Operation of ALBA RF

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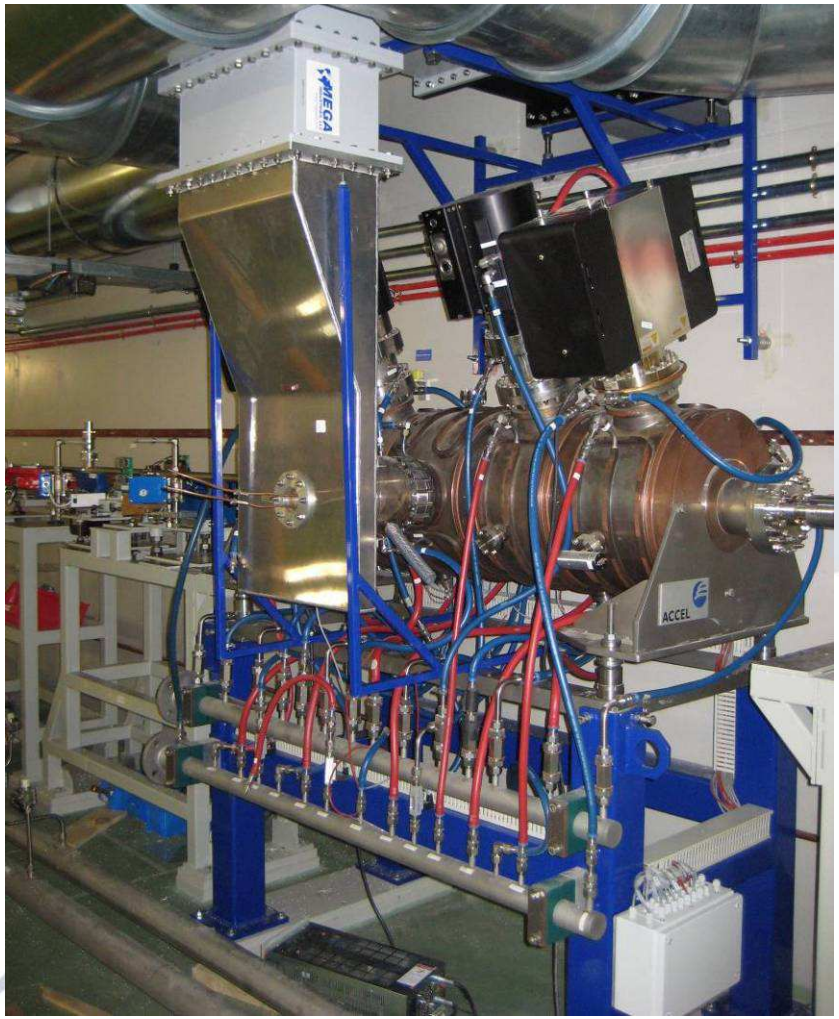
Outline

- ✓ ALBA RF Overview: Booster and SR
- ✓ RF Operation with beam
  - Statistics of first year operation
  - Cavities auto-recovery
  - Fast Data Logger Data
- ✓ Future RF upgrades
  - Costub
  - High Power RF Lab

