

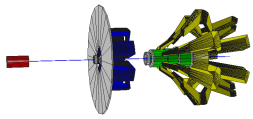
# **E09-005: MOLLER Status Update**

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UMass

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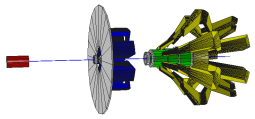
December 15, 2009



## E05-009: MOLLER Status Update

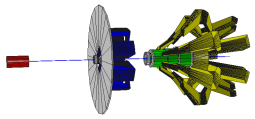
### Outline

- schedule
- Intro:
  - Proposed Measurement Details
  - Goals and Motivation
- Experimental Setup/Design
- Recent Work
- Timeline and Status



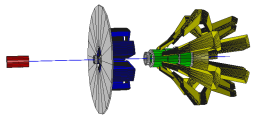
## E05-009 Scheduling

- Jlab (Director's) Review on Jan 14-15, 2010.  
Preparations ongoing.
  - Address Review Charges:
    - 1) Physics case (relevance, potential risk)
    - 2) Validity of experimental approach
- Collaboration Meeting Dec 4-5, 2009
- Collaboration Meeting Sept 18, 2009

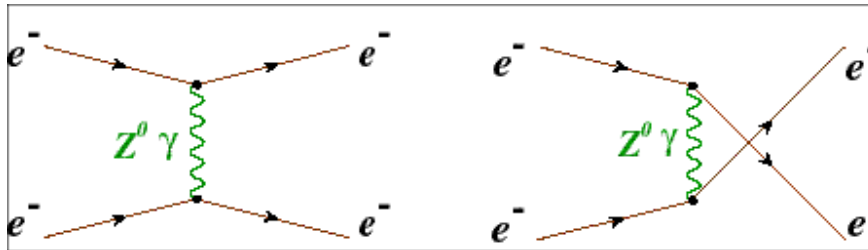


## MOLLER Collaboration

- ~100 authors from 30 institutions, with veterans from all the Jlab parity violating experiments



## Moller Scattering, $A_{PV}$ Measurement

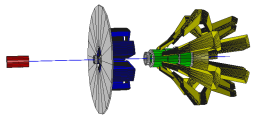


- Purely leptonic reaction provides clean probe of weak neutral current interactions via parity violating electroweak interference

$$A_{PV} = m_e E_{lab} \frac{G_F}{\sqrt{2}\pi\alpha} \frac{4\sin^2\theta}{(3 + \cos^2\theta)^2} Q_W^e, \quad (1)$$

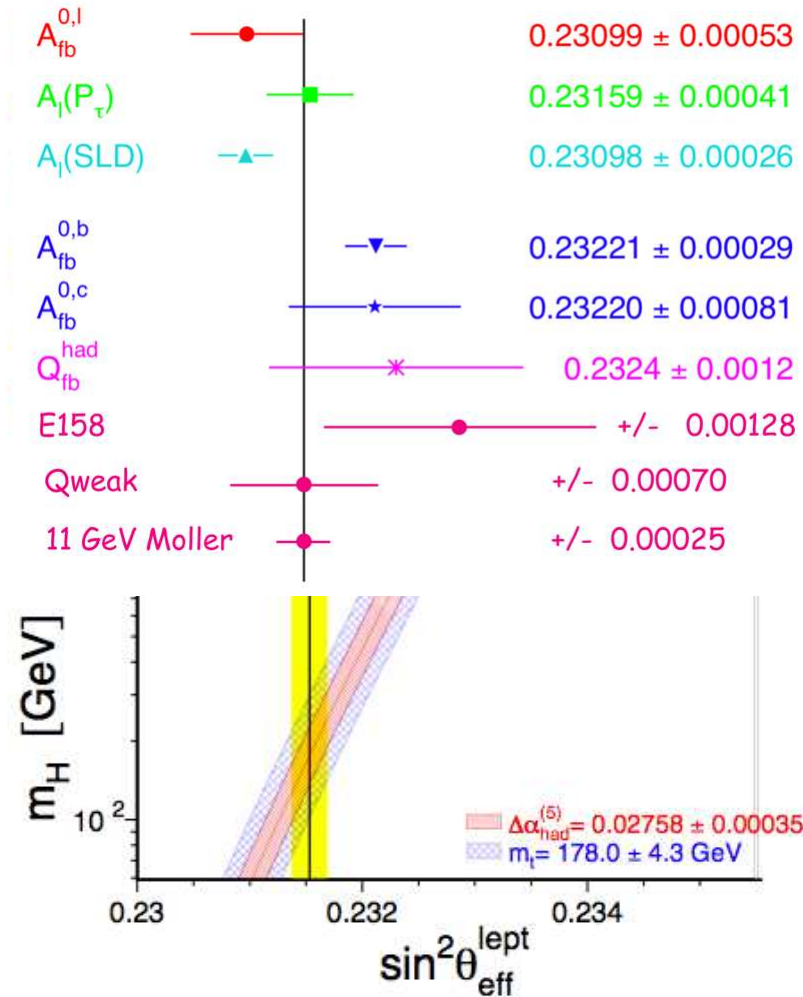
$$Q_W^e \equiv 4 \cdot g_V^e \cdot g_A^e = (1 - 4\sin^2\theta_W) \quad (2)$$

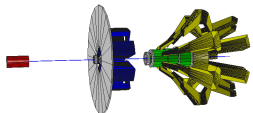
- $e_{beam}^-$ : 11GeV, 85 $\mu$ A, 85% polarization  
→  $\langle Q^2 \rangle = 0.0056 \text{ (GeV/c)}^2$ ,  $\langle A_{PV} \rangle = 35.6 \text{ ppb}$
- For 38 week run:  $\delta(A_{PV}) = 0.74 \text{ ppb}$ ,  $\delta(Q_W^e) = \pm 2.1(\text{stat}) \pm 1.0(\text{syst})$ :  
→  $\delta(\theta_W) = \pm 0.00026(\text{stat}) \pm 0.00012(\text{syst}) \sim 0.1\% \text{ precision!}$



