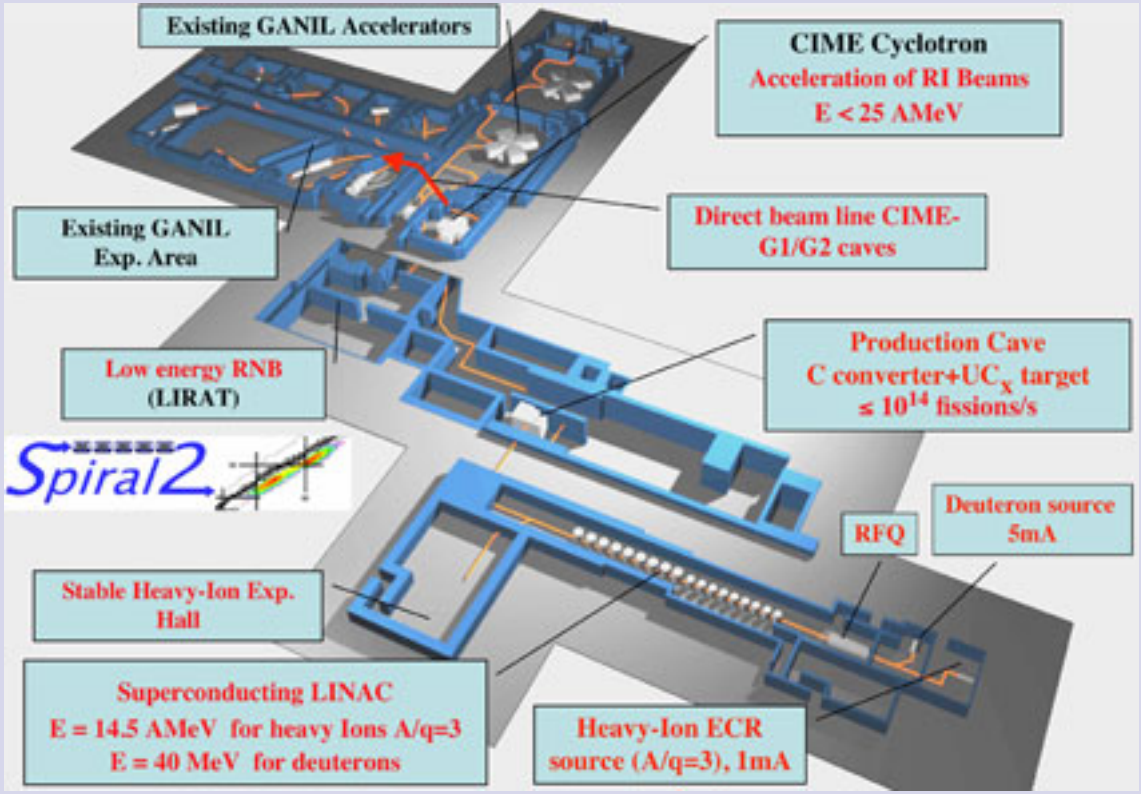
POWER COUPLERS FOR Spiral2



Spiral 1 & 2 at GANIL (France)

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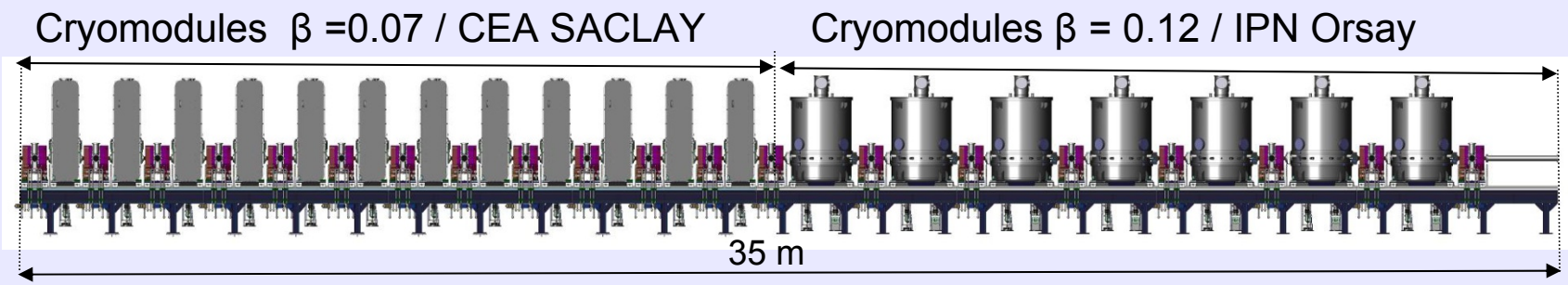
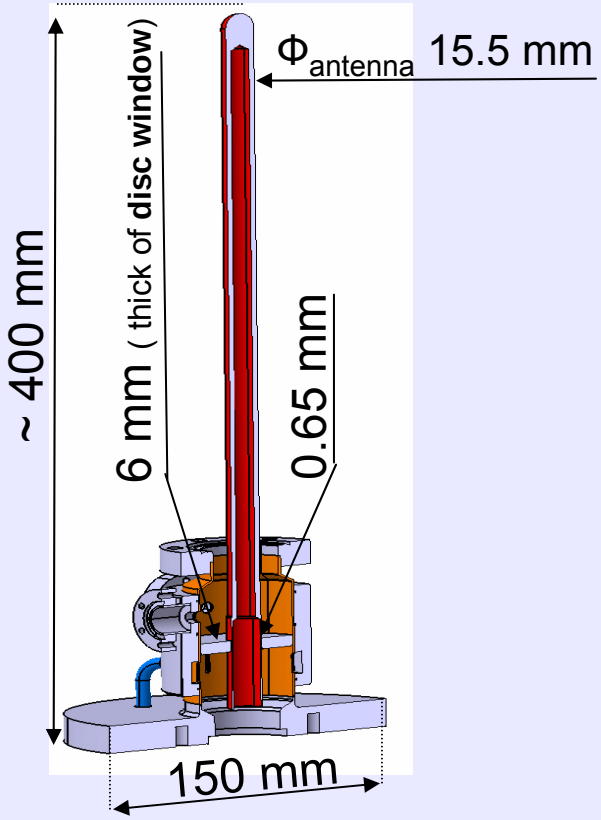
Outline

