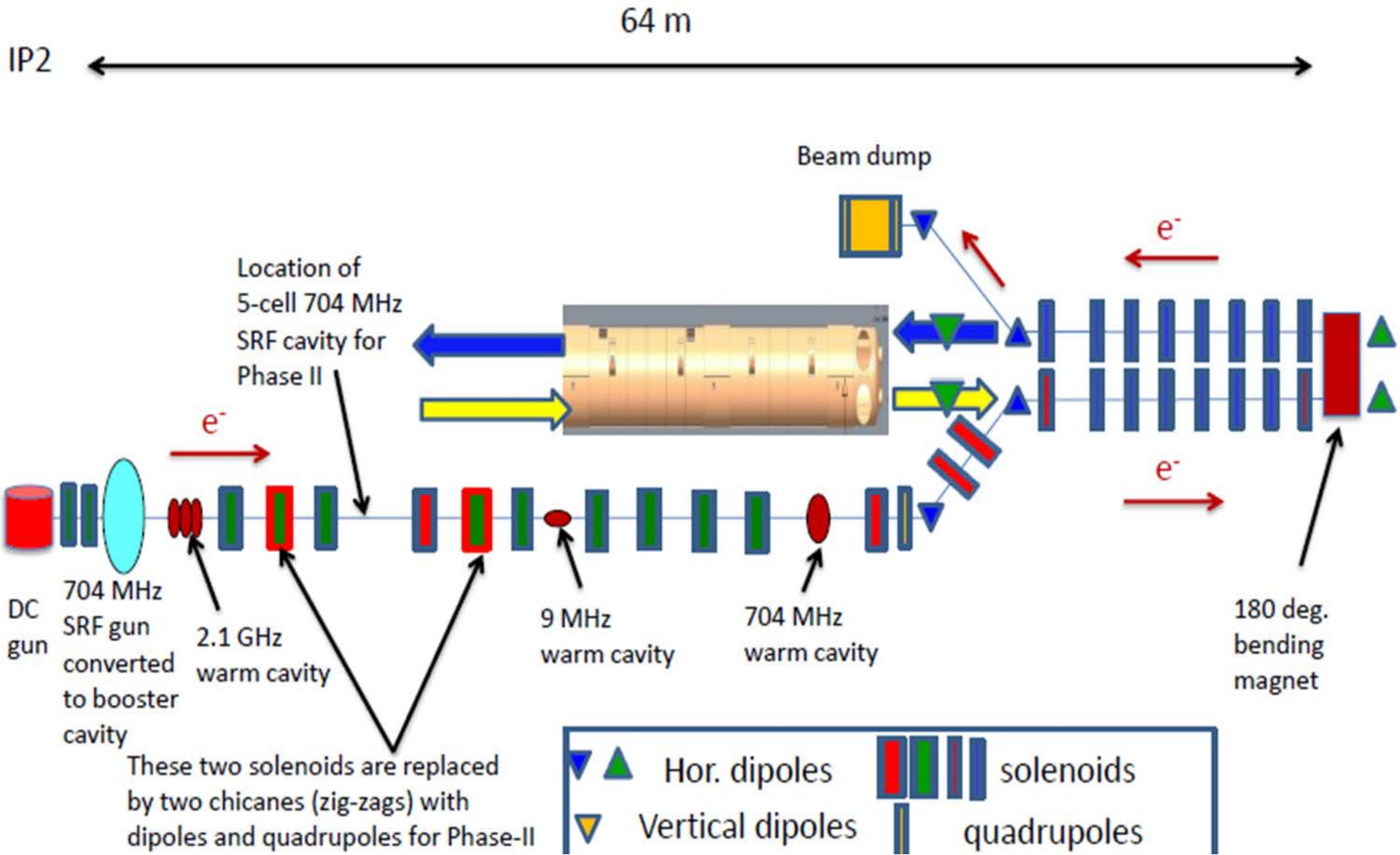
LEReC Phase-I (electron beam energies 1.6-2MeV): Gun-to-dump mode

July 8, 2015



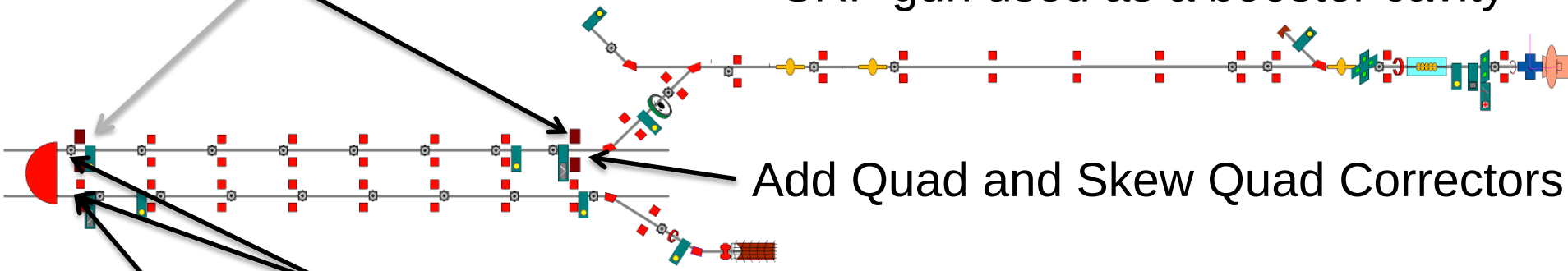
Overall Layout

64 m

IP2

H & V Correctors

LEReC-I (1.6-2MeV): Gun to dump
SRF gun used as a booster cavity

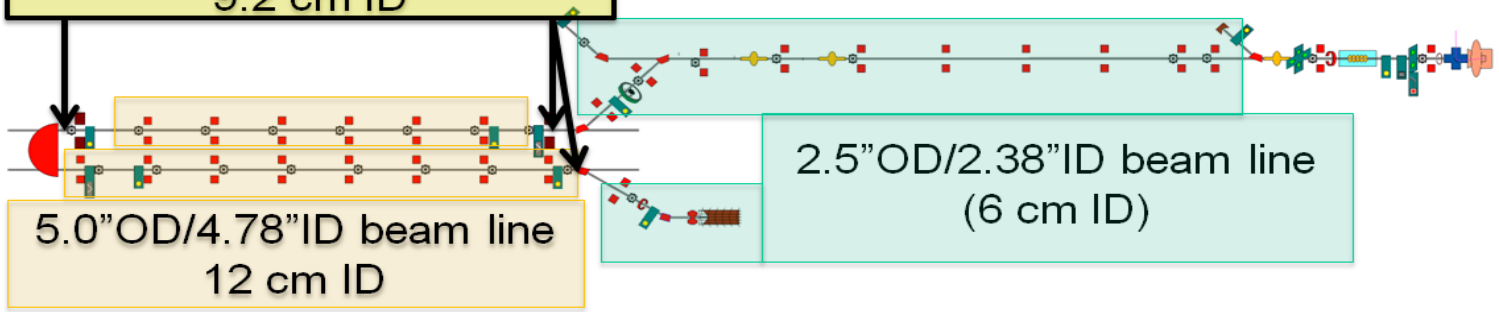


Add Quad and Skew Quad Correctors

Move BPM close to 180 magnet combine with PM.

Add Quad and Skew Quad Correctors

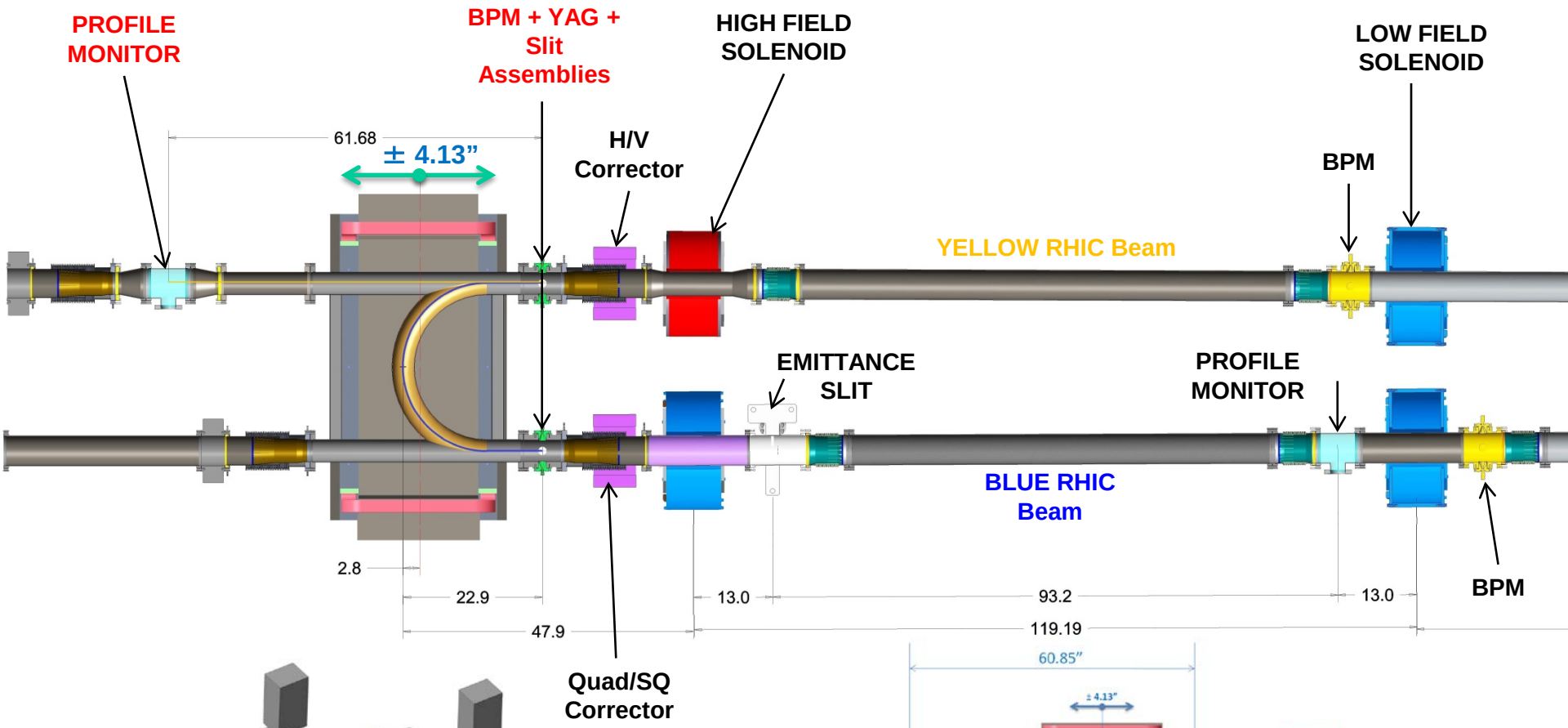
3.75”OD/3.62”ID beam line
9.2 cm ID

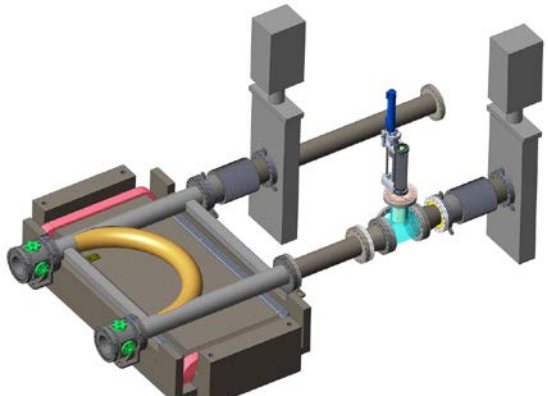


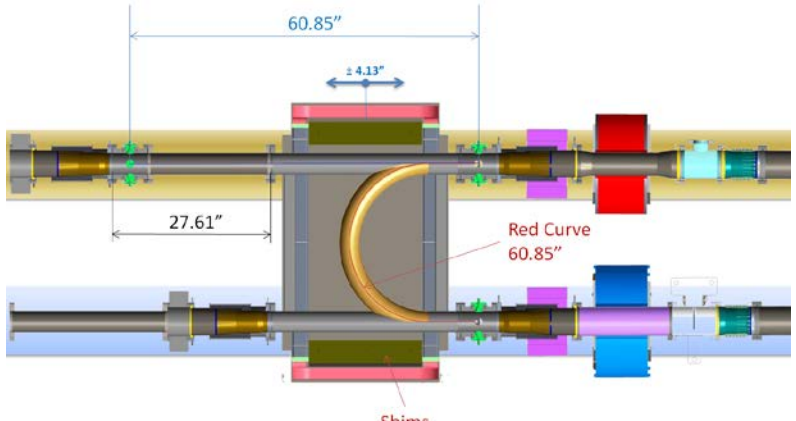
2.5”OD/2.38”ID beam line
(6 cm ID)

