WG2

Protons and Ions Accelerators

(G. Devanz, R. Laxdal, P. Michelato)

Mandate

Major initiatives are well underway for ion accelerators for nuclear astrophysics, such as FRIB, RAON and others. With the success of SNS, high intensity proton accelerator projects are progressing, such as ESS, PIP-II, Indian SNS, along with ADS ambitions, such as CADS and IADS. The aim of WG2 is to address the major on-going issues for each type of accelerator, how these issues are being addressed, as well as the needed developments. Demonstrated and needed advances in couplers and tuners for both accelerator classes should be included. Please avoid presentations that give project status summaries - more suited to other conferences.

WG2

Protons and Ions Accelerators

(G. Devanz, R. Laxdal, P. Michelato)

Tuesday 14:00 – 17:30

- High beta hadron cavities
- Low beta hadron cavities

Wednesday 09:00 – 12:30

- Cryomodules and ancillaries

WG2

Protons and Ions Accelerators

(G. Devanz, R. Laxdal, P. Michelato)

Tuesday 14:00 – 17:30

14:00	Introduction to session	Conveners	
14:10	PIPI-II General test results	Leanardo Ristori	FNAL
14:30	Buffer chemical polishing study on ESS medium beta cavities	Enrico Cenni	CEA
14:50	LASA activities on ESS MB cavities	Michele Bertucci	LASA
15:10	Summary Discussion		
15:30	Coffee		
16:00	ESS/Myrhha spoke technical issues	David Longuevergne	IPN Orsay
16:20	IMP HWR technical issues	Weiming Yue	IMP
16:40	PIP-II spoke technical issues	Leonardo Ristori	FNAL
17:00	Summary Discussion		
17:30	End of session		

WG2

Protons and Ions Accelerators

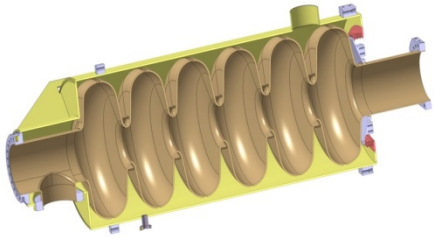
(G. Devanz, R. Laxdal, P. Michelato)

Wednesday 09:00 – 12:30

9:00	Pressure vessel code for IFMIF	Atsushi Kasugai	Rokkosho/IFMIF
9:20	Licensing of the IFMIF Cavities and Cryomodule	Aline Riquelme	CEA
9:30	Assembly of the IFMIF Cryomodule	Janic Chambrillon	CEA
9:45	Magnetic field suppression, cavity freq control, MP free coupler	Kenji Saito	FRIB
10:05	Coupler fabrication for low-beta cavities	Masao Irikura	Toshiba
10:25	Summary Discussion		
10:30	Coffee		
11:00	704 MHz bulk Nb cavities and a 4 cavity module at CERN	Luca Dassa	CERN
11:20	IMP cryomodule technical issues	Hao Guo	IMP
11:40	ESS tuner development	Nicolas Gandolfo	IPN Orsay
12:00	PIP-II spoke cryomodule technical issues	Leonardo Ristori	FNAL
12:20	Summary Discussion		
1230	Lunch		

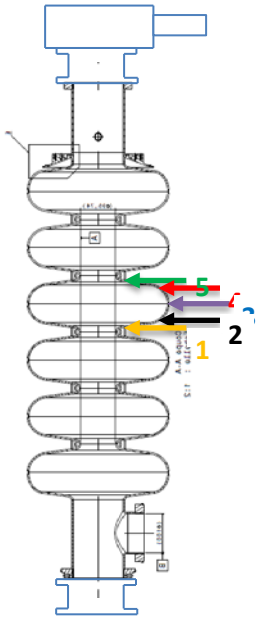
Medium Beta Cavity Issues

- CEA – ESS medium beta cavity – 704MHz – beta=0.67 - 6 cell
  - Developing BCP – will be done in industry
  - Issue - non-uniform etching rates and temperature across cell – evidence of strong hydrogen
  - BCP recipe – 1:1:2.4 – lab safety mandate

