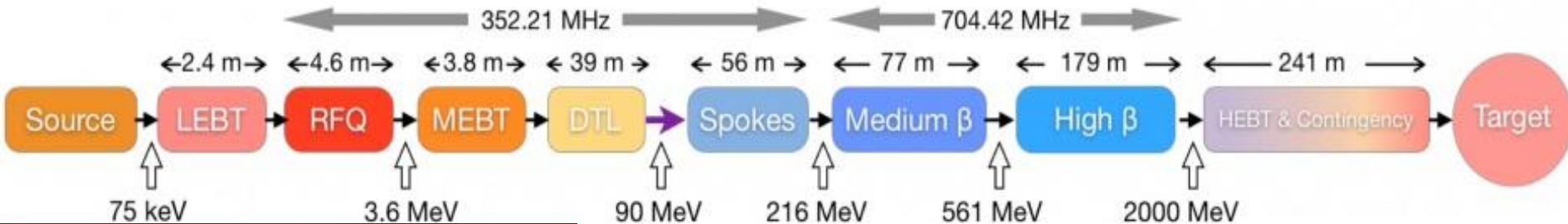


DE LA RECHERCHE À L'INDUSTRIE



STATUS OF THE RF POWER COUPLERS FOR THE ESS ELLIPTICAL CRYOMODULE PROTOTYPE M-ECCTD

Optimus+



SLHIP5 (March 18, 2015) | Christian Arcambal

GENERAL PRESENTATION OF THE PROTOTYPE COUPLER

Development strategy	P.04
General characteristics	P.05

STATUS OF COUPLER PARTS

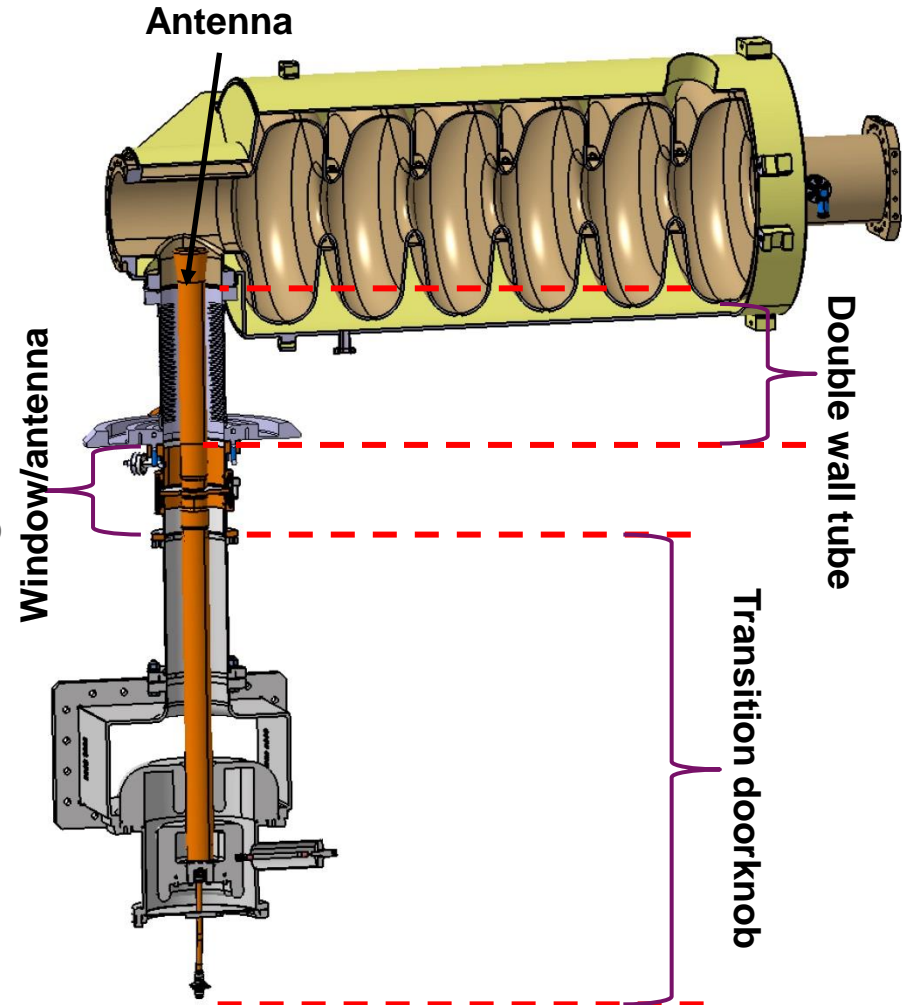
Coupler parts (double wall tube, window, doorknob transition)	P.8
Conditioning box	P.14
Schedule	P.16