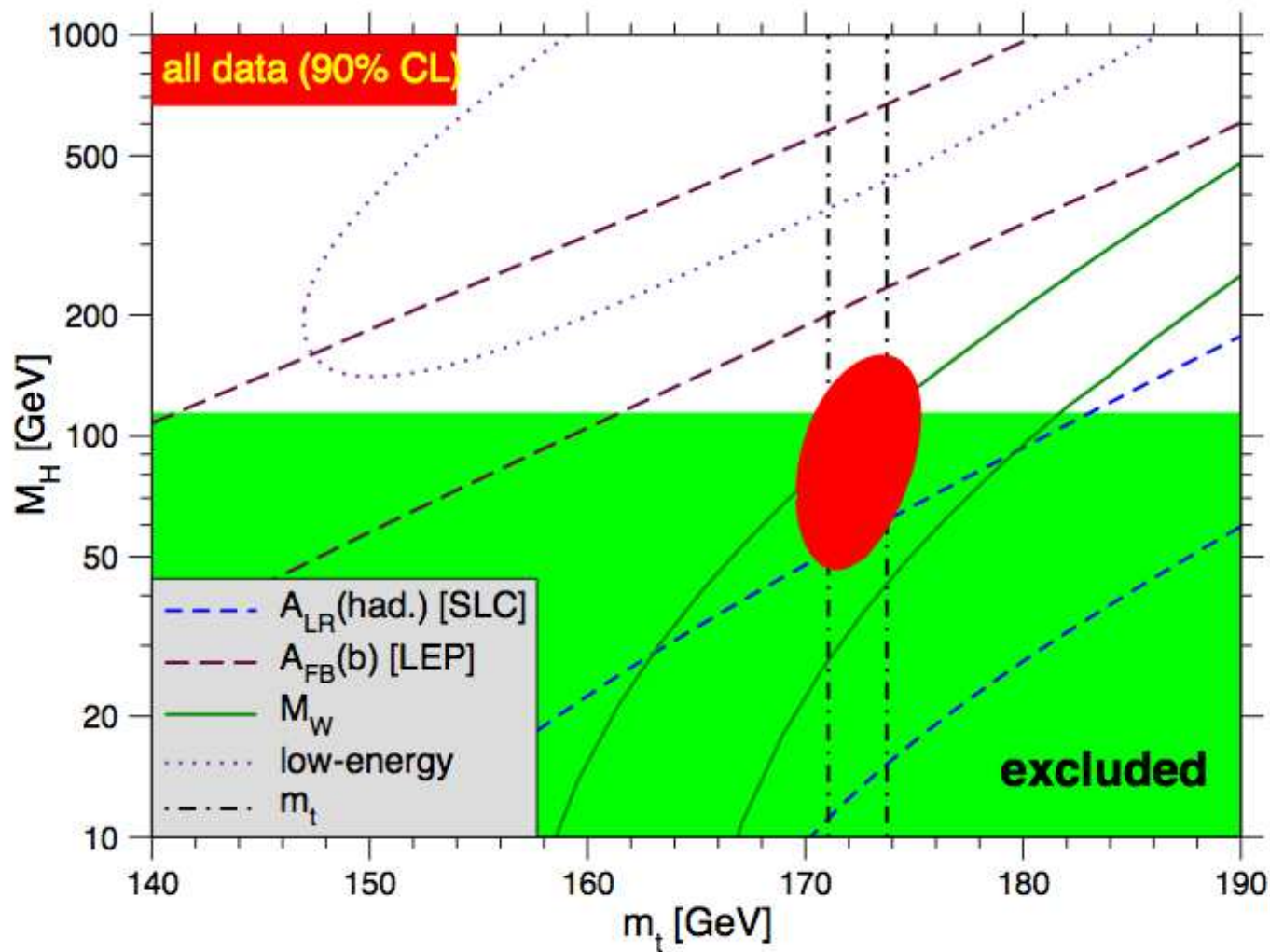
## Physics Motivation: $\sin^2\theta_W$ , the Higgs Mass, and Beyond the Standard Model

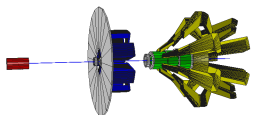
- World data avg:  $\sin^2\theta_W = 0.23122(17)$   
 $\Rightarrow m_H = 89^{+38}_{-28}$  GeV  
 (favors SUSY, rules out Technicolor)
- Avg dominated by two measurements separated by  $3\sigma$ :  
 $\rightarrow A_1(\text{SLD}) : 0.2310(3), \Rightarrow m_H = 35^{+26}_{-17}$  GeV  
 rules out SM!  
 $\rightarrow A_{fb}^{0,1} : 0.2322(3), \Rightarrow m_H = 480^{+350}_{-230}$  GeV  
 rules out SUSY, favors Technicolor
- Proposed measurement precise enough to effect the central value of  $\sin^2\theta_W$  and its implications for  $m_H$



