DE LA RECHERCHE À L'INDUSTRIE

CEA – Saclay

www.cea.fr

7TH OPEN COLLABORATION MEETING ON SUPERCONDUCTING LINACS FOR HIGH POWER PROTON BEAMS (SLHIPP-7)

8-9 JUNE 2017

-

ESS POWER COUPLERS FOR THE ELLIPTICAL CAVITIES

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CHRISTIAN ARCAMBAL

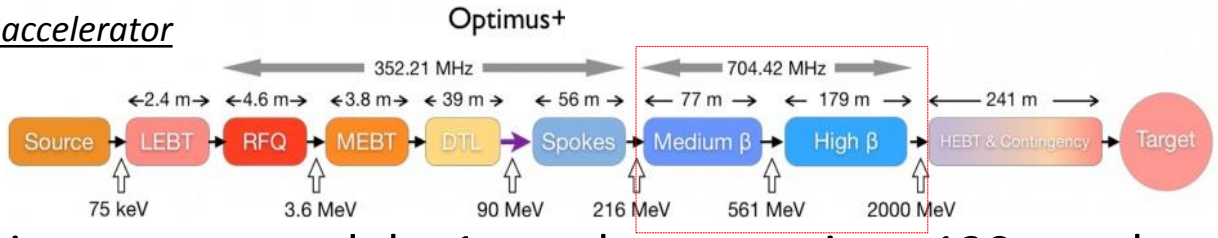
OUTLINE

- Overview of the cryomodule for elliptical cavities
- ESS couplers for elliptical cavities
- Coupler life cycle at CEA
- Conditioning of the 3 first pairs of couplers
- Overview of the production

OVERVIEW OF THE CRYOMODULE FOR ELLIPTICAL CAVITIES

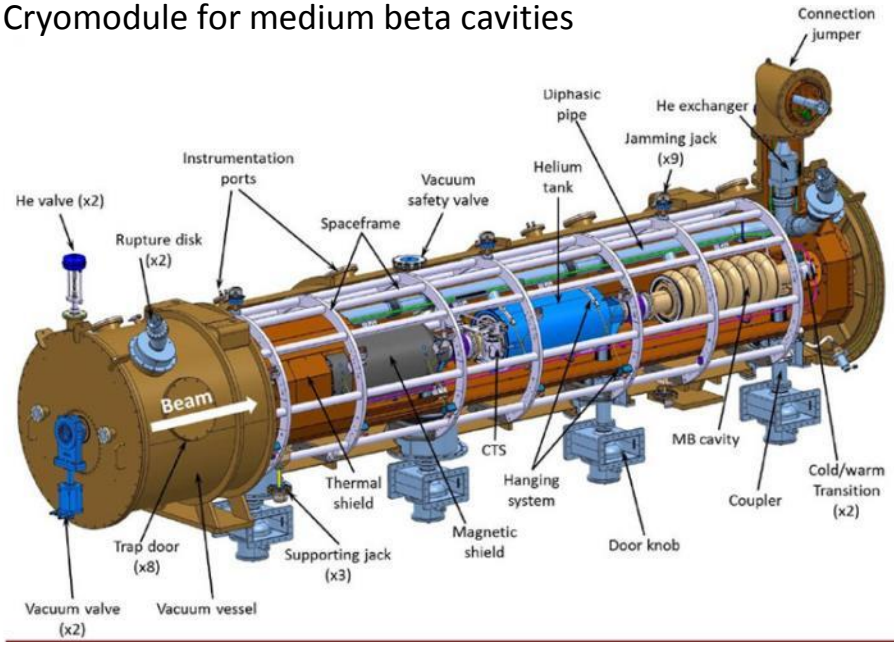
– LINAC composed of 9 medium beta cryomodules & 21 high beta cryomodules with elliptical cavities

