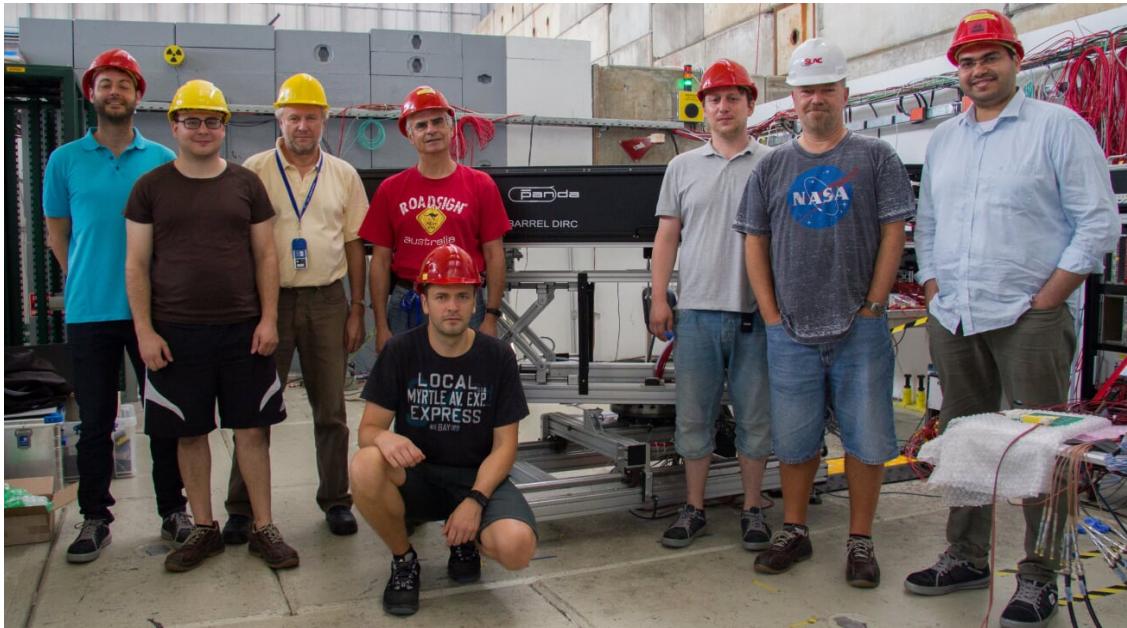


PANDA Barrel DIRC Prototype Test Beam 2017 at CERN



3 May 2018

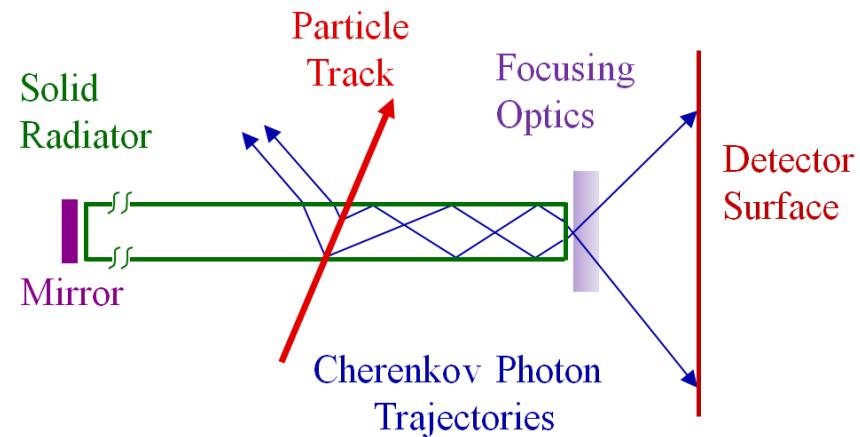
Ahmed Ali

Panda PID Computing
Workshop
3 May 2018

DIRC Concept

Detection of Internally Reflected Cherenkov Light

- Charged Particle traversing radiator with refraction index n with $\beta=v/c>1/n$ emits Cherenkov light.
- Light guide: bar, plate, disc geometries
- Magnitude of Cherenkov angle conserved during reflections
- Mirror attached to far end, to reflect photons back to readout end
- Photons focused onto readout plane
- DIRC is intrinsically a 3-D device, measuring:
 x, y , and time of Cherenkov photons,
defining $\theta_c, \phi_c, t_{\text{propagation}}$
- Likelihood for various charged particles (e, μ, π, K, p, \dots)



PANDA Barrel DIRC Prototype Test at CERN

Goal:

- evaluate performance of advanced/near-final configuration of the PANDA Barrel DIRC

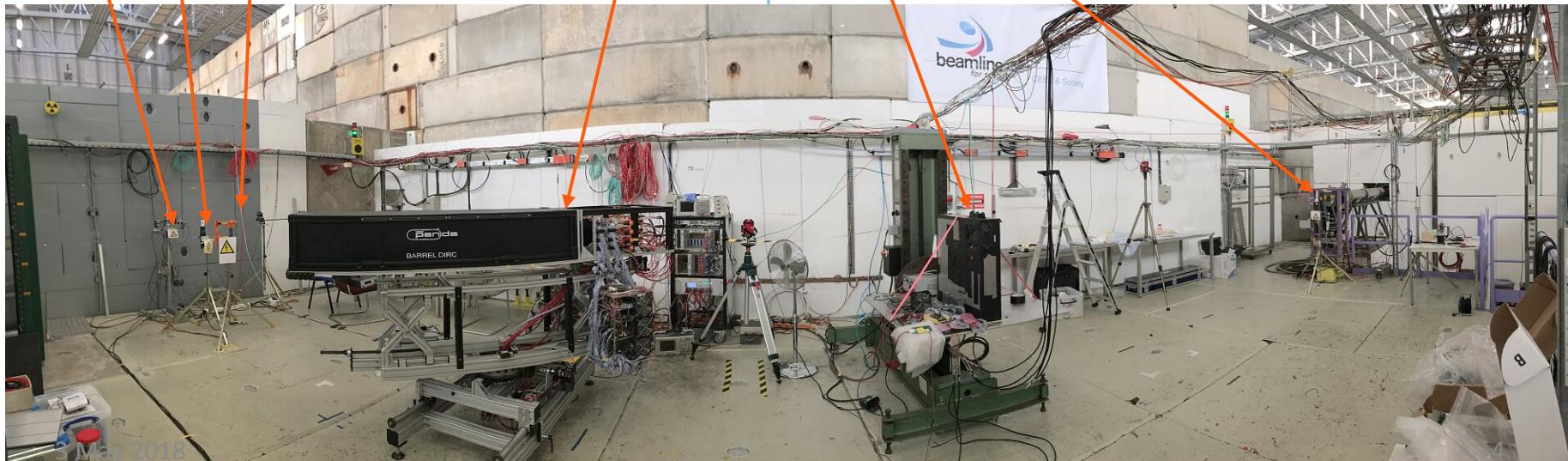
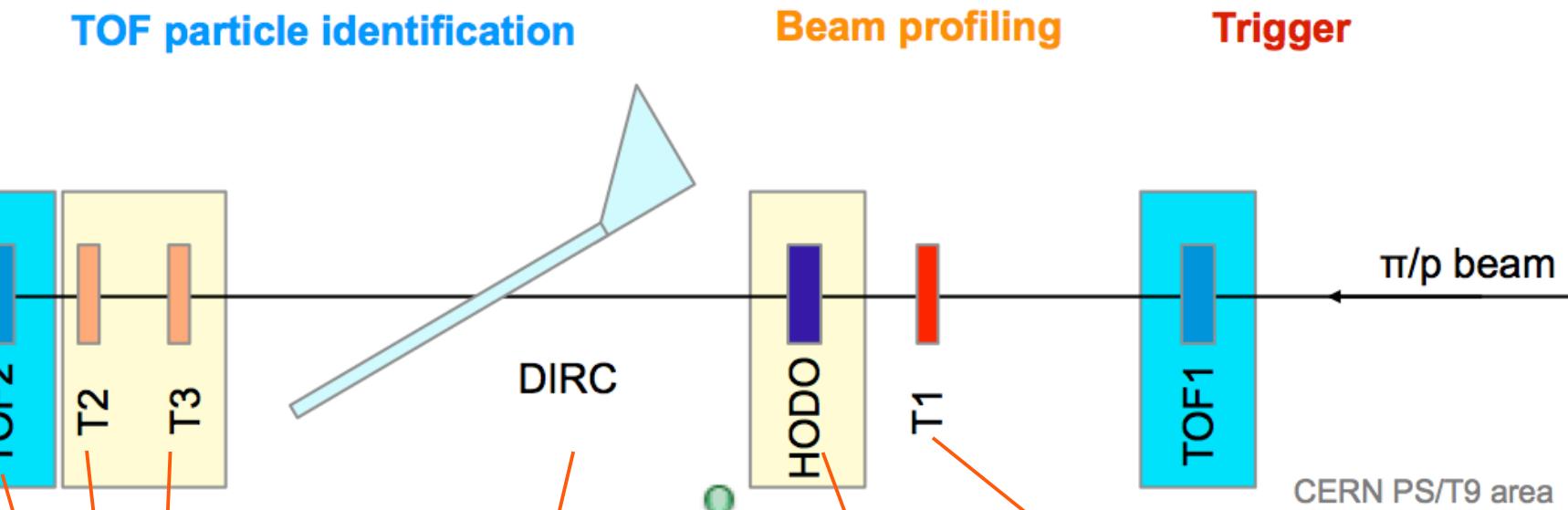
Highlights of the geometry:

- 33 degree prism as expansion volume => 12 MCP-PMTs (vs 9 at 2016)
- new readout modules
- new 3-layer spherical lens
- new 3-layer cylindrical lens
- narrow bar and plate as the radiators
- updated mechanics to study impact of azimuthal angle on hit pattern, PID performance

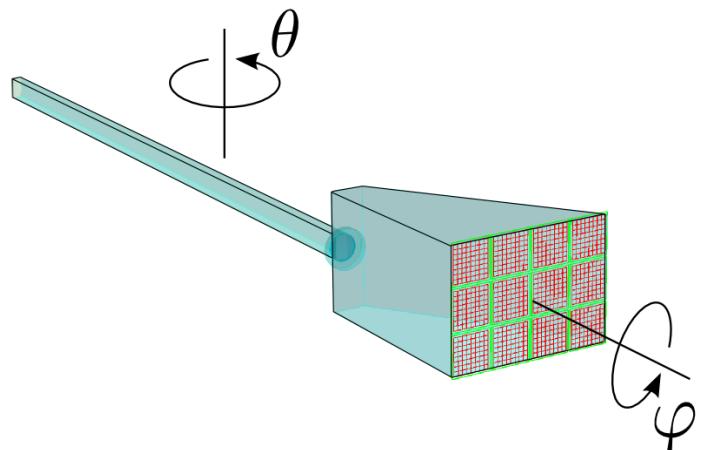
Test conditions:

- CERN PS/T9 area
- beam type: protons and pions
- beam momentum: 10, 9, 8, 7, 6, 5, 4, 3, 2 GeV/c
- TOF PID
- different configurations of the DIRC prototype
- different DIRC prototype angles