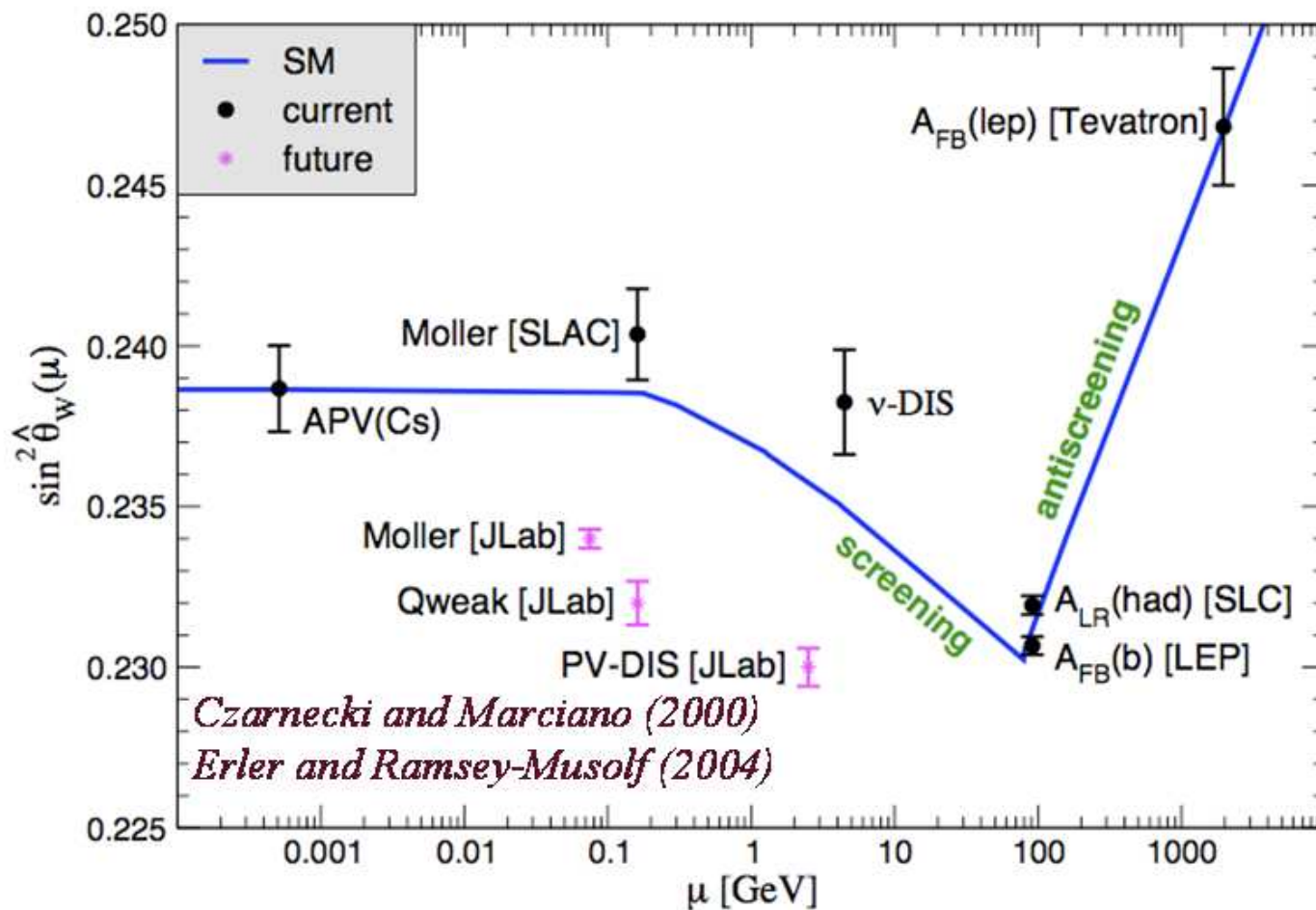


## The Search for the Higgs

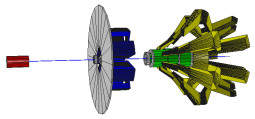




## Current and Future $\sin^2 \theta_W$ Measurements

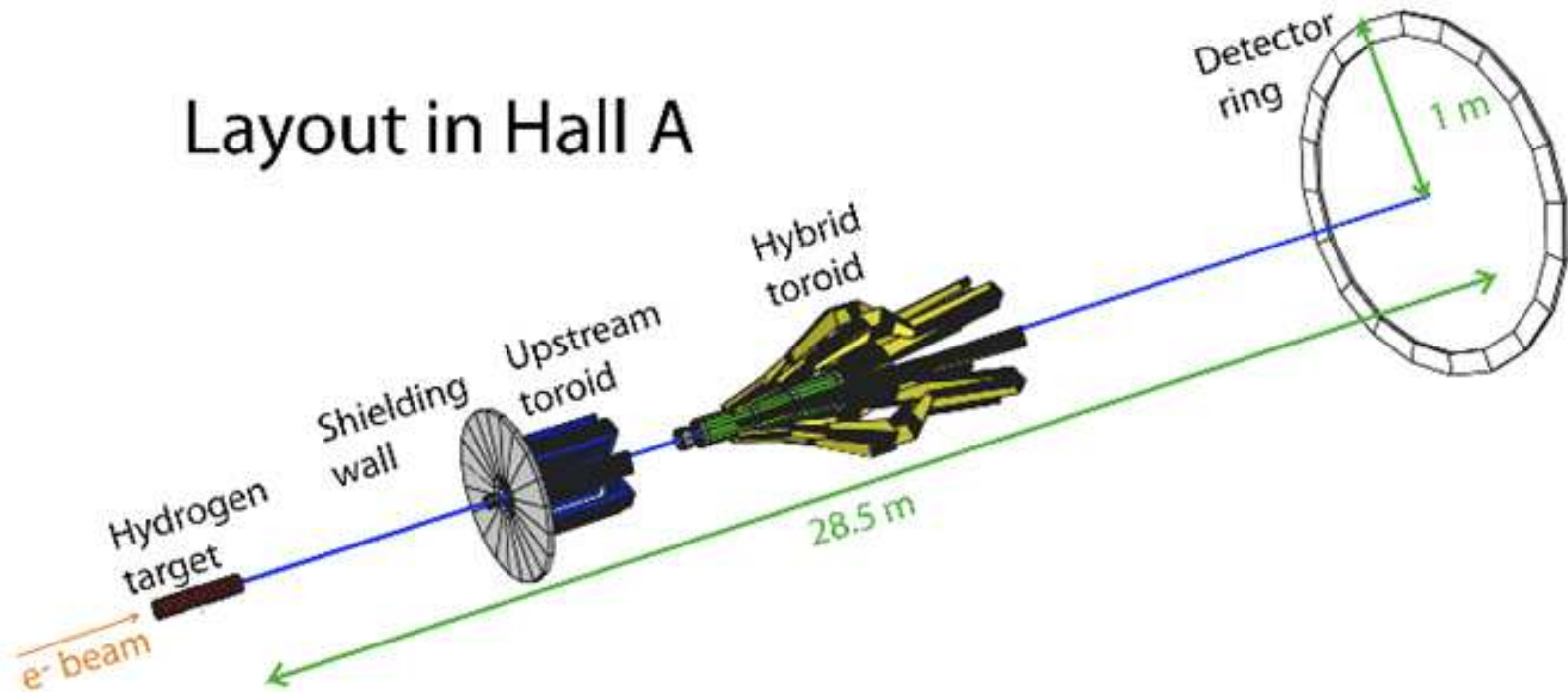




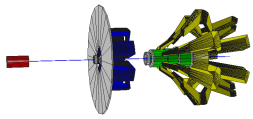


## Experimental Setup/Design

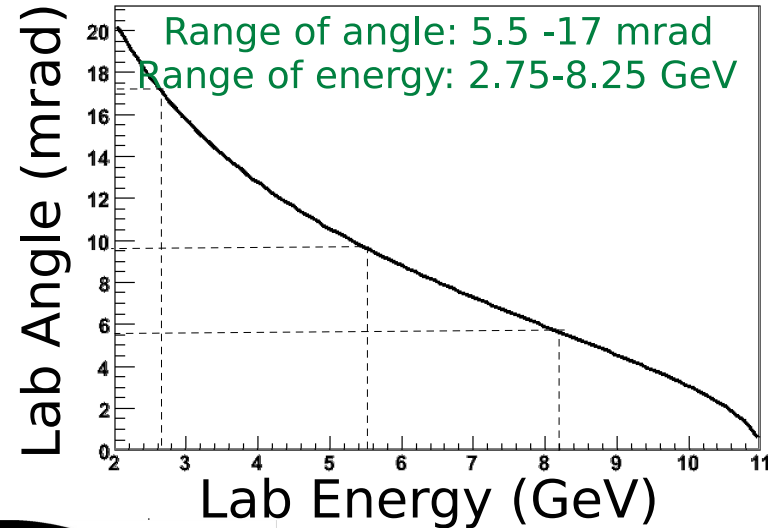
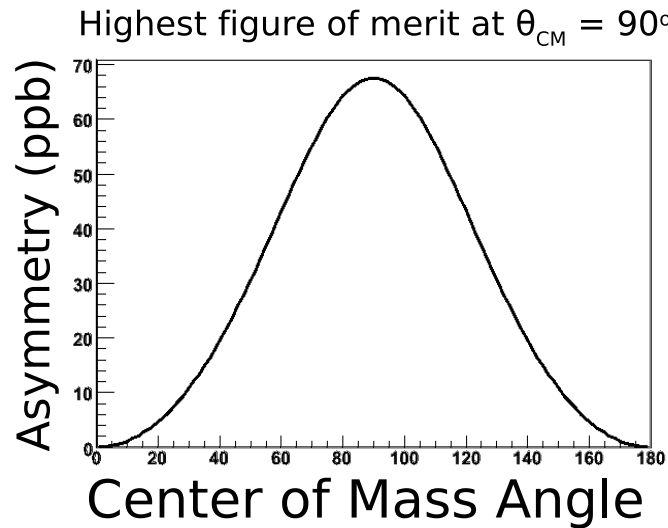
### Layout in Hall A



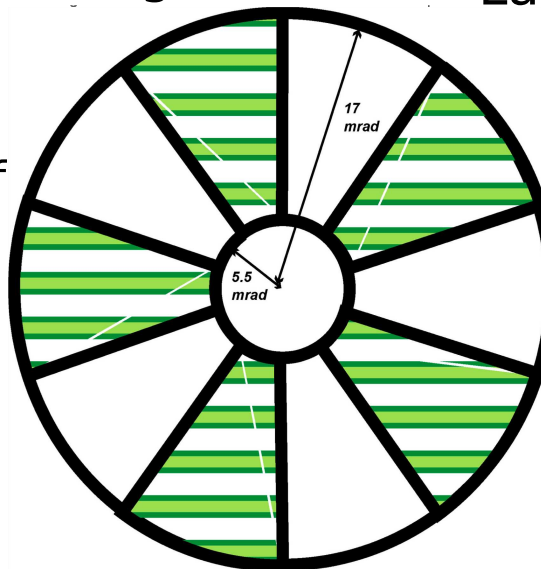
- Long and skinny design ( $\sim 30\text{m}$  from target to detector)
- 150cm  $1\text{H}_2$  target
- Novel two toroid spectrometer design (prebender and hybrid) with full azimuthal acceptance
- Flux integrating detector ring with azimuthal and radial segmentation