- Spiral 2 couplers layout & parameters
- Tests
  - Mechanical test
  - Radiofrequency (RF) tests
- Coupler processing
- Coupler status
- Summary

RF Spiral 2 couplers





Couplers / LPSC

Parameters	Values
Number	26 (12 + 7*2)
Frequency	88.05 MHz
Nominal power*	10 kW CW
Power during test	Up to 40 kW CW
S_{11}	< -25 dB
Thermal load at 4.2 K	< 1 watt
Accepted reflected power	100%
Q_{ext} at nominal current*	$1.3\ 10^6$ - $2.4\ 10^5$
**Spiral 2 nominal accelerating gradient*	*6.5 MV/m*
**Spiral 2 nominal current.*	*5 mA deuterons*

Outline

- Spiral 2 couplers layout & parameters
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  - RF tests
- Coupler processing
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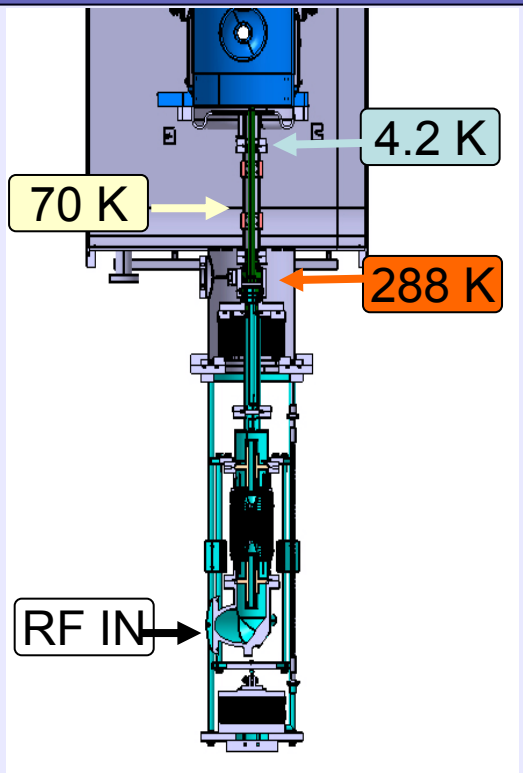
Coupler thermal test

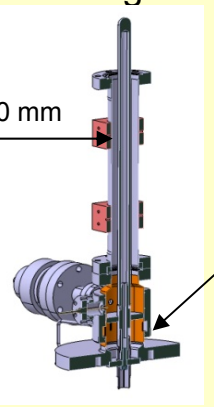
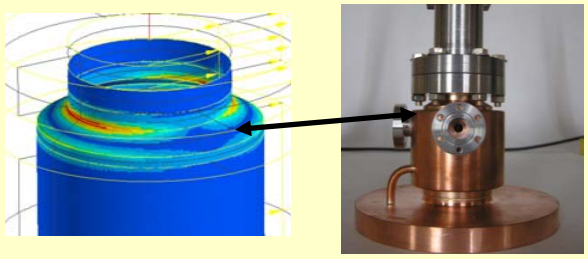
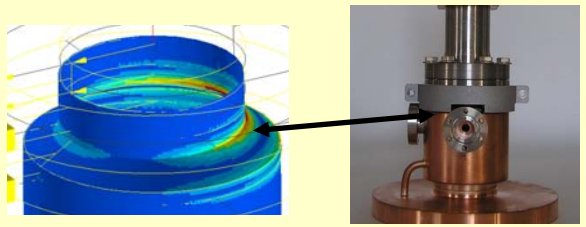
Temperatures in a cryomodule β = 0.07



- To minimize the heat flux to the cavities:
  - Only a 70 K screen is used
  - The position of the 70 K screen has been optimised
  - 20μm ± 10 % copper plating RRR ~ 10
- To keep the window temperature ~288 K (15 ° C) with and without RF, and to avoid water condensation, a hot, dry, cleaned air system is implemented (otherwise $T_{measured}$ < - 5 °C without RF and ~ 30 C with RF).

