JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

GCS GIESSEN COSMIC STATION

ATLAS PANDA HERMES AG Düren

The Giessen Cosmic Station

Simon Bodenschatz, Lisa Brück, Michael Düren, Avetik Hayrapetyan, Jan Niclas Hofmann, Sophie Kegel, İlknur Köseoğlu Sarı, Jhonatan Pereira de Lira, Mustafa Schmidt, Marc Strickert

DIRC 2019 - Rauischholzhausen

September 13, 2019

Introduction

Principle

- Using cosmic particles (esp. muons) for tests of DIRC detectors

Requirements

- Position and direction of the particles
- Selection of muons with a minimum energy
- Acceptance for slightly angled tracks (about 13°)

Introduction

Principle

- Using cosmic particles (esp. muons) for tests of DIRC detectors

Requirements

- Position and direction of the particles
- Selection of muons with a minimum energy
- Acceptance for slightly angled tracks (about 13°)

Overview

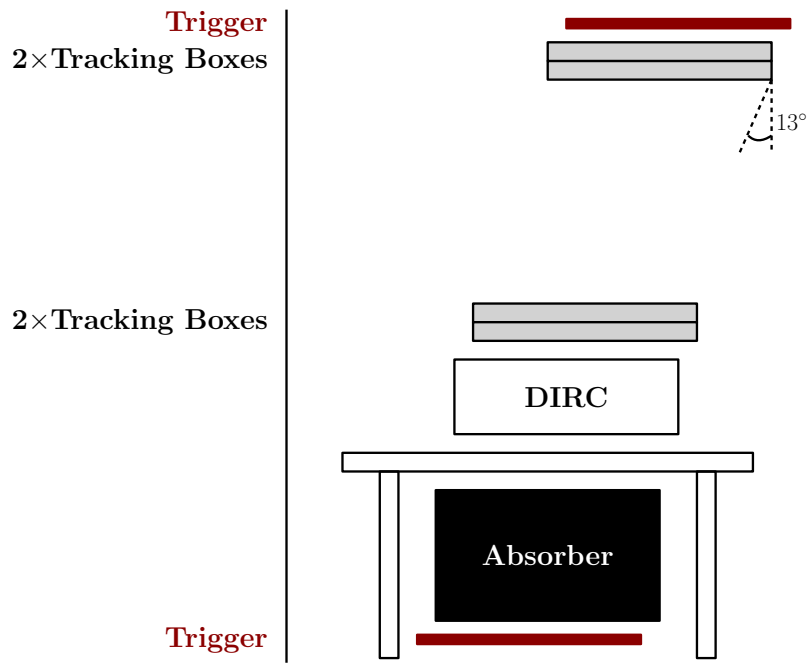
Track Reconstruction

- Track reconstruction via position measurment in two planes

Components

The test stand consists of

- Two scintillating plates defining a trigger
- Four layers of scintillating bars (track reconstruction)
- About 45 cm of lead in between the trigger plates (energy selection)



Overview

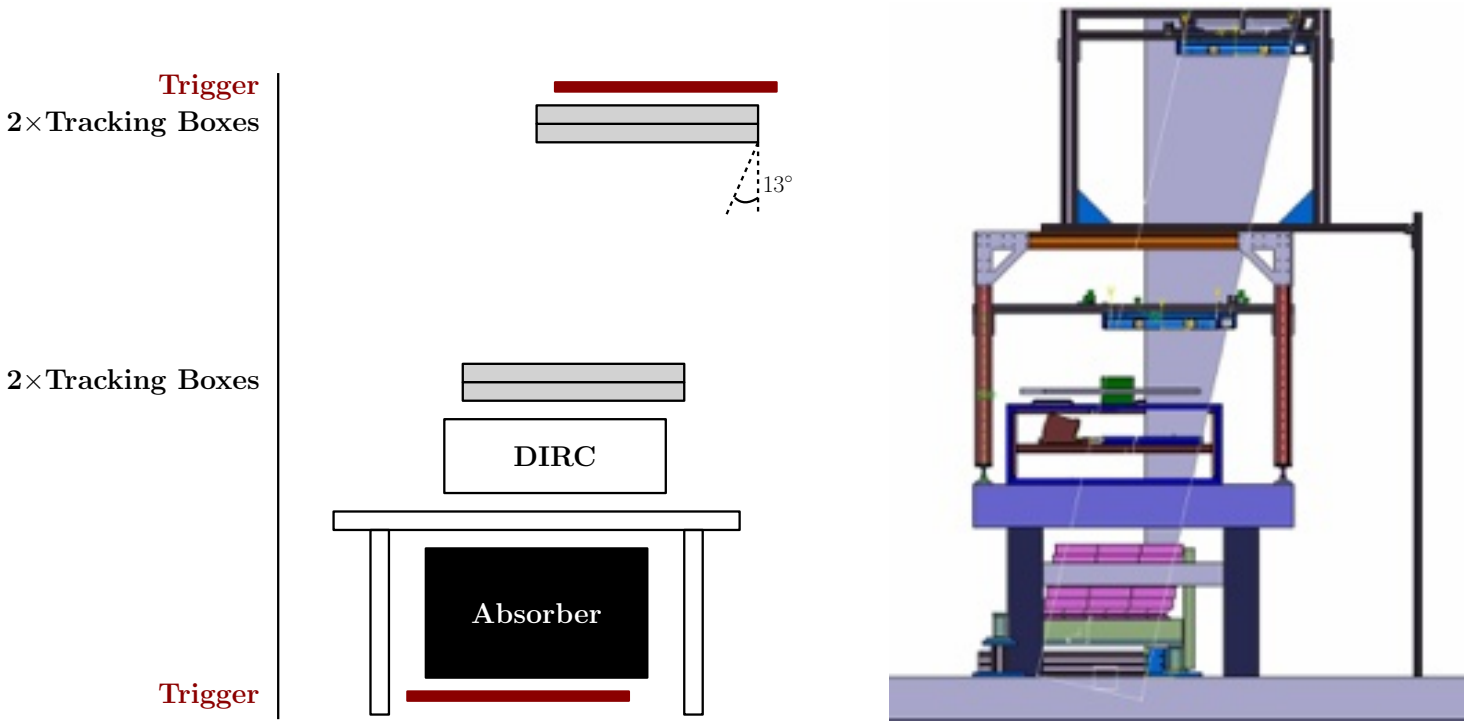


Figure: Schematic overview and CAD drawing.

Tracking Boxes

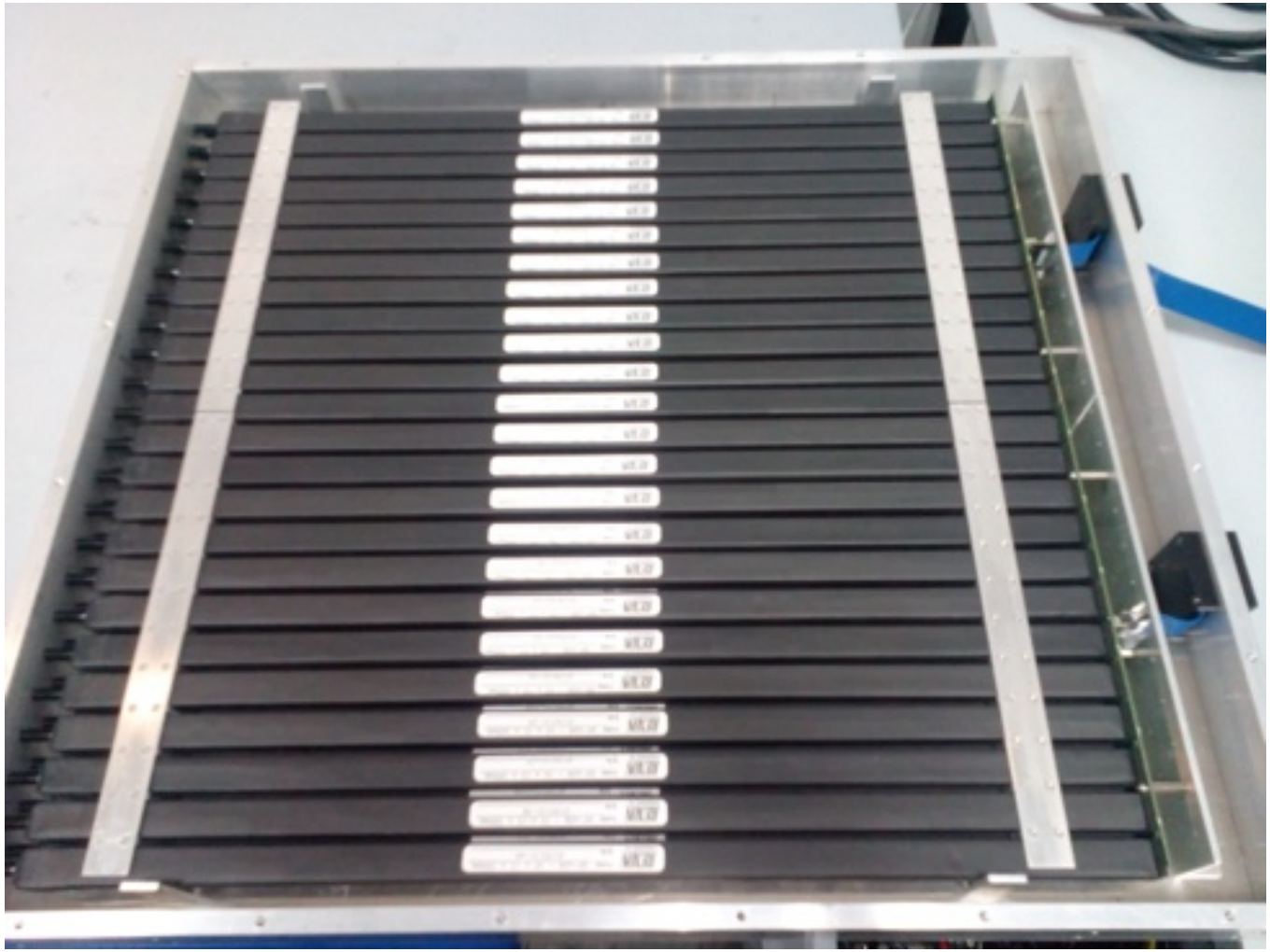
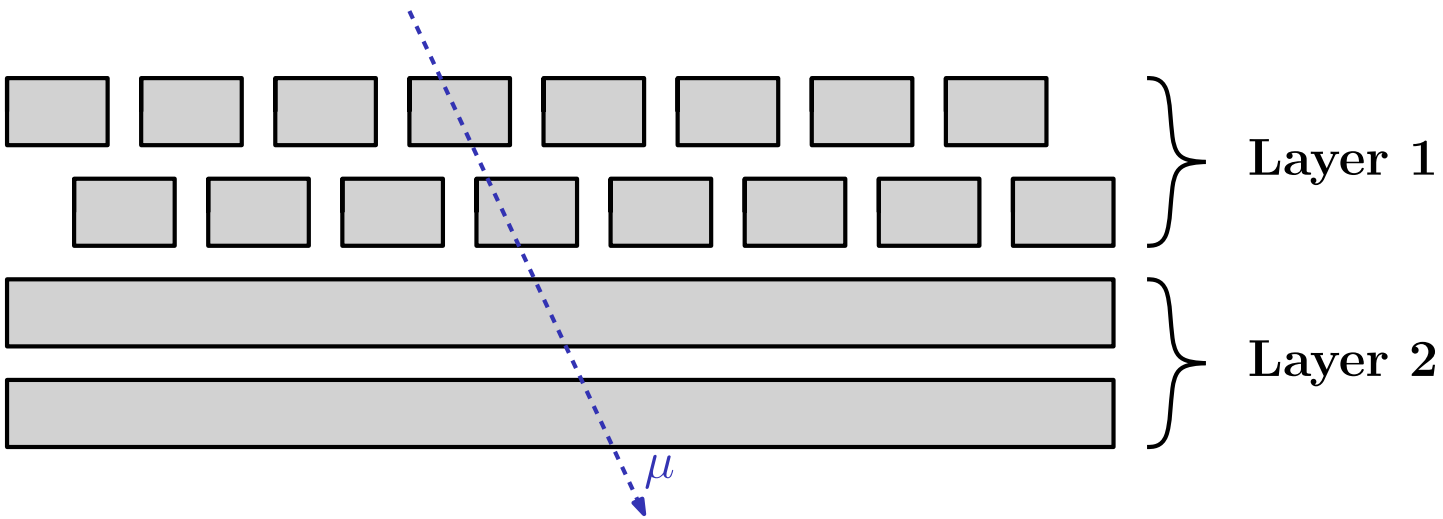


Figure: One of the tracking boxes without lid.

