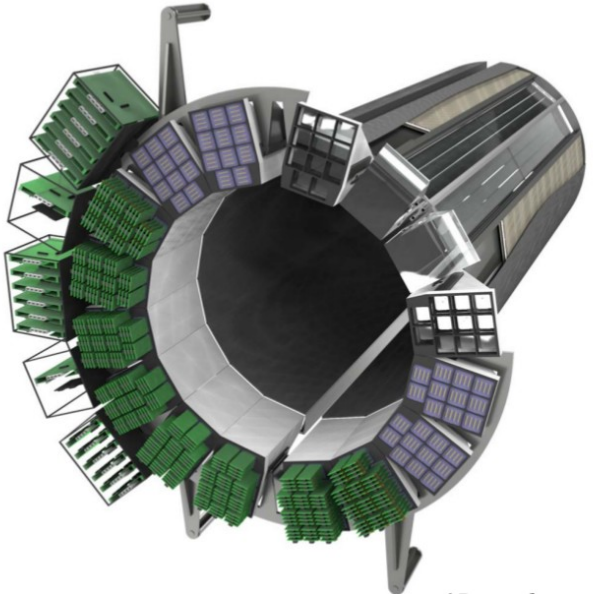
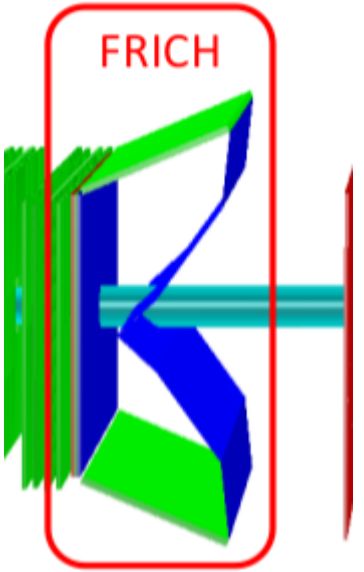
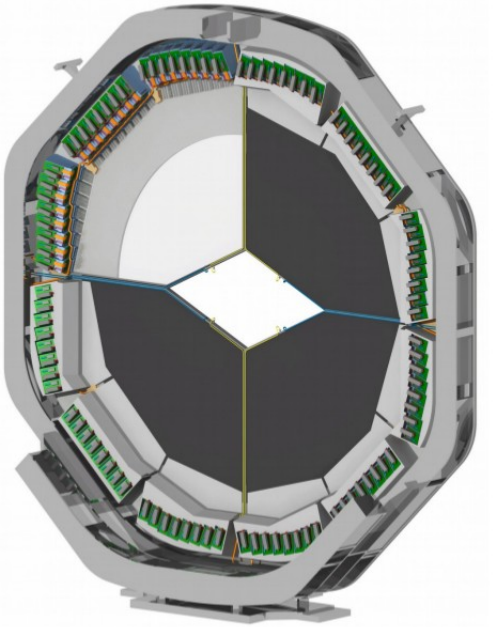
Particle Identification at the PANDA/FAIR experiment using DIRC and RICH detectors







A. Hayrapetyan on behalf of the PANDA Cherenkov Group

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

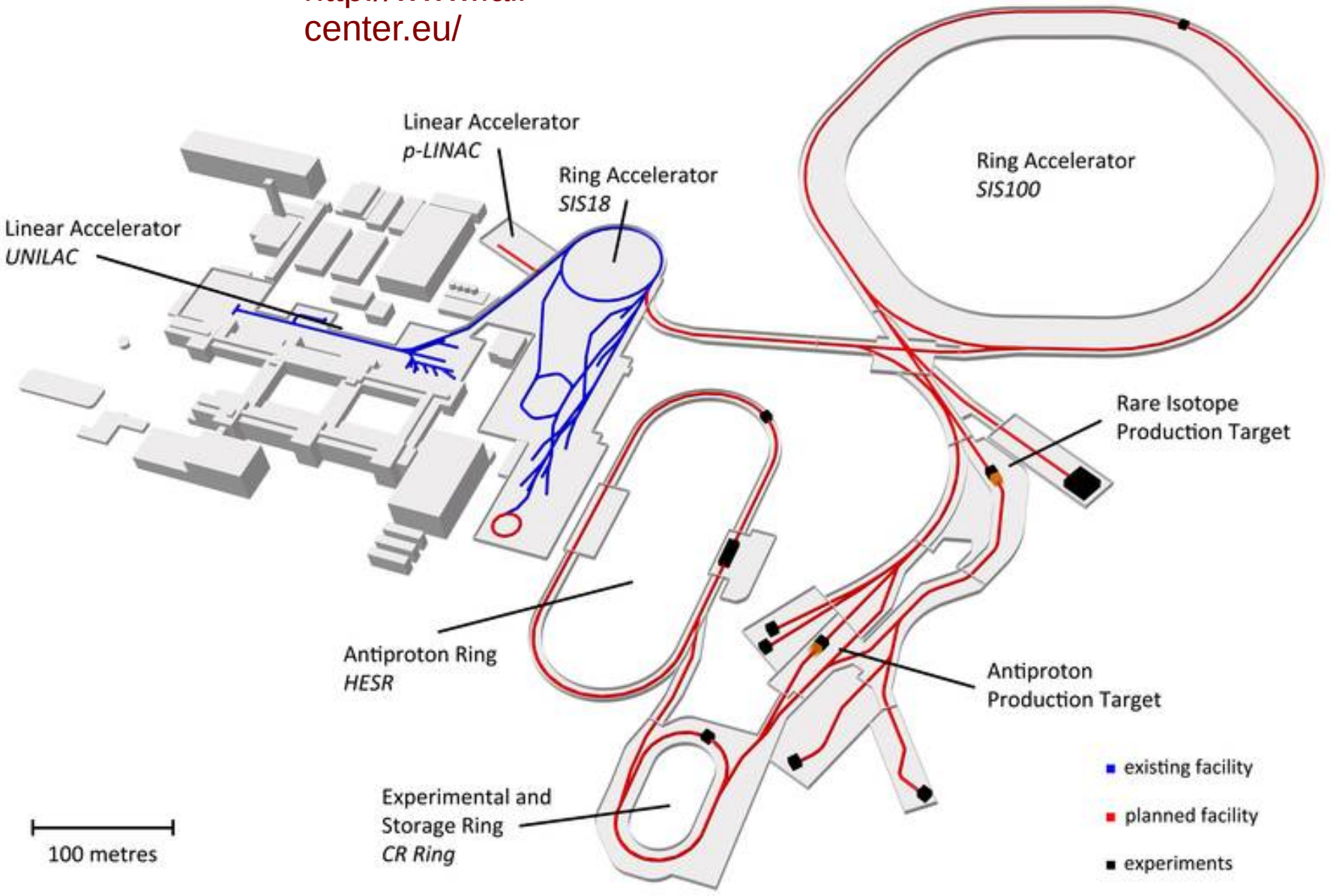
GSI panda

Bundesministerium für Bildung und Forschung

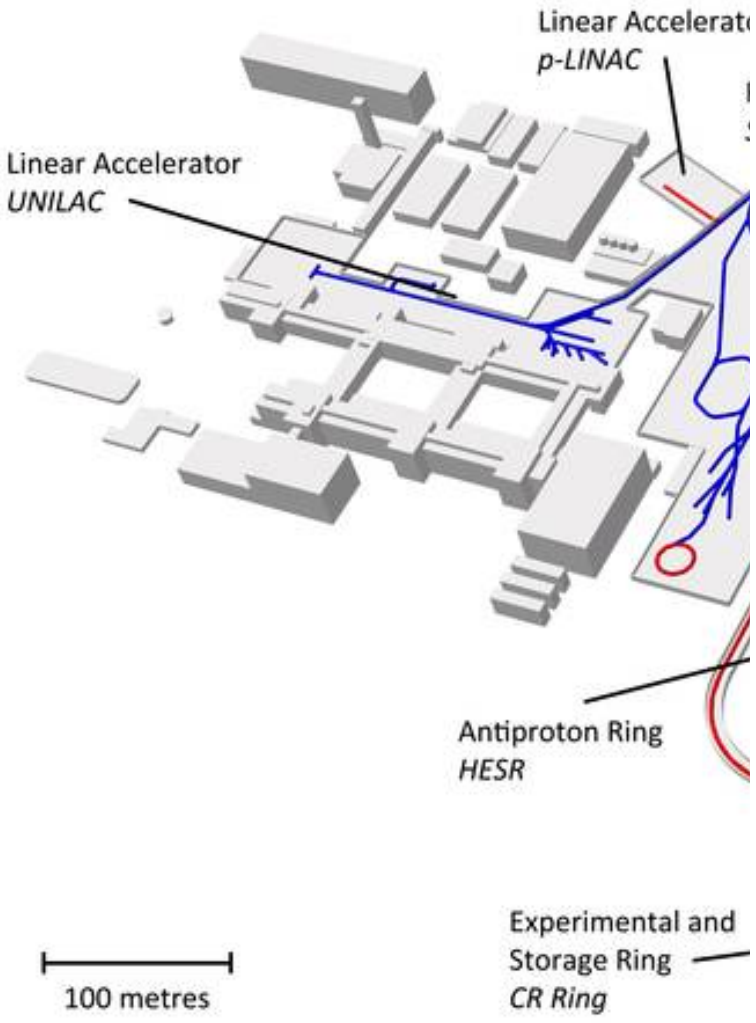
Facility for Antiproton and Ion Research

