Cavity Frequency Measurement and Initial Tuning at FLASH

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Goals

- Remote cavity tuning at FLASH and test stands
  - Remote and simultaneous frequency measurement of all cavities (no need to go into the tunnel)
  - Make use of standard RF distribution system, klystron, LLRF system, Master Oscillator etc.
- Check tuner step motors under warm conditions to exclude mistakes of connectors, wires and software
- Tuning of the cavities at the 1.3 GHz after cool down
- Relax the cavities to initial frequencies before warming up
- Test of the procedure with warm SC cavity
  - low power from klystron
  - checking the frequency range and resolution
- FLASH commissioning in March/April 2010
  - Check of tuner motors
  - Tuning of the cold cavities

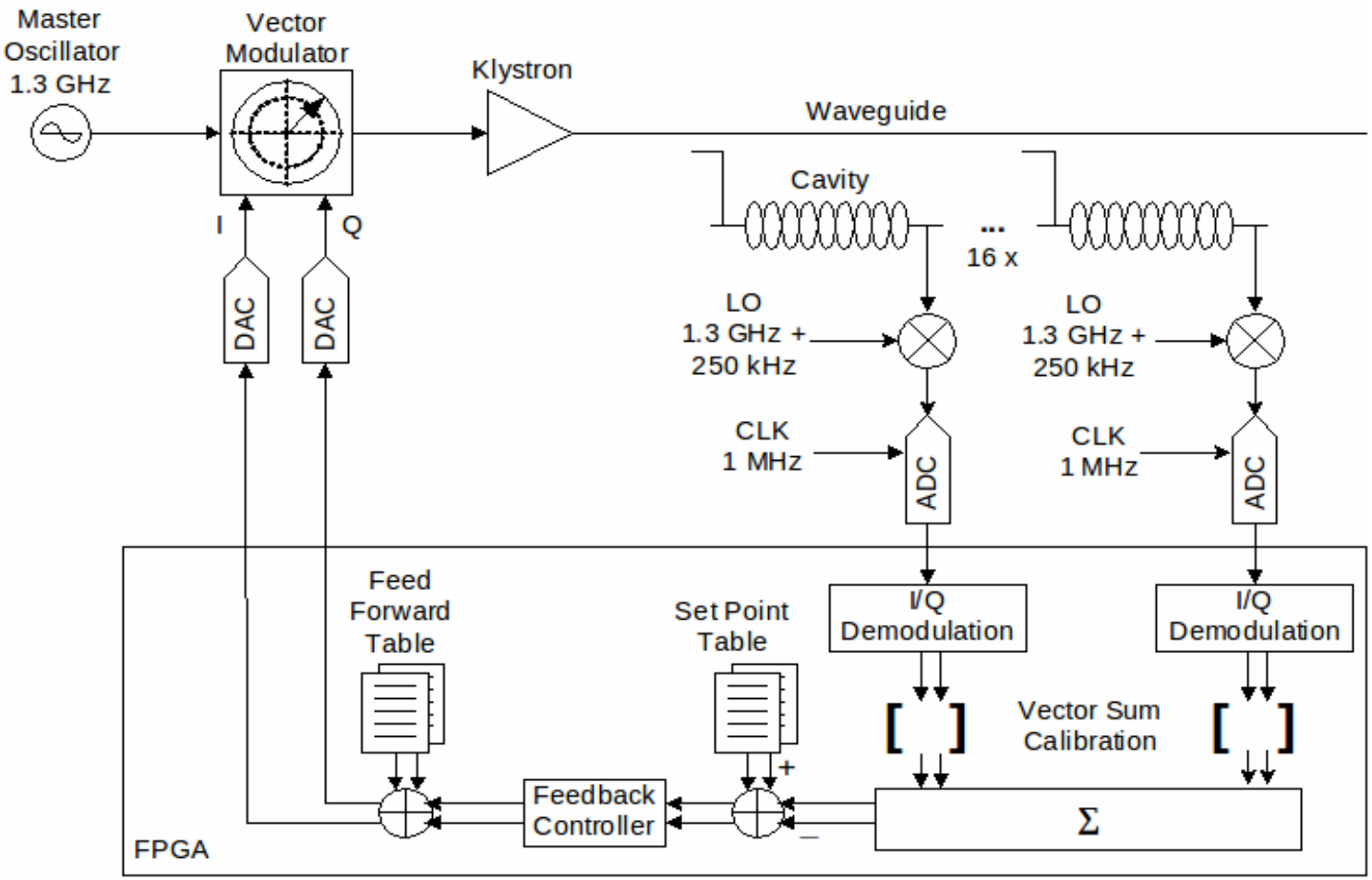
Measurement conditions

	Warm	Cold
Quality Factor	1.0e4	3.0e6
Frequency range [MHz]	1298.0 +/-0.4	1300.0 +/-0.4
Frequency step from pulse to pulse [kHz]	10	0.5
Measurement points (RF pulses)	80	1600
Frequency sensitivity [kHz]	25	1