Tracking Boxes

Geometry of the bars

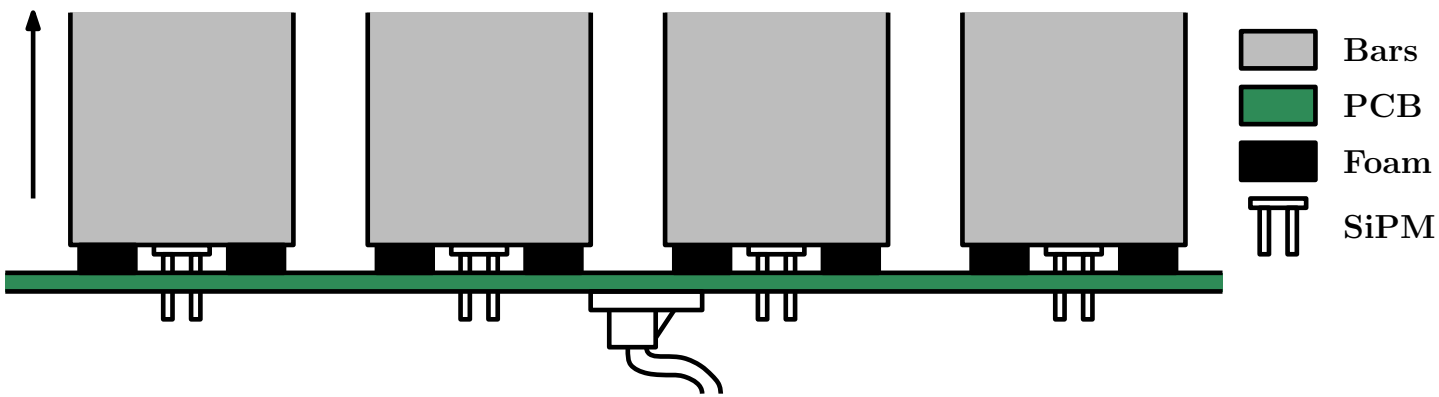
- 48 bars ($15 \times 10 \times 500$ mm) in two half-layers shifted against each other
- Second layer rotated by 90° for position resolution along the other axis
- Every layer in a separate light-proof box



Tracking Boxes

Readout of the bars

- Readout via one SiPM at the top of each bar
- 24 SiPMs are grouped together on one PCB
- Passing the signals to the readout system via micro-coaxial-cables
- Shielding of reflected light via foam



Trigger Plates

Trigger plates

- 50×50 cm^2 homogeneous scintillating plate with cut off corners
- Readout via four PMTs in each of the corners

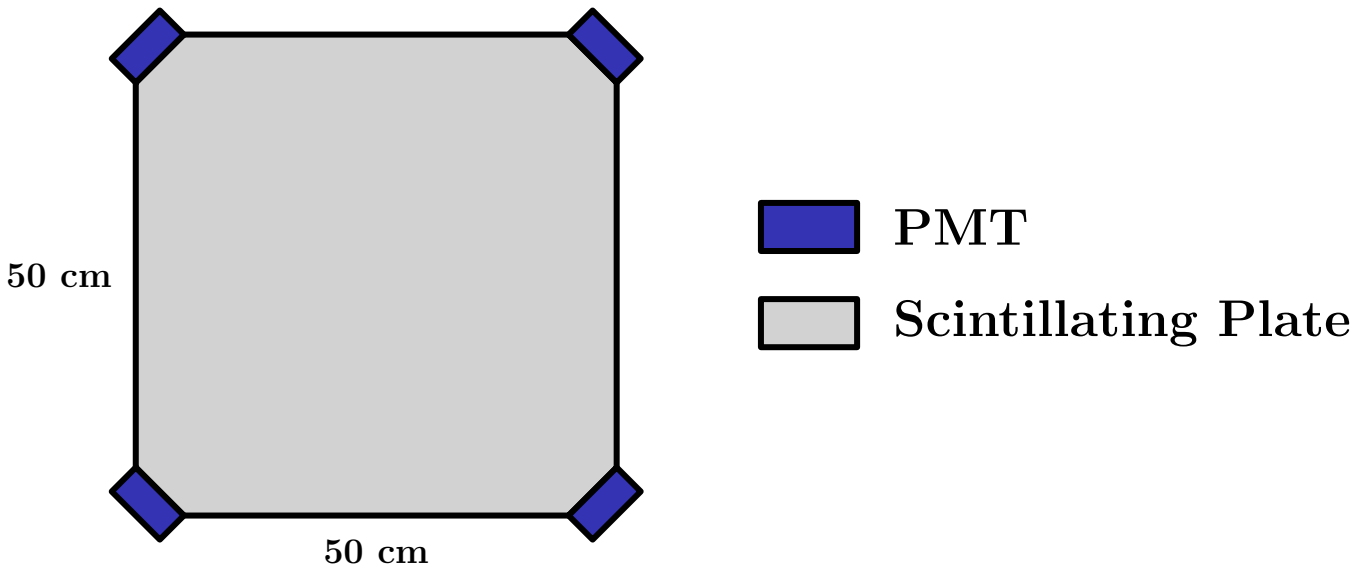


Figure: Schematic drawing of one of trigger plates.

Trigger Plates

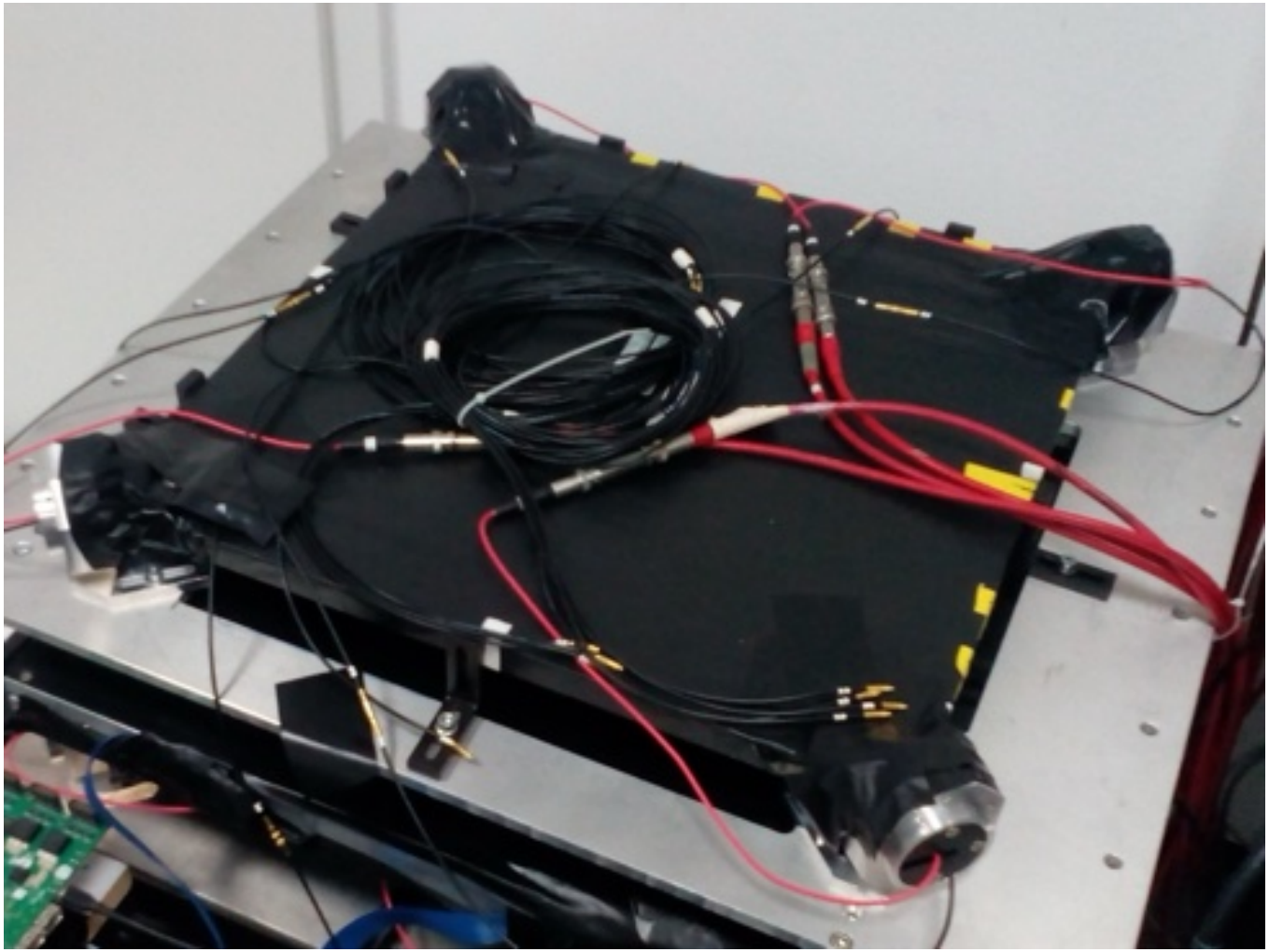
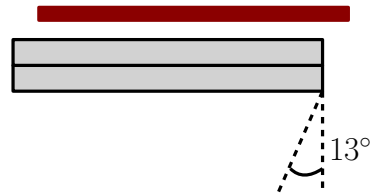


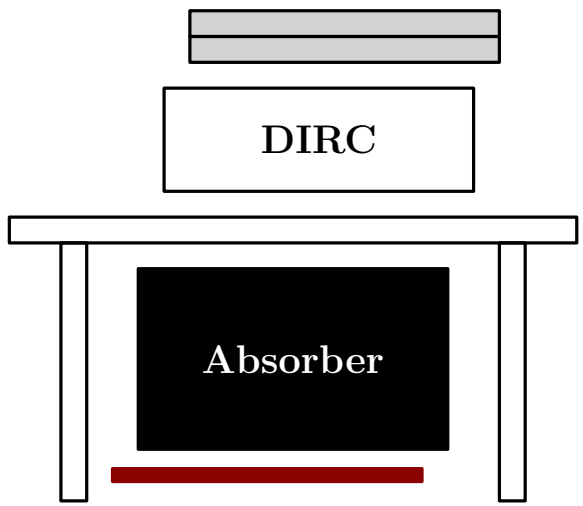
Figure: One of the trigger plates.

Absorber

Role of the absorber

- Flight distance in combination with timing resolution insufficient for momentum selection
- Instead energy discrimination via absorption in 45 cm lead