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

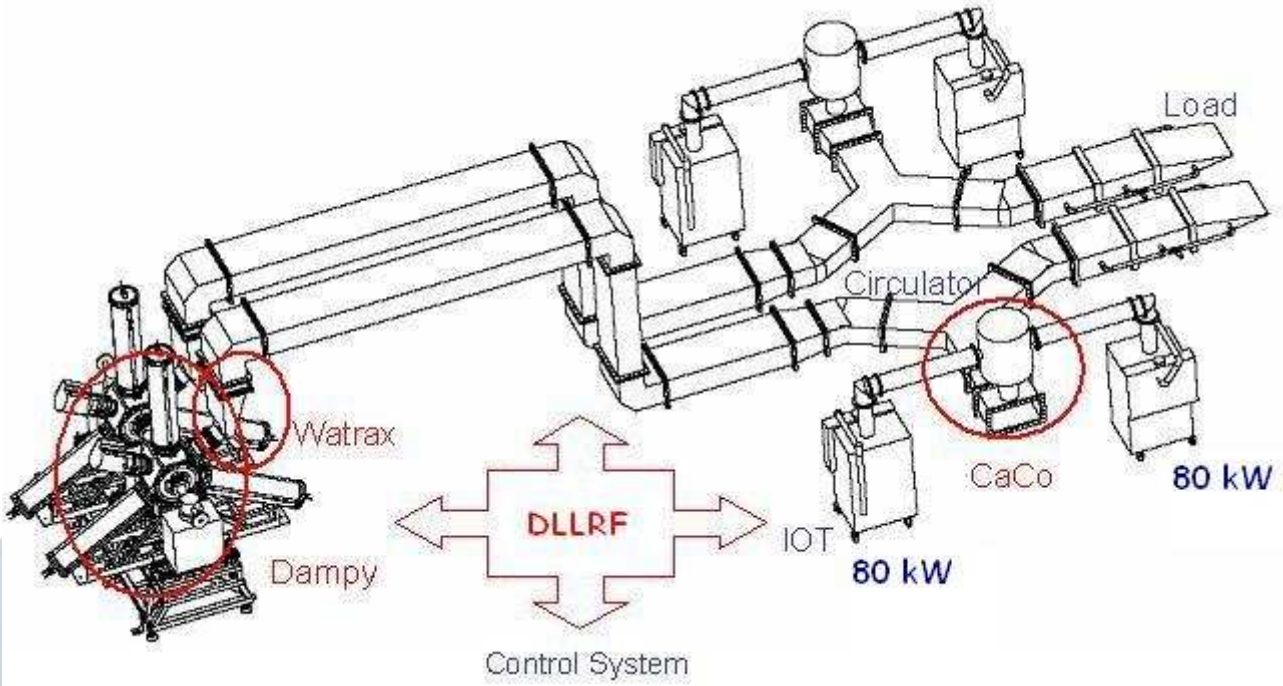
80kW CW - IOT

Booster cavity: 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

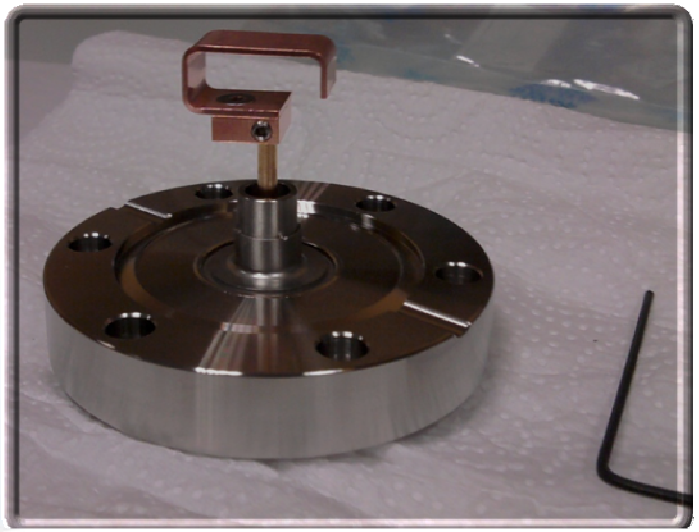
2 IOT Transmitters per RF cavity. Power combined in CaCo

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

Digital LLRF System based on IQ mod/demod

Storage Ring RF Plants

- ✓ New pick up loops designed by Bea and Filip
- ✓ Installed and working in 6 cavities of SR



- ✓ All RF signals calibrated (Bea & Jesus)
  - Power given to the beam (kW)
  - Beam phase respect to RF (º)
  - Cavity Voltage (kV)
  - Calibration allows easy diagnose the right status of the RF