PANDA Barrel DIRC Prototype Test at CERN



DIRC Prototype Photos

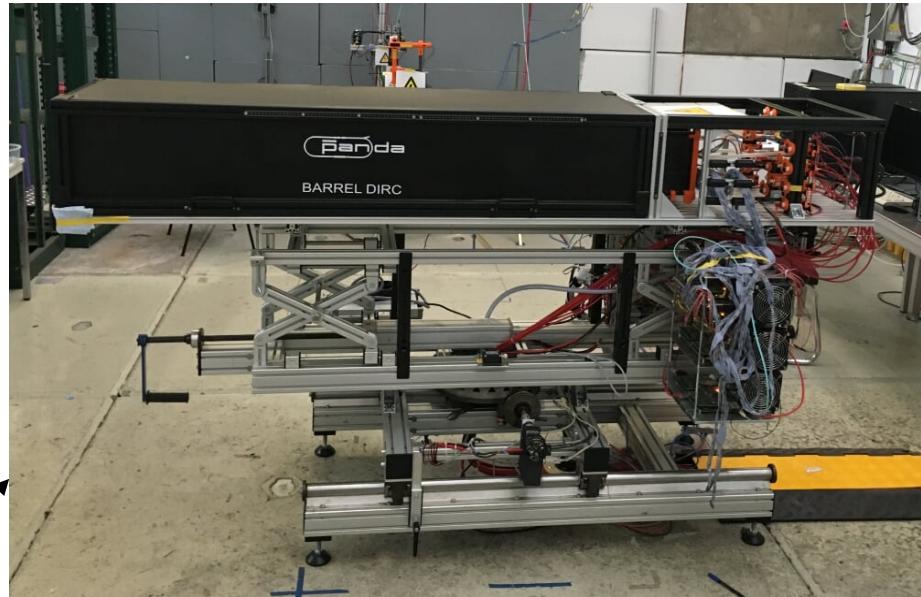


Polar angle
90°

Azimuthal angle 0°

Polar angle
25°

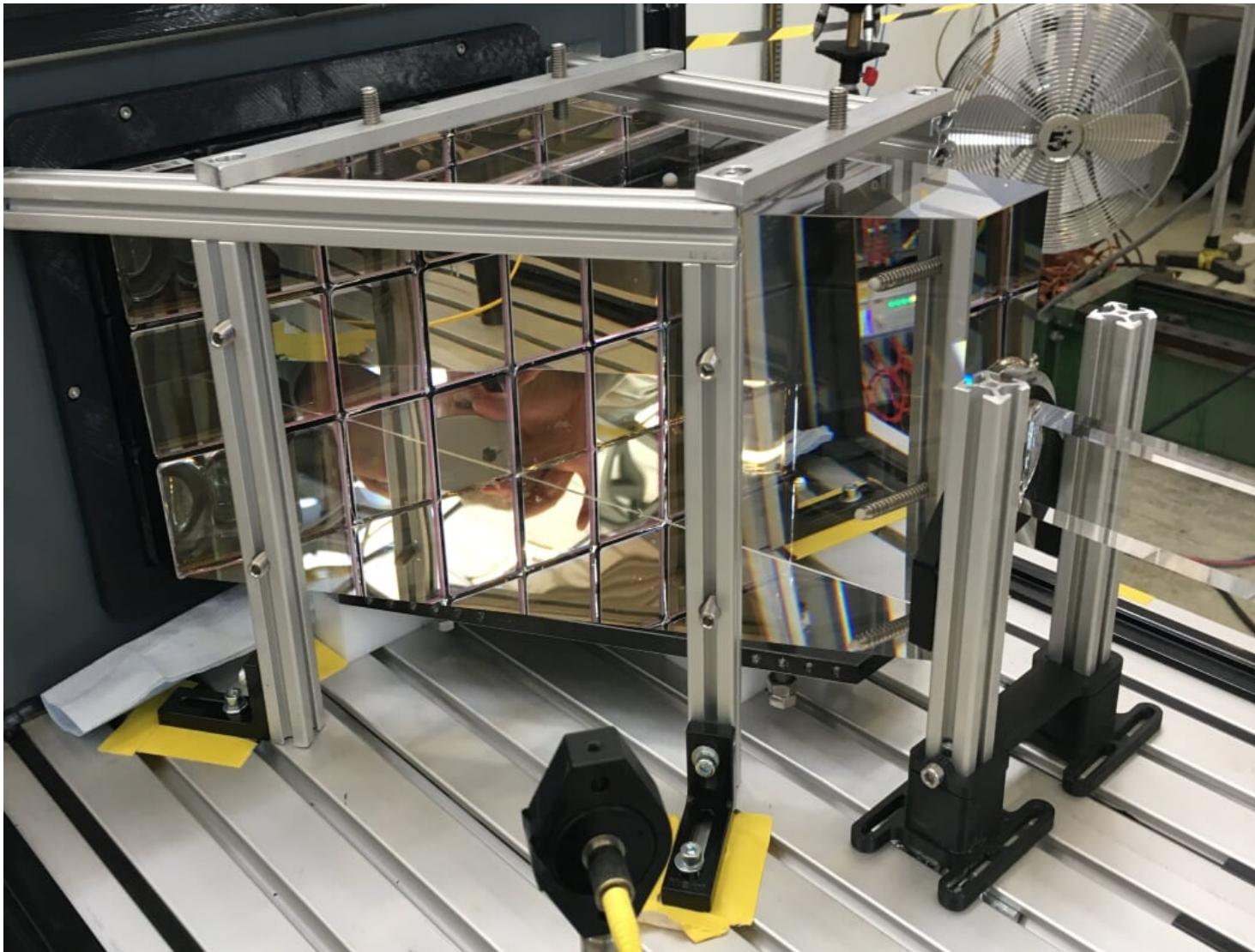
