352 MHz POWER COUPLER DEVELOPMENTS FOR THE ESS

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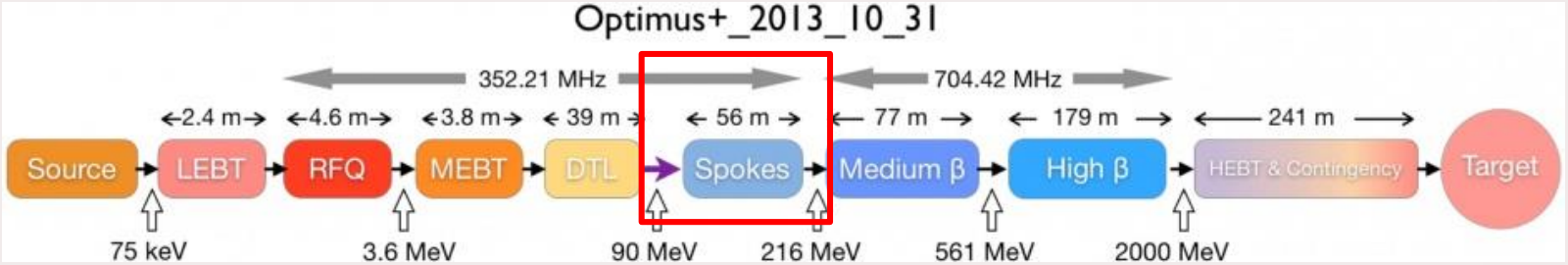
On behalf of the IPNO team

PROTOTYPE COUPLERS

ESS Accelerator

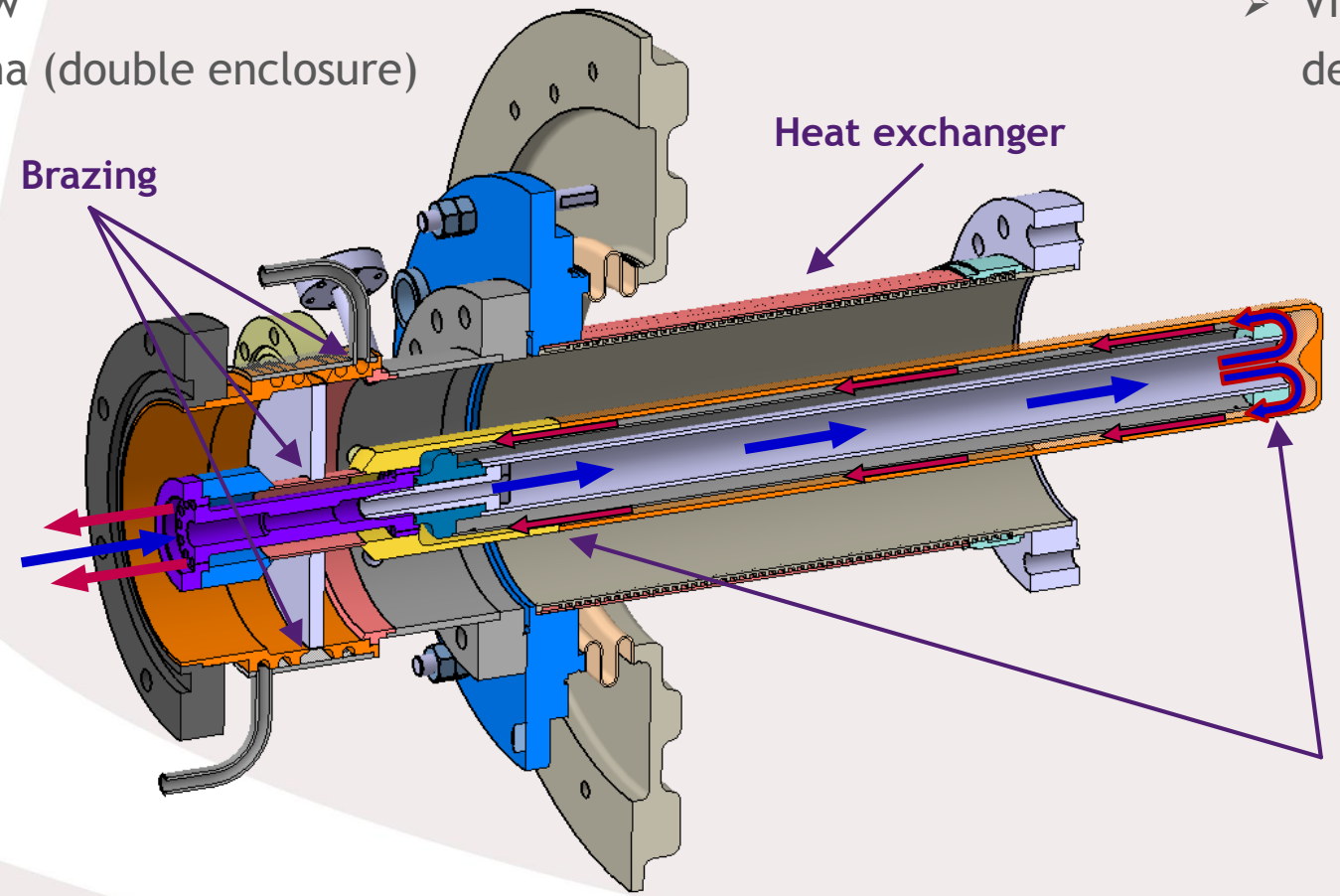
https://europeanspallationsource.se/accelerator



