CERN SPS 800 MHz IOT
Progress report

17th ESLS RF Meeting

18-19 September 2013

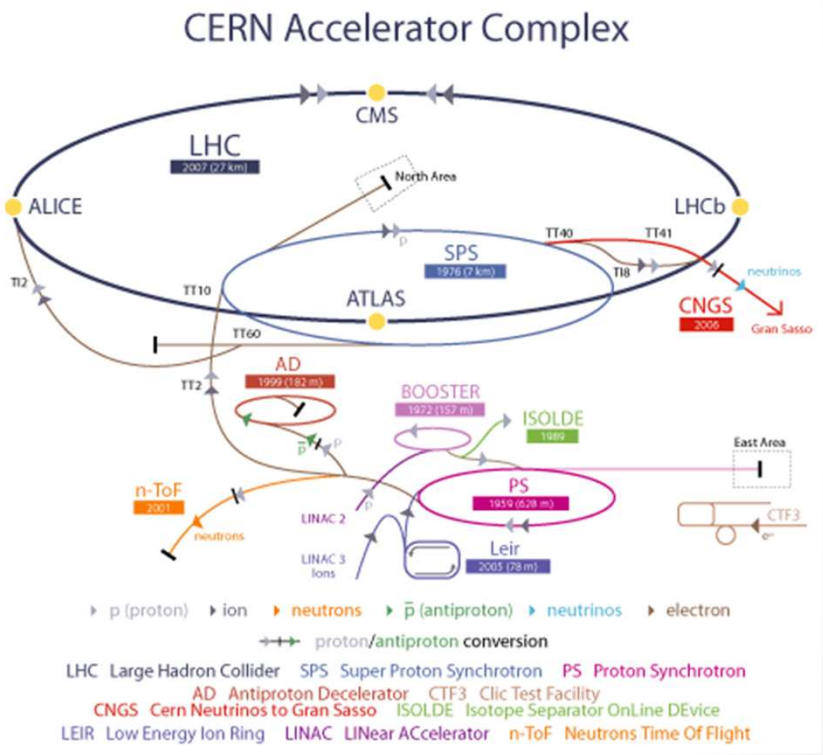
HZB Helmholtz Zentrum Berlin

Contents

- CERN SPS 800 MHz system
  & why upgrade to IOTs
- Major difficulties
  while commissioning the pre-series
- Series delivery & Future plans

800 MHz RF in the SPS

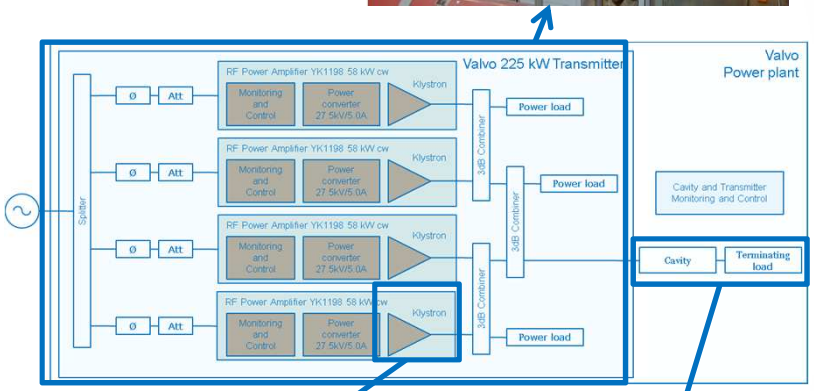
- SPS is the Injector for LHC
- Beams for the LHC can become unstable in the SPS
- One of the most important systems to keep beams stable is the 800 MHz RF system
- The RF power source must be of the highest reliability to ensure beams for LHC at all times



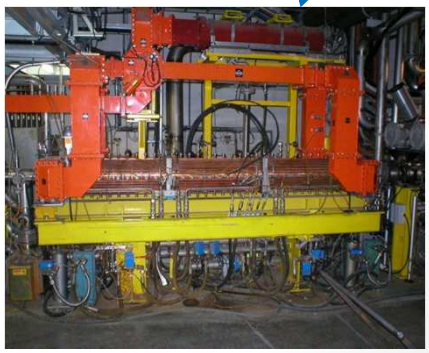
800 MHz power plant

- Since 1980 the system is composed of
  2 transmitters of 225 kW
- One transmitter has
  4 x 58 kW Valvo klystrons
  with 3 dB combiners
- Each transmitter is connected through
  ~ 120 m waveguides to its Travelling Wave Cavity

2 x 225 kW transmitters



YL1198 Klystron



800 MHz TWC

Obsolescence of the system

- This RF power system is getting very old

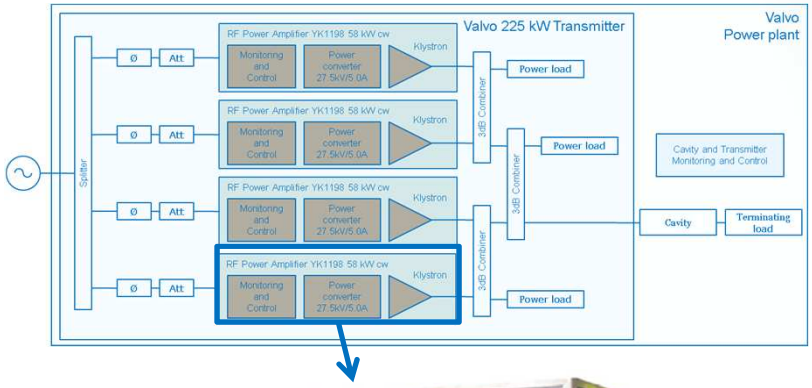
- We had major difficulties with klystron ceramic failures and with HV transformers

Broken ceramic window of a klystron

Effect of age on HV transformers

Upgrade proposal

- keep all existing ancillaries and replace Klystron Transmitters with new IOT Transmitters
- First and only IOT at CERN
- We wanted to get experience with this tube as it could be used for
  - LHC upgrade
  - new CERN accelerator RF system (SPL ?)