FAIR

http://www.fair-center.eu/



Facility for Antiproton and Ion Research
FAIR



High Energy Storage Ring

- Stochastic cooling
- Electron cooling

Beam momentum from 1.5 to 15 GeV/c

High luminosity mode

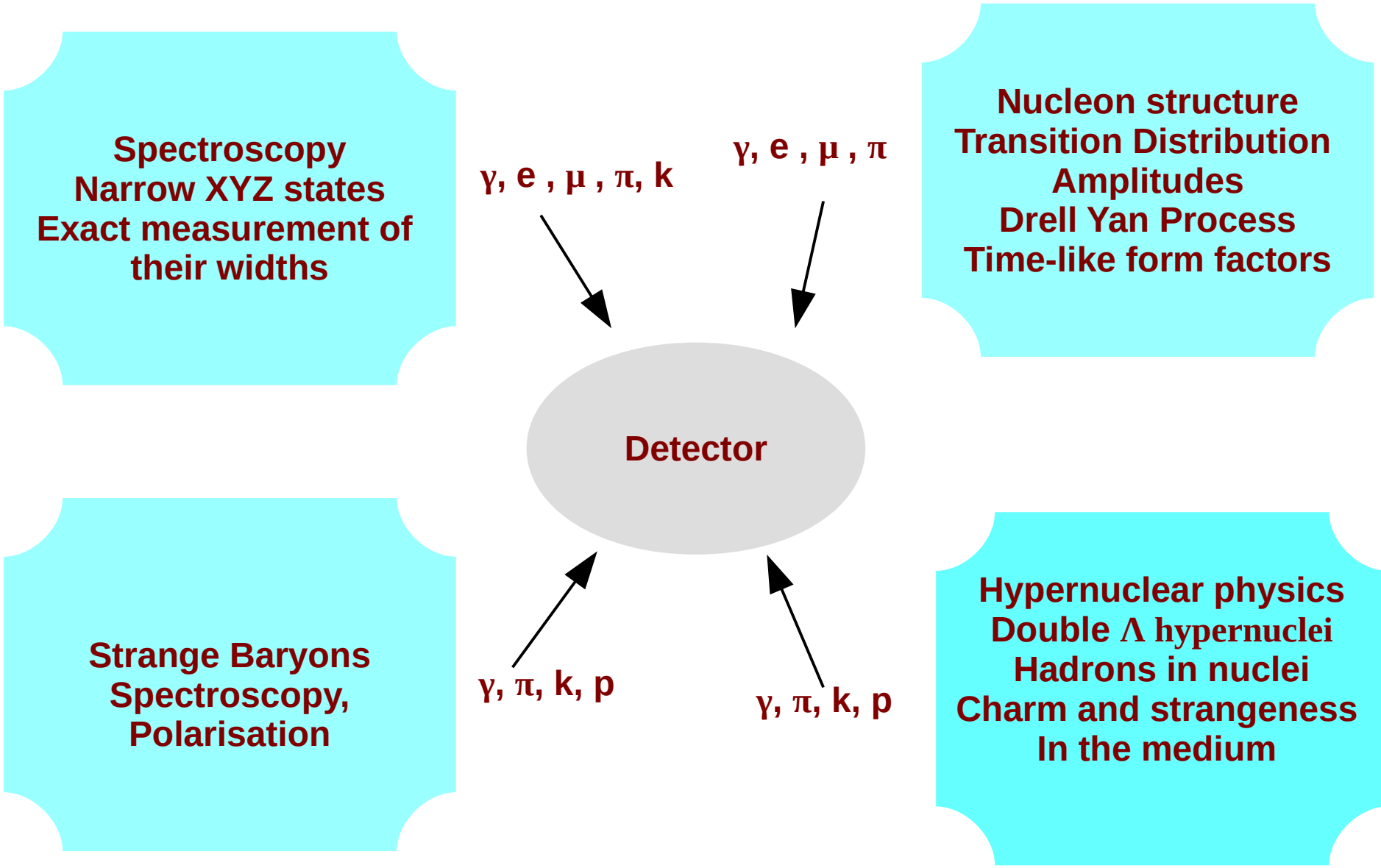
- $2 \cdot 10^{32} cm^{-2} s^{-1}$ (20 MHz)

High resolution mode

- $\Delta p/p = 4 \cdot 10^{-5}$ (2 MHz)

Cluster jet / pellet target

PANDA Objectives



PANDA Objectives

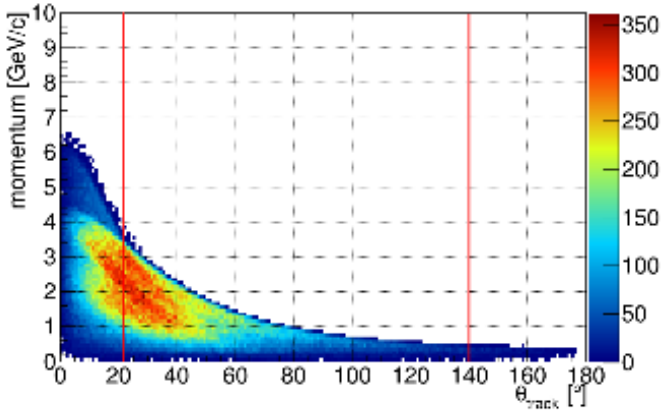
In all cases practically one needs to have PID

For all species **(γ, e, μ, π, k, p)**

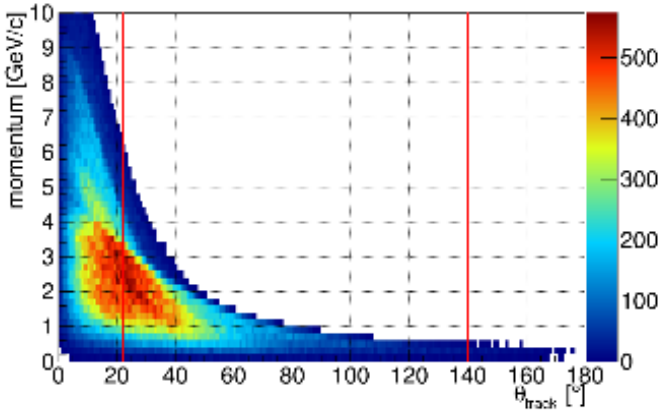
As the kaon identification is the most challenging , here their anticipated phase space

Spectroscopy
Narrow
Exact measu
w

P=3.5 GeV/c



P= 15.0 GeV/c



Nucleon structure
tribution
es
ocess
factors

Strange Baryons
Spectroscopy,
Polarisation

Hypernuclear physics
Double Λ hypernuclei
Hadrons in nuclei
Charm and strangeness
In the medium

PANDA Objectives

Details see here

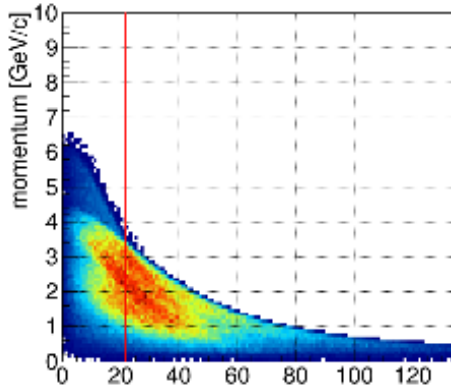
In all cases practically one needs to have PID

For all species **(γ, e, μ, π, k, p)**

As the kaon identificat

their anticipated phas

Spectroscopy
Narrow
Exact measu
w



Strange Baryons
Spectroscopy,
Polarisation

arXiv:0903.3905v1 [hep-ex]

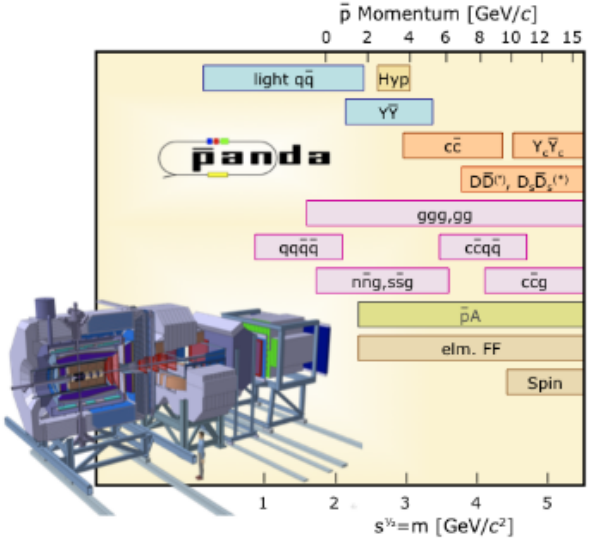
PANDA

(AntiProton Annihilations at Darmstadt)

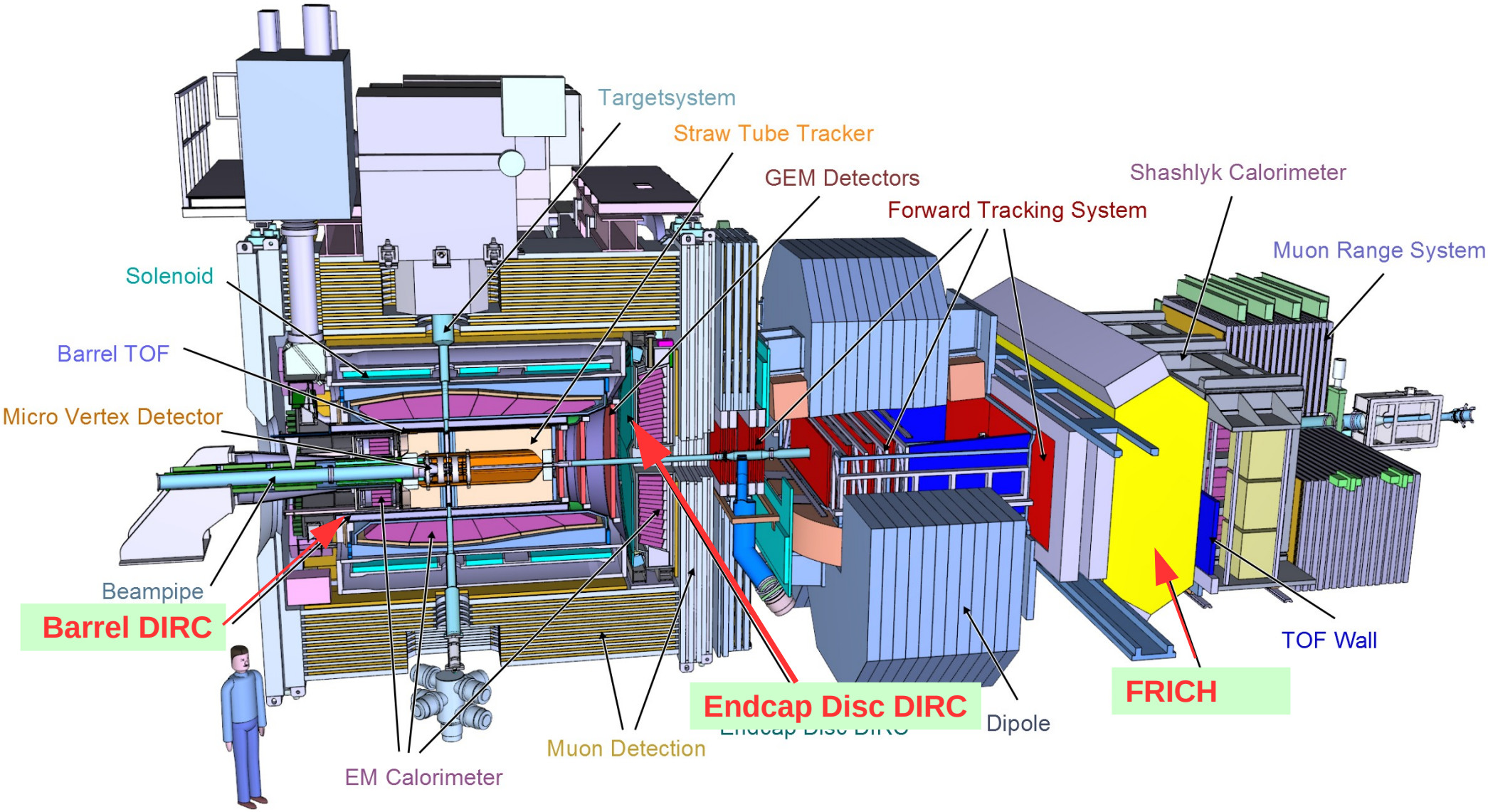
Strong Interaction Studies with Antiprotons

PANDA Collaboration

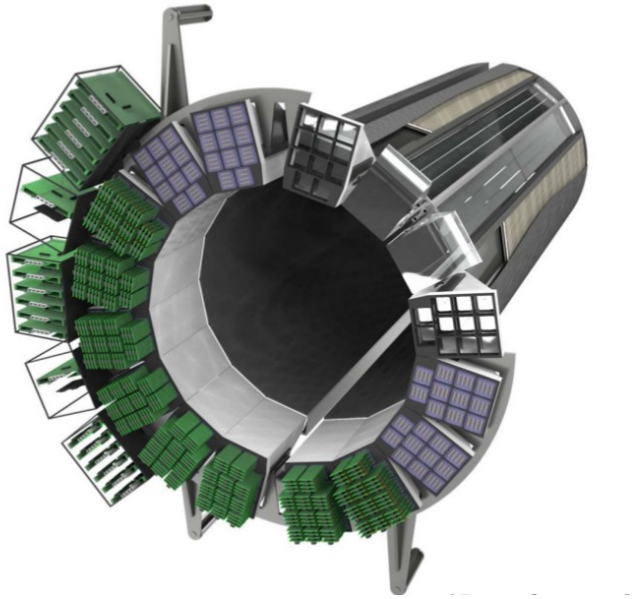
To study fundamental questions of hadron and nuclear physics in interactions of antiprotons with nucleons and nuclei, the universal PANDA detector will be build. Gluonic excitations, the physics of strange and charm quarks and nucleon structure studies will be performed with unprecedented accuracy thereby allowing high-precision tests of the strong interaction. The proposed PANDA detector is a state-of-the-art internal target detector at the HESR at FAIR allowing the detection and identification of neutral and charged particles generated within the relevant angular and energy range.
This report presents a summary of the physics accessible at PANDA and what performance can be expected.

