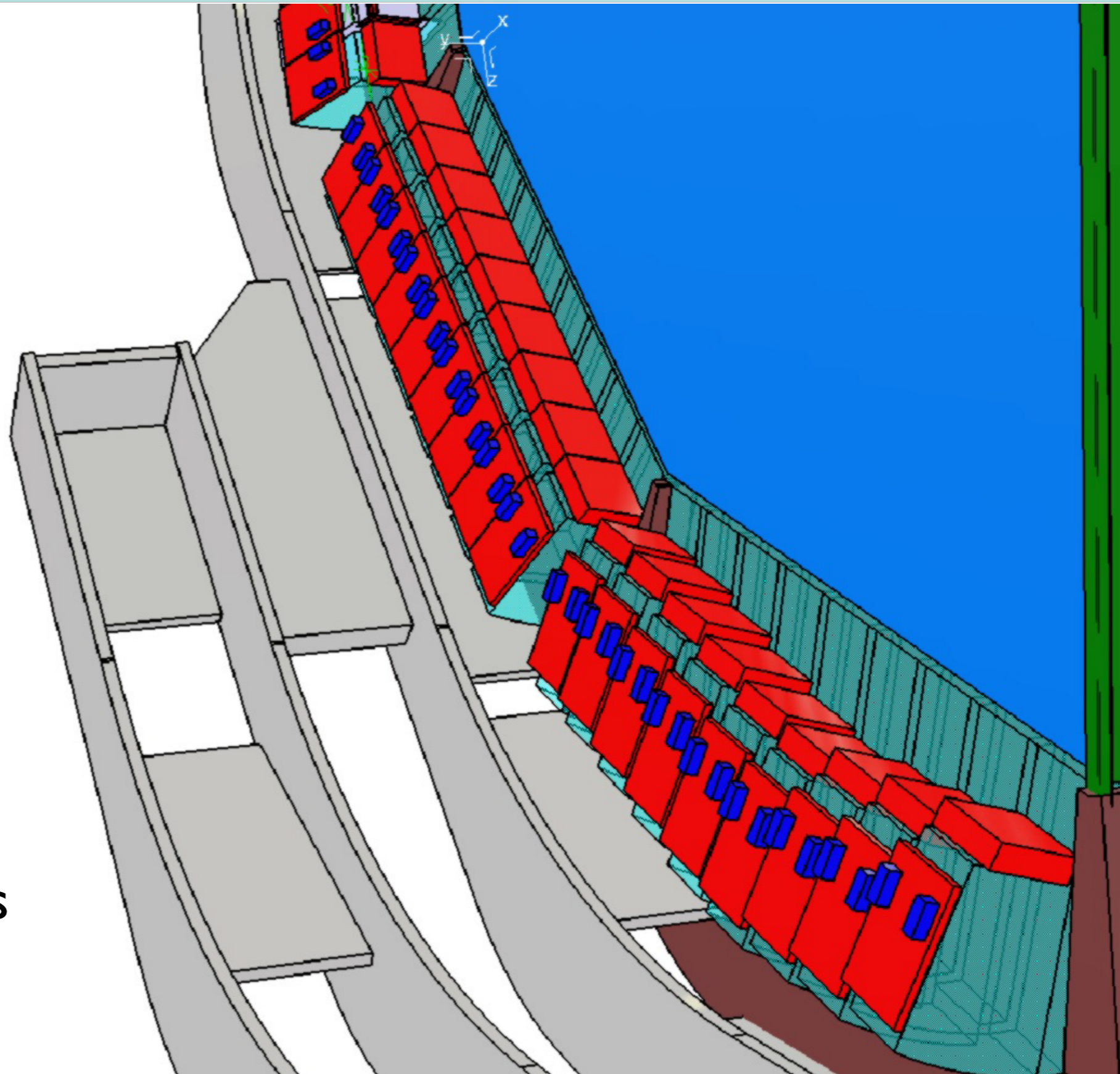


# The PANDA Disc DIRC project at FAIR

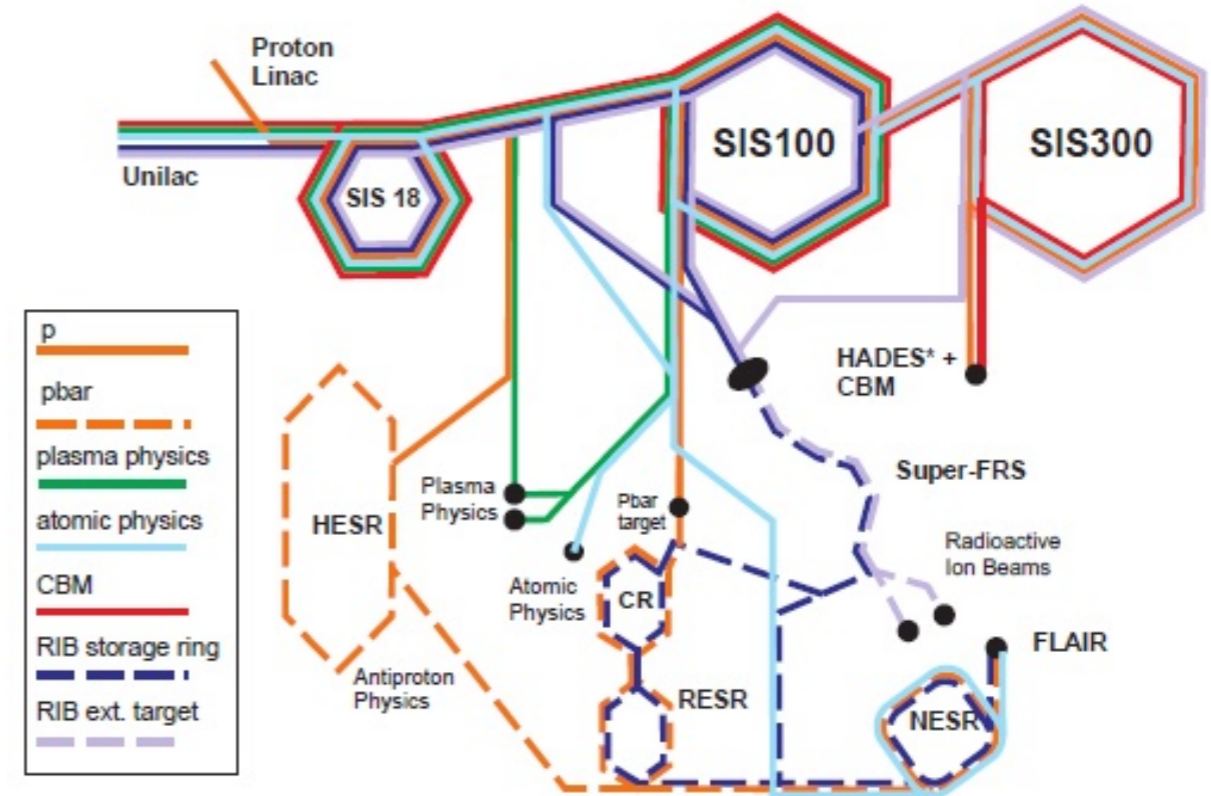
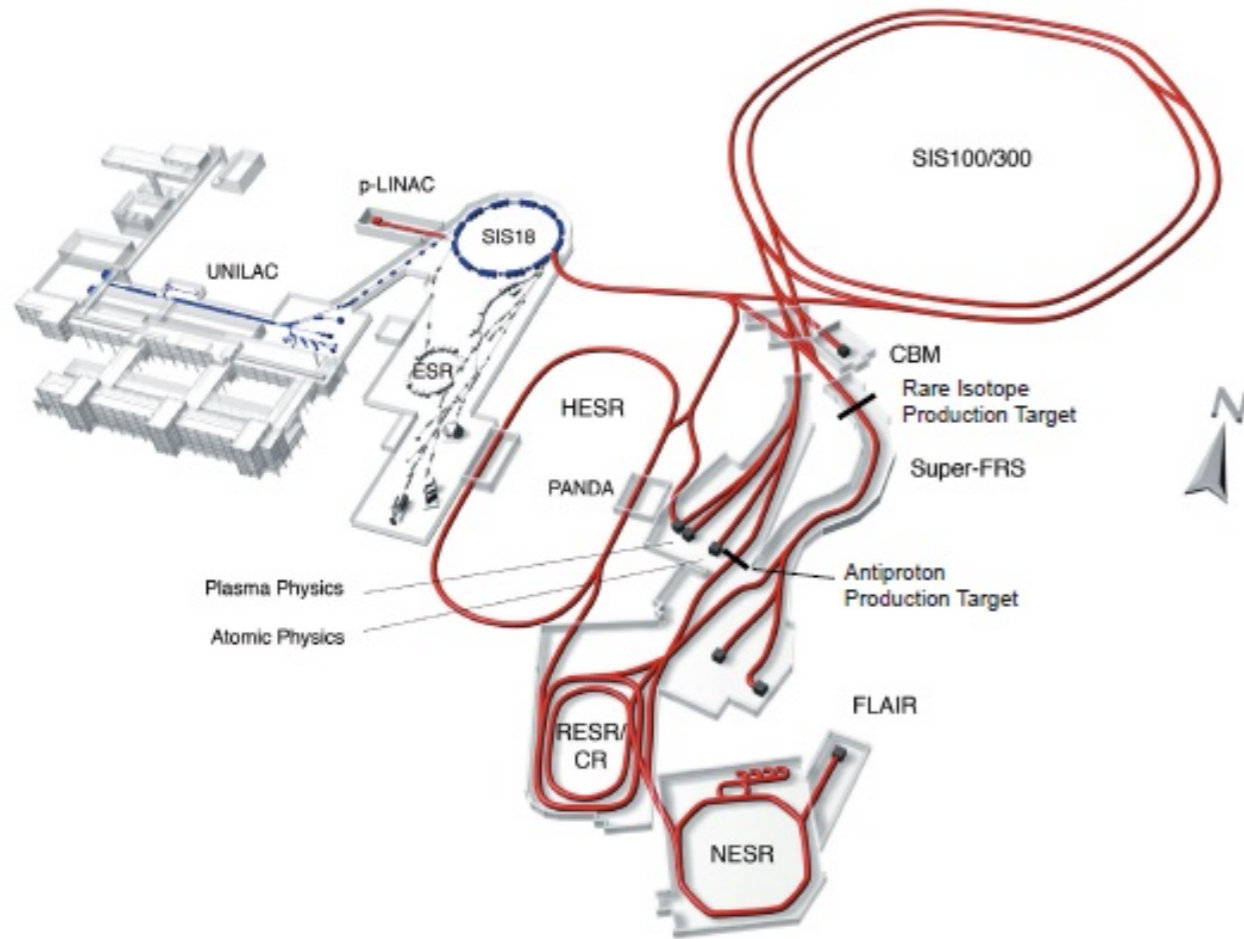
Erik Etzelmüller, Klim Bigunenko, Michael Düren, Klaus Föhl, Avetik Hayrapetyan,  
Kristof Kreutzfeldt, Oliver Merle, Julian Rieke, Mustafa Schmidt

DIRC2015: Workshop on fast Cherenkov detectors  
Rauischholzhausen, 12.11.2015

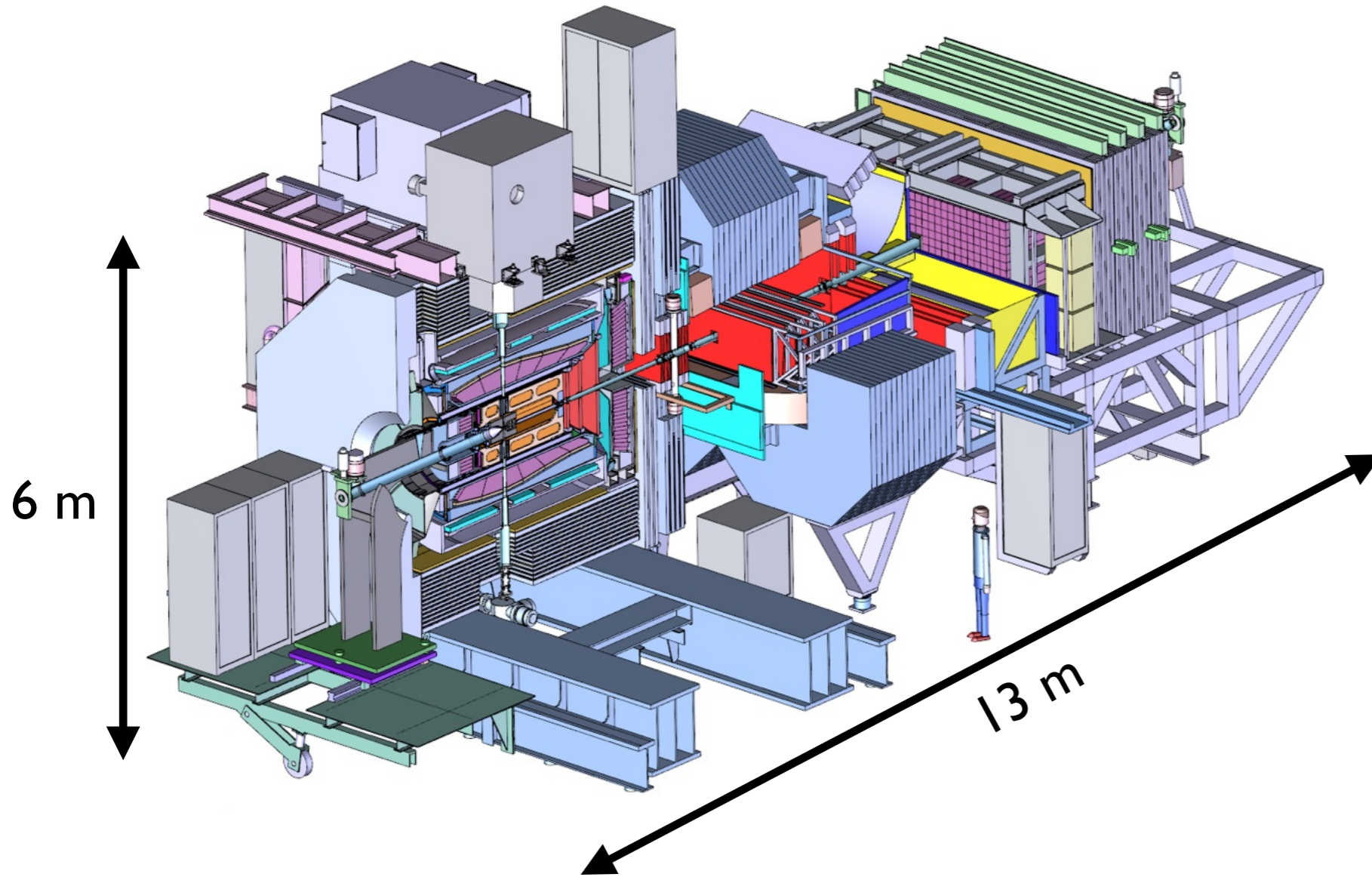
- PANDA @ FAIR
- DIRC design
- Simulation
- Optics and Readout
- Test experiments







- Large Upgrade of the existing GSI
- Versatile facility for different scientific topics
- PANDA is the only experiment dedicated to hadron physics and strong interaction



## Detector:

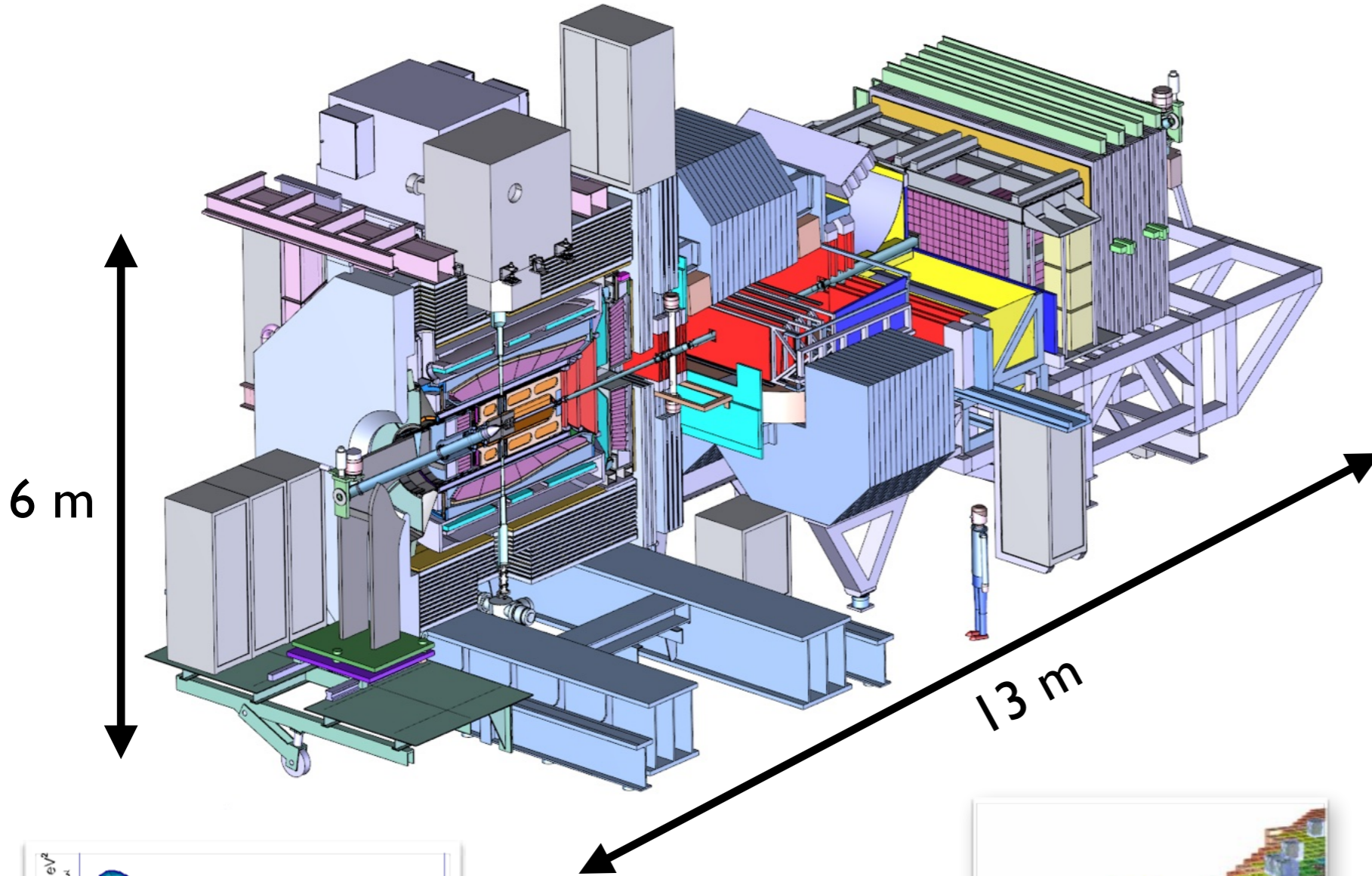
- fixed p-target
- p @ 1.5 - 15 GeV/c
- momentum resolution

$$\frac{\Delta p}{p} = 4 \cdot 10^{-5}$$

- maximum luminosity

$$2 \cdot 10^{32} \frac{1}{\text{cm}^2 \text{s}}$$





## Detector:

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- p @ 1.5 - 15 GeV/c
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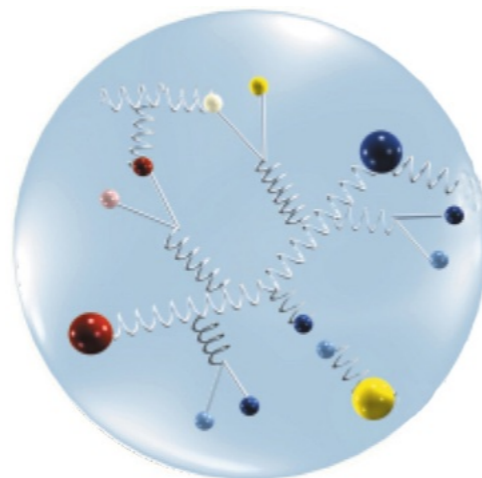
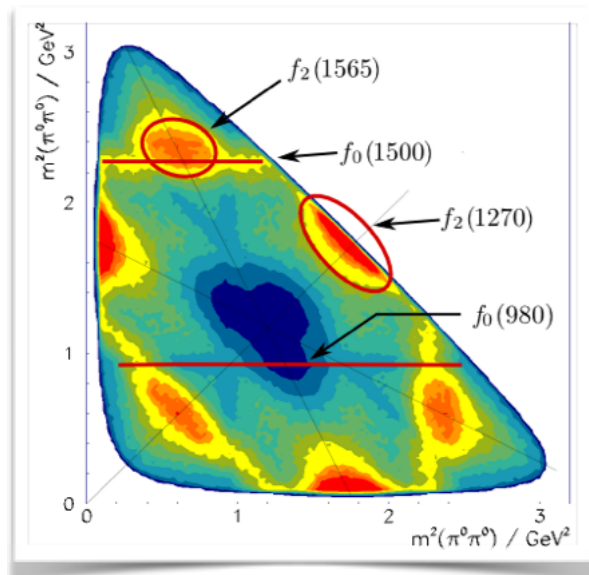
$$\frac{\Delta p}{p} = 4 \cdot 10^{-5}$$

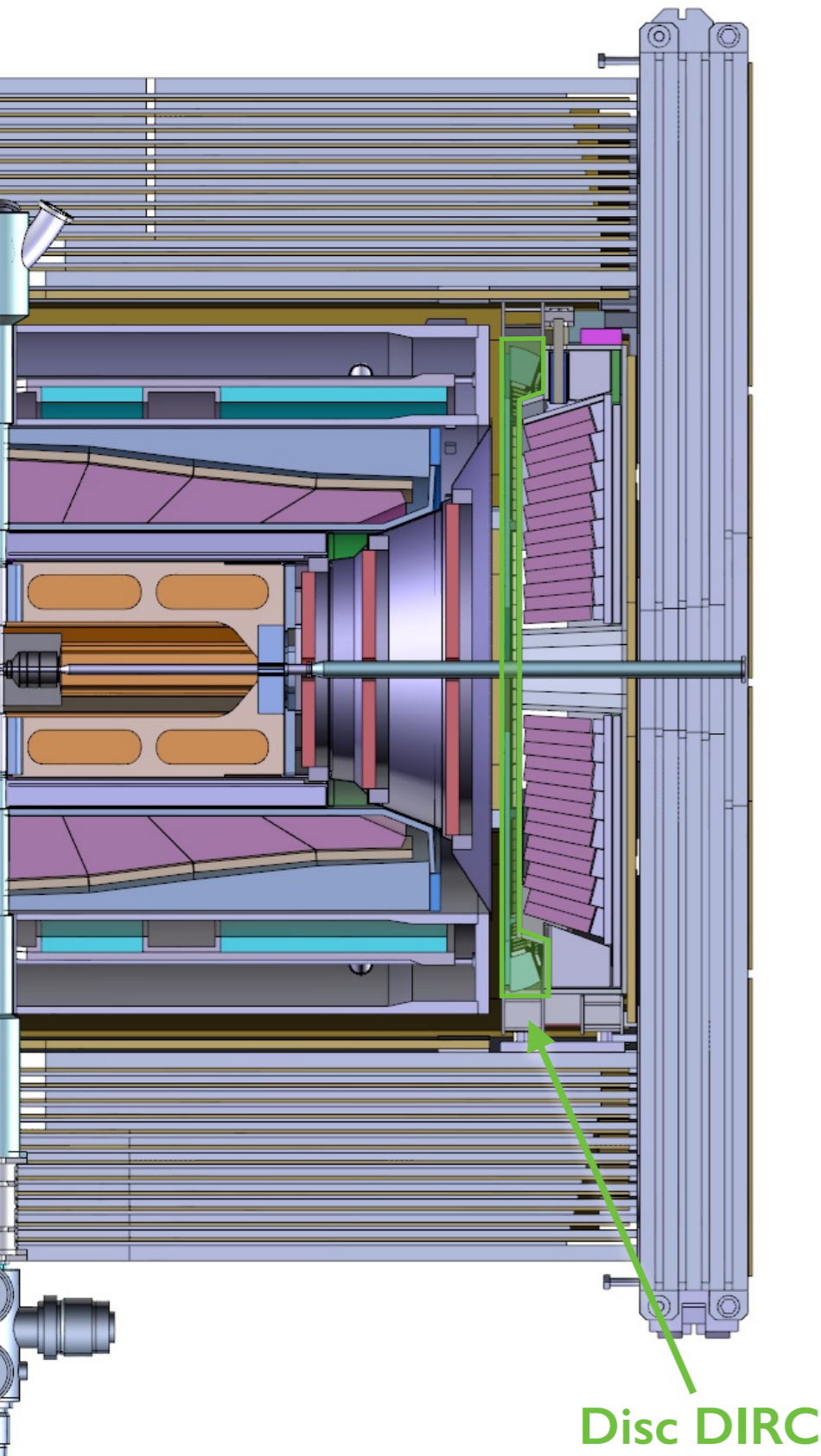
- maximum luminosity

$$2 \cdot 10^{32} \frac{1}{\text{cm}^2 \text{s}}$$

## Physics:

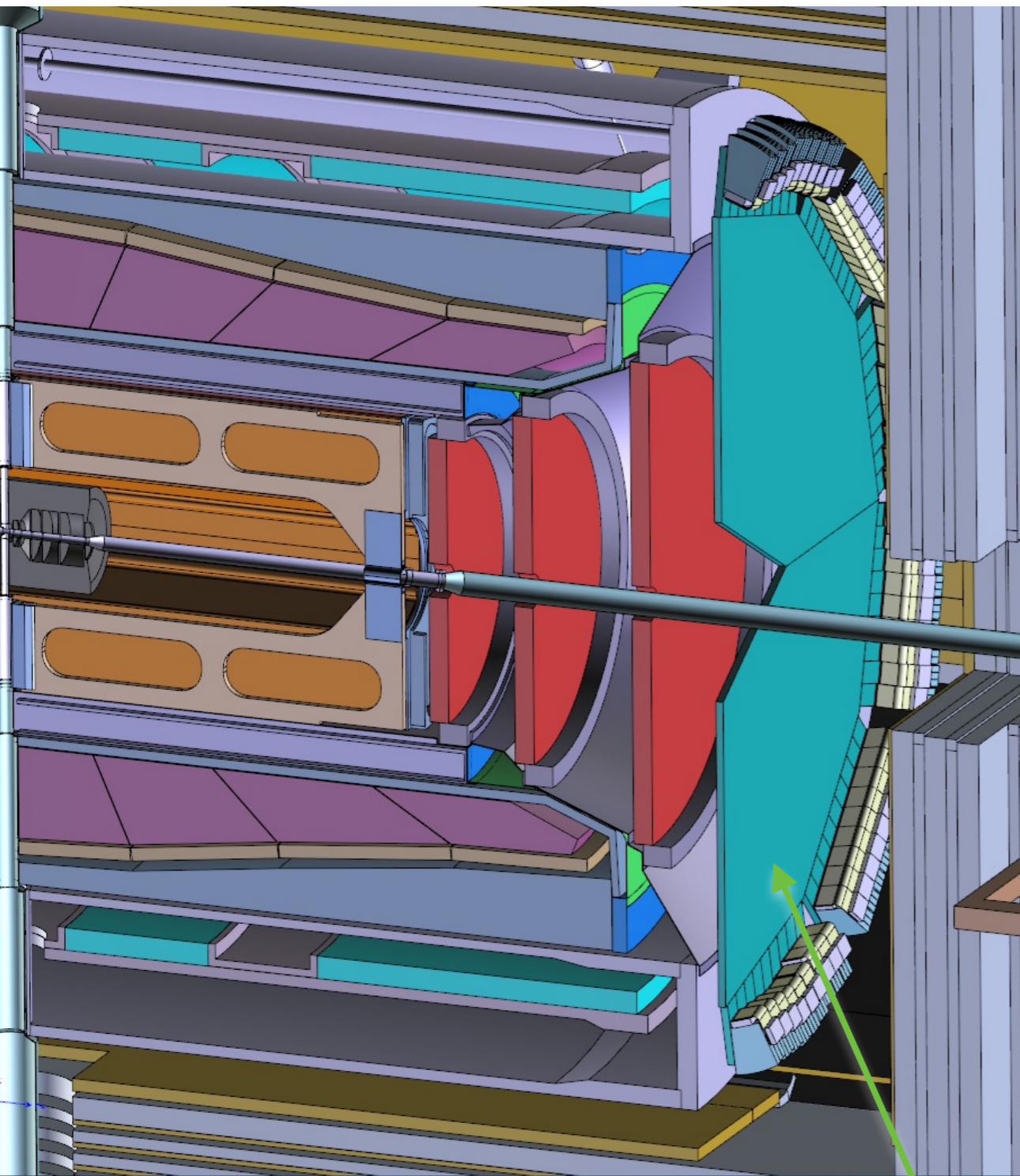
- hadron spectroscopy
- nucleon structure
- hadrons in matter
- hypernuclei





