Project X and IIFC SSR1 and SSR2 Cavity Status

IIFC MEETING

RONAK PATEL

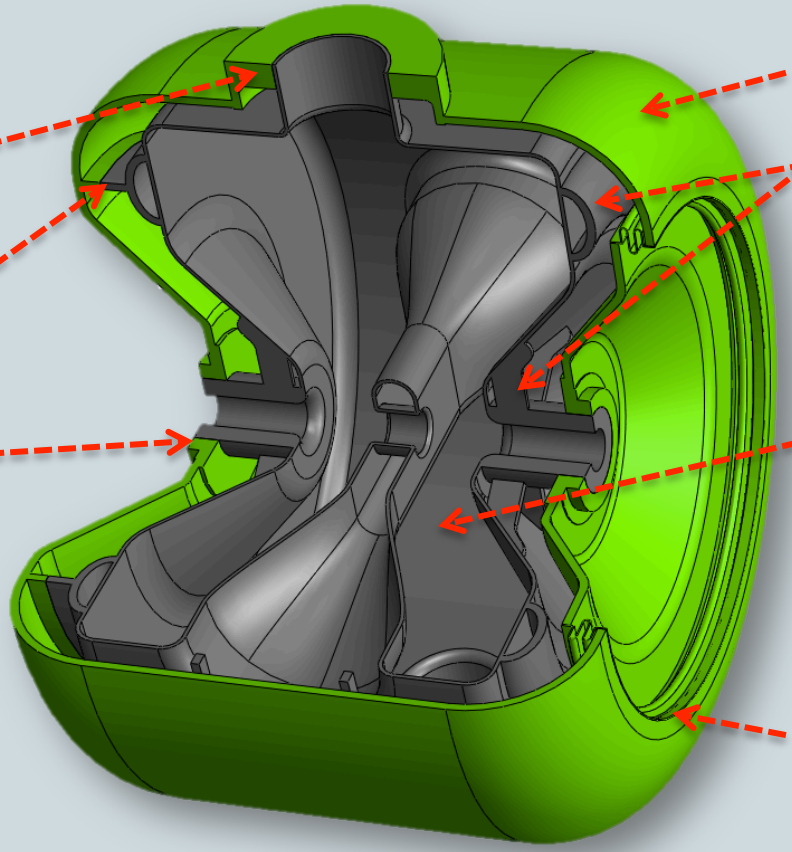
11/26/2012

Overview

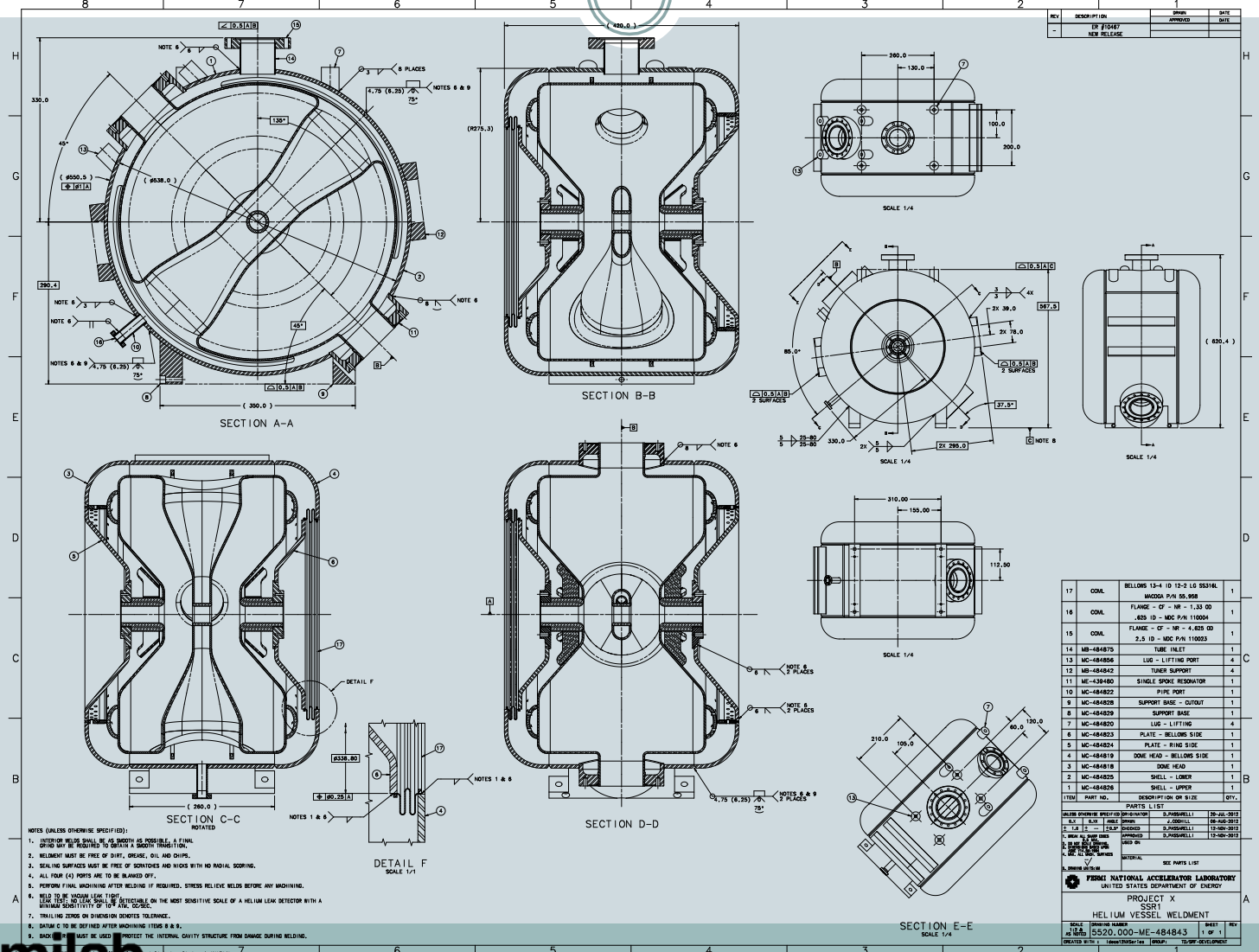
- SSR1 Status at Fermilab
  - He Vessel Design Overview
  - Inventory
  - VTS Test Results
  - Schedule
- SSR1 Status at IUAC
  - Developments
  - Schedule
- SSR2 Status at Fermilab

