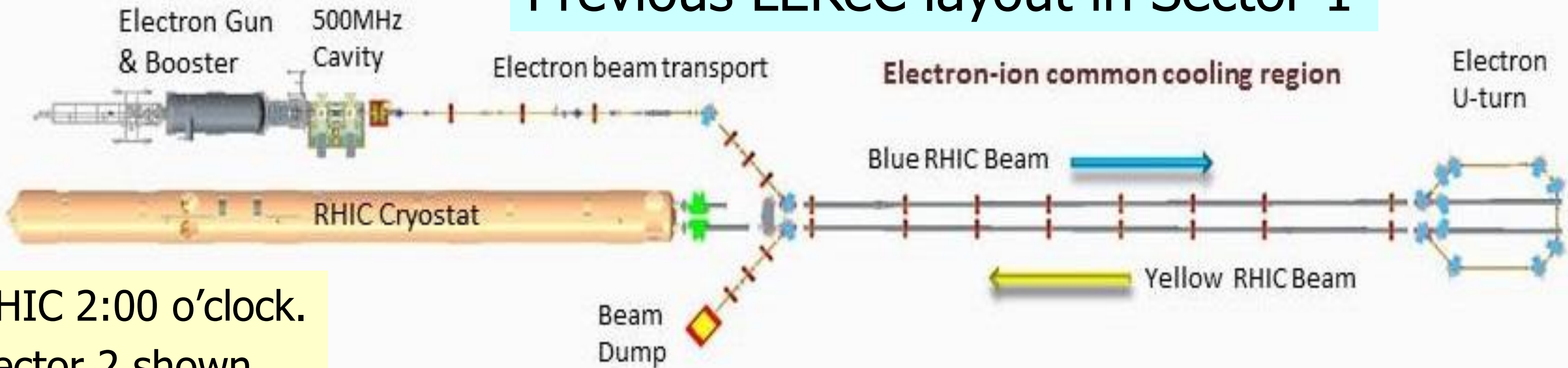
LEReC engineering meeting

November 1, 2013

- **New location in Sector 1**
- **Shielding of cooling section**
- **Diagnostics**
- **Beam dump**
- **New compact U-turn and magnets**

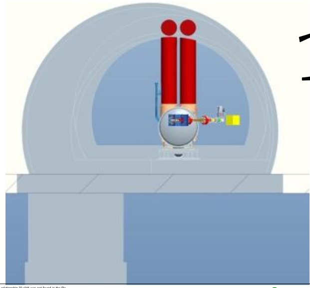
Previous LEReC layout in Sector 1

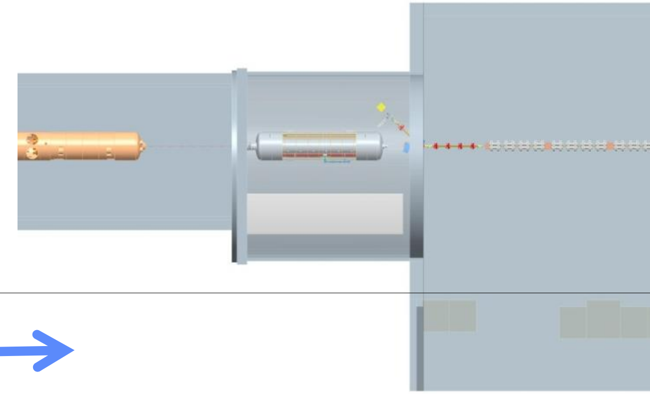


RHIC 2:00 o'clock.
Sector 2 shown.

- **84.5 MHz SRF gun with maximum energy of 2.5 MV.**
- **2.5 MV booster 84.5 MHz SRF cavity in the same cryostat.**
- **507 MHz energy correction warm cavity (6th harmonic).**
- **Electron beam transport.**
- **Cooling section in Blue RHIC ring – 20 m long. Short (10cm) correction solenoids (200G) located every 2m. U-turn between cooling section in Blue and Yellow RHIC rings.**
- **Cooling section in Yellow Ring.**
- **Dump for the electron beam.**

1:00 Tunnel





- 24m to larger tunnel
- + 32m to QHS

Offers more space
for longer cooling section
(gives some safety margin
for cooling)

Recent proposed changes

- LEReC location: changed to Sector 1
- Electron beam injected at 40m from IP
- Space used for cooling: 42-61m from IP (Effective cooling L=17m)
- Matching to U-turn: 61-63.4m
- 63.4m – compact U-turn

• We cannot use space after 63.4 due to timing issue betwee Blue and Yellow rings.

- Total space:

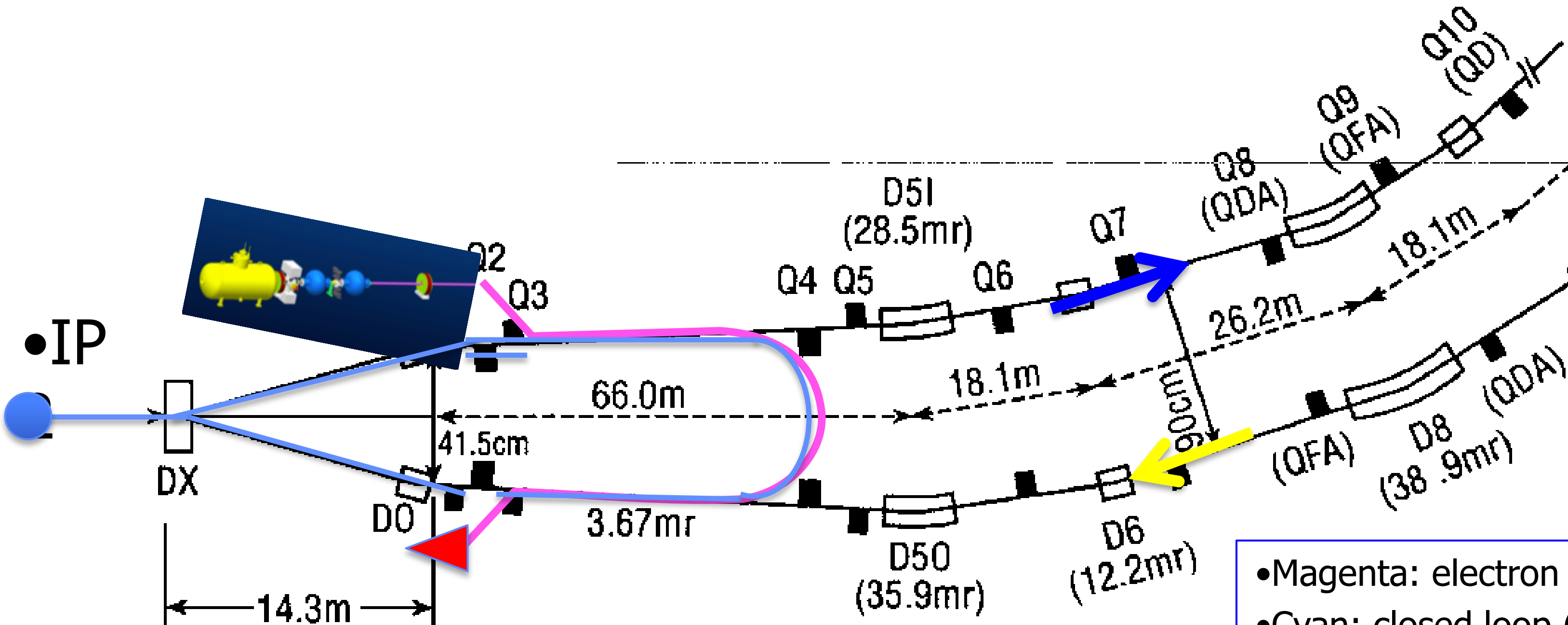
  23.5m in Sector 1

- Some diagnostics has to be moved to accommodate new cooling section in Sector 1:

  For example, IPM's and ARTUS kicker

•Same electron beam is used for cooling both ion beams

•IP

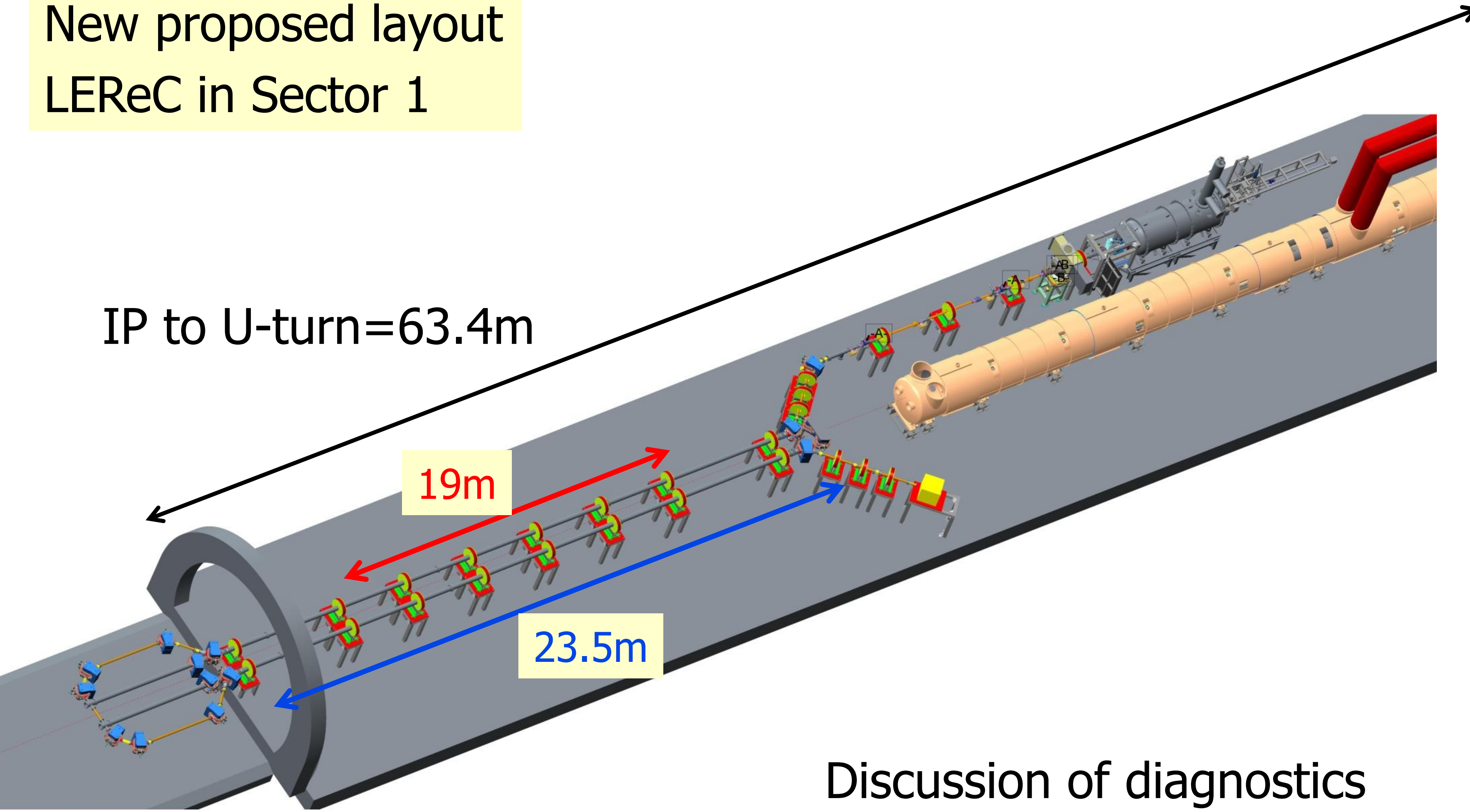


•Magenta: electron trajectory
•Cyan: closed loop (marker)
•Black: blue and yellow RHIC rings

•Closed loop from IP through RHIC rings, e-bunch turn around and back to the IP (cyan color) has to be integer number of RHIC bunches distance (63.9m corresponds to 60 bunches in each RHIC ring L_{RHIC}=3834 m)

Multiple of 32m for 120 bunches (9MHz RHIC RF)

