Meeting Minutes – 1/14/15

- Magnet Design
  - During DOE Review there was concern for magnet field quality of LF Solenoids. This concern was partially resolved by use of corrector windings.
- 20^o Dipole
  - Magnet gap is 4 inches. The 4 inch aperture to be confirmed as either magnet gap or inside vacuum chamber opening.
  - Inner shield design to be reviewed (approved by Mike Blaskiewicz).
- 180^o Dipole
  - Chamber position in magnet is slide-able 6 cm. Dmitry Kayran needs to verify this requirement
  - Magnet gap is 4 inches (same comment as 20deg dipoles above)
  - Inner shield design to be determined by Mike Blaskiewicz.
- Instrumentation:
  - During DOE Review there were many questions on the recombination monitors.
  - Flying wire to be in the merge section between 20 deg dipoles.

Meeting Minutes – 1/14/15

Comments on DOE Review of LEReC (See below and on following sheets):

- The Resource Loaded Schedule (RLC) needs to be fixed. There are about 10 items, 50% technical and the rest schedule related. DC Gun is part of the project, so it must be integrated into RLC.
- There will be another review in July to check the schedule.
- Magnet design documentation required (Analysis by W. Meng to be added to archive)
- For purchase of long lead items the DOE can influence PPM's priorities.
- Schedule shows instrumentation items to be ordered by 1 February. Check with Toby M. about this date.

Meeting Minutes – 1/7/15

- LF Solenoids: SOW and Specification change (D. Passarello)
- HF (Matching) Solenoids: Requisition complete; SOW and Spec. change (D. Passarello)
  (Magnet specifications approved – **need documentation**)
- 20^{o} Dipole
  - Magnet gap is 4 inches/transport lines 2.5 inches (2.5” RF shielded vacuum valves)
  - Inner shield design to be approved by Mike Blaskiewicz.
- 180^{o} Dipole
  - Chamber position in magnet is slide-able 6 cm
  - Magnet gap is 4 inches (same as 20deg dipoles)
  - Inner shield design to be approved by Mike Blaskiewicz.
- Beam Line magnetic shielding: 2.5 milligauss shielding of beam line required (AF).
  - Per Alexei the shielding of the instrumentation (esp., PM’s and slits) will be difficult. These devices should be kept as near to LF solenoids as possible.
- Instrumentation:
- BPM’s - small button standard design from MPF (or smaller).
- Chuyu Liu simulations for emittance and energy slits and profile monitor to finalize design.
- **Instrumentation is on the critical path for installation for the Cooling Section.**

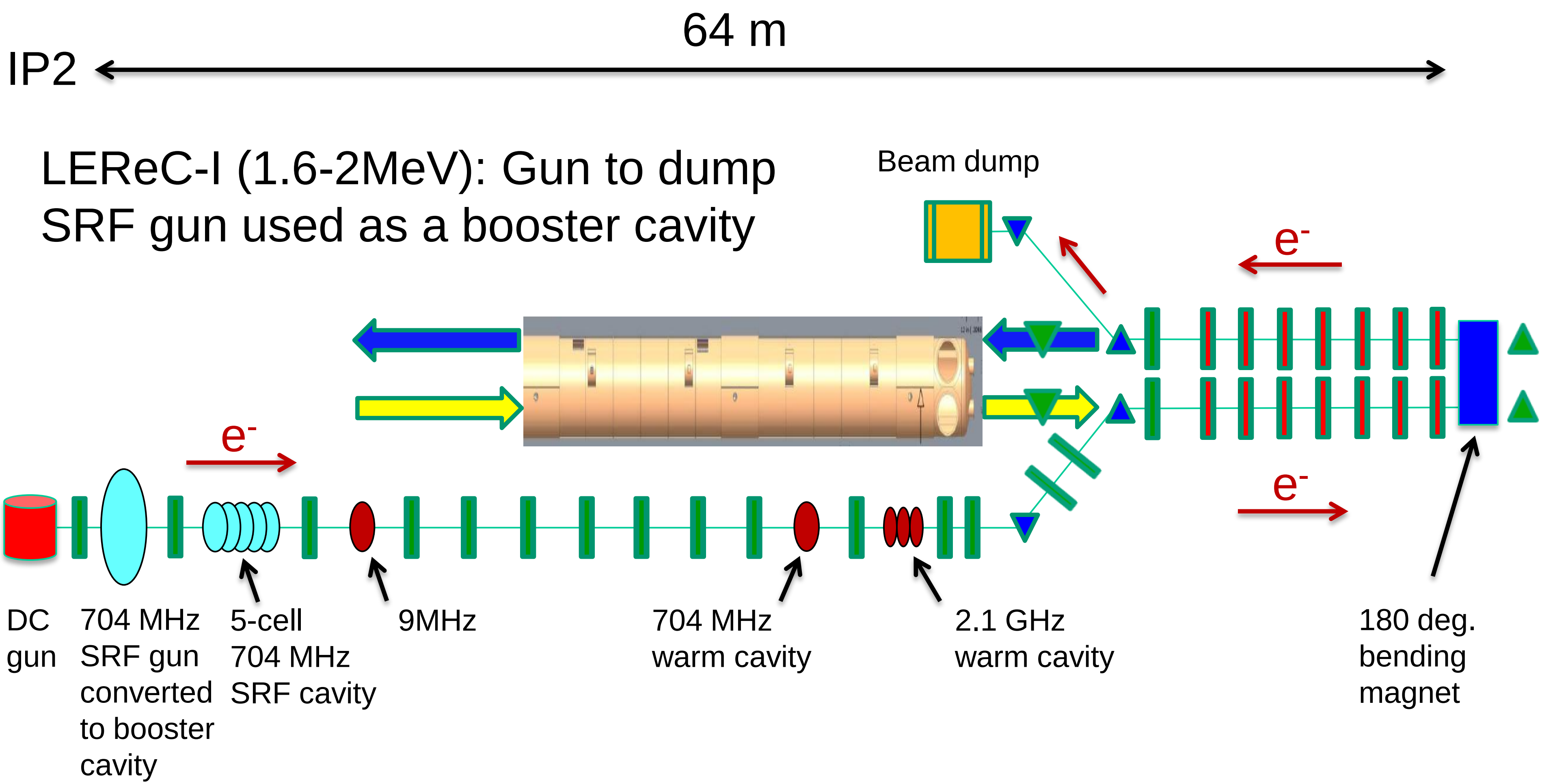
LEReC DOE Review: We are still in business; but, on the edge.