SSR1 STATUS AT FERMILAB

SSR1 Design Overview



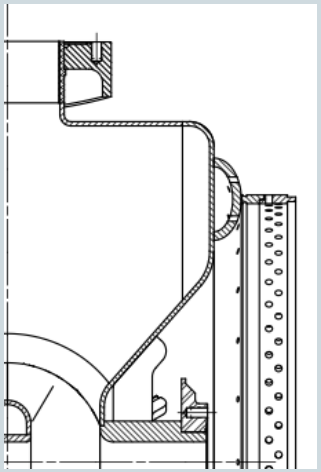
SSR1 Design Overview – He Vessel Drawings

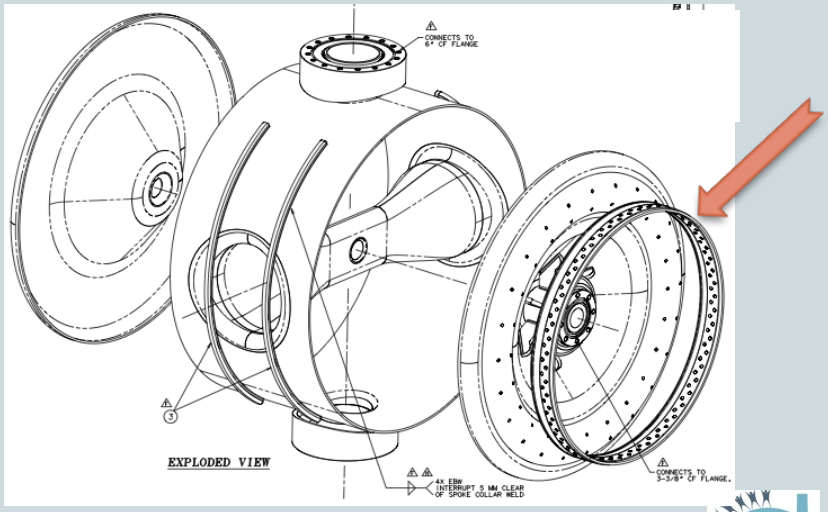


Fermilab

SSR1 Design Overview - Ring

- SSR1 resonators need to have a Nb-SST transition ring welded onto one of the two end-walls.
  - Rings currently being procured from ANL
  - Rings will be EBW onto resonator
- A large number of holes is present on the SST side to allow flow of He and also to allow flow of LCW during chemistry

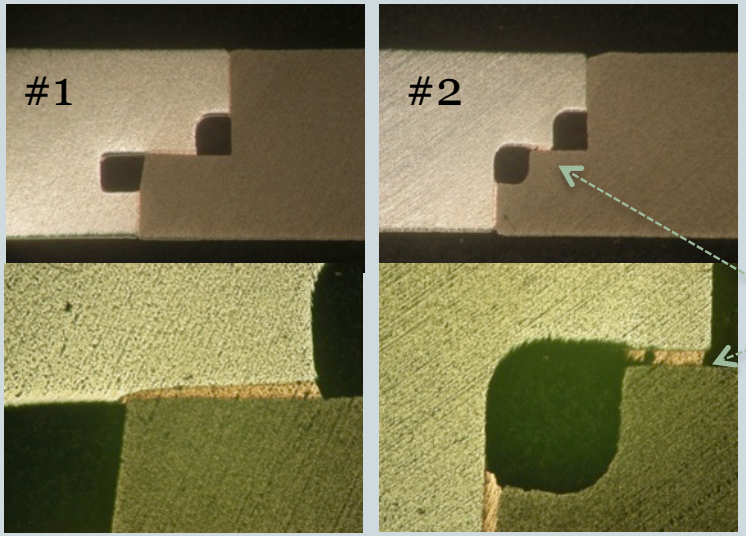




SSR1 Design Overview - Ring

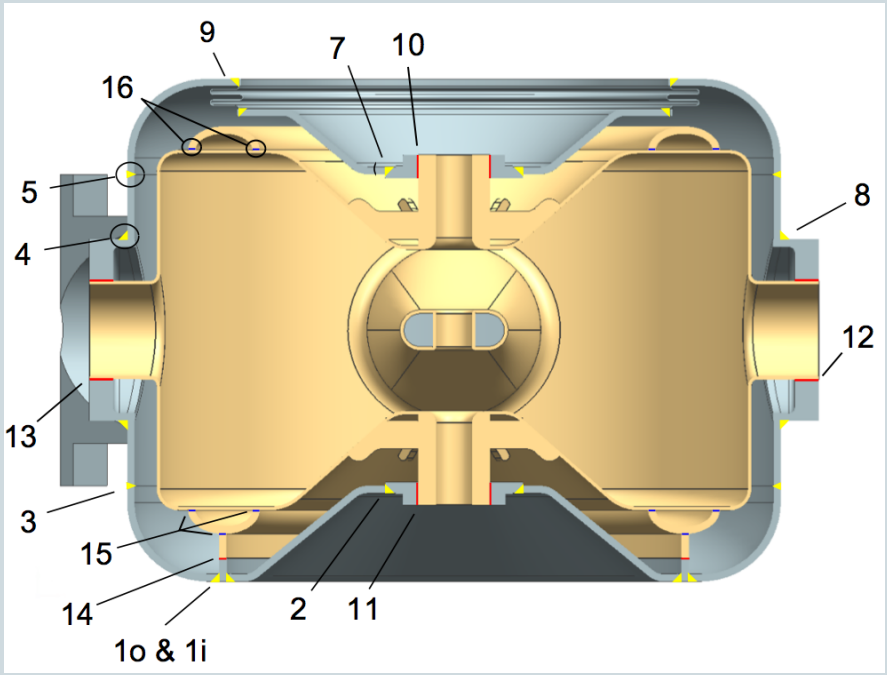
Successful development of small scale samples (3”, 10”). Actual rings to be EBW on cavities are being produced.

