

TO: M. Cole
FROM: P. L. Goranson

SUBJECT: NCSX Electrical Lead Closeout Summary

23June-08-PG

Scope

This effort covers all R&D, Title I, II, and III engineering design of the coil electrical leads inside the cryostat, connecting the coils to the power supply bus or cables outside the cryostat.

Work includes engineering design, procurement, and fabrication of leads, terminations, thermal transition boxes (TTB), and associated support hardware. Work in this WBS ends with delivery of components to machine assembly operations.

Status

At the time of closeout Conceptual Design of the Leads was in work with a PDR scheduled for 8/22/08.

Interfaces

- TF (WBS 131)
- PF (WBS 132)
- Modular (WBS 14)
- Cryostat (WBS 17)

Specifications

No work had begun on a system requirements document or CSPEC for the leads.

A formal FMECA was not anticipated.

Schematics

None

Models Completed

Pro E models of the following were made and are posted on the web:

- MC coil stub leads.
- Concepts for lead routing between the PF, TF, and MC coils and the Cryostat.
- Conceptual design and location for thermal transition boxes.
- Lead structural attachments

The overall configuration was shown in a presentation before the Lehman Review on 4/0/08 and is captured in that document (attached).

Drawings

None, but models are sufficient for a PDR. Some preliminary drawings would be ready at the time of the review.

Analyses

None completed by ornl Engineering. Lead attachment field error calculations were performed by A Brooks at pppl.

Testing

None

Costs

Cost estimates were updated on the latest WAF and were included in the 08 Lehmann review presentation (attached).

Remaining Work

- R&D to build and test lead spiders and mount brackets.
- The routing path for the leads.
- Location of TTB boxes.
- Analyses to confirm lead sizes.

The R&D was not required for the PDR.

Preliminary work (models) of two configurations of routing of leads and locating of TTB boxes were complete. Work would progress quickly (~2 weeks) once a choice was made.

Hand calculations of lead sizes were made, simply not formalized yet.

Conclusion

The work was in a preliminary phase, but was on schedule to meet the PDR schedule.

NCSX Coil Services

P.L. Goranson

Work Package 162

(Excerpts from the April 2008 Lehman Review)

Coil Services System Description



The coil services consist of the **cryogenic feeds** and **electrical leads** inside the cryostat, serving all of the coils, including conventional. It includes the specification of requirements for the coil protection system.

Lower-level elements include:

