

# Progress on the SRF developments for the high intensity projects in Europe

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TTC meeting JLAB Nov. 5 2012

# SPIRAL 2

## SC LINAC

- RIB installed in GANIL Caen
- Deuterons (5 mA) and ions up to  $q/A=1/6$
- Temperature: 4.5 K
- Frequency : 88 MHz
- $E_{\text{acc}}$  max : 6.5 MV/m

$\sim 35$  m

**7 high beta CMs**

14  $\beta = 0.12$  cavities

**IPN Orsay**

**12 Low beta CMs**

12  $\beta = 0.07$  cavities

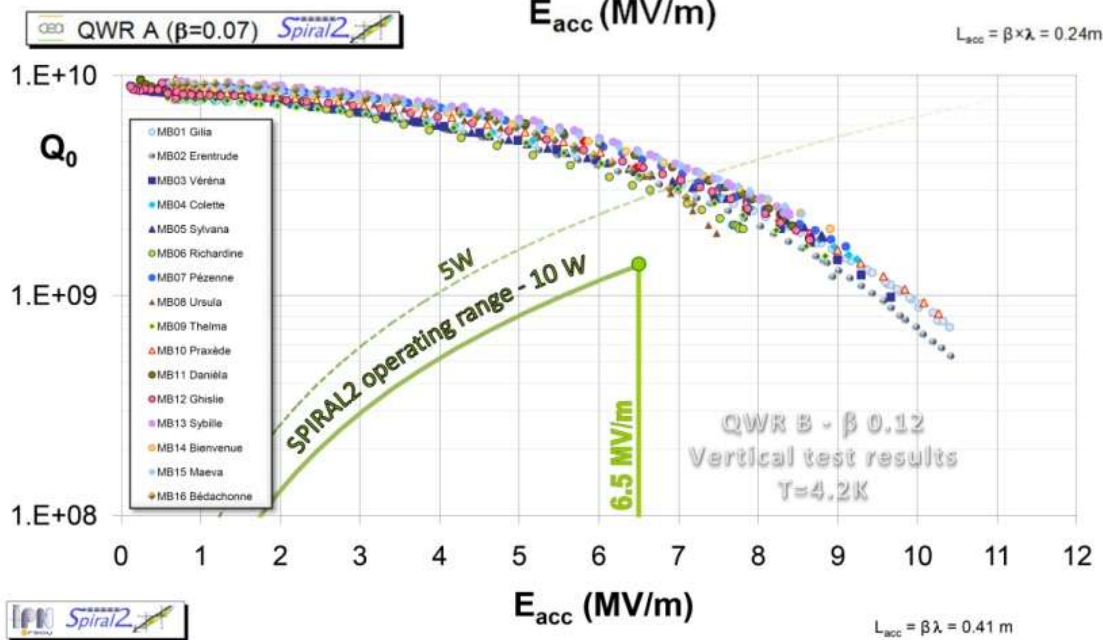
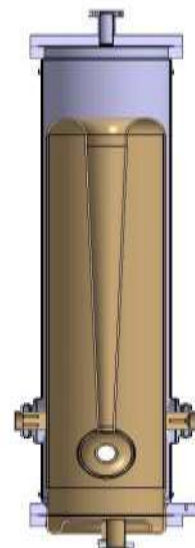
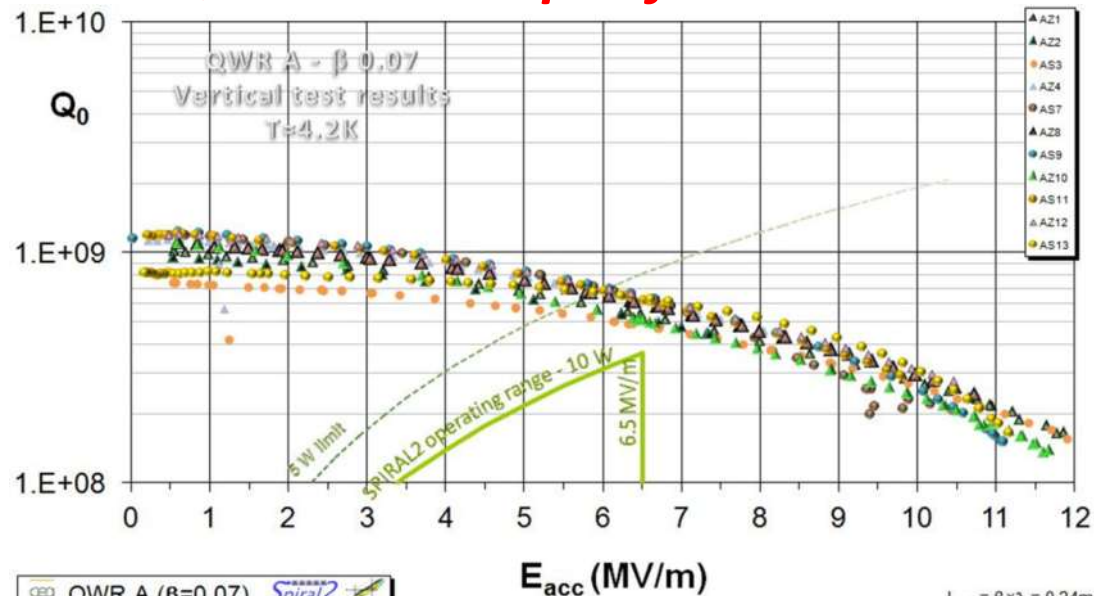
**IRFU Saclay**

**28 power couplers**

**LPSC Grenoble**

# SPIRAL 2 QWRs

*All QWRs above specifications in VT*



# CM status

- All components of the CMs are delivered
- Main activity of 2011-2012 period : looking for the source of strong FE and heating of cavities during cryomodule tests



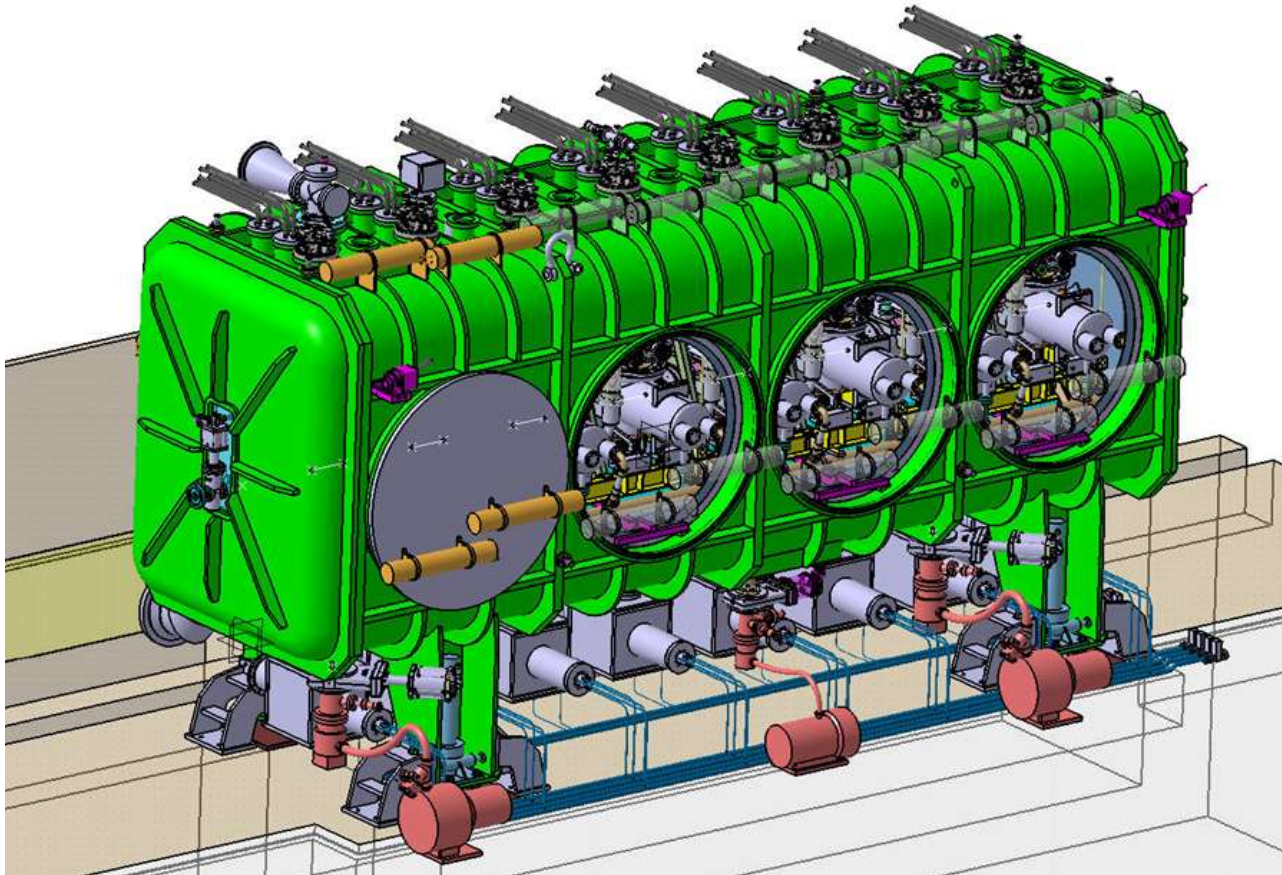
Discharge marks on coupler tip  
after high beta CM test (2010)  
Cavity Eacc limitation in CM =  $\frac{1}{2}$   
max. Eacc in VT



- Improved the power coupler cleaning procedure, now including 50  $\mu\text{m}$  EP on antenna, more thorough contamination control for the clean room assembly of vacuum components, pulsed conditioning of couplers
- Status
  - 2 low-beta CMs tested to specifications, one with a pre-2011 setup, one with 2012 procedures for FPC and vacuum components
  - No high beta CM tested with new procedures due to test area upgrade in 2012. Fully rebuild CMs (including plunger tuner with reduced hysteresis) await test

