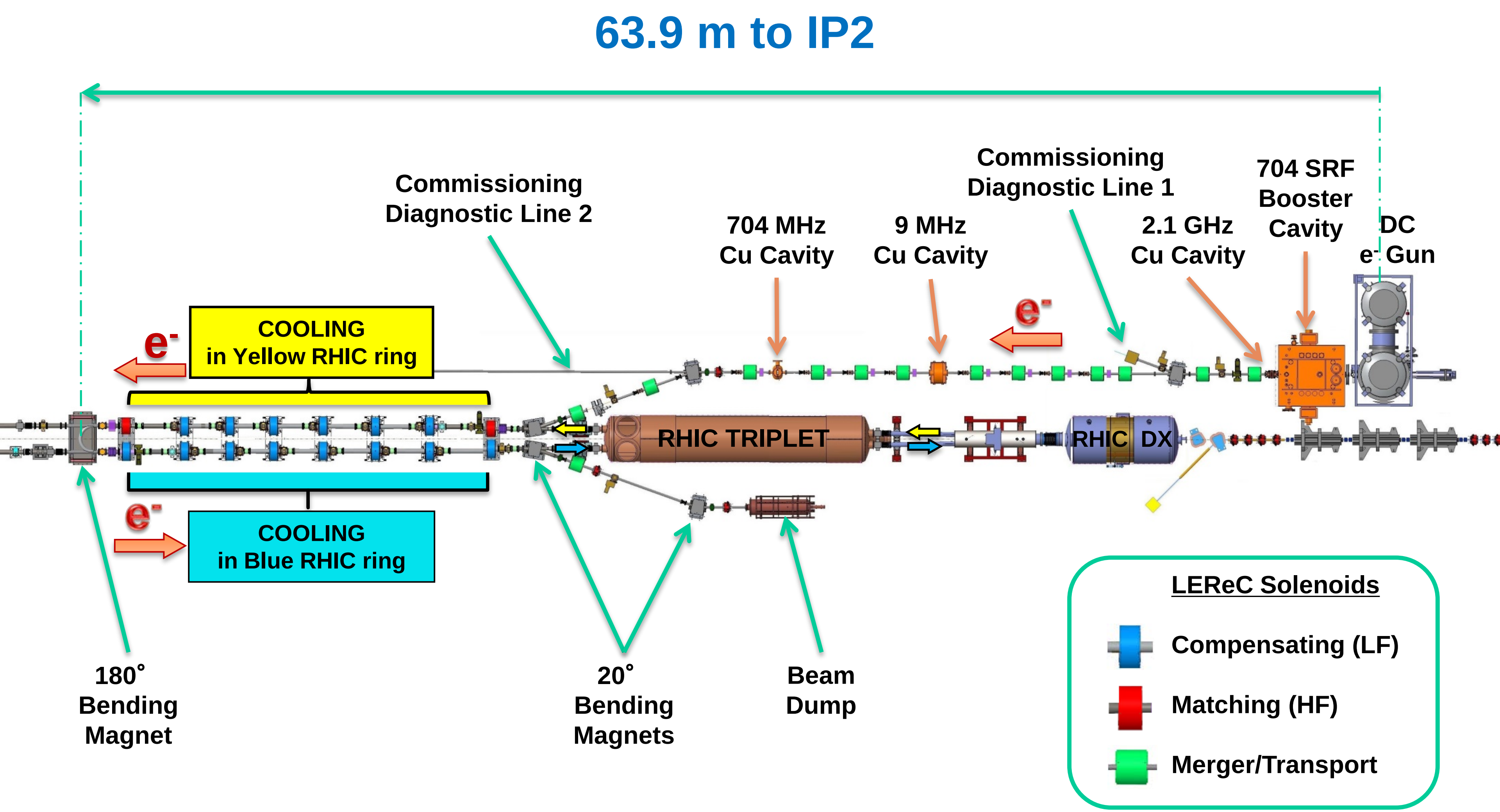
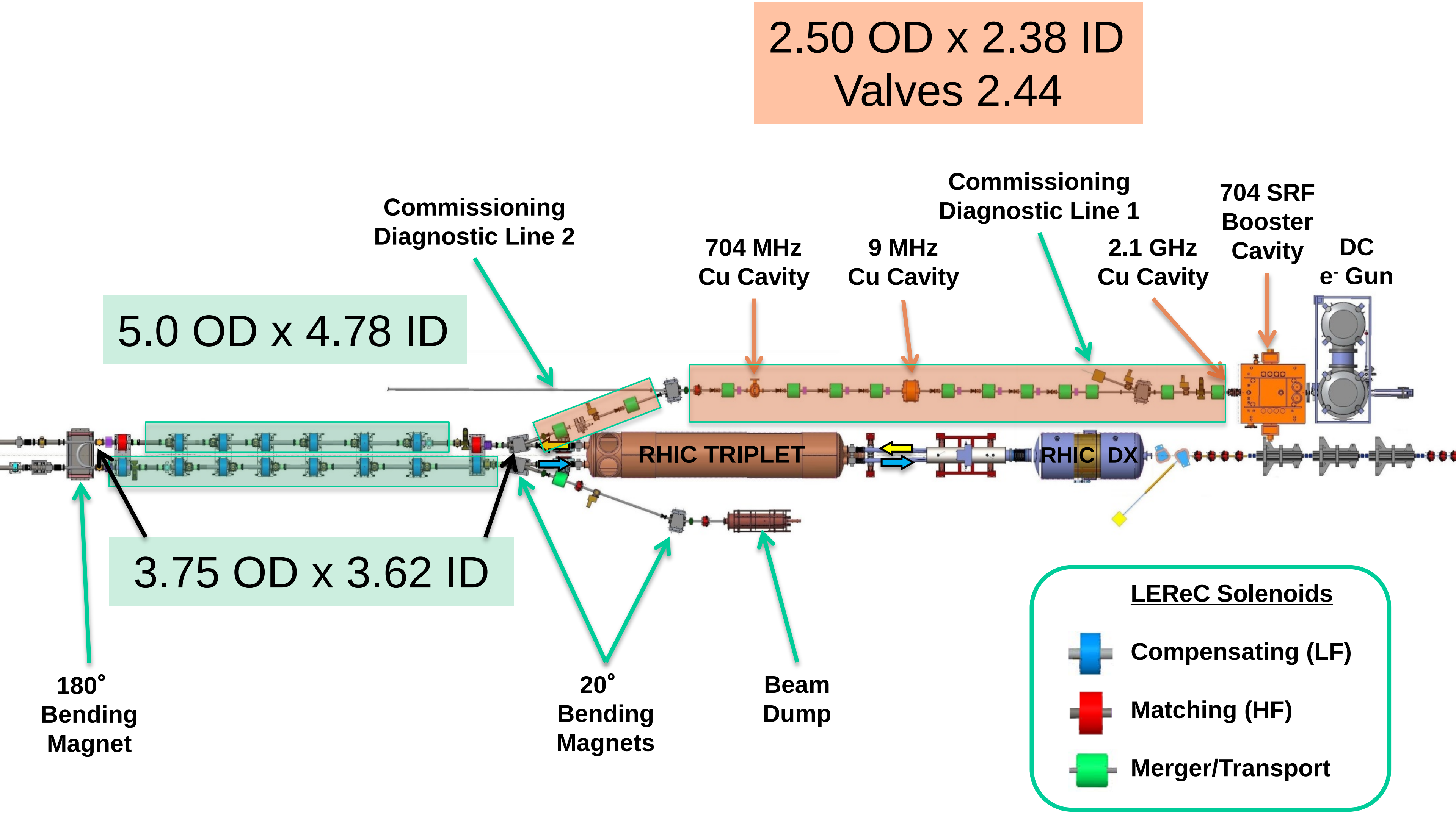
LEReC layout