Parameter	Value
Particle species	P
Average power	5 MW
Peak power	125 MW
Peak power per Spoke cavity	400 kW RF
Pulse length	2.86 ms
Pulse repetition frequency (rate)	14 Hz
Duty cycle	4 %
Reliability	95%
Operating time	5200 h/year

COUPLER TOPOLOGY

- RF Window without chokes
- 50Ω matching
- 2 water cooling systems
  - Window
  - Antenna (double enclosure)
- TiN deposit : 10 nm ± 5nm
- CuC2 deposit : 35 µm ± 20%
- 10 ≤ RRR ≤ 30
- 3 diagnostics pick-up
  - Vacuum gauge
  - Electron activity
  - Viewport for arc detector



COUPLERS MANUFACTURING

- 2 French companies manufactures 2 power couplers each → 4 couplers to test.

SCT

(based in Tarbes)

- Alumina ceramics manufacturer.
- Brazing facilities.
- TiN deposit achieved before the brazing step.

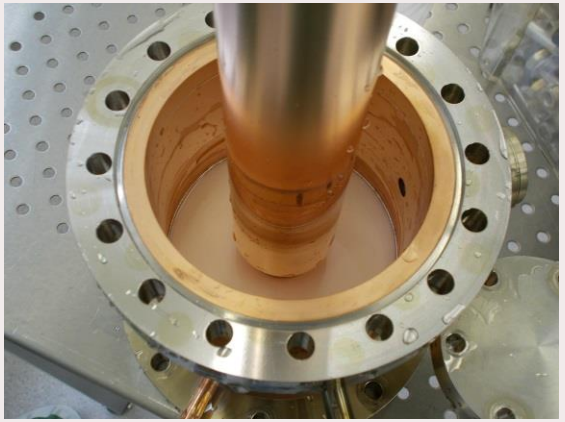
PMB

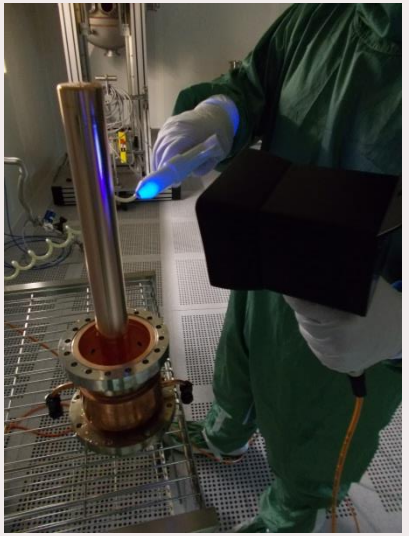
(based near Aix en Provence)

- WESGO ceramics.
- Brazing facilities.
- TiN deposit achieved after the brazing step.

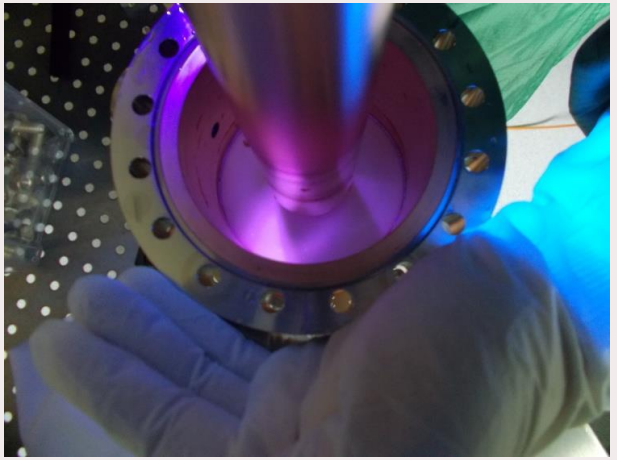
- All TiN deposits have been sub-contracted
- Lack of competencies from sub-contractors to get acceptable RRR value

CLEAN ROOM PREPARATION





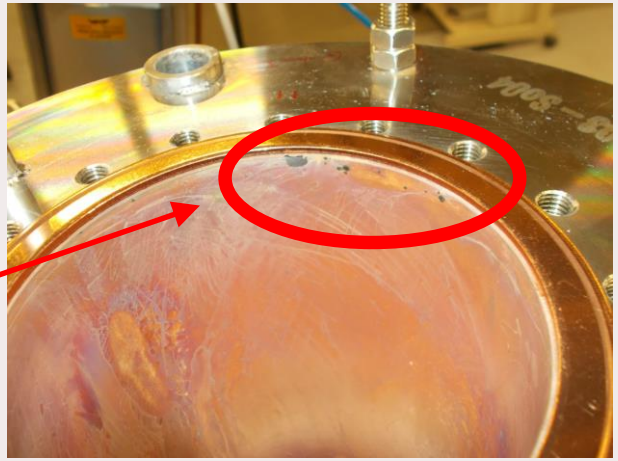
- Cleaning in clean room iso class 100
- Ultra Pure Water (UPW) rinsing
- Blowing with N2 in clean room iso class 10
- UV lamp to see dusts on metal parts
- Particle counting



