RICH Status Update (brief)

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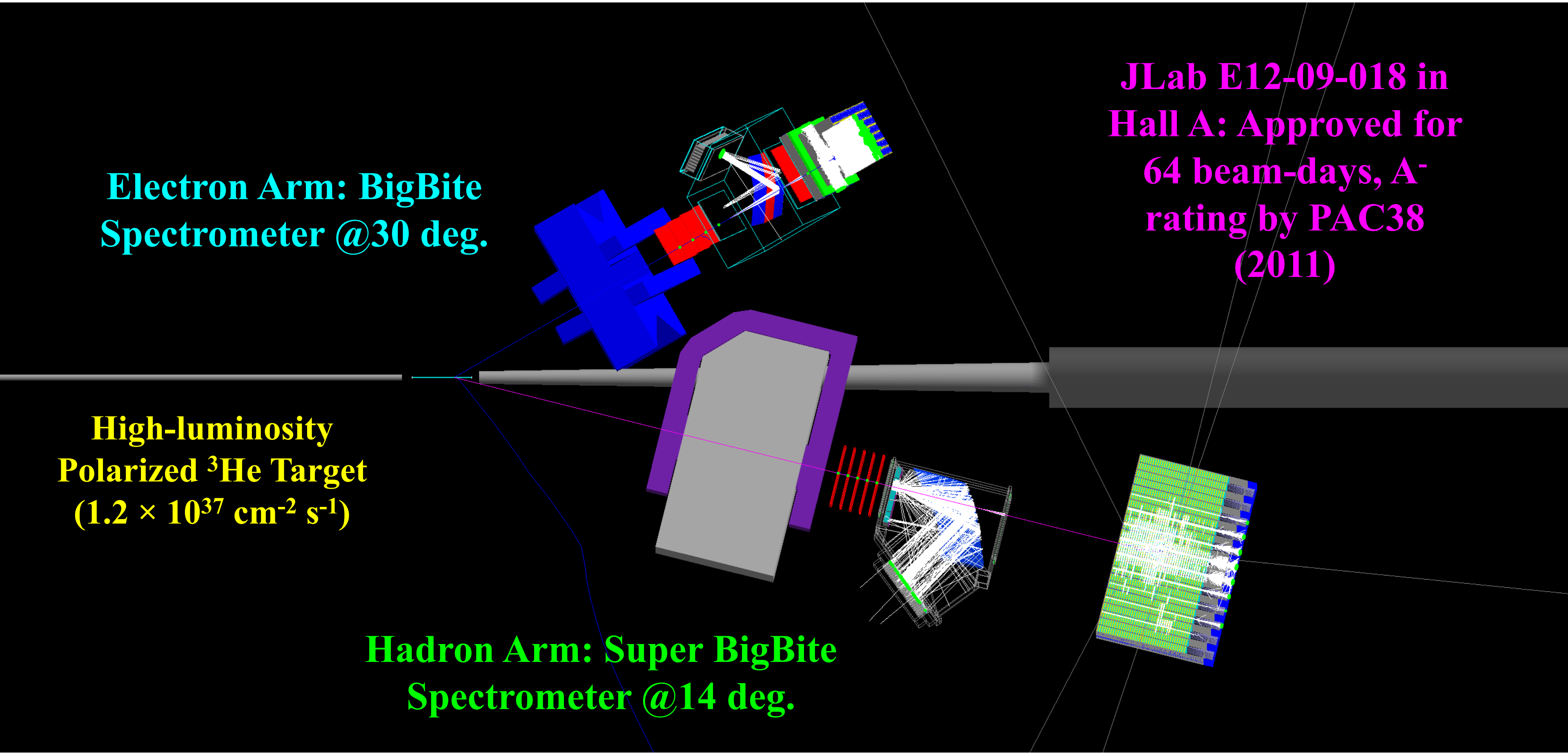
SBS Weekly Meeting
Oct. 25, 2017

