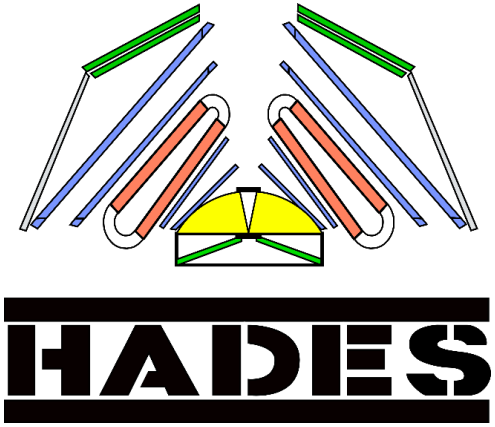
Diamond detectors in the HADES-experiment

S. Spies[1], J. Pietraszko[2], W. Koenig[2], M. Träger[2], M. Kis[2], A. Rost[3] and T. Galatyuk[3] for the HADES Collaboration
[1]Goethe University Frankfurt; [2]GSI Helmholtzzentrum für Schwerionenforschung; [3]Technical University Darmstadt

Performance and calibration of the single crystal scCVD reaction time detector of the HADES-experiment



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654168

AIDA 2020

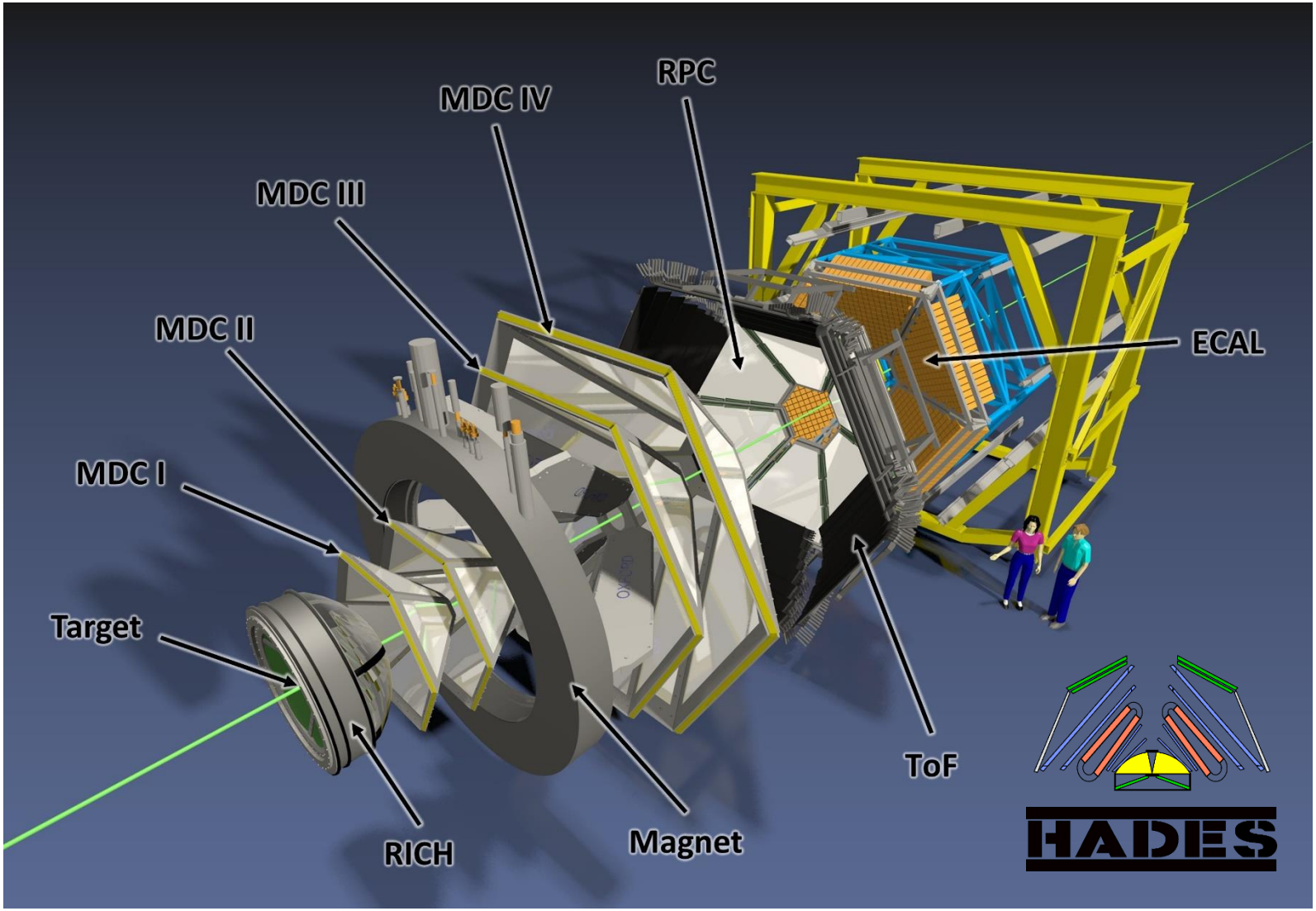
Outline

- The setup of the HADES-experiment
  - The reaction time (START) detector
  - The event quality (VETO) detector
- Time calibration
  - Preliminary channel-wise calibration
  - Precise final calibration using reconstructed particle tracks
- Summary and Outlook