RF Operation: Main Error Sources

✓ Body currents of IOTs → to be reported by J. Ocampo

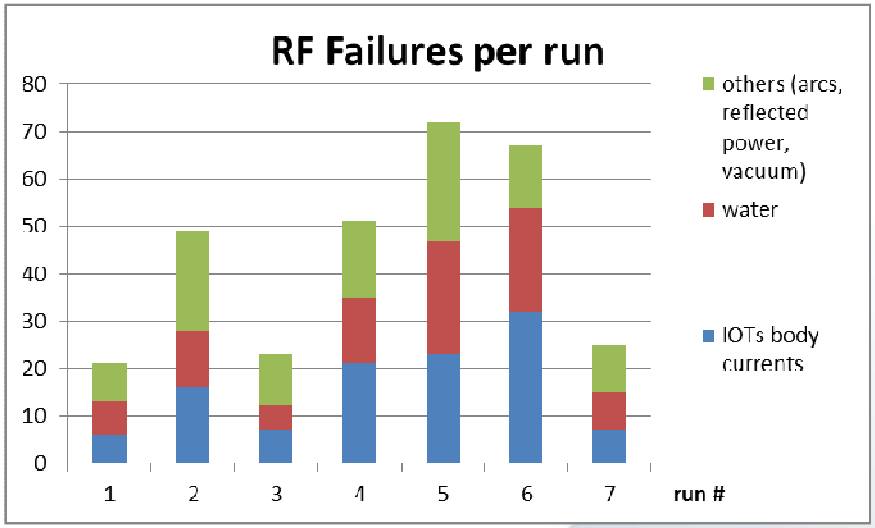
✓Cooling system:

- IOTs cooling system needs readjustment from time to time
- Sudden drops of water flows or pressure

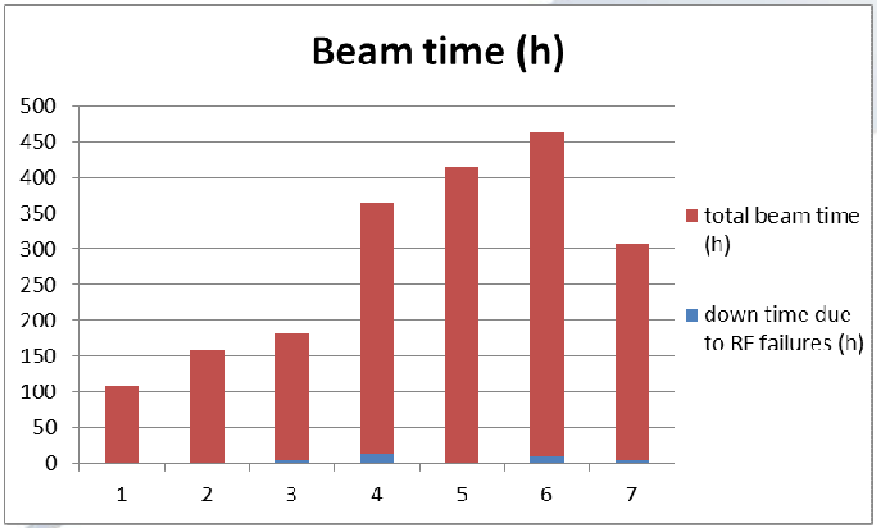
✓Other kind of error sources

- Transmitter Coaxial Switches → the insertion loss of the coaxial switch change with time (from 0.5dB to 4dB) due to overcurrent of the control signal during transients. Critical when combining 2IOTs
- Fake Arcs → very sensitive arc detector. Sometimes light detected when people taking pictures with flash
- Conditioning → Two absorbers in front of cavities have been replaced during 2012. Some contamination of the cavities due to the outgassing of the vacuum chamber when injecting beam. This produced arcs and reflected power trips.

RF statistics of 1st year operation



Run #	IOTs body currents	water	others (arcs, reflected power, vacuum)	total
1	6	7	8	21
2	16	12	21	49
3	7	5	11	23
4	21	14	16	51
5	23	24	25	72
6	32	22	13	67
7	7	8	15	30



Run #	RF Failures producing beam dump (%)	Downtime due to RF failures	
		h	%
1	14%	2	1.90%
2	29%	0.4	0.25%
3	22%	4.5	2.54%
4	45%	14	4.00%
5	8%	2	0.48%
6	37%	9.5	2.06%
7	23%	3.5	1.6%

Many RF Trips, but we recover fast

RF Autorecovery with beam

✓ Automatic Start up:

- When no RF in the cavity →LLRF Standby:
  - *Low RF drive*
  - *Disable tuning*
  - *Open loops (I&Q)*
- When RF ON → LLRF smooth startup
  - *Minimum RF Drive*
  - *Tuning enabled*
  - *Amplitude and phase loops closed*
  - *Smooth power increase*