Absorber

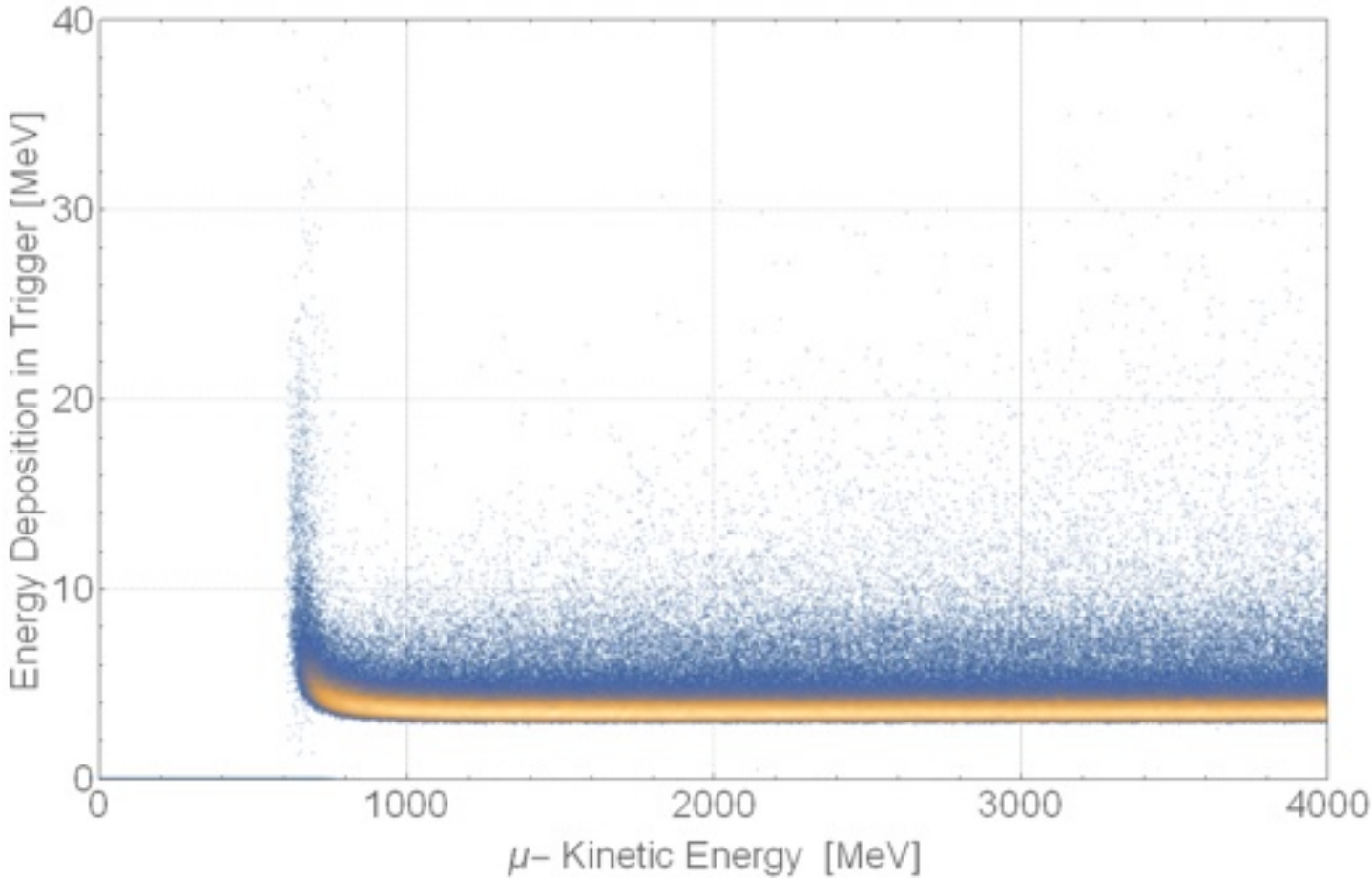


Figure: Energy deposition in trigger plate after passing though 45 cm of lead (Monte-Carlo simulation).

Absorber

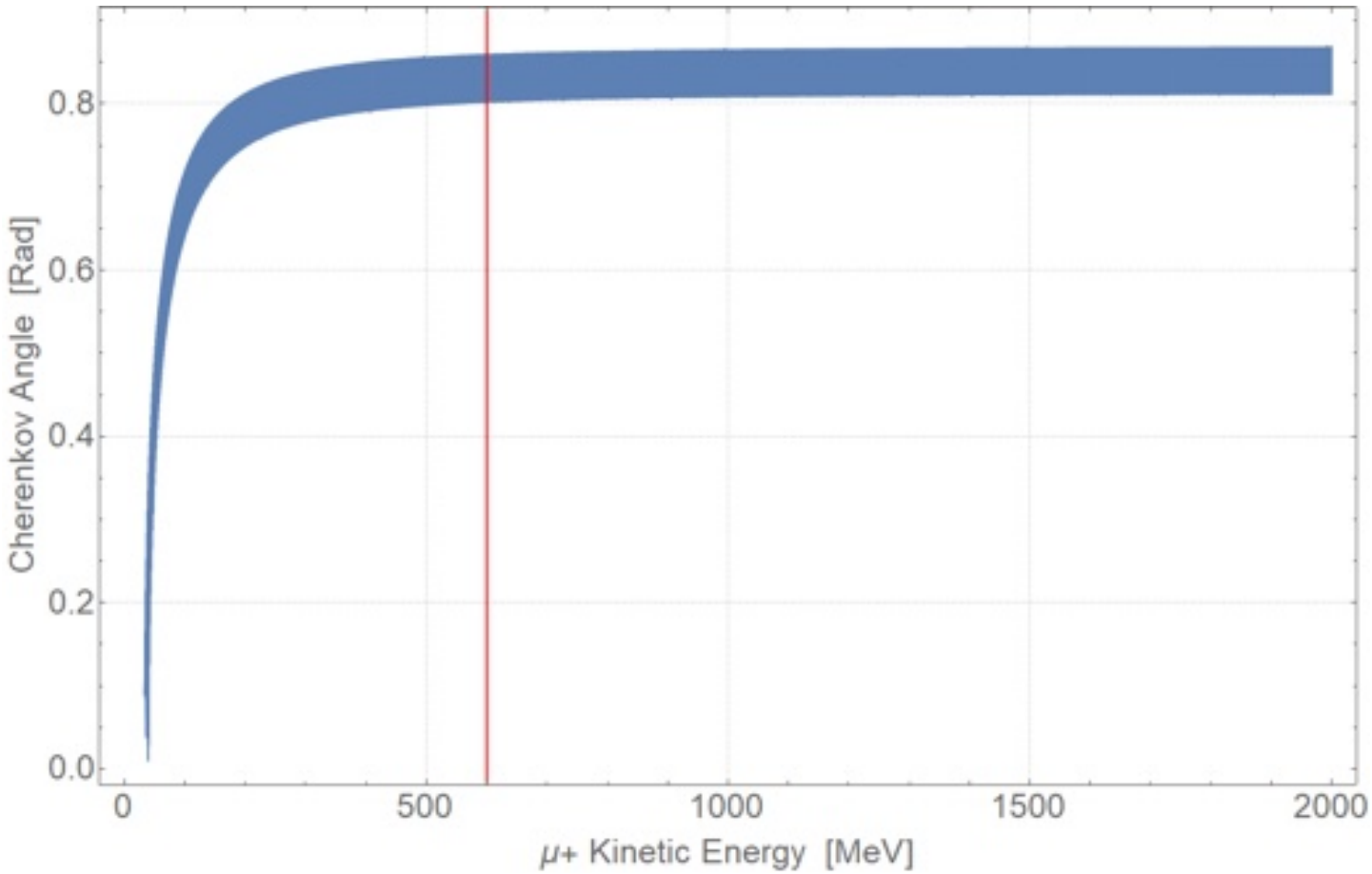


Figure: Cherenkov angle range in fused silica over muon kinetic energy (**blue**) and 600 MeV cutoff energy (**red**).

`Wavelength cut:` $200\ \mathrm{nm} < \lambda < 800\ \mathrm{nm}$ `// Sensor acceptance and emission probability not included.`

Finger Counters

Detector to test ...

- Cross of two small scintillating bars
- Readout via PMTs
- Overlapping area of approx. $1,8 \times 1,8$ cm

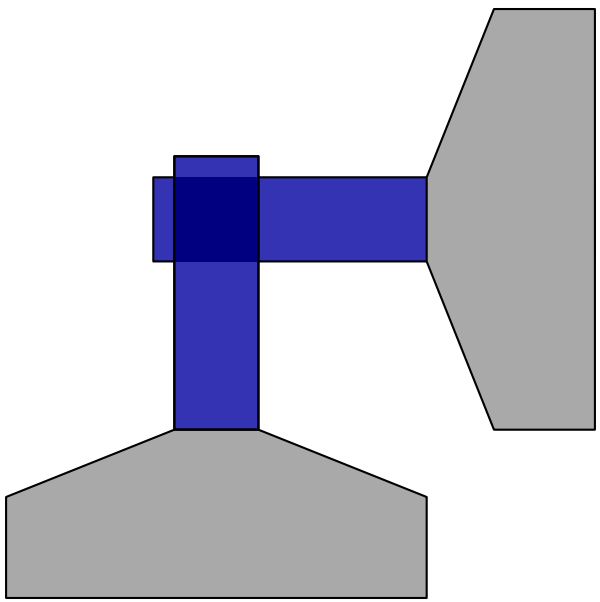


Figure: Schematic drawing of the finger counters.

Finger Counters

Figure: Overview and detailed image of the finger counters.

Readout and Slow Control

Readout

- All 202 channels readout with the same ASIC-based system (TOFPET 2)
- Trigger and finger signals are inverted
- Off-line analysis and event selection

Additional monitoring of . . .

- ASIC temperature
- Inverter current and HV channels
- Ambient pressure, temperature and humidity
- Light level

Readout and Slow Control

Readout

- All 202 channels readout with the same ASIC-based system (TOFPET 2)
- Trigger and finger signals are inverted
- Off-line analysis and event selection

Additional monitoring of . . .

- ASIC temperature
- Inverter current and HV channels
- Ambient pressure, temperature and humidity
- Light level

Readout and Slow Control

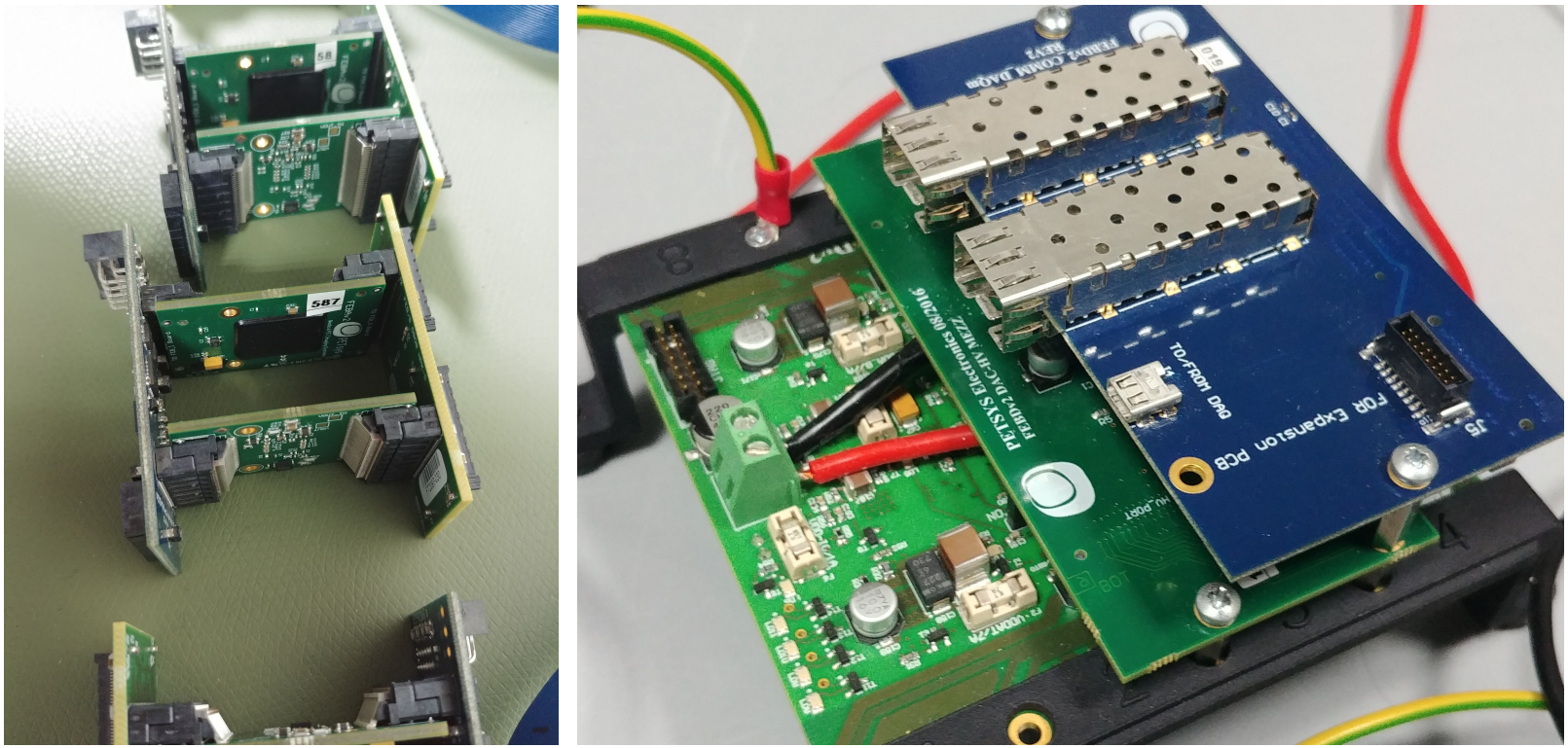


Figure: TOPFET frontend modules with two ASICs each **(left)** and intermediate "D-Board" **(right)**.

