Status of the APEX experiment

The A′ Experiment (APEX)
Searching for a new Vector Bosons *A′* Decaying to e^+e^-
Jefferson Laboratory

G.B. Franklin (Carnegie Mellon University)
for the APEX Collaboration

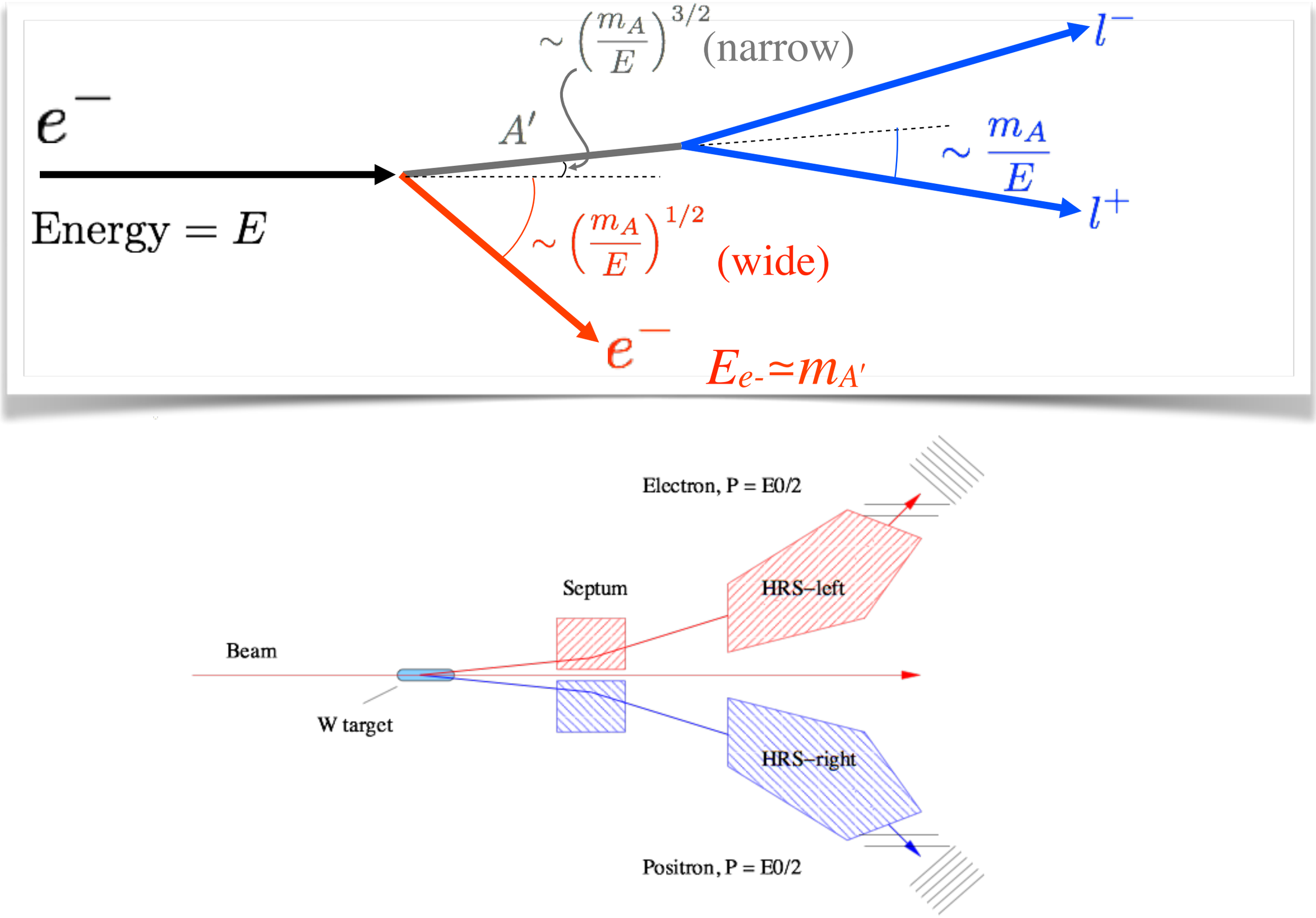
Spokespeople: R. Essig, P. Schuster, N. Toro, B. Wojtsekhowski

The APEX Collaboration

S. Abrahamyan, A. Afanasev, Z. Ahmed, E. Aliotta, K. Allada, D. Anez, K. Aniol, D. Armstrong, T. Averett, A. Barbieri, K. Bartlett, J. Beacham, S. Beck, J. D. Bjorken, J. Bono, P. Bosted, J. Boyce, P. Brindza, N. Bubis, A. Camsonne, G. Cates, O. Chen, K. Cranmer, C. Curtis, E. Chudakov, M. Dalton, S. Dusa, C. W. de Jager, A. Deur, J. Donaghy, R. Essig (co-spokesperson), C. Field, E. Folts, G.B. Franklin, A. Gasparian, A. Gavalya, S. Gilad, R. Gilman, A. Glamazdin, N. Goeckner-Wald, J. Gomez, M. Graham, O. Hansen, D. W. Higinbotham, T. Holmstrom, J. Huang, S. Iqbal, J. Jaros, E. Jensen, A. Johnson, M. Kalurachichi ,A. Kelleher, M. Khandaker, I. Korover, G. Kumbartzki, J. J. LeRose, R. Lindgren, N. Liyanage, E. Long, J. Mammei, P. Markowitz, T. Maruyama, V. Maxwell, J. McDonald, D. Meekins, R. Michaels, M. Mihovilovič, K. Moffeit, S. Nanda, V. Nelyubin, B. E. Norum, A. Odian, M. Oriunno, L. Ou, R. Partridge, M. Paolone, E. Piasetzky, I. Pomerantz, A. Puckett, V. Punjabi, Y. Qiang, R. Ransome, S. Riordan, Y. Roblin, G. Ron, K. Saenboonruang, A. Saha, B. Sawatzky, B. Schmookler, P. Schuster (co-spokesperson), J. Segal, L. Selvy, A. Shahinyan, R. Shneor, S. Širca, R. Subedi, V. Sulkosky, S. Stepanyan, N. Toro (co-spokesperson), D. Waltz, L. Weinstein, B. Wojtsekhowski (co-spokesperson), J. Zhang, Y. Zhang, B. Zhao,
and **The Hall A Collaboration**