5.0”OD/4.78”ID beam line
12 cm ID

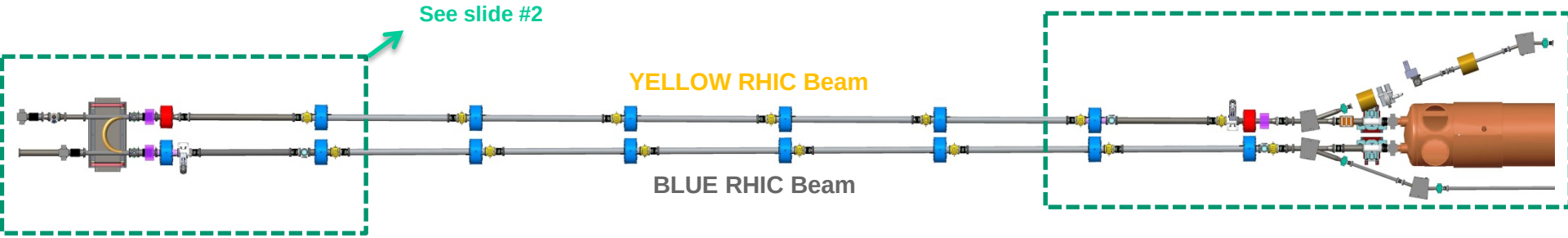
180º Dipole Magnet Neighborhood IV



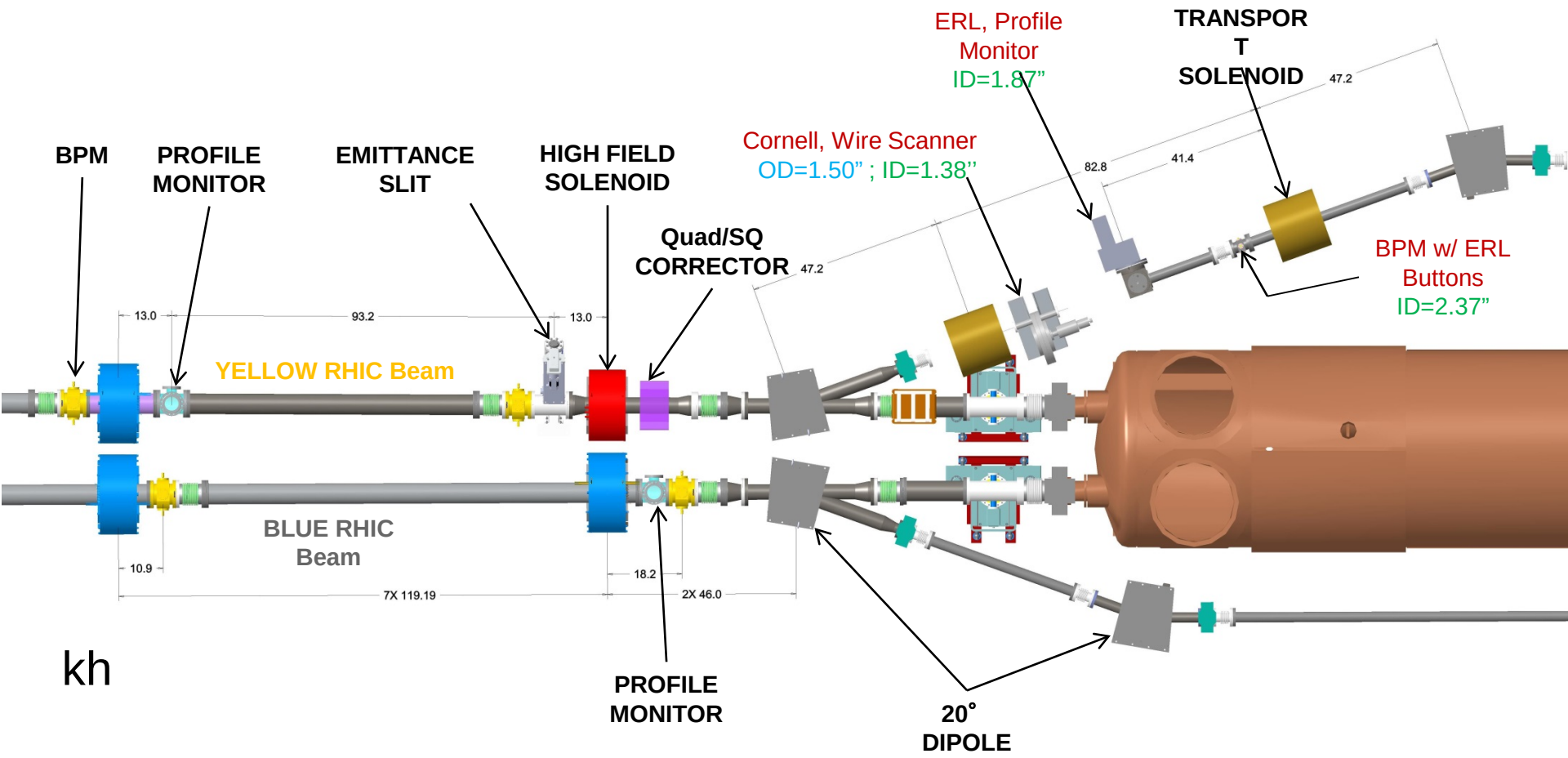




kh



20º Dipole Neighborhood IV

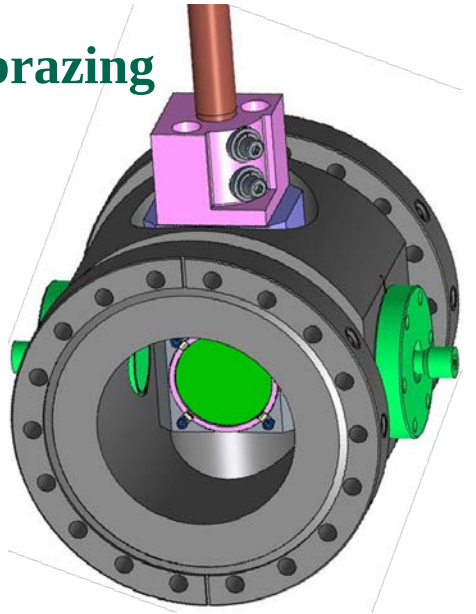


kh

BPMs in Cooling Section (14 Locations)

Large Dia. BPM Housings (4.8 ID), 28mm buttons

- **Order Placed with MPF**
- **Final Design Review 6/23/2015, no issues**
- **MPF approved to start fabrication**
- **Increased number of button first articles for 2 BPM's one standard, one 180 magnet special**
- **MPF updated delivery schedule**
- **Agreed on vacuum bakeout for components**
  - **MPF will vacuum bake buttons @900C/1hr during brazing**
  - **MPF will vacuum bake housing @450C/48hr**
  - **BNL will vacuum bake 1st article housing**
- **First Article delivery buttons 9/28/2015**
- **First Article delivery housing 9/01/2015**



Cooling Section *Standard* Profile Monitors

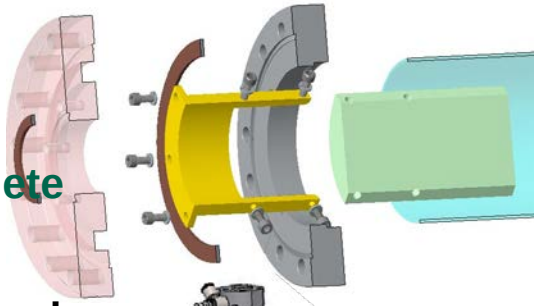
RF impedance design approved (Peter T.)

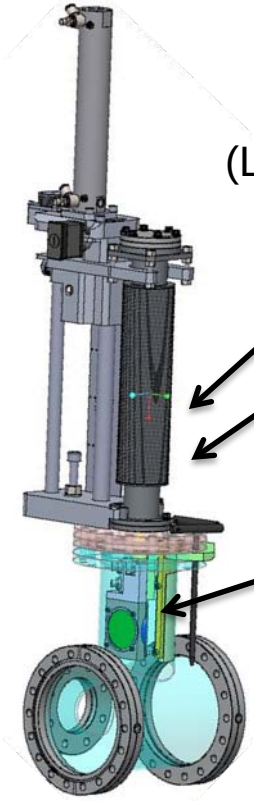
Ferrite ring mounting design complete. CMD5005 material.

Requisition for commercial vacuum linear stage, requisition complete

YAG screen/mirror holder design complete.

Fabrication drawings for YAG screen/mirror holder and vacuum chamber.

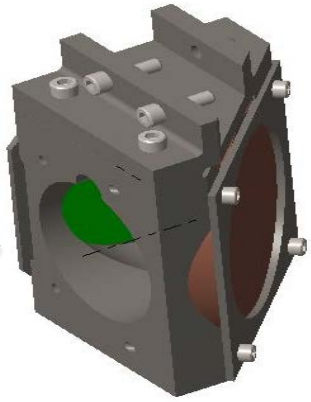


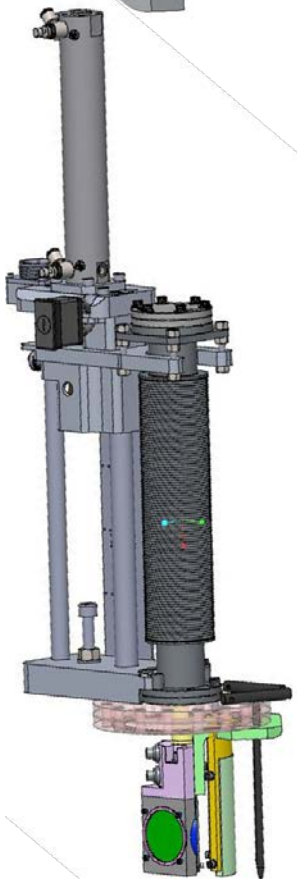


Stage Assembly
(Linear Feedthrough)

Zero Length adapter flange

Profile Monitor
YAG Screen Assy.