ESS accelerator

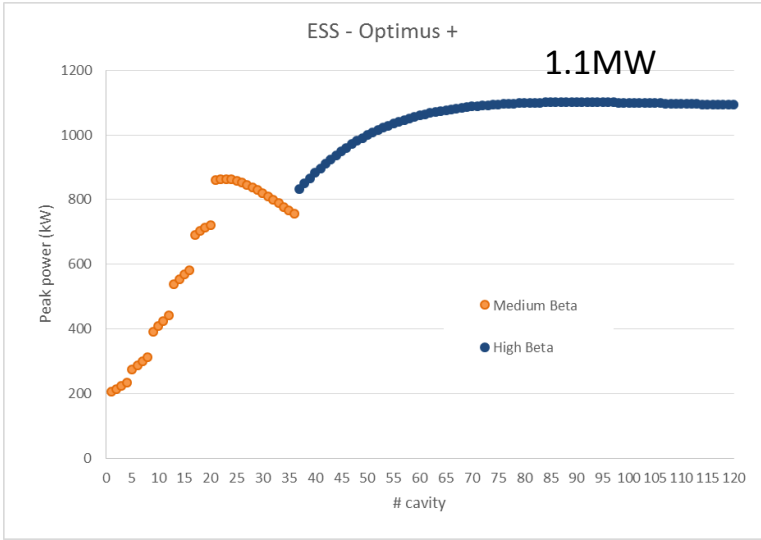


– 4 cavities per cryomodule, 1 coupler per cavity⇒120 couplers

Cryomodule for medium beta cavities

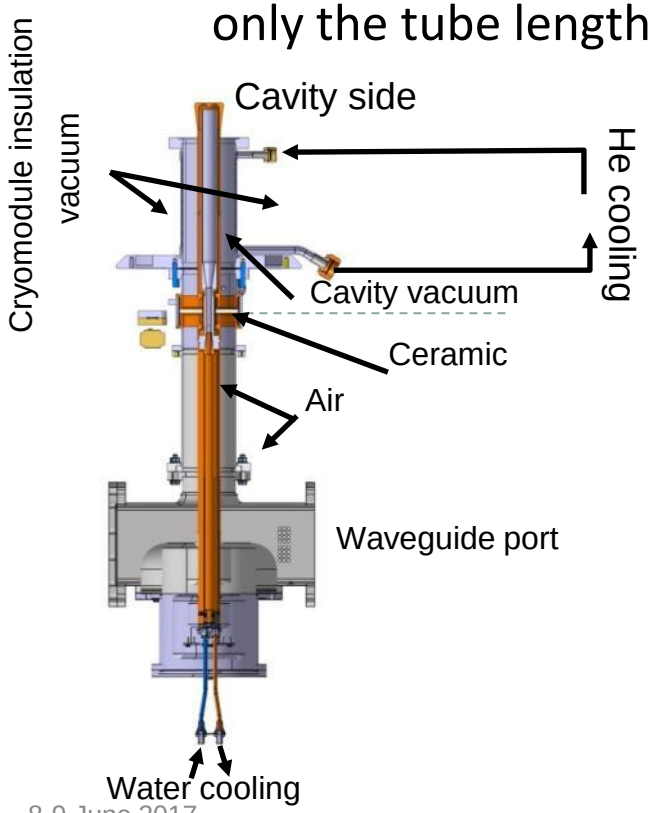


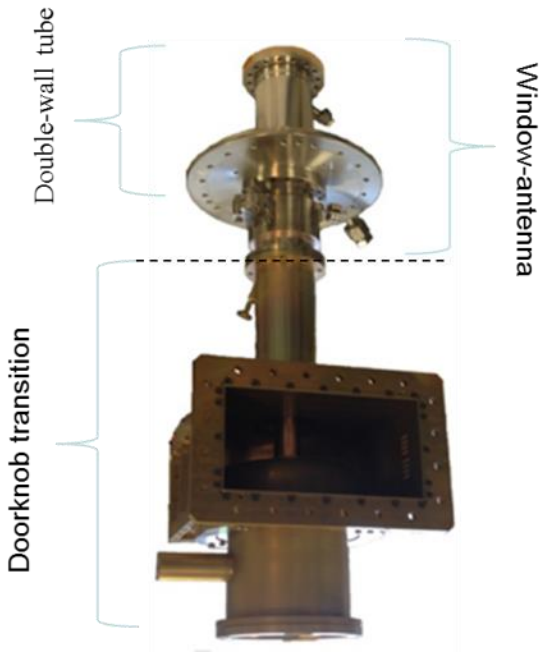
Maximal peak power (coupler)



OVERVIEW OF THE COUPLER

- Three main parts: a single window with its antenna, a double wall tube, a doorknob transition
- Window-antenna and doorknob transitions common to medium and high beta cavities
- Double-wall tube slightly different between the 2 kinds of cavities: only the tube length is modified





RF frequency	704.42MHz
Repetition frequency	14 Hz
Incident RF power	1.1 MW
RF pulse width in full reflection (all phases)	500 µs
RF pulse width in travelling waves	3.6 ms
Voltage withstand (voltage between internal conductor and external conductor)	±10 kV

