

# First Particle Identification with a Disc DIRC Detector

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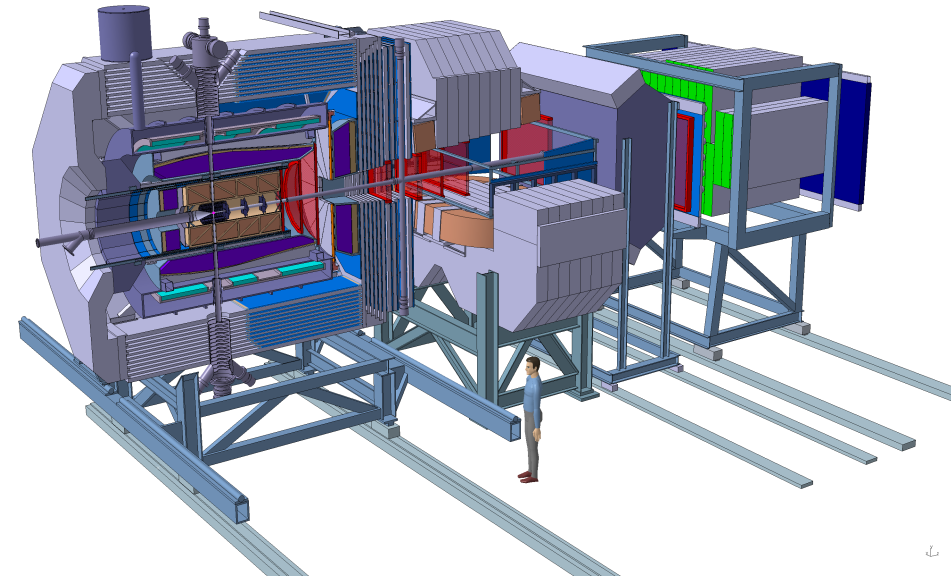
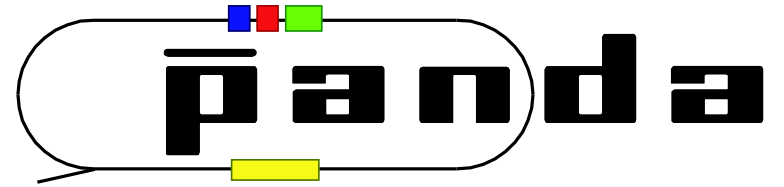
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VCI 2013

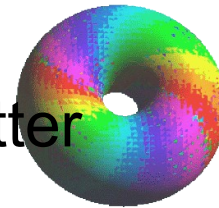
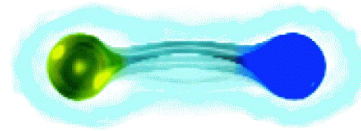
The 13<sup>th</sup> Vienna Conference on Instrumentation  
13 February 2013





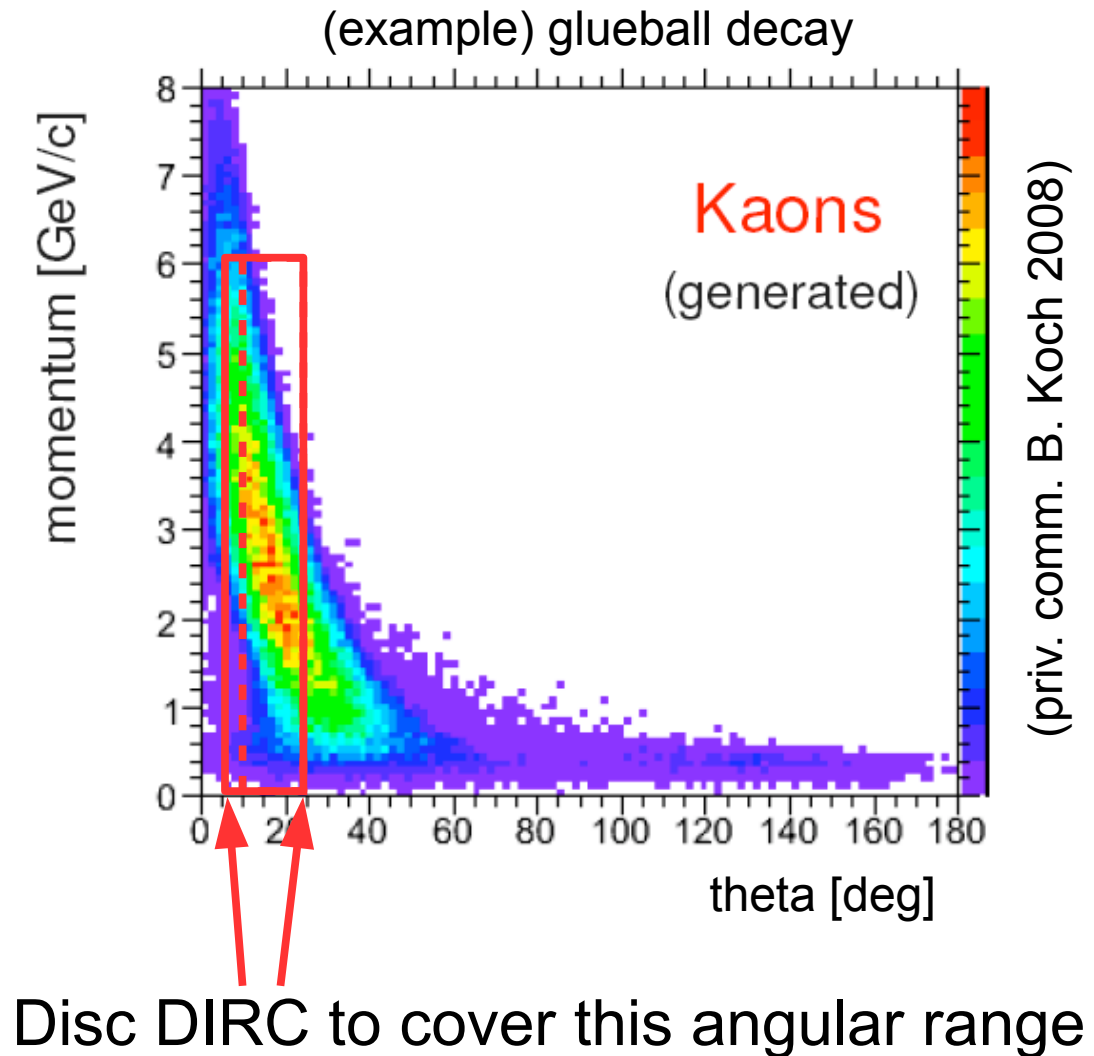
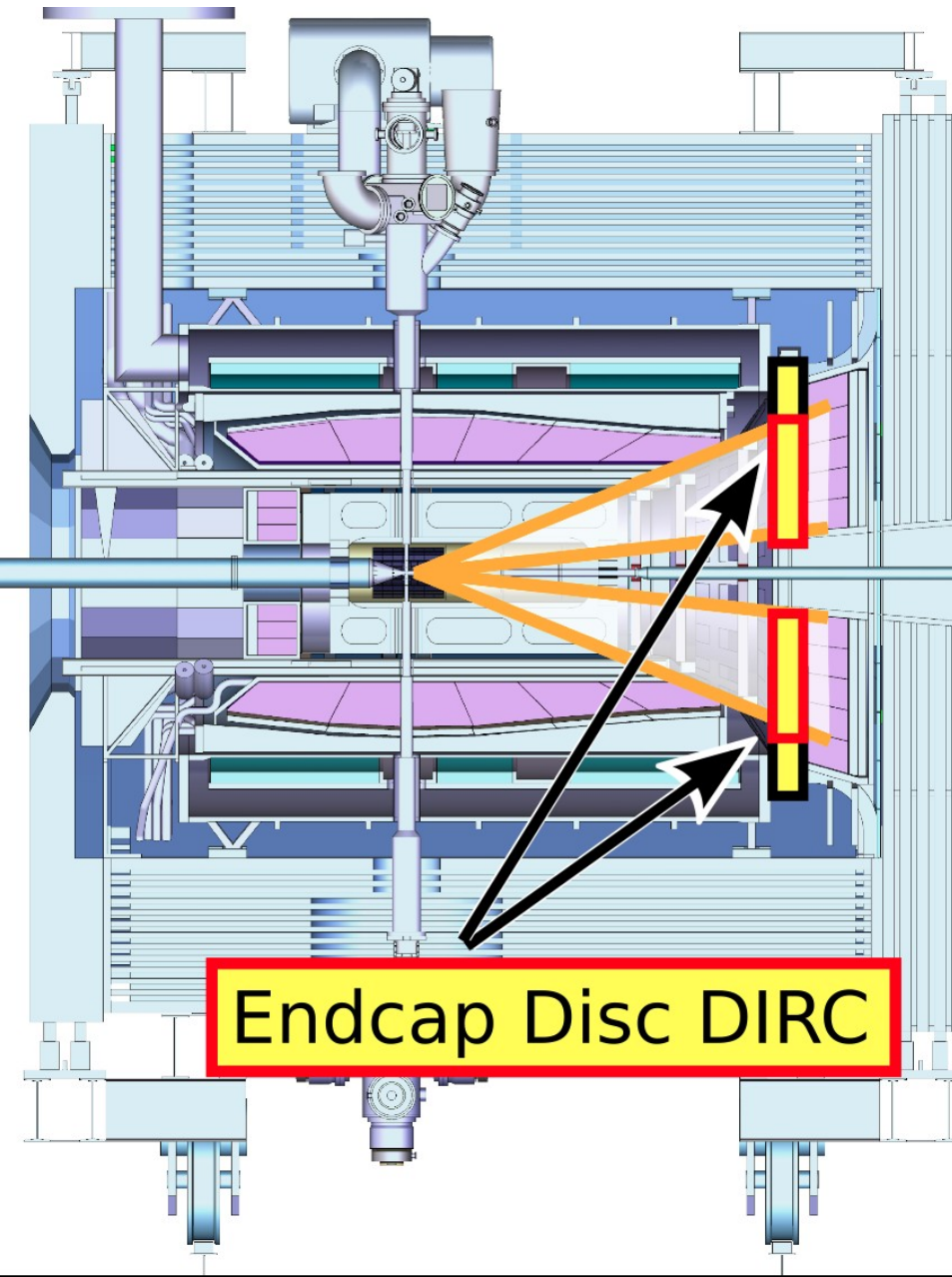


- Hadron spectroscopy
  - Charmonium spectroscopy
  - Gluonic excitations (hybrids, glueballs)
- Charmed hadrons in nuclear matter
- Double  $\Lambda$ -Hypernuclei



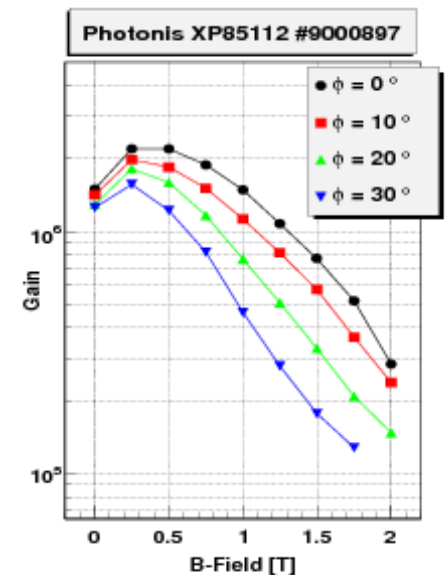
- $\bar{p}p$  interactions
- cooled beam
- $p=1.5-15\text{GeV}/c$
- high interaction rate ( $\sim 20\text{MHz}$ )

# Disc DIRC location in PANDA



# particular PANDA requirements

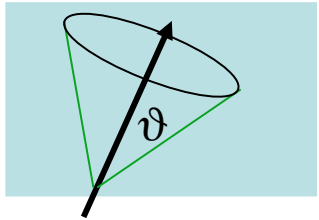
- 4 sigma pion-kaon separation up to 5 GeV/c
- tight spatial environment
- continuous beam, high interaction&data rate
- strong magnetic field B=1 to 1.5 Tesla
- high radiation levels (em, hadronic)
- high photon dose on light sensors



(a) Magnetic field dependence of the gain at 2.9kV.