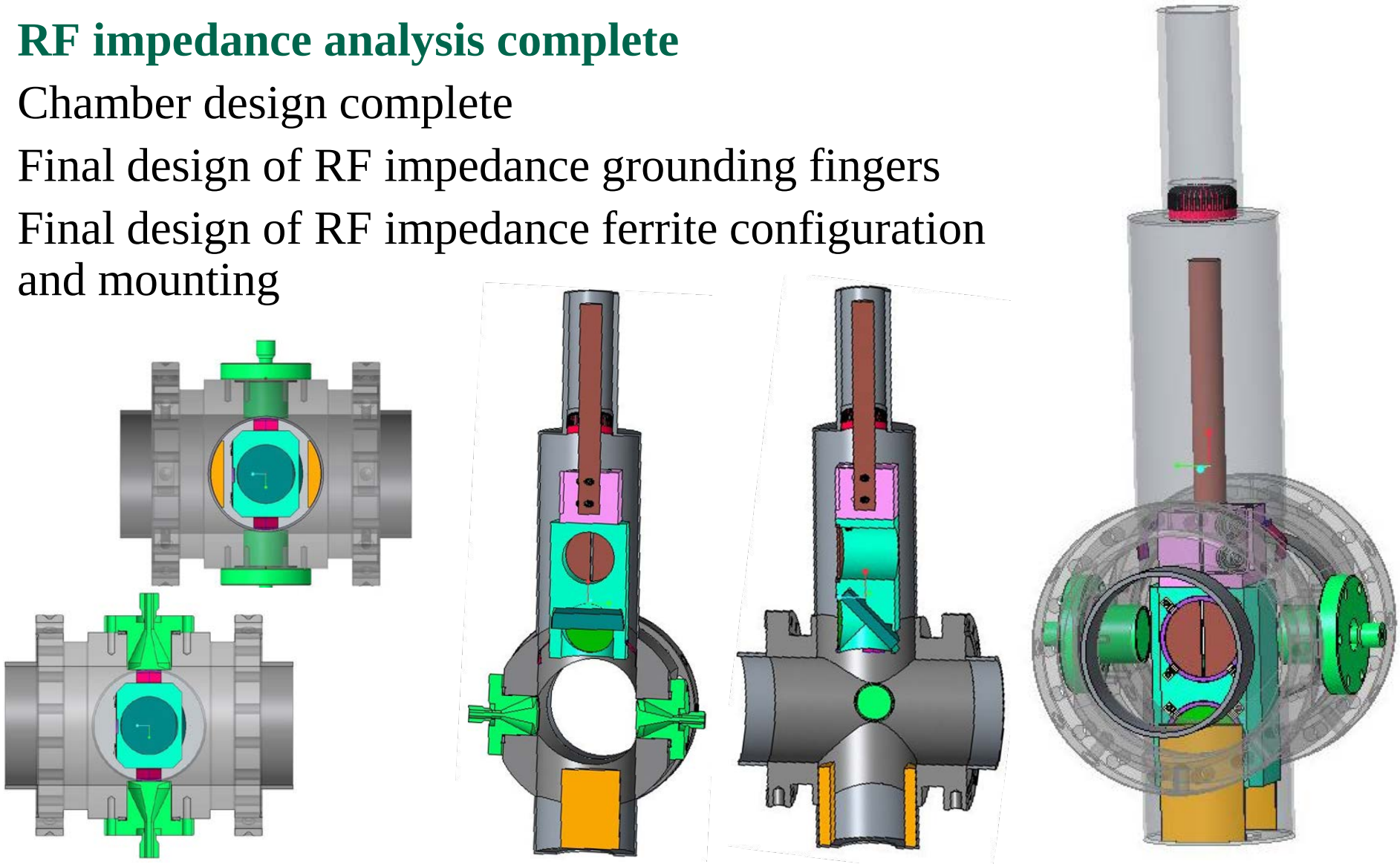
Cooling Section “hybrid” BPM, PM, Slit

RF impedance analysis complete

Chamber design complete

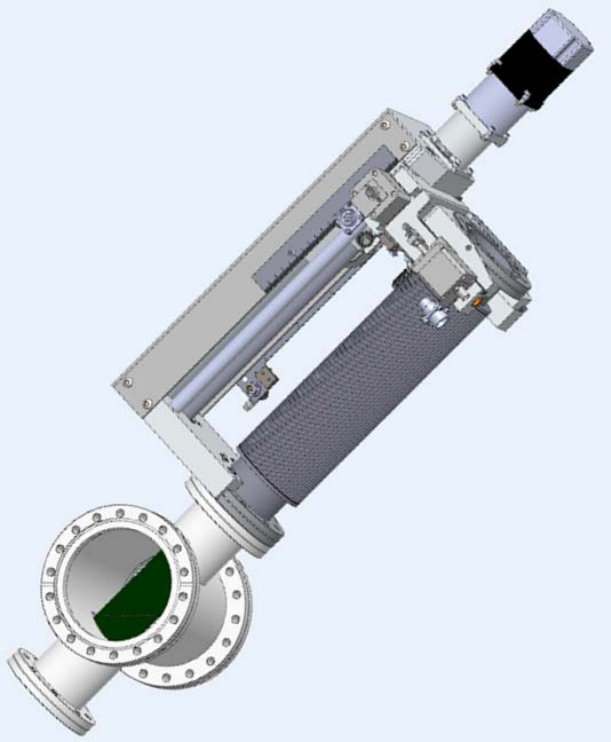
Final design of RF impedance grounding fingers

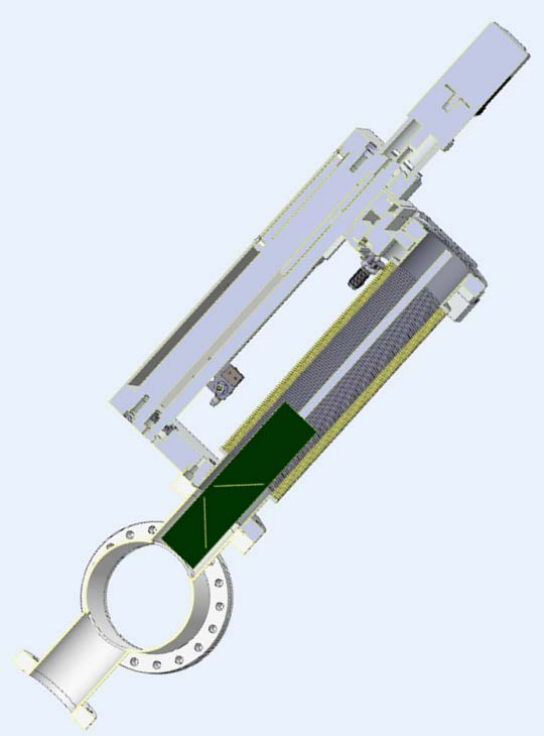
Final design of RF impedance ferrite configuration and mounting



Cooling Section Emittance Slits

- **Requisition for commercial vacuum linear stage.**
- **Fabrication drawings complete and approved.**
- **Central Shops requisition approved for vacuum chamber and W slit.**
- Delivery dates: shifter, vacuum chamber, W slit, mounting hardware.





Vacuum Hardware

Beam line bellows & 180 accordion bellows purchase orders.

“Standard Chamber Length” defined

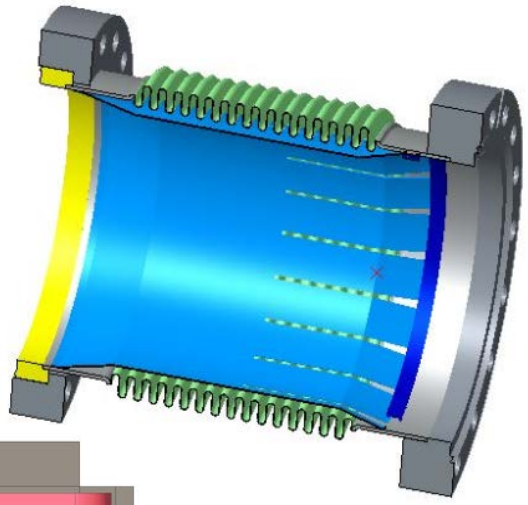
180 chamber 316L vacuum annealed to 900C after welding.

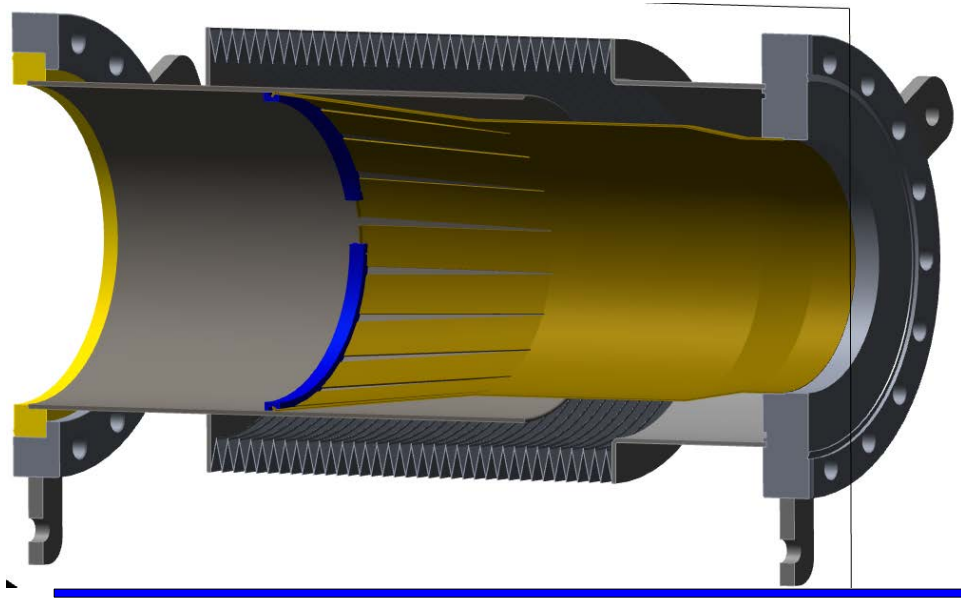
180 chamber in shops, 20 chamber prepare RFQ

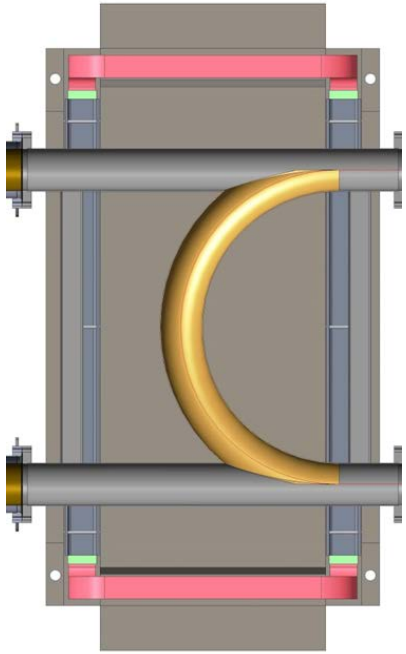
Test chamber welded and measured.

Shielded valves on order

DC Gun shielded valves and vacuum equipment.







20º Dipole Magnet

Requisition approved SOW – 2 magnets by 10/1/2015.

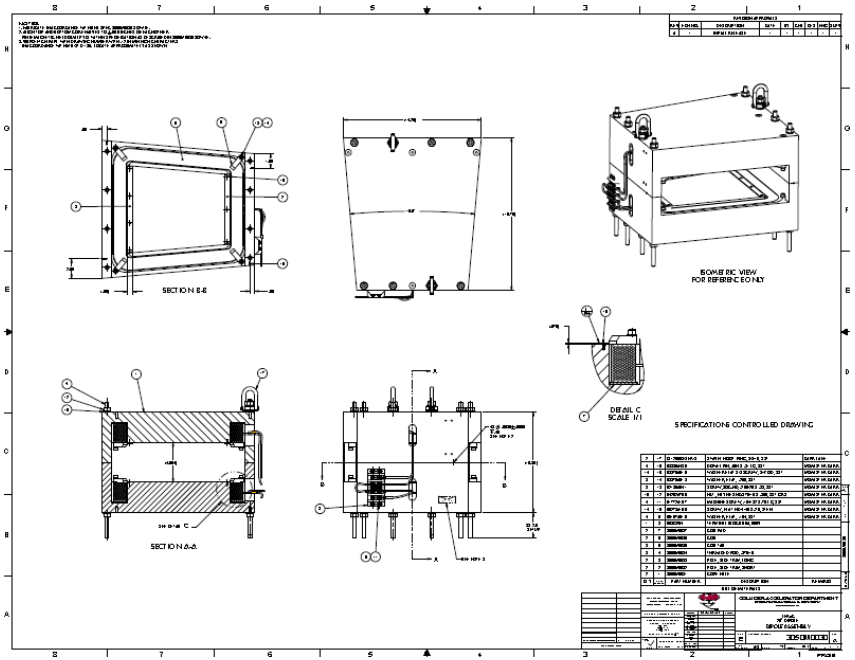
Order Placed 5/6/2015 Everson Tesla

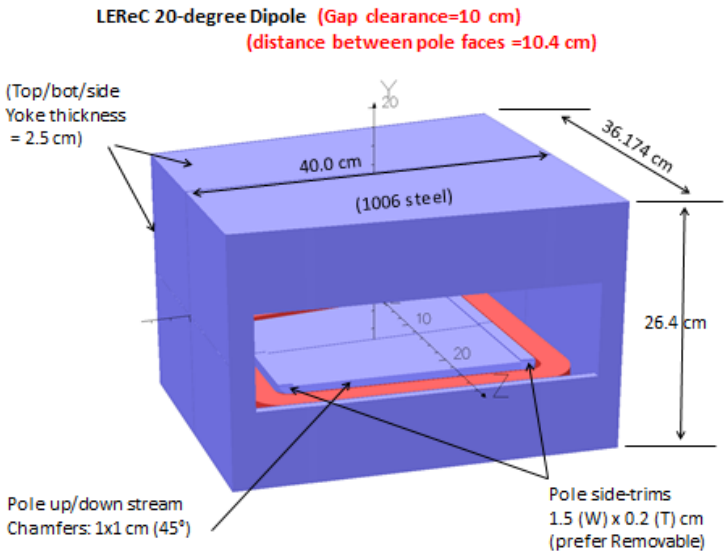
Estimated Delivery 1st two magnets 10/1/2015

Distance Between Pole Faces = 10.4 cm (4.1 in.)

Magnet Vertical Gap = 10 cm

Vacuum Chamber V Aperture = 9.5 cm (3.74 in.)

