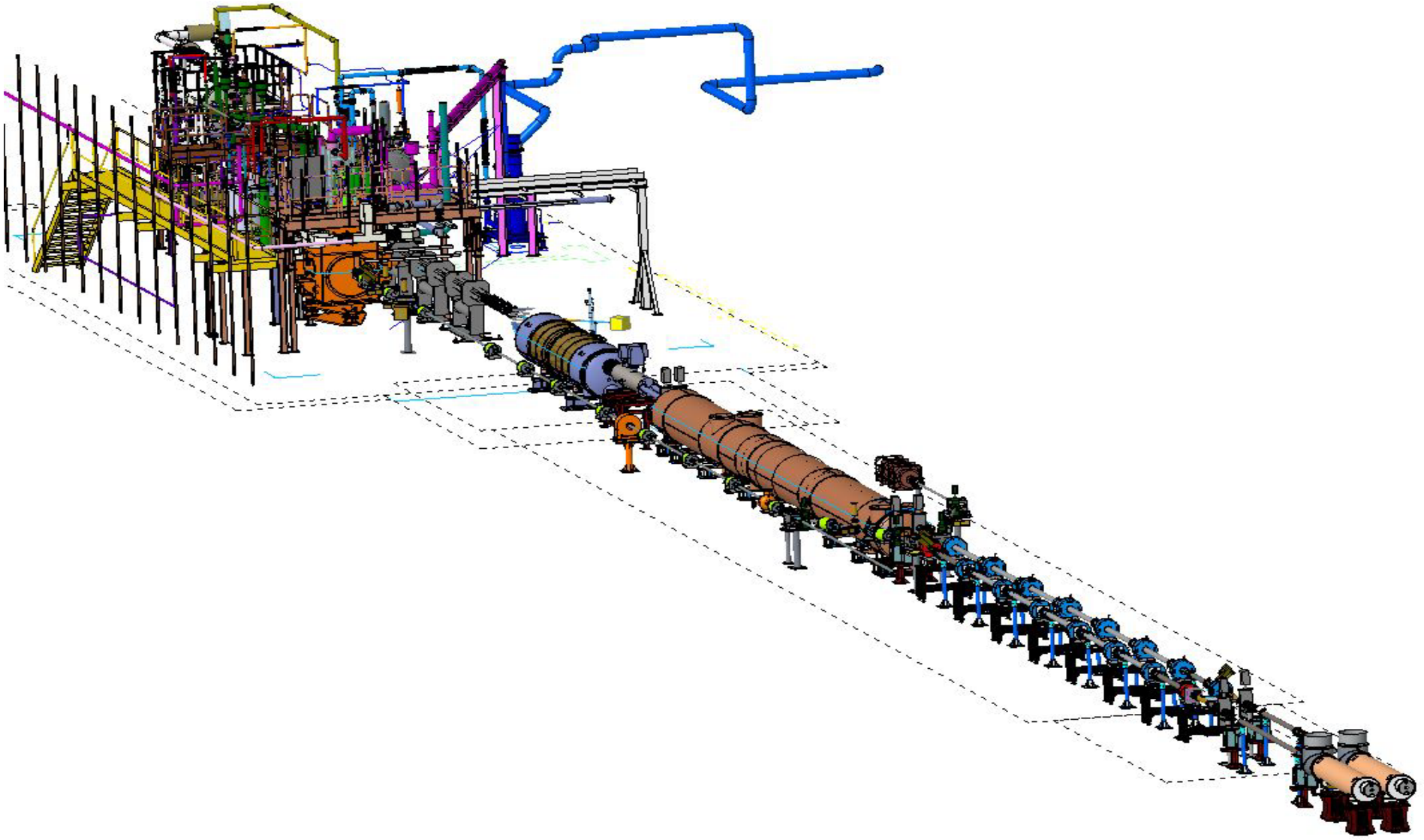
LEReC

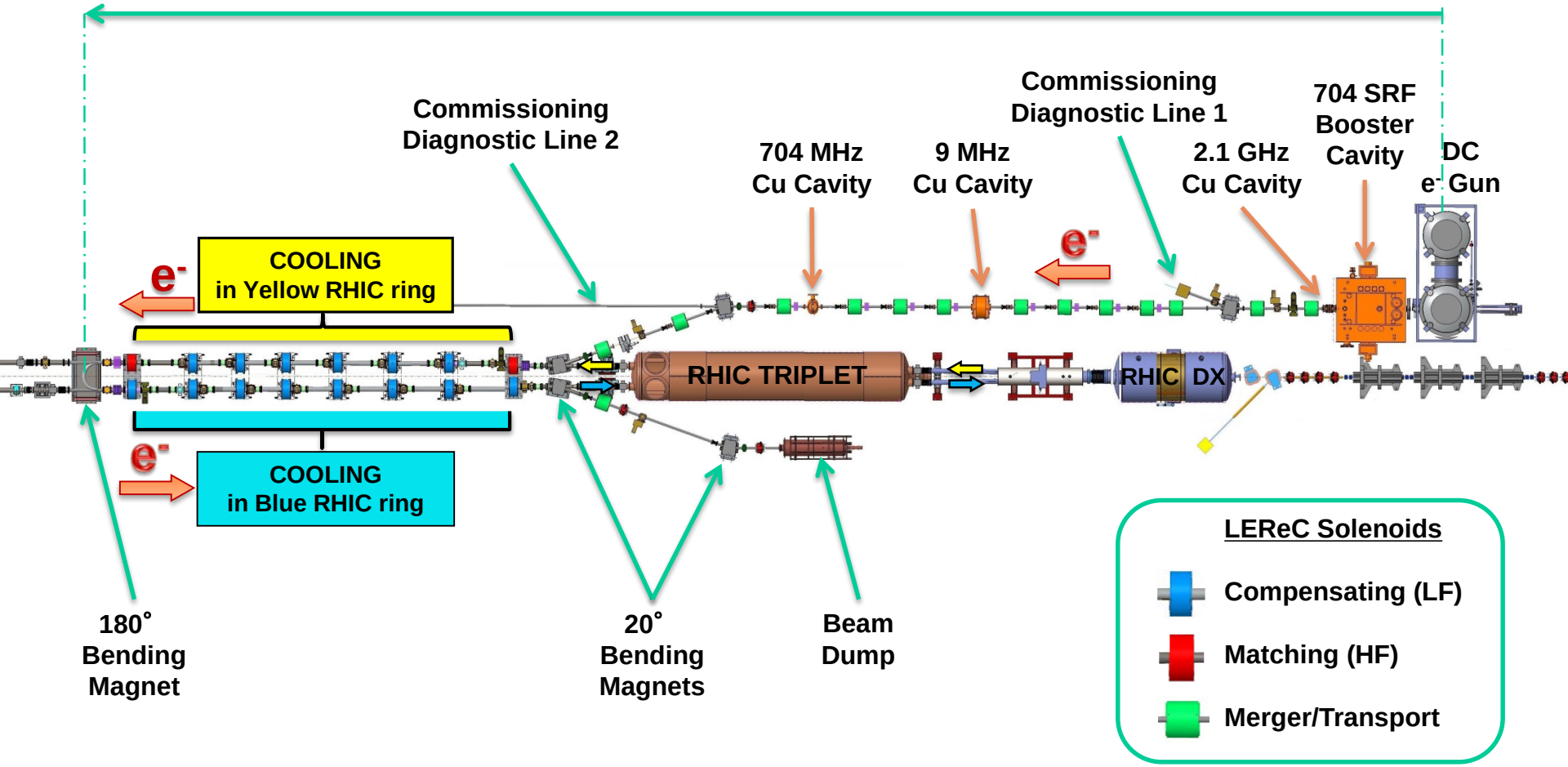


Low Energy RHIC electron *Cooling*

BROOKHAVEN NATIONAL LABORATORY

LEReC layout

63.9 m to IP2



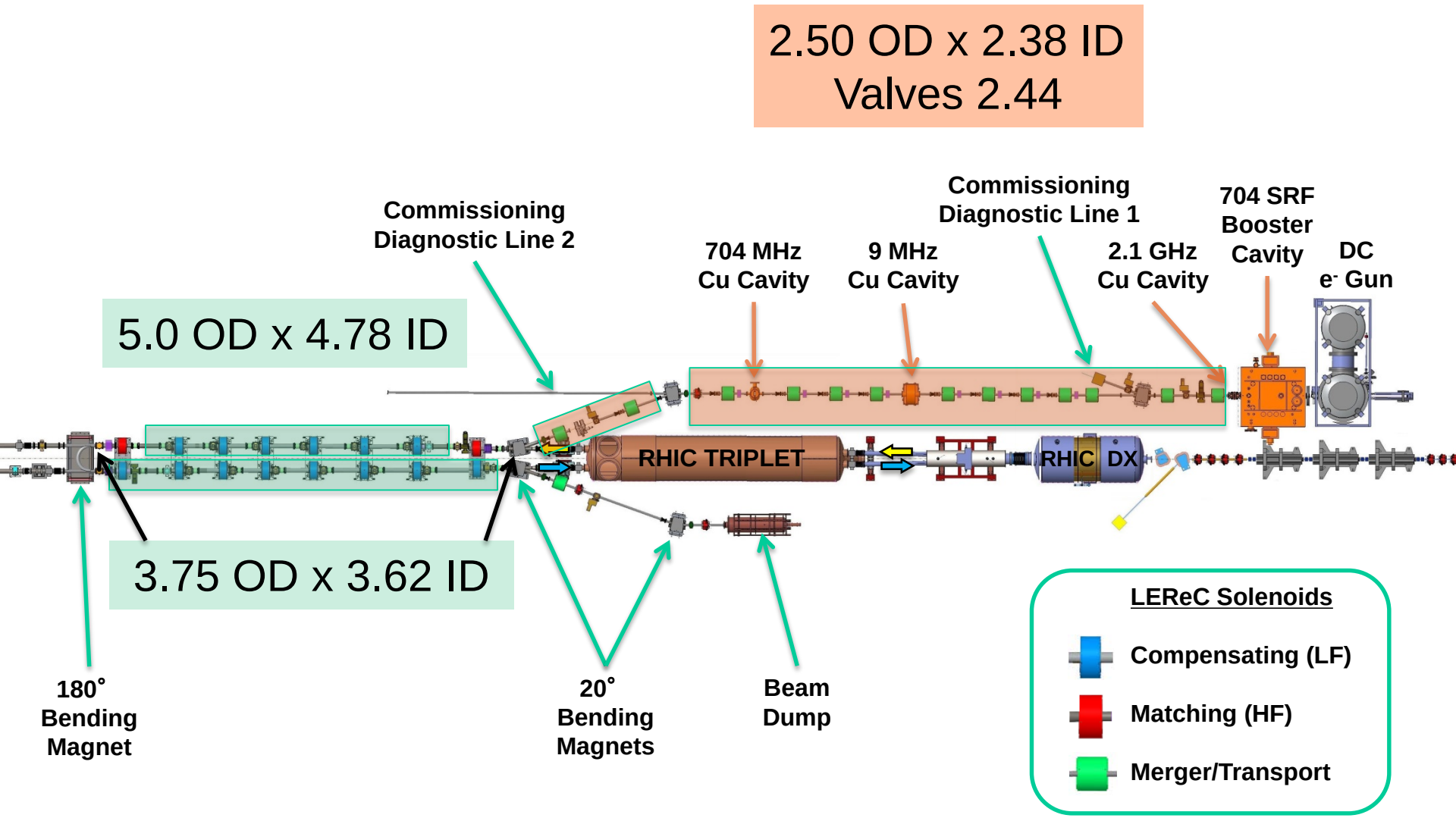
LEReC Meetings

- LEReC Beam Physics & Lattice
- LEReC Cathodes: usually Fridays C.J. Liaw, JT
- LEReC DC Gun: Phone conference with Cornell usually Fridays, bi-weekly C.J. Liaw
- LEReC DC Gun to Booster Cavity: bi-weekly, S. Nayak
- LEReC Booster Cavity Modification, K. Smith
- LEReC Diagnostic Beam Line: weekly, K. Smith
- LEReC warm RF Cavities: Vendor phone conferences, Purchasing, tuner and window design, A. Zaltsman
- LEReC beam diagnostics: weekly, T. Miller

- LEReC transport and cooling beam lines: bi-weekly, JT

Cooling section loose ends, transport instrumentation (DC Gun)

LEReC apertures



Cooling Section Installation

Issues:

1. **Fragile BPM button assemblies**
2. **Slit vacuum chamber leak**

Cooling Section 2016 Installations

Standard Profile Monitor Assemblies (3)

(2 chambers held for drive testing)

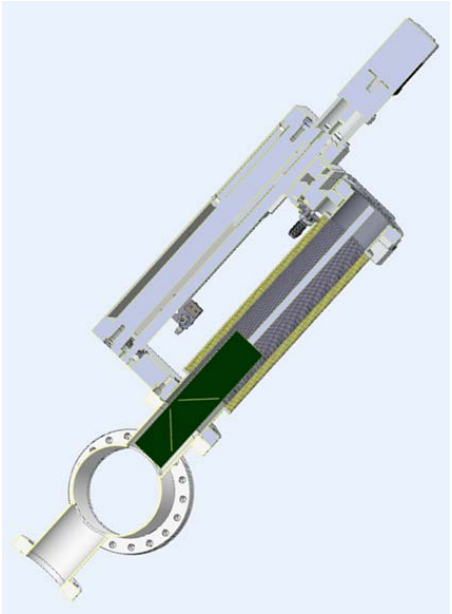
180o Magnet Assembly

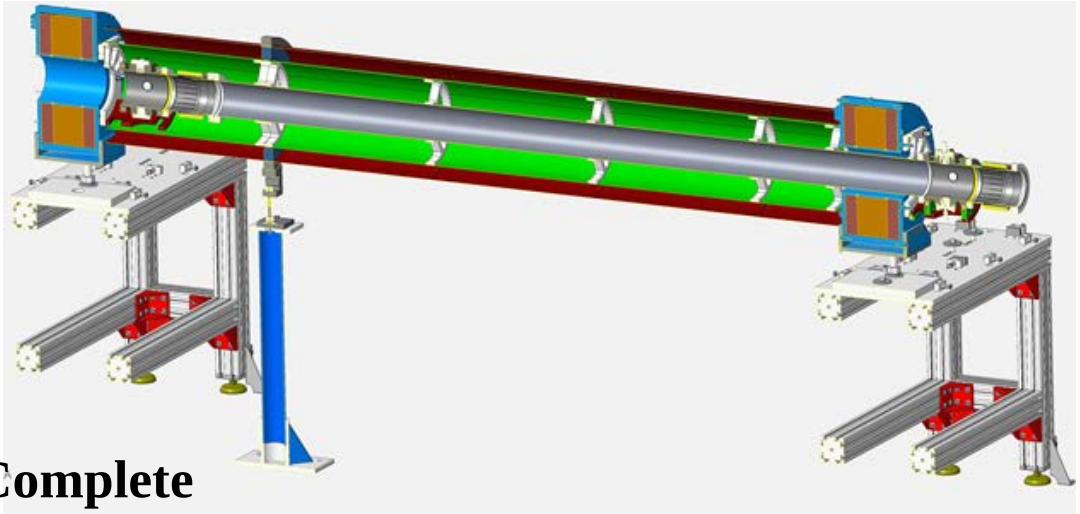
- Magnet (magnetic measured)
- Hybrid PM/ES/BPM Assemblies (2)
- Vacuum chamber (measured)
- Magnetic field monitoring (characterized)
- Stand (non-moving)
- Bellows assemblies

