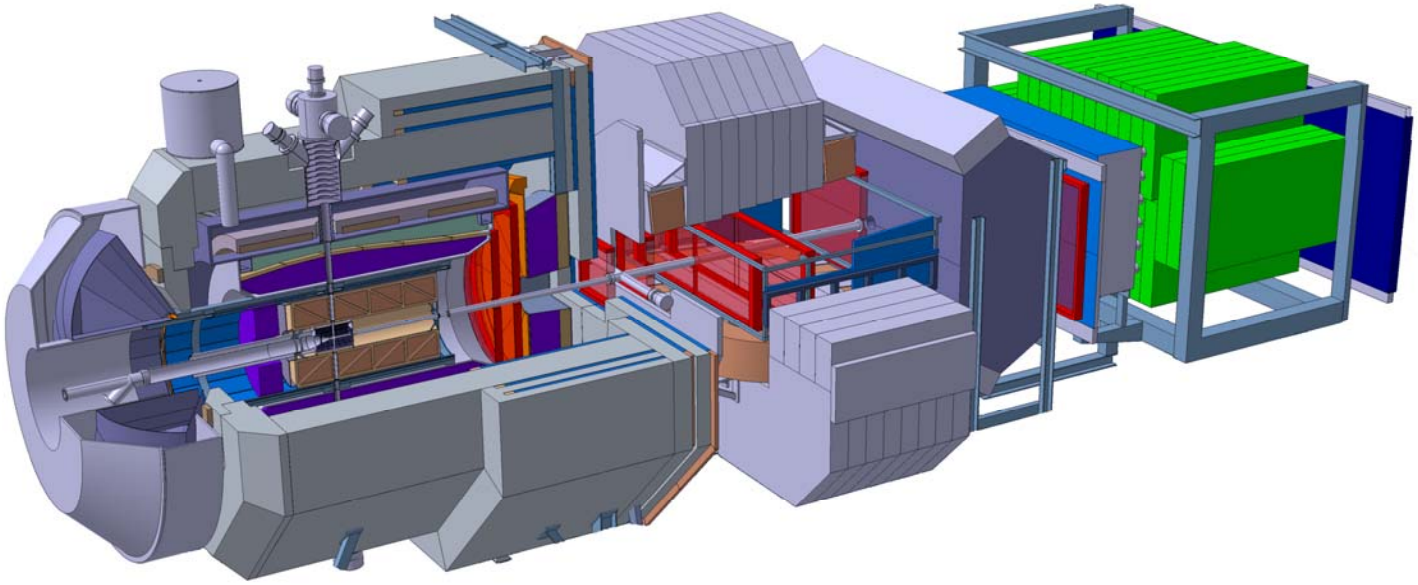
# The DIRC projects of the PANDA experiment at FAIR



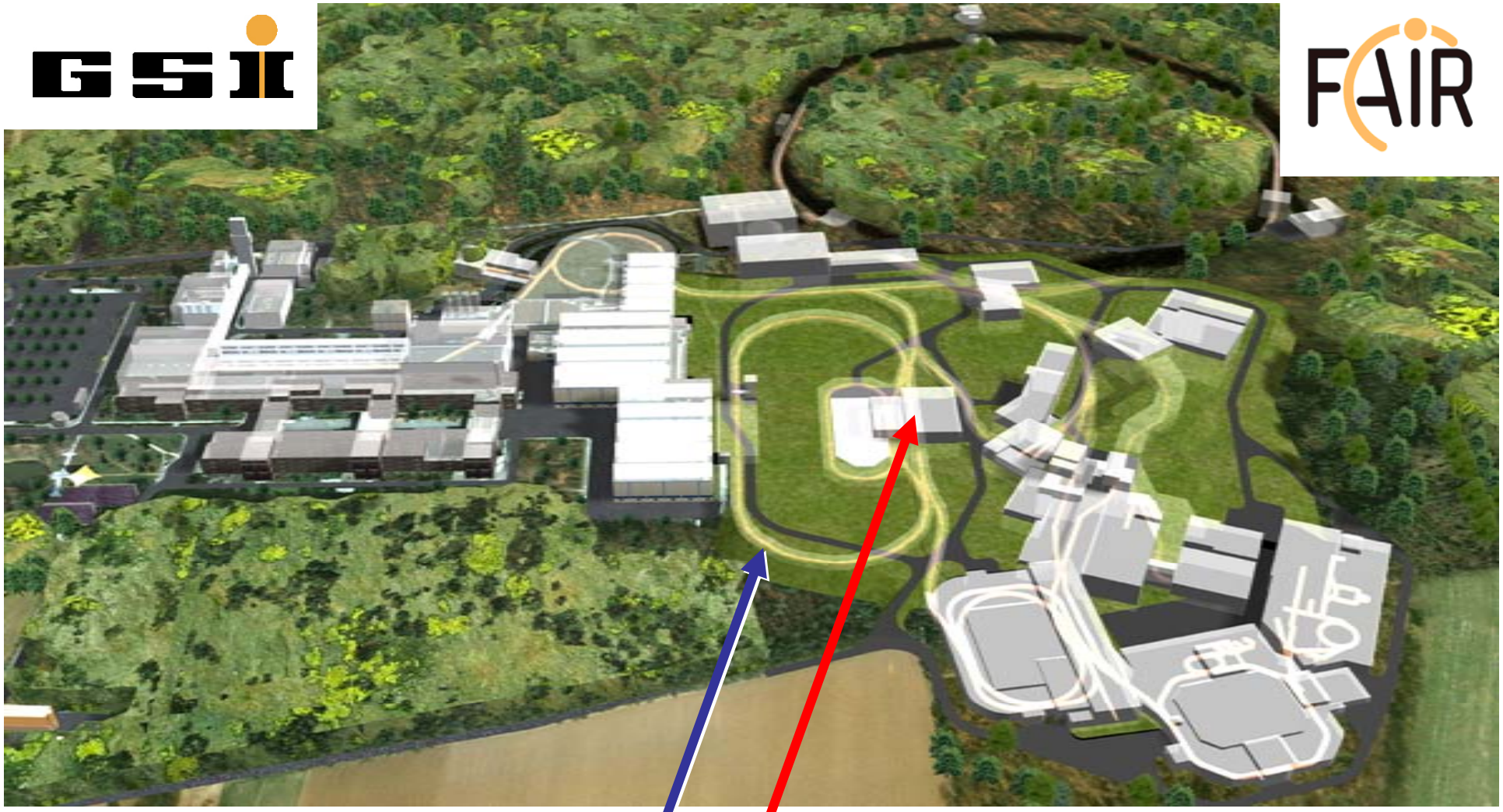
Klaus Föhl on behalf of the

**Cherenkov Group**

Darmstadt Dubna Edinburgh Erlangen Ferrara Giessen Glasgow Krakow Wien

RICH2007
Trieste, Italy
October 2007

Work supported
by EU FP6 grant
contract number 515837
DIRACsecondary-Beams



HESR

Nuclei Far From Stability
Compressed Nuclear Matter
High Energy Density in Bulk

**Antiprotons**

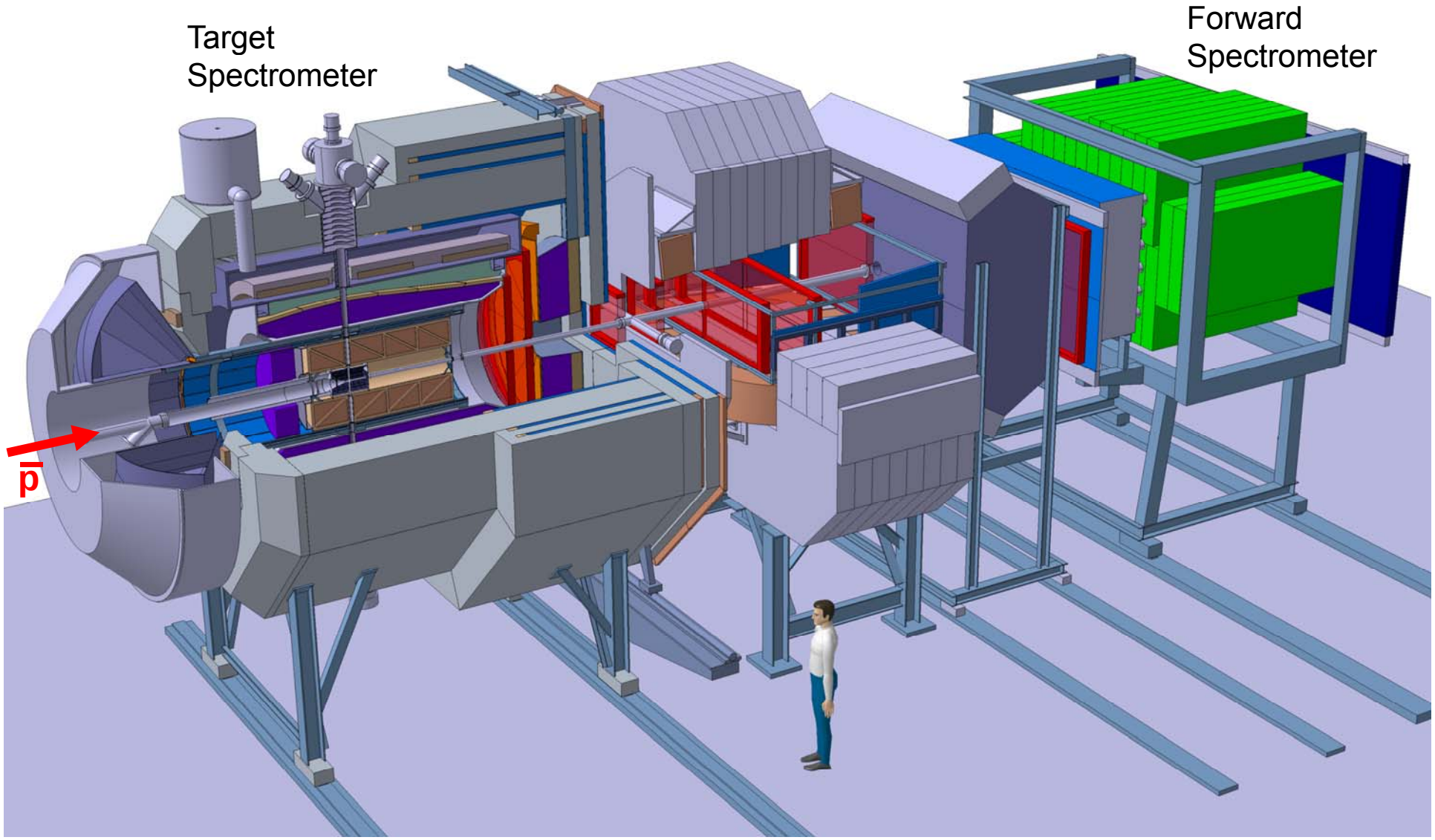
Hadron spectroscopy
- Charmonium spectroscopy
- Gluonic excitations (hybrids, glueballs)

