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:

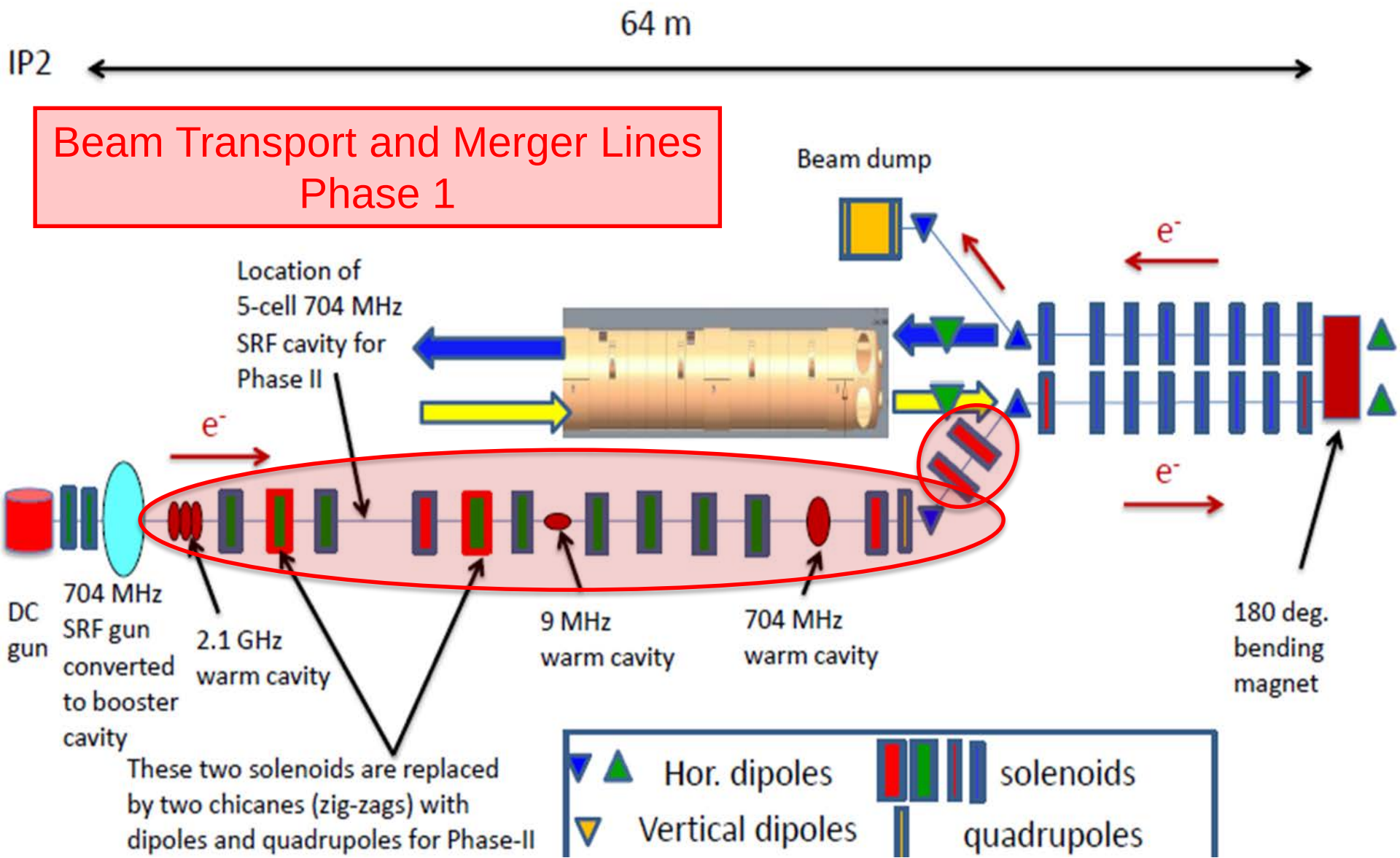
- Transport line shows 3 quadrupoles (in Phase II), In Phase II two solenoids are replaced by Zig-Zags (and associated dipoles).
- Correctors at DC eGun: There is a Cornell designed dipole corrector at the Cathode position (air side) and a corrector inside the first solenoid, also designed by Cornell.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

Diagnostics:

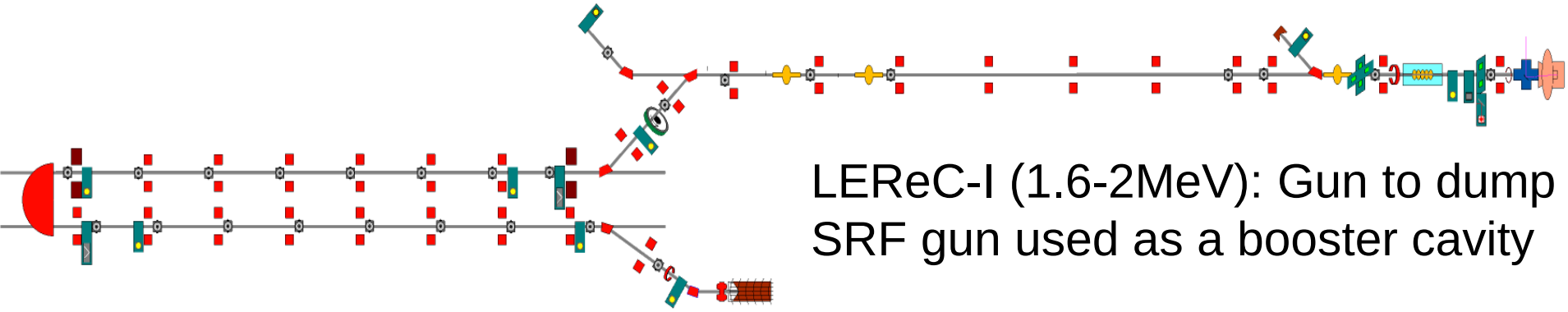
- May need more profile monitors in the transport line. ERL PM may be used; but, the aperture is different.
- BPMs: the vacuum chambers must be custom made to match the 2.38 aperture – buttons from ERL may be used.