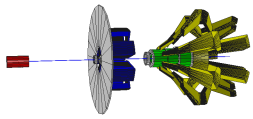
## Optimized Spectrometer ( $\sim 100\%$ Acceptance)



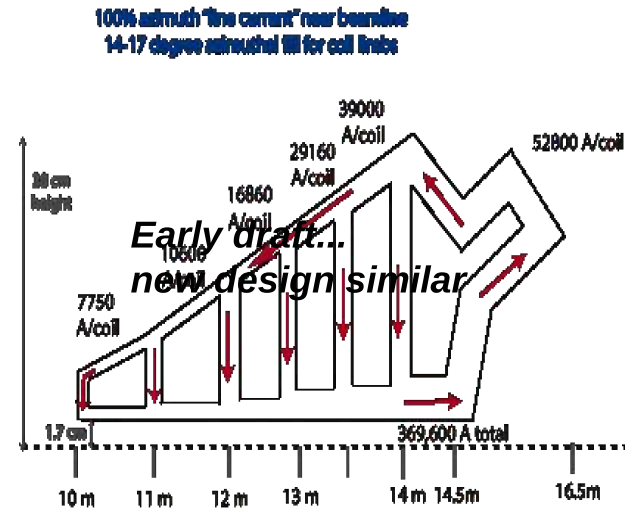
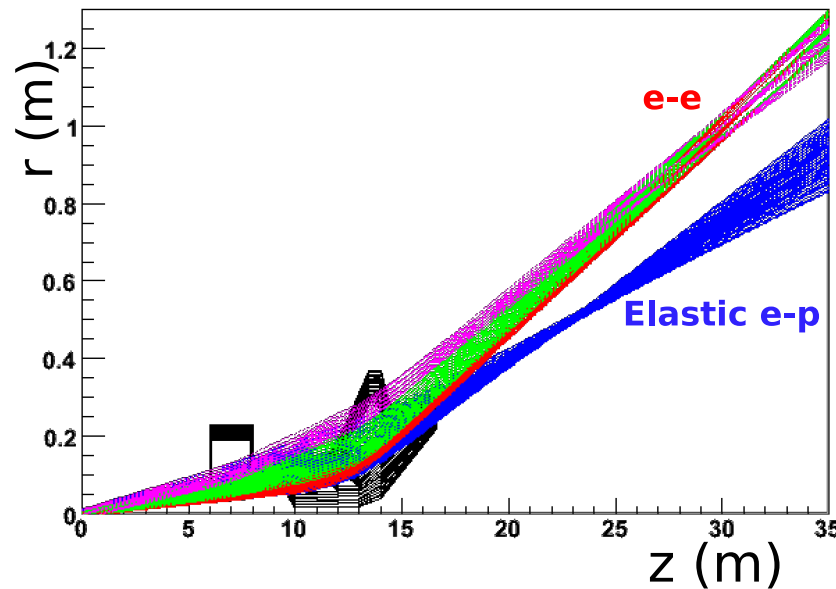
All of those rays of  $\theta_{CM}=[90,120]$  that you don't get here...



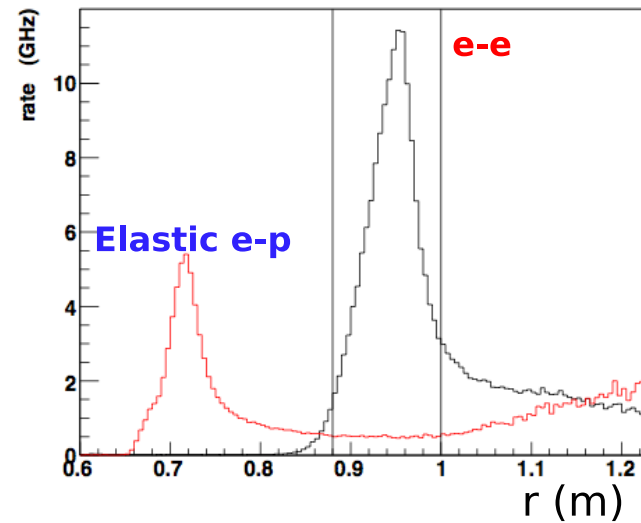
... are collected as  $\theta_{CM}=[60,90]$  over here!

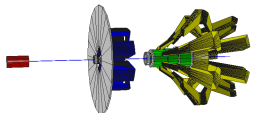


## Toroid Design Concept

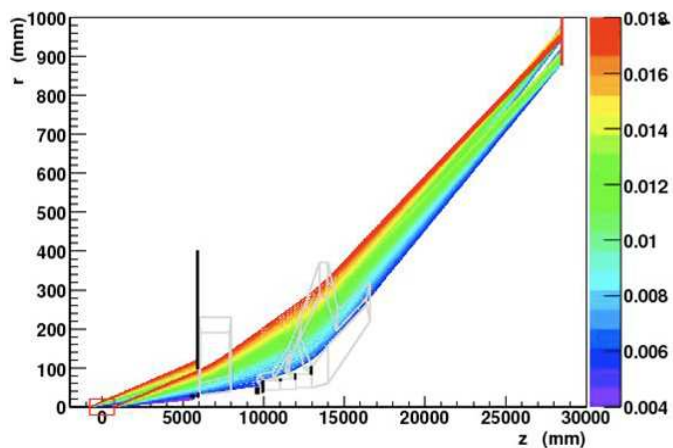


--Two Toroid design facilitates signal and bkgd separation while focusing Moller events onto narrow detector ring