*More details in D. Longuevergne talk on tuesday*

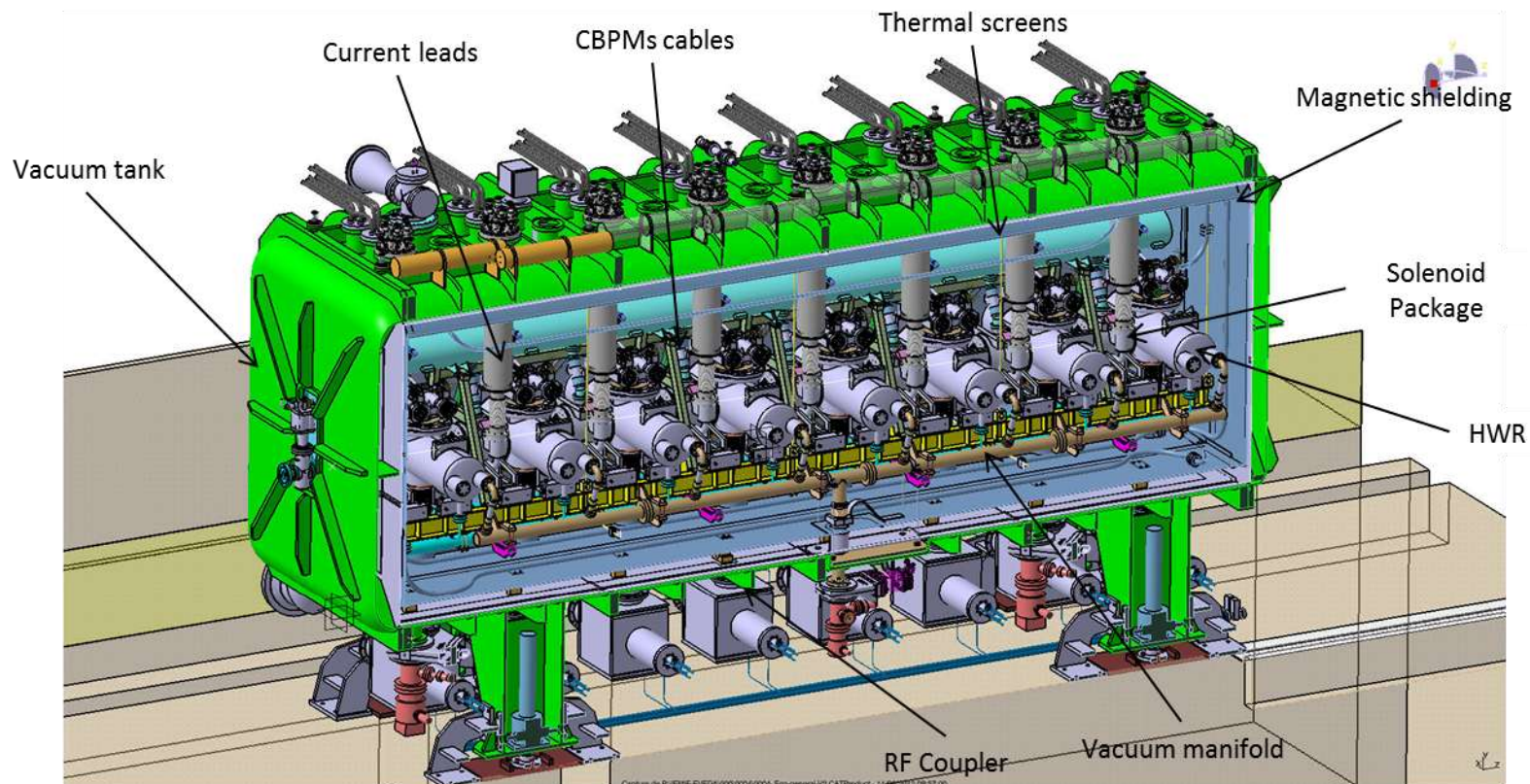
# IFMIF EVEDA



CW 125 mA deuteron beam

EVEDA aims at validating the technology for IFMIF with a single CM (8x beta= 0.095 HWRs)

# IFMIF EVEDA



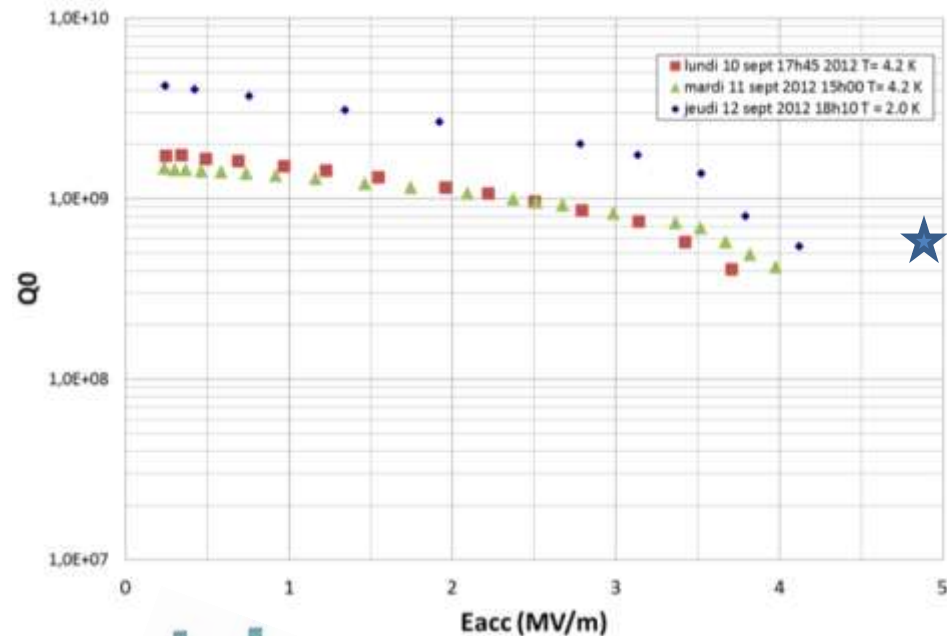
# IFMIF HWRs prototypes

Low performance of the two prototypes until summer 2012:

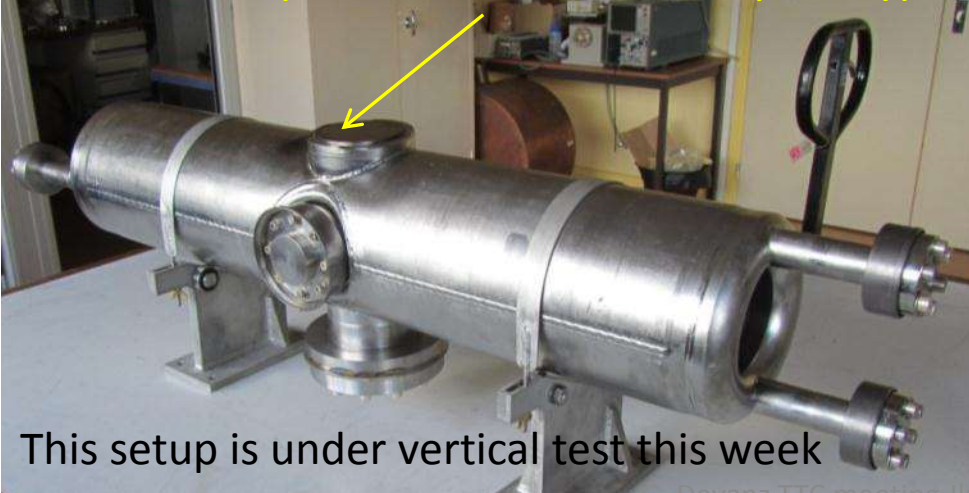
- Leaks at 4.2 K
- Early quench  $\sim 2.5 \text{ MV/m}$  (best for P01)
- Low  $Q_0 \sim 10^8$  at low field

analysis of failure :

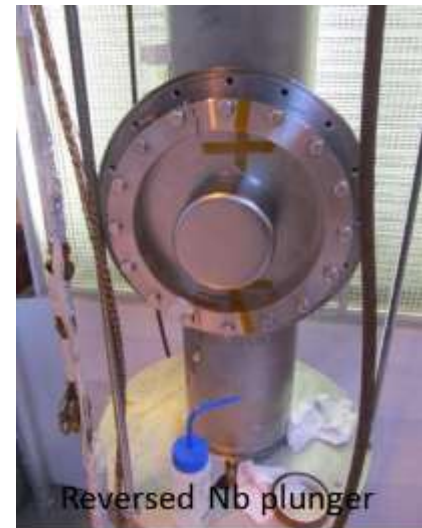
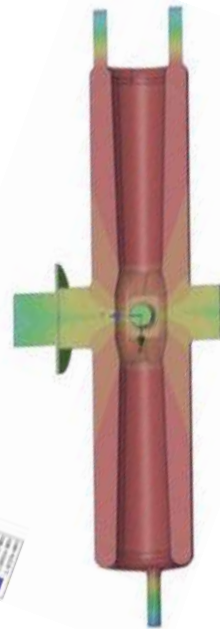
- NbTi plunger flange including weld to Nb located in too high a H field region
- Test of one prototype with in verted plunger to lower H in the flange area and prove it experimentally
- Recovered low field  $Q_0$ , quench at 4 MV/m due to sharp edges at the base of HPR ports



