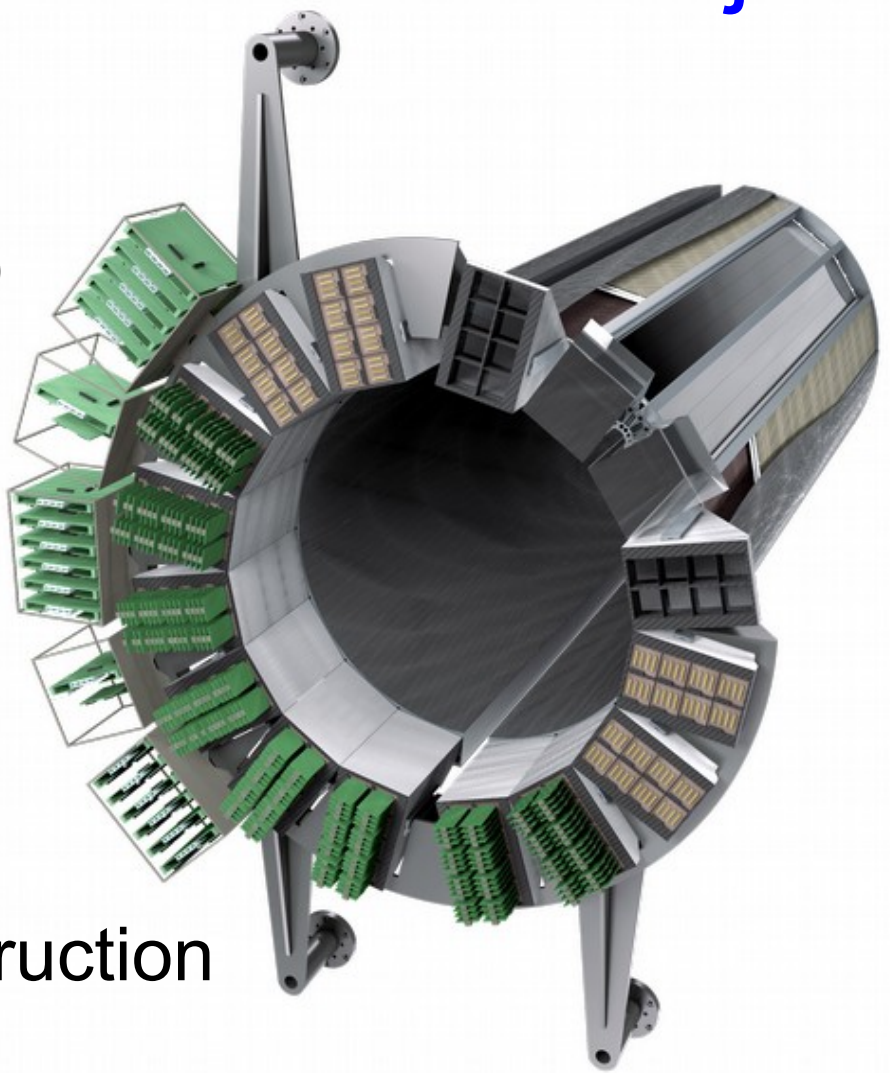
Status of the PANDA Barrel DIRC Project

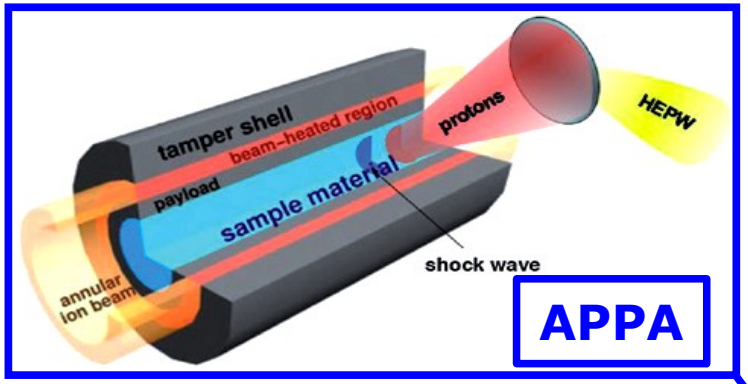
Carsten Schwarz, GSI
for the PANDA Cherenkov group
(GSI, Uni Giessen, Uni Erlangen, and Uni Mainz)

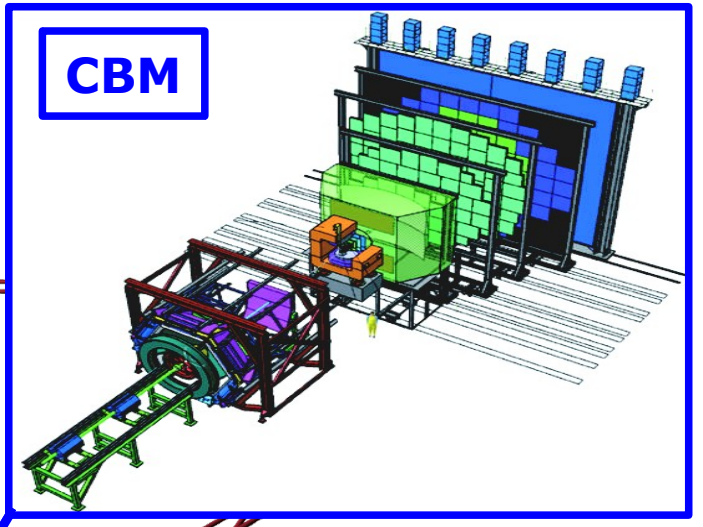


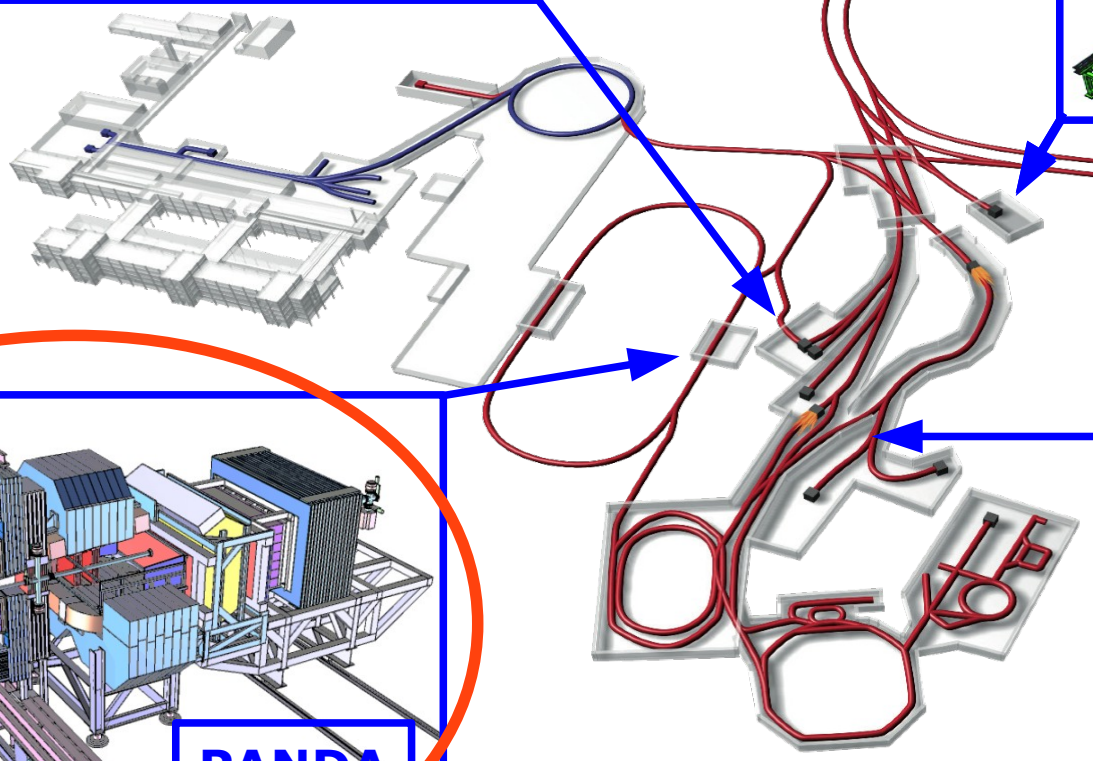
- FAIR & panda
- The Barrel DIRC design
- Experiments in test beams
- Finalizing the R&D and construction

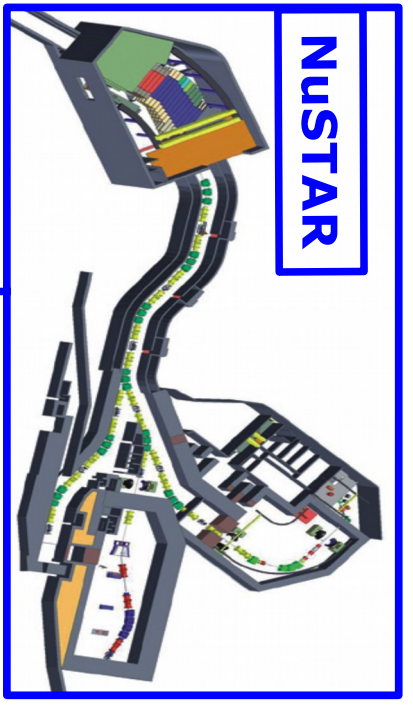

GSI HELMHOLTZZENTRUM
FAIR CONSTRUCTION SITE
ACCELERATOR TUNNEL
SUPPLY TUNNEL
FAIR RING ACCELERATOR SIS100
FIRST TUNNEL SECTIONS
FOR SIS100 ACCELERATOR