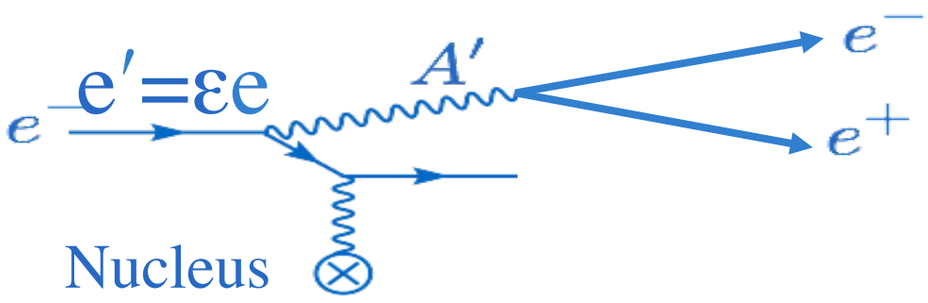
Yerevan Physics Institute, Syracuse University, University of Kentucky, Saint Mary's University, Haifa x, College of William and Mary, University of Virginia, University of New Hampshire, New York Uni versity, Florida International University, Thomas Jefferson National Accelerator Facility, SLAC Nation al Accelerator Laboratory, North Carolina Agricultural and Technical State University, Carnegie Mello n University, Longwood University, Massachusetts Institute of Technology, California State University at Los Angeles, Norfolk State University, Kent State University, University of Massachusetts, Universit y of South Carolina,[1]Tel Aviv University, Perimeter Institute for Theoretical Physics, Waterloo, George Washington University, Stanford University

APEX Dark Photon Production and Detection



The APEX A′ Signal

A′ Production



$\sigma \sim \varepsilon^2\alpha/m^2 = \alpha' /m^2$

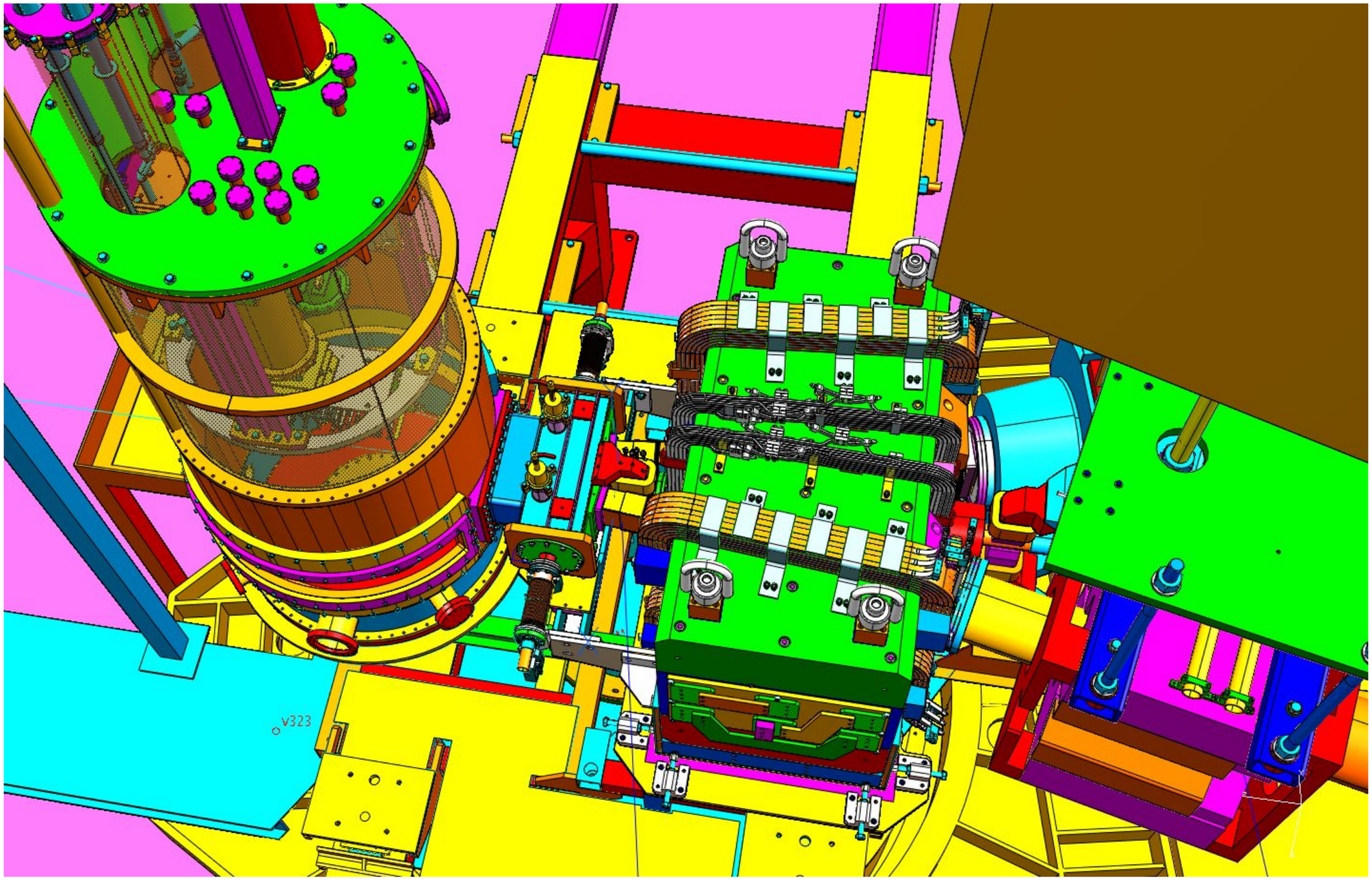
QED Backgrounds

$d\sigma \sim \alpha^2/m^3\, dm$

- Narrow peak on broad background
- Region of sensitivity: $\varepsilon^2 > 9 \times 10^{-8}$
  $65\ \text{MeV} \le m_{A'} \le 525\ \text{MeV}$

- Requires invariant-mass resolution: $\delta m = 0.5\%$
- APEX achieves this using:
  1) JLab's twin High Resolution Spectrometers (HRS)
  2) Septum Magnet to reach ± 5° central acceptance
  3) Novel tungsten-foil target