New proposed layout LEReC in Sector 1



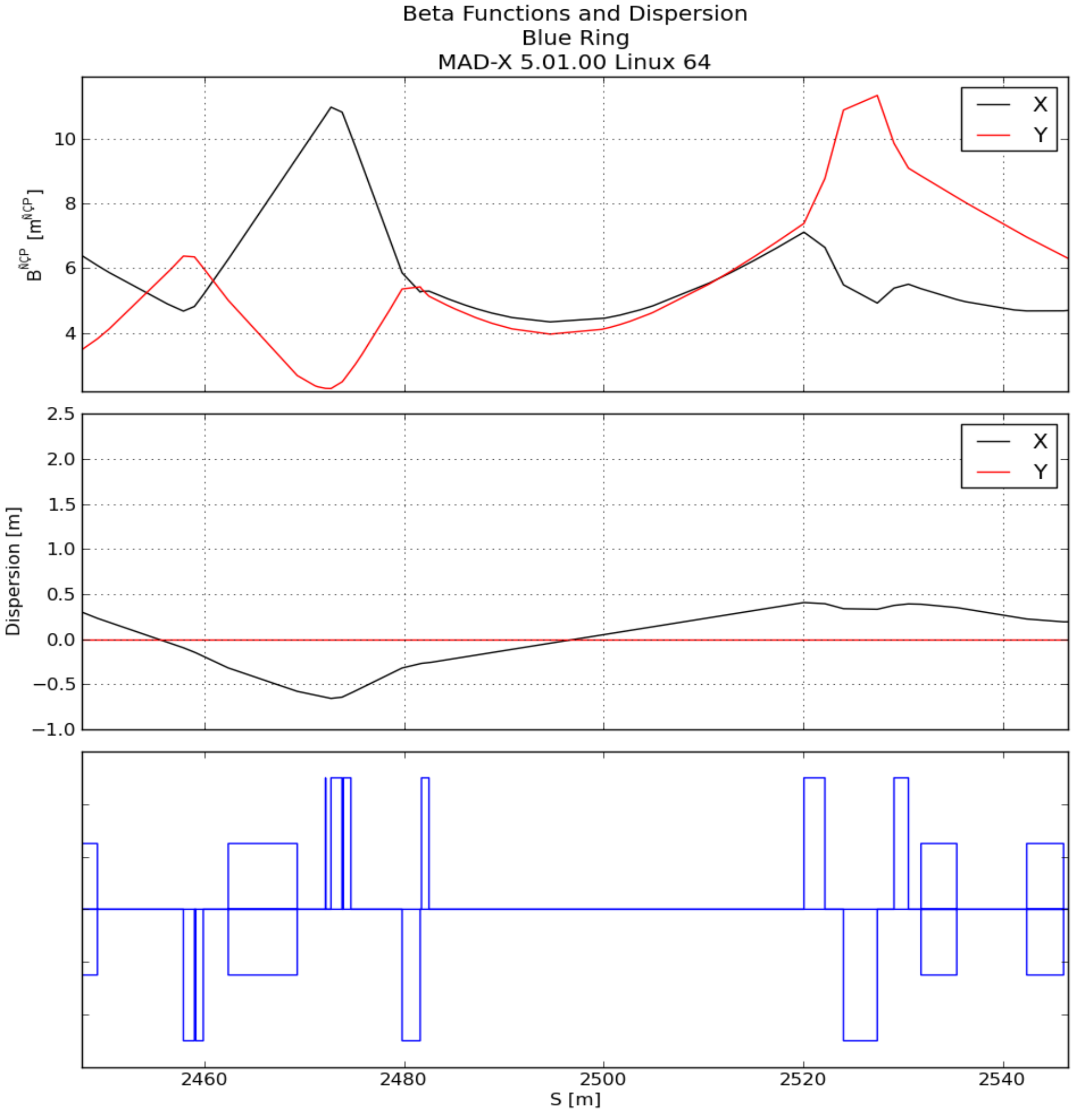
Discussion of diagnostics relocation is underway

Sector 1

Present diagnostics

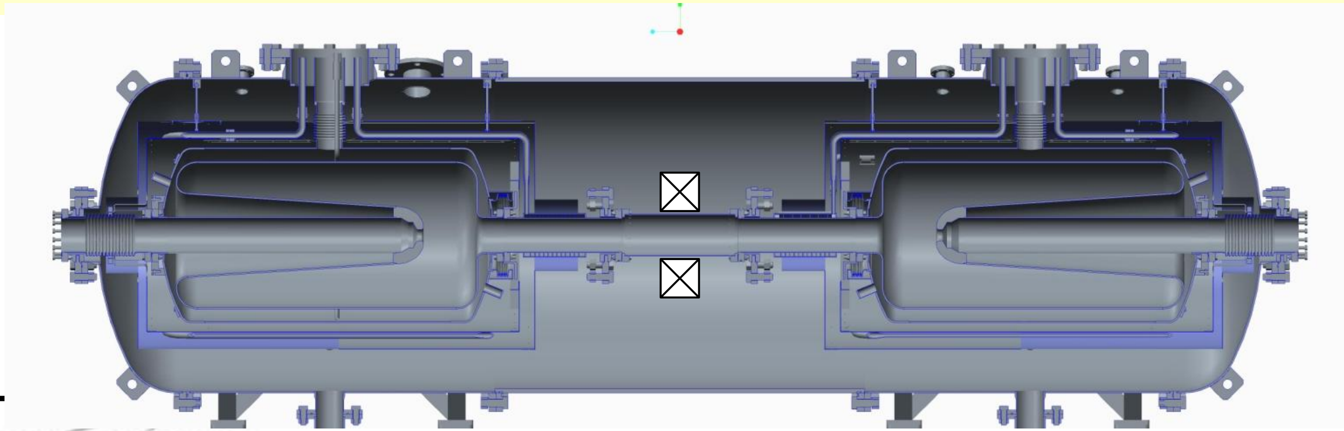
Meters from IP1	Yellow Outer Label	Name	Blue Inner Label	Name
38.4		Start of warm sector		Start of warm sector
38.7		10 Hz GOF Magnet		10 Hz GOF Magnet
40m			MBPM1	Moveable BPM (LF Schottky)
41.8	KKR-1	Quad pick-up		
41.8-43.5	KKR-2	PLL BBQ PU (Moveable)		
42.7	KKR-1		IPM H	B-Ionization PM Horiz
				Beam Loss Monitor
43.7			KKR-1	Hybrid Kicker
			Electron detector V	MCP & RHIC ED Vertical
45.7			EDH-ANL	Electron Detector Horizontal
46.1	TMKH	ARTUS Kicker Horizontal (start)		
48.1	TMKH	ARTUS Kicker Horizontal (end)		
	EDV	Electron detector V		
		Pin diodes (4)		
53.1	LM	Lumi-mon (only a cross)	GCK+TMKV	ARTUS Kicker V(or Bunch-by-Bunch longit damper?)
		Beam Loss Monitor	GCK+TMKV	ARTUS Kicker V(or Bunch-by-Bunch longit damper?)
55	IPM-V	Y-Ionization PM Vert		
63m				
65m		**New IPM-V ???**		**New IPM-H ???**

RHIC optics in cooling section will be different



LEReC SRF accelerator

- The electron accelerator (a short linac) will consist of a two-cavity superconducting RF (SRF) cryomodule producing beam with energy up to 5 MeV and normal conducting cavity for energy spread correction.
- The cryomodule will house:
  - A photoemission SRF gun of a quarter wave resonator (QWR) type, operating at 84.5 MHz;
  - A 84.5 MHz QWR SRF booster cavity;
  - There will be a superconducting solenoid (with magnetic field up to 1 kG) between two SRF cavities.
- 507 MHz normal conducting cavity will correct energy spread due to RF curvature of the SRF cavities.



designed
in collaboration
with ANL

Cooling section and shielding

- The cooling section is the region where the electron beam overlaps and co-propagates with the ion beam to produce cooling. The electron beam first cools ions in Blue RHIC ring then it is turned around (U-turn) and cools ions in Yellow RHIC ring and then goes to the dump. The electron beam must maintain its good quality all the way through the second cooling section in Yellow ring.
- The Blue and Yellow ring cooling sections are about 12 meters each (exact length to be fixed). No recombination suppression is planned. Some space is taken up by correction solenoids, steering dipoles and beam position monitors used to keep the electron beam and ion beam in close relative alignment.
- Short (10cm) correction solenoids will be place every 2 m of the cooling section.
- Distance covered by magnetic field from solenoids (100-200 G) will be lost from cooling. Expect about 20-25 cm to be lost from cooling from each solenoid, every 2m of cooling section (design by W. Meng).