CONCLUSION & OUTLOOK	P.17
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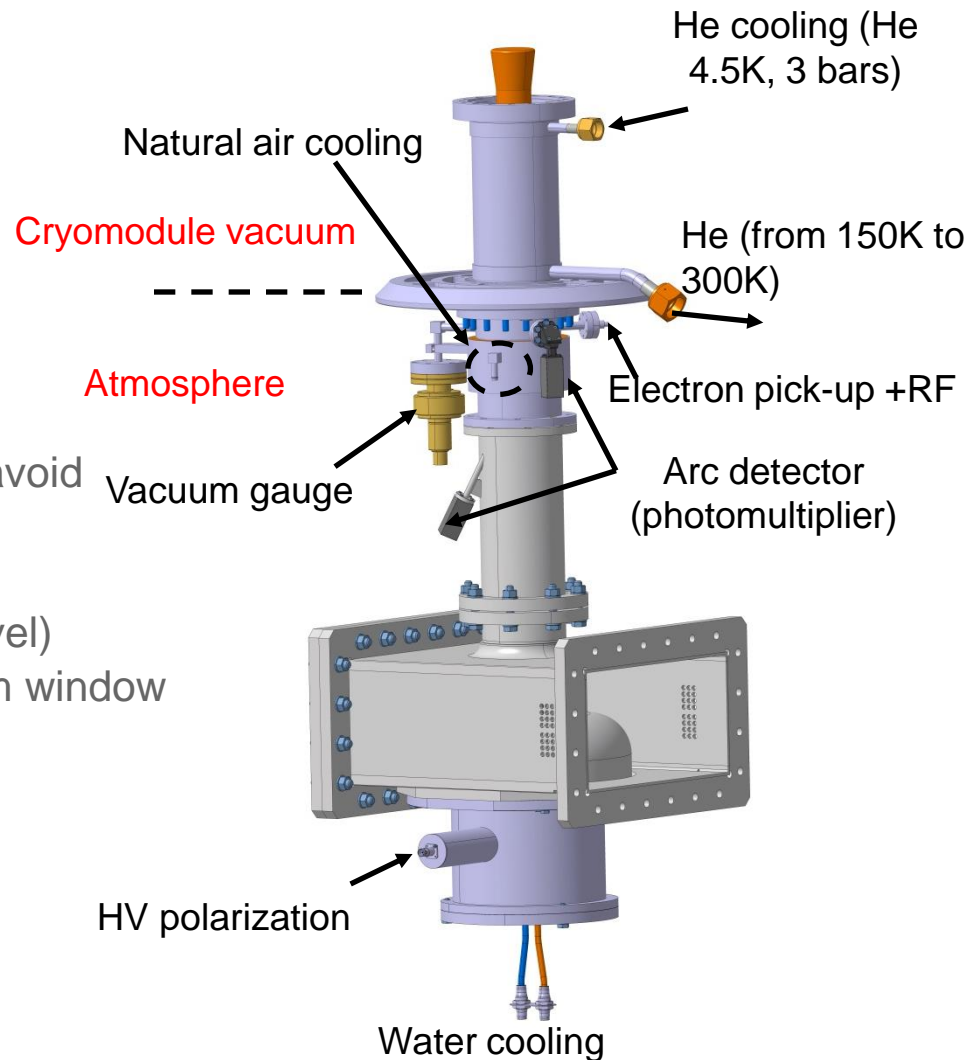


GENERAL PRESENTATION OF THE COUPLER PROTOTYPE

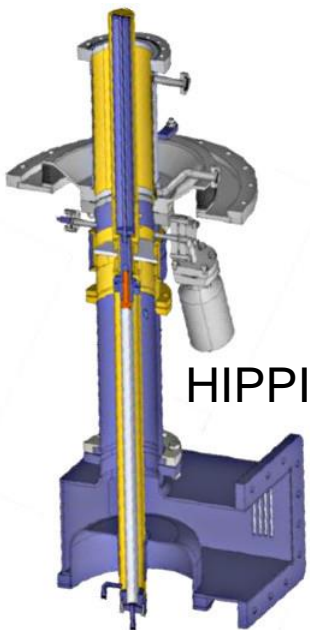
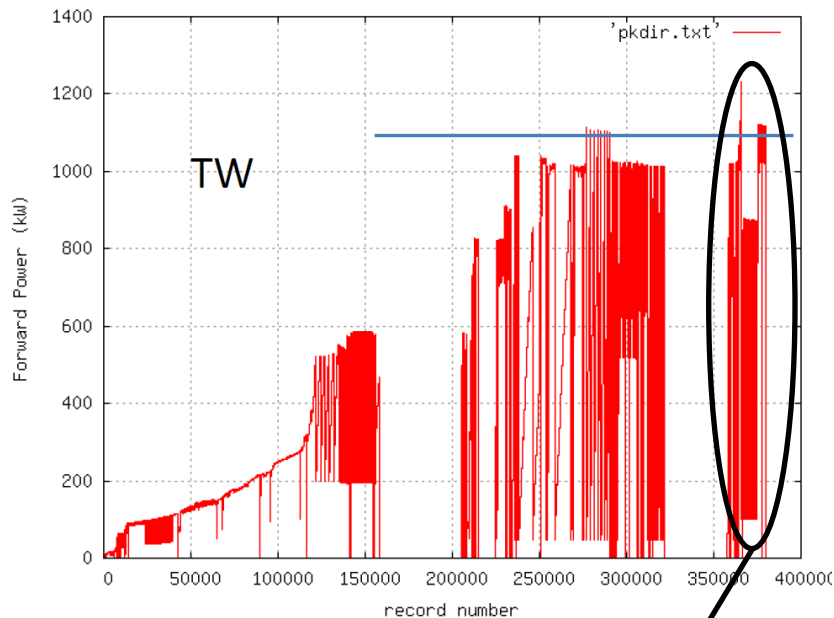
- 4 couplers per cryomodule
- Coupler very similar to the HIPPI coupler
- The coupler procurement divided into 3 main parts
 - * Double wall tube
 - * Window (with antenna)
 - * Doorknob transition
- Couplers common to medium beta and high beta cavities
 - * Same window and same transition doorknob
 - * Different double wall tube (tube length to be adjusted)
- Prototype need: 4 couplers for the medium β cryomodule prototype
- Procurement: 6 couplers (4+ 2 spares)



