HIFI ILT Stability

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1 General

1.1 Reference Documents

Issue	Date	Authorization	Title
RD01	23/06/2009	J. Kooi	Band7b_stability_Campaign_v1.0.pdf
RD02	15/07/2009	J. Kooi	HIFI_COP_B7b_stabilityInvestigation-15July2009.pdf
RD03	15/06/2009	J. Kooi	IFstability-and-SVMthermalStability_150609.pdf
RD04	09/09/ 2009	J. Kooi	FSW-CoP-09Sept2009.pdf

2 Introduction

Fig. 1 below outlines the three phases of the CoP stability measuring campaign. It should be kept in mind that B1-B5 are SIS bands and B6, B7 are the ‘Hot Electron Bolometer’ (HEB) bands. In addition, band 3-4 and 6-7 are the so called ‘diplexer’ bands (method of LO injection), with B1, B2, B5 the so called ‘beamsplitter’ bands. Especially in the frequency switch operation we shall see that the diplexer can have a significant impact on the baseline performance.

IF Stability
- IF Amplifier Warm-up
- Total Power Stability WBS, HRS
- Spectroscopic Stability WBS, HRS

System Stability
- Total Power Stability
- Spectroscopic Stability

Differential Stability
- LO Warm-up
- Internal Load (Int. Load)
- Double Beam Switch (DBS)
- Load switch (LS)
- Frequency switching (FSW)

Fig 1. *Overview of the stability test during the CoP campaign.*

During ILT and to some extend TBTV, several time constants important to HIFI operation were studied. For clarity we incorporate them in this report:

- **IF-1 amplifier turn-on stabilization (Section 3.4)**
- **LO warm-up, System and Differential (Section 4.1)**

We have found that the IF-1 amplifier warm-up time is approximately 10 minutes. The LO warm-up time is found to vary from 30 minutes to 55 minutes (5τ) in ILT and TB/TV with not surprisingly, the longest time constants are associated with the B6, B7 LO chains. Having said so, there is good evidence that I the HEB bands LO warm-up (5τ) > 1.5h is not unheard of.

Differential (DBS/Load-Switch) measurements should be possible ~ 3 minutes after LO turn in the SIS bands and ~13-15 minutes in the HEB bands. This is based on Internal Load measurements during LO warm up. However the baseline quality is likely to be somewhat degraded as there is frequently a 5-8% change of power in a 20 minute period. Naturally this is LO subband dependent, with B6, B7 having the longest settling time (and most sensitivity to a change in LO power being HEBs).

Differential FSW measurement were deemed especially sensitive to changing LO power, and were only scheduled after the LO had been thoroughly warmed up.

“In-band” frequency change settling time has been observed in nearly all bands, however it is most evident in band 6 and 7. The latter is likely due to the Hot electron Bolometer (HEB) sensitivity to LO power variations and general complexity (many cascaded stages) of the B6, B7 LO chains. No clear pattern has been observed, and as a rule it may be wise to do a LO-retuning in bands 6 and 7 five minutes after a frequency change event for long observations. One should also be aware that large frequency changes will presumably affect the LO thermalization time.

It should be noted here that in CoP significantly more spurious signal were detected. For some of the presented data the Batch stability Analyses shall need to be re-run after removal of narrow and weak spurs. It is also important that there is a spur detection/elimination tool in the pipeline. The statistics of the overall stability result should not be affected by weak spurs. The stronger spurs are cataloged by the ICC group.

Some general Stability observations:

- For beam splitter bands (B1, B2, B5) WBS sub-band 1-3 have similar stability, with sub-band 4 being generally a bit worse (7-8 GHz channel).
- Diplexer SIS bands (B3, B4), are most stable in the center of the IF (WBS sub-band 2, 3), followed by WBS sub-band 1 (4-5 GHz) and WBS sub-band 4 (6-7 GHz).
- HEB bands are most stable in WBS sub-band2 (4.4-4.8 GHz) where Tsys is the worst or highest. In the IF frequency range 2.4-3.4 GHz (WBS sub-band 4) Tsys is lowest (-3dB mixer gain corner frequency) and continuum/spectroscopic stability is the worst. Here the HEB mixer is most sensitive to standing wave power fluctuations and LO drift. Thus a tradeoff in the HEB bands is possible between sensitivity and sensitivity.
- For narrow line observations we find the best sub-bands as:

  B1, B2: WBS sub-band 1

  B3, B4: B5: WBS sub-band 2

  B6, B7: WBS sub-band 4
- Frequency switch differential measurements was an important point of investigation during CoP as in TBTV it was shown to be a promising mode. A separate report has been written in this regard [RD04]..
- The stability observation at the important CII line (1901 GHz USB) was very poor, as in TB/TV. A dedicated M1, M2 multiplier bias voltage test [RD02] found optimized setting quite a way away (M1 = -8.2V, M2 = -9.4V) from those used in TB/TV and most of CoP (M1 = -7.5V, M2 = -11.5V). Unfortunately all reported stability for OH and C^+ in the B7b multiplier band are with the pure, but unstable M1, M2 multiplier setting. In addition, C^+ FSW measurements failed due to a lack, or possible no LO power.

3 Obsid listing of all relevant differential stability measurements.

#band 1a OD44	Mode	Comment
1342179123	Stab Int. Load	Very minor LO warmup-> can be used.
1342179124	Int. Load	Good
1342179126	Int. Load	Good
#band 1b OD44		
1342179133	Stab Int. Load	LO warmup 1200s, do not use.
1342179134	Int. Load	Small residual warmup 3600s-> can be used.
#band 2a OD48		
1342179252	Stab Int. Load	Minor LO drift 600s-> can be used
1342179253	Int. Load	Good
1342179254	DBS	Good
1342179256	Int. Load	Good
#band 2b OD48		
1342179080	Stab Int. Load	LO warmup 400s --> do not use
1342179081	Int. Load	Imix jump after 800s, needs reanalyses --> do not use
1342179083	Int. Load	Current drifting for at least 1000s, needs reanalyses --> do not use
#band 3a OD48		
1342179244	Stab Int. Load	LO warmup 1000s --> do not use
1342179245	Int. Load	Strange Imix wiggles. WBS subband 1 saturated, HRS barely ok. Probably do not use.
1342179247	Int. Load	Diff int. Load, enourmous amount excess noise. Spur at 5.7 GHz --> do not use.
1342179248	Int. CBB	HRS Channel 2 messed up, affects full. Remaining channels ok. ??
#band 3b OD47		
1342179218	Stab Int. Load	LO warmup 1200s --> do not use
1342179219	Int. Load	HRS ok, WBS subband 1 saturated --> use only HRS
1342179221	Int. Load	1000s Exp decay in time series (15% in diff). Re-analyze w/o drift part --> do not use.
#band 4a OD43		
1342179092	Stab Int. Load	LO drift 500s else ok. --> rerun after 500s. Do not use.
1342179093	Int. Load	Good
1342179095	Int. Load	Good
#band 4b OD51		
1342179424	Stab	Data is fine. --> use
1342179425	Int. Load	Good
1342179426	DBS	Good
1342179428	Int. Load	WBS subband 1 spur, 4.3 GHz. HRS ok --> only use HRS data
#band 5a OD48		
1342179262	Stab Int. Load	600s exp decay. Can be used if data is re-run --> do not use.
1342179263	Int. Load	Good
1342179264	DBS	Good
1342179266	Int. Load	Minor stabilization for 1000s. --> Can be used.
#band 5b OD51		
1342179434	Stab	No LO drift --> use
1342179435	Int. Load	Weird LO drift for 1000s --> re-analyze, do not use.
1342179436	DBS	Good
1342179437	LSW	Good
1342179439	Int. Load	Good
1342179440	DBS	Good

1342179441	LSW	Good
#band 6a OD44		
1342179112	Stab	Erratic Lo warmup (Iheb) for 1200s. Garbage --> do not use
1342179113	Int. Load	1h, Lo does not warm up for 1h. --> LO warm-up time > 1.5h. Do NOT use System, --> Only Diff stab
1342179115	Int. Load	Odd current affect, garbage --> do not use
#band 6b OD43		
1342179068	Stab Int. Load	LO warmup 1200s --> do not use.
1342179069	Int. Load	LO warm-up for 3600s. LO never really warm up. --> Only use Diff Stab Int. Load
1342179070	Int. CBB	Good
1342179071	Int. Load	Good
#band 7a OD48		
1342179233	Stab Int. Load	LO warmup. Garbage --> do not use
1342179234	Int. Load	8% LO warm-up over 1h. use only Diff Stab Int. Load
1342179236	Int. Load	5% drift in power over 1h. Use only diff Stab Int. Load
#band 7b OD47		
1342179199	Stab Int. Load	5% LO drift, Imix 40-50uA. --> use Diff mode only
1342179200	Int. load	Good
1342179207	Int. Load	Good
#band 2b OD49		
1342179315	Stab Int. Load	Drop in Lo pwoer at 500s. --> do not use.
1342179316	Int. Load	Good
1342179318	Int. load	Int. Load: 15% power drift in 3000s (Isis drop). Affects both Stab Sys and Stab Diff. Only use Diff??
#band 4a OD49		
1342179327	Stab Int. Load	Serious LO drift 20min. --> do not use.
1342179328	Int Load	Good
1342179329	DBS	Good
1342179331	Int. Load	Good
#band 6b, OD61		
1342179412	Stab Int. Load	4% exp power rise. --> do not use.
1342179413	Int. Load	Good
1342179415	Int. Load	Good
#B5bExt-OD52		
1342179459	Stab Int. Load	50s LO warmup, WBS sub-band 2 has a very weak spur, data ok.
1342179460	FSW1	+-49 MHz. Imix drop outs typical of ALL FSW 0-300s. May affect result somewhat. Data ok
1342179461	FSW2	+-150 MHz. Imix drop outs typical of ALL FSW 0-300s. May affect result somewhat. Data ok
1342179462	FSW1	+-49 MHz. Imix drop outs typical of ALL FSW 0-300s. May affect result somewhat. Data ok
1342179463	FSW2	+-150 MHz. Imix drop outs typical of ALL FSW 0-300s. May affect result somewhat. Data ok
#B2bExt-OD52		
1342179464	Stab Int. Load	Mixer current jumps after 500s. Very similar to Band 2B OD43 result. (729.52 GHz) --> do not use.
1342179465	DBS	Good
1342179466	LS	Good
1342179467	FSW1	+-47 MHz. Imix drop outs typical of ALL FSW 0-300s. May affect result somewhat. Data ok
1342179468	FSW2	+-144 MHz. Bad LO tuning, garbage. --> do not use.
1342179469	DBS	5% power level decay over 1h. Do not use for System, Diff stab ok.
1342179470	LSW	Good
1342179471	FSW1	+-47 MHz. Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179472	FSW2	+-144 MHz. Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179473	FSW1	+-47 MHz. Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok

1342179474	FSW1	+-47 MHz. Imix drop outs typical of ALL FSW. May affect result somewhat. Some crappy Diff baseline at 7.4 GHz. Data ok
#B6bExt-OD52		
1342179448	Stab Int. Load	45 min exponential rise Power, Iheb just ok. --> do not use.
1342179449	DBS	Good
1342179450	LSW	Good
1342179451	FSW1	+-48 MHz. Data ok
1342179452	FSW2	-293 MHz, 27 MHz. Data ok
1342179453	DBS	Good
1342179454	LSW	Good
1342179455	FSW1	+-48 MHz. Data ok
1342179456	FSW2	-311 MHz, +130 MHz. Data ok
1342179457	FSW1	Analyses could not run to completion. Missing DF?
1342179458	FSW1	-167 MHz, +75 MHz. Data ok
#B1aExt-OD54		
1342179572	Stab Int. Load	No Stab Int. Load data good.
1342179573	DBS	Good
1342179574	LSW	Good
1342179575	FSW1	CBB, not sky. +-47 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179576	FSW2	+-144 MHz,Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179578	DBS	Good
1342179579	LSW	Good
1342179580	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179581	FSW2	+-144 MHz,Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179583	FSW1	+-47 MHz, Imix drop outs. Ringing on Isis. May affect result somewhat. Data ok
1342179585	FSW1	+-47 MHz, Imix drop outs. Periodic behavior. May affect result somewhat. Data ok
#B1bExt-OD54		
1342179590	Stab Int. Load	7% exponential decay for 20 min. --> Do not use.
1342179591	DBS	Good
1342179592	LSW	Good
1342179593	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179594	FSW2	+-144 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179596	DBS	Good
1342179597	LSW	Good
1342179598	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179599	FSW2	+-144 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179601	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179603	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
#B7bExt-OD57		
1342179677	Stab Int. Load	45 min, LO drifts out of range. --> bad data.
1342179678	DBS	Good
1342179679	LSW	Good
1342179680	FSW1	CBB, not sky. +-48 MHz, No LO --> bad data.
1342179681	FSW2	CBB, not sky. -123 MHz, +170 MHz, No LO --> bad data.
1342179682	FSW3	CBB, not sky. -24 MHz, +92 MHz, No LO --> bad data.
1342179708	DBS	Good
1342179709	LSW	Good
1342179710	FSW1	+-48 MHz Spur at 7.35 GHz. --> Bad data until removed

1342179711	FSW2	-240 MHz, +110 MHz. Spur at 7.60 GHz. --> Bad data until removed.
1342179712	FSW1	+-48 MHz Spur at 7.6 GHz. --> Bad data until removed
1342179713	FSW2	-167 MHz, +0 MHz Spur at 7.4 GHz. --> Bad data until removed
1342179740	FSW2	-367 MHz, +0 MHz Good data, no spur!
1342179742	FSW2	-140 MHz, +186 MHz Good data, no spur!
#B2aExt-OD59		
1342179746	Stab Int. Load	20% power change in 20 minutes. --> do not use
1342179747	LS	Something strange with Diff (needs checkout). --> do not use.
1342179748	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179749	FSW2	+-144 MHz,Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179751	DBS	Good
1342179752	LSW	Good
1342179753	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179754	FSW2	+-144 MHz,Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179756	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
1342179758	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May affect result somewhat. Data ok
#B3aExt-OD59		
1342179763	Stab Int. Load	10% power change in 1000s. --> do not use.
1342179764	DBS	Some excess noise in TP, but this is real. --> Data ok.
1342179765	LSW	Some excess noise in TP, but this is real. --> Data ok.
1342179766	FSW1	CBB, not sky. -75 MHz, +35 MHz, Current modulation in H. May affect result somewhat. Data ok
1342179767	FSW2	-75 MHz, +75 MHz, Current modulation in H with some current dropouts. May affect result somewhat. Data ok
1342179768	FSW3	-144 MHz, +144 MHz, Current modulation in H with some current dropouts. May affect result somewhat. Data ok
1342179770	DBS	Spur at 5.7 GHz, needs to be rerun. --> do not use.
1342179771	LSW	Spur at 5.7 GHz, needs to be rerun. --> do not use.
1342179772	FSW1	+-47 MHz, Current modulation in H with some current dropouts. May affect result somewhat. Excess noise, Data ok
1342179773	FSW2	+-15 MHz, Current modulation in H with some current dropouts. May affect result somewhat. Excess noise, Data ok
1342179774	FSW3	+-94 MHz, Current modulation in H with some current dropouts. May affect result somewhat. Excess noise, Data ok
1342179775	Int. CBB	Spur at 5.6 GHz, needs to be rerun. --> do not use.
1342179776	FSW1	+-47 MHz, Some current dropouts. May affect result somewhat. Excess noise, Data ok
1342179777	FSW3	-52, 0 MHz, Some current dropouts. May affect result somewhat. Excess noise, Data ok
1342179779	FSW1	+-47 MHz, Current modulation in H with some current dropouts. May affect result somewhat. Excess noise, Data ok
#B5aExt-OD60		
1342180158	Stab Int. Load	Good, barely any warm-up (negligible).
1342180159	LS	Good.
1342180160	FSW1	+-49 MHz, Some current modulation/dropouts. May affect result somewhat. Excess noise, Data ok
1342180161	FSW2	-115 MHz, +85 MHz, Some current modulation/dropouts. May affect result somewhat. Excess noise, Data ok
1342180162	DBS	Good.
1342180163	LSW	Good.
1342180164	FSW1	+-49 MHz, Some current modulation/dropouts. May affect result somewhat. Excess noise, Data ok
1342180165	FSW2	-97 MHz, +81 MHz, Some current modulation/dropouts. May affect result somewhat. Excess noise, Data ok
1342180166	FSW1	+-49 MHz, Some current modulation/dropouts. May affect result somewhat. Excess noise, Data ok
1342180167	FSW1	+-49 MHz, LO power drop at 300s + spur at 4.4 GHz. --> do not use.
#B4aExt-OD61		
1342179923	Stab Int. Load	5% drop in power in 20 min. --> do not use.
1342179924	LS	Good, some excess noise TP.
1342179925	FSW1	+-47 MHz, Current modulation in H with some current dropouts. May affect result. Excess noise TP. Data ok.
1342179926	FSW2	-20 MHz, +20 MHz, Current modulation in H with some current dropouts. May affect result. Excess noise TP.

		Data ok.
1342179928	DBS	Good.
1342179929	LS	Good.
1342179930	FSW1	+-47 MHz, Current modulation in H with some current dropouts. May affect result. Excess noise TP. Data ok.
1342179931	FSW2	-20 MHz, +20 MHz, Current modulation in H with some current dropouts. May affect result. Excess noise TP. Data ok.
1342179933	FSW1	+-47 MHz, Current modulation in H with some current dropouts. May affect result. Excess noise TP. Data ok.
1342179935	FSW1	+-47 MHz, Line detection! Current modulation in H with some current dropouts. Data seems ok.
#B6aExt-OD61		
1342179907	Stab Int. Load	Run out of LO, garbage --> do not use.
1342179908	DBS	Some Lo warmu for 1h. Clearly LO was not stabilized. Data ok.
1342179909	LSW	LO stabilized after 1.4h, nice data.
1342179910	FSW1	CBB, not sky. +-48 MHz, Some current dropouts. Data ok
1342179911	FSW2	CBB, not sky. +-88 MHz, Some current dropouts. Data ok
1342179913	DBS	No LO --> do not use data.
1342179914	LSW	Spur at 7.6 Ghz. Does not saturate, causes excess noise in WBS Full and Sub-band 3, Ta ok. --> use data for Ta only.
1342179915	FSW1	+-48 MHz, Spurs. Do not use.
1342179916	FSW2	+-154 MHz, + 160 MHz Spurs. Do not use
1342179918	FSW2	+-48 MHz, Some current dropouts. Data ok
1342179919	FSW2	+-48 MHz, Some current dropouts. Data ok
#B7aExt-OD62		
1342179944	Stab Int. Load	Garbage --> do not use.
1342179945	DBS	7% Lo warm-up for 1h. --> use only Diff. data.
1342179946	LSW	Lo Warmed up, but a small spur at 5.7 GHz. Does not affect things --> use data
1342179947	FSW1	+-48 MHz, Some current dropouts. Data ok
1342179948	FSW2	-152 MHz, +32MHz Some current dropouts. Data ok
1342179949	FSW3	-152 MHz, +118MHz Some current dropouts. Data ok
1342179951	DBS	Good
1342179952	LSW	Good
1342179953	FSW1	+-48 MHz, Some current dropouts. Data ok
1342179954	FSW1	-88 MHz,110 MHz Some current dropouts. Data ok
1342179956	FSW1	-0, +74 MHz, Some current dropouts. Data ok
1342179957	FSW2	-0, +253 MHz, Some current dropouts. Data ok
#B4bExt-OD62		
1342179963	Stab Int. Load	Negligible Lo warm-up --> use data
1342179964	LSW	Good
1342179965	FSW1	+-47 MHz, Some current dropouts. Very tiny spur at 5.9 GHz, does not seem to affect. Data ok
1342179966	FSW2	Very odd LO power turnon --> do not use.
1342179967	FSW3	-364 MHz, =0 Mhz Some current dropouts. Very tiny spur at 5.9 GHz, does not seem to affect. Data ok
1342179969	DBS	Small spur at 4.3 GHz. Does not affect Ta performance. HRS unaffected --> use data.
1342179970	LSW	Small spur at 4.3 GHz. Does not affect Ta performance. HRS unaffected --> use data
1342179971	FSW1	+-47 MHz, Small spur at 4.3 GHz. Does not affect Ta performance. HRS unaffected --> use data.
1342179972	FSW2	+-94 MHz, Small spur at 4.3 GHz. Does not affect Ta performance. HRS unaffected --> use data
1342179974	FSW1	-0, +94 MHz, Good.
1342179976	FSW1	-0, +94 MHz, WBS affected by spur, HRS is fine. --> use only HRS.
#B3bExt-OD63		
1342180284	Stab Int. Load	Lo Warmup, poor. --> do not use.
1342180285	DBS	Good

1342180286	LSW	Good
1342180287	FSW1	+-47 MHz, problem BSA from 0-100s, Rerun the analyses. Ta OK, fbw not ok.
1342180288	FSW2	Very odd LO power turnon --> do not use.
1342180290	DBS	OK, but 1h settling time
1342180291	LSW	Good.
1342180292	FSW1	-36MHz, +32 MHz, Good.
1342180293	FSW2	+-15 MHz, Good.
1342180294	FSW1	-72MHz, 0 MHz, Good
1342180295	FSW2	+-47 MHz, Good

(red)	Do not use
(purple)	Diff Only,HRS only, Vpol only.
(blue)	Unclear. OK for Ta, not for fbw, beta etc.

Table.1, ObsId listing of all differential measurements in CoP.

4 Differential Stability Tables

4.1 Internal Load

4.1.1 WBS

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	150.4	104.1	157.7	223.6	216.9	5.657	5.515	3.394	17.748	88.035
b1b	89.4	NaN	101.8	142.1	106.5	0	0	0	0	19.141
b2a	493.2	469.9	492.4	701.3	710	92.56	39.174	217.435	277.893	268.701
b2b	NaN	NaN	NaN	NaN	NaN	0	0	0	0	0
b3a	900	900	NaN	NaN	900	0	0	0	0	0
b3b	78	95.2	NaN	NaN	NaN	0	0	0	0	0
b4a	NaN	NaN	177.7	223.8	NaN	0	0	0	0	0
b4b	436	114.3	335.4	353.2	224.4	0	0	0	384.793	179.4
b5a	601.6	245.5	287	619.5	668.2	422.001	0	0	396.758	246.285
b5b	638	532.3	583.2	702	847.5	0	0	0	0	0
b6a	900	900	900	900	NaN	0	0	0	0	0
b6b	NaN	366.7	NaN	NaN	NaN	0	174.16	0	0	0
b7a	NaN	598.5	900	900	NaN	0	0	0	0	0
b7b	900	NaN	900	900	NaN	0	0	0	0	0

Table 2, WBS-H Int. Load Total Power differential stability (900s upper limit measurement)

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	118	98.3	97.7	361.9	228.2	29.246	17.883	13.93	373.946	154.079
b1b	NaN	NaN	NaN	128.9	NaN	0	0	0	0	0
b2a	362.4	298.4	340.2	405.4	683.5	29.204	49.922	53.882	5.02	165.675
b2b	NaN	NaN	NaN	NaN	NaN	0	0	0	0	0
b3a	NaN	NaN	NaN	NaN	NaN	0	0	0	0	0
b3b	740.3	165.6	900	777.8	743	0	0	0	0	0
b4a	NaN	900	NaN	NaN	117.8	0	0	0	0	0
b4b	441.3	401.2	280.9	384.9	388.8	0	0	103.167	194.596	205.415
b5a	900	486.2	692	900	900	0	366.423	294.227	0	0
b5b	654.9	482	312	NaN	821.7	0	0	0	0	0
b6a	900	430.6	900	900	NaN	0	0	0	0	0
b6b	244.3	370.8	343.6	NaN	NaN	0	250.423	36.77	0	0
b7a	900	900	900	900	NaN	0	0	0	0	0
b7b	900	900	900	900	NaN	0	0	0	0	0

Table 3, WBS-V Int. Load Total Power differential stability (900s upper limit measurement)

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	460.5	1105.9	767.5	1222.2	1050.2	263.751	981.606	326.754	817.203	1060.377
b1b	778.2	954.4	1800	1052.4	826.7	0	0	0	1057.337	0
b2a	706.4	1428.5	933.1	923.5	964.2	14.425	525.38	5.445	135.128	16.829
b2b	330.2	1800	1800	1800	1800	0	0	0	0	0
b3a	1800	NaN	NaN	NaN	367	0	0	0	0	0
b3b	NaN	NaN	597.5	612.3	749.2	0	0	0	0	0
b4a	NaN	539.4	1530	1800	NaN	0	194.019	467.596	0	0
b4b	1800	1800	1800	1800	1800	0	0	0	0	0
b5a	1800	1800	1800	1800	1800	0	0	0	0	0
b5b	1271	1800	1800	1800	1176	0	0	0	0	0
b6a	NaN	878.6	434	336.8	NaN	0	0	0	0	0
b6b	599.9	1537.3	1129.2	997.4	NaN	167.929	288.226	462.486	196.636	0
b7a	592.9	1800	703.3	712	NaN	0	0	298.894	265.872	0
b7b	1112.7	1520.5	652.3	849.8	NaN	971.989	395.273	143.684	274.711	0

Table 4, WBS-H Int. Load Spectroscopic differential stability (1800s upper limit measurement)

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	526.7	716	846.6	1289.7	698.4	231.719	60.387	177.13	721.673	415.637
b1b	276.7	1800	1030	597.2	402.1	0	0	0	472.701	0
b2a	911.8	1560.5	1800	1800	1433.5	95.53	338.704	0	0	518.309
b2b	572.6	598.4	832.9	765.2	787.8	0	0	0	0	0
b3a	503.4	847.1	945.5	659.8	793.3	0	0	0	203.01	0
b3b	849.9	944	990.5	1800	832.3	0	0	0	0	0
b4a	367.5	782.6	993.1	1055.8	292.7	49.526	239.487	289.217	85.089	34.24
b4b	888.2	835.3	1018.7	1410.5	1055	0	0	61.306	550.836	16.971
b5a	1631	1800	1800	1800	1800	239.002	0	0	0	0
b5b	1377	1800	1800	1800	1636	0	0	0	0	0
b6a	NaN	1131	500.6	396.1	NaN	0	0	0	0	0
b6b	971.1	1446.7	1112.2	1237.7	NaN	382.864	313.679	225.445	293.284	0
b7a	454.8	1442.5	612	1126	NaN	0	505.581	218.001	0	0
b7b	1066.3	1800	626.7	399.6	NaN	1037.608	0	12.799	71.771	0

Table 5, WBS-V Int. Load Spectroscopic differential stability (1800s upper limit measurement)

4.1.2 HRS

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	**138.9**	96.7	191	200.2	175.4	184.6	255.6	99.4	87.7
b1b	**85.2**	NaN	113.3	124.7	135.2	138.1	120.1	99.5	87.4
b2a	**471.8**	389.5	630.5	663.5	790.5	900	550.8	424.5	348.6
b2b	**NaN**	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
b3a	**NaN**	NaN	NaN	900	900	900	900	900	NaN
b3b	**NaN**	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
b4a	**NaN**	NaN	106.9	115.6	NaN	311.8	184.8	NaN	NaN
b4b	**373.8**	NaN	397.2	95.8	539.3	619.3	336.1	351.5	281.8
b5a	**312**	325.2	NaN	393.5	470.8	425.5	349.8	NaN	333.3
b5b	**119.1**	NaN	82	393.2	900	470.3	312.9	NaN	NaN
b6a	**900**	900	900	900	900	900	900	900	900
b6b	**NaN**	666.2	449.9	900	NaN	534	256.8	271.7	641.8
b7a	**NaN**	900	NaN	900	900	900	900	900	900
b7b	**900**	900	900	900	900	900	900	900	NaN

Table 6, HRS-H Int. Load Total Power differential stability (900s upper limit measurement)

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	**93.4**	82.9	NaN	100.8	348.9	309.3	102.9	83	93
b1b	**NaN**	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
b2a	**281.3**	163.4	313.6	292.1	383.2	355.6	247.7	150.1	292.1
b2b	**NaN**	NaN	NaN	NaN	97	NaN	NaN	NaN	NaN
b3a	**NaN**	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
b3b	**NaN**	206.4	NaN	NaN	734.6	662.3	NaN	NaN	200.2
b4a	**NaN**	NaN	NaN	NaN	163.4	NaN	NaN	NaN	496.4
b4b	**344.9**	157.4	266.7	392.3	299.1	595.7	290.3	445.1	188.9
b5a	**423**	347	605.9	463.1	679.2	719.8	483.3	506.1	381.2
b5b	**337.9**	104.9	172.5	242.8	497.8	548.1	410.1	485.5	118.7
b6a	**900**	NaN	900	900	900	900	900	900	186.1
b6b	**900**	850.6	900	900	900	900	900	900	862.9
b7a	**900**	900	900	900	900	900	900	900	900
b7b	**900**	900	900	900	900	900	900	900	900

Table 7, HRS-V Int. Load Total Power differential stability (900s upper limit measurement)

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	**445.7**	1800	1800	753.9	1260.3	447.4	1760.5	1504	1557.5
b1b	**891.1**	519.8	1459.5	1105.6	1164.8	1175	1505.5	1261.3	799.4
b2a	**694.9**	1800	1389.5	1380.7	1310.5	1800	1800	1648.5	1616.5
b2b	**274.7**	1800	NaN	1800	NaN	NaN	1800	1800	1800
b3a	**NaN**	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
b3b	**571.9**	637.7	666.8	978	828.1	801.2	859.7	643.3	526.2
b4a	**NaN**	1800	1800	1800	1246.9	1107.4	1710	1800	1800
b4b	**1632.5**	1800	1800	1800	1800	1800	1800	1800	1800
b5a	**1800**	1800	1800	1800	1800	1800	1800	1800	1800
b5b	**1109**	1800	NaN	NaN	1800	1800	NaN	1800	1800
b6a	**NaN**	559.5	251.1	350.2	NaN	305.1	364.2	412.4	664
b6b	**512.1**	1617	886	1302.5	977.3	1134.9	989	1349.4	1800
b7a	**474.8**	1319	474.1	1136.3	679.4	568.7	765.4	1007.1	1241.5
b7b	**1048.6**	1125	1156.2	1191.6	1169.2	1242.8	598.8	777.6	1164

Table 8, HRS-H Int. Load Spectroscopic differential stability (1800s upper limit measurement)

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	**557.9**	1453.5	941.2	1357	1274.4	1279.8	1435	1567.5	1800
b1b	**333.6**	1215.3	1084.7	951.4	901.3	1002.6	1027.1	838.1	1515.5
b2a	**1330.9**	NaN	NaN	1800	1522	1261	1800	1800	1800
b2b	**863.4**	1800	NaN	1800	1800	NaN	1800	1800	NaN
b3a	**367.2**	1074.7	1384	1800	1282.4	1291.4	932.6	1495.5	1107.5
b3b	**805.7**	1800	NaN	1800	1706	NaN	1800	1800	1800
b4a	**326.7**	1750	1800	1740.3	1225.9	1800	1800	1800	1794.7
b4b	**1800**	1800	1800	NaN	1250.4	1044.6	1800	1800	1800
b5a	**1800**	1800	1800	1800	1800	1800	1800	1800	1800
b5b	**1800**	NaN	1800	NaN	NaN	NaN	NaN	1800	NaN
b6a	**NaN**	754	283.9	350.4	301.2	320.6	372	458.6	557.2
b6b	**874.4**	1800	1002.8	1671	1185.3	1344.5	1507.3	1448.6	1701.7
b7a	**459.8**	1247.7	427.8	1800	1518	1513.5	1556	883.4	777.6
b7b	**1800**	1359.2	322.6	NaN	642.8	621.4	400.1	526	514.7

Table 9, HRS-V Int. Load Spectroscopic differential stability. (1800s upper limit measurement)

4.2 Double Beam Switch

4.2.1 WBS

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	408.3	498.2	574.4	508.9	900	102.813	367.413	460.468	25.88	0
b1b	NaN	NaN	277.5	NaN	NaN	0	0	0	0	0
b2a	356.8	520.6	692.6	544.9	900	0	0	293.308	0	0
b2b	135.3	900	729.9	551.5	900	0	0	240.558	492.924	0
b3a	NaN	797.1	NaN	NaN	NaN	0	0	0	0	0
b3b	770.5	NaN	99.1	837.7	900	0	0	0	0	0
b4a	745.8	595.6	748	900	711.4	218.142	430.487	215.031	0	266.721
b4b	194	92.7	492.9	826.5	900	0	0	575.712	104.015	0
b5a	900	900	900	900	900	0	0	0	0	0
b5b	366.2	705.4	550.9	900	289	95.813	275.206	0	0	0
b6a	702	800.2	778.7	621.4	NaN	280.085	141.209	171.615	394	0
b6b	759.5	698.8	752.1	776.8	NaN	0	0	0	0	0
b7a	298.8	323	682	900	NaN	0	0	308.299	0	0
b7b	900	640.1	900	900	NaN	0	367.625	0	0	0

Table 10, WBS-H DBS Total Power differential stability (900s upper limit measurement)

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	790.6	NaN	790.1	133	225.9	0	0	0	0	0
b1b	416.4	534.9	428.1	433.3	403.3	105.005	0	107.197	38.113	0
b2a	512.6	157.7	171.4	900	900	547.937	0	15.344	0	0
b2b	597	622.6	619.8	105.2	237.8	428.507	392.374	344.149	0	151.533
b3a	NaN	NaN	NaN	NaN	NaN	0	0	0	0	0
b3b	328.9	647.6	725.5	323	276.1	0	64.63	0	0	0
b4a	389.4	288.8	900	442.1	NaN	0	0	0	0	0
b4b	NaN	NaN	900	900	NaN	0	0	0	0	0
b5a	354.3	147.5	213.8	288.8	900	0	0	0	0	0
b5b	900	900	488.7	703.1	900	0	0	581.617	278.529	0
b6a	86.3	592.9	900	77.5	NaN	0	434.376	0	0	0
b6b	252	900	248.4	459.4	NaN	125.653	0	0	0	0
b7a	900	212.3	900	900	NaN	0	0	0	0	0
b7b	900	900	900	900	NaN	0	0	0	0	0

Table 11, WBS-V DBS Total Power differential stability (900s upper limit measurement)

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	1800	1800	NaN	1800	1800	0	0	0	0	0
b1b	1800	1800	1800	1800	1800	0	0	0	0	0
b2a	NaN	1800	1800	1800	1800	0	0	0	0	0
b2b	1800	1800	1800	1800	1800	0	0	0	0	0
b3a	NaN	NaN	1800	274.8	NaN	0	0	0	0	0
b3b	1800	1800	1800	1800	1800	0	0	0	0	0
b4a	486.1	1800	1800	1800	1800	0	0	0	0	0
b4b	1800	1800	1800	1800	1800	0	0	0	0	0
b5a	1800	1800	1800	1800	1800	0	0	0	0	0
b5b	1800	1800	1800	1800	1800	0	0	0	0	0
b6a	1800	1800	1800	1800	NaN	0	0	0	0	0
b6b	1800	1800	1800	1800	NaN	0	0	0	0	0
b7a	1538	1800	1046	1084.7	NaN	0	0	1066.388	1011.587	0
b7b	764.8	1488.5	1800	369.1	NaN	0	440.528	0	61.448	0

Table 12, WBS-H DBS Spectroscopic differential stability (1800s upper limit measurement)

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	NaN	1800	1800	1800	1800	0	0	0	0	0
b1b	1800	1800	1800	1800	1800	0	0	0	0	0
b2a	1800	1800	1800	1800	1800	0	0	0	0	0
b2b	1800	1800	1800	1800	1800	0	0	0	0	0
b3a	1800	1800	1800	1800	1800	0	0	0	0	0
b3b	1800	1800	1800	1800	NaN	0	0	0	0	0
b4a	1648.5	1800	1800	1800	1288.2	214.253	0	0	0	723.795
b4b	1800	1800	1800	1800	1800	0	0	0	0	0
b5a	1800	1800	1800	1800	1800	0	0	0	0	0
b5b	1800	1800	1800	1800	1800	0	0	0	0	0
b6a	1598	1800	1800	1800	NaN	0	0	0	0	0
b6b	1800	1800	1800	1800	NaN	0	0	0	0	0
b7a	1800	1800	1800	1066.4	NaN	0	0	0	1037.538	0
b7b	521.8	1800	1800	1062.6	NaN	0	0	0	853.407	0

Table 13, WBS-V DBS Spectroscopic differential stability (1800s upper limit measurement)

4.2.2 HRS

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	900	NaN	900	900	228.1	743.9	900	900	NaN
b1b	786.3	829.4	689.7	668.5	170.3	591.5	625	784.8	710.3
b2a	615.4	459.7	332.1	412.1	464.2	547.9	263.3	723.8	467
b2b	491.2	538.6	117.1	NaN	NaN	504.4	NaN	113.8	563.2
b3a	NaN	900	NaN	NaN	NaN	NaN	NaN	NaN	681.1
b3b	104.2	291.3	300	417.2	761.9	124.3	NaN	152.8	656
b4a	604.1	863.2	900	900	900	492.5	900	520.6	553.1
b4b	260.4	567.4	601.4	155.6	784.6	273.3	274.7	740.8	649.2
b5a	453.6	619.8	570.2	514.2	900	900	513.3	428.1	598.7
b5b	260.8	388.7	139.6	900	386.6	900	619.8	824.3	447
b6a	609.7	698.2	607.3	593.1	560.6	556.8	582	631.4	666.4
b6b	885.6	900	877.2	862.1	866.9	900	900	859.9	766.6
b7a	900	572.2	NaN	900	900	NaN	608.7	900	698
b7b	900	900	900	900	900	900	900	900	900

Table 14, HRS-H DBS Total Power differential stability (900s upper limit measurement)

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	876.8	887.8	900	867	432.9	737.5	900	900	771.1
b1b	664.2	635.5	755.3	696.1	457.7	693.1	666.5	845.5	658.7
b2a	770.2	809	656.7	842.2	134.9	465.1	598	840.7	864.2
b2b	796.2	746.9	548.6	521.9	407.7	631.4	732.1	639.5	699.1
b3a	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
b3b	775.8	803.1	782.7	567.4	855.1	684.5	721.4	797	741.3
b4a	900	900	900	900	NaN	725.4	900	900	900
b4b	354.8	365.5	539.7	293.3	308	653.9	309.7	531.7	410.4
b5a	98.4	391.2	192.7	495.1	522.8	900	NaN	312.2	270.3
b5b	712	423.6	307.7	501.4	900	900	900	313.1	300.3
b6a	NaN	900	900	514.2	900	900	900	NaN	900
b6b	429.6	655.1	900	900	NaN	336.3	336.4	238.3	425.2
b7a	900	900	900	900	900	900	900	900	900
b7b	900	900	900	900	900	900	900	900	900

Table 15, HRS-V DBS Total Power differential stability (900s upper limit measurement)

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	1800	1800	1639.5	1800	1589.5	1102.5	1800	1800	NaN
b1b	1800	1800	1800	1800	1800	1800	1800	1800	1542
b2a	1800	NaN	1800	1800	NaN	1800	1687	1800	1800
b2b	1800	1800	1800	1800	NaN	1800	1800	1800	1800
b3a	263.2	1800	NaN	1800	NaN	254.7	NaN	1800	1800
b3b	1800	1800	1800	1800	1800	1800	NaN	1800	1800
b4a	1800	NaN	1800	1800	1800	1800	1800	1800	1800
b4b	NaN	NaN	NaN	1739.5	1800	1800	1800	1800	NaN
b5a	NaN	1800	1800	1800	NaN	1065	1800	1800	NaN
b5b	1800	1800	1800	1800	1800	1800	1800	1800	1800
b6a	1800	1800	1800	1800	1800	1800	1800	NaN	1800
b6b	NaN	1800	1060.2	1800	282.4	1173.3	1532.5	1800	1800
b7a	863	1800	730.8	1296.8	556.2	1158.9	1800	1035.1	1800

Table 16, HRS-H DBS Spectroscopic differential stability (1800s upper limit measurement)

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	1045.1	NaN	1800	1800	481.3	1800	NaN	NaN	1354.7
b1b	1800	1800	1800	1800	1800	NaN	NaN	1800	1800
b2a	1800	1800	1800	266.3	NaN	1800	1800	1800	1800
b2b	1101.3	NaN	1800	1735	1800	259.4	1800	1800	1800
b3a	1800	NaN	1800	NaN	NaN	1800	NaN	1800	1800
b3b	1800	1800	1800	1800	1800	NaN	1800	1290	1800
b4a	1471	1779.5	1800	1800	1800	1800	1800	1800	1800
b4b	1800	1800	1800	1800	1800	1800	1800	1800	1800
b5a	1800	1800	1760	1800	1800	1800	1800	1800	1800
b5b	1800	1800	1800	1800	1800	1800	1800	1800	1800
b6a	1800	1800	1800	1800	1800	1800	1800	NaN	1800
b6b	1800	NaN	1800	1800	NaN	NaN	1800	1800	1800
b7a	1602.5	1800	1109.8	1187.7	1165.2	1098.4	1123.4	321.9	1800
b7b	1800	1800	NaN	553.9	789.5	302.2	1007.1	935.3	1355

Table 17, HRS-V DBS Spectroscopic differential stability (1800s upper limit measurement)

4.3 Load Switch

4.3.1 WBS

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	360	519.3	485.2	548.4	900	350.371	276.691	227.476	0	0
b1b	108.2	765.6	489.8	287.8	325.7	18.307	0	580.068	276.401	0
b2a	900	900	891.7	900	900	0	0	0	0	0
b2b	508.9	552	505.7	508.2	900	502.47	492.146	453.821	554.16	0
b3a	NaN	900	NaN	NaN	NaN	0	0	0	0	0
b3b	396.8	402.5	506.3	134.3	140.7	0	63.781	0	0	0
b4a	900	900	741.2	754.7	900	0	0	224.577	205.485	0
b4b	445.8	413	430.8	900	900	0	0	0	0	0
b5a	900	900	327	NaN	900	0	0	0	0	0
b5b	900	828.7	871.1	900	900	0	100.833	40.871	0	0
b6a	900	NaN	NaN	900	NaN	0	0	0	0	0
b6b	900	331.3	401.7	900	NaN	0	287.015	245.578	0	0
b7a	498.4	640.7	434.8	816.1	NaN	0	366.776	0	118.653	0
b7b	900	856.8	900	900	NaN	0	61.165	0	0	0

Table 18, WBS-H Load Switch (LS) Total Power differential stability (900s upper limit measurement)

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	708.3	689.4	501.9	883.3	785.6	271.105	297.904	0	23.617	161.857
b1b	528.8	449.3	116.7	539.8	900	2.899	223.304	0	509.4	0
b2a	336.4	128.7	151.7	250.8	900	0	0	0	0	0
b2b	331.2	900	804.4	NaN	301	0	0	135.27	0	141.704
b3a	NaN	NaN	NaN	NaN	NaN	0	0	0	0	0
b3b	442.8	240.6	224.5	604.7	686.8	186.605	48.366	36.77	417.617	301.51
b4a	274.9	77.1	333.5	342.7	NaN	0	0	0	0	0
b4b	900	900	789.7	900	900	0	0	155.988	0	0
b5a	900	900	900	900	900	0	0	0	0	0
b5b	589.9	245.4	NaN	900	NaN	0	0	0	0	0
b6a	900	900	900	900	NaN	0	0	0	0	0
b6b	450.6	551.1	367.3	556.6	NaN	0	493.49	0	0	0
b7a	900	498.9	900	900	NaN	0	567.192	0	0	0
b7b	900	900	900	900	NaN	0	0	0	0	0

Table 19, WBS-V Load Switch (LS) Total Power differential stability (900s upper limit measurement)

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	1800	1800	1800	1800	1786.5	0	0	0	0	19.092
b1b	1800	1800	1800	1800	1800	0	0	0	0	0
b2a	1800	1800	1800	1800	1800	0	0	0	0	0
b2b	1643.5	1800	1800	1800	1800	221.324	0	0	0	0
b3a	NaN	1800	1800	1800	1481	0	0	0	0	0
b3b	1800	1800	1800	1800	1800	0	0	0	0	0
b4a	633.9	746.5	1800	1800	631.2	0	0	0	0	0
b4b	1800	1800	1800	1800	1800	0	0	0	0	0
b5a	1800	1800	1800	1800	1800	0	0	0	0	0
b5b	1688	1800	1800	1800	1800	158.392	0	0	0	0
b6a	1800	1566.5	1492.5	1800	NaN	0	330.219	434.871	0	0
b6b	1665.5	1757	1800	1800	NaN	14.849	60.811	0	0	0
b7a	NaN	1800	1800	1800	NaN	0	0	0	0	0
b7b	1800	1800	1415.5	1800	NaN	0	0	543.765	0	0

Table 20, WBS-H Load Switch (LS) Spectroscopic differential stability (1800s upper limit measurement)

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	1800	1800	1800	1738	1800	0	0	0	0	0
b1b	1547	1800	1626.5	1800	1720	357.796	0	245.366	0	113.137
b2a	1800	1800	1800	1800	1800	0	0	0	0	0
b2b	NaN	1800	1800	1546	369.8	0	0	0	359.21	0
b3a	1800	1800	1800	1800	1800	0	0	0	0	0
b3b	1800	1800	1800	1800	1800	0	0	0	0	0
b4a	1085.4	1041.7	1036.9	1800	1182.7	1010.597	1072.469	1079.186	0	873.065
b4b	1800	1800	1800	1800	1800	0	0	0	0	0
b5a	1800	1800	1800	1800	1800	0	0	0	0	0
b5b	1800	1800	1800	1800	1800	0	0	0	0	0
b6a	1800	1800	1483	1800	NaN	0	0	0	0	0
b6b	1800	1800	1800	1800	NaN	0	0	0	0	0
b7a	1249.2	1800	1800	1800	NaN	779.02	0	0	0	0
b7b	255.8	NaN	1162.1	NaN	NaN	0	0	902.198	0	0

Table 21, WBS-V Load Switch (LS) Spectroscopic differential stability (1800s upper limit measurement)

4.3.2 HRS

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	830.8	826.8	844.2	656.3	706	545.3	712.2	746.2	840.9
b1b	168.9	628.6	900	875.5	664.6	93.5	900	900	264.7
b2a	900	356.7	84.1	578.4	NaN	NaN	103.6	102.5	106.3
b2b	877	900	900	195.7	377.4	288.9	271.2	833.8	900
b3a	NaN	900	NaN	NaN	NaN	NaN	NaN	NaN	900
b3b	496.6	595.7	545.1	479	153.2	285.4	413.1	712.6	745.1
b4a	900	900	515.5	900	900	NaN	497.2	526.9	900
b4b	574.1	816.2	555.8	579.3	76.2	875.1	532.7	733.3	644.2
b5a	298.4	402.2	525.2	900	900	900	573.3	542.5	432.4
b5b	384.6	900	627.3	407.5	900	301.5	619.6	702.1	177.8
b6a	900	900	900	900	900	900	900	900	196.8
b6b	900	767.3	900	900	900	900	NaN	900	773.2
b7a	900	900	900	900	900	900	868.6	900	754.3
b7b	900	900	900	900	900	900	900	900	900

Table 22, HRS-H Load Switch (LS) Total Power differential stability (900s upper limit measurement)

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	900	900	900	568.1	382.2	539.1	900	900	804.7
b1b	210.4	493.6	900	610.8	453.2	415.7	900	900	226.3
b2a	613.6	838	636.3	558.3	900	77.5	142	NaN	613.8
b2b	900	900	NaN	559.8	87.6	654.4	400.4	900	900
b3a	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
b3b	702.6	NaN	NaN	264.1	502.7	86	232.6	900	705.6
b4a	416.2	474.6	357.2	NaN	NaN	326.7	900	NaN	269.7
b4b	142.6	369.9	445.3	900	748.6	859.1	900	431.3	443.5
b5a	410.6	563.1	866.1	331.5	900	900	720.8	362.9	287.5
b5b	584.9	600.8	685.1	464	508.4	NaN	900	900	555.6
b6a	900	900	900	900	900	900	900	900	900
b6b	678.9	558.2	629.7	677.9	561.8	504.6	580.7	671.2	391.7
b7a	900	900	900	900	900	900	900	900	900
b7b	900	900	900	900	900	900	900	900	900

Table 23, HRS-V Load Switch (LS) Total Power differential stability (900s upper limit measurement)

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	1800	1800	1800	1800	1800	1800	NaN	1800	1800
b1b	1508	NaN	1800	1800	NaN	1457	1800	1800	1800
b2a	1800	NaN	NaN	NaN	1800	NaN	1800	NaN	1800
b2b	1800	1800	1800	NaN	1800	NaN	1800	NaN	1387.3
b3a	1800	1800	NaN	NaN	NaN	NaN	NaN	NaN	NaN
b3b	1800	1800	1800	1800	1800	1800	1800	1800	1800
b4a	NaN	1800	1800	1800	NaN	1800	1800	1800	1800
b4b	1800	1800	NaN	1800	1800	1800	1800	1800	1800
b5a	1800	1800	NaN	1800	1800	1800	1800	1800	1800
b5b	1800	1800	NaN	1800	1800	1800	1800	NaN	NaN
b6a	1800	1800	1218.5	973.6	531.8	1800	1255	1405	1800
b6b	1786.5	1800	1800	1800	1800	1800	1800	1800	1800
b7a	1800	1800	1533	1800	1800	1800	1114.5	1800	1800
b7b	NaN	1110.5	1800	1761	1655	1800	1800	607.1	1800

Table 24, HRS-H Load Switch (LS) Spectroscopic differential stability (1800s upper limit measurement)

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8
b1a	1800	1786.5	1800	1800	1586	1800	1800	1055	1800
b1b	1377	1800	1800	NaN	1800	1800	1800	NaN	1800
b2a	1800	1800	1800	NaN	NaN	1800	1800	1800	1800
b2b	468.5	1800	1800	1800	1800	NaN	1800	NaN	796.8
b3a	1800	1800	NaN	NaN	1800	1800	1800	NaN	NaN
b3b	1800	1800	1800	1800	1800	1800	1800	1800	1800
b4a	387.2	1800	1800	1800	1800	1800	1800	NaN	1800
b4b	1800	NaN	1800	1800	1800	1800	1800	1800	1800
b5a	1800	1800	1800	1800	NaN	NaN	1800	1800	1617
b5b	1800	1800	1800	1800	1800	1800	1800	1800	1800
b6a	1800	1800	609.2	1256.5	680.5	1068	1729.5	1800	1800
b6b	1800	1800	1800	1800	1800	1800	1800	1800	1800
b7a	1117.5	1800	1800	1800	1800	1800	1800	1800	1742.5
b7b	282.1	494.2	1121	NaN	658	1800	389.7	1800	1137

Table 25, HRS-V Load Switch (LS) Spectroscopic differential stability (1800s upper limit measurement)

5 Differential Stability

5.1 Internal Load Differential Stability

Objectives

Verify the internal Hot/Cold calibration load differential amplitude stability of HIFI instrument, due to broadband gain variations, standing wave modulation, temperature drift…
Provide input for the efficiency computation/loop-optimization AOT's.
Obtain Hot-Cold calibration loop parameters...

