



Status and new developments of ALBA RF system

Pol Solans on behalf of RF group:

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24/10/2019

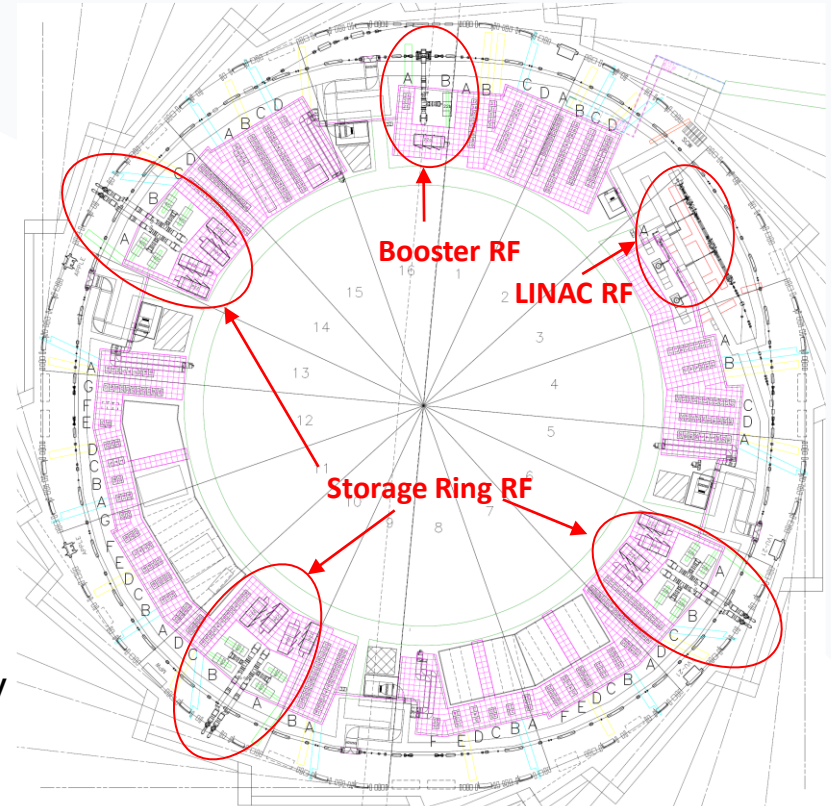
- ALBA RF overview
- 2019 Operation
- RF upgrades
- New developments
- Conclusions

- **ALBA RF overview**
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- 3rd generation Synchrotron Light Source located in Barcelona
- Energy: 3 GeV
- Circumference: 268.8 m
- Emittance: 4.58 nm·rad
- 8 BLs in operation
- 3 BLs under construction
- 1 diagnostics BL
- 6000 operation hours/year

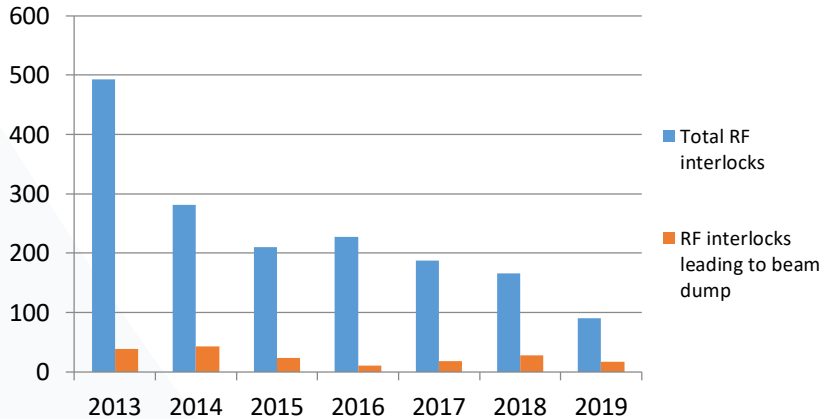
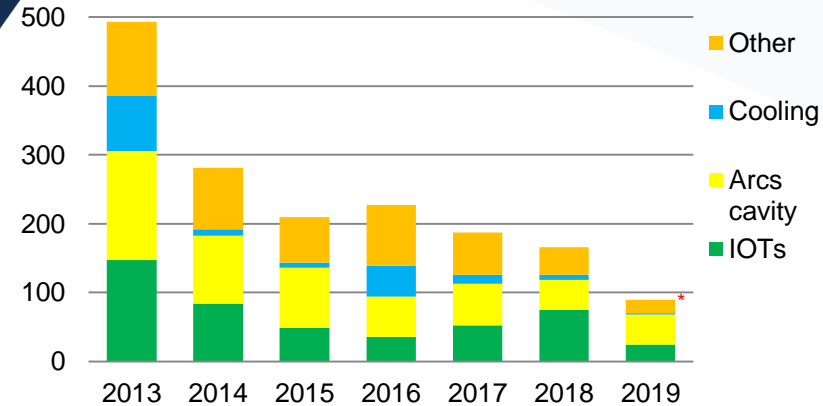


- LINAC
 - 2x Klystrons
 - Traveling wave cavities @ 3 GHz
 - 90 keV to 110 MeV
- Booster
 - 1x 50 kW SSPA
 - 5-cell cavity @ 500 MHz
 - 100 MeV to 3 GeV
- Storage ring
 - 12x 80 kW IOT
 - 6x 600 kV cavities @ 500 MHz
 - 2 IOT combined in CaCo for each cavity



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RF Interlocks



* Until September 2019

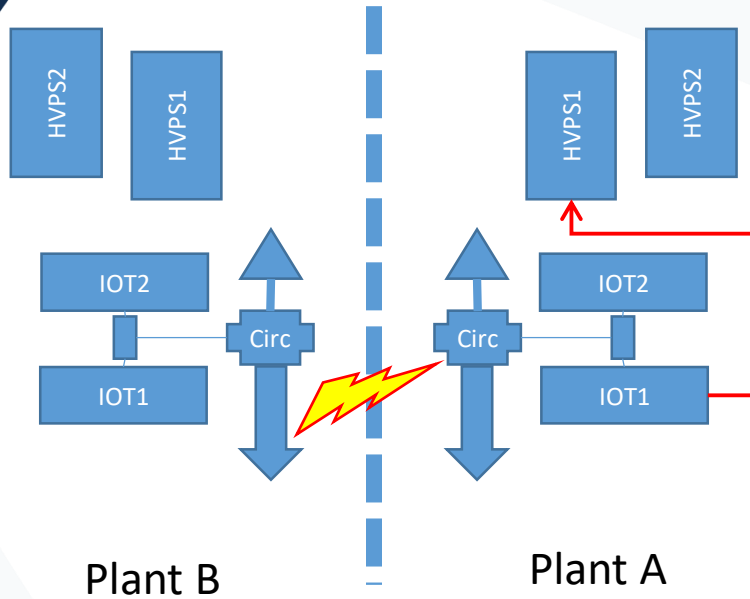
07/11/2019

- January 2019: current increase from 150 mA to 200 mA after SCW fixed.
- September 2019: 250 mA top-up.
- Cavities voltage increased. More conditioning is needed. 3 MV total RF voltage.
- SR fully filled with L3 IOT since May 2019.

