Fast SiPM Readout of the PANDA TOF Detector

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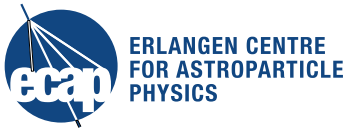
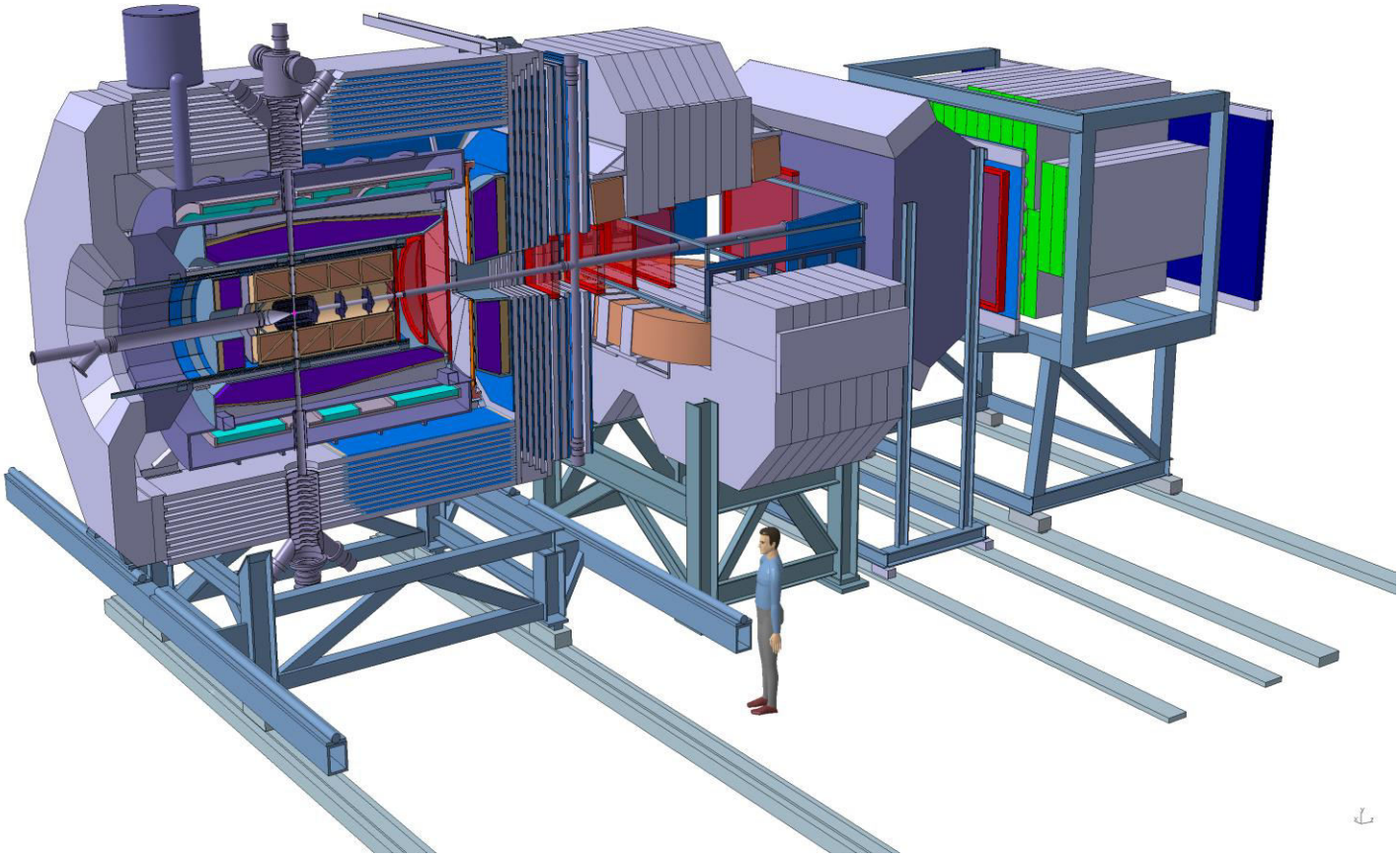
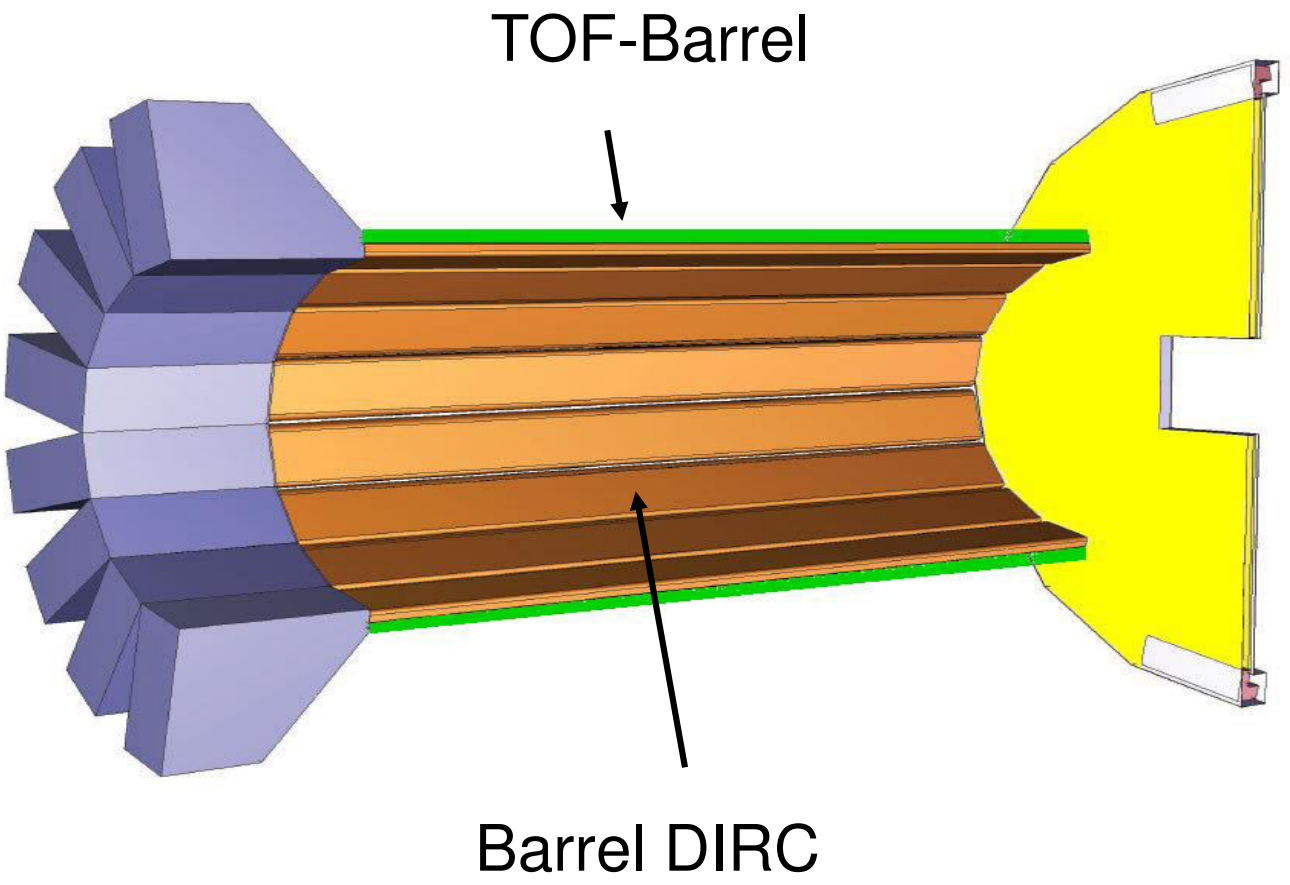
Rauischholzhausen, 13.11.2015