Expected Result

Differential total power and spectroscopic gain stability between internal CBB and internal HBB as a function of integration time in Load-Switch mode for each mixer band.
Loop parameters AOT & HSPOT

5.1.1 B1a 492.05 GHz Int. Load Differential Stability

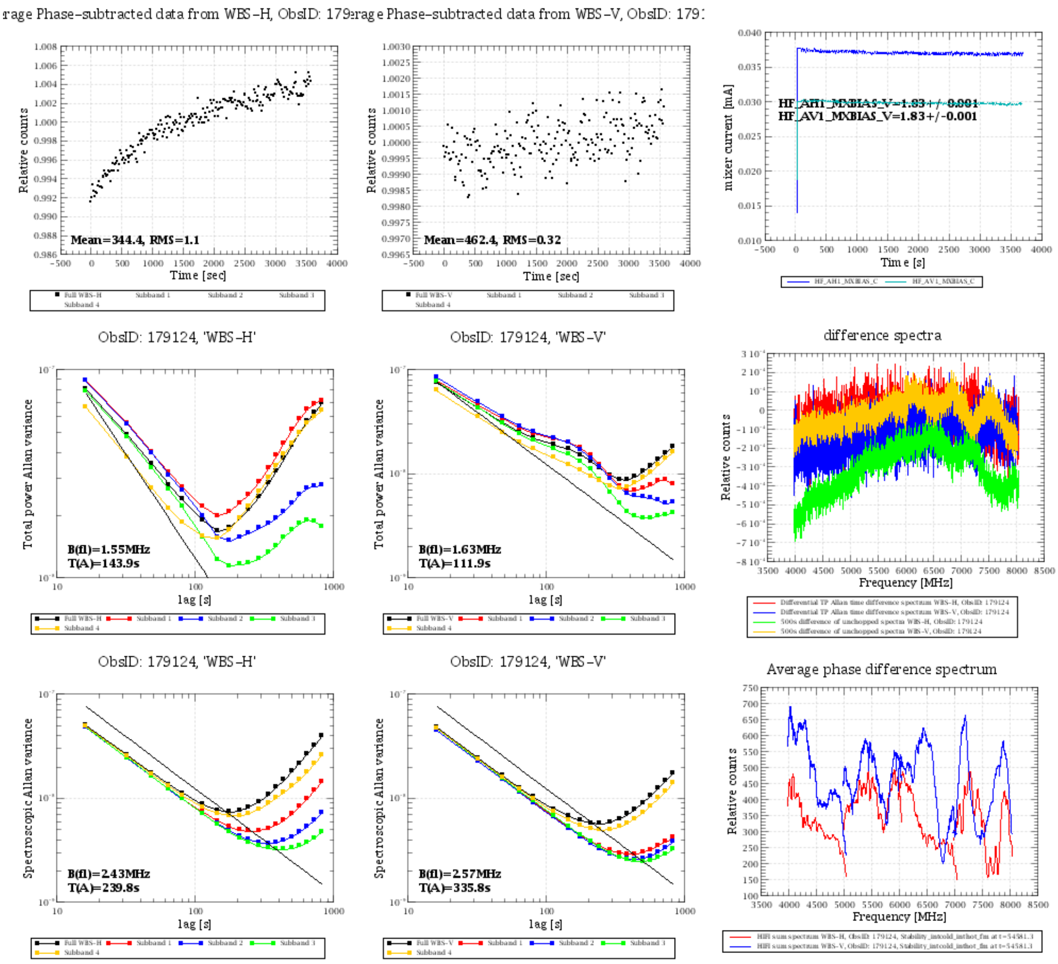

Fig. 1. B1a, OD 44, 492.05 GHz Int. Load differential stability for 3600s. Instability in the 500s baseline due to a standing wave change between Int CBB, Int HBB. Diff Allan time about ~ 200s.

5.1.2 B1a 542.88 GHz Int. Load Differential Stability

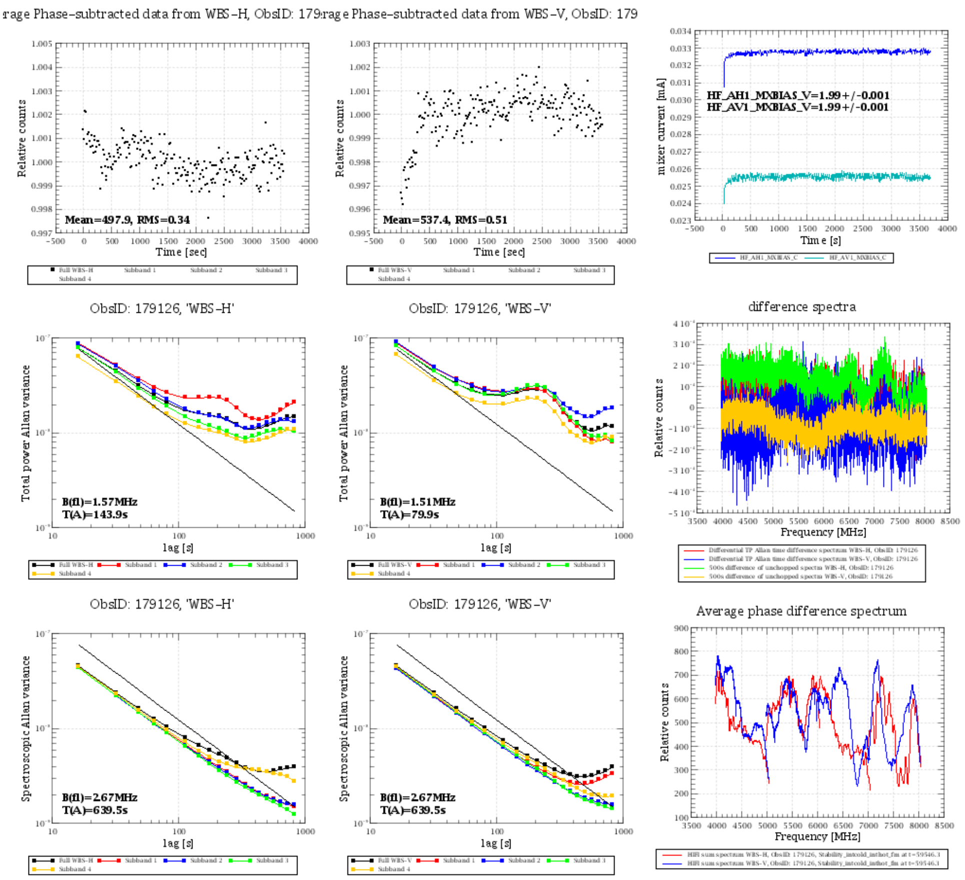

Fig. 2. B1a, OD 44, 542.88 GHz. Int. Load differential stability for 3600s. Some minor instability in the 500s baseline due to a standing wave change between Int CBB, Int HBB. Diff Allan time about >= 600s (as it was in Tb/TV and ILT).
Clearly a lot better then 492.05 GHz ni the previous slide..

5.1.3 B1b 563.74 GHz Int. Load Differential Stability

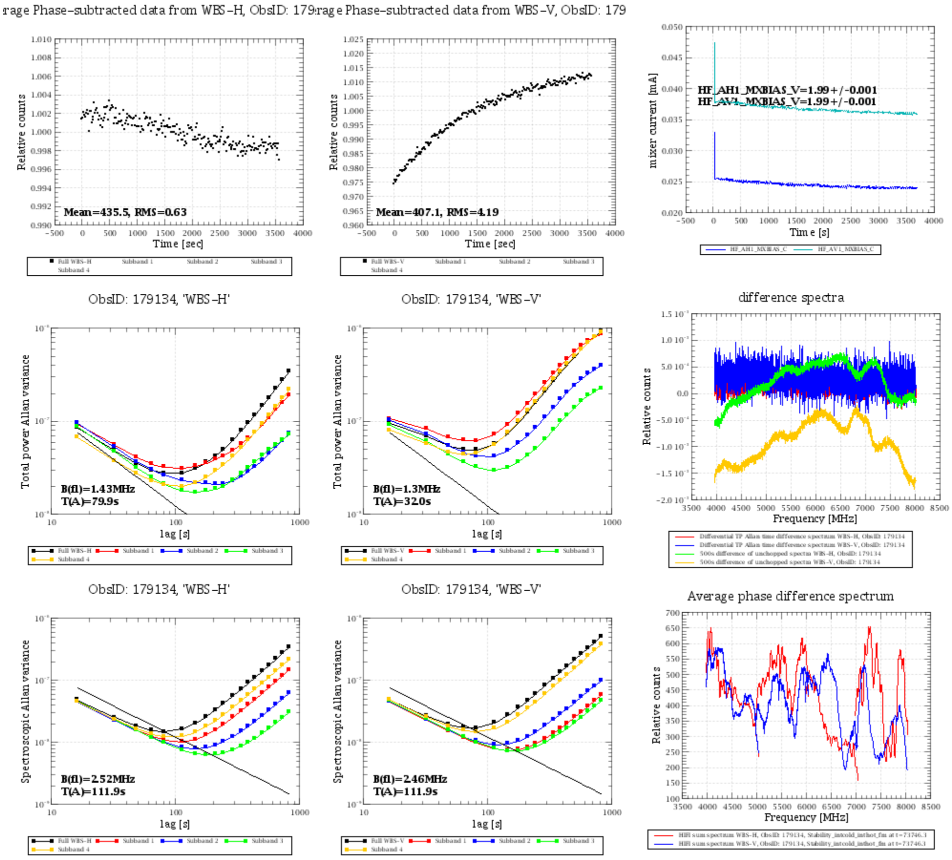

Fig. 3. B1b, OD 44, 563.74 GHz. Int. Load differential stability for 3600s. Instability in the 500s baseline due to a standing wave change between Int CBB, Int HBB. Diff Allan time about 100s.

5.1.4 B2a 640.97 GHz Int. Load Differential Stability

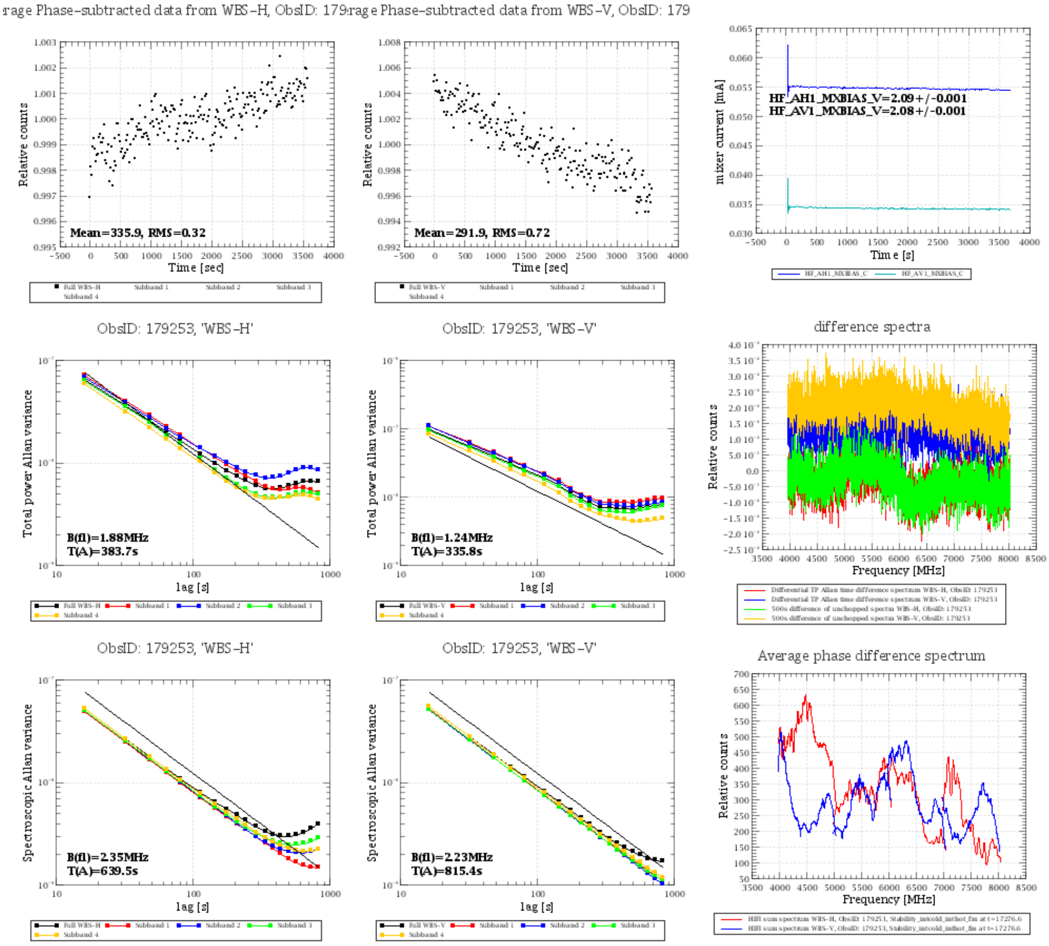

Fig. 4. B2a, OD 48, 640.97 GHz. Int. Load differential stability for 3600s. Very minor instability in the 500s baseline due to a standing wave change between Int CBB, Int HBB. Diff Allan time about 600s (as it was in Tb/TV and ILT)

5.1.5 B2a 686.86 GHz Int. Load Differential Stability

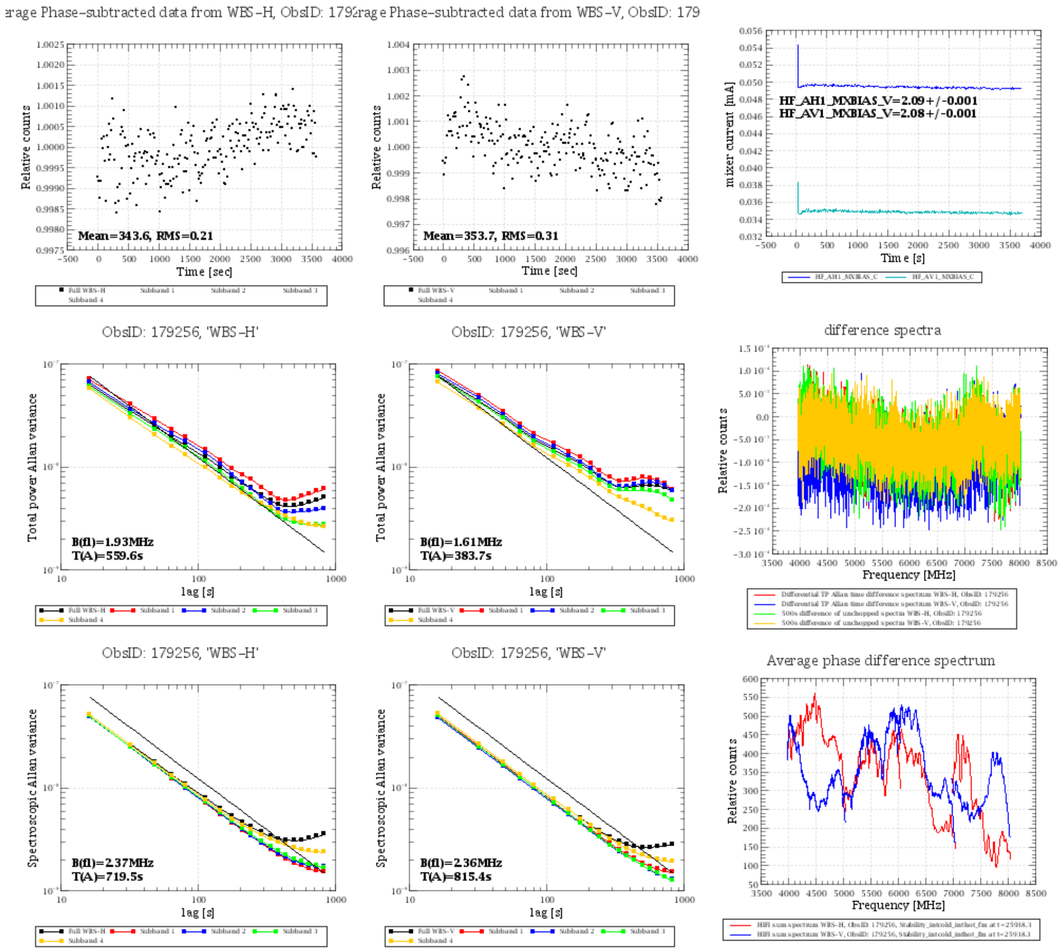

Fig. 5. B2a, OD 48, 686.86 GHz. Int. Load differential stability for 3600s. Very minor instability in the 500s baseline due to a standing wave change between Int CBB, Int HBB. Diff Allan time about 600s (as it was in Tb/TV and ILT). Consistent result.

5.1.6 B2b 756.83 GHz Int. Load Differential Stability

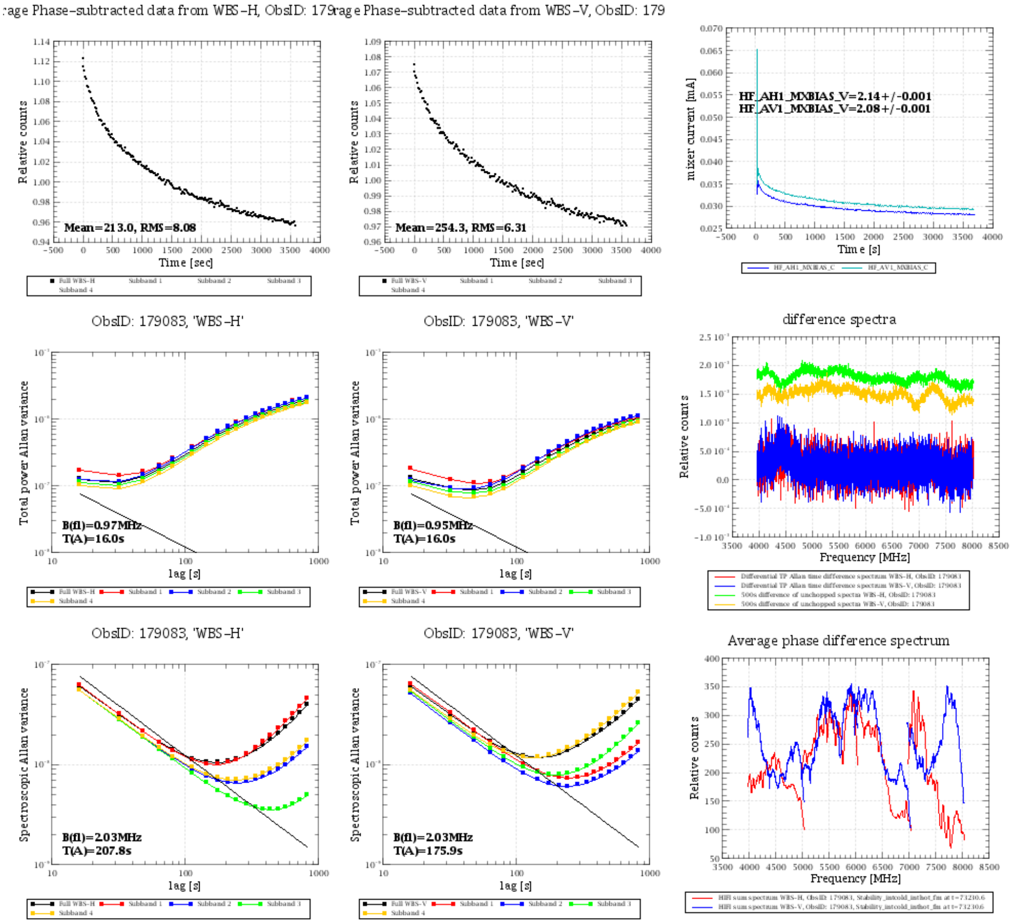

Fig.6. B2b Int. Load differential stability for 3600s. 756.83 GHz, OD 43. Effect of current drifting. The LO is stable, thus this is the effect of an in band frequency change! Diff Allan time has degraded to ~100s.

5.1.7 B2b 729.52 GHz Int. Load Differential Stability

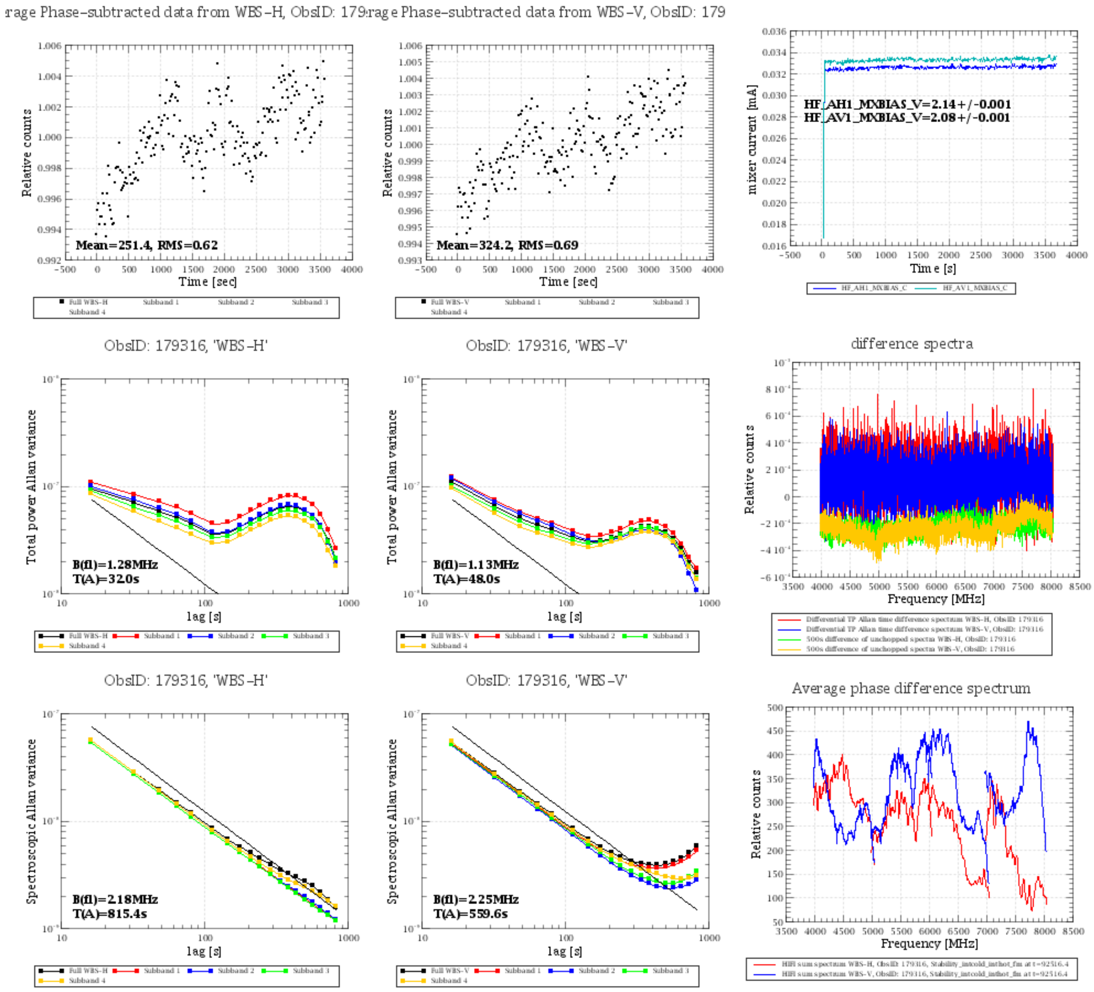

Fig.7. B2b Int. Load differential stability for 3600s. 729.52 GHz, OD 49. Very minor instability in the 500s baseline due to a standing wave change between Int CBB, Int HBB. Diff Allan time about >= 600s (as it was in TB/TV and ILT).

5.1.8 B3a 815.14 GHz Int. Load Differential Stability

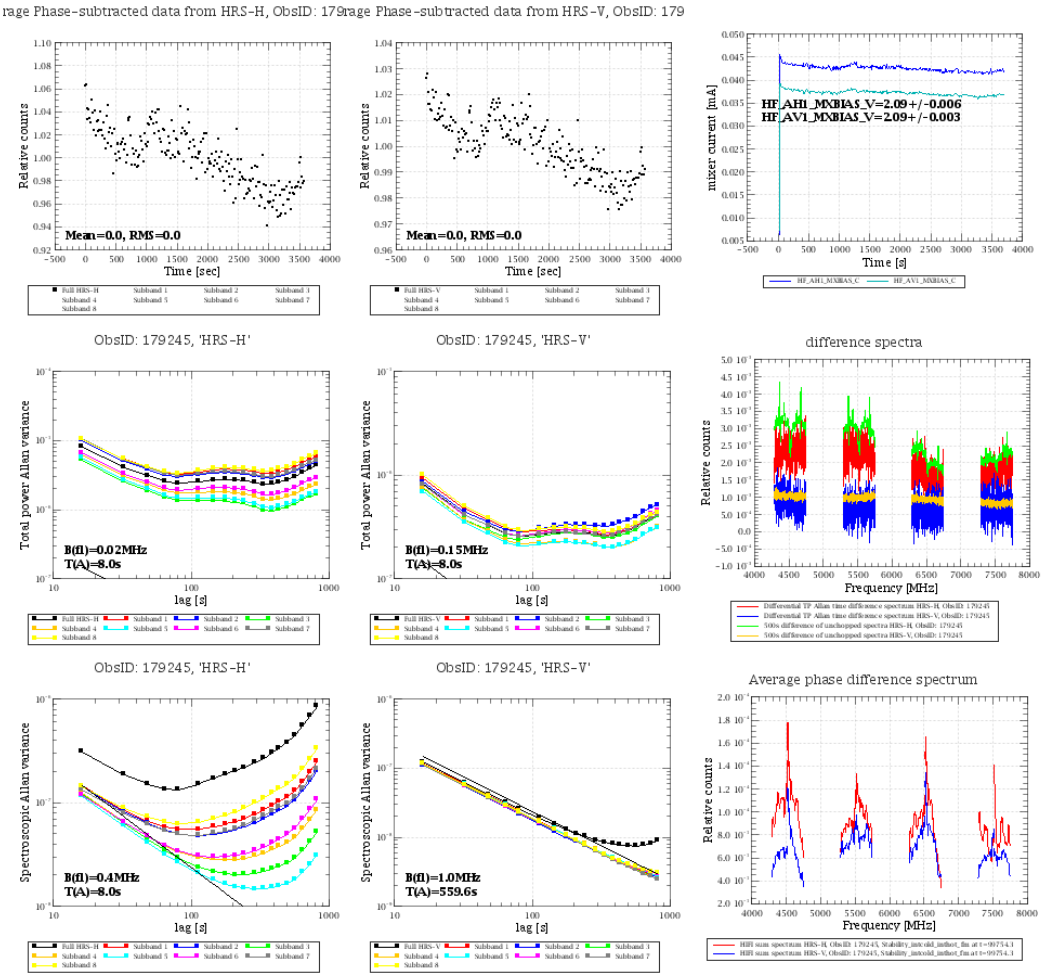

Fig.8. B3a Int. Load differential stability for 3600s. 815.14 GHz, OD 48. Very minor instability in the 500s baseline due to a standing wave change between Int CBB, Int HBB. Diff Allan time for V >= 600s (as it was in TB/TV and ILT).

5.1.9 B3b 927.60 GHz Int. Load Differential Stability

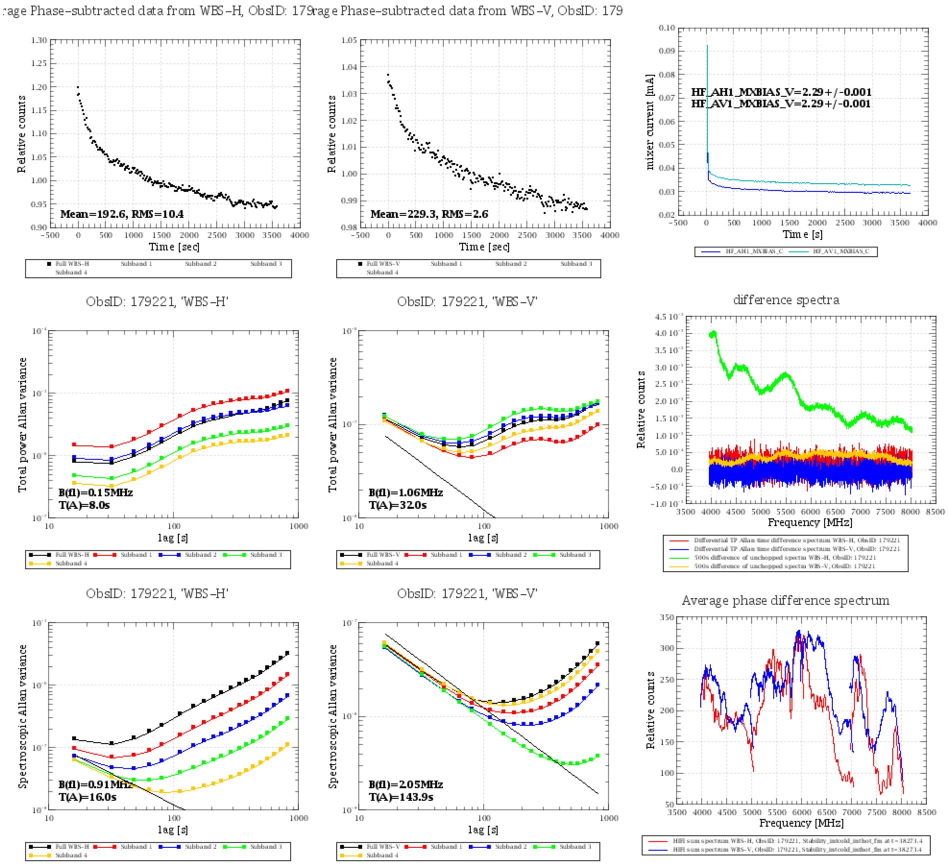

Fig.9. B3b Int. Load differential stability for 3600s. 927.60 GHz, OD 47. Significant instability in the 500s baseline due to a standing wave change between Int CBB, Int HBB (Diplexer band). Diff Allan time ! 100s for V.

5.1.10 B4a 968.66 GHz Int. Load Differential Stability

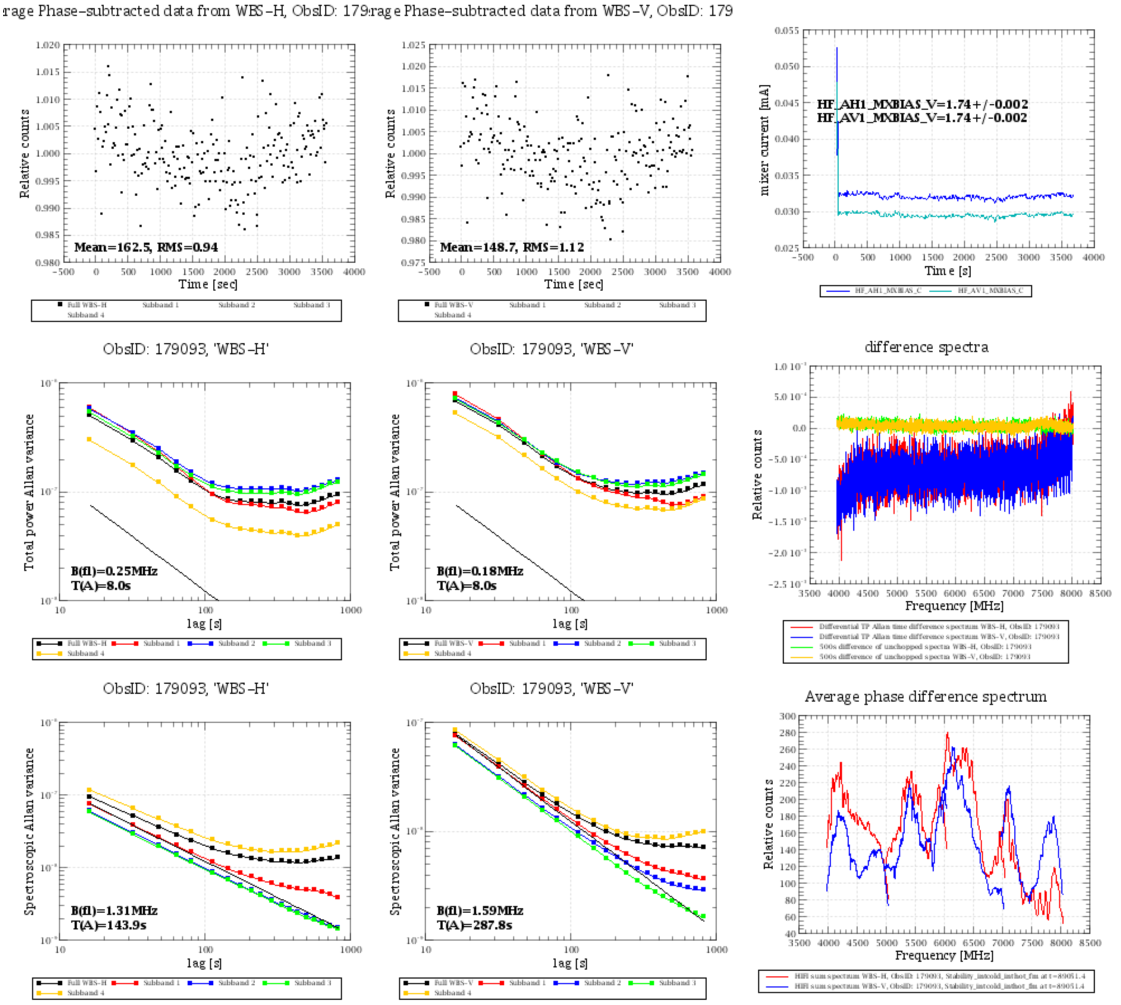

Fig.10. B4a Int. Load differential stability for 3600s. 968.66 GHz, OD 43. Minor in the 500s baseline due to a standing wave change between Int CBB, Int HBB (Diplexer band). Diff Allan time ! 300s for H & V.

5.1.11 B4a 993.73 GHz Int. Load Differential Stability

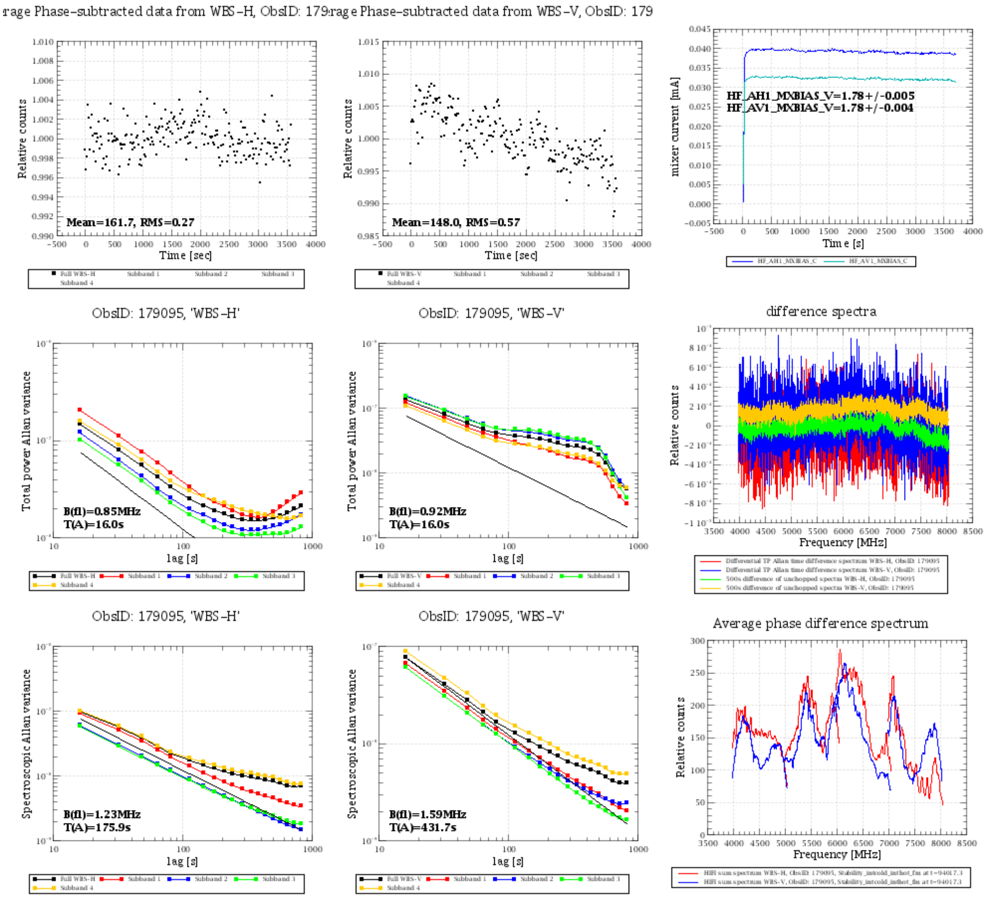

Fig.11. B4a Int. Load differential stability for 3600s. 993.73 GHz, OD 43. Minor in the 500s baseline due to a standing wave change between Int CBB, Int HBB (Diplexer band). Diff Allan time >= 400s for H & V.

5.1.12 B4b 1091.56 GHz Int. Load Differential Stability

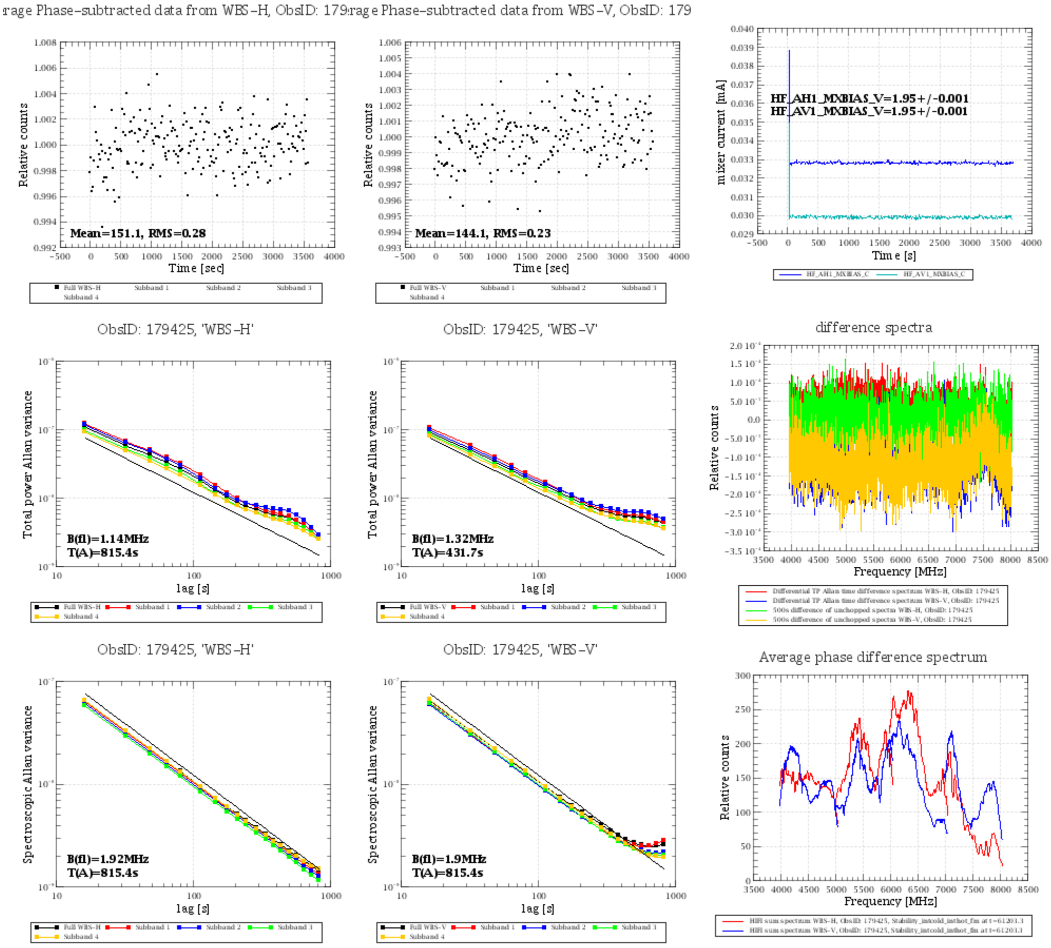

Fig.12. B4b Int. Load differential stability for 3600s. 1091.56 GHz, OD 51. Minor in the 500s baseline due to a standing wave change between Int CBB, Int HBB (Diplexer band). Diff Allan time >= 600s for H & V (Like in ILT3 and TB/TV).

5.1.13 B5a 1145.32 GHz Int. Load Differential Stability

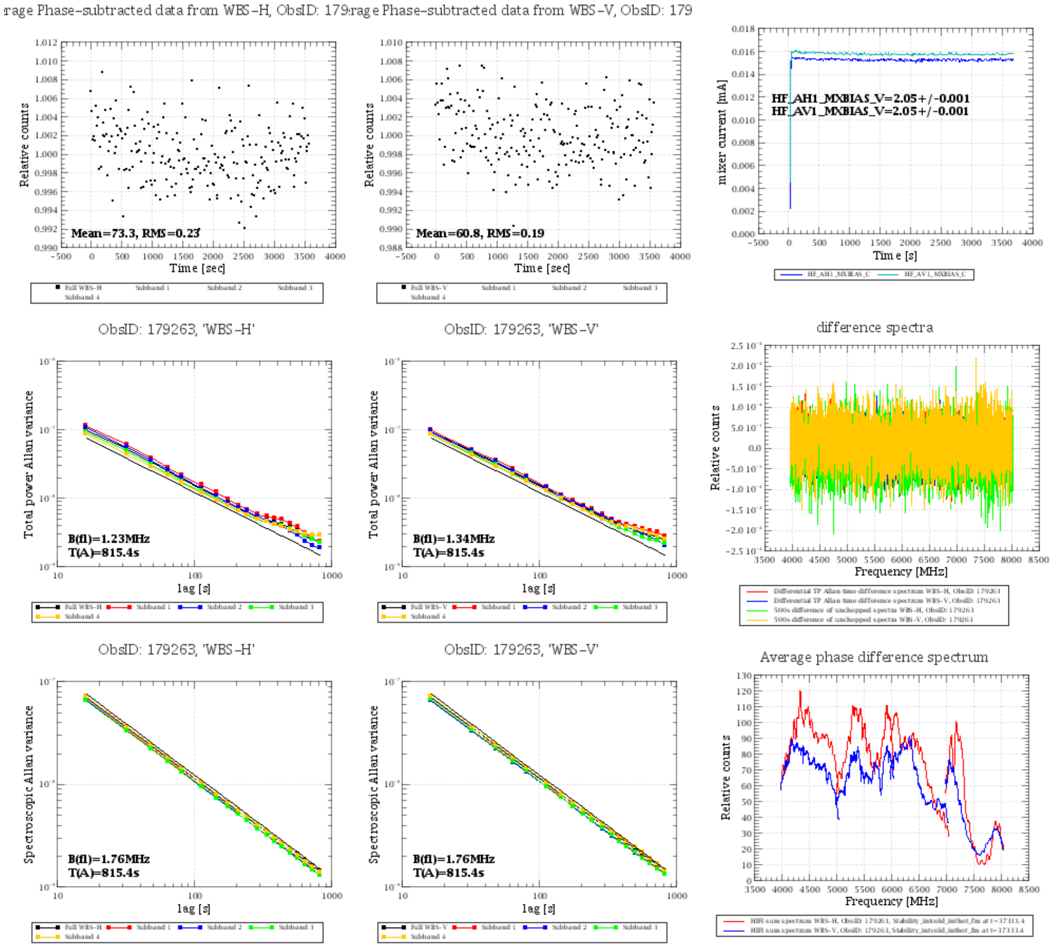

Fig.13. B5a Int. Load differential stability for 3600s. 1145.32 GHz, OD 48. No 500s baseline distortion. Diff Allan time >> 900s for H & V (Similar to ILT3 and TB/TV).

5.1.14 B5b 1242.90 GHz Int. Load Differential Stability

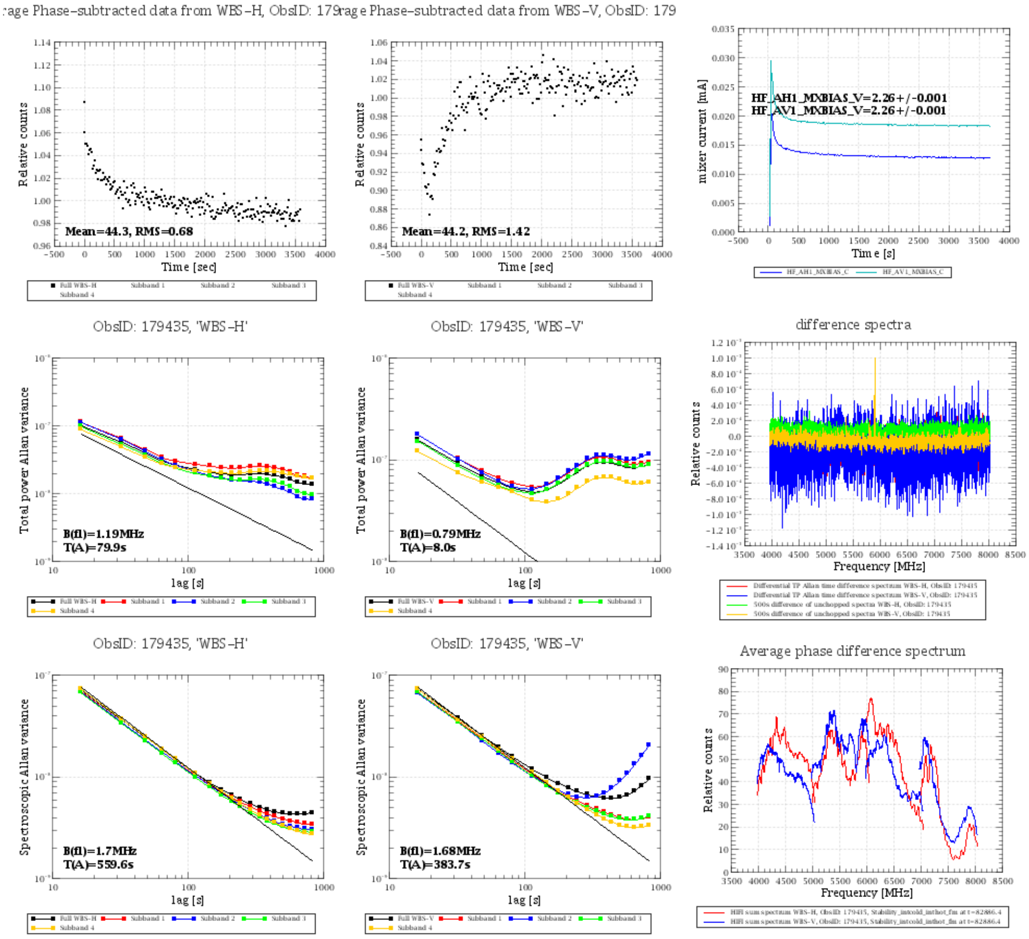

Fig.14. B5b Int. Load differential stability for 3600s. 1242.90 GHz, OD 51. No 500s baseline distortion. Diff Allan time ~ 600s for H & V (Like in ILT3 and TB/TV).

5.1.15 B5b 1270.93 GHz Int. Load Differential Stability

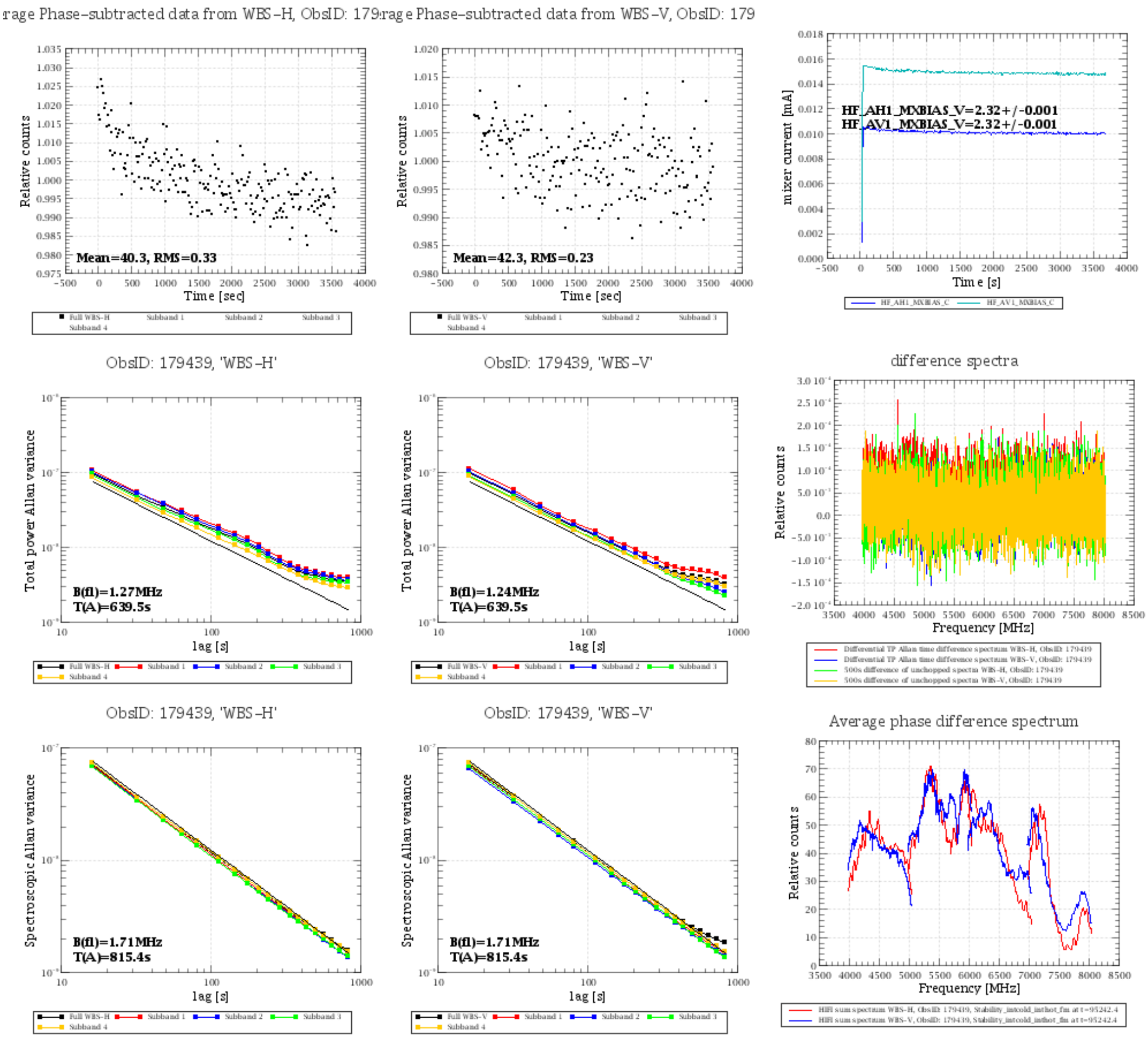

Fig.15. B5b Int. Load differential stability for 3600s. 1270.93 GHz, OD 51. No 500s baseline distortion. Diff Allan time >= 900s for H & V (Like in ILT3 and TB/TV).

5.1.16 B6a 1458.33 GHz Int. Load Differential Stability (N^+)

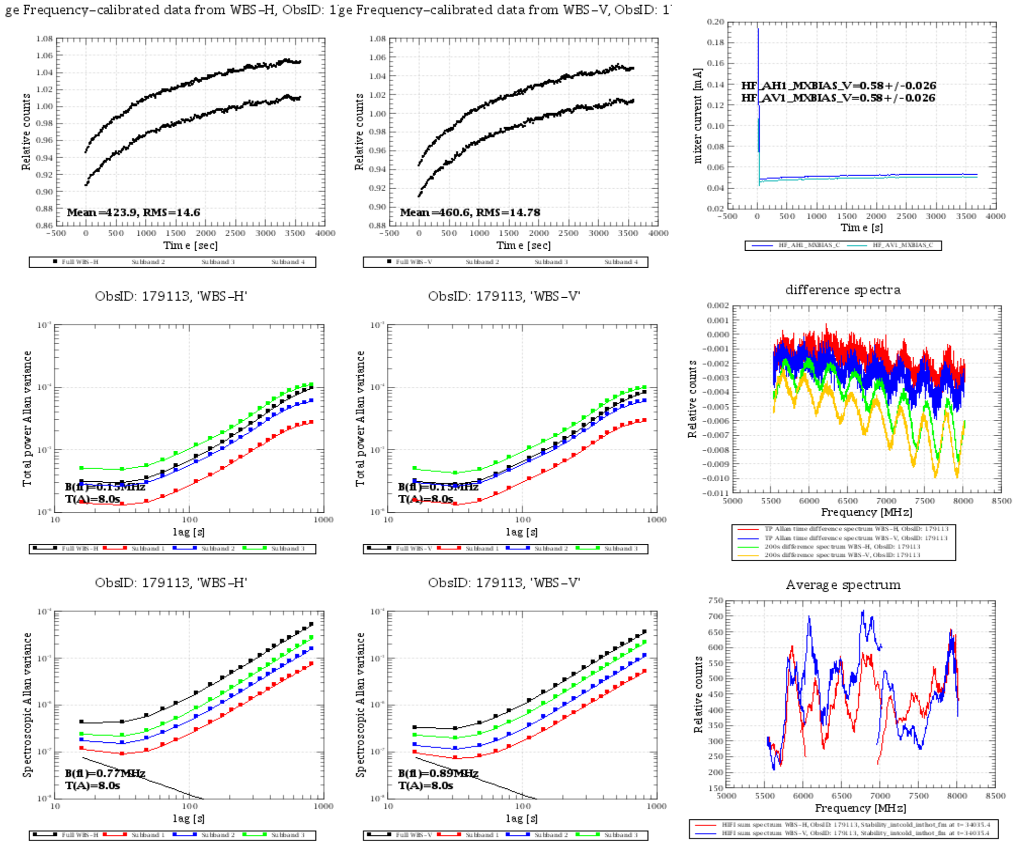

Fig.16. B6a Int. Load system stability for 3600s. 1458.33 GHz, OD 44.
The LO should have been stable after 45 min Stab. Result: Major distortion in the 500s baseline due to a standing wave change between Int CBB, Int HBB (Diplexer band).

