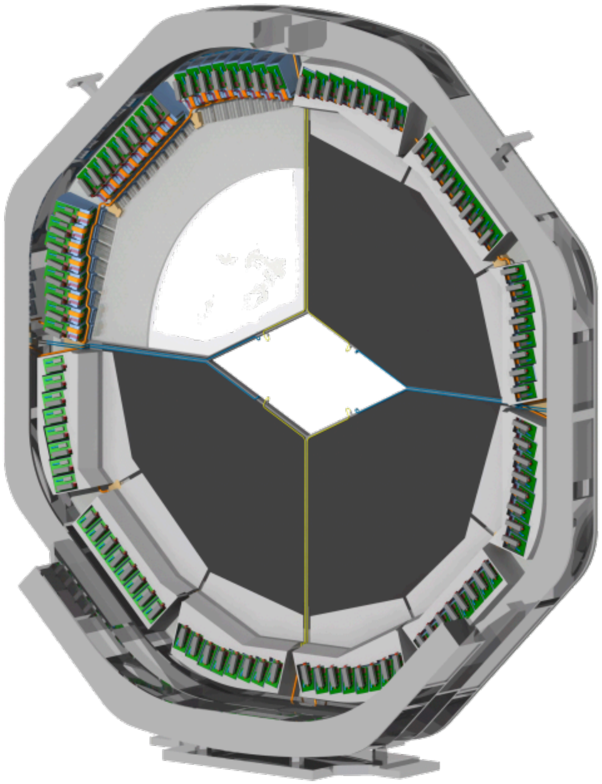
Status of the PANDA Endcap Disc DIRC Project



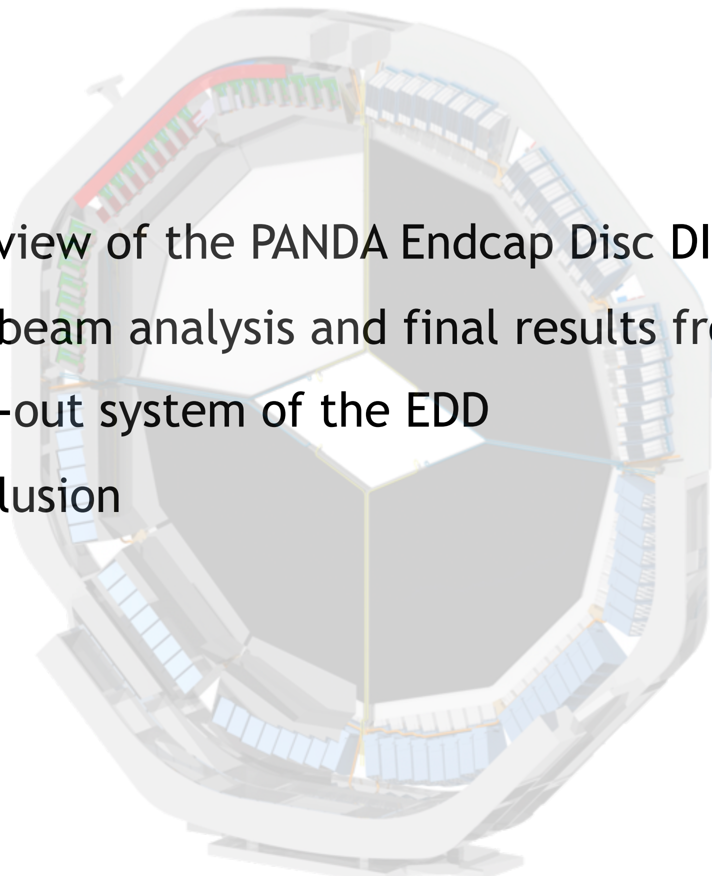
Simon Bodenschatz, Lisa Brück, Michael Düren, Avetik Hayrapetyan, Jan Hofmann, Sophie Kegel, İlknur Köseoğlu-Sari, Jhonatan Pereira de Lira, Mustafa Schmidt, Marc Strickert

DIRC 2019: Workshop on fast Cherenkov detectors - 2019/09/12

Bundesministerium für Bildung und Forschung
JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN
HGS-HIRe for FAIR Helmholtz Graduate School for Hadron and Ion Research
GSI Helmholtzzentrum für Schwerionenforschung GmbH
HIC for FAIR Helmholtz International Center
panda

Outline

1. Overview of the PANDA Endcap Disc DIRC
2. Test-beam analysis and final results from 2018
3. Read-out system of the EDD
4. Conclusion



The DIRCs in PANDA

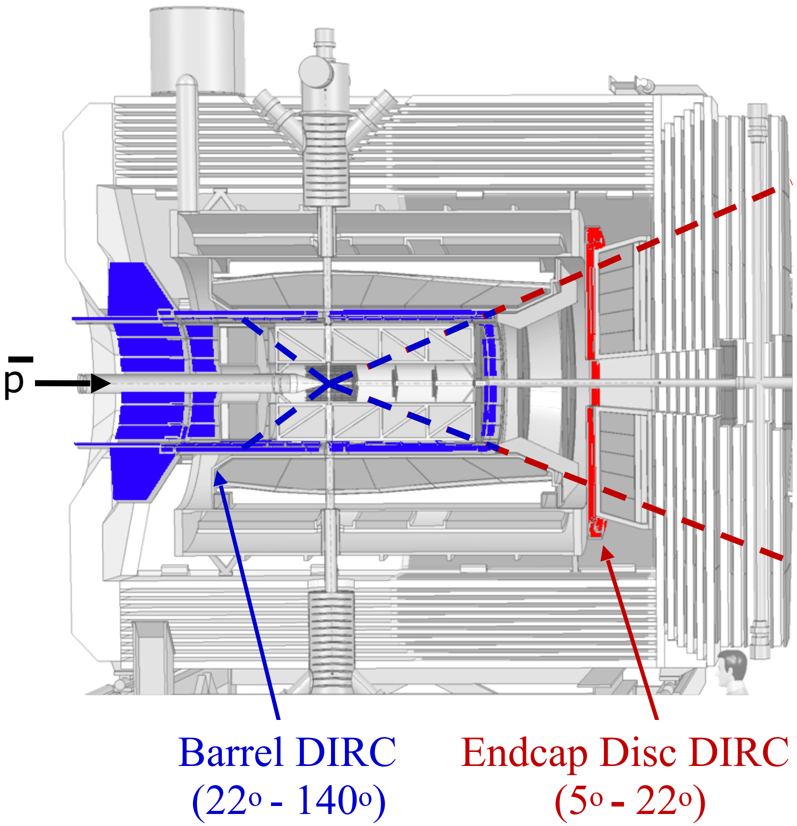
Two DIRC Detectors in target spectrometer for particle identification:

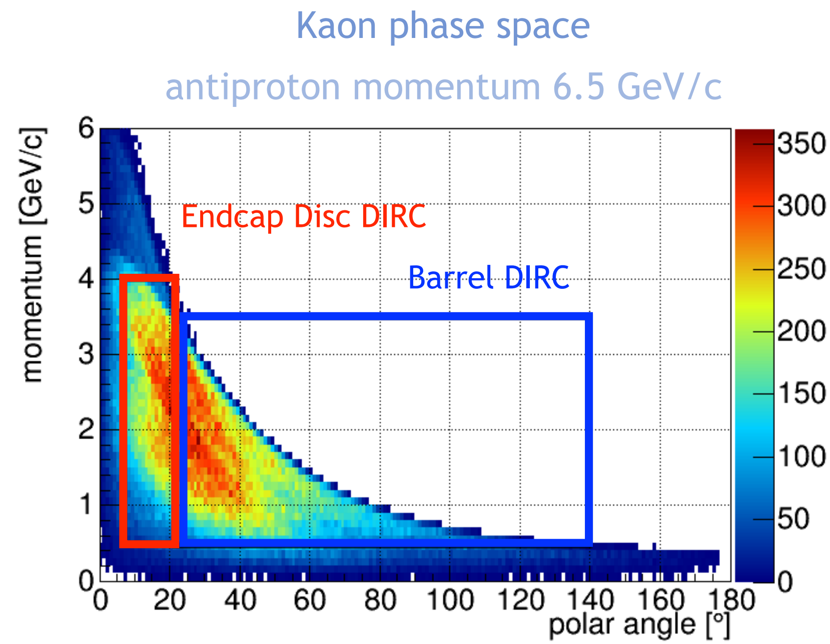
- Barrel DIRC Goal:

  3. s.d. π/K separation up to 3.5 GeV/c

- Endcap Disc DIRC Goal:

  3 s.d. π/K separation up to 4 GeV/c

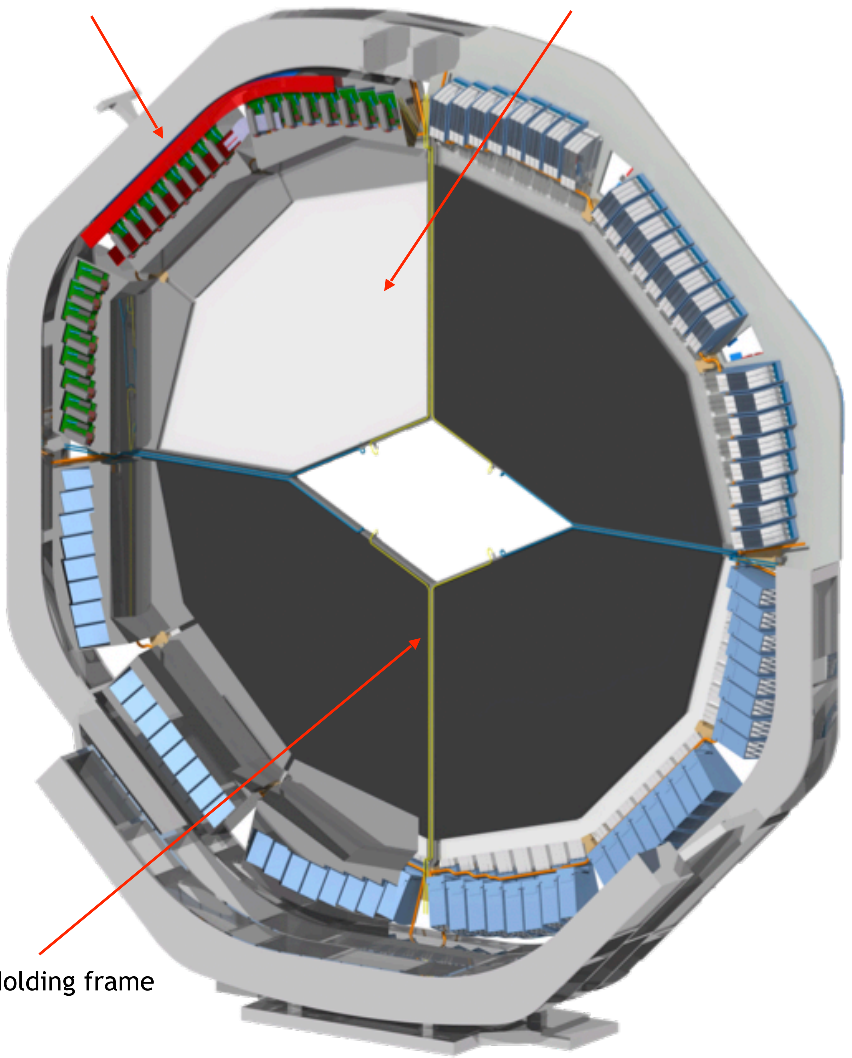




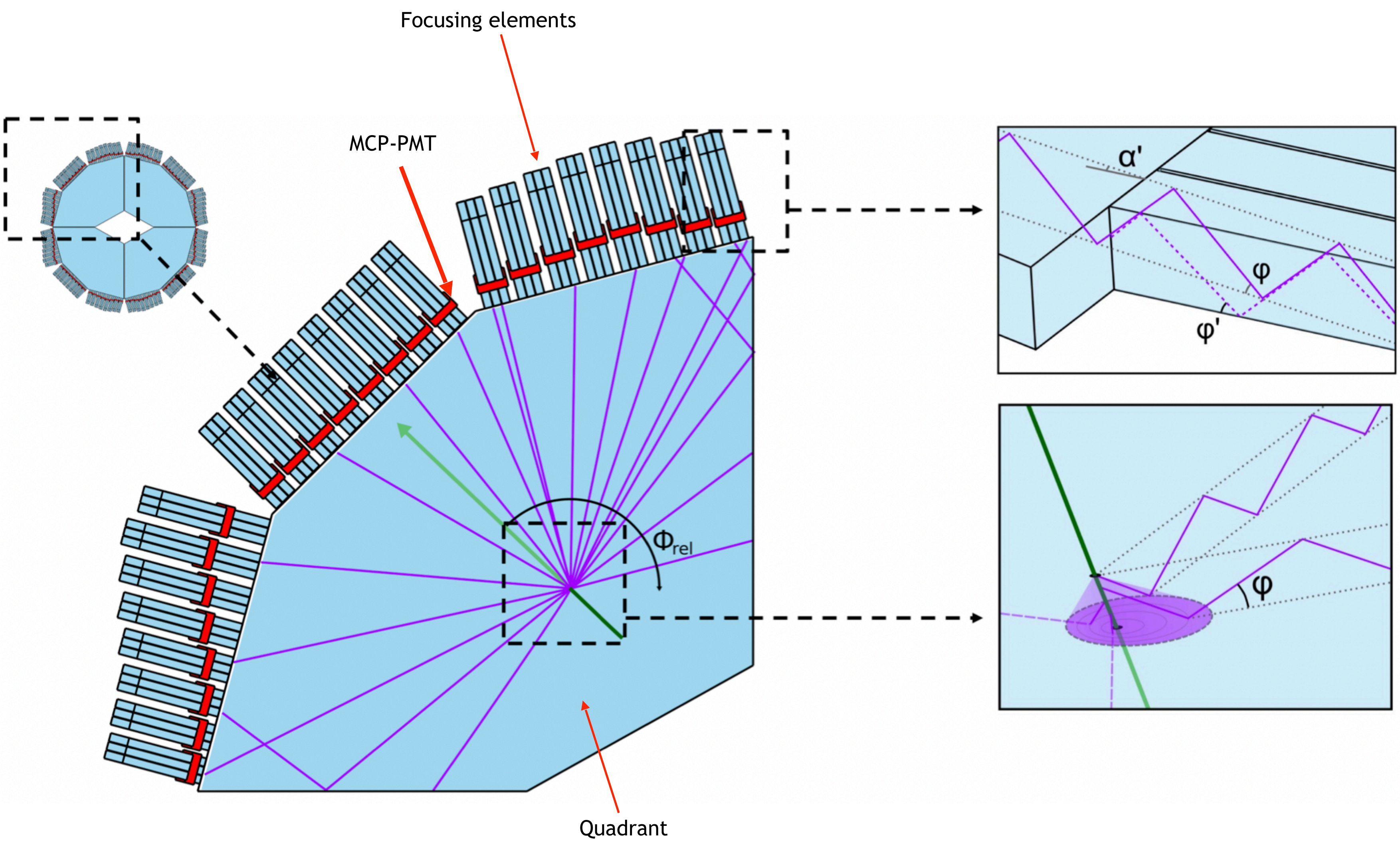
Full Coverage: Combination of Barrel and Disc DIRC

Overview of the EDD

- 4 independent quadrants,
  highly polished fused silica (Quartz), 20 mm thickness in z direction, 1056 mm outer radius
- Holding Frame:
  Stabilizing cross for all 4 independent quadrants
- Focusing optics:
  Focusing elements convert angle to position information, fused silica bars and expansion volume
- ASIC based readout electronics:
  Each readout module (ROM): 5 ASICs ,1 MCP-PMT.
- Sensors: 96 MCP-PMT sensors with highly segmented anode
- TofPET2 ASIC readout:
  24 (ROM)s per quadrant , ~28,800 pixel
  ToFPET2: compatible with positive signals

