PANDA barrel DIRC prototype test beam 2017 at CERN
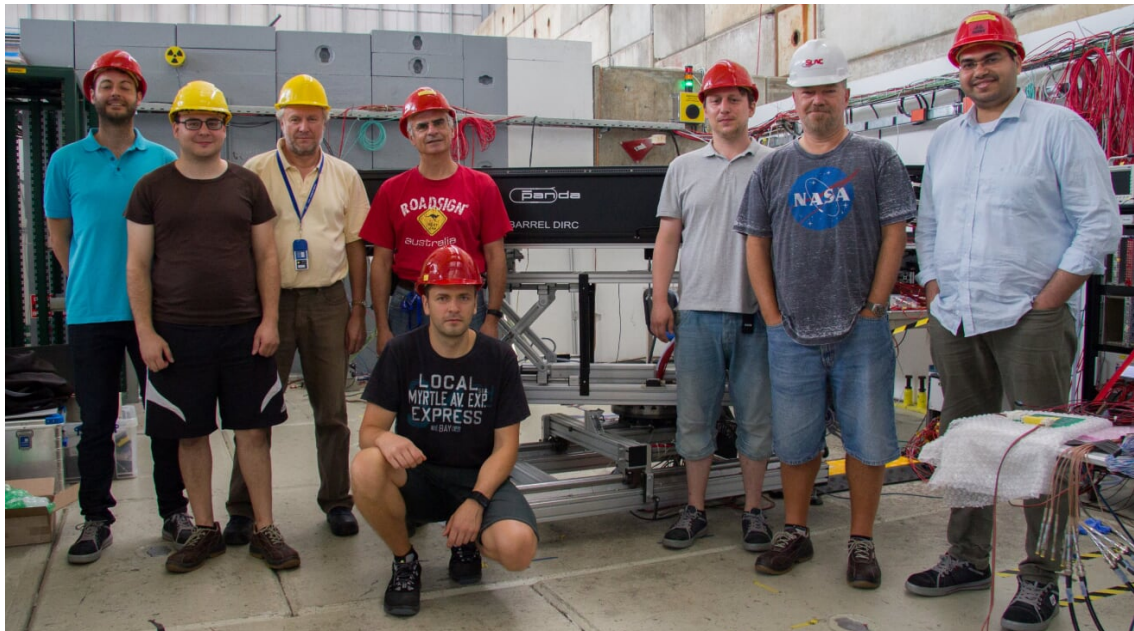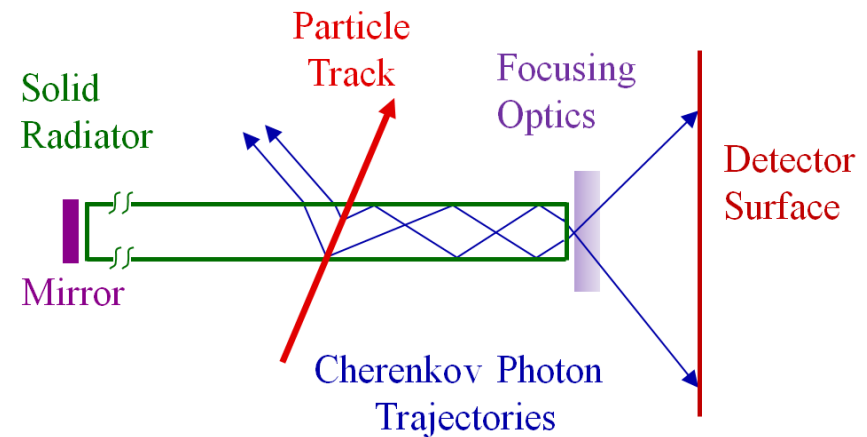
Ahmed Ali

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 $\theta_c, \phi_c, t_{propagation}$

➢ Likelihood for various charged particles

➢ $(e, \mu, \pi, K, p, ...)$

Particle Track

Solid Radiator

Focusing Optics

Detector Surface

Mirror

Cherenkov Photon Trajectories

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 cylindrical lens (eRD14 funding)
- narrow bar and plate as the radiators
- updated mechanics to study impact of azimuthal angle on hit pattern, PID performance
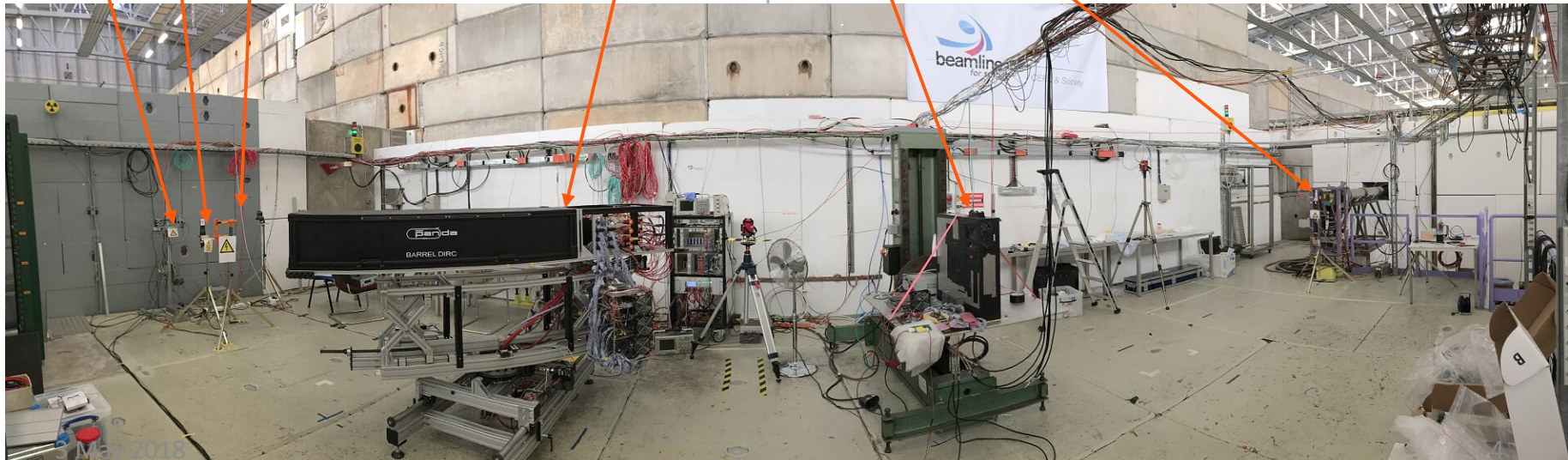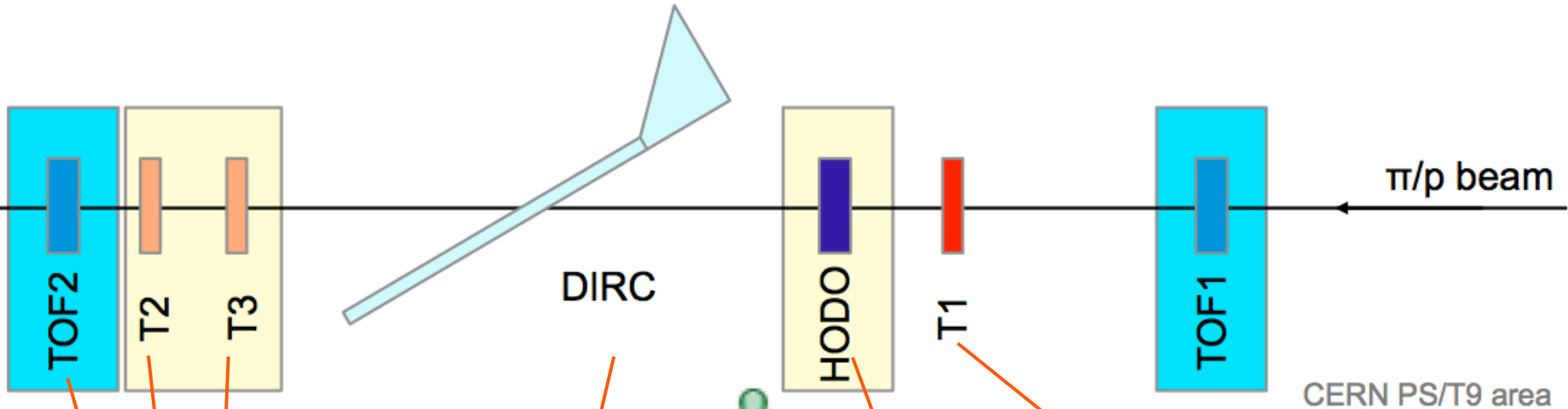
Test conditions:
- CERN PS/T9 area
- beam type: protons and pions
- beam momentum: 10, 9, 8, **7**, 6, 5, 4, 3, 2 GeV/c
- TOF PID
- different configurations of the DIRC prototype
- different DIRC prototype angles
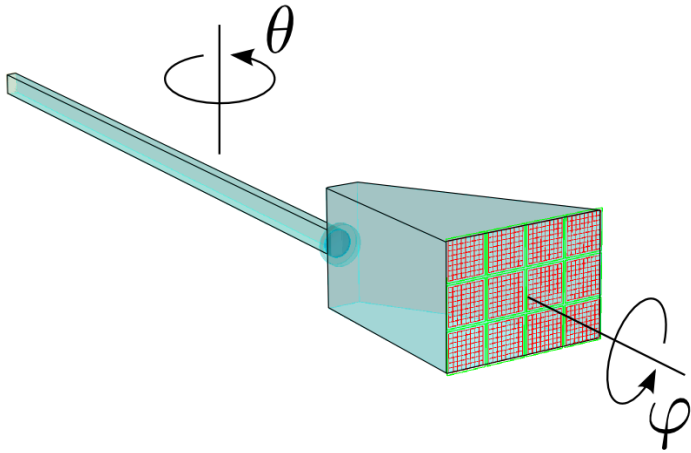
PANDA Barrel DIRC Prototype Test at CERN