- $4\sigma$   $\pi/K$  separation up to 4.5 GeV/c
- continuous beam with interaction rates up to 20 MHz
- strong magnetic field
- high radiation level and photon dose
- high-precision and large-area optics
- high time resolution, data rate and channel density
- very limited space

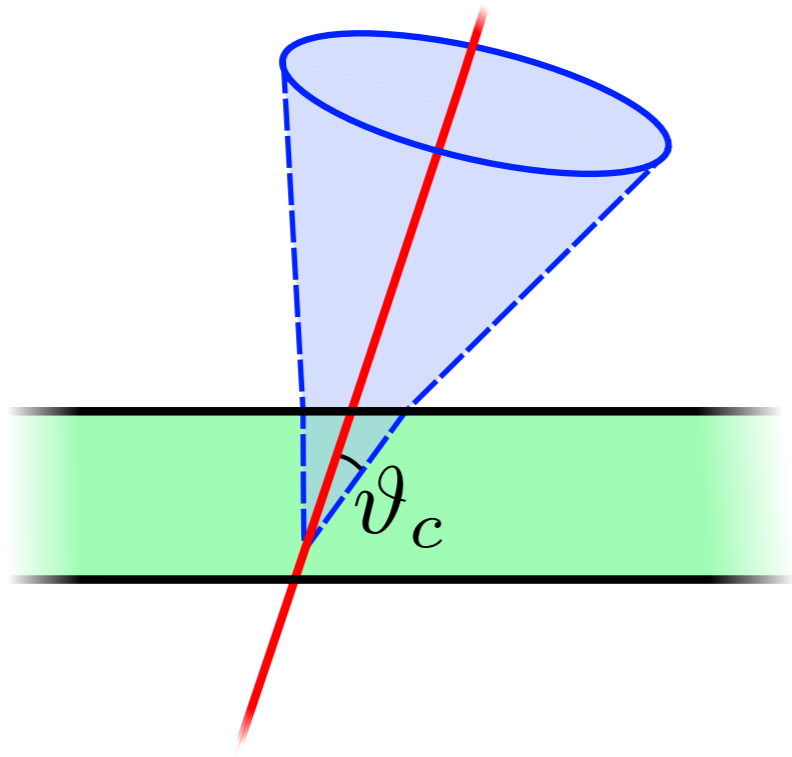




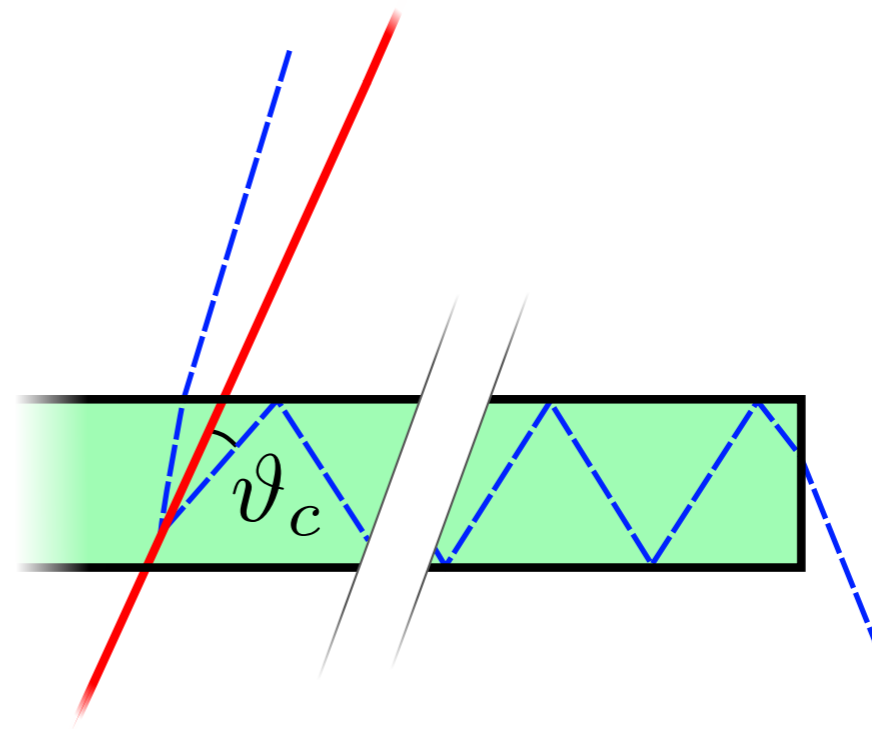
Disc DIRC

- $4\sigma$   $\pi/K$  separation up to 4.5 GeV/c
- continuous beam with interaction rates up to 20 MHz
- strong magnetic field
- high radiation level and photon dose
- high-precision and large-area optics
- high time resolution, data rate and channel density
- very limited space

$$\cos \vartheta_c = \frac{1}{n\beta} \qquad \frac{dN^2}{dkdx} = \alpha z^2 \sin^2 \vartheta_c$$



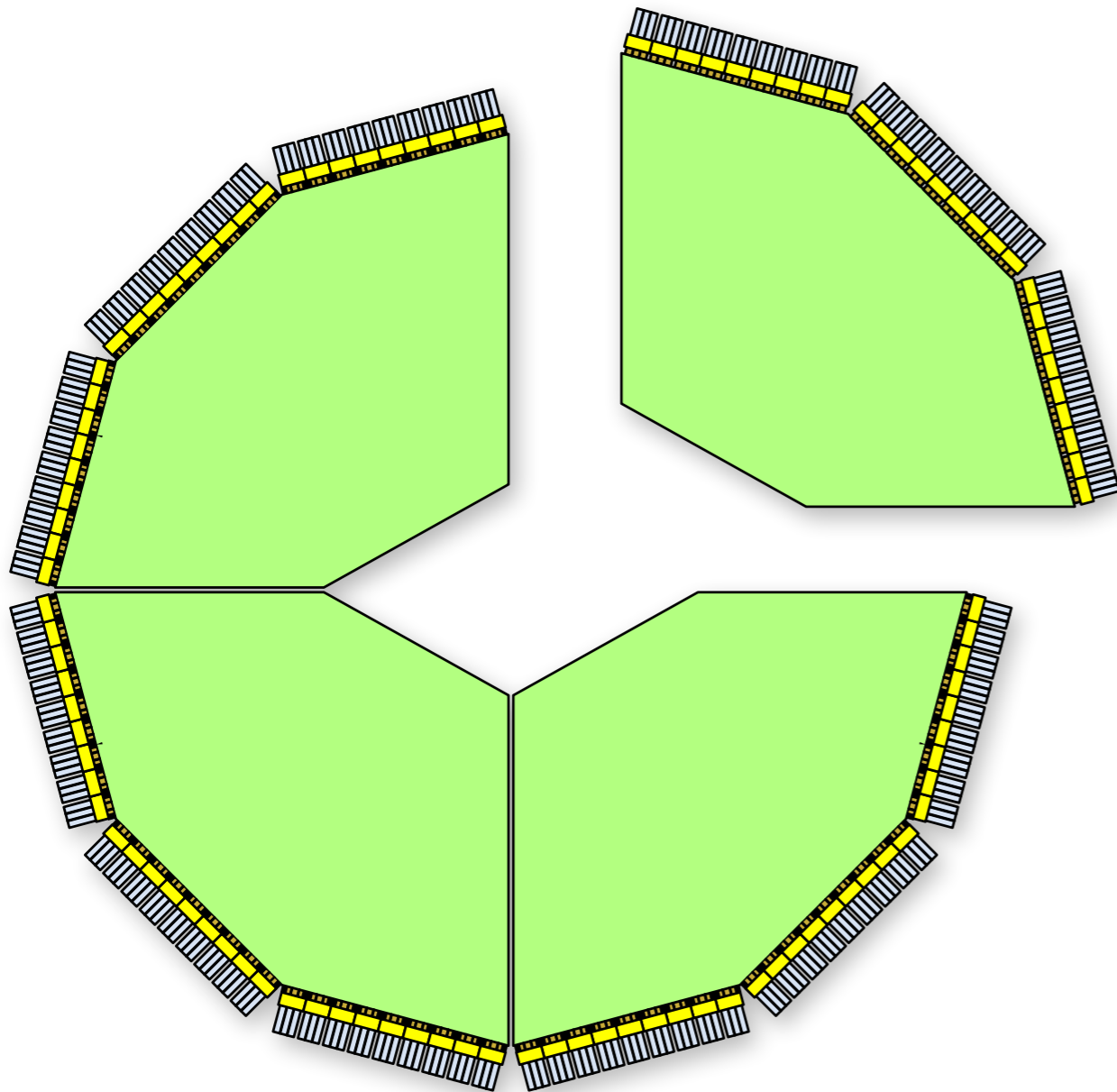
**RICH**



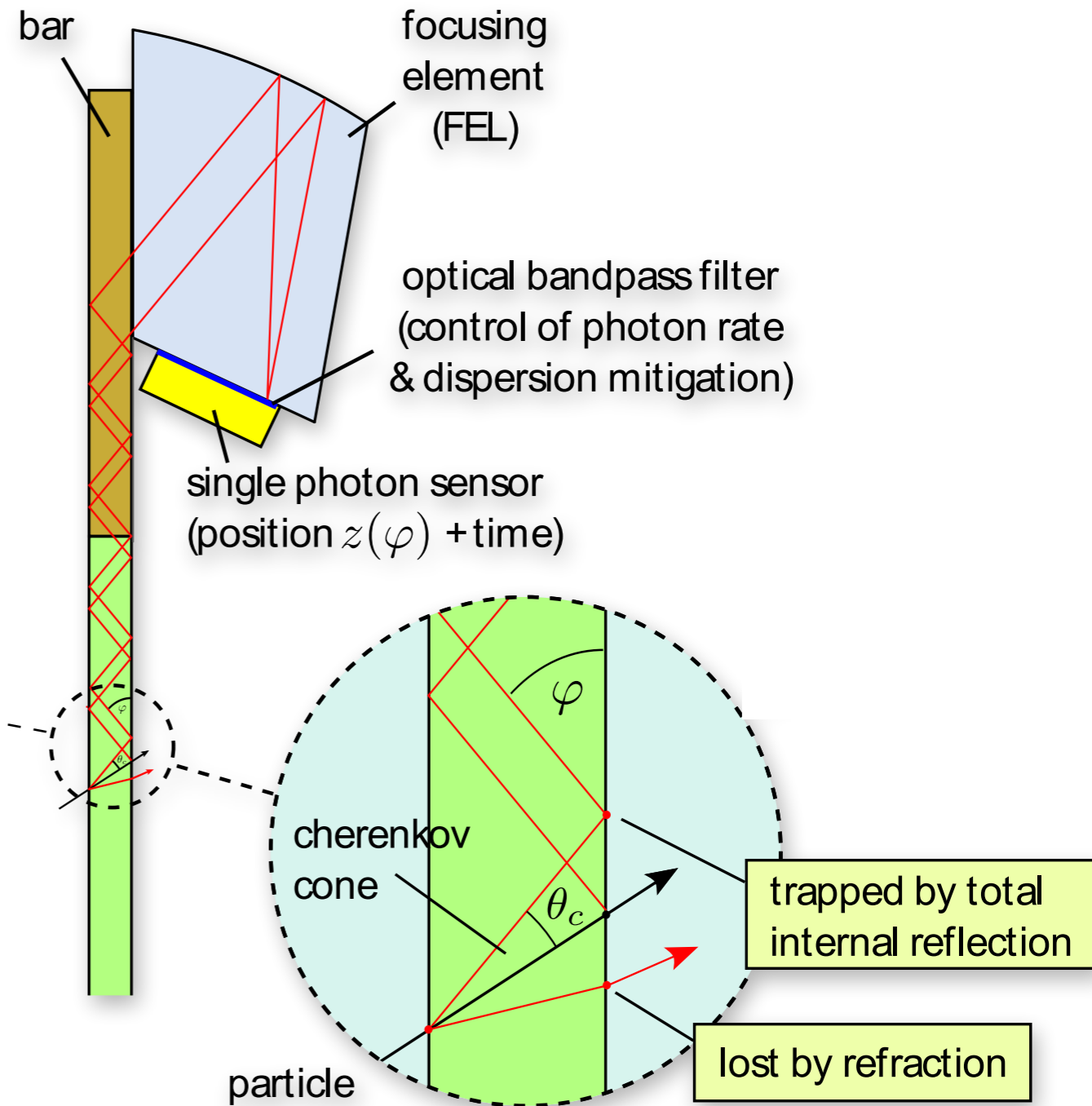
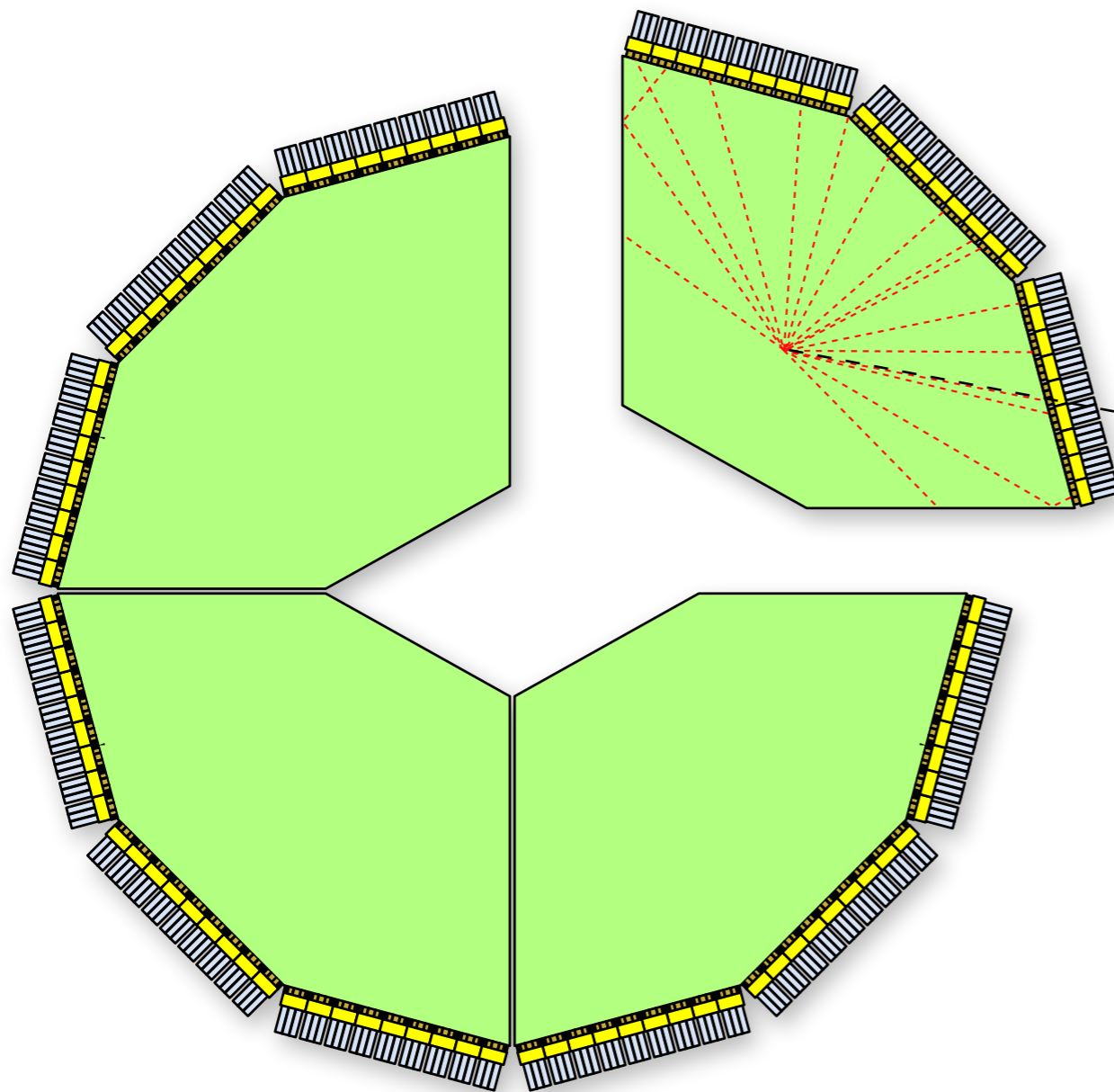
**DIRC**



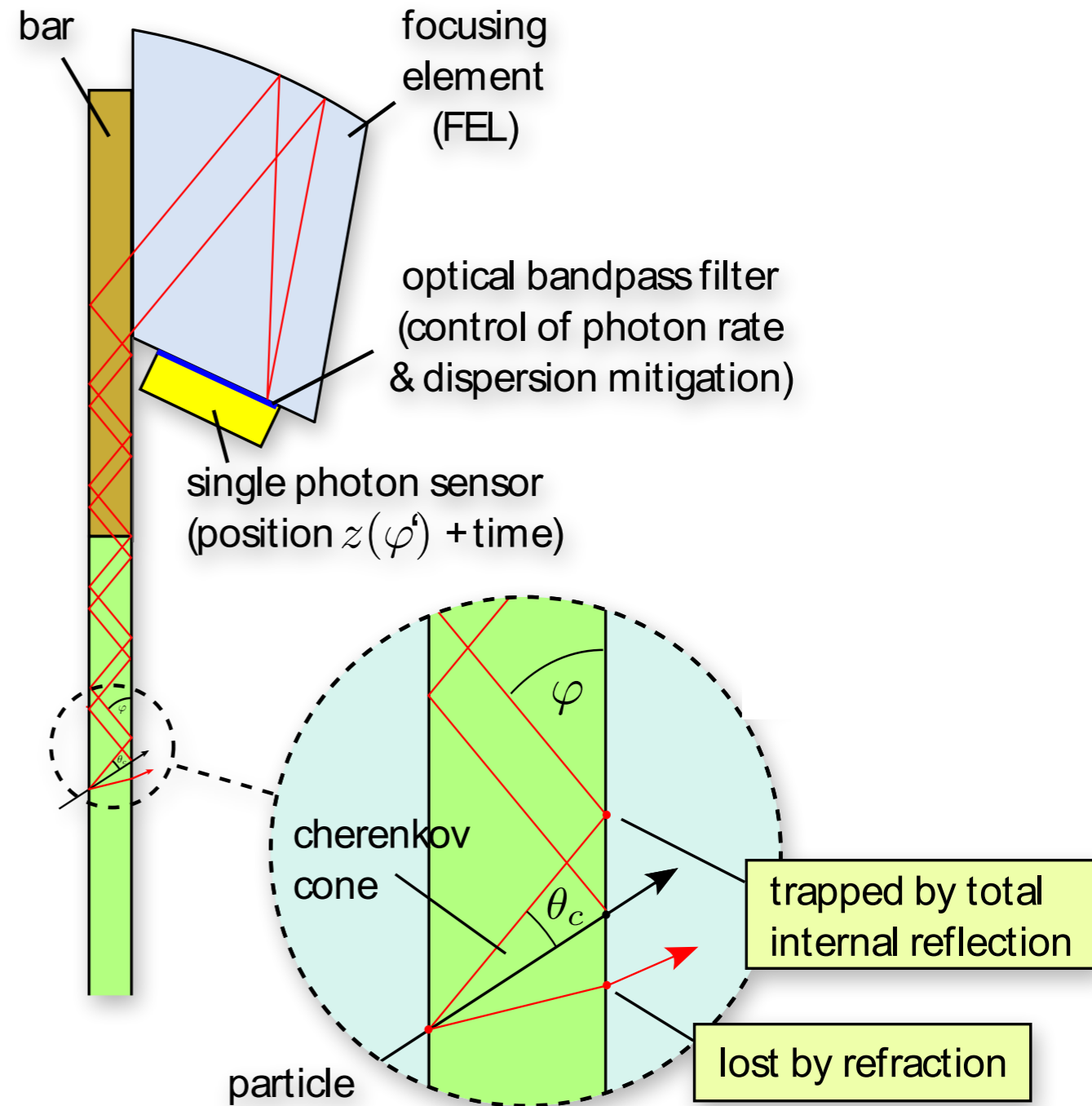
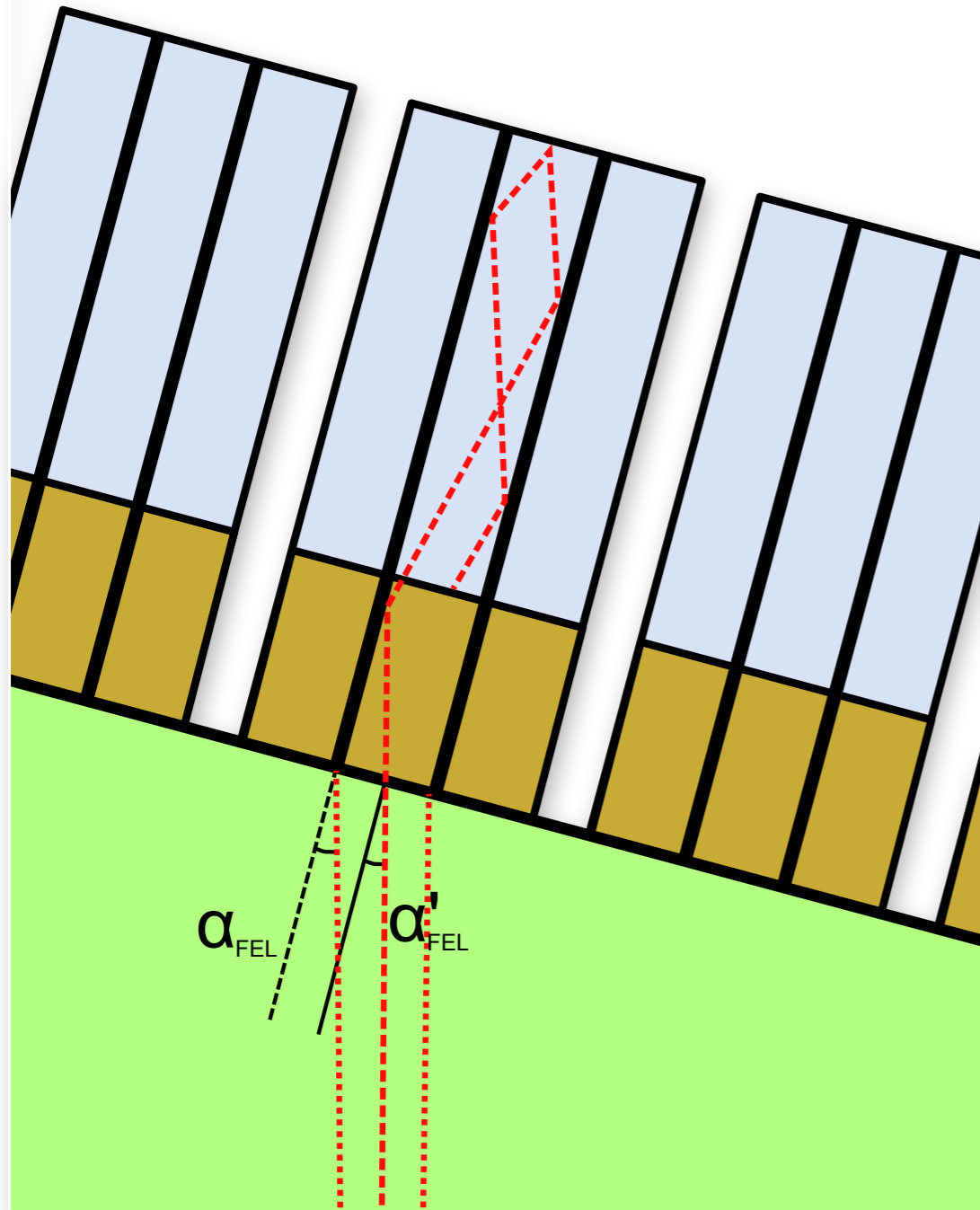
4 independent quadrants made of fused silica and equipped with a total of 108 read-out modules (ROMs)



4 independent quadrants made of fused silica and equipped with a total of 108 read-out modules (ROMs)