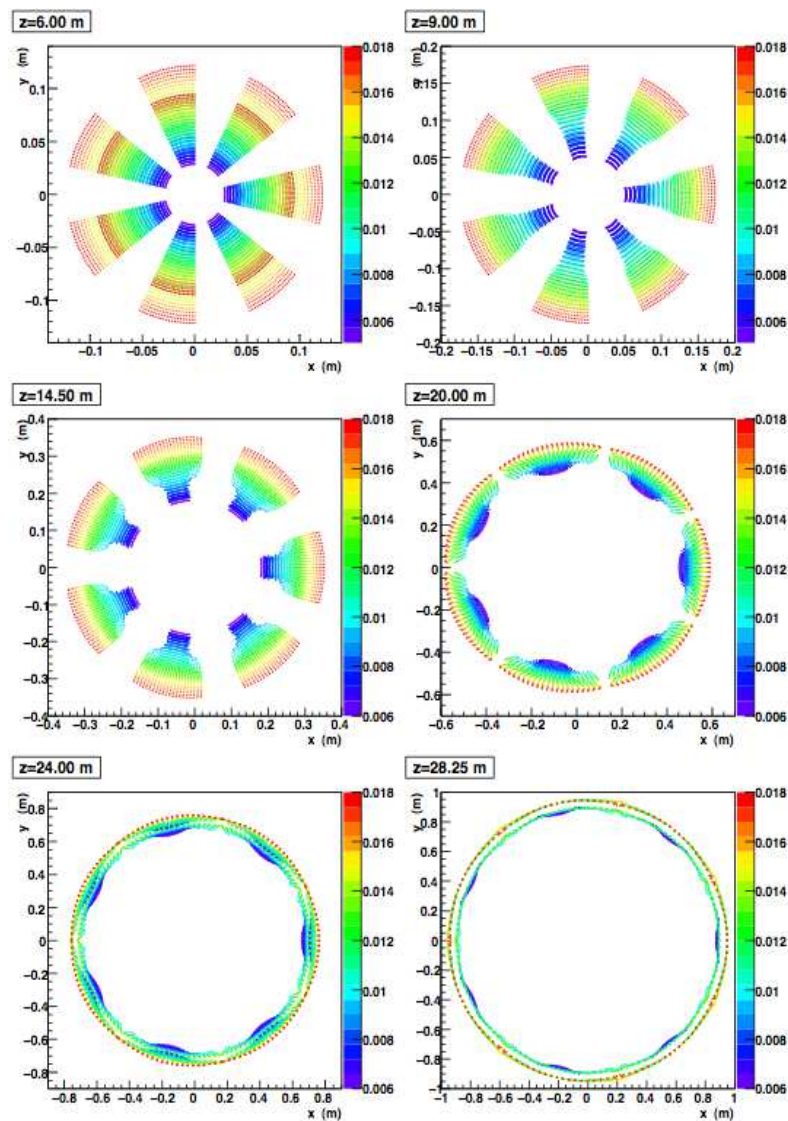


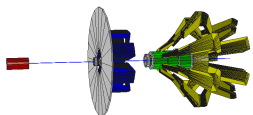


## Optics Raytrace

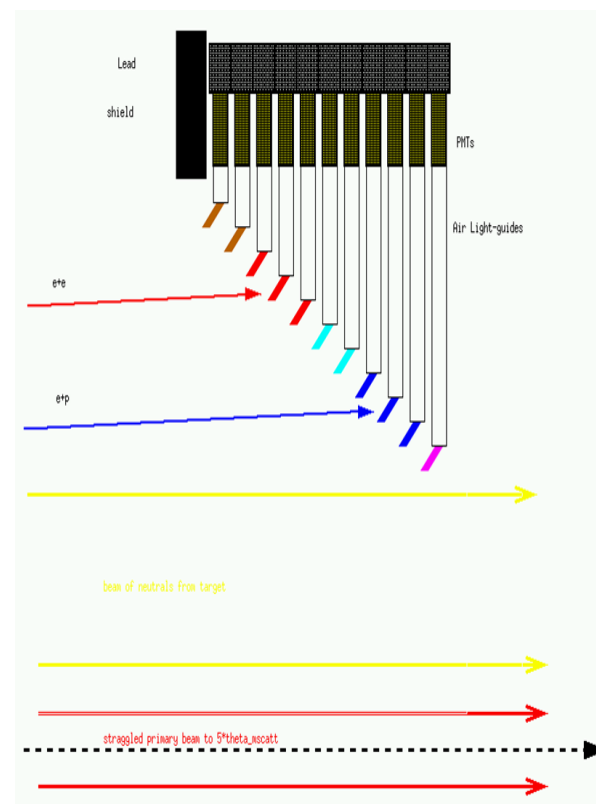
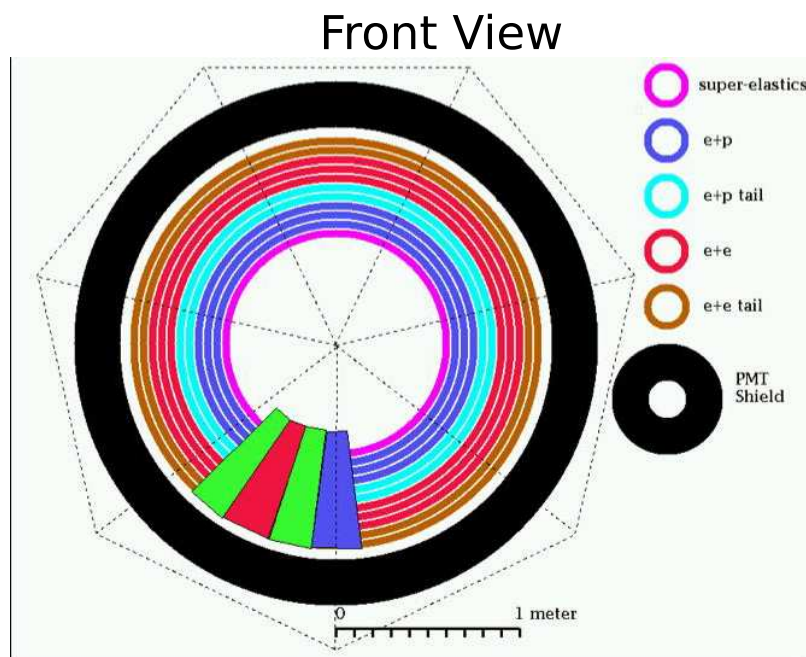


--Defocusing effects results in population of full azimuth



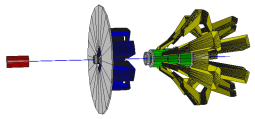


## Main Detector Reference Design



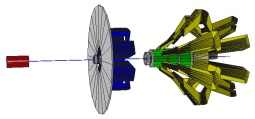
Side View

- Rad-hard flux, integrating detectors
- Radial segmentation for systematic checks (backgrounds)
- Azimuthal segmentation for systematic checks (e.g. parity conserving  $\cos(\phi)$  asym, azimuthal defocusing, beam sensitivities, backgrounds, etc.)
- Ancillary detectors (not shown): Tracking, pion, and lumi



## Recent Work

- Toroid design proof of principle: Started dialog with experts
- First discussion of scope of tracking devices
- Began work on more detailed cost breakdown
- First meeting with Jlab cryo folks
- First detailed look at hall beamline and instrumentation
- Background simulation studies: Photons and inelastic ep's
- First pass at more formal main detector design

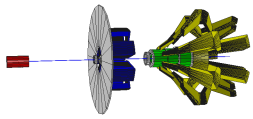


## Timeline and Status

- PAC 34 - full approval - strong endorsement

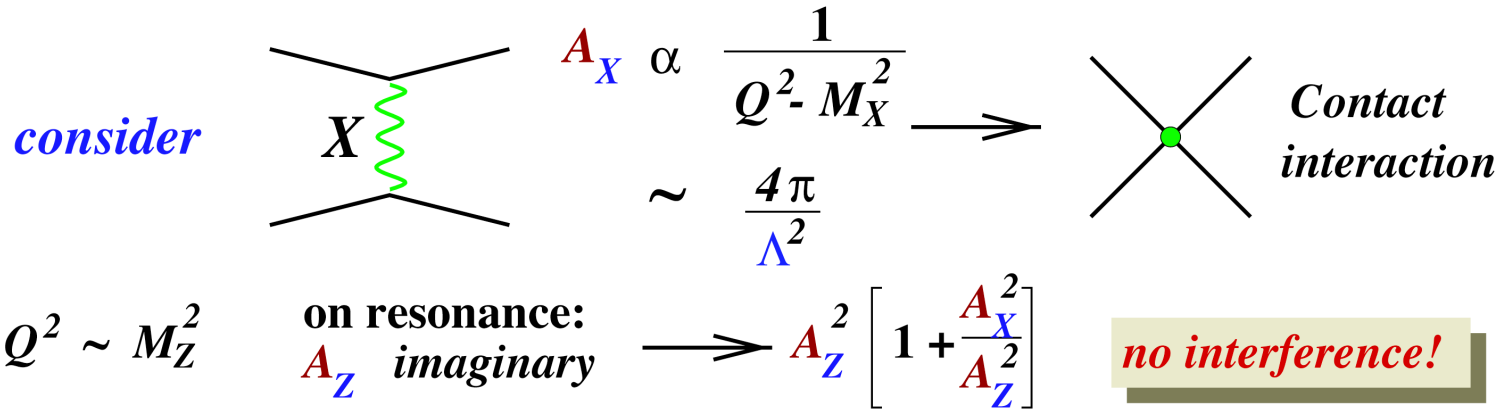
“The proposed physics reach is outstanding and capable of making this effort a flagship experiment at JLab. The PAC believes the mission of this experiment... is so important that the Laboratory should make every effort to support the securing of the resources required”