Panda Detector - Overview



Panda Detector – Barrel DIRC and TOF

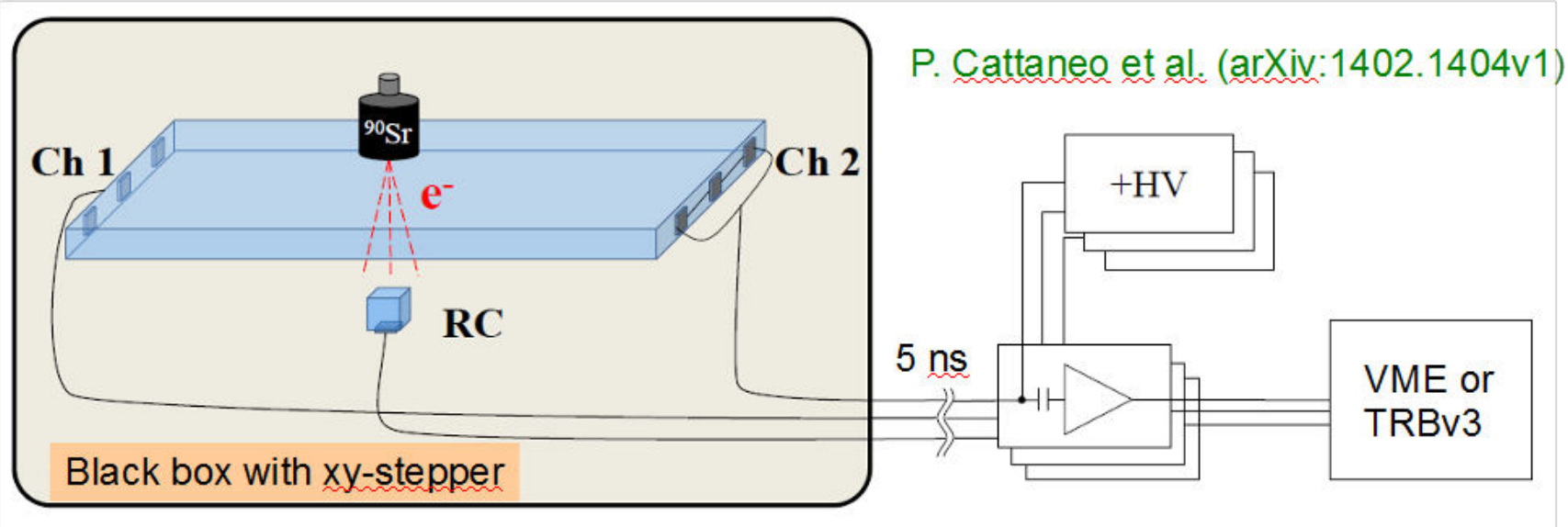


Motivation

- Event timing and particle identification for PANDA detector at FAIR
- Time of Flight (TOF) using small scintillation detectors
- Investigate different scintillator geometries and sensor (SiPM) configurations with respect to time resolution
- SciTils
  - Was first planned, 30x30x5 mm^3 with 1 sensor per side
  - Showed only moderate time resolution (~100 ps) -> Probably caused by photons distributed over large area and small photon solid angle -> many reflections
- SciRods
  - E.g., 120x5x5 mm^3 with 1 sensor per side
  - Use only totally reflected photons -> More collected photons arrive in shorter time window -> Better time resolution

Measurement Setup

Source: 1 mCi ^{90}Sr with 1 mm aperture **Trigger Scintillator (RC):** 5x5x5 mm^3

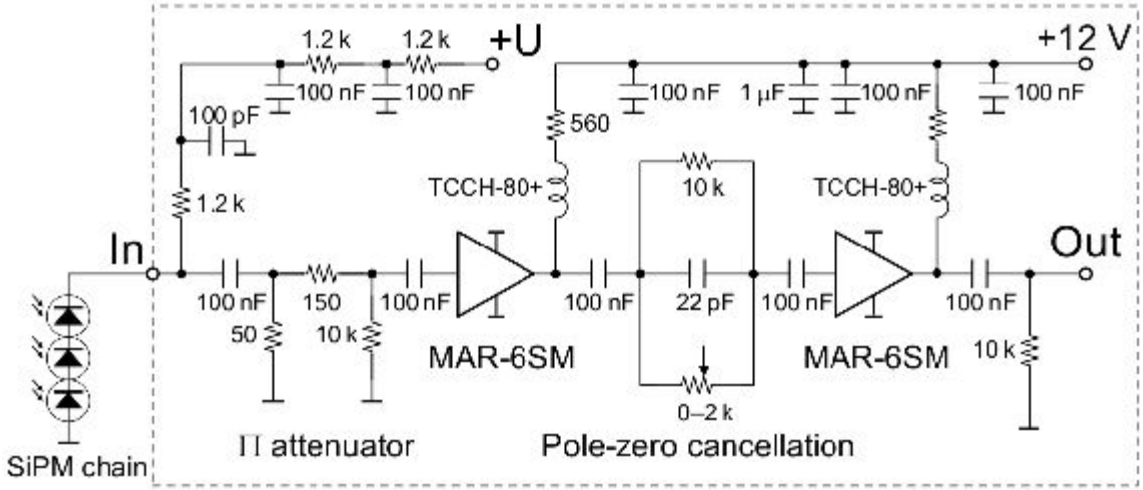


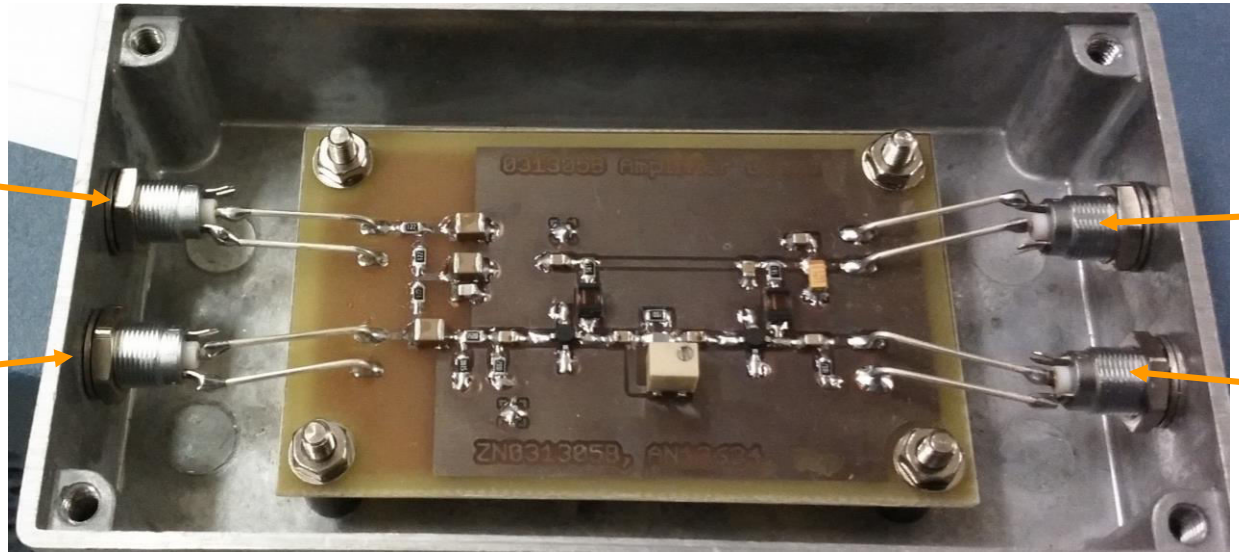
- Scintillator rods read out at opposite sides with MPPCs
  - Without and with wrapping (white paper and aluminum)
  - Measure pulse heights Npe (→ number of photons)
  - Measure time difference Tdiff (→ time resolution)
- xy-Scans of scintillator surface in 1-4 mm steps