- **DOE – schedule is tight early performance will be monitored closely.**
- **Must make the resource loaded schedule (RLS) real and use it.**
- **Need more 2^{nd} and 3^{rd} quarter 2015 milestones in RLS.**
- **Need Physics design reviews – they must be in the RLS.**
- **The cooling section requirements most be documented and approved ASAP.**
- **DC Gun most be part of the RLS.**
- **DC Gun cathode changing mechanism most provide 2 weeks operations.**
- **The ERL test goals related to LEReC need to be documented and included in the resource loaded schedule.**
- **SCRF Gun or DC Gun decision milestone in RLS.**
- **PPM performance in the RLS.**

LEReC DOE Review: We are still in business; but, on the edge.

- **surface plot of cooling force (or time) vs. delta and emittance (deadline 15 March?)**
- **- low-energy beam transport in risk register**
- **- KPP has 100 pC but simulations are done with 130 pC - need to have one number only**
- **- have responsibility of CPM stated correctly in PEP**
- **- need 3D simulations, simulations should specify tolerances**

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

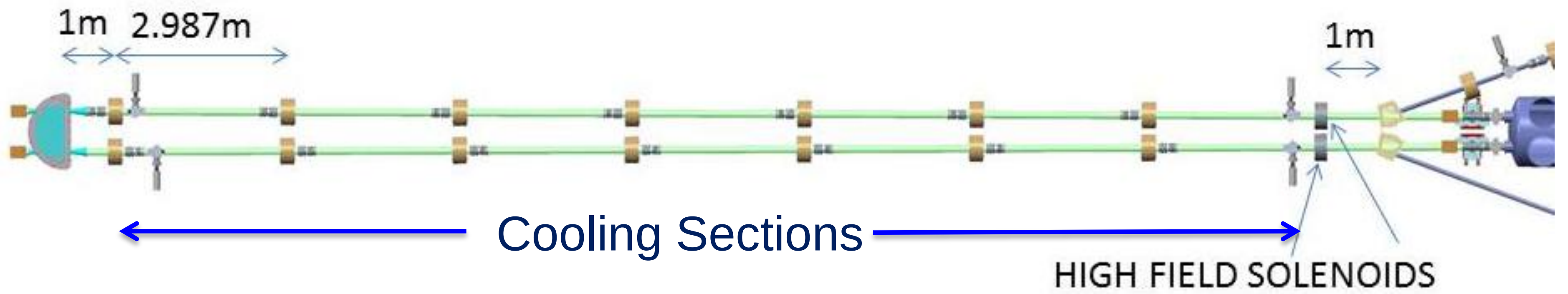


Cooling Sections

2 (matching) solenoids & PS.

2 high field H & V correctors – seperate assemblies(& PS)

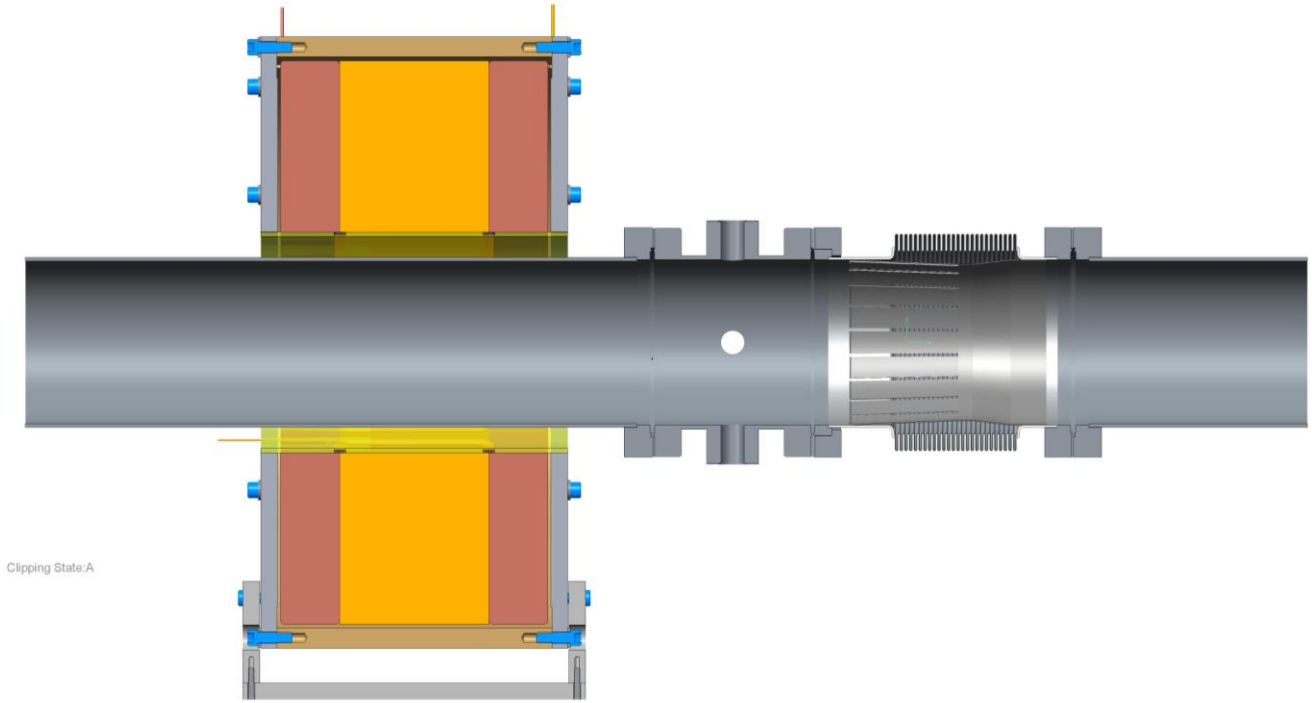
New:



Compensating Solenoids

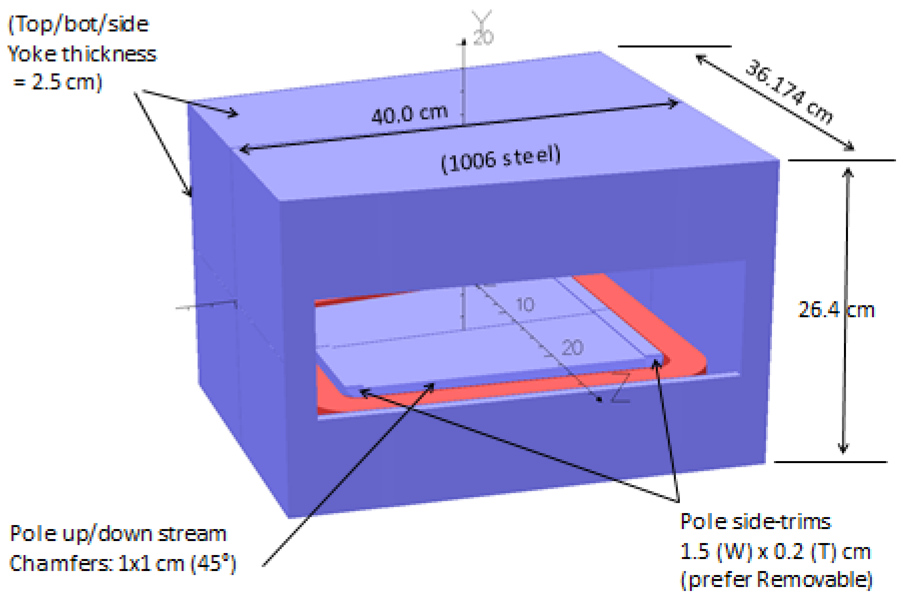
DOE Review comments:

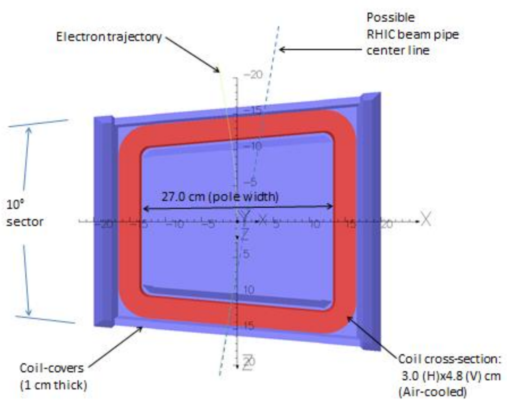
- Field measurements and positioning accuracy specifications.
- Magnetic shielding measurements.



20º Dipole Magnet - next

LEReC 20-degree Dipole (Gap clearance=10 cm)
(distance between pole faces =10.4 cm)



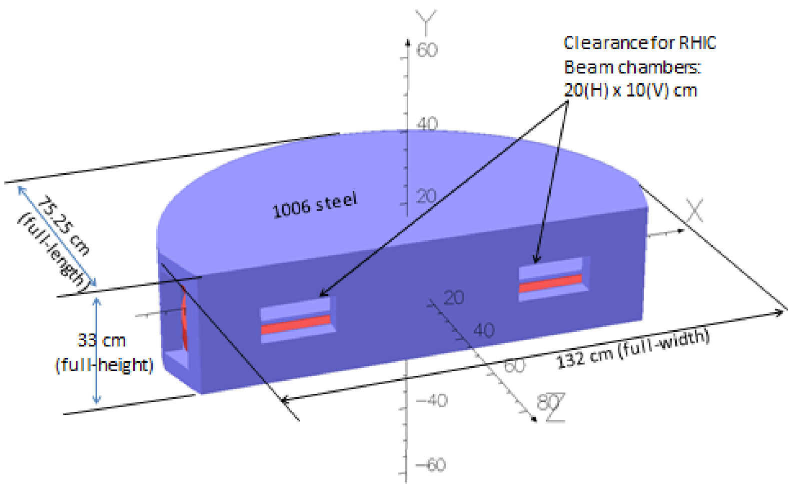


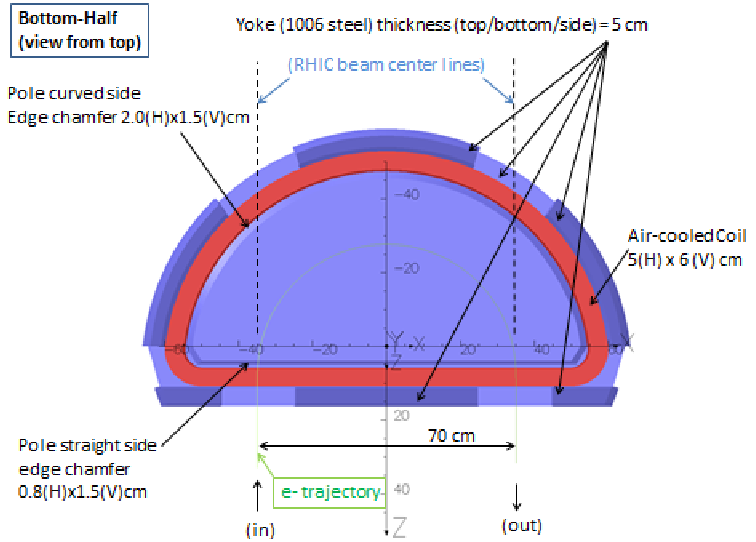
Electron tracking results and field qualities along trajectory on R=1 cm curved cylinder:

	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

Range of motion for magnet core?