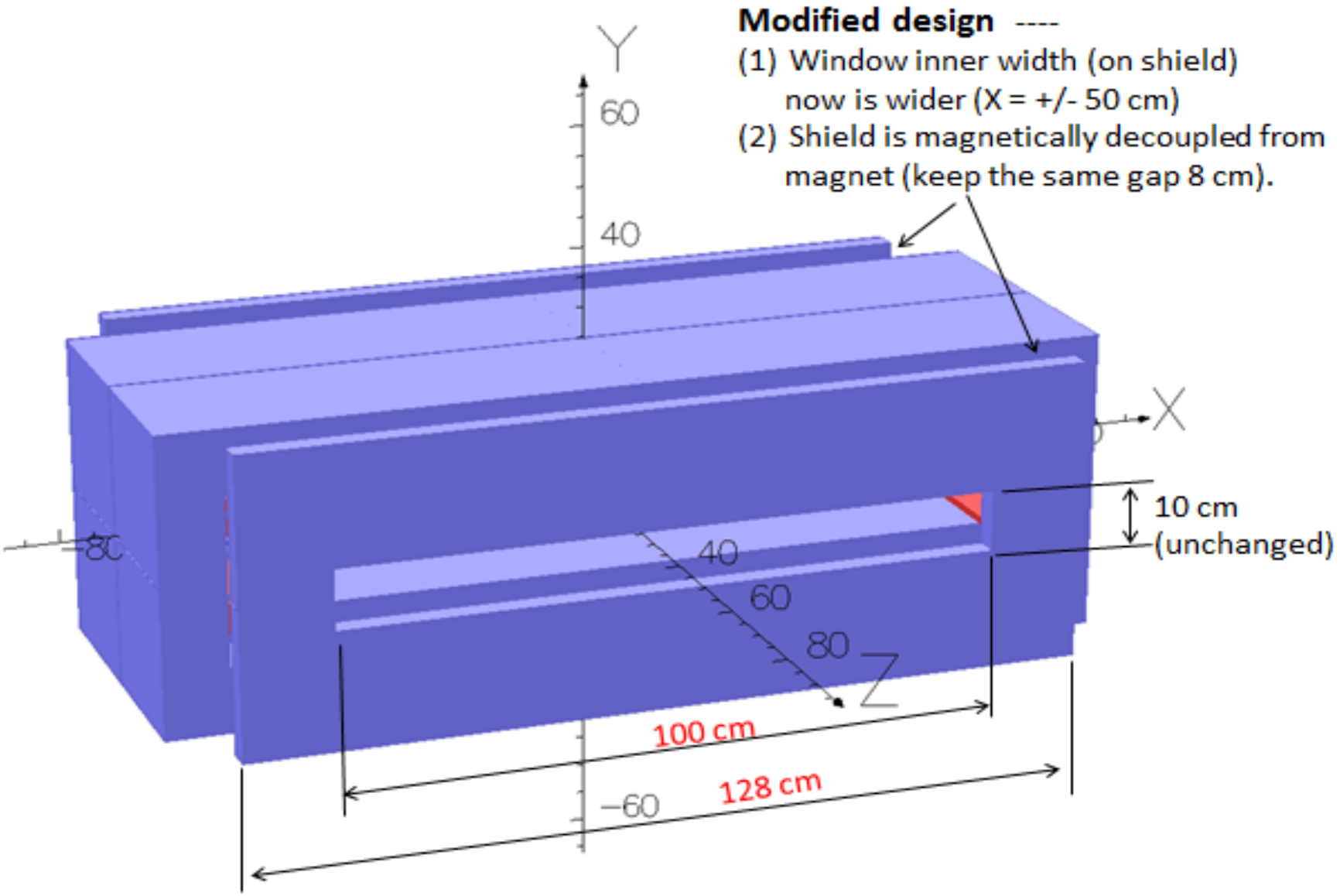




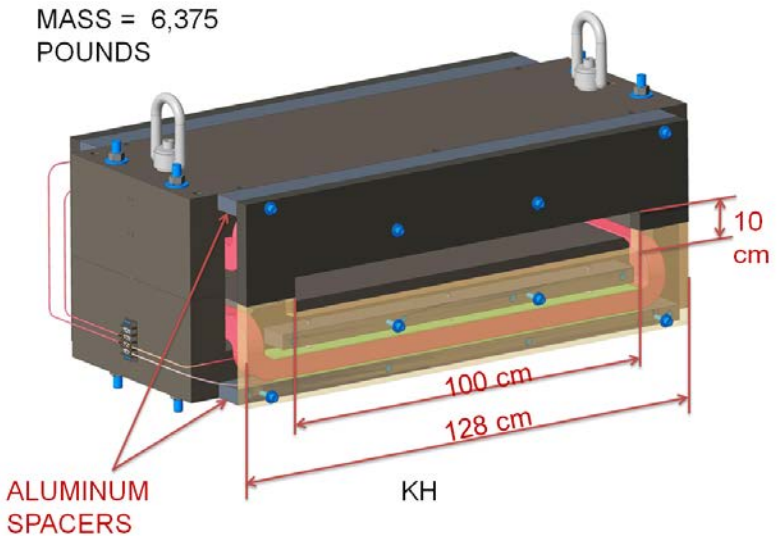
Electron tracking results and field qualities along trajectory on R=1 cm curved cylinder:

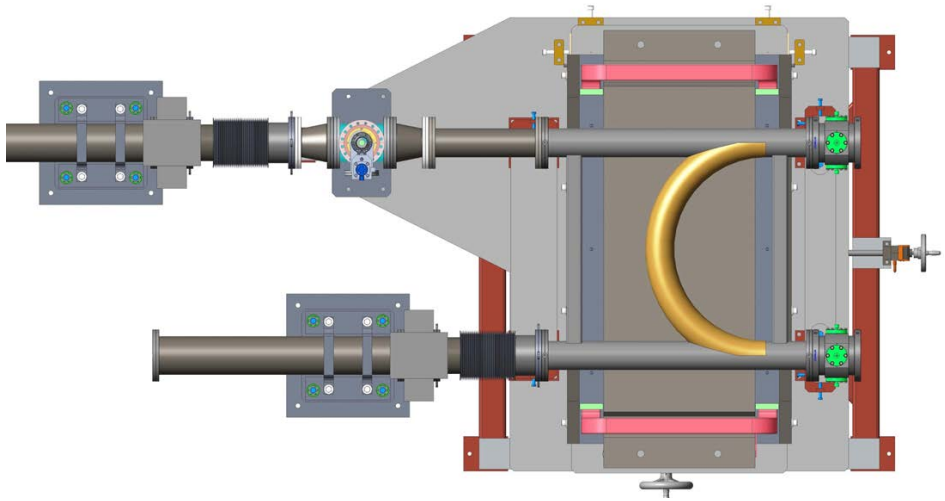
	Ek = 5 MeV	Ek = 1.6 MeV
Current per coil (Amp-turn)	1053.288	393.192
Overall current density (A/mm²) (overall coil cross-section 3.0x4.8 cm)	0.73145	0.27305
Central Gap Field (Gauss)	251.20	93.73
Half b1-integral (dipole) (G-cm)	3.1982E3	1.1930E3
Half b3-integral (6-pole) (G-cm) [Ratio to dipole integral]	1.803E-2 [5.64E-6]	7.019E-3 [5.88E-6]
Half bending angle from tracking tests (required 10°)	10.013°	10.006°

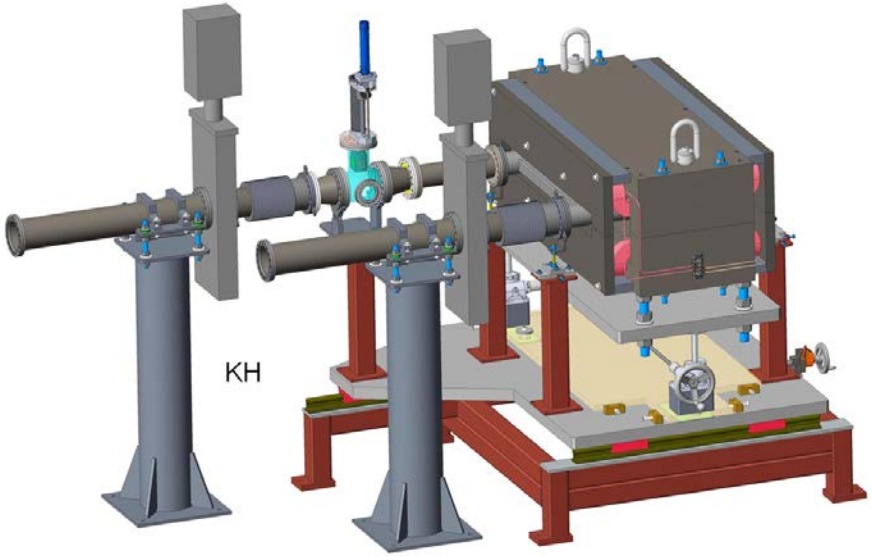
180º Dipole Magnet Revised

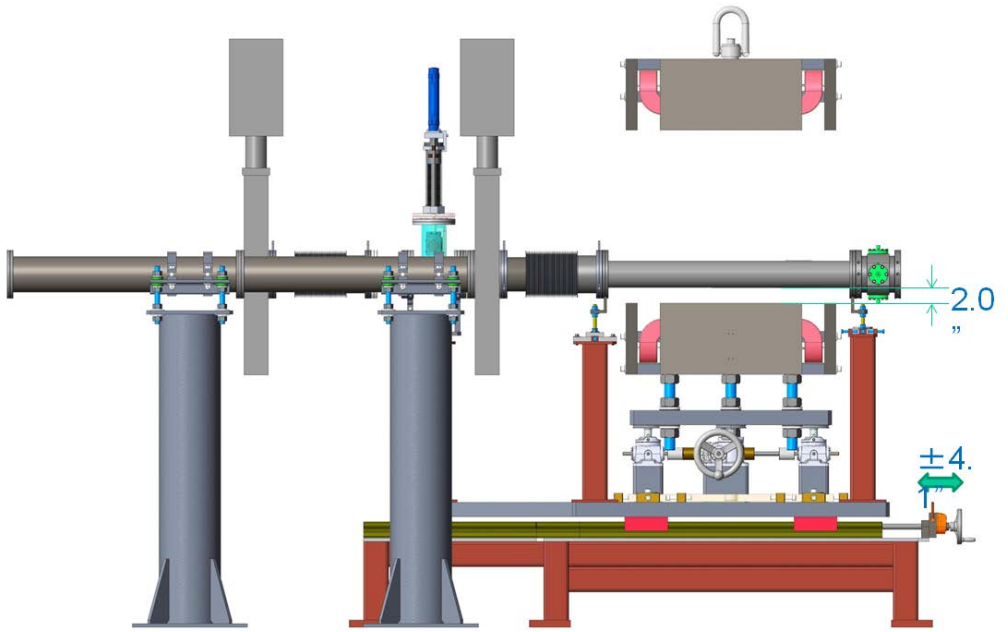


180º Dipole Magnet Revised





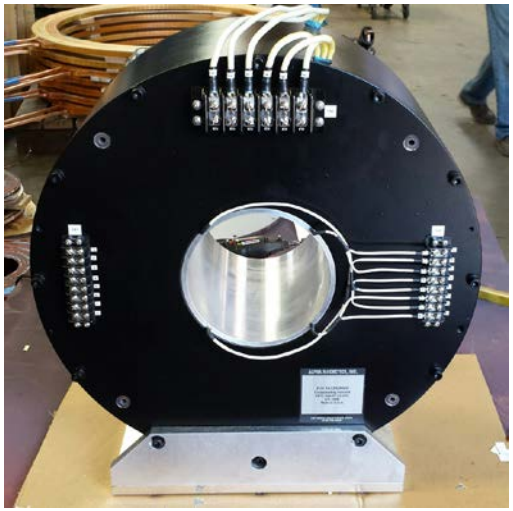


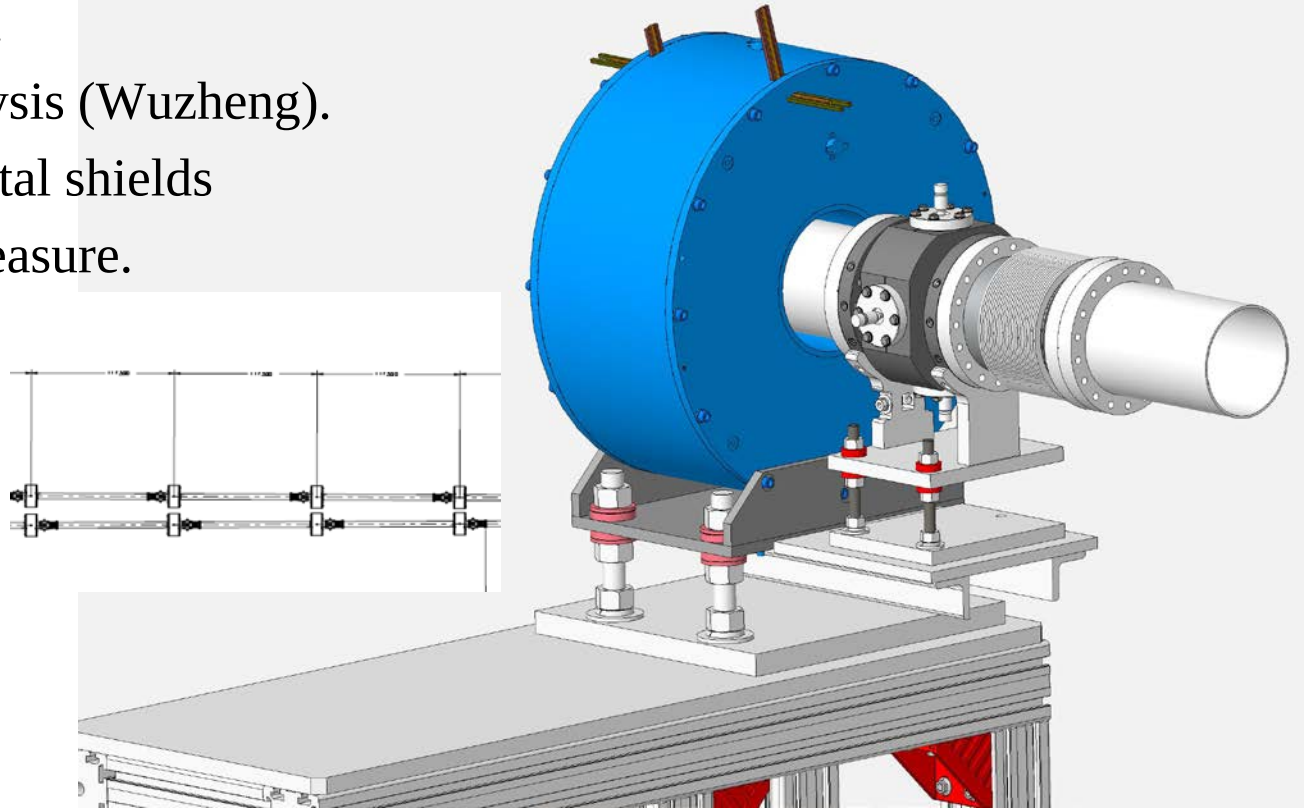


Compensating and Matching Solenoids

Buckley magnets complete 8/20/2015 + 6 weeks shipping + customs.
Alpha Magnetics update: first production magnet in house.
Magnetic Measurement ordered and **received 1% 3D probe**,
0.1% ordered, late August delivery.