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

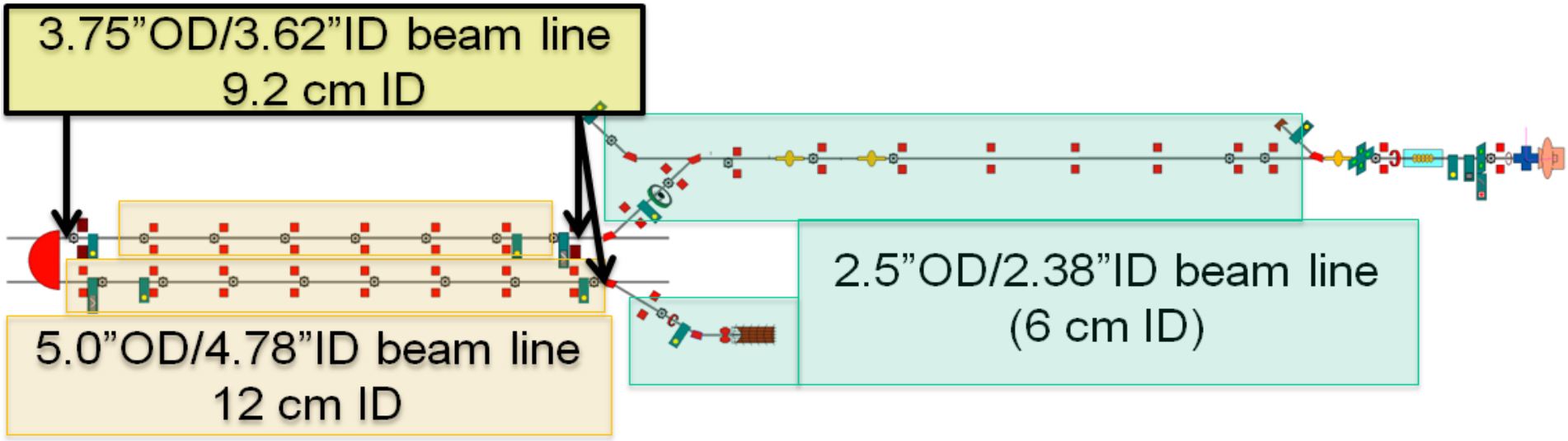
July 8, 2015



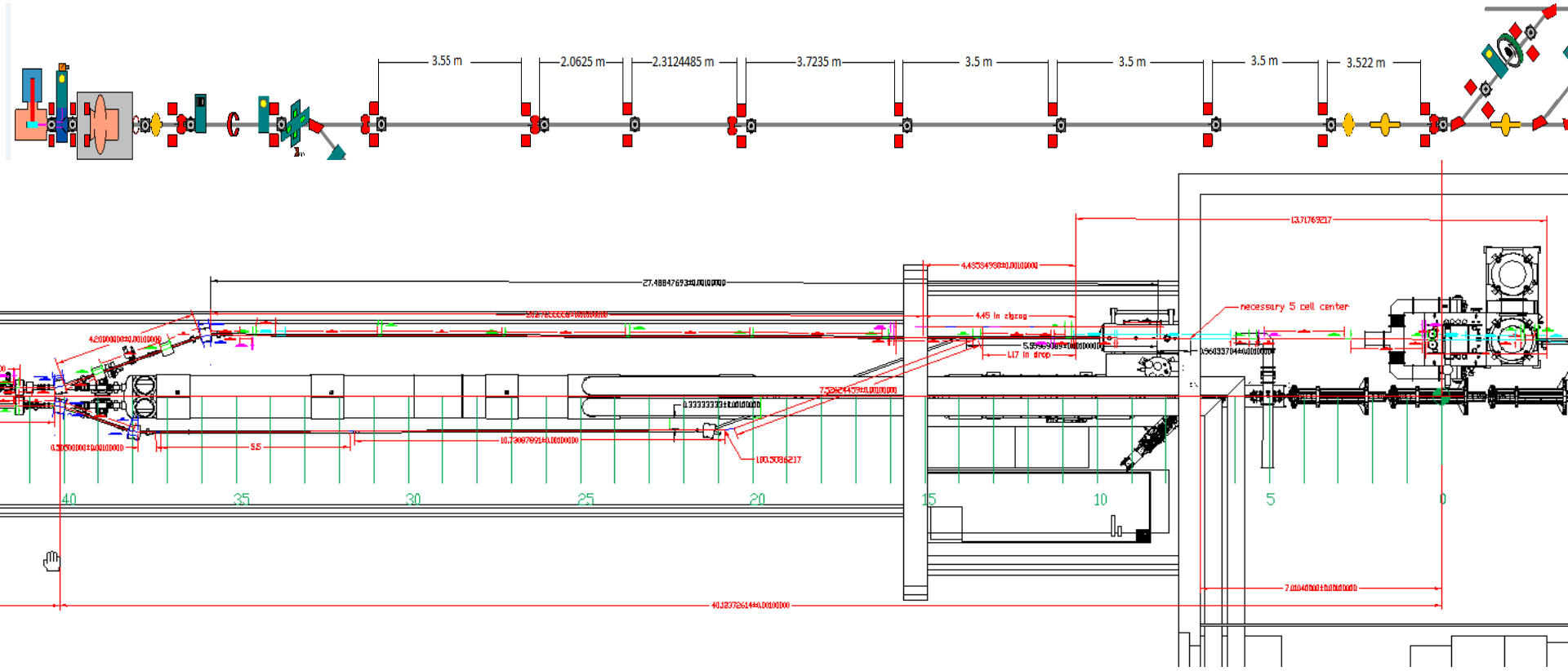
Overall Layout



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



Layouts


3.55 m
2.0625 m
2.3124485 m
3.7235 m
3.5 m
3.5 m
3.5 m
3.522 m
necessary 5 cell center
40
35
30
25
20
15
10
5
0