CLEAN ROOM PREPARATION

Four heat exchanger with Copper deposits have been manufactured

Copper deposit of three exchanger on four have a poor visual appearance



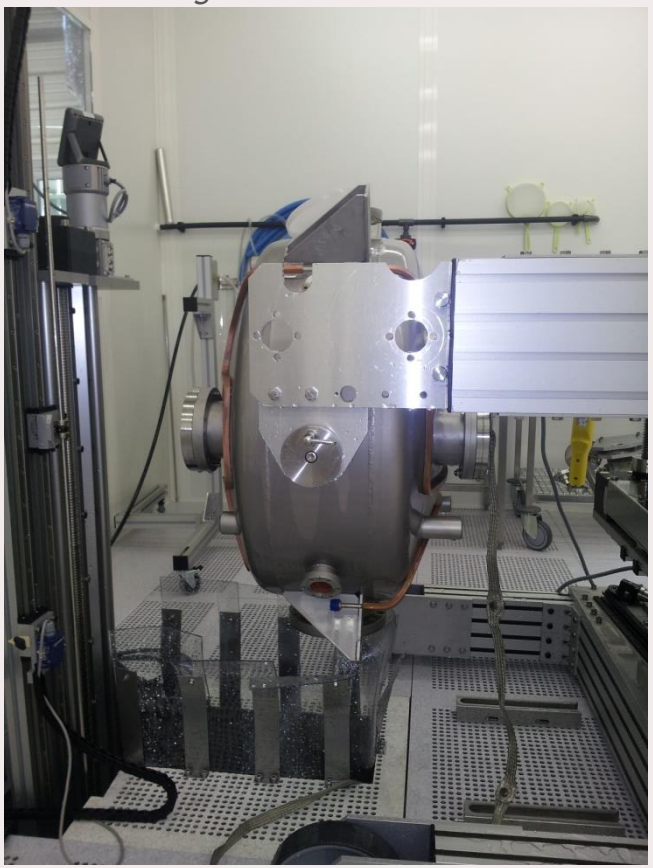
On one heat exchanger a part of the Cu deposit was torn under the pressure of the HPR (50 to 100 bars)

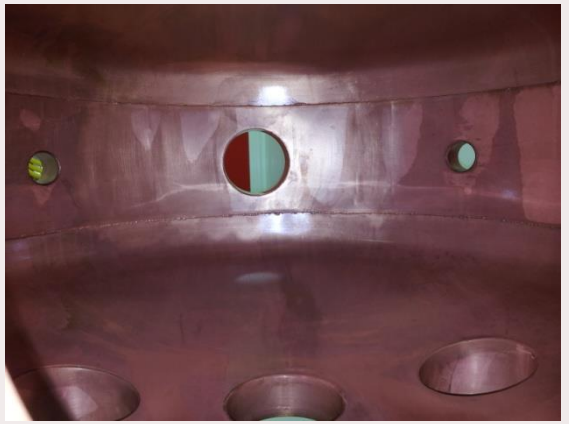
CLEAN ROOM PREPARATION

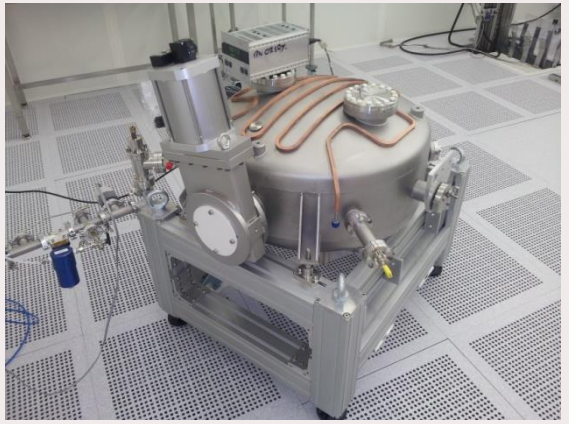
- Cleaning of the RF conditionning cavity with High Pressure Rising system (HPR)
- Use of handling truck to facilitate the cleaning and the assembly of vacuum components

Handling truck

HPR cleaning





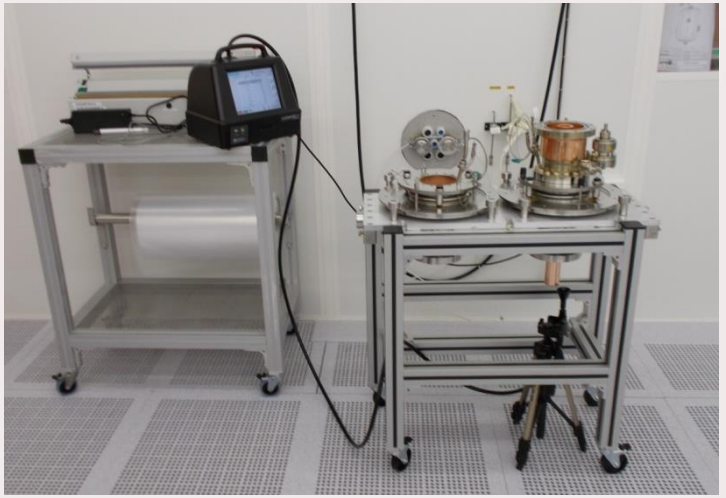


- Mounting of all vacuum components on the lower part of the cavity and vacuum test

