DIRC detector upgrade for the GlueX experiment

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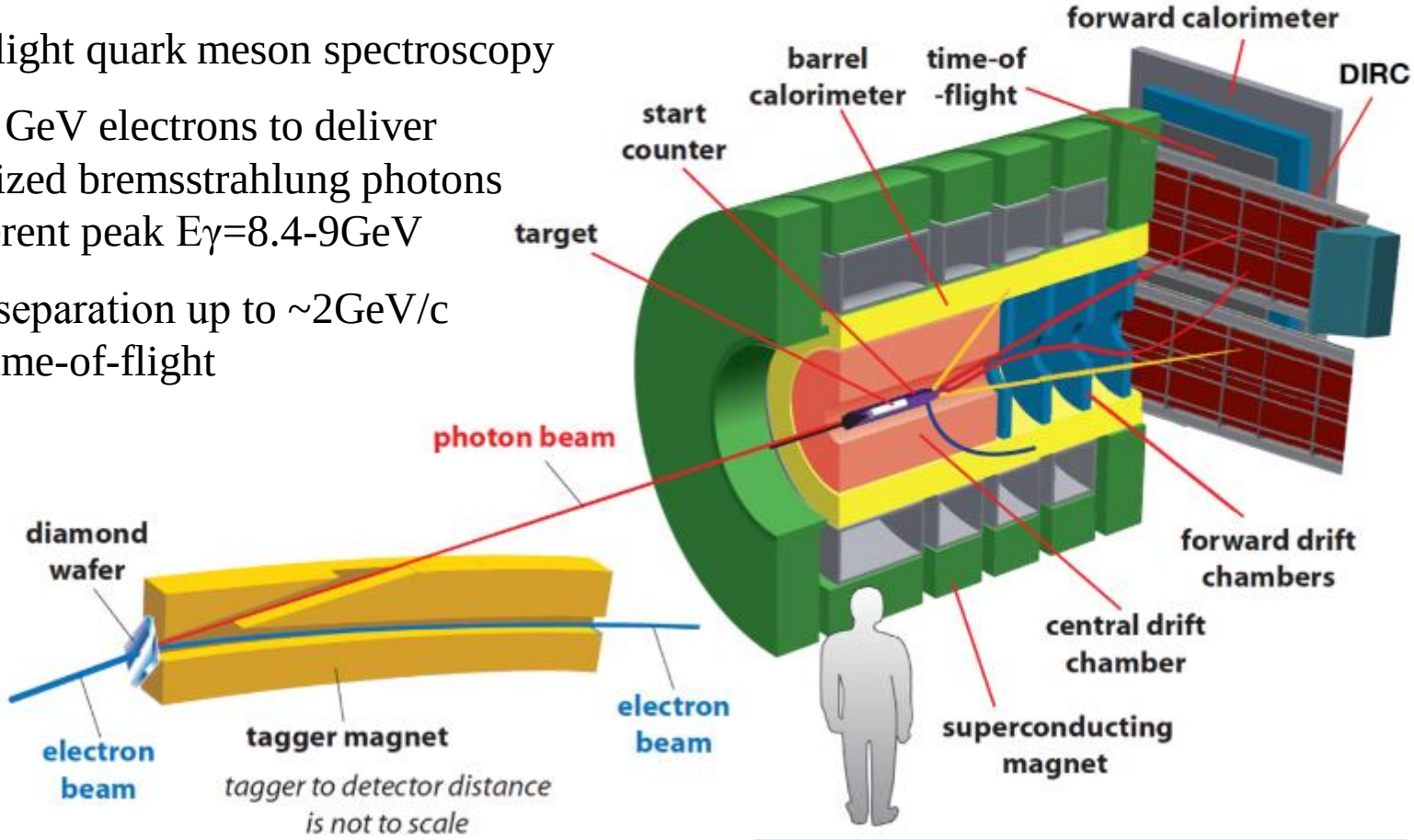
The GlueX Experiment is a key element of the Jefferson Lab 12 GeV upgrade. The experiment is at the end of a new beamline from the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab.