Two different joint designs investigated



- Chose option #2 for ease of machining but <u>increased length of central joint</u>
- Proceeded to 10” tests
- Passed Visual, Tensile tests, thermal cycling and leak checks.

SSR1 Design Overview - Welds



Weld Number	Elements Joined	Weld Type
1*i*	HV to Transition Ring (Inner)	TIG
1*o*	HV to Transition Ring (Outer)	
2	Plate to Beam Pipe	
3	HV to Head	
4	HV to Vacuum Port	
5	HV to Head	
6*ss*	HV to HV (Support Side)	
6*w*	HV to HV (Weld)	
7	Plate to Beam Pipe	
8	HV to Coupler Port	
9	Plate to Bellows	
10	Plate to Cavity	Braze
11	Plate to Cavity	
12	Cavity to Coupler Port	
13	Cavity to Vacuum Port	
14	Cavity to Transition Ring	
15	Donut Rib to Transition Ring	EBW
16	Cavity to Donut Rib	

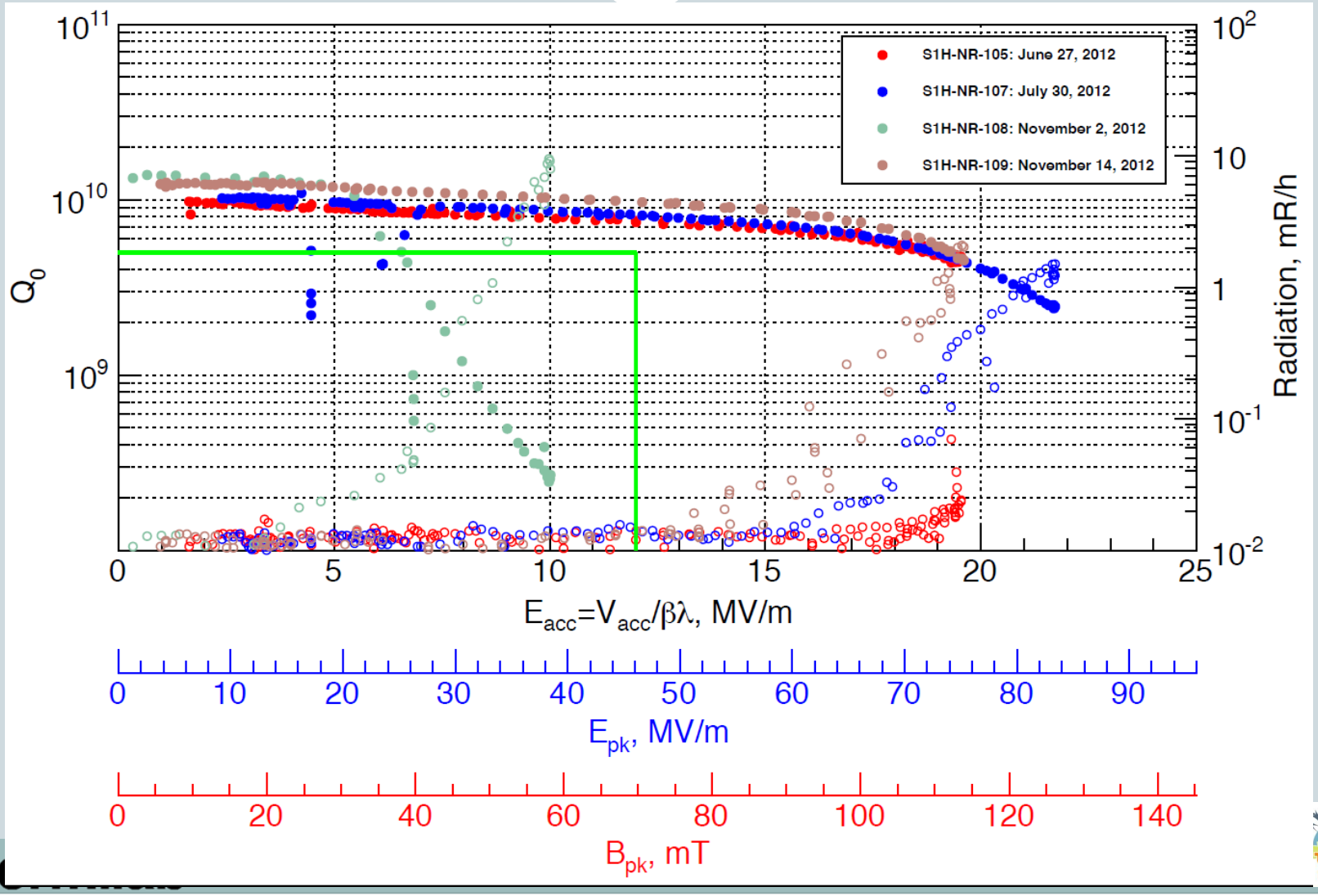
Fermilab SSR1 Inventory Status

