Frequency Switch Performance

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1.1 Document Change Record

Issue	Date	Authorization	Total pages	Sections affected	Description of change
1	21 July, 2009	J. Kooi			v1.0 FSW rapport
2	24 July 2009	J. Kooi		1, 3	Conclusion section updated, details added.
3	09 Sept 2009	J. Kooi		2	FSW obsid table added

1.2 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	09/10/ 2009	J. Kooi	SystemStab-CoP-10Sept2009.doc

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Abbreviations

FSW - frequency switching

USB - Upper sideband

2 Introduction

This memo summarizes the results for the CoP frequency switch campaign. As we will see it is very important to keep both the mixer current and the power amplifier Drain 2 voltage (current) fixed during frequency switching (Section 2). This is particularly so in the diplexer band with B3a being possibly as sensitive to changes in Imix, Vd2 as the HEB mixer bands. Band 5 is at the other end of the spectrum being very immune to changes in Imix and Vd2.

From the standing wave team we understand that the LO-mixer path provides the dominant 94 MHz standing wave. A slower ~ 650 MHz standing wave can be traced to reflections of the diplexer roof top mirror as shown in the Fig. 1 below. Note that all measurements were taken through the telescope on a dark section of sky.

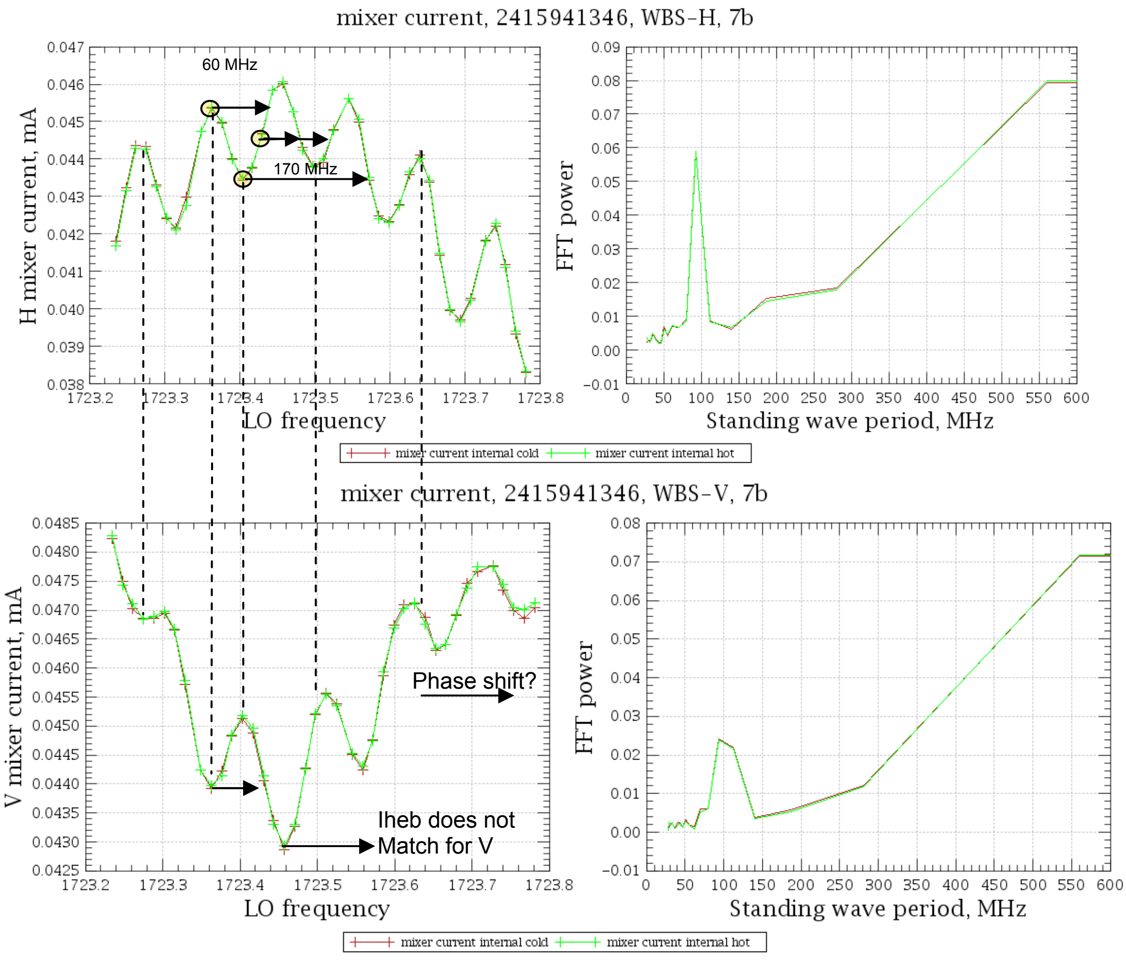

Fig. 1 Example of a Band 7b standing wave (TB/TV). Data from Ronan Higgens *et a*l. For mixer-H it is possible to have a 170 MHz frequency throw with Deta-Imix=0, whereas in the case of Mixer – V this particular throw would result in a change in Imix (change in mixer gain). Thus the 'off' subtraction for mixer V will be imperfect leaving a residual baseband ripple. Fortunately this can be dealt with in a matter described by Higgens *et al*. as briefly expanded upon below. We will see examples of this in the next sections.

HEB bands are particular sensitive to small changes in LO power (and to a lesser degree source temperature). These changes can be seen in the HEB impedance which in turn affects the electrical standing wave between the mixer and first LNA. When one does an ‘off’ calibration with a different mixer impedance one is then left with a standing wave residual. It was shown by R. Higgens, J. Kooi that the use of ‘current matched’ off spectra (as opposed to the more conventional time bias off subtraction) improves the effective removal of residual standing waves from the observed baseline. This principle is shown in Fig. 2.

Here the blue trace shows an optimized calibration routine where the matching ‘off‘ for each ‘on’ spectra is found in an intelligently manner. The plot here shows the average of 50 of those matched spectra. The green curve show a standard calibration matching consecutive ‘on’ spectra with ‘off’ spectra and then the average of 50.

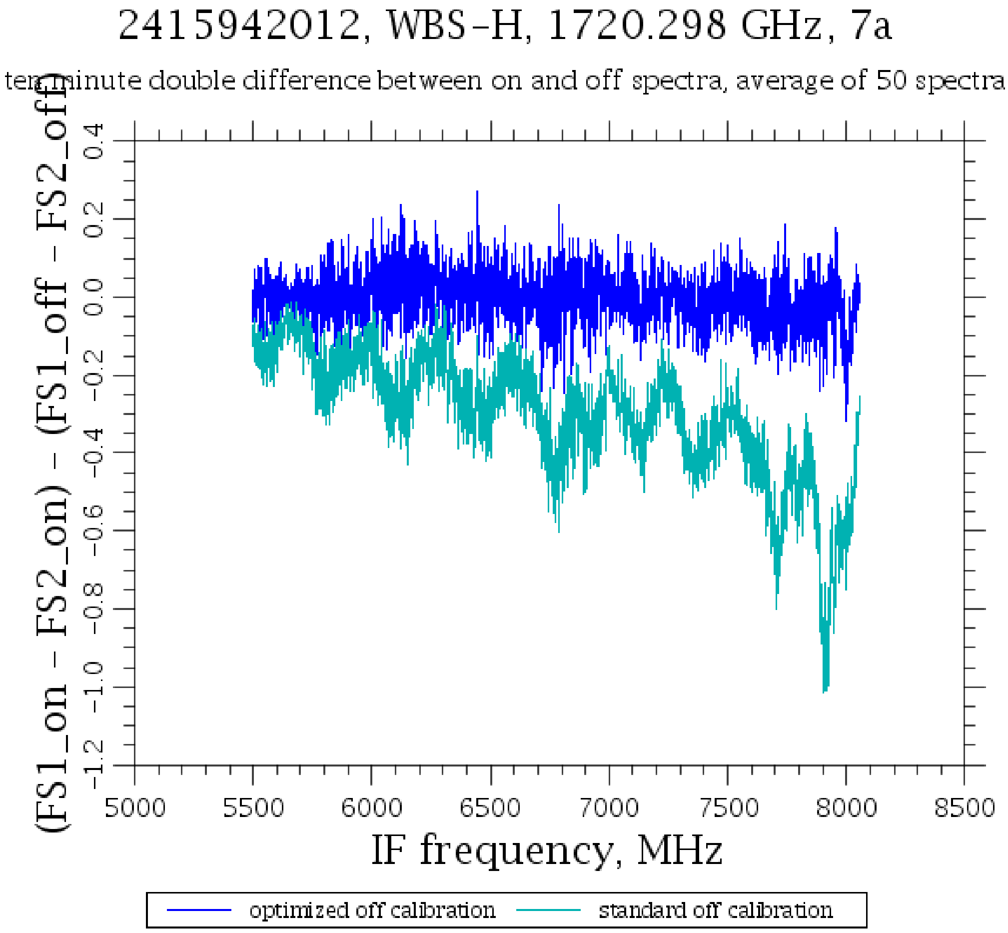

Fig. 2 Current algorithm (blue) searches through all available ‘off’ spectra and finds the best match for each on spectra. Same spectra can be used twice or more which will increase noise.

For astronomical purposes with lines presumably deeply embedded in the noise, it is of interest to achieve the most optimal ‘off’ subtraction so as to minimize the distortion of the final baseline. This may be achieves, as will be seen in section 2, by keeping Imix and Vd2 of the LO chain fixed (constant) during the frequency switch routine. To do this, a priory information on the starting frequency and desired throw (as was shown in Fig. 1) is required.

Having noted this concept in TB/TV, a dedicated test (Standing wave/Stability teams) has been devised to investigate the standing wave at approximately 5 important line frequencies per LO sub-band, and then use the information in the FSW stability campaign. Three techniques have been tried out:

- FSW with a default +- 47 MHz throw
- FSW designed to minimize variation in Imix (and thereby Vd2) for both H, V. As will be seen, this is often not quite possible. Thus for one polarization FSW should be optimized, while the other polarization acts as the slave (non-optimal). These throws are by there very nature asymmetric.
- FSW with a larger symmetric throws. (multiplies of the fundamental +- 47 MHz LO-mixer standing wave).

To help find the optimal throws (often asymmetric) a script was written with an output as shown in Fig. 3, 5 below. In the example we show the situation at for example 927.6 GHz, B3b.

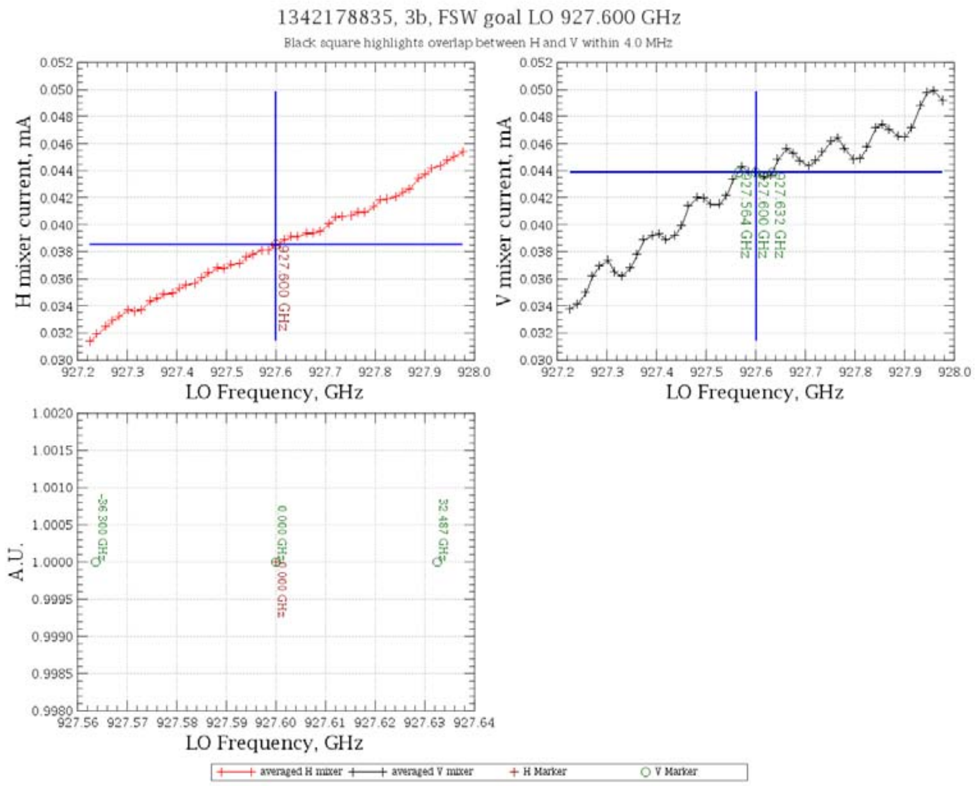

Fig. 3 Standing wave situation for νlo = 927.6 GHz, B3b. For H there is a strong drift of the LO, where as for V there is a clear standing wave pattern on the drift. As a result, for H there are no throws that will cause the mixer current to match. For V there is a throw at -36MHz, +32 MHz. Fig. 4 shows CoP result.

Fstart (GHz)	Throw 1 (MHz)	Fstop (GHz)	Throw 2 (MHz)
927.563	-36.3000	927.6322	32.486

Table. 1. Constant Imix for Imix-V of Fig. 3a.

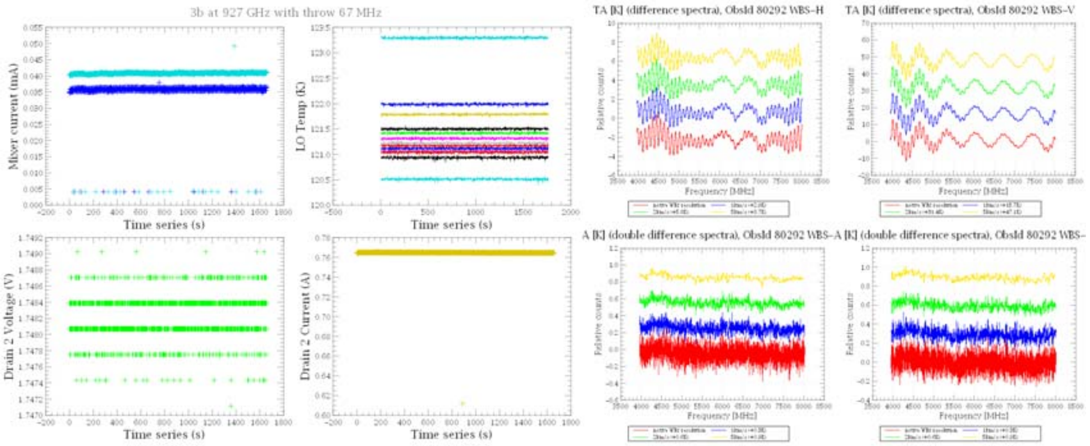

Fig. 4: Testmode_stability_freqswitch_TV_1. Throw: -36, +32 MHz. Mixer V has a slightly better baseline quality then mixer H. Vd2 is mostly constant, however there is some noise. Id2 is constant. (See Fig. 3).

Example of a B7a standing wave profile.

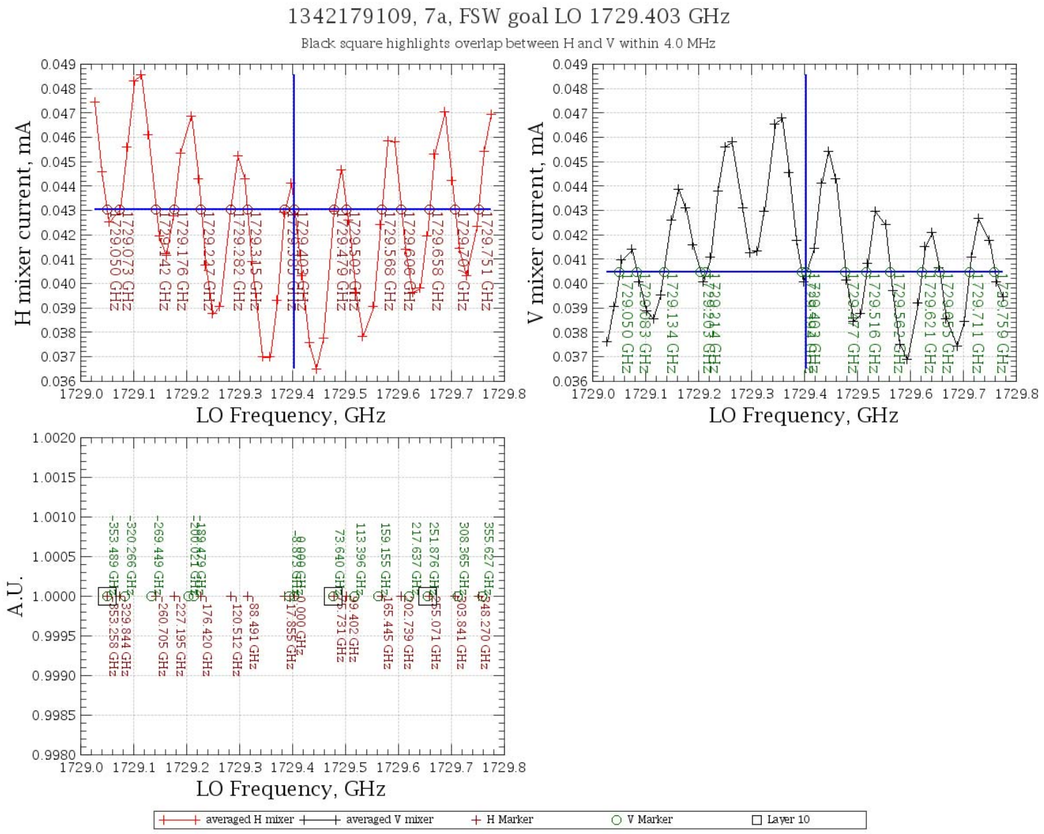

Fig. 5 Example of a standing wave of B7a, Freq = 1729.4 GHz, Obsids: 1342179956, 1342179957. In this case there are multiple FS throw solutions for with the H & V mixer current change is constant. See Figs. 104-105, for measured CoP results.

Fstart (GHz)	Throw 1 (MHz)	Fstop (GHz)	Throw 2 (MHz)
1729.049	-353.257	1729.403	0.0
1729.073	-329.843	1729.478	75.731
1729.175	-227.195	1729.502	99.401
1729.226	-176.419	1729.605	202.739
1729.314	-88.490	1729.706	303.841
1729.385	-17.855	1729.751	348.270

Table. 2 Some examples of constant Imix for both H & V (Fig. 3b.). See Figs. 104-105 for measured CoP result. Suitable combinations can be picked as scientifically desired.

3 Frequency Switch Throws Utilized

B1a (488-552)							
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop
O_2	492.049	487.249	3	-47	47	-144	144
CI (1-0)	496.961	492.161	3	-47	47		
ND	526.877	522.077	4	-47	47		
$H_2{}^{18}O$-*ortho*	542.876	547.676	18	-47	47	-144	144

CBB, not sky

B1b (563-628)							
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop
H_2O-*ortho*	563.736	556.936	19	-47	47	-144	144
HDO	595.127	599.927	2	-47	47		
HCO^+	614.21	624.208	1	-47	47	-144	144
H_2O^+	626.973	631.773	4	-47	47		

B2a (634-717)							
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop
H_2O-*para*	640.966	645.766	2	-47	47	-144	144
$H_2{}^{18}O$	666.157	661.357	2	-47	47		
D2H+/$CO_{6\text{-}5}$	686.86	691.66	6	-47	47	-144	144
$H_2{}^{18}O$	696.879	692.079	2	-47	47		

B2b (724-793)							
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop
CS	729.524	734.324	2	-47	47	-144	144
$H_2{}^{18}O$-*ortho*	740.52	745.32	3	-47	47		
H_2O-*para*	756.833	752.033	14	-47	47	-144	144
O_2	778.64	773.84	5	-47	47		

Same Diplexer setting for STWV as for FSW-Stabilty

B3a (807-852)									
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop	FSW-3 start	FSW-3 stop
CI 2-1	815.144	809.344	3	-75	35	-75	75	-144	144
$13CH^+$	824.331	830.131	5	-47	47	-52	0		
CH^+	840.871	835.071	11	-47	47	-15	15	-94	94
H_2CO	849.351	855.151	0	-47	47				
CBB									

B3b (866-953)							
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop
HDO	887.839	893.639	7	-47	47	-74	95
D_2O	903.747	897.947	3	-72	0		
COh	927.6	921.8	6	-36	32	-15	15
NHh_2	946.742	952.542	6	-47	47		

Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop
NH	968.662	974.462	13	-47	47	-20	20
NH	980.408	974.608	13	-47	47		
H_3O^+	990.512	984.712	10	-47	47		
H_2O-*para*	993.727	987.927	18	-47	47	-20	20

B4b (1059-1113)									
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop	FSW-3 start	FSW-3 stop
H_2O-*ortho*	1091.564	1097.364	12	-47	47	-165	0	-364	0
$H_2{}^{18}O$	1089.827	1095.627	6	0	94				
$C^{13}O$	1095.55	1101.35	10	-47	47				
H_2O-*para*	1107.543	1113.343	20	-47	47	-94	94		

Same Diplexer setting for STWV as for FSW-Stabilty

B5a (1116-1241)							
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop
H2O+	1145.315	1139.515	2	-49	49	-115	85
H_2O-*ortho*	1159.171	1153.371	9	-49	49		
H_2O-*para*	1222.989	1228.789	18	-49	49	-97	81
H_2O-*para*	1234.589	1228.789	18	-49	49		

B5b (1240-1272)							
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop
D_2O	1242.904	1247.704	0	-49	49	-150	150
OH	1270.933016	1266.133016	0	-49	49	-150	150

B6a (1429-1576)									
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop	FSW-3 start	FSW-3 stop
N^+	1458.334	1461.134	4	-48	48	-88	88		
D_2H^+	1479.4	1476.6	3	-48	48				
CO	1494.123	1496.923	3	-48	48				
^{13}CO	1543.789	1540.989	0	-48	48	-154	160		

CBB, not sky

B6b (1576-1699)									
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop	FSW-3 start	FSW-3 stop
H_2O^+	1653.013	1655.813	9	-48	48	-293	27		
^{13}CH	1644.439	1647.239	4	-220	135				
CH	1654.166	1656.966	8	-167	75				
H_2O-*ortho*	1667.105	1669.905	21	-48	48	-311	130		

B7a (1699-1796)									
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop	FSW-3 start	FSW-3 stop
H_2O-*ortho*	1719.565	1716.765	8	-48	48	-152	32	-152	118
CO	1729.403	1726.603	3	0	74				
H_2O-*ortho*	1756.714	1753.914	3	0	253				
HCN	1772.676	1769.876	0	-48	48	-88	110		

B7b (1795-1903)									
Line	νlo (GHz)[1]	νline (GHz)	Proposal	FSW-1 start	FSW-1 stop	FSW-2 start	FSW-2 stop	FSW-3 start	FSW-3 stop
	1756.71			-140	186				
CO	1844.146	1841.346	9	-48	48	-240	110		
OH	1834.947	1837.747	7	-48	48	-167	0		
H_2O-*ortho*	1870.549	1867.749	6	-367	0				
$^{13}C^+$	1897.745	1900.545	21	-48	48	-123	170	-24	92

CBB, not sky

Same Diplexer setting for STWV as for FSW-Stabilty

4 Obsid Listing of FSW measurements in CoP

#B5bExt-OD52	Mode	Comment
1342179460	FSW1	+-49 MHz. Imix drop outs typical of ALL FSW 0-300s. May effect result somewhat. Data ok
1342179461	FSW2	+-150 MHz. Imix drop outs typical of ALL FSW 0-300s. May effect result somewhat. Data ok
1342179462	FSW1	+-49 MHz. Imix drop outs typical of ALL FSW 0-300s. May effect result somewhat. Data ok
1342179463	FSW2	+-150 MHz. Imix drop outs typical of ALL FSW 0-300s. May effect result somewhat. Data ok
#B2bExt-OD52		
1342179467	FSW1	+-47 MHz. Imix drop outs typical of ALL FSW 0-300s. May effect result somewhat. Data ok
1342179468	FSW2	+-144 MHz. Bad LO tuning, garbage. --> do not use.
1342179471	FSW1	+-47 MHz. Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179472	FSW2	+-144 MHz. Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179473	FSW1	+-47 MHz. Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179474	FSW1	+-47 MHz. Imix drop outs typical of ALL FSW. May effect result somewhat. Some crappy Diff baseline at 7.4 GHz. Data ok
#B6bExt-OD52		
1342179451	FSW1	+-48 MHz. Data ok
1342179452	FSW2	-293 MHz, 27 MHz. Data ok
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		
1342179575	FSW1	CBB, not sky. +-47 MHz, Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179576	FSW2	+-144 MHz,Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179580	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179581	FSW2	+-144 MHz,Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179583	FSW1	+-47 MHz, Imix drop outs. Ringing on Isis. May effect result somewhat. Data ok
1342179585	FSW1	+-47 MHz, Imix drop outs. Periodic behaviour. May effect result somewhat. Data ok
#B1bExt-OD54		
1342179593	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179594	FSW2	+-144 MHz,Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179598	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179599	FSW2	+-144 MHz,Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179601	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179603	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
#B7bExt-OD57		
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.
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		
1342179748	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok

1342179749	FSW2	+-144 MHz,Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179753	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179754	FSW2	+-144 MHz,Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179756	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
1342179758	FSW1	+-47 MHz, Imix drop outs typical of ALL FSW. May effect result somewhat. Data ok
#B3aExt-OD59		
1342179766	FSW1	CBB, not sky. -75 MHz, +35 MHz, Current modulation in H. May effect result somewhat. Data ok
1342179767	FSW2	-75 MHz, +75 MHz, Current modulation in H with some current dropouts. May effect result somewhat. Data ok
1342179768	FSW3	-144 MHz, +144 MHz, Current modulation in H with some current dropouts. May effect result somewhat. Data ok
1342179772	FSW1	+-47 MHz, Current modulation in H with some current dropouts. May effect result somewhat. Excess noise, Data ok
1342179773	FSW2	+-15 MHz, Current modulation in H with some current dropouts. May effect result somewhat. Excess noise, Data ok
1342179774	FSW3	+-94 MHz, Current modulation in H with some current dropouts. May effect result somewhat. Excess noise, Data ok
1342179776	FSW1	+-47 MHz, Some current dropouts. May effect result somewhat. Excess noise, Data ok
1342179777	FSW3	-52, 0 MHz, Some current dropouts. May effect result somewhat. Excess noise, Data ok
1342179779	FSW1	+-47 MHz, Current modulation in H with some current dropouts. May effect result somewhat. Excess noise, Data ok
#B5aExt-OD60		
1342180160	FSW1	+-49 MHz, Some current modulation/dropouts. May effect result somewhat. Excess noise, Data ok
1342180161	FSW2	-115 MHz, +85 MHz, Some current modulation/dropouts. May effect result somewhat. Excess noise, Data ok
1342180164	FSW1	+-49 MHz, Some current modulation/dropouts. May effect result somewhat. Excess noise, Data ok
1342180165	FSW2	-97 MHz, +81 MHz, Some current modulation/dropouts. May effect result somewhat. Excess noise, Data ok
1342180166	FSW1	+-49 MHz, Some current modulation/dropouts. May effect 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		
1342179925	FSW1	+-47 MHz, Current modulation in H with some current dropouts. May effect result. Excess noise TP. Data ok.
1342179926	FSW2	-20 MHz, +20 MHz, Current modulation in H with some current dropouts. May effect result. Excess noise TP. Data ok.
1342179930	FSW1	+-47 MHz, Current modulation in H with some current dropouts. May effect result. Excess noise TP. Data ok.
1342179931	FSW2	-20 MHz, +20 MHz, Current modulation in H with some current dropouts. May effect result. Excess noise TP. Data ok.
1342179933	FSW1	+-47 MHz, Current modulation in H with some current dropouts. May effect result. Excess noise TP. Data ok.
1342179935	FSW1	+-47 MHz, Line detection! Current modulation in H with some current dropouts. Data sems ok.
#B6aExt-OD61		
1342179910	FSW1	CBB, not sky. +-48 MHz, Some current dropouts. Data ok
1342179911	FSW2	CBB, not sky. +-88 MHz, Some current dropouts. Data ok
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		
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
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		
1342179965	FSW1	+-47 MHz, Some current dropouts. Very tiny spur at 5.9 GHz, does not seem to effect. 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 effect. Data ok

1342179971	FSW1	+-47 MHz, Small spur at 4.3 GHz. Does not effect Ta performance. HRS uneffected --> use data.
1342179972	FSW2	+-94 MHz, Small spur at 4.3 GHz. Does not effect Ta performance. HRS uneffected --> use data
1342179974	FSW1	-0, +94 MHz, Good.
1342179976	FSW1	-0, +94 MHz, WBS effected by spur, HRS is fine. --> use only HRS.
#B3bExt-OD63		
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.
1342180292	FSW1	-36MHz, +32 MHz, Good.
1342180293	FSW2	+-15 MHz, Good.
1342180294	FSW1	-72MHz, 0 MHz, Good
1342180295	FSW2	+-47 MHz, Good

Red	Do note use
Purple	Diff Only,HRS only, Vpol only.
Blue	Unclear. OK for Ta, not for fbw, beta etc.

Table 3. Obsid listing of the FSW measurements in CoP. Note the comments.

5 Tabulated FSW Stability results

5.1 WBS Differential Total Power Stability

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	**NaN**	147.2	273	127.9	331.7	0	0	203.196	0	149.187
b1b	**NaN**	137.3	181.4	379.8	410.8	0	63.562	100.174	181.939	349.523
b2a	**604.3**	473.3	529.4	608.8	750.7	408.878	395.699	349.658	362.58	274.685
b2b	**488.9**	571.1	466.8	676.4	900	423.819	228.738	17.89	316.218	0
b3a	**754.1**	777.4	633.3	749.1	572.8	252.764	245.15	461.921	261.424	303.557
b3b	**167.6**	549.5	521.1	409.4	408.2	17.492	495.753	535.916	231.548	275.87
b4a	**541.5**	600.4	518.4	563	472.8	0	0	0	0	0
b4b	**140**	NaN	651.8	386.2	595	0	0	0	445.495	330.343
b5a	**684.9**	218.2	184.3	472	732.9	358.739	159.851	175.277	337.598	334.2
b5b	**232.3**	318.9	265.1	NaN	900	89.803	0	0	0	0
b6a	**900**	900	900	736.7	NaN	0	0	0	0	0
b6b	**256.7**	550.1	667.7	448.7	NaN	227.059	244.011	252.408	0	0
b7a	**440.1**	507.5	443.9	459.9	NaN	293.552	290.667	288.859	287.617	0
b7b	**900**	NaN	NaN	900	NaN	0	0	0	0	0

Table 4 WBS-H Total Power Differential Stability

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	**469.2**	175.2	459.7	326.4	203.3	269.541	55.861	317.289	106.854	109.93
b1b	**224.5**	247.1	194	210.8	536.8	136.279	52.373	67.137	141.28	272.308
b2a	**259.2**	266	291.4	236.3	556.6	151.73	168.51	180.987	162.818	382.719
b2b	**89.9**	495.8	86.3	105	298.5	0	571.59	9.192	36.444	238.116
b3a	**806.7**	871.6	861.7	787.7	665.5	114.543	56.8	72.885	176.8	176.503
b3b	**135.1**	114.2	158.7	408	175.2	16.9	25.017	32.385	427.561	64.135
b4a	**900**	900	900	900	664	0	0	0	0	333.754
b4b	**396.8**	NaN	457.4	270.7	546.9	0	0	391.44	106.844	425.029
b5a	**673.5**	691.4	507.9	813.9	582.3	264.748	295.076	392.35	172.15	398.073
b5b	**372.5**	223.7	329	900	638.8	0	0	0	0	452.469
b6a	**777.6**	412.7	751.4	824.5	NaN	211.945	242.483	257.325	75.751	0
b6b	**552.7**	293.5	499.1	559.6	NaN	491.156	151.262	363.81	481.398	0
b7a	**900**	776	900	900	NaN	0	204.593	0	0	0
b7b	**NaN**	198.7	NaN	900	NaN	0	0	0	0	0

Table 5 WBS-V Total Power Differential Stability

5.2 WBS Differential Spectroscopic Stability

Band	TaFull	Tasub1	Tasub2	Tasub3	Tasub4	stdFull	stdsub1	stdsub2	stdsub3	stdsub4
b1a	**1800**	1518.5	1475.5	1596.4	1800	0	563.05	649.05	407.3	0
b1b	**1800**	1800	1698.7	1800	1800	0	0	175.514	0	0
b2a	**1800**	1800	1713.2	1800	1800	0	0	212.697	0	0
b2b	**1270.9**	1365.9	1800	1800	1800	748.331	751.883	0	0	0
b3a	**1333.6**	1478.8	987.4	1513.6	1733.6	691.195	482.148	755.78	498.363	148.475
b3b	**1800**	1565.7	1418	1800	1367.4	0	405.877	501.451	0	499.779
b4a	**372.2**	611	1088.7	1792.7	473.2	0	373.077	616.022	12.702	0
b4b	**376.9**	489	1420.8	1800	1800	0	0	656.736	0	0
b5a	**1584.3**	1800	1545.9	1800	1800	431.45	0	508.25	0	0
b5b	**1163.6**	1387	1311.6	1800	1466.6	900.076	715.395	845.934	0	577.408
b6a	**1331.2**	1055.5	978.1	902.5	NaN	811.985	685.582	733.806	792.106	0
b6b	**1027.3**	1685.8	1108.8	1086.7	NaN	710.567	255.359	632.595	653.587	0
b7a	**1460.7**	1800	1483.1	1257.3	NaN	678.6	0	462.785	754.662	0
b7b	**1800**	451.5	327.1	1694	NaN	0	0	0	0	0

Table 6 WBS-H Spectroscopic Differential Stability

b1a	**1281.5**	1434.3	1549.8	1365.5	1800	704.27	633.411	500.4	514.794	0
b1b	**1800**	1800	1800	1800	1800	0	0	0	0	0
b2a	**1683.3**	1800	1800	1800	1800	233.5	0	0	0	0
b2b	**1150.4**	1100.3	1800	1800	1800	918.673	710.226	0	0	0
b3a	**1075.4**	673.6	979.7	1158.7	1046.2	836.981	497.588	759.626	755.166	606.584
b3b	**1800**	1800	1800	1800	1405.4	0	0	0	0	660.165
b4a	**996.5**	1379.3	1436.9	1403.8	504.1	736.376	625.94	628.85	686.181	0
b4b	**1800**	1001	1438.2	1800	1800	0	0	626.656	0	0
b5a	**1599.7**	1800	1800	1800	1587.8	400.6	0	0	0	424.5
b5b	**NaN**	1333.5	1800	1343.1	1376.5	0	808.059	0	791.432	733.466
b6a	**1800**	1394.9	847.7	1504	NaN	0	701.654	670.832	0	0
b6b	**982.9**	1576.5	1326.3	1357.6	NaN	566.291	499.806	663.772	511.704	0
b7a	**915.5**	1599.7	1739.5	993.9	NaN	619.372	346.988	3.536	755.402	0
b7b	NaN	495.4	412.1	250.9	NaN	0	0	0	0	0

Table 7 WBS-V Spectroscopic Differential Stability

5.3 HRS Differential Total Power Stability

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8	stdFull	stdsub1	stdsub2	stdsub3	stdsub4	stdsub5	stdsub6
b1a	302.9	228	271	299.9	498.1	546.4	524	725.8	589.3	0	0	0	232.791	568.316	500.066	410.122
b1b	364	567	468.5	233	291.2	336.5	373.7	288	590.2	319.74	385.918	337.988	65.777	350.681	159.346	300.85
b2a	267.2	250.8	286.8	257.6	459.9	408.1	233	211.2	270.3	47.677	113.567	94.862	140.751	310.277	388.33	64.51
b2b	394.6	714.2	339.4	399.4	549.8	260.7	507.2	412.2	450.7	259.23	371.6	136.33	346.275	337.419	157.363	284.778
b3a	786.7	756.4	792.5	814.9	709.1	826.5	765.2	802.3	793	196.3	248.722	146.157	190.2	218.679	110.184	233.538
b3b	431.1	250.4	359.2	598	235.4	235.1	430.6	288.6	566.7	321.08	61.876	373.167	349.305	60.267	139.602	318.962
b4a	604.2	598.8	576.9	615.4	487	421.3	620.1	599.2	632	0	0	0	0	0	437.841	0
b4b	200.5	531.2	243.6	267.7	668.2	392.4	544.2	211.6	344.6	71.913	319.546	0	21.991	401.489	282.47	503.248
b5a	321.7	137.6	248.3	164.2	191.1	97.9	282.8	364.7	473.5	155	48.572	115.627	86.704	139.33	0	43.75
b5b	84.6	203.1	203.6	260.9	284.1	200.1	156.6	642.4	271.8	0	145.68	88.271	0	0	22.769	107.487
b6a	900	900	900	900	865.3	867.7	897.3	900	900	0	0	0	0	49.073	45.679	4.677
b6b	715.1	526.7	705.7	717	782.8	782.3	717.6	775.9	746.3	261.56	0	274.852	258.872	203.054	203.862	258.023
b7a	633.2	465	629.8	697.1	732.6	731.7	603.3	650.2	540	195.25	288.103	210.438	149.689	144.897	201.582	239.266
b7b	900	900	900	900	900	900	NaN	900	NaN	0	0	0	0	0	0	0

Table 8 WBS-H Total Power Differential Stability (stdsub7, 8 omitted due to space)

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8	stdFull	stdsub1	stdsub2	stdsub3	stdsub4	stdsub5	stdsub6
b1a	173.9	215.5	375.3	562.1	396.9	191.8	565.9	647.2	405.1	42.78	155.351	277.64	322.987	225.361	18.343	370.03
b1b	324.4	374.5	369.3	701.4	222.8	318.7	363.7	355.1	456.6	98.719	145.209	45.853	343.928	83.667	48.87	83.471
b2a	408.7	430.1	495.2	446.3	451.7	311.3	363.1	437.9	486.8	266.368	228.119	263.079	373.368	377.836	229.752	423.139
b2b	900	229	241.6	521.3	493	257.7	419.9	726.4	189.8	0	0	58.973	438.479	575.564	220.829	354.527
b3a	837.1	897.5	863.4	723.1	659.1	628.8	872.2	812.4	861.2	87.063	5.501	81.885	177.578	103.054	175.929	55.6
b3b	377.5	336.8	607	123.5	182.7	215.8	489.2	372.9	319.3	119.925	17.1	395.838	53.075	19.819	0	359.727
b4a	900	900	784.4	873.5	900	686.8	900	900	900	0	0	163.483	37.477	0	301.51	0
b4b	194.7	198.7	338.8	174.2	297.3	900	276.1	171.4	570.6	0	103.483	52.255	8.91	0	0	108.515
b5a	188.3	183.8	176.9	275.7	595.4	444.3	224.6	155.1	255.8	131.225	12.381	62.631	104.497	430.84	280.836	130.633
b5b	254.8	421.8	763.9	174.2	715.5	106.8	692.8	76.6	494.9	0	256.255	192.545	0	319.506	0	293.025
b6a	879.1	894.9	894.7	858.3	857.9	900	823	831	816	36.142	8.833	9.238	72.284	53.133	0	133.368
b6b	612	529.5	534.6	374.1	699.2	768.4	359.7	736.6	605.7	0	0	361.739	419.413	0	186.111	348.886
b7a	900	854.6	897.9	900	900	900	900	875.8	874	0	64.276	2.97	0	0	0	0
b7b	NaN	900	NaN	900	NaN	900	796.1	900	NaN	0	0	0	0	0	0	0

Table 9 WBS-V Total Power Differential Stability (stdsub7, 8 omitted due to space)

5.4 HRS Differential Spectroscopic Stability

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8	stdFull	stdsub1	stdsub2	stdsub3	stdsub4	stdsub5	stdsub6
b1a	1324	1435.8	1540	1800	1103.3	1107.4	1800	1800	1108	824.23	630.755	177.484	0	985.35	979.484	0
b1b	1651	1447.6	1800	1089.3	1535	1792	1800	1533	1800	257.5	610.317	0	580.89	0	13.856	0
b2a	1800	1558.5	1644	1573.7	1800	1800	1554.3	1800	1800	0	483	312.5	392.02	0	0	491.35
b2b	298.4	981.4	1264	1800	1800	1800	1664	1800	1800	0	822.577	758.443	0	0	0	192.333
b3a	813.4	727.5	334.4	1390.9	1747.4	1259.9	1577.1	1365.4	620.4	678.7	581.653	20.577	620.69	117.62	635.404	545.95
b3b	1596	1800	1151	1800	NaN	1279.4	1800	1588.3	1800	409.05	0	562.368	0	0	539.78	0
b4a	1800	1598.5	1800	NaN	1334.9	1445.5	1417.8	1800	780.5	0	284.964	0	0	433.23	614.012	764.35
b4b	NaN	1800	1291	1800	1800	1800	1800	1486	1471	0	0	719.34	0	0	0	0
b5a	1800	1800	1800	1800	1530.1	1800	1333.3	1800	1800	0	0	0	0	467.54	0	406.023
b5b	298.5	NaN	1800	NaN	NaN	NaN	1800	1662	1374	0	0	0	0	0	0	0
b6a	649.5	585.4	1113	473.8	1091.4	922.4	1324.1	974.7	1437	0	369.602	972.343	0	642.82	763.881	673.095
b6b	336	674.8	1573	1383.2	1075.7	1619	889.2	1774.2	1800	7.656	0	507.409	721.98	689.7	313.501	387.475
b7a	1242	1494.6	1195	1027.8	1800	1288.4	1396.8	1536	1800	599.29	610.8	739.583	1092.1	0	886.059	575.982
b7b	NaN	645.5	270.8	NaN	NaN	400.5	578.8	368.8	759.6	0	0	0	0	0	0	0

Table 10 WBS-H Spectroscopic Differential Stability (stdsub7, 8 omitted due to space)

Band	TaFull	Ta-ch1	Ta-ch2	Ta-ch3	Ta-ch4	Ta-ch5	Ta-ch6	Ta-ch7	Ta-ch8	stdFull	stdsub1	stdsub2	stdsub3	stdsub4	stdsub5	stdsub6
b1a	1174.2	1648.7	1800	1205.4	1800	1800	1287.4	758.7	1206.2	885.086	262.12	0	840.962	0	0	724.926
b1b	1728	1547.3	1800	1446.6	1800	1800	1707.3	1624.3	1800	144	564.97	0	612.107	0	0	160.503
b2a	1800	1800	1800	1583.9	1800	1500.6	1447.9	1800	1673.5	0	0	0	432.2	0	518.634	609.797
b2b	NaN	388.2	1800	1800	1800	1438	1605.8	1800	1800	0	0	0	0	0	511.945	388.5
b3a	780.7	1320.6	1109	956.9	1148	1217.5	1076.3	1153.1	939.4	882.95	665.86	977.292	781.638	766.198	645.896	835.676
b3b	1800	1800	1588	1497.6	1048	1286.8	NaN	1800	1800	0	0	367.195	523.772	0	725.774	0
b4a	1177.8	1044.7	1011.9	1800	1800	1800	1800	1800	1176.5	879.924	1068.2	629.248	0	0	0	0
b4b	982.7	1800	1528.3	861.6	1800	1800	1800	1800	868.3	727.974	0	273.518	0	0	0	0
b5a	1800	1800	1800	1800	1800	1498	1548.9	1800	1800	0	0	0	0	0	427.092	479.801
b5b	1800	1800	1192.5	1127.7	1178	1263	1800	1800	1224	0	0	859.135	950.846	879.641	759.433	0
b6a	1800	1073.2	NaN	1774	1138	845.3	314.7	1185.1	1016.3	0	1027.9	0	36.77	473.762	0	0.071
b6b	1493.9	1800	1800	1567.6	1800	1289.4	1800	1426.5	1403.6	612.3	0	0	464.8	0	457.343	0
b7a	1055.5	963.5	698.4	922.5	991.7	916.8	1137.7	1352.3	1341.6	1052.88	0	651.007	764.582	719.22	645.836	629.473
b7b	NaN	505.9	NaN	256.3	NaN	290	405.7	384.9	363.3	0	0	0	0	0	0	0

Table 11 WBS-V Spectroscopic Differential Stability (stdsub7, 8 omitted due to space)

6 CoP measured FSW results

6.1 Band 1a

For band 1 and 2 the standing wave measurements indicated that the effect of the LO-mixer standing wave is at a sufficient low level that it does not materially affect the mixer performance. Hence any (reasonable) throw may be applied**.**

The length of the FSW measurements is 30 minutes, 15 minutes total / phase. In the simulated spectra below the difference spectrum shows six co-added 5 minutes difference (f1-f2) spectra. The double difference simulates three co-added 5 minute $(f1\text{-}f2)_{on}$ – $(f1\text{-}f2)_{off}$ spectra. If the stability with the 5 minutes is adequate then the off-source subtraction should be perfect.