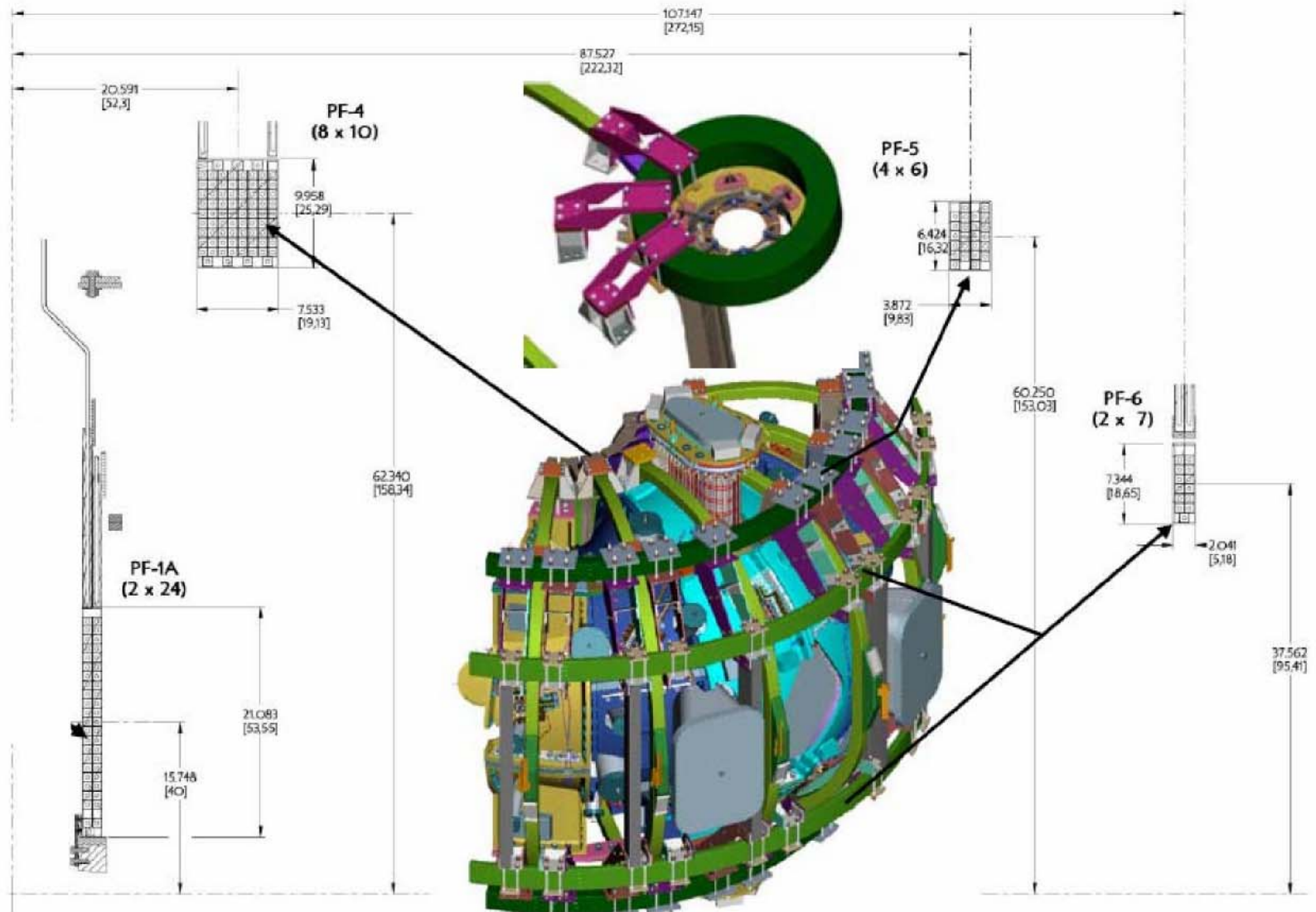
LN2 Distribution System (WBS 161);

Coil Electrical Leads (WBS 162); and

Coil Protection Requirements (WBS 163)



NCSX Coils



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WBS 162 Coil Electrical Leads



Description

This element covers the electrical leads within the cryostat, serving all the coils: the TF, PF, External Trim (WBS 133), and Modular Coils.

Scope

Work includes engineering design, procurement, and fabrication of cables, mounting brackets, thermal transition boxes, and associated supports. Work in this WBS ends with delivery of components to machine assembly operations.

Interfaces

The WBS161 interface begins at coil terminations and ends at the cryostat thermal transition/terminal box. It does not include I&C, bus work, or routing in the test area.

Requires penetration of cryostat.

Share real estate used by core structural support, floor mounted utilities, bus supplies, diagnostics, etc.



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Lead Requirements



- **Connect between bus supply in test cell and coil terminals inside cryostat.**
- **Operate nominally at 77-80 K but no active cooling is required, Cryo environment is sufficient to return temperature to operating level between shots.**
- **Provide Cryostat seal interface.**
 - **Minimize icing**
 - **Maintain positive pressure in Cryostat**
- **React internal magnetic loads.**
- **Cancel (minimize) field errors.**



Status



- MC design is most mature.
- To date, most of design effort has concentrated in this area as it is the more challenging.
- Conventional coils will be handled in a similar manner and use similar components. (cable, brackets, terminations, spacers, etc.)