Amplifier Layout

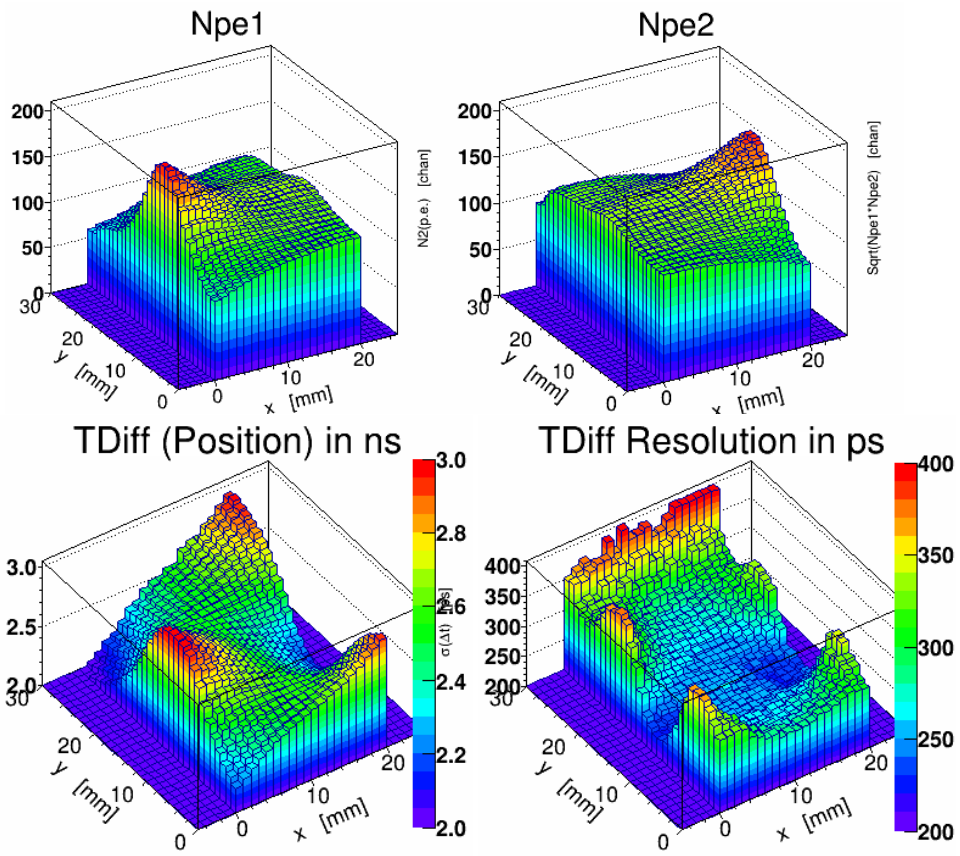
- Source:

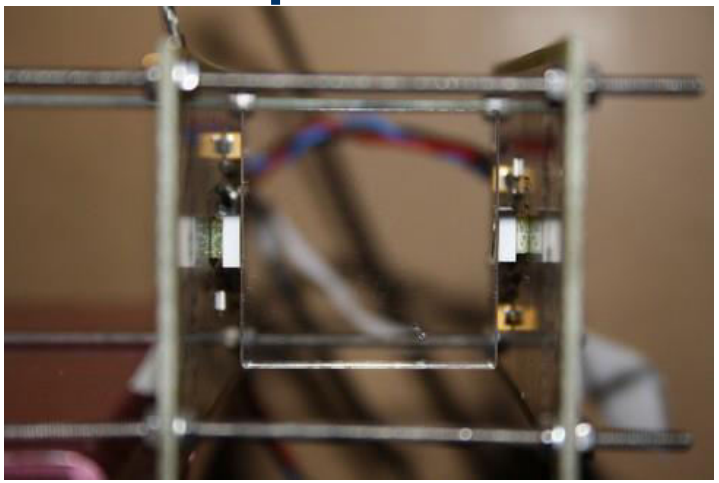
arXiv 1402:1404





SciTilScans (Npeand TDiff) with 1 sensor per side



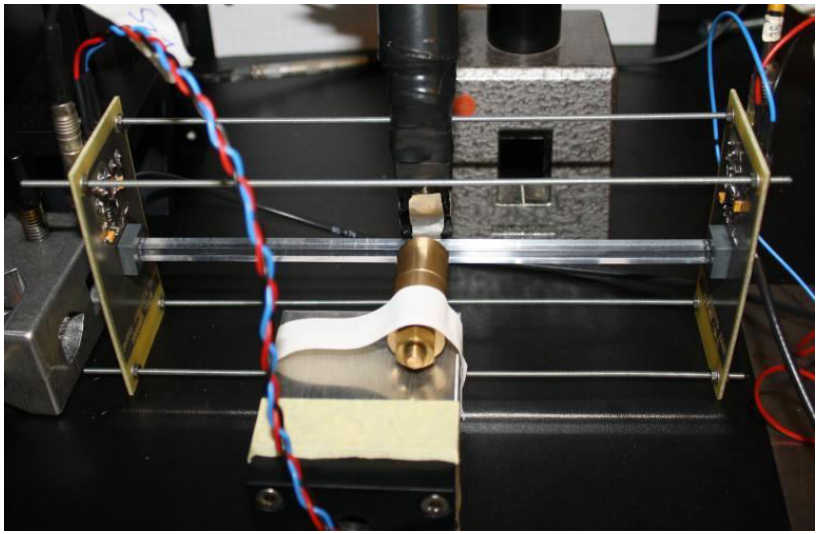


Scintillator: BC408
5x30x30 mm^3
MPPC S12652-050C

- Highest Npe close to MPPC and fewer far away from MPPC
- Best time resolution close to sensors, overall resolution 110-190 ps