9/16/15

Phase 1 Block 7.vsd

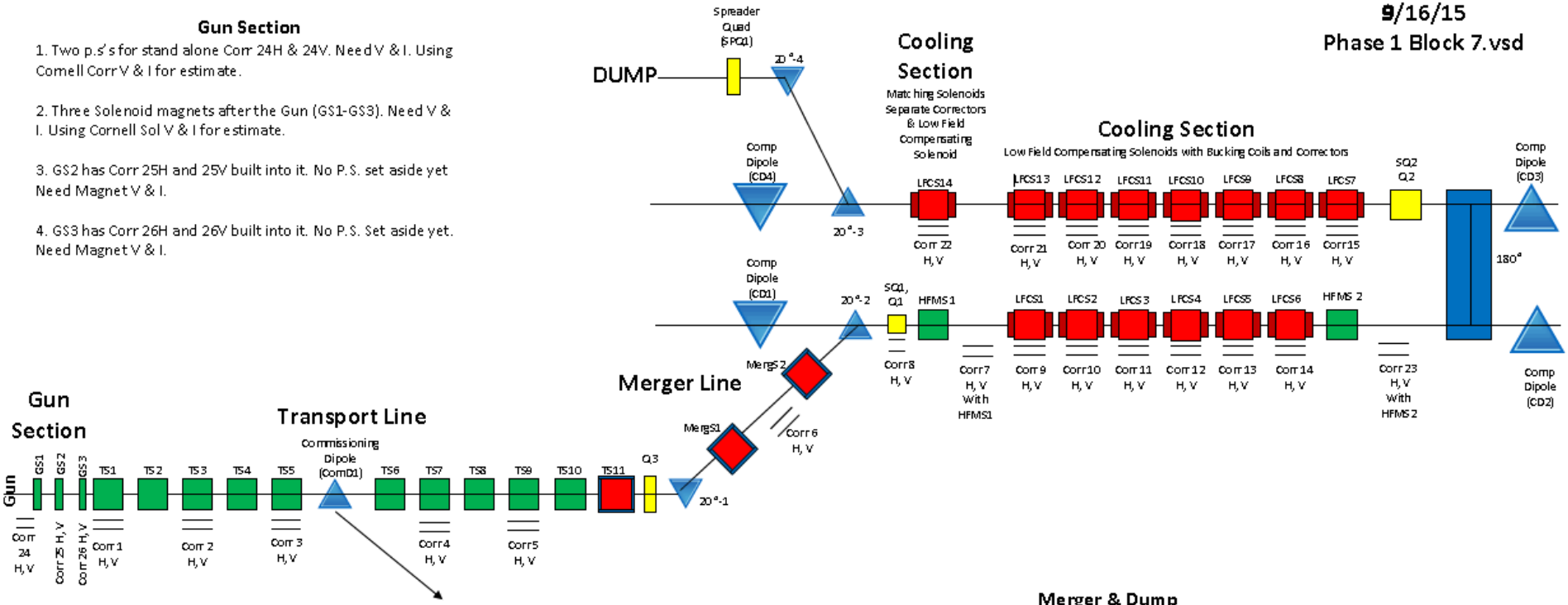
Gun Section

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

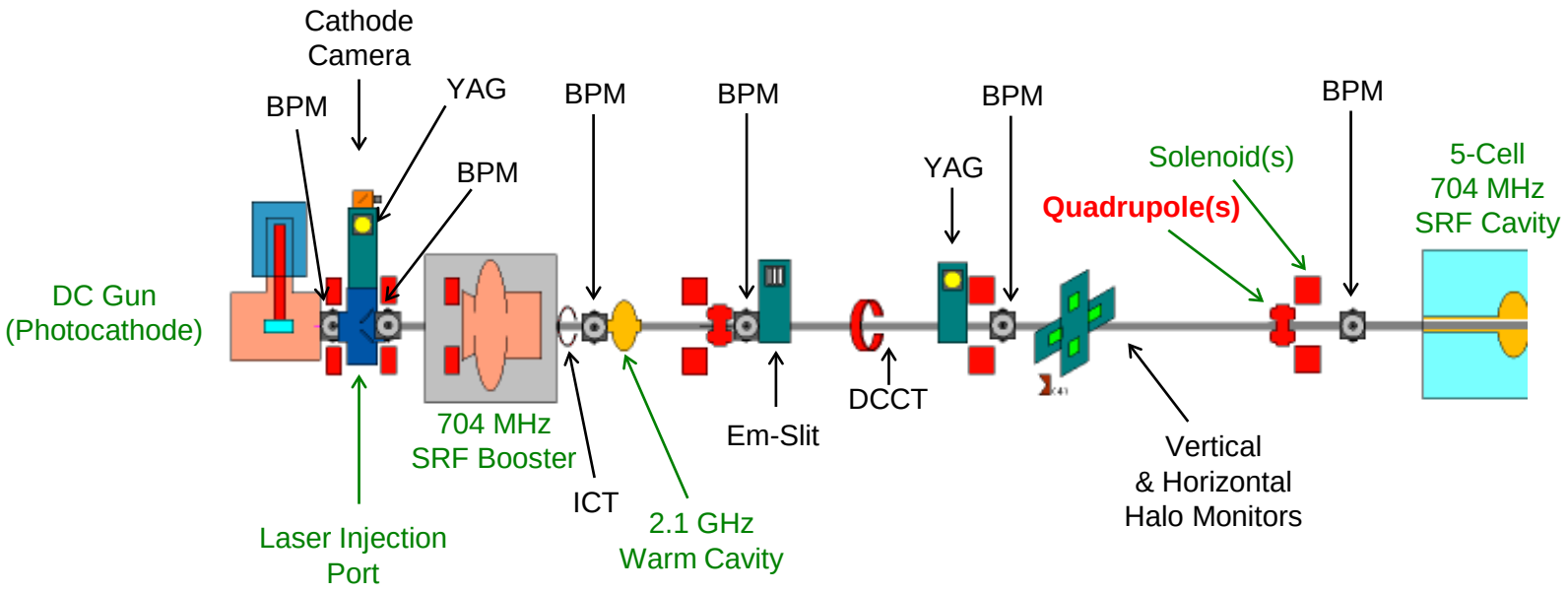
1. 1 p.s. needed for one Spreader Quad Magnet (SPQ1), No V & I, told to use ERL 15V 10A SHIM p.s.

Diagnostics Gun to Booster Cavity ™

- Beam pipe size shall match ERL devices
- **Bake-out to 200C only??**
- DC Gun instrumentation :
  - **Large Button or ERL Button BPM(s) or Striplines??**
  - Profile Monitor in Laser Cross
  - Cathode Camera in Laser Cross
  - Dual Solenoids & BPMs

Injection

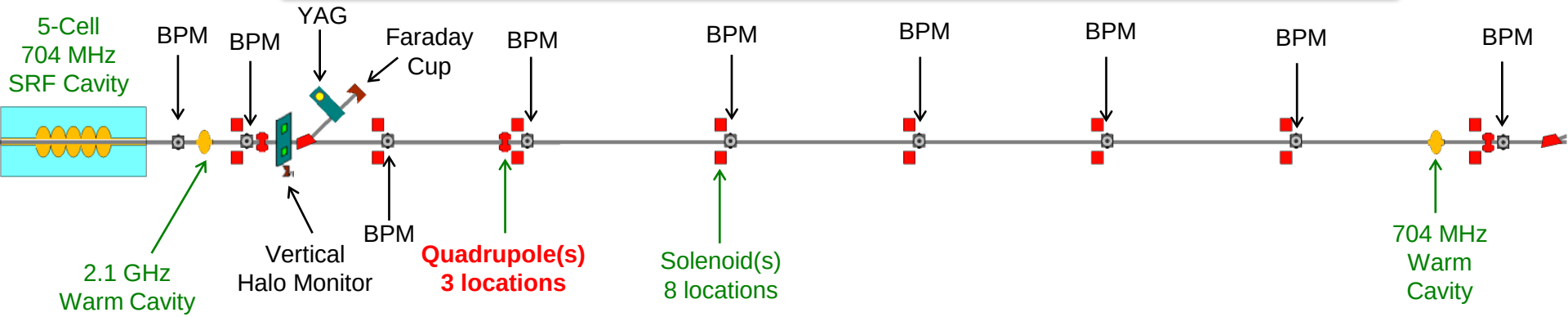
BPM = 6
YAG = 2
ICT = 1
DCCT = 1
Emittance Slit = 1
Halo Pairs = 2
Faraday Cup = 4



Diagnostics - Beam Transport ™

DETAILS:

1. 1st Diag. B/L for commissioning
2. Do we need to add YAG in transport?
3. REVISED LAYOUT BELOW – Per Jorg's model
4. Do we need more emittance measurements in transport? Could add Quad + PM… -> not in baseline and money is too tight