UCONN Jefferson Lab

Outline

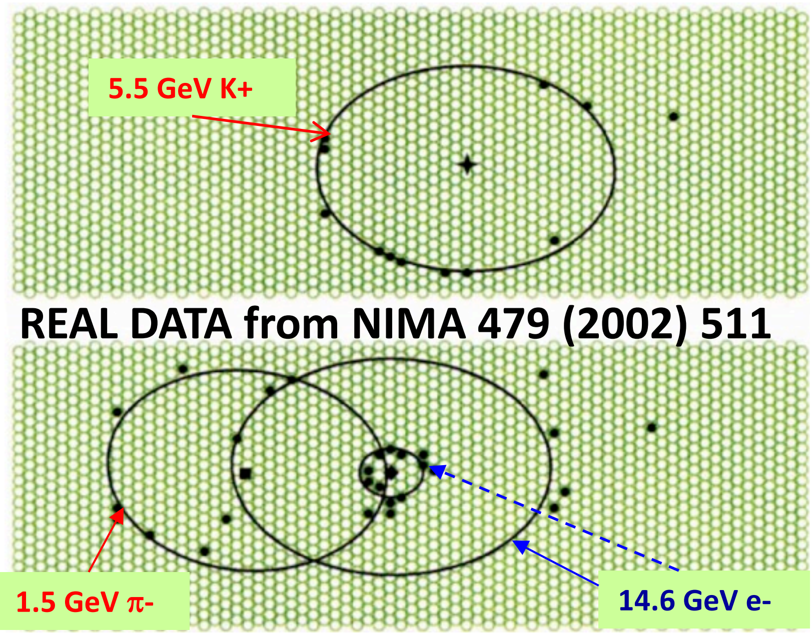
- Brief overview of RICH—design and purpose
  - Experiment E12-09-018 (SIDIS)—Ring-imaging Cherenkov for charged hadron PID
  - Experiment C12-15-006 (TDIS)—”threshold” Cherenkov for electron ID
- Ongoing activities at UConn
  - Absolute PMT quantum efficiency measurement
  - Uncrating of spare aerogel tiles and optical property checking
- Planning for shipment of the RICH to JLab
  - Meeting with rigger
  - Cost estimate

E12-09-018: Transverse Target SSA in ^{3}He(e,e'h)X

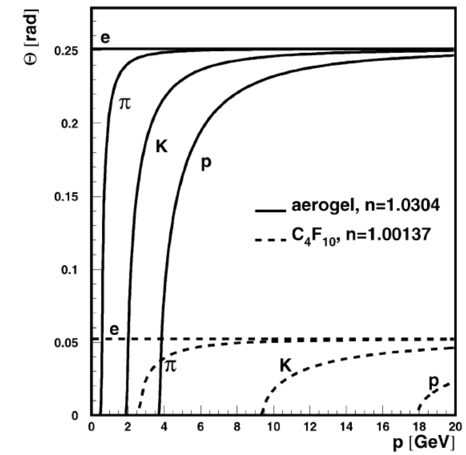


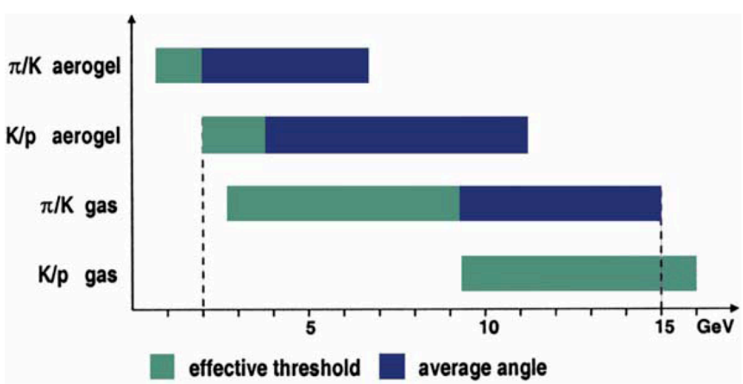
- **E12-09-018** in Hall A: transverse spin physics with high-luminosity polarized ^{3}He.
- 40 (20) days production at E = 11 (8.8) GeV—significant Q^2 range at fixed x
- Collins, Sivers, Pretzelosity, A_{LT} for n(e,e'h)X, h = $\pi^+/\pi^-/\pi^0/K^+/K^-$
- Re-use HERMES RICH detector for charged hadron PID
- Reach high x (up to ~0.7) and high statistical FOM (~1,000X Hall A E06-010 @6 GeV)