✓Main Inconvenients of former automatic startup with beam:

- After a trip, the cavity remains tuned → it steals power from beam
- After recovering the cavity, the beam induces more voltage in the cavity than the IOT → Tuning loop becomes crazy

RF Autorecovery with beam

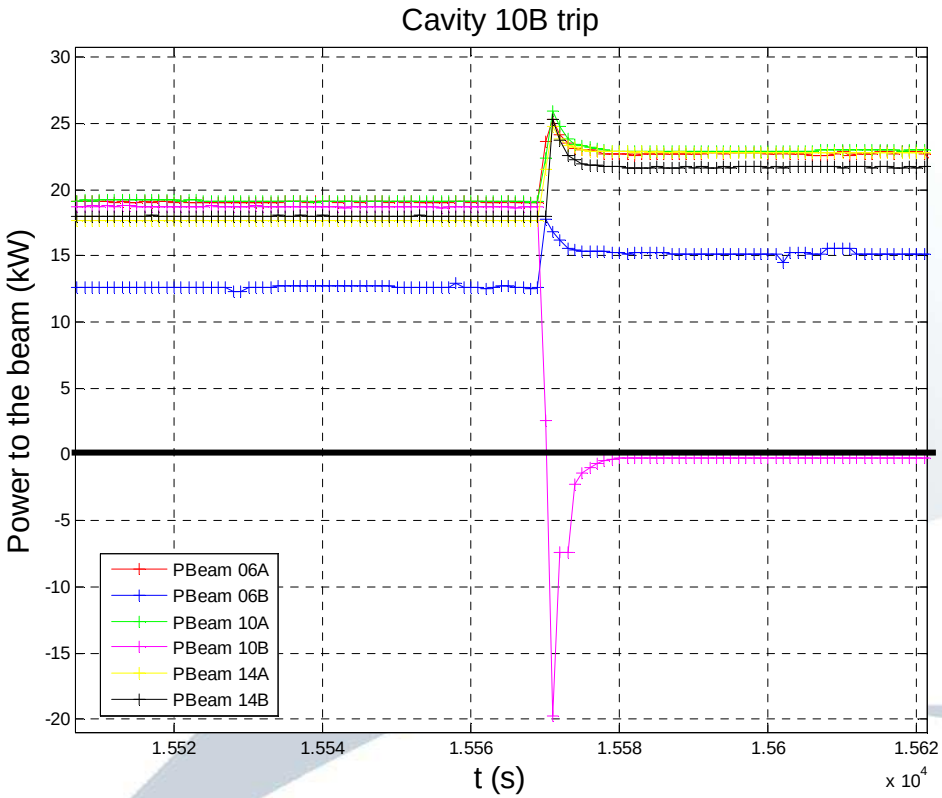
✓ **New Automatic Start up:**

- When RF trip
  - *Open loops (I&Q)*
  - *Disable tuning*
  - *Plunger moved 3000 steps up to detune cavity (parking)*

- When RF ON:
  - ***IOT power high enough*** *to induce more voltage in the cavity than the beam loading after unparking*
  - *Amplitude and phase loops open because cavity is completely detuned*
  - *Phase and amplitude of LLRF adjusted to have very similar conditions in open loop and close loop*
  - *Plunger moved back 3000 steps to tune cavity (unparking)*
  - *Amplitude and phase loops closed*
  - *Smooth power increase*