CLEAN ROOM PREPARATION

- Particle counting on each coupler with adapted accessories to lead the N_2 flow

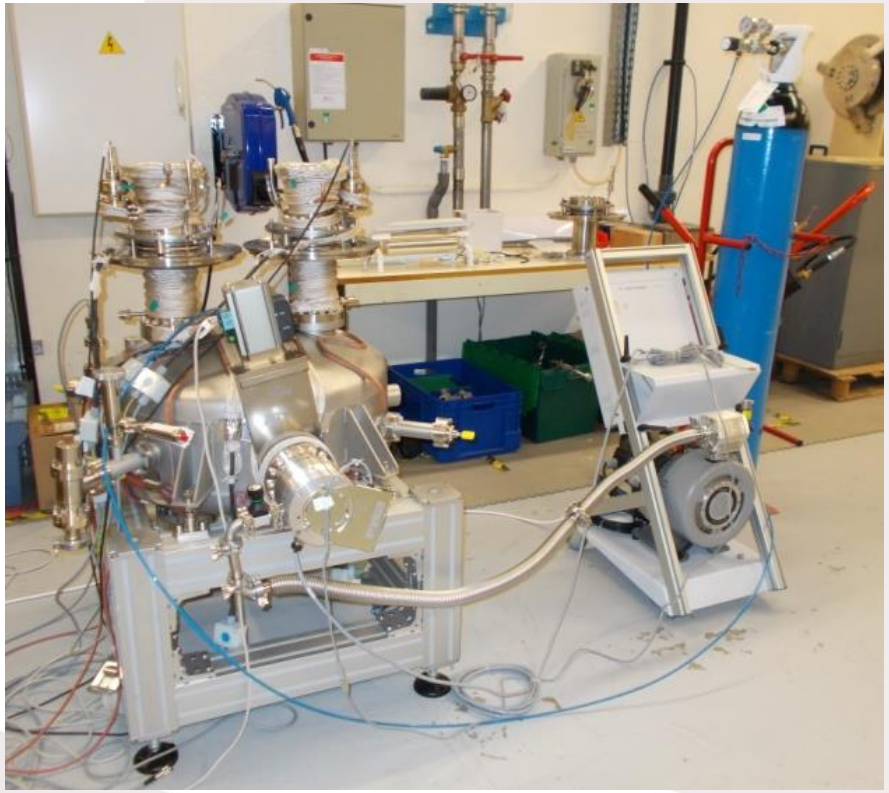
Checking the cleanliness

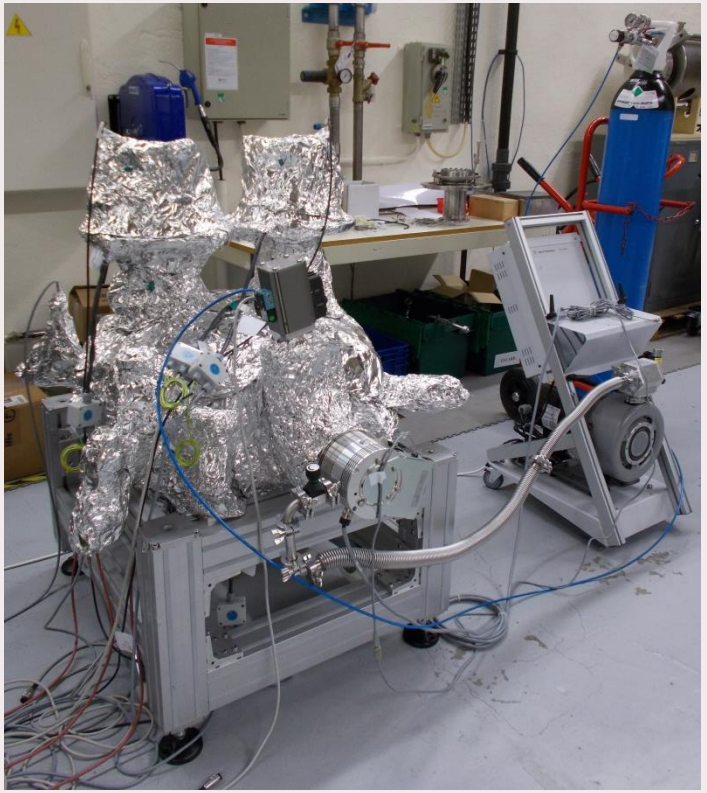


- Particle counting on each coupler + heat exchanger sets
- The two sets are positionned on a tray which allows to mount couplers in pairs and thus limit the number of moving
- Vacuum test
- N_2 injection in the cavity before it leaves the clean room