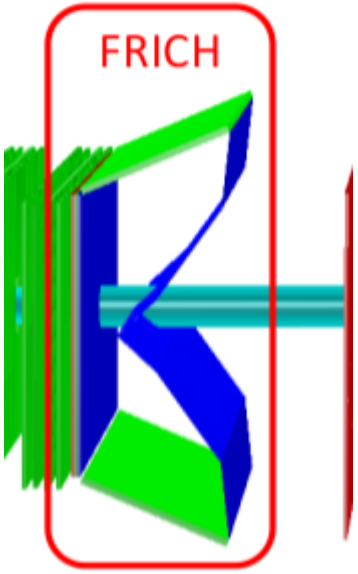


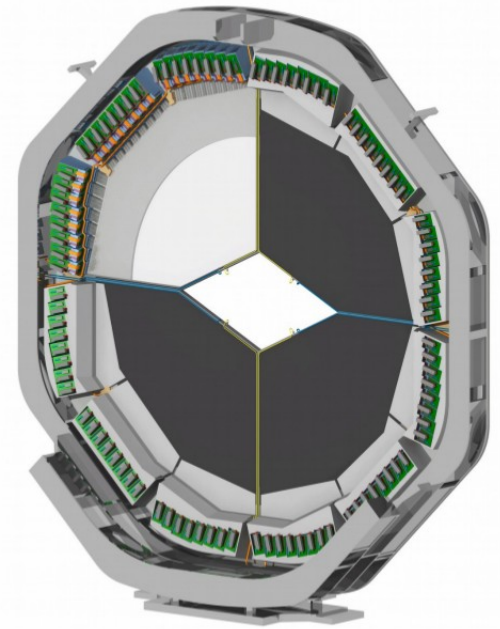
The PANDA detector



The PANDA Cherenkov Detectors







Barrel DIRC | **FRICH** | **Endcap Disc DIRC(EDD)**

Polar Angles

22-140 | **0-5(10)** | **5(10)-22 degree**

Goal

3 s.d. π/K separation Up to 3.5 GeV/C

3 s.d.π/K 2÷10 GeV/c μ/π possible till ~2.0 GeV/C

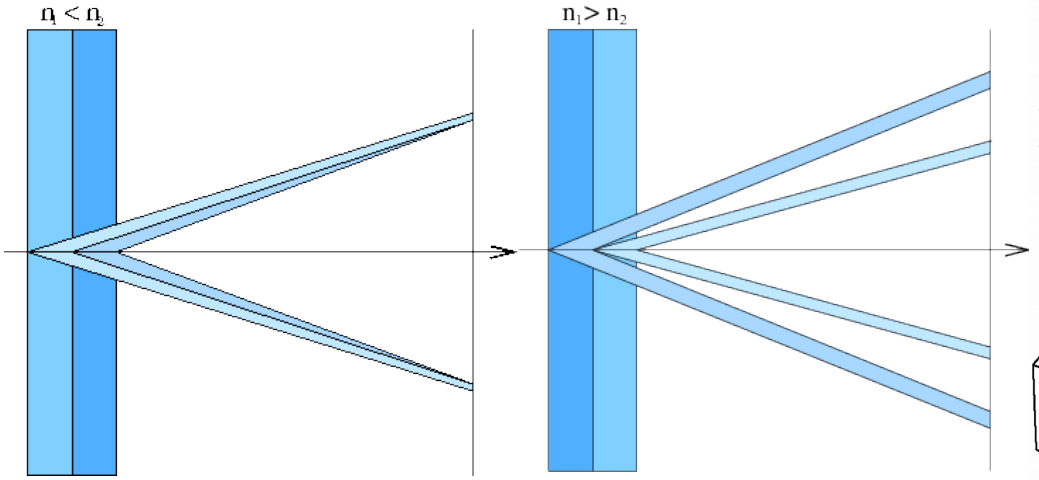
3s.d. π/K up to 4.0 GeV/C

The BARREL DIRC

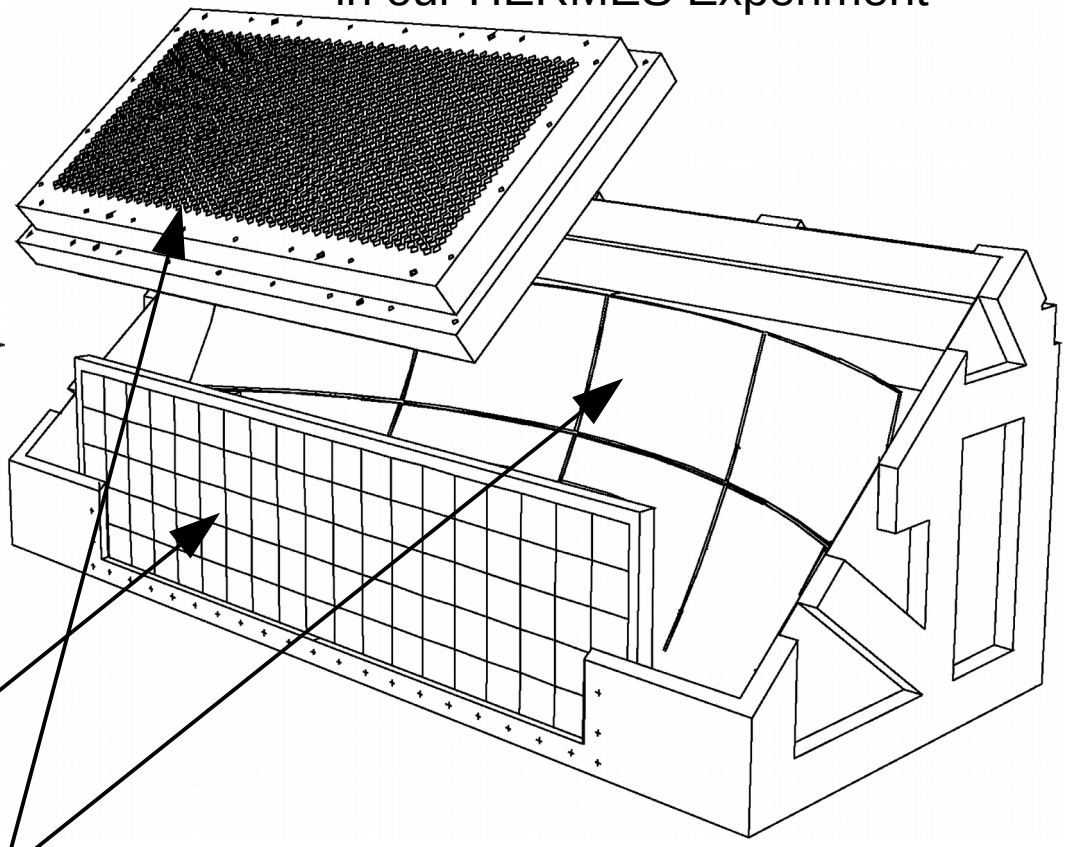
- See Jochen Schiwening talk in this session

The Forward RICH

The principle



as predecessor, 20 years ago
in our HERMES Experiment



T.Iijima et al., NIM A548 (2005)383
A.Yu.Barnyakov et al., NIMA553(2005)70

The HERMES RICH detector HERMES Collaboration

NIMA v. 433. Issues 1-2 (1999) 98-103

A few layer of Aerogel, Mirrors and Photon detector area outside of acceptance
See A. Barnyakov talk next for more

The Prototype of FRICH tested at BINP and CERN

Aerogel produced at BIC SB RAS in cooperation with BINP Novosibirsk

4-layer aerogel

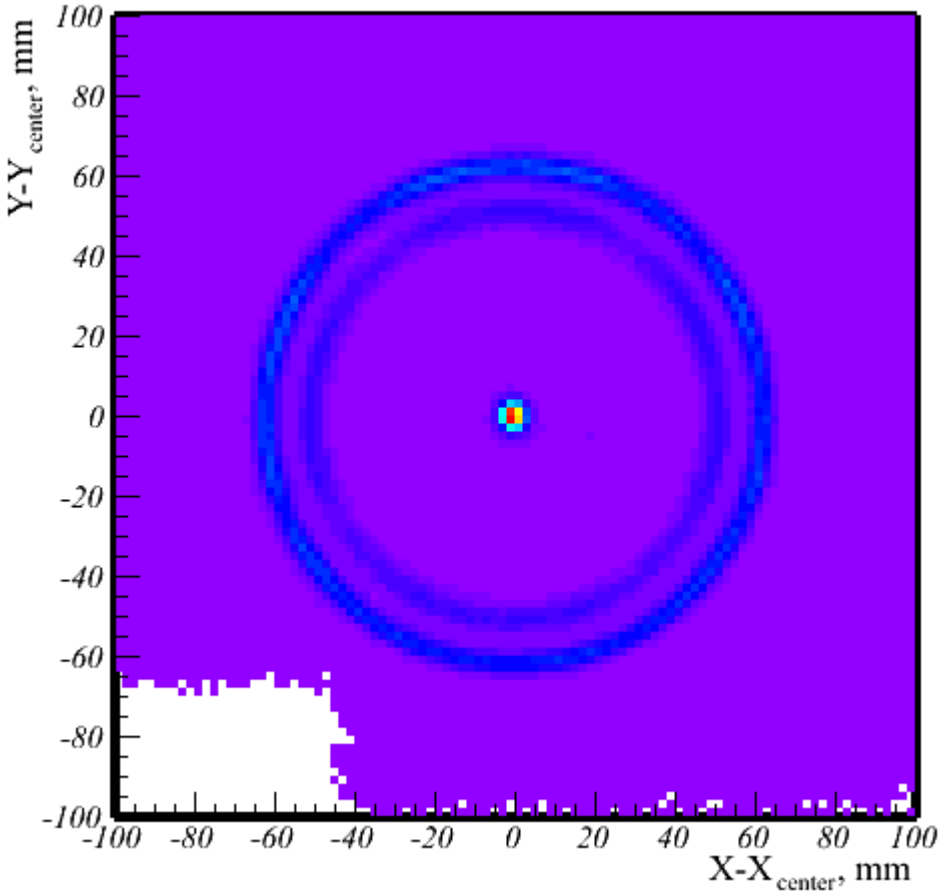
- n_{max} = 1.046
- Thickness 37.5 mm
- Calculated focal distance 200 mm
- Hermetic container with plexiglass window to avoid moisture condensation on aerogel