FAIR, Darmstadt
August 2019
FAIR



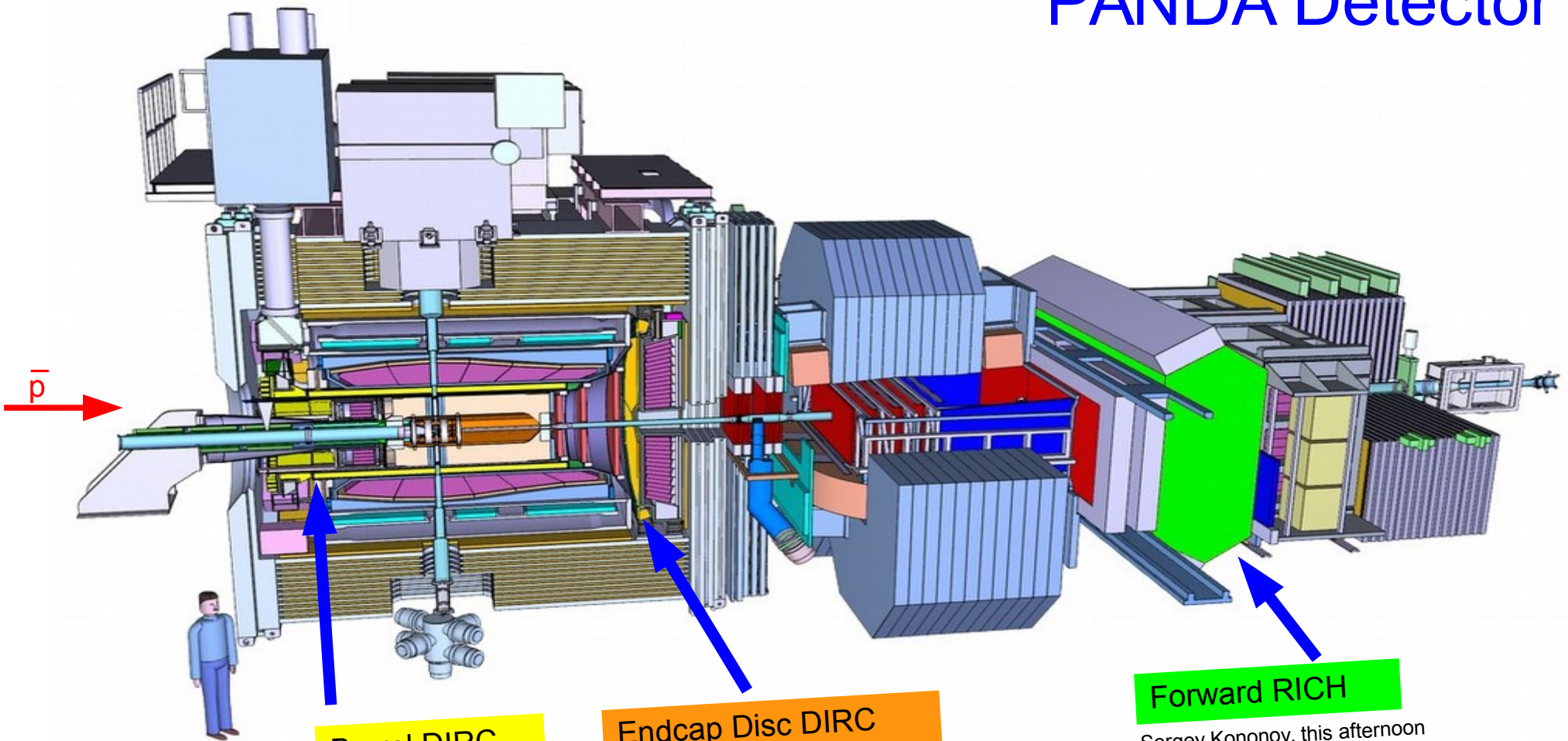






NUSTAR, PANDA, CBM, APPA
are fixed target experiments

PANDA Detector



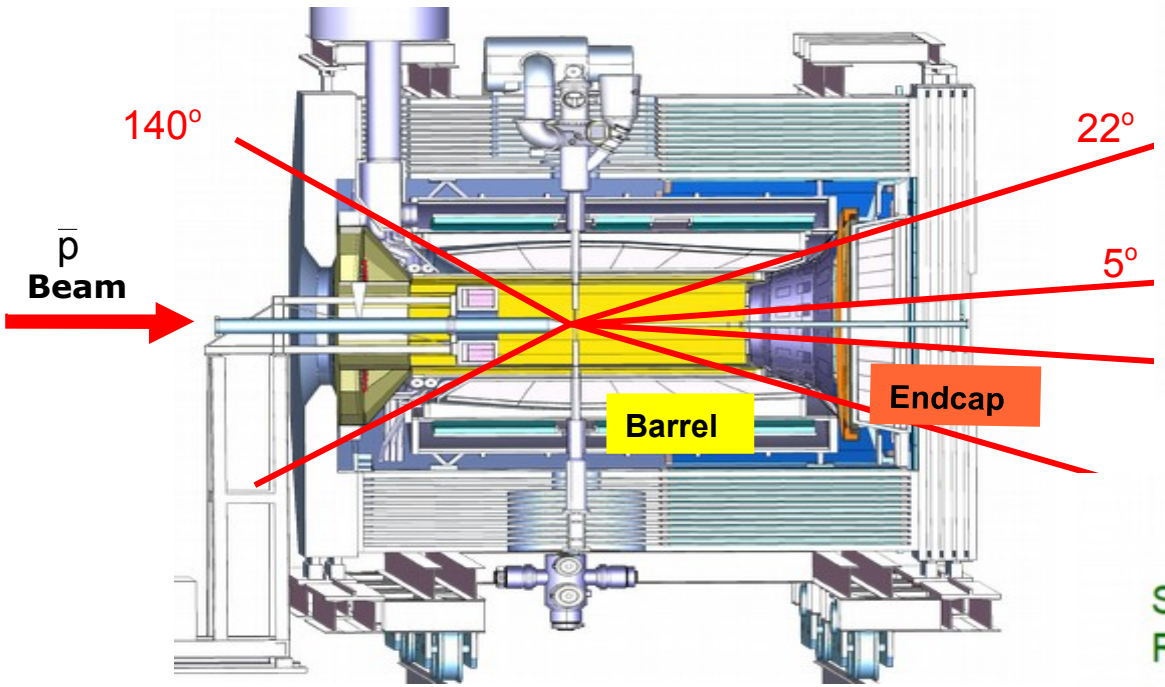
Ilknur Köseoglu, next talk

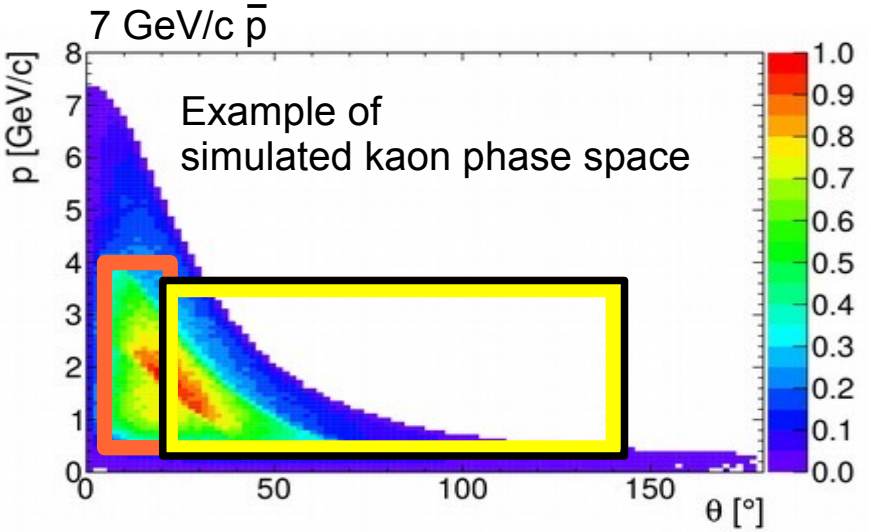
Status of the PANDA Endcap Disc DIRC Project

Sergey Kononov, this afternoon

The forward RICH detector at PANDA

PANDA DIRC counters



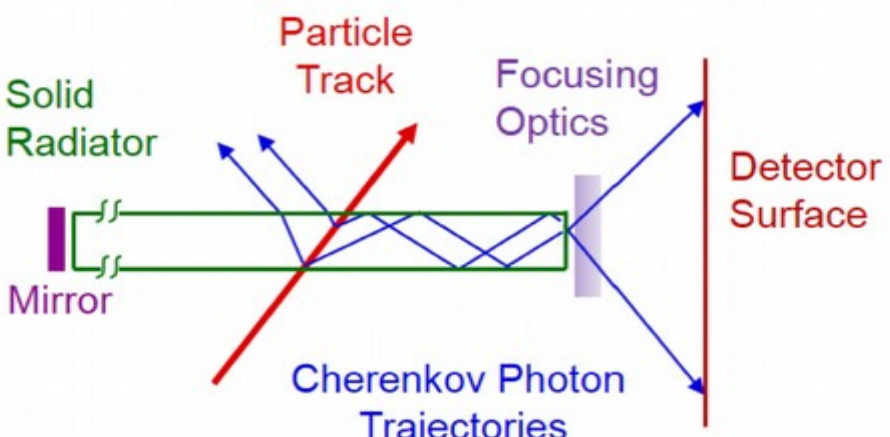


Barrel DIRC

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

Endcap Disc DIRC

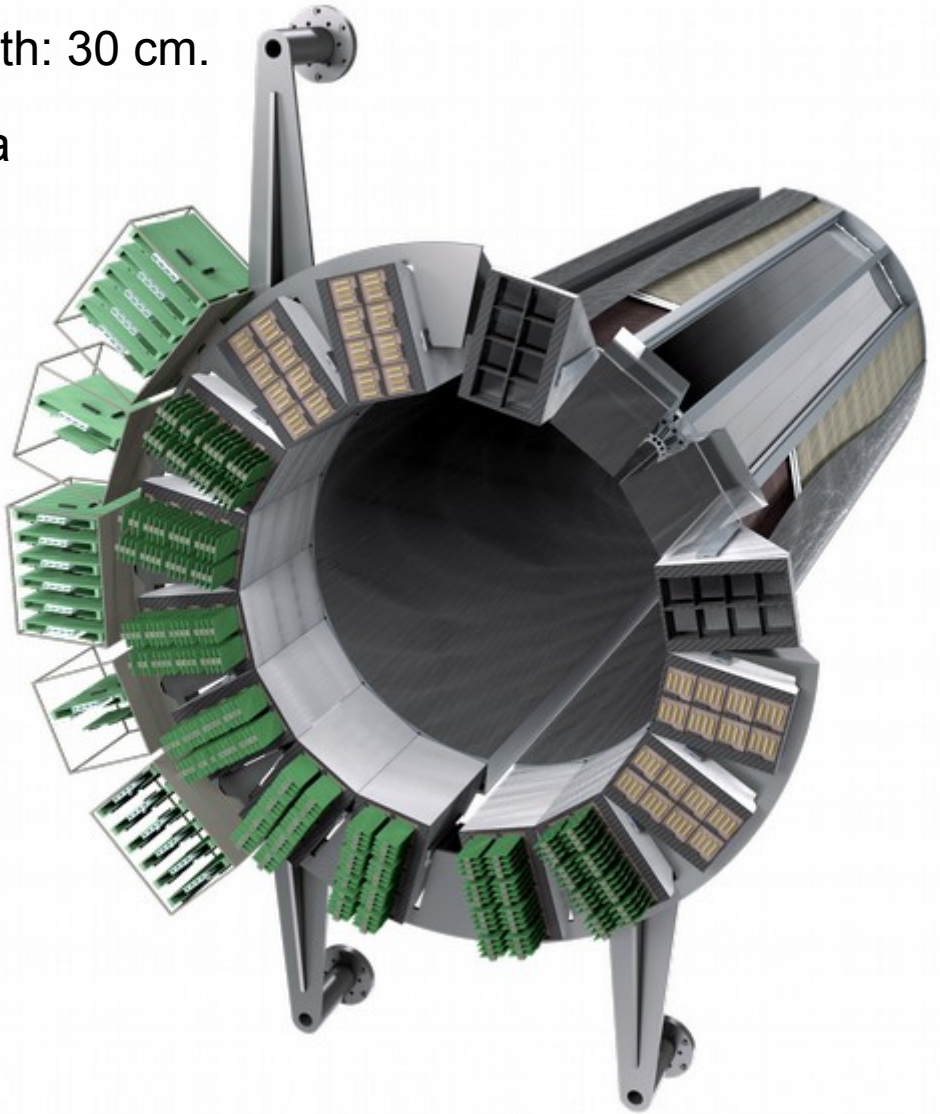
Goal: 3 s.d. π/K separation up to 4 GeV/c



Magnitude of photon angles in radiator preserved

Design: based on BABAR DIRC and SuperB FDIRC with key improvements

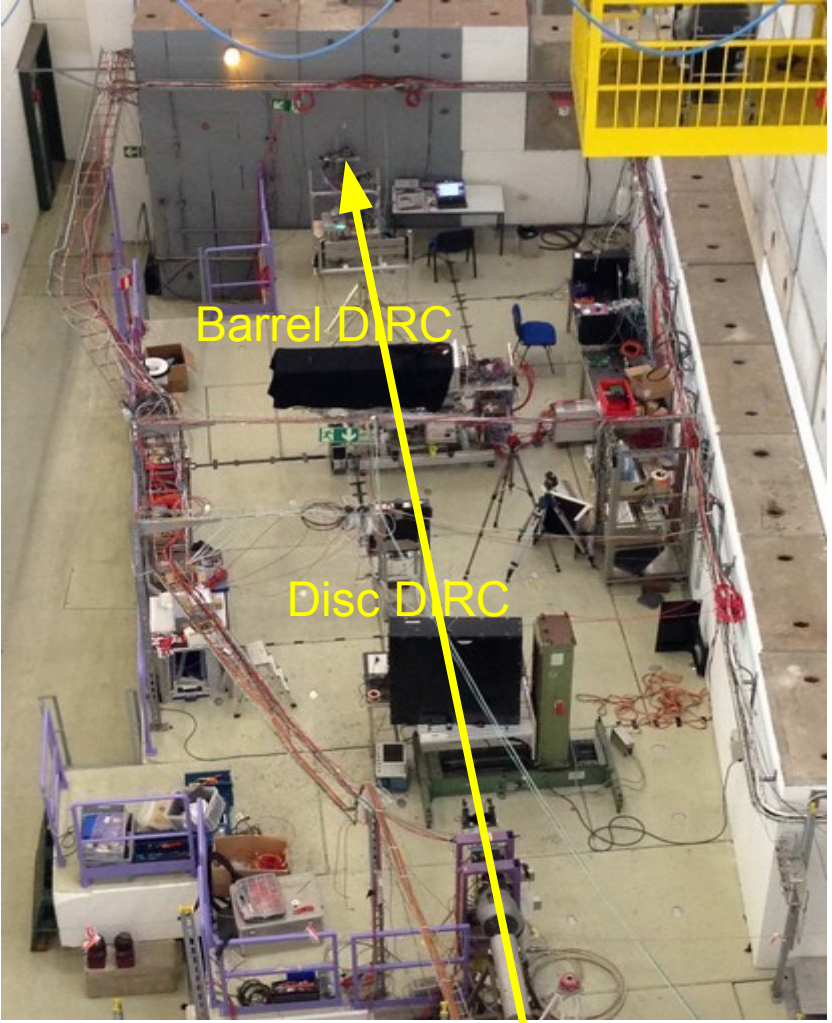
- Barrel radius ~48 cm; expansion volume depth: 30 cm.
- 48 narrow radiator bars, synthetic fused silica
  17 mm (T) x 53 mm (W) x 2400 mm (L).