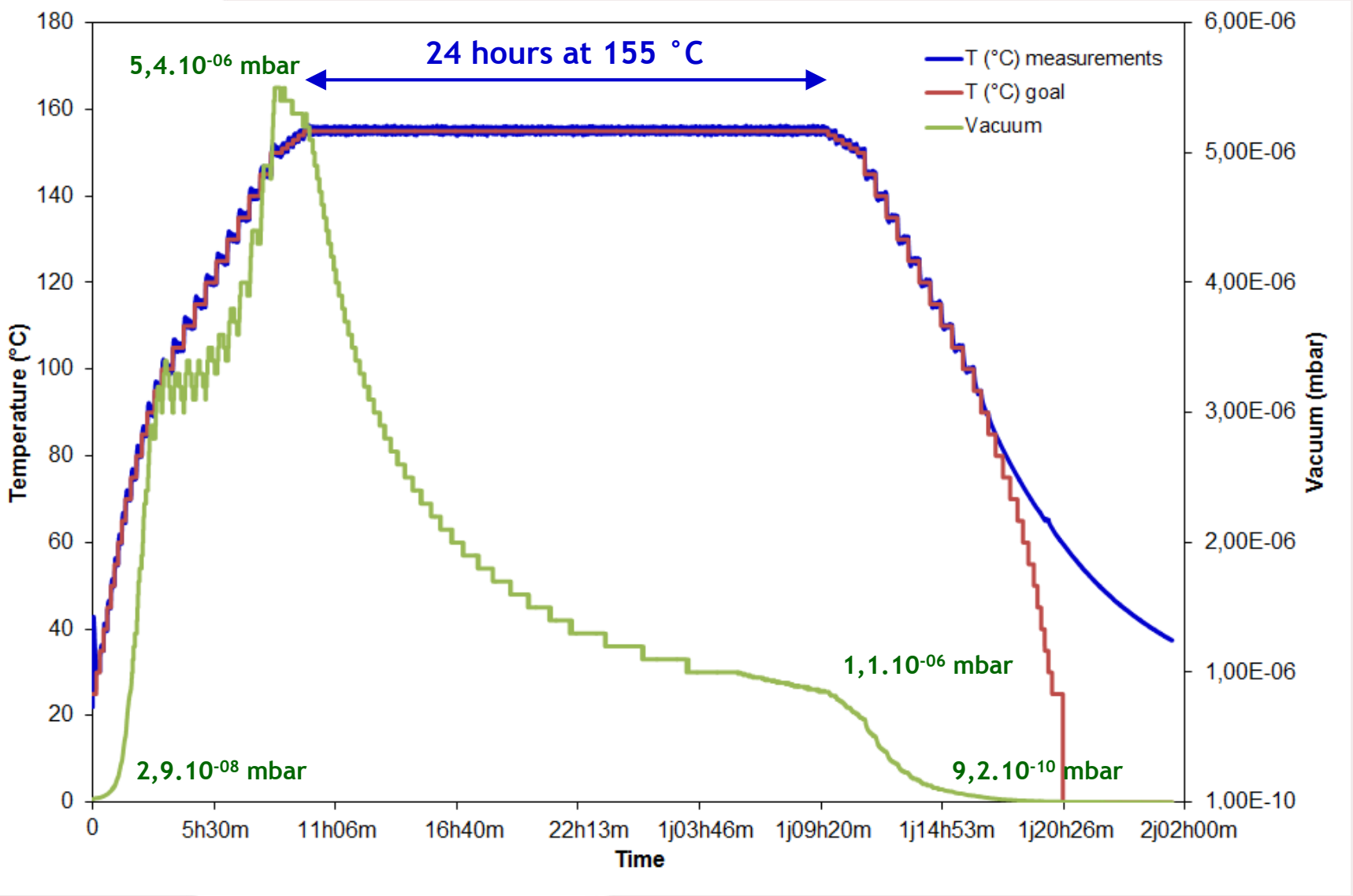
BAKING

- Use of heating cables associated with thermocouples which are monitored by a temperature controller
- Cover with Aluminum foil to distribute the heat
- Monitor the baking by a LabView program