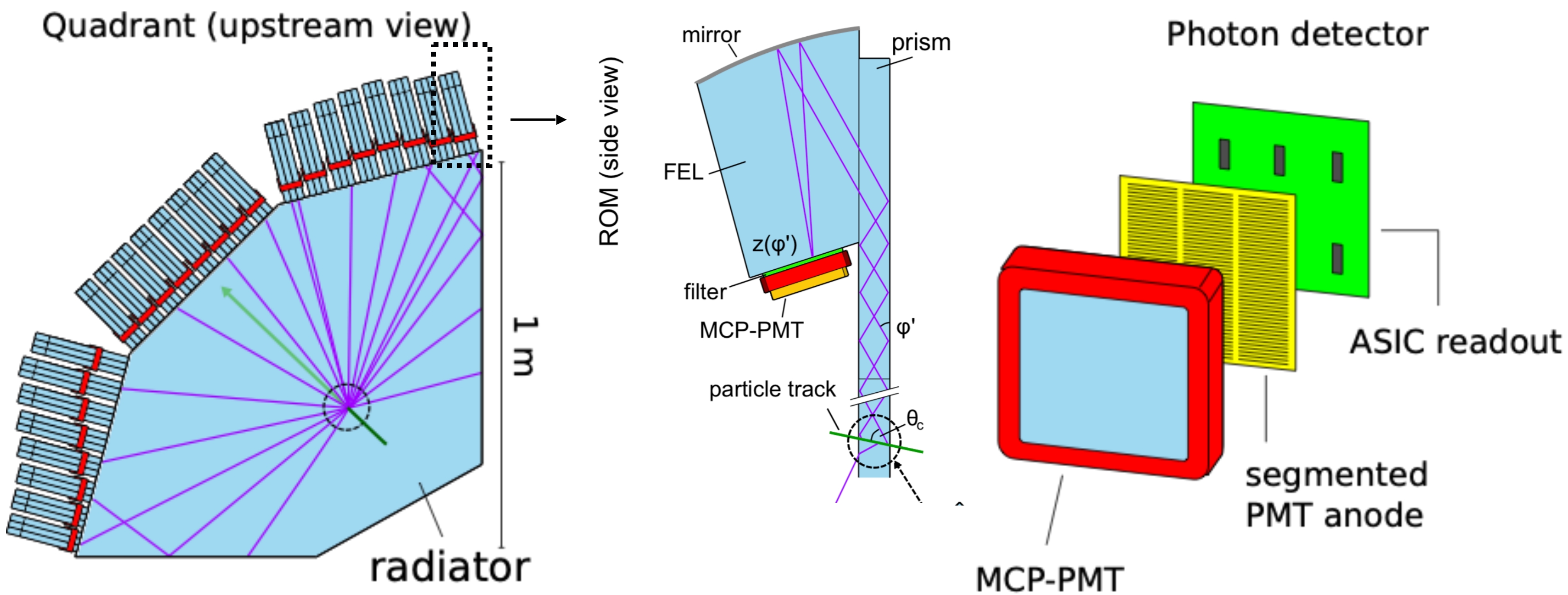


EDD Principle

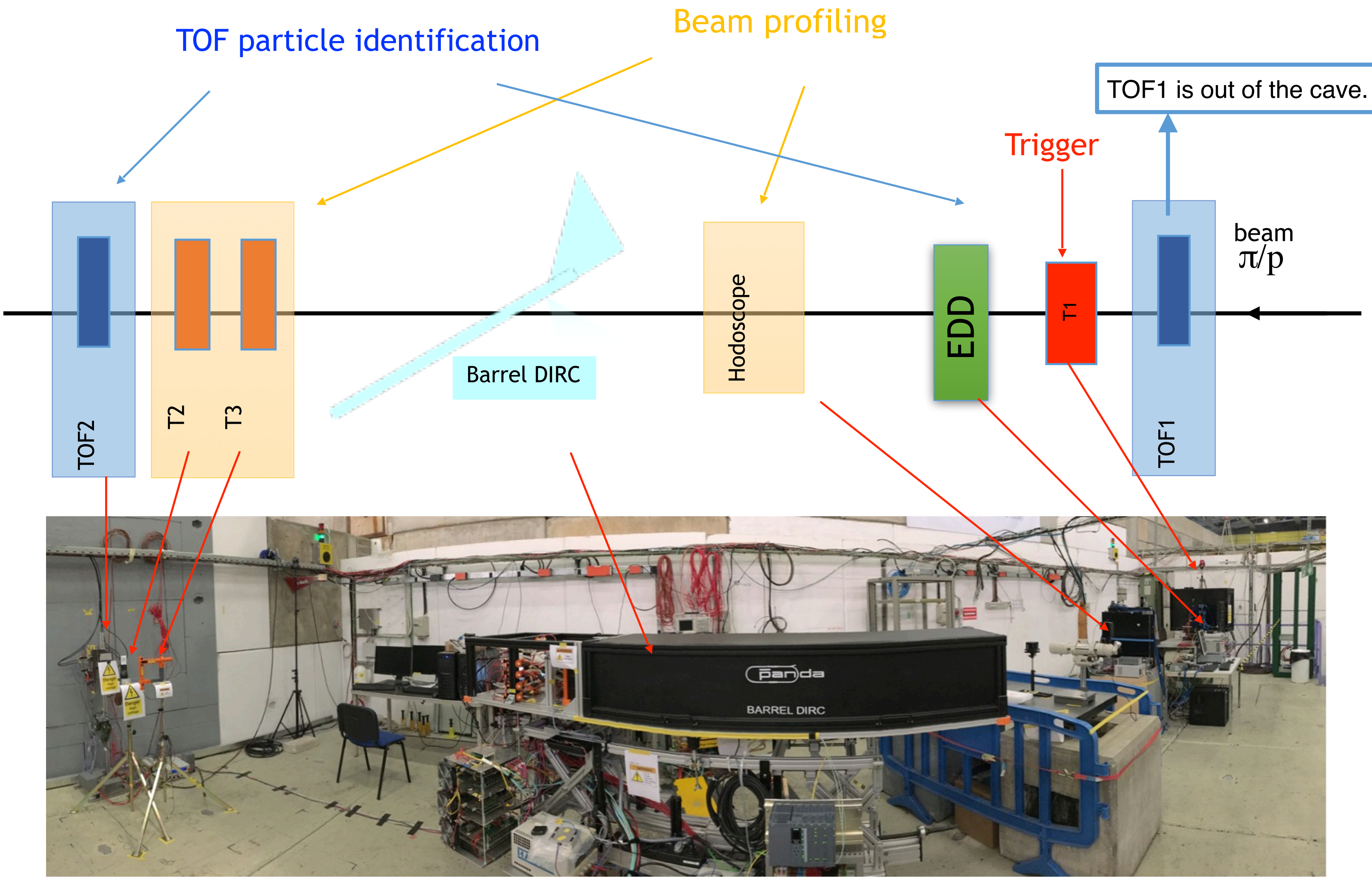


$$\theta_c = \arccos\left(\sin\theta_p \cos\phi_{\mathrm{rel}} \cos\varphi + \cos\theta_p \sin\varphi\right)$$

optics made of synthetic fused silica



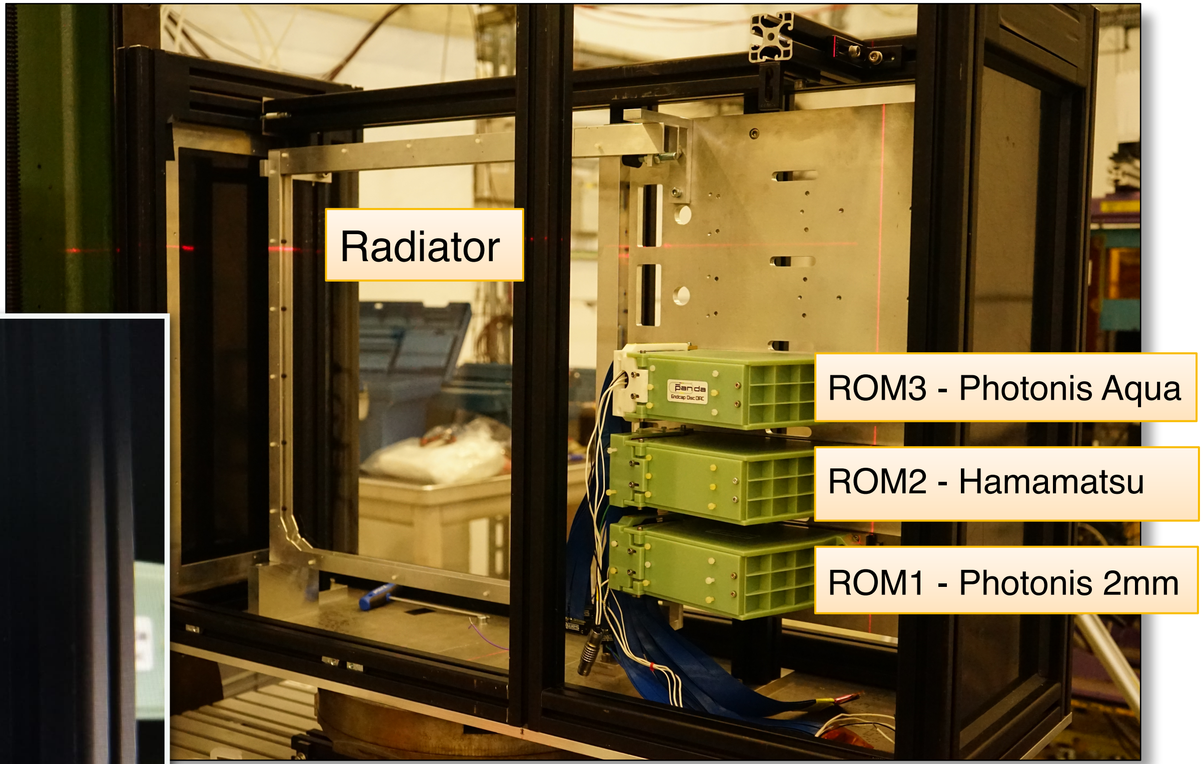
Test-beam area at CERN PS/T9: 2018

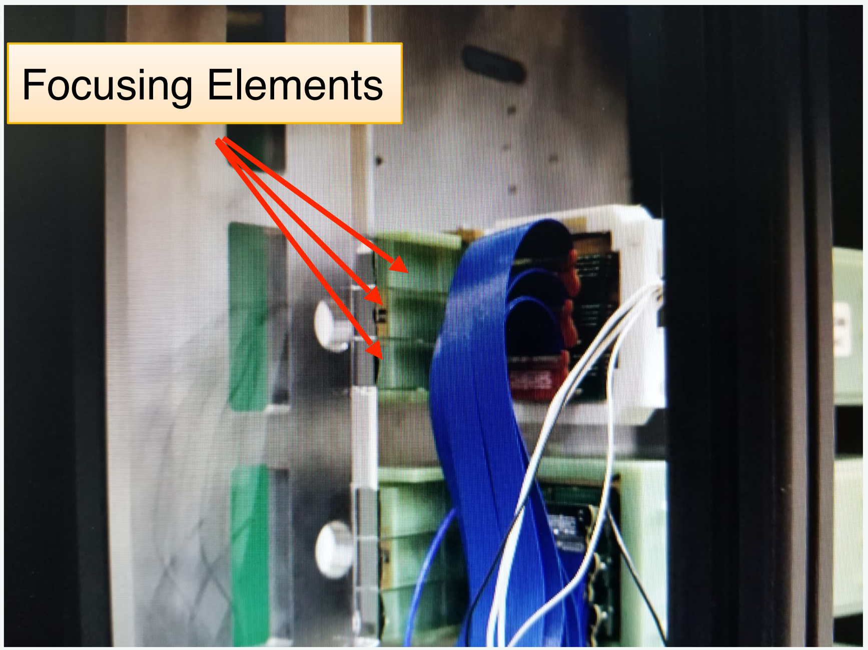


CERN PS/T9 area

Distance between TOF1 and TOF2 is ~ 29m.

EDD Prototype from test-beam 2018

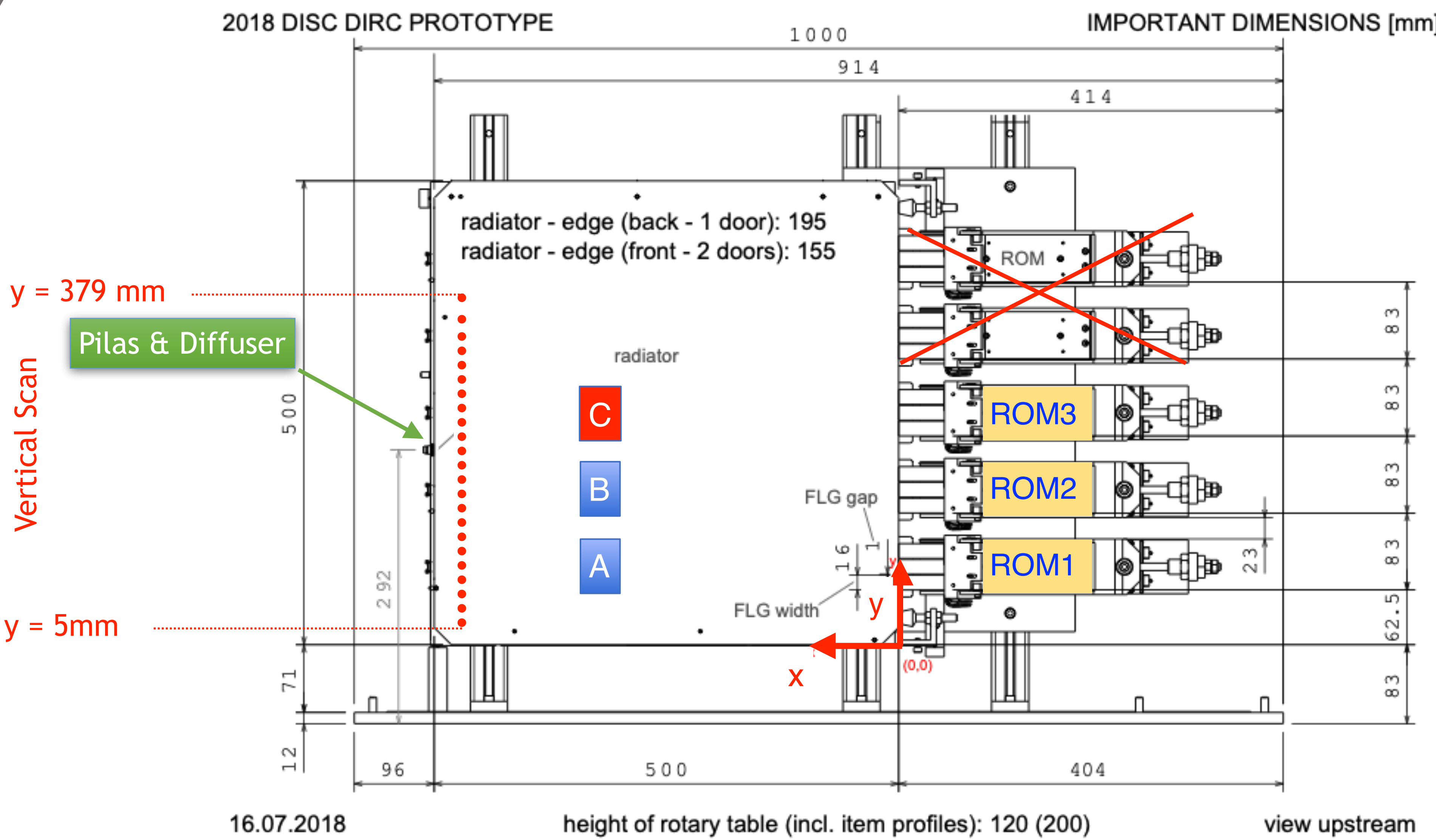




|← Prototype →|

- Radiator (fused silica) size is 500 mm x 500 mm x 20 mm
- 9 Focusing elements (FELs), 3 Readout modules (ROMs), 3 Photosensors (MCP-PMTs)

