APEX preparation status/outstanding tasks

Radiation shielding
SciFi
Online software
Magnet checkout
Vacuum chamber + corrector design
PID/Trig @ high rate
Target
Optics
VDC tracking efficiency
Analysis: Reach update
Analysis: Bump hunt

APEX status update

- HRS electronics upgrade, the beam test was performed in spring
- Septa magnet will be delivered by October 25
- Power supply for 2 kA, 650kW (SBS) is delivered
- Scintillator Fiber hodoscopes constructed, under commissioning
- Vacuum chambers/corrector: design is proceeding

APEX radiation analysis

- Radiation analysis and shielding:

Maduka Kaluarachchi, grad. student at UVa (G.Cates)
based on Pavel's models and help

- GEANT4 model of the magnet, hall A, beam line
- Full calculation of the radiation in the hall
- experimental studies of radiation level
  at electronics, implementation of the local shielding

APEX SciFi for optics

- SciFi:

  Jonathan Castellanos, grad. student at FIU (P.Markowitz)

  Welcome additional collaborators

  Recent progress:
  - the PMT side of the optical connection was improved
  - commissioning of the PMT readout;
    - the findings: need coax cables; significant cross talk;
    - an improved plan: implement fADC readout
      - a factor of 4-5 higher rate capability
      - need a few man-month for software
  - mitigation plan for cross talk: is pixels redistribution
      - need fund ($1000) + 2-3 man-weeks

APEX software

- Online software for the HRS detectors:

Welcome collaborators for the APEX specific DAQ
- coincidence timing, trigger, optics with septa, SciFi

Longwu Ou, Barack Schmookler grad. students at MIT (S.Gilad)

- GUIs and scripts are under commissioning for GMp
completion is projected in December 2014

APEX septa magnet

- Magnet checkout:

  Hall A techs and Jay Benesch

  - In the Testlab, 10% of full current

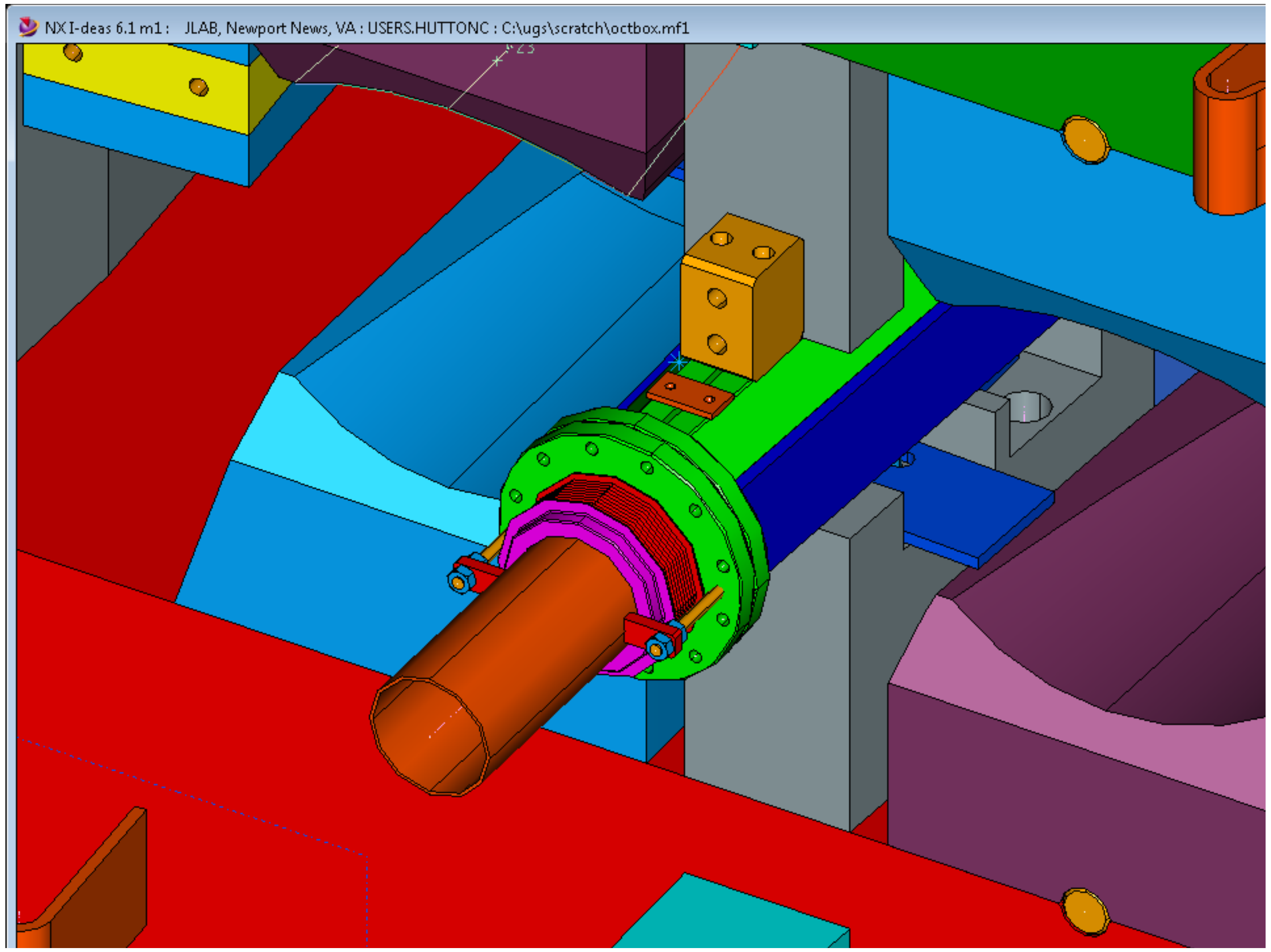
Welcome collaborators to do the field mapping

APEX vacuum chamber

- Vacuum chamber+corrector magnet design:

  Chuck Hutton, HU/NCCU/UVa/RU

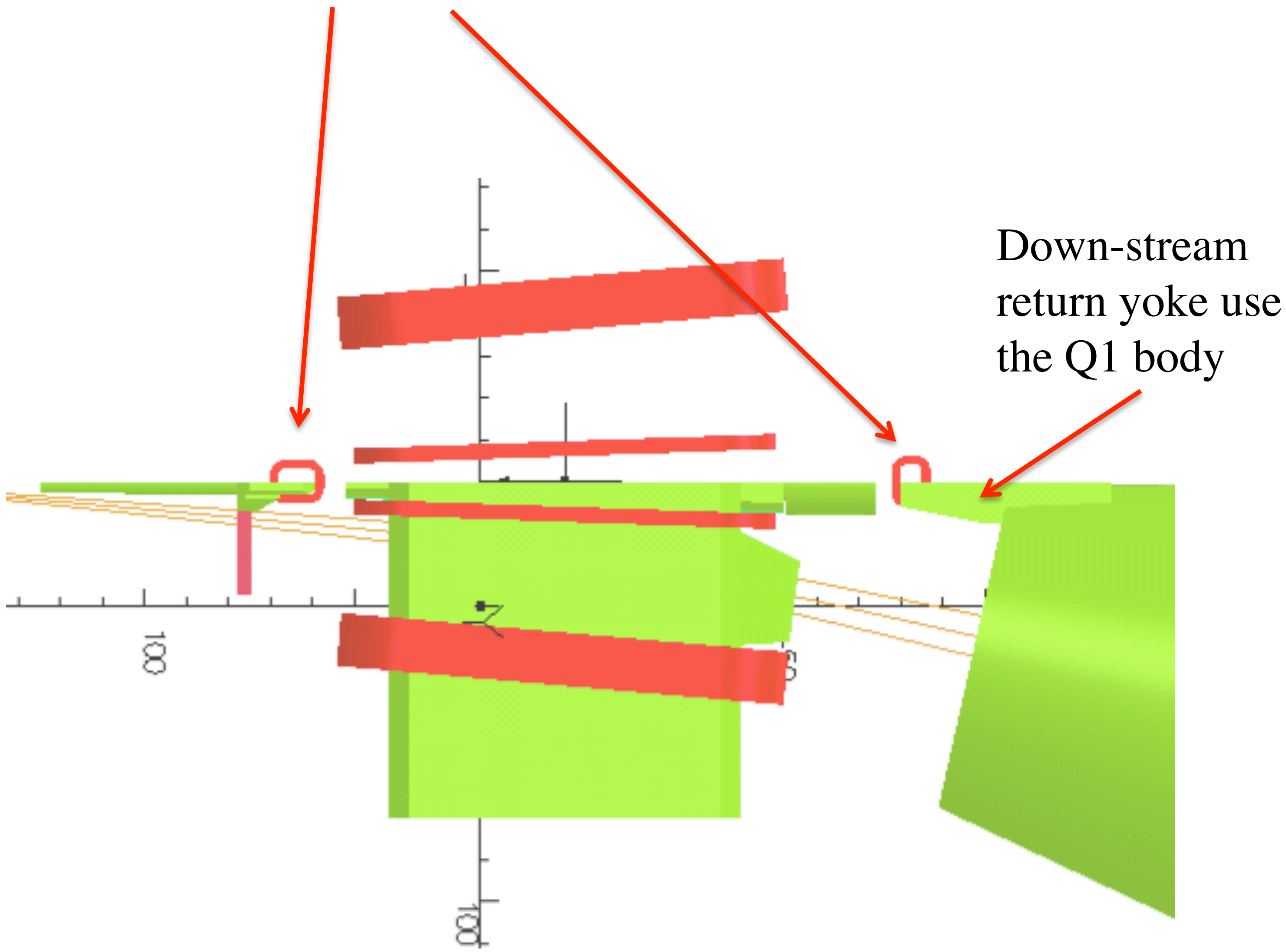
- design of the vacuum chamber – 99% completed; 90% paid



APEX beam line correctors

- Vacuum chamber+corrector magnet design:

- design of the correctors projected in November



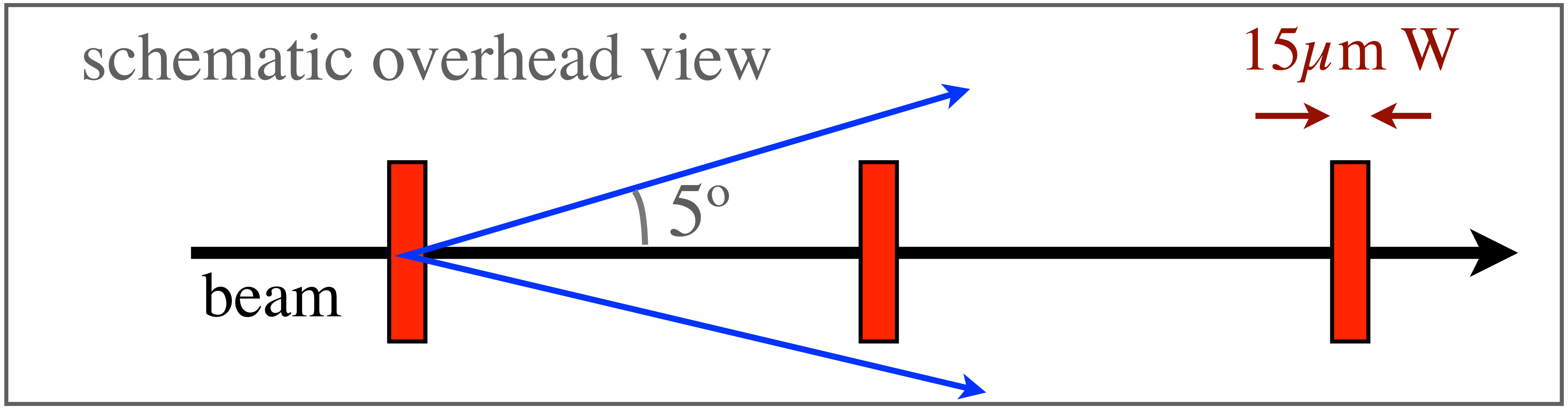
Outlook

- Scientific goals and motivation of the experiment
- Interest of the JLab physics community
- Proposal approval status
- Proof of experiment concept: the test run experience
- Collaboration capabilities
- New equipment preparation
- Experiment readiness review process
- Beam time schedule

Target Design: Minimizing Multiple Scattering

Goals:

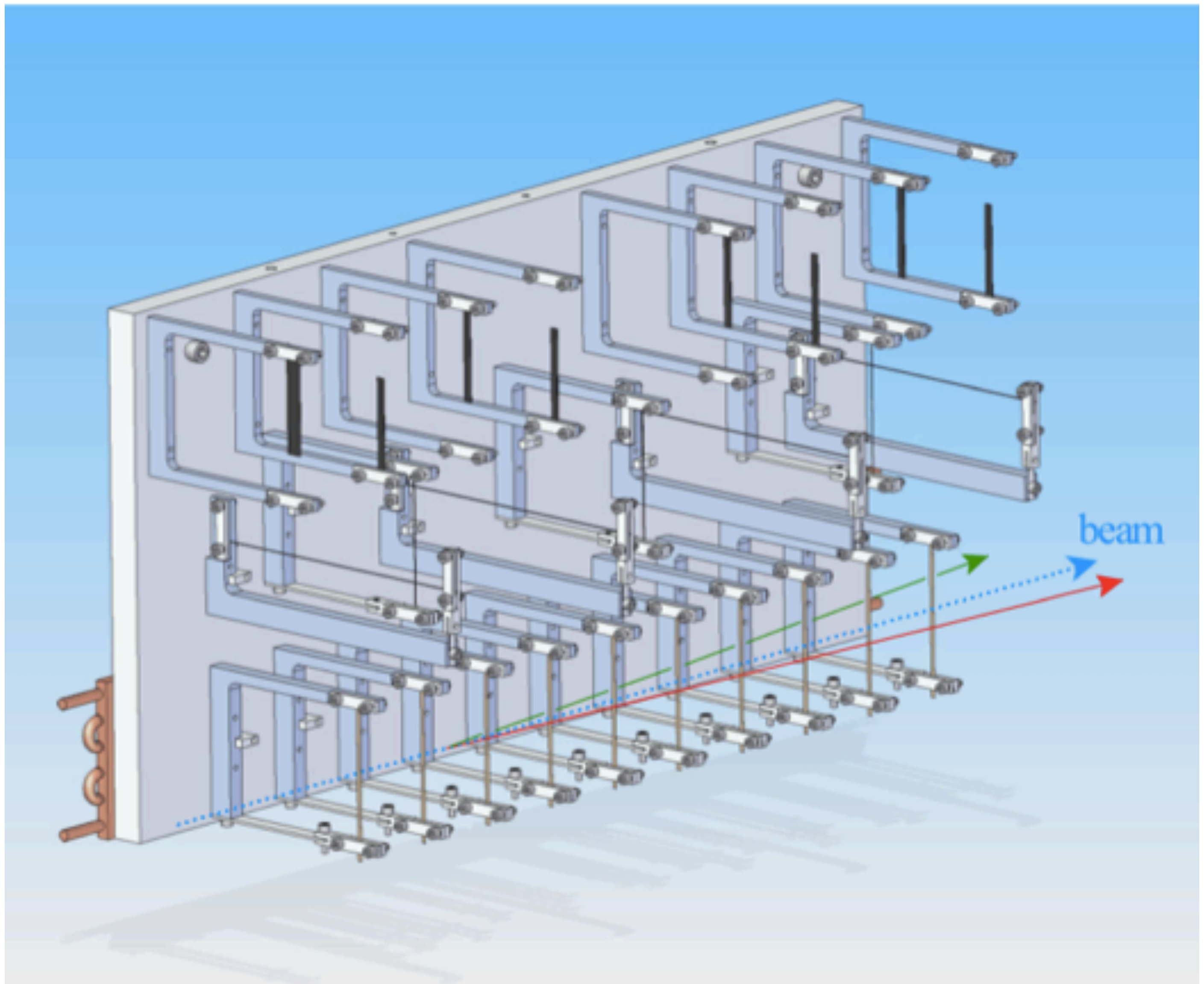
- $\sigma(\theta)_{\text{mult scat}} \leq 0.5$ mrad
  $\Rightarrow$ typical e^+e^- pair must only go through 0.3% X_0 (2-pass)
- Target thickness 0.7–8% X_0 (depending on E_{beam})



- High-Z target (reduce π yield for given QED rates)
- Stable under currents up to ~100 μA

long target $\Rightarrow$ wider single-run mass coverage

Target Design: Minimizing Multiple Scattering



Target To-Do List:

Silviu Covrig has taken charge of this project: collaborators are encouraged to work with Silviu

- ➢ Develop plan of target operation
- ➢ Additional target holders required.
- ➢ Analysis of heat load and cooling for 1, 3, & 4 pass settings needed, and repeat 2 pass analysis
- ➢ Target lifter needs to be integrated into system