Former tuner port now closed on 2nd prototype



This setup is under vertical test this week

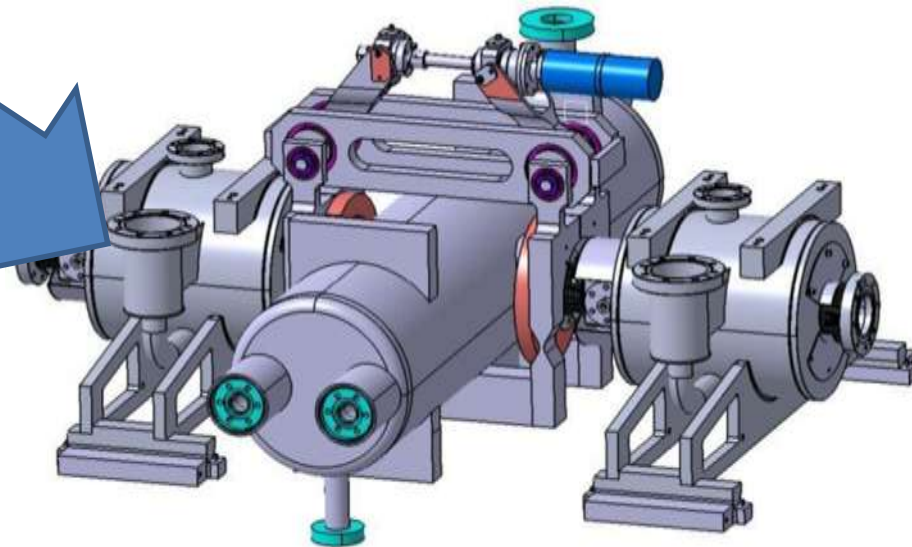
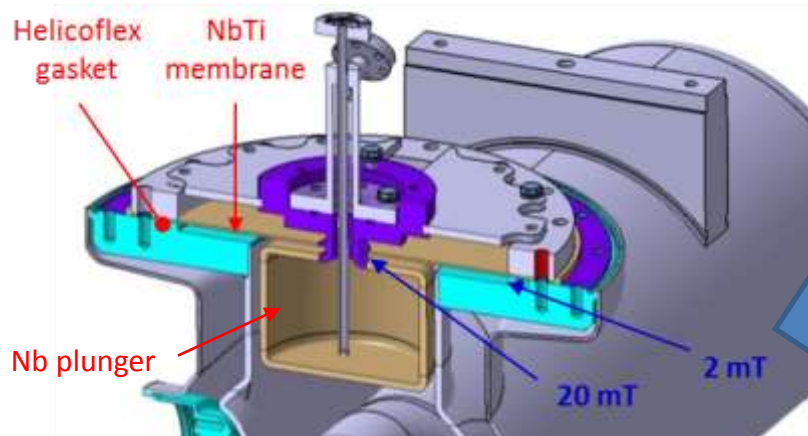


# IFMIF HWRs tuners

Plunger tuner development has been frozen, project decided to fold back to deformation tuner and extra space has been allotted around each cavity to

- > new mechanical design of the cavity and He vessel
- > deformation tuner with lever arm and dis-engagement system

*A0 plunger design*

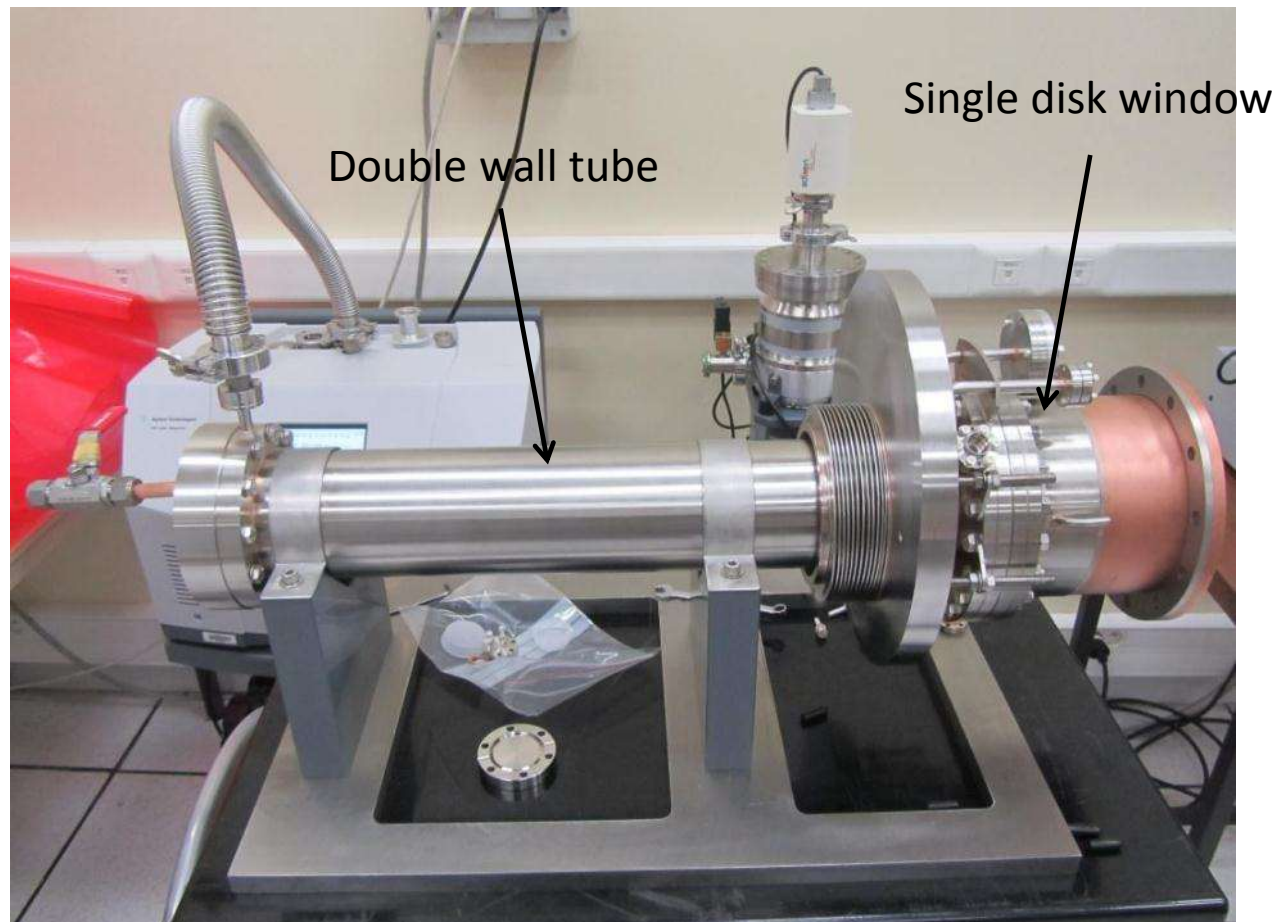
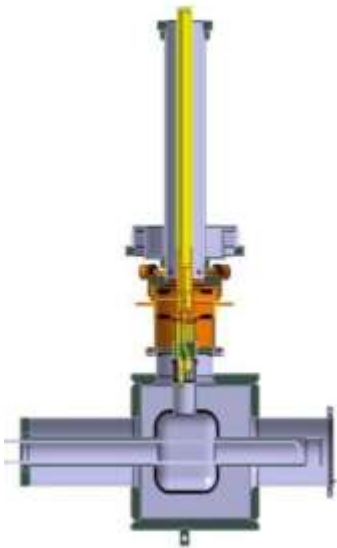


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# IFMIF – Power couplers

Couplers are designed for 200 kW CW power for IFMIF (CEA+ CPI)

Will be tested up to 80 kW CW for EVEDA phase

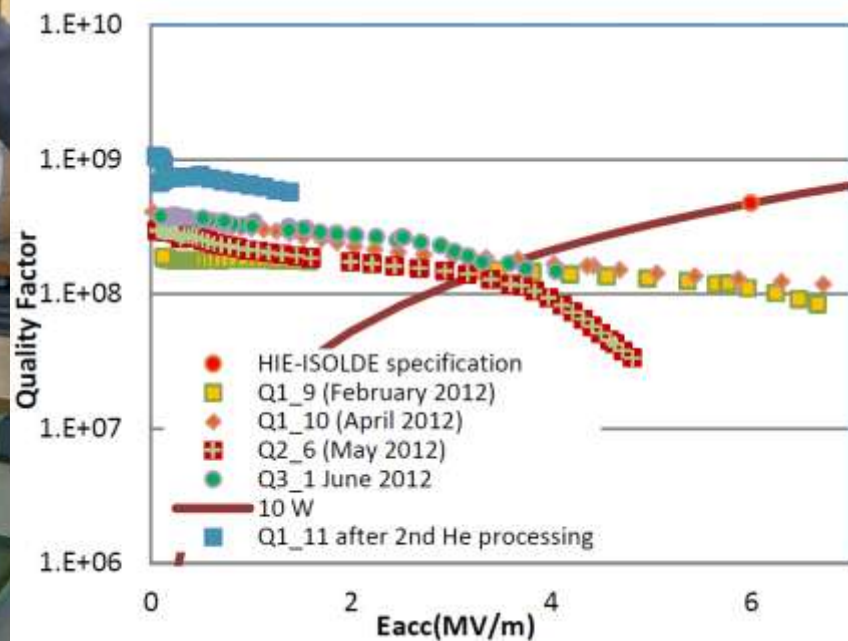
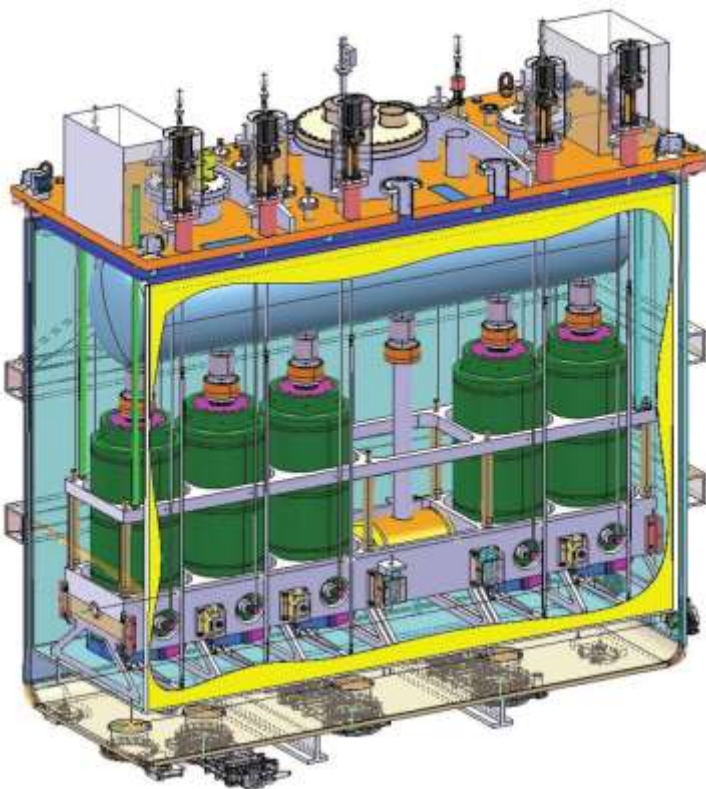


2 pre-series couplers delivered at Saclay, will be conditioned in spring at CIEMAT

# HIE Isolde

first stage of REX Isolde upgrade with two high beta 5-QWR CMs ( from 2.8 MeV/u to 5.5 MeV/u for  $q/A=1/4.5$ . Operation for physics in 2015.

