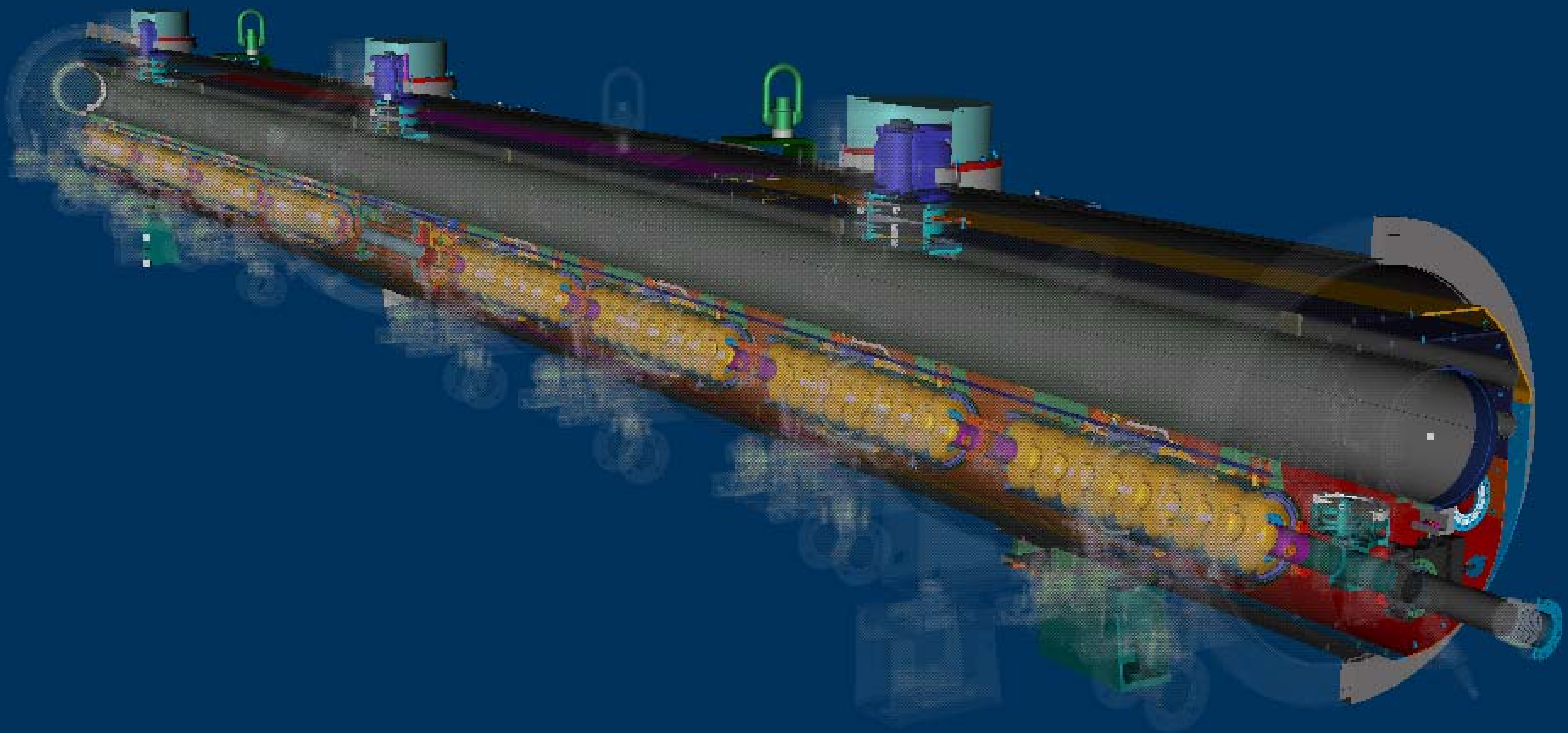
Type IV Cryomodule Design Status



September 12, 2007

Don Mitchell, FNAL

Type IV Cryomodule Design Status

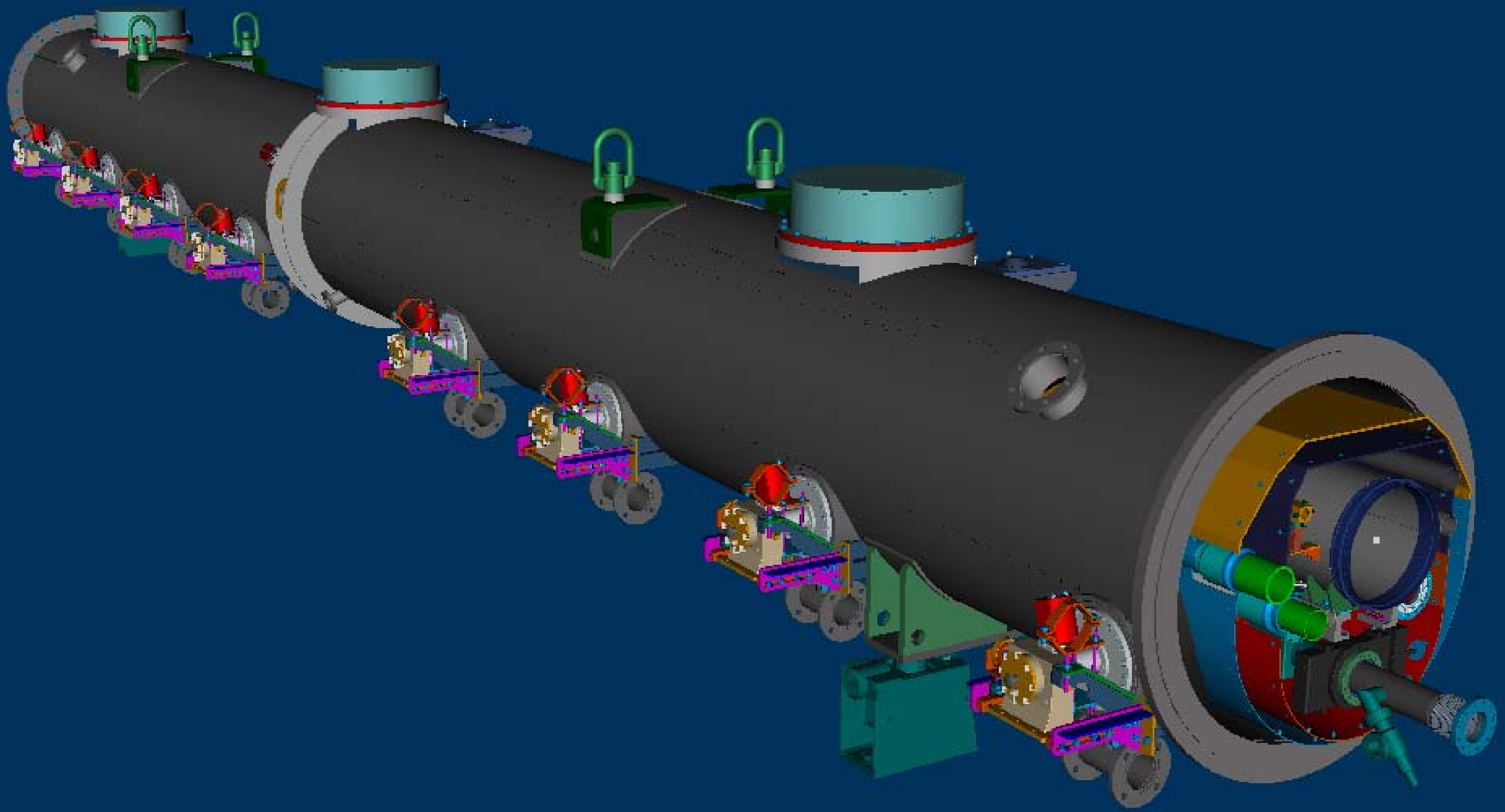
- Agenda
  - T4CM design status
    - Purpose and Current status
    - Projected completion dates
    - Outstanding issues
  - Design resources
    - The people
    - The tools
  - Component overview
  - T5CM and beyond

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

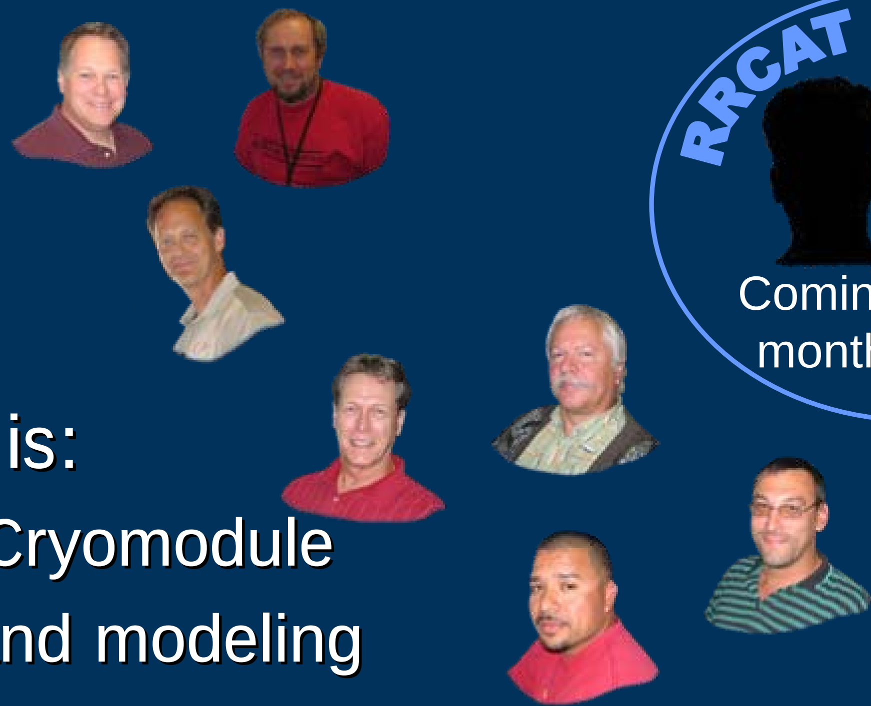
- The following components will be detailed in October:
  - HGRP, 90% Piping, Needle bearings, Magnetic shielding, Helium vessel, and Coldmass supports
- The following components will not be completed until the magnet and BPM are finalized:
  - Cryovessel, Heat shields, and 10% Piping
- Smaller misc. 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

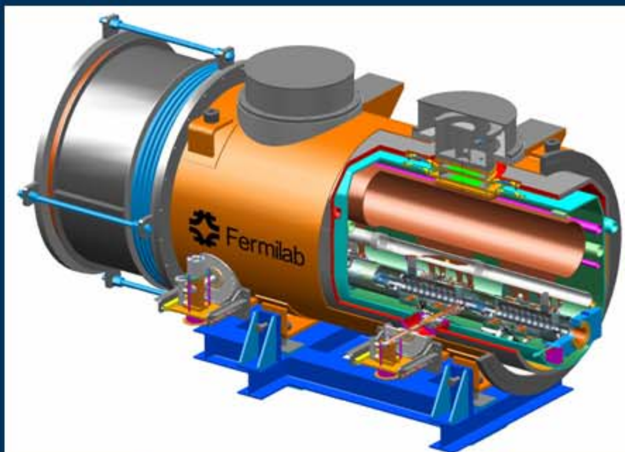
Fermilab Cryomodule Resources

- Who?
  - 2 engineers
  - 1 designer
  - ~~4~~ 3 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

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

ILC International Resources

- 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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Calendar

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

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

Click here **for NALCAL, a weekly calendar with links to additional information.**

Feature Story

Planning for ILC success through shared databases

Participants in the five-day course at Fermilab.*

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.

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.

Safety Tip of the Week

Where did you get that?

There are things you just can't find on eBay.

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.

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.

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

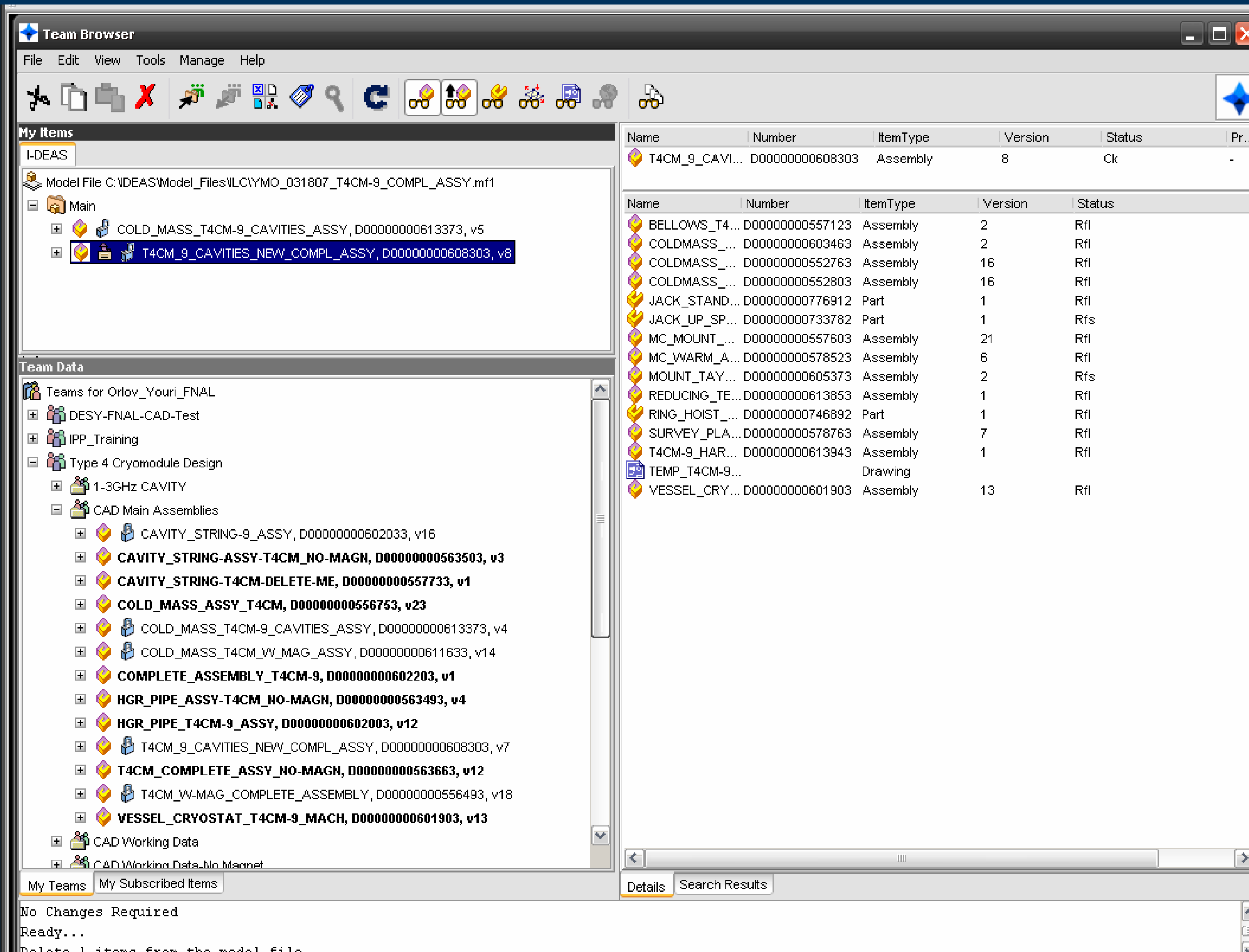
- FNAL: I-DEAS v.12
- SLAC: Solidedge
- JLAB: I-DEAS
- INFN Milan: UG-NX & I-DEAS v.12
- INFN Pisa: I-DEAS v.12
- KEK: I-DEAS (recent purchase)
- DESY: I-DEAS v.12

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.

