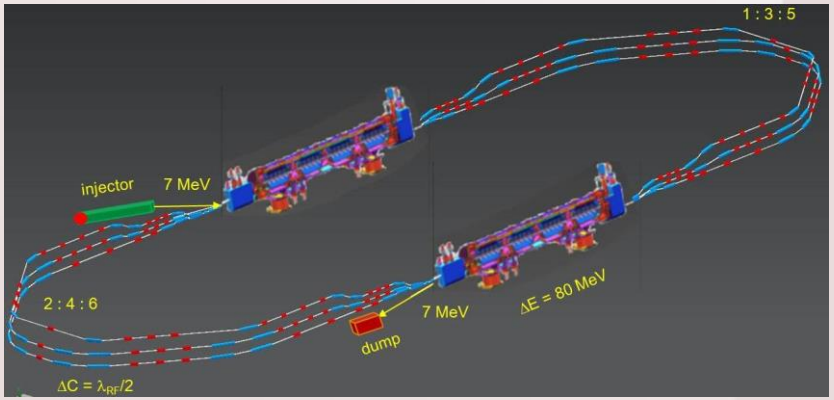
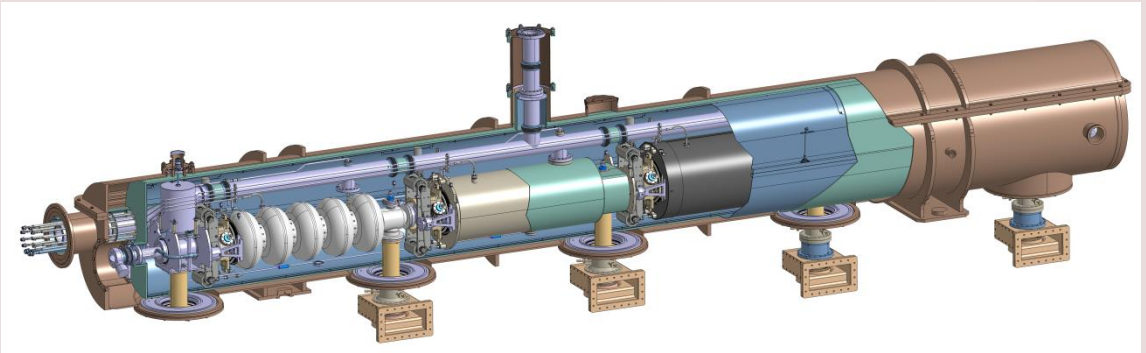
TOWARDS A FIRST CRYOMODULE FOR PERLE @ ORSAY



ELECTRONS FOR THE LHC:
Workshop on the LHeC, FCC-eh and PERLE

CHAVANNES DE BOGIS
October 24/25, 2019



CRYOMODULE FOR PERLE @ ORSAY

PERLE @ ORSAY

- 5 cells elliptical cavities at 801,58MHz
- 2 cryomodules composed of 4 superconducting cavities

FIRST MILESTONE

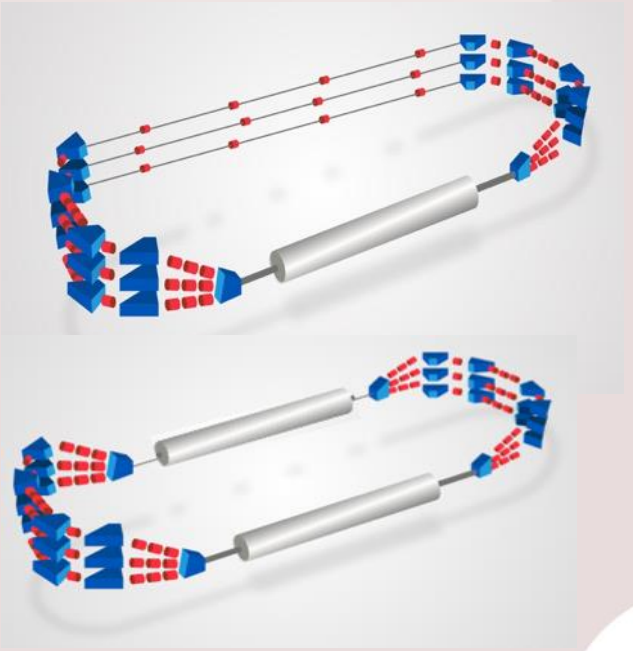
- 1 cryomodule prototype
- Complete cryomodule ready for test
- Limited cryogenic plant
- Full RF power on one cavity