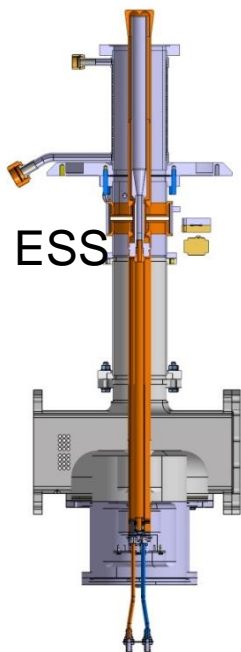
- Frequency: 704.42MHz
- Power: 1.1MW peak
- Beam pulse width: 2.86ms
- $F_{rep}=14\text{Hz}$
- Cooling:
 - He for the double wall tube
 - Natural air for the window
 - Water for antenna
- High Voltage polarization of the antenna to avoid multipactor (10kV)
- Control instruments
 - * Electron pick-up / RF control (window level)
 - * Arc detector with photomultiplier (vacuum window side/ air window side)
 - * Vacuum gauge (IKR70 Pfeiffer)



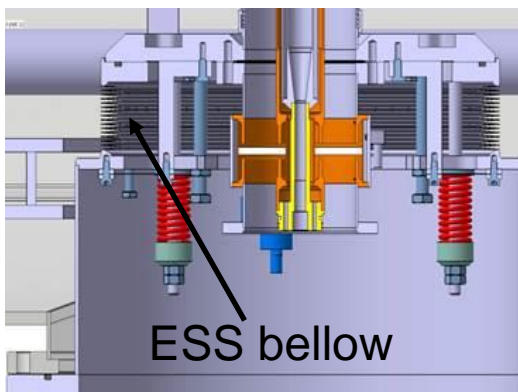
- Same window tested with HIPPI klystron
 - *Pmax klystron:1MW
 - *HIPPI window tested at 1.1MW
 - *HIPPI klystron power limitation at 1.2MW (outgassing of the gun)
- Bellow removed from the double wall tube to allow an easier cleaning (bellow on the ESS cryomodule)
- HV polarization added (+ RF trap)



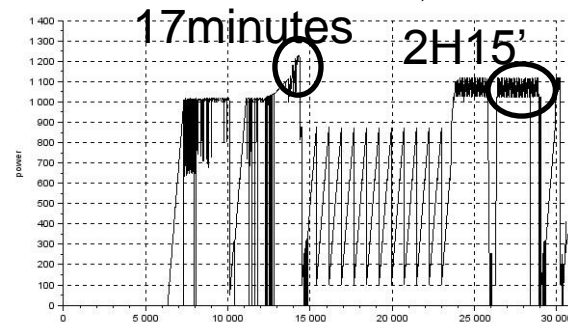
HIPPI



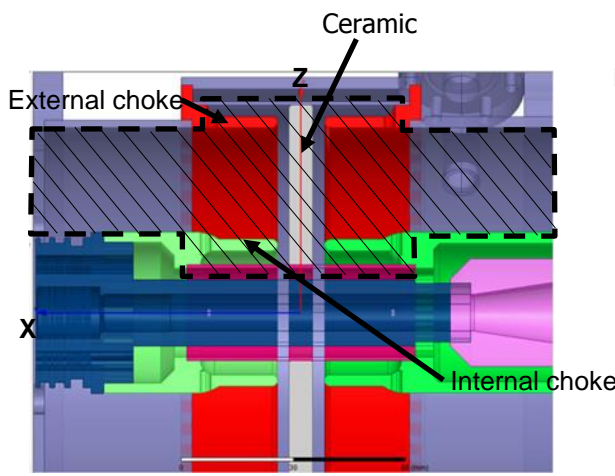
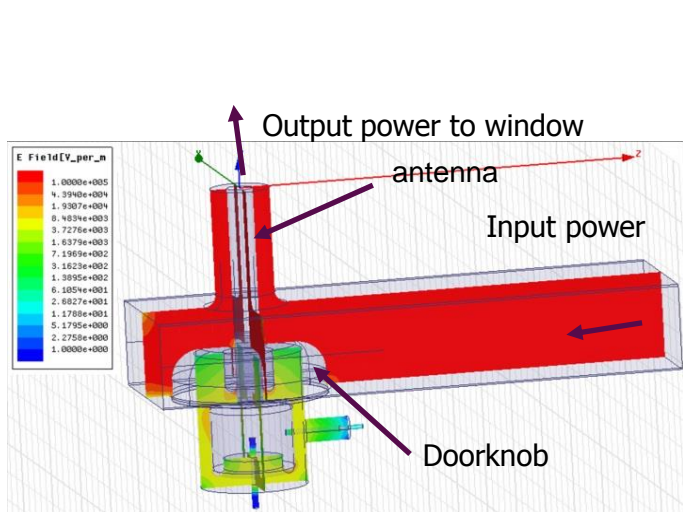
ESS



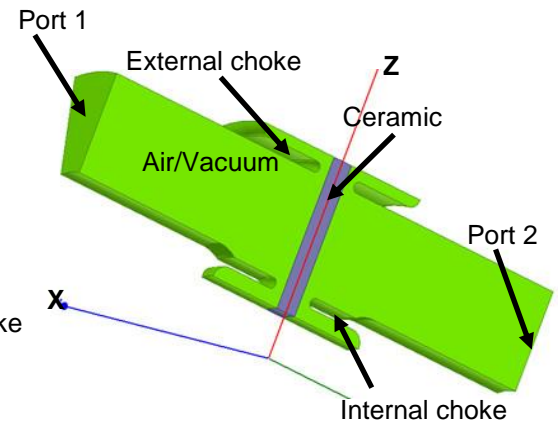
ESS bellow



- Calculation of the power at doorknob transition level (HFSS simulation)
- Calculation of the power at window level (chokes taken into account)
- Analytical estimation for the other part of the antenna