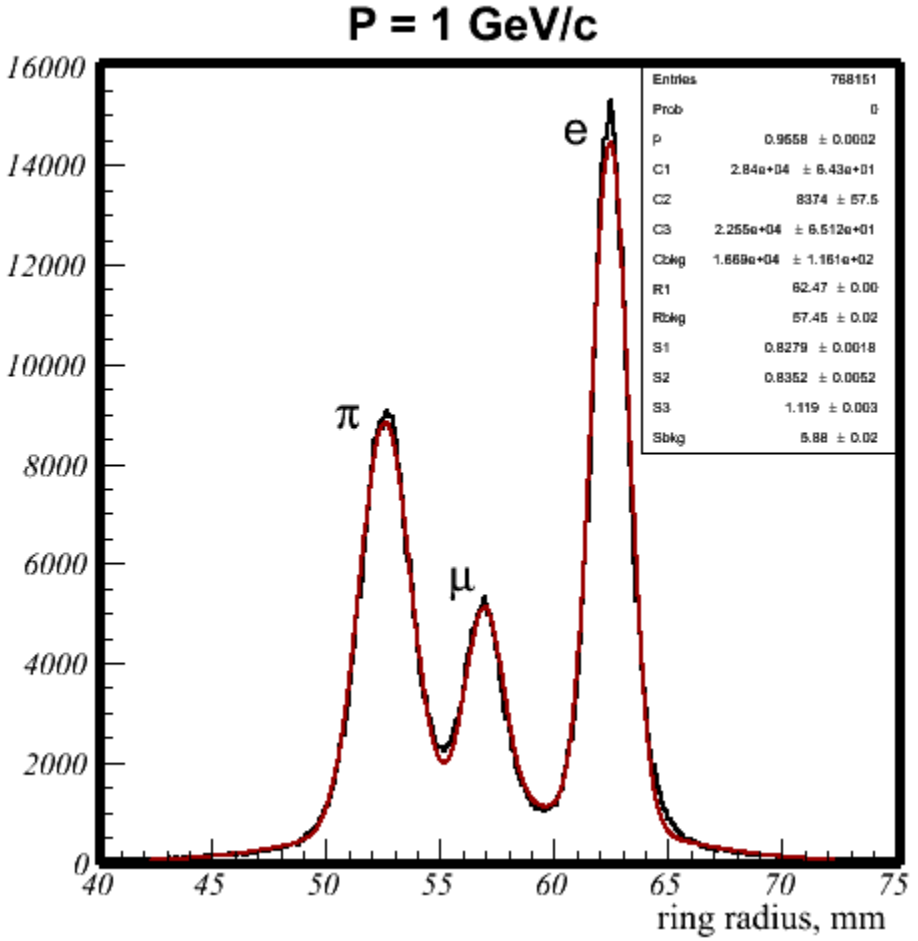
Photon detector , Philips Digital Photon Counting (PDPC)
https://www.digitalphotoncounting.com

Square matrix 20x20 cm^2

- Sensors: DPC3200-22-44
- 3x3 modules = 6x6 tiles = 24x24 dies = 48x48 pixels in total
- 576 time channels
- 2304 amplitude (position) channels
- 4 levels of FPGA readout: tiles, modules, bus boards, test board

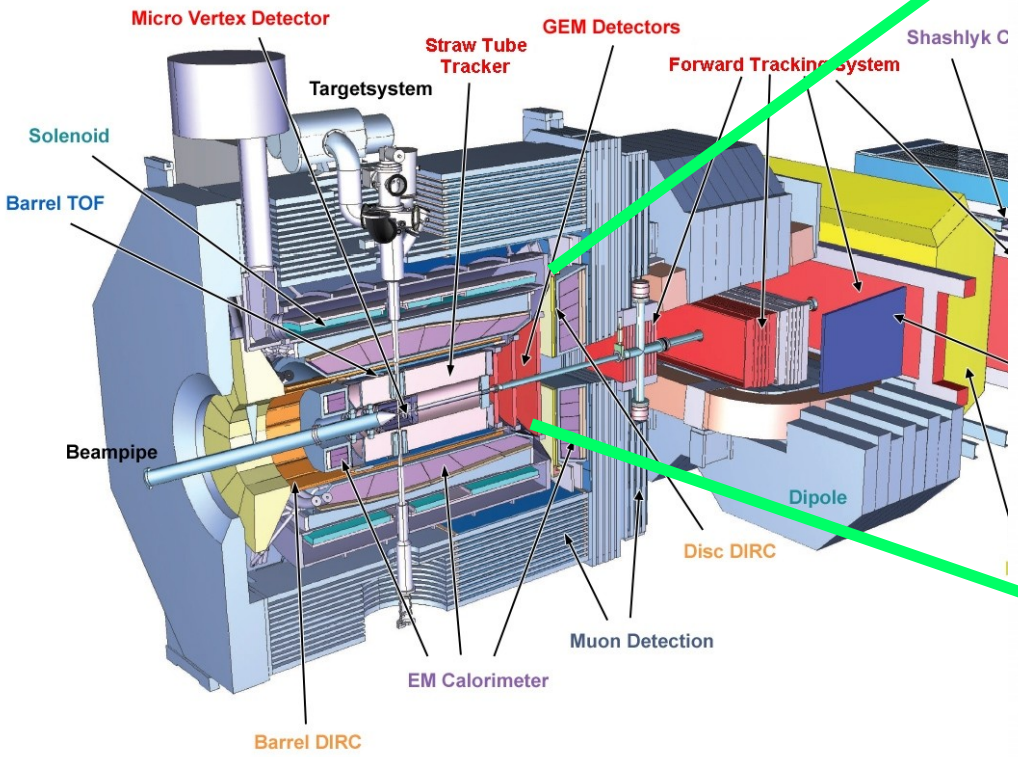
The FRICH Prototype results

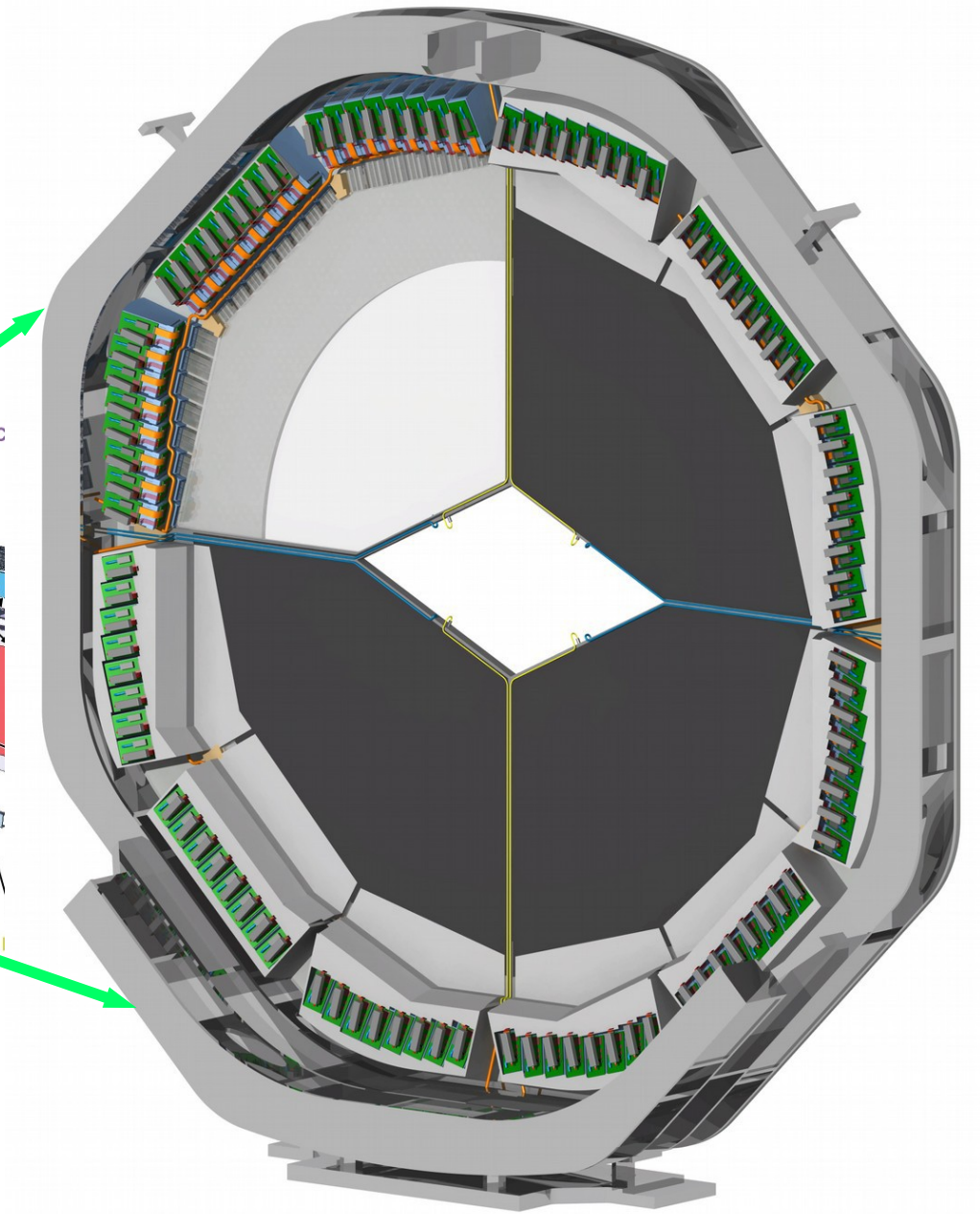




Ring 2D distribution for P=6 GeV/C(left) and ring radius distribution for P= 1 GeV/C Momentum beam measured by FRICH prototype at CERN T9 test beam