	Forming	sub-assy EBW	Trim	final EBW	Delivery to FNAL	QC	Bulk BCP	Bake	RF tune	Light BCP	VTS	Jacketing	BCP	HTS
S1 ZN 101					11-May-07									
S1 RK 102					31-Jul-08							Oxidized	at AES	
S1 IU 103														
S1 IU 104														
S1 NR 105					9-Mar-11						exceeds pxie spec			
S1 NR 106				eq hole repaired	24-Oct-11					leak @ bp	back at Roark			
S1 NR 107					4-Nov-11						exceeds pxie spec			
S1 NR 108					4-Nov-11						Below pxie spec			
S1 NR 109					19-Dec-11						exceeds pxie spec			
S1 NR 110					19-Dec-11	FNAL								
S1 NR 111				eq hole	30-Nov-12									
S1 NR 112				ready	31-Dec-12									
S1 NR 113		spoke hole rep.		ready	31-Dec-12									
S1 NR 114		spoke hole rep.		ready	31-Dec-12									
S1 RK 115	Nb sent													

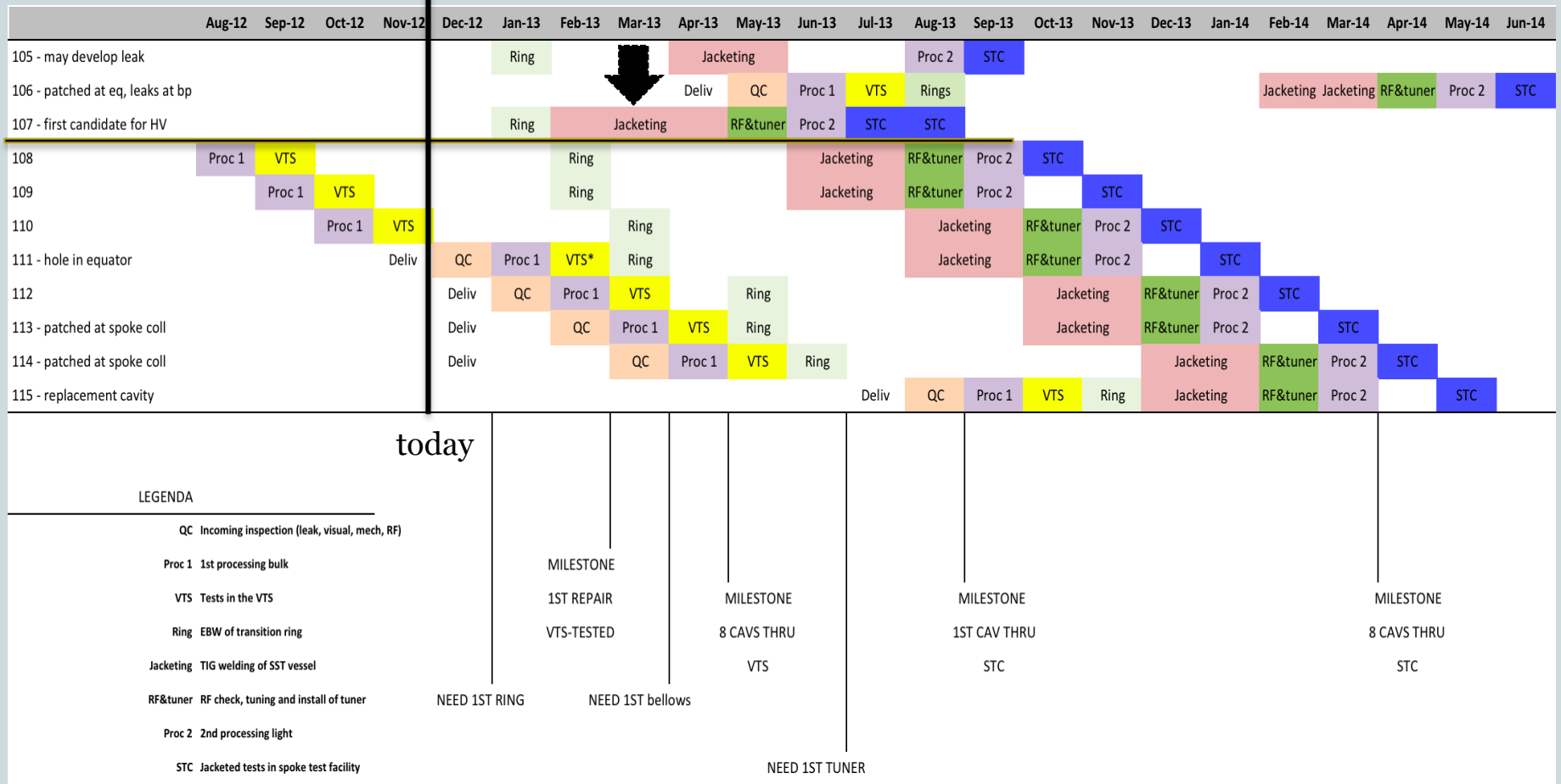
	ready for activity				in progress
	completed				issue