Emittance Slit Assemblies (3)

(Chamber held for drive testing)

Magnet shielding test assembly



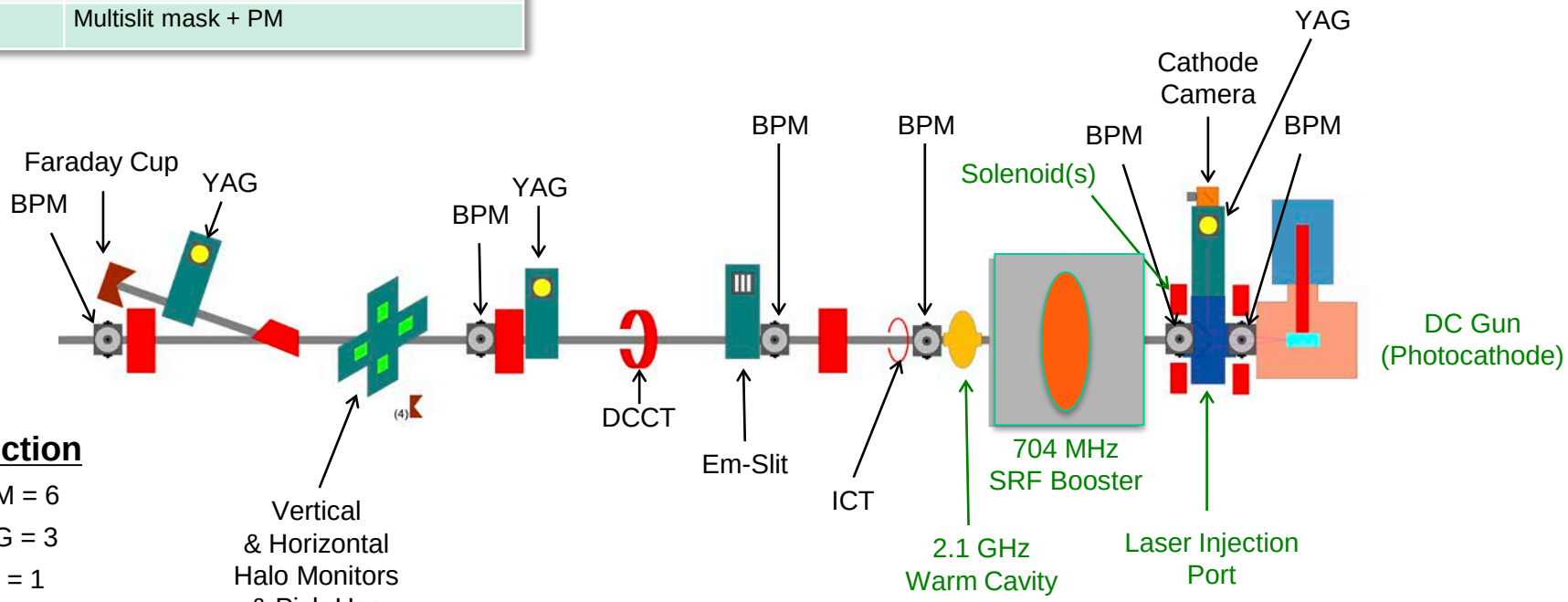


April DOE Review: Test Set-ups Complete

Diagnostics: Gun to Booster Cavity

Parameter	Instrument
Position	BPM System
Current / Charge	ICT, DCCT, Faraday Cup
Profile	Profile Monitors (PM)
Halo	Moveable Halo Detectors
Emittance	Multislit mask + PM

Equipment specifications:
- Solenoids, Dipole, BPM's
- Beam diagnostics hardware and electronics
- Beam line vacuum



Injection

- BPM = 6
- YAG = 3
- ICT = 1
- DCCT = 1
- Emittance Slit = 1
- Halo Pairs = 2
- Faraday Cup (& pick-ups) = 5

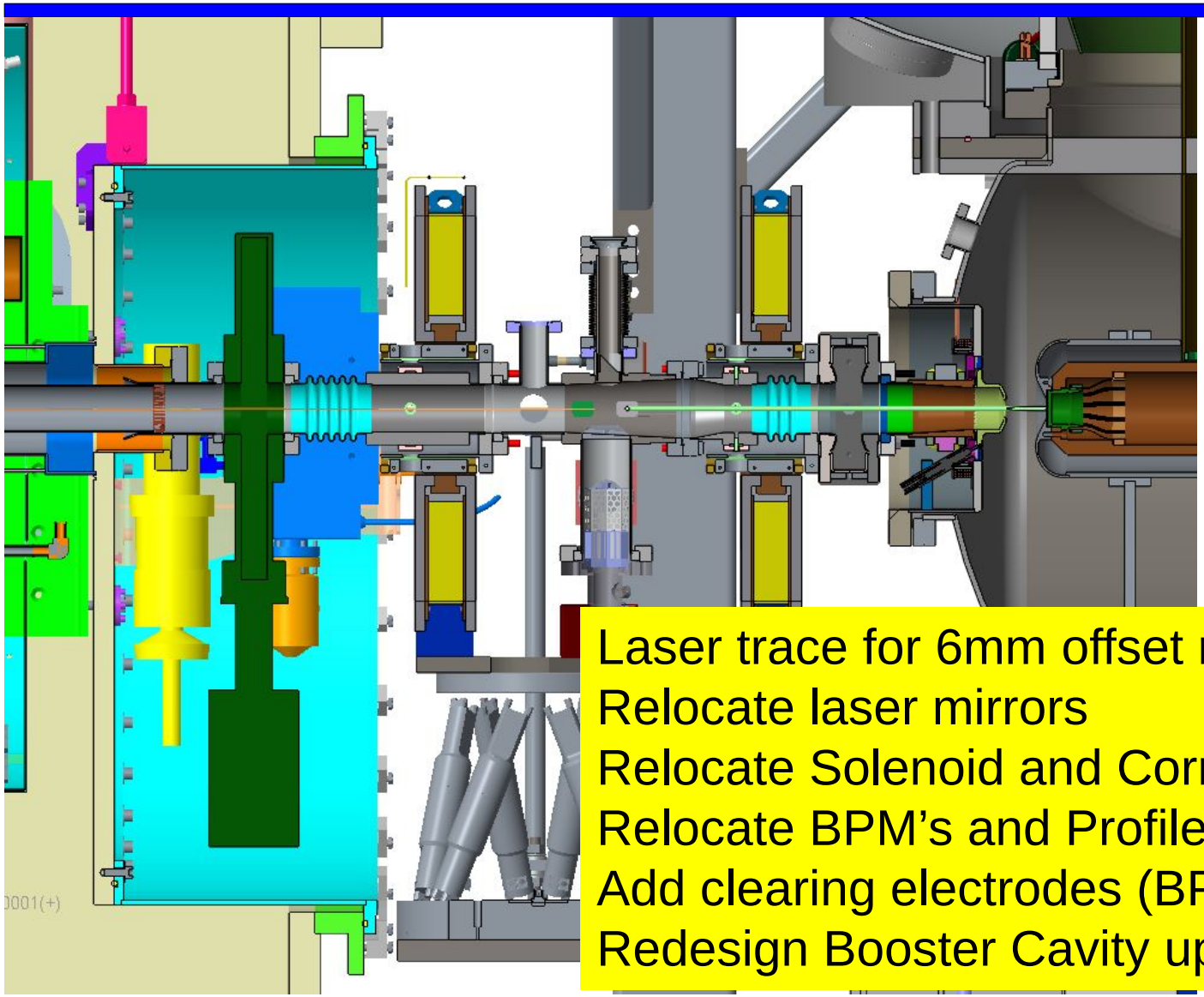
Cornell Layout GtB,
Bake-out to 200C near DC Gun
DC Gun instrumentation:
- **Large Button or ERL Buttons or Striplines??**
- Profile Monitor in Laser Cross
- Cathode Camera in Laser Cross

Transport Line Instrumentation

Analysis and Mechanical Design

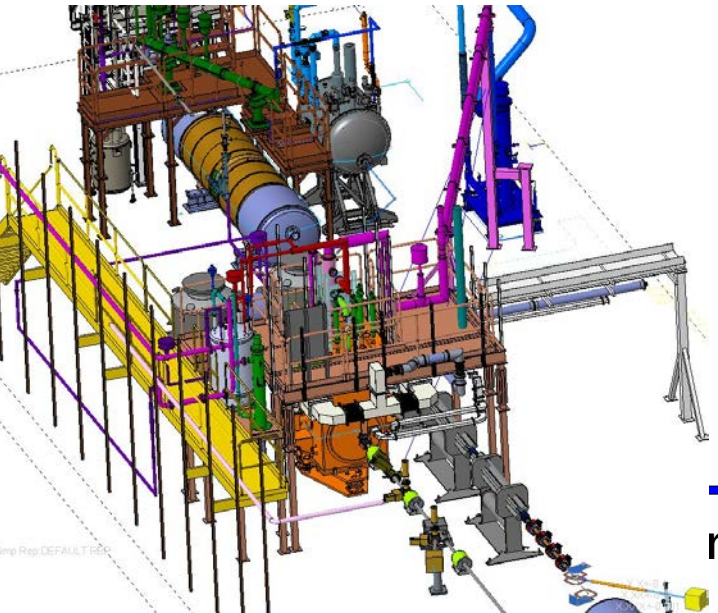
- BPM chamber assemblies and stands (new or ERL buttons?)
- Profile monitor vacuum chambers (ERL drive assemblies)
- Emittance slits (ERL parts?)
- Halo monitor
- Faraday cup for diagnostic line 1
- DCCT and ICT

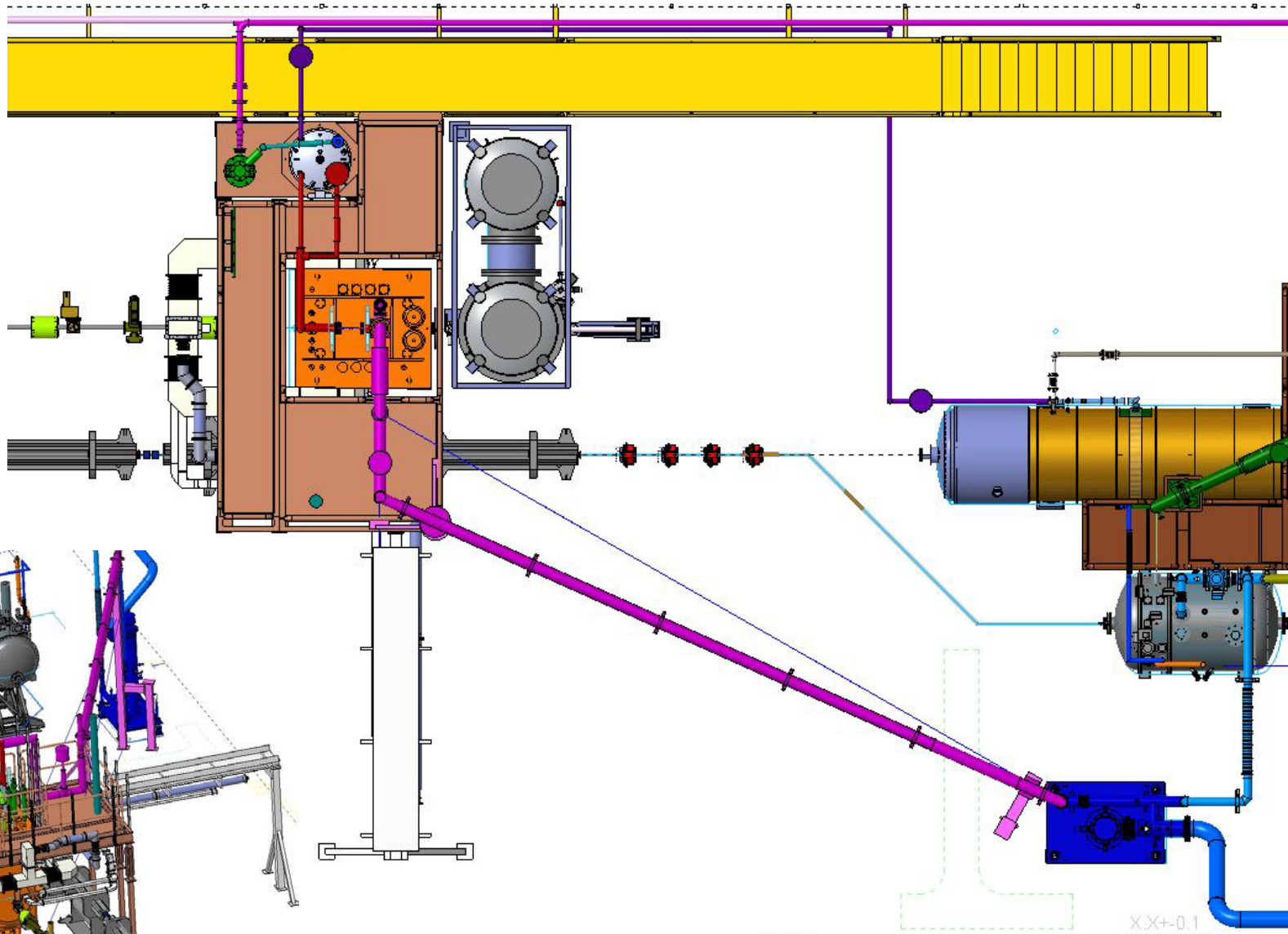
Gun to Booster



Laser trace for 6mm offset redesign
Relocate laser mirrors
Relocate Solenoid and Corrector Magnets
Relocate BPM's and Profile Monitor
Add clearing electrodes (BPM buttons)
Redesign Booster Cavity upstream end