SECOND MILESTONE

- Integration of the cryomodule in the PERLE phase 1 layout
- Operation at 250MeV

THIRD MILESTONE

- Integration of the second cryomodule
- Final PERLE layout (phase 2)
- Operation at 500MeV



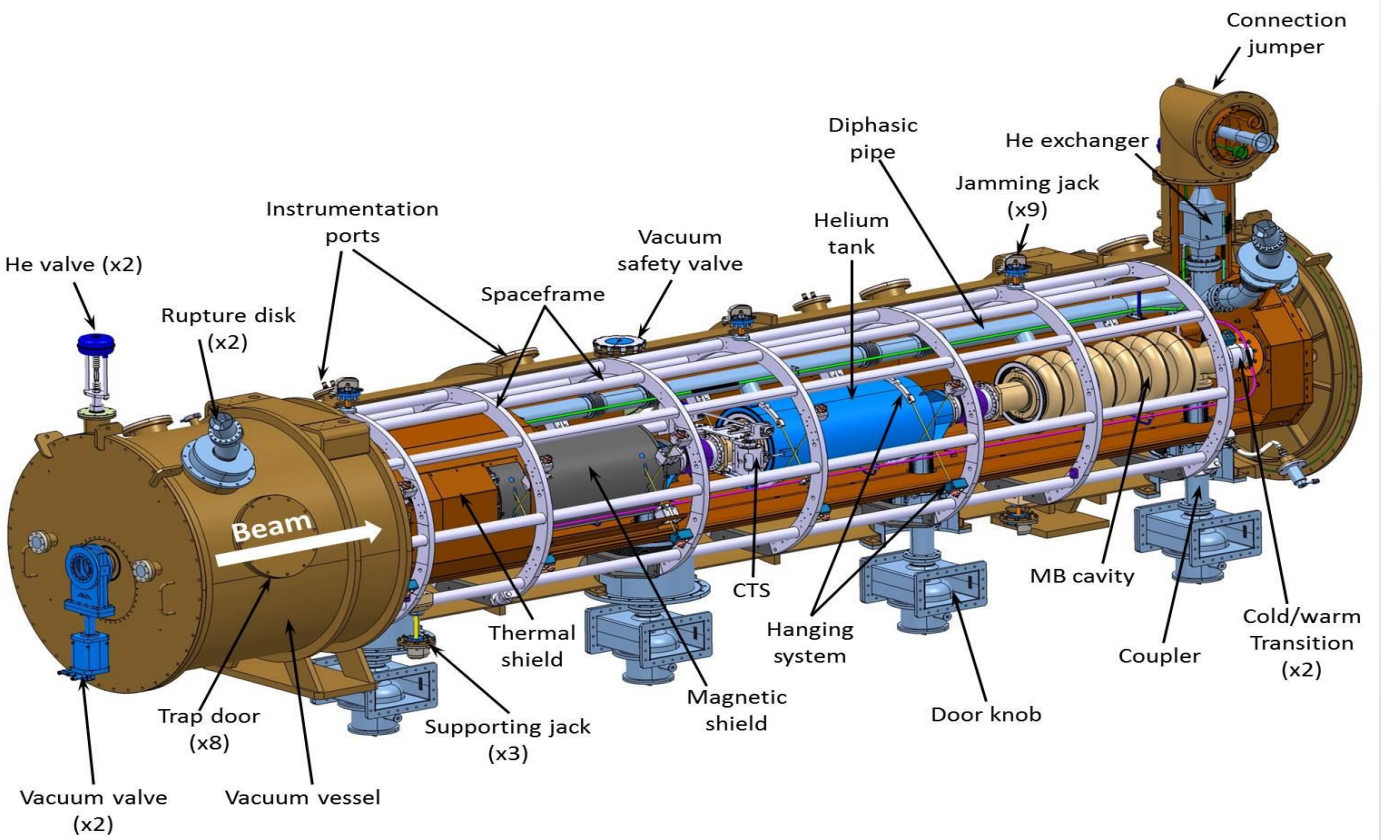
DESIGN OF THE CRYOMODULE

WICH DESIGN?