e-Beam Transport

BPM = 9

YAG = 1

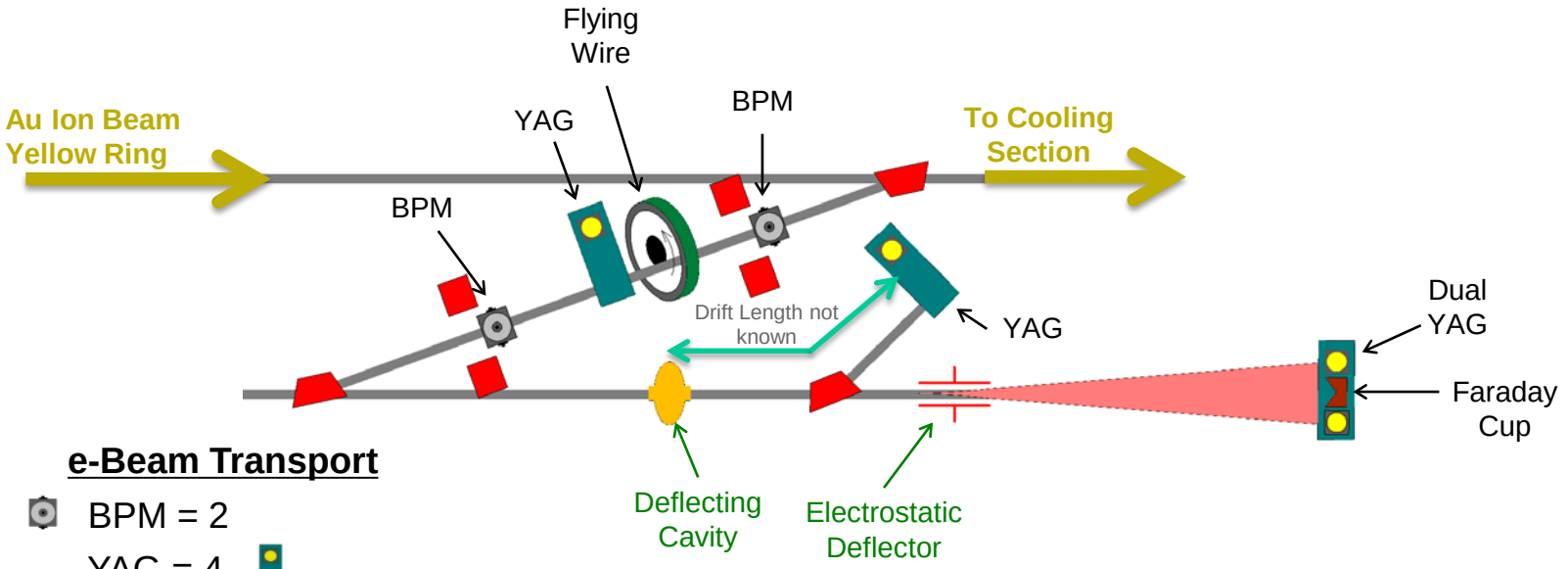
Faraday Cup = 1 + 2

Halo Scraper Pair = 1

Merger & Diagnostic Beam Lines™

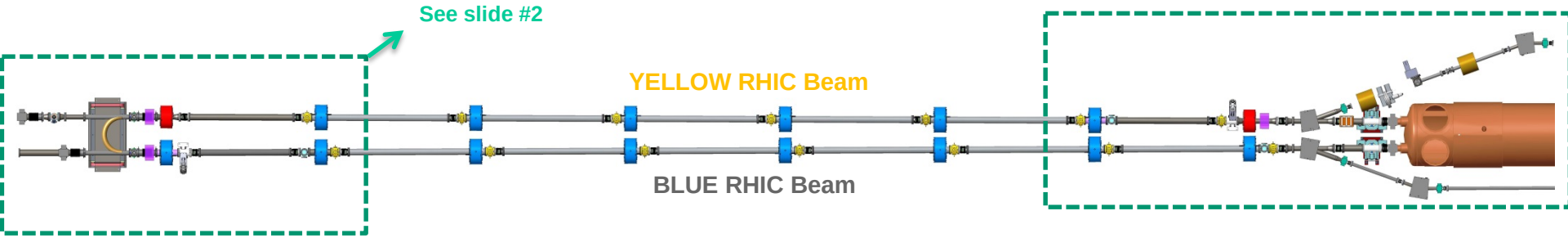
DETAILS:

1. Drift length for RF deflecting cavity not know.
2. Need electrostatic kicker and beam dump parameters for diagnostic line.
3. Waiting on information from the Cornell RF deflecting cavity design.

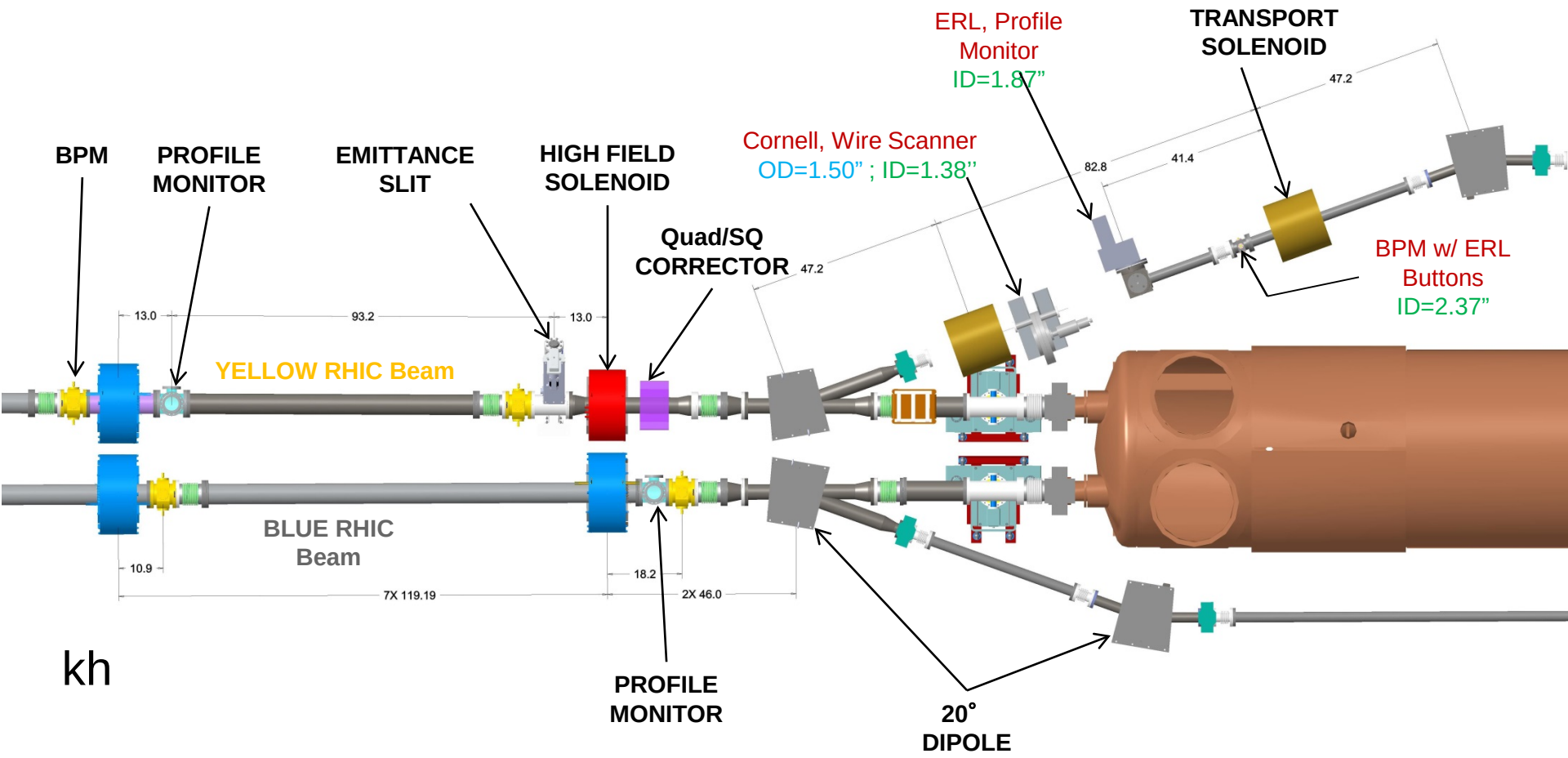


e-Beam Transport

- BPM = 2
- YAG = 4
- Faraday Cup = 1
- Flying Wire = 1



20º Dipole Merger Section



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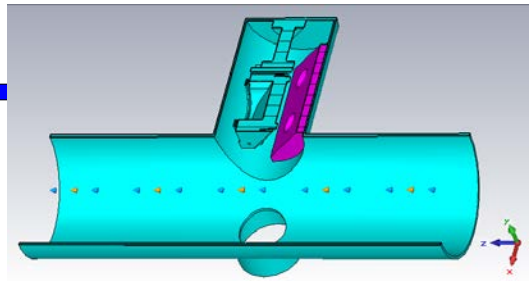
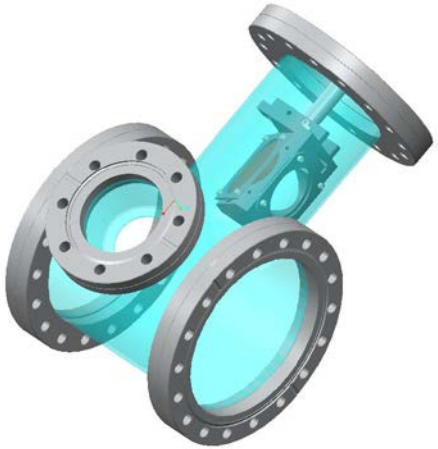
Profile Monitors