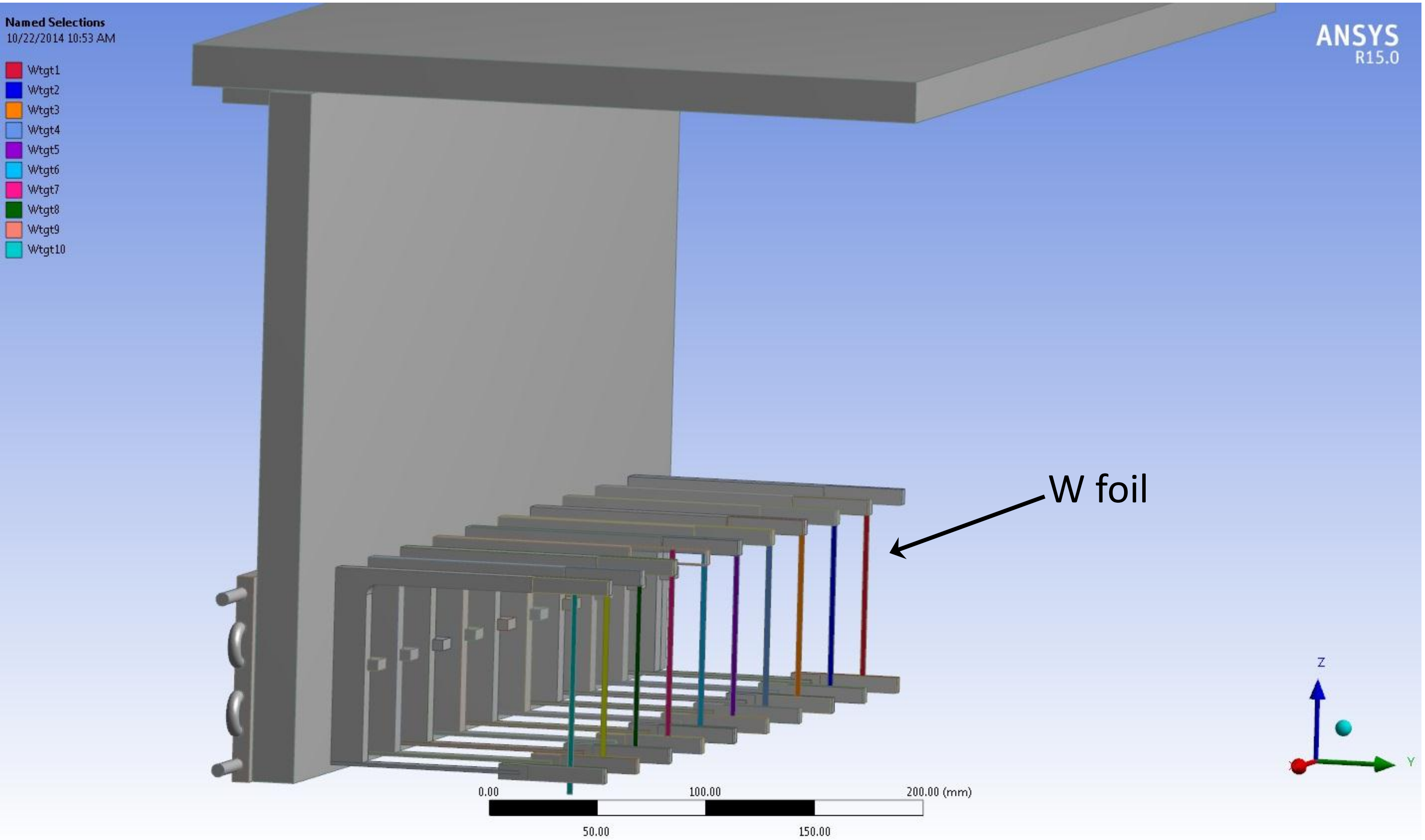
APEX Target Update

Silviu Covrig Dusa

JLab 23 Oct 2014

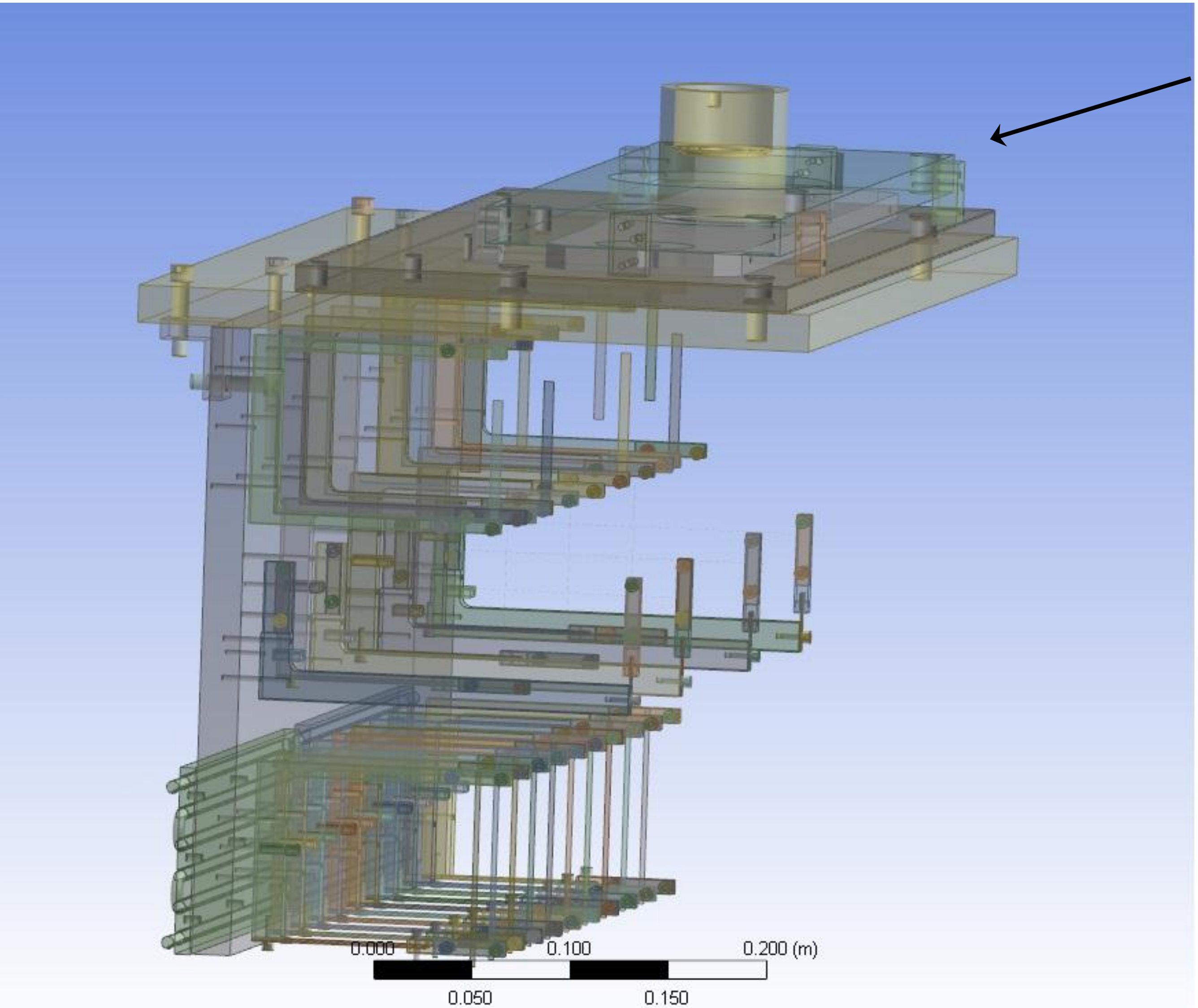
- Got a step file of target layout from Marco in June 2014
- 3D model of target generated by Hall C designer
- 3D model of target motion interface generated by high school summer student (Michael Williams) from Bogdan’s 2D drawings
- Working on thermal analysis of target with computational fluid dynamics (CFD) software, work impacted badly by the availability of mechanical designers at JLab
- Meshing issues due to geometry aspect ratios (W foils are 15 μm thick, 8 cm long, easy to mesh, hard to interface the foil mesh with the rest of the frame mesh)

APEX 3D Target Model



A Hall C mechanical designer generated the 3D model in July 2014 while working for CFD-Facility (CFDFAC). The designer was repurposed in Aug 2014 and since then the thermal analysis of this target stalled.

APEX Target with Motion Interface



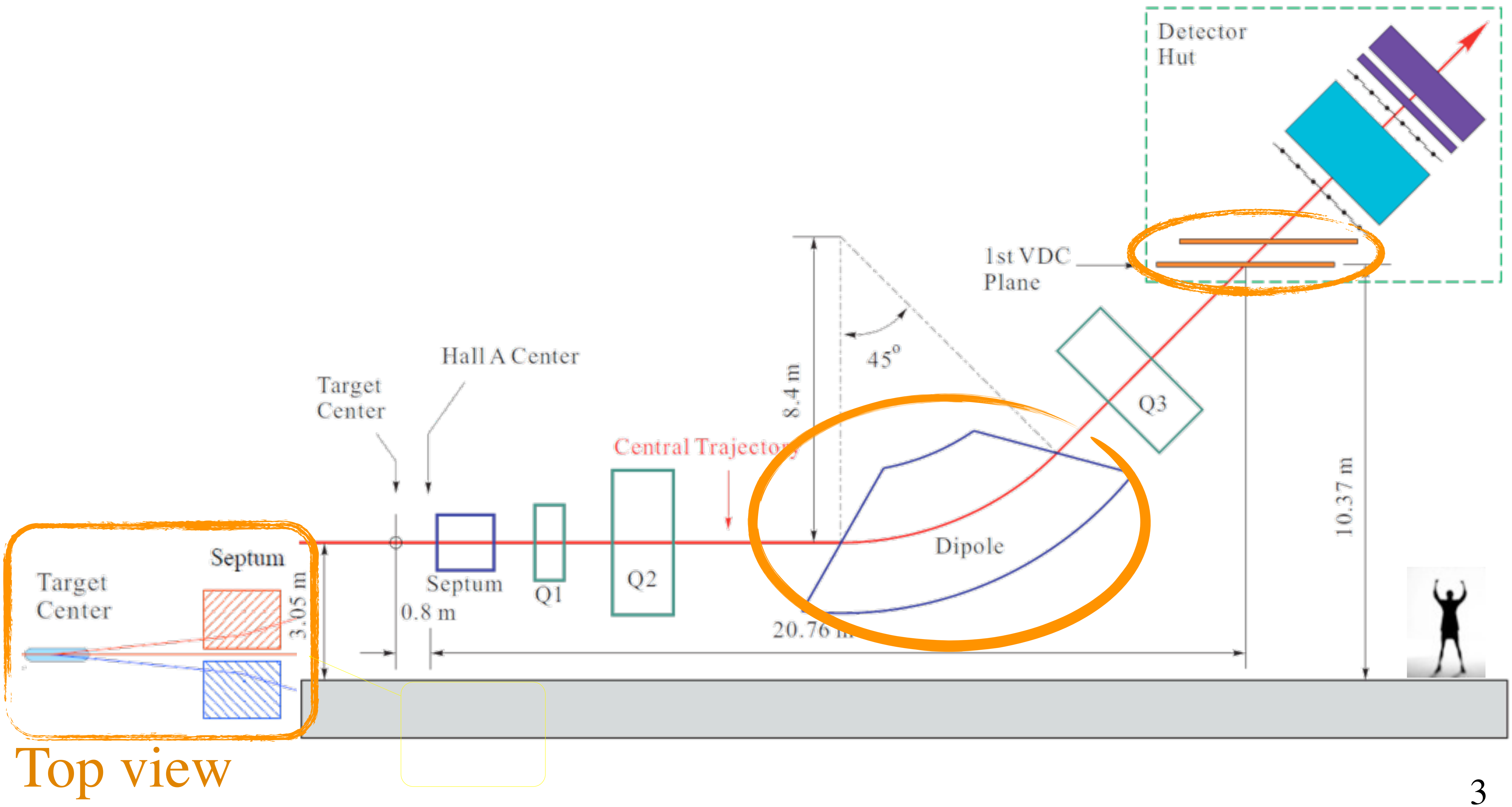
Motion interface mechanism, originally drawn in 2D by Bogdan and modeled in 3D by a high school honors summer 2014 student: Michael Williams (great work done by a high school student who had no prior experience with 3D mechanical modeling software!)