Charmed hadrons in nuclear matter

Double $\Lambda$-Hypernuclei

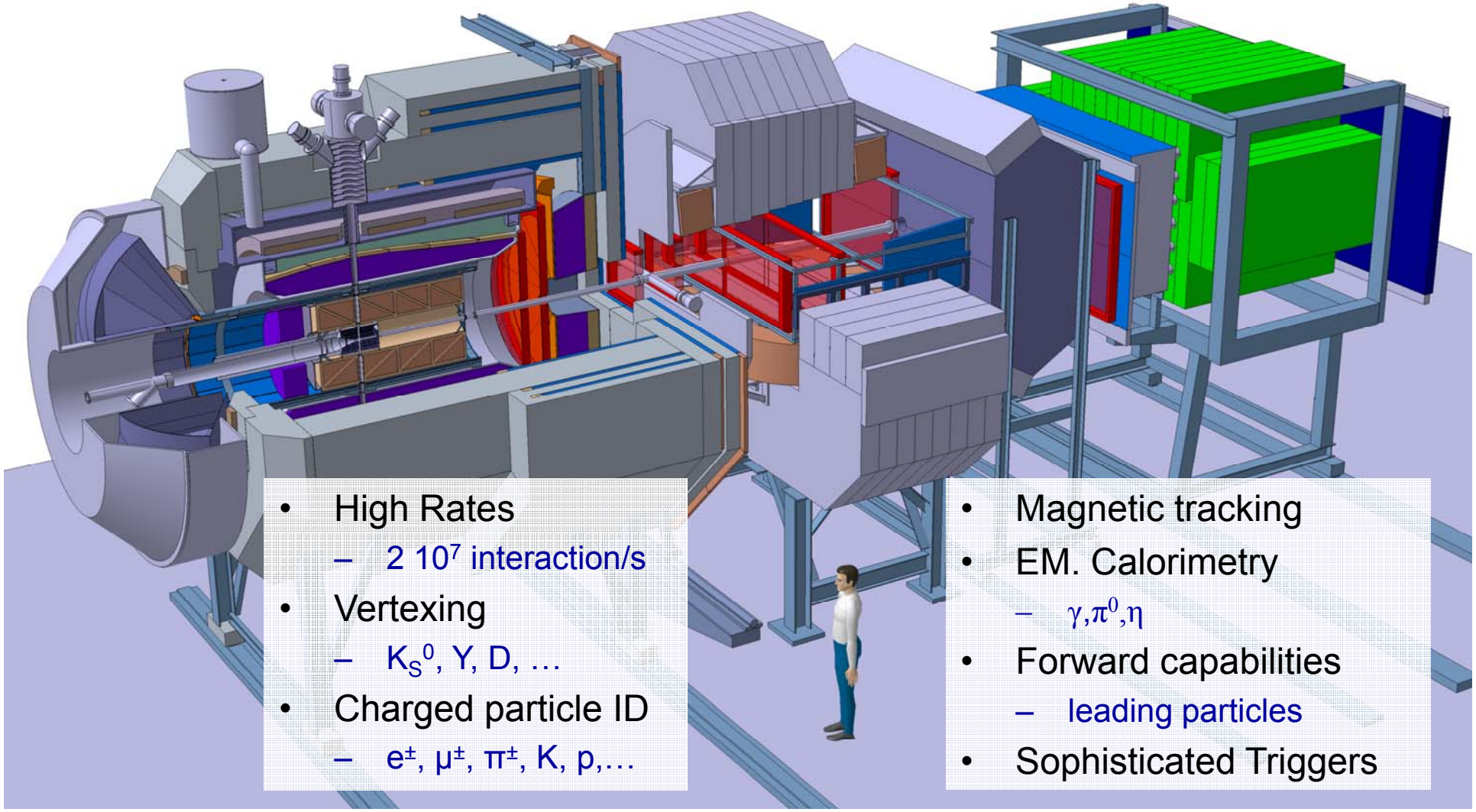
# A View of PANDA

AntiProton ANnihilations at DArmstadt



# A View of PANDA

AntiProton ANnihilations at DArmstadt



- High Rates
  - 2 $10^7$ interaction/s
- Vertexing
  - $K_S^0$, Y, D, …
- Charged particle ID
  - $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, K, p,…

- Magnetic tracking
- EM. Calorimetry
  - $\gamma, \pi^0, \eta$
- Forward capabilities
  - leading particles
- Sophisticated Triggers

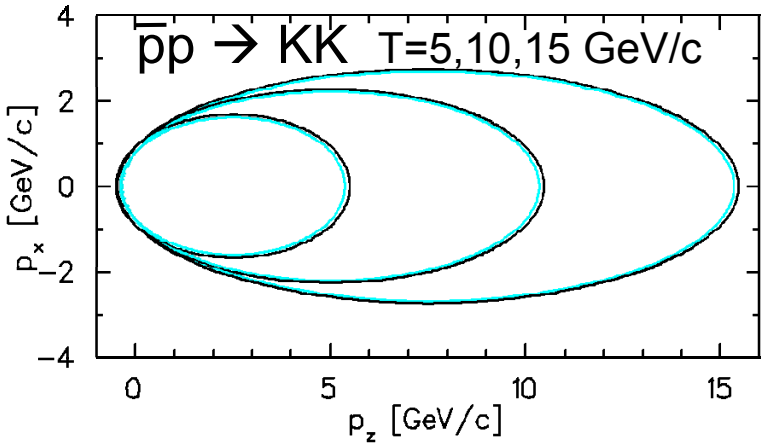
# Particle ID & Kinematics

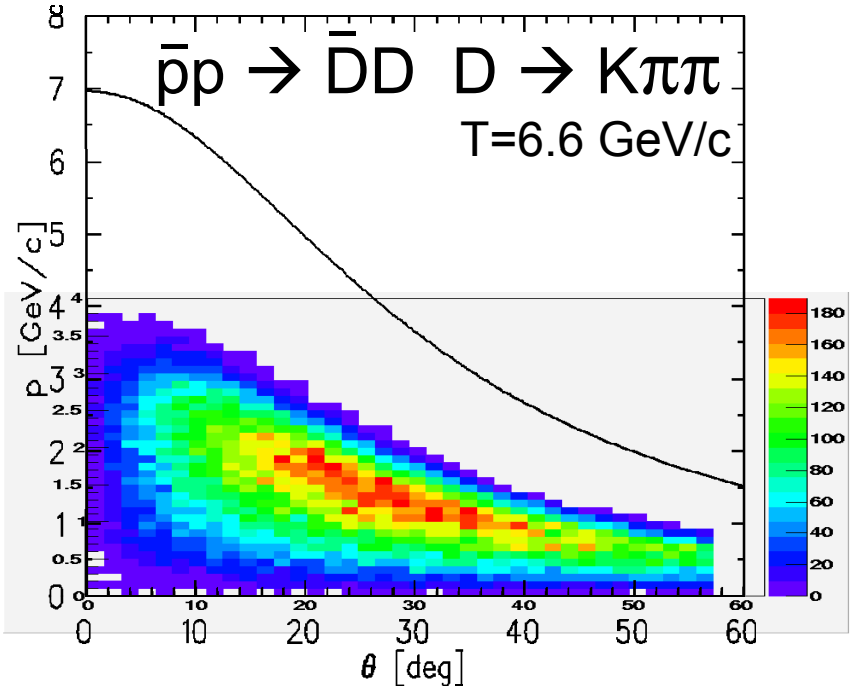
$\bar{p}p$ i.e. open charm production

$D^+ \rightarrow K^-\pi^+\pi^+$
$\pi^-\pi^+\pi^+$
$K^-K^+\pi^+$

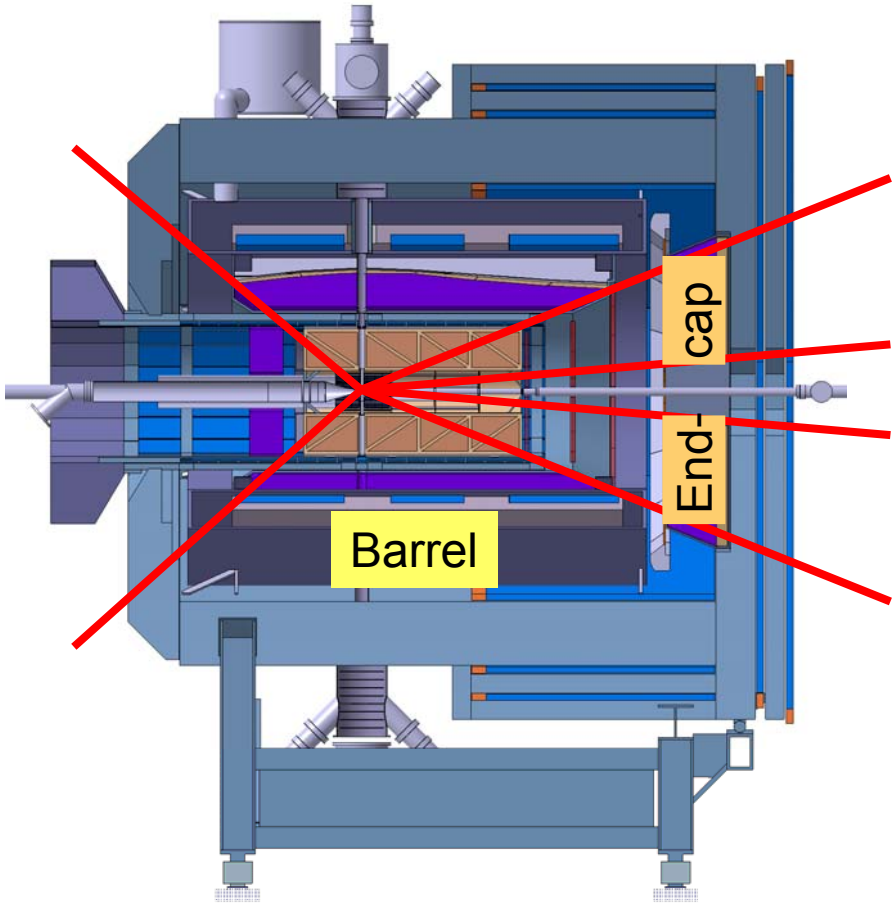
$\pi^-\pi^+K^+$ even
or $K^-\pi^-\pi^+\pi^+\pi^+$

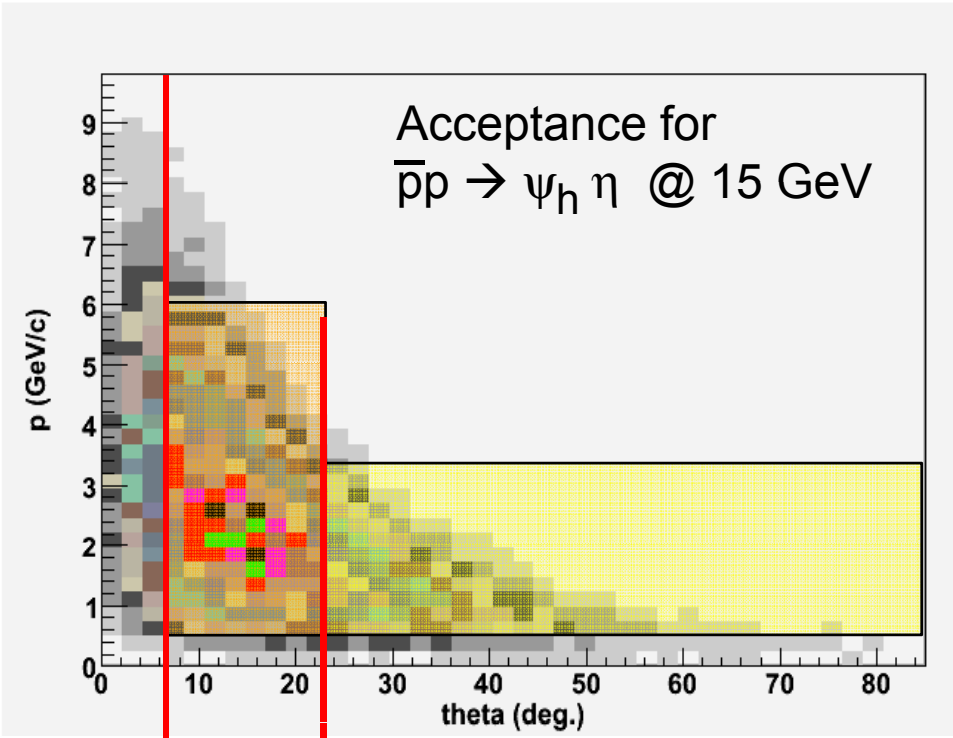
distinguish $\pi$ and K (K and p) ...