Booster Cavity Installation

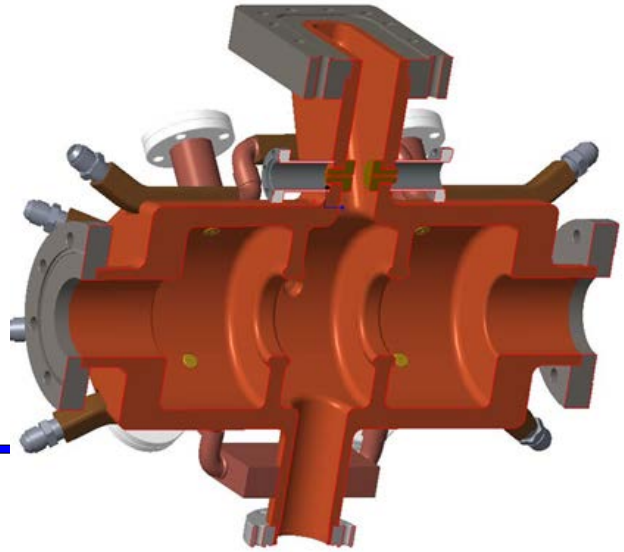




nergy RHIC electron *Cooling*

2.1 GHz Cavity

- **Cavity fabrication contract awarded, first vendor meeting yesterday.**
- **Windows ordered, JLAB testing next week.**
- **Frequency change and tuner section redesign complete, ECN complete**
- **Aluminum cavity testing underway**
- **Tuner design**
- **Vacuum wave guide and wave guide**
- Stand assembly design



704 MHz Cavity

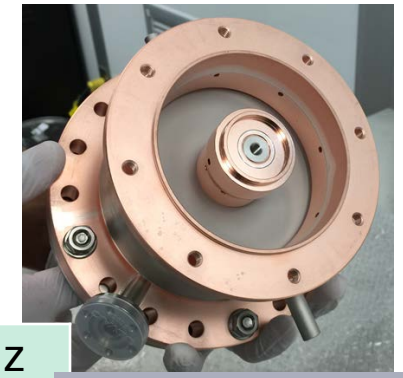
Cavity fabrication requisition prepared

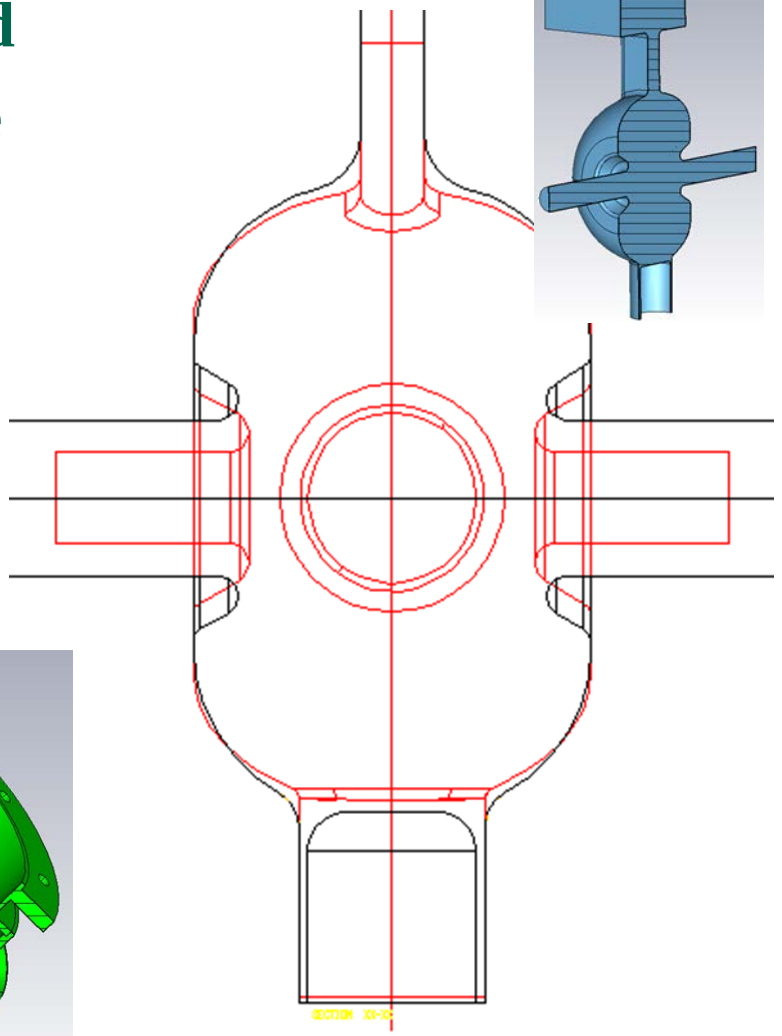
Drawing revision for frequency change

RFP out – Bids due 2/5/15

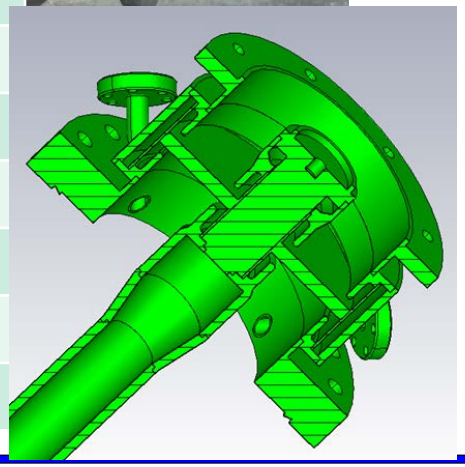
Tuner design

Window design





Frequency	703.6 MHz
No. of cells	1
R_{sh}	5.0 MOhm
R/Q_{acc}	178 Ohm
Cavity voltage	430 kV
Required RF power	37.0 kW
Installed RF power	50 kW



LEReC Cooling Section Design Room

- LF & HF solenoid and 20° dipole magnets fabrication drawings (KH)
- Beam Diagnostics: BPM chamber and buttons (VDM)
- Beam Line 5” bellows with shields fabrication drawings (GW)
- 20° dipole vacuum chamber for impedence review (KH)
- 180° dipole fabrication drawings (KH) Spectrometer magnet (180° dipole) revisions (KH)
- 180° vacuum chamber + large sliding bellows fabrication drawing (KH)
- Beam Diagnostics ES W slit & chamber fabrication drawings (VDM)
- 20° dipole vacuum chamber fabrication drawings (KH)
- Cable tray and penetration drawings and excel sheet (AF)
- Beam Diagnostics: PM vacuum chamber fabrication drawings (GW)
- 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° magnet stand drawing (KH)
- *180° magnet w/hybrid assembly BPM stand drawings (KH) on hold*
- Magnetic shielding drawing and solenoid magnetic measurement test station (VDM) *on hold*
- In tunnel, magnetic measurement “mole” for stray field studies
- 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 SRF booster cavity beam line (JH)

DC Gun to SRF booster cavity laser port, view port, profile monitor (JH)

DC Gun to SRF booster cavity solenoid/corrector magnets (JH)

DC Gun to SRF booster cavity BPM's

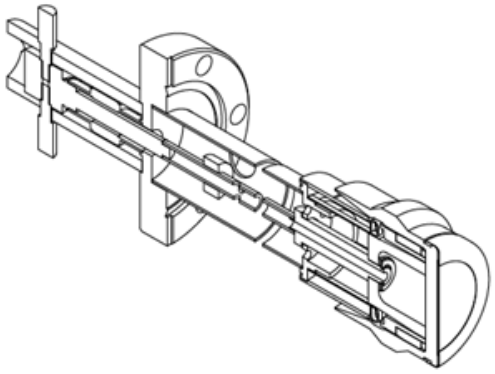
DC Gun cathode insertion drive assembly

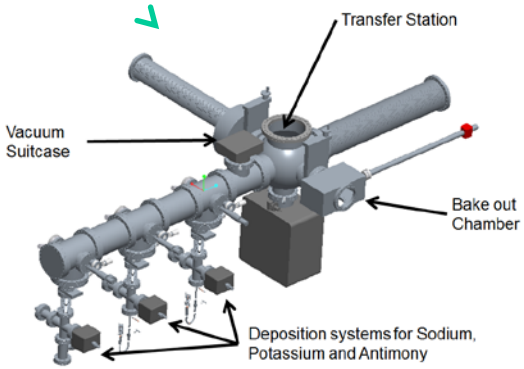
ERL Gun to Booster Cavity Modifications: U/S cathode to beam tube, FPC, D/S beamline & HOM (SS, JH)

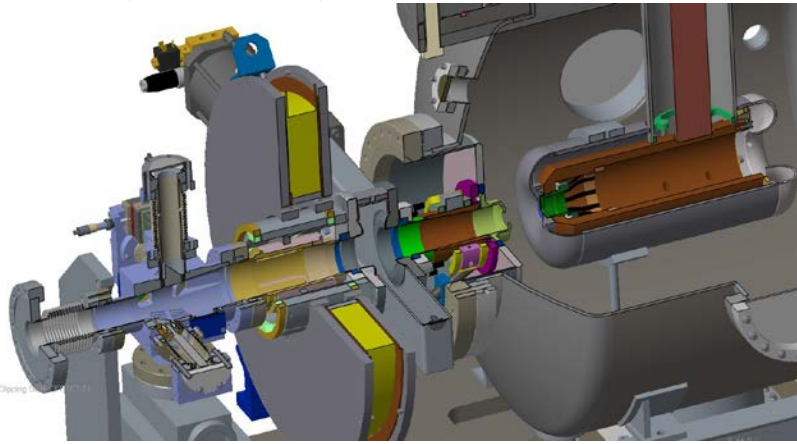
Cathode coating system cathode bakeout vacuum chamber & heater (KH & BM)

Cathode coating system deposition vacuum chamber w/internal cathode transport system (KH)

Cathode coating system transport vacuum chamber – *ferris wheel* (KH & WJ)







LEReC Design Room Other Work

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

Cryogenic system layout (RM)

2.1 GHz warm cavity spec. control drawings (MG)

2.1 GHz warm cavity tuner, wave guide, and warm test model (MG)

704 MHz warm cavity spec. control drawings (SP)

Transport & Merger line layout (RM, KH)

Locate booster cavity, solenoids, BPM's, RF Cavities, PM's, Diagnostic Lines

Transport & Merger Line Solenoids (KH)

Transport Line Solenoid Stands

Transport & Merger Line Bellows and Pump Ports (GW)

Transport & Merger Line CT's (GW)

Transport & Merger Line BPM's (GW)

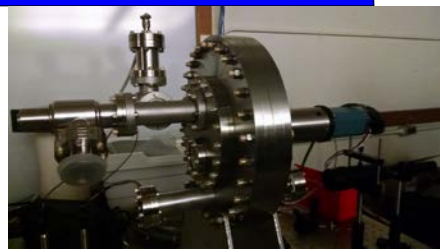
Transport & Merger Line Correctors

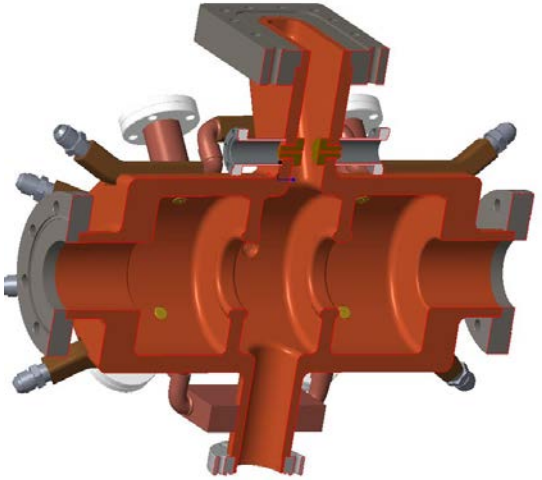
Transport & Merger Line Profile Monitors