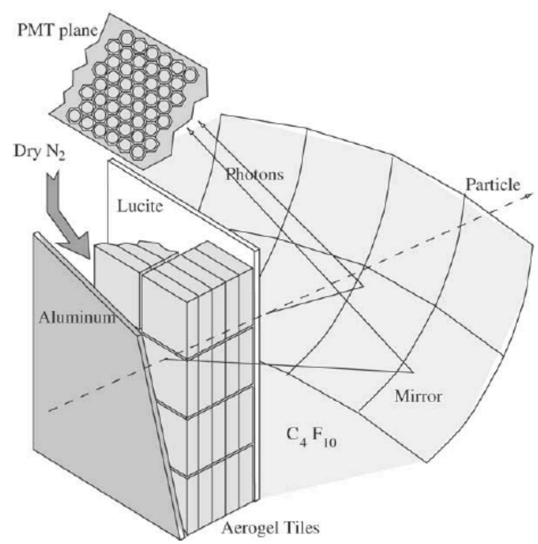
The HERMES RICH detector

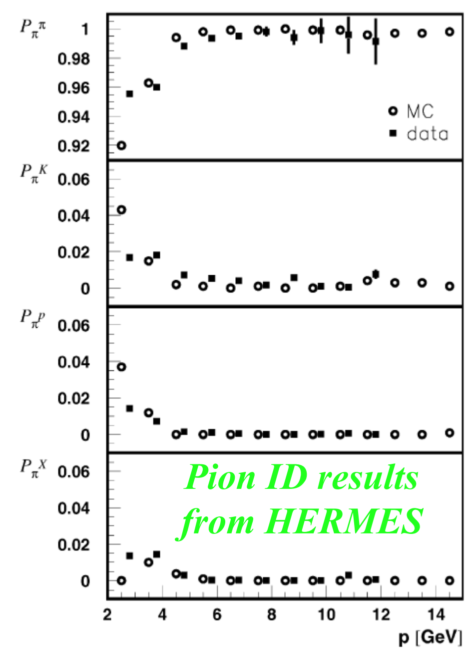


- ***HERMES RICH geometry, performance characteristics well matched to SBS needs.***
- π/K/p separation for p from 2-15 GeV based on dual-radiator design.
- Re-use one half of detector, both aerogels

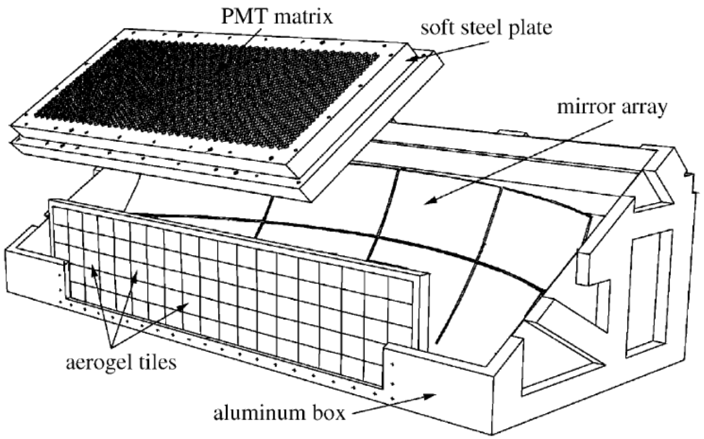


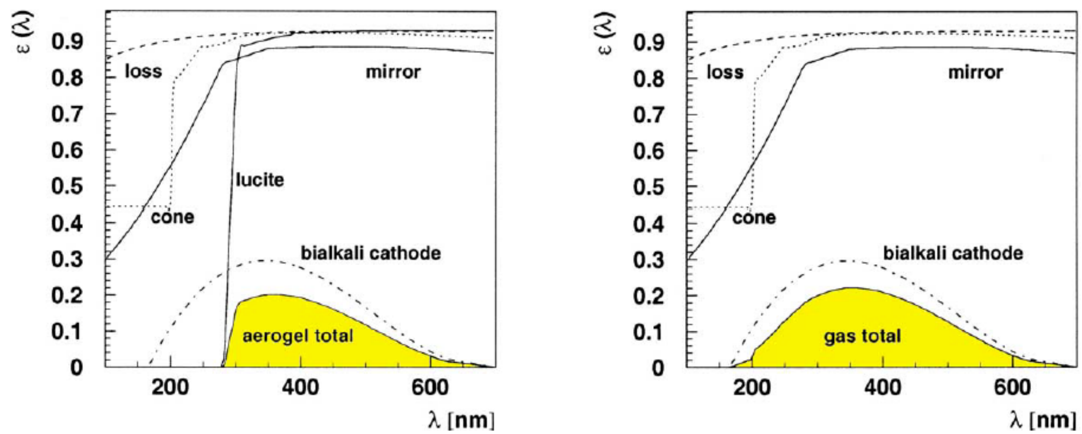






HERMES RICH Design Aspects





Optical properties contributing to overall detection efficiency

- Aerogel wall: tiles 11.4 x 11.4 x 1.13 cm^3, stacked in 5 rows, 17 columns, 5 tiles deep.
- Sheets of Tedlar between tiles reduce distortion from photons crossing track boundaries
- UVT-lucite window protects aerogel from C_4F_{10} and absorbs UV photons $\lambda < 300$ nm (Rayleigh scattering dominates at UV wavelengths)
- Windows:
  - Entry: 1 mm-thick Al, dimensions 187.7 x 46.4 cm^2
  - Exit: 1 mm-thick Al, dimensions 257 x 59 cm^2
- Mirrors: Carbon-fiber composite, 0.01 X_0 thickness, spherical geometry, R = 2.2 m
- Photon detector: Phillips XP1911/UV PMTs, 0.75"-diameter (15 mm active diameter). Hexagonal close-packed arrangement, packing fraction ~0.38. Light-collecting funnels increase collection efficiency.

