Status and Operation of the ALBA RF system

J. Ocampo on behalf of the ALBA RF Group:

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    1. 06B cavity arching
    2. IOT status
3. Upgrades and new developments
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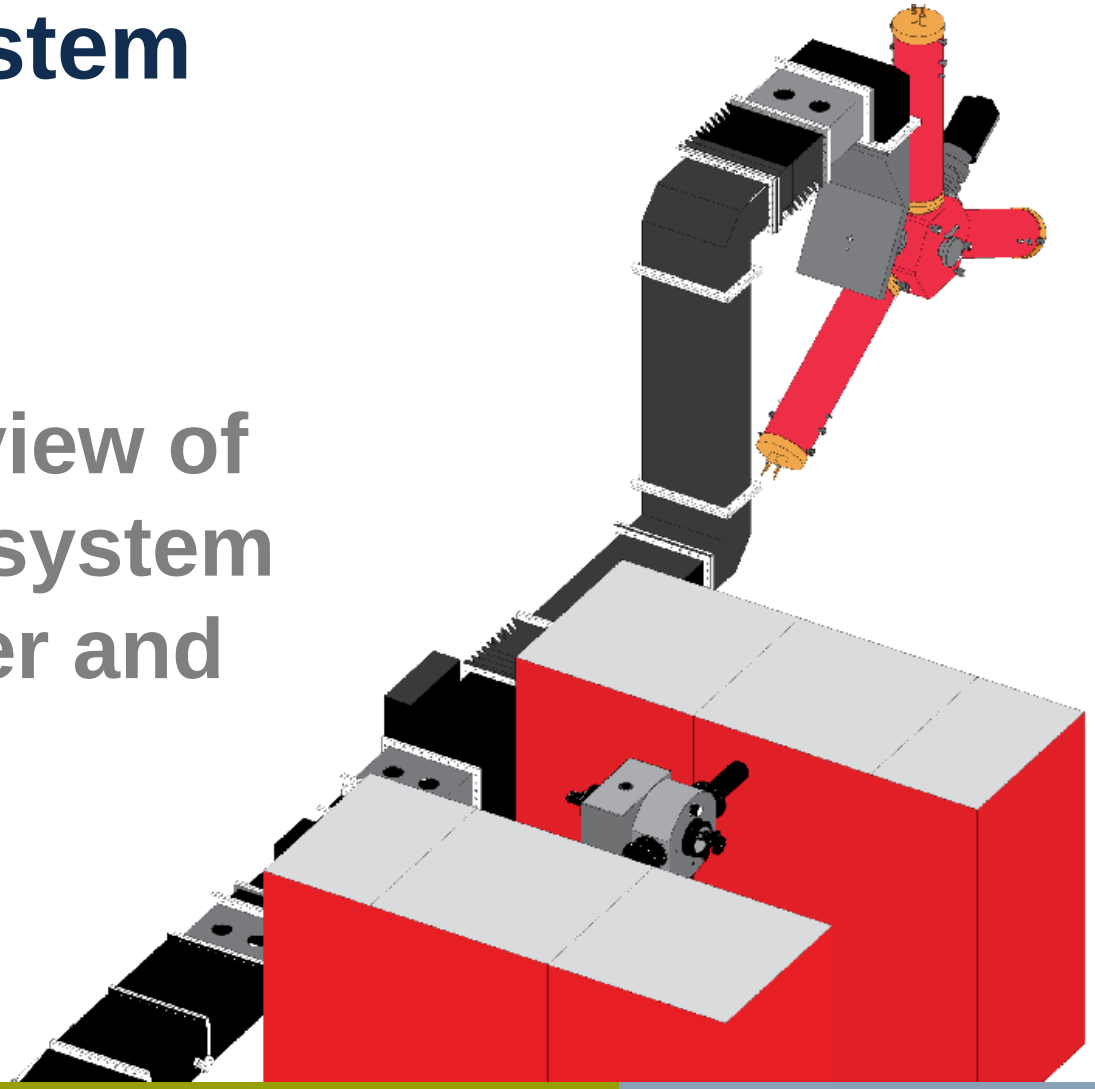
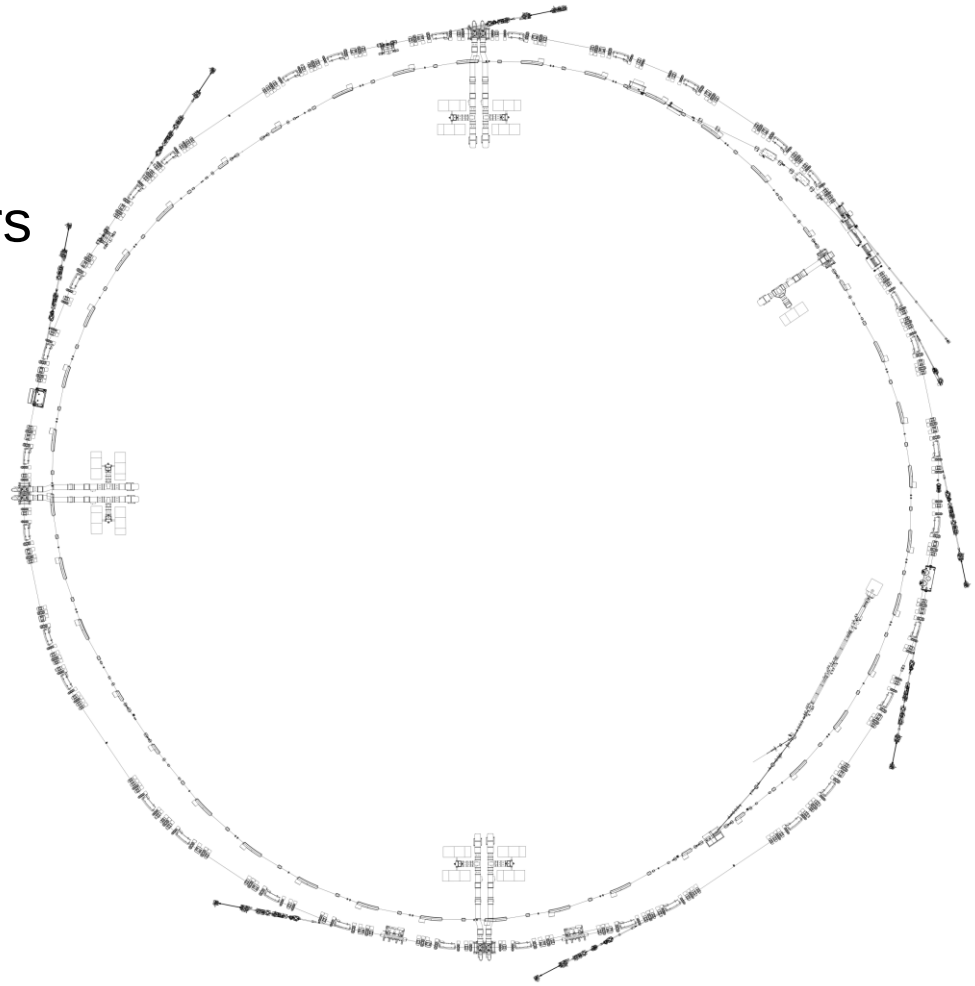
ALBA RF system