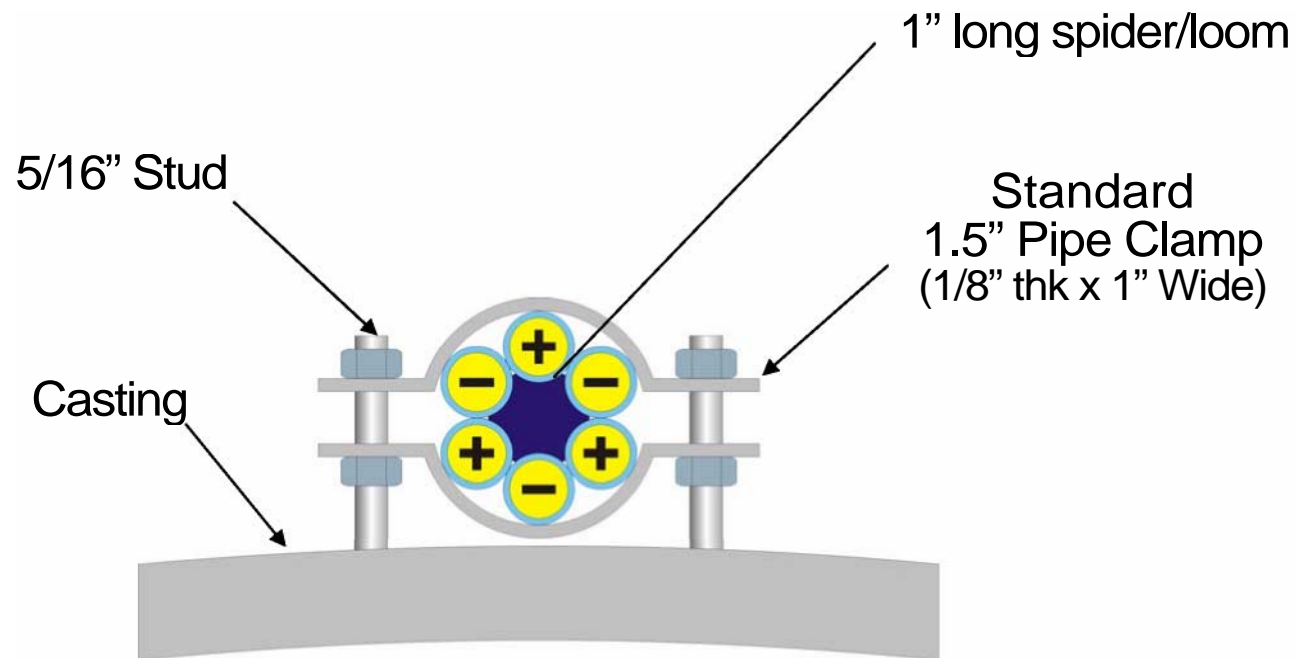
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MC Lead Configuration