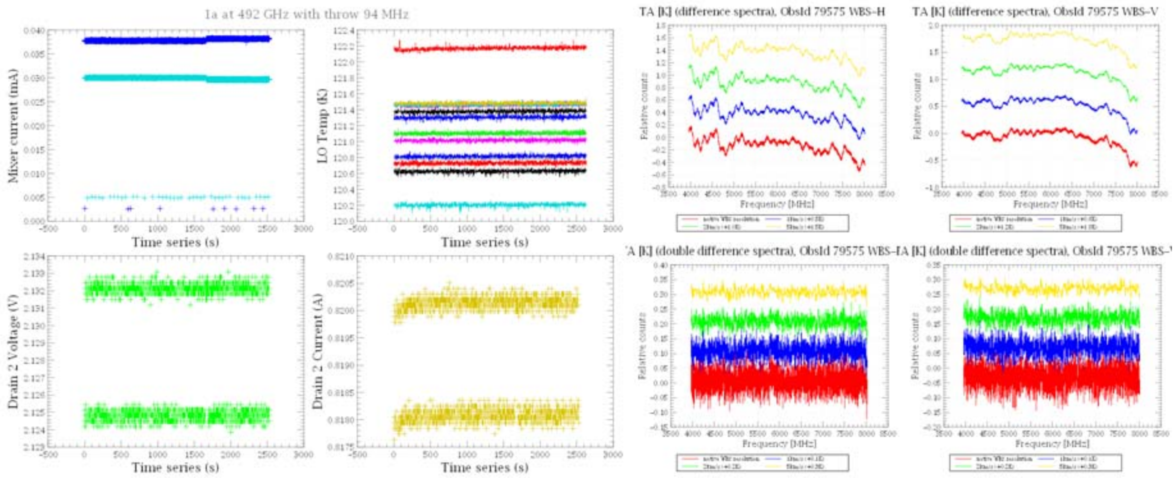

Fig. 7. Testmode_stability_freqswitch_TV_1 against Internal CBB. Throw: -47 MHz, 47MHz, Freq = 492.05 GHz, Obsid: 1342179575, B1a. The CBB measurement shows a pronounced 90MHz SW not present towards the sky, but being very stable. In the HRS the stability is identical to the sky measurement.

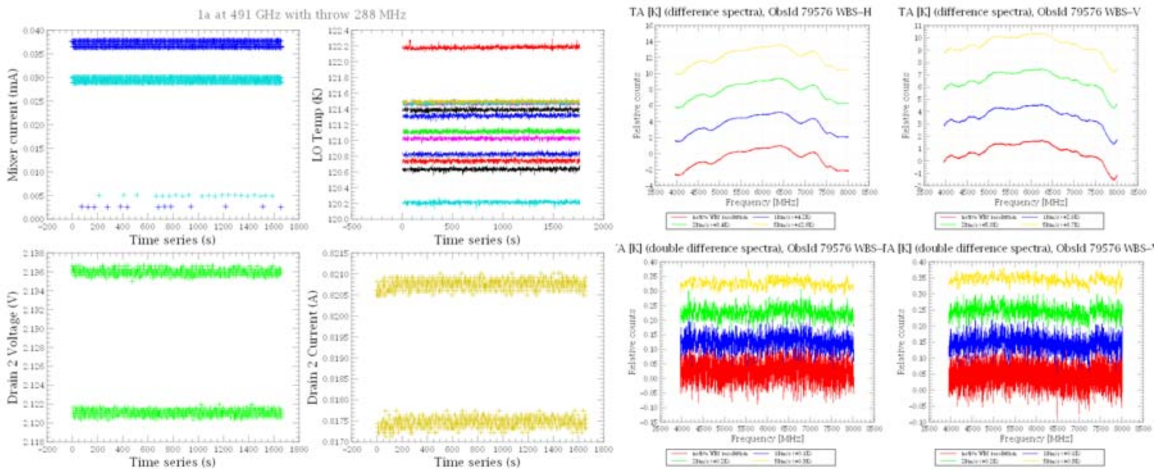

Fig. 8. Testmode_stability_freqswitch_TV_1, Throw: -144 MHz, 144 MHz, Freq = 492.05 GHz , Obsid: 1342179576. The larger throw shows more baseline structure, B1a, however this is against the sky rather then the internal CBB (Fig. 7).

Important FSW HK features to track are: the modulation in Vd2 for each frequency throw, and the modulation in mixer current (dark blue is H, cyan is V). If the throw is picked properly as described in section 1, or as is the case for bands 1, 2 where it does not matter, then there should not be a modulation of the mixer current and Vd2. However the tuning mechanism will attempt to keep Imix constant, and thus we will find that occasionally Vd2 will adjust itself (for each phase). For Fig 1 below we see that Imix (H & V) is constant and so is Vd2, in agreement with the physical reality that there is ~ 60dB of isolation between the mixer and the local oscillator. Of course this is very band dependent. IN case of the diplexer bands there will be a much stronger coupling between LO and mixer. However with the additions of optical attenuators in the LO path this is to some extend (LO band dependent) mitigated.

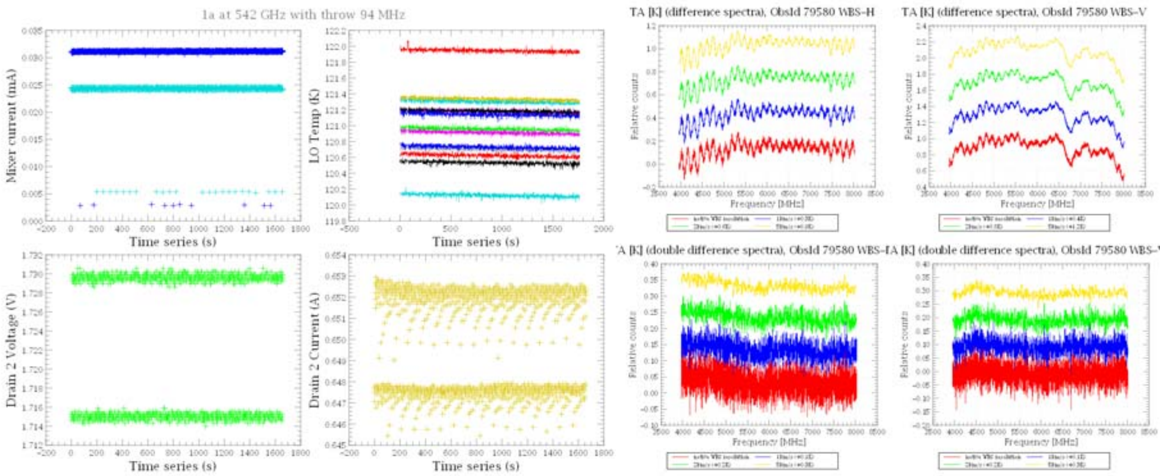

Fig. 9. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47MHz, Freq = 542.88 GHz, Obsid: 1342179580. Imix and Vd2 are constant. Note the Id2 time constant, B1a.

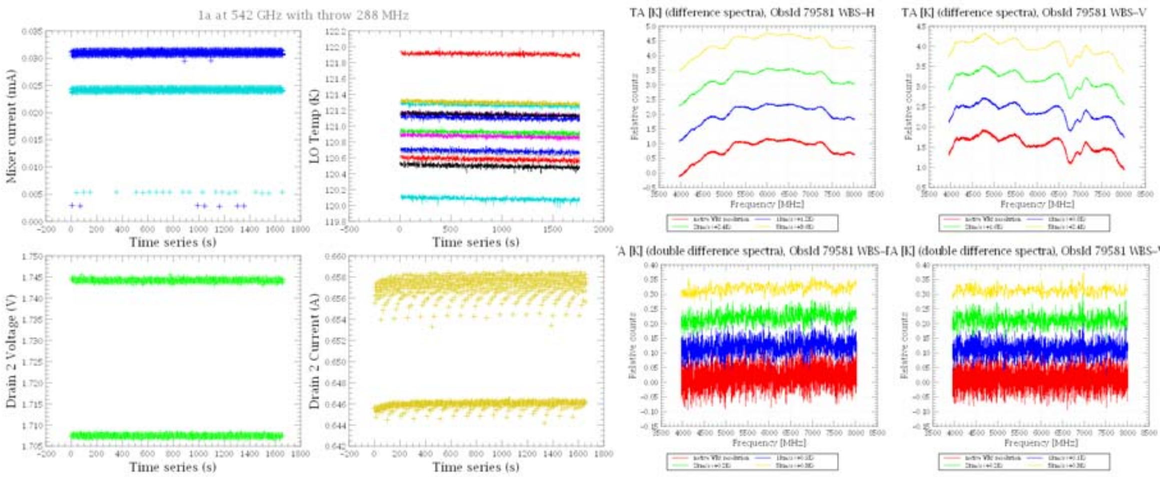

Fig. 10. Testmode_stability_freqswitch_TV_2, Throw: -144 MHz, 144 MHz, Freq = 542.88 GHz, Obsid: 1342179581, B1a. Imix and Vd2 are constant. Note the Id2 time constant. At this frequency the baselines look better then with the smaller throws. This is related to how well Vd2 can be kept constant (for an ideal throw Imix is constant, but so is the Power Amplifier bias (Vd2, Id2) → no thermalization issues between throws.

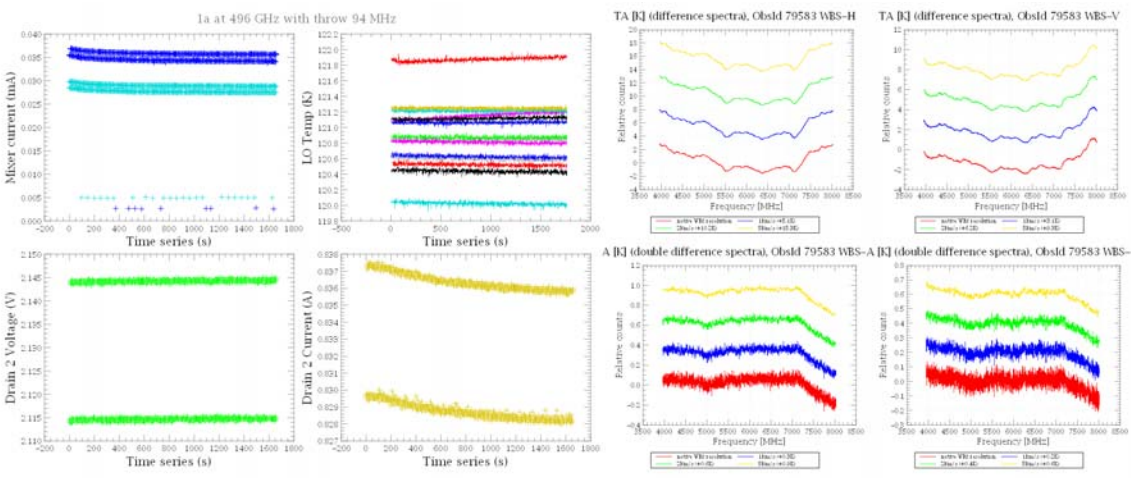

Fig.11. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47MHz, Freq = 496.96 GHz, Obsid: 1342179583, **1a** Imix for both H. & V is not constant, and neither is the power amplifier dissipation (Vd2 x Id2). The result is a distorted baseline.

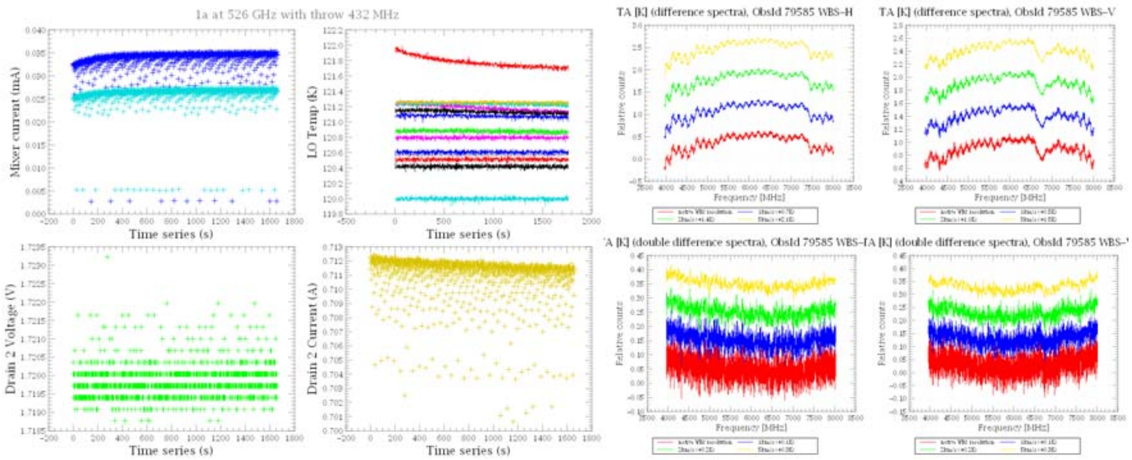

Fig.11. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47MHz, Freq = 526.88GHz, Obsid: 1342179585, B1a. Imix for both H. & V has drop outs, clearly caused by trouble in the PA bias. Cause ??

6.2 Band 1b

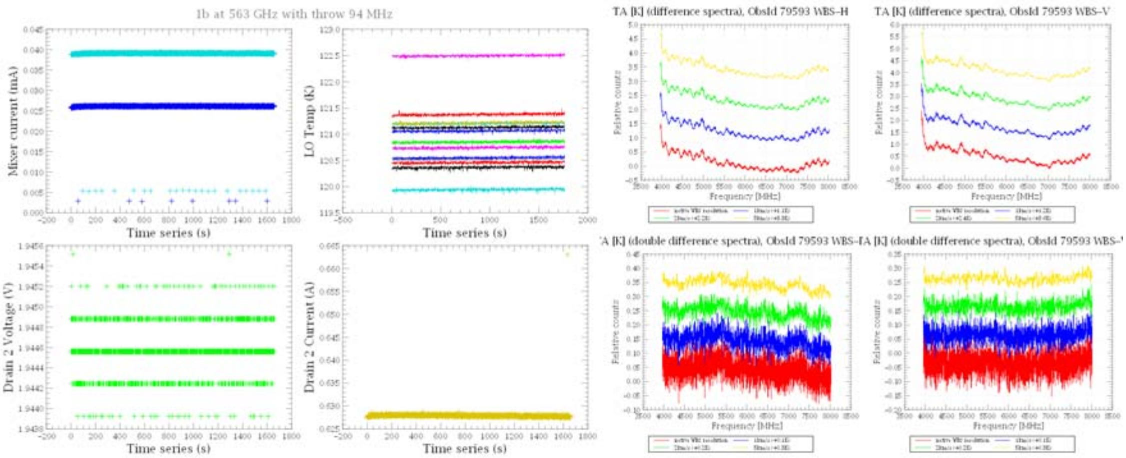

Fig.12. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 563.74GHz, Obsid: 1342179593, B1b. It is cleat that Vd2 has to switch between two states, e.g. there is a thermal non-equilibrium. Thoug the mixer current is constant for both H & V, the baselines look quite poor due to this effect. → Keep the power dissipation in the PA constant. (Can be done by mapping out the standing wave as described in section 1).

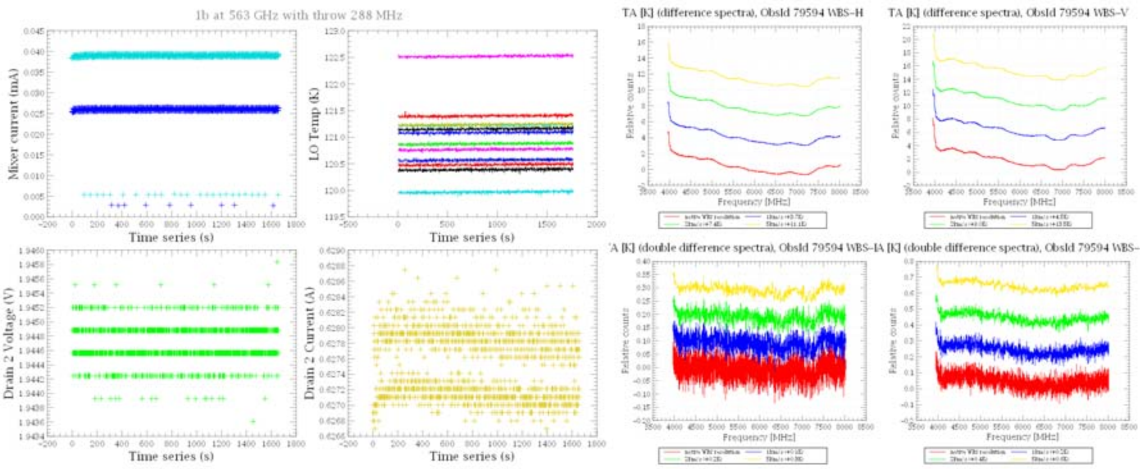

Fig.13. Testmode_stability_freqswitch_TV_2, Throw: -144 MHz, 144 MHz, Freq = 563.74GHz, Obsid: 1342179594, B1b. It is cleat that Vd2 has to switch between two states, e.g. there is a thermal non-equilibrium. Thoug the mixer current is constant for both H & V, the baselines look quite poor due to this effect. → Keep the power dissipation in the PA constant. (Can be done by mapping out the standing wave as described in section 1)

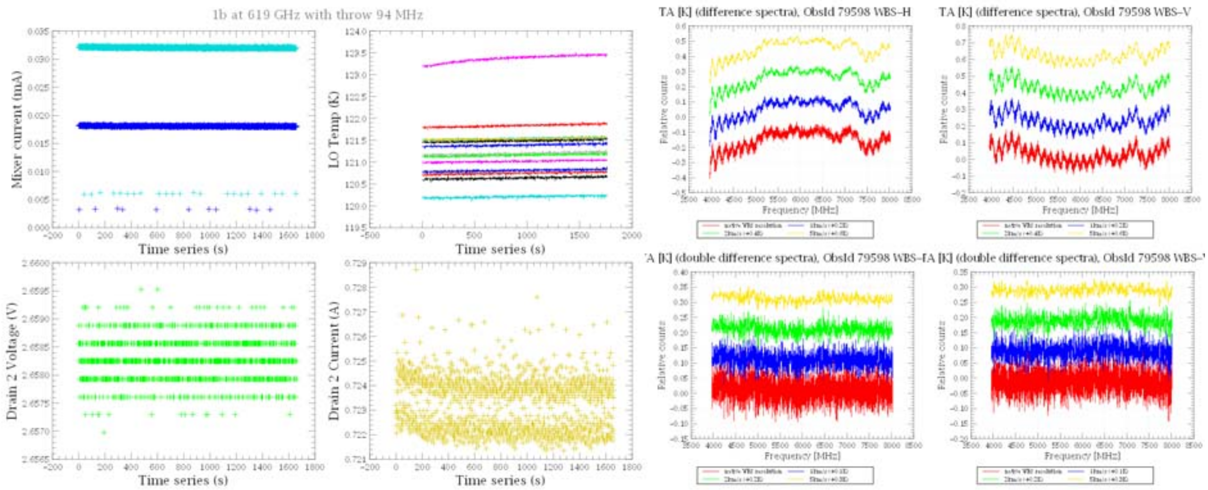

Fig.14. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 614.21GHz, Obsid: 1342179598, B1b It is cleat that Vd2 has to switch between two states, with occasional drop spikes. Clearly there is a tuning problem here. Also since there is a thermal non-equilibrium. the baselines are somewhat distorted. → Keep the power dissipation in the PA constant. (Can be done by mapping out the standing wave as described in section.

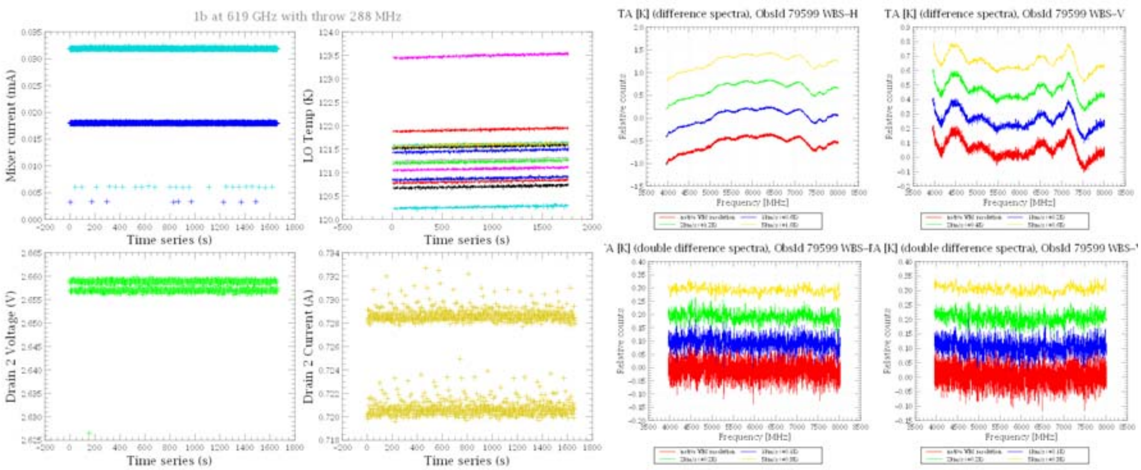

Fig.15. Testmode_stability_freqswitch_TV_2, Throw: -144 MHz, 144 MHz, Freq = 614.21GHz, Obsid: 1342179599, B1b. VD2 is constant and Id2 has just occasional mistuning. The double difference baselines looks therefore somewhat reasonable. Note that this is a bit of good fortune as we did not really map the precise phase/amplitude as well as drift of the LO at this frequency.

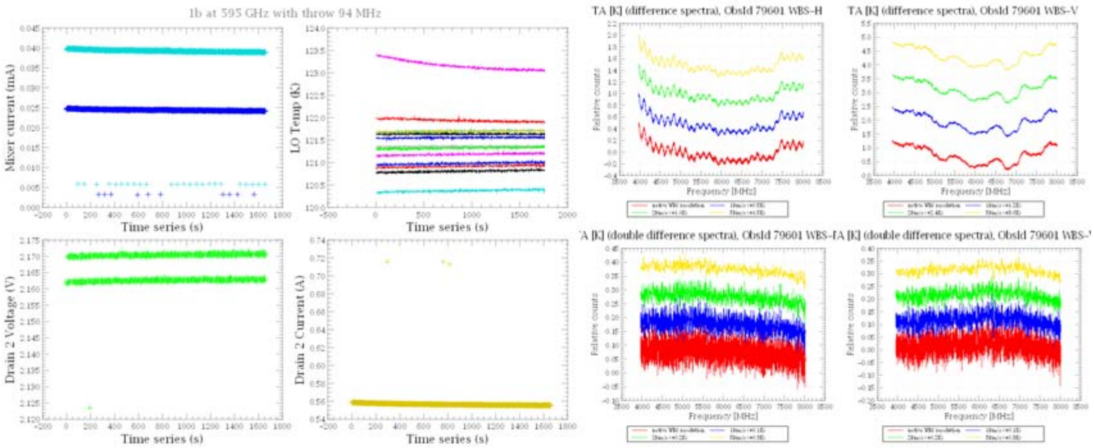

Fig.14. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 595.33 GHz, Obsid: 1342179601, B1b. Vd2 and Imix look constant. Unclear why the baselines have structure, except that the system stability time is poor at this frequency.

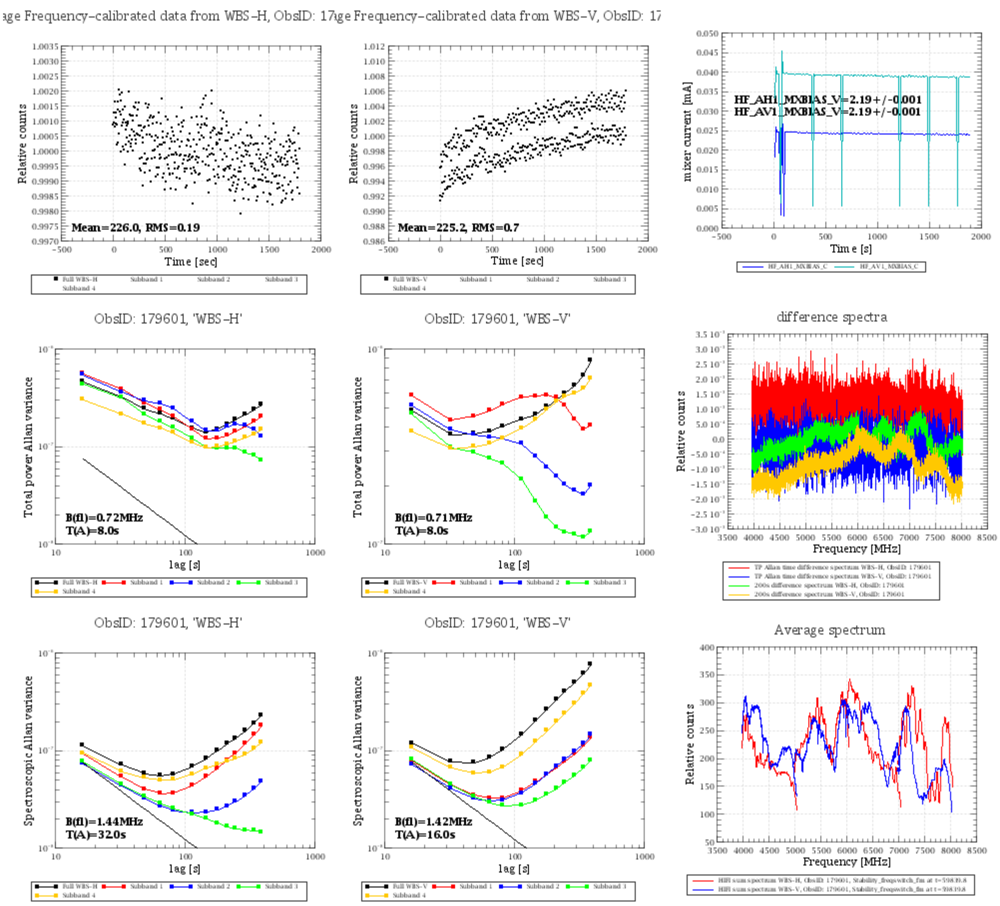

Fig. 15. System stability of Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 595.33 GHz, Obsid: 1342179601, B1b. Not took great, resulting in FSW baseline distortion.

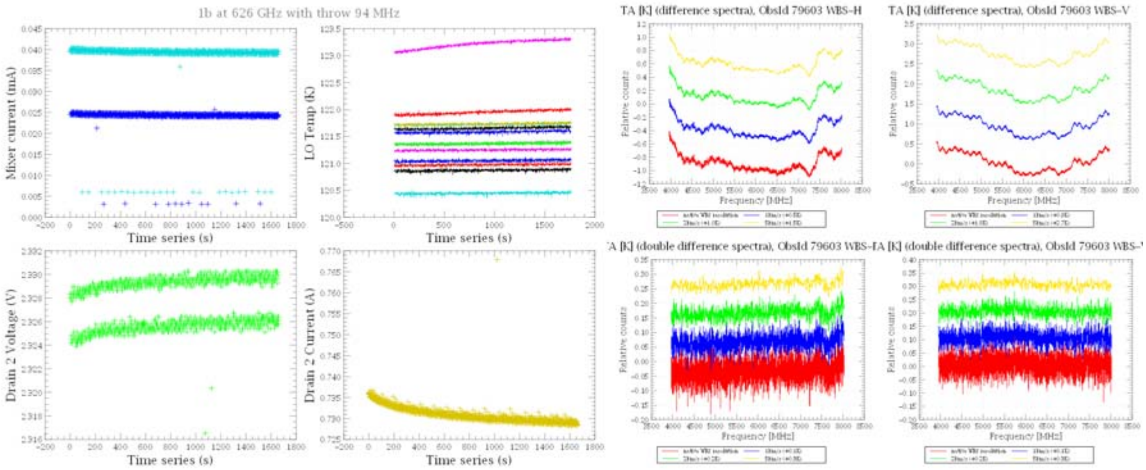

Fig.16. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 626.97GHz, Obsid: 1342179601, B1b. Vd2 and Imix are reasonably constant except for a thermal drift in the PA.

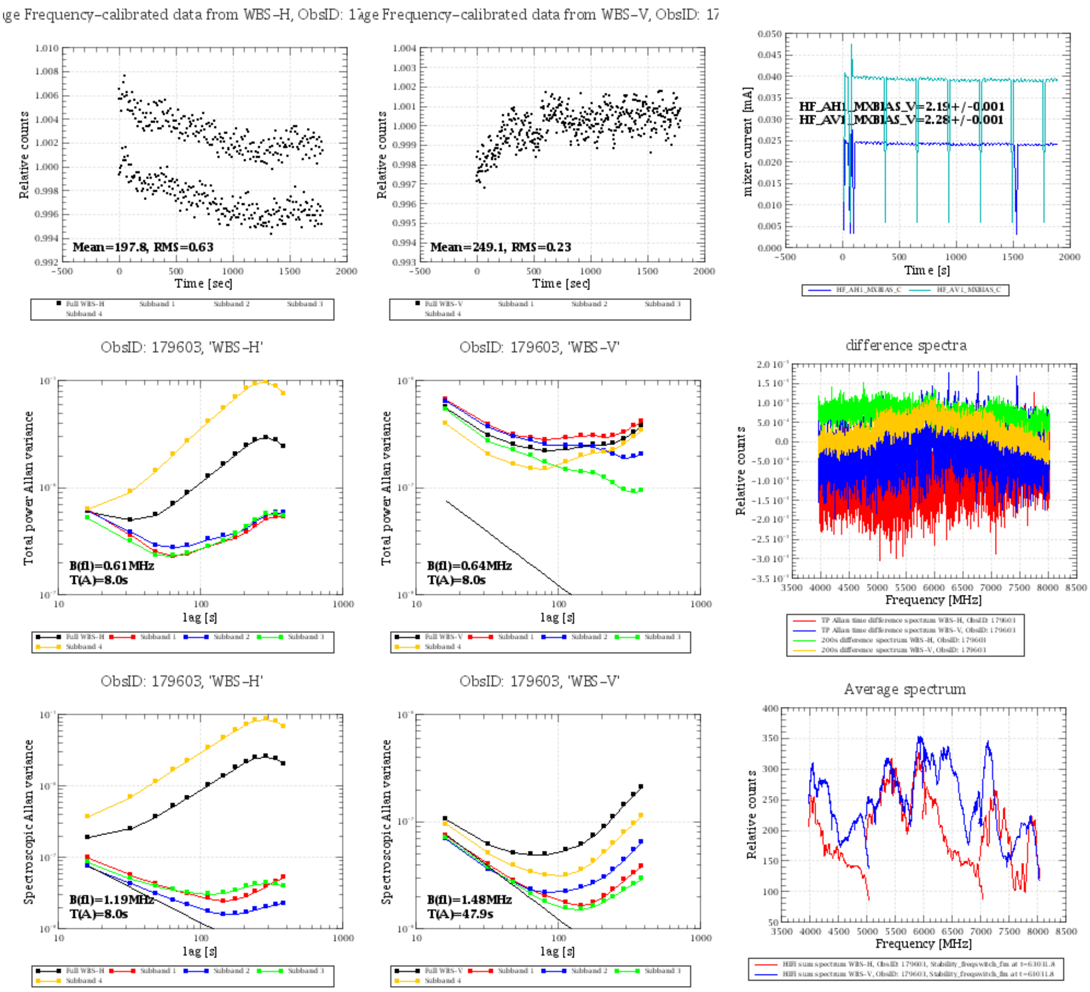

Fig.17. System stability Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 626.97GHz, Obsid: 13421779601, B1b. Vd2 and Imix are reasonably constant except for a thermal drift in the PA..

6.3 Band 2a

Also for B2, the frequency throw is rather arbitrary as the LO-mixer standing wave is not dominant (few percent of the mixer current) .

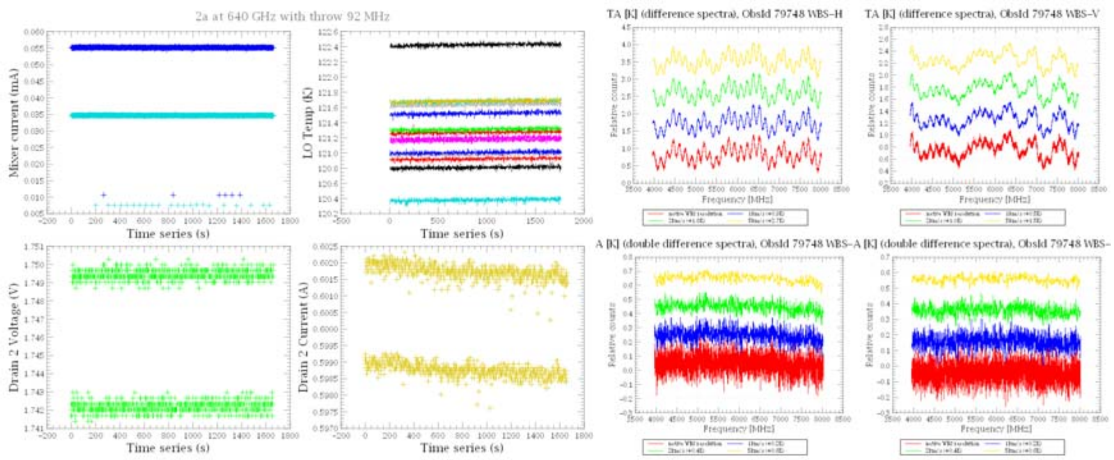

Fig.18. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 640.97GHz, Obsid: 1342179748, B2a. Vd2 and Imix look constant. Baseline ok.