Azimuthal angle 10°



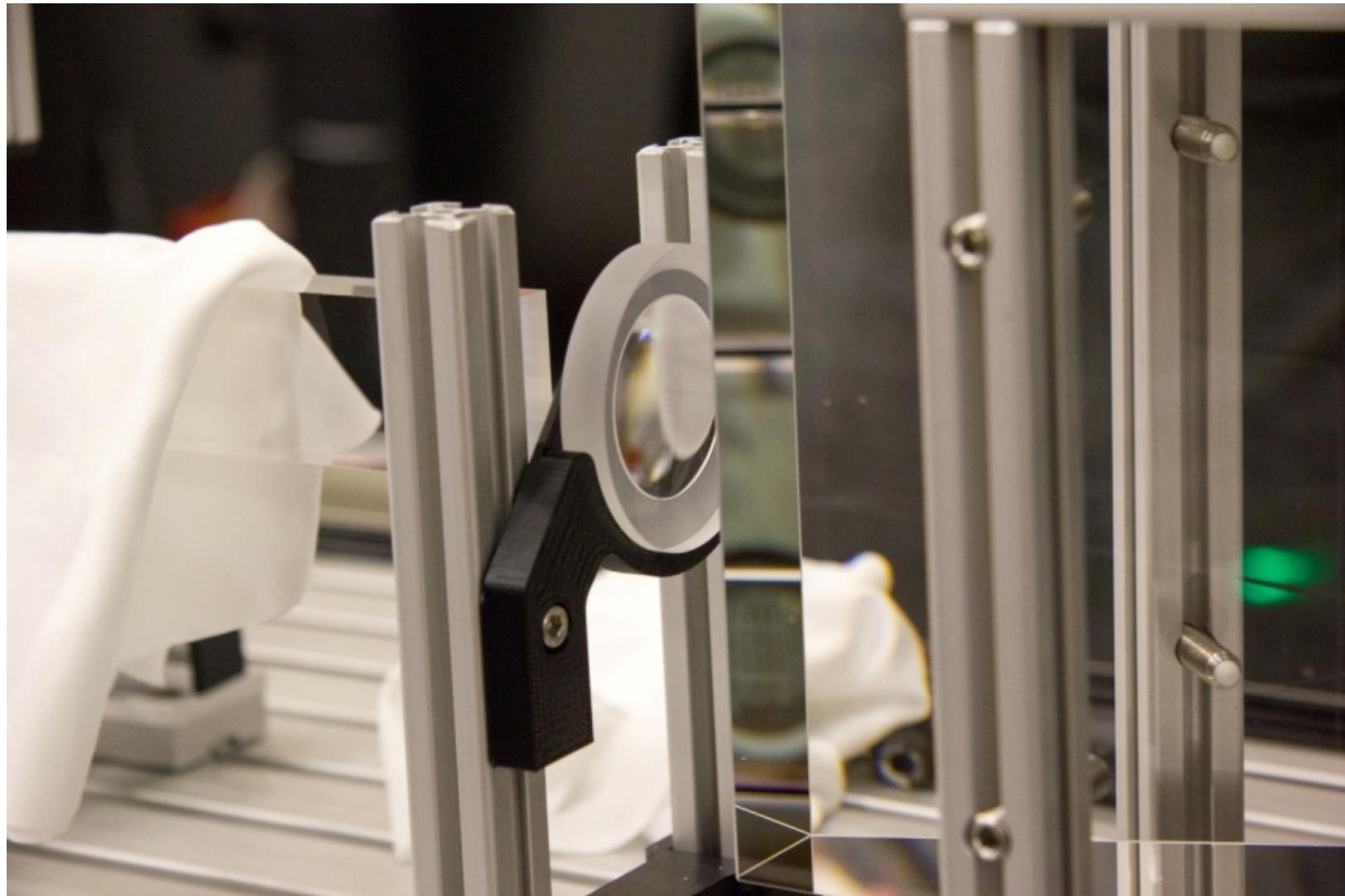
Readout Modules



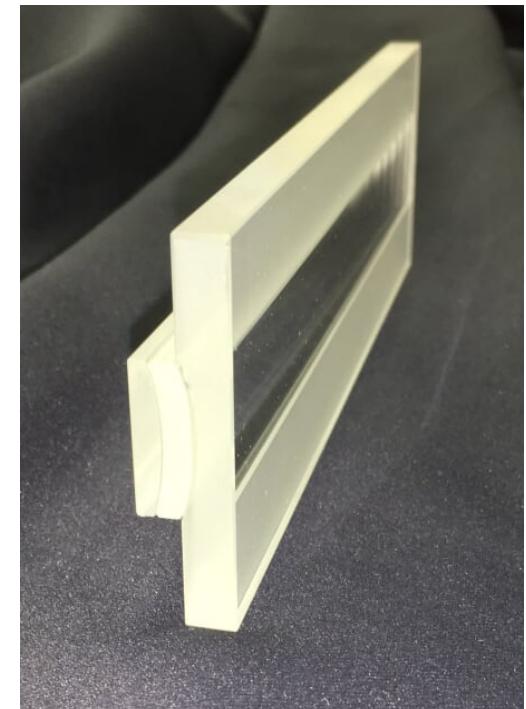
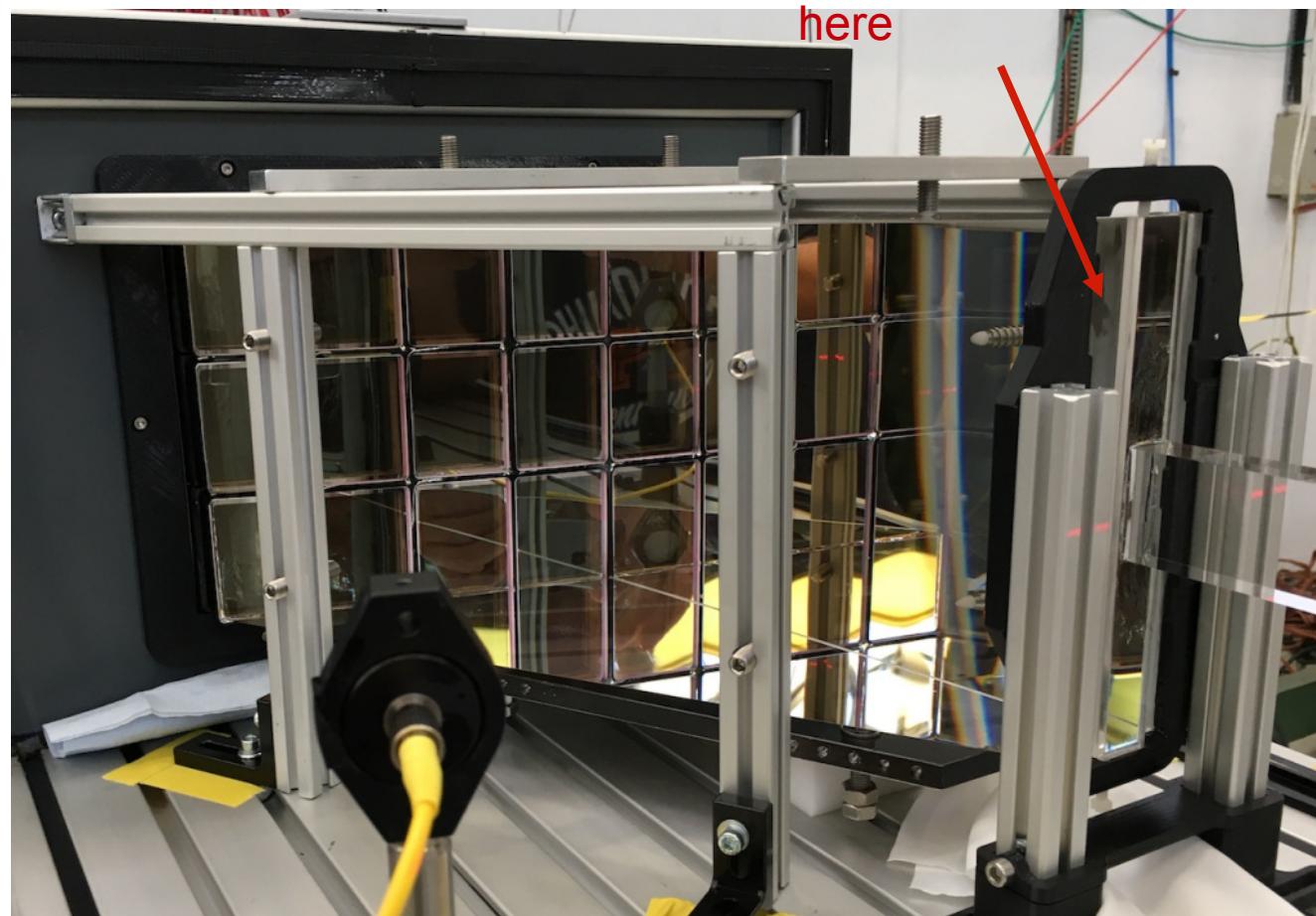
33 Degree Prism