- Tested in all cavities at **100mA**

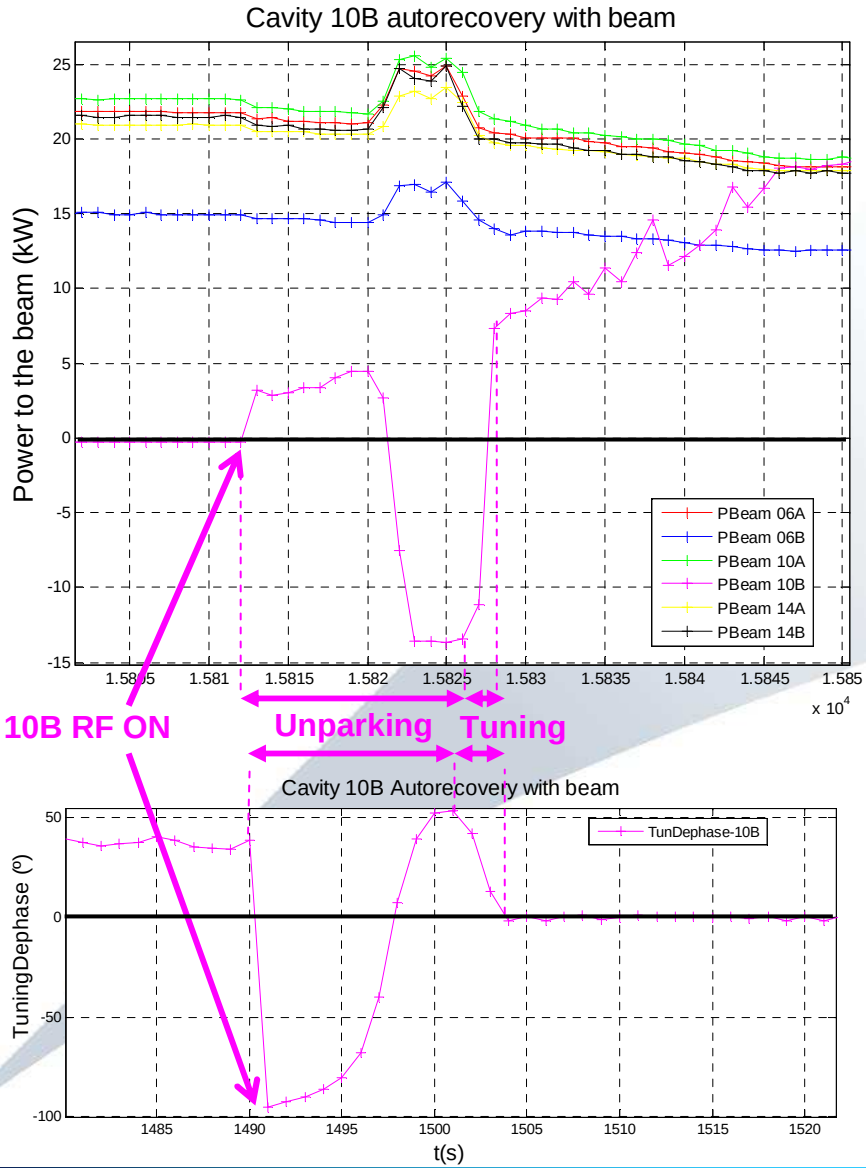
RF Autorecovery with beam



Cavity 10B trip:

- ✓Other 5 cavities increase power
- ✓10B steals -20kW power to the beam
- ✓After trip **Parking Process** starts
- ✓After 15s, 10B power = 0kW

RF Autorecovery with beam



Cavity 10B autorecovery

✓RF ON in 10B: some power to the beam

✓**Unparking Process** starts

✓After unparking, 10B steals power to the beam

✓Tuning Loop Enable (10B power > 0kW)

✓Amplitude and phase loop enable and power increased

Tuning Dephase during autorecovery

✓RF ON : TuningDephase = -90º

✓**Unparking Process** starts → Tuning dephase approaching 0º and then overpasses this value