	With NO RF	with 20 kW CW
Heat flux to the cavity$_{TH}$	< 0.6 W	~ 1 W
Power dissipated by the coupler$_{TH}$	~ 0 W	< 17 W
Temperature antenna extremity $_{TH}$	295 K	348 K
Power radiated to the cavity$_{TH}$	~ 0 W	~ 0 W

Coupler mechanical test

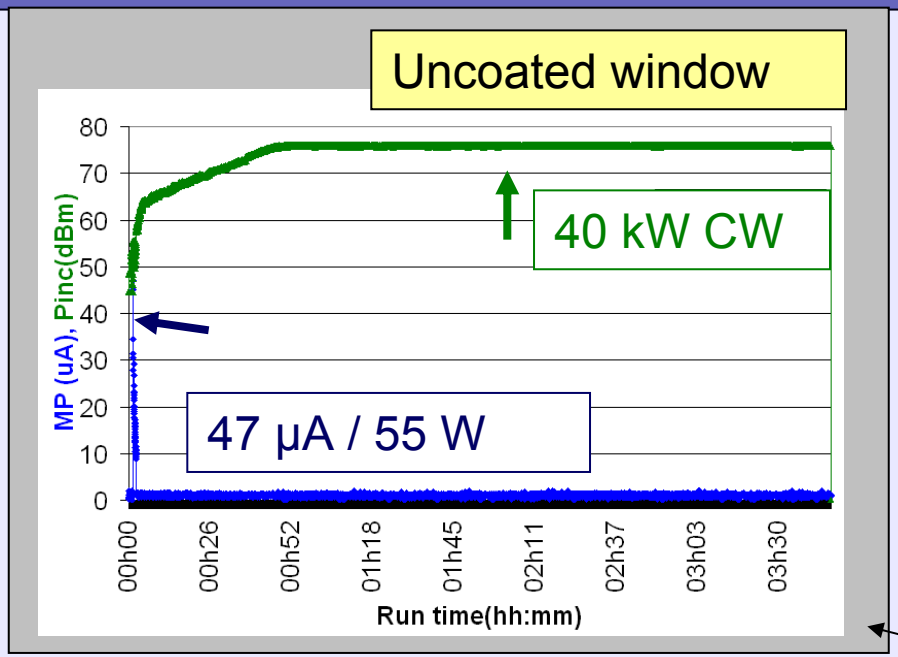
Upgrades	Without	With
Hollow antenna with an internal clamp [to be far from the 50 Hz frequency (EU electrical network frequency) and to avoid plastic deformation of the antenna]	f1 = f2 = 59 Hz $\Phi_{antenna:}$ 15.5 mm 0.65 mm ~ 400 mm  First mode	f1 = f2 = 73.5 Hz Acceleration max 10 g $\Phi_{hole:}$ 10 mm   support
support to the CF40 flange. [to avoid the deformation of the flange]	Acceleration$_{max:}$ 4g to get 70 MPa 	Acceleration $_{max}$: 8g to get 70 MPa 

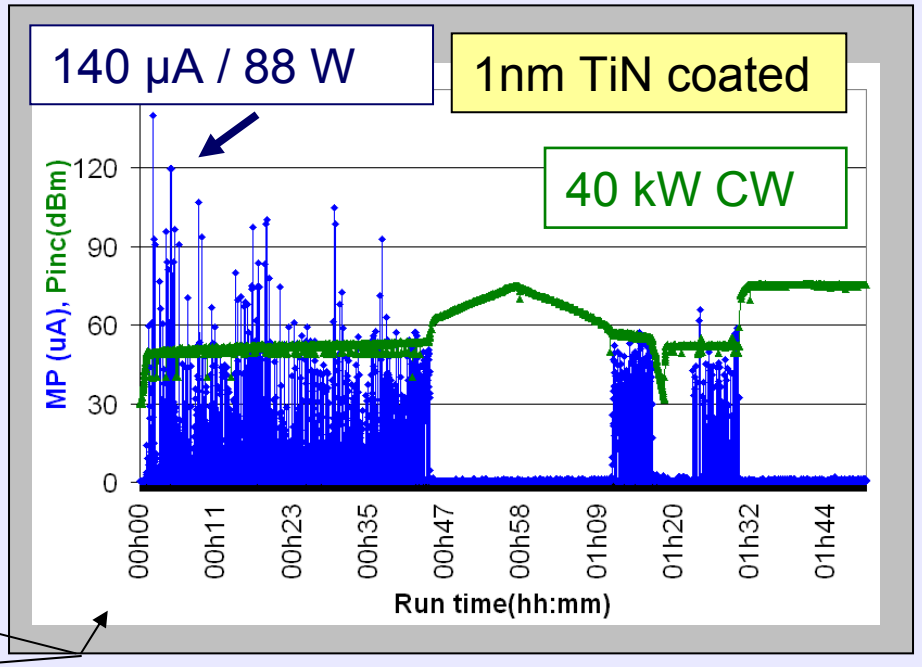
Elastic limit of annealed Cu OFE = 70 MPa
Maximum acceleration measured till now : **6 g**