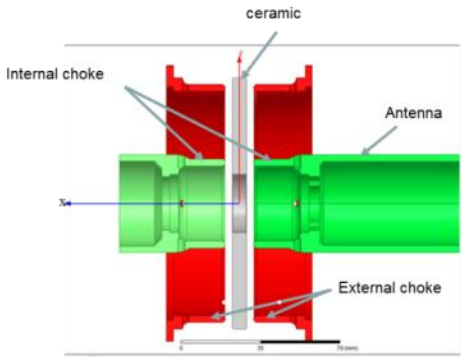
Technical specifications

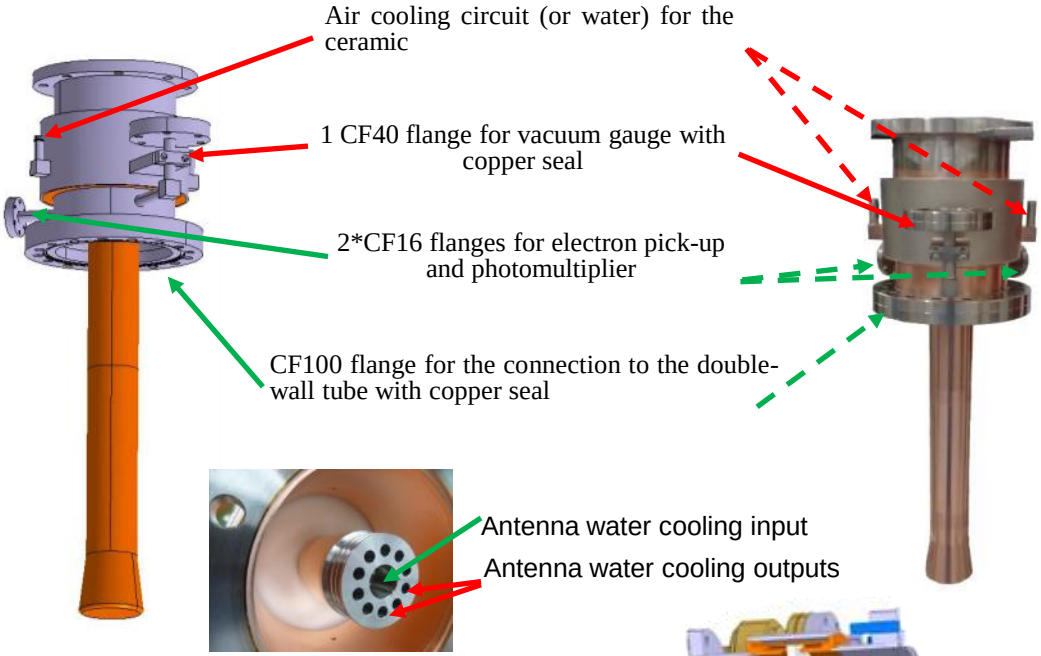
Nominal temperature	20°C
Temperature during baking	Max : 200°C for 100h
Water pressure in cooling circuit	3 bars
Water flow in cooling circuit	3 l/min
Water temperature in the antenna	from 20 to 25°C

Use conditions

WINDOW-ANTENNA

- Vacuum tightness obtained with the brazing of ceramic
- Design of chokes to improve the impedance matching
- TiN coating for multipactor effect (vacuum side)

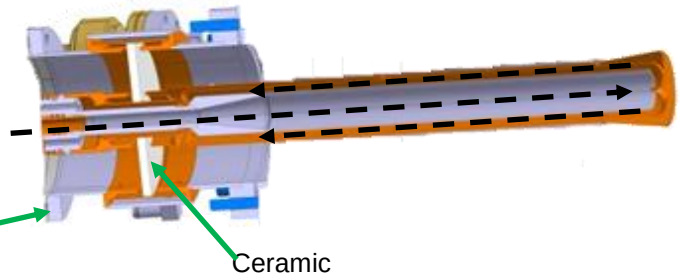




Electron pick-up (+80dB RF coupling)

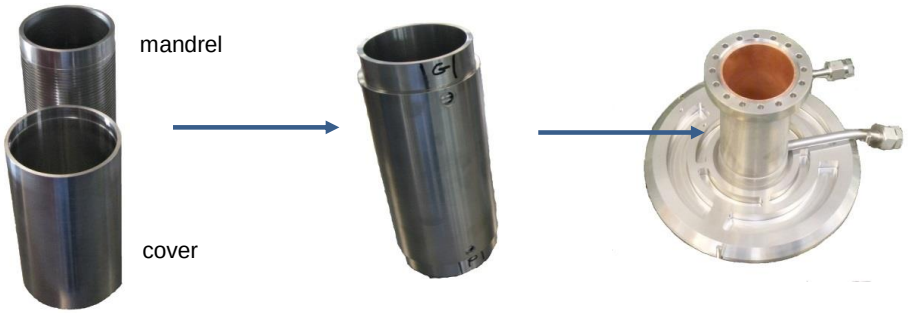
Vacuum gauge (IKR070 from Pfeiffer, range [10^{-11};5×10^{-3}])

Window for photomultiplier



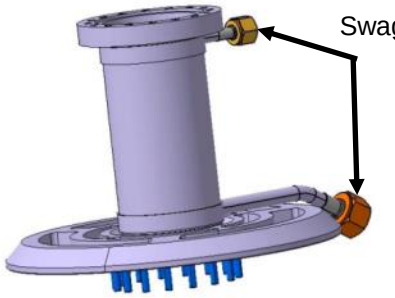
DOUBLE-WALL TUBE

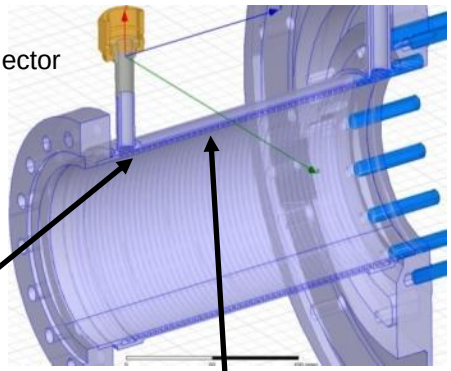
- Stainless steel 316L
- Cooling circuit manufactured with the shrink-fitting method
- Copper coating with 10µm(-3/+2µm) thickness and RRR∈ [20;40] (threshold between RF and thermal aspects)

