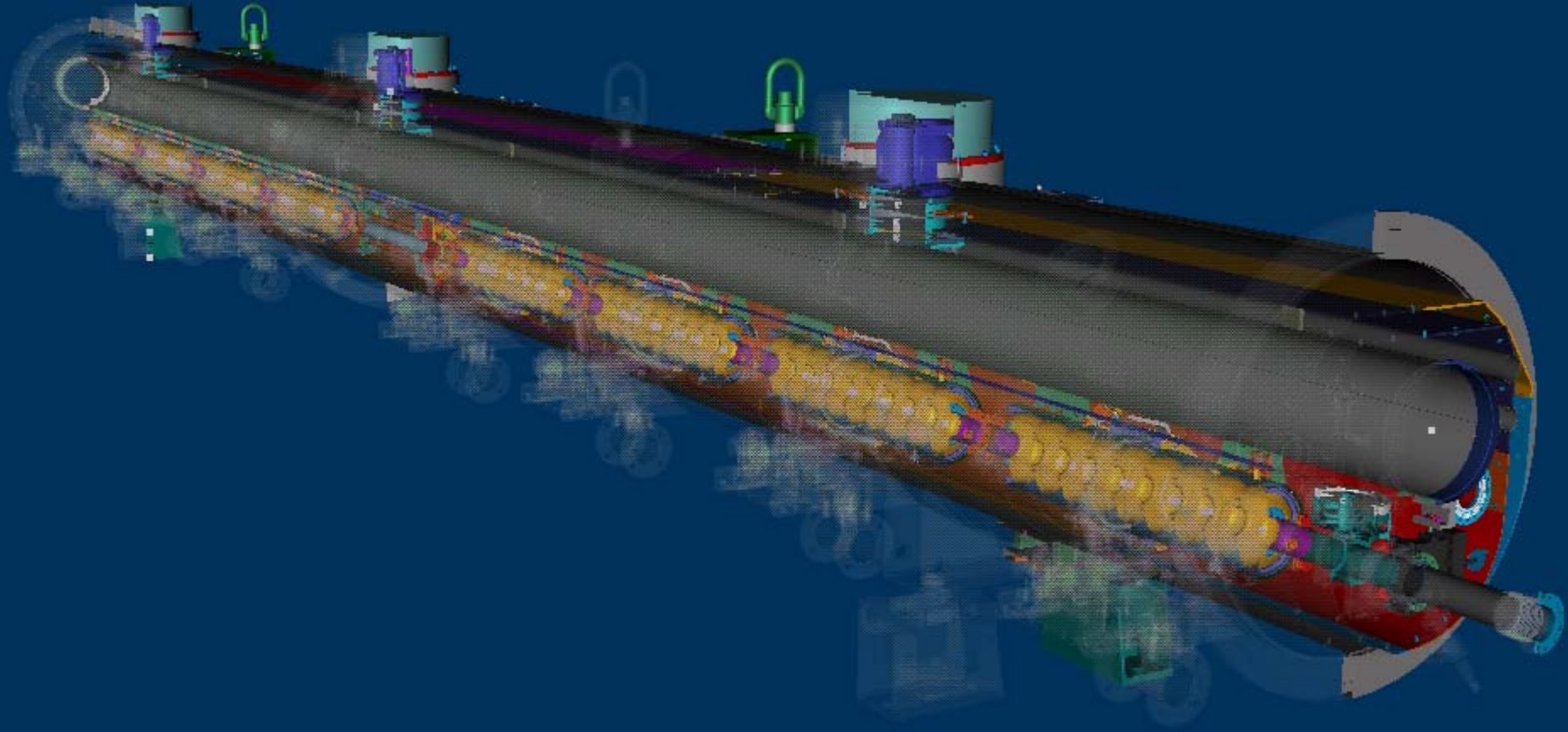




Type IV Cryomodule Design Status



September 12, 2007

Don Mitchell, FNAL



Type IV Cryomodule Design Status



- Agenda

- T4CM design status

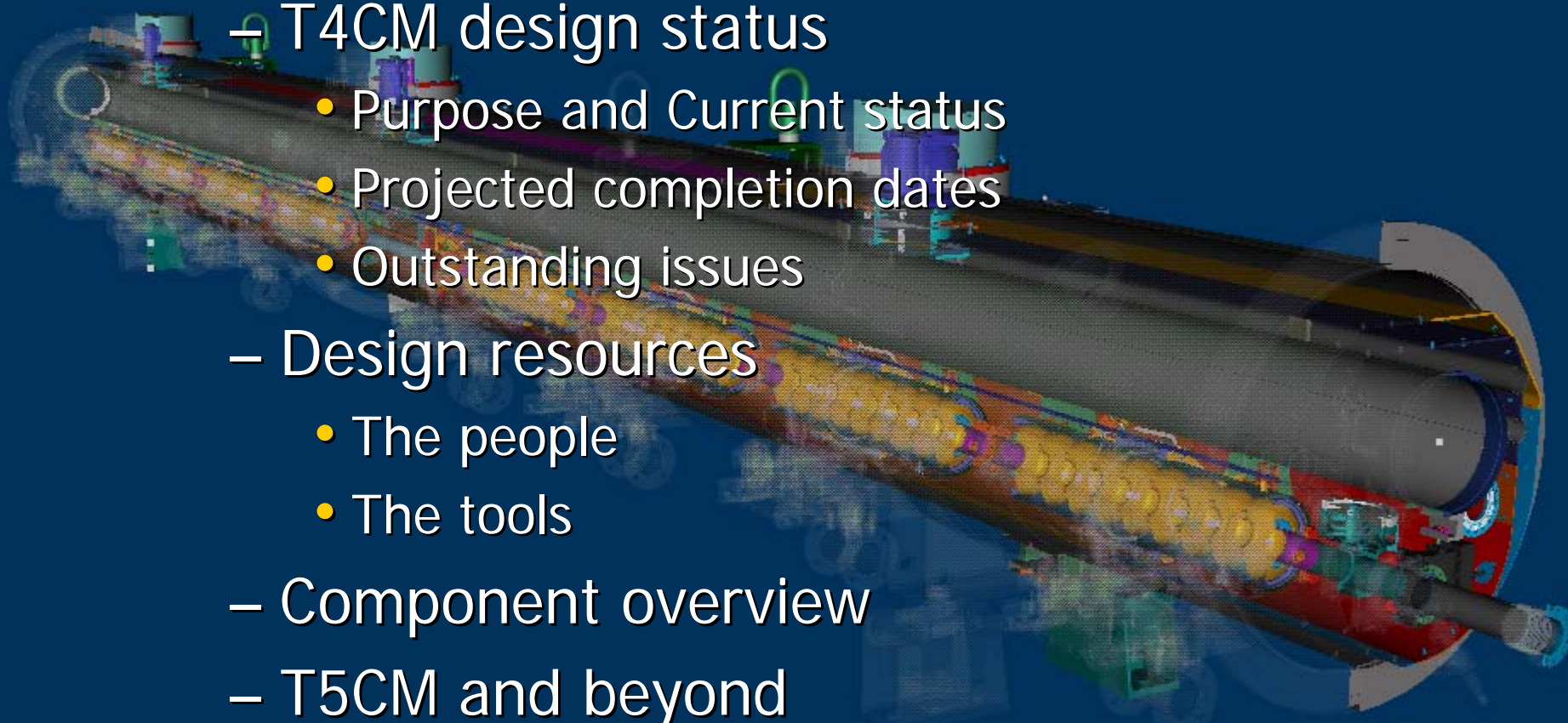
- Purpose and Current status
- Projected completion dates
- Outstanding issues

- Design resources

- The people
- The tools

- Component overview

- T5CM and beyond





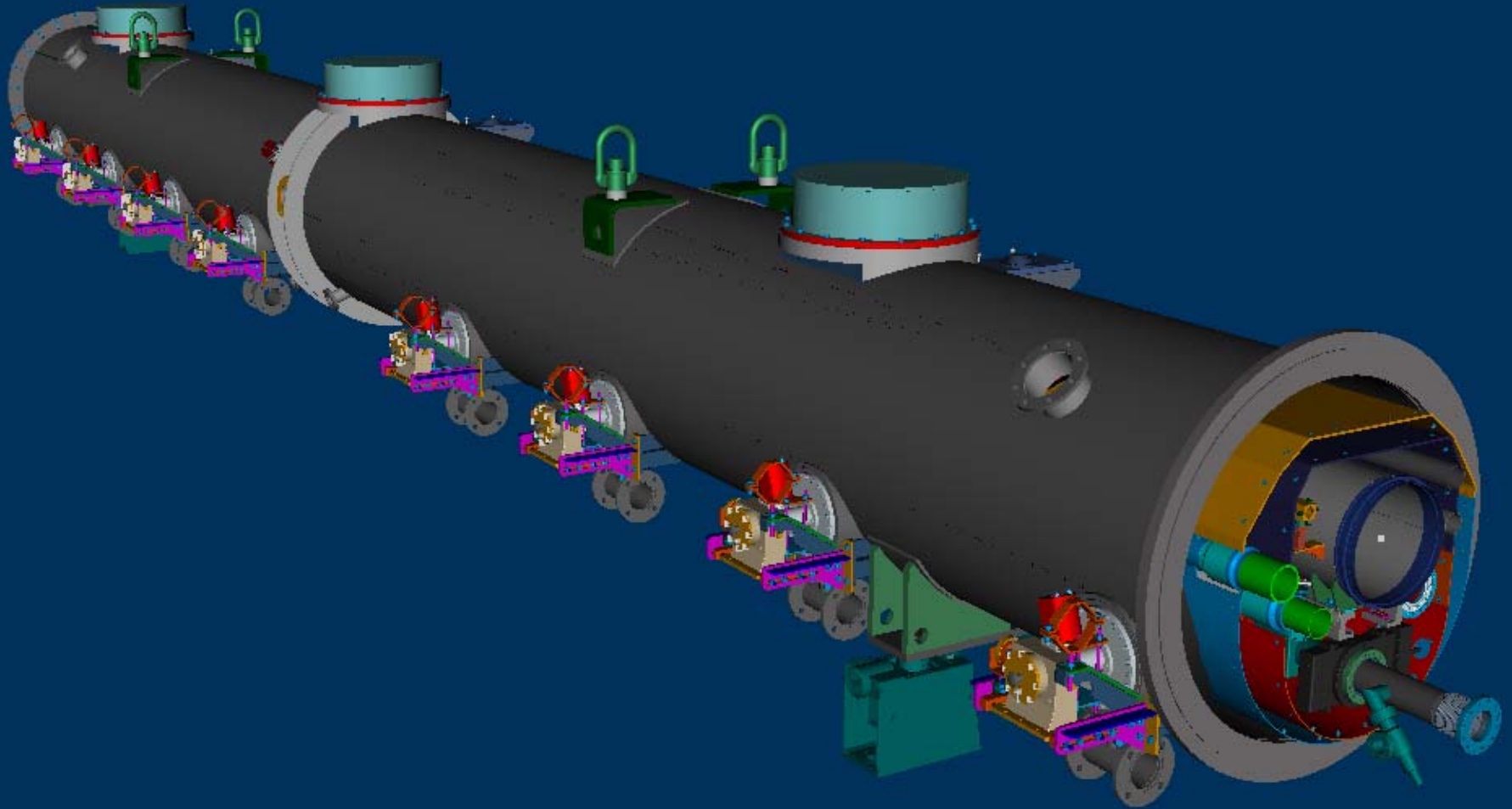
Purpose of the T4CM



- The T4CM's main purpose is to test the sensitivity of the quadrupole magnet package mounted under the center post of the cryomodule rather than at the usual end position.
 - The magnet mounted at the cryomodule end is more prone to vibration.
 - The center of the cryomodule, directly under the fixed post, provides the most stable location for the magnet package.
 - The T4CM will have additional instrumentation to take adequate measurements of the magnet package location both in the warm and cold positions.
 - If this design modification does not perform significantly better than the previous end support design, then an alternative support and alignment system, or a separate cryomodule for the magnet, must be investigated.
- A secondary purpose of building this cryomodule at Fermilab is to gain experience in the design, procurement, and assembly of a complete cryomodule. To-date, only existing TTF style cryomodules and cavity strings are being built at Fermilab. Beginning now, Fermilab and the ILC collaborators need to be able to develop every aspect of a complete cryomodule.
- **THIS IS NOT THE ILC CRYOMODULE PROTOTYPE!**



Type IV Cryomodule 3-D Model





Current Status of T4CM w/ Magnet Package



- All components are well defined except for the magnet package, BPM, and HOM absorber.
 - Current 3-D model reflects this design.
 - 2-D drawings of fixed components are ~70% complete.
- We are dealing with frustrating EDMS issues with our assemblies. UGS to roll-out solution soon.
- Our current focus is on the T4CM w/ magnet
 - Kashikhin's magnet prototype is advancing
 - Orlov designing quad leads, supports, and shield & vessel penetrations
 - Wendt's BPM prototype is advancing



Current Status of T4CM w/ Magnet Package



- The following components will be detailed in October:
 - HGRP, 90% Piping, Needle bearings, Magnetic shielding, Helium vessel, and Coldmass supports
- The following components will not be completed until the magnet and BPM are finalized:
 - Cryovessel, Heat shields, and 10% Piping
- Smaller misc. components to be completed by end of December 2007.
- Design and drafting completion date by end of March 2007.



Current Status of T4CM w/ Magnet Package



- What we still need...
 - ASME BPVC document on cryovessel design
 - Documentation and safety approval for:
 - Helium vessel
 - BPM
 - Magnet package
 - A magnet plan for T4CM usage in NML
 - Smaller quad with added mass to simulate an ILC magnet but with correct operating parameters for New Muon Lab at Fermilab.
 - Vibration and stability studies
 - BPM & Magnet integration
 - Instrumentation plan

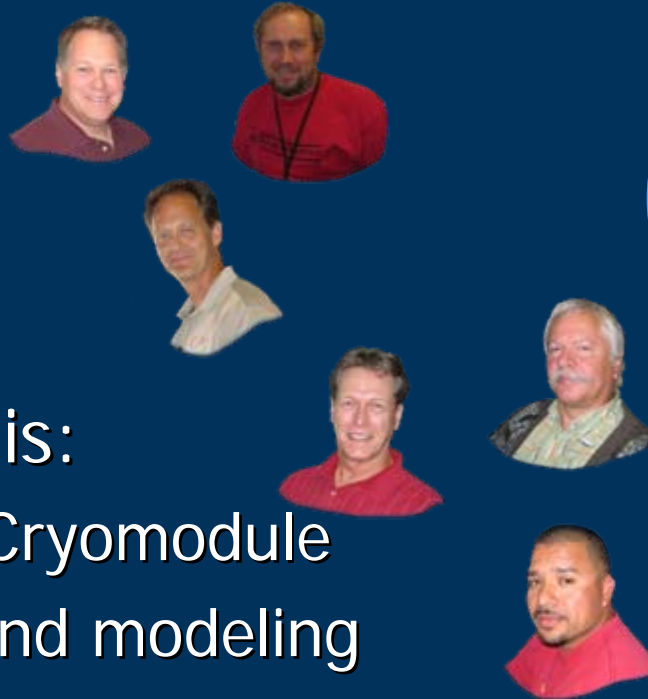


Fermilab Cryomodule Resources



- Who?

- 2 engineers
- 1 designer
- ³4 contractors



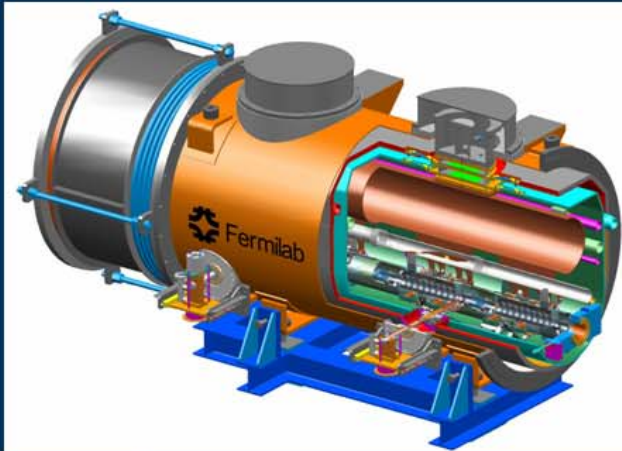
- What our focus is:

- 3rd Harmonic Cryomodule
- T4CM design and modeling
- Misc. infrastructure design support
 - Horizontal and vertical test
 - High-pressure rinse
 - Drafting checking



Recently added
to the team

3rd Harmonic SRF Cryomodule



Cryomodule design completed in May 2007.

1st successful cavity test in Spring 2007!

Fabrication in process at MP9.

2008 delivery to DESY.



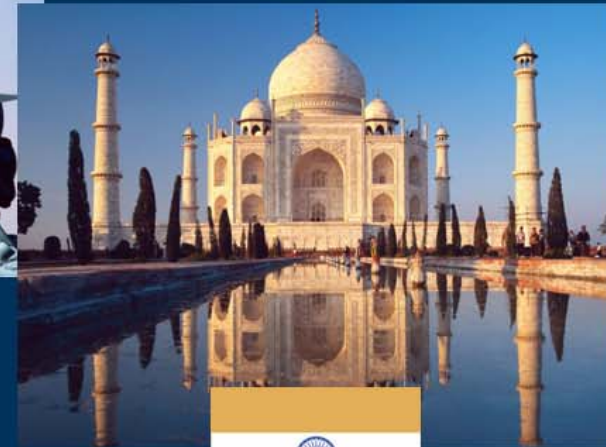
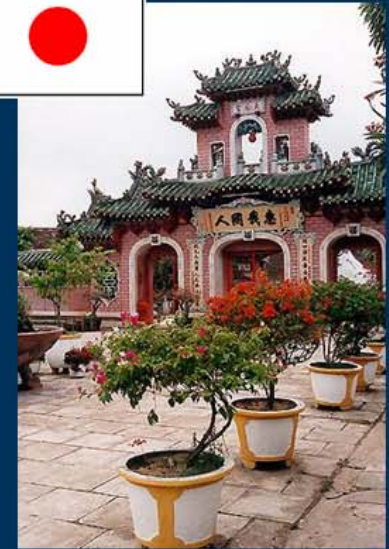
An International Cryomodule Design Team founded in May 2006

November 2006: Training EDMS
to the international team.



Collaboration Team:

- ▶ FNAL (USA)
- ▶ INFN (Pisa, Italy)
- ▶ INFN (Milan, Italy)
- ▶ KEK (Japan)
- ▶ RRCAT (India)
- ▶ DESY (Germany)





ILC International Resources



- INFN-Milan: **Carlo - Paolo - Nicola - Serena**
 - Bladetuners – main effort
 - Titanium vessel & cryomodule consultants
 - Future cavity end-group development – low effort
- INFN-Pisa: **Franco – Andrea**
 - Bi-metallic transitions w/ Dubna – main effort
 - Cavity interconnect bellows – medium effort
 - Vibration studies – low effort
- KEK: **Norihito – Norio**
 - R&D efforts on internal magnetic shielding



- RRCAT: **Jishnu**
 - Process of learning cryomodule design & fabrication
 - Jack stands for cryomodule
 - Will participate much more in future designs
- DESY: **Lars – Norbert – Andreas – Jasper – Silke**
 - EDMS support
 - Working very closely with UGS to solve database problems with assembly check-in / check-out
 - Vis-View and Web-Ex support
 - Select training



A Working Collaboration



- A *real* international collaboration!
- Cryomodule development as a team!
- Sharing common data!