- Design support stand assembly – provide space for mu metal shields, separate beam pipe stand support.
- Magnetic shielding analysis (Wuzheng).
- Design prototype mu metal shields and supports - measure.





Compensating and Matching Solenoids

HALL PROBE / SOLENOID GRANITE TABLE (Measurement Schedule)

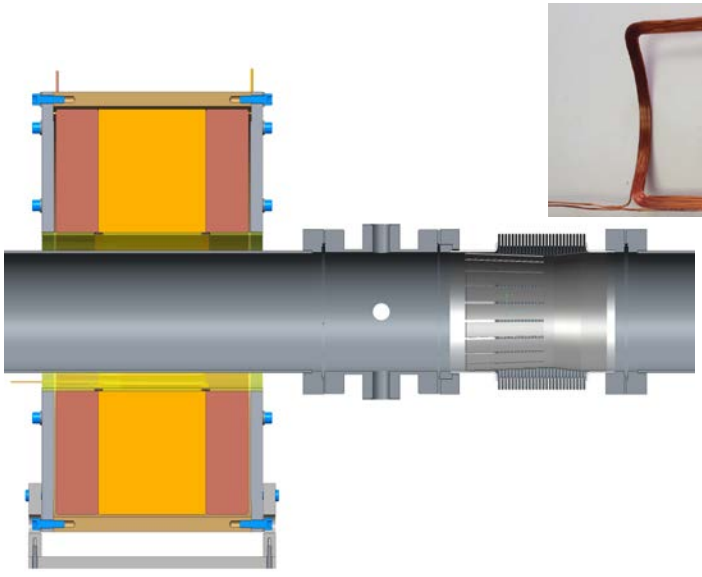
August 3-7: complete permanent magnet measurements

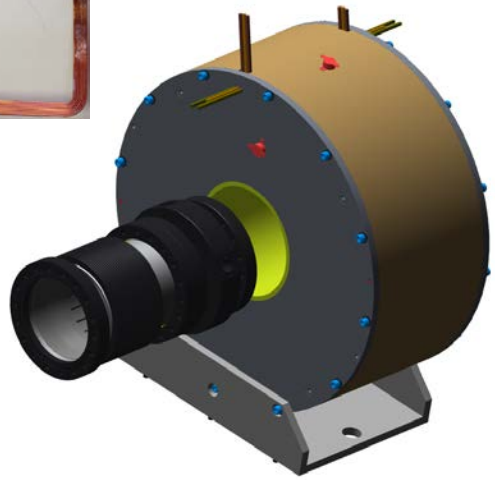
August 10-14:

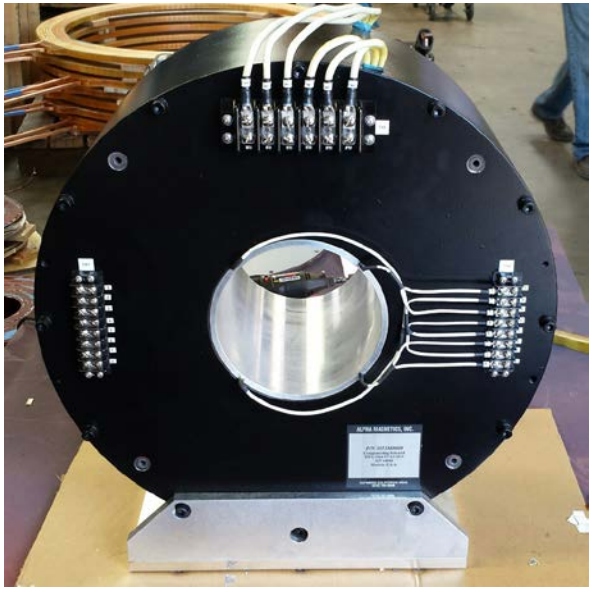
August 17-21: reconfigure Hall probe (Sullivan), then resurvey (Karl)

August 24/25: Jain reviews survey data, first solenoid (Sauerwald)

August 26 – Sept. 30: move solenoid granite table out of Annex







LEReC Cooling Section Design Room

LF & HF solenoid and 20^{o} dipole magnets fabrication drawings (KH)

Beam Diagnostics: BPM chamber and buttons (VDM)

Beam Line 5” bellows with shields fabrication drawings (GW)

20^{o} dipole vacuum chamber for impedence review (KH)

180^{o} dipole fabrication drawings (KH) **Spectrometer magnet (180^{o} dipole) revisions** (KH)

180^{o} vacuum chamber + large sliding bellows fabrication drawing (KH)

Beam Diagnostics ES W slit & chamber fabrication drawings (VDM)

20^{o} dipole vacuum chamber fabrication drawings (KH)

Beam Diagnostics: standard PM fabrication drawings (GW)

Beam Diagnostics: special “hybrid” ES/PM/BPM fabrication drawings (GW)

Beam line solenoid/BPM stands & vacuum chamber stand (VDM)

20^{o} magnet stand drawing (KH)

180^{o} magnet w/hybrid BPM stand drawings (KH)

Cable tray and penetration drawings (AF)

Magnetic shielding drawing and solenoid magnetic measurement test station

HF dipole, quadrupole, and skew quadrupole corrector drawings

LEReC Design Room Source Design Work

DC Gun Vacuum Chamber Fabrication Drawings (JH)

DC Gun SF6 Pressure chamber specification control drawings (JH)

DC Gun cathode cooling design for Karl S. Cornell (JH)

DC Gun stands (JH)

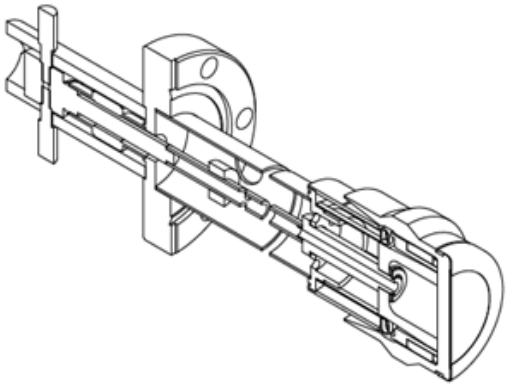
DC Gun to Booster SRF booster cavity beam line (JH)

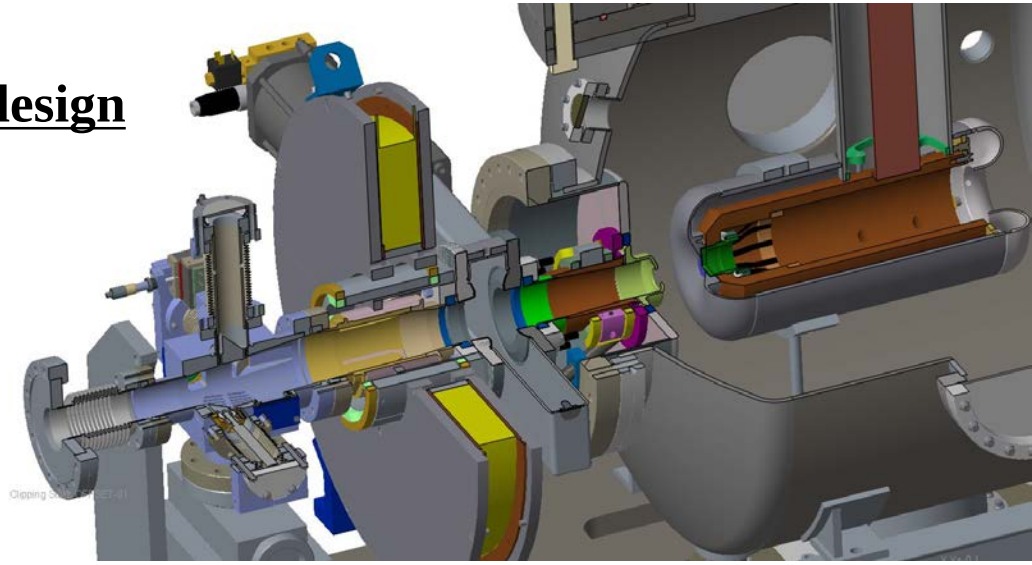
DC Gun cathode coating system vacuum chamber (PC)

DC Gun cathode transfer load lock and vacuum chamber

DC Gun cathode insertion drive

Cathode production coating system design





LEReC Design Room Other Work

RHIC 1:00 move real estate drawings (V.DM.)

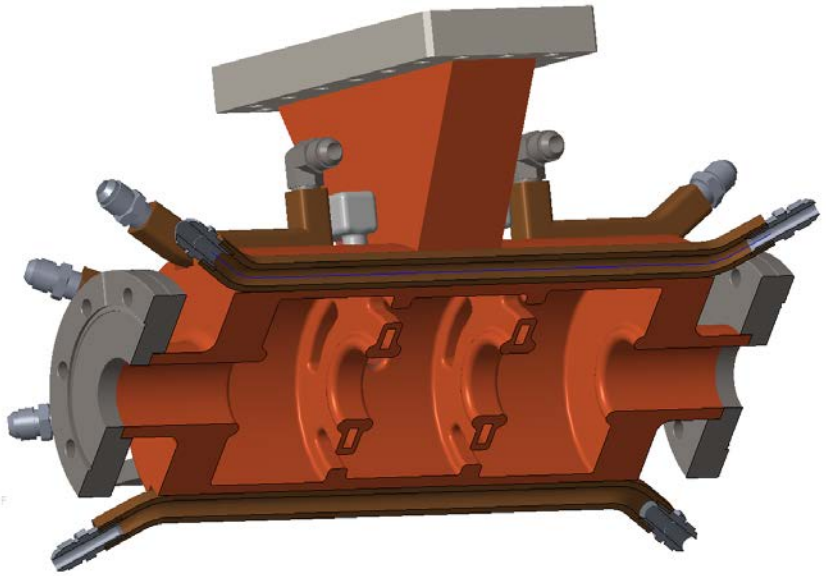
Phase 2: 5 cell cavity positioning (RM) – Revised Position on hold

Phase 1 and 2 cryogenic system layout (RM)

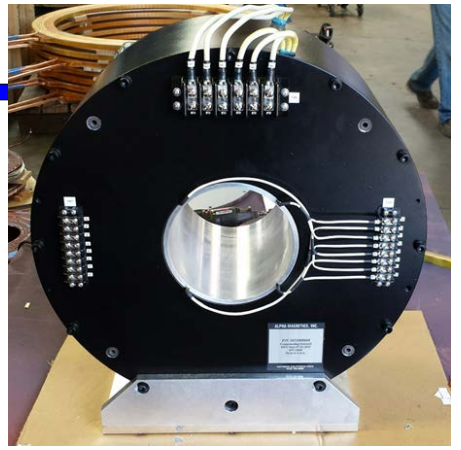
2.1 GHz warm cavity fabrication drawings (MG)

704 MHz warm cavity fabrication drawings

Transport line layout drawing (RM/VDM)



Installation Step – 2015 Shutdown

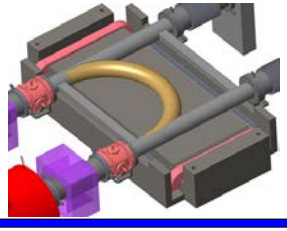


Cooling Section Purchase Orders in Place

- HF and LF solenoid magnets in fabrication, 1st article in transit
- Shielded vacuum valves, bellows, tuning (sliding) bellows, gauges?
- Beam tubes being coated
- BPM chambers and buttons ordered FDR approved
- 20º merger magnets
- Beamline shielded bellow and 180º magnet sliding bellows
- Profile monitor and emittance slit vacuum linear drives