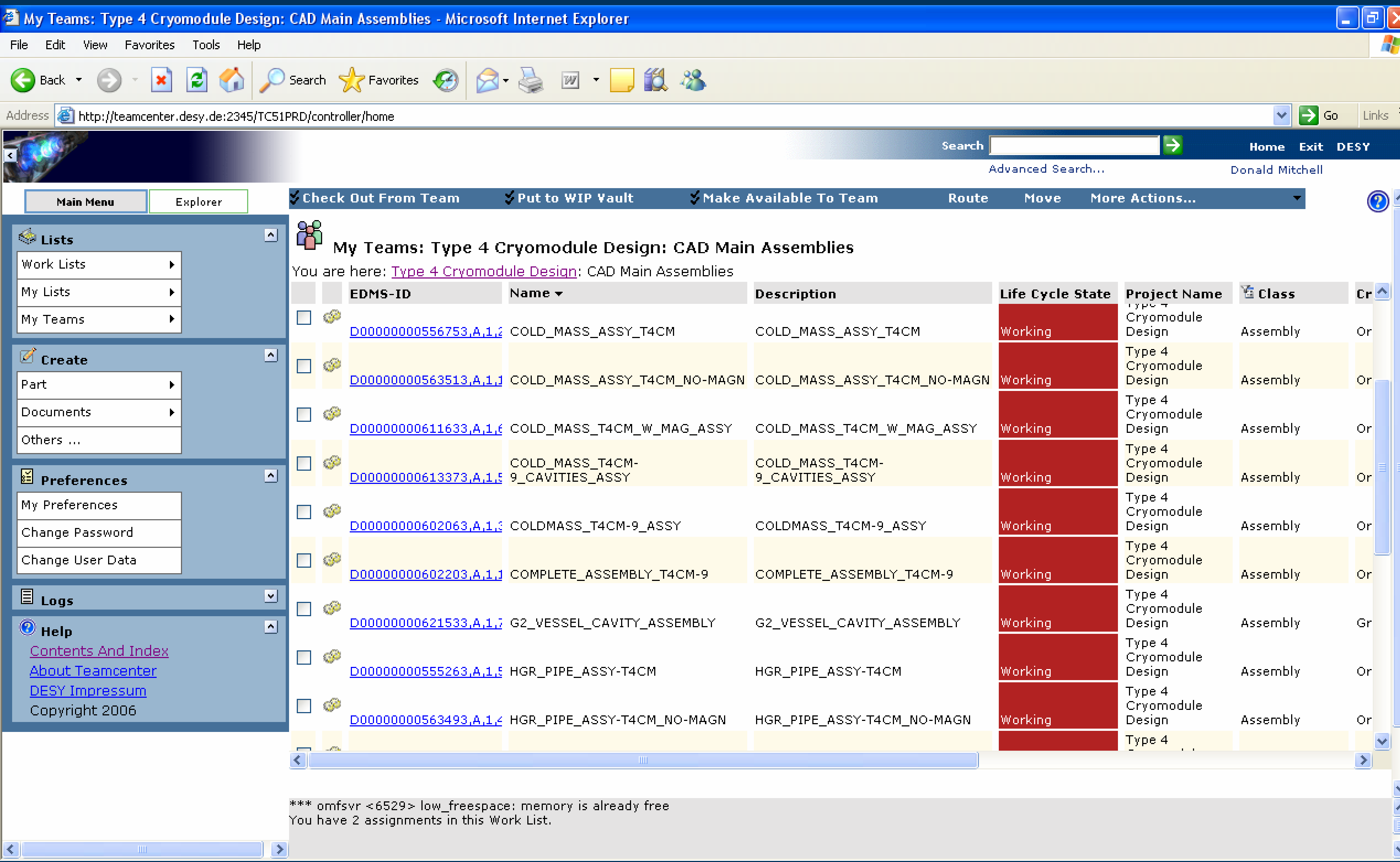
Common CAD tools (cont.)

- 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 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 Search Favorites

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...

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- My Lists
- My Teams

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- My Preferences
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- Change User Data

Logs

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- Contents And Index
- About Teamcenter
- DESY Impressum
- Copyright 2006

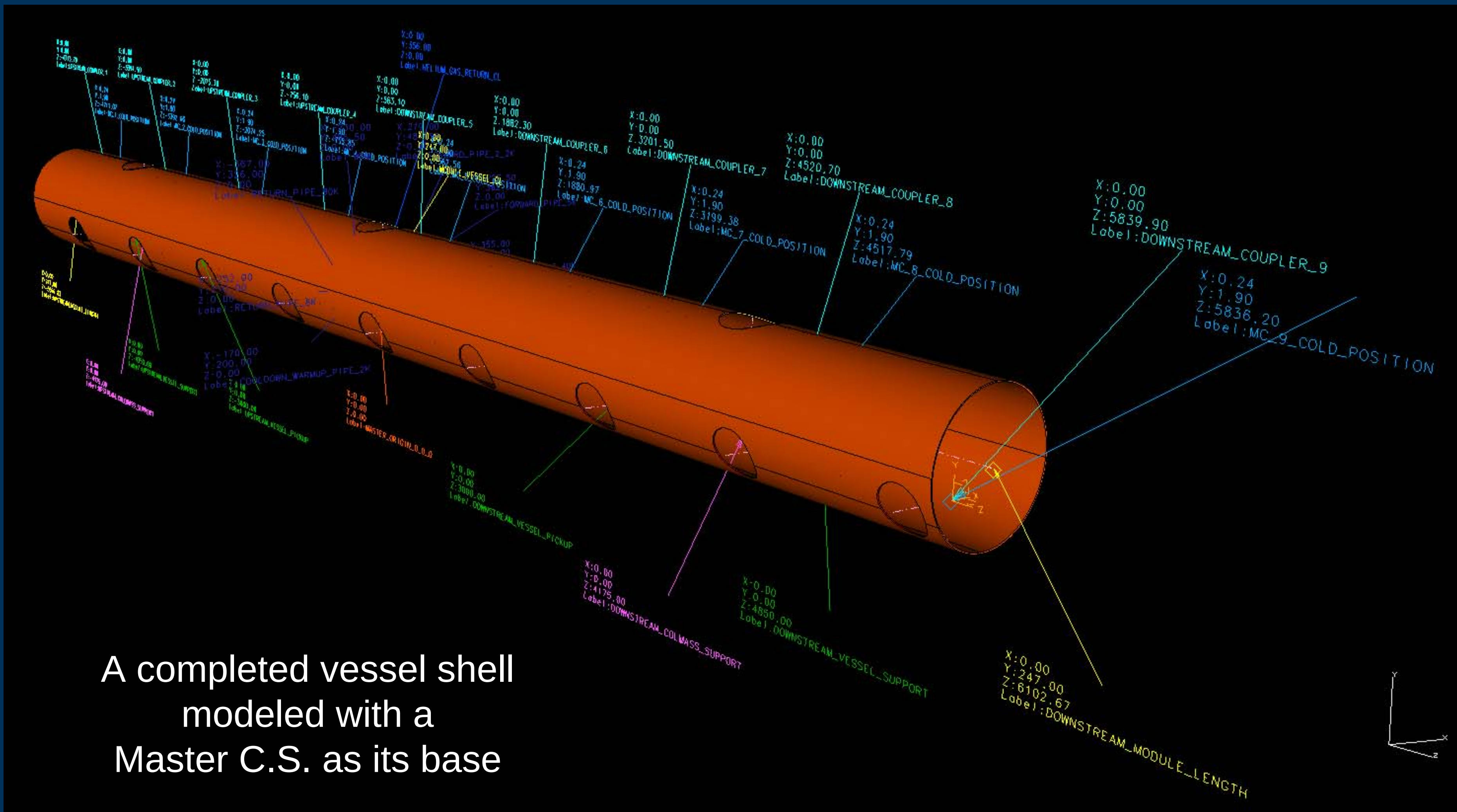
My Teams: Type 4 Cryomodule Design: CAD Main Assemblies

You are here: Type 4 Cryomodule Design: CAD Main Assemblies

EDMS-ID	Name	Description	Life Cycle State	Project Name	Class	Cr
D00000000556753,A,1,2	COLD_MASS_ASSY_T4CM	COLD_MASS_ASSY_T4CM	Working	Type 4 Cryomodule Design	Assembly	Or
D00000000563513,A,1,1	COLD_MASS_ASSY_T4CM_NO-MAGN	COLD_MASS_ASSY_T4CM_NO-MAGN	Working	Type 4 Cryomodule Design	Assembly	Or
D00000000611633,A,1,6	COLD_MASS_T4CM_W_MAG_ASSY	COLD_MASS_T4CM_W_MAG_ASSY	Working	Type 4 Cryomodule Design	Assembly	Or
D00000000613373,A,1,5	COLD_MASS_T4CM-9_CAVITIES_ASSY	COLD_MASS_T4CM-9_CAVITIES_ASSY	Working	Type 4 Cryomodule Design	Assembly	Or
D00000000602063,A,1,3	COLDMASS_T4CM-9_ASSY	COLDMASS_T4CM-9_ASSY	Working	Type 4 Cryomodule Design	Assembly	Or
D00000000602203,A,1,1	COMPLETE_ASSEMBLY_T4CM-9	COMPLETE_ASSEMBLY_T4CM-9	Working	Type 4 Cryomodule Design	Assembly	Or
D00000000621533,A,1,7	G2_VESSEL_CAVITY_ASSEMBLY	G2_VESSEL_CAVITY_ASSEMBLY	Working	Type 4 Cryomodule Design	Assembly	Gr
D00000000555263,A,1,5	HGR_PIPE_ASSY-T4CM	HGR_PIPE_ASSY-T4CM	Working	Type 4 Cryomodule Design	Assembly	Or
D00000000563493,A,1,4	HGR_PIPE_ASSY-T4CM_NO-MAGN	HGR_PIPE_ASSY-T4CM_NO-MAGN	Working	Type 4 Cryomodule Design	Assembly	Or
				Type 4		

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

“Key” Parts built with the Master C.S.



A completed vessel shell
modeled with a
Master C.S. as its base

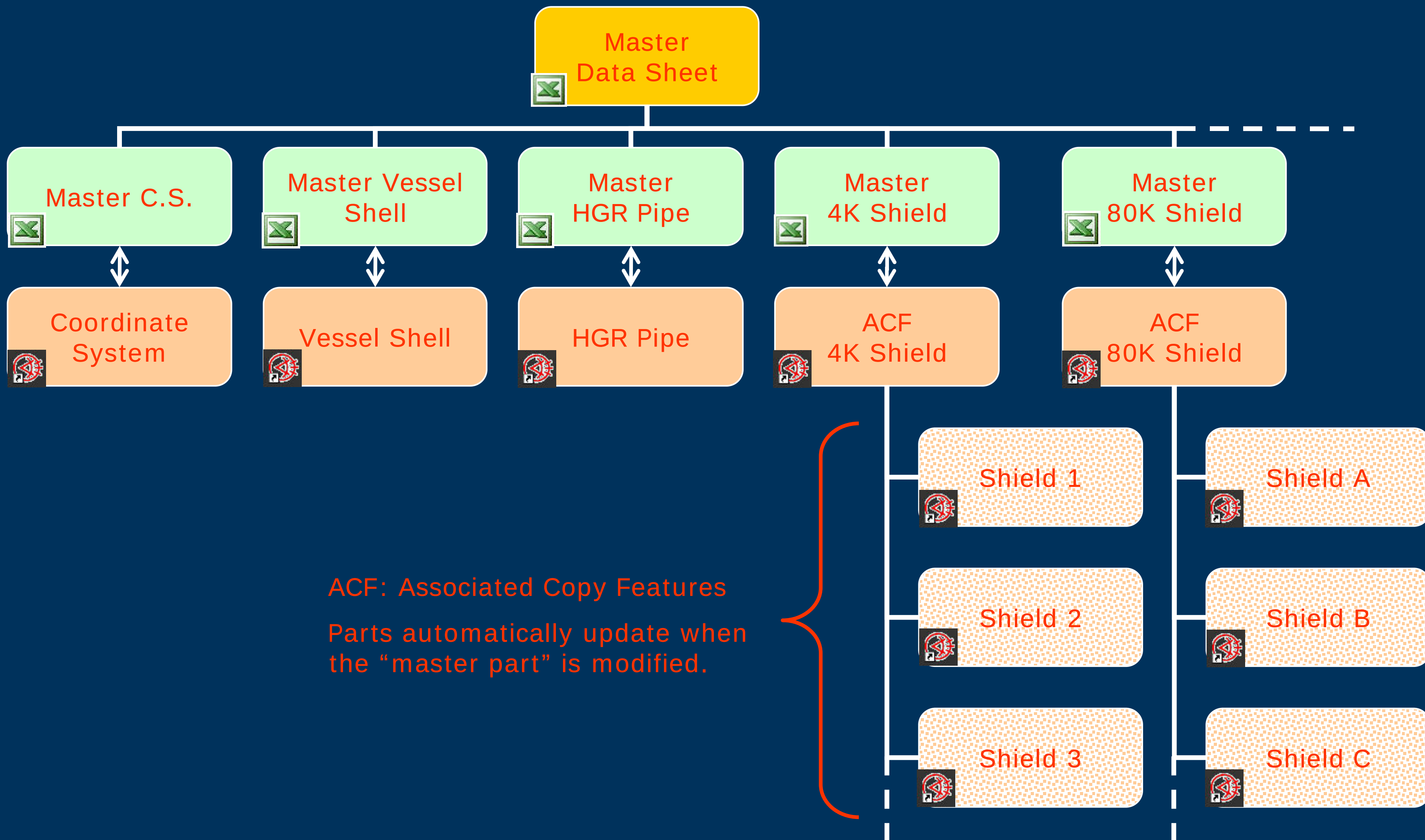
The *Part* Excel File

Microsoft Excel - VESSEL-CRYOMODULE_TUBE-9.xls

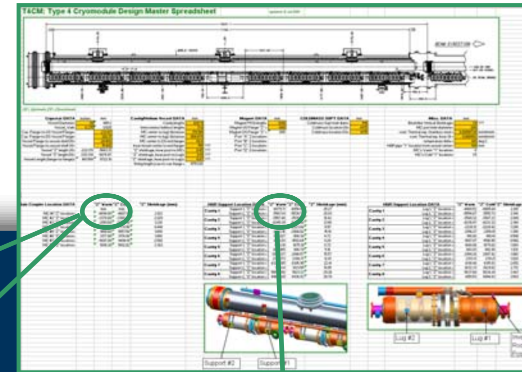
	Name	Expression	Results	Units	Status
3	Part Name	VESSEL_CRYOSTAT_TUBE-9			
4	Part Number				
5	UPSTREAM_COUPLER_1_X		0	mm	
6	UPSTREAM_COUPLER_1_Y		0	mm	
7	UPSTREAM_COUPLER_1_Z		-4713.7	mm	
8	UPSTREAM_COUPLER_2_X	UPSTREAM_COUPLER_1_X	0	mm	
9	UPSTREAM_COUPLER_2_Y	UPSTREAM_COUPLER_1_Y	0	mm	
10	UPSTREAM_COUPLER_2_Z		-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	
20	DOWNSTREAM_COUPLER_6_X	UPSTREAM_COUPLER_1_X	0	mm	
21	DOWNSTREAM_COUPLER_6_Y	UPSTREAM_COUPLER_1_Y	0	mm	
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



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Part Number					
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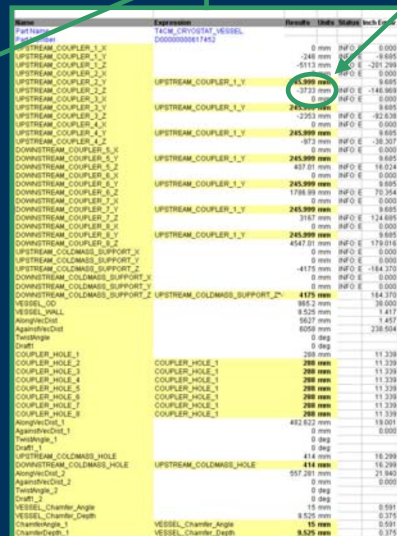
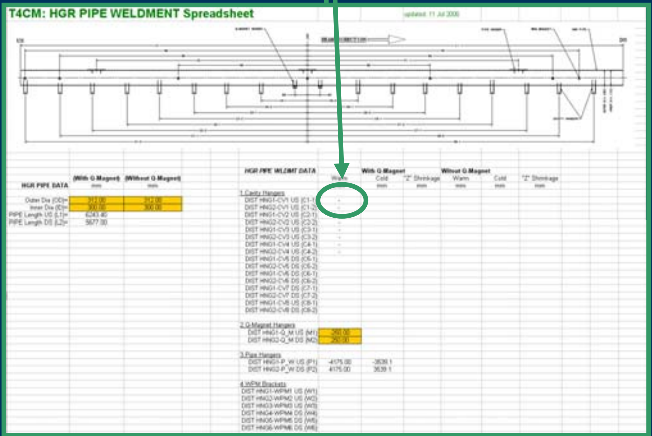
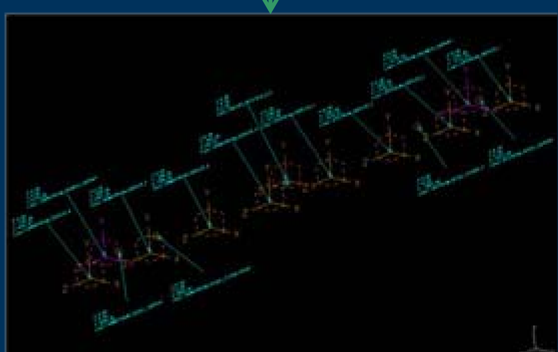
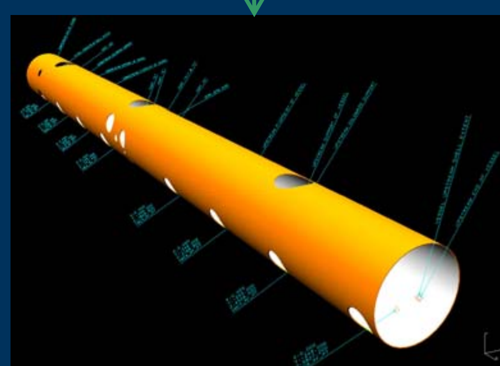
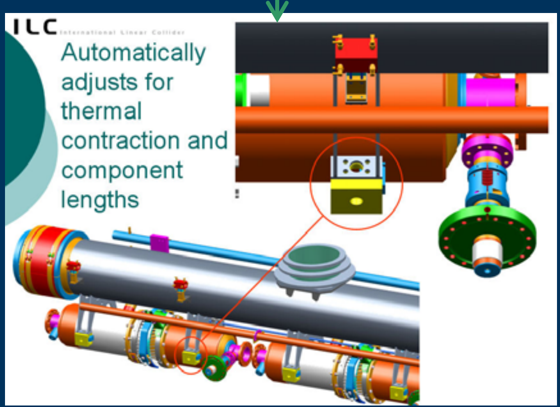
UPSTREAM_COUPLER_1_Y		-246	mm		-9.685
UPSTREAM_COUPLER_1_Z		-5113	mm		-201.299
UPSTREAM_COUPLER_2_X		0	mm		0.000
UPSTREAM_COUPLER_2_Y	UPSTREAM_COUPLER_1_Y	245.999	mm		9.685
UPSTREAM_COUPLER_2_Z		-3733	mm		-146.969
UPSTREAM_COUPLER_3_X		0	mm		0.000
UPSTREAM_COUPLER_3_Y	UPSTREAM_COUPLER_1_Y	245.999	mm		9.685
UPSTREAM_COUPLER_3_Z		-2353	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		-973	mm		-38.307
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*-1	4175	mm		164.370