Fermilab Today

Monday, December 4, 2006

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Search

Calendar	Feature Story	Safety Tip of the Week
<p>Mon., December 4 2:30 p.m. Particle Astrophysics Seminar - Curia II Speaker: E. Lim, Yale University Title: Large Non-Gaussianities from Single Field Inflation 3:30 p.m. Director's Coffee Break - 2nd floor crossover 4:00 p.m. All Experimenters' Meeting - Curia II Special Topics: SciBooNE Construction Progress; Tevatron Low-Beta Optics Measurements and Upgrade Plans</p> <p>Tue., December 5 3:30 p.m. Director's Coffee Break - 2nd floor crossover 4:00 p.m. Accelerator Physics and Technology Seminar - 1 West Speaker: N. Eddy, Fermilab Title: Beam Control and Monitoring with FPGA-Based Electronics: Status and Perspectives</p> <p>Click here for NALCAL, a weekly calendar with links to additional information.</p>	<h3>Planning for ILC success through shared databases</h3>  <p>Participants in the five-day course at Fermilab.*</p> <p>Designing, building and operating the ILC will require an unprecedented level of world-wide collaboration. To make this possible, collaborators will use a shared Electronic Data Management System. This will allow them to contribute, extract and edit live data in real time. A pilot EDMS, set up by DESY in Hamburg, is already in use by the ILC cryomodule design team. Its success will provide a model for other ILC databases.</p> <p>This week Fermilab hosted a five-day training course for scientists, physicists and engineers in the use of the design database. This database will allow all engineering data to be shared amongst the collaboration in real time. This is a first.</p>	<h3>Where did you get that?</h3>  <p>There are things you just can't find on eBay.</p> <p>When you procure something, how do you know you'll get a good fit to your needs? Will regulations be violated, hazards introduced, benefits overlooked? At Fermilab, most procurement actions are reviewed for environmental, safety and health issues at the division and section level. This process is described in ES&H Manual chapter 5010, which is being updated to include acquisition from government excess.</p> <p>As with many new rules, this addition was motivated by a particular incident. Fermilab acquired two laminar flow hoods from government surplus. They came equipped with germicidal UV lamps that an employee used to illuminate material samples for photographing. Later that night the worker experienced face redness and eye irritation from his brief exposure to UV. Fortunately, there was no lost work time and the effects of exposure completely resolved in a few days.</p>



Communication is essential!



- We needed a way to share information.
- We needed common tools.
- DESY has been very accommodating and has provided their Team Center Enterprise (EDMS) as well as their IT services as part of their collaboration effort. No cost to the user. –Thanks!



Common CAD tools



- FNAL: I-DEAS v.12
- SLAC: Solidedge
- JLAB: I-DEAS
- INFN Milan: UG-NX & I-DEAS v.12
- INFN Pisa: I-DEAS v.12
- KEK: I-DEAS (recent purchase)
- DESY: I-DEAS v.12

Note: These are all UGS CAD products and are “team browser” compatible with Team Center Enterprise. However, the current supported platform is I-DEAS v.12 with plans to add other CAD packages soon.



Common CAD tools (cont.)



- Common CAD software: I-DEAS v.12m2
- Common database: DESY EDMS
 - Live
 - Daily use
 - Integrated with collaboration
 - Web viewable data and BOM structure
 - CAD and data file storage
 - 3-D, 2-D, specs, engineering notes, etc.
- Visualization and collaborative meetings
 - VisView software from UGS
 - Licenses supplied by DESY (no cost to users)
 - On-line collaborative meetings with file sharing.
 - WebEx meetings with desktop sharing



Team Center Enterprise EDMS Team Browser hosted by DESY



Team Browser

File Edit View Tools Manage Help

My Items

I-DEAS

Model File C:\DEAS\Model_Files\LCYMO_031807_T4CM-9_COMPL_ASSY.mfl

- Main
 - COLD_MASS_T4CM-9_CAVITIES_ASSY, D00000000613373, v5
 - T4CM_9_CAVITIES_NEW_COMPL_ASSY, D00000000608303, v8**

Team Data

Teams for Orlov_Youri_FINAL

- DESY-FNAL-CAD-Test
- IPP_Training
- Type 4 Cryomodule Design
 - 1-3GHz CAVITY
 - CAD Main Assemblies
 - CAVITY_STRING-9_ASSY, D00000000602033, v16
 - CAVITY_STRING-ASSY-T4CM_NO-MAGN, D00000000563503, v3**
 - CAVITY_STRING-T4CM-DELETE-ME, D00000000557733, v1
 - COLD_MASS_ASSY_T4CM, D00000000556753, v23
 - COLD_MASS_T4CM-9_CAVITIES_ASSY, D00000000613373, v4
 - COLD_MASS_T4CM_VV_MAG_ASSY, D00000000611633, v14
 - COMPLETE_ASSEMBLY_T4CM-9, D00000000602203, v1
 - HGR_PIPE_ASSY-T4CM_NO-MAGN, D00000000563493, v4
 - HGR_PIPE_T4CM-9_ASSY, D00000000602003, v12
 - T4CM_9_CAVITIES_NEW_COMPL_ASSY, D00000000608303, v7
 - T4CM_COMPLETE_ASSY_NO-MAGN, D00000000563663, v12**
 - T4CM_VV-MAG_COMPLETE_ASSEMBLY, D00000000556493, v18
 - VESSEL_CRYOSTAT_T4CM-9_MACH, D00000000601903, v13
 - CAD Working Data
 - CAD Working Data-No Magnet

Item List

Name	Number	ItemType	Version	Status	Pr...
T4CM_9_CAVI...	D00000000608303	Assembly	8	Ck	-
BELLOWS_T4...	D00000000557123	Assembly	2	Rfl	
COLDMASS_...	D00000000603463	Assembly	2	Rfl	
COLDMASS_...	D00000000552763	Assembly	16	Rfl	
COLDMASS_...	D00000000552803	Assembly	16	Rfl	
JACK_STAND...	D00000000776912	Part	1	Rfl	
JACK_UP_SP...	D00000000733782	Part	1	Rfs	
MC_MOUNT_...	D00000000557603	Assembly	21	Rfl	
MC_WARM_A...	D00000000578523	Assembly	6	Rfl	
MOUNT_TAY...	D00000000605373	Assembly	2	Rfs	
REDUCING_TE...	D00000000613853	Assembly	1	Rfl	
RING_HOIST...	D00000000746892	Part	1	Rfl	
SURVEY_PLA...	D00000000578763	Assembly	7	Rfl	
T4CM-9_HAR...	D00000000613943	Assembly	1	Rfl	
TEMP_T4CM-9...		Drawing			
VESSEL_CRY...	D00000000601903	Assembly	13	Rfl	

My Teams | My Subscribed Items

Details | Search Results

No Changes Required
Ready...
Delete 1 items from the model file



Team Center Enterprise EDMS Thin-Client hosted by DESY



My Teams: Type 4 Cryomodule Design: CAD Main Assemblies - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Refresh Print Mail New Tab

Address <http://teamcenter.desy.de:2345/TC51PRD/controller/home> Go Links

Search Home Exit DESY

Advanced Search... Donald Mitchell

Main Menu Explorer

Check Out From Team Put to WIP Vault Make Available To Team Route Move More Actions...

My Teams: Type 4 Cryomodule Design: CAD Main Assemblies

You are here: [Type 4 Cryomodule Design](#): CAD Main Assemblies

	EDMS-ID	Name	Description	Life Cycle State	Project Name	Class	Cr
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<input type="checkbox"/>	D00000000563513.A.1.1	COLD_MASS_ASSY_T4CM_NO-MAGN	COLD_MASS_ASSY_T4CM_NO-MAGN	Working	Type 4 Cryomodule Design	Assembly	Or
<input type="checkbox"/>	D00000000611633.A.1.1	COLD_MASS_T4CM_W_MAG_ASSY	COLD_MASS_T4CM_W_MAG_ASSY	Working	Type 4 Cryomodule Design	Assembly	Or
<input type="checkbox"/>	D00000000613373.A.1.1	COLD_MASS_T4CM-9_CAVITIES_ASSY	COLD_MASS_T4CM-9_CAVITIES_ASSY	Working	Type 4 Cryomodule Design	Assembly	Or
<input type="checkbox"/>	D00000000602063.A.1.1	COLDMASS_T4CM-9_ASSY	COLDMASS_T4CM-9_ASSY	Working	Type 4 Cryomodule Design	Assembly	Or
<input type="checkbox"/>	D00000000602203.A.1.1	COMPLETE_ASSEMBLY_T4CM-9	COMPLETE_ASSEMBLY_T4CM-9	Working	Type 4 Cryomodule Design	Assembly	Or
<input type="checkbox"/>	D00000000621533.A.1.1	G2_VESSEL_CAVITY_ASSEMBLY	G2_VESSEL_CAVITY_ASSEMBLY	Working	Type 4 Cryomodule Design	Assembly	Gr
<input type="checkbox"/>	D00000000555263.A.1.1	HGR_PIPE_ASSY-T4CM	HGR_PIPE_ASSY-T4CM	Working	Type 4 Cryomodule Design	Assembly	Or
<input type="checkbox"/>	D00000000563493.A.1.1	HGR_PIPE_ASSY-T4CM_NO-MAGN	HGR_PIPE_ASSY-T4CM_NO-MAGN	Working	Type 4 Cryomodule Design	Assembly	Or

*** omfsvr <6529> low_freespace: memory is already free
You have 2 assignments in this Work List.



The Part Excel File



Microsoft Excel - VESSEL_CRYOMODULE_TUBE-9.xls

File Edit View Insert Format Tools Data Window Help

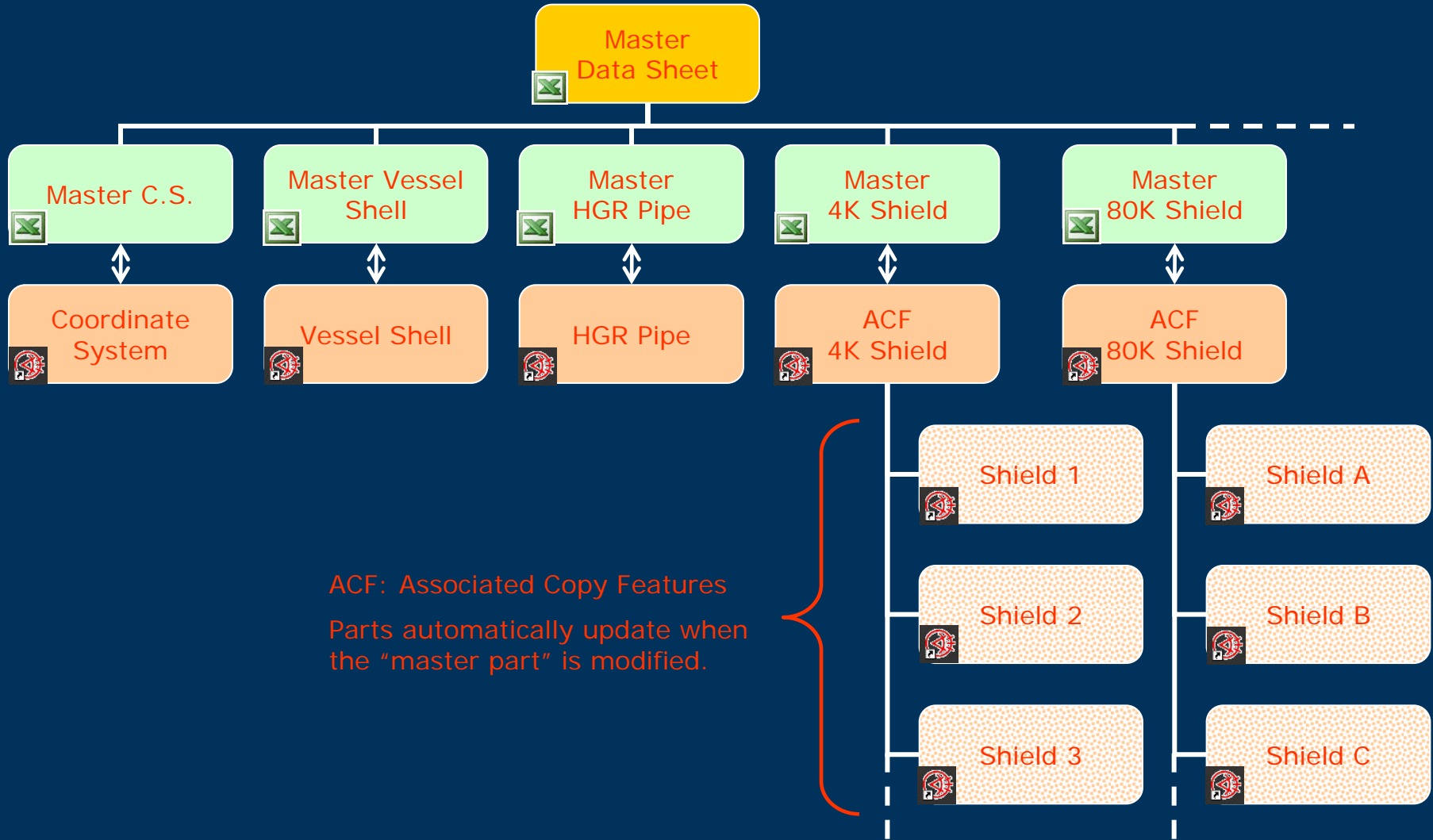
A1

	A	B	C	D	E	F
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4	Part Number					
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6	UPSTREAM_COUPLER_1_Y		0 mm			
7	UPSTREAM_COUPLER_1_Z		-4713.7 mm			
8	UPSTREAM_COUPLER_2_X	UPSTREAM_COUPLER_1_X	0 mm			
9	UPSTREAM_COUPLER_2_Y	UPSTREAM_COUPLER_1_Y	0 mm			
10	UPSTREAM_COUPLER_2_Z		-3394.5 mm			
11	UPSTREAM_COUPLER_3_X	UPSTREAM_COUPLER_1_X	0 mm			
12	UPSTREAM_COUPLER_3_Y	UPSTREAM_COUPLER_1_Y	0 mm			
13	UPSTREAM_COUPLER_3_Z		-2075.3 mm			
14	UPSTREAM_COUPLER_4_X	UPSTREAM_COUPLER_1_X	0 mm			
15	UPSTREAM_COUPLER_4_Y	UPSTREAM_COUPLER_1_Y	0 mm			
16	UPSTREAM_COUPLER_4_Z		-756.1 mm			
17	DOWNSTREAM_COUPLER_5_X	UPSTREAM_COUPLER_1_X	0 mm			
18	DOWNSTREAM_COUPLER_5_Y	UPSTREAM_COUPLER_1_Y	0 mm			
19	DOWNSTREAM_COUPLER_5_Z		563.1 mm			
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22	DOWNSTREAM_COUPLER_6_Z		1882.3 mm			
23	DOWNSTREAM_COUPLER_7_X	UPSTREAM_COUPLER_1_X	0 mm			
24	DOWNSTREAM_COUPLER_7_Y	UPSTREAM_COUPLER_1_Y	0 mm			
25	DOWNSTREAM_COUPLER_7_Z		3201.5 mm			
26	DOWNSTREAM_COUPLER_8_X	UPSTREAM_COUPLER_1_X	0 mm			
27	DOWNSTREAM_COUPLER_8_Y	UPSTREAM_COUPLER_1_Y	0 mm			
28	DOWNSTREAM_COUPLER_8_Z		4520.7 mm			
29	UPSTREAM_COLDMASS_SUPPORT_X		0 mm			
30	UPSTREAM_COLDMASS_SUPPORT_Y		0 mm			
31	UPSTREAM_COLDMASS_SUPPORT_Z		-4175 mm			
32	DOWNSTREAM_COLDMASS_SUPP	UPSTREAM_COLDMASS_SUPPORT	0 mm			
33	DOWNSTREAM_COLDMASS_SUPP	UPSTREAM_COLDMASS_SUPPORT	0 mm			
34	DOWNSTREAM_COLDMASS_SUPP	UPSTREAM_COLDMASS_SUPPORT	4175 mm			
35	MODULE_VESSEL_CL_X		0 mm			
36	MODULE_VESSEL_CL_Y		247 mm			
37	MODULE_VESSEL_CL_Z		0 mm			
38	HELIUM_GAS_RETURN_CL_X		0 mm			
39	HELIUM_GAS_RETURN_CL_Y		356 mm			
40	HELIUM_GAS_RETURN_CL_Z		0 mm			
41	MC_8_COLD_POSITION_X	MC_1_COLD_POSITION_X	0.24 mm			
42	MC_8_COLD_POSITION_Y	MC_1_COLD_POSITION_Y	1.9 mm			
43	MC_8_COLD_POSITION_Z		4517.789 mm			
44	MC_7_COLD_POSITION_X	MC_1_COLD_POSITION_X	0.24 mm			
45	MC_7_COLD_POSITION_Y	MC_1_COLD_POSITION_Y	1.9 mm			
46	MC_7_COLD_POSITION_Z		3199.38 mm			
47	MC_6_COLD_POSITION_X	MC_1_COLD_POSITION_X	0.24 mm			
48	MC_6_COLD_POSITION_Y	MC_1_COLD_POSITION_Y	1.9 mm			
49	MC_6_COLD_POSITION_Z		1880.972 mm			

- ▶ Only a portion of the file is shown.
- ▶ Column A shows the variable names used in your part's history.
- ▶ Includes names of:
 - ▶ Ref Pts.
 - ▶ Coord. Sys.
 - ▶ Wireframe variables
- ▶ Column C shows the variable's current value.
- ▶ Yellow highlighted items cannot be modified.
- ▶ The Data / Protection can be turned off to give you more editing control.



Managing the CAD Assembly with Excel & I-DEAS





Managing the CAD Assembly with Excel & I-DEAS

T4CM_Type 4 Cryomodule Design Master Spreadsheet

This spreadsheet contains multiple data tables including:

- Component Properties:** Lists part numbers, descriptions, and quantities.
- Assembly Data:** Details the assembly sequence and relationships between parts.
- Material Properties:** Lists materials used in the assembly.
- 3D Model Views:** Includes images of the cryomodule assembly from different perspectives.