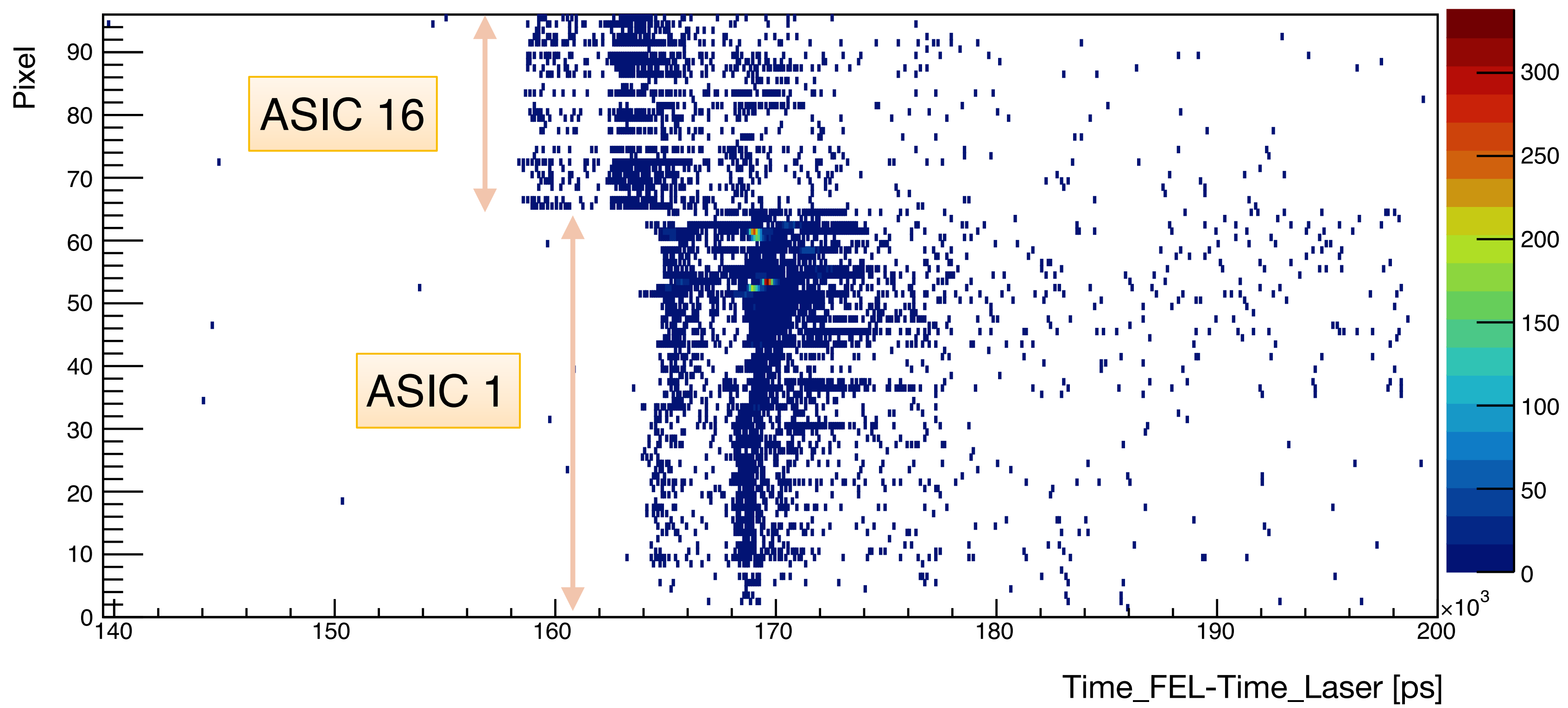
EDD prototype sketch



A,B & C: Beam levels

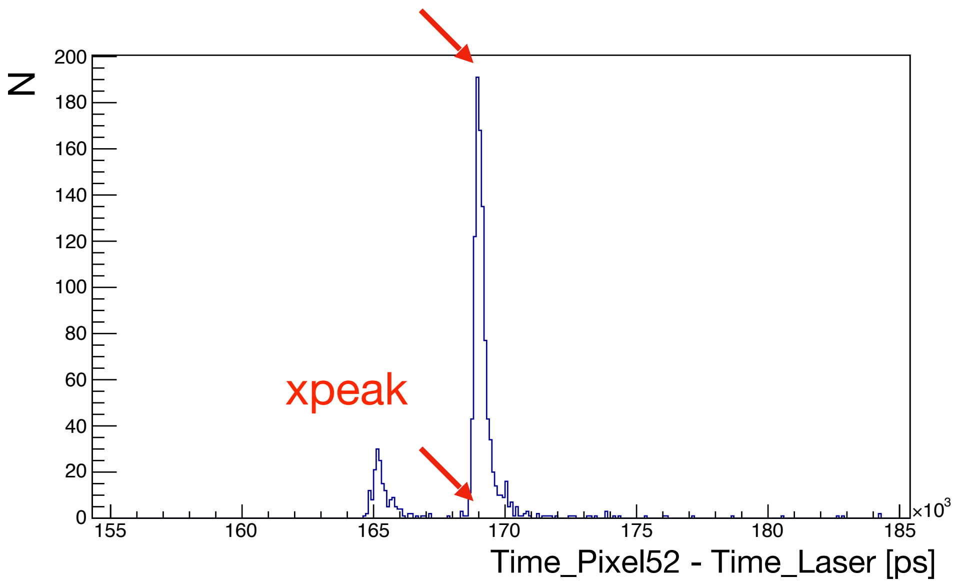
One focusing element is connected to two different ASICs.

(1 FEL = 96 Channels, 1 ASIC = 64 Channels)

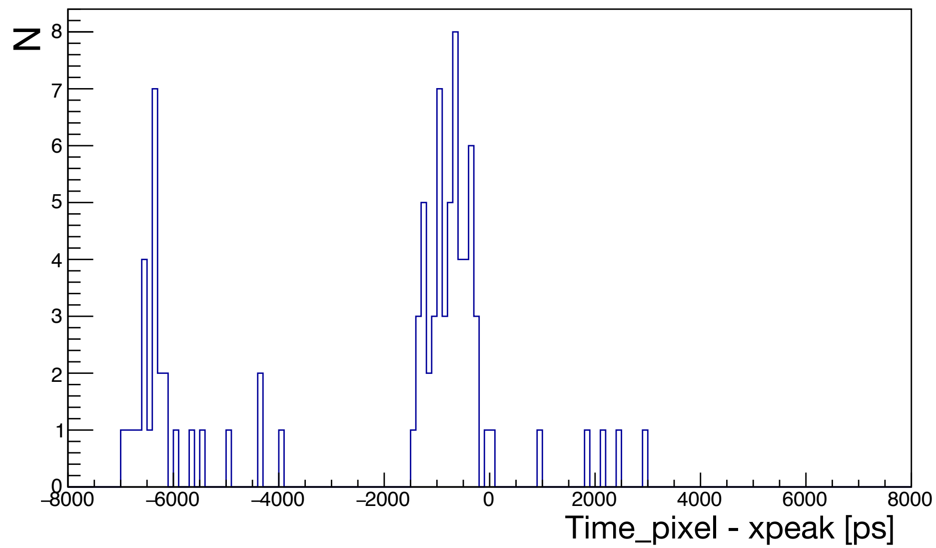


Time offset correction with laser

Pixel 52 has the largest amount of events, xpeak is chosen as a reference time.

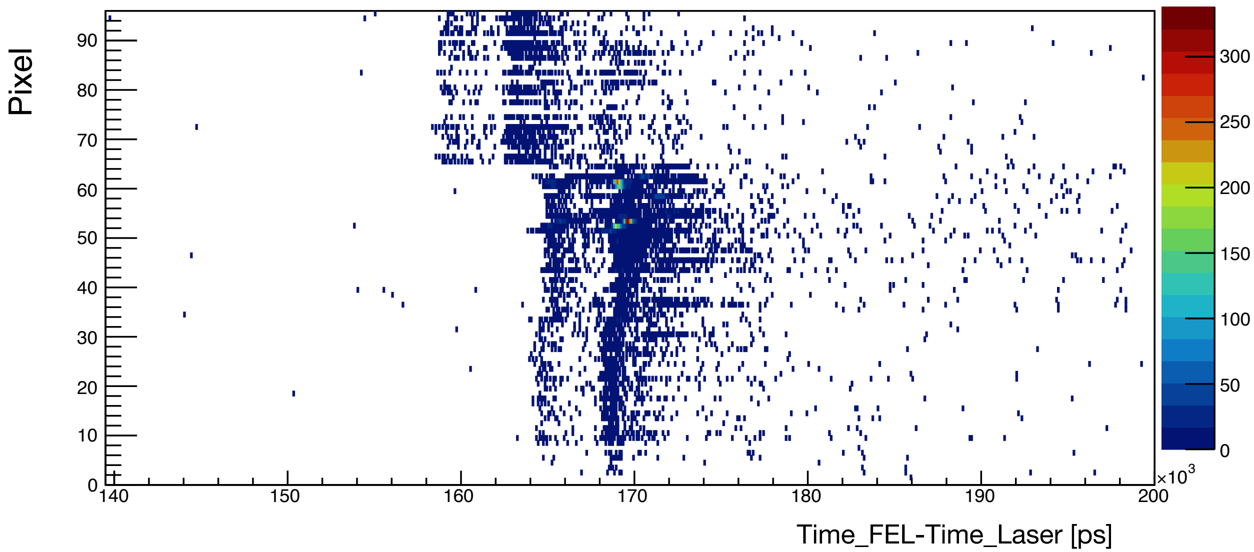


Time difference between all pixels and xpeak for FEL2

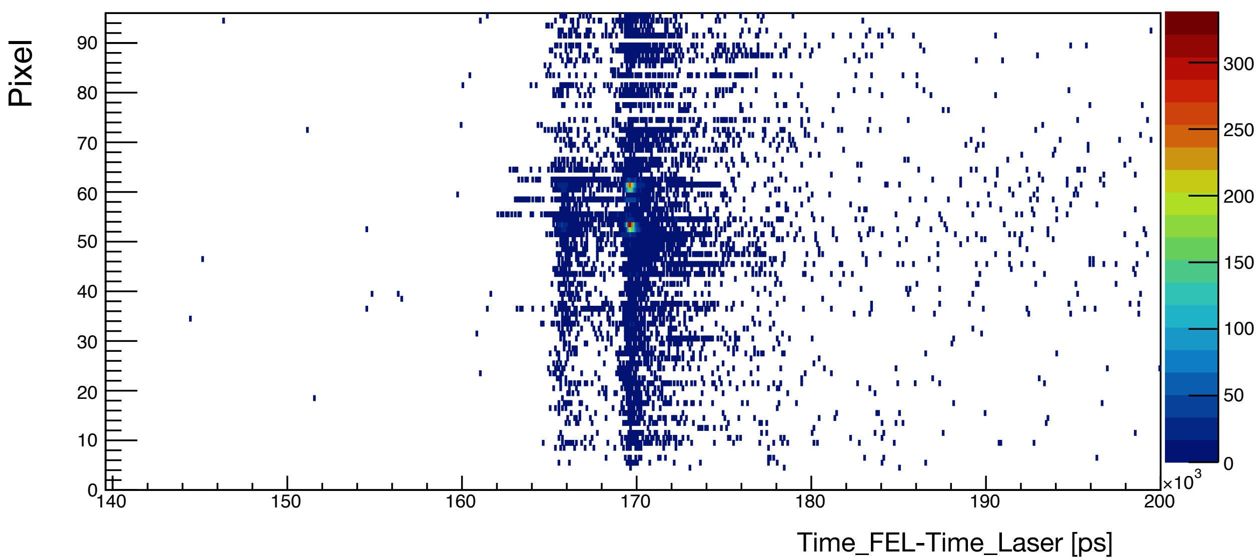


Time offset correction with laser

Before correction



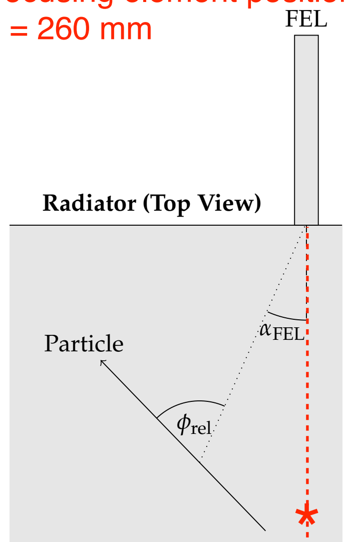
After correction

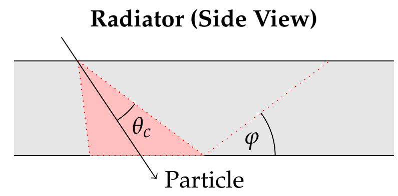


Optical calibration

* : Focusing element position
y = 260 mm

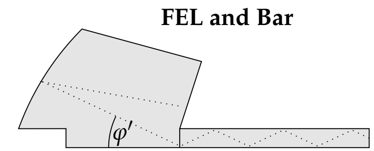
$$\varphi'(z) = mz + b \qquad \tan\varphi' = \frac{\tan\varphi}{\cos\alpha_{FEL}}$$