Recently, several projects worldwide have designed cryomodules for elliptical cavities with a cavity configuration (number, length and diameter) which is very close to the one required by PERLE

PROJECT	Number of cavities	Number of cells	Frequency (MHz)	β
PERLE à Orsay	4	5	802	1
ESS	4	6 5	704	0,67 0,85
SPL	4	5	704	1

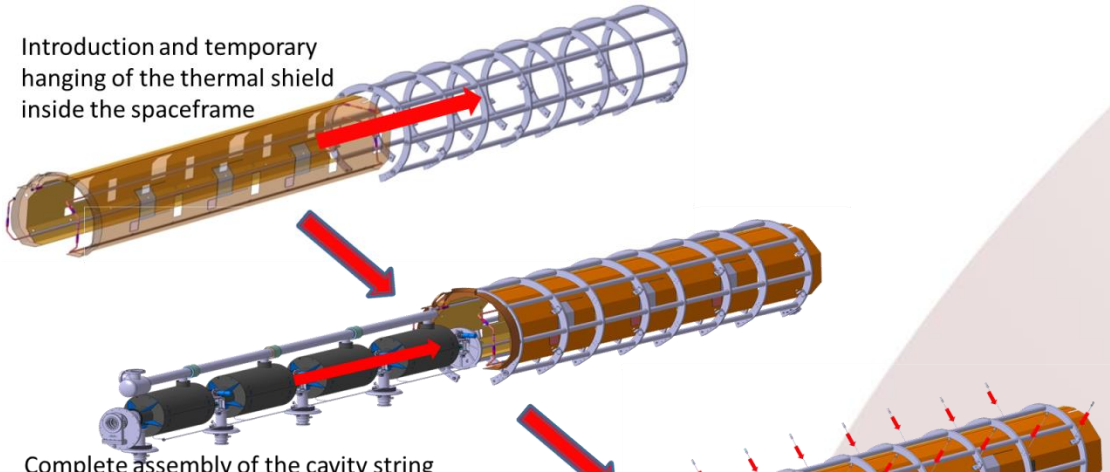
ESS (SNS) CRYOMODULE



- based on an intermediate support system, called the spaceframe, which is horizontally translated inside the cryomodule vacuum vessel
- All the hanging and alignment operations of the cavities string and shielding are implemented outside the vacuum tank, using the spaceframe

ESS CAVITY STRING POSITIONING & CRYOSTATING PROCEDURES

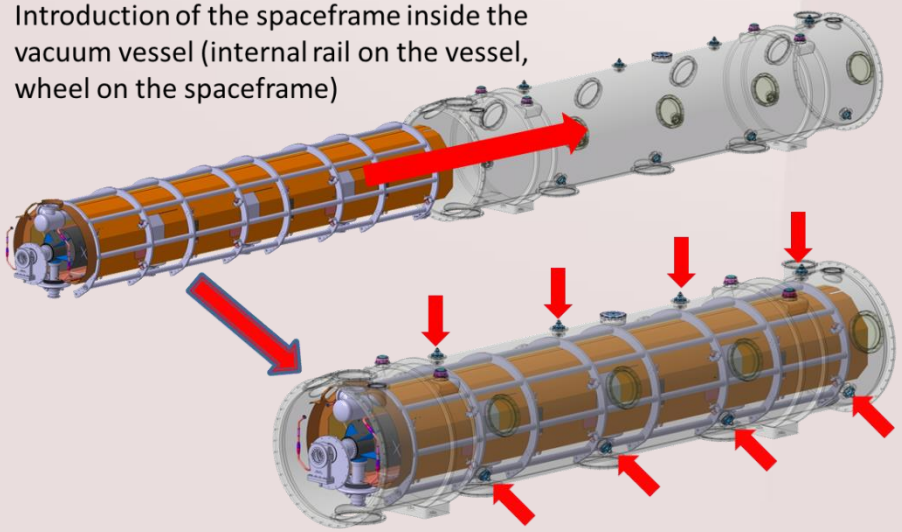
Introduction and temporary hanging of the thermal shield inside the spaceframe