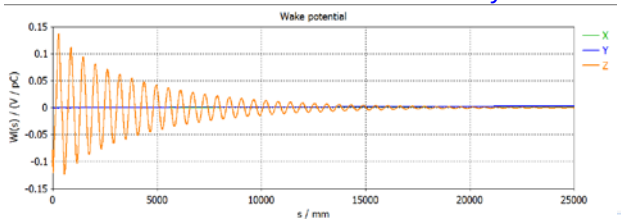


- Cooling Section PMs
  - Vacuum chamber modified
    - Enlarged 1.75” optics port penetration to 2.37” for illumination & ease of fabrication.
    - Simulation shows acceptable results.
  - 100μm YAG current choice
  - Ferrite temp rise due to 19mW => 2.2˚ C (low enough to disregard)
  - 20cm Radius of Mu Metal puts optics assembly ~20cm away from YAG crystal

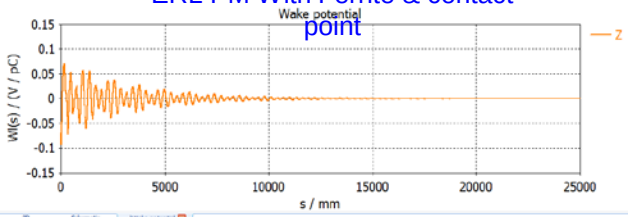


- Transport ERL PMs
  - Beam size (4mm sigma) in TWO transport PMs too large for 25x15mm YAG
    - require redesign of YAG & holder for TWO PM’s
    - Location of 25x15mm YAG PMs needs to be determined
      - All in transport (2 with modified – larger – YAG crystals)
    - Need beam size simulation in energy spectrometer beam line
  - Cage in all 5 ERL PMs will require modification
    - Addition of ferrite rings
    - May require single contact point in vacuum

ERL PM With Ferrite only



ERL PM With Ferrite & contact point



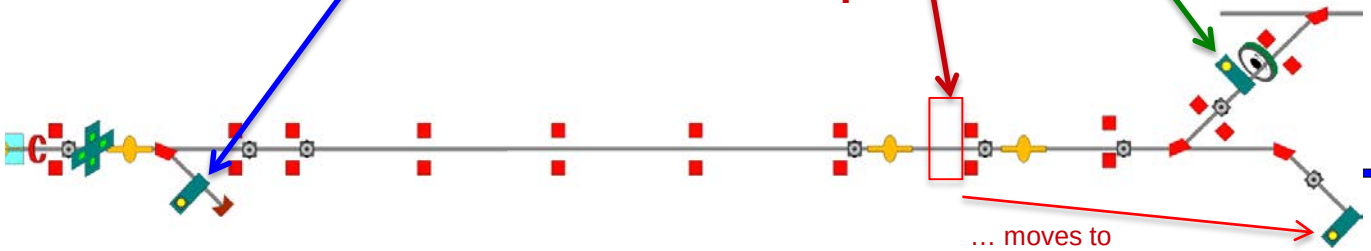
25x15mm YAG

Mod needed for larger YAG

Mod needed for larger YAG

?

25x15mm YAG

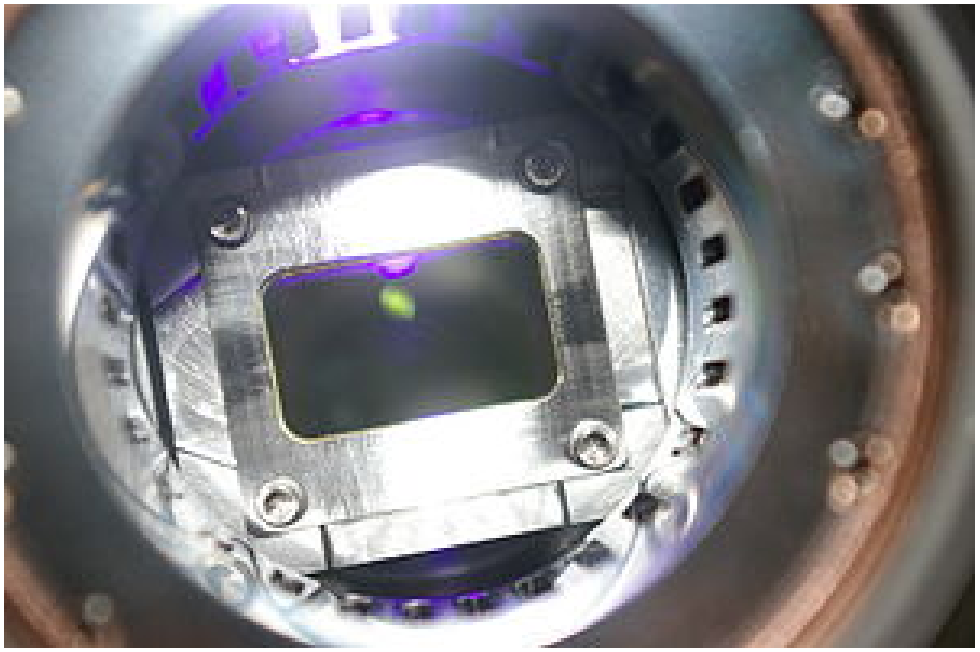


… moves to energy meas. B/L

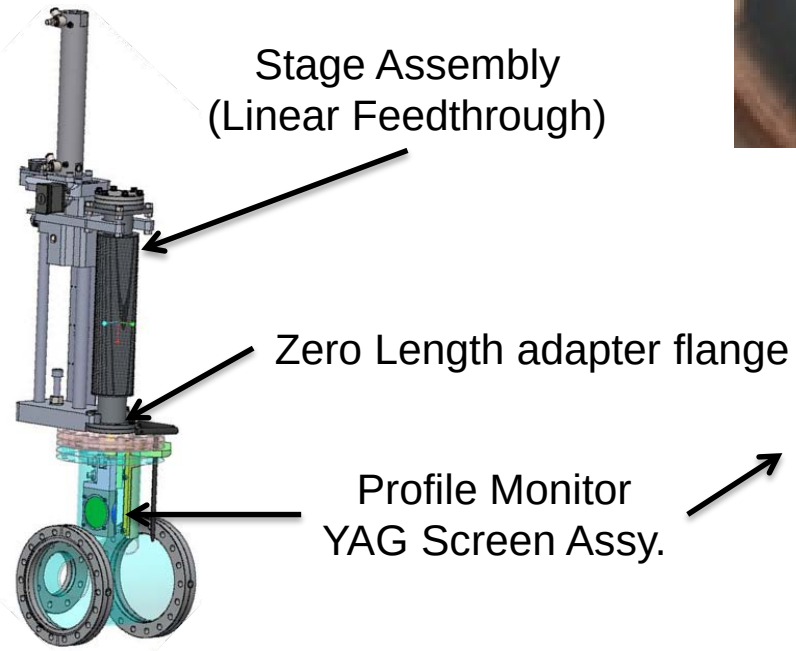
40mm YAG

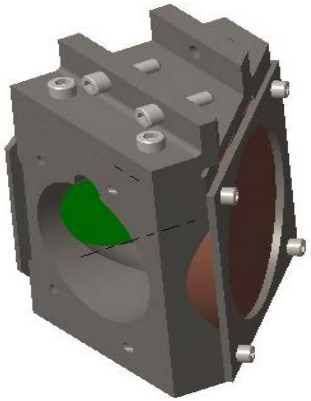
Profile Monitors

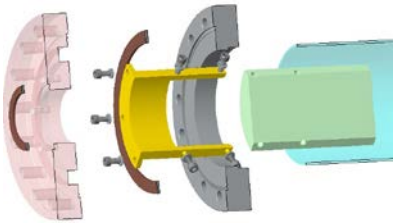
ERL Profile Monitor from Radiabeam



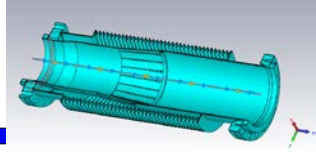
Cooling Section Profile Monitor



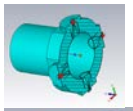


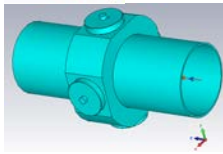


Impedance matching



Need 180 deg chamber
& rest of Transport line

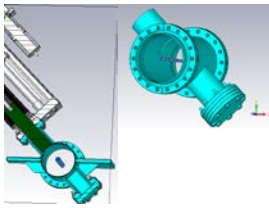


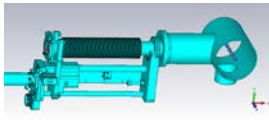


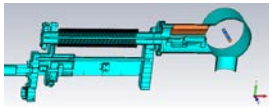
Cooling section energy losses for a 300 pC, 1.5 cm rms long bunch