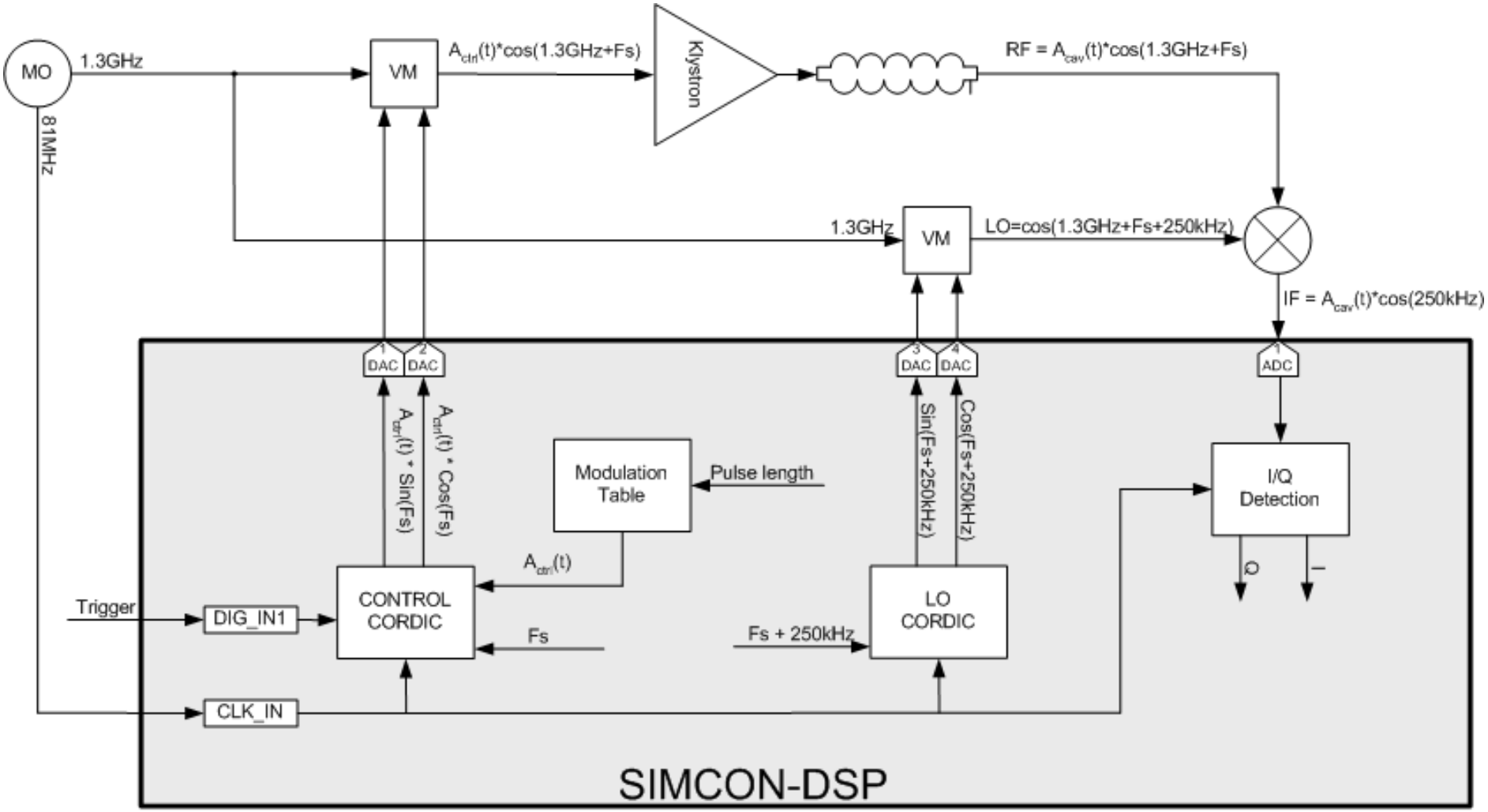
Requirements for the Frequency Sweeping System

- Sweeping with constant reference frequency – 1.3GHz from Master Oscillator
- Frequency range from -2.4 MHz to +0.4 MHz relative to 1.3GHz
- Frequency resolution at least 0.5 kHz
- Standard methods for field detection by diagnostic ADCs using DOOCS

