Meeting Notes

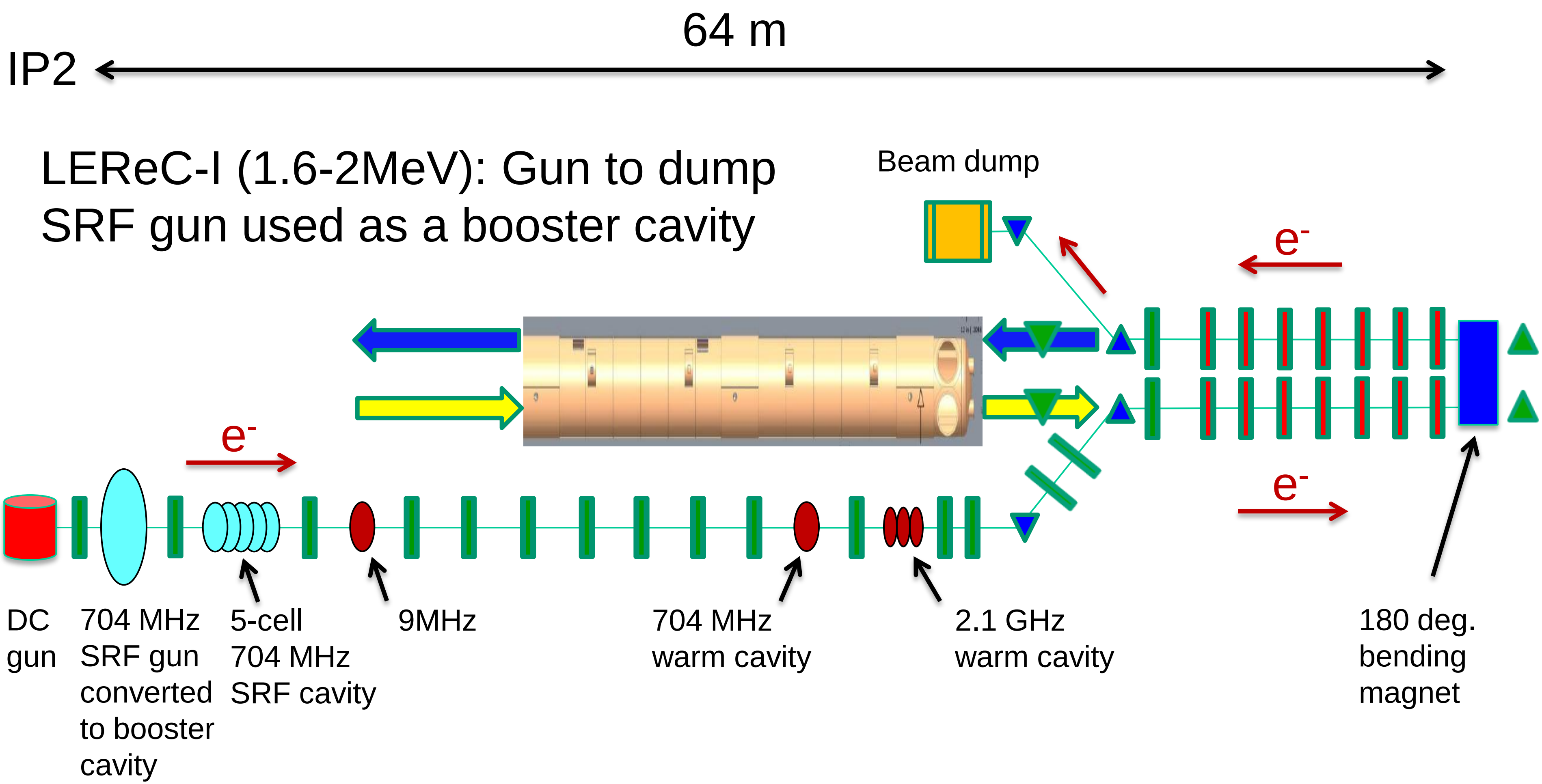
- LF Solenoids & HF (Matching) Solenoids: Out for bid???
- 20^o Dipole
  - Magnet gap is 4 inches/transport lines 2.5 inches (2.5” RF shielded vacuum valves)
  - Inner shield design to be approved by Mike Blaskiewicz.
- 180^o Dipole
  - Chamber position in magnet is slide-able 6 cm
  - Magnet gap is 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.**

Design Room Priorities

Design Work List for LEReC:

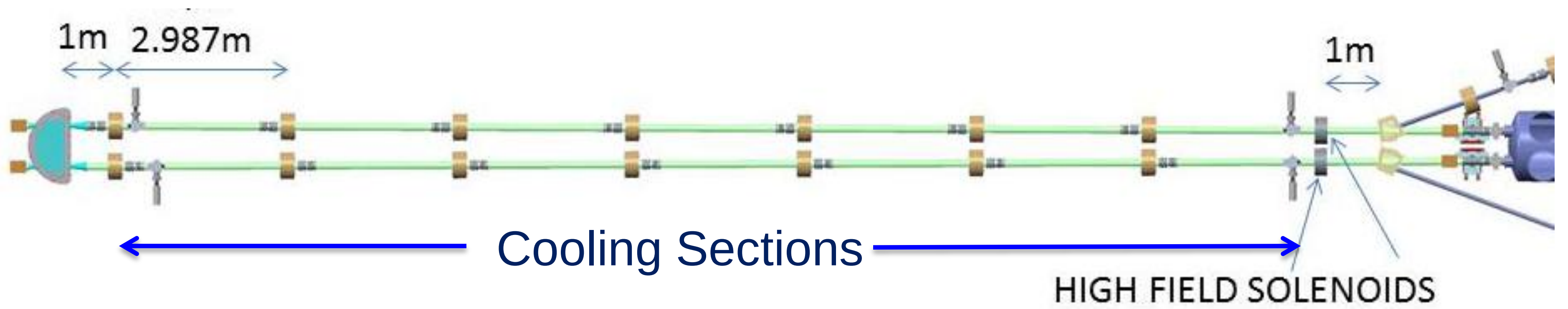
- **(20o and 180o magnets) Fabrication drawings, specification, and SOW.**
- **(20o and 180o magnets) Detailed vacuum chamber design with internal beamline shielding for M. Blaskiewicz review and approval.**
- **(20o and 180o magnets) Stand design – separate survey supports for vacuum chamber and magnet to allow magnet disassembly for vacuum chamber bakeout.**
- **(Solenoid Magnets) Stand design with separate survey supports for solenoid magnet assembly, bpm assembly, and beam tube.**
- **(Solenoid Magnets) 5” shielded bellows assembly**
- **(Solenoid Magnets) Magnetic measurement test stand extended for umetal testing including bellows, bpm, and beam tubes.**
- **(beam instrumentation) Layout support for profile monitors, slits, etc.**
- **(warm RF Cavities) Model Layouts and specification control drawings**

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



Magnet Lattice Physics Review

New:

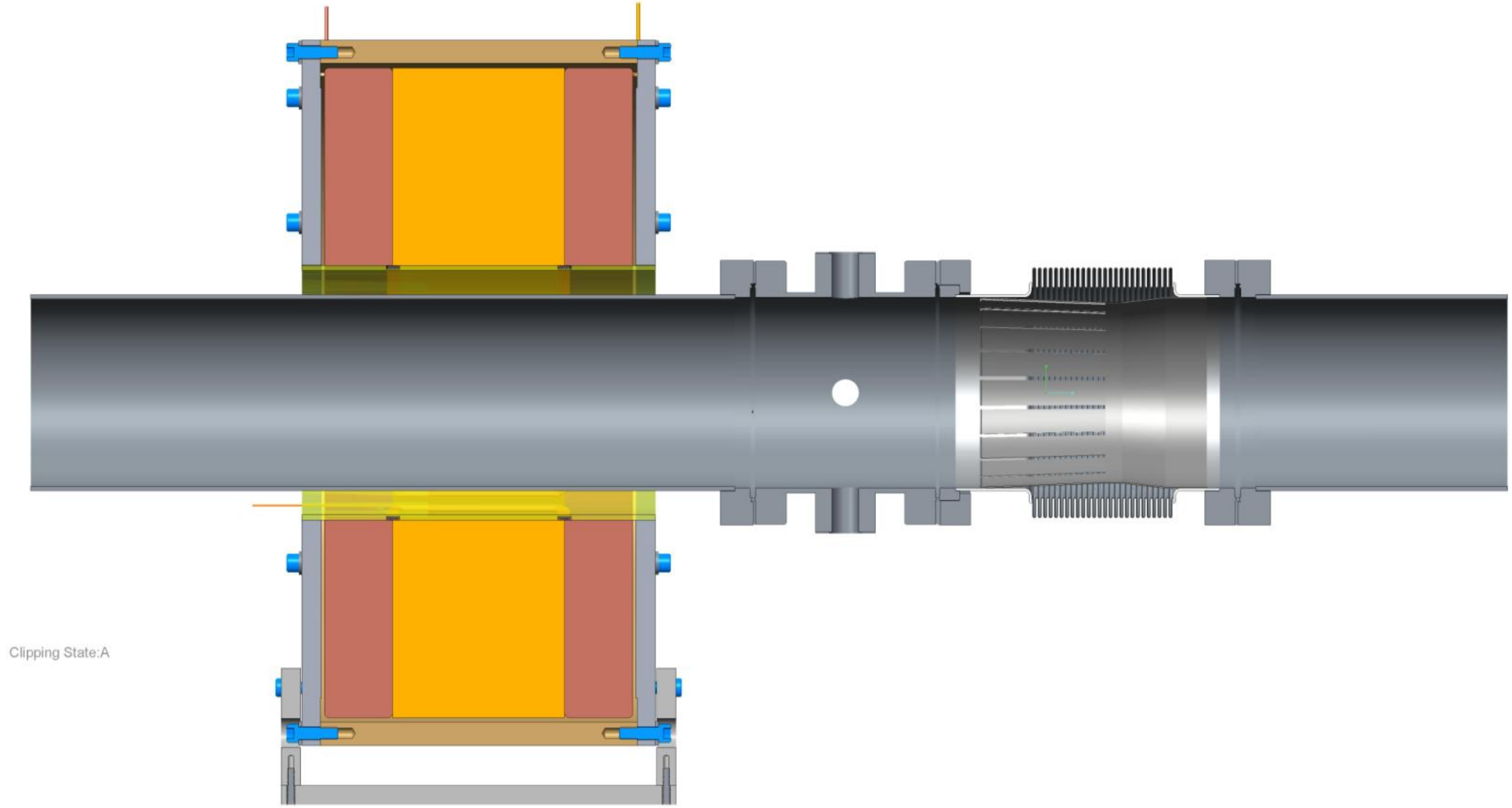


Compensating Solenoids

DOE Review comments:

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

Design: Stand and supports for magnet, BPM, and vacuum chamber.