New IOT transmitter

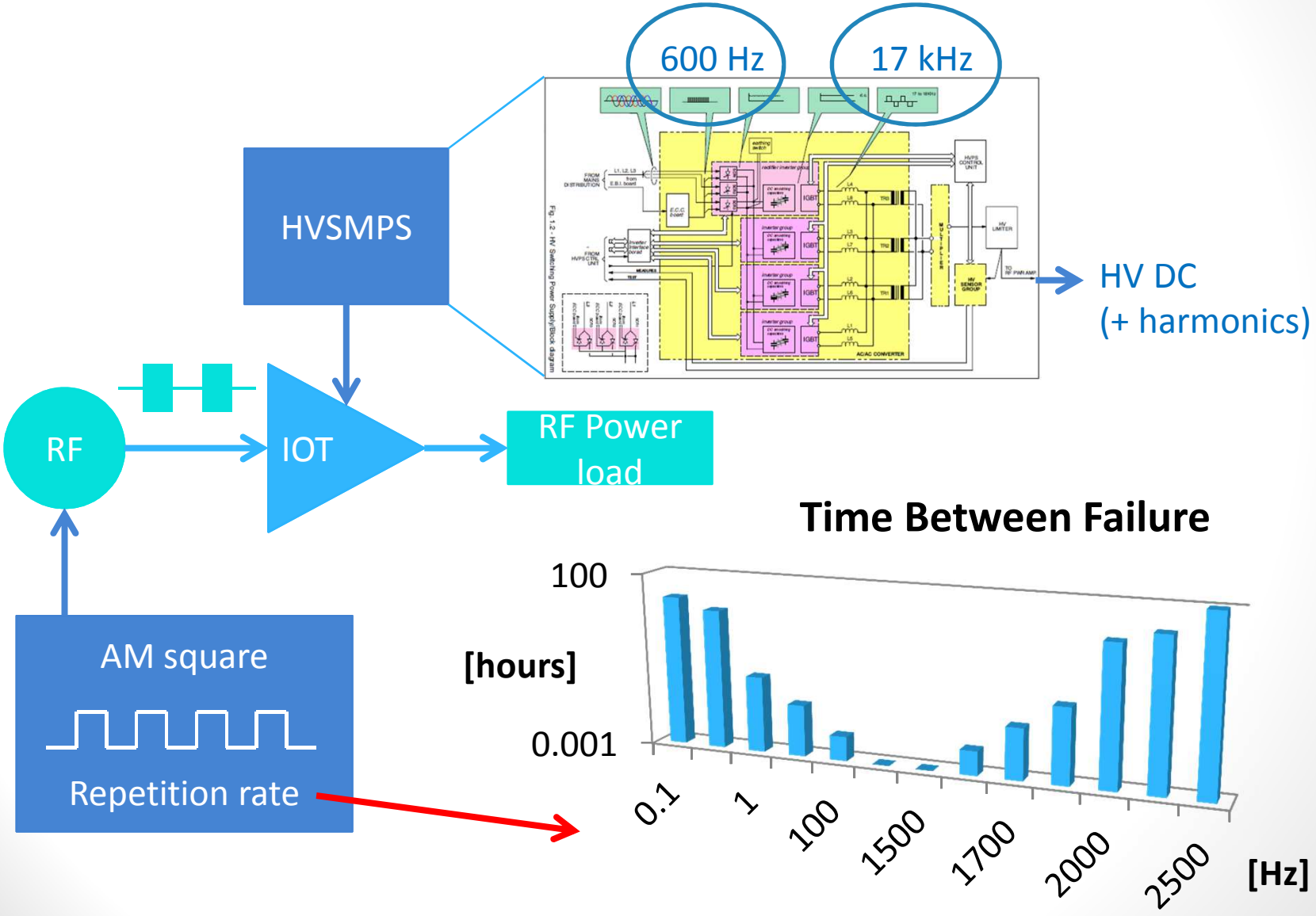
Major troubles

- All Factory Acceptance Tests have shown compliance
- Pre-series Amplifier at CERN was ok with short duration tests

- Long duration tests, we started to experience difficulties:
  - HVSMPS
  - Conventional HVPS
    - HV monitoring transformers
    - Ferrites in the IOT input circuit
  - Erratic faults from 3 to 6 am & from 4 to 7 pm