# PANDA Target Spectrometer




Endcap Barrel

FS Target Spectrometer

PANDA: 4π detector
desire to keep EMC small
→ hence we suggest DIRCs

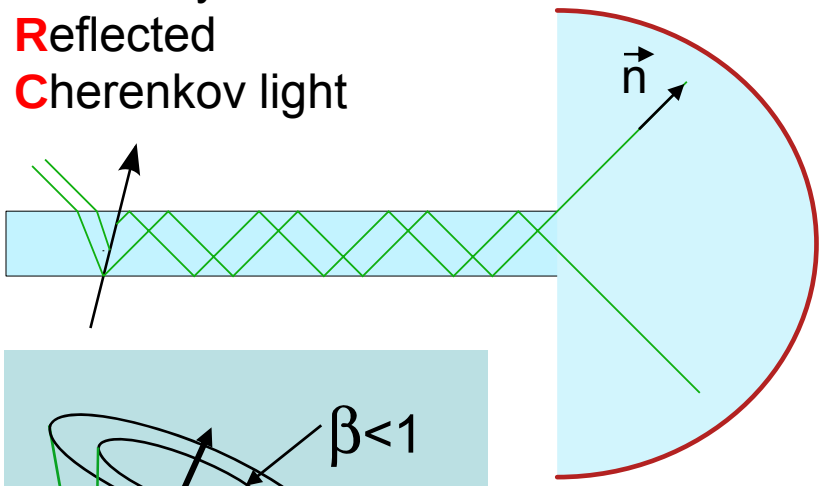
two areas – two detector geometries

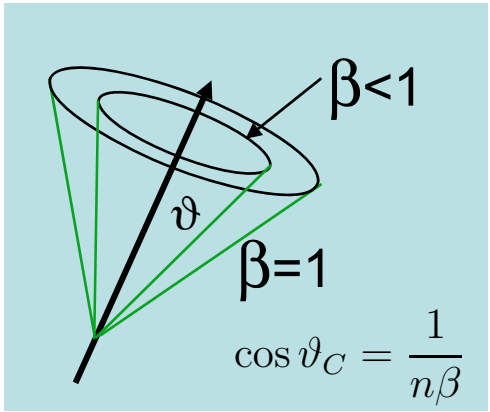
*...shipping coal to Newcastle...*

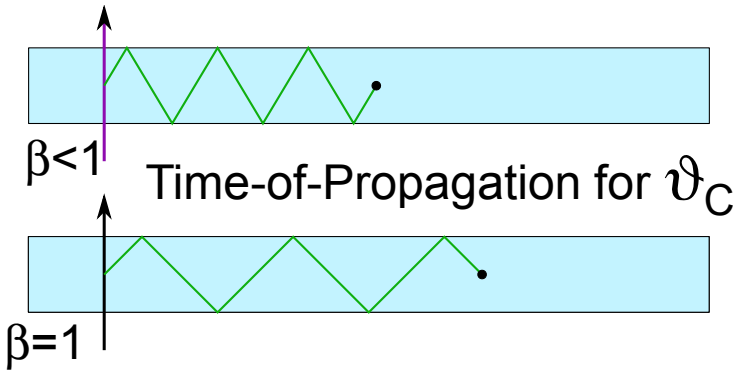
*...talking about DIRC at RICH...*

# DIRC Principles

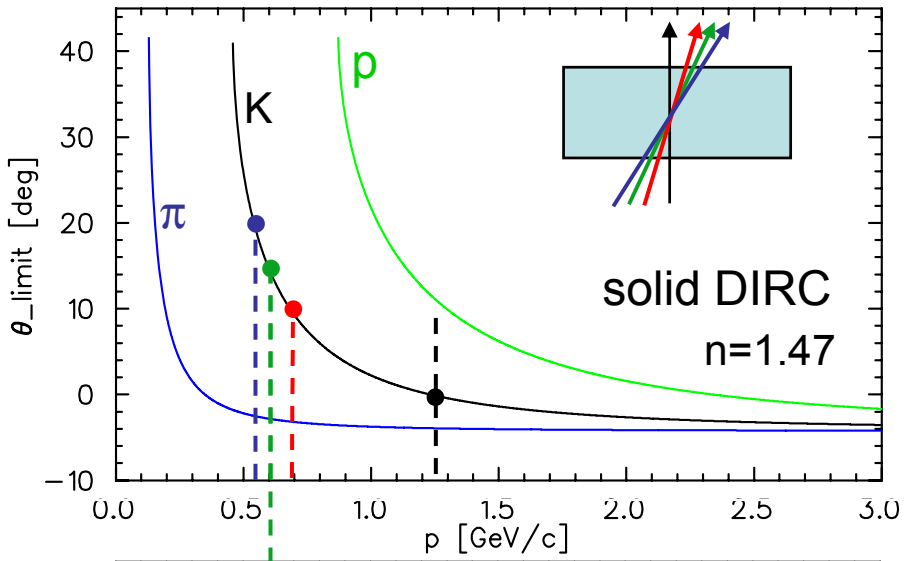
**D**etector of
**I**nternally
**R**eflected
**C**herenkov light