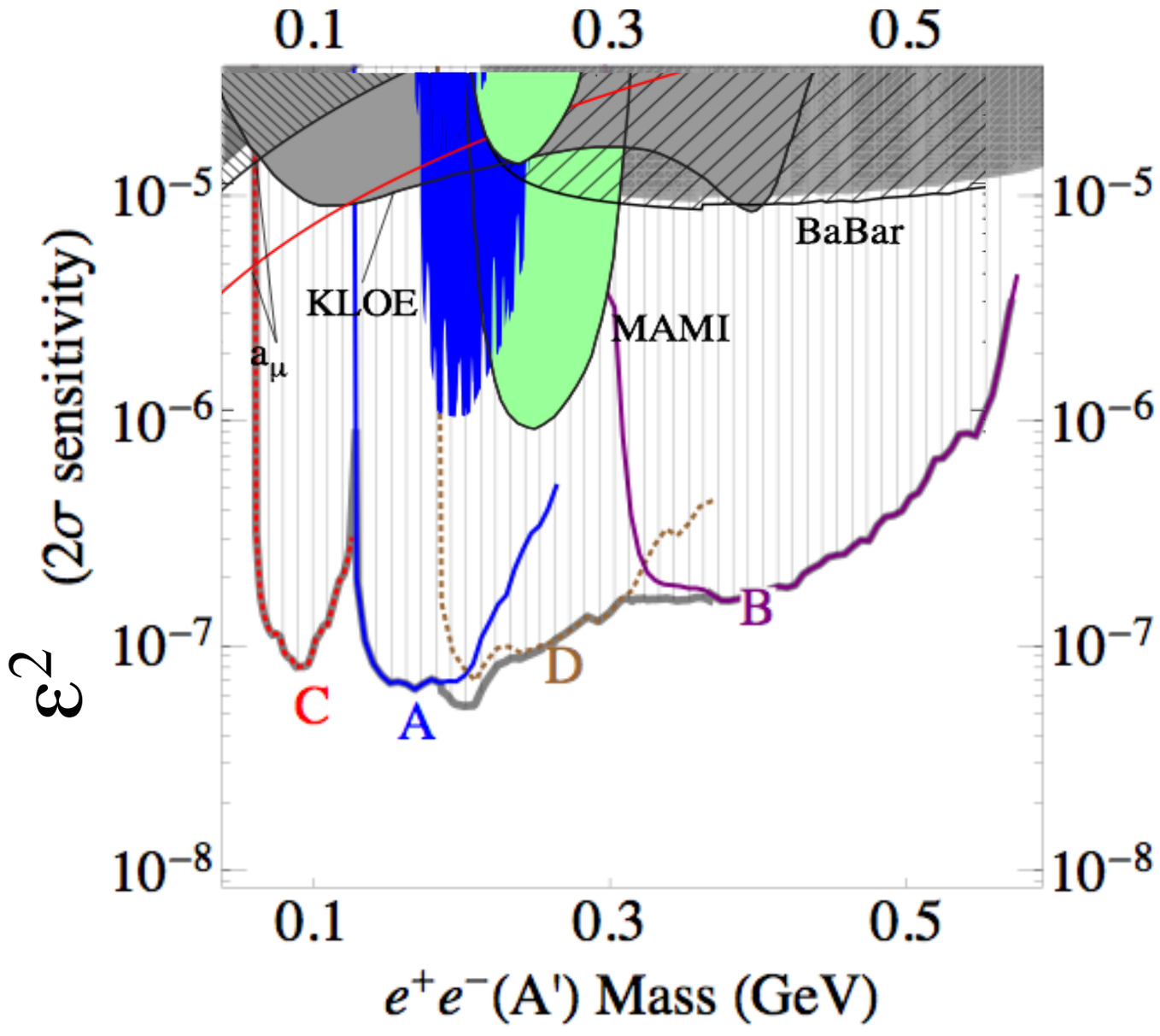
APEX A′ target region and septum magnet



From Alan Gavala

Coverage Achieved With 4 Kinematic Settings

65 MeV ≤ $m_{A'}$ ≤ 525 MeV



1 Month Beam Time

A) 6 days @ 2.3 GeV

B) 12 days @ 4.5 GeV

C) 6 days @ 1.1 GeV

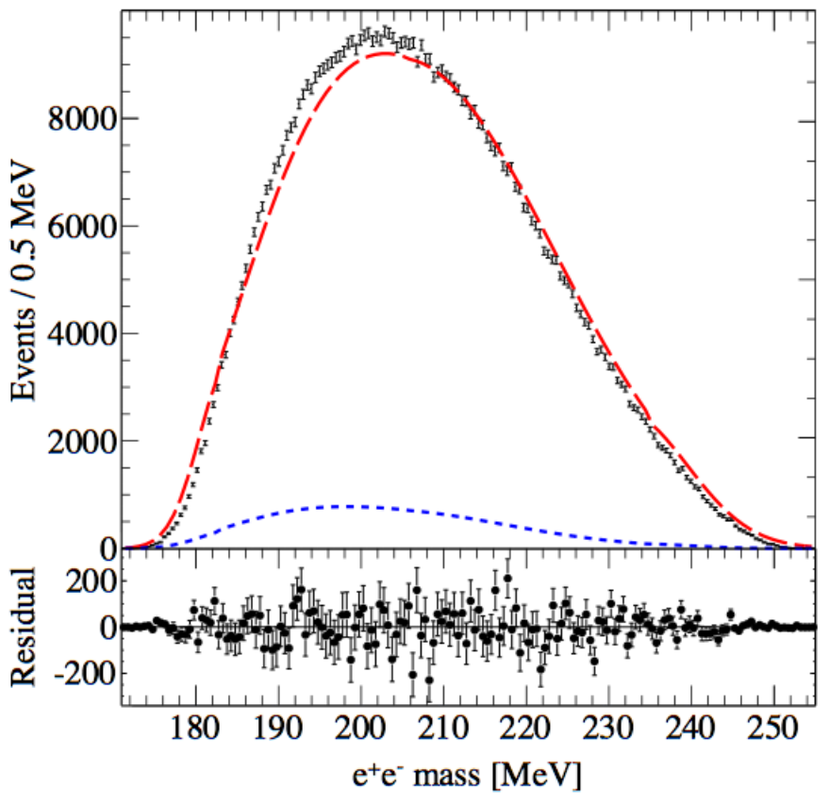
D) 6 days @ 3.3 GeV

Status:

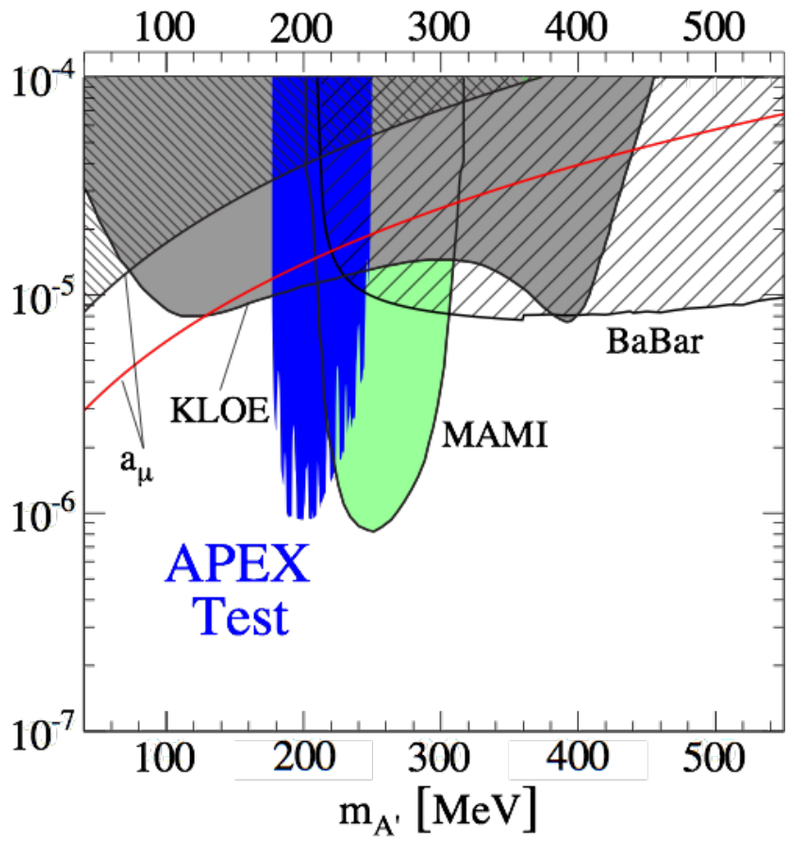
Status: The APEX Test Run

- Test run performed in Hall A, July 2010
- Verified all key aspects of apparatus performance
- 700k good trident events

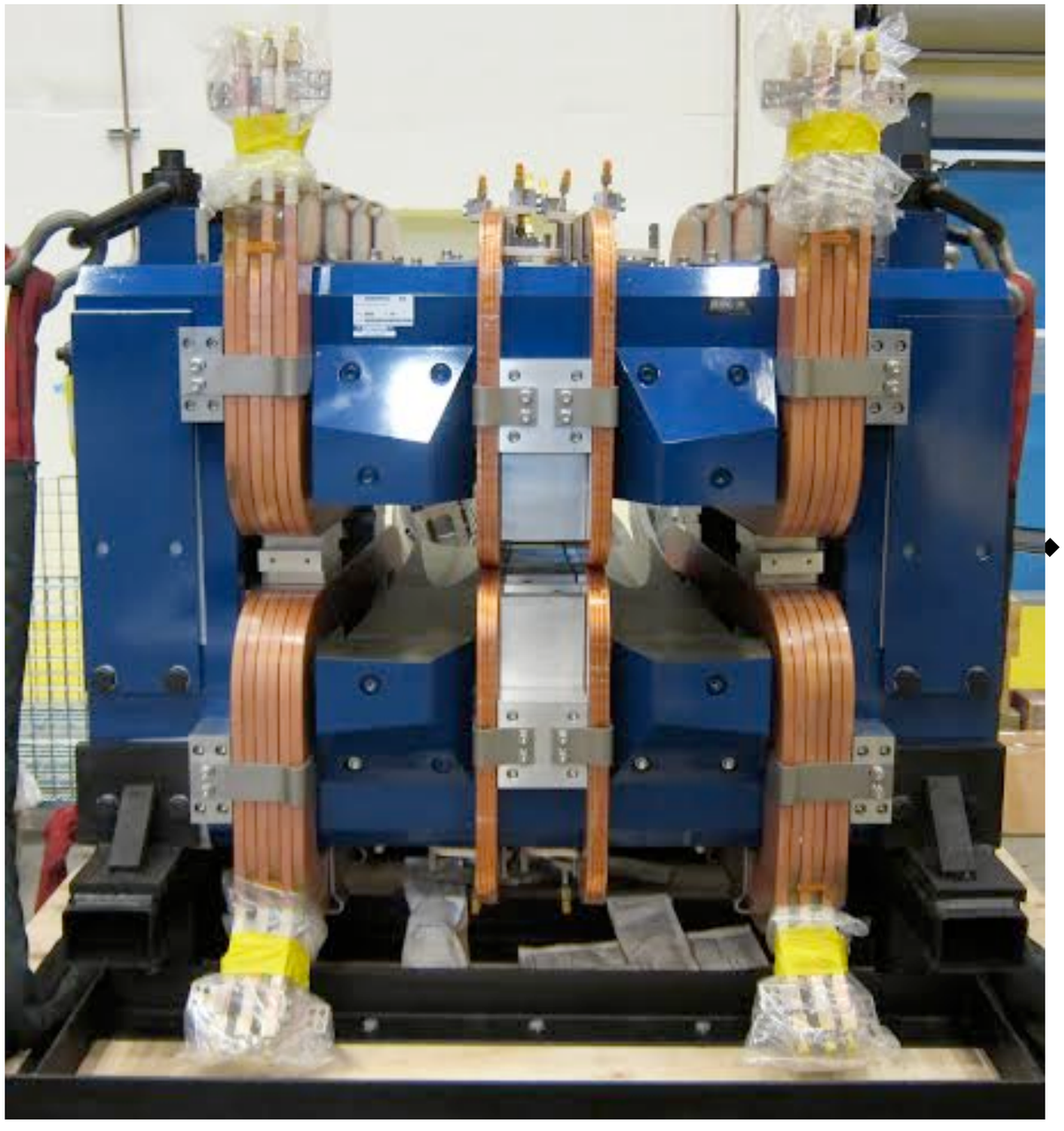
JHEP 1102:009,2011, arxiv:1001.2557
PRL 107:191804,2011, arxiv:1108.2750