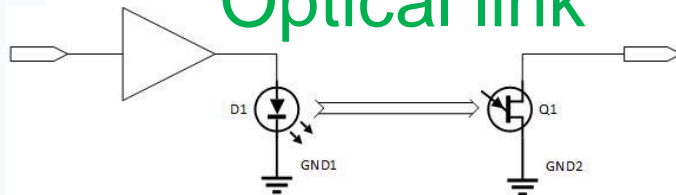
RF ITCK Types	...	2016	2017	2018	2019
IOTs	...	36	52	75	24
Arcs cavity	...	58	61	43	44
Cooling	...	45	13	8	2
Other	...	88	61	40	20
TOTAL	...	227	187	166	90

RF ITCK with beam dump	...	10	18	28	17
Beam Downtime due to RF [hours]	...	11.2	12.3	18.1	9.9*

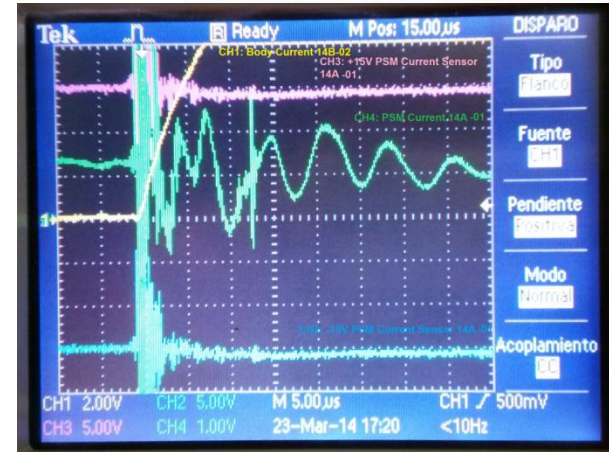
Noise induced by BCI



Optical link

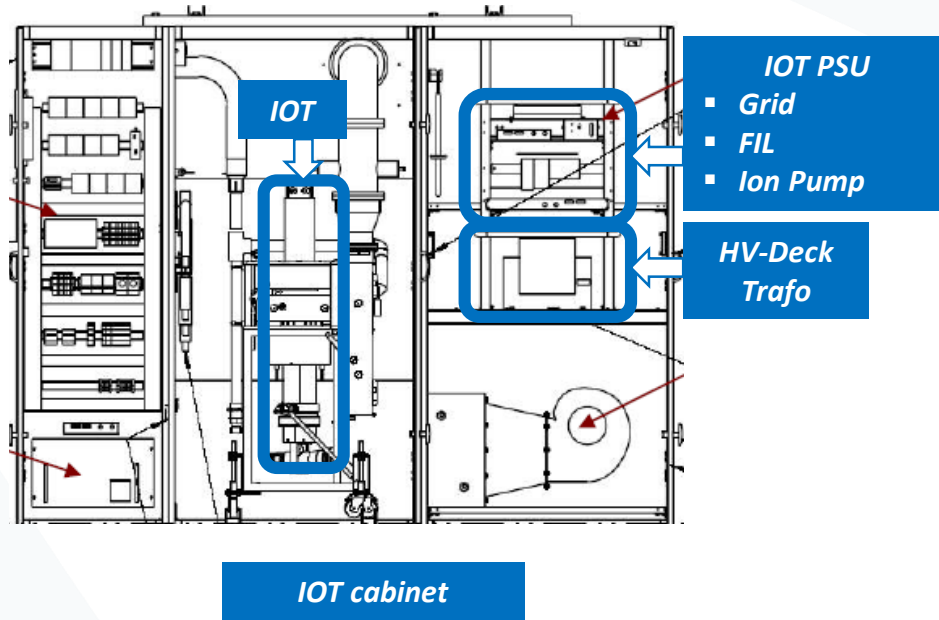


- After Body Current interlock, noise is induced in electronics of neighbour plant.
- Causing the 70 % of beam loss in 2018 and 35 % in 2019
- Filters added to measurements of HVPS (current and voltage) in all sectors

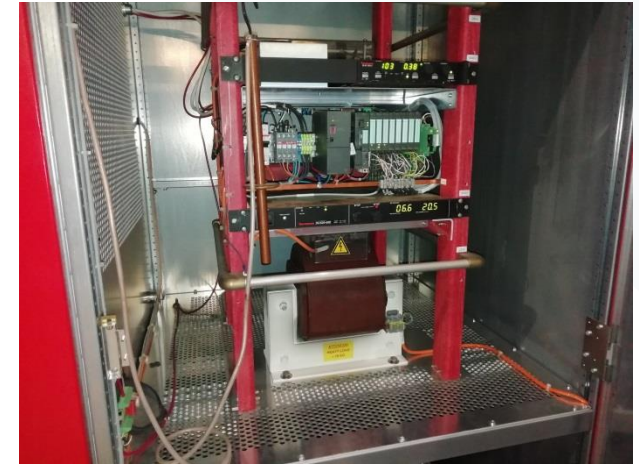


- New signal affected by BCI: HV-Enable
- ✓ 5 Body Current interlock without beam loss (100 %)

HV transformer replacing

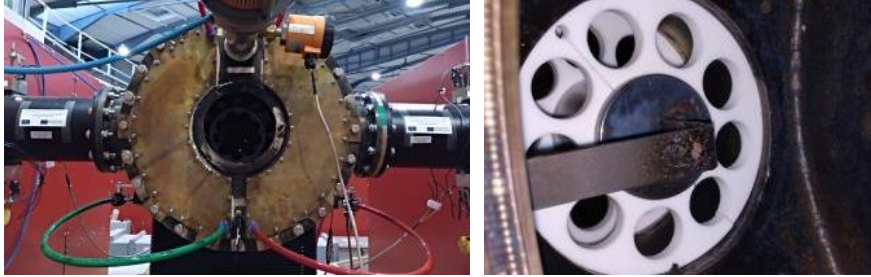


- Arcs produced in the HV transformer feed auxiliary PSU.
- 2 transformers have been replaced in 2019.
- Isolation problem detected during high voltage conditioning.