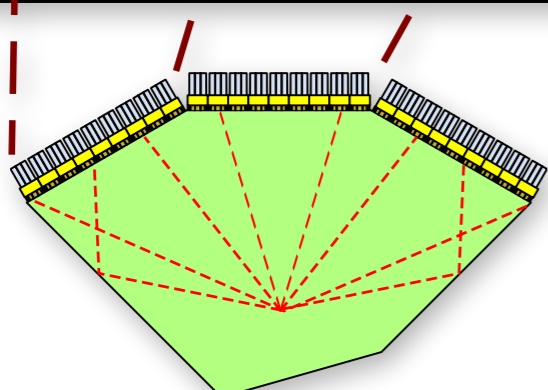
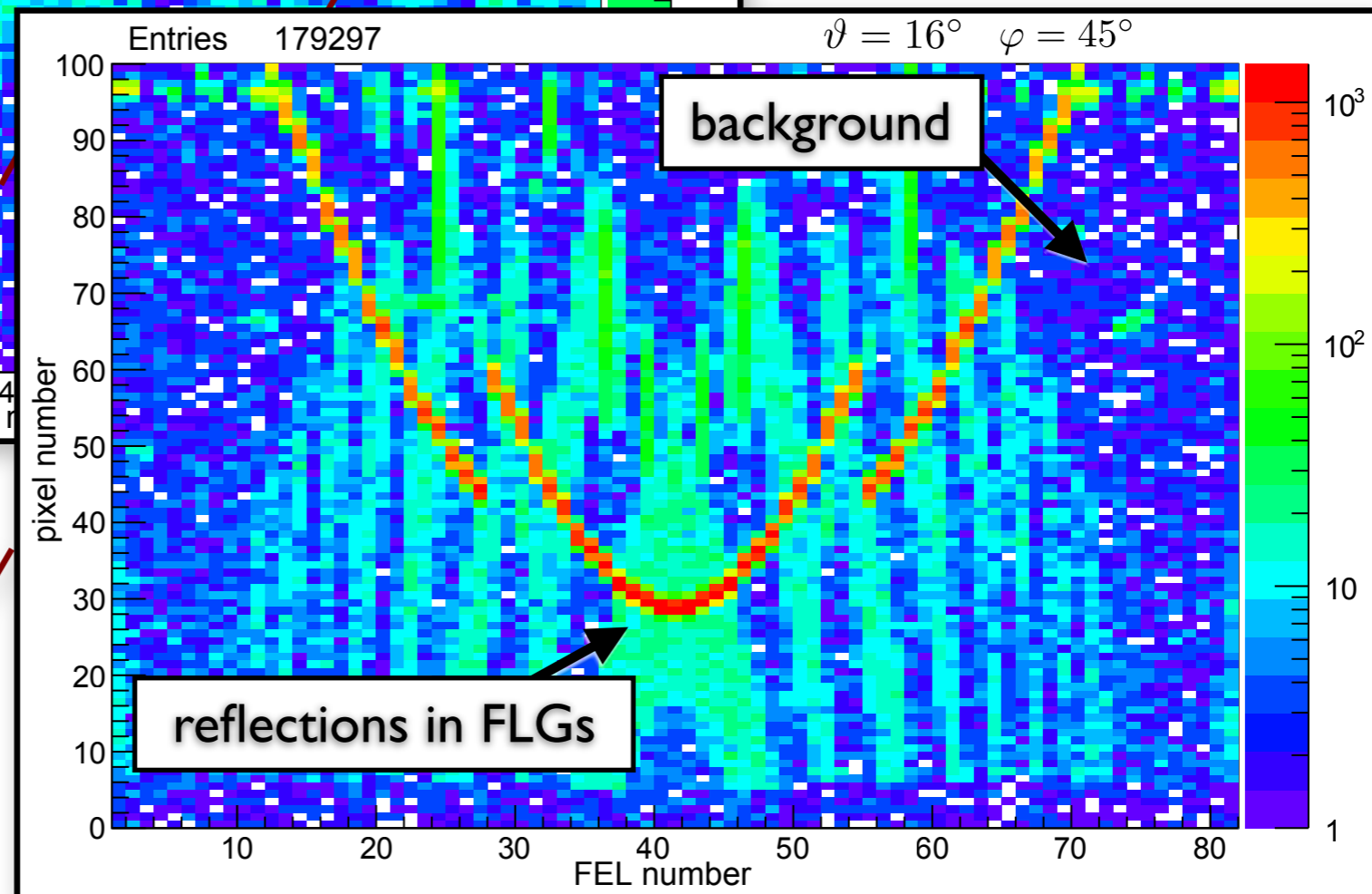
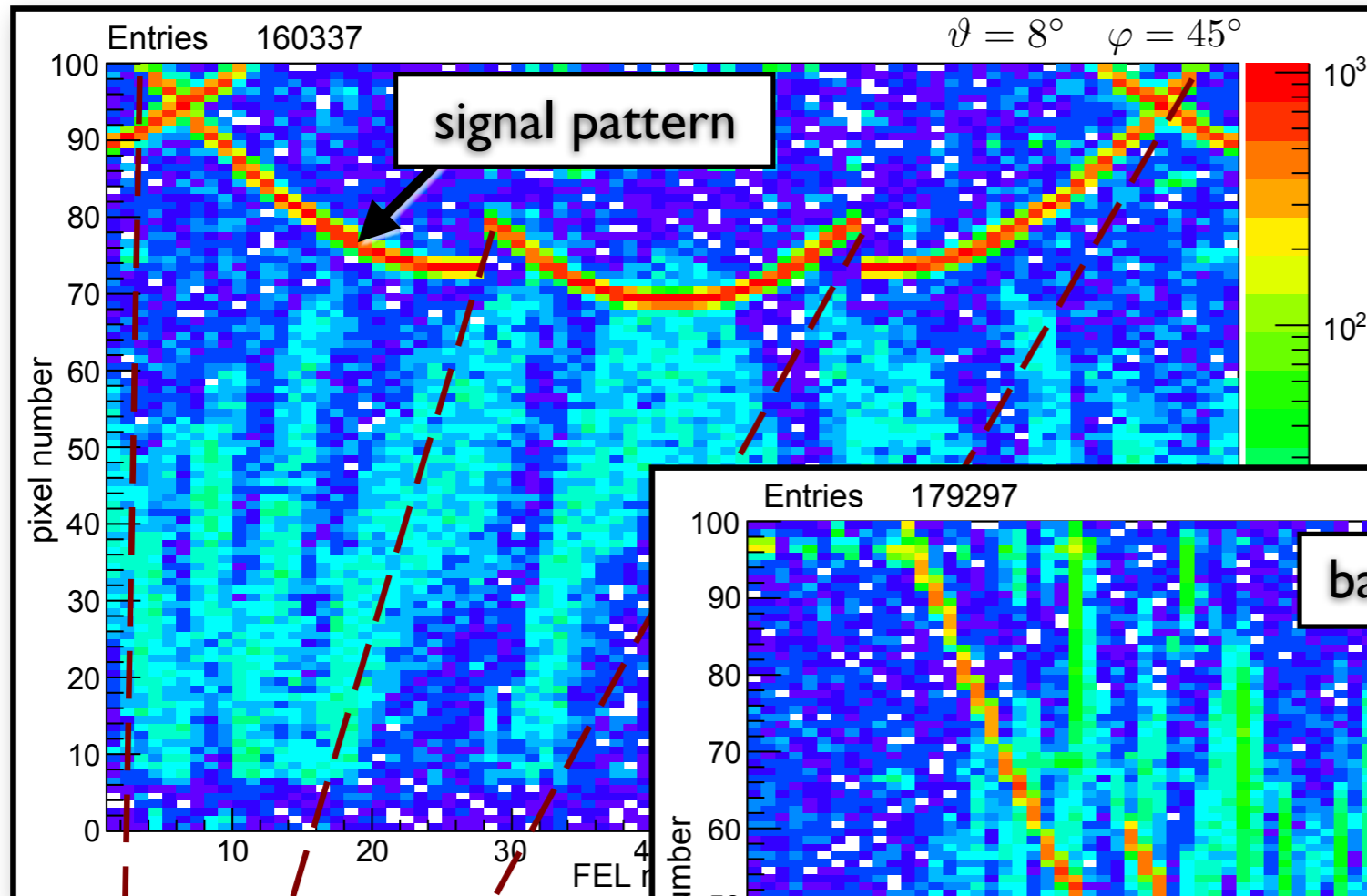




## accumulated hit patterns

Geant4 simulation

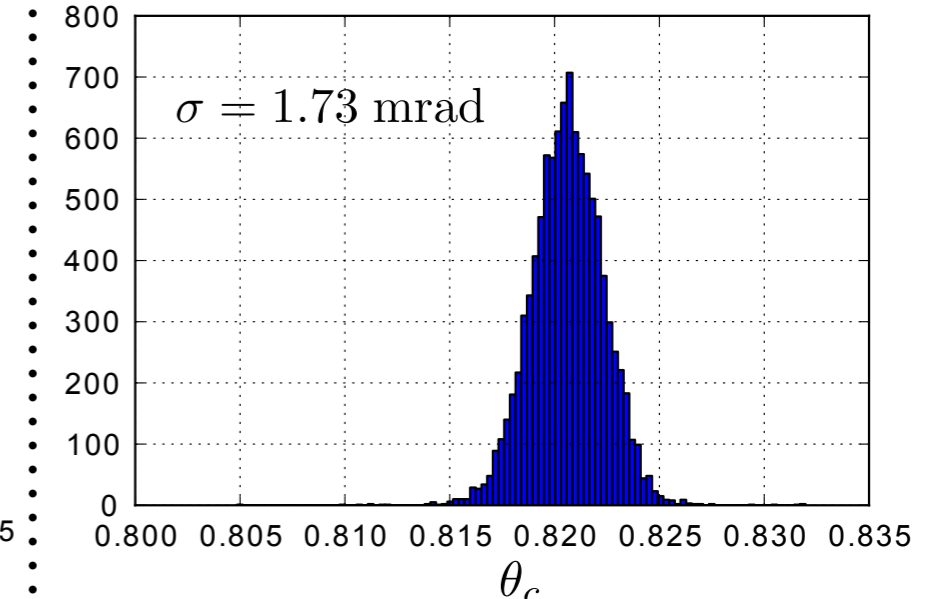
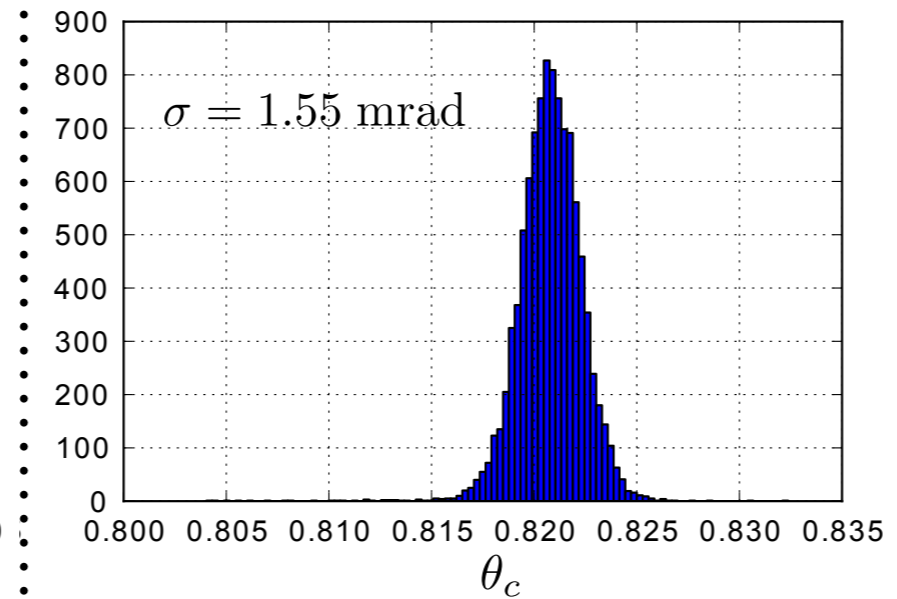
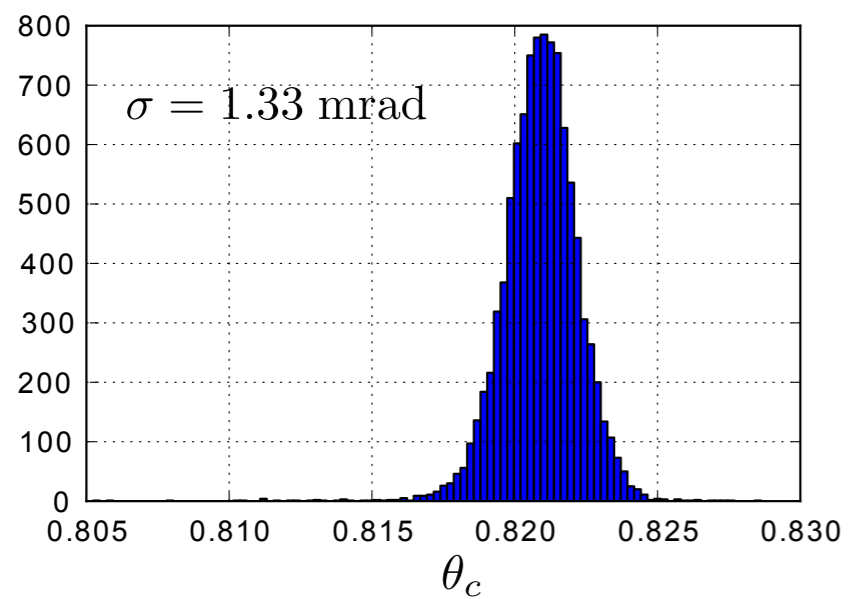
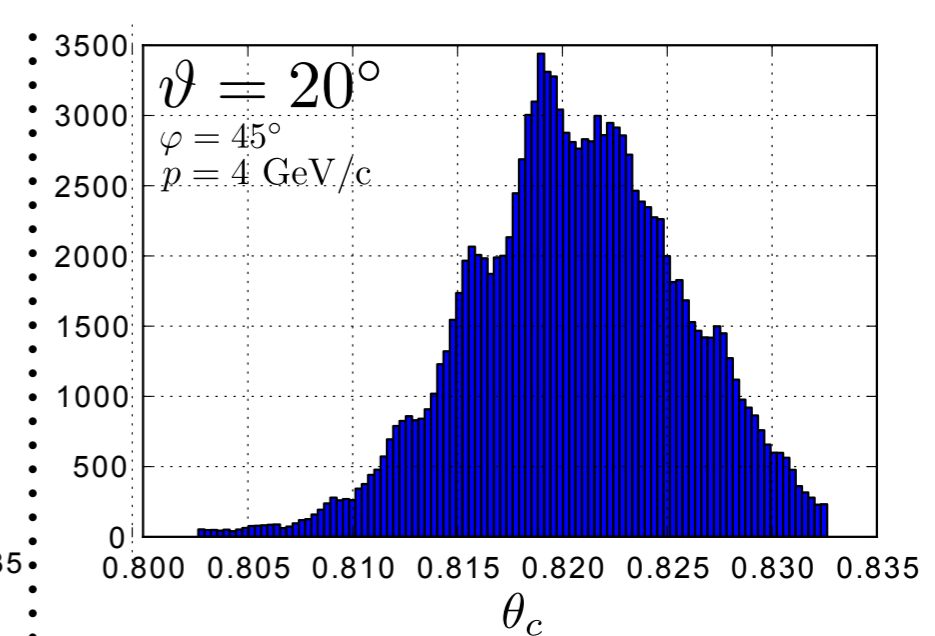
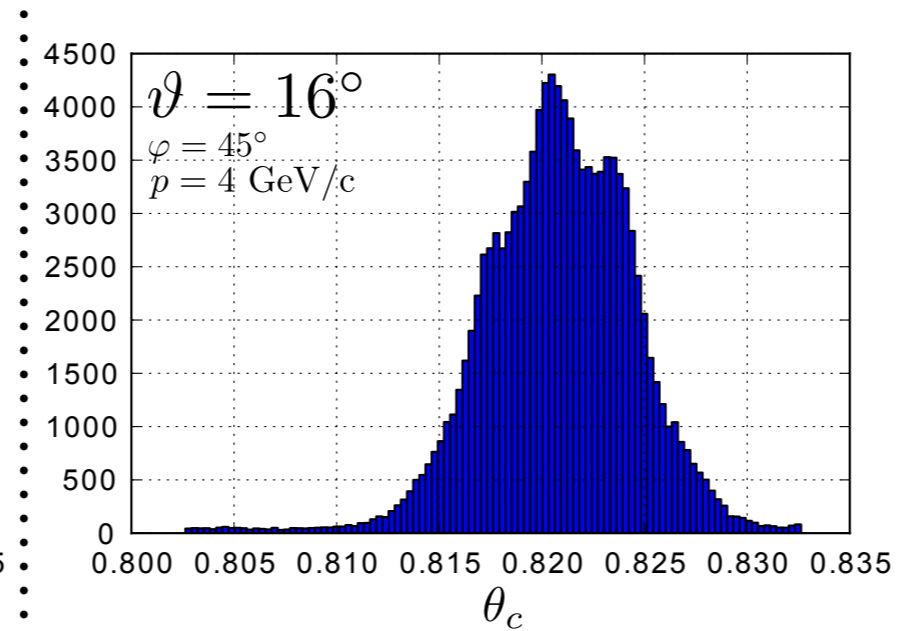
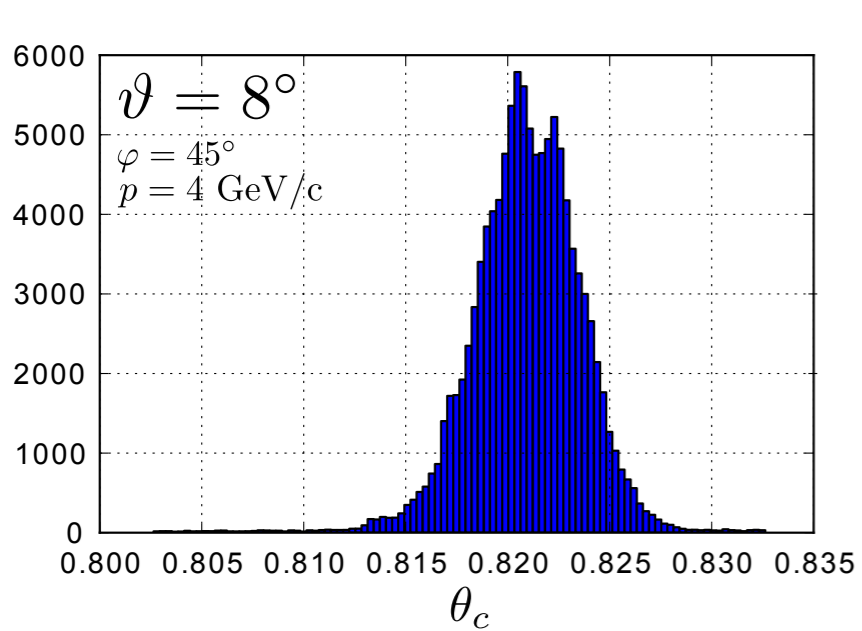
10k  $\pi$ -tracks at 4 GeV/c  
per histogram



O. Merle (RICH 13)



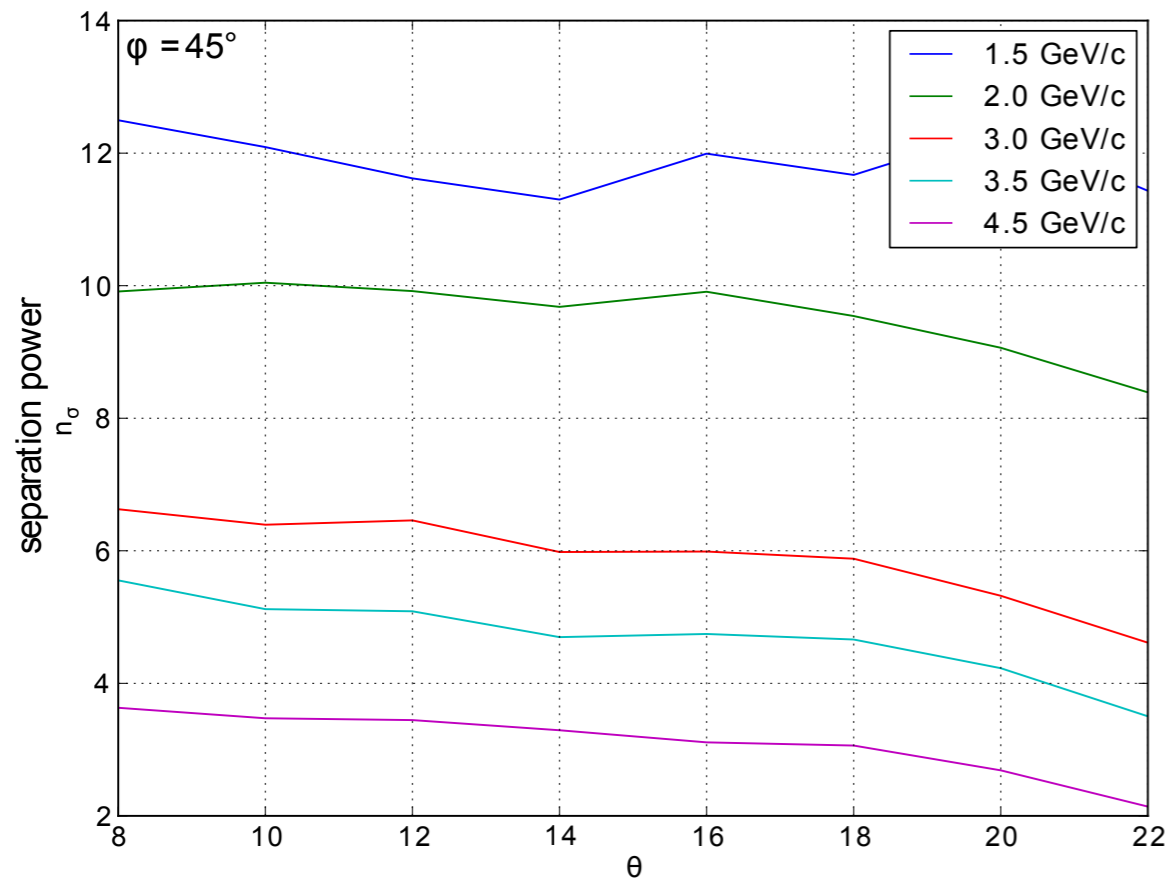
## reconstructed $\theta_c$ per single-photon



## reconstructed $\theta_c$ per track

O. Merle (RICH 13)

## $\pi/K$ separation theta vs. momentum

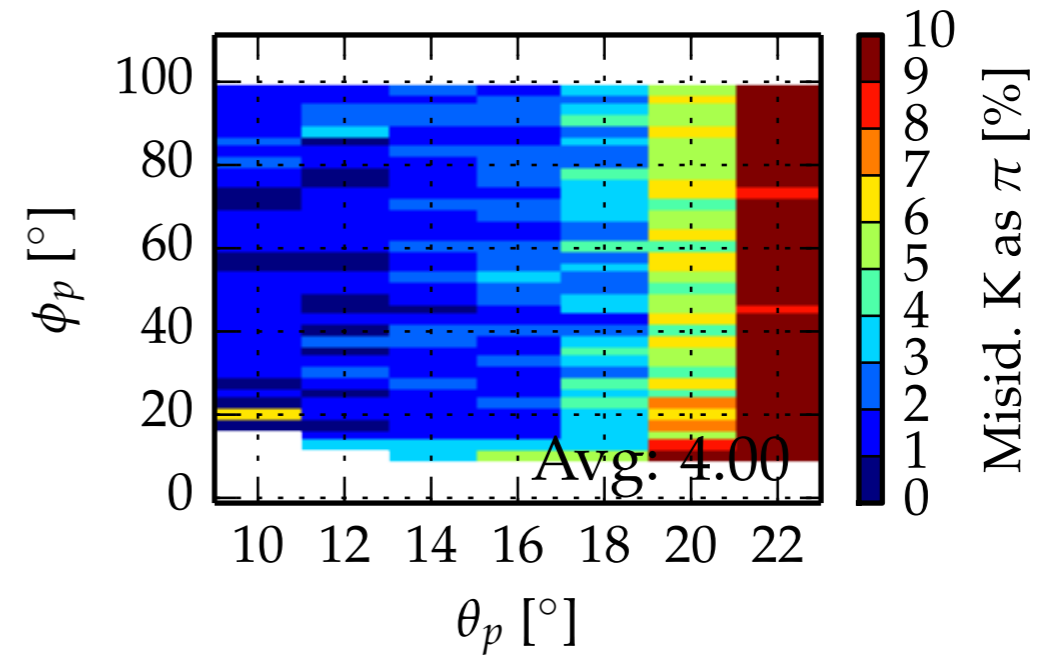


2 x 10k tracks/marker

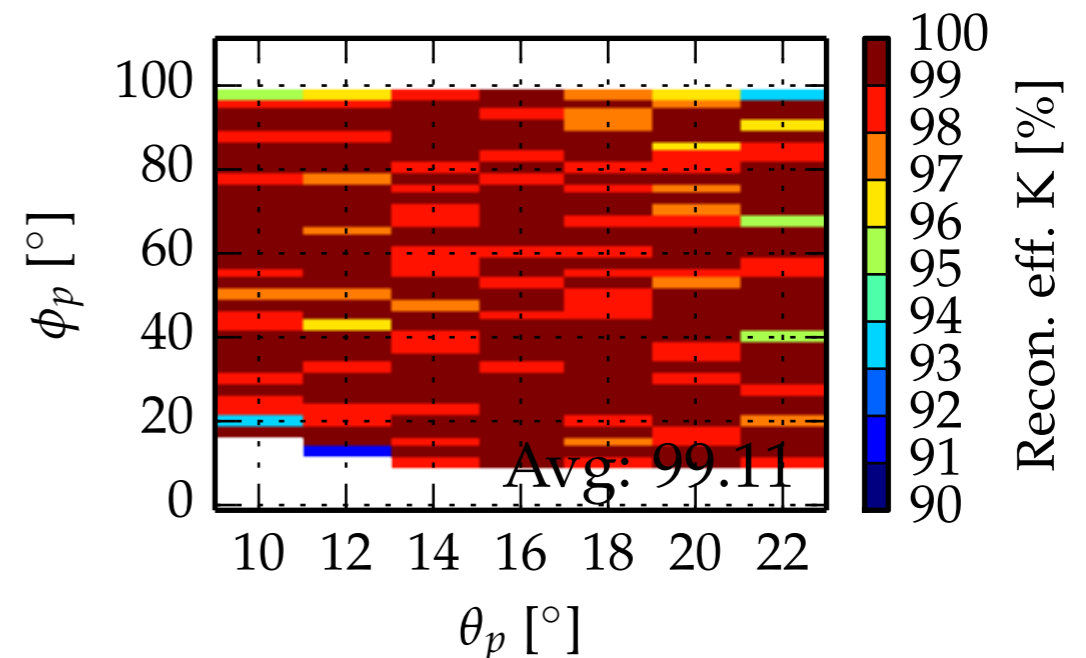
1 mrad smearing of track in  $\theta$  and  $\varphi$

0,5 mm pixel size, passband: 385 - 460 nm

## K misidentification @ 4 GeV/c



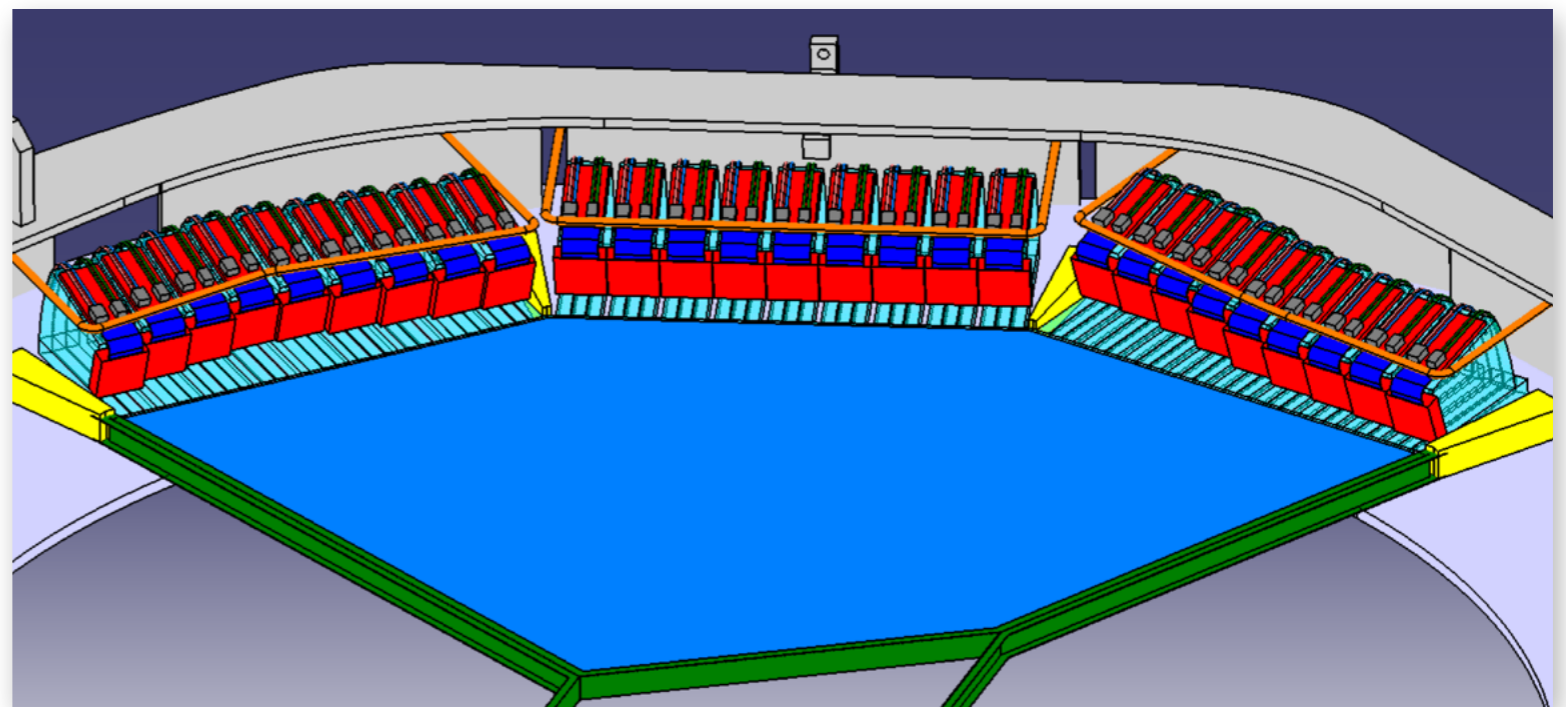
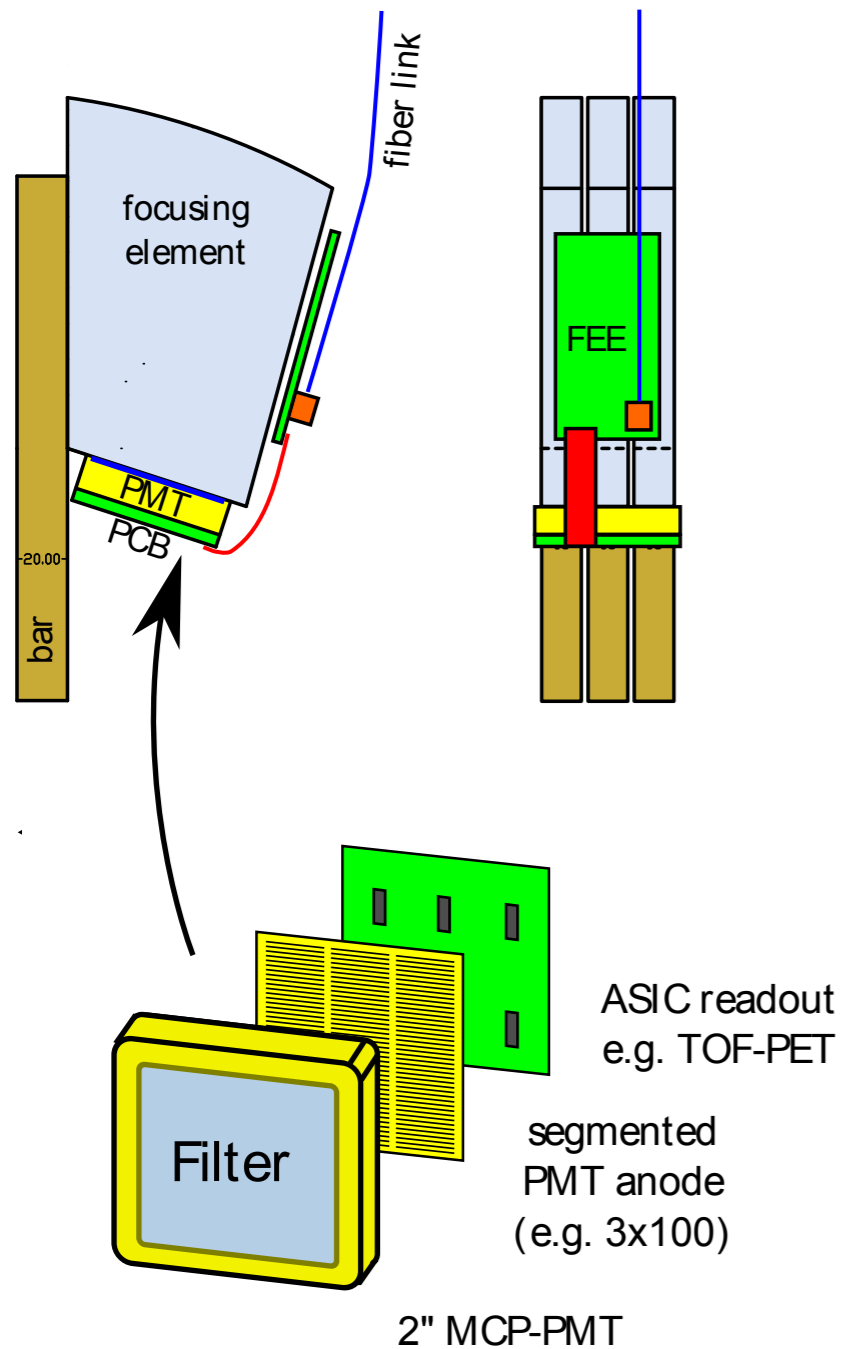
## K reconstruction eff. @ 4 GeV/c