Future Plans

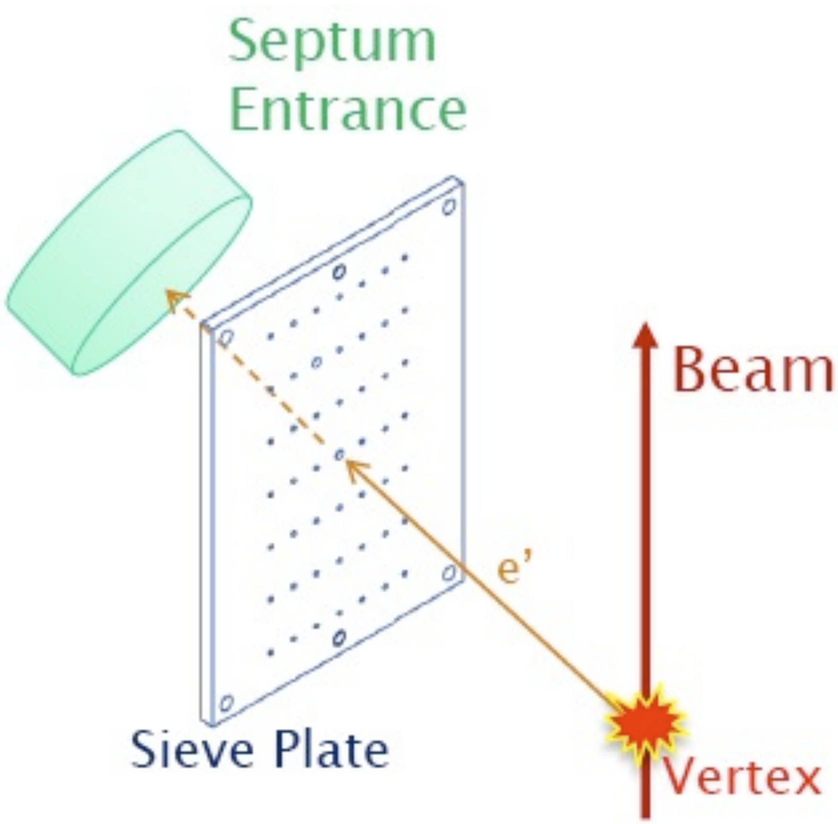
- In the process of hiring a mechanical designer to support the needs of CFDFAC (including the APEX target), subsequently will do the thermal analysis of the target
- Could not locate all the parts of the SLAC target at JLab
- A grad student would be needed to start working on the target, the student will interface with me, the target group here and my mechanical designer to make sure all target parts are here and in good standing (if not, new parts will have to be procured/made), the target can be interfaced with the existing motion system, mounted in the target chamber and surveyed in-situ.

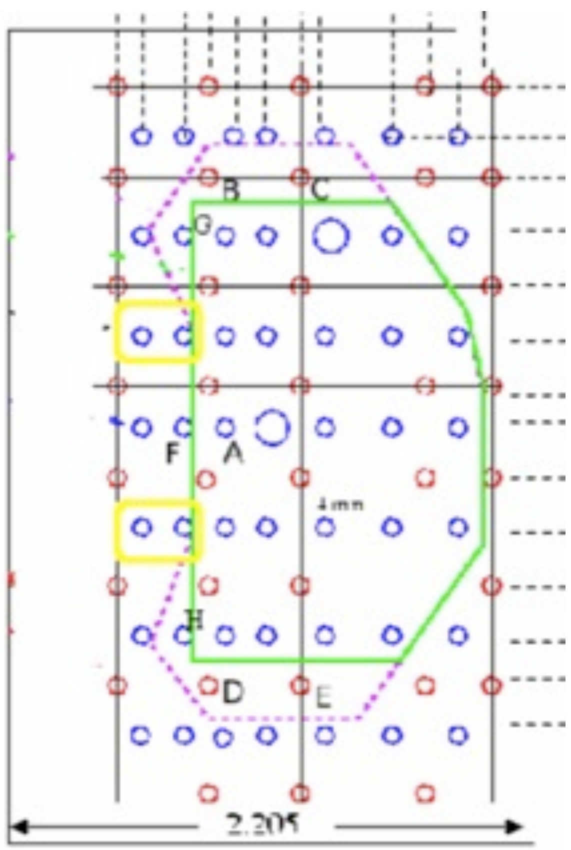
Magnetic Spectrometer Optics

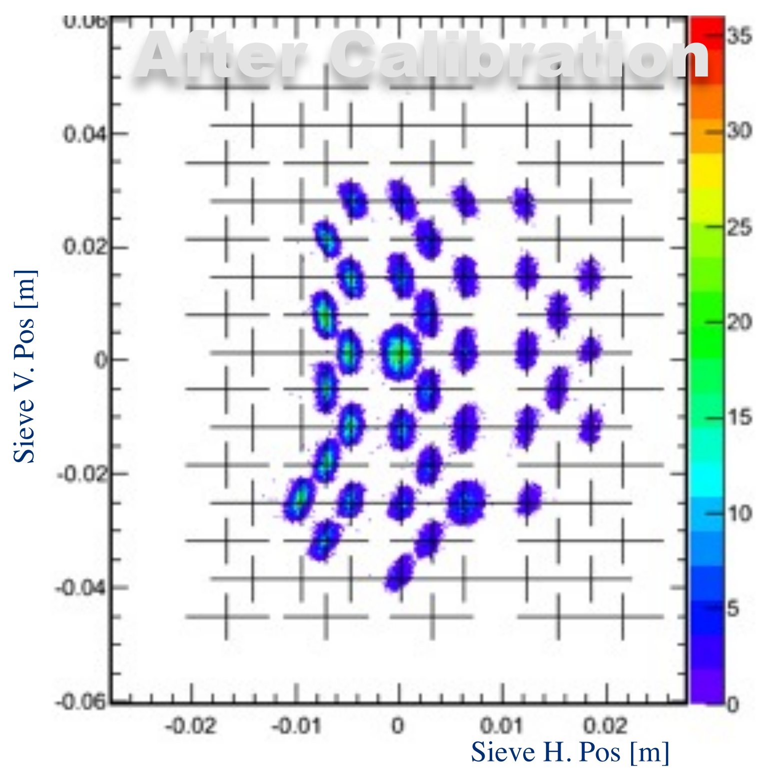
Measuring Contributions to the Mass Resolution
(dominant: **angular resolution** + mult. scatter)



Test Run Optics Calibration







Removable sieve plate is inserted upstream of septum.