General overview of the ALBA RF system for the Booster and Storage Ring

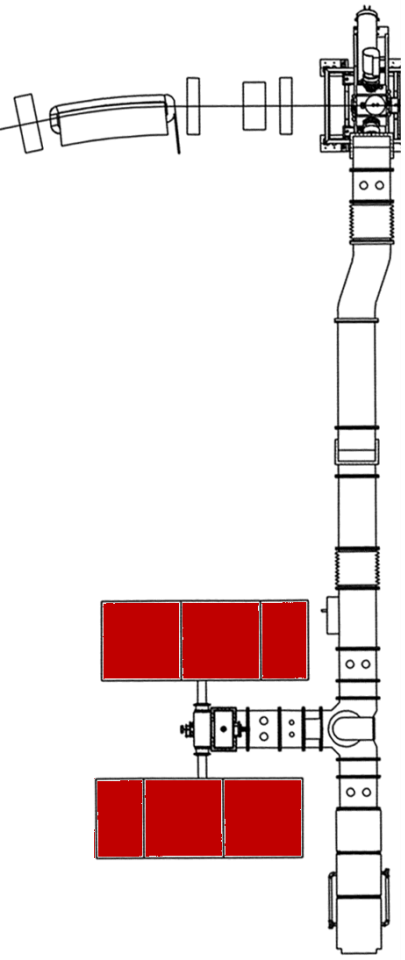


ALBA RF System

- Storage Ring:
  - 6 DAMPY cavities
    - 600kV each
  - 12 x 80kW IOT amplifiers
  - 500MHz – 3GeV
- Booster:
  - 1 PETRA 5 Cell cavity
    - 900kV
  - 1 x 80 kW IOT
  - 100MeV to 3GeV
  - Ramping at 3Hz