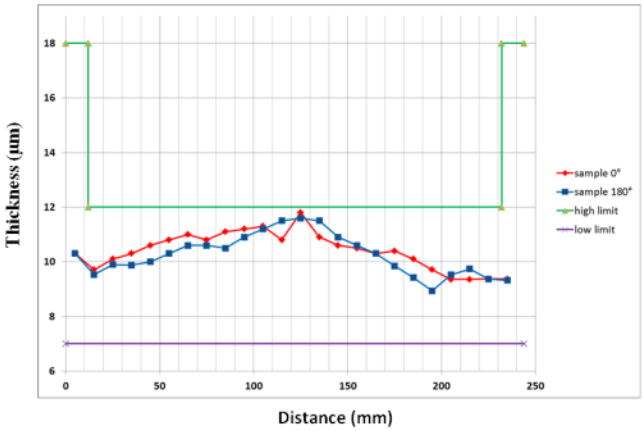


Copper deposit samples

Measurement of RRR: [30;39]

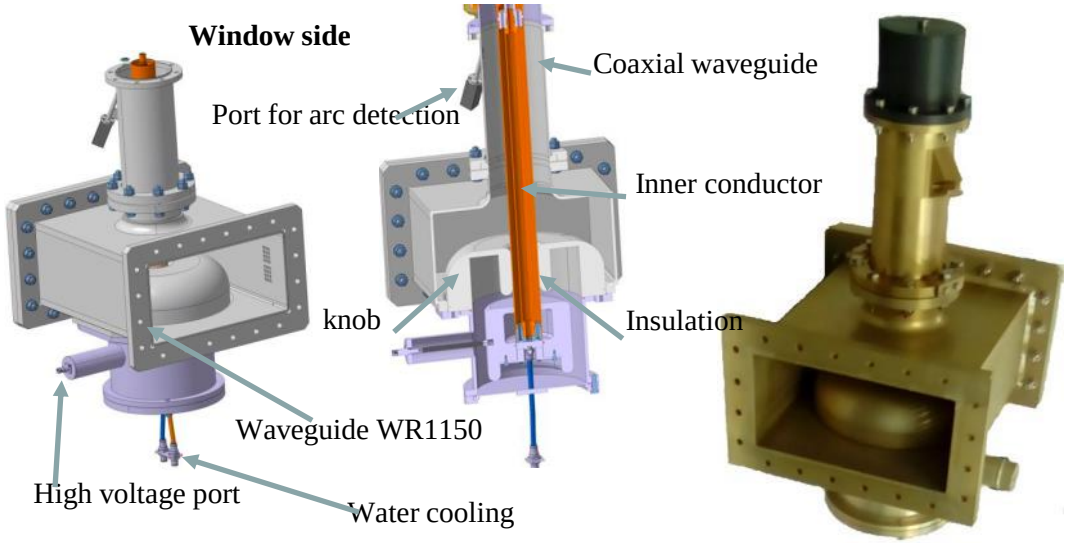


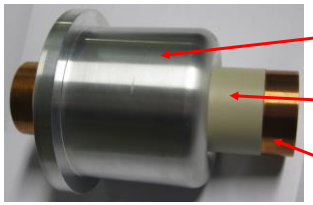




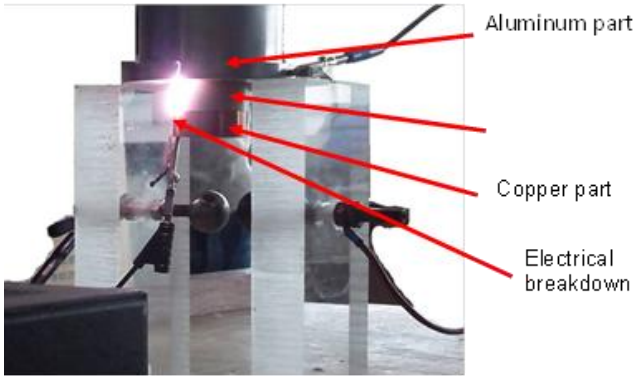
DOORKNOB TRANSITION

- Insulation obtained with a material with a dielectric constant =3.3 (+/- 10%) able to provide 10kV insulation (breakdown voltage ≥18kV). Use of PEEK
- Insulation cylinder obtained from solid material and machining.
- Protective coating for aluminum parts: alodine 1200
- Water tightness