GlueX Experiment

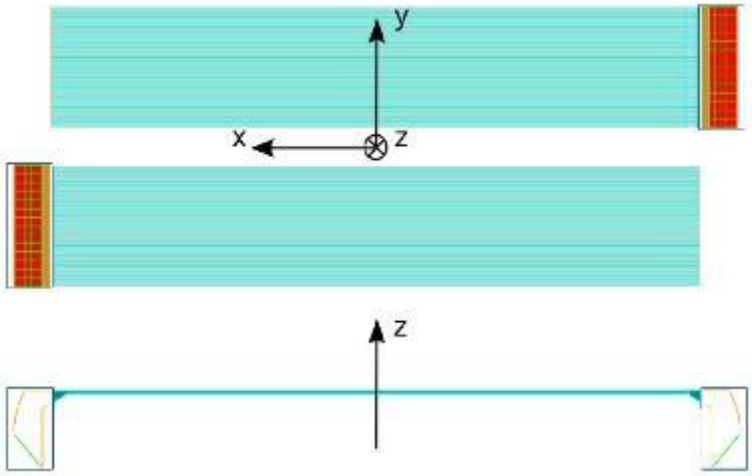
- Designed for light quark meson spectroscopy
- Beam: use 12 GeV electrons to deliver linearly-polarized bremsstrahlung photons $10^8\gamma$/s in coherent peak $E\gamma$=8.4-9GeV
- Baseline π/K separation up to ~2GeV/c provided by time-of-flight

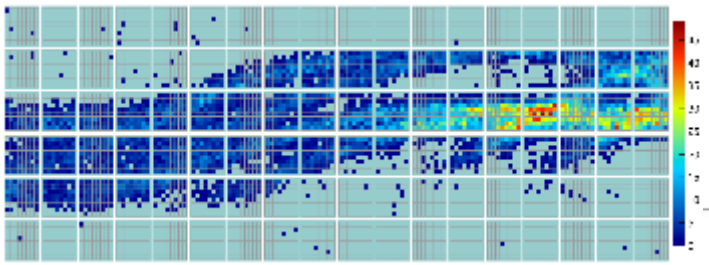


For GlueX Physics Program, see talk by Nacer

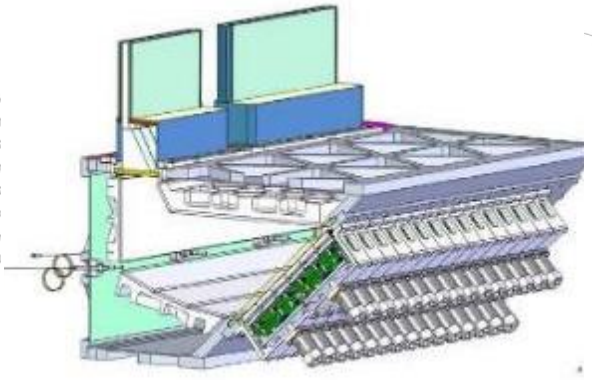
GlueX DIRC

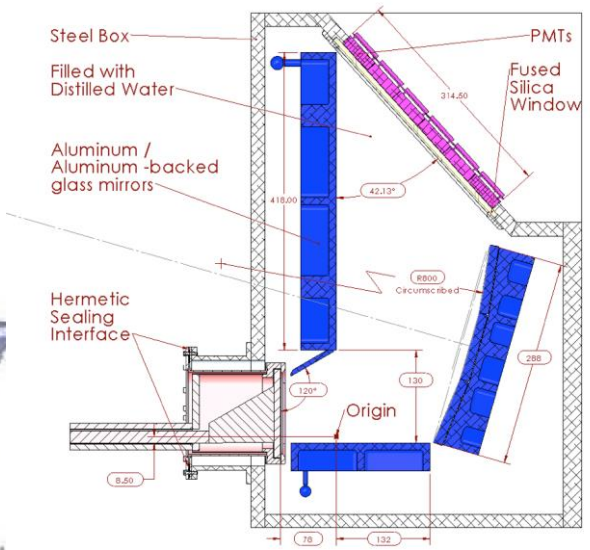
- **Radiators**: reusing 48 synthetic fused silica bars (4 bar boxes) from BaBar experiment at SLAC.
- **Expansion volume:** The water tanks are new and follow the concept from SuperB FDIRC, there are two water tanks each one is coupled to two bar boxes and filled with distilled water.
- **Focusing**: segmented mirror.
- Design options for GlueX DIRC limited to expansion volume, focusing, sensors, and electronics.