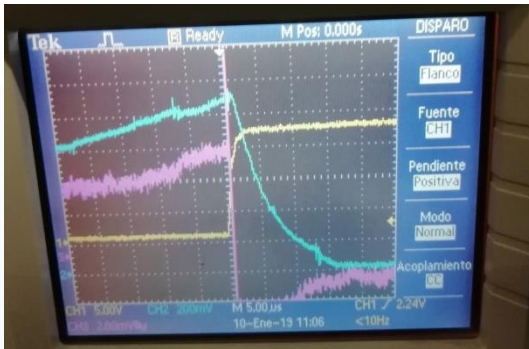


CaCo loop burned

- Reflected power interlock > 45 kW
- Noise could be heard



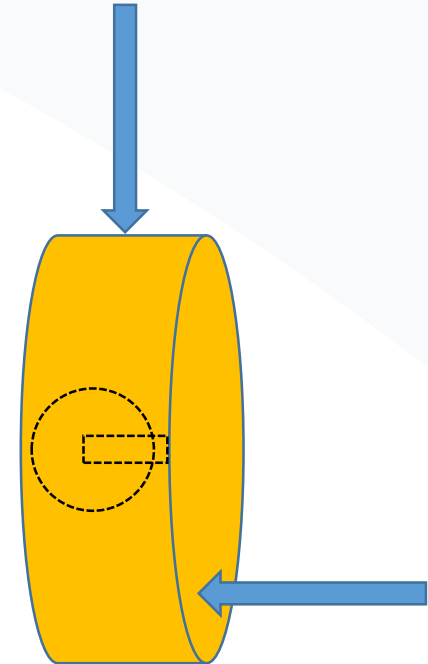
- Arc duration is estimated in ~75 us



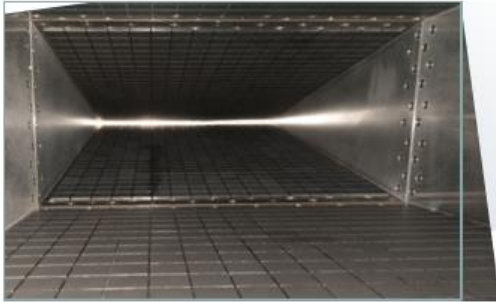
1. Blue: Reflected power DC
2. Pink: Reflected power RF
3. Yellow: Interlock trigger

 No arc detected via optical fiber

✓ Viewport position moved and loops survey



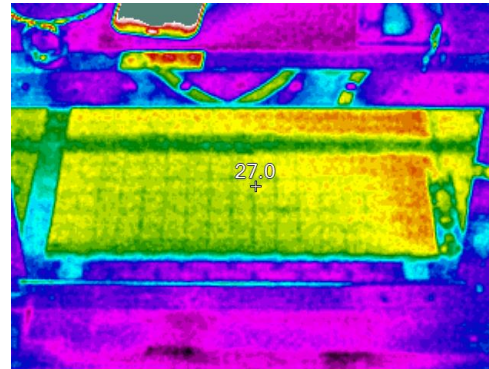
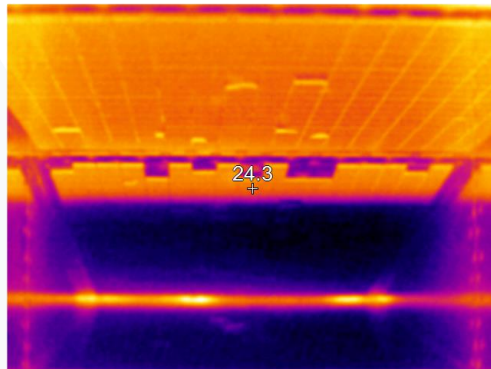
- Some arcs occurred in the RF lab load



Booster RF load



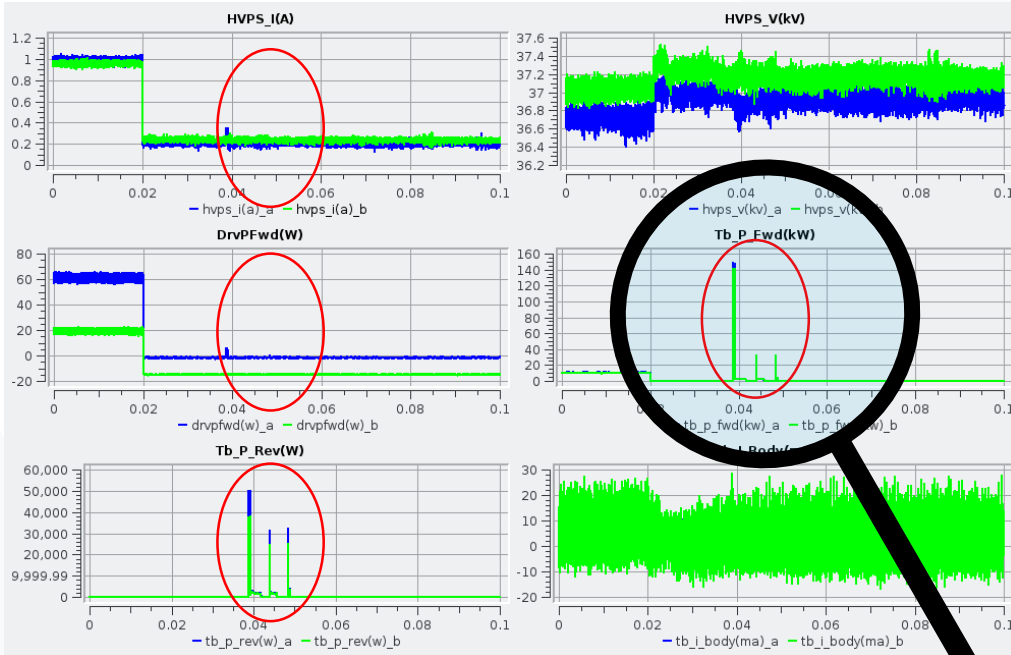
Damaged RF Load



- Water quality in the RF lab not good enough.
- Obstructions found in the cooling pipes.
- New load bought to AFT.

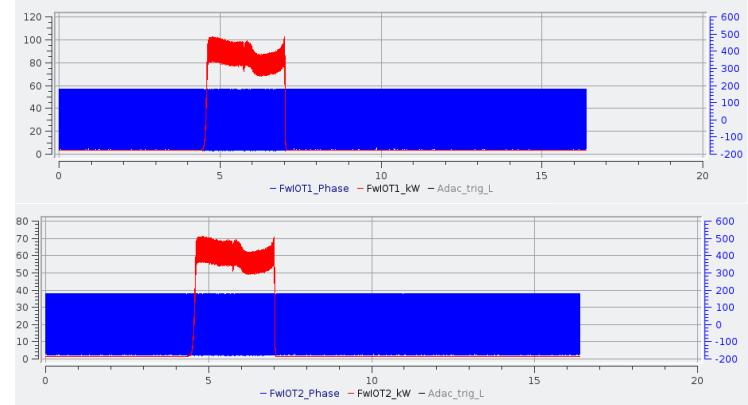
SSPA driver not stable

- Some extremely high power glitches arised after a trip.