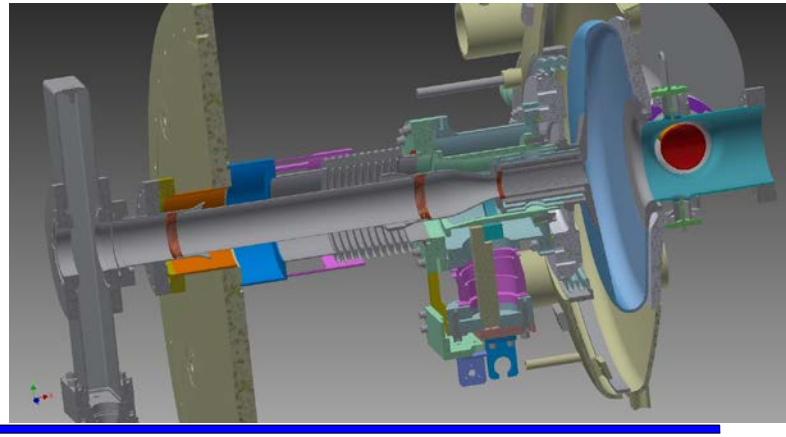
Merger Line Flying Wire

Diagnostic Beam Lines and Components

Kickers, RF cavity, beam dump,

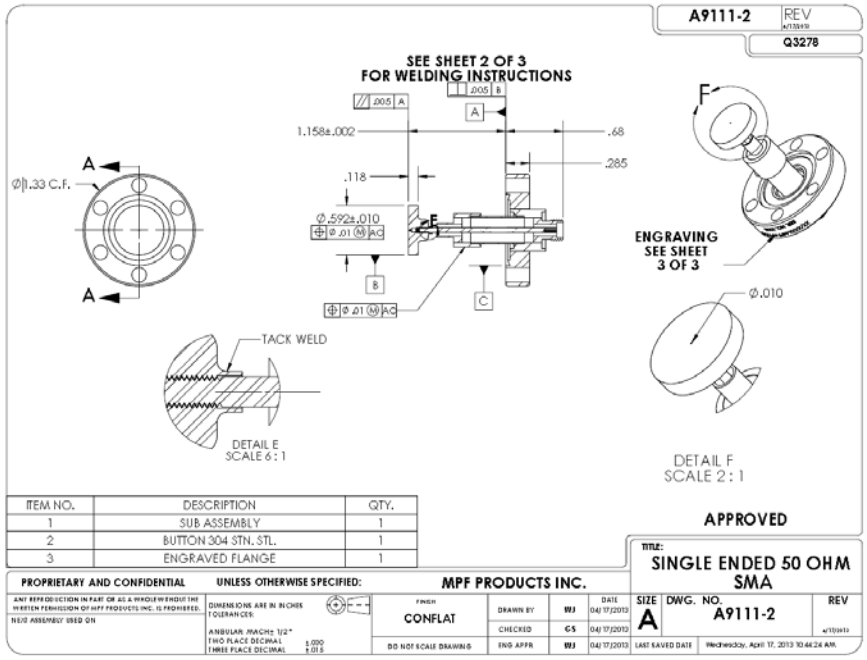


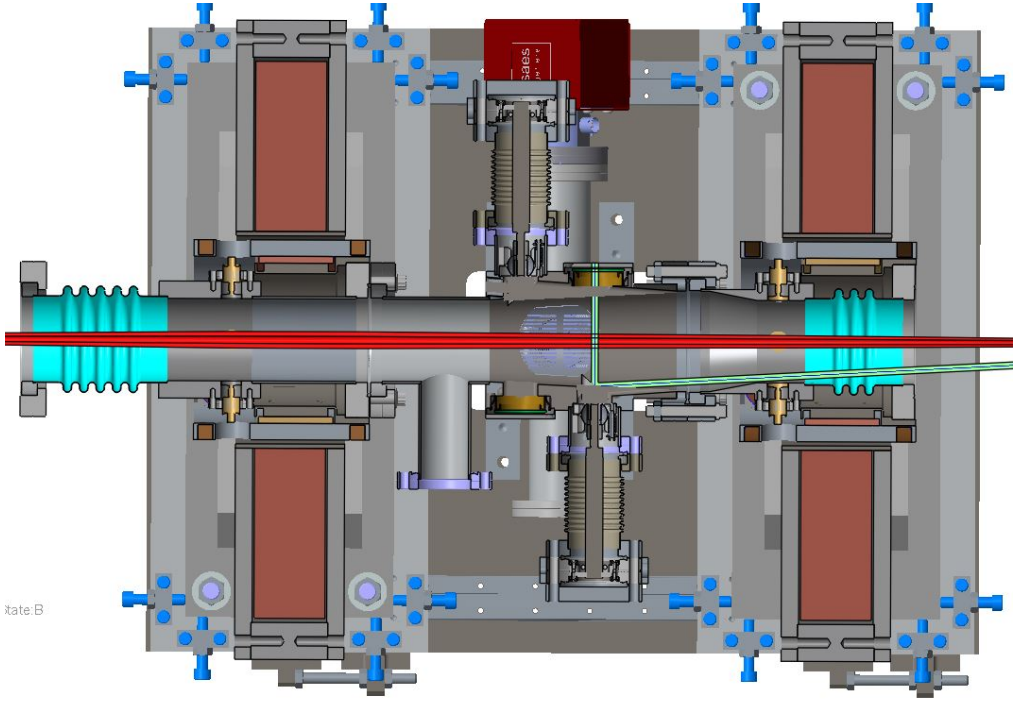




Gun to Booster

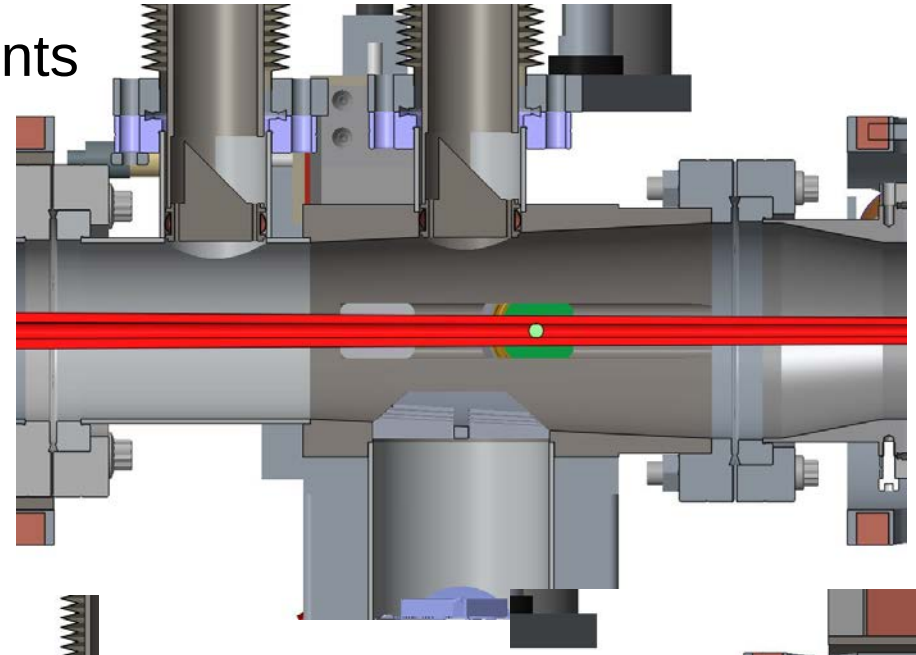
- Dipole Correctors moved offset (D/S) from solenoid center line.
- BPM moved offset (D/S) for solenoid center line.
- BPM configuration defined??
- Quad and Skew Quad correctors (weak) shortened to allow BPM clearance.

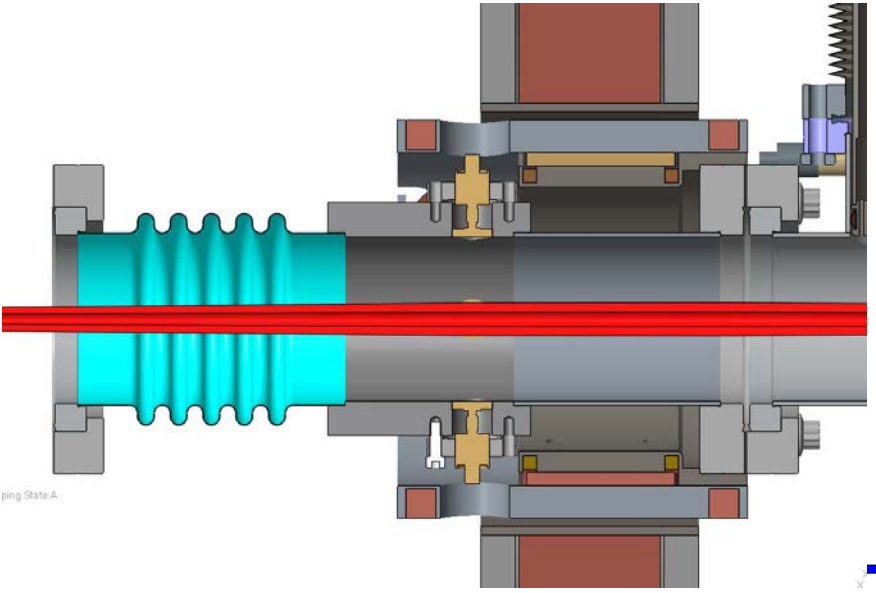


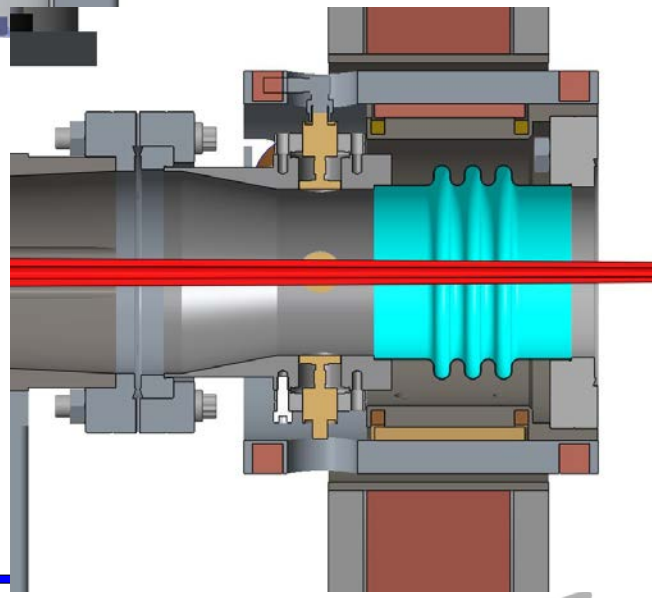


Gun to Booster

Define Laser box requirements
Detail solenoid
Defining correctors

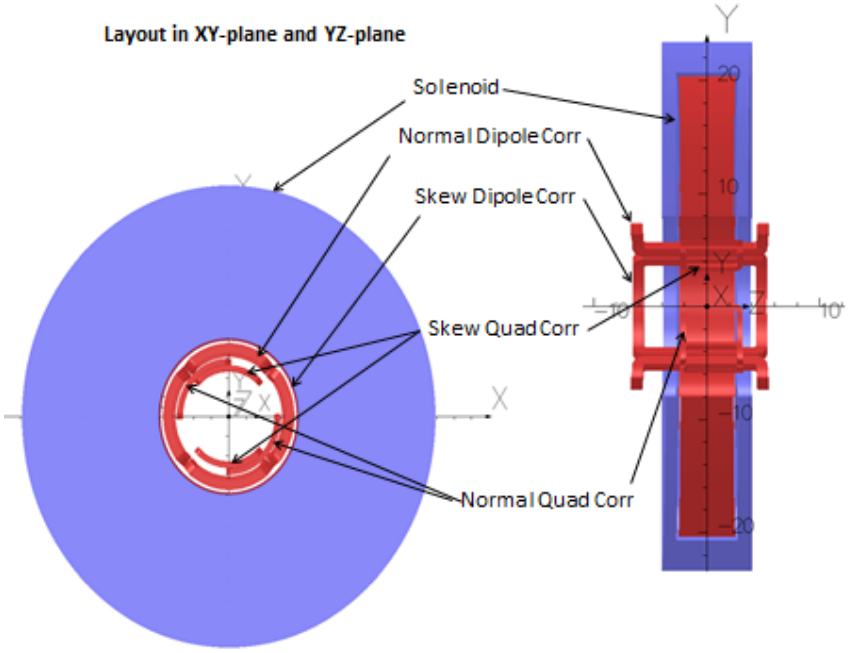






Modified solenoid and correction coils (in DC gun line)

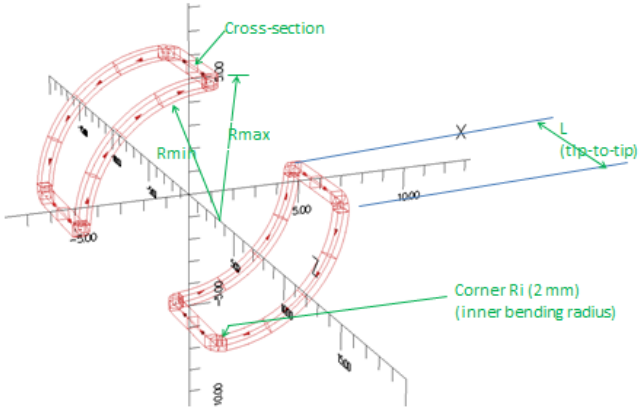
- The lengths of nQ and sQ correction coils are reduced to fit the limited space between BPM port and flanges
- The radii (R_{min}, R_{max}) of correction coils are also modified according to the mechanical layouts
- The inner radius of solenoid is increased from 7.5cm to 8cm (3.150")
- Centers of Correction coils are shifted from solenoid center by ~0.4 to ~0.6 cm



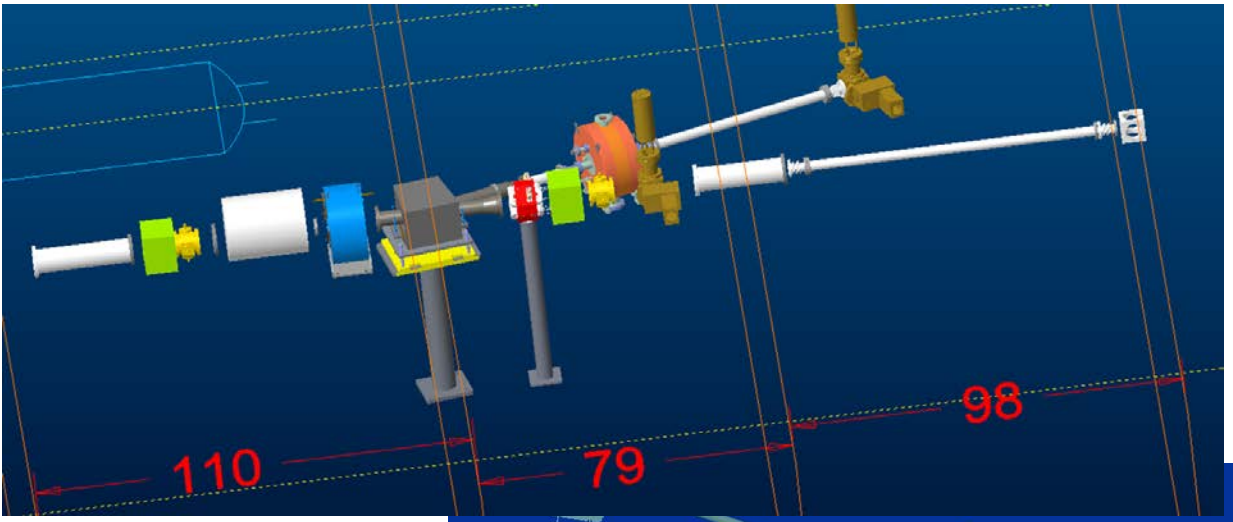
Parameter List: Solenoid and Correction-Coils