- Compact photon detector:
  30 cm fused silica expansion volume
  8192 channels of MCP-PMTs
  in ~1T B field
- Focusing optics: spherical lens system
- Fast photon detection:
  fast TDC plus TOT electronics,

  → 100-200 ps timing

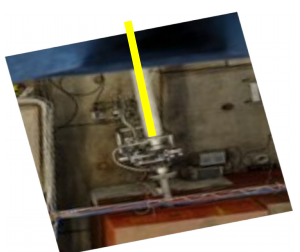
Experiments in test beams,

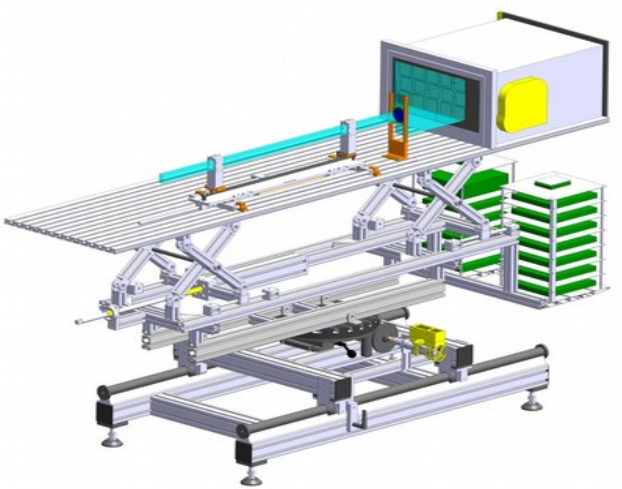


2008 – GSI
2009 – GSI
2011 – GSI, CERN
2012 – CERN
2013 – Mainz
2014 – GSI
2015 – CERN
2016 – CERN
2017 – CERN
2018 – CERN

Groups:
GSI Darmstadt
Uni Erlangen
Uni Giessen
Uni Mainz
EIC groups
JLAB/CUA

29 m TOF





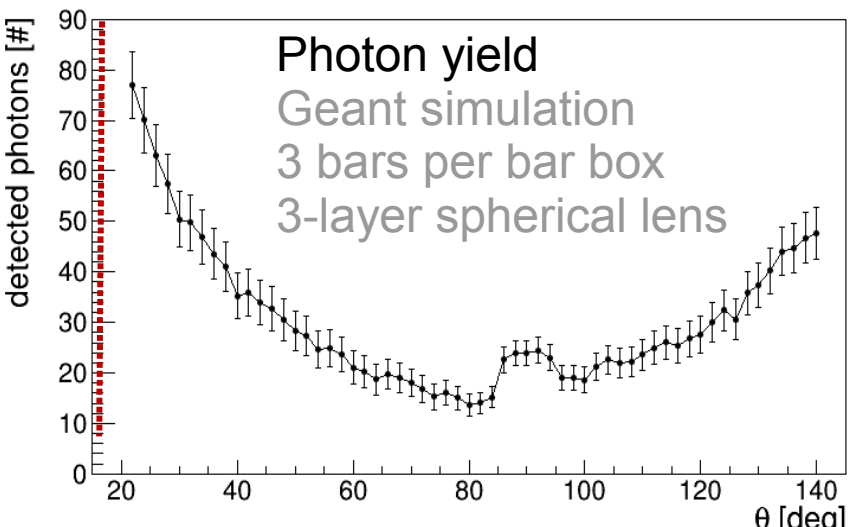
Expected performance

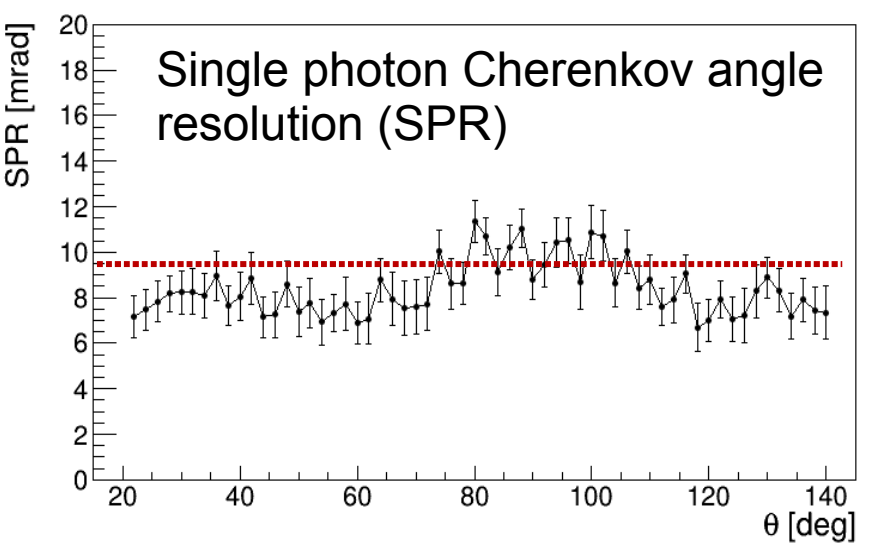
Cherenkov track resolution:

(using spatial coordinates)

$$\sigma_{\theta_C}^{track} = \sqrt{\left(\frac{\sigma_{\theta_C}^{photon}}{\sqrt{N_{photons}}}\right)^2 + (\sigma^{correlated})^2}$$

tracking resolution 2-3 mrad



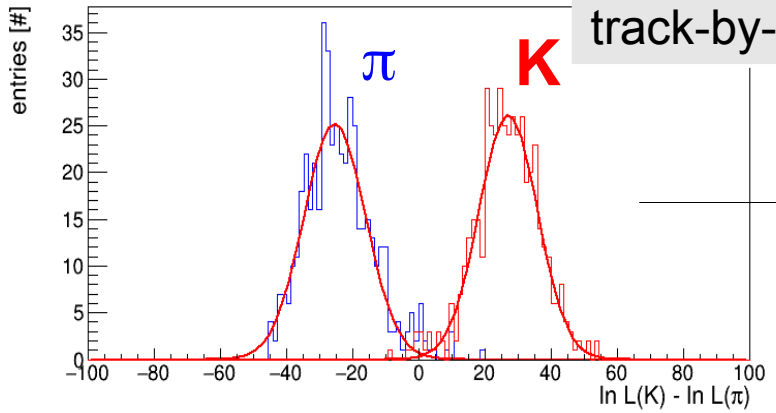


➡ Yield and SPR reach performance goal

Expected performance

→ Roman Dzhygadlo, GSI, Talk tomorrow

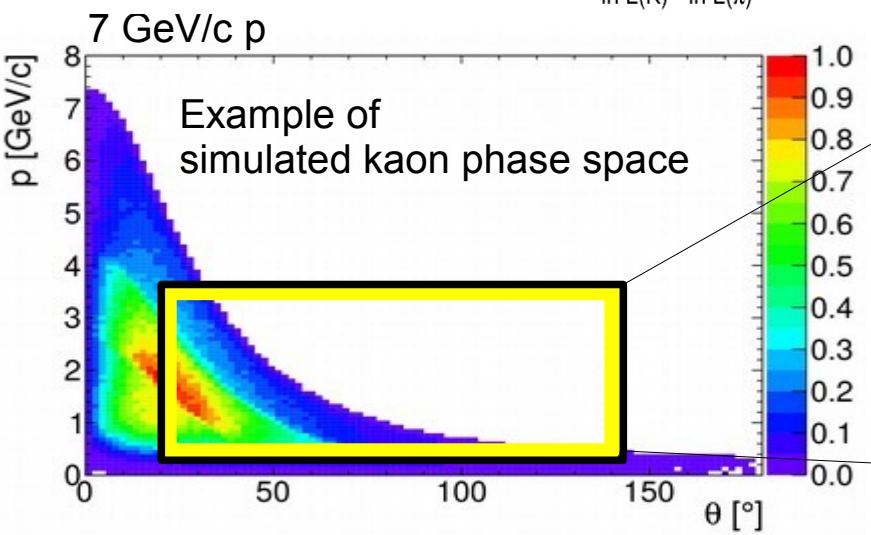
Time imaging reconstruction for the PANDA Barrel DIRC