▨ : Modeled part Window cut



Simulation model

$$P_{antenna} = \frac{1}{2} R_s \times \iint_{Surface} |Ht|^2 dS$$

- For 1.1 MW peak, duty cycle 5%, in travelling wave 58W (+9.3W in ceramic)
- For 1.1 MW peak, duty cycle 5%, in standing wave 135W with ceramic losses (40W)



STATUS OF THE COUPLER PARTS
DOUBLE WALL TUBE
WINDOW
DOORKNOB
+
CONDITIONING BOX

■ Procurement

- * Need: 6 double wall tubes (4 + 2 spares)
- * Kick-off meeting (T0=March 13, 2015): Sominex
- * Delivery of the tubes: T0 + 7 months (October 2015)

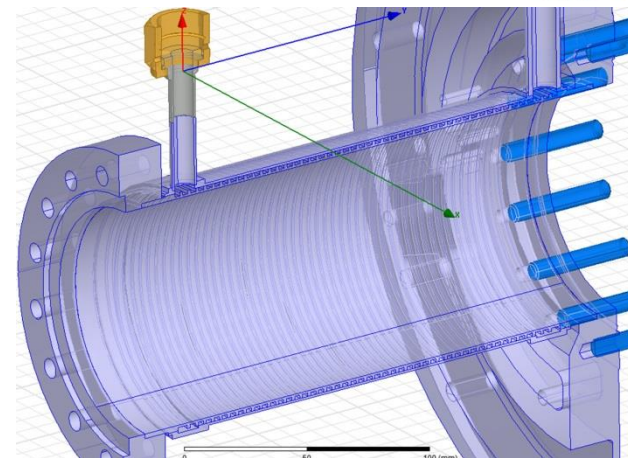
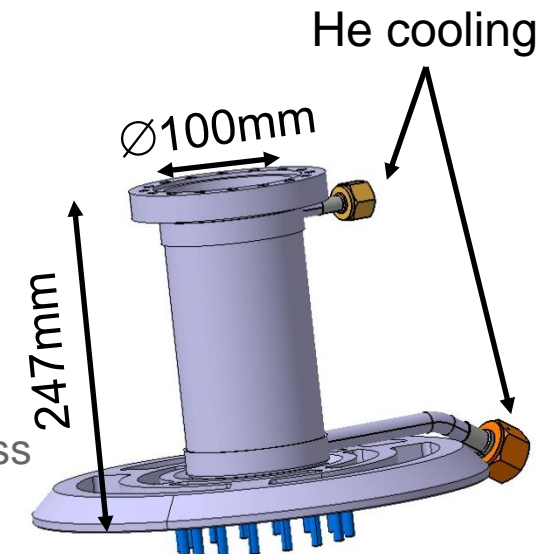
■ Specific characteristics

- * Copper coating (thickness : $10\mu\text{m}$, $-3\mu\text{m}/+2\mu\text{m}$),
RRR $\in [20,40]$
- * 3 helical channels for the cooling

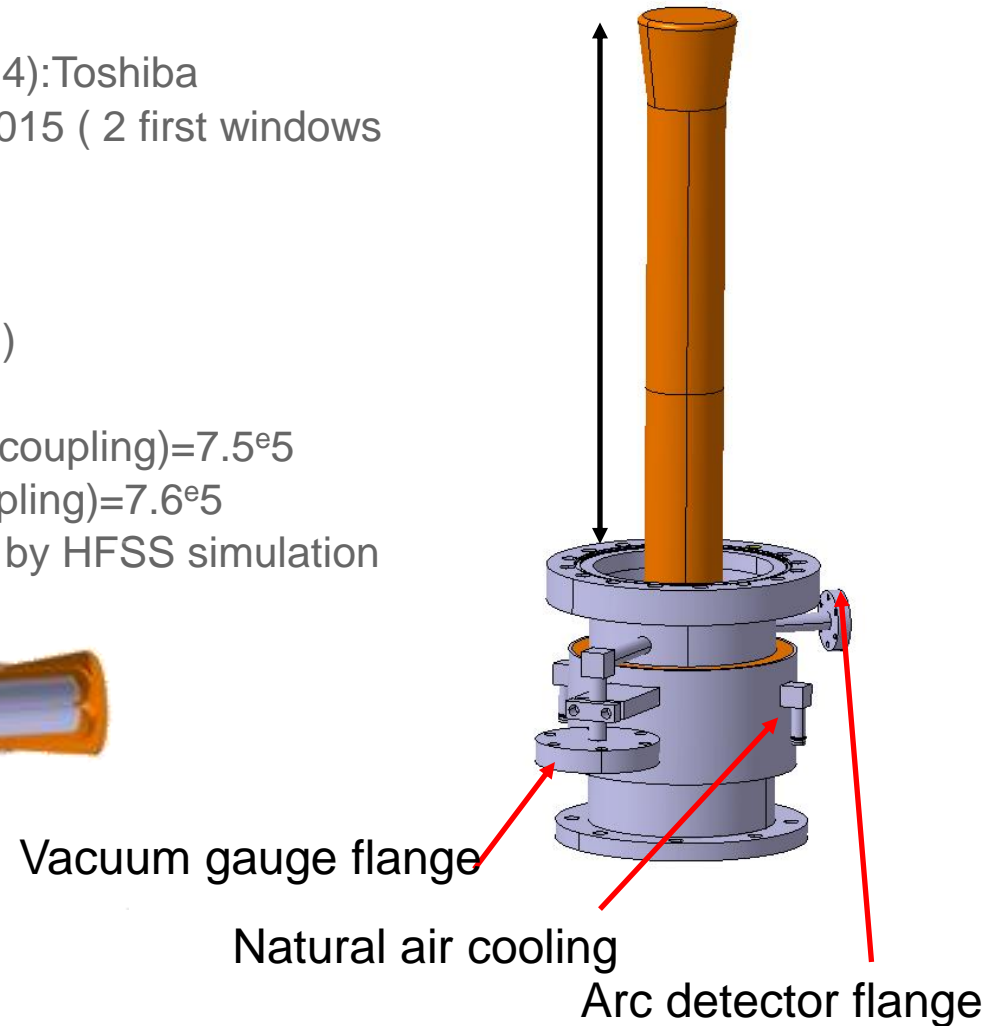
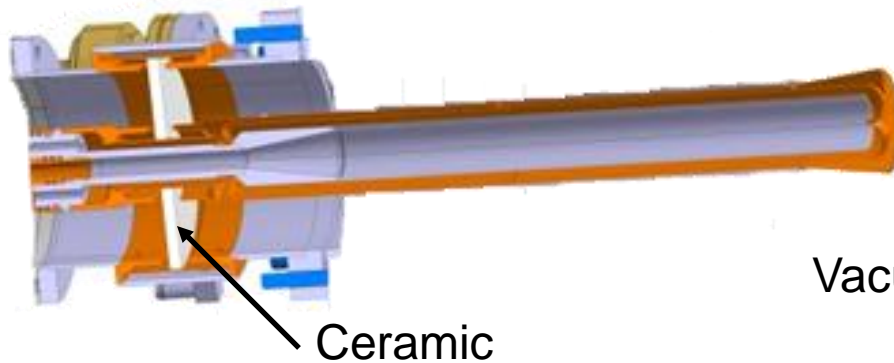
■ Study of the tube cooling (influence of RRR, copper thickness on the He mass flow to limit heat losses at 1W)