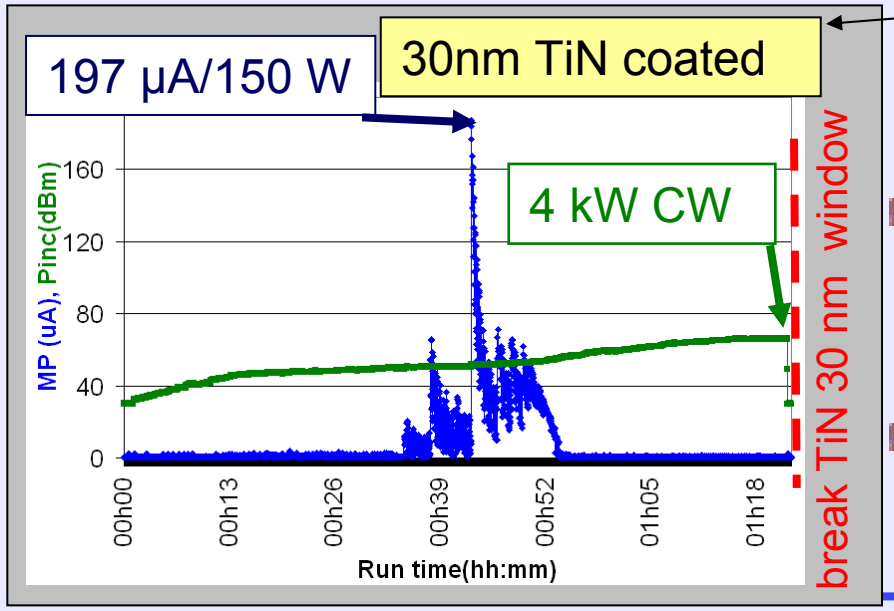
Outline

- Spiral 2 couplers layout & parameters
- Tests
  - Mechanical test
  - **RF tests**
- Coupler processing
- Coupler status

RF power test. Power / Multipactor







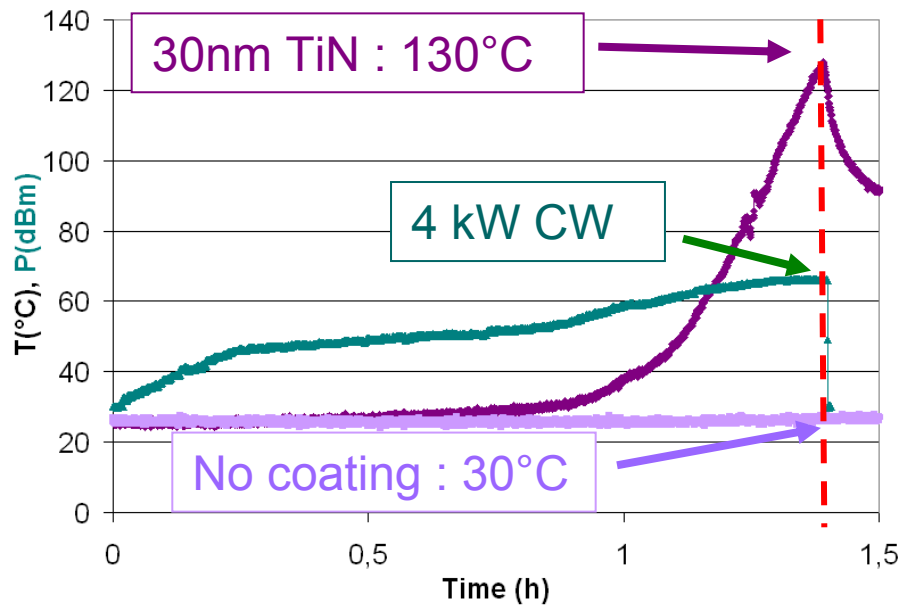
Multipactor and power of an uncoated , a 1 nm TiN and 30 nm TiN coated window.

- **40 kW CW was reached except for the 30 nm TiN coated window**
- **Almost no multipactor was observed**