Cooling Section Critical Items (not ordered yet)

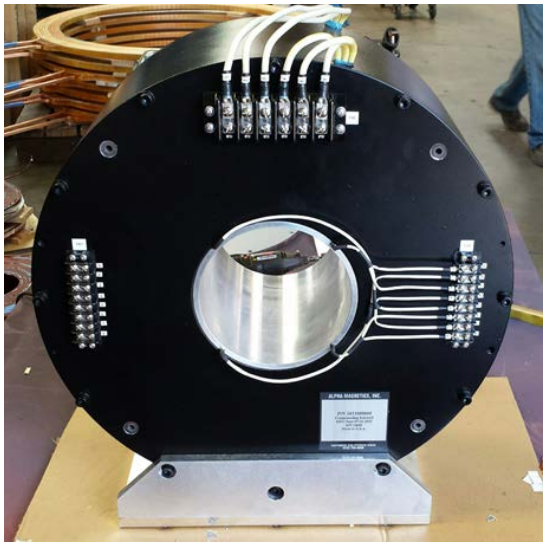
- 20º magnet vacuum chamber (MM preparing RFQ)
- Special RF vacuum gaskets
- Diagnostics chambers & hardware: PM, ES, PM/ES/BPM
- beamline equipment stands
- 180º magnet (spectrometer magnet – moved to 2016)



Installation Step – 2015 Shutdown Punchlist

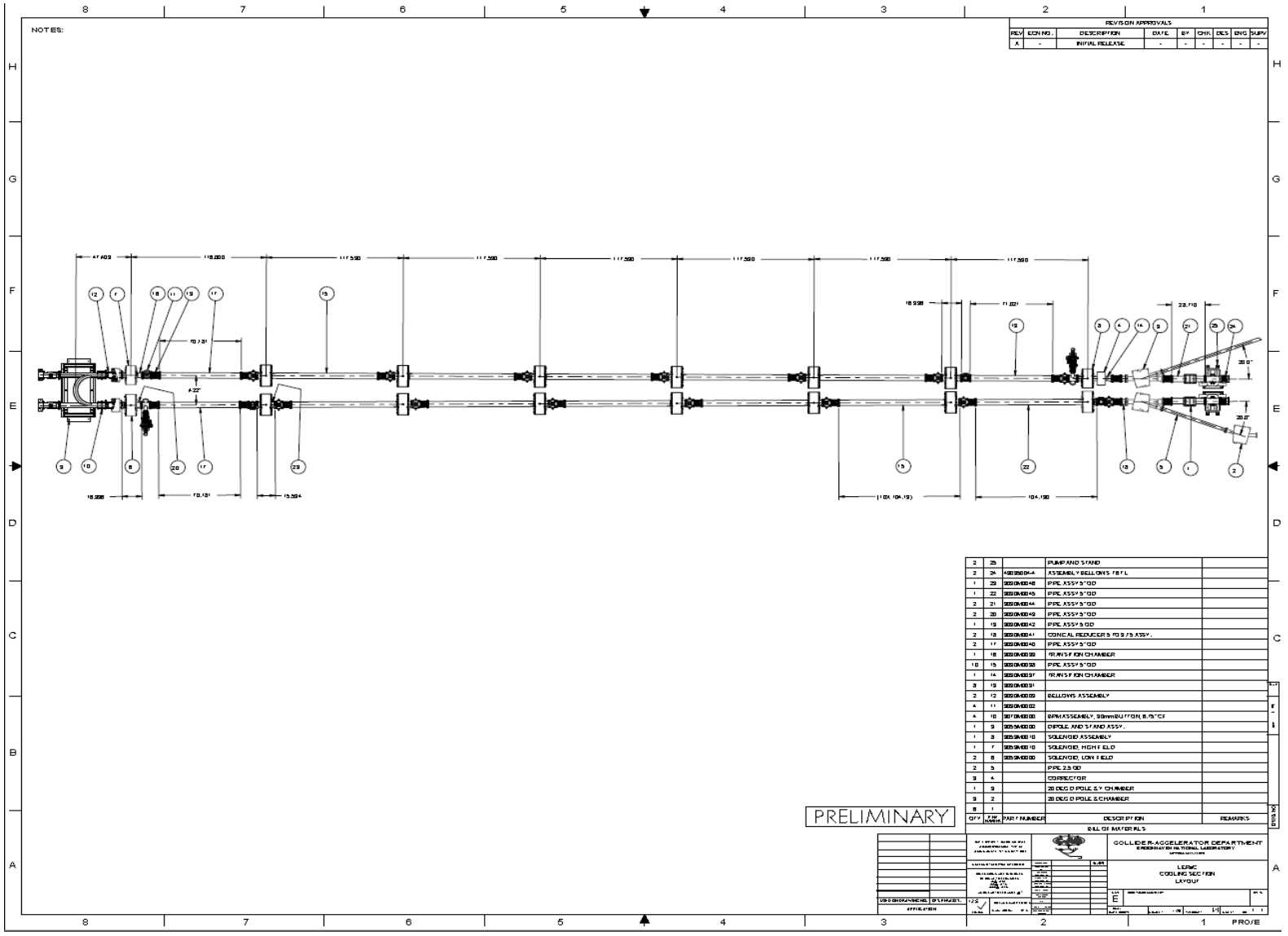
Cooling Section Parts in Hand

- 1st LF solenoid magnet
  (4 magnets to be shipped this week)
- 5” beam tubes
- Shielded vacuum valves and flanges.

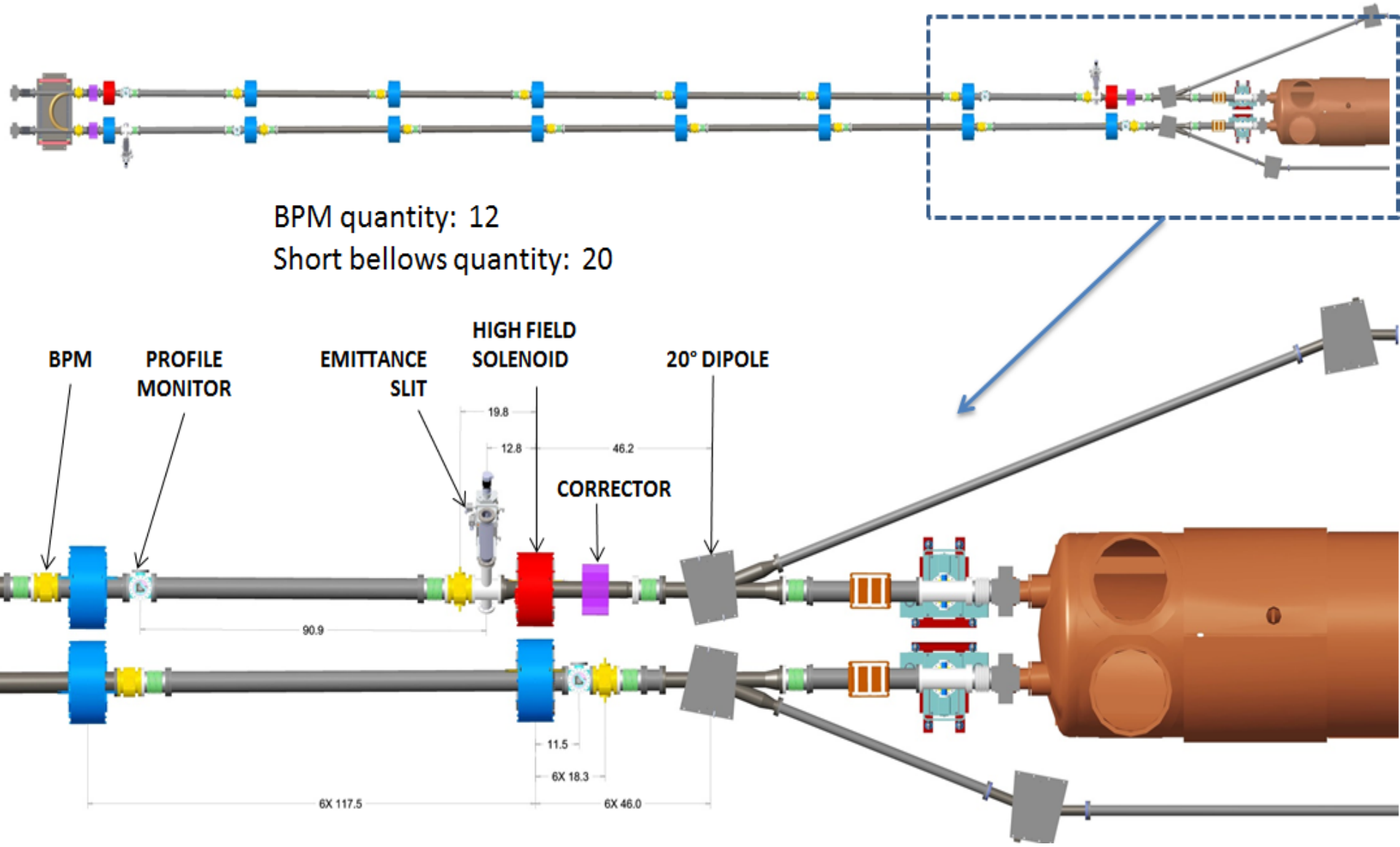


Reference Slides

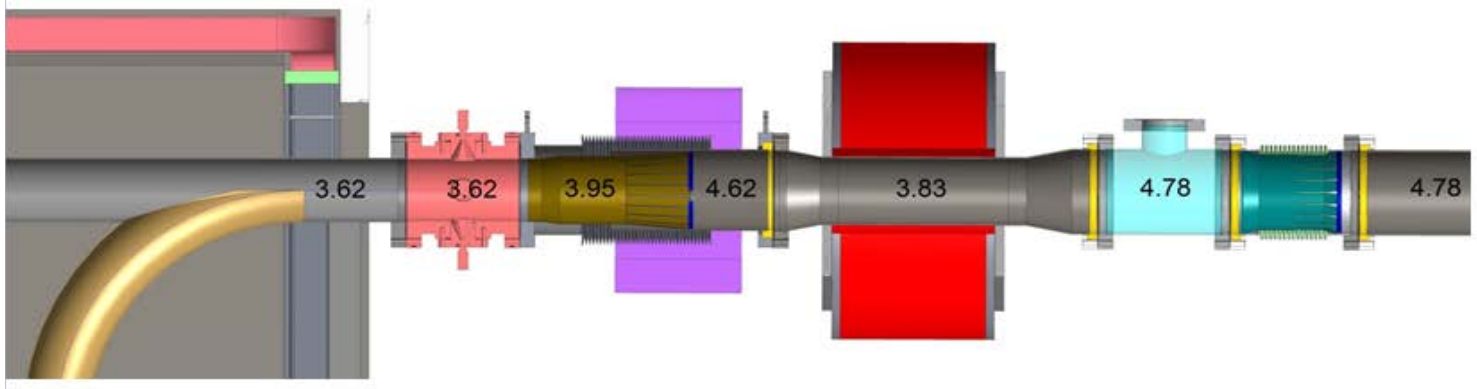
Freeze Cooling Section??