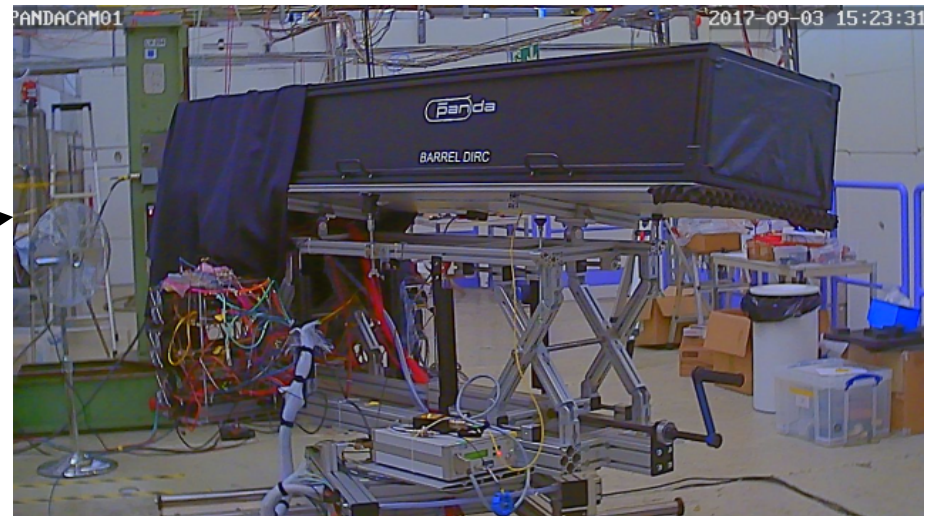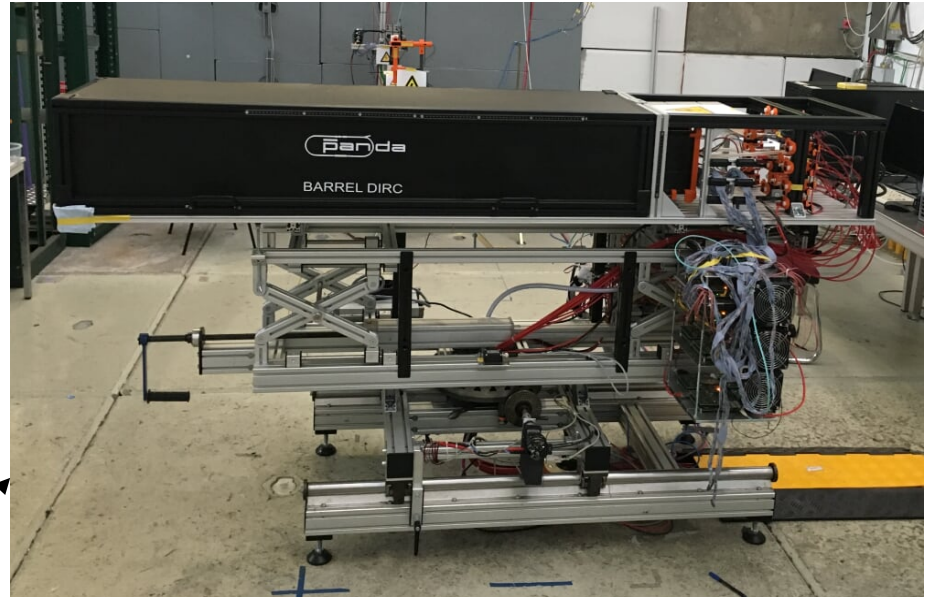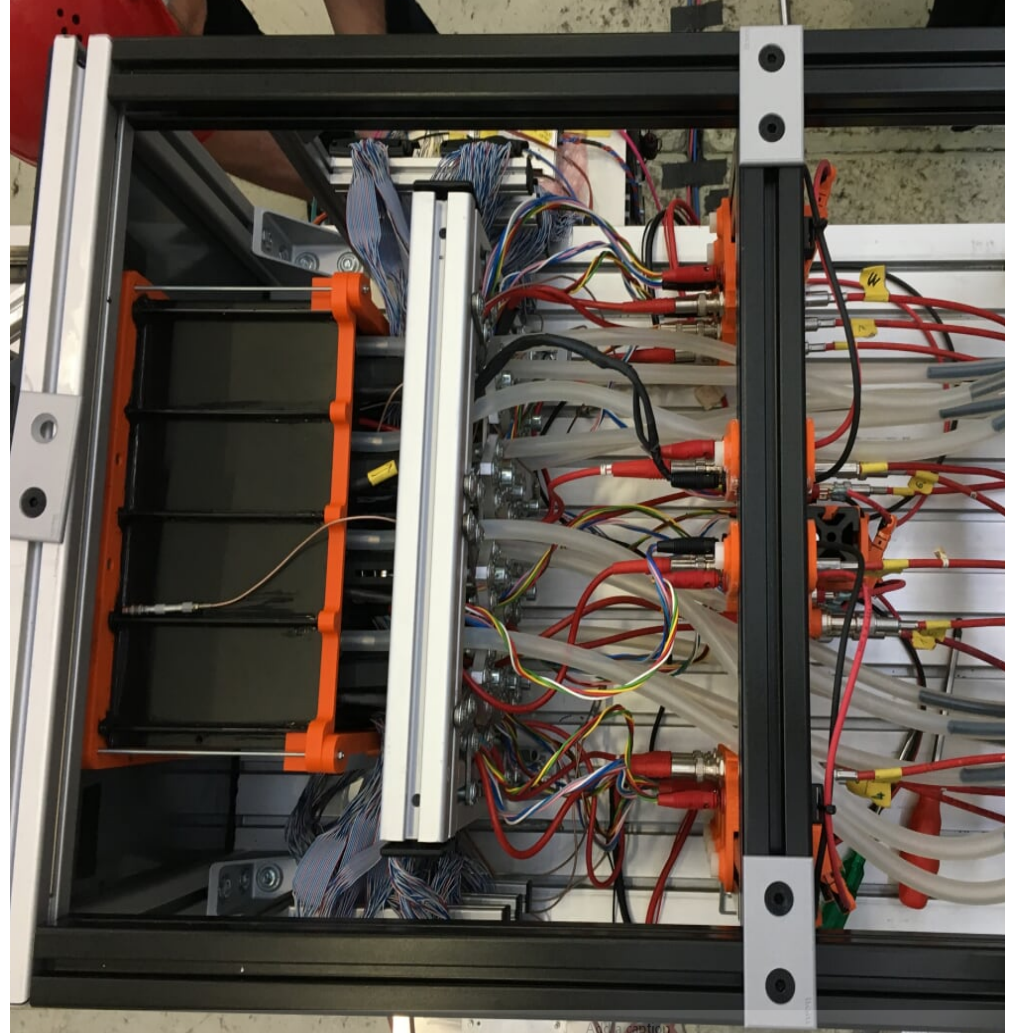# DIRC Prototype Photos

