RF Status of ALBA

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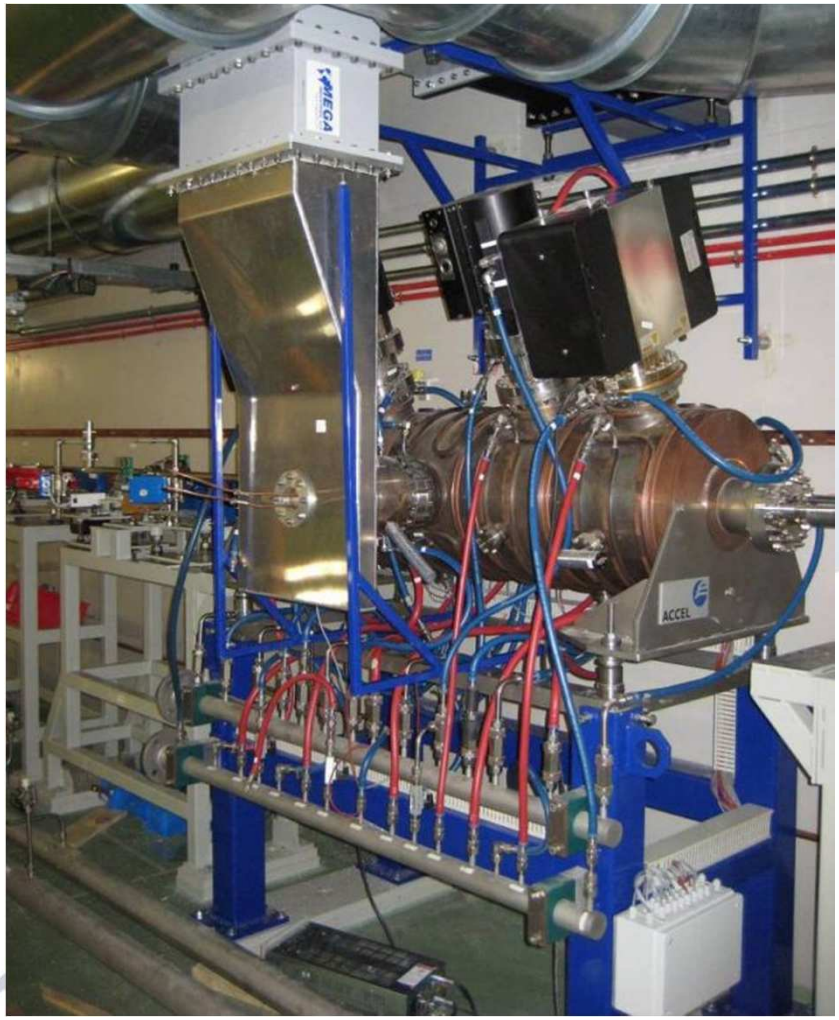
Outline

- ✓ ALBA RF Overview: Booster and SR
- ✓ RF Operation with beam
  - Statistics of RF operation
  - RF Incidents
  - Spring Shutdown
  - RF Upgrades: Costubs and cooling
- ✓ Future RF upgrades
  - Feedforward loops

Booster RF Plant

Ramping from 100MeV to 3GeV at 3Hz



	Injection	Extraction
Cavity voltage	55kV	1000kV
Energy loss	0.001keV/turn	627keV/turn
Cavity power	0.1kW	33kW
Beam Power	0kW	2.5kW
Sync. Freq	13.7kHz	9.4kHz

Petra Cavity type (5 Cells)