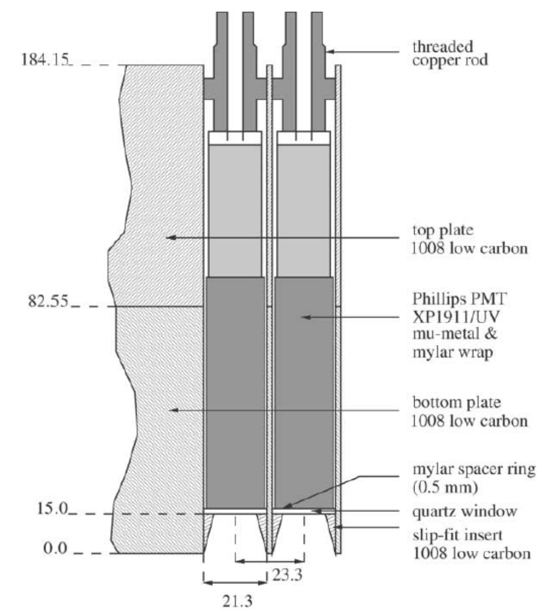
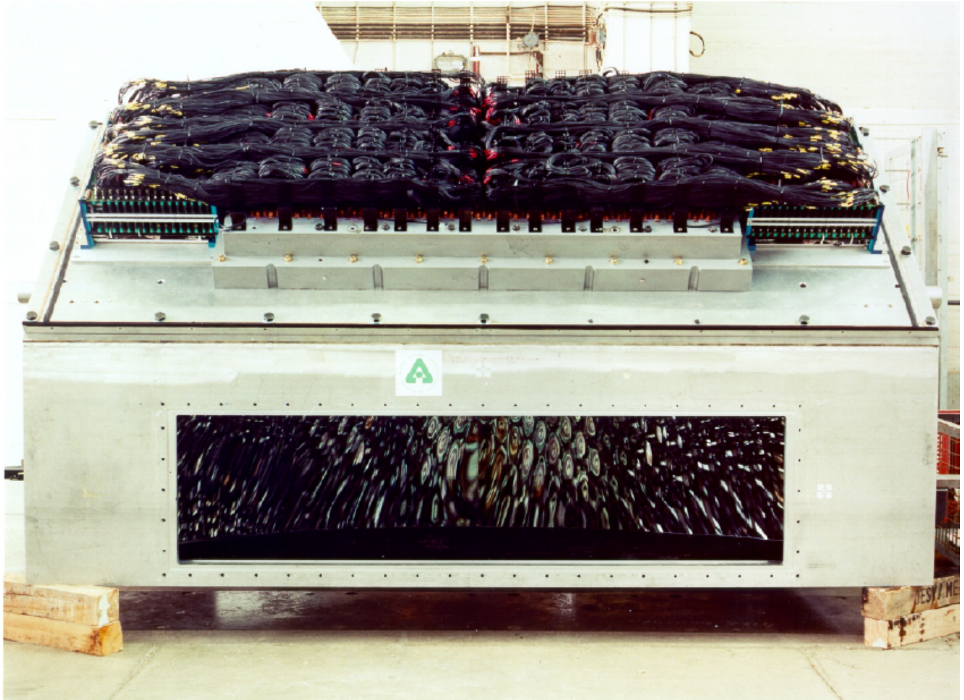
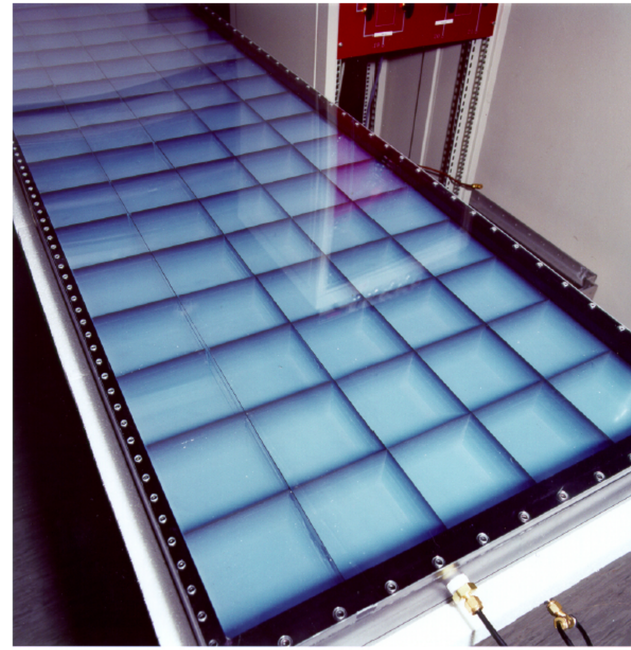


Fig. 7. Schematic photon detector design. All units are in mm.