Transmitter FDL data

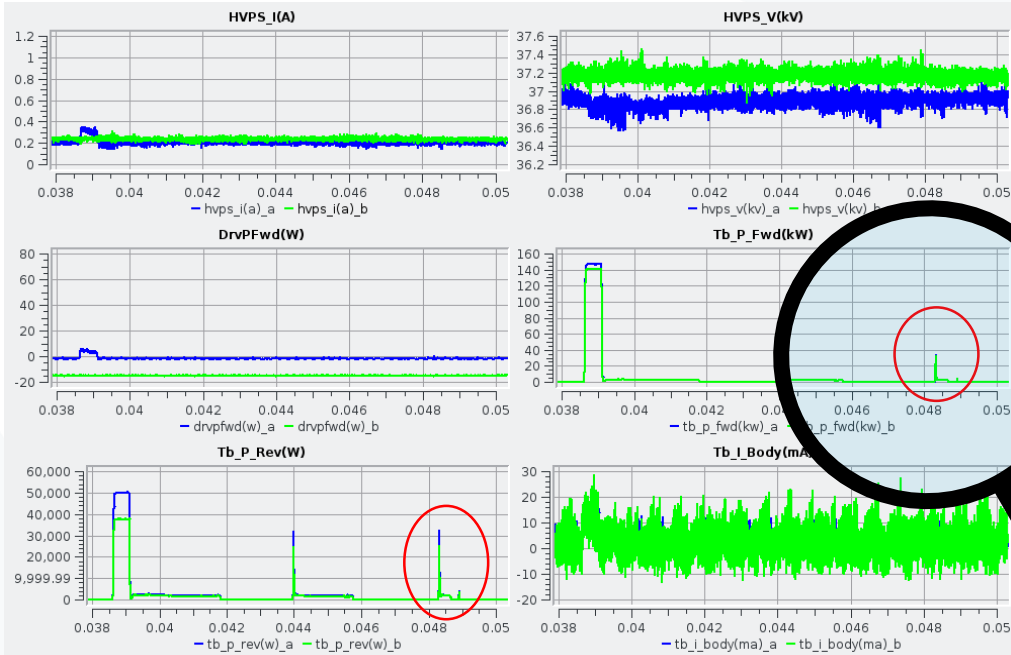
- ~140 kW forward power peak
- ~50 kW revers power peak
- ~0.35 A HVPS current consumption in Tx1
- ~5 W of driver power into the IOT in Tx1



LLRF FDL data

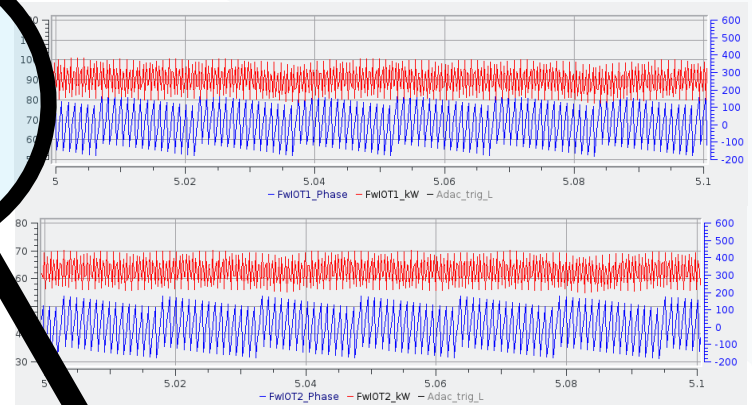
SSPA driver not stable

- Some extremely high power glitches happened after a trip.



Transmitter FDL data

- LLRF data shows frequency is not 500 MHz
- Lower power peaks

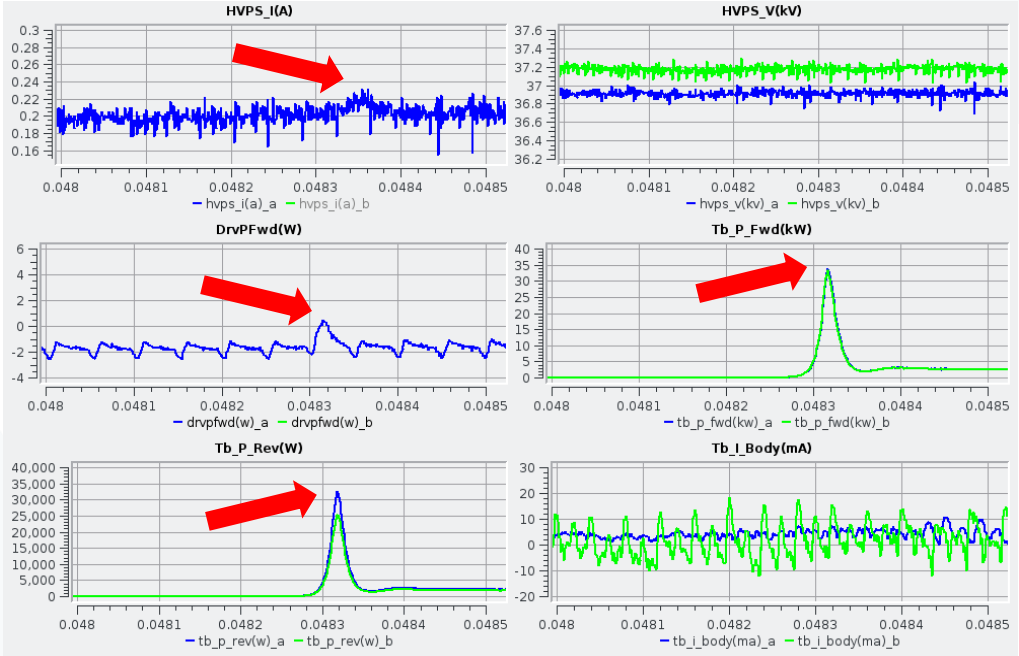


LLRF FDL data

SSPA driver not stable

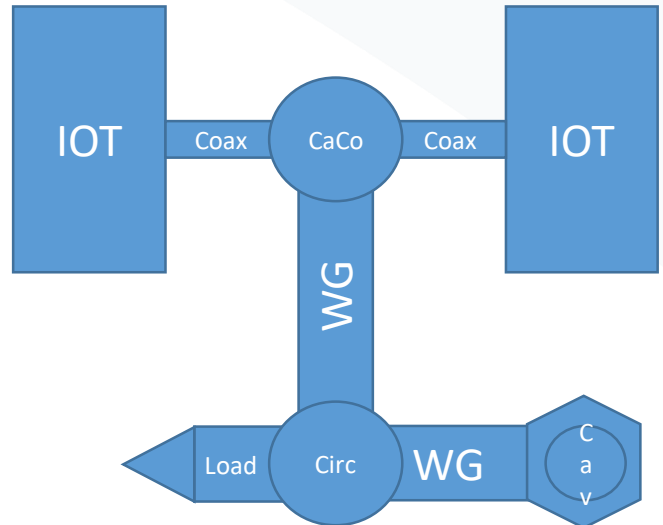


- Some extremely high power glitches happened after a trip.