θ

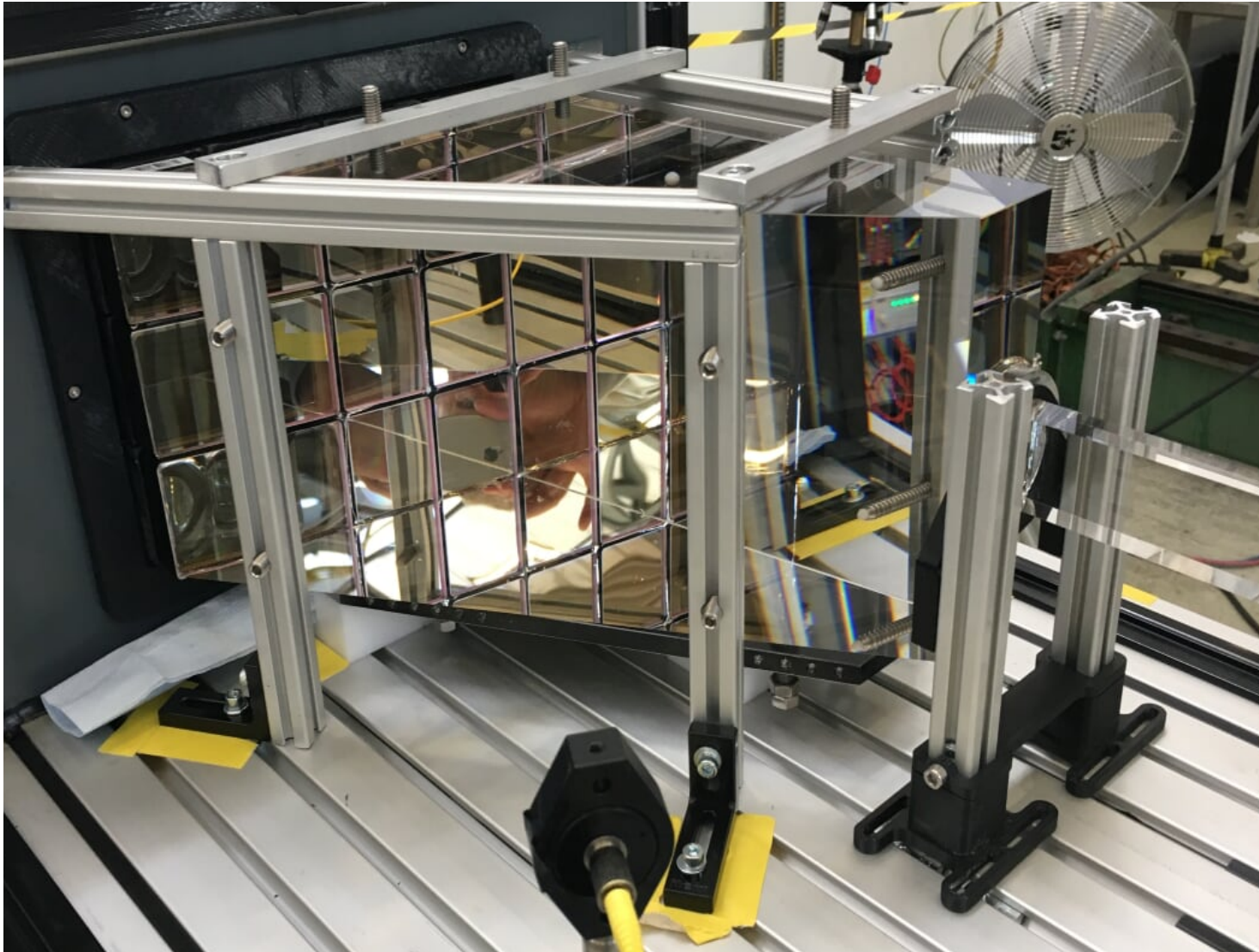φ

Polar angle 90°

Azimuthal angle 0°

Polar angle 25°

Azimuthal angle 10°

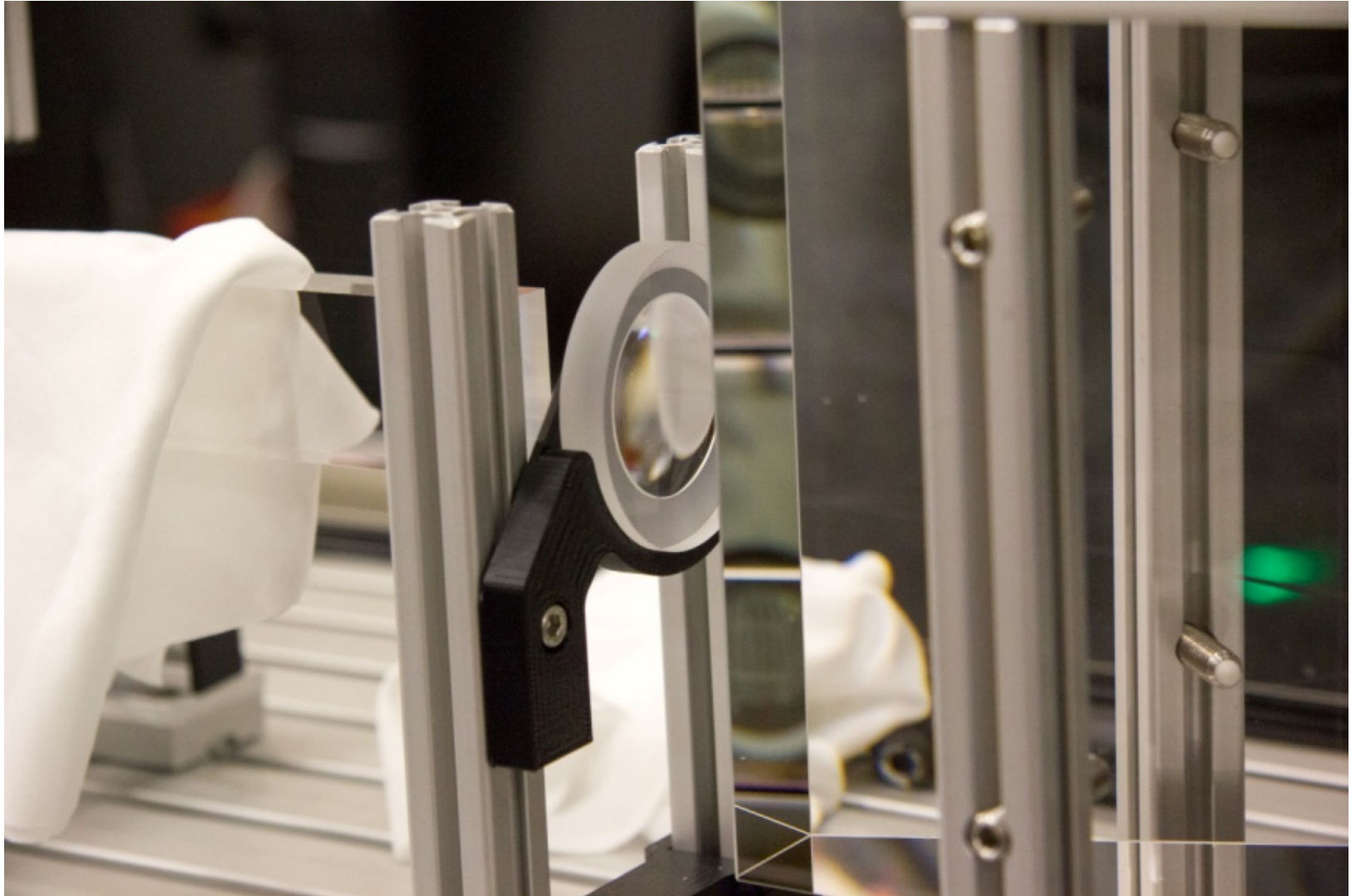