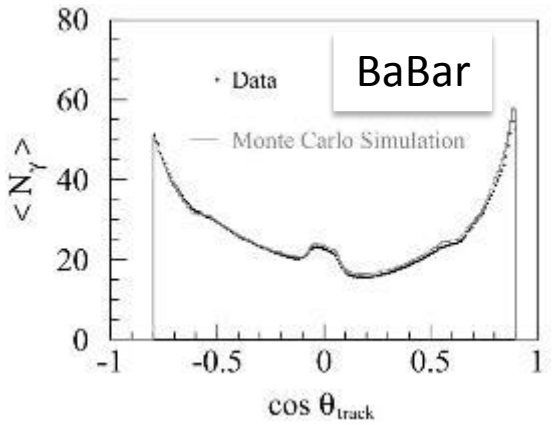
Hit pattern example

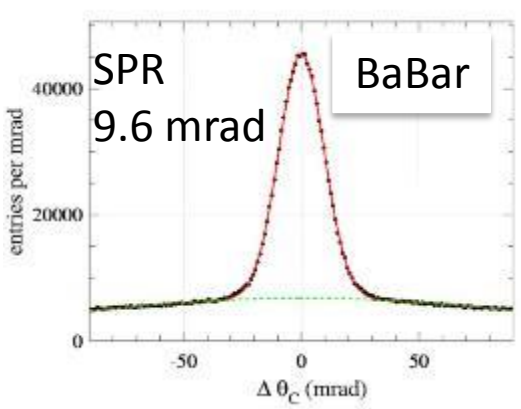


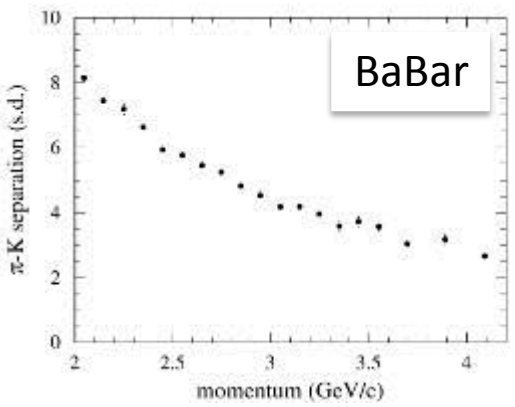


Expected GlueX DIRC Performance

Expected Performance based on BaBar results:



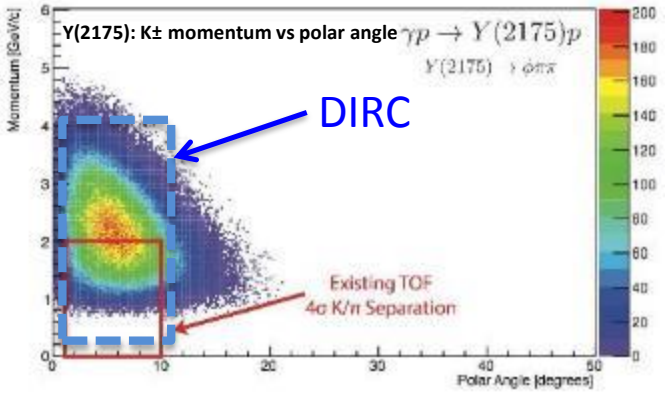




GlueX DIRC expected to provide particle identification, particularly separate K and π to better than 3 sigmas for momenta between 0.15 up to 4 GeV/c

GlueX improvements:

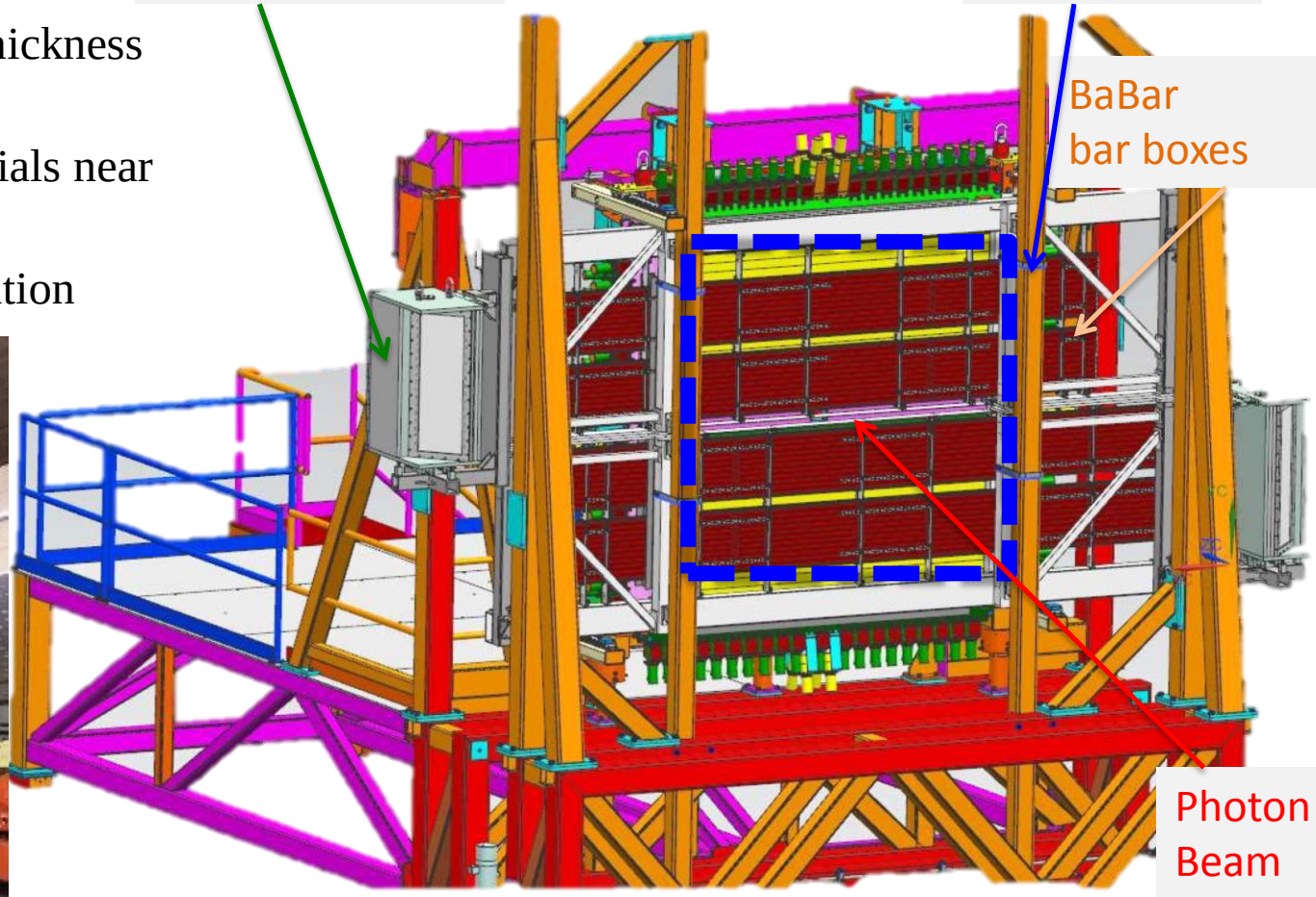
- Smaller expansion volume (due to focusing)
- PMTs with better quantum efficiency with higher photon yield