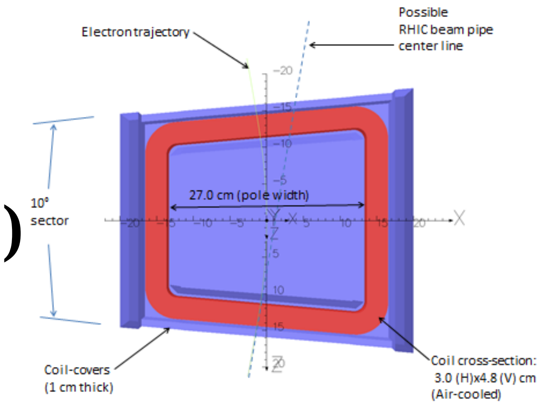


20º Dipole Magnet

Distance Between Pole Faces = 10.4 cm (4.1 in.)

Magnet Vertical Gap = 10 cm

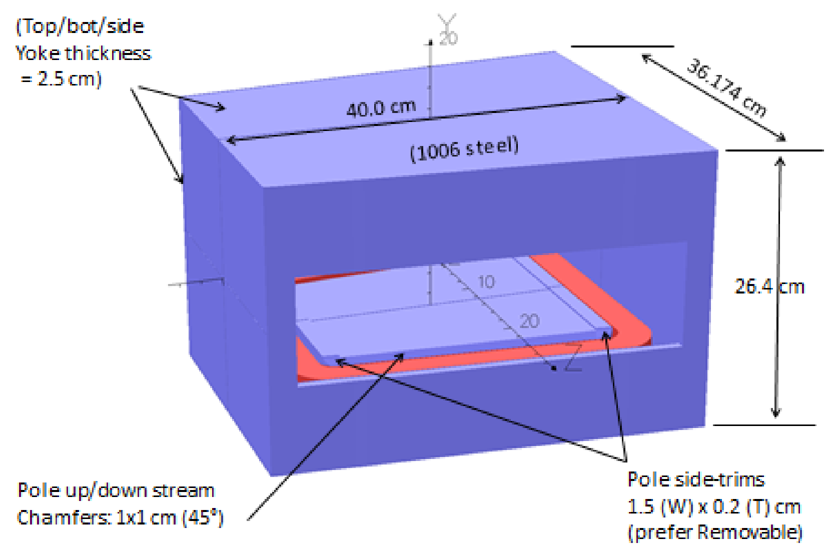
Vacuum Chamber V Aperture = 9.5 cm (3.74 in.)