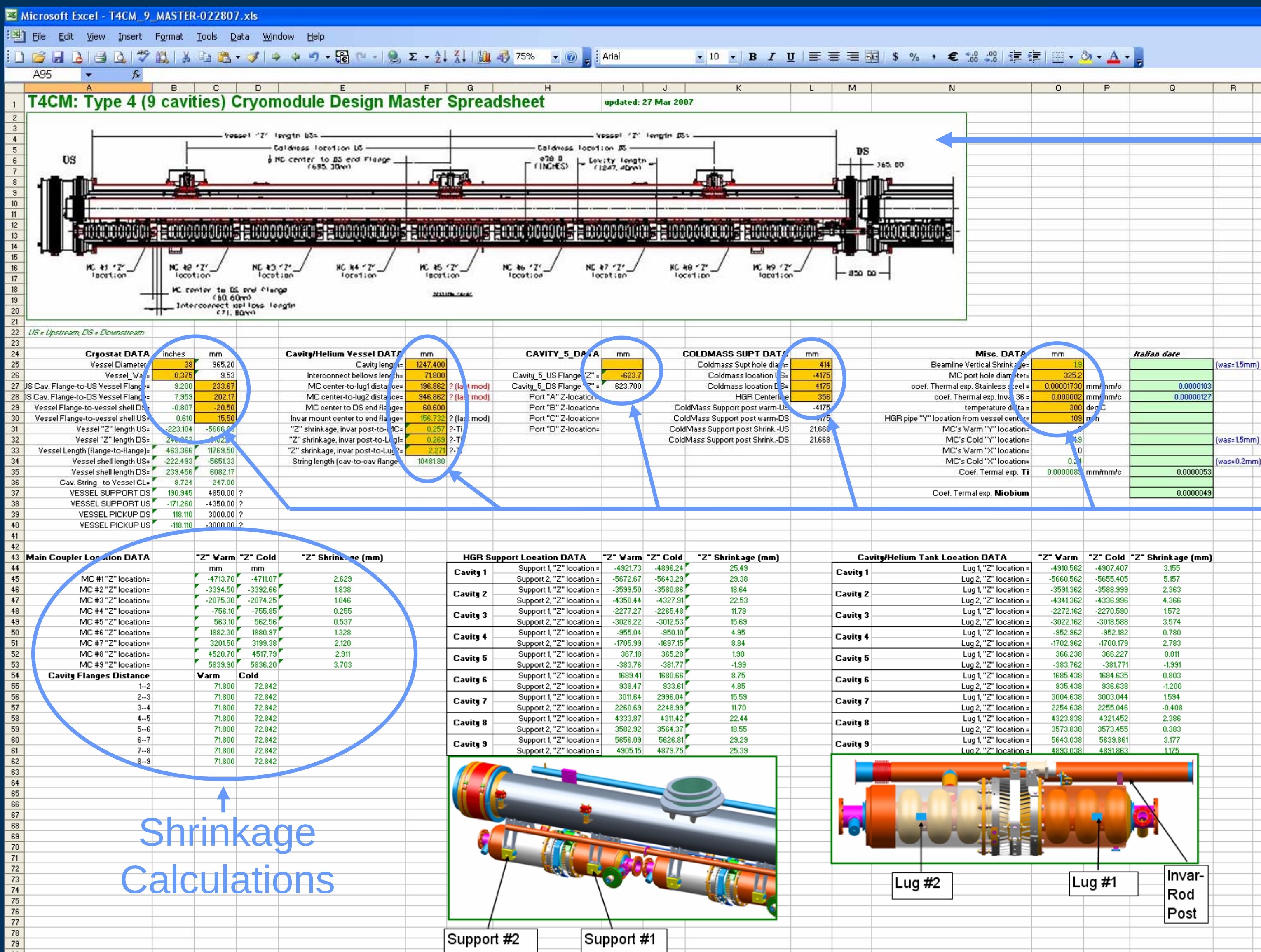








The Master Spreadsheet, A Closer Look



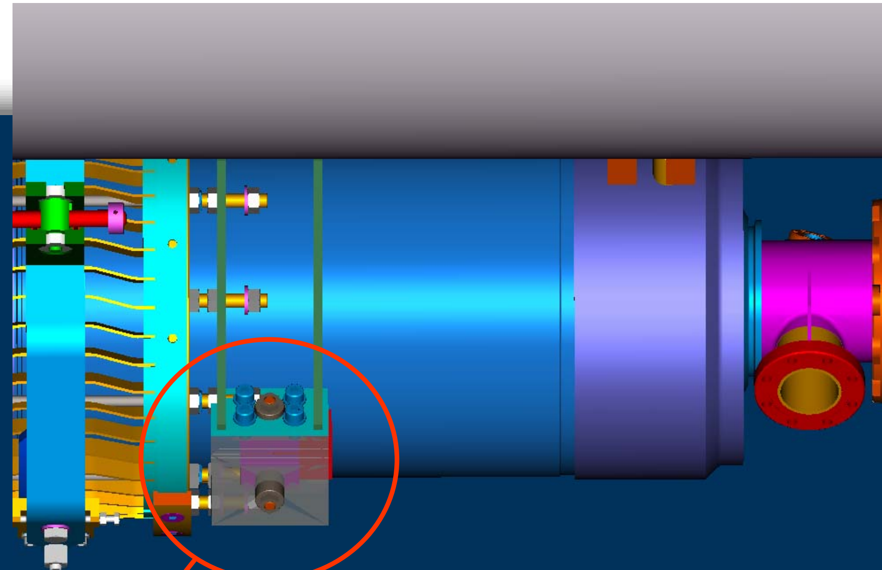
Hyperlinked to a detailed PDF drawing

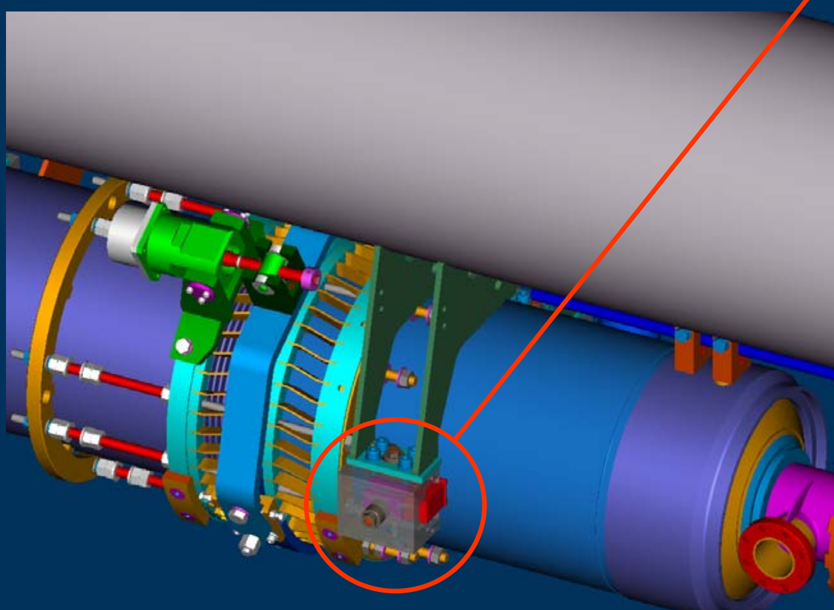
Values which can be modified

Shrinkage Calculations

Change the Master …

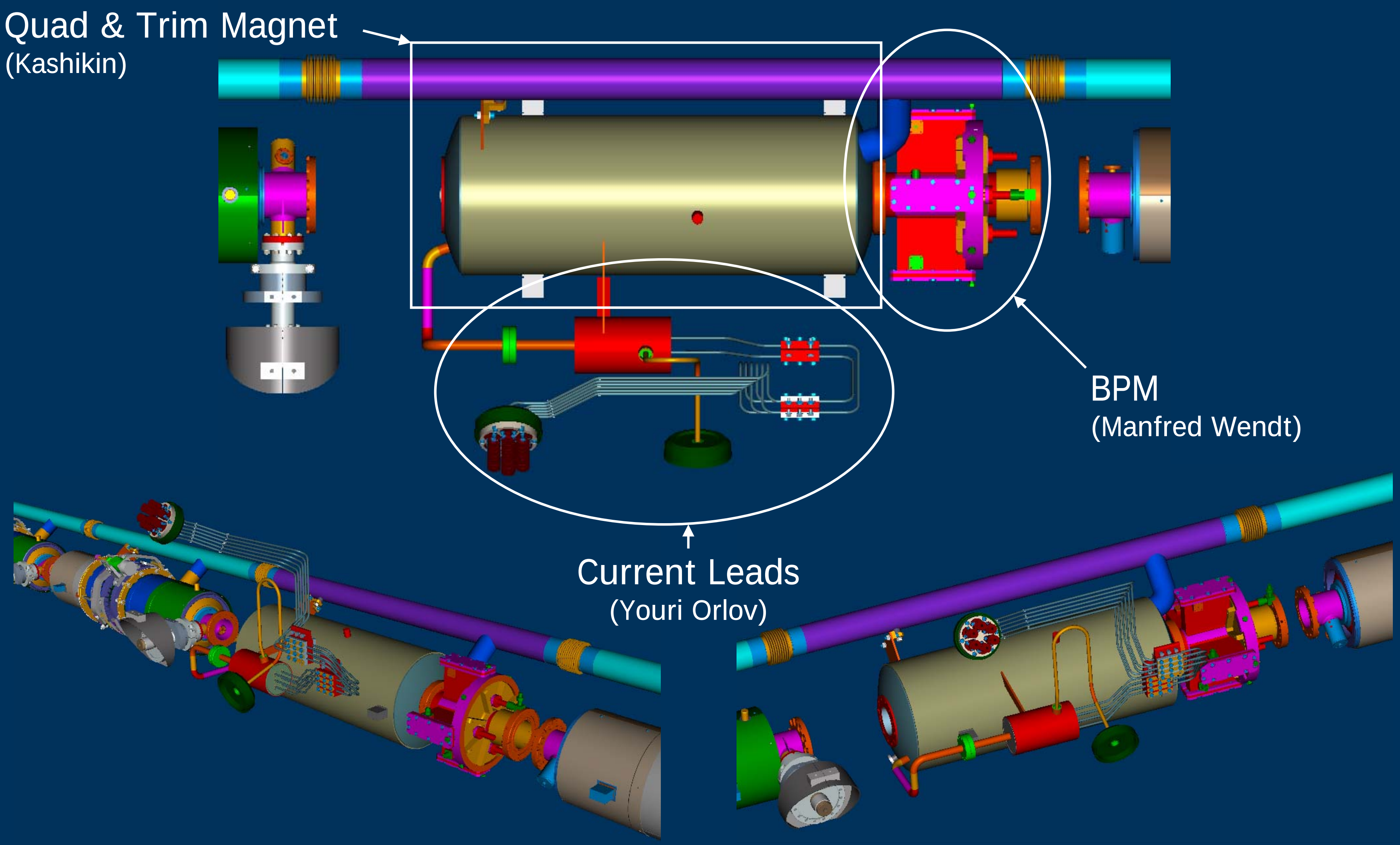
The master spreadsheet will automatically adjust all computed values.





- **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



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, um	5
Liquid Helium temperature, K	2
Quantity required	560

NbTi Superconductor Parameters

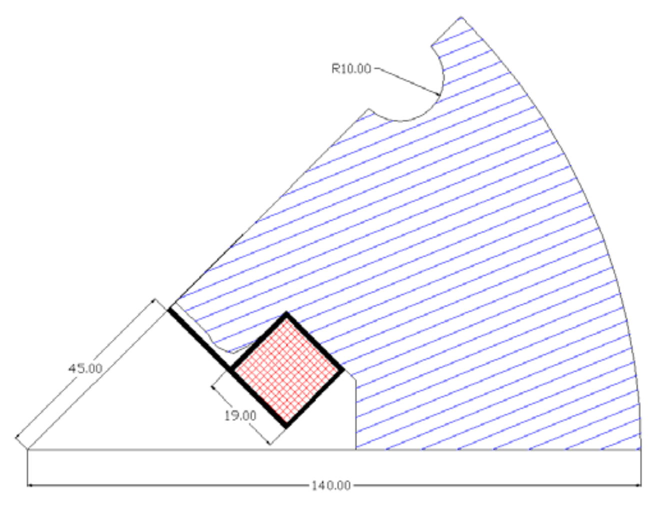
Quadrupole Coils

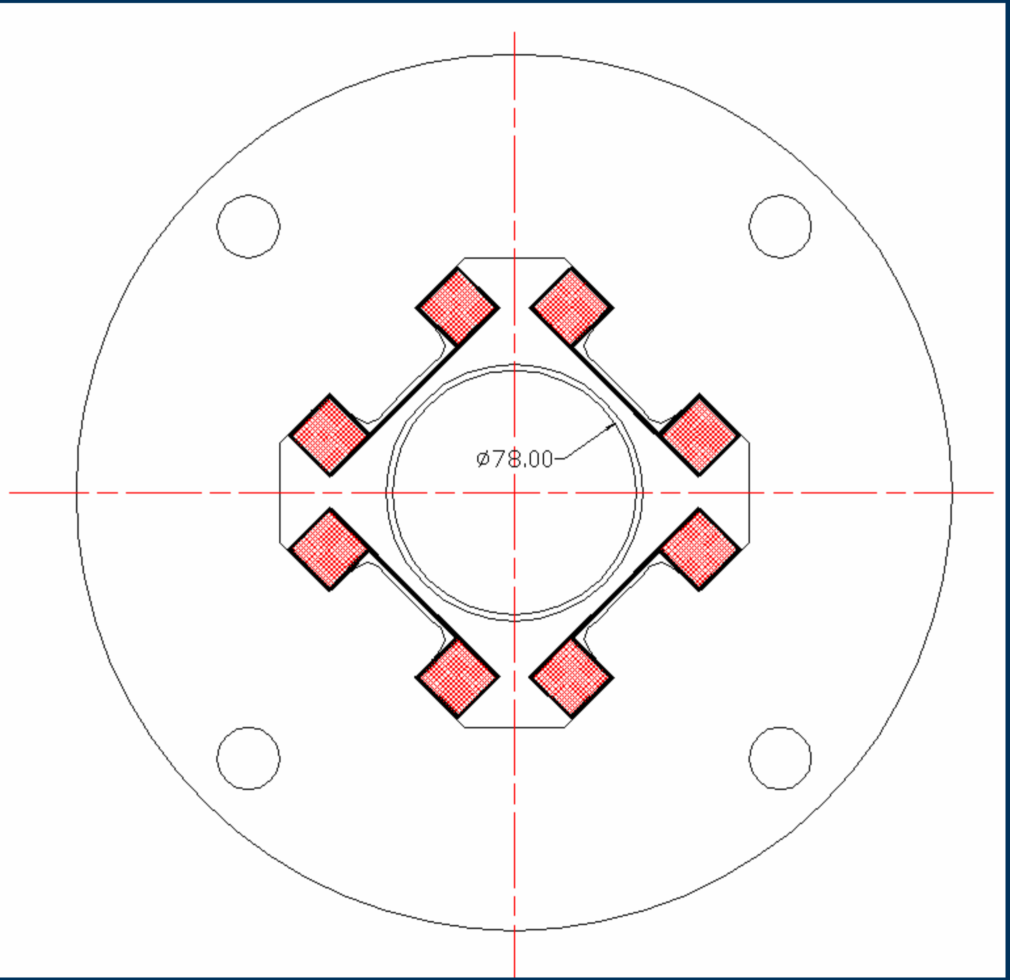
NbTi wire diameter, mm	0.5
Number of filaments	7242
Filament diameter, um	3.7
Copper : Superconductor	1.5
Insulated wire diameter, mm	0.54
Insulation	Formvar
Twist pitch, mm	25
RRR of copper matrix	100
Critical current Ic @ 4.2K, at 5T	204 A