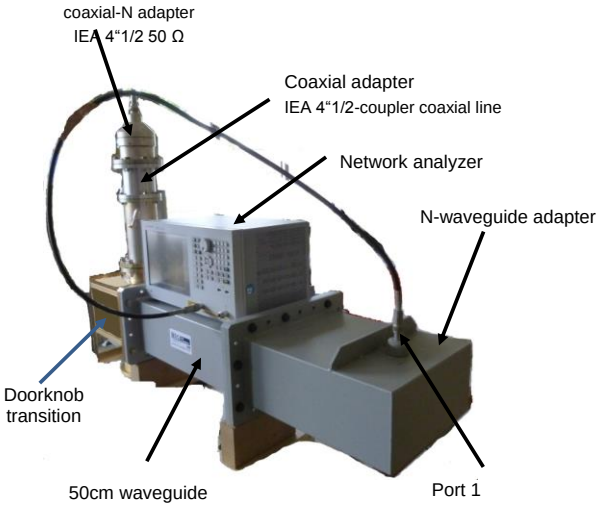


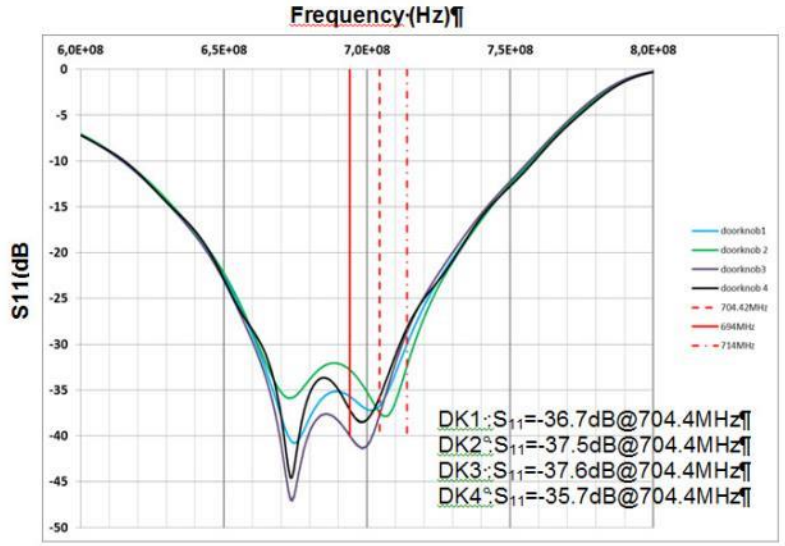
Sample



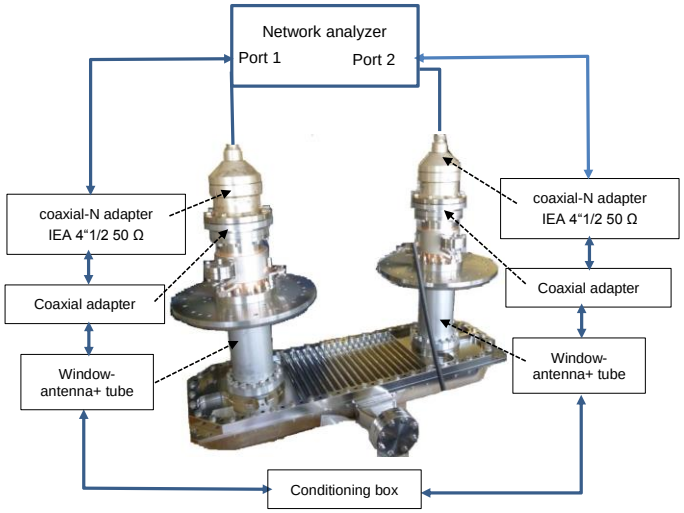
RF CHARACTERIZATION

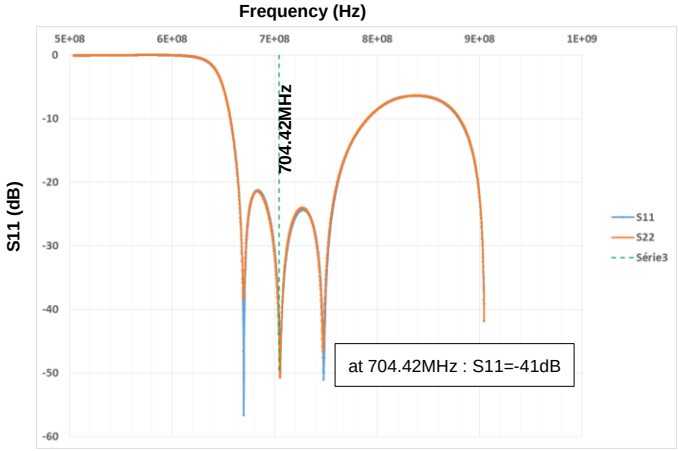
- Doorknob





- Couplers on the conditioning box





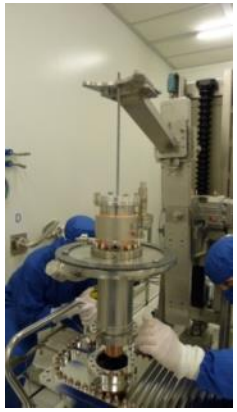
COUPLER LIFE CYCLE AT CEA (1/2)

- Cleaning of each part of the coupler

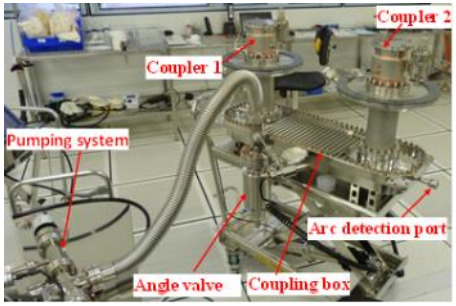
Tube in ultrasonic bath (Tickopur R33)

Coupling box in ultrasonic (TFD4)