All components together

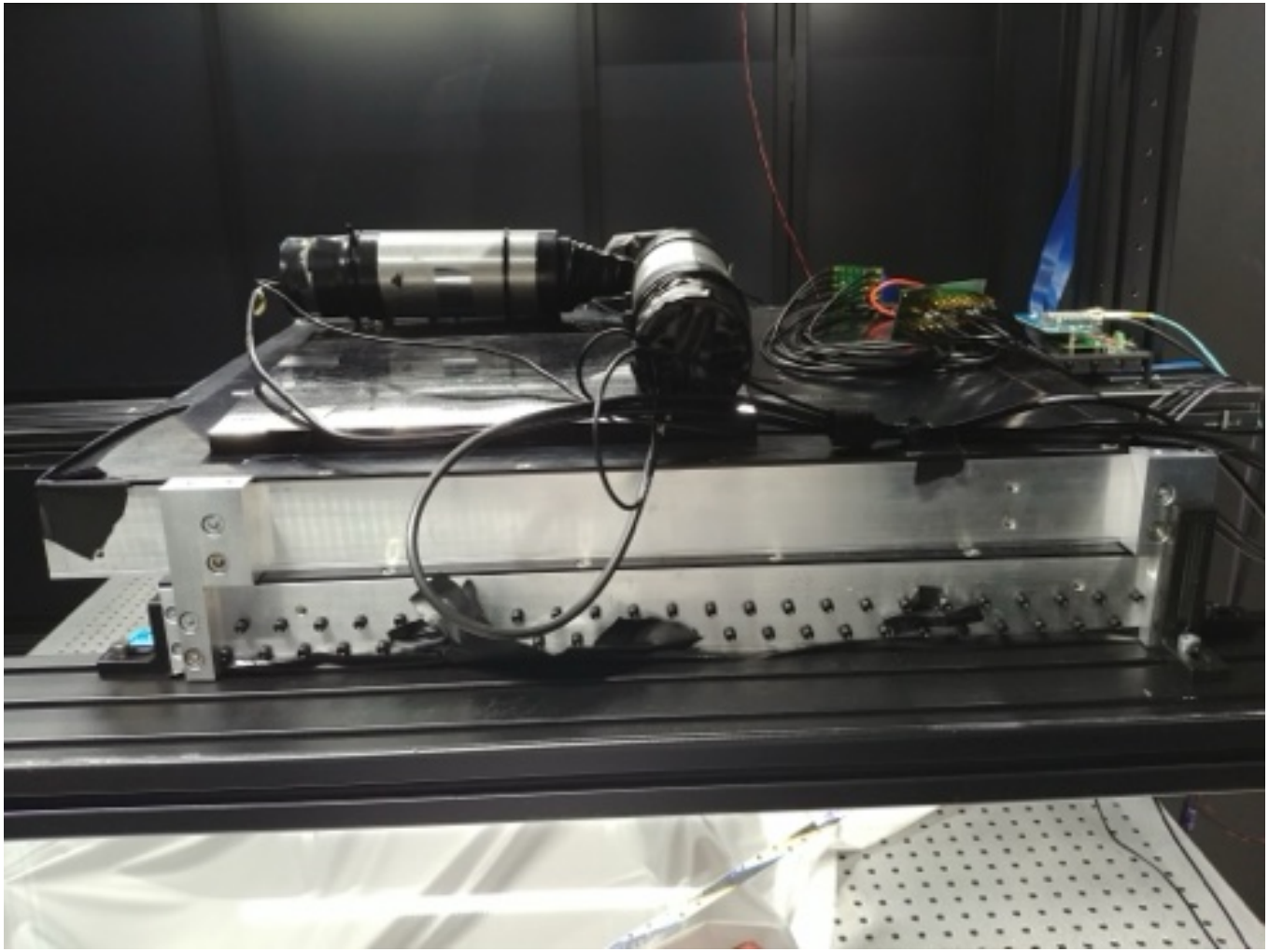


Figure: Tracking box, finger counters and read out electronics.

Measurment - Run 1

- Running nonstop for approx. 64 days
- Acquisition performed in 30 minute runs (2922 in total)
- A total of approx. $6.7 \cdot 10^6$ events with "clean" tracking information collected ($600 \cdot 10^3$ trigger hits)

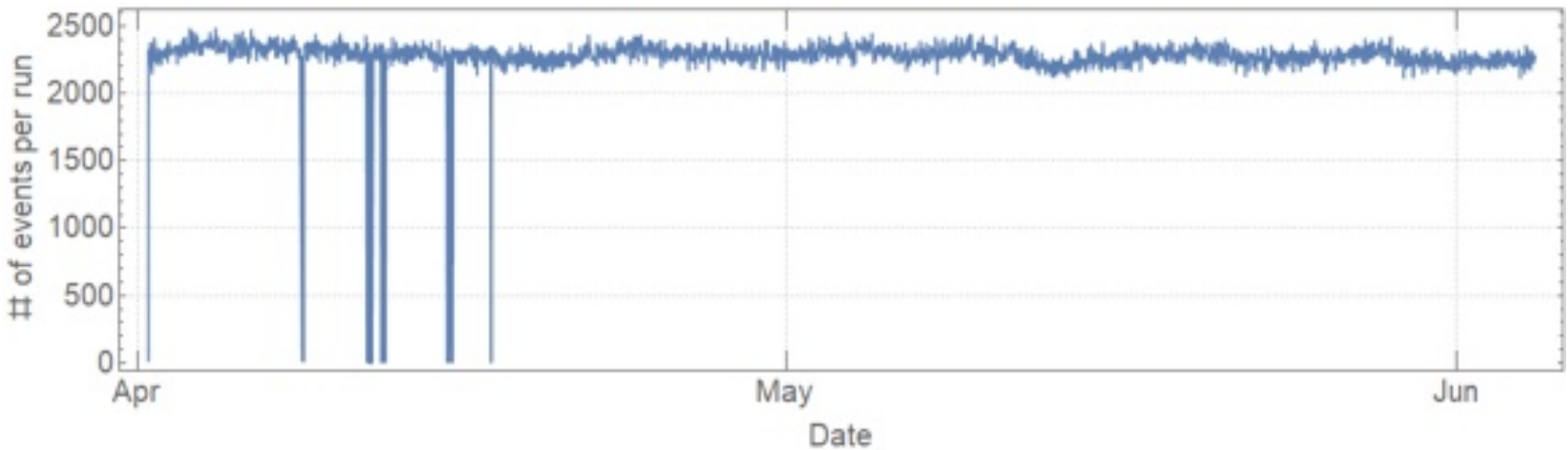
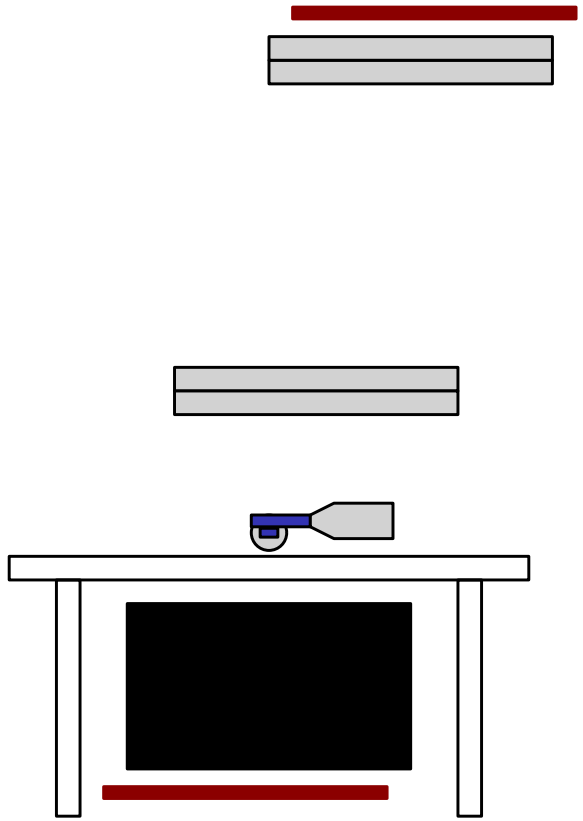


Figure: Number of "clean" tracking events per run.

Testruns

Test setup

- Finger counters instead of prototype
- Counters placed directly on the table
- Find tracks in coincidences with the counters



Reconstruction - Finger Counters

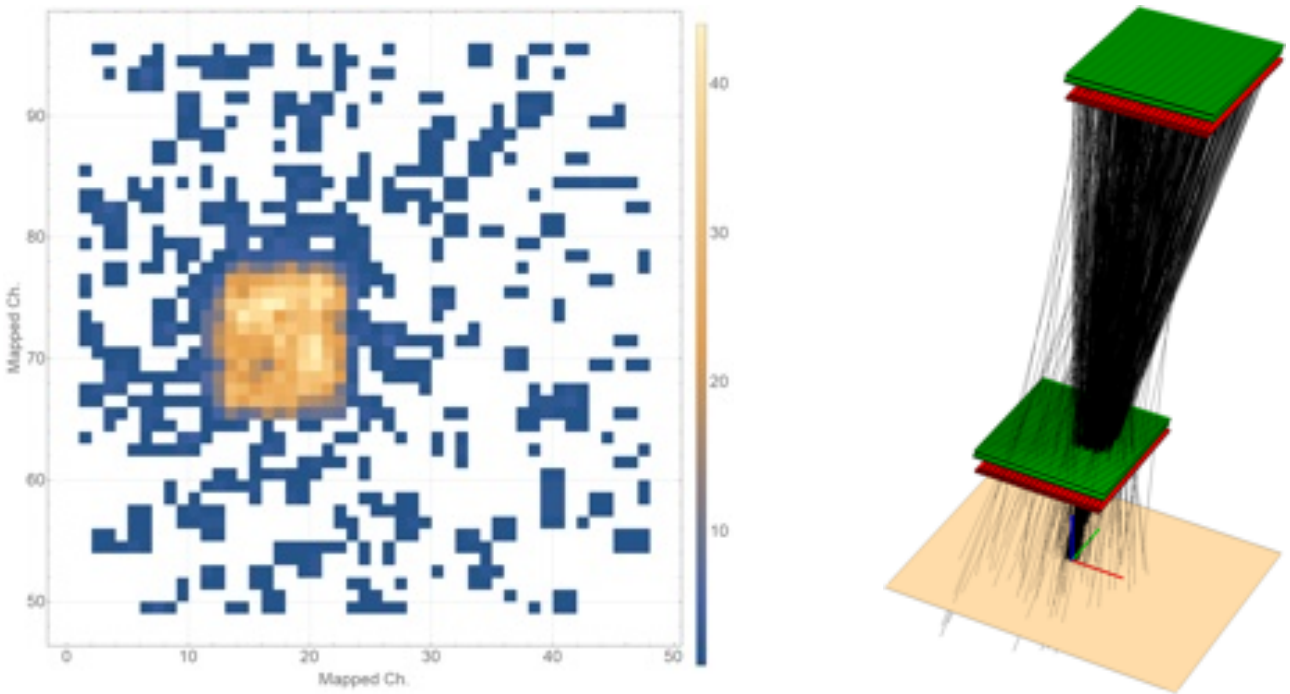


Figure: 2D-Histogram of the coordinate combinations (X_{bot}, Y_{bot}) for events in coincidence with the finger counters and the top tracking ensemble (**left**) and a 3D Visualisation of the tracks (**right**).