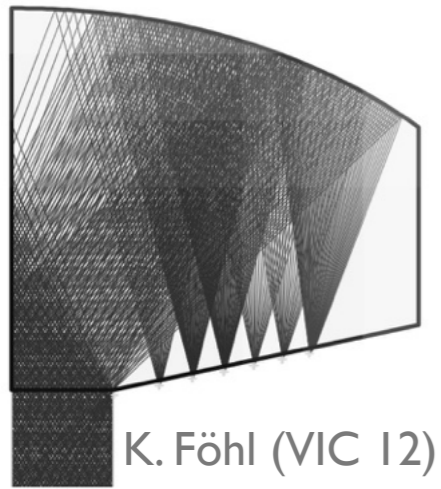
O. Merle (PhD-Thesis, 2015)

## the envisaged ROM

- realization of the optomechanical system and the readout is ongoing
- different test setups for QA of sensors and optical components are available





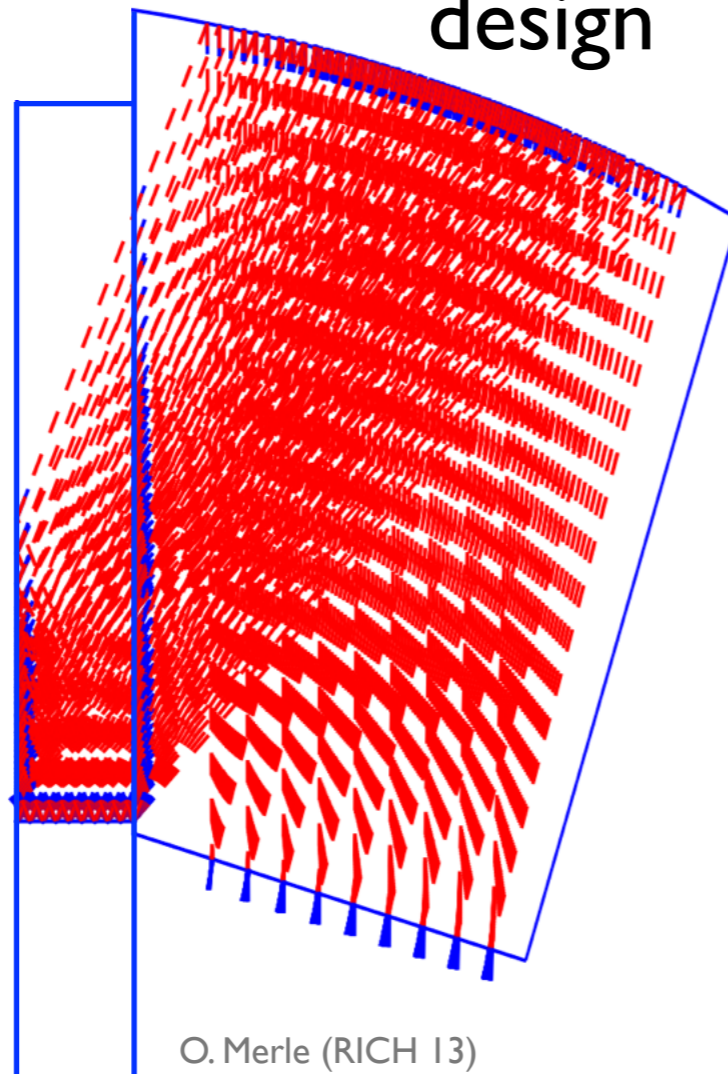


old dSiPM  
design

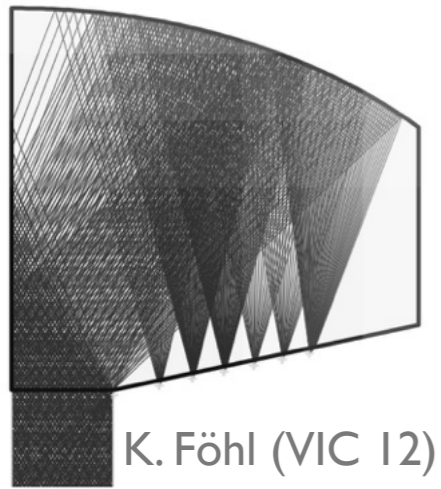


light-guides are to scale

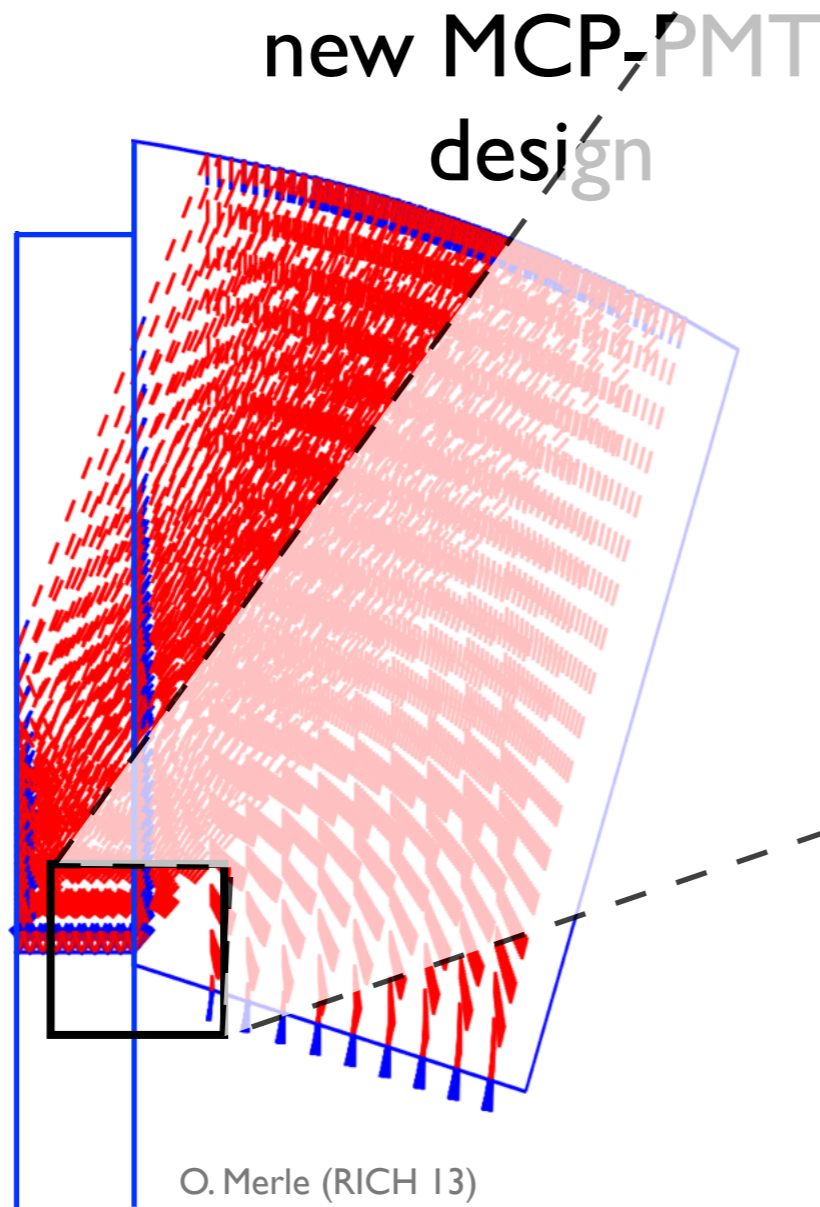
new MCP-PMT  
design



- spot width for focussing matches with the step size of the MCP-PMT anode



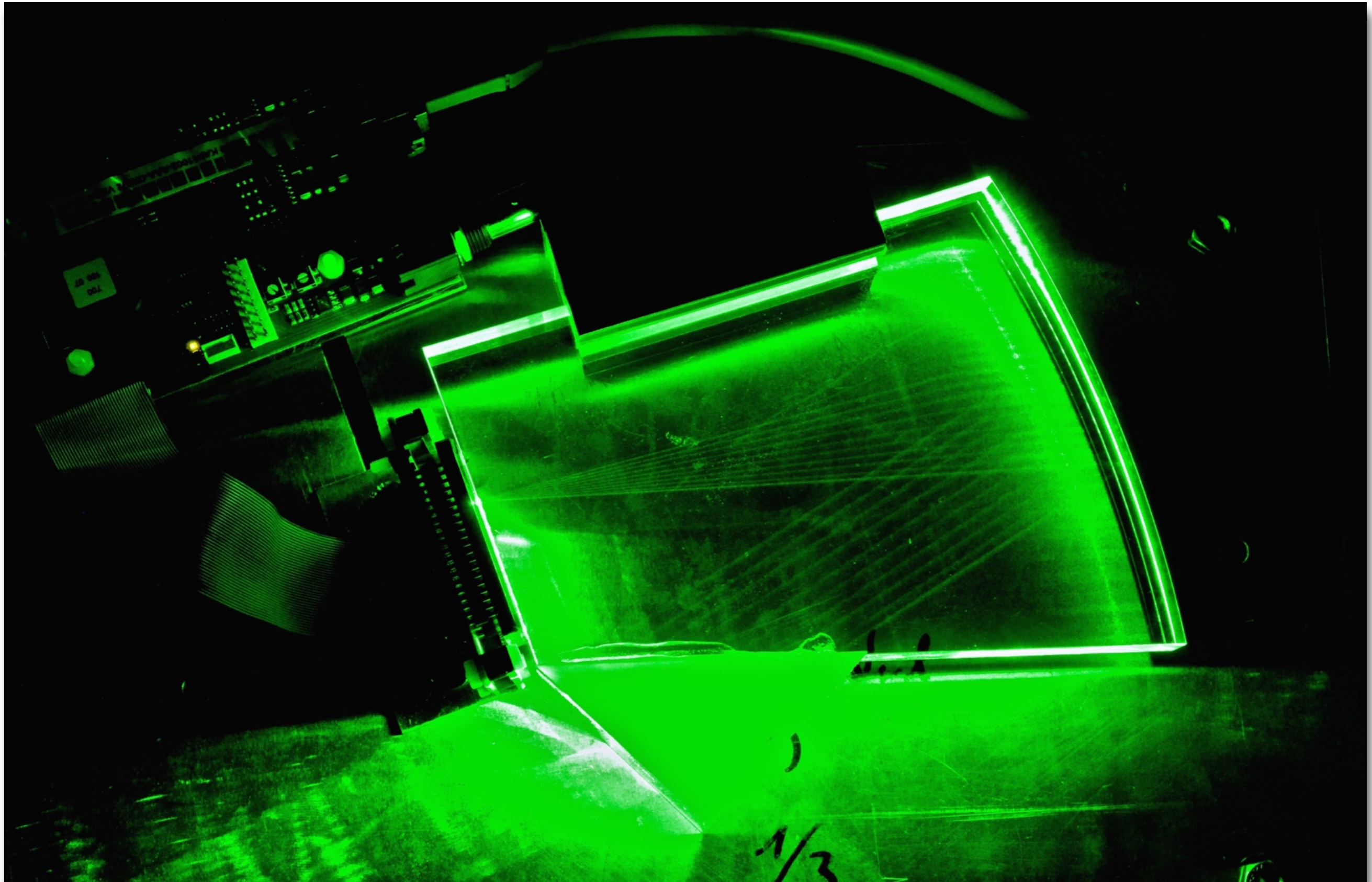
old dSiPM  
design



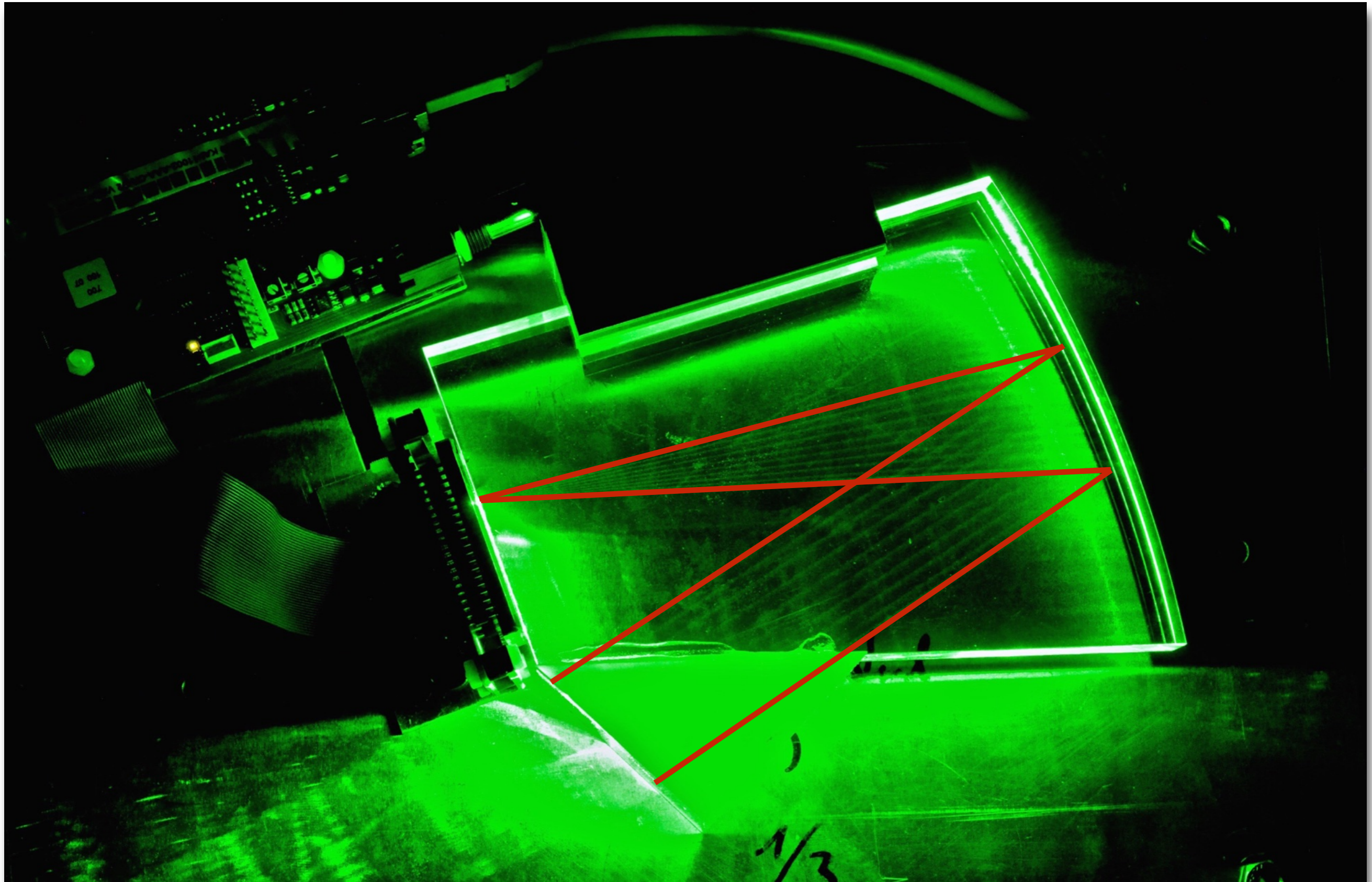
light-guides are to scale

- spot width for focussing matches with the step size of the MCP-PMT anode
- non-adhesive bonding of prism and FLG prevents from losses or defocussing of trespassing photons

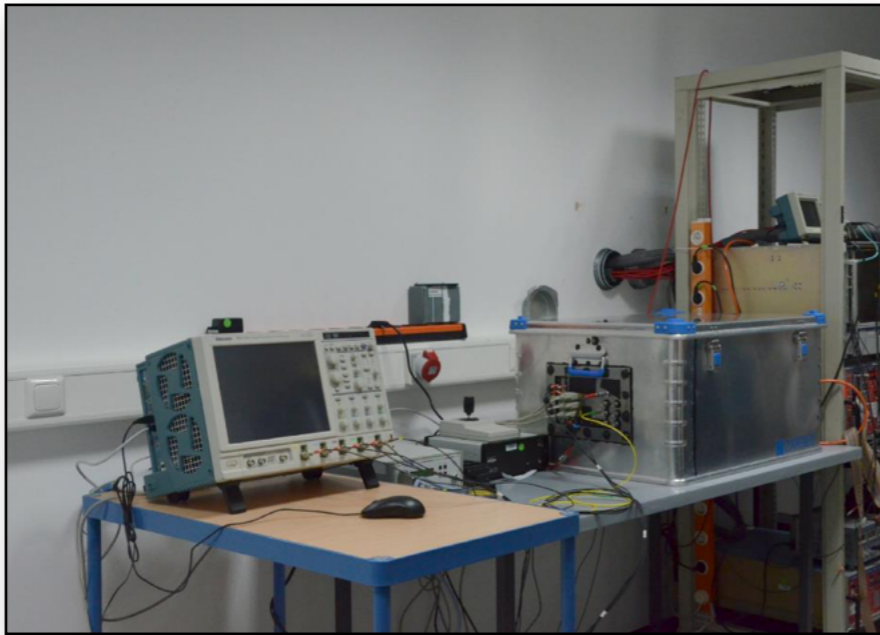








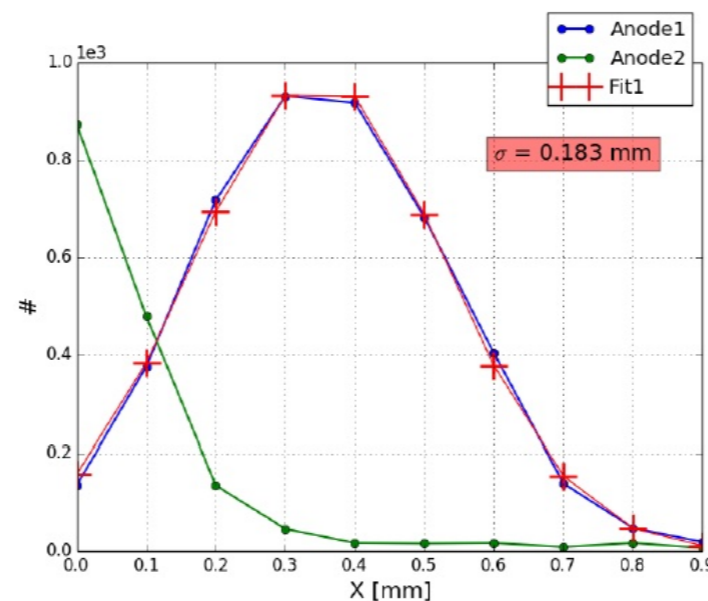
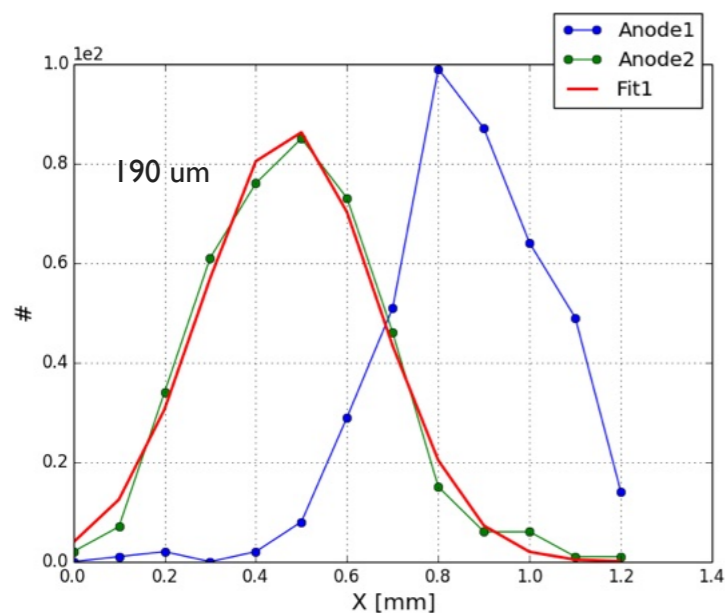
- automated setup for precise MCP-PMT QA measurements and setup with permanent magnets available
- Photonis MCP-PMT without proximity focussing works well in a magnetic field
- Hamamatsu measurements are on the way



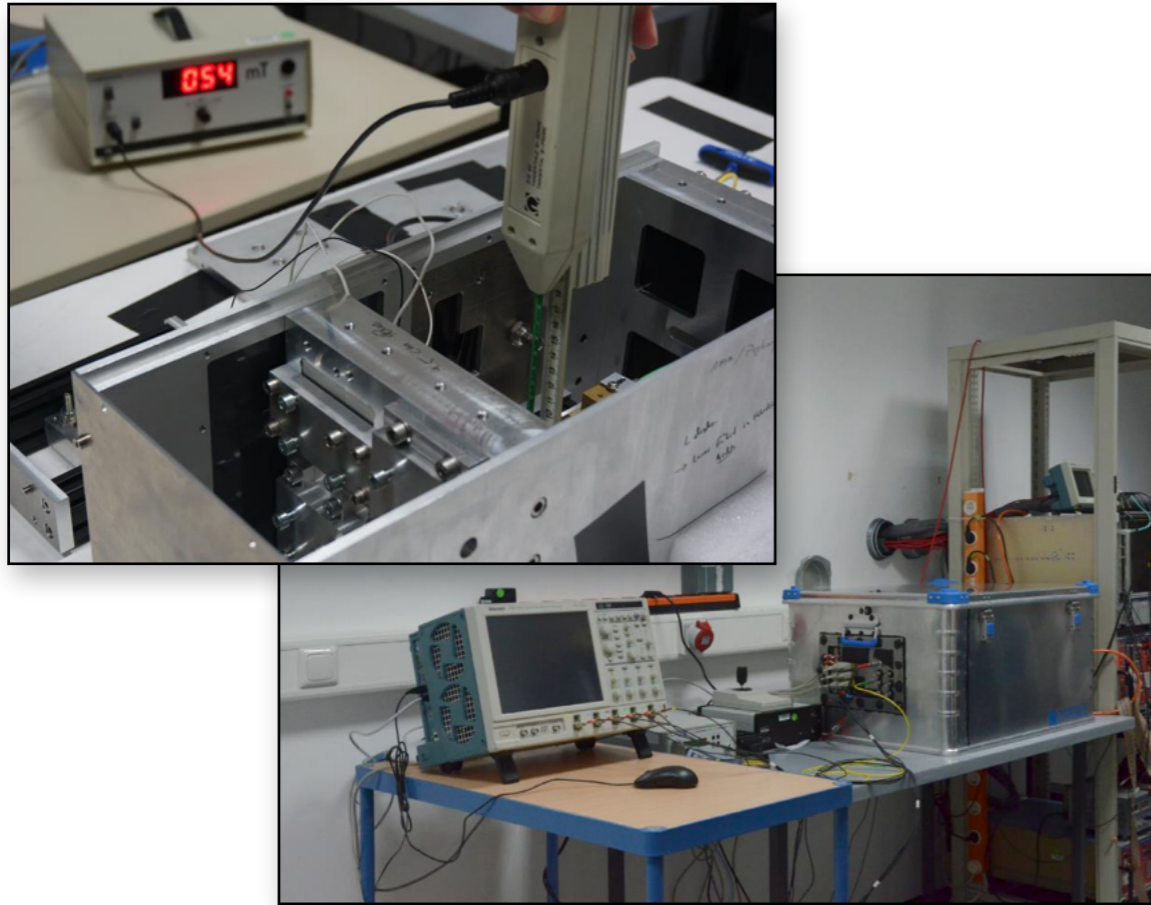
Photonis

Hamamatsu

prox. focus

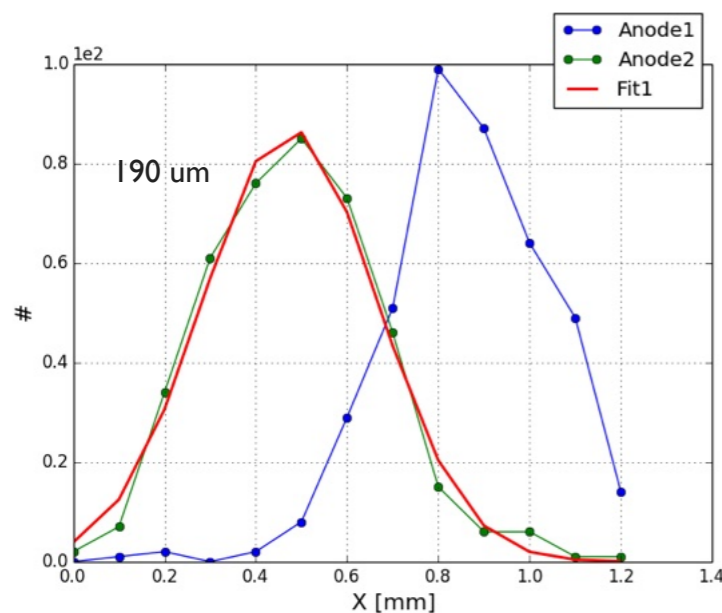






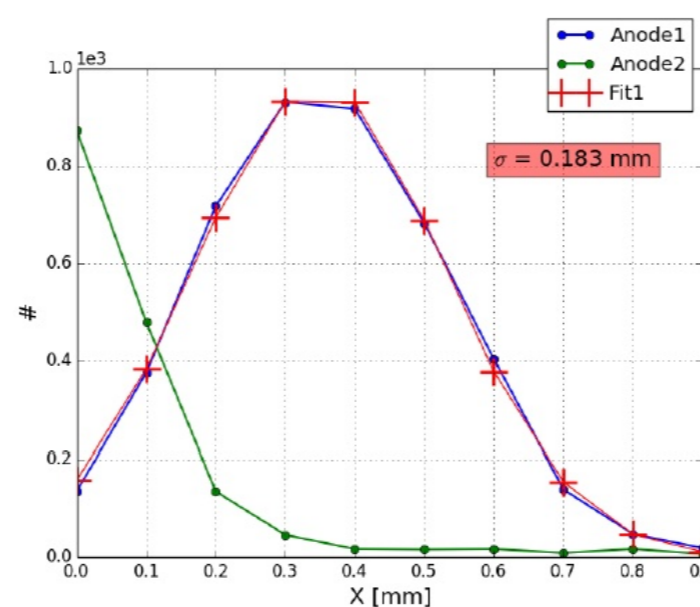
- automated setup for precise MCP-PMT QA measurements and setup with permanent magnets available
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Hamamatsu