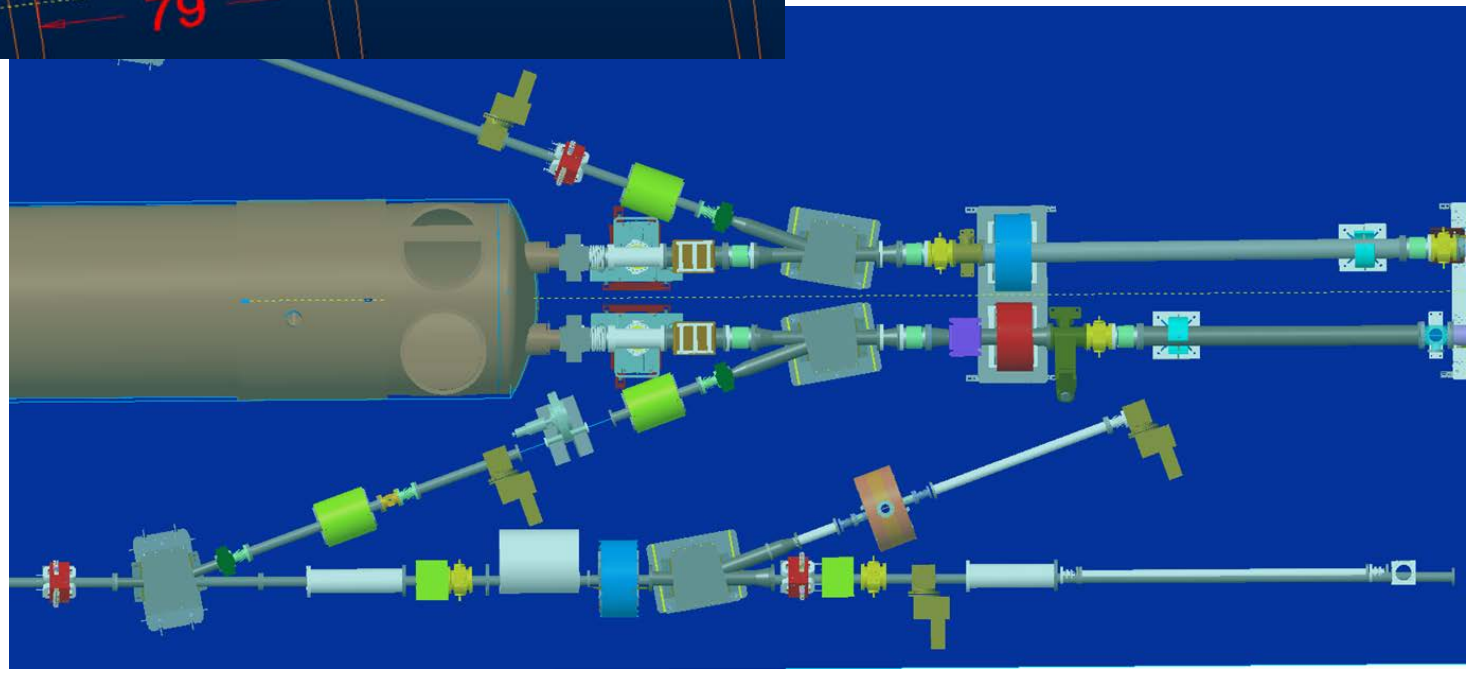
	Rmin/Rmax (winding)	Total length L	Cross-section	Corner Bend Ri	Amp-turn per coil	Field Integral
Solenoid	8.0 / 20.4 (cm)	5.06 (cm)	12.4x5.06 (cm^2)	(N/A)	4705.8 (A-turn)	1.603E6 (G^2-cm $\int Bz^2dz$)
S-Quad Corr.	5.0 / 5.5 (cm)	5.6 (cm)	0.5 x 0.5 (cm^2)	0.2 cm	18 (A-turn)	3.23 (G/cm)-cm
N-Quad Corr.	5.62 /6.12 (cm)	5.6 (cm)	0.5 x 0.5 (cm^2)	0.2 cm	18 (A-turn)	3.23 (G/cm)-cm
S-Dipole Corr.	6.22 / 7.22 (cm)	12.2 (cm)	1.0 x 1.0 (cm^2)	0.2 cm	60 (A-turn)	86.94 G-cm
N-Dipole Corr.	6.22/ 7.22 (cm)	12.2 (cm)	1.0 x 1.0 (cm^2)	0.2 cm	60 (A-turn)	86.93 G-cm

Example of Parameters (nQ-Correction) – **(ref. next Table)**

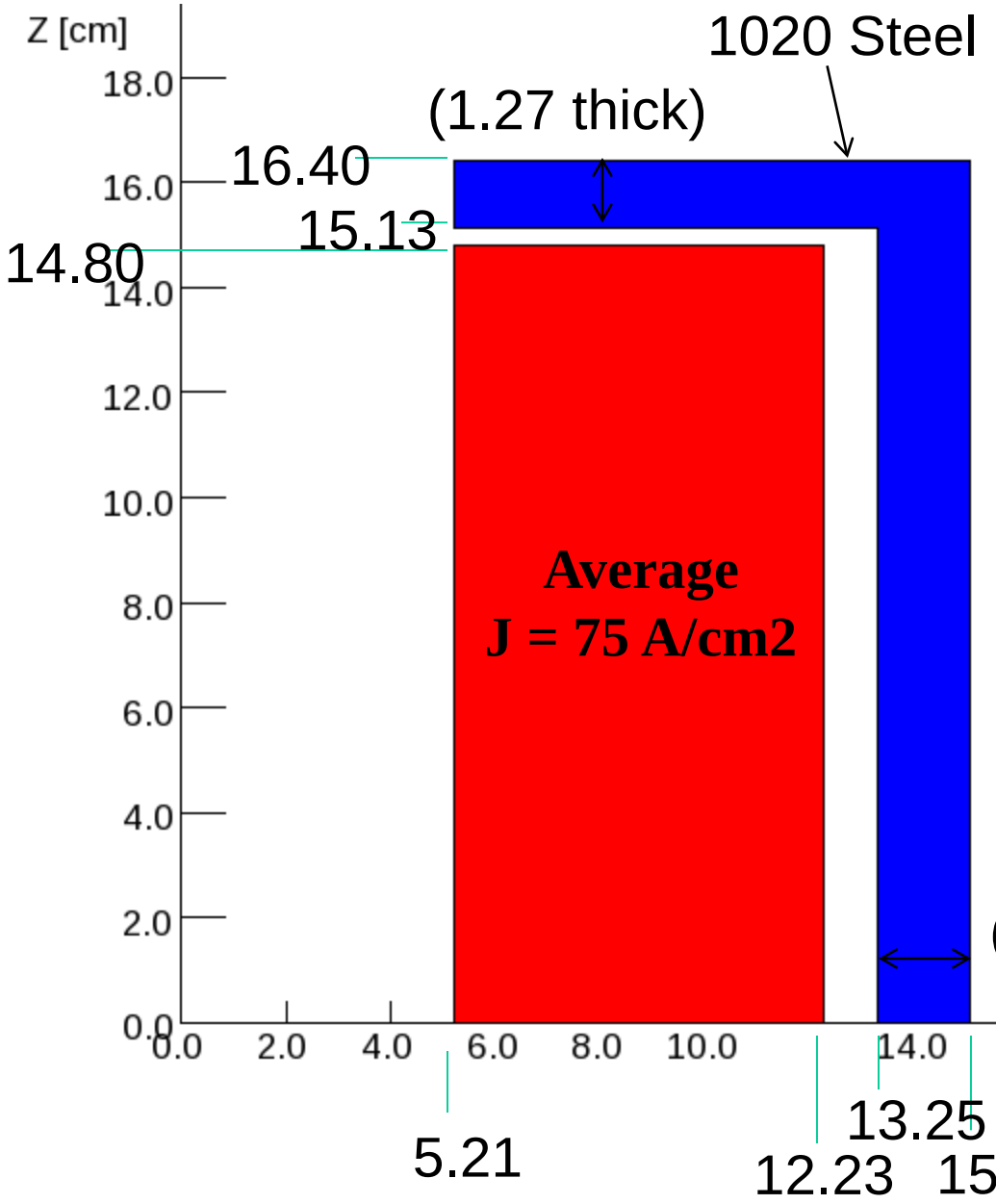


Diagnostic Line - 2017





12/15 Revised Transport Solenoid



Parameters:

Conductor: #5 square, solid wire

Total ampere turn:

2 x 7792.2 = 15,584.4 AT

(**plus some safety margin**)

Center field B = 647.3 Gauss

Integral Bz^2 = 1.081E7 G^2-cm

(Req. 1.080E7 G^2-cm)

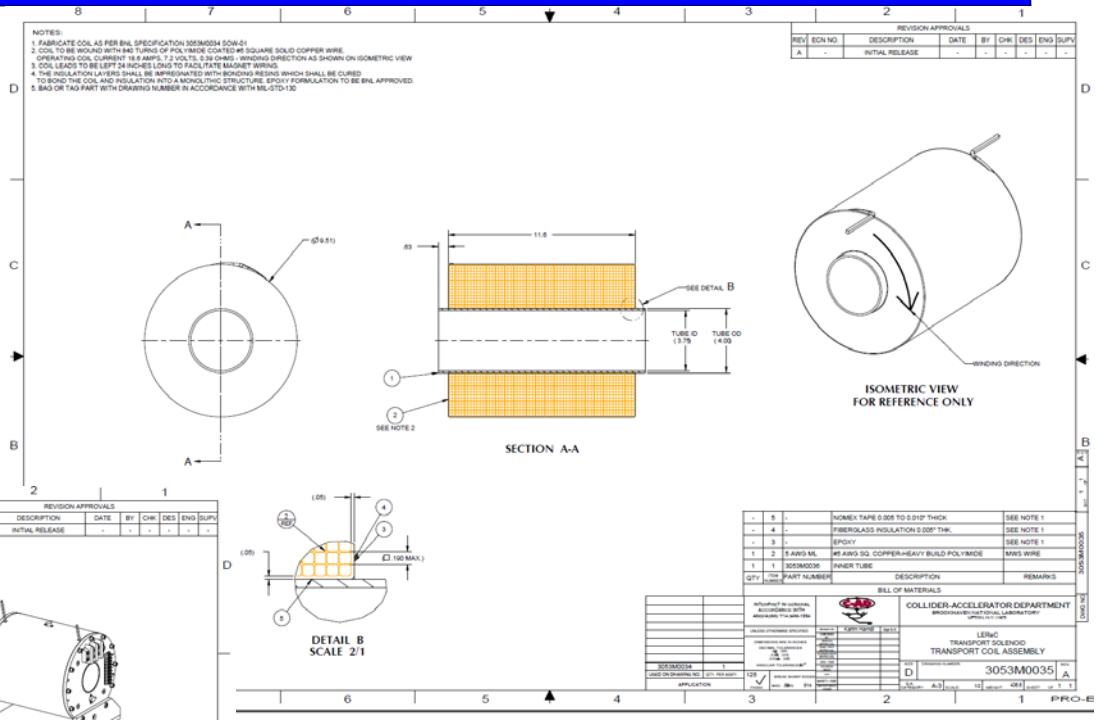
12/15 Revised Transport Solenoid

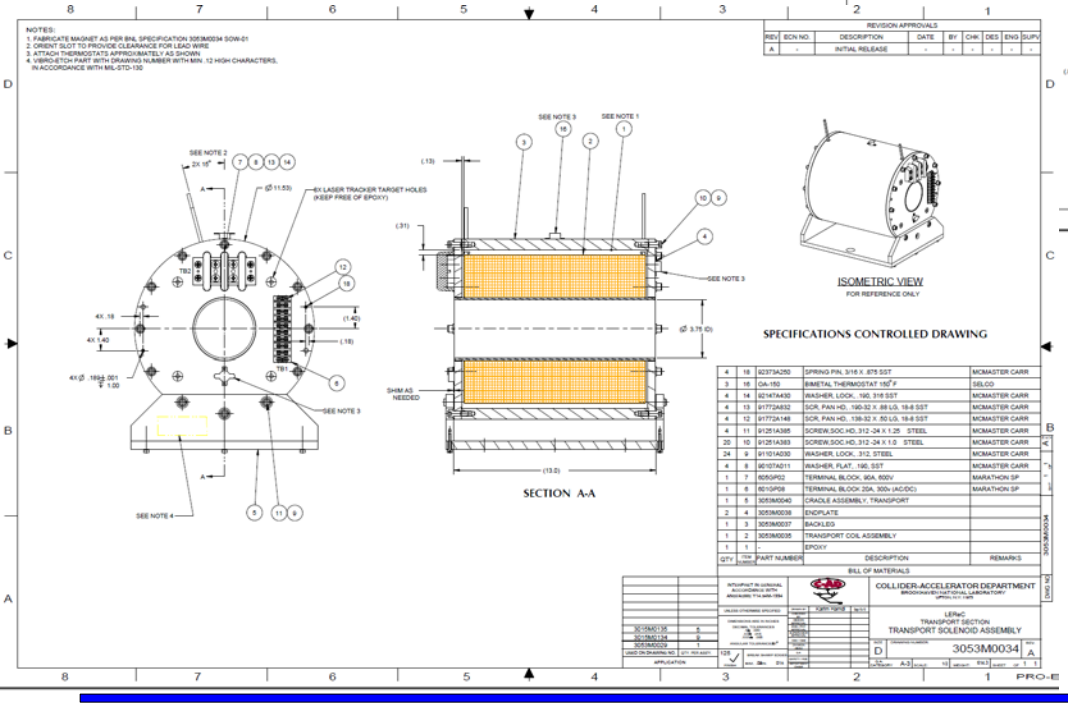
840 Turns, #5 square copper conductor.