NbCu technology : Cu substrate quality extremely important for Nb thin layer properties → Raw Cu material processing : multidirectionnal hot forging+cold forging



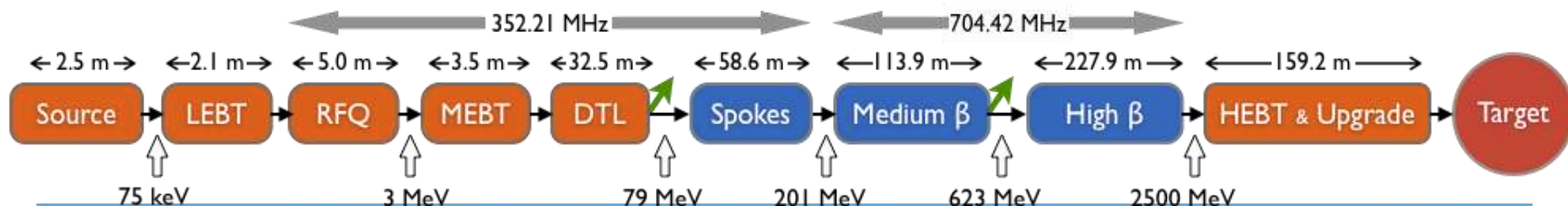
Performance improvement in 2012:  
Bulk Cu 3D machining +EBW  
instead of rolling+ deep  
drawing+EBW

More details S. Calatroni talk on wednesday

# European Spallation Source

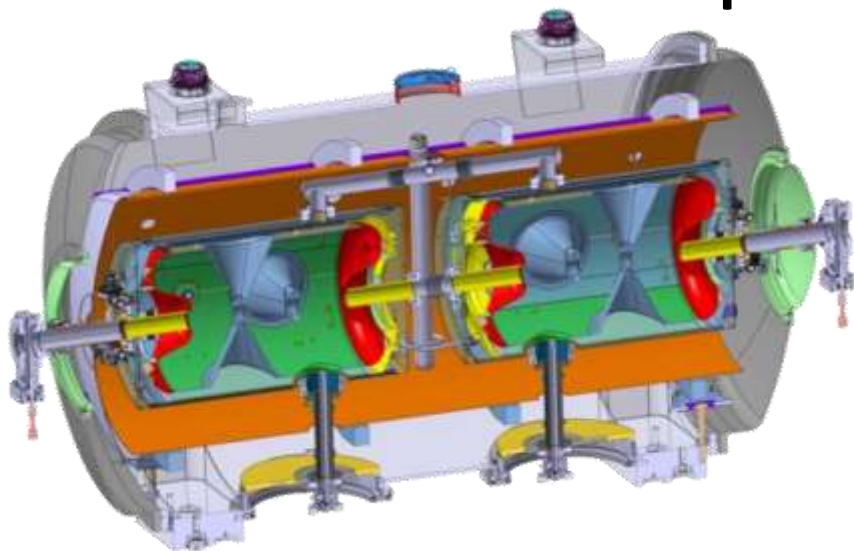
Main design choices:

- SRF linac includes a spoke cavity section
- Spokes operate at 2 K
- Short 4-cavity CMs are used for both elliptical cavity sections
- HOM couplers are discarded



	Length (m)	Input Energy (MeV)	Frequency (MHz)	Geometric $\beta$	# of Sections	Temp (K)
LEBT	2.05	$75 \times 10^{-3}$	--	--	--	$\approx 300$
RFQ	4.95	$75 \times 10^{-3}$	352.21	--	1	$\approx 300$
MEBT	3.53	3	352.21	--	--	$\approx 300$
DTL	32.58	3	352.21	--	4	$\approx 300$
Spoke	58.46	79	352.21	0.50	14 (2C)	$\approx 2$
Medium Beta	113.84	201	704.42	0.67	15 (4C)	$\approx 2$
High Beta	227.86	623	704.42	0.92	15 $\times$ 2 (4C)	$\approx 2$
HEBT (Projection)	158.66	2500	--	--	--	--

# ESS 352 MHz spoke section (IPN Orsay)



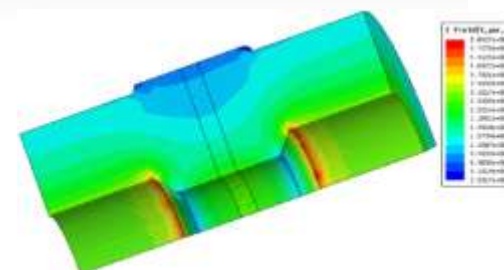
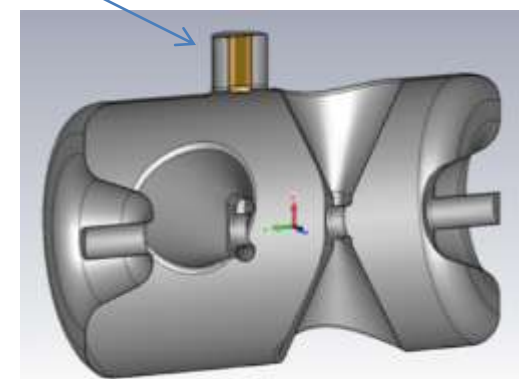
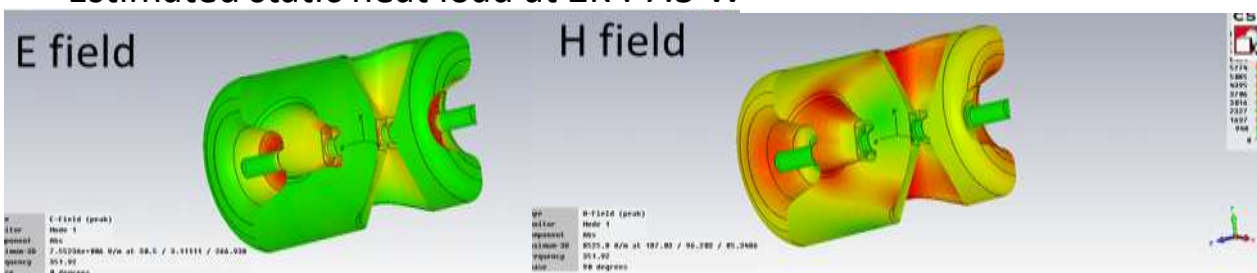
Nr of spokes	2
Optimal beta	<b>0.50</b>
Epk/Ea	<b>4.96</b>
Bpk/Ea [mT/MV/m]	<b>7.03</b>
G [Ohm]	<b>133</b>
r/Q [Ohm]	<b>428</b>
Qext	<b>2.6e5</b>
FPC port diameter [mm]	<b>100</b>

2 cavities/CM supported by rods

Ti He vessel

## Lever arm deformation tuners (incl. Piezo)

Estimated static heat load at 2K : 7.5 W



Status : RF and mechanical design done. A call for tender for

2+1 cavity by two distinct manufacturers has been issued

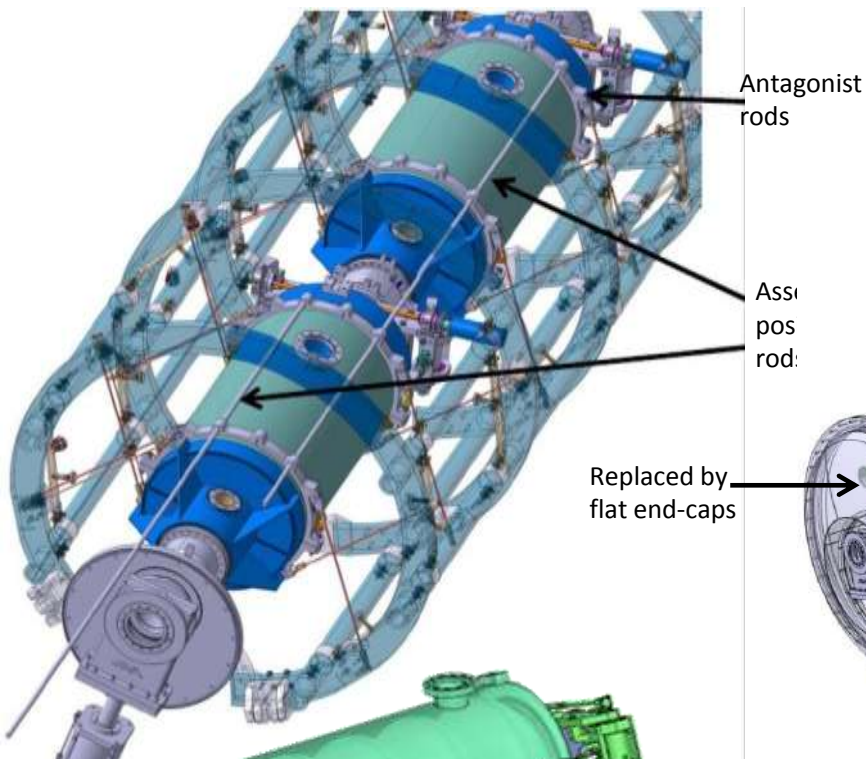
## Full test of prototype forseen in 2015