LEReC apertures



9/16/15
Phase 1 Block 7.vsd

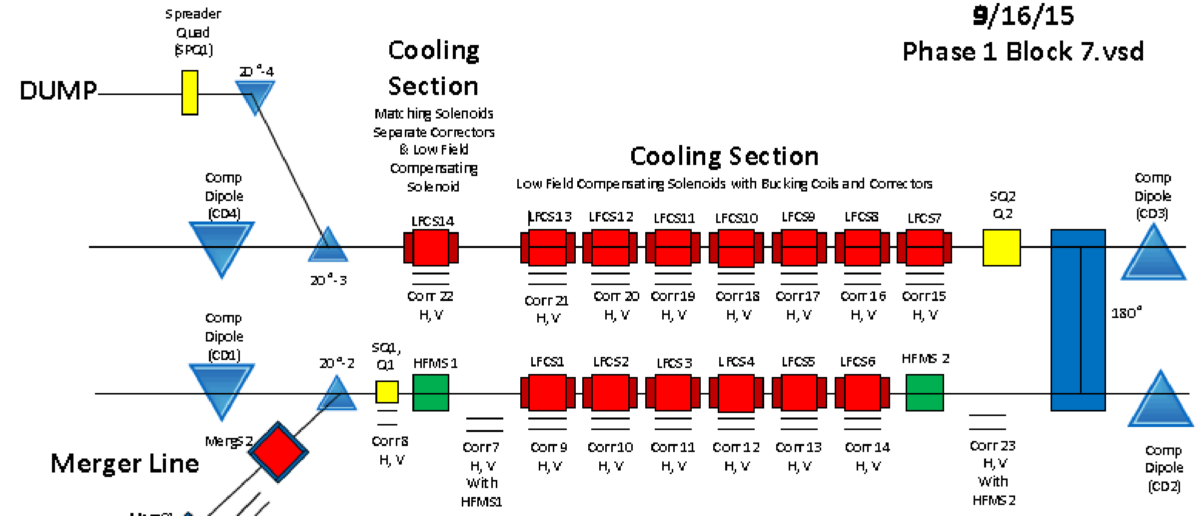
Gun Section

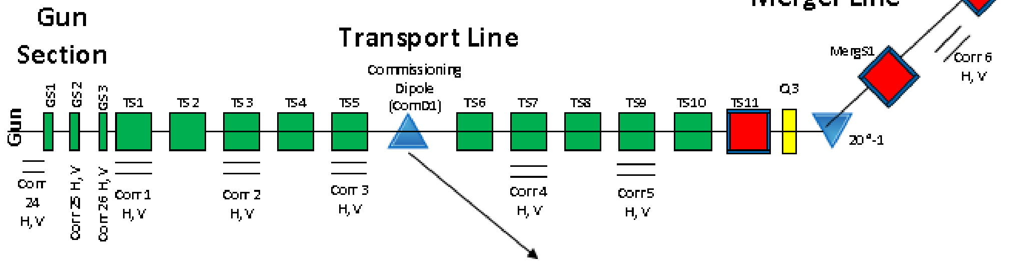
1. Two p.s.'s for stand alone Corr 24H & 24V. Need V & I. Using Cornell Corr V & I for estimate.

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

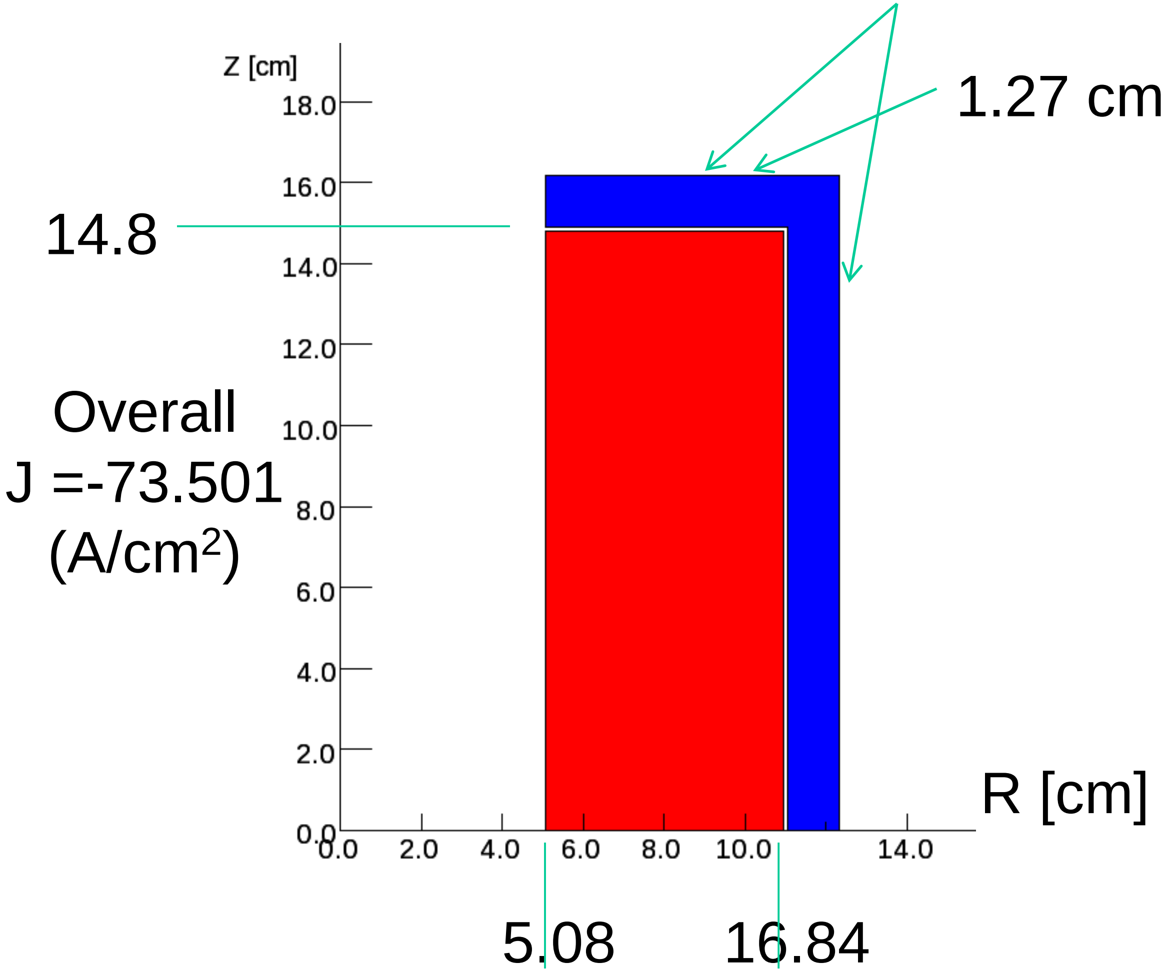
1. 1 p.s. 150V 22A for LFCSc1-6 cores 6 in series
2. 1 p.s. 150V 22A for LFCSbc1-6 buck coils (2x) 6 in series
3. 28 p.s.'s 20V 2A BIRA MCOR for Correctors, Corr 9-22 with LFCS magnets.
4. 1 p.s. 150V 22A for LFCSc7-13 cores 7 in series
5. 1 p.s. 150V 22A for LFCSbc7-13 buck coils (2x) 7 in series
6. 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.

Transport Line Matching Solenoid

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



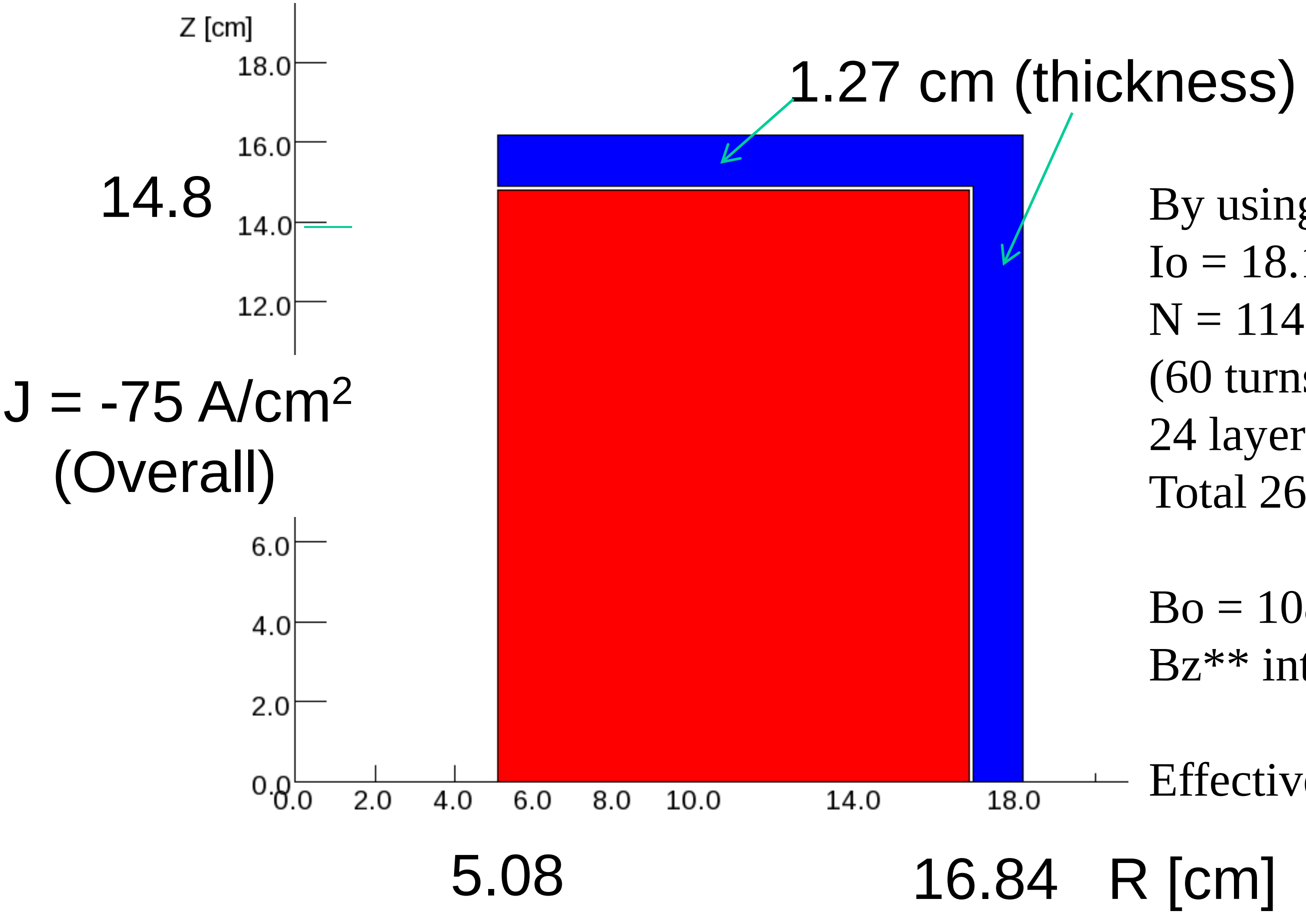
By using #5 square wire
Io = 17.77 A
N = 720
(60 turns along Z-axis;
12 layers along R)
Total 12792.7 A-turn