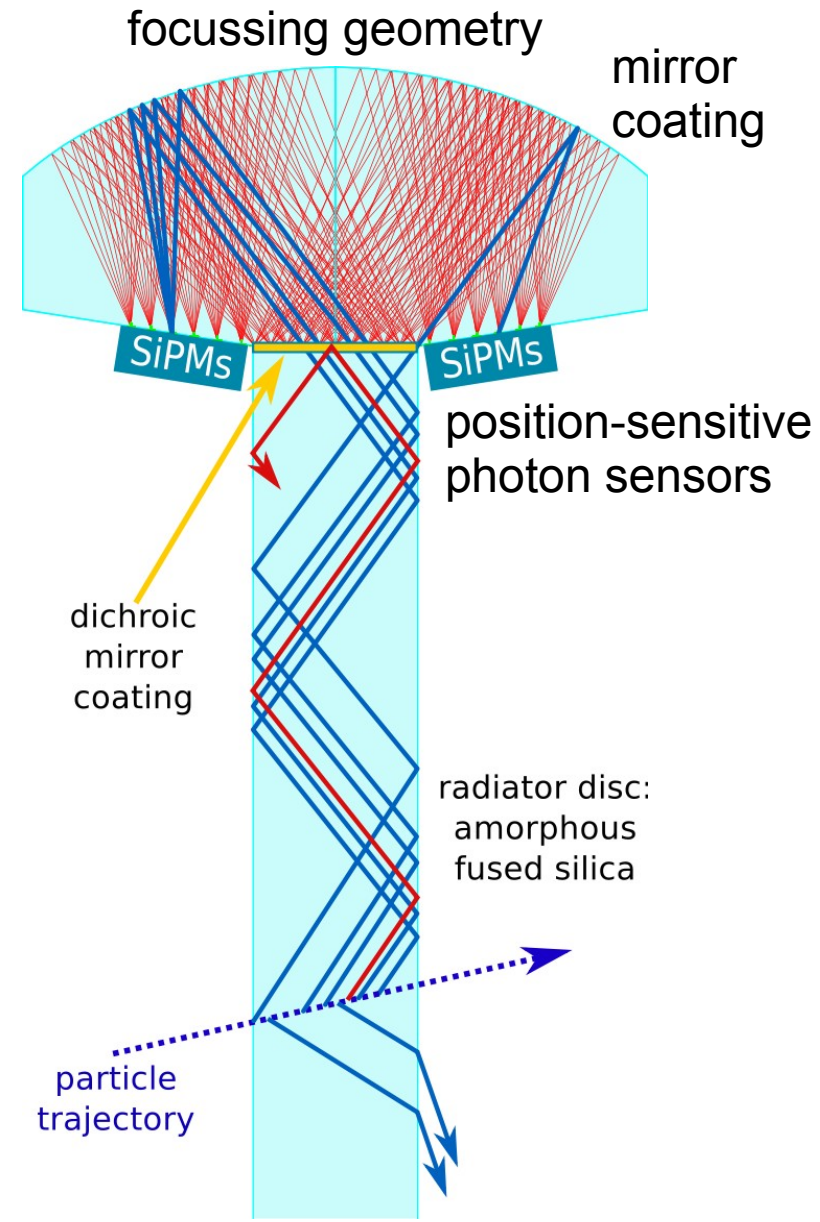
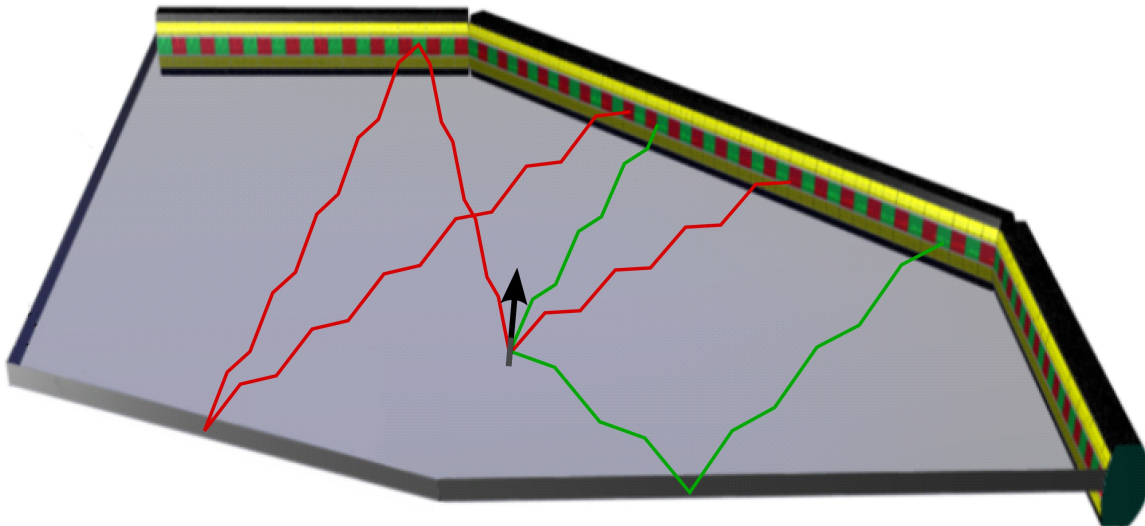


# DIRC - Detection of Internally Reflected Cherenkov light

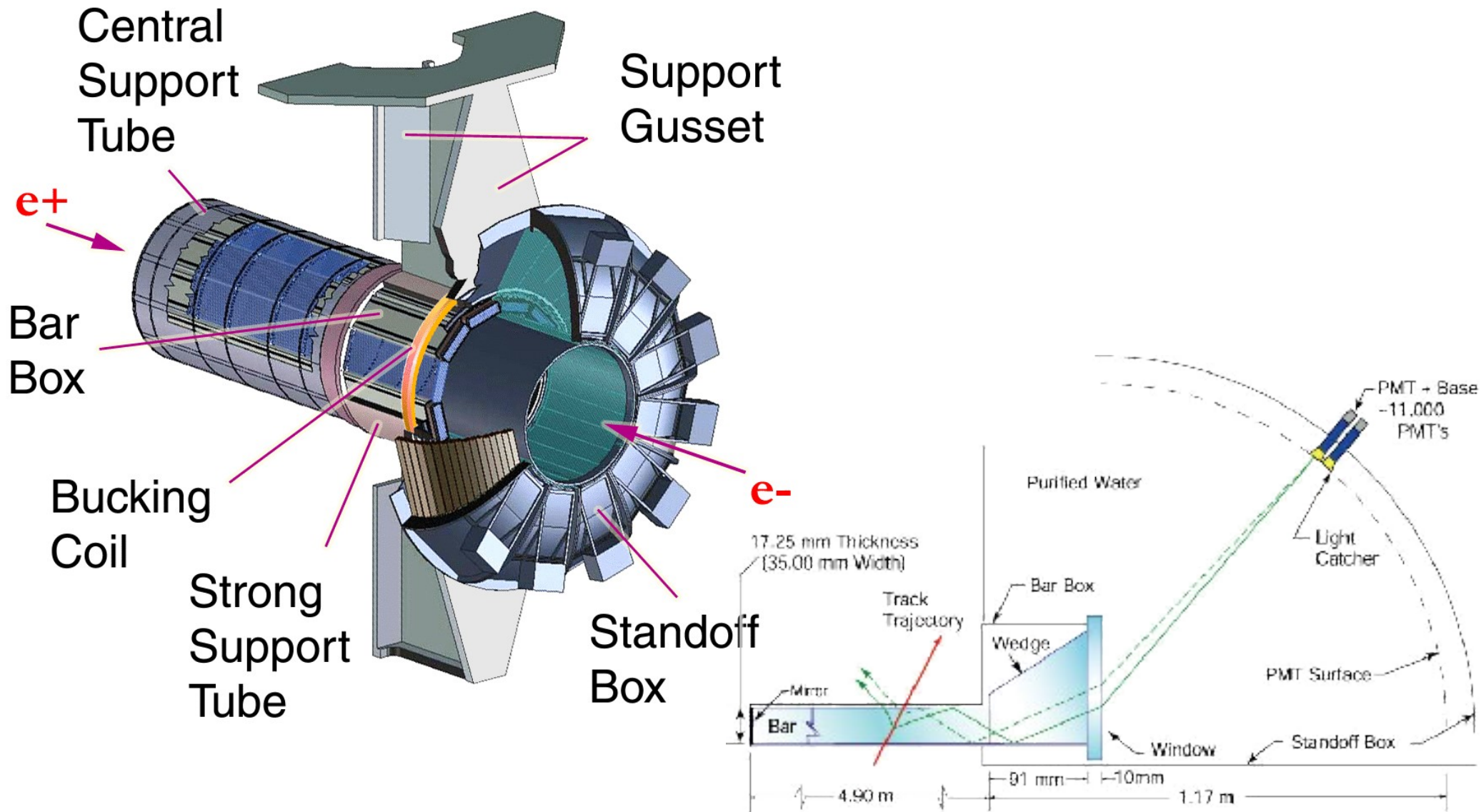


$$\cos \vartheta_C = \frac{1}{n\beta}$$

$$\frac{dN^2}{dk dx} = \alpha z^2 \sin^2 \vartheta_C$$

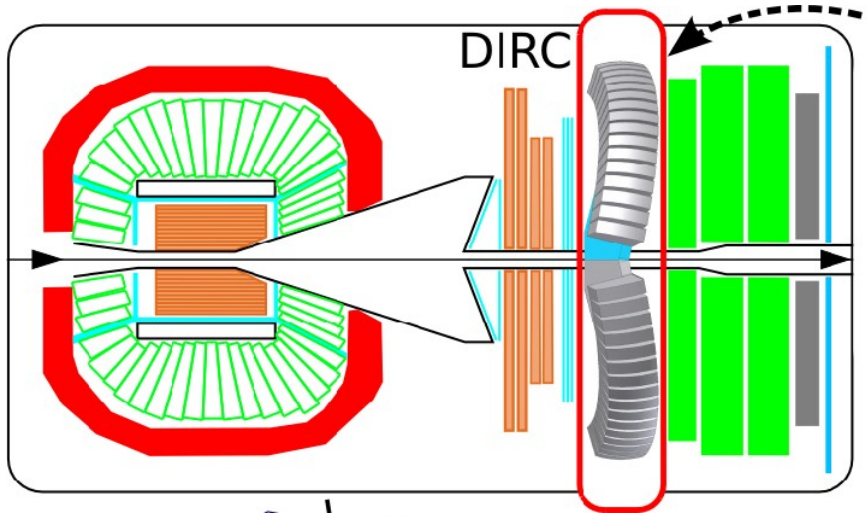


# BaBar DIRC at SLAC





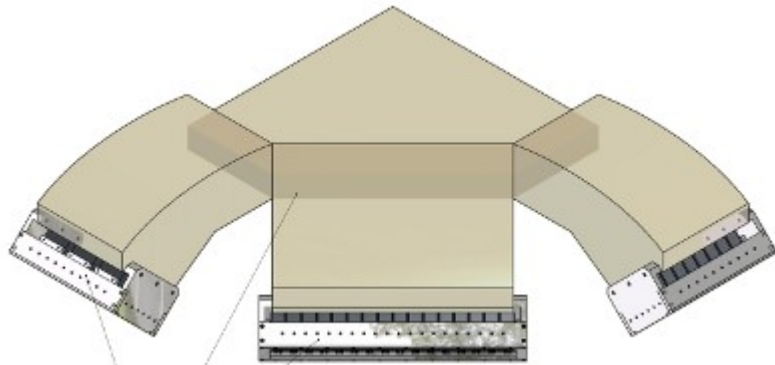
# WASA-DIRC prototype



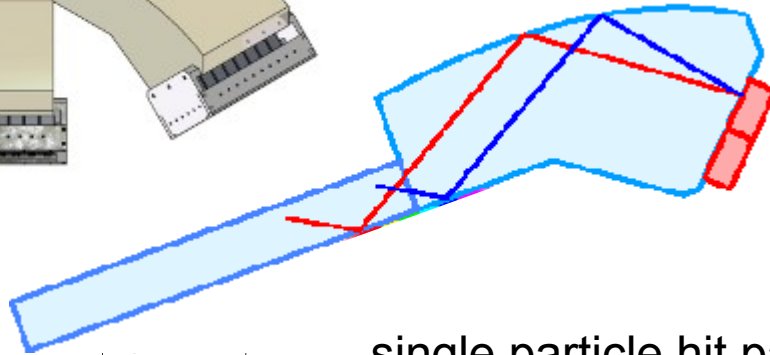
DIRC designed to enhance WASA energy resolution, measuring the velocity



November 2012 test at FZ Jülich

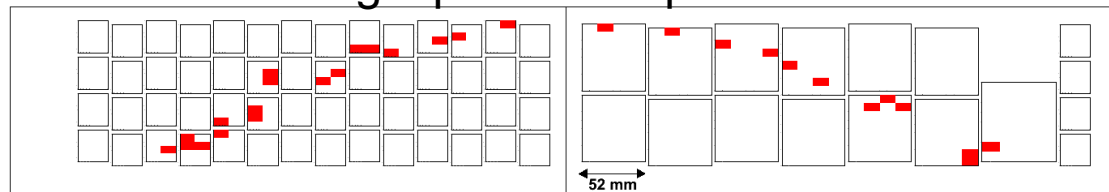


plexiglas radiator & optical elements



single particle hit pattern

Erlangen prototype

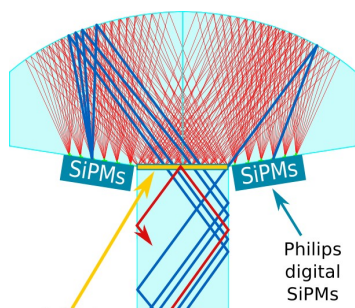
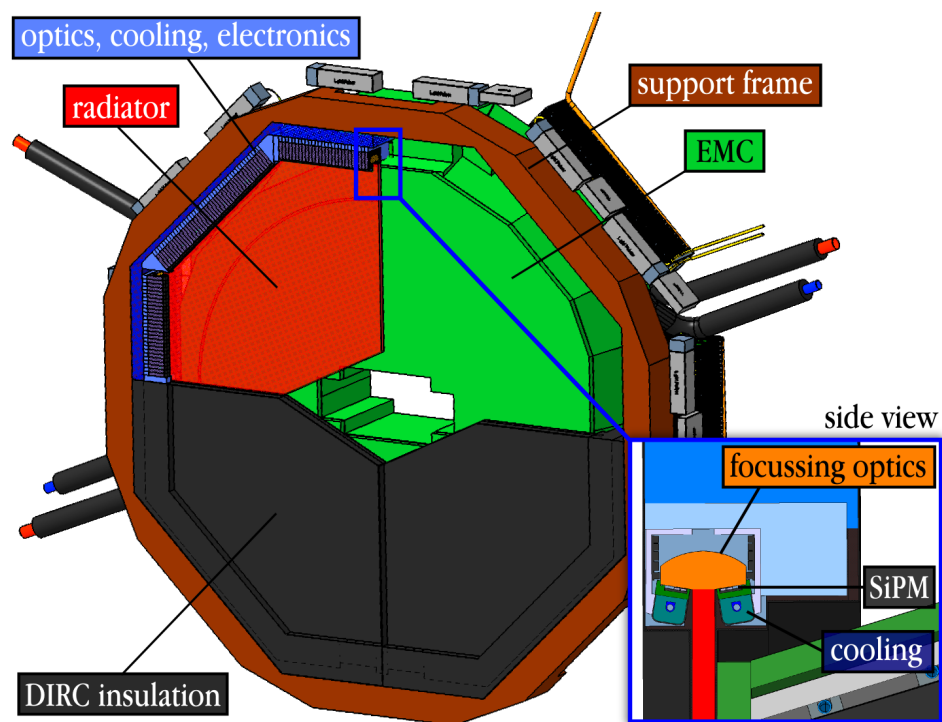