Reconstruction - Finger Counters

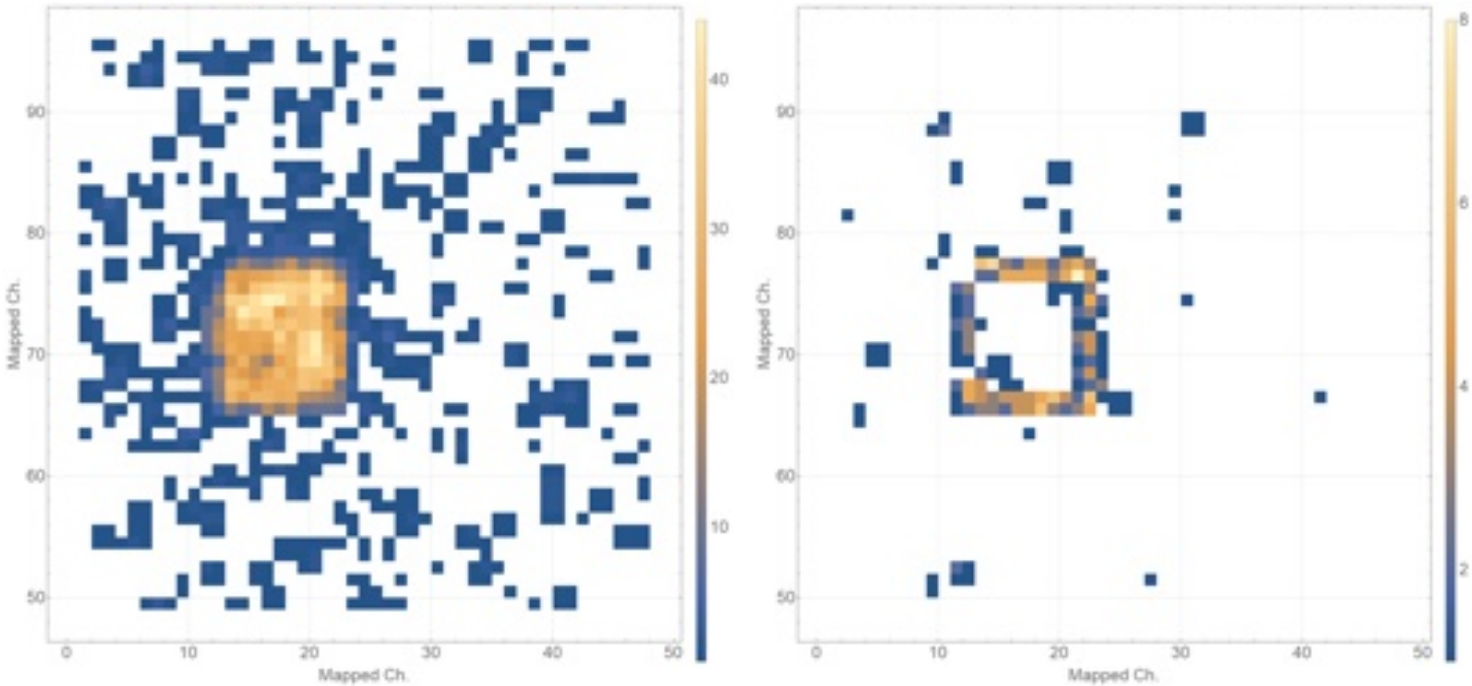


Figure: 2D-Histogram of the coordinate combinations (X_{bot}, Y_{bot}) for events in coincidence with the finger counters and all bars of the top tracking ensemble (**left**) and only a selected "frame" (**right**).

Reconstruction - Spatial Acceptance

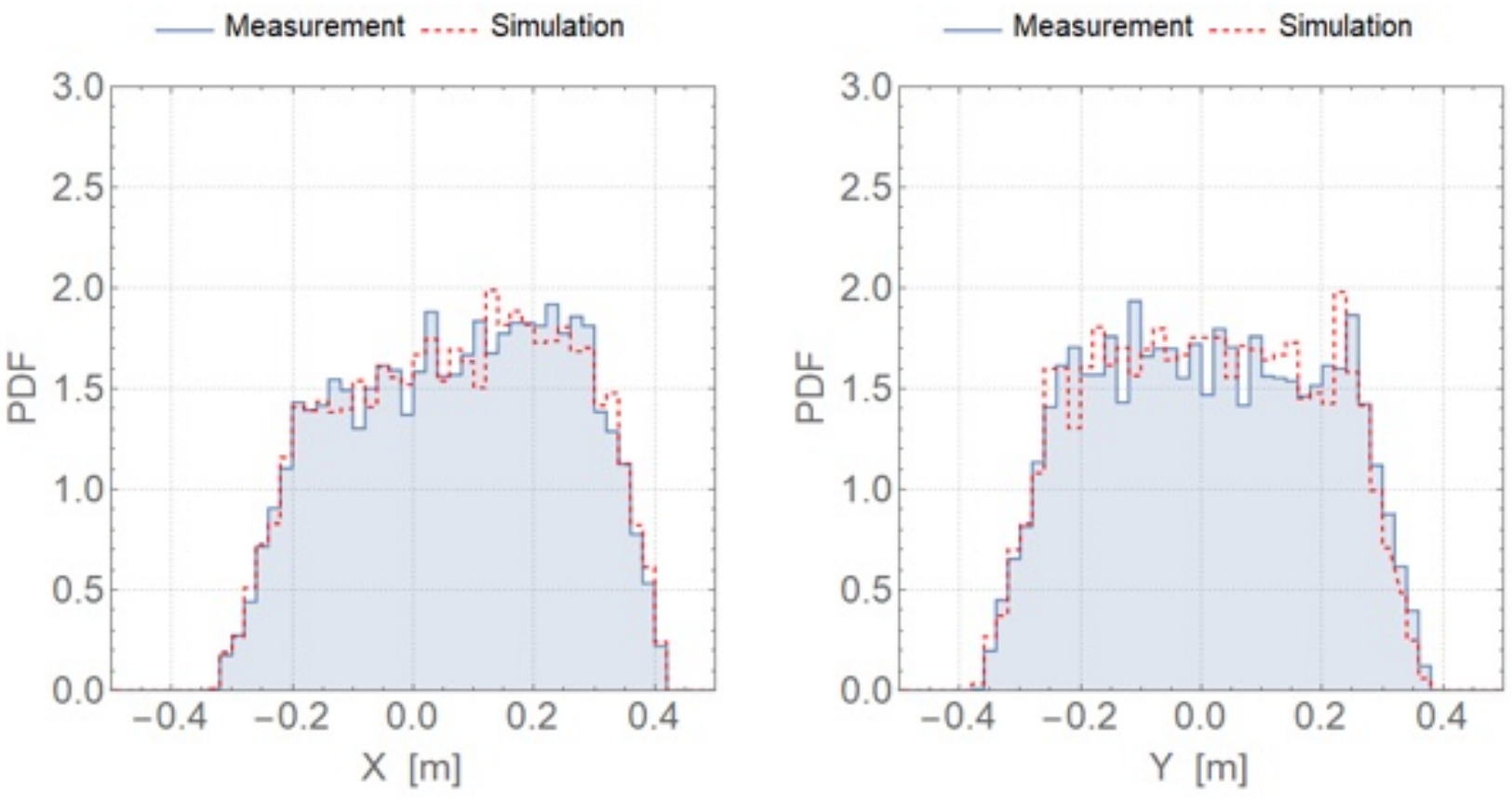


Figure: Spatial acceptance without trigger.

Simulation: Geant4 [1] with CRY [2] event generator.

[1] S.Agostinelli et al. (2007). Geant4—a simulation toolkit. Nuclear Instruments and Methods in Physics Research Section A.
[2] Hagmann, Chris& Lange, David & Wright, Douglas. (2007). Cosmic-ray shower generator (CRY) for Monte Carlo transport codes. IEEE Nuclear Science Symposium.

Reconstruction - Spatial Acceptance

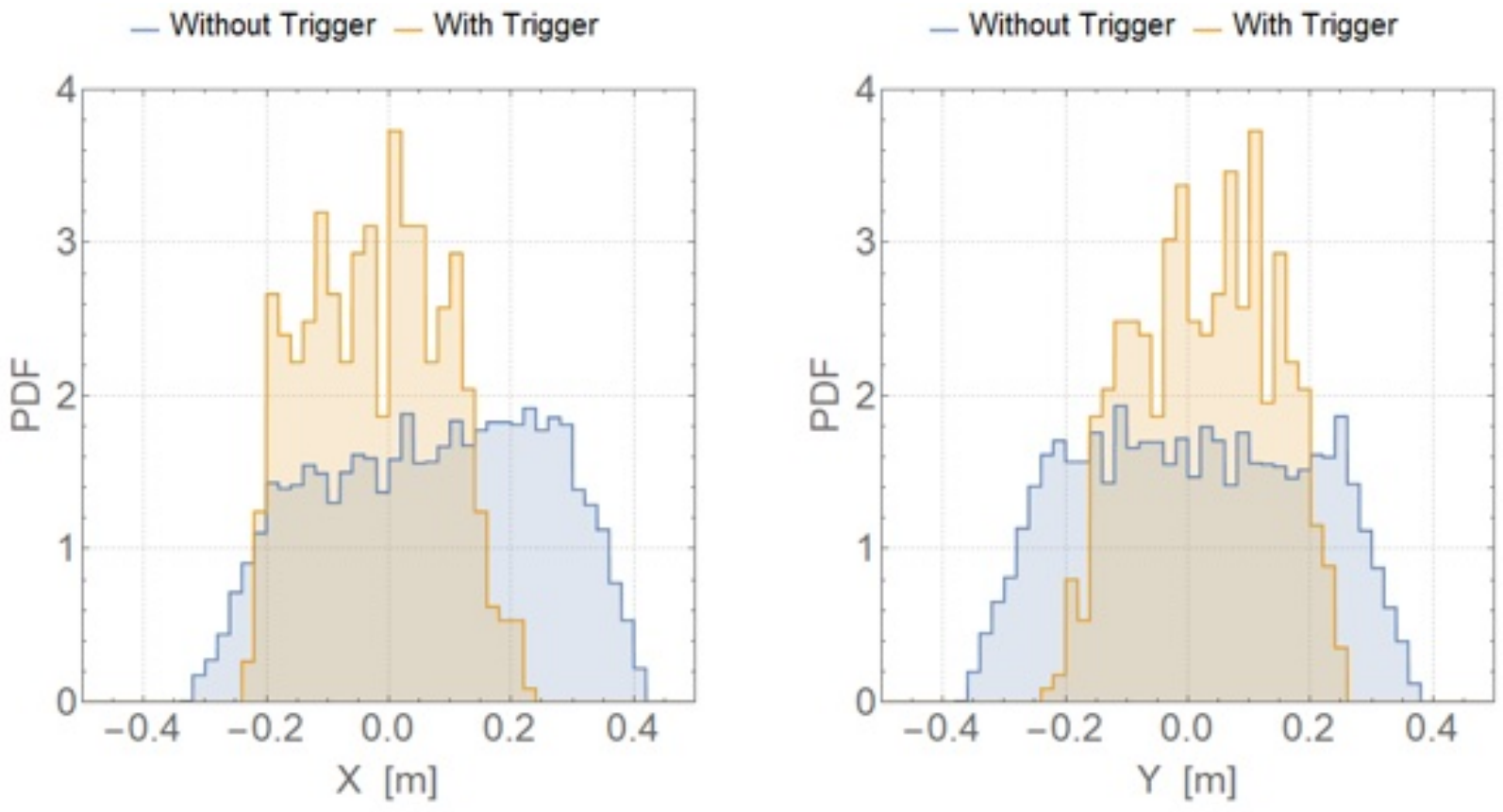


Figure: Spatial acceptance with and without trigger.

Reconstruction - Angular Acceptance

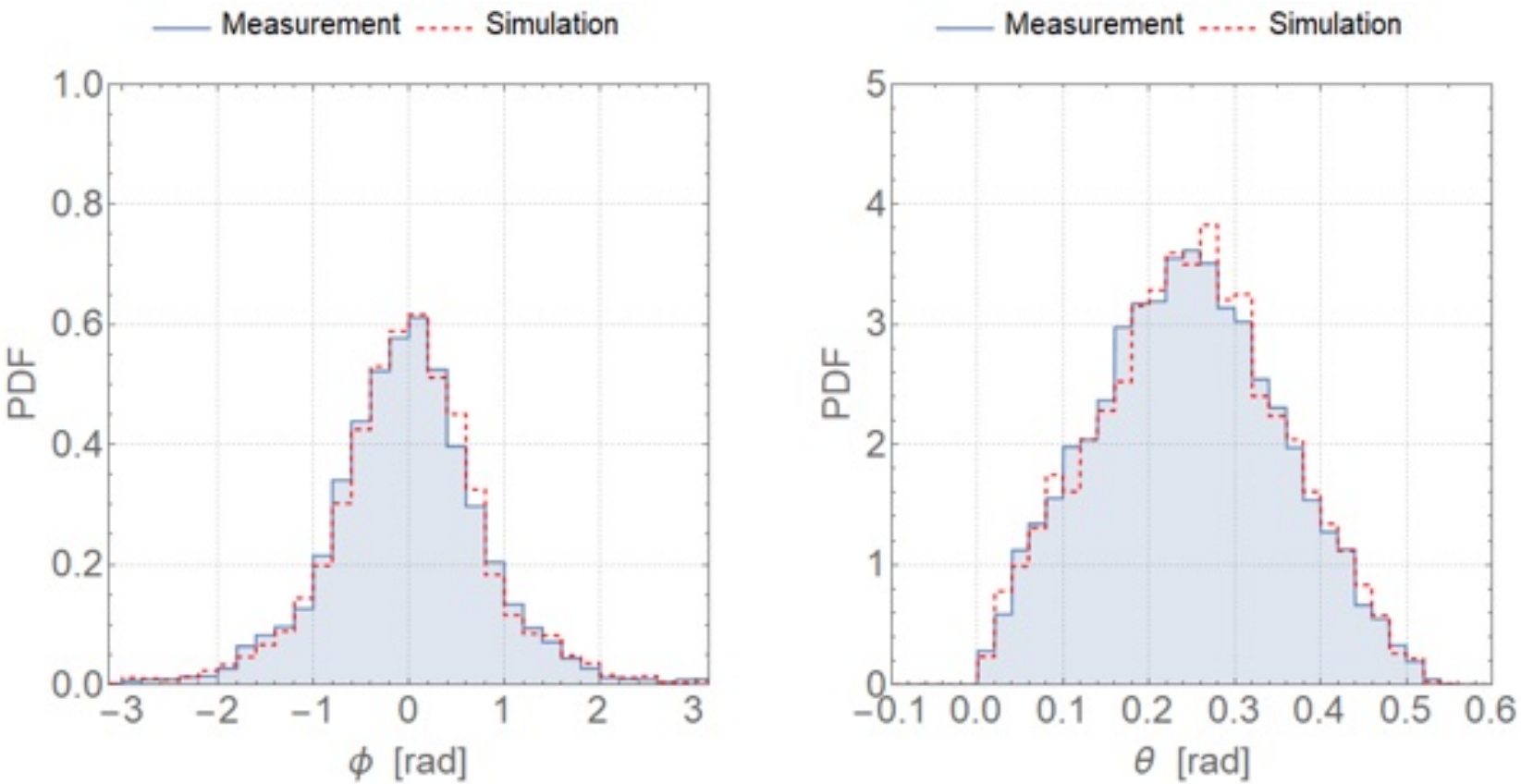


Figure: Angular acceptance without trigger.