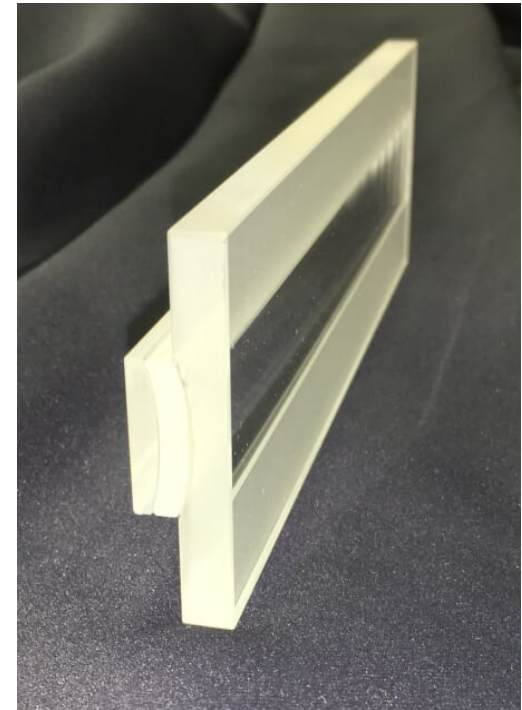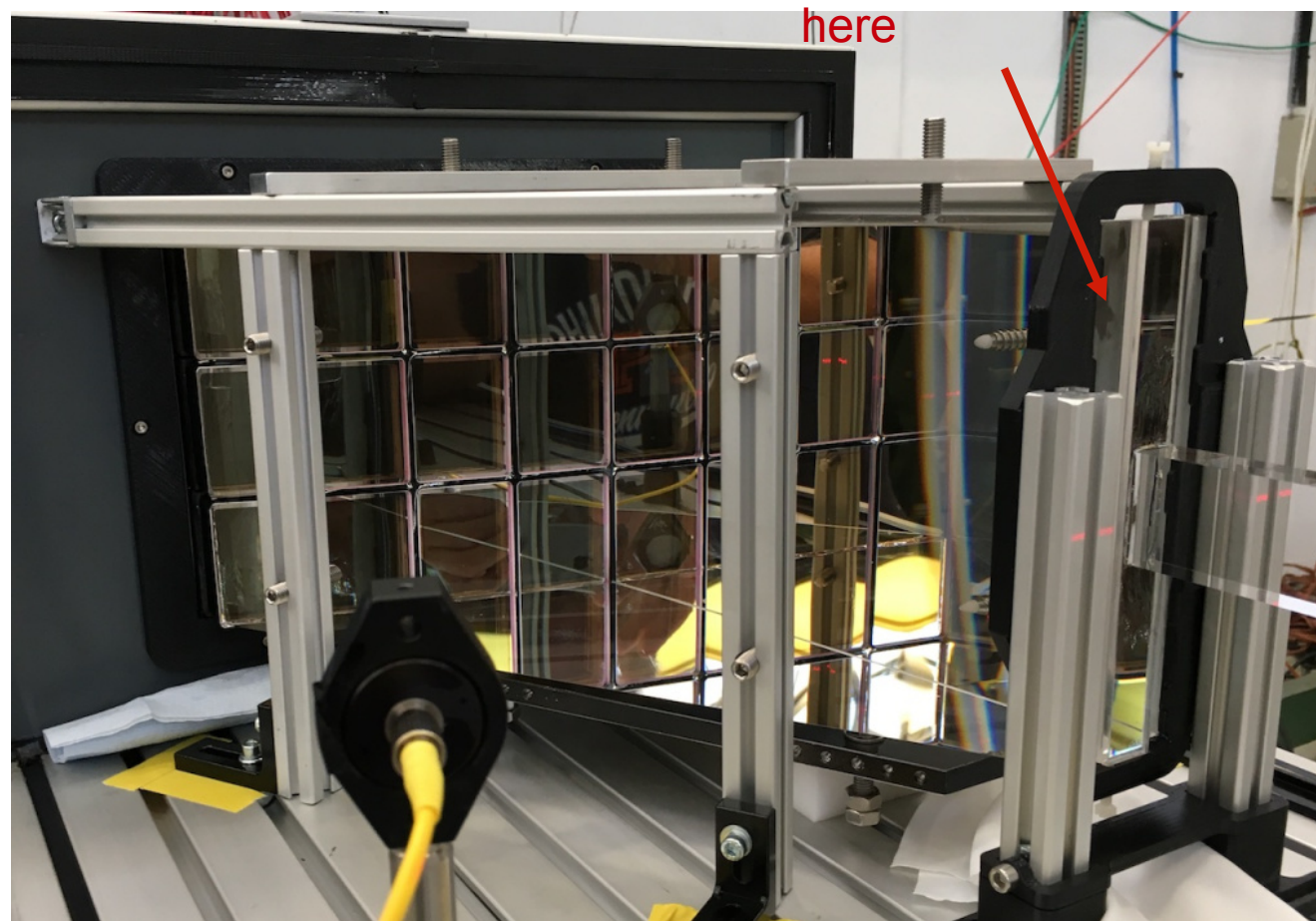# Readout Modules
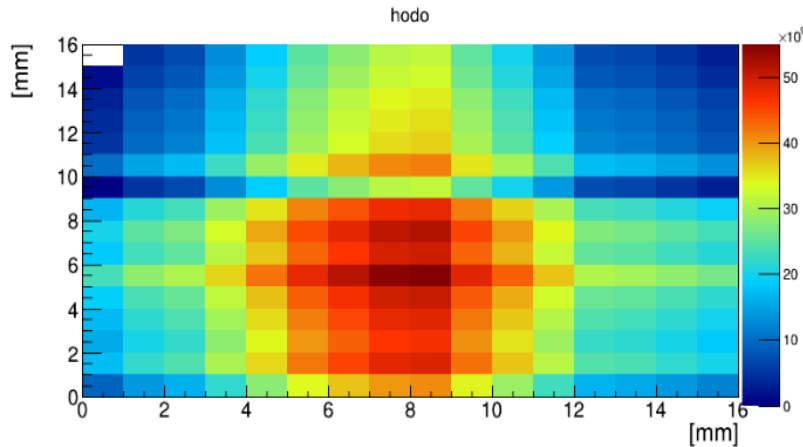
33 Degree Prism