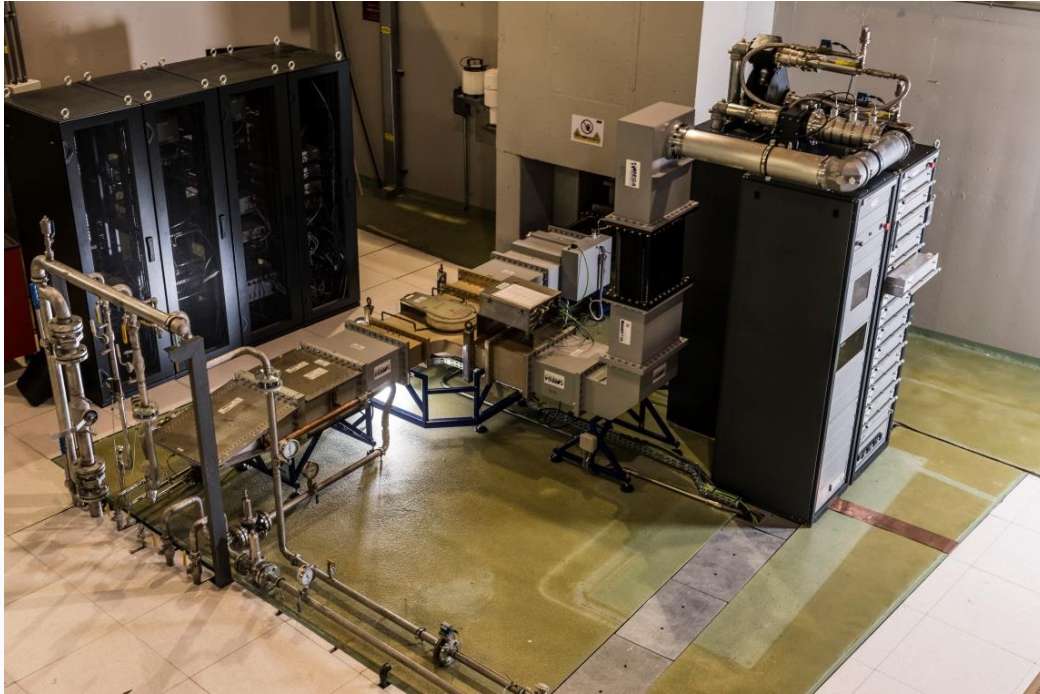
Transmitter FDL data

- Forward and revers power measurement are the same! Revers power measurement may be saturated at highest peaks.
 - There is current consumption and drive signal only in Tx1.
- ✓ Problem was solved by replacing the driver.

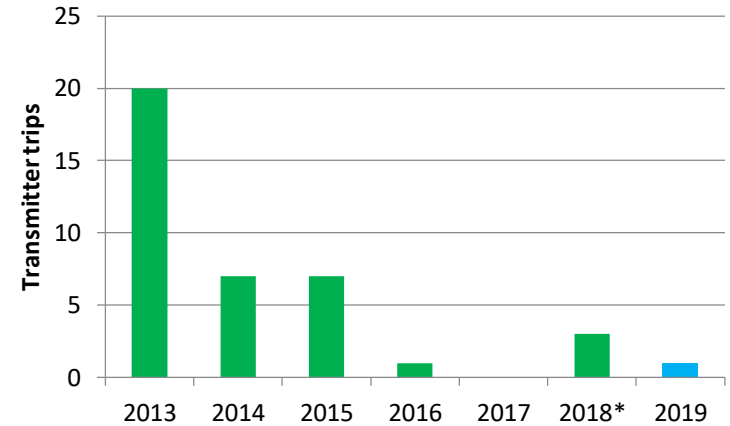


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New BO SSPA transmitter operation



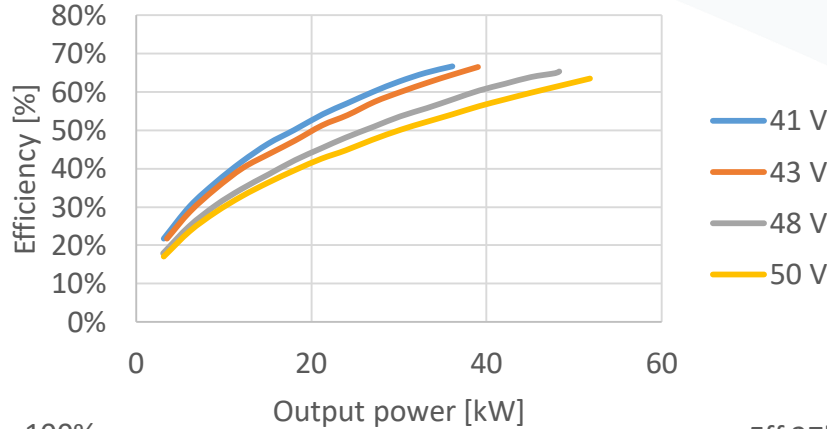
- Installation of a new solid state based transmitter in August 2018
- Several minor problems without impact into operation due to the high redundancy.



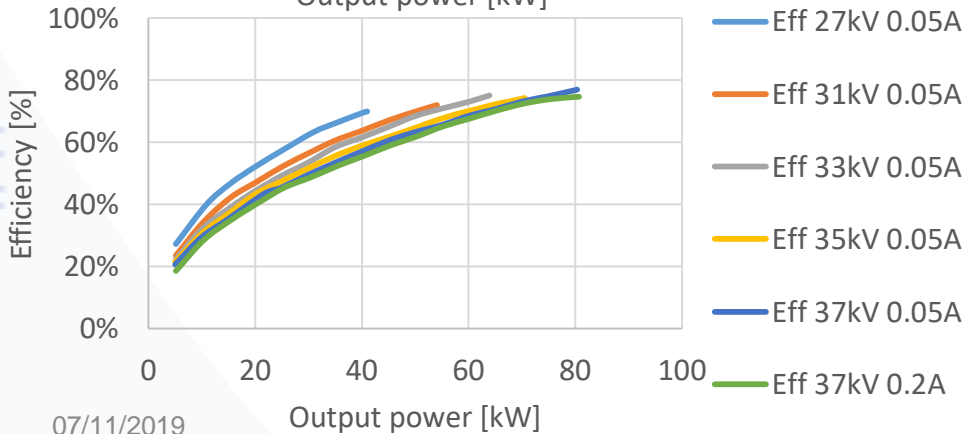
- 1 ITLCK: Short circuit tripped the whole transmitter