RF Autorecovery with beam

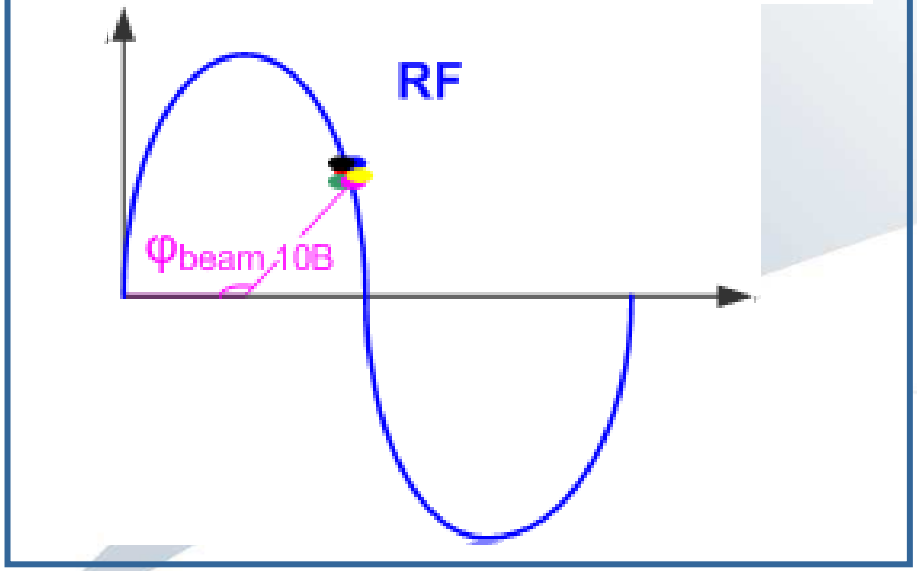
Cavity 10B autorecovery

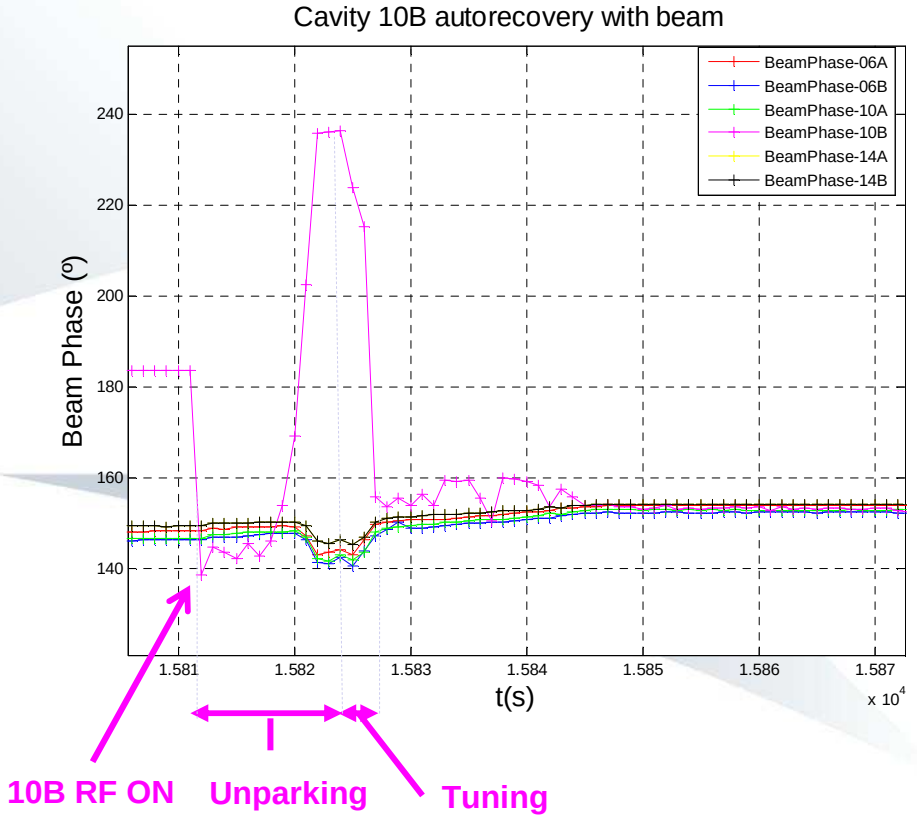
✓RF ON: 10B Beam phase ~ 140º

✓**Unparking Process** finishes: 10B Beam phase ~ 230º

✓Conclusion: the unparking process should move the plunger less steps than the parking process → already implemented and to be tested in next run

Beam Phase respect to RF ~ 150º





Trips Post Mortem Analysis

✓ Sometimes beam does not survive after RF trip

- The less # of cavities, the more likely to have beam dump due to RF trips
- The higher the current, the higher reflected power in other cav. after a RF trip

✓Will the beam survive at 400mA after a RF trip?