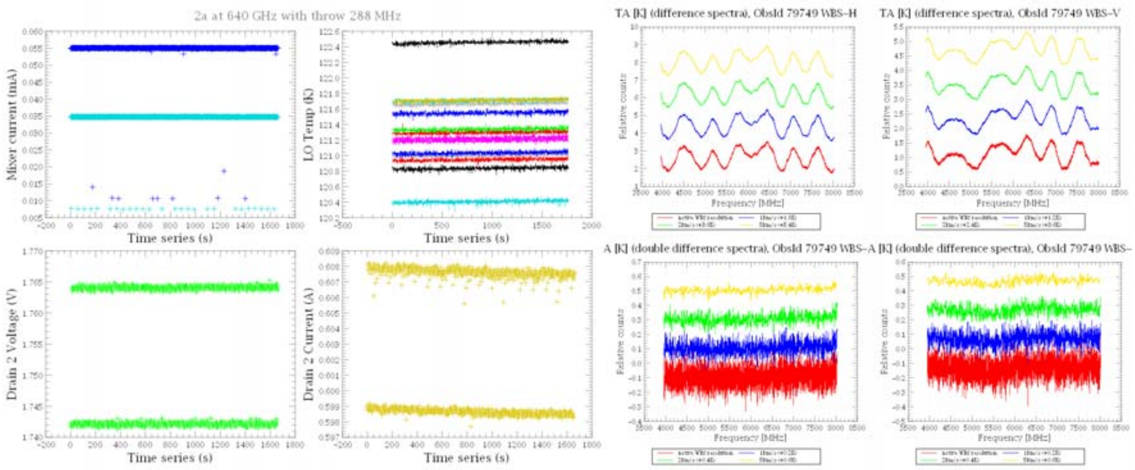

Fig.19. Testmode_stability_freqswitch_TV_2, Throw: -144 MHz, 144 MHz, Freq = 640.97GHz, Obsid: 1342179749, B2a. Vd2 and Imix look constant. Baseline ok. (throws more or less arbitrary in mixer B1, B2).

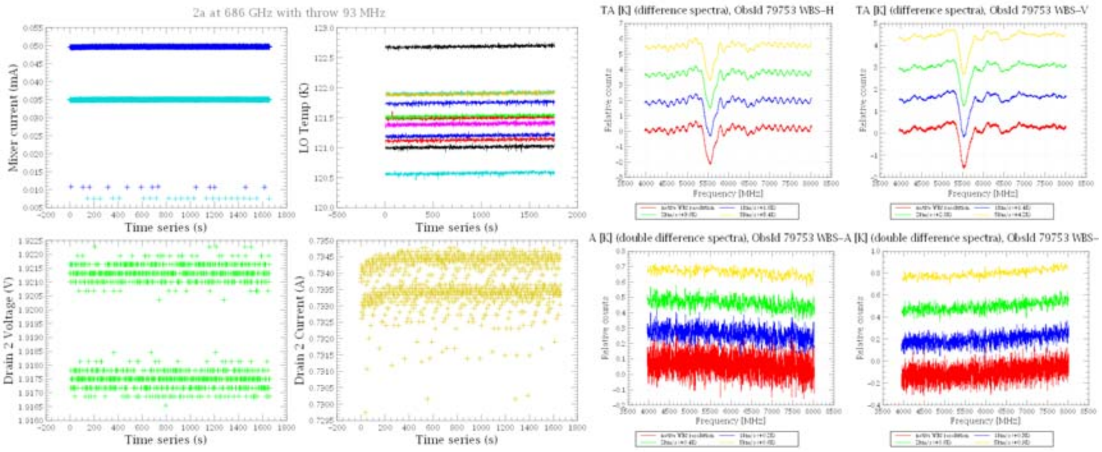

Fig.20. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 686.86 GHz, Obsid: 1342179753, B2a Modulation on Vd2, Imix look constant. Baseline ok. Spikes may indicate tuning probe (common occurrence as in TB/TV).

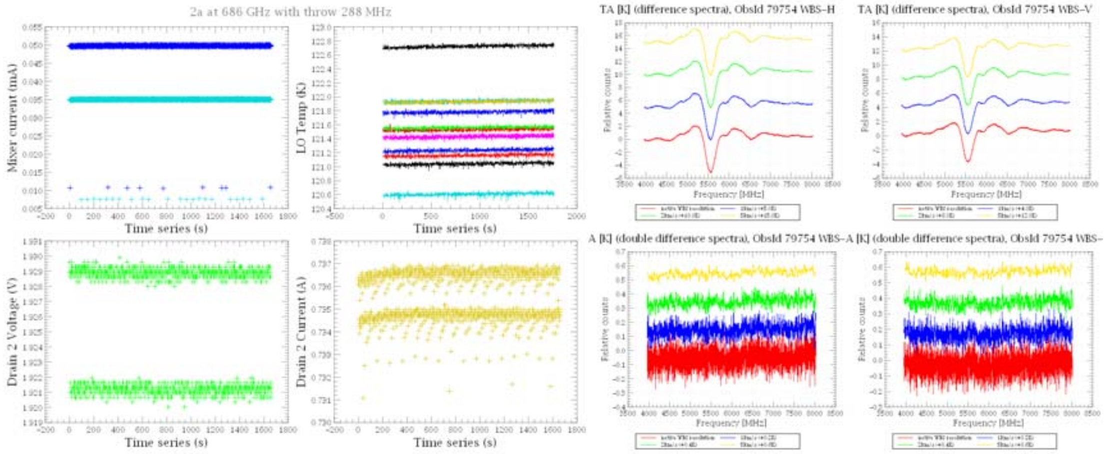

Fig.21. Testmode_stability_freqswitch_TV_2, Throw: -144 MHz, 144 MHz, Freq = 686.86 GHz, Obsid: 1342179754, B2a. Modulation on Vd2, Imix look constant. Baseline ok. Spikes may indicate tuning probe (common occurrence as in TB/TV).

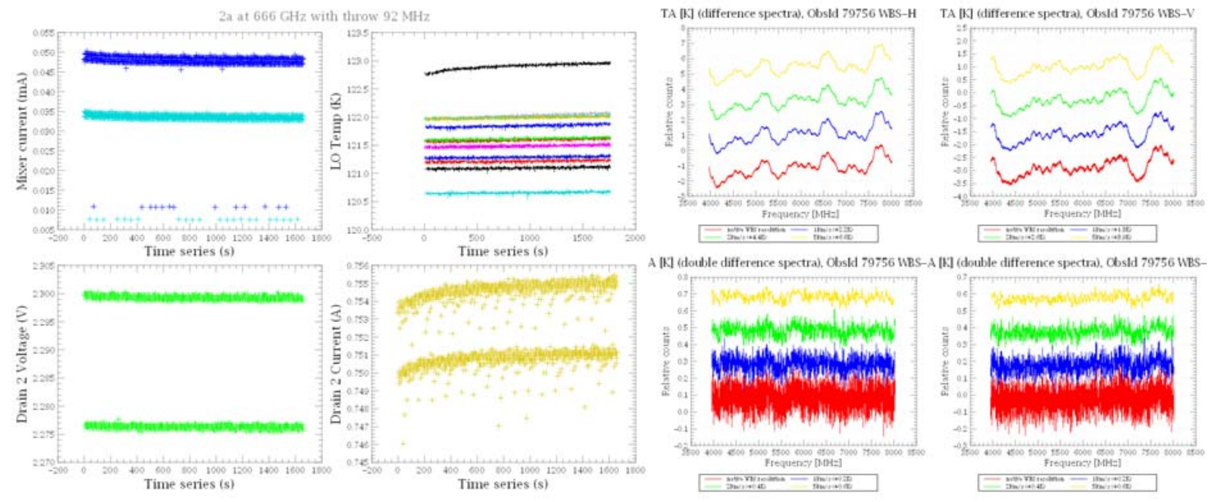

Fig.21. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 666.16 GHz, Obsid: 1342179756, B2a. Modulation on Vd2, Imix look constant. Baseline ok. Spikes may indicate tuning probe (common occurrence as in TB/TV).

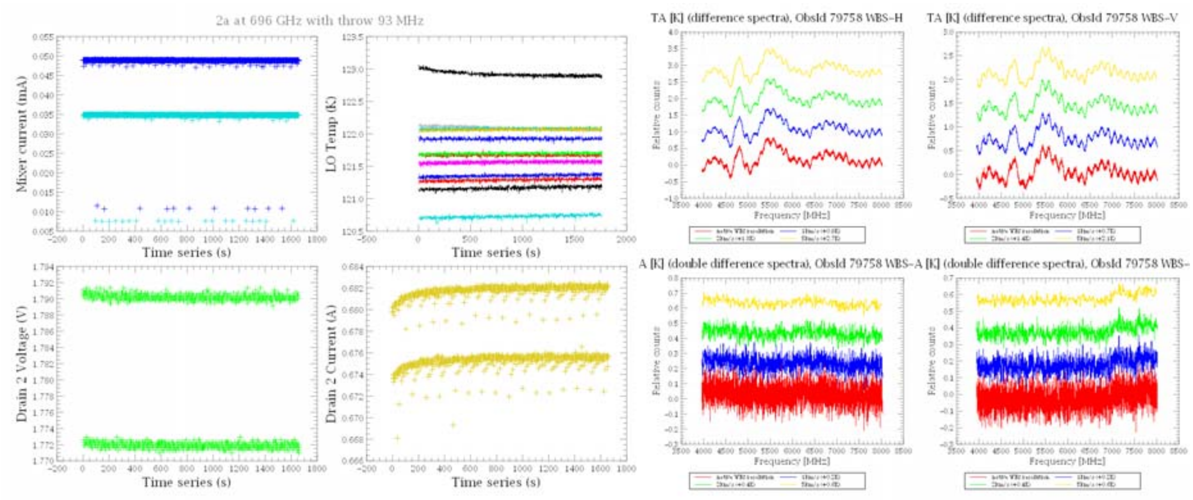

Fig.22. Testmode_stability_freqswitch_TV_1, Throw: -144 MHz, 144 MHz, Freq = 666.16 GHz, Obsid: 1342179758, B2a. Modulation on Vd2, Imix look constant. Baseline ok. Spikes may indicate tuning probe (common occurrence as in TB/TV).

6.4 Band 2b

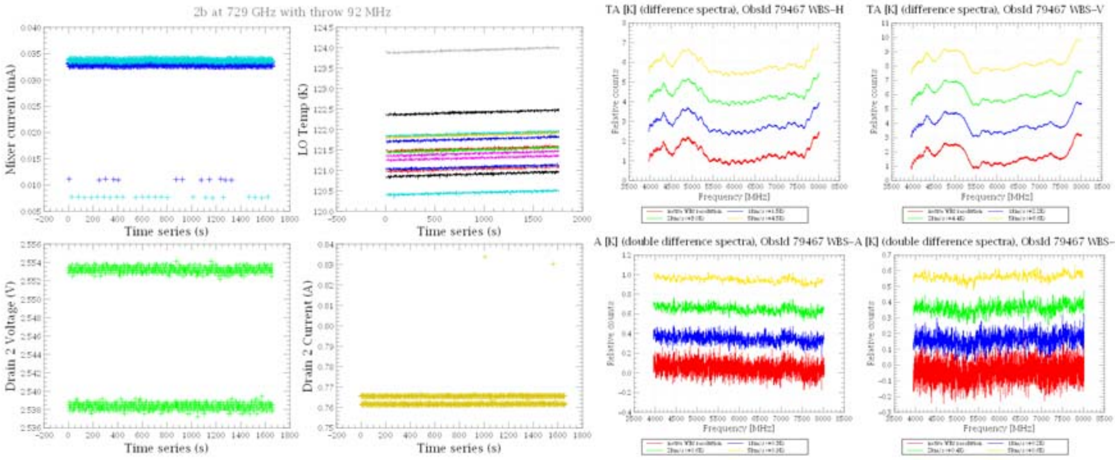

Fig.23. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 729.52 GHz, Obsid: 1342179467, B2b. Modulation on Vd2, Imix look constant. Baseline ok.

Obsid 1342179468 failed due to LO power drop out (green limit?) at t=400s.

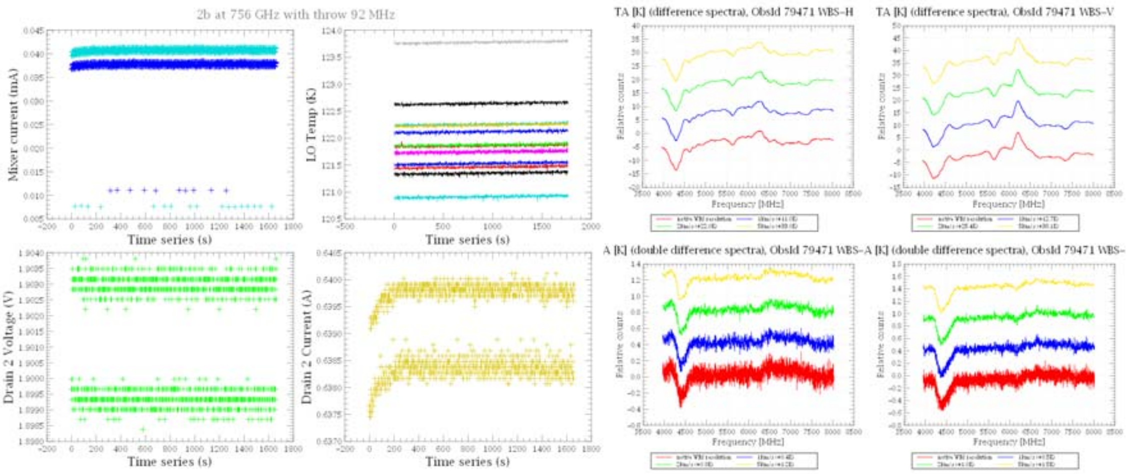

Fig.24. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 756.83GHz, Obsid: 1342179471, B2b. Modulation on Vd2, Id2, Imix looks constant. Baseline distortion due to thermal instability.

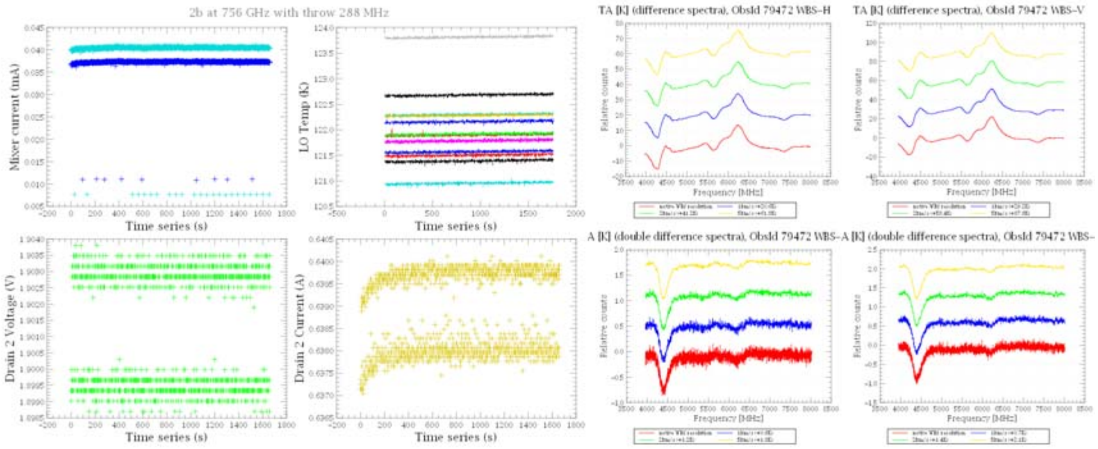

Fig.25. Testmode_stability_freqswitch_TV_2, Throw: -144 MHz, 144 MHz, Freq = 756.83GHz, Obsid: 1342179472. Modulation on Vd2, Id2, Imix looks constant. Baseline distortion due to thermal instability.

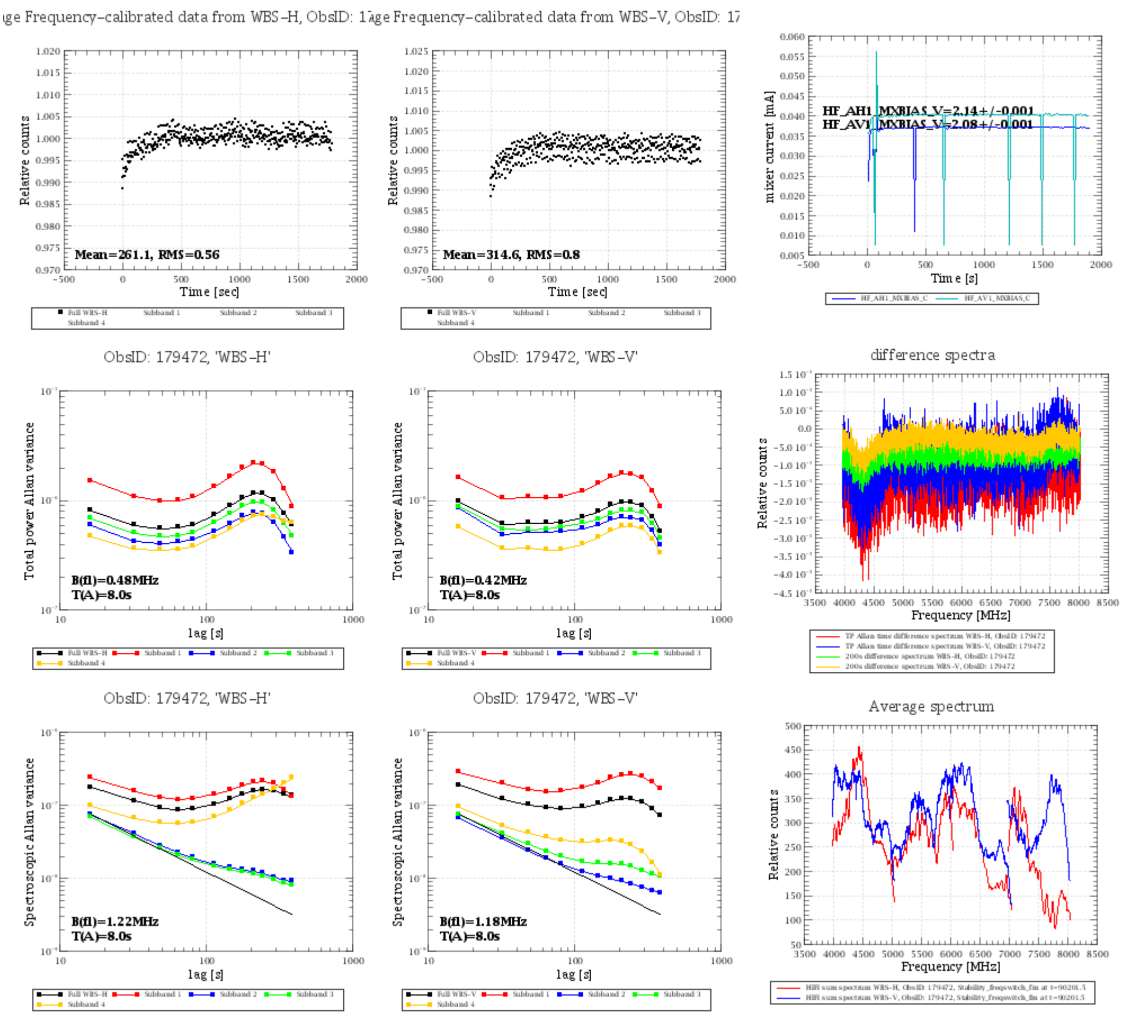

Fig. 26. Testmode_stability_freqswitch_TV_2, Throw: -144 MHz, 144 MHz, Freq = 756.83GHz, Obsid: 1342179472, B2b. System stability looks ok. → Problem with thermal stability PA, need to keep Vd2, Id2 constant.

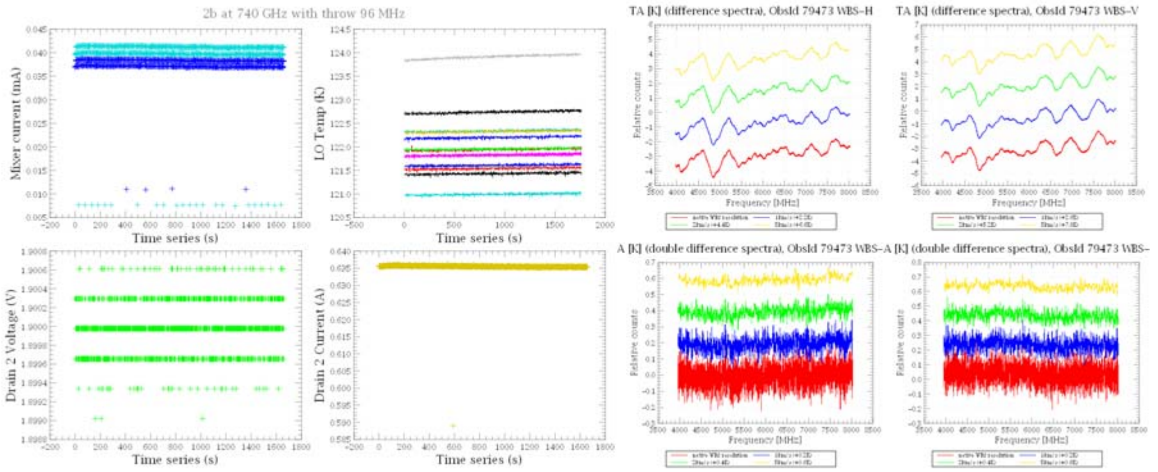

Fig.27. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 740.52 GHz, Obsid: 1342179473, B2b. Some modulation on Vd2, Id2, Imix looks constant. Baseline ok.

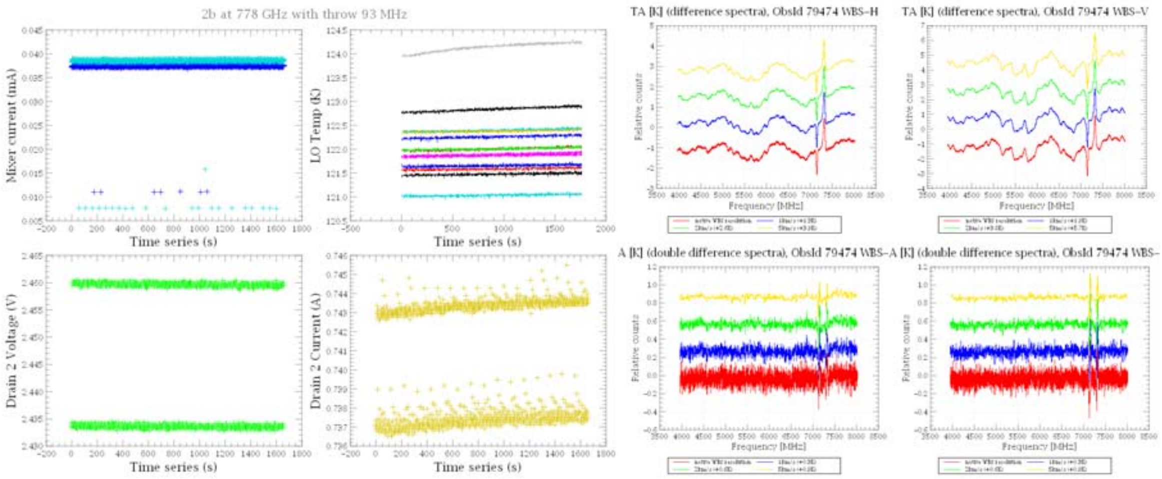

Fig.28. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 778.64 GHz, Obsid: 1342179474, B2b. Some modulation on Vd2, Id2, Imix looks constant. Baseline ok. Spikes on Imix back.

6.5 Band 3a

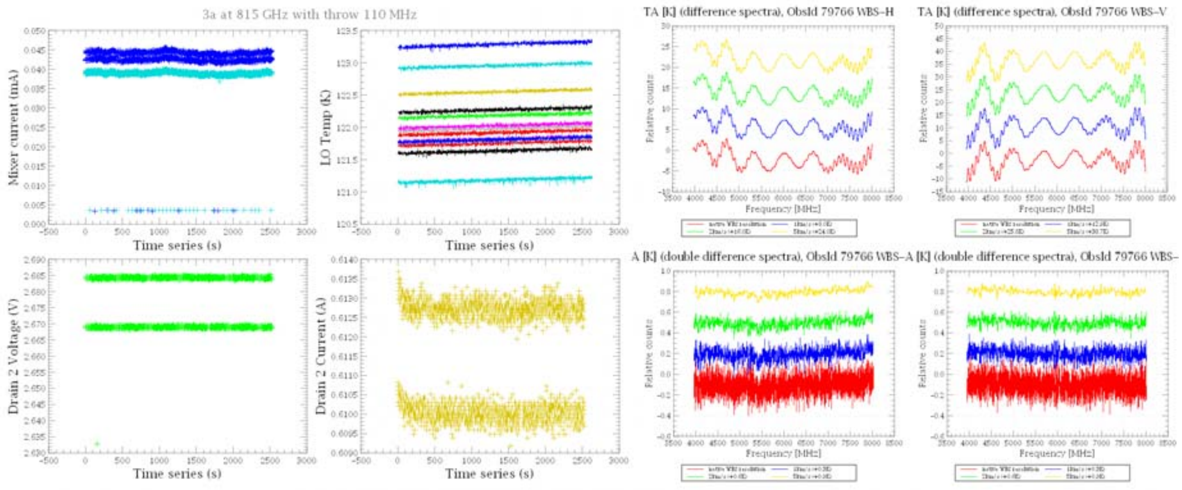

Fig.29. Testmode_stability_freqswitch_TV_1 on Int. CBB, Throw: -75 MHz, 35 MHz, Freq = 815.14 GHz, Obsid: 1342179766, B3a. Imix H (blue) a small modulation, Cyan (V) is constant. Vd2, Id2 constant. ➔ Baseline V ok (right), H has a slight distortion. There is a strong 90 and 650 MHz standing waves in both FSW measurements, However no significant difference between sky and CBB measurement.

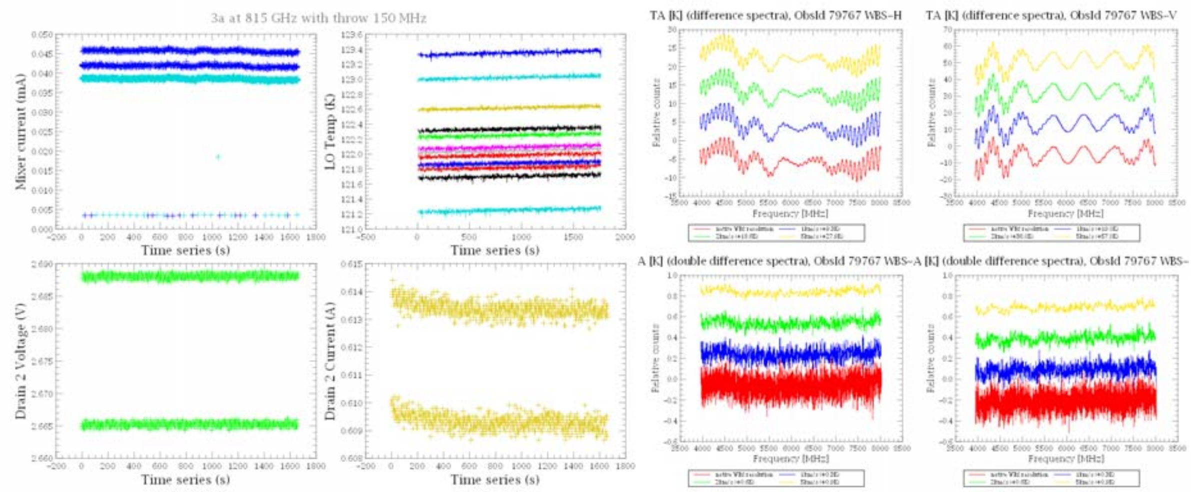

Fig.30. Testmode_stability_freqswitch_TV_2, Throw: -75 MHz, 75 MHz, Freq = 815.14 GHz, Obsid: 1342179767, B3a. Imix tuned for V, but not for H. There is a strong 90 and 650 MHz standing wave.

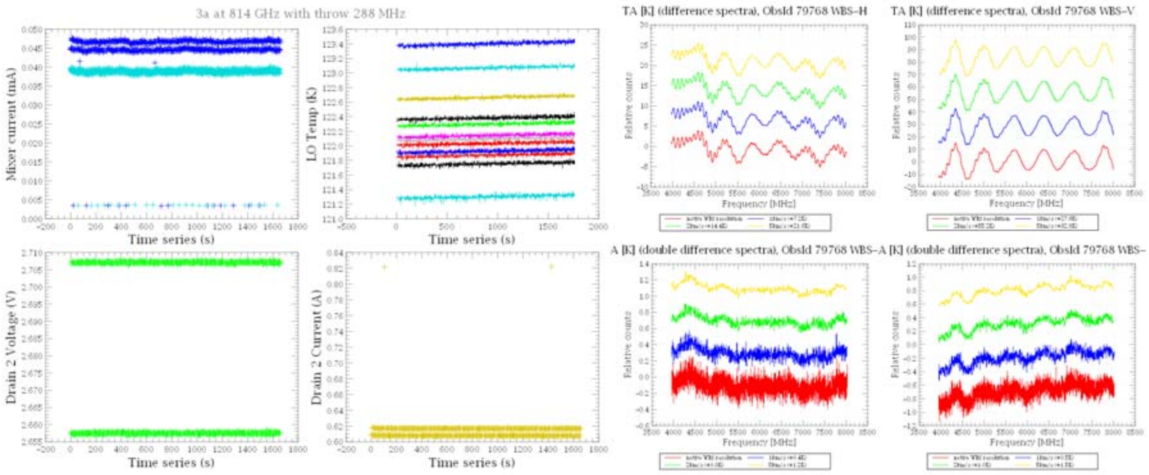

Fig.30. Testmode_stability_freqswitch_TV_3, Throw: -144 MHz, 144 MHz, Freq = 815.14 GHz, Obsid: 1342179768, B3a. Default throw large throw, NOT taking into account the phase/amplitude of the standing wave profile. → significant baseline distortion.. Probably too much LO drift over 288 MHz. There is a strong 650 MHz standing wave, and weak 90 MHz standing wave that gets subtracted by double differencing.

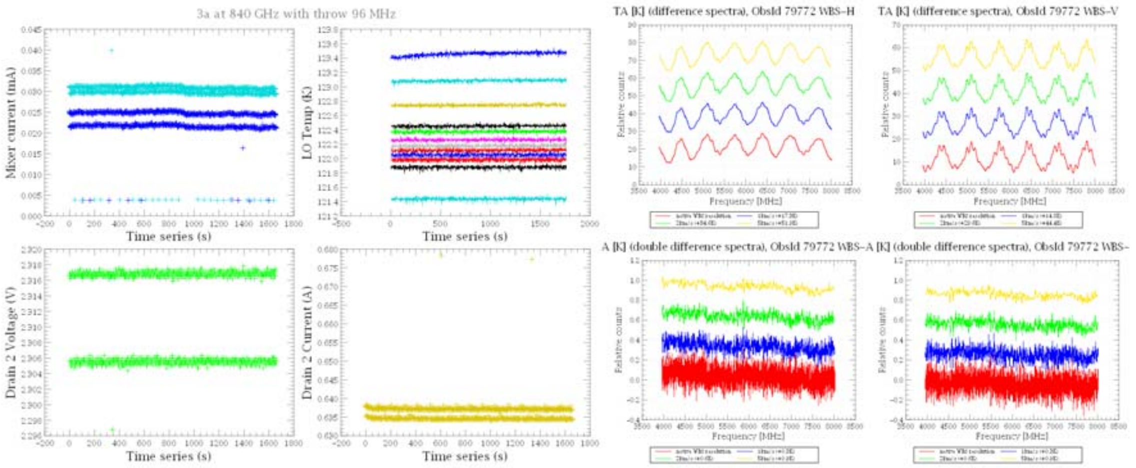

Fig.31. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 840.87 GHz, Obsid: 1342179772, B3a. Default throw, NOT taking into account the phase/amplitude of the standing wave profile. → Vd2constant, though Imix some modulation. Differential stability adequate to allow off source subtraction. There is a strong 650 MHz standing wave, and weak 90 MHz standing wave that gets subtracted by double differencing.

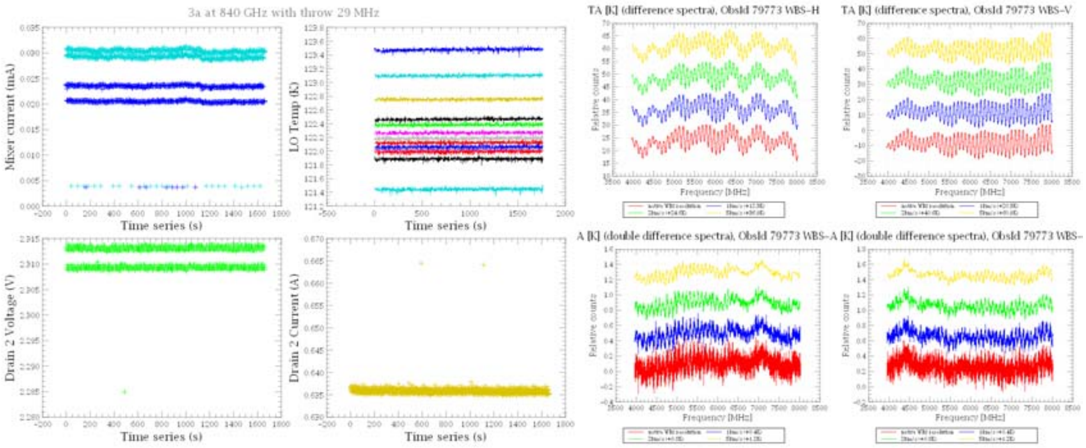

Fig.32. Testmode_stability_freqswitch_TV_2, Throw: -15 MHz, 15 MHz, Freq = 840.87 GHz, Obsid: 1342179773, B3a. Small fixed throw, NOT taking into account the phase/amplitude of the standing wave profile. → Vd2, I mix constant, though Imix is not quite constant and unbalanced between H & V.The 94 MHz modulation is clearly visible, giving poor double difference baseline subtraction. → do not use small throws, stay on default multiple of the Lo-mixer standing wave throw or carefully selected asymmetric throw. There is a strong 650 MHz and 90 MHz standing wave that gets subtracted by double differencing.

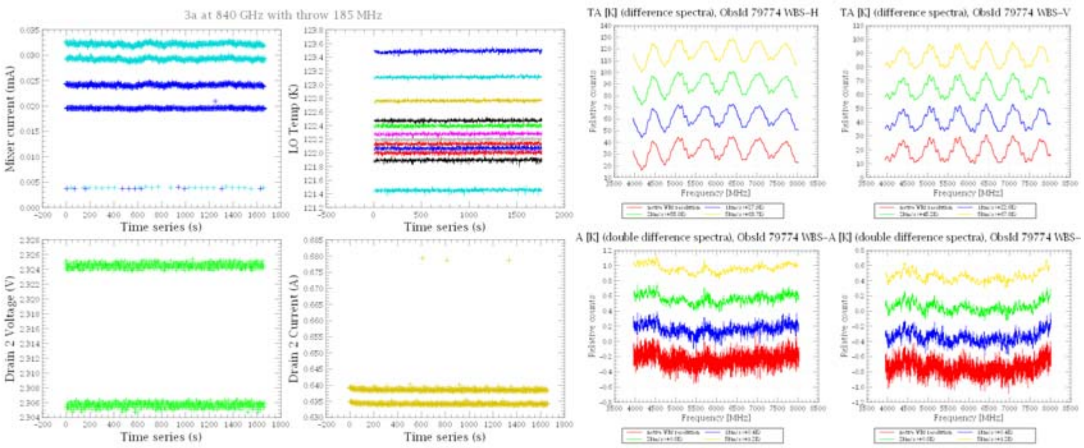

Fig.33. Testmode_stability_freqswitch_TV_3, Throw: -94 MHz, 94 MHz, Freq = 840.87 GHz, Obsid: 1342179774, B3a. Default throw, NOT taking into account the phase/amplitude of the standing wave profile. → Vd2, Id2 constant. Imix is not constant. → poor baseline subtraction. There is a strong 650 MHz standing wave, and weak 90 MHz standing wave that gets subtracted by double differencing.

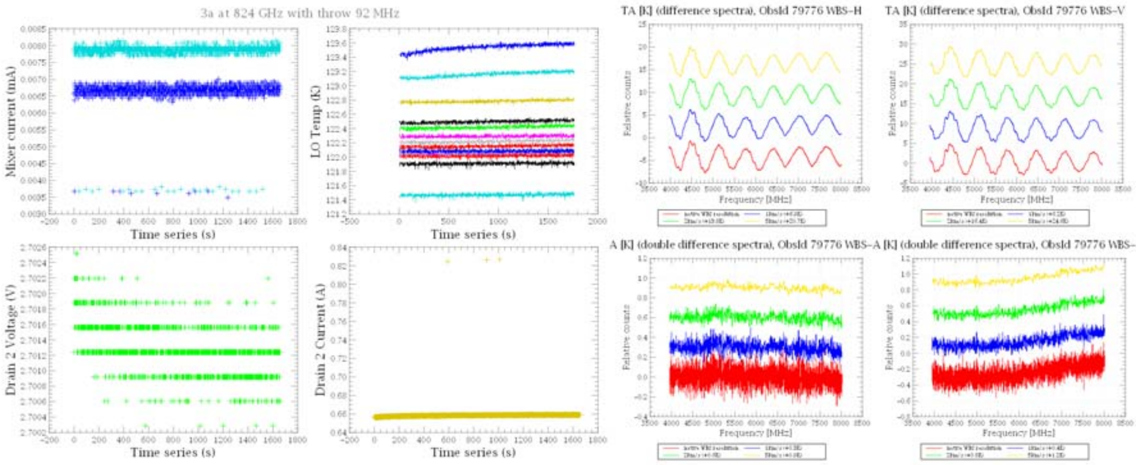

Fig.34. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 824.33GHz, Obsid: 1342179776, B3a. Default throw, NOT taking into account the phase/amplitude of the standing wave profile. Imix constant, though some problems with the tuning of Vd2. (is the tuning algoritm stable?) → some baseline distortion. Because Imix is constant the baseline subtraction is reasonable. There is a strong 650 MHz standing wave, and weak 90 MHz standing wave that gets subtracted by double differencing.

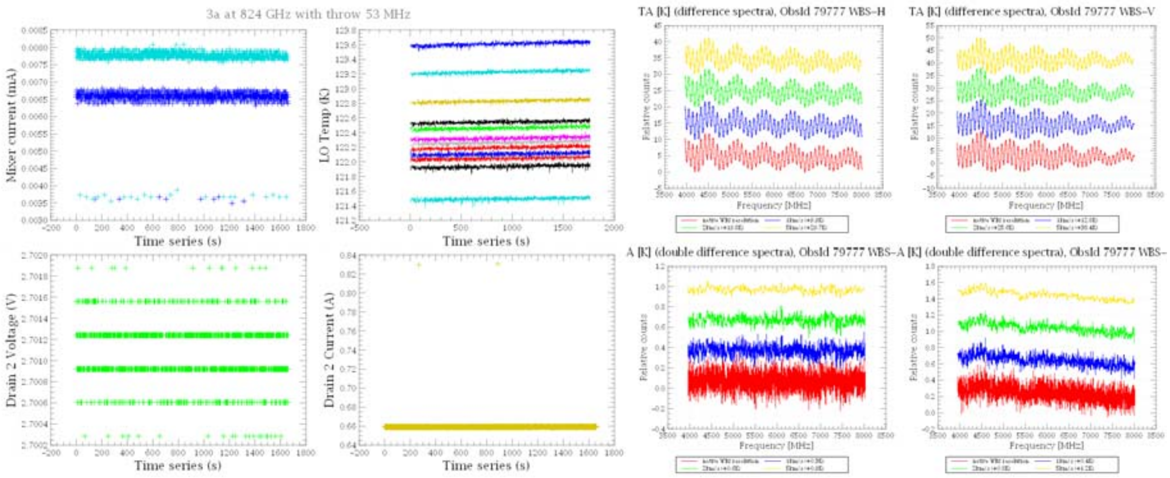

Fig.35. Testmode_stability_freqswitch_TV_3, Throw: -52 MHz, 0 MHz, Freq = 824.33GHz, Obsid: 1342179777, B3a. Asymmetric throw, taking into account the phase/amplitude of the standing wave profile. Imix constant, though there are some drop outs. → problems with the tuning of Vd2. (Is the tuning algorithm stable?) . There is a strong 650 MHz standing wave, and weak 90 MHz standing wave that gets subtracted by double differencing.