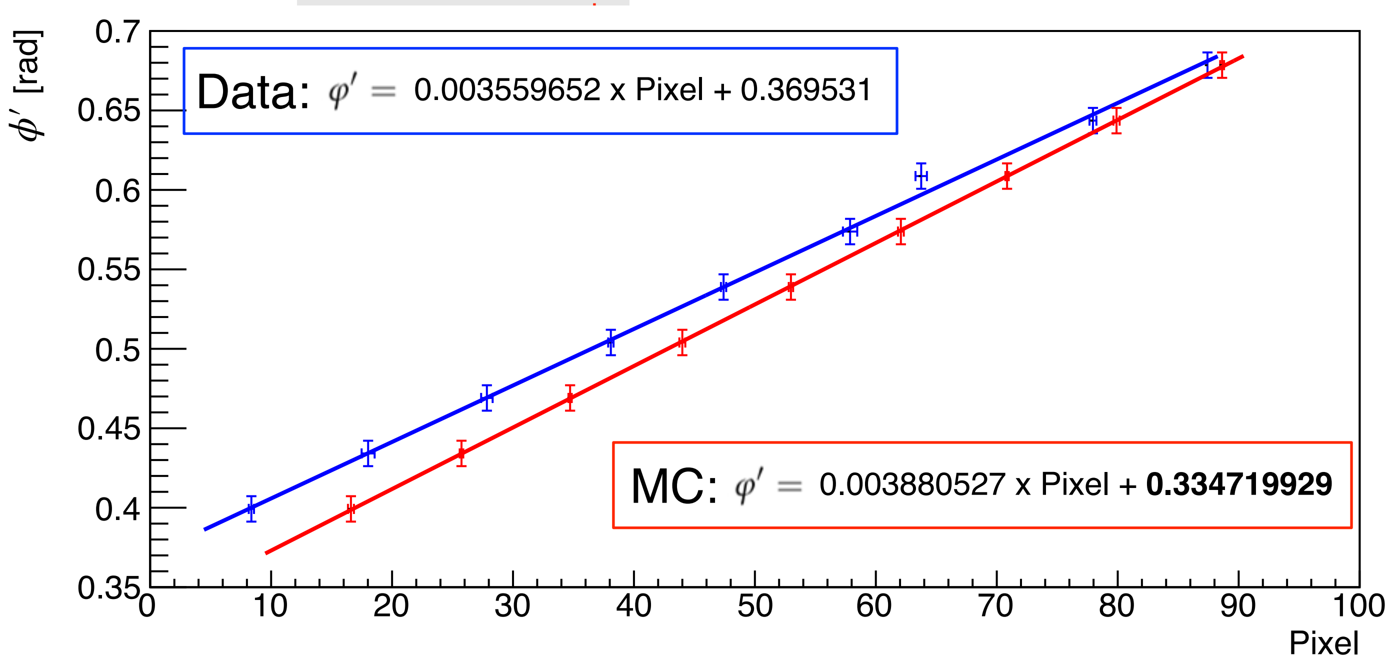




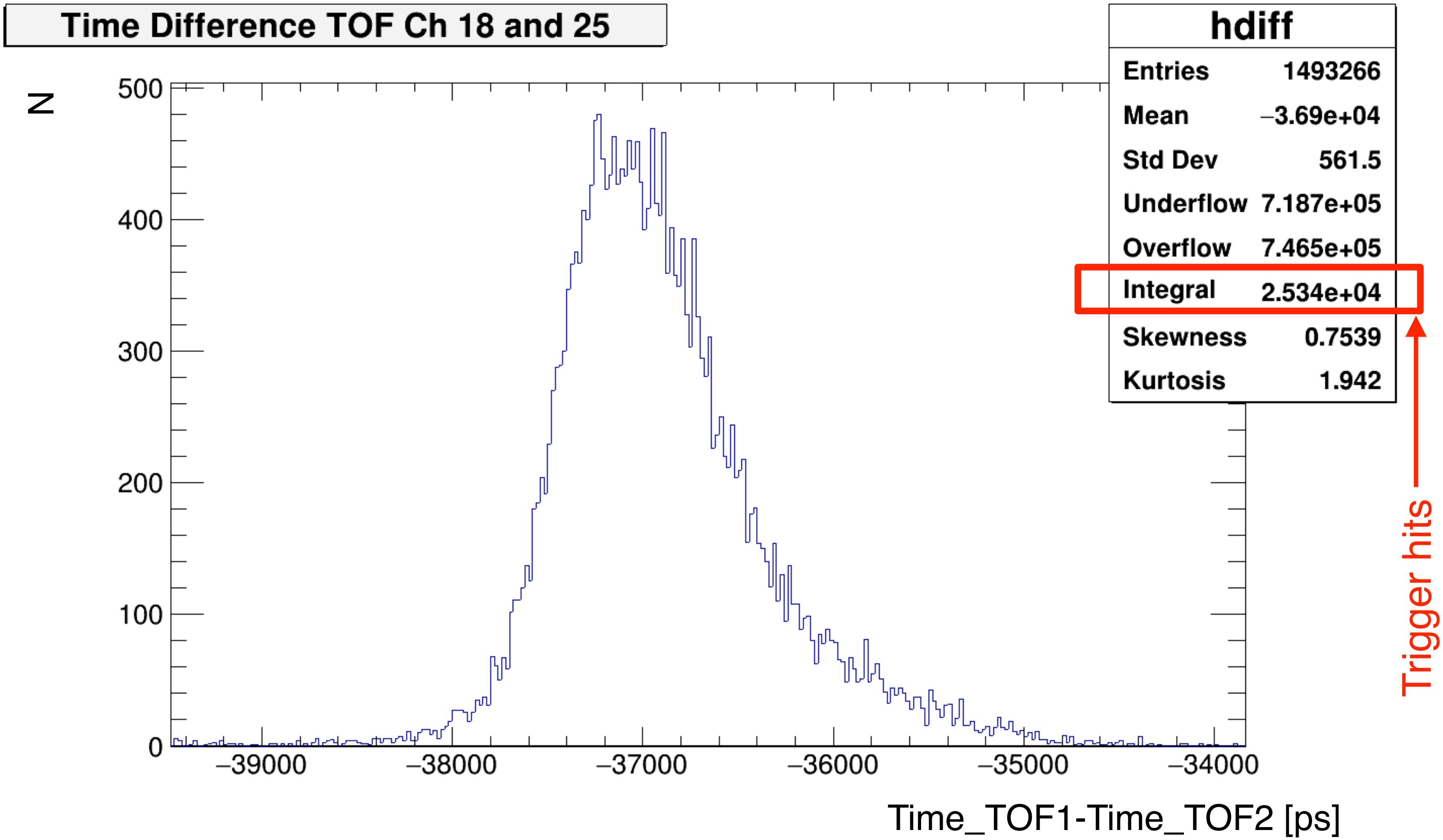
α_{FEL} = 0

$\varphi' = \varphi$

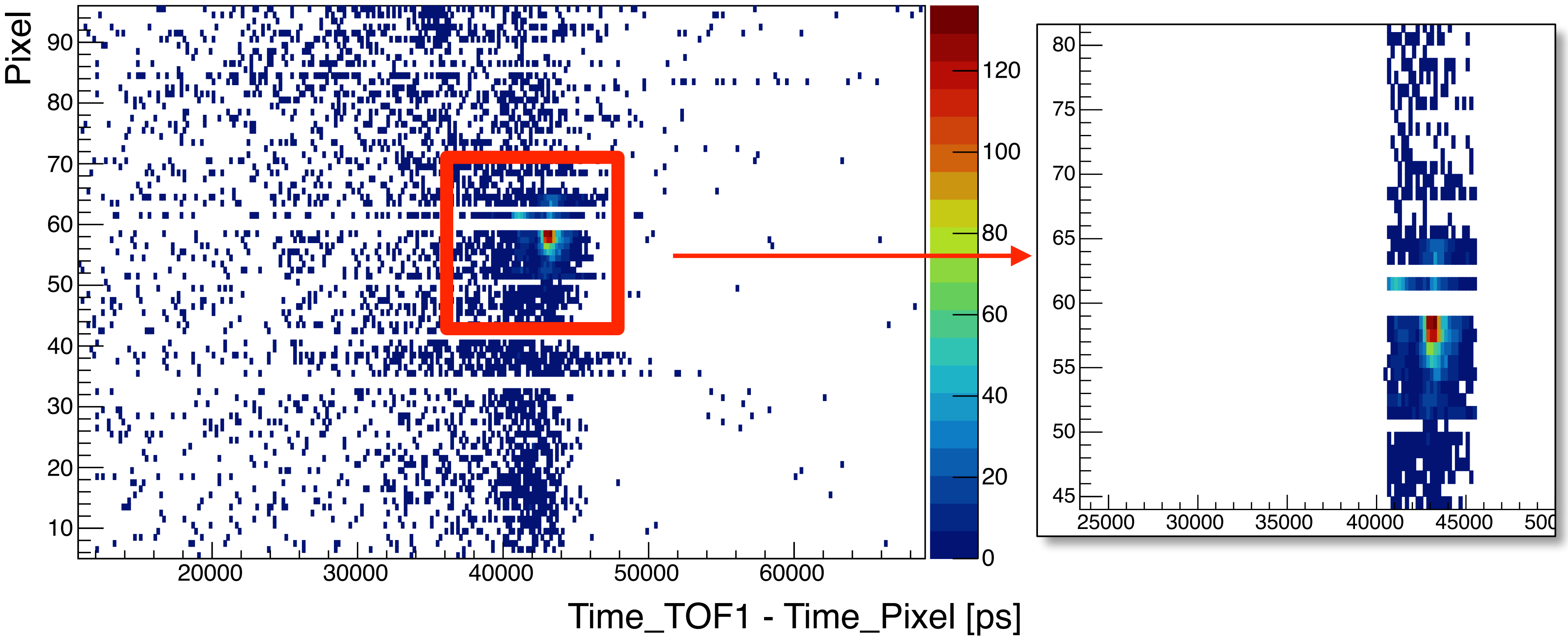




Trigger selection @ 10 GeV/c



Time cut



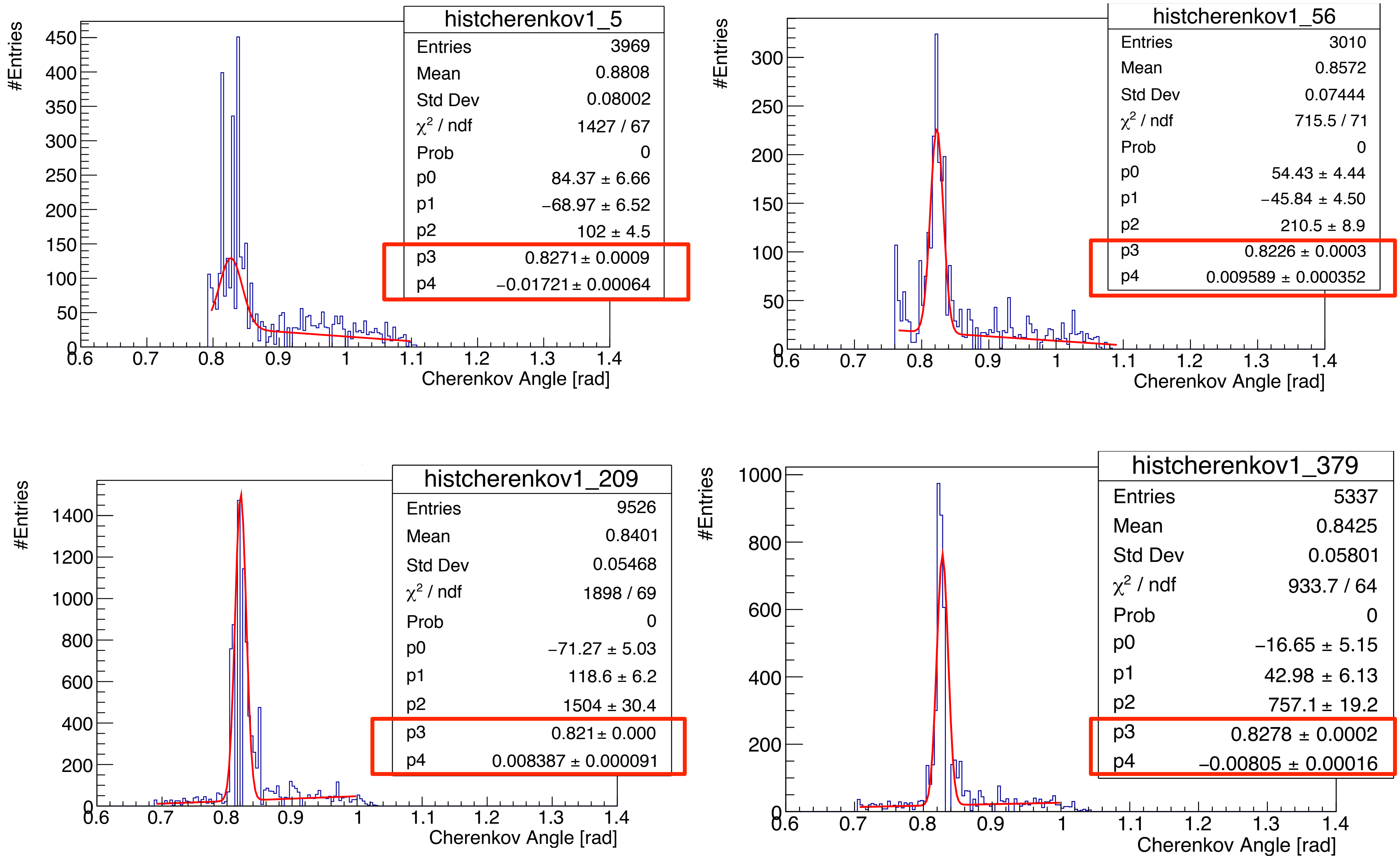
- Time cut applied in maximum coincidence region, 40 ns - 45 ns to reduce background.
- There are missing channels.
- Cherenkov angle calculated: $\theta_c = \arccos(\sin \theta_p \cos \varphi_{rel} \cos \varphi + \cos \theta_p \sin \varphi)$

θ_p: Angle of beam

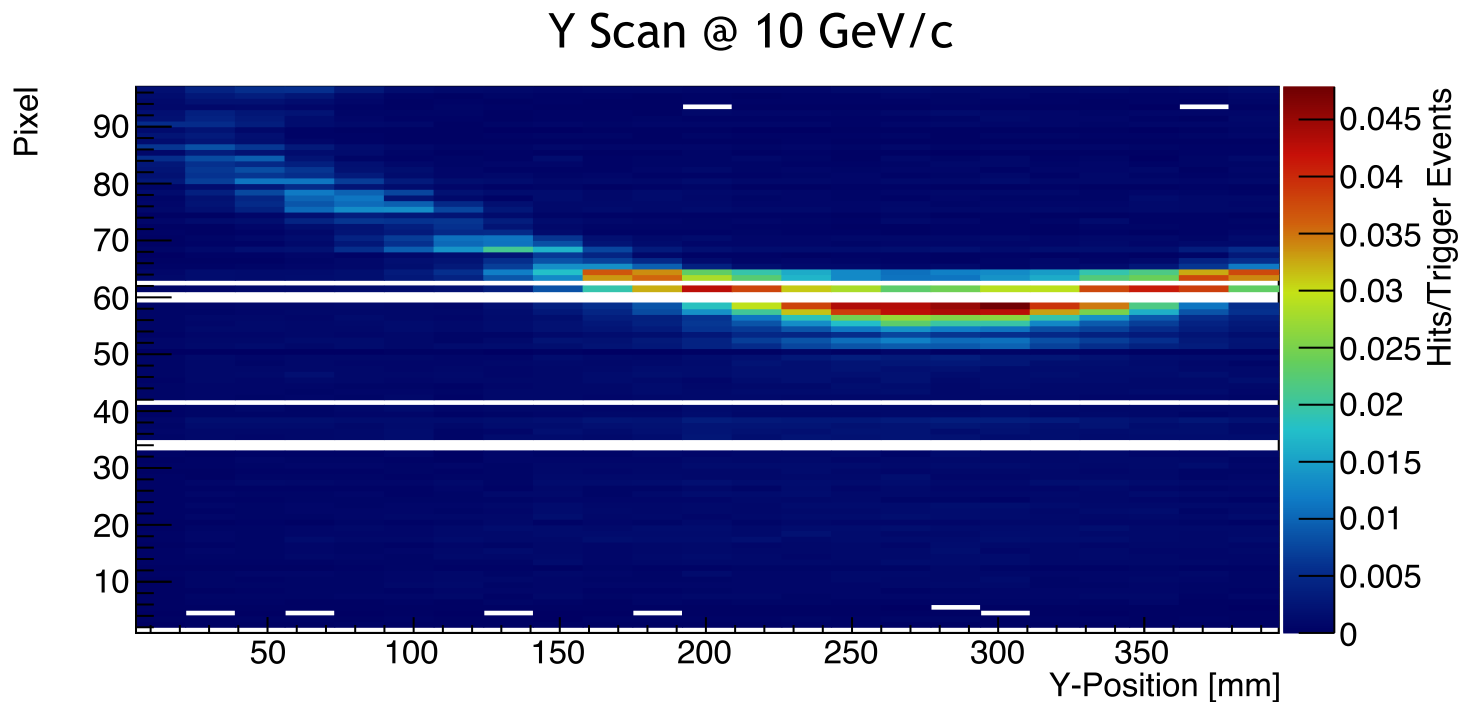
φ_{rel}: Angle between the measured photon and the trajectory of primary particle