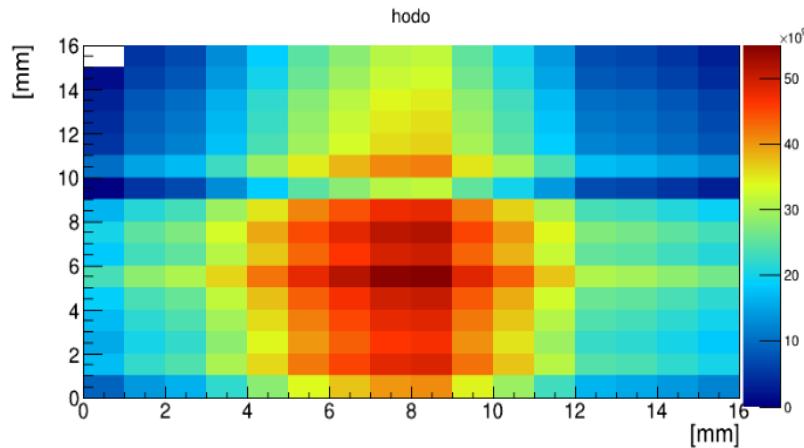
New 3-layer spherical lens



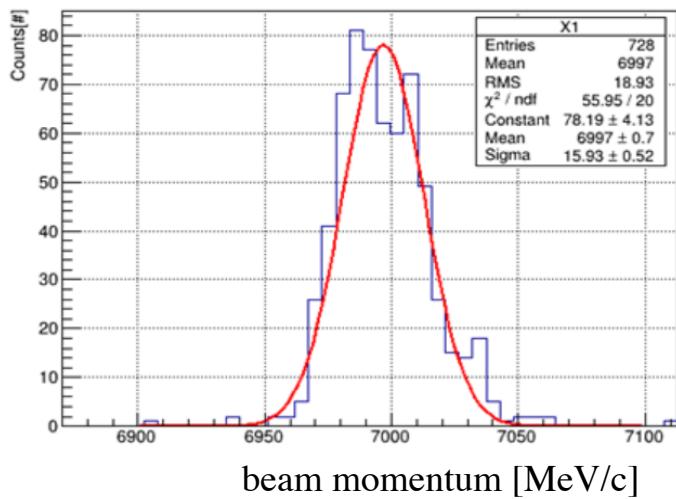
New 3-layer cylindrical lens



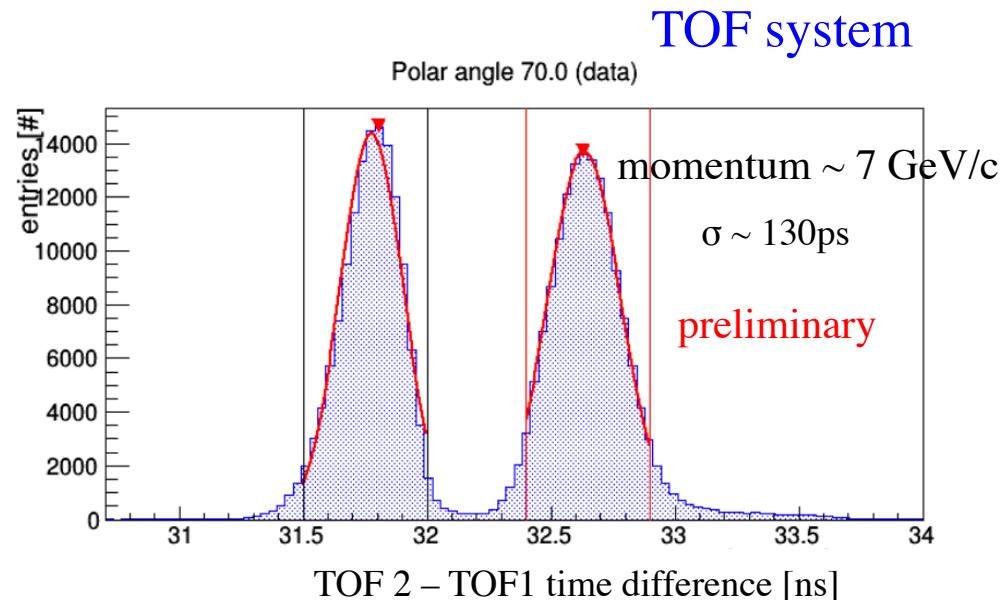
Beam Profile, Momentum and TOF PID



Beam profile from hodoscope
selection: 4 mm x 4 mm



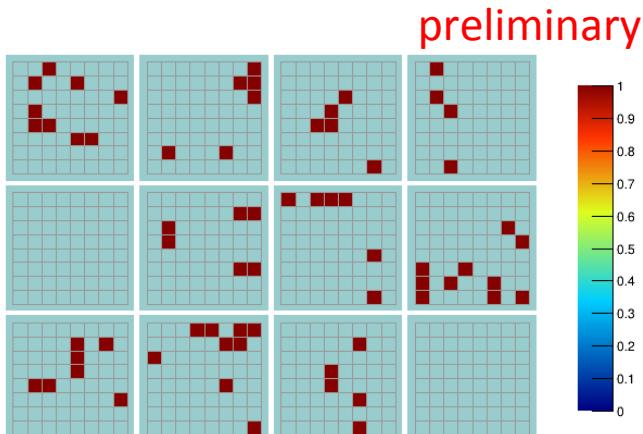
Beam momenta from each run:
stable with time $p = 6997 \pm 16$ MeV/c



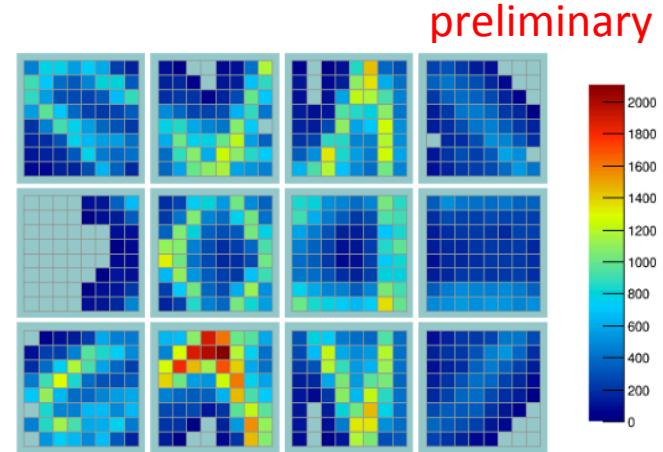
π/p tagging provided by the time-of-flight system at ~ 7 GeV/c momentum and ~ 28.5 m distance between TOF1 & TOF2.

Hit pattern

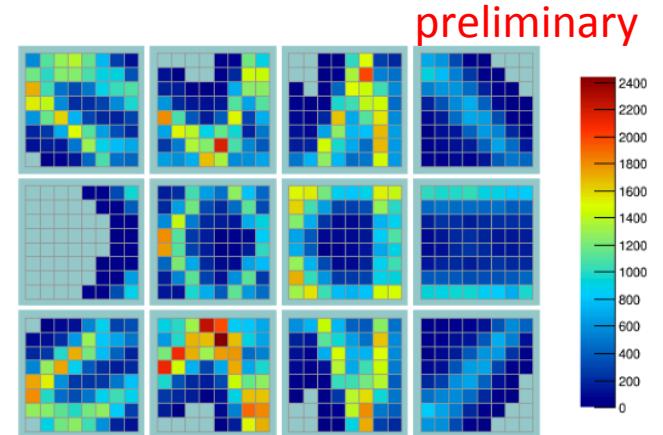
- ❑ Event selection uses fiber hodoscope, scintillator triggers and time-of-flight.
- ❑ Data calibrated using picosecond laser pulser.
- ❑ Specific prototype simulation, tuned to beam parameters, includes quantum efficiencies from 2D scan data for each MCP-PMT



Hit pattern form one event



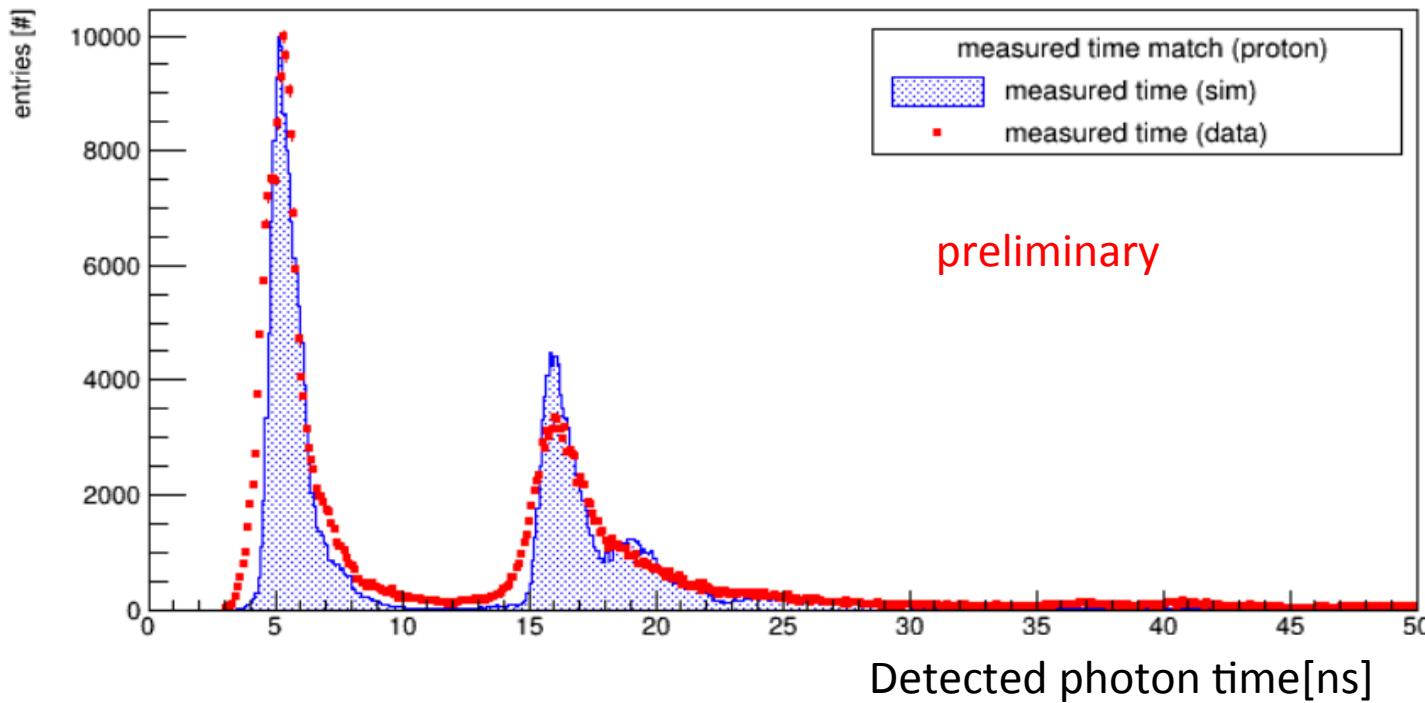
Hit pattern for proton-tagged data for the narrow bar with a 3-layer spherical lens and a 7 GeV/c beam with a polar angle of 20°.