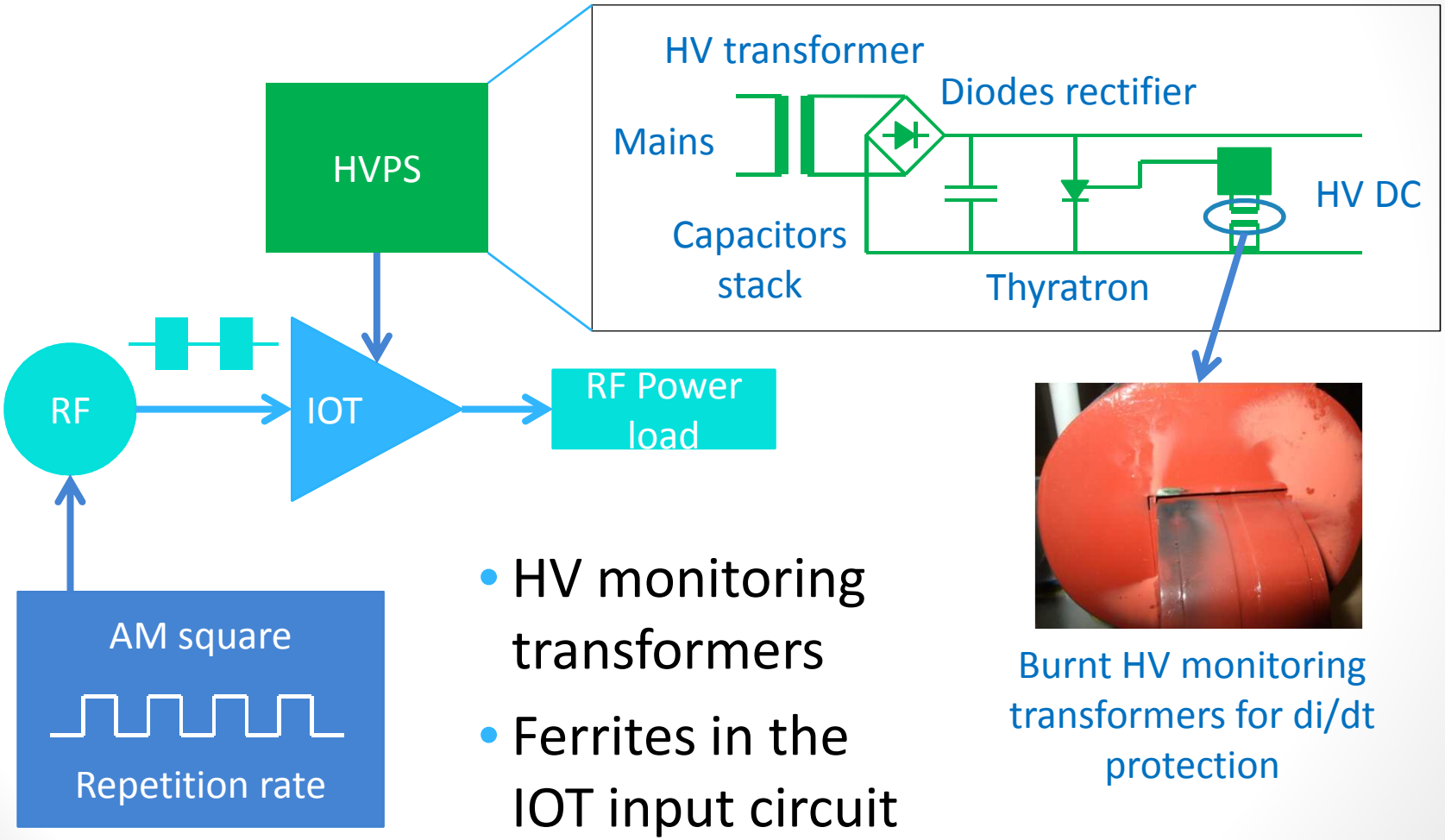
Main difficulties while commissioning the pre-series

HVSMPS instabilities 2011



Main difficulties while commissioning the pre-series

HVPS troubles 1st half 2012

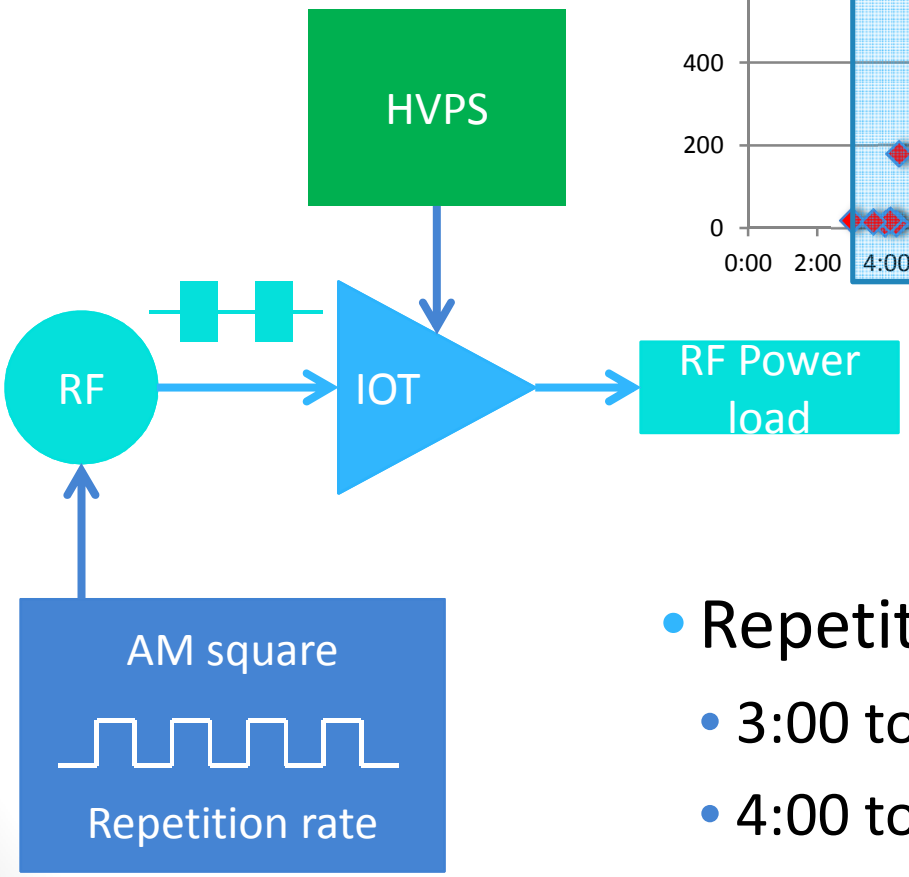


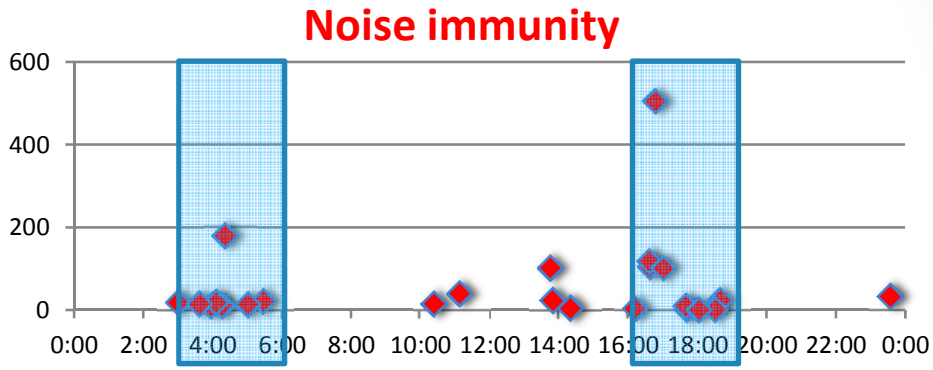
- HV monitoring transformers
- Ferrites in the IOT input circuit