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

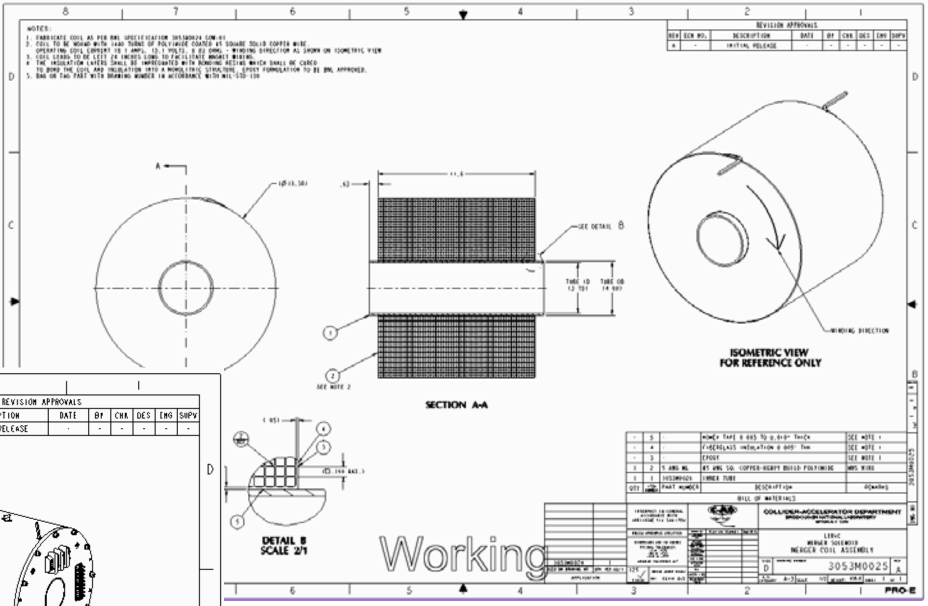
Merger (High Field) Solenoid

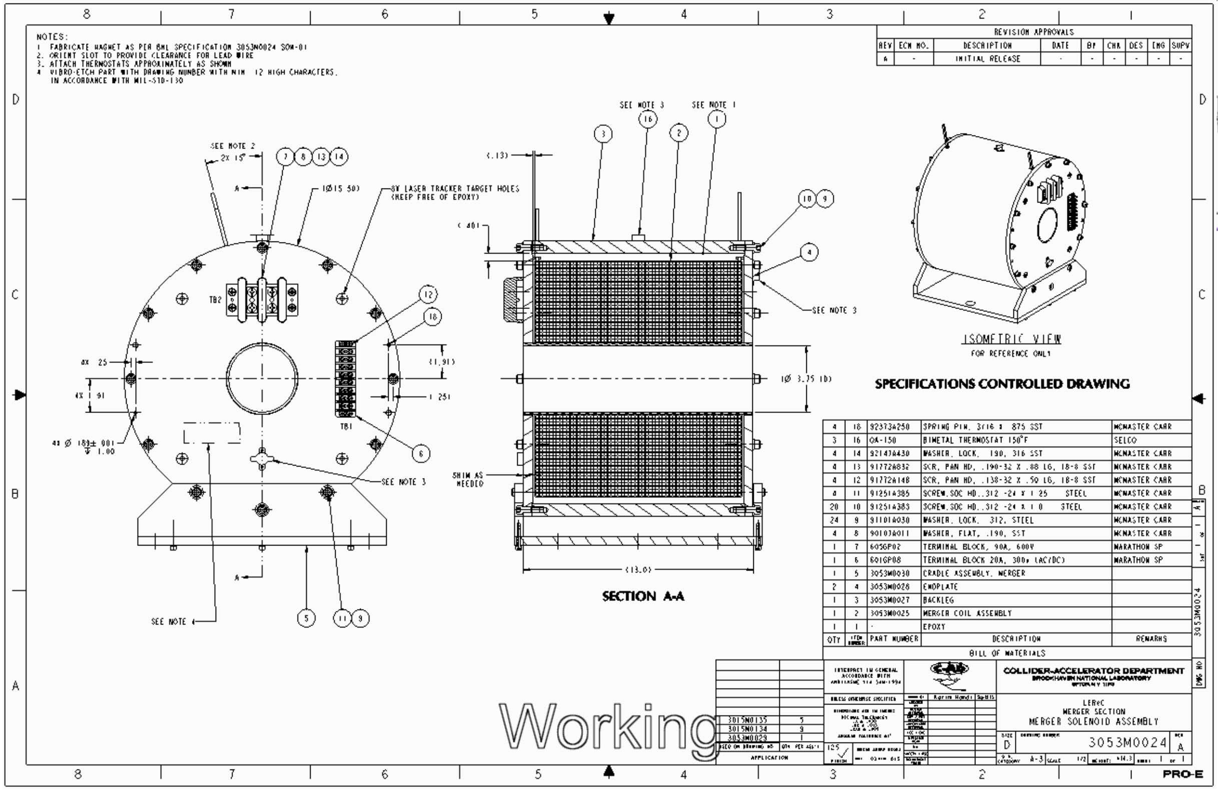
1440 Turns, #5 square copper conductor.

18.1 A, 15.1 V, 0.83 Ohms.

Will use for both Merger and Transport Solenoids – Need 13, order 14?

Diagnostic line solenoid – same spec's?

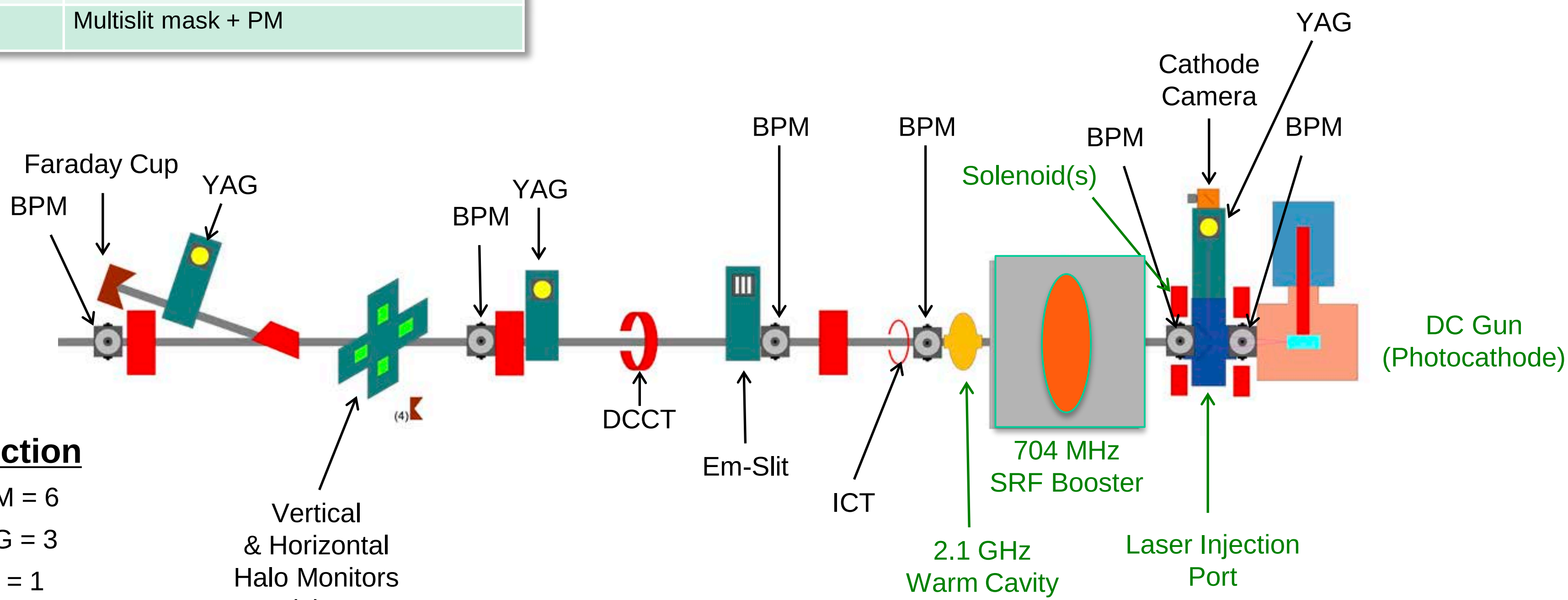




Solenoid magnets:
1000 Gauss Merger solenoids,
535 Gauss Matching solenoids.
These solenoids are designed for 2.5" pipe.