18.6 A, 7.2 V, 0.39 Ohms

Will use for both Merger and Transport Solenoids

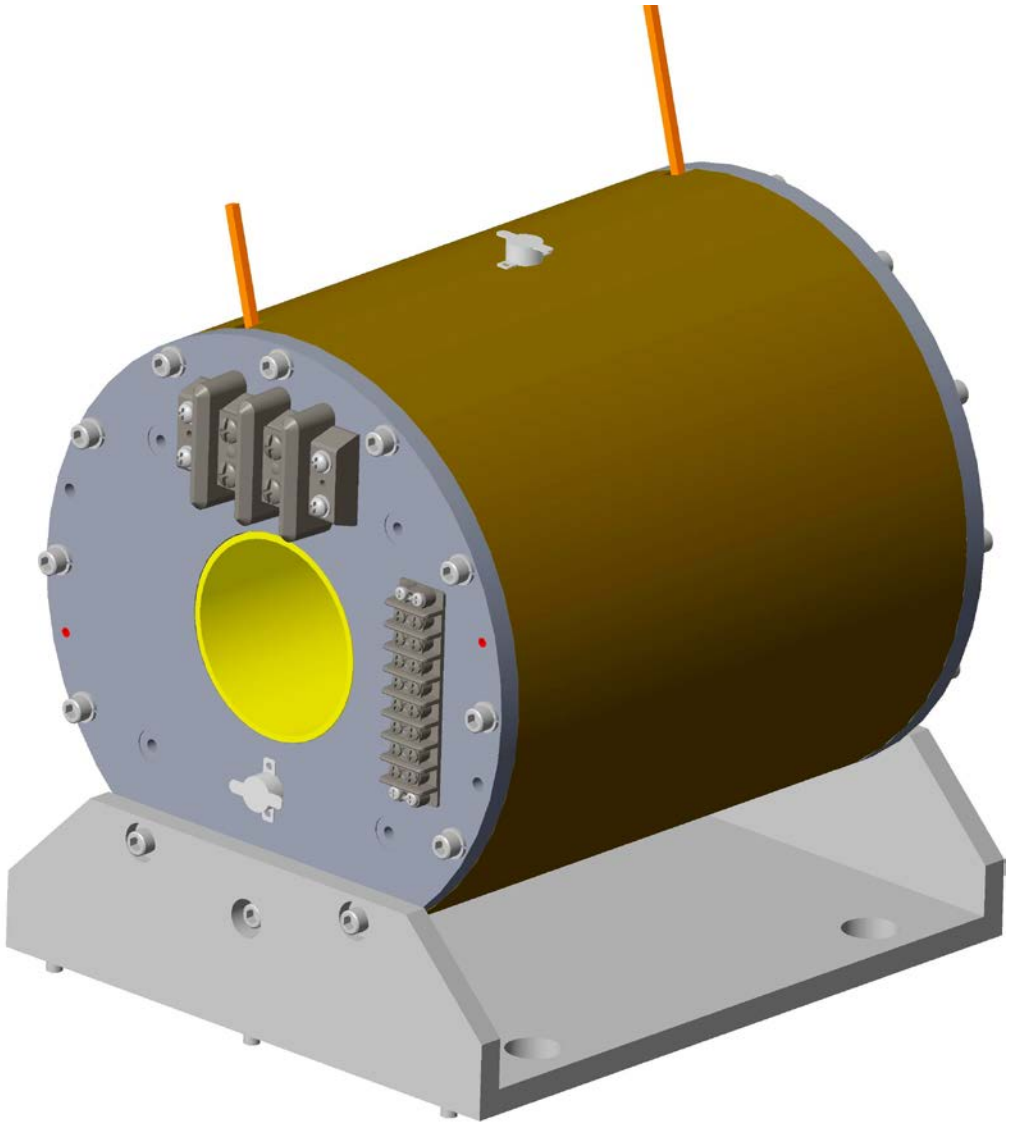
Magnets designed for 2.5” pipe.

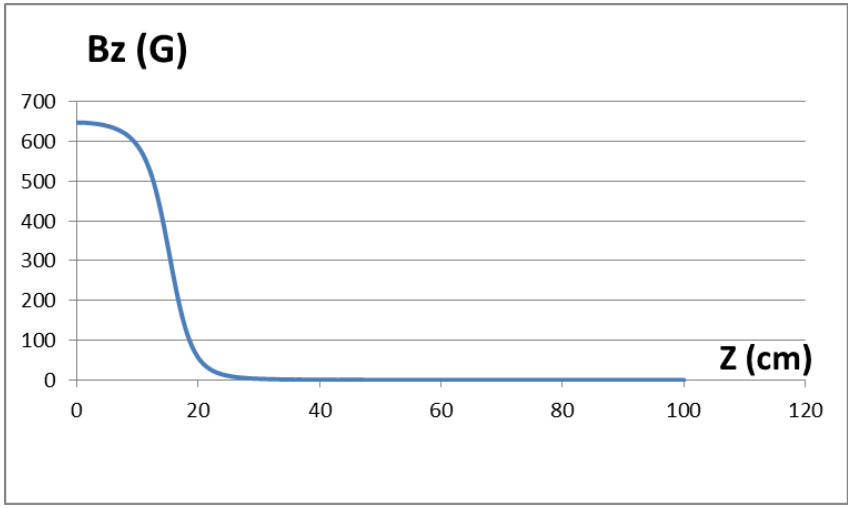


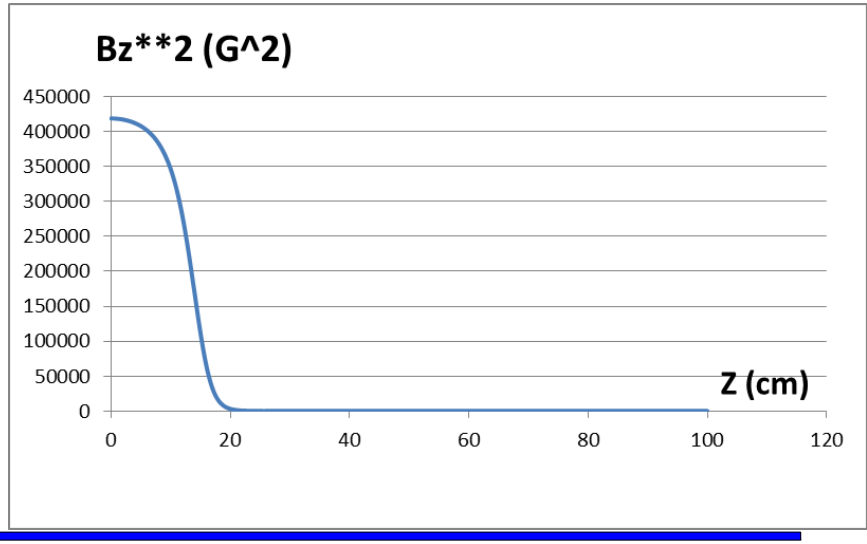


- **Need 13, will this number be changed? when**
- **Diagnostic line solenoid – same spec’s?**