RF power test . TiN coating

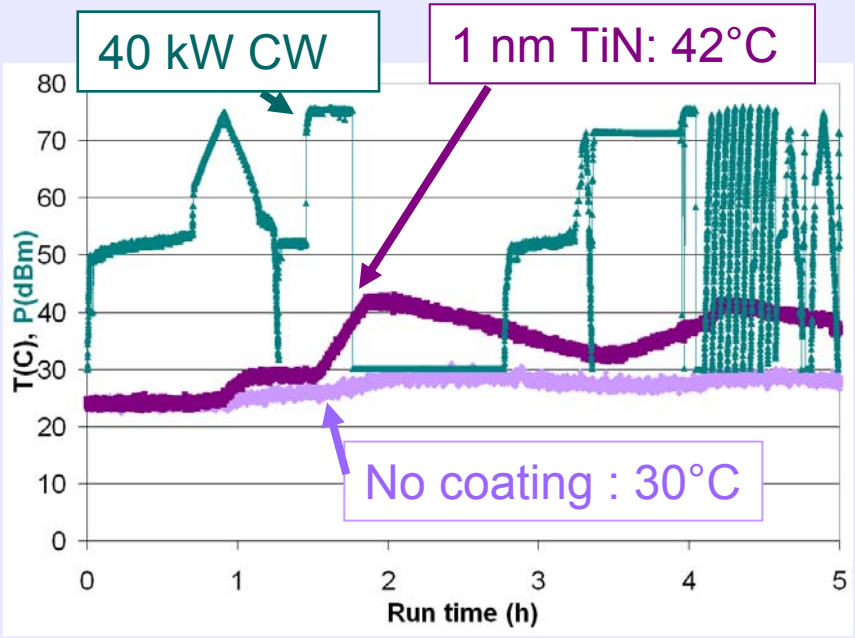
30nm TiN coated window

BREAK TiN 30 nm window



Temperature and power of an uncoated and a 30 nm TiN coated window

1nm TiN coated window

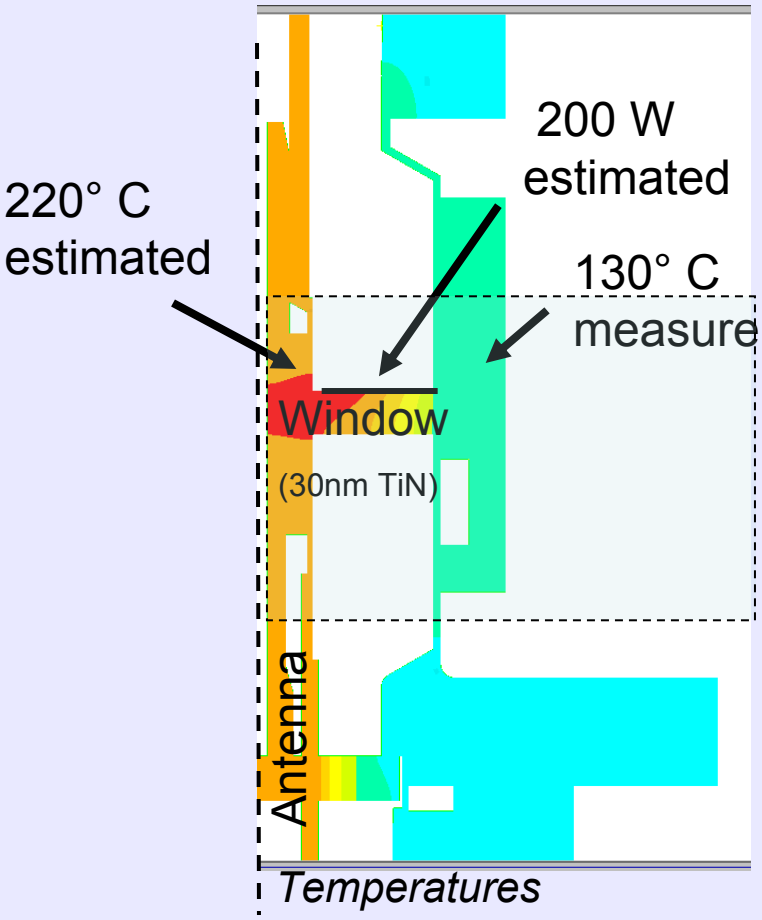


Temperature and power of an uncoated and a 1 nm TiN coated window

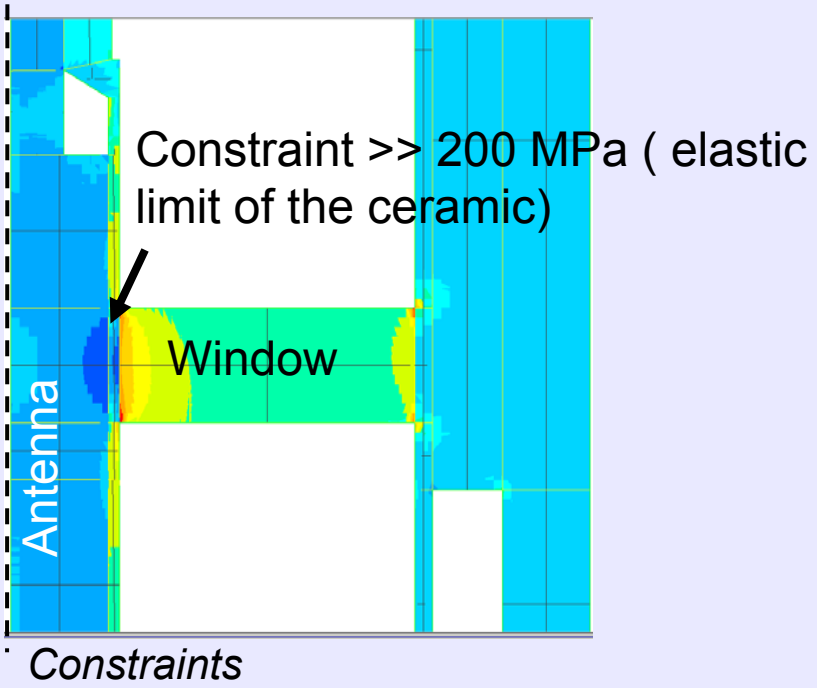
Temperature safety threshold: 40° C.