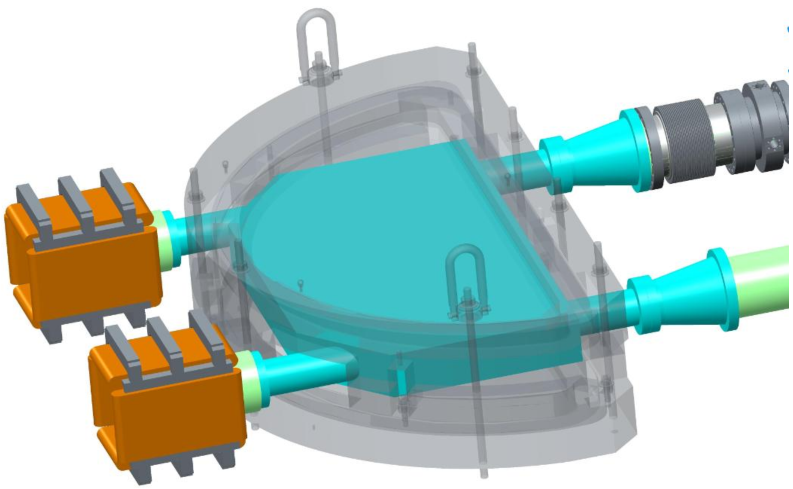


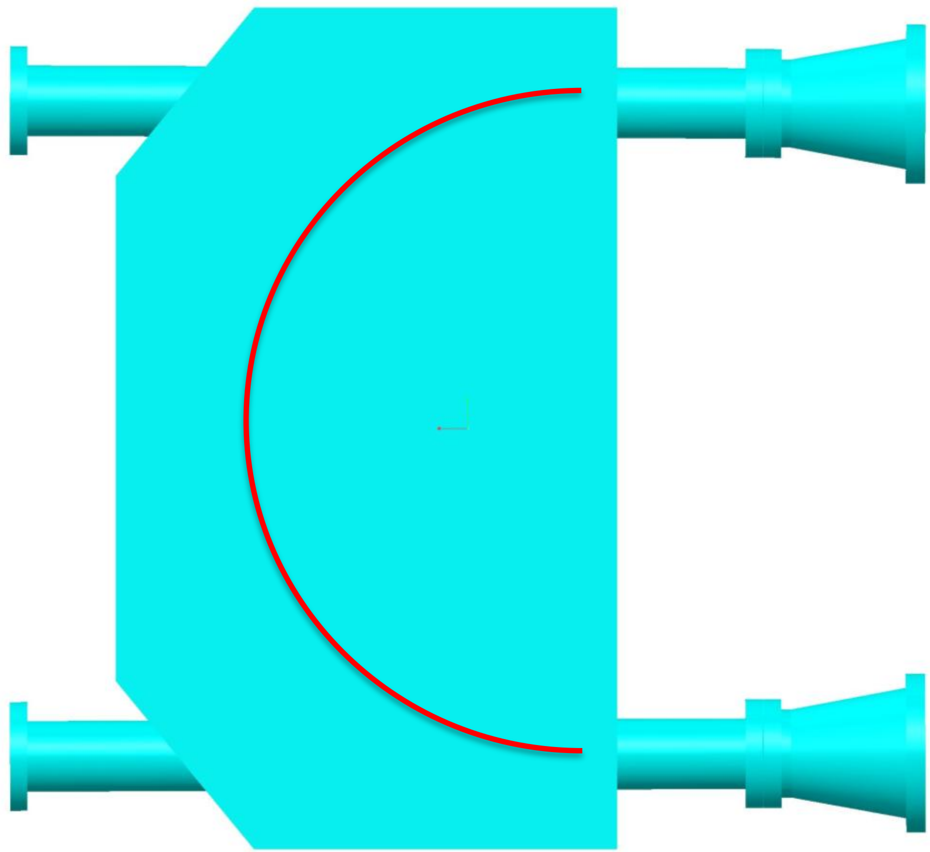
Electron tracking results and field qualities along entire trajectory on R=2 cm curved cylinder:

	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°

Vacuum Hardware

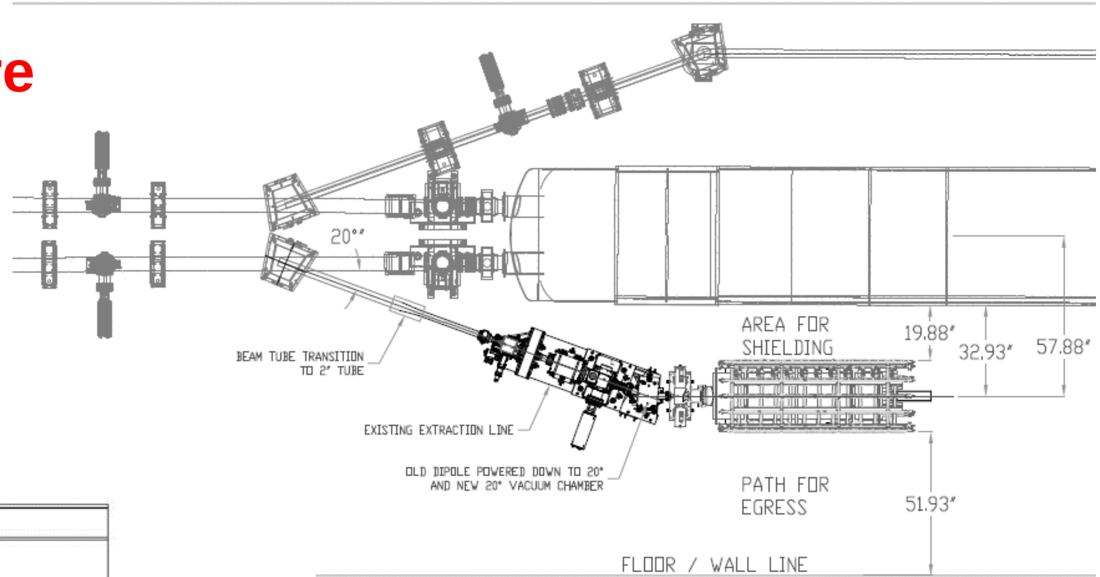
- Large open 180º vacuum chamber and 20º chamber - beam impedance concerns shield the electron beam path.
- Design and order beamline RF shielded bellows. Recombination monitors??
- Order RF shielded valves.



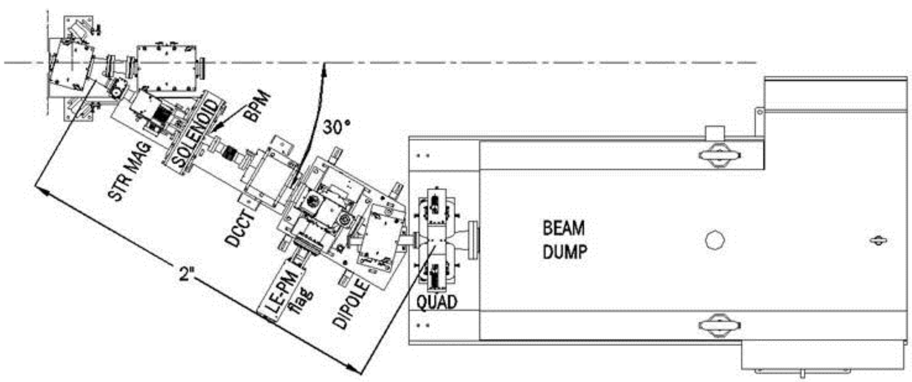


Beam Dump Line to Vacuum Valve:

(4) 20º dipoles 10 cm aperture



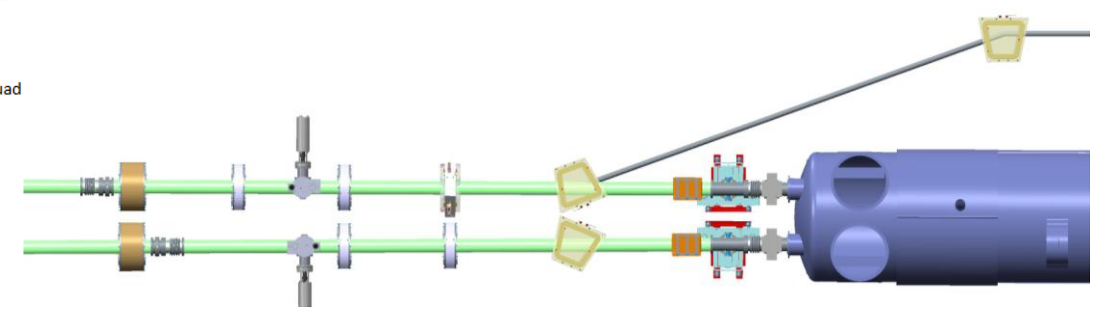
What components can we take from ERL extraction line? To be determined.