Transmitters



- HVPS
  - 38kV
  - 4A
  - PSM technology
- IOT Amplifier
  - 80kW CW
  - Compatible with several IOT's
    - THALES: TH793-1, TH794, TH795
    - L3: 4444-C

L3 IOT's for ALBA

- Public tender awarded to BTESA (Spain) to acquire 5 IOTs from L3
  - Collaboration with Comark TV (USA) for Thomson transmitter adaptation
  - Strategic decision to have two different IOT providers
  - L3 IOTs SAT:
    - 1 prototype tested in February 2015
    - 4 more units installed in August 2015

ALBA operation & Status of the RF

MTBF evolution since 2013

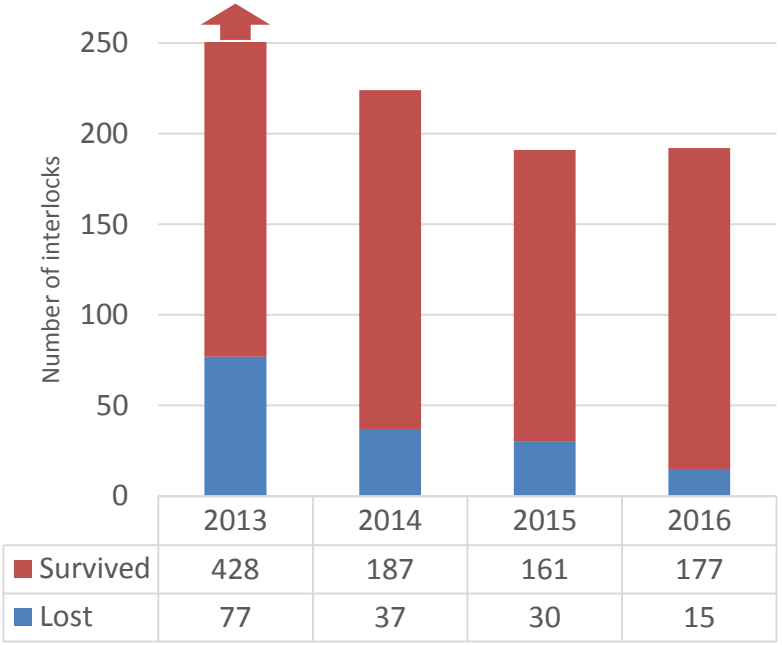
Interlock count 2013 to 2016

06B cavity arching

IOT’s

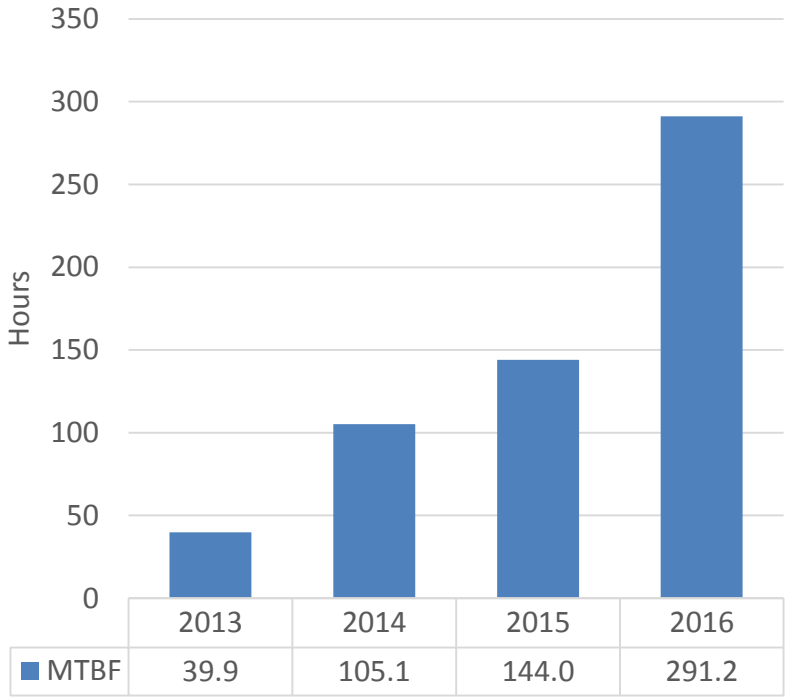
RF MTBF