■ Tests during manufacturing

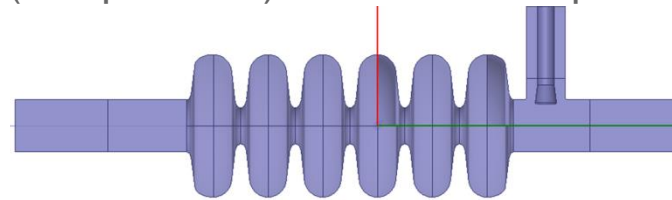
- * Control of copper coating
- * Vacuum tightness tests
- * Pressure test for the cooling channels
- * Dimensional control



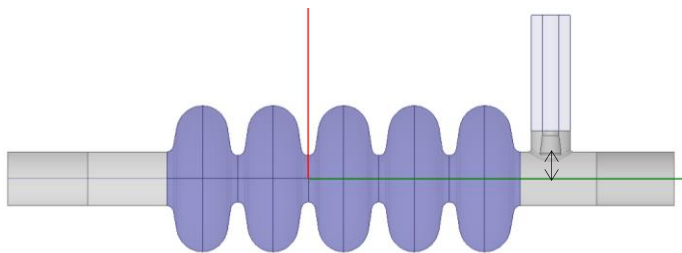
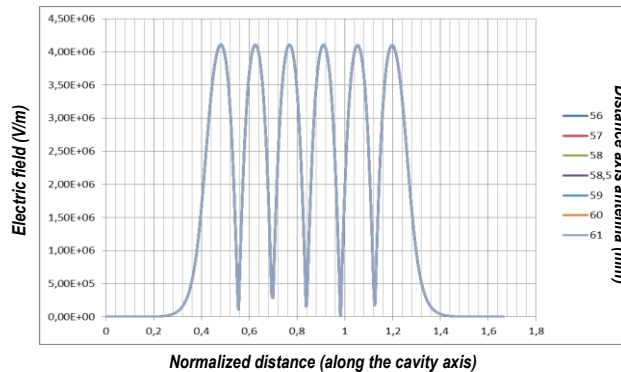
- Procurement
 - * 8 windows to be manufactured
 - * Kick-off meeting (T0=October 22,2014):Toshiba
 - * Delivery of the windows: November 2015 (2 first windows delivered in September 2015)
- Specific characteristics
 - * Copper coating (30 μ m +/-10 μ m)
 - * TiN coating on ceramic (10nm +/-5nm)
- Quality coefficient
 - * For medium β cavity couplers : Q_{ext} (coupling)=7.5 $\times 10^5$
 - * For high β cavity couplers : Q_{ext} (coupling)=7.6 $\times 10^5$
 - ⇒ Determination of the antenna length by HFSS simulation