Fermilab

Fermilab – SSR1 VTS Test Results



Schedule for SSR1 Activities



Fermilab

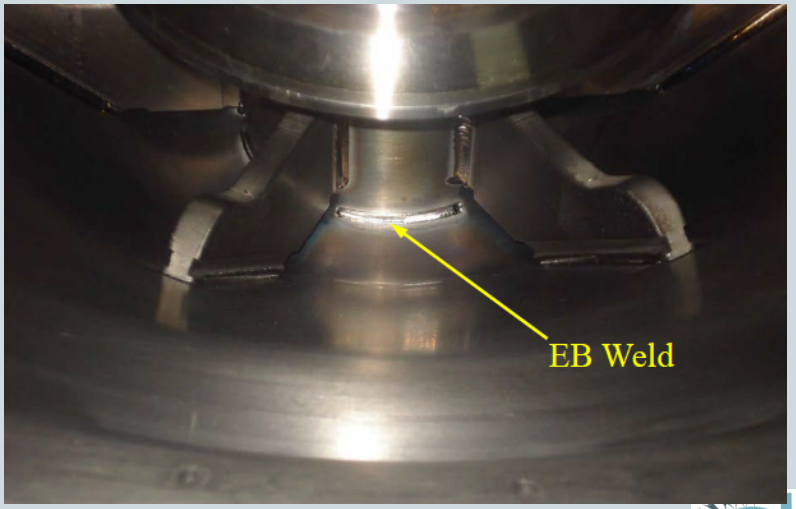
SSR1 STATUS AT IUAC

SSR1 Deliverables

- SSR1 Deliverables under Supplement 1 to Addendum III of MOU between Fermilab and Indian DAE Laboratories:
  - 2 - Bare SSR1 Spoke Resonator Cavities (Q1-2013)
    - IUAC will fabricate these initial cavities
  - 4 – Dressed SSR1 Spoke Resonator Cavities (2014-15)
    - IUAC will fabricate SSR1 cavities
    - VECC will install Helium Jacket on these cavities

Developments – End Walls

- Welds on all four end walls are complete
  - Due to an oversight, the daisy ribs got welded without making a weld pass from the non-RF side of the Beam Port to End Wall.
  - This weld was performed afterwards with 6 welds that add up to a little over 80% coverage
    - (both tensile and shear stress below allowable)
  - This option was more favorable than attempting to achieve more weld coverage at the risk of damaging the RF side of the cavity.

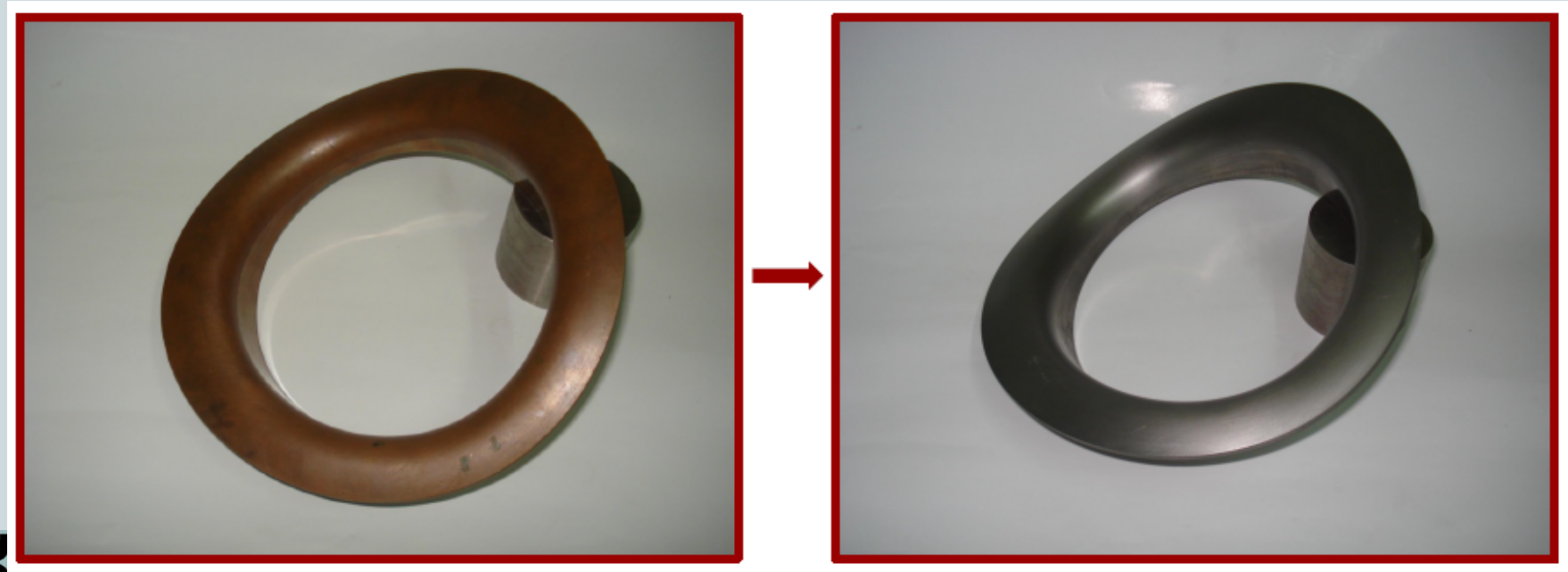


Developments – End Walls

- All four end walls have been electropolished.
  - First EP fixture was found to be of faulty material (polypropylene)
  - New fixture has been successful
  - Setup with fixture (left) and final product (right)