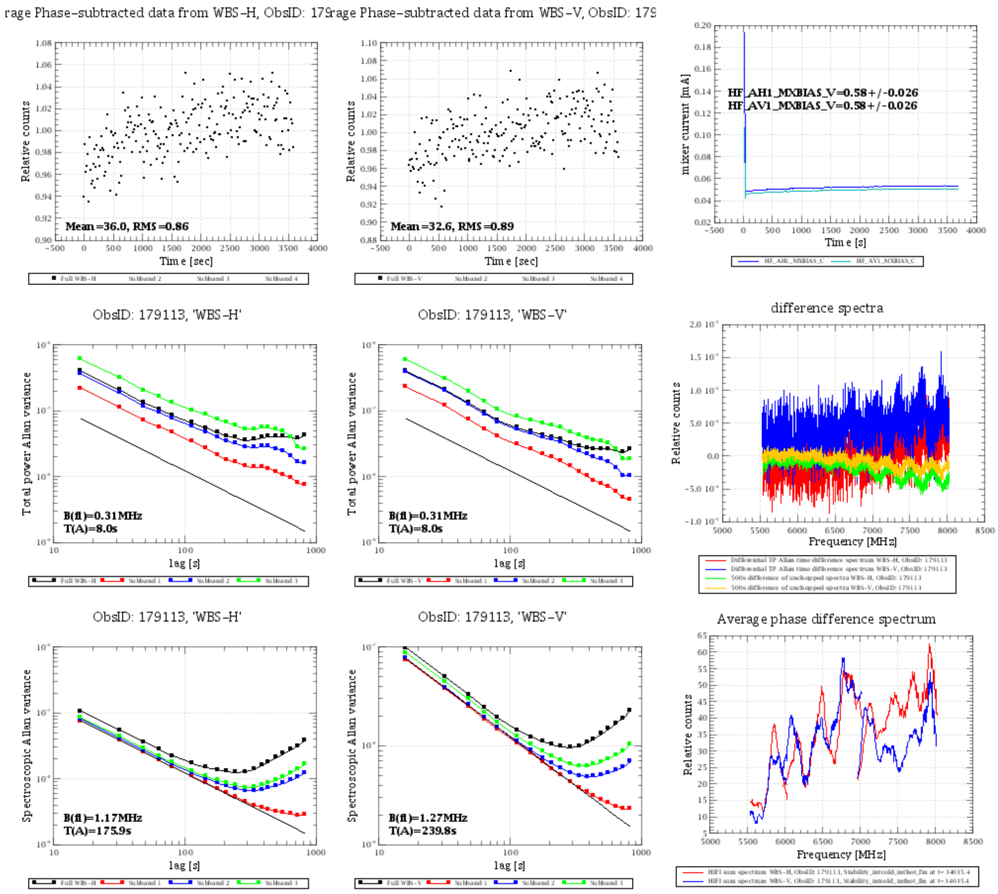

Fig.17. B6a Differential Load system stability for 3600s. 1458.33 GHz, OD 44.
The LO is not stable, (previous pic), however the differential results is rather good (HEB and dipler band). Ta >= 200s.

5.1.17 B6b 1653.01 GHz Int. Load Differential Stability

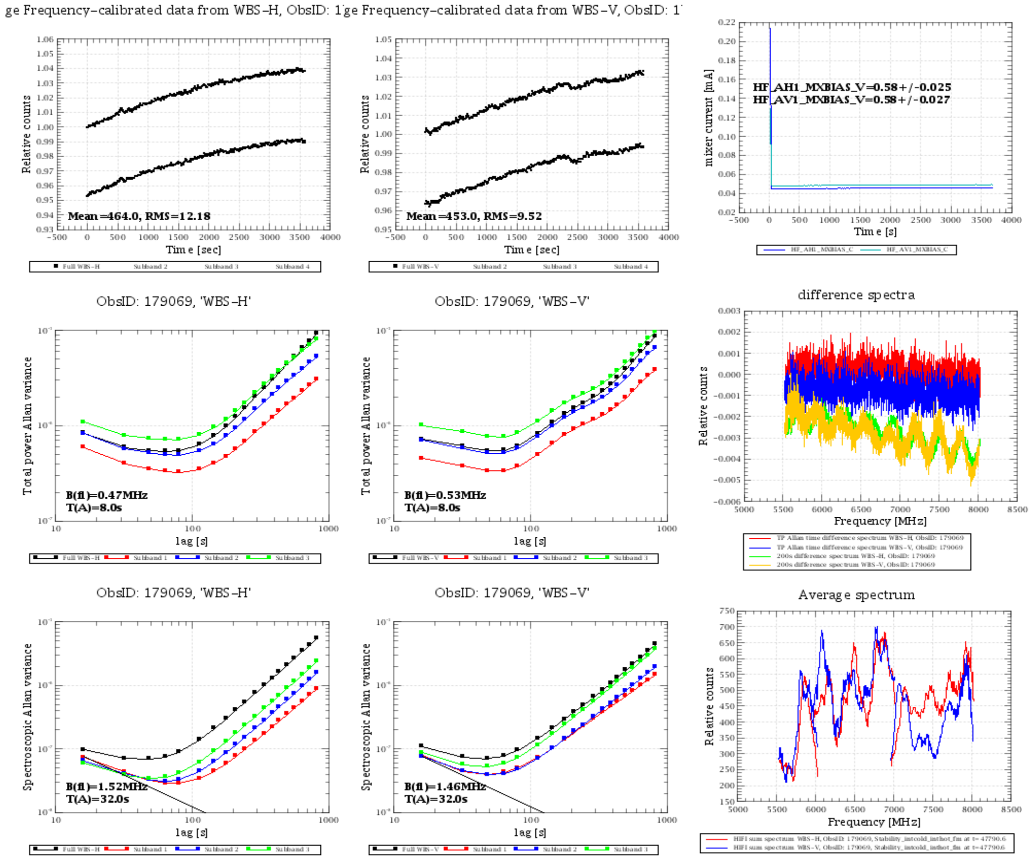

Fig.18. B6b Int. Load system stability for 3600s. 1653.01 GHz, OD 43. The LO should have been stable after 45 min Stab. This affects total power stability and baseline distortion.

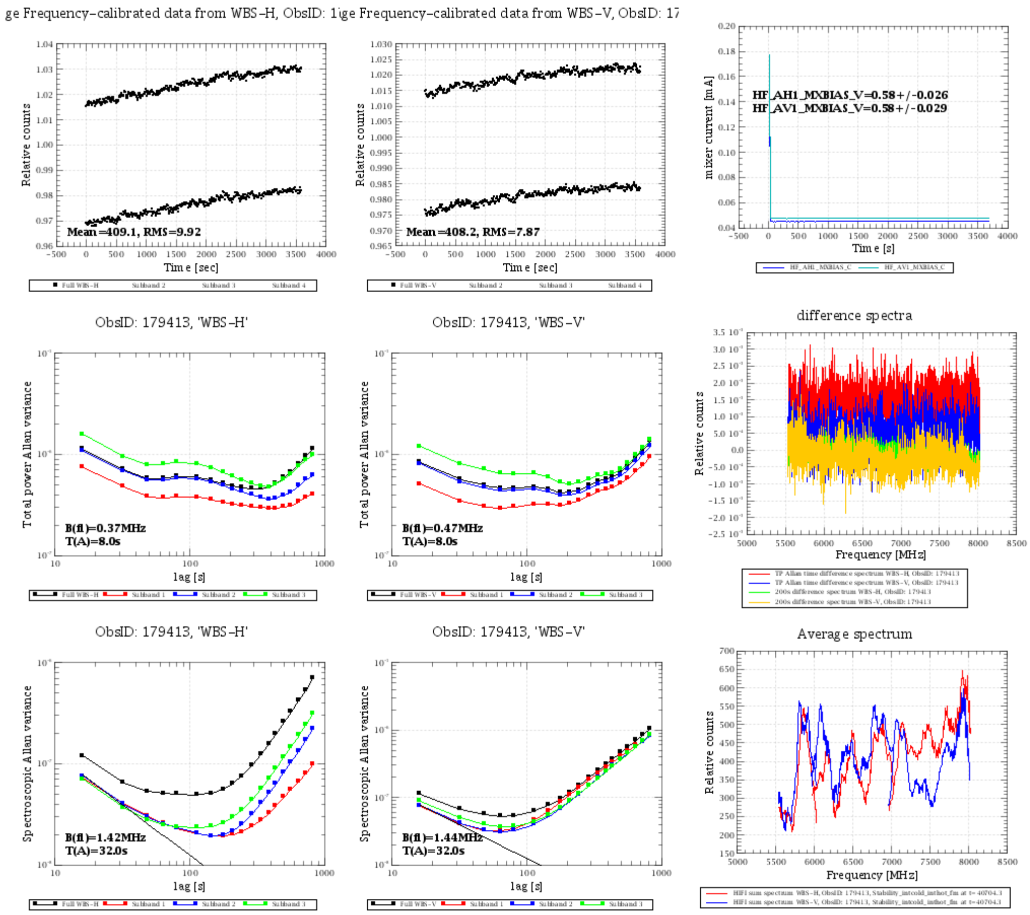

Fig.19. B6b Int. Load system stability for 3600s. 1653.01 GHz, OD 61.
<u>The LO should have been stable after 45 min Stab</u>. The LO is not stable,
→ consistent result with previous measurement on a different OD, but same frequency/band.

Despite this, the differential measurement is rather good (HEB and diplexer band) which indicates that differential measurements with an un stabilized LO are fine.

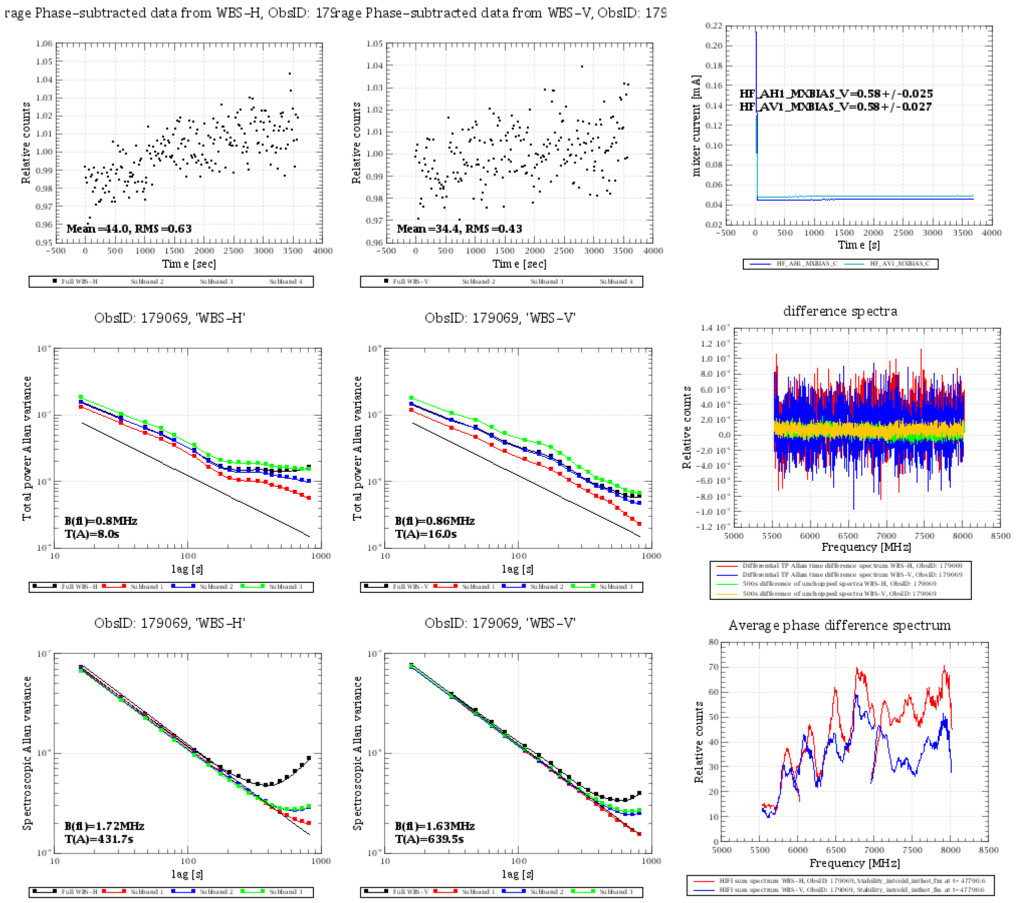

Fig.20. B6a Differential Load system stability for 3600s. 1653.01 GHz, OD 43.
The LO is not stable, (previous pic), however the differential results is good (HEB and diplexer band). Ta >= 300s.

As usual, subband 3 is the most stable sinc the mixer is least sensitive to LO AM noise,
And subband 1 is the least stable as it is the most sensitive band.

5.1.18 B6b 1667.11 GHz Int. Load Differential Stability

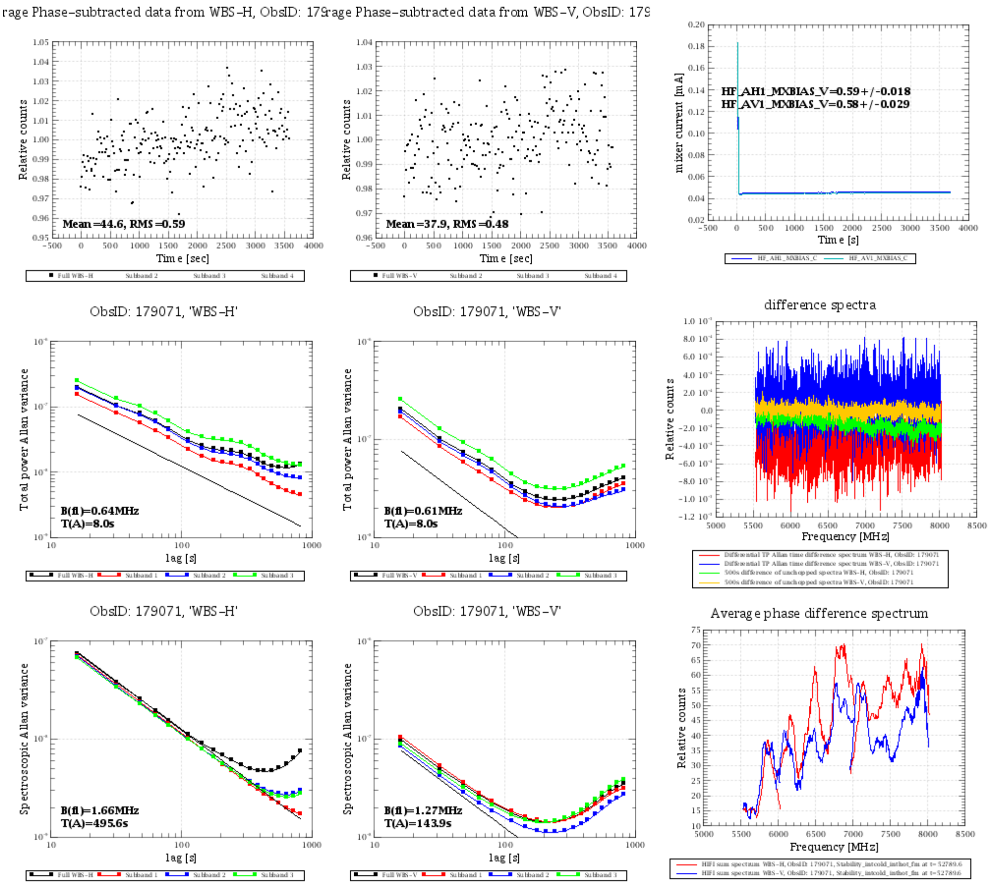

Fig.21. B6b Differential Load system stability for 3600s. 1667.11 GHz, OD 43.
Minor in the 500s baseline due to a standing wave change between Int CBB, Int HBB (Diplexer band).
Diff Allan time >= 300s for H & V (Similar to ILT3 and TB/TV).

5.1.19 B7a 1719.57 GHz Int. Load Differential Stability

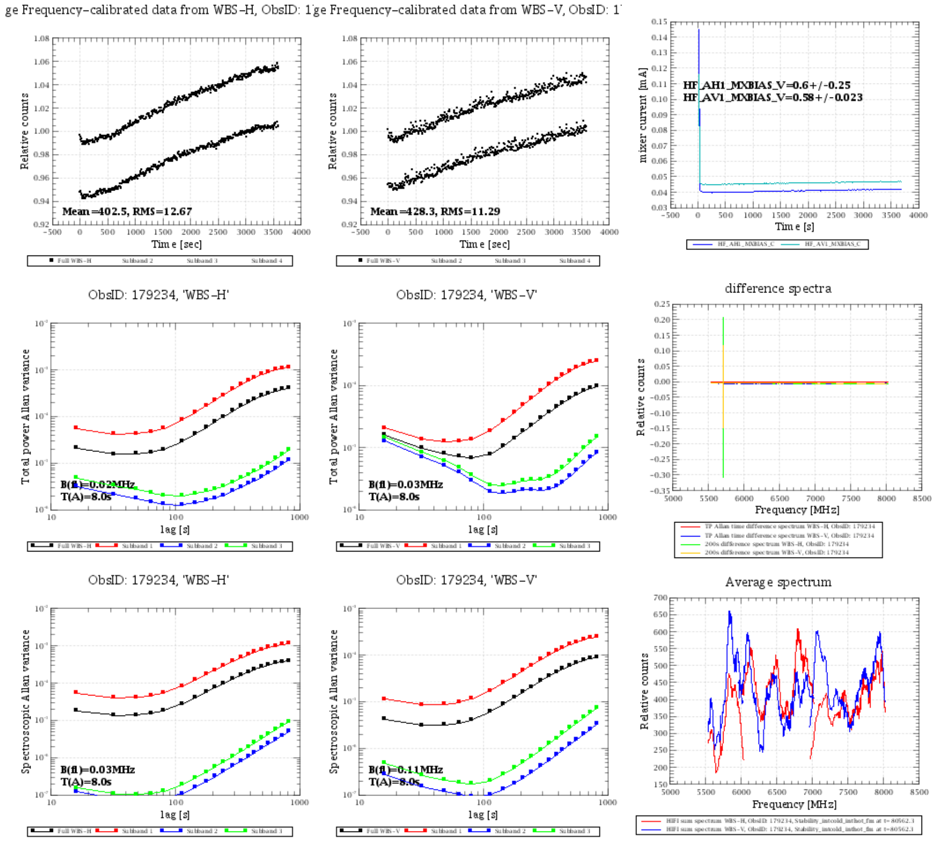

Fig.22. B7a Int. Load system stability for 3600s. 1719.57 GHz, OD 48.
The LO should have been stable after 45 min Stab. The LO is not stable effecting TP and Spectroscopic system stability. The spur has no effect on this result.

Despite this, the differential measurement is rather good (HEB and diplexer band) which indicates that differential measurements with an un stabilized LO are fine.

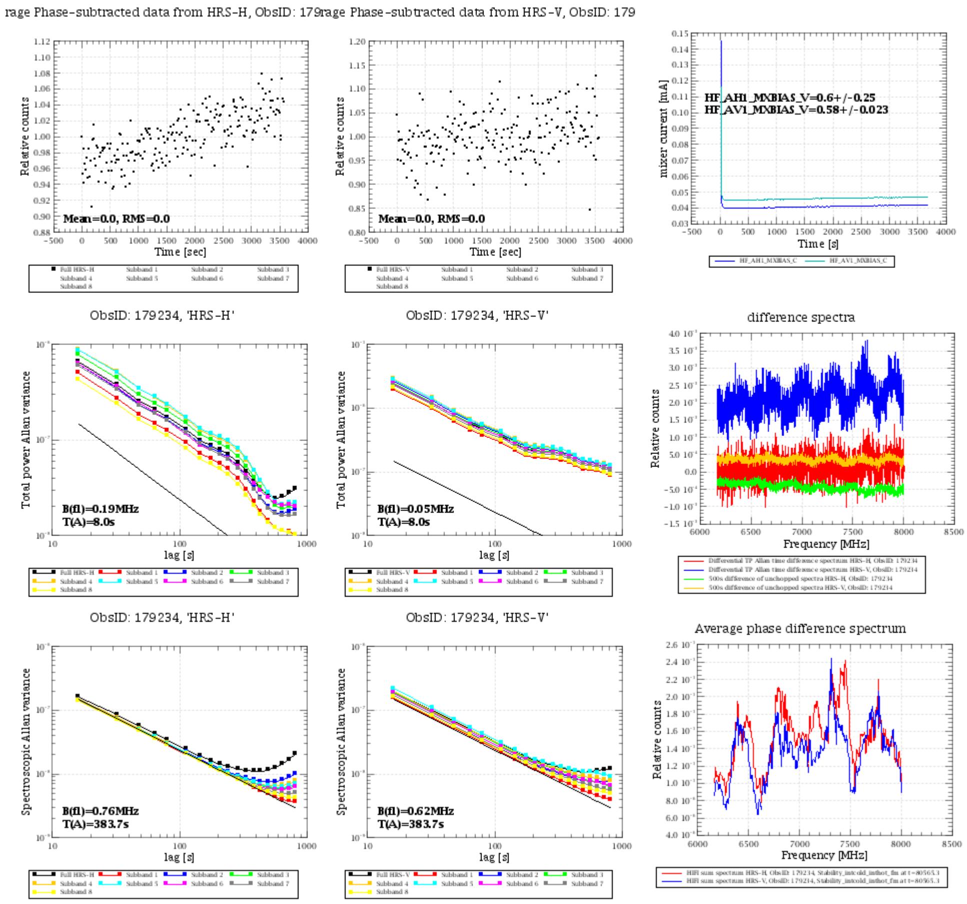

Fig. 23 HRS to avoid the spur. B7a Differential Load system stability for 3600s. 1719.57 GHz, OD 48. Minor in the 500s baseline due to a standing wave change between Int CBB, Int HBB (Diplexer band). Diff Allan time >= 400s for H & V, which corresponds to about 300s for the WBS.

5.1.20 B7a 1772.68 GHz Int. Load Differential Stability

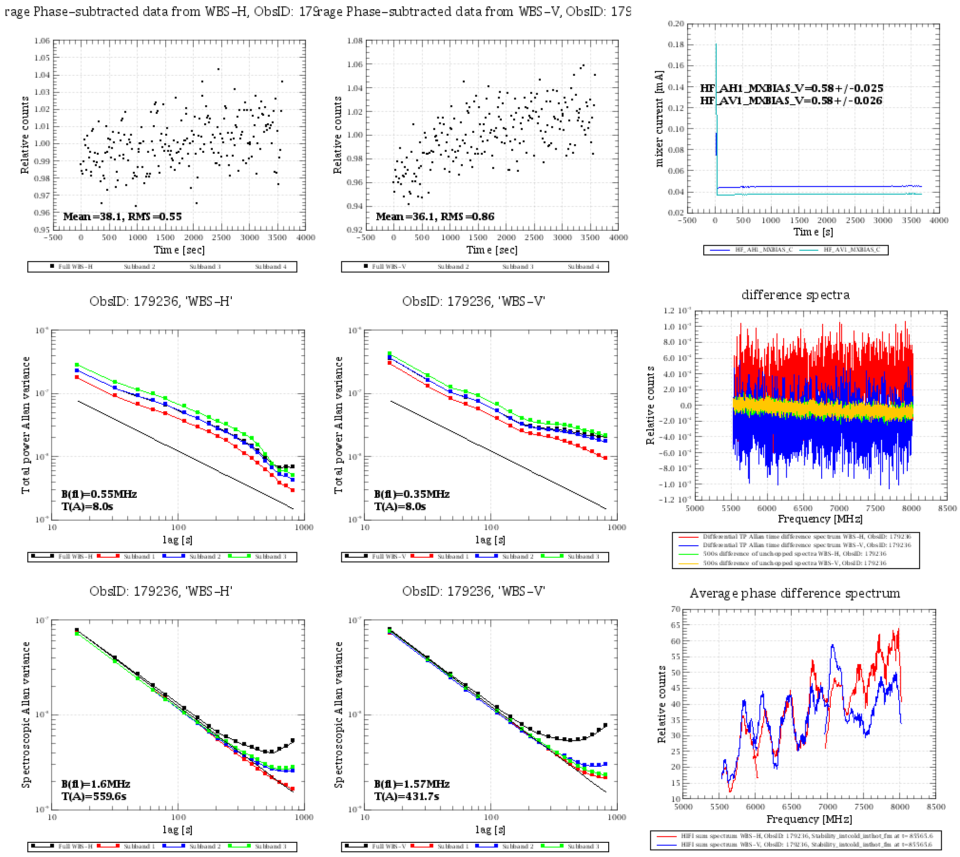

Fig.24. B7a Differential Load system stability for 3600s. 1772.68 GHz, OD 48.
Minor in the 500s baseline due to a standing wave change between Int CBB, Int HBB (Diplexer band).
Diff Allan time >= 500s for H & V (Similar to ILT3 and TB/TV).

5.1.21 B7b 1897.75 GHz Int. Load Differential Stability (C^+)

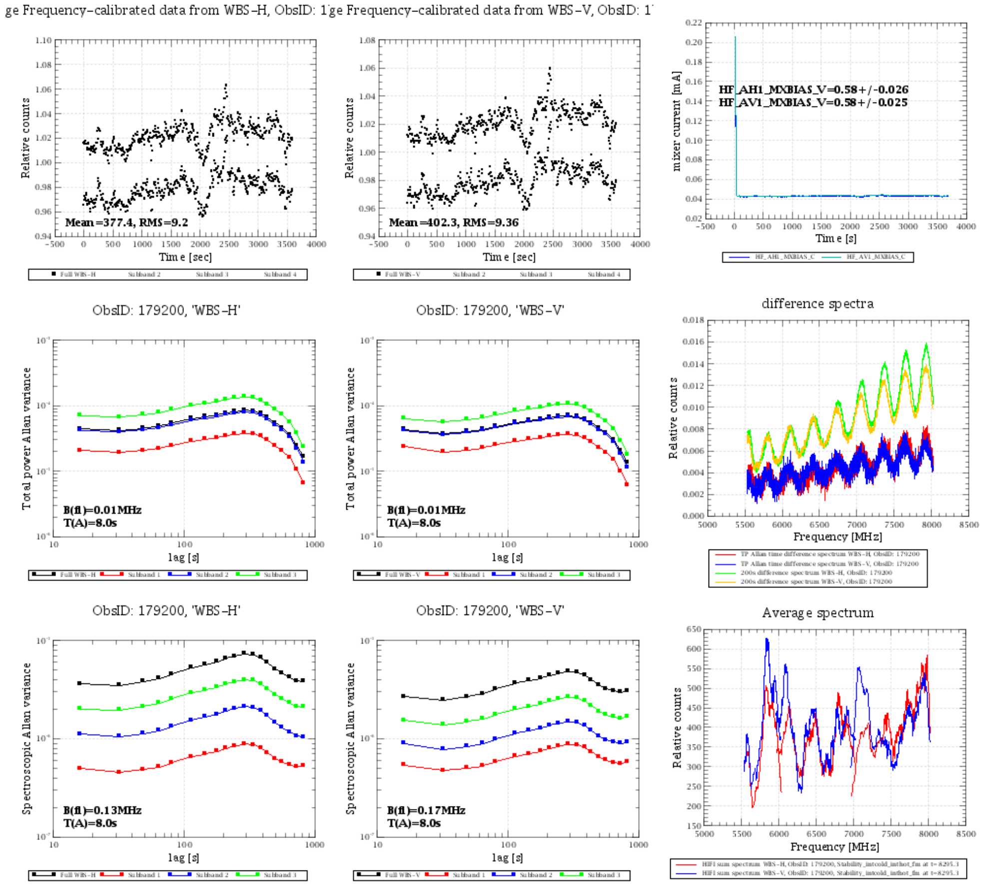

Fig. 25. B7b, 1897.75 GHz, OD47. Int. Load system stability for 3600s at the pure C^+, but unstable multiplier bias settings. Major instability. There is unfortunately no data with the stability optimized multiplier bias setting. Nevertheless the differential stability is not too bad.

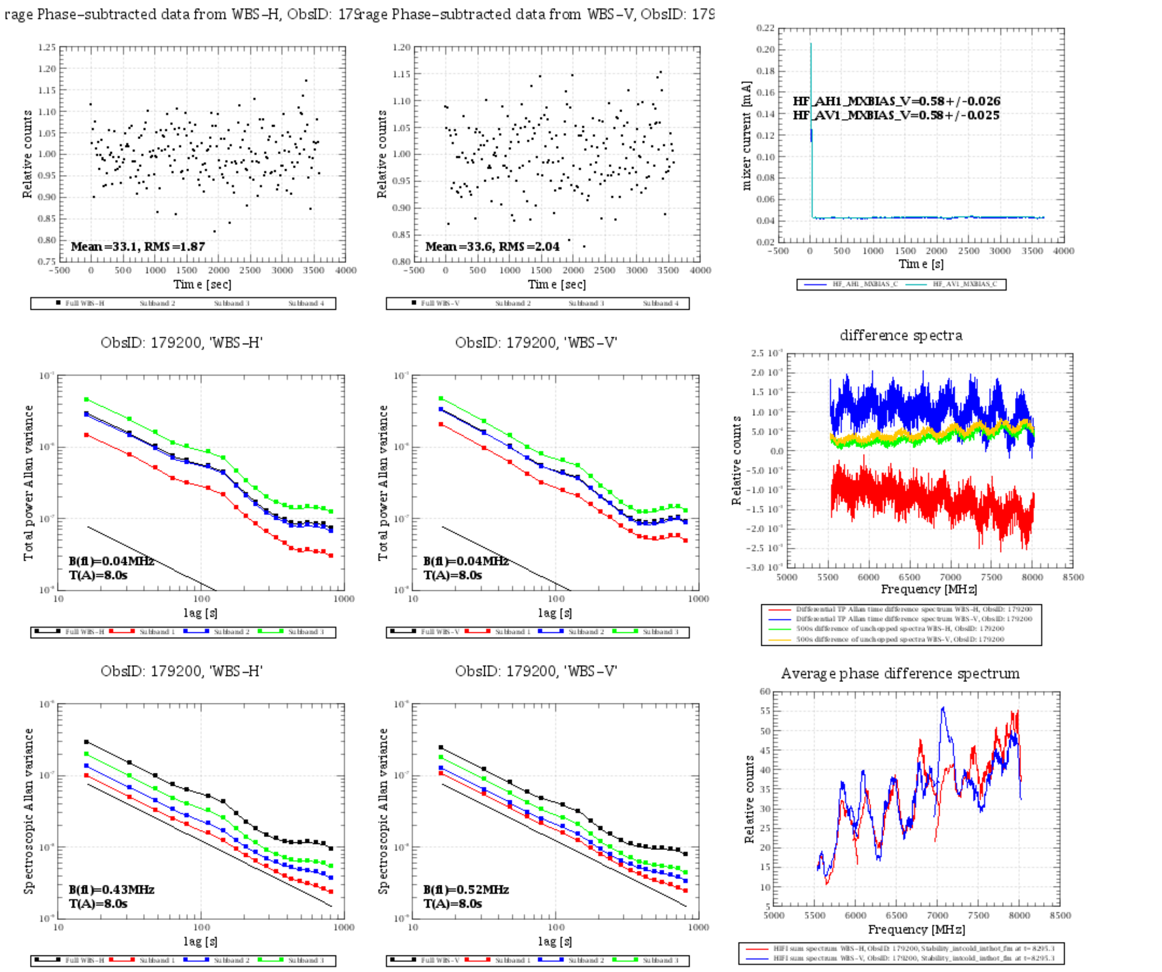

Fig.26. B7b Differential Load system stability for 3600s. 1897.75 GHz, OD 47.
Minor in the 500s baseline due to a standing wave change between Int CBB, Int HBB (Diplexer band).
Diff Allan time >= 500s for H & V (Similar to ILT3 and TB/TV). Note the excess noise which manifest itself in a reduced 'noise fluctuation bandwidth'. The 300 MHz ripple in the baseline is due to not having an IF isolator in the mixer IF path.

5.1.22 B7b 1844.15 GHz Int. Load Differential Stability (CO)

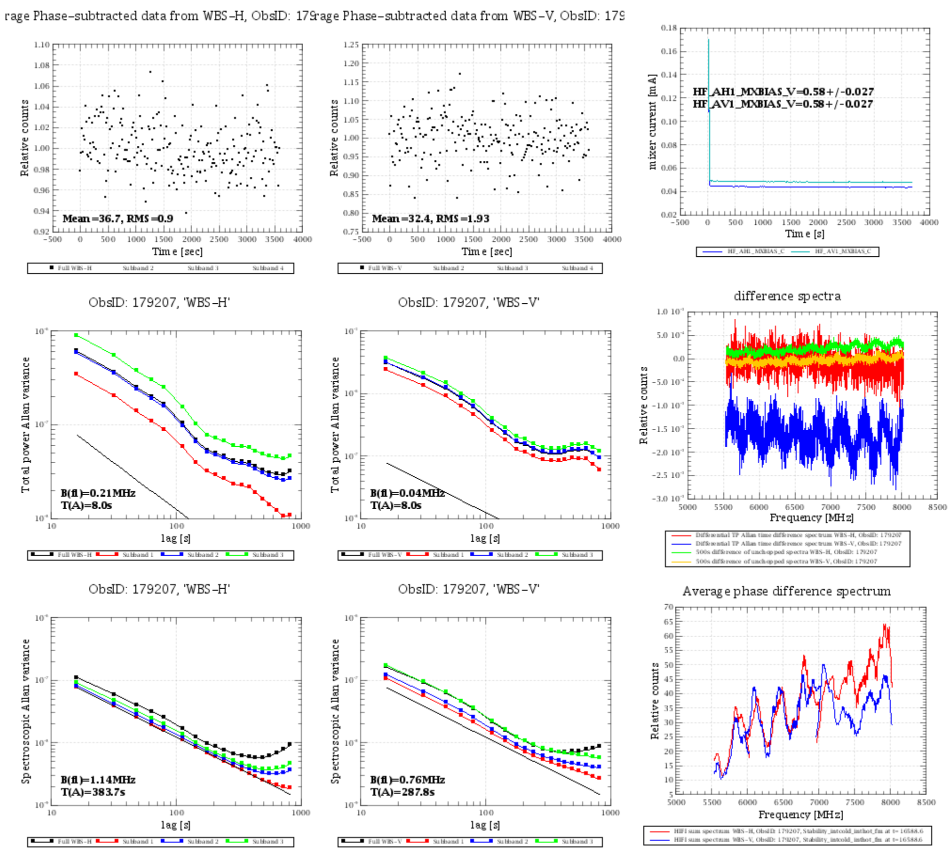

Fig.27. B7b Differential Load system stability for 3600s. 1844.15 GHz, OD 47.
Noticeable distortion in the 500s baseline due to a standing wave change between Int CBB, Int HBB (Diplexer band). Diff Allan time ~ 300s for H & V (Similar to ILT3 and TB/TV). Note the excess noise which manifest itself in a reduced 'noise fluctuation bandwidth'. The 300 MHz ripple in the baseline is due to not having an IF isolator in the mixer IF path.

5.2 Load-Switch Differential Stability

Objective

Verify the differential stability between internal CCB and external Cold load (telescope) due to broadband gain variations, standing wave modulation, temperature drift…

Expected Result

Differential total power and spectroscopic gain stability between internal CBB and external CBB as a function of integration time in load-switch mode for each mixer sub-band (14).
Loop parameters AOTs (HSPOT).
Possible standing wave modulation in the telescope.

5.2.1 B1a 492.05 GHz Load-Switch

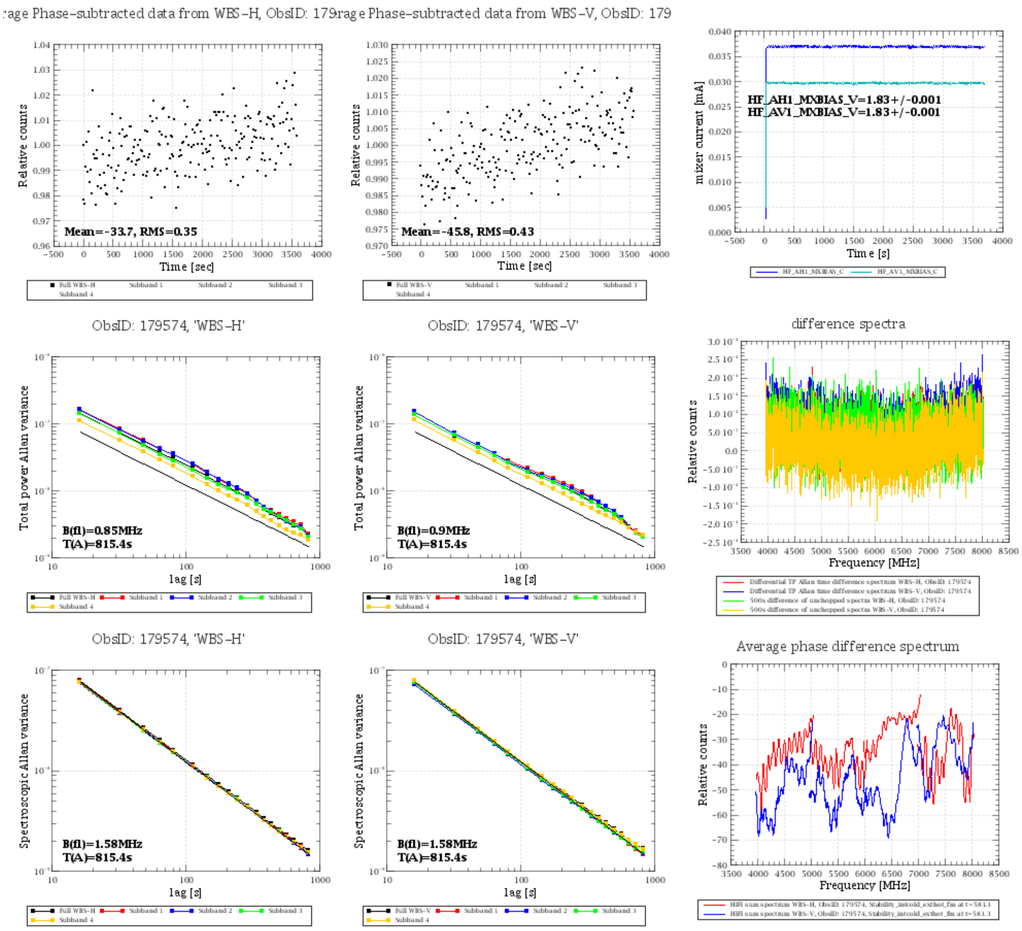

Fig. 28. B1a, OD 54, 492.05 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

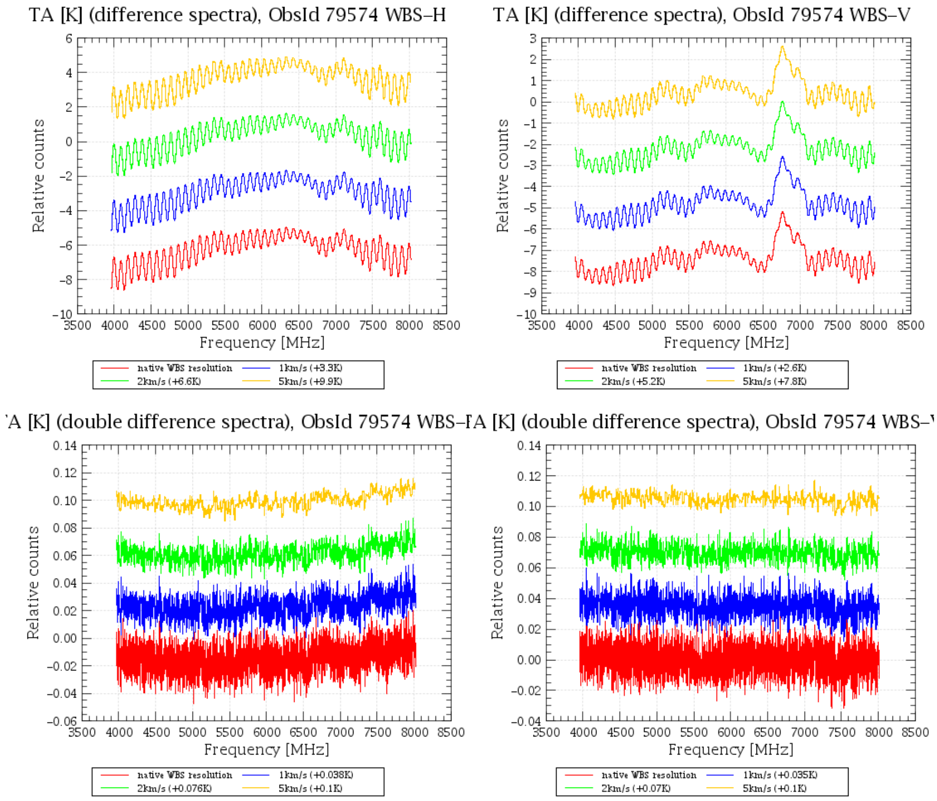

Fig. 29. B1a, OD 54, 492.05 GHz , simulated LSW spectrum. 10 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.2.2 B1a 542.88 GHz Load-Switch

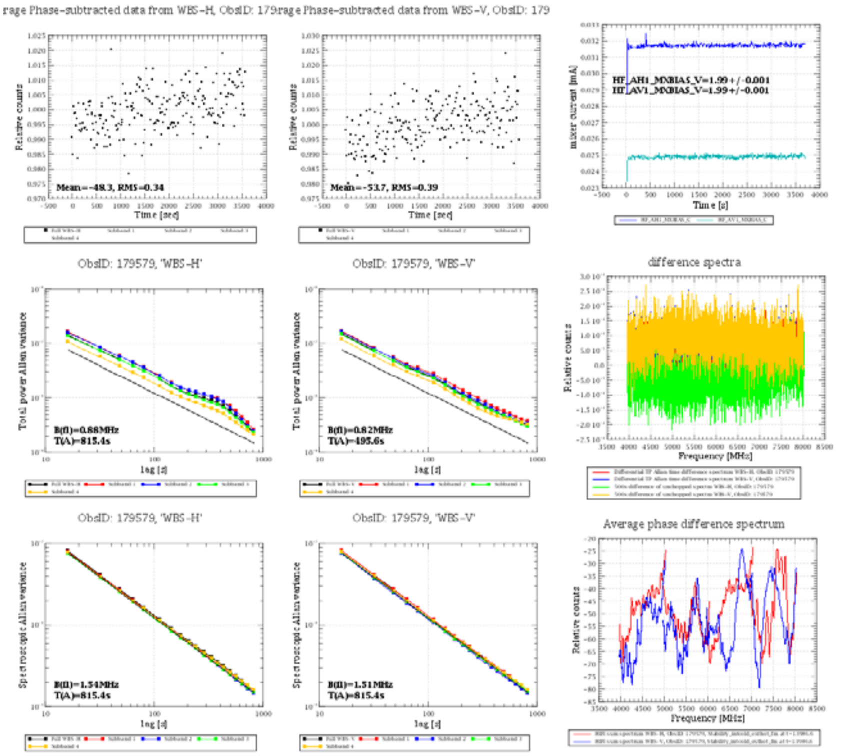

Fig. 30. B1a, OD 54, 542.88 GHz. Int. Load differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

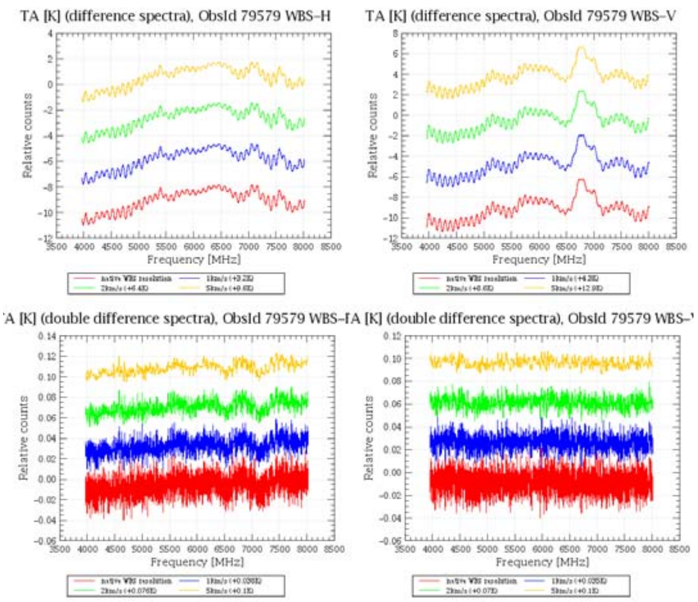

Fig. 31. B1a, OD 54, 542.88 GHz, simulated LSW spectrum. 10 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.2.3 B1b 563.74 GHz Load-Switch

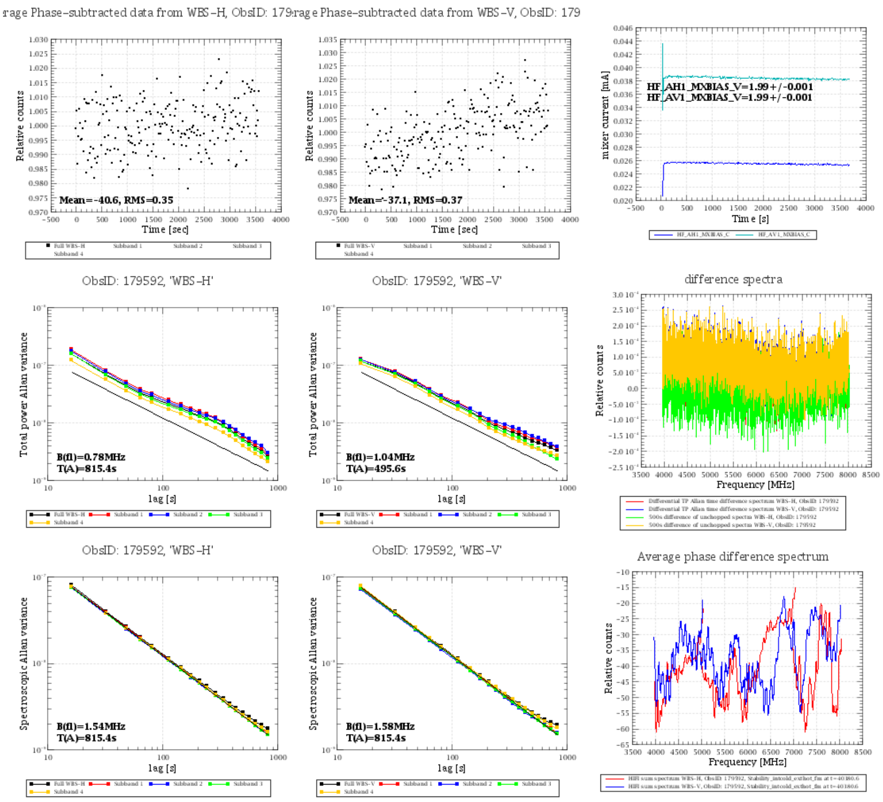

Fig. 32. B1b, OD 54, 563.74 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

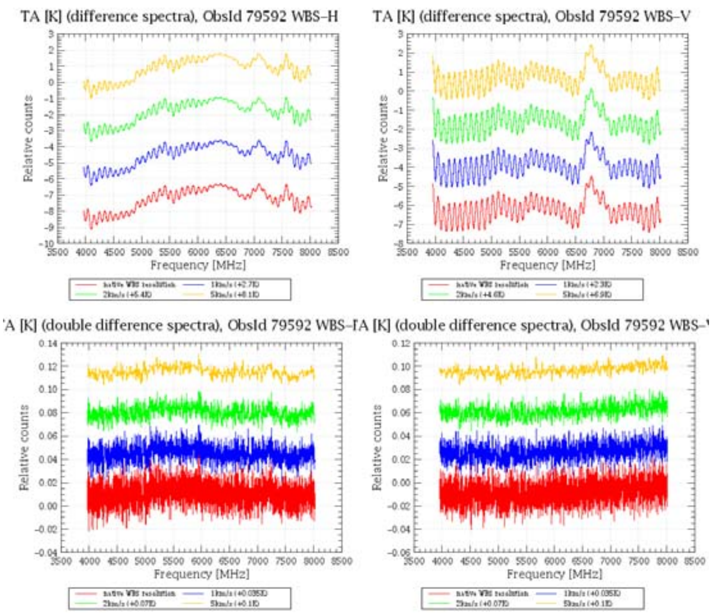

Fig. 33. B1b, OD 54, 563.74 GHz, simulated LSW spectrum. 10 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.2.4 B1b 614.21 GHz Load-Switch

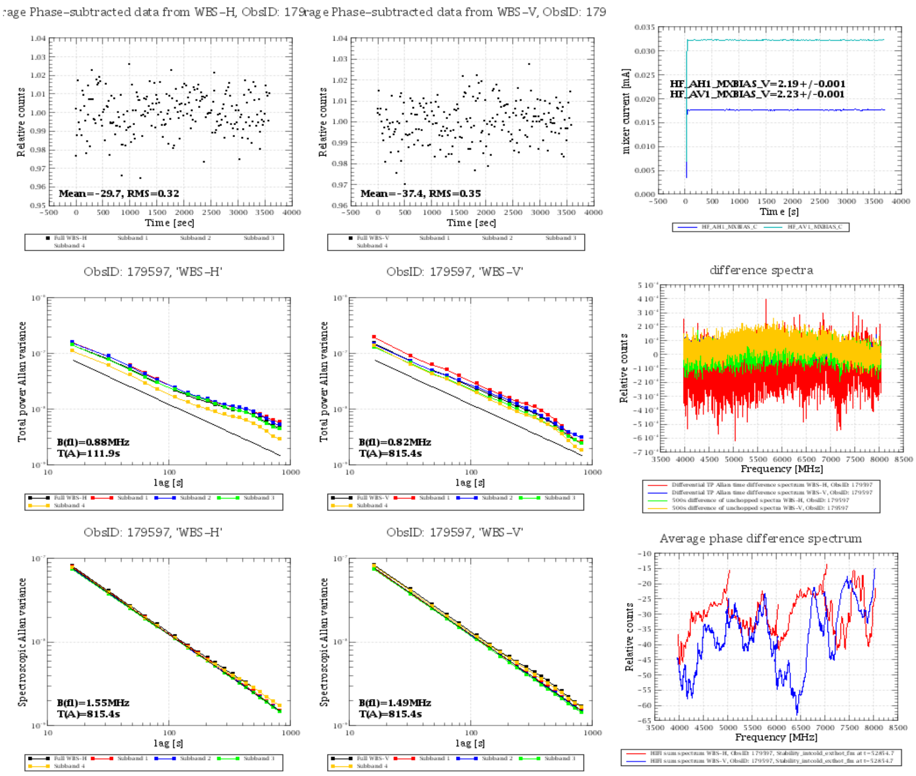

Fig. 34. B1b, OD 54, 614.21 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

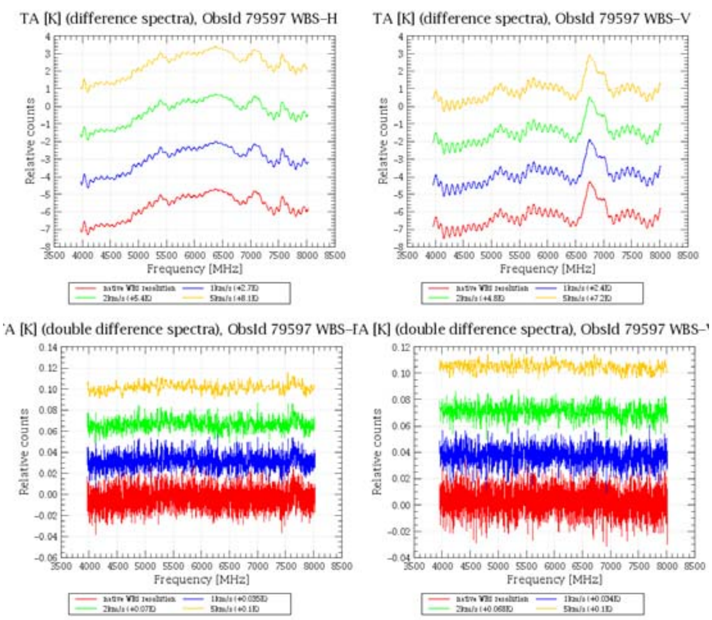

Fig. 35. B1b, OD 54, 614.21 GHz, simulated LSW spectrum. 10 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.2.5 B2a 686.86 GHz Load-Switch