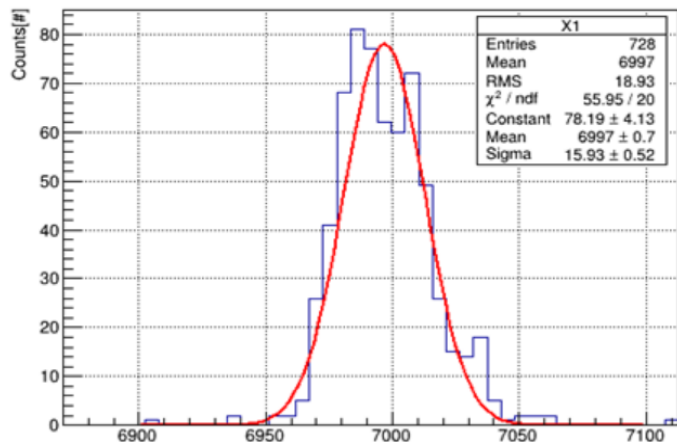# New 3-layer spherical lens

New 3-layer cylindrical lens
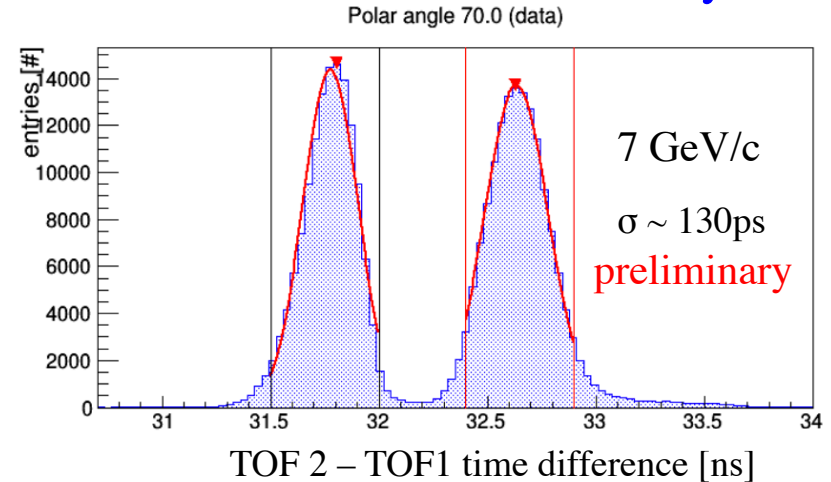

here

Beam Profile, Momentum and TOF PID

hodo

Beam profile from hodoscope
selection: 4 mm x 4 mm

beam momentum [MeV/c]

Beam momenta from each run:
stable with time p = 6997 +/- 16 MeV/c

TOF system

Polar angle 70.0 (data)

7 GeV/c

$\sigma \sim$ 130ps

preliminary

TOF 2 – TOF1 time difference [ns]

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

PID performance ecaluated for π/p at 7 GeV/c.
(Close match to π/K at 3.5 GeV/c.)

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
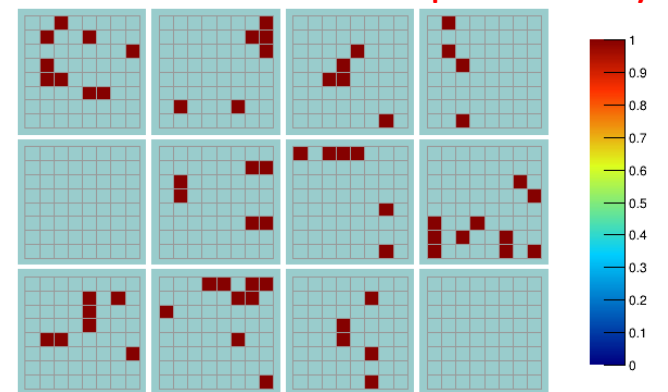- ❑ parameters, includes quantum efficiencies from 2D scan data for each MCP-PMT
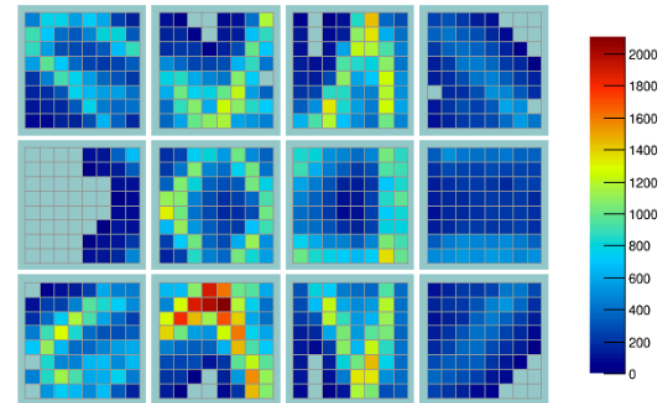
Hit pattern for proton-tagged data for the narrow bar with a 3-layer spherical lens and a 7 GeV/c beam with a polar angle of 20˚.
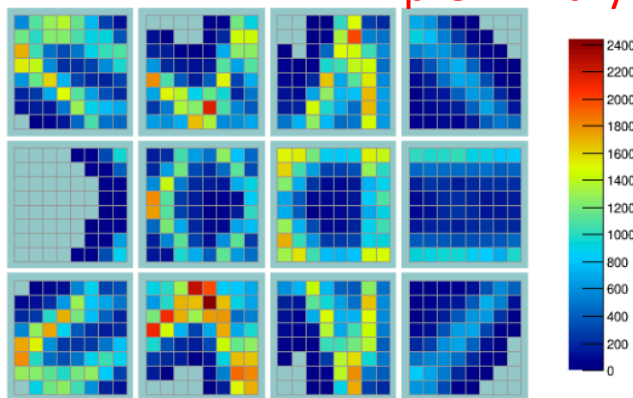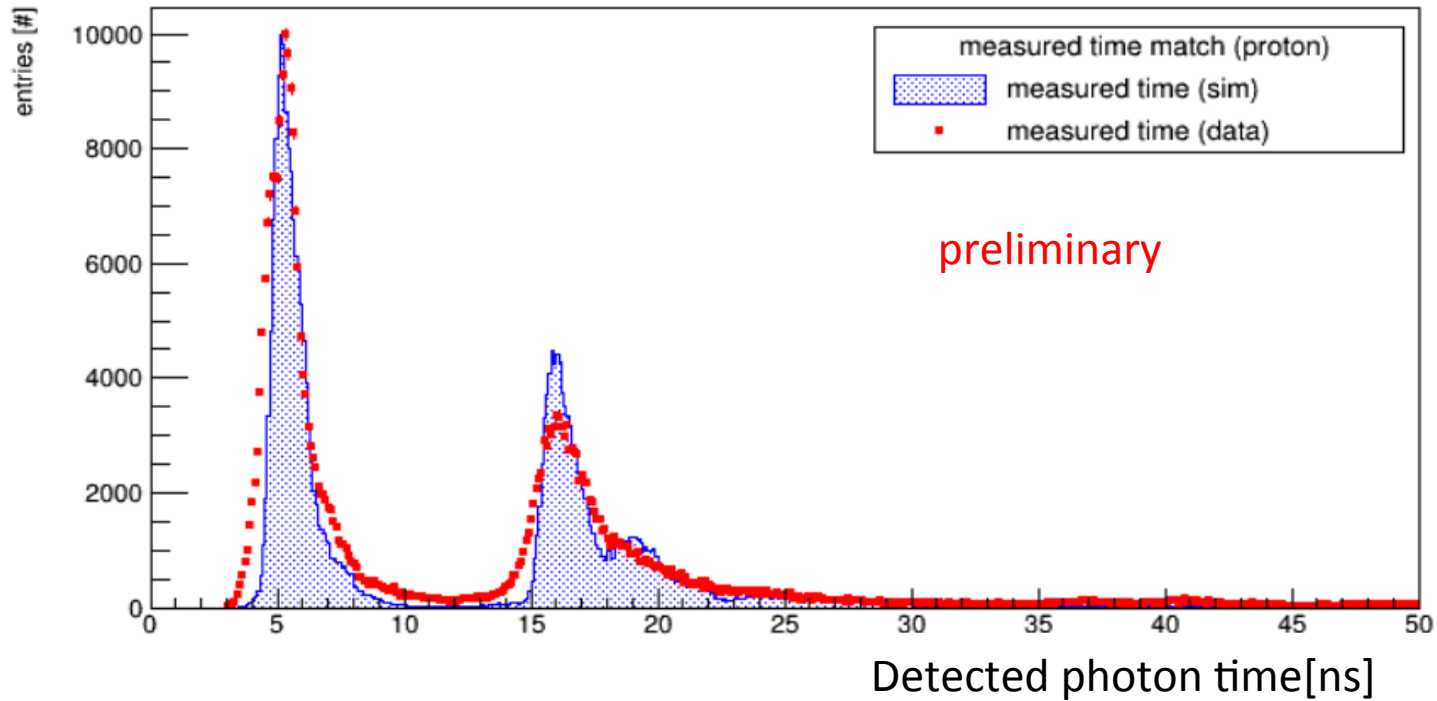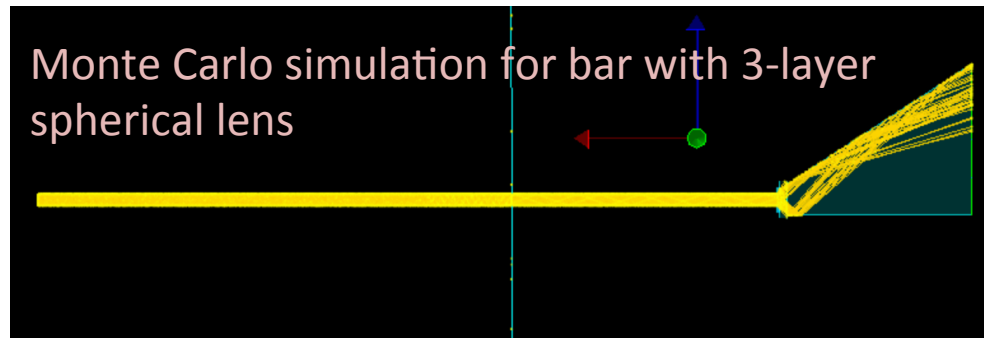
Hit pattern proton GEANT simulation

