

## The Endcap Disc DIRC for PANDA at FAIR

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*on behalf of the PANDA Cherenkov group*

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# $\bar{P}$ ANDA Spectrometer

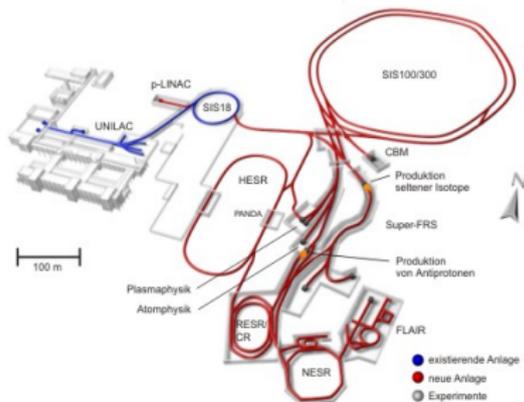
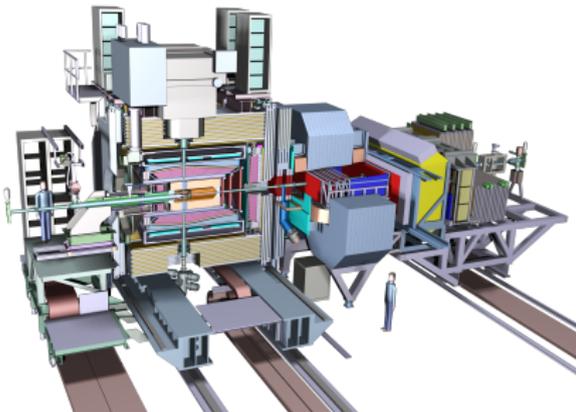
## FAIR

- Antiprotons  $\bar{p}$  from HESR
- High luminosity mode:

$$\mathcal{L} = 2 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$$

- Average interaction rate:

$$\dot{N} = 2 \cdot 10^7 \text{ s}^{-1}$$

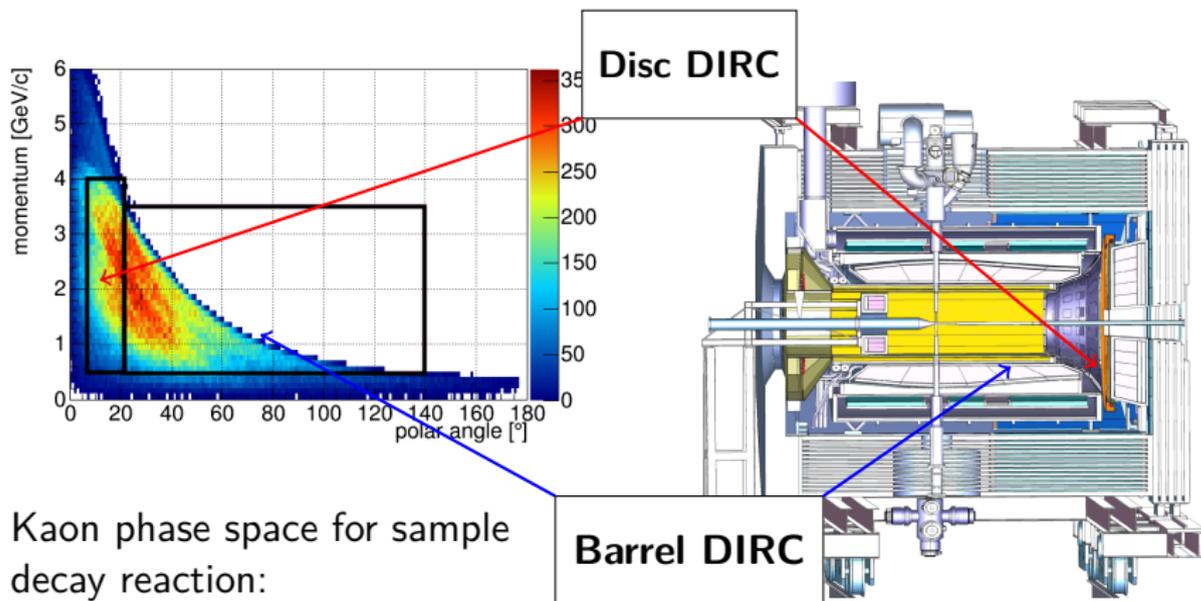


## PANDA

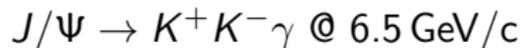
- $p\bar{p}$  collisions with hydrogen target
- Created particles with forward boost in z-direction
- Excellent PID necessary to fulfill physics program goals