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



Injection

BPM = 6

YAG = 3

ICT = 1

DCCT = 1

Emittance Slit = 1

Halo Pairs = 2

Faraday Cup (& pick-ups) = 5

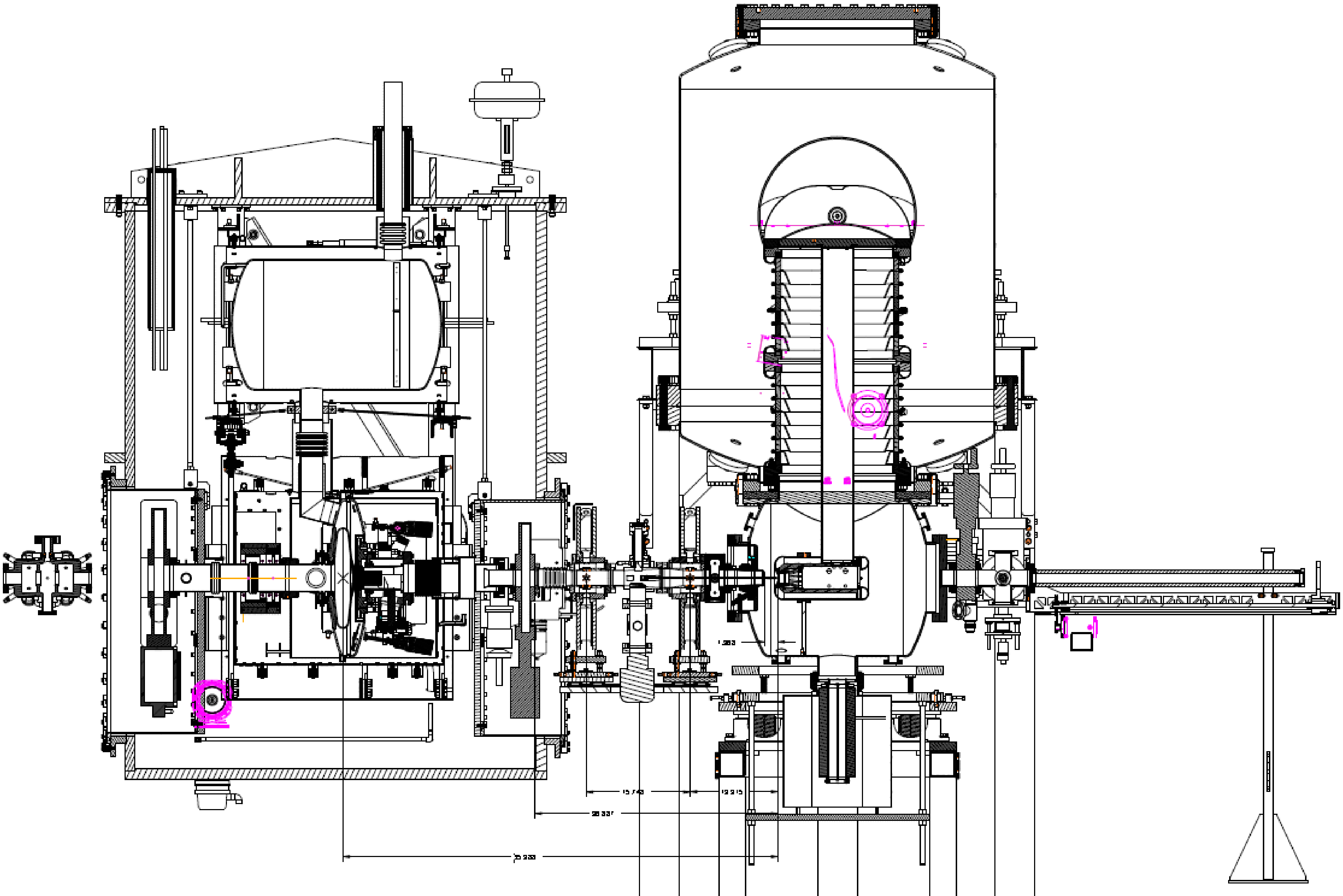
Cornell Layout GtB,

Bake-out to 200C near DC Gun

DC Gun instrumentation:

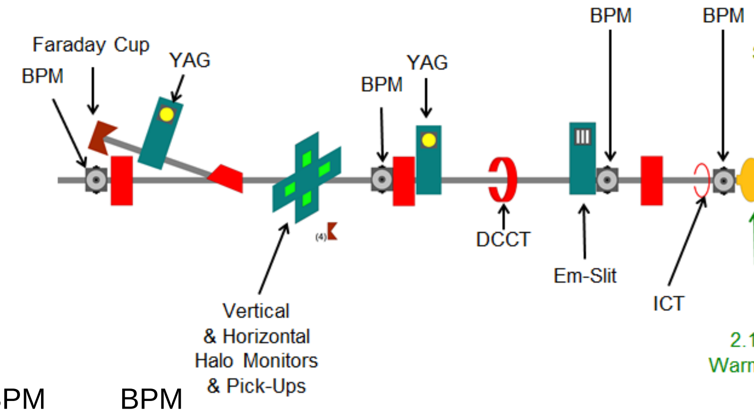
- **Large Button or ERL Buttons or Striplines??**
- Profile Monitor in Laser Cross
- Cathode Camera in Laser Cross

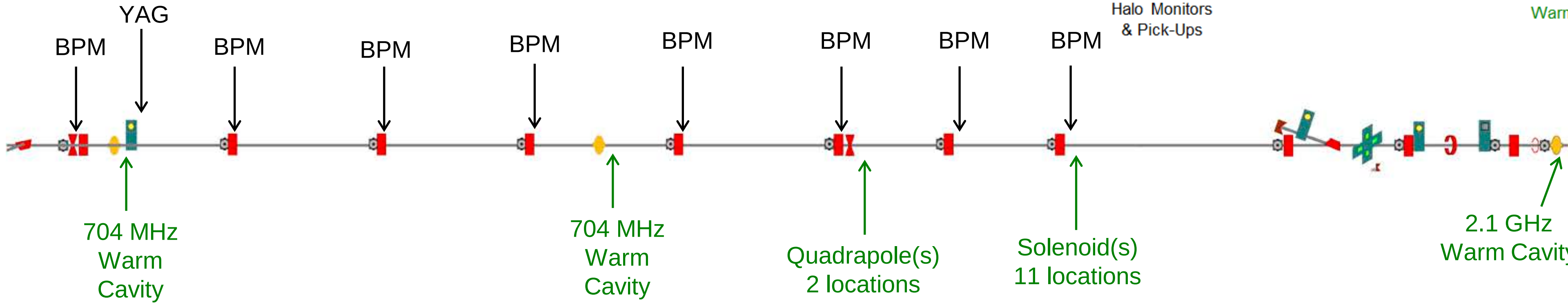
Gun to Booster Cavity



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

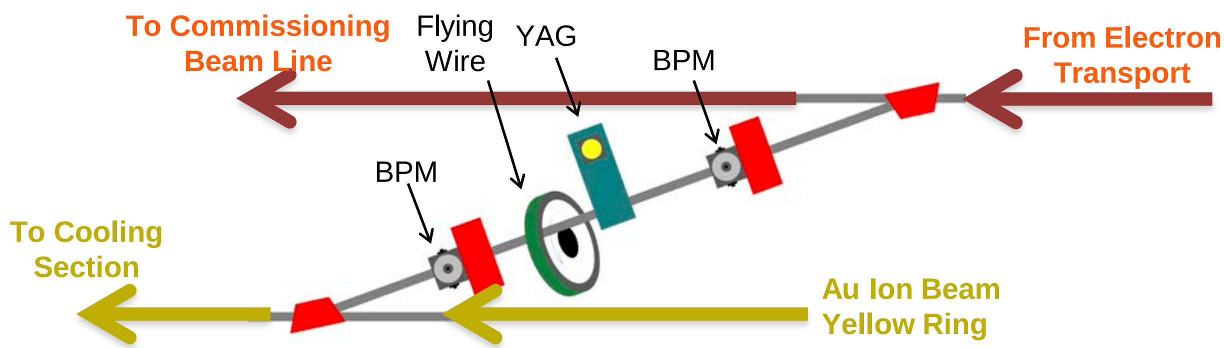
Commissioning line dipole angle

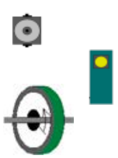
2nd 2.1 GHz cavity location?