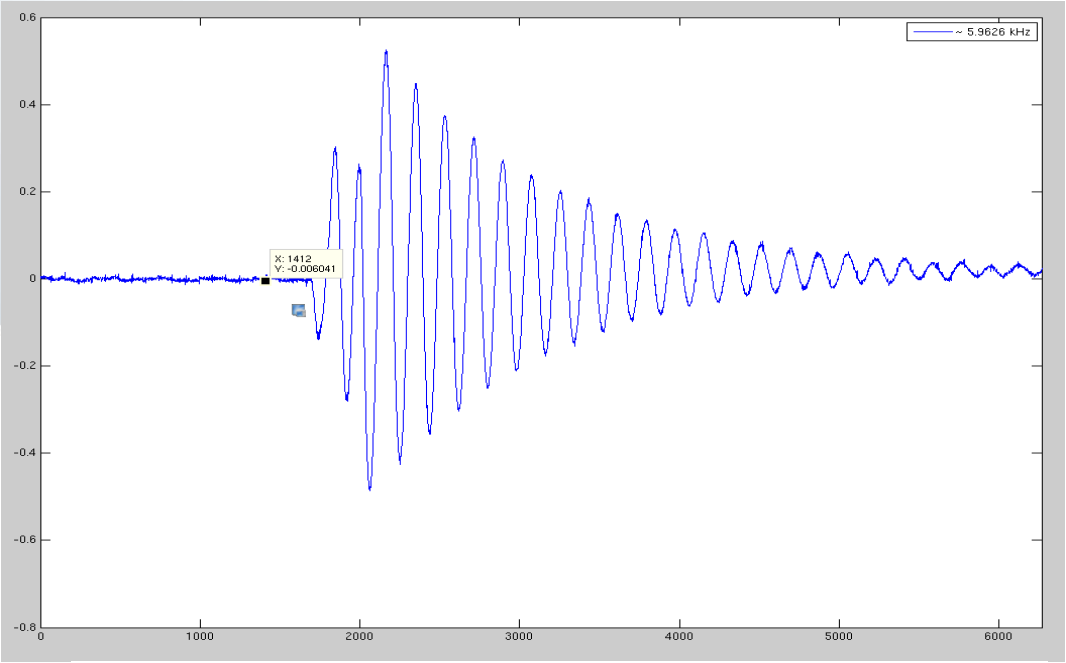
Behaviour of 06B after a trip in 10B and no beam dump (61mA)

✓Power to the beam increases

✓Beam phase gets reduced

✓Frequency oscillations ~ 6kHz (synchrotron freq)

✓Stabilization time ~ 3ms (damping time longitudinal)



Effect on beam trajectory (BPMs reading after RF ITCK – Data provided by A. Olmos)

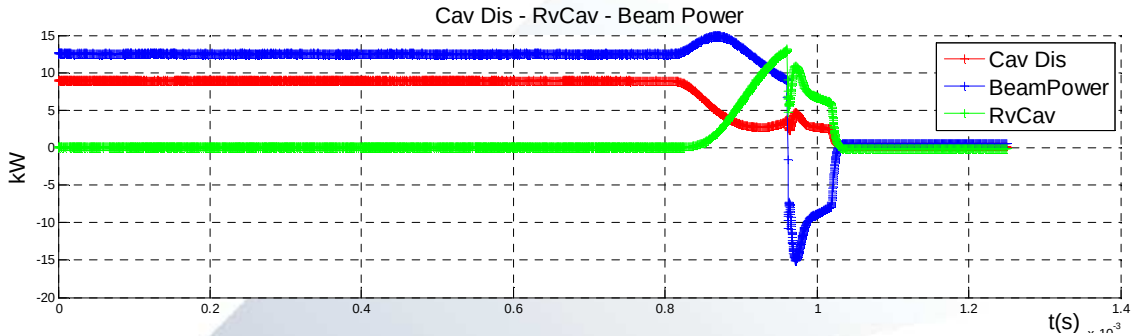
Trips Post Mortem Analysis

Behavior of 06B after a trip in 10A and Beam Dump (100mA)

✓Power to the beam starts to increase

✓Beam phase starts to get reduced

✓BUT Reflected power reaches interlock level: 16kW



Provisional solution: Reflected power interlock level increased up to 23kW

Maximum reflected power calculated when working at 400mA (data provided by Bea Bravo)