Reconstruction - Angular Acceptance

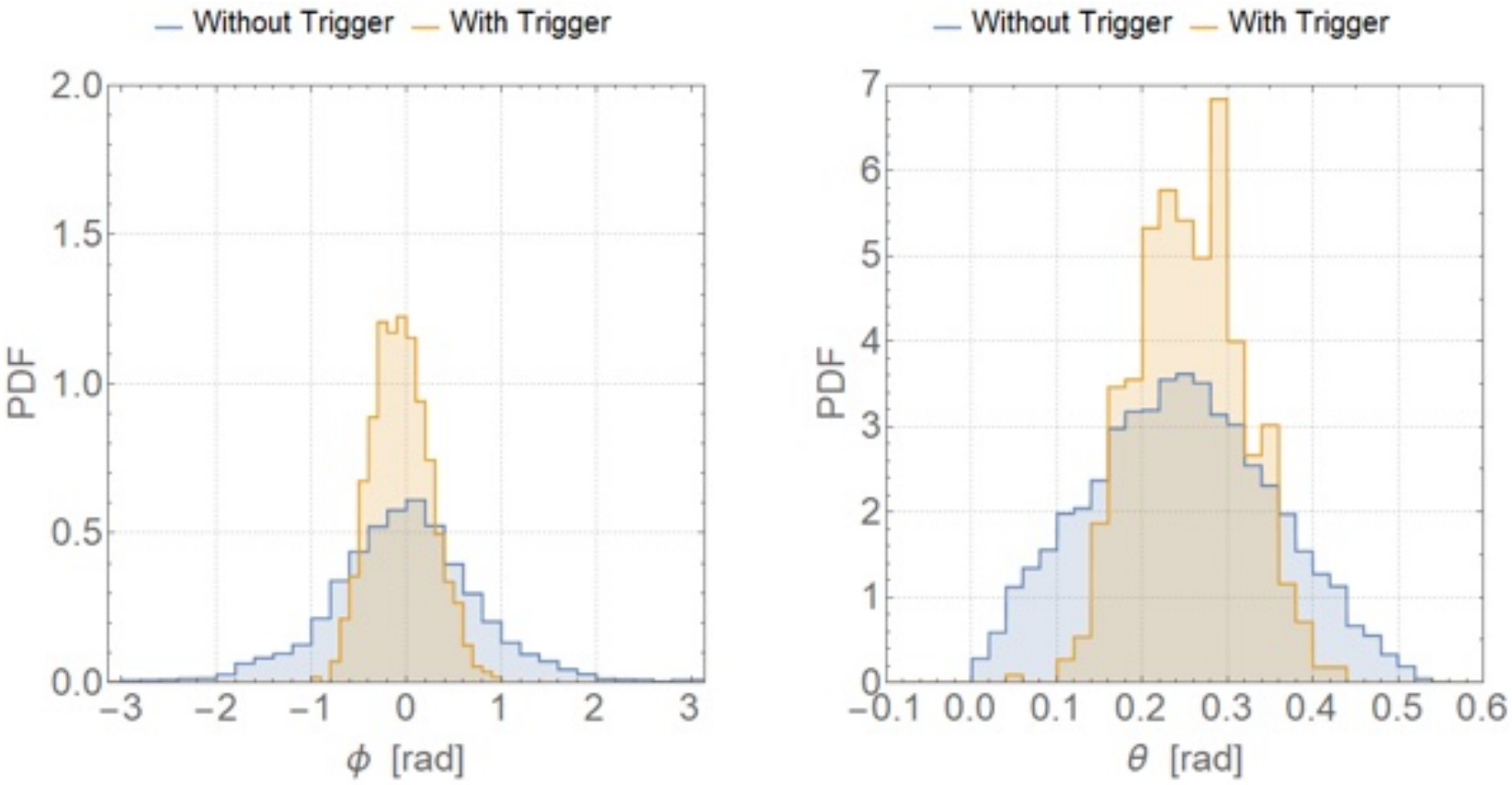


Figure: Angular acceptance with and without trigger.

Reconstruction - Expected Angular Resolution

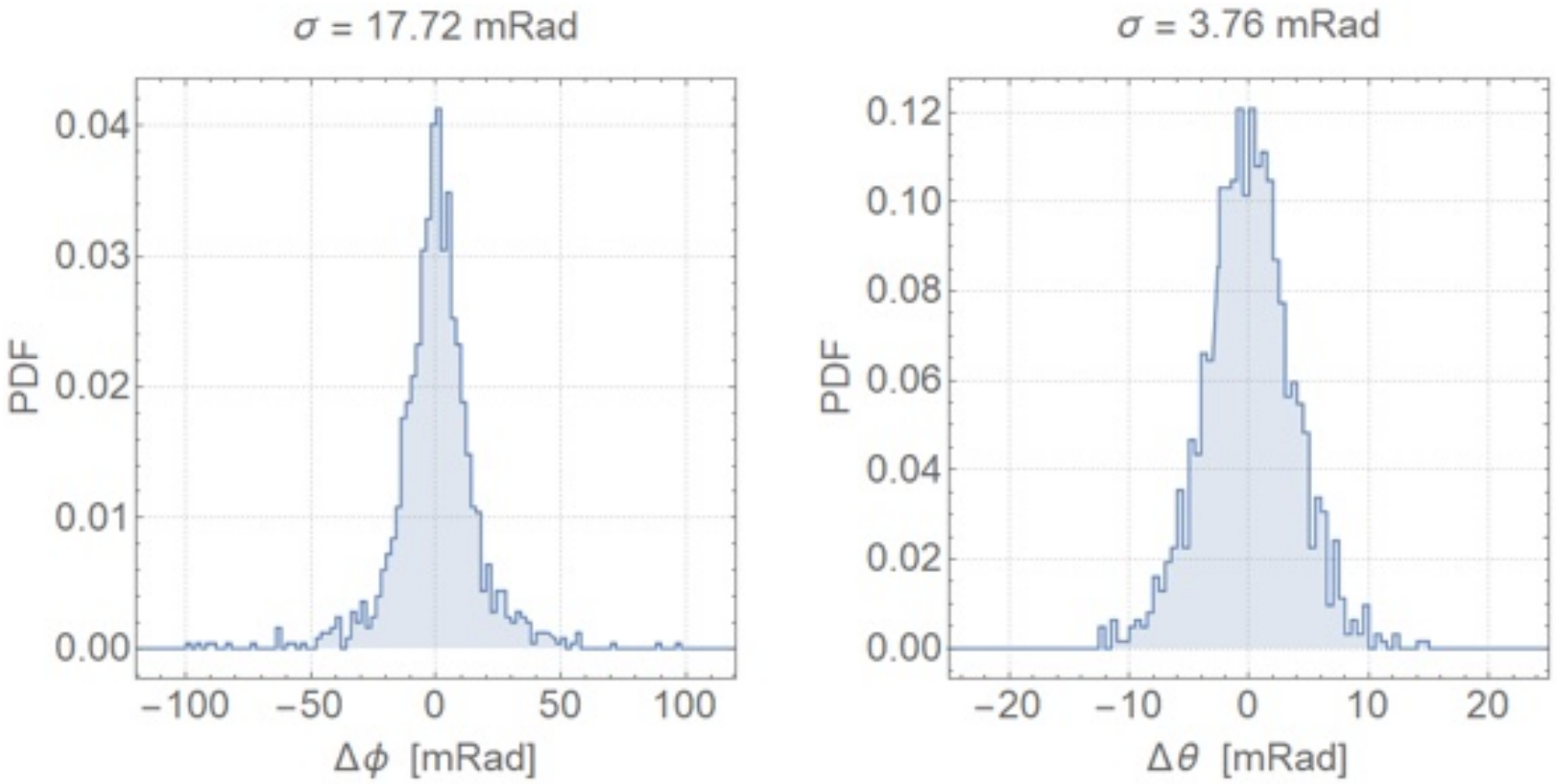


Figure: Expected angular resolution (Monte-Carlo-Estimate).

Reconstruction - Expected Spatial Resolution

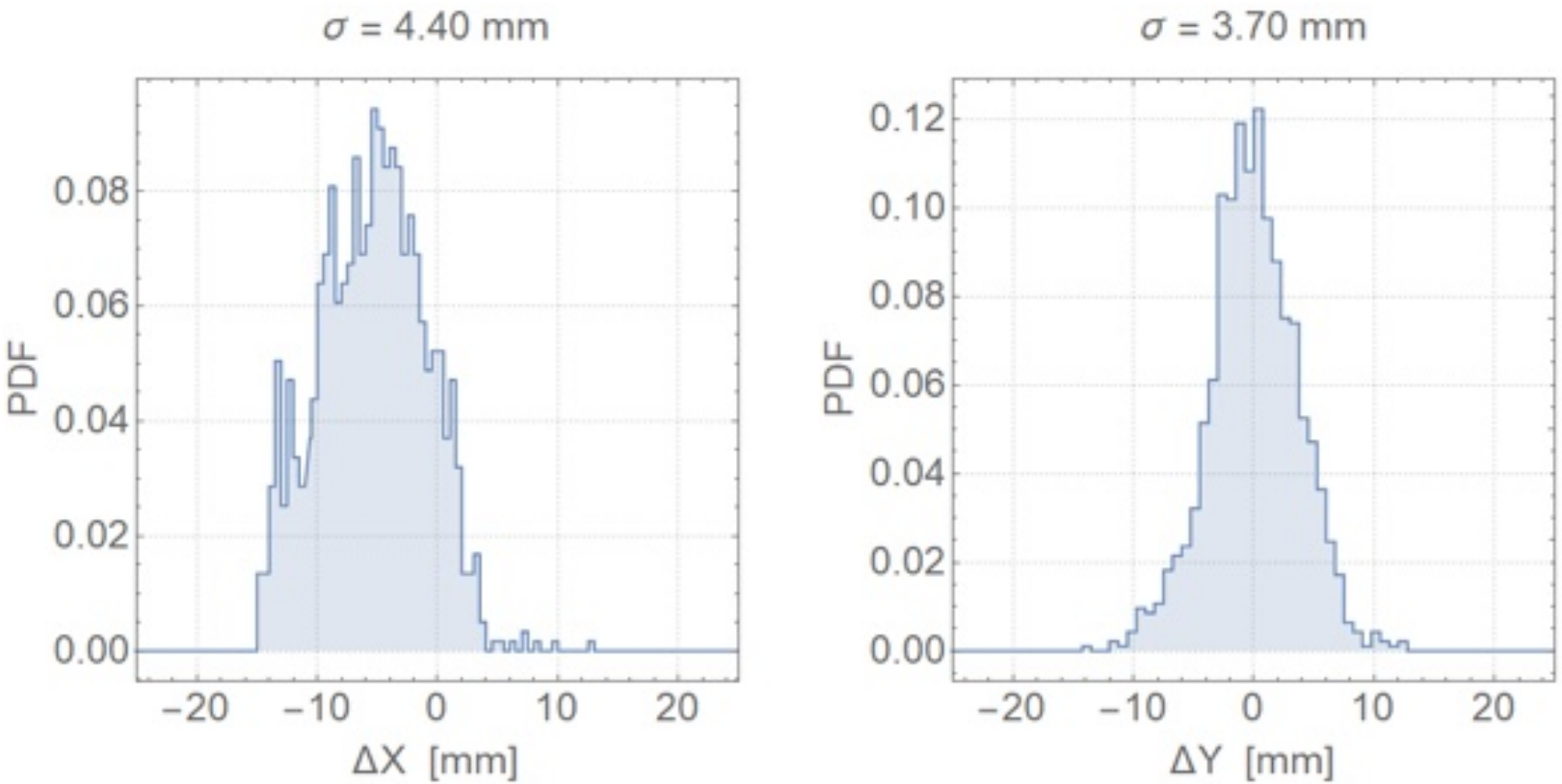


Figure: Expected spatial resolution (Monte-Carlo-Estimate).