- **A temperature increase produced by the coating has been observed**

RF power test . TiN coating



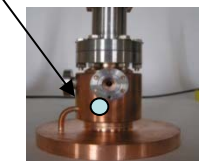
	Thermal expansion coefficient
Alumina	$7.4\ 10^{-6}\ K^{-1}$
Copper	$1.55\ 10^{-5}\ K^{-1}$



- **This very high constraint led to window's break**

RF power test

Problem during production

Coating	Uncoated	TiN sputtering before brazing			
Coating thickness	0	1±0.2nm	10± 2nm	30 ± 5nm	
Nb couplers tested	20	1	0	2	
Resistivity $_{25°C\ th}$ *(Ω cm)*	$Al_2O_3 > 10^{12}$	*TiN ~ 25*10 $^{-6}$; TiO_2 ~ 10^{12} [RBS: Ti (%): 40; N (%): 42; O (%) : 18] (IPN Lyon. Ch. Peaucelle)*			
S_{11} (dB)	~ -41.2	-40.4	--	-25.4	-28
$P_{max\ tested}$(kW)	40	40	--	7 kW CW	4 kW CW
Outside windows temperature / P(kW). 	30° C ↔	42 °C	--	Not measured	130 ° C à 4 kW CW TW
Multipactor (μA) $_{max}$	~ 50 μA	~ 140 μA	--	~ 35 μA	~ 190 μA

Window broken

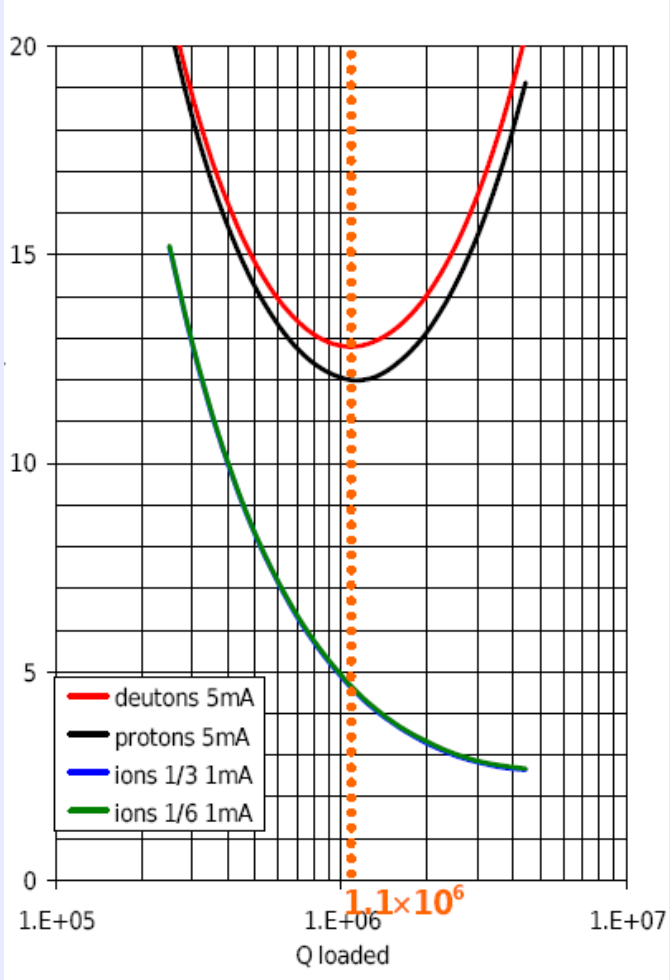
- Almost no multipactor was observed
- Coating window led to temperature increase
- So it was decided not to coat the window

RF power test. Coupling

- Electrical coupling
- Same coupler for all the accelerator
- All the cavities β =0.07 have the same coupling and all the cavities β =0.12 have the same coupling. The coupler is on a fixed position

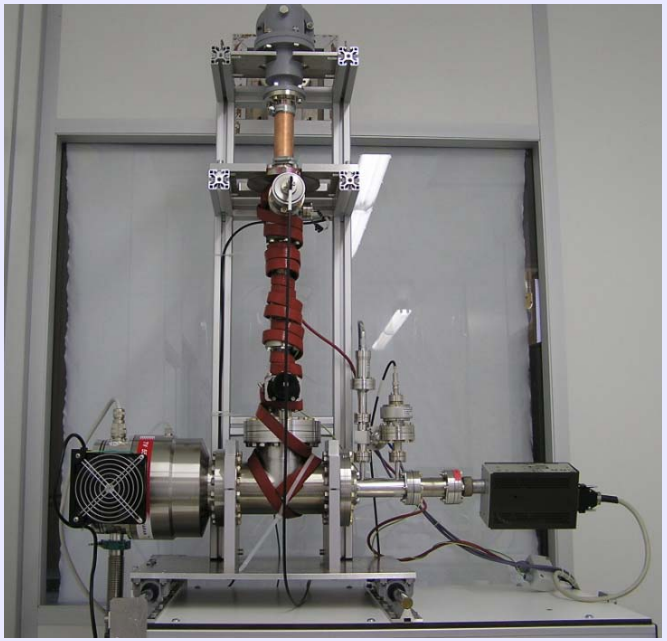
CMs	QEXT Theorical	Q ext measured	Antenna 's penetration (mm)
β =0.07	5.5 10^5	5.3 10^5	10.6 mm
β =0.12	1.1 10^6	10^6	16.6 mm