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

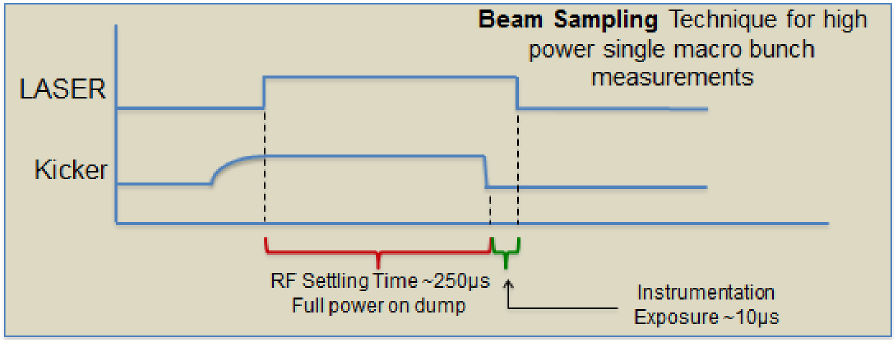
Flying Wire = 1

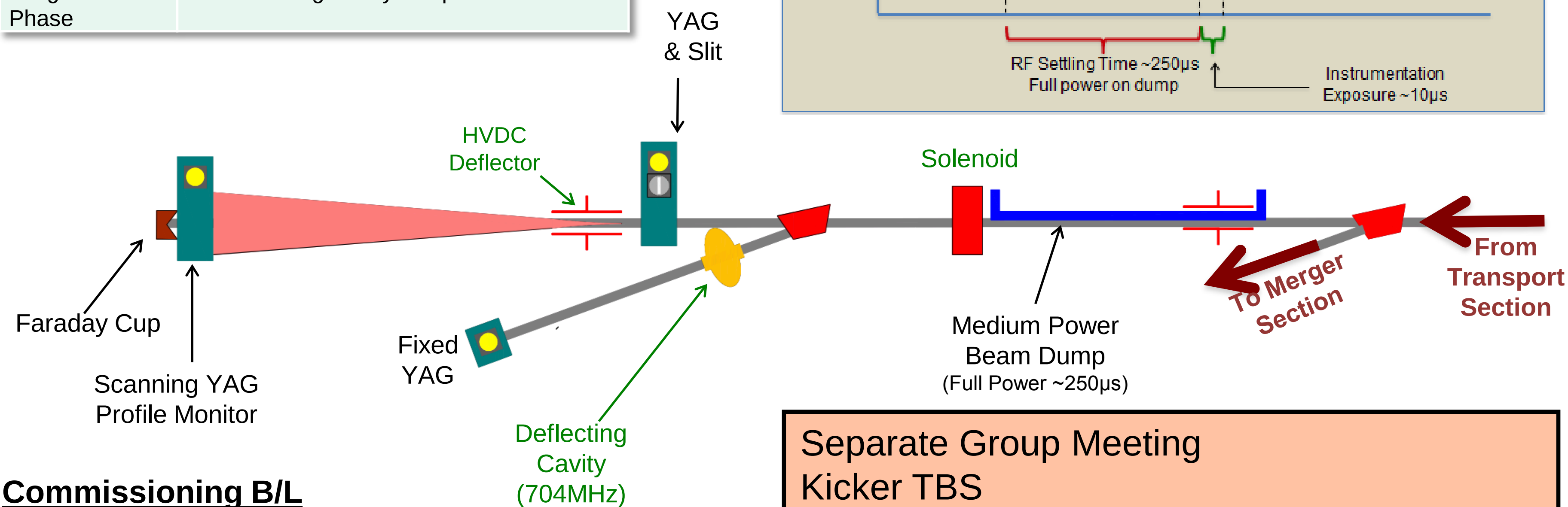
Beam pipe size 2.38 ID does not match ERL
Bake-out to 200C?? near RHIC
Flying wire system or equivalent TBD

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

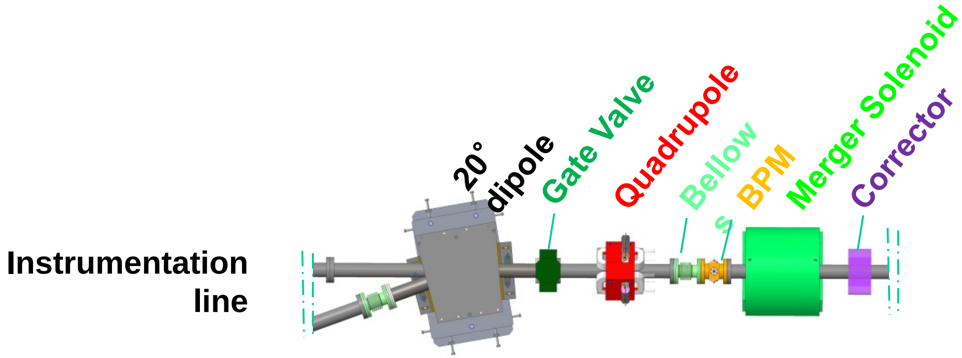
YAG = 3

Faraday Cup = 1

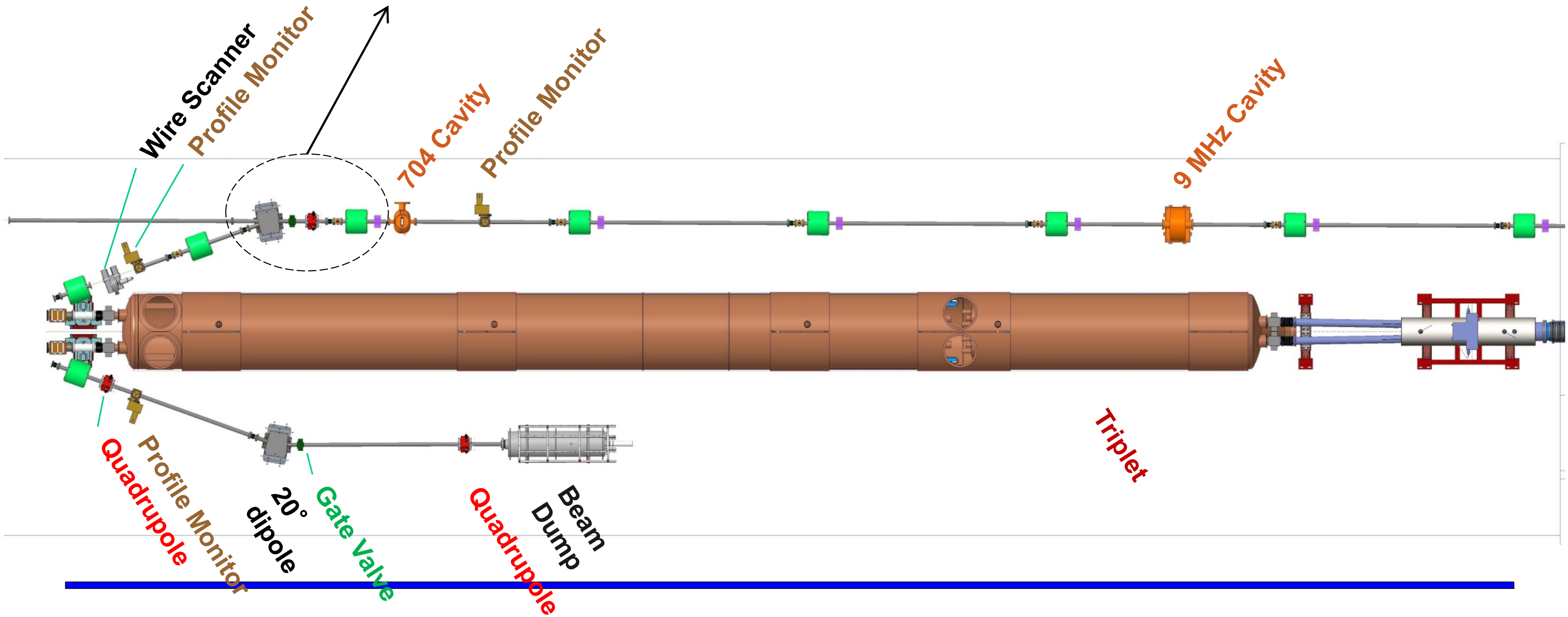
Defining Slit = 1

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

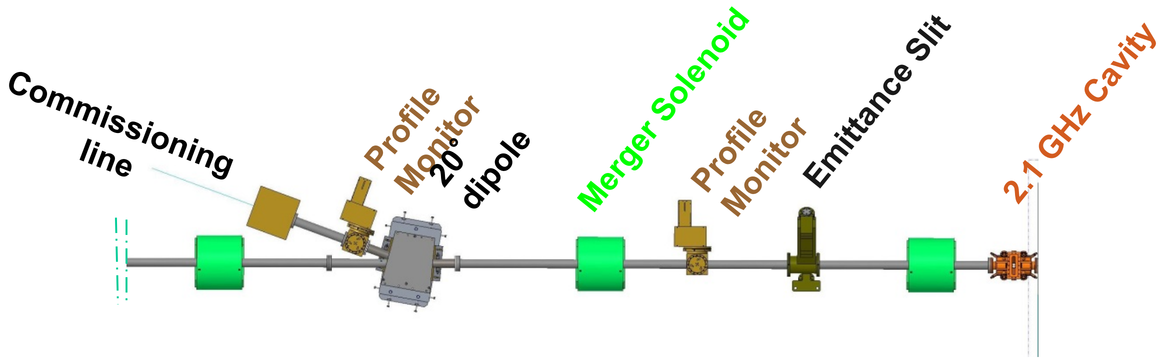
Merger/Transport



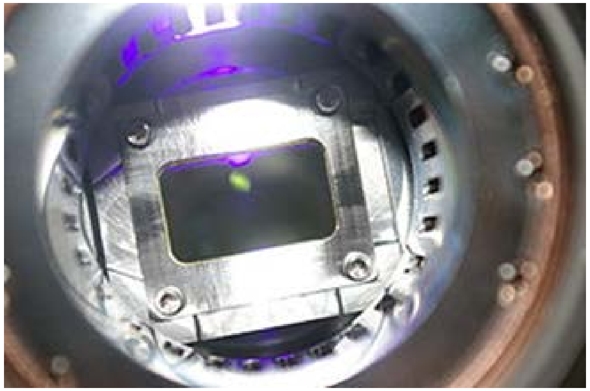
Need Quadrupole Magnet Spec’s
Same as dump quadrupole?
Move gate valve down stream of 20o?