# Particle Identification

Two Cherenkov detectors for particle identification covering different angles and energies



Kaon phase space for sample decay reaction:



Introduction to PANDA and Barrel DIRC see talk

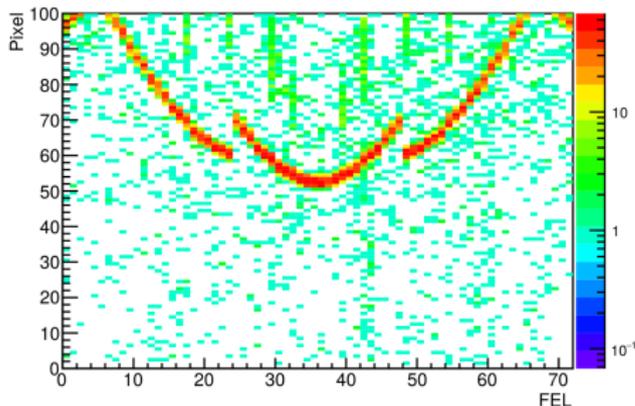
*The innovative Design of the PANDA Barrel DIRC* by G. Schepers

# Cherenkov Effect

Opening angle of Cherenkov cone:

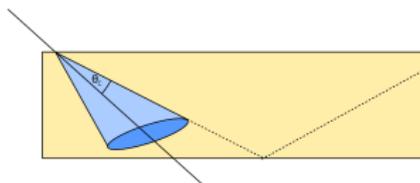
$$\cos \theta_C = \frac{1}{n(\lambda)\beta}$$