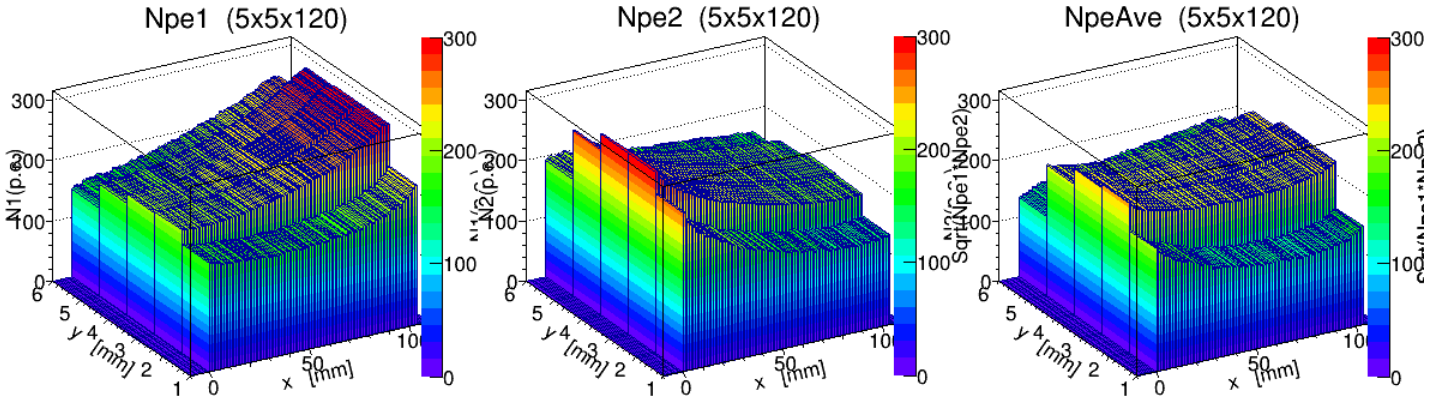
SciRod time resolutions

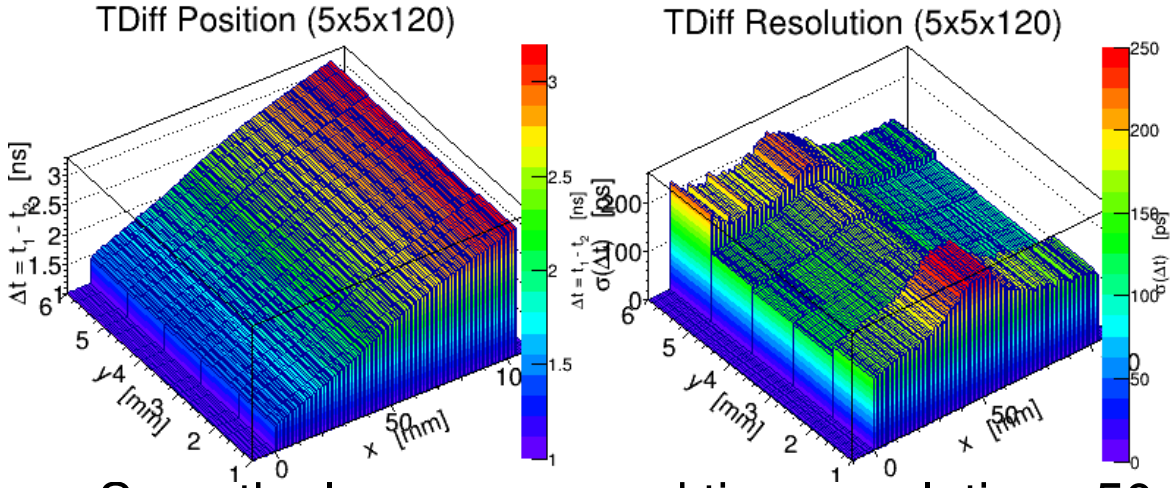
- Sensor: MPPC S12652-050C
- Slight dependence
  along scintillator length



	BC408	BC420
5x5x120 mm³	81 ± 12	68 ± 10
5x5x50 mm³	83 ± 6	62 ± 5

SciRod Scans (Npe and Tdiff)





Npe ist...

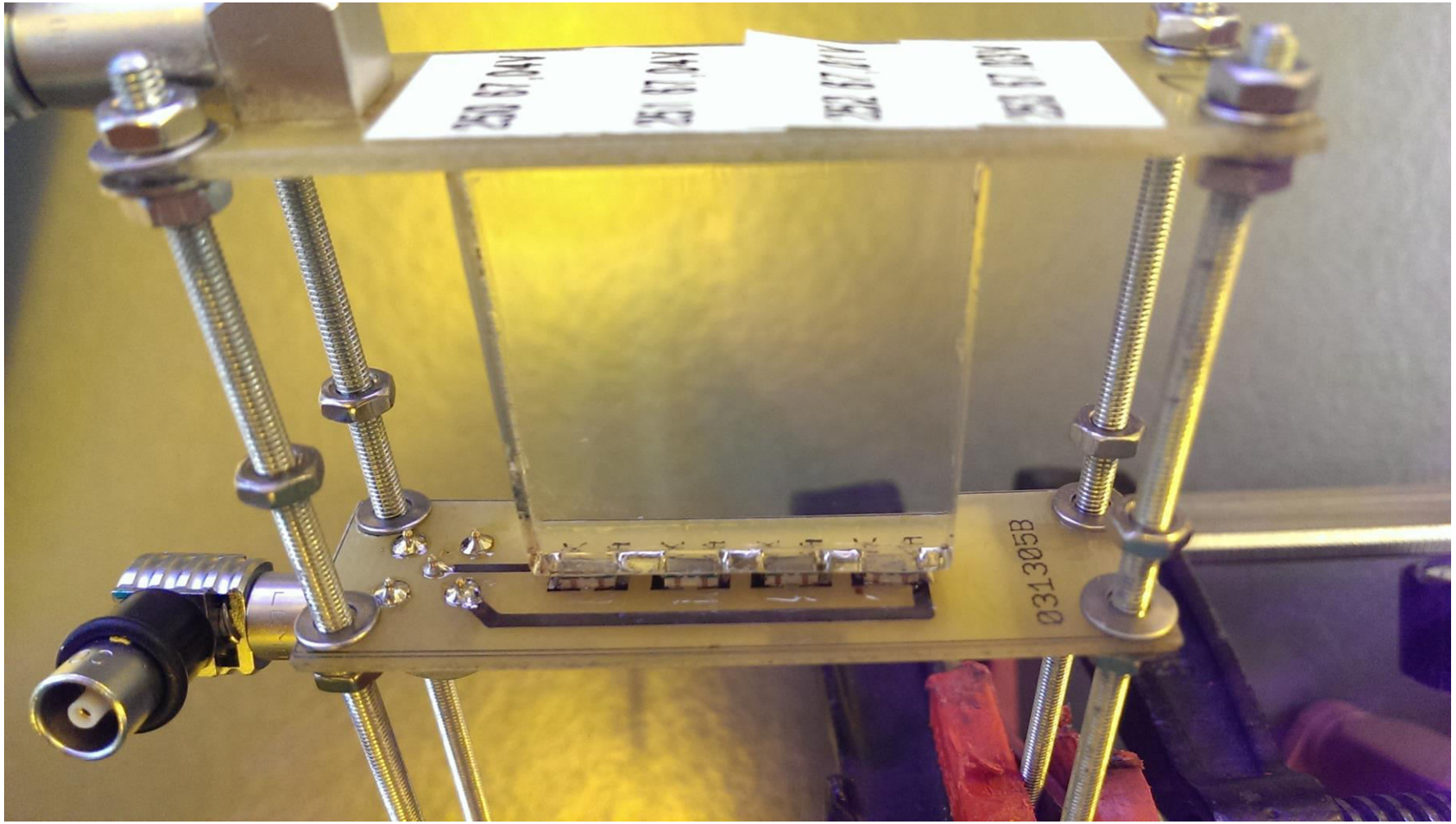
Scintillator: BC420
5x5x120 mm^3
MPPC S12652-050C

- Smooth slope, very good time resolution ~50 ps
- Possible to determine x-position