Beam losses and total number of interlocks



	2013	2014	2015	2016
Survived	428	187	161	177
Lost	77	37	30	15

Beam loss MTBF

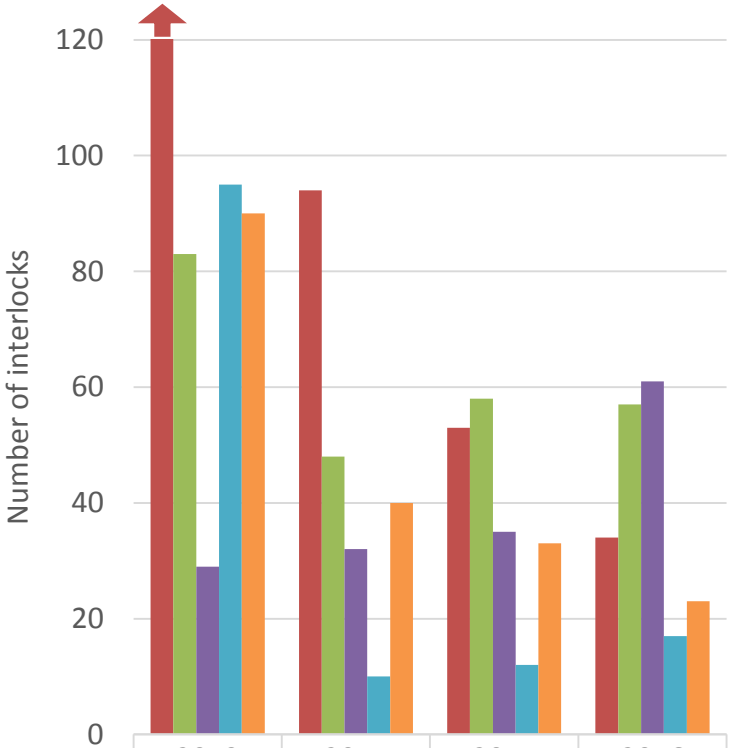


	2013	2014	2015	2016
MTBF	39.9	105.1	144.0	291.2

The MTBF continues to improve!

Data for 2016 has been extrapolated to the total number of operation hours

Number of failures



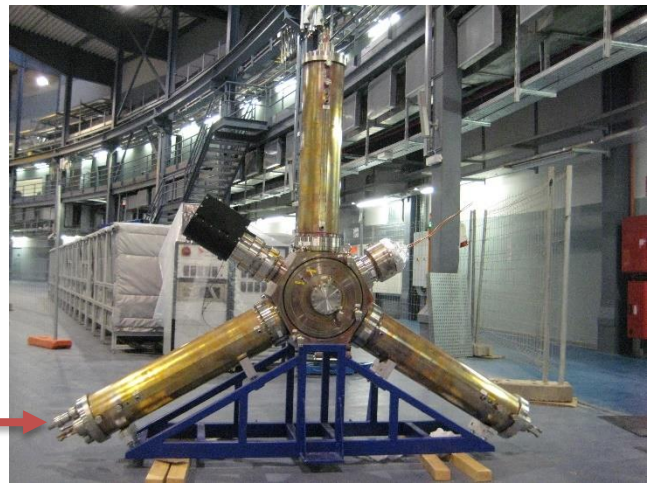
	2013	2014	2015	2016
IOT Arc	208	94	53	34
CAV arc	83	48	58	57
OTHER arc	29	32	35	61
Cooling	95	10	12	17
Other	90	40	33	23

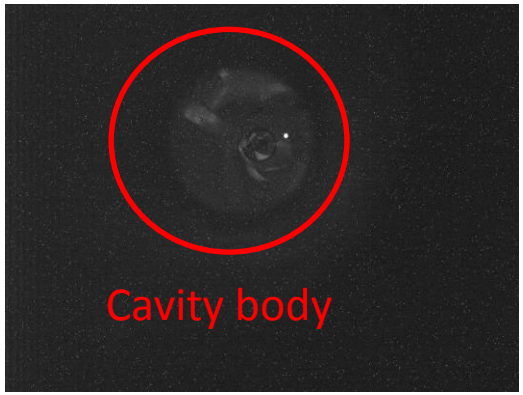
- The number of interlocks has decreased since 2013
- Cavity and IOT arcs are still our main concern
  - 68% of all cavity arcs happen in the same cavity: 06B