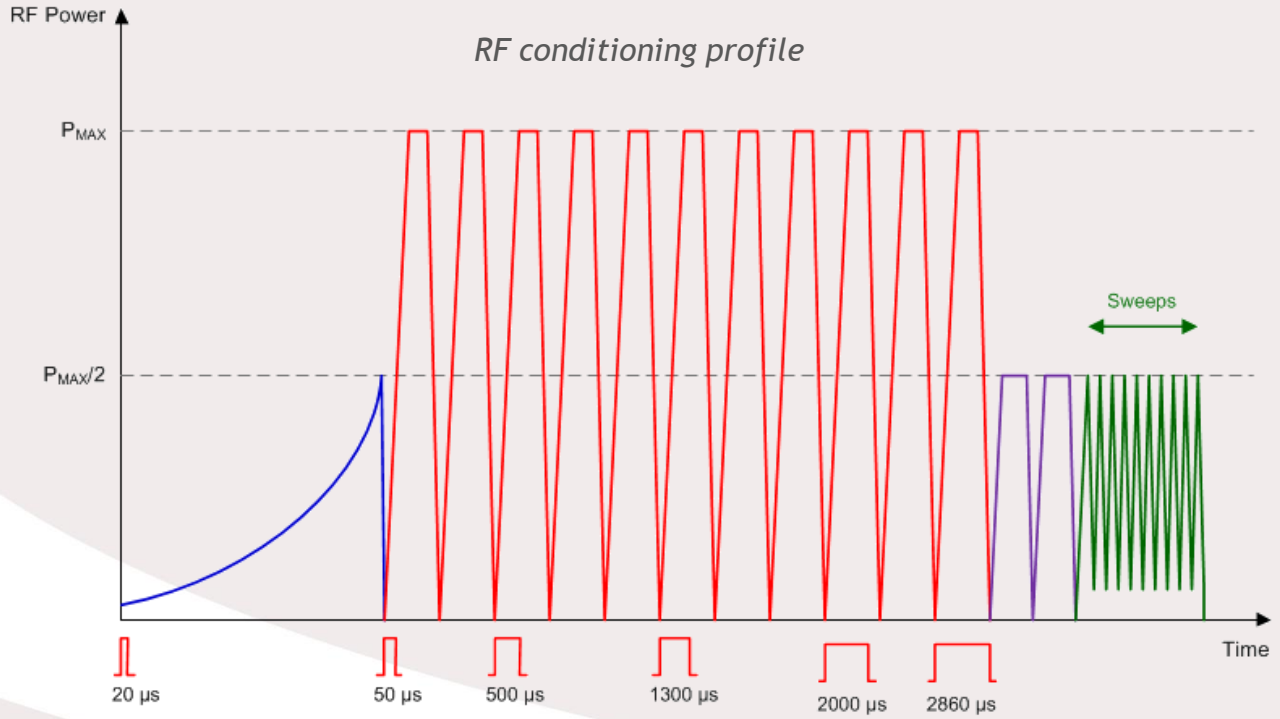


BAKING


5,4.10-06 mbar
24 hours at 155 °C
T (°C) measurements
T (°C) goal
Vacuum
1,1.10-06 mbar
2,9.10-08 mbar
9,2.10-10 mbar
Temperature (°C)
Vacuum (mbar)
Time
0
20
40
60
80
100
120
140
160
180
1,00E-10
1,00E-06
2,00E-06
3,00E-06
4,00E-06
5,00E-06
6,00E-06
0
5h30m
11h06m
16h40m
22h13m
1j03h46m
1j09h20m
1j14h53m
1j20h26m
2j02h00m

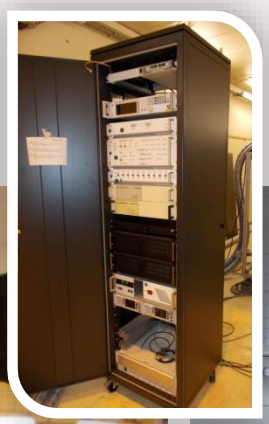
RF CONDITIONING

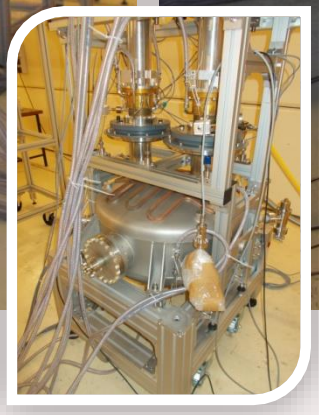
- RF conditioning in pulse mode in SW and TW mode
- RF conditioning depends on the level of vacuum (managing the rise or fall of the RF level)
- Presence of hardware safety (electric arc, multipactor, vacuum) to cut off the RF
- Gradual increase of the pulse width until accelerator requirement



RF CONDITIONING TEST STAND

- Standing wave configuration
- Short circuit has been motorised by a step by step engine

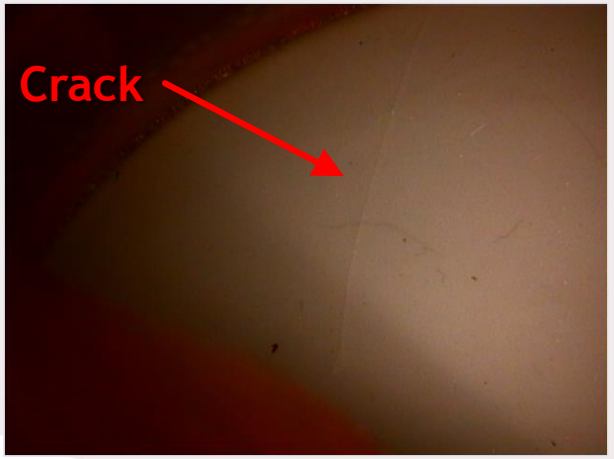




FIRST RF CONDITIONING (01/2016)

- RF conditioning of **two SCT couplers**
- Short circuit located to have RF peak power on the ceramic of the input coupler
- RF conditioning with four pulse widths : 20 µs – 300 µs – 1.5 ms 2.86 ms
- 400 kW RF on input coupler and 250 kW RF on output coupler
- All safeties have been take off inadvertently
- RF conditioning until a RF pulse of 2.86 ms and suden rise of vacuum level → 0.6 mbar
- **Lead to the break-in of the Input power coupler**