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 Ic @ 4.2K, at 5T	51

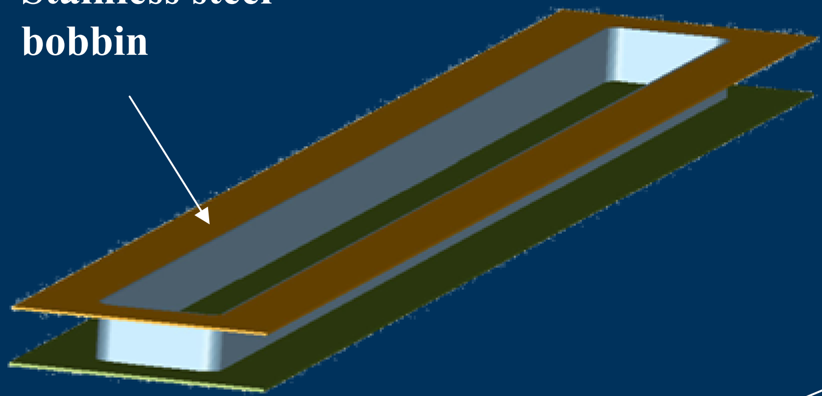
Quadrupole Cross-Section

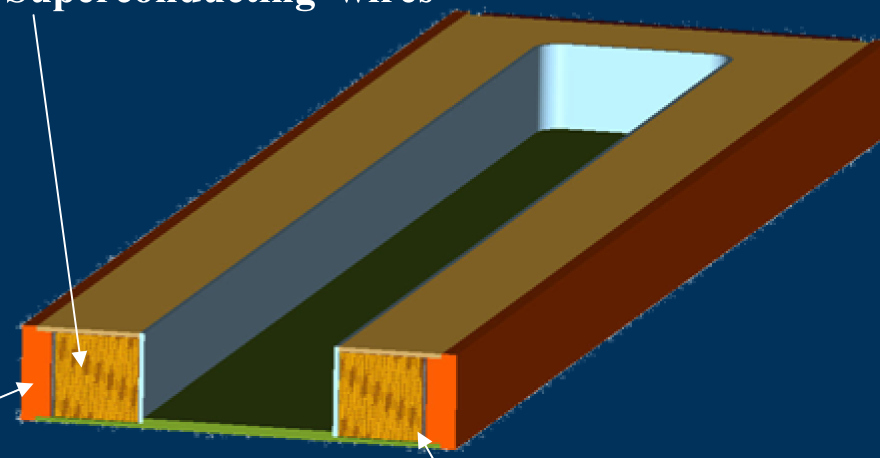




Cold mass diameter	280 mm
Cold mass length	680 mm
Pole length	600 mm
Peak current	100 A
Superconductor length	5 km
Yoke weight	250 kg

Quadrupole Coil Design



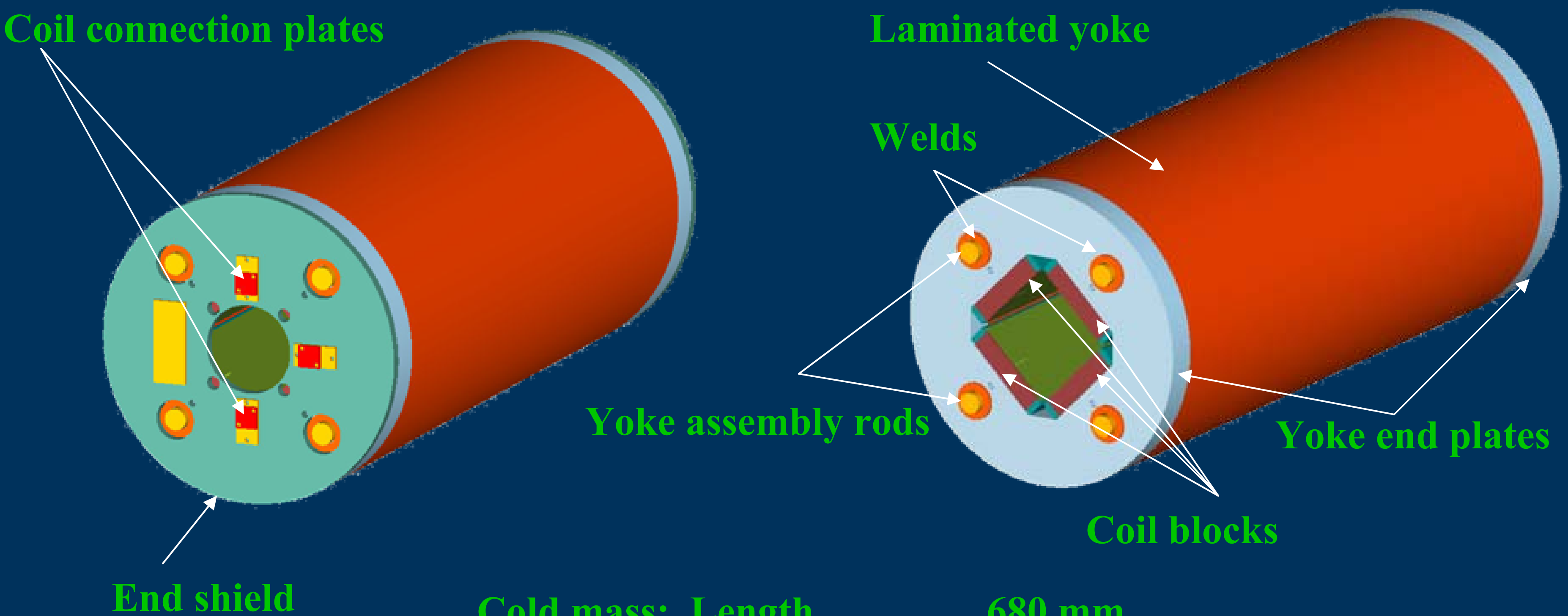


Coil bobbin

Coil assembly

- 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

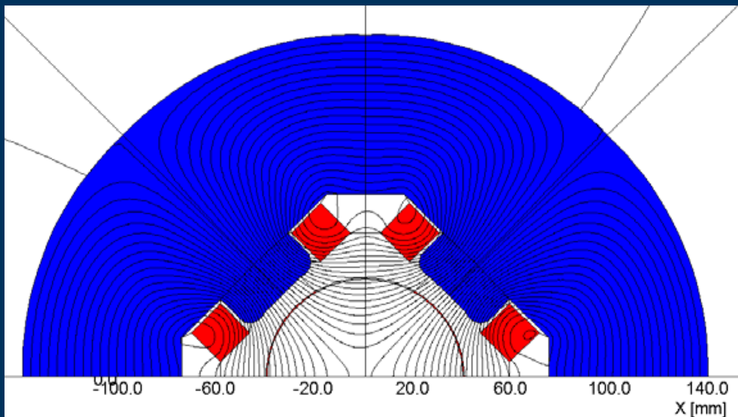
Quadrupole cold mass



Cold mass: Length 680 mm

Outer diameter 280 mm

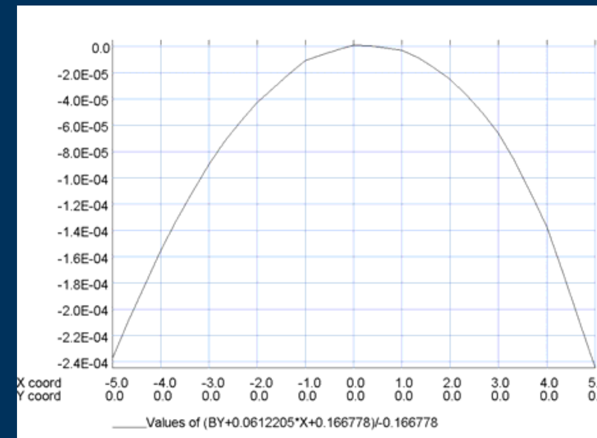
Dipole Correctors



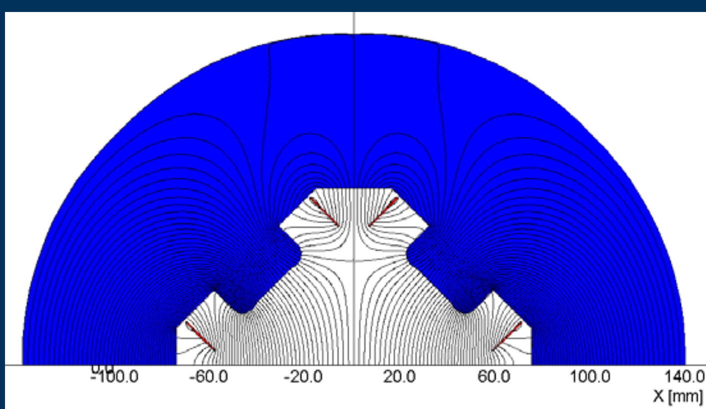
Shell type dipole field homogeneity

Dipole integrated field 0.075T-m

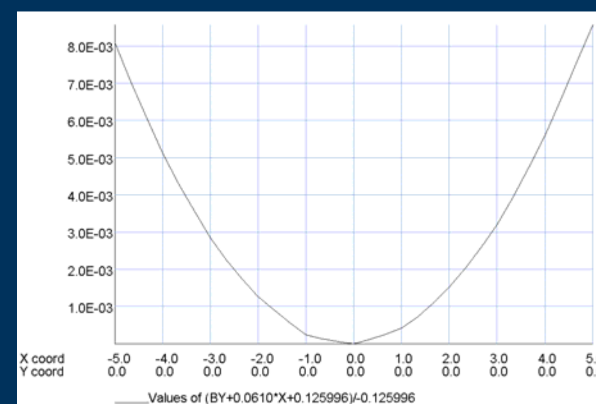
Dipole center field 0.125T at 0.6 m effective length



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



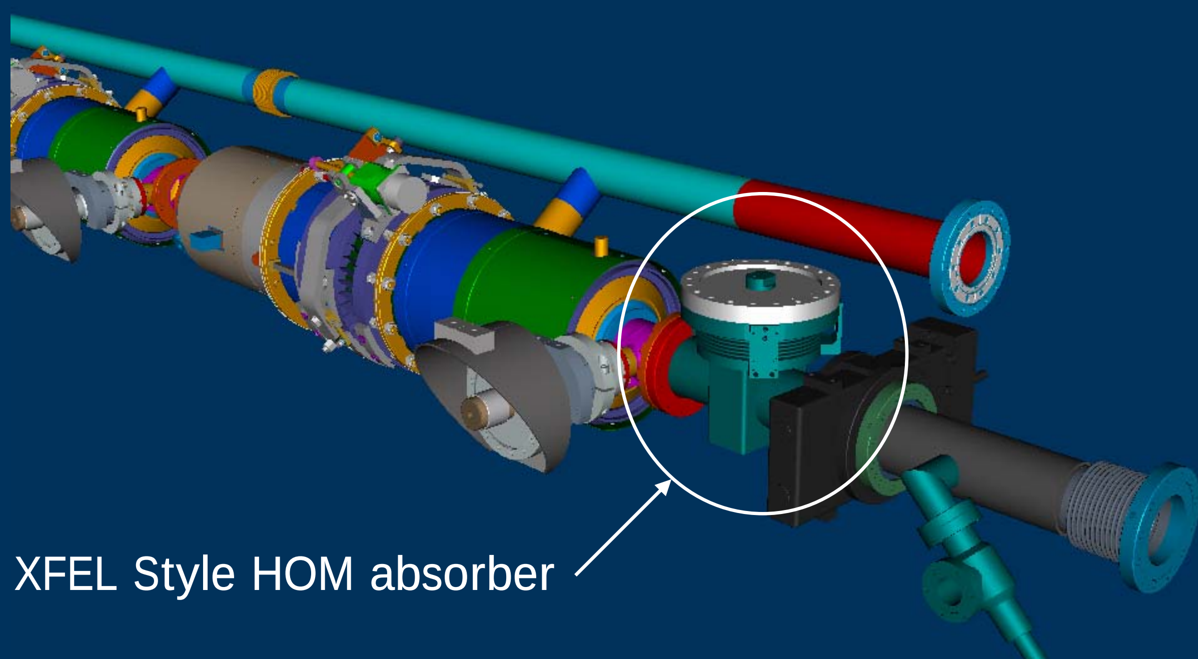
Racetrack type dipole field at zero quadrupole field



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

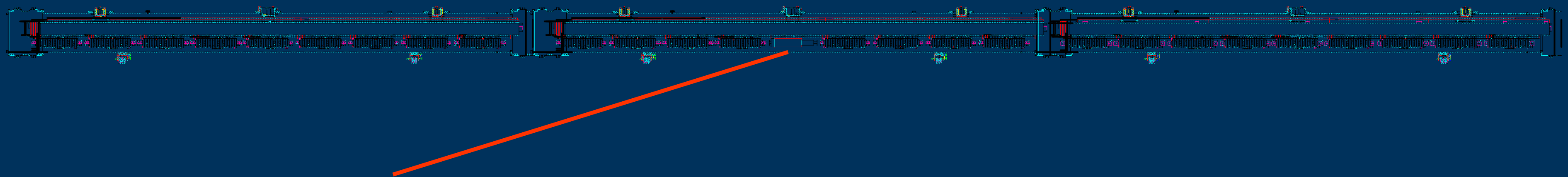
HOM Absorber

- 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

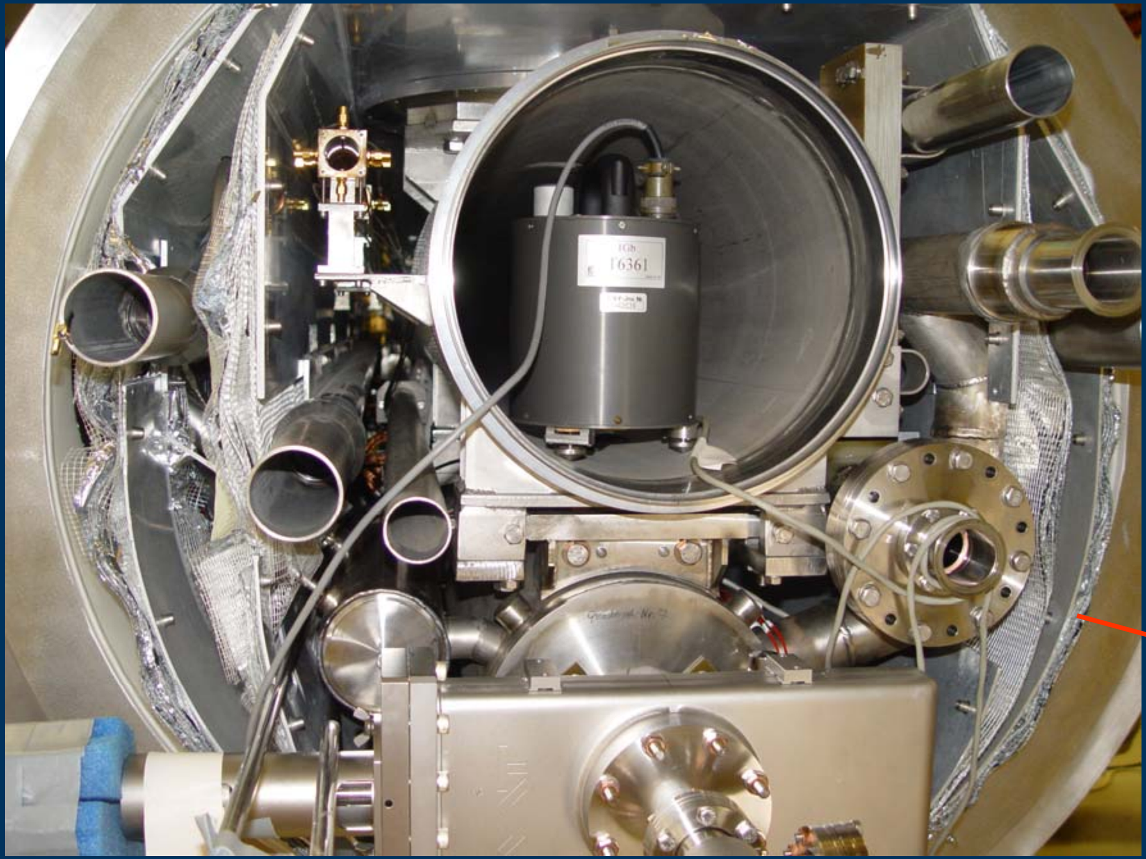
All results are provided in 3-in-series with (fixed-fixed) end condition to address effects of unknown end conditions.