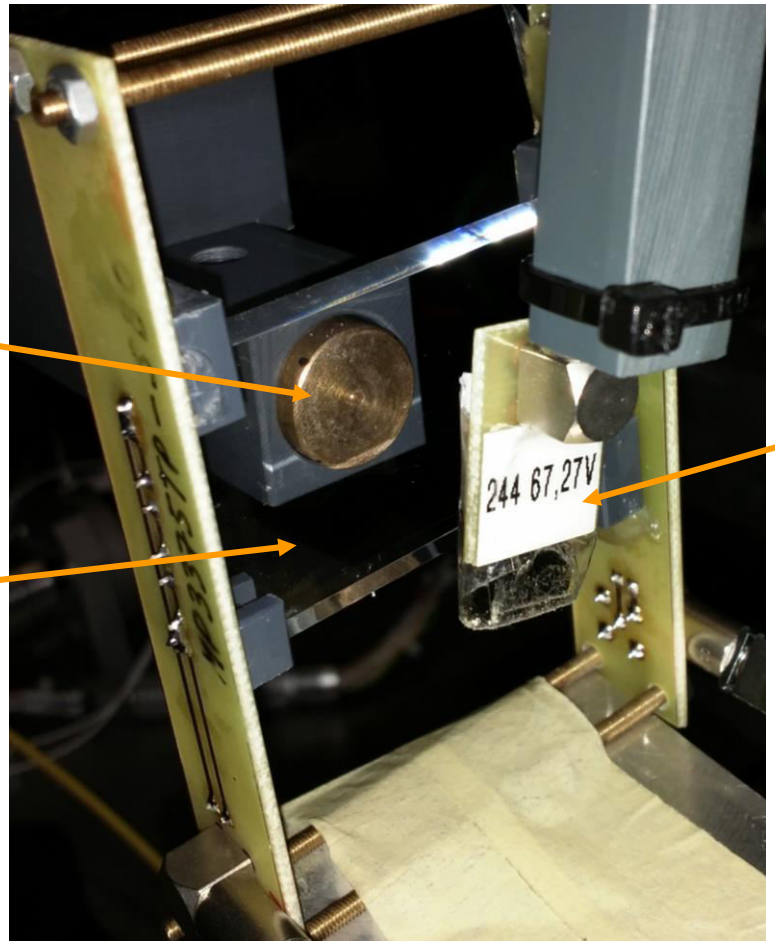
Motivation - more than 1 sensor per side

- Possible advantages
  - Collection of more scintillation photons
    - More solid angle
    - Better time resolution
  - Better geometrical coverage
    - Catch more photons from corners
    - more homogeneity in light collection and time resolution across surface
  - Sensors in series -> Reduced readout capacity
    - Faster signal rise time
    - Better time resolution

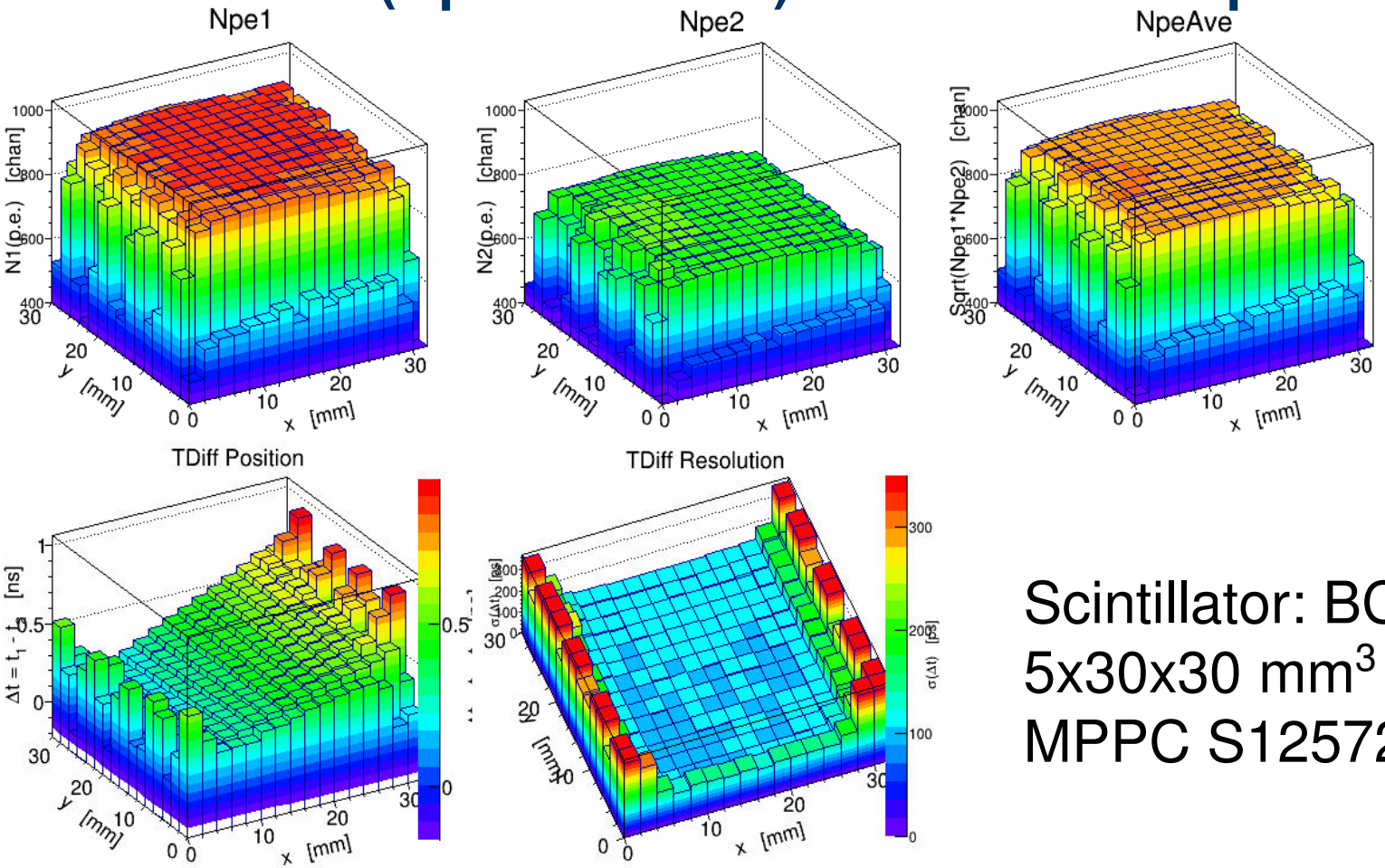
Motivation - more than 1 sensor per side



Motivation - more than 1 sensor per side



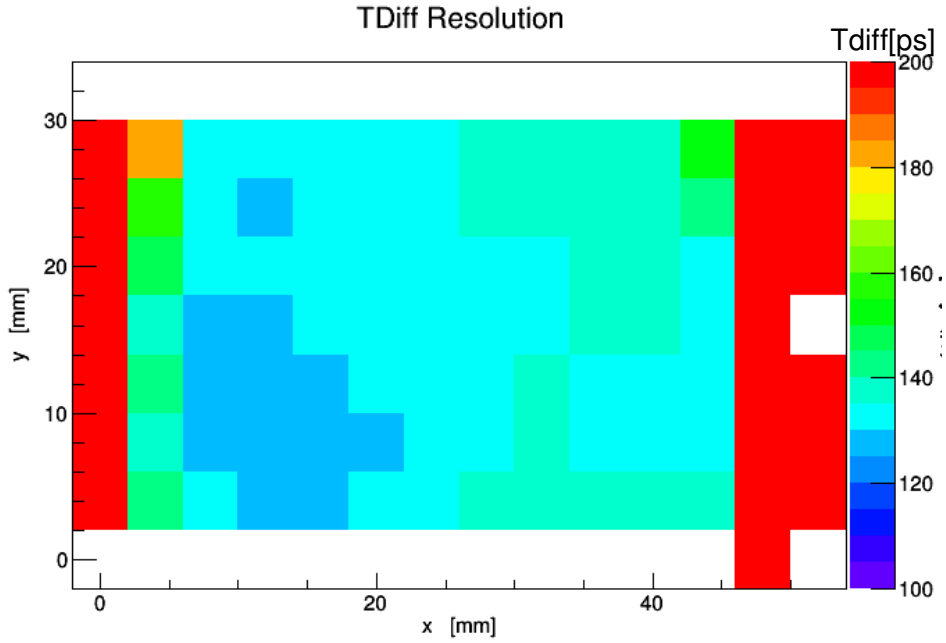
SciTil Scans (Npe and TDiff) with 4 sensors per side