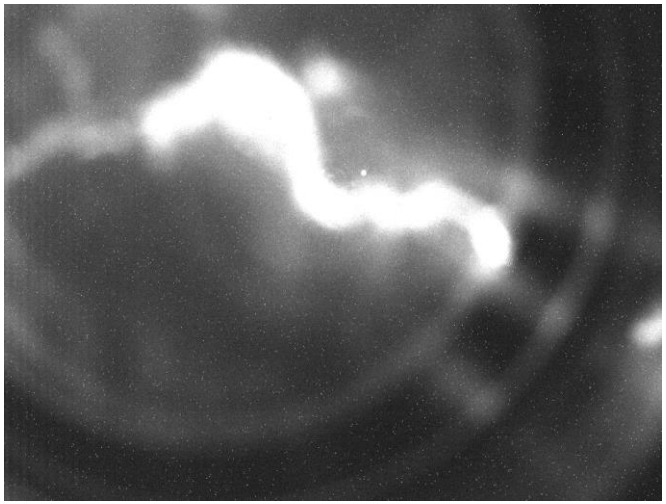
Data for 2016 has been extrapolated to the total number of operation hours

Arcs in 06B

- Arcs only happen with beam
- CCD camera installed in the cavity
- Cavity voltage was reduced to mitigate the problem



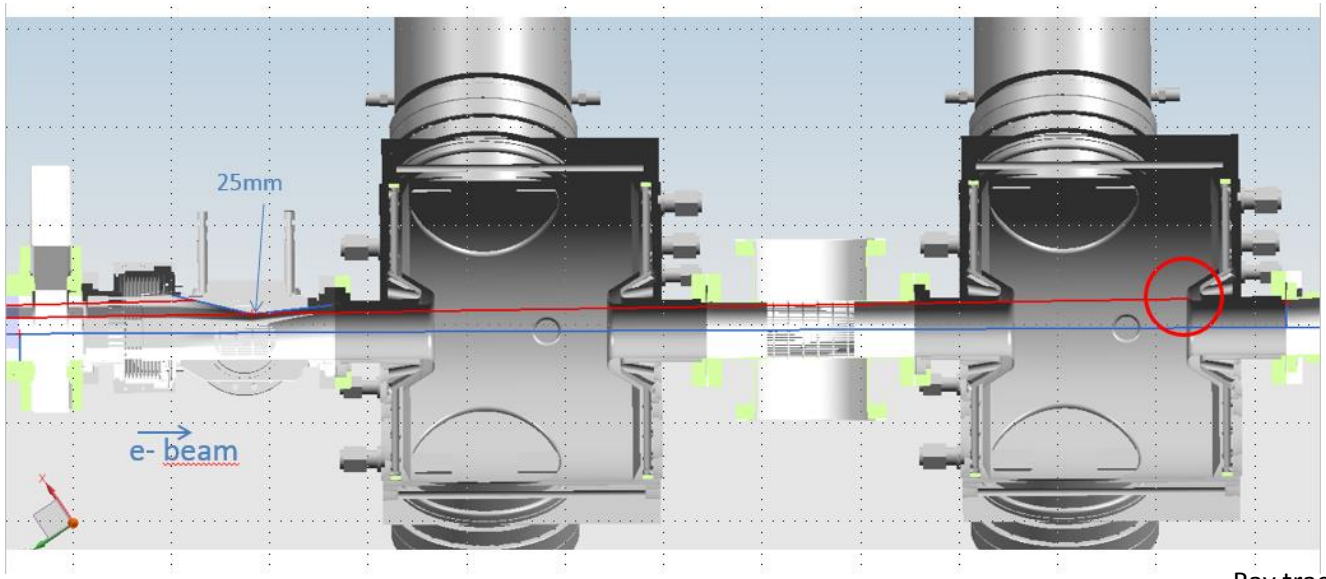




Arc pictures courtesy of A. Nosych (Diagnostics group)

06B cavity arching

- Cavity opened in January 2016
  - Marks of synchrotron radiation impact in the nose cone
  - Ray tracing shows the origin: radiation from the previous bending magnet not blocked by the absorber
  - Absorber to be replaced in August



Ray tracing courtesy of R. Monge (Vacuum group)