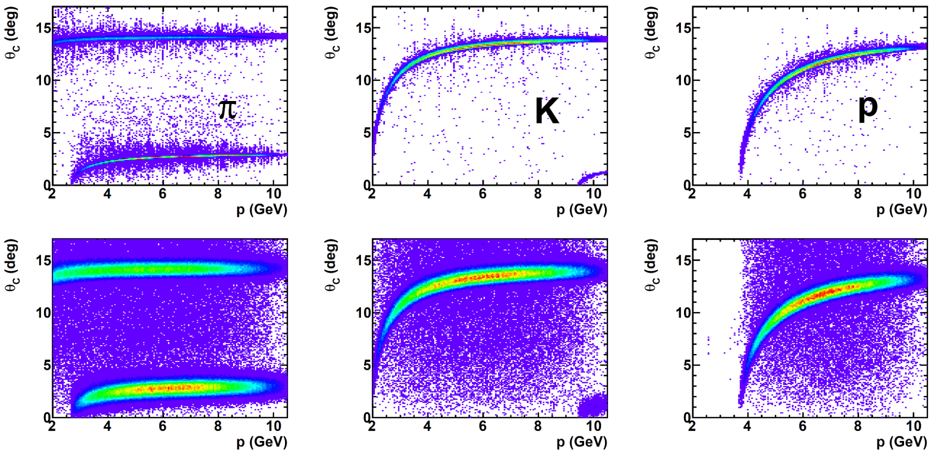
SBS RICH Detector Photos

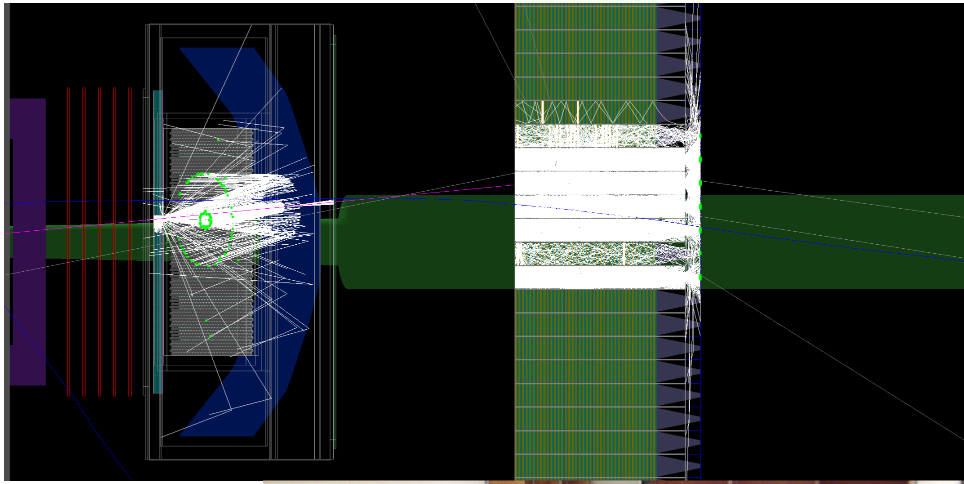




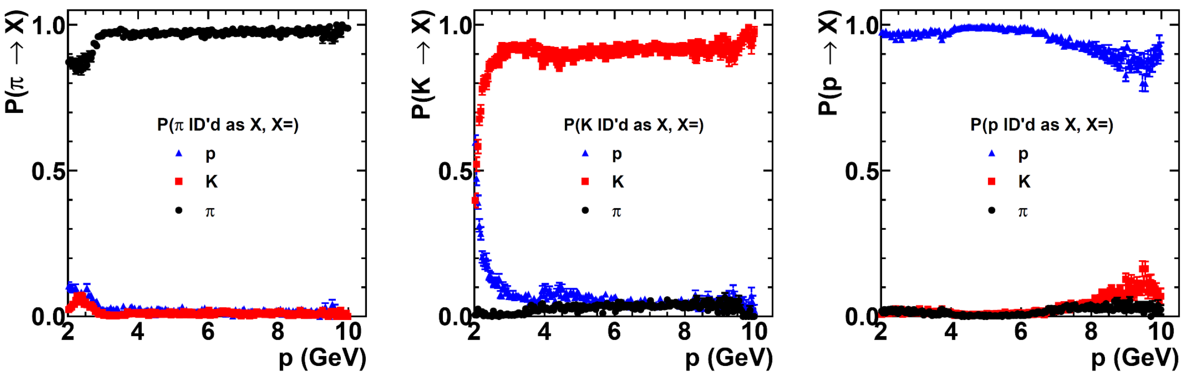
- Above, left: Old picture of one half of RICH with aerogel wall and entry window removed
- Above, right: Old picture of one aerogel wall w/containment vessel
- Bottom right: RICH delivery to storage facility @UVA, 2009