Complete assembly of the cavity string before insertion inside the spaceframe

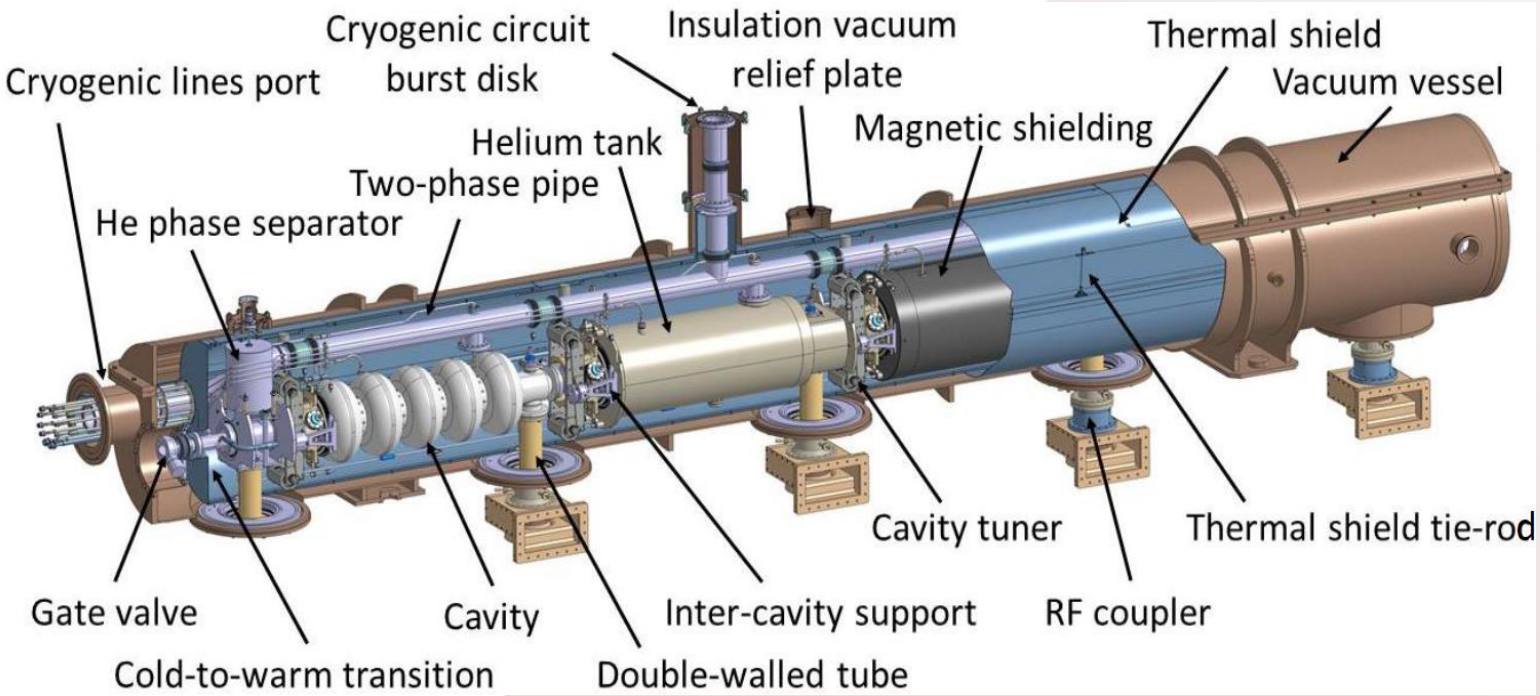
Hanging of the rods to the spaceframe
Cross positioning of the cavities
Hanging of the thermal shield to the rods

Introduction of the spaceframe inside the vacuum vessel (internal rail on the vessel, wheel on the spaceframe)



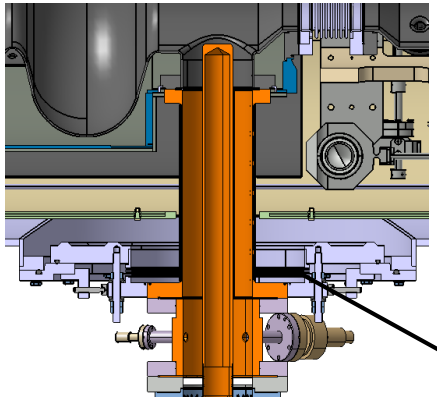
Positioning of the whole assembly inside the vacuum vessel by means of jacks