Photon propagation to outer rim via internal reflection

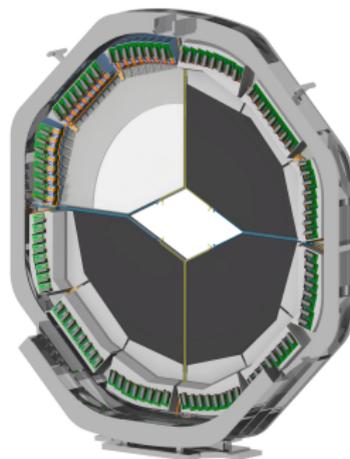


$\approx 1000$  photons created  $\rightarrow 21$  remain

## Cherenkov Cone

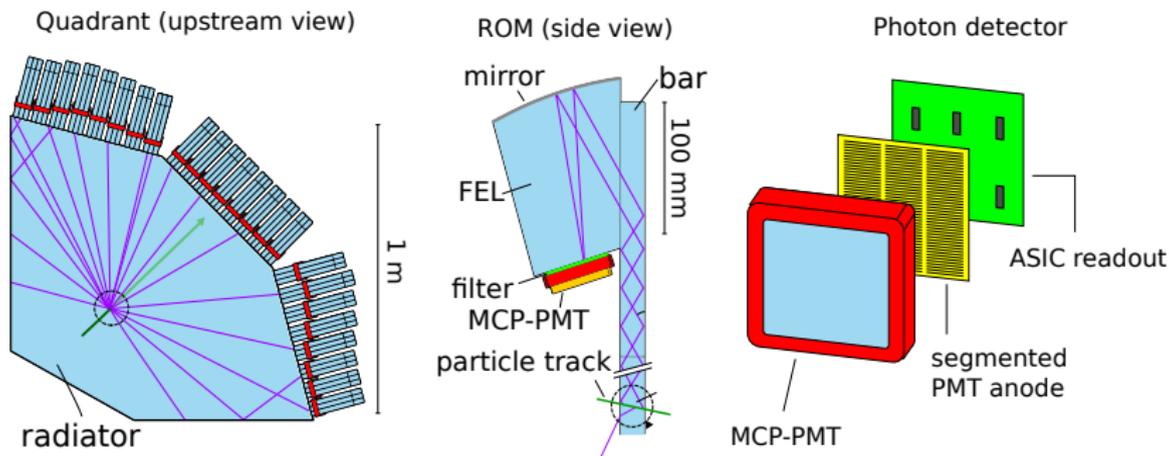


## Disc DIRC



## Disc DIRC Design Parameters:

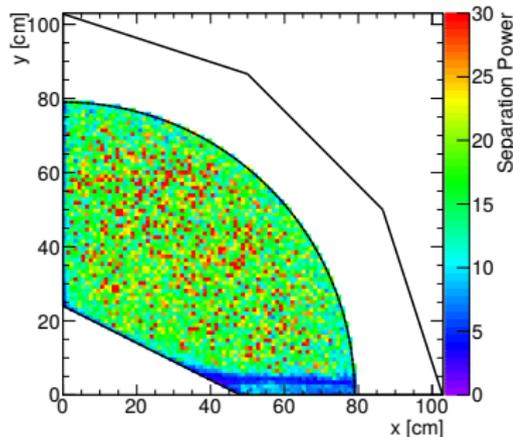
- Separation of  $\pi/K$
- Momentum range:  $0.5 \text{ GeV}/c \leq p < 4 \text{ GeV}/c$
- Polar angle range:  $5^\circ \leq \theta \leq 22^\circ$
- Performance goal:  $\geq 3 \text{ s.d.}$  separation over full phase space  
⇒ Average detector resolution  $\leq 1.7 \text{ mrad}$  required



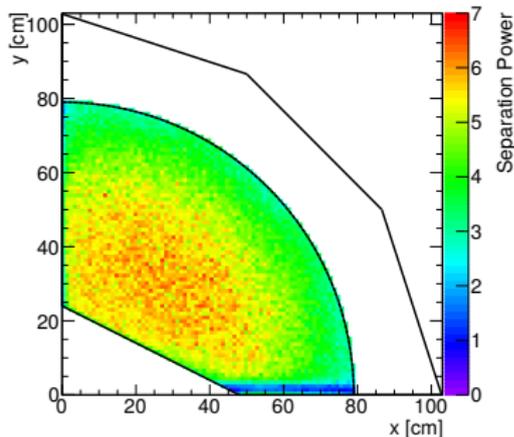
# High-Resolution Scan

High-resolution scan for  $\pi^+/K^+$  for full radiator quadrant including PANDA solenoid field:

Momentum 2 GeV/c

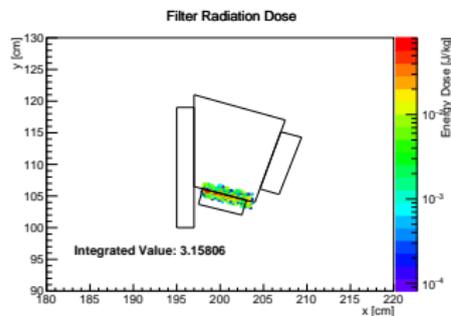
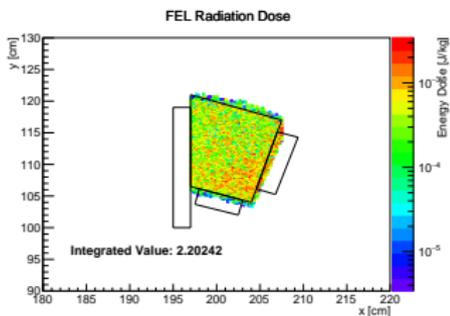


Momentum 4 GeV/c



- Overlapping of hit patterns (drop of separation power)
- *Inefficient Area* shifting as function of momentum (magnetic field)