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

DEVICE	Wake loss factor	Wake loss for 300 pC	Count	Total
	(V/pC)	(eV)		(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

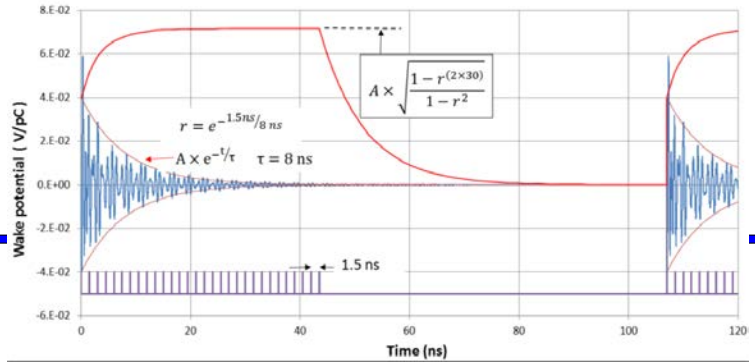


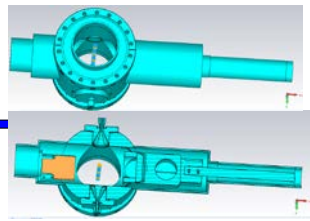




TOTAL **316.82 eV**

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.

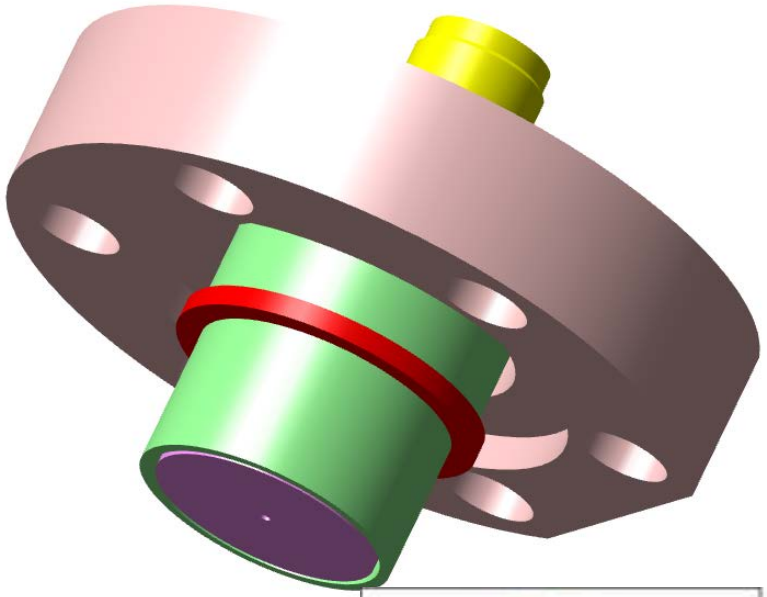


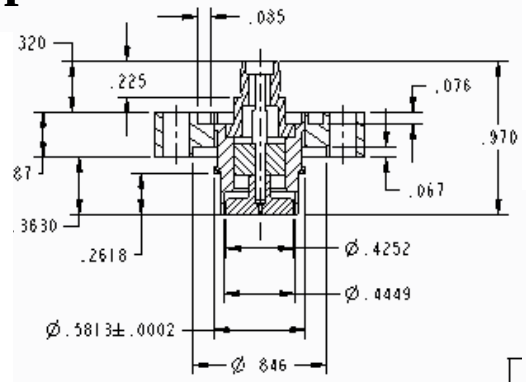


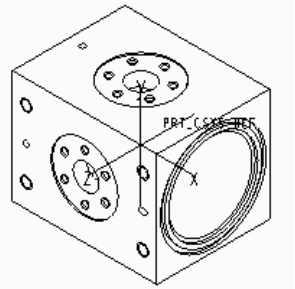
BPMs in Transport Section

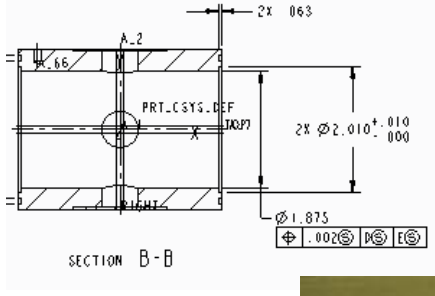
Small Dia. BPM Housings (2.38 ID), 10mm buttons

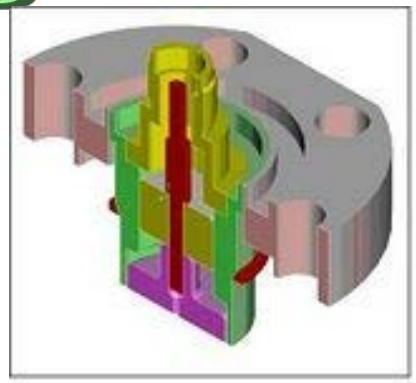
- **ERL Buttons different size and shape**