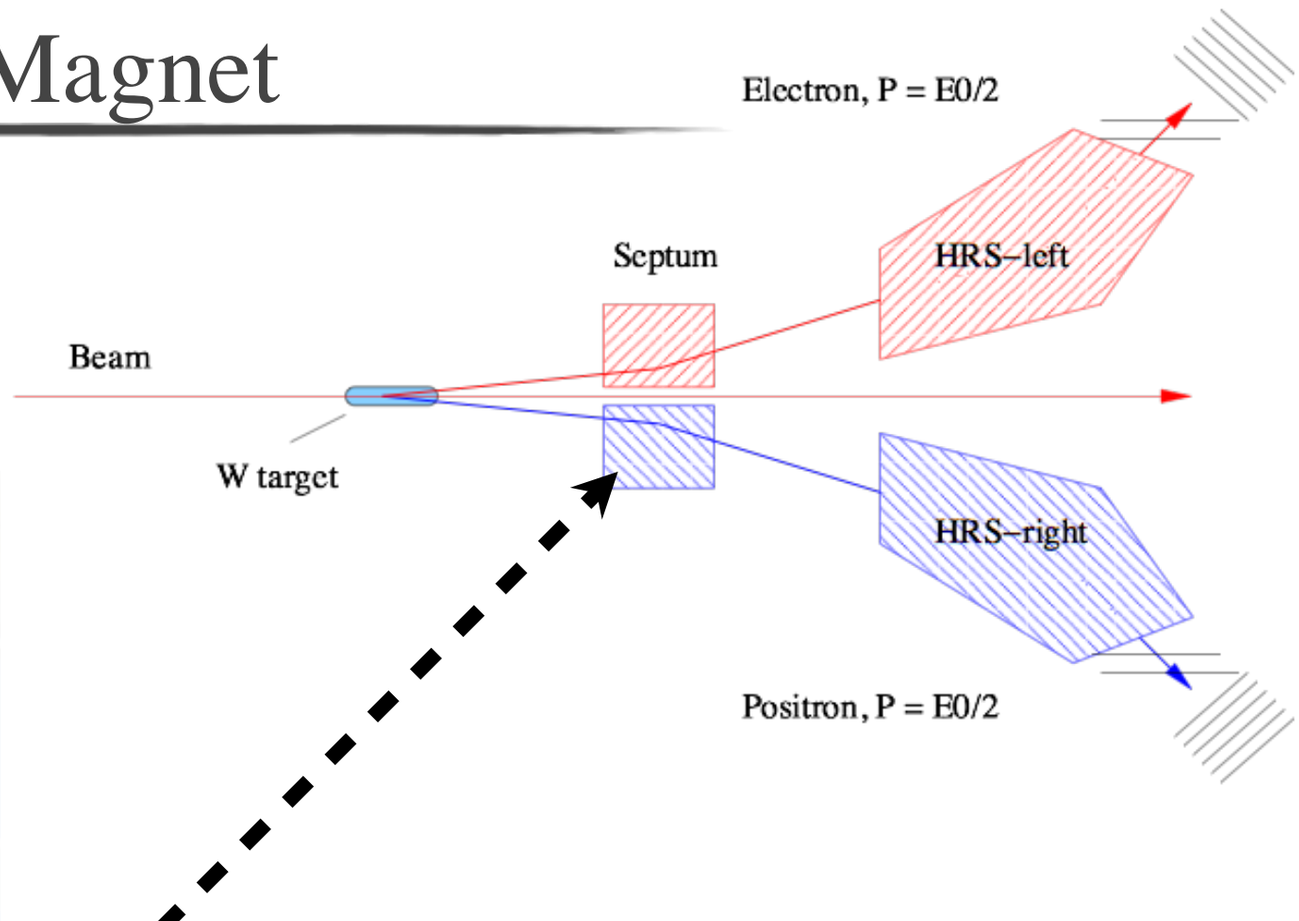


ε^2



Status: The APEX Septum Magnet

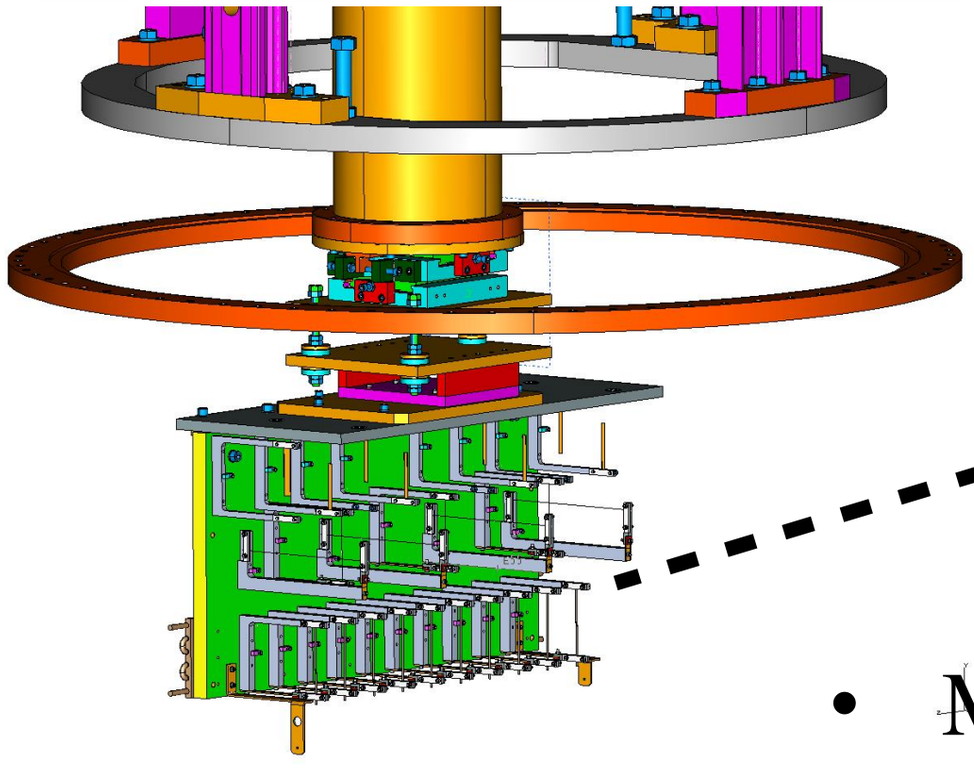


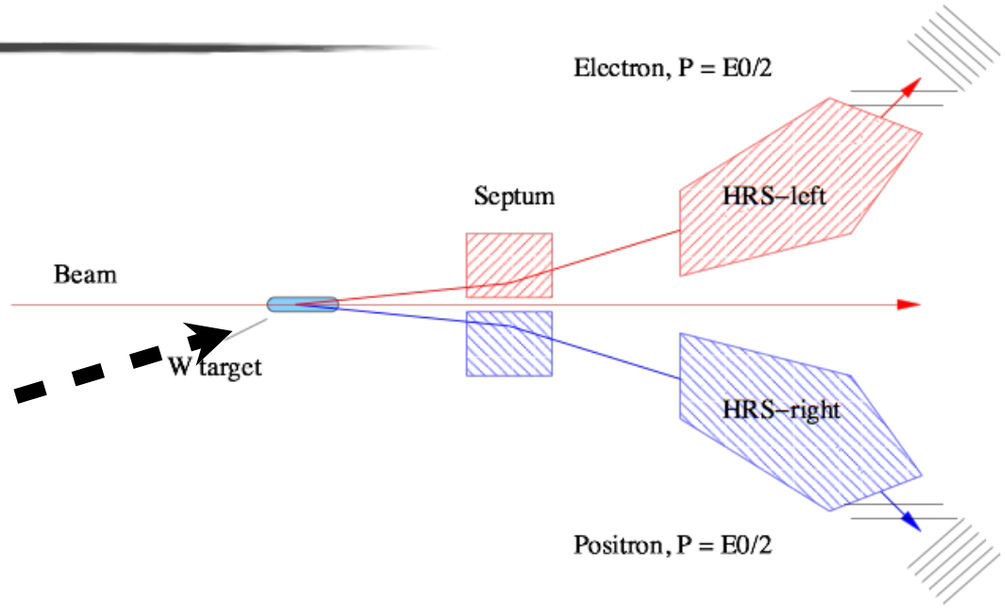


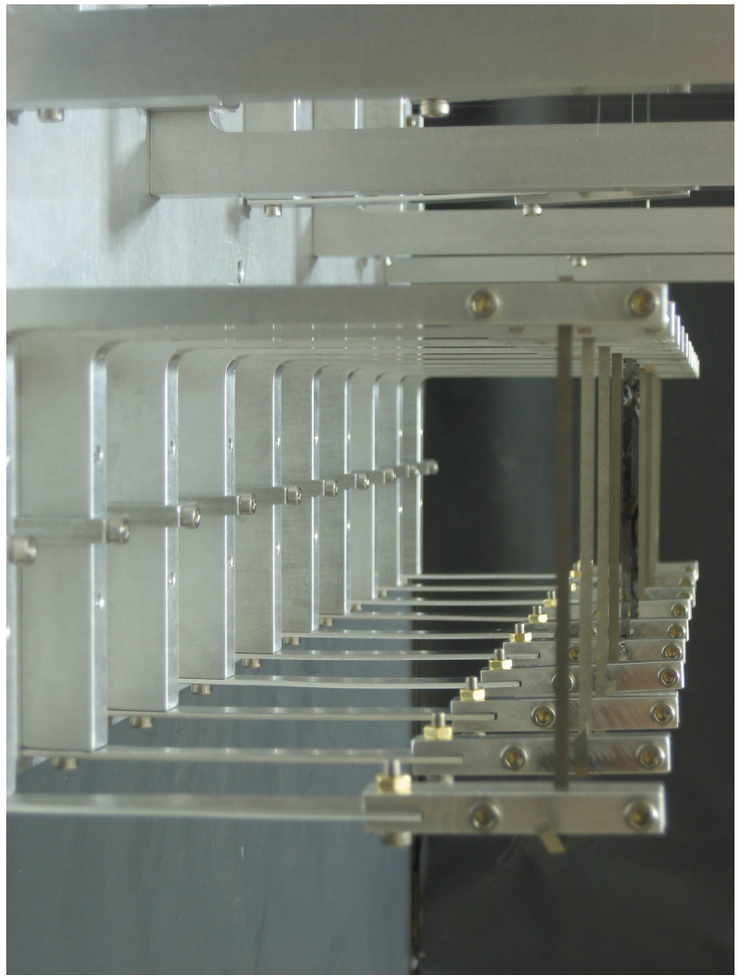
- e^+e^- pairs at ~±5°
- Septum magnet required
- Completed Aug. 2014
- Assembly in test lab
- Being readied for testing

Funding was provided by five universities: NCCU, CMU, CSULA, SBU, UW(Ca)

Status: Tungsten-Foil Target