Normal Conducting

500MHz

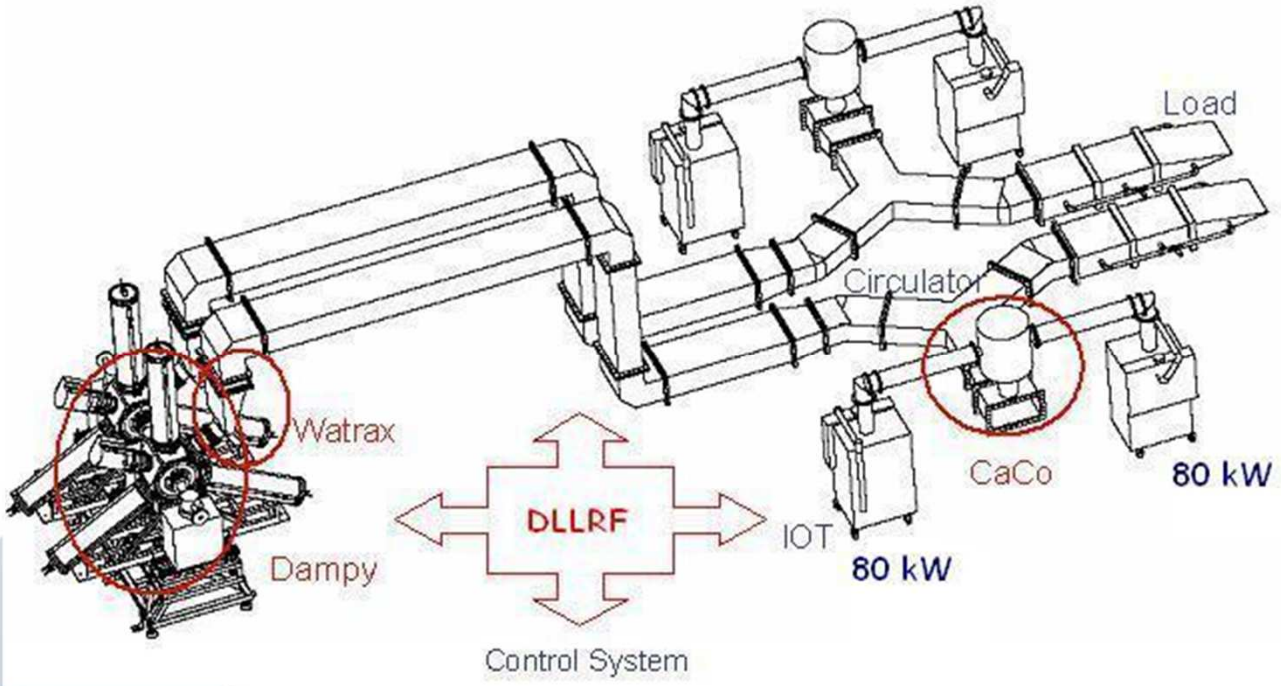
80kW CW - IOT

Booster: Operation without major incidents

Storage Ring RF Plants

RF Parameters

U_0	1.3MeV/turn
V_{total}	3.6 MV
q	≈ 2.5
f_s	≈ 9kHz
P_{RF}	960kW



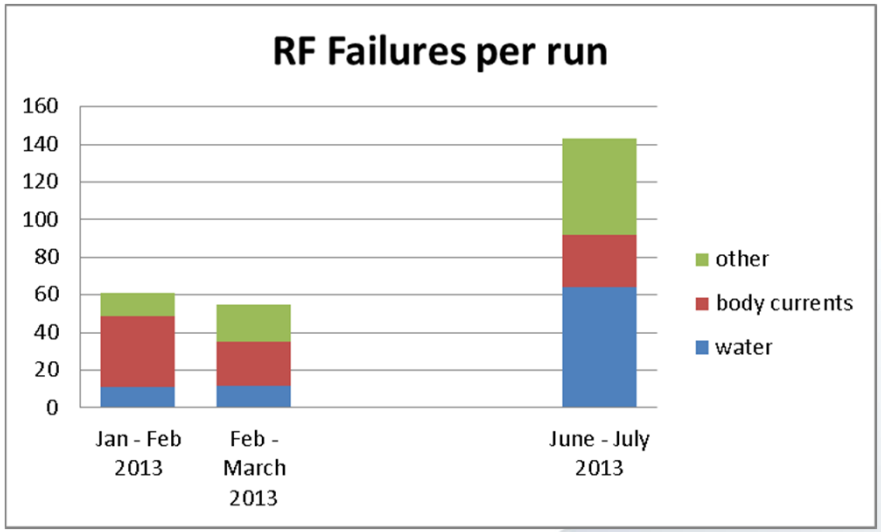
6 RF Plants of 160kW at 500 MHz

2 IOT Transmitters per RF cavity. Power combined in CaCo

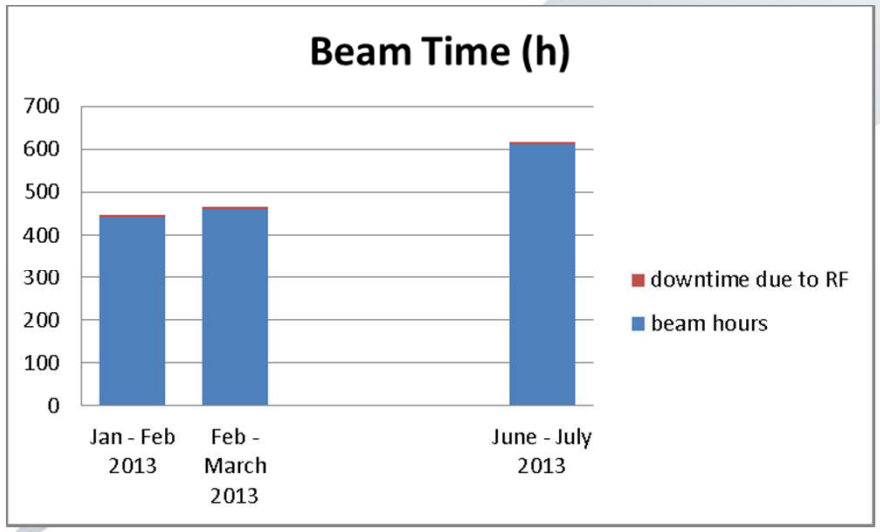
Dampy Cavity
- Normal Conducting
- Single cell, HOM damped
- 3.3 MΩ