Novel Endcap Disc DIRC(EDD) will be built by Giessen

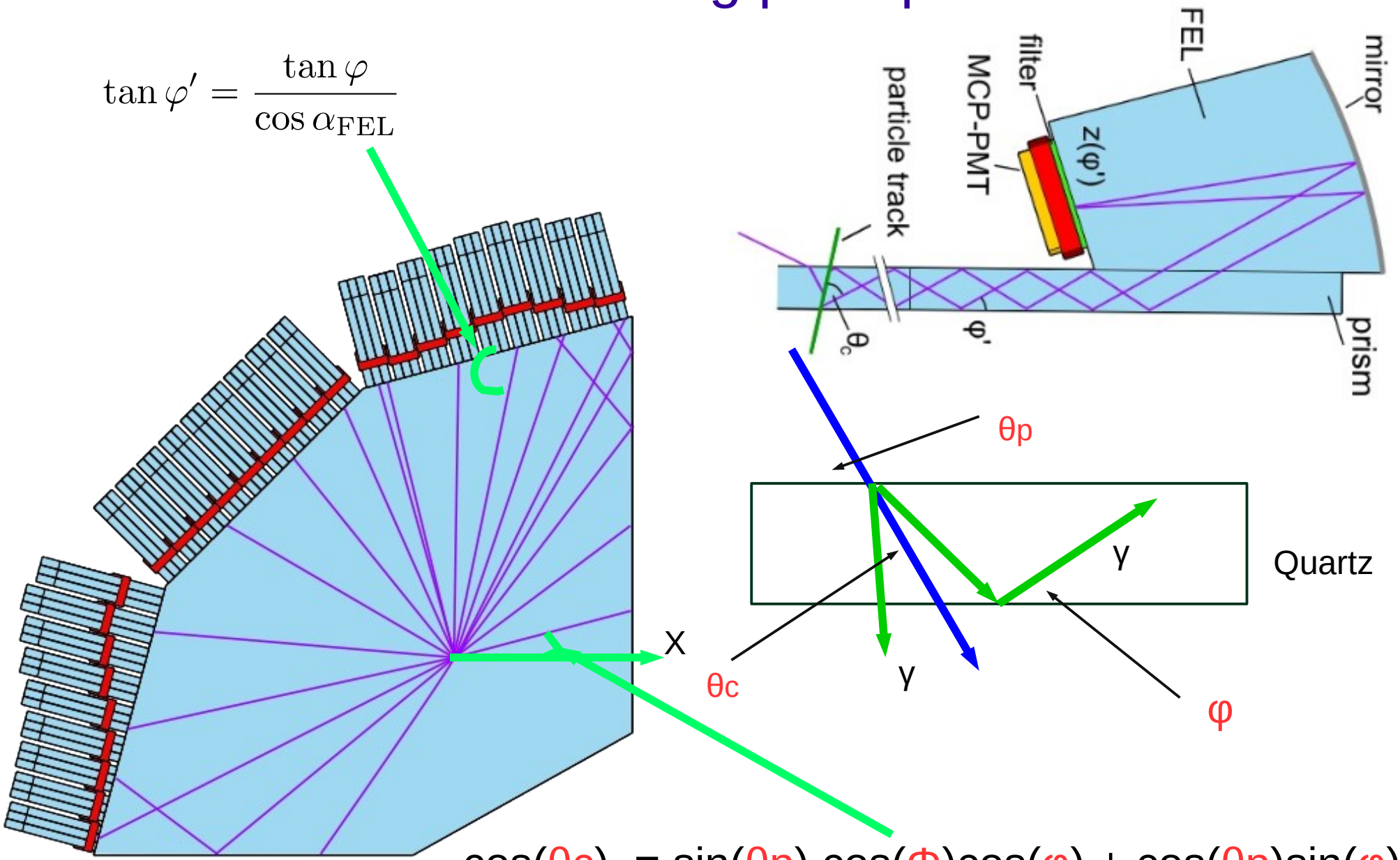




http://www.uni-giessen.de/dueren

The working principle

$$\tan\varphi' = \frac{\tan\varphi}{\cos\alpha_{\mathrm{FEL}}}$$

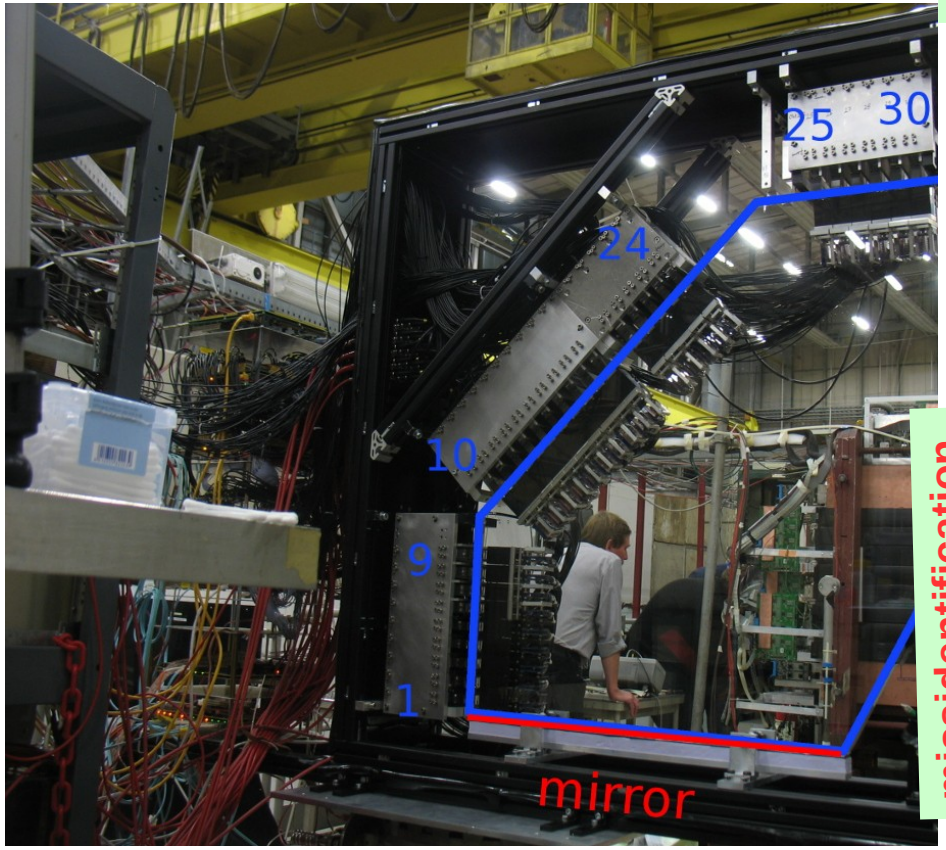


$$\cos(\theta c) = \sin(\theta p)\cos(\Phi)\cos(\varphi) + \cos(\theta p)\sin(\varphi)$$

One can calculate the Cherenkov angle analytically, hence EDD could be a part of online trigger at any level

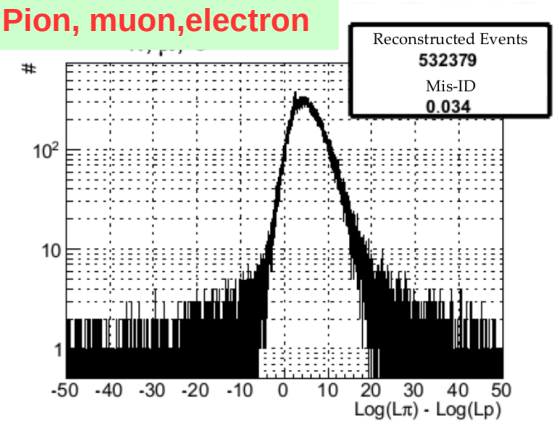
The first full size EDD

prototype at CERN T9

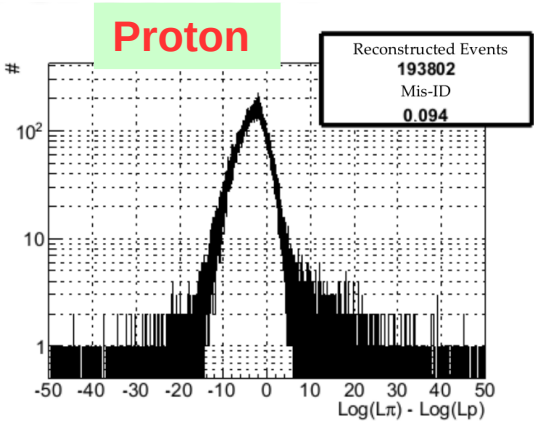


PID probabilities

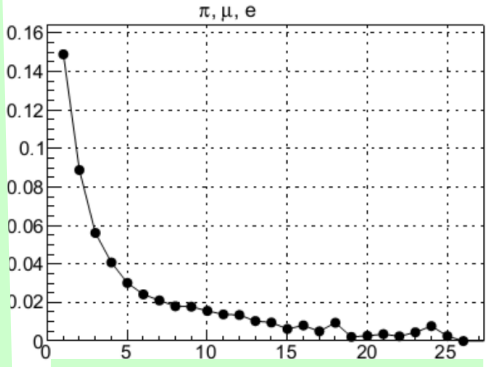
Pion, muon,electron



Proton

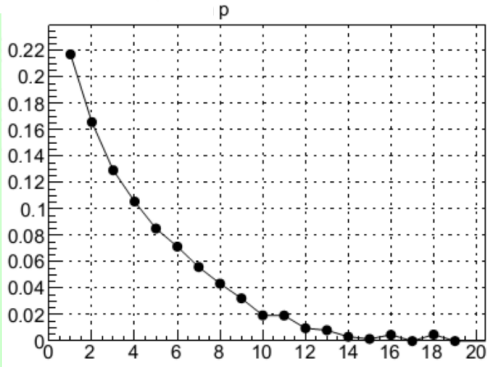


missidentification



Number of Photons

missidentification

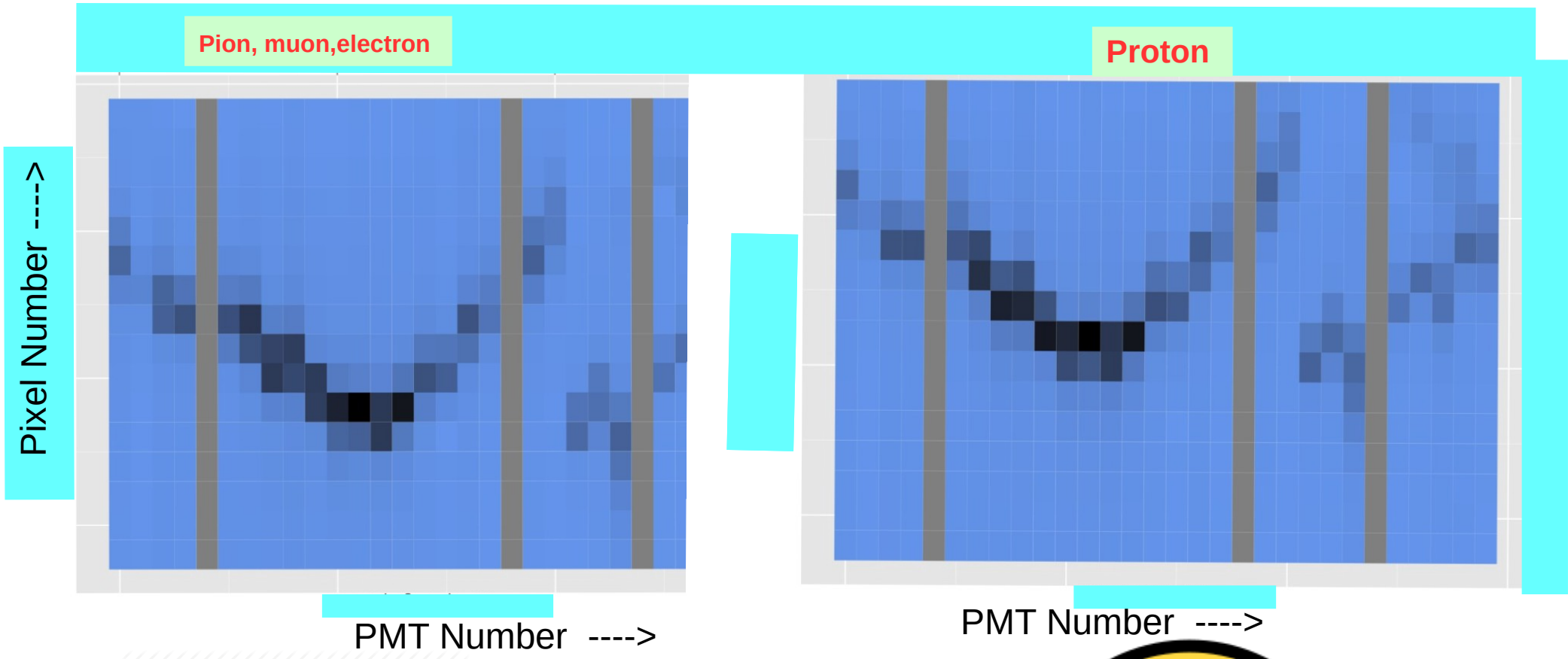


Number of Photons

- radiator made of float glass
- FELs made of acrylic glass
- photo sensors: MA-PMT with 16 strips
- mixed hadron beam at CERN

One can see that by enough hits
the misidentification is then negligible

The hit pattern shows what we call "SMILE"