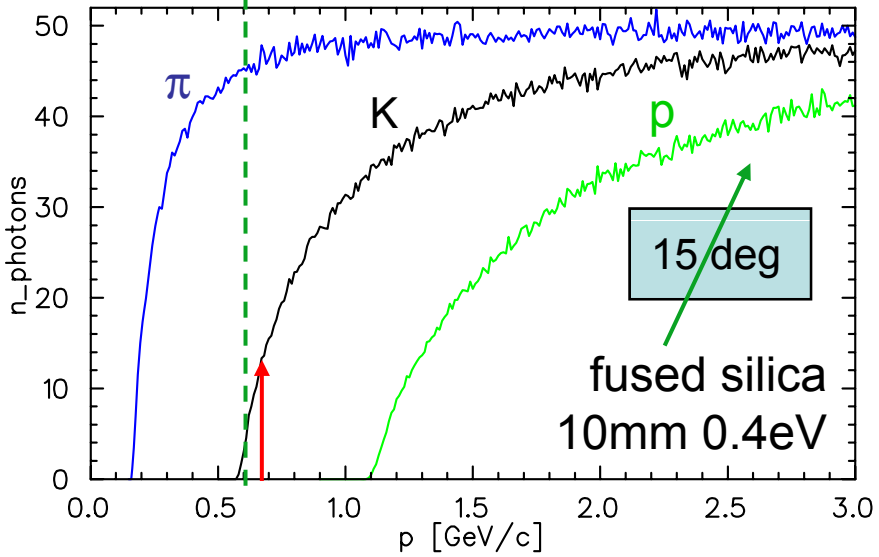


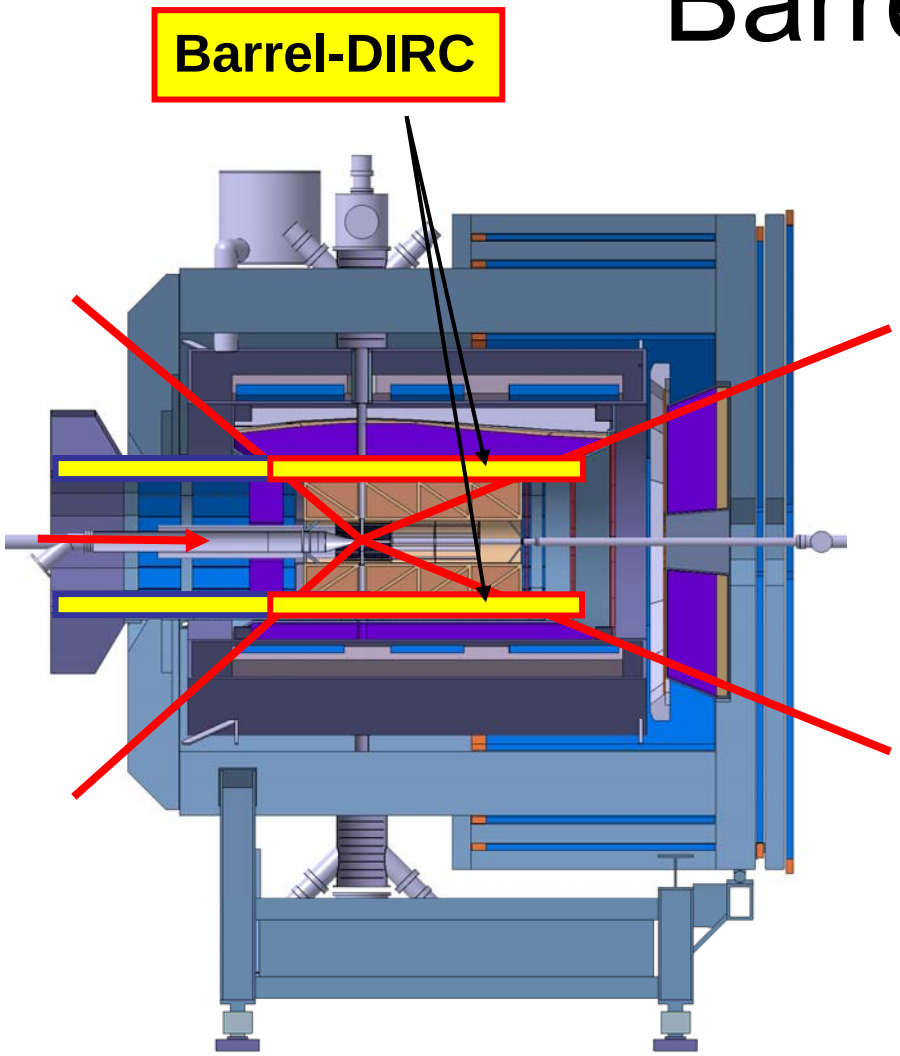



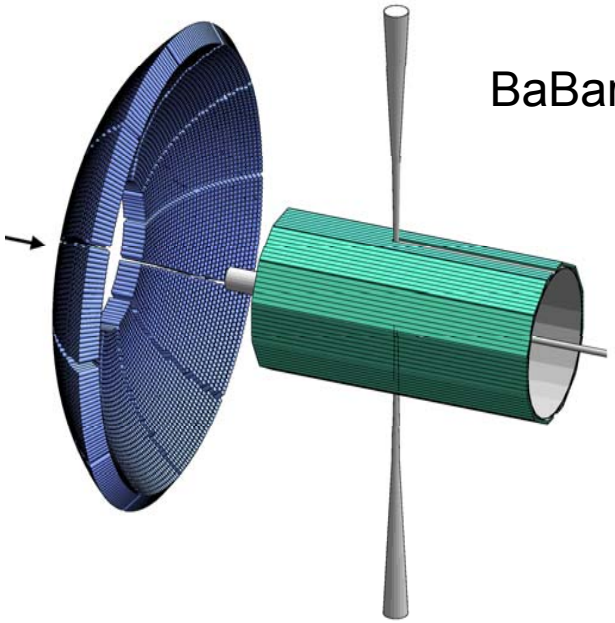

**lower p threshold**



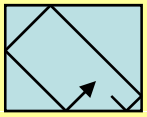
# Barrel DIRC




2D + t or (2+1)D design

2-dimensional imaging type

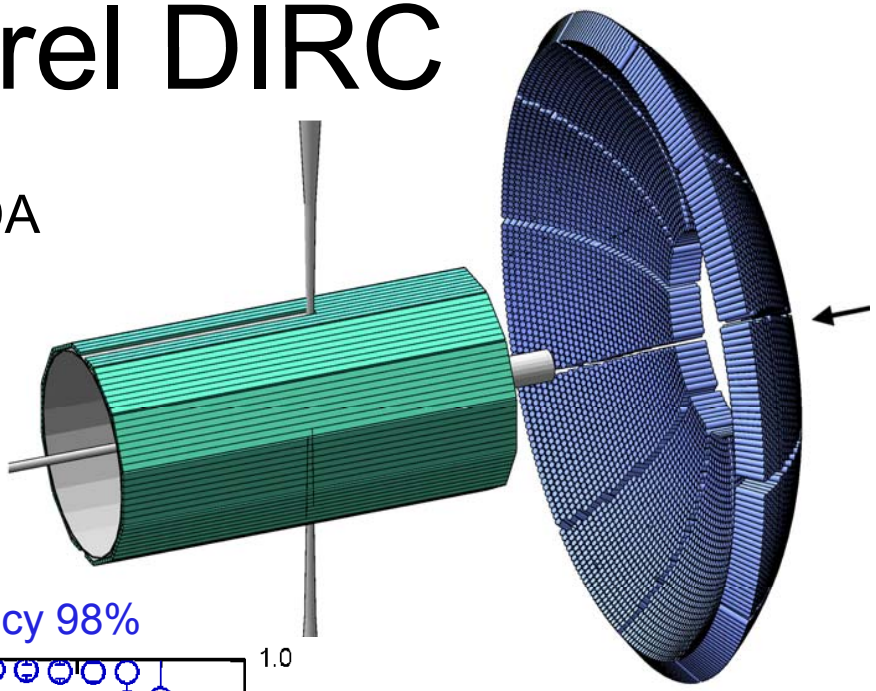


Poster → Carsten Schwarz: The Barrel DIRC of the PANDA experiment

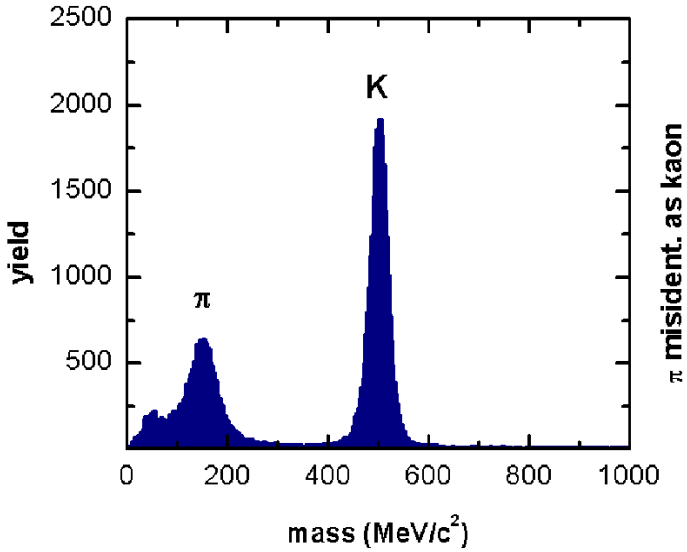
# PANDA barrel DIRC

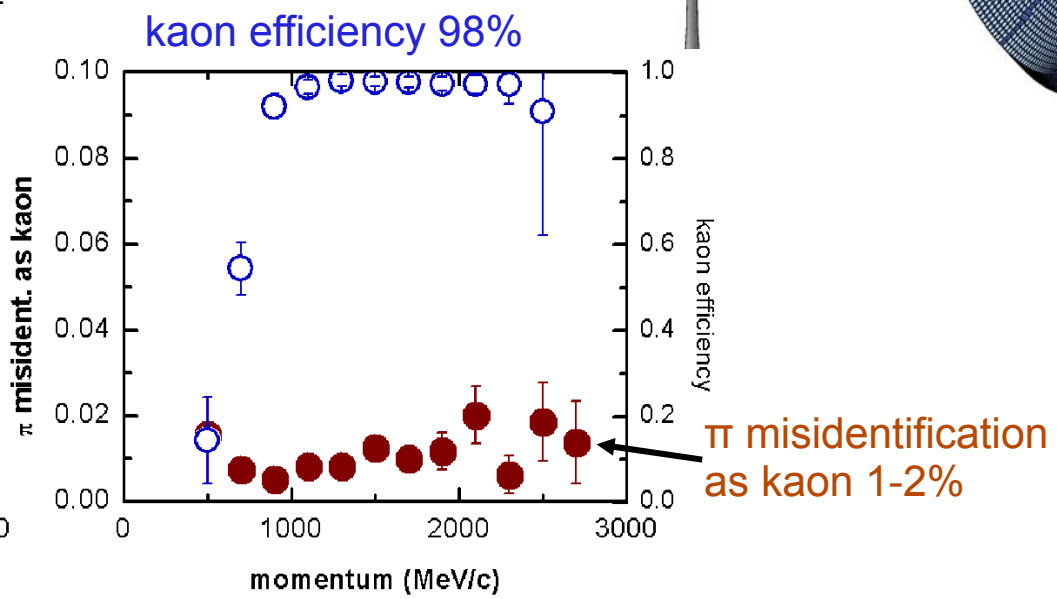
scaled BaBar version suits PANDA

"only" 7000 PMT
(BaBar 11000 PMT)



Simulations
$\bar{p}p \rightarrow J/\psi\ \Phi\ \sqrt{s} = 4.4\ GeV/c^2$



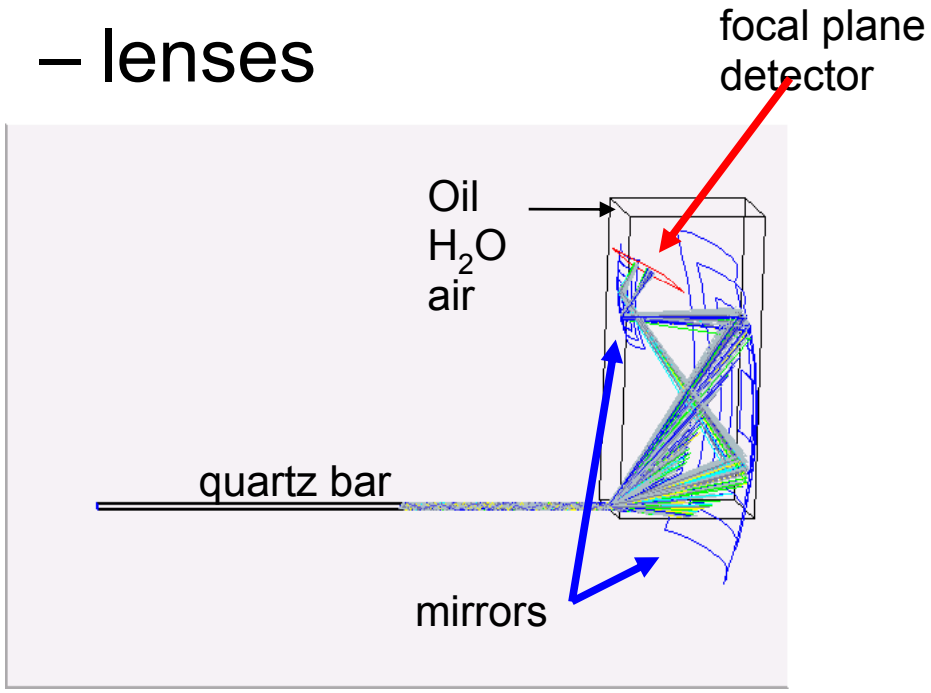
# PANDA barrel DIRC

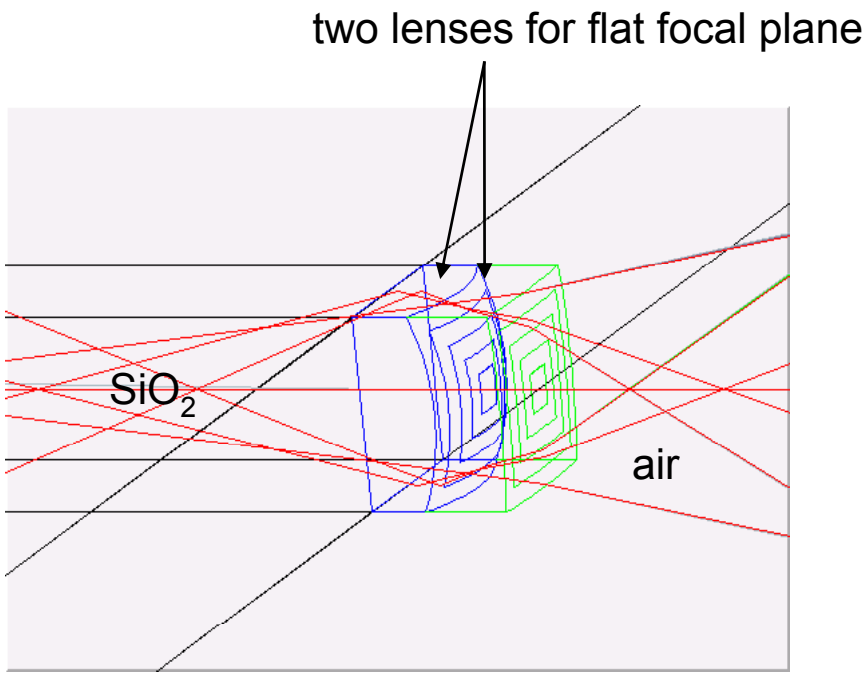
- **R&D towards smaller photon detector**