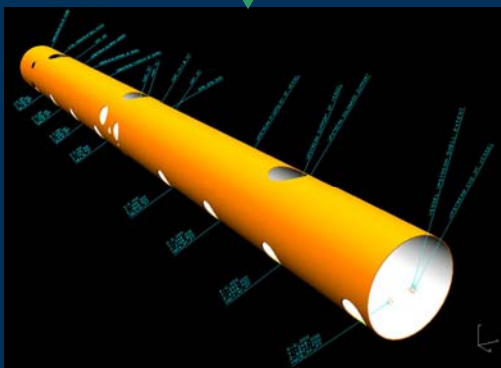
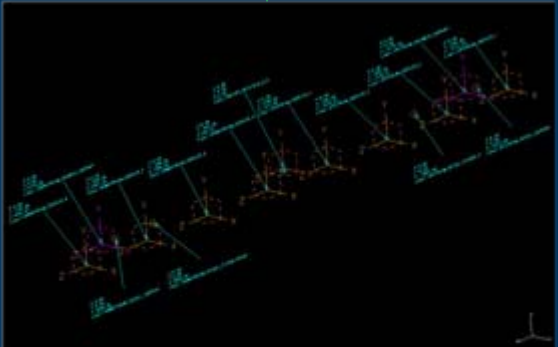
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Part Number					
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UPSTREAM_COUPLER_1_Y		-246 mm			-9.685
UPSTREAM_COUPLER_1_Z		-5113 mm			-201.299
UPSTREAM_COUPLER_2_X		0 mm			0.000
UPSTREAM_COUPLER_2_Y	UPSTREAM_COUPLER_1_Y	9.685 mm			0.381
UPSTREAM_COUPLER_2_Z		-146.969 mm			-5.825
UPSTREAM_COUPLER_3_X		0 mm			0.000
UPSTREAM_COUPLER_3_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
UPSTREAM_COUPLER_3_Z		-2363 mm			-92.638
UPSTREAM_COUPLER_4_X		0 mm			0.000
UPSTREAM_COUPLER_4_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
UPSTREAM_COUPLER_4_Z		-38.307 mm			-1.507
DOWNSTREAM_COUPLER_5_X		0 mm			0.000
DOWNSTREAM_COUPLER_5_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
DOWNSTREAM_COUPLER_5_Z		407.01 mm			16.024
DOWNSTREAM_COUPLER_6_X		0 mm			0.000
DOWNSTREAM_COUPLER_6_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
DOWNSTREAM_COUPLER_6_Z		1786.99 mm			70.354
DOWNSTREAM_COUPLER_7_X		0 mm			0.000
DOWNSTREAM_COUPLER_7_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
DOWNSTREAM_COUPLER_7_Z		3167 mm			124.685
DOWNSTREAM_COUPLER_8_X		0 mm			0.000
DOWNSTREAM_COUPLER_8_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
DOWNSTREAM_COUPLER_8_Z		4547.01 mm			179.016
UPSTREAM_COLDMASS_SUPPORT_X		0 mm			0.000
UPSTREAM_COLDMASS_SUPPORT_Y		0 mm			0.000
UPSTREAM_COLDMASS_SUPPORT_Z		-4175 mm			-164.370
DOWNSTREAM_COLDMASS_SUPPORT_X		0 mm			0.000
DOWNSTREAM_COLDMASS_SUPPORT_Y		0 mm			0.000
DOWNSTREAM_COLDMASS_SUPPORT_Z	UPSTREAM_COLDMASS_SUPPORT_Z	4175 mm			164.370

Name	Expression	Results	Units	Status	Inch Equiv
Part Name	T4CM_CRYOSTAT_VESSEL				
Part Number	00000000142				
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UPSTREAM_COUPLER_1_Y		-246 mm			-9.685
UPSTREAM_COUPLER_1_Z		-5113 mm			-201.299
UPSTREAM_COUPLER_2_X		0 mm			0.000
UPSTREAM_COUPLER_2_Y	UPSTREAM_COUPLER_1_Y	9.685 mm			0.381
UPSTREAM_COUPLER_2_Z		-146.969 mm			-5.825
UPSTREAM_COUPLER_3_X		0 mm			0.000
UPSTREAM_COUPLER_3_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
UPSTREAM_COUPLER_3_Z		-2363 mm			-92.638
UPSTREAM_COUPLER_4_X		0 mm			0.000
UPSTREAM_COUPLER_4_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
UPSTREAM_COUPLER_4_Z		-38.307 mm			-1.507
UPSTREAM_COUPLER_5_X		0 mm			0.000
UPSTREAM_COUPLER_5_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
UPSTREAM_COUPLER_5_Z		407.01 mm			16.024
UPSTREAM_COUPLER_6_X		0 mm			0.000
UPSTREAM_COUPLER_6_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
UPSTREAM_COUPLER_6_Z		1786.99 mm			70.354
UPSTREAM_COUPLER_7_X		0 mm			0.000
UPSTREAM_COUPLER_7_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
UPSTREAM_COUPLER_7_Z		3167 mm			124.685
UPSTREAM_COUPLER_8_X		0 mm			0.000
UPSTREAM_COUPLER_8_Y	UPSTREAM_COUPLER_1_Y	245.999 mm			9.685
UPSTREAM_COUPLER_8_Z		4547.01 mm			179.016
UPSTREAM_COLDMASS_SUPPORT_X		0 mm			0.000
UPSTREAM_COLDMASS_SUPPORT_Y		0 mm			0.000
UPSTREAM_COLDMASS_SUPPORT_Z		-4175 mm			-164.370
DOWNSTREAM_COLDMASS_SUPPORT_X		0 mm			0.000
DOWNSTREAM_COLDMASS_SUPPORT_Y		0 mm			0.000
DOWNSTREAM_COLDMASS_SUPPORT_Z	UPSTREAM_COLDMASS_SUPPORT_Z	4175 mm			164.370
COUPLER_HOLE_1		280 mm			11.024
COUPLER_HOLE_2		280 mm			11.024
COUPLER_HOLE_3		280 mm			11.024
COUPLER_HOLE_4		280 mm			11.024
COUPLER_HOLE_5		280 mm			11.024
COUPLER_HOLE_6		280 mm			11.024
COUPLER_HOLE_7		280 mm			11.024
COUPLER_HOLE_8		280 mm			11.024
AGASSHINCH1		0 mm			0.000
AGASSHINCH2		0 mm			0.000
AGASSHINCH3		0 mm			0.000
AGASSHINCH4		0 mm			0.000
AGASSHINCH5		0 mm			0.000
AGASSHINCH6		0 mm			0.000
AGASSHINCH7		0 mm			0.000
AGASSHINCH8		0 mm			0.000
AGASSHINCH9		0 mm			0.000
AGASSHINCH10		0 mm			0.000
AGASSHINCH11		0 mm			0.000
AGASSHINCH12		0 mm			0.000
AGASSHINCH13		0 mm			0.000
AGASSHINCH14		0 mm			0.000
AGASSHINCH15		0 mm			0.000
AGASSHINCH16		0 mm			0.000
AGASSHINCH17		0 mm			0.000
AGASSHINCH18		0 mm			0.000
AGASSHINCH19		0 mm			0.000
AGASSHINCH20		0 mm			0.000
AGASSHINCH21		0 mm			0.000
AGASSHINCH22		0 mm			0.000
AGASSHINCH23		0 mm			0.000
AGASSHINCH24		0 mm			0.000
AGASSHINCH25		0 mm			0.000
AGASSHINCH26		0 mm			0.000
AGASSHINCH27		0 mm			0.000
AGASSHINCH28		0 mm			0.000
AGASSHINCH29		0 mm			0.000
AGASSHINCH30		0 mm			0.000
AGASSHINCH31		0 mm			0.000
AGASSHINCH32		0 mm			0.000
AGASSHINCH33		0 mm			0.000
AGASSHINCH34		0 mm			0.000
AGASSHINCH35		0 mm			0.000
AGASSHINCH36		0 mm			0.000
AGASSHINCH37		0 mm			0.000
AGASSHINCH38		0 mm			0.000
AGASSHINCH39		0 mm			0.000
AGASSHINCH40		0 mm			0.000
AGASSHINCH41		0 mm			0.000
AGASSHINCH42		0 mm			0.000
AGASSHINCH43		0 mm			0.000
AGASSHINCH44		0 mm			0.000
AGASSHINCH45		0 mm			0.000
AGASSHINCH46		0 mm			0.000
AGASSHINCH47		0 mm			0.000
AGASSHINCH48		0 mm			0.000
AGASSHINCH49		0 mm			0.000
AGASSHINCH50		0 mm			0.000
AGASSHINCH51		0 mm			0.000
AGASSHINCH52		0 mm			0.000
AGASSHINCH53		0 mm			0.000
AGASSHINCH54		0 mm			0.000
AGASSHINCH55		0 mm			0.000
AGASSHINCH56		0 mm			0.000
AGASSHINCH57		0 mm			0.000
AGASSHINCH58		0 mm			0.000
AGASSHINCH59		0 mm			0.000
AGASSHINCH60		0 mm			0.000
AGASSHINCH61		0 mm			0.000
AGASSHINCH62		0 mm			0.000
AGASSHINCH63		0 mm			0.000
AGASSHINCH64		0 mm			0.000
AGASSHINCH65		0 mm			0.000
AGASSHINCH66		0 mm			0.000
AGASSHINCH67		0 mm			0.000
AGASSHINCH68		0 mm			0.000
AGASSHINCH69		0 mm			0.000
AGASSHINCH70		0 mm			0.000
AGASSHINCH71		0 mm			0.000
AGASSHINCH72		0 mm			0.000
AGASSHINCH73		0 mm			0.000
AGASSHINCH74		0 mm			0.000
AGASSHINCH75		0 mm			0.000
AGASSHINCH76		0 mm			0.000
AGASSHINCH77		0 mm			0.000
AGASSHINCH78		0 mm			0.000
AGASSHINCH79		0 mm			0.000
AGASSHINCH80		0 mm			0.000
AGASSHINCH81		0 mm			0.000
AGASSHINCH82		0 mm			0.000
AGASSHINCH83		0 mm			0.000
AGASSHINCH84		0 mm			0.000
AGASSHINCH85		0 mm			0.000
AGASSHINCH86		0 mm			0.000
AGASSHINCH87		0 mm			0.000
AGASSHINCH88		0 mm			0.000
AGASSHINCH89		0 mm			0.000
AGASSHINCH90		0 mm			0.000
AGASSHINCH91		0 mm			0.000
AGASSHINCH92		0 mm			0.000
AGASSHINCH93		0 mm			0.000
AGASSHINCH94		0 mm			0.000
AGASSHINCH95		0 mm			0.000
AGASSHINCH96		0 mm			0.000
AGASSHINCH97		0 mm			0.000
AGASSHINCH98		0 mm			0.000
AGASSHINCH99		0 mm			0.000
AGASSHINCH100		0 mm			0.000

T4CM: HGR PIPE WELDMENT Spreadsheet

This spreadsheet includes:

- HGR PIPE DATA:** A table with columns for 'With O Magnet' and 'Without O Magnet', listing various dimensions and parameters.
- 1.5mm Holes:** A list of hole locations and diameters.
- 2.5mm Holes:** A list of hole locations and diameters.
- 3.5mm Holes:** A list of hole locations and diameters.
- 4.5mm Holes:** A list of hole locations and diameters.
- 3D Model:** A detailed 3D rendering of the pipe weldment assembly.



ILC INTERNATIONAL LINAC COLLIDER

Automatically adjusts for thermal contraction and component lengths

The Master Spreadsheet, A Closer Look



Microsoft Excel - T4CM_9_MASTER-022807.xls

T4CM: Type 4 (9 cavities) Cryomodule Design Master Spreadsheet updated: 27 Mar 2007

US = Upstream, DS = Downstream

Cryostat DATA		Cavity/Helium Vessel DATA		CAVITY_5_DATA		COLDMASS SUPT DATA		Misc. DATA		Italian date	
Inches	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	(was=15mm)
Vessel Diameter	30	765.20		Cavity Length	1247.400	Coldmass Supt hole dia	414	Beamline Vertical Shrink	13		
Vessel V _A	0.375	9.53		Interconnect bellows length	71.900	Coldmass location 1 S	-4175	MC port hole diameter	325.0		
US Cav. Flange-to-US Vessel Flange	9.200	233.67		MC center-to-lug distance	196.862	Coldmass location 2 S	-4175	coef. Thermal exp. Stainless steel	0.00001730	mm/m/m	0.0000103
US Cav. Flange-to-DS Vessel Flange	7.950	202.17		Interconnect bellows length	346.862	HGR Centerline	356	coef. Thermal exp. Invar	0.000002	mm/m/m	0.00000127
Vessel Flange-to-vessel shell DS	-0.807	-20.50		MC center to DS end flange	60.600	Port "A" "Z" location		temperature delta	300	deg C	
Vessel Flange-to-vessel shell US	0.630	16.00		Invar mount center to end flange	196.732	Port "B" "Z" location		HGR pipe "Y" location from vessel center	193	mm	
Vessel "Z" length US	223.934	5695.50		"Z" shrinkage, invar post-to-DS	0.257	Port "D" "Z" location		MC's Varm "Y" location			(was=15mm)
Vessel "Z" length DS	216.262	5492.25		"Z" shrinkage, invar post-to-Lugs	0.293			MC's Cold "Y" location	19		(was=15mm)
Vessel Length (flange-to-flange)	463.386	11769.50		String length (cav-to-cav flange)	10481.80			MC's Varm "X" location	0		(was=0.2mm)
Vessel shell length US	-222.433	-5651.33						MC's Cold "X" location	0.4		
Vessel shell length DS	239.456	6082.17						Coef. Thermal exp. Ti	0.000008	mm/m/m	0.0000053
Cav. Shrink to Vessel DS	8.324	211.80						Coef. Thermal exp. Niobium			0.0000049
VESSEL SUPPORT DS	190.945	4850.00									
VESSEL SUPPORT US	-171.260	-4350.00									
VESSEL PICKUP DS	118.110	3000.00									
VESSEL PICKUP US	-118.110	-3000.00									

Main Coupler Location DATA		"Z" Varm		"Z" Cold		"Z" Shrinkage (mm)	
	mm	mm	mm	mm	mm	mm	mm
MC #1 "Z" location	-4712.70	-4711.07		2.629			
MC #2 "Z" location	-3334.50	-3332.65		1.839			
MC #3 "Z" location	-2075.20	-2074.25		1.046			
MC #4 "Z" location	-756.10	-755.85		0.255			
MC #5 "Z" location	563.10	562.56		0.537			
MC #6 "Z" location	1882.30	1880.97		1.328			
MC #7 "Z" location	3201.50	3199.38		2.120			
MC #8 "Z" location	4520.70	4517.75		2.911			
MC #9 "Z" location	5839.90	5836.20		3.703			

Cavity Flanges Distance		Varm		Cold	
	mm	mm	mm	mm	mm
1-2	71900	72842			
2-3	71900	72842			
3-4	71900	72842			
4-5	71900	72842			
5-6	71900	72842			
6-7	71900	72842			
7-8	71900	72842			
8-9	71900	72842			

HGR Support Location DATA		"Z" Varm		"Z" Cold		"Z" Shrinkage (mm)	
	mm	mm	mm	mm	mm	mm	mm
Cavity 1	Support 1, "Z" location	-4321.73	-4386.24		25.49		
Cavity 1	Support 2, "Z" location	-5672.67	-5643.29		29.38		
Cavity 2	Support 1, "Z" location	-3599.50	-3590.96		18.64		
Cavity 2	Support 2, "Z" location	-4390.44	-4327.91		22.93		
Cavity 3	Support 1, "Z" location	-2277.27	-2265.48		11.79		
Cavity 3	Support 2, "Z" location	-3028.22	-3012.53		15.63		
Cavity 4	Support 1, "Z" location	-985.04	-950.10		4.95		
Cavity 4	Support 2, "Z" location	-1705.99	-1637.16		8.84		
Cavity 5	Support 1, "Z" location	267.16	365.29		139		
Cavity 5	Support 2, "Z" location	583.76	-381.77		-139		
Cavity 6	Support 1, "Z" location	1639.41	1630.66		8.75		
Cavity 6	Support 2, "Z" location	938.47	933.61		4.85		
Cavity 7	Support 1, "Z" location	3016.64	2996.04		15.93		
Cavity 7	Support 2, "Z" location	2260.69	2249.93		11.70		
Cavity 8	Support 1, "Z" location	4333.87	4311.42		22.44		
Cavity 8	Support 2, "Z" location	3582.92	3564.37		18.55		
Cavity 9	Support 1, "Z" location	5656.09	5626.81		29.29		
Cavity 9	Support 2, "Z" location	4905.15	4879.75		25.39		

Cavity/Helium Tank Location DATA		"Z" Varm		"Z" Cold		"Z" Shrinkage (mm)	
	mm	mm	mm	mm	mm	mm	mm
Cavity 1	Lug 1, "Z" location	-4910.562	-4907.407		3.155		
Cavity 1	Lug 2, "Z" location	-5660.562	-5655.405		5.167		
Cavity 2	Lug 1, "Z" location	-3591.362	-3589.999		2.363		
Cavity 2	Lug 2, "Z" location	-4341.362	-4336.996		4.366		
Cavity 3	Lug 1, "Z" location	-2272.162	-2270.990		1.572		
Cavity 3	Lug 2, "Z" location	-3022.162	-3018.588		3.574		
Cavity 4	Lug 1, "Z" location	-952.962	-952.182		0.780		
Cavity 4	Lug 2, "Z" location	-1702.962	-1700.179		2.783		
Cavity 5	Lug 1, "Z" location	366.238	368.227		0.011		
Cavity 5	Lug 2, "Z" location	-383.762	-381.771		-1.991		
Cavity 6	Lug 1, "Z" location	1635.438	1634.635		0.803		
Cavity 6	Lug 2, "Z" location	936.438	936.838		-1.200		
Cavity 7	Lug 1, "Z" location	3004.638	3003.044		1.594		
Cavity 7	Lug 2, "Z" location	2254.638	2255.046		-0.408		
Cavity 8	Lug 1, "Z" location	4323.838	4321.452		2.386		
Cavity 8	Lug 2, "Z" location	3573.838	3573.455		0.383		
Cavity 9	Lug 1, "Z" location	5643.038	5639.961		3.177		
Cavity 9	Lug 2, "Z" location	4893.038	4891.863		1.175		

Support #2 Support #1

Lug #2 Lug #1 Invar-Rod Post

Hyperlinked to a detailed PDF drawing

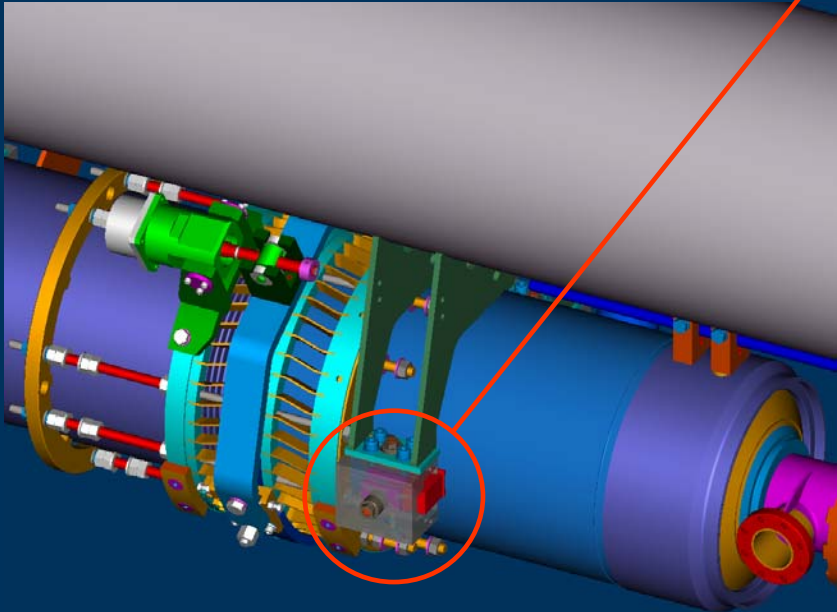
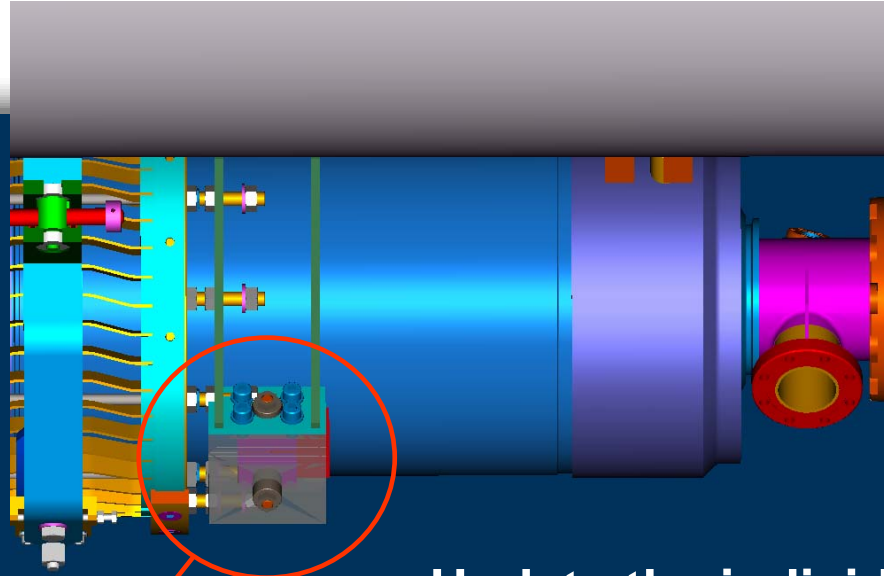
Values which can be modified

Shrinkage Calculations



Change the Master ...

The master spreadsheet will automatically adjust all computed values.