Schematic of the RF Station

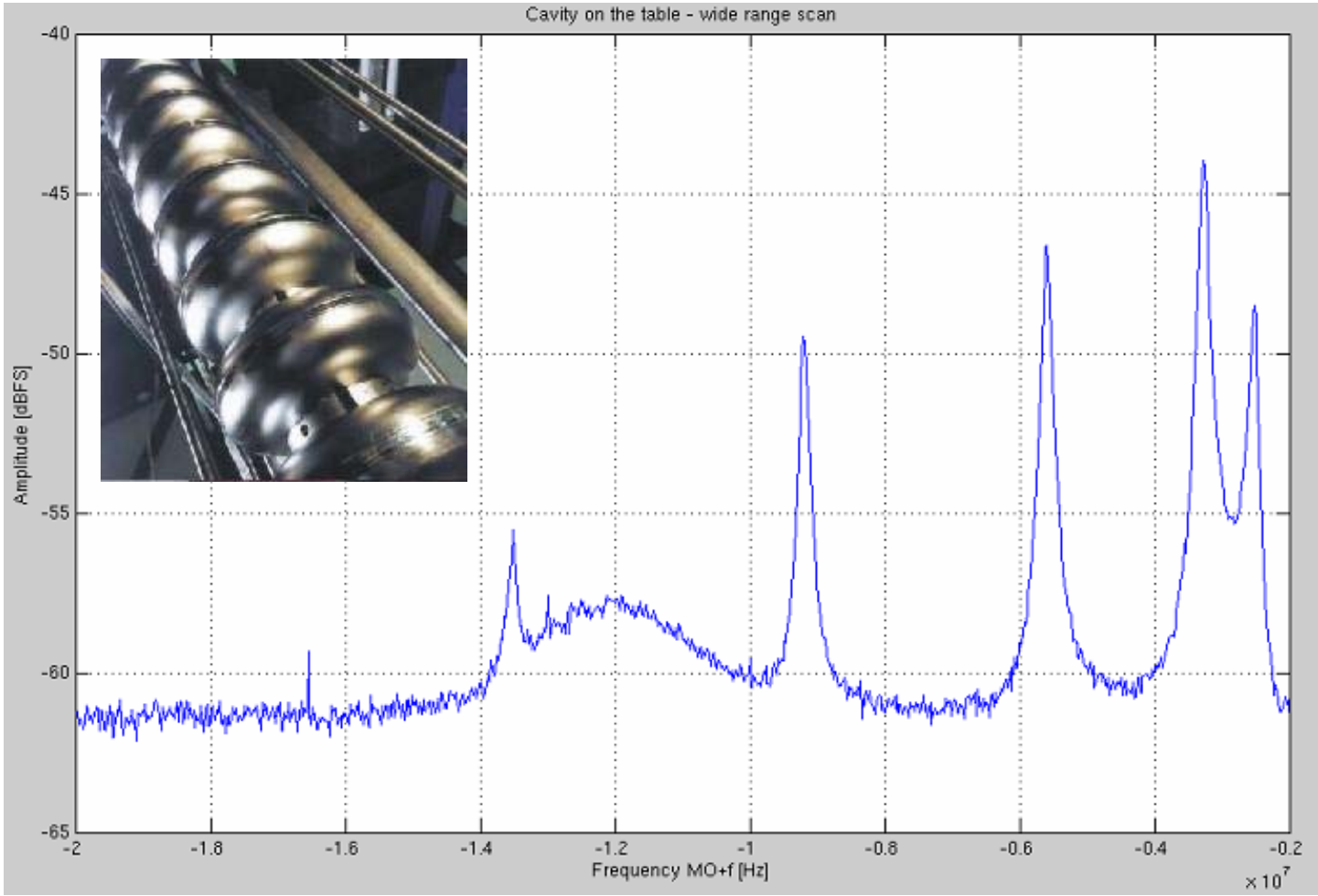


Hardware and Software of the Measurement Setup



Measurements: Warm SC Cavity on a Table

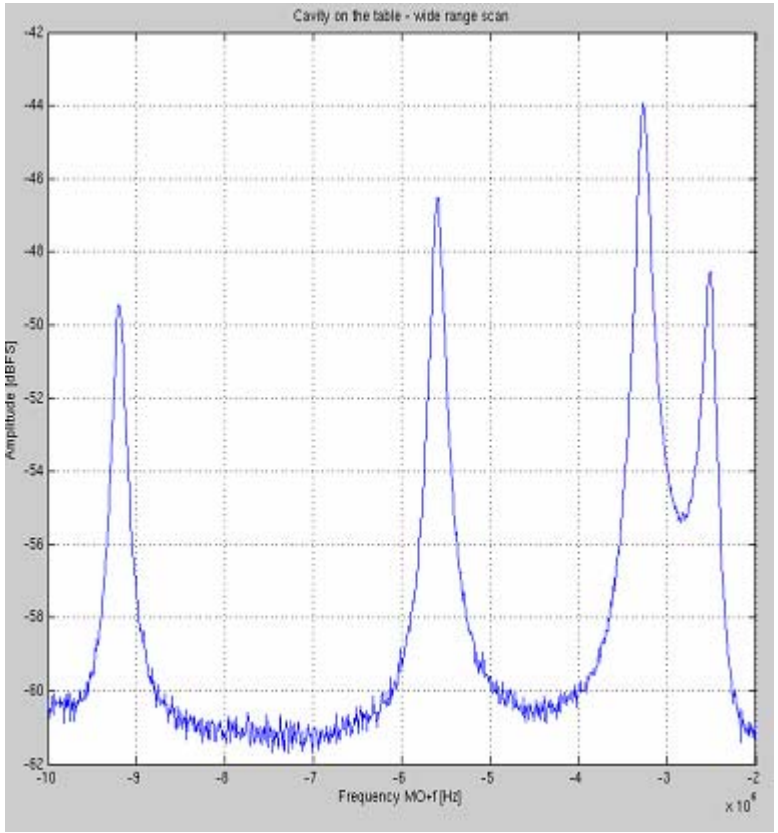
Frequency sweep (-2MHz; -20MHz) with step 10kHz