  needs optical elements instead of pinhole focus

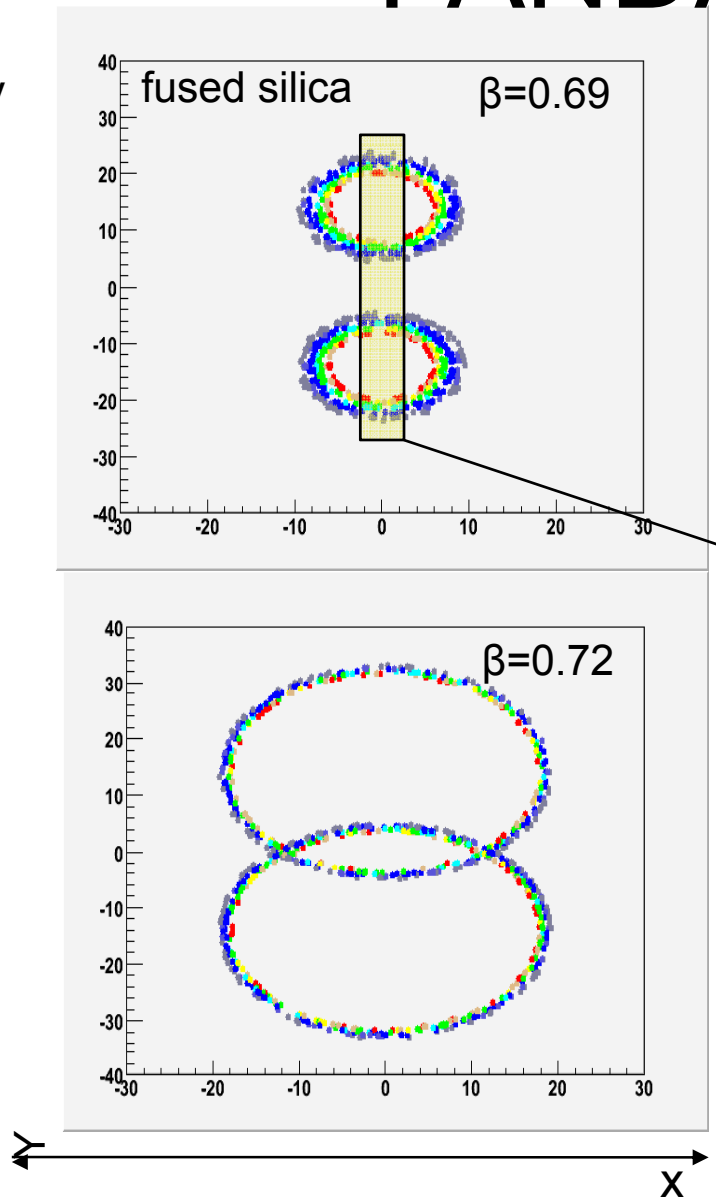
  – mirrors

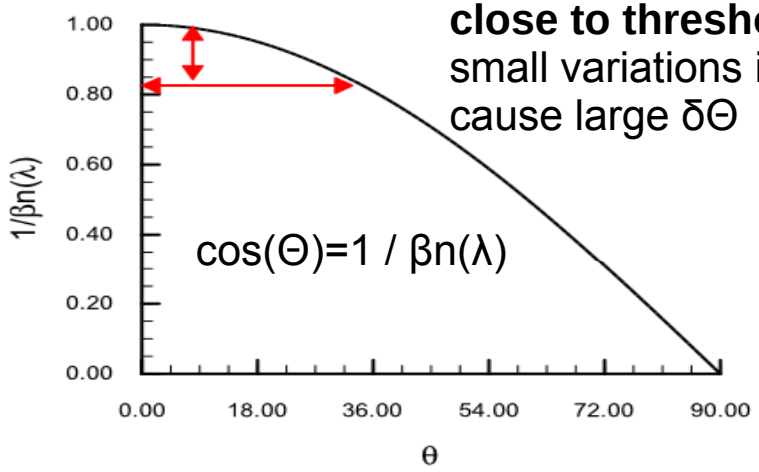
  – lenses



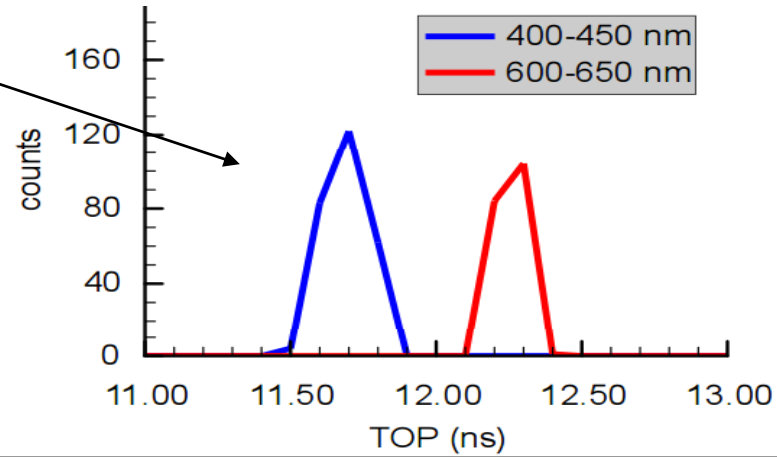



# PANDA barrel DIRC



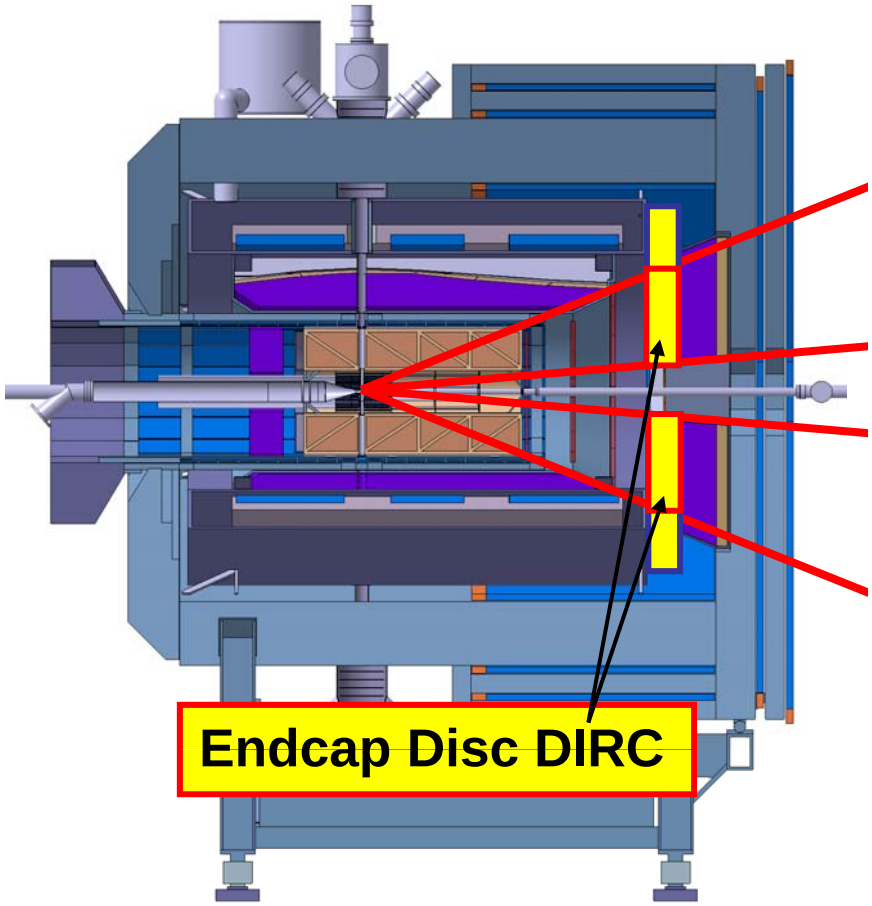




**close to threshold**:
small variations in n(λ)
cause large δΘ



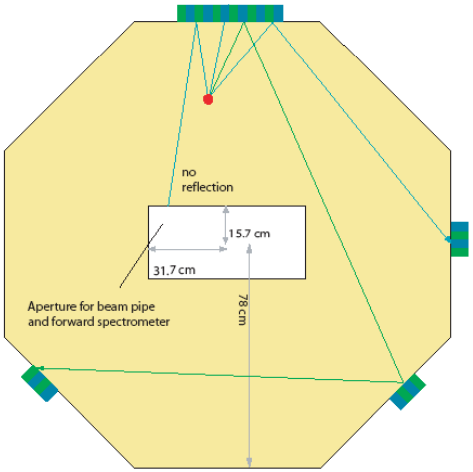

Time of Propagation (TOP) measurement better 0.5ns
allows to correct dispersion
for high and low momenta→x,y,t→3D-DIRC

# PANDA Target Spectrometer



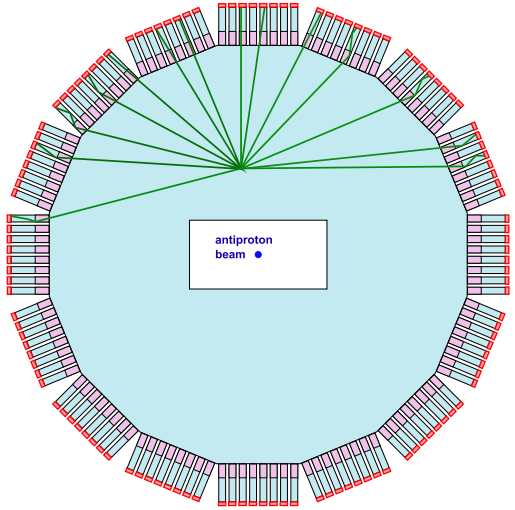

Two different readout designs:

Time-of-Propagation



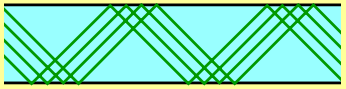

(1+1)D design

Focussing Lightguide



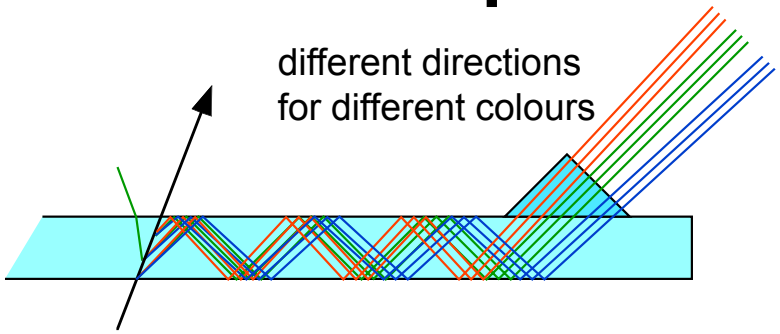

2D + t design

1-dimensional
imaging type



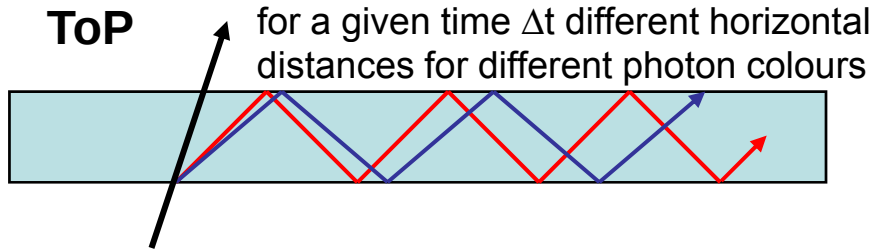
Poster → Peter Schönmeier: The Endcap DIRC of the PANDA experiment