300 kW peak power

## RF window optimization

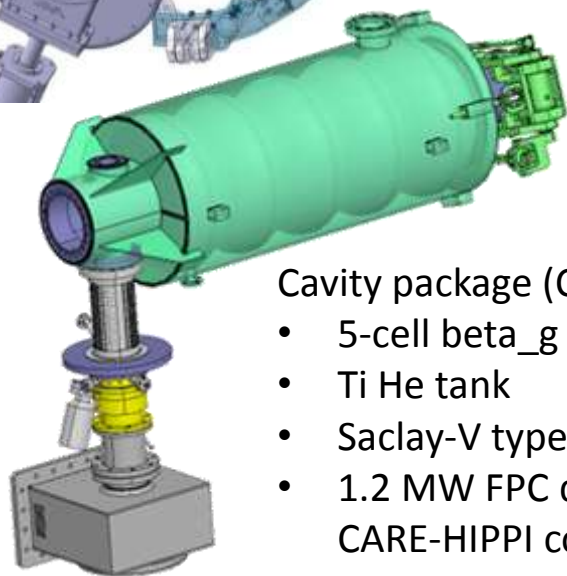
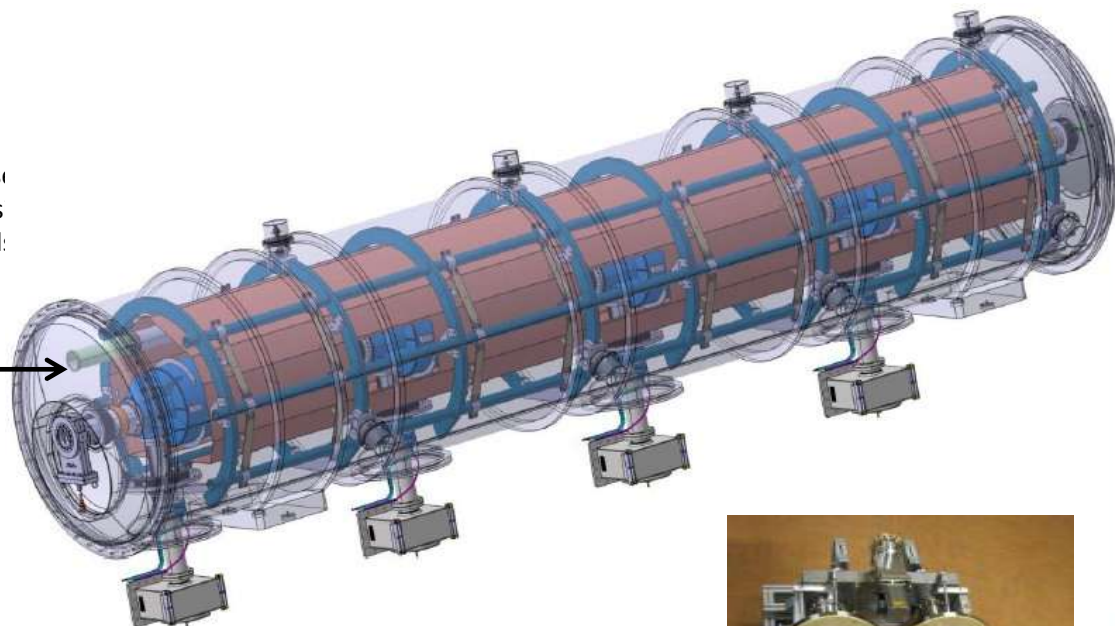
*More details S. Bousson talk on tuesday*

# ESS high beta 704 MHz elliptical section



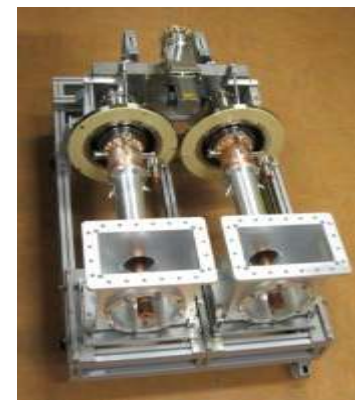
4-cavity CMs w/ SNS-like structure

Conceptual design on-going at IPN Orsay + Saclay



Cavity package (CEA Saclay)

- 5-cell beta<sub>g</sub> = 0.86
- Ti He tank
- Saclay-V type tuner
- 1.2 MW FPC derived from CARE-HIPPI coupler



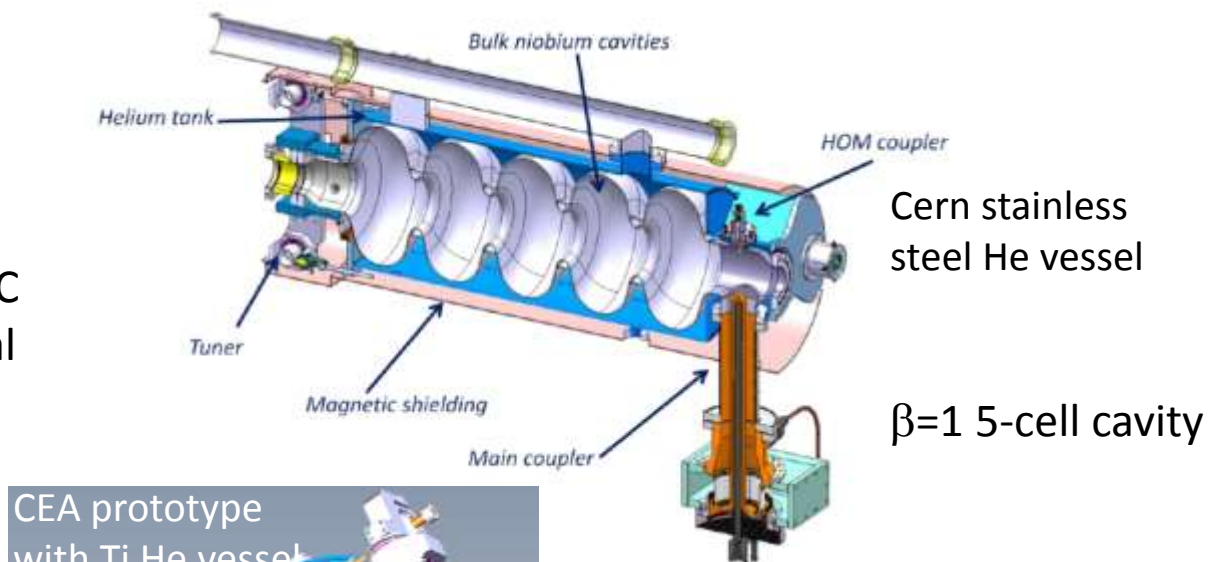
Status : 2 cavity prototypes under manufacturing in industry

# CERN SPL

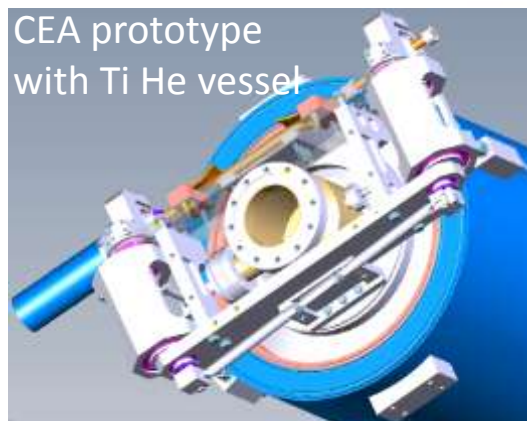
## HP SPL :

- 4 MW beam power
- 20 to 40 mA beam intensity
- 1 MW Max peak power in FPC
- Two families of 5-cell elliptical cavities

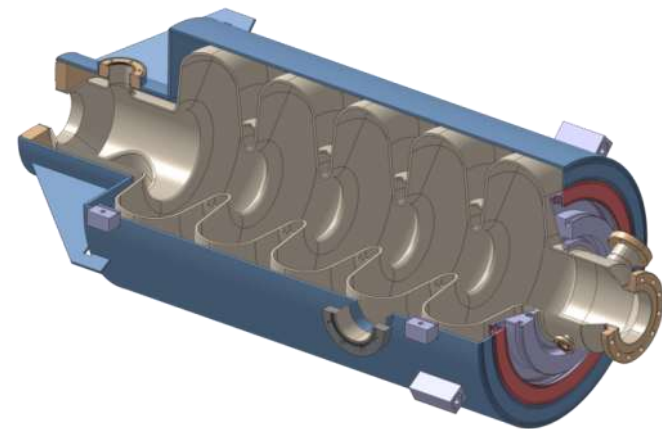
geom. beta	0.65	1
f (MHz)	704.4	704.4
Design gradient (MV/m)	19	25
Ep <sub>k</sub> /E <sub>acc</sub>	2.63	2
Bp <sub>k</sub> /E <sub>acc</sub> (mT/MV/m)	5.12	4.2
K (%)	1.45	1.9
r/Q (Ohm)	275	566
G (Ohm)	197	270