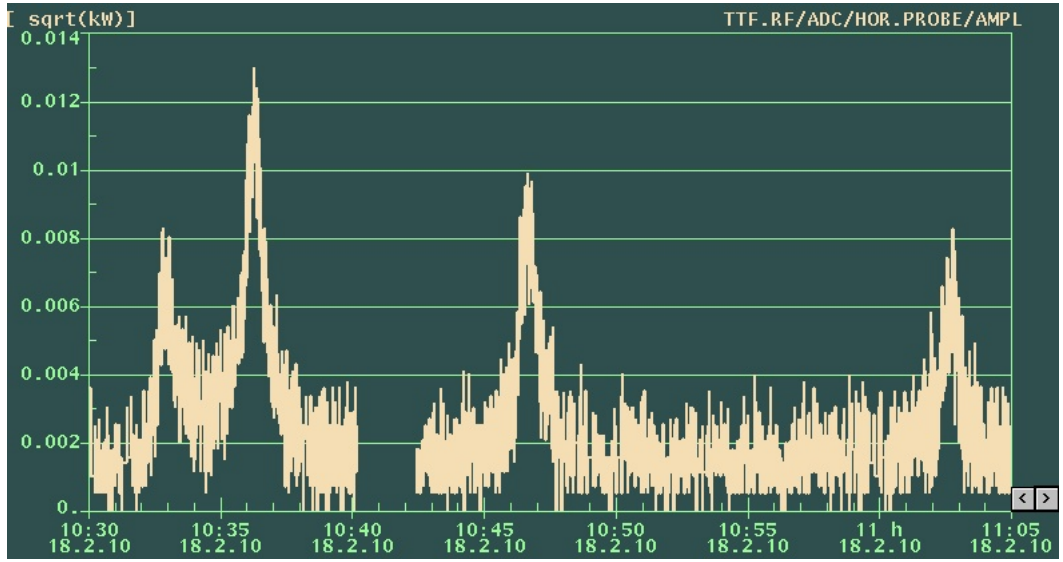
Measurements: Warm SC Cavity on a Table

Frequency sweep (-2MHz; -10MHz) with step 10kHz

Matlab interface

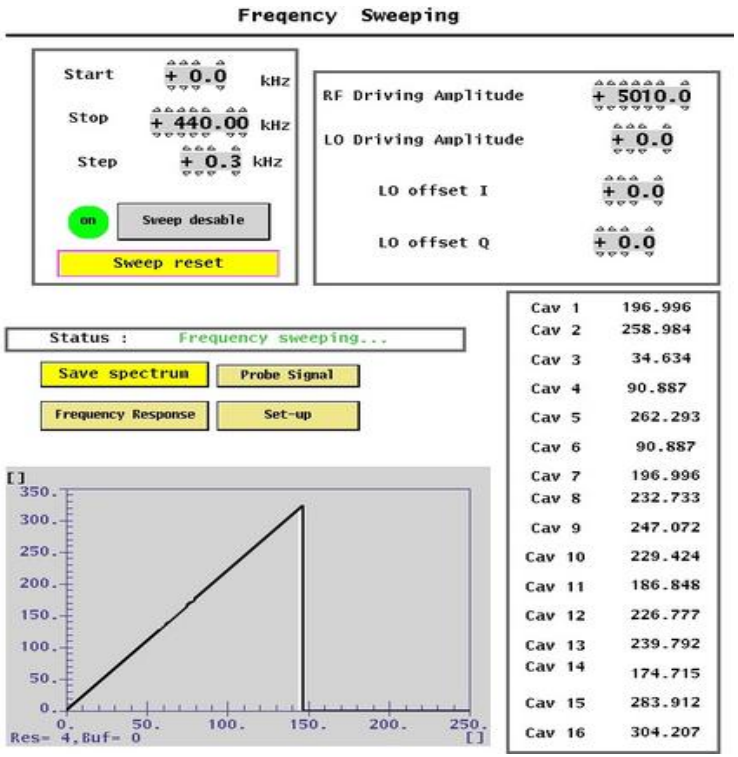


DOOCS panel

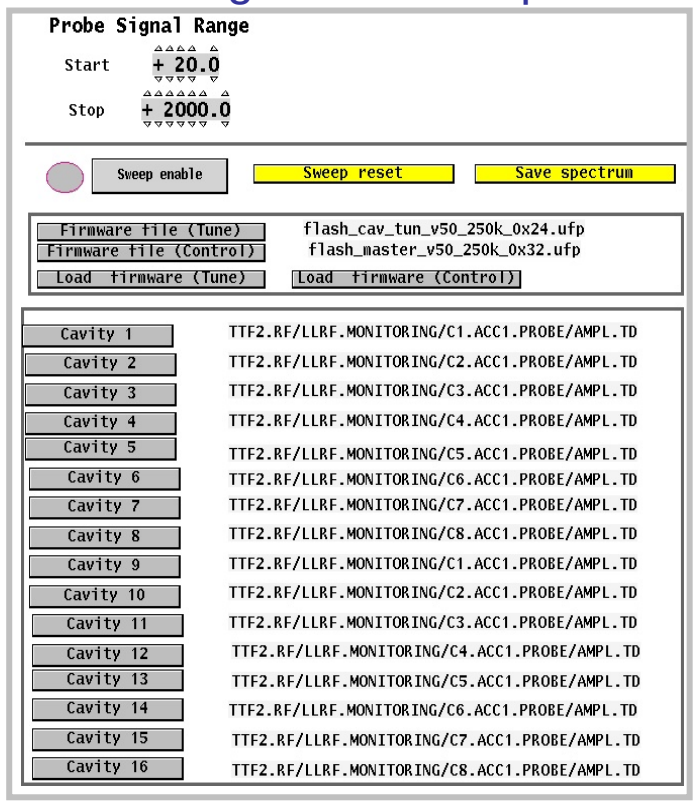


Integration with LLRF Control System

- New version of firmware for frequency sweeping
- Created DOOCS frequency sweeping procedure server
- Operator Interface
- Automated data logging