SPL CRYOMODULE

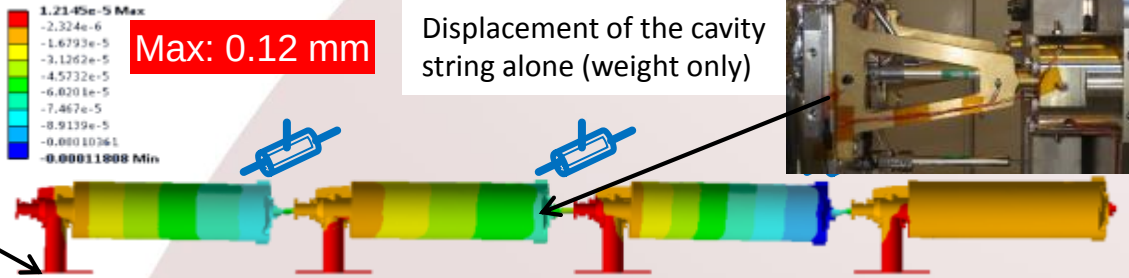


- the cavity string directly supported by the power coupler and with dedicated inter-cavity support features.
- integrates a full length demountable top lid, enabling the cavity string assembly from the cryomodule top

SPL CAVITY STRING POSITIONING & CRYOSTATING PROCEDURES



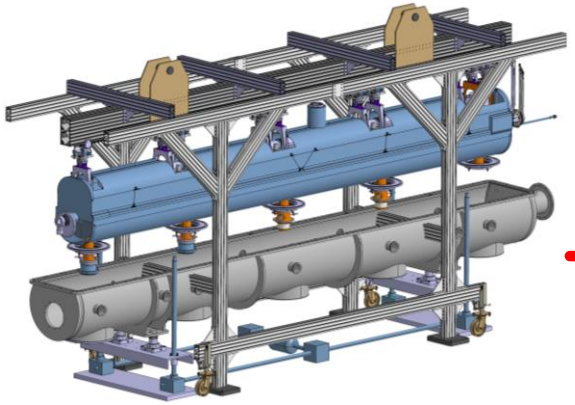
The cavities are supported and positioned directly by their coupler flange. The opposite side (with respect to the coupler) of each cavity is supported and positioned by means of a spherical joint fixed on the next cavity.



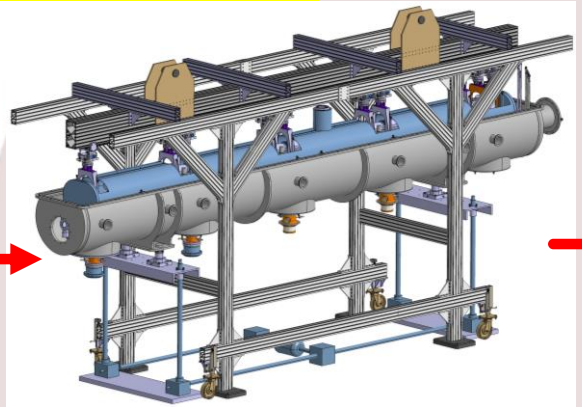
Displacement of the cavity string alone (weight only)

CERN test stand & mock up

2 innovative points

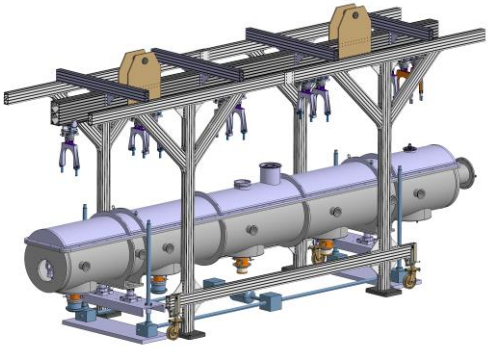


Cavity string equipped with magnetic shield, CTS, cryogenic lines and thermal shield



