#### Initial Performance of the GlueX DIRC Detector



International Conference on Technology and Instrumentation in Particle Physics

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on behalf of the GlueX DIRC group

- GlueX experiment
- DIRC assembly
- Commissioning results
- Summary





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#### **GlueX Experiment**



- Located at Jefferson Laboratory
- Initial beam provided by Continuous Electron Beam Accelerator Facility (CEBAF)
- Hall D tagged coherent photon beam up 12 GeV

CEBAF:



GlueX detector in Hall D:





#### **GlueX** Experiment

- Phase-I: light quark meson (hybrid) spectroscopy. PID: baseline  $\pi/K$  tracks separation up to ~2 GeV/c provided by time-of-flight
- Phase-II: high-luminosity strangeness program. PID: 3 s.d.  $\pi/K$  tracks separation up to 3.7 GeV/c by DIRC

**PID** coverage

with DIRC

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momentum [GeV/c]

#### Detection of Internally Reflected Cherenkov Light

Novel type of Ring Imaging CHerenkov detector based on total internal reflection of Cherenkov light

- Charged particle traversing radiator with refractive index  $(n_1 \approx 1.47)$  and  $\beta = v/c > 1/n$  emits Cherenkov photons on cone with half opening angle  $\cos \theta_c = 1/\beta n(\lambda)$
- Some photons are always totally internally reflected for  $\beta \approx 1$  tracks
- Radiator and light guide: polished, long rectangular bar made from Synthetic Fused Silica ("Quartz")
- Proven to work (BABAR DIRC)







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#### **GlueX DIRC**



Mirrors

#### **Photon Detection and Readout**

#### 8 x 8 pixels each



- Photosensors: 180 H12700 MaPMT
- Electronics: MAROC3-based (from CLAS12 RICH)
- 11520 channels (timing resolution ~1 ns)



### **Readout Assembly and Optical Coupling**

Quartz window





Optical coupling: silicone RTV-615 cookies (saves up to 15% photons)





Applying silicon cookies to MaPMT:



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## **GlueX DIRC Assembly**



Installation / data taking timeline:

- Lower box assembly: Jan 2018
- Lower box commissioning: Feb 2018
- Upper box assembly and installation: Nov 2018
- Full DIRC commissioning: Feb 2019 and Dec 2019
- Production data: Spring / Summer 2020 (used for performance evaluation)

Bar boxes covered by TEVLAR fabric for light tightness



#### **Performance Evaluation**

Reference PID from kinematically identified pions and kaons:





#### **Hit Patterns**





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#### **Hit Patterns**



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#### **Hit Patterns**





Good agreement between beam data and simulation



#### **Geometrical Reconstruction**

- Adapted from PANDA Barrel DIRC reconstruction
- Geometrical algorithm determines Cherenkov angle per photon using Look Up Tables



 PID: unbinned maximum likelihood fit to the Cherenkov angle distribution per photon for different mass hypotheses



#### **Photon Propagation Time**



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#### **Reconstructed Photon Yield**



- Simulation overestimates photon yield by 36%
- Observed degradation of mirror surfaces due to corrosion in water during 2020
- Improved protection of the mirror surfaces is foreseen for next data taking period

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#### **Single Photon Resolution**

Reconstructed Cherenkov angle for pions and kaons @ 3.5 GeV/c:



Good agreement between beam data and simulation

# **Chromatic Correction**

 Refractive index and therefore Cherenkov angle depend on energy of emitted photons



 Cherenkov angle corrected by photon propagation time difference



Clear improvement of Cherenkov angle resolution per photon after correction



# **Single Photon Resolution Map**



Good agreement between beam data and simulation

#### **Cherenkov Track Resolution**



• 8.5 / 2.2 = 3.8 s.d. separation @ 3.5 GeV/c ( $\pi$ /K Cherenkov angle difference is 8.5 mrad)

- Non Gaussian tails reduce the performance
- Simulation predicts 1.2 mrad for correlated term b further improvements are possible

## **Separation Power**



Difference between beam data and simulation reflects difference of the correlated term

#### Summary

- Successful DIRC commissioning (2019) and fist GlueX II physics run (2020)
- GlueX DIRC worked right from the start, bar boxes fully functional, hit patterns as expected
- Reconstructed Cherenkov angle resolution per photon agrees with design and simulation
- Initial DIRC performance achieved: 3.0 ± 0.1 s.d.  $\pi/K$  separation at 3.5 GeV/c
- Analysis well underway, performance expected to improve with better calibration

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#### Thank you for the attention

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![](_page_25_Picture_10.jpeg)

## **Backup 01: Mirror Surface Degradation**

![](_page_26_Picture_1.jpeg)

Type II anodized AI strongback in optical box. Coated with white cloudy residue after few months in water.

![](_page_26_Picture_3.jpeg)

![](_page_26_Picture_4.jpeg)

South/lower box experience: Oct 2018 - May 2019, optical box suffered from degradation in water

Pitted surface

- Mirror developed non-removable white traces
- Reflective coating are pitted
- White residue on the anodized surfaces

W. Li & J. Schwiening | GlueX DIRC | INSTR'20

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