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°

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

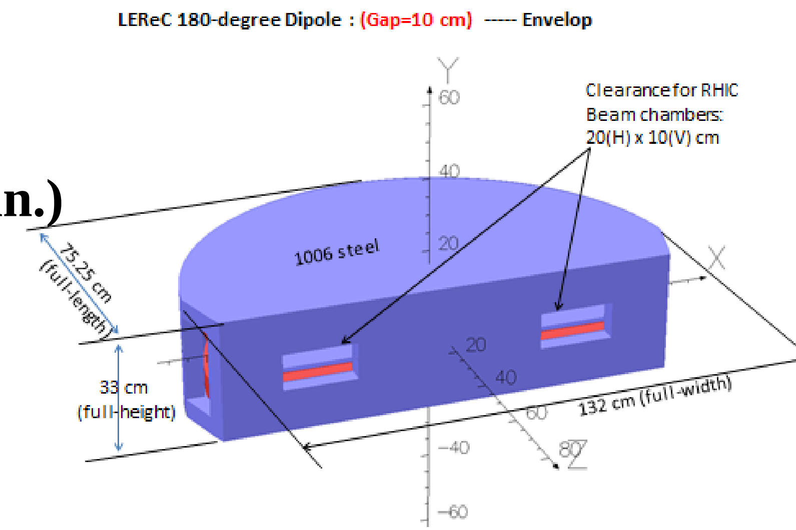


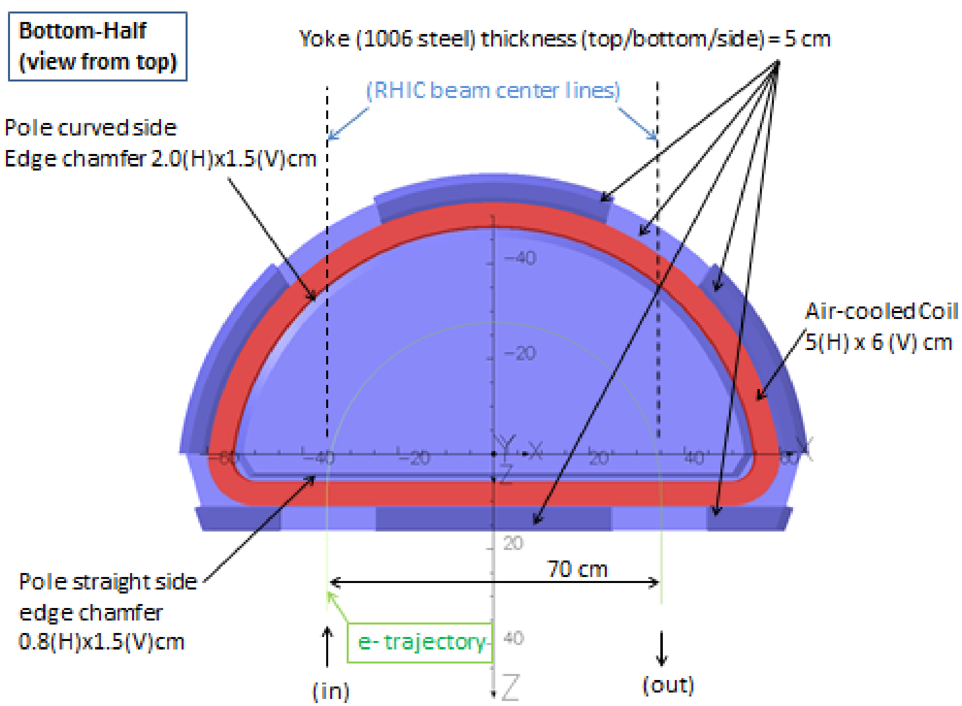
180º Dipole Magnet

Range of motion for magnet core?

Magnet Vertical Gap = 10.0 cm (3.94 in.)

Vacuum Chamber V Aperture = 9.5 cm (3.74 in.)



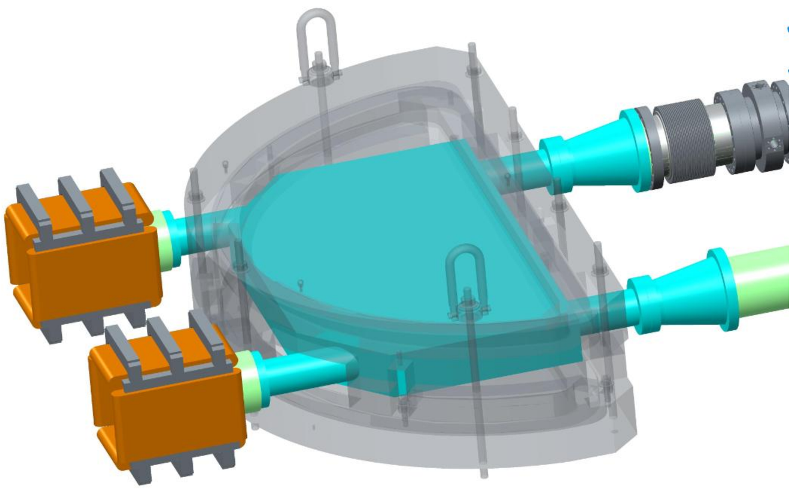


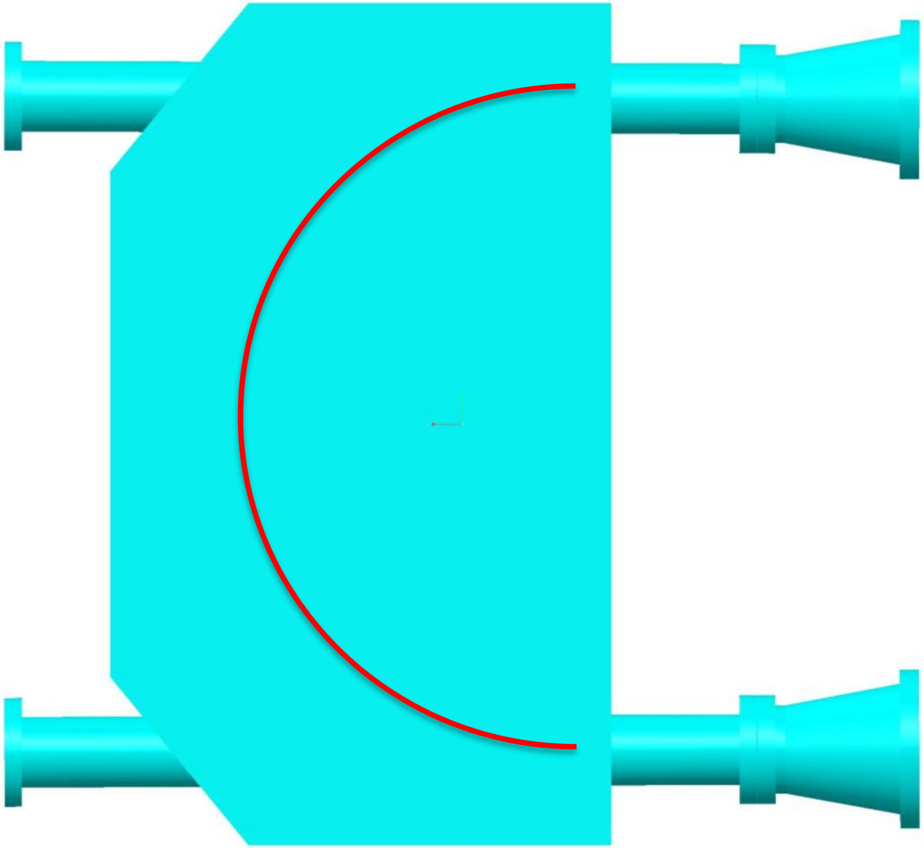
Electron tracking results and field qualities along entire trajectory on R=2 cm curved cylinder:

	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°

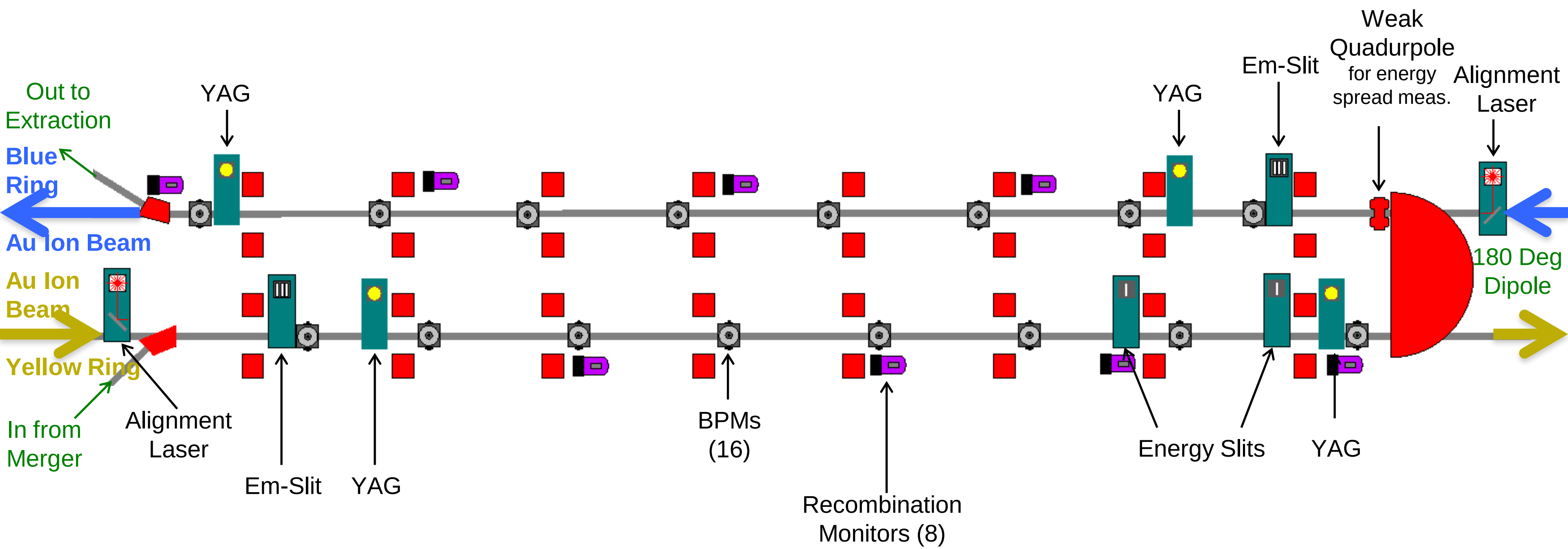
Vacuum Hardware

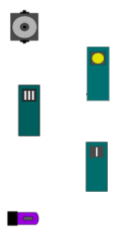
- Large open 180° vacuum chamber and 20° chamber - beam impedance concerns shield the electron beam path.
- Design and order beamline RF shielded bellows. Recombination monitors??
- Order RF shielded valves.