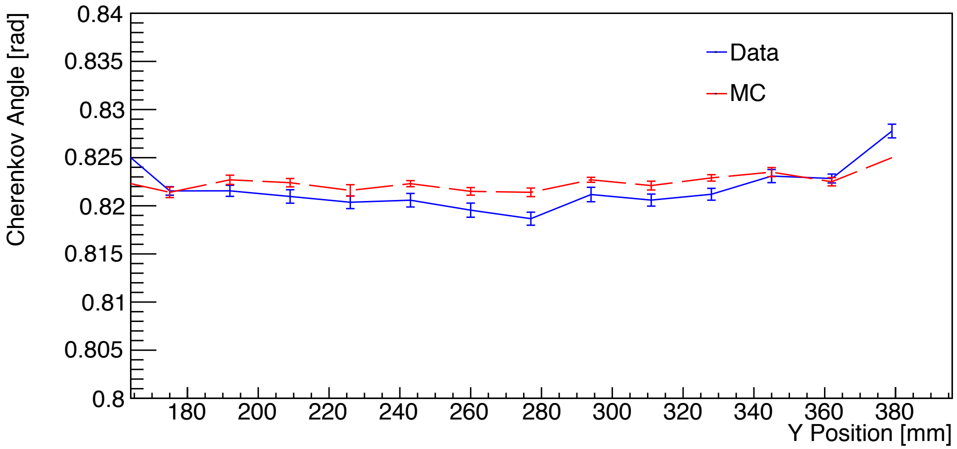
ϕ: Azimuthal position of the active FEL

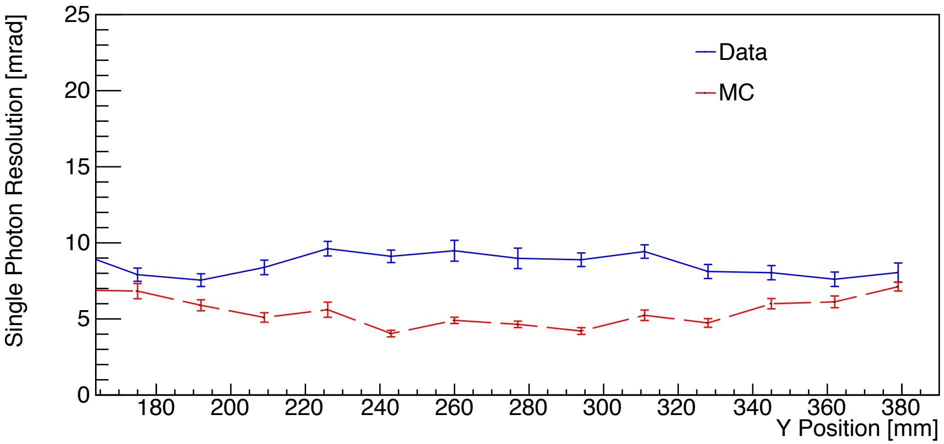
Fitting data @ 10 GeV/c



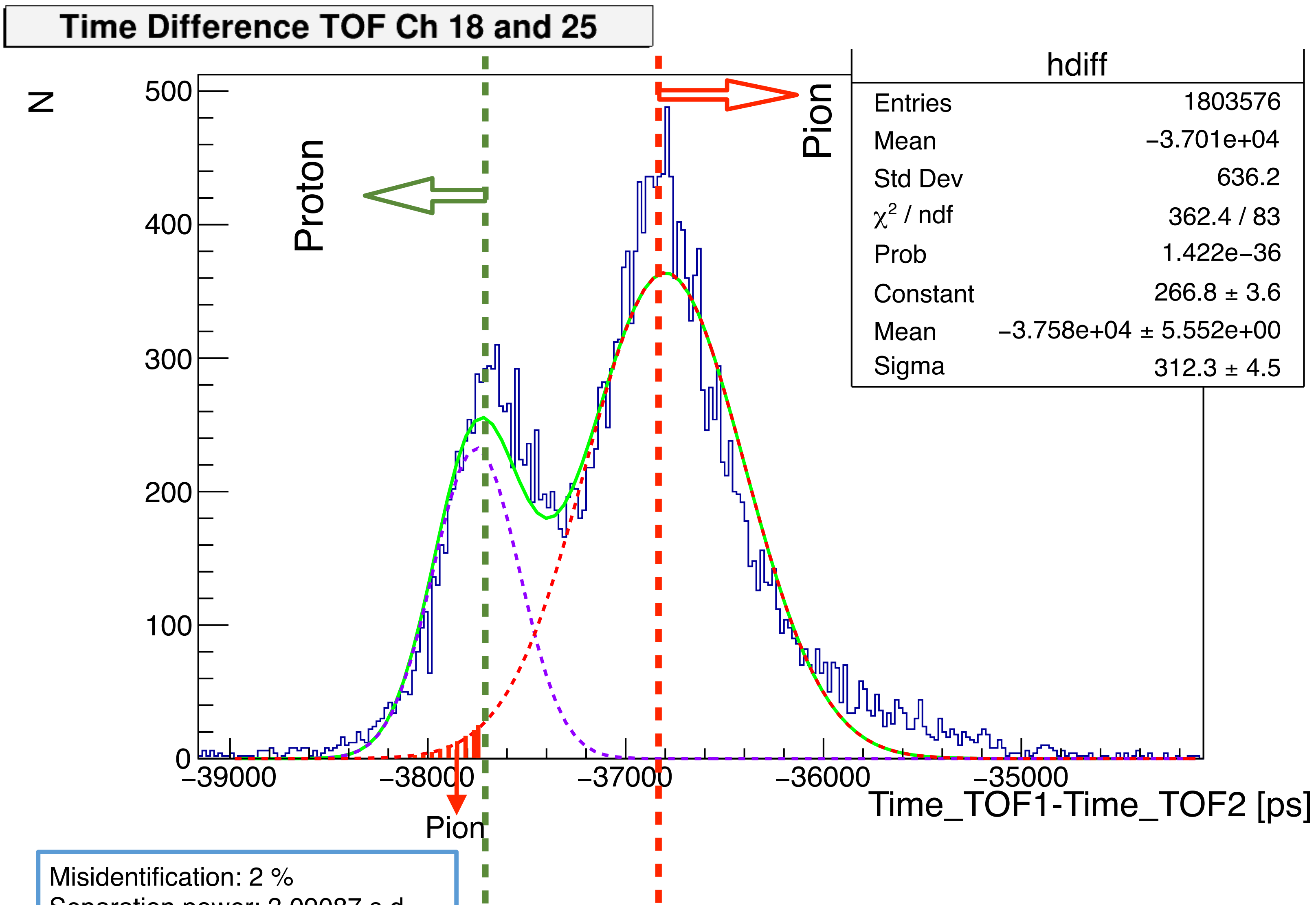
Selected test-beam results for the EDD Prototype: 2018







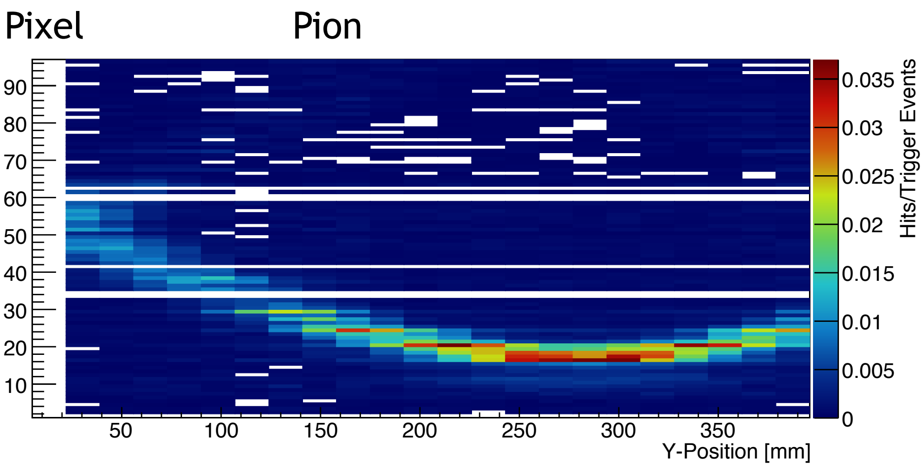
Trigger selection @ 7 GeV/c

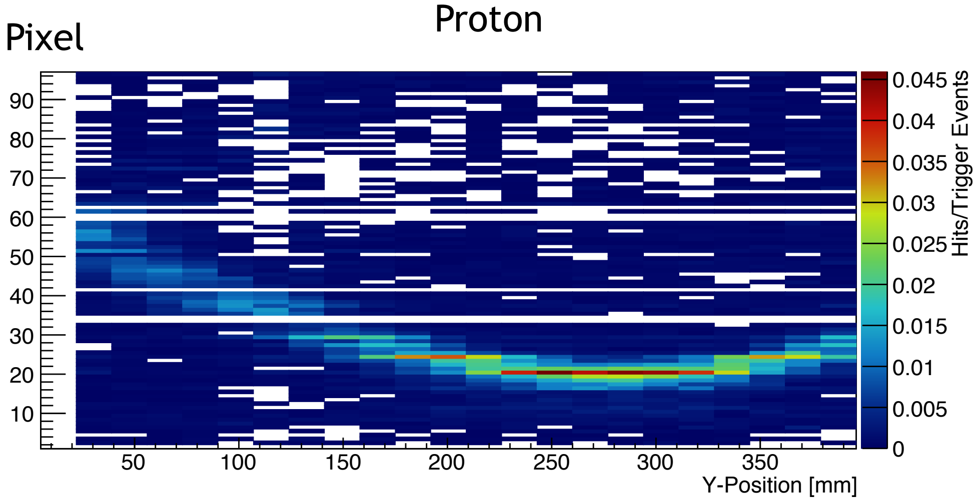


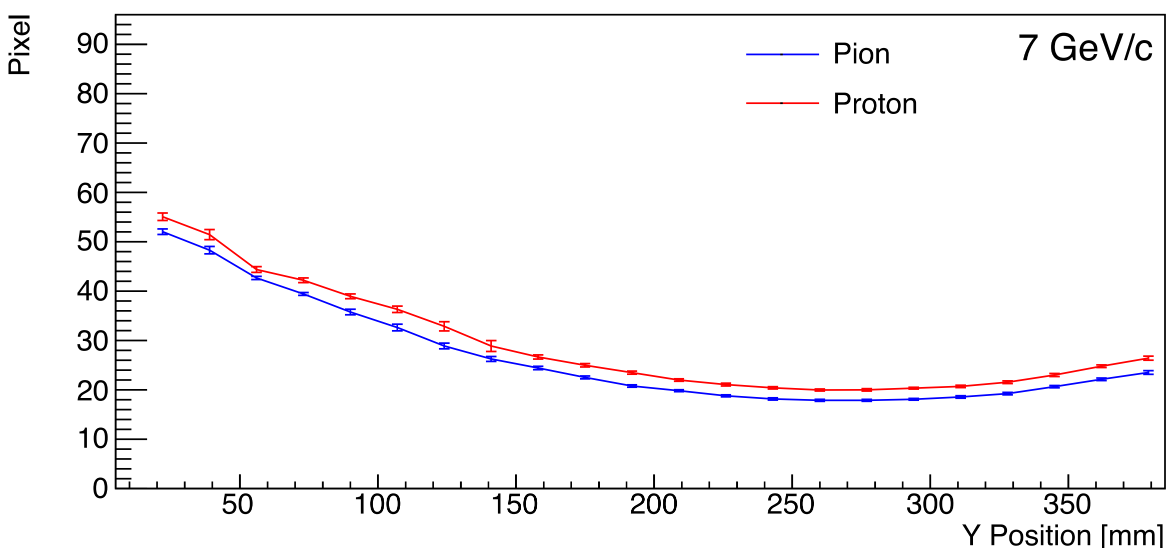
Misidentification: 2 %
Separation power: 3.09087 s.d.

Selected test-beam results for the EDD Prototype: 2018

Vertical Scan @ 7 GeV/c

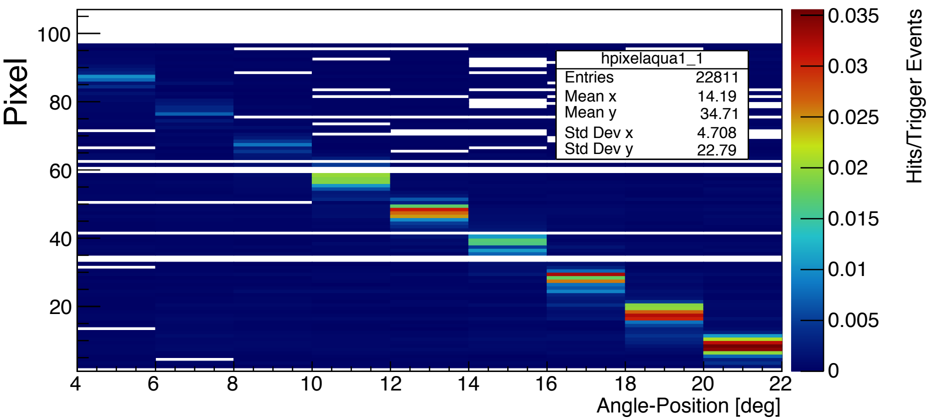




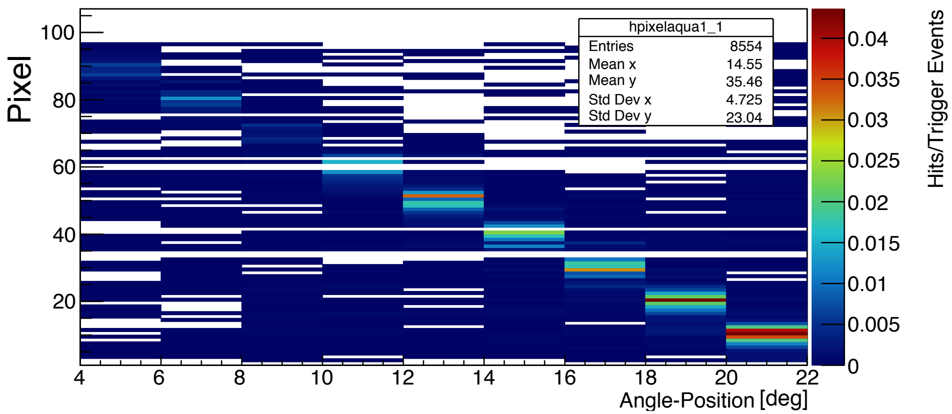


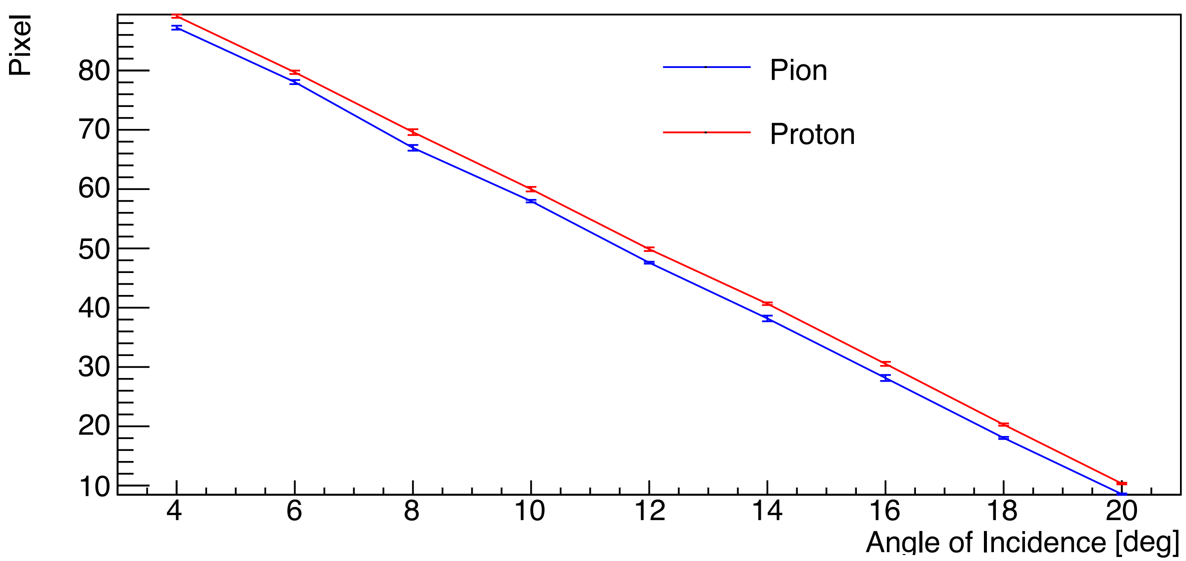
Angle Scan @ 7 GeV/c

Pion



Proton

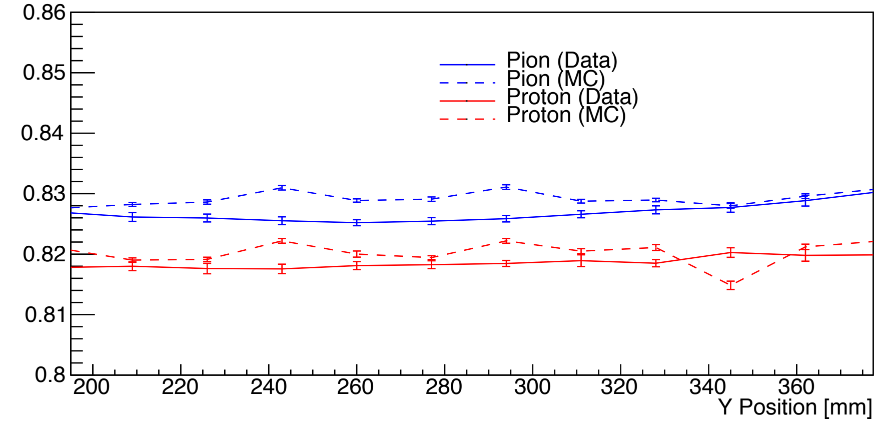




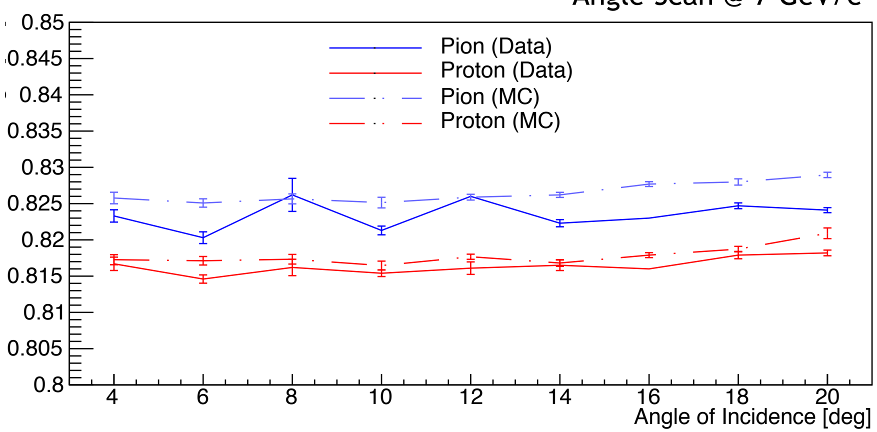
Selected test-beam results for the EDD Prototype: 2018