Digital LLRF System based on IQ mod/demod

RF statistics of 2nd year operation



Run #	IOTs body currents	Water ITCKS	others (arcs, reverse , vacuum)	total
1	38	11	12	61
2	23	12	20	55
3	28	64	51	143



Run #	RF Failures producing beam dump (%)	Total beam hours	Downtime due to RF failures (h)
1	24.6%	443.5	5
2	14.5%	461.9	6
3	10.5%	652	7.2

- ✓ Many RF Trips, but most of them do not have impact on operation
- ✓ Fast recovery of faulty RF Plants

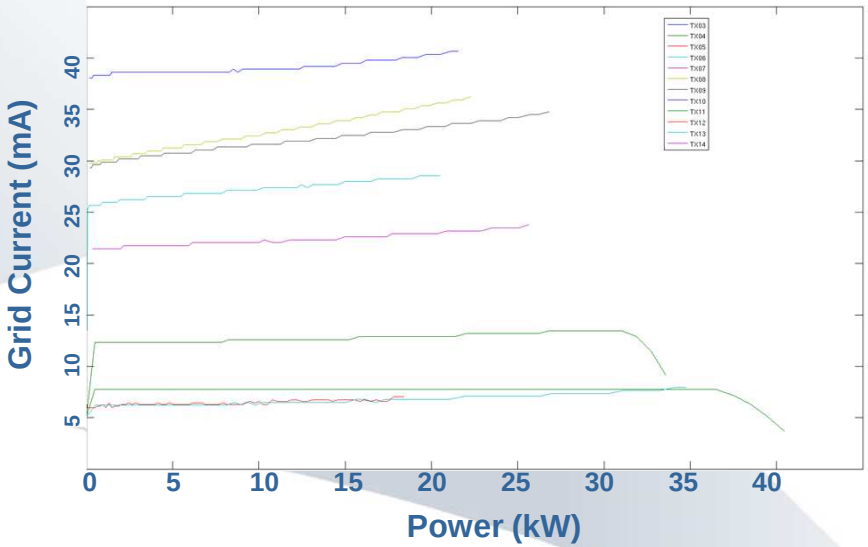
IOTs status

operational IOTs	Serial #	FIL (h)	HV (h)
2	499443	16793	11467
3	617551	12733	9887
4	747211	new	new
5	623096	13213	9373
6	720105	4361	3461
7	634238	12042	9849
8	617302	14016	10231
9	617302	14523	10472
10	617549	4616	3762
11	793734	14272	10107
12	620408	1714	1087
13	720785	13949	10715
14	623099	14094	10699

Broken Tubes	FIL (h)	HV (h)	Comment
608802	10627	7585	
617550	10290	6970	
629734	7828	5080	
610735	7408	4815	Water leak
610732	4221	3324	
499413	1639	1101	First IOT installed
623097	2316	515	

✓ 13 IOTs: 1 Booster – 12 SR

- 9 old IOTs. FIL~ 14000h, HV ~ 9200h
- Degradation observed in some of them. At low power:
  - New IOTs grid current < 10mA.
  - Old IOTs grid current > 30mA