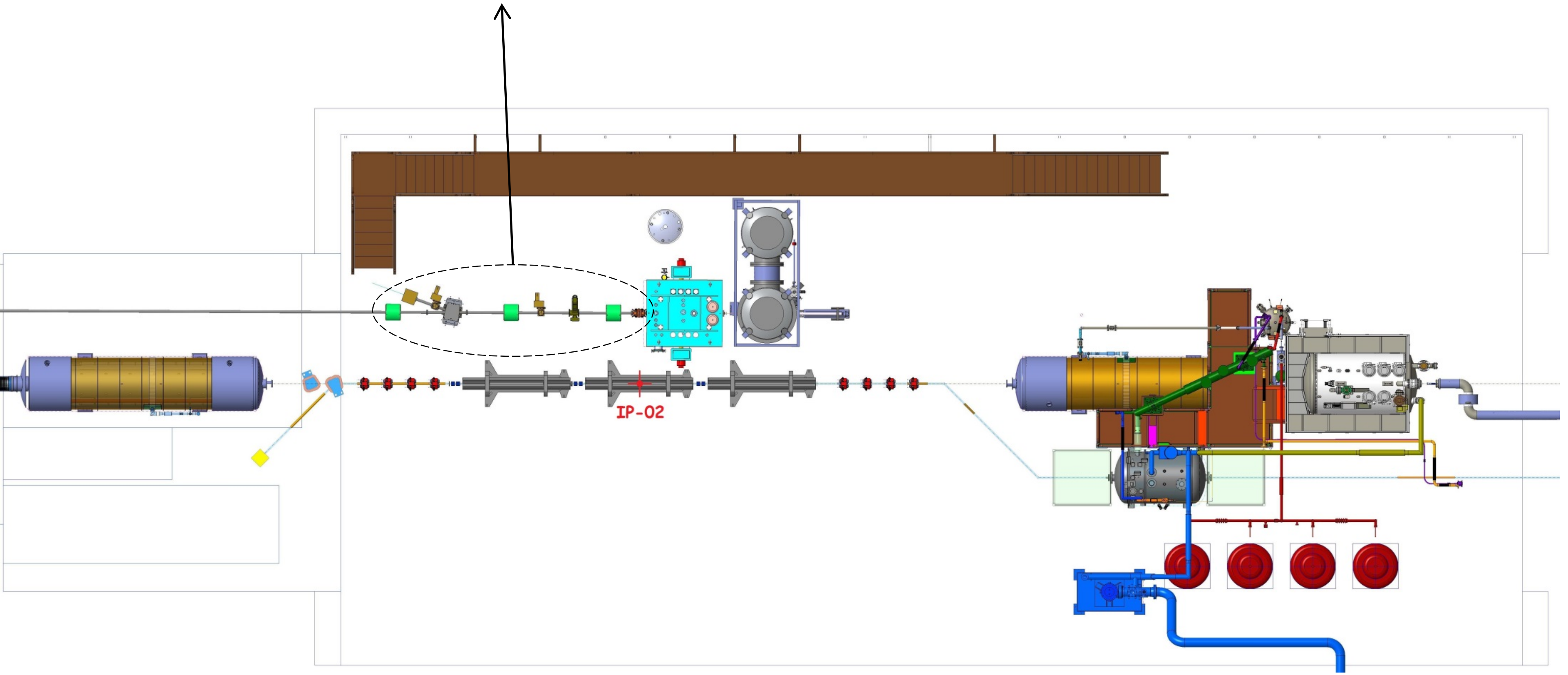


IP 02:00



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





IP-02

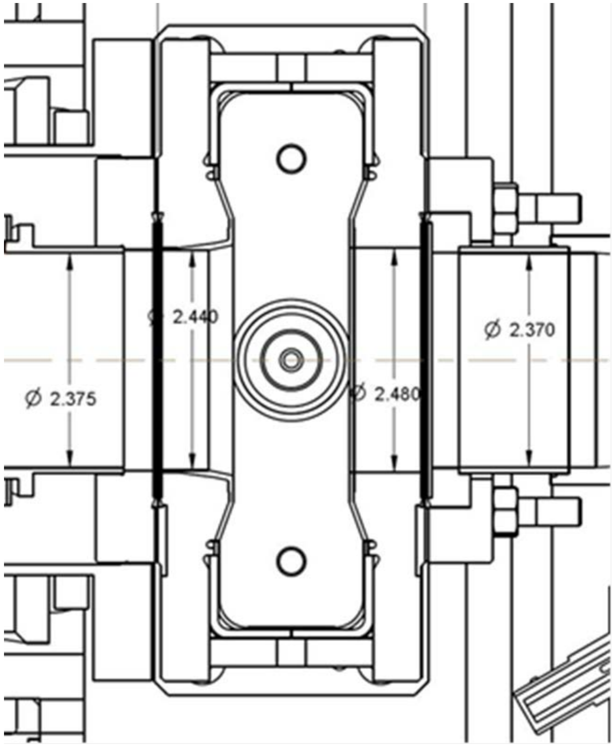
Vacuum Hardware

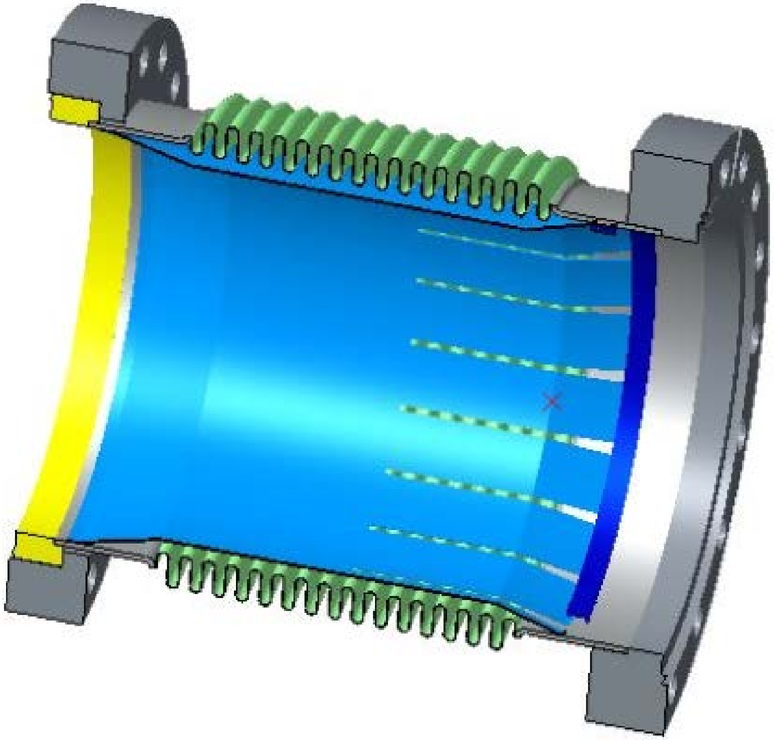
Standard beam tube: 2.5 OD x 2.375 ID 304L Stainless Steel

Beam line bellows 2.38 shielded design.

VAT RF shielded valves, do we need an adapter flange for ID change?.

RF Shielded gauge and pump cross.





20º Dipole Magnet

Delivery four magnets 10/30/2015

Magnet measurement, Dec. – Jan.

Trim windings or Horz. Corrector?

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°

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)
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^o magnet stand drawing (KH)
180^o magnet w/hybrid 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

DC Gun to SRF booster cavity BPM’s

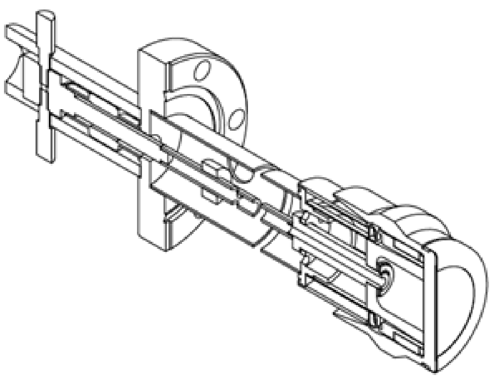
DC Gun cathode insertion drive assembly

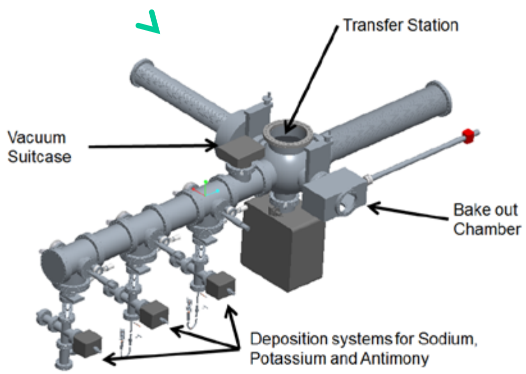
ERL Gun to Booster Cavity Modifications: U/S cathode to beam tube, FPC, D/S beamline & HOM (SS, JH)