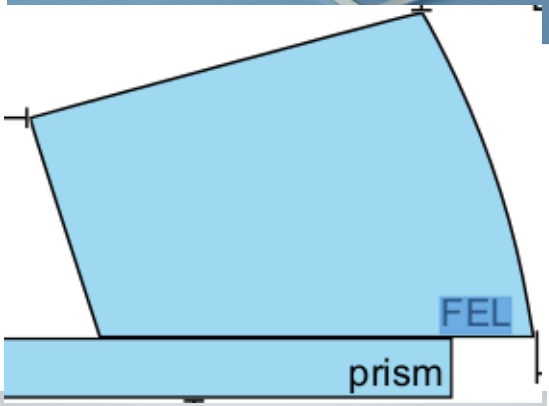


One sees that Protons are more happy than Pions&Co

Moving in EDD final design direction

Radiator

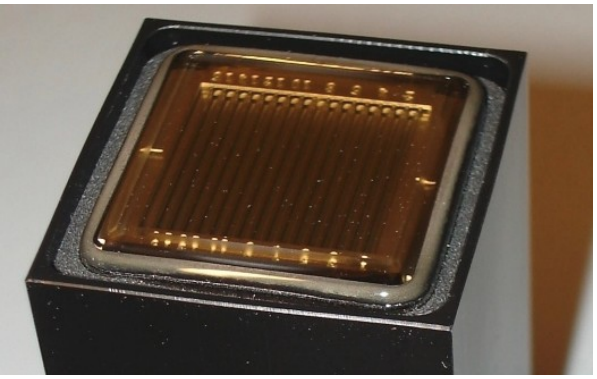
Borofloat Glass ---- fused Silica

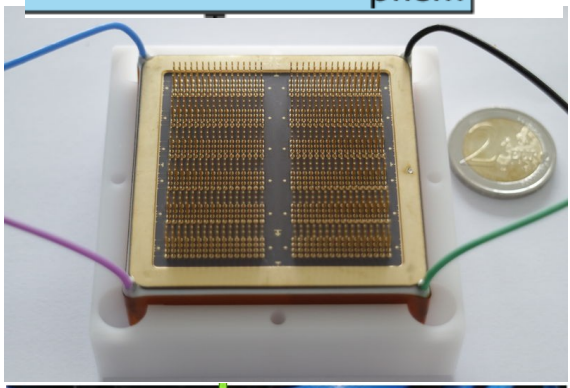


FEL

Plexiglas

Quartz with prism
With optic bonding





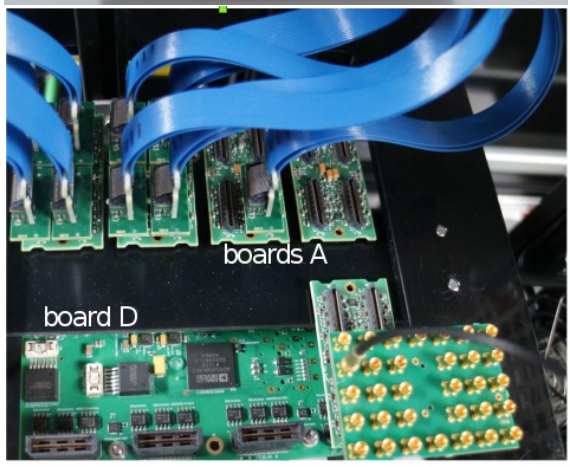
Photon Detector

MaPMT(16 channels)---MCP-PMT
(>=300 channels)

Readout FEE

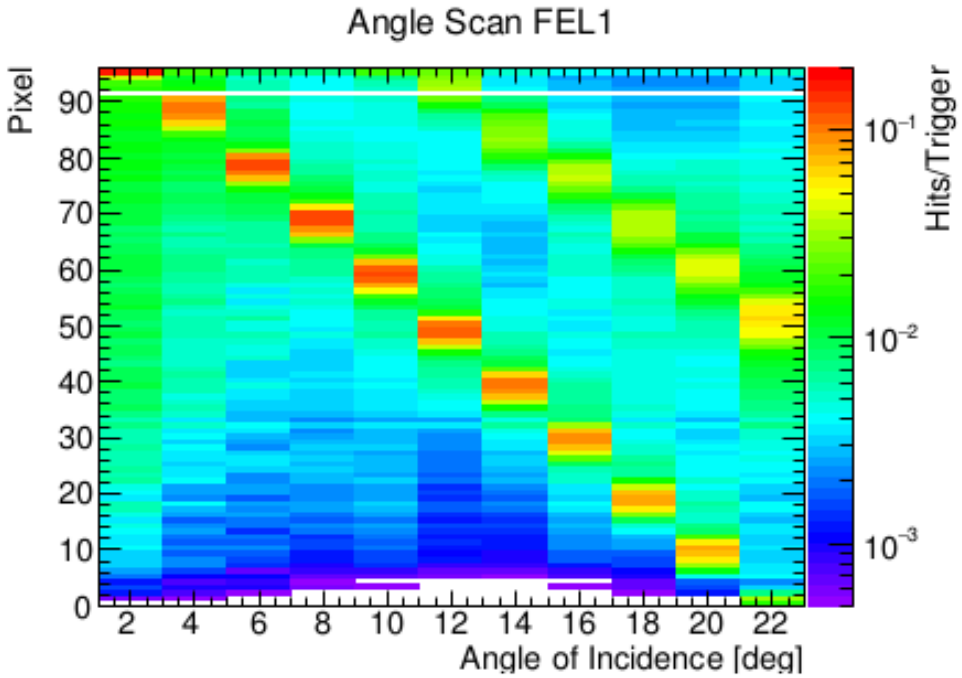
FPGA based
channels (256 single edge,
192 with ToT)
TRB3

TOFPET ASIC compact
design
8X128=1024 channels

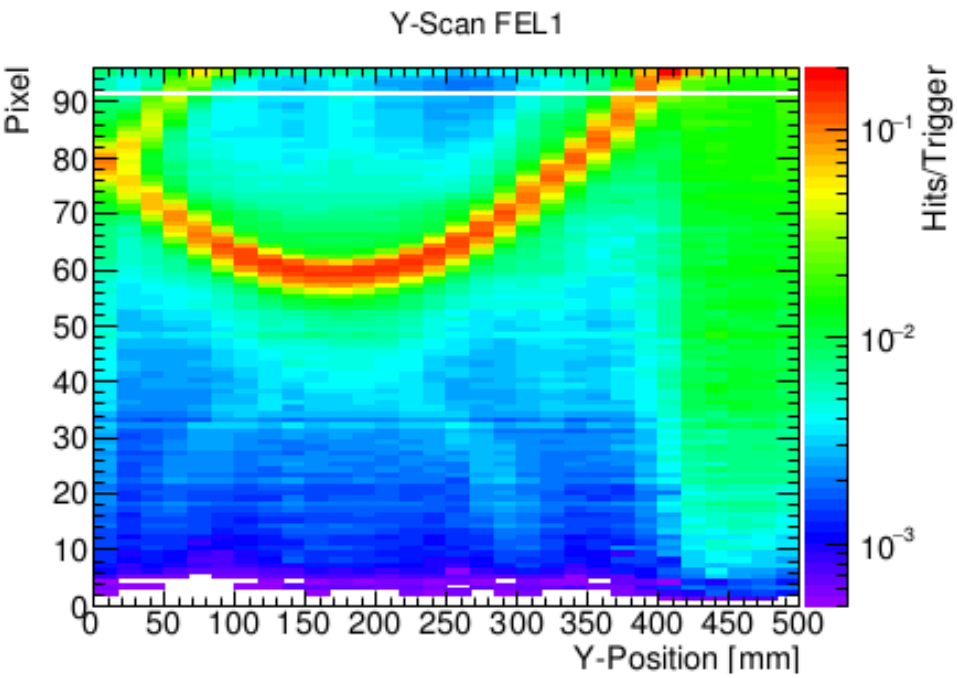


New prototype

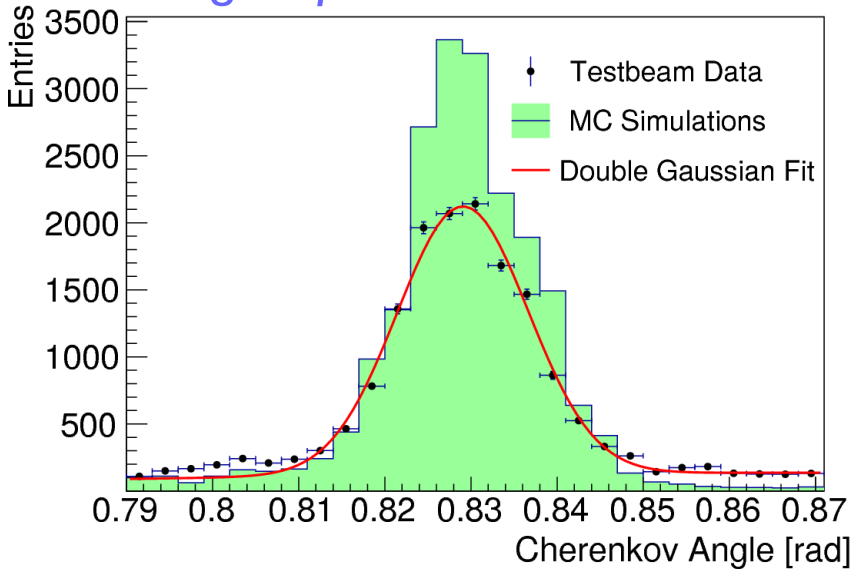
finer scaling



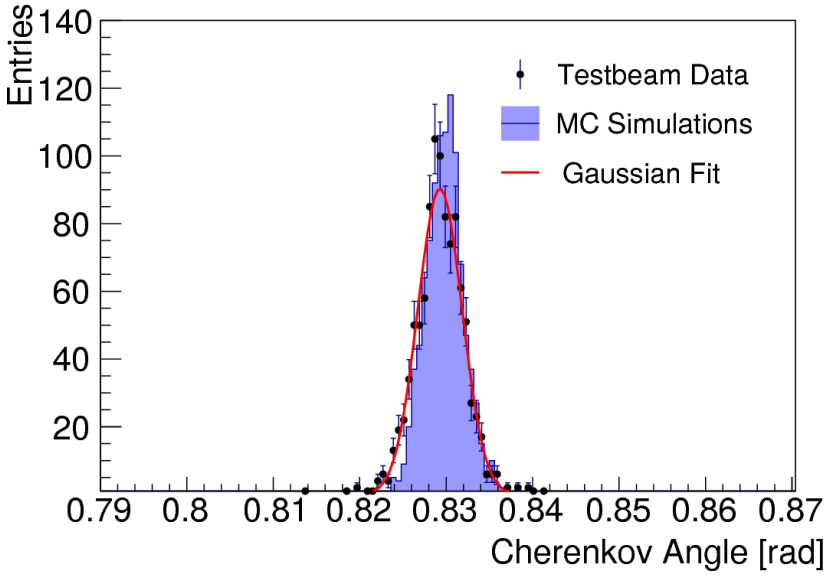
new “SMILE”