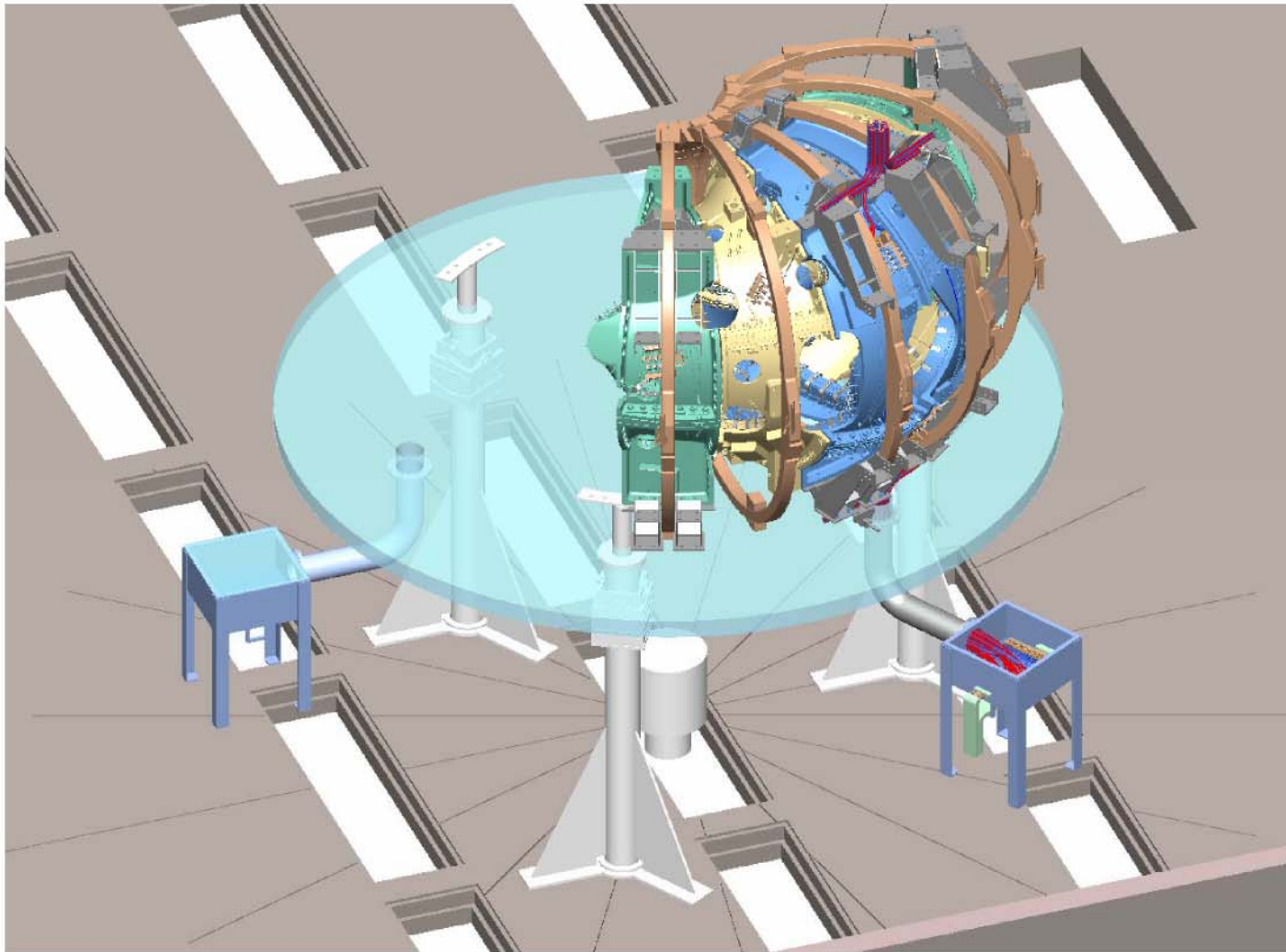
Cable is 250 MCM



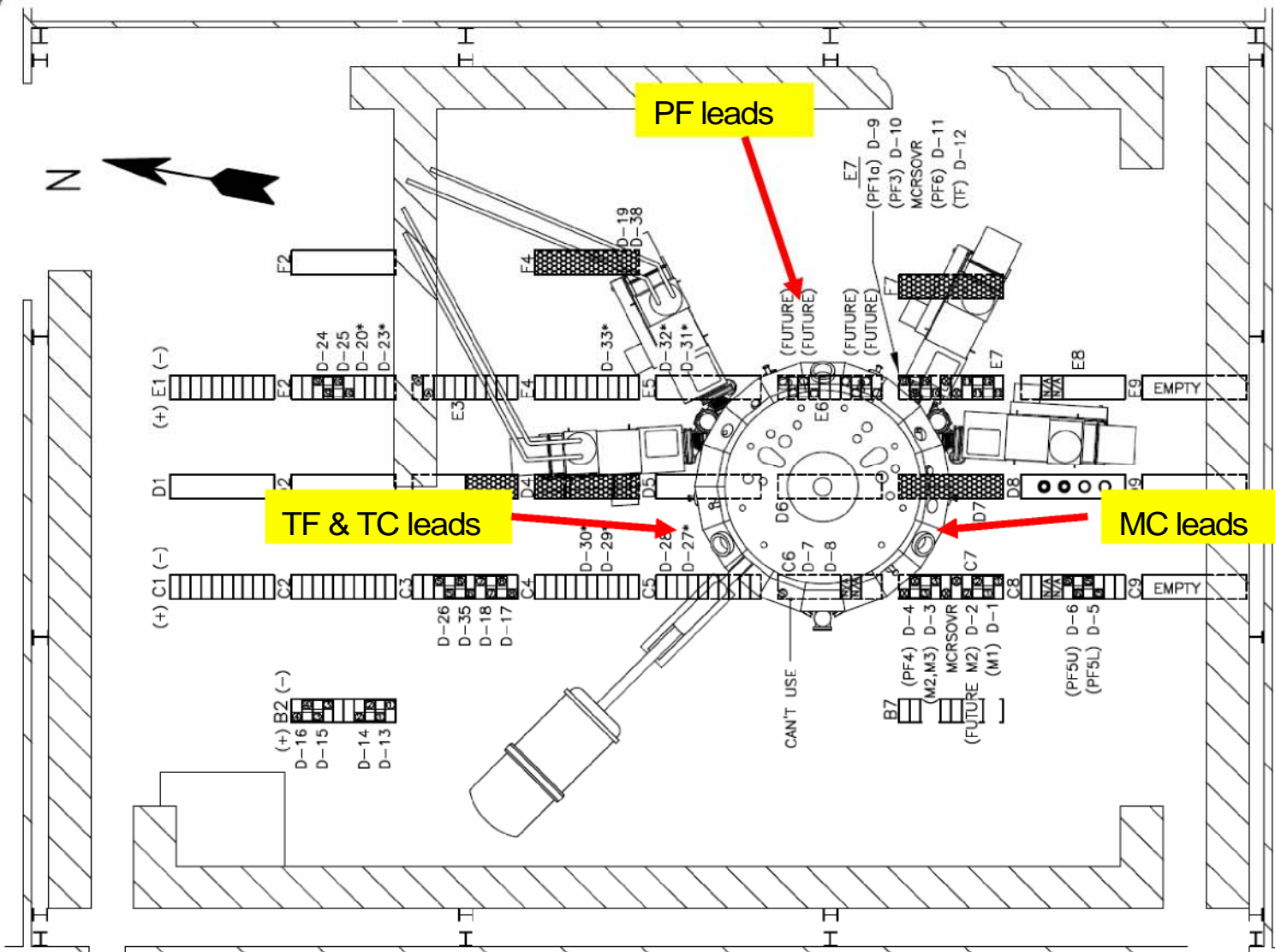
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System Layout