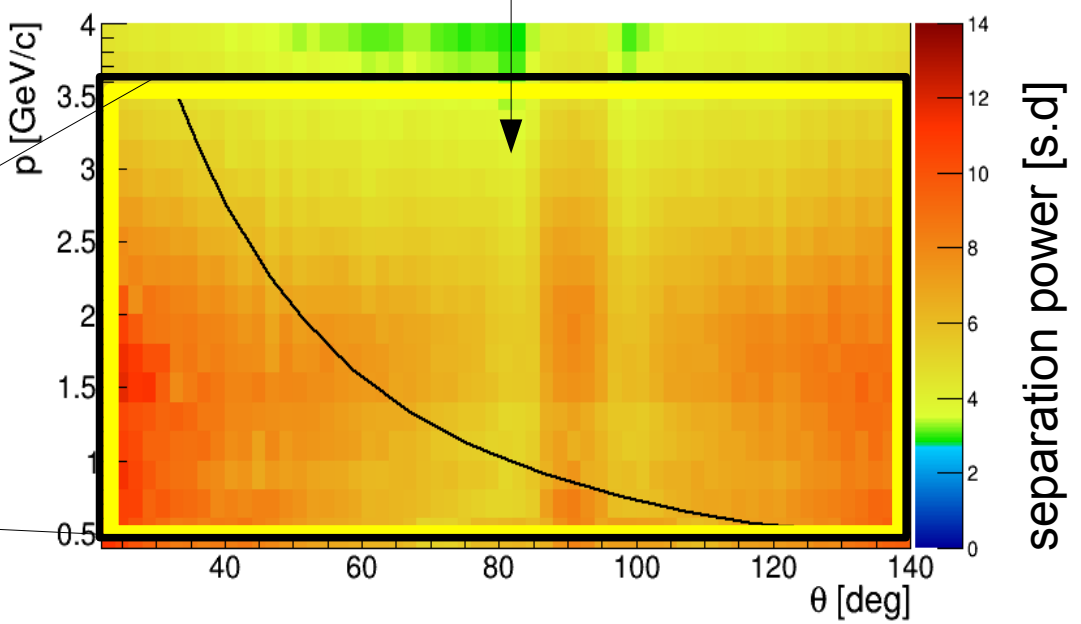


track-by-track max. likelihood fit

Time imaging reconstruction

$$N_{sep} = \frac{|\mu_1 - \mu_2|}{\frac{1}{2}(\sigma_1 + \sigma_2)}$$

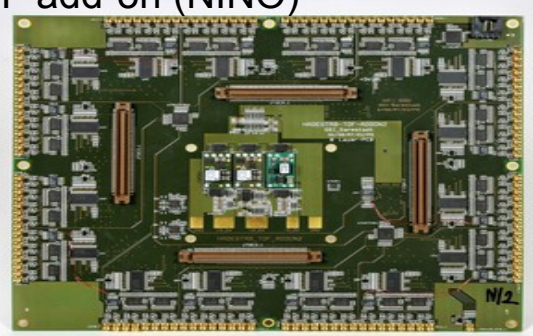


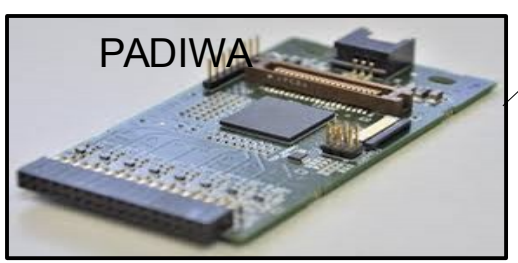


Design meets and exceeds PID requirements

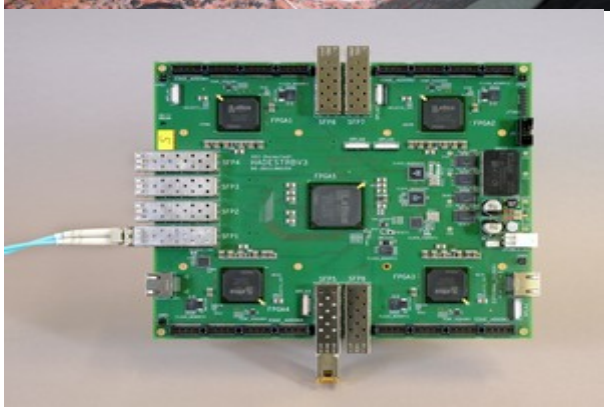
Electronics

TOF add-on (NINO)





Customized
for DIRC



TRB 2

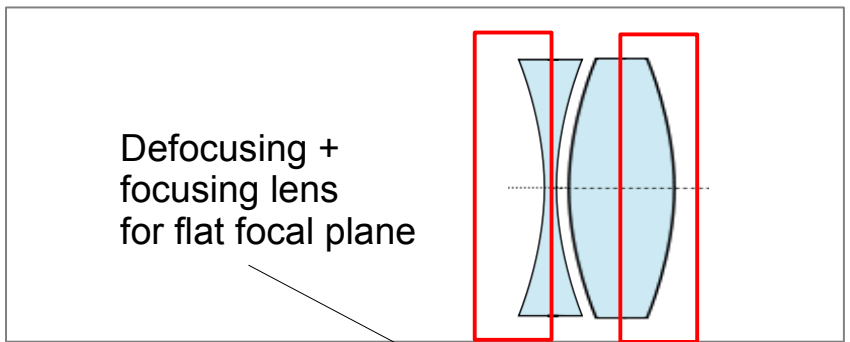
TRB 3

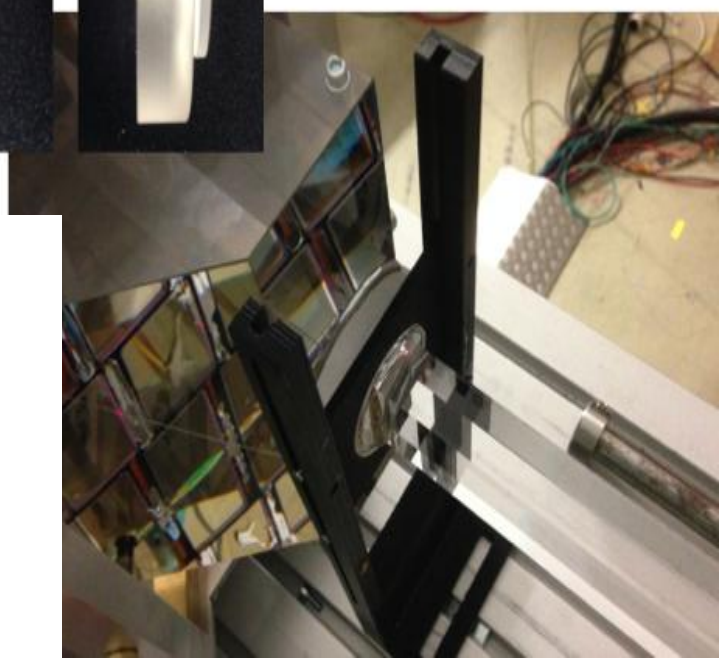
To get rid of out long cables

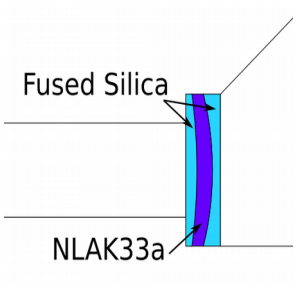
Last: DiRICH
Collaboration of
PANDA
CBM
HADES

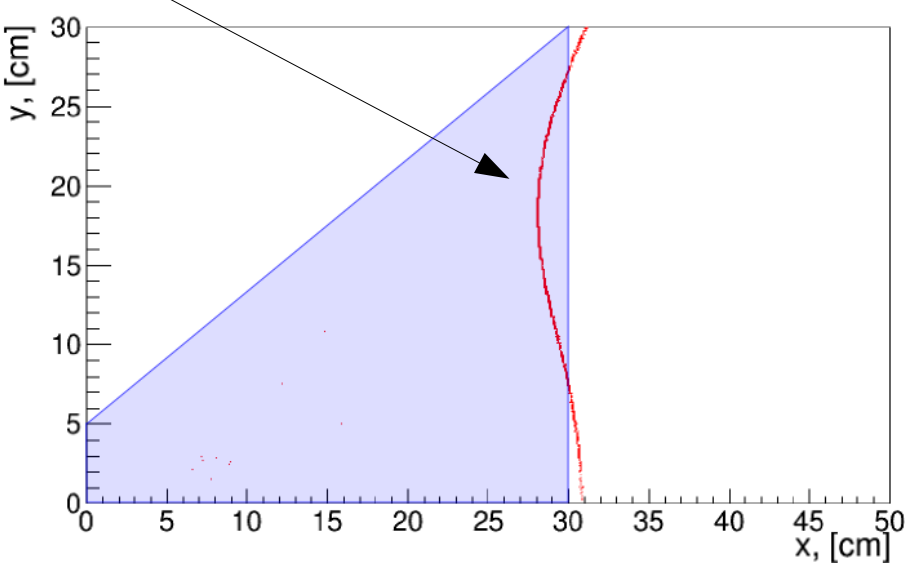
Focusing optics

Defocusing +
focusing lens
for flat focal plane

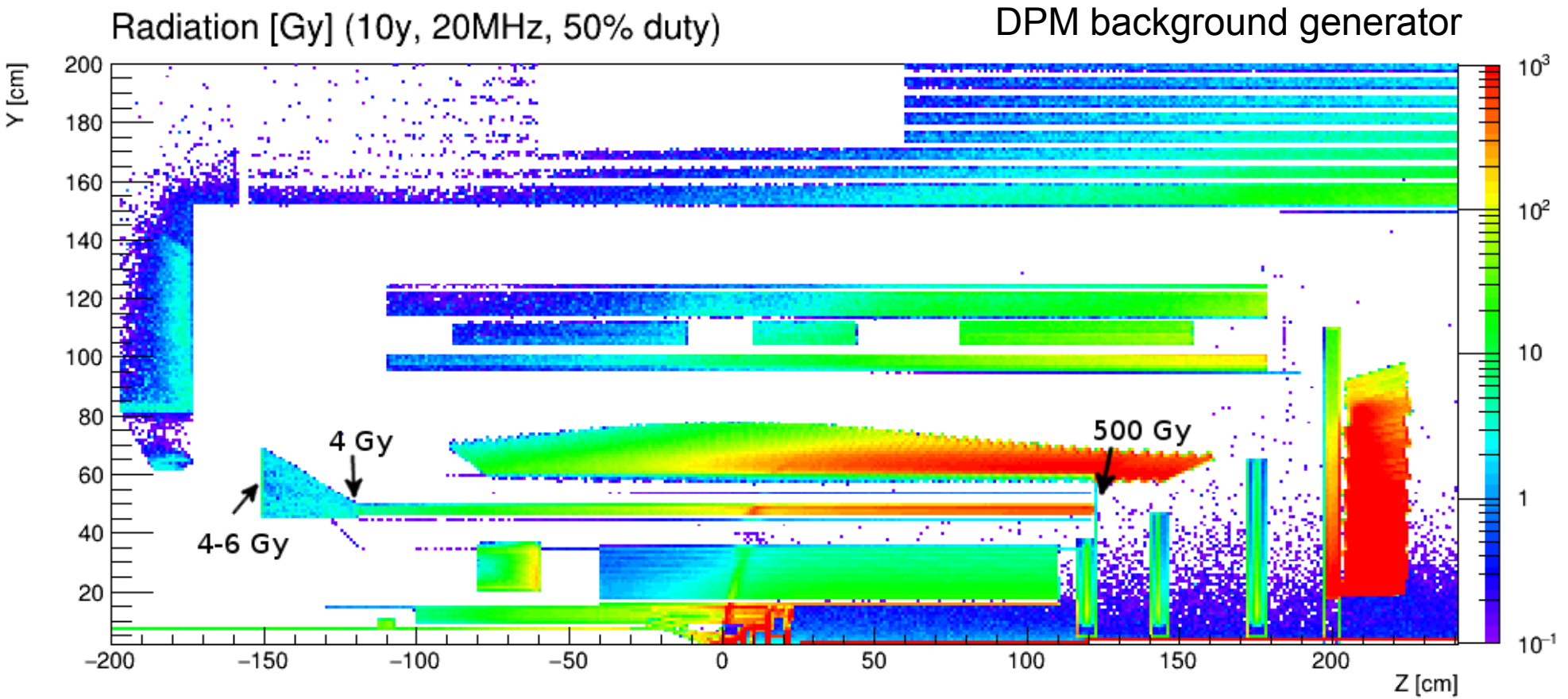








Radiation map

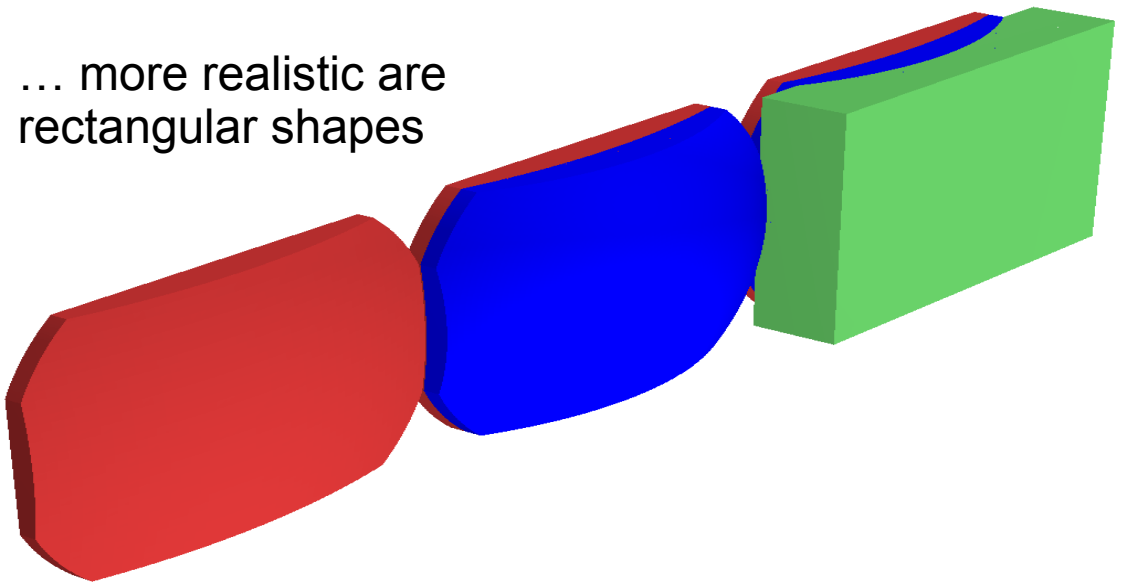


Measurements at CUA for NLAK33A: 1% / Gy @420nm x-ray
NLAK33A is sufficient radiation hard for PANDA.