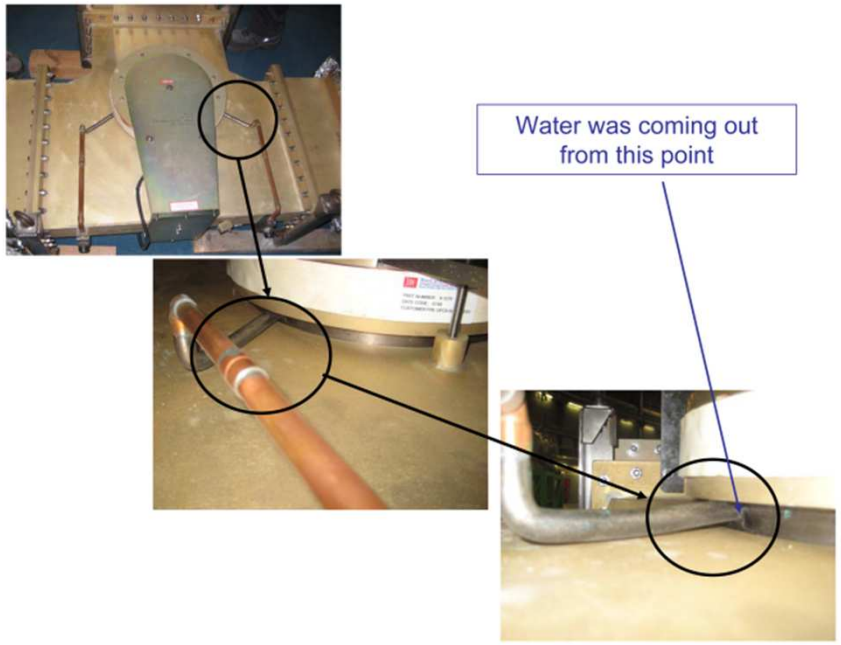


✓Statistics of broken IOTs

- IOT average life: FIL ~ 6400h, HV ~4200h

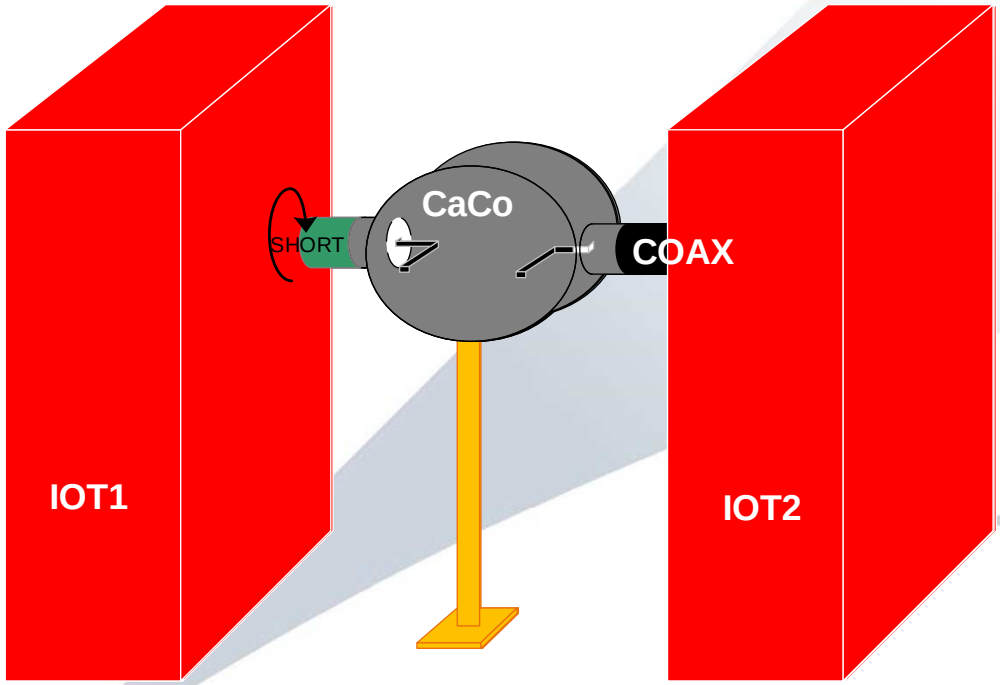
Main RF Incidents

- ✓ **1st run: 14th Jan – 16th Feb**
  - 2 IOTs got broken (Fil hours
- ✓ **2nd run: 25th Feb – 22nd March**
  - 2 circulators got broken
    - First one: Water leak in c
    - Second one: short-circui
  - 2 Brand New IOTs got broke
    the ceramic. Thales provided



Main RF Incidents

- ✓ During Spring Shutdown: Loops of CaCo got broken when installing short-circuit
  - CaCo Symmetric mode: Combines power of two IOTs
  - CaCo Asymmetric mode: one IOT is switched off while 2nd IOT is active