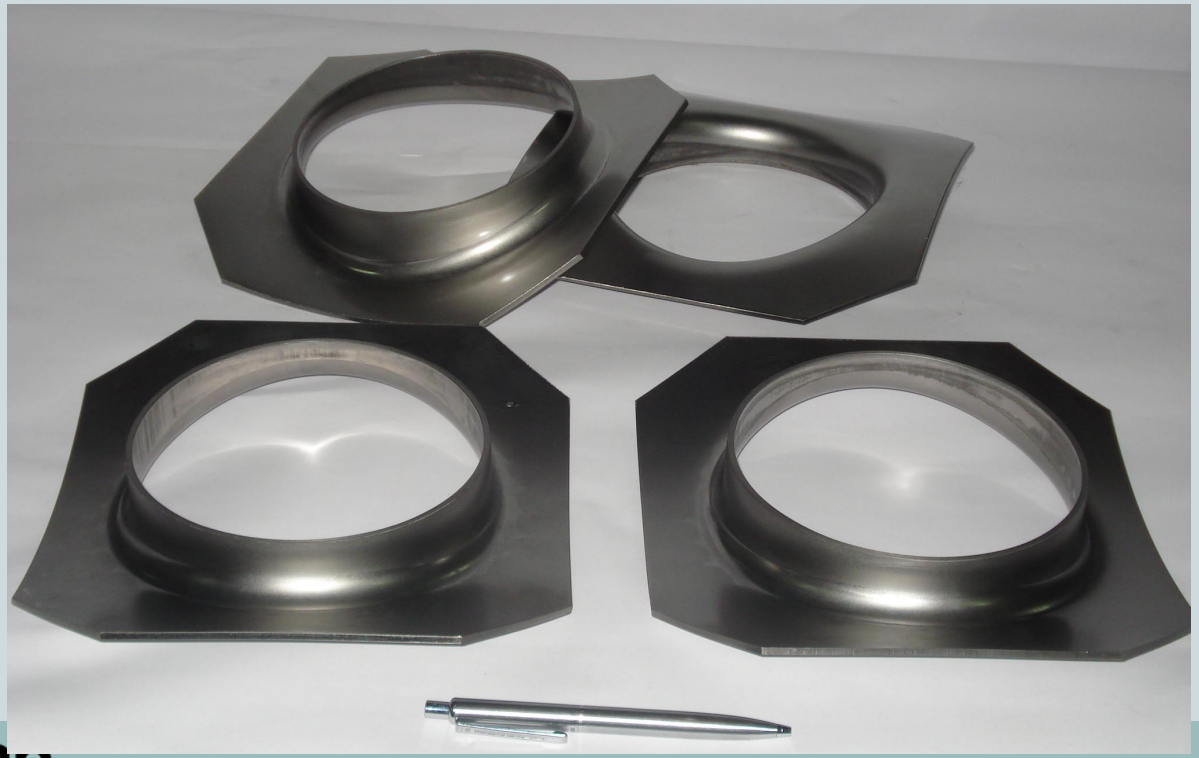
Developments - Spoke

- Spoke to Shell Collar (STSC)
  - Copper trials were performed to develop the proper die/punch procedure for Nb.
  - One trial piece was formed from Nb. This trial piece mated very well with the corresponding end of the niobium spoke



Developments - Spoke

- Spoke to Shell Collar (STSC)
  - The four STCS collars for the two spoke assemblies have been formed:



Developments - Spoke

- The shell was measured to determine the length that the spoke and spoke collars need to be.
- This fixture will be used to bore the holes for the spoke assembly as well as for the EBW of the spoke to shell.
- Weld and EP fixtures for spoke assembly have been prepared.

Future Schedule for 2 bare Cavities

COMPLETION SCHEDULE FOR THE TWO SINGLE SPOKE RESONATORS SSR1 AT IUAC						
S.No	Item	November '12	December '12	January '13	February '13	March '13
1	Spoke to Shell Collar (STSC) forming					
2	Assy & EBW Fixtures for Spoke & STSC					
3	EBW of Spoke to STSC + EBW of Beam Port					
4	Electropolishing of the Spoke assembly					
5	EBW of Spoke to Shell					
6	Tuning of SSR1s					
7	Fixture for End Wall to Outer Shell EBW					
8	EBW of End Walls to Shell assembly					
9	EBW of Bridge Ribs to Shell					
10	Shipment of 2 SSR1 Resonators					

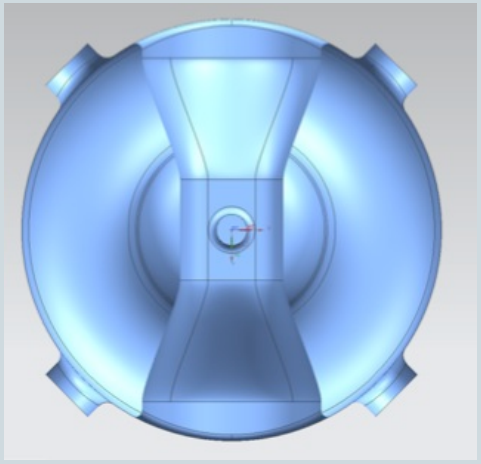
Indian Cavity Logistics

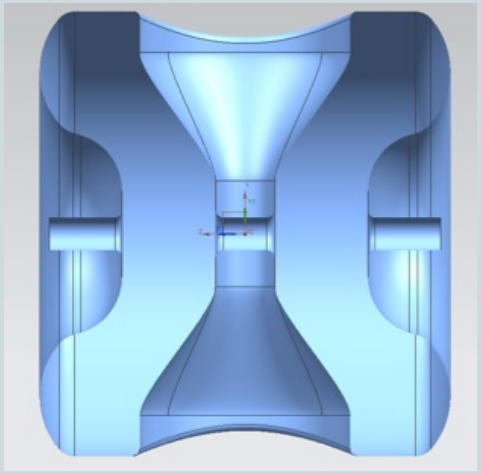
- Cavity Logistics for 2 bare cavities
  - IUAC -> Fermilab (VTS Test)
- Cavity Logistics for 4 dressed cavities
  - IUAC -> VTS Test (??)-> IUAC (welding of transition ring) -> VECC (jacketing) -> Fermilab (HTS Test)

- Will the second batch of SSR1 cavities fabricated at IUAC be sent to fermilab for VTS or will this occur at some other lab?