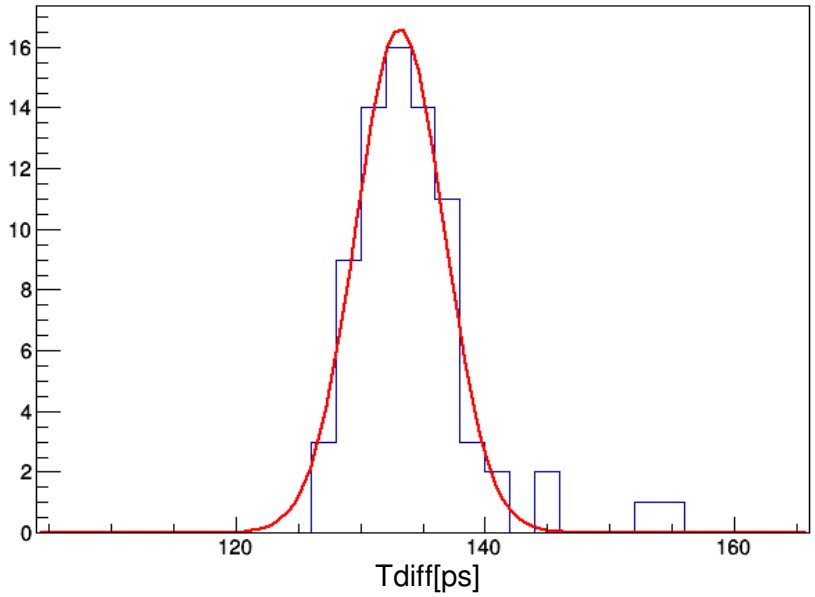


Scintillator: BC420
5x30x30 mm^3
MPPC S12572-050P

- Npe and TDiff distributions much smoother than with 1 sensor per side

Comparison between different configurations





Time resolution $\sigma_t = \frac{T_{Diff}}{2}$

Comparison between different configurations - Different scintillators

- Scintillator: 5x30x50 mm^3, -20mV threshold
- Sensor: Hamamatsu S12572-050P, 4 per side in series

	Unwrapped 4V	Unwrapped 6V	Paper 4V	Paper 6V
BC420	93 ± 4	72 ± 3	84 ± 3	68 ± 2
BC418	92 ± 3	74 ± 2	79 ± 2	67 ± 2
BC408	135 ± 4	95 ± 2	-	-

σ_t [ps]

Comparison between different configurations - Wrapping the scintillator

- BC420, 5x30x120 mm^3
- Sensor: Hamamatsu MPPC S12572-050P, 4 per side in series

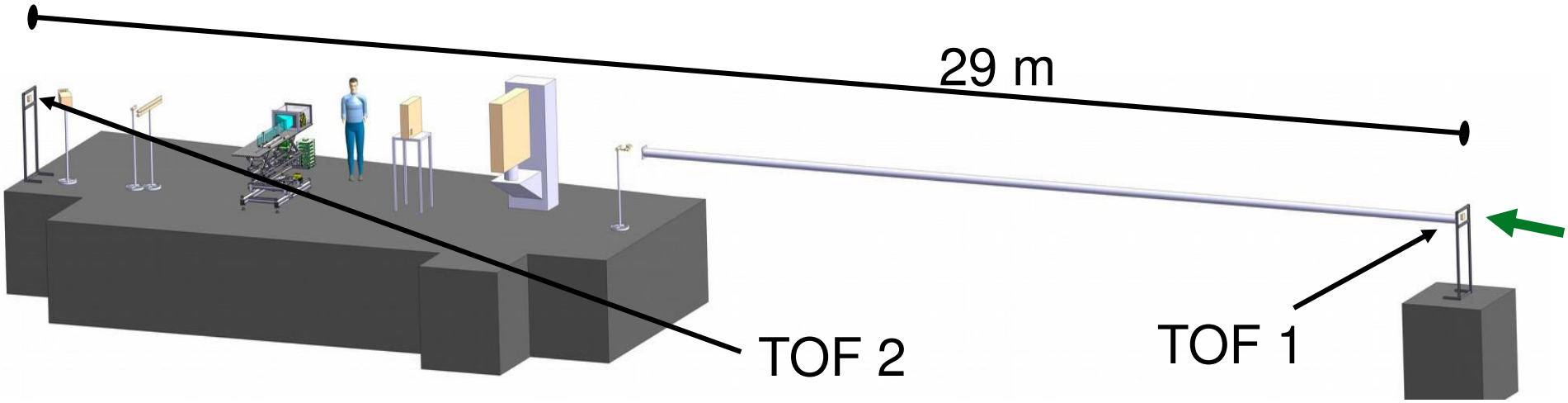
	Unwrapped	Paper	Aluminum foil
σ_t [ps]	83 ± 3	80 ± 2	76 ± 2
N_{pe} [chan]	658 ± 12	700 ± 15	743 ± 10

- BC418, 5x30x30 mm^3
- Sensor: Ketek PM3350TP-SB0, 4 per side in series

	Unwrapped	Paper	Aluminum foil
σ_t [ps]	53 ± 2	48 ± 1	45 ± 1
N_{pe} [chan]	321 ± 8	420 ± 3	448 ± 1

CERN Beamtime 2015 - Setup

- Setup
  - Two TOF-Stations, 29 m appart
  - Beam 2-10 GeV/c containing mainly Protons, Pions, Electrons and Kaons