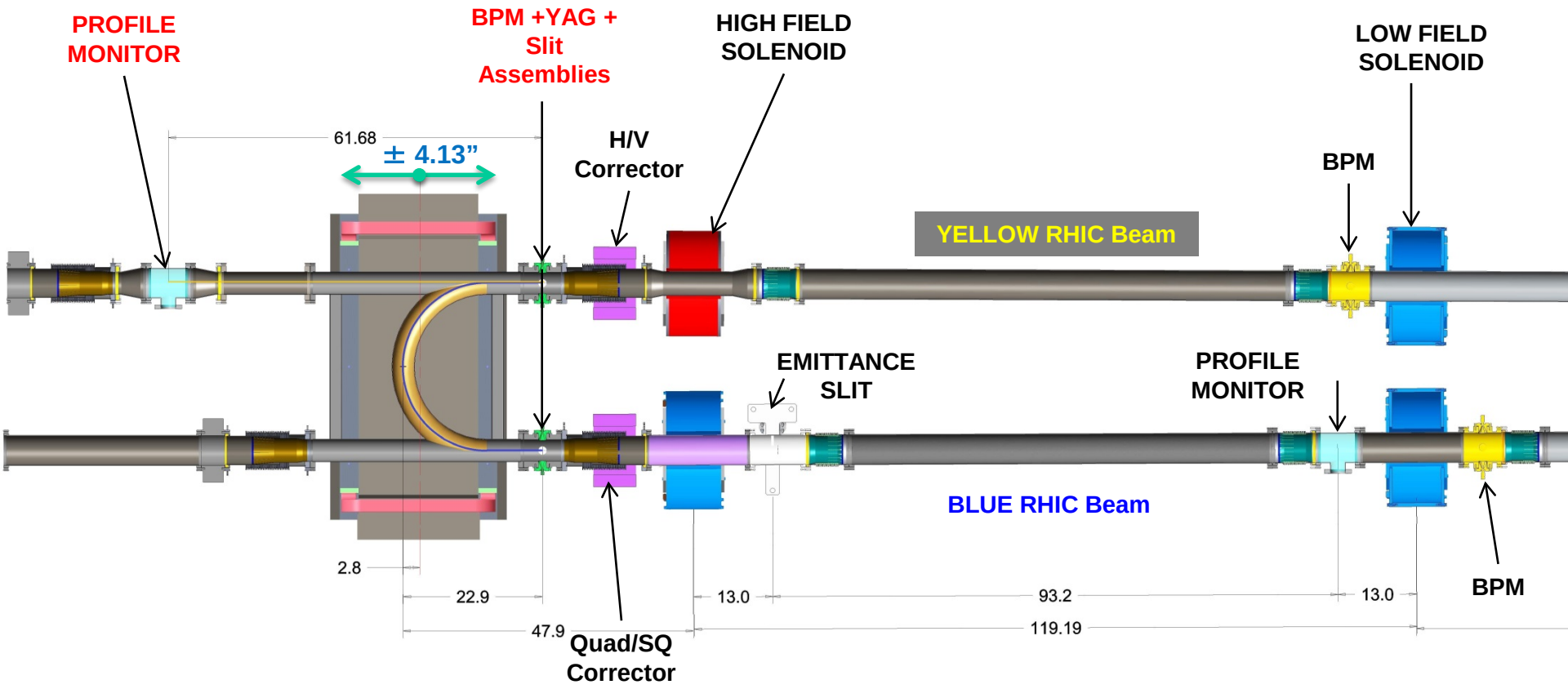
12/15 Revised Transport Solenoid





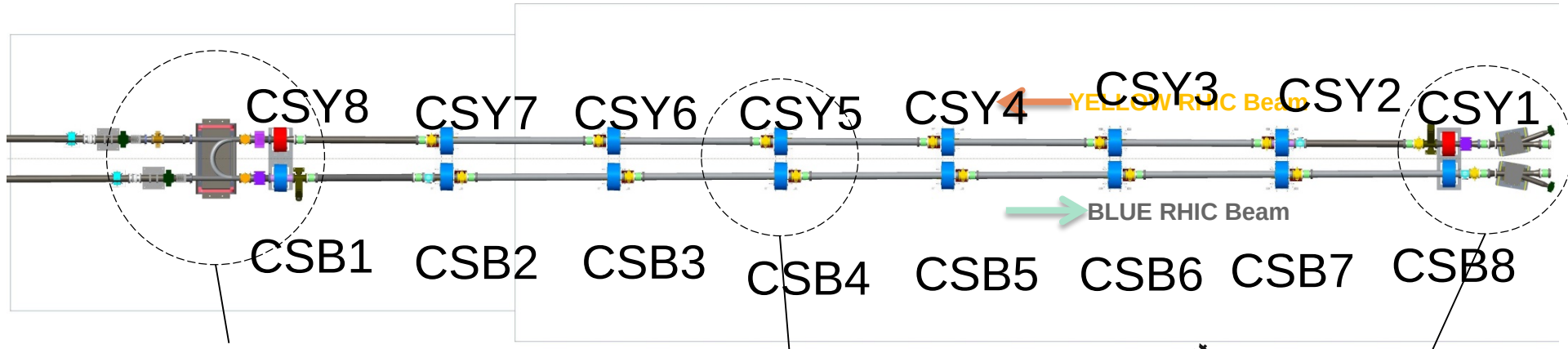


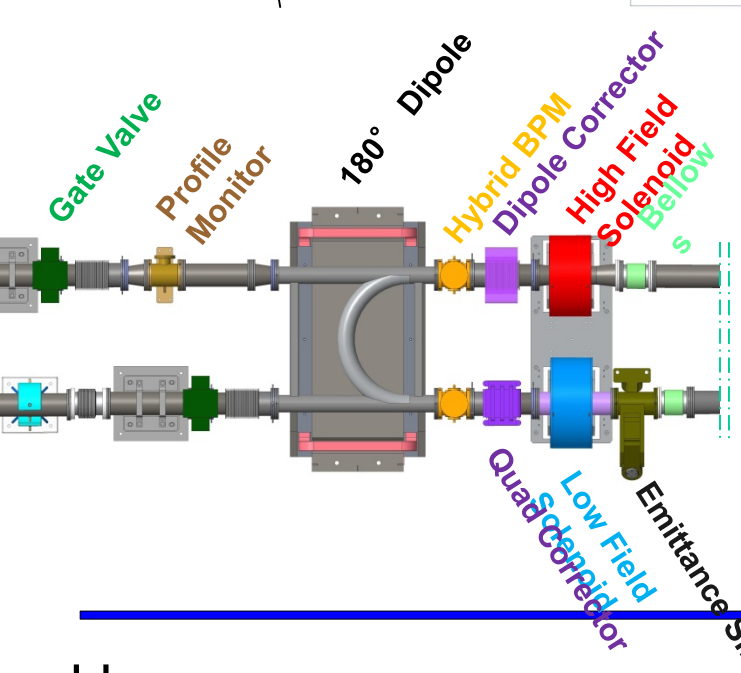
180º Dipole Magnet Neighborhood 2016

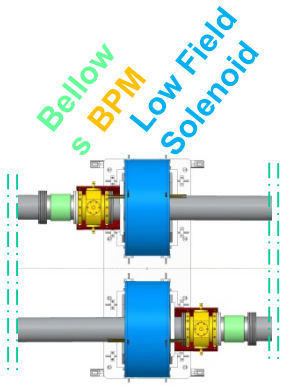


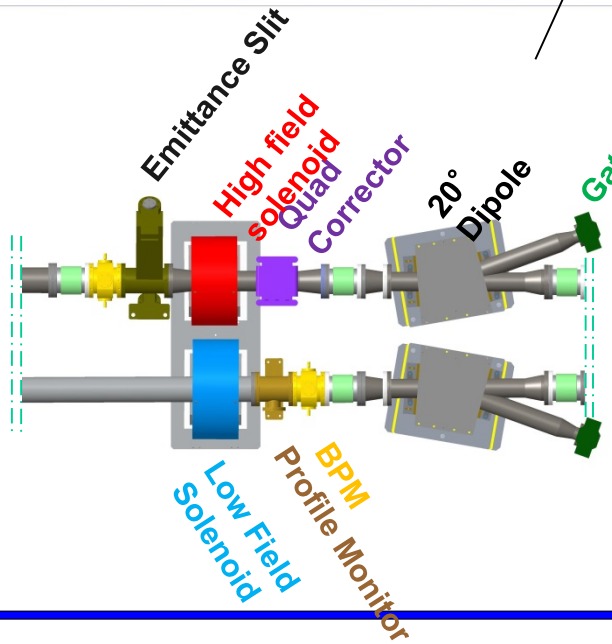
kh

COOLING Section Solenoids









kh

9/16/15
Phase 1 Block 7.vsd

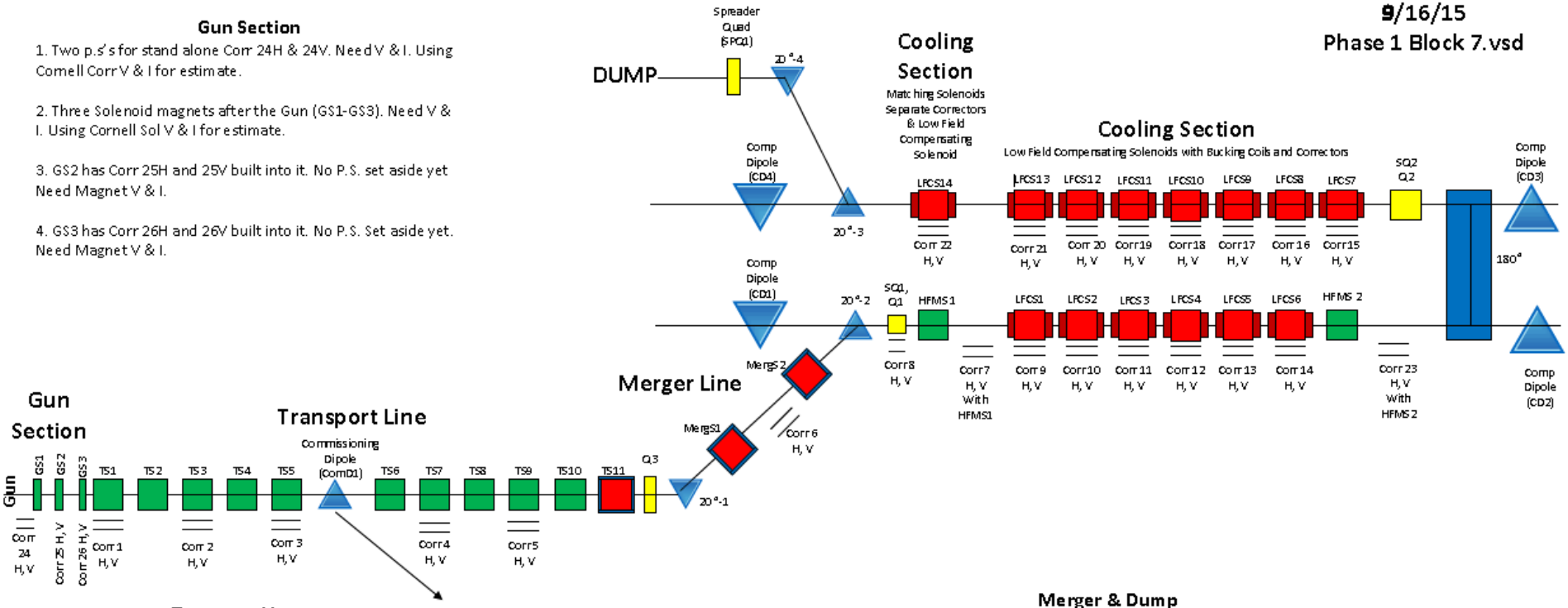
Gun Section

1. Two p.s's for stand alone Corr 24H & 24V. Need V & I. Using Cornell Corr V & I for estimate.

2. Three Solenoid magnets after the Gun (GS1-GS3). Need V & I. Using Cornell Sol V & I for estimate.

3. GS2 has Corr 25H and 25V built into it. No P.S. set aside yet Need Magnet V & I.

4. GS3 has Corr 26H and 26V built into it. No P.S. Set aside yet. Need Magnet V & I.



Transport Line

1. 11 p.s's for 11 Sol magnets (TS1-11) . Need V & I, For now using 11-250V 50A GEN ps's. Need V & I. TS1-10 are 500G. TS11=1.1kG.

2. 10 Corr p.s.'s for only 5 Corrector (Corr1-5) magnets. Need V & I, For now using ten ERL 15V 10A SHIM p.s.'s. Do we need more than 5 Corr magnets? Are they in the correct location?

3. 1 p.s. for one Commissioning Dipole (ComD1). Need V & I, For now using ERL extraction dipole with ERL ps which is Kepco BOP GL 50V 20A

4. 1 p.s. for one Quad, Q3, Use ERL 15V 10A SHIM ps, taking quad from ERL.

Notes

1. Don't forget we need FWD's and for kepcos we might need blocking diode to make it unipolar, however this may not be true because we may want kepcos to work bipolar to get rid of remnant field
2. Tell Bob V about new 30V 25A ps's we added because LFCS14 is running as a single magnet and update D Phillips racks.
3. I really need V & I for TS1-11 and MergS1-S2.
4. TS2 & TS5 are replaced by 2 chicanes (zig zags) for Phase II.

Merger & Dump

1. 2 p.s.'s needed for two 1.1kG Solenoid Magnets (MergS1-2). I~20A?, V is ~146.8V? I don't know what I should be for 1.1kG. Use 200V 50A Gen ps
2. 2 p.s.'s needed for one Corrector magnet (Corr 6). Need V & I, For now using 2 ERL 15V 10A SHIM p.s.'s.
3. 1 p.s., ERL Kepco BOP GL 50V 20A for four 20° magnets in series. 20°-1&2 in Merger Section. 20°-3&4 in dump section.

Cooling Section

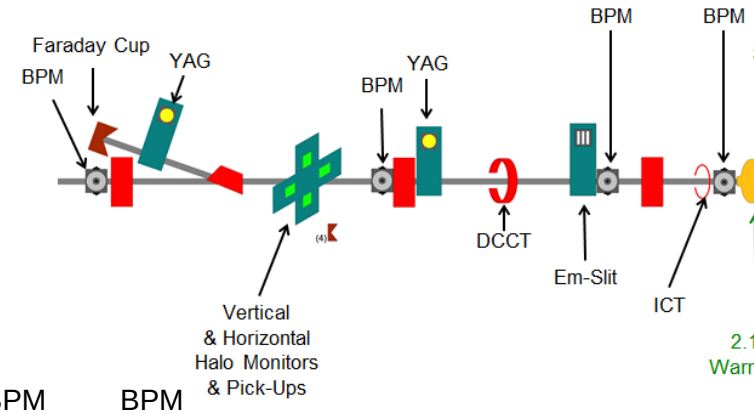
1. 1 p.s. 150V 22A for LFCSc1-6 cores 6 in series
2. 1 p.s. 150V 22A for LFCSbc1-6 buck coils (2x) 6 in series
3. 28 p.s.'s 20V 2A BIRA MCOR for Correctors, Corr 9-22 with LFCS magnets.
4. 1 p.s. 150V 22A for LFCSc7-13 cores 7 in series
5. 1 p.s. 150V 22A for LFCSbc7-13 buck coils (2x) 7 in series
6. 1 p.s. 30V 25A for LFCSc14 core single
7. 1 p.s. 30V 25A for LFCSbc14 buck coils 2 in series from one magnet
8. 1 180° p.s. +/-30ppm? Need to sit down with Alexei, Bob about specs, have 3 options, 39.3V, 7.8A
9. 2 p.s.'s 30V 25A for High Field Matching Solenoids (HFMS1-2)
10. 4 p.s.'s for HFMS Correctors (Corr 7 & 23), need real Mag V & I. For now using ERL 15V 10A SHIMS
11. 1 p.s. for Compensating Dipoles (CD1-4). All 4 in series. Use one kepco 50V 20A p.s.
12. 1 p.s. for Skew Quad (SQ1) V & I needed, 1 p.s. for Quad (Q1) V & I needed, 2 ps's for Corr 8 (V&I needed)
13. 1 p.s. for Skew Quad (SQ2) V & I needed, 1 p.s. for Quad (Q2) V & I needed

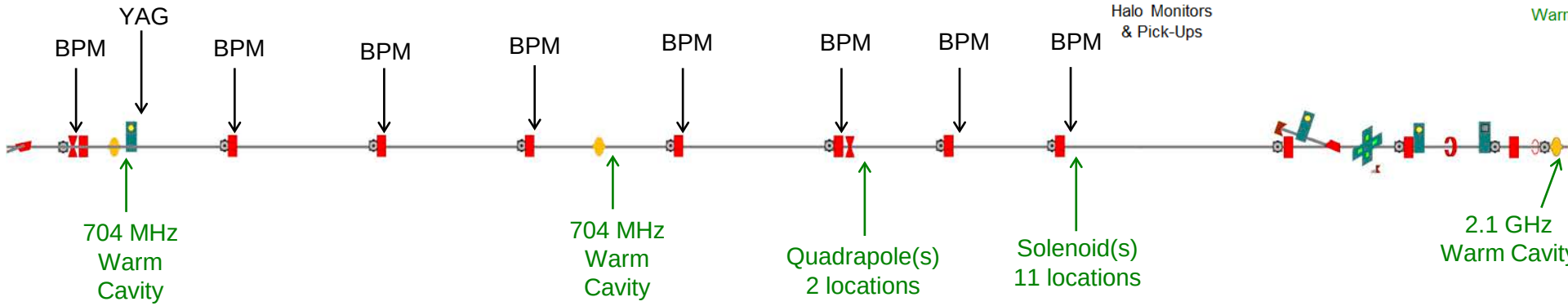
Dump

1. 1 p.s. needed for one Spreader Quad Magnet (SPQ1), No V & I, told to use ERL 15V 10A SHIM p.s.

Diagnostics: Transport

Parameter	Instrument
Position	BPM System
Profile	YAG Profile Monitors (PM)





e-Beam Transport

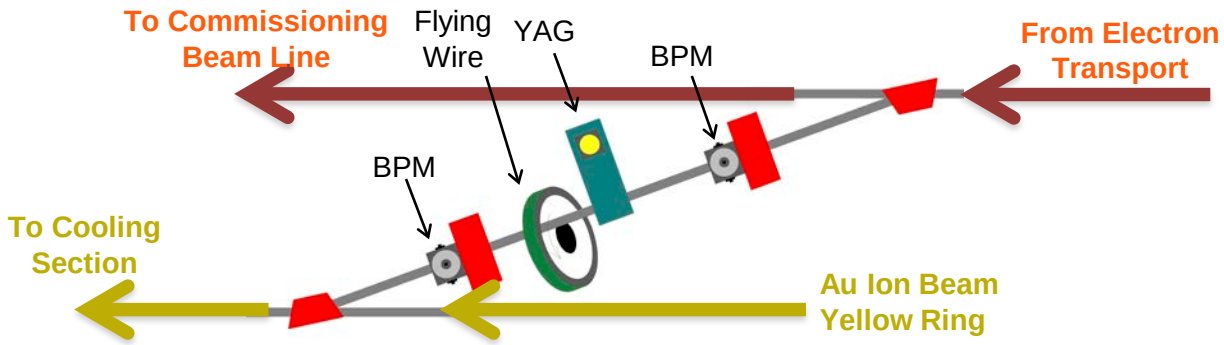
BPM = 8

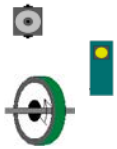
YAG = 1

Beam pipe size 2.38 ID does not match ERL
Bake-out to near RHIC and near Booster Cavity??
ERL Buttons for BPM's OK??
Profile Monitor drives from ERL, vacuum chamber?
ERL emittance slit drive
Commissioning line dipole angle
2nd 2.1 GHz cavity location?
Another 20o dipole?

Merger Beam Line

Parameter	Instrument
Position	BPM System
Profile	YAG & Flying Wire Profile Monitors (PM)
Energy Spread	Slit + PM in dispersive section





e-Beam Transport

BPM = 2

YAG = 1

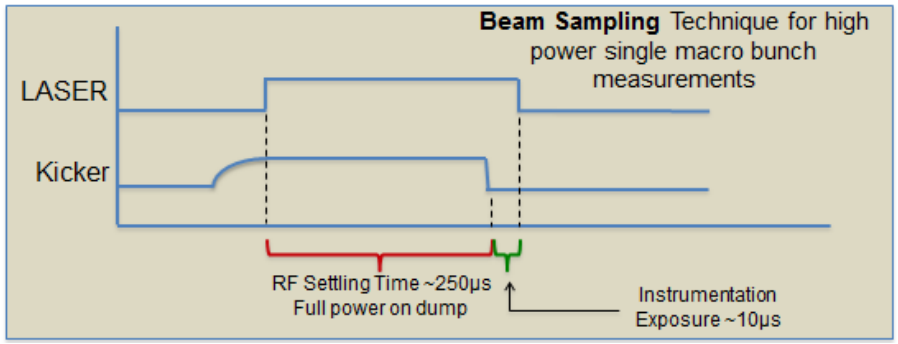
Flying Wire = 1

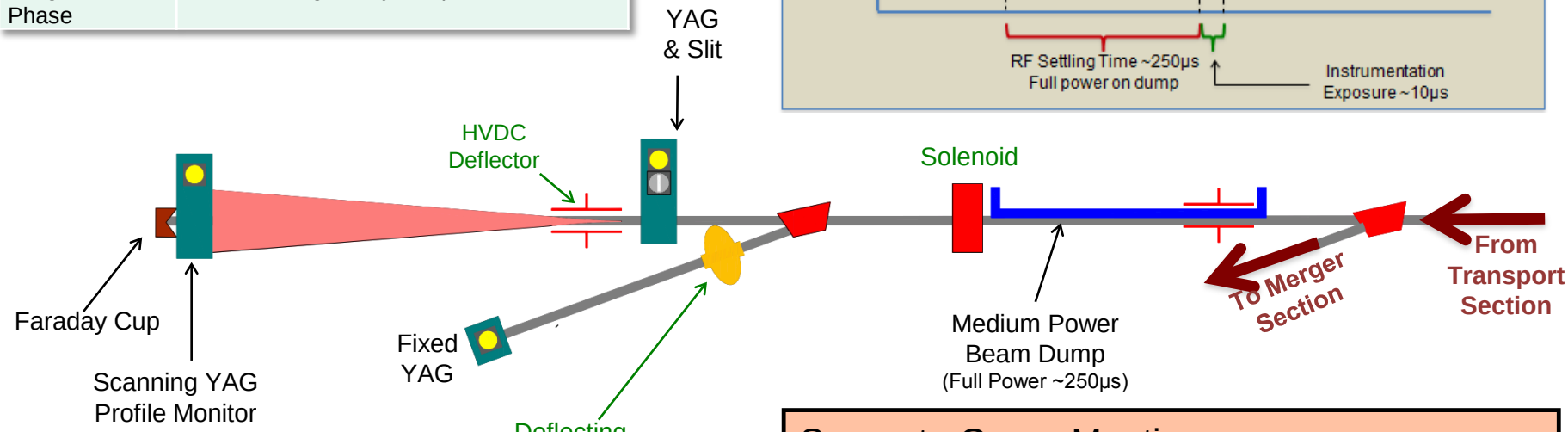
Beam pipe size 2.38 ID does not match ERL
Bake-out to 200C?? near RHIC
Flying wire system or equivalent TBD