Requirement of magnetic field suppression in cooling section:

γ=4.1: B_residual=2.5mG ->angles: 70 μrad after L=2m.

Passive (mu-metal shielding) or active (Helmoltz coils) should guarantee that B_residual is below required level in free space between compensating solenoids.

Present approach: shielding <0.2mG (angles <35 μrad after 12 m).

Requirement on total rms angular spread : < 150 μrad (γ=4.1)

Emittance of 2 μm gives 130 μrad for 30m β-function.

transverse momentum imparted to the electron beam by these magnetic fields is acceptably low if the fields can be limited to approximately 2 mGauss.

In order to accomplish this, the Electron Cooling section will be shielded by three concentric cylindrical layers of high initial permeability alloy. A geometry that achieves this goal and that fits within the radial limitations imposed by the solenoid design is parameterized in Table 2.

Table 2: Magnetic Shielding Parameters

Mu (initial)	11000
Layer thickness	1 mm
Inside radius of layer 1	109.5 mm
Inside radius of layer 2	120.6 mm
Inside radius of layer 3	133.3 mm
Total magnetic attenuation for DC fields	3000

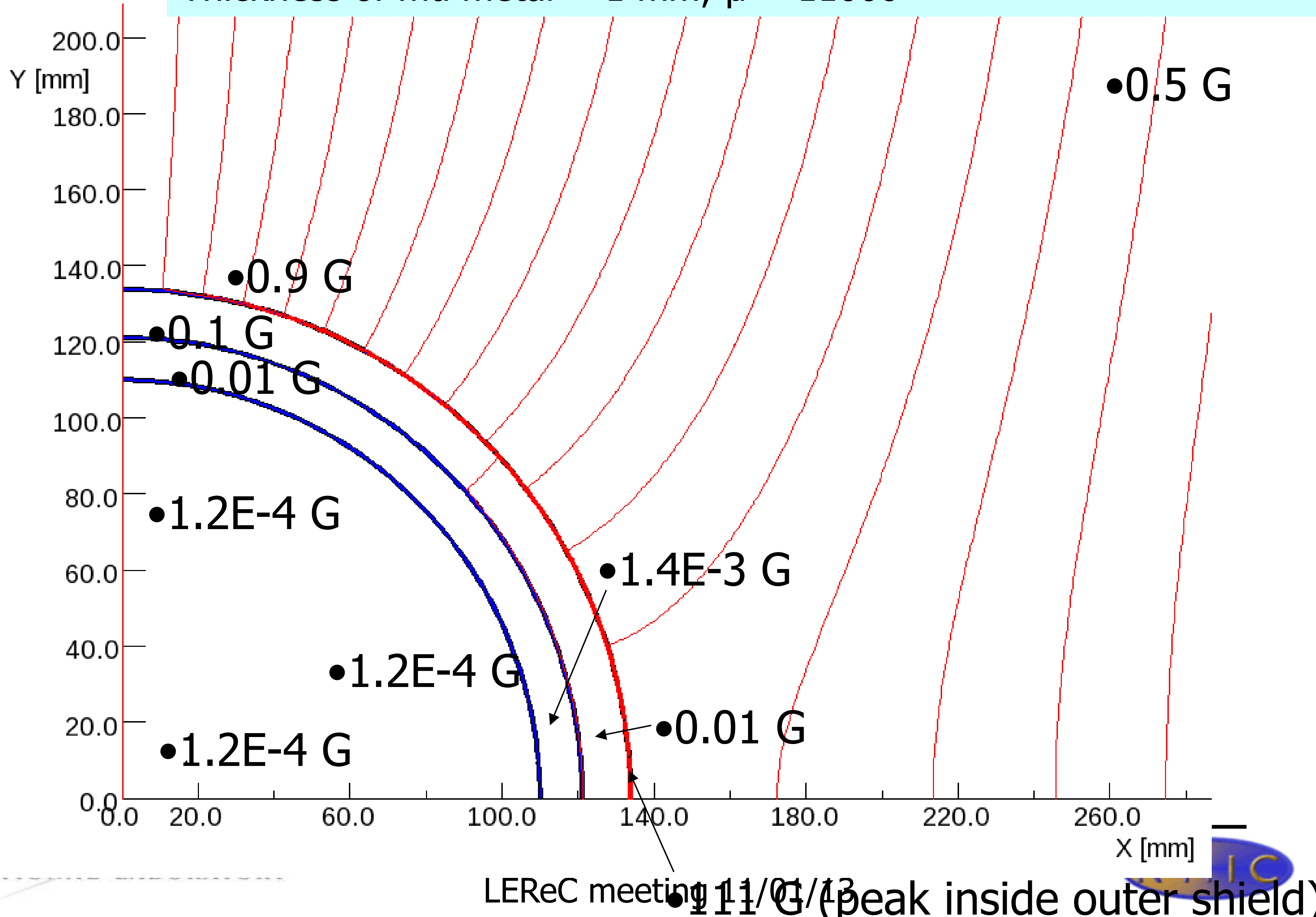
FNAL

Using an 80% Nickel-Iron-Molybdenum alloy satisfies

W. Meng

FNAL 3-layer case: Inner Radius = 109.5 mm,120.6 mm, 133.3 mm

Thickness of mu metal = 1 mm; μ = 11000



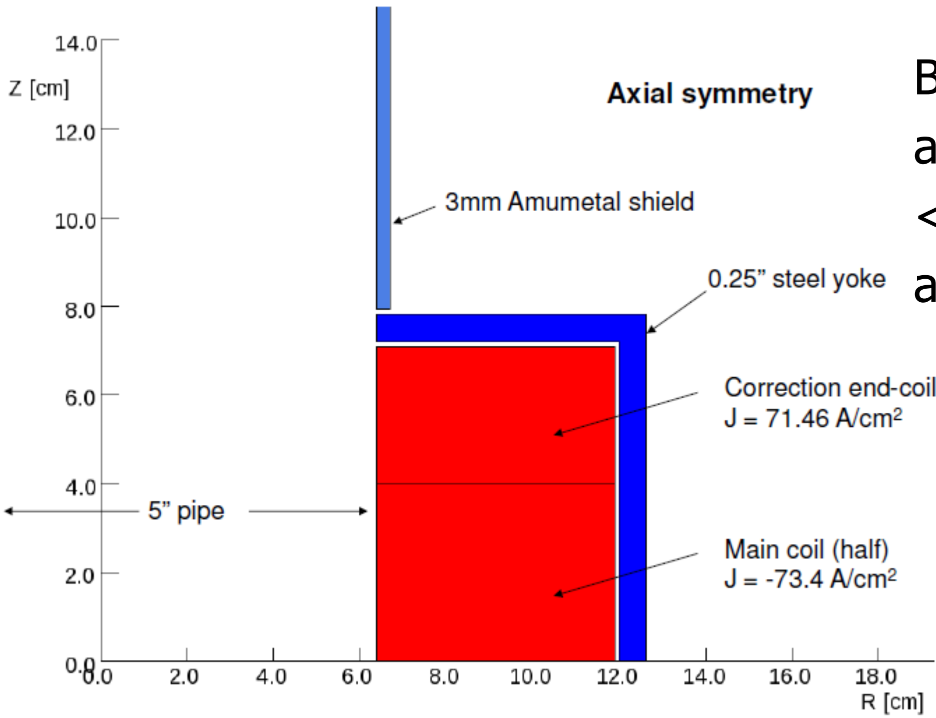
Residual magnetic field from solenoids in cooling region