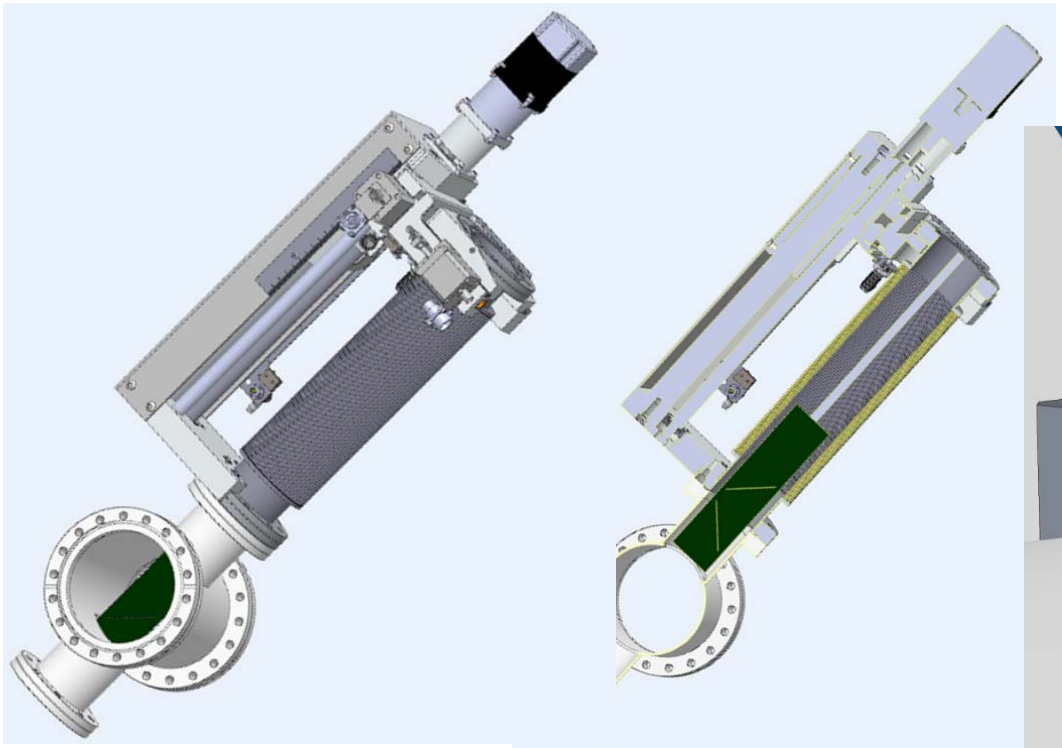


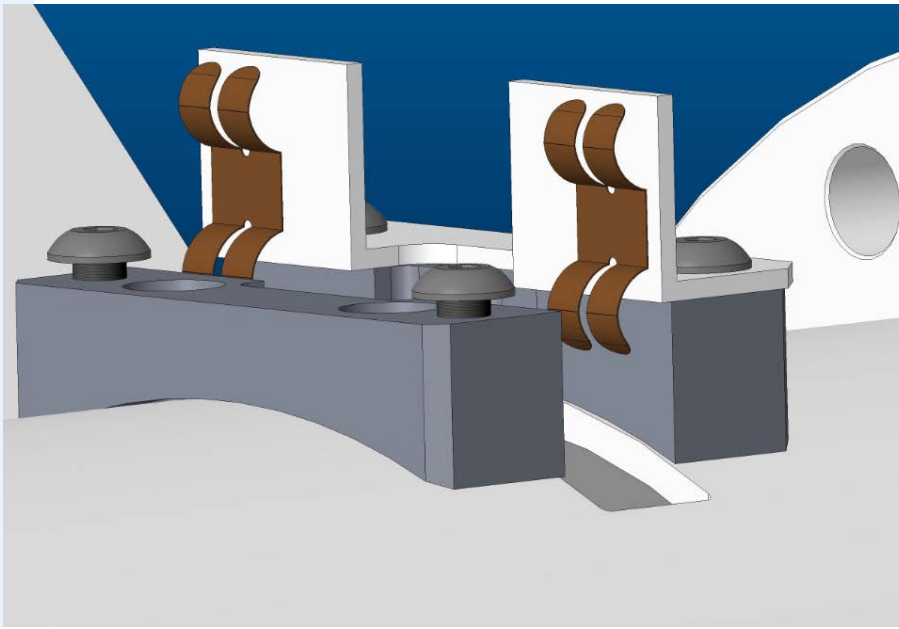




Cooling Section Emittance Slits

- **Requisition for commercial vacuum linear stage.**
- **Fabrication drawings complete and approved.**
- **Central Shops requisition approved for vacuum chamber and W slit.**
- **The slit needs to be grounded at the vacuum chamber when scanning.**
- Delivery dates: shifter, vacuum chamber, W slit, mounting hardware.





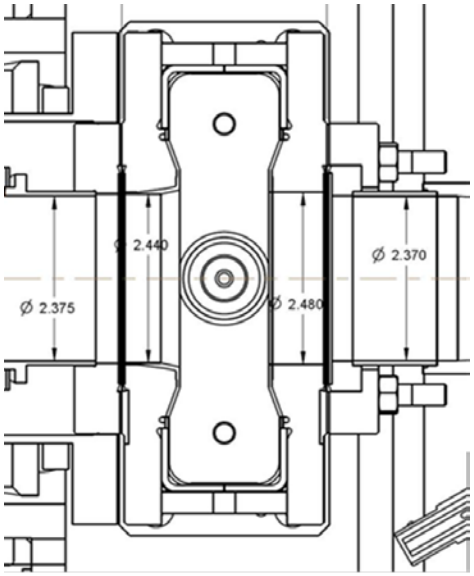
Vacuum Hardware

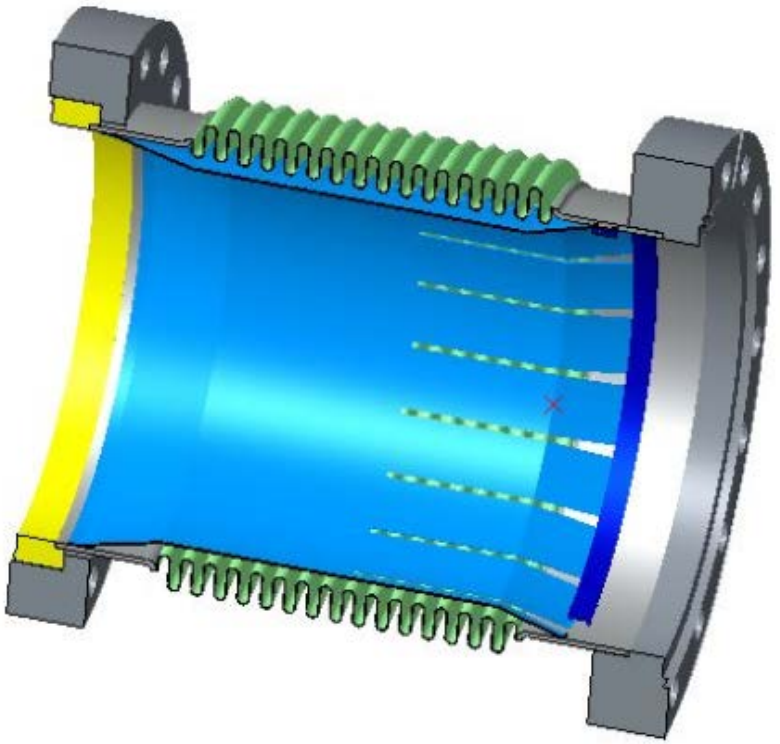
Standard beam tube: 2.5 OD x 2.375 ID 304L Stainless Steel

Beam line bellows 2.38 shielded design.

VAT RF shielded valves.

RF Shielded gauge and pump cross.





20º Dipole Magnet

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

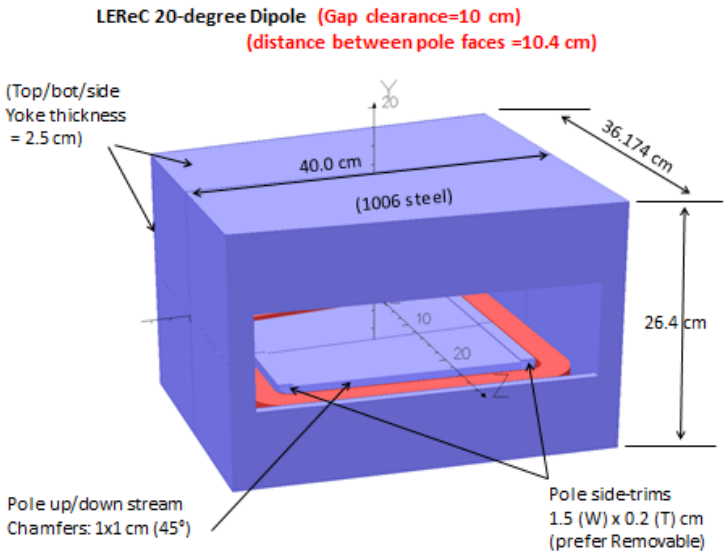
Order Placed 5/6/2015 Everson Tesla

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.)