Detector Setup

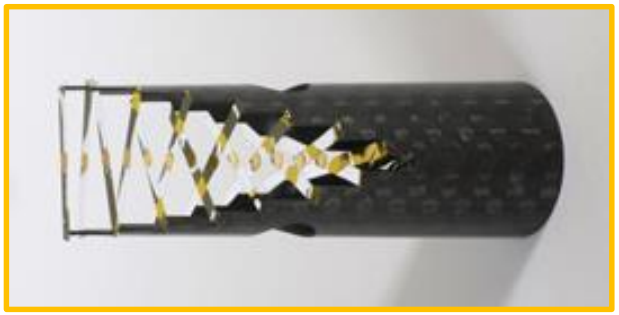
Setup and Layout of START and VETO detector

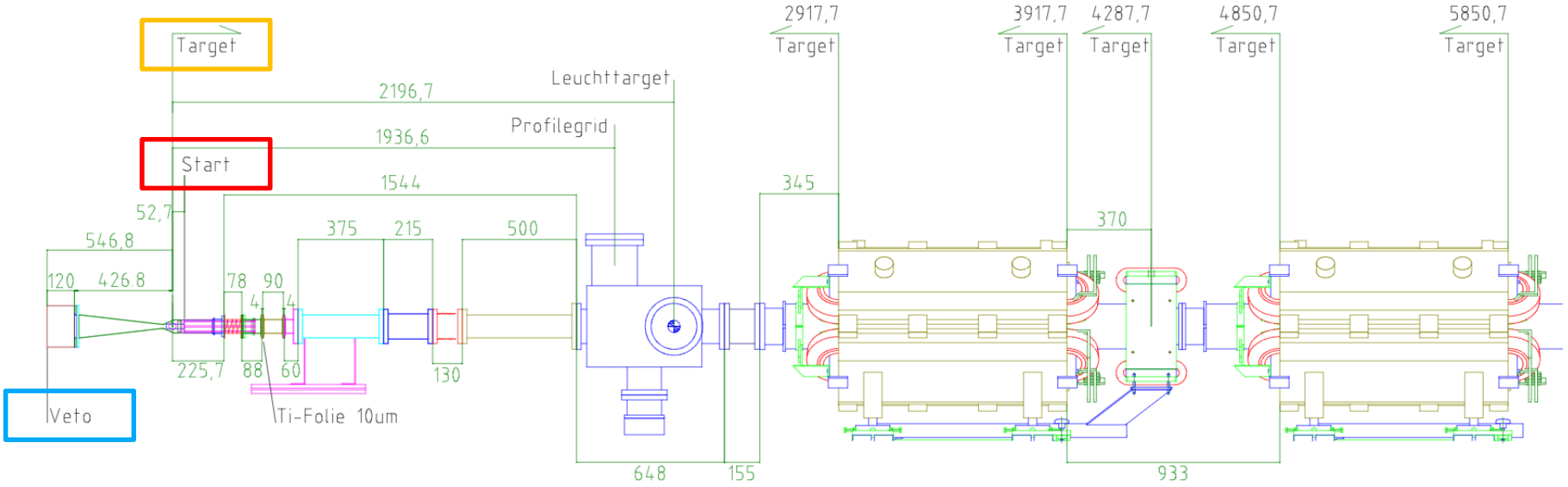
High **A**cceptance **Di** **E**lectron **S**pectrometer