PhD thesis  
Adrian Schmidt  
Uni Erlangen

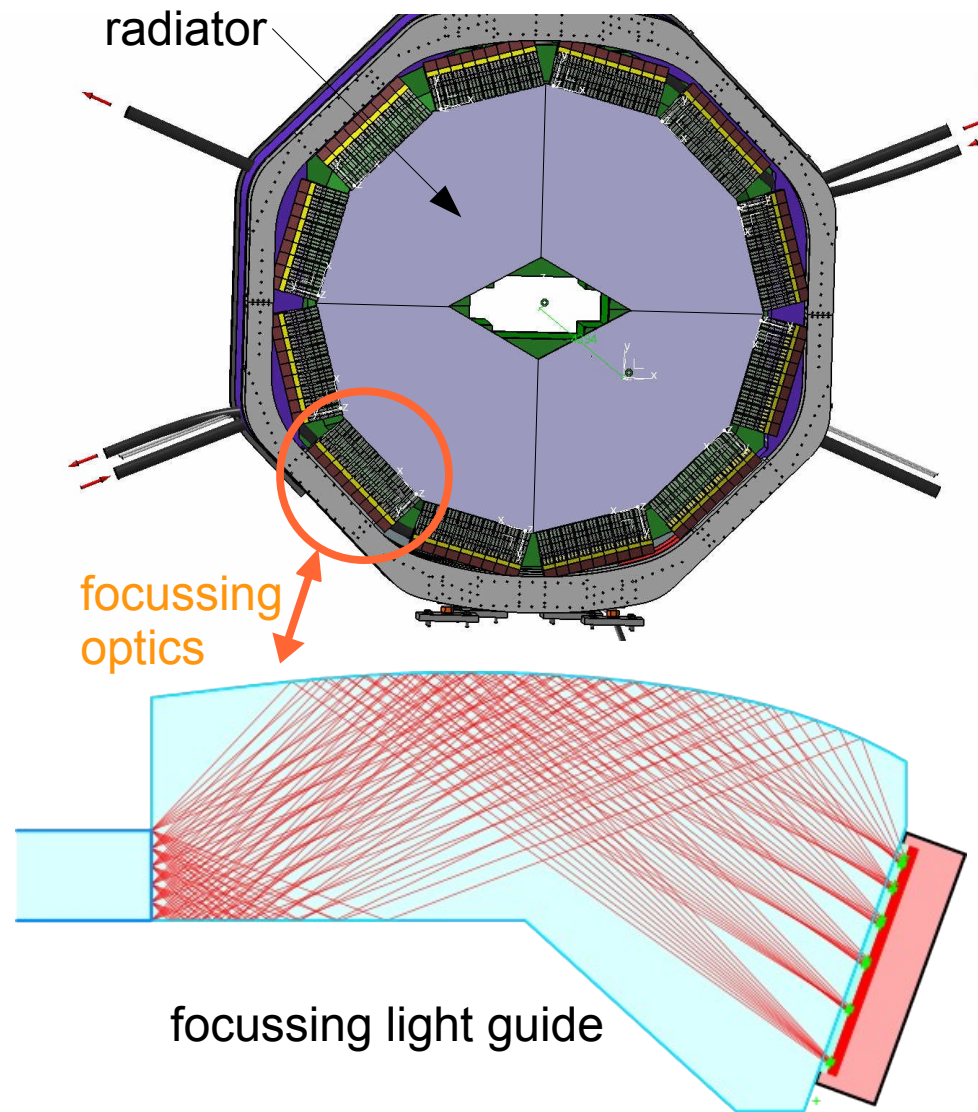


# PANDA 3D Disc DIRC

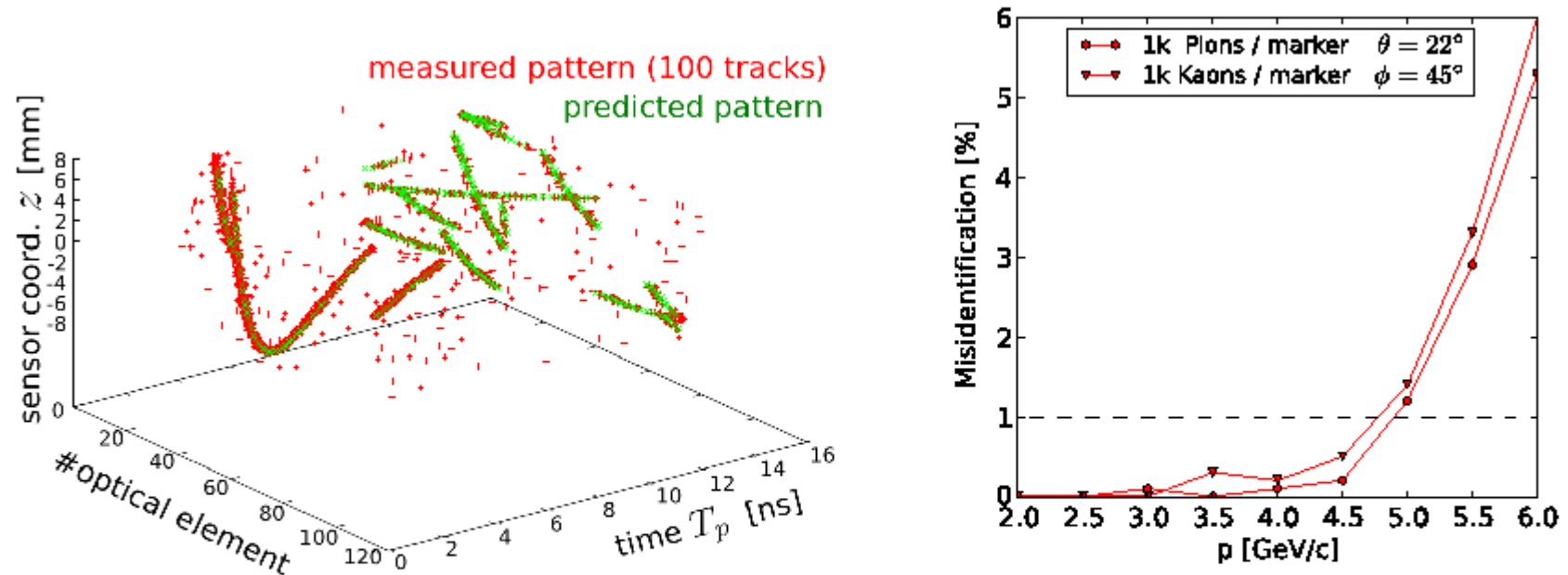
## dSiPM option



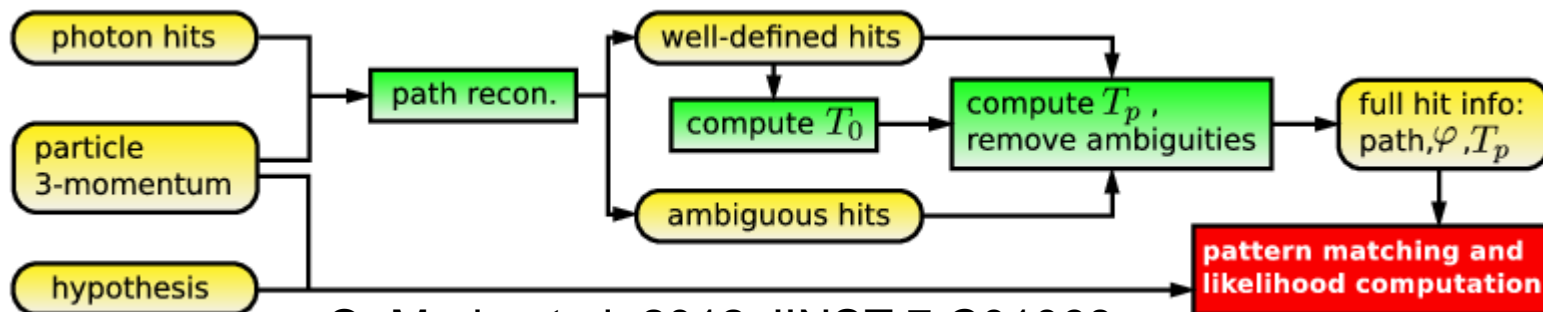
## MCP-PMT option



# Simulations and Analysis



**Figure 4:** Left: Photon hit-pattern generated by means of a Geant4 simulation (red), and the corresponding hypothesis computed by the described reconstruction approach (green). Right: Misidentification obtained by reconstructing 1000 pions/kaons at different momenta but equal direction.



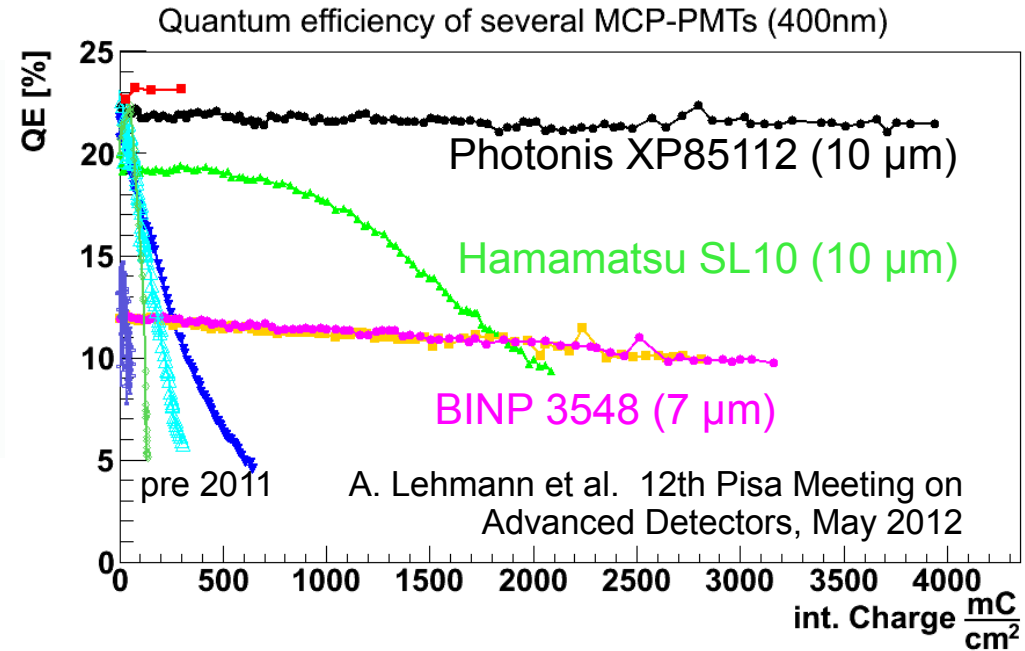
# The 3D-Disc-DIRC needs non-off-the-shelf items

- synthetic amorphous fused silica material
  - i.e. controlled OH impurities levels
- highly polished Cherenkov radiator plate
  - to be polished on all faces
- aspheric (acylindric) focussing elements (FLGs)
- dispersion “correction” components
- newly developed single photon sensors
  - dedicated R&D efforts for years
  - several strands of sensor technologies

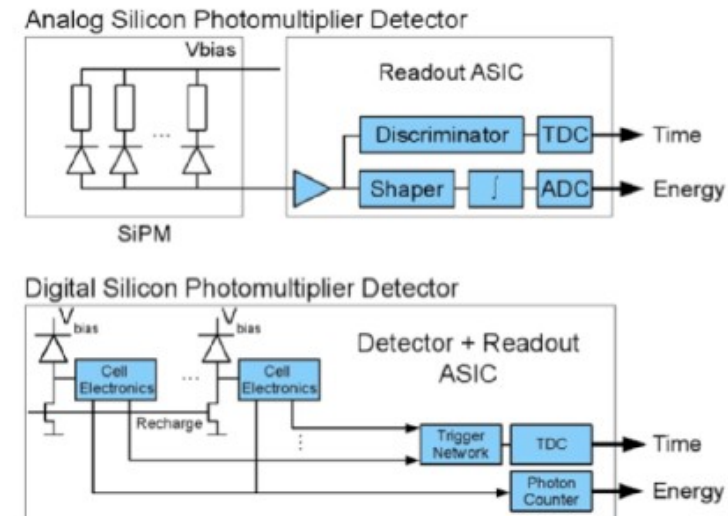
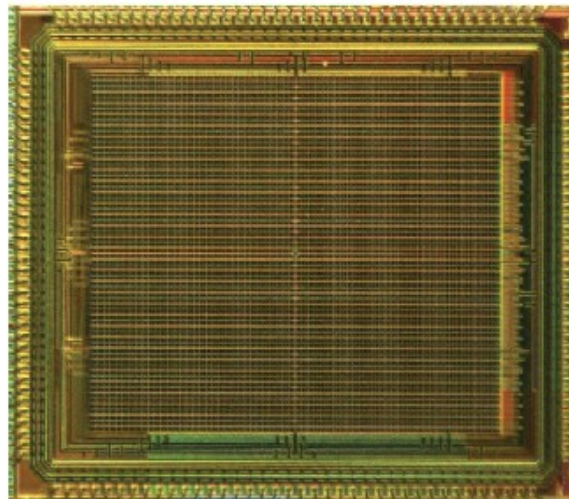