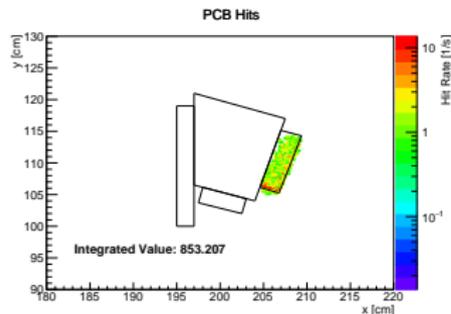
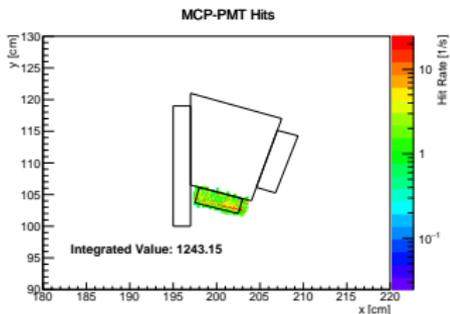
## Simulated Radiation Dose for MCP-PMTs and Filter



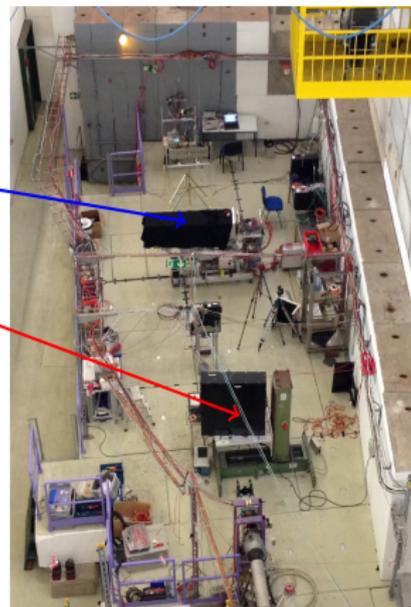
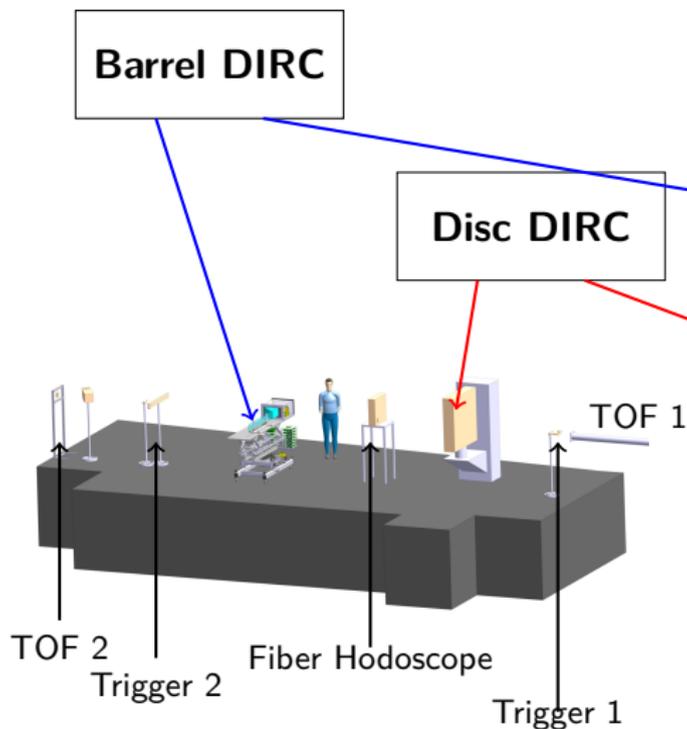
Measured transmission damage for different filter types:

0% – 3.5% @ 3 Gy and 0.5% – 4.5% @ 30 Gy depending on filter

## Simulated Charged Hadron Rate for MCP-PMTs and PCBs

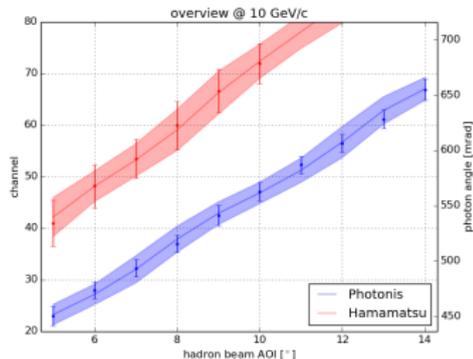


## Combined testbeam of Disc and Barrel DIRC in May 2015 at CERN in T9 testbeam area



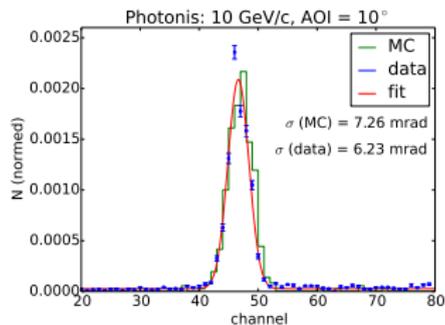
# Testbeam Results 2015

Results from Test beam at 10 GeV/c momentum and comparison with Geant4 Monte-Carlo simulations:

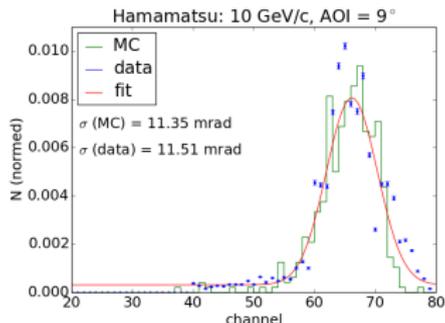


Single photon resolution matching well with Geant4 simulations  
Photon multiplicity not matching → further studies necessary

## Resolution Photonis



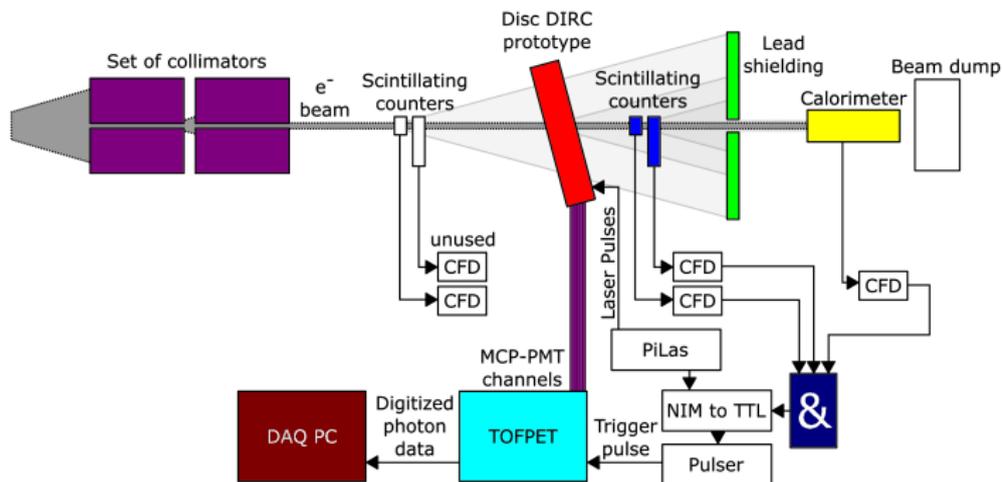
## Resolution Hamamatsu



# Testbeam Setup 2016

DESY Testbeam photos in T24/1 testbeam hall:

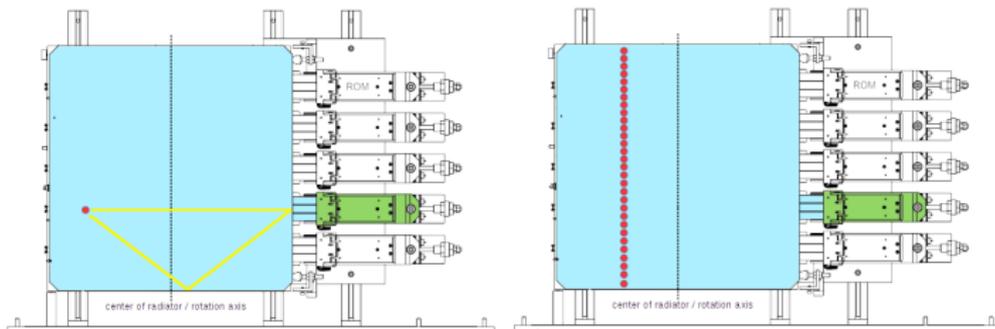




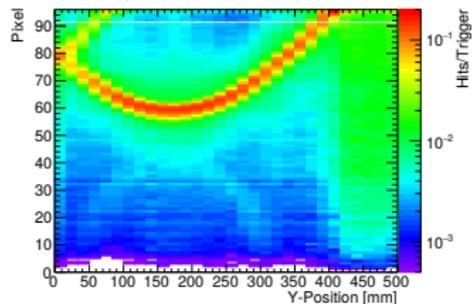
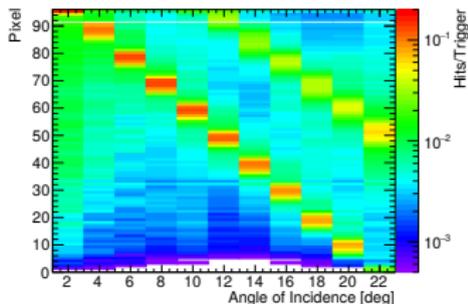
- DESY Testbeam with electrons at  $p = 3 \text{ GeV}/c$
- Free-running readout system (ToFPET) with 50 ps resolution
- Using scintillation counters and calorimeter as software trigger
- Trigger signal discrimination with Constant Fraction Discriminator (CFD) NIM module to avoid time-walk effects

## Hit patterns including vertical position and angle scan

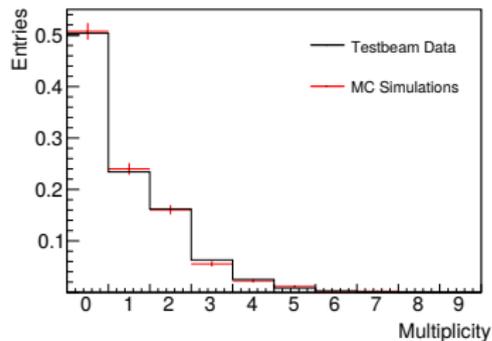
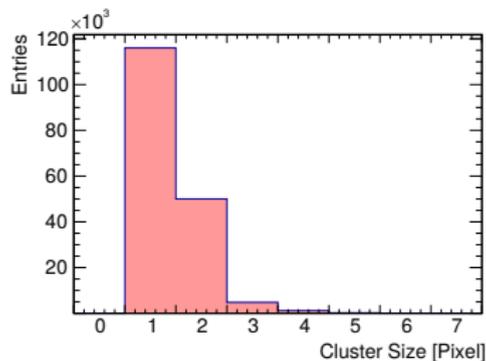
### Radiator with Beam Position



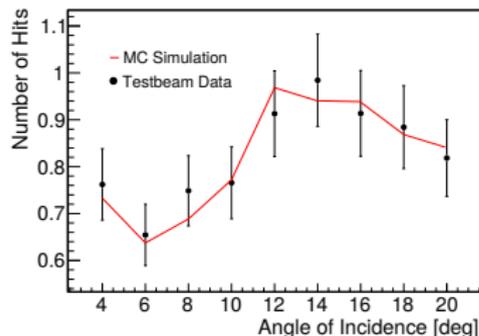
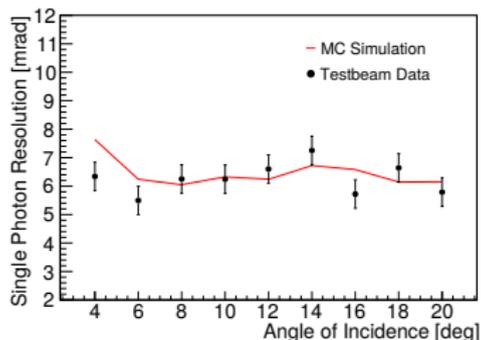
Only center FEL analyzed:

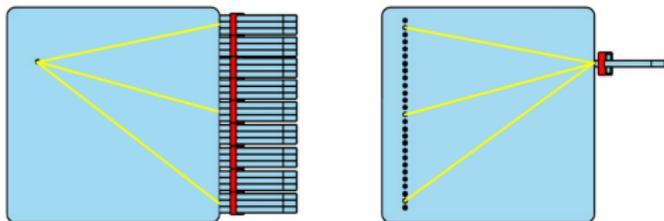


Estimating charge sharing in MCP-PMT from cluster size ( $\approx 33\%$ ):



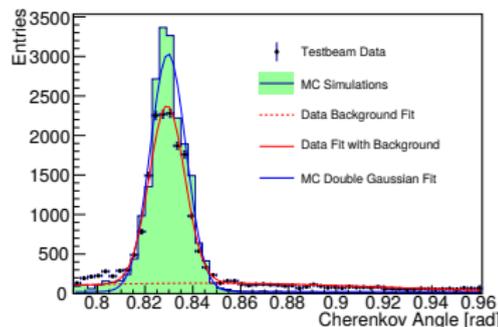
Single photon resolution and photon yield:



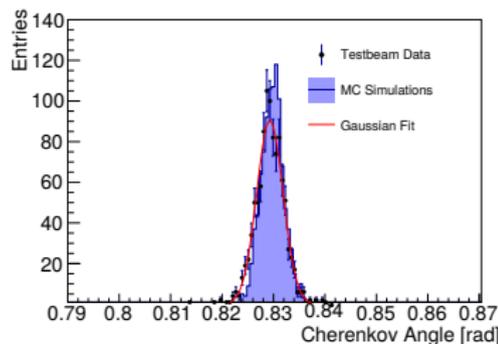


- Combining each event from every position to one new event
- Making a coarse time cut according to photon propagation time
- Reduction of background with truncated mean of pixel hits
- Obtained resolutions:  
 $\sigma_{\theta} = 7.4 \text{ mrad}$  (single photon)  
 $\sigma_{\bar{\theta}} = 2.5 \text{ mrad}$  (average)

## Single Photon Distribution



## Mean Ch. distribution



- Still remaining open questions regarding background and photon yield for different scans
- New testbeam campaign (July/August 2018 in T9 at CERN) with new version of readout system (ToFPET-2-ASIC) **just finished**



- Results currently being analyzed

## Summary:

- Full detector simulations in dedicated framework (PandaRoot)
- Updated detector design based on simulation results
- Successful prototype testbeams matching well with Monte-Carlo simulations