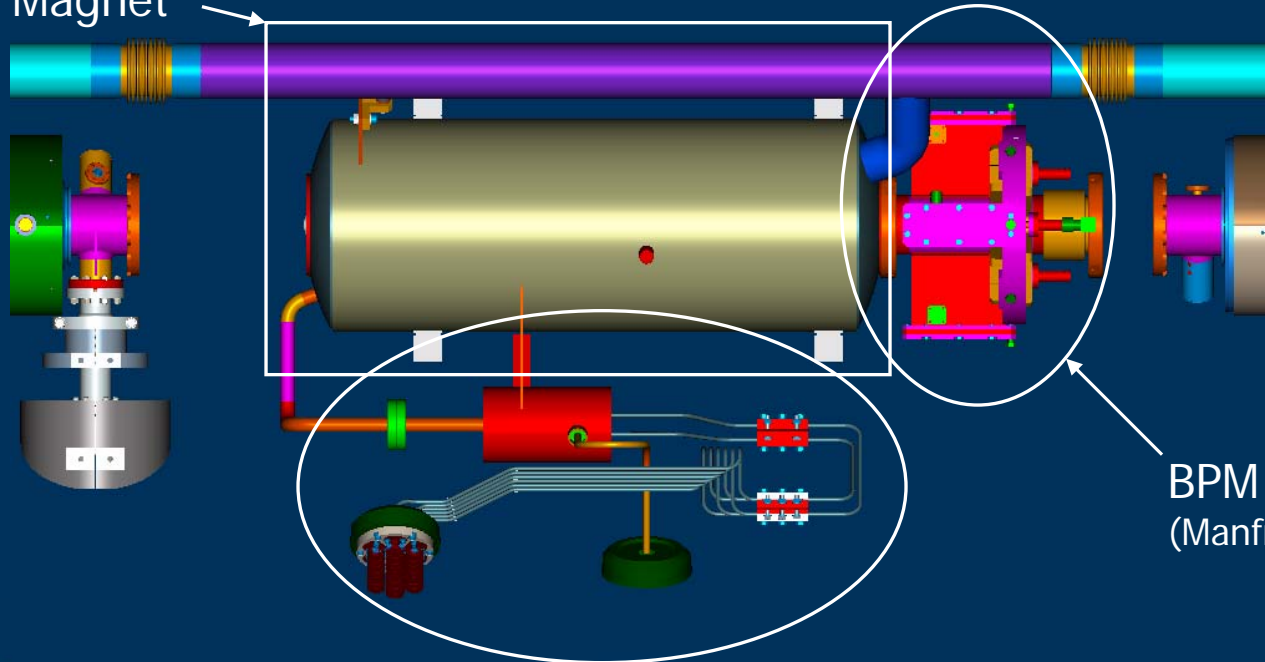
- ▶ Update the individual Excel files by just opening them and clicking save. The linked cells will update.
- ▶ Modify the I-DEAS “Key” parts by selecting Update from Excel.
- ▶ Access your assemblies and perform an update.



ILC Style Quad & Steering Magnet FNAL

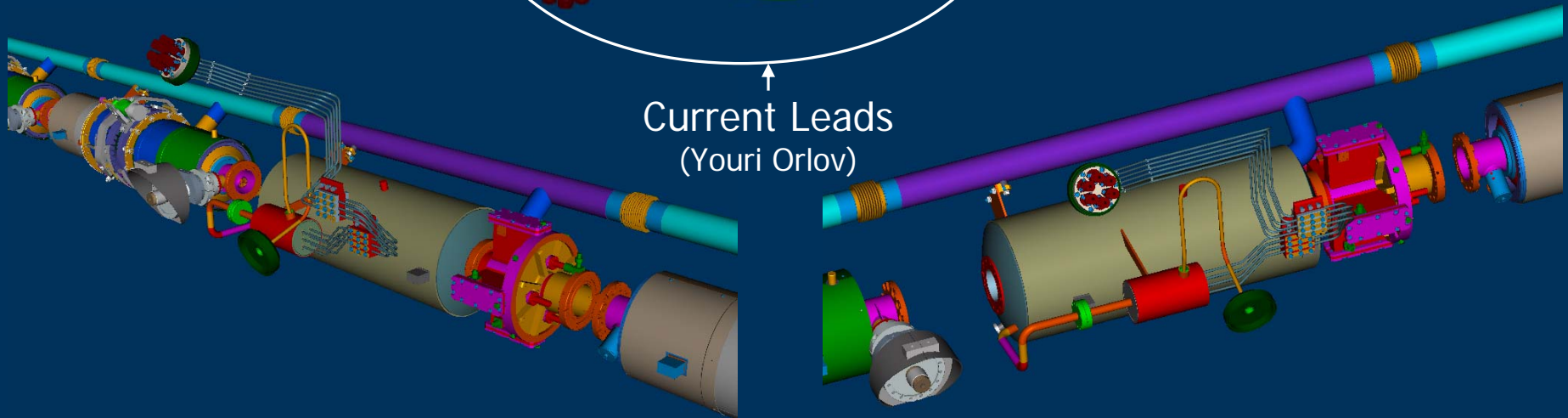


Quad & Trim Magnet
(Kashikin)



BPM
(Manfred Wendt)

Current Leads
(Yuri Orlov)





ILC Quadrupole Specifications



Integrated gradient, T	36
Aperture, mm	78
Effective length, mm	666
Peak gradient, T/m	54
Field non-linearity at 5 mm radius, %	0.05
Dipole trim coils	Vertical+Horizontal
Trim coils integrated strength, T-m	0.075
Quadrupole strength adjustment for BBA, %	-20
Magnetic center stability at BBA, μm	5
Liquid Helium temperature, K	2
Quantity required	560



NbTi Superconductor Parameters



Quadrupole Coils

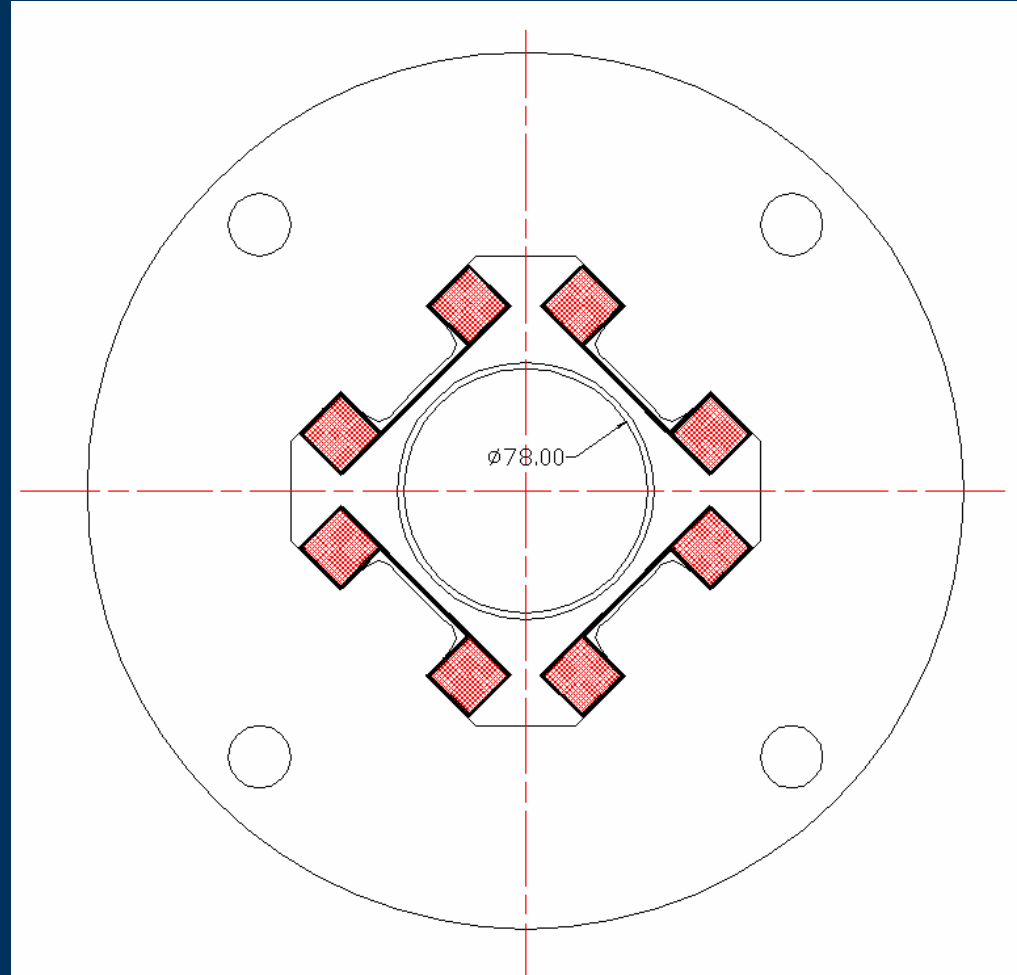
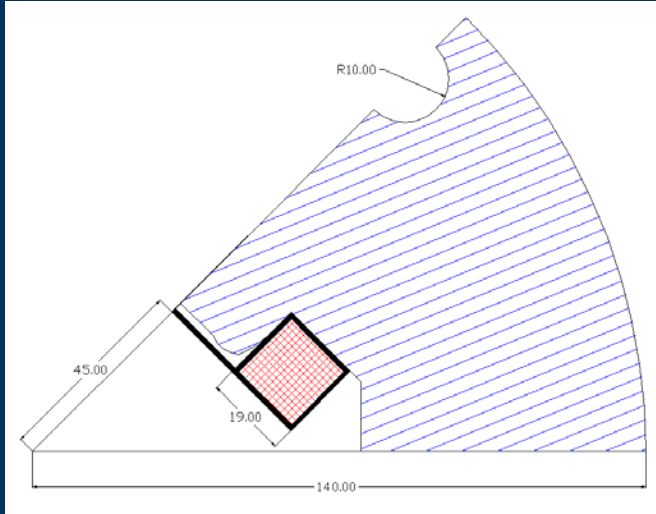
NbTi wire diameter, mm	0.5
Number of filaments	7242
Filament diameter, um	3.7
Copper : Superconductor	1.5
Insulated wire diameter, mm	0.54
Insulation	Formvar
Twist pitch, mm	25
RRR of copper matrix	100
Critical current I_c @ 4.2K, at 5T	204 A

Trim Coils

NbTi wire diameter, mm	0.3
Number of filaments	7242
Filament diameter, um	2.2
Copper : Superconductor	1.5
Insulated wire diameter, mm	0.33
Insulation	Formvar
Twist pitch, mm	25
RRR of copper matrix	100
Critical current I_c @ 4.2K, at 5T	51



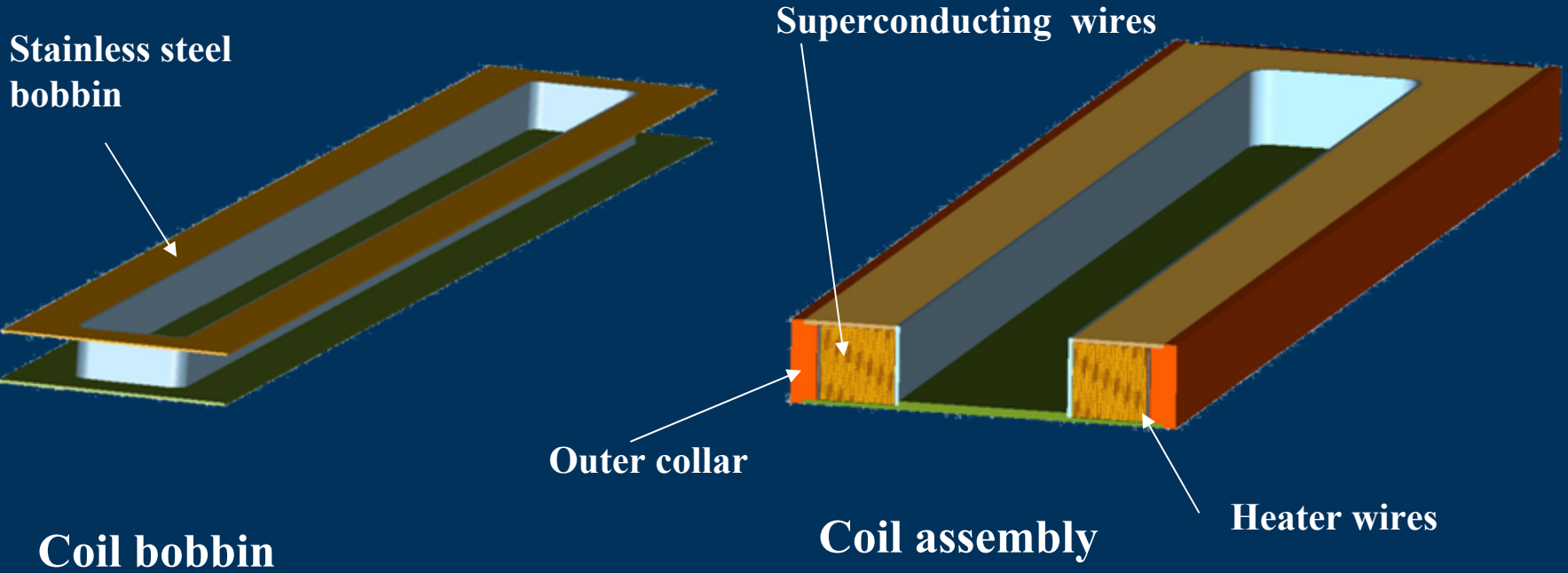
Quadrupole Cross-Section



Cold mass diameter	280 mm
Cold mass length	680 mm
Pole length	600 mm
Peak current	100 A
Superconductor length	5 km
Yoke weight	250 kg



Quadrupole Coil Design



Coil bobbin used as mandrel for superconducting coil winding

Kapton film used as ground insulation between bobbin and wires

Bobbin and outer collar structure forms closed mold for epoxy vacuum impregnation

Easy assemble coil structure with an iron yoke

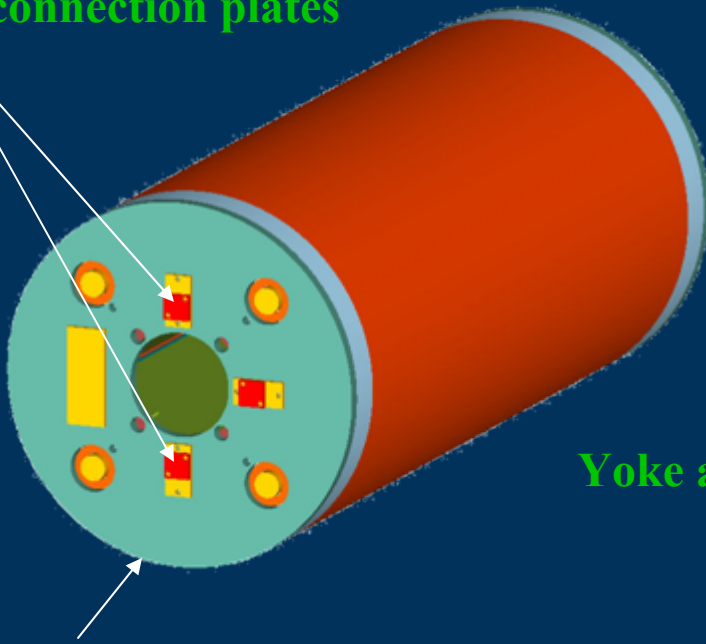
Coil attached to the pole on both ends



Quadrupole cold mass



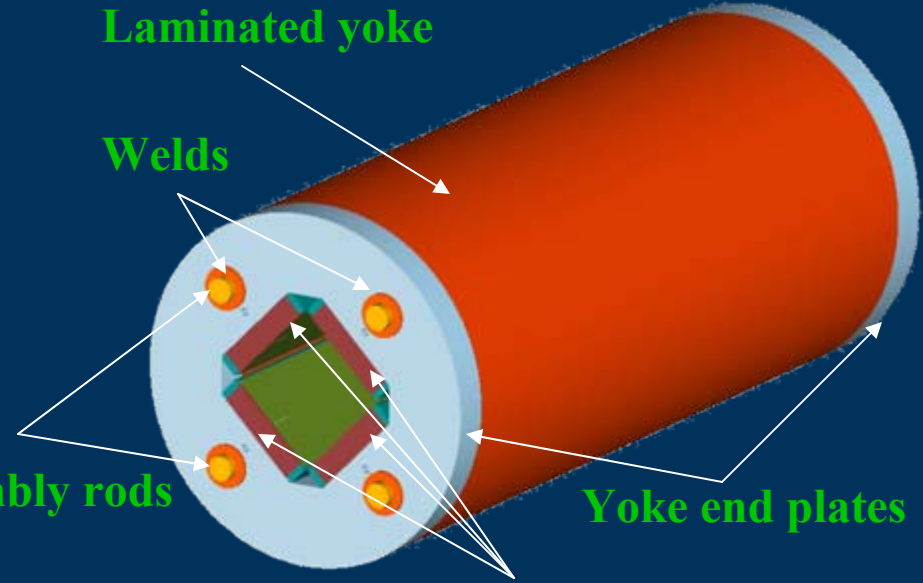
Coil connection plates



End shield

Laminated yoke

Welds



Yoke assembly rods

Coil blocks

Yoke end plates

Cold mass: Length

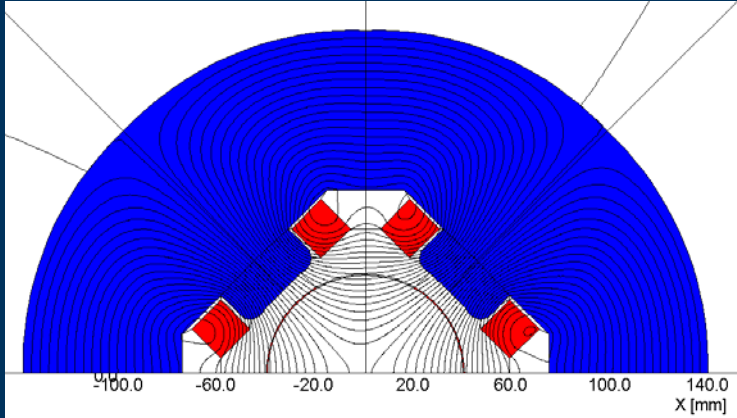
680 mm

Outer diameter

280 mm



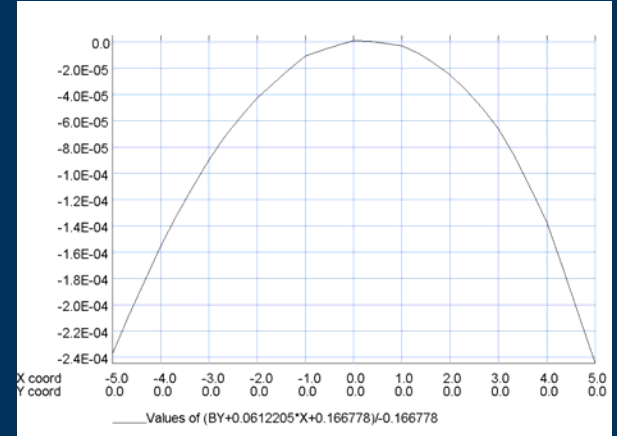
Dipole Correctors



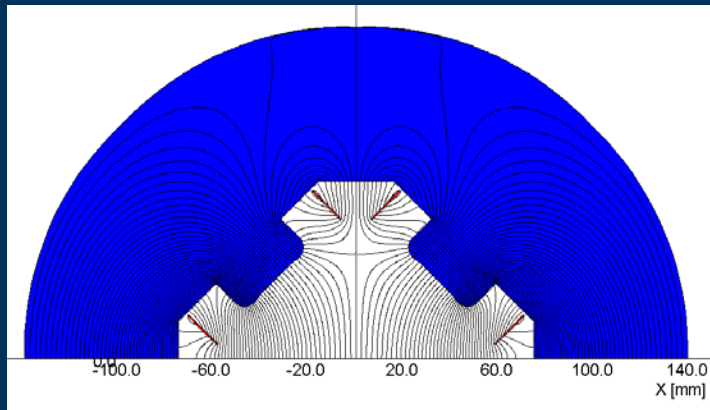
Dipole integrated field 0.075T-m

Dipole center field 0.125T at 0.6 m effective length

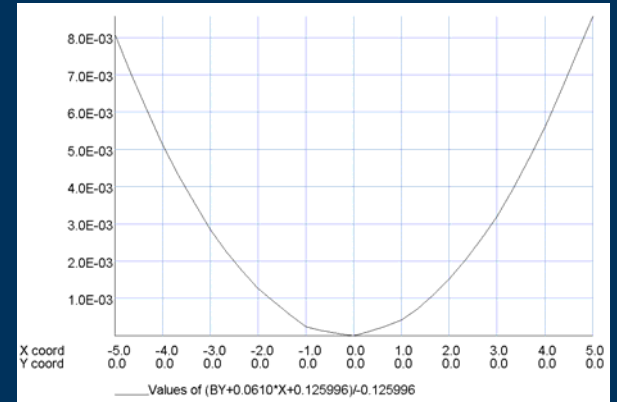
Shell type dipole field homogeneity



Shell type dipole field homogeneity at 61 T/m gradient and 0.166 T vertical dipole field



Racetrack type dipole field at zero quadrupole field



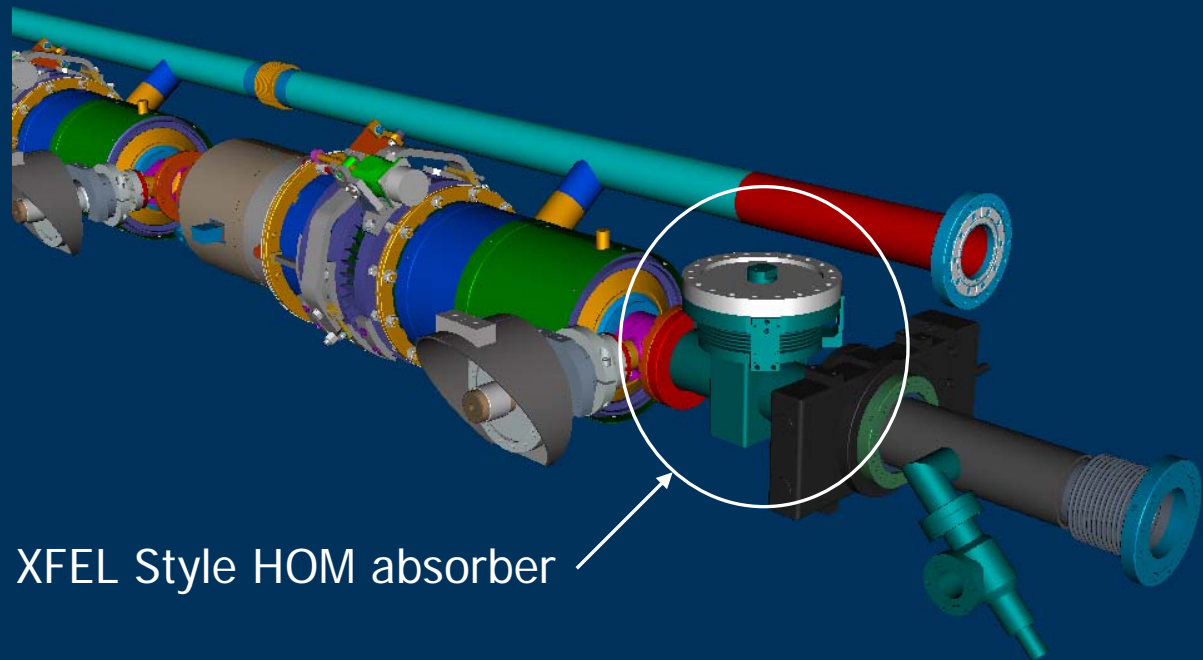
Racetrack type dipole field homogeneity at 61 T/m gradient and 0.125 T vertical dipole field



HOM Absorber



- Our current model depicts the DESY HOM absorber design. However, FNAL is designing a new HOM absorber using ILC parameters.
- With the magnet moved to the center of the cryomodule, the HOM absorber can be installed at the end of the cavity string and not in the interconnect region.