W. Meng

$$B_z < 1G$$

$$\int B_r dz < 0.5 G \cdot cm$$

at z=10.7 cm

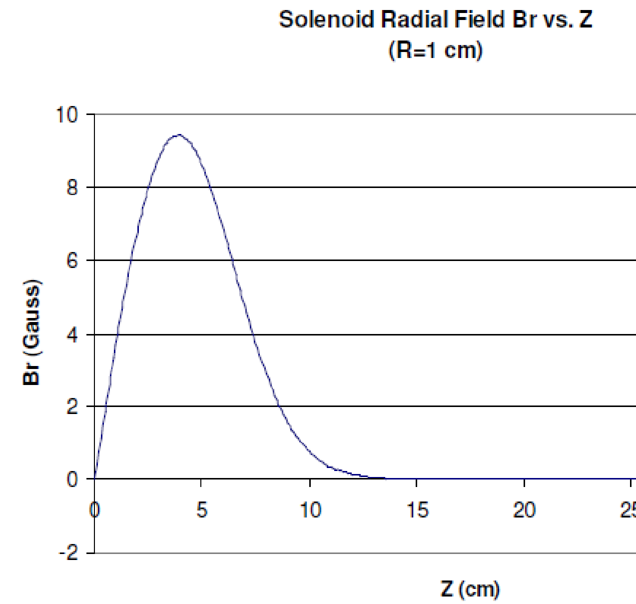


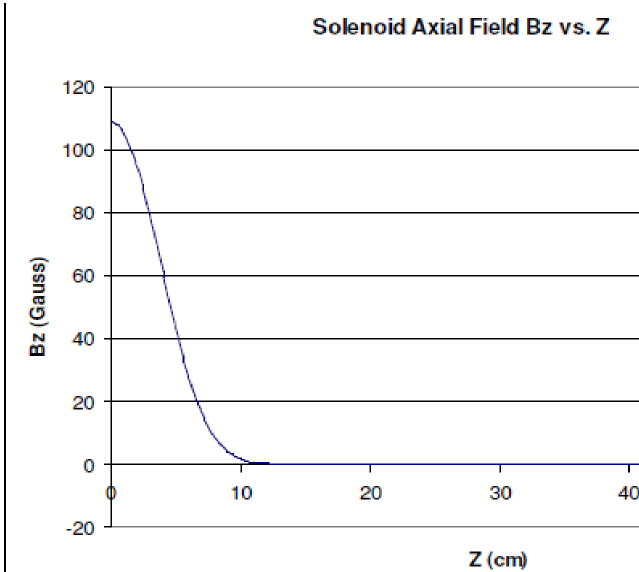
B_z=0.5 G

at z=11.3cm

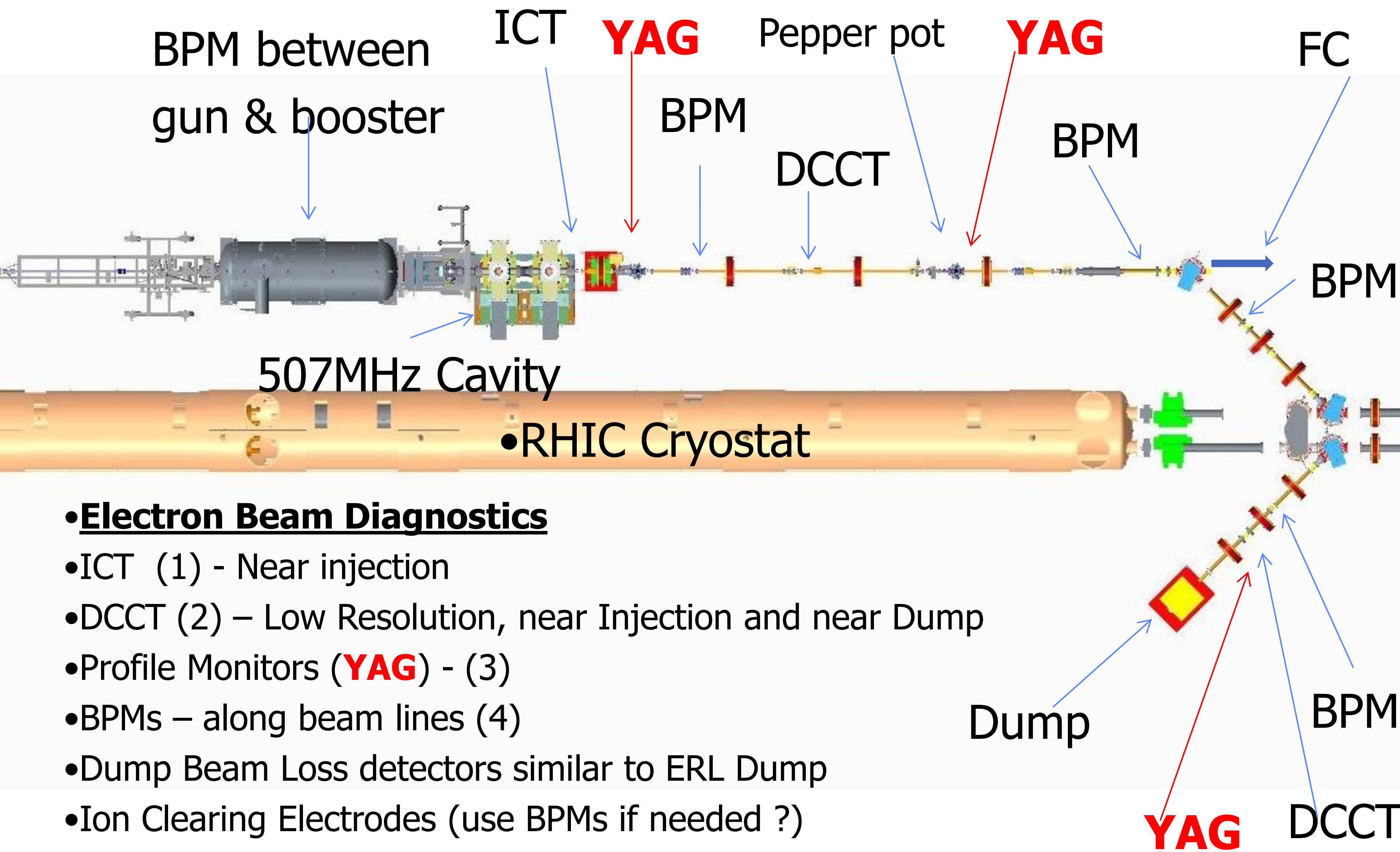
<0.01 G

at Z=13cm





•LEReC injection and Dump Instrument Layout



•Electron Beam Diagnostics

- •ICT (1) - Near injection