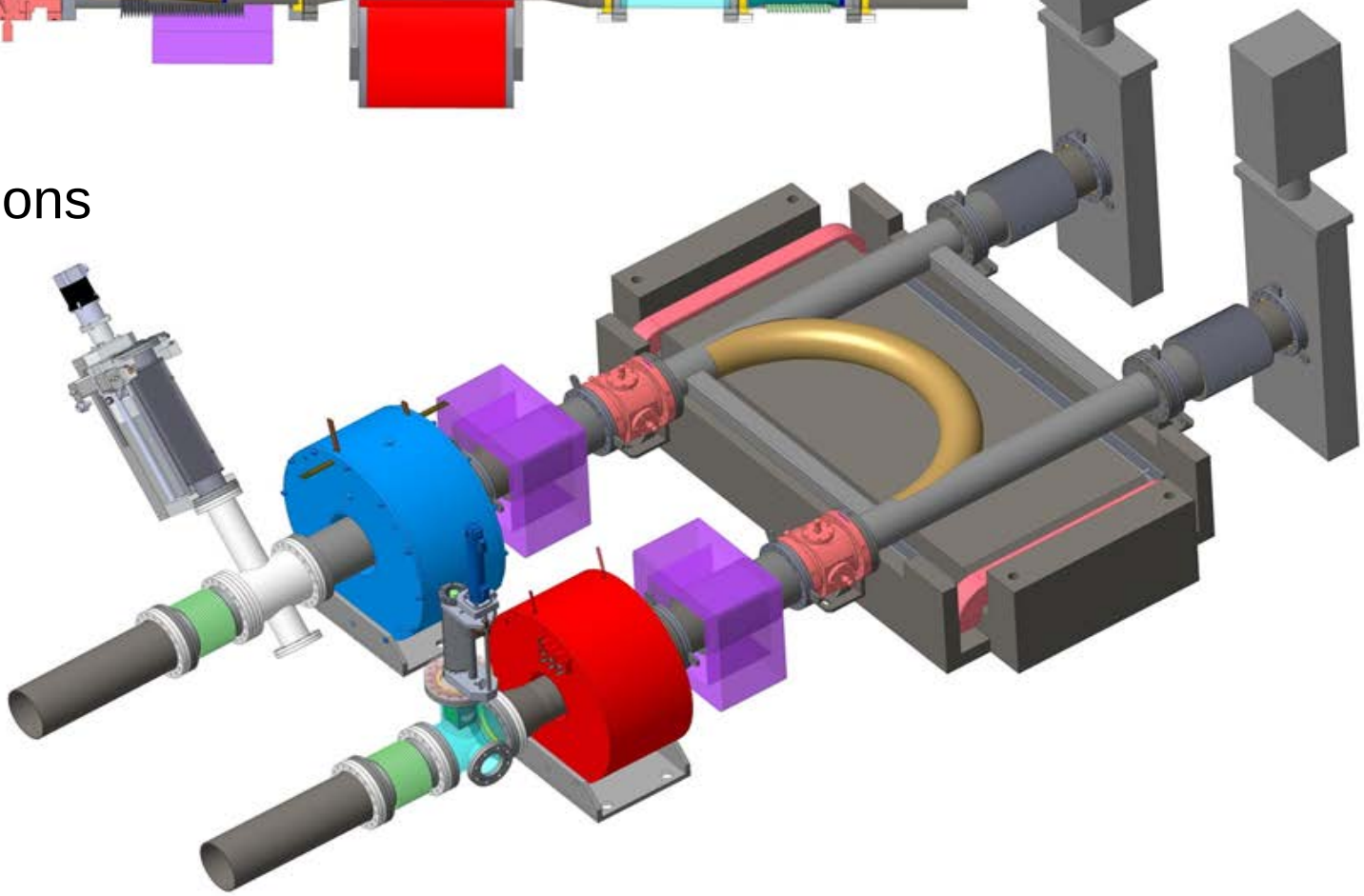
20º Dipole Magnet Neighborhood



180º Dipole Magnet Neighborhood II

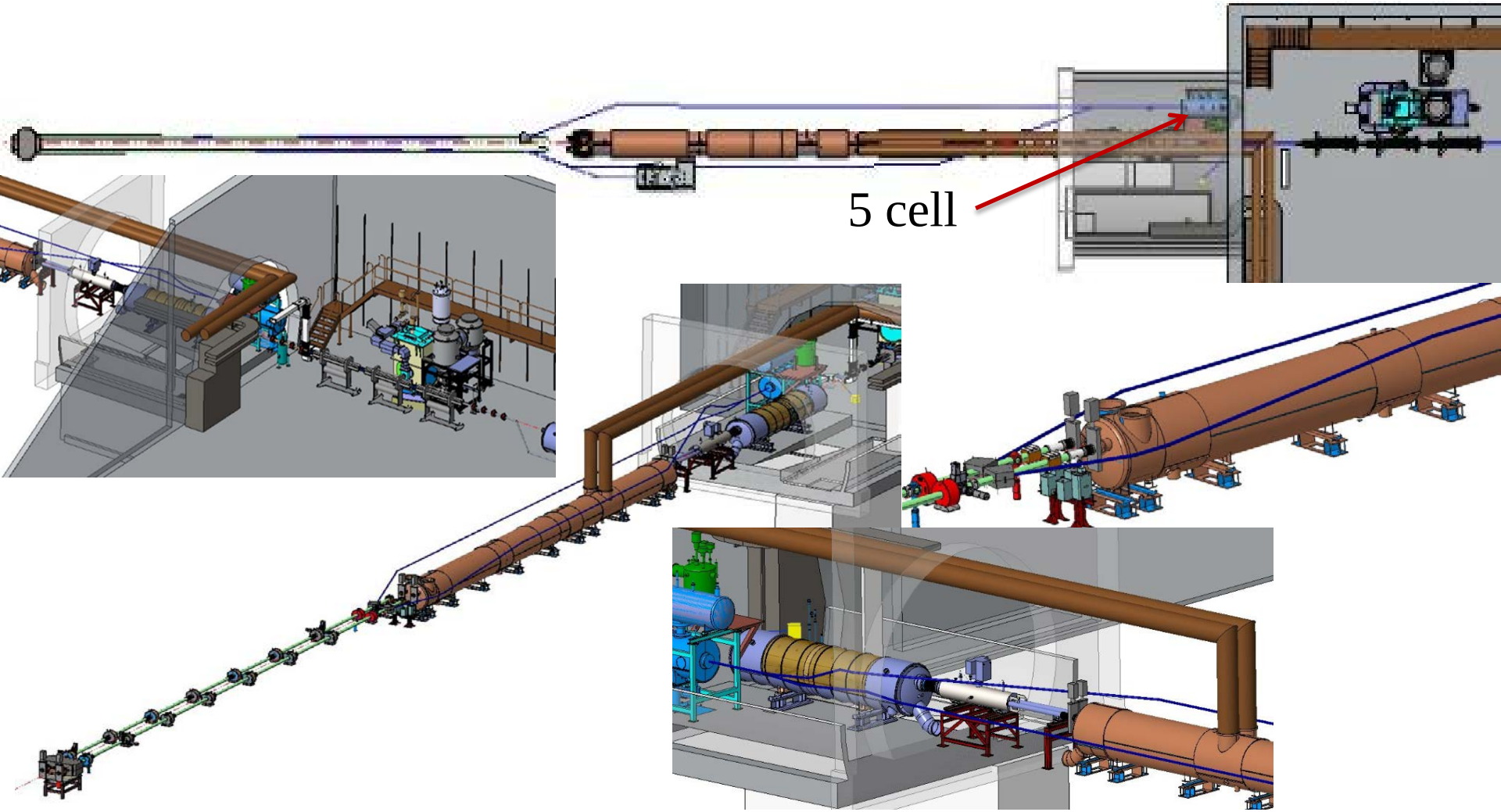


Aperture Transitions



5 cell cavity location

New updates?



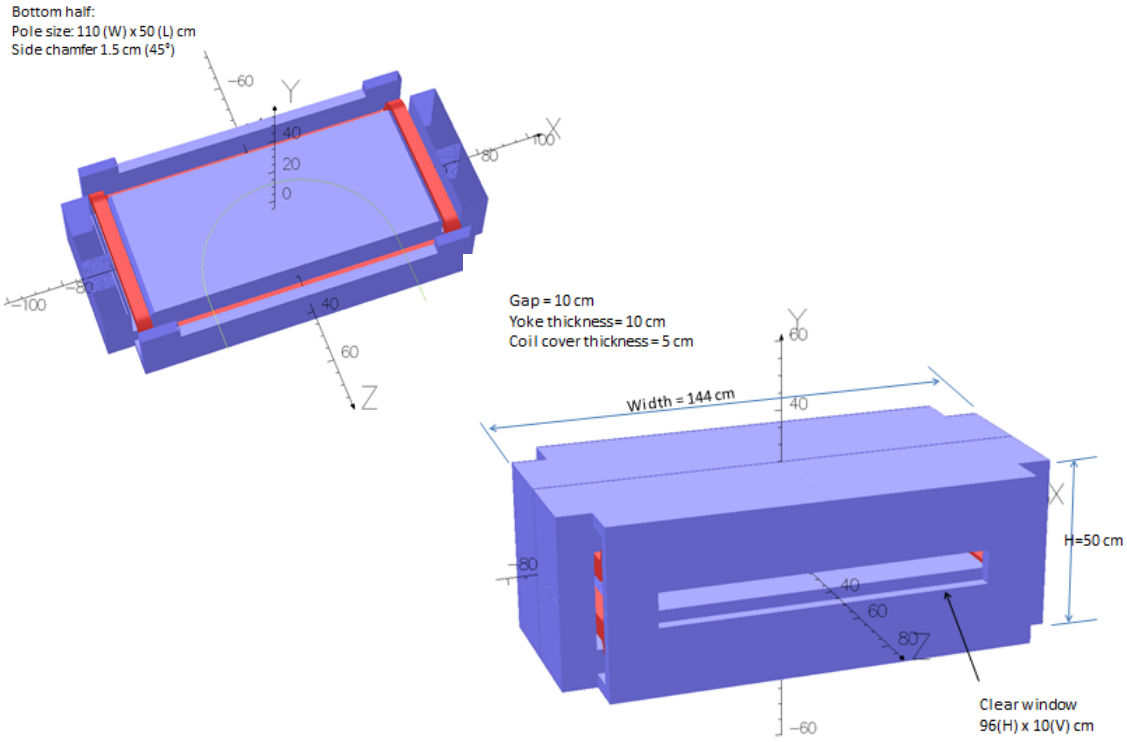
180º Dipole Magnet

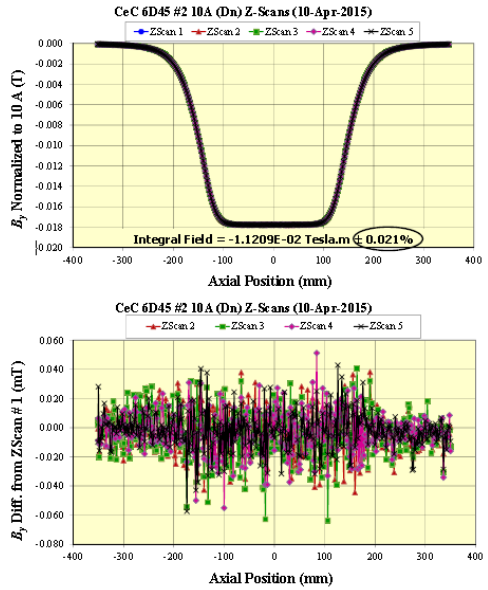
Requisition Status

Range of motion for magnet core +/- 10cm.
Magnet Vertical Gap = 10.0 cm (3.94 in.)
Vacuum Chamber Aperture = 9.5 cm (3.75 in.)

Electron tracking results and field qualities along entire trajectory on R=2 cm curved cylinder:

	Ek = 5 MeV	Ek = 1.6 MeV
Total current per coil (Ampere-turn)	2119.146	791.077
Overall current density (A/mm²) (coil-pack cross-section: 5.0 x 6.0 cm)	0.7064	0.2637
Central Field deep inside magnet (Gauss)	525.21	195.78
Effective Magnetic Length (cm)	109.43	109.57
Full b1-integral (dipole) (G-cm)	5.7471E4	2.1452E4
Full b3-integral (6-pole) (G-cm) [Ratio to dipole integral]	0.132 [2.30E-6]	0.005 [2.44E-7]
Full bending angle as shown in tracking studies (required 180°)	180.002°	180.003°