Reconstruction - Resolution Verification

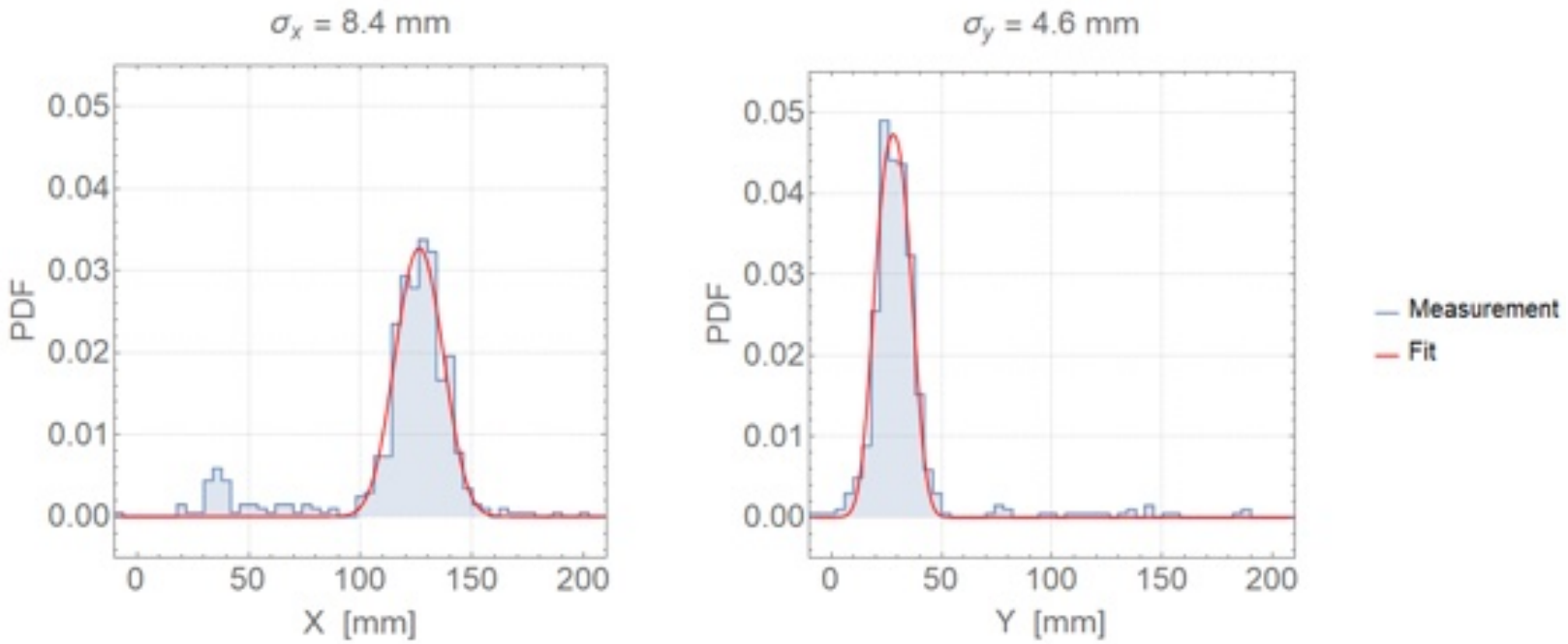


Figure: Fit of the finger hits with a convoluted normal distribution.

Event Rate

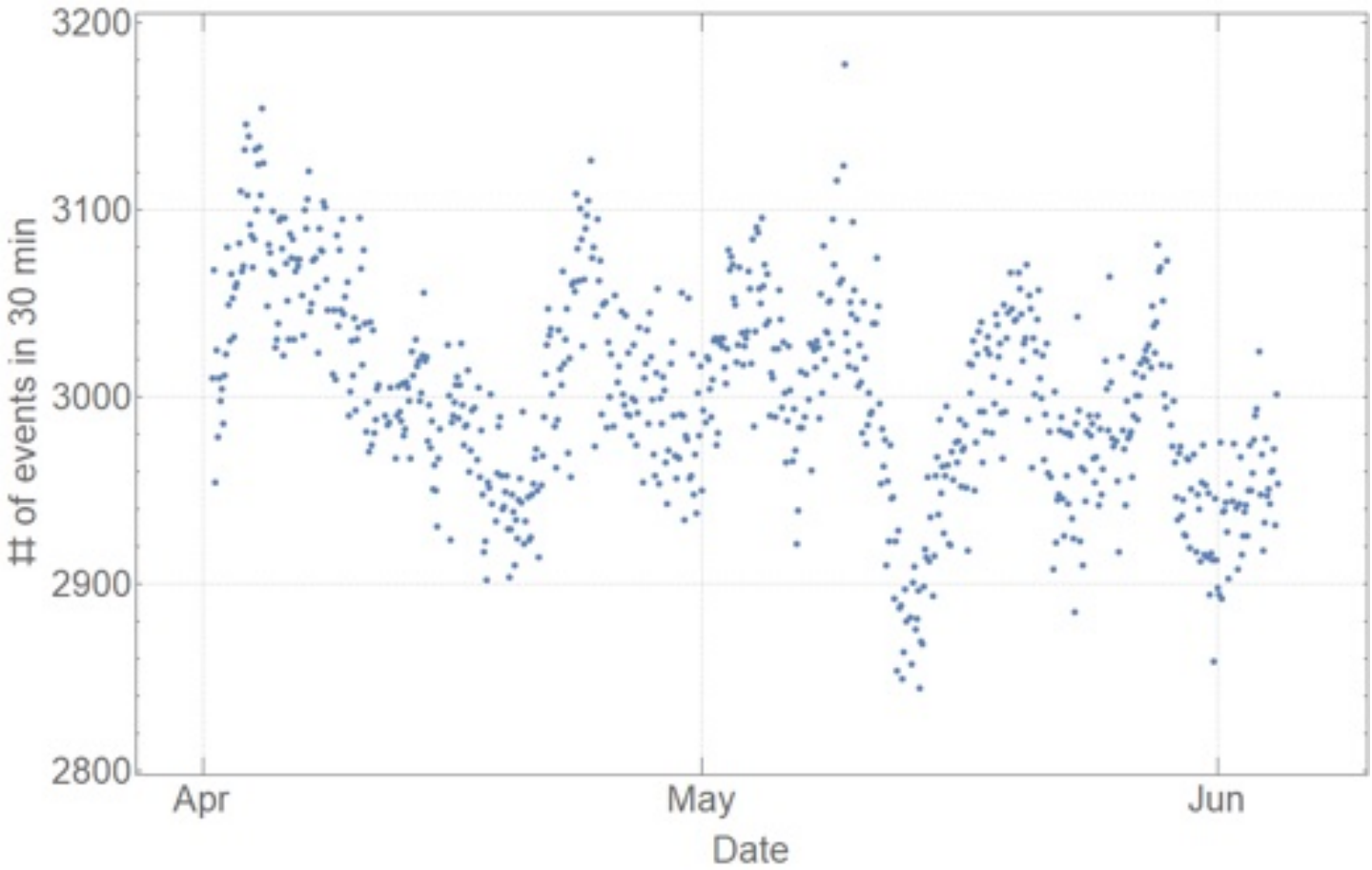


Figure: Number of events in 30 minutes averaged over 4 runs.

Event Rate - Pressure Correlation

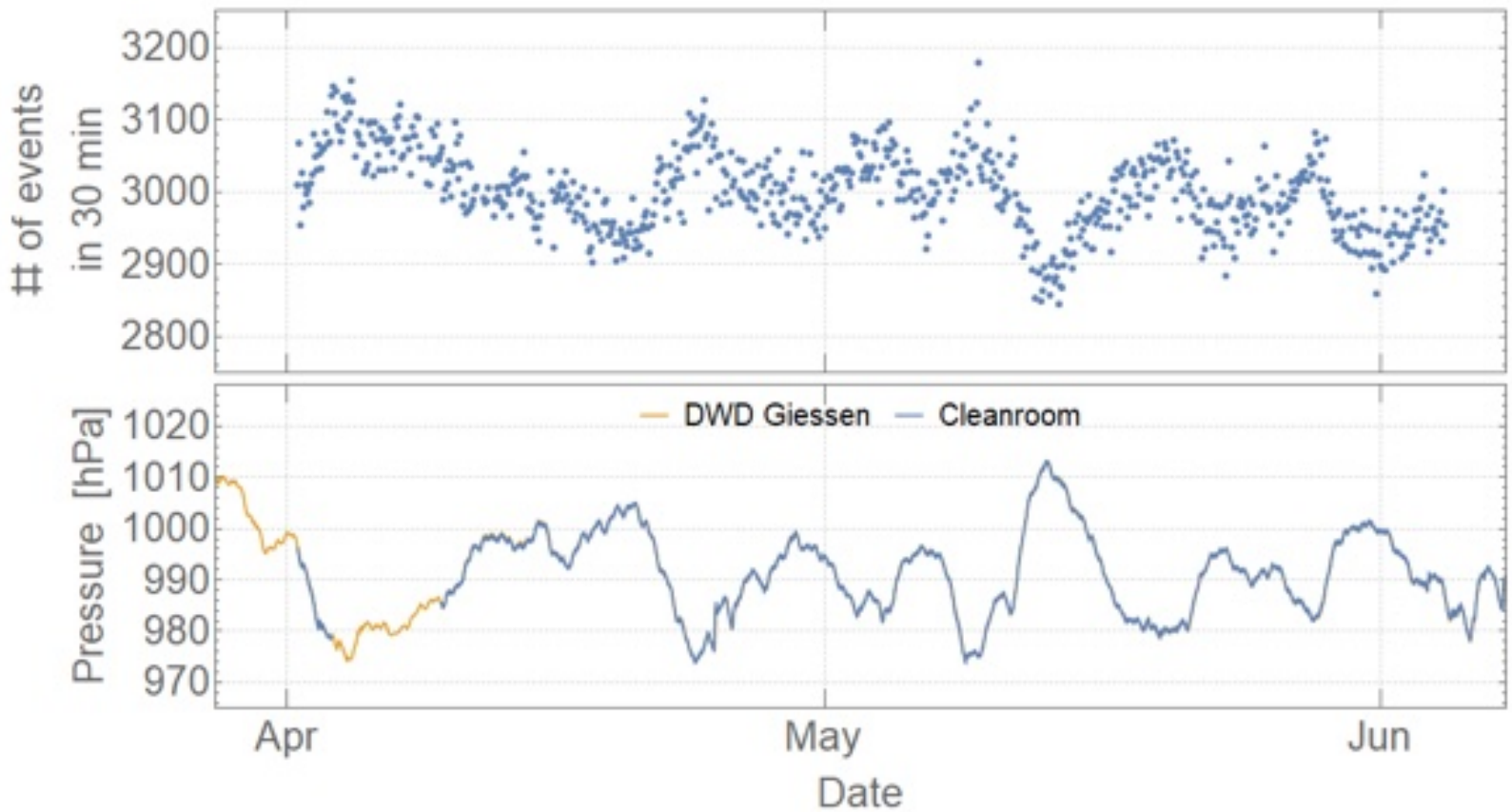


Figure: Comparison of rate and ambient pressure - local data (blue) and data provided by german weather service (orange).