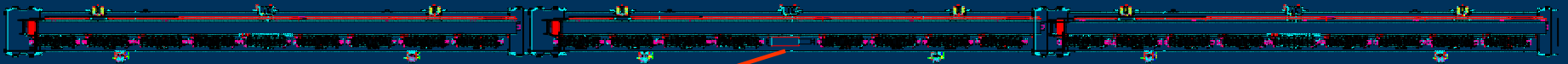




Vibration Studies



All results are provided in 3-in-series with (fixed-fixed) end condition to address effects of unknown end conditions.

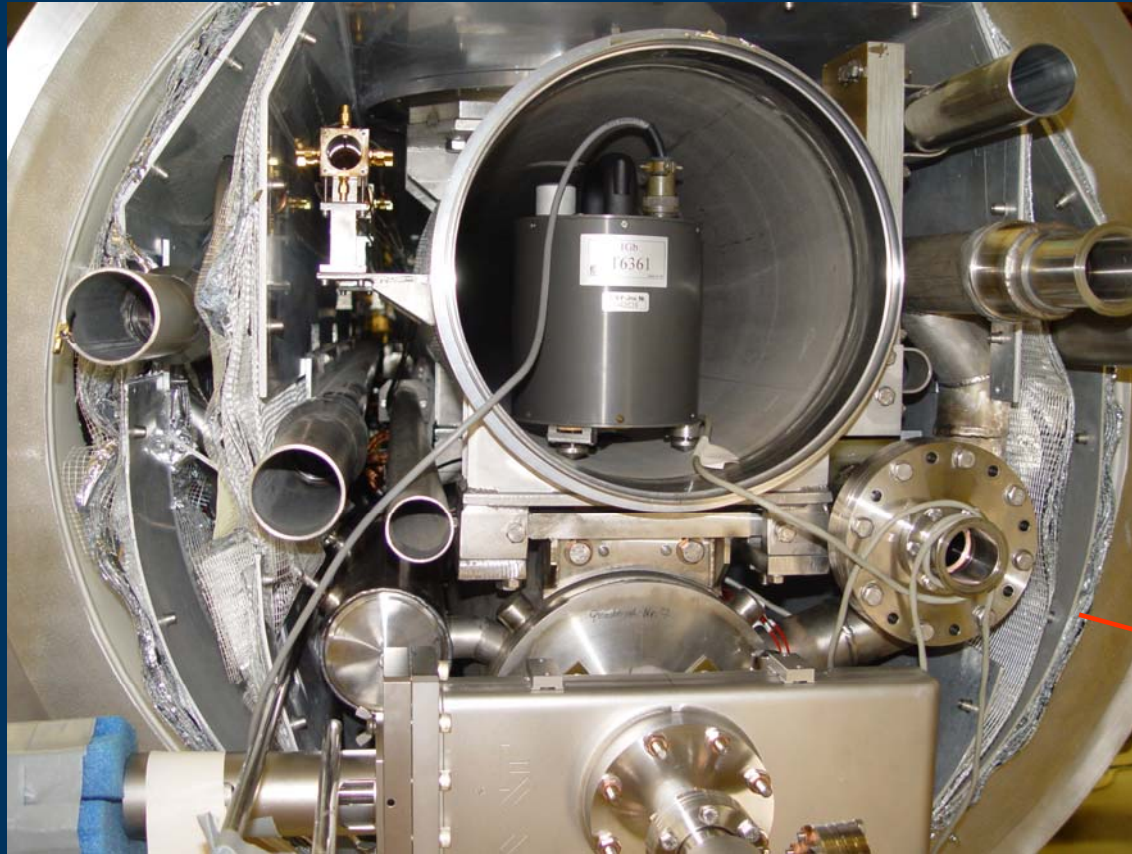


Center quad

for T4CM 9-8-9 configuration was used



Transverse Spring-Damping Study



Attempt to account for added stiffness of thermal straps and cables

Add stiffness and damping

Transverse frequencies beneath ~ 20 Hz were not measured on Cryomodule #6

Courtesy of DESY





DESY Measurement Transfer Functions



2) Vacuum Vessel Top vs HeGRP



3) HeGRP vs Quad

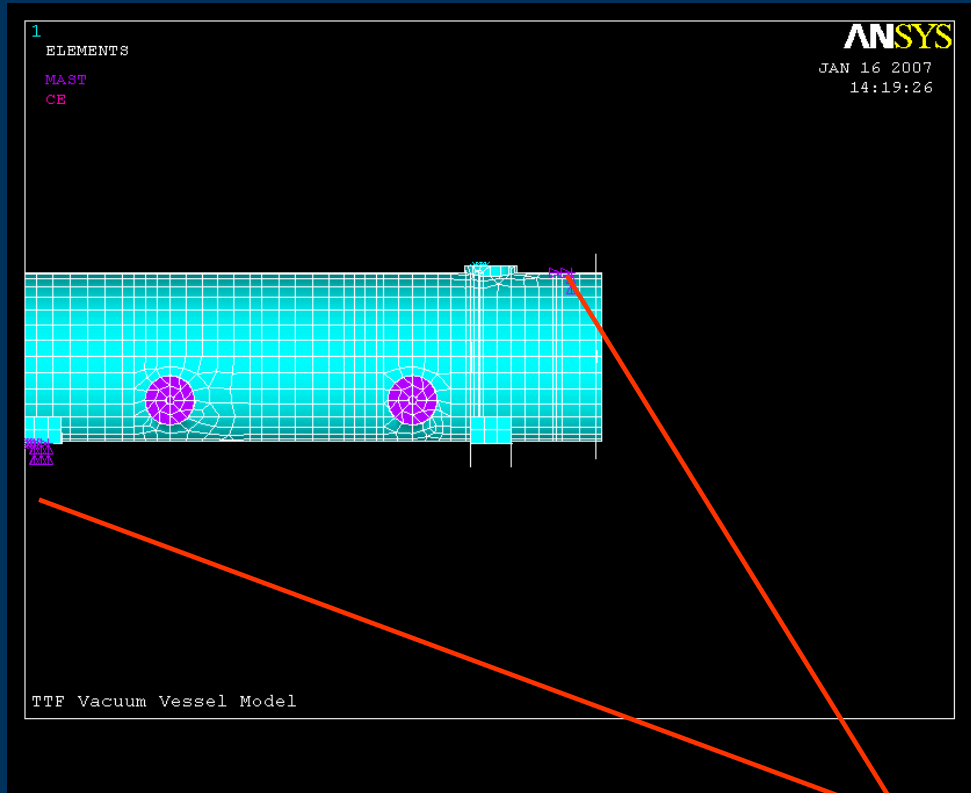


Courtesy of DESY





TTF Single ANSYS Model Applied



Consider the DESY vertical measurement, by applying sine wave input with displacement (amplitude) at specific frequencies.

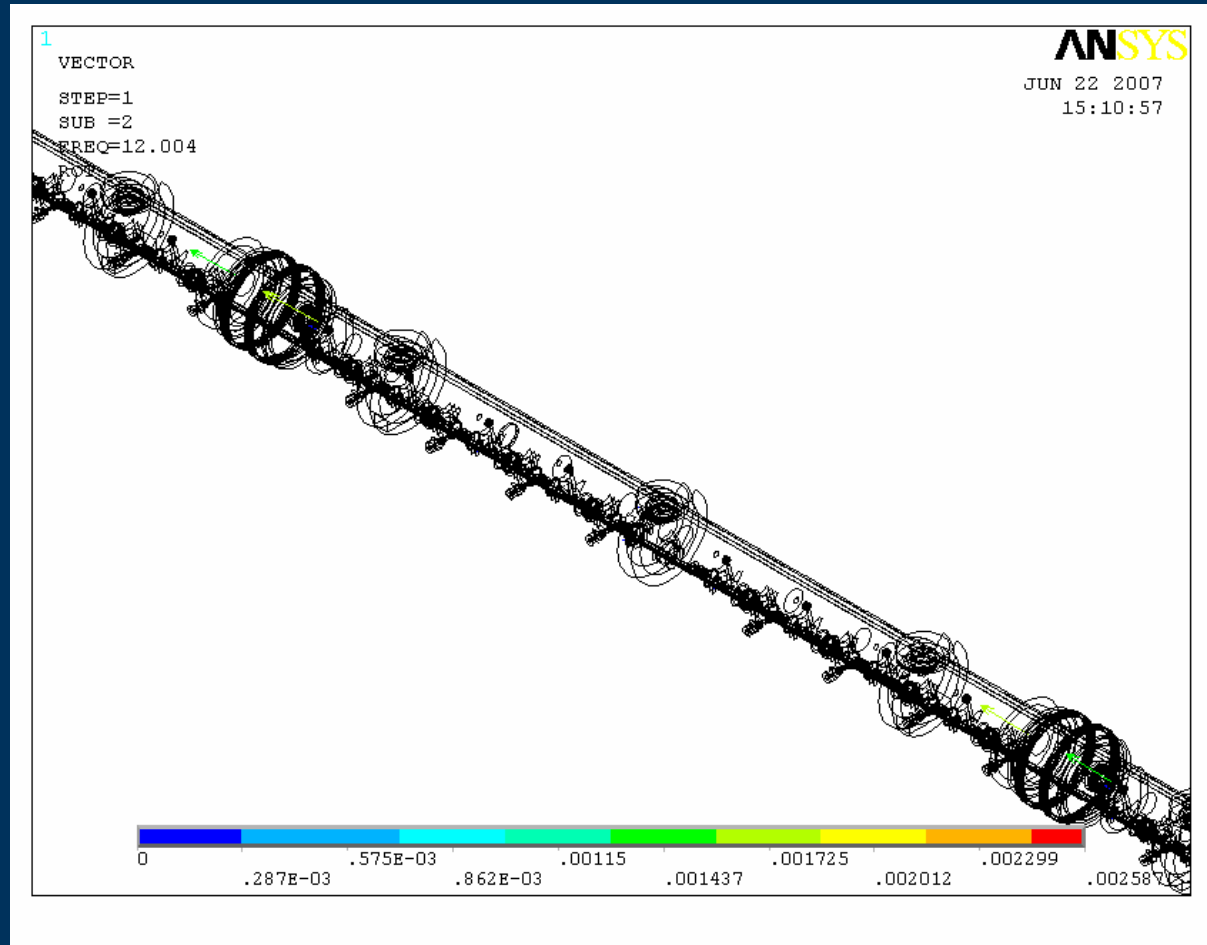
Example: Transfer function between ground and vessel top

Courtesy of DESY





Modal Example (combination of superelements)

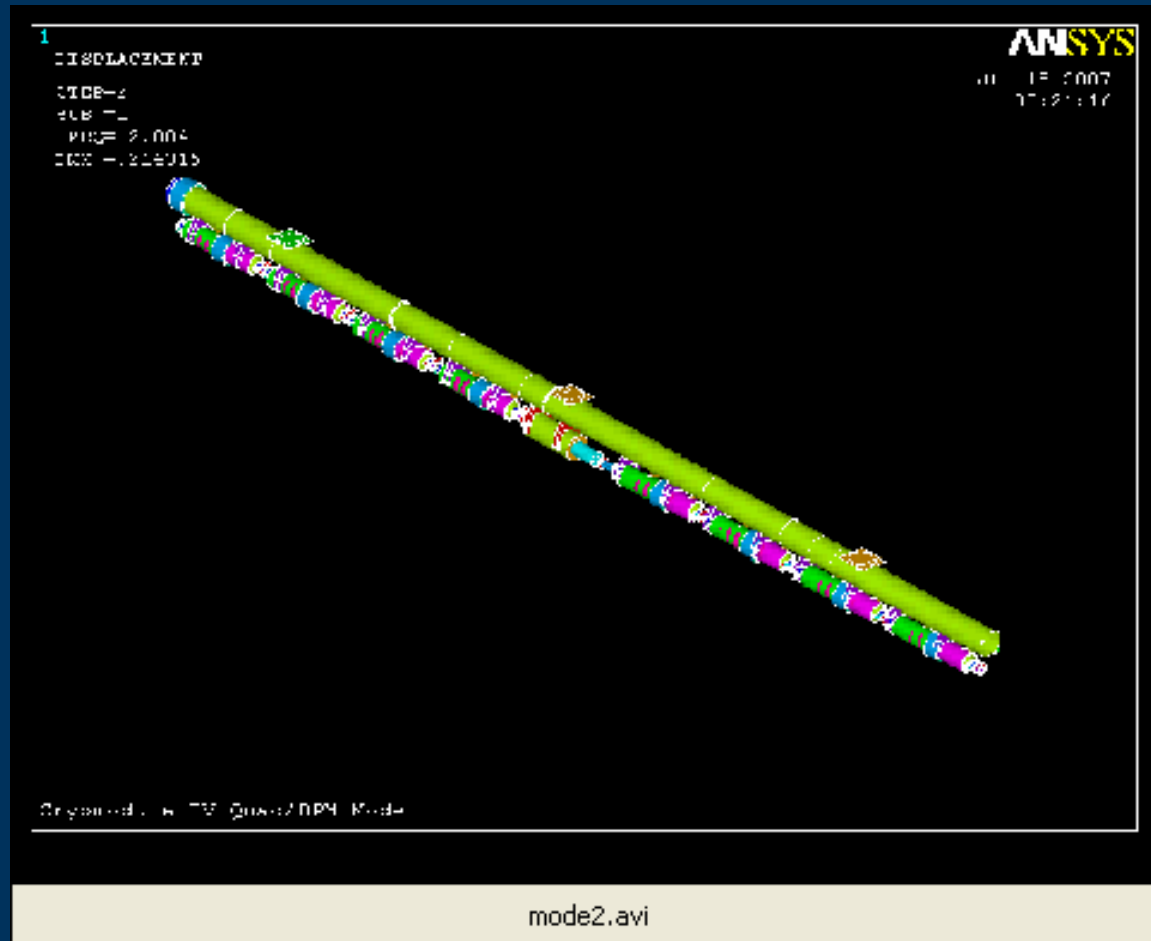


Vector plots (view of center cryomodule)





T4CM Mode 2 – 12 Hz (transverse pendulum)