Single y resolution

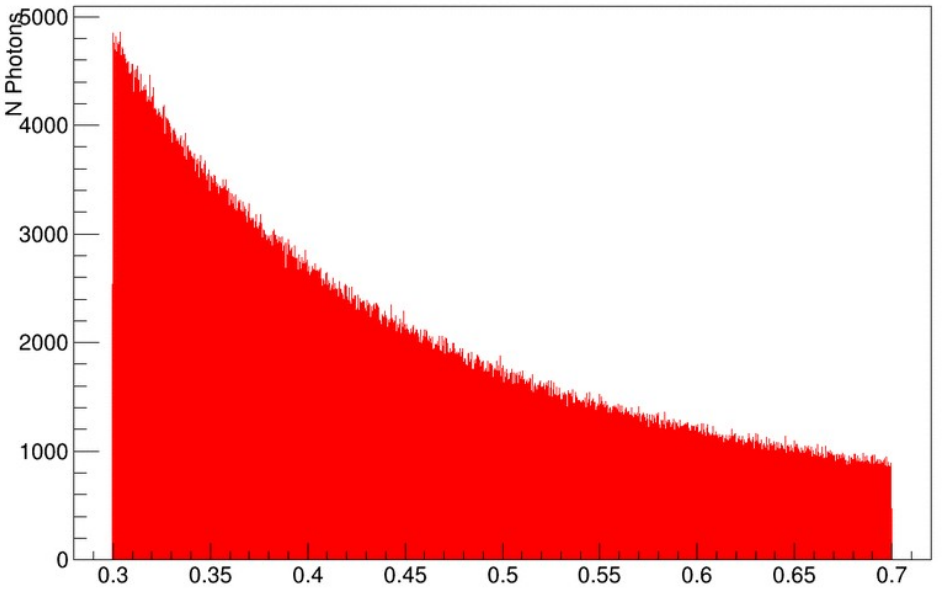


“mimicking” full prototype



The importance of the Filter

In Silica produced Cherenkov Photons Number Against wavelength –>

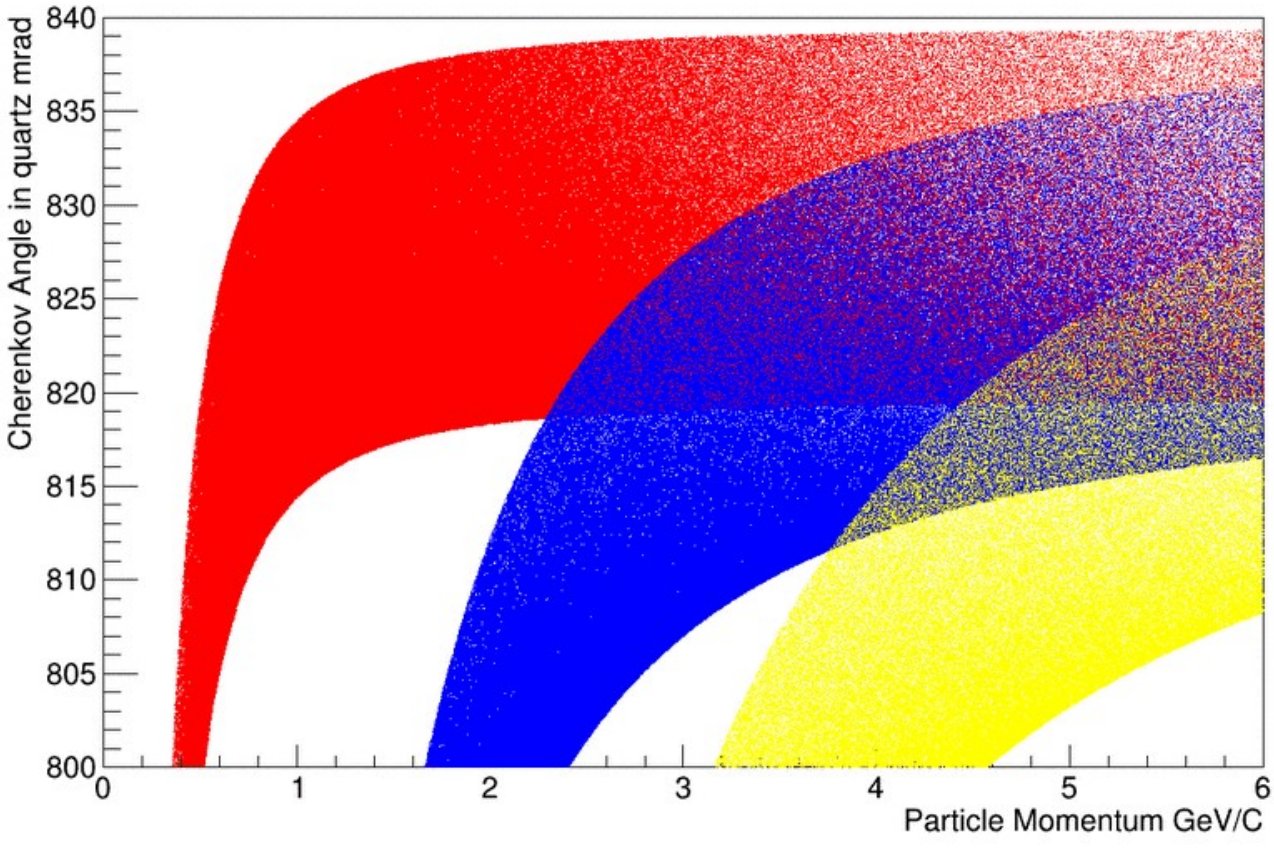


Pions

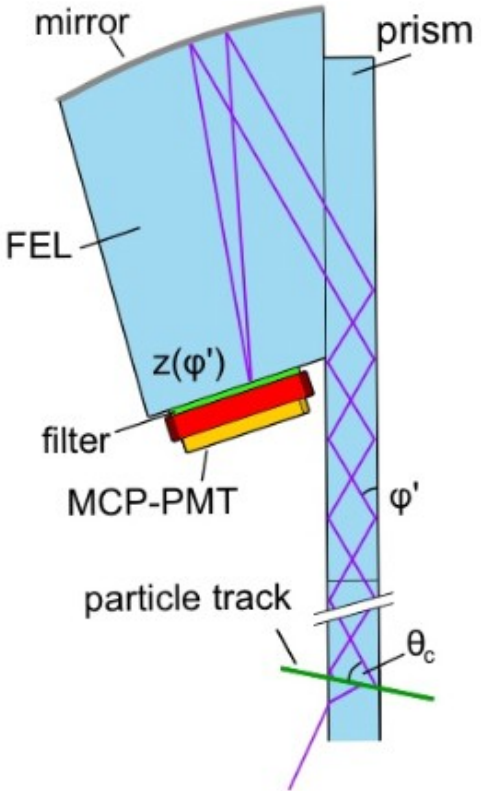
Kaons

Protons

Cherenkov angle against momentum



λ um

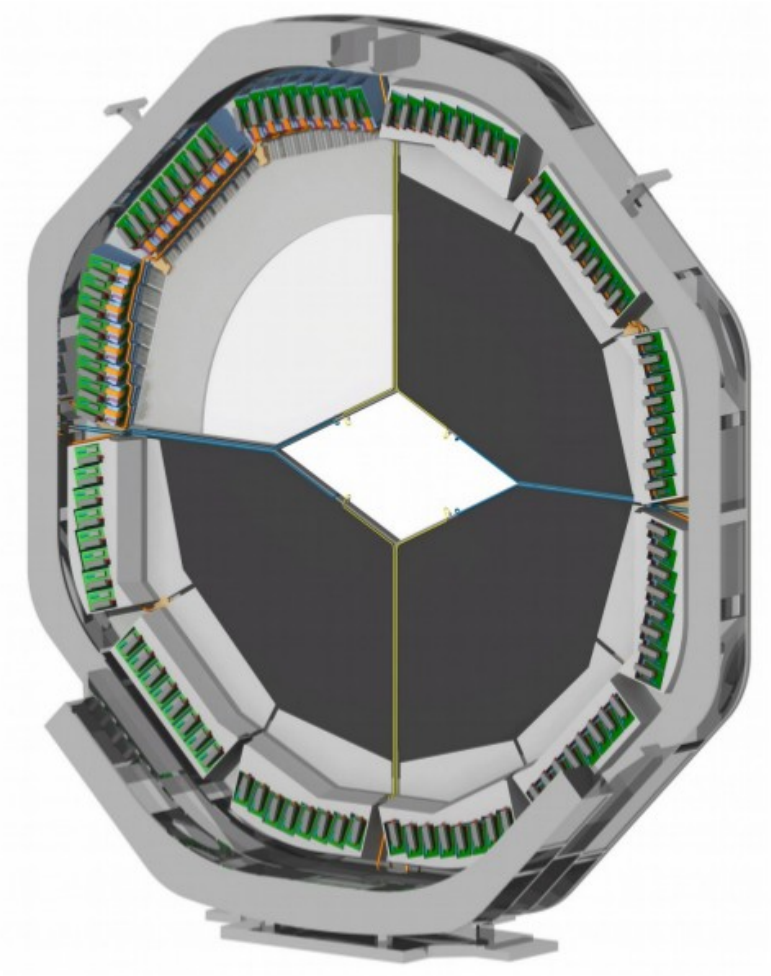


The Endcap DIsc DIRC design

Full Weight ~ 450 kg
For 1 Quadrant ~ 85 kg

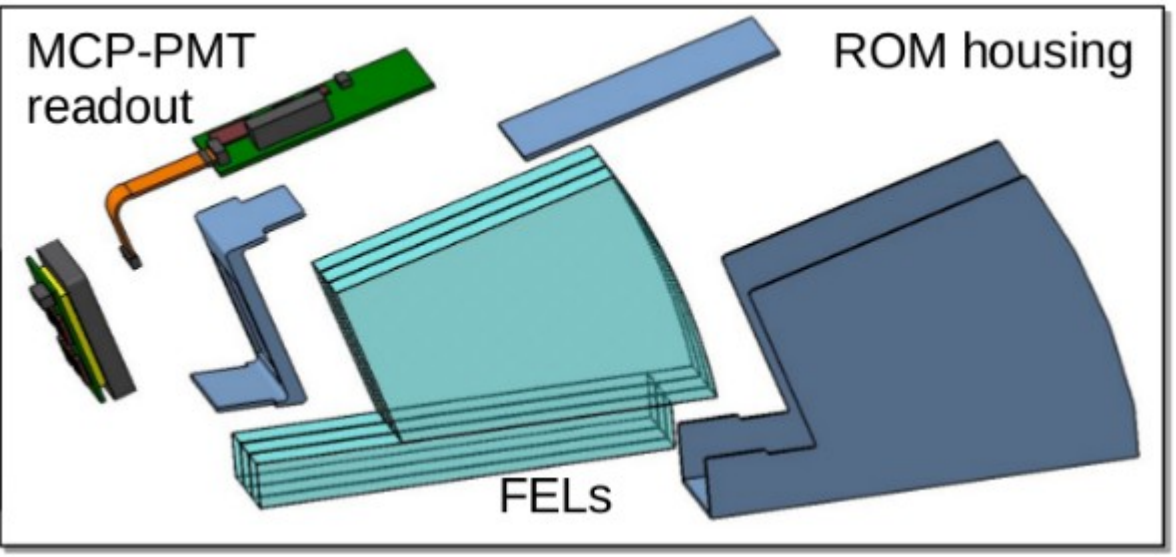
Quadrants 4
ROMs 96 = 4X3X8
(Readout Modul)
Photon detection area ~600cm^2
FELs 288 = 4X3X8X3
(Focusing Element)
Readout Channels ~30k
free running readout system
Wavelength Filters ~ 100 or
New “green” photocatode MCP