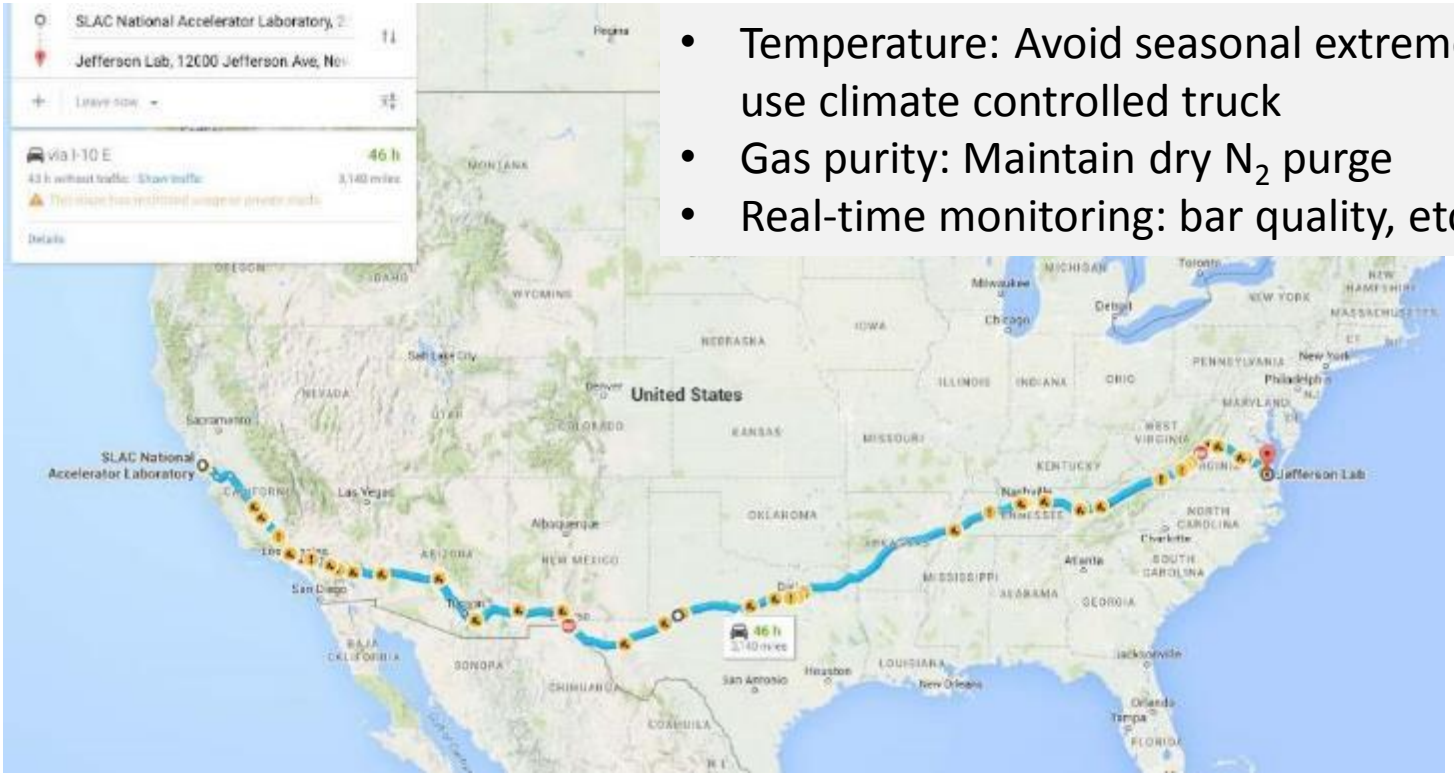
Significantly extends reach in search for exotic hadrons (hybrid, multi-quark, etc.) containing strange quarks