- Working with lab management to prepare funding request (DOE nuclear,+...)
- Goals:
  - CD-0 request targeted for spring 2010
  - construction 2012 - 2015
- First review (Jlab initiated) scheduled for January 14-15 2010



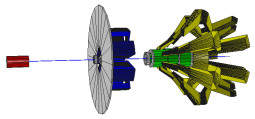
## Establishing Limits for New Contact Interactions (Off the Z Resonance)

Important component of indirect signatures for "new physics"



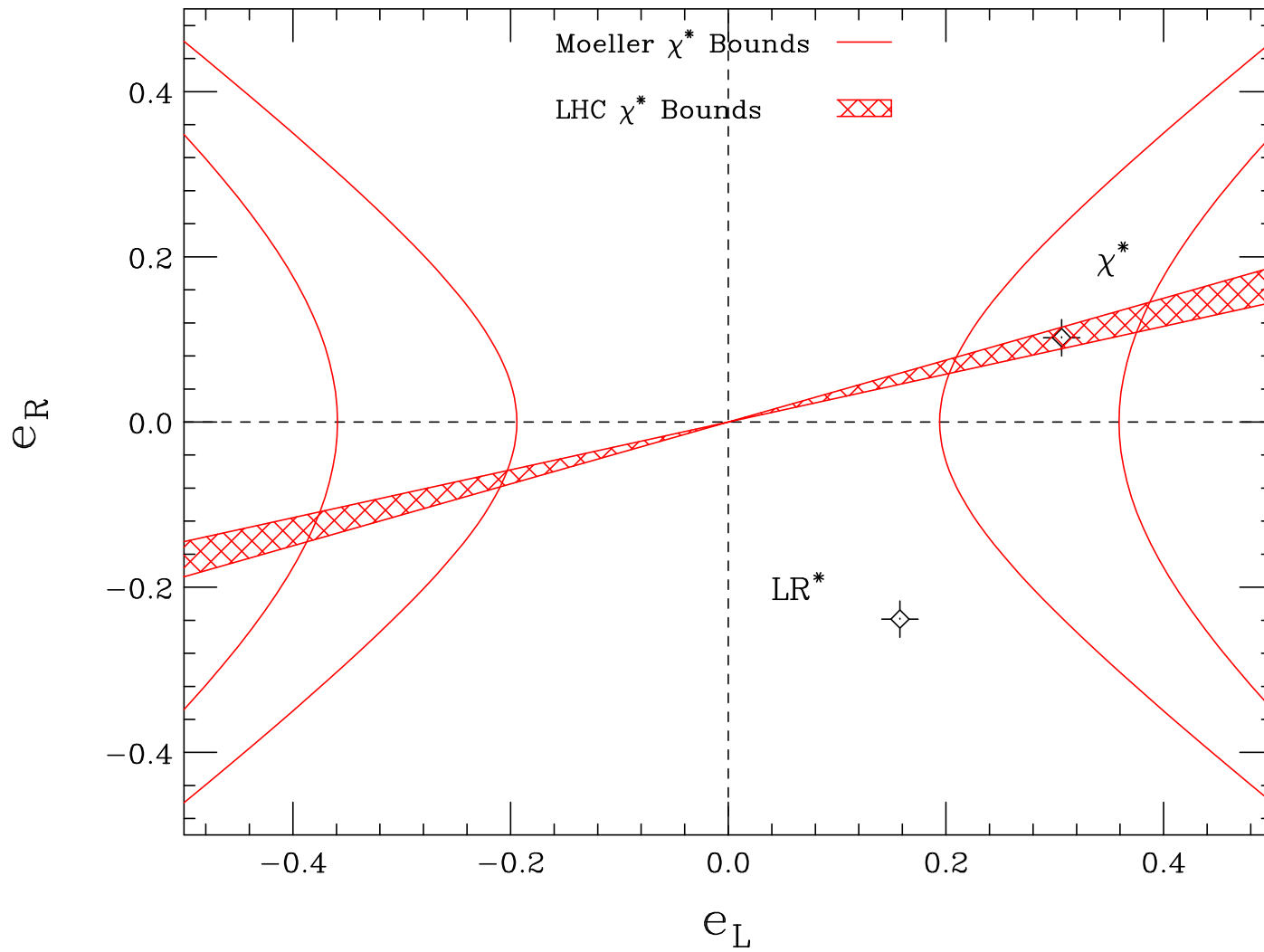
- Near the Z resonance, new physics interactions (e.g.  $Z'_X$  exchange) don't visibly mix with standard model  $A_Z$  (Collider Experiments)
- This underscores importance of low energy measurements of  $Q_W^e$ : E158, Qweak, PVDIS, and 12GeV Moller
- Best current limits on  $4e^-$  contact interac. come from LEP, LEP II:  $\Lambda/g \sim 5$  TeV, but insensitive to  $|g_{RR}^2 - g_{LL}^2|$
- Proposed Measurement will reach  $\sim 7.5$  TeV interaction scale

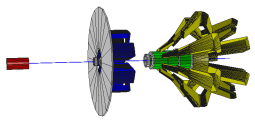




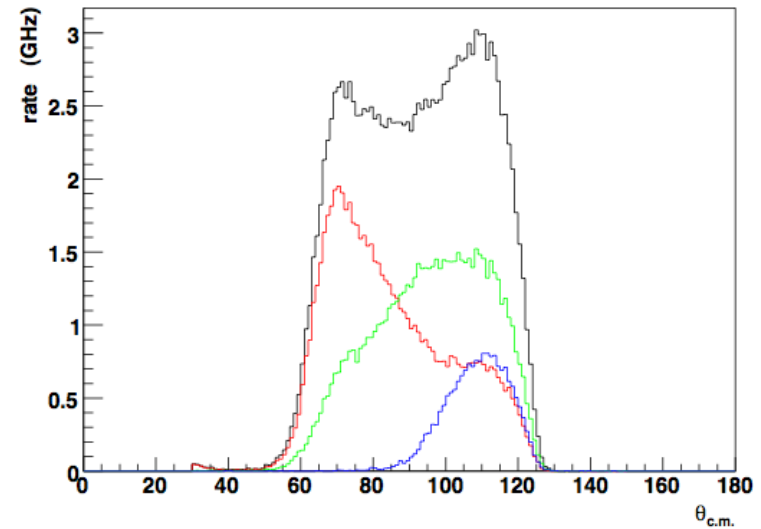
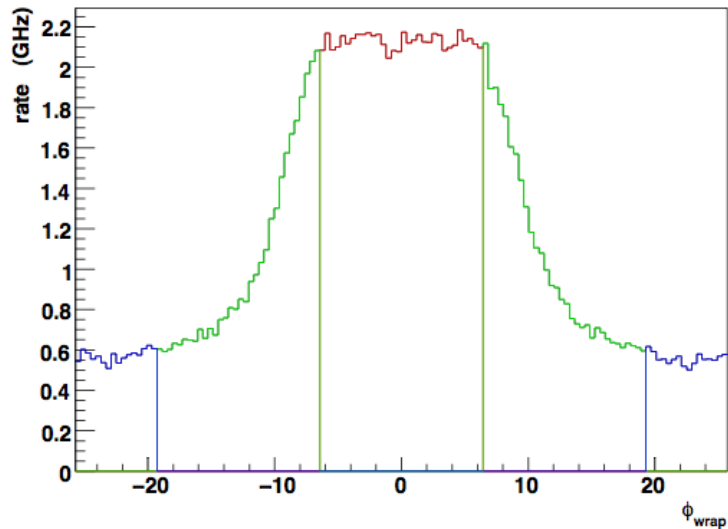
# Extra-Slide: Complimentary Measurement to LHC