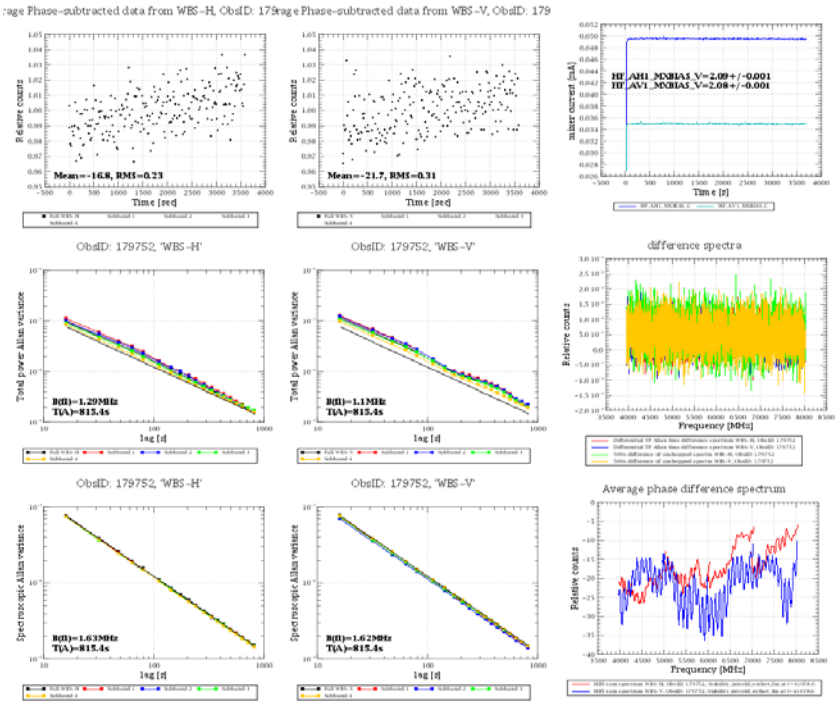

Fig. 36. B2a, OD 59, 686.86 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

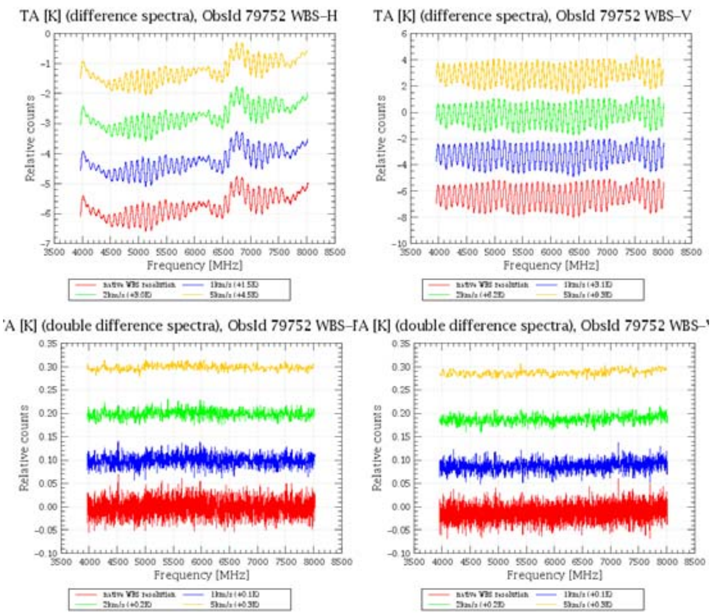

Fig. 37. B2a, OD 59, 686.86 GHz, simulated LSW spectrum. 10 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.2.6 B2b 729.52 GHz Load-Switch

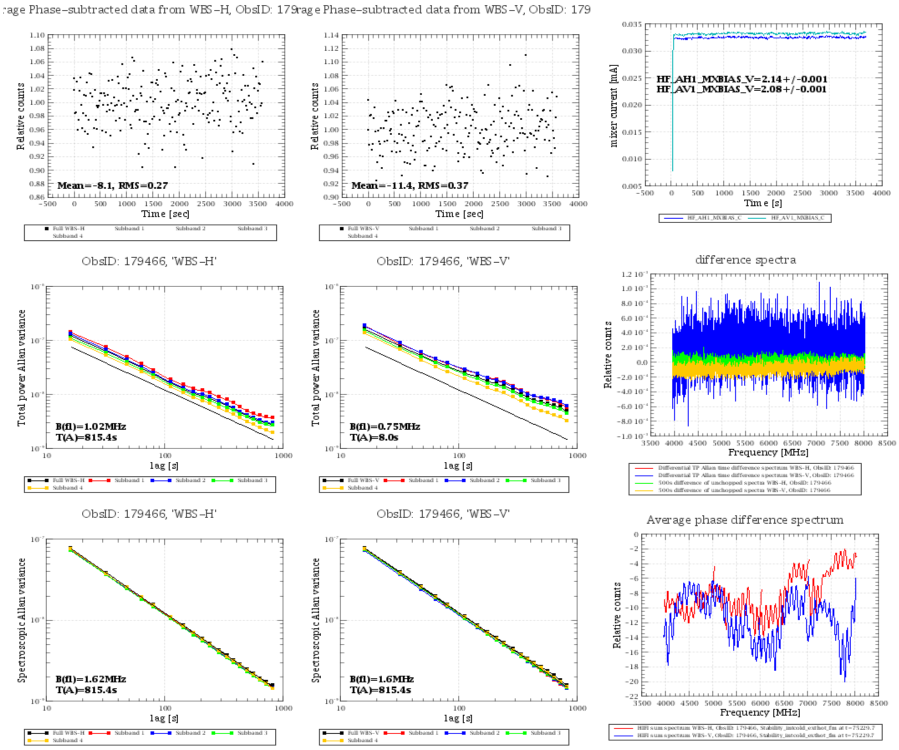

Fig. 38. B2b, OD 52, 729.52 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

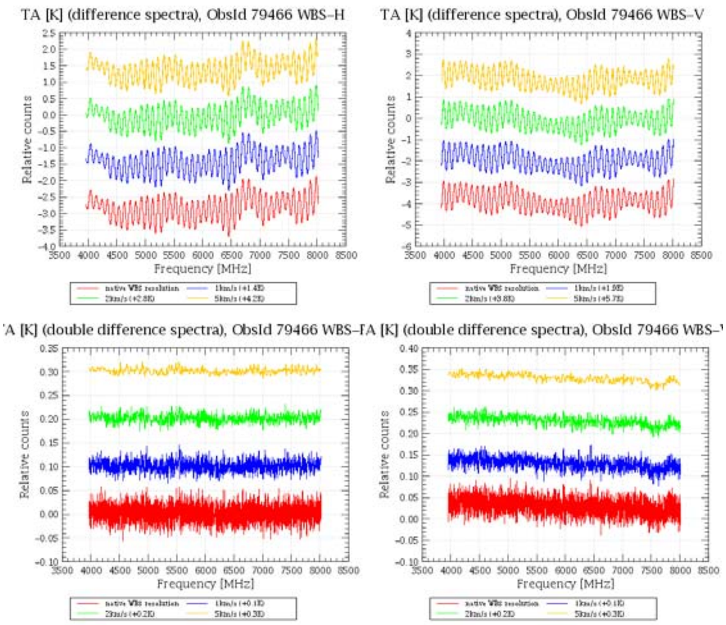

Fig. 38. B2b, OD 52, 729.52 GHz, simulated LSW spectrum. 10 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.2.7 B2b 756.83 GHz Load-Switch

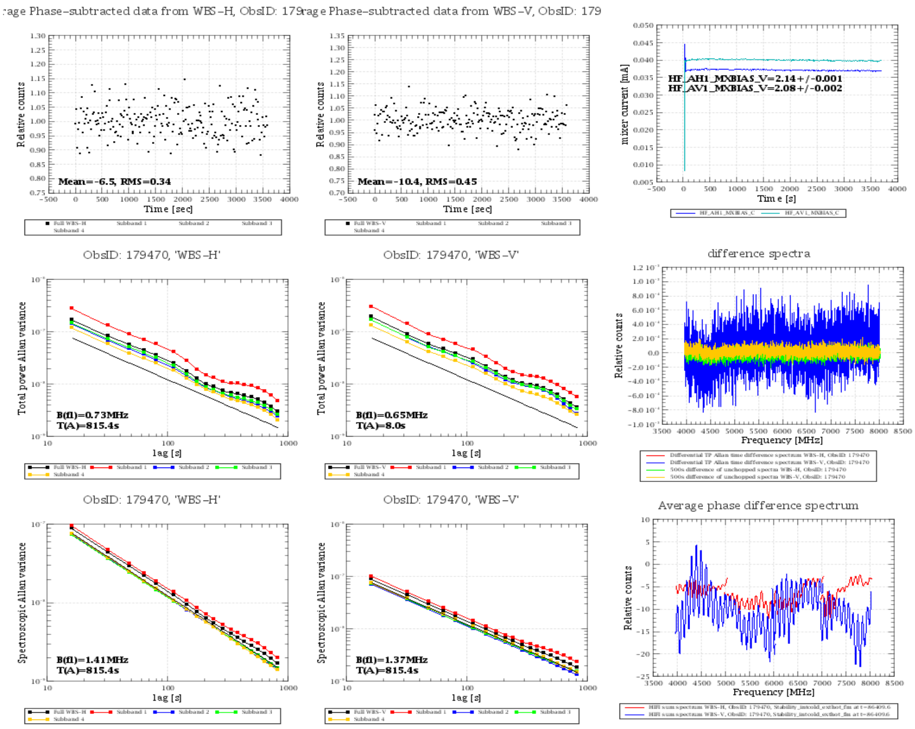

Fig. 40. B2b, OD 52, 756.83 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

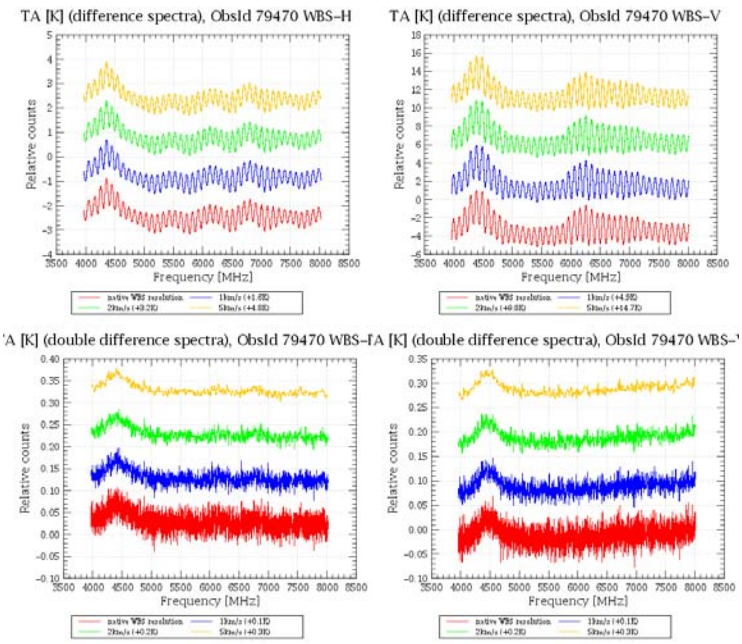

Fig. 41. B2b, OD 52, 756.83 GHz, simulated LSW spectrum. 10 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.2.8 B3a 841 GHz Load-Switch

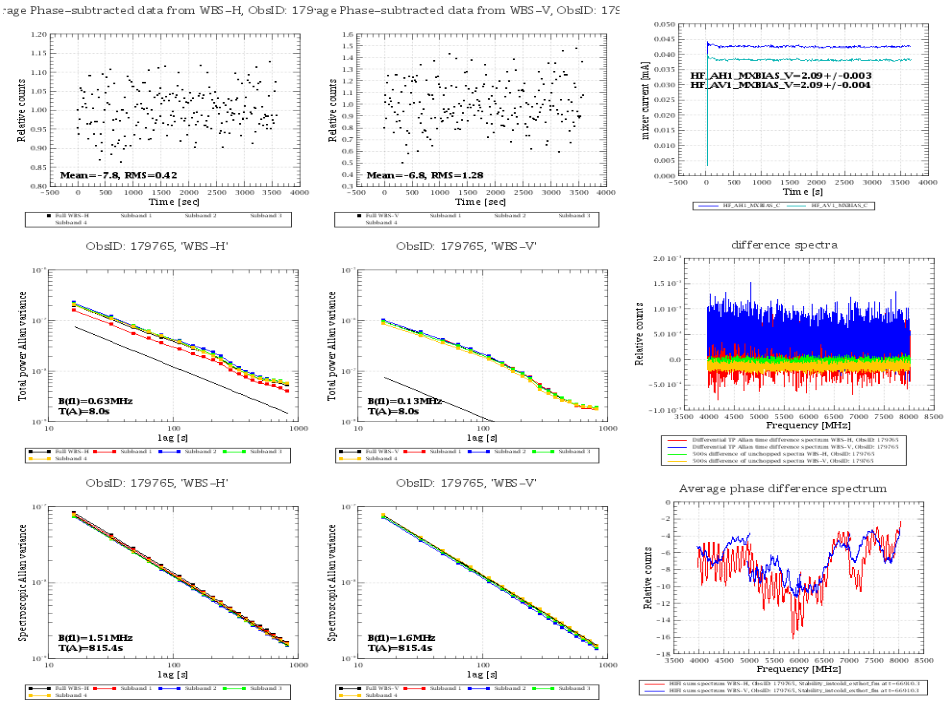

Fig. 42. B3a, OD 59, 815.14 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

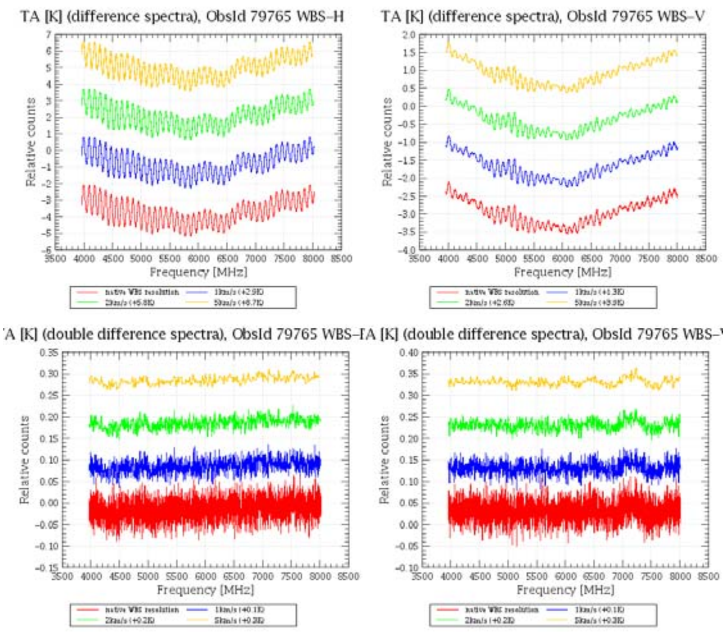

Fig. 43. B3a, OD 59, 815.14 GHz., simulated LSW spectrum. 10 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase

5.2.9 B3b 887.84 GHz Load-Switch

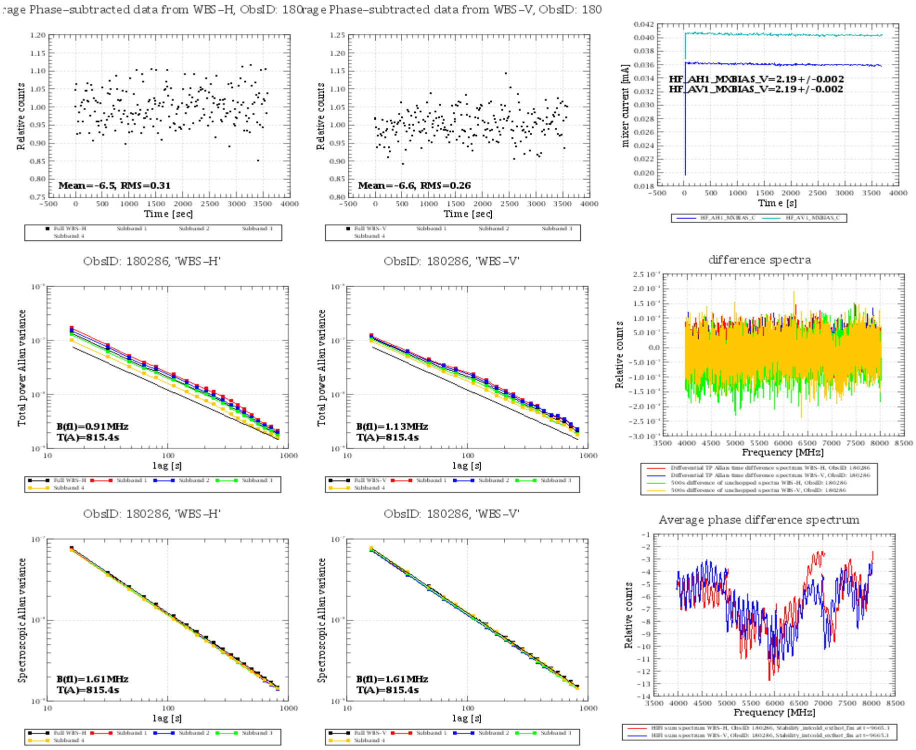

Fig. 44. B3b, OD 63, 887.84 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

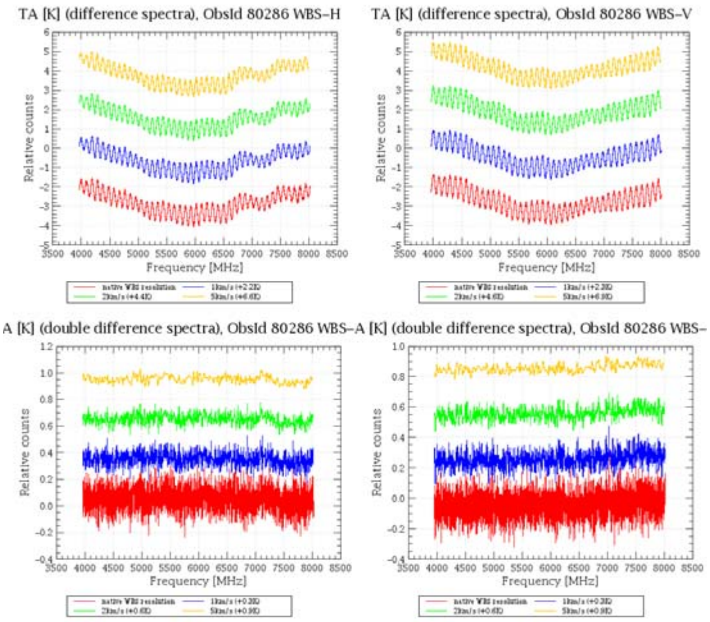

Fig. 45. B3b, OD 63, 887.84 GHz, simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase

5.2.10 B3b 927.60 GHz Load-Switch

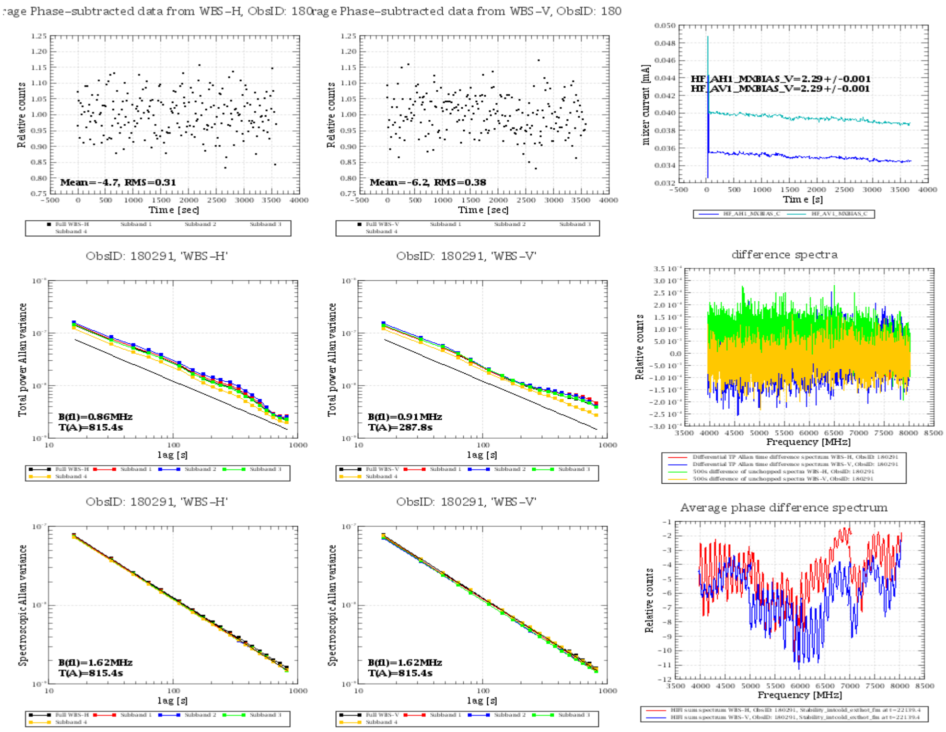

Fig. 46. B3b, OD 63, 927.60 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

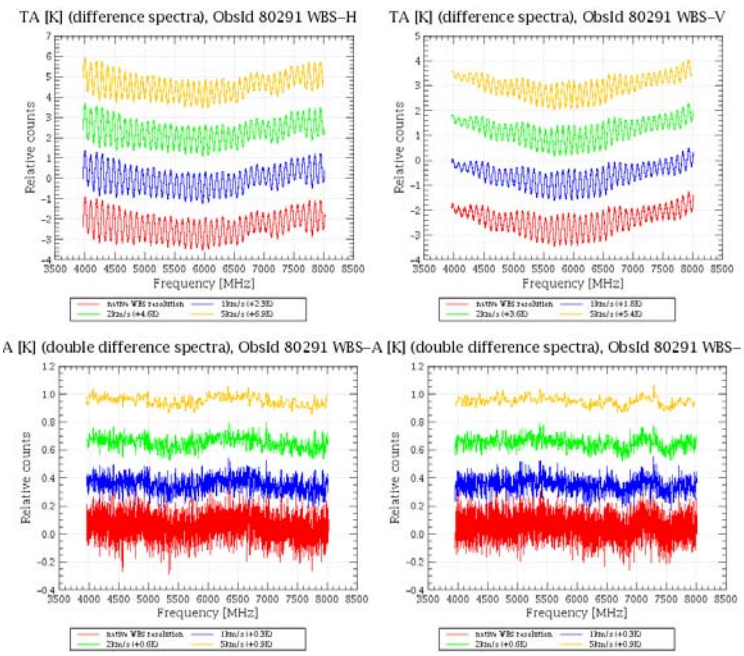

Fig. 47. B3b, OD 63, 927.60 GHz, simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra show some distortion. Duration of the measurement is 1h, 30 minutes/phase

5.2.11 B4a 968.66 GHz Load-Switch

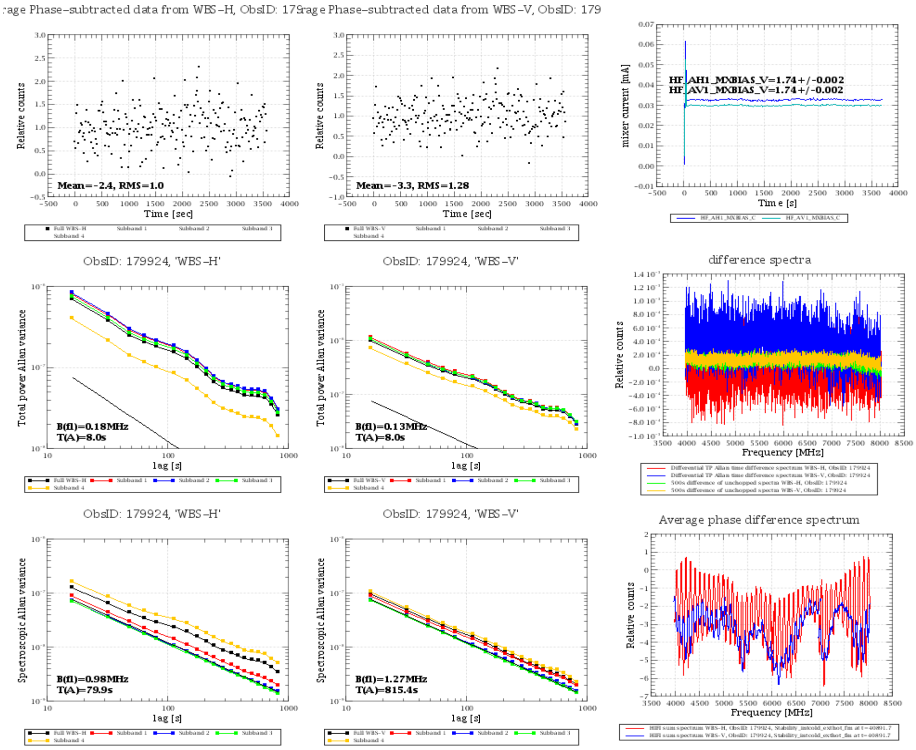

Fig. 48. B4a, OD 61, 968.66 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

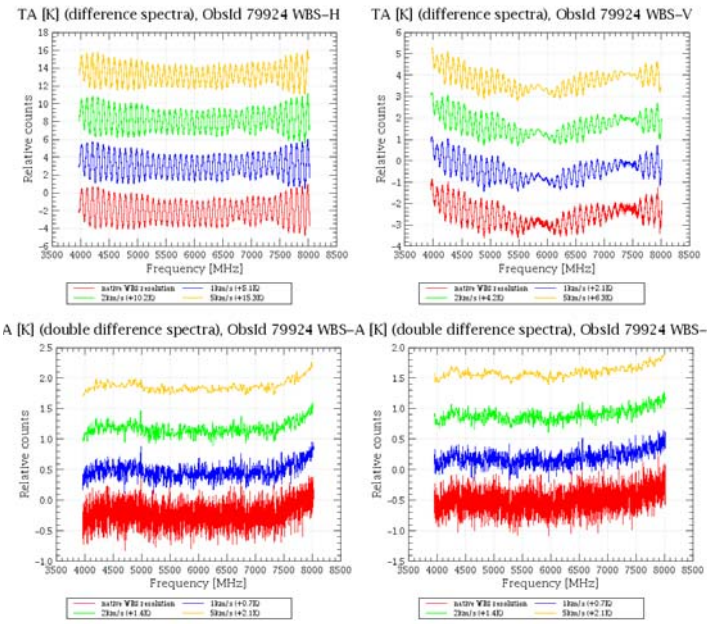

Fig. 49. B4a, OD 61, 968.66 GHz, simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra show some distortion. Duration of the measurement is 1h, 30 minutes/phase

5.2.12 B4a 993.73 GHz Load-Switch

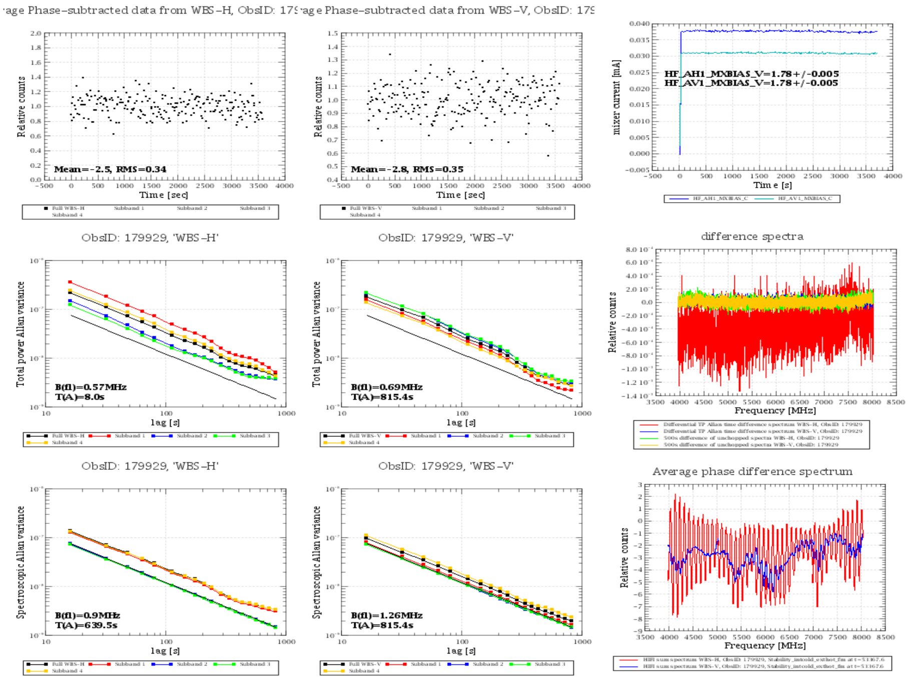

Fig. 50. B4a, OD 61, 993.73 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

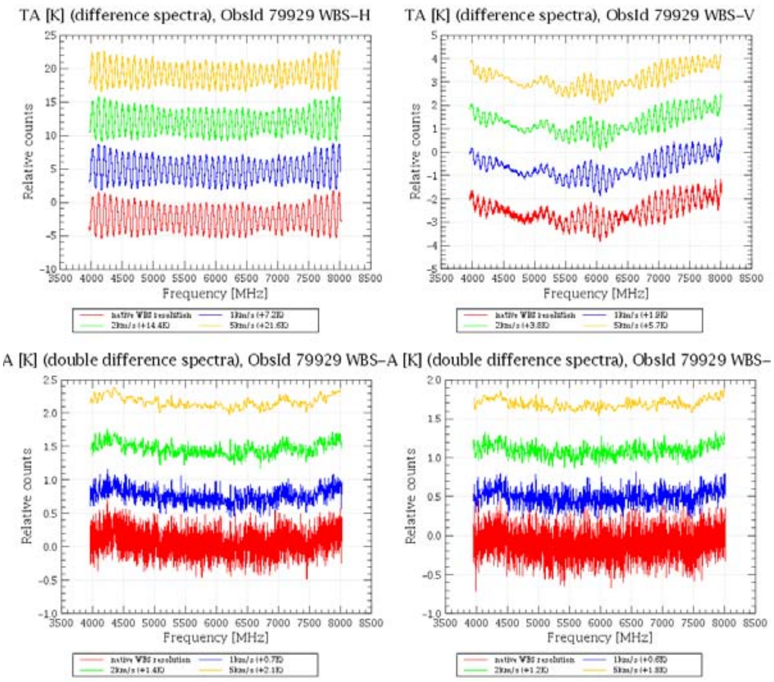

Fig. 50. B4a, OD 61, 993.73 GHz, simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra show some distortion as well as the diplexer passband shape. Duration of the measurement is 1h, 30 minutes/phase.

5.2.13 B4b 1091.56 GHz Load-Switch

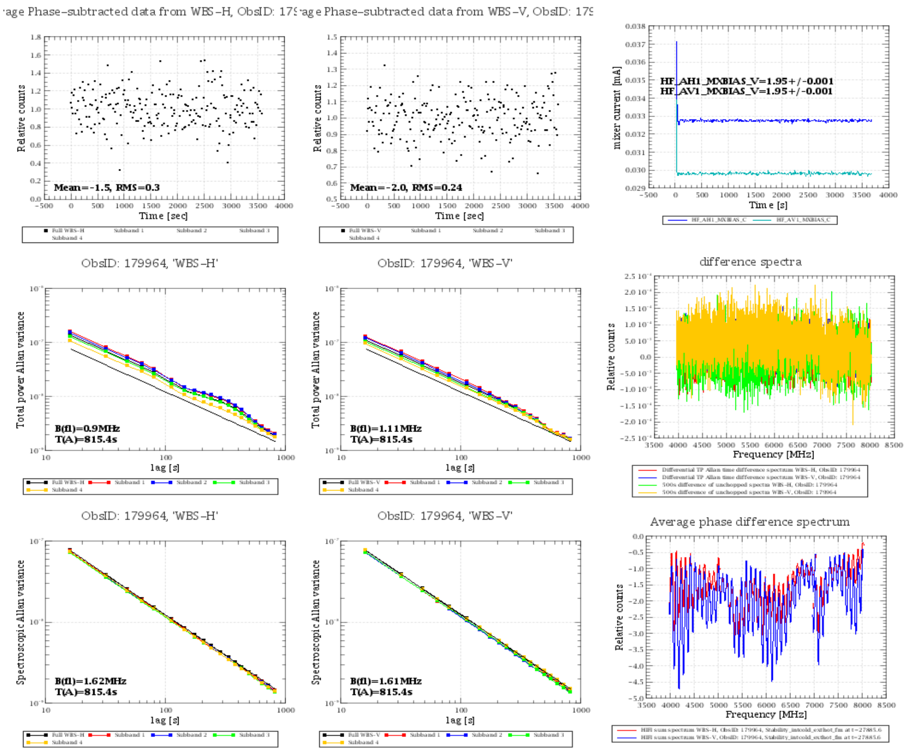

Fig. 51. B4b, OD 62, 1091.56 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

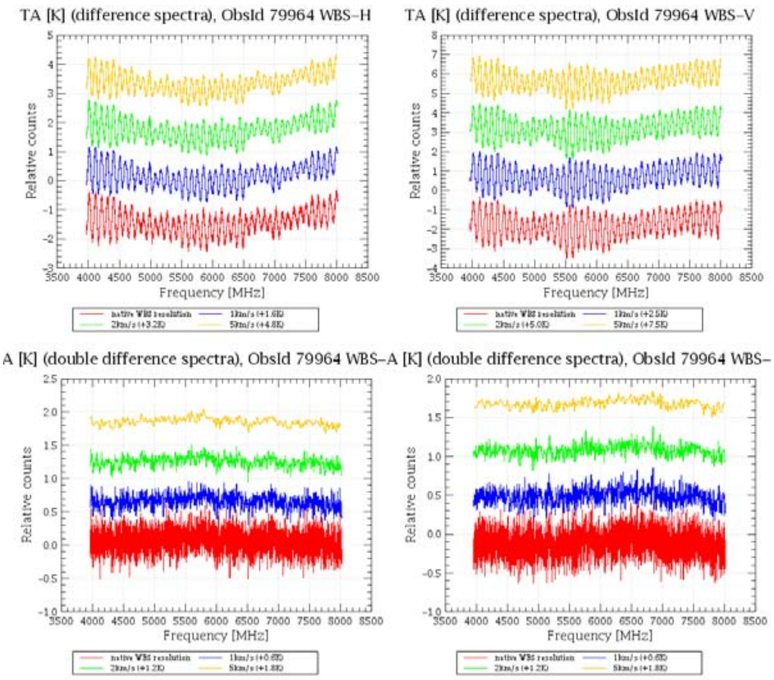

Fig. 52. B4b, OD 62, 1091.56 GHz, simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra show some distortion. Duration of the measurement is 1h, 30 minutes/phase.

5.2.14 B4b 1107.54 GHz Load-Switch

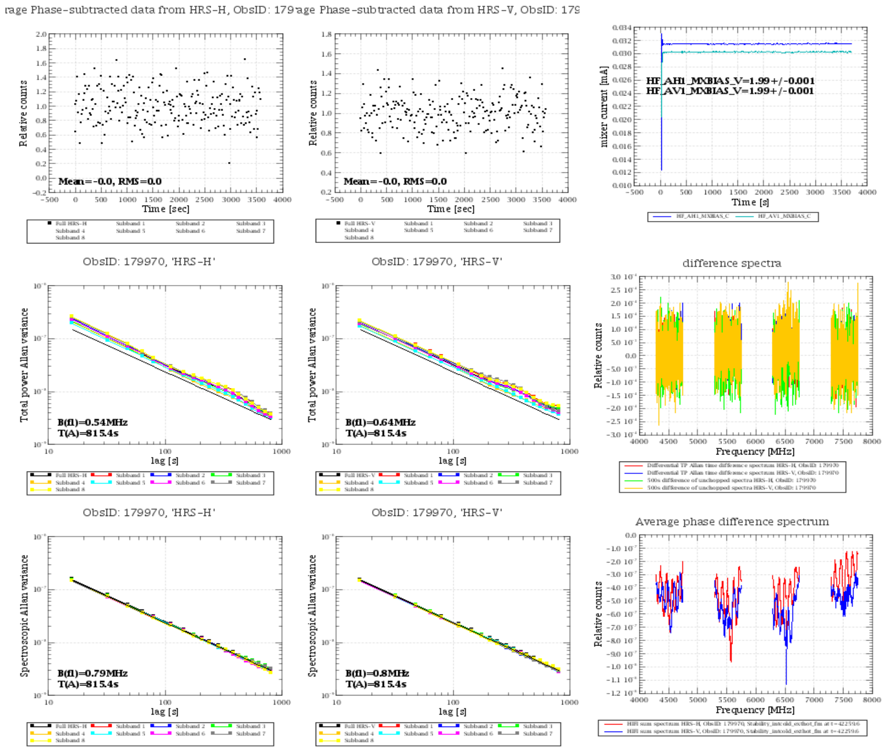

Fig. 53. B4b, OD 62, 1107.54 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

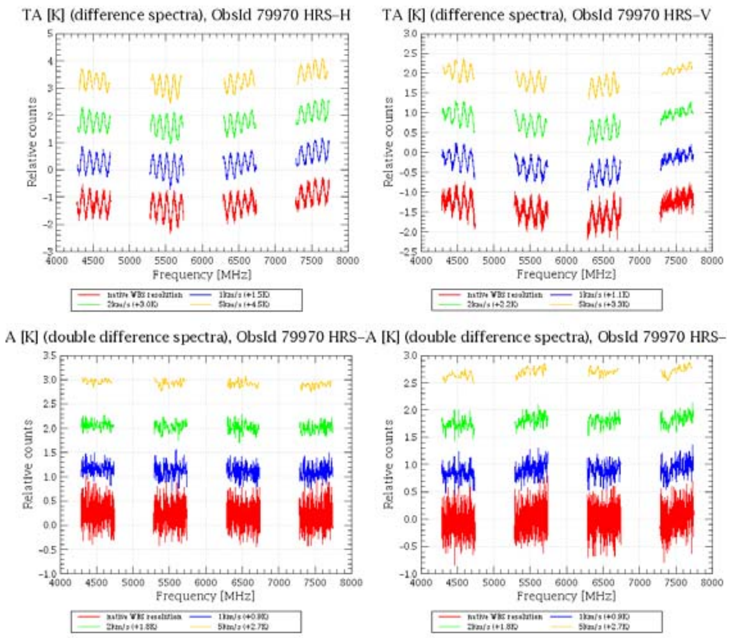

Fig. 54. HRS. B4b, OD 62, 1107.54 GHz., simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra show little or no distortion. Duration of the measurement is 1h, 30 minutes/phase. WBS suffers from a weak spur.

5.2.15 B5a 1145.32 GHz Load-Switch

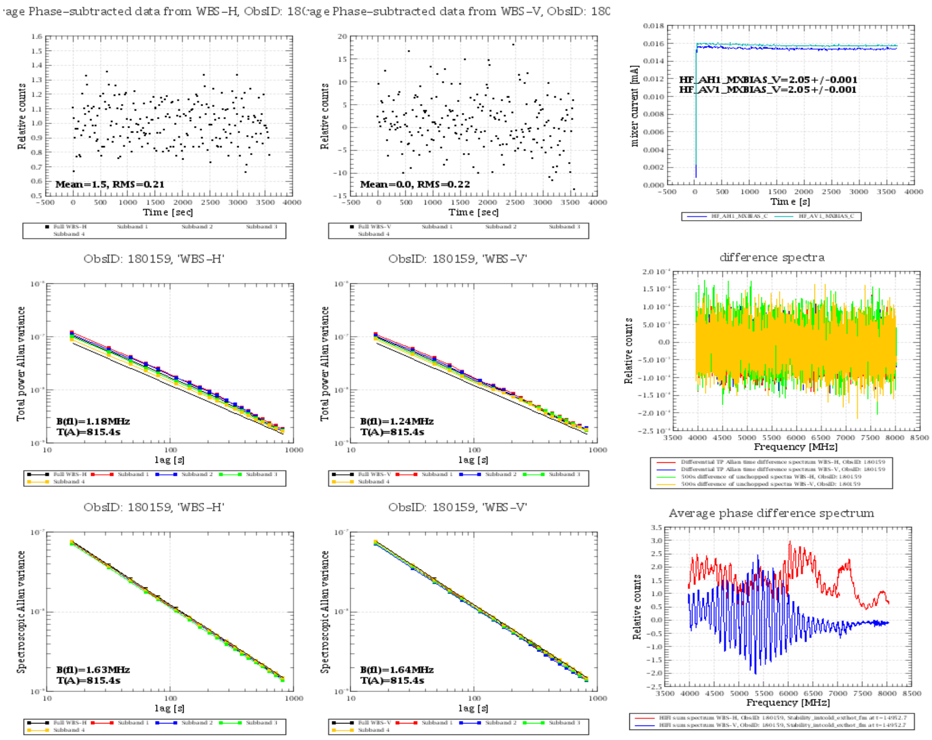

Fig. 55. B5a, OD 60, 1145.32 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s

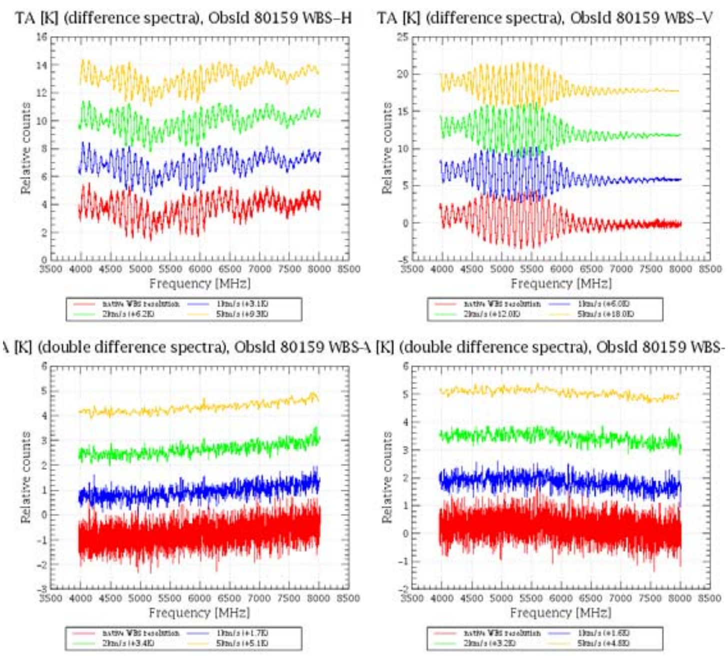

Fig. 56. B5a, OD 60, 1145.32 GHz., simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 5 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra show little distortion. Duration of the measurement is 1h, 30 minutes/phase. WBS suffers from a weak spur.

5.2.16 B5b 1242.90 GHz Load-Switch

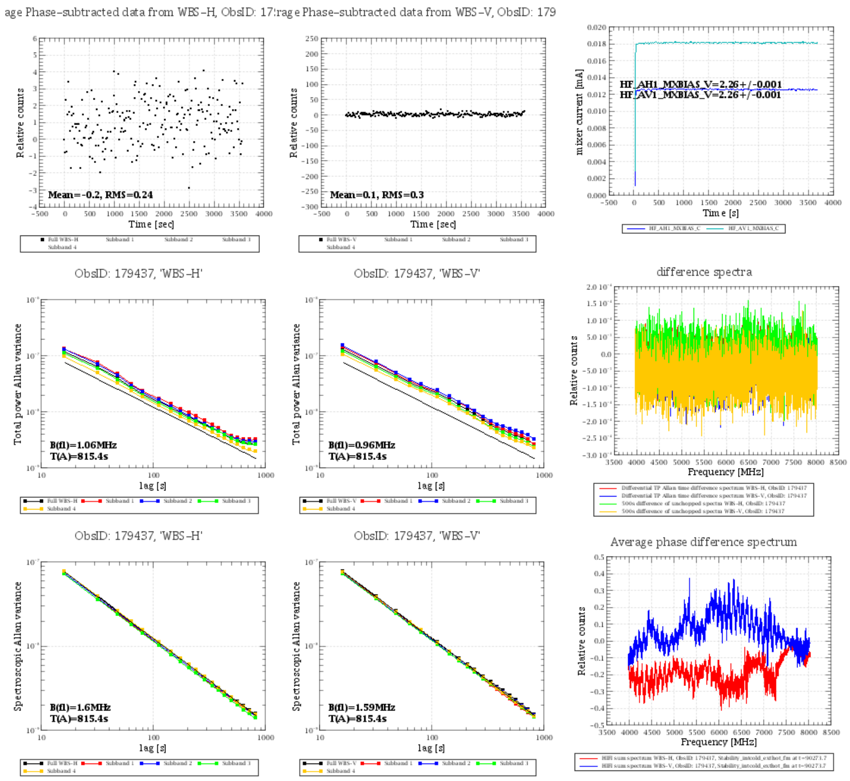

Fig. 57. B5b, OD 51, 1242.90 GHz. Load-Switch differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s

5.2.17 B6a 1458.33 GHz Load-Switch (N^+).

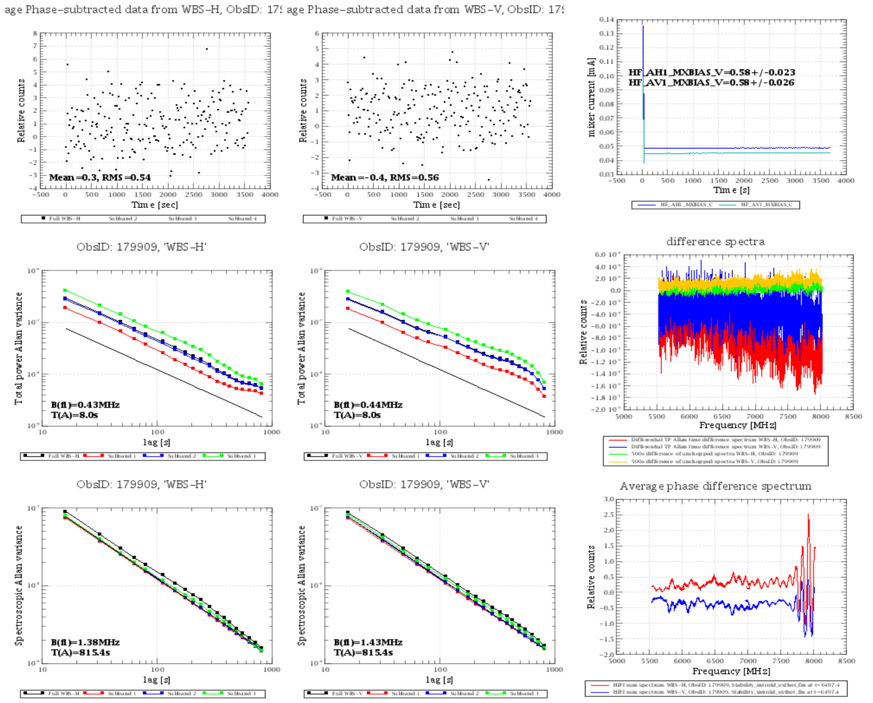

Fig. 58. B6a, OD 61, 1458.33 GHz. Load-Switch differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s

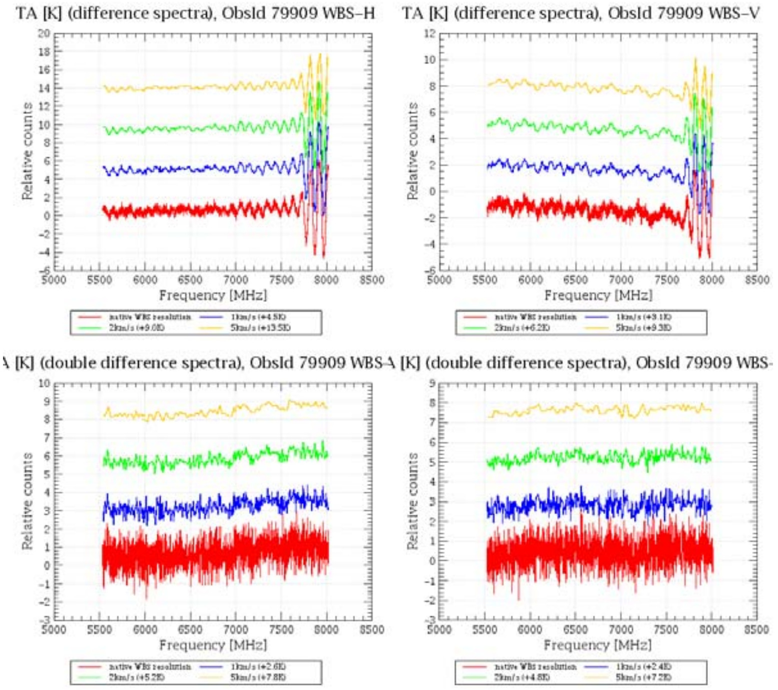

Fig. 59. B6a, OD 61, 1458.33 GHz., simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 5 minutes. The binned (yellow) double difference spectra show a little distortion. Duration of the measurement is 1h, 30 minutes/phase.