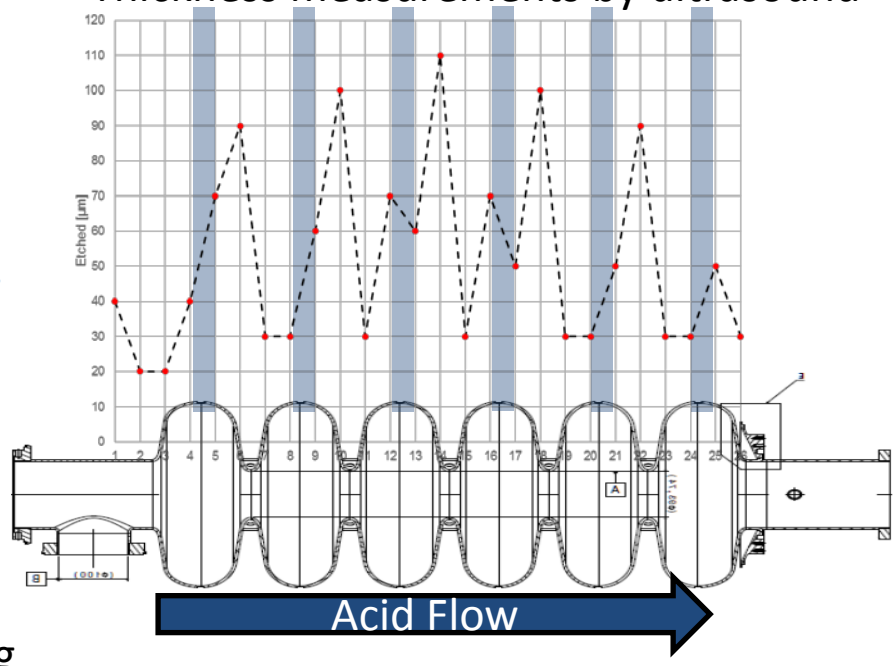


- INFN Milano
  - Will oversee delivery of 36 cavities to CEA – testing at DESY – delivery in 2017/18
  - Building 2 Proto types for ESS – plug compatible with CEA – one fine grain and one large grain – large grain material from CBMM – saw cut from ingot
    - Testing in Sept

CEA ESS medium beta(BCP)



Thickness measurements by ultrasound



•We can't control the temperature rise during the BCP without an external cooling

- ➢ Equip the cavity with a water tank?
- ➢ External tube?
- ➢ Bigger acid tank?

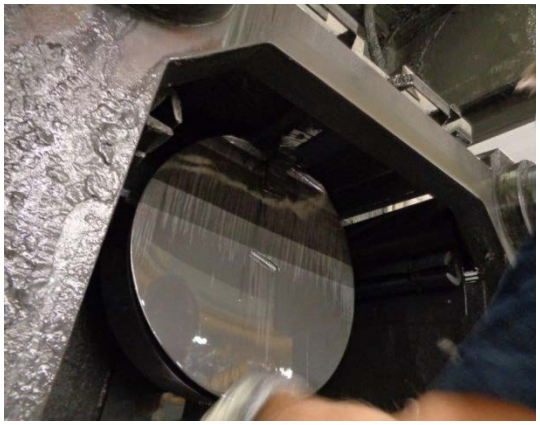
- We have observed a temperature gradient across the cell (looking for explanation).
  - ➢ Viscous layer formation?
  - ➢ Gas bubble formation?

<u>BCP integrated system</u>:

- 200 liters acid tank
- $HF/HNO_3/H_3PO_4$ 1:1:2.4
- Flow: 20 l/min

INFN ESS LG prototype

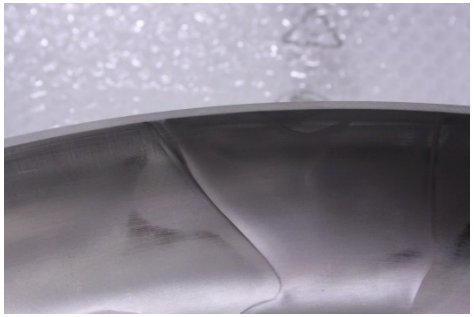
CBMM ingot. Ø=480 mm
RRR>300



Wire sawing with oxygen
Protection @Heraeus

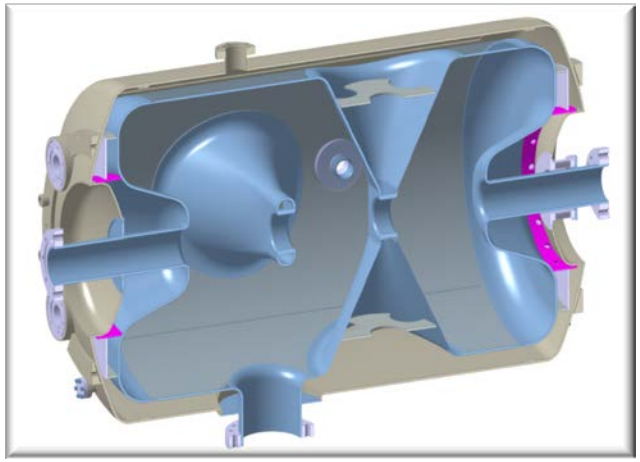
25 (+2) 4.675 mm slices
produced:

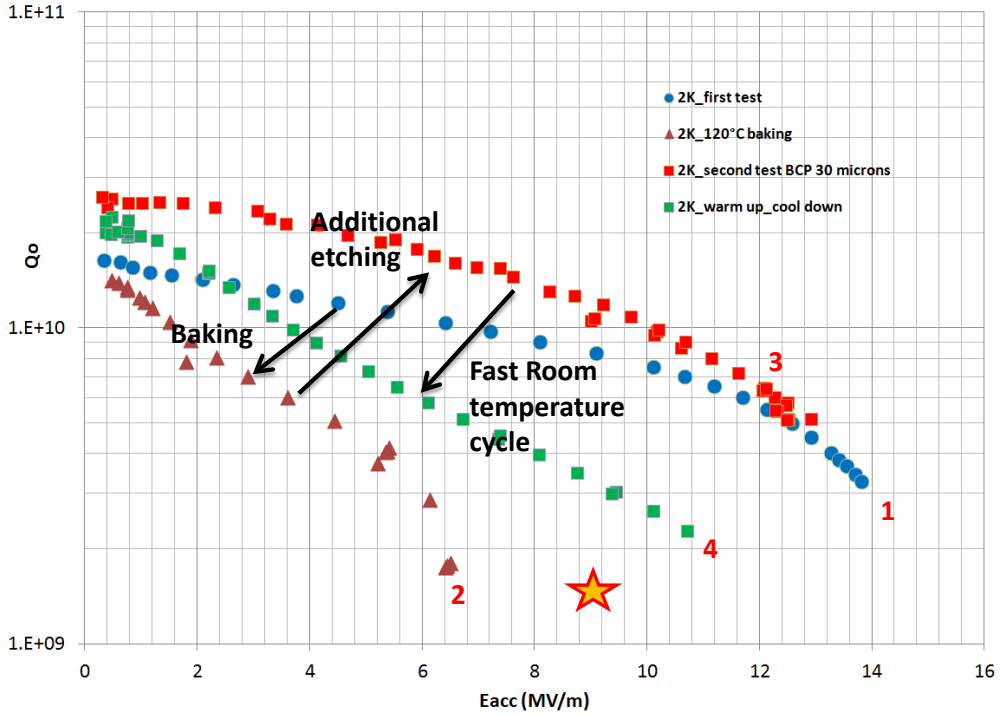
Here and there,
Some dislocation on both irises
And equators, to be ground
after DB welding



Low Beta Cavity Issues

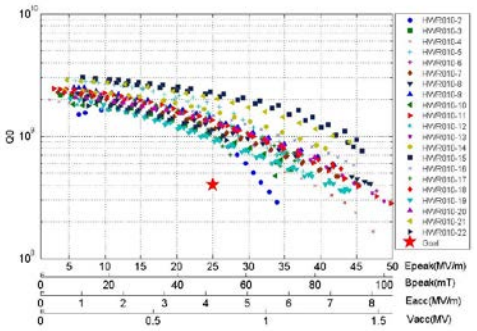
- IPN Orsay
  - Double spoke for ESS – 325MHz
  - mysterious Q-disease behaviour – Retest without changing gives worse results after only a temperature cycle – baking makes things worse
  - no observation of hydride skeletons on samples
  - New degassing furnace being commissioned