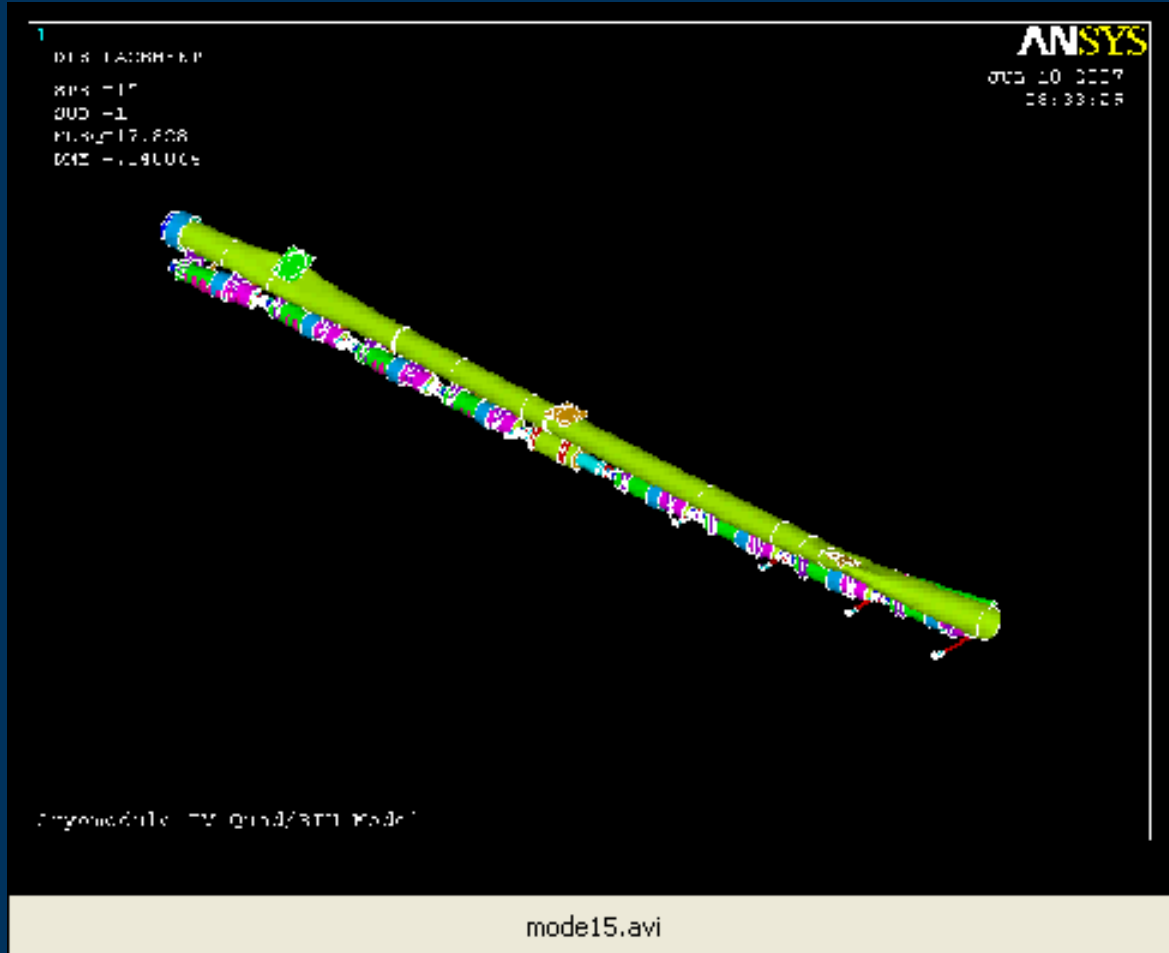


Note: vacuum vessel and other components are present, but not shown



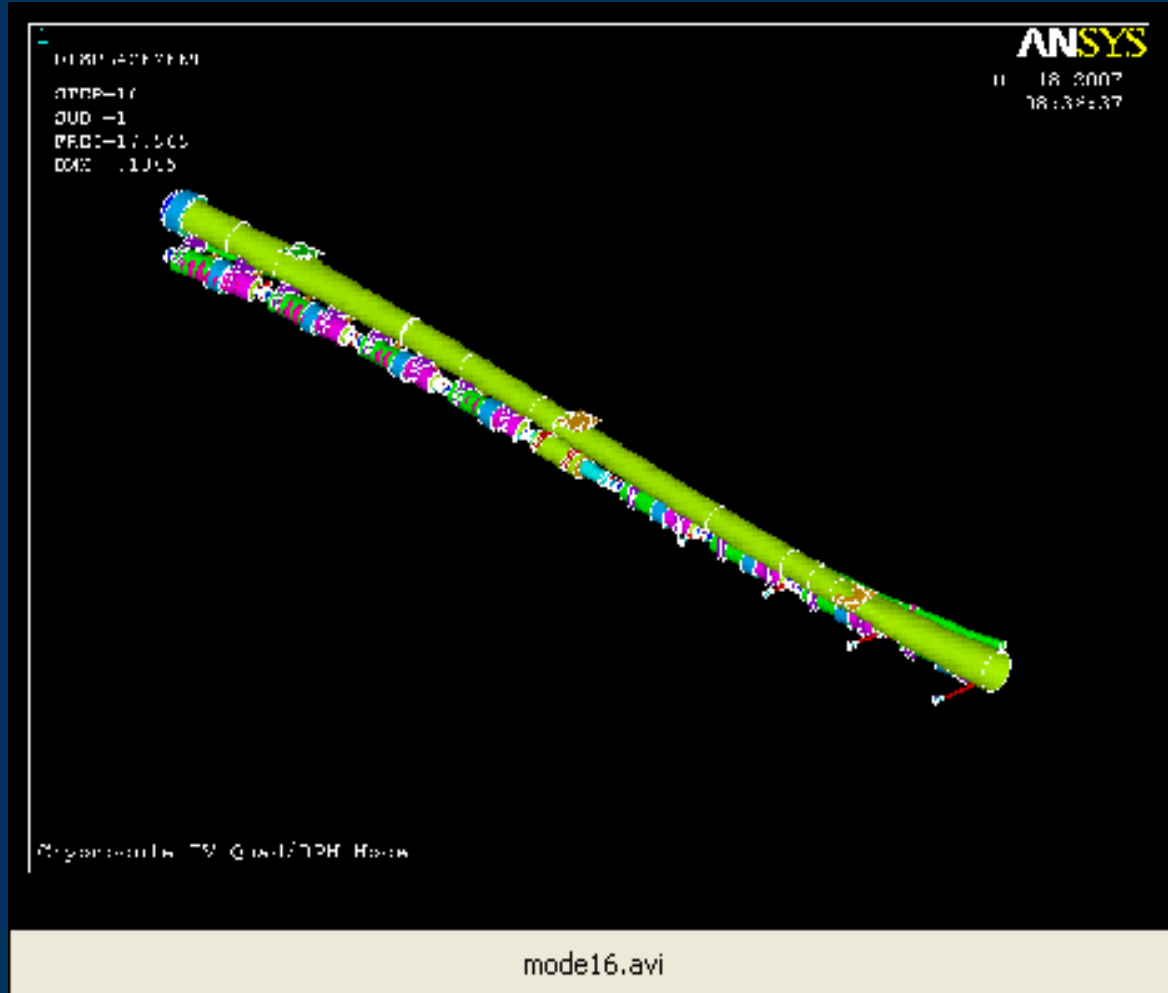


T4CM Mode 15 – 17.8 Hz (transverse pendulum 2nd harmonic)





T4CM Mode 16 – 18 Hz (transverse pendulum 2nd harmonic)



Modes 15 & 16 are symmetric





Cryomodule Instrumentation Team



- FNAL TD Members (Ruben Carcagno, Chair)
 - Mark Champion
 - Joe Ozelis
 - Darryl Orris
 - Yuriy Pischalnikov
 - Warren Schappert
 - Dmitri Sergatskov
- FNAL AD Members
 - Christine Darve
 - Mike McGee
 - Shavkat Singatulin
 - Jim Volk





Cryomodule Instrumentation Tasks



- Develop experience with cold geophones using HTS
- Apply cold geophones to cryomodule measurement
 - Define geophone locations within CM (implement cold calibration as developed by DESY)
 - Provide DAQ support
- Instrument TTF and T4CM Coldmass prior to installation at Fermilab's New Muon Lab (NML)



Future Work



- Begin Sensitivity Studies using T4CM model
- Study external floor support
- Implement instrumentation for cryomodules geophone and differential pressure transducer (TTF style and T4CM)
- Perform flow induced vibration studies through experiment at HTS and FEA (possible collaboration with INFN-Pisa)



Cavity Interconnect Flange R&D



- Investigate the possibility to use a seal with low setting load:
 - minimize the flange dimensions
 - reduce distance between cavities
 - simplify the fastening system
- Tests performed on **Garlock Ultra-Flex seals**

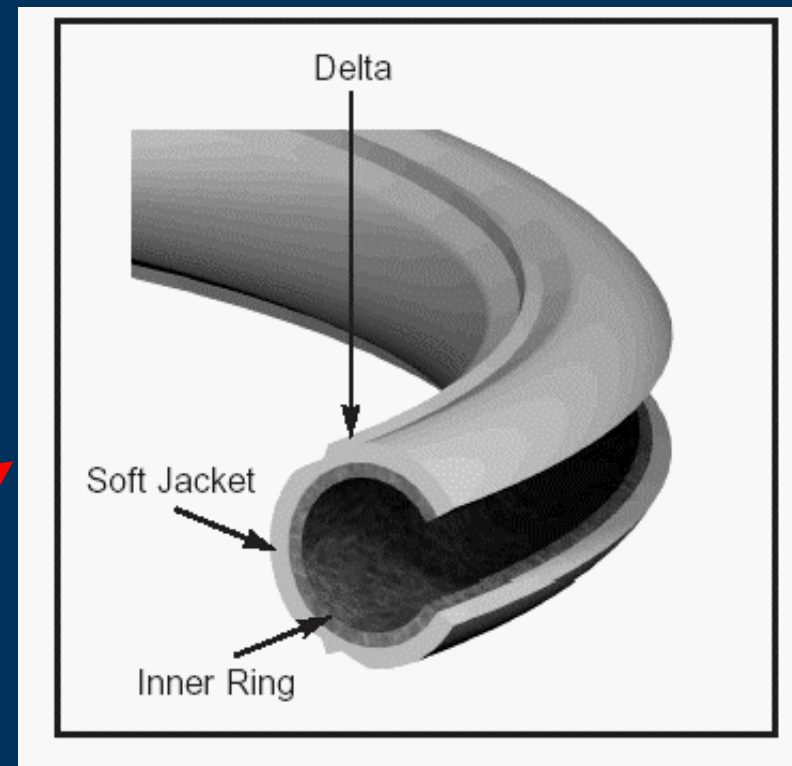


Garlock Ultra-flex gasket



- General specs:

- Inner ring - Inconel (X750)
- Ext. jacket - Aluminum (A5)
- Inner/outer diameter: 99.6 x 106.1 mm
- Cross-section outer diameter: 4.65 mm
- Compression gap: 0.55 mm
- Seal working force $Y2 = 26 \text{ N/mm}$
- Total contact force = 8401 N





Second pollution contamination measurements in Pisa



- We opened also the blind flange to have a flow of clean air inside during the flange assembly.
- We put the probe inside the tube of the bottom flange and the top tube in contact with the starting point of laminar flow inside the hood.
- We flow clean air inside the flanges for all the night before the final tightening of the screws.

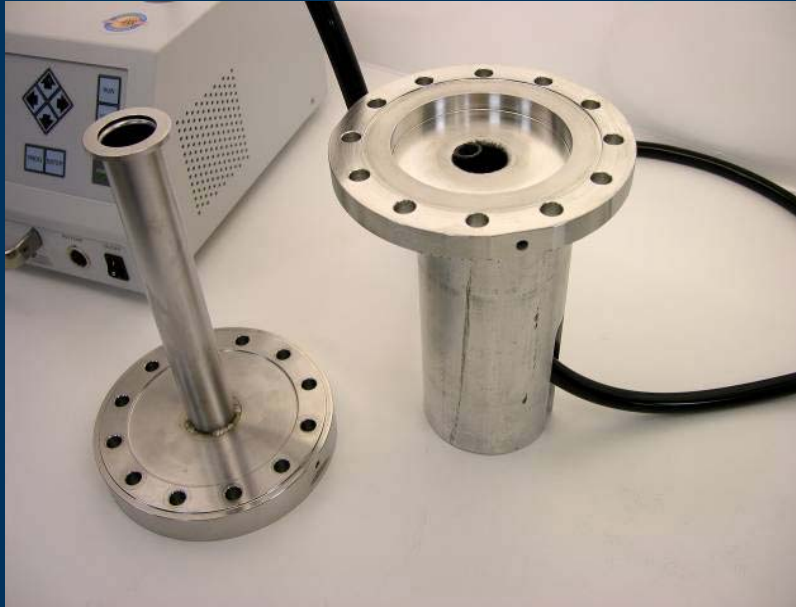


RESULTS:

- No particles detected using both Diamond shaped and Ultra-Flex gaskets.



Pictures from second pollution contamination measurements in Pisa clean rooms





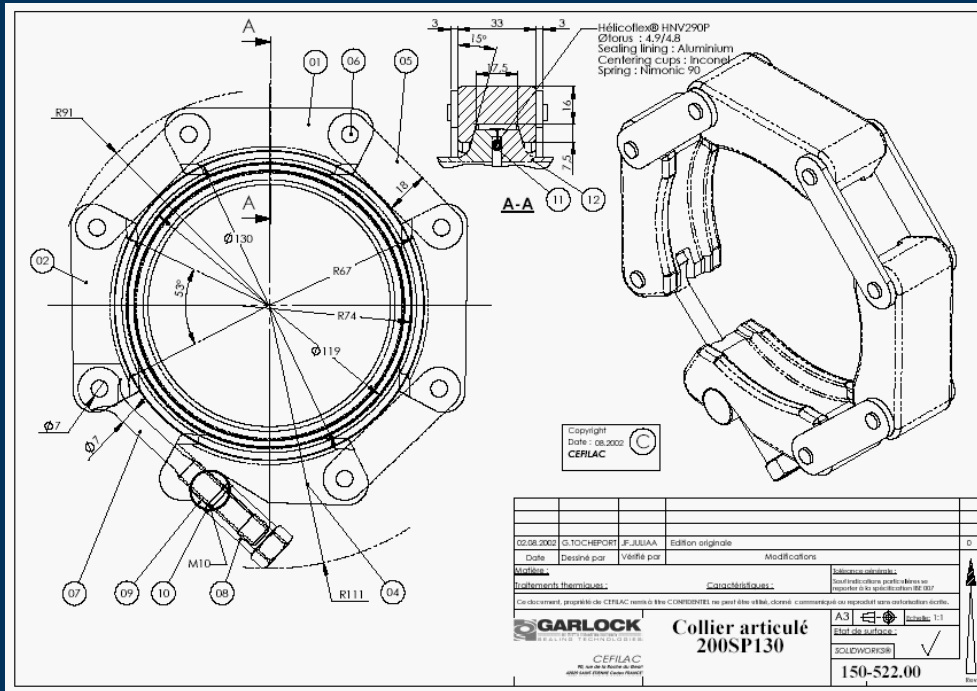
Preliminary conclusions:



- Ultra-flex gaskets have shown He leak-rate at room temperature and 77 K adequate for cavity specifications ($< 10^{-10}$ mbar *l /s)
- The gasket setting load is indeed very low
- Some problems noticed during thermal transitions and sometimes at LN₂ temperature
- With proper procedure no particulate detected during the assembly phase and the final tightening of the bolts
- Compression plot shows a very low spring-back (possibly related to the problems observed)
 - Will test new o-rings with larger transverse section and helico-flex (specially made)



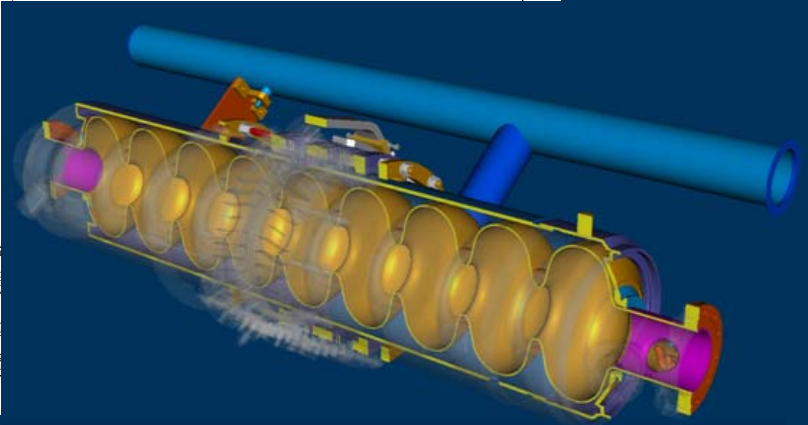
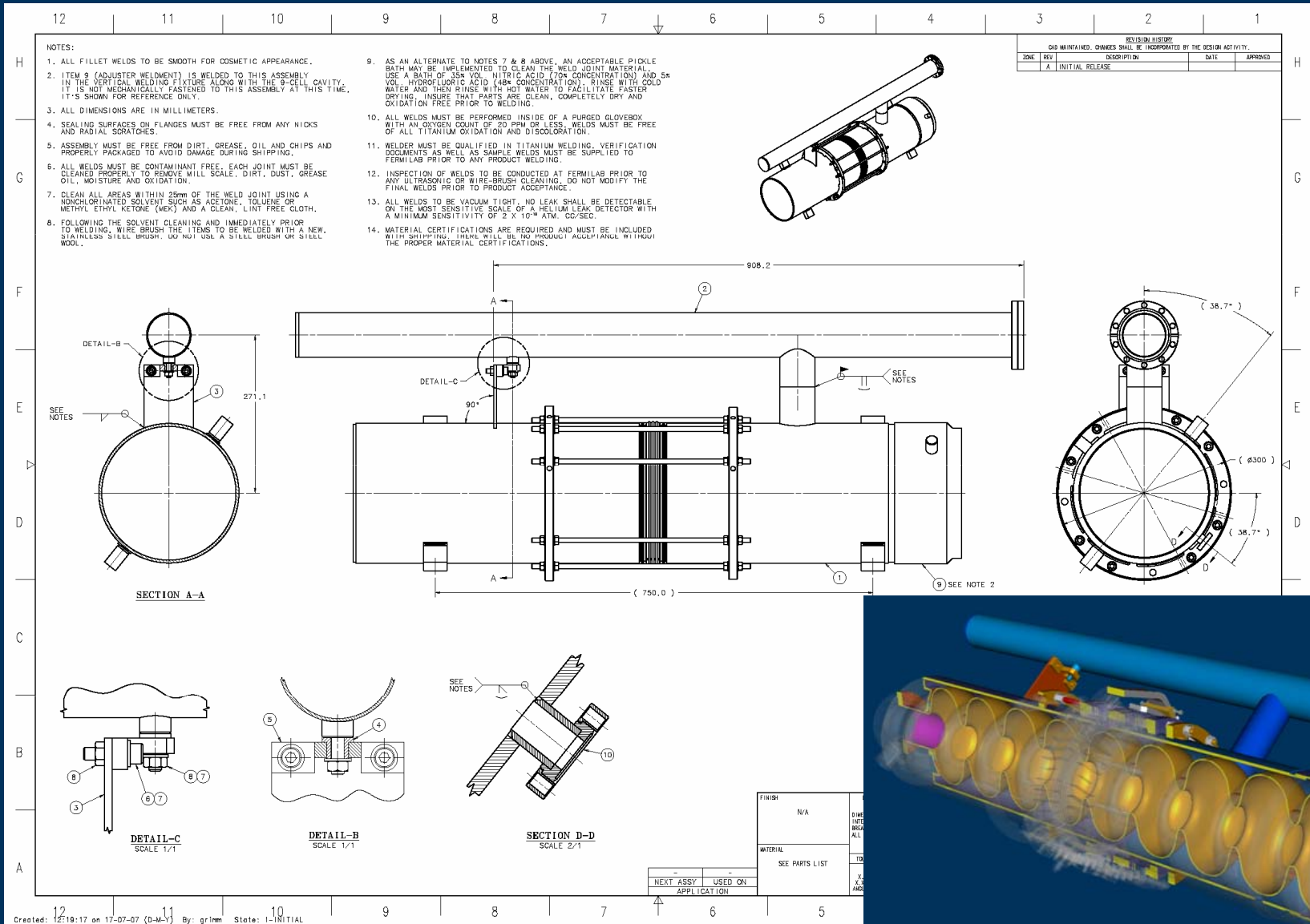
Next steps:



- Will receive from Garlock a clamp as drawn
 - Will prepare two matching flanges to repeat all tests made
- Will test also larger section gaskets and helico-flex



Helium Vessel Design

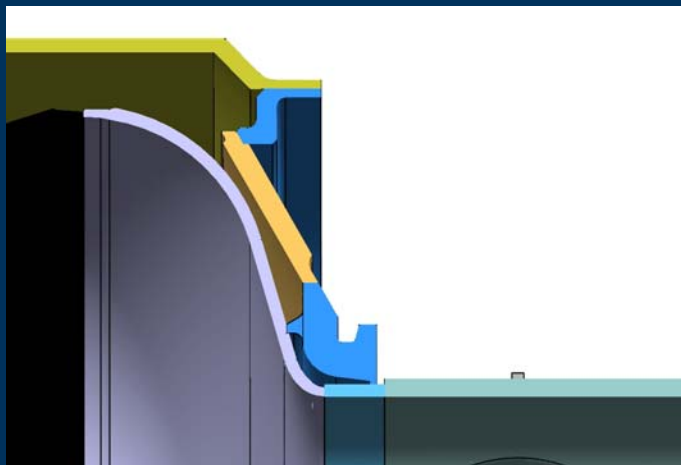




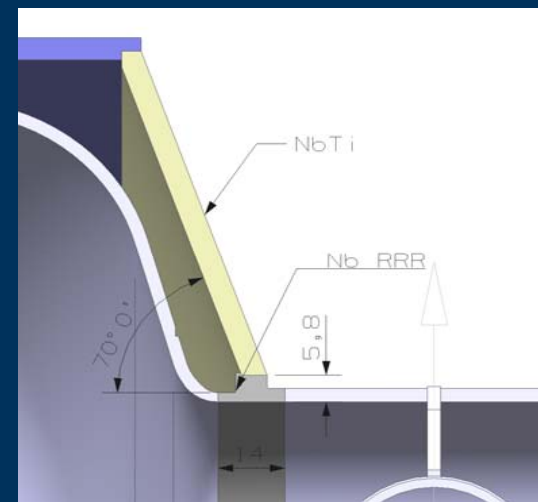
Helium Vessel History - Versions



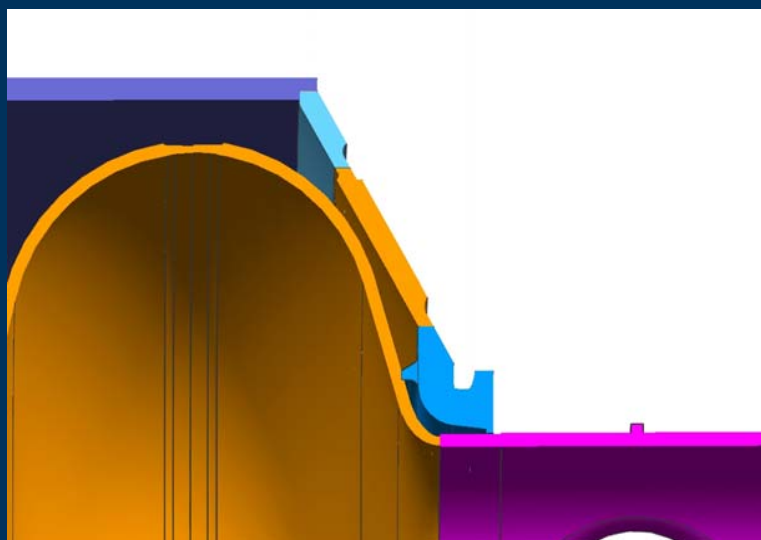
ILC 1.0 (traditional)