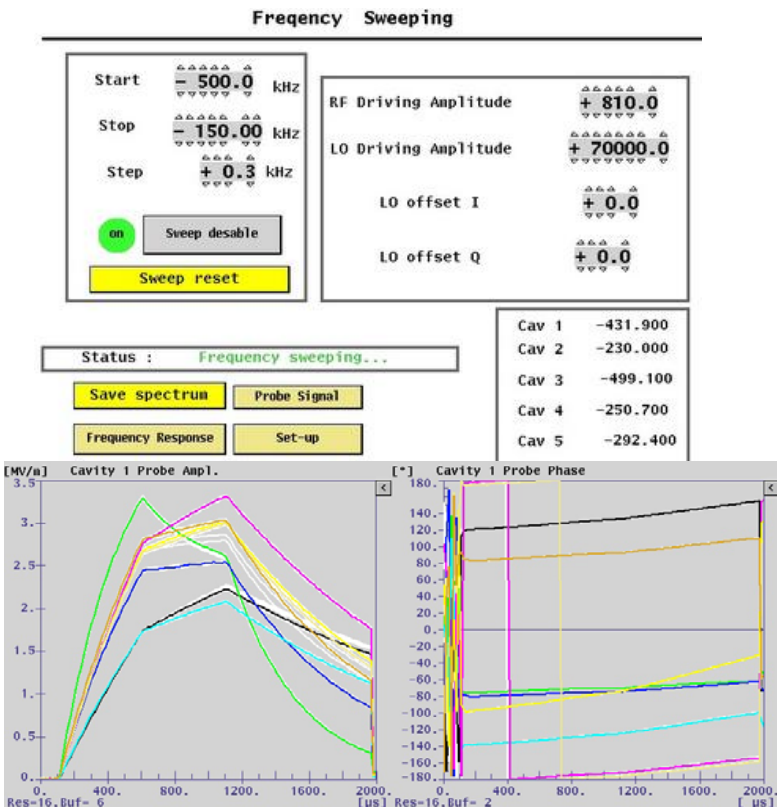


Configuration set-up

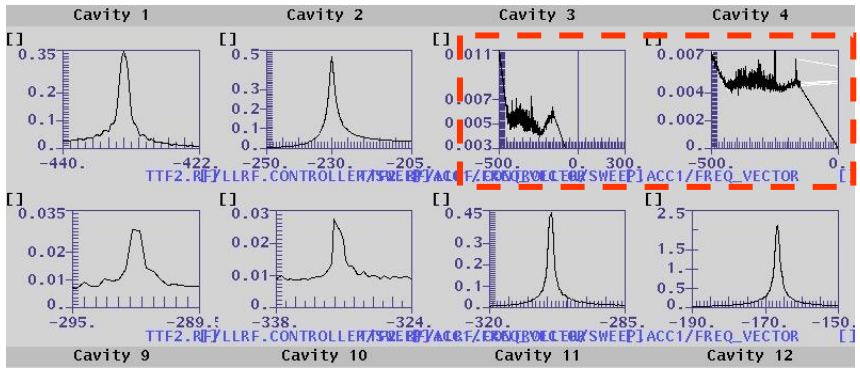


FLASH Commissioning: ACC1

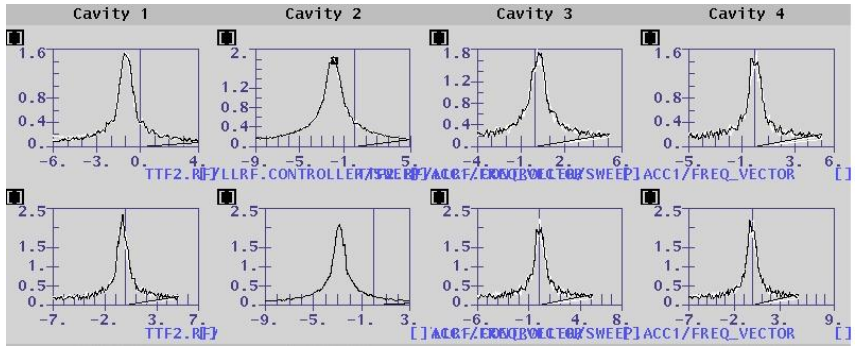
- Cavities 3 & 4 no change of frequency
- Motor current needs to be raised 40%