Service routing to test cell penetrations



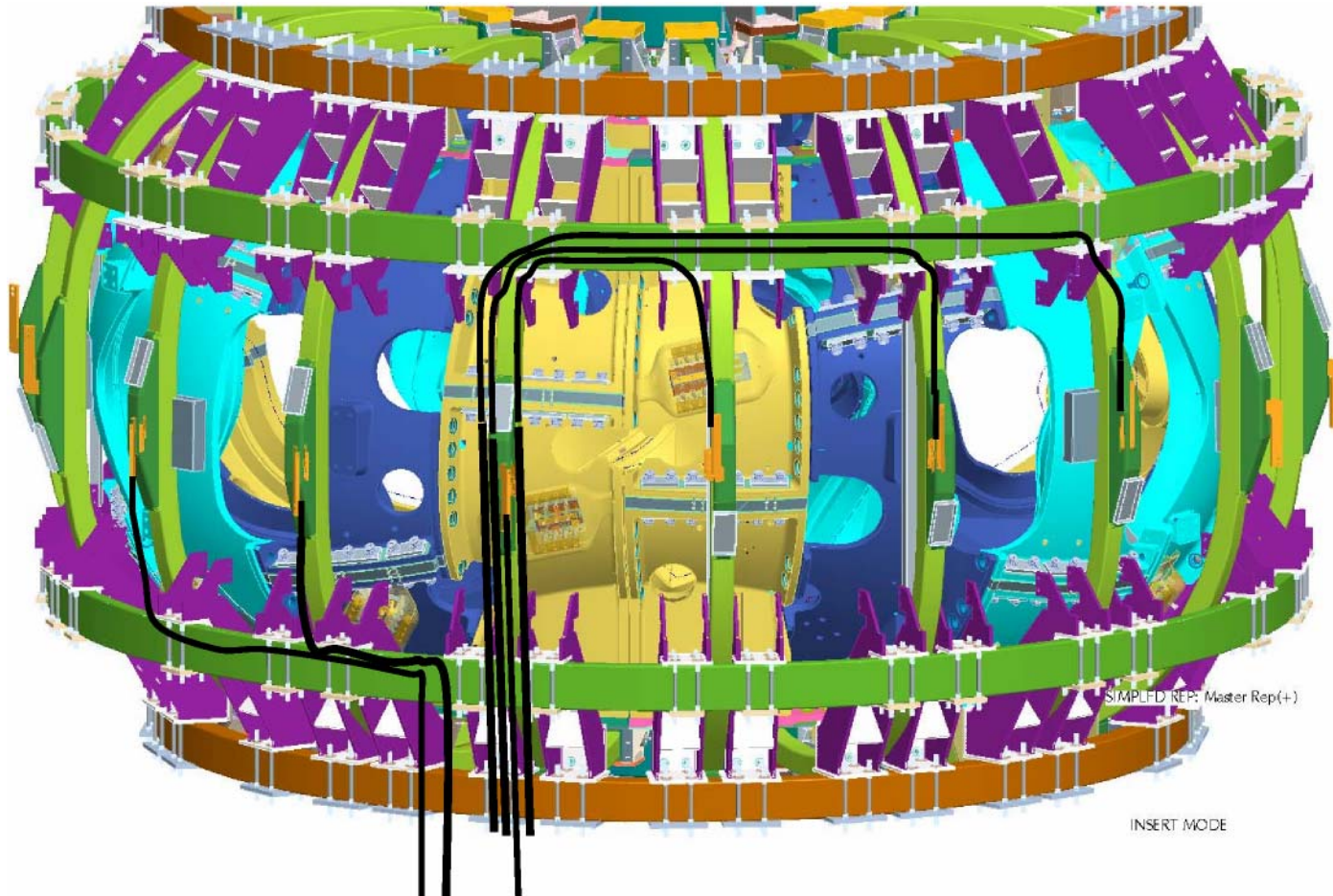
MC Lead Stub Connections



Lead Routing



Services will be routed to each of the three C-C interfaces.



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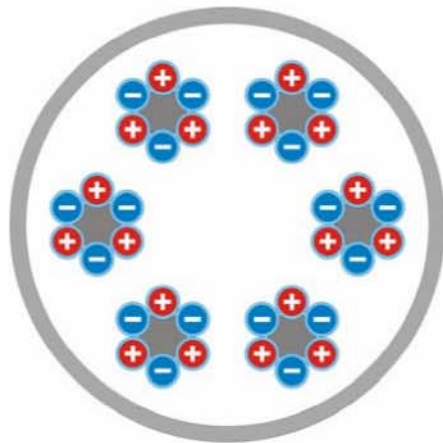