- Assembly in cleanroom

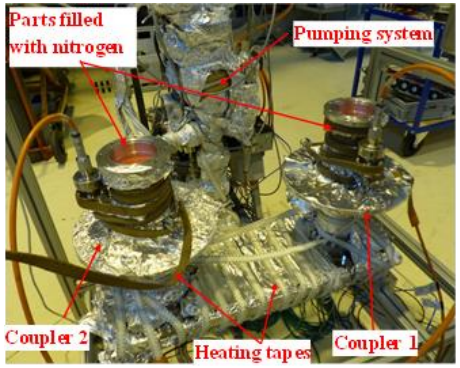


Assembly of the tube and window on the coupling box



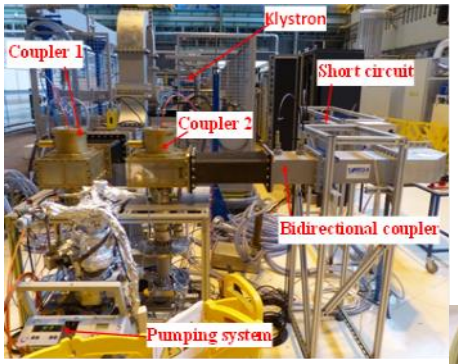
Vacuum leak test

- Baking (couplers: 170°C for 72 to 120 hours]; pumping system: 120°C for 48 hours then 60°C)
  - silicon and fibre glass heating tapes for prototype, furnaces for series



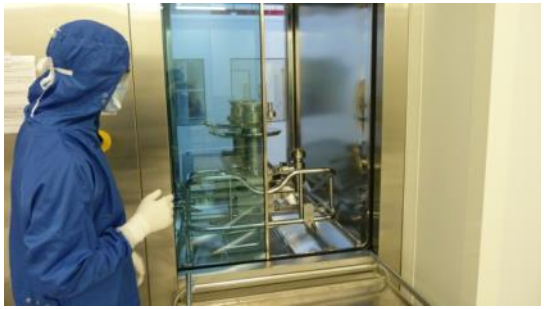
COUPLER LIFE CYCLE AT CEA (2/2)

- Conditioning of pairs of couplers (a)
- Cleaning before disassembly in cleanroom (b)
- Assembly on cavity (c)
- Conditioning on the cryomodule (d)