5.2.18 B6a 1543.79 GHz Load-Switch.

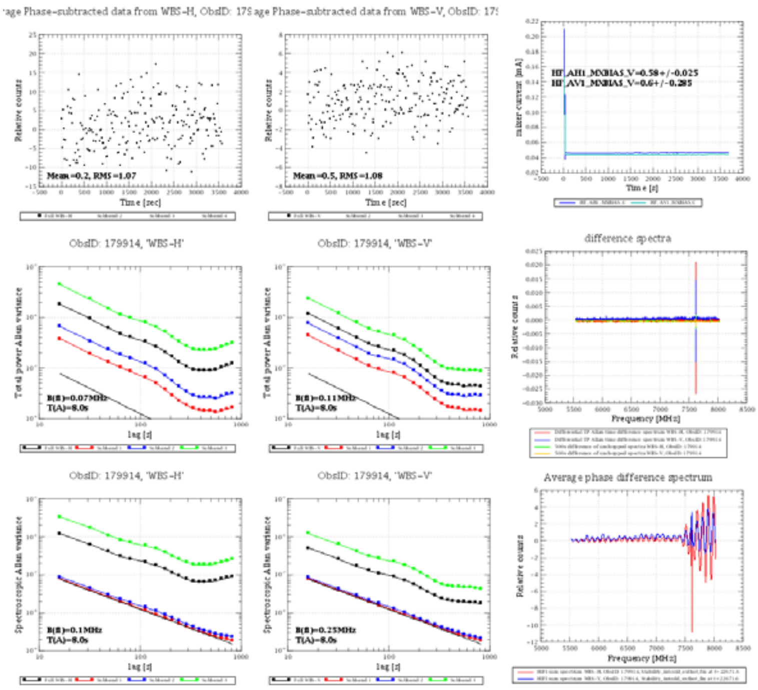

Fig. 60. B6a, OD 61, 1543.79 GHz. Load-Switch differential stability for 3600s. The spur throws off subband 3 (most sensitive subband). Diff Allan time >> 900s

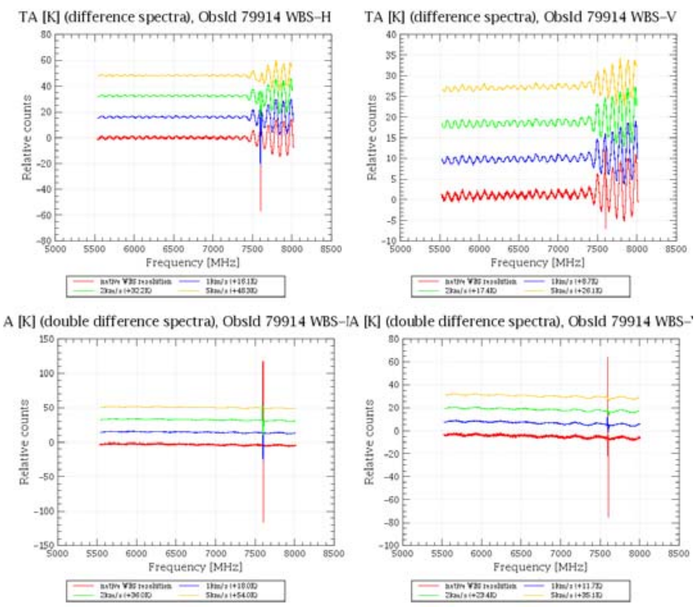

Fig. 61. B6a, OD 61, 1543.79 GHz simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 5 minutes. Spur wipes out the subtraction. Spectrum needs spur removal tool

5.2.19 B6b 1653.01 GHz Load-Switch

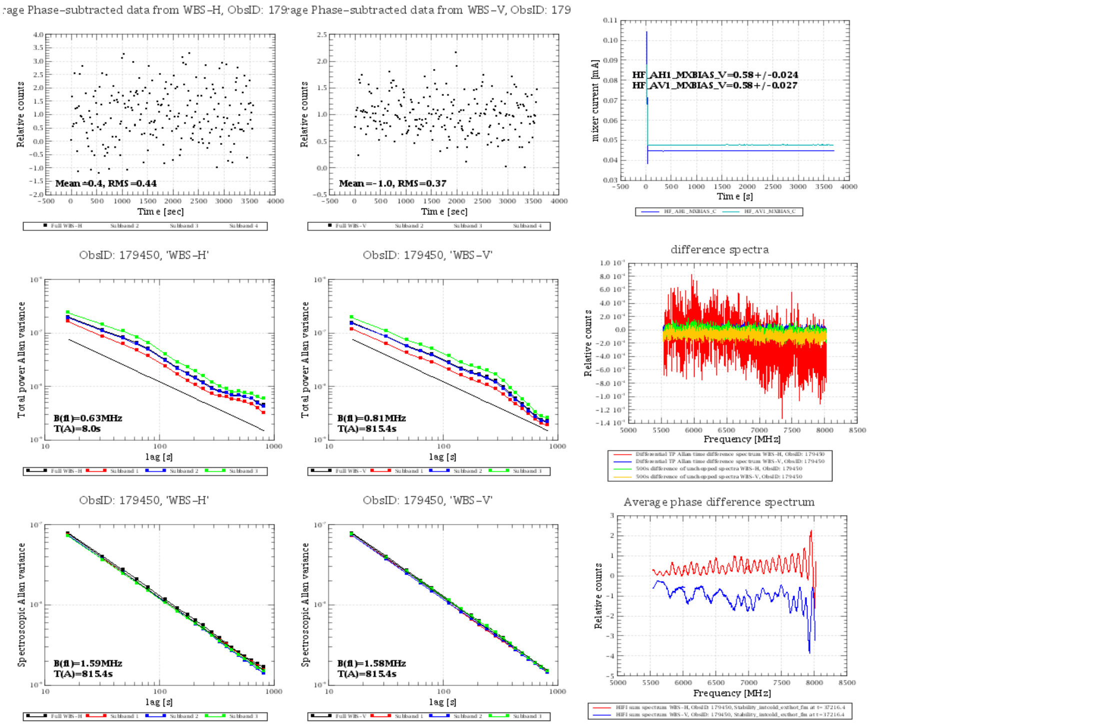

Fig. 62. B6b, OD 52, 1653.01 GHz. Load-Switch differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s

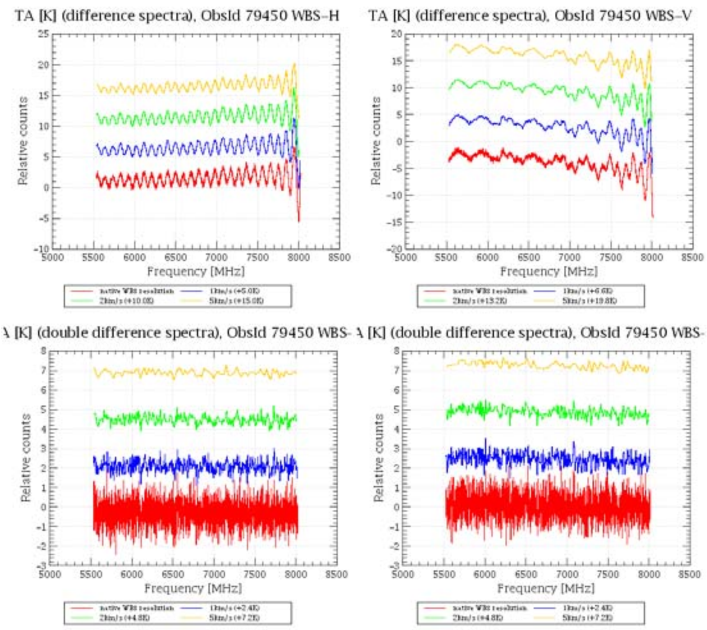

Fig. 63. B6b, OD 52, 1653.01 GHz.., simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 5 minutes. The binned (yellow) double difference spectra show little distortion. Duration of the measurement is 1h, 30 minutes/phase.

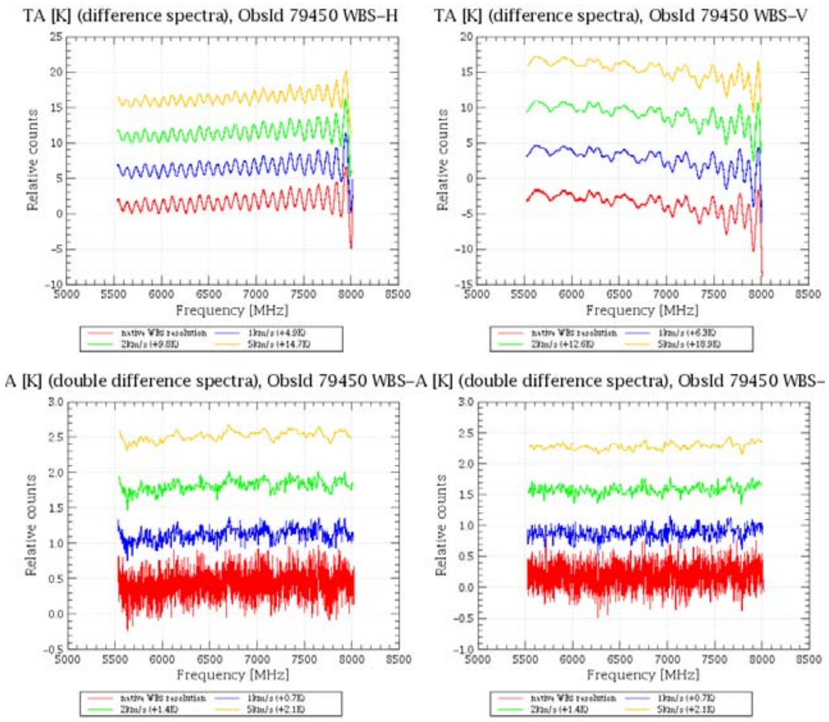

Fig. 64. B6b, OD 52, 1653.01 GHz.. Same as above, but now with a 10 minute simulated LSW spectrum. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. The binned (yellow) double difference spectra shows quite a bit more distortion then with 5 minutes off's. Duration of the measurement is 1h, 30 minutes/phase.

5.2.20 B6b 1667.11 GHz Load-Switch

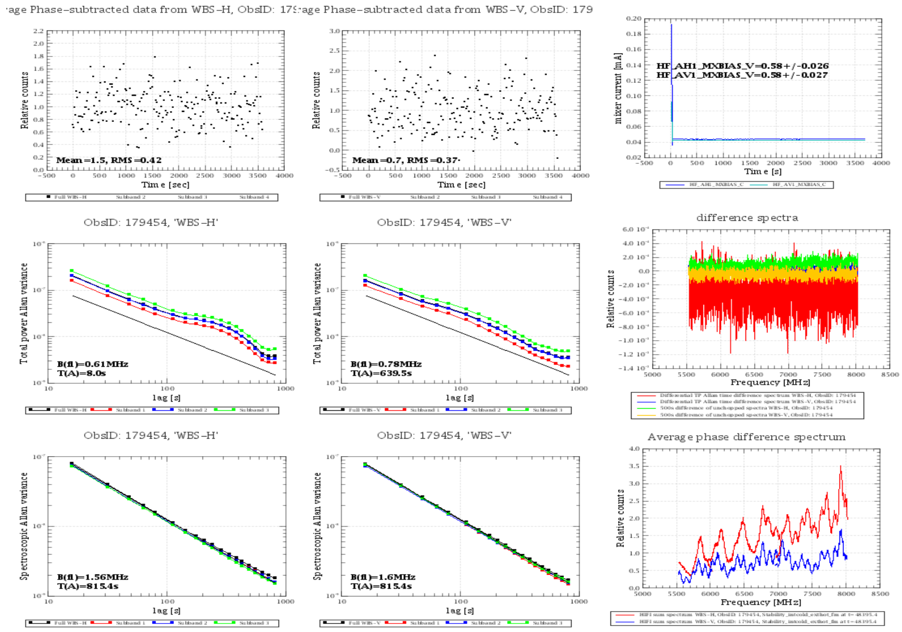

Fig. 65. B6b, OD 52, 1667.11 GHz. Load-Switch differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s. LO not quite warmed up.

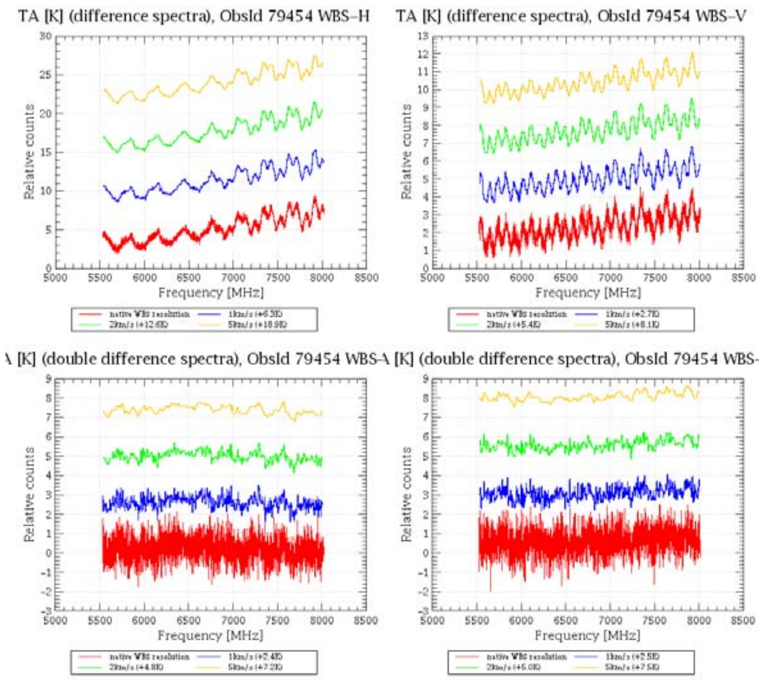

Fig. 66. B6b, OD 52, 1667.11 GHz simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 5 minutes. The binned (yellow) double difference spectra show little distortion. Duration of the measurement is 1h, 30 minutes/phase.

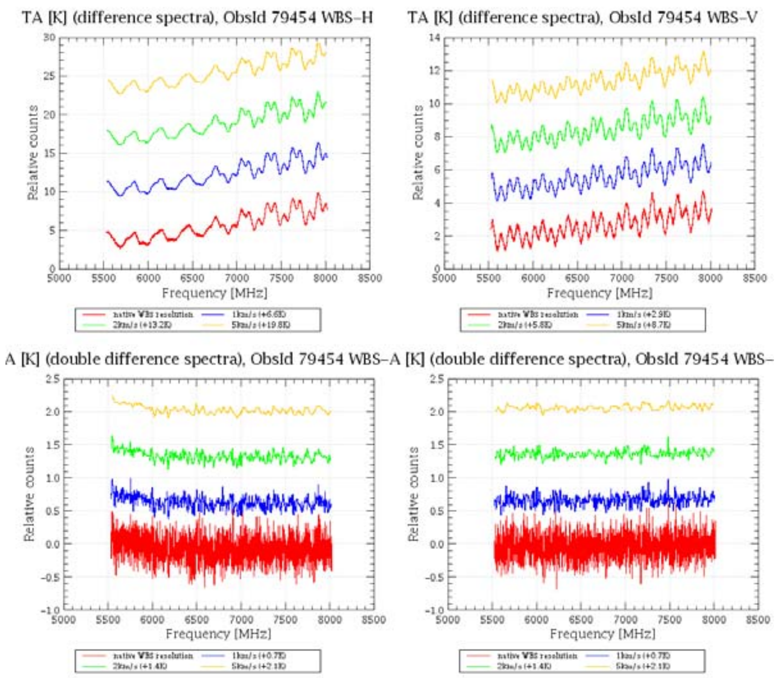

Fig. 67. B6b, OD 52, 1667.11 GHz Same as above, but now with a 10 minute simulated LSW spectrum. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. The binned (yellow) double difference spectra shows a bit less distortion then with 5 minutes off's ?? Duration of the measurement is 1h, 30 minutes/phase.

5.2.21 B7a 1719.57 GHz Load-Switch

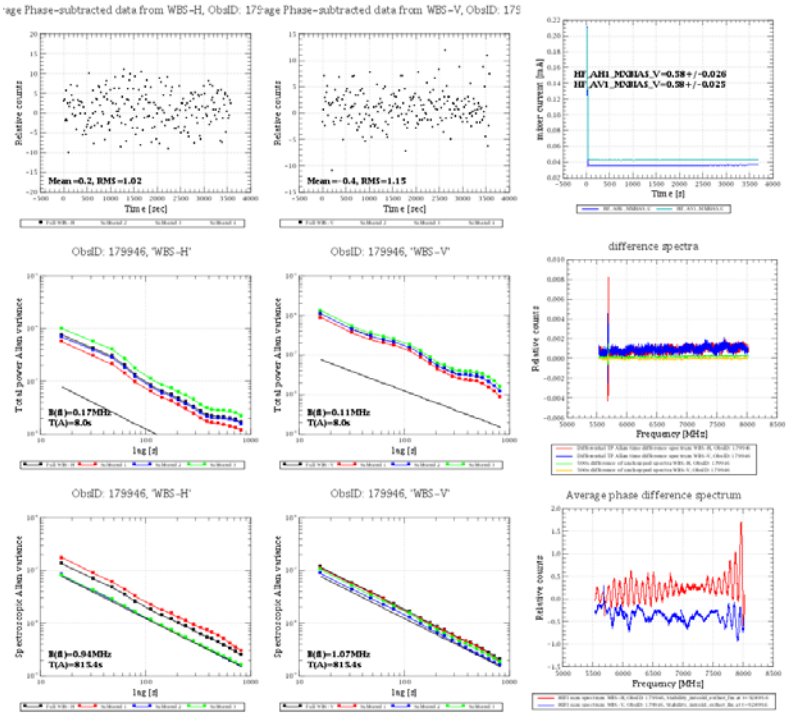

Fig. 68. B7a, OD 62, 1719.57 GHz. Load-Switch differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s. LO typically not quite warmed up.

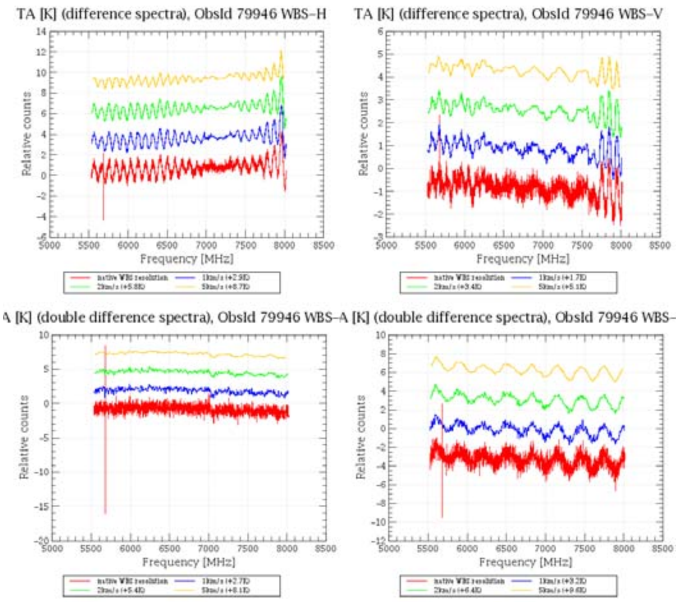

Fig. 69. B7a, OD 62, 1719.57 GHz simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 5 minutes. The binned (yellow) double difference spectra show little distortion. Duration of the measurement is 1h, 30 minutes/phase. Unclear why there is so much baseline structure. The 300 MHz ripple is the electrical standing wave on the IF side of the HEB mixer.

5.2.22 B7a 1772.68 GHz Load-Switch

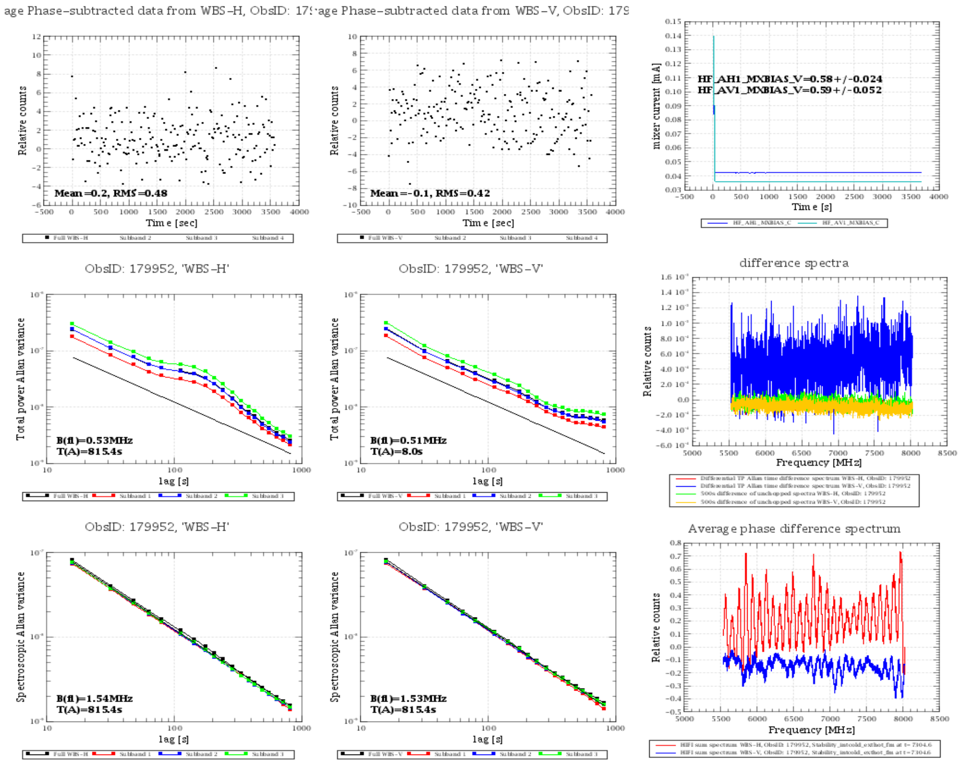

Fig. 70. B7a, OD 62, 1772.68 GHz. Load-Switch differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s. LO typically not quite warmed up.

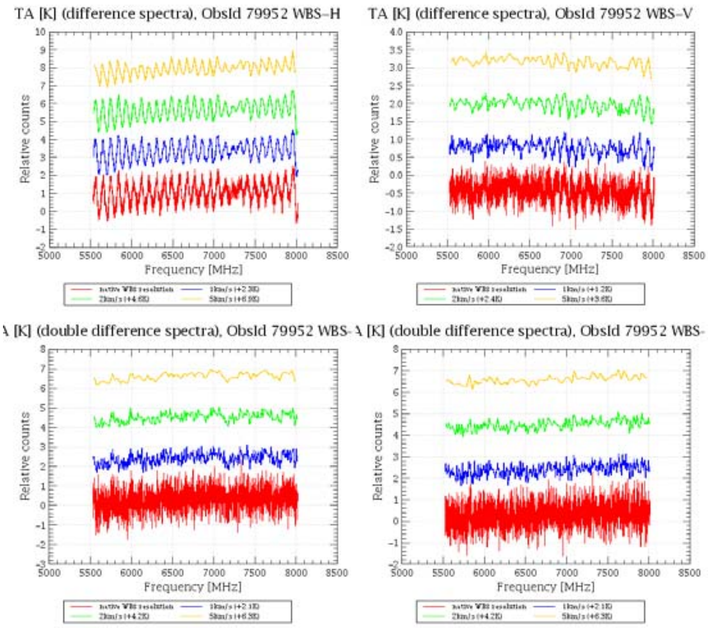

Fig. 71. B7a, OD 62, 1772.68 GHz simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 5 minutes. The binned (yellow) double difference spectra shows little distortion. Duration of the measurement is 1h, 30 minutes/phase.

5.2.23 B7b 1897.75 GHz Load-Switch (C^+)

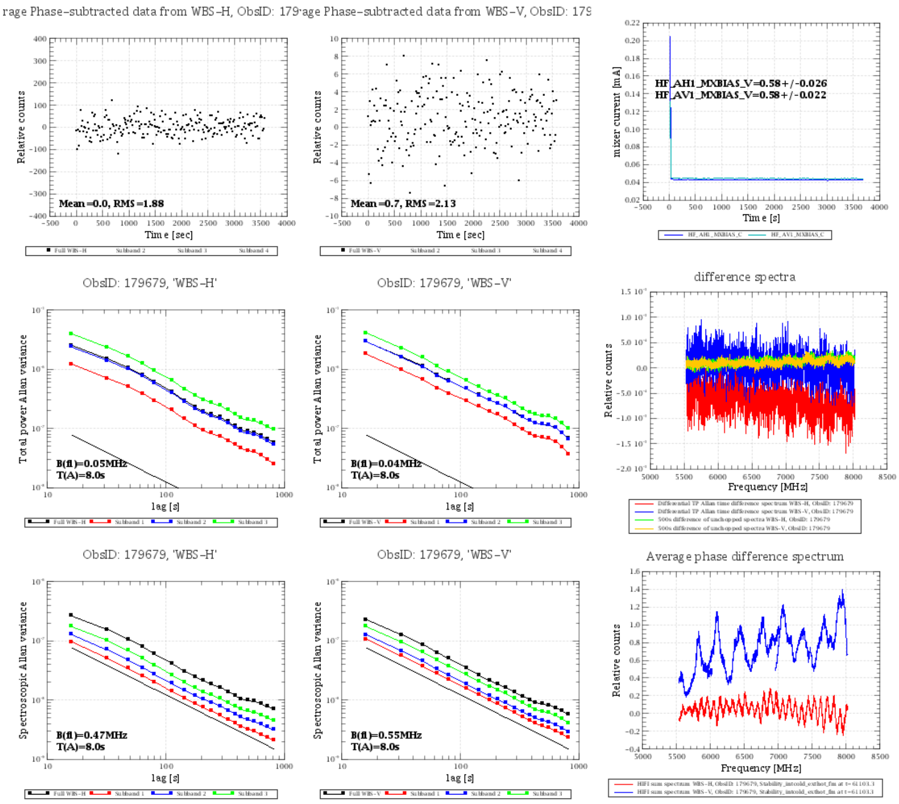

Fig. 72. B7b, OD57, 1897.75 GHz. Load-Switch differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s. This is the very unstable C^+ multiplier bias setting. The improved multiplier bias setting (factor ~ 10x) should significantly improve the results (reduced excess noise).

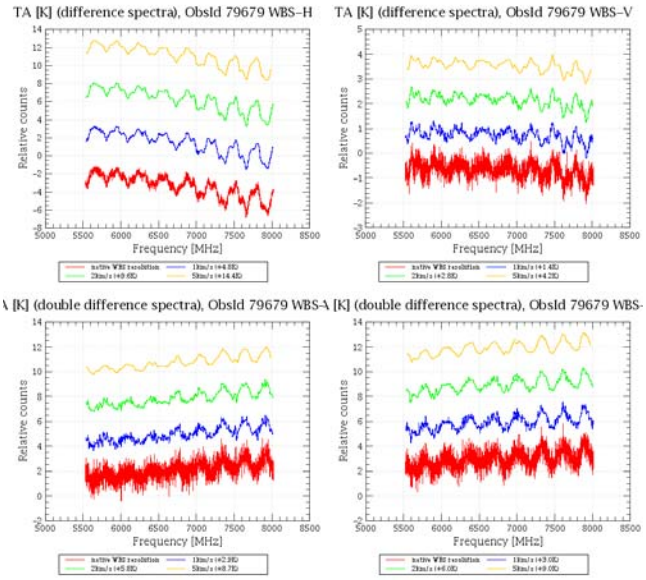

Fig. 73. B7b, OD57, 1897.75 GHz. Simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 5 minutes. Duration of the measurement is 1h, 30 minutes/phase. The ripple is due to an electrical 9IF) standing wave between the HEB mixer and first LNA.

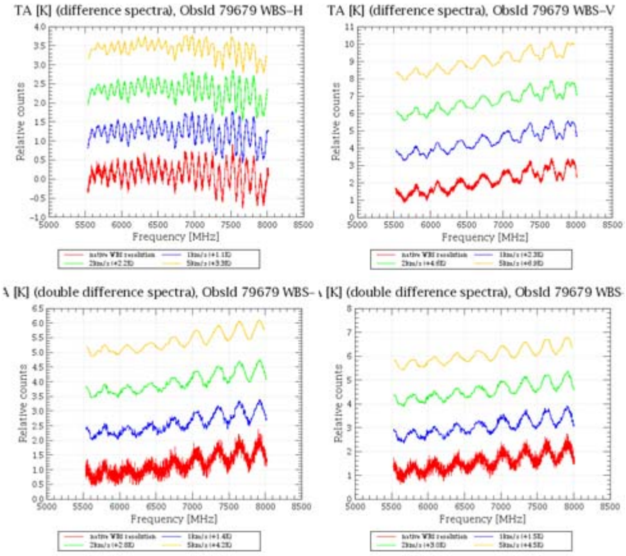

Fig. 74. B7b, OD57, 1897.75 GHz. Simulated LSW spectrum. 10 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Duration of the measurement is 1h, 30 minutes/phase. The ripple is due to an electrical 9IF) standing wave between the HEB mixer and first LNA. With a 10 minute integration cycle the residual IF standing wave becomes more pronounced. Should try the current off-subtraction technique here.

5.2.24 B7b 1844.15 GHz Load-Switch

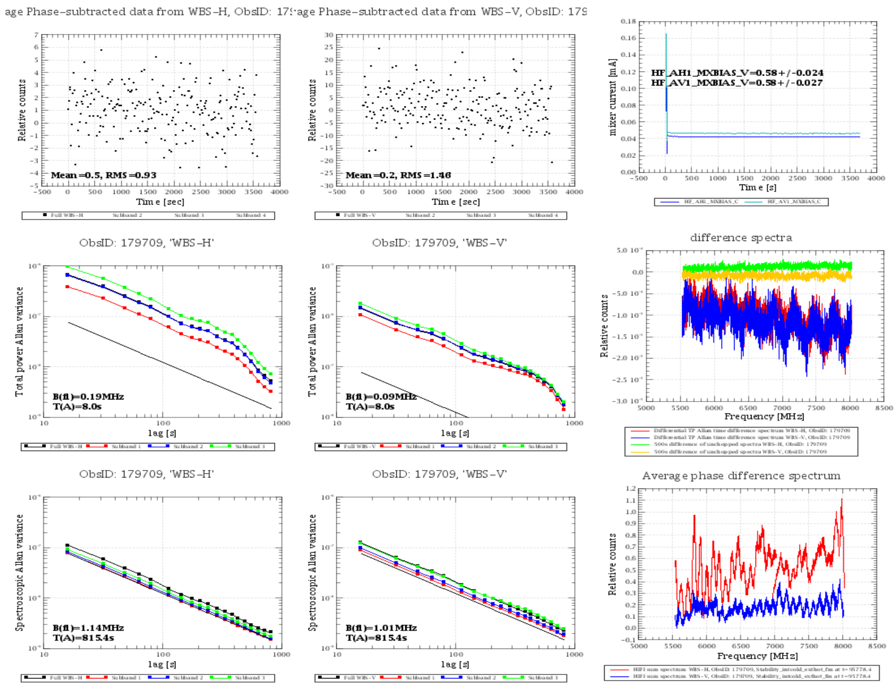

Fig. 75. B7b, OD57, 1844.15 GHz. Load-Switch differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

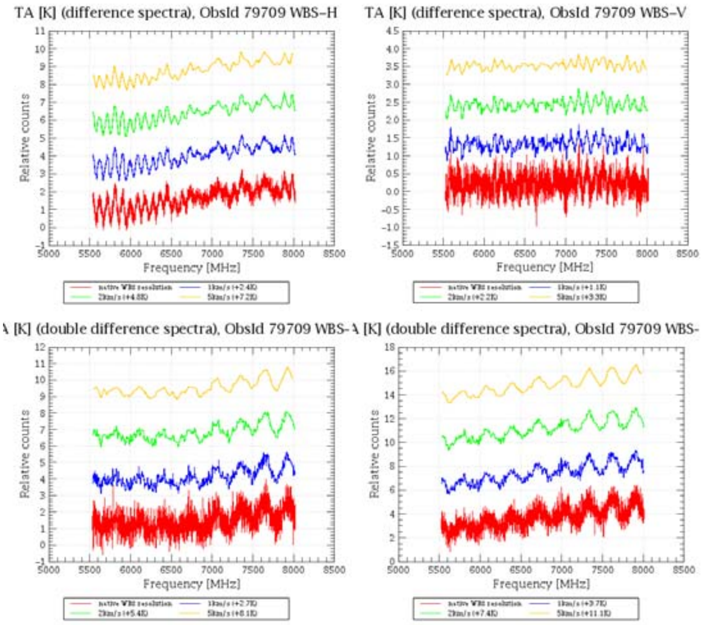

Fig. 76. B7b, OD57, 1844.15 GHz. Simulated LSW spectrum. 5 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 5 minutes. Duration of the measurement is 1h, 30 minutes/phase. The ripple is due to an electrical 9IF) standing wave between the HEB mixer and first LNA.

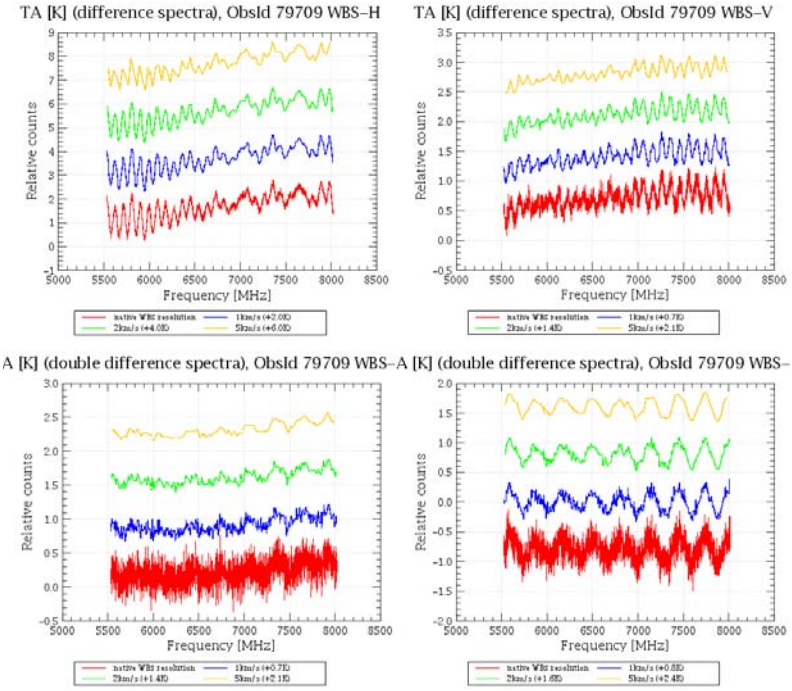

Fig. 77. B7b, OD57, 1844.15 GHz. Simulated LSW spectrum. 10 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Duration of the measurement is 1h, 30 minutes/phase. The ripple is due to an electrical 9IF) standing wave between the HEB mixer and first LNA, and has now become more noticeable. The current-off subtraction method should be applied here.

5.3 Beam Switch (DBS) Differential Stability

Objectives

To simulation beam switching, verify the differential stability between two positions on the external cold (dark) sky. This test will provide information on instability due to broadband gain variations, standing wave modulation, temperature drift…
Provide input for the efficiency computation/loop-optimization AOT's.
Obtain Hot-Cold calibration loop parameters..

Expected Result

Differential total power and spectroscopic gain stability between two positions on dark sky as function of integration for each mixer sub-band.
Knowledge of plat forming spectrometers, systematic baseline offsets
Loop parameters AOT (HSPOT)
Possible standing wave modulation in the telescope.

5.3.1 B1a 492.05 GHz DBS

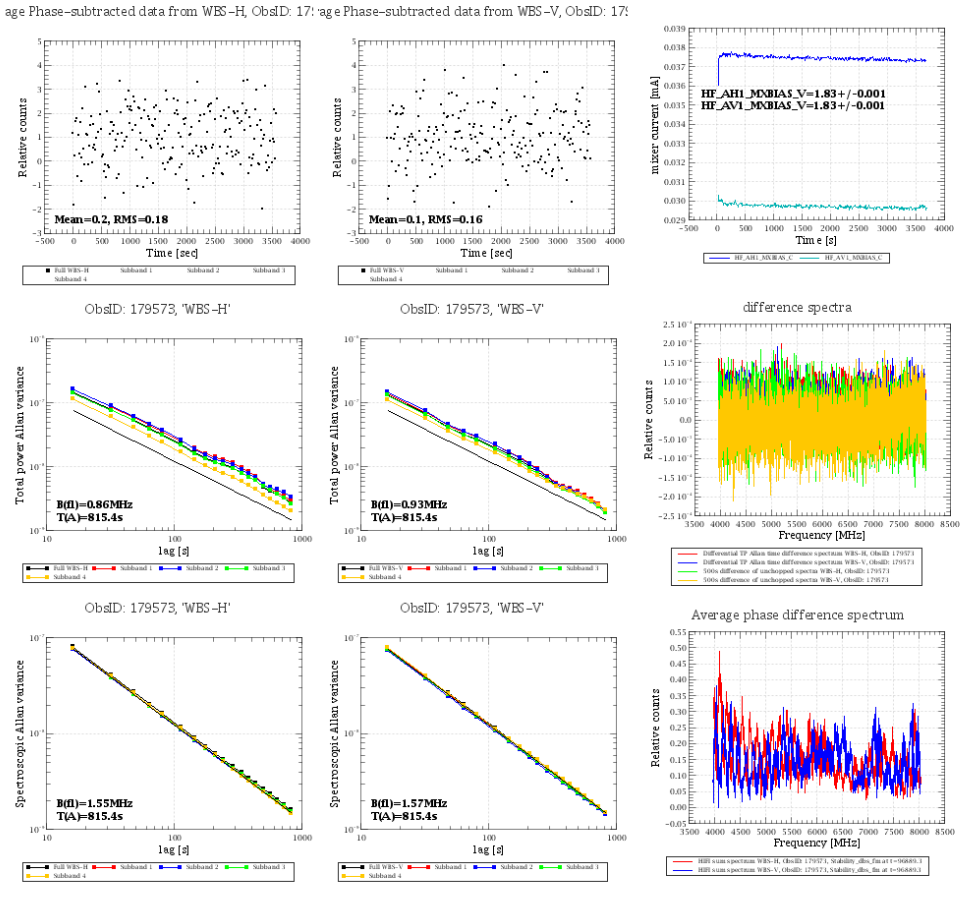

Fig. 78. B1a, OD 54, 492.05 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s

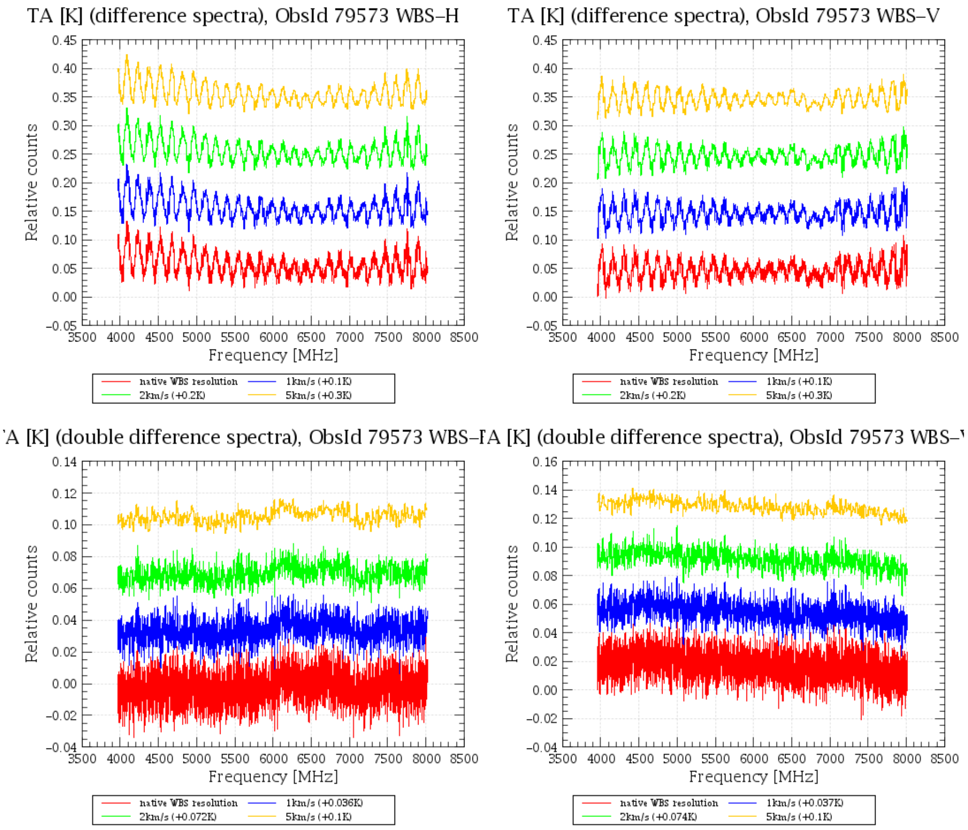

Fig. 79. B1a, OD 54, 492.05 GHz , simulated DBS spectrum. 10 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.
minutes/phase.

5.3.2 B1a 542.88 GHz DBS

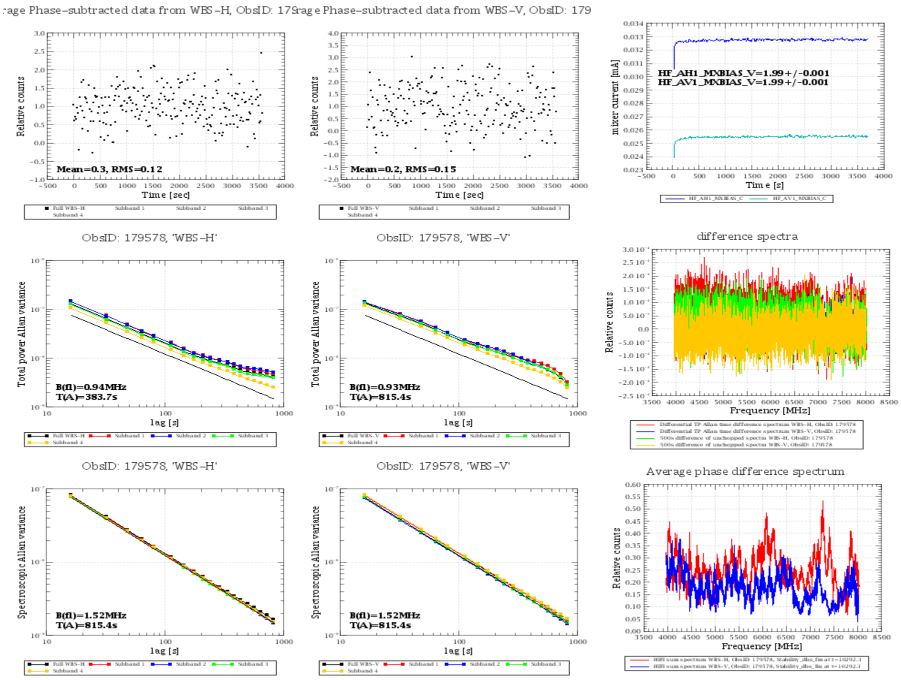

Fig. 80. B1a, OD 54, 542.88 GHz. Int. Load differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s

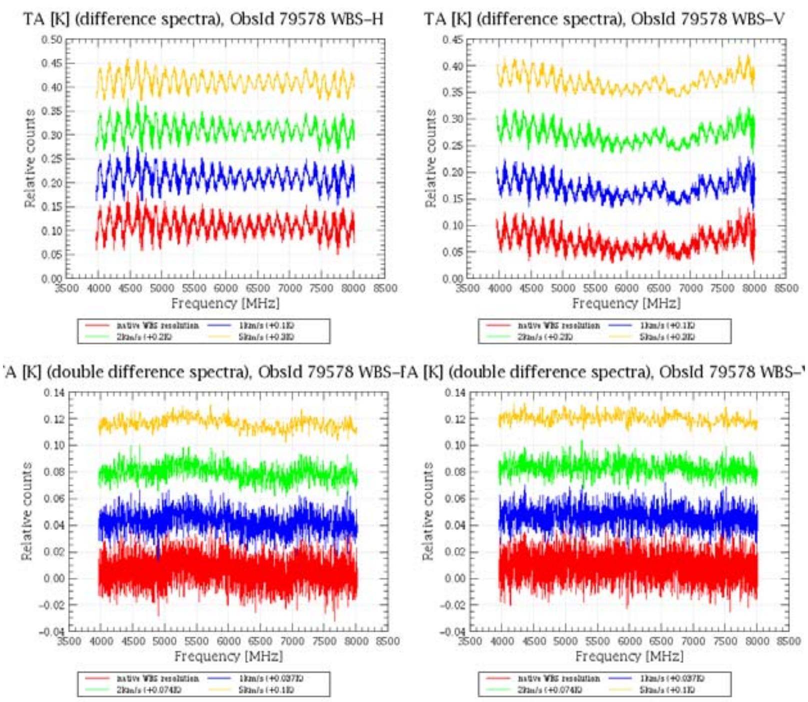

Fig. 81. B1a, OD 54, 542.88 GHz, simulated LSW spectrum. 10 minutes integration cycles. Top row: Single difference, LSW. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the LSW is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.3.3 B1b 563.74 GHz DBS

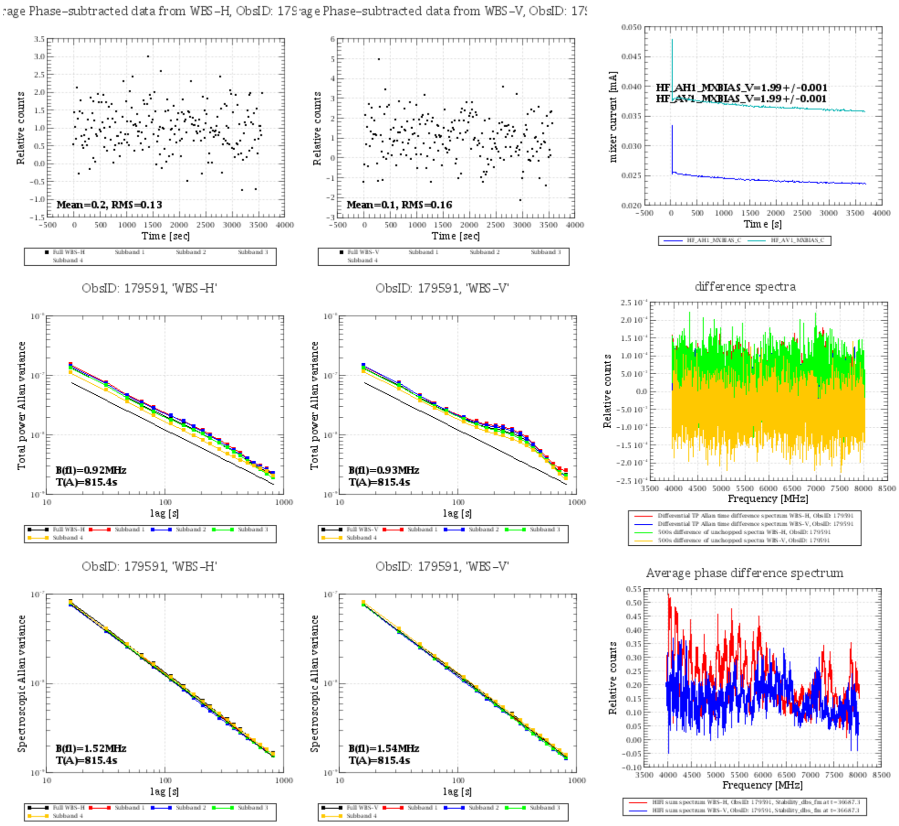

Fig. 82. B1b, OD 54, 563.74 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

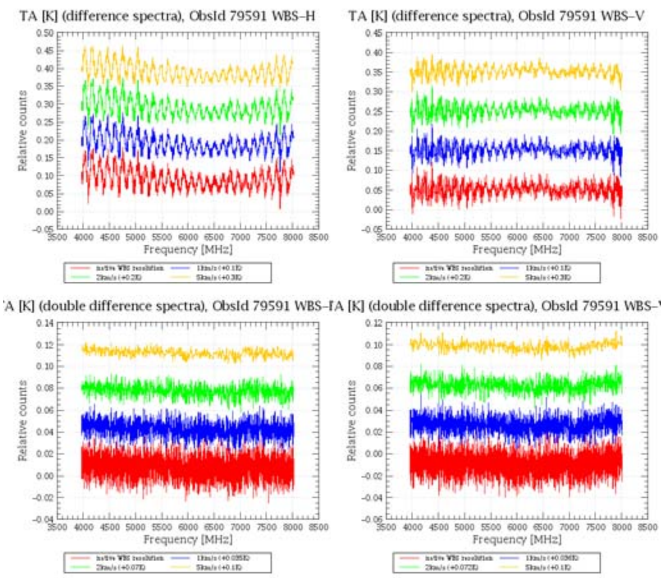

Fig. 83. B1b, OD 54, 563.74 GHz, simulated DBS spectrum. 10 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the DBS is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.3.4 B1b 614.21 GHz DBS

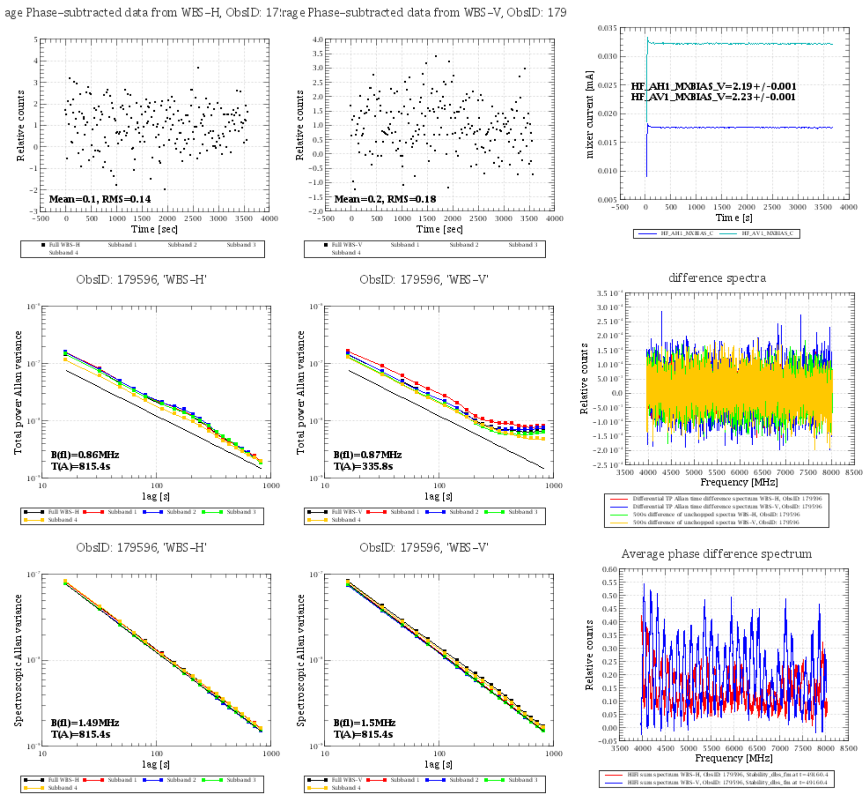

Fig. 84. B1b, OD 54, 614.21 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

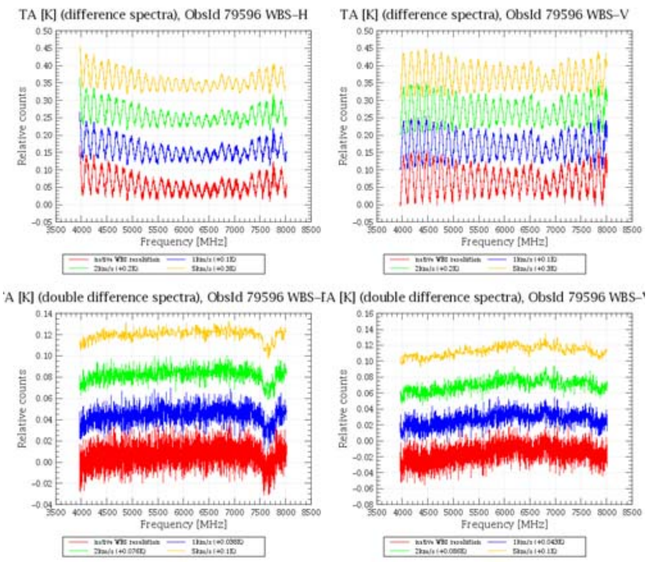

Fig. 85. B1b, OD 54, 614.21 GHz, simulated DBS spectrum. 10 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the DBS is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.3.5 B2a 686.86 GHz DBS

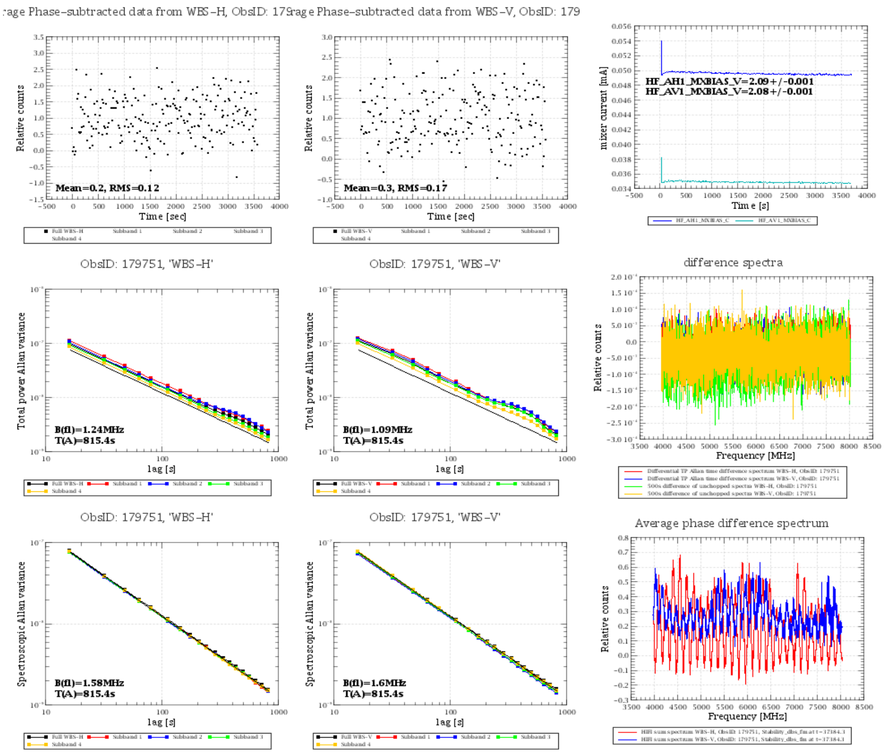

Fig. 86. B2a, OD 59, 686.86 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

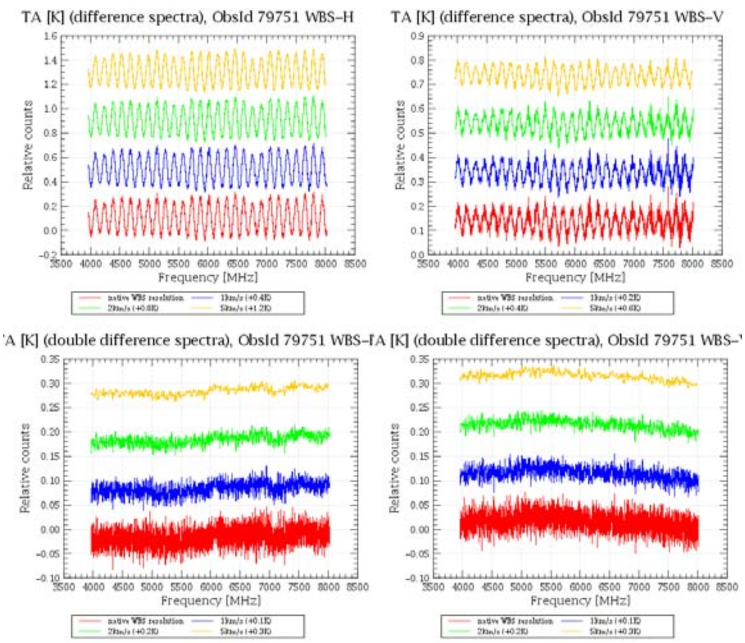

Fig. 87. B2a, OD 59, 686.86 GHz, simulated DBS spectrum. 10 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the DBS is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.3.6 B2b 729.52 GHz DBS