Hit pattern form one event

Photon time

Polar angle 90.0

preliminary

Detected photon time[ns]

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

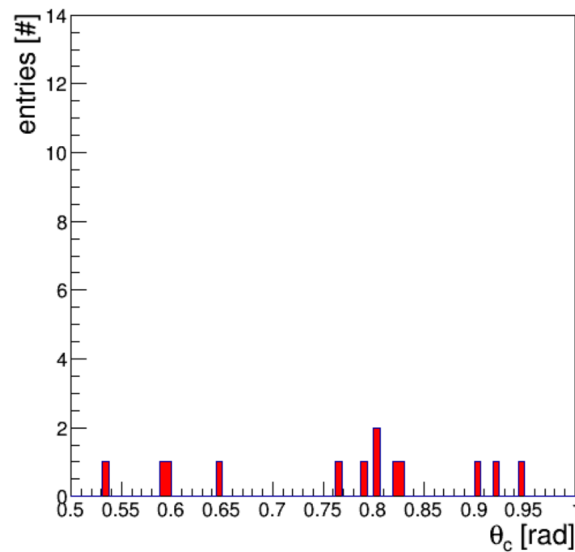Monte Carlo simulation for bar with 3-layer spherical lens
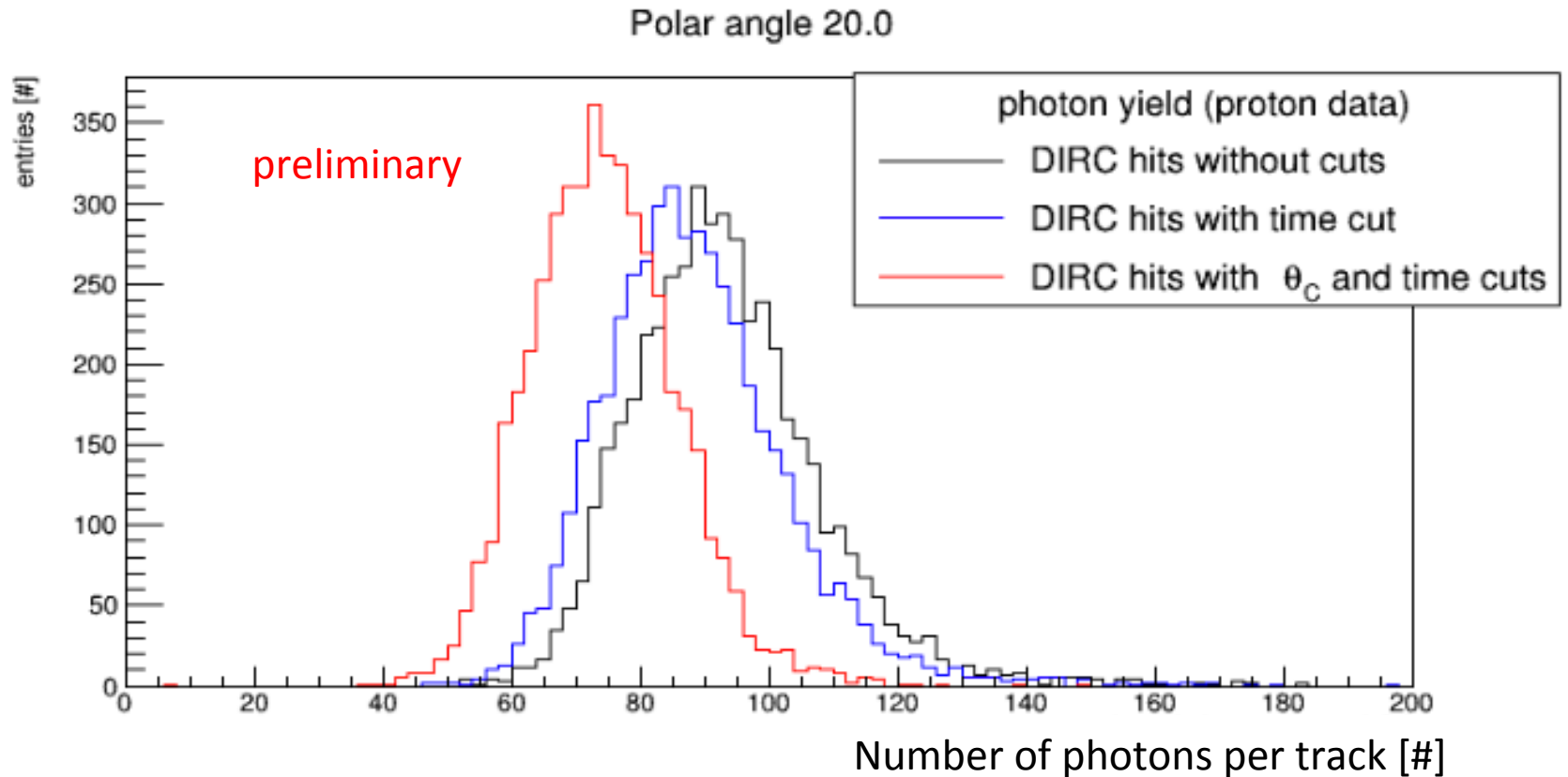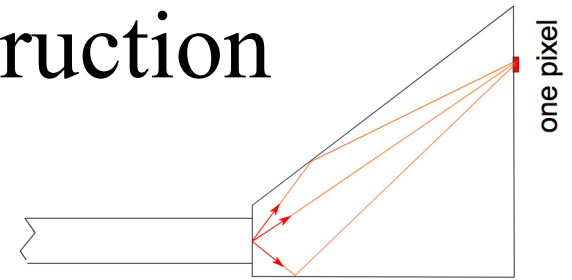
Photon Yield