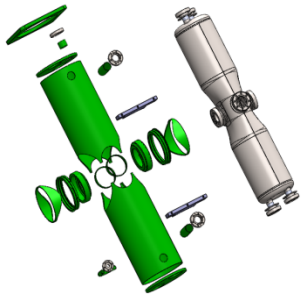


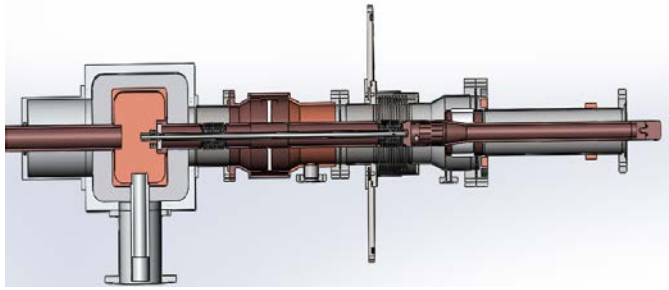


Low Beta Cavity Issues

- IMP Lanzhou
  - HWR – 625MHz – beta=0.1 - 22 produced with good vertical test performance
  - Reducing LFD and df/dp with RIBs – trying to optimize
  - Coupler conditioning in CM – developed vacuum leak
    - Issue - need for fast interlocks during conditioning
    - New dual window coupler designed – tested to 20kW
  - Issue – what heat treatment for a jacketed cavity with a Ti jacket
    - Heat treatment with Ti components – differential expansion an issue
    - Bellow can help mitigate
    - Recommend 600C only – verify properties if you want to go higher
    - Rules needed for protecting components during heat treatments
    - Take care about change of yield strength of material (pressure code)

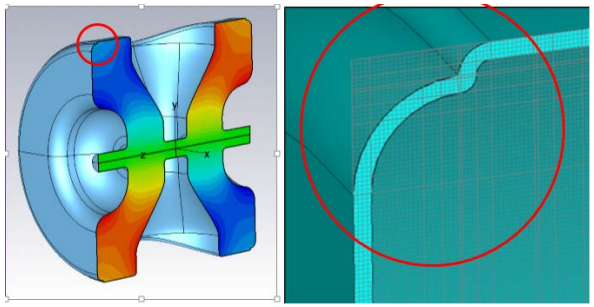


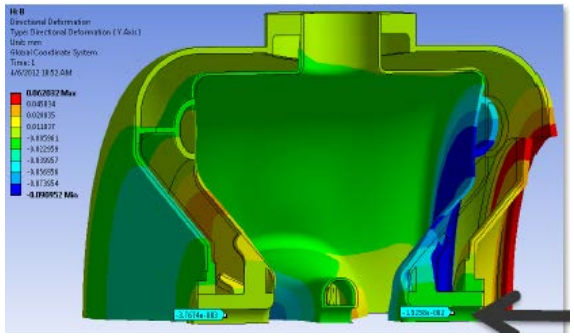




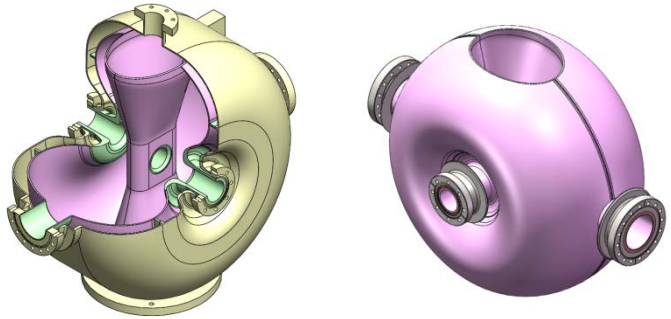
Cavities cont

- PIP-II Spoke Cavity - FNAL
  - Strong MP
    - Looking at the high field barriers – using simulation to slightly modify wall shape to push barriers away from operating zone
  - Design with compensation of magnetic and electric volumes to minimize df/dp
    - measure very well the bellow – diameter is a sensitive parameter for df/dp compensation
  - Type of gaskets – CF –> aluminum
  - BCP – pre-chill to 5C wth a 10degree external bath

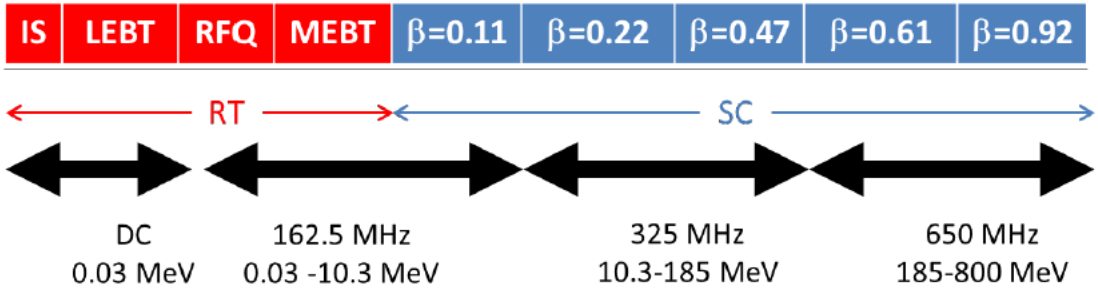




- TRIUMF – beta=0.3 Balloon cavity for RISP is being prototyped to move to a low MP design