HERMES RICH in SBS





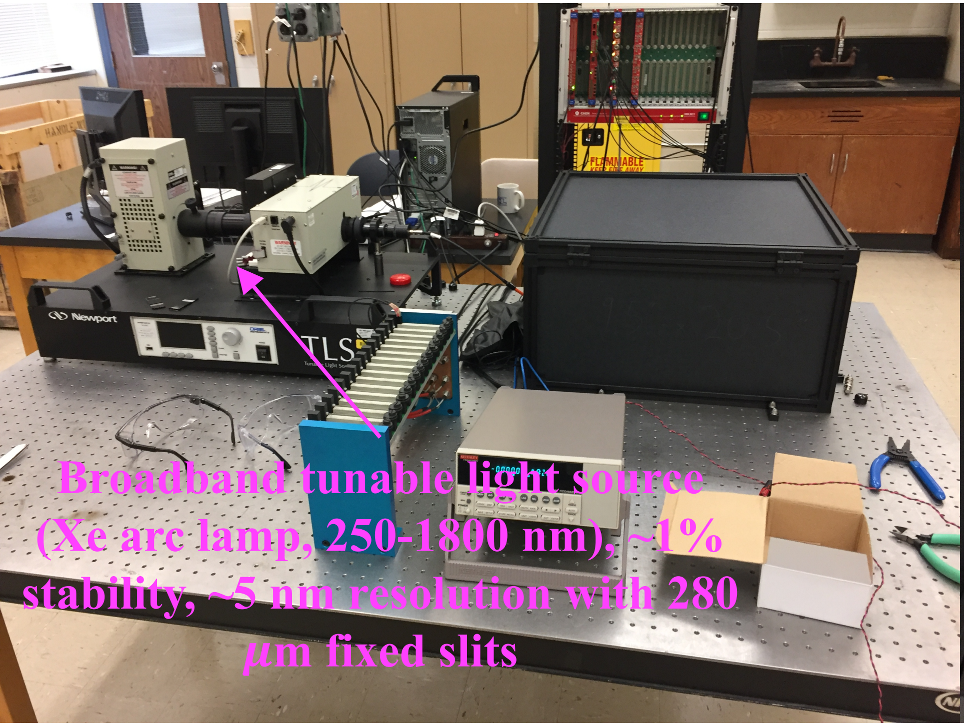
GEANT4-simulated RICH performance in SBS