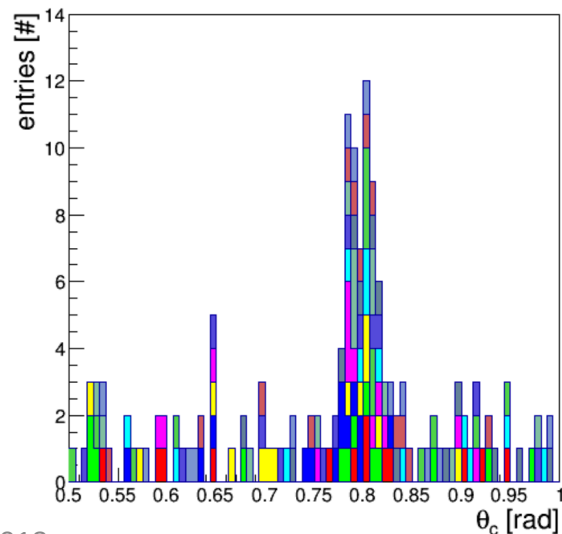
Photon yield for a beam with 7 GeV/c momentum and 20˚ polar angle.
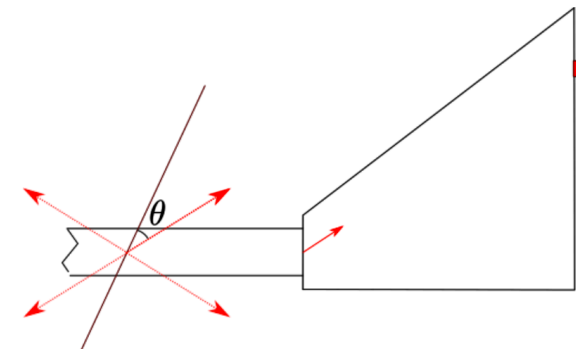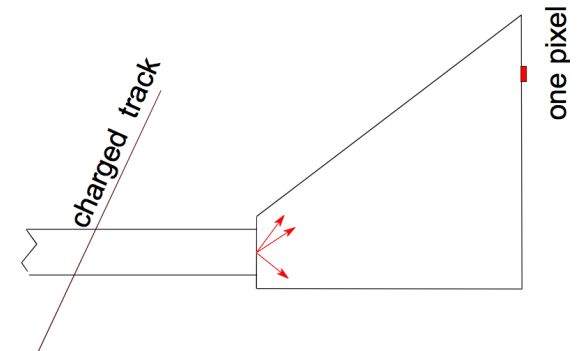
Geometrical reconstruction

number of photons: 1

Look-Up Table creation: store direction at the end of the radiators for each hit pixel
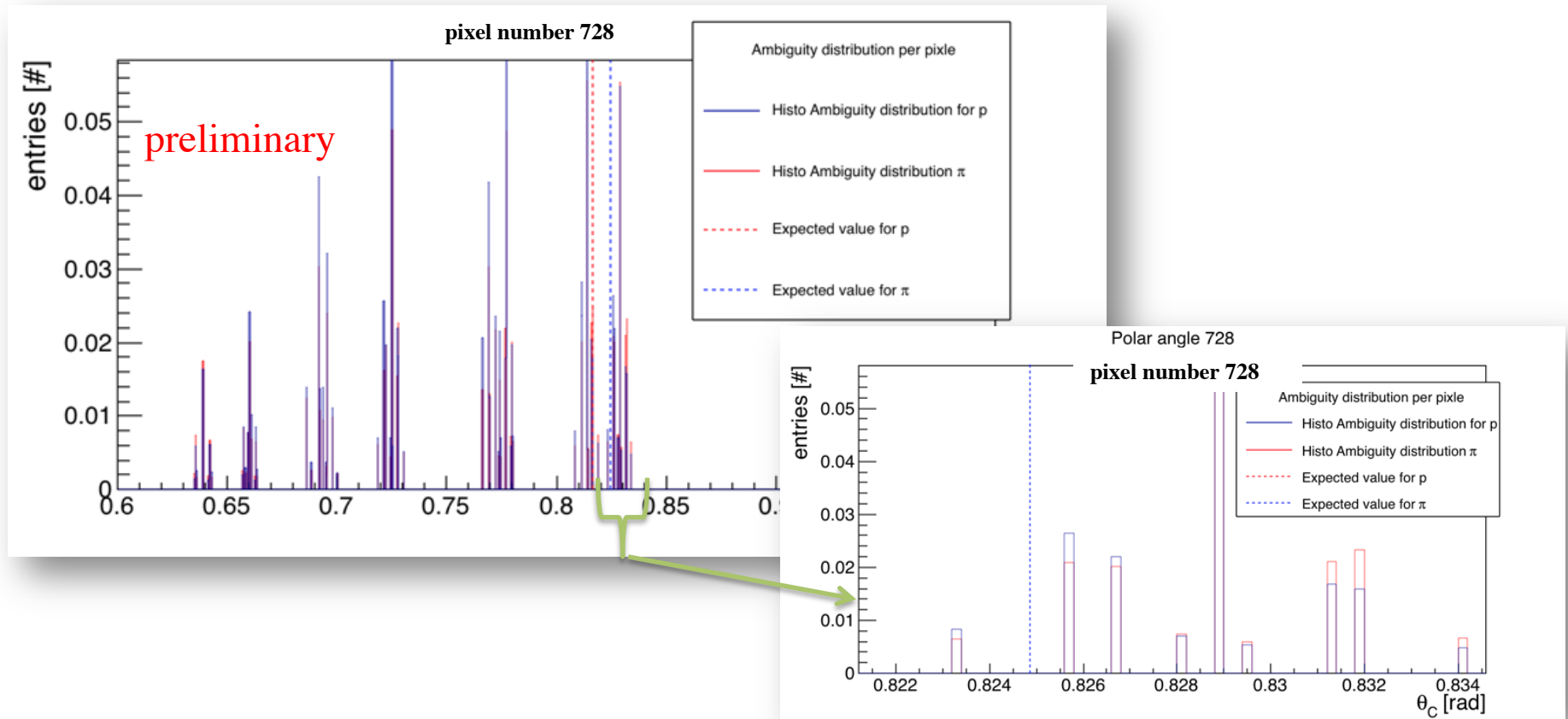
number of photons: 12