PIP-II Technology Map



Section	Freq	Energy (MeV)	Cav/mag/CM	Type
RFQ	162.5	0.03-2.1		
HWR (β_{opt}=0.11)	162.5	2.1-10.3	8/8/1	HWR, solenoid
SSR1 (β_{opt}=0.22)	325	10.3-35	16/8/ 2	SSR, solenoid
SSR2 (β_{opt}=0.47)	325	35-185	35/21/7	SSR, solenoid
LB 650 (β_g=0.61)	650	185-500	33/22/11	5-cell elliptical, doublet*
HB 650 (β_g=0.92)	650	500-800	24/8/4	5-cell elliptical, doublet*

*Warm doublets external to cryomodules

All components CW-capable

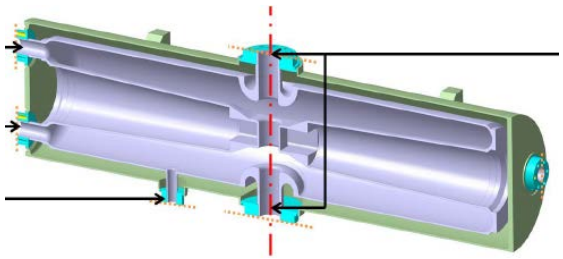
ANL

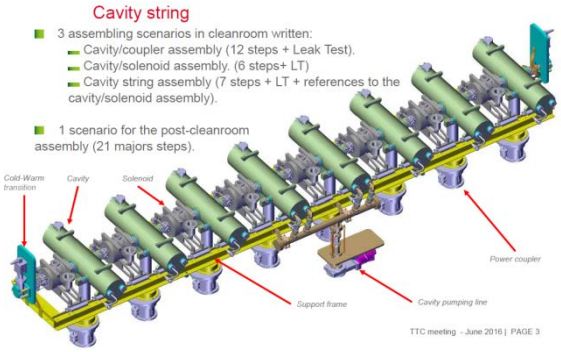
MP issues

N-doping

Cryomodule and ancillaries

- IFMIF – pressure code issue - Rokkasho
  - Translation between Europe and Japan authority
  - Took a lot of time
  - Lot's of back and forth on design – took ~ two years
    - Pressure code engineering issues – test samples prepared – many tests done to qualify design
  - Issue
    - What qualification tests are required – it would be good to standardize our approach as a community - in general there is a push to go to ASME VIII
- IFMF cryomodule – CEA Saclay
  - Magnetic hygiene – strategy is to minimize magnetized parts
  - Sending a CM in a parts box – the CM will not be assembled before arriving as a `kit' for assembly in Japan
    - Setting up a clean room assembly space and local infrastructure in Rokkasho
  - Mock-up stand for testing assembly helps test procedures

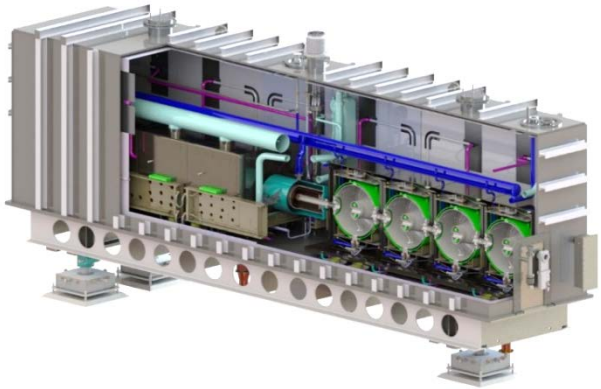


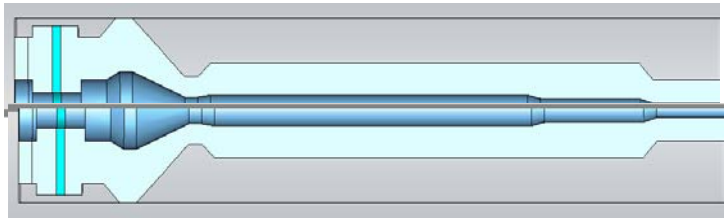


Cryomodule cont'd

- FRIB
  - Magnetic shielding strategy – local shield around cavities – demagnetize components – 15mG
  - Frequency control – HWR has proven a difficult cavity to consistently tune during manufacture
    - Have developed virtual welding, custom etching
  - MP free coupler variant has reduced MP heating issues in HW coupler