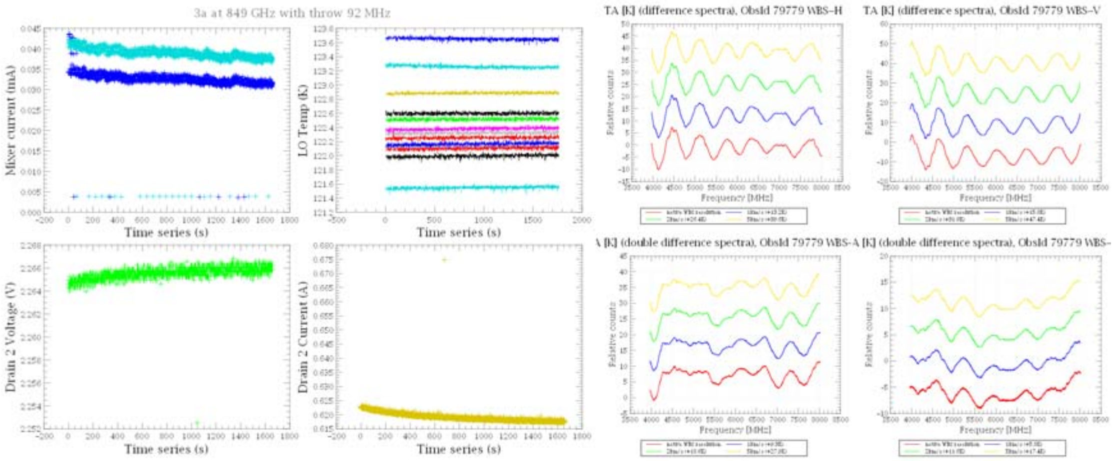

Fig.36. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 849.35 GHz, Obsid: 1342179779, B3a. Default throw, not taking into account the phase/amplitude of the standing wave profile. Imix constant, though some problems with the tuning of Vd2. (Is the tuning algorithm stable?) .

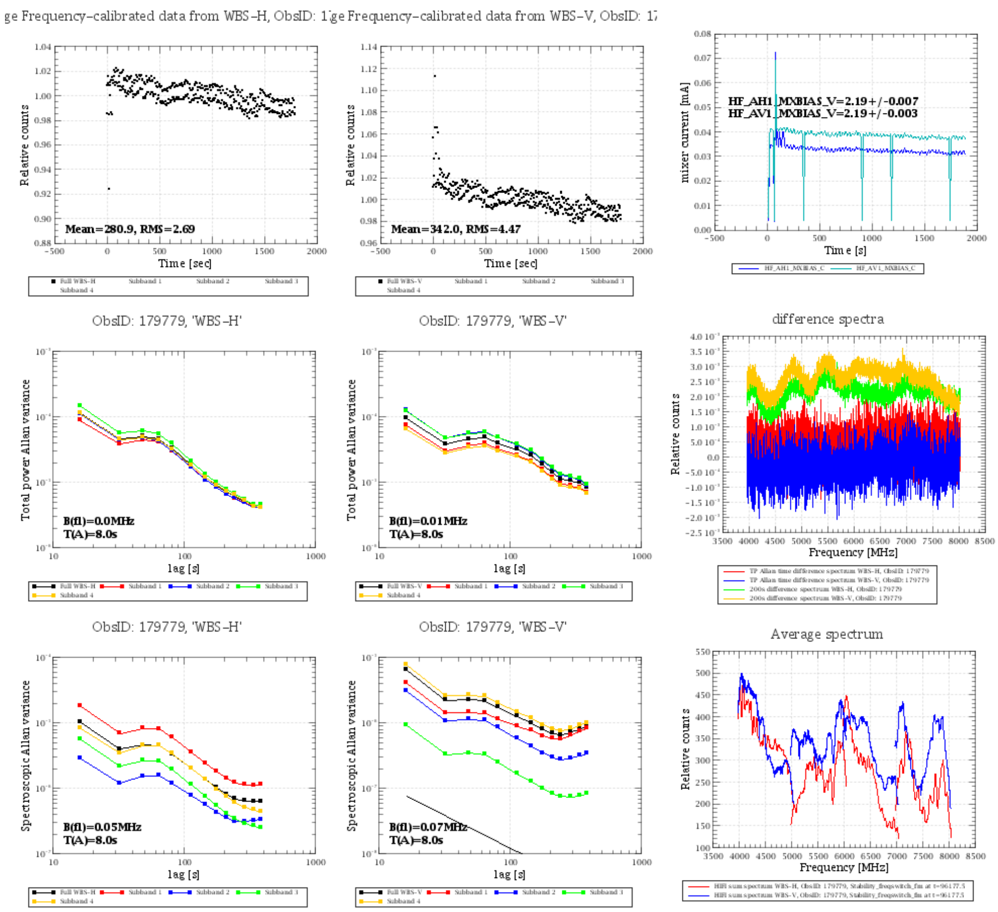

Fig. 37. Looks like there is a problem in the first 30 seconds affecting the analyses. → rerun analyses.

6.6 Band 3b

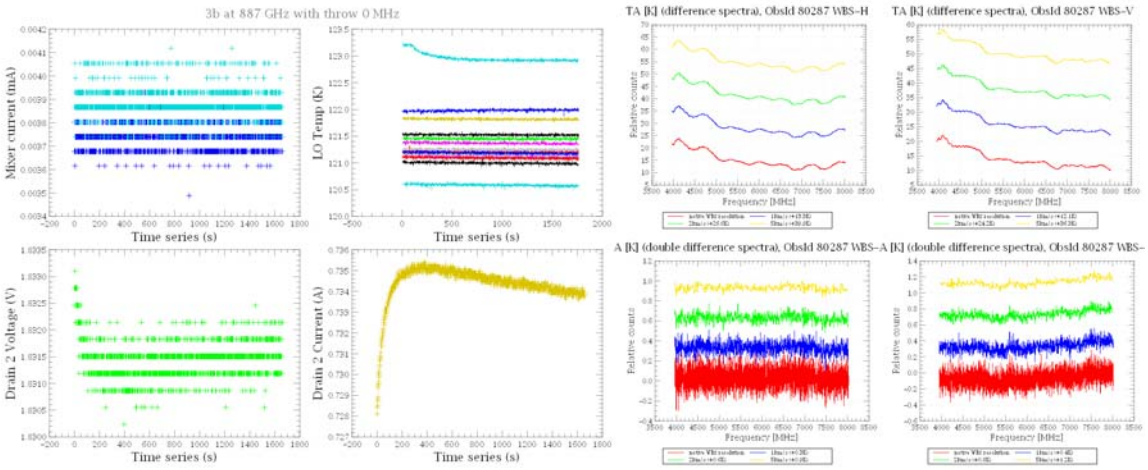

Fig.38. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 887.84 GHz, Obsid: 1342180287, B3b. Default throw, NOT taking into account the phase/amplitude of the standing wave profile. Tuning problems. Surprisingly the baseline looks very good. Stable system. but improve robustness of the FSW tuning routine.

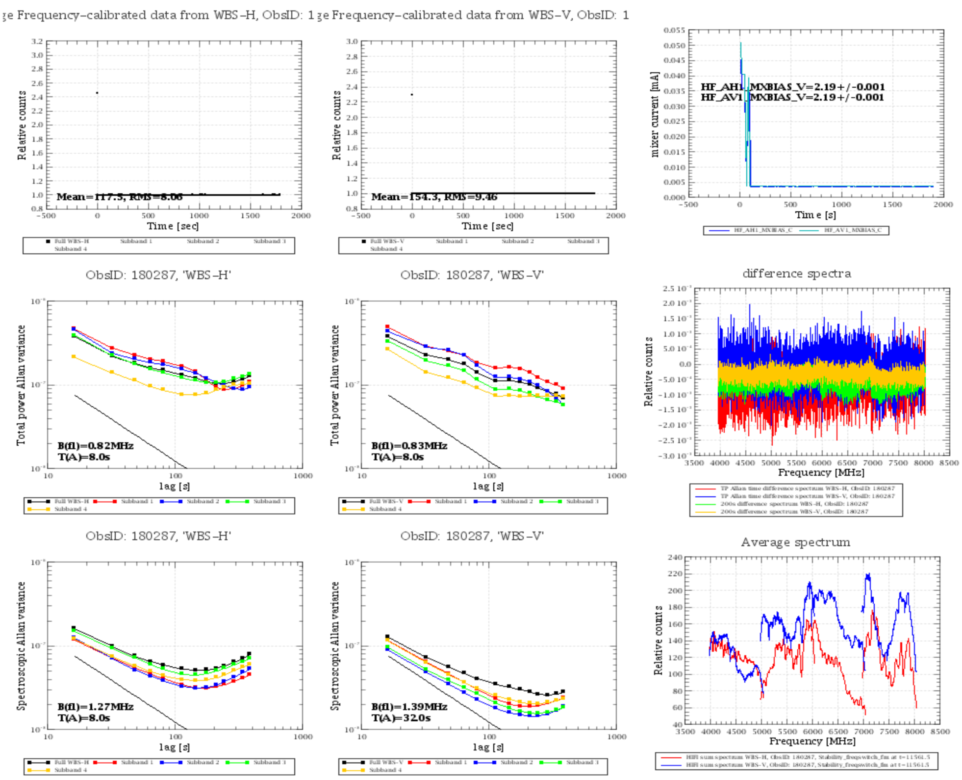

Fig.39. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 887.84 GHz, Obsid: 1342180287, B3b. Tuning problems the first few 30s due to a large settling time in the LO.

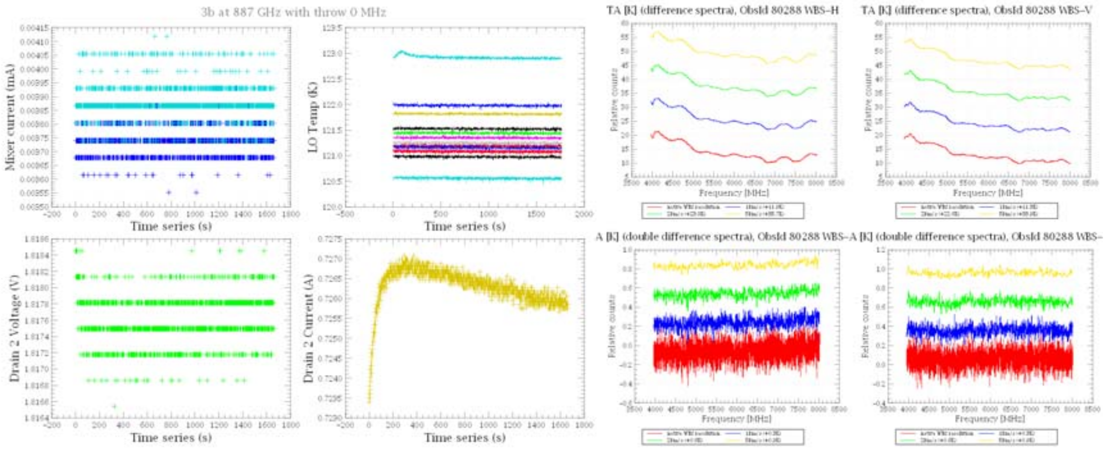

Fig.40. Testmode_stability_freqswitch_TV_2, Throw: -74 MHz, 95 MHz, Freq = 887.84 GHz, Obsid: 1342180288, B3b. Asymmetric throw, taking into account the phase/amplitude of the standing wave profile. Tuning problems, however very nice baseline subtraction still the case. → strengthen FSW tuning routine.

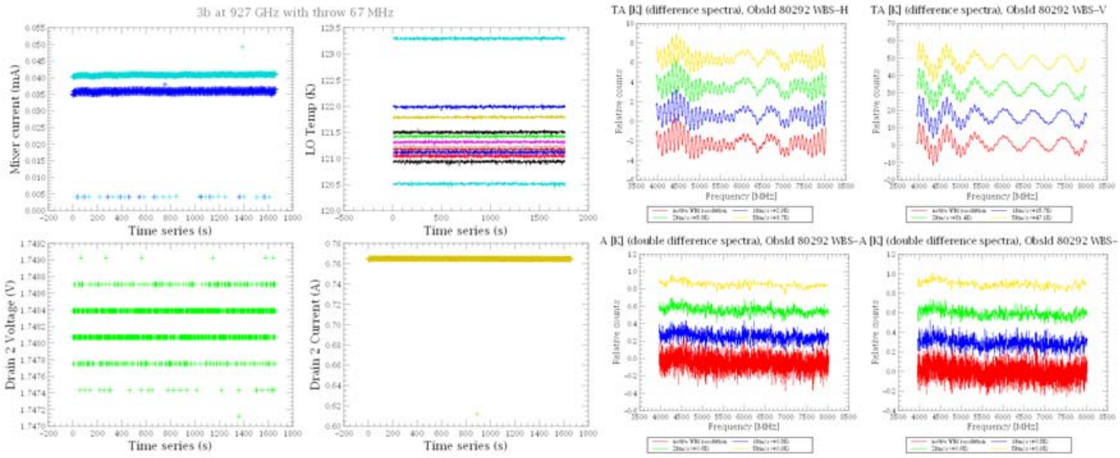

Fig.41. Testmode_stability_freqswitch_TV_2, Throw: -36 MHz, 32 MHz, Freq = 927.6GHz, Obsid: 1342180292, B3b. Asymmetric throw, taking into account the phase/amplitude of the standing wave profile. Imix constant, Vd2 mostly constant. Quite reasonable baselines. There is a strong 650 MHz standing wave, and weak 90 MHz standing wave that gets subtracted by double differencing.

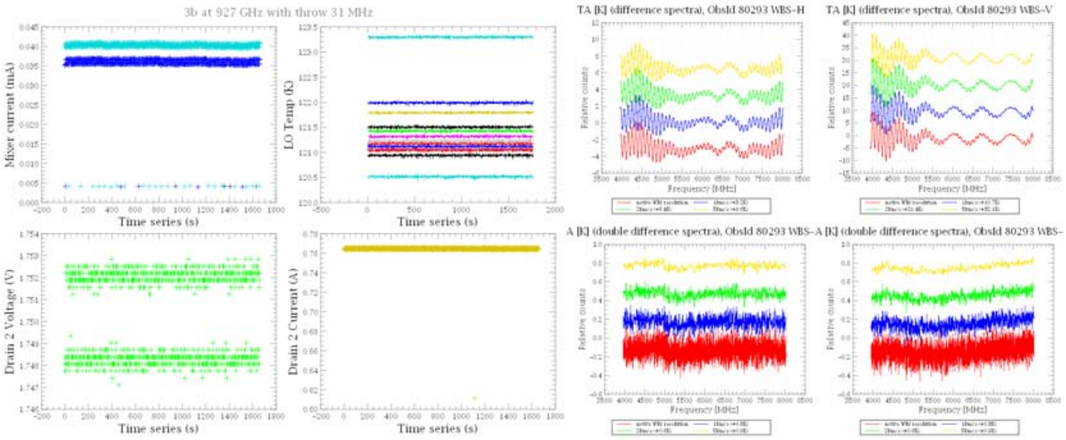

Fig.42. Testmode_stability_freqswitch_TV_2, Throw: -15 MHz, 15 MHz, Freq = 927.6GHz, Obsid: 1342180293, B3b. Small throw, Not taking into account the phase/amplitude of the standing wave profile. Imix constant, Vd2 mostly constant. Quite reasonable baselines. There is a strong 650 MHz standing wave, and weak 90 MHz standing wave that gets subtracted by double differencing.

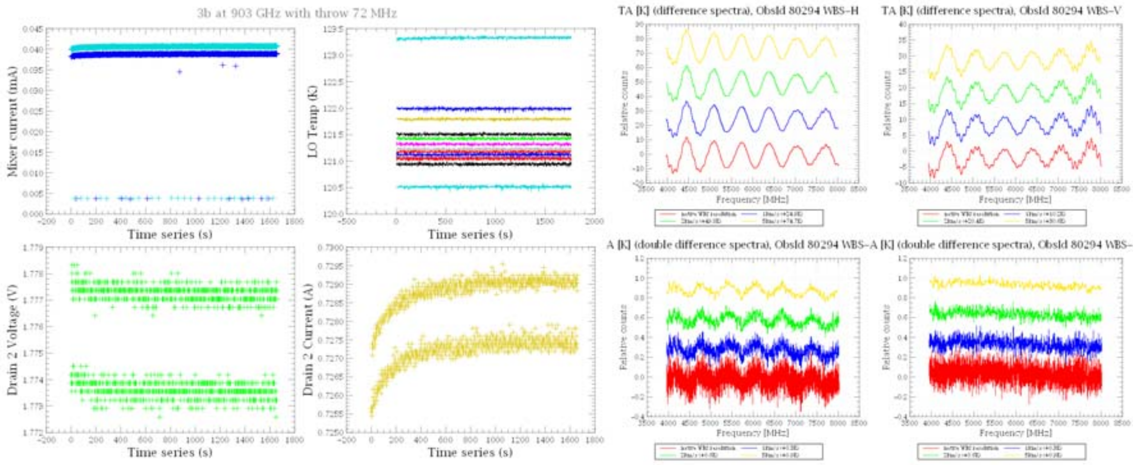

Fig.43. Testmode_stability_freqswitch_TV_1, Throw: -72 MHz, 0 MHz, Freq = 903.75 GHz, Obsid: 1342180294, B3b. Asymmetric throw, taking into account the phase/amplitude of the standing wave profile. Imix constant, Vd2 mostly constant. Looks like V is tuned properly, H is not (section 1). This can however be improved with the use of Higgens FSW tuning algorithm of section 1. There is a strong 650 MHz standing wave that gets subtracted by double differencing.

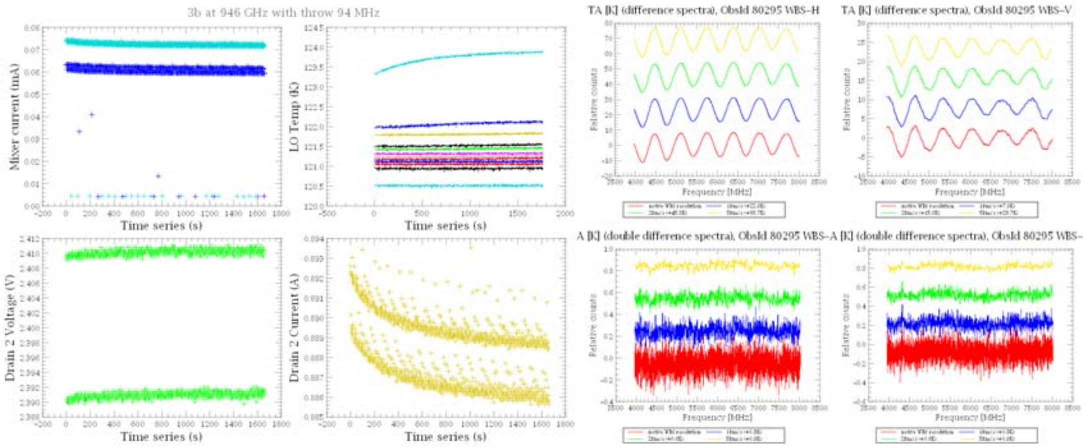

Fig.44. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 946.74 GHz, Obsid: 1342180295, B3b. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix constant, Vd2 constant → nice baselines. Some tuning spikes in the Id2. There is a strong 650 MHz standing wave that gets subtracted by double differencing.

6.7 Band 4a

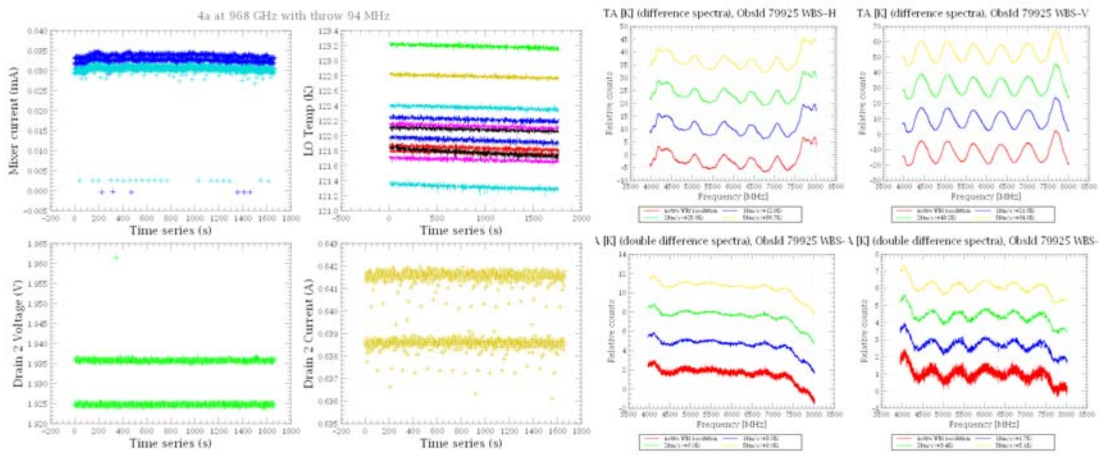

Fig.44. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 968.66GHz, Obsid: 1342179925, B4a. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix constant, Vd2 constant → poor system stability.

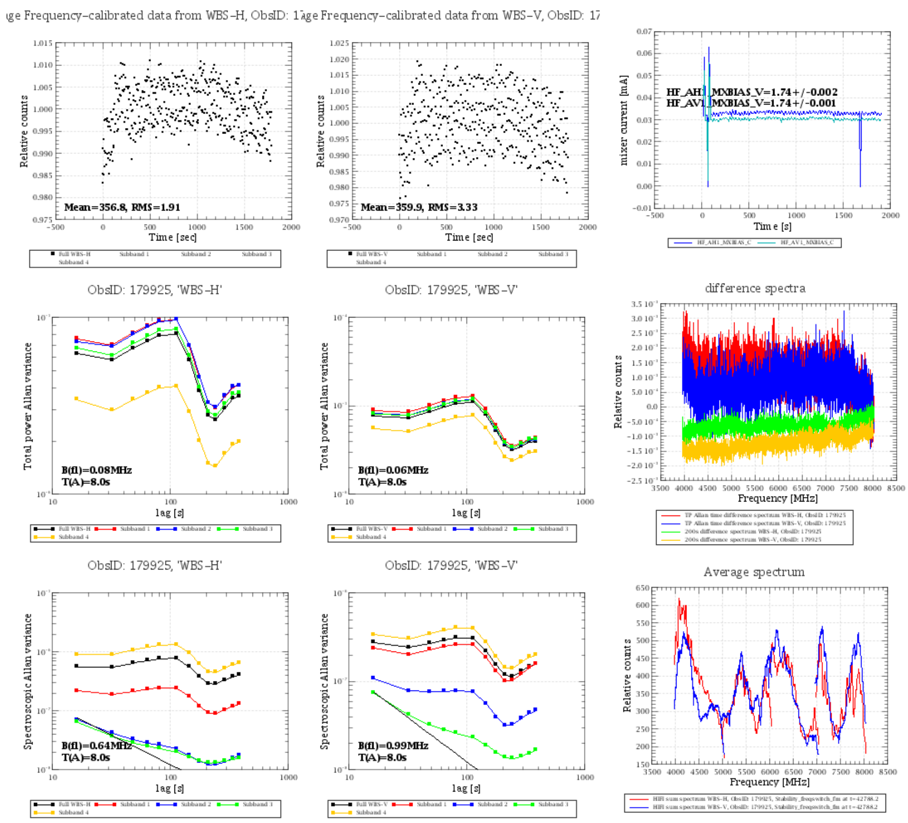

Fig.45. System Stability. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 968.66GHz, Obsid: 1342179925, B4a.

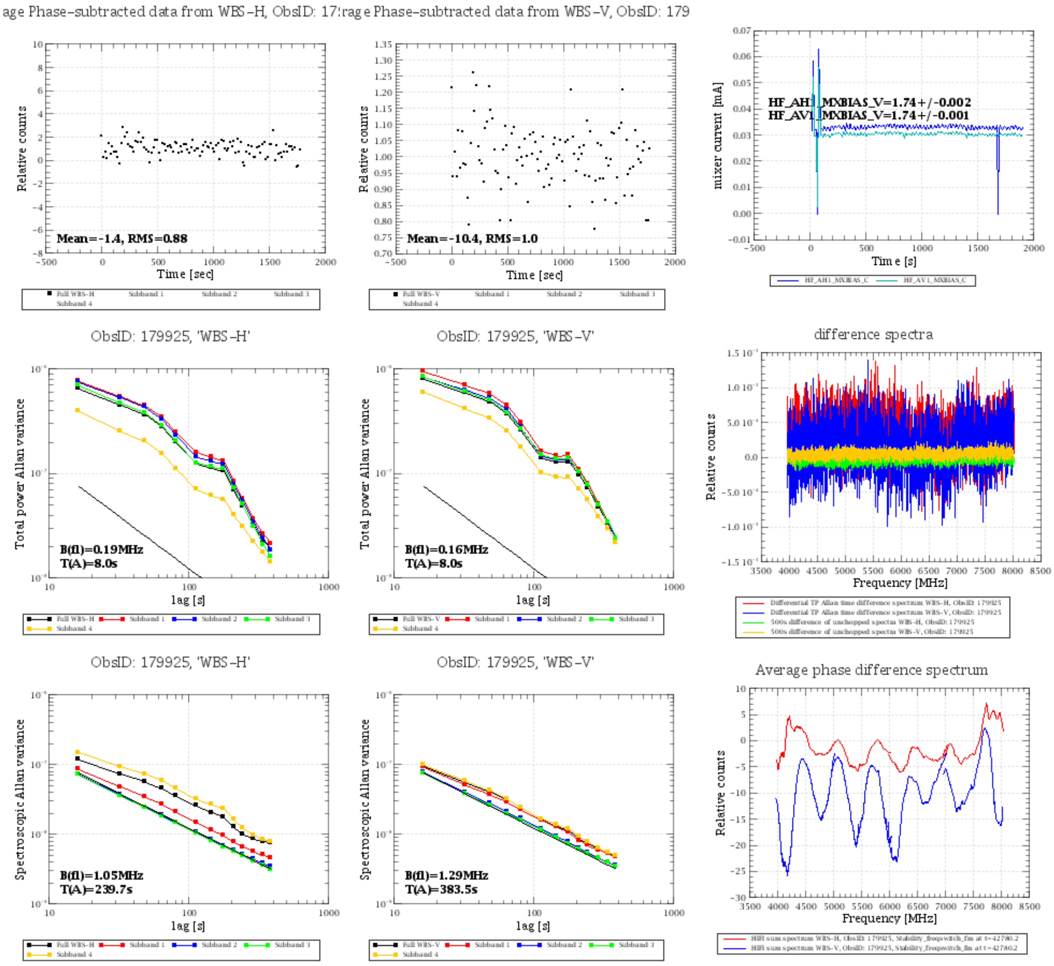

Fig.46. System Stability. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 968.66GHz, Obsid: 1342179925, B4a.

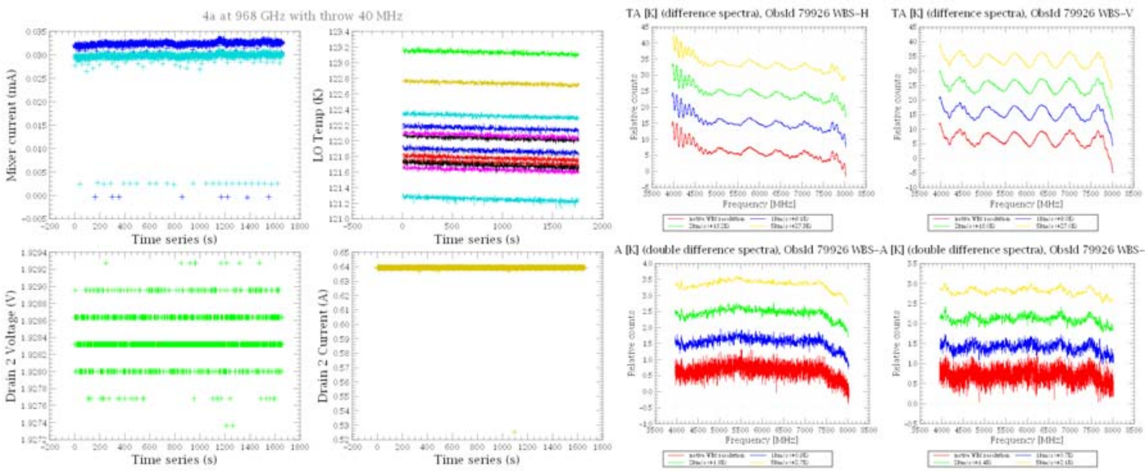

Fig.47. Testmode_stability_freqswitch_TV_2, Throw: -20 MHz, 20 MHz, Freq = 968.66 GHz, Obsid: 1342179926, B4a.   Small throw.

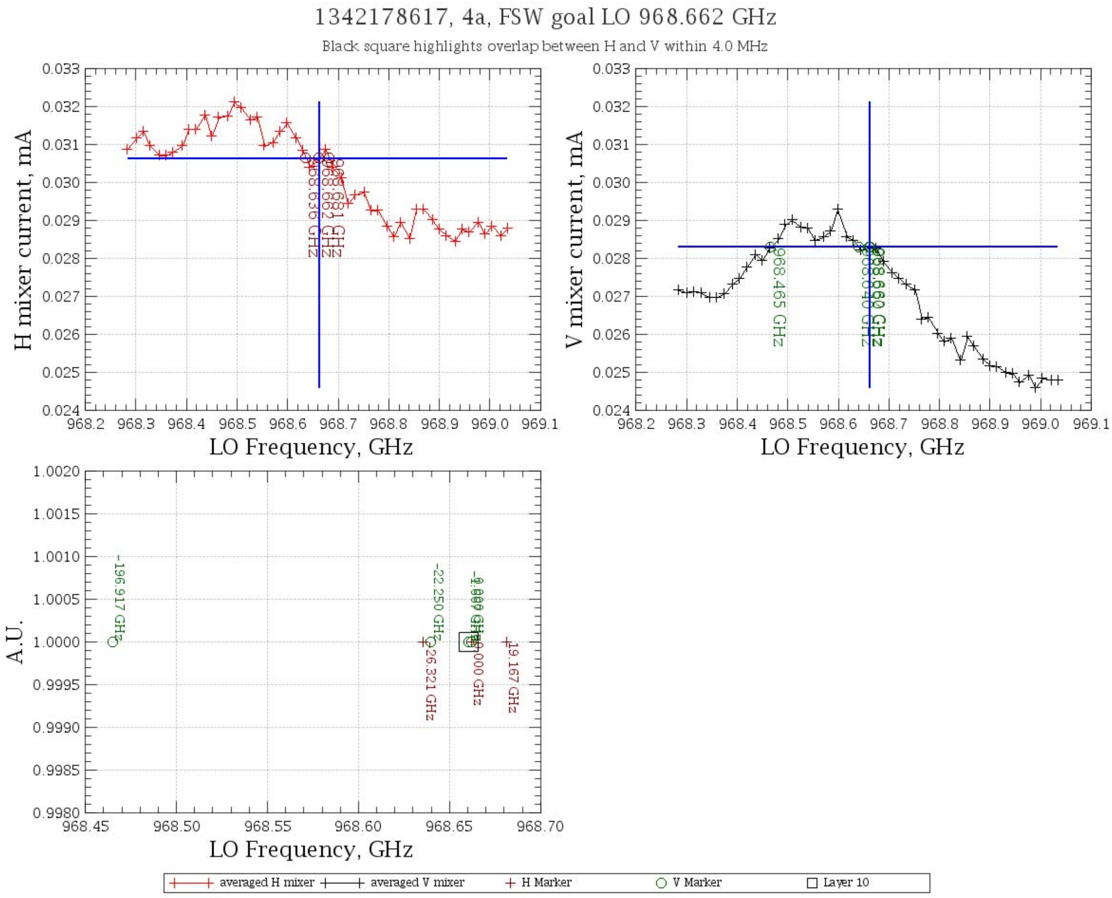

Fig.48. Testmode_stability_freqswitch_TV_2, Freq = 968.66 GHz, Obsid: 1342179926, B4a. Small throw.(Figs 44-48)

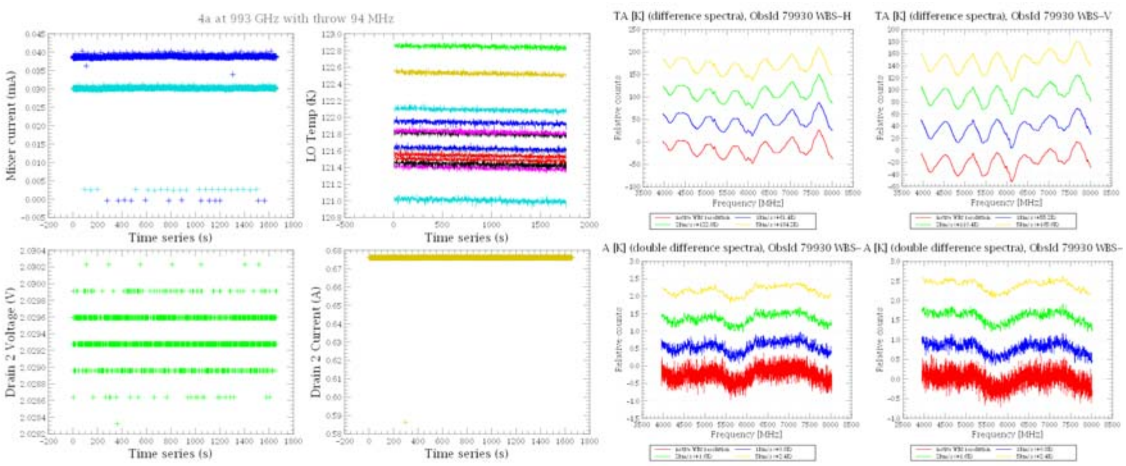

Fig.49. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 993.73 GHz, Obsid: 1342179930, B4a. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix constant, Vd2 reasonably constant.

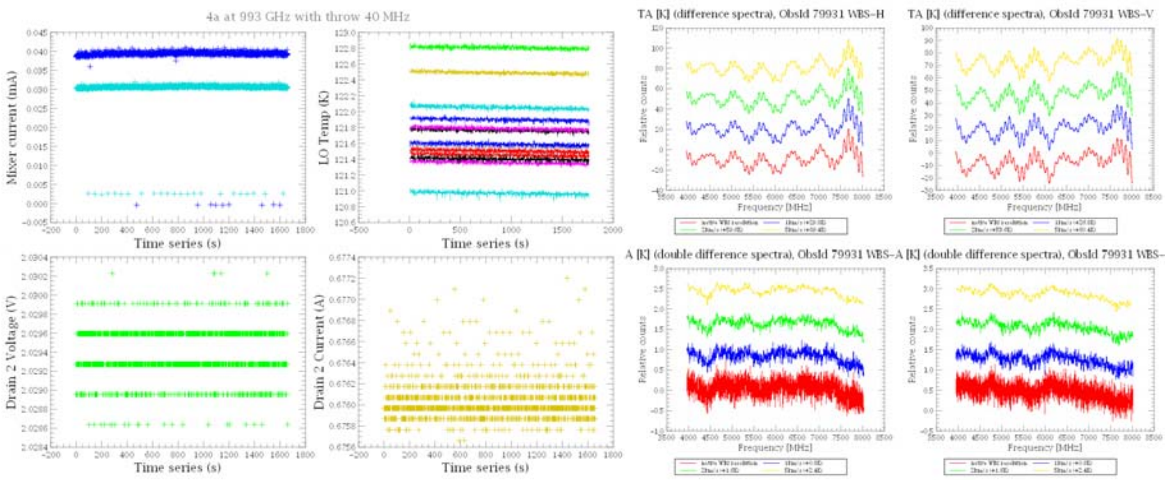

Fig.50. Testmode_stability_freqswitch_TV_1, Throw: -20 MHz, 20 MHz, Freq = 993.73 GHz, Obsid: 1342179931, B4a. Small throw, Imix constant, Vd2 reasonably constant

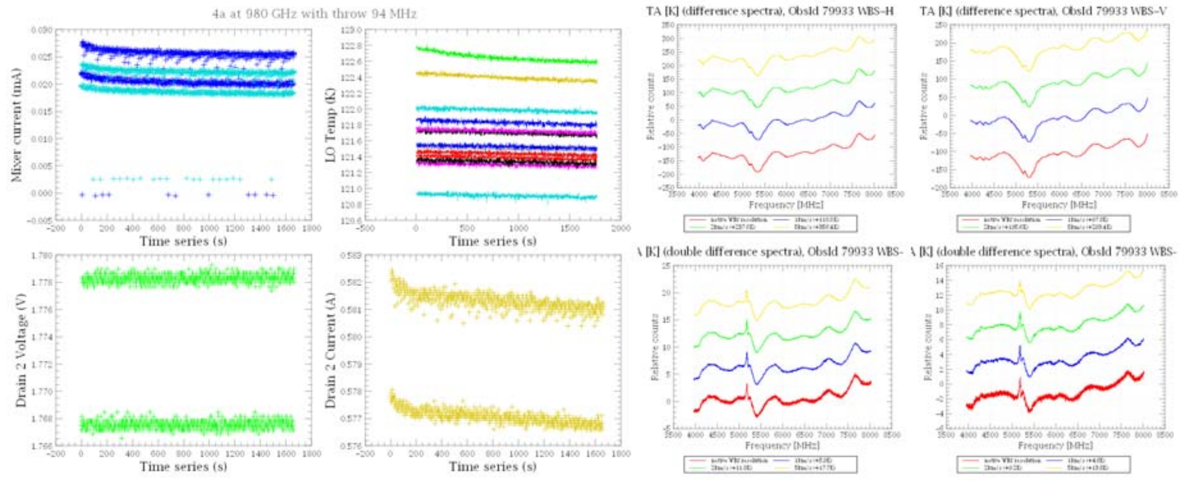

Fig.51. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 980.41 GHz, Obsid: 1342179933, B4a. Small throw,. Imix very unstable. (see Fig. 52).