ILC 2.0 (future)



ILC 1.3 (T4CM)

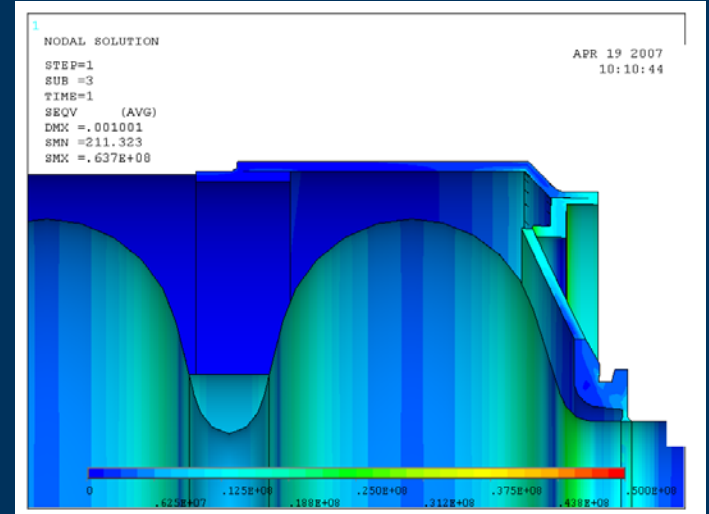
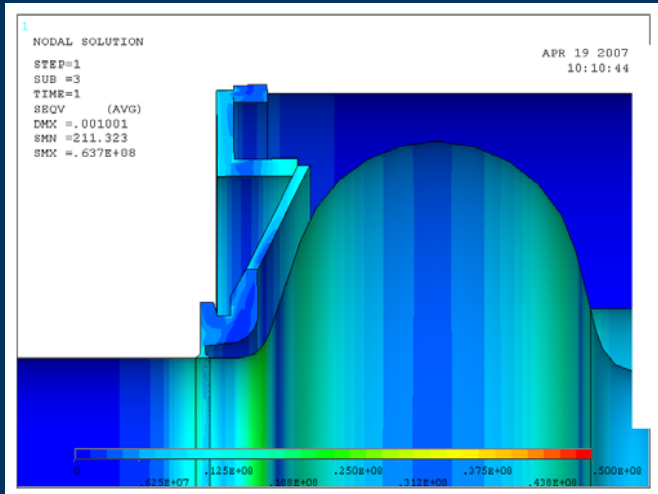




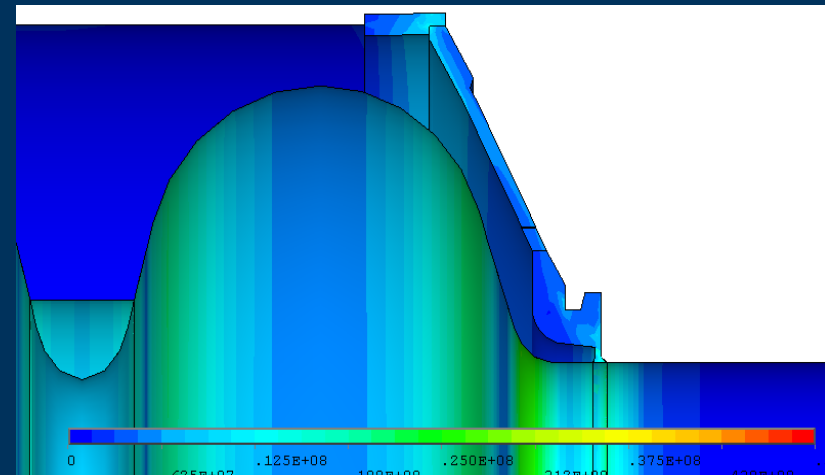
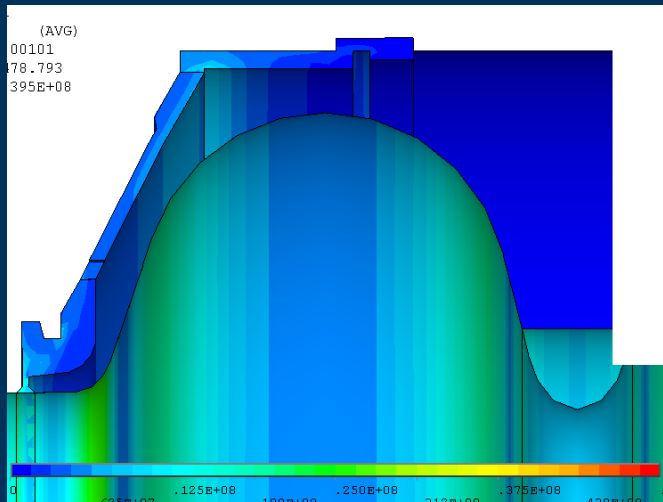
Stress During Tuning



ILC 1.0



ILC 1.3

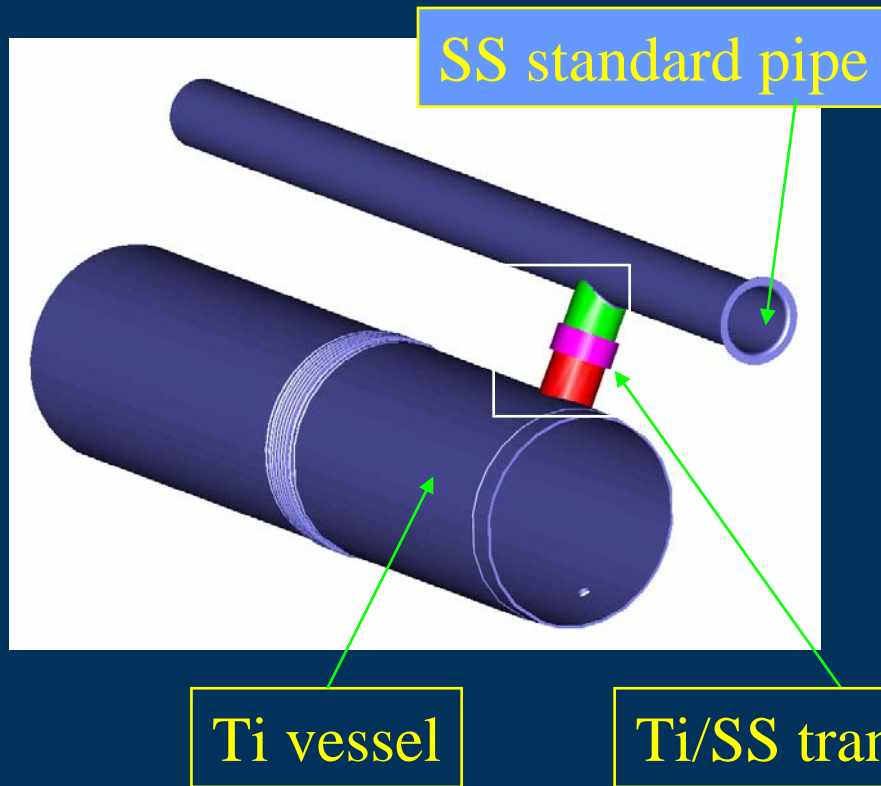




Ti/SS transition in TCM4 design



- Ti/SS transitions between the He vessel and the 2-phase pipe can be easily introduced in the TCM4/Type 3+ design
- This solution was already been adopted in KEK cryomodules.
- A design of that is ready and approved from Russian colleagues.



❖ The Russian colleagues are ready to produce samples with this dimensions (2” pipes).

❖ In Pisa we are ready to fully validate these transitions and develop a faster procedure to test them.

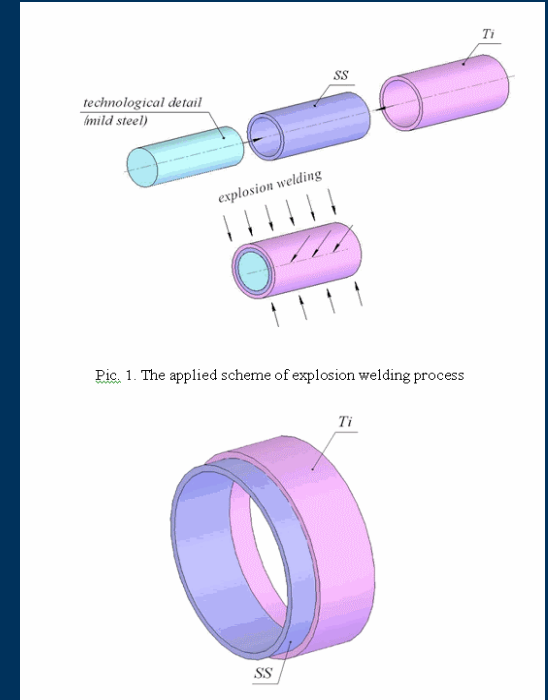
❖ **What is needed to decide to use this technology in the next cryomodules?**



First explosion welding sample from Dubna



- Full report from Russian company about this sample available
- He-leak tests re-made at Pisa at both 300K and 77K
- Will test at 4 K in the near future



• RESULTS:

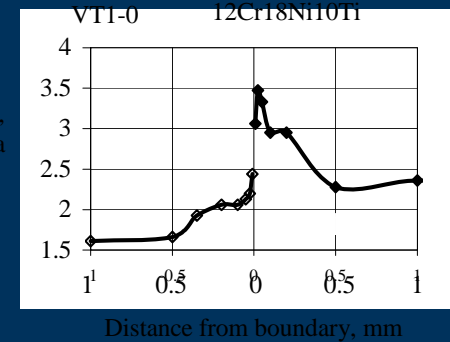
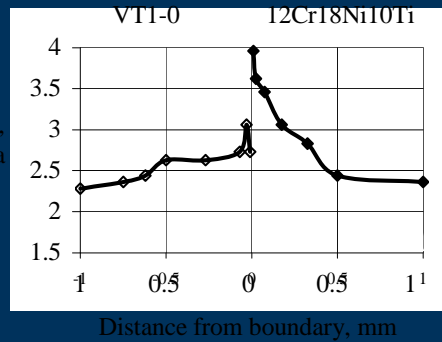
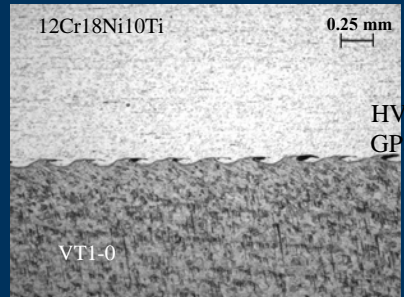
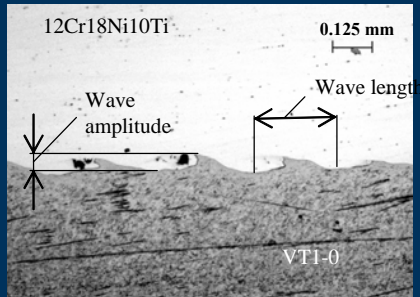
- No He-leak in all test conditions (leak rate $< 10^{-10}$ mbar *l /s with a vacuum of the order of 10^{-3} mbar)

- The small sample dimensions doesn't allow to fully qualify the joint and they are not comparable with any cryomodule pipe dimensions too.

A. Basti, INFN-Pisa



Pictures of first explosion welding sample



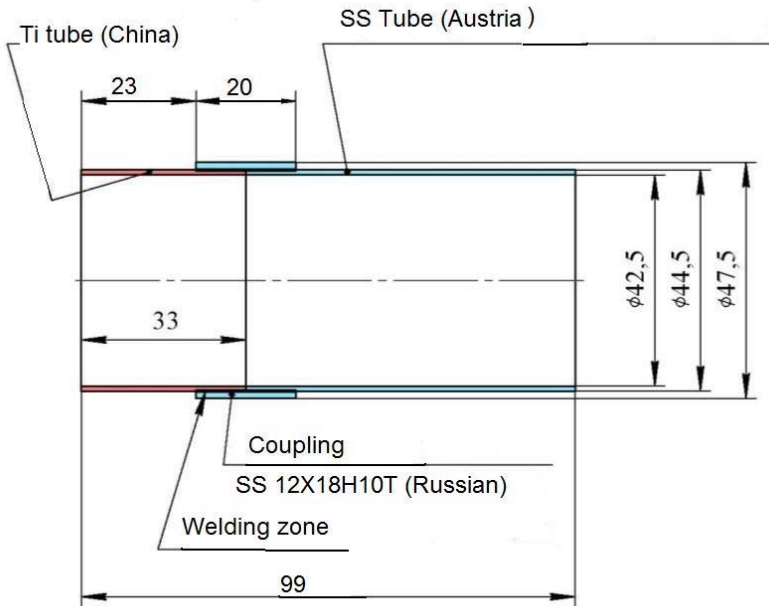
Figures taken from Russian company report



Second explosion welding sample from Dubna



- External diameter comparable with diameter of transition pipe between He-vessel and 2-phase pipe in Fermilab 3th harmonic cryomodule
- Tests made :
 - He-leak tests at 300 K and 77 K



SS sleeve

SS tube

Ti tube



- Thermal cycles between 300 K and 77 K and He-leak checks
- He-leak test with pressure inside (6 bar)
- Welding tests



Welding test preparation (company qualification)



- Prepared closed box with Argon flow to make the Ti welds (small company close to Pisa)
- Test setup welding two plates and a standard vacuum connector to a 3" pipe
- Fully tested this sample at 300 K and 77 K without finding defects, leaks or cracks in the welds.





Welding of transition joint



- Inside the welding box we put a container with ice and water in which we soak the sample during welding.
- The fluid level was close to the welding area.
- We welded a 3 mm Ti cover on top of the transition joint.
- We monitor the temperature of transition joint with a probe in contact with external sleeve surface.
- The welding procedure was very fast (about 5 min) and the temperature detected was always 3-4 degree.
- On the other side of sample we welded a SS cover with a standard vacuum flange holding the piece in the same bath.





Sample after welding

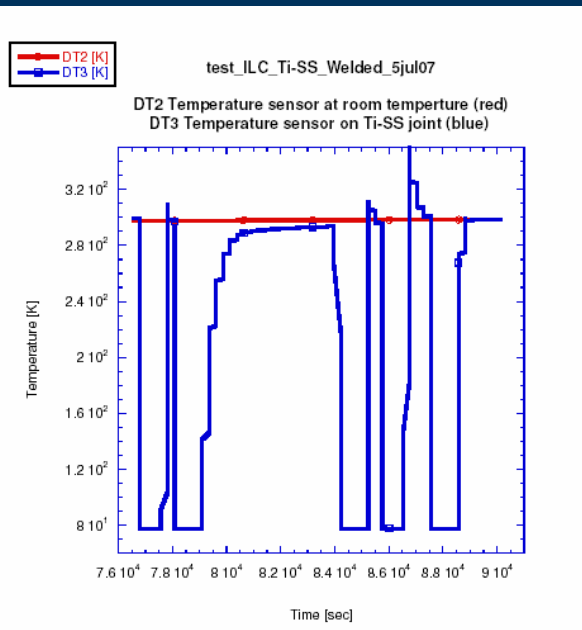




He leak-test after the welding



- We repeated all leak-tests make before :
 - leak check at room temperature with bag filled with He;
 - thermal cycles between 300 and 77 K and after new leak checks at room temperature.
 - Leak test with pressure inside (6 bars of He).



- At the end after the thermal cycles we found only a small leak in the weld between the SS tube and its cover (5×10^{-9} mbar *1 /s).

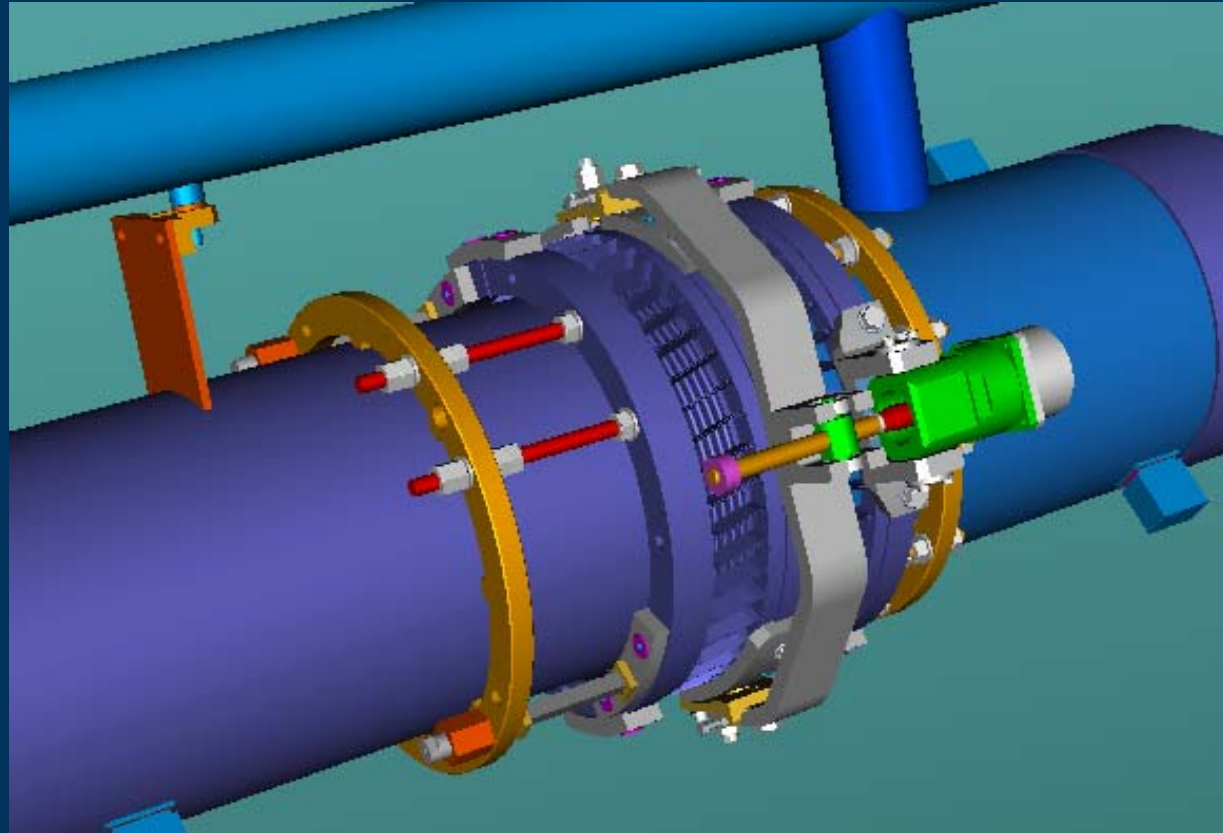


Bladetuner Design Status



INFN Milan is developing new bladetuners with the following features:

- Reduced weight
- Stainless steel
- Optimized blade design
- Optimized piezo fast tuner
- Minimized part count
- Removal of lever
- Rotated motor system