Cherenkov Angle [rad]

Vertical Scan @ 7 GeV/c

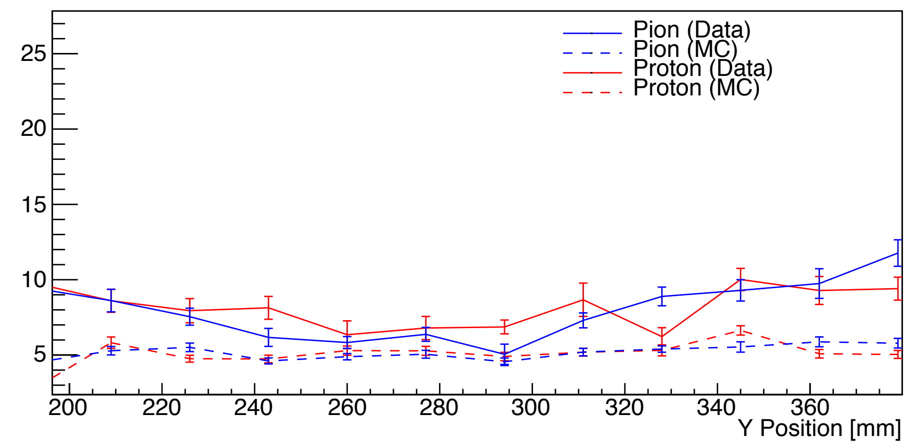


Angle Scan @ 7 GeV/c

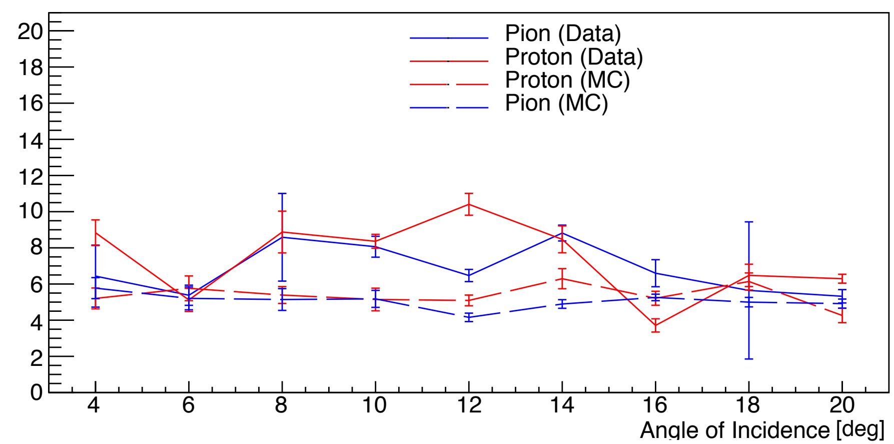


Single Photon Resolution [mrad]