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

Fermilab

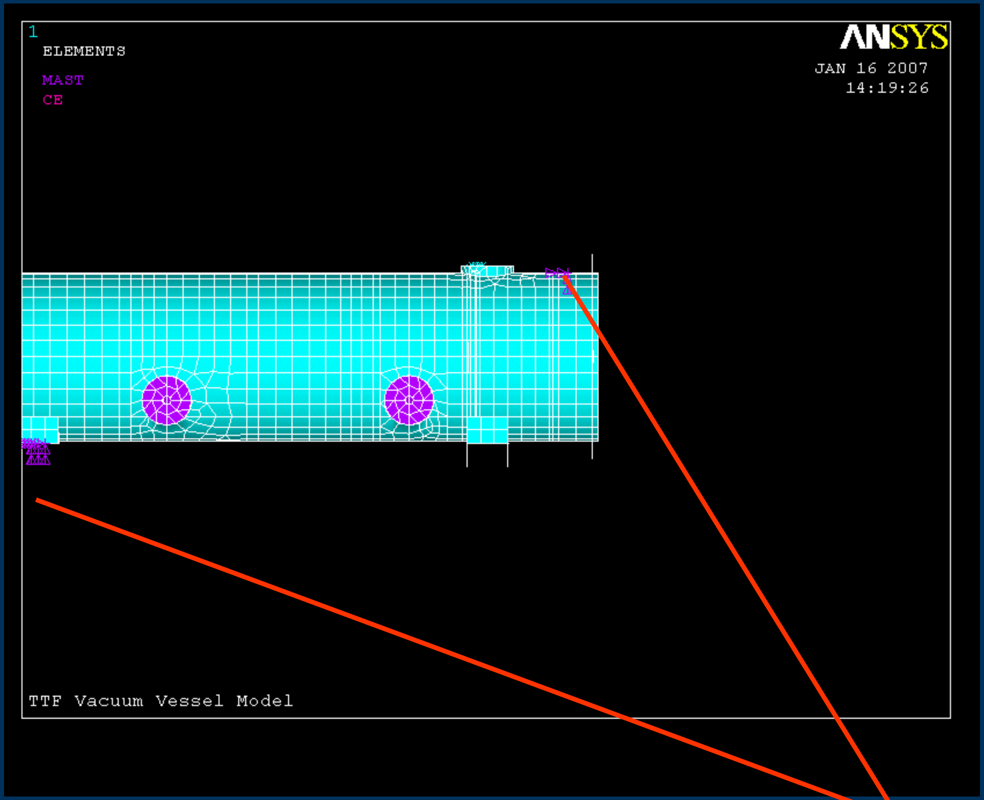
DESY Measurement Transfer Functions

2) Vacuum Vessel Top vs HeGRP

3) HeGRP vs Quad

Courtesy of DESY

TTF Single ANSYS Model Applied

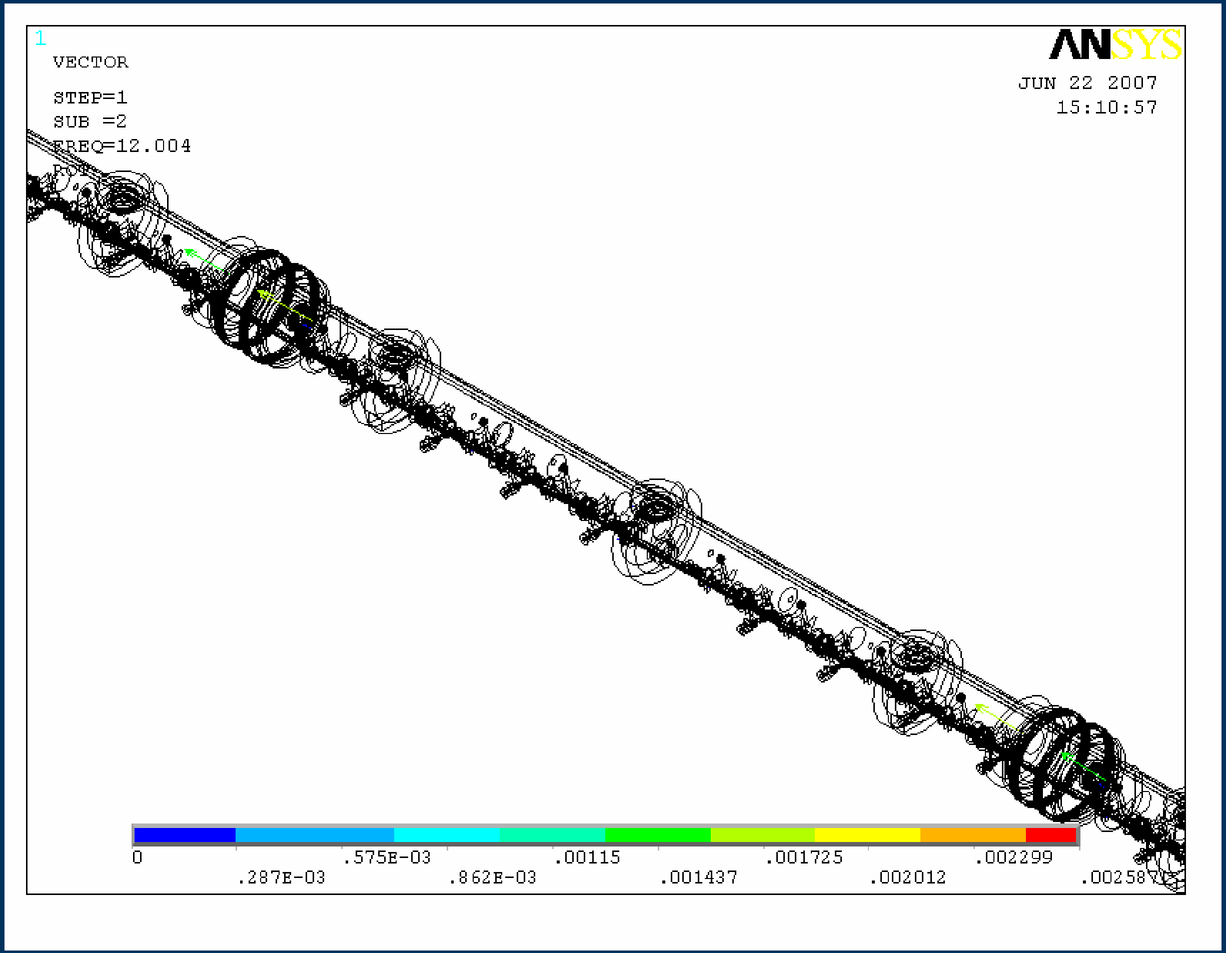


Consider the DESY vertical measurement, by applying sine wave input with displacement (amplitude) at specific frequencies.

Example: Transfer function between ground and vessel top

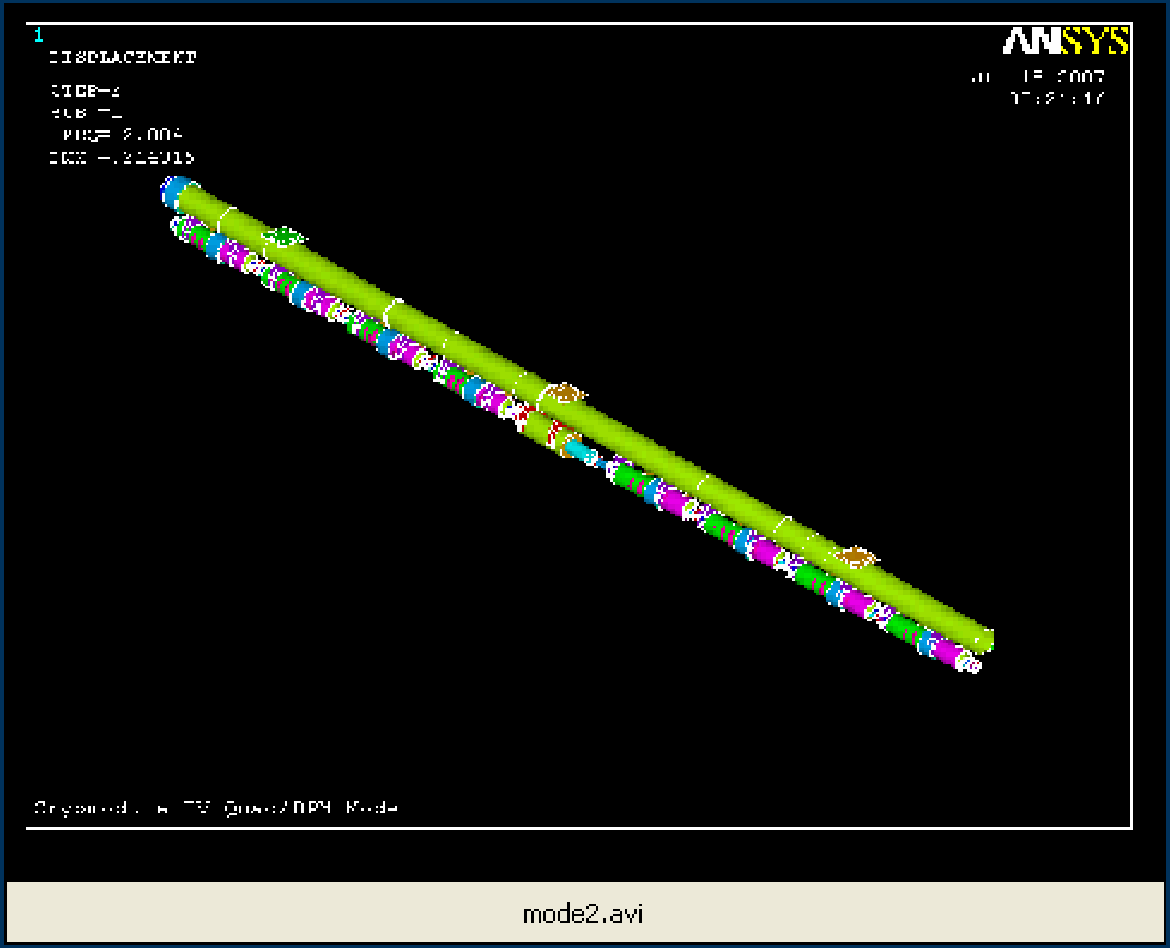
Courtesy of DESY

Modal Example (combination of superelements)



Vector plots (view of center cryomodule)

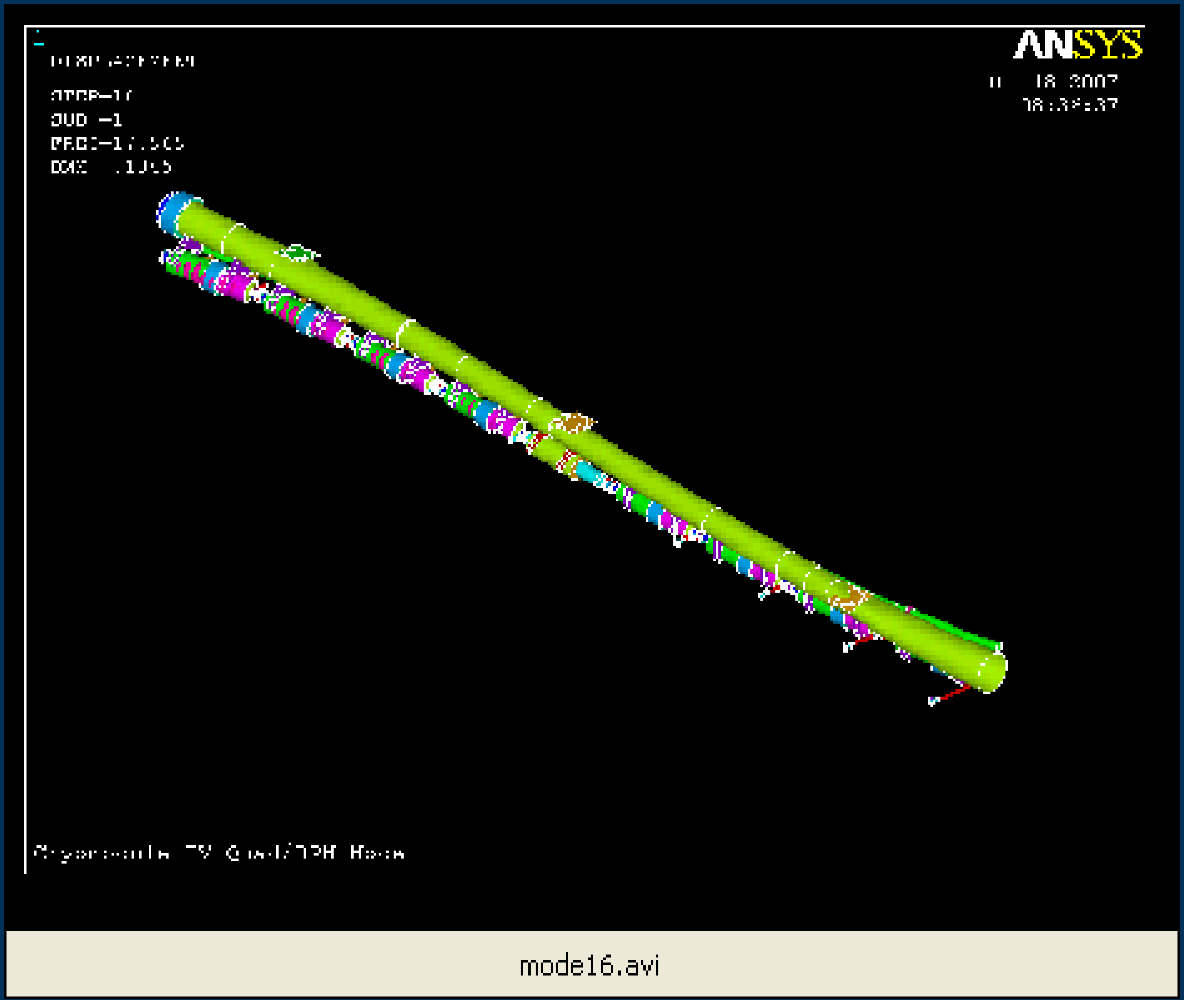
T4CM Mode 2 – 12 Hz (transverse pendulum)



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)

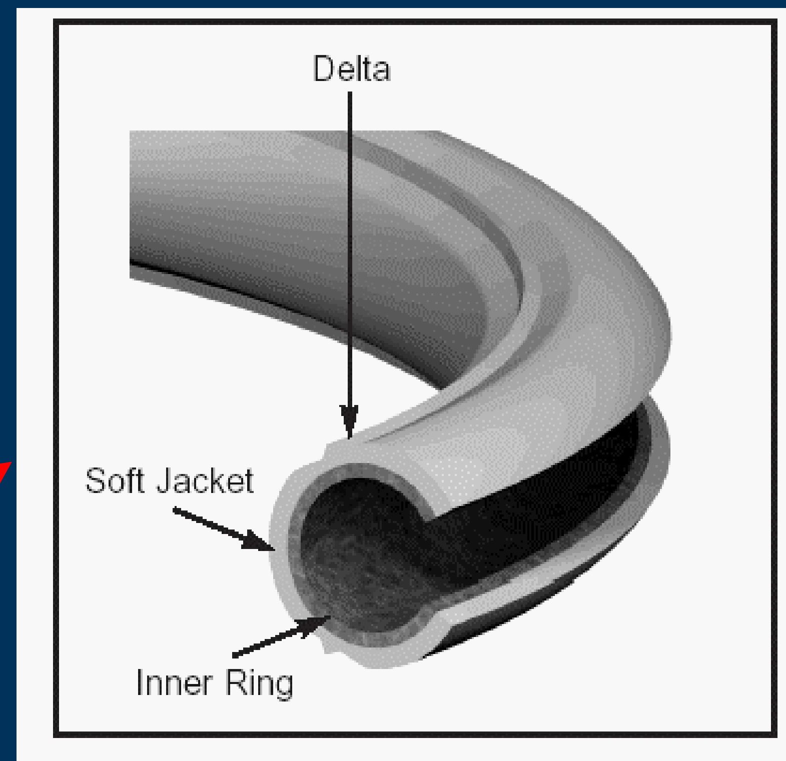
Cavity Interconnect Flange R&D

- 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**

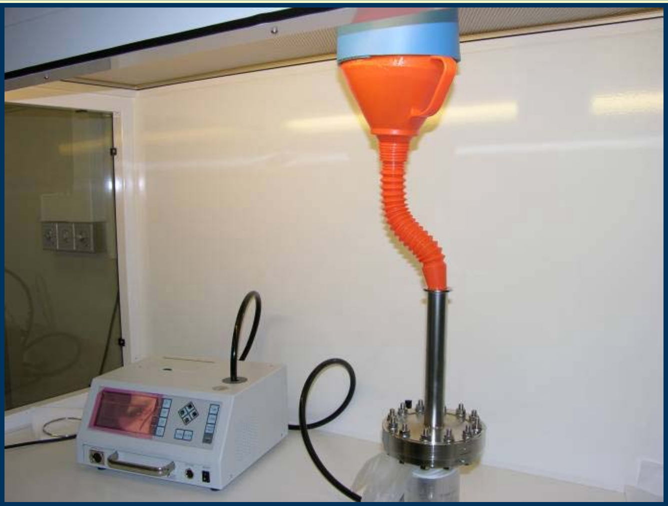
Garlock Ultra-flex gasket

- 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 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.