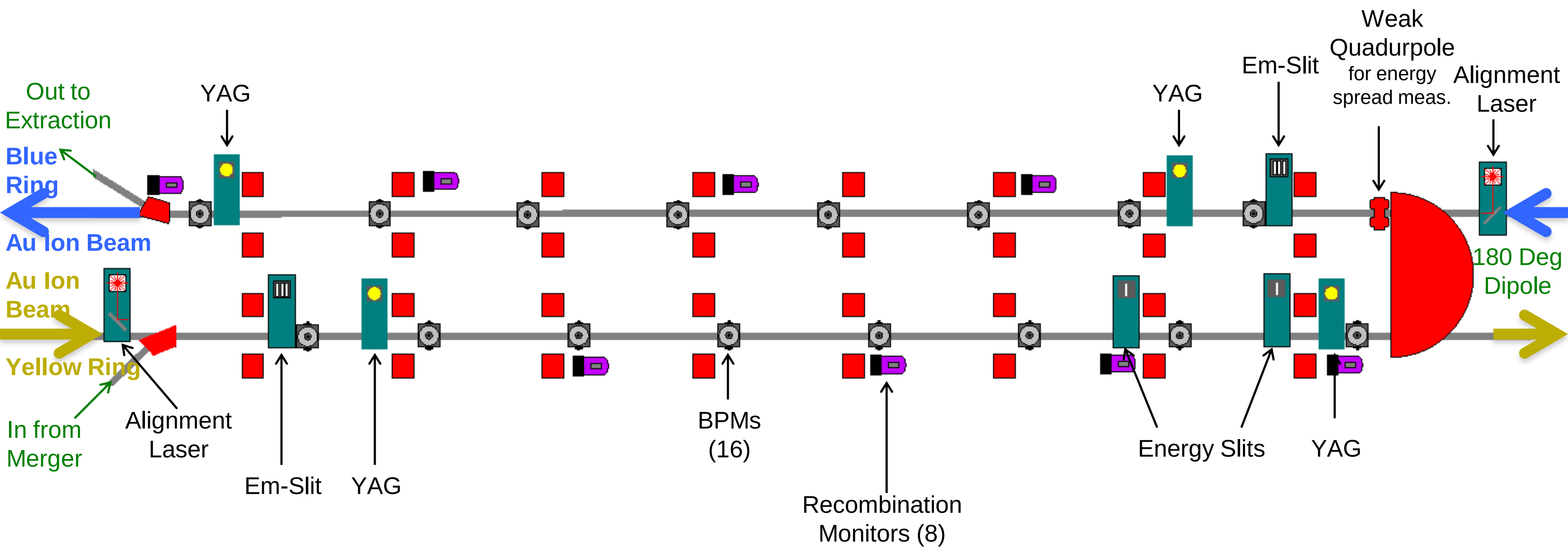
Extraction Line Components

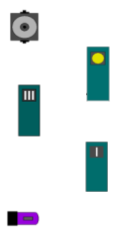
Per Alexei, LEReC aperture is 9.0cm (3.6"). ERL BD is 4.0" dia, upstream of quad is 2.0". The solenoid and quad

GM	Extraction Dipole - 20°w/ chamber(1)	new
GM	Steering magnet (1)	new
GM	Solenoid (1)	from ERL extraction
DG/TM	BPM (1)	new
DG/TM	DCCT (1)	new
DG/TM	Profile Monitor (1)	new
GM	Dipole magnet - 20° w/ chamber (1)	new
-	Quad (1)	from ERL extraction
MM	Bellows (2)	new



Scope: Cooling Sections





Cooling Sections

BPM = 16

YAG = 4

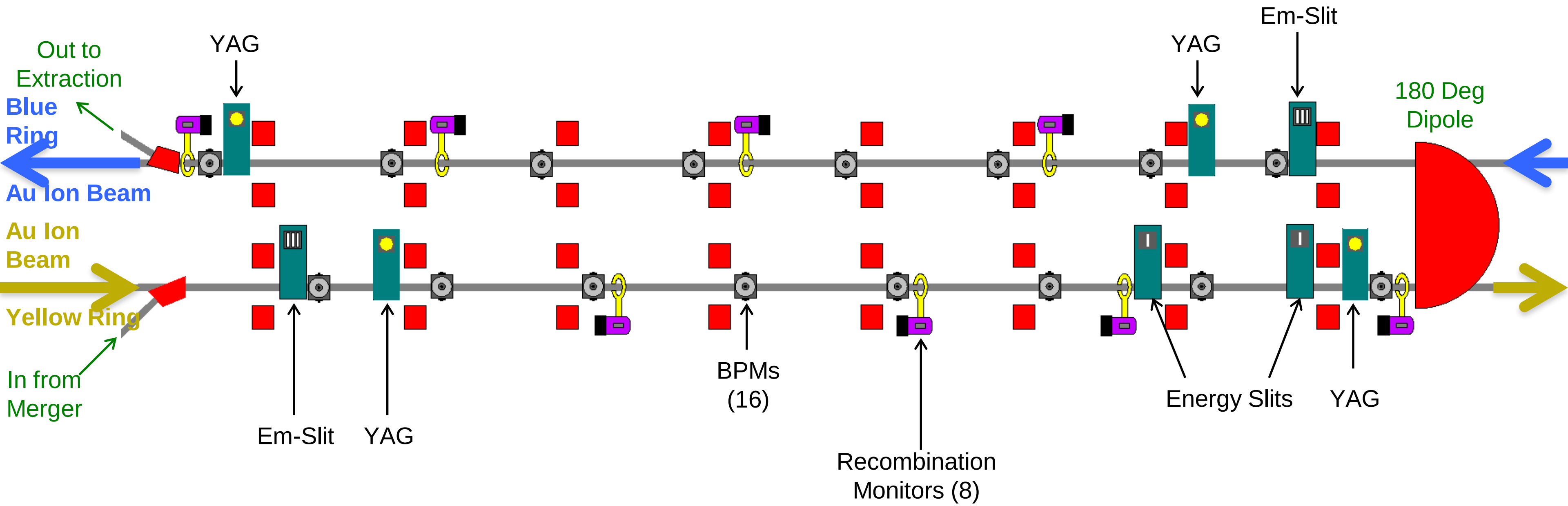
Emittance slits = 2

Energy Slits = 2

Recombination Mon = 8

Alignment Laser = 2

Scope: Cooling Sections from DOE review



Cooling Sections

BPM = 16

YAG = 4

Emittance slits = 2

Energy Slits = 2

Recombination Mon = 8

Procurement & Repurpose: High Priority Items

- Cooling Sections elements installed in 2015 shutdown (**July '15 – Jan '16**)