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

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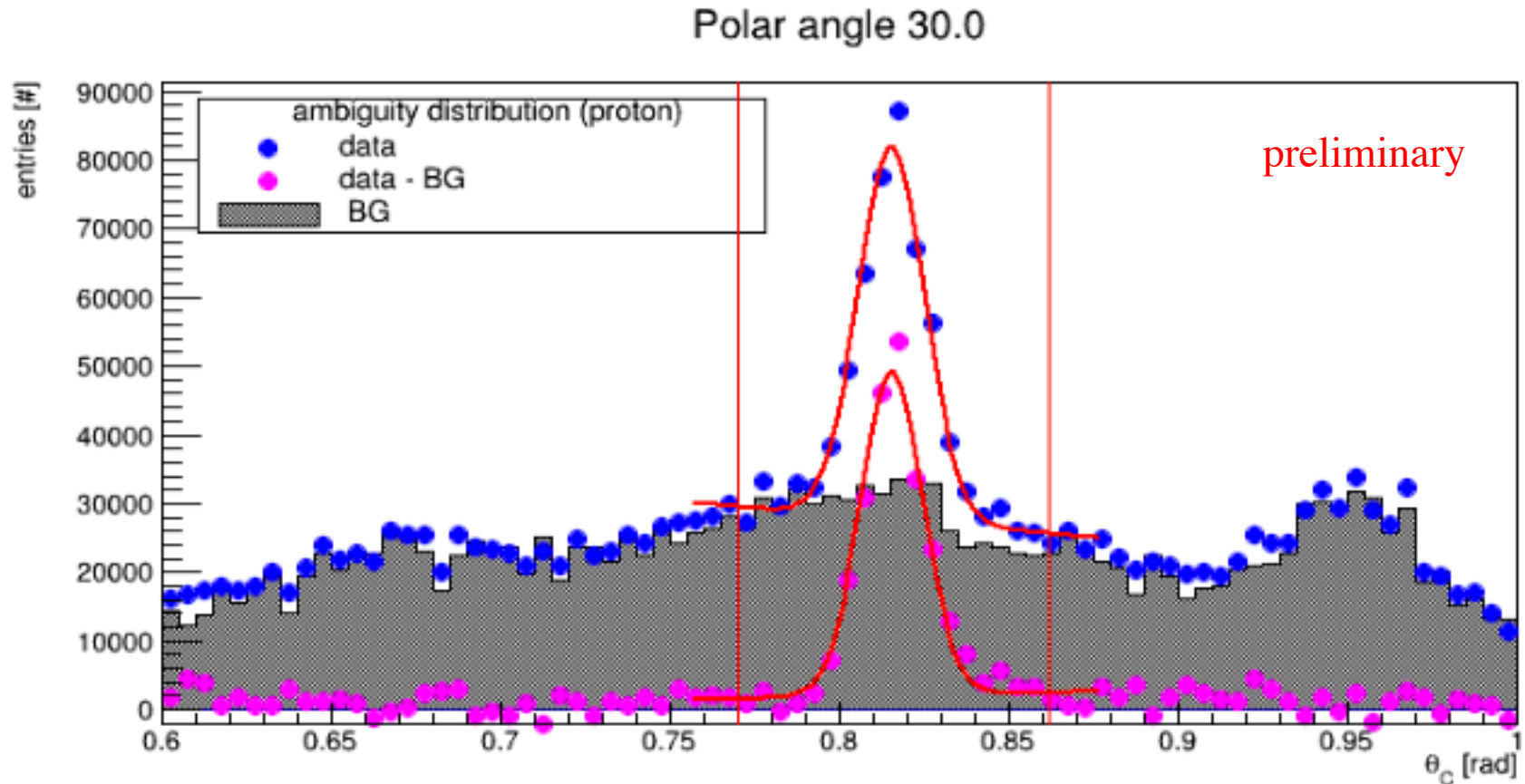
Single photon Cherenkov angle distribution for proton-tagged data compared with simulations for the narrow bar and the 3-layer spherical lens. The beam momentum was 7 GeV/c and the polar angle 30°.

# 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)

preliminary

Separation power = 3.41 s.d.
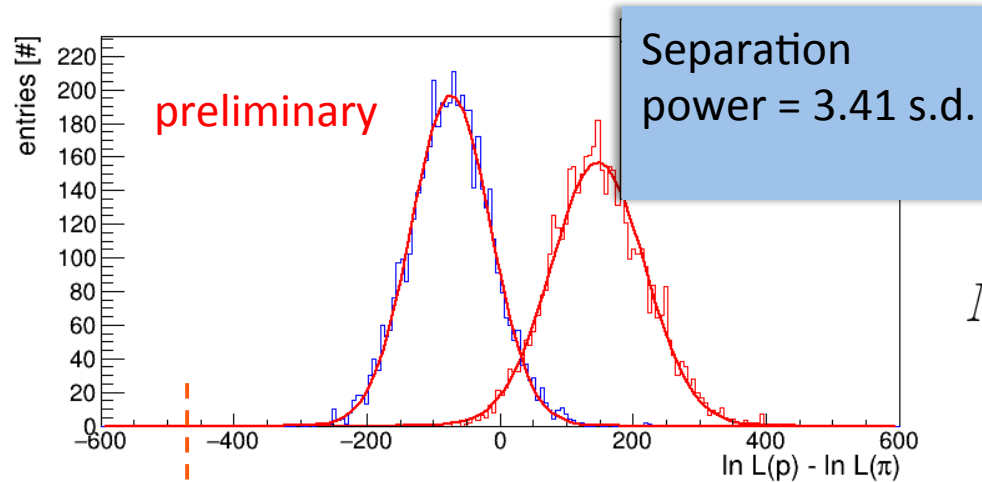
$$N_{\mathrm{sep}} = \frac{|\mu_1 - \mu_2|}{0.5(\sigma_1 + \sigma_2)}$$

Proton-pion log-likelihood difference distributions 20°

separation power geometrical reconstruction

— Data (standard method w/o θ_c correction)
— Cherenkov PDF Method

preliminary
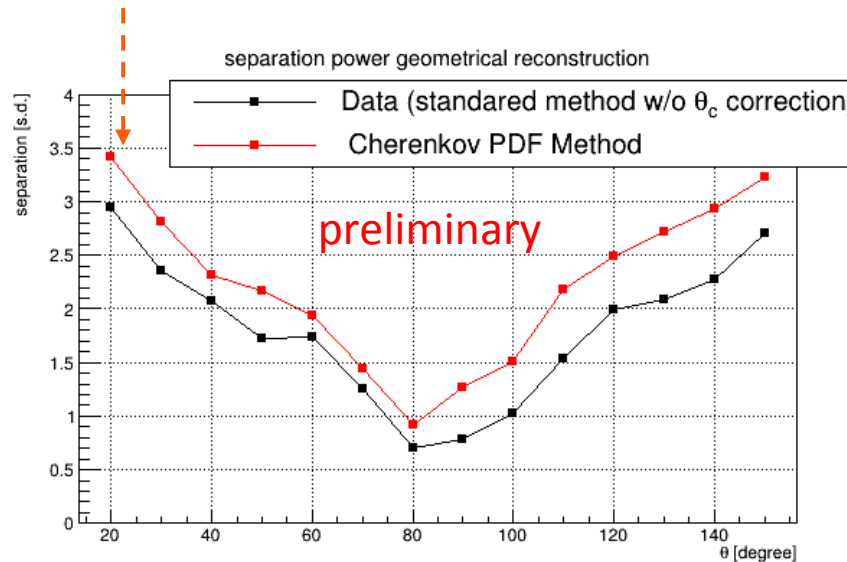
Separation power vs prototype polar angle

Summary

- ➢ Test beam was successful (recorded >1B triggers for different prototype config.)
- ➢ Time resolution of the system was determined to be ~250 ps
- ➢ Improved pi/p separation compared to 2016
- ➢ Validated 3LC lens
- ➢ Good agreement between data and simulations

Thank you for your attention