- •DCCT (2) – Low Resolution, near Injection and near Dump
- •Profile Monitors (**YAG**) - (3)
- •BPMs – along beam lines (4)
- •Dump Beam Loss detectors similar to ERL Dump
- •Ion Clearing Electrodes (use BPMs if needed ?)

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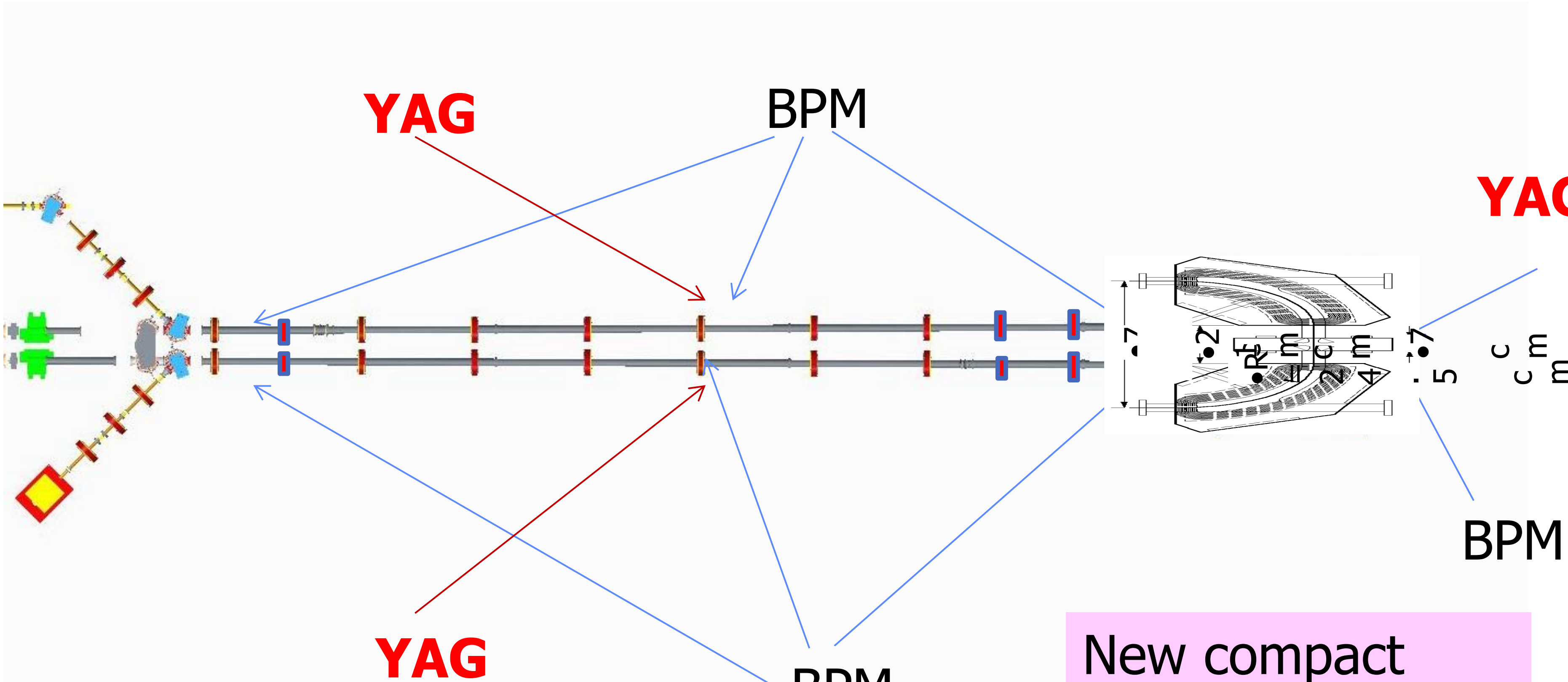
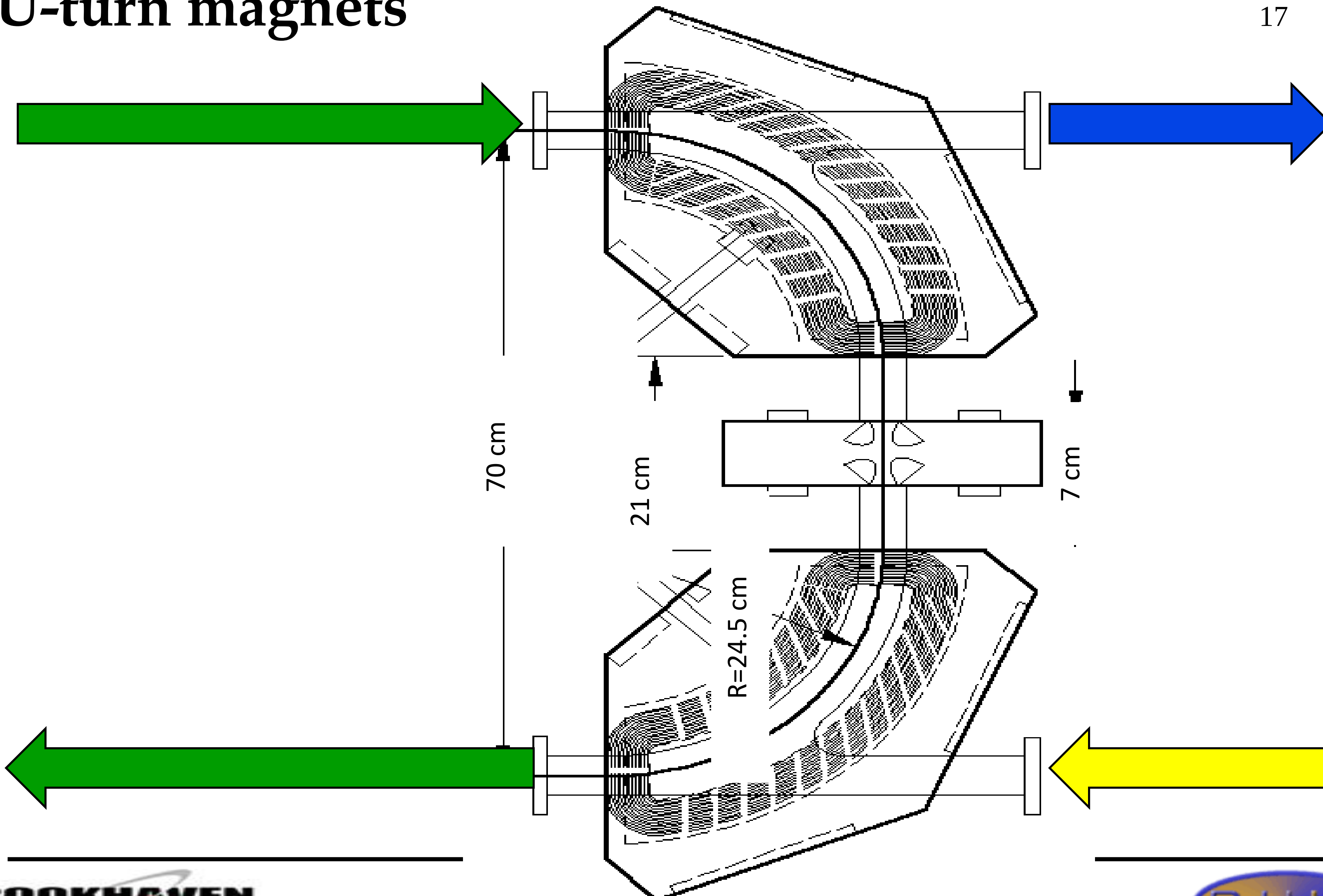
LEReC Cooling Section & U-Turn