Support Structure

- Radiators retractable
- Minimize material thickness in active area
- Non-magnetic materials near solenoid field
- Even weight distribution



Bar Box Transportation

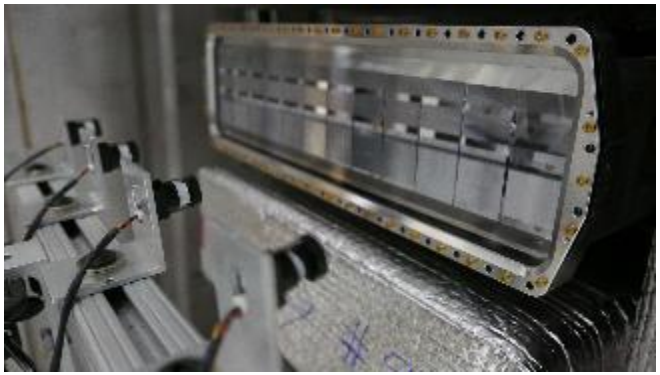


- Temperature: Avoid seasonal extremes and use climate controlled truck
- Gas purity: Maintain dry N_2 purge
- Real-time monitoring: bar quality, etc.

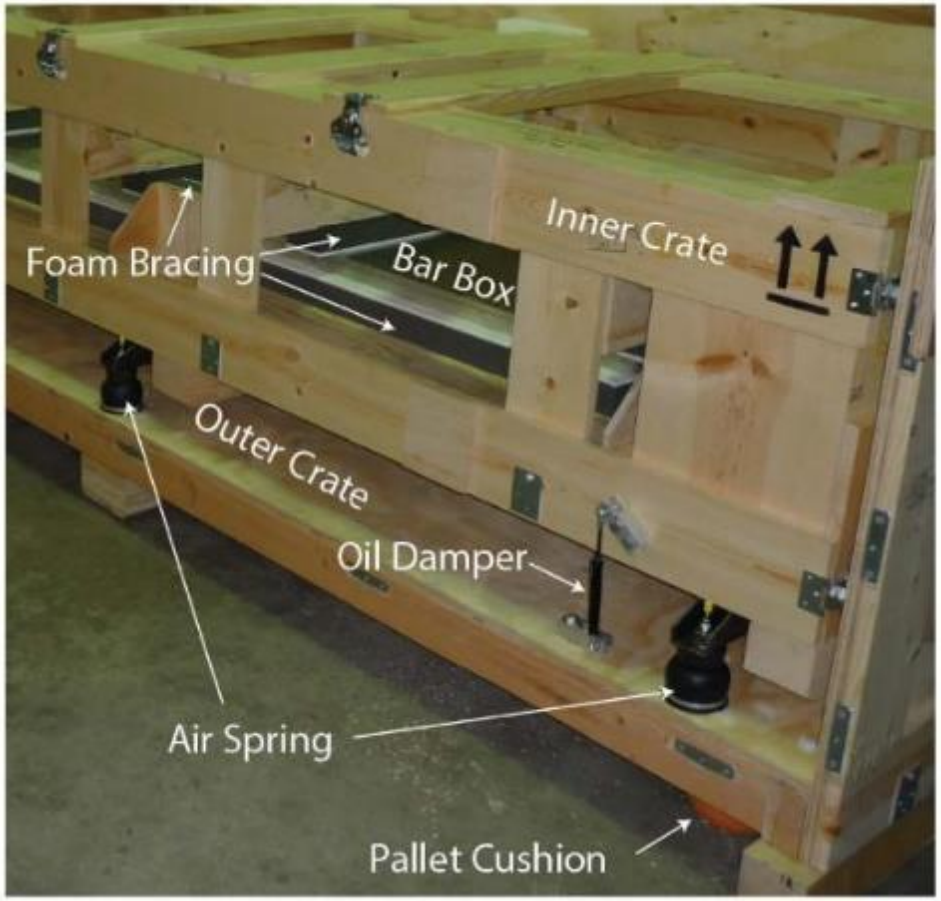
- Transporting the very fragile DIRC bar boxes from SLAC to JLab, after a decade in storage, was a major concern and logistical challenge.
- Integrity of the glue joints and bar surfaces during transport achieved by complex crate design and detailed monitoring.