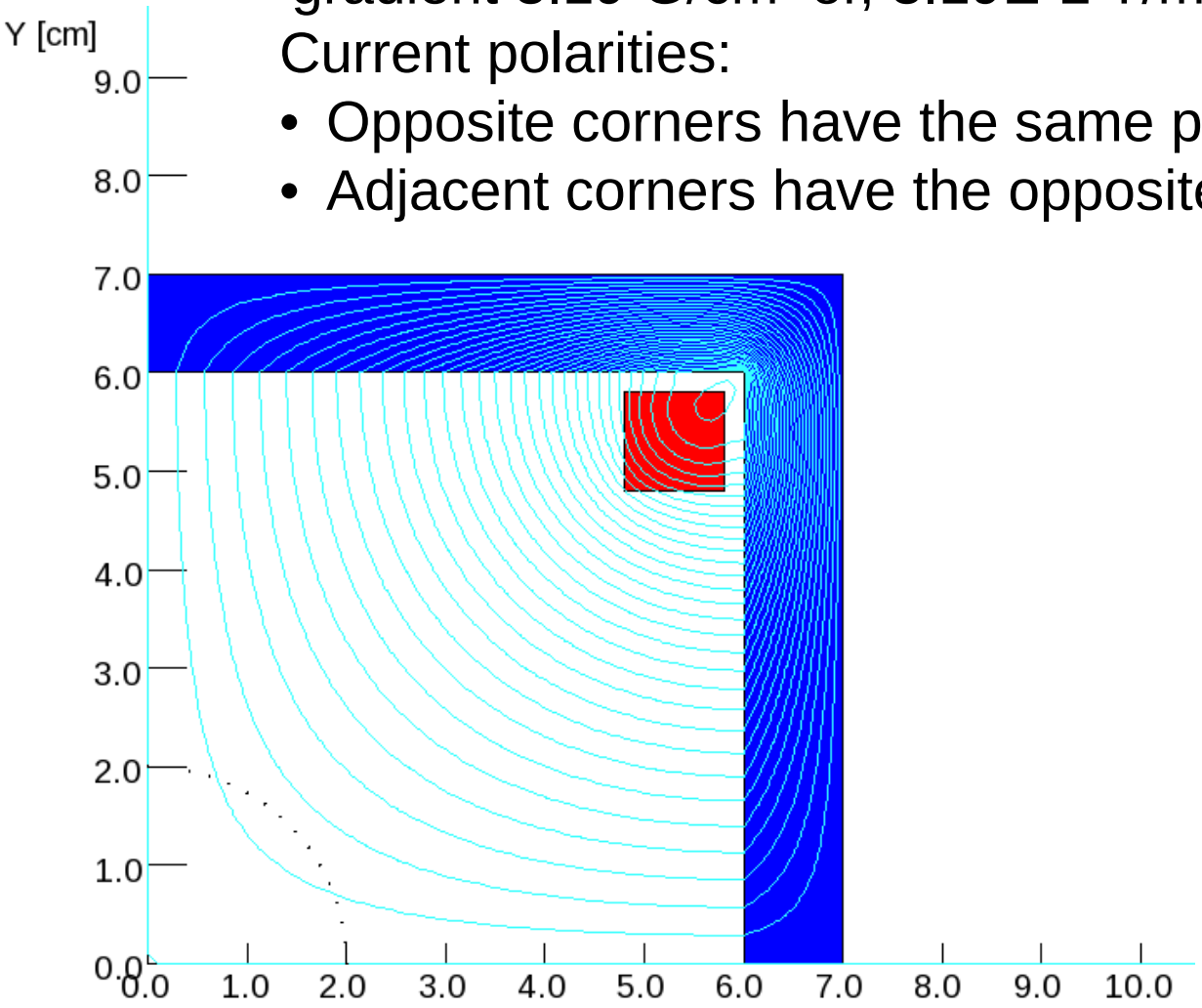


LEReC Dipole Skew Quad Corrector

Window-frame Skew Quad: 100 A-turn per corner = s-quad gradient 3.19 G/cm or, 3.19E-2 T/m

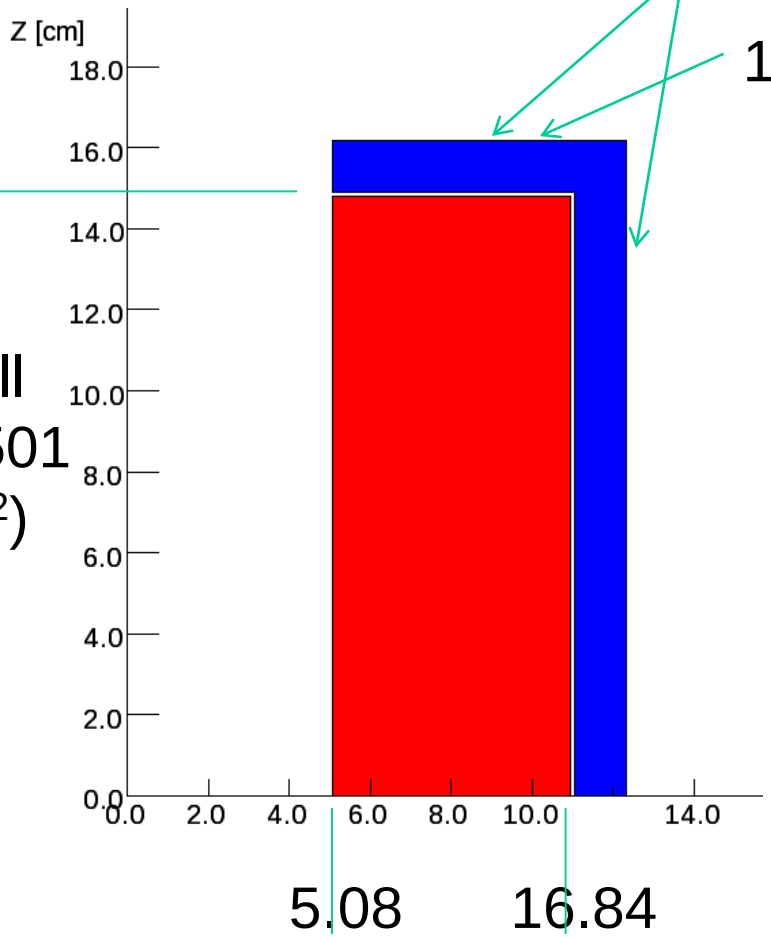
Current polarities:

- Opposite corners have the same polarity
- Adjacent corners have the opposite polarities.



Transport Line Matching Solenoid

Transport Solenoid (preliminary) ----- to be mounted on 2.5” pipe
(Copper winding starts at R=2”)



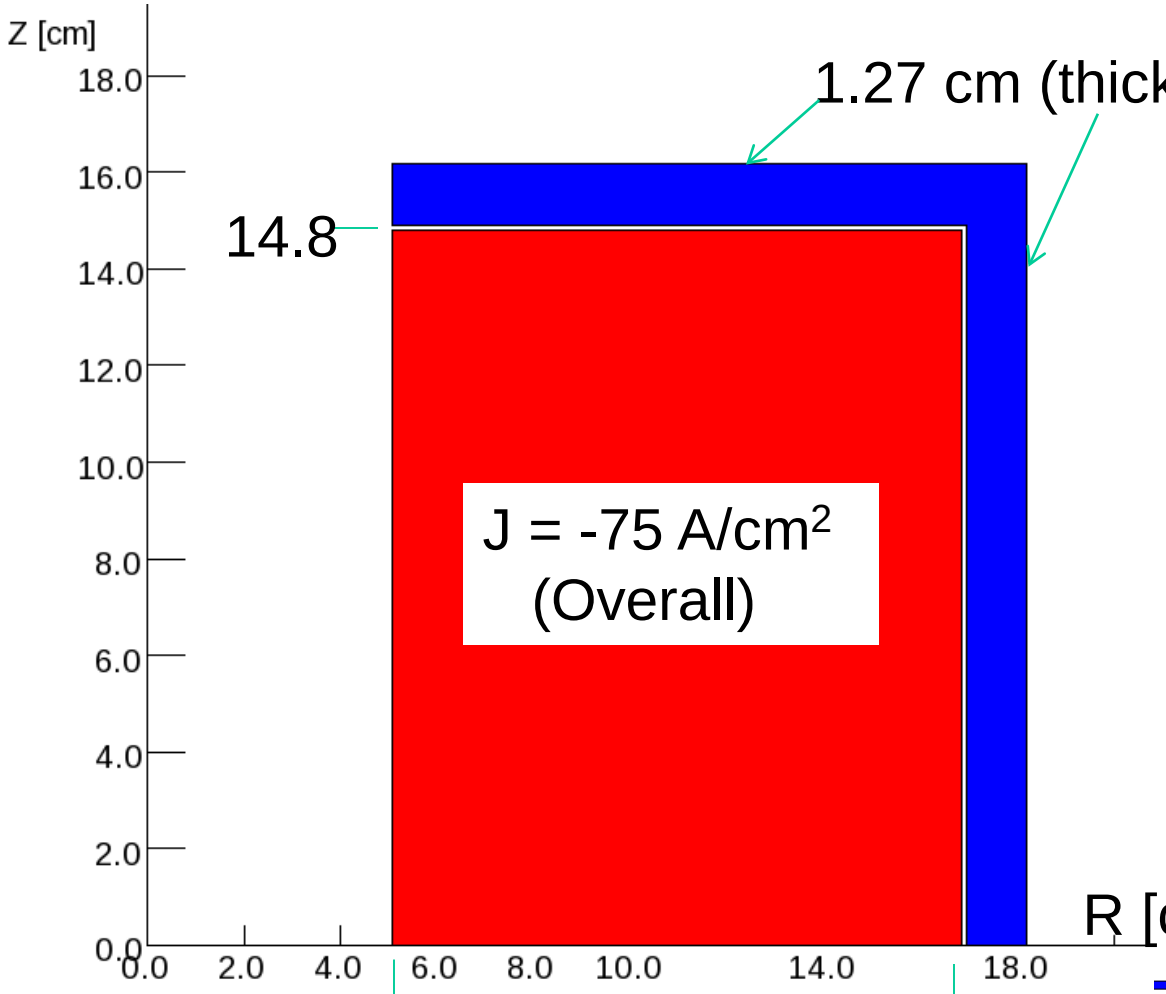
By using #5 square wire
Io = 17.77 A
N = 720
(60 turns along Z-axis;
12 layers along R)
Total 12792.7 A-turn

Bo = 535.4 G
Bz** integral = 7.27E6 G^2-cm

Effective Lm = 29.5 cm

Transport Line Merging Solenoid

Merging Solenoid (preliminary) ----- to be mounted on 2.5” pipe
(Copper winding starts at R=2”)



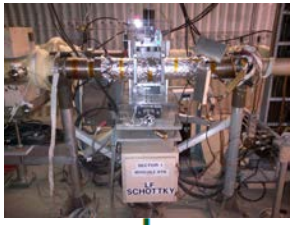
By using #5 square wire
Io = 18.13 A
N = 1140
(60 turns along Z-axis;
24 layers along R)
Total 26112 A-turn

Bo = 1088.39 G
Bz** integral = 3.06E7 G^2-cm

Effective Lm = 30.14 cm

Sector 1 Relocation Meeting 5/22/2015

Sector 1 Instrument Relocation for LEReC



Summary

Champions need to confirm the relocation plan so the *mechanical design* work can proceed.

More details can be found here:
http://www.cadops.bnl.gov/Instrumentation/InstWiki/index.php/Instrumentation_Relocation

Systems in the LEReC Region (40m - 63m) to be Relocated

7 separate mechanical assemblies	New Location	Champion	Mech E.
ARTUS Kickers - Blue V, Yellow H	Sector 2	Drees	
IPMs (Ionization Profile Monitors)- Blue H, Yellow V	Sector 12	Tepikian	Fite
Moveable BPM & LF Schottky, X-Y stage BI1 41m	Sector 1 (closer to Q4)	Brown/Blaskiewicz	
BBQ PLL Kicker stripline (1m) YO1	Sector 1 (closer to Q4)	Marusic	
Triple Purpose Pick-Up on Moveable X-Y Stage YO1 ~42m	Sector 1 (closer to Q4)	Minty/Marusic	
Cable Tray Waterfall			Phillips/Sampson

Systems to be Removed

Electron Detectors (8)	Zhang/Blaskiewicz	
Quad Pick-up (0.25m) YO1 40.1m	Minty	
Luminescence Monitor Cross at B02 53.1m	Minty	
Stochastic Cooling Ceramic Pick-Ups[6-9 GHz] at BI1 67.8m	Mernick	

Beam Loss Monitor Detector Reconfiguration, Sector 1

1 BLM per IPM will move with the IPMs to sector 12 — Drees

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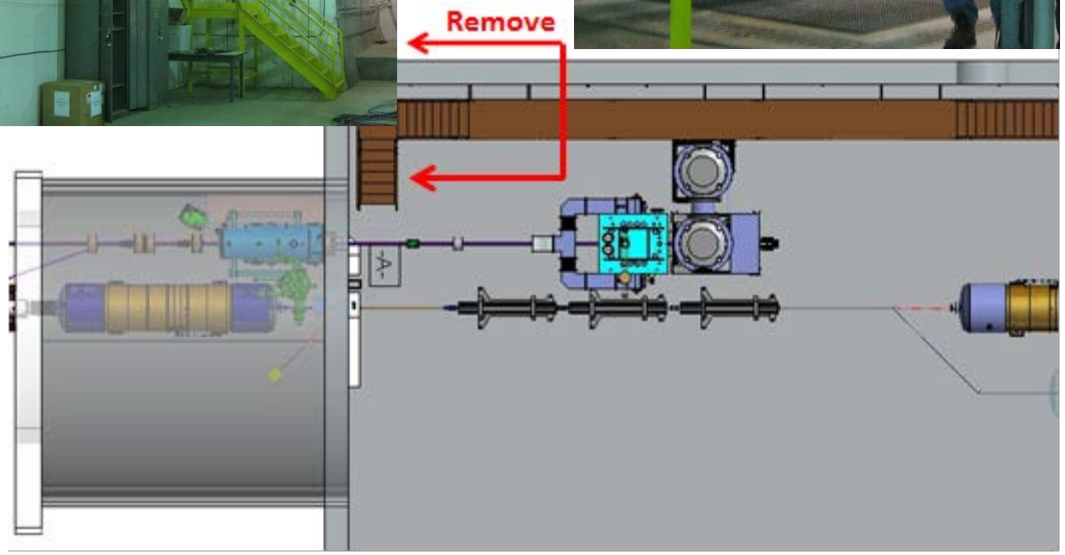
Sector 2 Modifications

LEReC:

- Move cable tray/Modify cable tray
- Move Access Controls Gate
- Remove stairway and part of cross-over platform
- Tunnel Penetrations