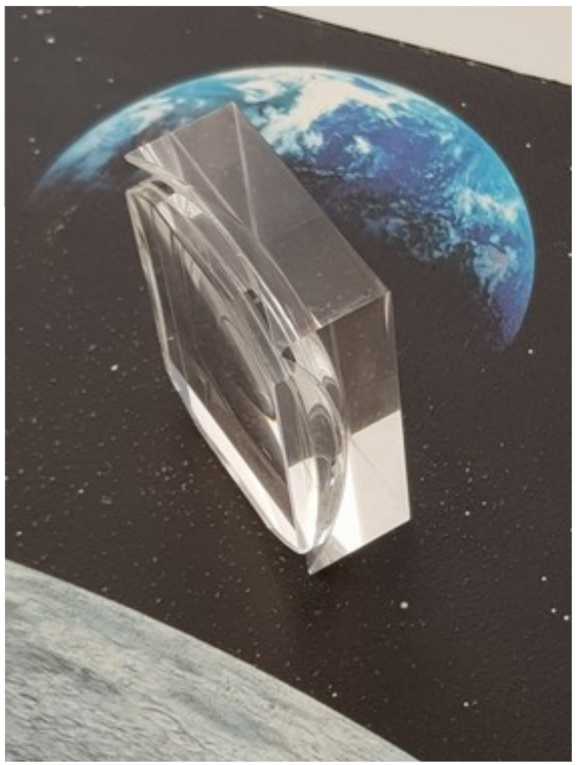
Greg Kalicy, Catholic University of America, last talk in this session
The hp DIRC Detector for the future EIC

Focusing optics

… more realistic are rectangular shapes



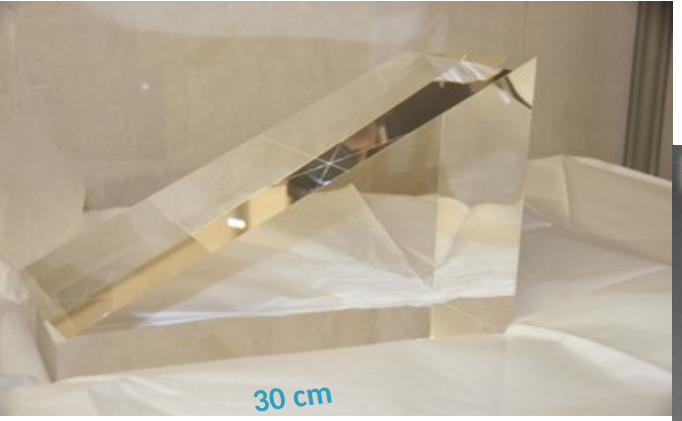
Produced by RMI

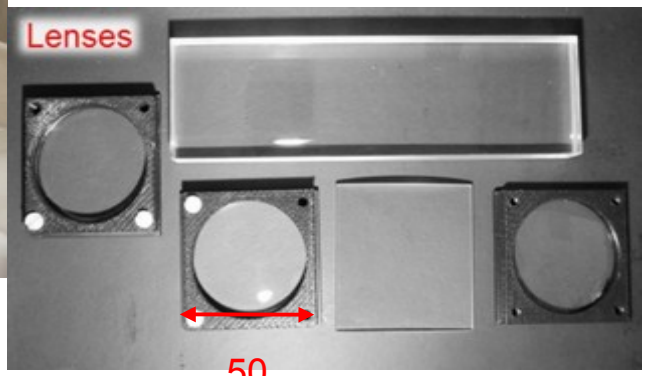


Three lenses systems close to final design ordered from Befort, Wetzlar.

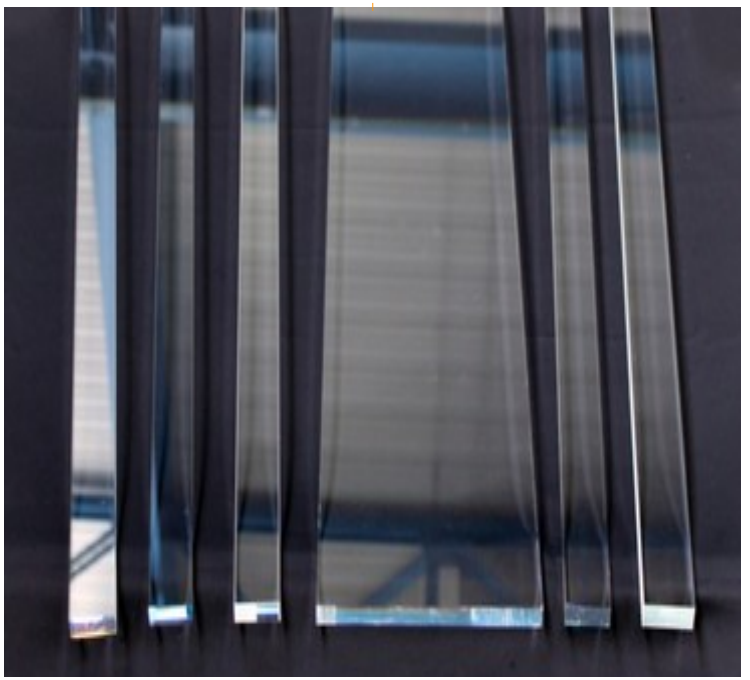
May be installed and used in PANDA.

Prototyping of optical elements

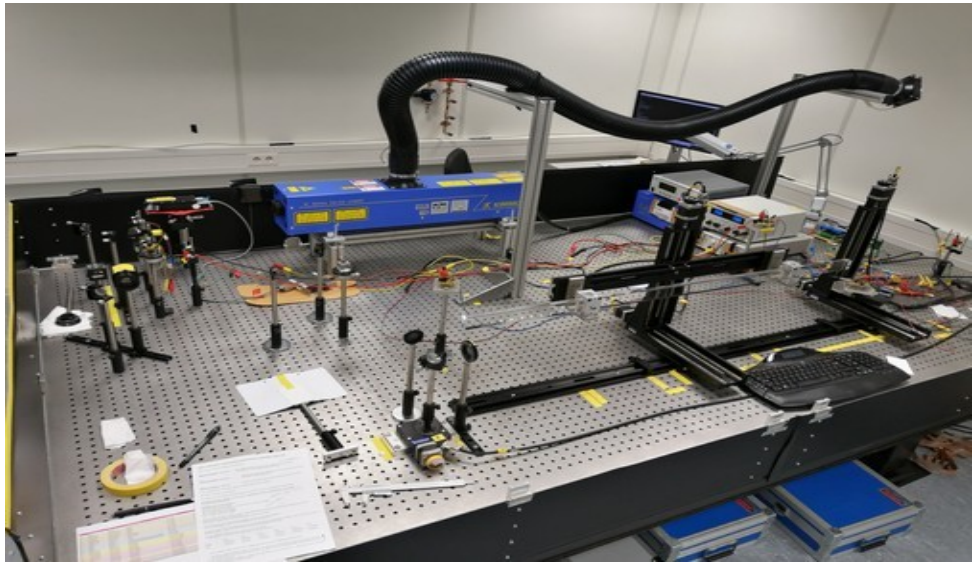




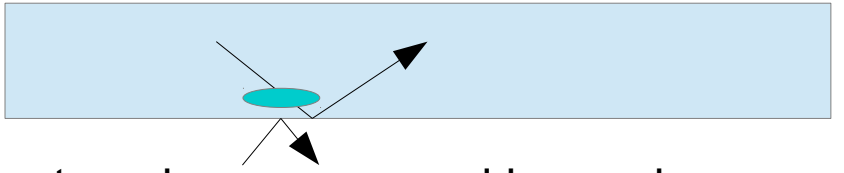
Optical elements:



Radiators produced with different technologies and materials



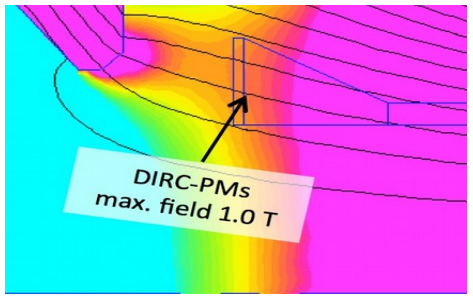
Precision measurement of internal reflection coefficient in optical laboratory at GSI,



external one measured by producer.

Photon detector

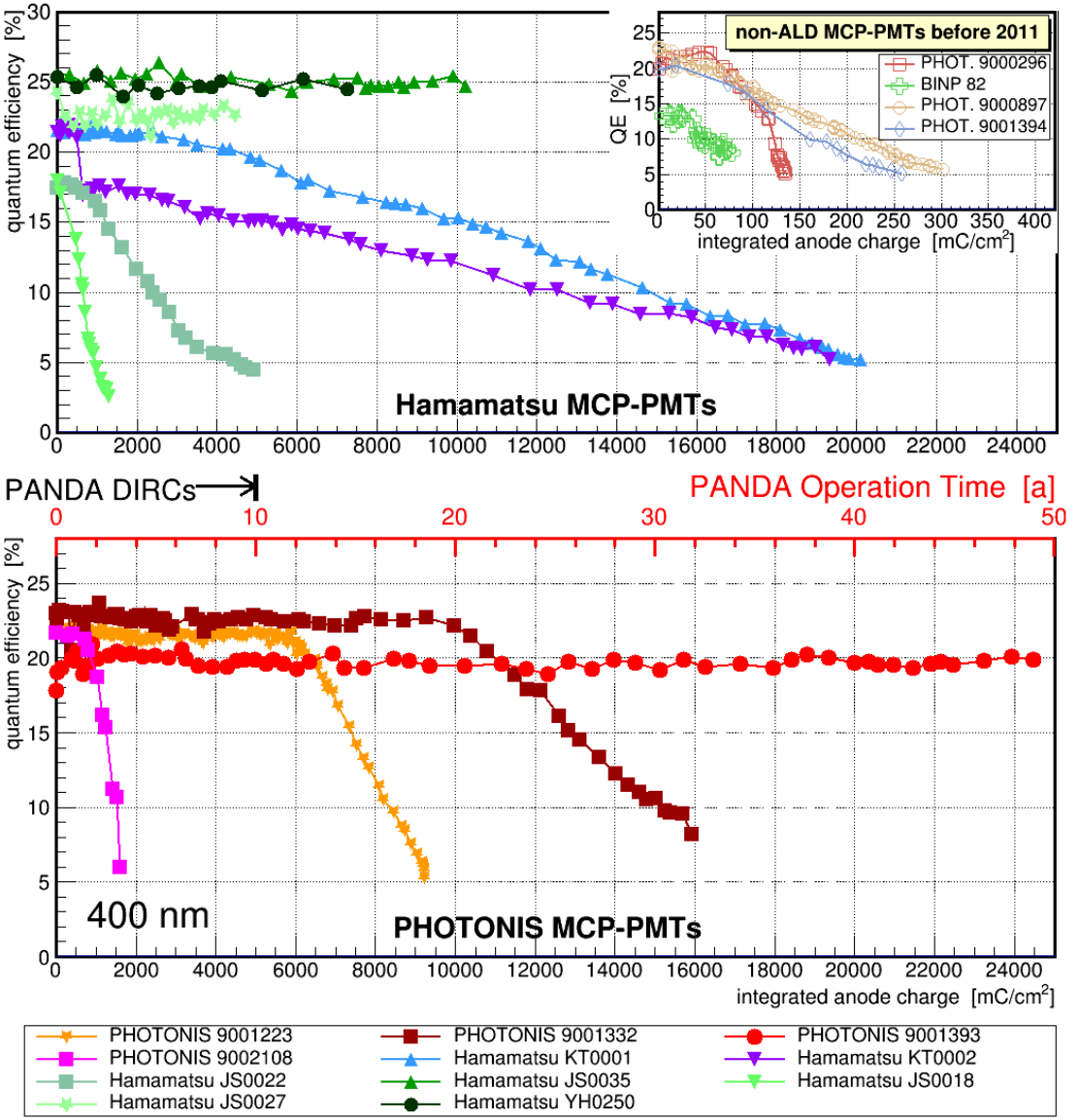
Yesterdays talk of
Merlin Böhm, Erlangen