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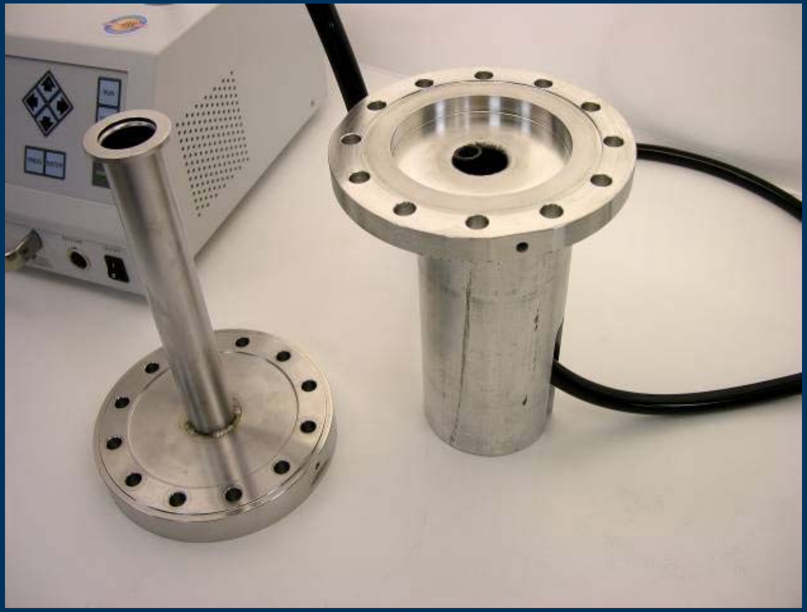
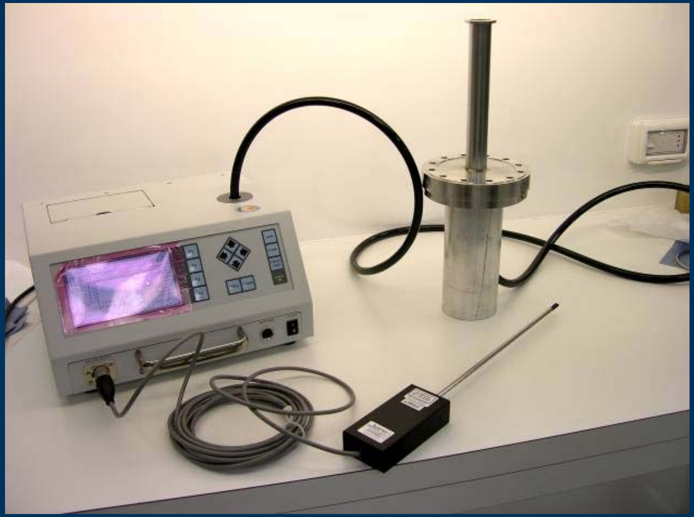
Pictures from second pollution contamination measurements in Pisa clean rooms





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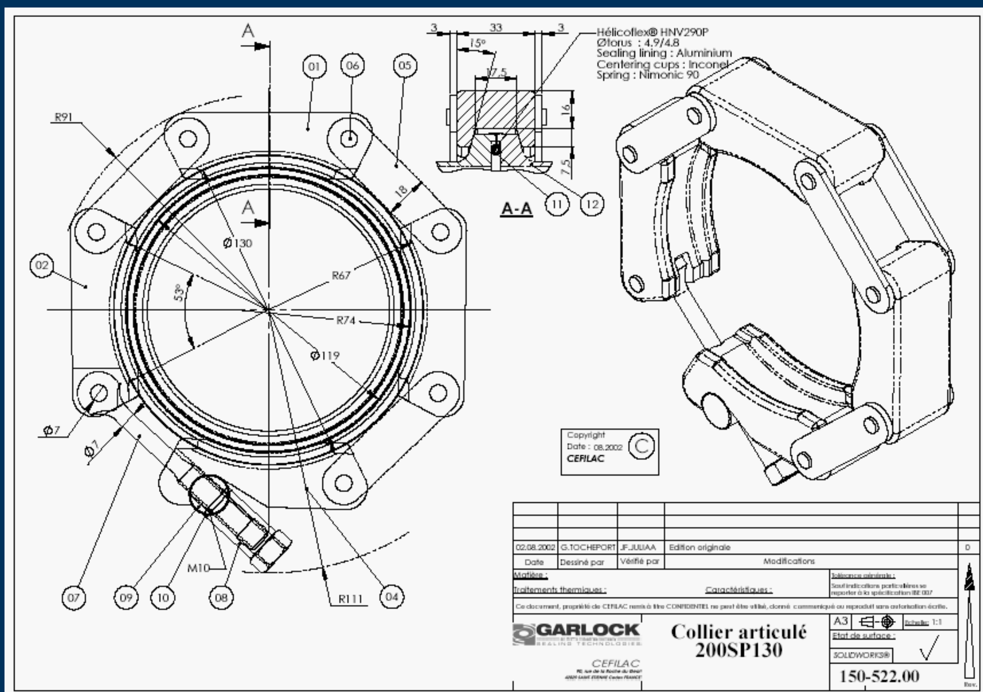
Preliminary conclusions:

- 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 LN_2 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

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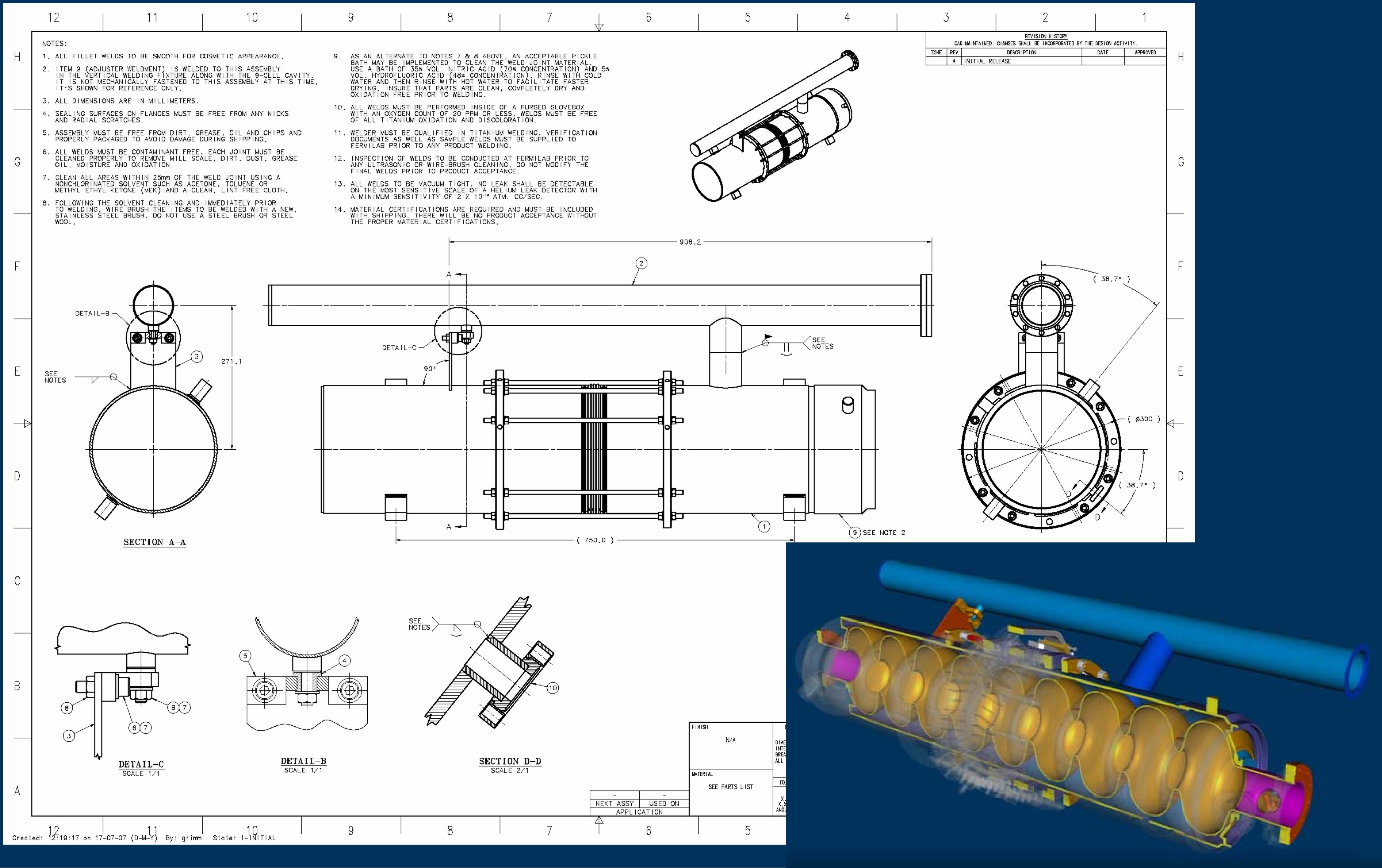
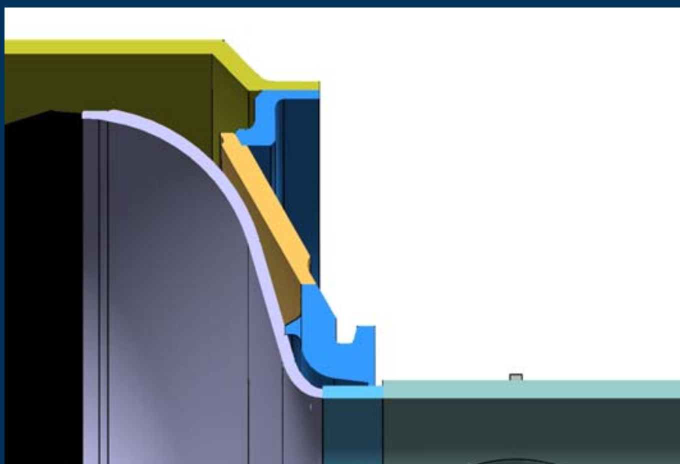
Helium Vessel Design

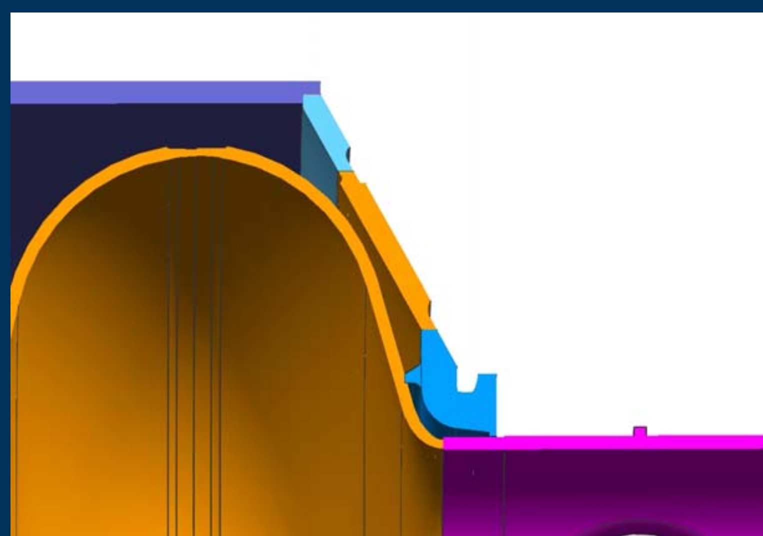


Helium Vessel History - Versions

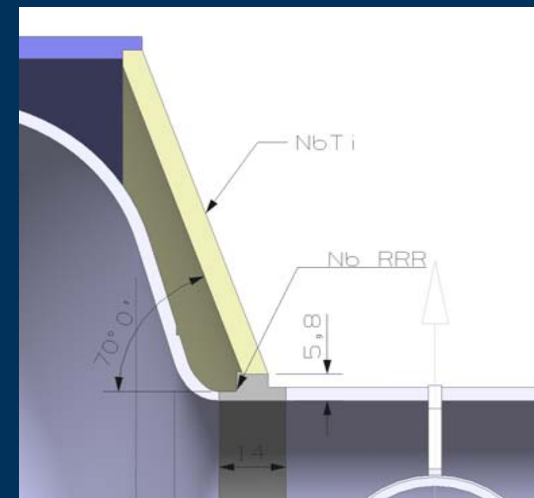
ILC 1.0 (traditional)



ILC 1.3 (T4CM)

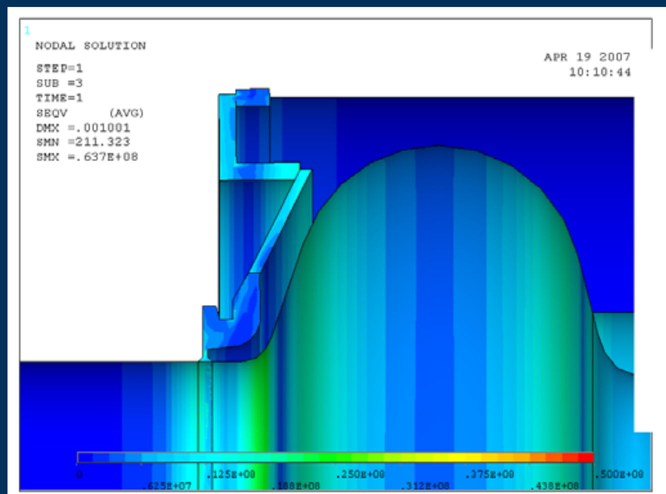


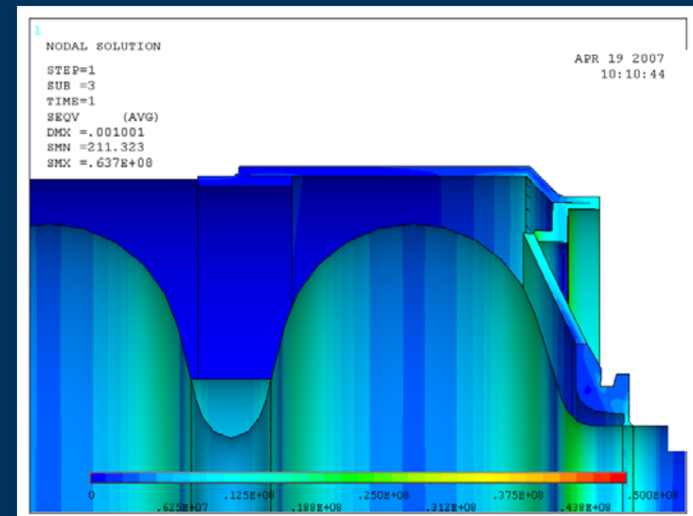
ILC 2.0 (future)



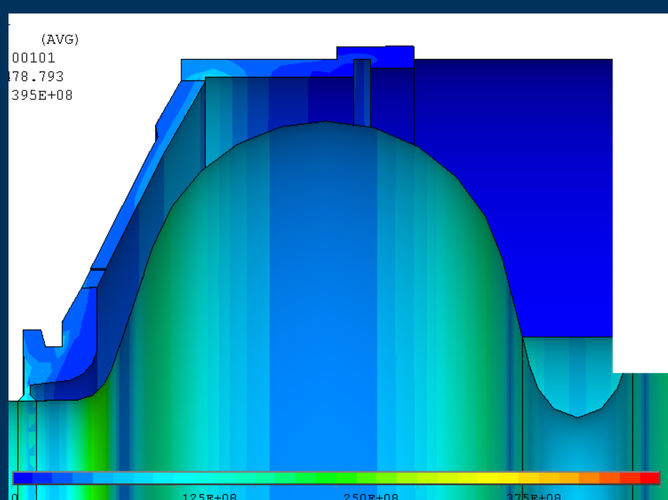
Stress During Tuning

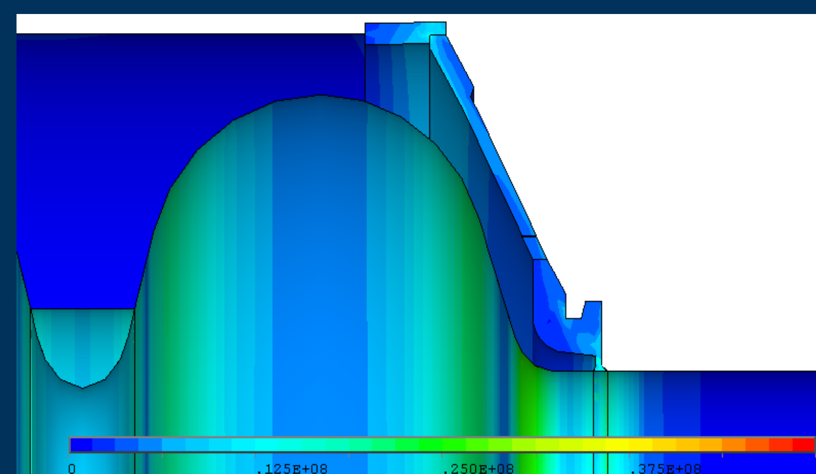
ILC 1.0





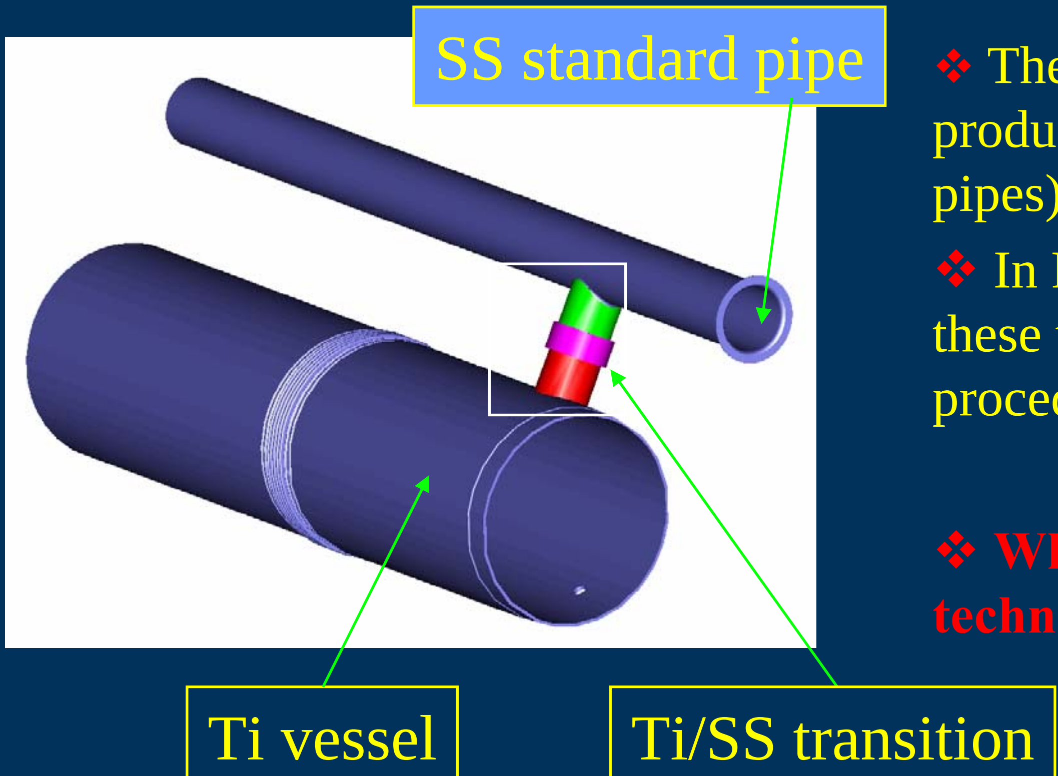
ILC 1.3





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.