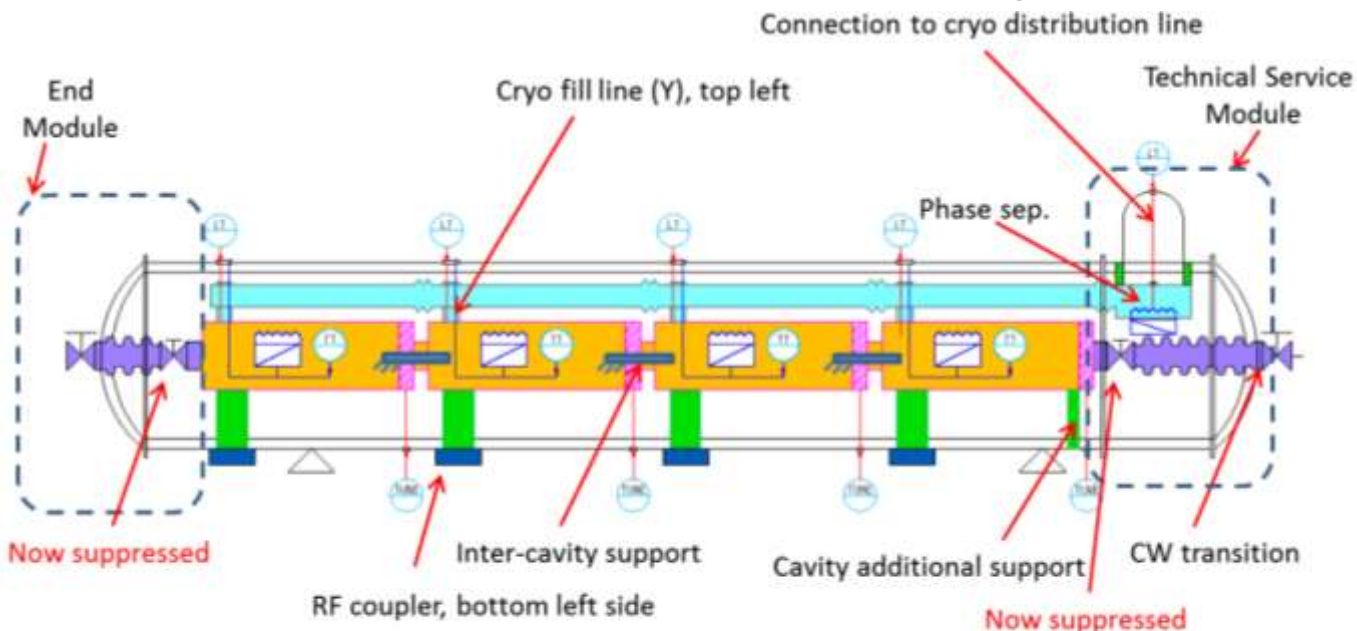
$\beta=1$  5-cell cavity



IPNO  $\beta=0.65$   
Ti He vessel

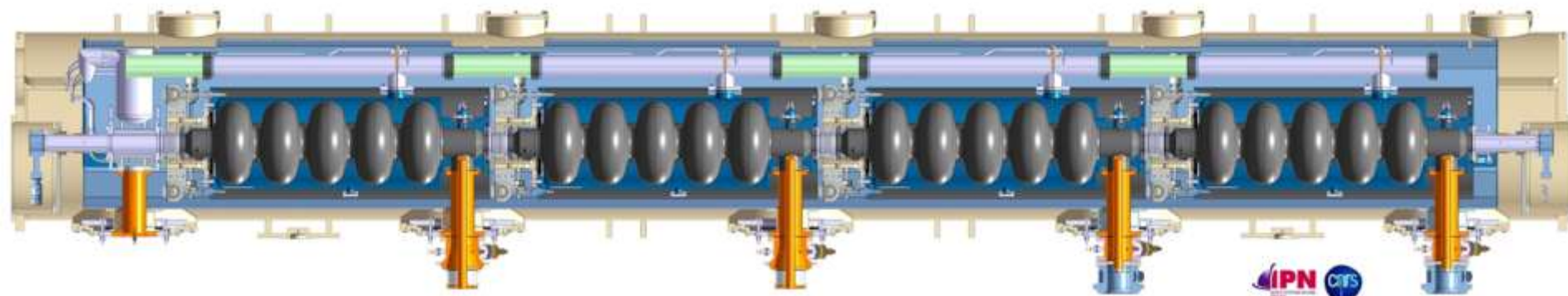


# SPL short cryomodule



CERN and IPN Orsay design

- Top loading cryomodule
- Cavities supported by power couplers
- Stainless steel He vessels



Status: detailed design on-going

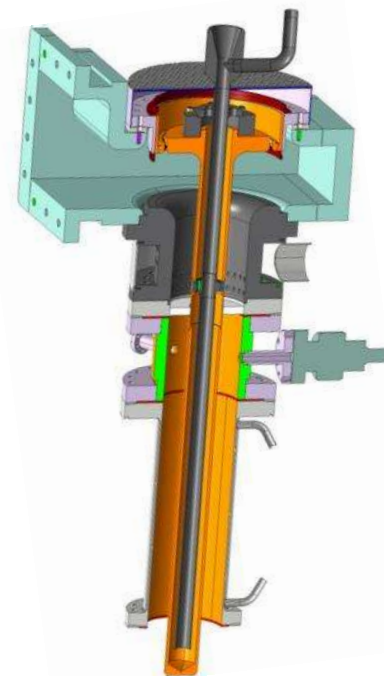
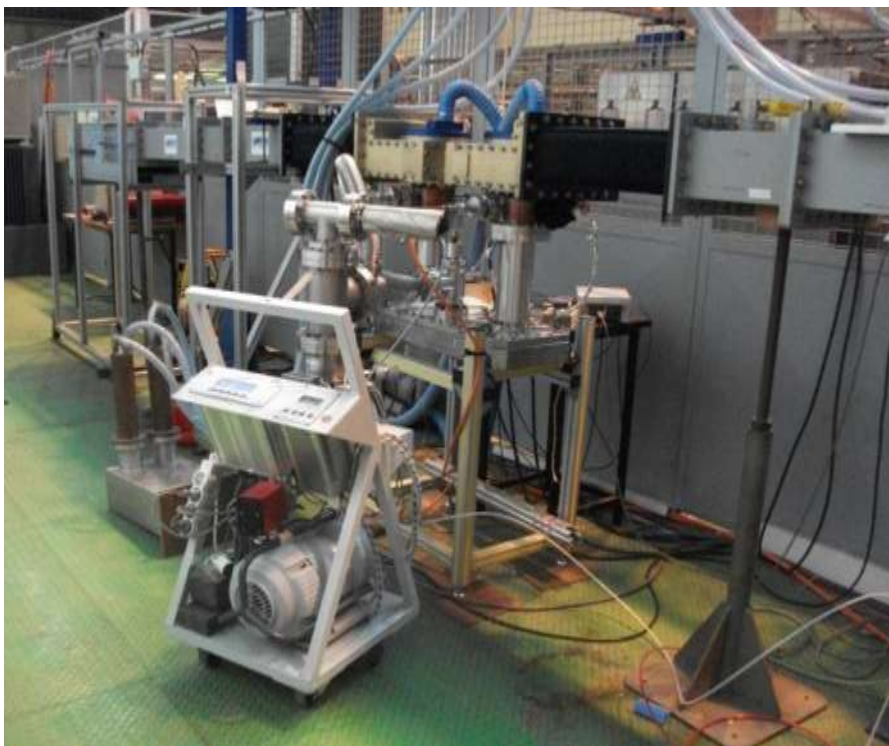
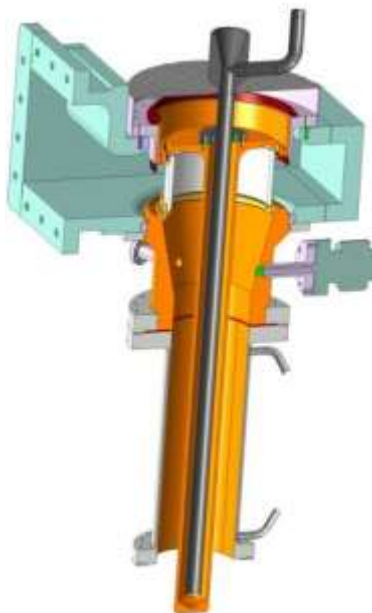
More details O. Capatina talk on wednesday

# CERN SPL couplers : RF power tests at CEA

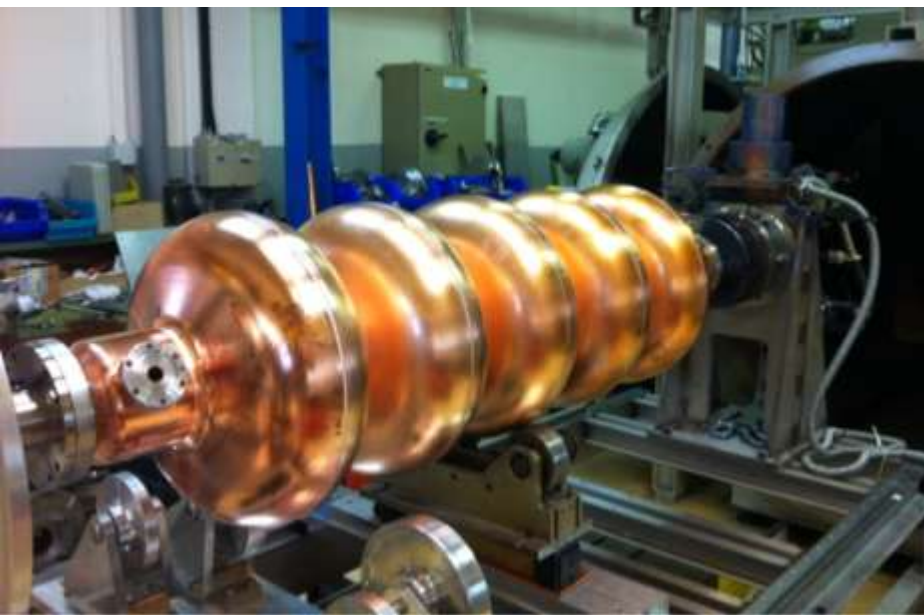
High average power **air cooled** couplers

Limitation of average power to 20 Hz (instead of 50 Hz) due to uncoated TD

- Cylindrical window :
  - TW : 1000 kW 2 ms 20 Hz
  - SW : 550 kW 500  $\mu$ s 8 Hz  
(Arcing limitation : under investigation)
- Coaxial disk window :
  - TW : 1000 kW 2 ms 20 Hz
  - SW : 1000 kW 1.5 ms 4 Hz  
(Tests pending : test bench availability)



# SPL cavity prototyping



Beta = 1 CERN copper model (EB welded)

four 5-cell cavities  
will be  
manufactured in  
industry+ one at  
CERN

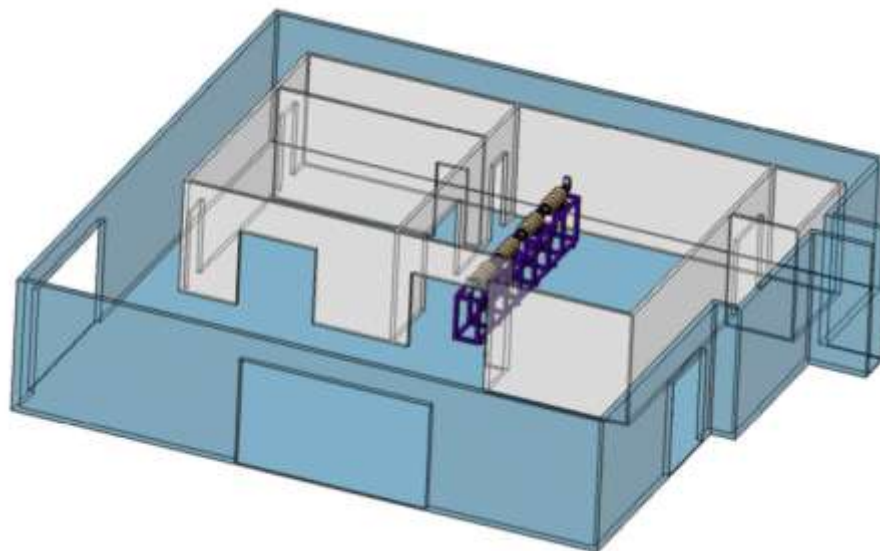
G. Devanz TTC meeting Jlab Nov. 5th 2012