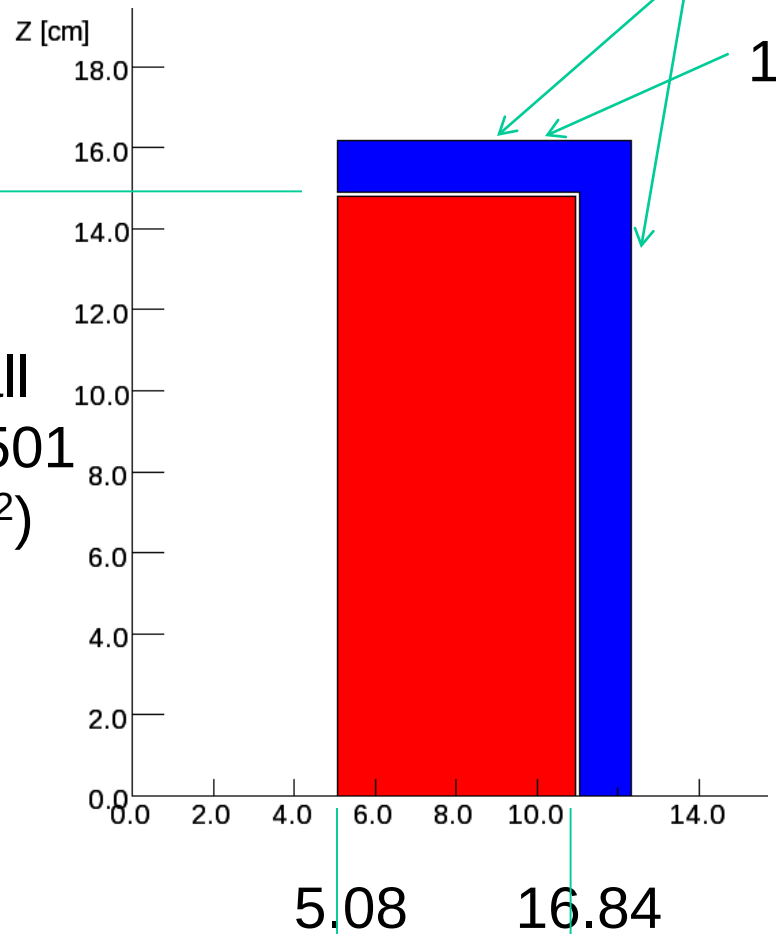


Electron tracking results and field qualities along trajectory on R=1 cm curved cylinder:

	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°

Transport Line Matching Solenoid

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



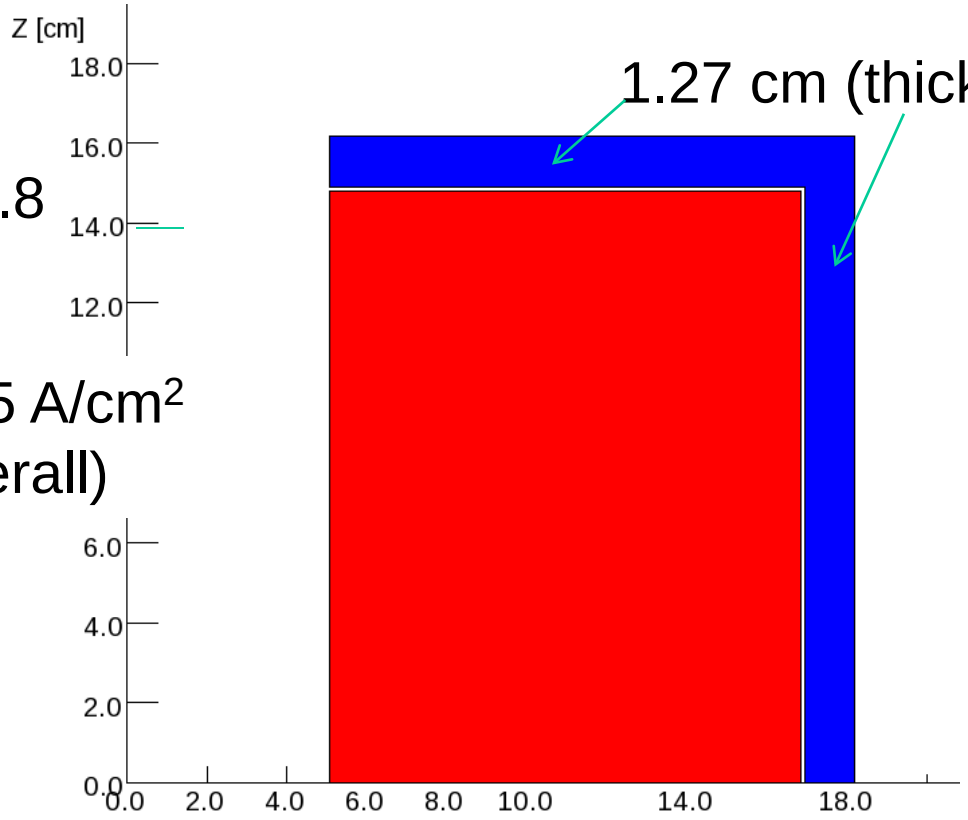
By using #5 square wire
Io = 17.77 A
N = 720
(60 turns along Z-axis;
12 layers along R)
Total 12792.7 A-turn

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

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 BPM stand drawings (KH) ***on hold***

Magnetic shielding drawing and solenoid magnetic measurement test station (VDM)

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)

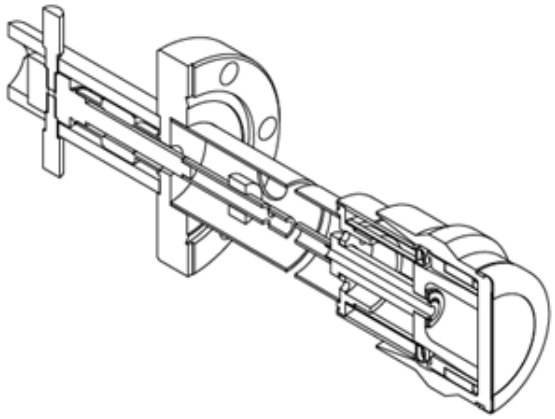
DC Gun to Booster SRF booster cavity beam line (JH)

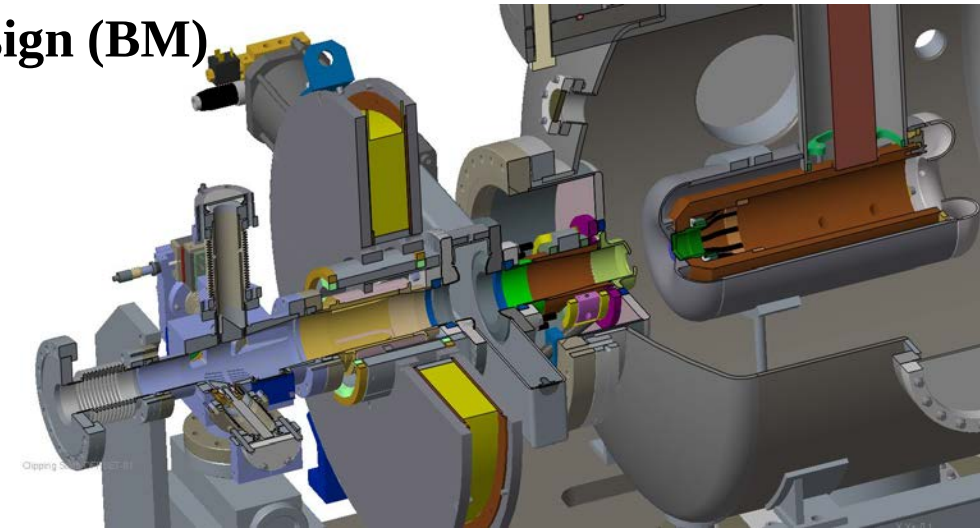
DC Gun cathode insertion drive (WJ/VDM)

DC Gun cathode coating system vacuum chamber (PC)

DC Gun cathode transfer load lock and vacuum chamber (WJ)

Cathode production coating system design (BM)





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 fabrication drawings (MG)

704 MHz warm cavity fabrication drawings (SP)

Transport & Merger line layout (RM)

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

Transport & Merger Line Solenoids

Transport & Merger Line Correctors

Transport & Merger Line BPM's

Transport & Merger Line Profile Monitors

Merger Line Flying Wire

Diagnostic Beam Lines and Components

- **Kickers, RF cavity, beam dump,**