Scope: Cooling Sections





Cooling Sections

BPM = 16

YAG = 4

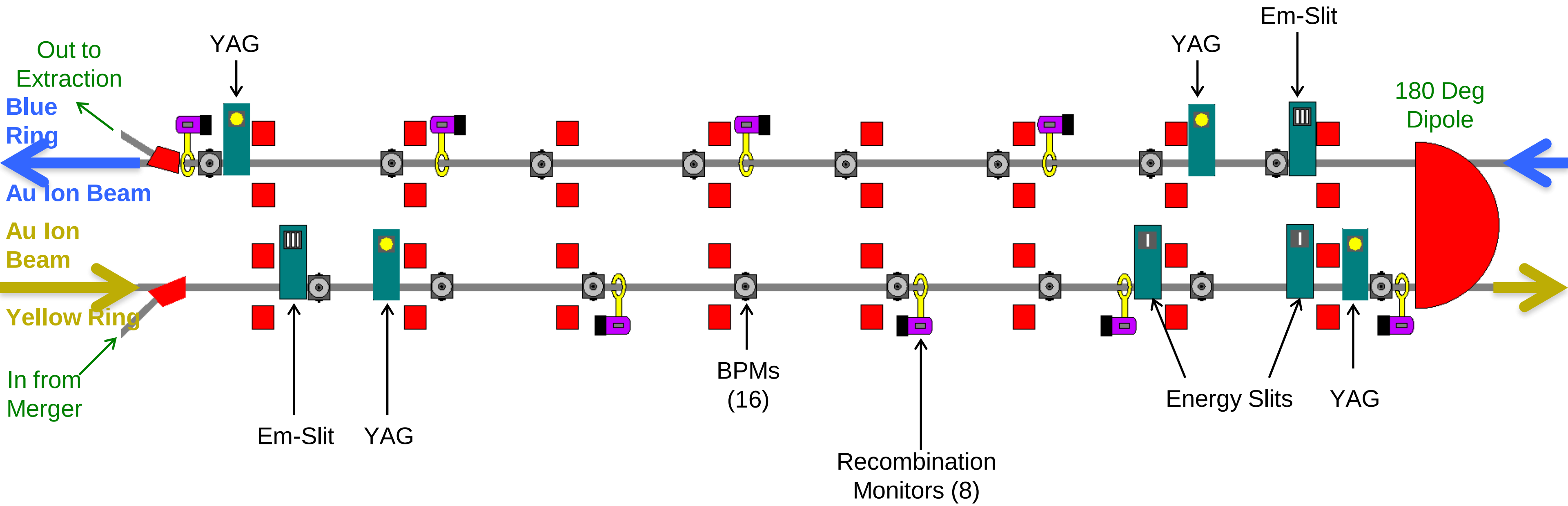
Emittance slits = 2

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

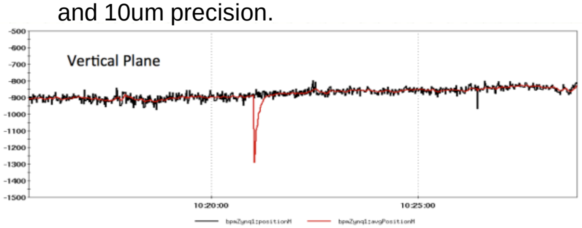
BPMs in Cooling Section (14 Locations)

Shared Pick-Ups:

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

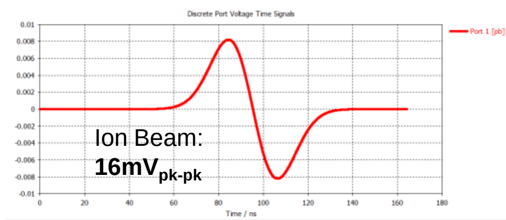
BNL Zync Electronics Design:

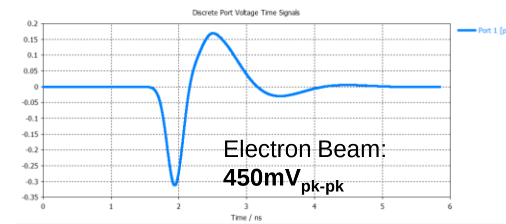
- VME Form Factor
  - Use RHIC Controls Infrastructure
- Configurable Front End RF Section
  - **39 MHz** for Ions
  - **700 MHz** for electrons
- 4 x 400MSPS A/D Converters
  - 2 Planes of Measurement / Board
- Integrated Front End Computer
  - FEC & FPGA on Single Chip (Zynq)
- Ethernet Connectivity (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.

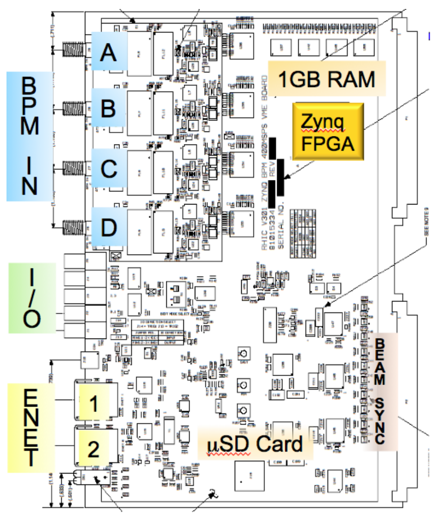




γ= 4.1
Ions/bunch = 7.5E8
Charge/bunch = 9.48E-9 C
RMS length = 3.2 m

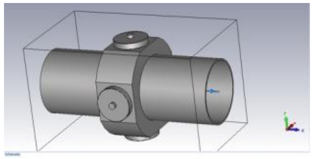
Simulations: Courtesy of Peter Thieberger

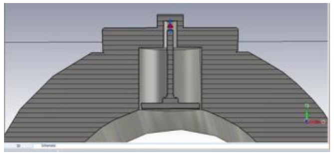
γ= 4.1
Charge/bunch = 100 pC
RMS length = 100 ps
RMS length = 30 mm



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

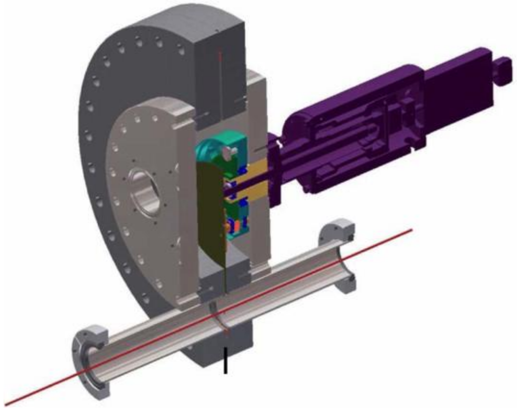
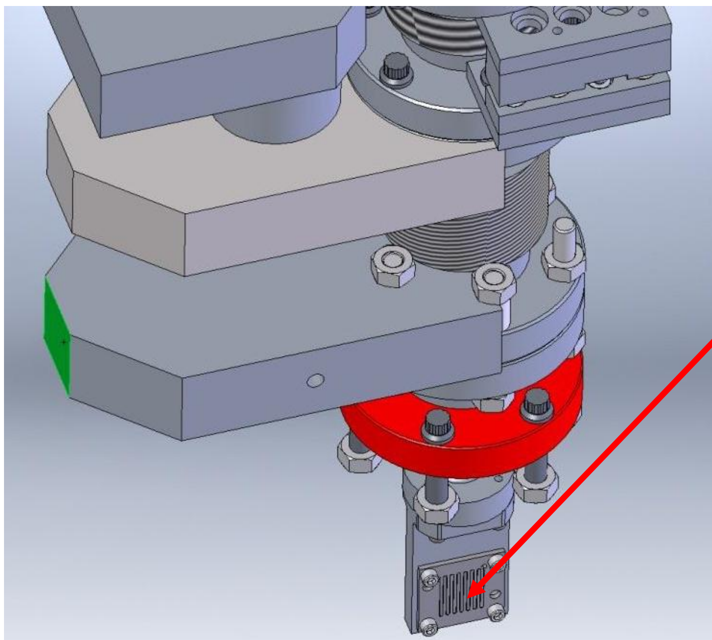