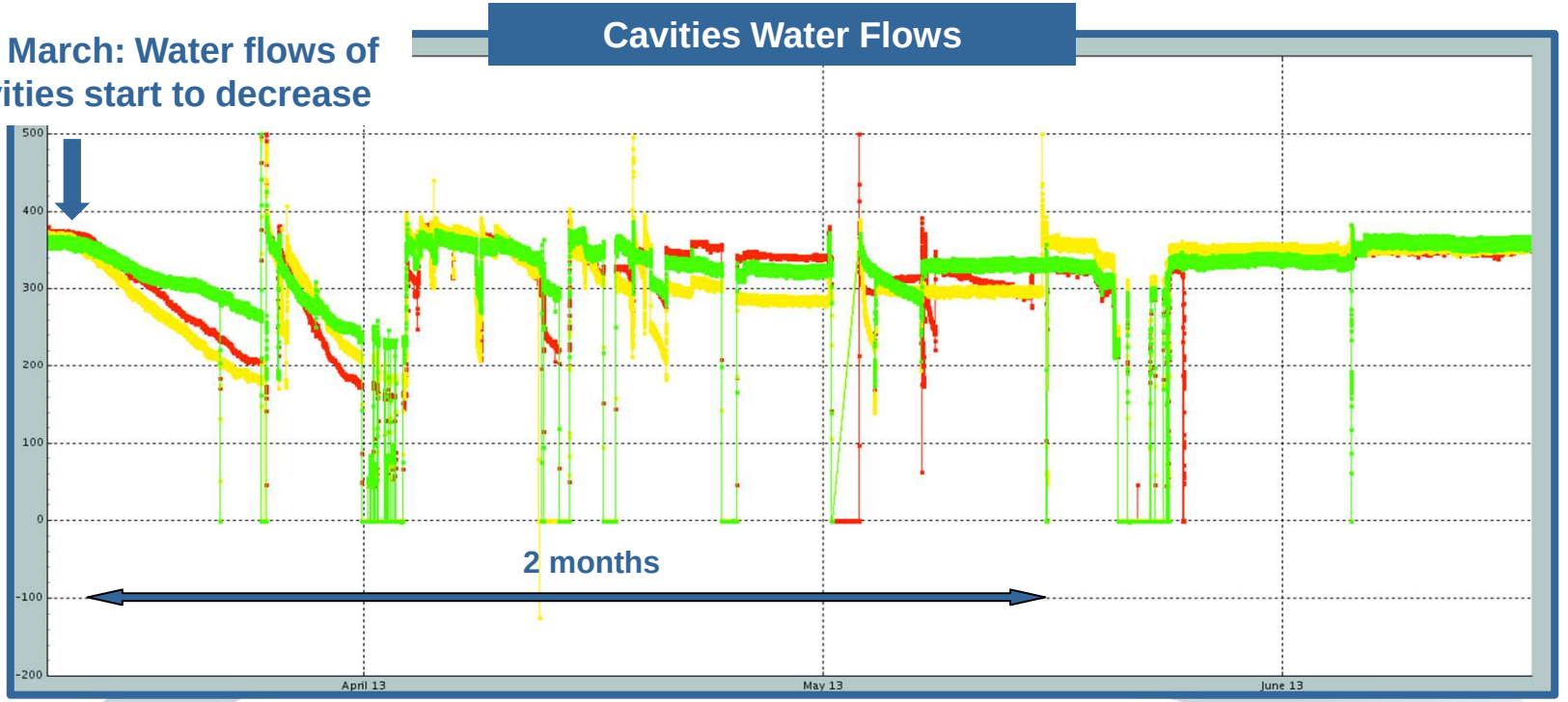
- Asymmetric mode: Coaxial WG removed
- Short-circuit installed
- Result: CaCo Loops twisted and finally broken

All loops of CaCo had to be reviewed and replaced during summer shutdown

Spring Shutdown

- ✓ After Easter Shutdown Cooling System of whole accelerator became unstable (problem persistent during 2 months)

28th March: Water flows of cavities start to decrease

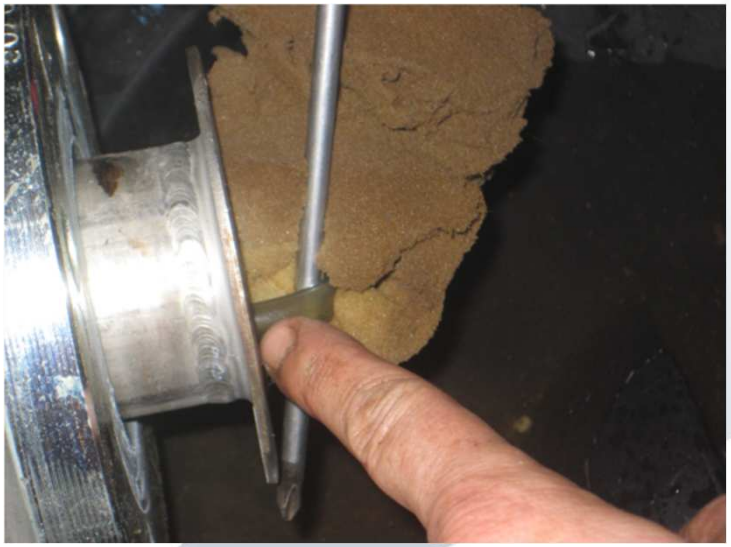


- Air in the cooling system made the pressure drop steadily causing the accelerators sub-systems to trip.