Insertion of the complete assembly inside the vacuum vessel

Courtesy of P DUTHIL / S ROUSSELOT (IPNO)



Closing of the top lid and of the beam ports

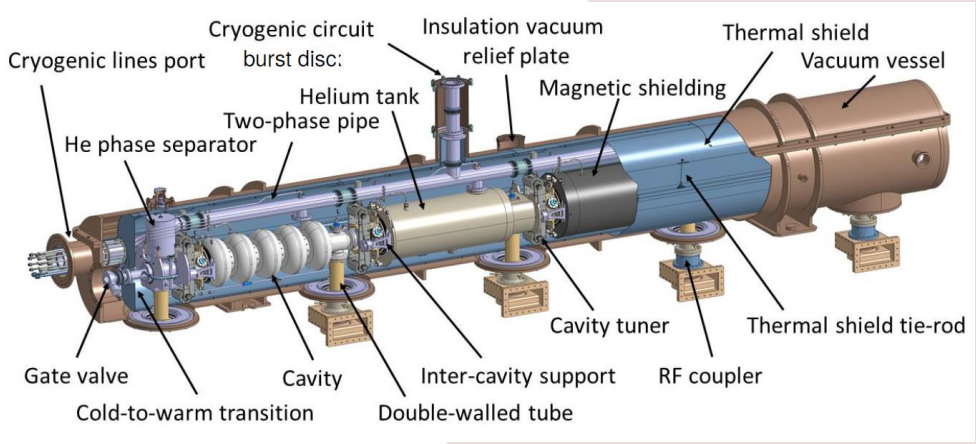
POTENTIAL REUSE OF THE SPL/HG CRYOMODULE DESIGN AND COMPONENTS

CERN proposed to re-use the existing SPL short cryomodule prototype either as it is or replacing the 704 MHz cavities by the perle referenced 802 MHz cavities

For more details about SPL (HG) cryomodule design and status:
see presentation of Luca DASSA. PERLE workshop, Daresbury on January 15th , 2018.

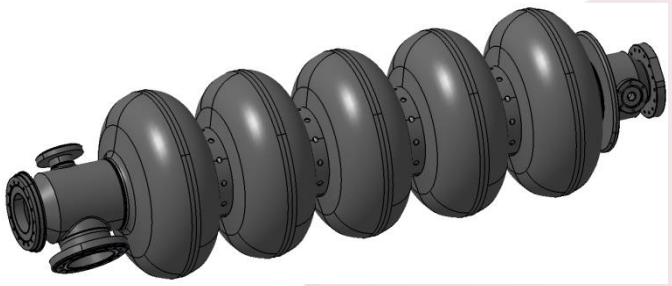
Design of the cryomodule performed by IPNO and updated by CERN.

Vacuum vessel and most of cryogenic lines delivered.



CAN THIS DESIGN AND THESE COMPONENTS BE REUSED FOR PERLE @ ORSAY ?