# Some new infrastructures for 700 MHz SRF activities

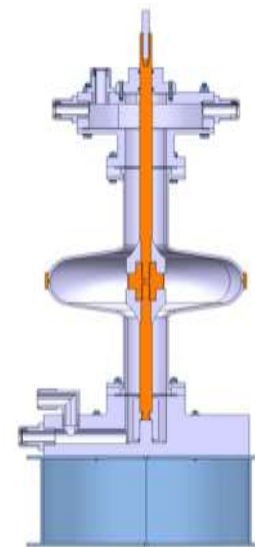


Operating Vertical EP station at Saclay:  
(Eucard beta=1 cavity, ESS HB ellipsicals,  
tested on 1.3 GHz single cells, 9-cells)

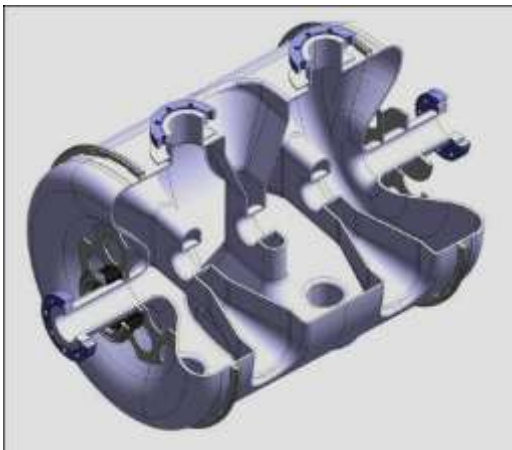


New clean room at Saclay designed for ESS prototype  
cryomodule , spiral 2 series CM assembly, build in 2013

Vertical EP at CERN:  
First tests on a  $b=0.65$  single cell cavity  
(S. Calatroni )



# Eurisol triple spoke (IPN Orsay)



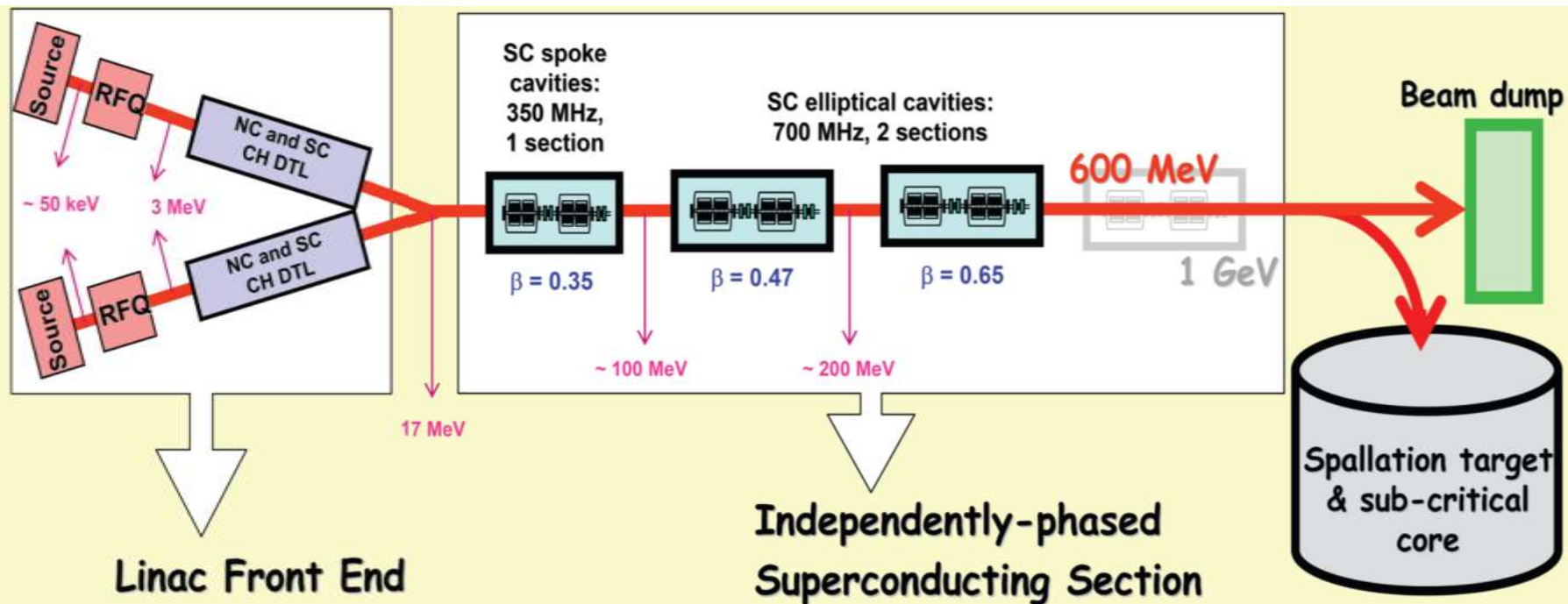
- Eacc limited to 3.5 MV/m after first chemical processing
- Cavity is now integrated in its He vessel
- It will be equipped with a plunger tuner
- A test cryostat is being equipped for horizontal testing



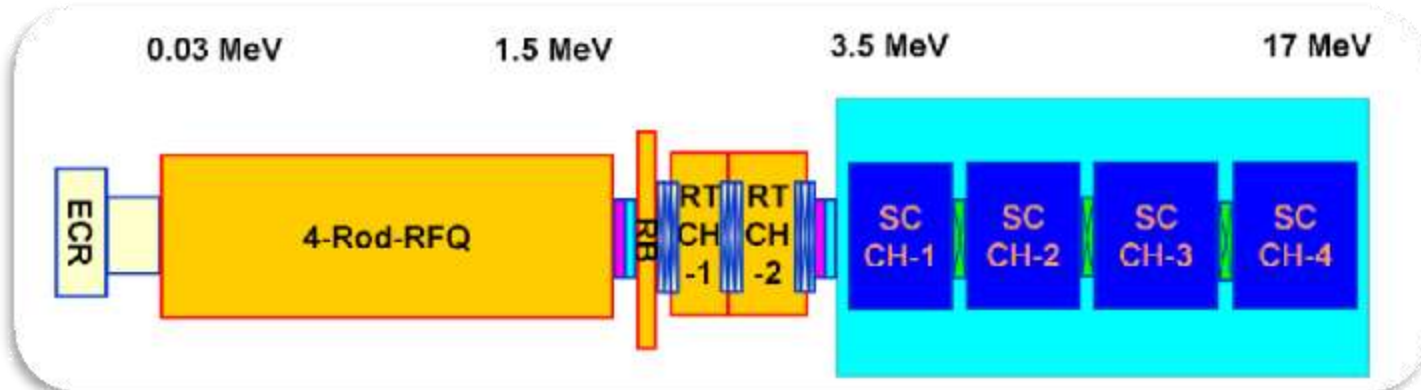
*More details in S. Bousson talk on tuesday*

# Myrrha - Generic scheme of the European ADS accelerator

Redundant injector + Modular SC main linac

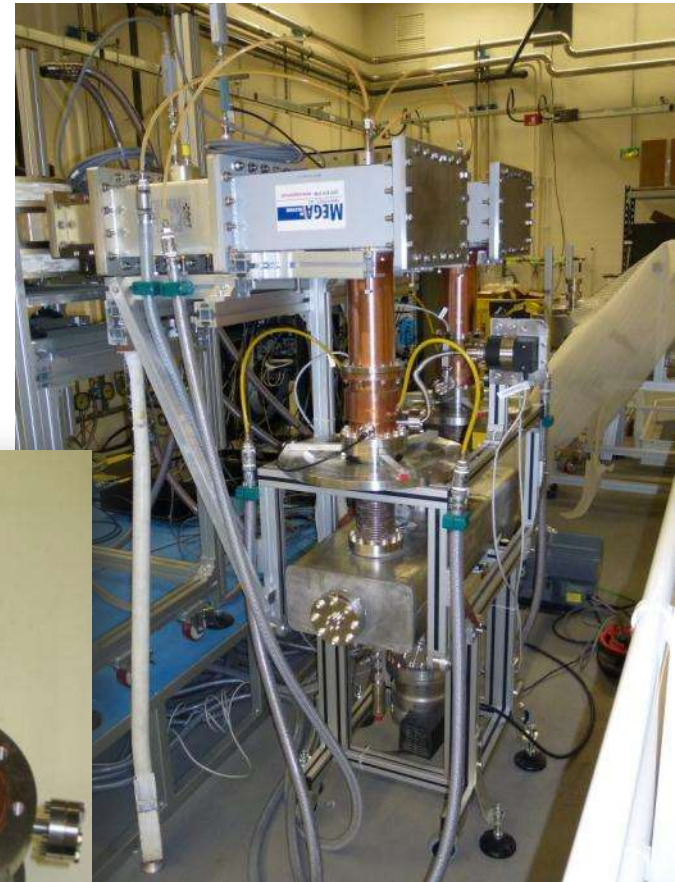
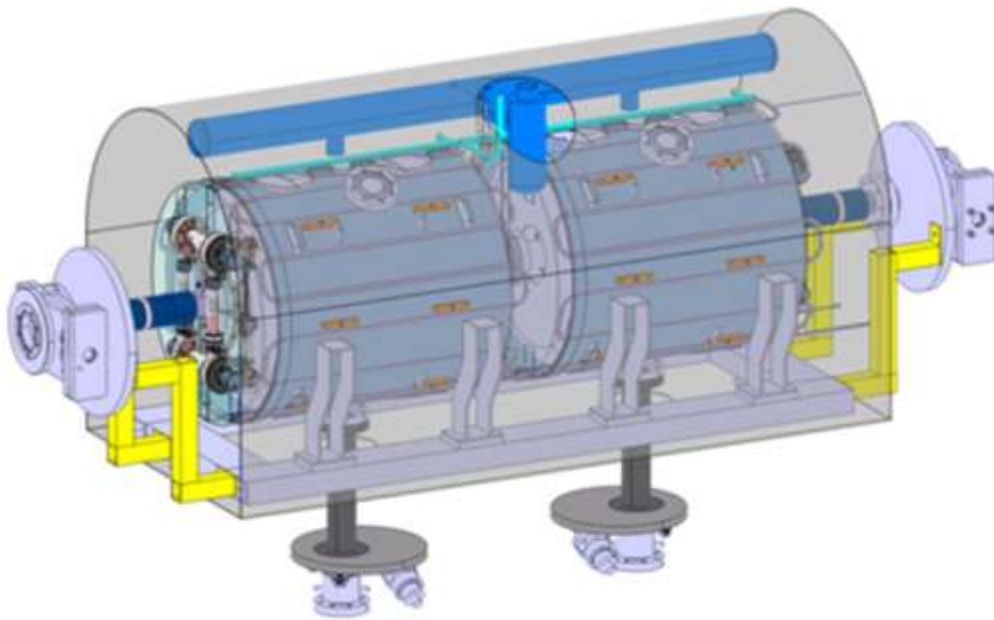