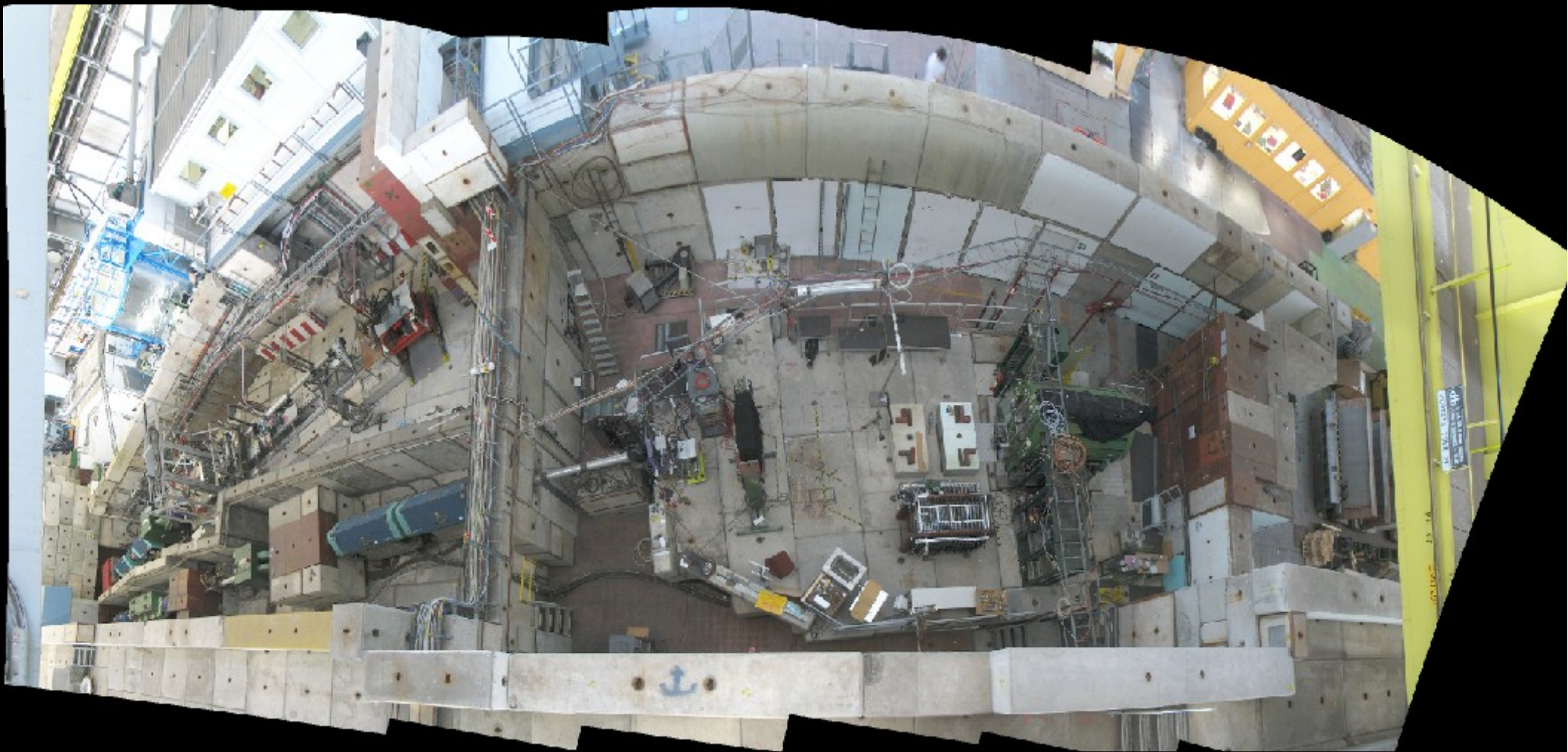
# Candidate photon sensors

- MCP-PMT
  - cumulative photon dose



- dSiPM
  - radiation hardness



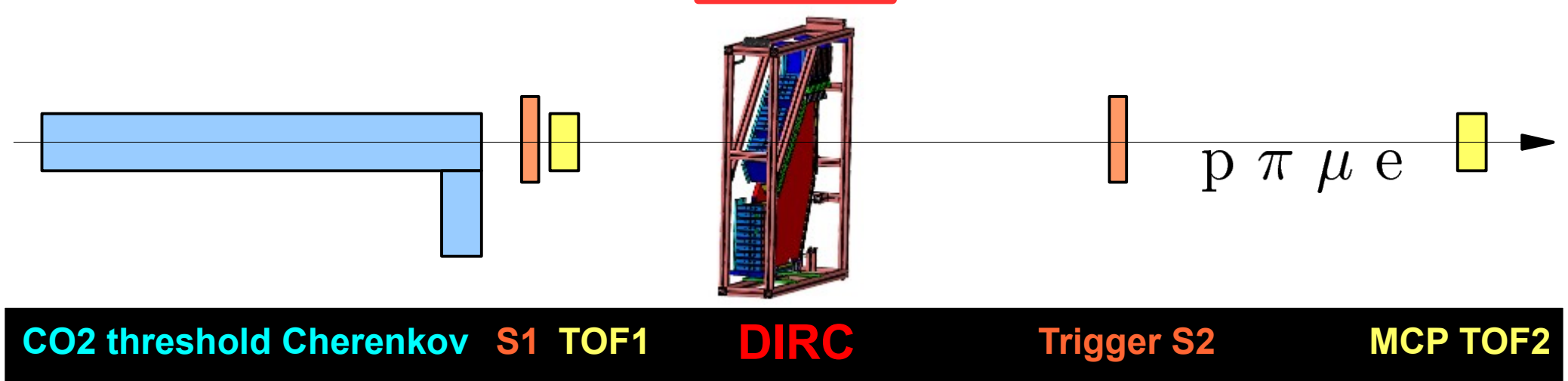
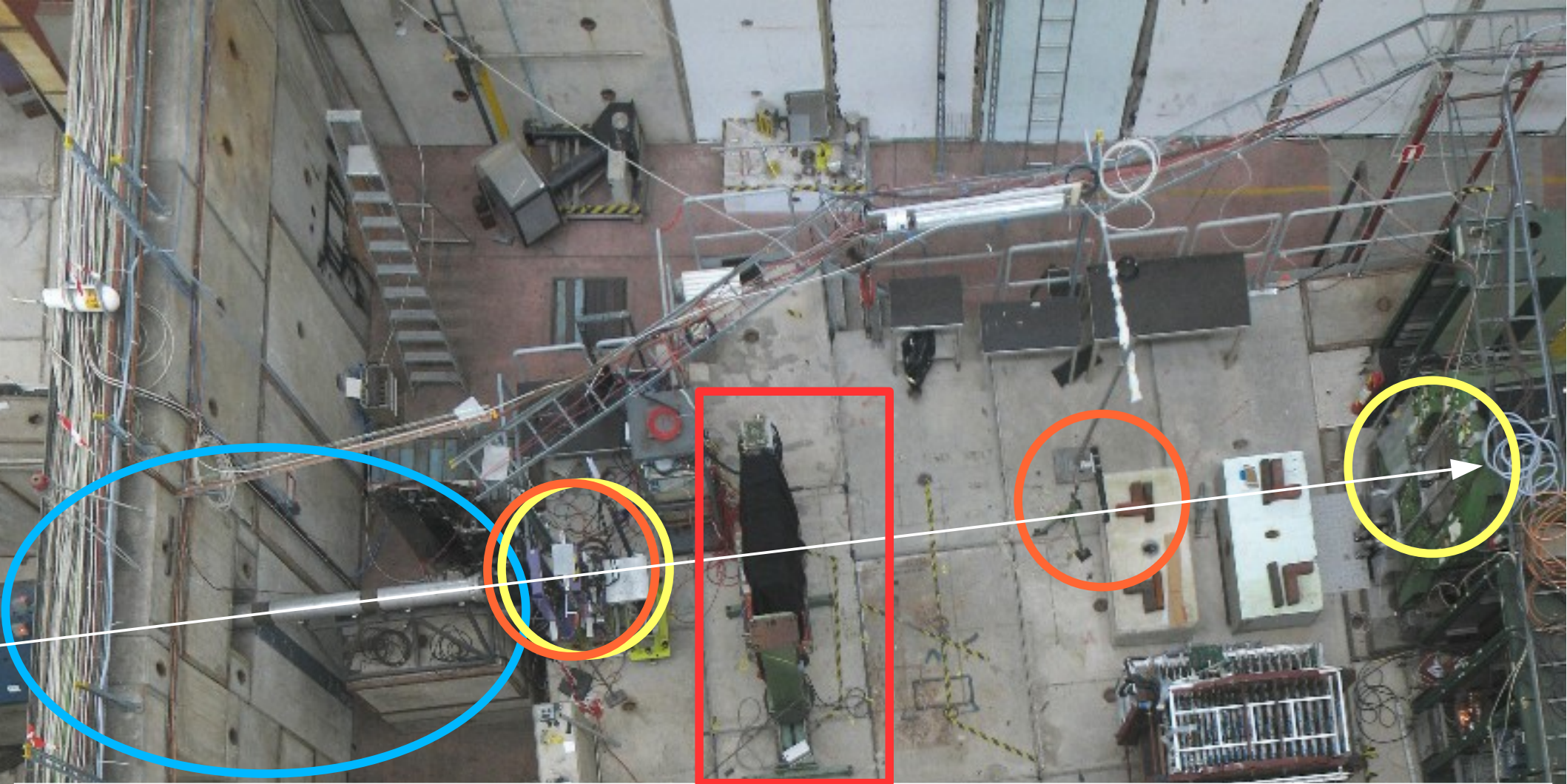


PS-T9 Area    East Hall CERN     $p=3.5\text{GeV}/c$



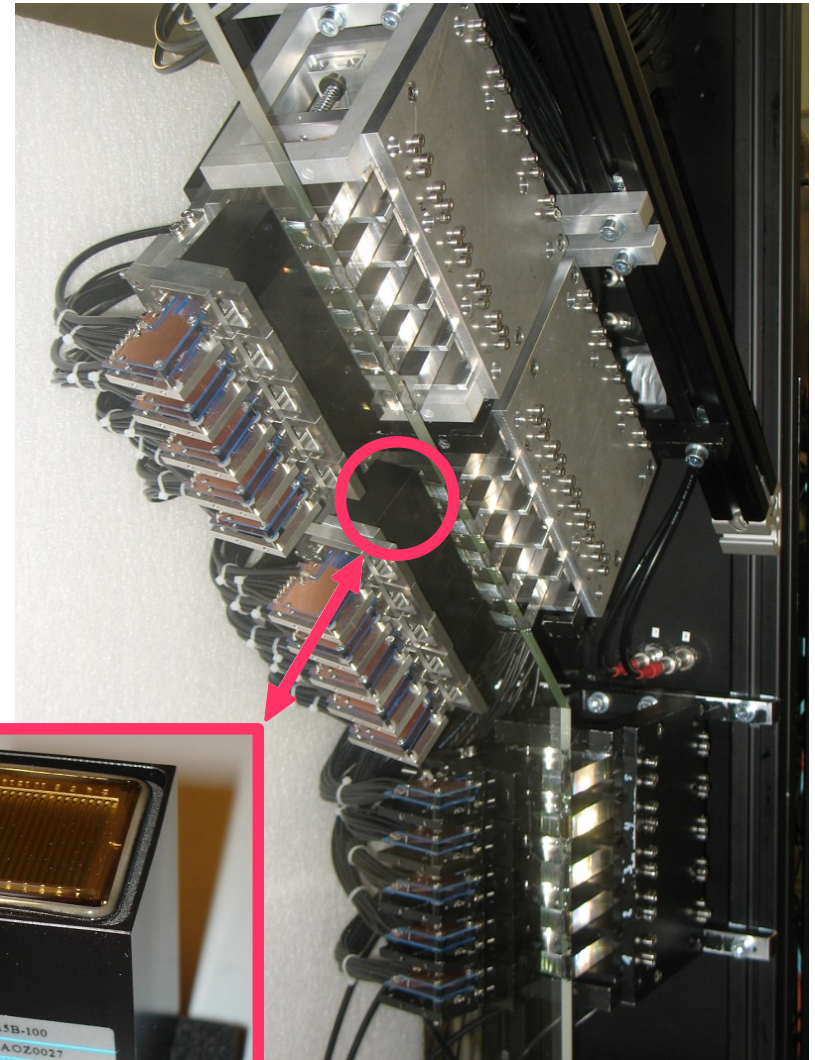
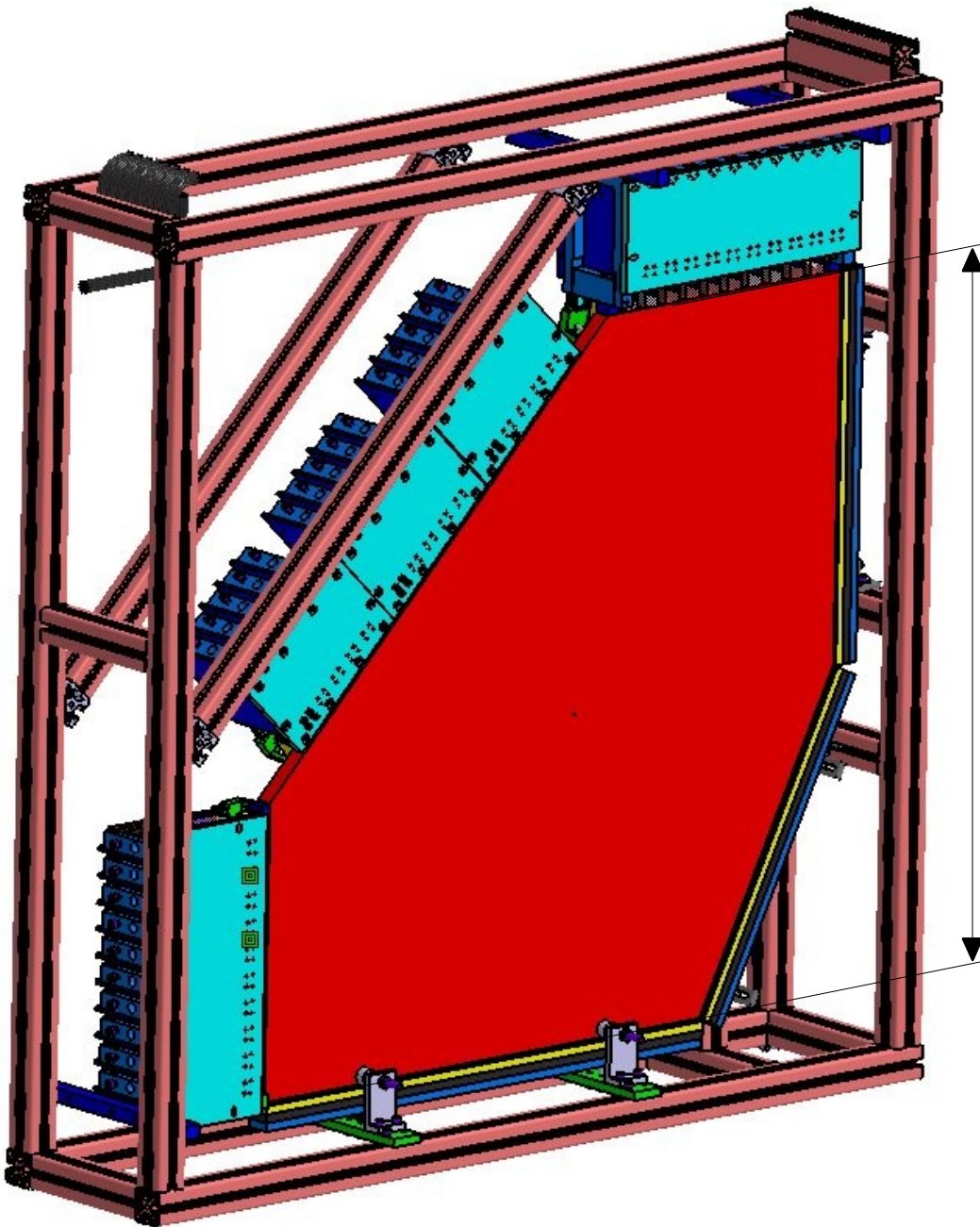