Current IOT stock

TX	Type	SN	Status	HV hours	FIL hours
TX02	L3 4444-C	100005	Active	8313	9257
TX03	L3 4444-C	100009	Active	5340	6163
TX04	L3 4444-C	100007	Active	4459	5212
TX05	TH 795	830864	Active	0	0
TX07	TH 794	759044	Active	12728	14238
TX08	TH 794	771181	Active	10290	11559
TX09	TH 794	762037	Active	12646	14393
TX10	TH 794	1634010	Active	8851	9959
TX11	TH 794	731330	Active	20143	23431
TX12	TH 794	747211	Active	18375	20829
TX13	L3 4444-C	100006	Active	5343	6242
TX14	L3 4444-C	100008	Active	4547	5385
TX01	TH 793	720105	Spare	13735	16466
TX06	TH 793	499443	Spare	22182	29661
	TH 793	617549	Refurb.	25320	31832
	TH 793	623099	Refurb.	13053	18956
Average				**11582**	**13974**

Broken IOT's

17 broken during operation

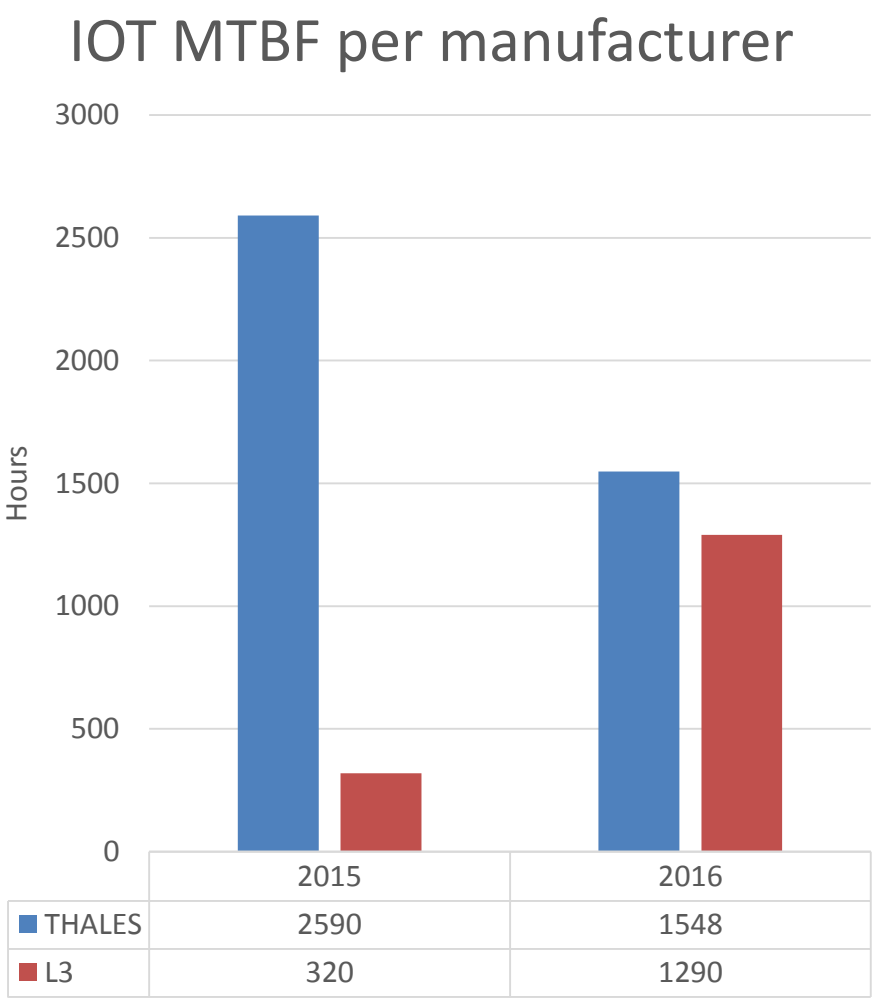
SN	Type	HV hours	FIL hours
610736	TH 793	25	200
499413	TH 793	840	1280
761523	TH 794	1482	1694
720785	TH 794	1088	1714
623097	TH 793	515	2316
610737	TH 793	3324	4221
629734	TH 793	5080	7828
723734	TH 794	6501	8203
758883	TH 794	7977	8977
760354	TH 794	8273	9496
766836	TH 794	8643	9833
617550	TH 793	6970	10296
608802	TH 793	7585	10627
623098	TH 793	12004	15456
617551	TH 793	13637	18621
634238	TH 793	15713	18979
617302	TH 793	17377	22507
Average		**6884**	**8956**