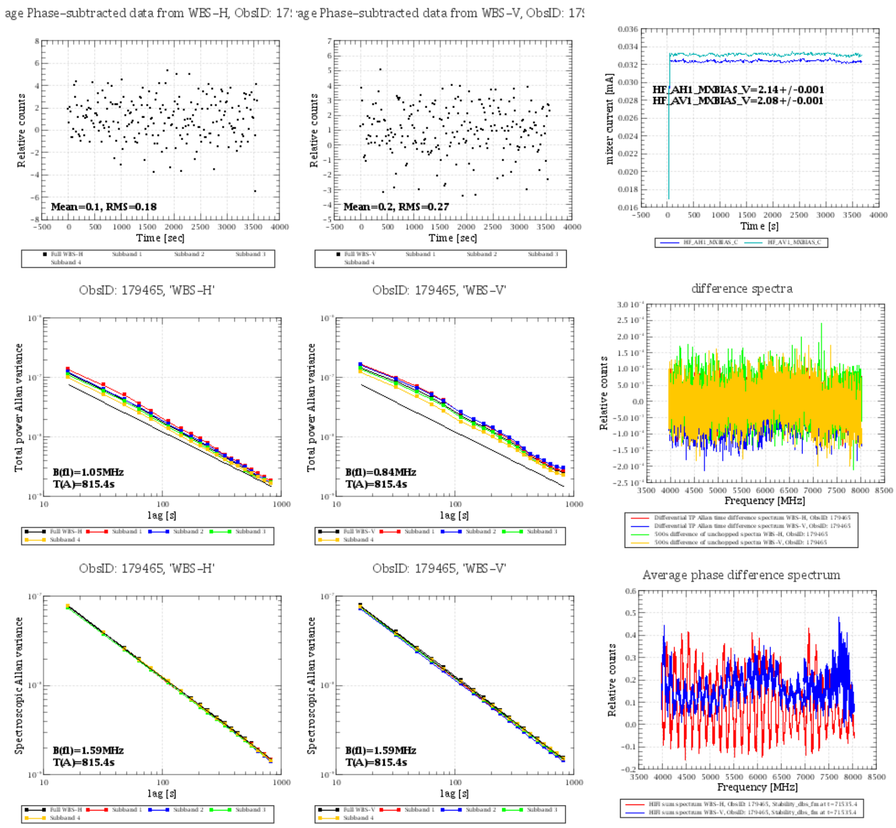

Fig. 88. B2b, OD 52, 729.52 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s

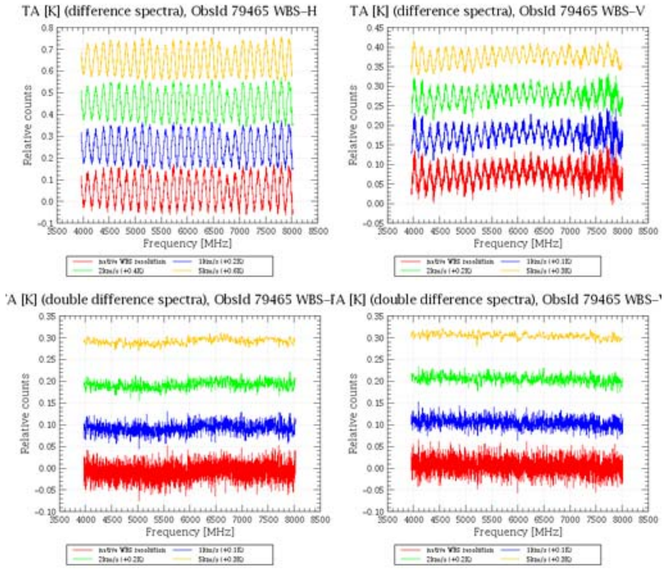

Fig. 89. B2b, OD 52, 729.52 GHz, simulated DBS spectrum. 10 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the DBS is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.3.7 B2b 756.83 GHz DBS

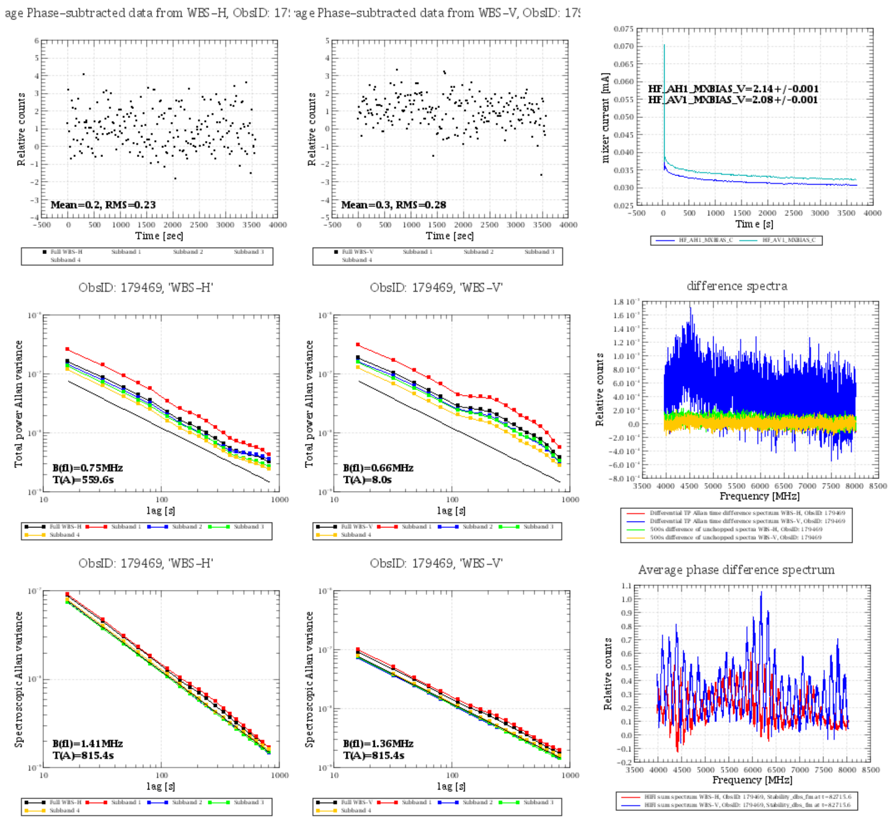

Fig. 90. B2b, OD 52, 756.83 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

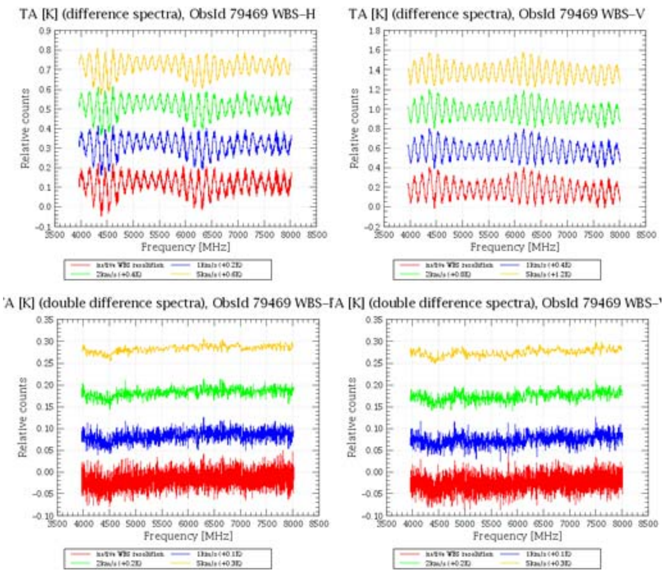

Fig. 91. B2b, OD 52, 756.83 GHz, simulated DBS spectrum. 10 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the DBS is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

5.3.8 B3a 815.14 GHz DBS

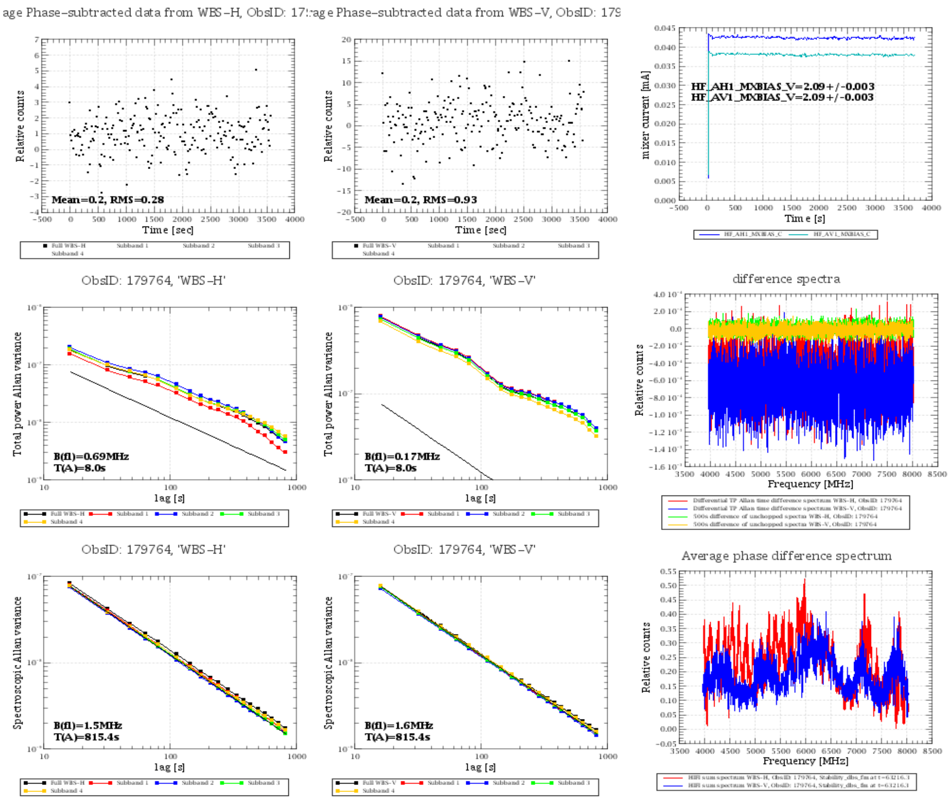

Fig. 92. B3a, OD 59, 815.14 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

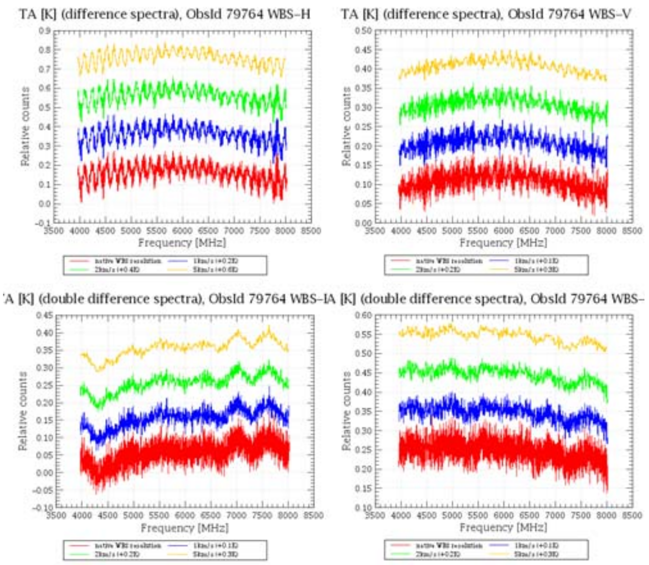

Fig. 93. B3a, OD 59, 815.14 GHz., simulated DBS spectrum. 10 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the DBS is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase

5.3.9 B3b 887.84 GHz DBS

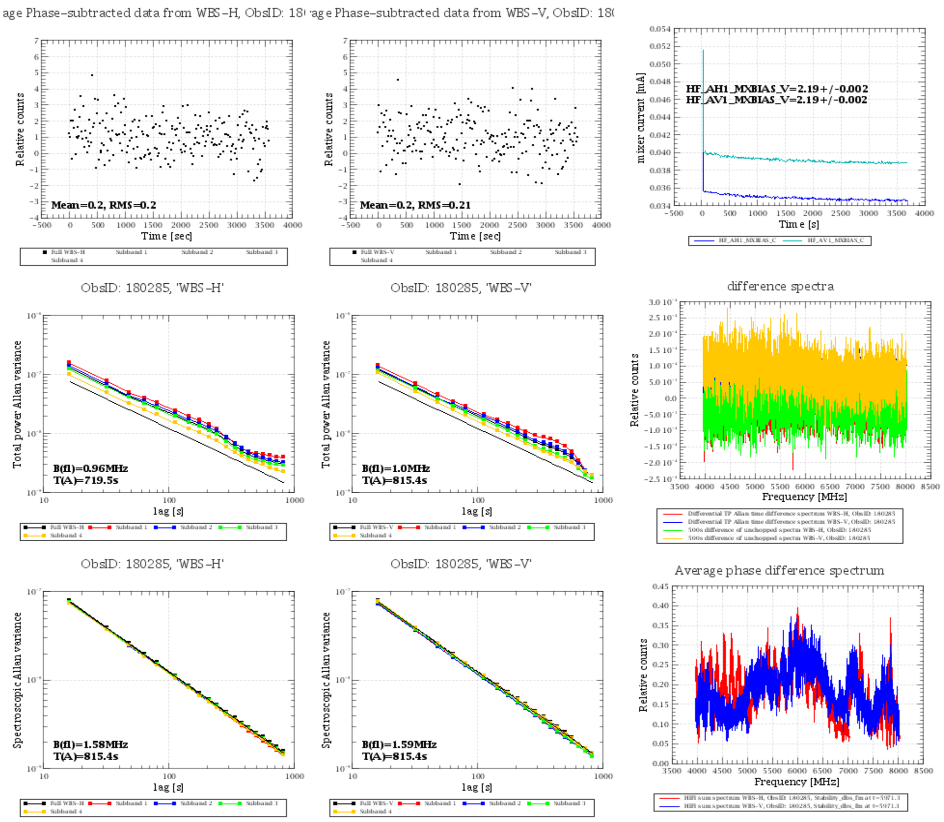

Fig. 94. B3b, OD 63, 887.84 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

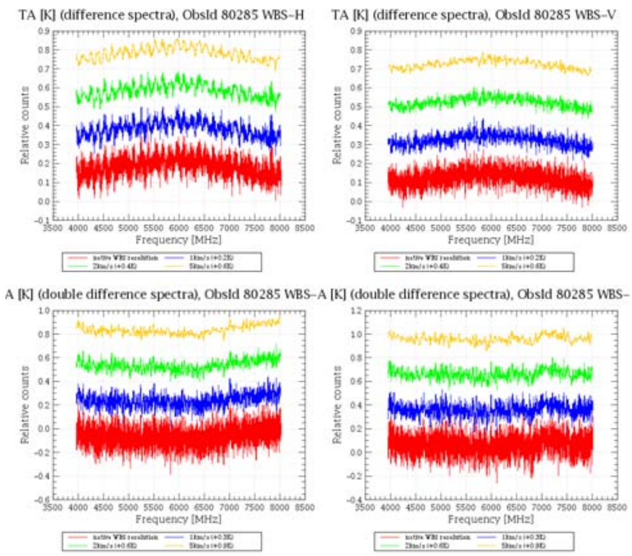

Fig. 95. B3b, OD 63, 887.84 GHz, simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the DBS is a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase

5.3.10 B3b 927.60 GHz DBS

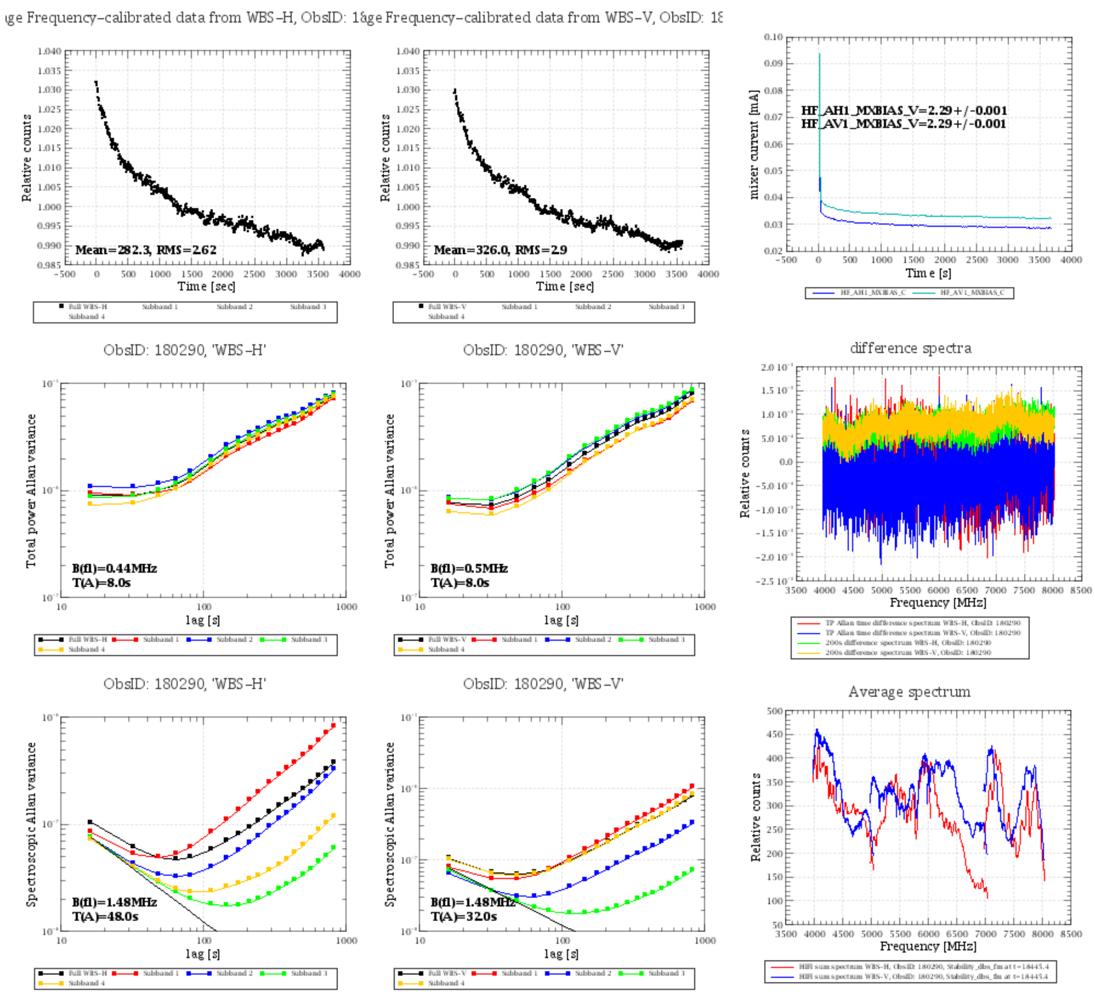

Fig. 96. B3b, OD 63, 927.60 GHz. DBS system stability for 3600s. Note the decay in LO power. Has not much effect on differential DBS

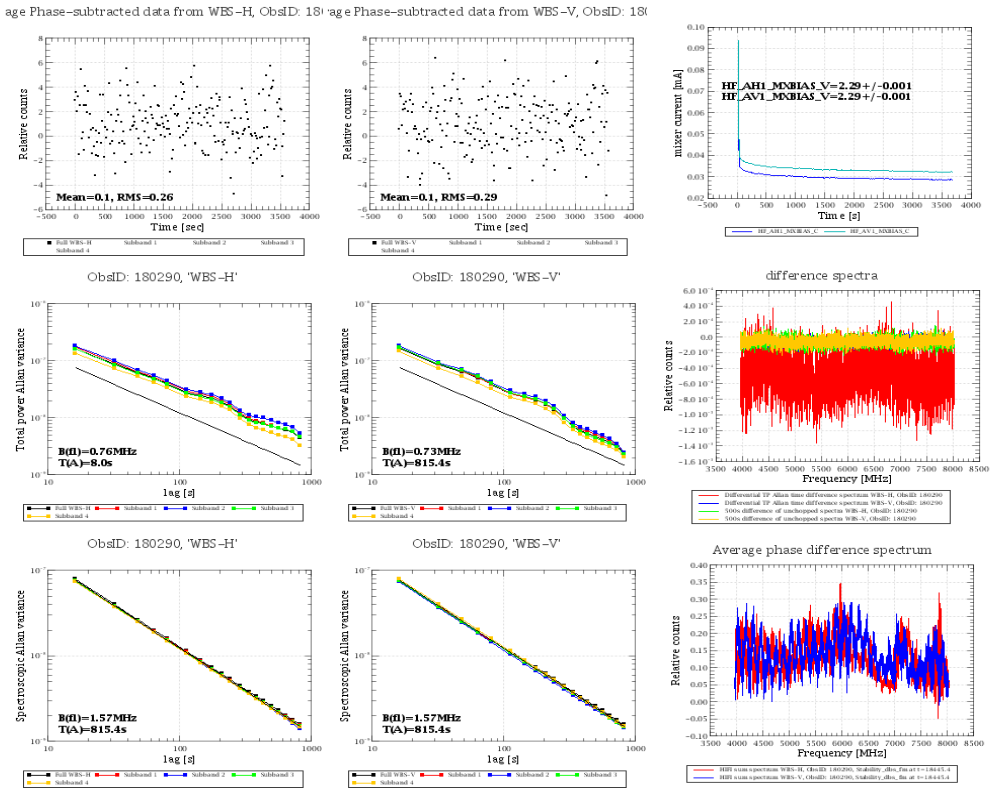

Fig. 97. B3b, OD 63, 927.60 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

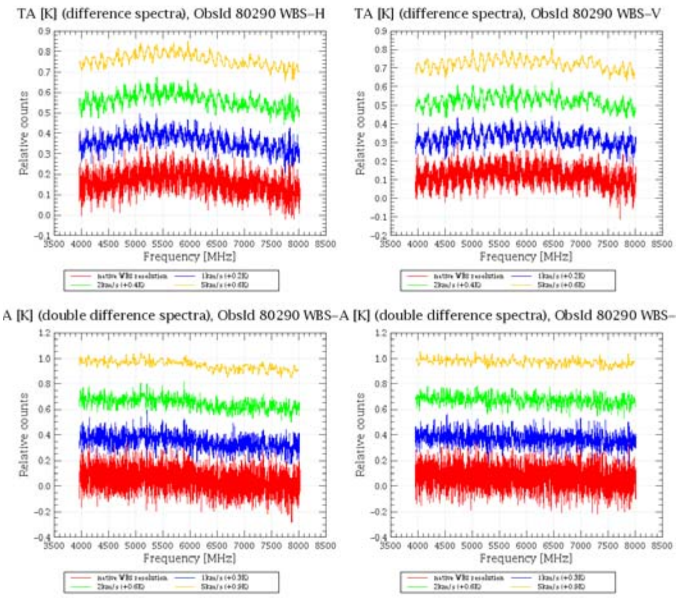

Fig. 98. B3b, OD 63, 927.60 GHz, simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the DBS is a 95 MHz standing wave. The double difference spectra show some distortion. Duration of the measurement is 1h, 30 minutes/phase

5.3.11 B4a 968.66 GHz DBS

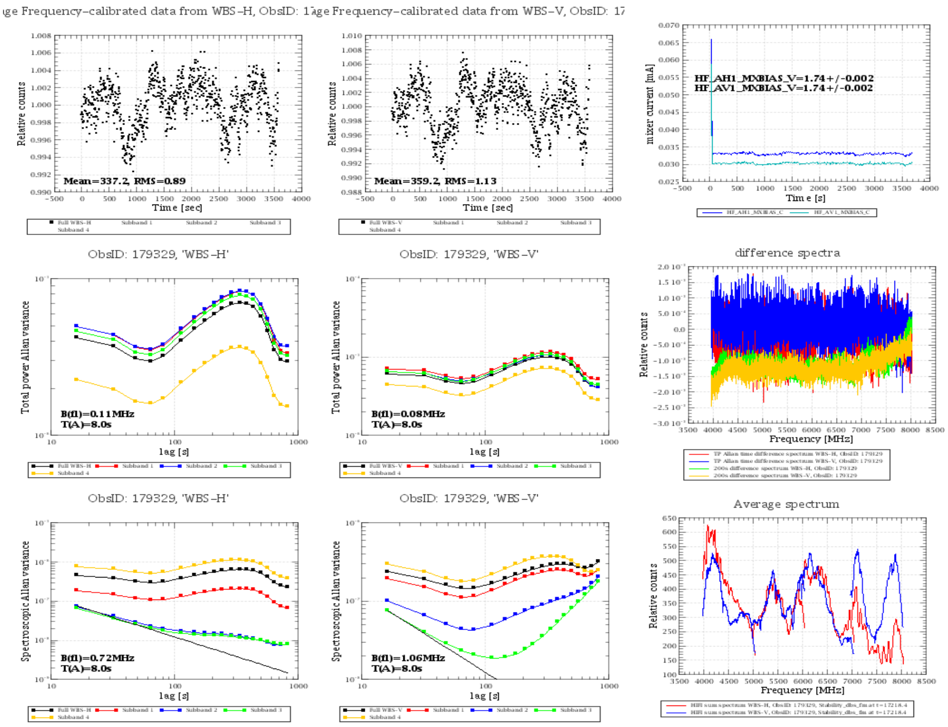

Fig. 99. B4a, OD 49, 968.66 GHz. DBS system stability for 3600s. Note the unstable behavior in LO power. This effects the differential stability.

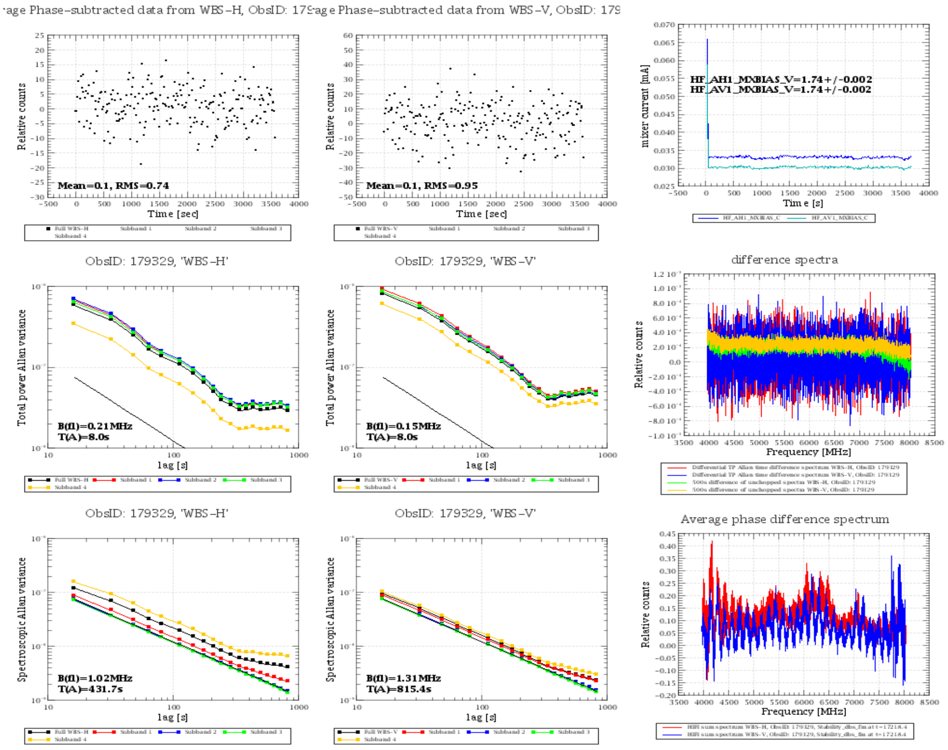

Fig. 100. B4a, OD 49, 968.66 GHz. DBS differential stability for 3600s. Lot of excess noise. Diff Allan time >> 900s

5.3.12 B4a 993.73 GHz DBS

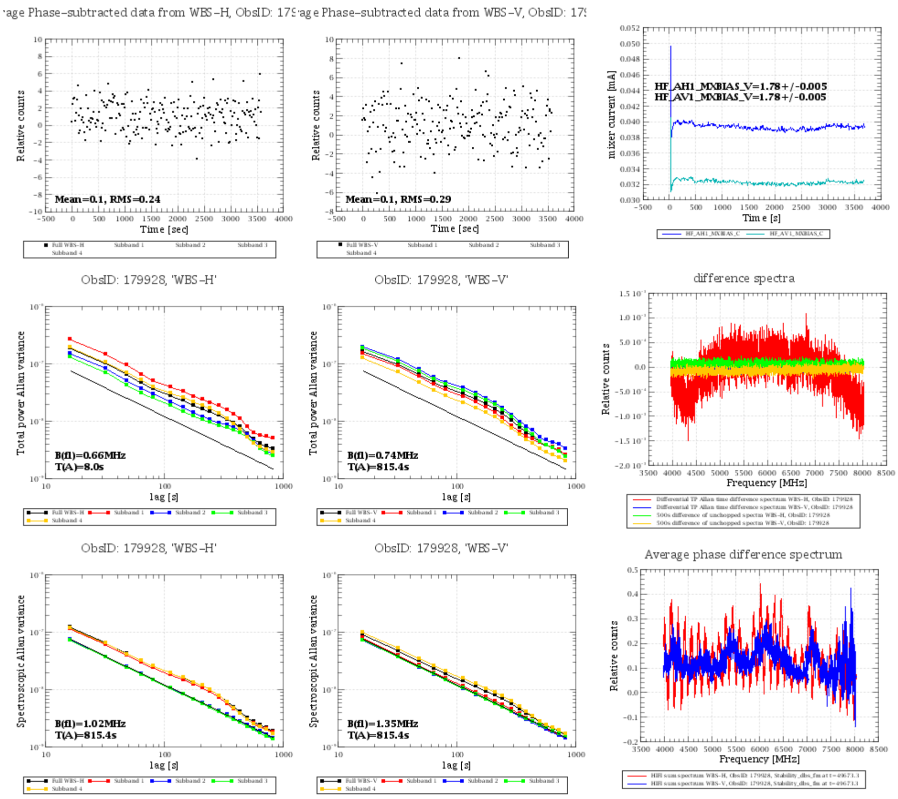

Fig. 101. B4a, OD 61, 993.73 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

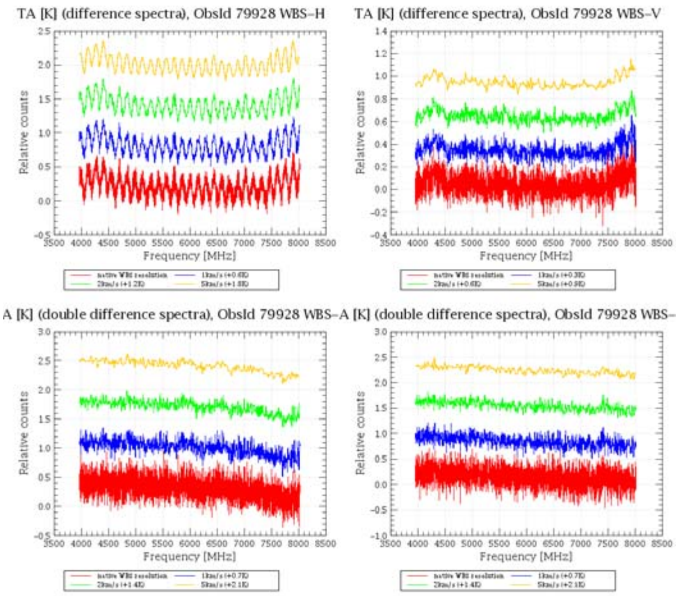

Fig. 102. B4a, OD 61, 993.73 GHz, simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the DBS is a 95 MHz standing wave. The double difference spectra show some distortion. Duration of the measurement is 1h, 30 minutes/phase

5.3.13 B4b 1091.56 GHz DBS

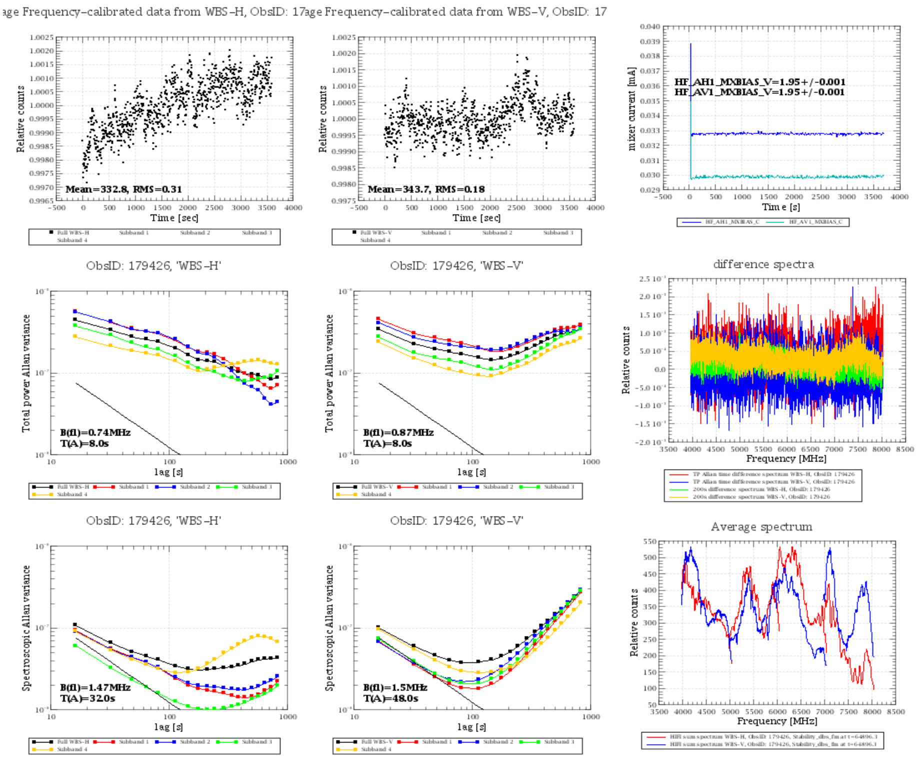

Fig. 103. B4b, OD 51, 1091.56 GHz. DBS system stability for 3600s. Quite unstable behavior with a lot of excess noise.

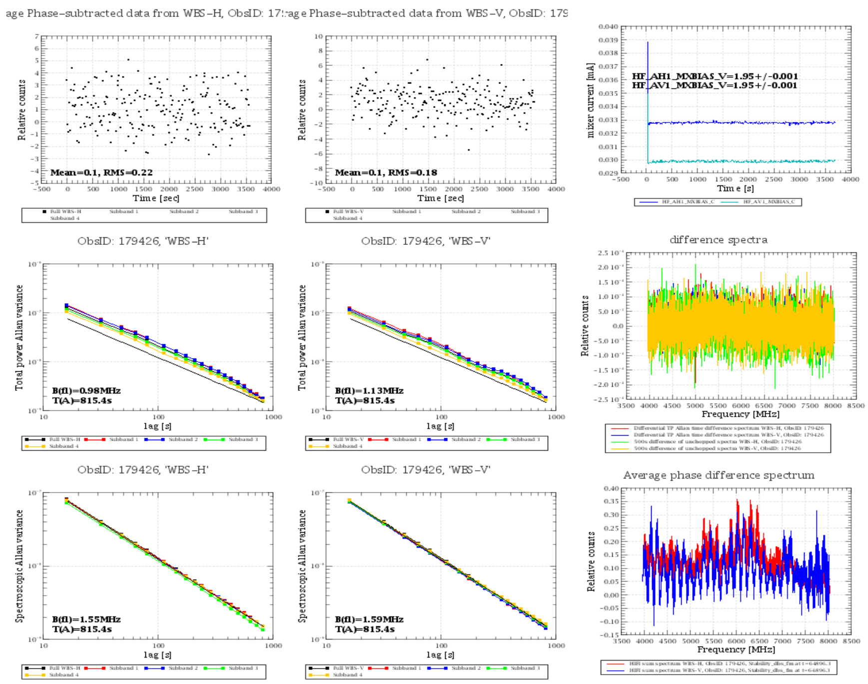

Fig. 104. B4b, OD 51, 1091.56 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

5.3.14 B4b 1107.54 GHz DBS

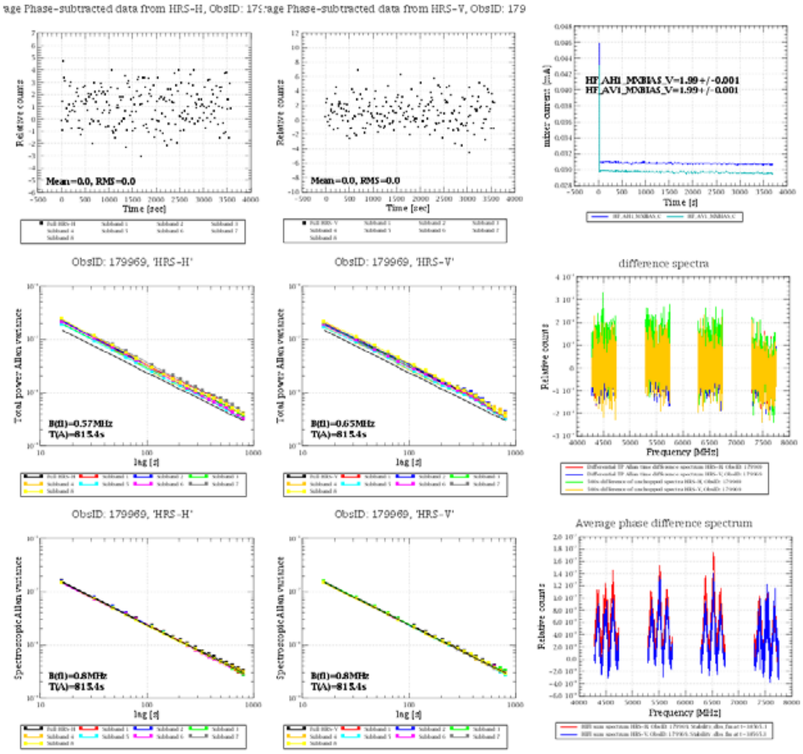

Fig. 105. B4b, OD 62, 1107.54 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s

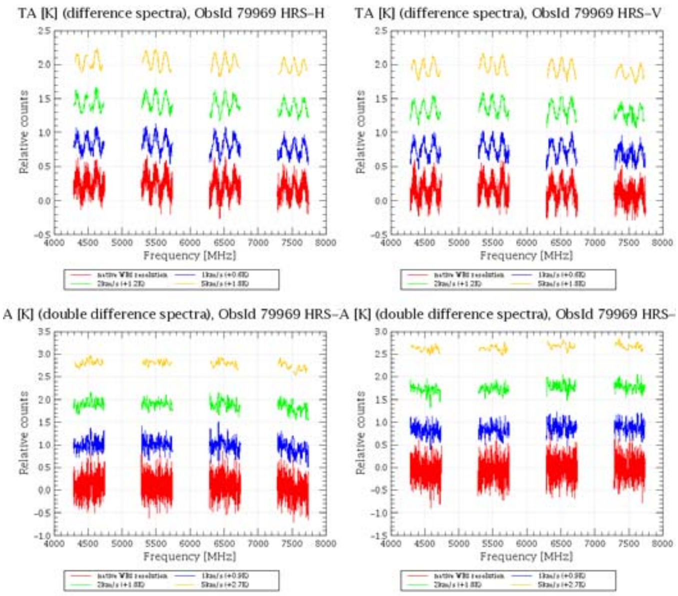

Fig. 106. HRS. B4b, OD 62, 1107.54 GHz., simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Clearly visible in the DBS is a 95 MHz standing wave. The double difference spectra show little or no distortion. Duration of the measurement is 1h, 30 minutes/phase. WBS suffers from a weak spur.

5.3.15 B5a 1222.99 GHz DBS

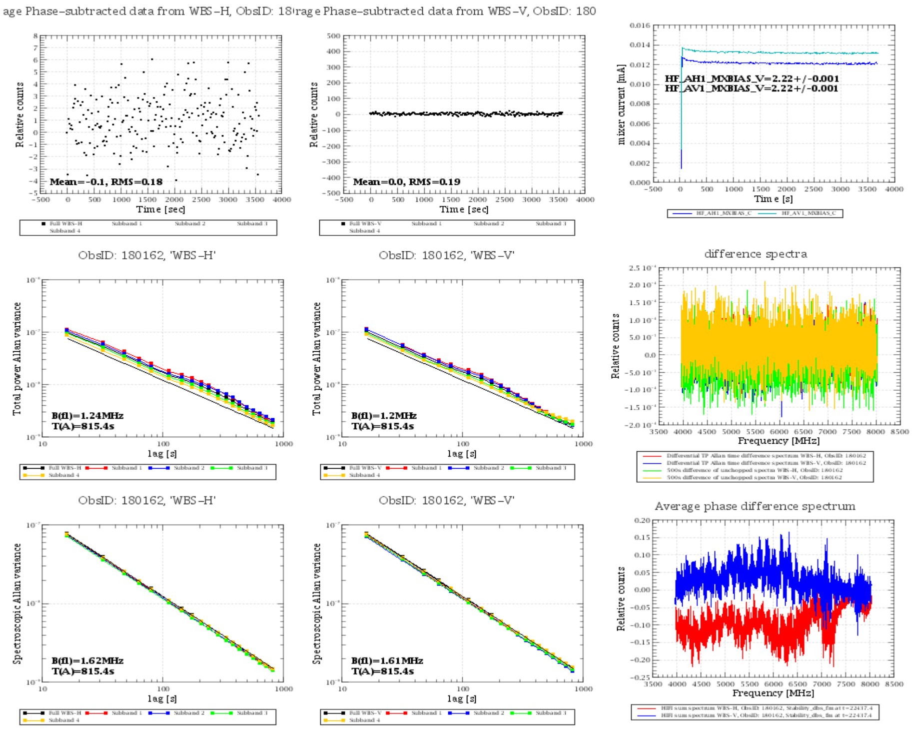

Fig. 107. B5a, OD 60, 1222.99 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

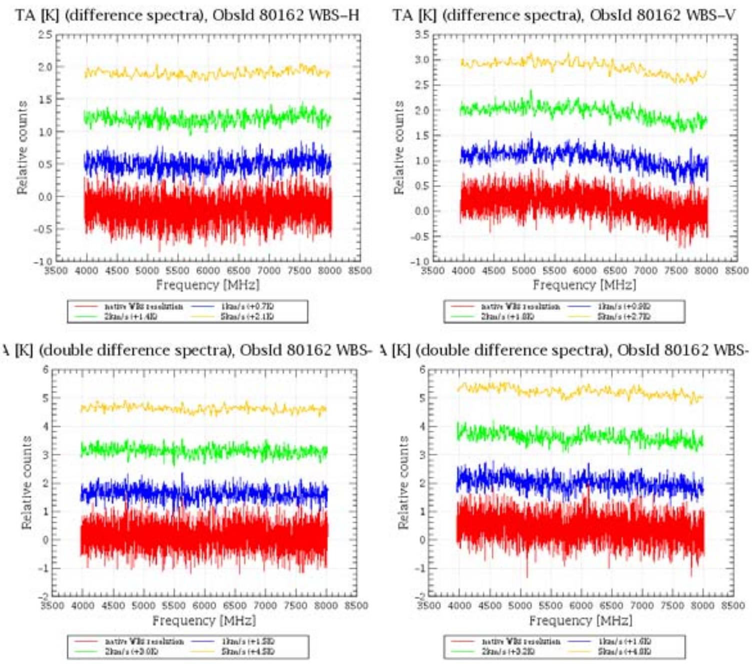

Fig. 108. B5a, OD 60, 1222.99 GHz., simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 5 minutes. Clearly visible in the DBS is a 95 MHz standing wave. The double difference spectra show little distortion. Duration of the measurement is 1h, 30 minutes/phase.

5.3.16 B5b 1242.90 GHz DBS

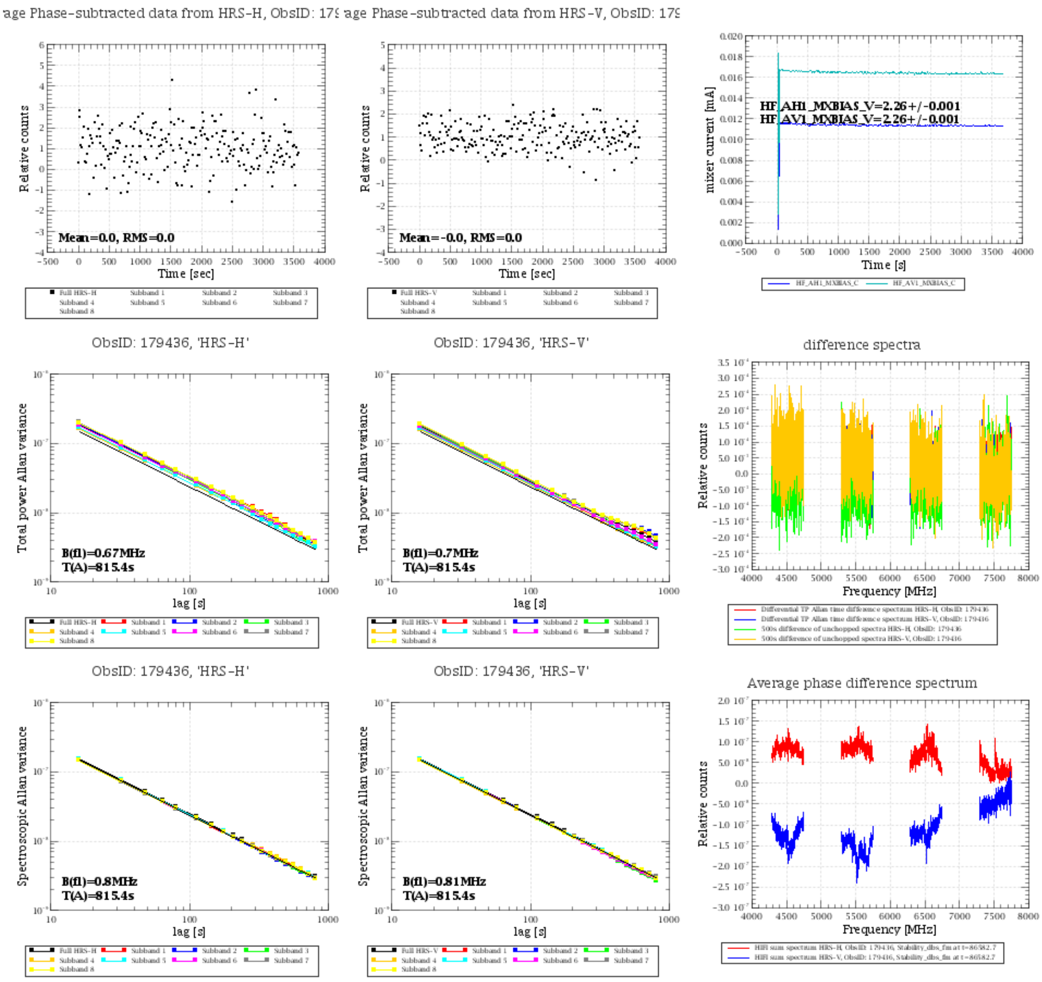

Fig. 109. HRS, B5b, OD 51, 1242.90 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

5.3.17 B5b 1270.93 GHz DBS

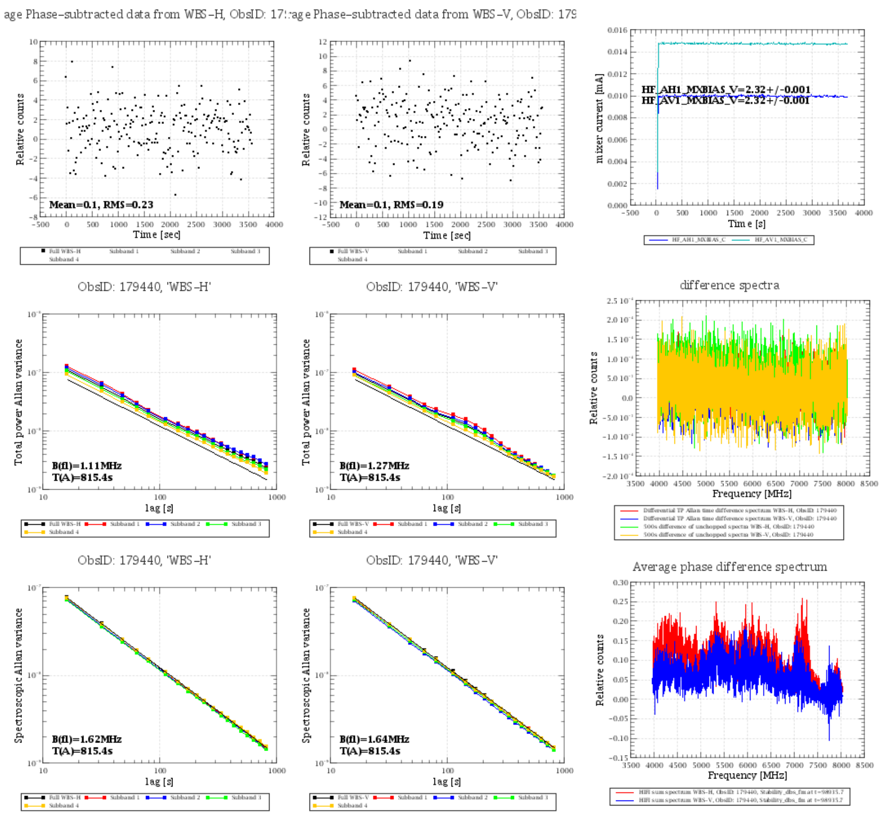

Fig. 110. HRS, B5b, OD 51, 1270.93 GHz. DBS differential stability for 3600s. No instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

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5.3.18 B6a 1458.33 GHz DBS (N^+)

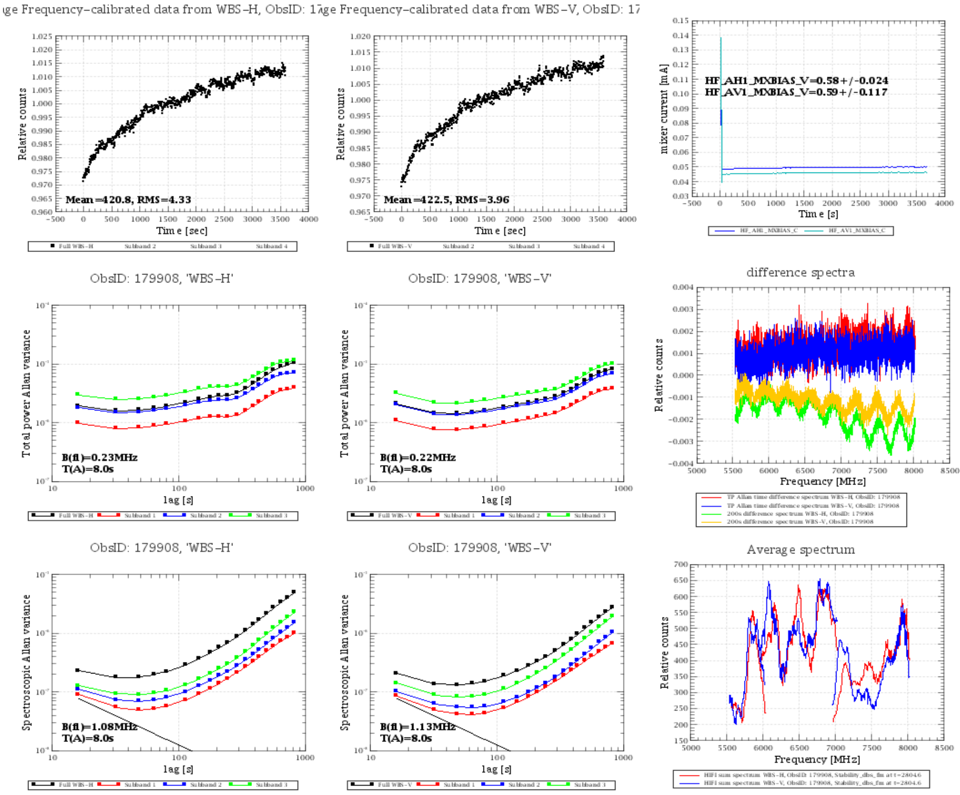

Fig. 111. B6a, OD 61, 1458.33 GHz. DBSsystem stability for 3600s.
This is after a 45 minute Stab time.