ACC1 spectrum, initial sweep



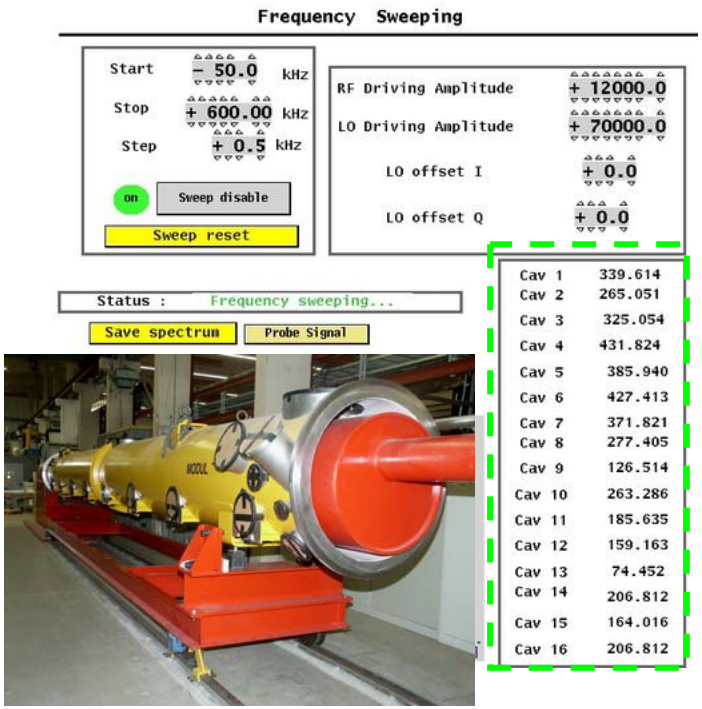
ACC1 spectrum after fine adjustment



First RF on ACC1 after cavity tuning, 07.04.2010

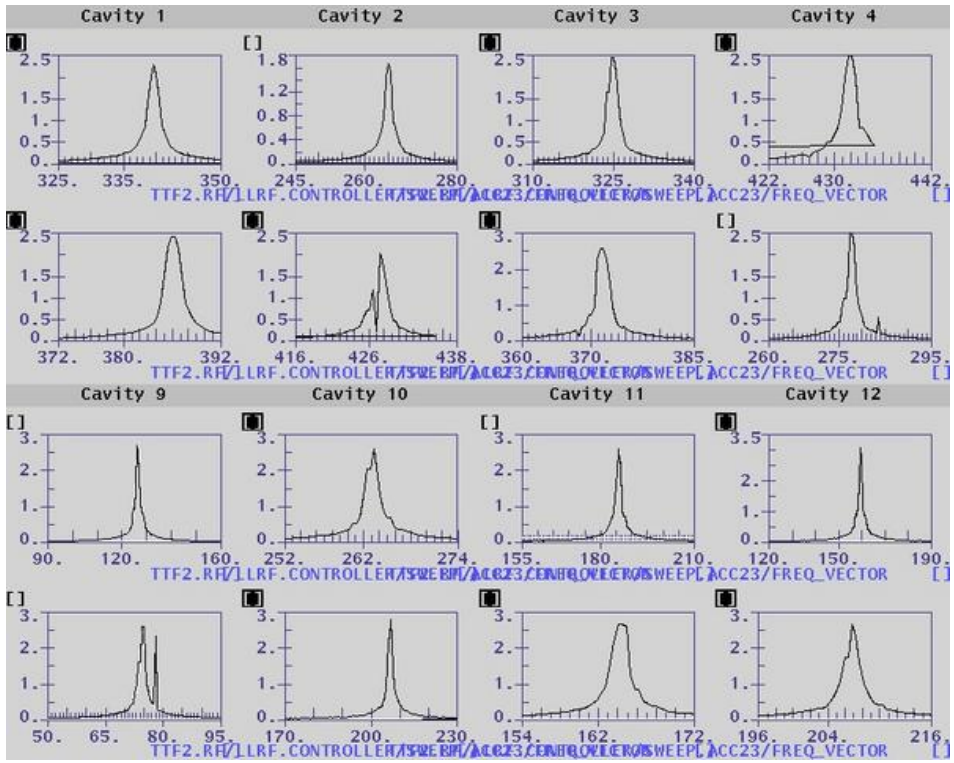
FLASH Commissioning: ACC23

The frequencies are mirrored with respect to 1.3GHz (i. e. wrong sign)