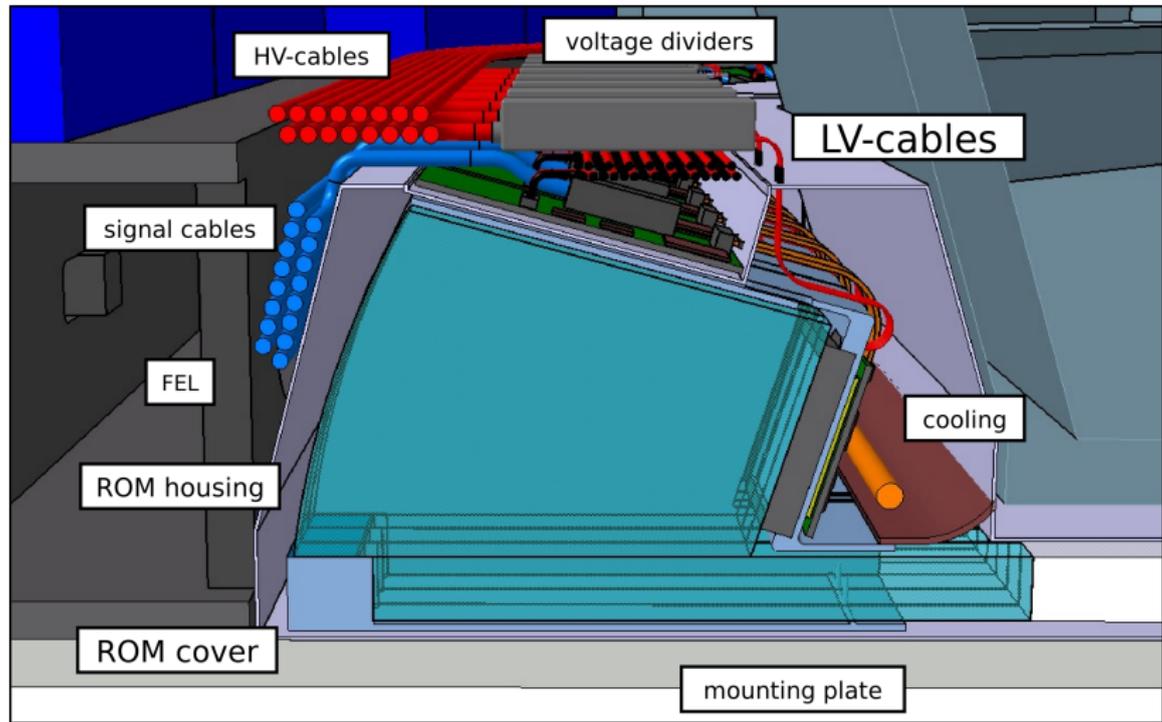
## Outlook:

- Analysis of the last testbeam (CERN 2018)
- Redesign of the readout boards (custom designed with smaller form factors)
- Construction and implementation of a *first-of-series* DIRC quadrant in PANDA

**Thank you very much  
for your attention!**

# Backup Slides

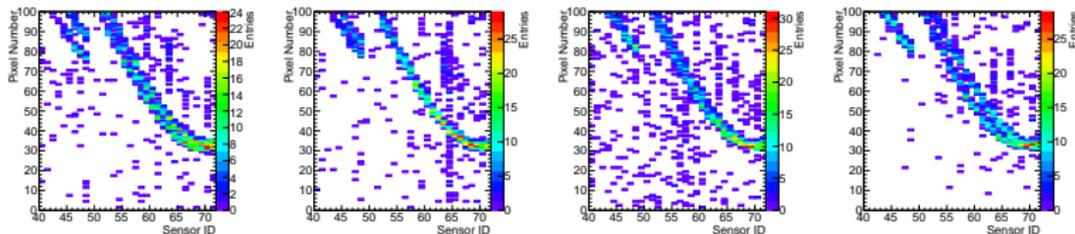
## TOFPET ASICs attached to MCP-PMTs



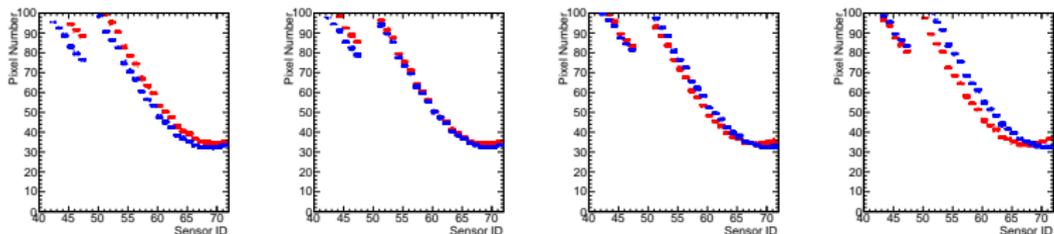
# Overlapping Hitpattern

Hitpattern overlap due to reflections at outer rim

## Simulated hitpattern



## Calculated hitpattern



- Simulated hitpatterns are shifting as function of azimuth angle
- Full overlap cannot be observed due to bending inside magnetic field