CERN Beamtime 2015 - Setup

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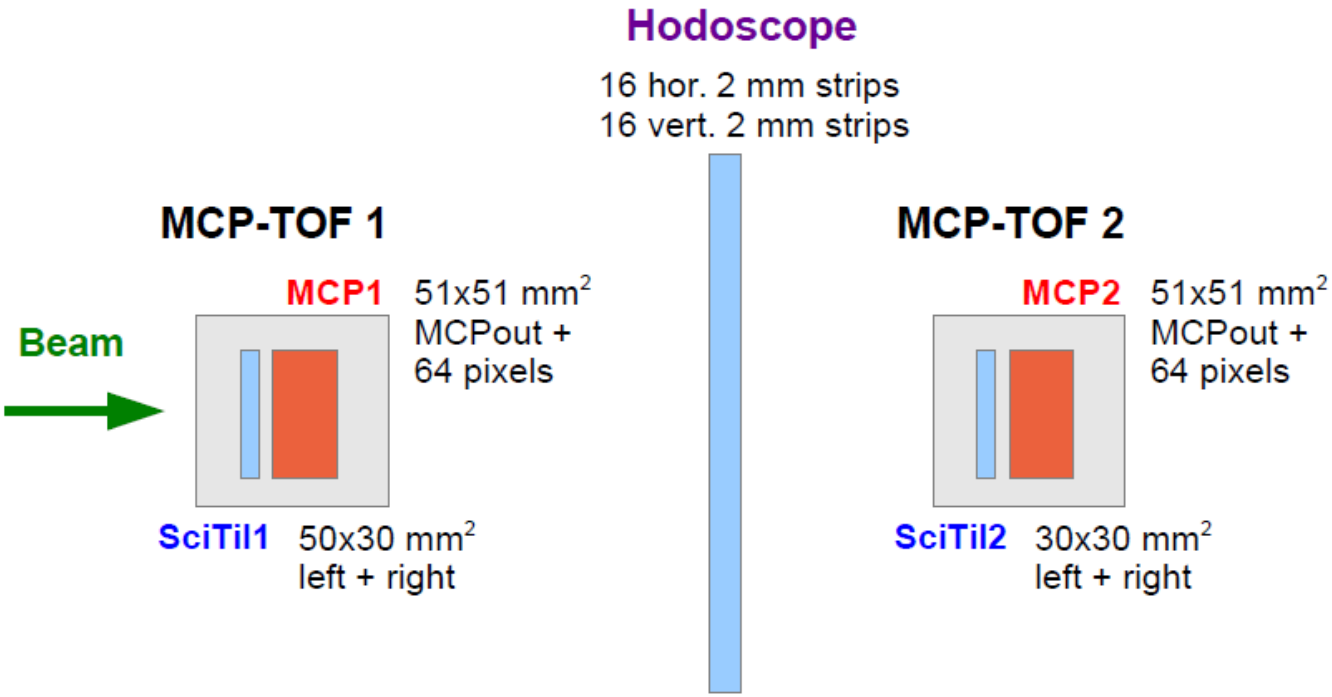
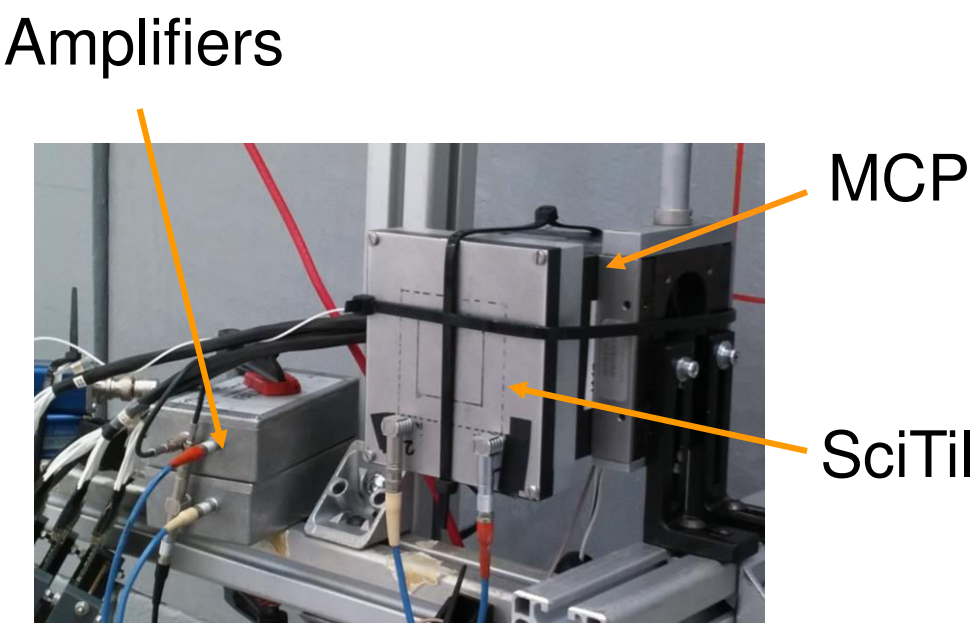
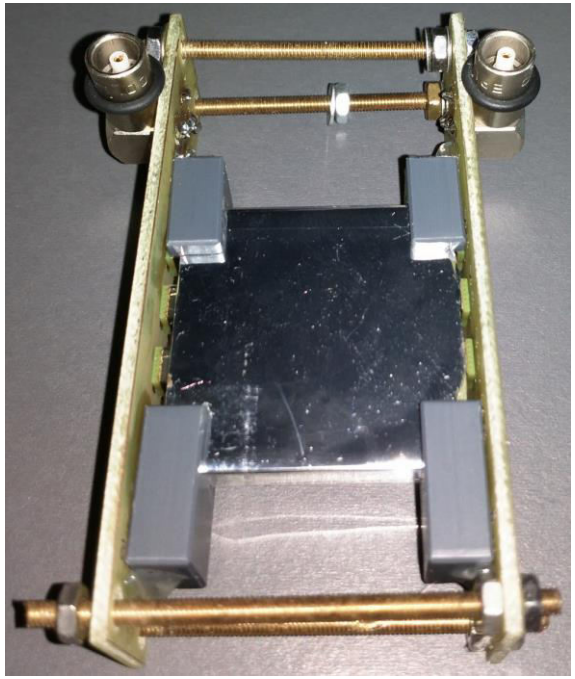


CERN Beamtime 2015 - Setup

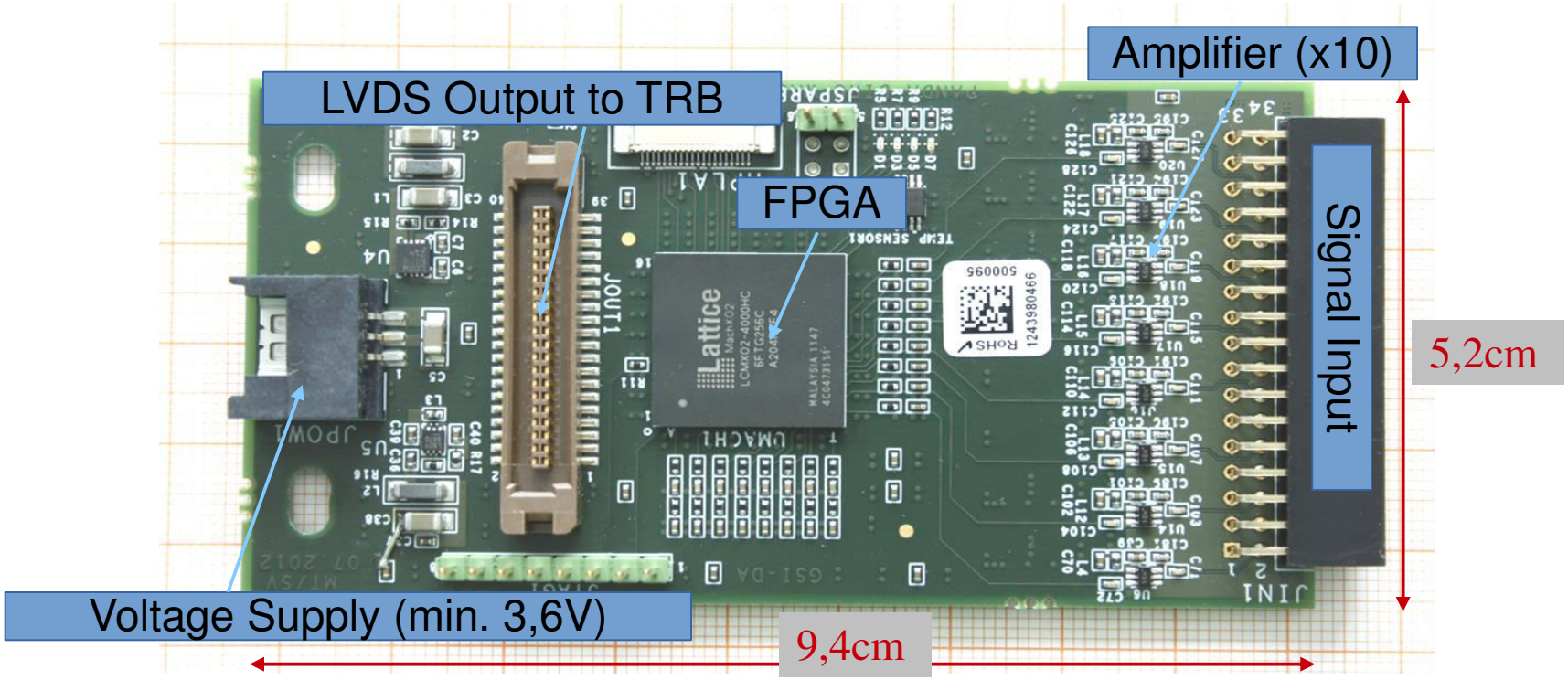
- Setup
  - 5x3 cm² and 3x3 cm² BC418 Scinsillators
  - Photon detection with 4 Ketek sensors per side in series