- Efficiency measurement in both SSPA and IOT

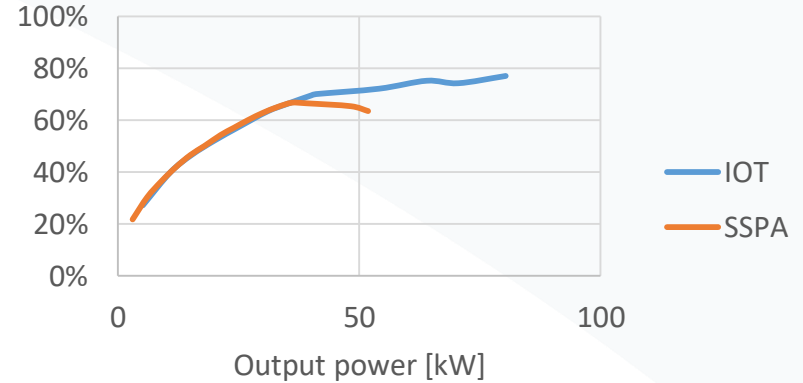
SSPA



IOT

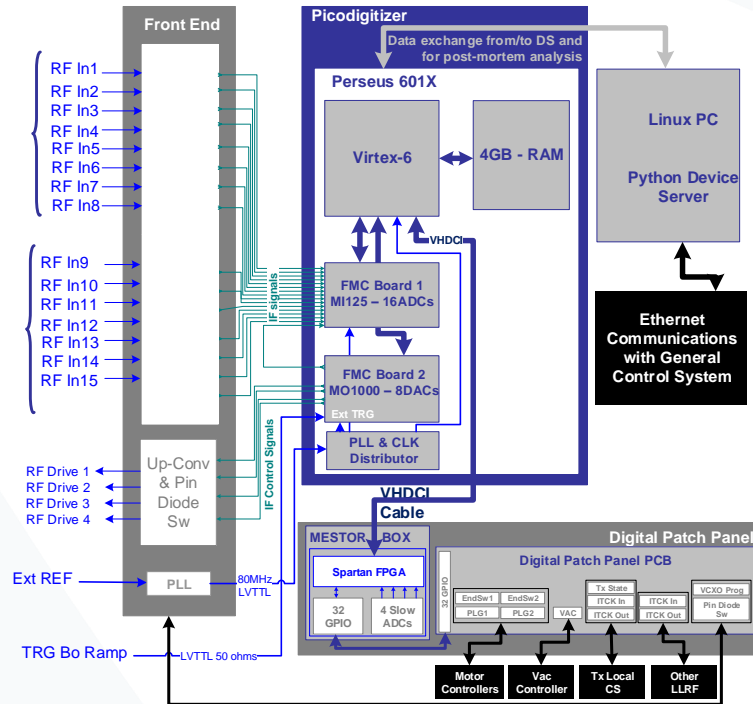


Best measured efficiency for each output power



- ✓ Same efficiency at low power
- ✓ IOT present better efficiency at high power

- New hardware platform: Picodigitizer from Nutaq.

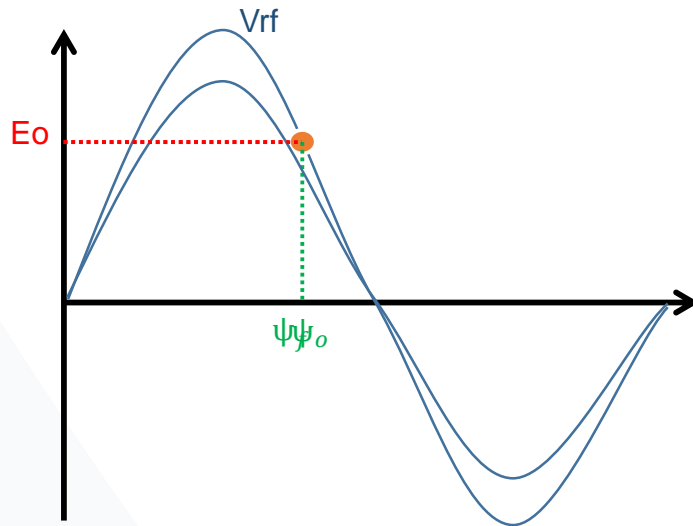


- Standalone board
- Ethernet communications and Linux drivers
- 16 ADCs: 14 bits @ 125 MHz
- 8 DACs: 16 bit @ 250 MHz
- 32 digital GPIO
- 4 GB RAM memory
- FPGA virtex-6 SX315T

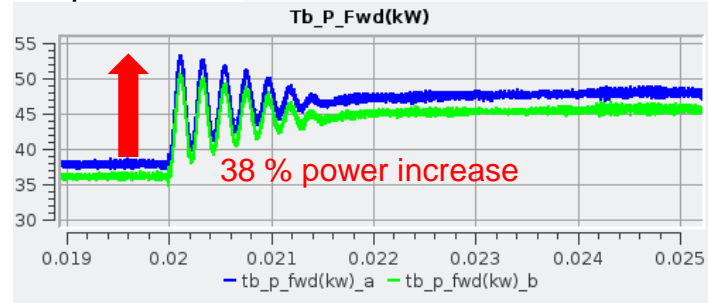
- ✓ Same LLRF functionalities
- ✓ Already working in one cavity

Trip compensation: phase modulation

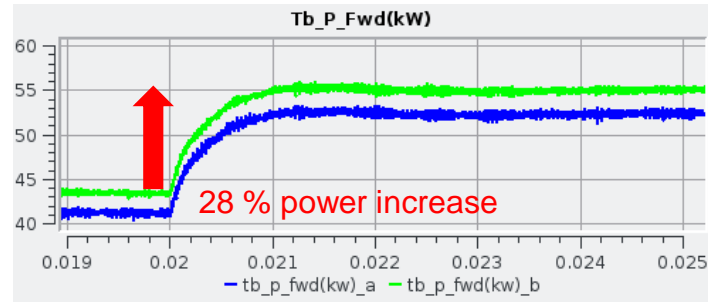
- Over oscillations in the beam after a trip can cause voltage drop in the cavity and there fore to lose the beam
- Trigger is sent to the DLLRF for feedforward compensation



1. Amplitude modulation

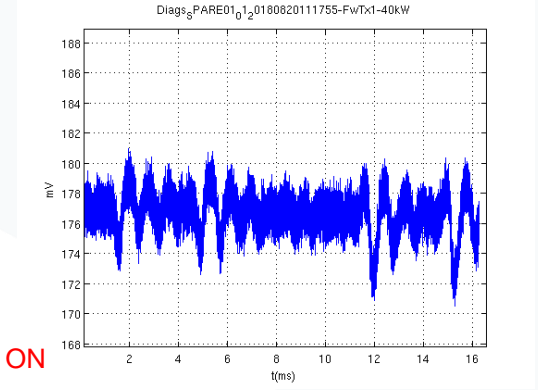
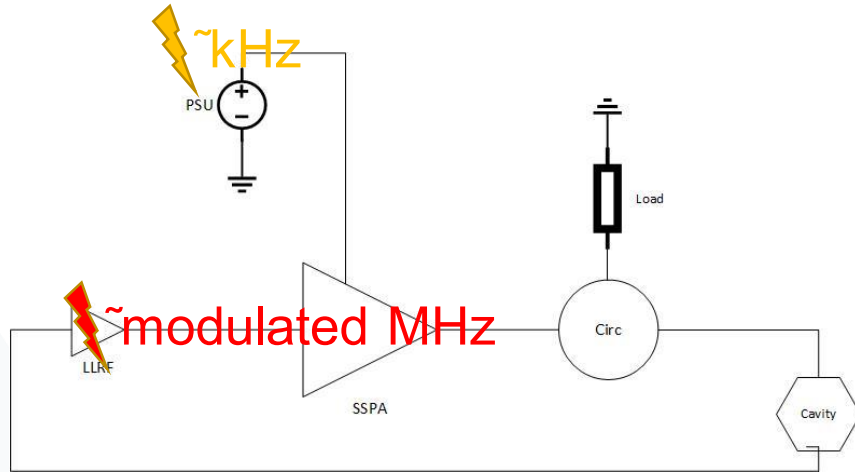