# Dispersion Corrections



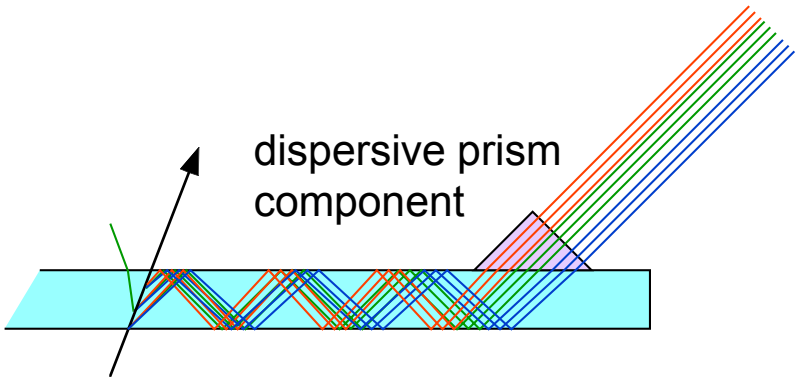

$$\cos\vartheta_C = \frac{1}{n_{Phase}(\lambda)\beta}$$

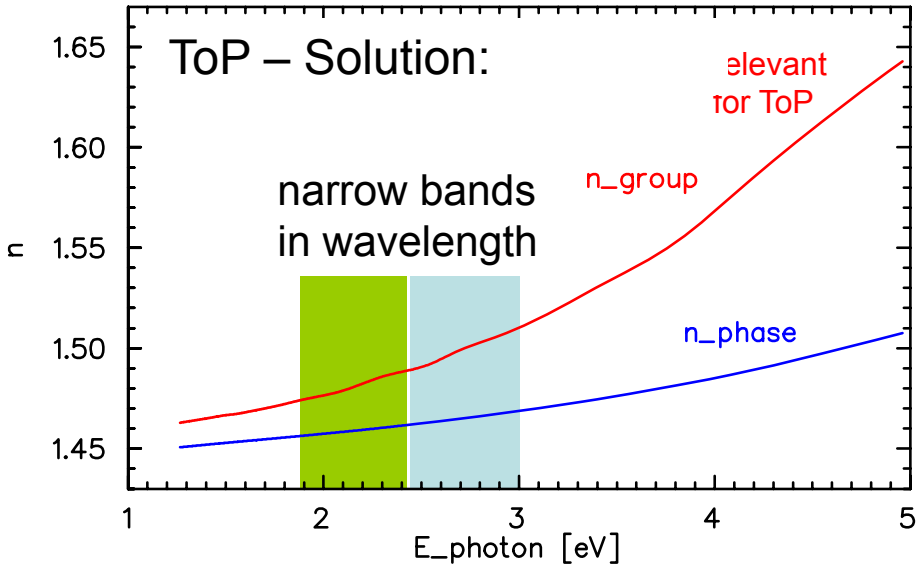
**ToP**



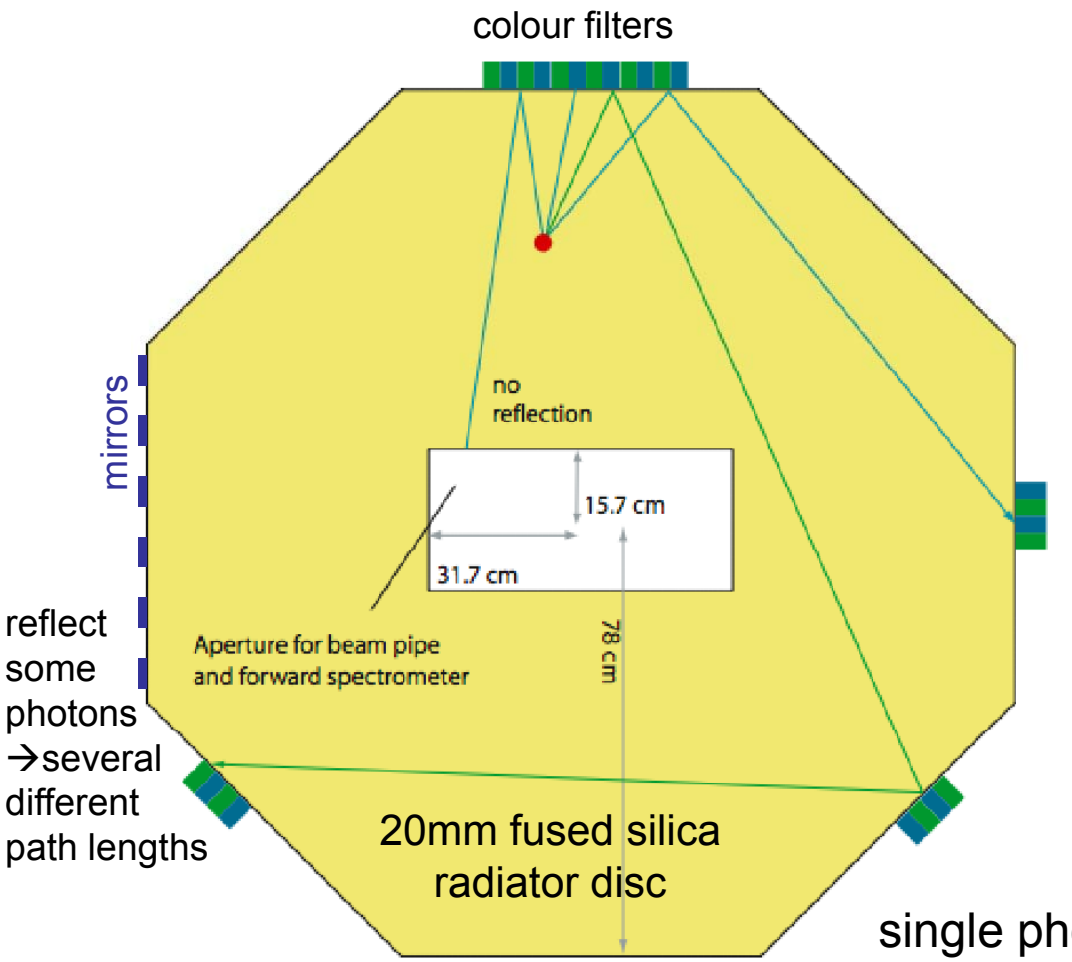

$$v = \frac{c}{n_{Group}(\lambda)}$$

Focussing – Solution:



# Time-of-Propagation design




dichroic mirrors as colour filters
allows two wavelength bands
→higher photon statistics

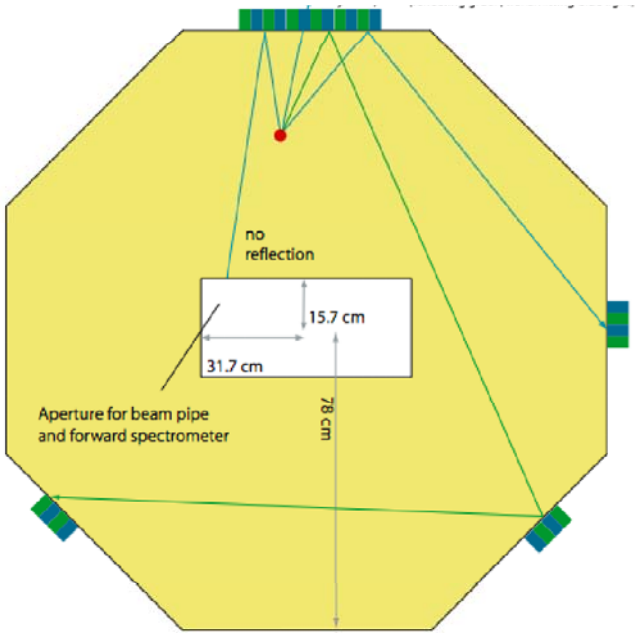
small wavelength bands
minimise dispersion effect
+optimised photocathodes

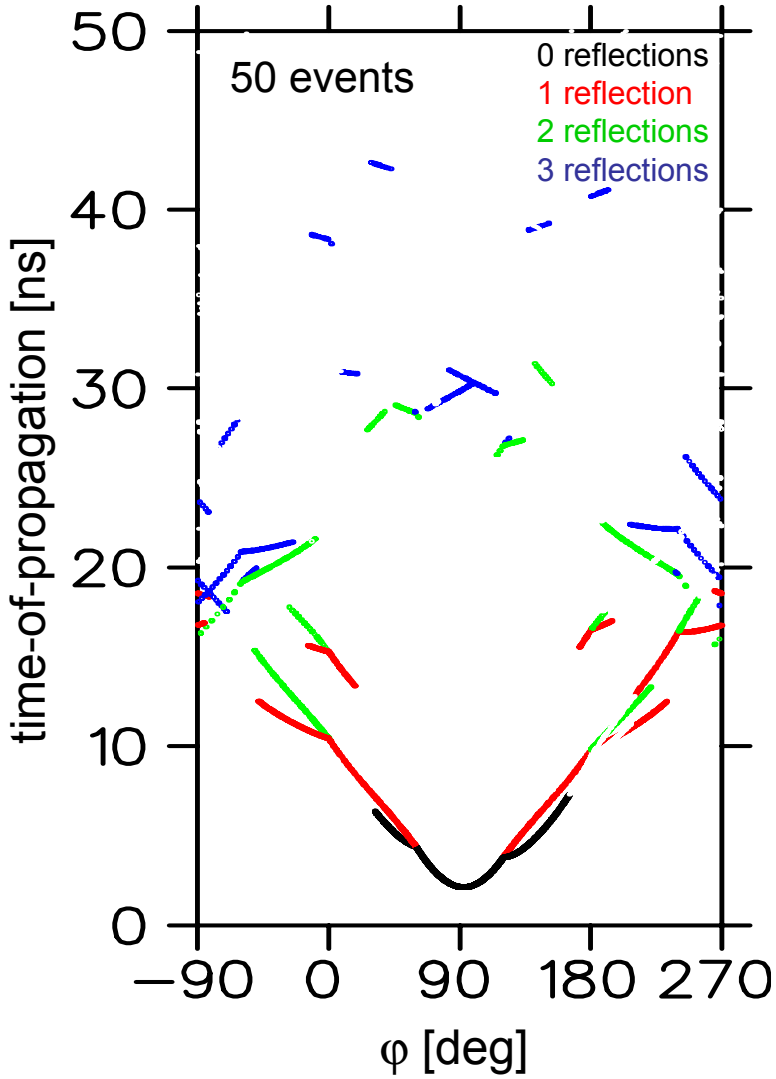
mirrors give different path lengths
→ self timing design