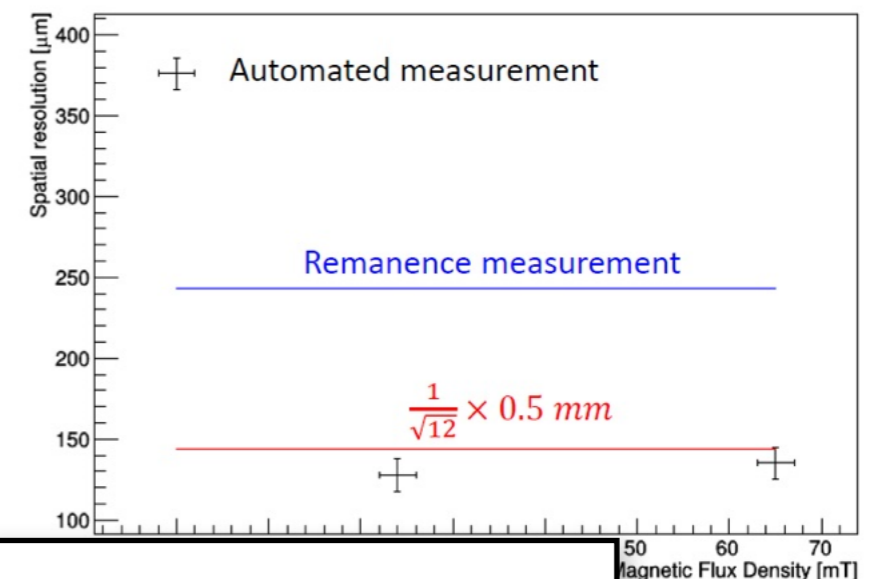


Photonis

prox. focus

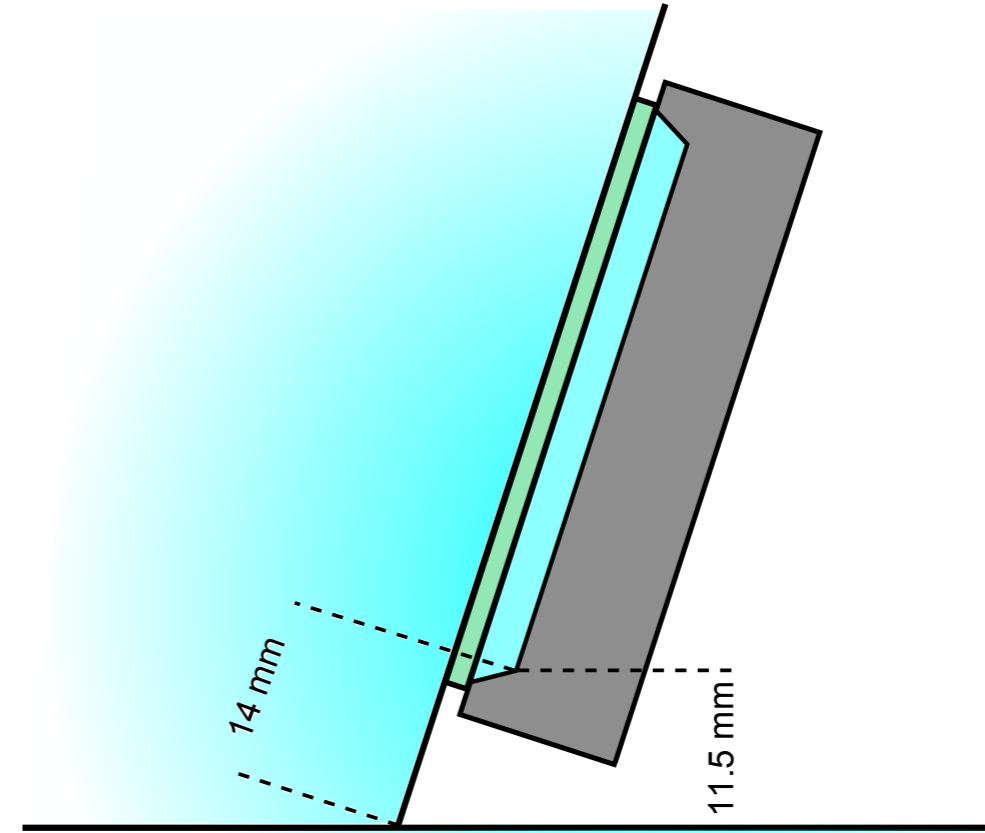
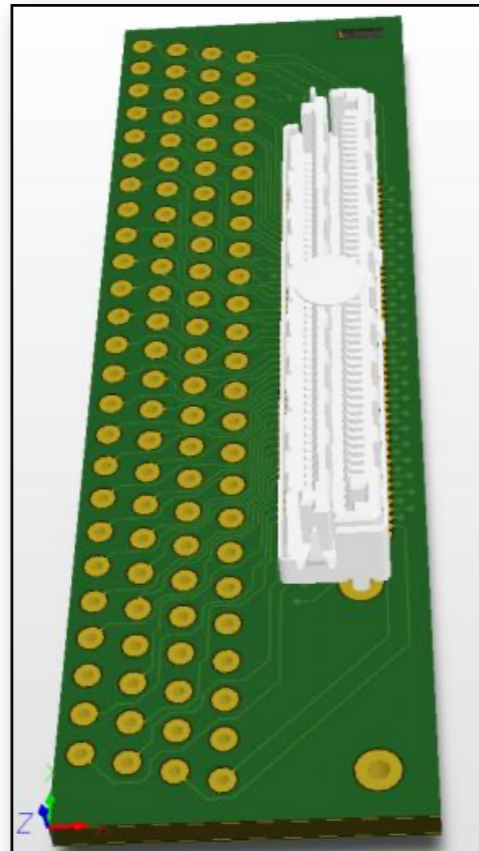
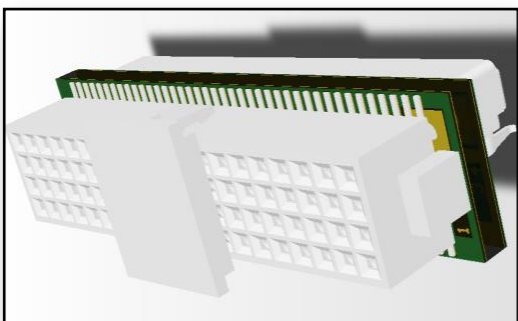
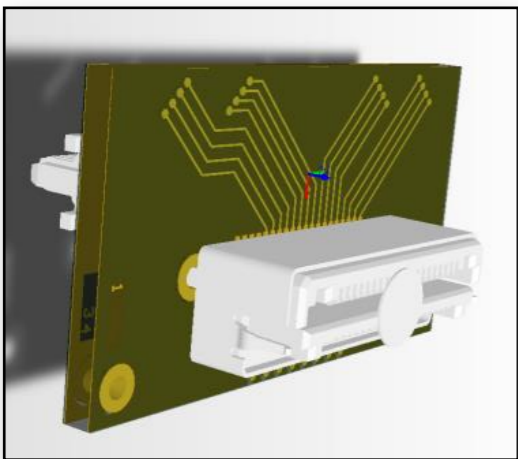
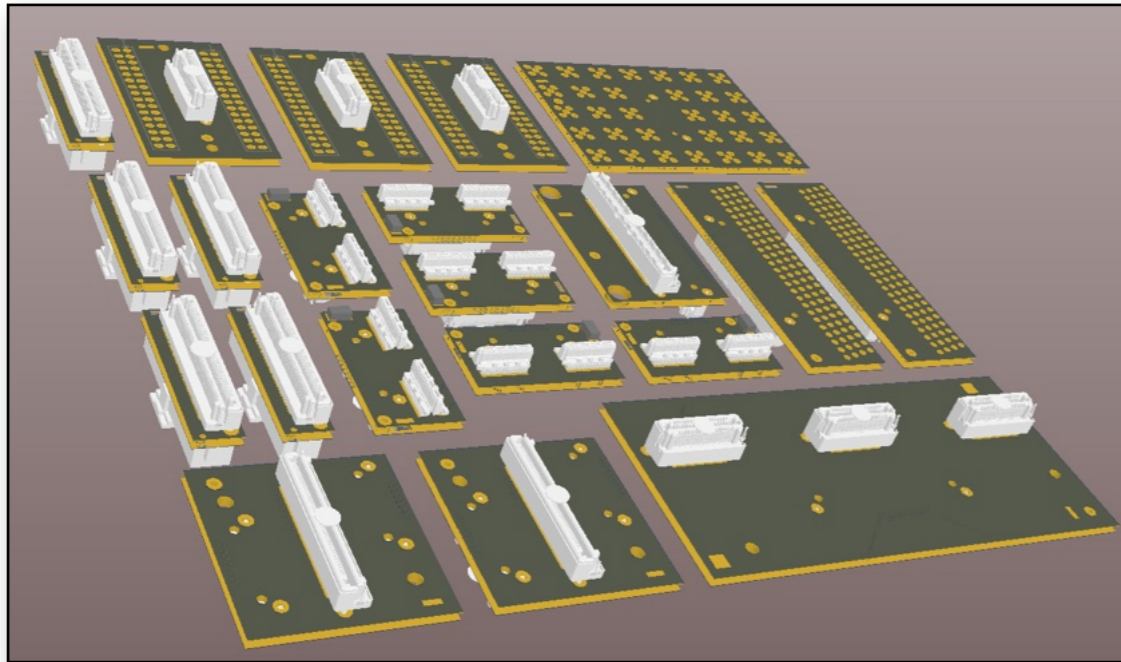


no prox. focus



see talk by J.Rieke

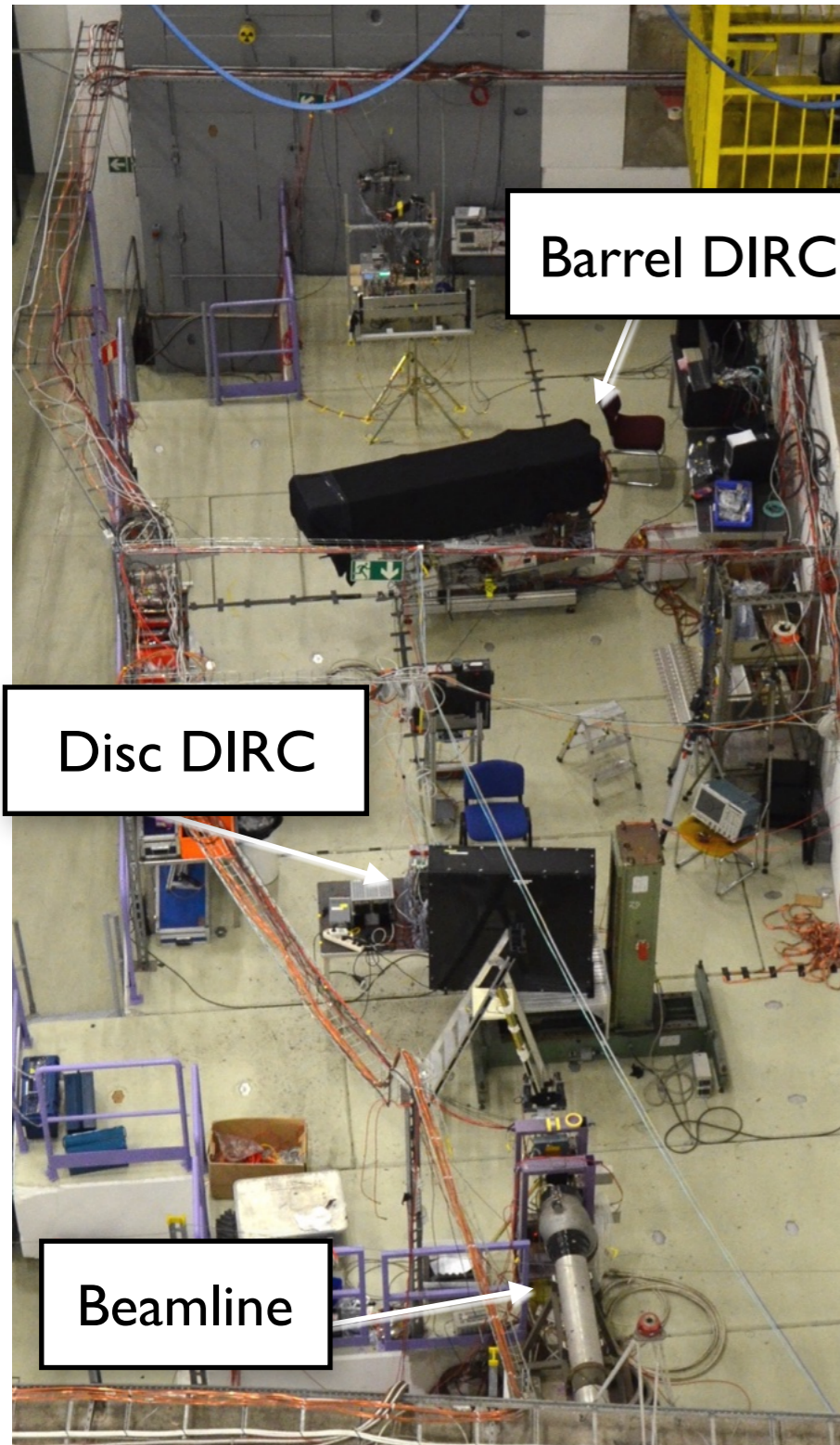




- pointed angle between prism and FLG requires a compact solution
- second iteration of PCBs is being produced in preparation for a TOFPET readout

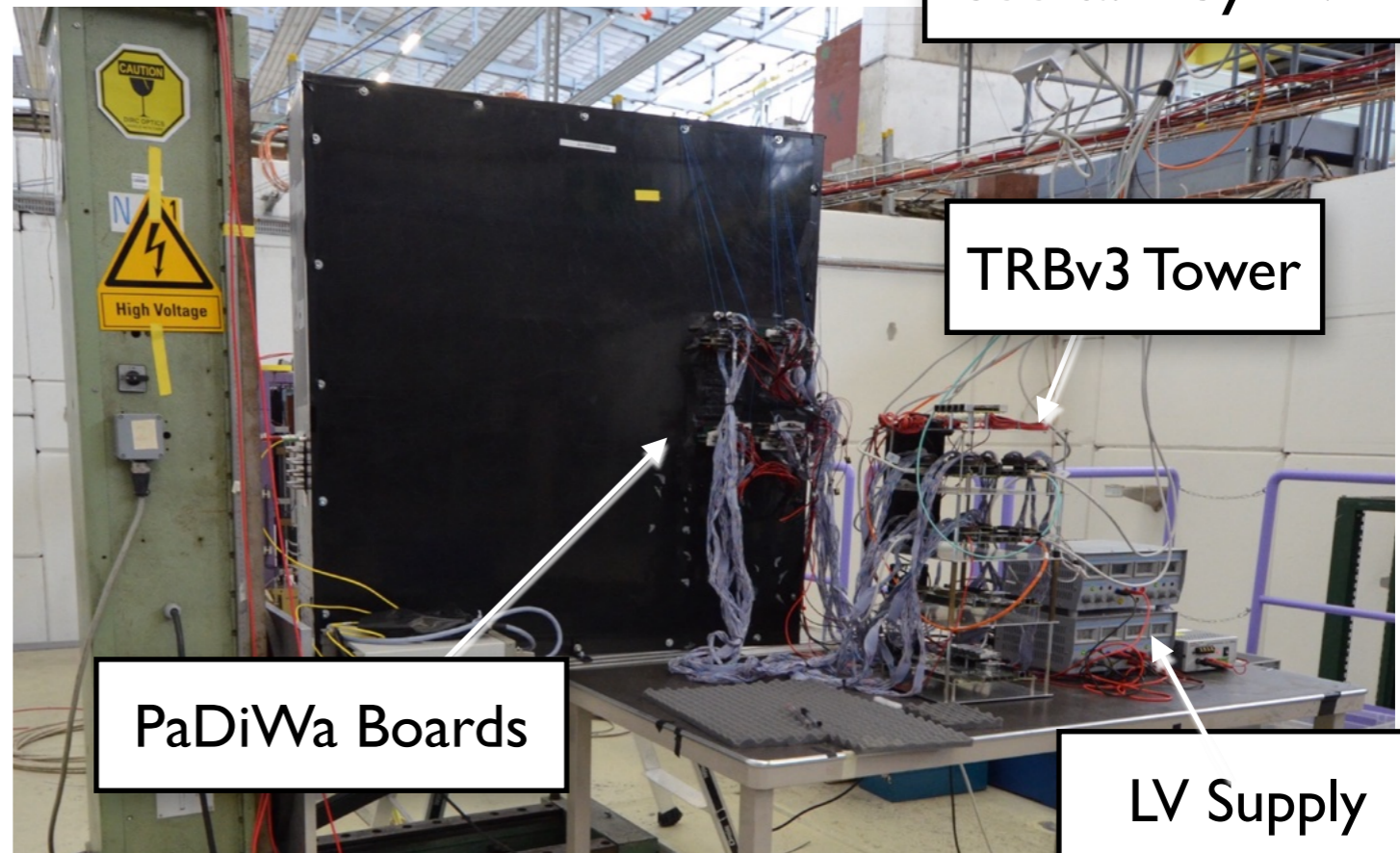
see talk by L. Ferramacho



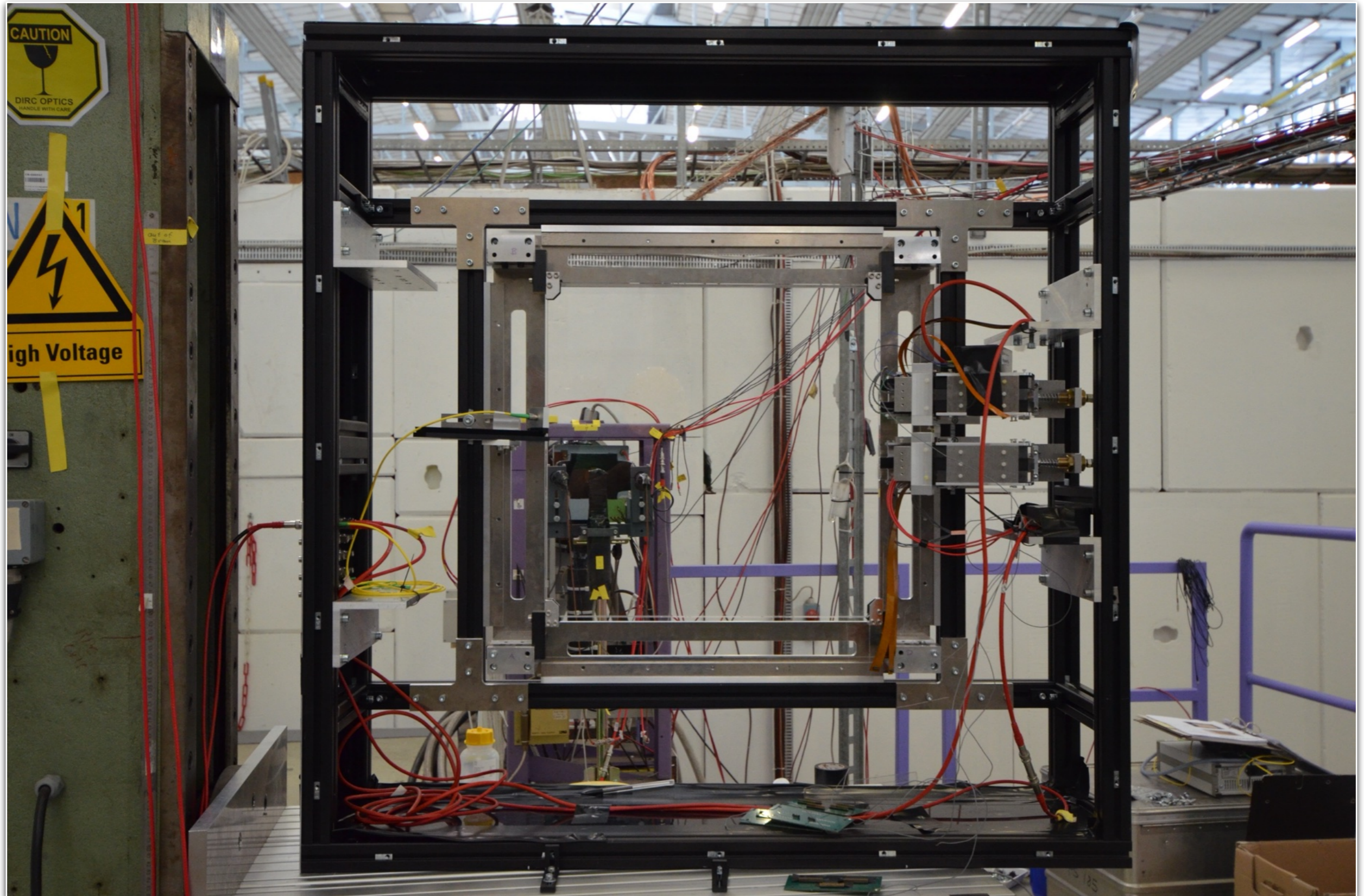


- joint testbeam of the Barrel and Disc DIRC prototypes
- mixed hadron beam up to 10 GeV/c
- common system for data taking (TRBv3)