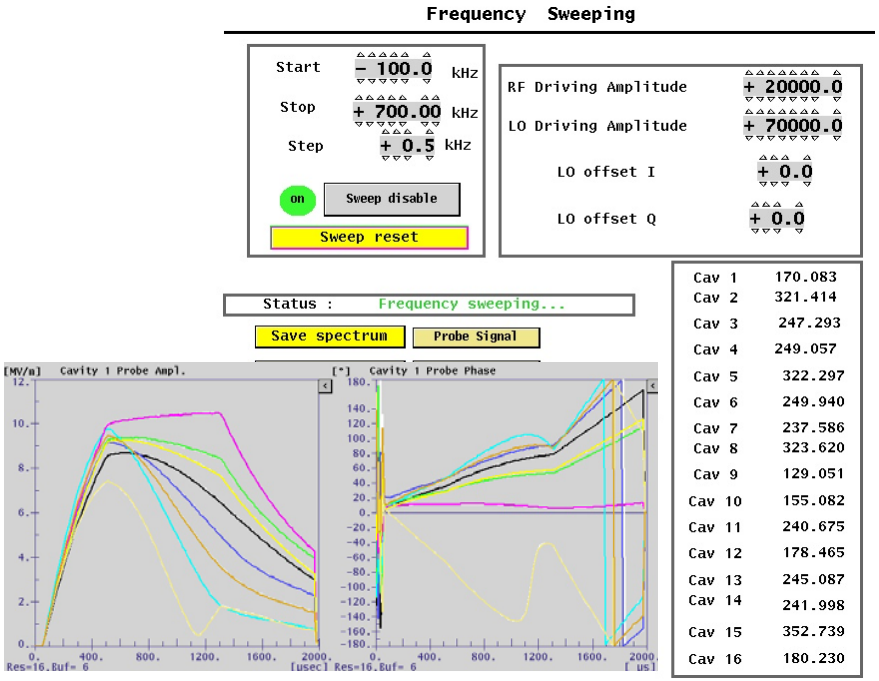
Frequency spread range: 74kHz - 430kHz

ACC23 spectrum, initial sweep

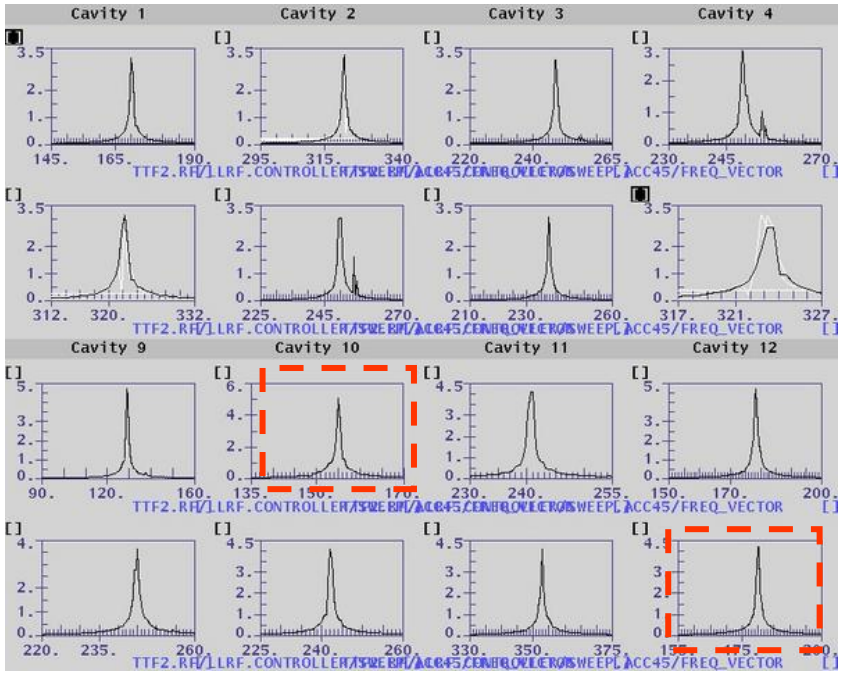


FLASH Commissioning: ACC45

- ACC4 is OK
- ACC5: cavities 2 & 8 no changes on frequency
- Motor current needs to be raised 50%