Vertical Scan @ 7 GeV/c

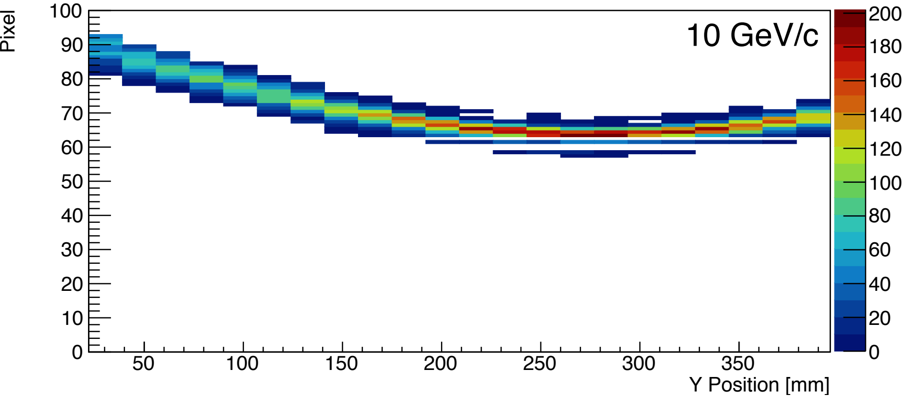


Angle Scan @ 7 GeV/c

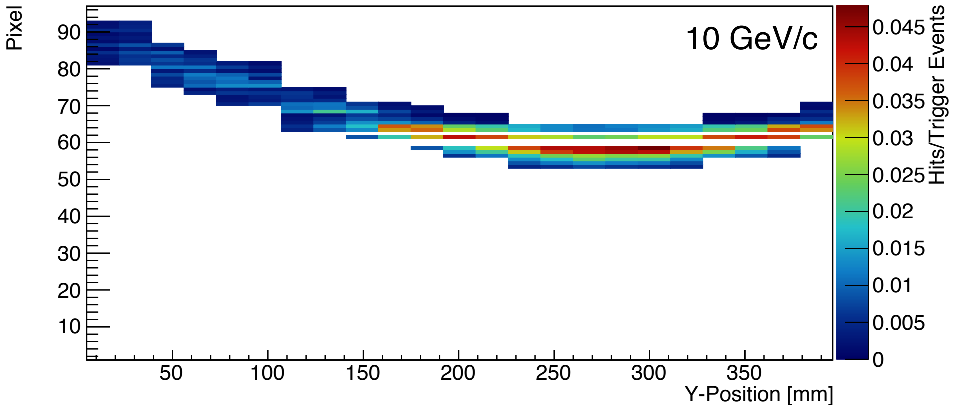


Data hits

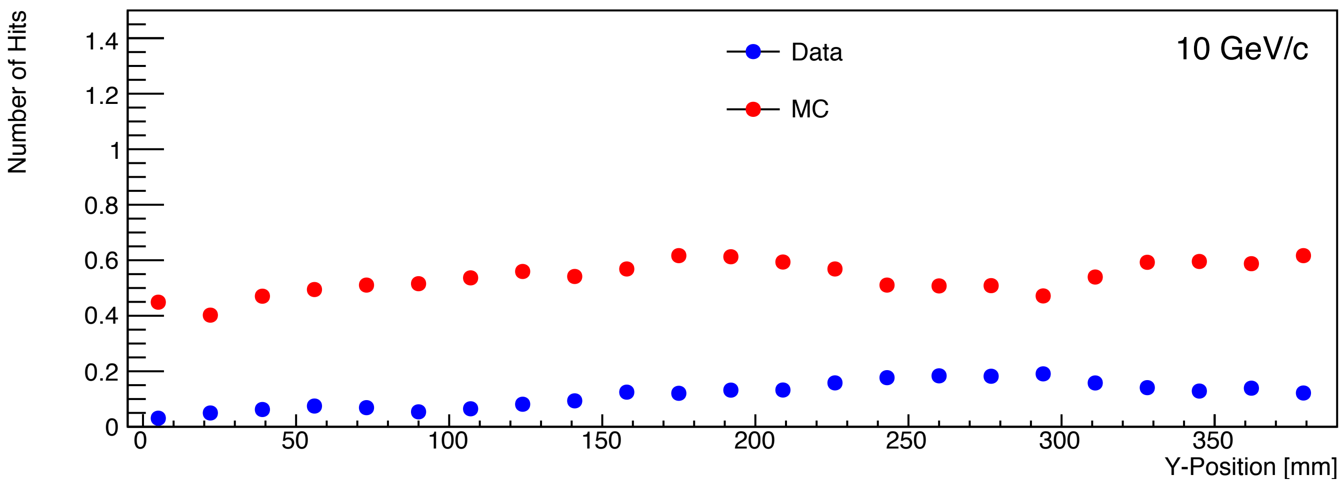
MC Simulation



Data

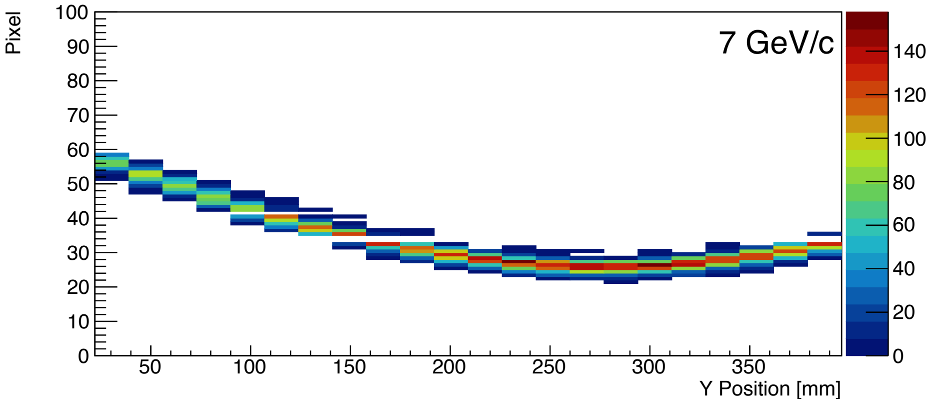


Photon yield

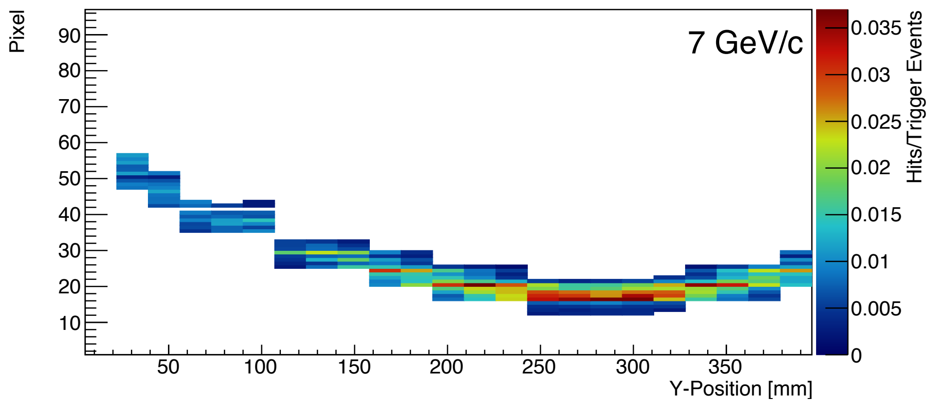


Data hits

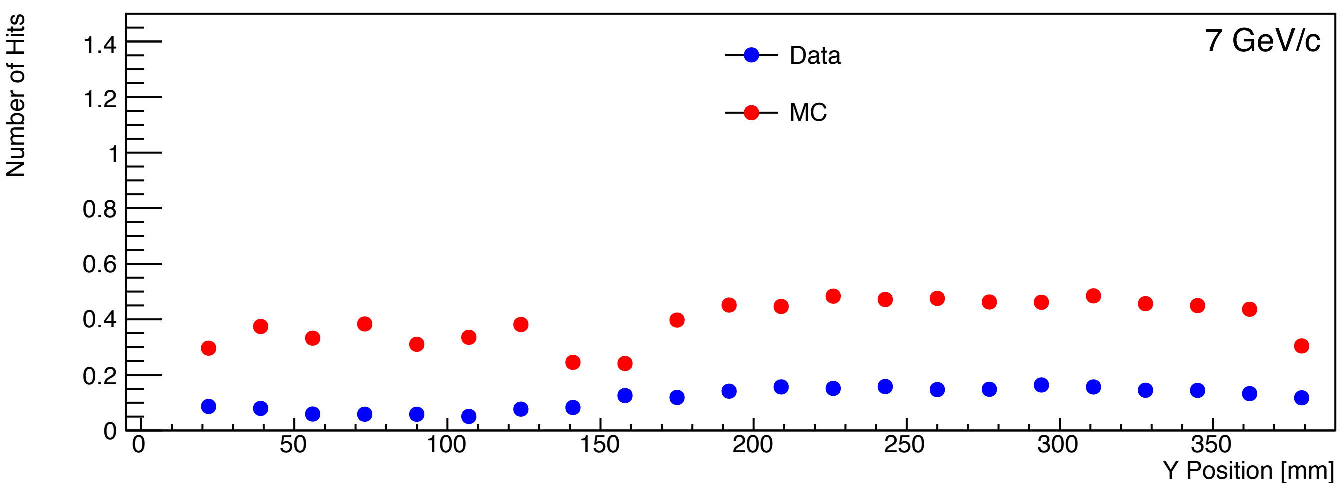
MC Simulation

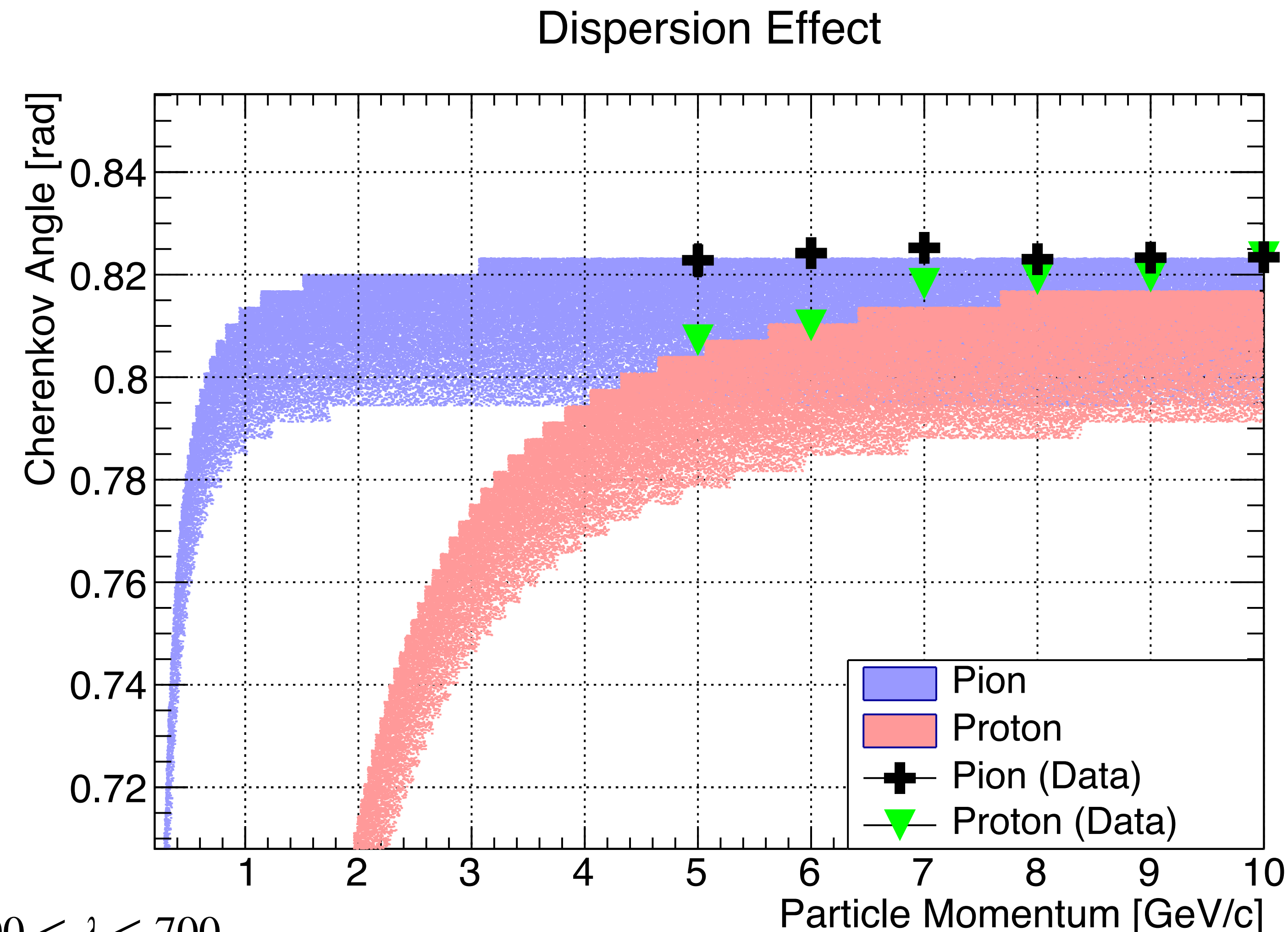


Data



Photon yield

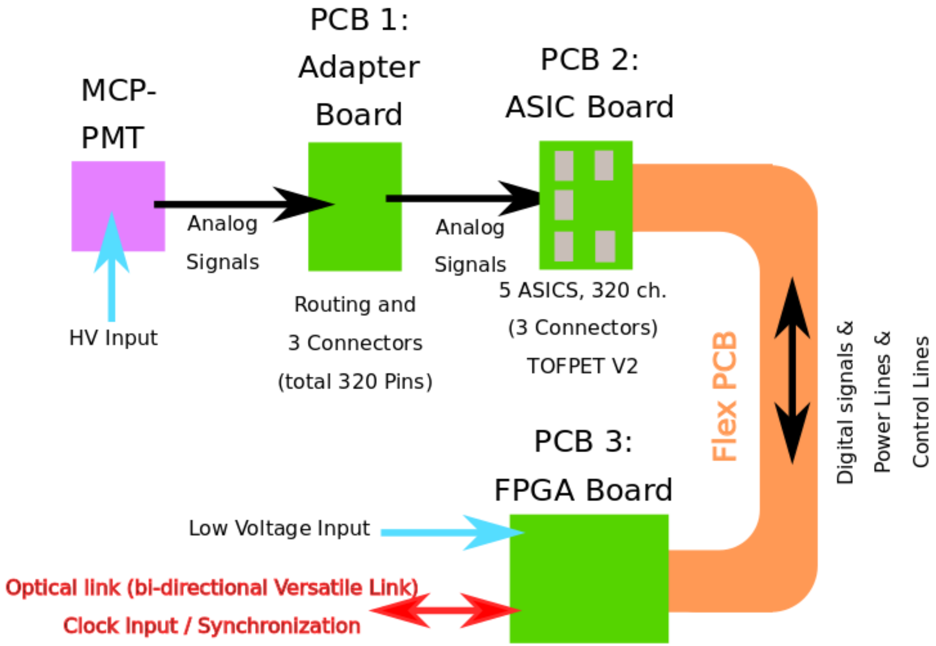


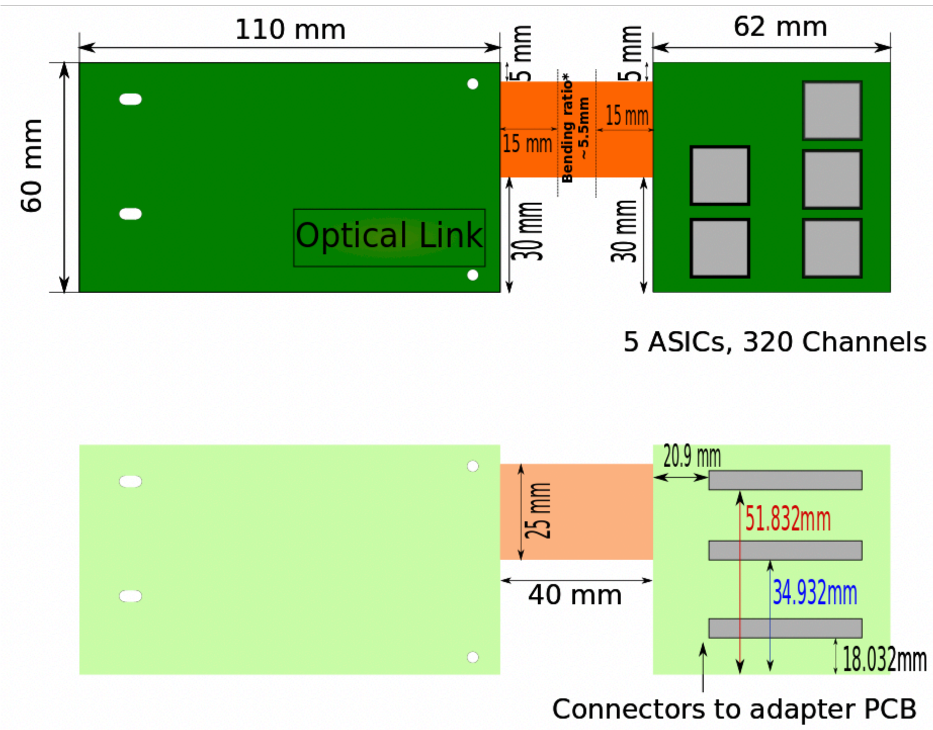


$300 \leq \lambda \leq 700$

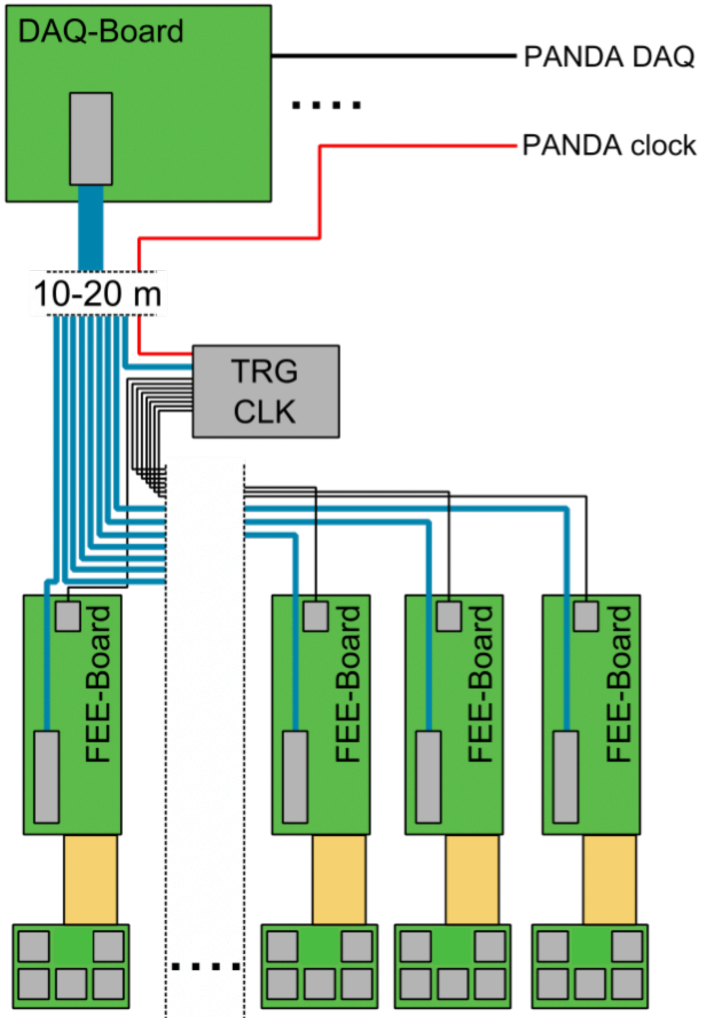
$1.45 \leq n \leq 1.47$

Rigid-flex design





12 DAQ-Boards in total



Requirements:

• at maximum 100 kHz per channel

→ converts to 30 MHz per ROM

FEB/D allows up to 10^8 events/s

✓ DAQ-Board allows up to $2.5 \cdot 10^8$ events/s

➢ 8 ROMs per DAQ-Board

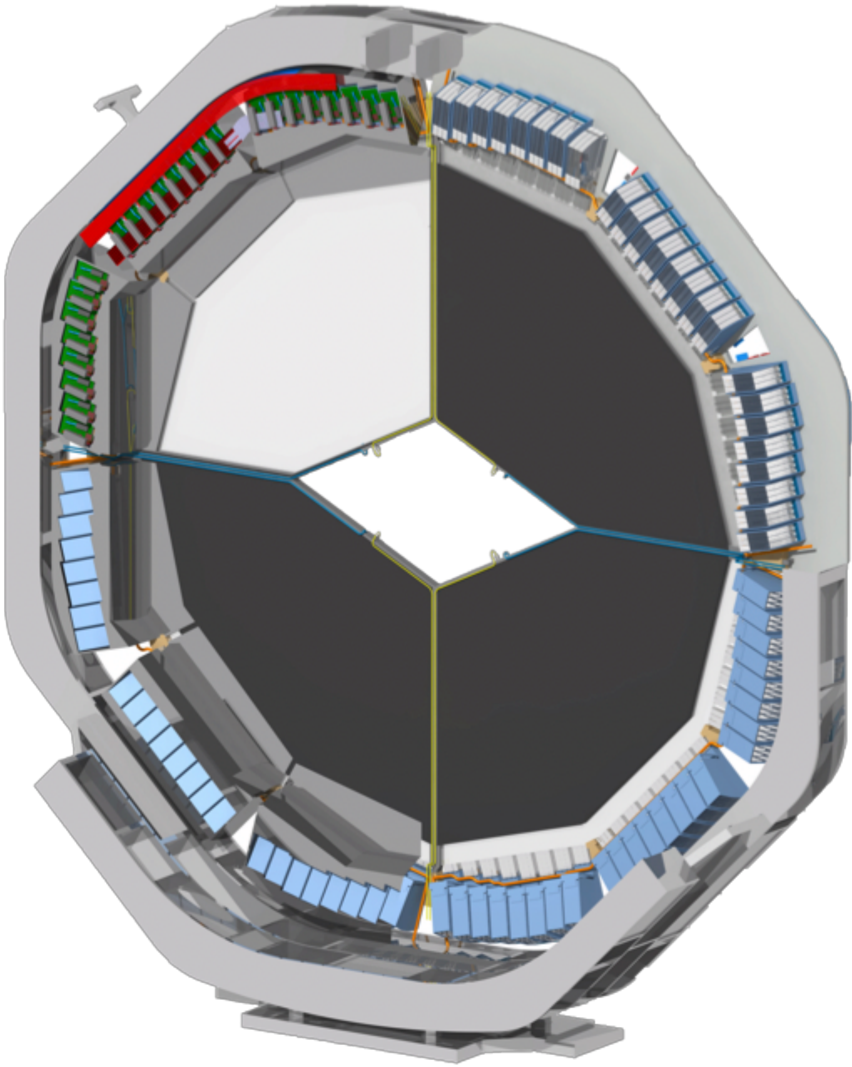
➢ 3 DAQ-Boards per Quadrant

➢ 12 DAQ-Boards in total

(96 FEE-Boards)

Summary of PANDA EDD

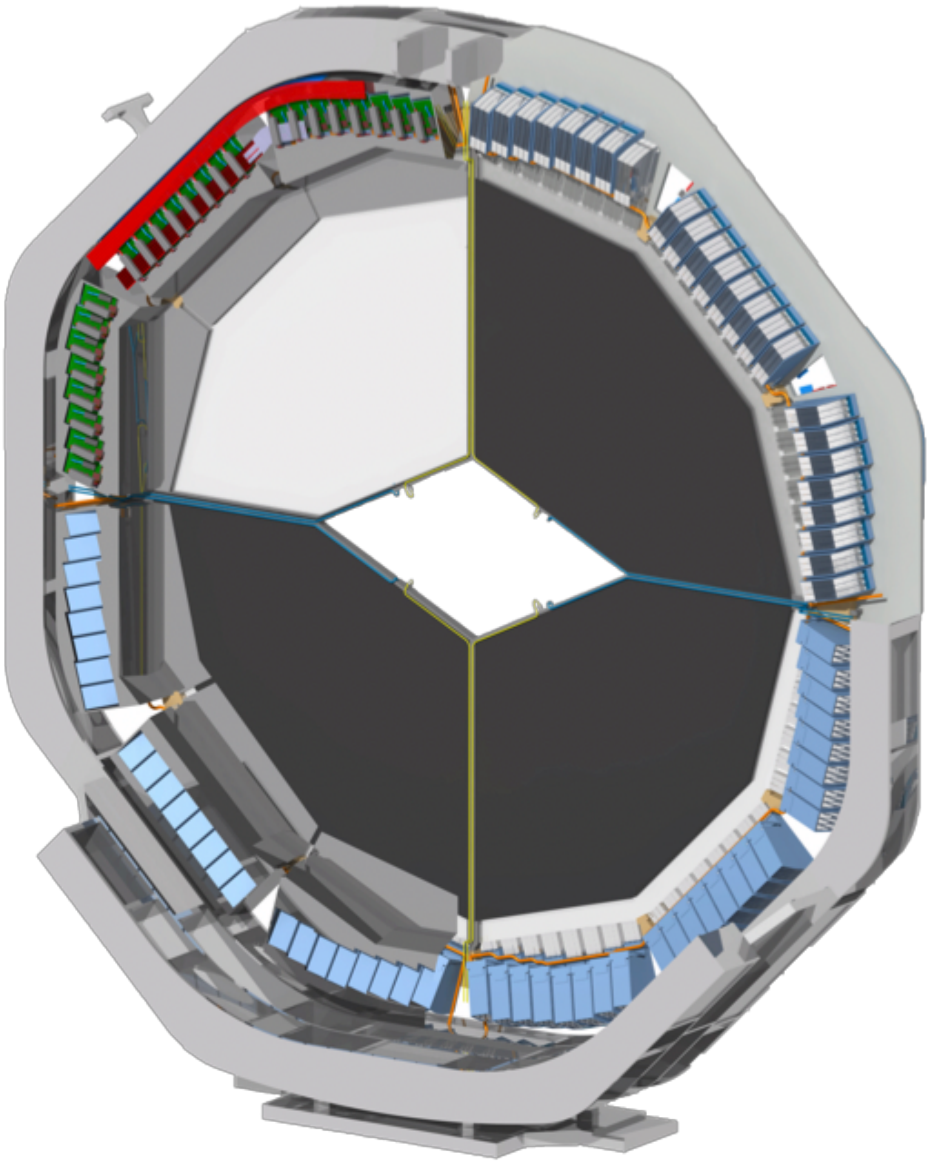
- The PANDA EDD is a key component of the PANDA PID system
- Design features are high polished fused silica components and compact assembly
- Successfully validated PID performance in particle beams
- Simulations predict separation of π/K more than 3 s.d. at 4 GeV/c