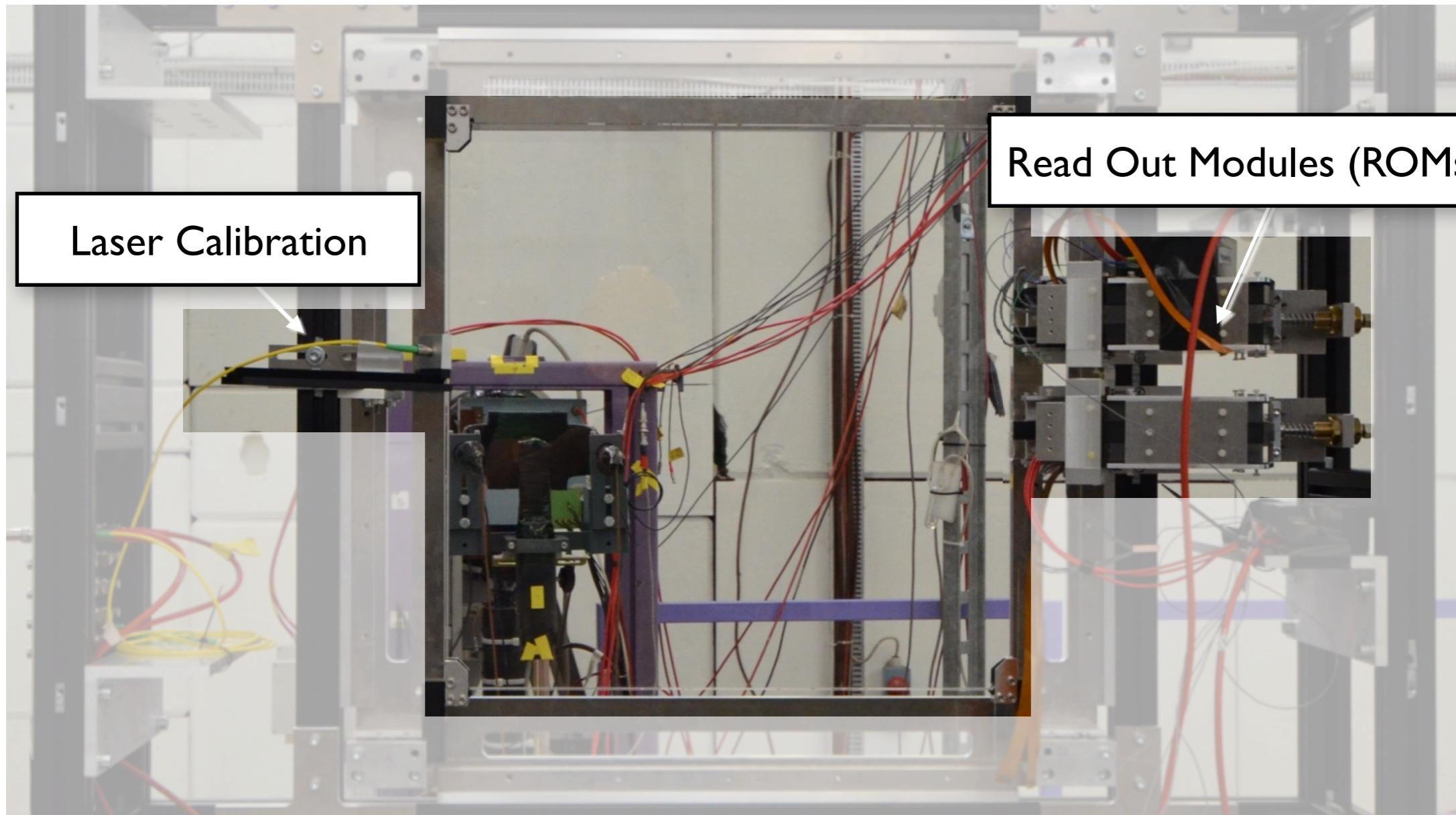
see talk by M.Traxler





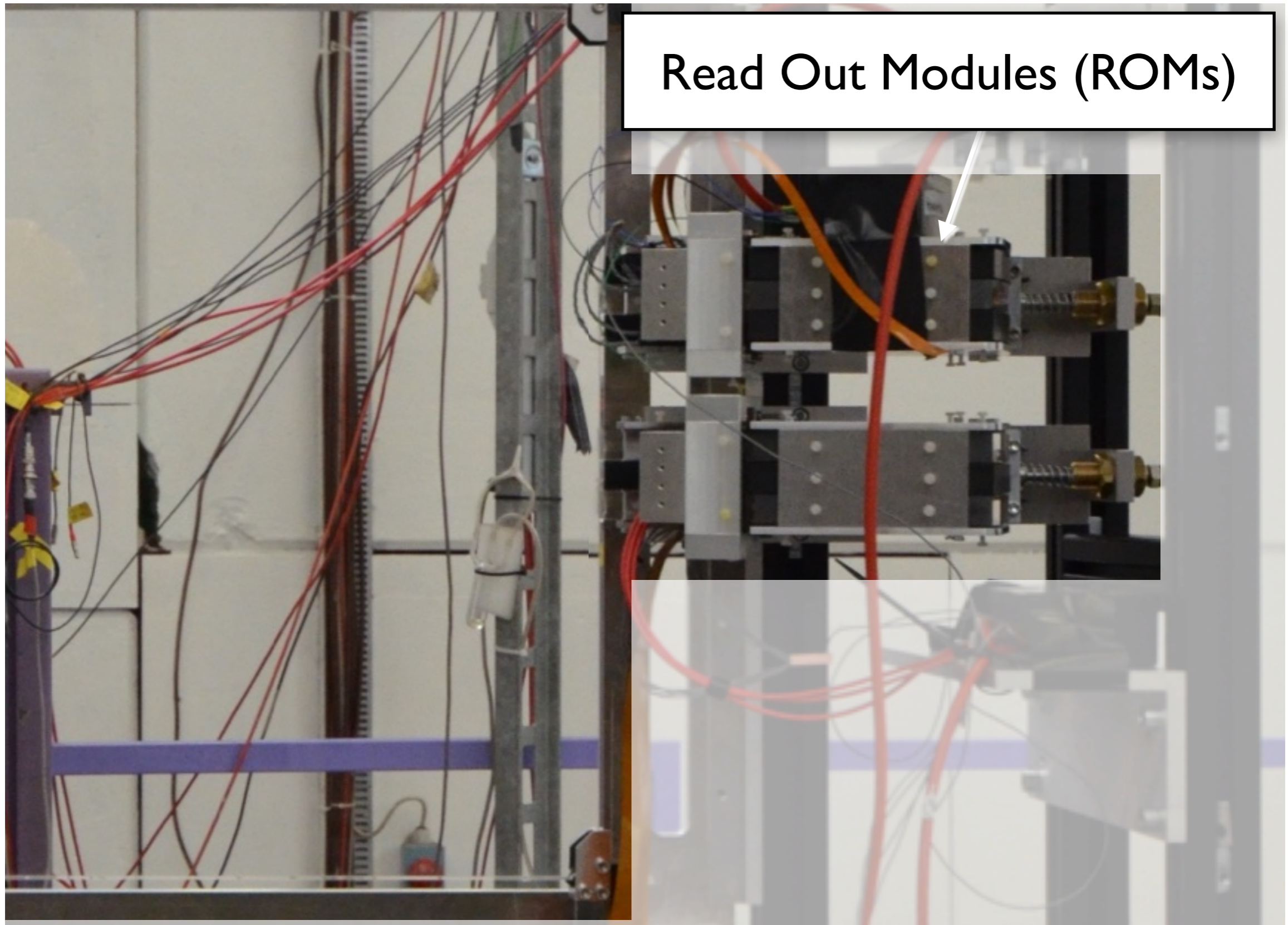




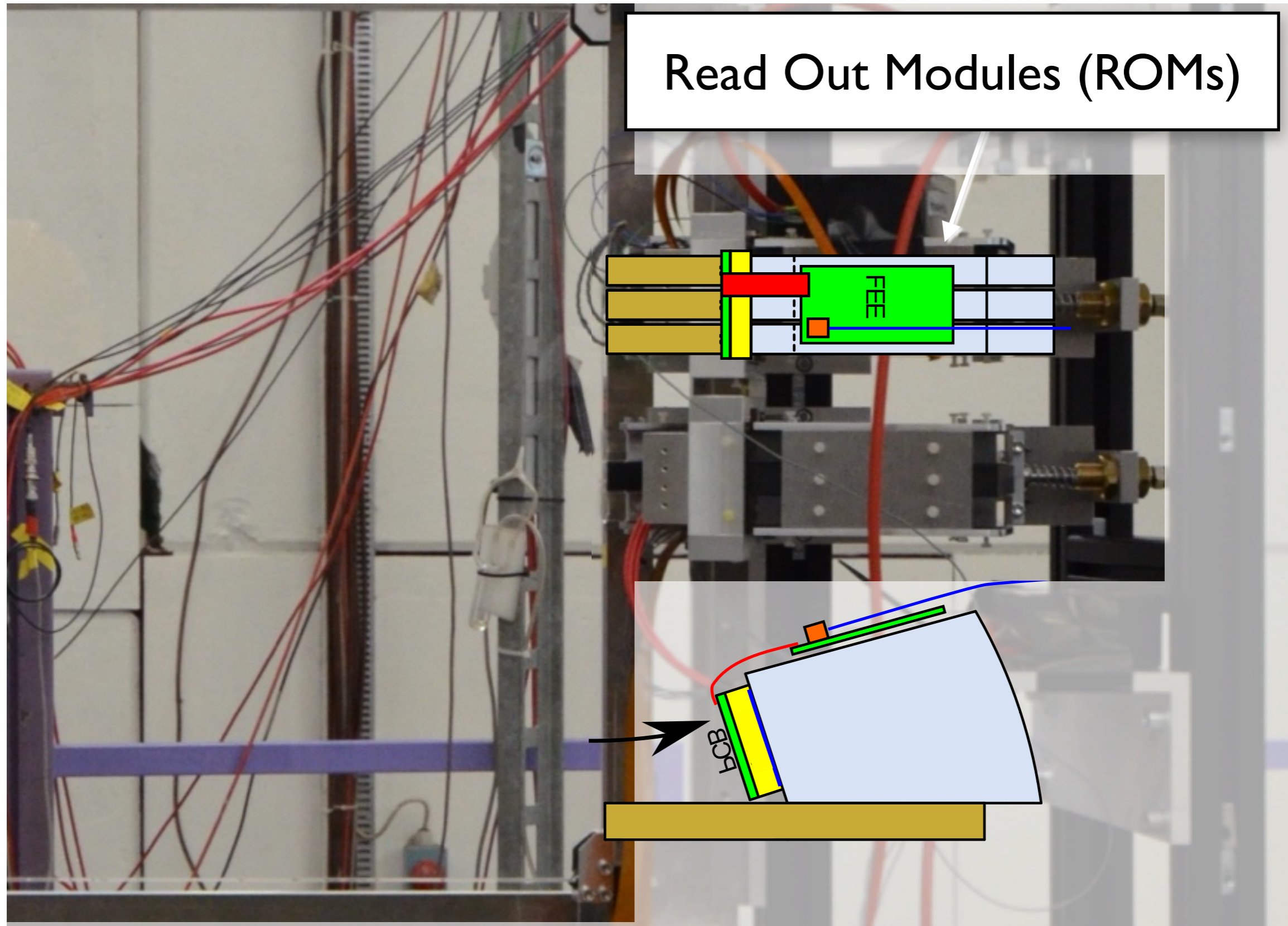


- Minimal setup with laser calibration
- Nevertheless over 300 readout channels
- Fused silica optics

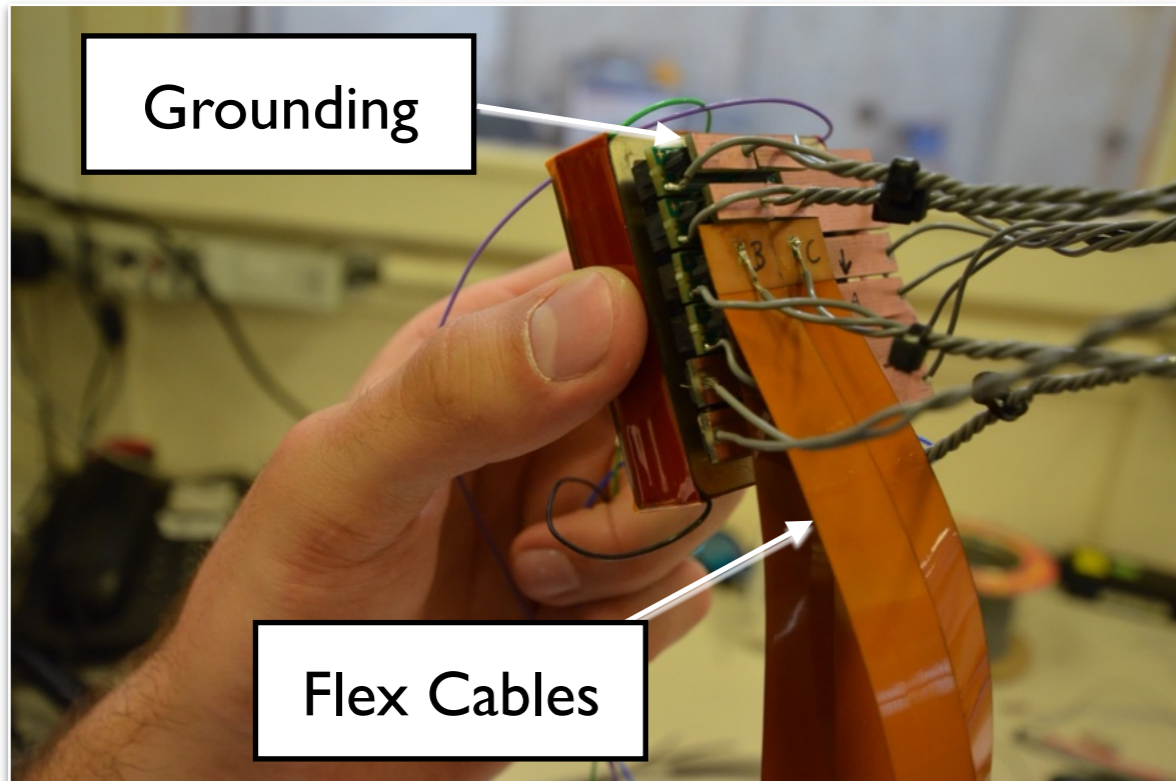
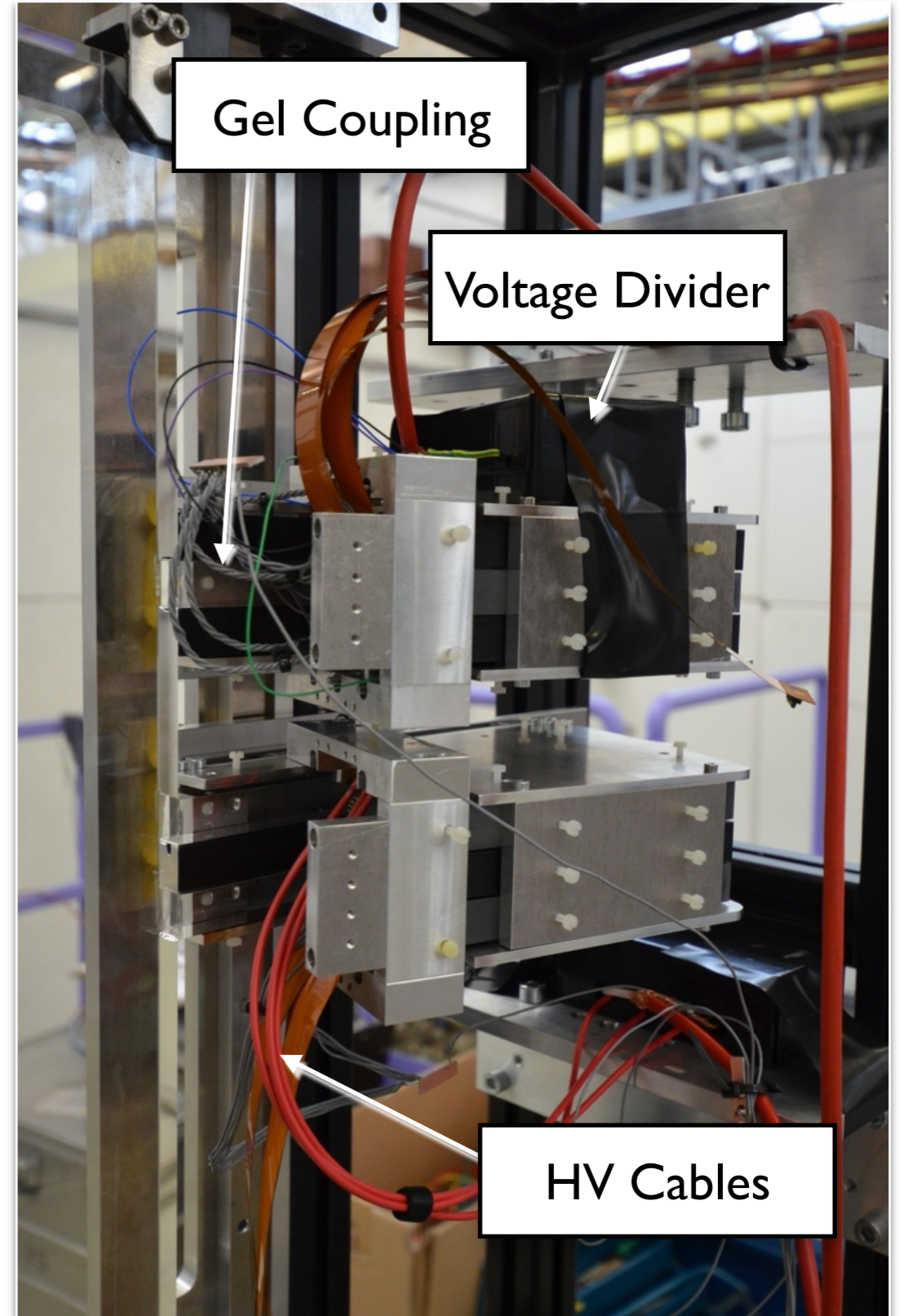
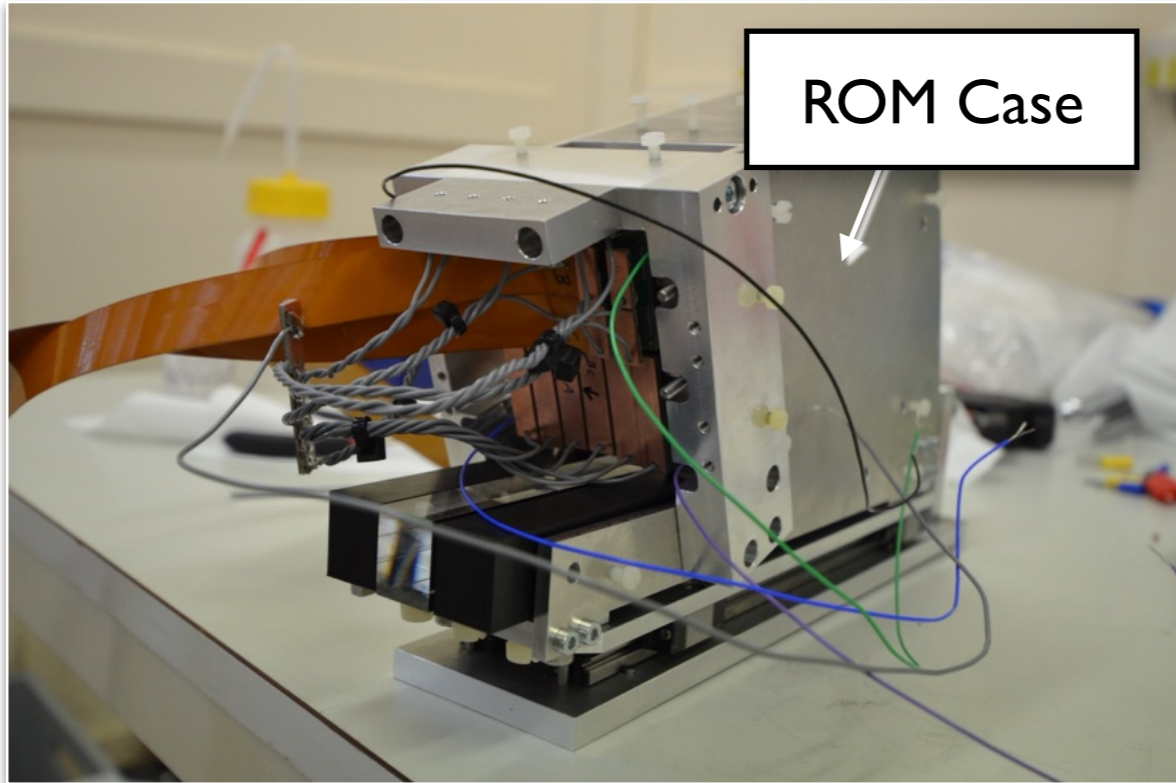


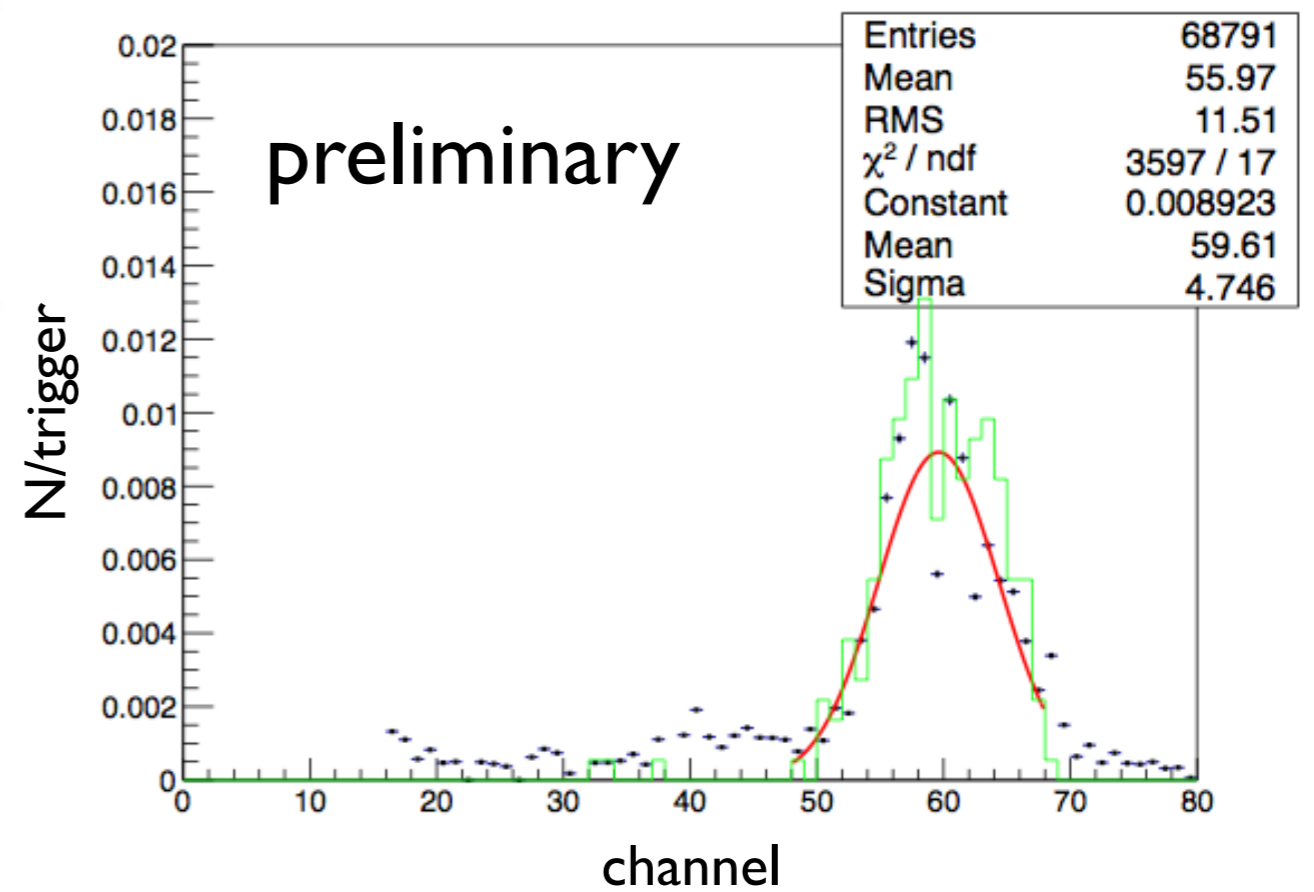
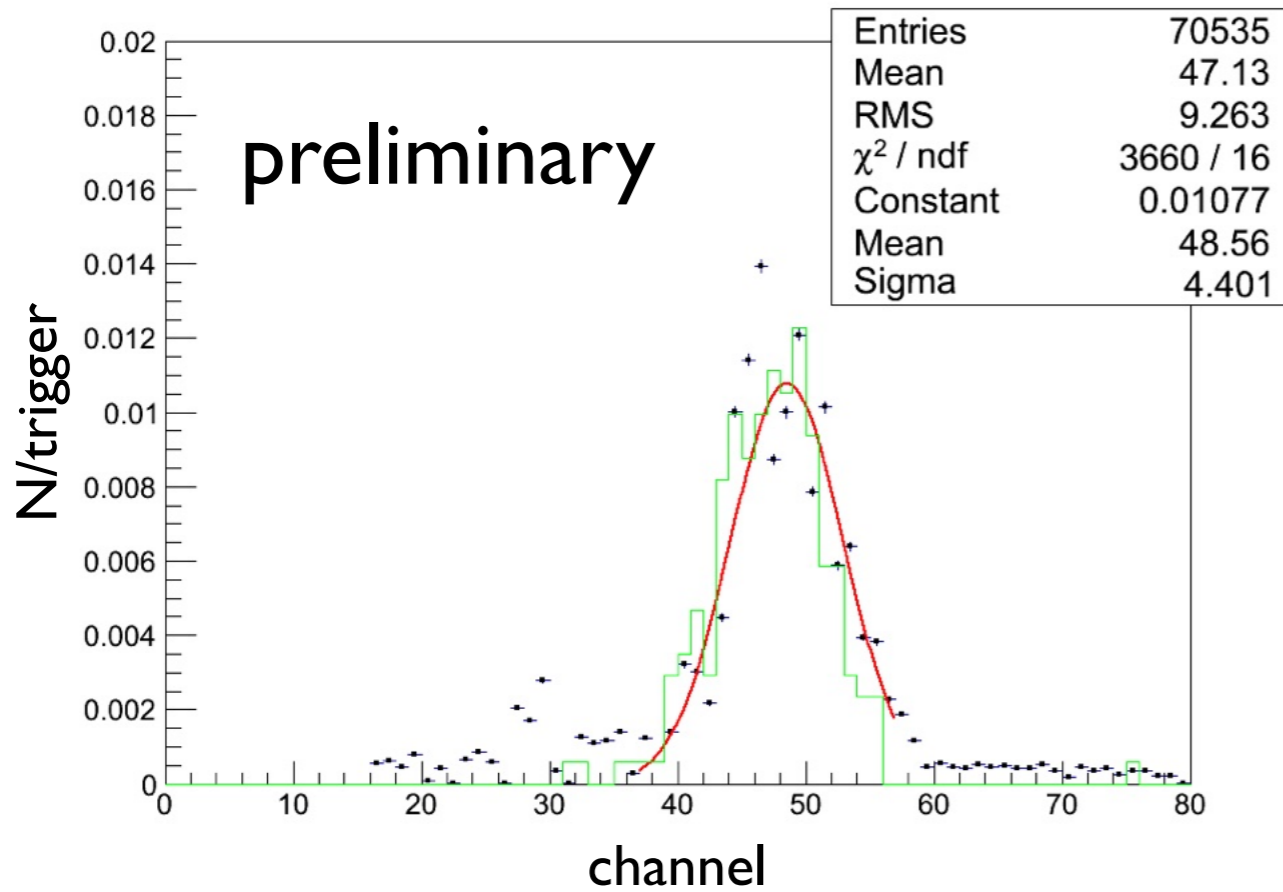






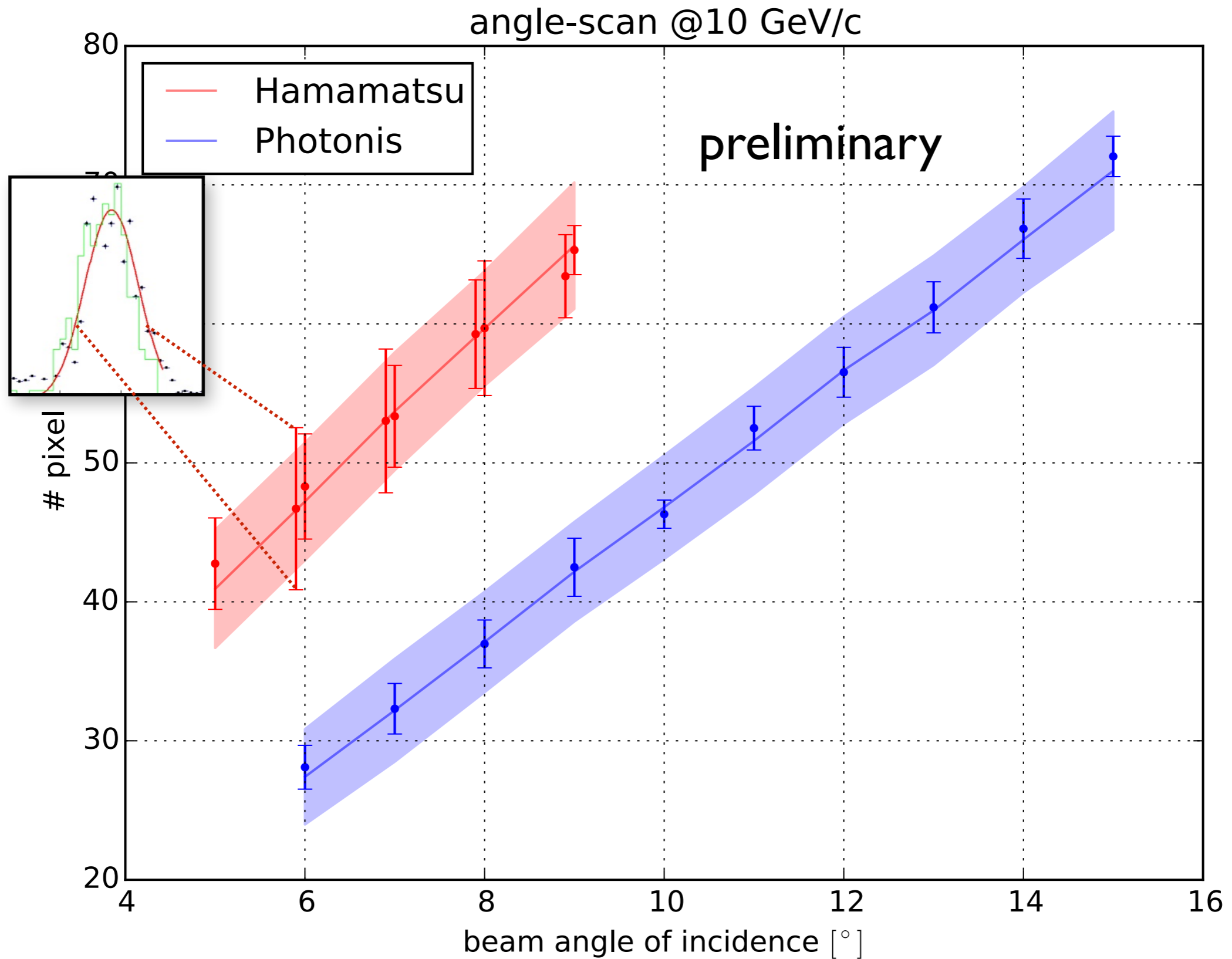


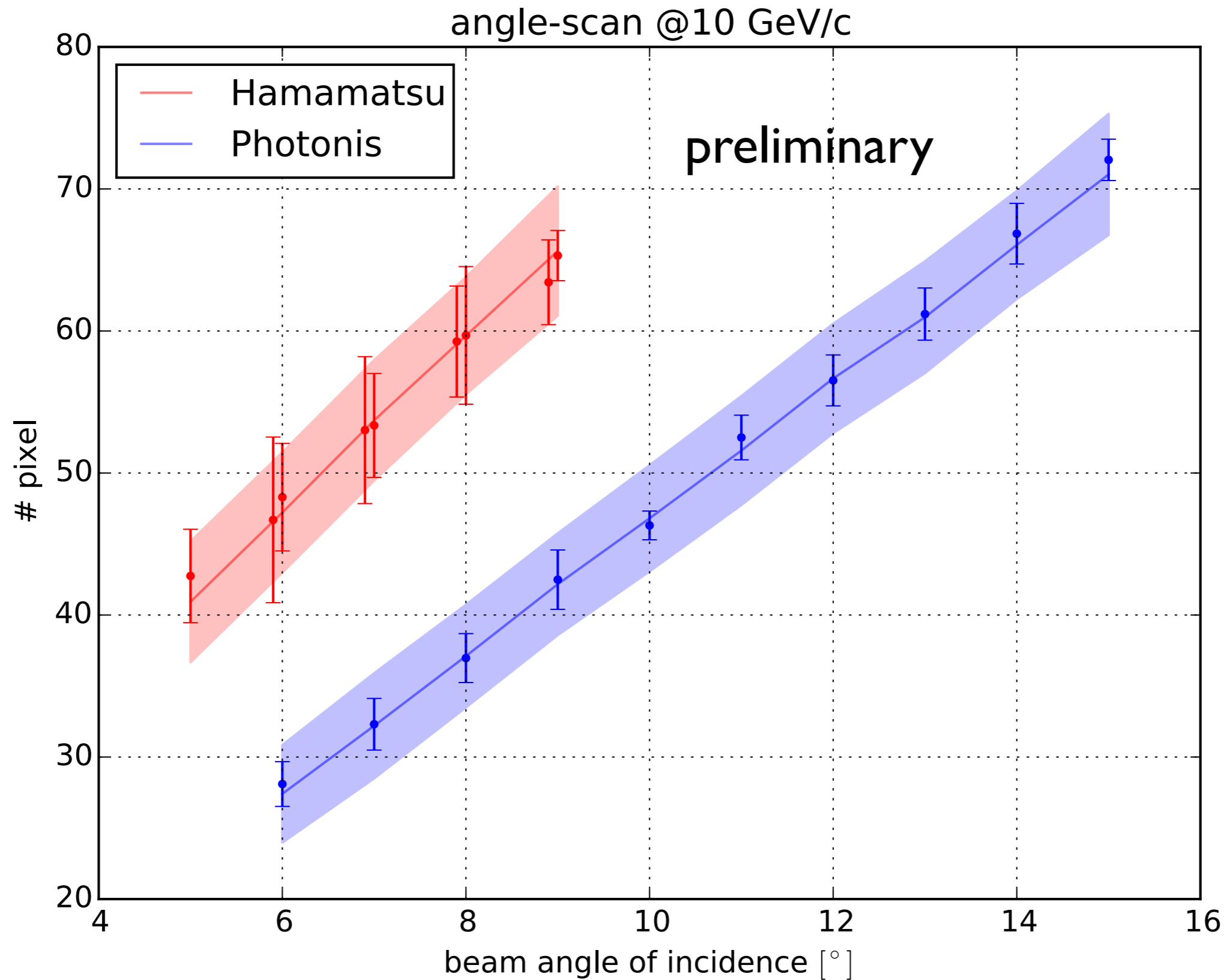




- 10 GeV/c mixed hadron beam
- angles of incidence are  $6^\circ$  (left) and  $8^\circ$  (right)
- Preliminary plots show a good agreement between MC and real data for number of hits vs. channel number