Burnt HV monitoring transformers for di/dt protection

Main difficulties while commissioning the pre-series

HVPS troubles 2nd half 2012

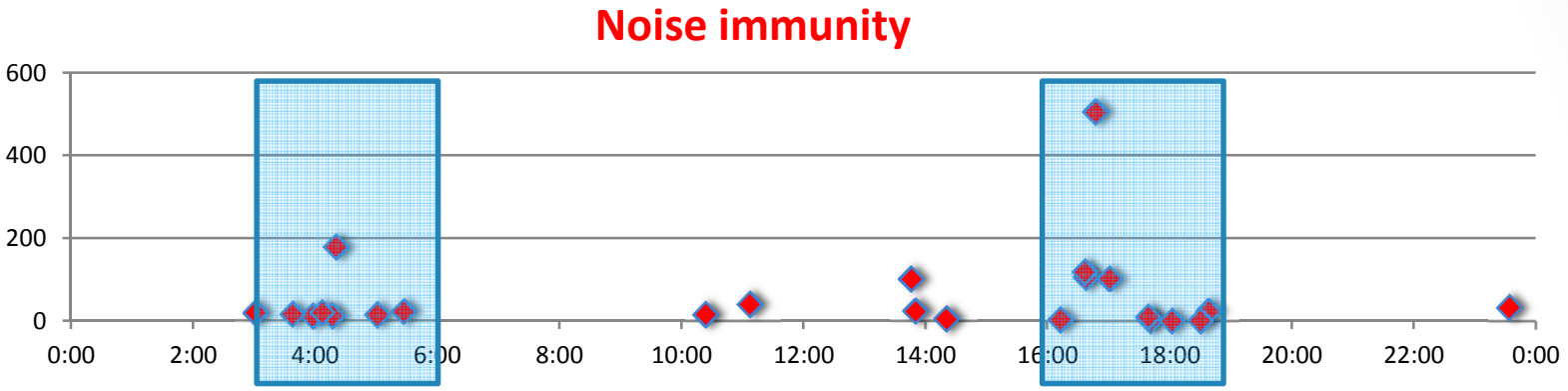




- Repetitive faults from
  - 3:00 to 6:00 am
  - 4:00 to 7:00 pm

Main difficulties while commissioning the pre-series

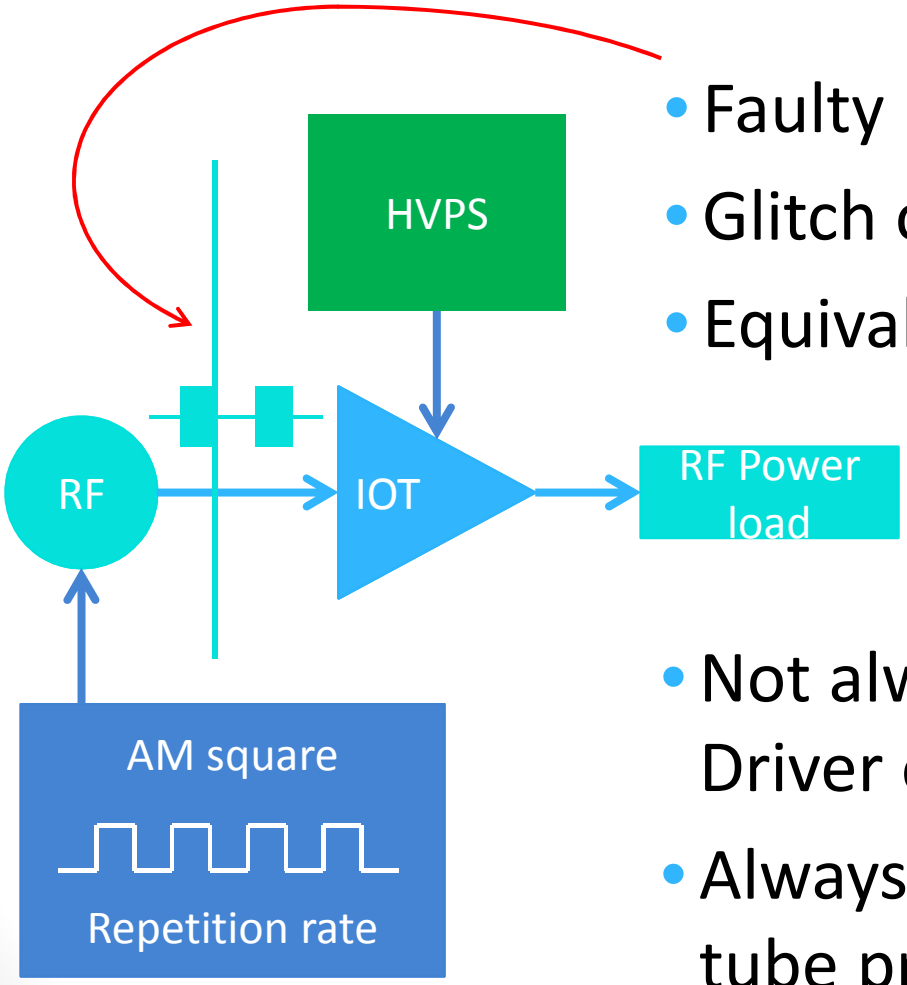
HVPS troubles 2nd half 2012



- We were not able to link it with any external 'perturbation'
  - CERN workers, security people or firemen checking the building
  - Automatic lighting of the building
  - GSM or Wifi antenna in the building
  - Traffic lights close to the building
  - Public lighting day & night light detection
  - Airport traffic: no planes before 7 am at Geneva airport
  - Train: old story with TGV (high speed train) disturbing LEP beams, not able to link with any train timetable
  - Etc…