The HADES Beamline

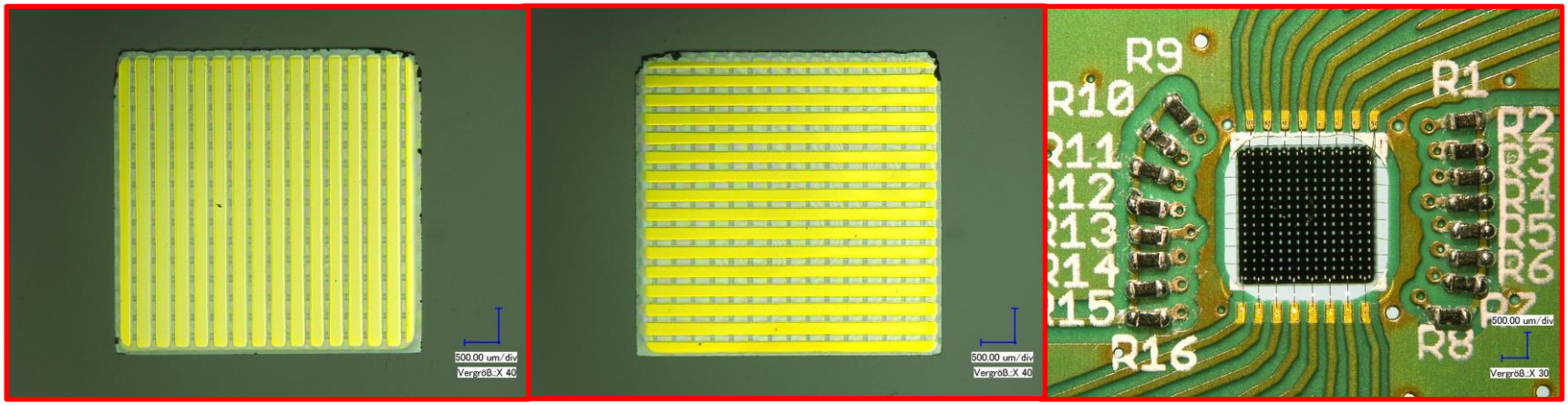
- START detector 5,27cm in front of target
- VETO detector 54,68cm behind target





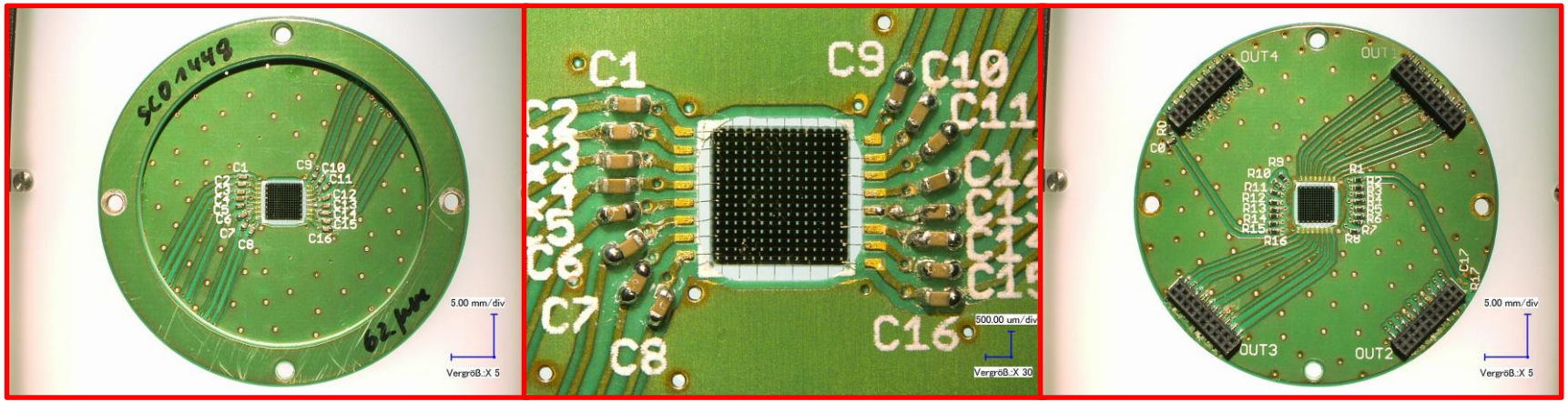
The START Detector

- Double-sided multi-strip scCVD Diamond sensor for HI
- 16 Strips on each side with widths of 200µm and gaps of 90µm
- 60µm thick detector → high field inhomogeneity