SSR2 (v0)
STATUS AT FERMILAB

SSR2 Preliminary Design





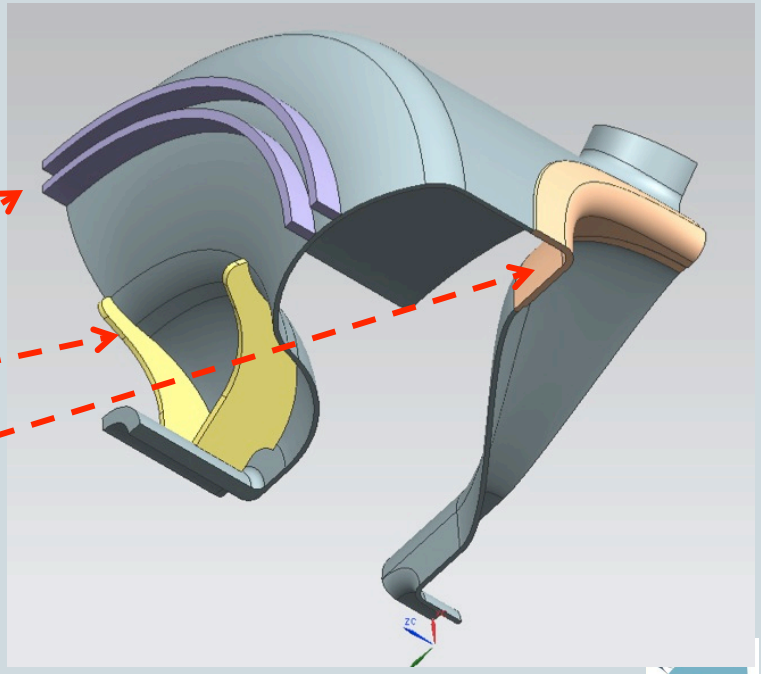
- 4 coupler ports
- 270.7 mm radius
- 478 mm beam pipe to beam pipe length

Parameter	Value
Frequency	325 MHz
Shape	Single Spoke Resonator
β_g, β_o	NA , 0.471
$L_{eff} = 2*(\beta_o \lambda/2)$	434.8
Iris Aperture	40 mm
Inside diameter	541.4 mm
Bandwidth	
E_{pk}/E_{acc}	3.45
B_{pk}/E_{acc}	6.107 mT/(MV/m)
G	112.98 Ω
R/Q	289.94 Ω
Q_0	> 8 x 10^9

SSR2 Preliminary Design Conditions

- MAWP: 2 bar warm, 4 bar cold
  - End wall reaction to this design condition has been studied and stiffening elements have been introduced to avoid yielding of the material.
  - Once the end wall has been defined the entire model of the cavity has been evaluated under the same loading conditions
- Materials:
  - Cavity is made of RRR Nb (2.8-3.1mm)
  - Stiffeners from reactor grade Nb

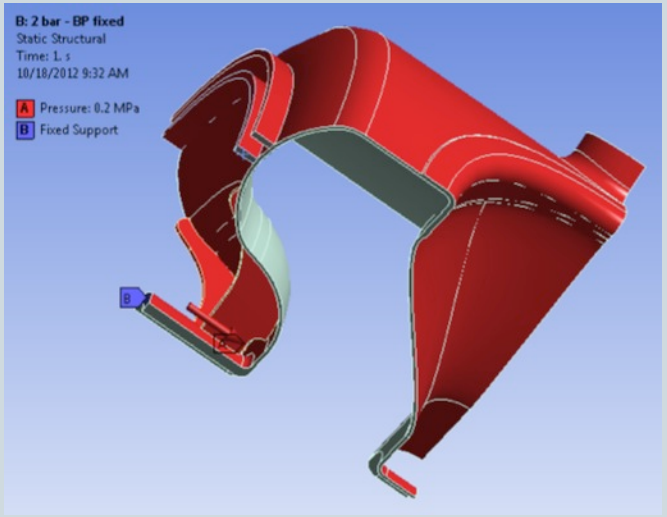
•4 transition rings (2 for each endwall) *required for the cavity to survive the Leak Check*
•12 Beam pipe ribs (6 for each endwall) *required for the cavity to survive the VTS*
•4 mm spoke collar *required for the cavity to survive the VTS*



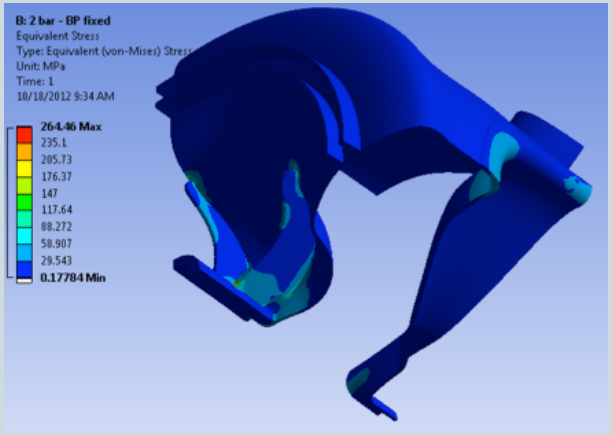
SSR2 Preliminary Design - Mech Analysis

Analysis Setup:

- Beam Pipe Fixed
- 0.2 MPa pressure applied to the cavity
- Symmetry condition imposed on all the 3 planes