Requirements:

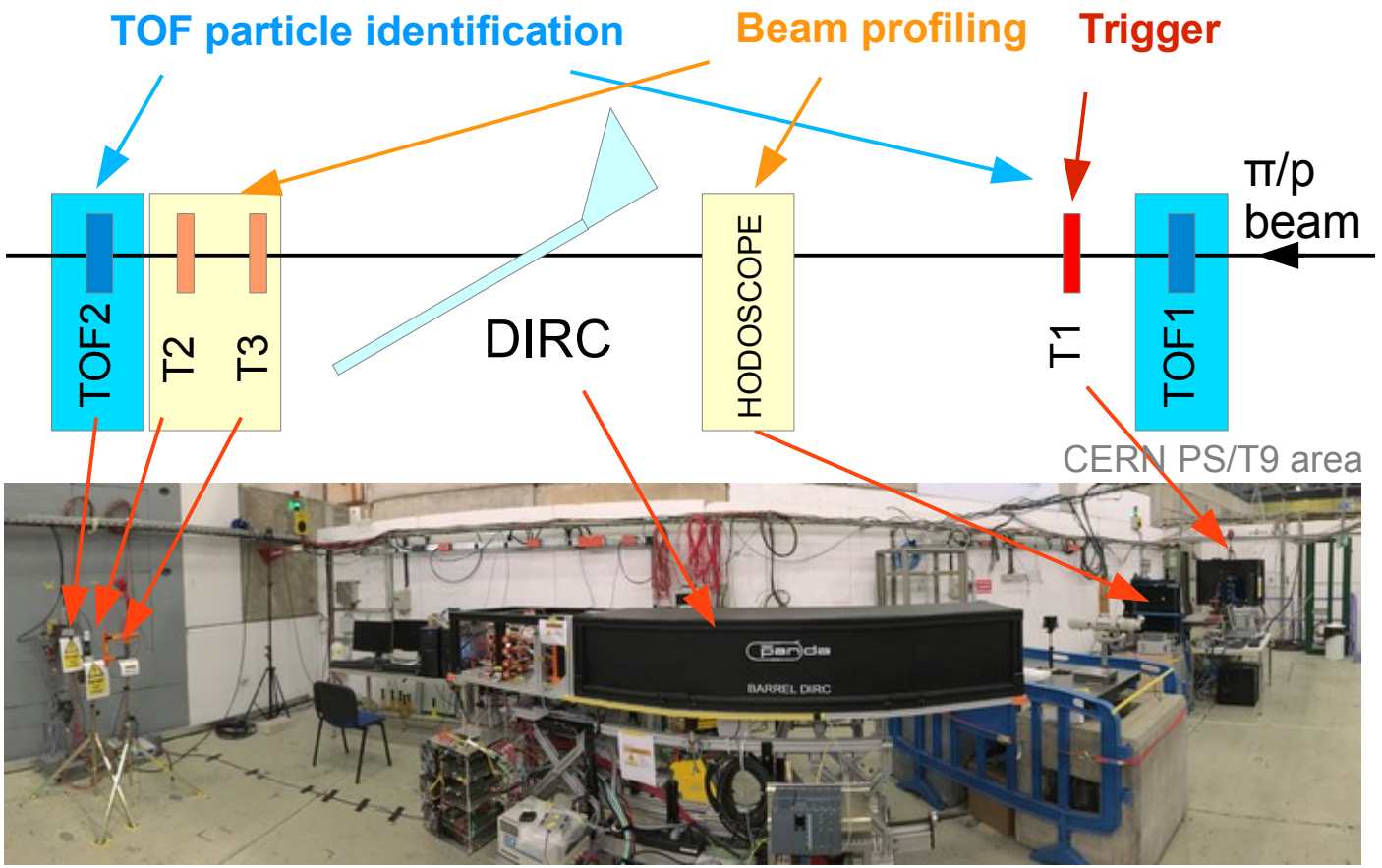
- **few mm** spatial resolution
- **~100 ps** timing resolution

Bar-box:
8 MCP-PMT, 512 pixels
(total 8 k readout channels)
with **pixel size 6 x 6 mm²**
work in **1T magnetic field**
survive **10 years** of PANDA
(aging)

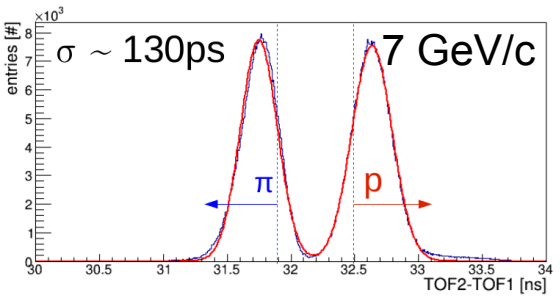


Most sensors with **ALD coated** MCPs have **lifetime > 5 C/cm²**

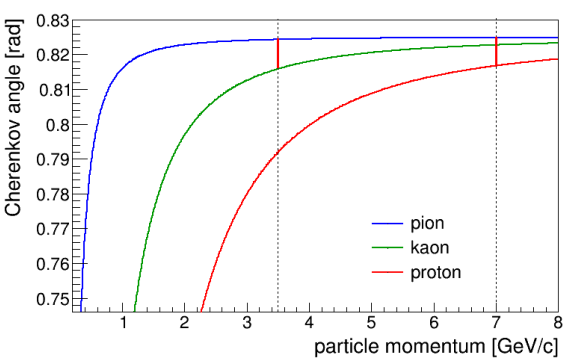
Beam Test at CERN 2017-2018



External TOF PID

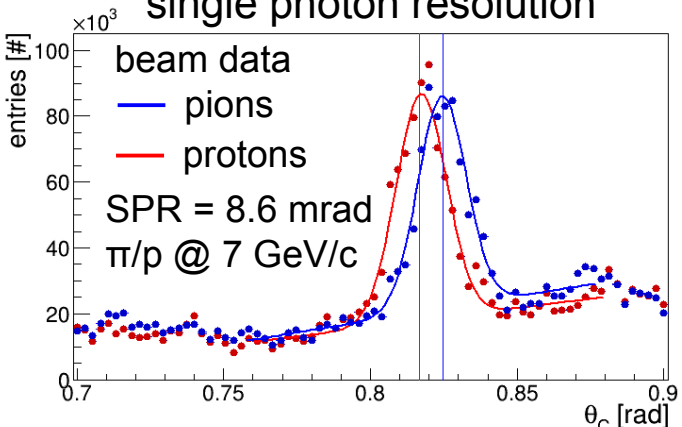


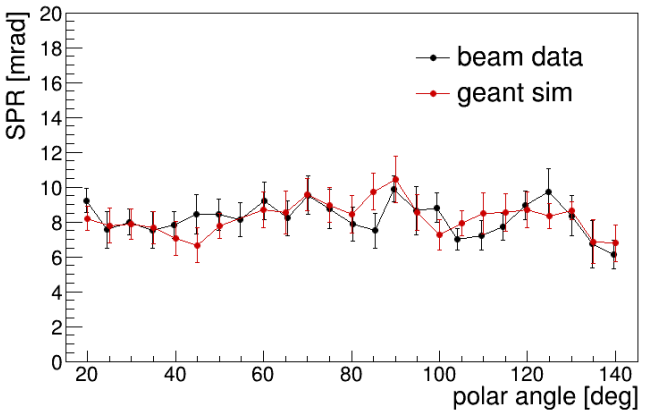
Most of the data taken at 7 GeV/c
(7 GeV/c π/p sep. ≈ 3.5 GeV/c π/K)



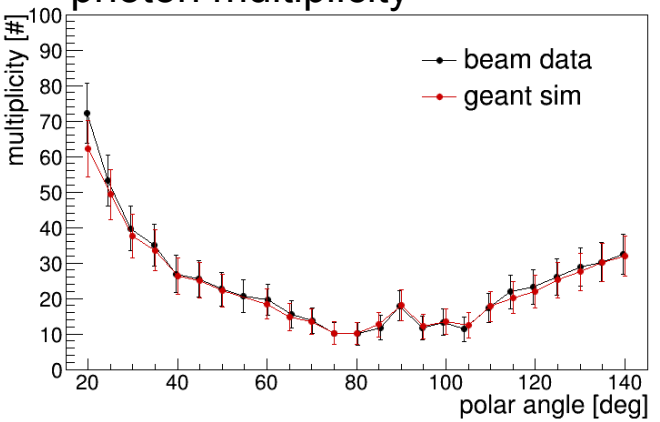
Beam Test at CERN 2018

single photon resolution

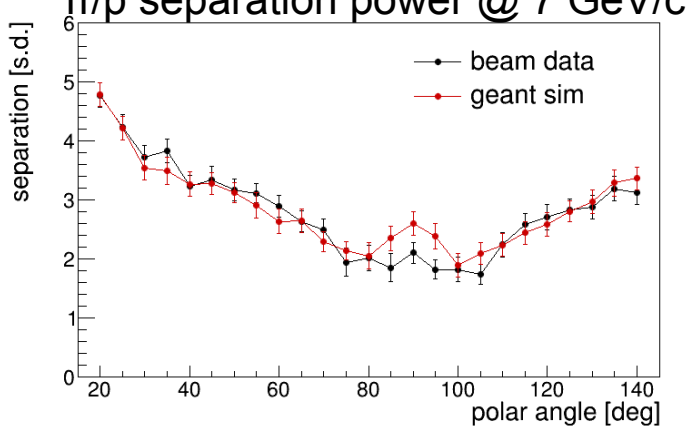




photon multiplicity



π/p separation power @ 7 GeV/c

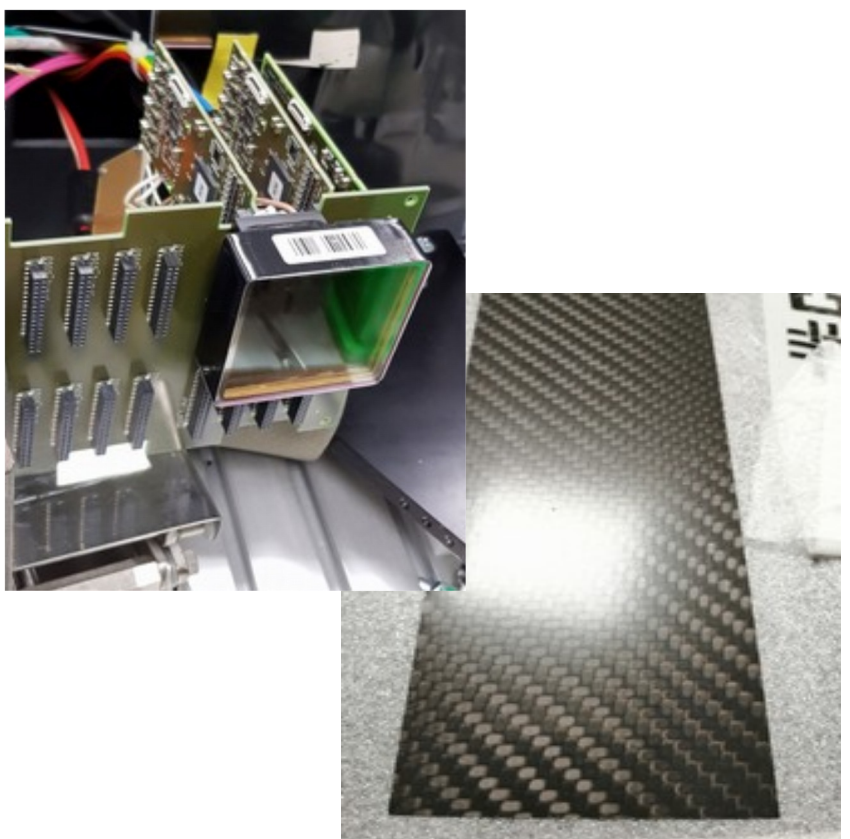


➡ Good performance

Good agreement with Geant simulations

The status of the Barrel DIRC

- Bars
  - ordered from Nikon Corporation
- MCP-PMTs
  - call for tender procedure
  - in an advanced stage
- Electronic readout
  - characterization of DiRICH system
  - ongoing
- Mechanical design
  - validate materials