Moderate Priority
High Priority

	Begin Procurement	Procurement	Lead Time	Testing	Installation
Profile Monitors	Feb. 2015	2 mo.	6 mo.	3 wks.	Dec. 2015
Emittance Slits	Feb. 2015	2 mo.	6 mo.	3 wks.	Dec. 2015
Defining Slits	Feb. 2015	2 mo.	6 mo.	3 wks.	Dec. 2015
BPMs	Feb. 2015	2 mo.	4 mo.	6 wks.	Oct. 2015
Recomb. Mon. Chamber	April 2015 (2 mo. Design)	1 mo.	2 mo.	3 wks.	Sept. 2014

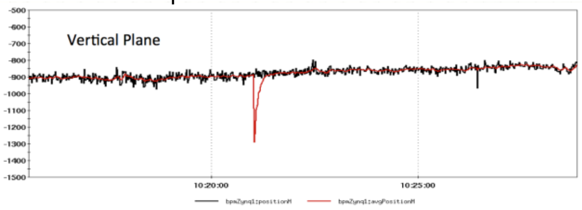
BPMs in Cooling Section (14 Locations)

Shared Pick-Ups:

One dual plan station at each solenoid is shared by two electronics boards, one measuring ions and one measuring electrons.

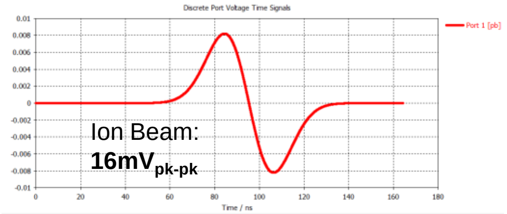
BNL Zync Electronics Design:

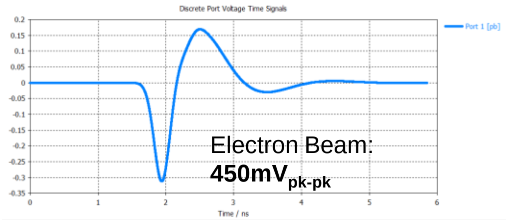
- VME Form Factor
  - Use RHIC Controls Infrastructure
- Configurable Front End RF Section
  - **39 MHz** for Ions
  - **700 MHz** for electrons
- 4 x 400MSPS A/D Converters
  - 2 Planes of Measurement / Board
- Integrated Front End Computer
  - FEC & FPGA on Single Chip (Zynq)
- Ethernet Connectivity (x2)
  - Controls Network
  - High Speed Interface for Feedback
- Test results below at the ATF with 9.3mm buttons showed better than 100um accuracy and 10um precision.



Signal Simulations:

Simulations were made with the short electron bunches and long ion bunches to determine expected signal amplitudes on the buttons.

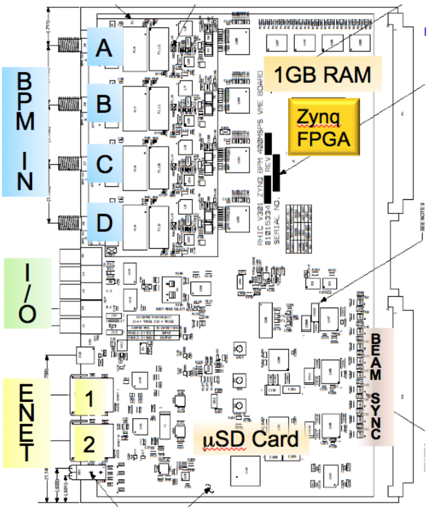




γ= 4.1
Ions/bunch = 7.5E8
Charge/bunch = 9.48E-9 C
RMS length = 3.2 m

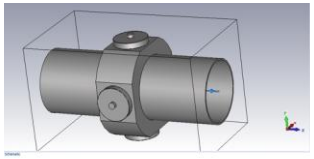
Simulations:
Courtesy of Peter Thieberger

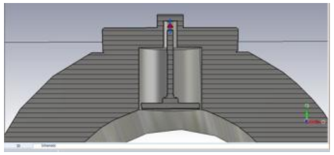
γ= 4.1
Charge/bunch = 100 pC
RMS length = 100 ps
RMS length = 30 mm



New Pickup Design:

- Large Dia. BPM Housings
- 28mm buttons
- N-Type feedthrough
- MPF Q7031-1





Profile Monitors – New designs for Cooling Section

Low Power profile measurement

- 4 or 6 stations
- Two Position plunger (similar to ERL Design)
- 100um thick YAG crystal
- Impedance matching cage
- Large cube for 5" beam pipe
- Same optics as ERL design

Photo courtesy of Radiabeam

High Power profile measurement

- 2 stations
- Compact offset cam design
- 9 μm carbon fiber passes beam only once @ 20 m/s
- accelerate/coast/decelerate in two rotations
- PMT detects X-rays generated by the scattered electrons

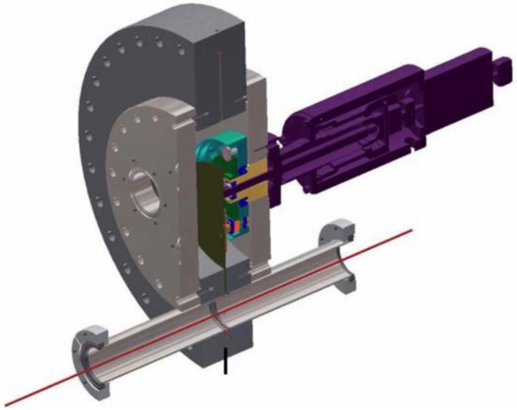
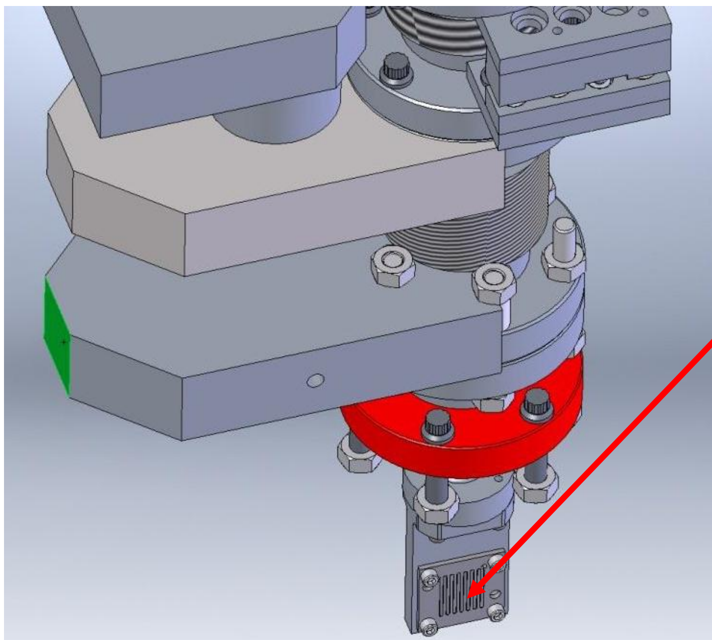