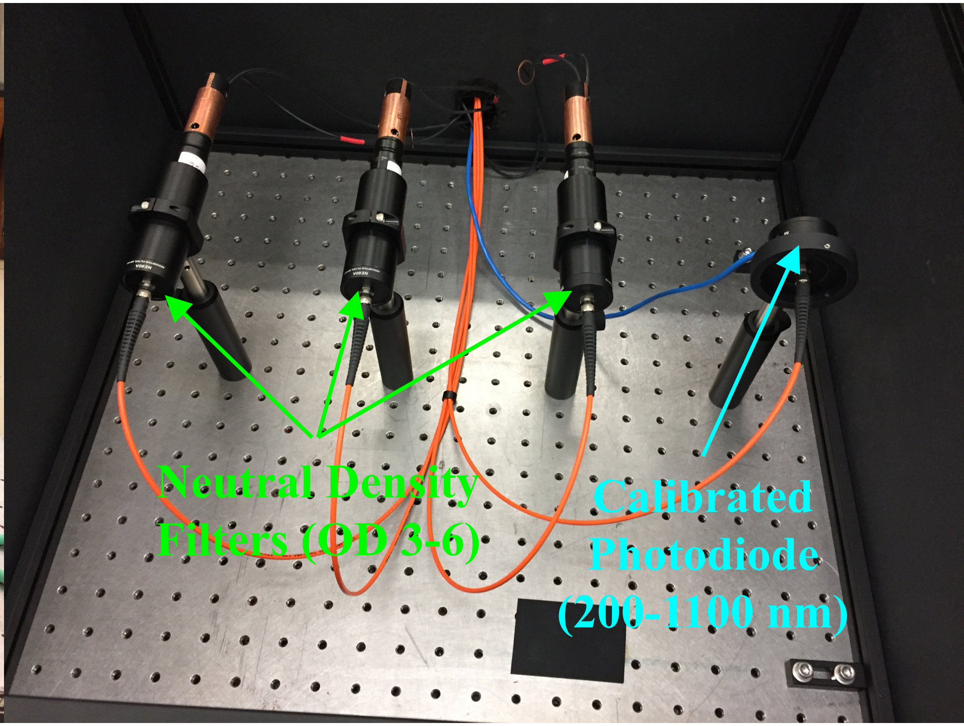


GEANT4 simulated RICH PID performance in SBS for π/K/p

HERMES/SBS RICH @UConn, Sept. 2014

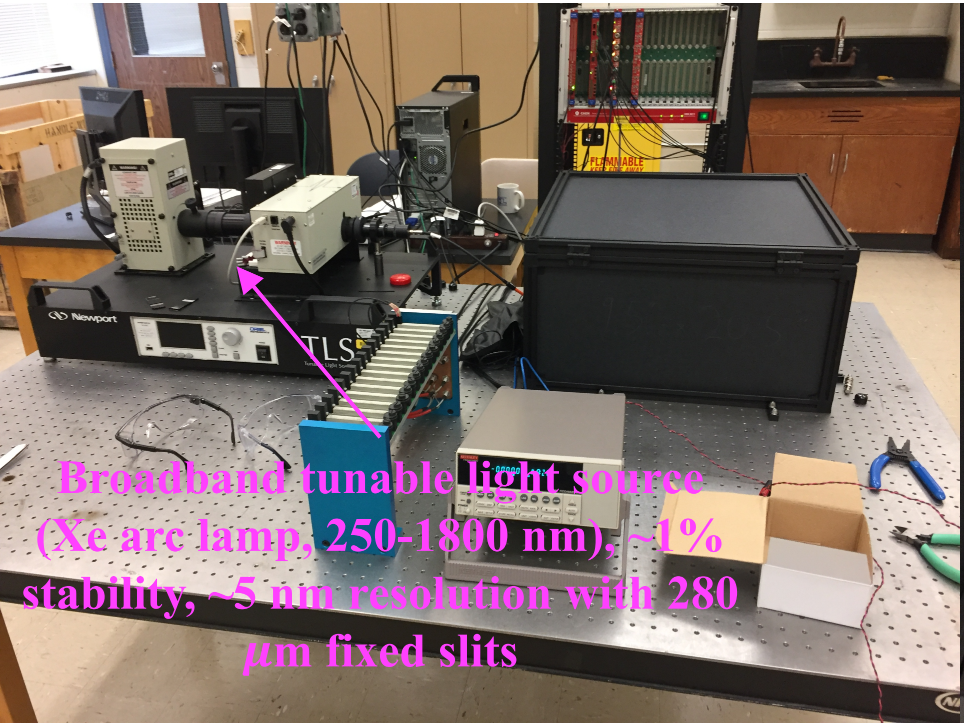
New-–PMT absolute quantum efficiency measurement

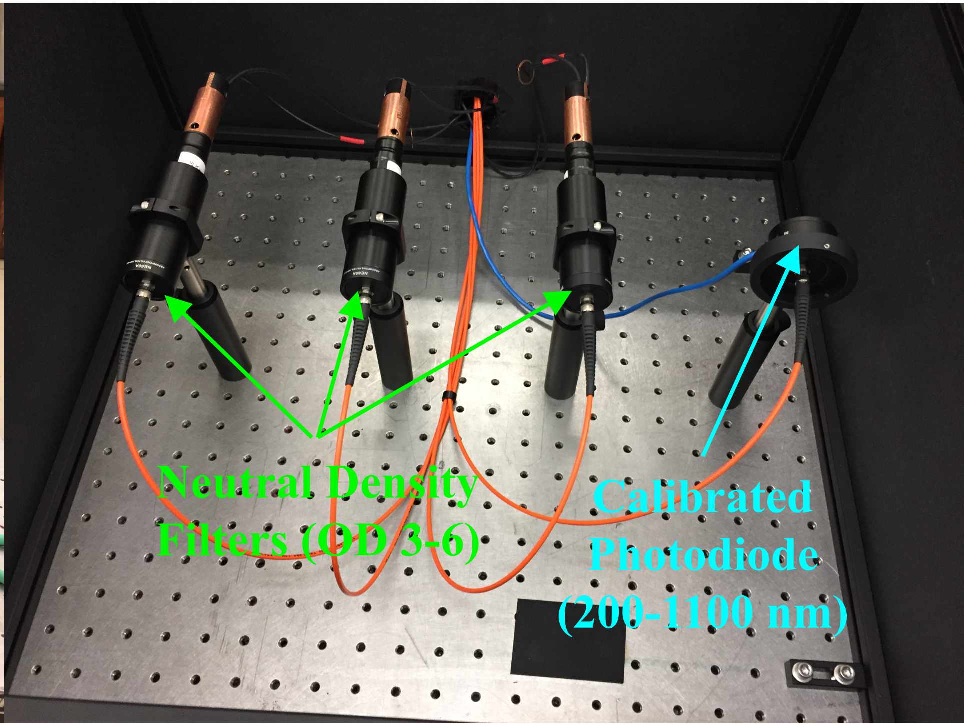




- Reconfiguration of UConn PMT test stand to measure absolute PMT quantum efficiency vs. wavelength (with ~5-10% absolute accuracy)
- Use broadband (250-1800 nm) tunable light source based on a 300 W Xe arc lamp with ~1% stability illuminating a monochromator with ~5 nm spectral resolution (up to 0.7 nm possible using smaller slit width)
- Measure the optical power output vs wavelength for each fiber using a calibrated photodiode.
- Monitor relative fluctuations in lamp output during the measurement by viewing the fourth fiber output with the calibrated photodiode
- Passively filter/attenuate the (DC) output of each fiber illuminating a PMT using ND filters to reduce the counting rate to something manageable ($\frac{dN}{dt} \leq 1\ MHz$) at any given wavelength.

PMT absolute quantum efficiency measurement (cont.)