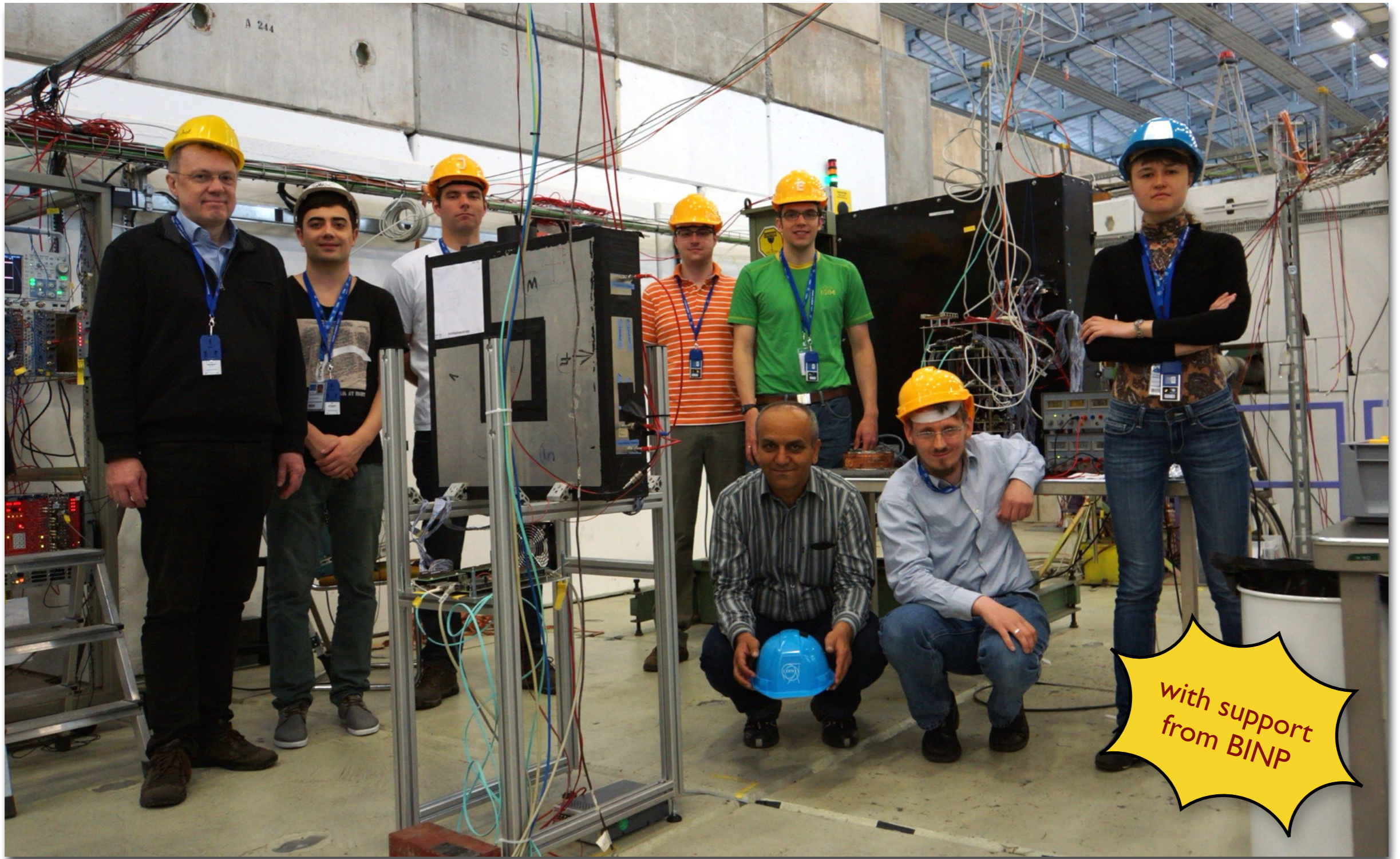






- final design found, realization is ongoing
- first prototype with final components has been tested  
(analysis is ongoing)
- a larger prototype (with more ROMs) is currently being designed
- readout is being minimized and ASICs are being tested
- mechanical design and assembly has to be determined

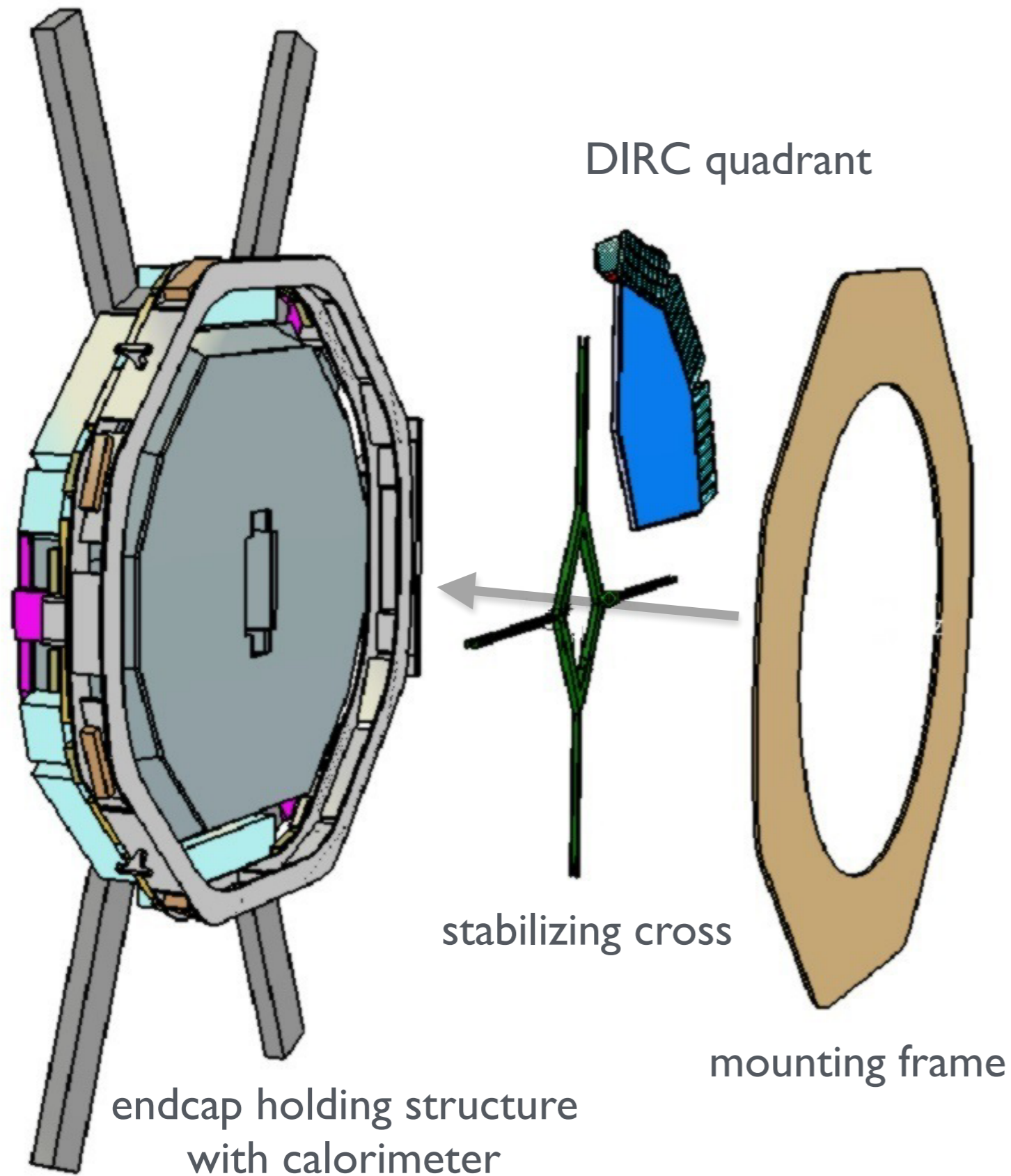




## Thank you for your attention



# Backup

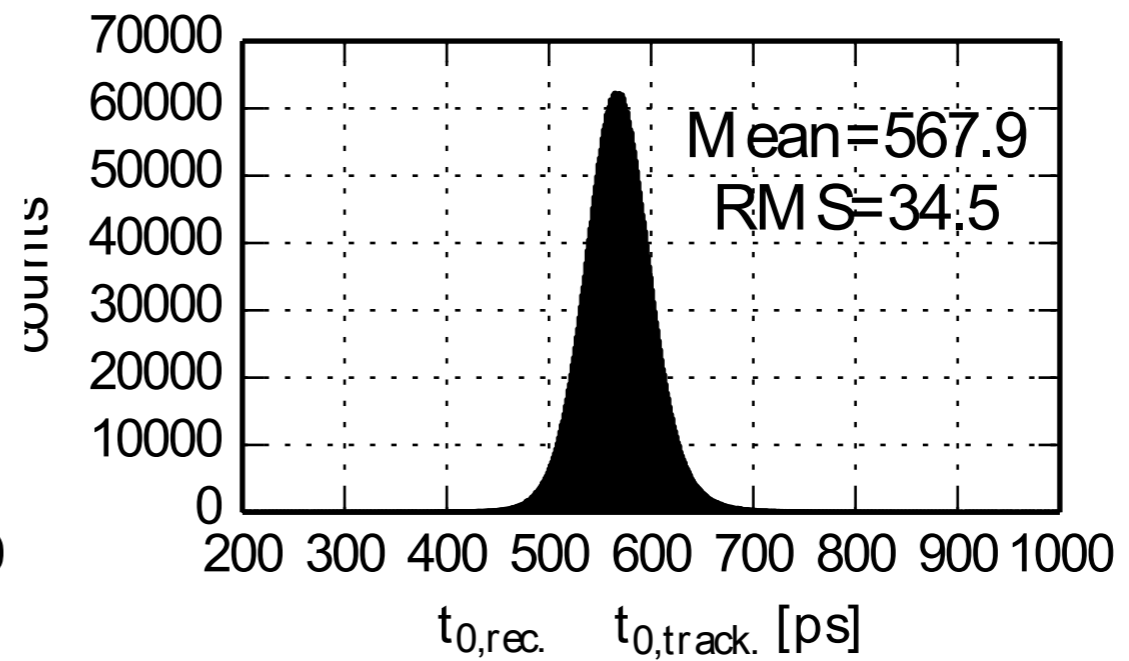
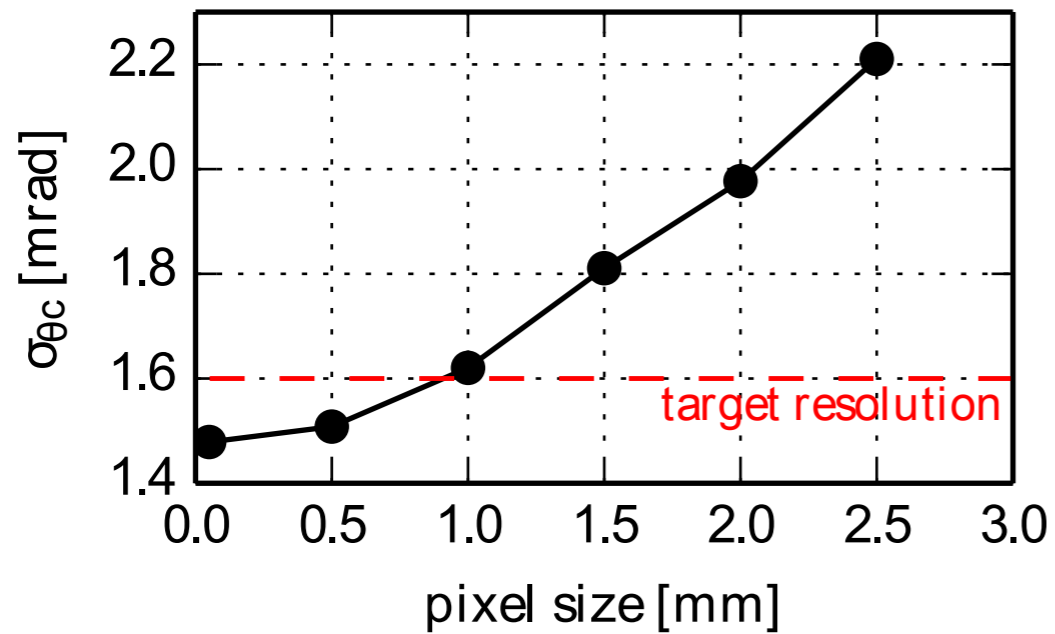
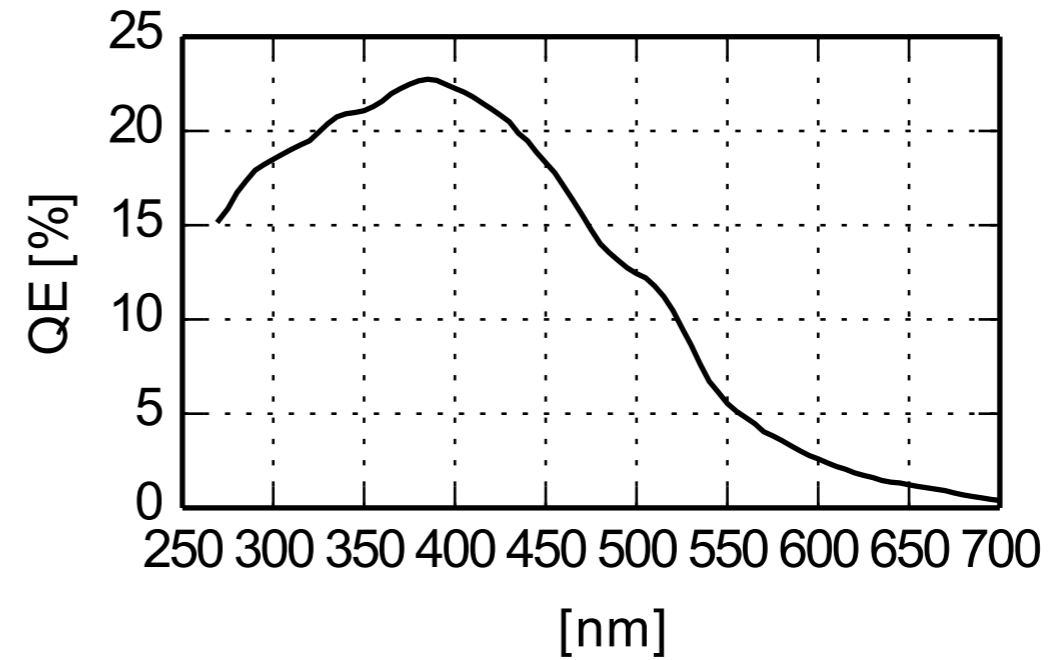
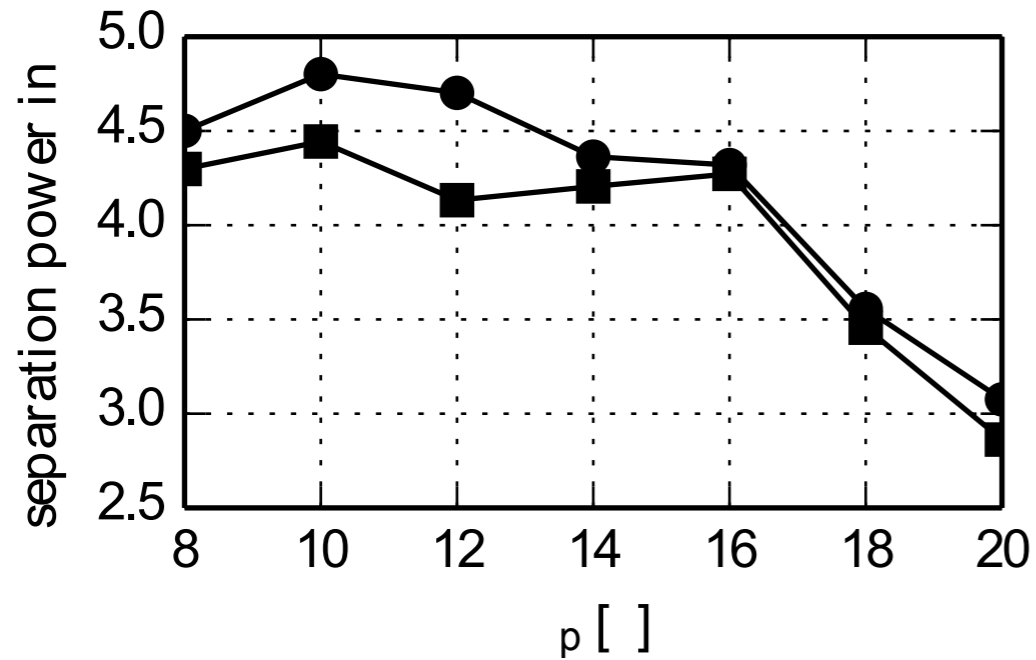


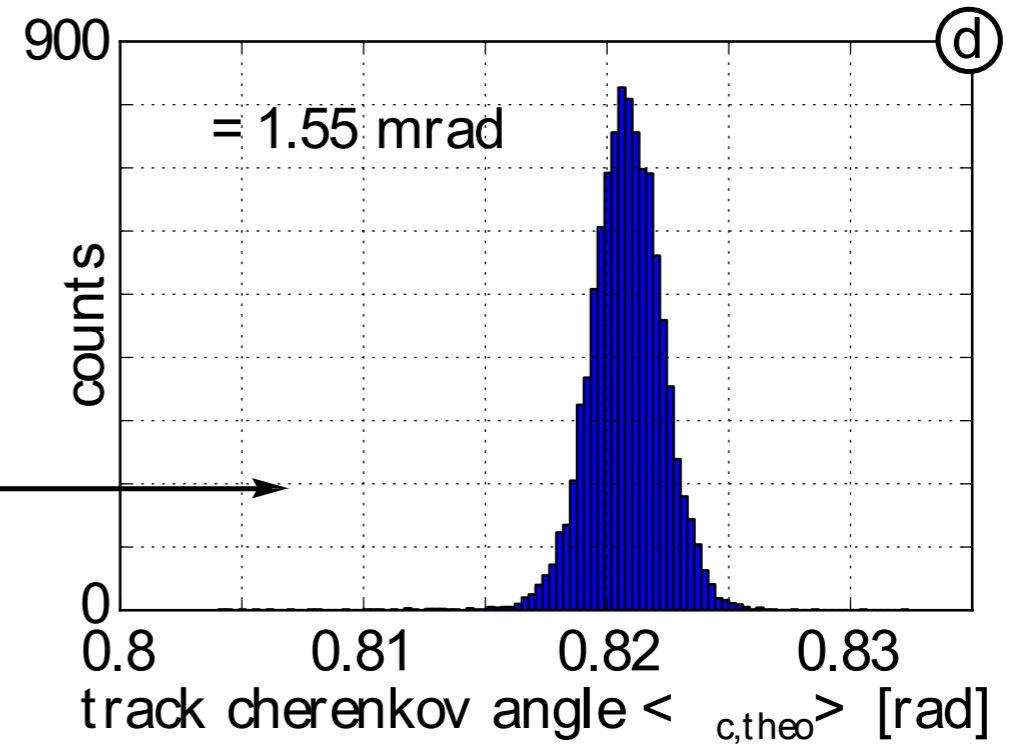
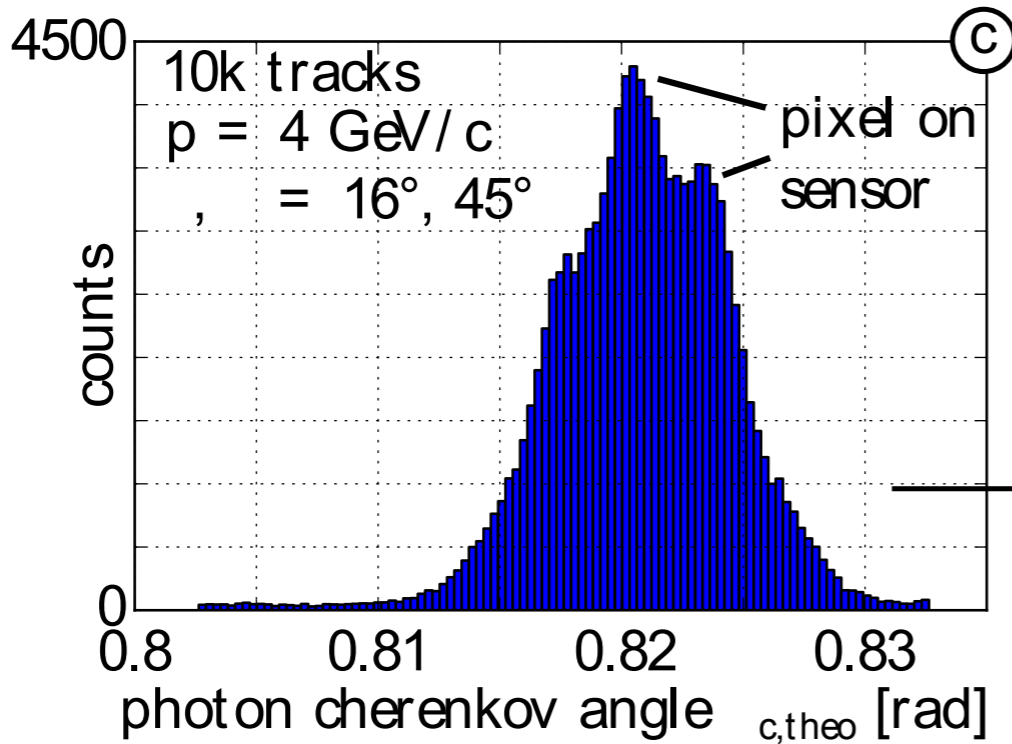
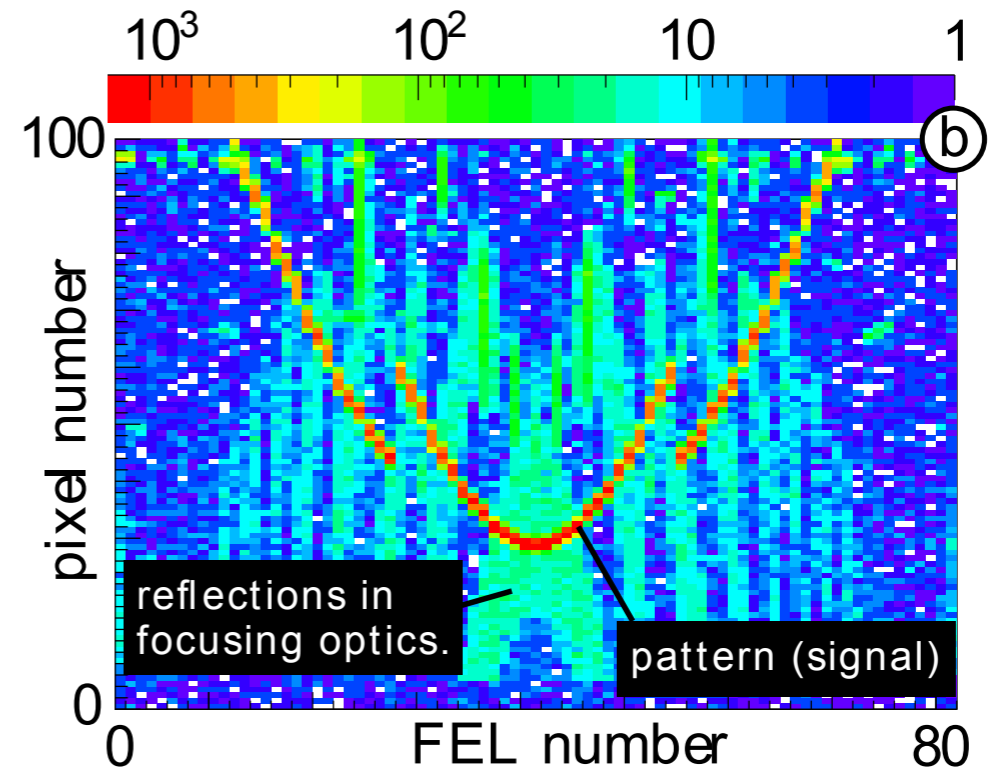
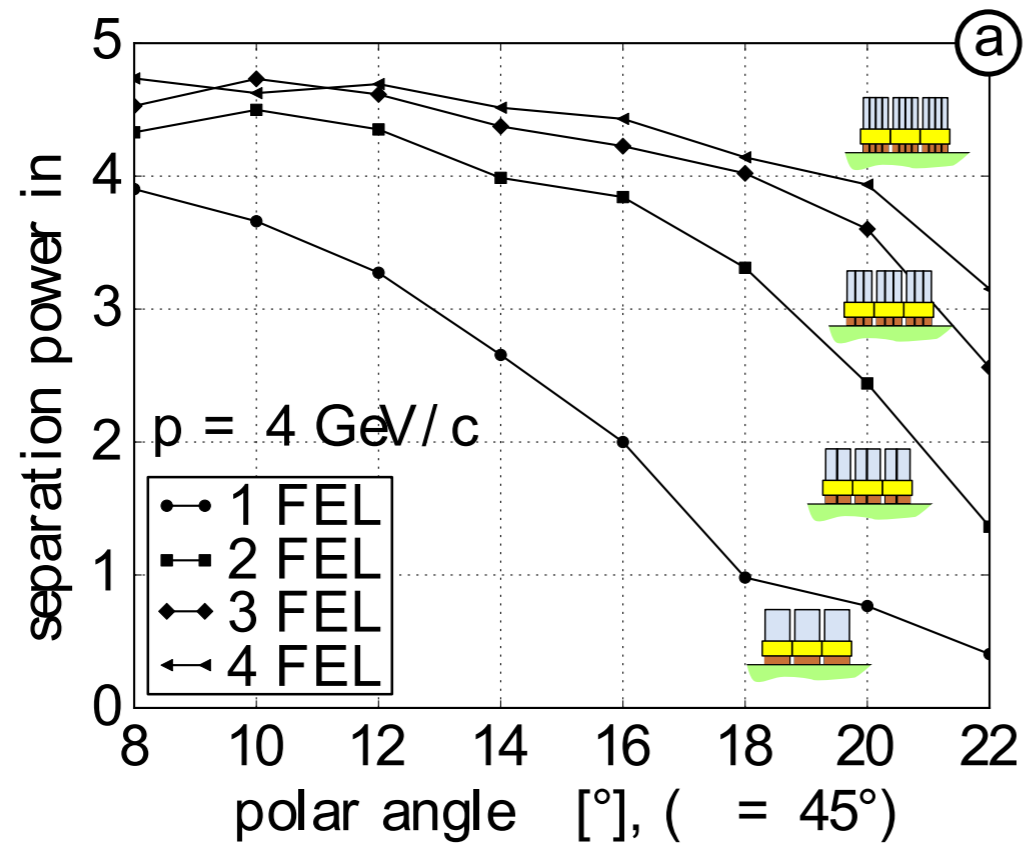
assembly of **DIRC** quadrants with **stabilizing cross** and **mounting frame** in horizontal position