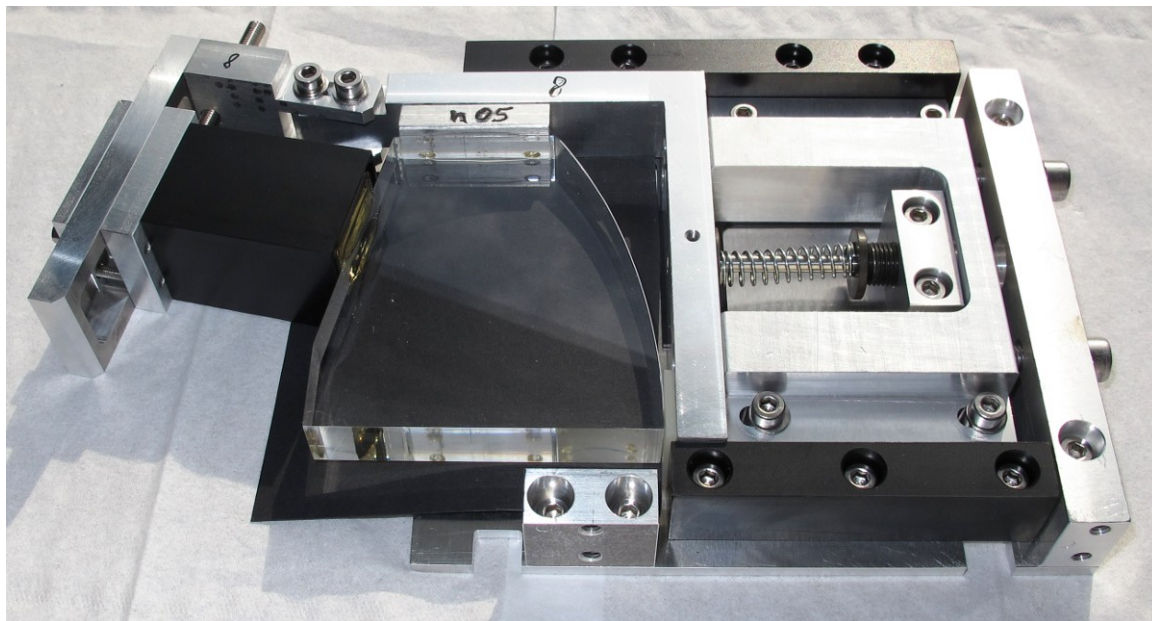
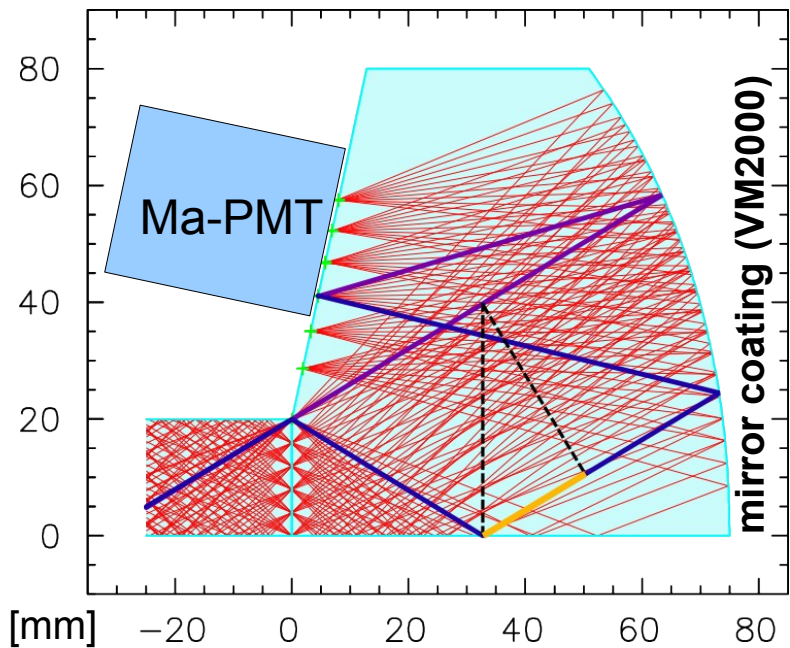
# 2012 Prototype 80% scale



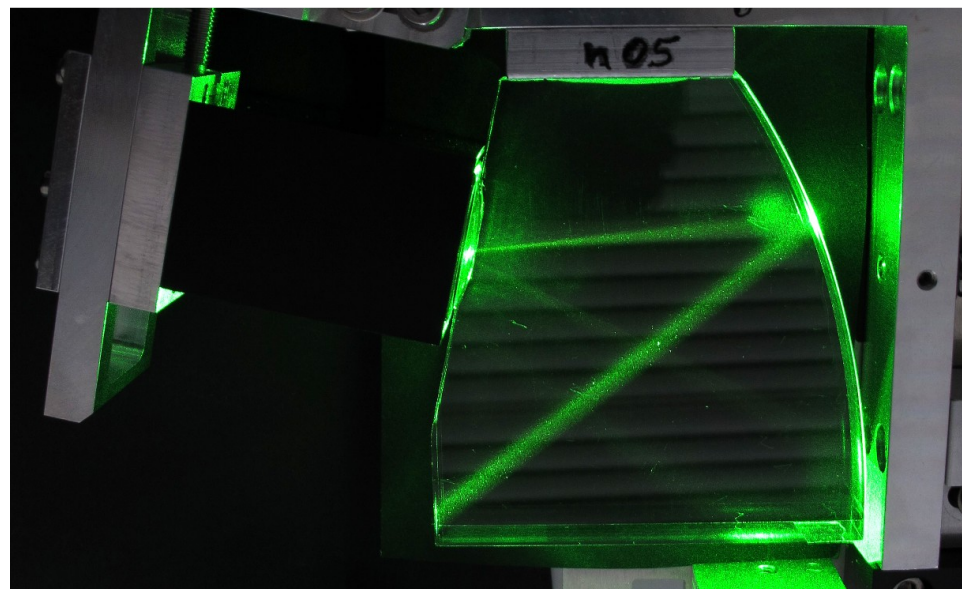
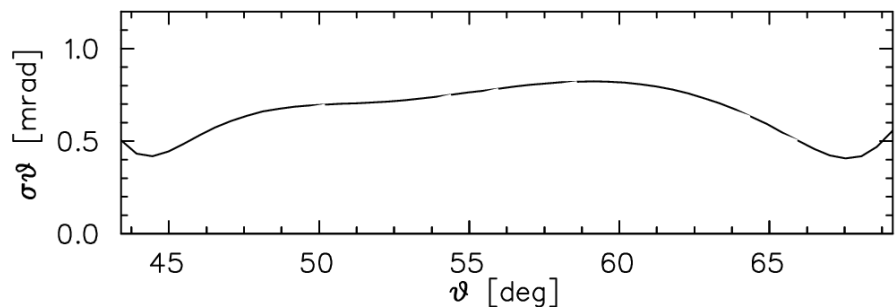
16x1 MaPMT



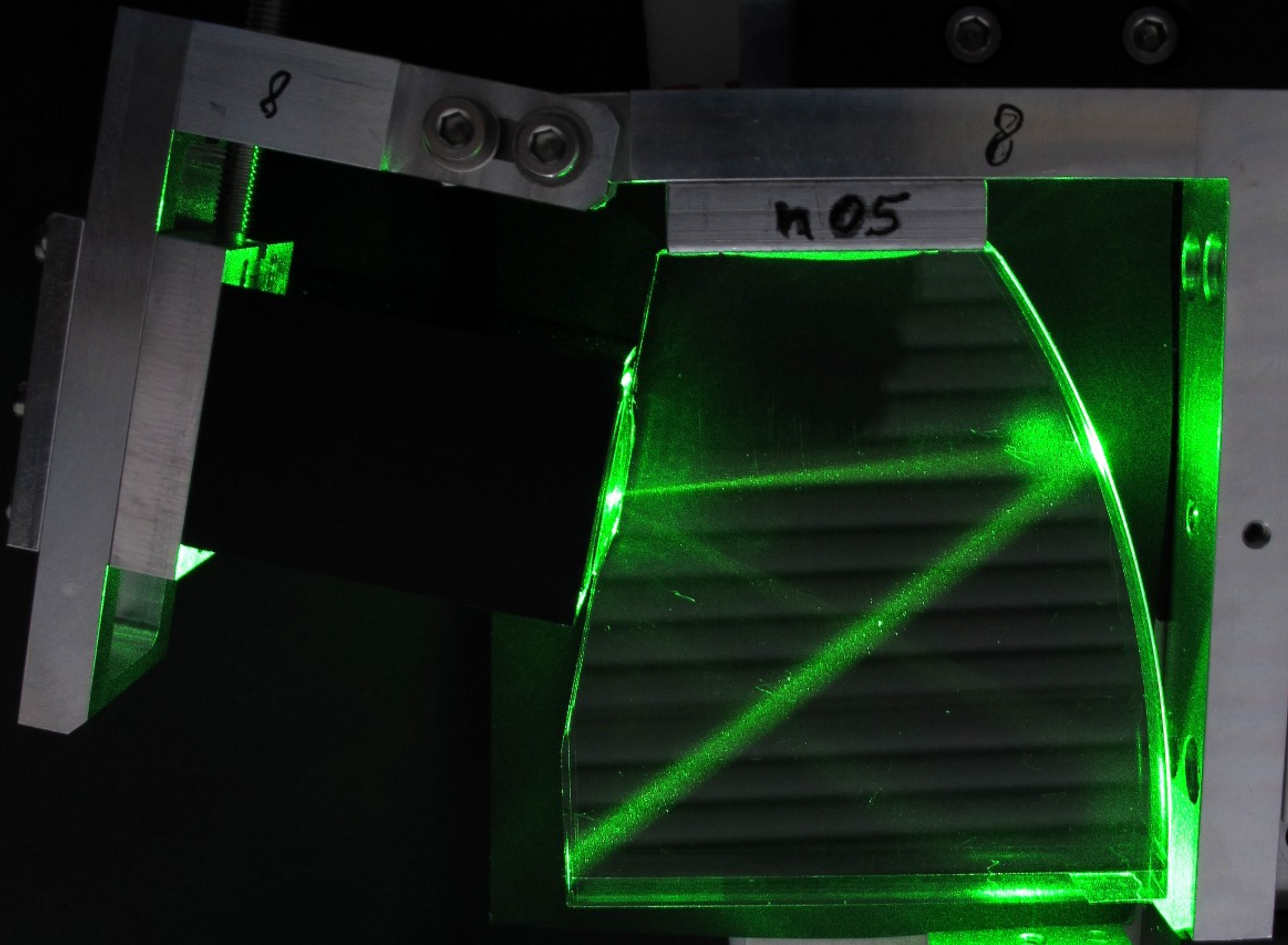
# Focussing Light Guide & Sensor



acylindrical (cylindrical aspheric) curvature





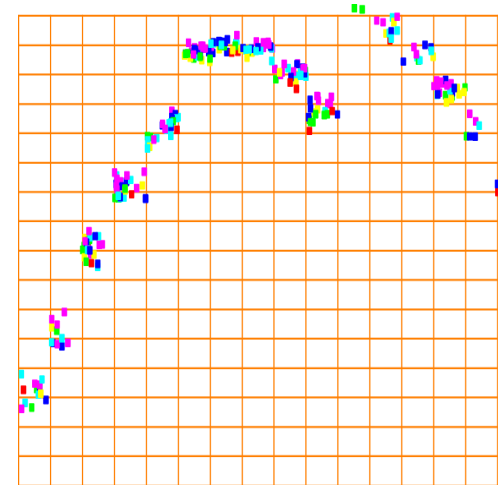
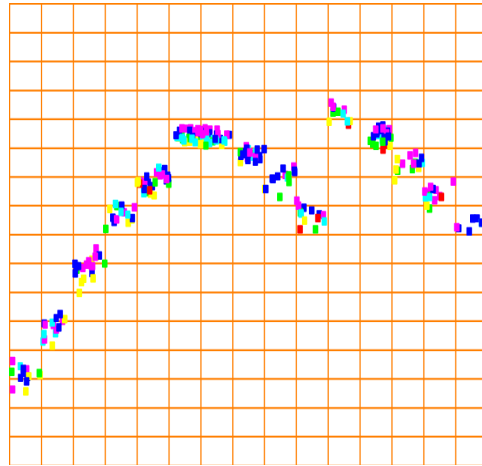