Main difficulties while commissioning the pre-series

HVPS troubles 2nd half 2012

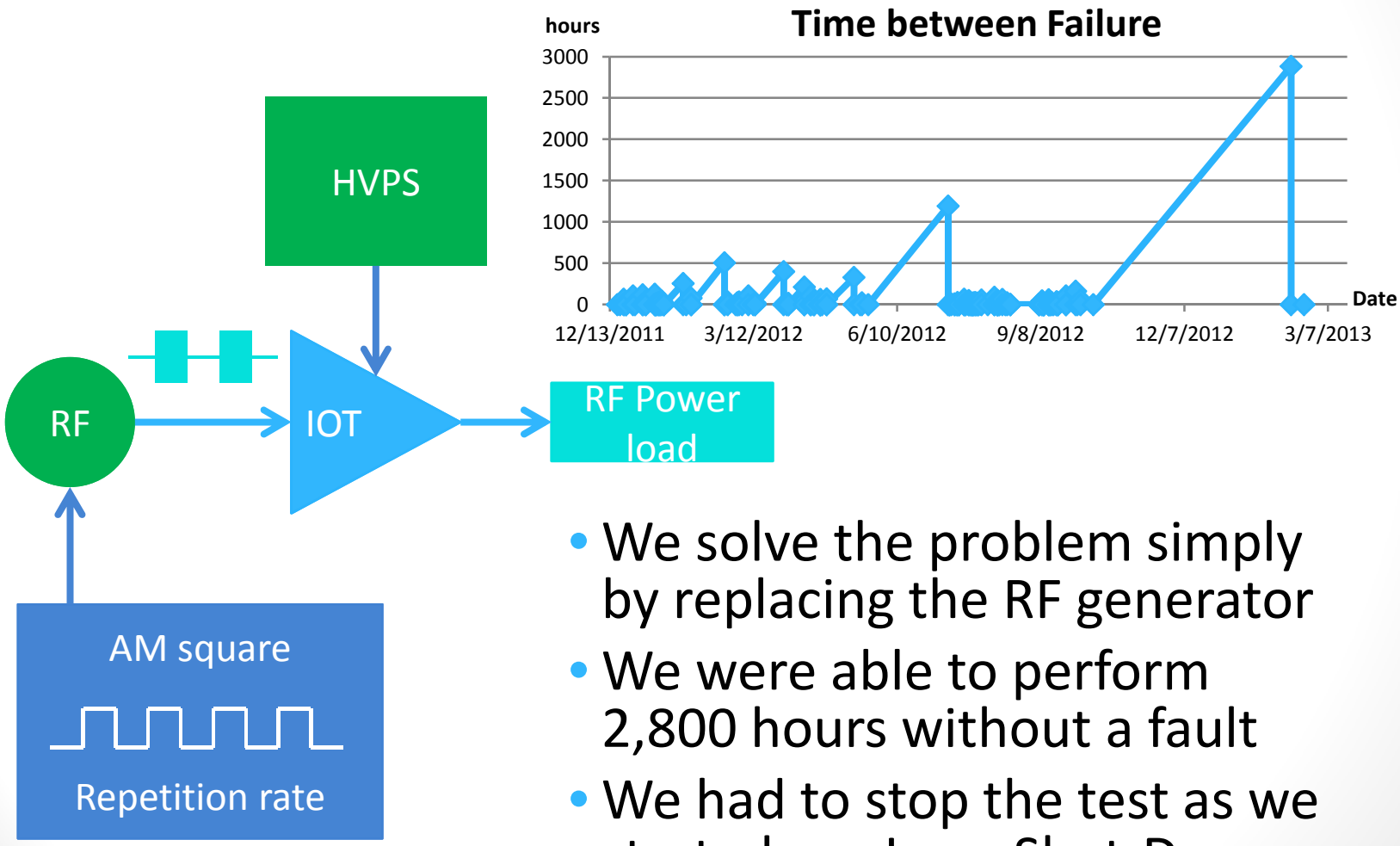


- Faulty RF generator
- Glitch on top of the RF pulse
- Equivalent to 10 x power

- Not always detected by the Driver overdrive protection
- Always triggering the di/dt tube protection

Main difficulties while commissioning the pre-series

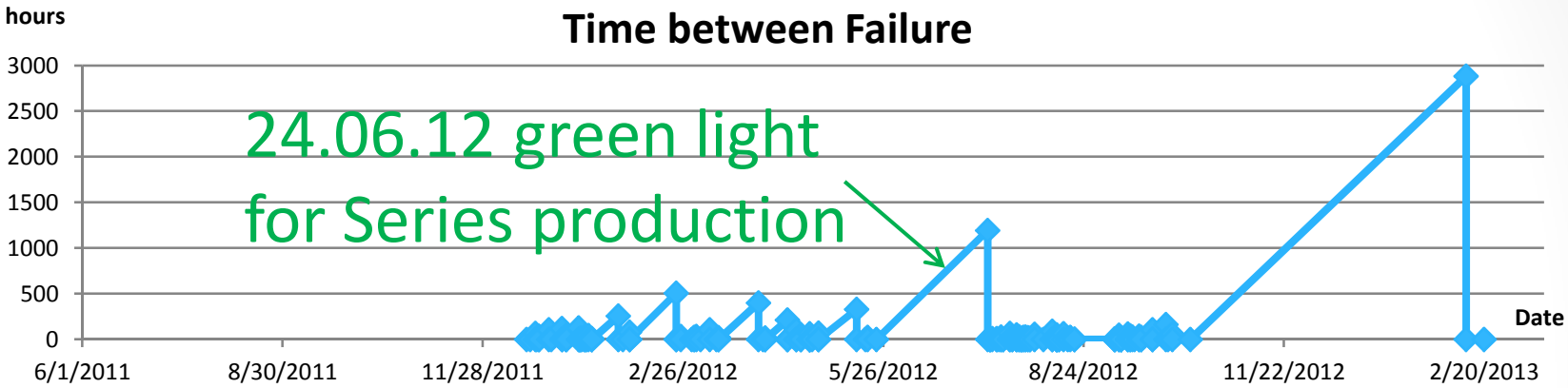
HVPS troubles 2nd half 2012



- We solve the problem simply by replacing the RF generator
- We were able to perform 2,800 hours without a fault
- We had to stop the test as we started our Long Shut-Down