Transportation Strategy

- Transport 4 bar boxes from SLAC to JLab in two separate shipments
- First bar box shipment in Fall 2017, second shipment of remaining three will be in June 2018.
- Real-time monitoring system for bar boxes in transit. Multiple cameras for viewing bars N_2 flow sensors, accelerometers, etc.

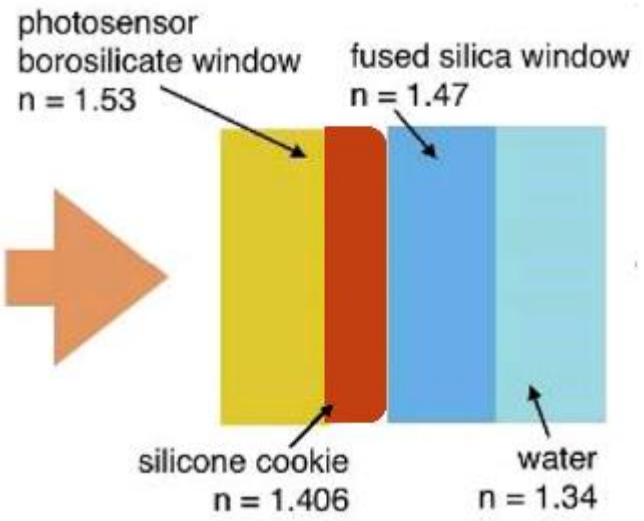


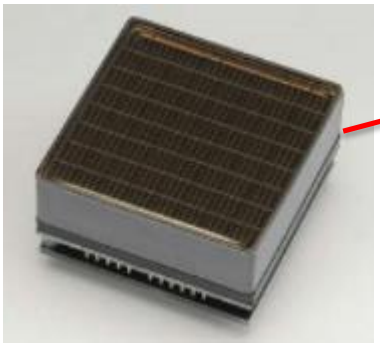
Camera tests at SLAC

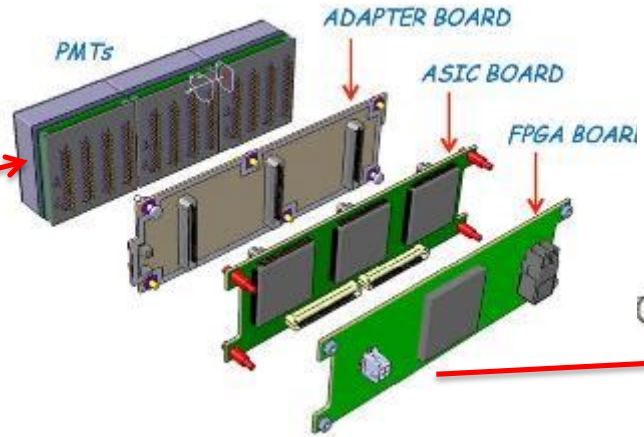


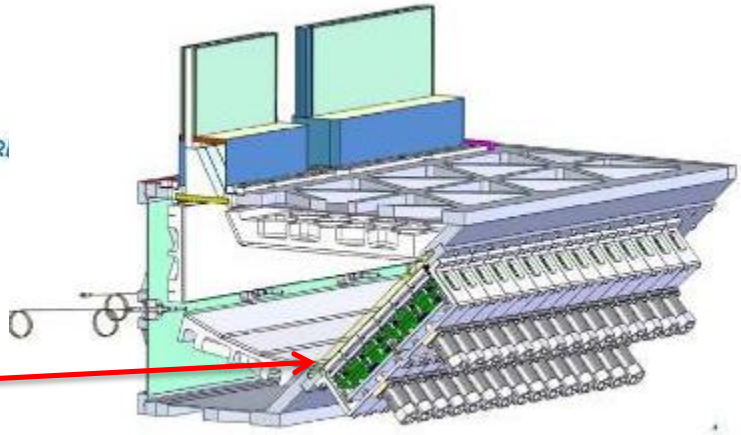
Photon Detection and Readout

- Photosensors: 216 Hamamatsu H12700 MaPMTs (~14k channels)
- Optical coupling: silicone cookies (only 2-4% photon loss vs. 25% with the air gap)
- Electronics: boards developed for CLAS12 RICH in HallB (JLab), the core of the design is to use the MAROC3 chip. Compatible with generic JLab DAQ