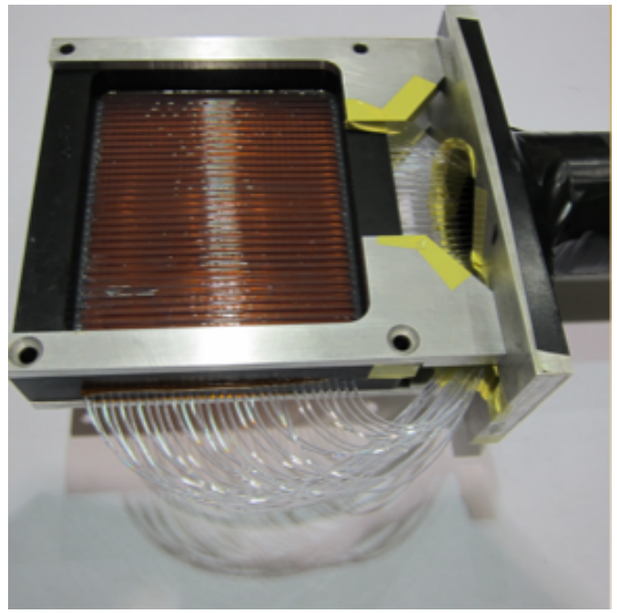




- Multi-foil, high-Z target
- Minimizes multiple scattering
  e^+e^- pairs miss downstream foils
- Distributed along beam
  increases HRS angular acceptance
- SLAC-designed target at JLab
  Dec. 2015 Meeting with JLab engineers
  Motion, cooling, alignment…
- $10k for completion

Status: SciFi Detectors

- "Active sieve-slit" – enables optics calibration without switching beam energy & e^+ arm polarity