8

8

n05

# Expected hit patterns

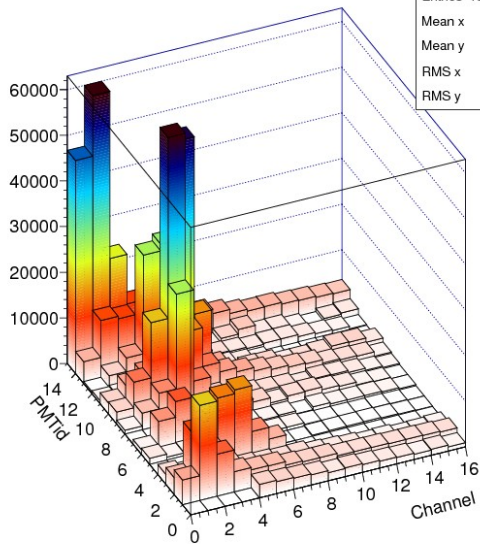


x=500mm  
y=341mm

+4 deg

Hitmap

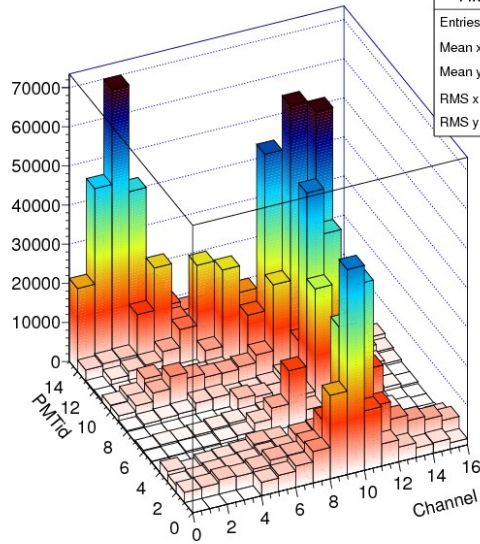
Hitmap	
Entries	1052386
Mean x	4.245
Mean y	9.184
RMS x	3.502
RMS y	4.224



-4 deg

Hitmap

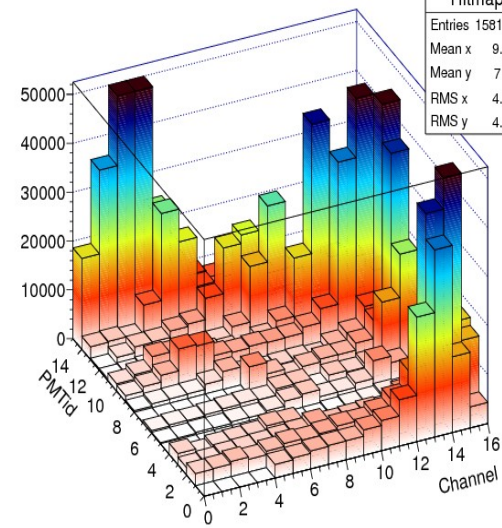
Hitmap	
Entries	1714071
Mean x	7.841
Mean y	7.821
RMS x	3.585
RMS y	4.633



-8 deg

Hitmap

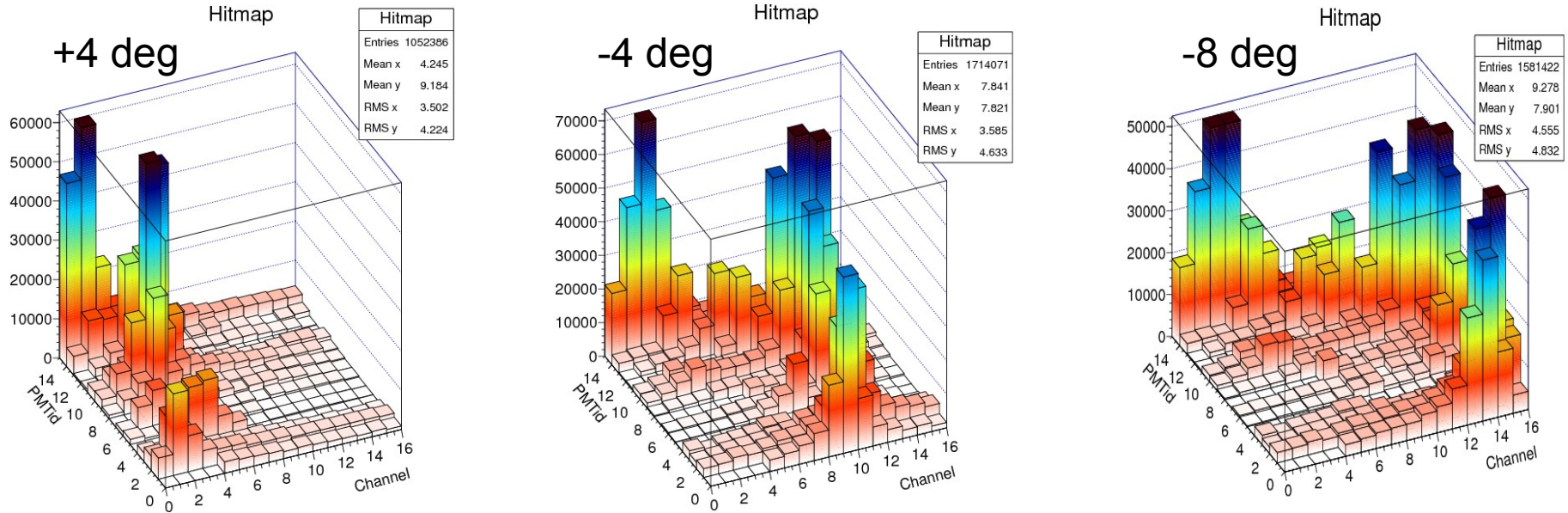
Hitmap	
Entries	1581422
Mean x	9.278
Mean y	7.901
RMS x	4.555
RMS y	4.832



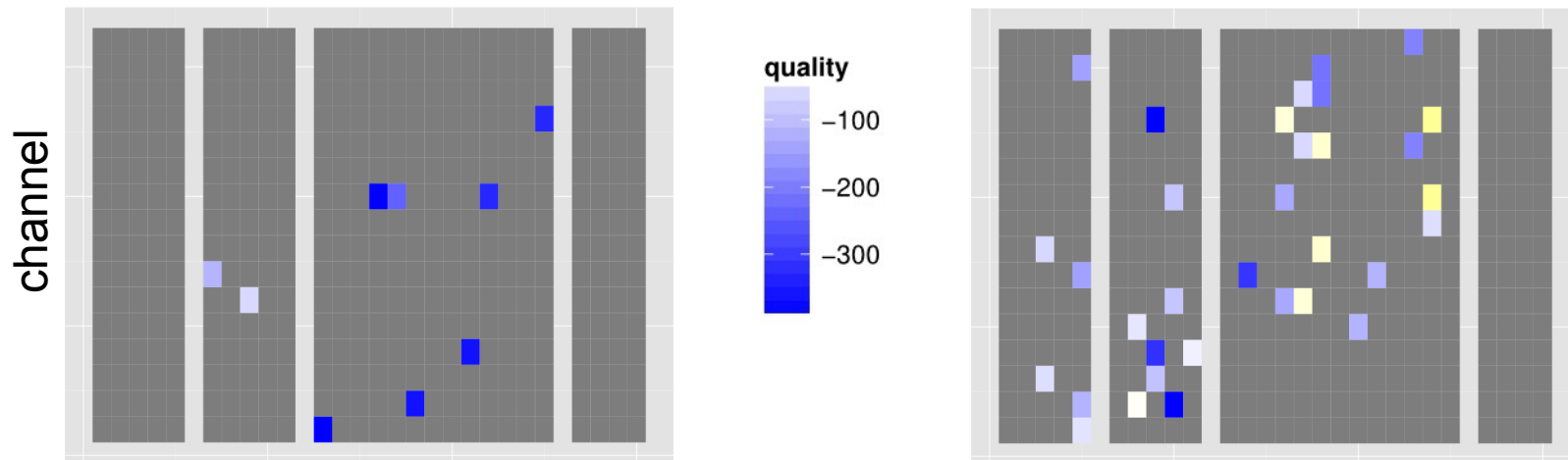
DESY June 2012 cumulative electron hit patterns



# Real hit patterns



DESY June 2012 cumulative electron hit patterns

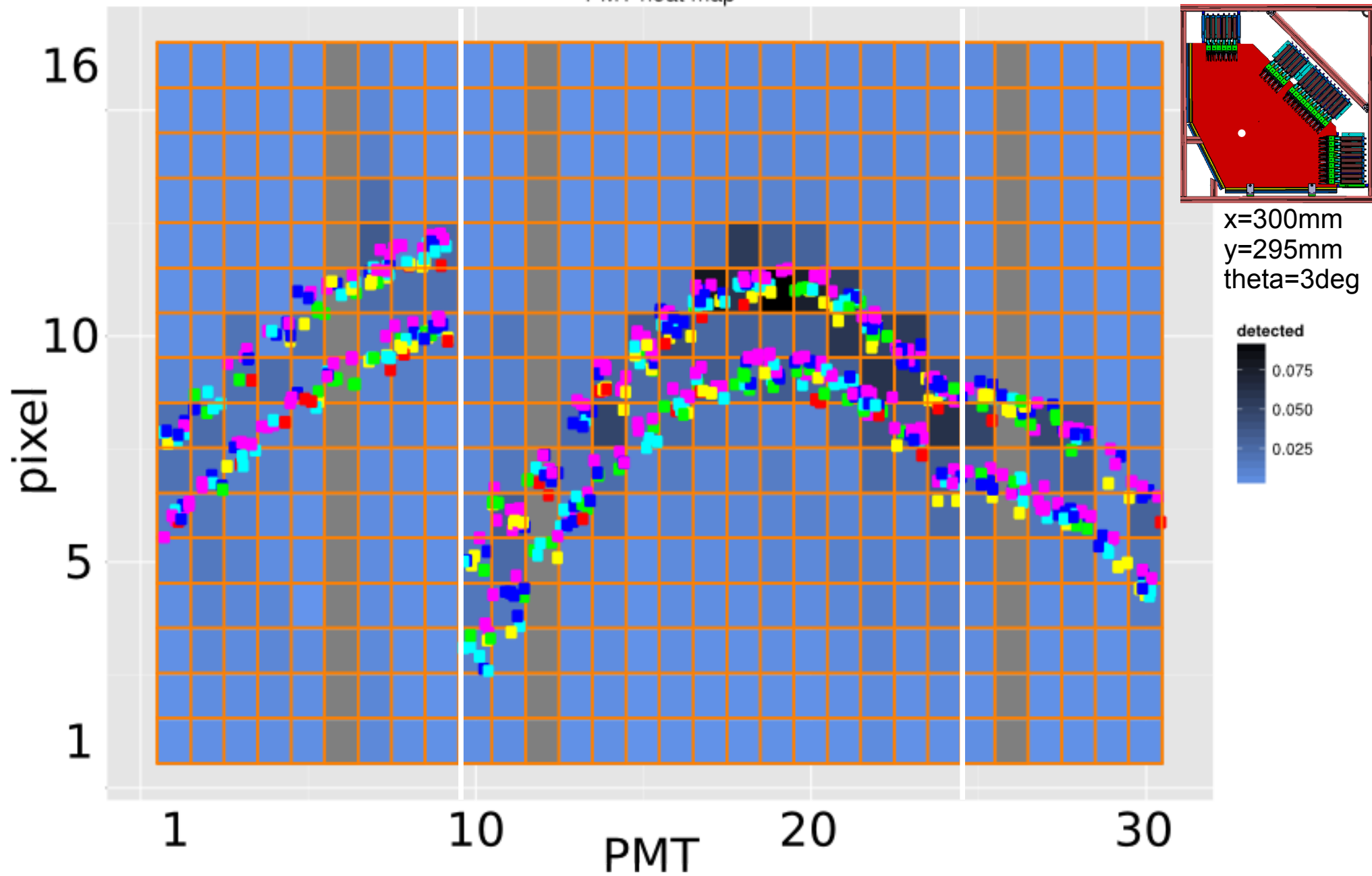


CERN October 2012 single particle hit patterns

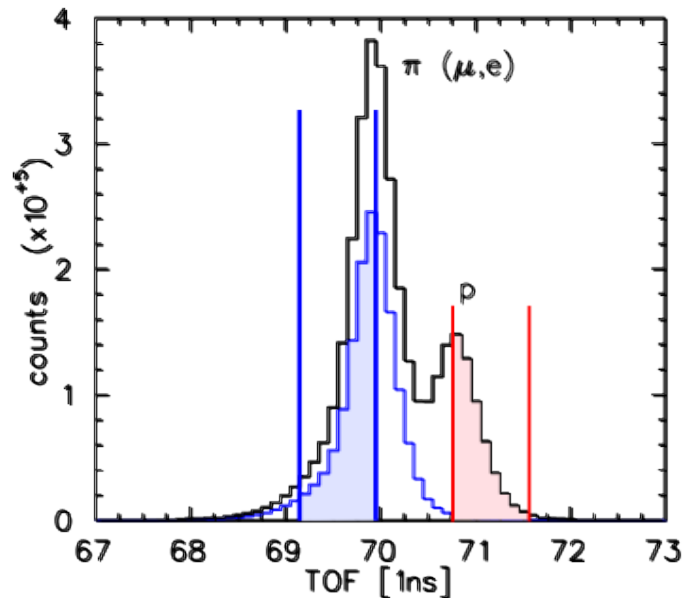
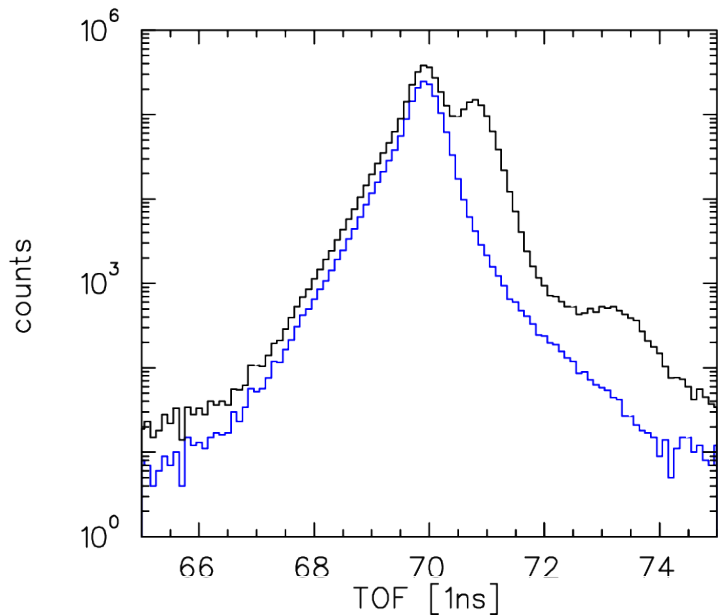