- The choice of the coupling is defined by the optimization of the RF power required, its cost and safety margin. (Calculated by IPN Orsay)

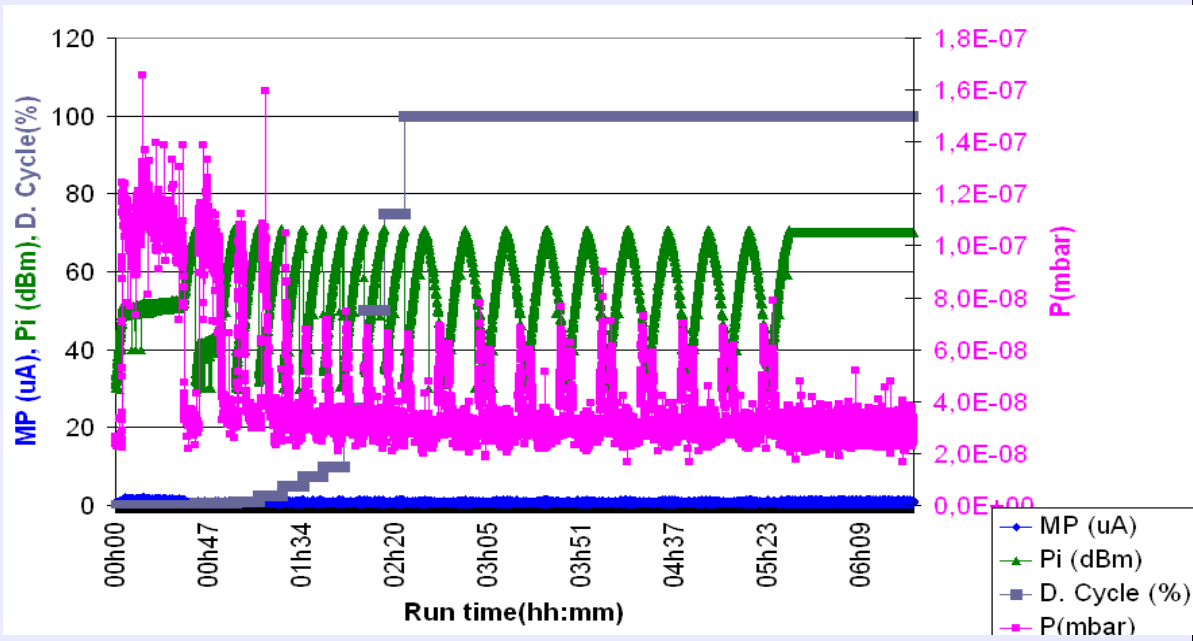


Nominal RF power for β 0.12

Coupleur processing at LPSC



Coupler commisioning at LPSC



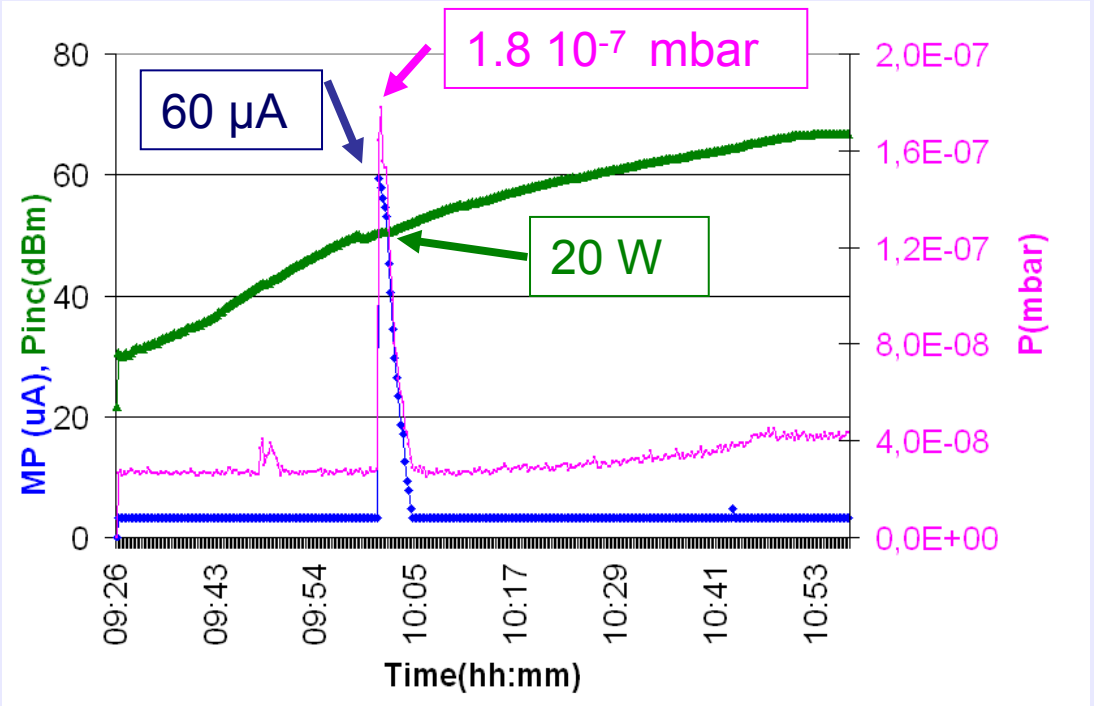
Processing at LPSC till 12 kW CW standing wave