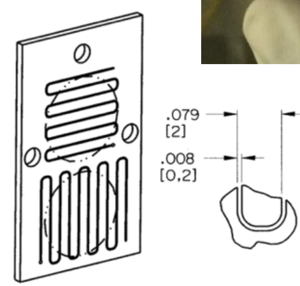
Photo courtesy of B. Dunham, Cornell

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

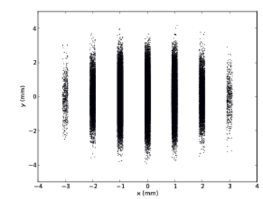
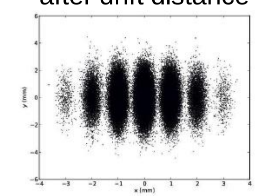
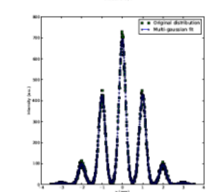


Image on profile monitor after drift distance

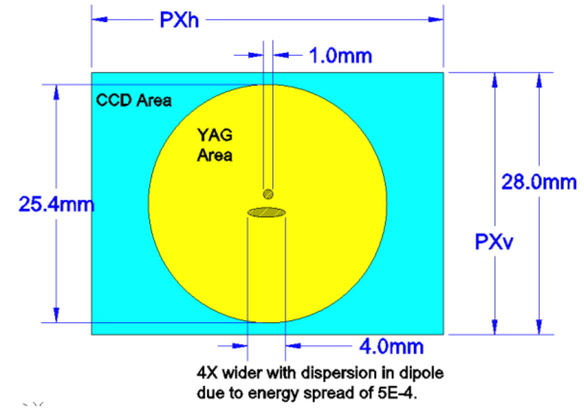




Energy Spread Measurements – 2 Locations

- 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



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

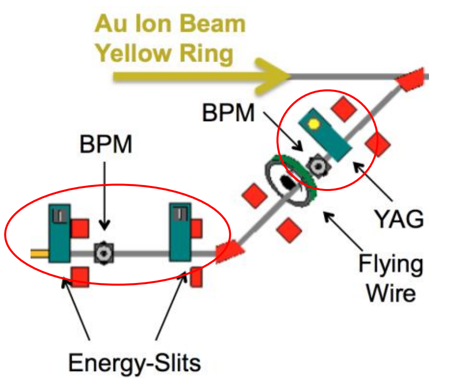
Before Cooling Sections

•σ_δ = 750µm

•Resolution = σ_δ / $Pitch_{YAG}$

- 750µm / 29µm/px = 25 px

➔ 4% Resolution



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

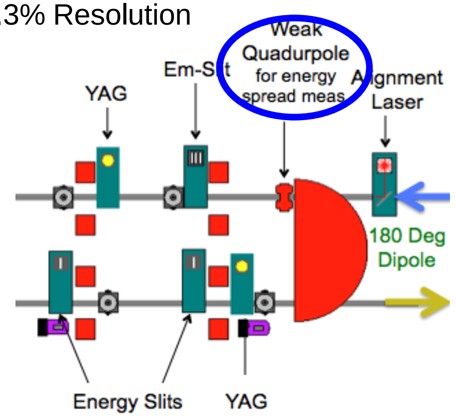
Between Cooling Sections

•σ_δ = 350µm

•Resolution = σ_δ / $Pitch_{YAG}$

- 350µm / 29µm/px = 25 px

➔ 8.3% Resolution



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

Recombination Monitor: Ion Collection

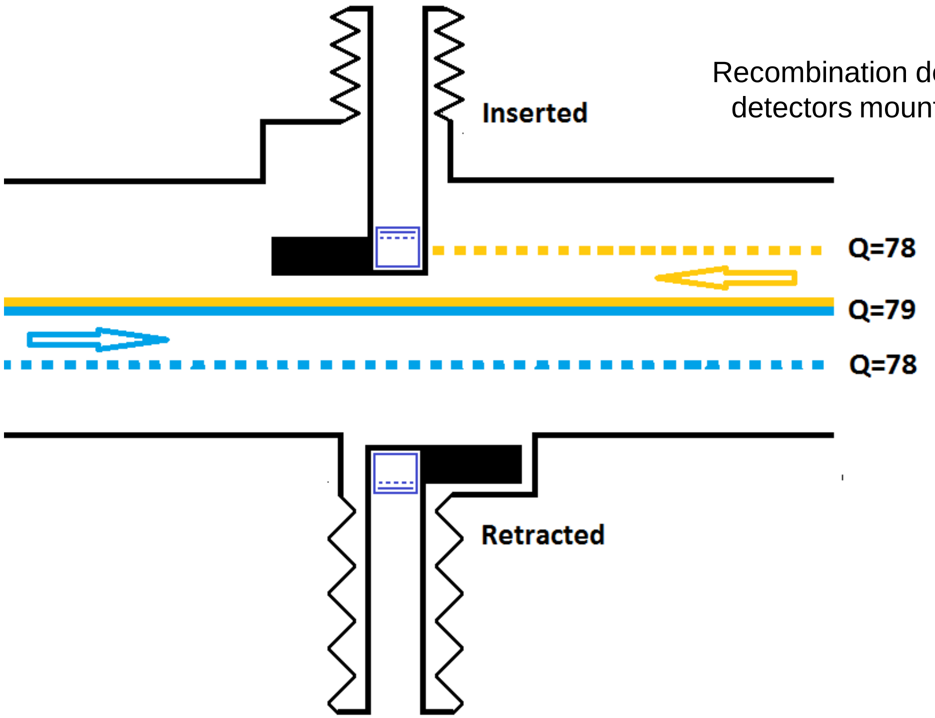
E-Ion RECOMBINATION:

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

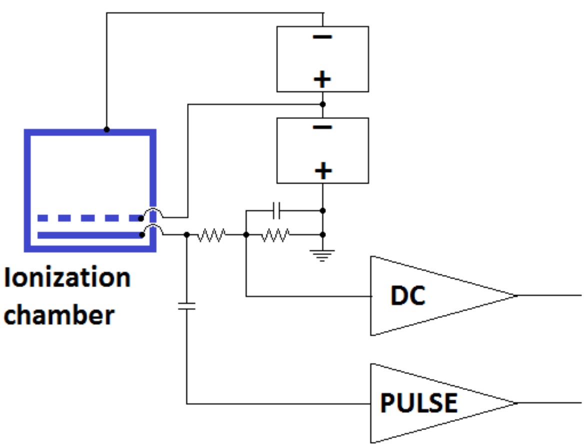
ION (wrong charge**) COLLECTION:**

- 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.

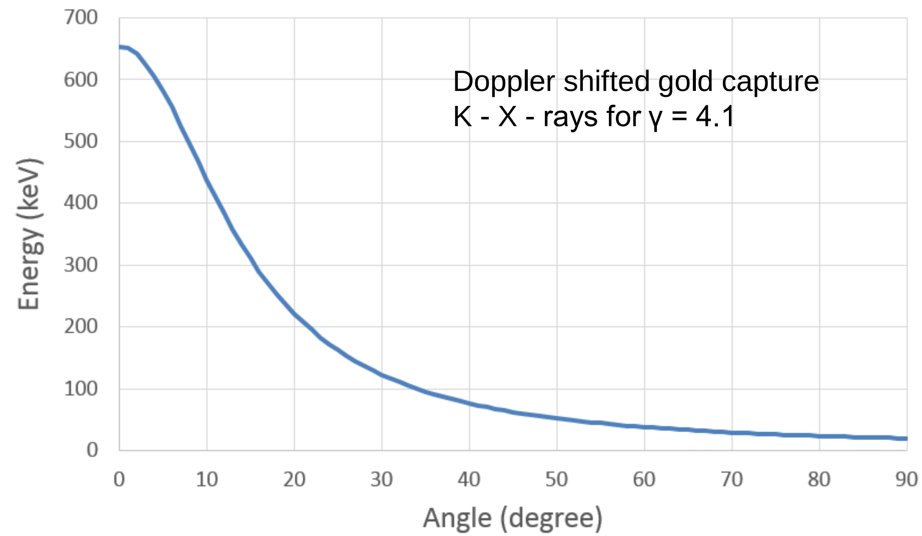


Courtesy of Peter Thieberger

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



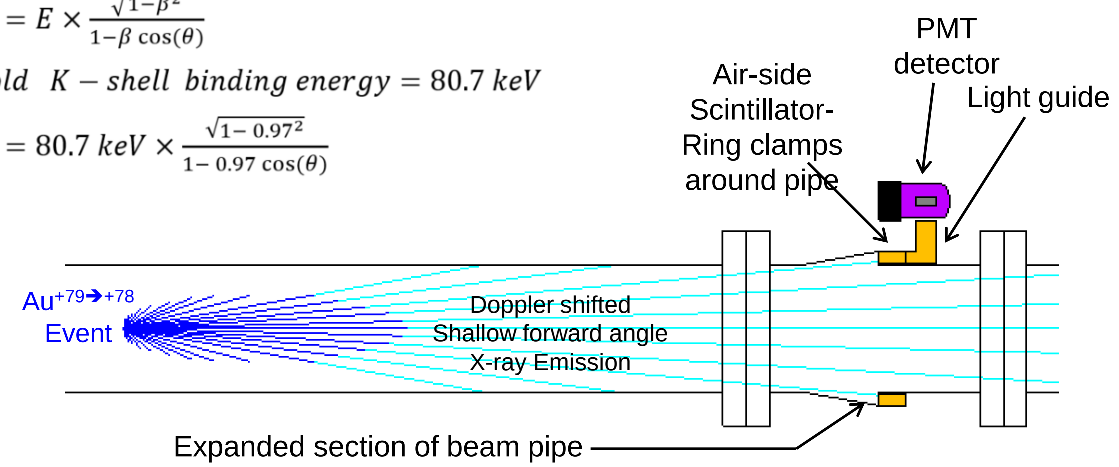
$$for\ \gamma = 4.1$$

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

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

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

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



Courtesy of Peter Thieberger