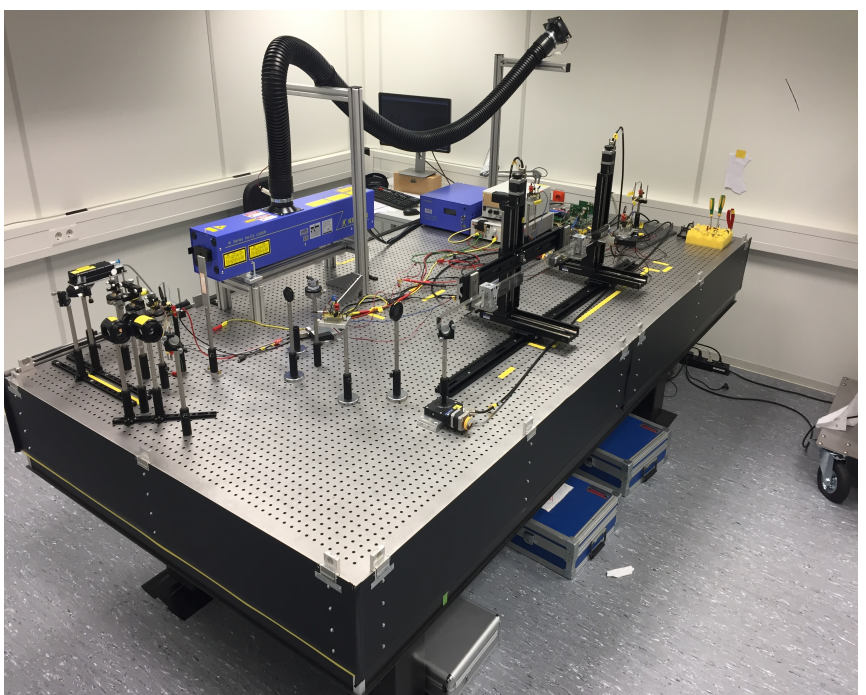
Longterm behaviour of materials

Can we replace aluminum/hex-cell bar boxes of BaBar/Belle II by carbon fiber boxes?

Long term study of the internal reflection coefficient of the DIRC bars as a function of quartz surface pollution

Possible Pollutants

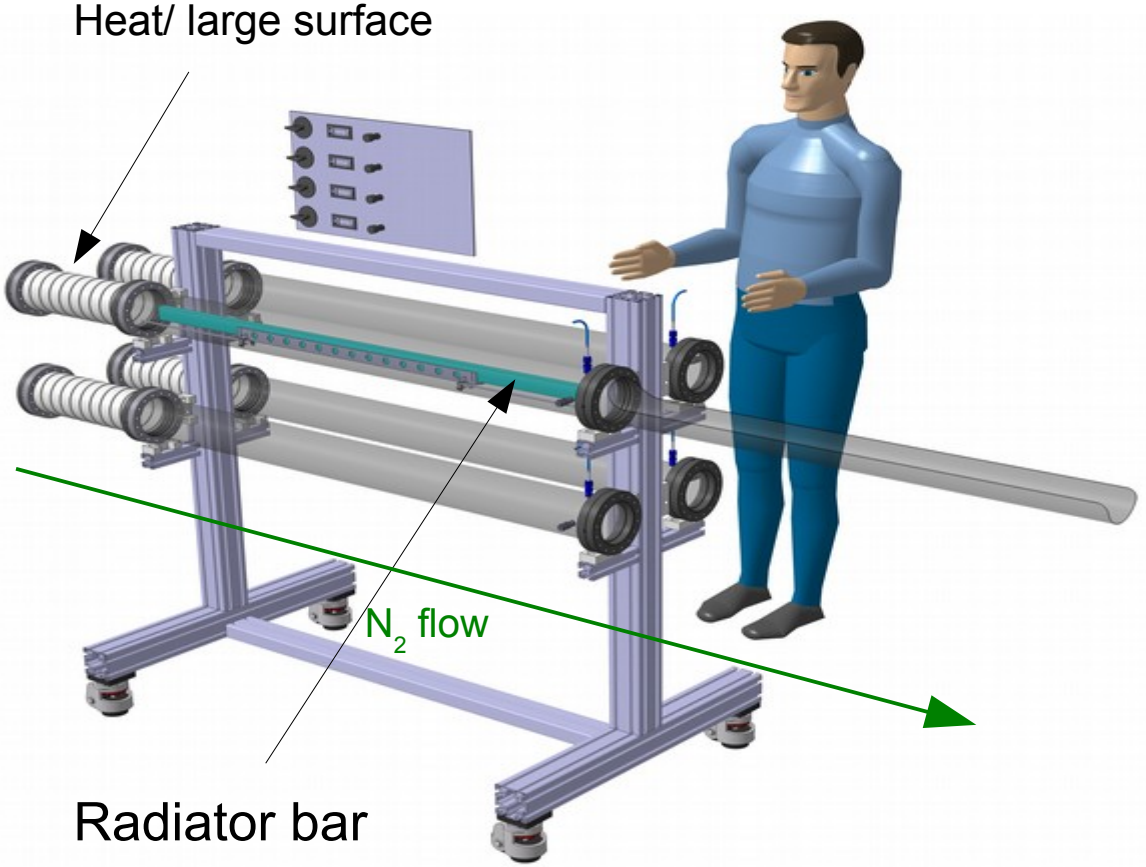
- Carbon fiber laminate
- Glue for bar connections (Epotek 301-2)
- PEEK-screws/buttons
- Material for the silicone cookies