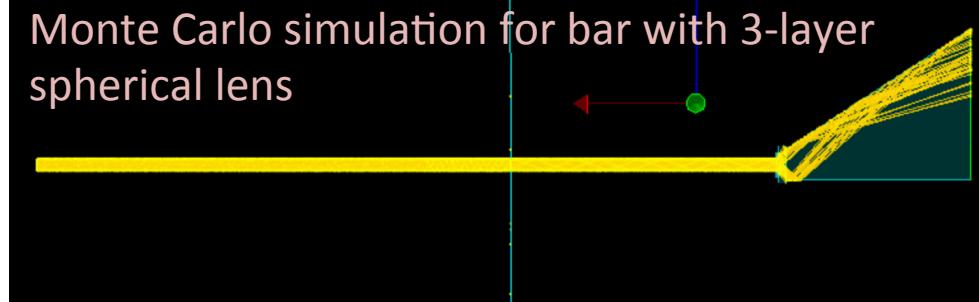
Hit pattern proton GEANT simulation

Photon time

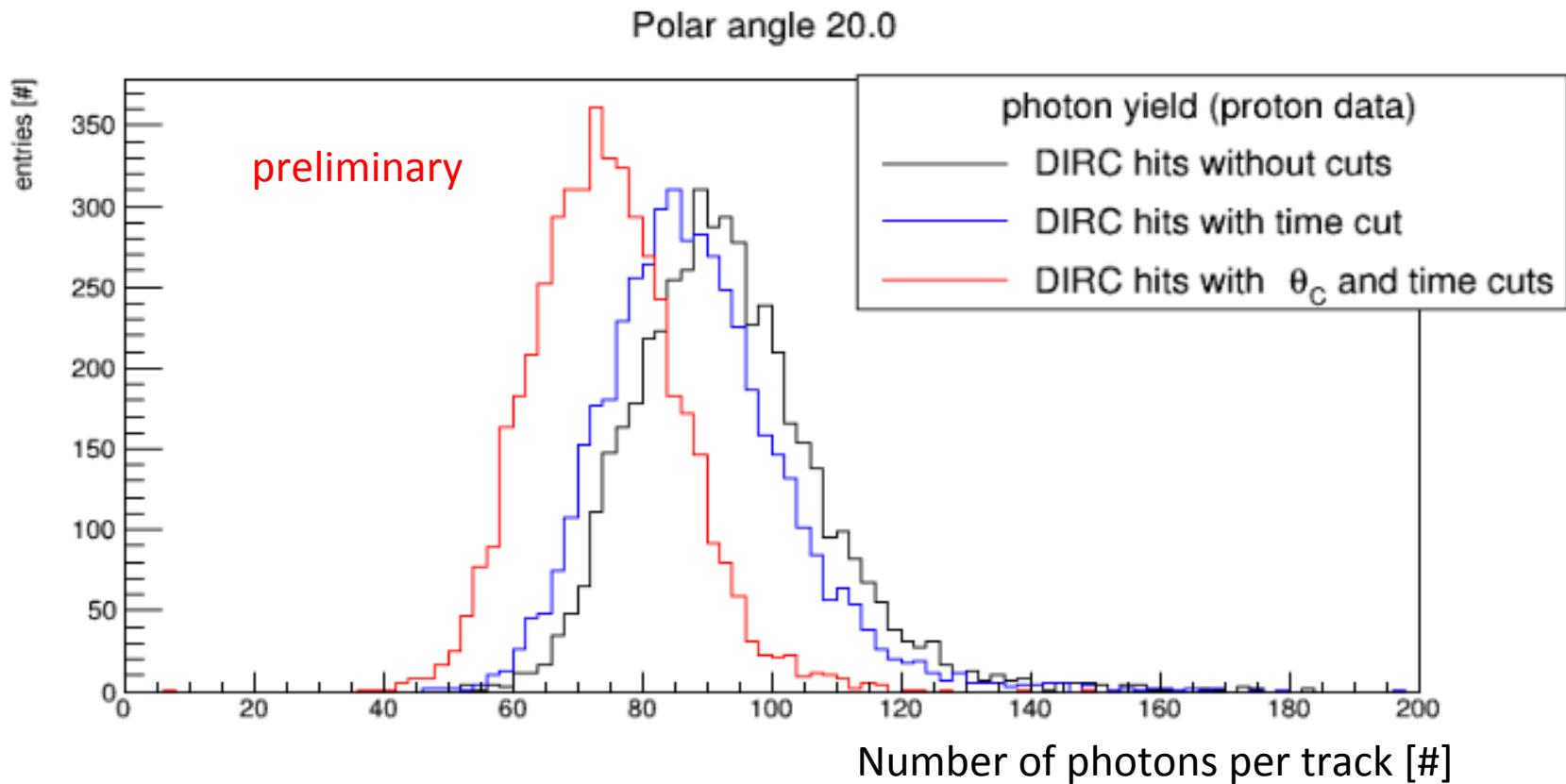
Polar angle 90.0



Measured photon time for protons with 7 GeV/c momentum and 90° polar angle



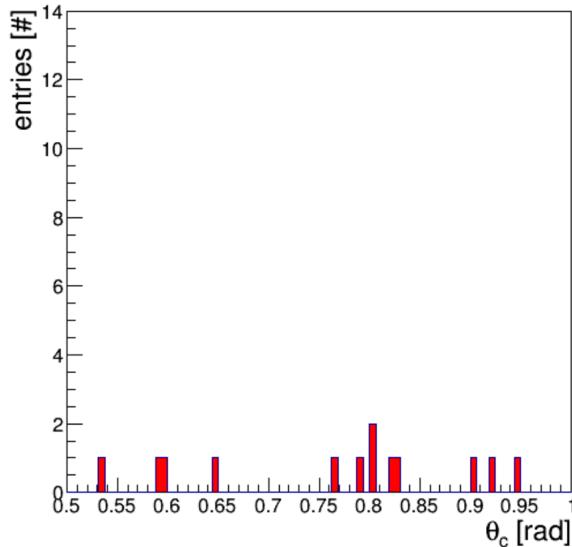
Photon Yield



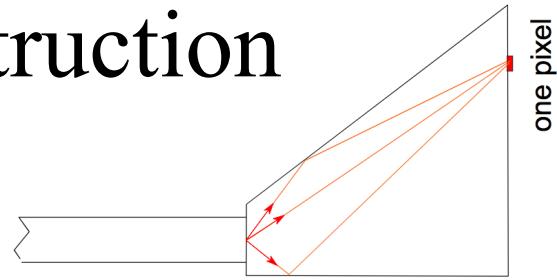
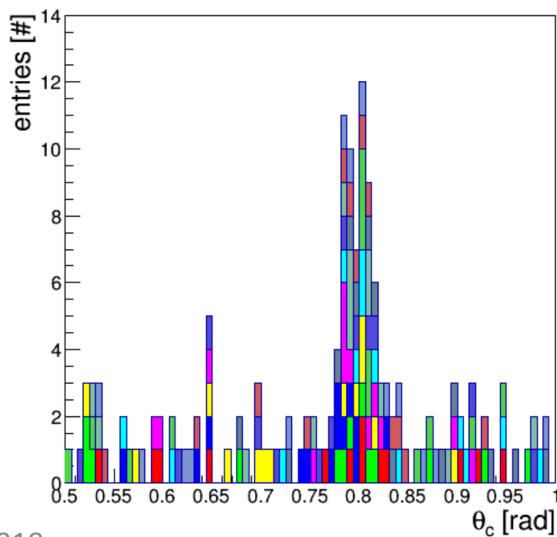
Photon yield for a beam with 7 GeV/c momentum and 20° polar angle.