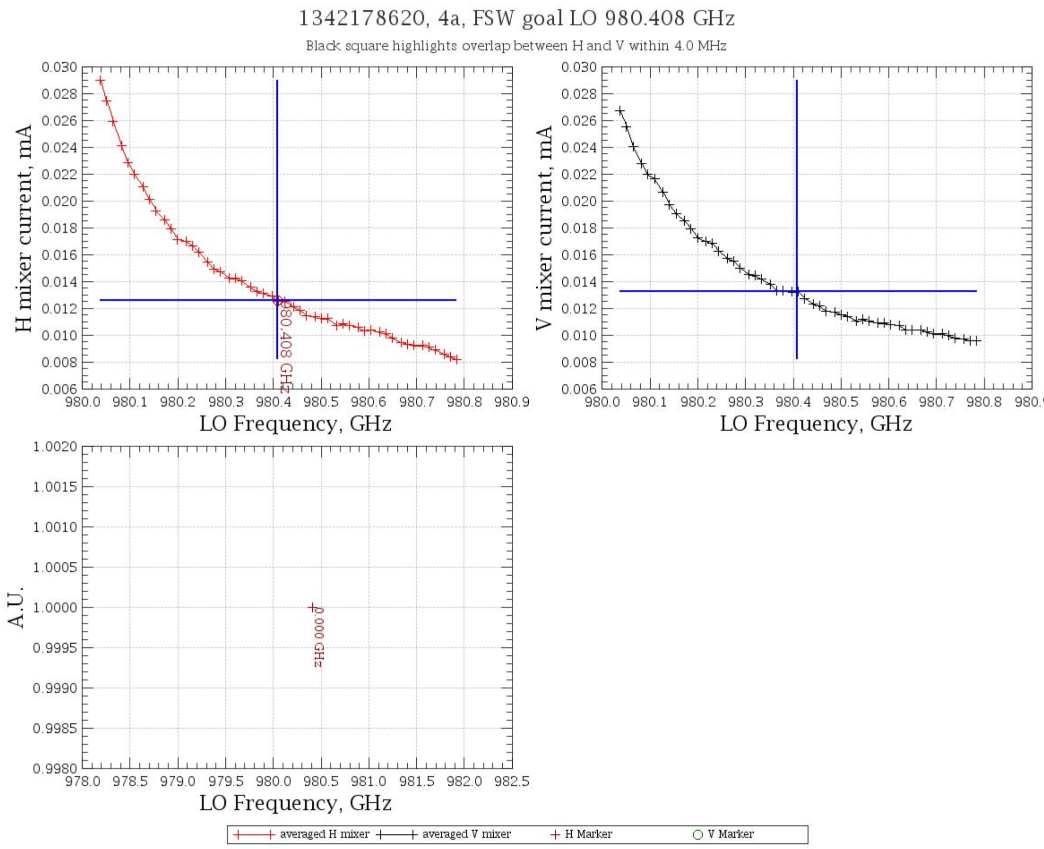

Fig.52. Testmode_stability_freqswitch_TV_1, Standing wave profile. Dominated by drift.

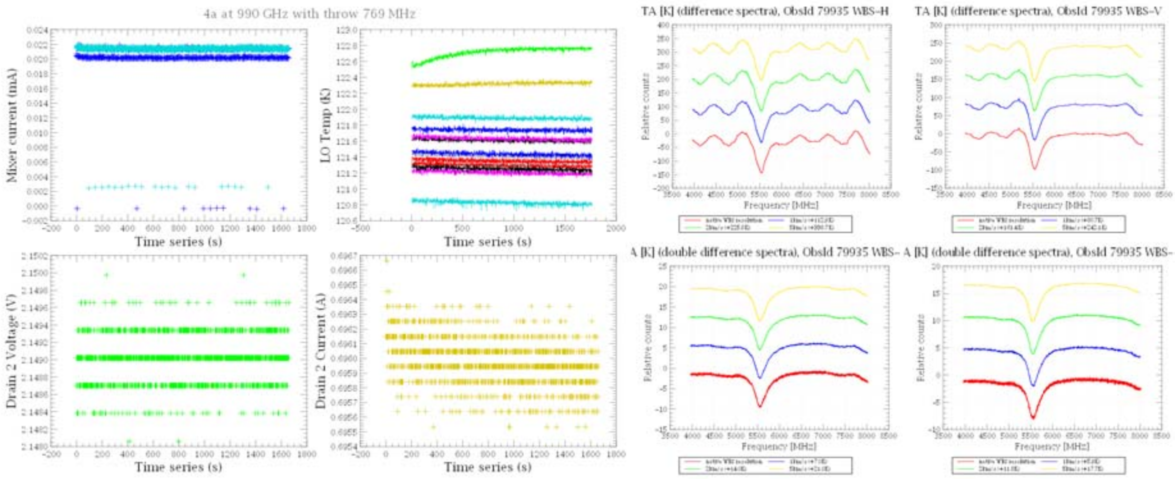

Fig.51. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 990.51GHz, Obsid: 1342179935, B4a. Default throw,. Imix constant Vd2 unstable. (H2O??)

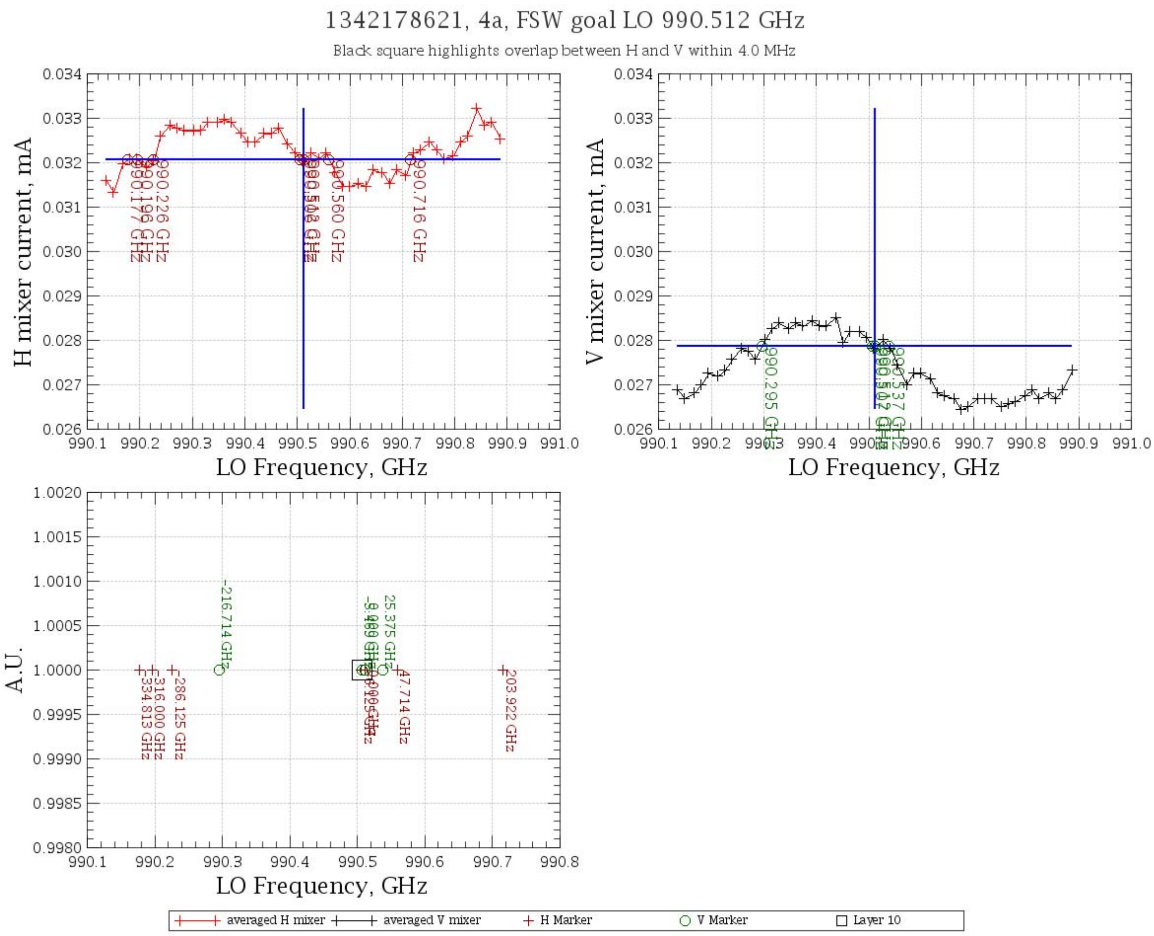

Fig.52. Testmode_stability_freqswitch_TV_1, Freq = 990.51GHz, Obsid: 1342179935, B4a. Default throw.

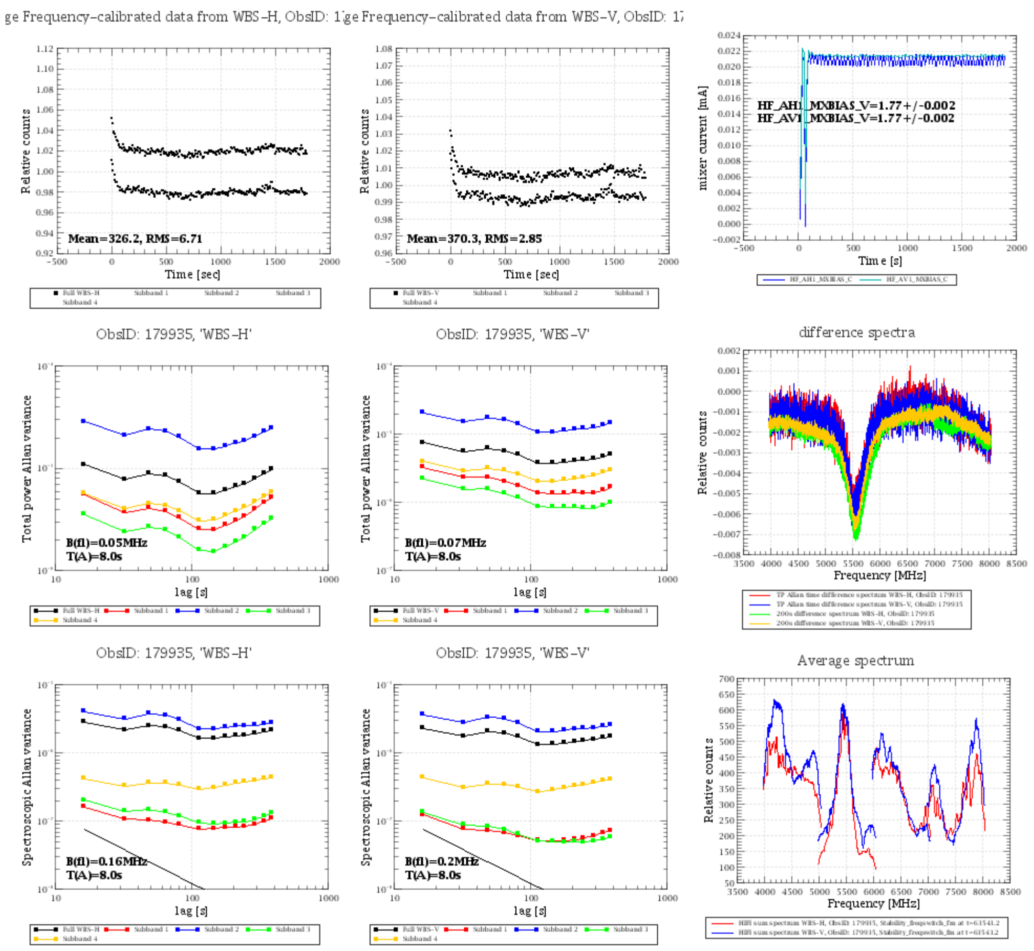

Fig.53. System stability Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 990.51GHz, Obsid: 1342179935, B4a.   Default throw,. Imix constant Vd2 unstable. (H2O??)

6.8 Band 4b

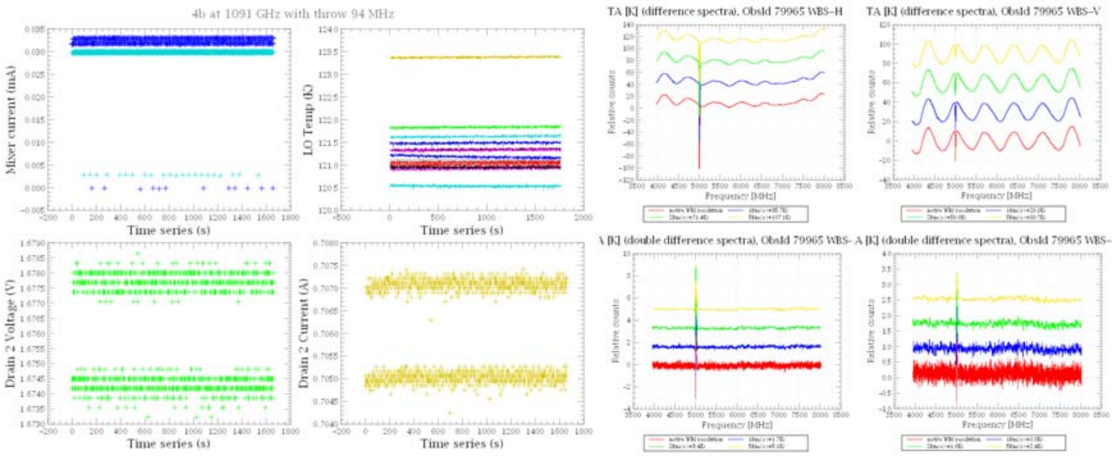

Fig.54. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 1091.56 GHz, Obsid: 1342179965, B4b. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan) is stable, Imix-H has a small modulation. Vd2 reasonably constant. Good baseline. There is a strong 650 MHz standing wave that gets subtracted by double differencing.

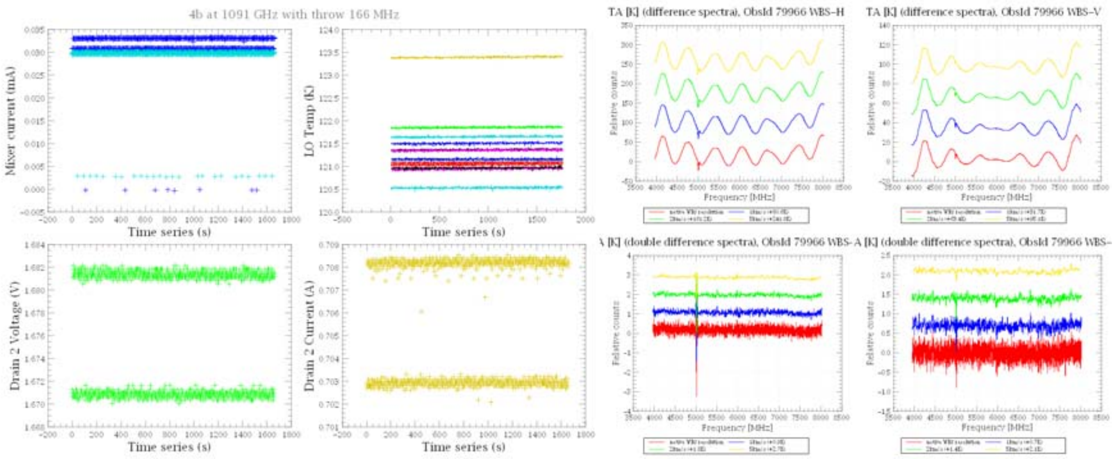

Fig.55. Testmode_stability_freqswitch_TV_1, Throw: -165 MHz, 0 MHz, Freq = 1091.56 GHz, Obsid: 1342179966, B4b. Asymmetric throw, taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan) is stable, Imix-H has a small modulation. Vd2 is constant. Even better baseline.

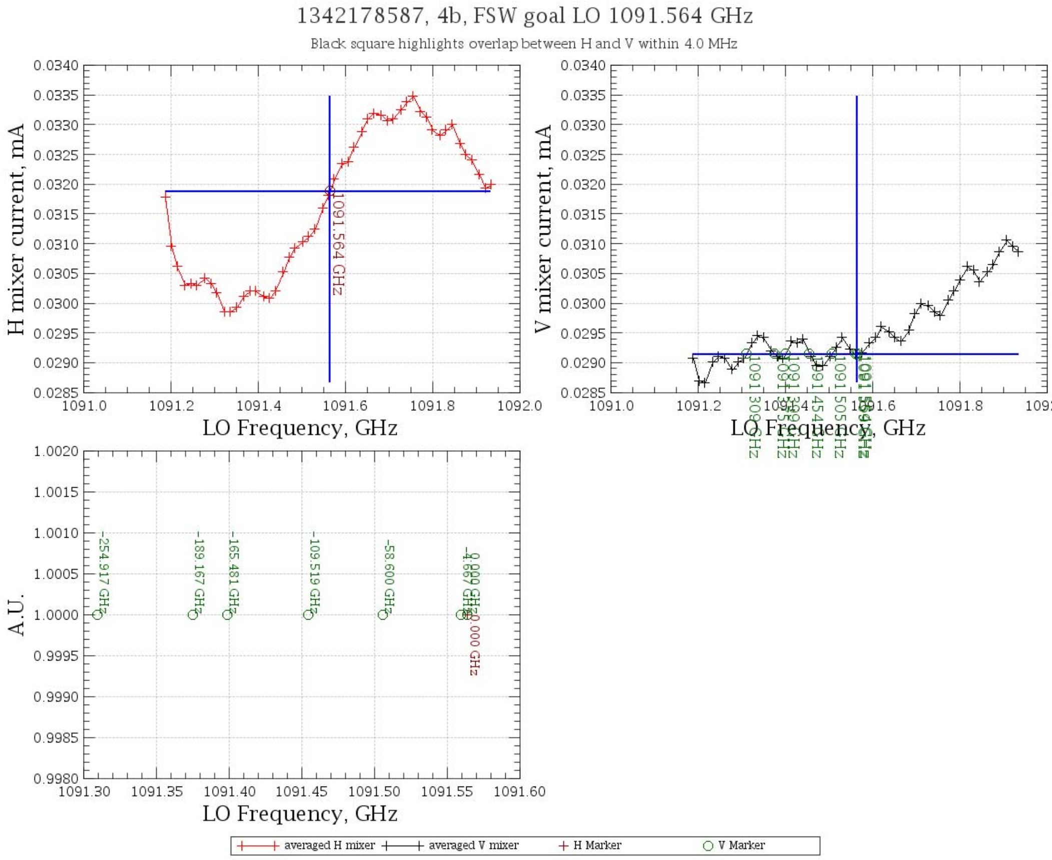

Fig.56. Standing wave profile. Testmode_stability_freqswitch_TV_2, Throw: -165 MHz, 0 MHz, Freq = 1091.56 GHz, Obsid: 1342179966, B4b.

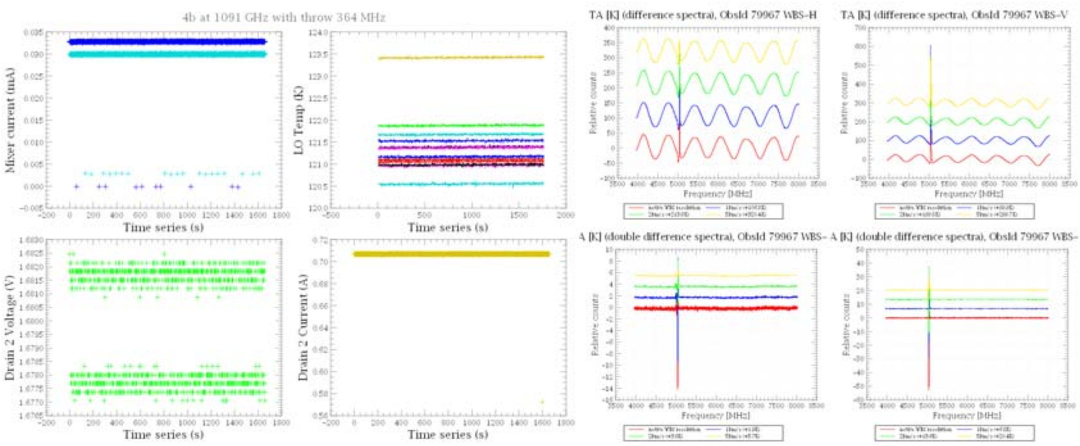

Fig.57. Testmode_stability_freqswitch_TV_3, Throw: -364 MHz, 0 MHz, Freq = 1091.56 GHz, Obsid: 1342179967, B4b. Asymmetric throw, taking into account the phase/amplitude of the standing wave profile. <u>Imix-V (cyan) is stable, Imix-H is stable</u> despite the very large asymmetric throw. Baselines, looks good as well.   Some noise on Vd2, Id2 is constant. There is a strong 650 MHz standing wave that gets subtracted by double differencing.

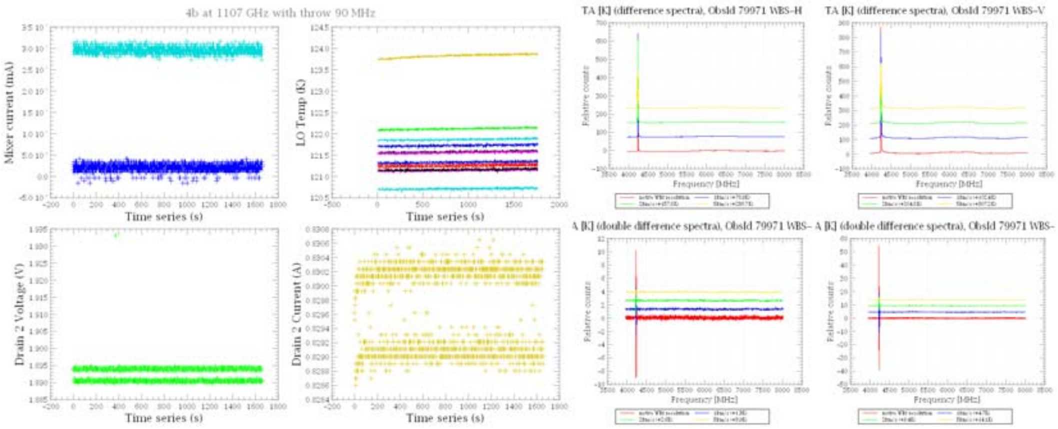

Fig.58. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 1107.54 GHz, Obsid: 1342179971, B4b. Default throw, Not taking into account the phase/amplitude of the standing wave profile. <u>Imix-V (cyan) is stable, Imix-H is stable</u>. Vd2, Id2 are constant. Baselines, looks good as well. .

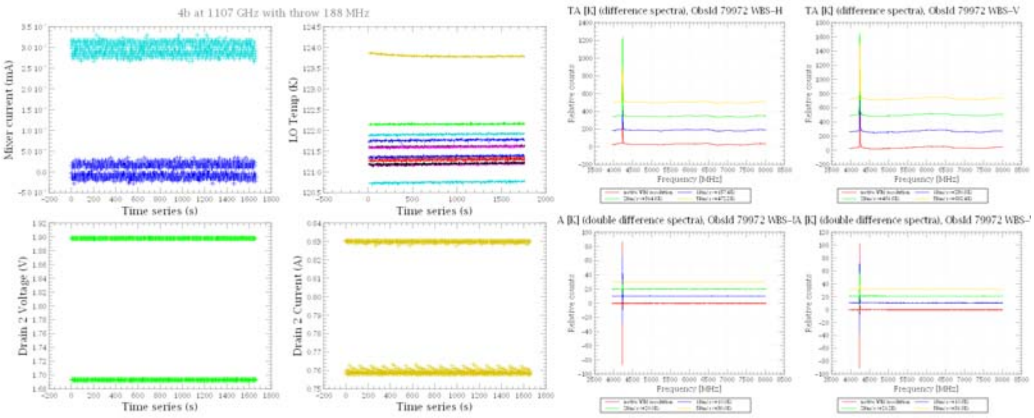

Fig.59. Testmode_stability_freqswitch_TV_2, Throw: -94 MHz, 94 MHz, Freq = 1107.54 GHz, Obsid: 1342179972, B4b. Default throw, Not taking into account the phase/amplitude of the standing wave profile. <u>Imix-V (cyan), Imix-H show modulation</u>. Vd2, Id2 are constant.

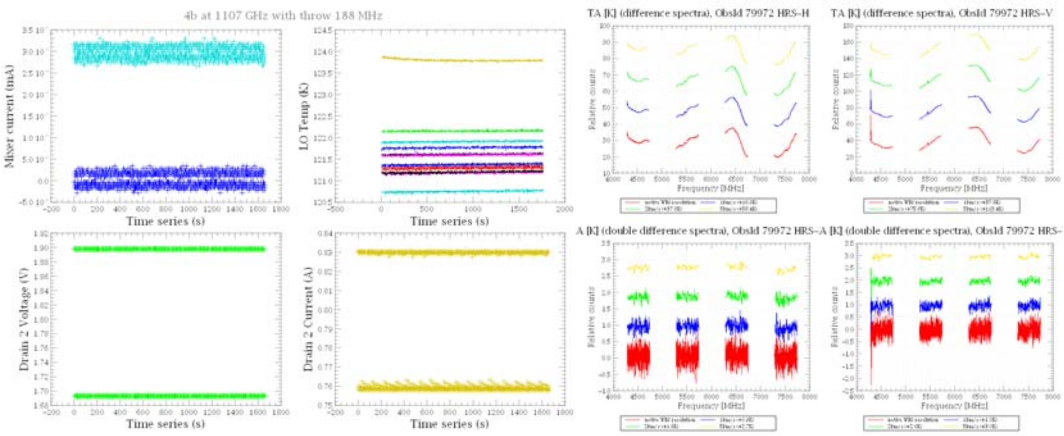

Fig.60. Testmode_stability_freqswitch_TV_2, Throw: -94 MHz, 94 MHz, Freq = 1107.54 GHz, Obsid: 1342179972, B4b. HRS baseline looks ok.

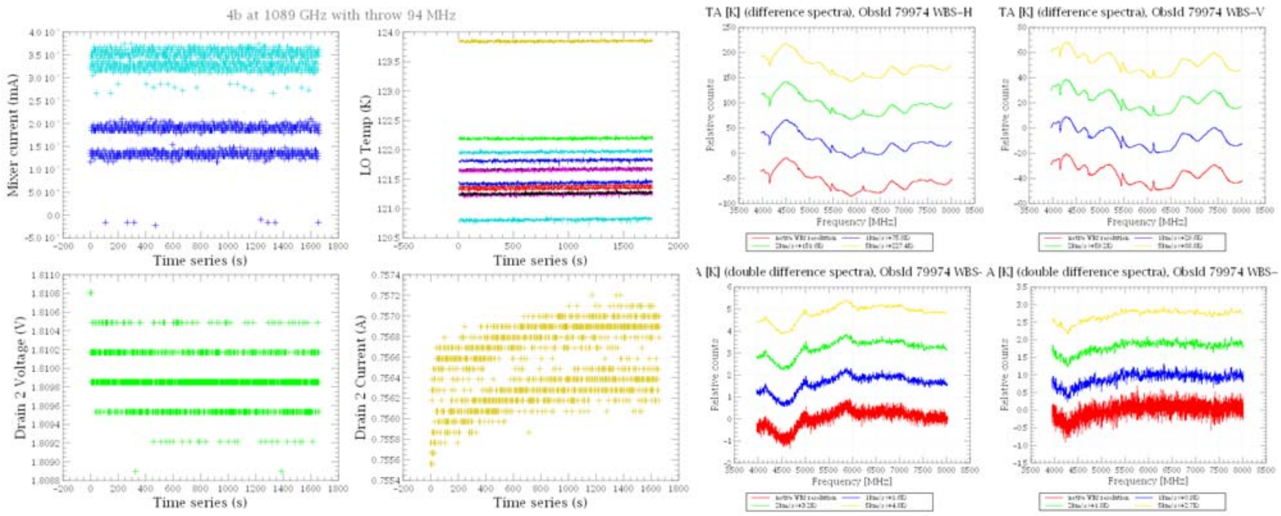

Fig.61. Testmode_stability_freqswitch_TV_1, Throw: 0 MHz, 94 MHz, Freq = 1089.83 GHz, Obsid: 1342179974, B4b. Asymmetric throw throw. Imix-V (cyan), Imix-H,. Vd2, Id2 show modulation.

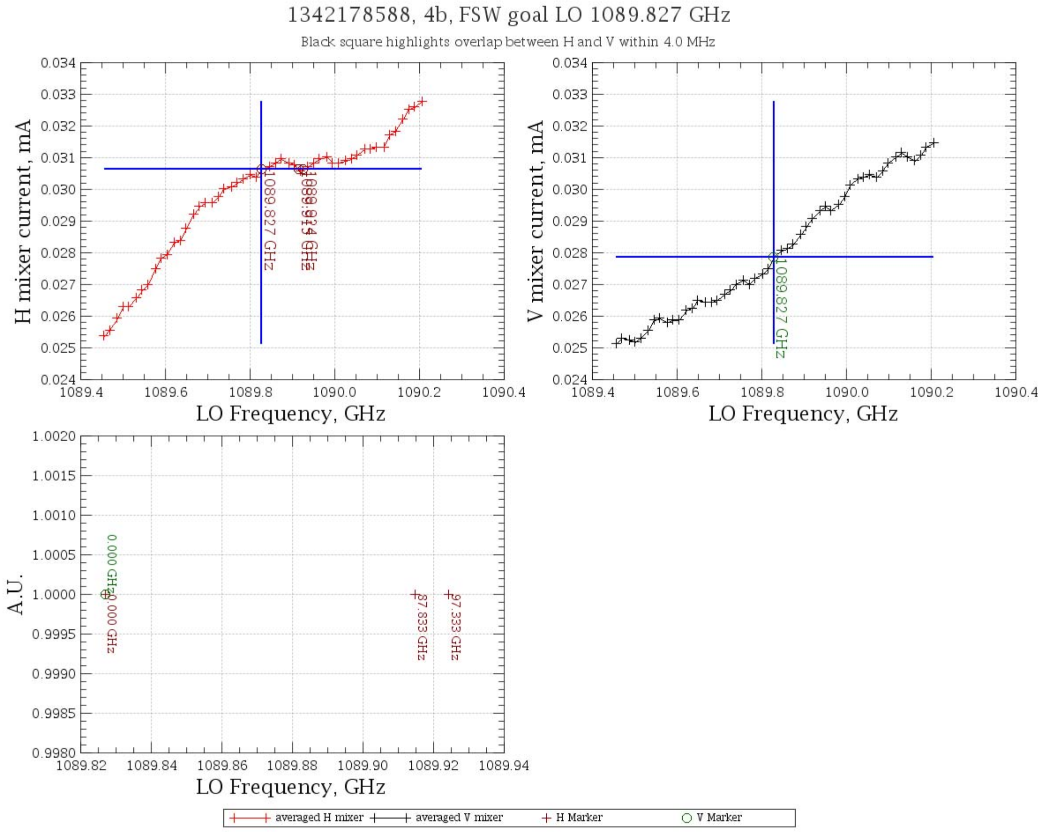

Fig.62. Testmode_stability_freqswitch_TV_1, Throw: 0 MHz, 94 MHz, Freq = 1089.83 GHz, Obsid: 1342179974, B4b. Asymmetric throw. Imix-V (cyan), Imix-H,. Vd2, Id2 show modulation. In this case the tuning obviously failed. Perhaps the slope of the standing wave profile is due to a time constant and not reproducible.

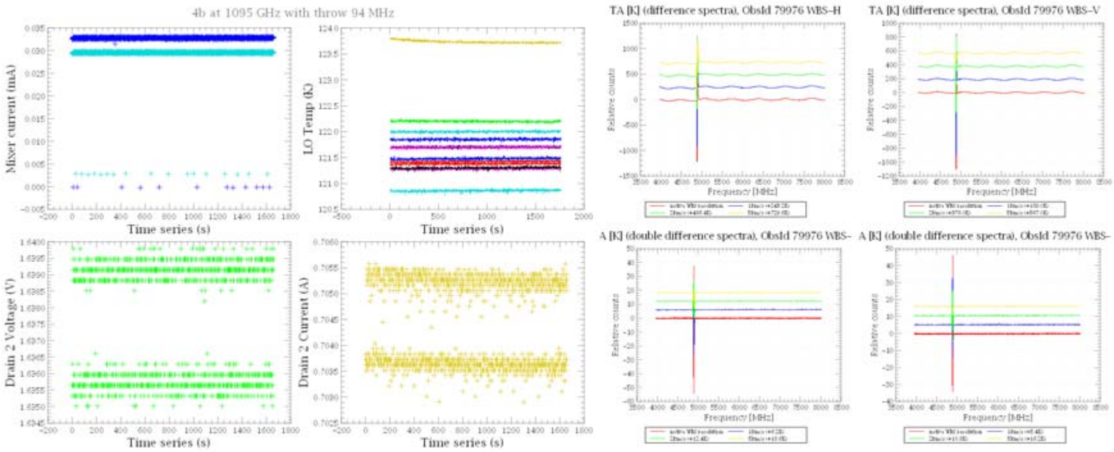

Fig.63. Testmode_stability_freqswitch_TV_1, Throw: 0 MHz, 94 MHz, Freq = 1095.55 GHz, Obsid: 1342179976, B4b. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Vd2 shows modulation. From the Fig below it is clear that the default throw suffices.

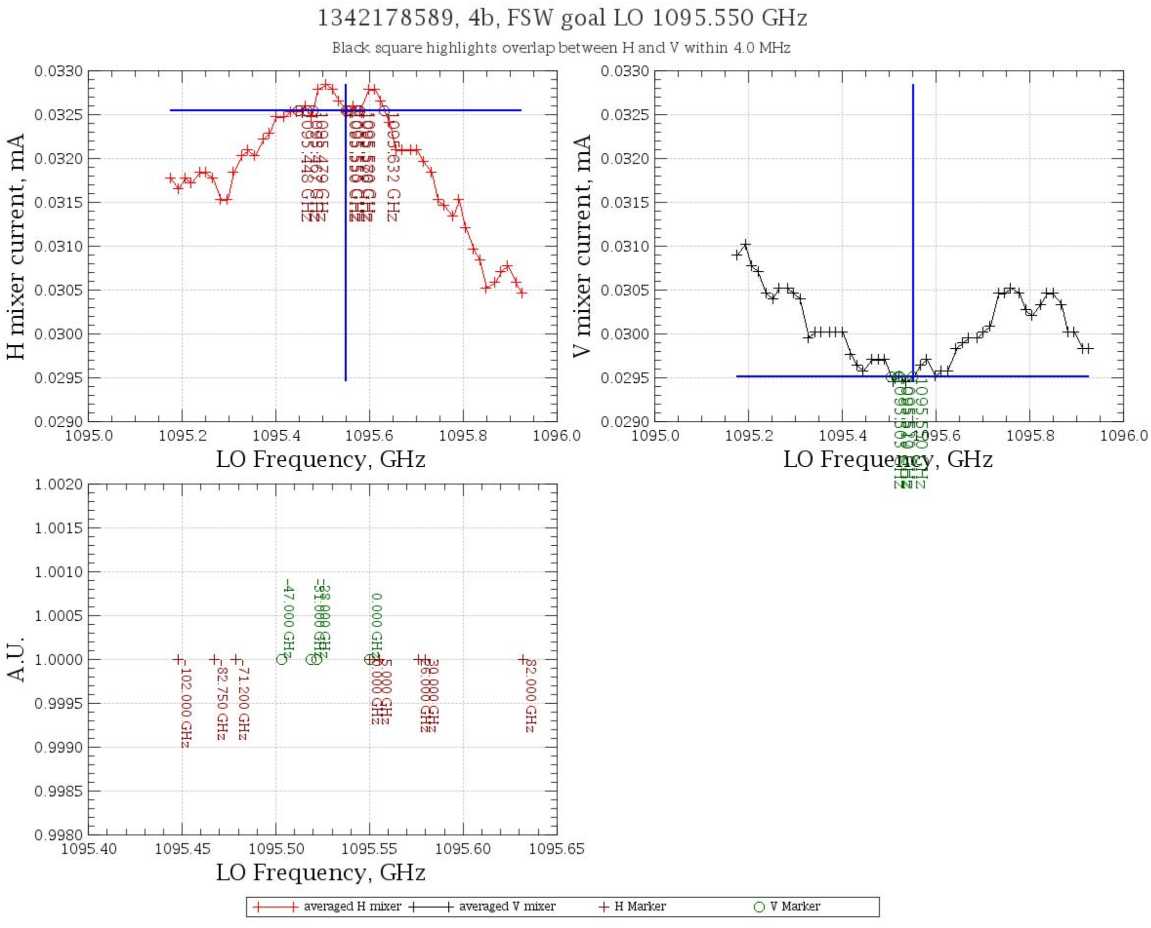

Fig.64. Testmode_stability_freqswitch_TV_1, Throw: 0 MHz, 94 MHz, Freq = 1095.55 GHz, Obsid: 1342179976, B4b. Default throw.

6.9 Band 5a

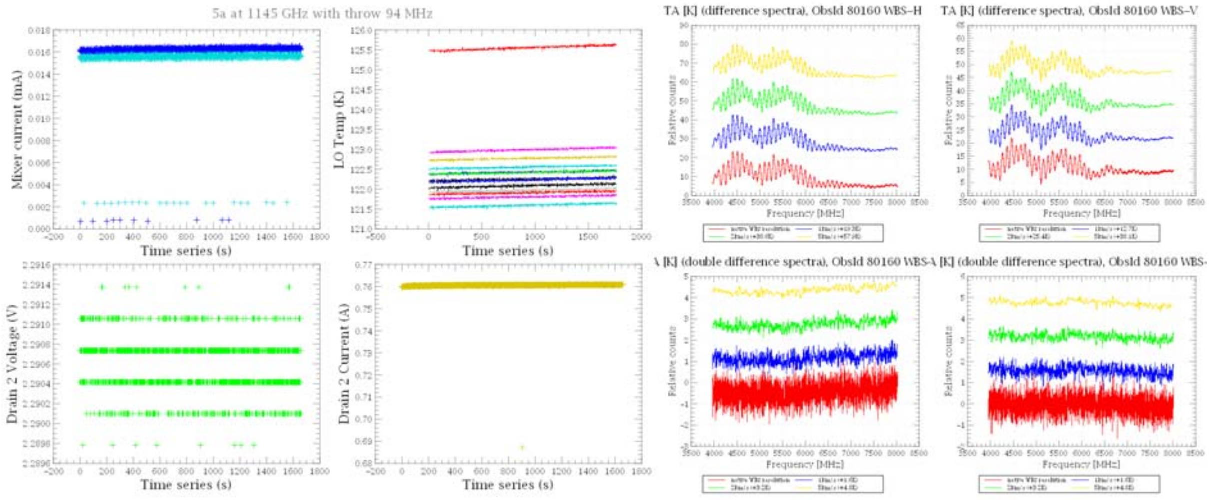

Fig.65. Testmode_stability_freqswitch_TV_1, Throw: -49 MHz, 49 MHz, Freq = 1145.32 GHz, Obsid: 1342180160, B5a. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Vd2 shows minor modulation. Nice baseline.

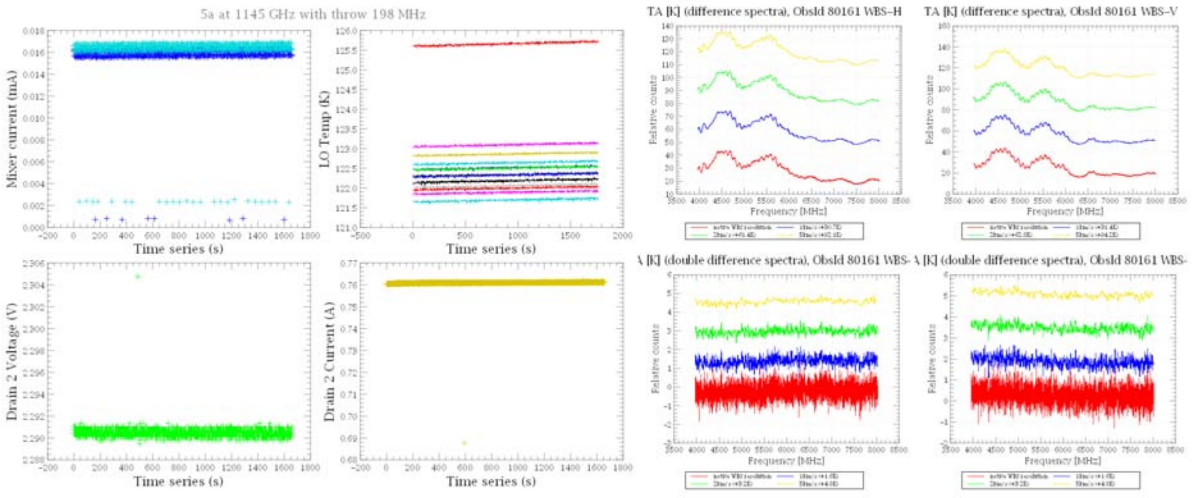

Fig.66. Testmode_stability_freqswitch_TV_2, Throw: -115 MHz, 85 MHz, Freq = 1145.32 GHz, Obsid: 1342180160, B5a. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Vd2 shows minor modulation. Slightly more optimal baseline.