PMT heat map



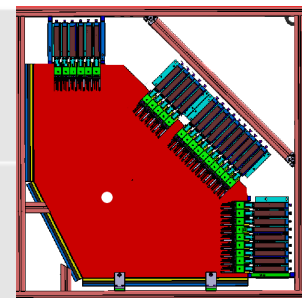
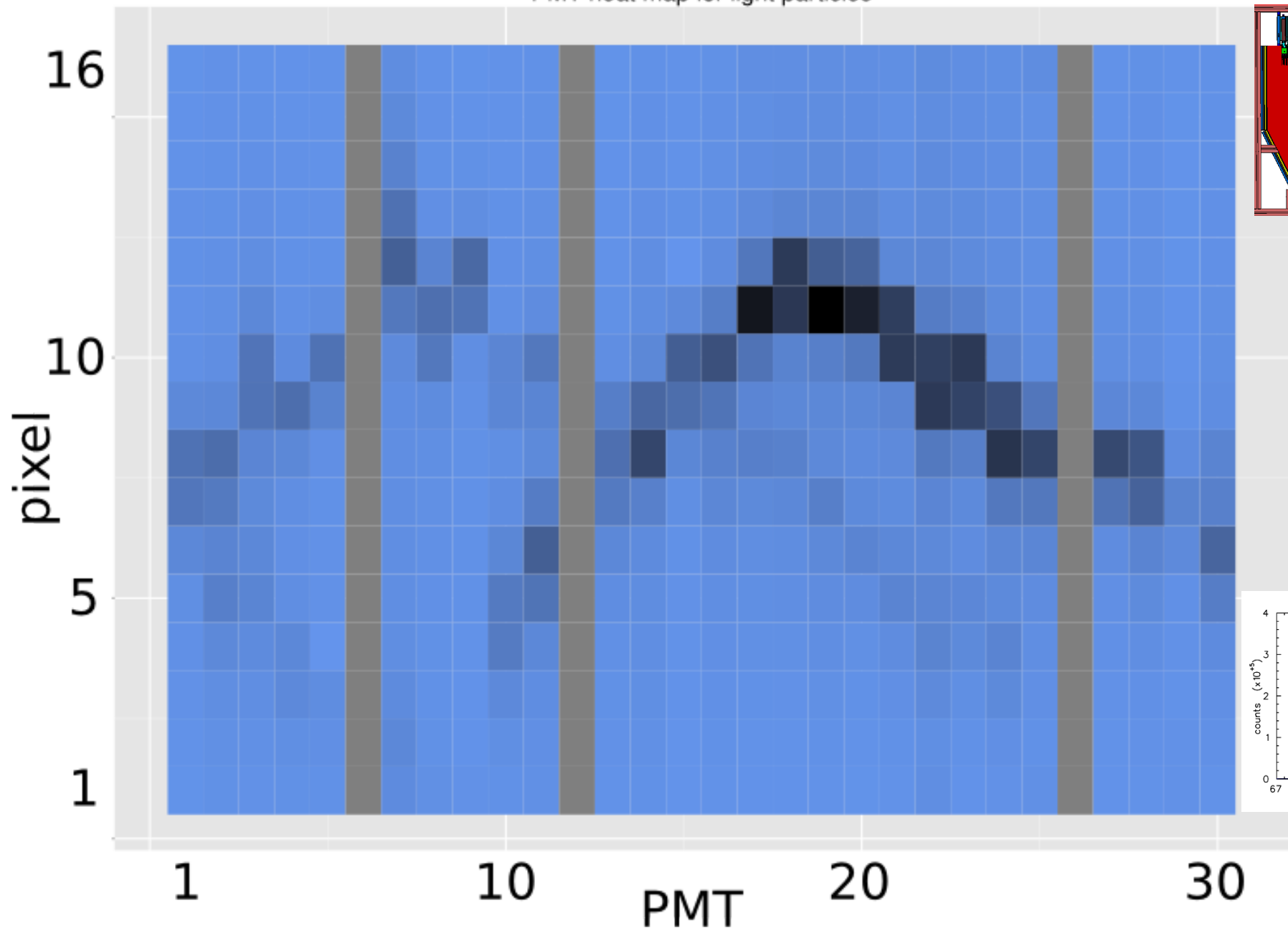
# TOF and threshold Cherenkov



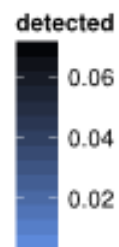
- 7m TOF distance with start/stop MCP-PMTs (time resolution  $\sim 200$ ps)
- $\text{CO}_2$  Cherenkov counter additionally providing positive ID for  $\pi, \mu, e$
- tight cuts chosen



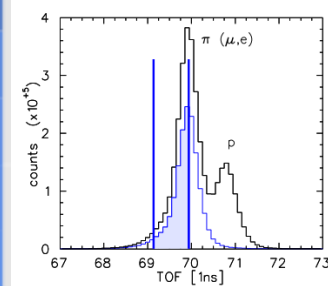
PMT heat map for light particles



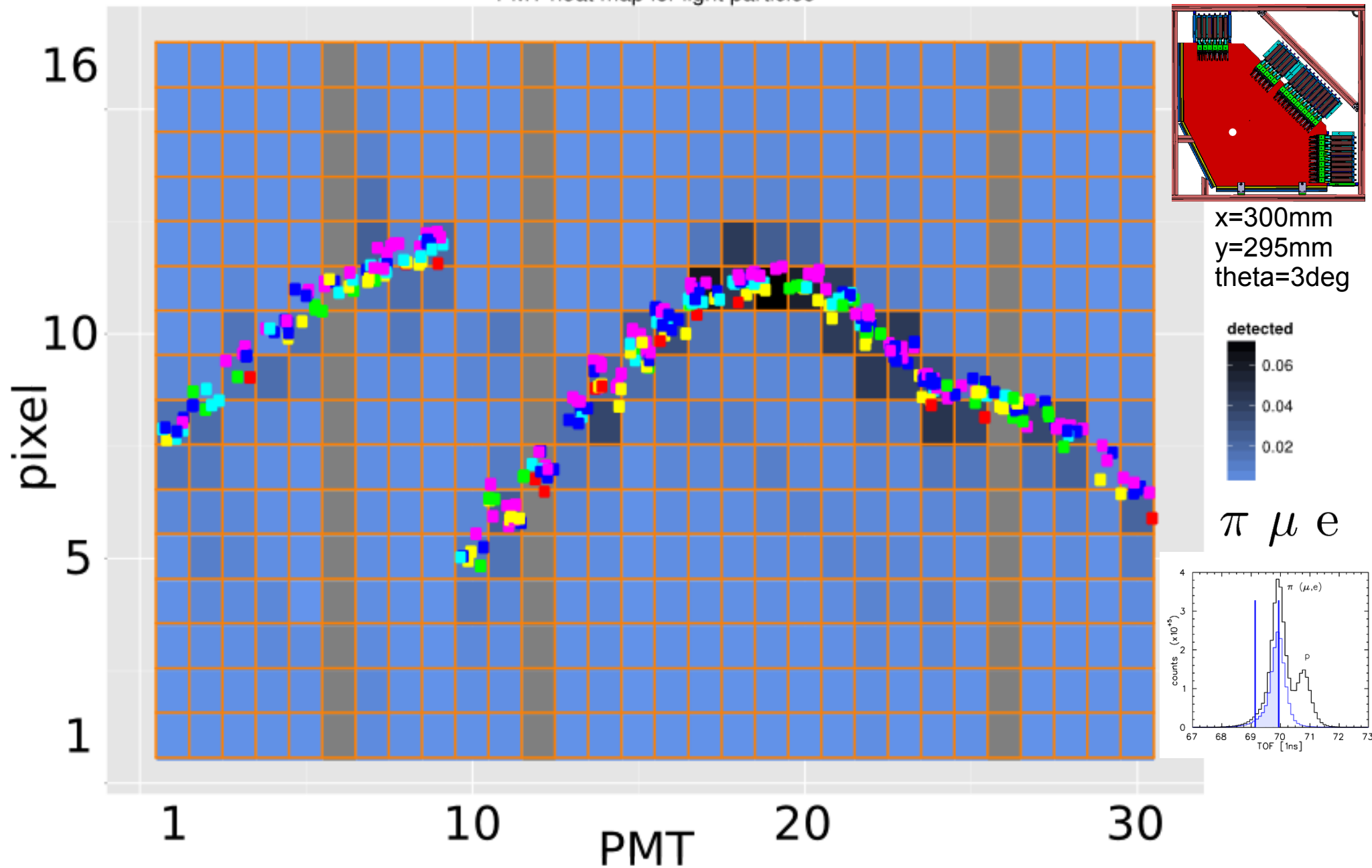
$x=300\text{mm}$   
 $y=295\text{mm}$   
 $\theta=3\text{deg}$



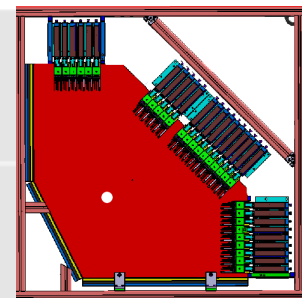
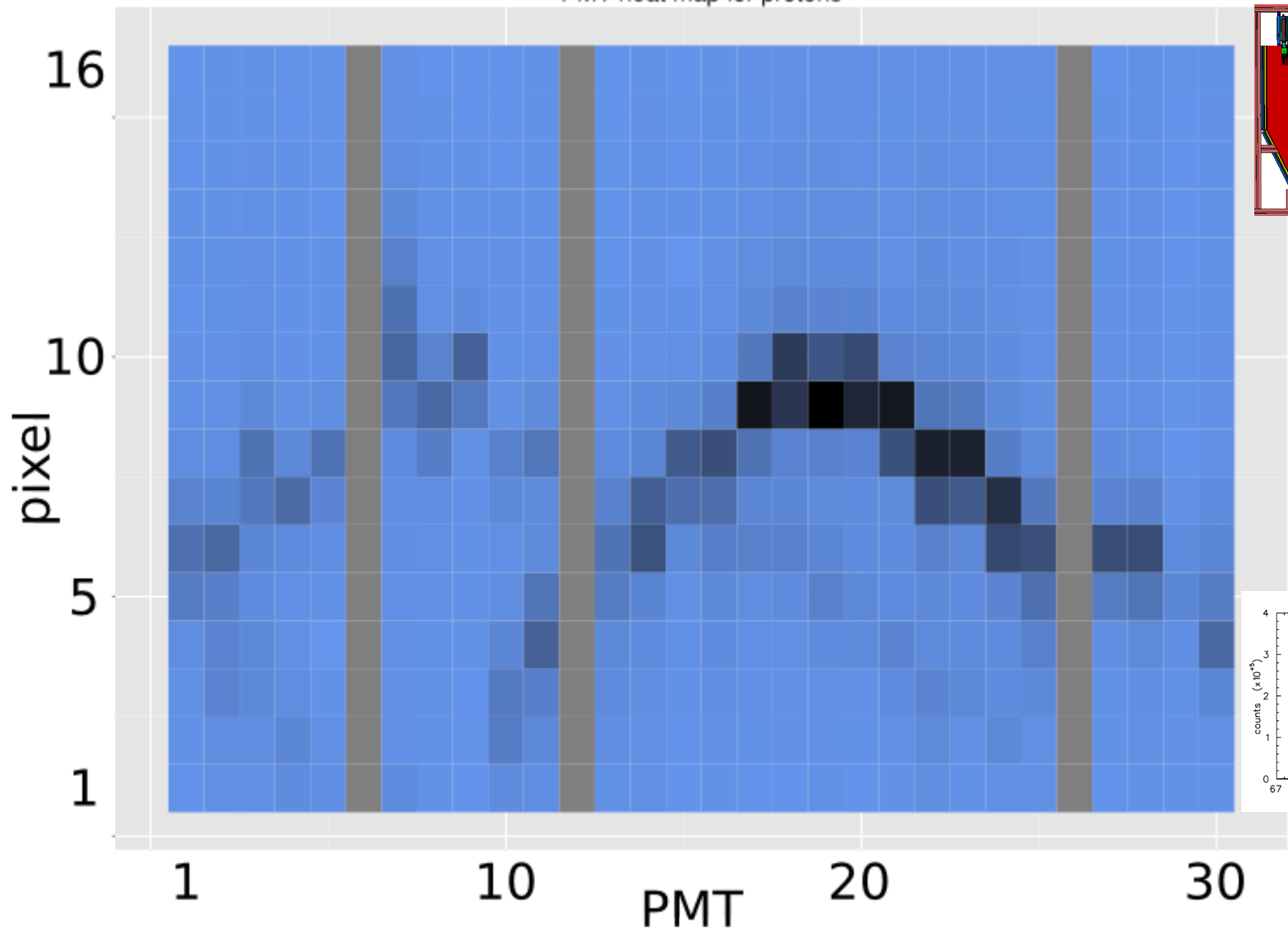
$\pi \mu e$