Geometrical Reconstruction

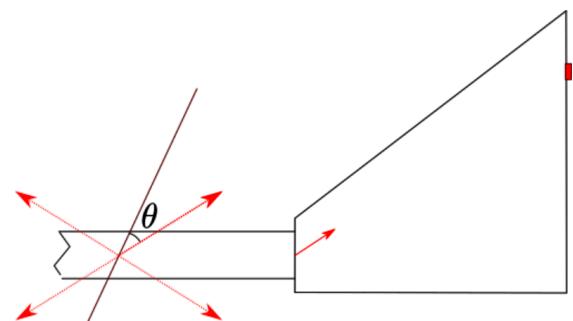
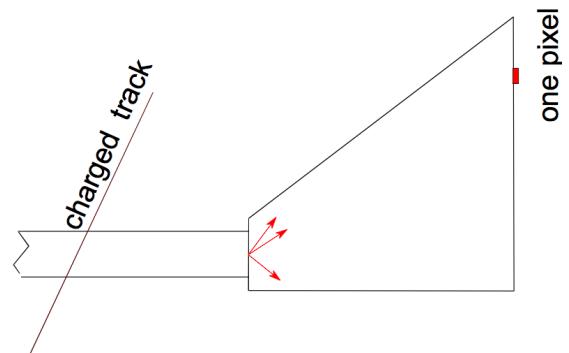
number of photons: 1



number of photons: 12



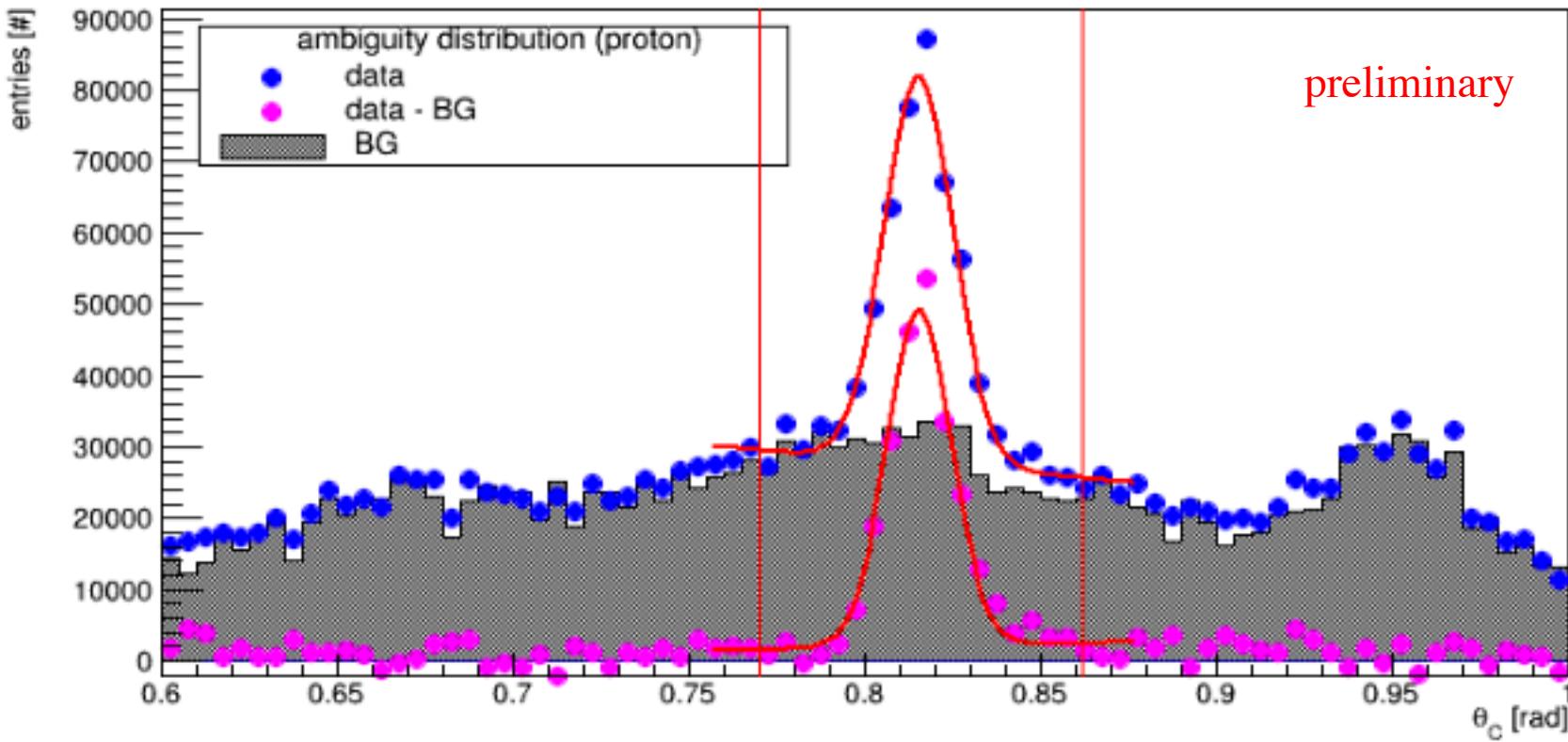
Look-Up Table creation: store direction at the end of the radiators for each hit pixel



Reconstruction: direction from LUT for hit pixels are combined with charge track direction

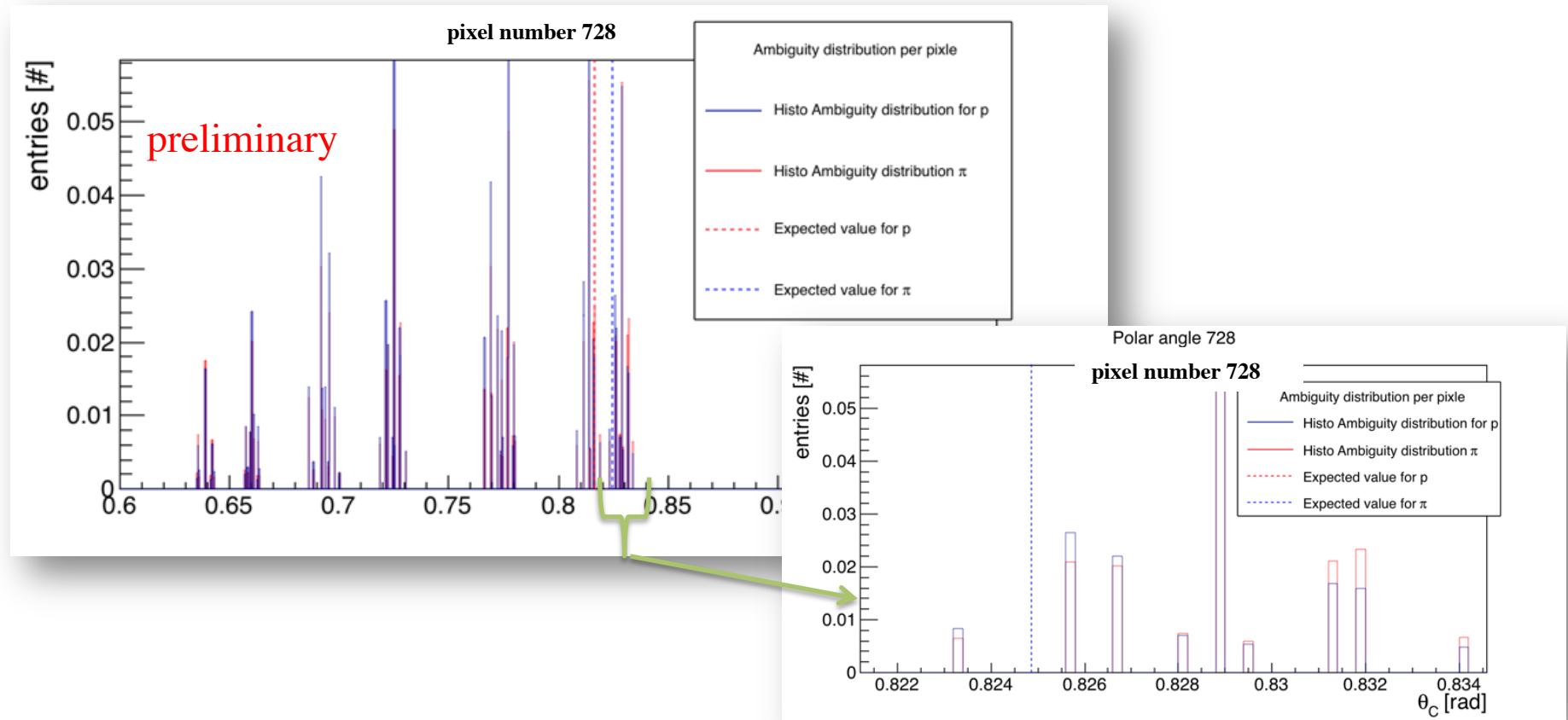
Single Photon Cherenkov Angle distribution