bring fully assembled **DIRC** to a vertical position using a custom-built mounting device

slowly move **DIRC** up to the **endcap holding structure**

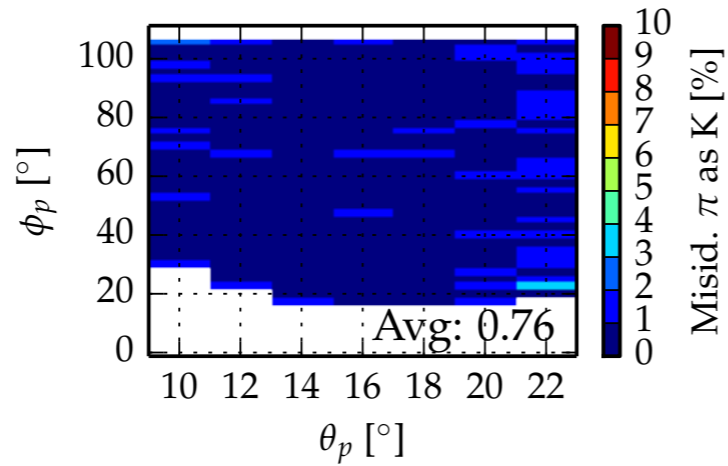




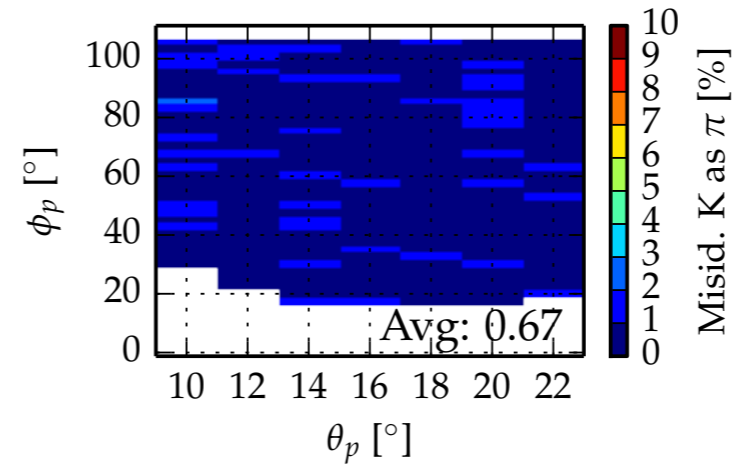


O. Merle (PhD-Thesis, 2015)

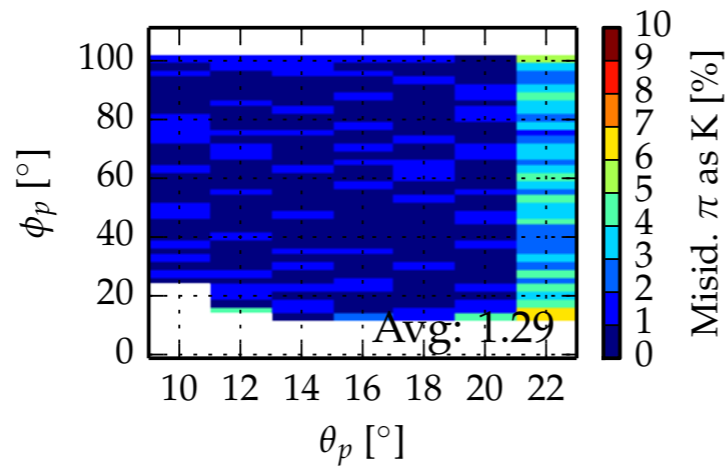




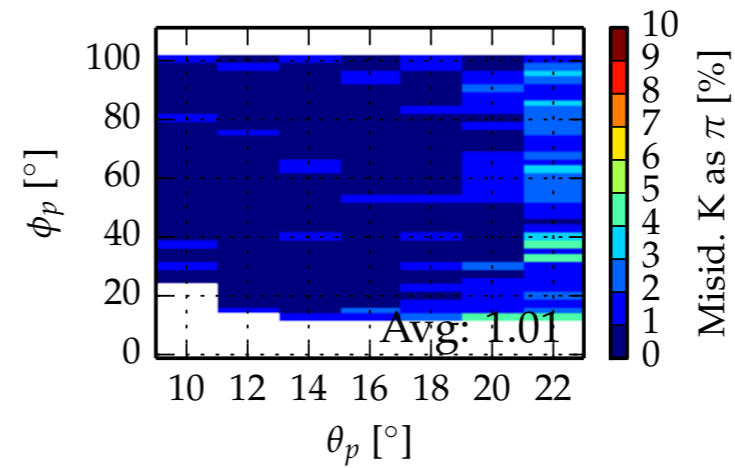
(a)  $\pi$  at 2 GeV/c



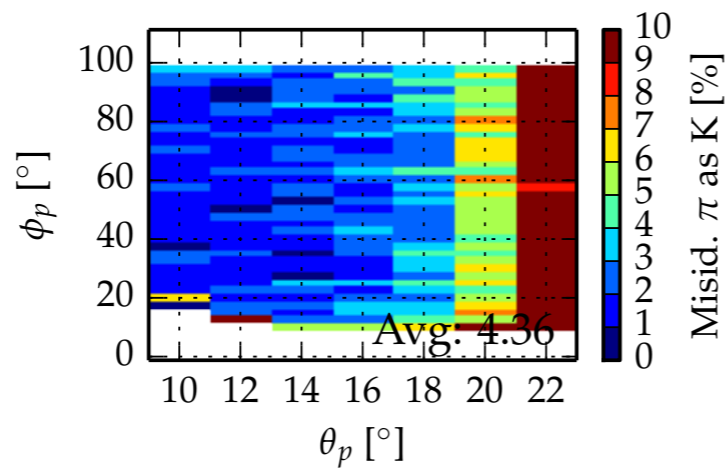
(b) K at 2 GeV/c



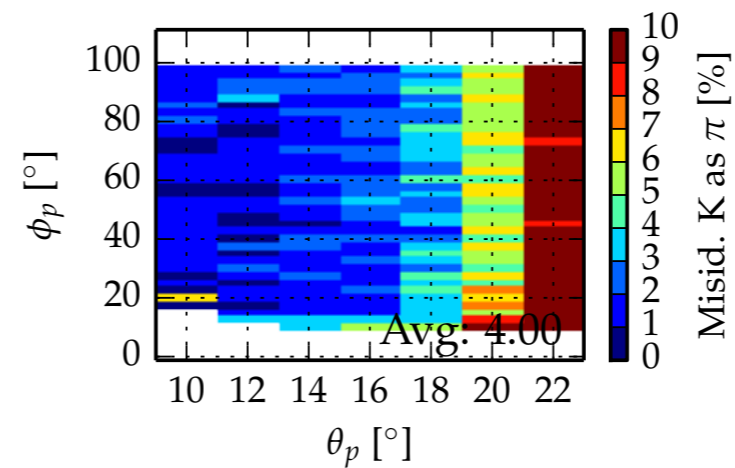
(c)  $\pi$  at 3 GeV/c



(d) K at 3 GeV/c

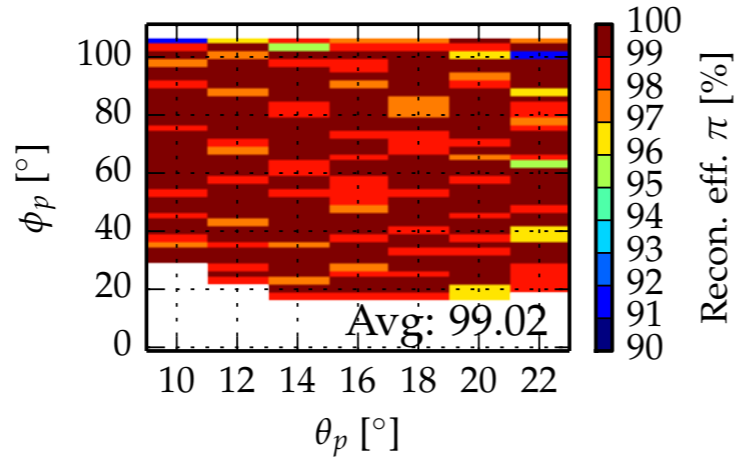


(e)  $\pi$  at 4 GeV/c

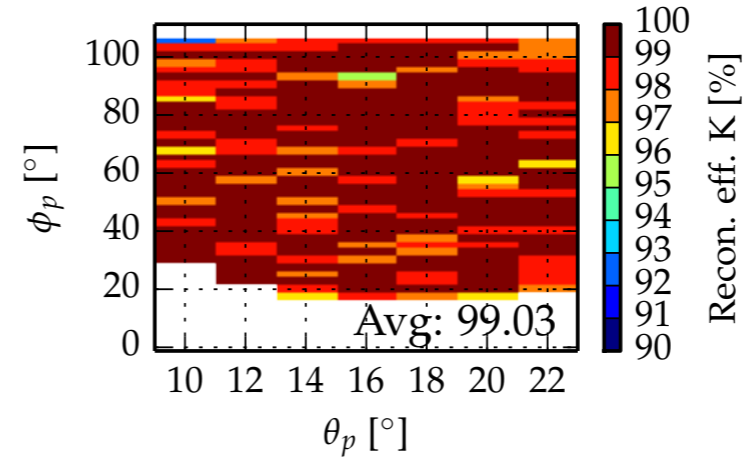


(f) K at 4 GeV/c

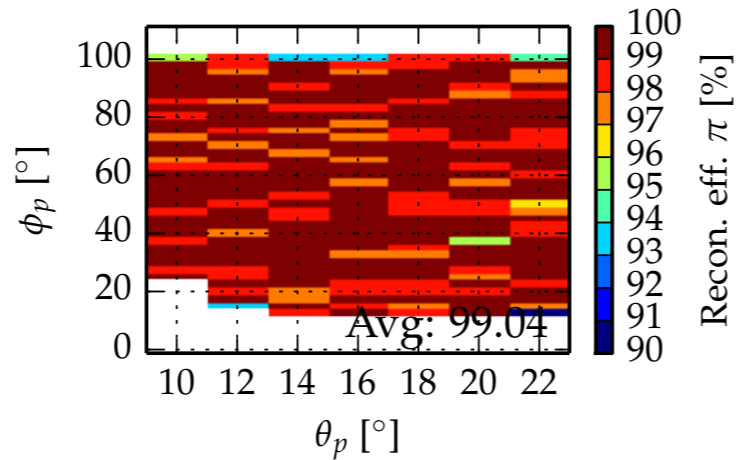
O. Merle (PhD-Thesis, 2015)



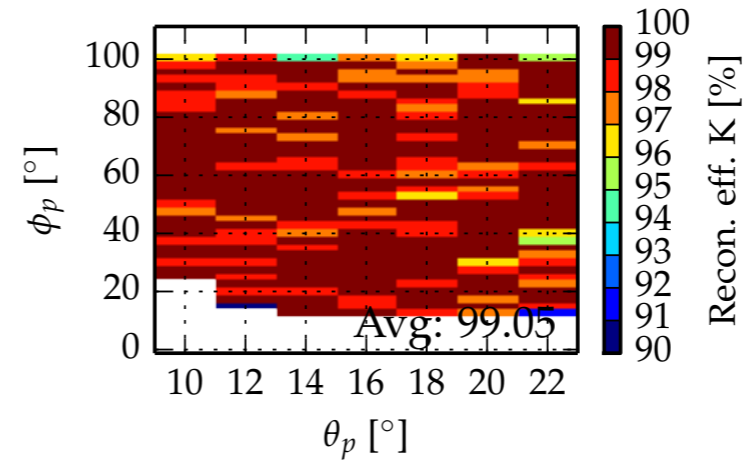
(a)  $\pi$  at 2 GeV/c



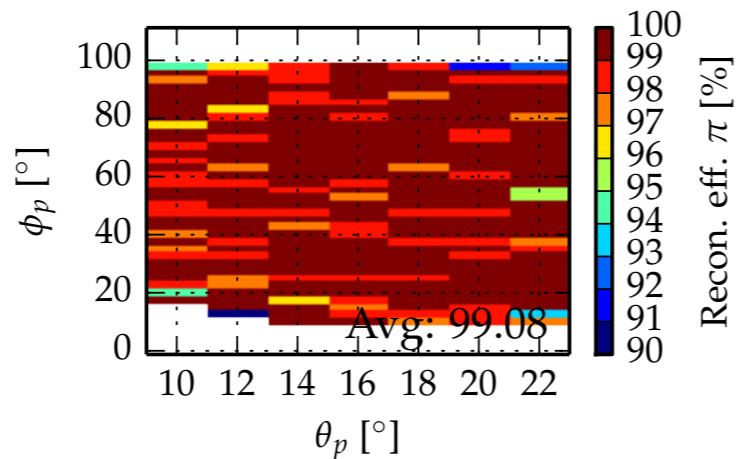
(b) K at 2 GeV/c



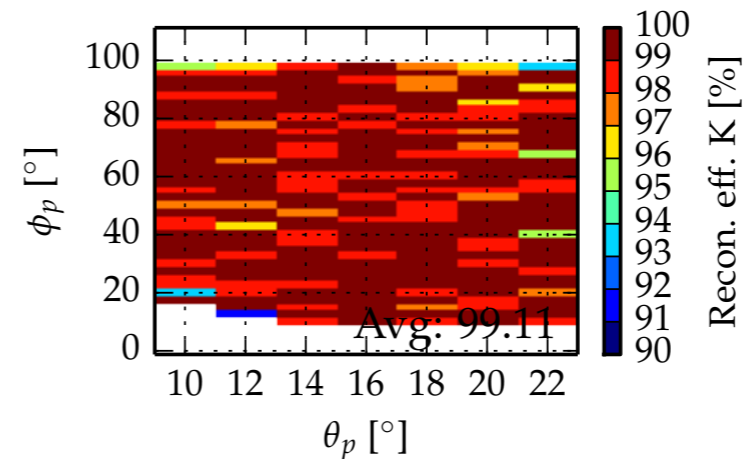
(c)  $\pi$  at 3 GeV/c



(d) K at 3 GeV/c



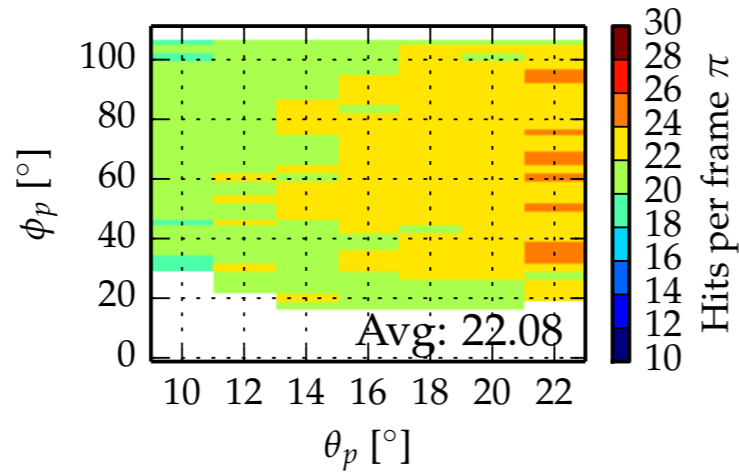
(e)  $\pi$  at 4 GeV/c



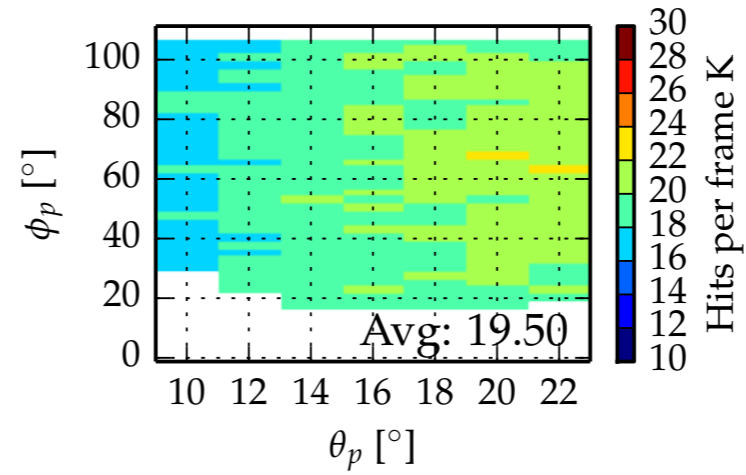
(f) K at 4 GeV/c

O. Merle (PhD-Thesis, 2015)

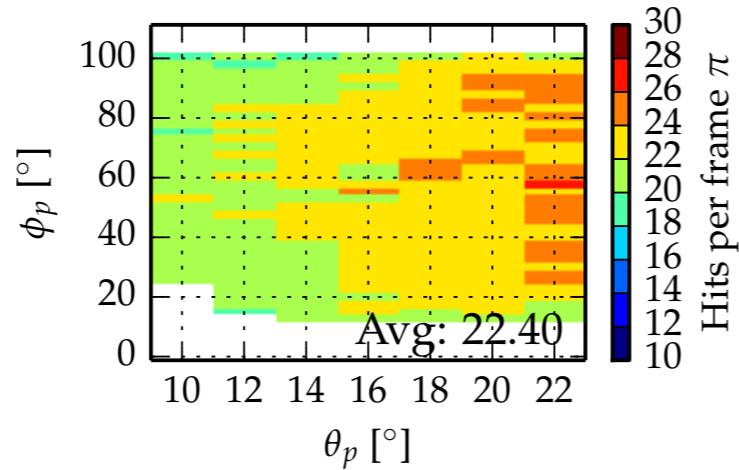




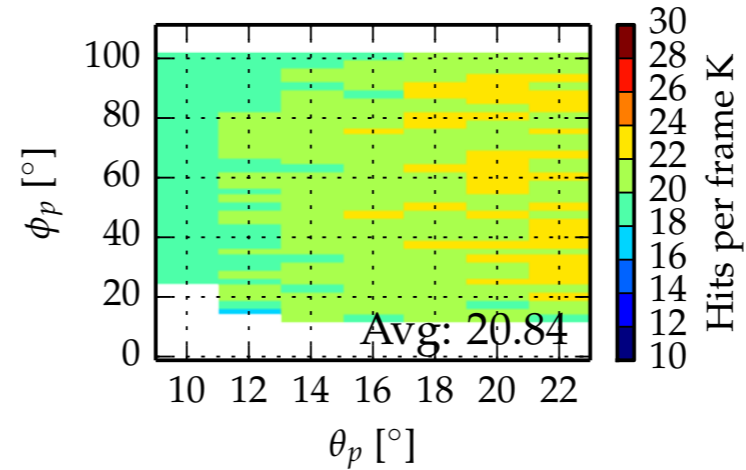
(a)  $\pi$  at 2 GeV/c



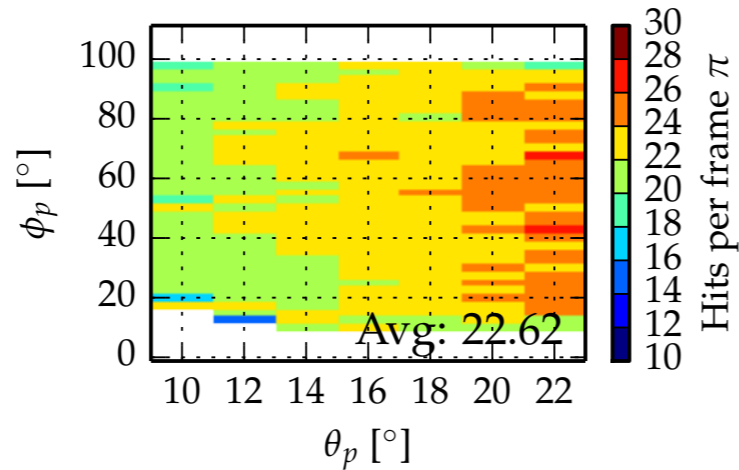
(b) K at 2 GeV/c



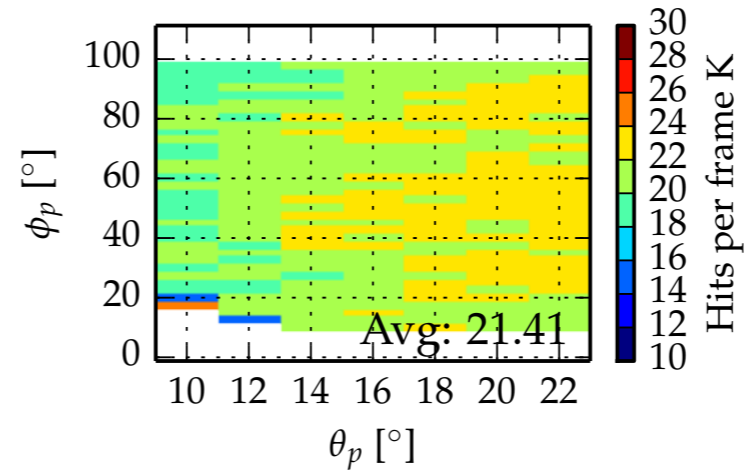
(c)  $\pi$  at 3 GeV/c



(d) K at 3 GeV/c

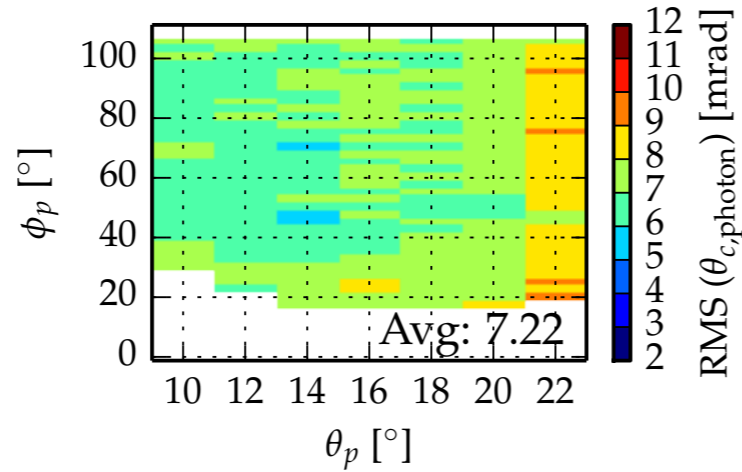


(e)  $\pi$  at 4 GeV/c

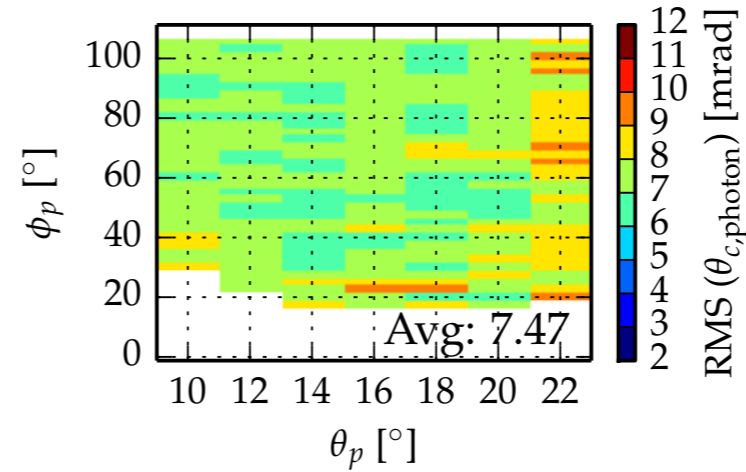


(f) K at 4 GeV/c

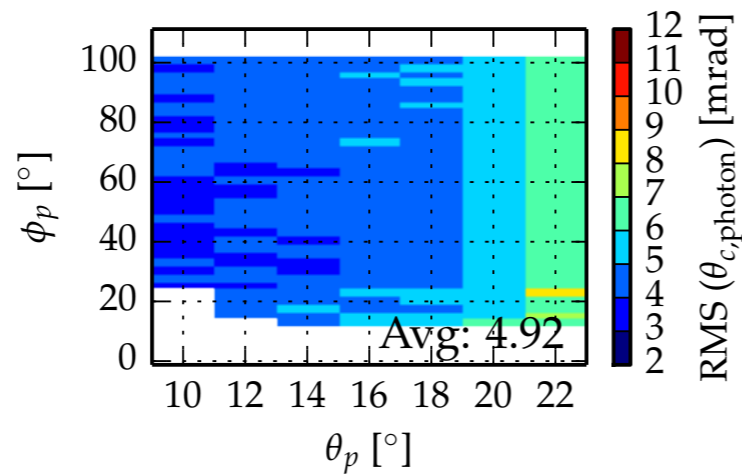
O. Merle (PhD-Thesis, 2015)



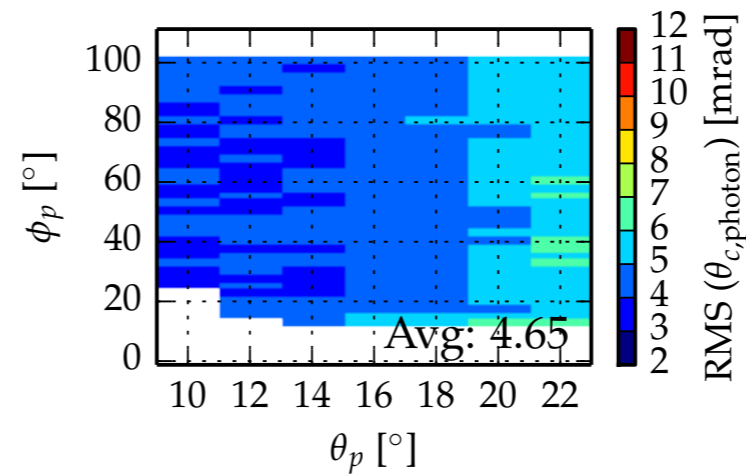
(a)  $\pi$  at 2 GeV/c



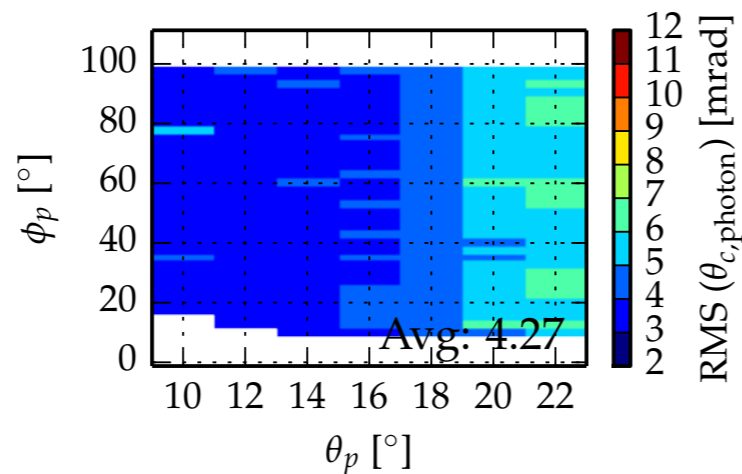
(b) K at 2 GeV/c



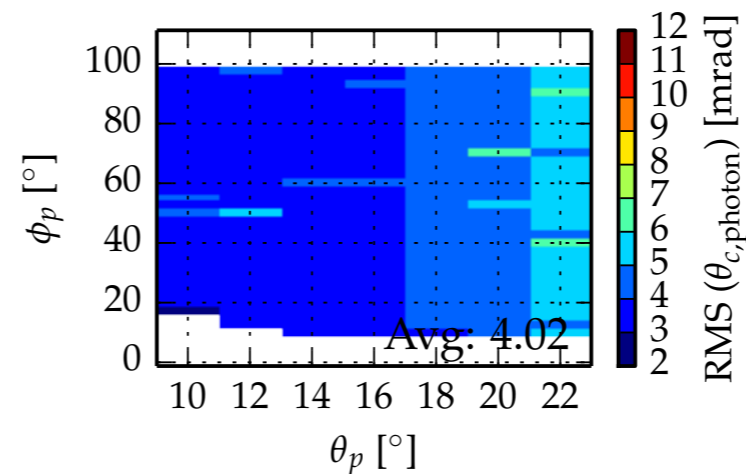
(c)  $\pi$  at 3 GeV/c



(d) K at 3 GeV/c



(e)  $\pi$  at 4 GeV/c



(f) K at 4 GeV/c

O. Merle (PhD-Thesis, 2015)