Von Mises Stress Plot



- There are limited regions with stresses above the Yield, but they can be tolerated
- The 4 mm thick spoke collar allows to reduce high stresses in this area under these loads

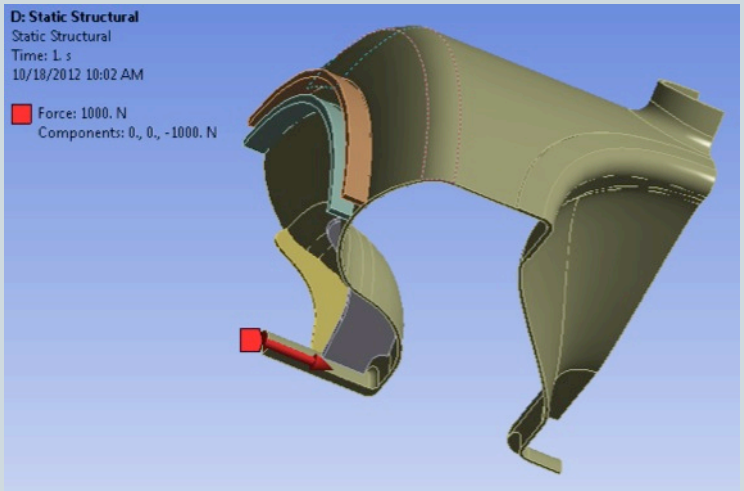
SSR2 Preliminary Design - Stiffness

The stiffness at the beam pipe directly affects the tuning force that will be required during operations:

$$F_{tuning} = \frac{Range}{Sensitivity} Stiffness$$

For *given range* and *sensitivity*, a lower stiffness reduces the force required for tuning.

Symmetry imposed about the three planes



$$k = 4\frac{1000N}{0.195mm} \cong 20500\ {}^{N}/_{mm}$$

It's less than what we have for SSR1 (25kN/mm).
The Sensitivity will be also smaller
~300 vs. 540 kHz/mm

SSR2 Preliminary Design – He Vessel

The Helium Vessel will be designed in such a way to allow the cavity to have a df/dp the closest possible to zero.

Methodology (see http://accelconf.web.cern.ch/AccelConf/IPAC2012/papers/weppc056.pdf) :

- Define the interfaces between the cavity and the helium vessel, identify the related **N** degrees of freedom
- df/dp behavior of the cavity can be expressed and a linear combination of the displacements x_i of the N degrees of freedom

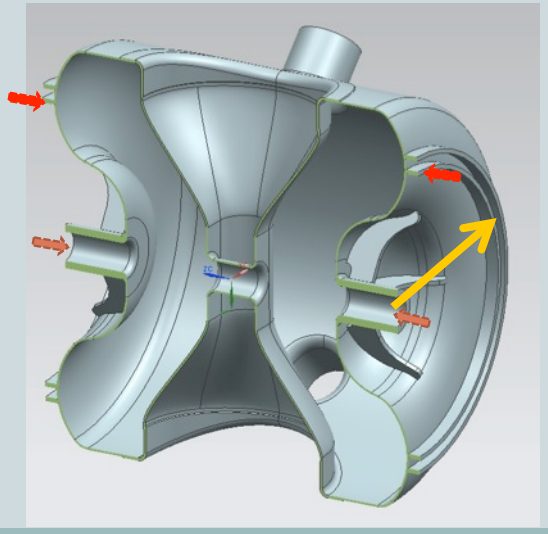
- The helium vessel will have to allow displacements x_i such that their linear combination according to the formula above gives df/dp=0

Interfaces between cavity and HV:

- Beam pipes
- Ring

Degrees of freedom

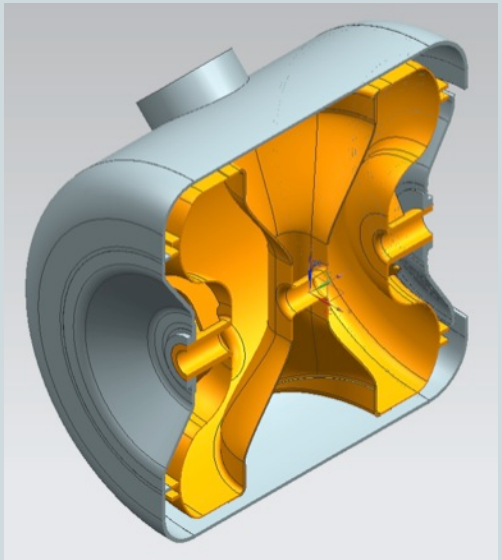
- Longitudinal displacement of BP (Bellows)
- Longitudinal displacement of ring
- Radial displacement of ring



SSR2 Preliminary Design – He Vessel

The current Helium Vessel for the SSR2 – v0 cavity has the following features:

- Material: Stainless Steel SS316L
- Thickness: 6 mm
- Bellow radius: 193 mm
- The cavity will be coupled to the helium vessel by means of a *transition ring*, at *r = 195 mm*



df/dp of the system:
- 3.41 Hz/mbar free state sensitivity

SSR2 Preliminary Design - Conclusions

- The baseline version of SSR2 b=0.47 has been introduced (v0)
- A preliminary solution for the mechanical design has been identified such that the bare cavity will survive during the leak check and VTS tests.
- Typical circumferential ribs on the cavity cylinder have been omitted in favor of a thicker spoke collar. This will allow substantial savings and simplifications.
- The Stiffness of the cavity end-wall has been evaluated and it appears ok from the tuning point of view.
- A helium vessel is being designed in order to achieve a df/dp the closest possible to zero.
- Improved profiles of the end-wall are currently under study. It appears possible to reduce the number of end-wall rings to only one per side.

Thank You!