Polar angle 30.0



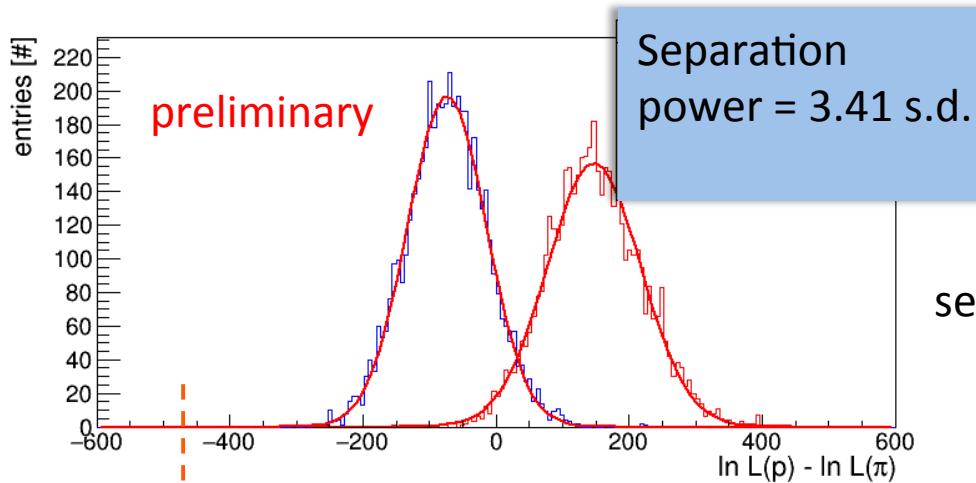
Single photon Cherenkov angle distribution for proton-tagged data compared with simulations for the narrow bar and the 3-layer spherical lens. The beam momentum was 7 GeV/c and the polar angle 30°.

Geometrical Reconstruction (Cherenkov PDF)



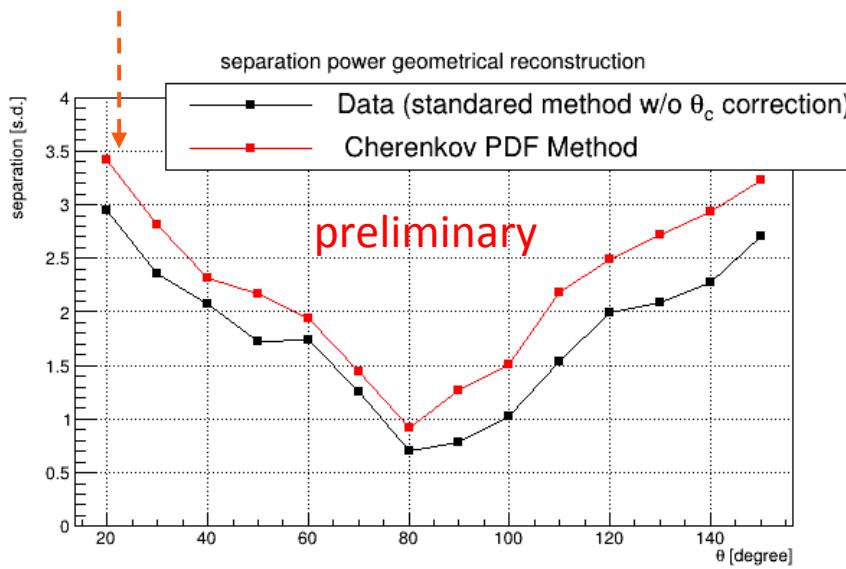
Creation of Cherenkov PDFs for proton-tagged and pion-tagged beam data for each prototype polar angle. The Cherenkov PDF Histograms were normalized based on number of photons

Separation Power (Cherenkov PDF)



$$\text{separation power} = \frac{|\mu_1 - \mu_2|}{0.5(\sigma_1 + \sigma_2)}$$

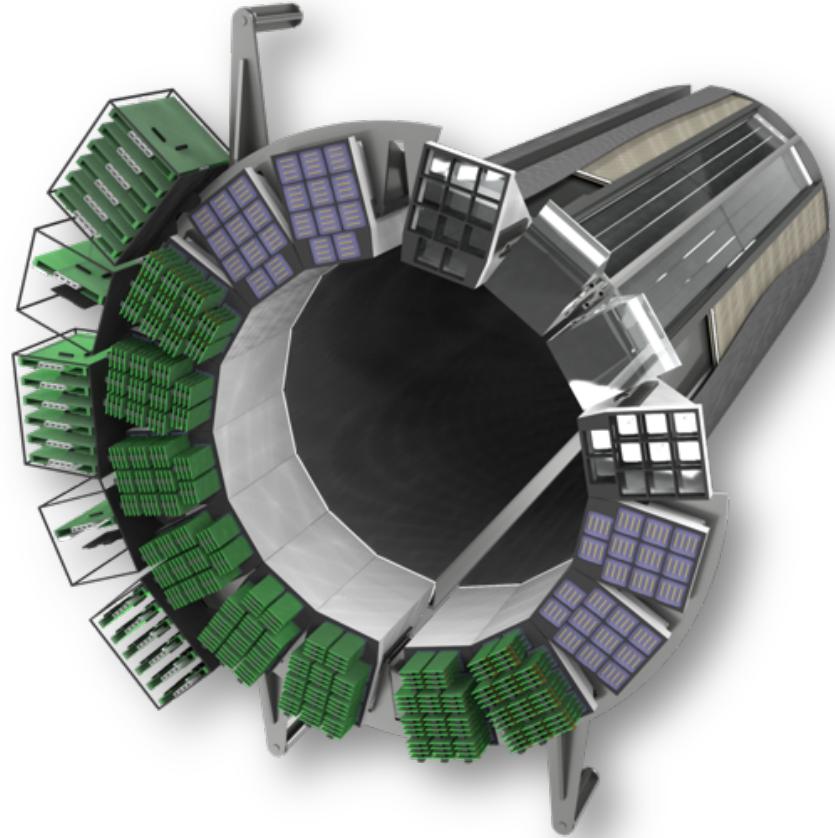
Proton-pion log-likelihood difference distributions 20°



Separation power vs prototype polar angle

Outlook

- Test beam was successful
- Improved pi/p separation compared to 2016
- Validated 3-layer spherical lens and 3-layer cylindrical lens
- Good agreement between data and simulations



Thank you for your attention