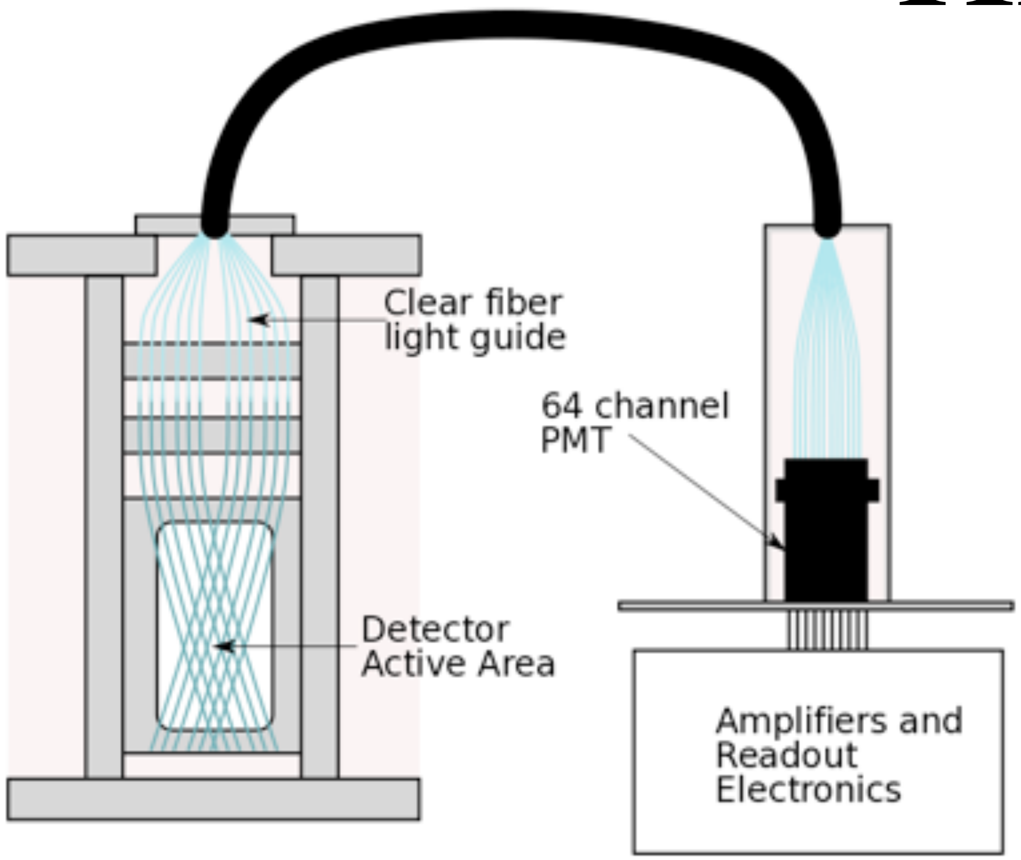
Use surveyed locations of sieve holes to calibrate magnetic optics.

Use reconstructed hole sizes to measure resolution.

...this method only works for negative polarity, and requires running at different beam energy.