mirrors allow longer path lengths
→ better relative time resolution

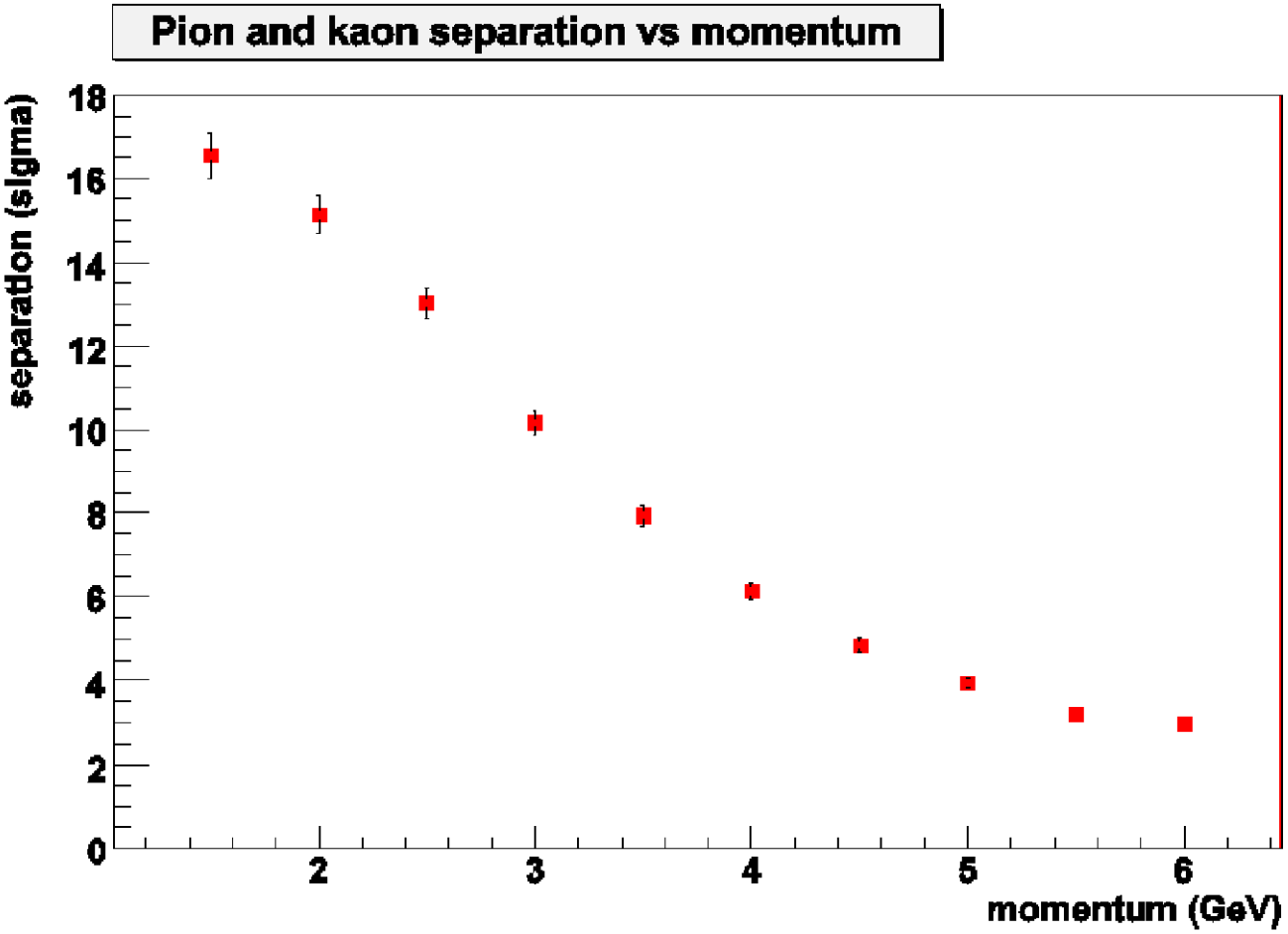
single photon resolution $\sigma_t$~30-50ps required

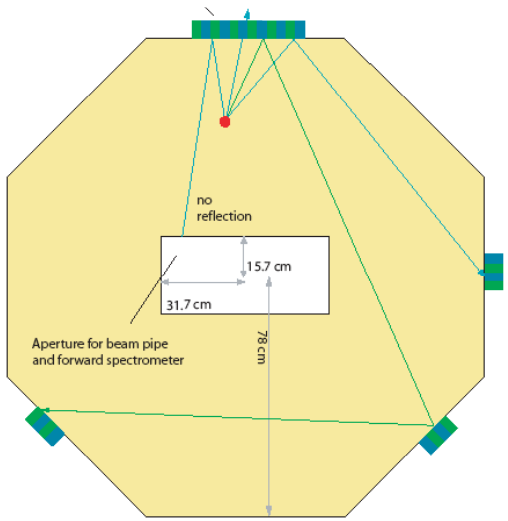
# Time-of-Propagation design



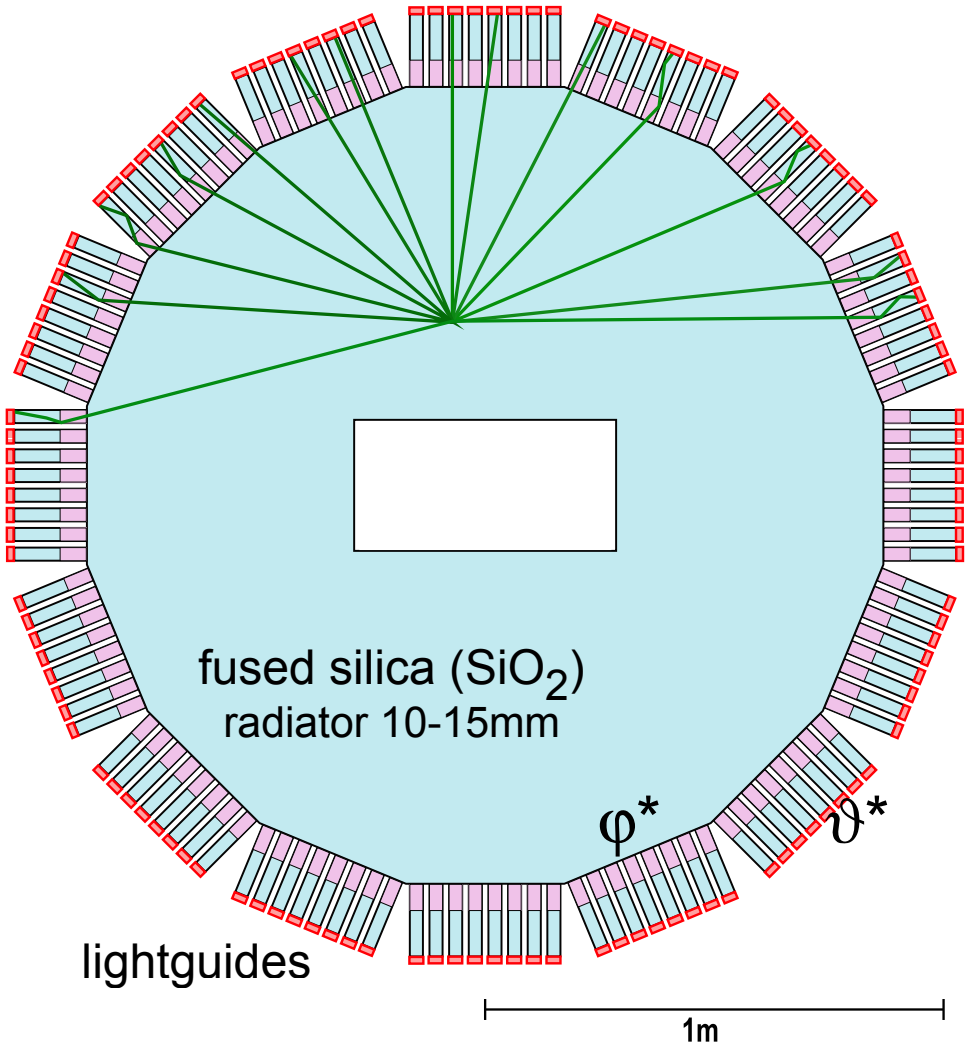
# Time-of-Propagation

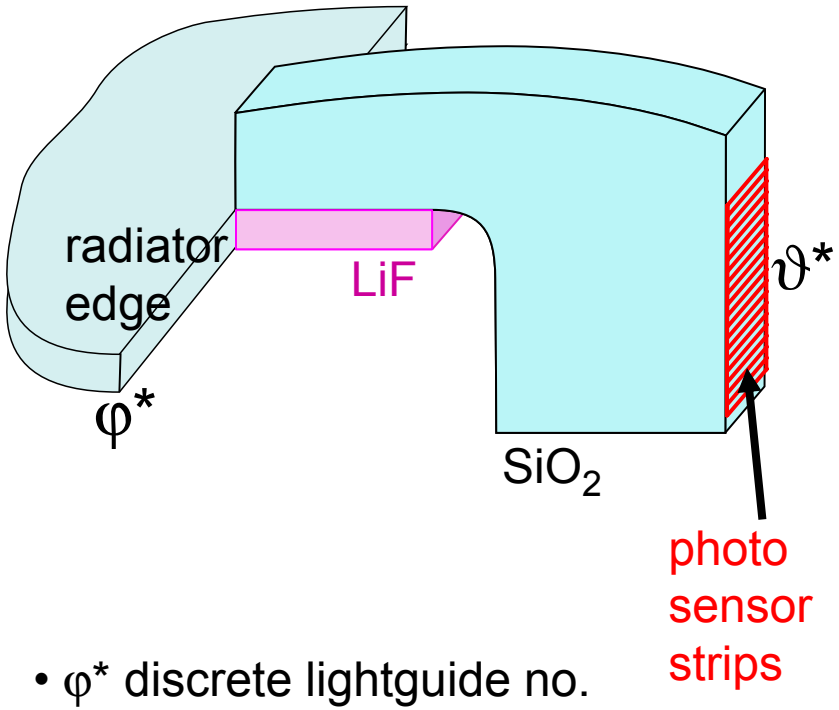



particle angle 15 deg
$\sigma_t$=50ps
$\Delta E \times \varepsilon_{QE}$=(0.18+0.2)eV
disc with black hole