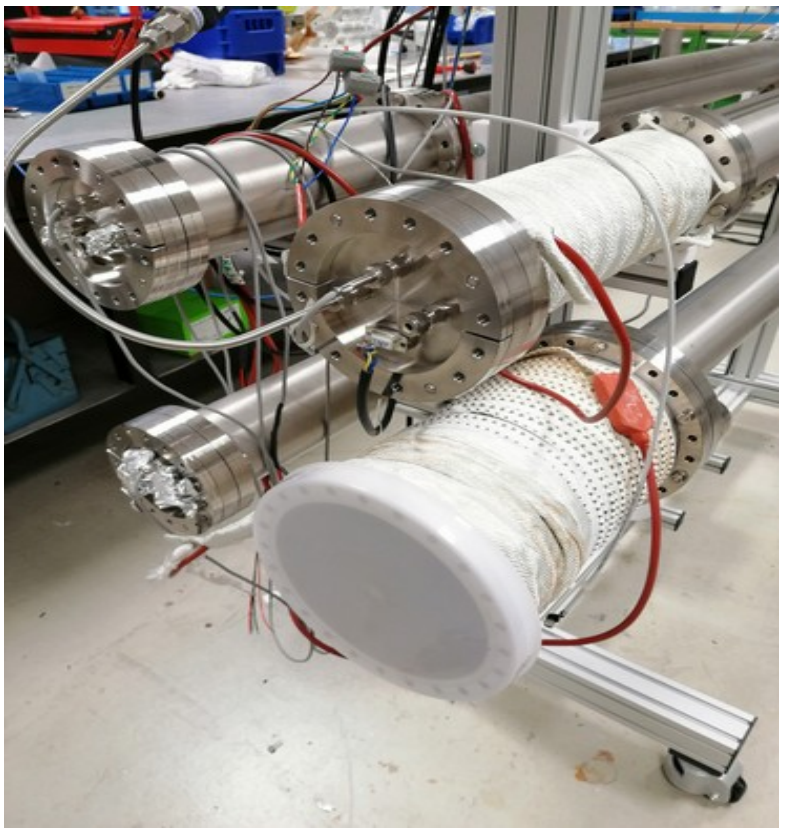


Longterm behaviour of materials

Material to test

Options:
Heat/ large surface

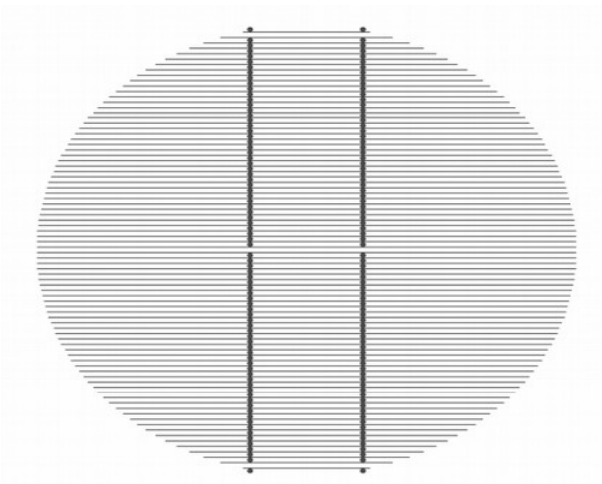


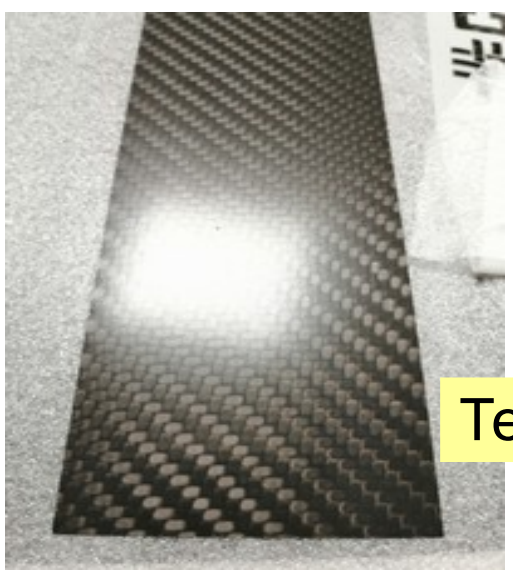


4 Stations

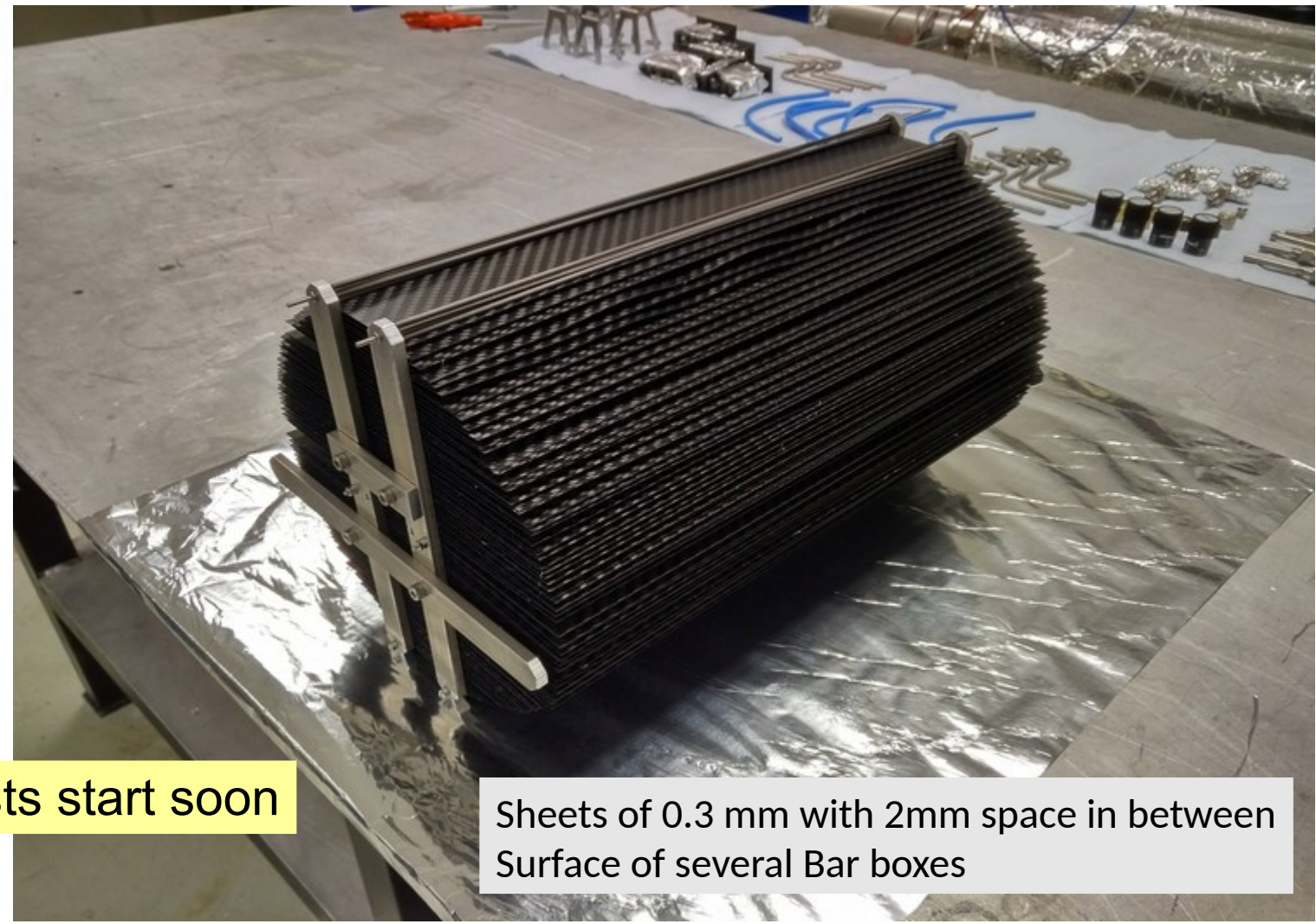
- One empty vessel: reference bar
- 3 filled with pollutants

Longterm behaviour of materials

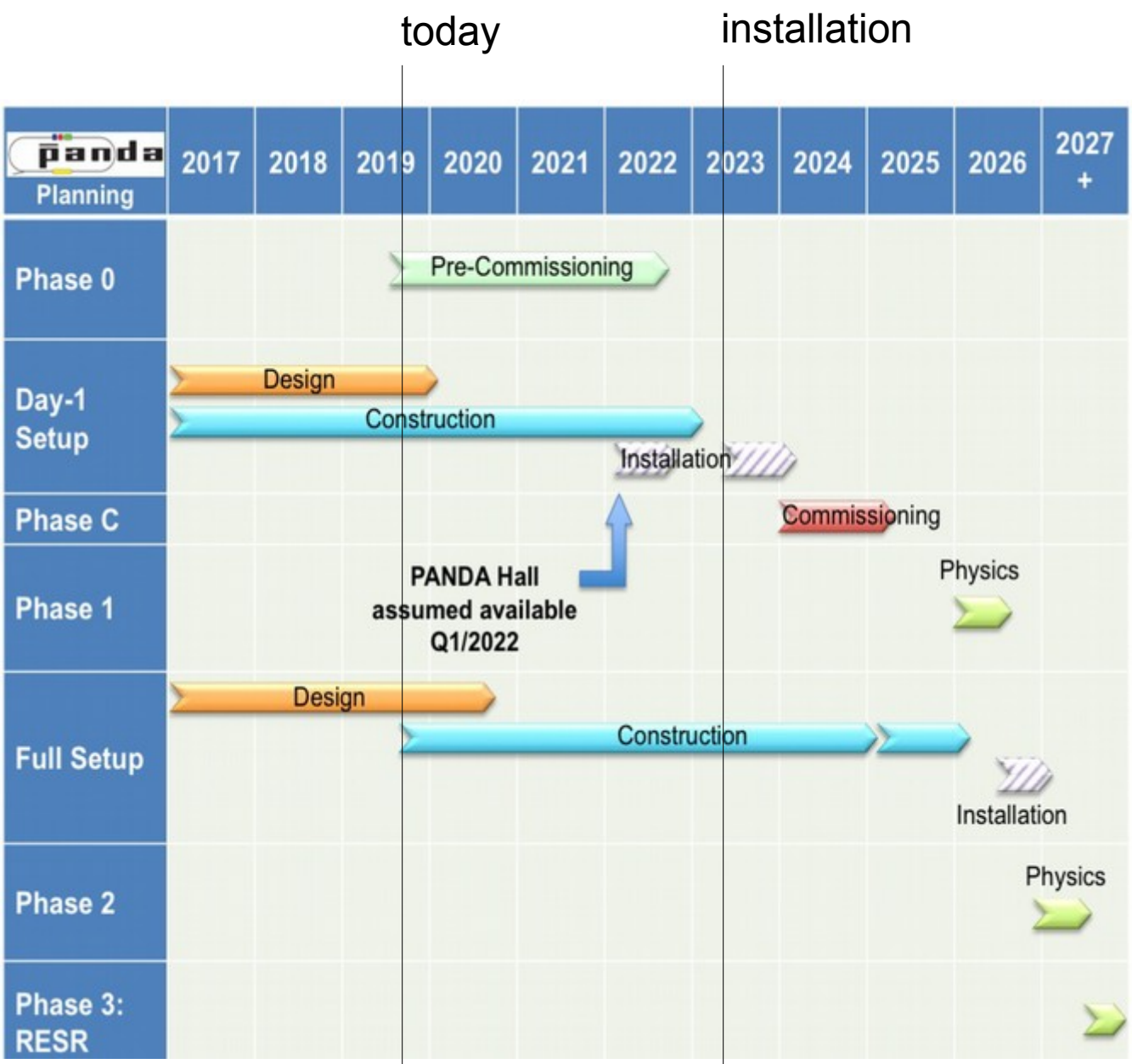




Tests start soon



Sheets of 0.3 mm with 2mm space in between
Surface of several Bar boxes



Experiments with PANDA detectors and software at HADES, MAMI, and GlueX

Construction of Phase 1 systems

Two Phase 1 installation periods
1. Solenoid, dipole, supports
2. All Phase 1 detectors

Commissioning with cosmics and beam (protons / antiprotons)

Physics with antiprotons

Construction of Phase 2 systems

Installation period for remaining Phase 2 detectors

Physics with antiprotons

Summary

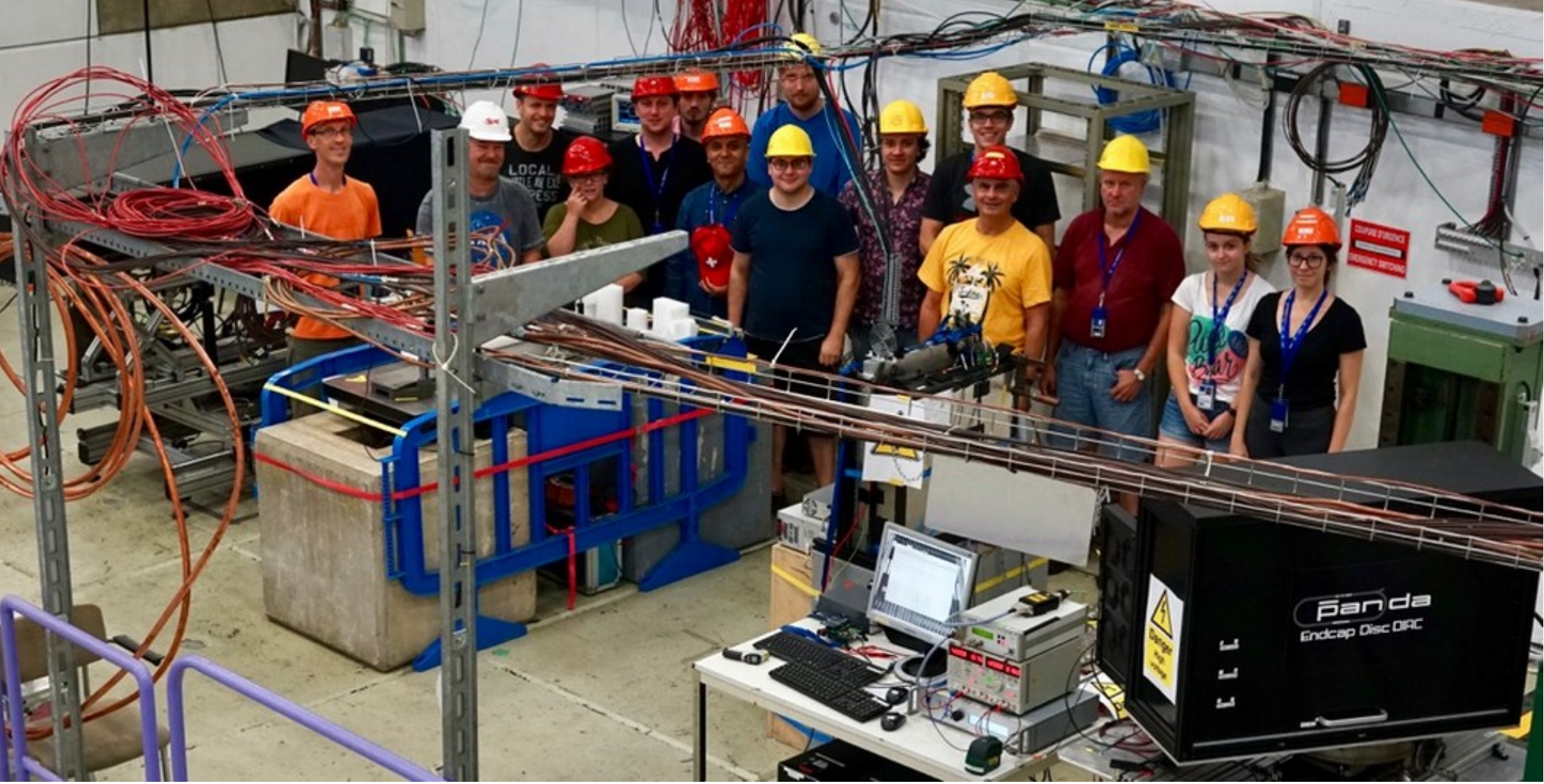
The Barrel DIRC design with narrow bars, 3-layer spherical lens, and compact prisms meets or exceeds the PANDA PID requirements.

The mass production has started.

The mechanical design, the R&D of electronic and optical elements will be finalized.

Outlook

- 2019: Finalize R&D and start construction phase.
- 2019-2021: Industrial fabrication of main components (sensors, bars, lenses, prisms), Production and QA of readout electronics
- 2019-2022: Industrial fabrication of bar boxes and mechanical support frame; QA of all components; gluing of long bars, assembly of complete sectors
- 2023/2024: Installation in PANDA, commissioning



Thank you...