PMT heat map for light particles

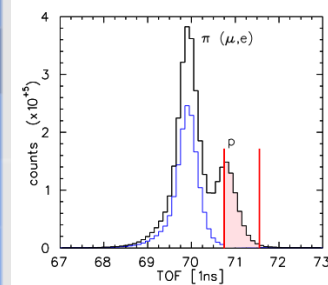


PMT heat map for protons



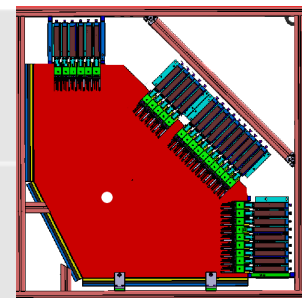
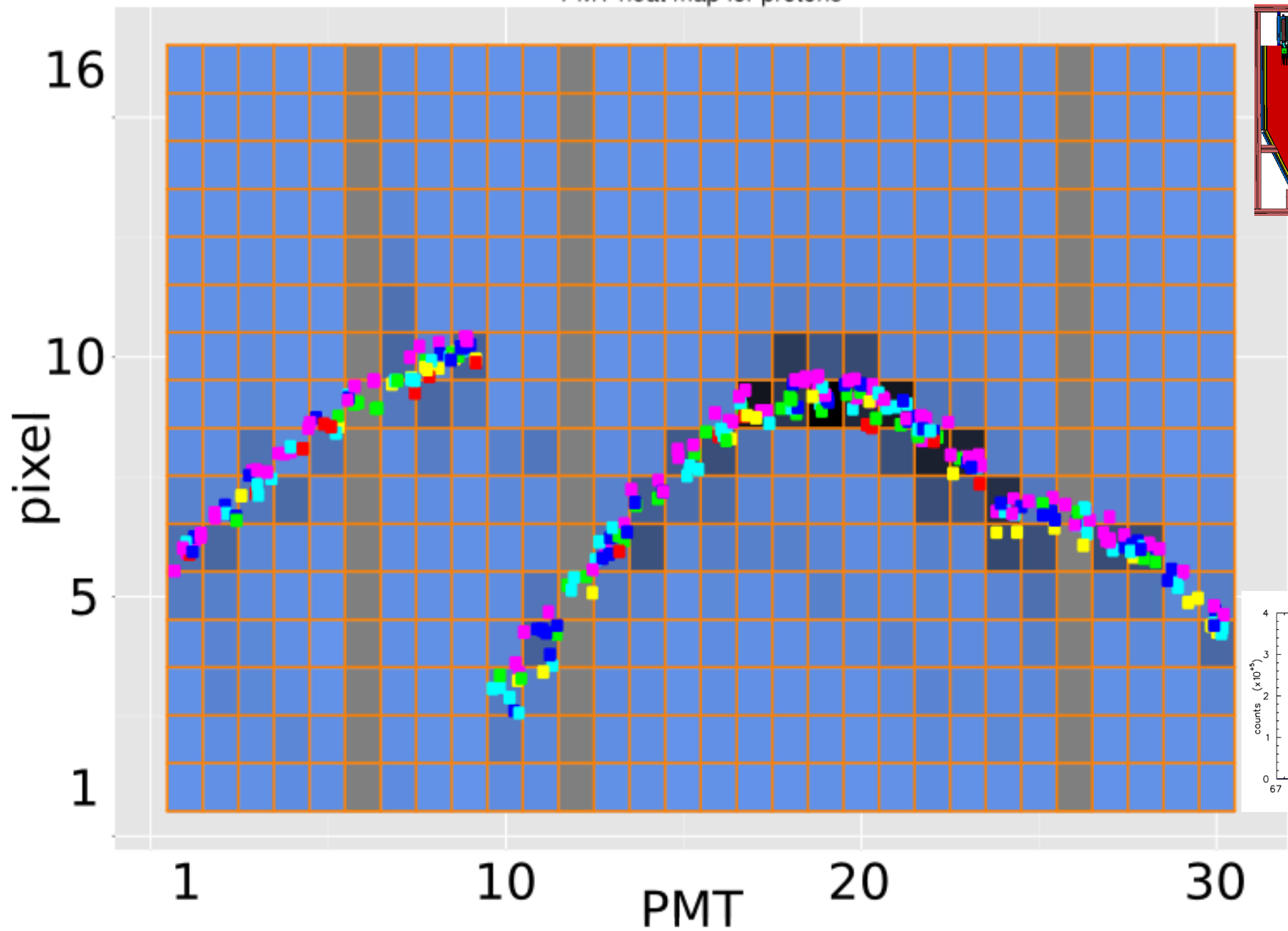
x=300mm  
y=295mm  
theta=3deg

p





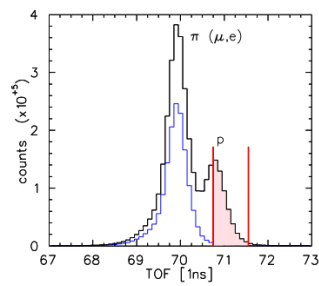
PMT heat map for protons



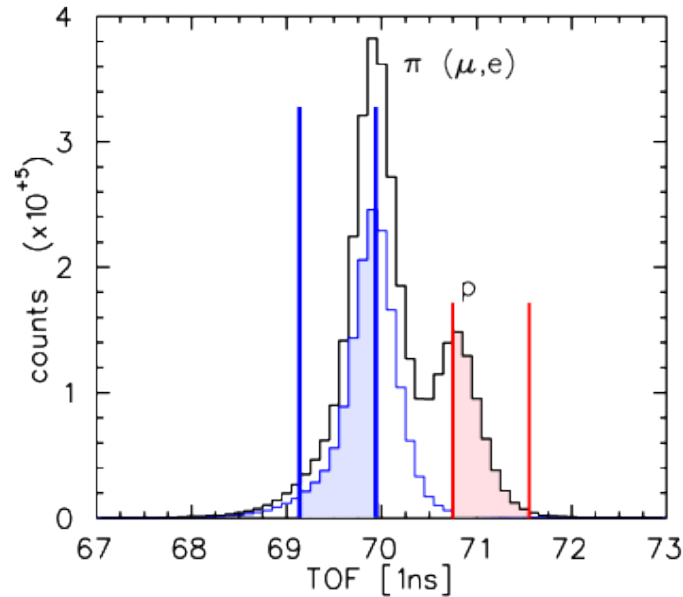
x=300mm  
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theta=3deg



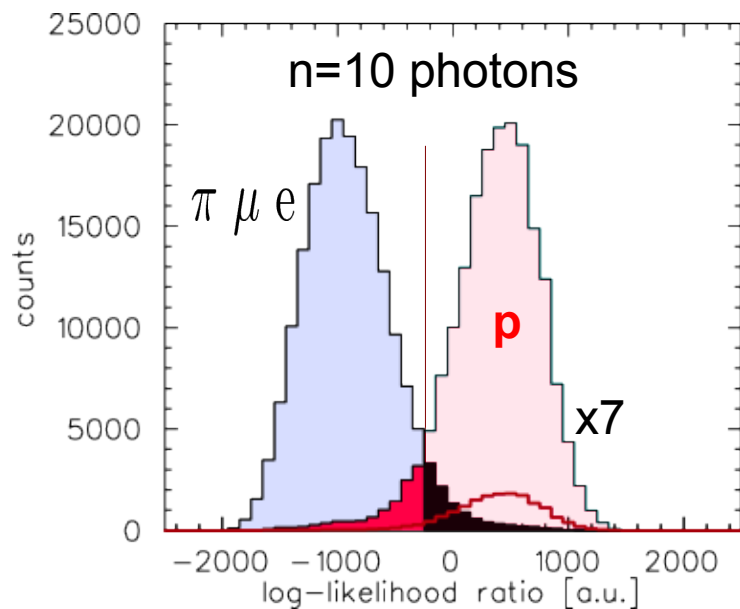
p



# Log likelihood analysis

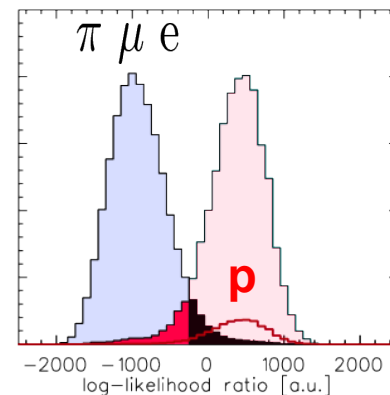
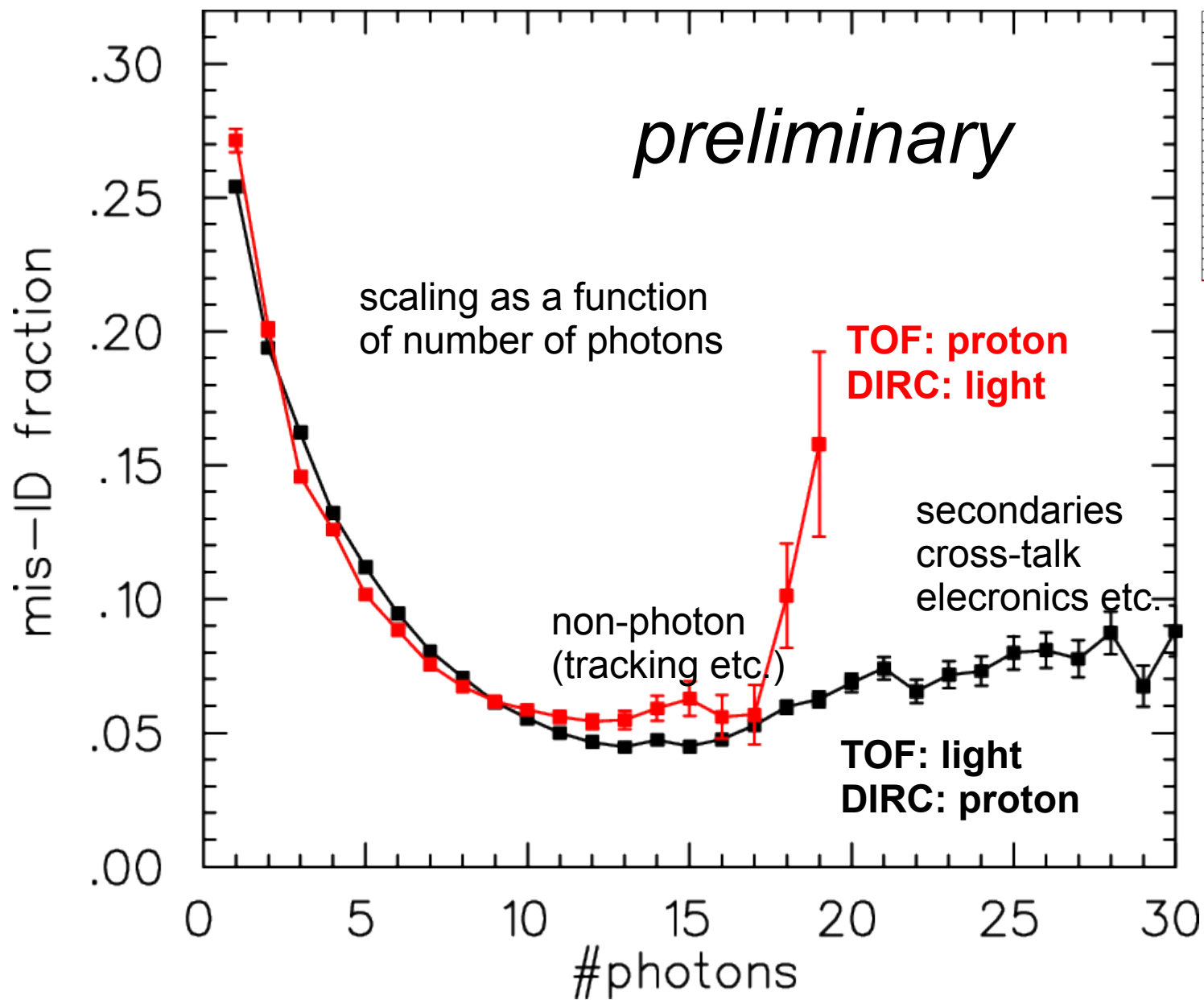


- log-likelihood ratio computed from data for each pixel
- equal mis-ID chosen
  - light particles  $L < I(n)$
  - protons  $L > I(n)$



- systematics derived from distributions(n)

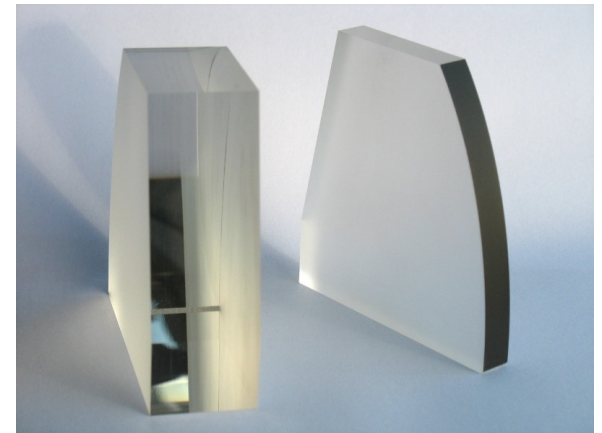
# PID - misidentification





# Conclusions and Outlook

- Disc DIRC prototype in DESY&CERN test beams
- particle identification achieved for single events (protons vs pions, muons, electrons)
- light yields not yet fully understood
- next steps: prototype with radiator and light guides from amorphous fused silica and fast MCP sensors



*Thank you for your attention*