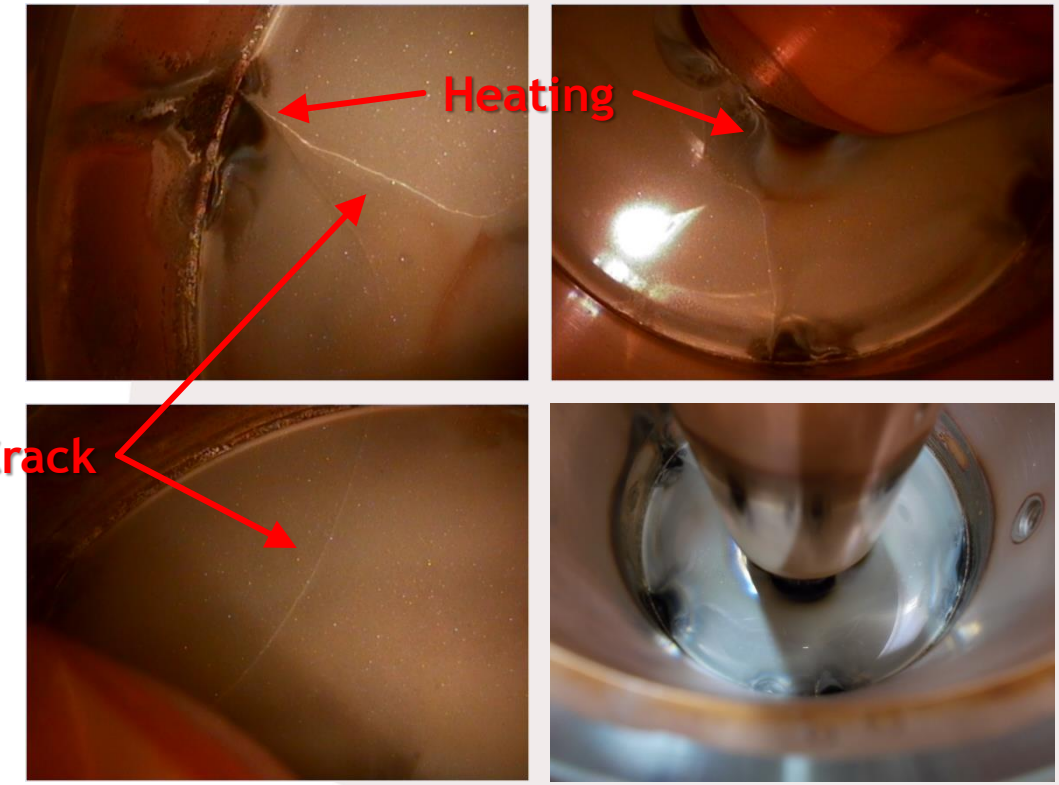
Air side



FIRST RF CONDITIONING (01/2016)