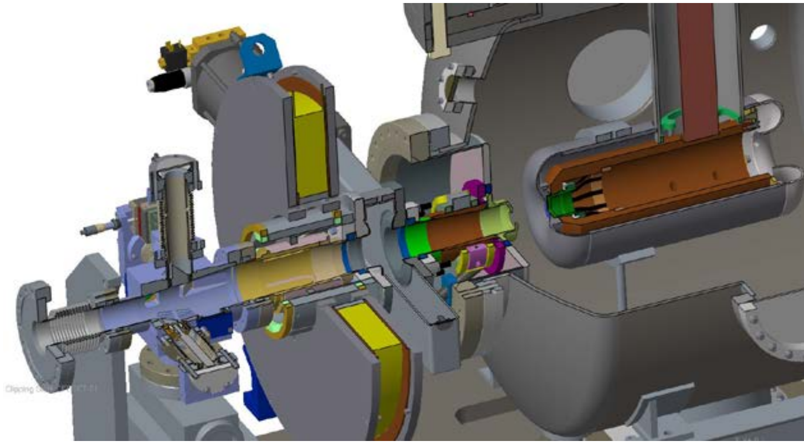
Cathode coating system cathode bakeout vacuum chamber & heater (KH & BM)

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

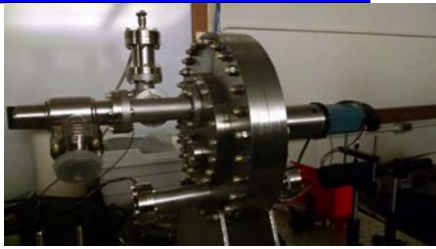
Cathode coating system transport vacuum chamber – ***ferris wheel*** **(KH & WJ)**







LEReC Design Room Other Work



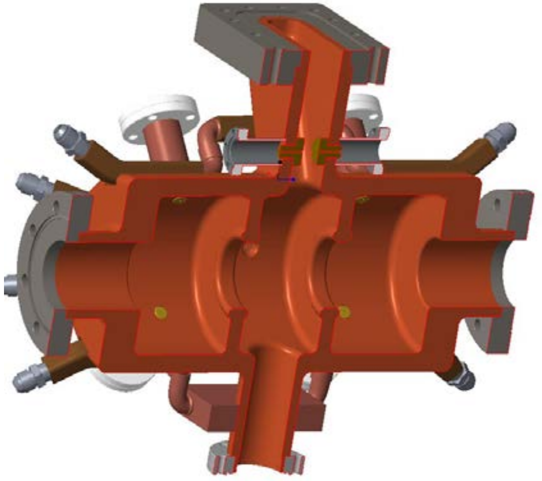
RHIC 1:00 move real estate drawings (V.DM.)

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

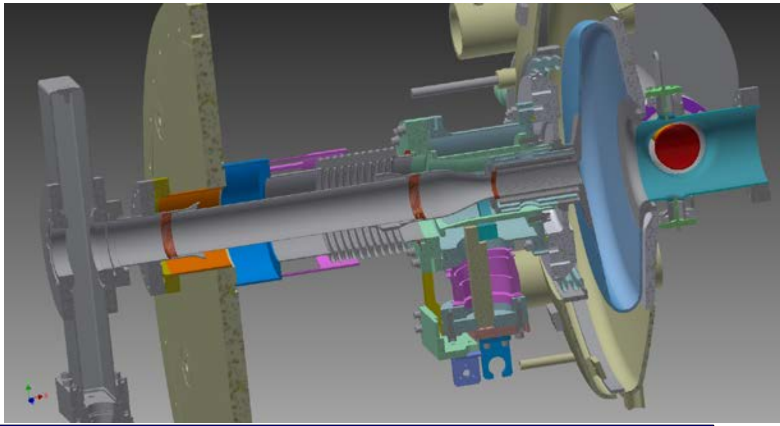
Transport & Merger Line Solenoids (KH)

Transport & 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,

LEReC Cooling Section Design Room

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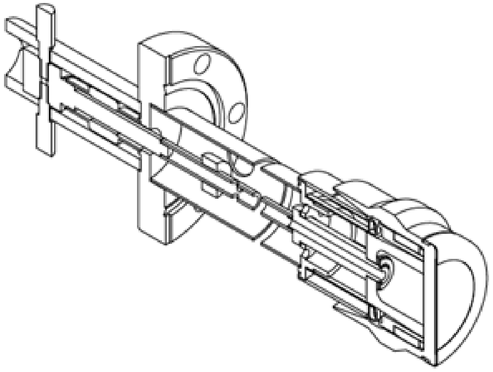
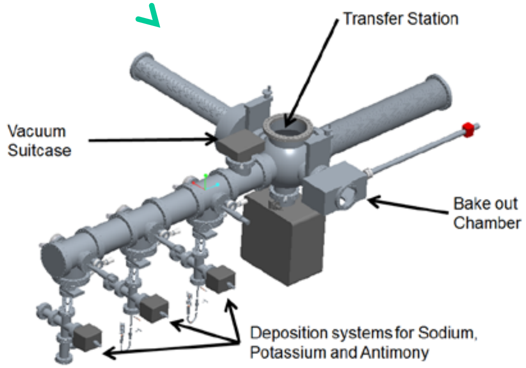
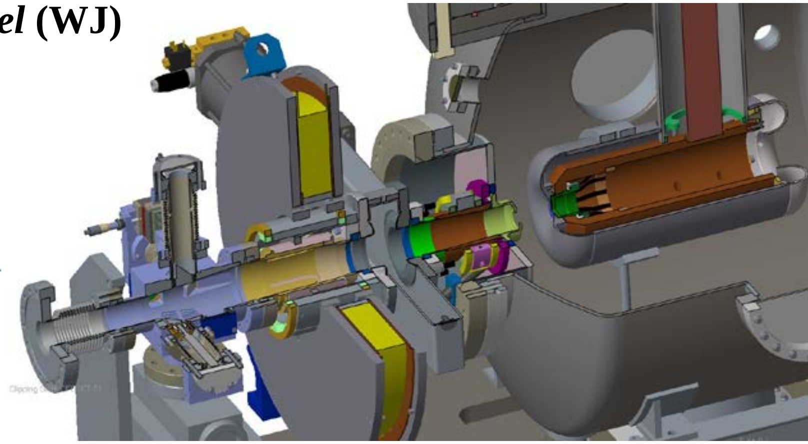
Cathode coating system cathode bakeout vacuum chamber & heater (BM)

Cathode coating system deposition vacuum chamber w/internal cathode transport system

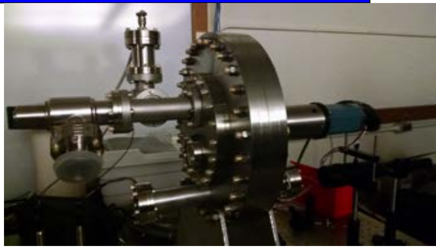
Cathode coating system transport vacuum chamber – *ferris wheel* (WJ)







LEReC Design Room Other Work



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

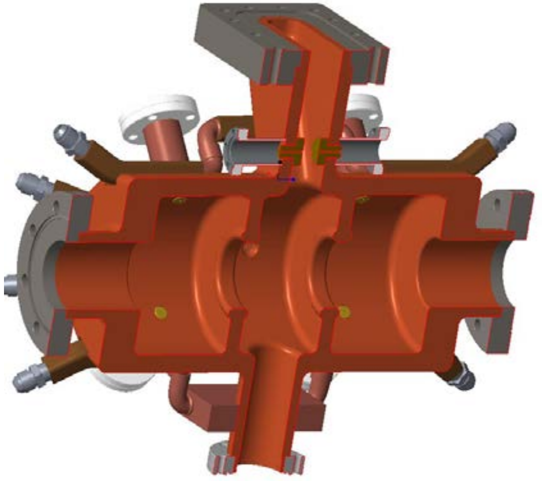
~~Phase 2: 5 cell cavity positioning (RM) – Revised Position on hold~~

Phase 1 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)

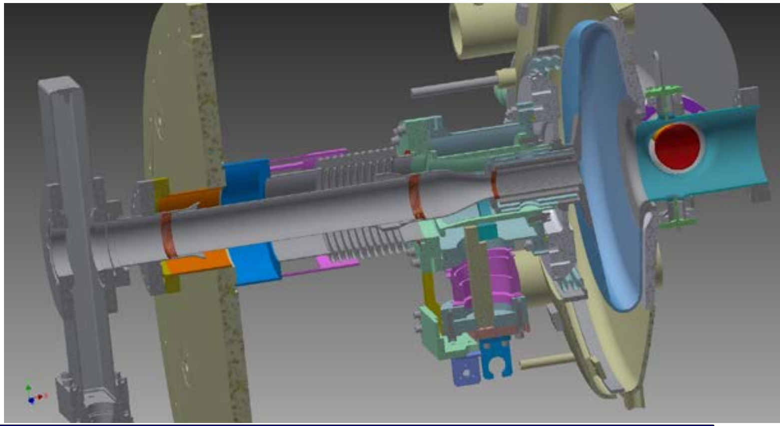
Locate booster cavity, solenoids, BPM’s,

RF Cavities, PM’s, Diagnostic Lines

Transport & Merger Line Solenoids (KH)

Transport & Merger Line CT’s (GW)

Transport & Merger Line BPM’s (GW)



Transport & Merger Line Correctors

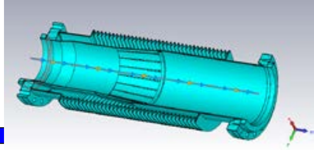
Transport & Merger Line Profile Monitors