- To obtain the quantum efficiency, we measure the counting rate as a function of wavelength for each PMT, divide by the transmittance of the ND filter, and convert the photon counting rate to an optical power via $E_{photon} = \frac{hc}{\lambda}$, $\epsilon(\lambda) = \frac{E_{photon}(\lambda)}{P_{fiber}(\lambda)T_{filter}(\lambda)} \frac{dN_{photon}(\lambda)}{dt}$
- We calibrate the spectral distribution of the transmittance of each ND filter in a separate, dedicated measurement. This increases the uncertainty of the final result.
- The distance from the output of each fiber to the PMT photocathode (or photodiode surface, as applicable) is fixed to be small enough to ensure 100% "effective" collection efficiency while illuminating a reasonable fraction of the photocathode surface area.

PMT Quantum Efficiency Measurement—Status and Plans

- UConn undergraduate physics major Chris Oldham is leading this effort as part of an independent study project
- We are currently debugging and troubleshooting LabView-based control of the "slow" instrumentation:
  - The monochromator (Setting wavelength scan parameters, including the table of gratings and order-sorting filters to use in appropriate wavelength ranges)
  - The picoammeter (photodiode readout synchronized with wavelength scan)
- Picoammeter also has scaled analog voltage output which could be sent directly to the oscilloscope and/or the DAQ—we are evaluating several options for using the analog voltage output.
- After establishing measurement procedure and uncertainties, plan is to do detailed measurement on a subset of (50-100) PMTs to determine the level of variations of absolute QE among existing PMTs, then cross-reference this subset against existing pulsed LED data for all PMTs by comparing relative photoelectron yields for other PMTs viewing the same LED/fiber—this could allow us to estimate absolute QE for all PMTs, albeit with lower accuracy, since LED data were obtained under varying conditions with many uncontrolled parameters (LED-PMT window distance, LED max. driving voltage, etc).

”Spare” aerogel uncrating

- This is the “spare” aerogel wall from the “other” half of the RICH detector not in our possession, that was crated and shipped separately from the main detector.
- We uncrated this over the summer, it appears visually to be in good condition, relatively uniform appearance in terms of color, texture, consistency, cloudiness, etc.
- We will soon attempt to open the containment vessel and begin optical measurements on a subset of the tiles.
- We have no plans to open the main RICH tank at UConn. The aerogel in the main tank is presumably in similar condition to the “spare” one.

Planned measurements for "spare" aerogel tiles

- Refractive index (two or more different methods for cross-check of systematics):
  - Minimum-deflection method with violet laser (405 nm) and possibly also red laser to check dispersion
  - Interferometric method—use a Michelson-type interferometer, count fringes while rotating a tile through a known angle
  - Indirect method—measure tile density and use the approximate relation between aerogel density and refractive index.
- Transparency
- Tile dimensions
  - using caliper
  - using interferometry

Preparations for shipment to JLab

- We met with UConn's contract rigger on Tuesday morning (Oct. 24).
- This is the same rigger who uncrated and moved the RICH into its current location in a basement lab space at UConn.
- I expect to have a cost estimate for the shipment imminently (~few days timeframe).
- When I have a moving cost estimate in hand, my group will coordinate with JLab on the location/preparation of the space for RICH testing/preparation activities (and/or storage) at JLab, and also the funding of the shipment, as appropriate.
- UConn physics department is eager to recover the space where the RICH is currently stored as lab space for recent experimental faculty hires in AMO.
- Physics department will move into a newly renovated space in the 2018-2019 time frame.

Other near-term activities for RICH

- Prepare "white paper" detailing system requirements for SIDIS/TDIS
- New simulations: optimize SBS detector layout for SIDIS:
  - SBS magnetic field strength → lower is better for acceptance and fringe field near polarized target. Clarify minimum momentum resolution requirements for PID and kinematic reconstruction
  - HCAL distance → with lower SBS field, increase distance to HCAL to lower background rates without cutting acceptance (and improve pi0 resolution).
    - Also improve HCAL angular + TOF resolution, improved constraints for tracking
  - Revisit background rates/PID performance
  - Develop analysis framework for SBS in SIDIS: trigger, tracking and PID
  - Trigger/DAQ rates and occupancies
- Start to think about beamline and SIDIS target design.
  - What is truly needed vs. what is "nice to have"?

Summary/conclusions

- Re-use of HERMES RICH in SBS is a low-cost PID solution enabling high-impact SIDIS physics with SBS, can be adapted to future novel applications such as TDIS.
- Mass testing of 2,158 RICH PMTs was completed Oct. 2016:
  - Single-ph.e. spectra
  - Absolute gain curves vs. HV
- PMTs are in good condition; less than 2% of tested PMTs rejected → we have ~10% spare capacity to run SIDIS
- Longer-term issues:
  - gas system is a major question mark—mainly a cost issue, but technical questions also exist—issues similar to GRINCH, but on a larger scale.
  - Design of support structure/installation
  - Interface to front-end electronics (NINO cards)—will require some reconfiguration of the cabling layout; new patch panels/ribbon cables/etc.
  - Aim to re-use existing cables, readout electronics, and HV power supplies as much as possible.
  - Requires 61 channels of positive HV power supplies; 32 PMTs/channel, 40 μA/PMT @1,350 V = 1.3 mA/1.7 W