Mass resolution≈1 MeV ~0.5%

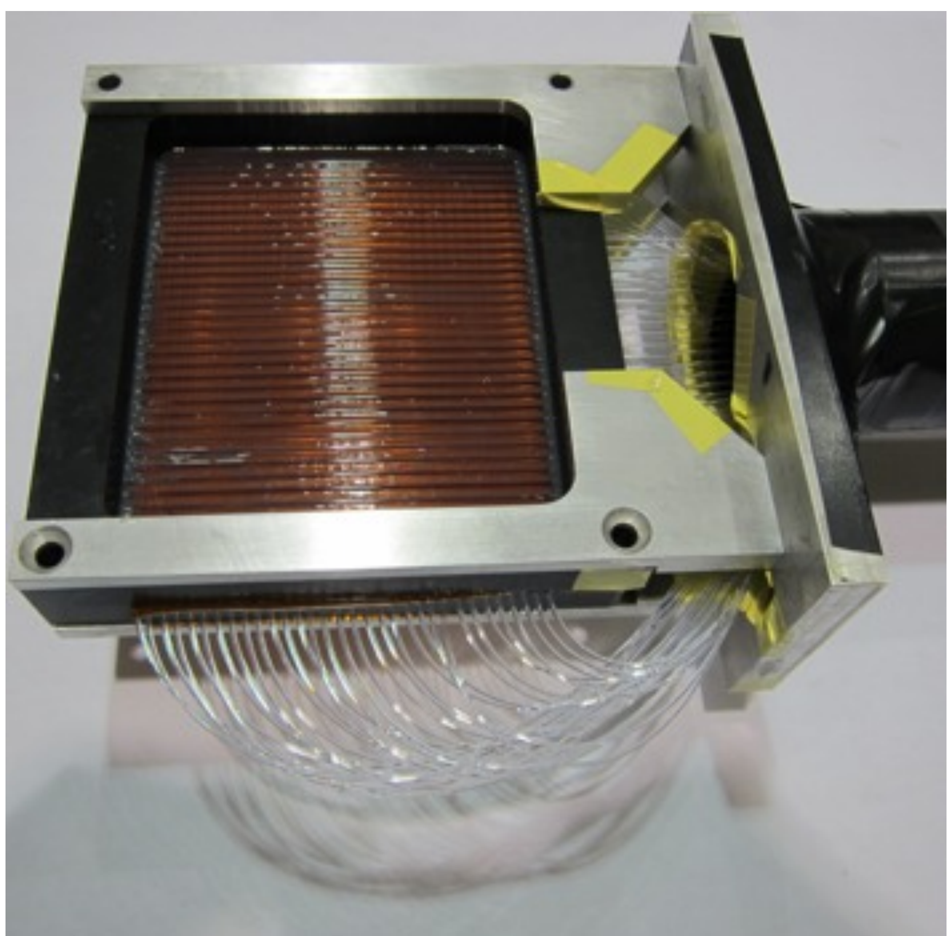
HRS optics

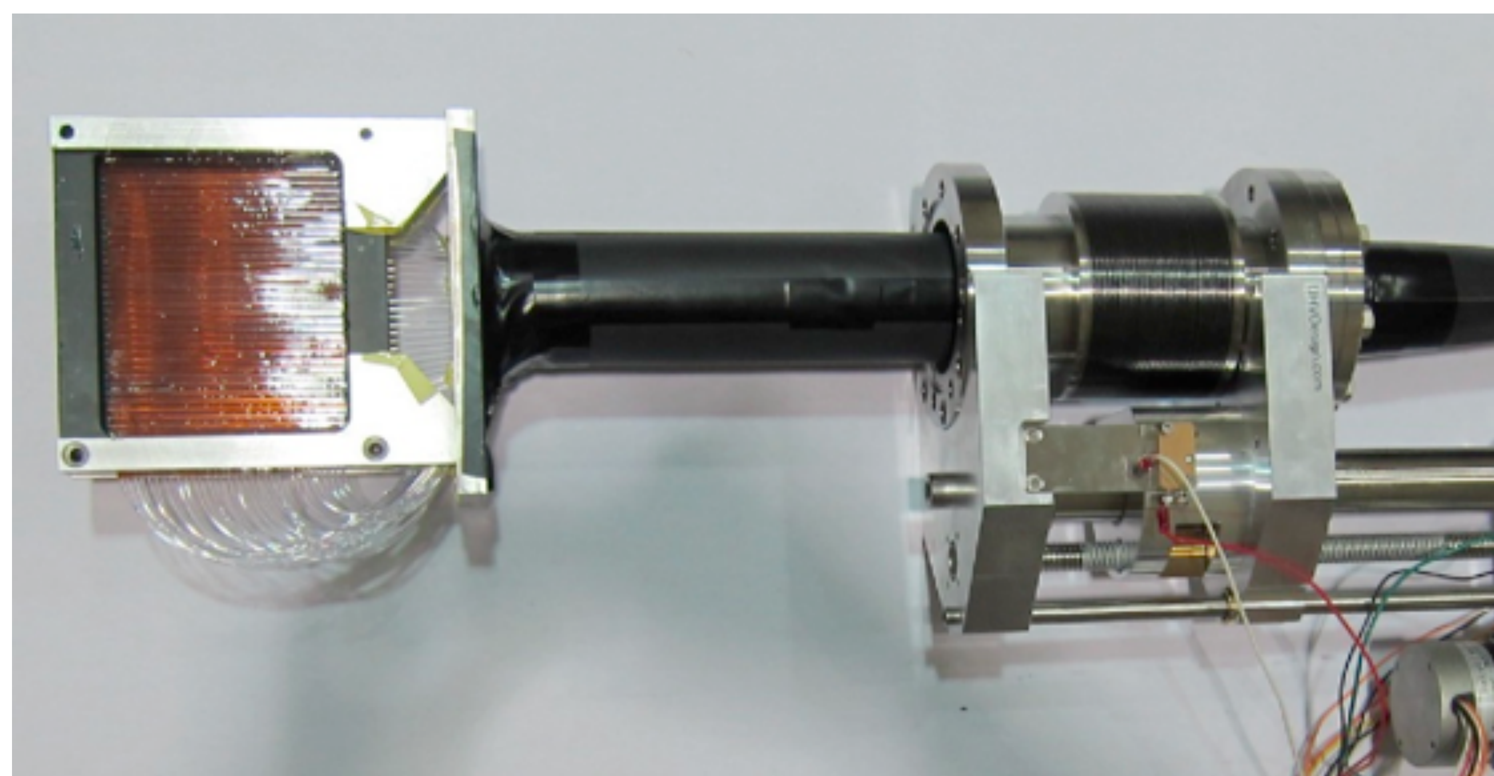


"Active sieve slit": tagging by a Sci Fiber detector

- 1 mm fibers with 1/16" pitch
  (equivalent to 1024 sieve holes)
- Projected rate: 1-3 MHz per fiber
- Off-line time window < 5 ns
- **Help needed to complete project**

Allows optics calibration at production beam energy & for both polarities





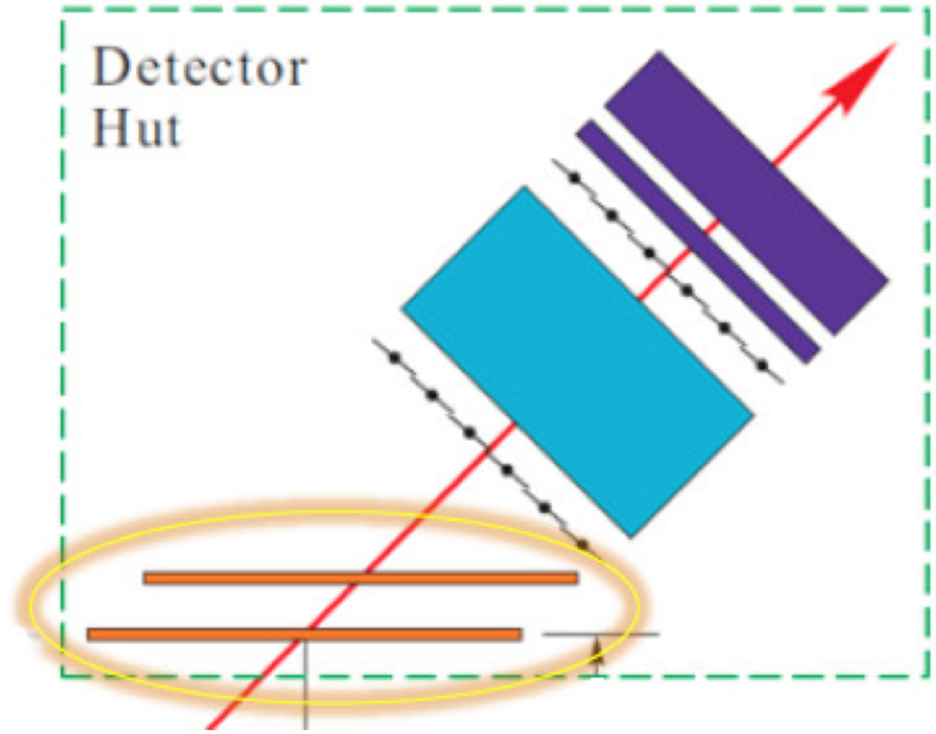
Optics Calibration:

- ✦ Develop an initial optics model based on magnetic field mapping
  - John LeRose used to be JLab expert on this
  - Seamus has been looking into it (joint project with PREX) but needs APEX point person

- ✦ Integrate SciFi data into existing optics calibration software
  - Need point person to gain expertise with code and take lead in integrating SciFi