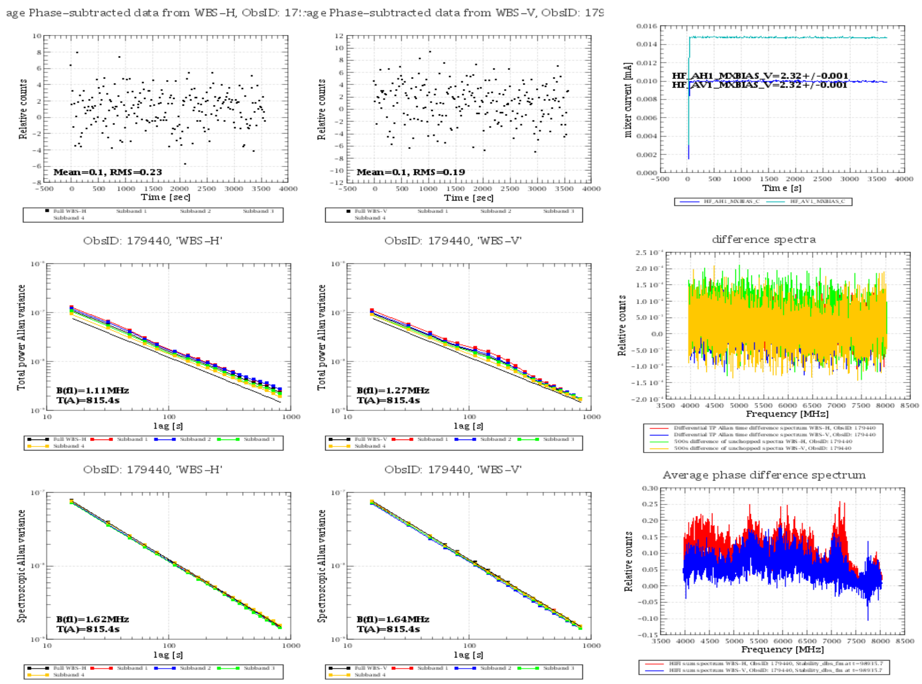

Fig. 112. B6a, OD 61, 1458.33 GHz. DBS differential stability for 3600s. Little instability as a result of the Lo warming up in differential mode. Diff Allan time >> 900s.

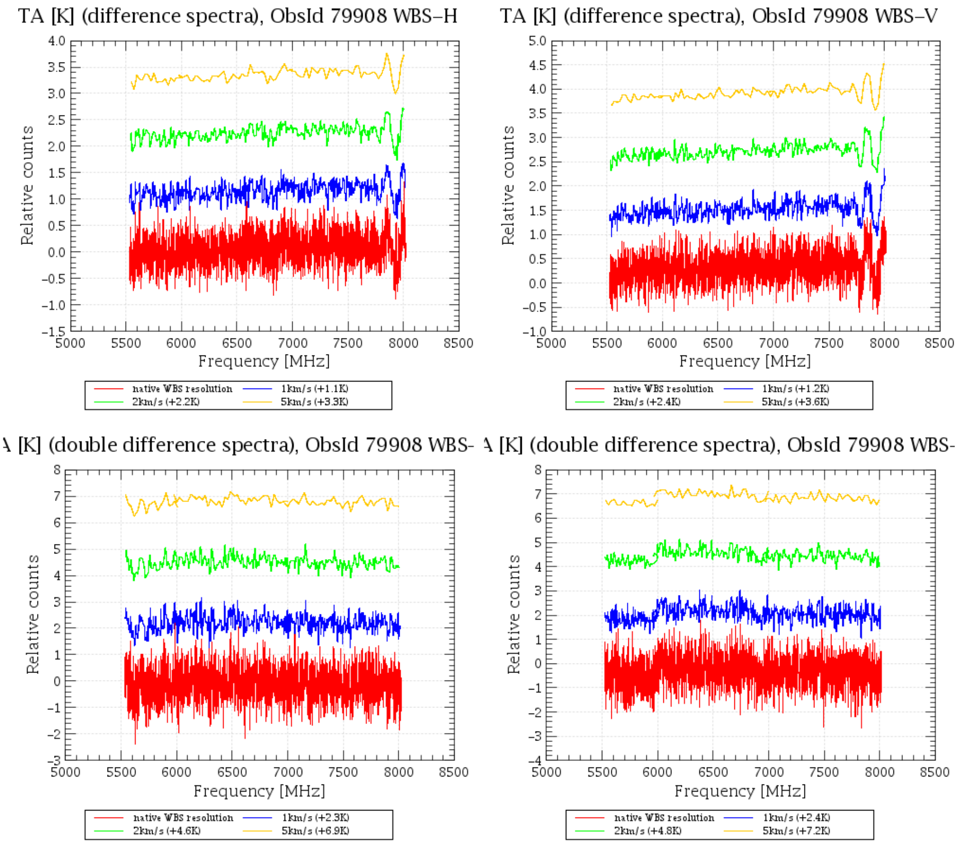

Fig. 113.. B6a, OD 61, 1458.33 GHz, simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 5 minutes. The binned (yellow) double difference spectra show a little distortion. Duration of the measurement is 1h, 30 minutes/phase.

5.3.19 B6b 1653.01 GHz DBS

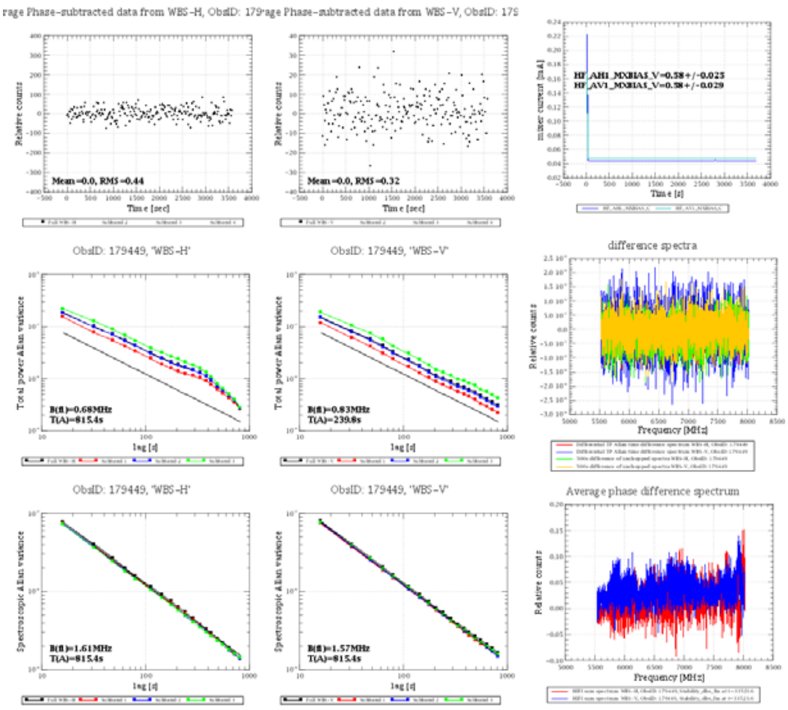

Fig. 114.. B6b, OD 52, 1653.01 GHz. DBS differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s

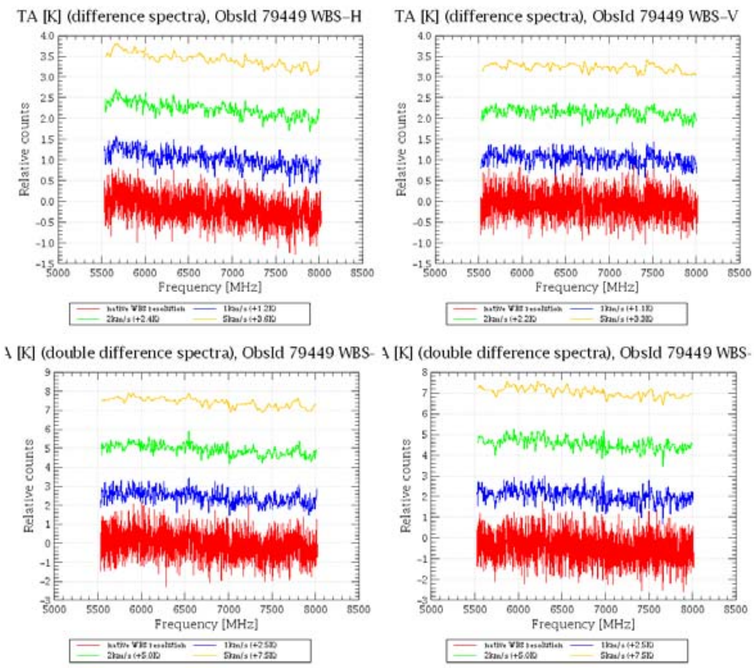

Fig. 115.. B6b, OD 52, 1653.01 GHz.., simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 5 minutes. The binned (yellow) double difference spectra show little distortion. Duration of the measurement is 1h, 30 minutes/phase.

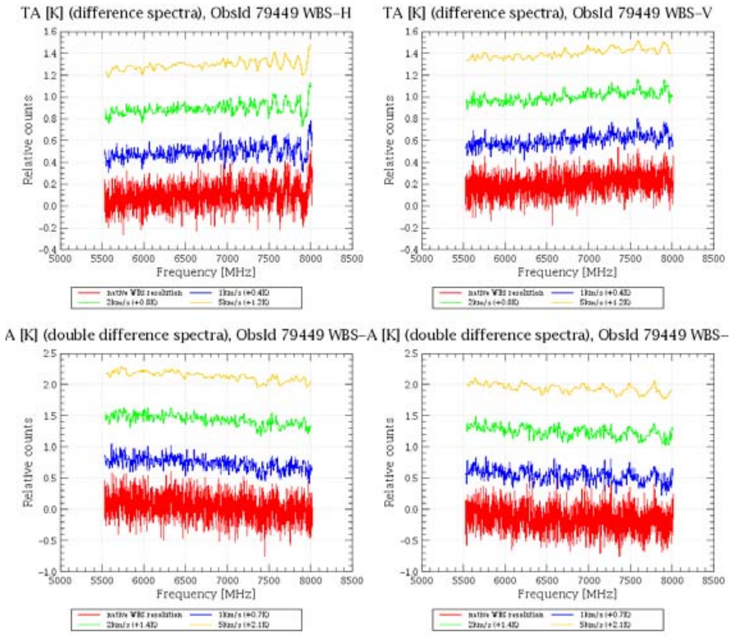

Fig. 116.. B6b, OD 52, 1653.01 GHz.. Same as above, but now with a 10 minute simulated DBS spectrum. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. The binned (yellow) double difference spectra shows quite a bit more distortion then with 5 minutes off's. Duration of the measurement is 1h, 30 minutes/phase.

5.3.20 B6b 1667.11 GHz DBS

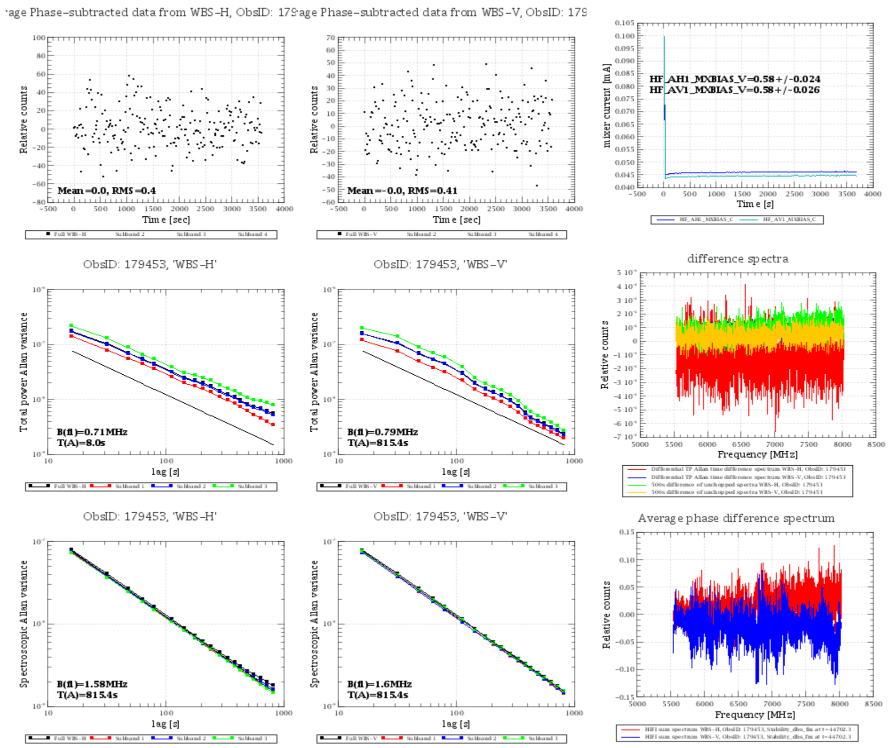

Fig. 117. B6b, OD 52, 1667.11 GHz. DBS differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s. LO not quite warmed up.

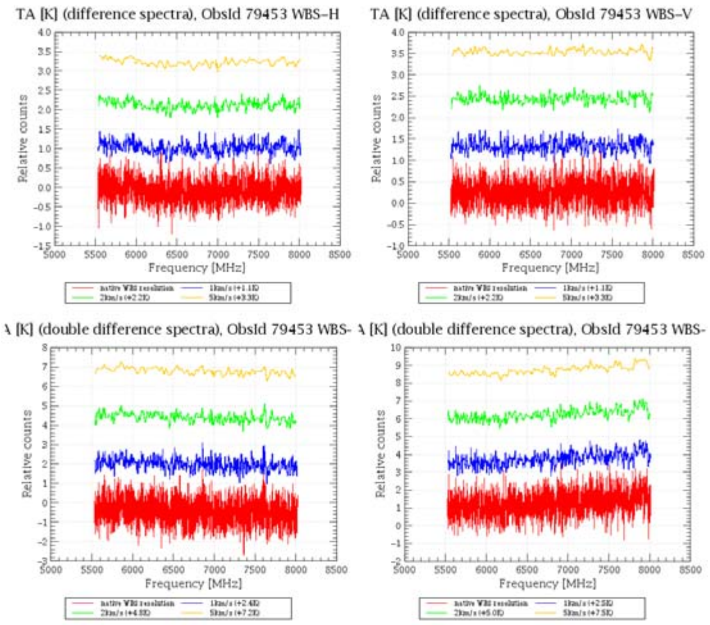

Fig. 118.. B6b, OD 52, 1667.11 GHz simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 5 minutes. The binned (yellow) double difference spectra show little distortion. Duration of the measurement is 1h, 30 minutes/phase.

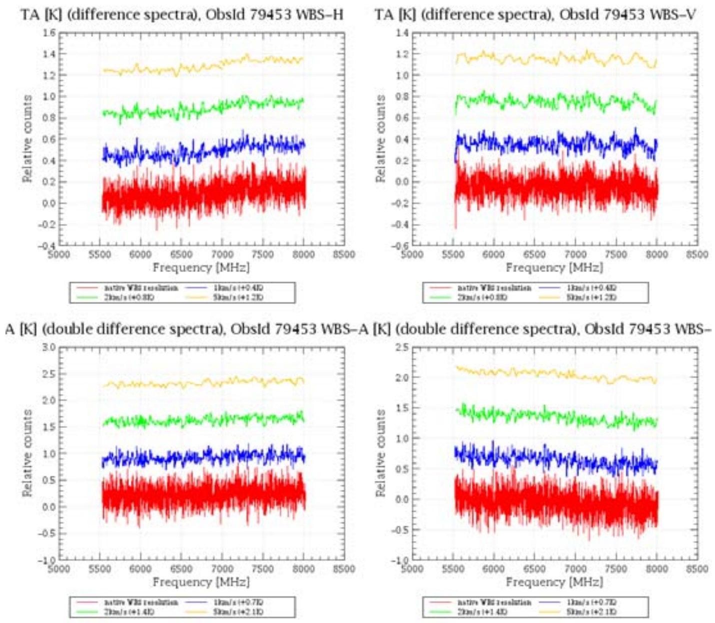

Fig. 119. B6b, OD 52, 1667.11 GHz Same as above, but now with a 10 minute simulated DBS spectrum. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. The binned (yellow) double difference spectra shows a bit less distortion then with 5 minutes off's ?? Duration of the measurement is 1h, 30 minutes/phase.

5.3.21 B7a 1719.57 GHz DBS

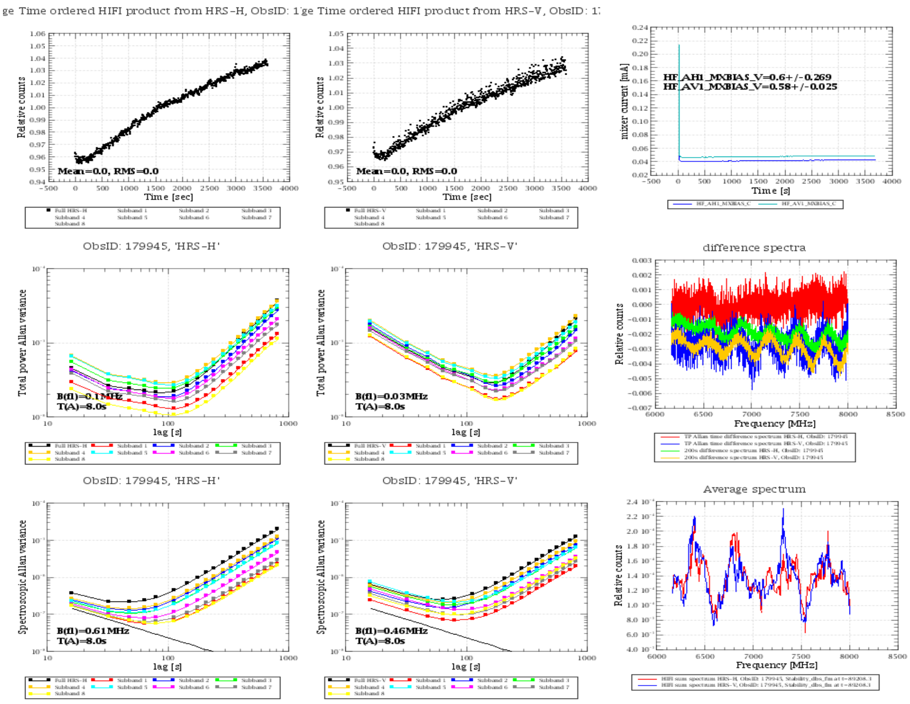

Fig. 120. B7a, OD 62, 1719.57 GHz. DBSsystem stability for 3600s
LO not quite warmed up. This does not seem to affect the diff stability too badly.

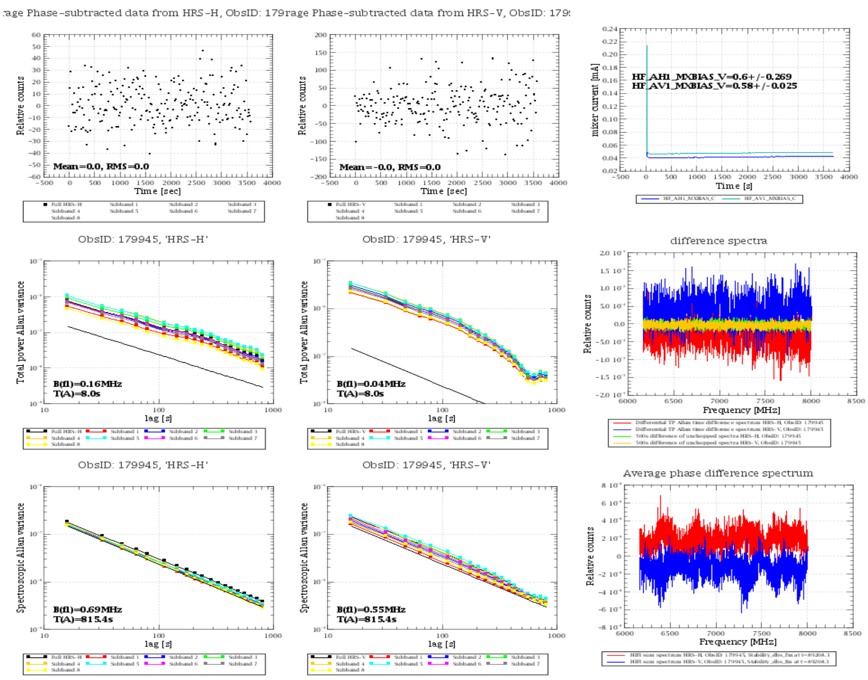

Fig. 121. B7a, OD 62, 1719.57 GHz. DBS differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s. LO typically not quite warmed up.

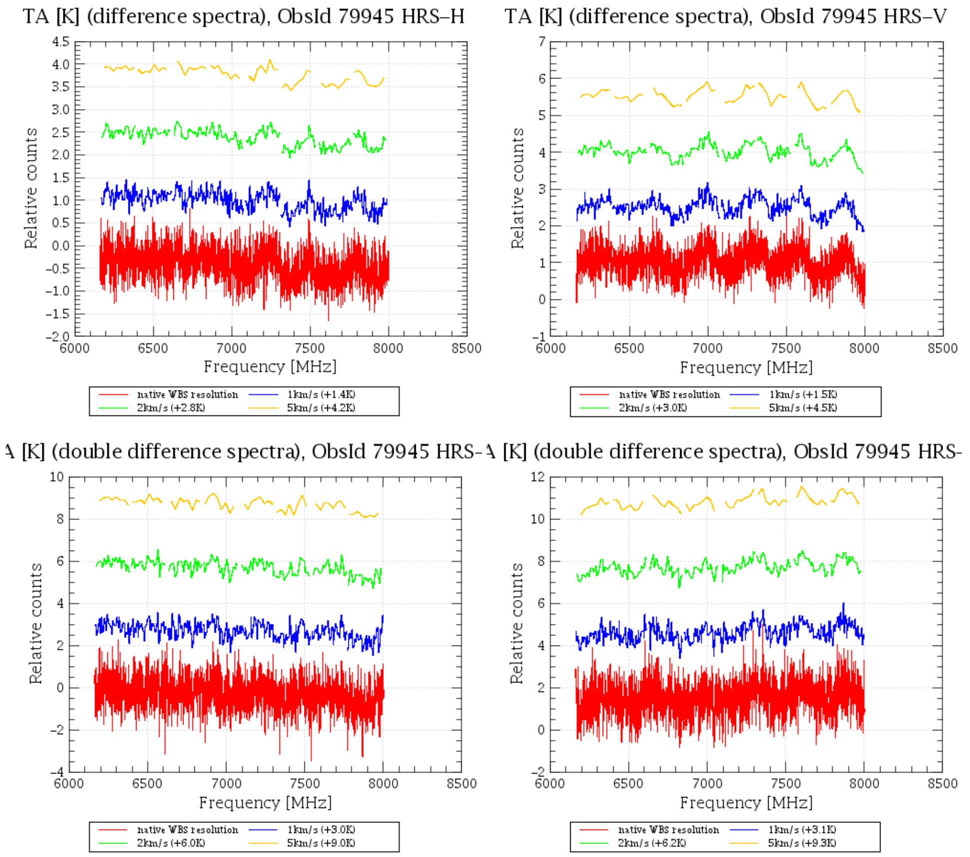

Fig. 122. B7a, OD 62, 1719.57 GHz simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 5 minutes. The binned (yellow) double difference spectra show little distortion. Duration of the measurement is 1h, 30 minutes/phase. Unclear why there is so much baseline structure. The 300 MHz ripple is the electrical standing wave on the IF side of the HEB mixer

5.3.22 B7a 1772.68 GHz DBS

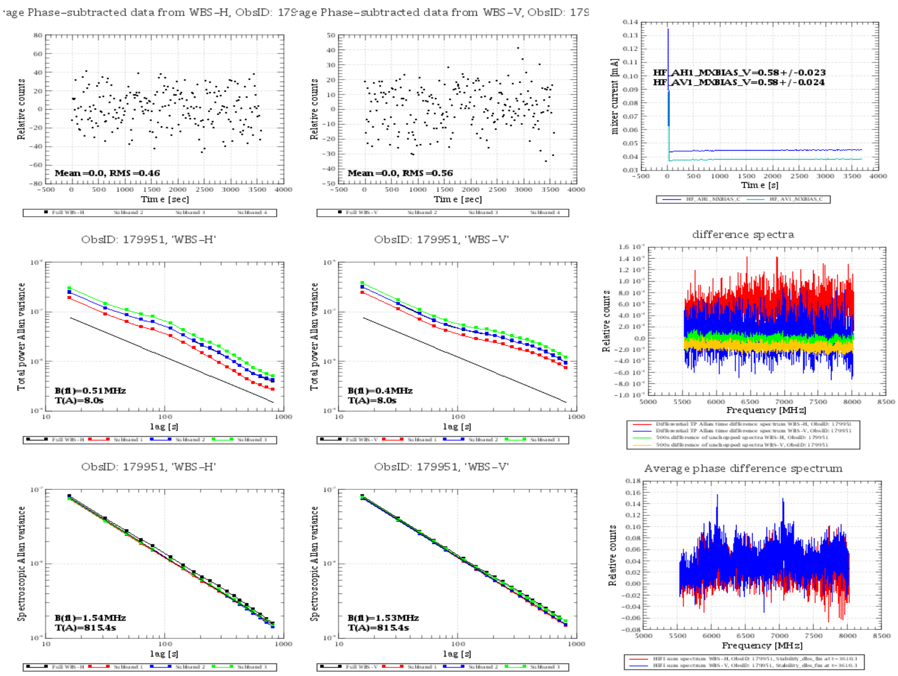

Fig. 123. B7a, OD 62, 1772.68 GHz. DBS differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s. LO typically not quite warmed up.

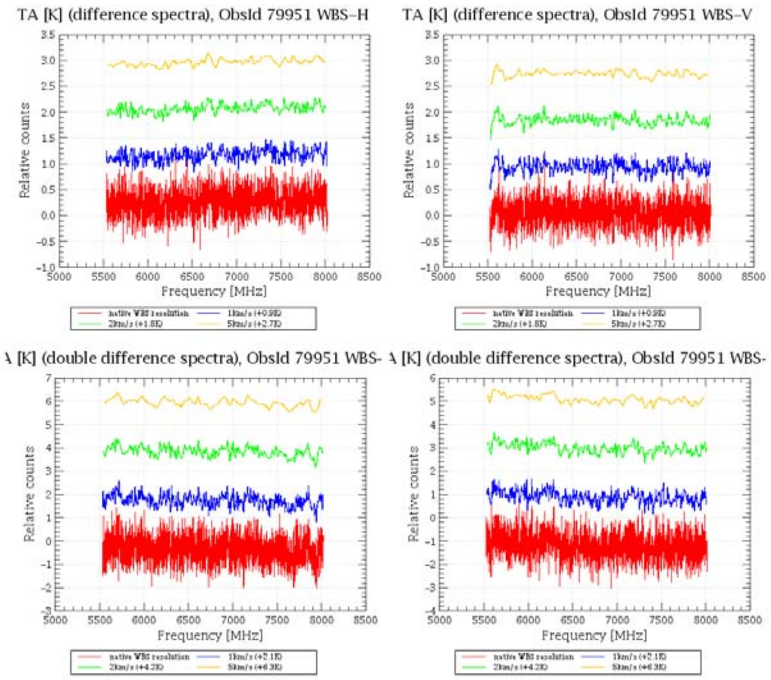

Fig. 124. B7a, OD 62, 1772.68 GHz simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 5 minutes. The binned (yellow) double difference spectra shows little distortion. Duration of the measurement is 1h, 30 minutes/phase.

5.3.23 B7b 1897.75 GHz DBS

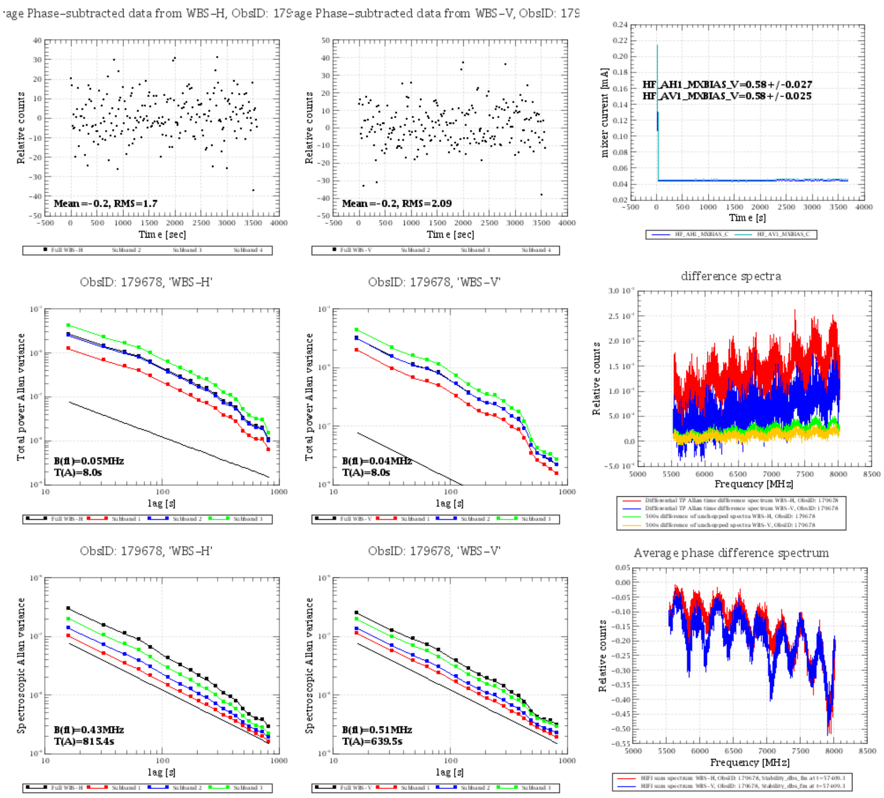

Fig. 125. B7b, OD57, 1897.75 GHz. DBS differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s. This is the very unstable C^+ multiplier bias setting. The improved multiplier bias setting (factor ~ 10x) should significantly improve the results (reduced excess noise).

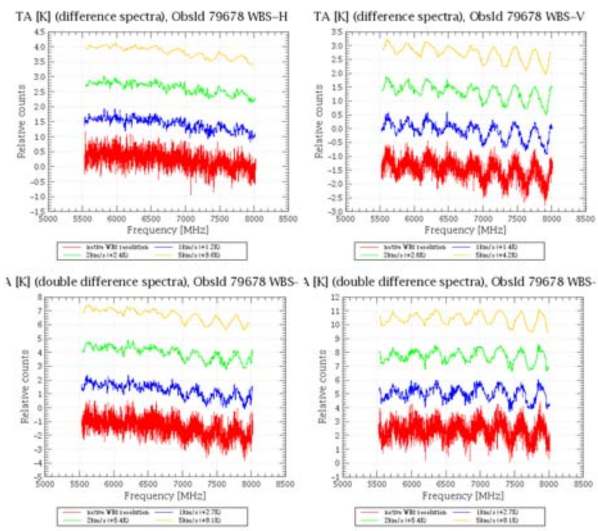

Fig. 126. B7b, OD57, 1897.75 GHz. Simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 5 minutes. Duration of the measurement is 1h, 30 minutes/phase. The ripple is due to an electrical 9IF) standing wave between the HEB mixer and first LNA.

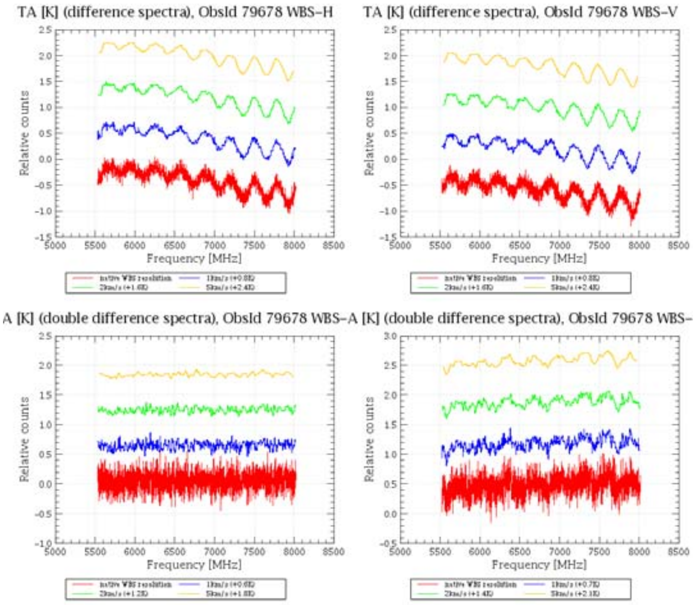

Fig. 127. B7b, OD57, 1897.75 GHz. Simulated DBS spectrum. 10 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Duration of the measurement is 1h, 30 minutes/phase. The ripple is due to an electrical 9IF) standing wave between the HEB mixer and first LNA. With a 10 minute integration cycle the residual IF standing wave becomes more pronounced. Should try the current off-subtraction technique here.

5.3.24 B7b 1844.15 GHz DBS

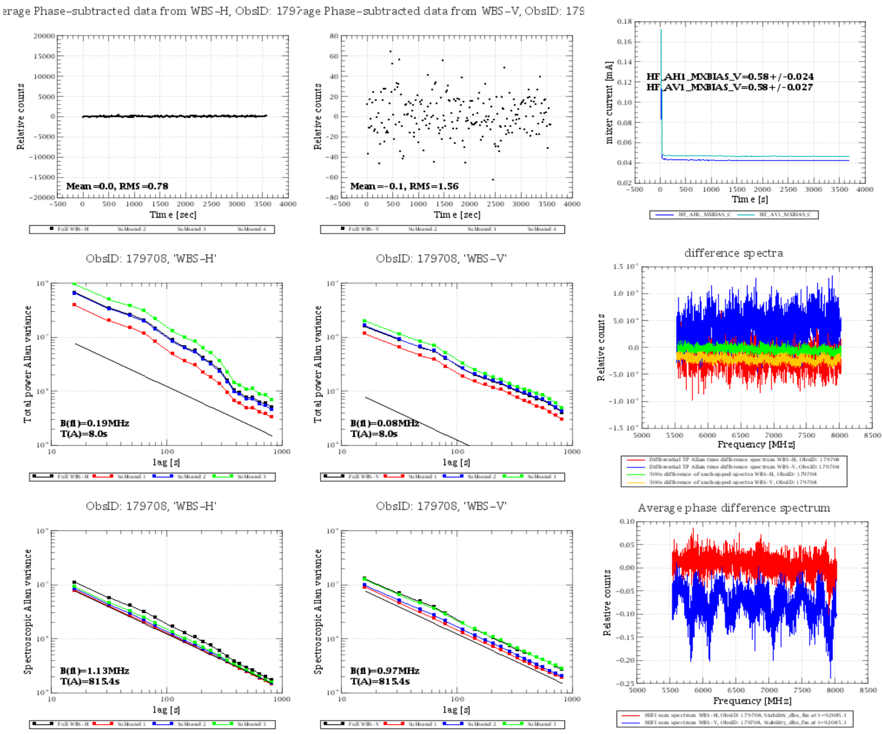

Fig. 128. B7b, OD57, 1844.15 GHz. DBS differential stability for 3600s. Little instability in the 500s baseline due to a standing wave change between Int. CBB, telescope. Diff Allan time >> 900s.

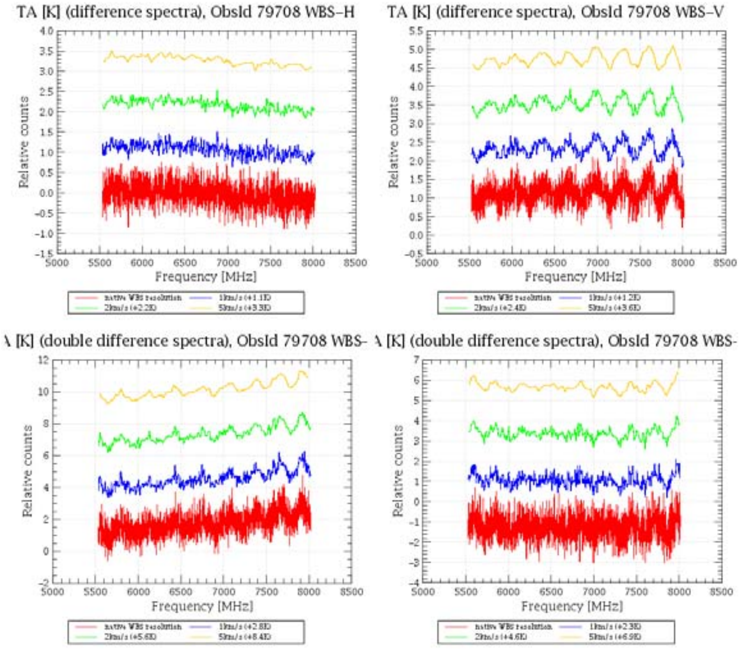

Fig. 129. B7 B7b, OD57, 1844.15 GHz. Simulated DBS spectrum. 5 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 5 minutes. Duration of the measurement is 1h, 30 minutes/phase. The ripple is due to an electrical 9IF) standing wave between the HEB mixer and first LNA.

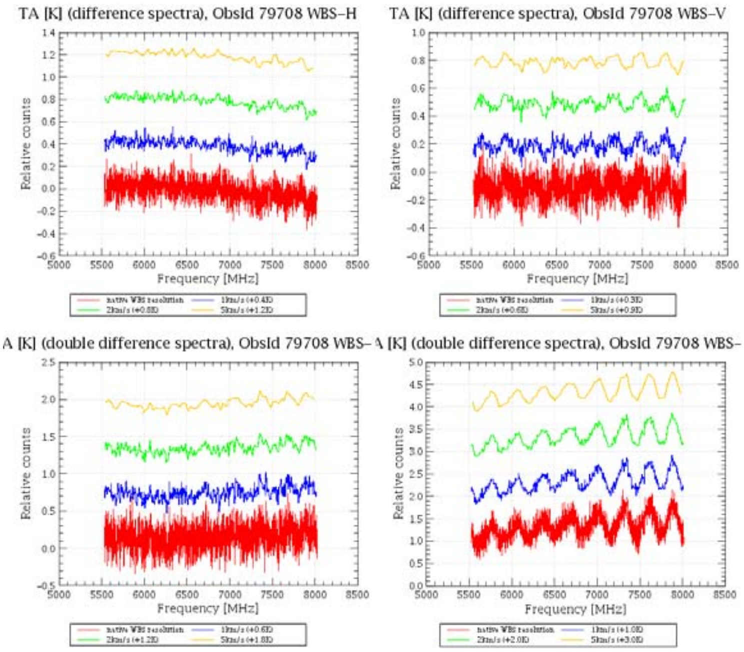

Fig. 130. B7 B7b, OD57, 1844.15 GHz. Simulated DBS spectrum. 10 minutes integration cycles. Top row: Single difference, DBS. Bottom row: Double difference assuming an off source every 10 minutes. Duration of the measurement is 1h, 30 minutes/phase. The ripple is due to an electrical 9IF) standing wave between the HEB mixer and first LNA, and has now become more noticeable. The current-off subtraction method should be applied here.

5.4 Frequency Switch Differential Stability

See RD04 (FSW-CoP-09Sept2009.pdf)

6 DBS and LSW Synthesized Spectra Compared

6.1 Band 1a DBS and LSW sample spectra

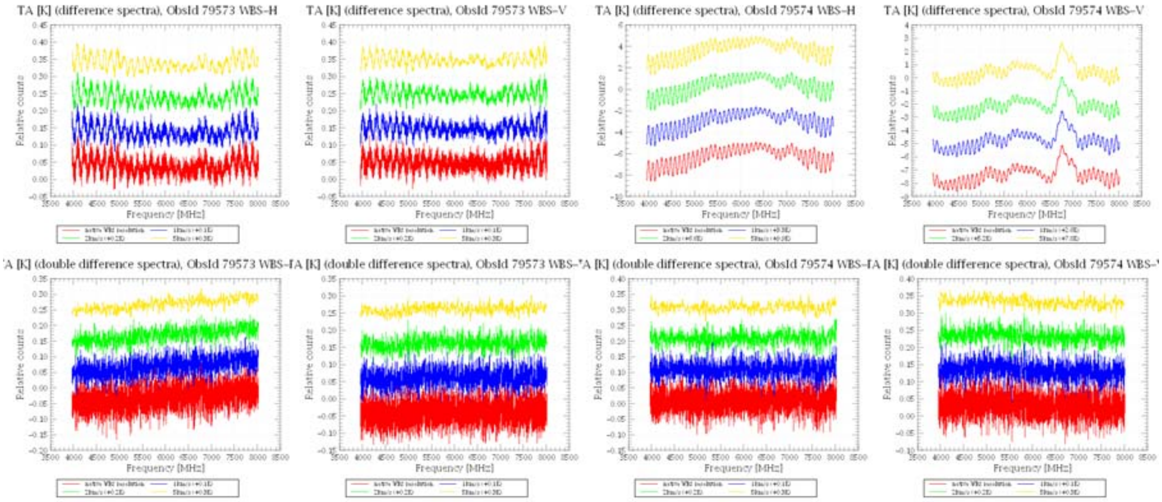

Fig. 131. 492.05 GHz (O_2). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Clearly visible in the DBS is a ~142 MHz standing wave. In the LSW we find a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase. Smoothing to a 5km/s (yellow) shows relatively little structure. Since the DBS was taken directly after a 21 min Stab LO warm-up, the effect of doing DBS measurement 20 minutes after LO turn-on manifests itself in a slight slope (structure) across the IF band.

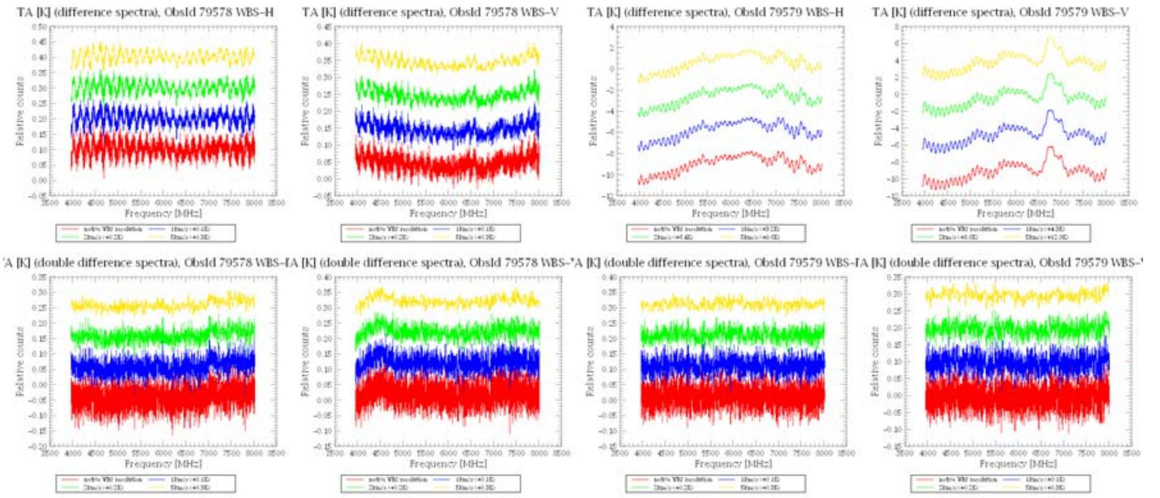

Fig. 132. 542.88 GHz ($H_2{}^{18}O$-*ortho*). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Clearly visible in the DBS is a ~142 MHz standing wave. In the LSW we find a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase. Interesting, smoothing to a 5km/s (yellow) shows slightly more structure in DBS ‘V” then LSW. The LO was warmed up at this point.

6.2 Band 1b DBS and LSW sample spectra

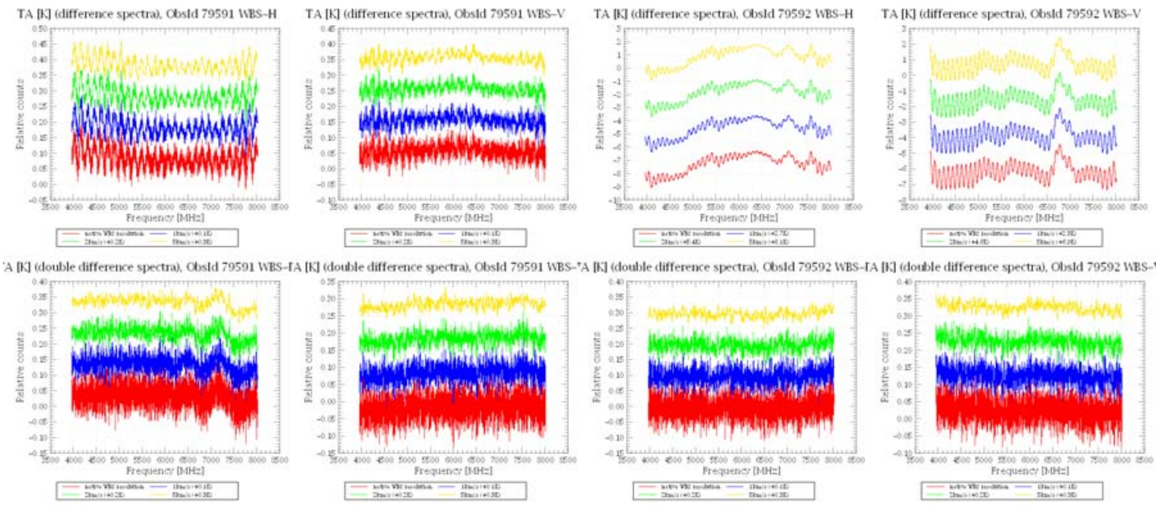

Fig. 133. 563.74 GHz (H_2O-*ortho*). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Clearly visible in the DBS is a ~142 MHz standing wave. In the LSW we find a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase. Interesting, smoothing to a 5km/s (yellow) shows more structure in DBS ‘H” then LSW. Since the DBS was taken directly after a 21 min Stab LO warm-up, the effect of doing DBS measurement 20 minutes after LO turn-on is clearly visible.

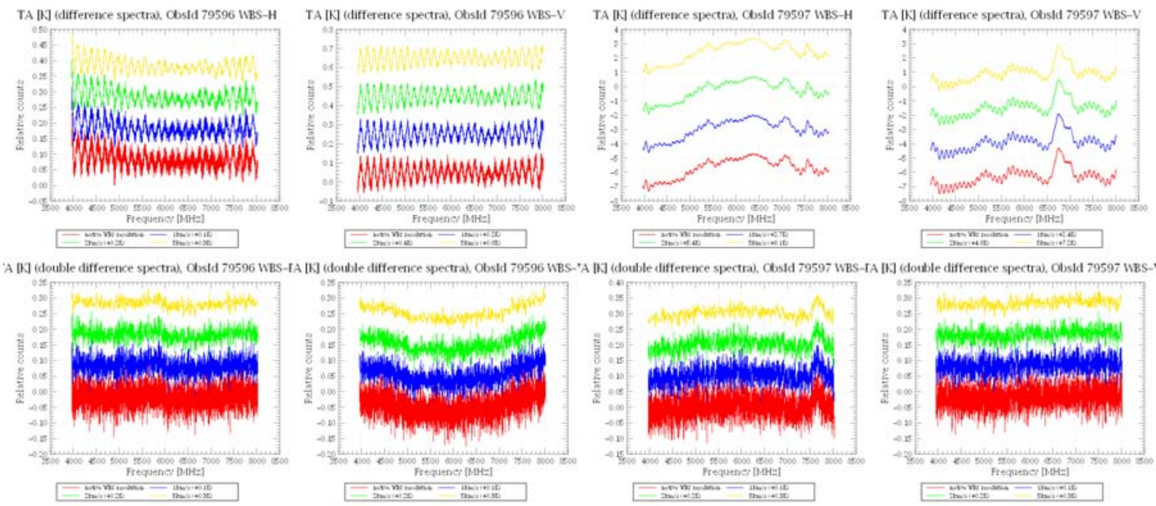

Fig. 134. 614.21 GHz (H_2O-*ortho*, D_2O). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Clearly visible in the DBS is a ~142 MHz standing wave. In the LSW we find a 95 MHz standing wave. The double difference spectra show some structure. Duration of the measurement is 1h, 30 minutes/phase. The LO is warmed up at this stage.

6.3 Band 2a DBS and LSW sample spectra

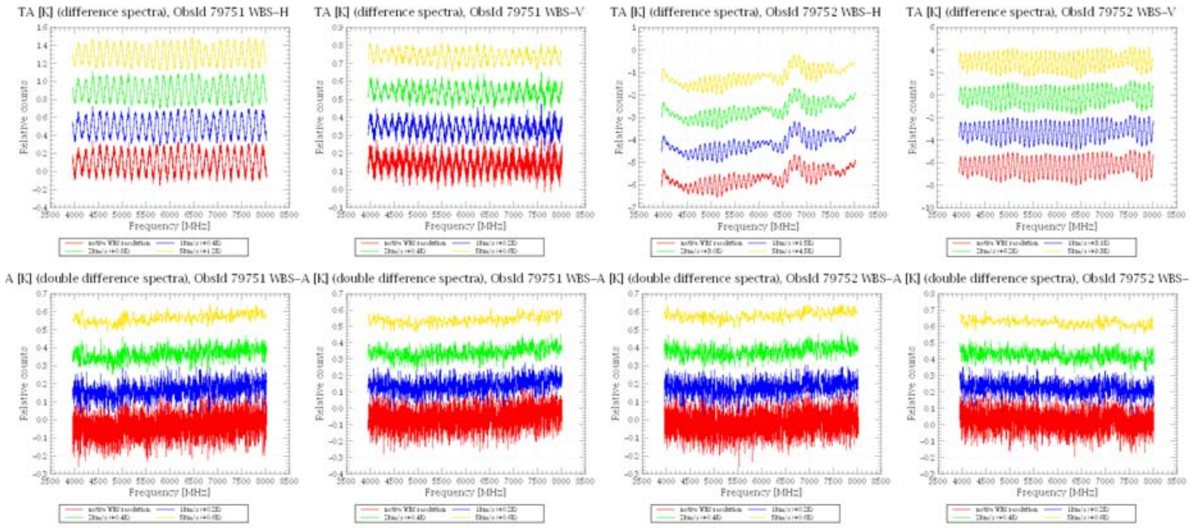

Fig. 135. 686.86 GHz ($D_2H+/CO_{6\text{-}5}$). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Clearly visible in the DBS is a ~142 MHz standing wave. In the LSW we find a 95 MHz standing wave. The double difference spectra show minor structure. Duration of the measurement is 1h, 30 minutes/phase. The LO is warmed up at this stage.

6.4 Band 2b DBS and LSW sample spectra

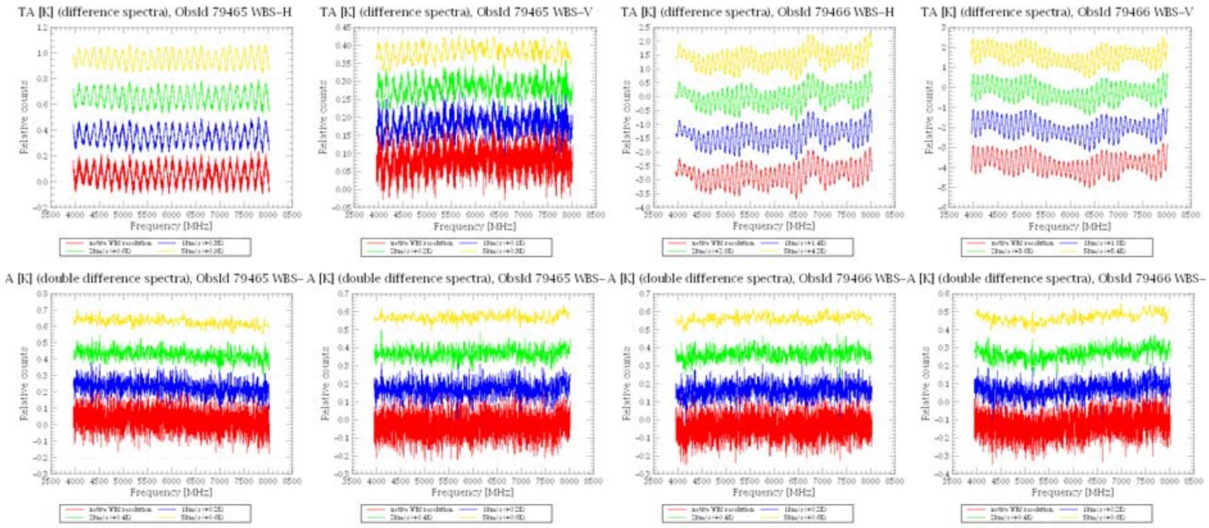

Fig. 136. 729.52 GHz (CS). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Clearly visible in the DBS is a ~142 MHz standing wave. In the LSW we find a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase. Since the DBS was taken directly after a 21 min Stab LO warm-up, the effect of doing DBS measurement 20 minutes after LO turn-on is clearly visible (none).