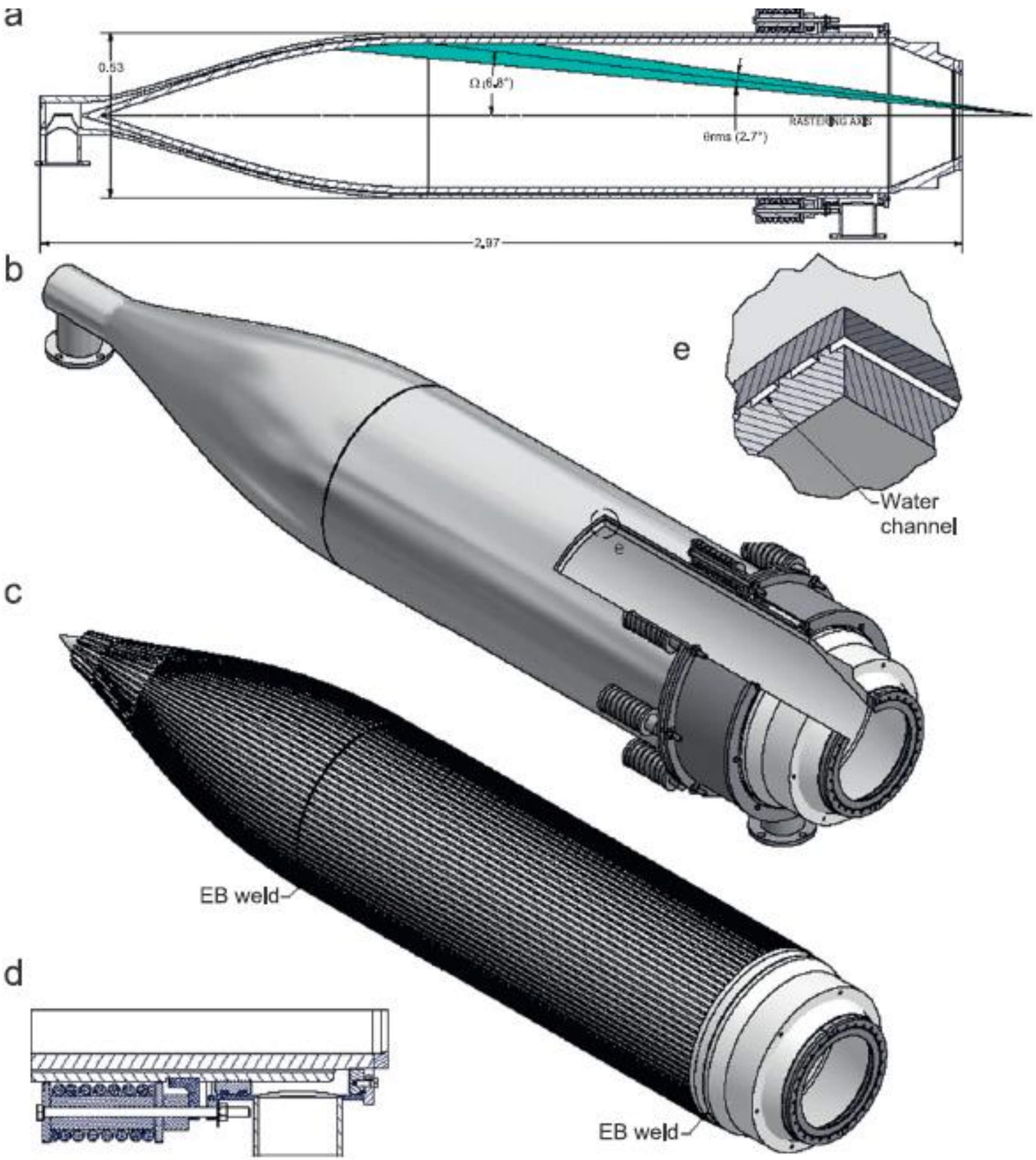


New compact U-turn between RHIC beam pipes.

- **Electron Beam Diagnostics**
- Profile Monitors (**YAG**) - (3) – Plunging YAG screens
- BPMs – (7)
- Corrector locations – at every solenoid,
- For sector 1: L=18m with 9 solenoids every 2 m.