Spring Shutdown

✓ Cooling Improvements

- General pipes of cooling system were cleaned (sponges found in the process)

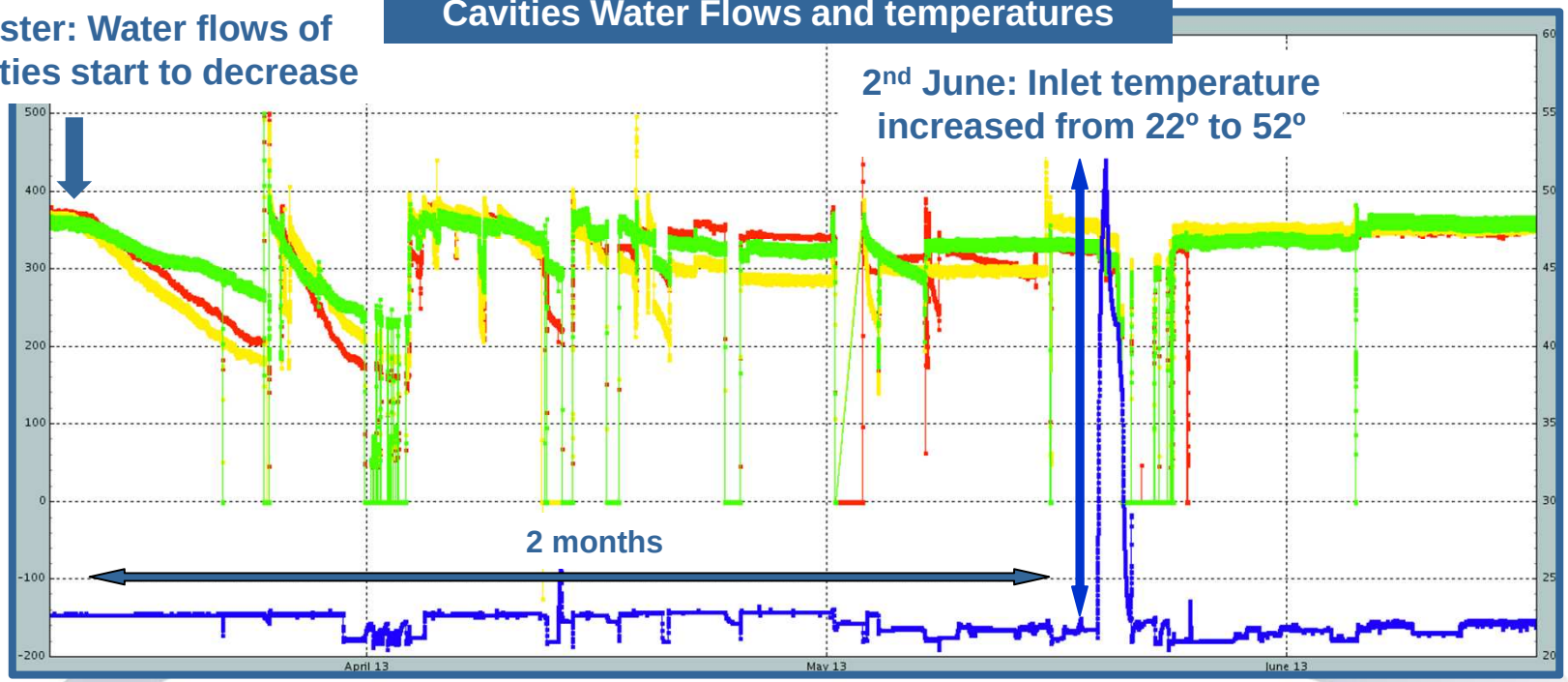


- Water pumps operation conditions changed to avoid cavitation
- Flow Control and distribution optimized
- Air purging
- Air releasers installed in whole machine

Spring Shutdown

- ✓ After solving cooling problem, cooling control PLC misconfiguration error stopped heater exchanger operation and water temperatures rose above 50º