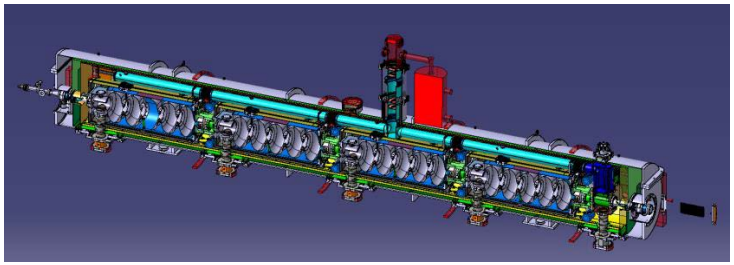
- General Coupler comment
  - Copper plating quality remains an issue

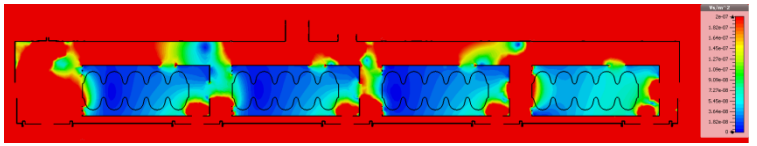




Cryomodule cont'd

- CERN - high performance CM development
  - <1.5Bar absolute pressure window – using valves in valve box to achieve
  - Ultra-low magnetic field – two layers of mu metal with Helmholtz coil
    - <0.1muT – 10 times lower than typical practise
    - Want a magnetic sensor for cold application – in the bath
  - Cavity performance
    - Steady performance gains in VT

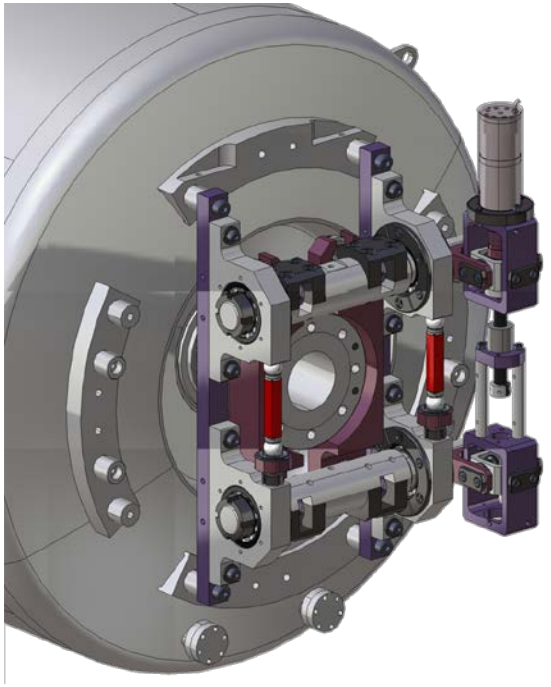




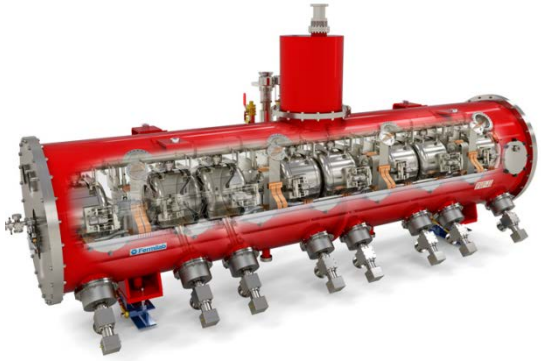
- IMP CM technical issues
  - Cleaning parts
    - HPWR on bellows, solenoid, BPM, coupler reported
  - Alignment method was described

Cryomodule cont'd

- IPNO - Double spoke tuner (ESS)
  - 20kN force required – very strong
  - Long Piezo tried – moved from 60 – 90 mm stack – but no improvement at low temp
  - Development to allow tuner relaxation at warm-up – to reduce risk of plastic deformation during transient
    - Works with differential expansion – Aluminum and Titanium – with a local heater to release
  - Advice from IPNO – test, test, test



Cryomodule cont'd



- PIP-II
  - Spoke CM
  - Pumping manifold or no manifold – opt for none – studies show that cavity will eventually pump out – what is the spec for pre-cooldown vacuum?
  - Off line assembly station to practise clean room activities
    - Expanded bellow with 2 cm between cavities – edge welded bellow
    - Nice tooling
  - Tuner with piezo developed
  - Coupler – breaking test completed – achieved 47kW for operation at 20kW – some braze quality issue - New ones look much better
  - Electro-deposited bellow – one US supplier

Thanks for a nice workshop!