$Z'$  Leptonic Couplings,  $M_{Z'} = 1.5$  TeV

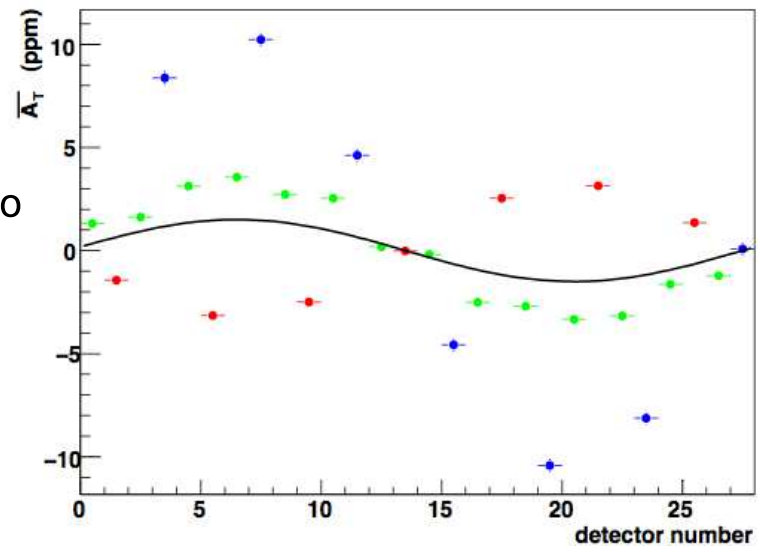




## Extra-Slide: Transverse Asymmetry Measurement

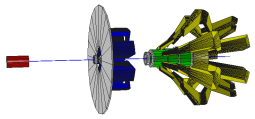


Average transverse asymmetry



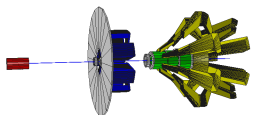
-- $A_T \sim 12$  parts per million ... 3 orders of magnitude bigger than  $A_{PV}$

--We must be sure that this averages to a negligible contribution!

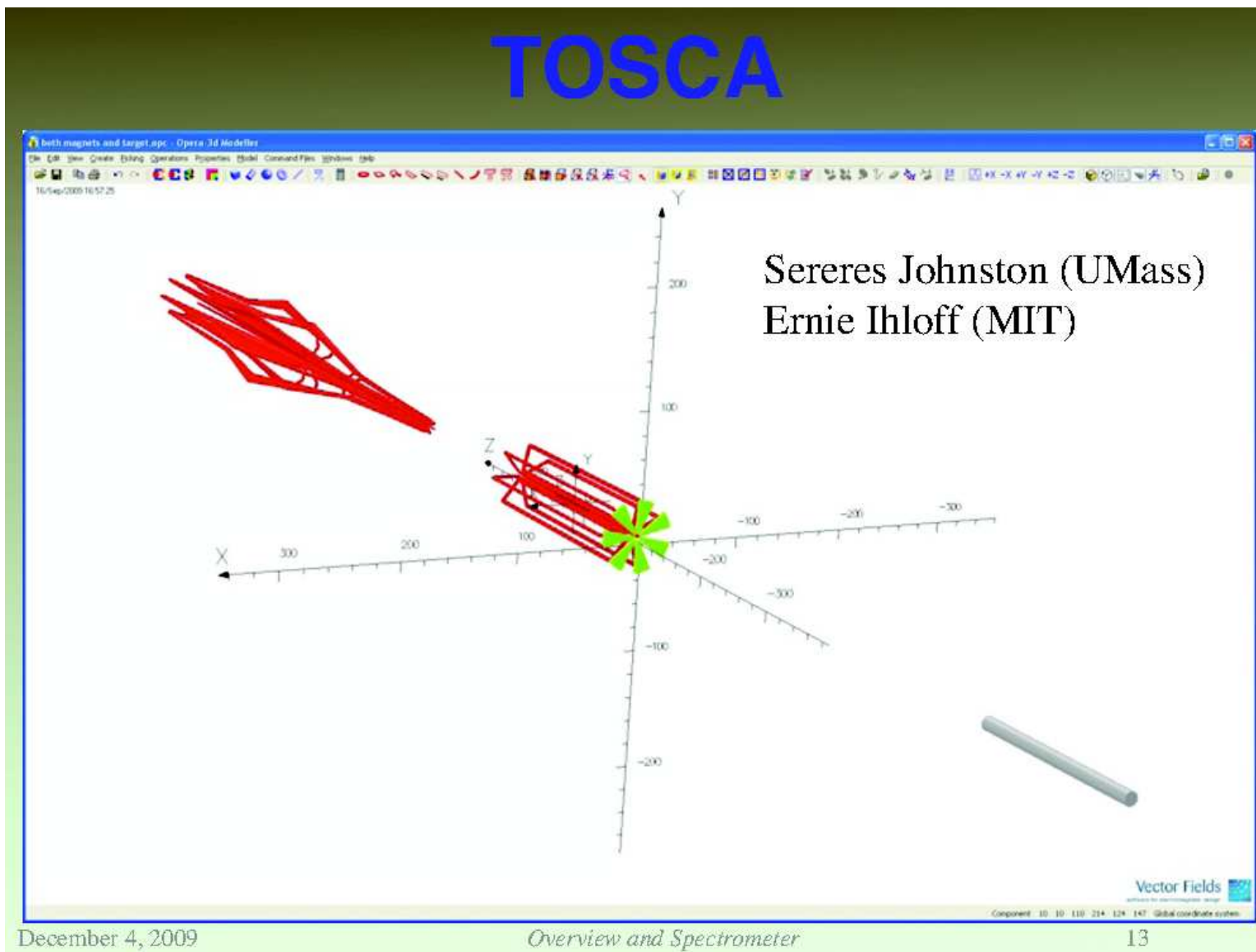


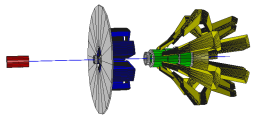
## Extra-Slide: New Challenges

- 150GHz total detected Moller event rate
  - Must flip pockels cell at  $\sim 2\text{kHz}$
  - 80ppm pulse-to-pulse statistical fluctuations
    - Electronic noise and density fluctuations  $< 10^{-5}$
    - Pulse-to-pulse beam monitoring res. a few microns at 1kHz
- 0.5nm/0.05nrad control of beam on target
  - Requires improvement on control of pol. src. laser transport
  - Improved methods of “slow helicity reversal” (double wien)
- Target requires  $\sim 5\text{kW}$  of cooling power at  $85\mu\text{A } I_{\text{beam}}$
- Full azimuthal acceptance with  $\theta_{\text{lab}}$  between 5 and 17mrad
  - Aggressive spectrometer design
  - Complex collimation and shielding issues
- Robust and redundant 0.4% beam polarimetry
  - Plan to pursue both Compton and atomic Hydrogen techniques