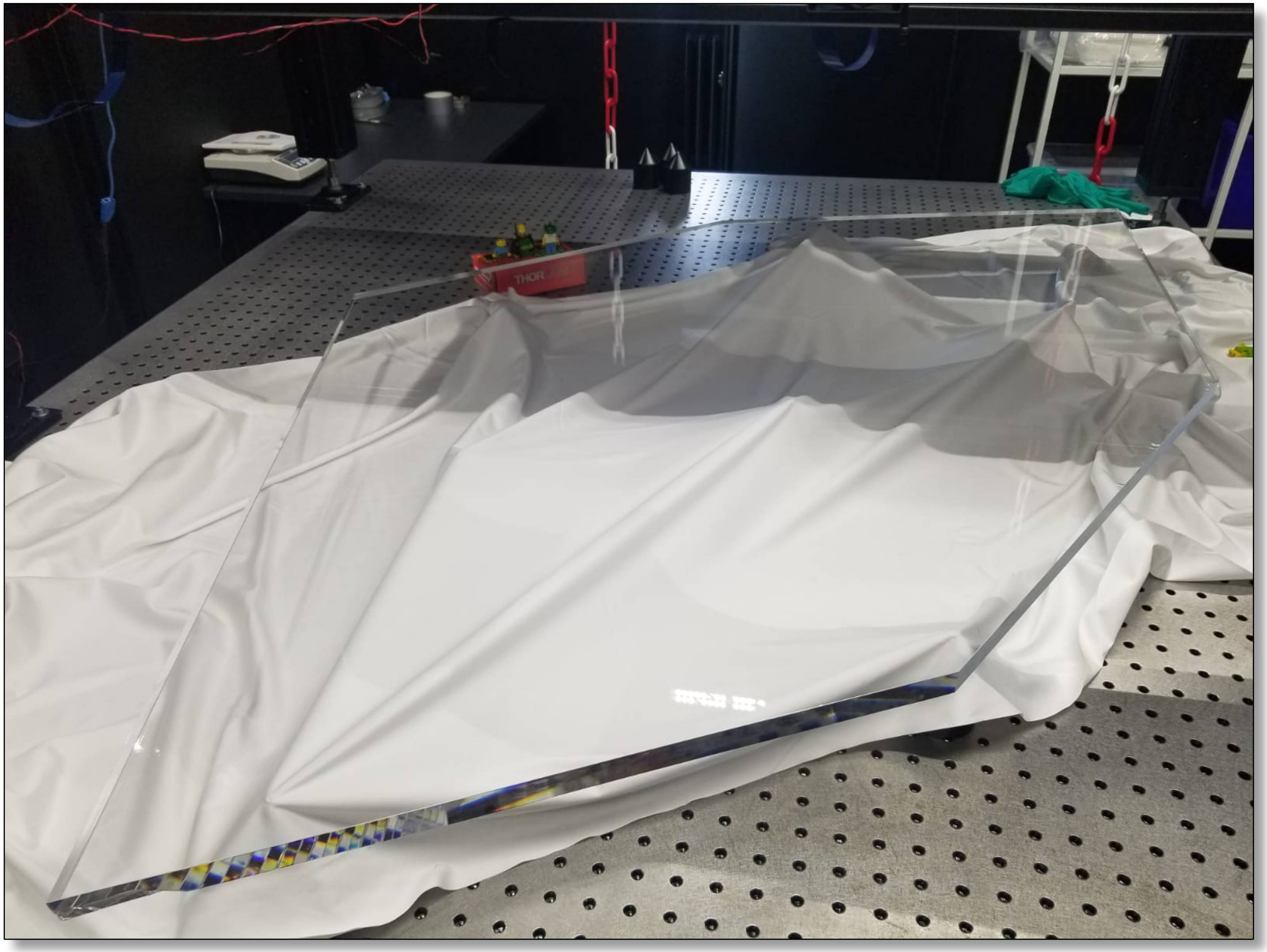
Outlook of EDD

2021-2027: Component Fabrication, Assembly, Installation

- 2021-2022: Industrial production of MCP-PMTs Production and QA of readout electronics
- 2022-2024: Industrial fabrication of first quadrant prototype
- 2021-2024: Industrial fabrication of 4 independent quadrants and mechanical support frame, gluing of focusing elements/plates, detailed scans of all sensors assembly of readout units
- 2025: Completing the quality assurance of components
- 2026-2027: Installation of the Endcap Disc DIRC into the PANDA detector and commissioning

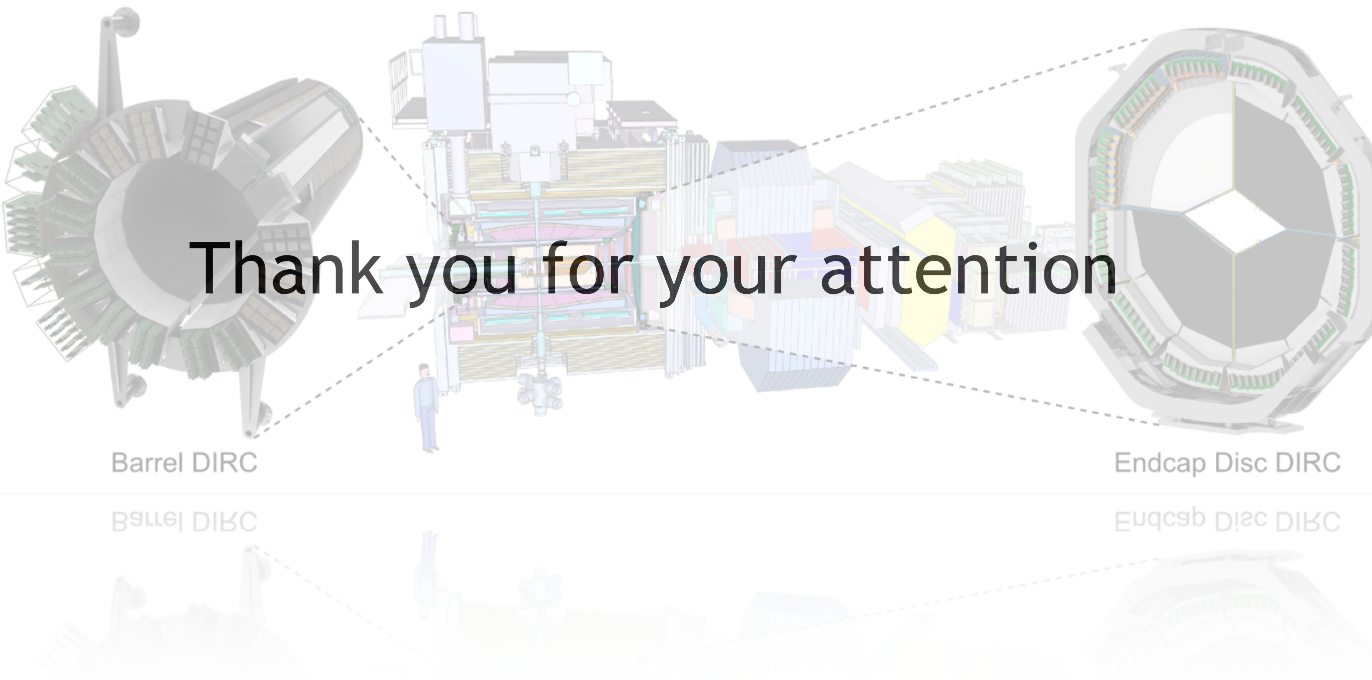


Radiator plate in full size



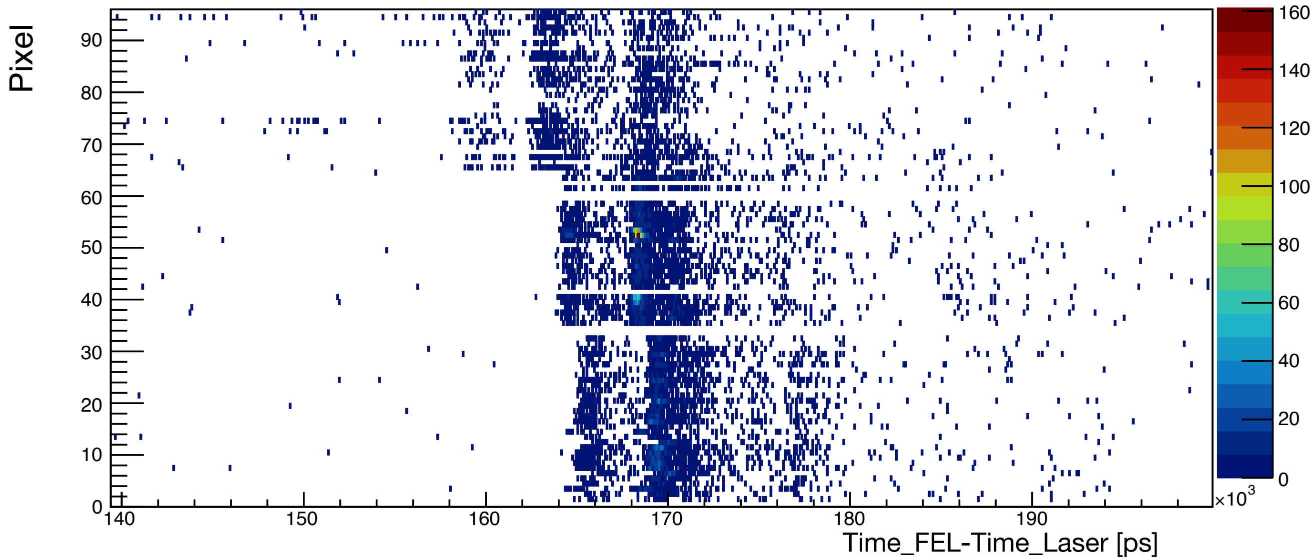
✦ Quality measurements will be done

Thank you for your attention

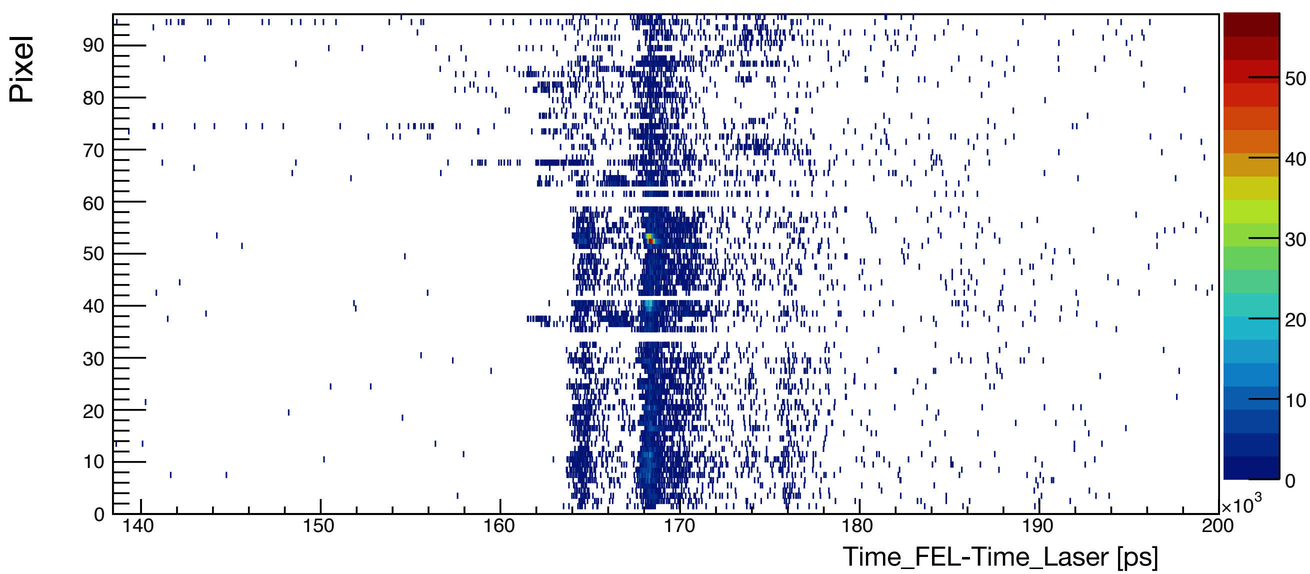


Backup

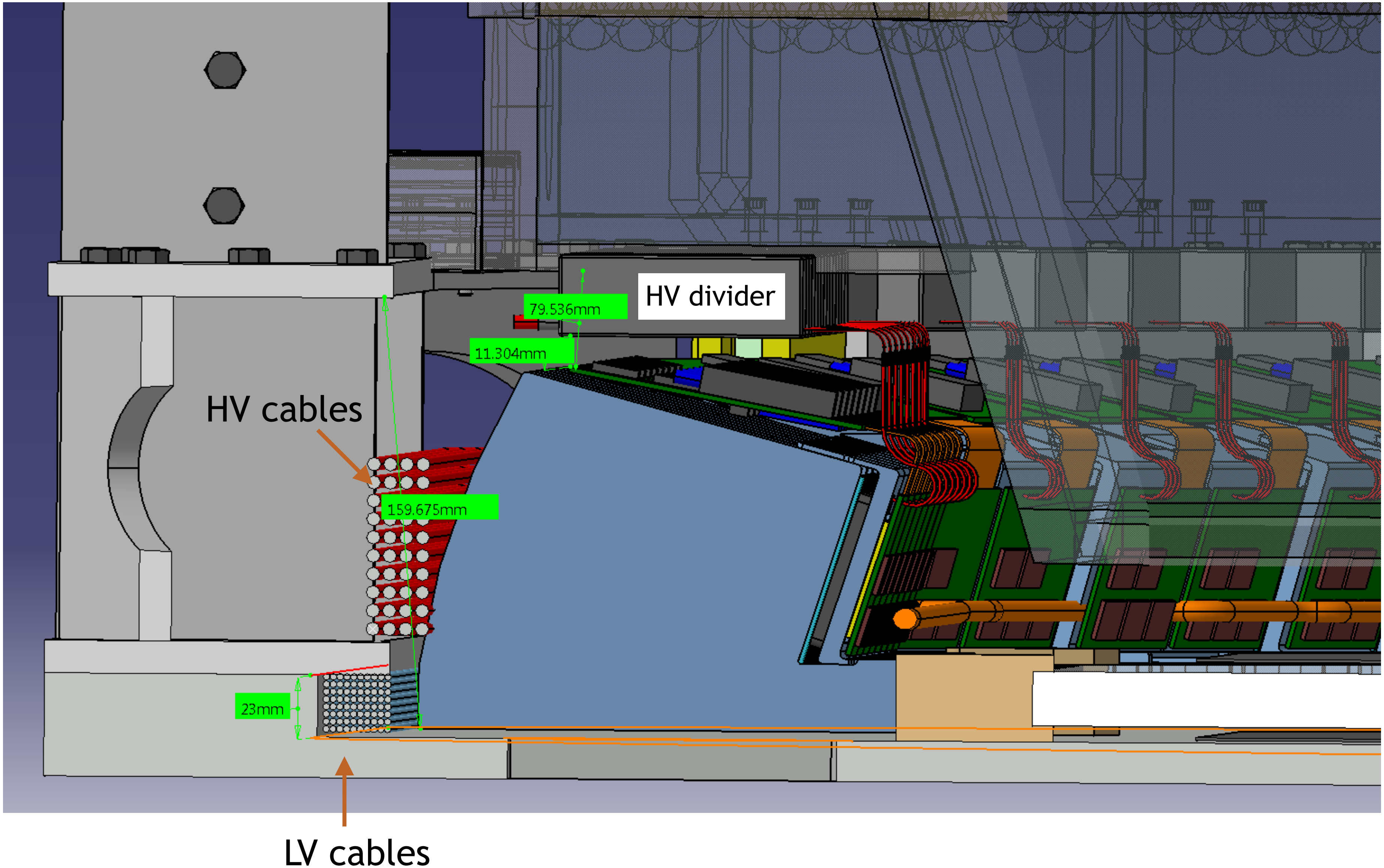
Before correction



After correction



CAD Drawing


HV divider
79.536mm
11.304mm
HV cables
159.675mm
23mm
LV cables

ToFPET2