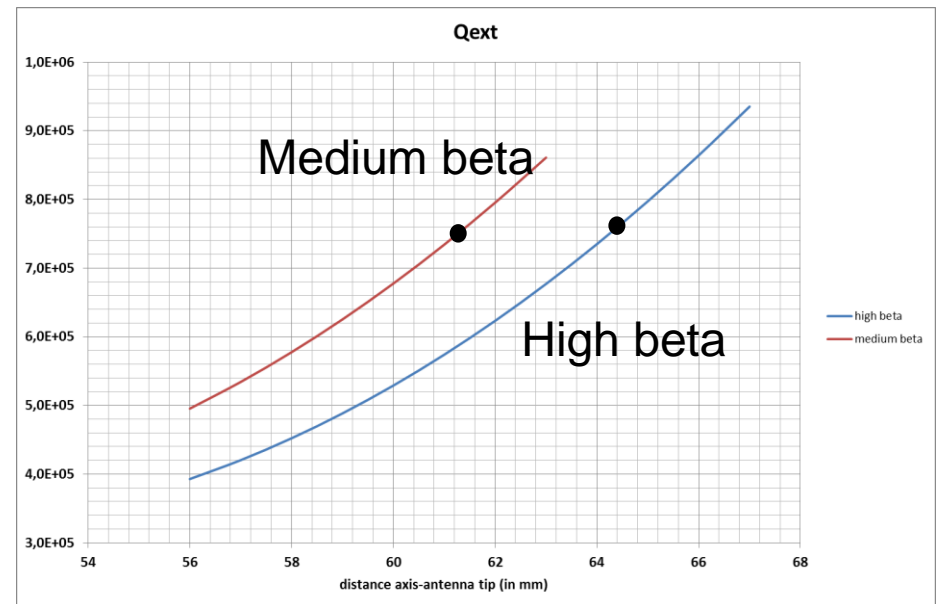
- Procedure to evaluate the antenna length
 - * HFSS simulation to determine the distance cavity axis –antenna tip + curve interpolation : dist=61.26mm for the medium β cavity, dist= 64.41mm for the high β cavity
 - * Taking into account the seals (compression) and thermal expansion of the double wall tube (stainless steel 316L)



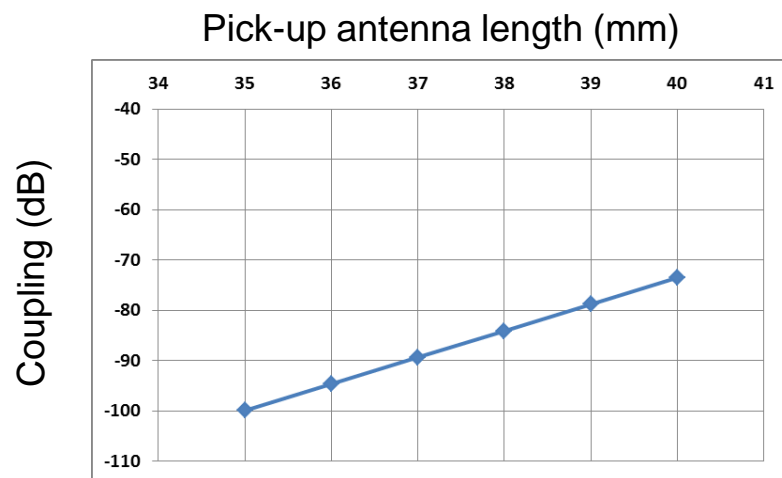
HFSS model of the medium β cavity and coupler



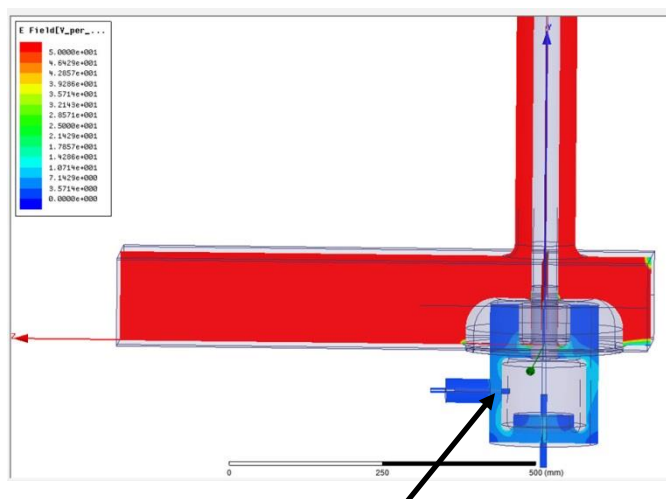
HFSS model of the high β cavity and the coupler



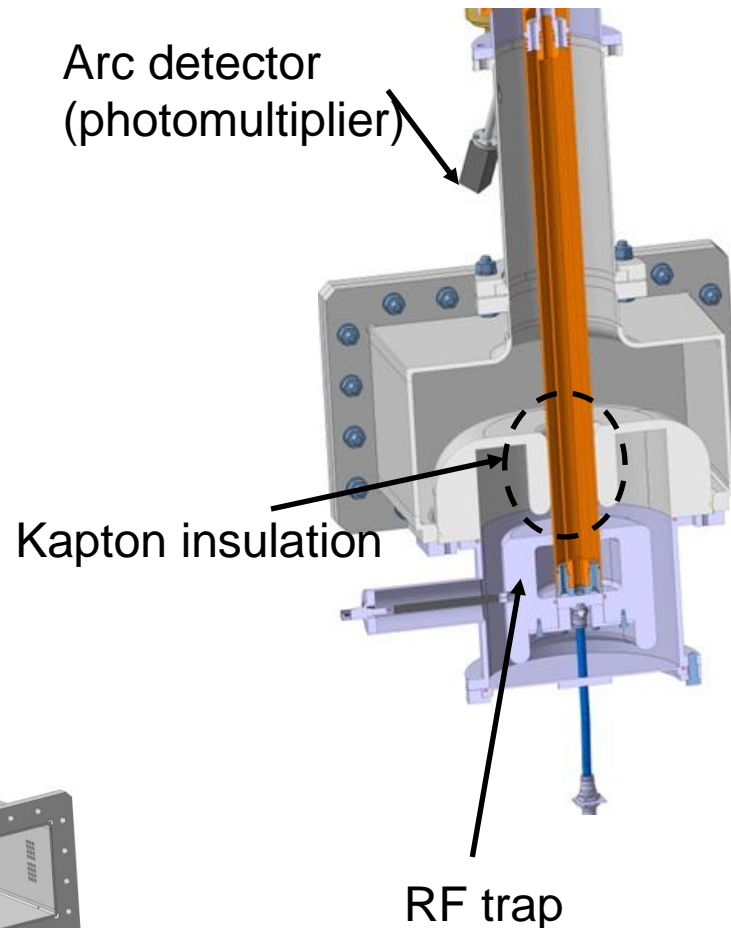
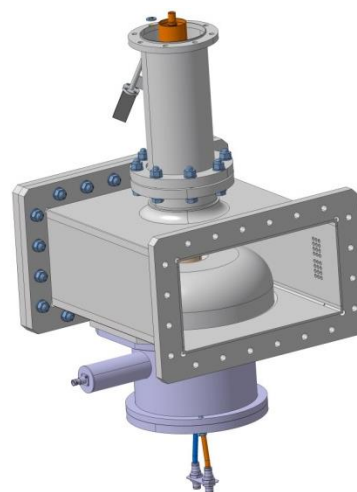
- Foreseen tests and controls during manufacturing
 - * TiN coating check on vitreous carbon samples (RBS, Rutherford backscattering spectroscopy)
 - * Control of copper coating, insulation, vacuum-tightness, pressure in the cooling circuits
 - * Dimensional control
- Electron pick-up definition
 - * Antenna to collect electrons and to measure the image of RF power at the ceramic level
 - * Determination of the antenna length to obtain a coupling between -80 & -90dB
⇒HFSS simulation