✓Cavities β adjusted to have minimum reflected power at 400mA

✓Working with 6 Cavities, 600kV/cav, 400mA → RF trip causes:

- ✓ Reflected Power transient of 73kW per cavity
- ✓ Circulator incapable to react against fast transients→ Reflected power will reach IOTs

Will beam survive at 400mA after RF trip? Still don't know, but not likely

Future RF upgrades

Installation of CoStubs in all IOTs

✓CaCo:

- ✓ Symmetric mode: Combines power of two IOTs
- ✓ Asymmetric mode: one IOT is switched off while 2nd IOT is active

✓CoStub: coaxial stubs

- ✓ Shortcircuit the coaxial waveguide of the passive IOT to avoid arcs in that IOT

With CoStubs, if one IOT is not operational, we still can power that cavity with only one IOT

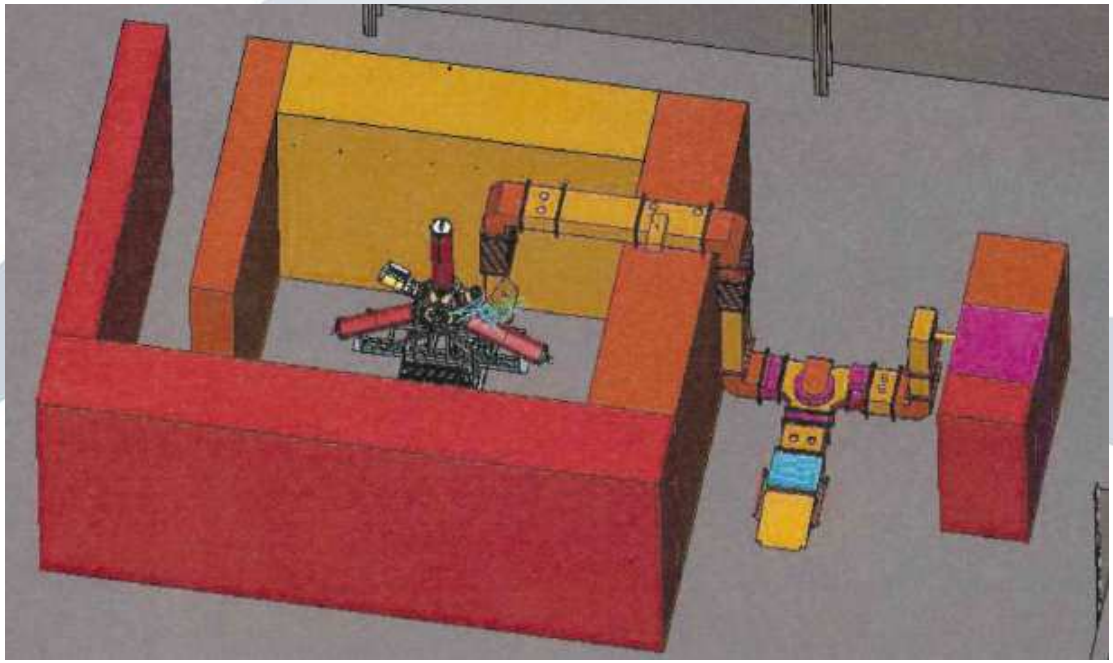
Future RF upgrades

High Power RF Lab

✓Installation of a high power RF lab in CELLS Warehouse

- ✓ 1 IOT – 80kW
- ✓ Radiation bunker to allocate Booster or Dampy cavity
- ✓ Cooling, electricity installation and safety bunker already built
- ✓ Foreseen completion date: January 2013

✓It will be used to recondition problematic IOTs, testbench of new RF upgrades and SAT of new IOTs



Summary

✓SR RF: Many water trips and IOT trips

✓Fast Recovery after RF trips (usually less than 10 minutes)

✓RF robust enough for operation at 100mA

✓Still learning and adding improvements to the RF Systems

Acknowledgments

✓RF team: Francis Perez, Bea Bravo and Jesus Ocampo

✓Operators, technicians and controls support, specially to Filip Mares, Joan Pages, Antonio Milan

Thanks for your attention