Main difficulties while commissioning the pre-series

Time spent per problem



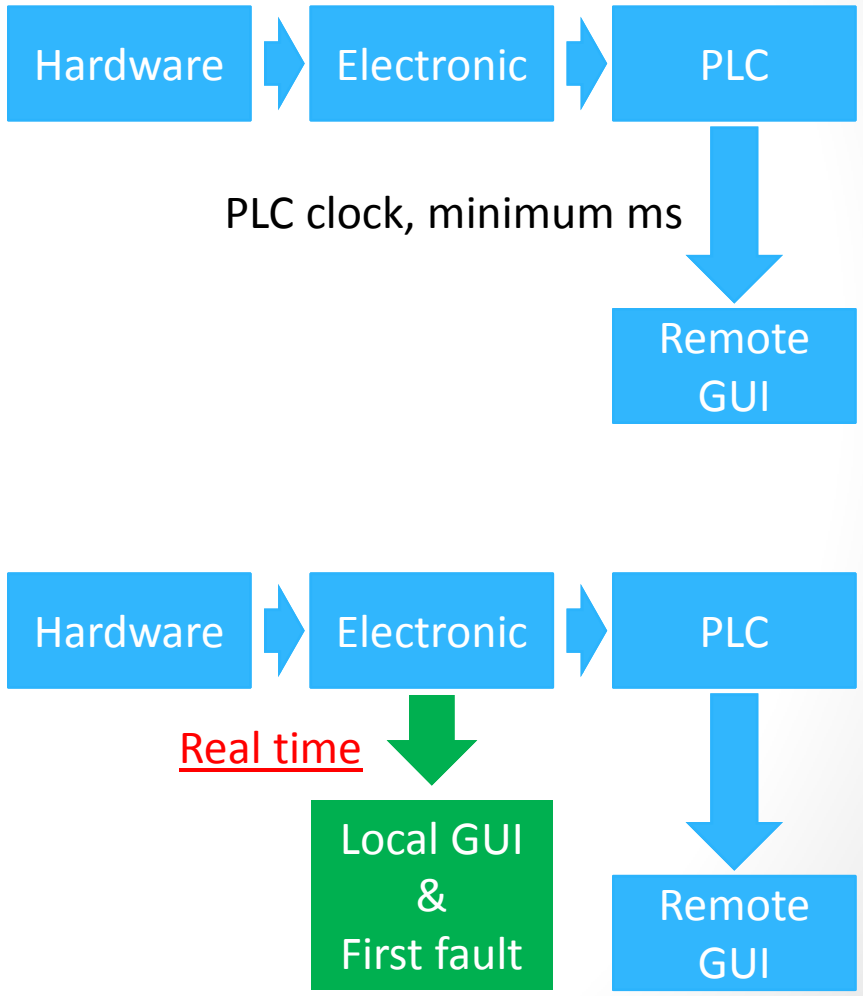
HVSMPS

HV monitoring transformers & Input circuit ferrites

RF Generator & Faulty Overdrive protection

Series production

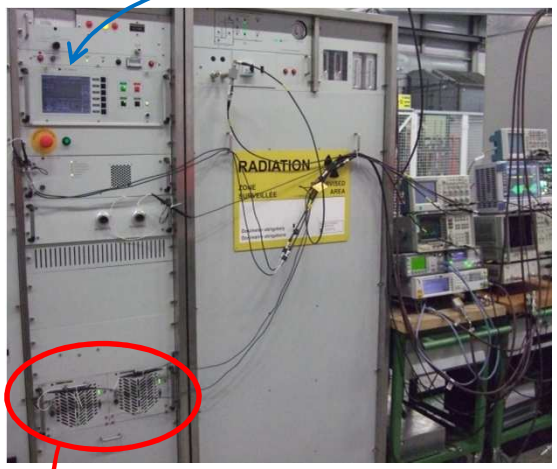
- We asked for several modifications
  - Driver overdrive protection
  - Additional air cooling for coaxial lines
  - Direct access to hardware interlocks through a monitoring panel with ‘blinking first fault’



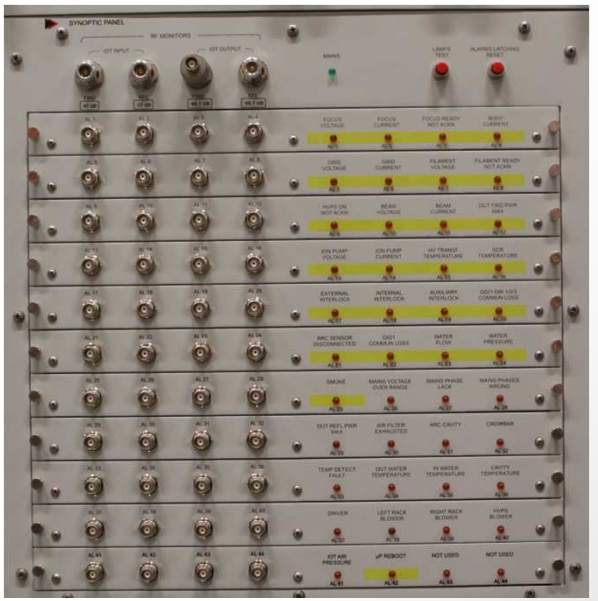
Series delivery ongoing & present status

Series production

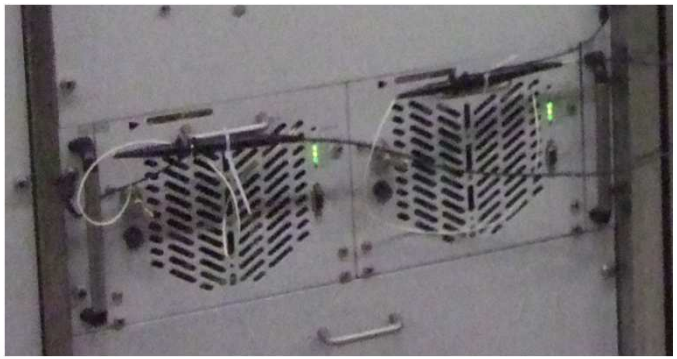
Remote GUI



In addition we have a panel for quick identification of faults (LEDs) & with direct access to hardware interlocks (BNC) for real time monitoring