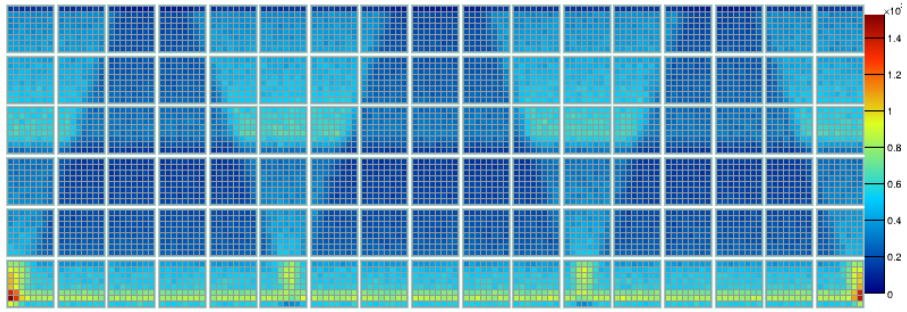


Calibration System Simulations Study

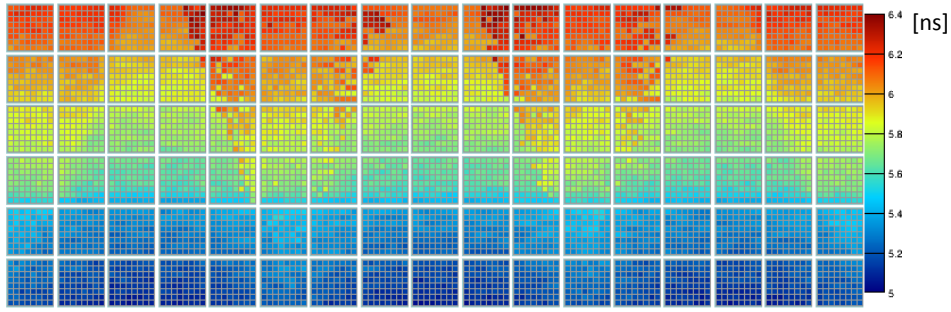
- Time offsets between pixels, due to cable length and pixel-to-pixel differences inside the photon sensors, have to be removed to achieve the time resolution required for the GlueX DIRC.

- The light will be distributed by optical fibers to the expansion volume and coupled via square optical diffusers to illuminate the entire readout plane.

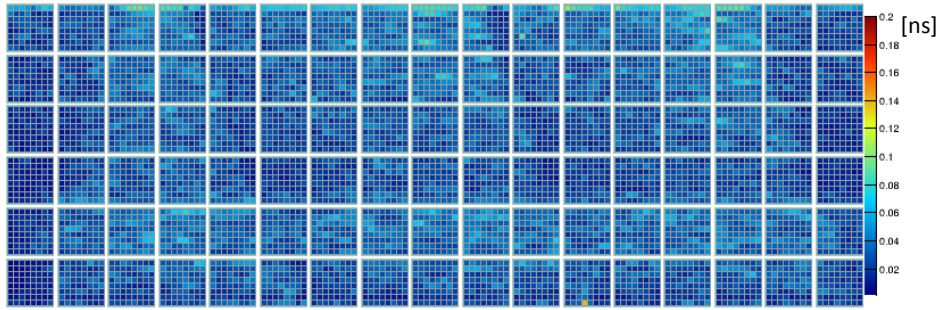
- Simulation of the LED-based calibration system shows stable t_0 determination with an error < 100 ps.