Current design shown



Post parts



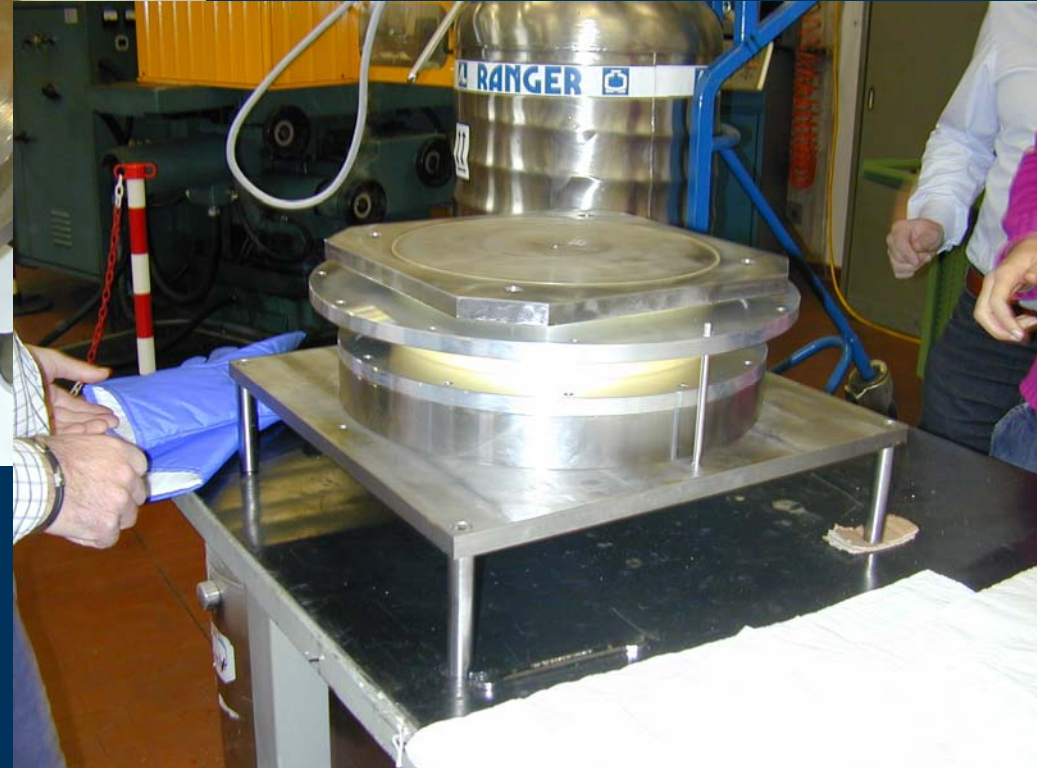
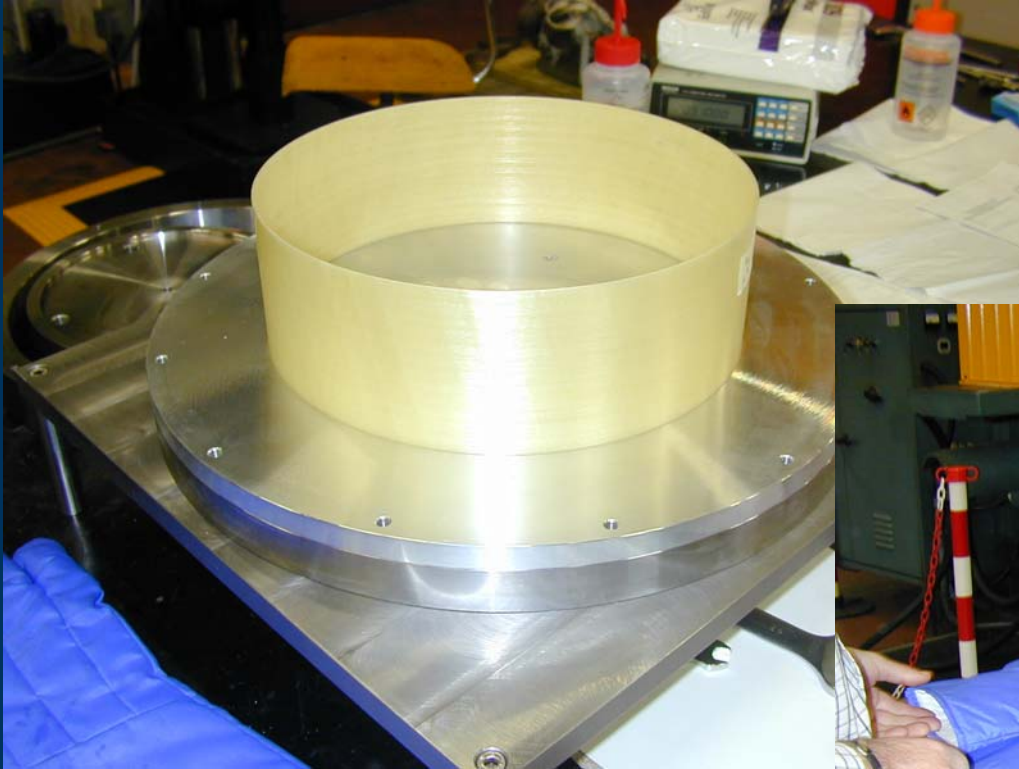


Cooling and heating





Assembly





Traction test

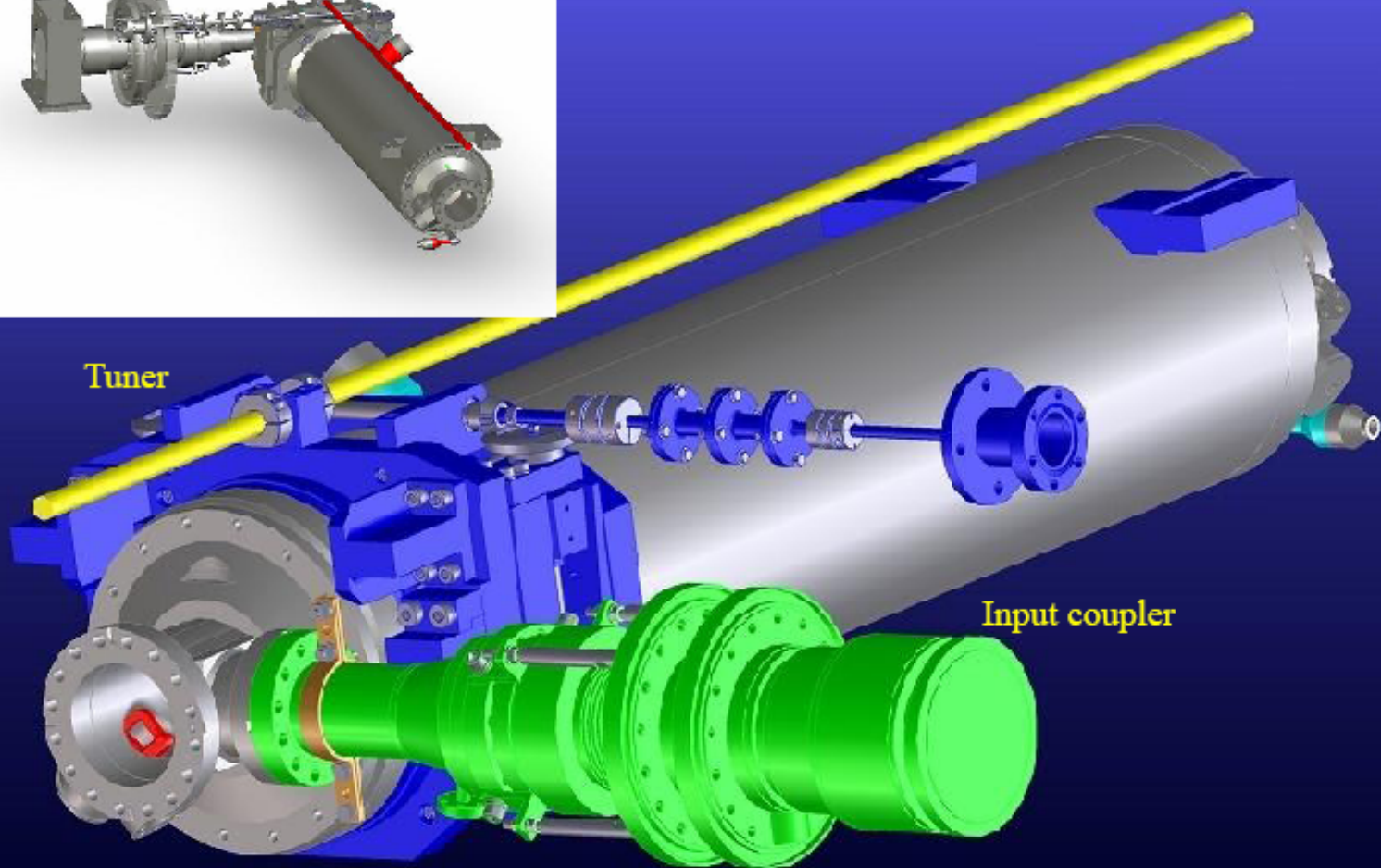
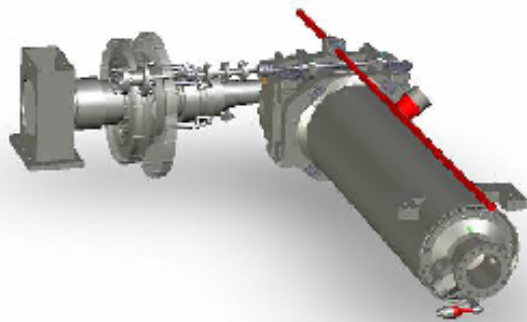




Internal Magnetic Shielding, KEK



Configuration of the helium vessel for Tesla-like-cavity

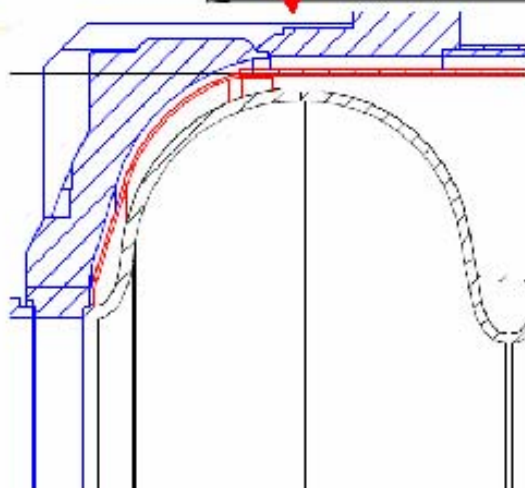
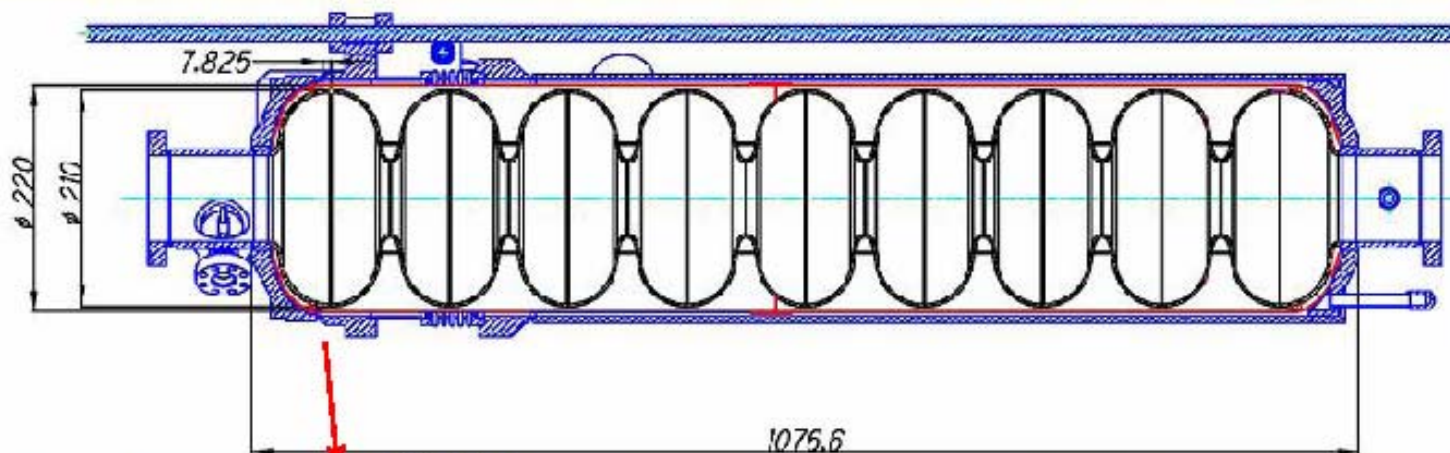




Internal Magnetic Shielding, KEK



Magnetic shield for Tesla-like-cavity



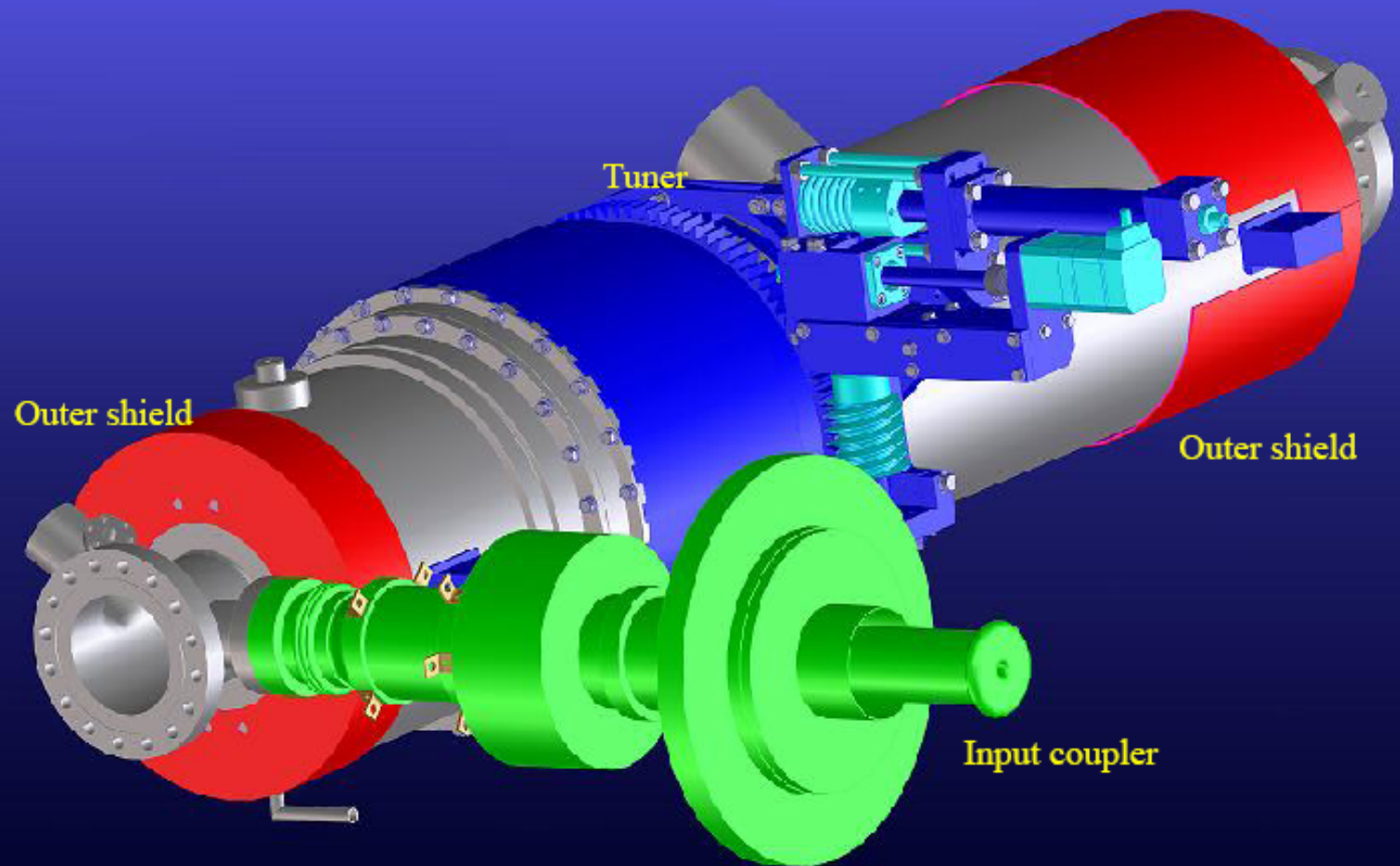
- The magnetic shield system consists of the inner cylinder and the inner ends.
- The thickness of the shield is 1 mm.
- The shield is one layer.
- The length of the cylinder is 978 mm, and the inner diameter is 220 mm.



Internal Magnetic Shielding, KEK

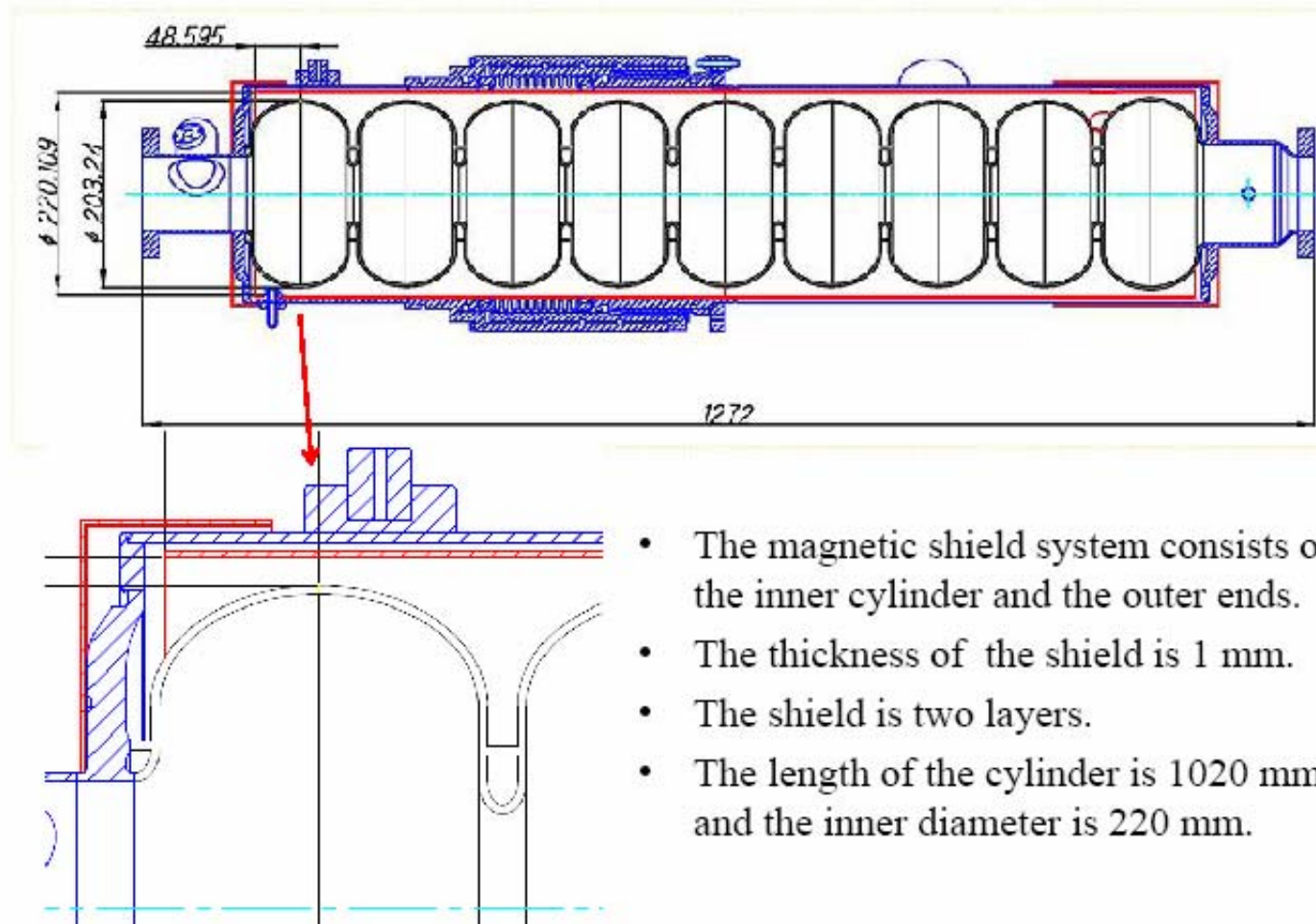


Configuration of the helium vessel for Low-Loss type cavity





Magnetic shield for Tesla-like-cavity





T5CM



- The T5CM (type 5 cryomodule) will be the ILC prototype. It will be designed with the following:
 - Cryogenic pipes sized for the ILC
 - Center mounted quad/steering/BPM package (if T4CM design is acceptable)
 - All stainless steel helium vessel construction
 - Redesigned cavity position monitor system
 - Optimized slow and fast tuner design
 - Cost reduced design on cavity end-groups
 - Internal or external magnetic shielding decision
 - Support post redesigned with shipping constraints
 - Industrial input
 - Designed for shipping



T5CM and Beyond



- During the T4CM fabrication phase, all R&D efforts on design variants need to be evaluated.
 - Cavities
 - Tuners
 - Couplers
 - Magnetic shields
 - HOM absorber
 - BPM/Trim/Quad magnet package
- The best concepts need to be brought forward into the T5CM and future cryomodule designs.
- The T5CM will be the first integrated ILC prototype cryomodule.