Injector scheme



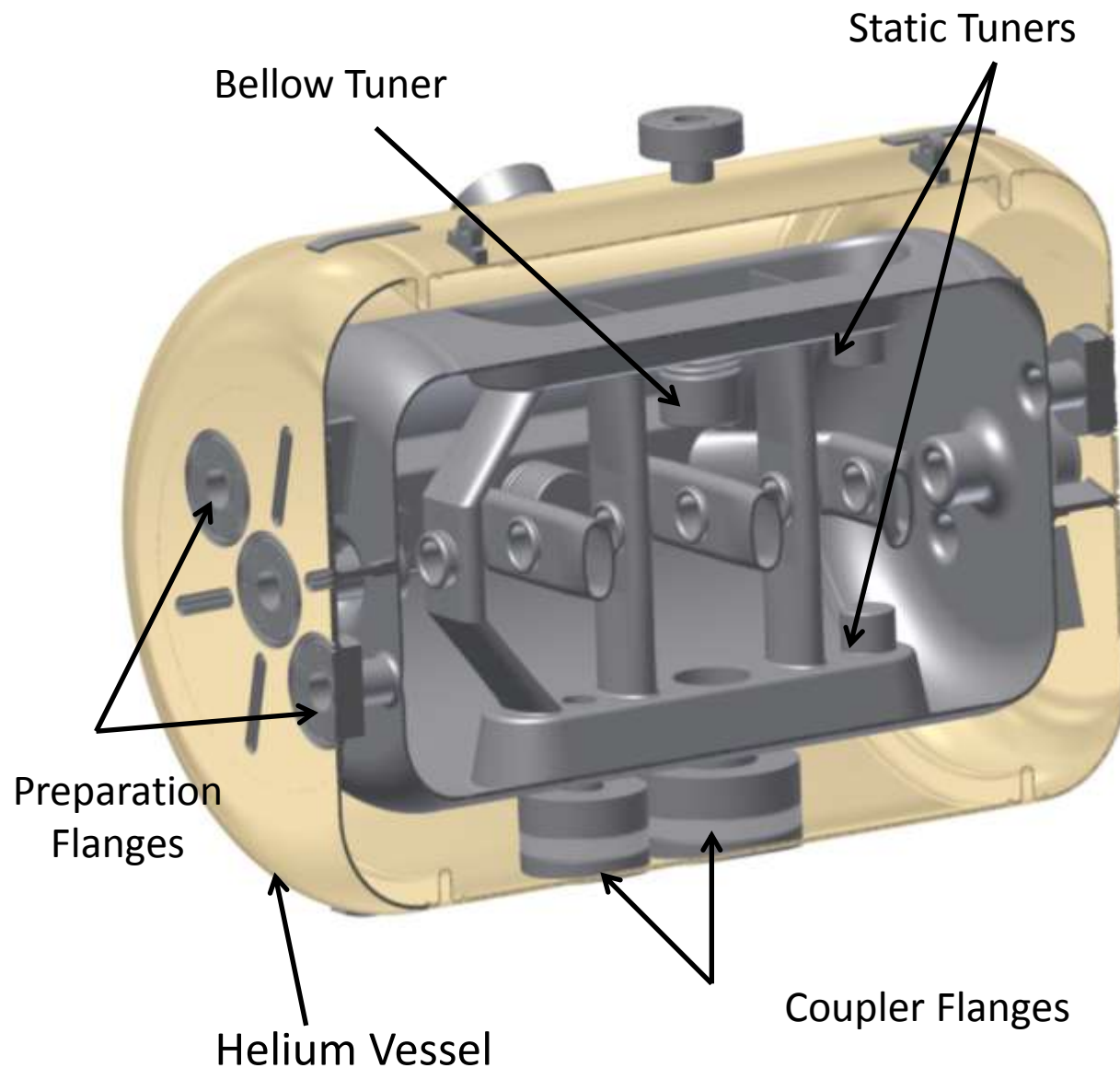
# Myrrha/MAX R&D

- Power couplers 704 MHz 80 kW CW conditioning is started  
P>30kW CW obtained last week, on going
- Ellipticals full test foreseen after the FPC conditioning (INFN  
beta=0.5 5-cell cavity w/ blade tuner)
- Single spoke design on-going. One prototype will be build  
and tested in 2013
- Spoke CM conceptual design on going

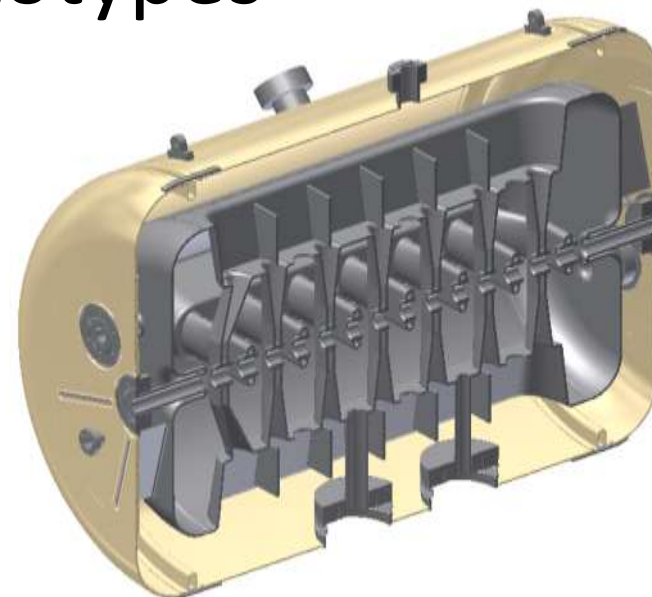
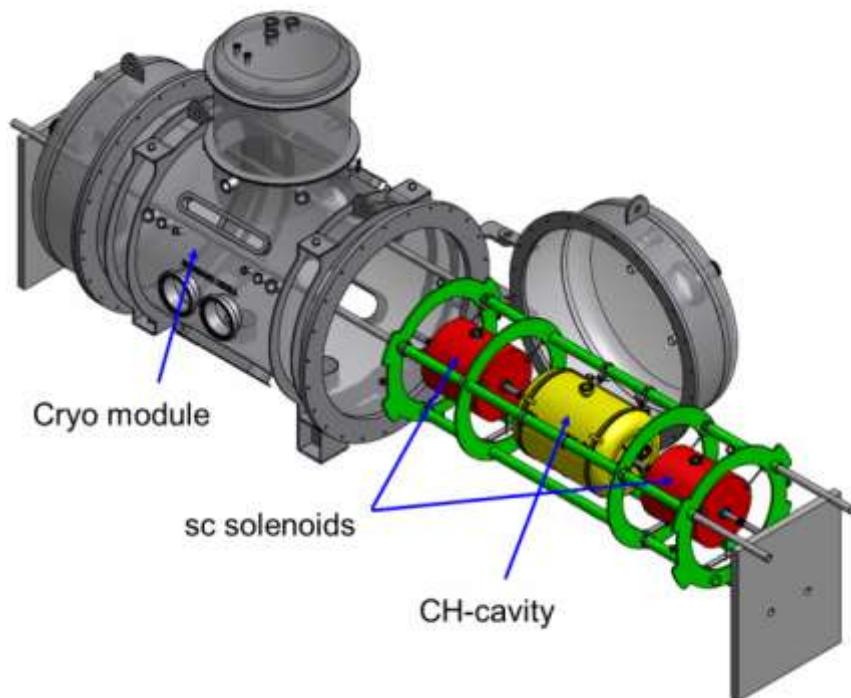


# 325 MHz CH-Prototype

$\beta$	0.1545
Frequency (MHz)	325.224
Cells	7
Length $\beta\lambda$ -def (mm)	505
Diameter (mm)	348
$E_a$ (MV/m)	5
$E_p/E_a$	5.1
$B_p/E_a$ [mT/(MV/m)]	13
$G$ ( $\Omega$ )	64
$R_a/Q_0$ ( $\Omega$ )	1248
$R_a R_s$ ( $\Omega^2$ )	80000



# Frankfurt CH prototypes



**217 MHz 15-gap CH** ( $\beta = 0.059$ )  
to be tested with beam at GSI

Status : cavity in fabrication  
Cryomodule ordered



*More details in H.Podlech talk on tuesday*

# Thanks!

J.-L. Biarrotte IPNO

P. Bosland CEA

S. Bousson IPNO

S. Calatroni CERN

O. Capatina CERN

E. Montesinos CERN

G. Olry IPNO

H. Podlech U. Frankfurt

E. Rampnoux IPNO