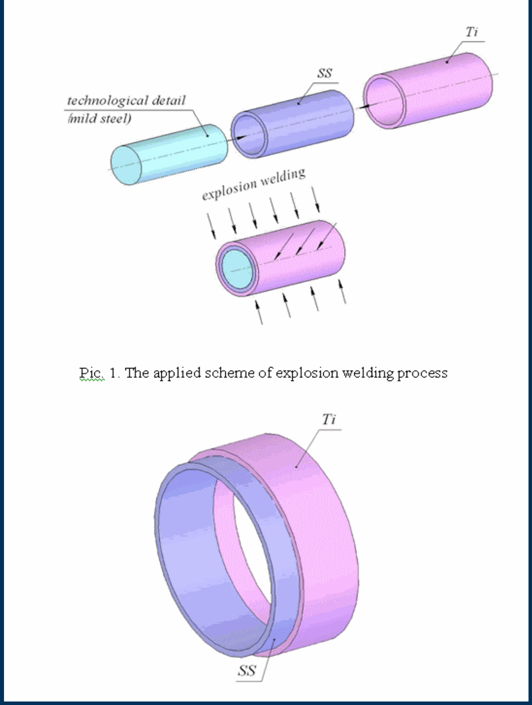
❖ The Russian colleagues are ready to produce samples with this dimensions (2” pipes).

❖ 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



Pic. 1. The applied scheme of explosion welding process

- 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.

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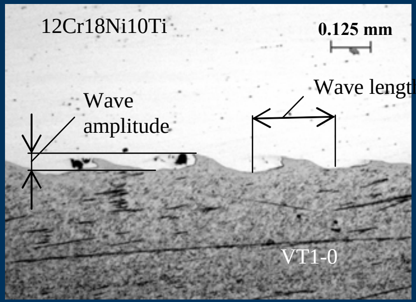
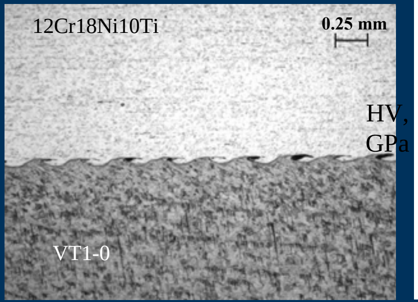
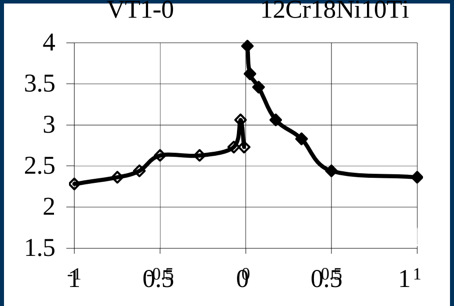
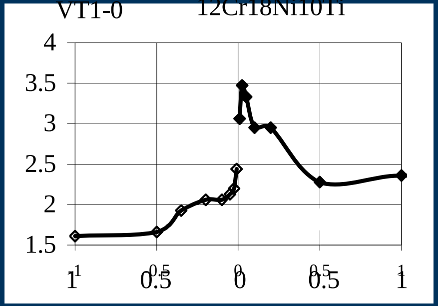
Pictures of first explosion welding sample









Figures taken from Russian company report

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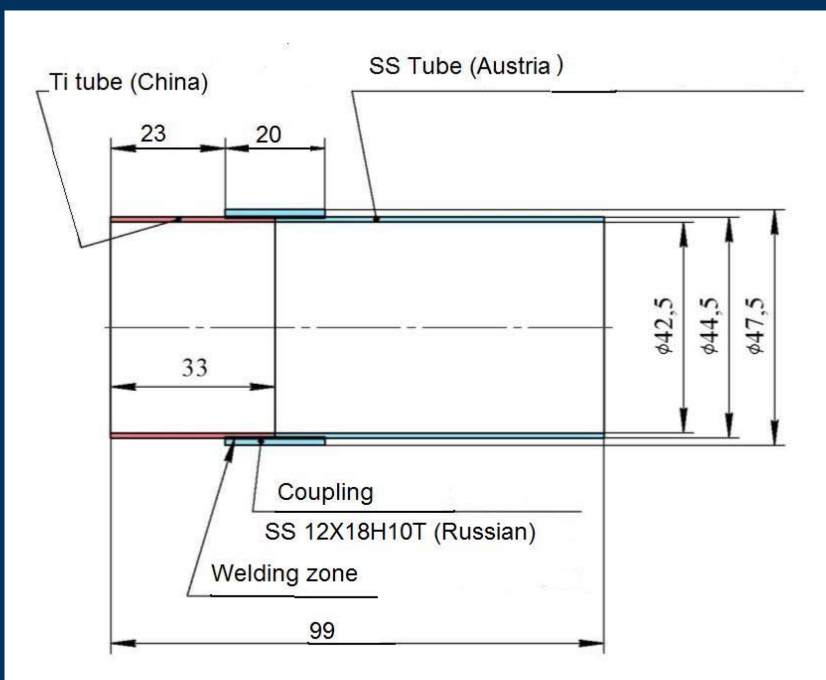
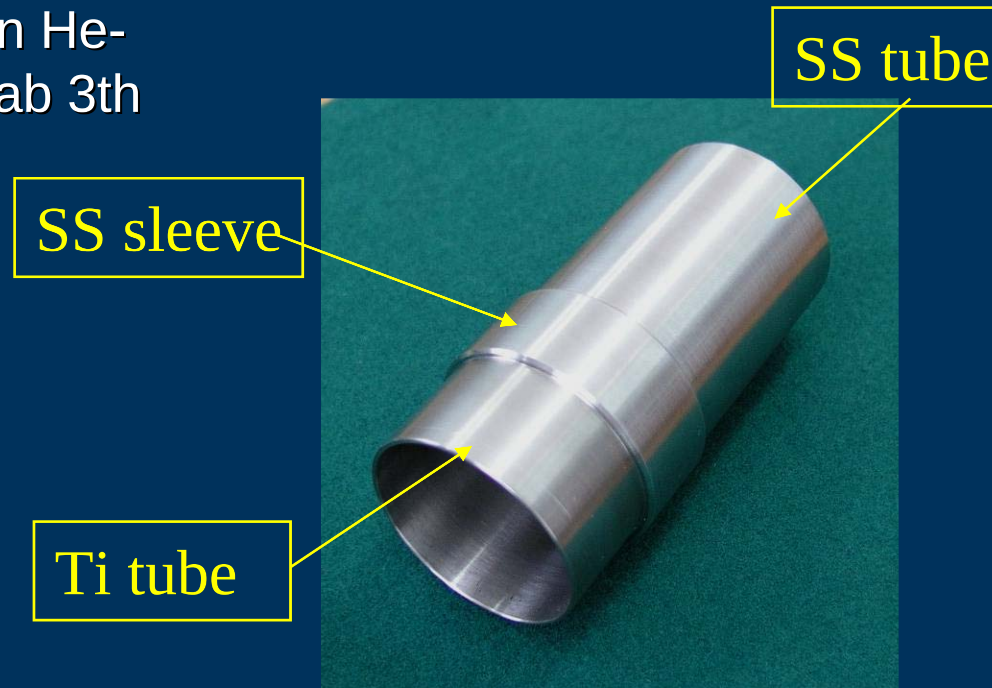
Second explosion welding sample from Dubna

- 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





- 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.

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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.

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Sample after welding

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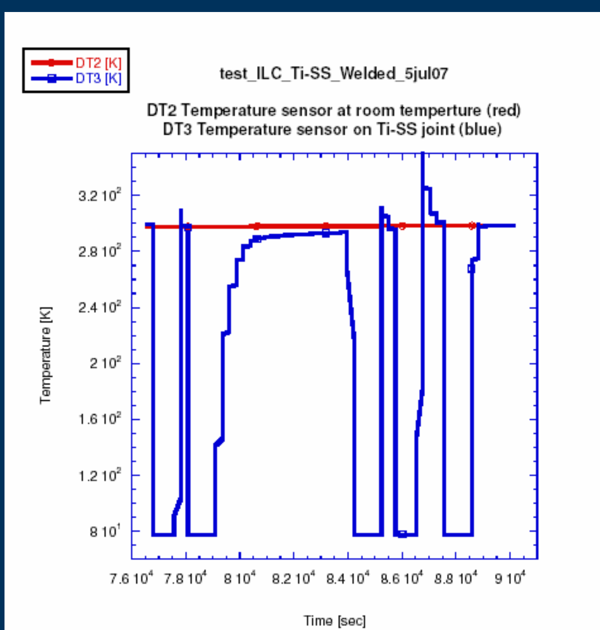
He leak-test after the welding

- 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).

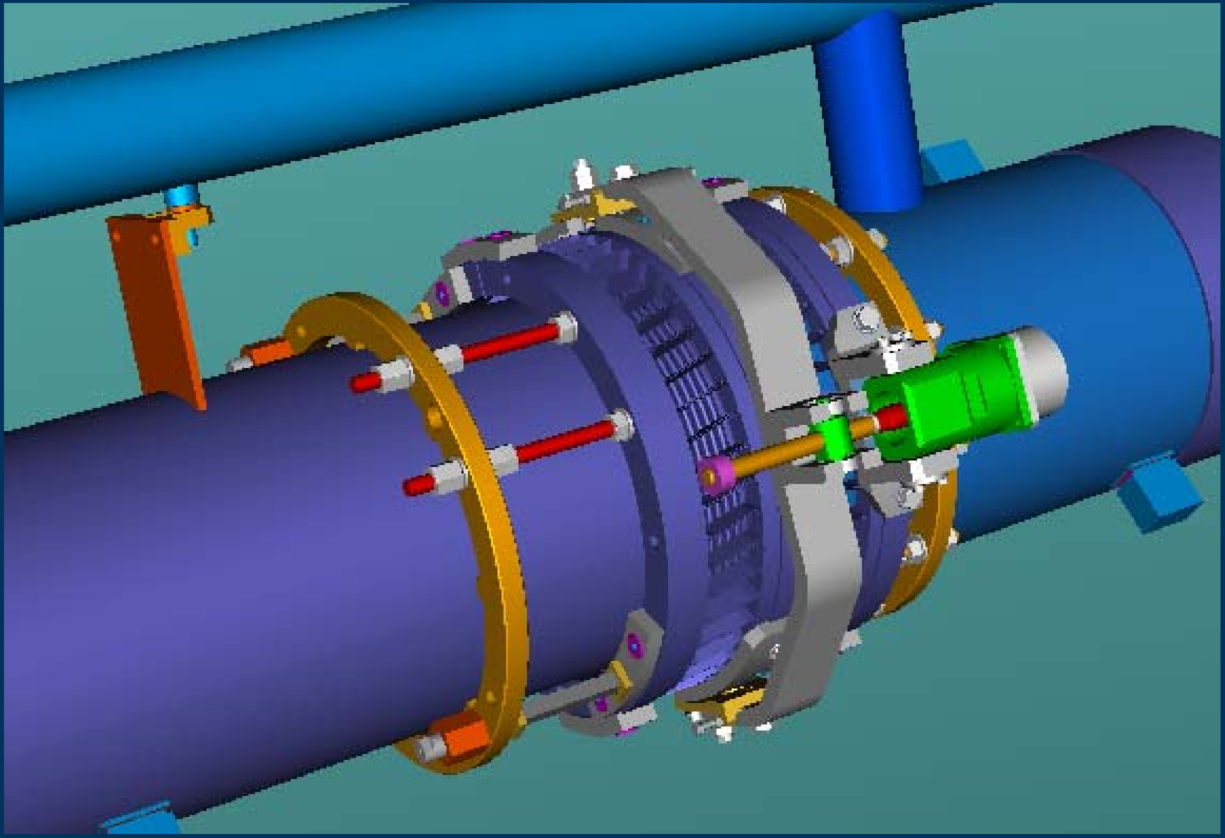


- At the end after the thermal cycles we found only a small leak in the weld between the SS tube and its cover (5 x 10^{-9} mbar *l /s).

Bladetuner Design Status

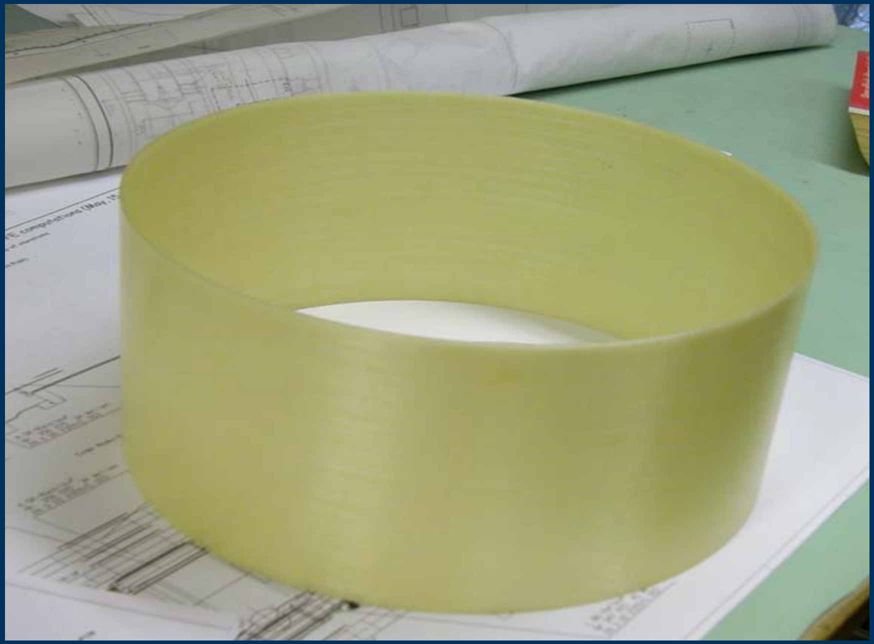
INFN Milan is developing new bladetuners with the following features:

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



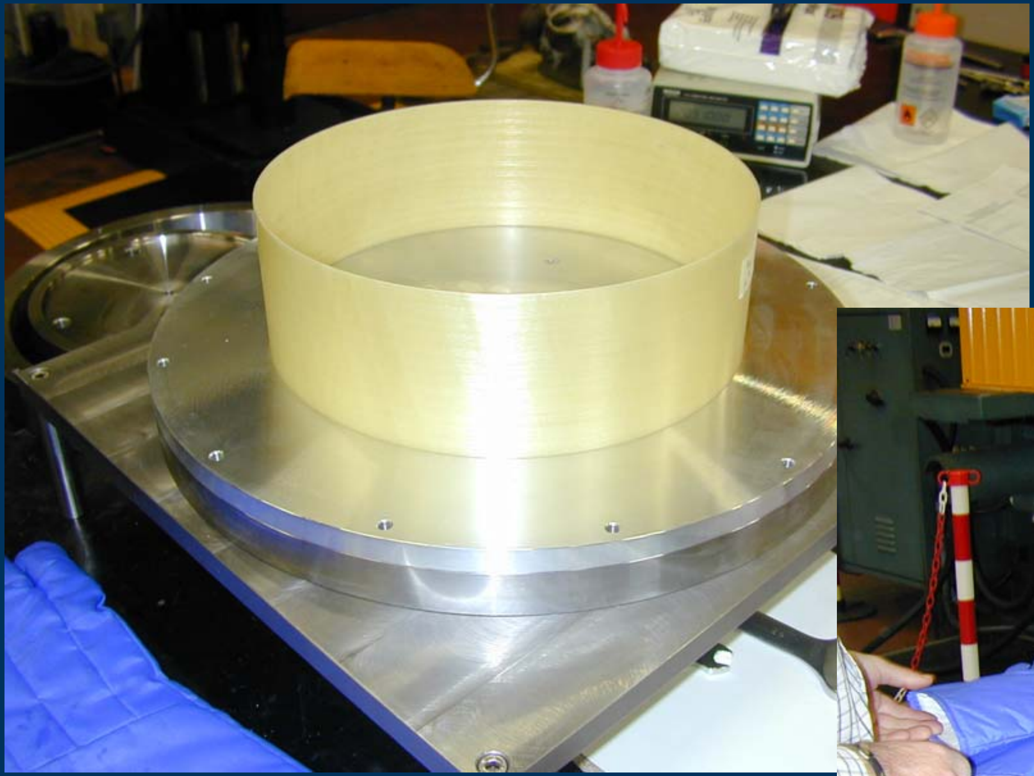
Current design shown

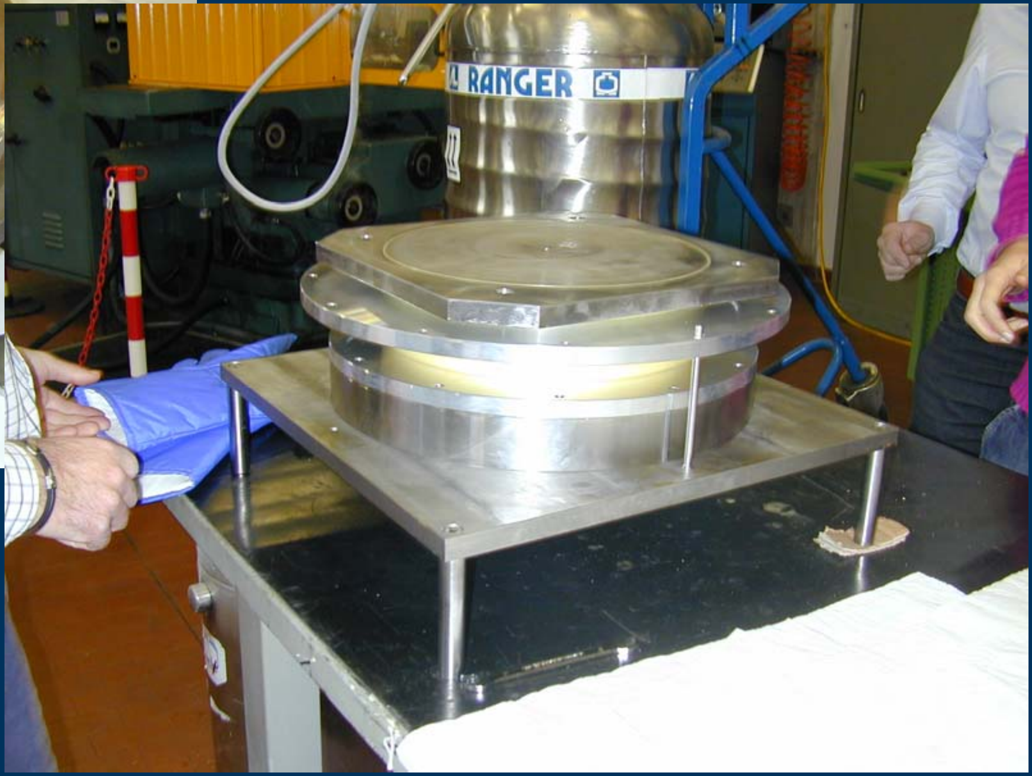
Post parts



Cooling and heating

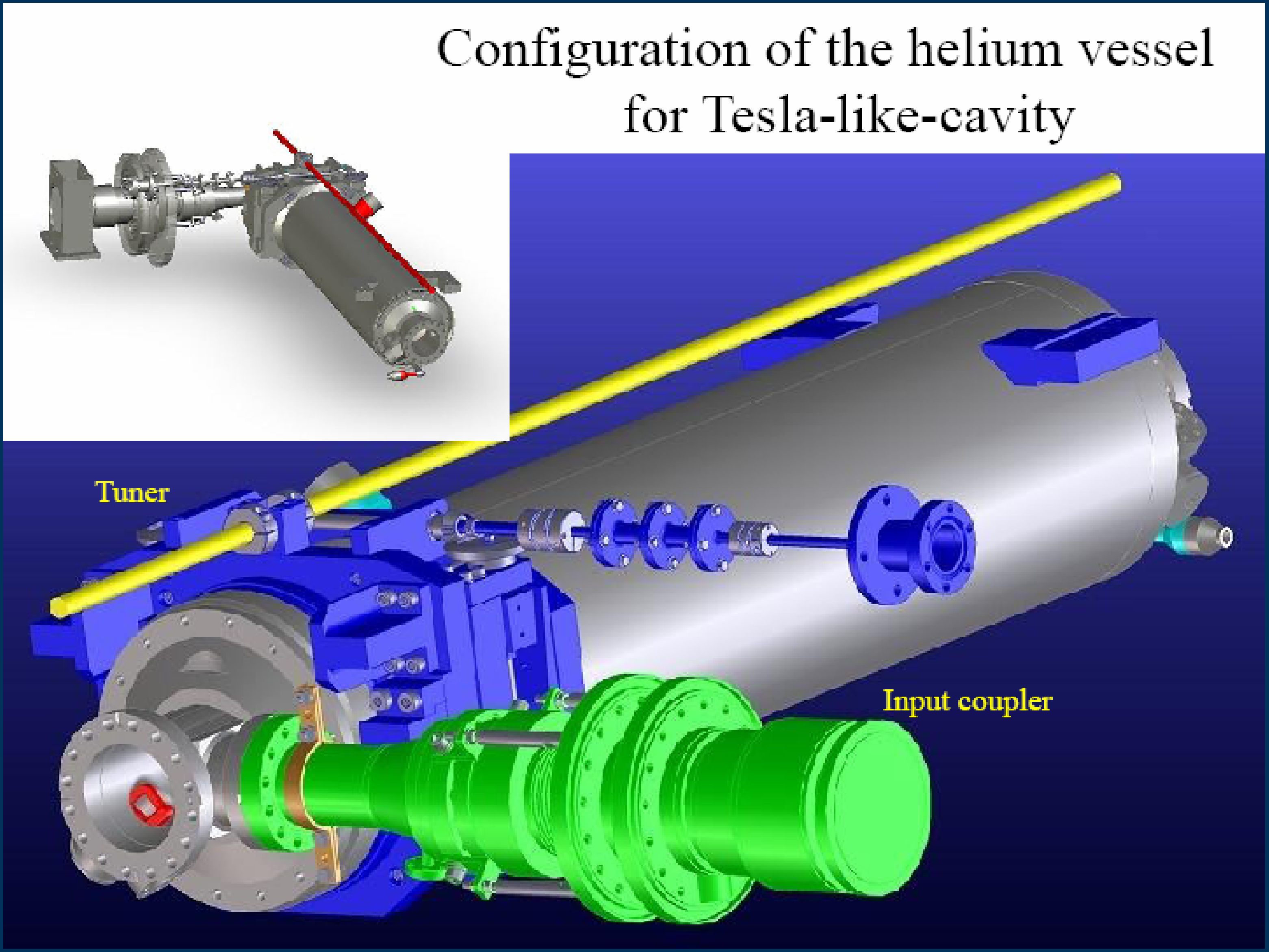
Assembly





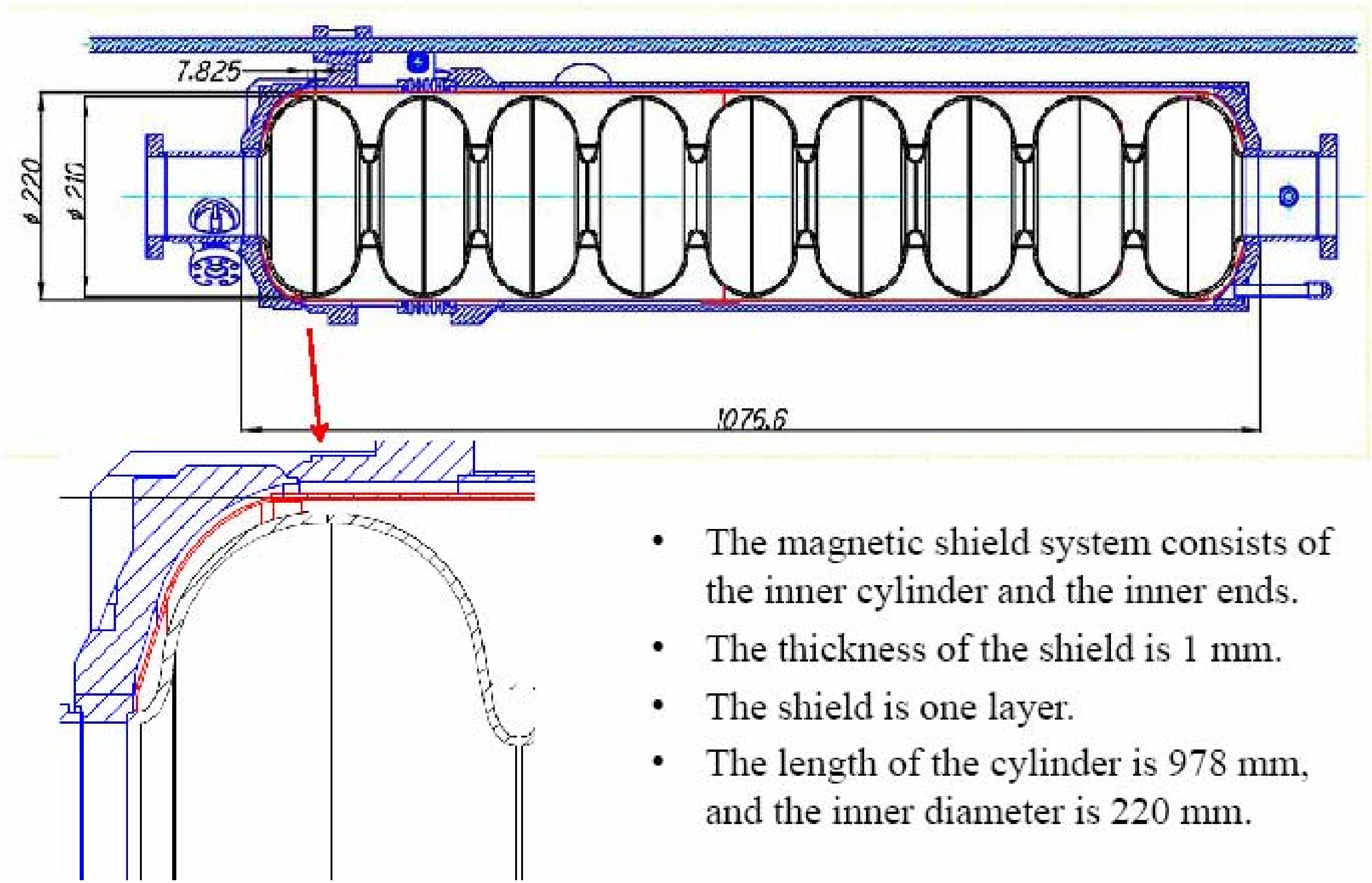
Traction test

Internal Magnetic Shielding, KEK



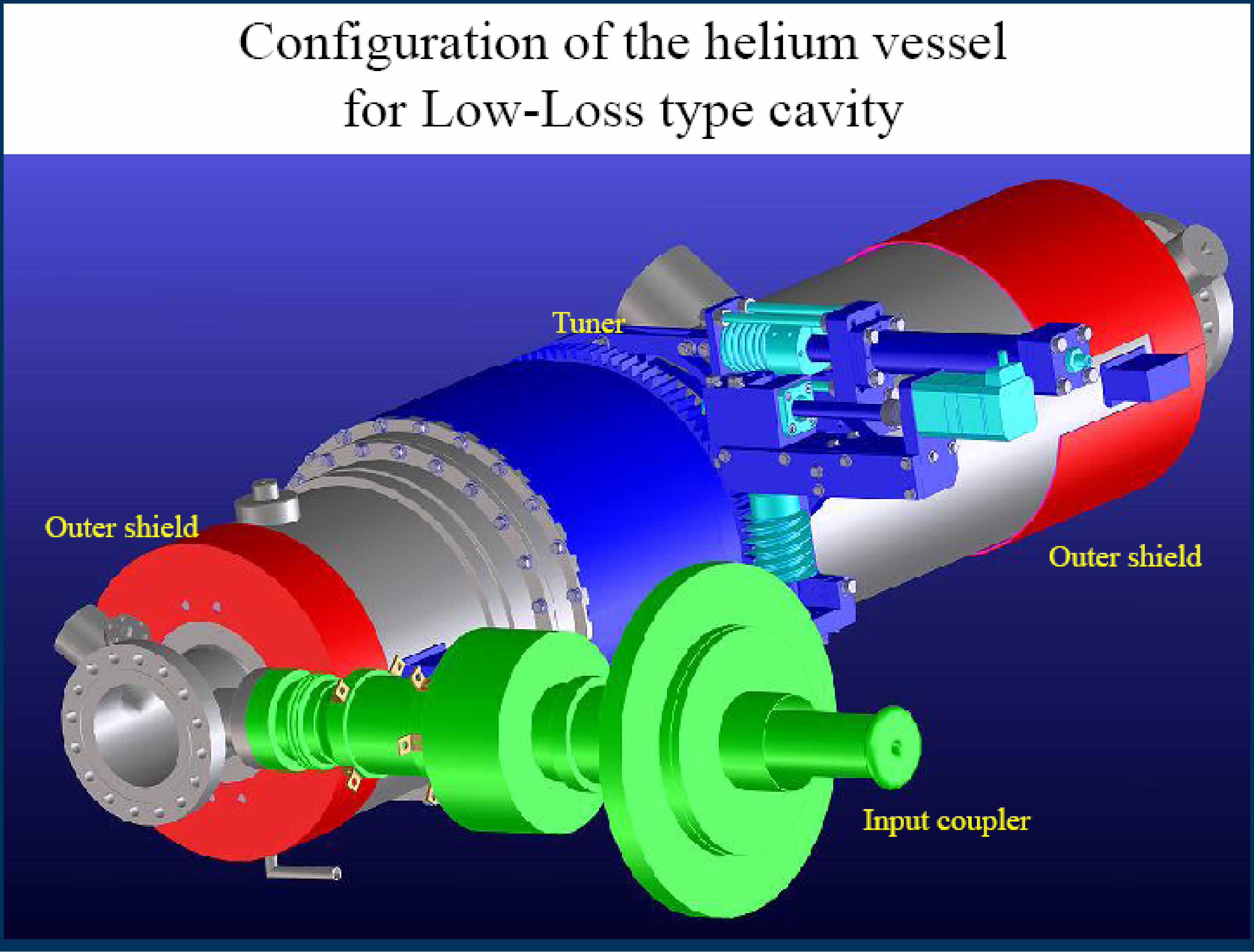
Internal Magnetic Shielding, KEK

Magnetic shield for Tesla-like-cavity



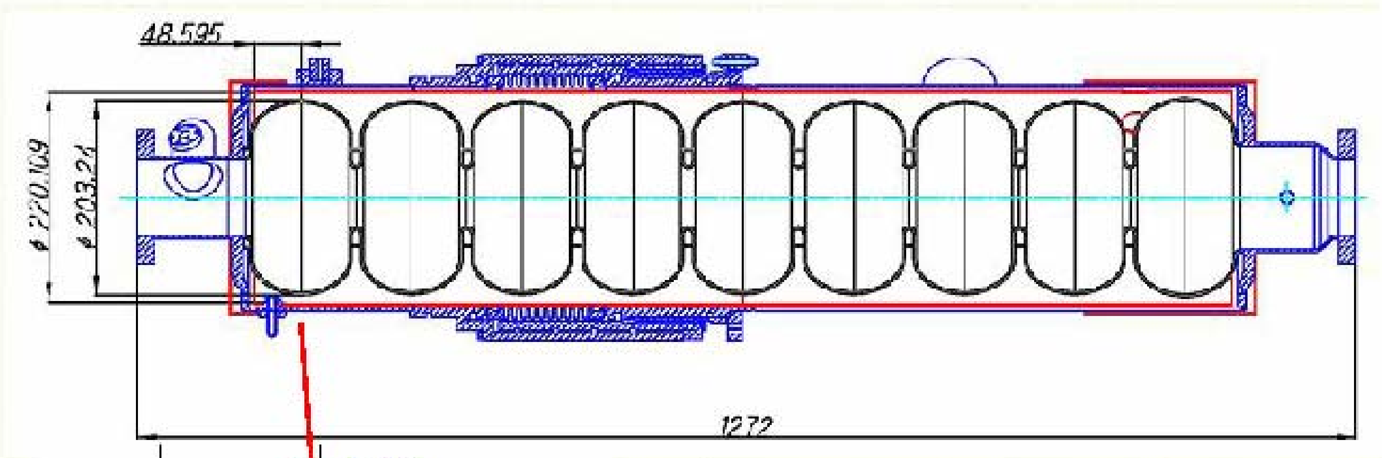
- The magnetic shield system consists of the inner cylinder and the inner ends.
- The thickness of the shield is 1 mm.
- The shield is one layer.
- The length of the cylinder is 978 mm, and the inner diameter is 220 mm.

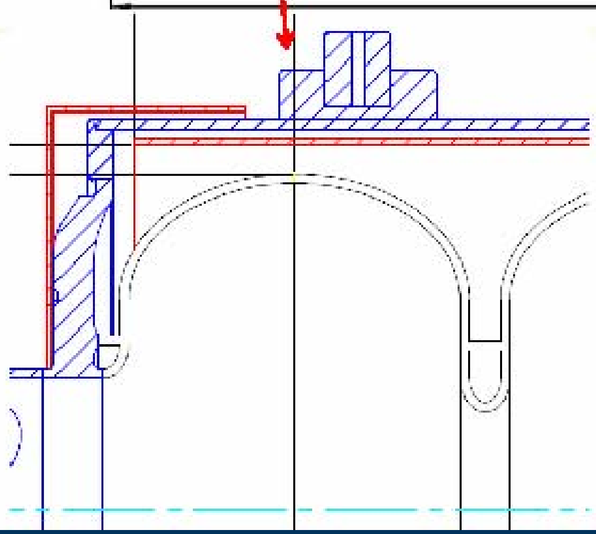
Internal Magnetic Shielding, KEK



Internal Magnetic Shielding, KEK

Magnetic shield for Tesla-like-cavity





- The magnetic shield system consists of the inner cylinder and the outer ends.
- The thickness of the shield is 1 mm.
- The shield is two layers.
- The length of the cylinder is 1020 mm, and the inner diameter is 220 mm.

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.