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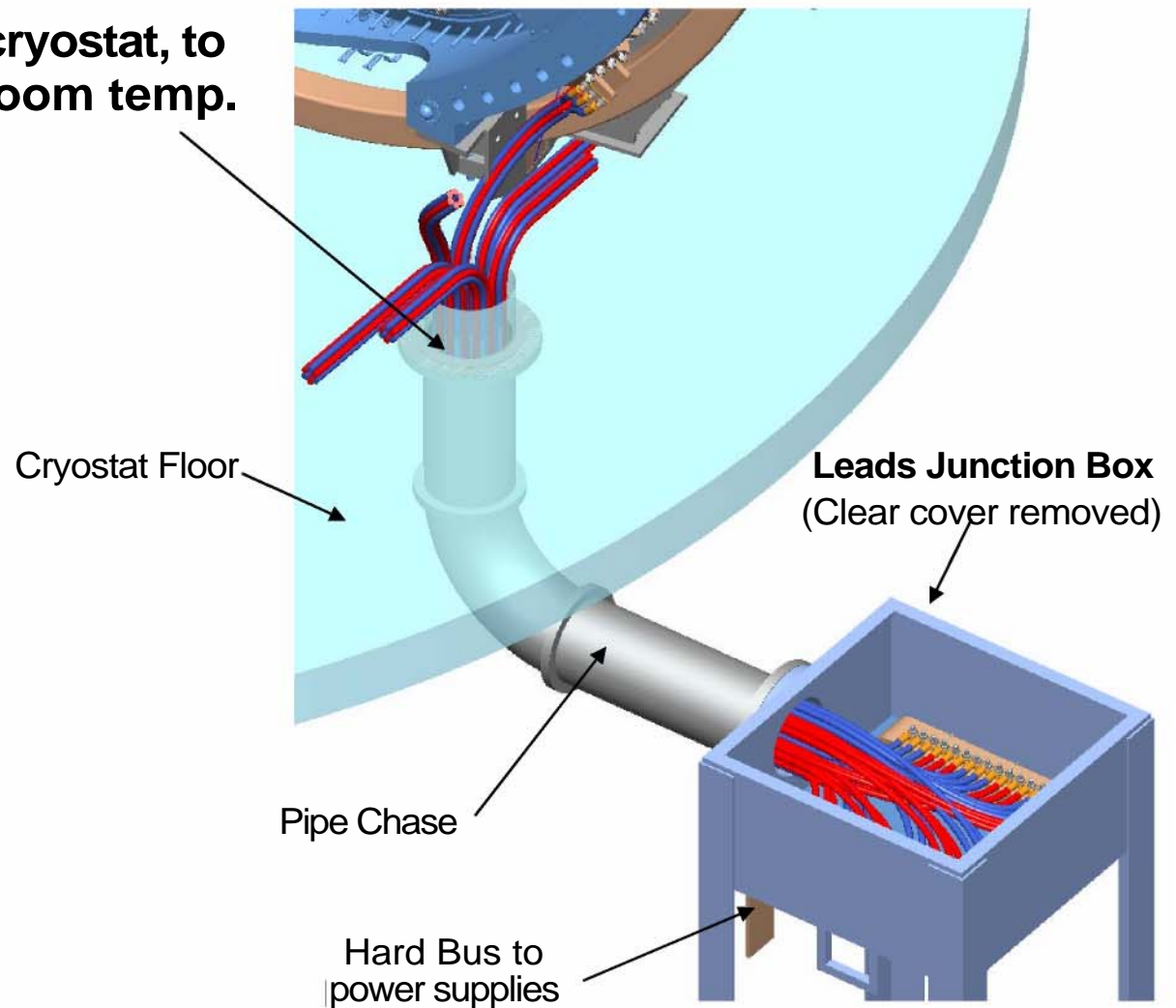
Modular coil Interface at Cryostat



Leads transition thru the cryostat, to room temp.



Top View of an 8" diameter pipe chase showing the (6) modular coil leads cables from a field period



Cost Estimate Basis



- **Cables are catalog items**
 - Lengths are based on sketches in work sheet.
- **Material cost of supports, spacers, and terminations is estimated on either:**
 - \$ per lb at current market or:
 - \$/length of cable.
- **Engineering time is based on number and type of drawings for each element, specifications, and the analyses anticipated.**



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Labor



Description:

This effort covers all R&D, Title I, II, and III engineering design of the coil electrical leads inside the cryostat connecting the coils to the power supply bus or cables outside the cryostat.

Task ID	Multiplier	Unit	Number of Units	Hours	ORNL EM
Title I and II Design					
Pro-E models (avg)	8	hrs/model	50	400	400
assy dwgs	16	hrs/dwg	15	240	240
Detail drawings	8	hrs/dwg	40	320	320
installation dwg	16	hrs/dwg	29	464	464
cooling schematic	0	hrs/dwg	1	0	0
electrical schematic	8	hrs/dwg	14	112	112
I&C schematic	8	hrs/dwg	0	0	0
stress analysis	0	hrs/calc	0	0	0
thermal analysis	24	hrs/calc	1	24	24
special analysis (electromagnetics)	40	hrs/calc	1	40	40
Procurement Specifications	40	hrs/spec	1	40	40
preliminary and final design reviews	40	hrs/rev	1	40	40
Resolve PDR comments	40	hrs/pdr	1	40	40
meetings/reporting/presentations	10%	% of tot hrs		172	172
Subtotal Title I & II Design					1892
R&D Activities					
R&D design time to build mounts (clamp, spider), lead terminations				40	40
Title III					
vendor inspection & oversight	8	hrs per	1	8	8
Disposition of deviation requests and non-conformances	0.5	hrs/wk	20	10	10
In-House fab/assy oversight & inspection	2	hrs/wk	4	8	8
As-built drawings	1	hrs/dwg	84	84	84
Subtotal Title III Design					110

Total

2042

HOURS



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Description:

This effort covers all coil leads that connect the coil terminals to the buswork at the boundary of the cryostat.