a

b

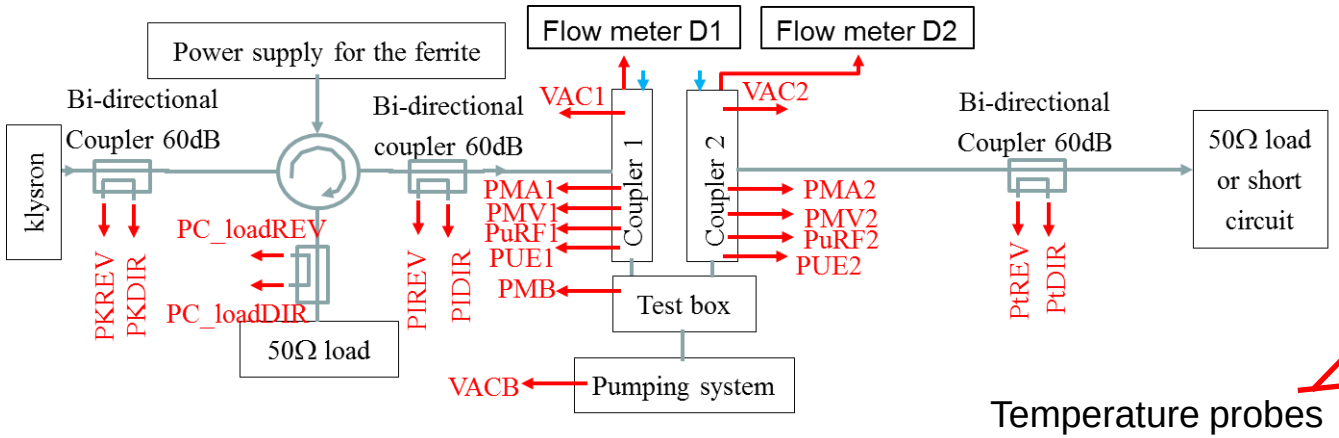


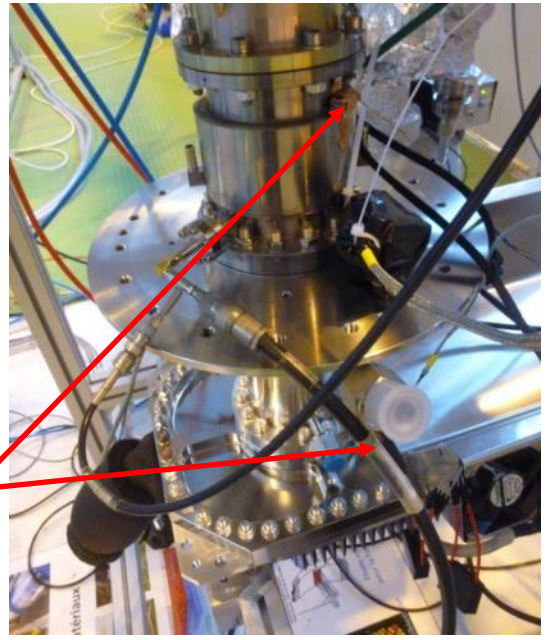
c

d

CONDITIONING

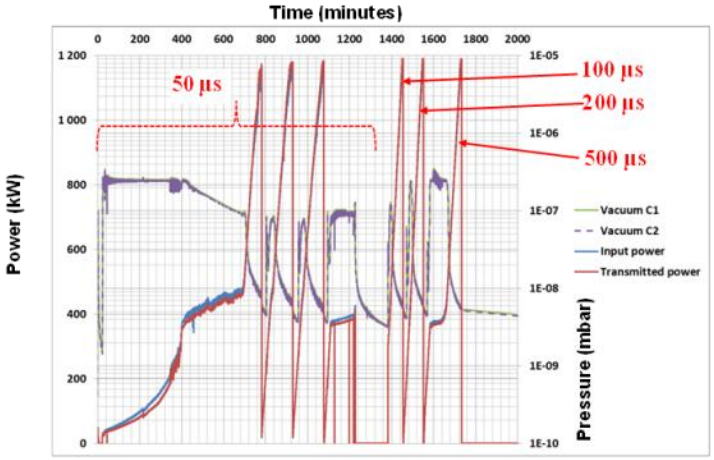
- Conditioning sequence in travelling waves (TW) : RF power ramp from 15kW to 1200kW (pulse width from 50µs to 3.6ms), repetition frequency: 1Hz then 14Hz
- Conditioning sequence in standing waves (SW): 2 positions of short circuit, RF power ramp from 15kW to 1200kW (pulse width from 50µs to 500µs, 1Hz), from 15kW to 300kW (pulse width: 500µs to 3.6ms, 14Hz)
- RF test stand: check of vacuum (VAC1, VAC2,VACB), arc detection (vacuum side: PMV1, PMV2, PMB and air side: PMA1, PMA2), multipactor detection (PUE1 ,PUE2) , RF check (PuRF1, PuRF2…), temperature (box, window, water), water flowmeter, security signals (vacuum, water)



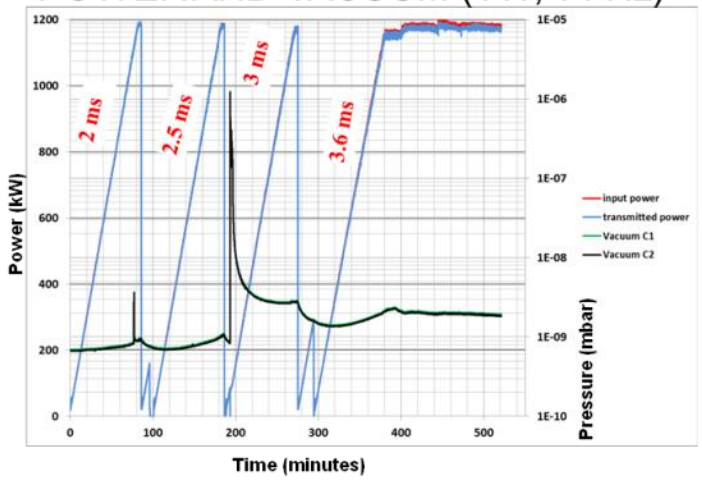


CONDITIONING

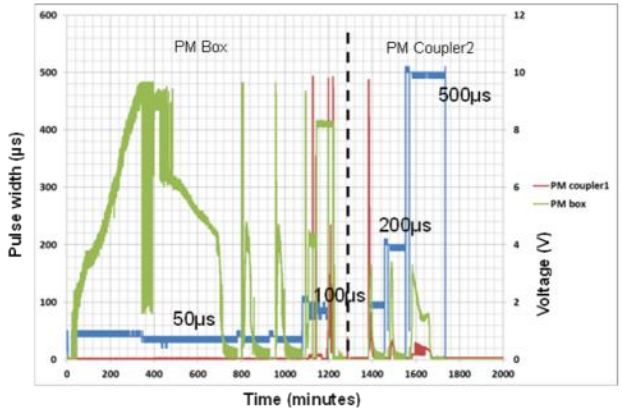
POWER AND VACUUM (TW, 1 Hz)



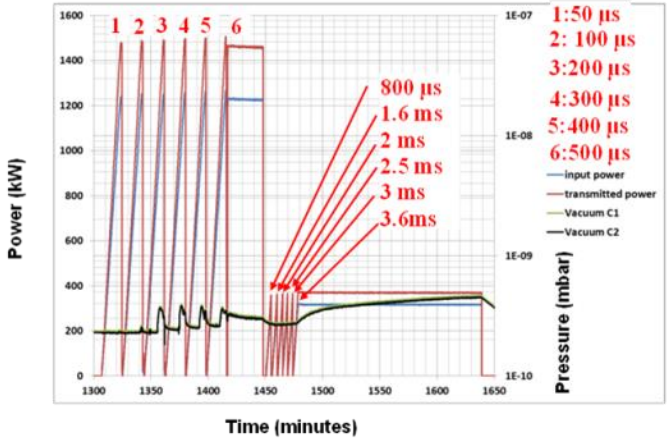
POWER AND VACUUM (TW, 14 Hz)



PULSE WIDTH & PHOTOMULTIPLIER(TW, 1 Hz)



POWER AND VACUUM (SW, 14 Hz)