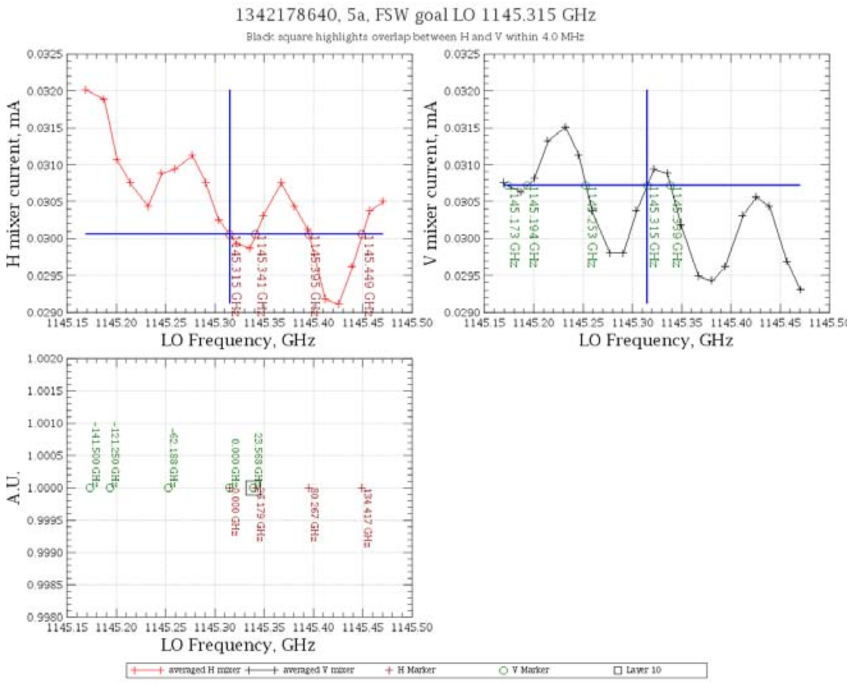

Fig.67. Testmode_stability_freqswitch_TV_2, Throw: -115 MHz, 85 MHz, Freq = 1145.32 GHz, Obsid: 1342180160, B5a. Standing wave profile for band 5a.

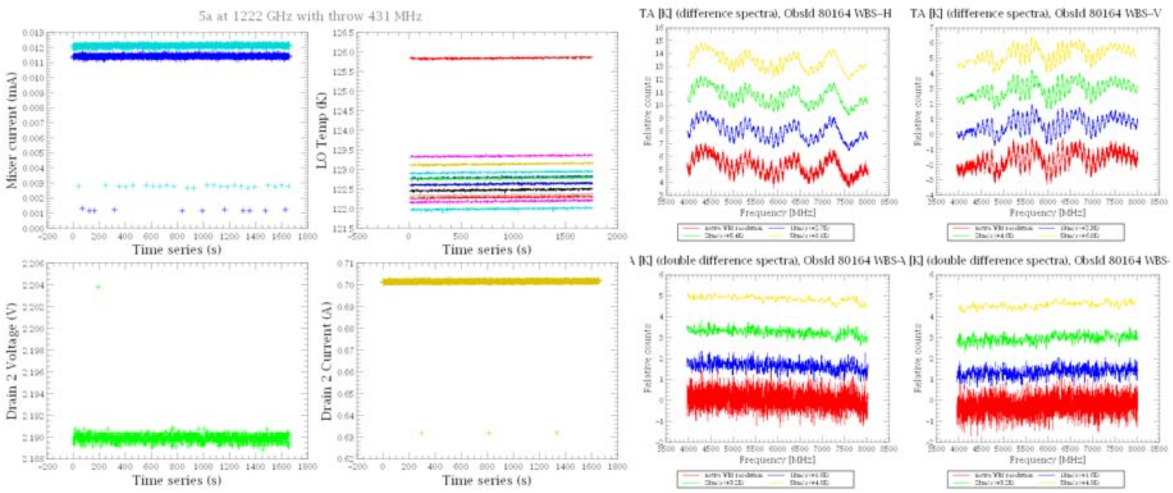

Fig.68. Testmode_stability_freqswitch_TV_1, Throw: -49 MHz, 49 MHz, Freq = 1222.99 GHz, Obsid: 1342180164, B5a. Default throw, Not taking into account the phase/amplitude of the standing wave profile. <u>Imix-V (cyan), Imix-H constant.</u> Nice baseline. There is a strong 650 MHz standing wave, and weak 90 MHz standing wave that gets subtracted by double differencing.

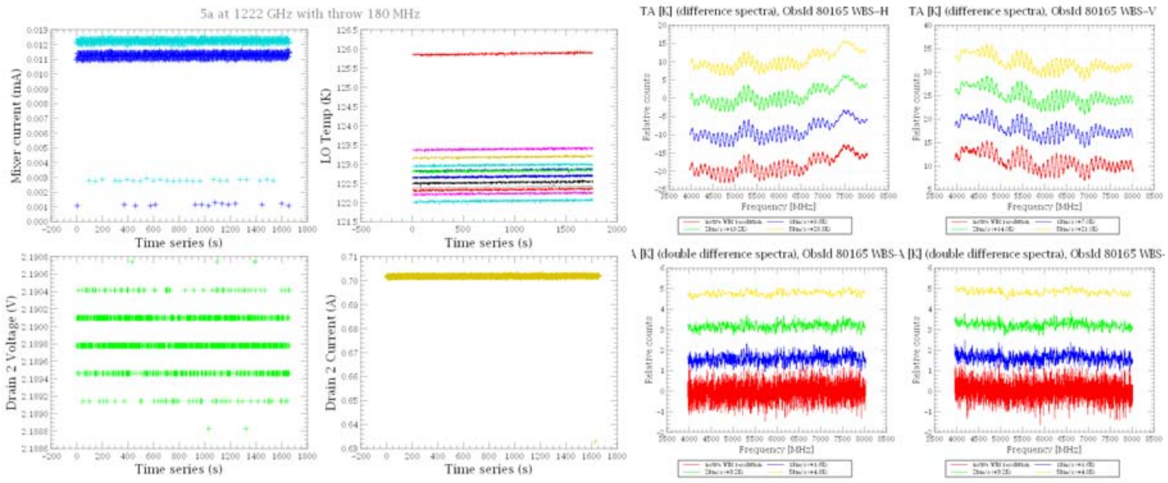

Fig.69. Testmode_stability_freqswitch_TV_2, Throw: -97 MHz, 81 MHz, Freq = 1222.99 GHz, Obsid: 1342180165, B5a. Asymmetric throw, taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Vd2 shows minor modulation. Nice baseline. There is a 90 MHz standing wave that gets subtracted by double differencing.

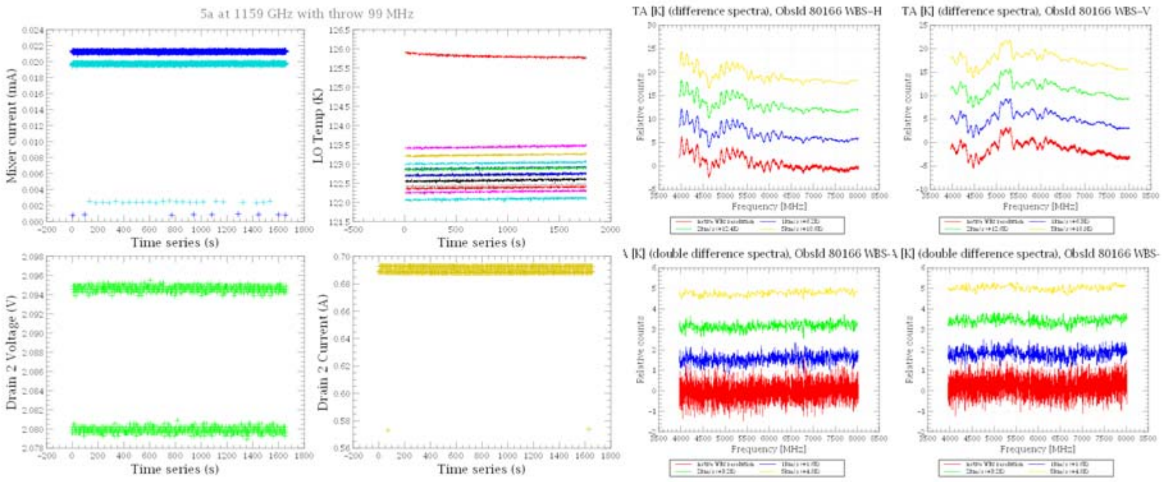

Fig.70. Testmode_stability_freqswitch_TV_1, Throw: -49 MHz, 49 MHz, Freq = 1159.17 GHz, Obsid: 1342180166, B5a. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Nice baseline

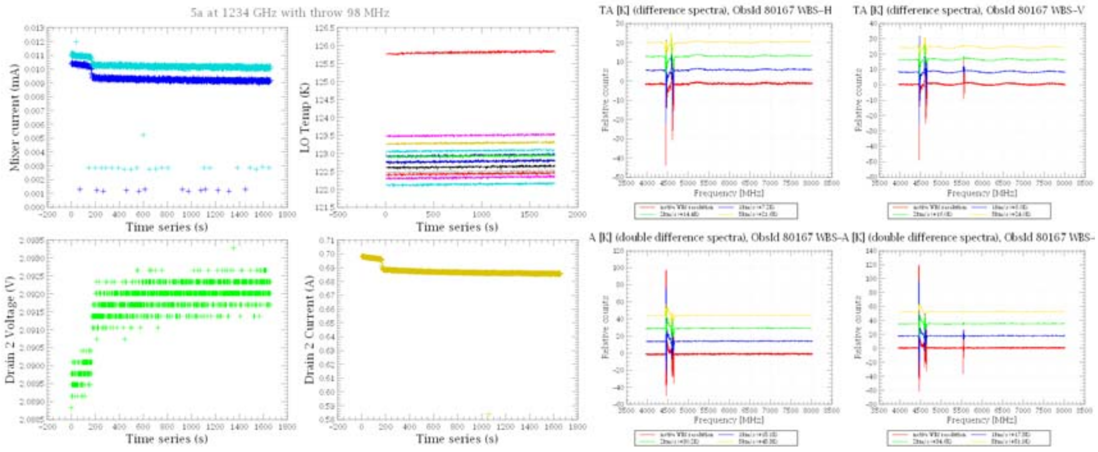

Fig.71. Testmode_stability_freqswitch_TV_1, Throw: -49 MHz, 49 MHz, Freq = 1234.59GHz, Obsid: 1342180167. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Jump in power after 200s. Impure region, mode jump?

6.10 Band 5b

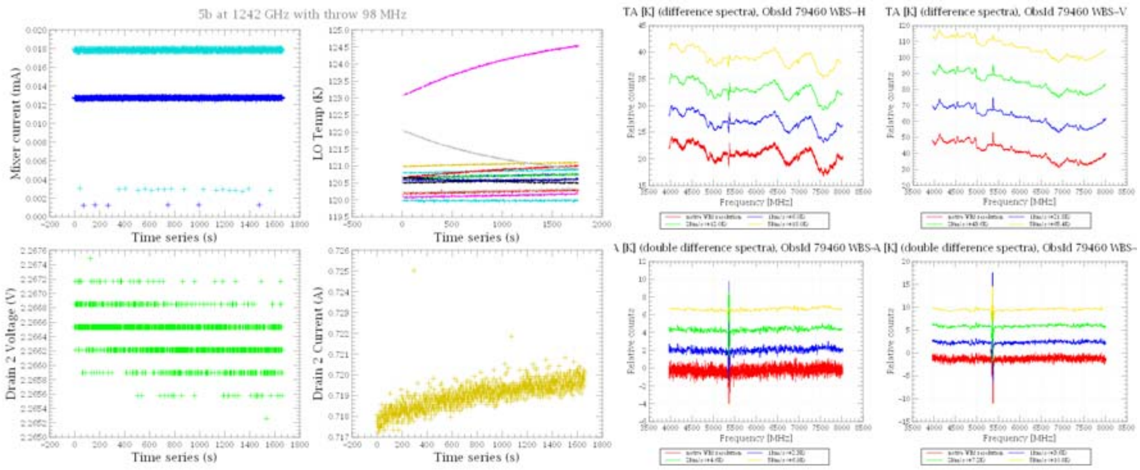

Fig.72. Testmode_stability_freqswitch_TV_1, Throw: -49 MHz, 49 MHz, Freq = 1242.9 GHz, Obsid: 1342179460, B5b. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Some thermal drift.

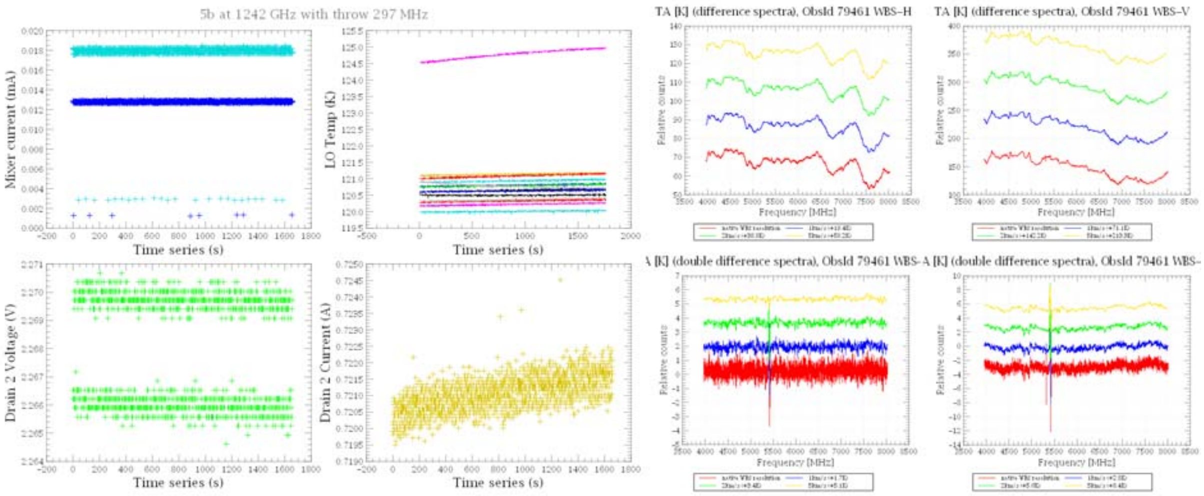

Fig.73. Testmode_stability_freqswitch_TV_2, Throw: -150 MHz, 150 MHz, Freq = 1242.9 GHz, Obsid: 1342179461, B5b. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant.

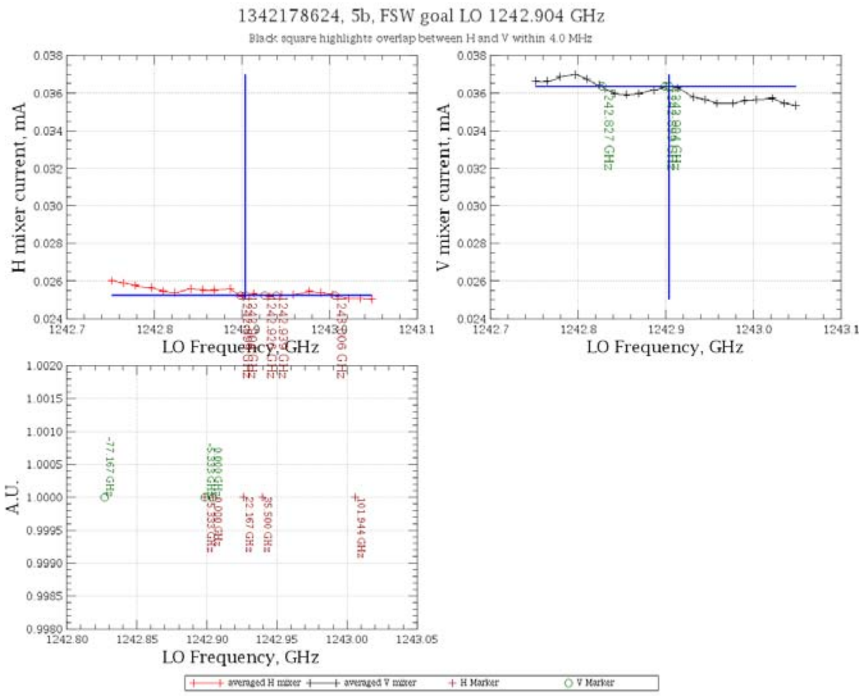

Fig.74. Standing wave profile (flat) allowing a range of throws. Testmode_stability_freqswitch_TV_2, Throw: -150 MHz, 150 MHz, Freq = 1242.9 GHz, Obsid: 1342179461.

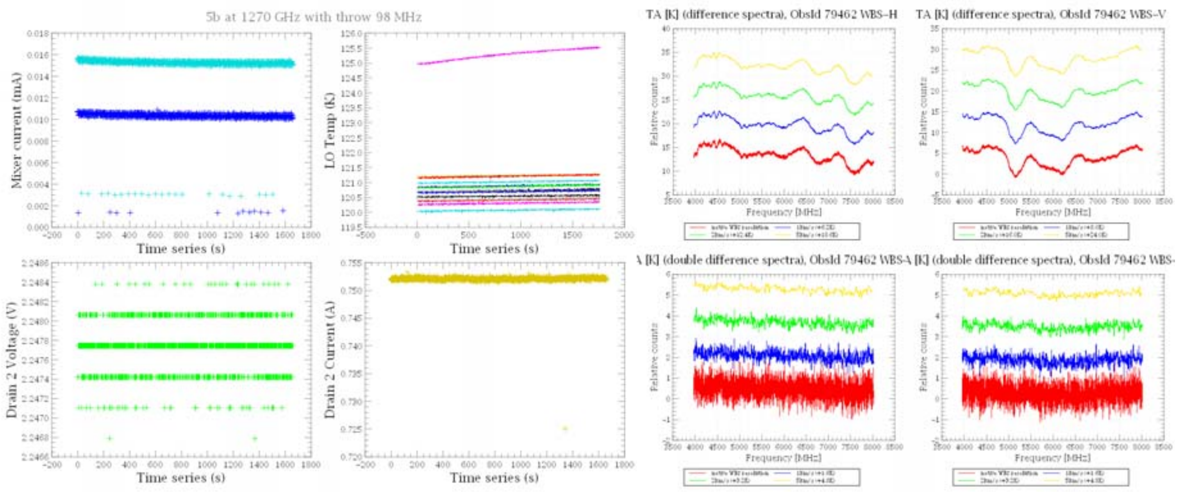

Fig.75. Testmode_stability_freqswitch_TV_1, Throw: -47 MHz, 47 MHz, Freq = 1270.93 GHz, Obsid: 1342179462, B5b. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Nice baseline.

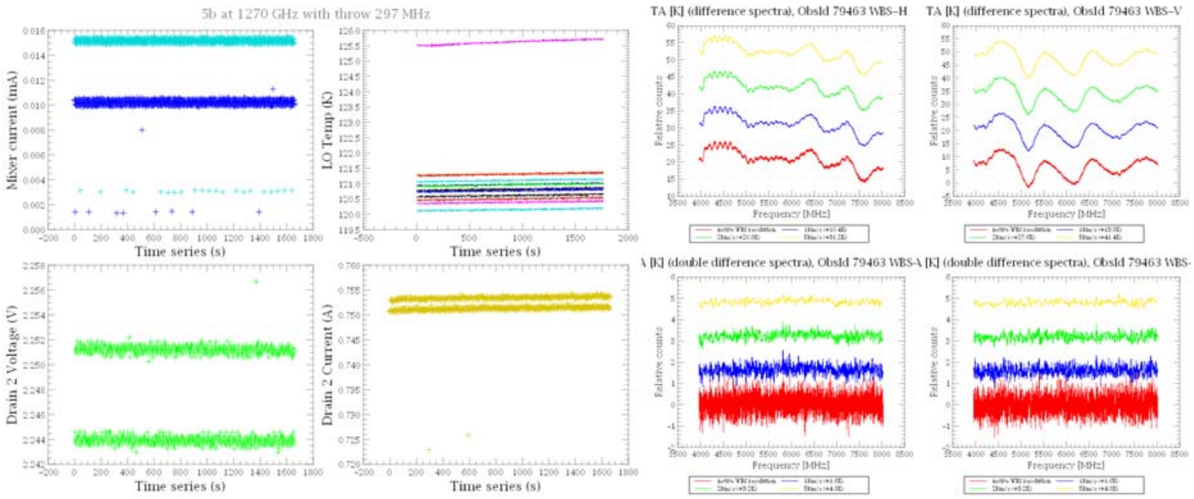

Fig.76. Testmode_stability_freqswitch_TV_2, Throw: -150 MHz, 150 MHz, Freq = 1270.93 GHz, Obsid: 1342179462, B5b. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Vd2 constant, Id2 constant. (Ideal) Even nicer baseline.

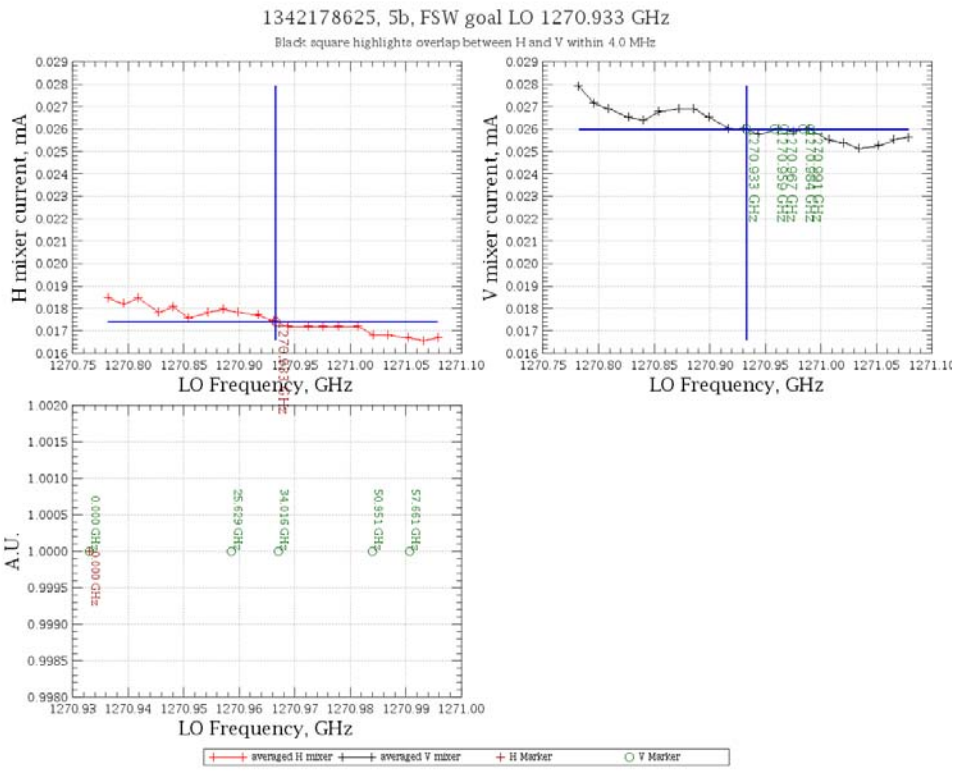

Fig.77. Standing wave profile (flat) allowing a range of throws. Thus the LO-mixer standing wave is not dominant on Imix. Testmode_stability_freqswitch_TV_2, Throw: -150 MHz, 150 MHz, Freq = 1242.9 GHz, Obsid: 1342179461.

6.11 Band 6a

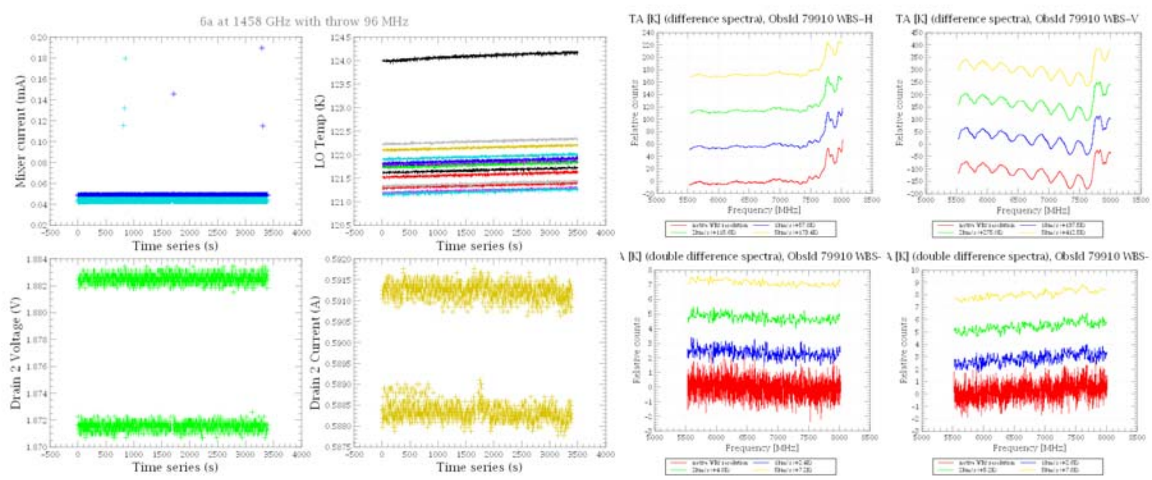

Fig.78. Testmode_stability_freqswitch_TV_1, Throw: -48 MHz, 48 MHz, Freq = 1458.33 GHz, Obsid: 1342179910, B6a. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Vd2 constant, Id2 constant. (Ideal) Nice HEB FSW baseline.

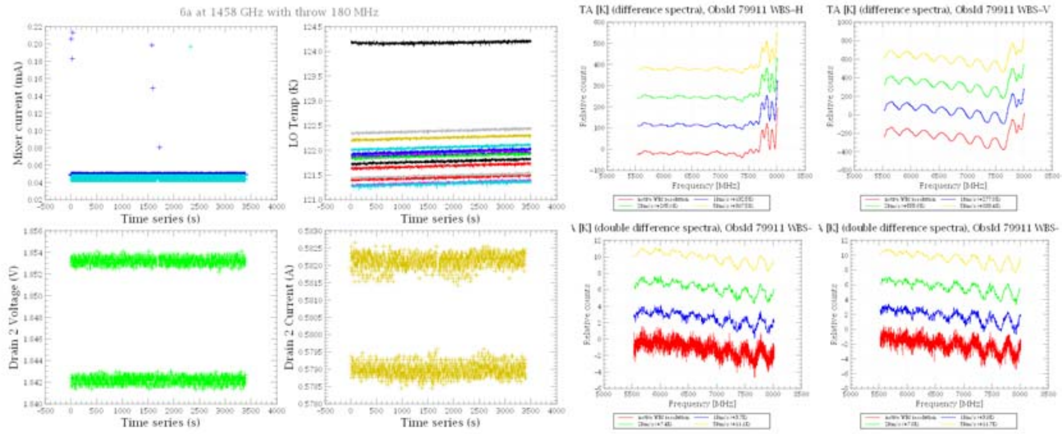

Fig.79. Testmode_stability_freqswitch_TV_1, Throw: -88 MHz, 88 MHz, Freq = 1458.33 GHz, Obsid: 1342179911, B6a. largethrow, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Vd2 constant, Id2 constant. But optical standing wave subtraction not ideal. This can be explained by the standing wave profile below. A throw of -145, 0 MHz would have been better.

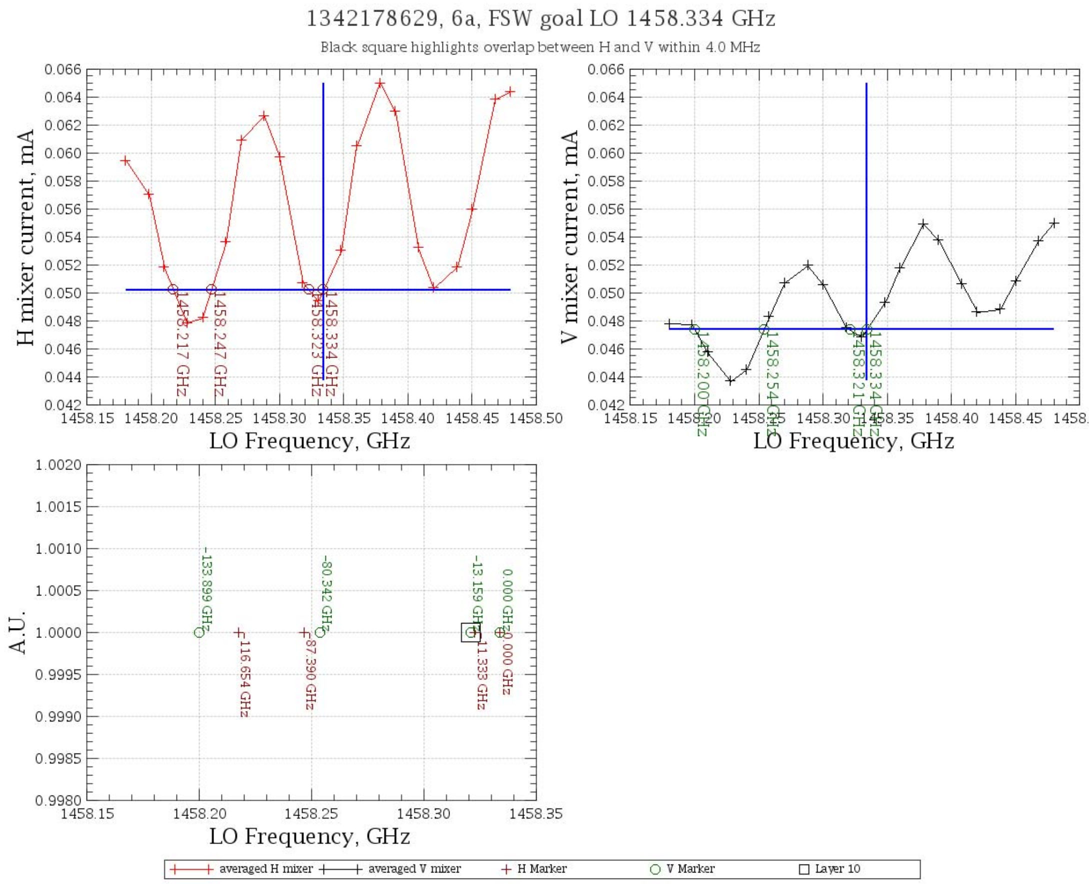

Fig.80. Standing wave profile. A throw of -88, 88 MHz does not fit the profile very well.

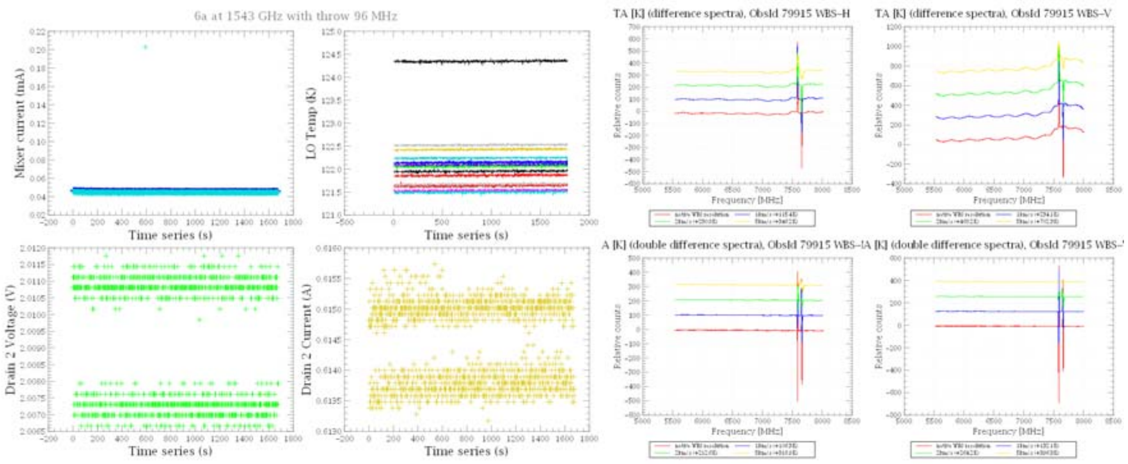

Fig.81. Testmode_stability_freqswitch_TV_1, Throw: -48 MHz, 48 MHz, Freq = 1543.79 GHz, Obsid: 1342179915, B6a. Default throw, Not taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Vd2 is not constant, Id2 constant.

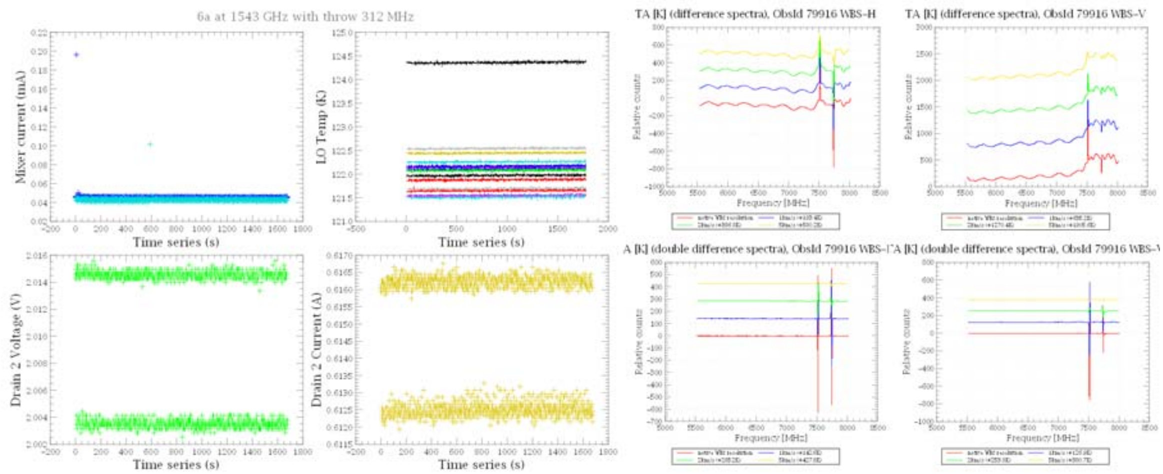

Fig.82. Testmode_stability_freqswitch_TV_2, Throw: -154 MHz, 160 MHz, Freq = 1543.79 GHz, Obsid: 1342179916, B6a. Assymetric throw, taking into account the phase/amplitude of the standing wave profile. Imix-V (cyan), Imix-H constant. Vd2 is not constant, Id2 constant.

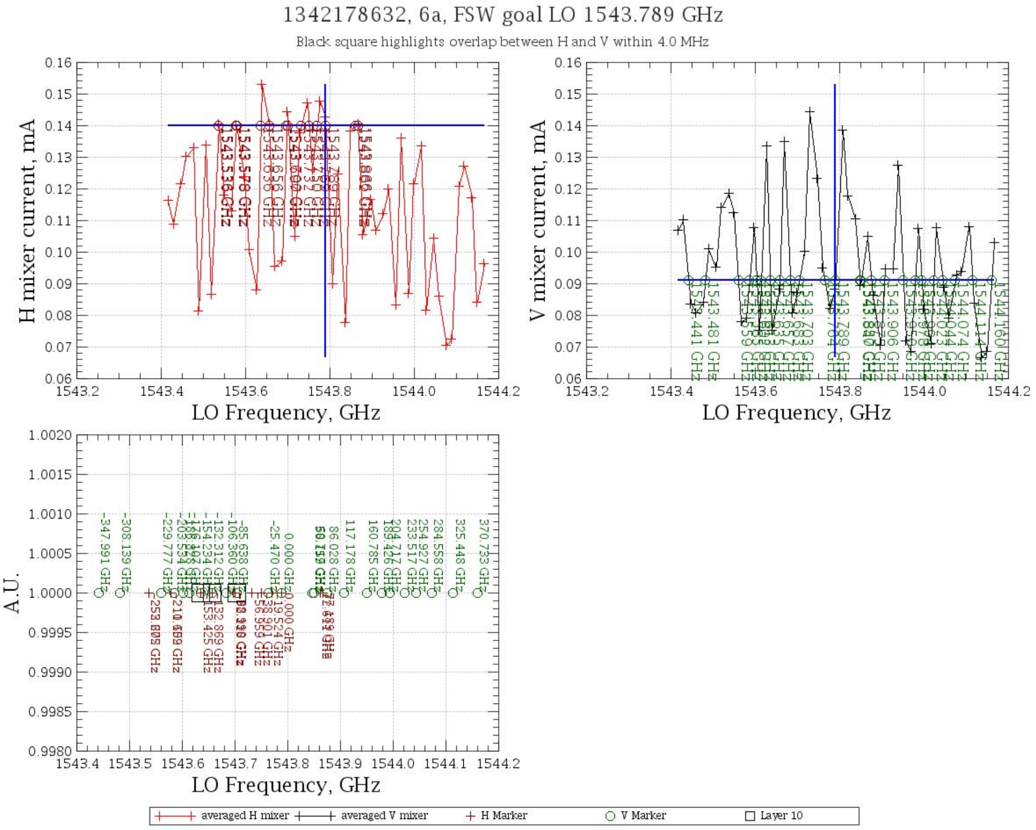

Fig.83. Testmode_stability_freqswitch_TV_2, Throw: -154 MHz, 160 MHz, Freq = 1543.79 GHz, Obsid: 1342179916, B6a. This is one of many possibilities. Inthe HEB bands it is important to get the standing wave profile as the Lo-mixer standing wave is a considerable fraction of the HEB LO pump current.

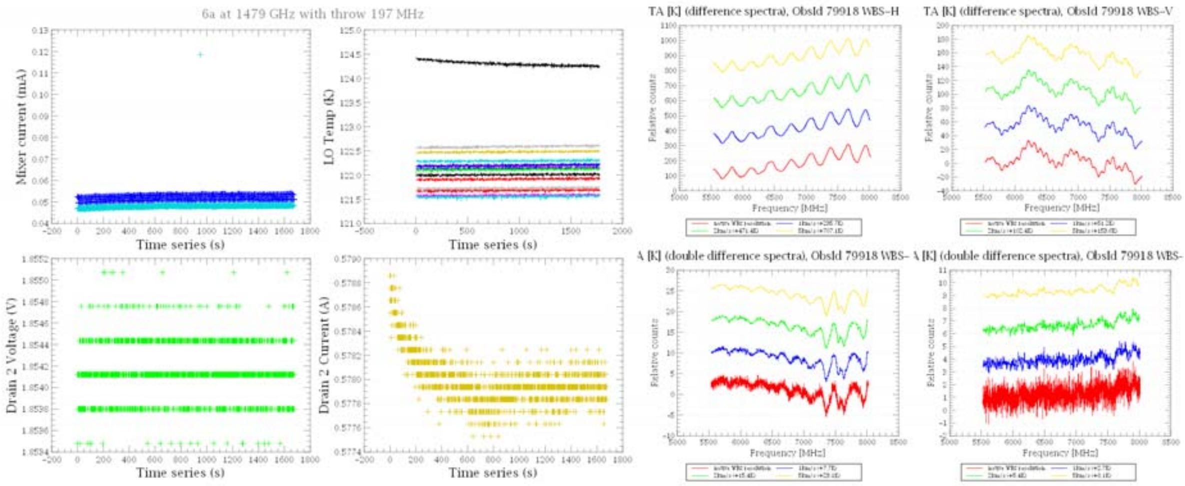

Fig.84. Testmode_stability_freqswitch_TV_1, Throw: -48 MHz, 48 MHz, Freq = 1479.4 GHz, Obsid: 1342179918, B6a. This is one of many possibilities. In the HEB bands it is important to get the standing wave profile as the Lo-mixer standing wave is a considerable fraction of the HEB LO pump current.