Merger Line Flying Wire

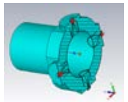
Diagnostic Beam Lines and Components

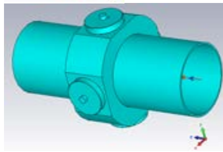
Kickers, RF cavity, beam dump,

Impedance matching



Need 180 deg chamber
& rest of Transport line

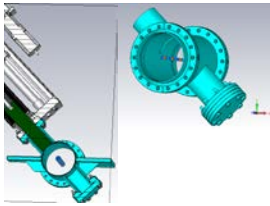


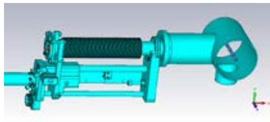


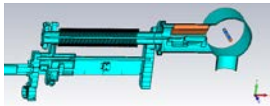
Cooling section energy losses for a 300 pC, 1.5 cm rms long bunch

(180 degree magnet chamber and tow welded bellows not yet included)

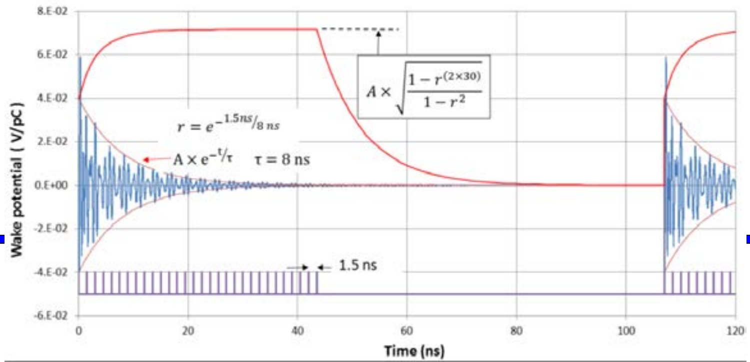
DEVICE	Wake loss factor (V/pC)	Wake loss for 300 pC (eV)	Count	Total (eV)
Toby's hybrid device	6.28E-02	18.84	2	37.68
Profile monitor	2.33E-02	6.99	2	13.98
Emittance slits	1.68E-02	5.04	2	10.08
BPM	5.30E-03	1.59	14	22.26
Welded bellows	9.07E-02	27.21	2	54.42
Formed Bellows	3.00E-02	9.00	18	162.00
180 degree chamber			1	
40 cm of beam pipe	5.70E-04	0.17	1510"	16.40



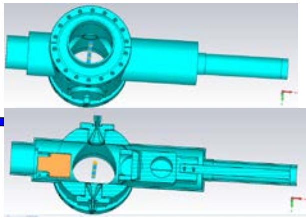




Estimate of the wake amplitude superposition of the 30 electron bunches using the one-bunch simulation shown on the previous slide. The oscillation amplitude decay is approximated by and exponential. The contributions from individual bunches added in quadrature are elements of a geometric series.



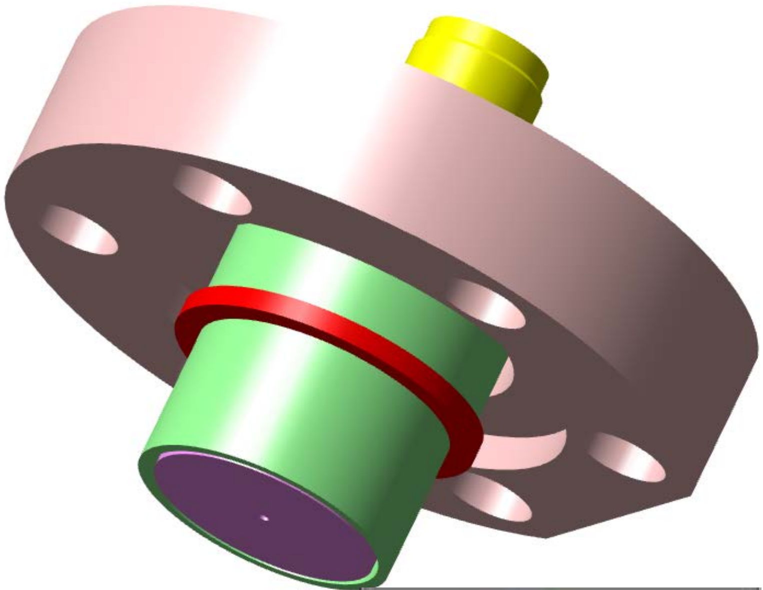
TOTAL **316.82 eV**

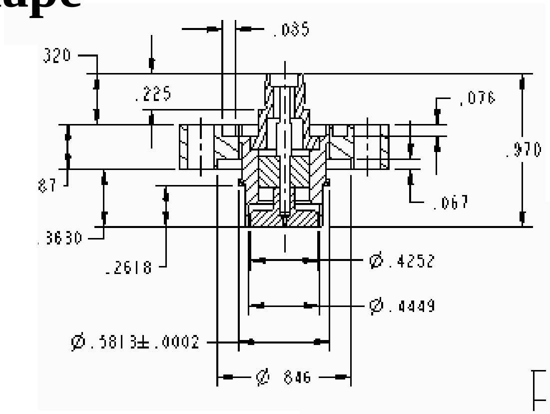


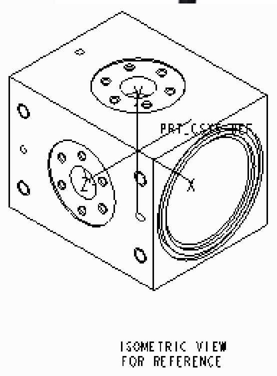
BPMs in Transport Section

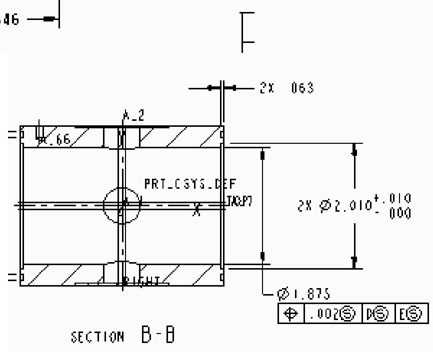
Small Dia. BPM Housings (2.38 ID), 10mm buttons

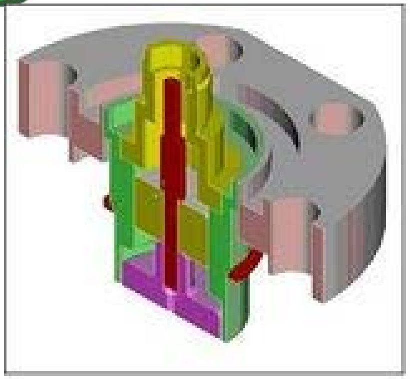
- **ERL Buttons different size and shape**











Minutes 9 22 2015 meeting

A Fedotov, K Hamdi, D Kayran, L Snydstrup, K Smith, J Tuozzolo, A Zaltsman

Transport Beam Line
- Design development of beam line will be from the Booster to the 2nd 20 degree dipole.
- There are 2 diagnostic lines shown branched toward the inside of the ring. They will not fit this way because the tunnel wall interferes and must be flipped toward the inside of the RHIC ring (toward the triplet).
- The transport line is 2.38 inch inside diameter, larger than ERL (approximated 2.0 inch).

Discussion on diagnostic line:
- Is a separate beam line with a high power beam dump needed or is the macro bunch train short enough that heating into the faraday cups and YAG screens is not a problem.

RF Cavities Design
- Current beam line configuration has the following RF cavities: SCRF Booster Cavity (from ERL), 2.1 GHz Cavity (new procurement), 9 MHz (from RHIC), and 704 MHz Cavity (new procurement). A deflection cavity is now shown in the second diagnostic stub line after the 20 magnet. This cavity is used to characterize longitudinal phase space to be used for 2.1 or 704 cavity tuning.
- The warm 9 MHz cavity is an existing device – the RHIC “bouncer” cavities. A. Zaltsman cites power at 3 kW; A. Fedotov said the required power has been estimated at 6 kW, but the beam loading needs to be determined and the power may be less.
- Drawings for 2.1 GHz are completed (also Spec and SOW). We should be ready to go out for bidding in about 3 weeks.
- K. Smith to call a meeting to start discussion of the RF design of the transport section, the deflection cavity, and the diagnostic lines.

Solenoid magnets: 1000 Gauss Merger solenoids, 535 Gauss Matching solenoids. These solenoids are designed for 2.5” pipe. They have Ri=5.08cm, Ro=16.84cm. The Merger Sol. is 14.8cm long; the Matching Sol. length is incorrectly shown at 14.8 (should be about 11cm).
- Should just the high field solenoid be purchased? Its field requirement is 2x the low field; it may be cost effective to purchase just one magnet type. Same thought for power supply.
- Should the horizontal and vertical corrector be integrated into the solenoid design. Field requirement is 100 g/cm; Wuzheng is analyzing.

Other magnets:
- Transport line shows 3 quadrupoles (in Phase II), In Phase II two solenoids are replaced by Zig-Zags (and associated dipoles).
- Correctors at DC eGun: There is a Cornell designed dipole corrector at the Cathode position (air side) and a corrector inside the first solenoid, also designed by Cornell. Maybe this corrector can be integrated into the solenoid design.

Diagnostics:
- May need more profile monitors in the transport line. ERL PM may be used; but, the aperture is different.
- BPMs: the vacuum chambers must be custom made to match the 2.38 aperture – buttons from ERL may be used.