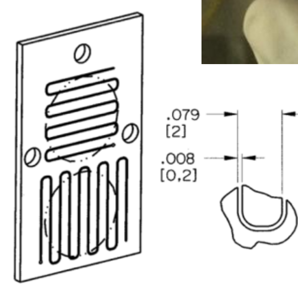
Photo courtesy of B. Dunham, Cornell

Emittance Slit Measurement

- Low Power Operations Only
- New Dual axis design for Horizontal & Vertical measurements.
- Positioned 0.16 – 1 m upstream of profile monitor
  - Final spacing TBD…
- Tungsten Slit mask, optimized for beam parameters
  - Mask 1.5mm thick… # slits & TBD…



Dual Station Actuator retrofitted for new dual axis mask.



ANALYSIS:
An algorithm was developed for analyzing the image from a multi-slit mask for emittance measurement.

Future plans are to automate the image analysis for on-line processing and data logging.

Intensity Distribution at mask

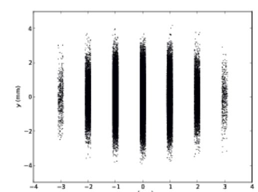
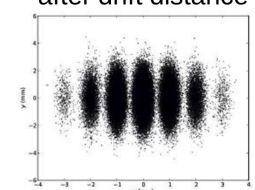
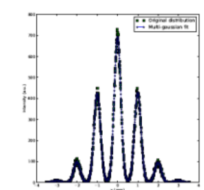


Image on profile monitor after drift distance

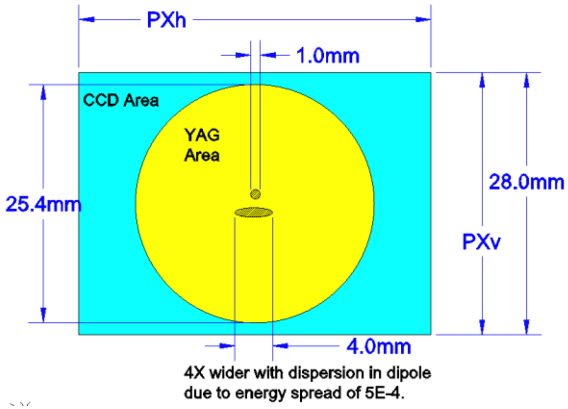




Energy Spread Measurements – 2 Locations

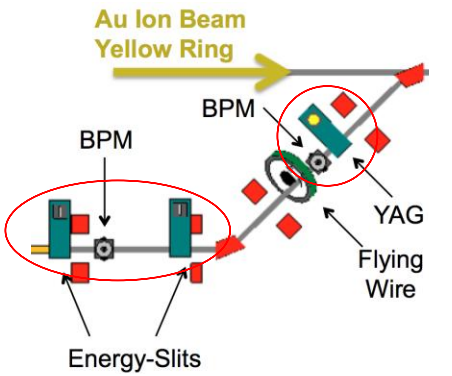
- Max. Energy Spread: $\Delta p/p$ = <5e-4
- Beam Size (d): 1mm (dia.)
- Double Slit before dipole & drift to YAG
- May use **Quad** to increase resolution between cooling sections
- *Considering alternatives:*
  - *Dedicated energy spectrometer beam line*
  - *Cornell's method of using deflecting cavity*

Image of YAG as projected onto CCD



Before Cooling Sections
- σ_δ = 750μm
- Resolution = σ_δ / $Pitch_{YAG}$
- 750μm / 29μm/px = 25 px

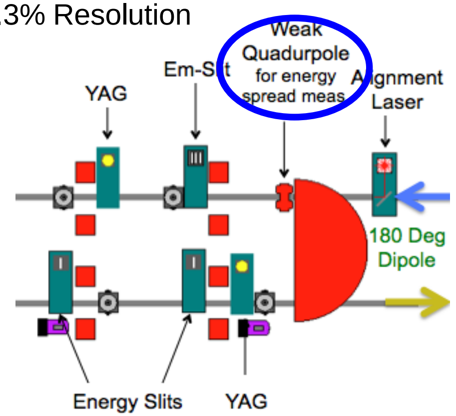
➔ 4% Resolution



$\sigma_\delta = \eta\delta = 1.5m(5x10^{-4}) = 750\mu m$

Between Cooling Sections
- σ_δ = 350μm
- Resolution = σ_δ / $Pitch_{YAG}$
- 350μm / 29μm/px = 25 px

➔ 8.3% Resolution



$\sigma_\delta = 2R\delta = 2(0.35m)(5x10^{-4}) = 350\mu m$

- 2MP CCD: 1292_h X 964_v px
- $Pitch_{YAG}$ = proj-H_{CCD}/px_v = 29μm/px

Recombination Monitor: Ion Collection

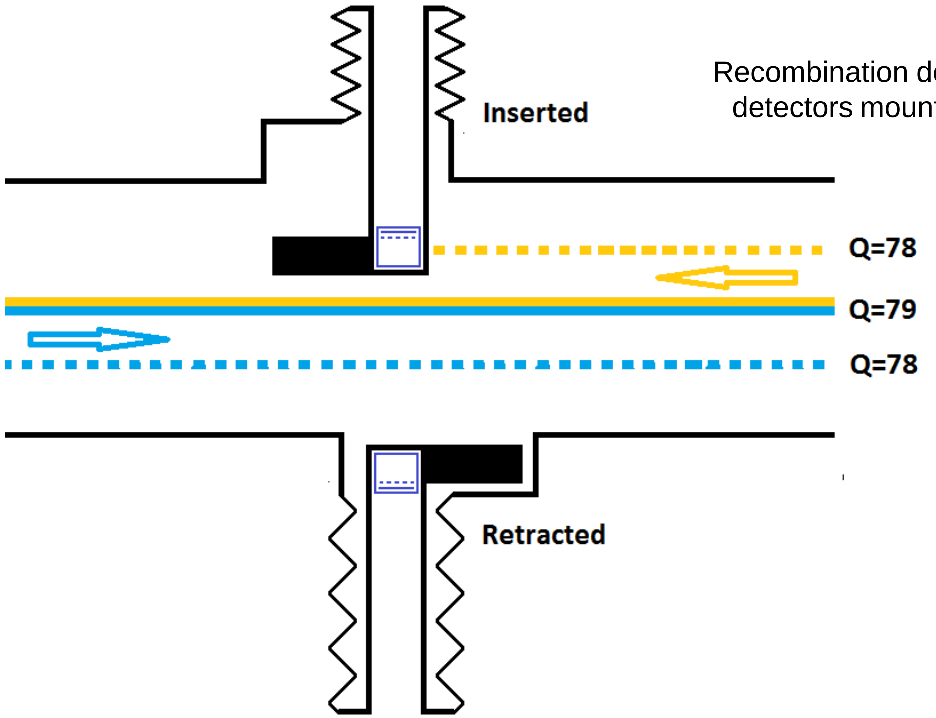
E-Ion RECOMBINATION:

- Au^{+79} ➔ Au^{+78}, Expected rate ~5e6 per second
- Creates ions of wrong charge
- Generates X-rays in cooling section
- loss rate ≈ alignment

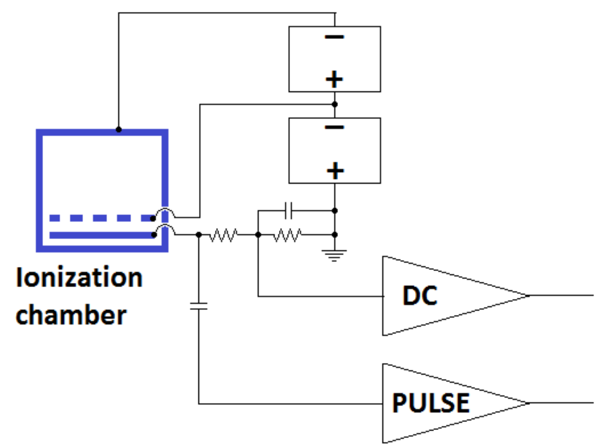
ION (wrong charge) **COLLECTION:**

- Lost at predictable location (collimators)?
- Detector: PMT + Counter
- ! Lattice simulation predicts lattice aperture acceptance of Au^{+78} ions !

  => **Work underway to develop a lattice with dispersive section.**



Recombination detector concept showing two ionization detectors mounted in retractable roman pot systems.



Courtesy of Peter Thieberger

Recombination Monitor: Radiative Detector

RADIATIVE RECOMBINATION DETECTION:

- Recombination radiation
  - 10-80keV x rays emitted a shallow forward angle
  - Scintillators located at in COOLING SECTION
- Detector
  - Scintillator + PMT + Counter
  - => loss rate ≈ alignment

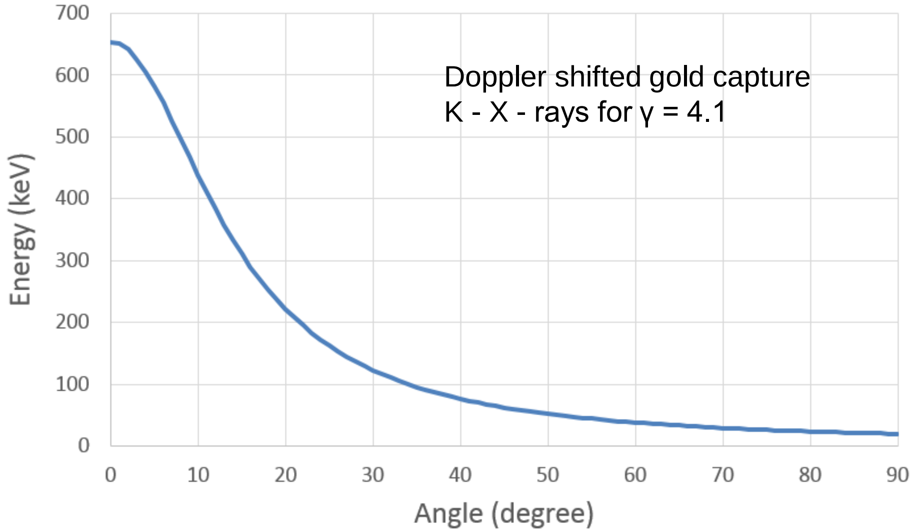
$$for\ \gamma = 4.1$$

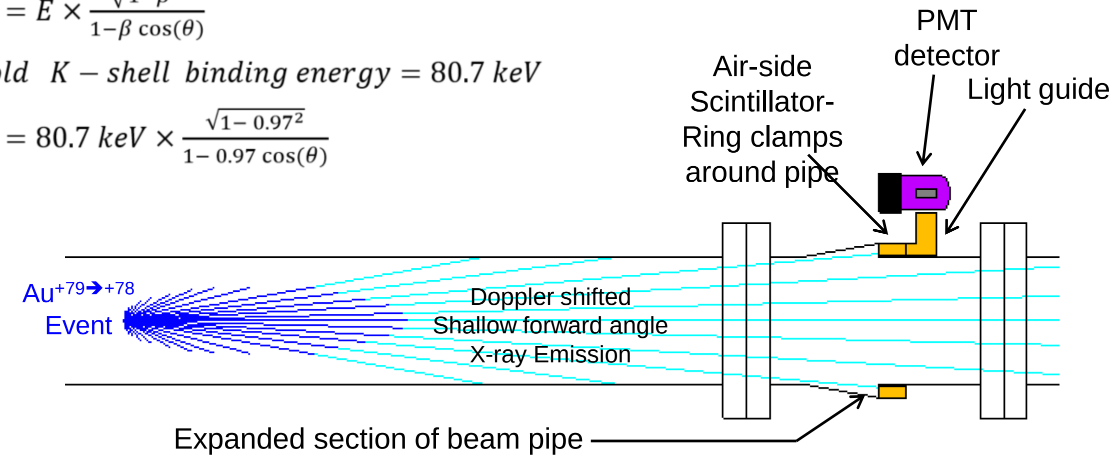
$$\beta = \sqrt{1 - \frac{1}{\gamma^2}} = 0.970$$

$$E' = E \times \frac{\sqrt{1-\beta^2}}{1-\beta\cos(\theta)}$$

$$Gold\ \ K - shell\ \ binding\ energy = 80.7\ keV$$

$$E' = 80.7\ keV \times \frac{\sqrt{1-0.97^2}}{1-0.97\cos(\theta)}$$





Courtesy of Peter Thieberger