- Procurement
 - * Need: 6 doorknobs
 - * Tender foreseen at the end of March 2015 (delivery at the end of September)
 - * Statement of work completed, writing of the tender by commercial department
- Specific characteristics
 - * Kapton insulation (10kV)
 - * RF trap to allow insulation with HV



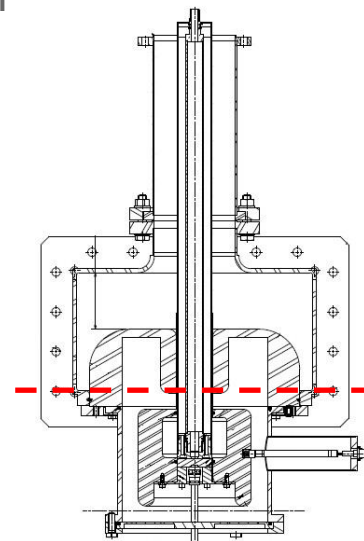
Dissymmetry and low E field



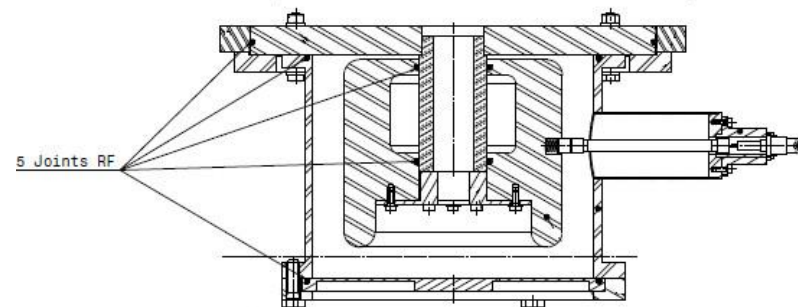
- Mock-up to check
 - * The assembly procedure at the RF trap with the RF seals
 - * The definition of seal grooves
 - * The seal performance when assembly and disassembly



Spring seal



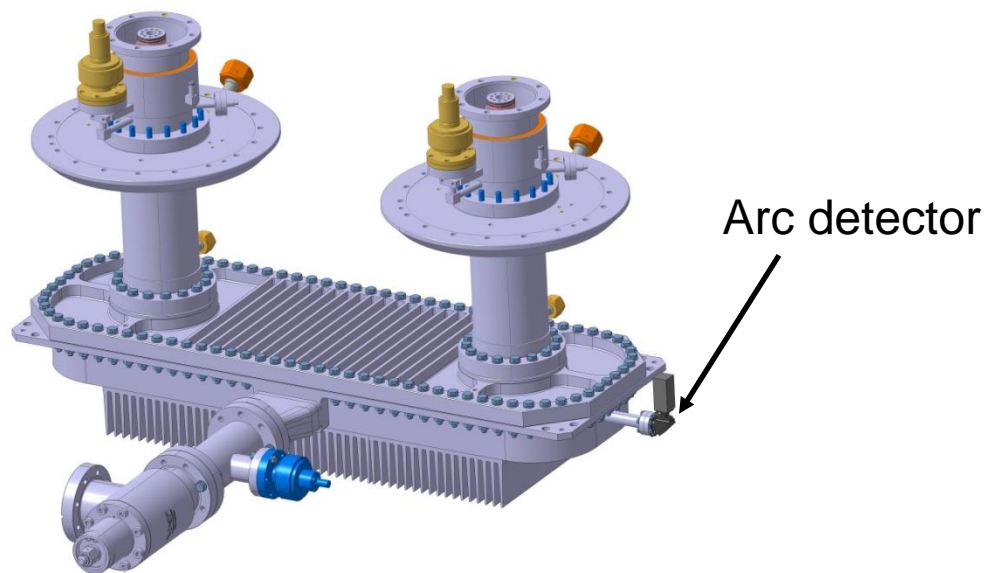
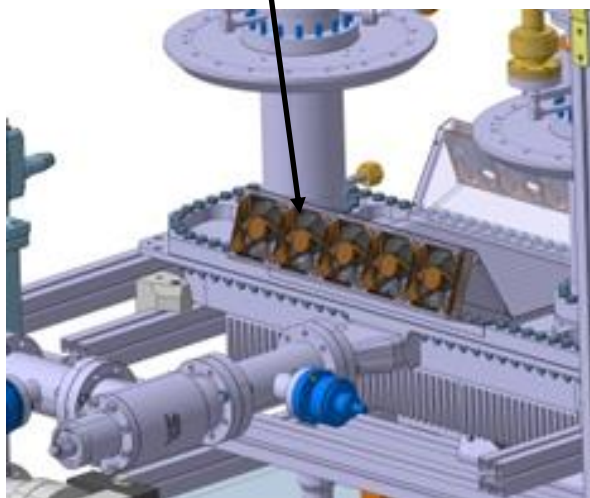
Tested part