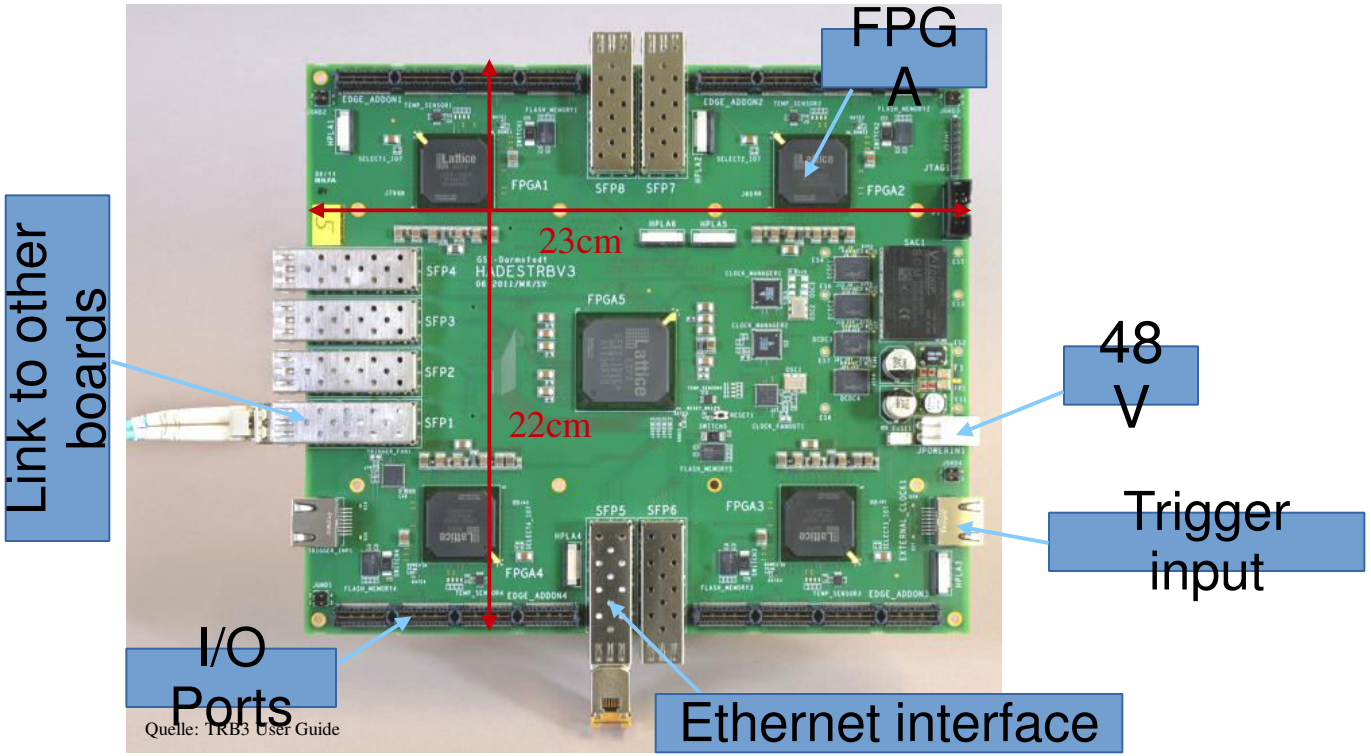
CERN Beamtime 2015 – Readout

- Padiwa
  - 16 Channels input, LVDS output
  - Threshold selection and other settings via TRB3 board



CERN Beamtime 2015 – Readout

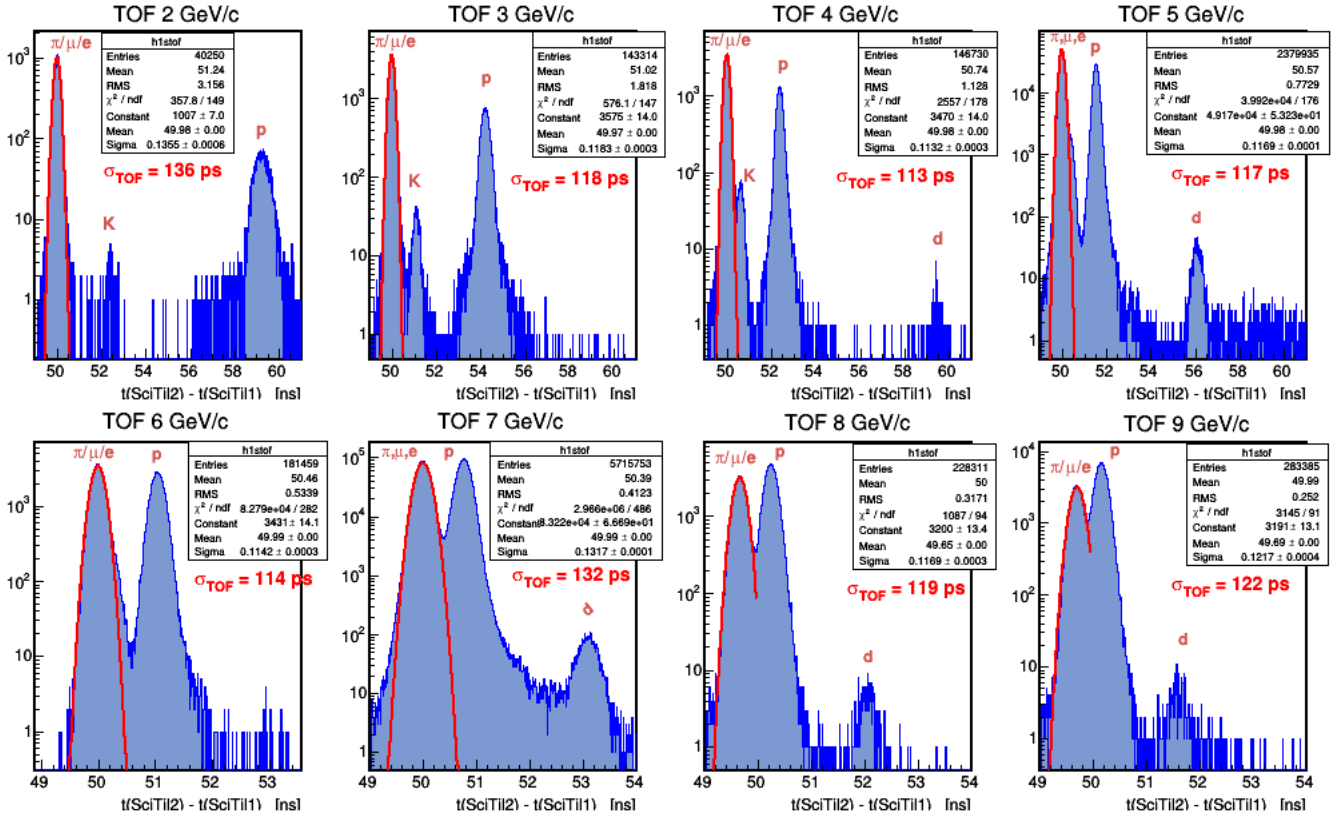
- TRBv3
  - FPGA based TDC and trigger board with 256 TDC channels/board
  - 3.6ps time resolution possible (~10ps with 256 chans)



Quelle: TRB3 User Guide

CERN Beamtime 2015 – Results

- SciTil1: ~50 ps
- SciTil2: ~70 ps



Summary and Outlook

- Conclusion
  - New scintillator/SiPMdesigns (SciRods) show better time resolution than the originally planned SciTils (with 2 SiPMs)
  - Improved time resolution with wrapping and faster scintillators
  - Best time resolution so far: 45 ± 1 ps with 5x30x30 mm^3 BC418 wrapped in aluminum foil with Keteksensors
  - Beamtime showed SciTil resolution of 50-70 ps under real experimental conditions
- Outlook
  - Compare differet amount of sensors per side

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