ACC45 spectrum, initial sweep

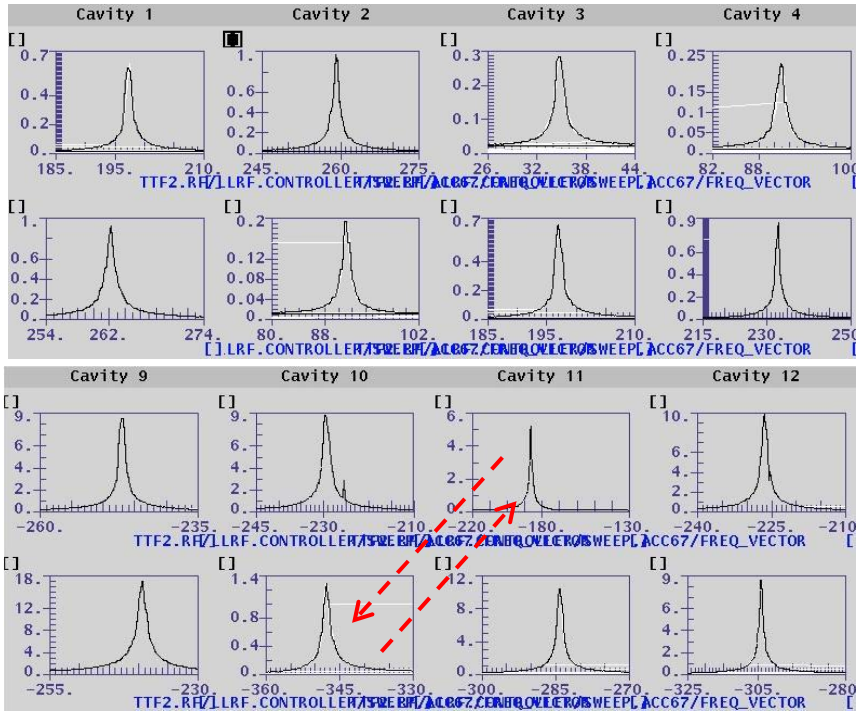


First RF on ACC5 after cavity tuning, 09.04.2010

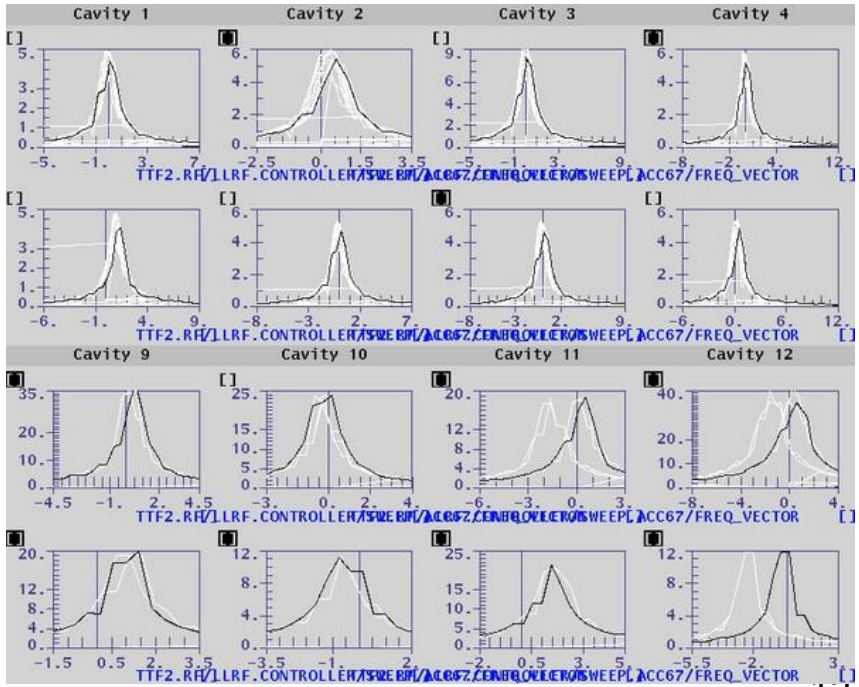
FLASH Commissioning: ACC67

- ACC6 is OK
- ACC7: bad signals, wrong cabling
- ACC7: cavity 3 and cavity 6 are interchanged

ACC67 spectrum before tuning



ACC67 spectrum after fine adjustment



Documentation

- Complete and detailed commissioning documentation has been done
- Excel document with links to FLASH logbook
- User Manual: http://msk.desy.de

-273.15 °C.
0 K

ACC2 04/2010 commissioning

31000 steps will cause a difference of 25 kHz

		Date	Iso-Vac.	Beamplpe	Temp	CAV 1	CAV 2	CAV 3	CAV 4	CAV 5	CAV 6	CAV 7	CAV 8
		TT.MM.JJJJ	y / n	status	K (elvin)	kHz	kHz	kHz	kHz	kHz	kHz	kHz	kHz
	Tuner-resonance-run												
	act. value of steps					70400	70400	70400	70400	70400	70400	70400	70400
1	act. frequency	08.04.2010	y	borrowed	2K	1299673	1299783	1299727	1299618	1299667	1299623	1299681	1299764
2	run to abs. stepvalue					0	0	0	0	0	0	0	0
3	frequency after run					1300339	1300285	1300345	1300431	1300385	1300427	1300371	1300477
	true frequency					1300339	1300285	1300345	1300431	1300385	1300427	1300371	1300477
4	Δ F					-11	-47	-60	-49	-52	-49	-52	-41
5	run to abs. stepvalue					477200	372200	456100	607100	542500	600900	522500	390300
6	frequency after run					1300005	1300005	1299999	1299988	1299987	1299994	1299985	1300040
7	Δ F					343	259	332	419	372	420	356	317
8	run to abs. stepvalue					483800	379400	454800	590200	523100	59200	501300	447300
9	frequency after run					1300000	1300000	1300000	1300000	1300000	1300000	1300000	1300000
10	Δ F					-5	-5	1	12	13	6	15	-40

Measured frequency(difference to 1.3 GHz) are mirrored. I.e. wrong sign
After correction of sign

-273.15 °C.
0 K

ACC5 04/2010 commissioning

31000 steps will cause a difference of 25 kHz

		Date	Iso-Vac.	Beamplpe	Temp	CAV 1	CAV 2	CAV 3	CAV 4	CAV 5	CAV 6	CAV 7	CAV 8
		TT.MM.JJJJ	y / n	status	K (elvin)	kHz	kHz	kHz	kHz	kHz	kHz	kHz	kHz
	Tuner-resonance-run												
	act. value of steps					70400	70400	70400	70400	70400	70400	70400	70400
1	act. frequency	08.04.2010	y	borrowed	2K	1300129	1300155	1300240	1300178	1300245	1300241	1300352	1300160
2	run to abs. stepvalue					110400	140400	110400	140400	110400	140400	110400	140400
3	frequency after run					1300098	1300139	1300211	1300146	1300214	1300189	1300275	1300164
4	Δ F					-31	-16	-29	-32	-31	-52	-77	-16
5	run to abs. stepvalue					249500	35700	408800	346300	412000	407800	497700	432400
6	frequency after run					1299996	1299992	1299992	1299993	1299991	1299992	1300037	1299993
7	Δ F					-102	-147	-219	-153	-223	-198	-238	-171
8	run to abs. stepvalue					243500	345500	397300	335400	398600	395600	550800	422700
9	frequency after run					1300000	1300000	1300000	1300000	1300000	1300000	1300000	1300000
10	Δ F					4	8	8	8	9	9	-37	7

CAV 2/ 8 no change of frequency. Raise of motor current needed to 50 %.

Conclusions

- Automated and simultaneous scan of many cavities speed up setup of FLASH, and modules where commissioned within two days including software debugging
- Developed important procedure for large scale machines like XFEL & ILC
- Cavity characterization in wide range of frequency ±20 MHz with high resolution 0.1 kHz
- Safe solution for warm cavities – possible measurement of very small field gradient (only 10kW forward power per cavity at CHECHIA and CMTB)
- No need for hardware change for the sweeping procedure (RF reference signal from MO)

Acknowledgements

We want to express our thanks to our colleagues for the advise and help:

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