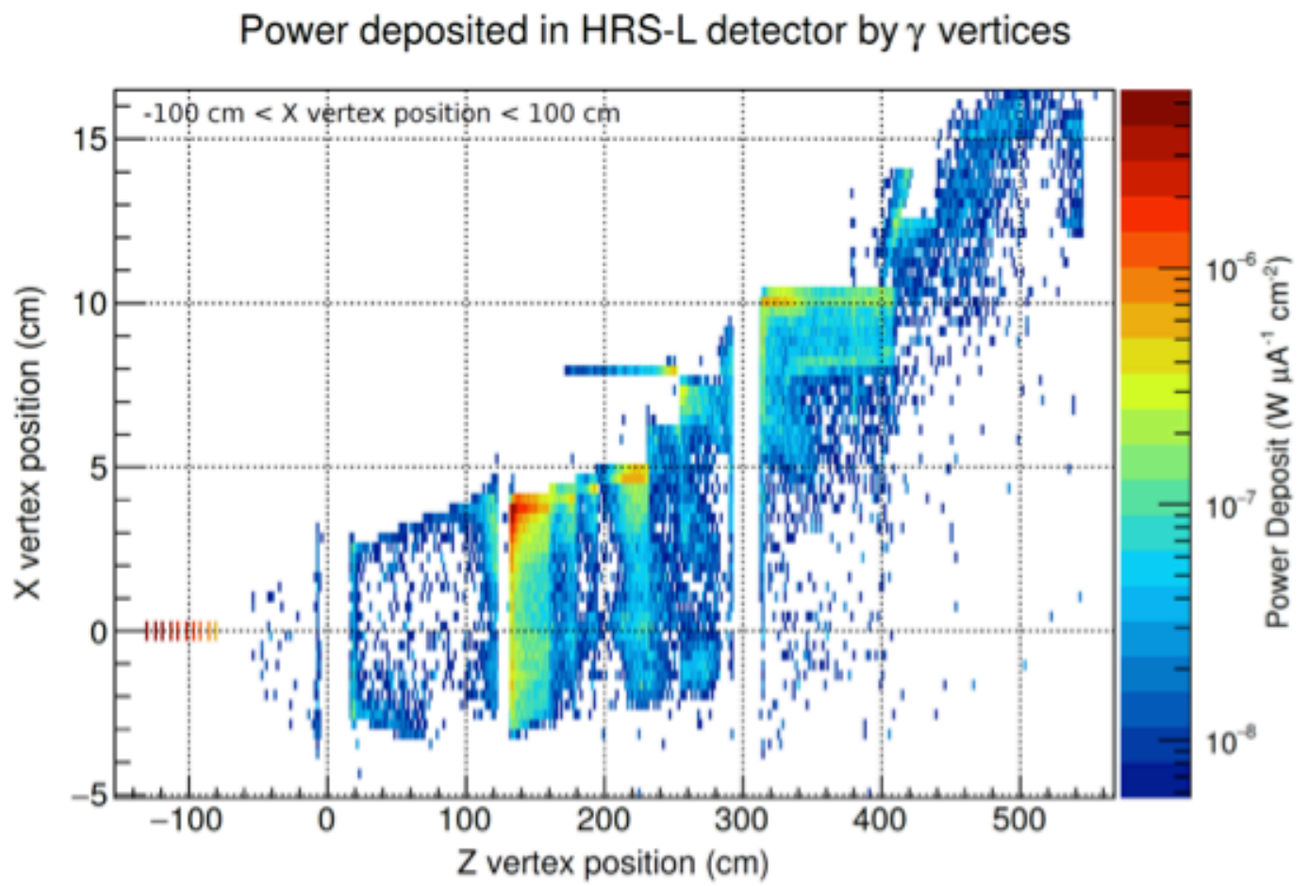
  - For low-current optics calibration runs only; will be removed during production runs

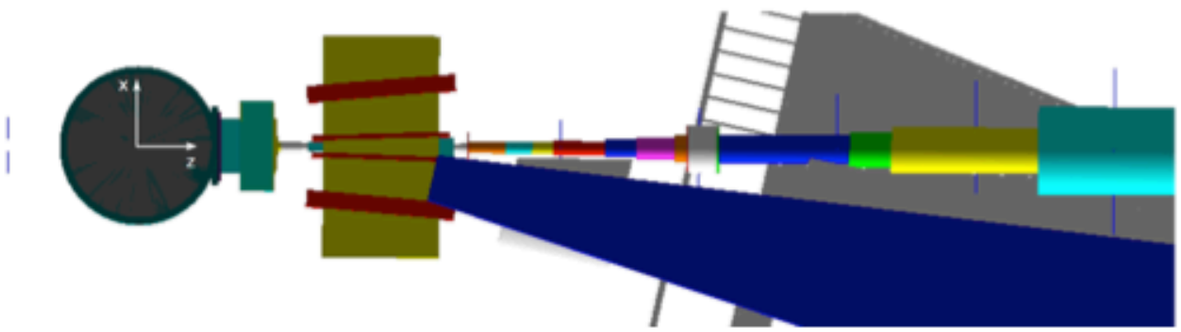
- Two hodoscopes assembled 2012 & 2013
- New readout electronics (FADC) being installed
- Cross talk and photo-electron measurements at CMU
- Needs commissioning and incorporating in optics fit