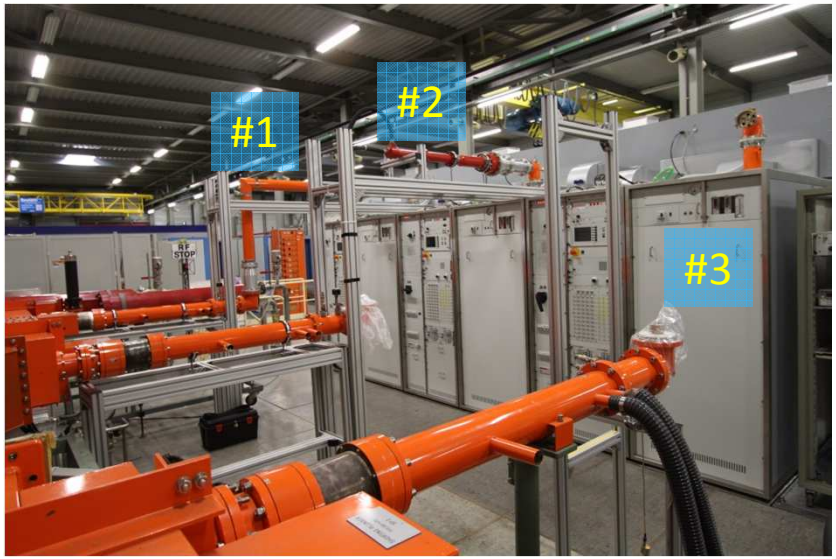


External probes with risky possible false contacts



Series tests at CERN

- A first series transmitter was delivered and successfully tested in June 2013
- Two additional series transmitters were delivered in July and successfully tested in August
- Remaining 5 transmitters are expected before the end of October 2013 (contractually September)
- If everything is ok, we will have our 2 x 4 transmitters operational before the end of 2013

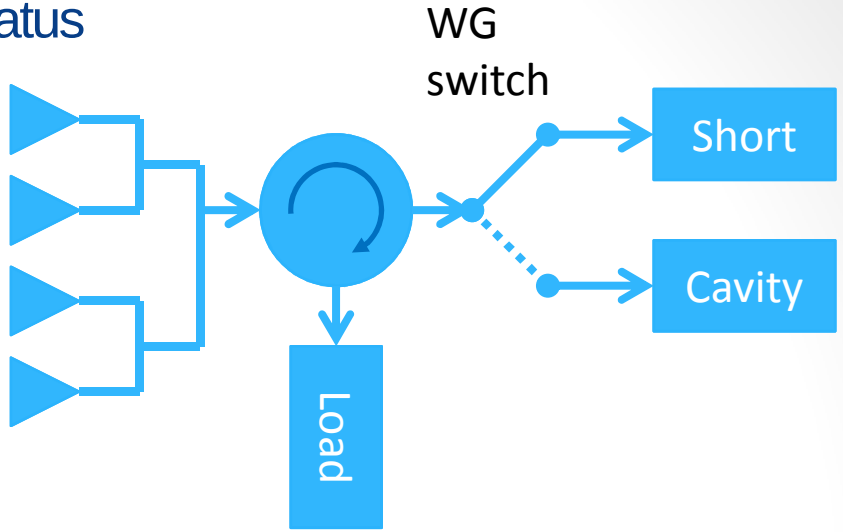


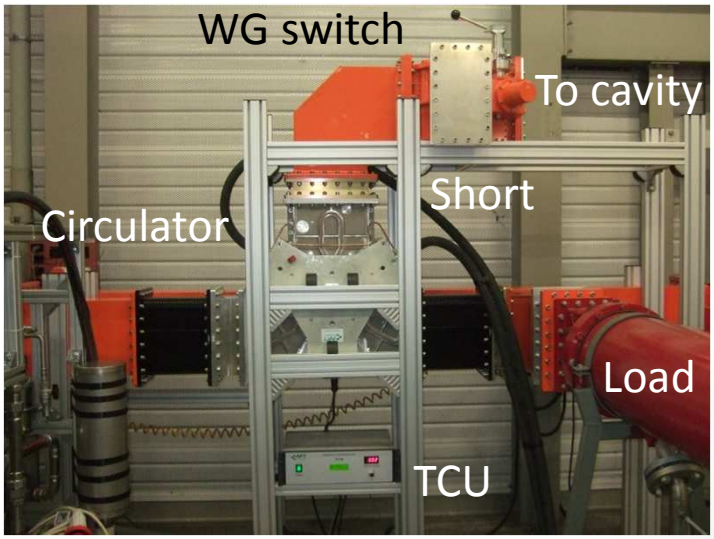
- Transmitter #1 connected to main combiners
- Transmitter #2 connected to RF load for CERN Acceptance Test
- Transmitter #3 not yet connected

Circulator

- Thales asked us to protect the tubes with a circulator against full reflection that could occur while conditioning the couplers

- We kept our Waveguide switch to allow quick test onto the power load





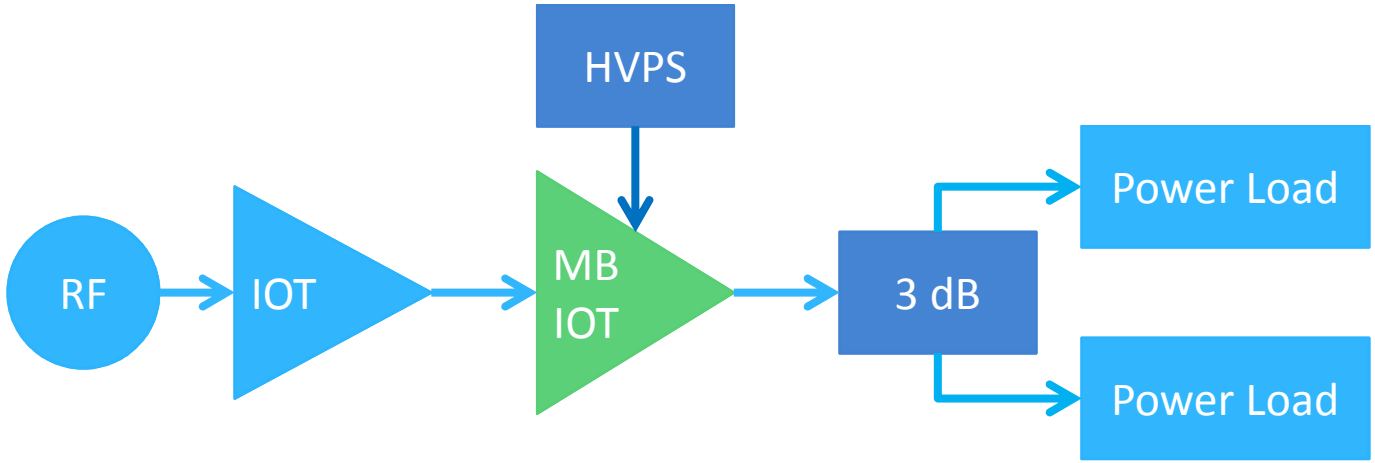
Circulator – WG switch (cavity or short) – Power load