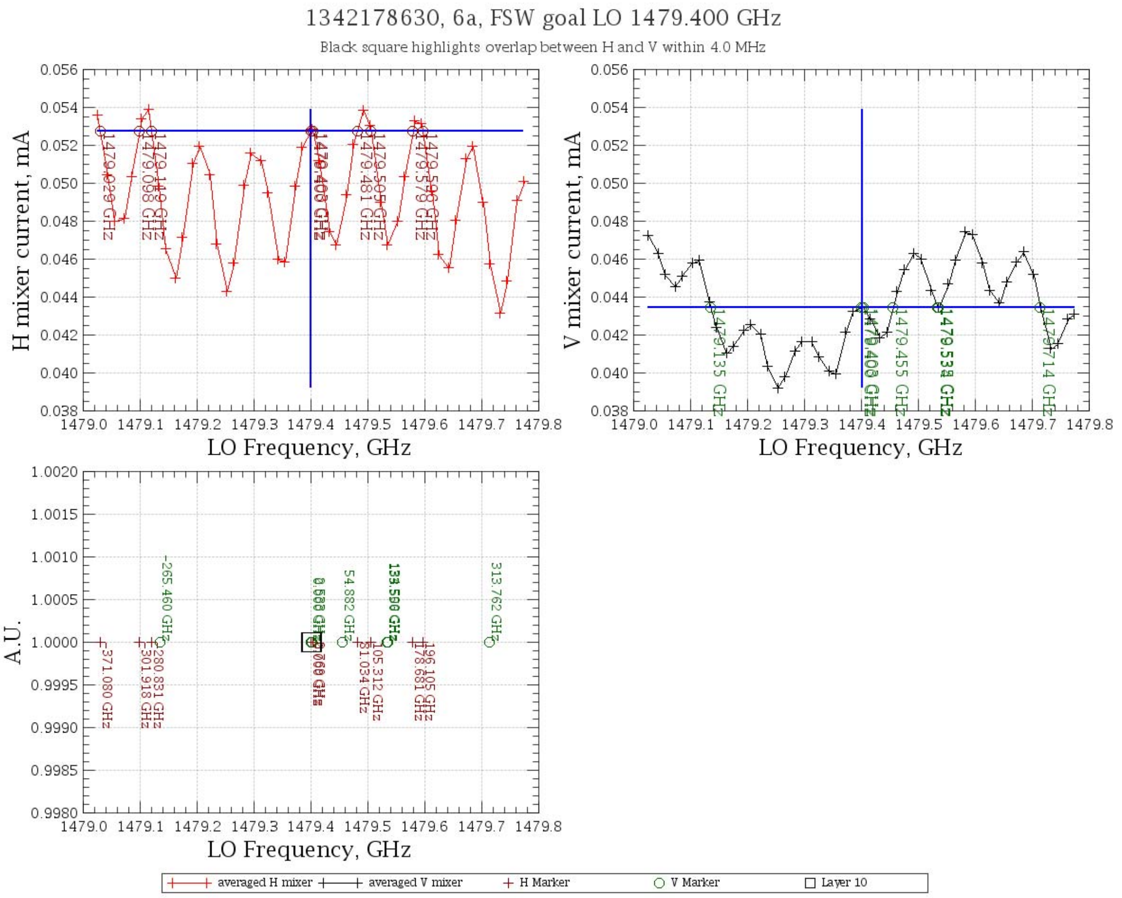

Fig.85. Standing wave profile. Testmode_stability_freqswitch_TV_1, Throw: -48 MHz, 48 MHz, Freq = 1479.4 GHz, Obsid: 1342179918, B6a. There are clearly more preferred then the default +- 48 MHz throw.

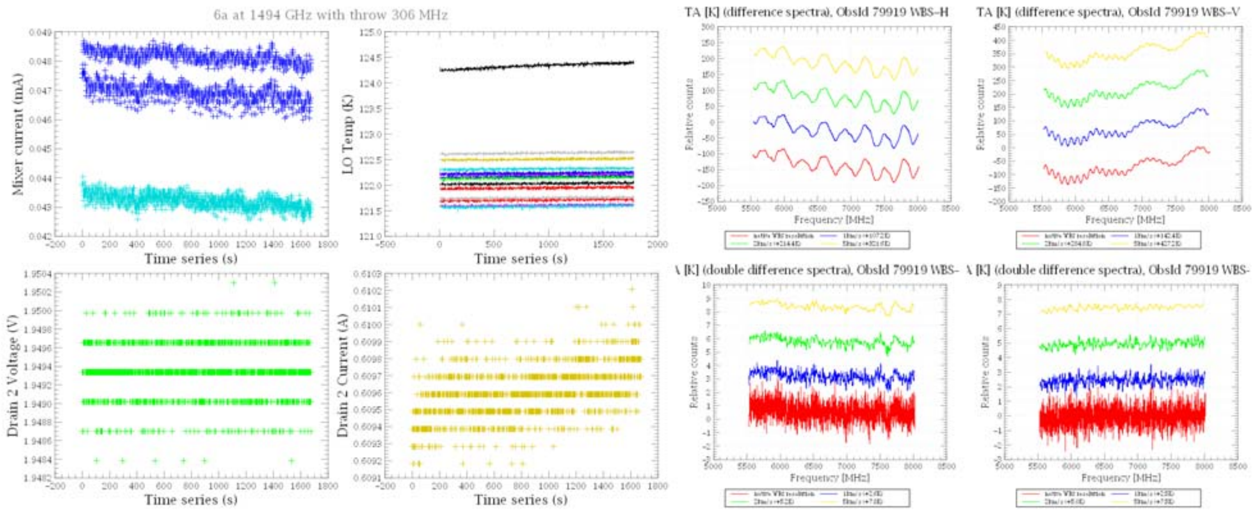

Fig.85. Testmode_stability_freqswitch_TV_1, Throw: -48 MHz, 48 MHz, Freq = 1494.12 GHz, Obsid: 1342179919, B6a. In this case V got the current matched, H did not. However there are solutions to optimize both. From the double difference spectra it is also evident that V is better then H.

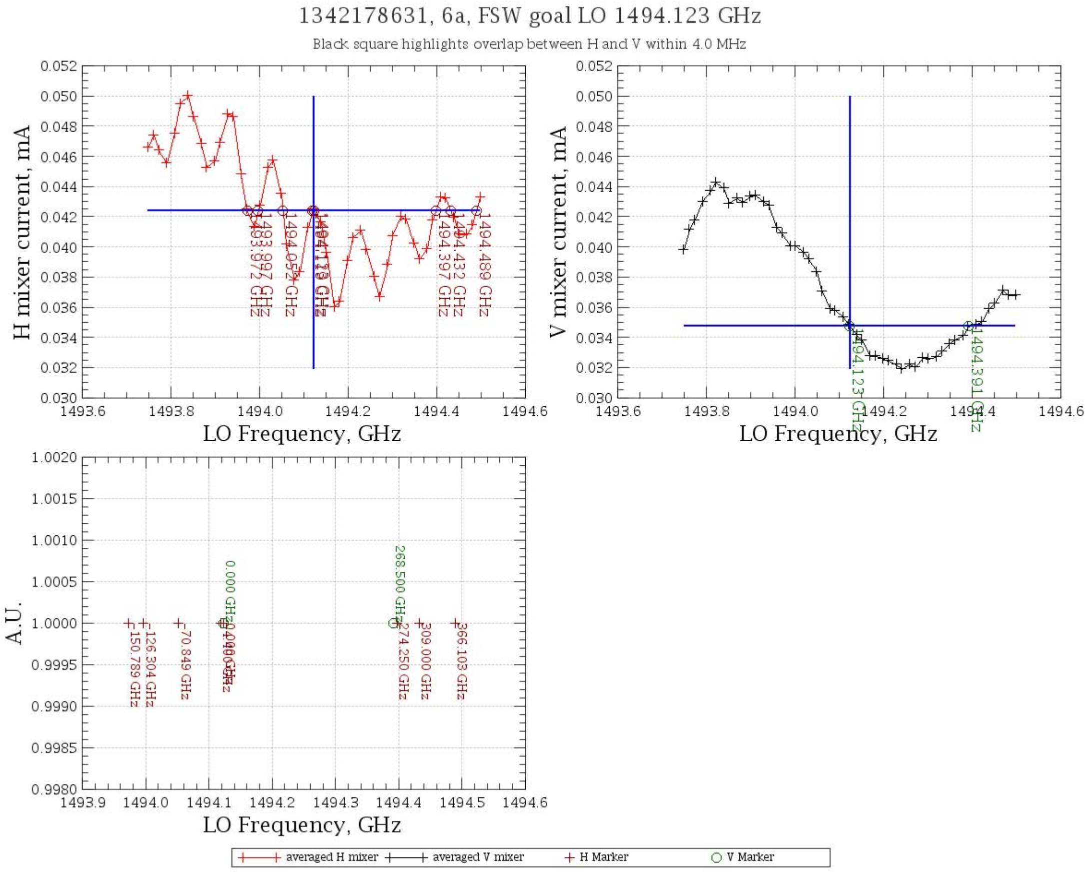

Fig.86. Standing wave profile Testmode_stability_freqswitch_TV_1, Throw: -48 MHz, 48 MHz, Freq = 1494.12 GHz, Obsid: 1342179919, B6a. There are clearly more preferred then the default +- 48 MHz throw.

6.12 Band 6b

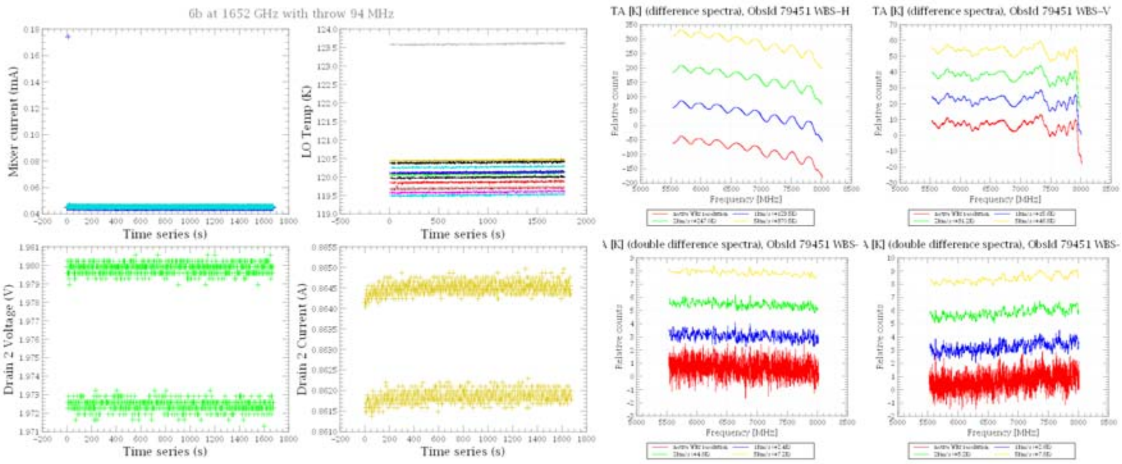

Fig.87. Testmode_stability_freqswitch_TV_1, Throw: -48 MHz, 48 MHz, Freq = 1653.01 GHz, Obsid: 1342179451, B6b. Both H & V have constant Imix, Vd2, Id2 also constant. Only a small optical standing wave is left. The standing wave is 300 MHz correposnign to the distance between the mixer and the first LNA.

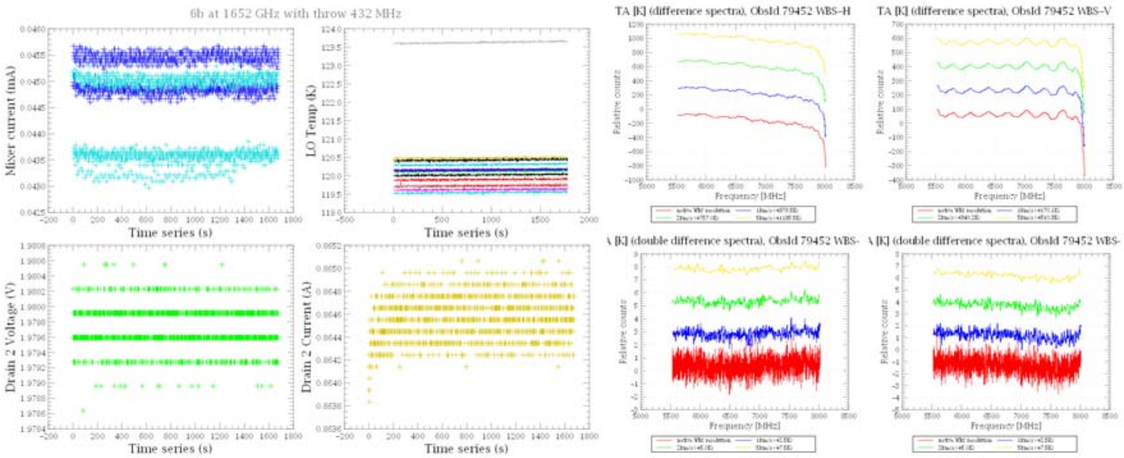

Fig.88. Testmode_stability_freqswitch_TV_2, Throw: -293 MHz, 27 MHz ?? (Typo?), Freq = 1653.01 GHz, Obsid: 1342179451, B6b. Both H & V have constant Imix, Vd2, Id2 also constant. Only a small optical standing wave is left. Unclear what throw was used.

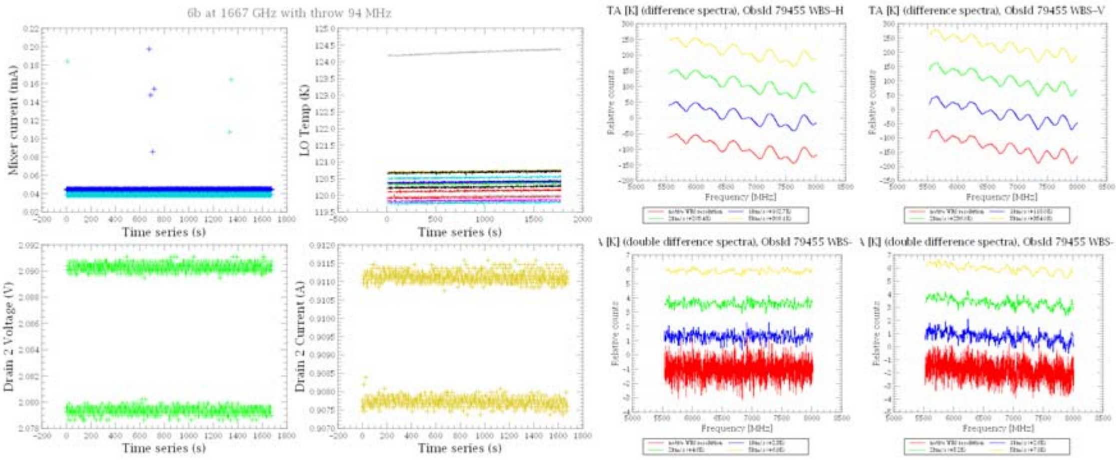

Fig.89. Testmode_stability_freqswitch_TV_2, Throw: -48 MHz, 48 MHz. Freq = 1667.11 GHz, Obsid: 1342179455, B6b. Both H & V have constant Imix, Vd2, Id2 also constant. Only a small optical standing wave is left.

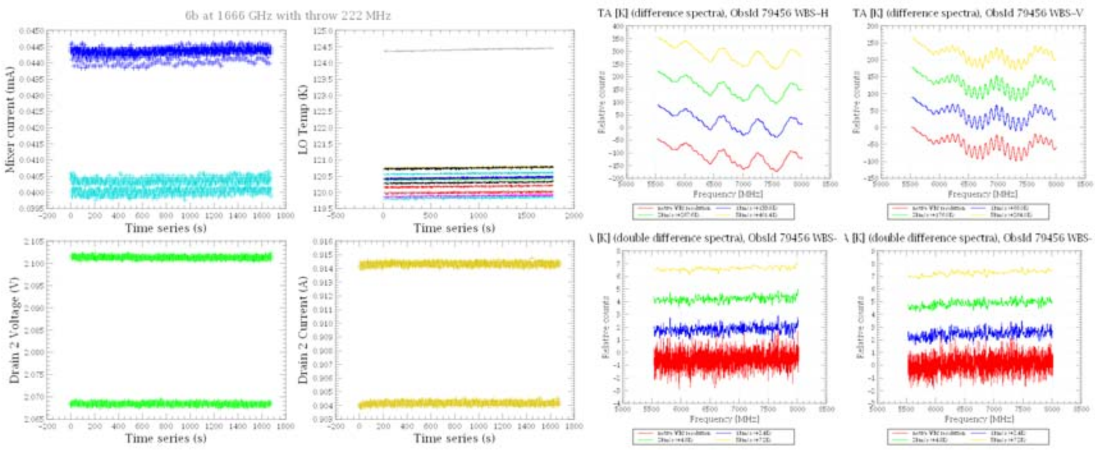

Fig.90. Testmode_stability_freqswitch_TV_2, Throw: -311 MHz, 130 MHz ?? (Typo 442/2?), Freq = 1667.11 GHz, Obsid: 1342179456, B6b. Both H & V have constant Imix, Vd2, Id2 also constant.

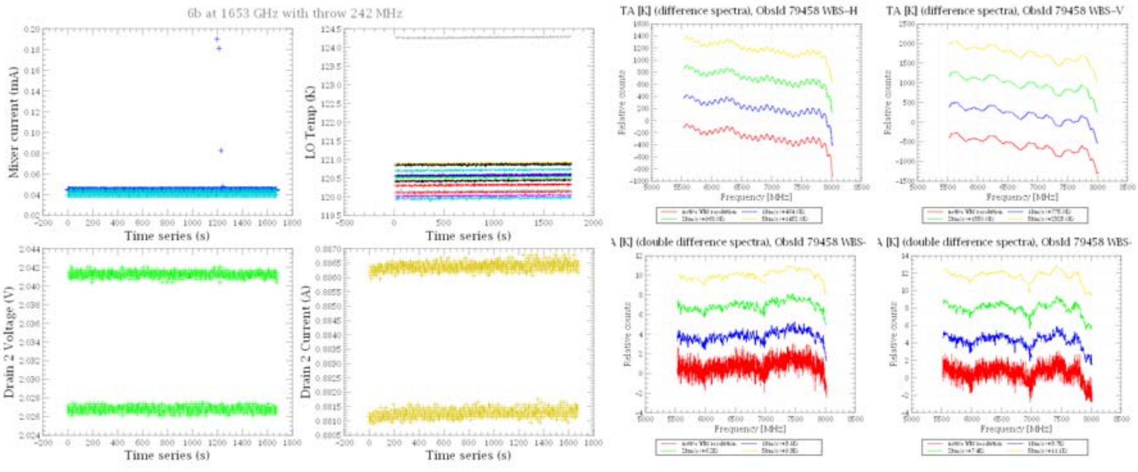

Fig.93. Testmode_stability_freqswitch_TV_2, Throw: -167 MHz, 75 MHz , Freq = 1654.17 GHz, Obsid: 1342179458, B6b. Both H & V have constant Imix, Vd2, Id2 also constant. This should have given a good baseline.

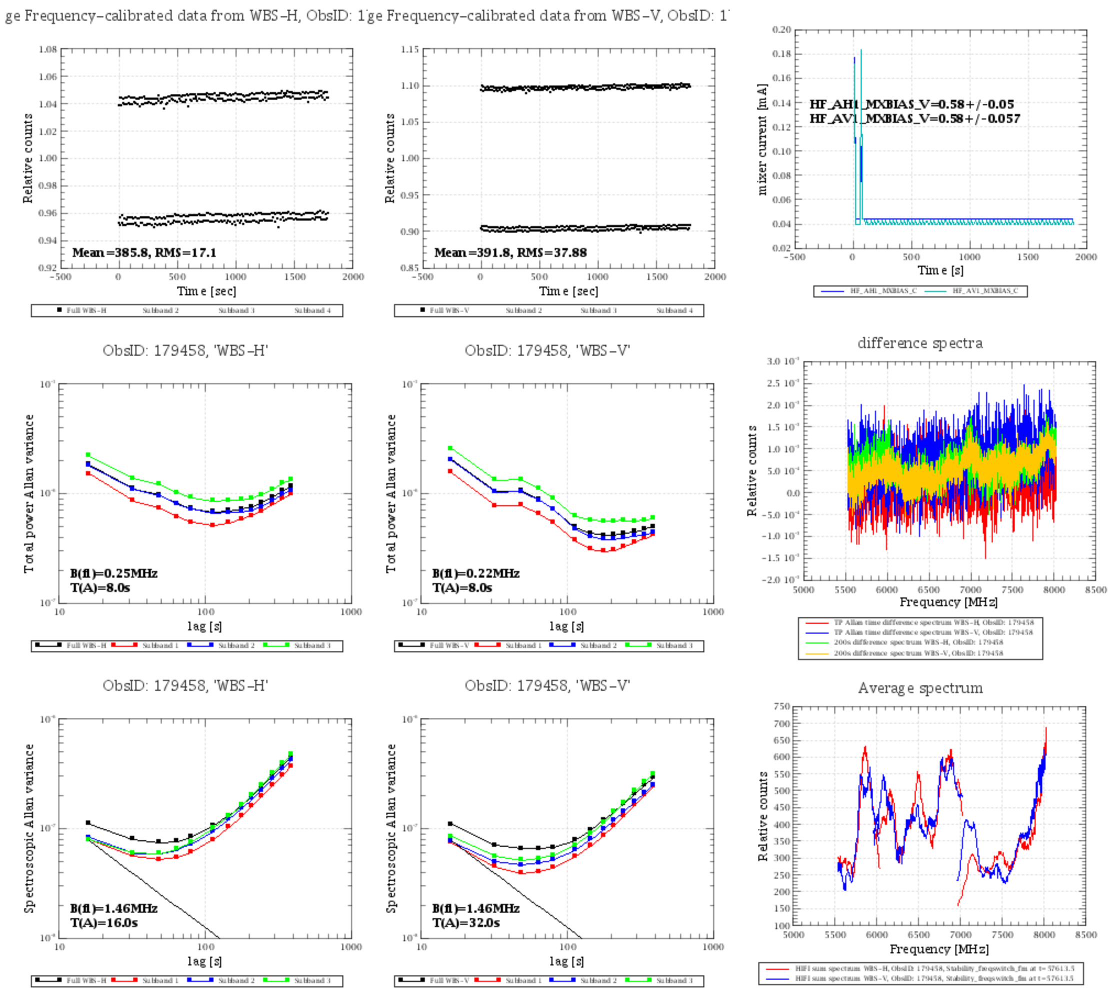

Fig.94 System stability. Freq = 1654.17 GHz, Obsid: 1342179458, B6b. Relatively poor.

6.13 Band 7a

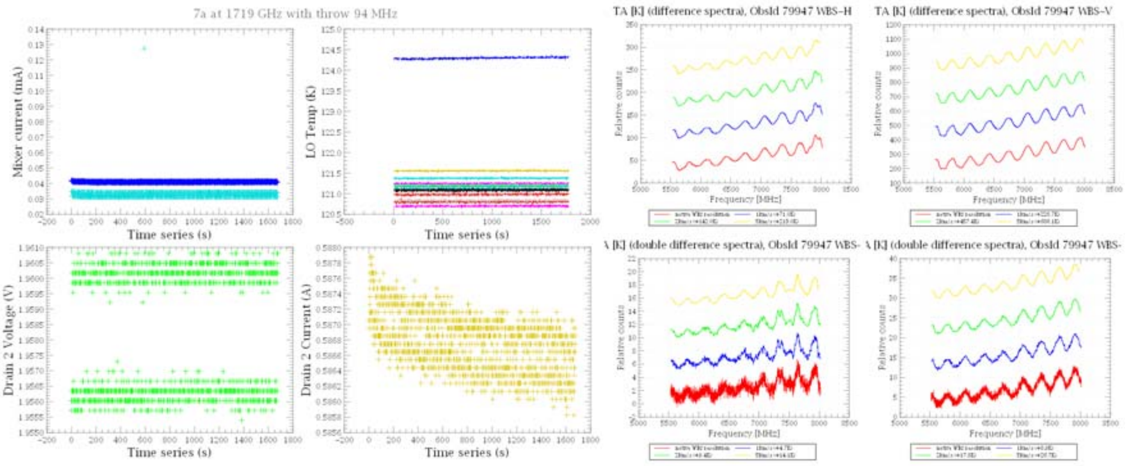

Fig.95. Testmode_stability_freqswitch_TV_1, Throw: -48 MHz, 48 MHz, Freq = 1719.57 GHz, Obsid: 1342179947, B7a. Both H & V have constant Imix, V perhaps slightly more current modulation. Vd2, not constant. Electrical 300 MHz standing wave residual.

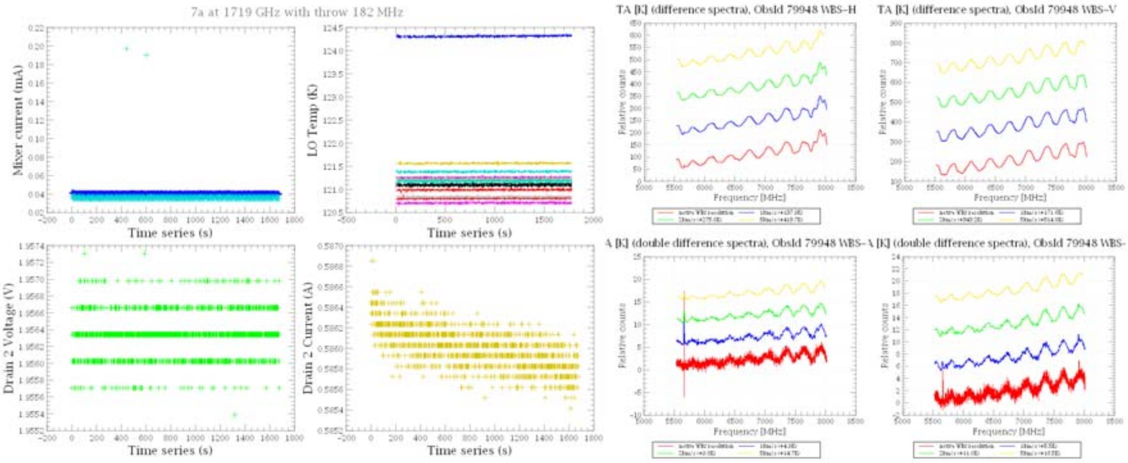

Fig.96. Testmode_stability_freqswitch_TV_2, Throw: -152 MHz, 32 MHz, Freq = 1719.57 GHz, Obsid: 1342179948, B7a. Both H & V have constant Imix, Vd2 almost constant. Perhaps slightly improved 300 MHz electrical standing wave residual. However LARGER effective throw. The standing wave is 300 MHz correposnign to the distance between the mixer and the first LNA.

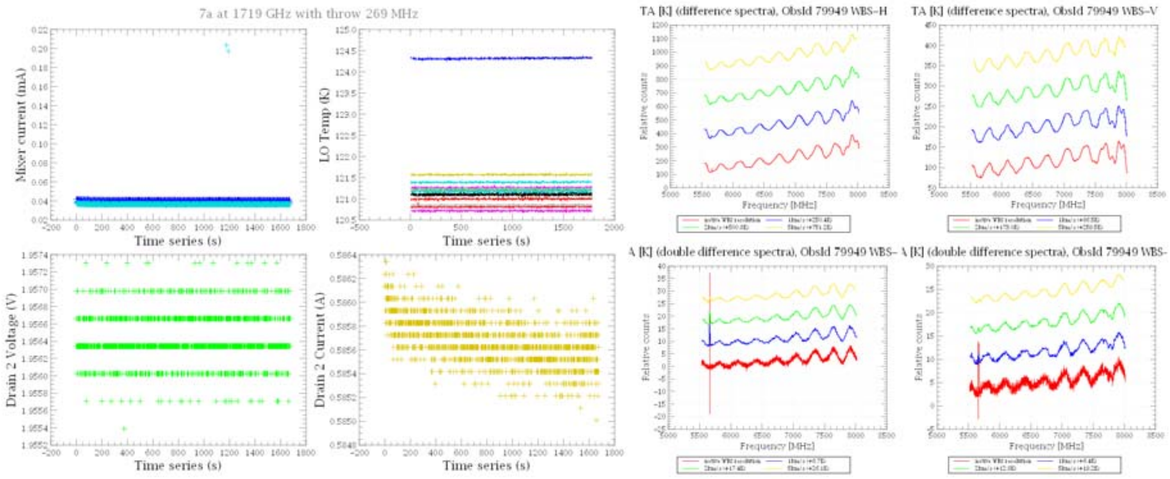

Fig.97. Testmode_stability_freqswitch_TV_3, Throw: -152 MHz, 118MHz, Freq = 1719.57 GHz, Obsid: 1342179949, B7a. Both H & V have constant Imix, Vd2 almost constant. Perhaps slightly improved 300 MHz electrical standing wave residual. However even LARGER effective throw. The reason the 300 MHz standing wave does not subtract is that the instrument stability is not good enough. The standing wave is 300 MHz correposnign to the distance between the mixer and the first LNA.

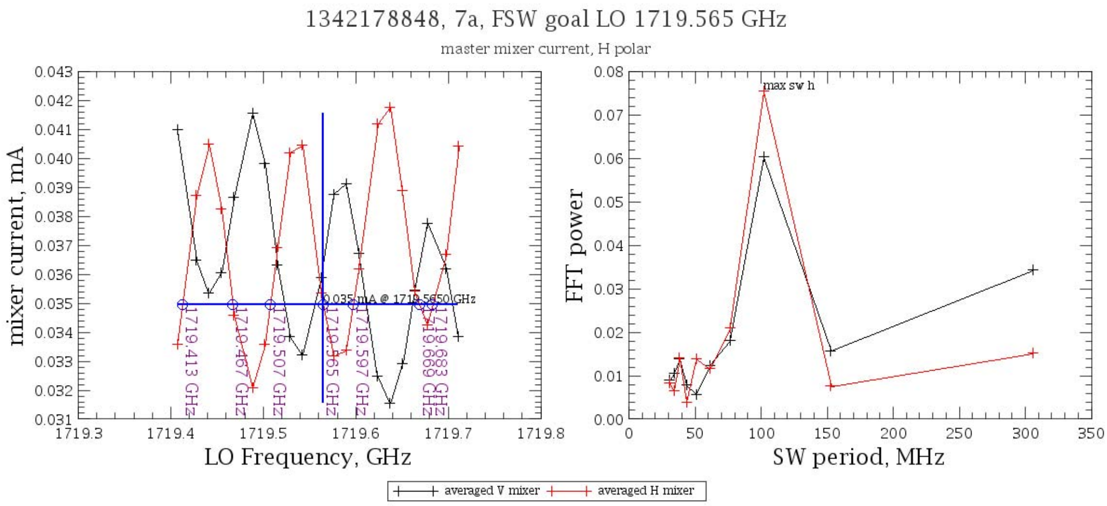

Fig. 98. Residual standing wave. From the above it is clearly possible to obtain constant mixer current at larger throws. However the standing wave will has to be measured fist. Something we have done in CoP for 54 frequencies.

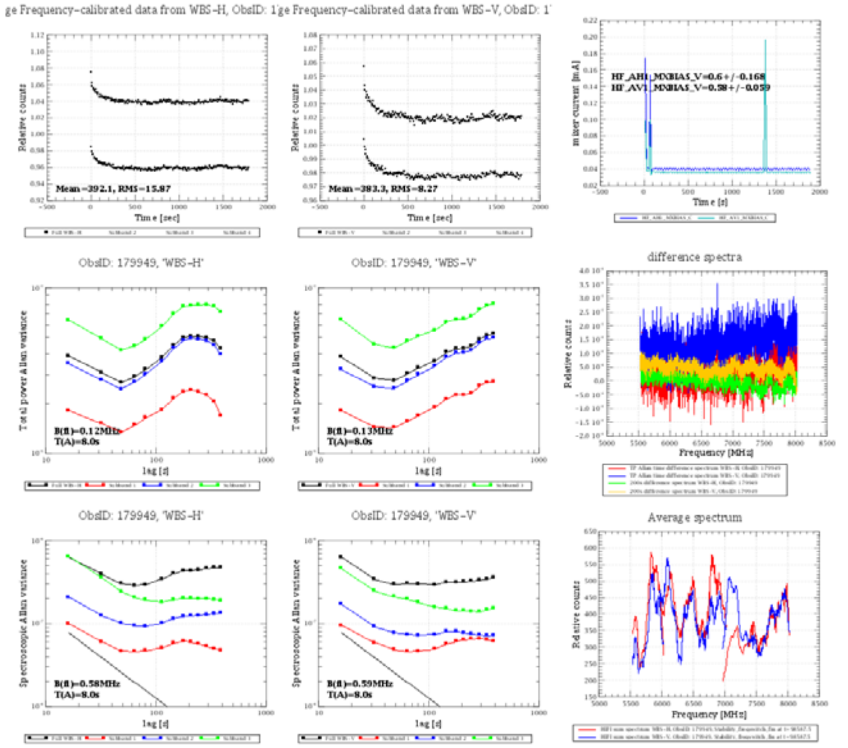

Fig.99. System stability of freqswitch_TV_3, Throw: -152 MHz, 118 MHz, Freq = 1719.57 GHz, Obsid: 1342179949, B7a.

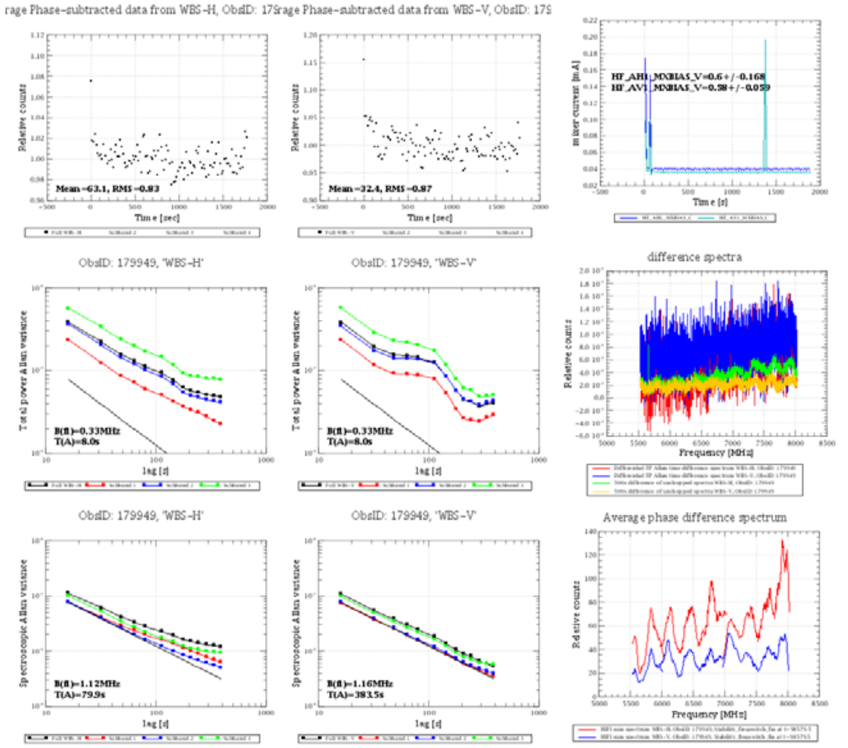

Fig.100.Differential stability of freqswitch_TV_3, Throw: -152 MHz, 118 MHz, Freq = 1719.57 GHz, Obsid: 1342179949, B7a.

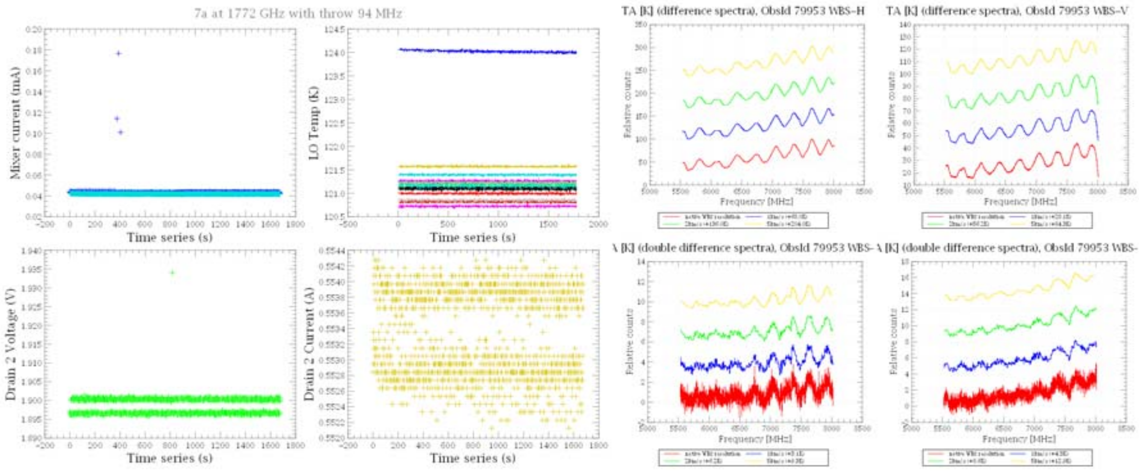

Fig.101. Testmode_stability_freqswitch_TV_1, Throw: -48 MHz, 48 MHz, Freq = 1772.68 GHz, Obsid: 1342179953, B7a. Both H & V have constant Imix, Vd2 constant. Electrical 300 MHz standing wave residual due to instability in B7a. Try current matched 'off' subtraction method. The standing wave is 300 MHz correposnign to the distance between the mixer and the first LNA.

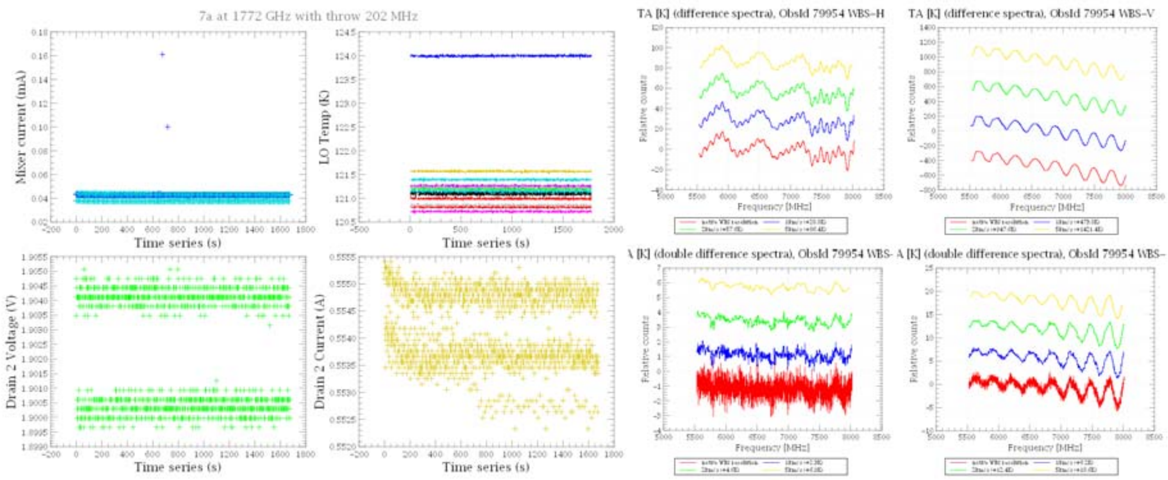

Fig.102. Testmode_stability_freqswitch_TV_2, Throw: -88 MHz, 110 MHz, Freq = 1772.68GHz, Obsid: 1342179954, B7a. Both H & V have constant Imix, Vd2 not constant. Electrical 300 MHz standing wave residual due to instability in B7a. Try current matched 'off' subtraction method. The standing wave is 300 MHz correposnign to the distance between the mixer and the first LNA.