U-turn magnets





Cornell's ERL beam dump

Used
at 5 MeV
300 kW

LEReC:
5MeV, 250kW

Magnet elements:

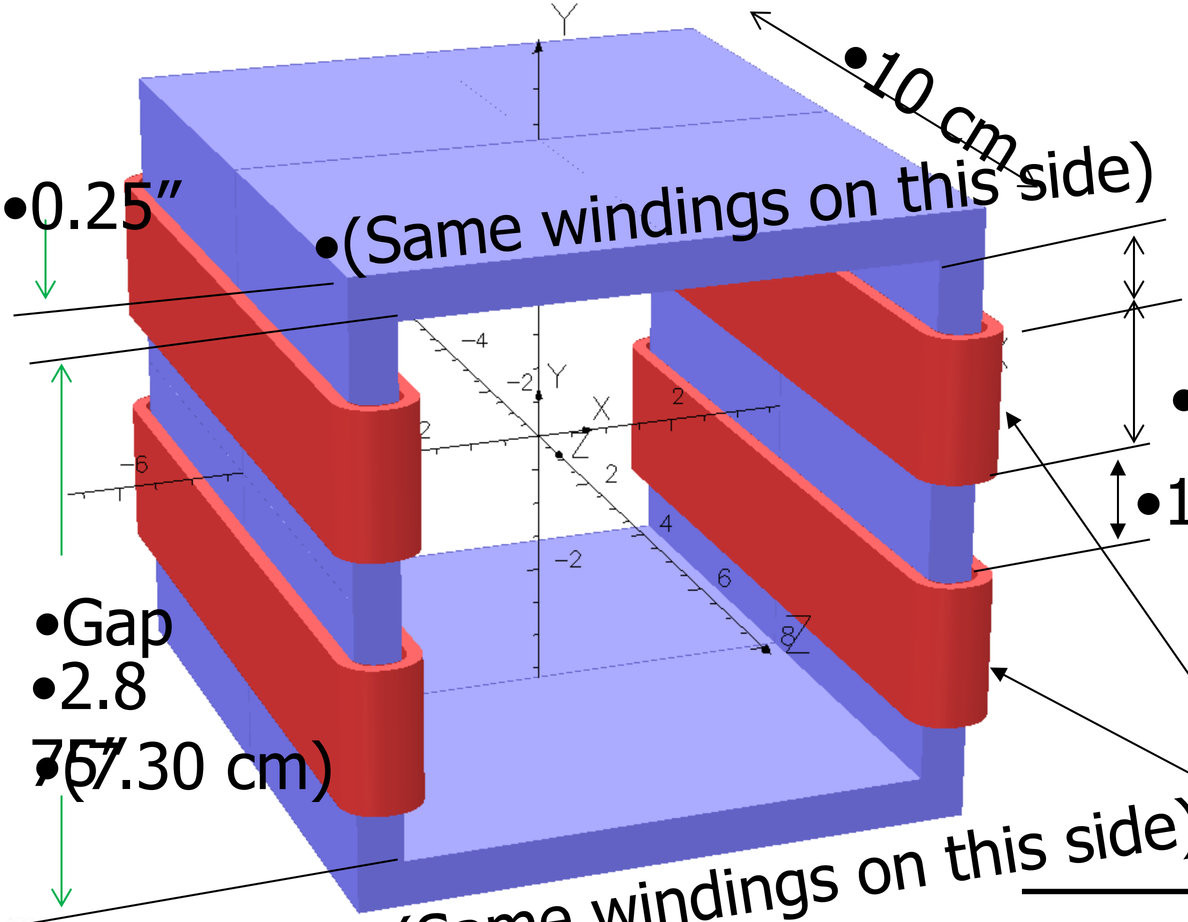
- **Number=6: 45° dipoles, Gap 13 cm, maximum field 500 Gauss; R=38.2 cm, Lm=30 cm**
- **Number=14: Solenoids ID 13 cm, maximum field 1.3 kGauss, Lmag=10cm**
- **Number=9: Cooling section solenoids ID 13cm, maximum field 0.2 kGauss, Lmag=10cm**
- **Number=2: 90° dipoles (U-turn), Gap 13 cm, maximum field 1 kGauss; R=24.5 cm, Lm=? cm**
- **Quad for U-turn ?**
- **Quads for the dump ?**
- **An important feature of beam transport is that magnets should provide stable operation in full range of electron beam energies: 0.9-5 MeV.**

1. Transport line correctors: **G5 Steering Magnet**

2. Correctors inside each cooling section solenoid

- Maximum current: 30.13 A-turn per coil
  - or 60.26 A-turn per leg
  - or 3.35 A per turn
  - or 1 A/mm^2 in Cu area

Maximum B ~ 10 Gauss (each set)



- Each coil has 9 turns
- **AWG-12** wire (cross-section
- Area = 0.2 x 2 cm)
- 18 turns (2 coils) per leg

New RHIC (4.5MHz or 9MHz) RF

Presently, switching to 9 MHz RF.

- A concept and feasibility study has been started for the 4.5MHz cavity design for the low energy gold program.

- Two design typologies are being considered for this effort.

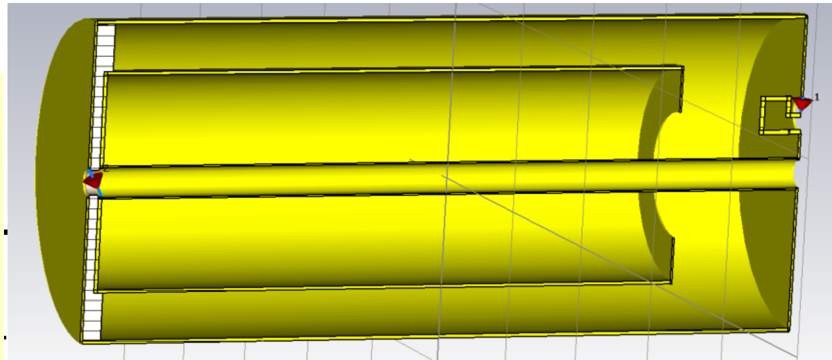
  » **Ferrite Loaded Cavity**

  A ferrite loaded cavity design has been fabricated and initial performance testing has been performed.

Alumina Disk Reentrant Cavity

Preliminary simulations of an alumina disk reentrant cavity design have been completed and building a scaled down version is currently underway.

- •Center Frequency = 4.55MHz
- •Estimated Q = 4000
- •Estimated Drive Power = 5KW
- •Max Voltage = 40KV



WBS and cost estimate

- Preliminary WBS from groups – November 18
- Preliminary cost estimate from groups – November 18