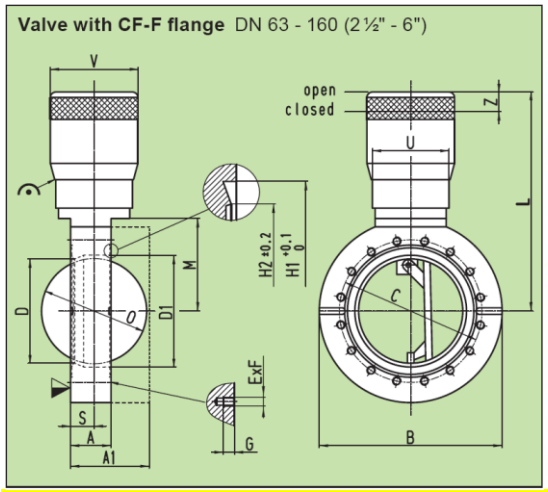
MAIN DIMENSIONAL CHARACTERISTICS OF THE CAVITIES

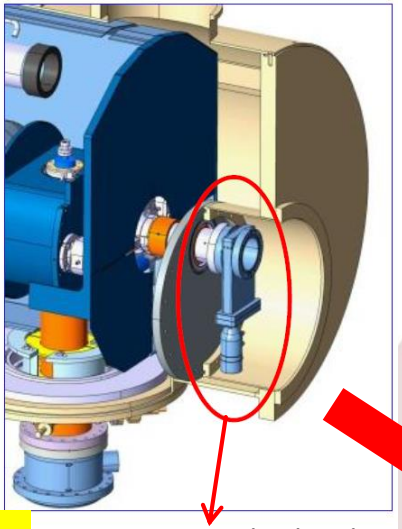


CHARACTERISTICS	SPL (704MHz)	PERLE / JLAB (802MHz)
Coupler to coupler length (mm)	1490,5	-
Length flange to flange (mm)	1397,3	1292,5
Coupler to flange dimension (mm)	116,4	96,7
Cells external diameter (mm)	386,5	335
Beam port internal diameter (mm)	129,8 / 139,8 (coupler side)	130
Flanges internal diameter (mm)	79,7 (CF100)	130 (CF160)
Vacuum valve diameter	CF63	tbd
Coupler internal diameter (mm)	100	100
Coupler flange	CF100	CF100
Beam axis to ext. coupler flange	403	tbd

SIMILAR FEATURES

BEAM VACUUM VALVES

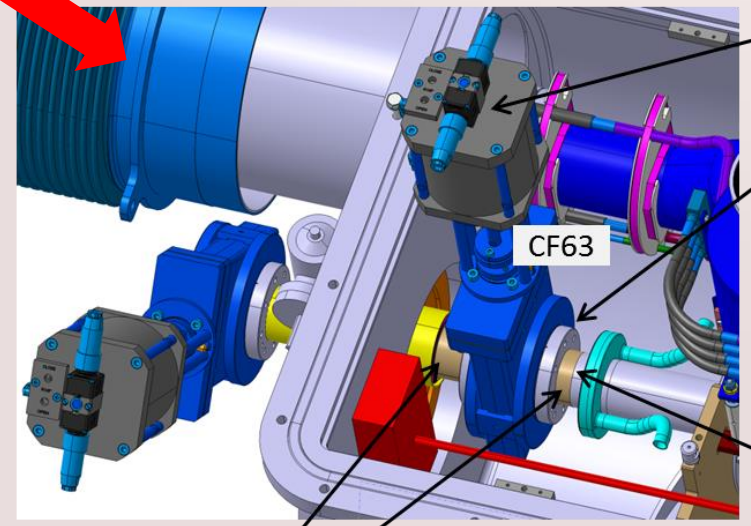




CF63 "Vatterfly" valve with manual actuator
VAT Ref. 20336-CE14

Maximum valve height:
180mm (from beam axis)

NEED OF A "TWO STAGES" SOLUTION TO USE AN ALL METAL GATE VALVE



Actuator to remove

300K thermalization for valve and flange

High T° gradient between 50 and 300K

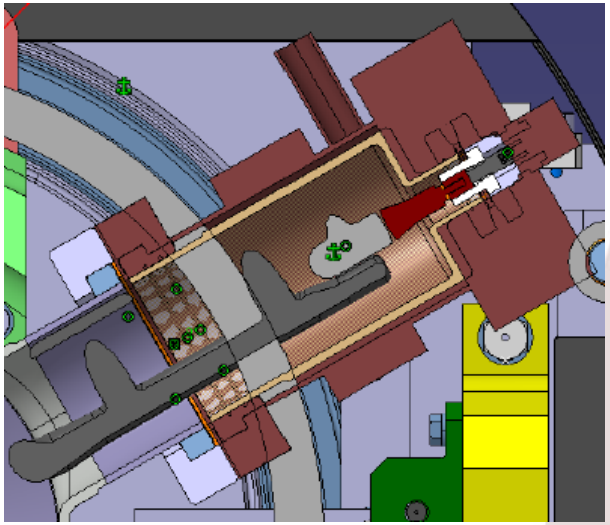
Limited space for screwing on each side (but OK)

Leak rate: body / valve seat	$< 5 \cdot 10^{-10}$ / $< 1 \cdot 10^{-9}$ mbar ls^{-1}	All metal gate valves (commonly used)
Pressure range	$1 \cdot 10^{-9}$ mbar to 1.2 bar (abs)	< 1.10-10 mbar.l/s
	Height of all metal gate valves (VAT series 48)with pneumatic actuator: CF40: 312mm CF63: 527mm	< 1.10-10 mbar
		All metal
Seal - Bonnet - Plate	metal FKM (VITON)	
Mounting position	any	