Occupancy distribution on PMT plane using square diffuser



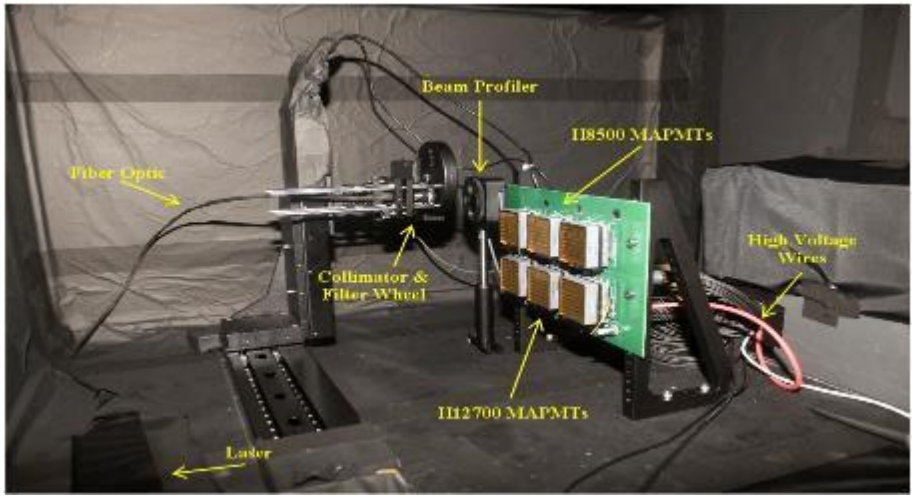
Photon time map

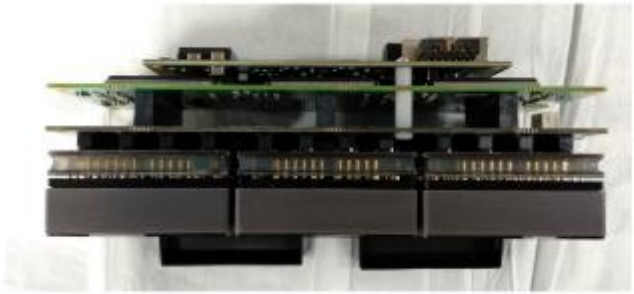


Photon time error map

PMTs Testing System

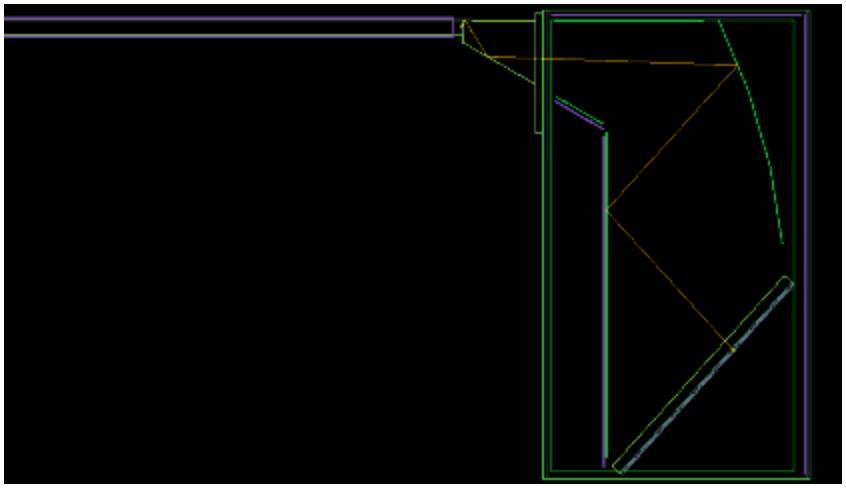
- System setup was completed
- PMTs testing going to start soon
- Two sets of (6) PMTs can be mounted at the same time
- Testing: Gain, HV threshold, cross talk, timing resolution.

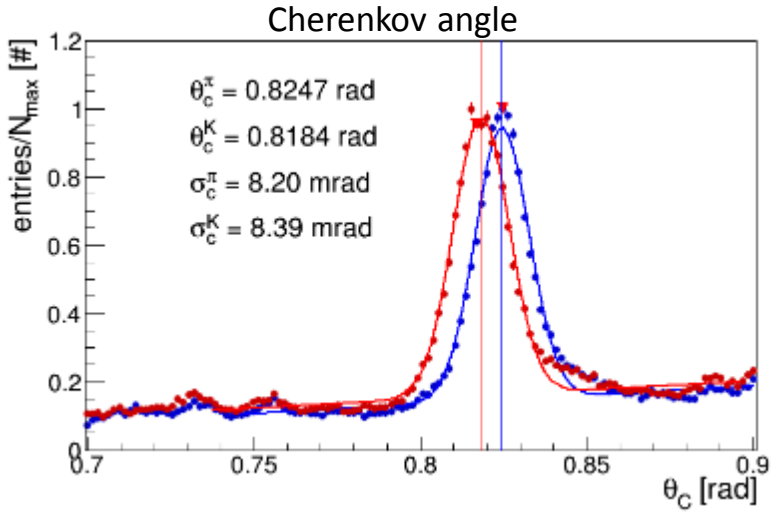




Reconstruction Methods

- Geometric reconstruction (BaBar method)
  - Lookup Table (LUT): store direction at the end of the radiators for each fired pixel by full simulation using photon gun.
  - Reconstruction: direction from LUT for fired pixels are combined with charge track direction to determine Cherenkov angle.
- Kernel Density Estimation
  - Creating Probability Density Function based on hit patterns of different particles species.
  - Reconstruction: calculating likelihoods
- Time Imaging
  - Creating PDF based on propagation time of different particle species.
  - Reconstruction: calculating likelihoods





Geometric reconstruction example: Cherenkov angle resolution per photon for π/K at (θ=11, Φ=90) degree at 4GeV/c

Summary & Outlook

- DIRC will extend the physics potential of the GlueX experiment by separating π and K up to 4 GeV/c.
- Installation of the support structure and services for first optical box was completed.
- GlueX DIRC will reuse 4 BaBar bar boxes, the first bar box was successfully transported from SLAC to JLab, the second shipment of remaining three will be in June 2018.
- Simulation of the LED-based calibration system shows stable t_0 determination with an error < 100ps.
- PMTs testing setup was completed.
- Three reconstruction methods are developed and constantly improved.
- 2018: Install first optical box and available MaPMTs and begin commissioning detector with available beam time.
- 2019: Complete installation and commission complete detector.