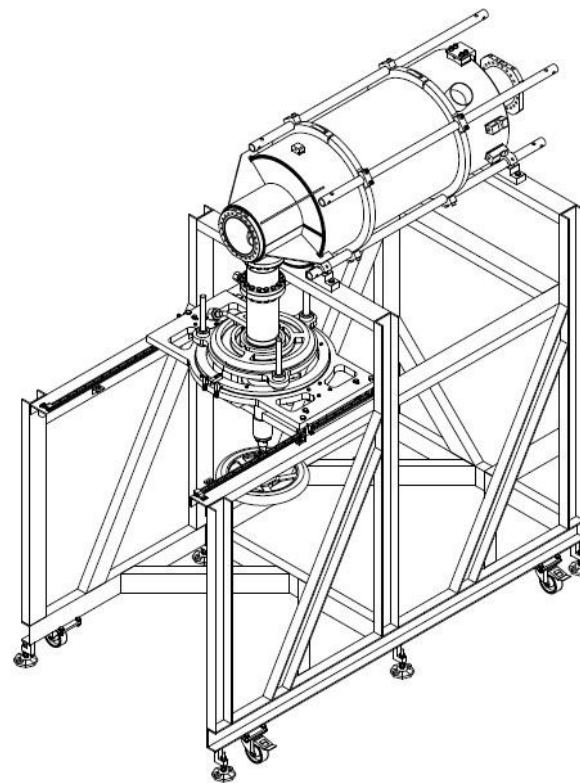
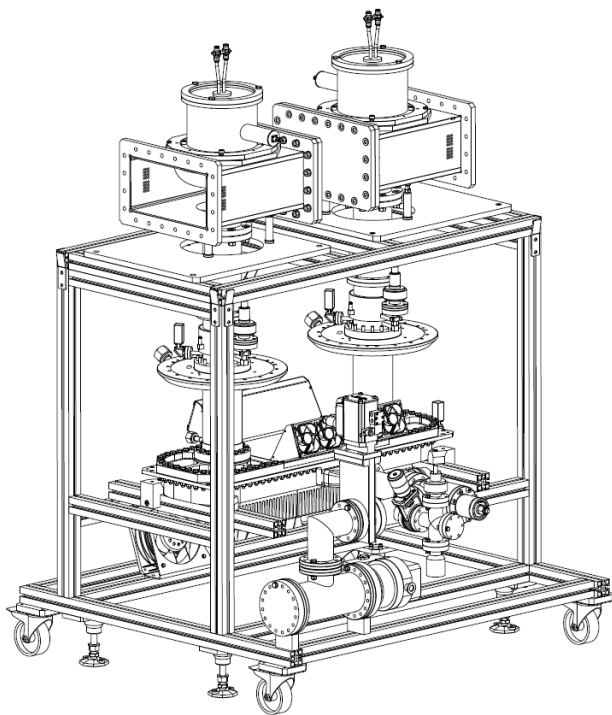
Mock-up with 5 seal locations

- Conditioning box for 2 couplers
- Mechanical, thermal and RF study of the conditioning box performed (Comsol simulations)
 - * Box in stainless steel 316L under vacuum without copper coating
 - * Cooling by forced air (fans) + temperature probes on the box
- Procurement
 - * Need: 3 conditioning box
 - * Statement of work completed, tender to be launched

Fans



- Drawings for the conditioning bench completed
- Drawings for the coupler assembly on a cavity completed
- Study of other tools for assembly and test \Rightarrow Based on HIPPI experiment
- Next phase: procurement



- Goal: in October 2015, a whole coupler (double wall tube, window, doorknob transition)
 - *window: until November 2015, manufacturing and delivery (first pair in September 2015)
 - *double wall tube: until November 2015, manufacturing and delivery (first pair expected in October 2015)
 - *doorknob: tender until end of April then manufacturing and delivery until October.
 - *conditioning box: tender until end of April then manufacturing and delivery until October 2015
 - *Electron pick-up: in April 2015, completed drawing then manufacturing and delivery until September 2015
- Tooling (for acceptance test, preparation, cleanroom assembly and cavity assembly)
 - *in April 2015: end of study
 - * From May to September 2015: procurement, manufacturing, delivery
- RF conditioning:
 - *from December 2015 to January 2016: 1st pair
 - *From February to March 2016: 2nd pair
 - *From April to May 2016: 3rd pair
- When 4 couplers are ready, assembly on the cavity

- Schedule: 1 pair of couplers in October 2015, 3 pairs in November 2015. Preparation and RF conditioning in December 2015.
- All mechanical, RF, thermal studies completed
- Coupler procurement
 - * Double wall tube: in progress, kick-off meeting performed
 - * Window: in progress, kick-off meeting performed
 - * Doorknob transitions: tender to be launched
- Conditioning box: tender to be launched
- Definition of all the tools to be completed (study, drawing, procurement)
- Writing of the test procedures for the coupler

CEA coupler team:

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M. Luong

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THANKS FOR YOUR ATTENTION

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