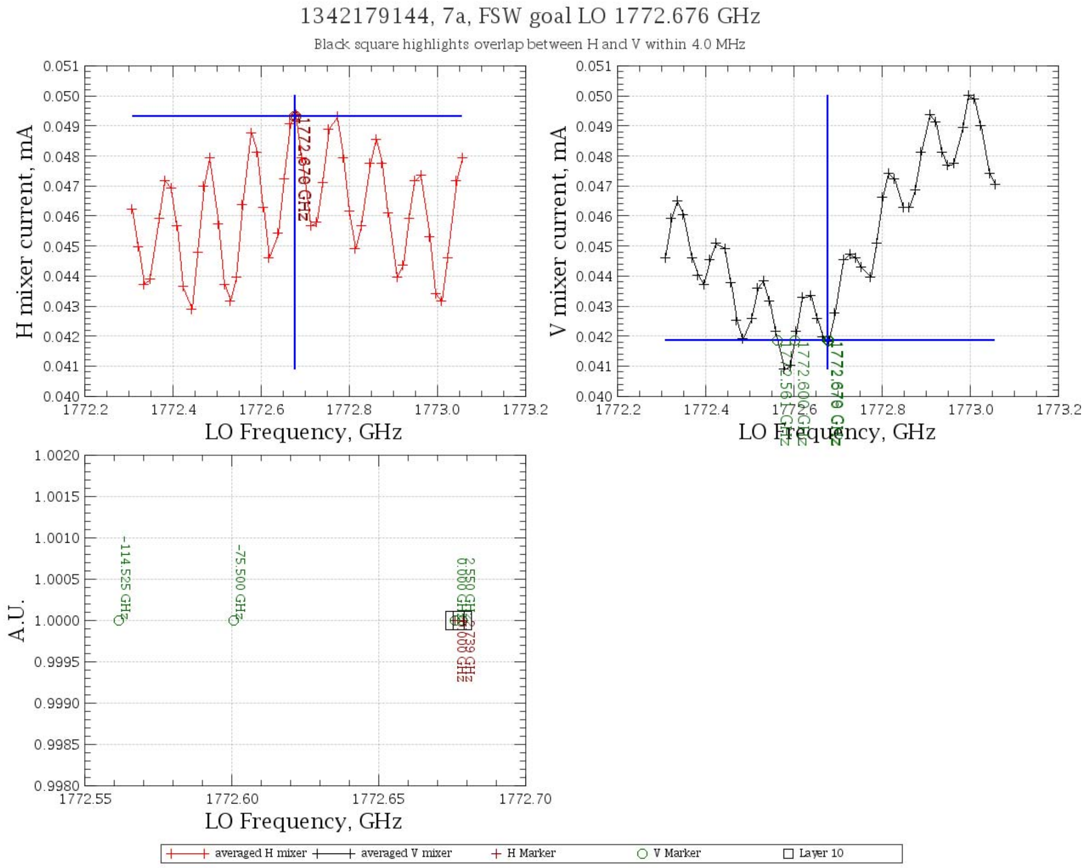

Fig.103. The situation for Freq = 1772.68 GHz, Obsid: 1342179954, B7a. Difficult to get a good match for both H & V.

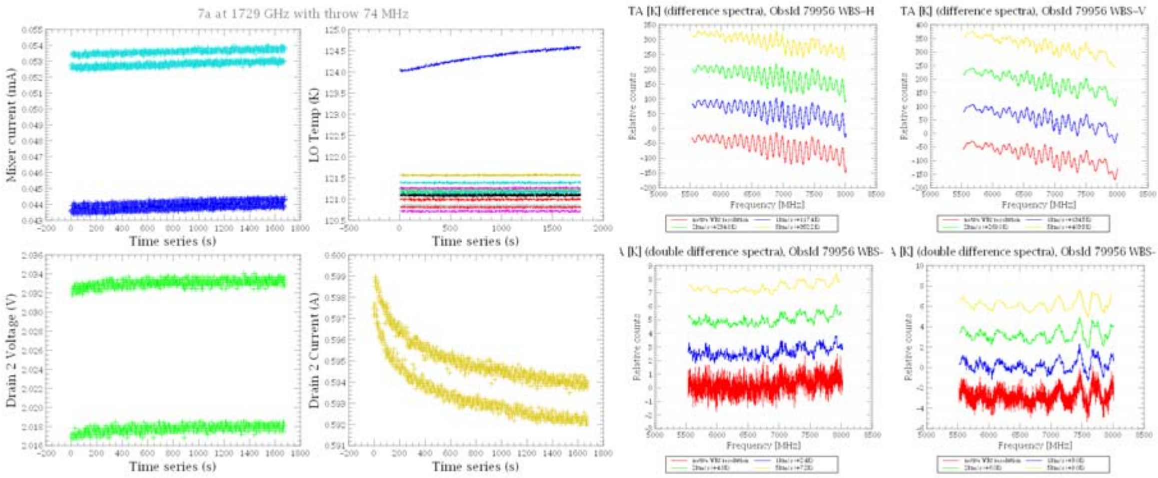

Fig.104. Testmode_stability_freqswitch_TV_1, Throw: 0 MHz, 72 MHz, Freq = 1729.4 GHz, Obsid: 1342179956, B7a. Both H current better matched then V current Vd2 not constant. In this case V may be the slave as the technique to try to match both H & V had not yet been applied universally. Electrical 300 MHz standing wave residual due to instability in B7a. Try current matched 'off' subtraction method.

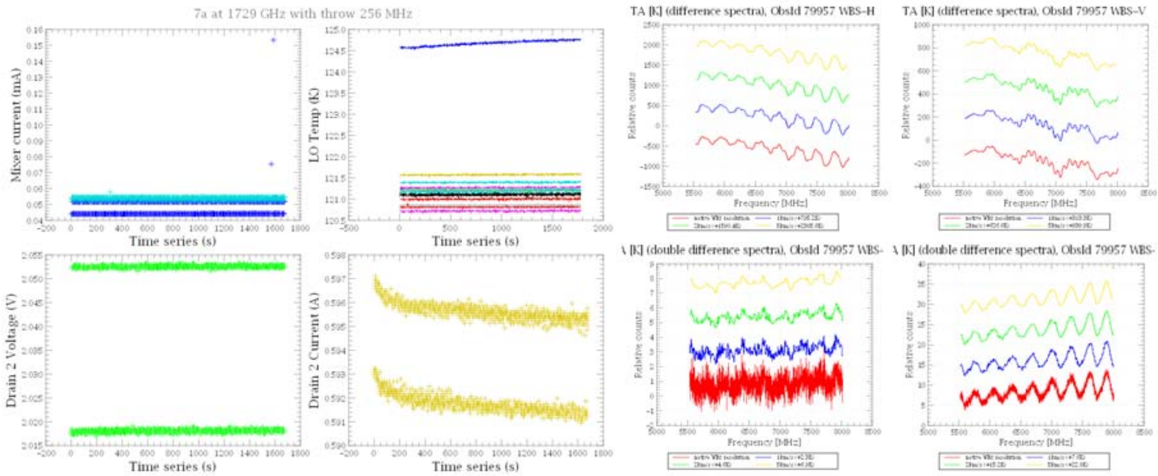

Fig.105. Testmode_stability_freqswitch_TV_2, Throw: 0 MHz, 253 MHz, Freq = 1729.4 GHz, Obsid: 1342179957, B7a. V seem better matched then H, though the spectra show the opposite?. Throw quite large. Electrical 300 MHz standing wave residual due to instability in B7a. Try current matched 'off' subtraction method. The standing wave is 300 MHz correposnign to the distance between the mixer and the first LNA.

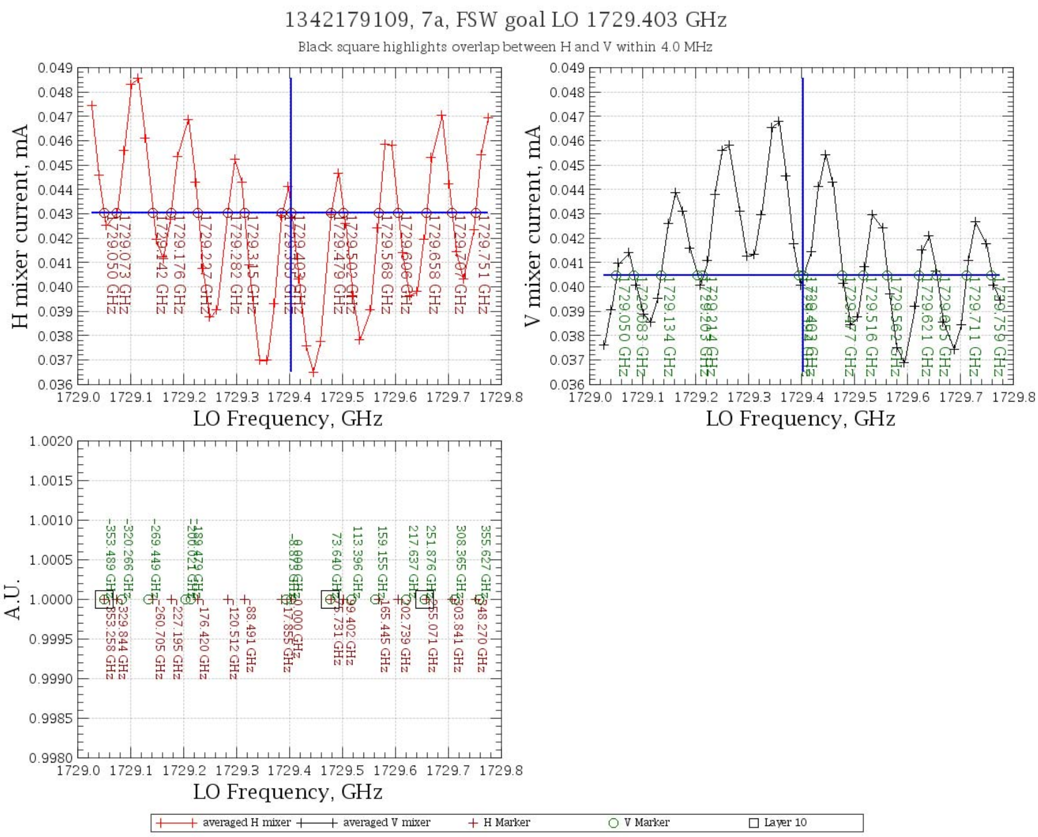

Fig. 106. Standing wave of Freq = 1729.4 GHz, Obsid: 1342179956, 1342179957, B7a.

6.14 Band 7b

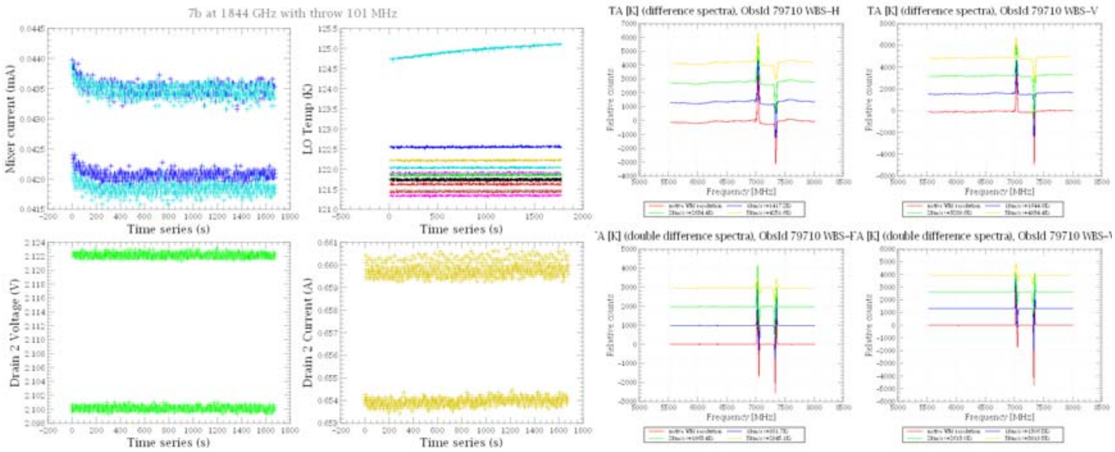

Fig.107. Testmode_stability_freqswitch_TV_1, Throw: -48 MHz, 48 MHz, Freq = 1844.15 GHz, Obsid: 1342179710, B7b. Mixer current seem quite unmatched. Remove spur, re-analyze.

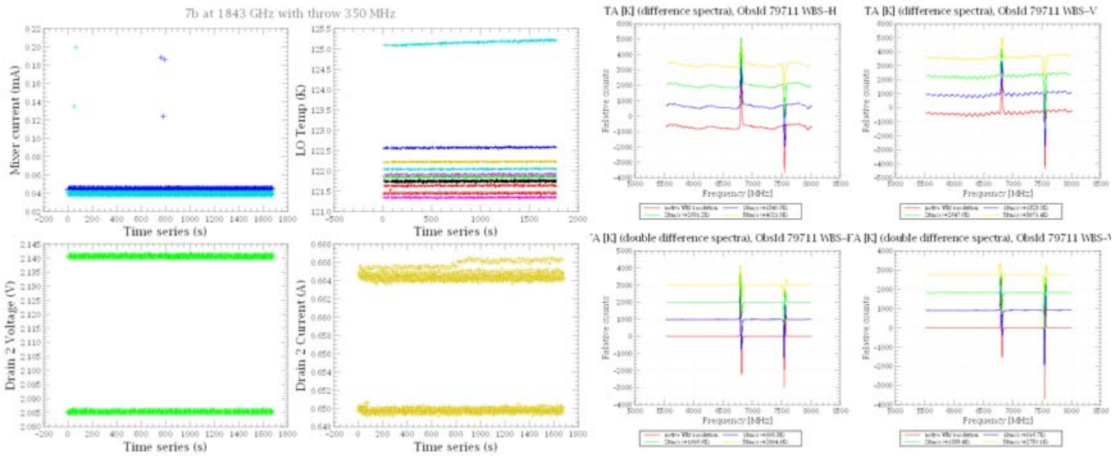

Fig.108. Testmode_stability_freqswitch_TV_2, Throw: -240 MHz, 110 MHz, Freq = 1844.15 GHz, Obsid: 1342179711, B7b. H & V much better matched then Obsid: 134217971. . Remove spur, re-analyze.

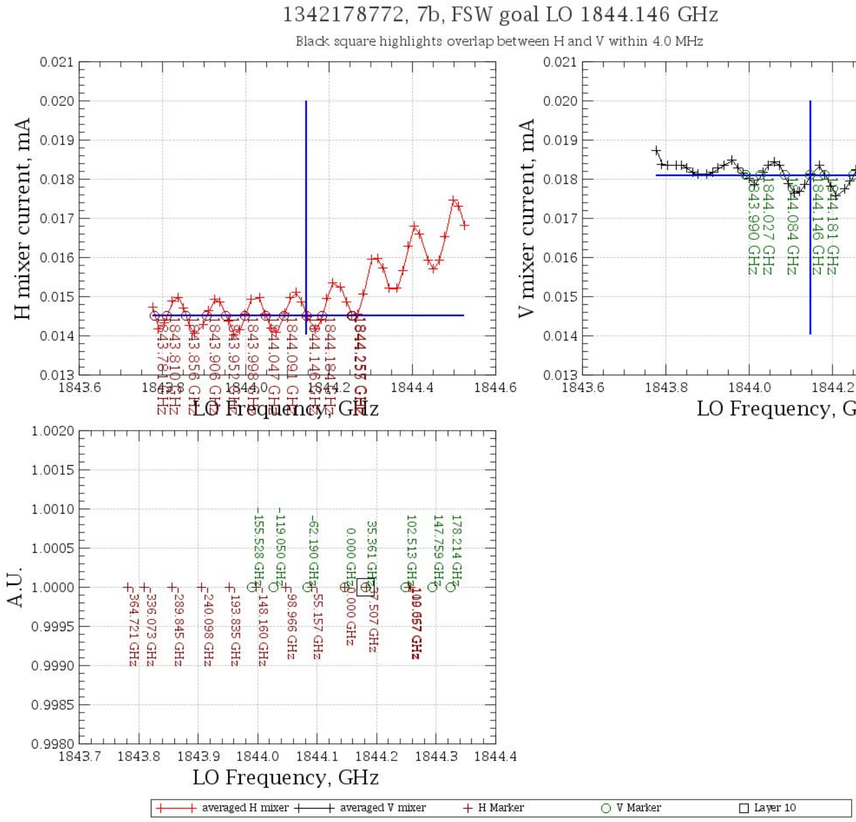

Fig. 109. Standing wave situation for Obsid: 1342179710, 1342179711, B7b. Freq = 1844.15 GHz

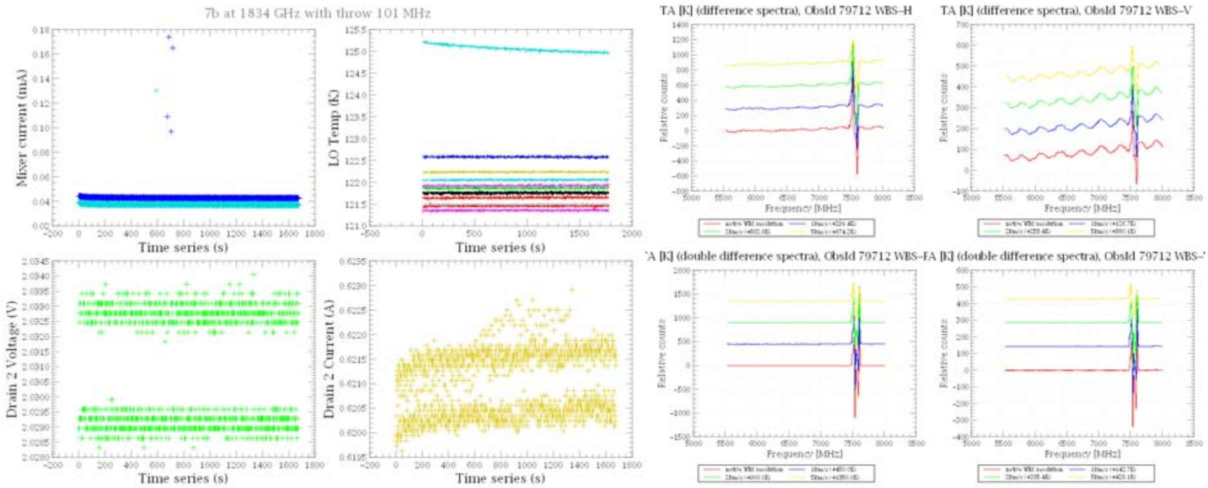

Fig.110. Testmode_stability_freqswitch_TV_1, Throw: -48 MHz, 48 MHz, Freq = 1834.95 GHz, Obsid: 1342179712, B7b. Mixer current matched. Remove spur, re-analyze.

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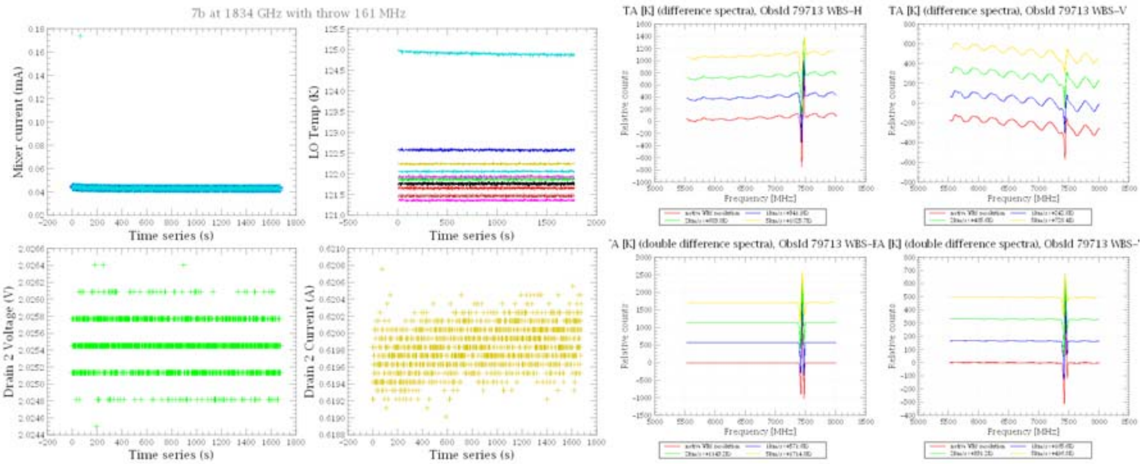


Fig.111. Testmode_stability_freqswitch_TV_2, Throw: -167 MHz, 0 MHz, Freq = 1834.95 GHz, Obsid: 1342179713, B7b. Mixer current matched. Remove spur, re-analyze. Mixer current matched. Remove spur, re-analyze.

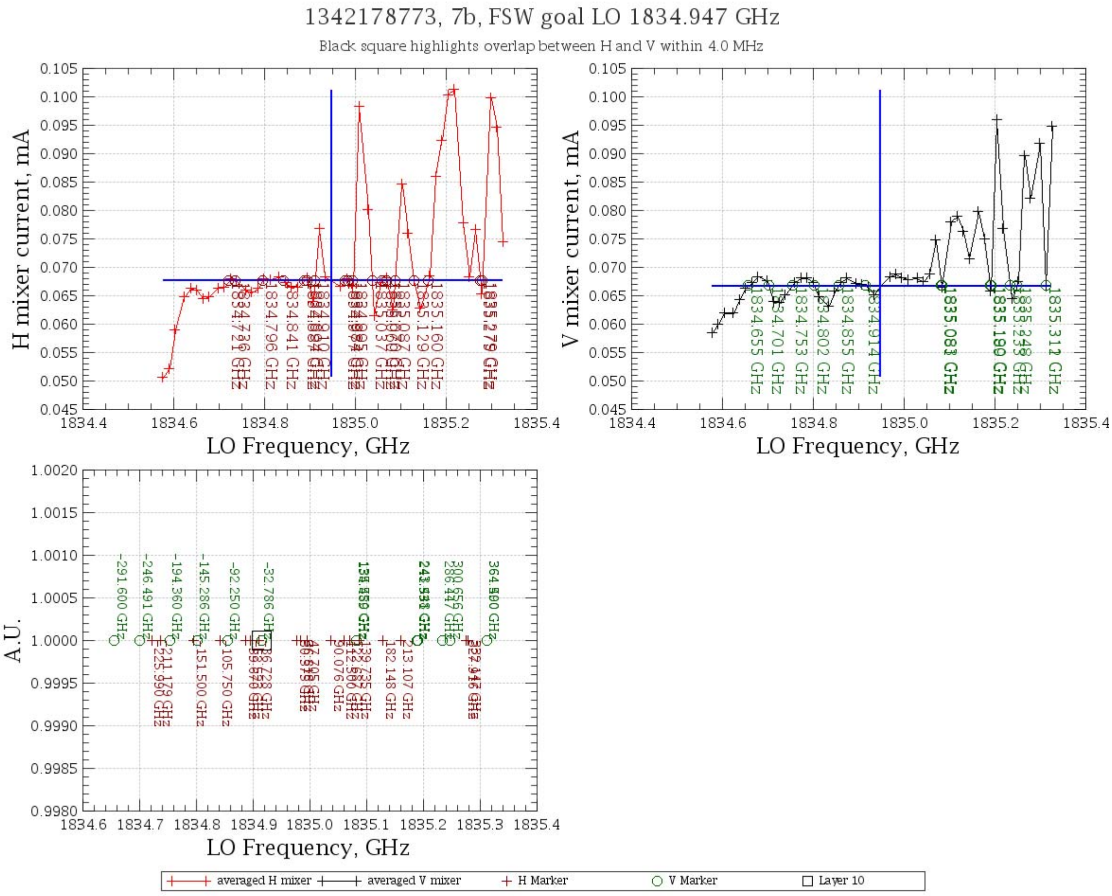


Fig. 112. Standing wave profile. , Freq = 1834.95 GHz, Obsid: 1342179712, 1342179713, B7b.

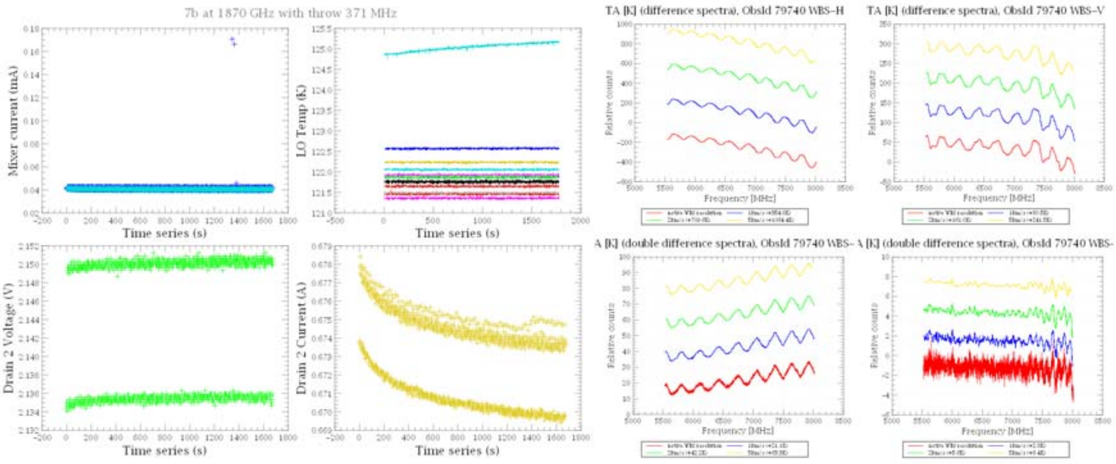


Fig.111. Testmode_stability_freqswitch_TV_2, Throw: -367 MHz, 0 MHz, Freq = 1870.55 GHz, Obsid: 1342179740, B7b. Mixer current matched, some PA drift due to frequency change. This is seems on occasion in the high frequency bands. V slightly better matched that H. Try current off subtraction technique. The standing wave is 300 MHz correposnign to the distance between the mixer and the first LNA.

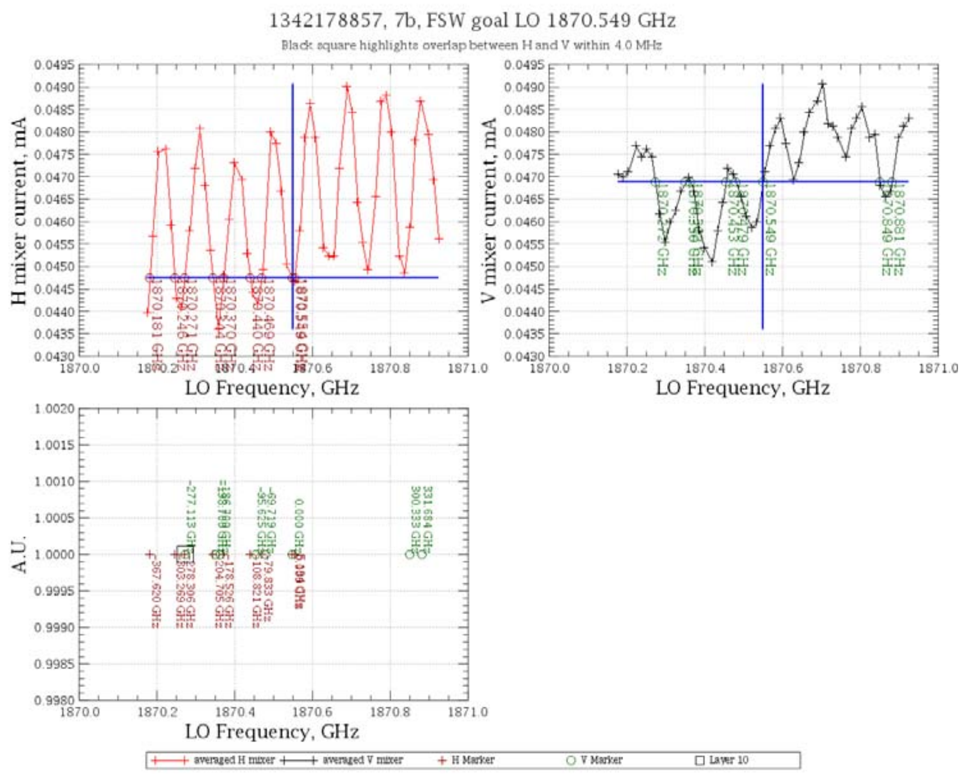


Fig. 112. Standing wave profile for Testmode_stability_freqswitch_TV_2, Throw: -367 MHz, 0 MHz, Freq = 1870.55 GHz, Obsid: 1342179740, B7b.

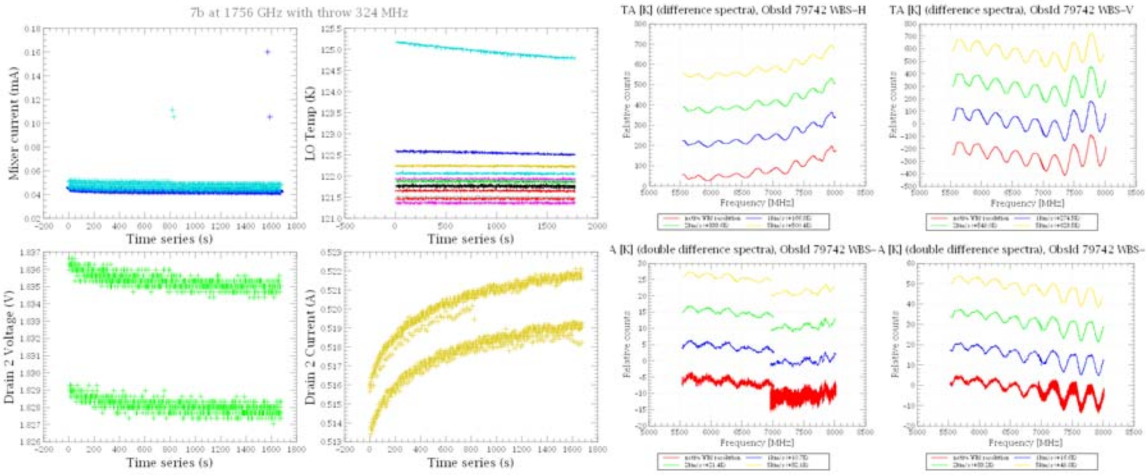
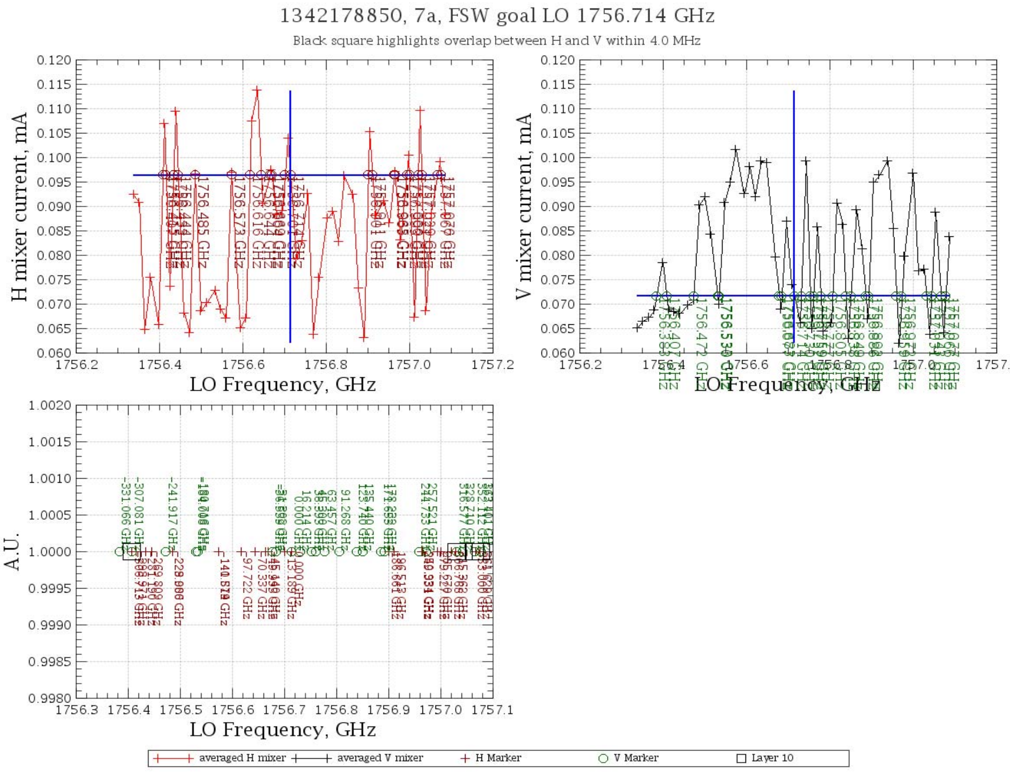


Fig.113. Testmode_stability_freqswitch_TV_2, Throw: -140 MHz, 186 MHz, Freq = 1756.71 GHz, Obsid: 1342179742, B7b. Mixer current matched, some PA drift due to frequency change. This is seems on occasion in the high frequency bands. V slightly better matched that H. Try current off subtraction technique.



Standing wave profile for Testmode_stability_freqswitch_TV_2, Throw: -140 MHz, 186 MHz, Freq = 1756.71 GHz, Obsid: 1342179742, B7b.

Note; C+, FSW on Int. CBB (1342179680, 1342179681, 1342179682) failed. (No mixer current).

7 Conclusion

7.1 General

To properly understand the FSW observation mode, system stability and the mixer-LO standing wave profiles will need to be taken into account. This makes for a complex situation. In general we find that:

- Optimum FSW appears, as in TB/TV when Imix and Vd2 are constant. This can only be really achieved if either the standing wave pattern is measured (section 1).
- The power dissipation (Vd2 * Id2) seems to matter (thermal equilibrium). Even if we cannot guarantee that Vd2 is constant, at least variations should be minimized!!
- In the order of baseline quality/minimum distortion we find:
  - Imix, Vd2 constant
  - Imix constant (Vd2 allowed to change to keep Imix constant)
  - Vd2 constant (I mix changes)
  - Imix and Vd2 are vary
- For B1, B2, B5 the FSW throw is rather arbitrary. The reason is that for B1, B2 the LO-mixer standing wave is a small fraction (percent) of the mixer current. For B5 there is a measurable LO-mixer standing wave, however the system stability is quite good providing proper off-source subtraction.
- The provided (simulated) spectra ALL utilize 5 minute on-off source subtraction. Needless to say, for the diplexer bands (3, 4, 6, 7) the obtained baselines profiles will degrade if longer than 5 minute off-source subtraction is utilized. Often the baseline off-subtraction performance is compromised after already 5 minutes, therby effecting observation efficiency.
- It is often found that there are standing wave profile solutions to tune both H or V mixer currents optimally (ΔImix=0, section 1). This technique appears to work well, and is especially useful for FSW throws that are greater that the default +- 48 MHz throw. It does require a priori knowledge of the standing wave between the mixer and LOU.
- The standing wave between the mixer and the telescope appears to be at a sufficiently low level that it does not dominate the FSW observation mode.
- The technique to try to match both H & V has not yet been applied universally. It came up after analyzing the standing wave data with little or no time to implement.
- Not surprisingly, asymmetric throws allow for larger frequency throws.
- For larger throws it is advisable to first map the standing wave at the particular frequency, something we have done in CoP at 54 frequencies, and then use the info to determine the f1, f2 so that both H & V mixer currents are constant. LO drift is important, thus the local oscillator needs to be adequately warmed up for the standing wave test.
- The current-matching off-subtraction technique should be tried on all FSW observations, both for the HEB mixer and SIS mixers to determine its effectiveness. A comparison in terms of baseline quality and rms noise between the conventional and new technique will be useful.
- There may be a problem with the general robustness of the FSW tuning algorithm. On quite a few occasions there are current dropout spikes in Id2, or a noise on Vd2. This should be investigated.

- Occasional power amplifier drift due to frequency change is seen at the higher frequency bands.
- Tuning at C+ failed altogether (on Int CBB). Robustness of the tuning algorithm should be strengthened.
- With the new M1, M2 multiplier bias for OH and C+, it may be a good idea to repeat FSW, DBS, LSW and Int. CBB System stab measurements.
- In general there is no significant difference between FSW on the Sky and FSW on Int. CBB

7.2 LO subband specifics

Band 1a:

- General good baselines with 5 minute off-source subtraction.
- 496.96 GHz shows degraded performance. (1342179583). Somewhat poor system stability.
- Fast Id2 drops outs in Id2 at 526.88 GHz. (1342179585)
- FS Throw arbitrary

Band 1b

- General good baselines with 5 minute off-source subtraction.
- Baseline ripple at 563.74 GHz, poor system stability.
- FS Throw arbitrary

Band 2a

- General good baselines with 5 minute off-source subtraction.
- FS Throw arbitrary

Band 2b

- General good baselines with 5 minute off-source subtraction.
- Obsid 1342179468 failed after t=400s. Green limit?
- 756.83 GHz bad. Poor stability.
- FS Throw arbitrary

Band 3a

- Some baseline structure evident everywhere, however baselines do not look too bad. Some post-processing shall be needed. System stability of B3a is not very good leading to this overall result.
- 815.14 has significant structure
- 849.35 very bad (useless) due to a LO jump at t=30s. Can be recovered with re-analyses.
- Default throw ok, optimized throw better when larger FS throw is desired.

Band 3b

- General good baselines with 5 minute off-source subtraction. Some minor residual structure that will need to be removed by post processing.
- Default throw ok, optimized throw better when larger FS throw is desired.

Band 4a

- Significant baseline structure everywhere. Post-processing shall be needed.
- 968.66 bad. Default +- 48 MHz throw bad, +- 22 MHz better which can be understood from the standing wave profile. See Fig. 48.
- 980.41 very bad
- Default throw ok, optimized throw better when larger FS throw is desired.
- 990.52 H_2O ?? (Fig 51, 53)

Band 4b

- General good baselines with 5 minute off-source subtraction. Some minor residual structure that will need to be removed by post processing.
- 1091.56 GHz narrow spur
- 1107.54 GHz narrow spur
- 1089.83 GHz Poor baseline. This is understood from the standing wave profile due to LO power drift. The multiplier has a very small instantaneous bandwidth here.
- Default throw ok, optimized throw better when larger FS throw is desired.

Band 5a

- General good baselines with 5 minute off-source subtraction.
- There is a noticeable LO-mixer standing wave, however due to stable mixer behavior this can be stably subtracted with an off-source measurement.
- 1234.59 GHz Spur (not pure?).
- FS Throw arbitrary

Band 5b

- General good baselines with 5 minute off-source subtraction.
- FS Throw arbitrary

Band 6a

- General good baselines with 5 minute off-source subtraction. Some minor residual structure that will need to be removed by post processing.
- +- 88 MHz gives a poor baseline. Better to use optimize throw as described in section 1
- 1543.70 MHz narrow spur
- Default throw ok, optimized throw better when larger FS throw is desired.
- Check on the use of the current matched off-source technique.

Band 6b

- General good baselines with 5 minute off-source subtraction.
- 1654.17 GHz is very bad due to poor system stability.
- Check on the use of the current matched off-source technique.

Band 7a

- Significant baseline structure everywhere. Post-processing shall be needed.
- 300 MHz IF ripple visible everywhere.
- Check on the use of the current matched off-source technique.

Band 7b

- Significant baseline structure everywhere. Post-processing shall be needed.
- 300 MHz IF ripple visible everywhere.
- Check on the use of the current matched off-source technique.
- C+ failed.
- 1844.15 narrow spur
- 1834.95 narrow spur
- Occasional in-band LO drift → instability in FSW baselines.