Assumptions:

outside engr rate =	120 \$ per hour
outside fab rate =	60 \$ per hour
outside inspection/technician rate =	80 \$ per hour

Purchased parts:

set of cables	\$32,552
misc attachment hardware	\$16,162 @10\$/ft
thermal transition box material	\$0
<i>subtotal, purchased parts</i>	\$48,715

Lead bundles consist of six, 250 MCM cable with teflon sleeve. Lead ends are cooled by bleed liquid nitrogen supplied by the coil coolant header (WBS 161)

Leads connect from coil terminals to buswork at bottom of machine.

Each coil is connected separately except PF1 and PF2, which are connected in series within the central solenoid assembly

Schedule & Staffing



Activity ID	MILE-STONE LEVEL	Activity Description	Duration (work days)	SHIFTS	Forecast Start	Forecast Finish	Total Float	Cost to Complete	FY08												FY09												FY10														
									Q1				Q2				Q3				Q4				Q1				Q2				Q3				Q4				Q1				Q2		
162 - Electrical Leads																																															
132-001		Title I design WBS 162 Coil leads	180*		03DEC07A	21AUG08	199	91,800.00	ORNL = 938hr ;																																						
132-002		Electrical Coil leads - PDR	1		22AUG08	22AUG08	199	1,208.00	ORNL = 08hr ;																																						
162-003		Resolve PDR comments	5		25AUG08	29AUG08	337	6,040.00	ORNL = 40hr ;																																						
132-011		Title II design WBS 162 Coil leads	139		02SEP08	26MAR09	337	119,231.03	ORNL = 938hr ;																																						
162-011A		R&D pressure drop simulation	15		02SEP08	22SEP08	461	13,640.00	ORNL = 40hr ; ornl41=7.6																																						
162-013		Release final drawings for MC lead stubs	26		25AUG08	30SEP08	207	0.00																																							
162-013.1		Procure MC lead stubs	65		01OCT08	12JAN09	207	18,806.40	41=14.4k																																						
132-012		Electrical Coil leads - FDR	1		27MAR09	27MAR09	337	1,263.60	ORNL = 08hr ;																																						
132-015		Title III design WBS 162 Coil leads	263		30MAR09	19APR10	337	17,778.35	ORNL = 110hr																																						
132-037		Prep Req,Bid,Award Lead hardware and cables	25		26AUG09	30SEP09	340	0.00																																							
132-038		Deliver Lead hardware and cables	130		01OCT09*	14APR10	340	475,798.19	41=355.87\$K ;																																						
132-047		Prep Req,Bid,Award Material for transition box	25		26AUG09	30SEP09	427	0.00																																							
132-048		Deliver Material for Transition Boxes	40		01OCT09*	25NOV09	427	1,550.92	41=1.157\$K ;																																						

Staff

Jobs	start	end	days	weeks	Paul G 40% hrs	Sorin H 100% hrs	Scott 100% hrs	total work hours available	Total WAF hours
leads(162)	14-Mar	1-Feb-09	324	46.3	692.6	1351.4	2044	2044	



Cost Estimate Risks



Coil Electrical Leads (WBS 162)

Maturity – medium

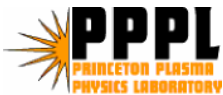
Routing and interfacing is in early stages of design.

Design of cables is not firmly established, satisfying field error requirements could require more costly solutions and longer lead time.

Complexity – low

Design is straight forward and large ticket procured items (cable and mounts) are commercially stocked.

No complications such as active cooling are required.



Risk Mitigation



Schedule Milestones

- The Designer was assigned to Leads full time and his LN2 System responsibilities reassigned.
 - Permitted acceleration of design schedule to assure critical components (coil stubs) will be procured for Station 5 assembly.
- Field error calculations are being performed up front to minimize the risk that designs will have to be redone.

Design Integrity

- The terminations and clamps will be prototyped at MDL to confirm their design is acceptable.