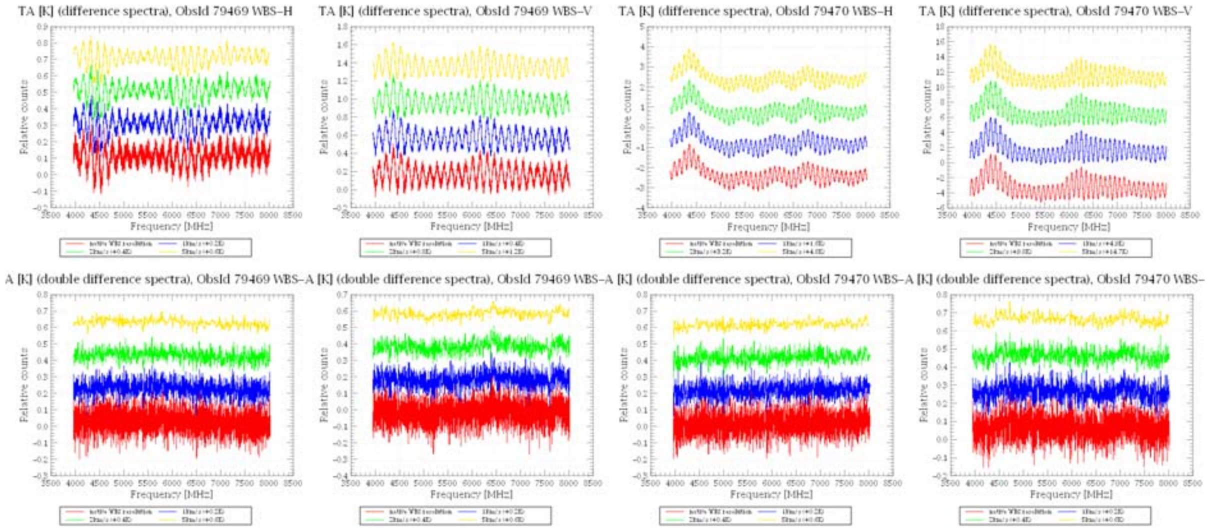

Fig. 137. 756.83 GHz (H_2O-*para*). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Clearly visible in the DBS is a ~142 MHz standing wave. In the LSW we find a 95 MHz standing wave. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase

6.5 Band 3a DBS and LSW sample spectra

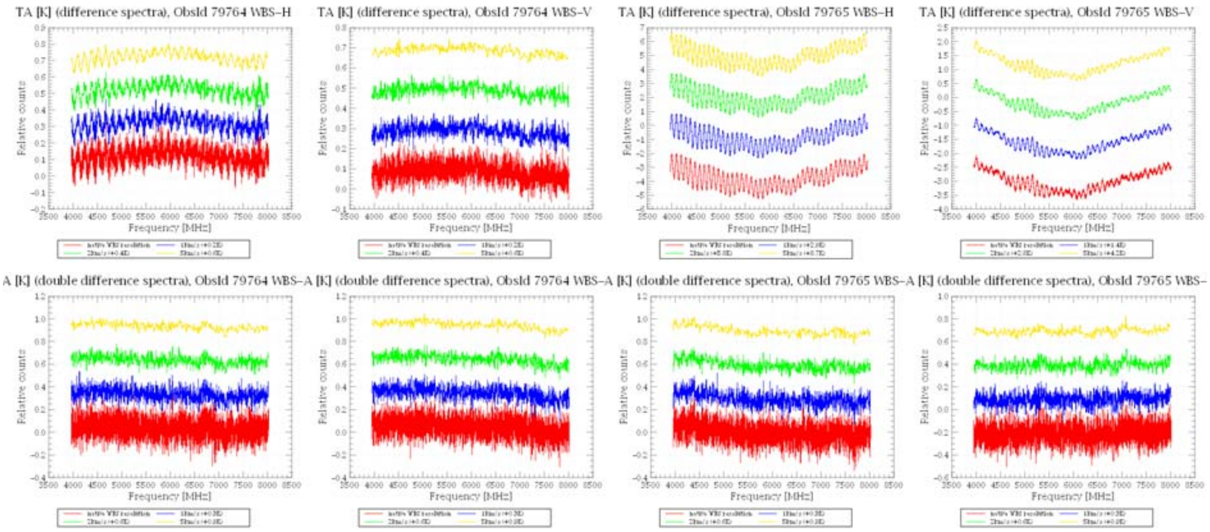

Fig. 138. 815.14 GHz (CI 2-1). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Clearly visible in the DBS is a ~142 MHz standing wave. In the LSW we find a 95 MHz standing wave. For both spectra the diplexer shape is visible in the single difference spectra as well. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase. Since the DBS was taken directly after a 21 min Stab LO warm-up, the effect of doing DBS measurement 20 minutes after LO turn-on is clearly visible (not much).

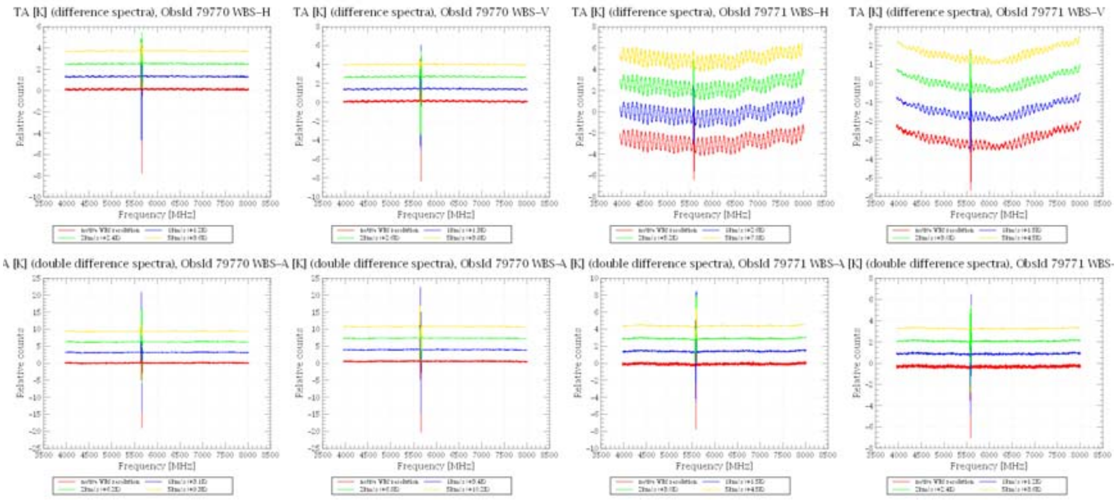

Fig. 139. 840.87 GHz (CH^+). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Spur at 5.6 GHz.

6.6 Band 3b DBS and LSW sample spectra

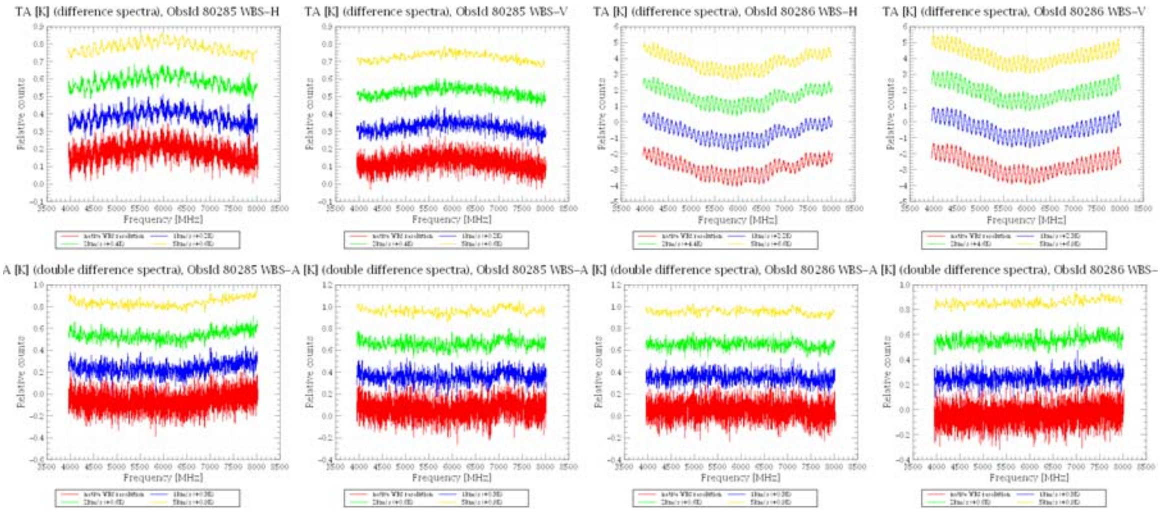

Fig. 140. 887.84 GHz (HDO). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Clearly visible in the DBS is a ~142 MHz standing wave. In the LSW we find a 95 MHz standing wave. For both spectra the diplexer shape is visible in the single difference spectra as well. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase. Since the DBS was taken directly after a 21 min Stab LO warm-up, the effect of doing DBS measurement 20 minutes after LO turn-on is clearly visible (not much).

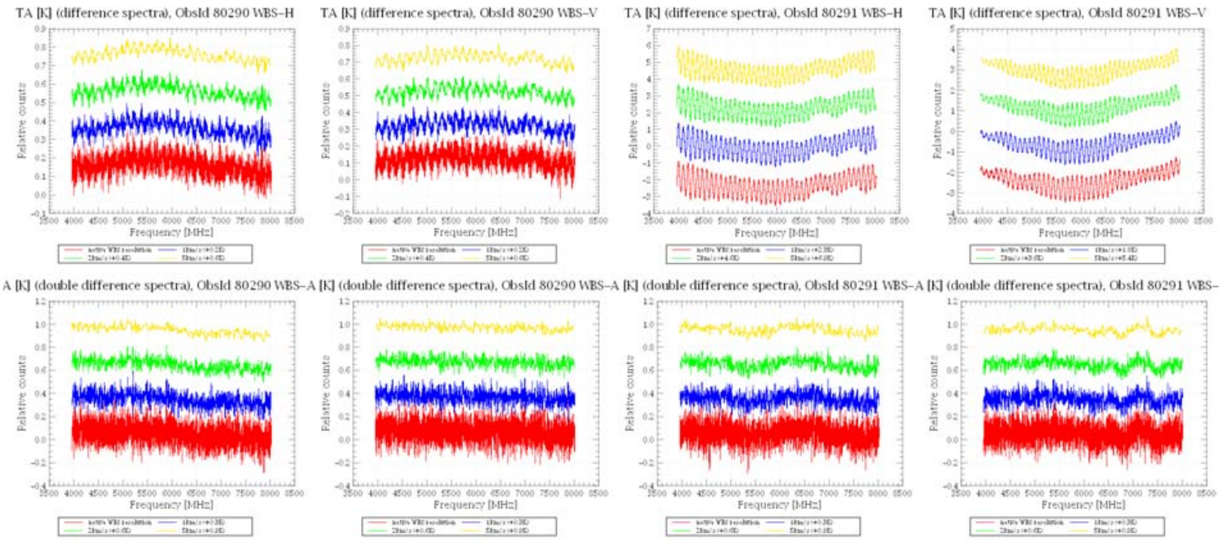

Fig. 141. 927.60 GHz (COh). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Clearly visible in the DBS is a ~142 MHz standing wave. In the LSW we find a 95 MHz standing wave. For both spectra the diplexer shape is visible in the single difference spectra as well. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

6.7 Band 4a DBS and LSW sample spectra

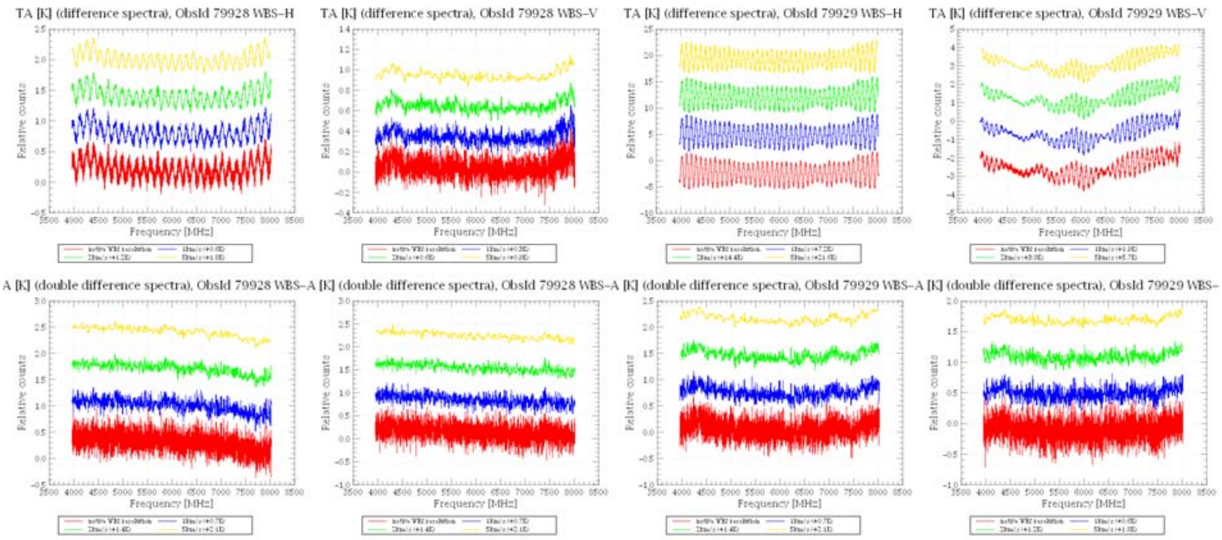

Fig. 142. 993.73 GHz (H_2O-*para*). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. Clearly visible in the DBS is a ~142 MHz standing wave. In the LSW we find a 95 MHz standing wave. For both spectra the diplexer shape is visible in the single difference spectra as well. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

6.8 Band 4b DBS and LSW sample spectra

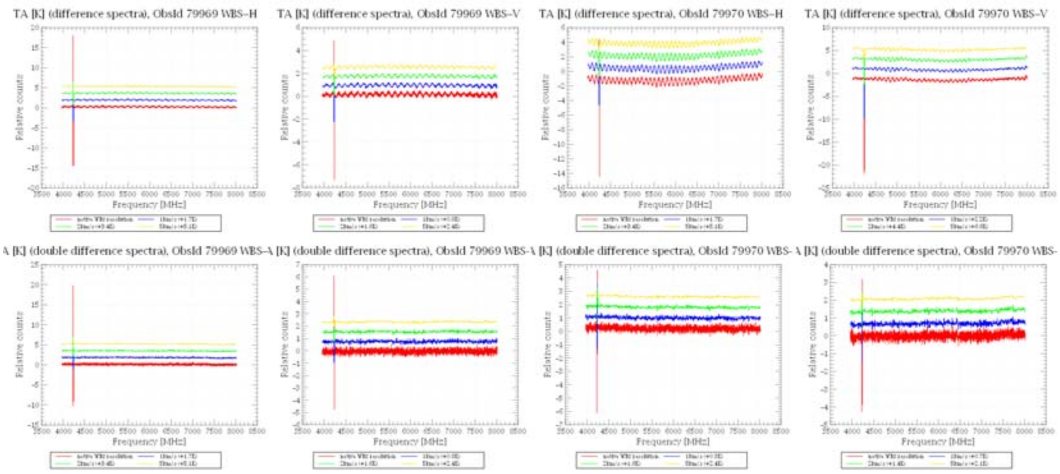

Fig 143. 1107.54 GHz ($H_2^{18}O$-*para*). Spur in Subband 1. Double difference looks good.

6.9 Band 5a DBS and LSW sample spectra

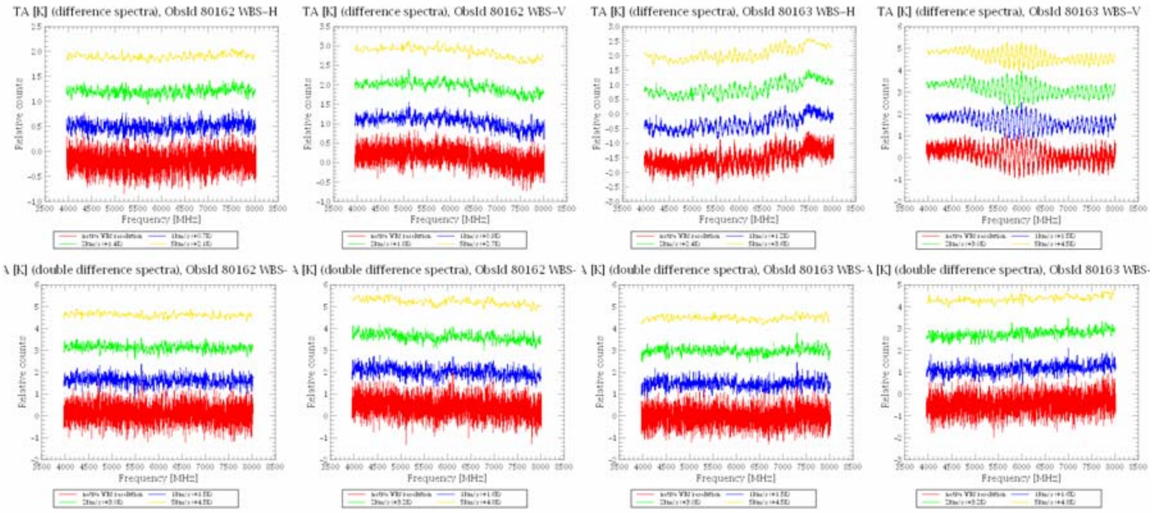

Fig. 144. 1222.99 GHz (H_2O-*para*). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. In the LSW we find a 95 MHz standing wave. For both spectra the diplexer shape is visible in the single difference spectra as well. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase.

6.10 Band 6a DBS and LSW sample spectra

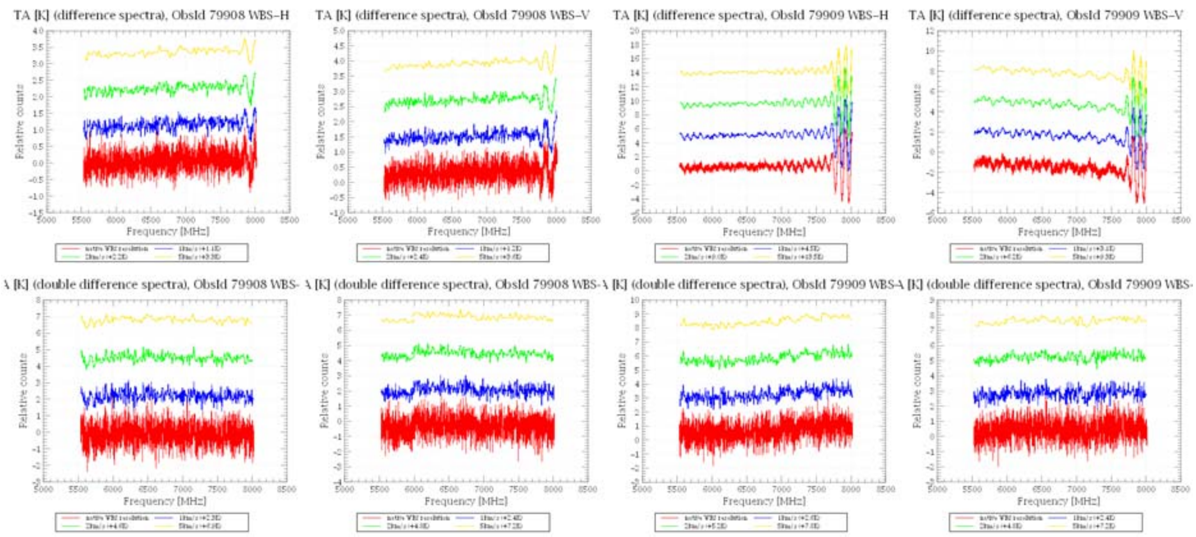

Fig. 145. 1458.33 GHz (N^+). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. In the LSW we find a 95 MHz standing wave. For both spectra the diplexer shape is visible in the single difference spectra as well. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase. Since the DBS was taken directly after a 45 min Stab LO warm-up, the effect of doing DBS measurement 20 minutes after LO turn-on is clearly visible (not much). The most sensitive (and also most unstable) section of the IF is in WBS subband 3, 7-8 GHz.

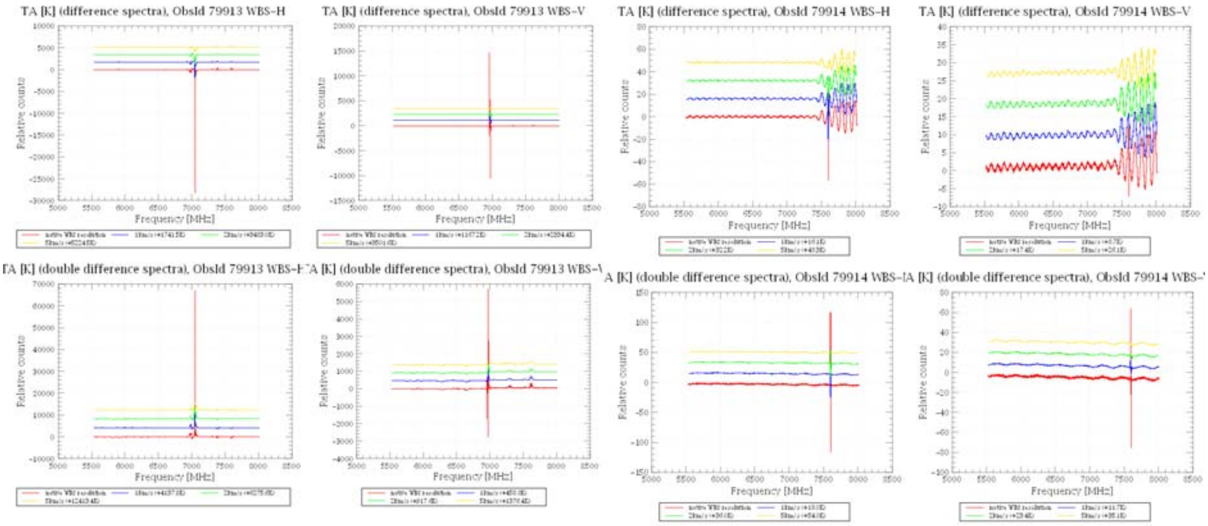

Fig. 146, 1543.79 GHz (^{13}CO), Needs reprocessing after spur removal.

6.11 Band 6b DBS and LSW sample spectra

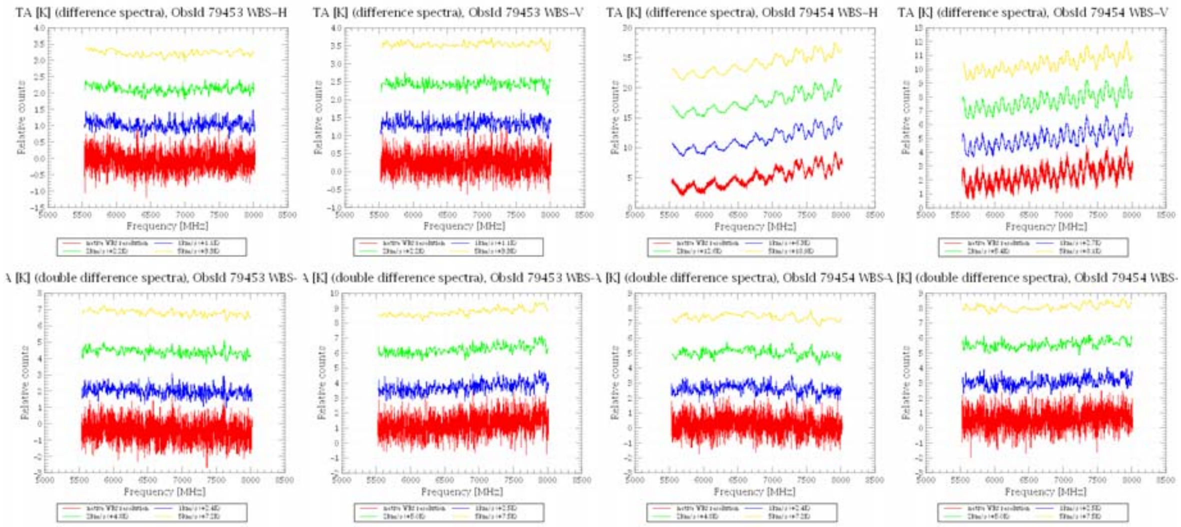

Fig. 147. 1667.11 GHz (H_2O-*ortho*). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. In the LSW we find a 95 MHz standing wave. For both spectra the diplexer shape is visible in the single difference spectra as well. The double difference spectra are nice. Duration of the measurement is 1h, 30 minutes/phase. Since the DBS was taken directly after a 45 min Stab LO warm-up, the effect of doing DBS measurement 20 minutes after LO turn-on is clearly visible (not much). The most sensitive (and also most unstable) section of the IF is in WBS subband 3, 7-8 GHz.

6.12 Band 7a DBS and LSW sample spectra

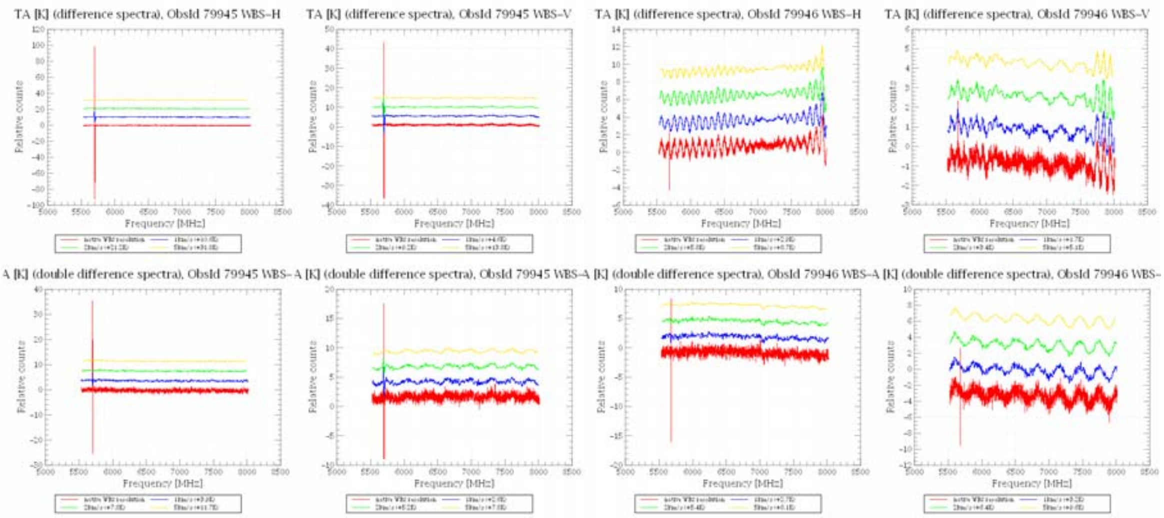

Fig. 148. 1719.57 GHz (H_2O-*ortho*). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. In the LSW we find a 95 MHz standing wave. The double difference shows the 300 MHz IF standing wave. The double difference spectra are promising. Duration of the measurement is 1h, 30 minutes/phase. Since the DBS was taken directly after a 45 min Stab LO warm-up, the effect of doing DBS measurement 45 minutes after LO turn-on is not much. The most sensitive (and also most unstable) section of the IF is in WBS subband 3, 7-8 GHz.

It will be a useful exercise to remove the spur and apply the current-matched off subtraction technique.

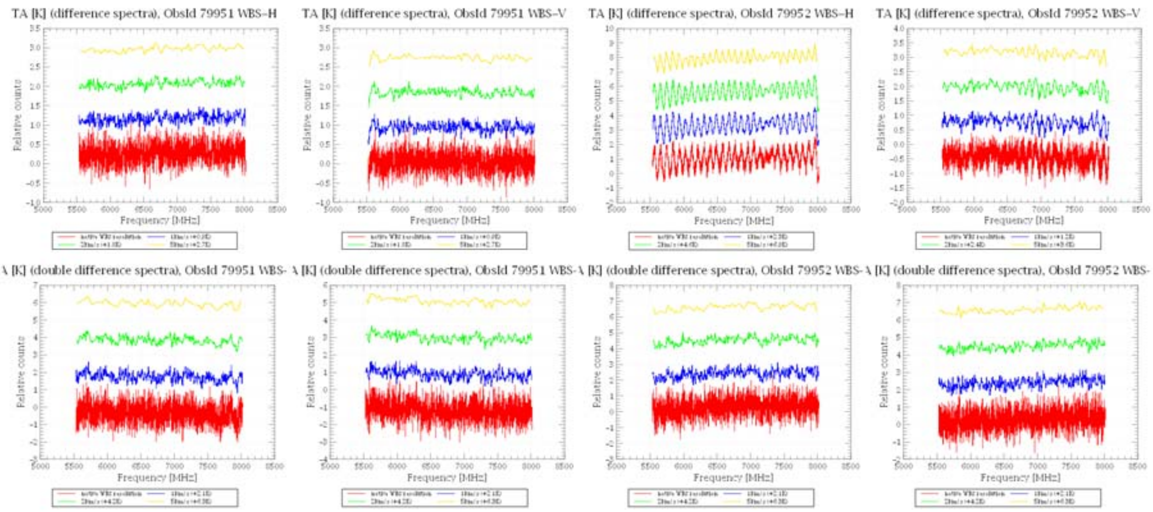

Fig. 149. 1772.68 GHz (HCN). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. In the LSW we find a 95 MHz standing wave. The double difference shows the 300 MHz IF standing wave. The double difference spectra are promising. Duration of the measurement is 1h, 30 minutes/phase. The most sensitive (and also most unstable) section of the IF is in WBS subband 3, 7-8 GHz

6.13 Band 7b DBS and LSW sample spectra

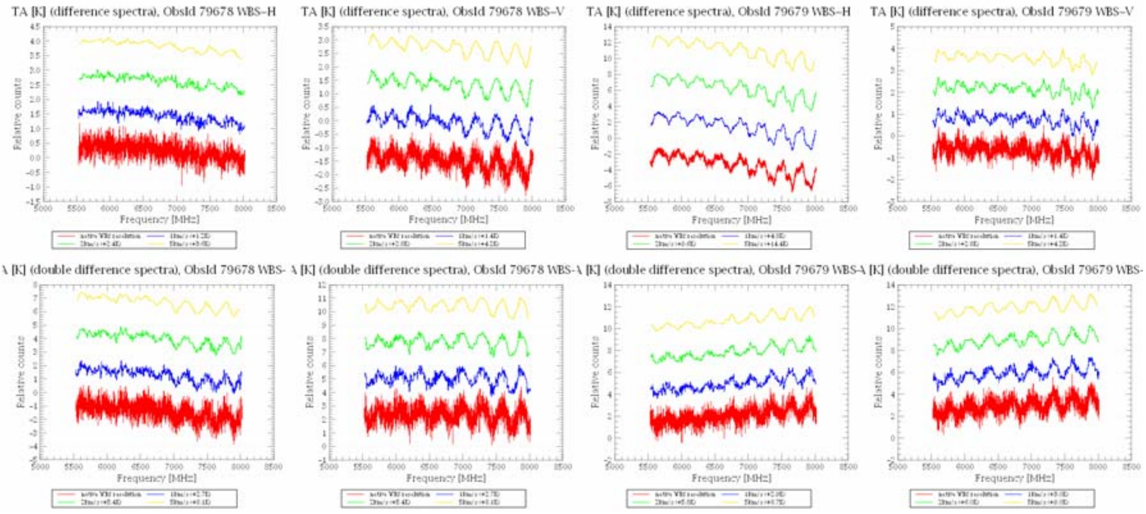

Fig. 160. 1897.75 (C^+) GHz. Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. The single & double difference spectra show the 300 MHz IF standing wave. This data was taken with the unstable M1, M2 B7b multiplier setting. One may therefore expect that the new M1, M2 (-8V, -9V) settings will much improve this result. Duration of the measurement is 1h, 30 minutes/phase. The DBS measurement was taken directly after a 45 min Stab LO warm-up, the effect of doing DBS measurement 45 minutes after LO turn-on is not clear (probably overshadowed by system instability). The most sensitive (and also most unstable) section of the IF is in WBS subband 3, 7-8 GHz

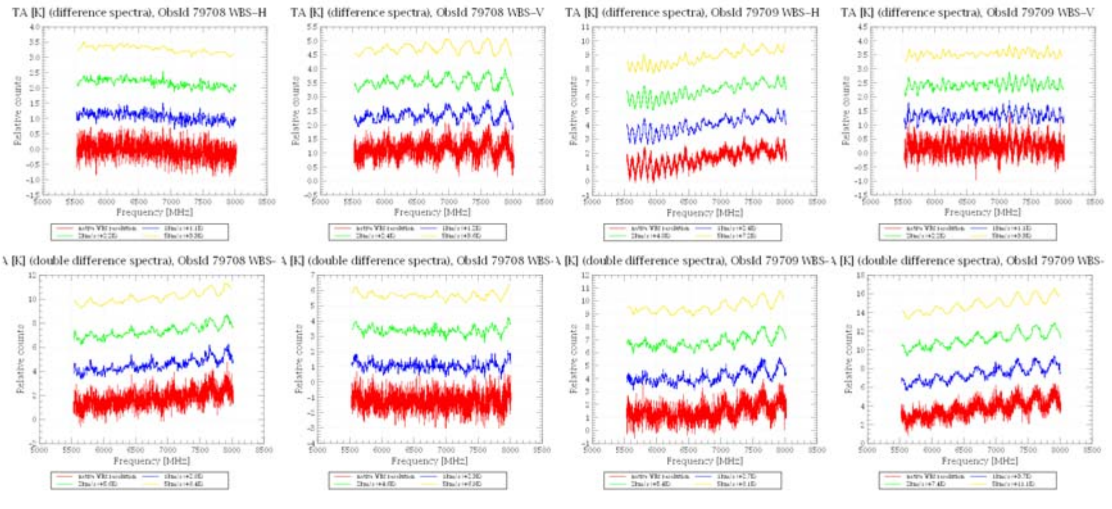

Fig. 161. 1844.15 GHz (CO). Left: DBS. Right: LSW. Top row: Single difference DBS, LSW. Bottom row: Double difference assuming an off source DBS, LSW every 5 minutes. The single & double difference spectra show the 300 MHz IF standing wave. The most sensitive (and also most unstable) section of the IF is in WBS subband 3, 7-8 GHz

7 Conclusion

General

- In most bands we notice very short, non-Gaussian total power fluctuations - TP spikes - in the time series. They affect the total power stability, also in differential measurements, and if large in amplitude, they also affect the spectroscopic stability.
- The known effect of a not well thermally stabilized WBS-V was noticed in several tests.
- We noticed frequently some warm-up drifts when changing the LO frequency within one particular band. They may affect the overall stability in case of frequent LO frequency changes. It is also not clear that these are 100% reproducible as much depends on the initial condition.
- Because of the good reproducibility of the results it is clear that the stability differences between different frequencies are real, i.e. cannot be considered as scatter. Given the statistics of ~8 stability measurements/LO-subband, it is evident that the full frequency-dependence system stability is not entirely known. However it may be reasonably expected that uncovered results will fall within the boundary conditioned sampled by the CoP measurements, and provided in this memo.
- DBS, LSW, FSW (all) spectra need a 'double different off subtraction. To remove passband structure and standing waves. 10 min off-cycles are quite often noticeably worse then 5 min off-cycles.
- With an in-band frequency switch there is on occasion a thermal time response. This noticeably degrades the differential stability. Thus following a frequency change it is advisable to shorten the calibration loop time. Similarly, when the LO is not quite warmed up, reduce the loop parameters.
- Using 4s slow chop, even if the TP or spectroscopic stability is very poor with significant excess noise, the spectroscopic differential stability is generally reasonable.
- DBS and LSW have comparable differential stability times.

LO subband specifics

Band 1a

Typical instability signature:	Broad irregular features across the whole IF
Comparison WBS-HRS stability:	Good match (apart from known difference in fluctuation bandwidth)
Reproducibility:	HRS: OD 44 (Fig 1), W BS: OD54 (Fig. 3)
Comparison of different modes:	Surplus noise visible in internal-load-chop measurements, not visible in system stability ? differential load-mixer heating? IF interference?
Band warm-up:	Very small effect, < 1% in 1200s, negligible
In-band warm-up effects:	527: 600s, 547: 200s, 514: 400s only in V, no effect seen in H
Spurs:	HRS at 532GHz (Ch7), WBS: spur at 547 GHz in subband 2 (5.2 GHz)
TP spikes:	Prominent at 492, 543 GHz
Differential stability:	TP reduced by spikes, spectroscopic mediocre
System stability good:	492, 543, 547, 514, 532
	mediocre: 497, 527

	bad: none
	unusable: none
Spectroscopic stability/ subband:	>100s HRS, ~100s WBS
Total Power stability/subband:	20-30s HRS, 10-20s WBS
Spectra	5 min Double difference DBS, LSW spectra look good.
Comments:	5-6 GHz passband most stable (WBS subband 2, HRS Ch2).

Band 1b

Typical instability signature:	Broad irregular features > 200 MHz across the whole IF
Comparison WBS-HRS stability:	No direct evidence of thermal instability for WBS-V. (Fig 8).
Reproducibility:	HRS: OD 44, WBS: OD54
Comparison of different modes:	Good match
Band warm-up:	> 1200s, 7% in H, 2% in V (only case with strong H-V-difference)
In-band warm-up effects:	None
Spurs:	None
TP spikes:	prominent at 614, 595, 568
Differential stability:	WBS-V TP reduced, spectroscopic good at 614, bad at 564
System stability good:	564, 614, 568, 612
	mediocre: 595, 627, 565
	bad: none
	unusable: none
Spectroscopic stability/subband:	>100s HRS, ~100s WBS
Total Power stability/subband:	20s HRS, 10s WBS
Spectra	5 min Double difference DBS, LSW spectra some residual structure.
Comments:	All subband very similar stability.

Band 2a

Typical instability signature:	Broad wiggles > 300 MHz across the whole IF
Comparison WBS-HRS stability:	very good match
Reproducibility:	HRS OD 48, WBS OD59
Comparison of different modes:	good match
Band warm-up:	2% in 1000s
In-band warm-up effects:	666: 400s
Spurs:	None
TP spikes:	prominent at 641, 697
Differential stability:	very good everywhere
System stability good:	everywhe

	mediocre:	none
	bad:	none
	unusable:	none

Spectroscopic stability/subband: >100s HRS, ~100s WBS

Total Power stability/subband: 20s HRS, 10s WBS

Spectra: 5 min Double difference DBS, LSW spectra look good.

Comments: Evidence of WOV instability due to SPIRE DCU (Fig. 12).

Band 2b

Typical instability signature:	Prominent broad instability features, strong in subband 1, other features across whole IF
Comparison WBS-HRS stability:	good match, details depend on the coverage of the instability features
Reproducibility:	in general very good match of OD 43 and OD49, but “step” of a 5% drop observed in stabilization phase on OD49, similar step in internal-load-chop phase half an hour later on OD43, spur at 771 GHz only on OD49
Comparison of different modes:	good match
Band warm-up:	2% in 500s
In-band warm-up effects:	757: 3000s (very strong ? 10%)
Spurs:	779, 771 on OD49
TP spikes:	prominent at 729.5, 757
Differential stability:	mediocre, affected by in-band stabilization
System stability good:	729.5, 771, 740, 779, 766
mediocre:	757, 746
bad:	none
unusable:	none
Spectroscopic stability/subband:	>100s HRS, ~100s WBS
Total Power stability/subband:	20s HRS, 10s WBS
Spectra	5 min Double difference DBS, LSW spectra look good
Comments:	Good reproducibility between OD 43 & OD49. Spur at 771 GHz on OD 49 only.

Band 3a

Typical instability signature:	Long range baseline pattern, no diplexer pattern visible
Comparison WBS-HRS stability:	Reasonable match, but WBS saturated below 4.5GHz IF not covered by HRS
Reproducibility:	HRS OD 48, WBS OD59

Comparison of different modes:	good match	
Band warm-up:	25% in 1000s (very strong)	
In-band warm-up effects:	none detectable due to bad TP stability	
Spurs:	841 (strong and strong variability)	
TP spikes:	prominent at 841, 828	
Differential stability:	Screwed up by spur at 841 and by saturation at 815 – next order effects not quantifiable yet	
System stability good:	815-V, 841-V	
	mediocre:	828, 849-V
	bad:	824
	unusable:	815-H, 841-H, 849-H
Spectroscopic stability/subband:	>50-90s HRS, ~50-90s WBS	
Total Power stability/subband:	<4s	
Spectra	5 min Double difference DBS, LSW spectra look good	
Comments:	The total-power stability is extremely bad and variable everywhere.	
	Large variance on spectroscopic stability as well.	
	WBS saturated at low IF frequencies? extreme IF power slope.	
	H is much worse than V (HRS, OD48)	
	H & V similar on OD59. → repeatability??	

Band 3b

Typical instability signature:	Long range wiggles (several 100 MHz), no diplexer pattern	
Comparison WBS-HRS stability:	Good match	
Reproducibility:	HRS OD 47, WBS OD63	
Comparison of different modes:	good match	
Band warm-up:	>12% in 1000s	
In-band warm-up effects:	904: 100s, 947: 600s, 870: 200s	
Spurs:	None	
TP spikes:	prominent at 888, 928	
Differential stability:	Good at 888GHz, bad at 928 GHz due to bad TP stability there	
System stability good:	888, 928-V, 904-V, 947-V, 922-V, 940	
	mediocre:	904-H, 922-H
	bad:	928-H, 947-H, 870
	unusable:	912
Spectroscopic stability/subband:	>100s HRS-V, ~50s HRS-H, ~50-90s WBS	
Total Power stability/subband:	<4s	

Spectra	5 min Double difference DBS, LSW spectra look good
Comments:	Very bad total power stability at 928 GHz. System at 912GHz unstable (Fig. 24)

Band 4a

Typical instability signature:	Main instability at high IF frequencies. WBS subband 4 always very bad, subband 1 also instable, center of the IF quite stable, distortions broad (500MHz) only seen in WBS or full HRS	
Comparison WBS-HRS stability:	Good match for subbands 2,3	
Reproducibility:	extremely good agreement between OD43 and OD49	
Comparison of different modes:	good match	
Band warm-up:	4% in 800s	
In-band warm-up effects:	980: 1000s, 990.5: 200s, 974: 600s, 978: 800s, 1007: 400s, 1031: 200s	
Spurs:	None	
TP spikes:	prominent at 969, 990.5, 1007, 1031	
Differential stability:	TP stability bad, due to low system TP stability. Spectroscopic stability o.k.	
System stability good:	969, 1031, 994-V, 990.5-V	
	mediocre:	994-H, 990.5-H, 980, 978
	bad:	974, 1000.5, 1007
	unusable:	none
Spectroscopic stability/subband:	>80s HRS-V, ~50s WBS	
Total Power stability/subband:	~8s	
Spectra	5 min Double difference DBS, LSW spectra look good	
Comments:	The total-power stability is bad everywhere (<< 10s) due to “band-edge flapping” (diplexer effect). → use WBS subband 2,3 where possible.	

Band 4b

Typical instability signature:	Main effect in WBS subband 4 at high IF, irregular pattern over the rest of the IF
Comparison WBS-HRS stability:	WBS-V noticeably worse, WBS-H in good agreement (probably due to temperature environment)
Reproducibility:	HRS OD 51, WBS OD62.
Comparison of different modes:	very good match

Band warm-up:	None
In-band warm-up effects:	1109: 400s, 1090: 100s
Spurs:	1107.5 (very strong)
TP spikes:	prominent at 1107.5, 1095.5
Differential stability:	Strong effect from spur, small effect of TP spikes, spectroscopic diff. stability o.k.
System stability good:	1091.5, 1107.5, 1090, 1095.5, 1069
mediocre:	1109
bad:	none
unusable:	none
Spectroscopic stability/subband:	>>100s HRS, ~100s WBS (subband 2, 3)
Total Power stability/subband:	~20-30s HRS, 10s WBS
Spectra	5 min Double difference DBS, LSW spectra look good but there is a spur. Needs to be rerun after spur removal.

Comments: Looks very good in general.

Band 5a

Typical instability signature:	Long range instability patterns, worst effect at the IF edge above 7.5 GHz, platforming in HRS
Comparison WBS-HRS stability:	reasonable. WBS subband 4 worse, platforming only in HRS.
Reproducibility:	only OD 48 (no WBS data)
Comparison of different modes:	very good match
Band warm-up:	1% in 500s
In-band warm-up effects:	None
Spurs:	1235 (very strong), 1238
TP spikes:	noticeable at 1145, 1169, weaker than in other bands
Differential stability:	Good in TP and spectroscopic
System stability good:	everywhere (outside spurs)
mediocre:	none
bad:	none
unusable:	none
Spectroscopic stability/subband:	>>100s HRS
Total Power stability/subband:	~40s
Spectra	5 min Double difference DBS, LSW spectra look good
Comments:	Sudden 25% power change at 1235 possibly related to spur intensity change (see fig 38), otherwise looks good.

Band 5b

Typical instability signature:	Long range irregular wiggle
Comparison WBS-HRS stability:	Good match, some wiggles only seen in WBS or full HRS
Reproducibility:	only OD 51 (no WBS data)
Comparison of different modes:	good match at 1271, variation for 1243 (possibly caused by variation of spur)
Band warm-up:	20% in 200s, effect unclear: no warm-up observed in stabilization measurement, but sudden warm-up pattern in subsequent internal-load-chop measurement
In-band warm-up effects:	None
Spurs:	1266 (very strong), 1243
TP spikes:	noticeable at 1271
Differential stability:	Good in TP and spectroscopic
System stability good:	everywhere (outside spurs)
	mediocre: none
	bad: none
	unusable: none
Spectroscopic stability/subband:	>>100s HRS
Total Power stability/subband:	~40s
Spectra	non yet.
Comments:	looks good.

Band 6a

Typical instability signature:	Standing wave patterns (approx 600MHz), saturation effects
Comparison WBS-HRS stability:	Consistent behavior, WBS more affected by saturation
Reproducibility:	HRS OD 44, WBS 61
Comparison of different modes:	consistent
Band warm-up:	Very erratic, oscillations in first 1000s, ending with saturation, after 1300s still drift by 8% in the subsequent 3500s
	Needs 1.3h of total warm-up, see Fig. 44.
In-band warm-up effects:	none detectable due to overall bad TP stability
Spurs:	1530 (strong), 1544 (this spur only occurred on June 26, 19:25 for about 500s, resulted in a complete distortion of the measurement)
TP spikes:	prominent at 1458, 1494
Differential stability:	reasonable at 1458GHz, completely distorted by spur at 1544.
System stability good:	none

	mediocre:	1458, 1544 (outside of spur), 1494
	bad:	1479
	unusable:	1530

Spectroscopic stability/subband: ~50s HRS, WBS ~ 20s.

Total Power stability/subband: <2s

Spectra: 5 min Double difference DBS, LSW spectra look good even after 22 min LO warm-up. Will need some residual 300 MHz electrical standing wave clean up. Try current matched off subtraction technique.

Comments: Extremely bad TP stability translated into poor spectroscopic stability. Nevertheless the per subband spectroscopic stability quite usable with good looking double difference spectra even after LO warm-up.

Band 6b

Typical instability signature: Standing wave patterns (approx 600MHz)

Comparison WBS-HRS stability: Consistent behavior, WBS-V suffering from thermal drifts

Reproducibility: slightly better overall stability in most tests in OD51 compared to OD43, WBS-V strongly suffering from thermal drifts on OD43, much better on OD51, good match of all HRS stabilities

Comparison of different modes: consistent

Band warm-up: 12% in > 2500s

In-band warm-up effects: none – no steady-state ever reached in the band (> 1.5h)

Spurs: 1530 (strong), 1544 (this spur only occurred on June 26, 19:25 for about 500s, resulted in a complete distortion of the measurement)

TP spikes: pronounced at 1644, 1654, 1609, 1631, 1583, 1667

Differential stability: Additional TP noise by factor 2-3 due to TP spikes, spectroscopic o.k.

System stability	good:	1653, 1667, 1654
	mediocre:	1583, 1609, 1630, 1664, 1686
	bad:	none
	unusable:	none

Spectroscopic stability/subband: ~100s HRS.

Total Power stability/subband: ~10s

Spectra: 5 min Double difference DBS, LSW spectra look good even after 22 min LO warm-up. Will need some residual 300 MHz electrical standing wave clean up. Try current matched off subtraction technique.

Comments: Best HEB band as seen from decent Spectroscopic and TP stability.

Band 7a

Typical instability signature:	Irregular, saturation, 600 MHz standing wave pattern	
Comparison WBS-HRS stability:	Good agreement	
Reproducibility:	HRS OD 48, WBS OD62	
Comparison of different modes:	differential mode slightly worse than system test	
Band warm-up:	Very erratic stabilization. Oscillations. After 2700s still 6% change in 3500s. No steady-state reached (> 1.9h)	
In-band warm-up effects:	none – hardly steady-state reached.	
Spurs:	1719	
TP spikes:	pronounced at 1719, 1794, 1729, always present	
Differential stability:	Additional TP noise by factor 2-3 due to TP spikes, spectroscopic o.k.	
System stability good:	1773, 1717-V	
	mediocre:	1719, 1729, 1722, 1763, 1794, 1717-H
	bad:	none
	unusable:	none
Spectroscopic stability/subband:	~80-100s HRS, ~50S WBS	
Total Power stability/subband:	~<=4s HRS, <2s WBS.	
Spectra	5 min Double difference DBS, LSW spectra look good even after 22 min LO warm-up. Will need some residual 300 MHz electrical standing wave clean up. Try current matched off subtraction technique.	
Comments:	Again tendency towards worse stability at the end of the observations, i.e. after operating the chain for a long period (see 6b).	

Band 7b

Typical instability signature:	600 MHz standing wave pattern
Comparison WBS-HRS stability:	Good agreement
Reproducibility:	HRS OD 47, WBS OD 57
Comparison of different modes:	Good match
Band warm-up:	10% in 2000s
In-band warm-up effects:	None
Spurs:	1834
TP spikes:	pronounced at 1719, 1794, 1729, always present
Differential stability:	Additional TP noise by factor 4-5, too high noise also reduces spectroscopic differential stability significantly. As was seen from the CII, OH tests, this problem may be related to interaction between M1, M2 of the B7B multiplier chain. There may thus be more optimal settings, however it will take a very long time to find them all

	and it would thus be impractical to even try to find optimal settings except for CII and OH.	
System stability good:	1844, 1885, 1834	
	mediocre:	1800, 1870
	bad:	1897
	unusable:	none
Spectroscopic stability/subband:	~80s HRS, ~40S WBS	
Total Power stability/subband:	< 2s HRS	
Spectra	5 min Double difference DBS, LSW spectra look good even after 22 min LO warm-up. Will need some residual 300 MHz electrical standing wave clean up. Try current matched off subtraction technique.	
Comments:	Very strong total-power fluctuation (10%). There is a large spread in the spectroscopic stability, mainly due to CII and OH. However with the optimized M1, M2 multiplier bias settings this is hopefully be improved.	

Issues that need further investigation

- Surplus noise in band 1a internal-load-chop measurements
- Cause of TP spikes
- Reason for bad differential stability at 564 GHz
- Possible reason for spur at 771 GHz on OD49 while same observation shows the same behaviour but no spur on OD43.
- TP drop by 5% in band 2b in both measurement periods.
- Extreme warm-up effect in band 3a.
- Strong IF power slope in 3a driving the WBS into saturation.
- Strong imbalance between polarizations in band 3, H worse on OD 48., not on OD59.
- Extremely bad stability at B3b, 912GHz (1342179226) single event?
- B4a 977.60 GHz, 1342179100. There is a 5% drop in mixer current after t=400s
- Lack of warm-up effects in band 4b at band switch-on.
- Strong difference between 4a and 4b.
- Weaker TP spikes in band 5
- Band switch on stabilization in 5b
- Reason for spur at 1544 GHz on June 26, 19:25 (for about 500s).
- Very bad stability in 6a. 1530, 1479GHz.
- Poor band stabilization in 6b even after >4000s.
- Reducing stability in HEB bands after operating the chain for > 6h.
- No steady state for bands 6b and parts of 7a ever.

- Are there any specific frequencies that can benefit from a parametric stability test as was done on OD 63 for OH, CII

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