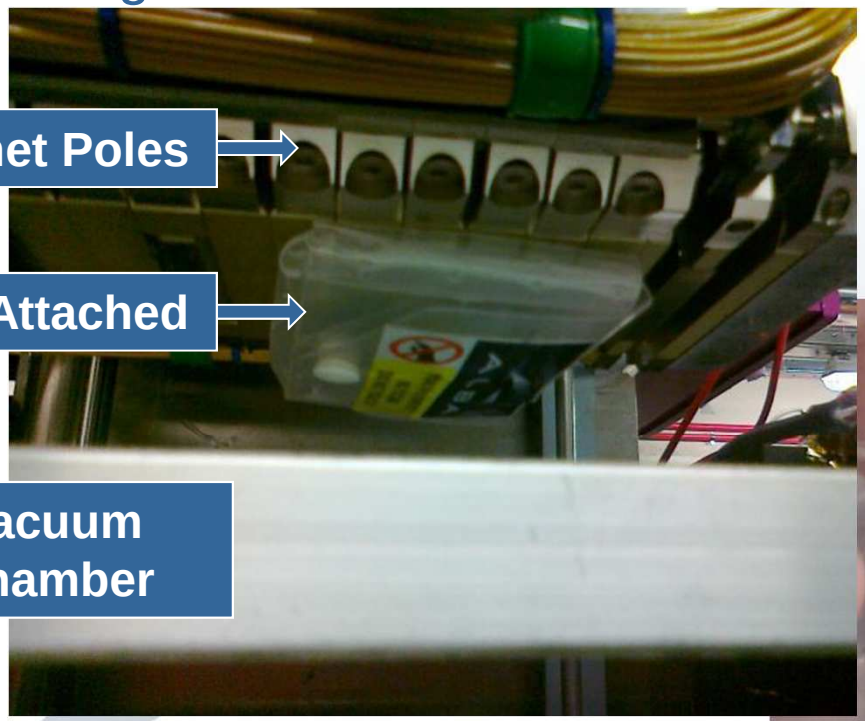
Easter: Water flows of cavities start to decrease

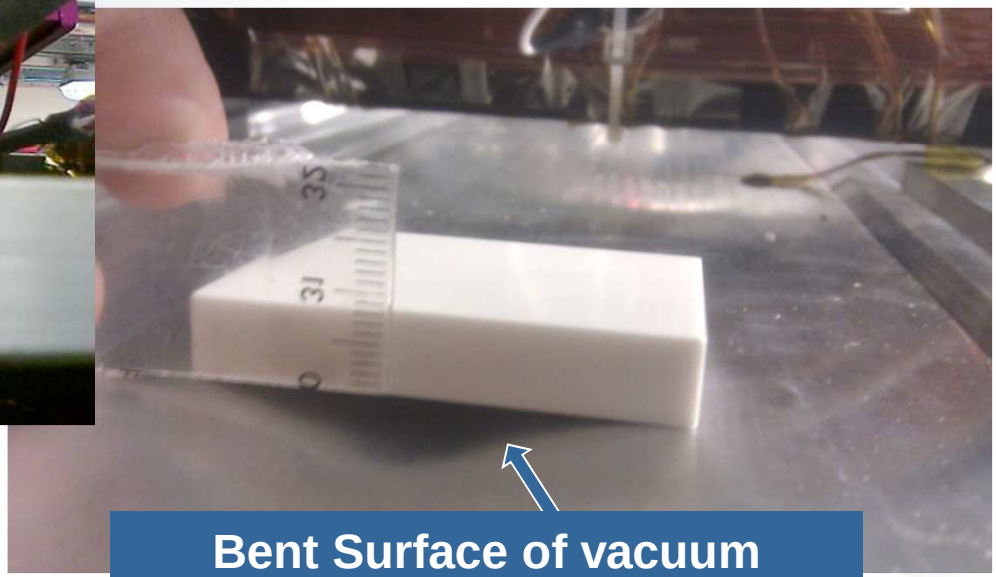


- High temperatures damaged cooling hoses of power supplies
- One hose got broken a couple of days later → Power supply got damaged
- All PS cooling hoses had to be replaced

Spring Shutdown

- ✓ After PS problem: Vacuum chamber of Multipole Wiggler got damaged when closing gap due to a TLD attached to pole magnets





RF Operation: Main Error Sources

✓ Body currents of IOTs – 50% of RF Interlocks per run

- 80-90% of these body current interlocks located in the same IOTs (2 or 3)
- “Bad” IOTs combined together in the same plant and working at lower power
- IOTs conditioning (20% pulse mode – 20-30kW) every Monday morning (machine shutdown)

✓Cooling system – 20% of RF Interlocks per run

- Water Flow Meters of IOTs (WFM) sampling rate is 0.5s.
- Monitoring WFM analogue data, we found out that randomly some WFM samples were lost and WFM digital output went to interlock state during 0.5s
- Delay relays added to the digital output of WFM. If interlock lasts less than 0.7s, it is disregarded → Since then, no IOT cooling interlocks

✓Other kind of error sources

- Two absorbers replaced during 2013: cavities had to be reconditioned. Many interlocks during last run due to reverse power interlocks
- Radiation: Some electronic boards placed inside tunnel got damaged and produced fake temperature interlocks