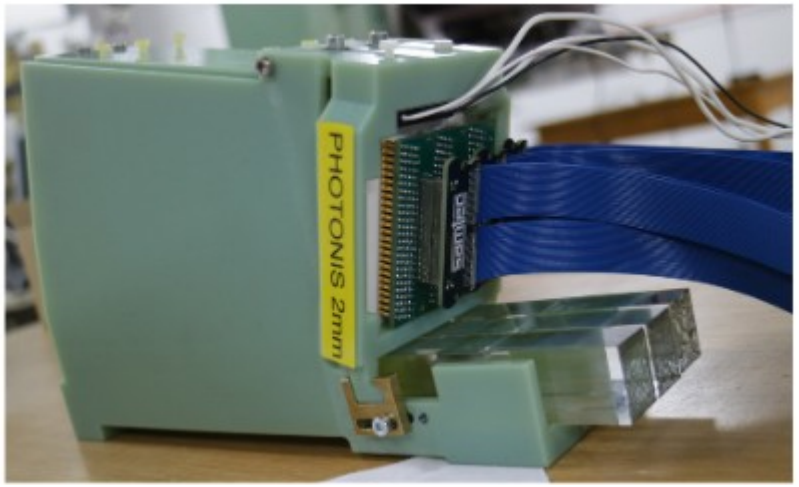
We are waiting ~22 detected hits
(per track)
We promise >3 s.d. for π/K separation
till 4 GeV/c momentum

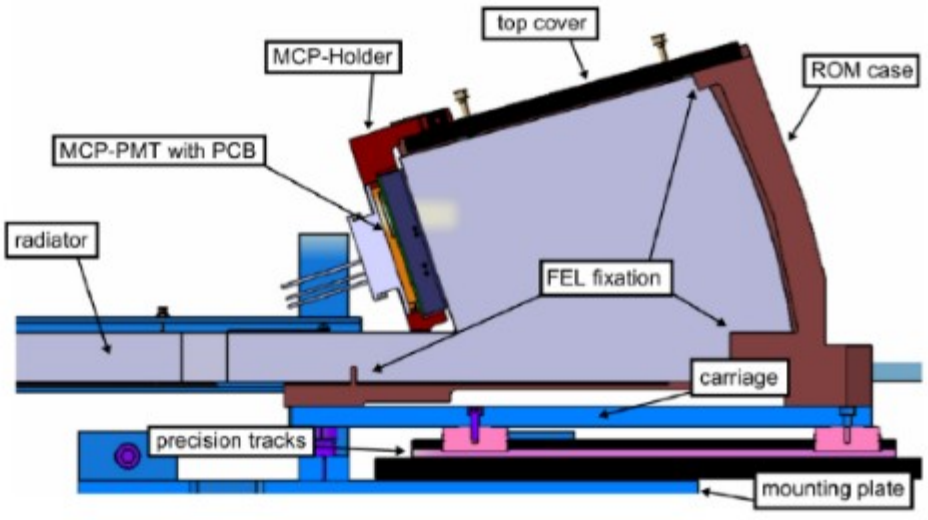


The EDD Read Out Module

In design or in Prototype(in 3d printed housing)



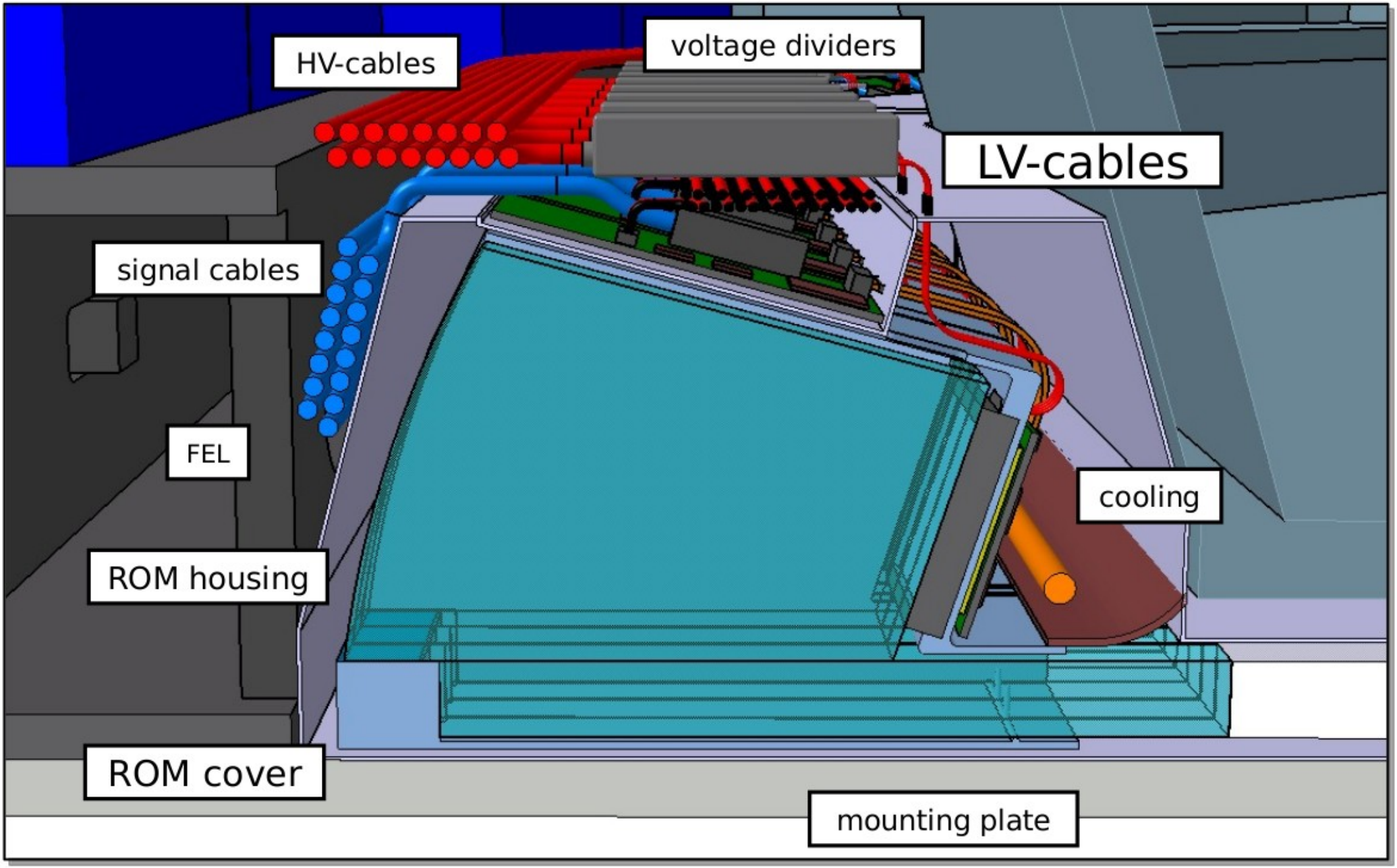




EDD final design

Finalizing the specifications , algorithms, TDR for a EDD Quadrant readiness for Phase1, 2018 new Testbeam at T9

The complete design in CAD



The Time-lines

Barrel DIRC

2018 component procurement

2019-2021 bar box and readout module Assembly

2022-2023 installation in PANDA Hall

2023-2024 commissioning with cosmic and beam

TDR approved(arXiv:1710.00684)

EDD

2018 R&D fine tuning

2018-2021 1st Quadrant production

2022-2023 Installation of First Quadrant

2023-2024 commissioning

2025 completion of remaining 3 Quadrants

FRICH

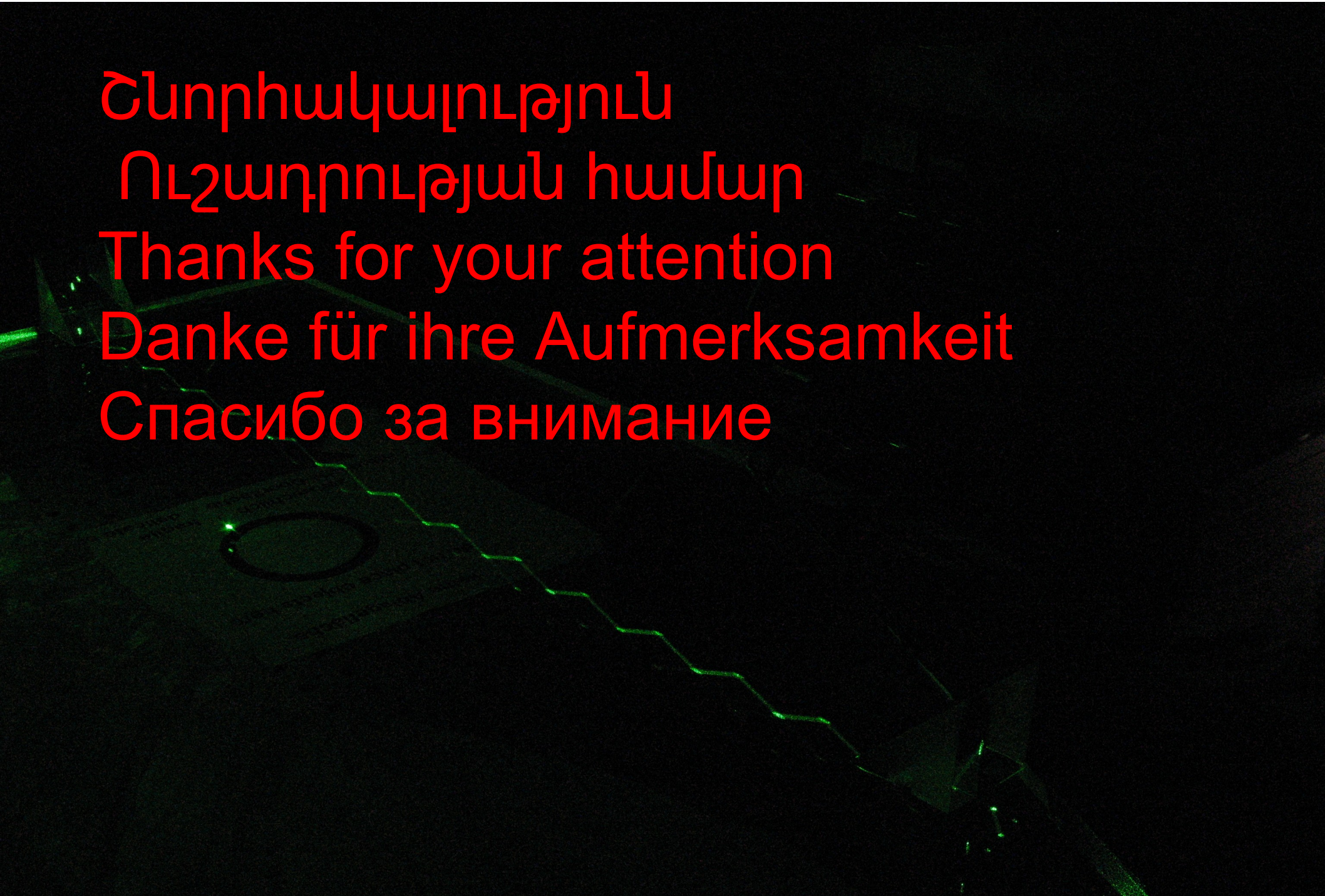
2018 TDR expected

Mirror layout optimization in 2D

MC simulation PANDAROOT

Aerogel Optimization

Photon detector investigation


Շնորհակալություն
Ուշադրության համար
Thanks for your attention
Danke für ihre Aufmerksamkeit
Спасибо за внимание