Commissioning Beam Line

Parameter	Instrument
Profile	YAG Profile Monitors (PM)
Absolute Energy	Electrostatic Energy Spectrometer Magnetic Energy Spectrometer
Energy Spread	Slit + PM in dispersive section
Longitudinal Phase	RF Deflecting Cavity + Dipole & PM

Beam Sampling Technique for high power single macro bunch measurements





Commissioning B/L

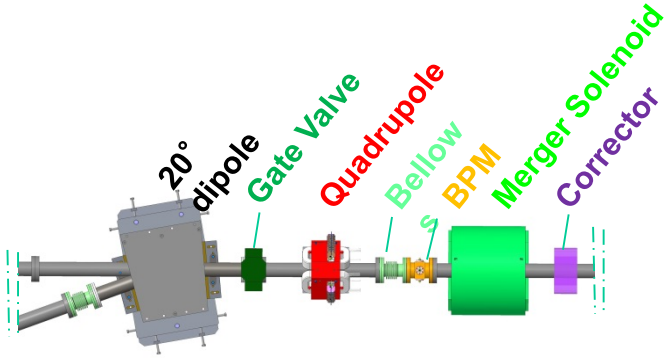
YAG = 3

Faraday Cup = 1

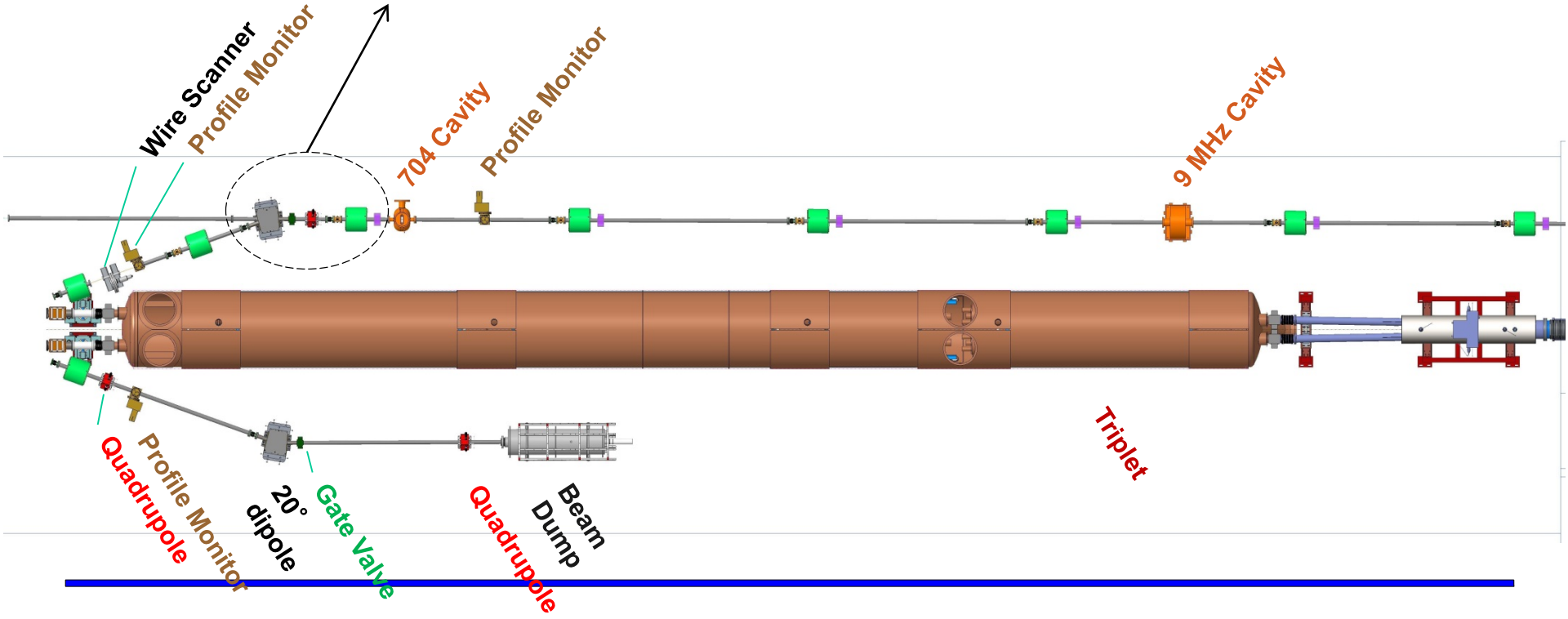
Defining Slit = 1

Separate Group Meeting
Kicker TBS
Merger solenoid??
Internal beam dump TBD
Deflecting cavity design underway
HVDC deflector TBD
Another 20o dipole? TBD
Fixed and Scan YAG's dumps

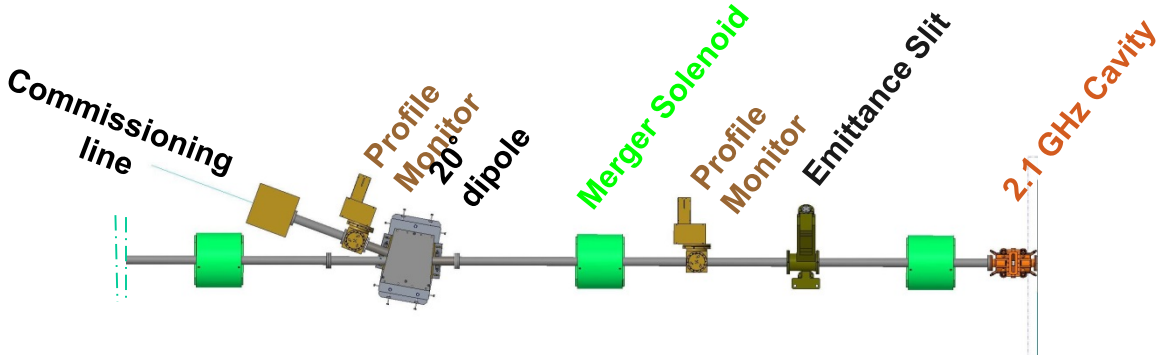
Merger/Transport

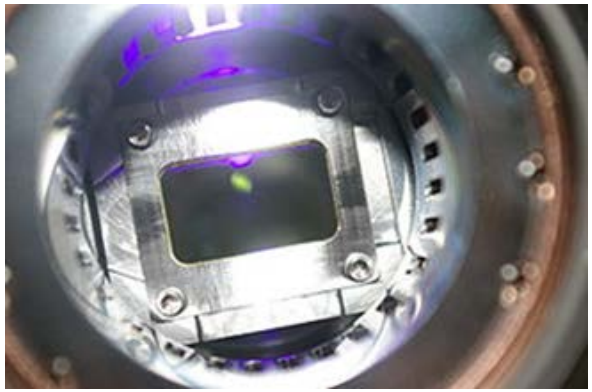


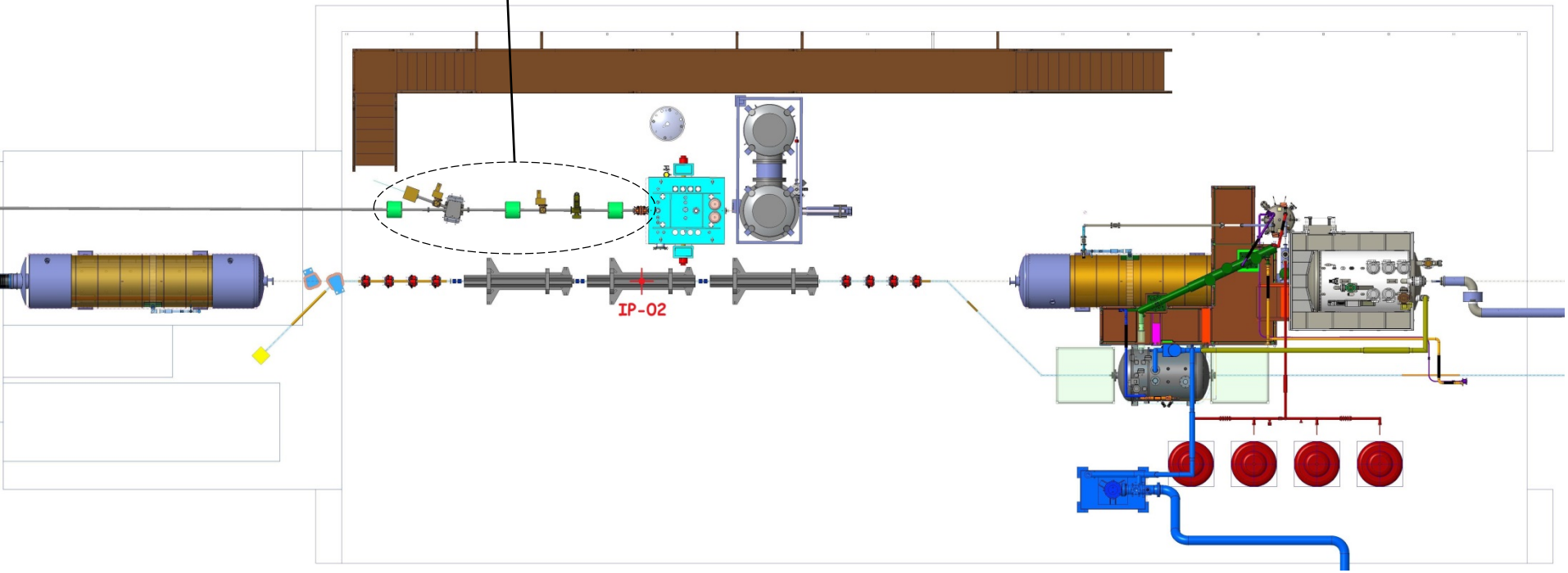
Need Quadrupole Magnet Spec's
Same as dump quadrupole?
Move gate valve down stream of 20o?



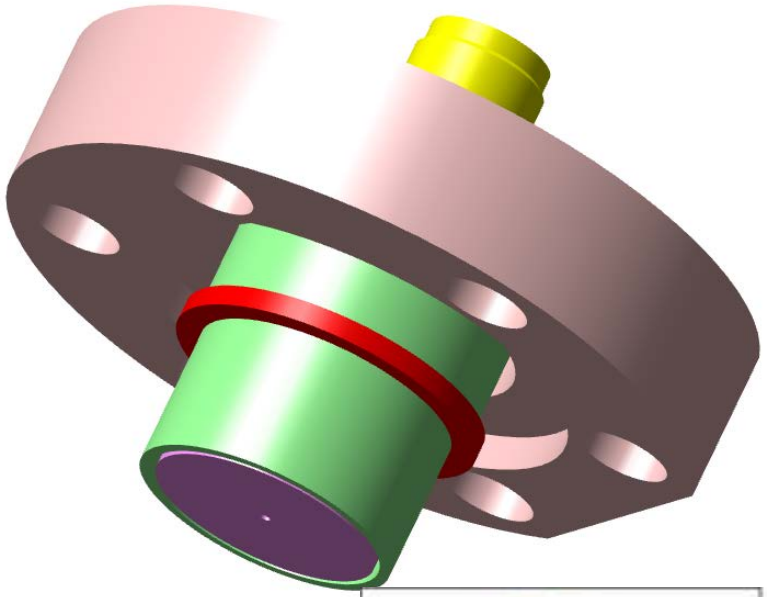
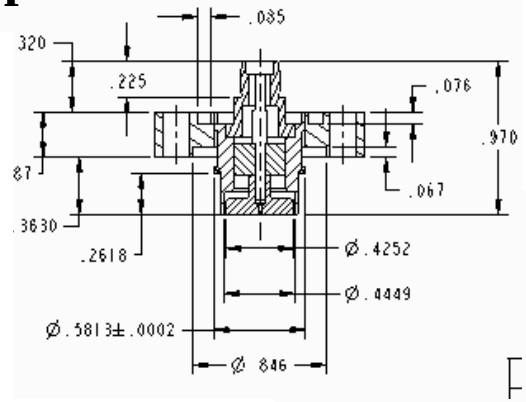
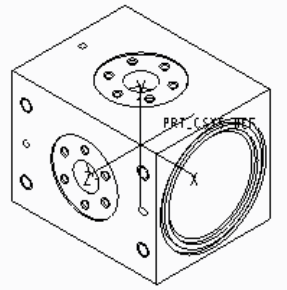
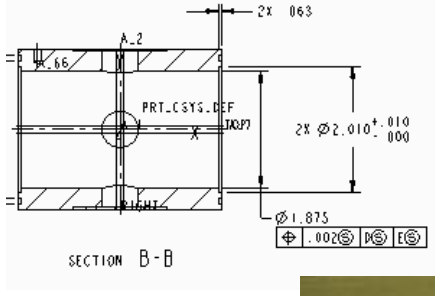
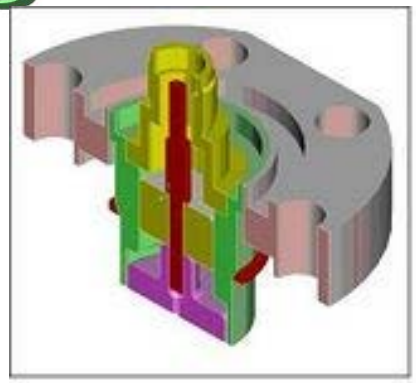
IP 02:00


Commissioning line
Profile Monitor
20° dipole
Merger Solenoid
Profile Monitor
Emittance Slit
2.1 GHz Cavity




IP-02

BPMs in Transport Section

Small Dia. BPM Housings (2.38 ID), 10mm buttons

- **ERL Buttons different size and shape**