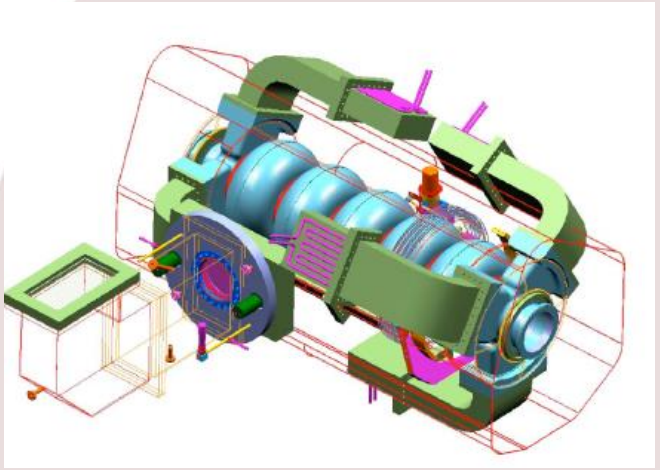
HOM EXTRACTION

- How many extraction ports (interferences with CTS)?
- Location and position of these ports?
- Which power per HOM (W/tens of W, potentially much more if resonant excitation)?
- What kind of damper (waveguide, loop coupling)?
- What kind of RF line to the external load (cable sufficient, which kind of connector)?
- Intermediate thermalization only? Risky.
- Active helium cooling?
- External cooled RF loads?
- HOM signal for diagnostic purpose?

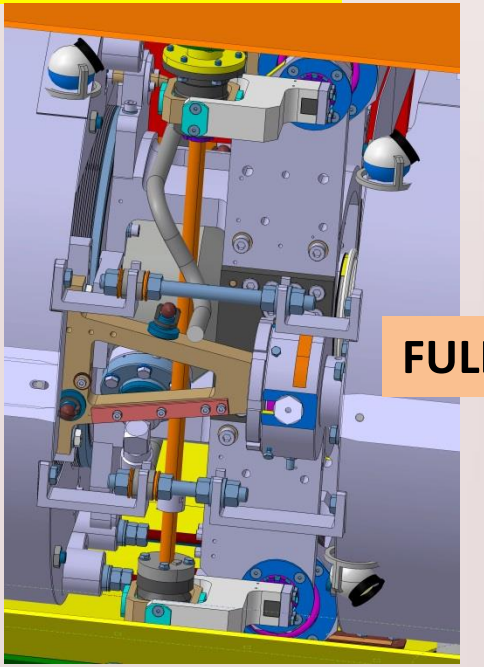
POTENTIALLY THE MAIN ISSUE DUE TO THE LACK OF SPACE



Loop coupling with active cooling. Courtesy of CERN



Waveguide HOM coupler. Courtesy of Brookhaven NL



FULL

OTHER POTENTIAL ISSUES

- CW operation
- 20mA
- 500MeV
- 17,5MV/m gradient

→ **RADIATIONS**
Are elastomeric seals compatible (vacuum vessel, valves)?
OK with operating time limited

- Dynamic heat losses
- HOM cooling
- Operating He pressure
- Pressure vessels standards

→
- Helium cooling circuit available?
- Safety devices (1 bursting disk foreseen for SPL)

POTENTIAL REUSE OF THE SPL/HG CRYOMODULE DESIGN AND COMPONENTS

- Vacuum vessel could be reused without refurbishing. What about the top cover?
- Cryogenic lines to be adapted. Potentially important refurbishing for HOM cooling and adding of a second burst disk
- Thermal and magnetic shields are well designed for PERLE operation parameters and are not yet purchased. They can be modified.
- Input coupler designed for SPL cavities could be easily adapted to meet PERLE requirements

- The internal space is almost full
- Risk of interference between CTS and HOM dampers
- **The reuse of the cryomodule will depend on the number, the type and the location of the HOM dampers**

THANK YOU FOR YOUR ATTENTION