TEMPERATURE DURING CONDITIONING

- Temperature of the water

  During the conditioning: for Φ=2.4l/min

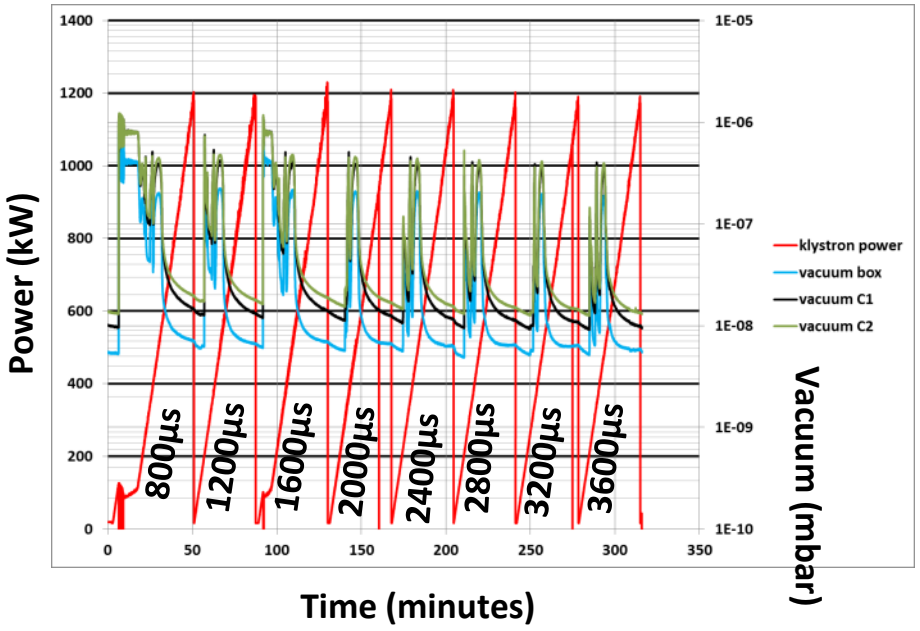
  T water input=25.6°C

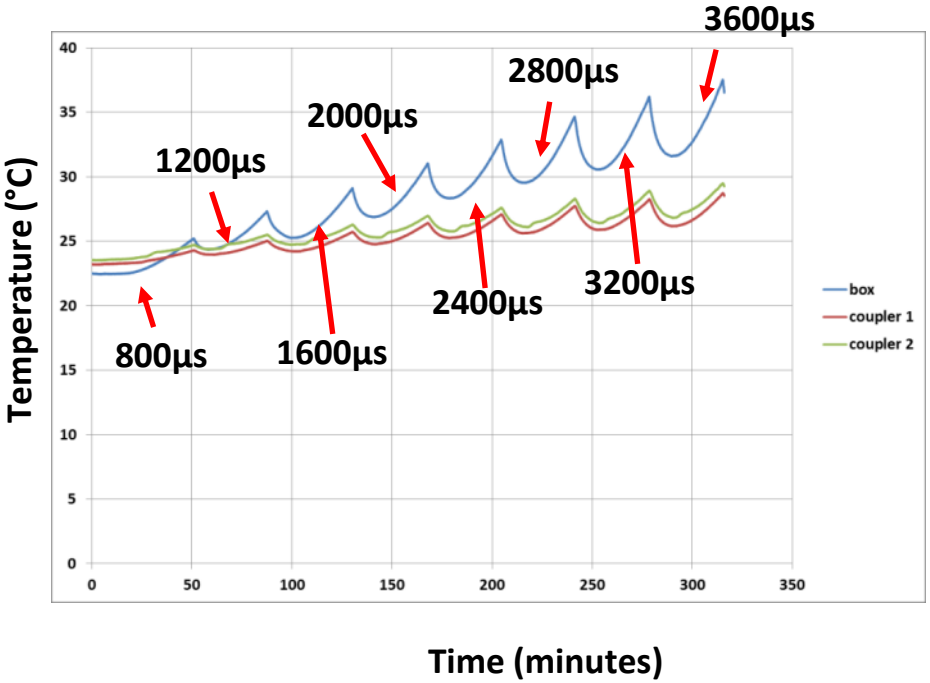
  T water output=26.2°C

Estimation of the water flow

Φ	ΔT
2 l/min	0.97°
2.5 l/min	0.78°
3 l/min	0.65°

- Temperature of the coupler (TW, 14Hz)





OVERVIEW OF THE COUPLER PRODUCTION

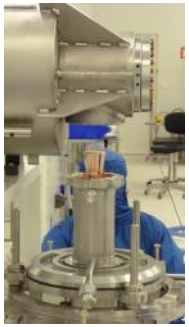
- Production of the 120 couplers (window, electron pick-up, double-wall tube, doorknob transition) performed by PMB.
- First couplers of the pre-series foreseen at the end of 2017

- Production of the coupling box performed by SDMS
- First boxes of the pre-series foreseen at the end of October 2017

- Delivery of a second klystron (1.5MW) : July 2017
- Development of a specific area with the possibility to perform the conditioning of 2 pairs in parallel

CONCLUSION

- Overview of the manufacturing for prototypes:
  - 6 medium beta double-wall tubes
  - 10 windows
  - 8 doorknob transitions
  - In progress, manufacturing of 6 high beta double-wall tubes (delivery in June 2017)
- Conditioning of 3 pairs of couplers with success (whose 4 couplers are now assembled in cavities)



- Production of series couplers and series coupling boxes in progress

CEA coupler team:

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- M. Desmons
- L. Maurice
- P. Carbonnier
- C. Servouin
- M. Baudrier
- P. Hardy
- F. Leseigneur
- V. Hennion
- N. Berton
- D. Gevaert
- A. Bruniquel
- C. Cloué
- T. Trublet

- 8-9 June 2017

Thank you

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