RF upgrades

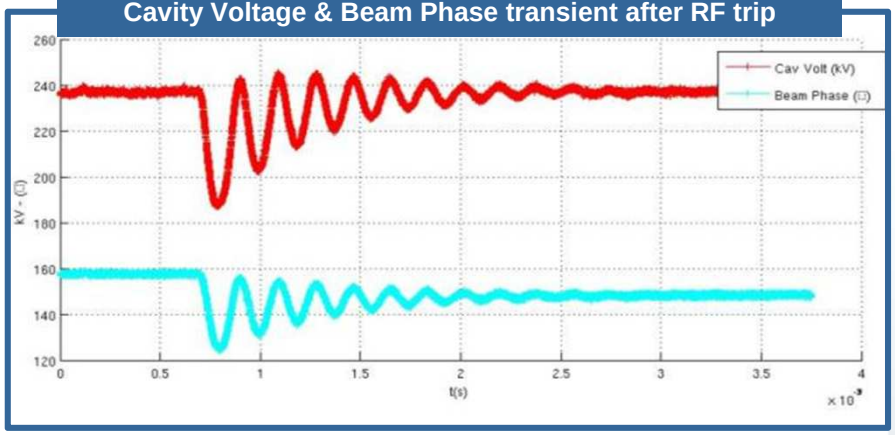
During Summer Shutdown, Costubs installed in all IOTs of SR and CaCo Loops replaced

- ✓ Change between symmetric and asymmetric mode has become very fast (less than 10 minutes)
- ✓ Very helpful for analyzing IOT problems independently

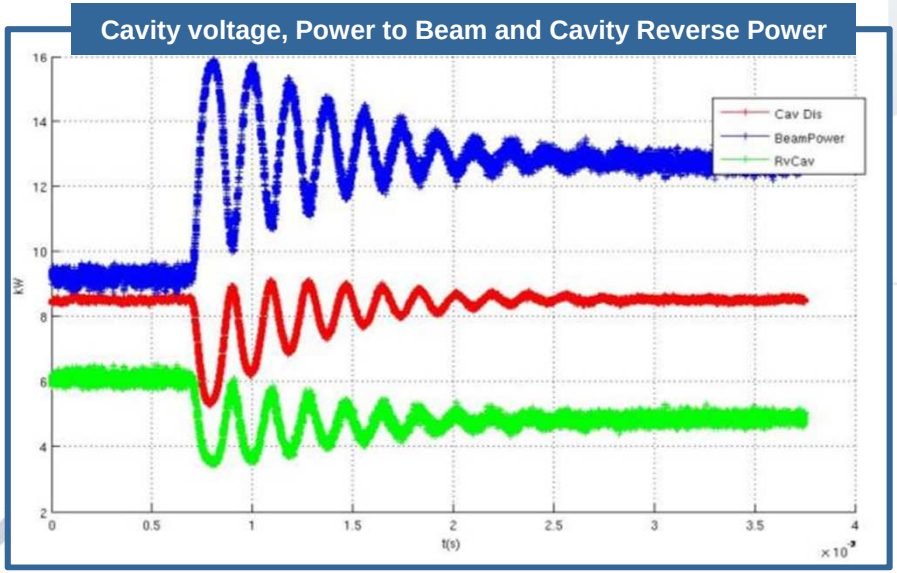
Future RF upgrade

Feedforward loop to compensate transient when RF cavity trips

Cavity Voltage & Beam Phase transient after RF trip



Cavity voltage, Power to Beam and Cavity Reverse Power



✓When cavity trips

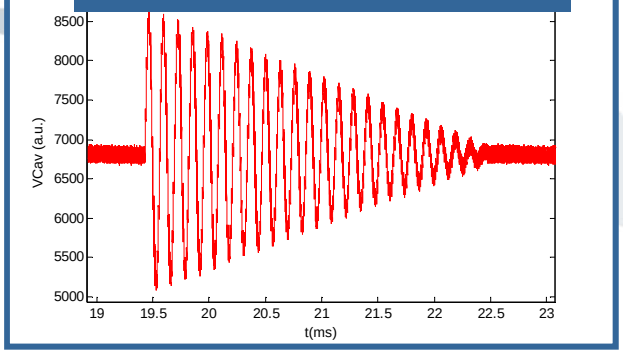
- Cavity Voltage oscillates with frequency equal to synchrotron tune
- Transient time equal to damping time of machine

✓Compensation

- Amplitude modulation triggered when one cavity trips
- Frequency, amplitude and phase of modulation are adjustable parameters

✓ Tests with beam still pending

Amplitude Modulation of Cavity after fake interlock



Summary & Conclusions

✓Next year can only be better!

✓Costubs allow much faster recovery of RF plants when an IOT is down

✓IOTs cooling interlocks upgrade has improved statistics

✓RF robust enough for operation at 120mA

Acknowledgments

✓RF team: Francis Perez, Bea Bravo, Jesus Ocampo, Joan Pijuan and Pol Solans.

✓Operators, technicians and controls support

Thanks for your attention

Ancillary slides: Phase jump in 14B