2. Phase modulation

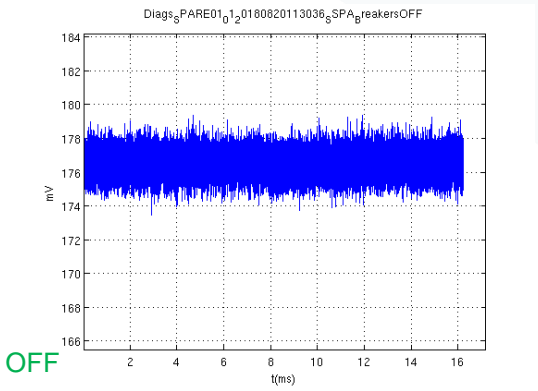


SSPA electrical noise filtering

- Induced noise from switching PS into the LLRF.
- Drive is modulated with this ~kHz rate noise.

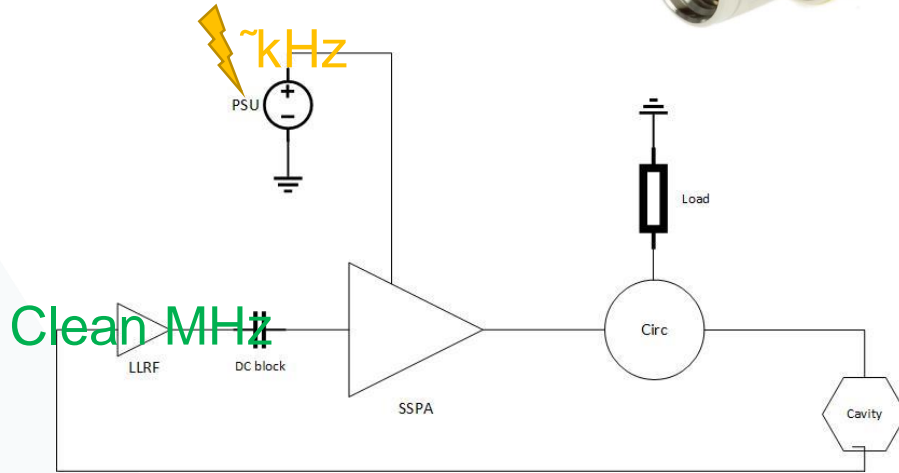


Breakers ON

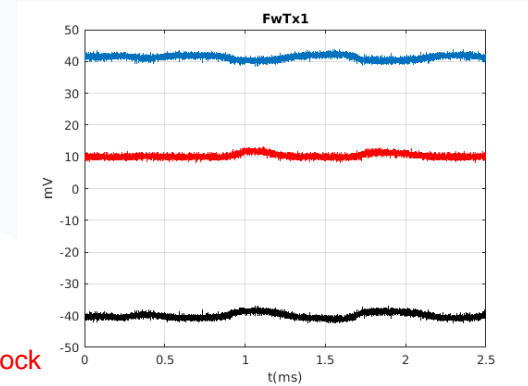


Breakers OFF

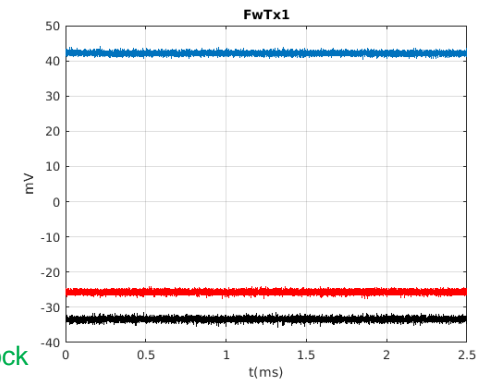
- Optical fiber transmitted drive
- DC block capacitor



No DC block



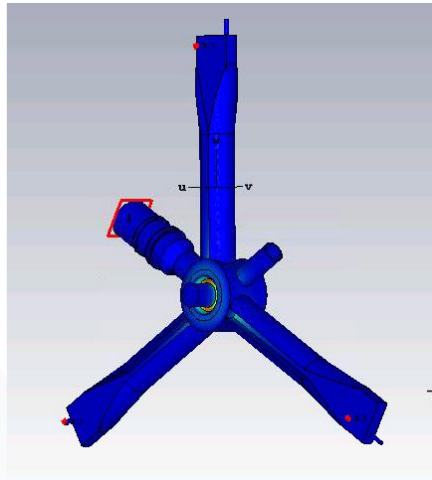
DC block



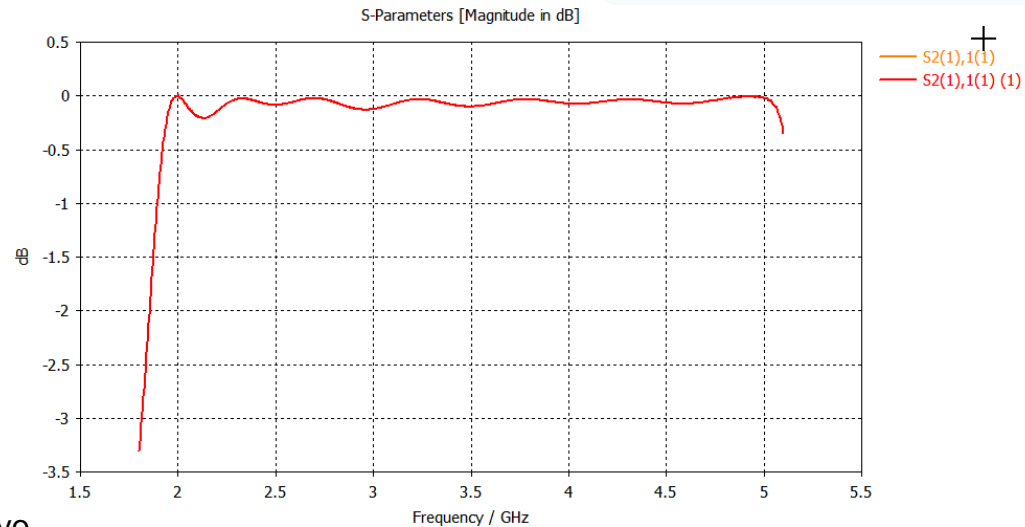
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3rd harmonic cavity system