Improve VDC tracking efficiency

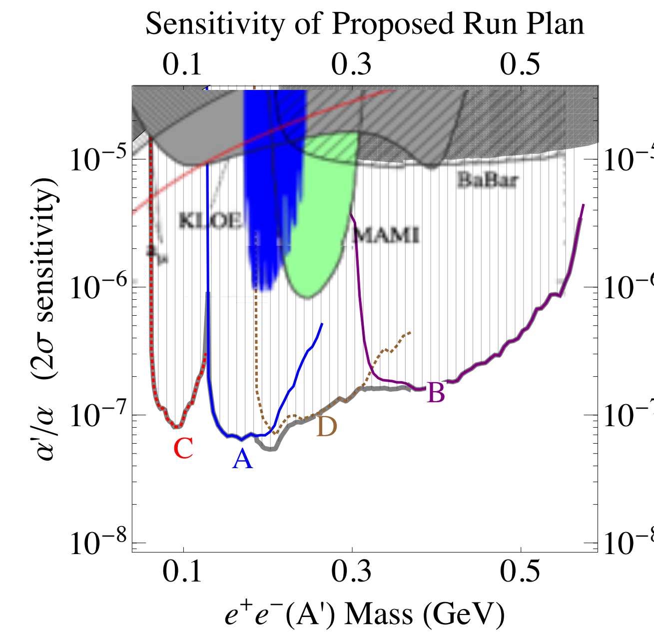
- APEX wants to collect as many e^+e^- pairs as possible, but in the process produces an enormous rate of single particle events
- Vertical Drift Chamber (VDC) in electron arm has to handle a very high rate, ~5 MHz
- Existing algorithms find only about 60-80% of the tracks at these rates
- For current status see talk by Seamus:



http://hallaweb.jlab.org/experiment/APEX/collab2014/riordan_apexvdc.pdf

- Previous work from S. Riordan, M. Graham, O. Hansen, and M. Paolone
- Project: improve this efficiency, which will improve A' signal efficiency and lead to better sensitivity
- Vlassis Petousis has taken on this project under Seamus' guidance; if you want to get involved please let them (and spokespeople) know

APEX Analysis: Reach Update



Projected sensitivity in PAC37 proposal:

- Monte Carlo events are simulated for the Bethe-Heitler, radiative tridents, and the continuum trident background including the full interference effects between the diagrams. The latter background is computationally intensive, and only a small statistics sample is generated, sufficient to obtain the cross-section from MadEvent.
- The cross-section ratio of the full continuum background (with interference effects) to the sum of the Bethe-Heitler and radiative tridents is calculated, and represents a multiplicative factor by which the latter must be multiplied to get the background cross-section.
- The rates of all reactions impinging the spectrometer acceptance were calculated by integrating over a chosen target profile, which usually extended from 4.5 to 5.5 degrees. For Bethe-Heitler, radiative tridents, and the continuum trident background, the calculation of the rate was performed as a function of invariant mass.
- Using the expressions in Appendix B, we calculated the mass resolution δ_m. We then tiled the acceptance region with bins of size $2.5 \times \delta_m$ in invariant mass.
- As a function of α'/α, the total number of signal (S) and background (B) events was calculated with the help of the formulas in §3 for each bin.
- We then set $S/\sqrt{B} = 2$, and solved for α'/α.

APEX PAC37

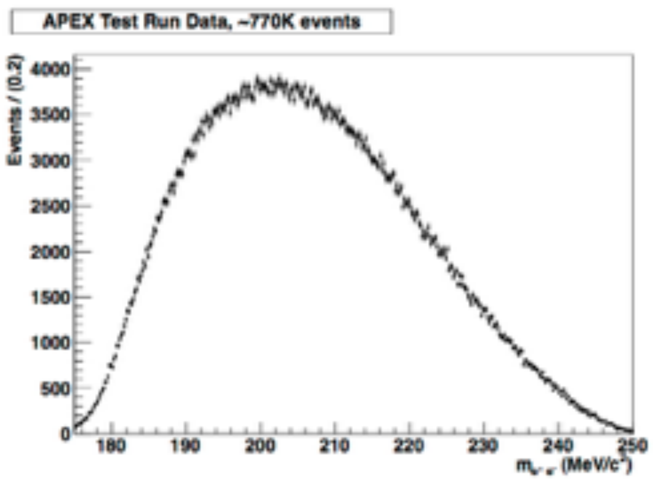
Much of the infrastructure prepared by James Beacham, not yet fully validated (see his talk at collab. meeting)

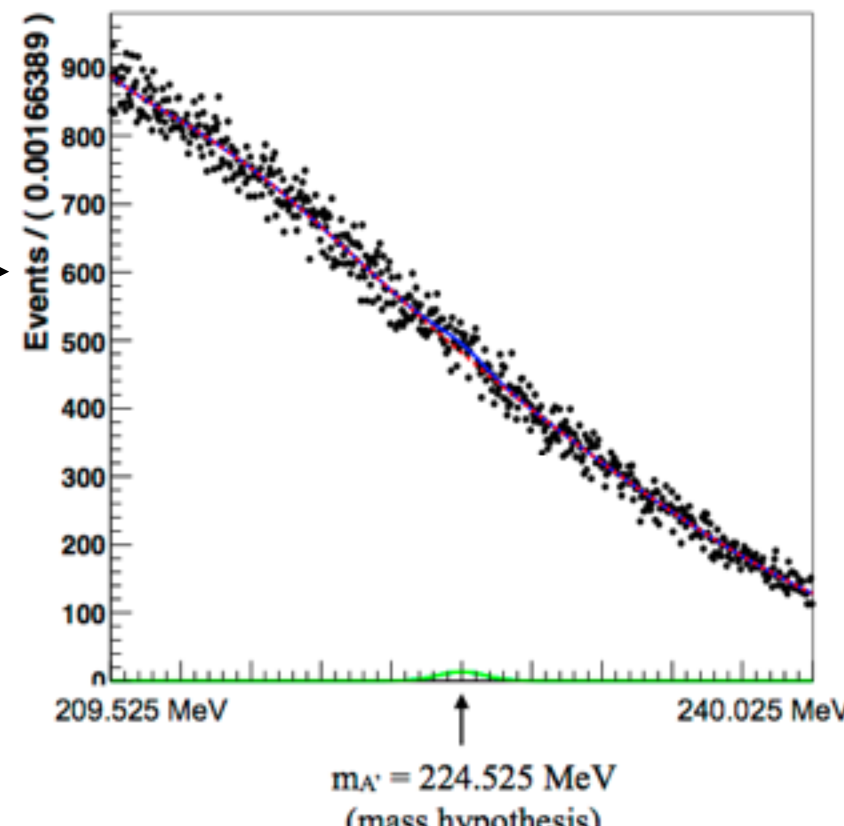
Natalia & James can provide support, but need someone to take over lead role for MC and sensitivity analysis

- *Should include more realistic models for*
  - *target profile*
  - *septa acceptance*
  - *detection efficiencies*
- *Will allow us to re-assess optimization of run plan in light of current limits*
- *Assess and minimize* ***systematics*** *in limit*
- *Simplified MC procedure to also plug in to the analysis*

APEX Analysis: Bump Hunt

Starting point: Test run PRL analysis [all figures from J. Beacham's collab. meeting talk]





- *Fit data in mass window by 7th-order polynomial + signal Gaussian*
- *Standard profile-likelihood ratio analysis to search for significant excess, set limits*
- *High statistics → sensitive to bkg model (hence 7th order), pathologies in ROOT fits (small bins)*

Modeling background by polynomial w/ 7 free coefficients decreases sensitivity.

We know a lot about this background – It is QED ($d\sigma/dm \sim 1/m^3$), convolved with detector acceptance & efficiency! Modeling from MC & data (x lower-order free fn.) should ⟹ immediate sensitivity gain.

[Do we need additional pre-scaled triggers to calibrate?]

Like reach calculation, would benefit from simplified (but more CPU-intensive) background event generation. Important enough to cross-check two ways (e.g. MadGraph/MadEvent + T. Beranek's calculations)

Again, Natalia and James can both support whoever wants to take key role in this effort.