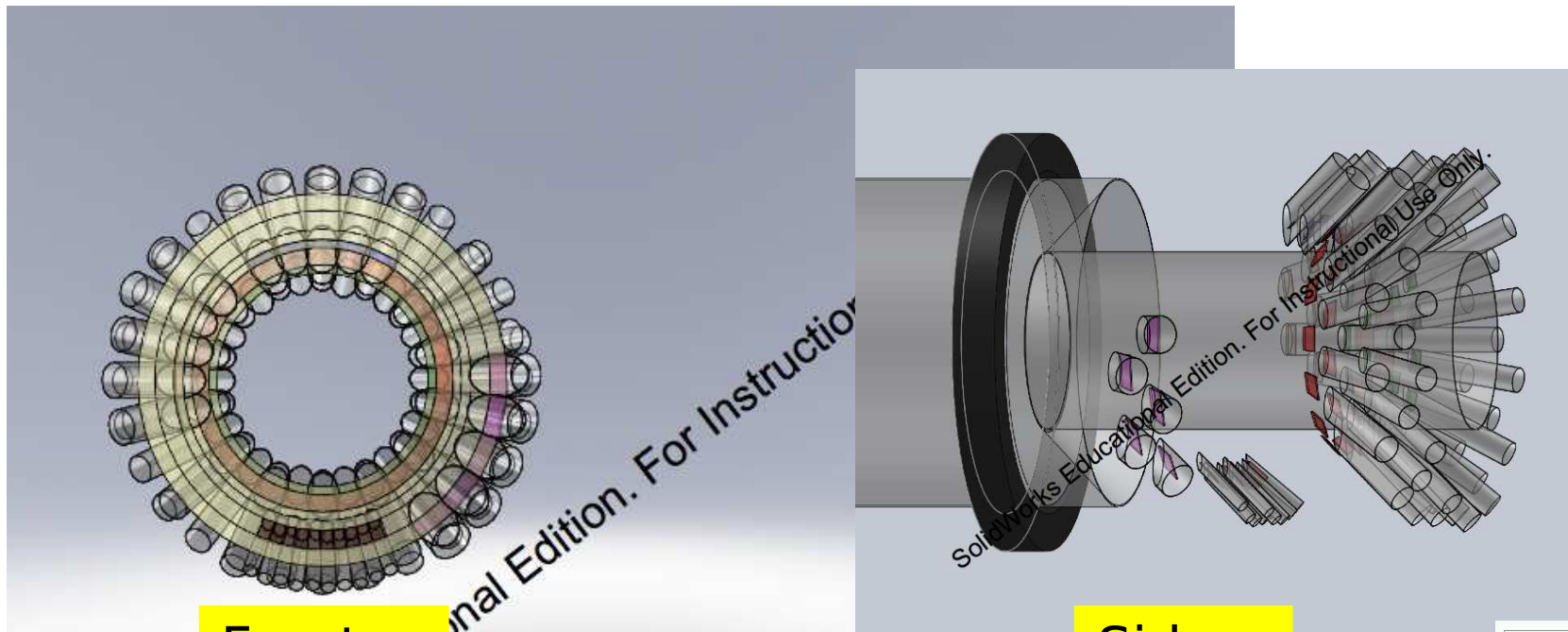
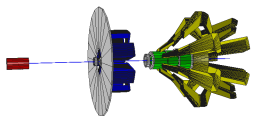


## Extra-Slide: Magnet Design



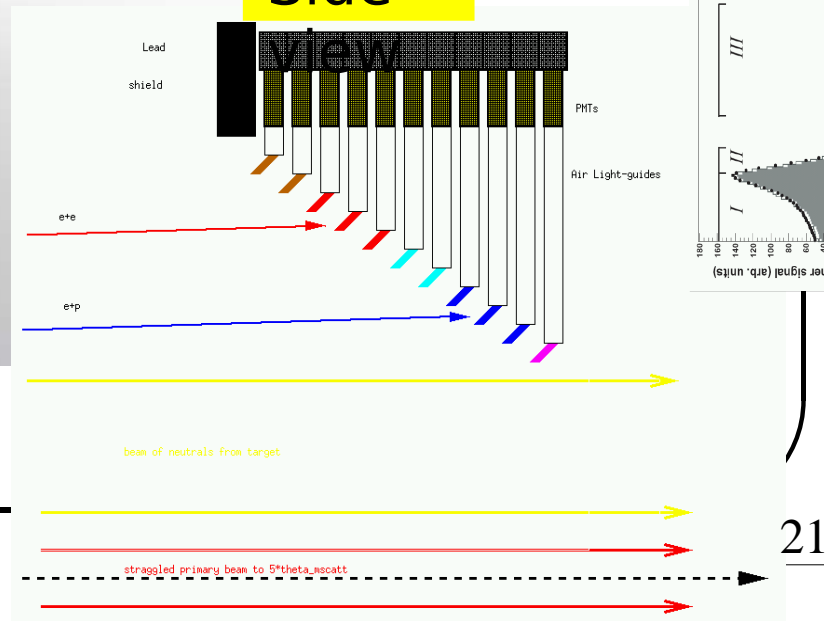
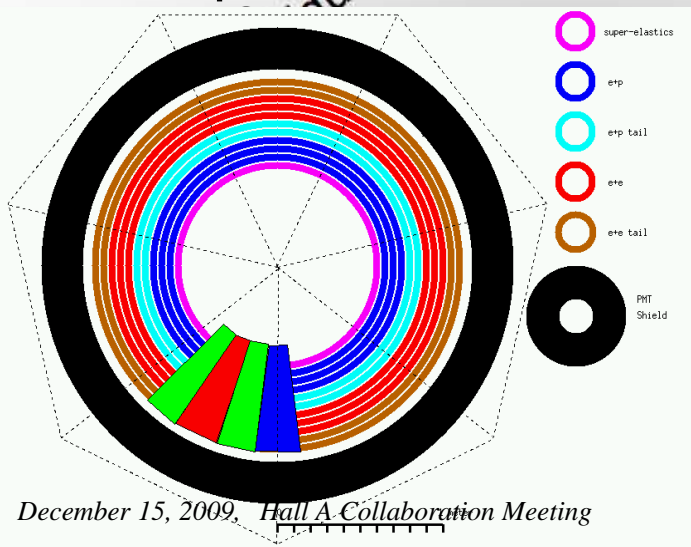


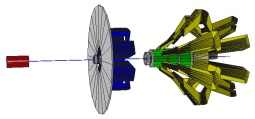
**Extra-Slide: Main Detector Reference Design**



Front

Side





## Extra-Slide: Spectrometer Beamline Draft