Other problems

SN	Type	HV hours	FIL hours	Reason
611024	TH 793	34	58	Human error
620408	TH 793	13250	18257	Human error
623096	TH 793	19651	25429	Human error
610735	TH 793	4851	7468	Trolley damage
591095	TH 793	106	150	TV type (not broken)
747014	TH 794	0	0	Defective
726543	TH 794	50	74	Defective
724075	TH 794	39	97	Defective

IOT MTBF per manufacturer

- Isolated cases:
  - During 2015 two L3 IOT's caused 67% interlocks
  - During 2016 one L3 IOT is causing 75% interlocks
- 2016 MTBF is comparable
  - THALES: 8 tubes, 8 trips
  - L3: 5 tubes, 8 trips



Upgrades and New developments

TH-795 test

RF trip compensation

New IOT drivers

CIEMAT collaborations

3rd harmonic system

TH795 test

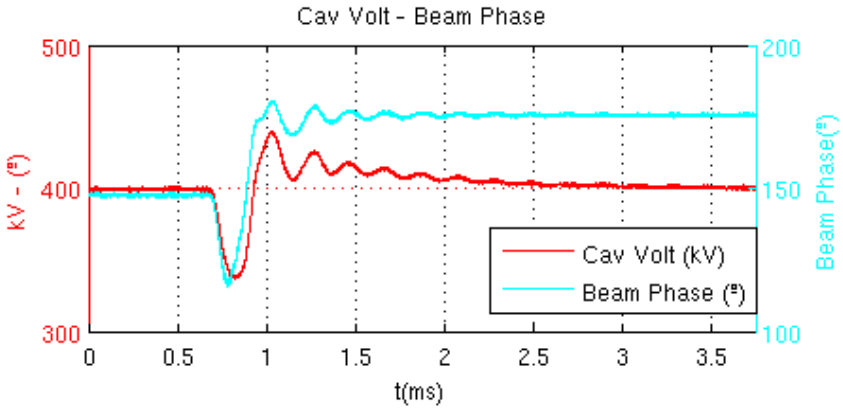
- TH795
  - New ceramic and gun: more reliable
  - Production is more stable
- Smaller ceramic and contacts: <u>An adaptation kit is needed</u>
- Demonstrated up to 80 kW in factory and ALBA transmitter

TH795 with upper adaptation ring installed

Lower ring of the adaptation kit

RF trip compensation

- When one cavity trips, voltage of the other cavities decreases temporarily.
  - If total voltage is lower than 1MV the beam is lost



Voltage in an active cavity during trip

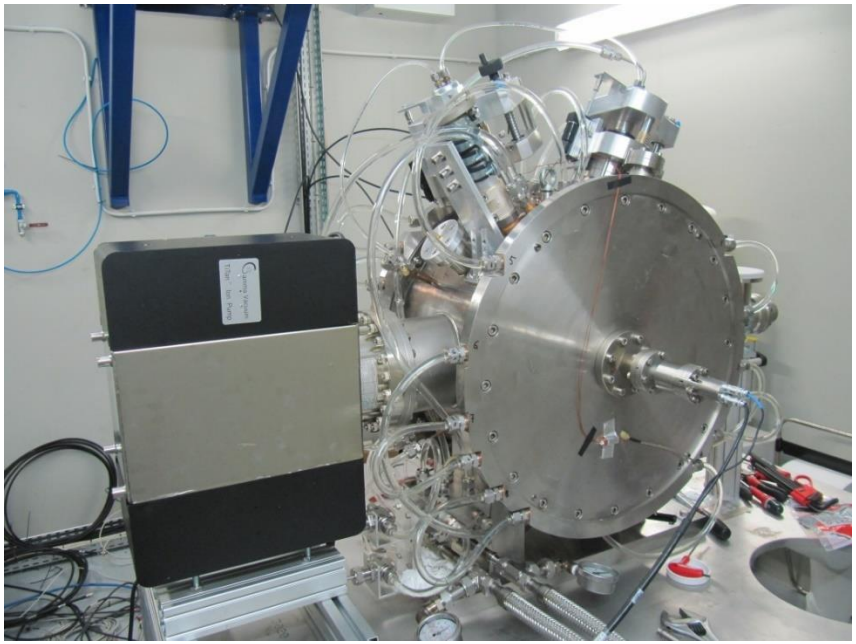
- After a cavity trip, the remaining cavities introduce a phase modulation that compensates the perturbation.
- Phase compensation works and is active for users operation.