Coupler preparation at LPSC Grenoble:

- Ultrasonic bath during 15 min @ 50°C with Ticopur
- Baking during 60 h @ 200°C and 10^{-2} mbar
- Oven is vented with flow-controlled (< 1l/min) N_2 filtered alphagaz 2
- Baking in situ during 30 h @ 90 °C and around 10^{-8} mbar

Coupler processing at cryomodule β =0.07 / CEA SACLAY

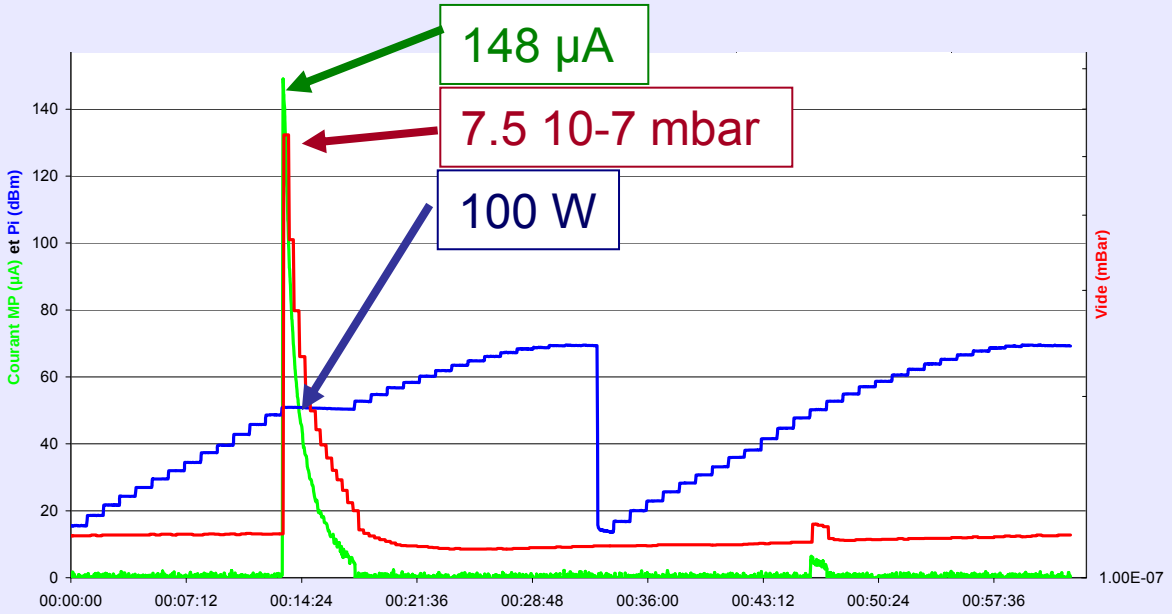
Coupler integration at the low energy- cavity.



Processsing at 4.2 K

- Power coupler conditioned up to 10 kW CW at 300K and 4.2K
- Multipacting barriers (< 200 uA) at very low power (< 200 W)
- The nominal accelerating field (6.5 MV/ m) has been reached

Coupler processing at cryomodule β =0.12 / IPN ORSAY



Processsing at 4.2 K

- Power couplers conditioned up to 10 kW CW at 300K and 4.2K
- Multipacting barriers (< 200 µA) at very low power (≤ 200W)
- The nominal accelerating field has been reached

Coupler status

- All couplers have been manufactured.
- 17 couplers have been processed.

Summary

- The coupler has been optimised:
  - A new design of clamps and supports bear 8g accelerations (more than 6g measured during transport)
  - A hot, dry , cleaned air system is implemented to avoid condensation for the window
  - The coupler's window is not coated.
- The manufacturing is finished
- Power couplers have been conditioned successfully in both cryomodules types
- The remaining couplers processing is under way

THANK YOU

- From LPSC
  - Maud BAYLAC
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  - Julien GIRAUD
  - Roger MICOUD
  - Myriam MIGLIORE
  - Jerome MORFIN
  - Francis VEZZU
- From CEA Saclay
  - Pierre BOSLAND
- From IPN Orsay
  - Guillaume OLRY
  - Philippe SZOTT
- From GANIL
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  - Marco DI GIACOMO
  - Robin FERDINAND