Status: Radiation and Shielding Studies

GEANT4 Studies
Maduka Kaluarachchi
U. Virginia

- Target optimization
- Electronics Hut



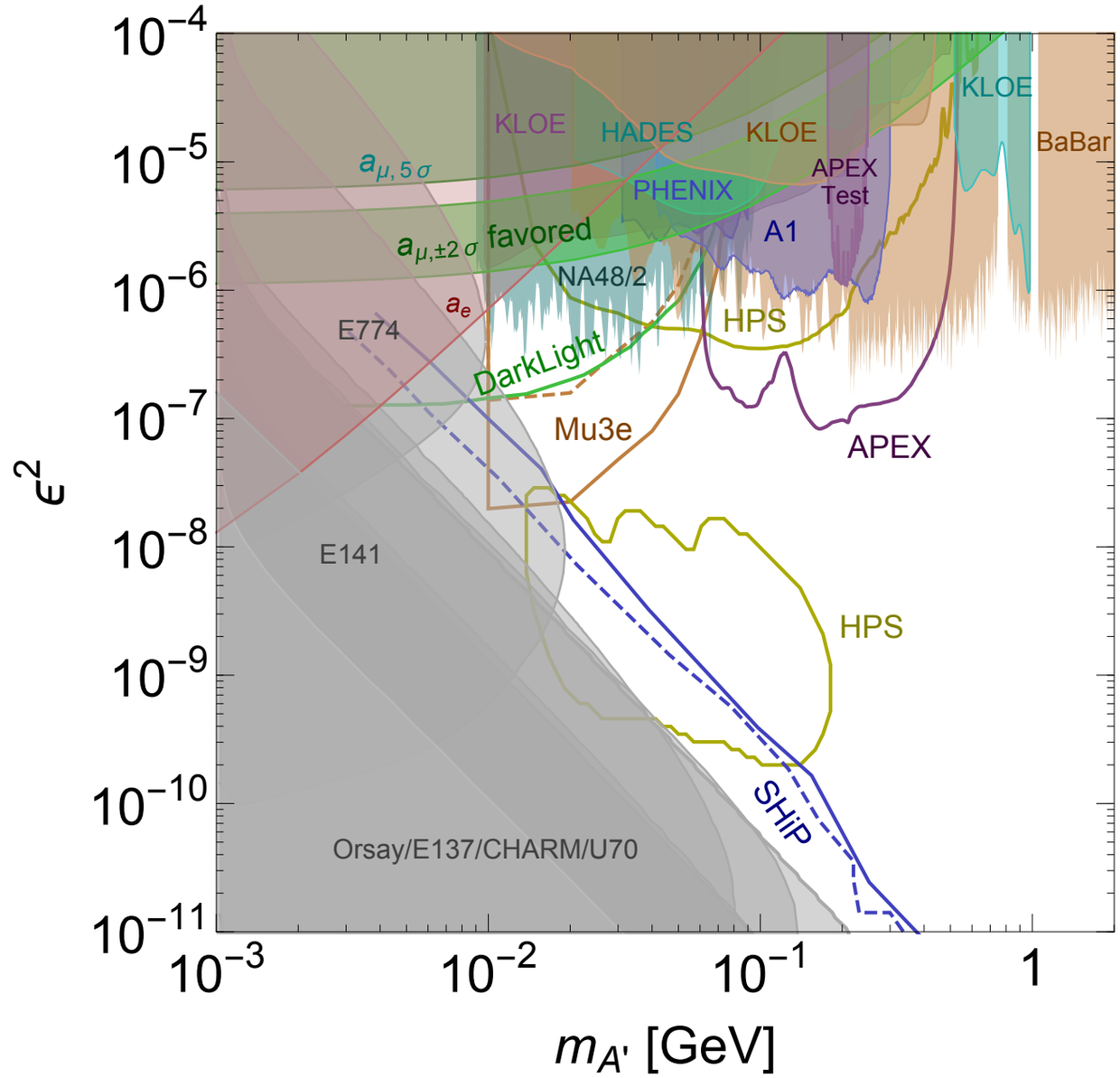


Status: Other Ongoing Projects and Recent Updates

- Vacuum chamber
  - Design and procurement complete
- Corrector magnet design
  - 1 completed, design time for 2nd in queue
- DAQ and Analysis:
  - High-rate VDC reconstruction
  - Online software
  - HRS Cerenkov FADC for PID
- Update reach & QED background model
- APEX post-doc starts in 1 month

Summary: The APEX Reach

2σ reach of published results and future expectations compiled by R. Essex

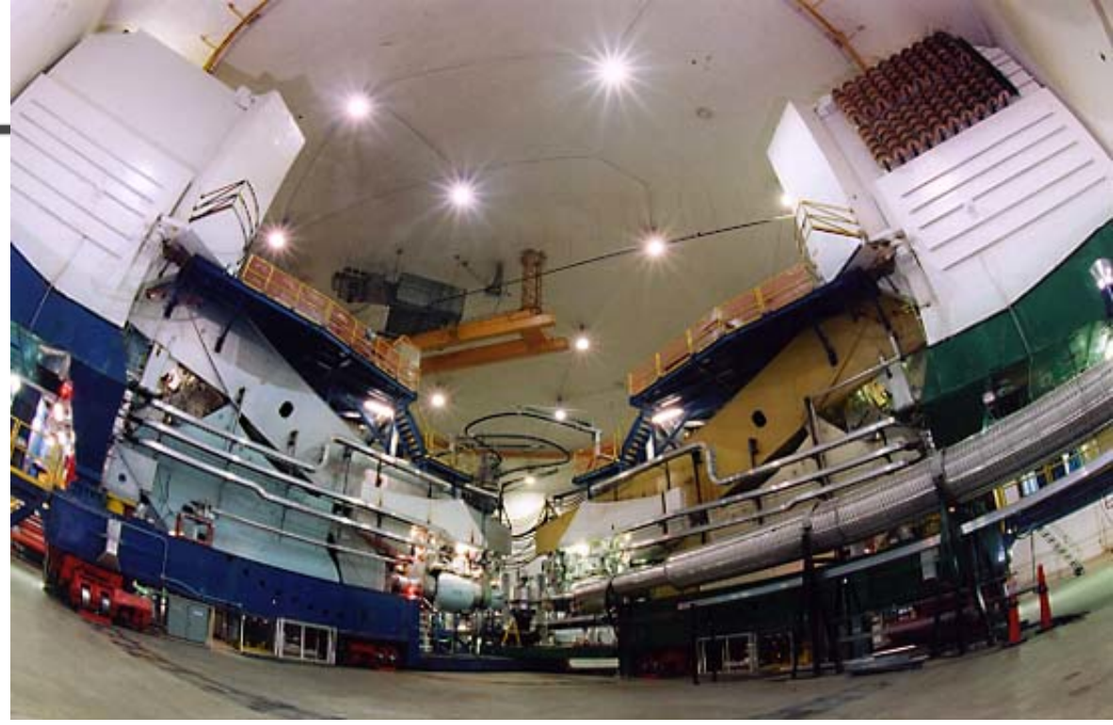


- Extensive activity in field since our 2010 test run
- More in the pipeline
- APEX reach remains high impact in our kinematic regime

Concluding Remarks

- Reach: $\varepsilon^2 > 9 \times 10^{-8}$

  $65\ \text{MeV} \leq m_{A'} \leq 525\ \text{MeV}$



JLab High Resolution Spectrometers

- APEX identified as "High Impact Experiment" (JLab PAC41)

- Could be ready for installation in 4 months.