- 3dr harmonic cavity contract awarded to AVS.
- Preliminary design review to be finished in December 2019 and approved in February 2020
- FAT on March 2021

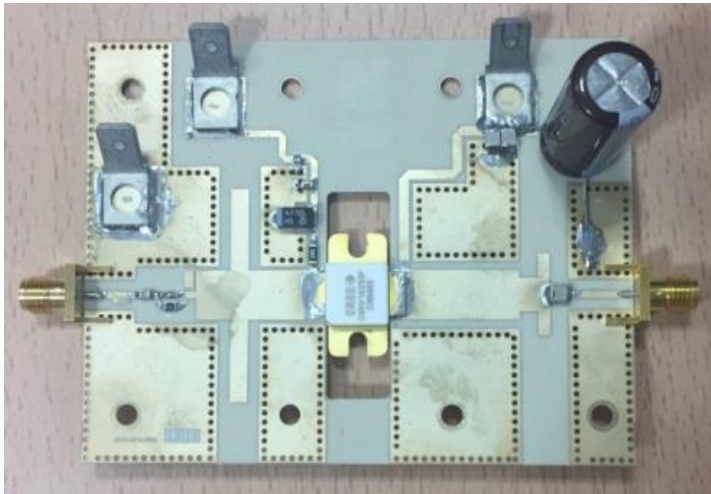


Design and simulations by B. Bravo

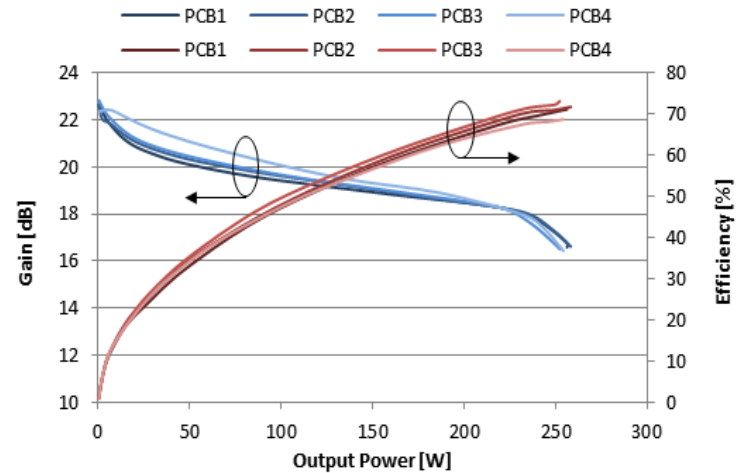


3rd harmonic cavity system

- SSPA in house design based in the GaN CREE CGH14250
- Input and output matching via stubs
- 250 W per module

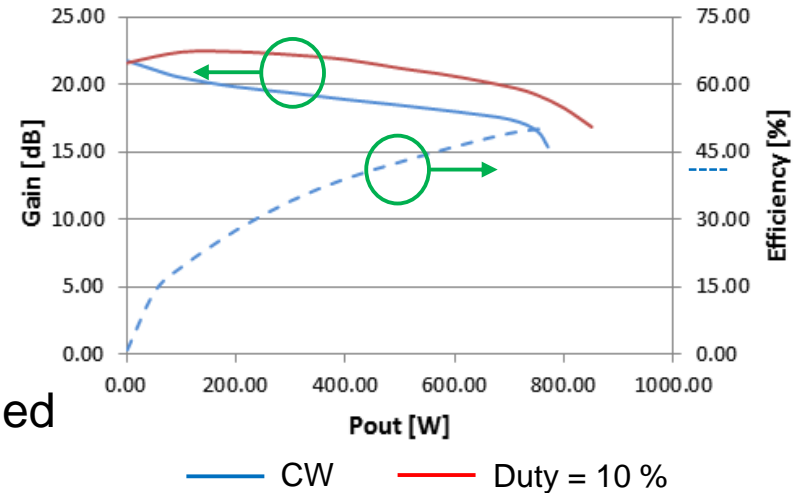
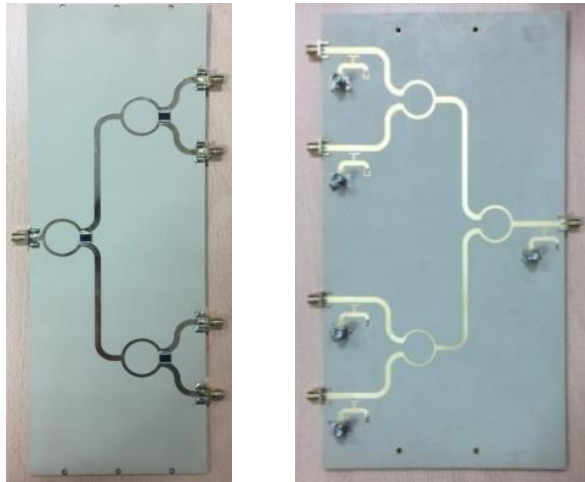
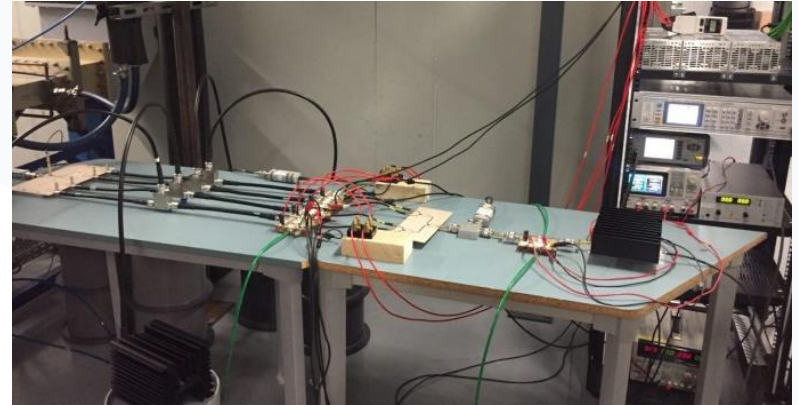


Design and measurements by Z. Hazami



3rd harmonic cavity system

- 4 modules combined: 1 kW
- Output isolation via circulator
- One module used as driver
- Shunt resistors for current measurement



- Call for tender published but not awarded

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- Absolute number of interlocks keep decreasing and major problem causing beam dump has been solved.
- First year of the new booster SSPA transmitter was satisfactory with one single trip.
- CaCo arc detection improved
- IOT harmful forward and reverse power needs further investigation
- RF upgrades satisfactory
 - Booster SSPA transmitter DC block
 - New DLLRF hardware
 - Phase trip compensation
- 3rd harmonic cavity tender ongoing and cavity expected in March 2021
- 3rd harmonic transmitter tender still pending

THANK YOU!