- SCT compagny

Input cavity coupler → ceramic broken

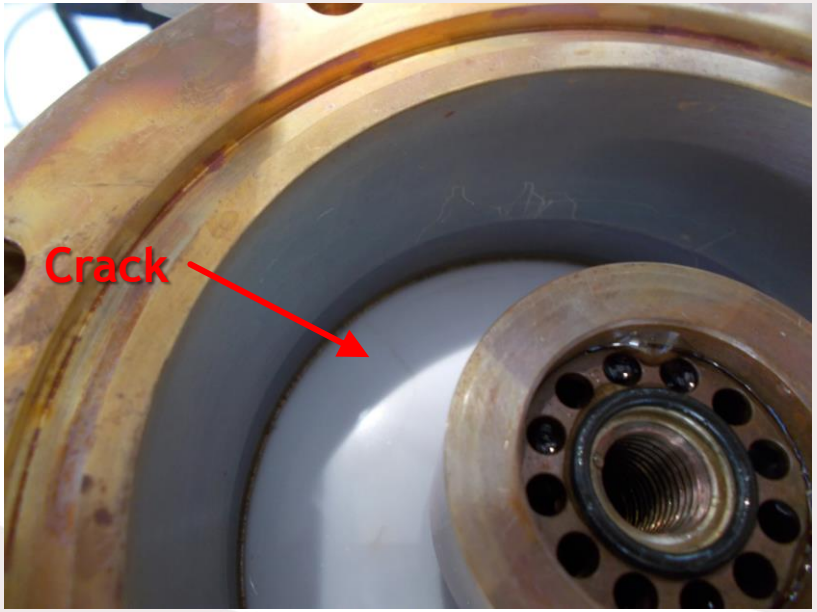


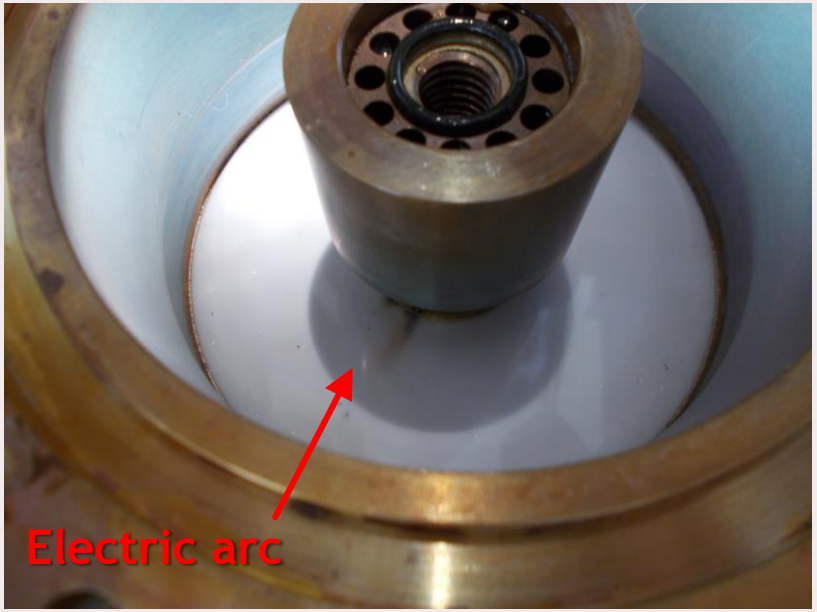
Output cavity coupler → sealed

Antenna side

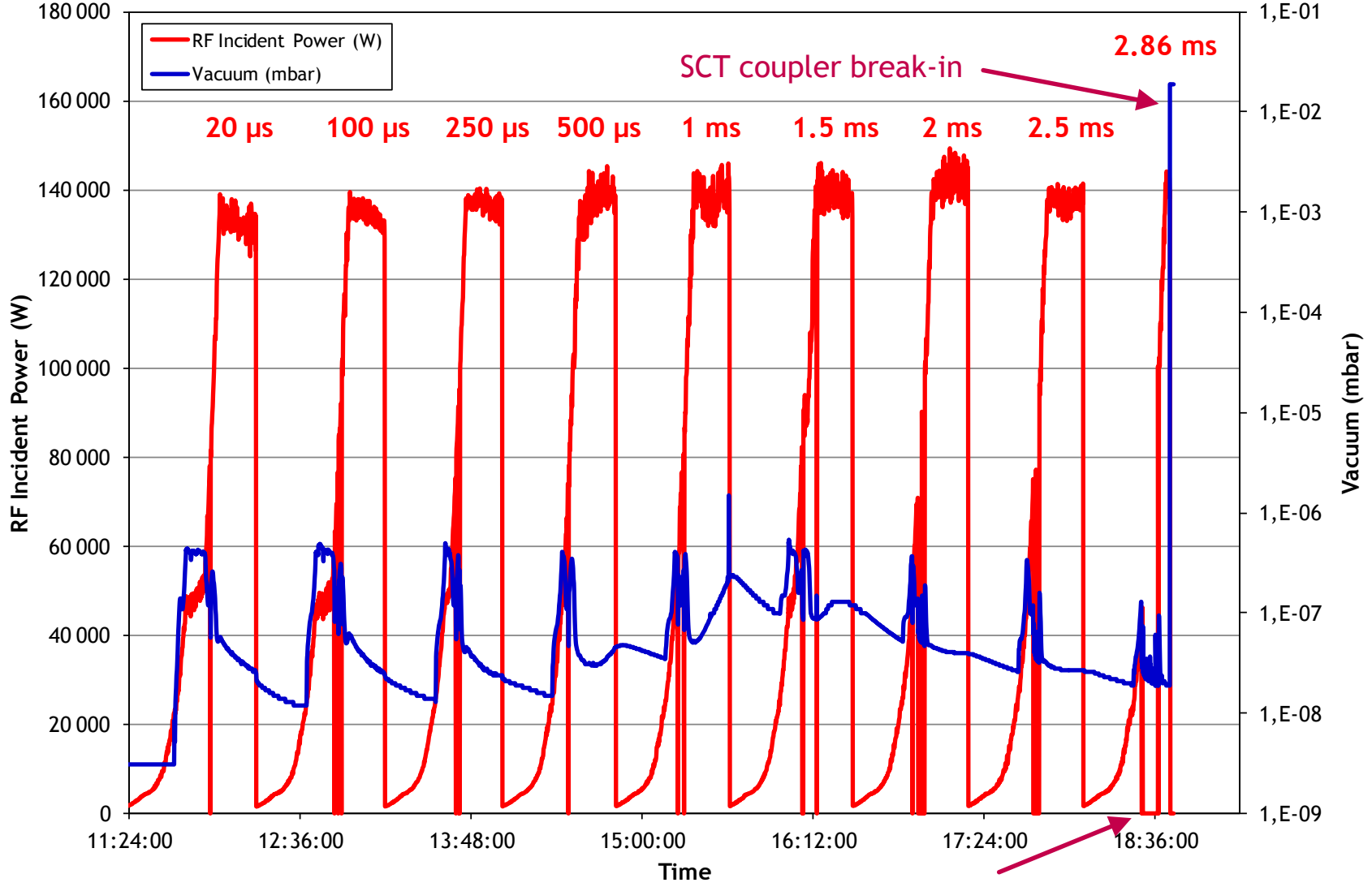
SECOND RF CONDITIONING (06/2016)

- RF conditioning of **one PMB coupler (input) and one SCT coupler (output)**
- Short circuit located to have RF peak power on the ceramic of the input coupler (PMB)
- 400 kW RF on input coupler (PMB) and 250 kW RF on output coupler (SCT)
- All safeties have been **take on**
- RF conditioning until a RF pulse of 2.86 ms and suden rise of vacuum level → 0.1 mbar
- **Lead to the break-in of the Output power coupler (SCT)**





SECOND RF CONDITIONING (06/2016)



SECOND RF CONDITIONING (06/2016)

- **No particular event when the ceramic broke even before**
- Short circuit located to have RF peak power on the ceramic of the input coupler (PMB)
- Conditioning at 400 kW RF on input coupler (PMB) and 250 kW RF on output coupler (SCT) with a 2.86 ms RF pulse width at the time of the break-in
- PMB coupler is intact visually – no trace of electron activity and/or heating
- Was the SCT coupler damaged further to the first RF conditioning ?
- Investigation:
  - Thickness of TiN deposit is in accordance with the IPNO specification (for all couplers)
  - SCT couplers solders are coarser than PMB
  - Perhaps SCT compagny must adapt their manufacturing process to more important thermomechanical stresses ?

Thank you for your attention…