Data for station 01639 (Gießen) provided by "Deutscher Wetterdienst" (Open data server). Last accessed 25.06.2019.

ftp://ftp-cdc.dwd.de/pub/CDC/observations_germany/climate/hourly/pressure/recent/stundenwerte_P0_01639_akt.zip

Event Rate - Pressure Correlation

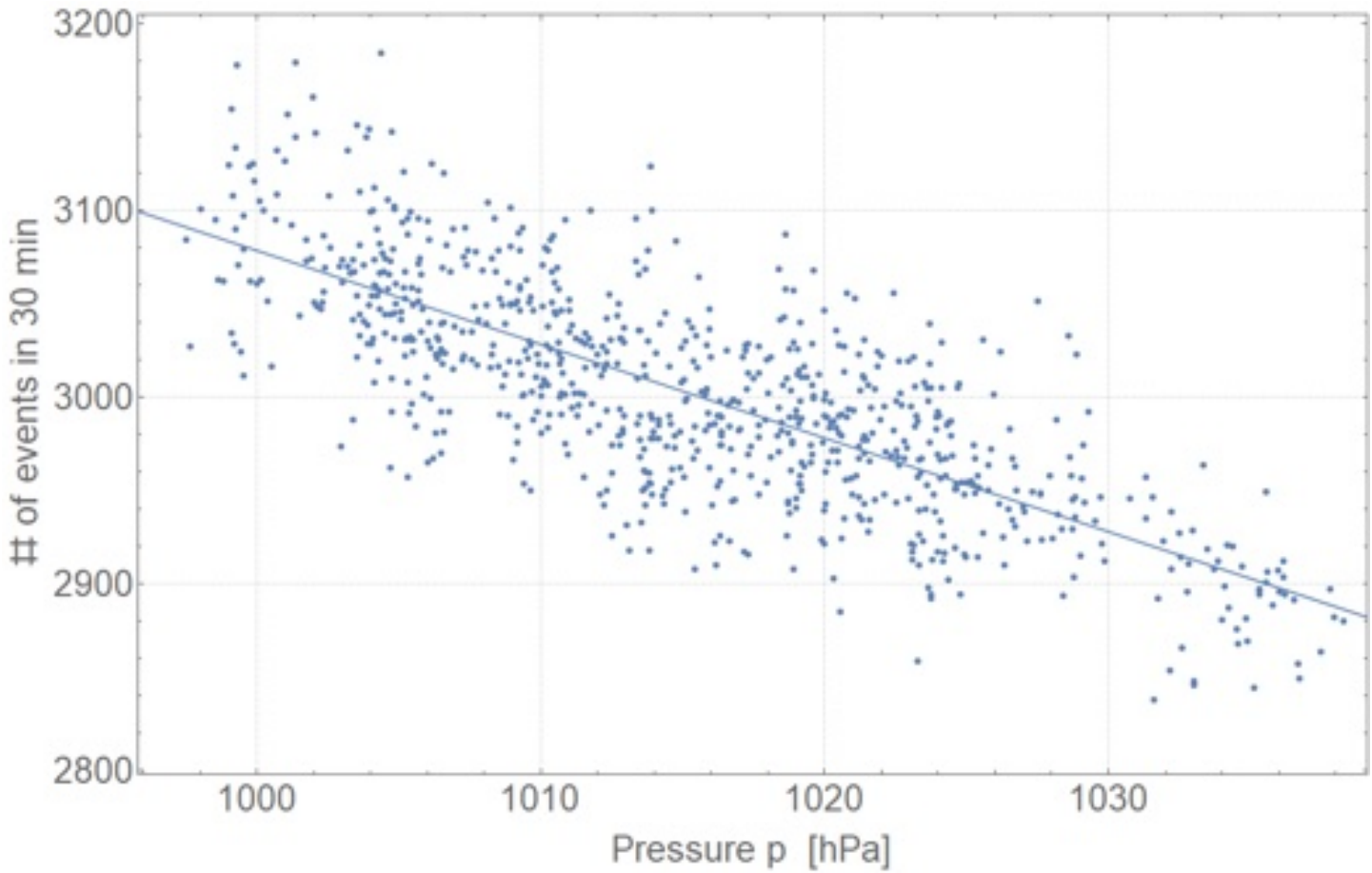


Figure: Scatter plot with fit of the ambient pressure versus the number of events in 30 minutes. $(8096 - 5.018 \frac{1}{hPa} \cdot p)$

GCS "Datasheet"

Angular acceptance

θ	0.1 . . . 0.4	rad
ϕ	-1.0 . . . 1.0	rad

Angular resolution

θ	3.8	mrad
ϕ	17.7	mrad

Spatial acceptance

x	-25 . . . 25	cm
y	-25 . . . 25	cm

Spatial resolution

x	4.4	mm
y	3.7	mm

Event rate, trigger and timing

- $\sim$ 2400 "clean" events in 30 minutes (10% with trigger)
- $\sim$ 600 MeV muon kinetic energy threshold
- $\sim$ 500 ps global time difference resolution

New Radiator Plate

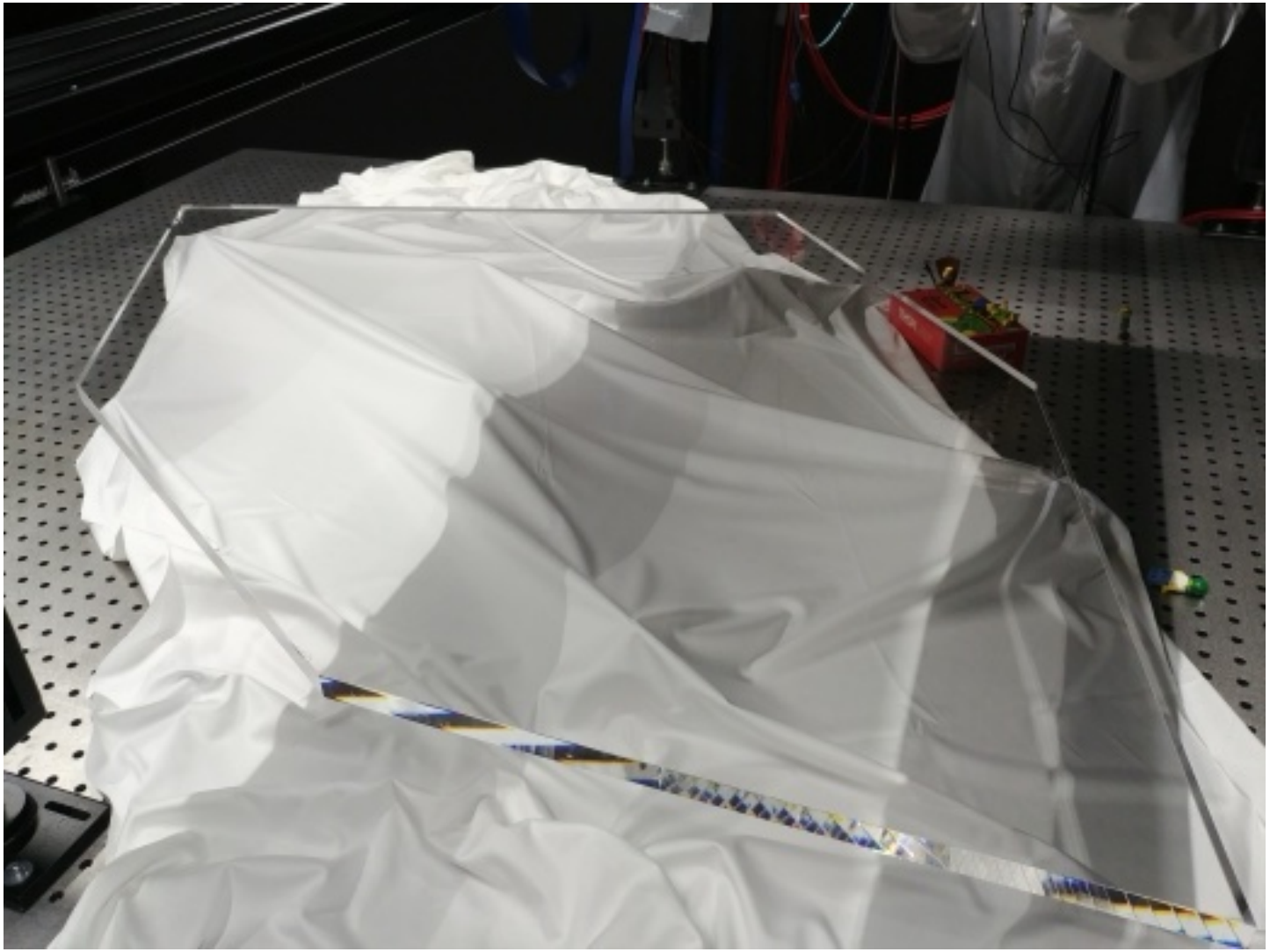


Figure: The new radiator plate.

Conclusion

Summary

- Data acquisition and reconstruction working
- Successful operated for several months
- Tracking is stable

Current status

- Tests with the new radiator plate planned

Thank you for your attention!

Multiplicity Distribution

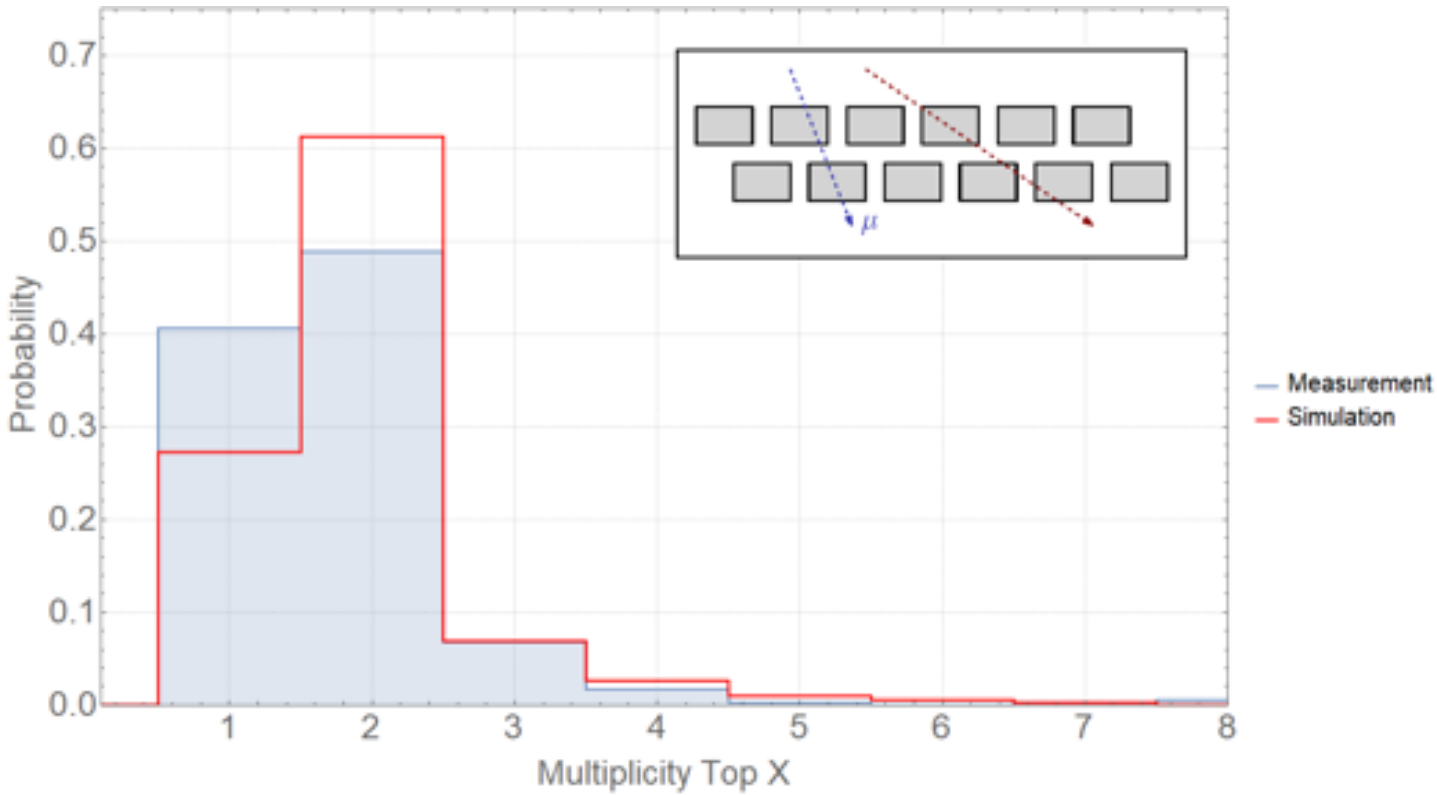


Figure: Multiplicity distribution for top x-coordinate tracking layer (Measurement and simulation).