Future plans

Already available at CERN

To be built by CERN

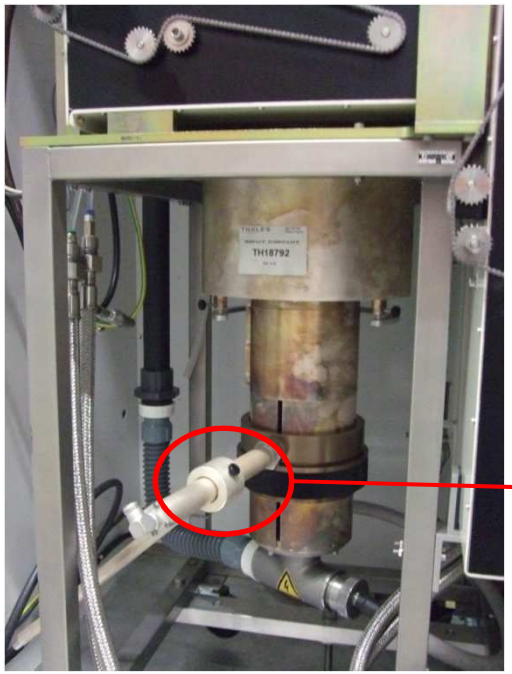
Provided by ESS



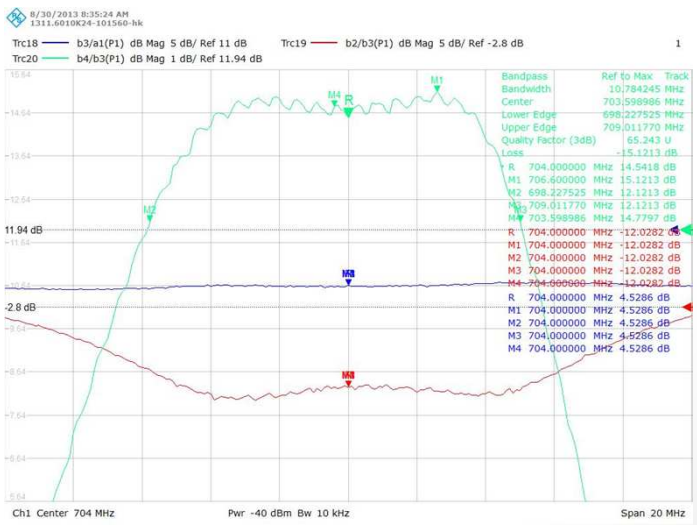
- In collaboration with ESS,
  we plan to test a new MB-IOT, 1.5 MW 4 ms – 14 Hz, 150 kW average
- ESS will buy the MB-IOT(s)
- CERN will provide the test bench
- Driver will be the SPS IOT

Future plans

- Pre-series transmitter tuned from 801 MHz to 704 MHz
  - TH793 #640963 broken ceramic
  - Input circuit arcing
  - Replaced the tube with second TH793 #595368
- Achieved 40 kW CW for 4 hours
- IOT as a driver for MB-IOT is already ready



Input circuit arcing while tuning from 801 MHz to 704 MHz

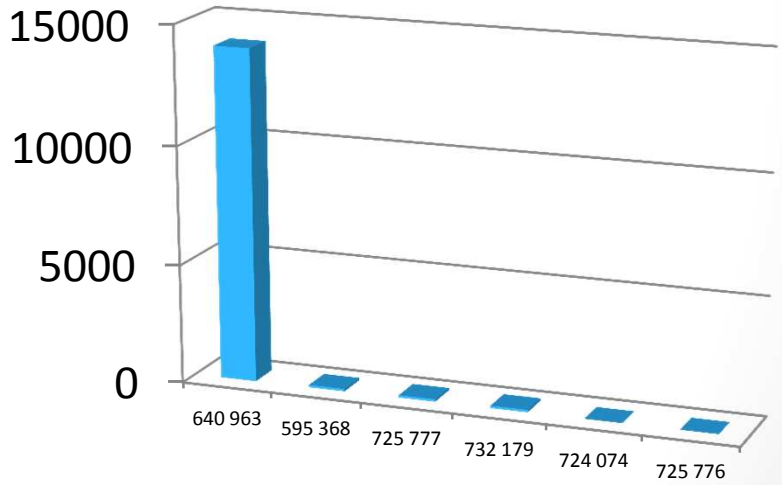


Tube(s) statistics

- **TH793** (# 640 963) 14’000 hours (broken during 704 MHz tests)
- **TH793** (# 595 368) 100 hours (tuned to 704 MHz)

- **TH795** (# 725 777) 100 hours
- **TH795** (# 732 179) 100 hours

- **TH795** (# 724 074) spare
- **TH795** (# 725 776) spare



- Additional 10 tubes are expected by the end of the year

Conclusion

- A low power device can be the trouble maker of an high power system (RF generator & bad Driver overdrive protection)
- Our first IOT performed 14,000 hours before failure, despite being maltreated a lot
- It failed due to 'non operational' tests, we could have expected more
- We now have 3/8 systems fully commissioned + 1 pre-series system in our test area
- All 8 operational systems are expected before the end of this year, afterward we will start accumulating data
- MB-IOT tests are already operational from driver point of view

Thank you very much for inviting me