SSA IOT driver

- 500W SSA preamplifier
  - Currently: THALES TH 15701-1 AMPSIUM
- Asked for prototypes to:
  - TTI (www.ttinorte.es)
  - BTESA (www.btesa.com)

CIEMAT collaboration

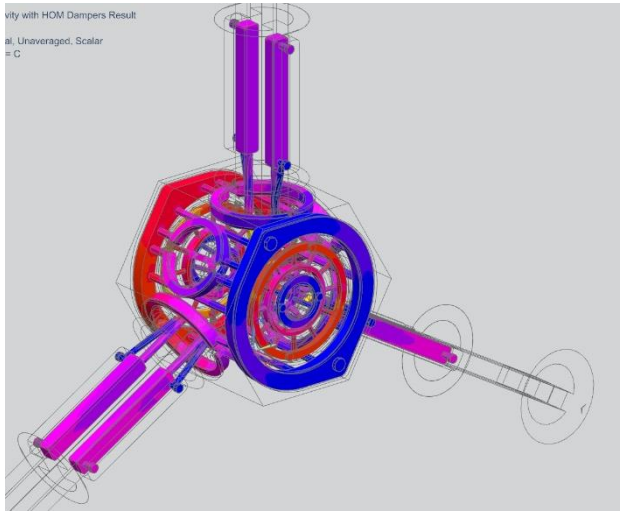
Conditioning of 2 rebuncher cavities for IFMIF



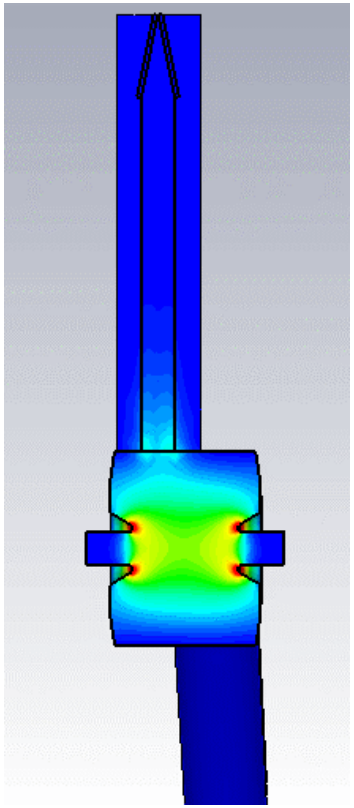
September 2016: conditioning of a cyclotron cavity

3rd harmonic system

- In collaboration with CLIC
- NC active cavity based in DAMPY
- 1.5GHz SSA design in-house
- Digital LLRF design in-house

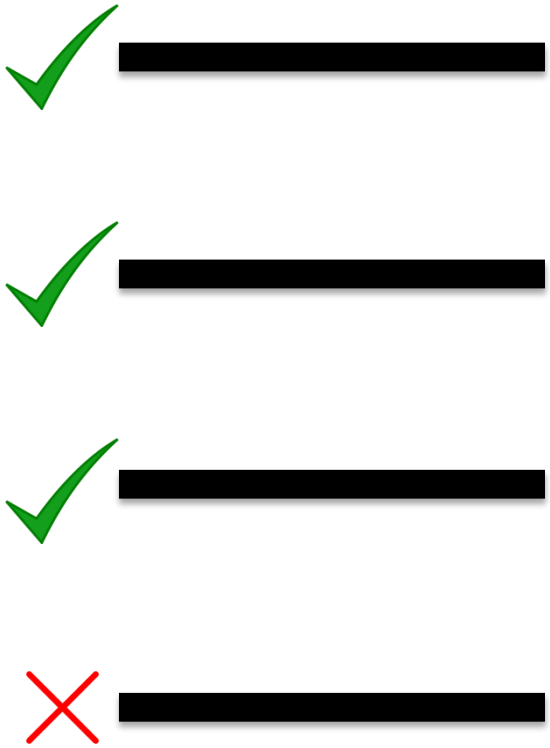


Cavity thermal simulations



Cavity electromagnetic simulations

Summary



Summary

- ALBA RF system has 2-3 trips/week
  - The beam is able to survive most of the time
  - MTBF can be considered good
- The root cause for 06B cavity arching is understood.
  - A solution will be implemented this summer
- IOT's
  - L3 IOT's perform adequately
  - THALES is introducing improvements in their IOT's
- The development of the 3rd harmonic system is ongoing

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