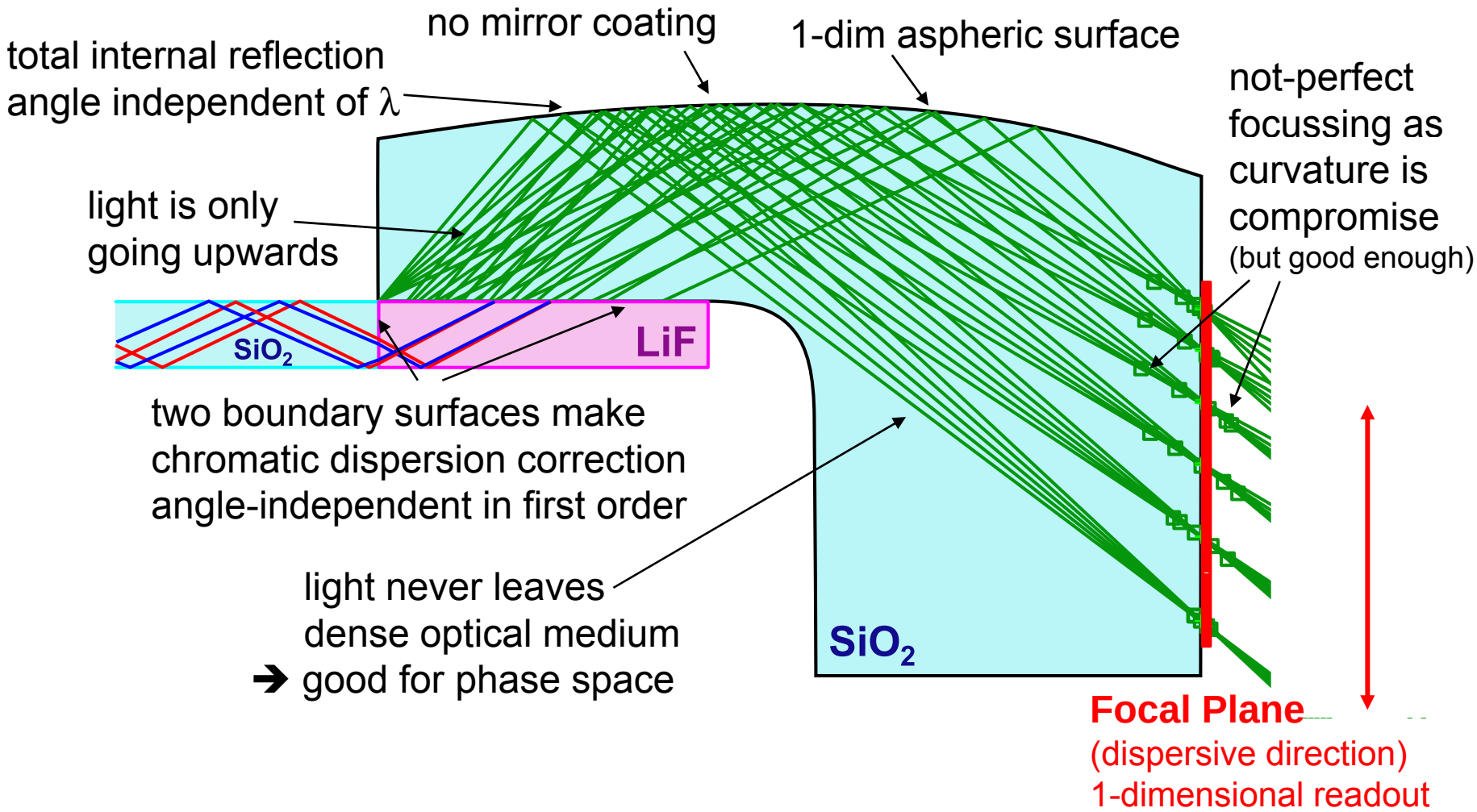
# Focussing Lightguide



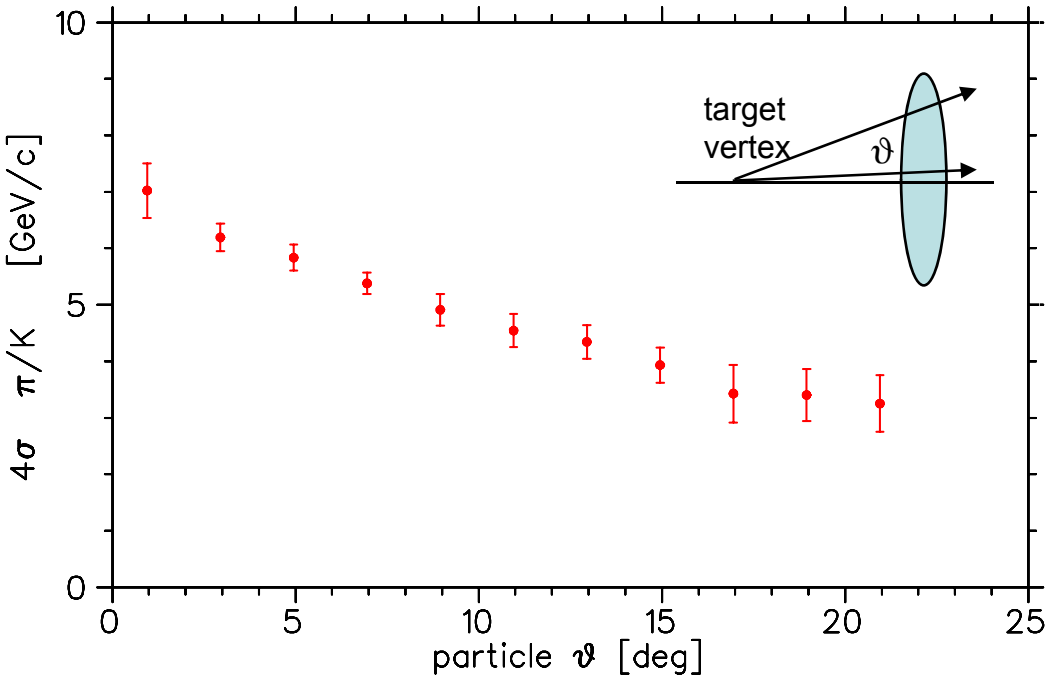



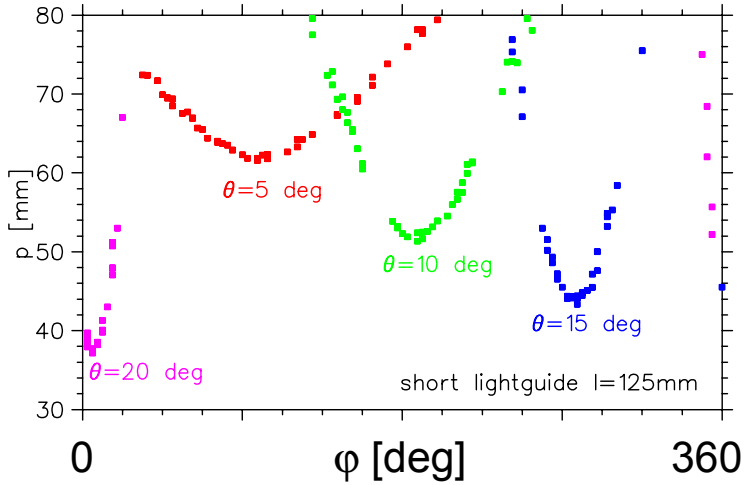

- φ* discrete lightguide no.
- ϑ* angle in (r-z) plane
- LiF for dispersion correction
- photon extraction into lightguide lifts up-down direction ambiguity
- focussing inside lightguide

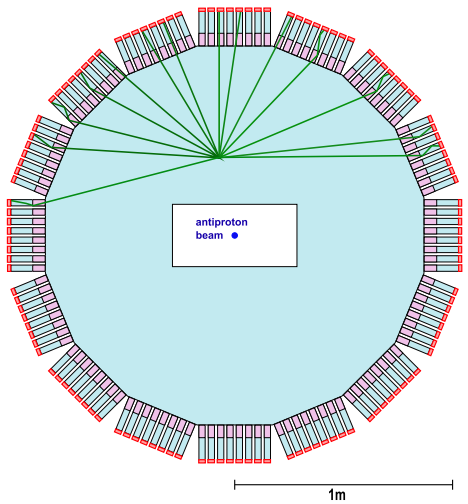
# Focussing & Chromatic Correction



# Focussing Lightguide



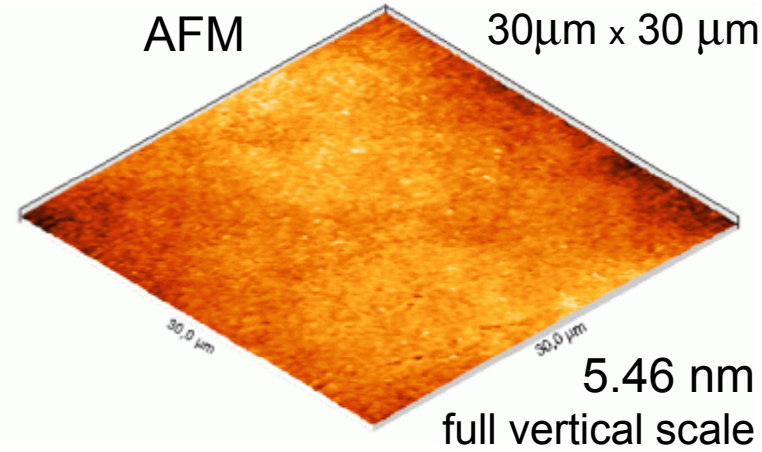




simulation example with $\chi^2$ fit analysis
disc 10mm thick, 0.4eV
short lightguide 125mm, focal plane 48mm

# Research & Development

- Polishing Effectiveness




- Radiator Tests

- Radiation Hardness

Friday → Matthias Hoek: Radiation Hardness Study on Fused Silica

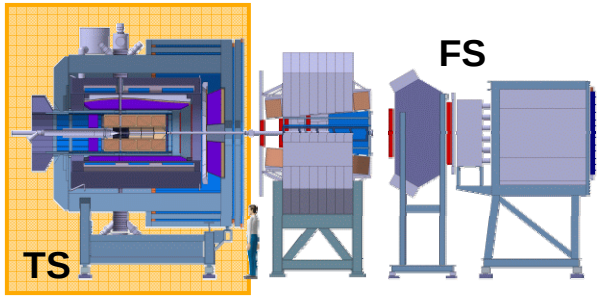
- Photon Detectors

magnetic field (up to B=2T), photon rate (MHz/pixel), light cumulative dose, radiation dose

Thursday → Albert Lehmann:
Studies of Microchannel Plate PMTs in High Magnetic Fields

# Summary

- High antiproton rates require novel detectors for PID
- We propose DIRCs for the PANDA Target Spectrometer




- Several designs with innovative solutions
  - Barrel DIRC with optical elements
  - Endcap DIRC – Time-of-Propagation
  - Endcap DIRC – Focussing Lightguide
- R&D in progress

# Panda Participating Institutes

more than 300 physicists (48 institutes) from 15 countries

U Basel
IHEP Beijing
U Bochum
U Bonn
U & INFN Brescia
U & INFN Catania
U Cracow
GSI Darmstadt
TU Dresden
JINR Dubna (LIT,LPP,VBLHE)
U Edinburgh
U Erlangen
NWU Evanston
U & INFN Ferrara
U Frankfurt
LNF-INFN Frascati
U & INFN Genova
U Glasgow
U Gießen
KVI Groningen
U Helsinki
IKP Jülich I + II
U Katowice
IMP Lanzhou
U Mainz
U & Politecnico & INFN Milano
U Minsk
TU München
U Münster
BINP Novosibirsk
LAL Orsay
U Pavia
IHEP Protvino
PNPI Gatchina
U of Silesia
U Stockholm
KTH Stockholm
U & INFN Torino
Politechnico di Torino
U Oriente, Torino
U & INFN Trieste
U Tübingen
U & TSL Uppsala
U Valencia
IMEP Vienna
SINS Warsaw
U Warsaw