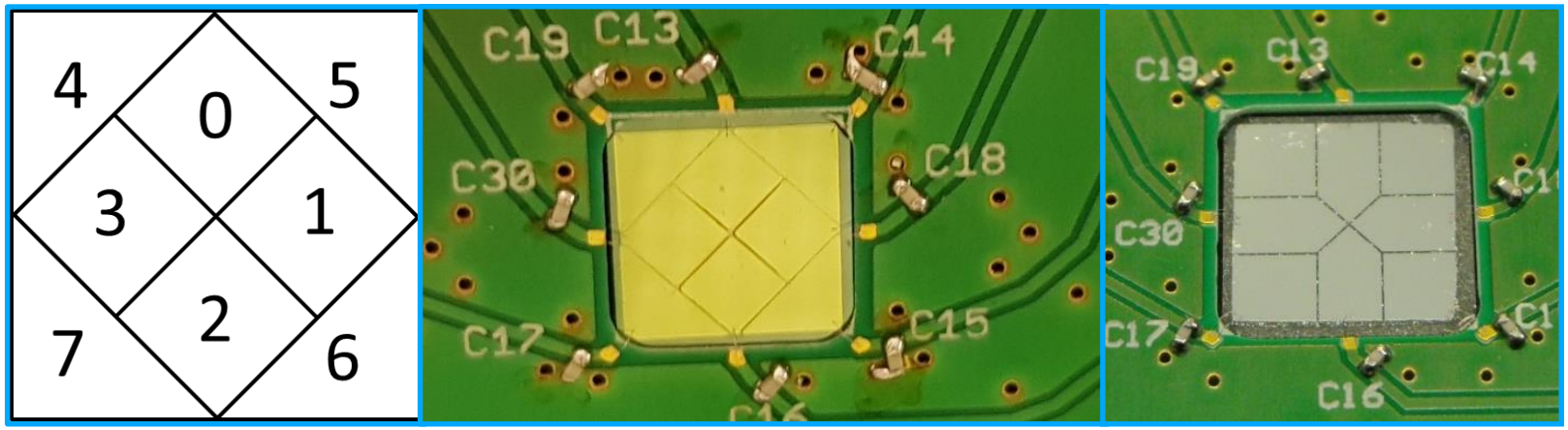
The START Detector

- Total active area 4.7mm x 4.7mm, mounted on a holder allowing for movement in x- and y-direction
- Read out by one multihit-TDC per channel with $\Delta t \approx 17$ps and up to 10MHz readout rate
- After full calibration $\Delta t \approx 50$ps possible



The VETO Detector

- 8mm x 8mm pCVD Diamond detector with 8 channels
- Necessary to discard problematic events (e.g. Pile-Up events)
- Used also as reference to calibrate START detector

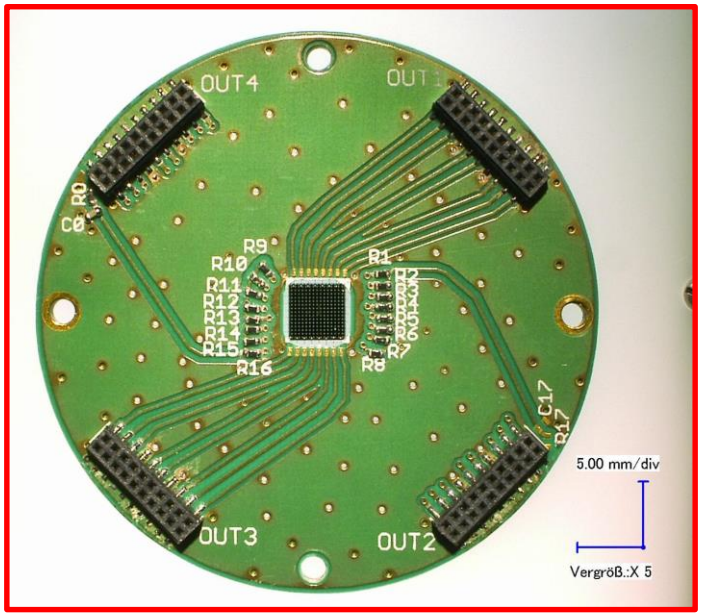


Time Calibration

Calibrating START and VETO detector

Rough channel-wise calibration

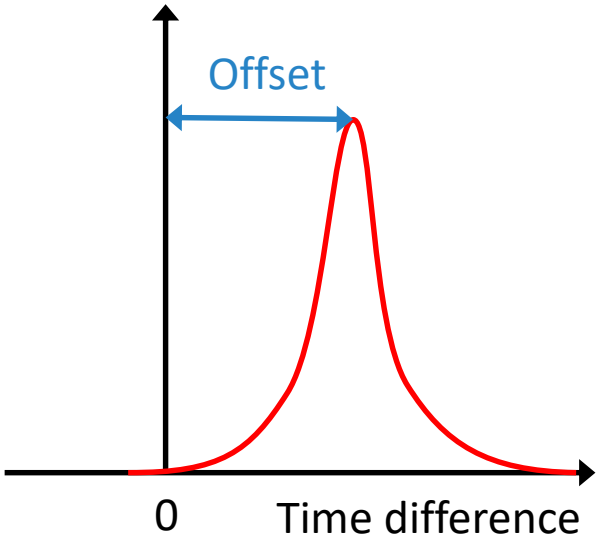
- Speed of electric signals ≈ 2/3 c
  = 200,000 km/s = 0.2 mm/ps
- Aim: Time precision of 50ps
  order of magnitude
- Problem: Already few mm difference in cable length lead to noticeable differences in signal delay



- Solution: Define individual offsets for each channel to compensate differences in signal propagation time
- Define global offset so that absolute START Times are equal 0

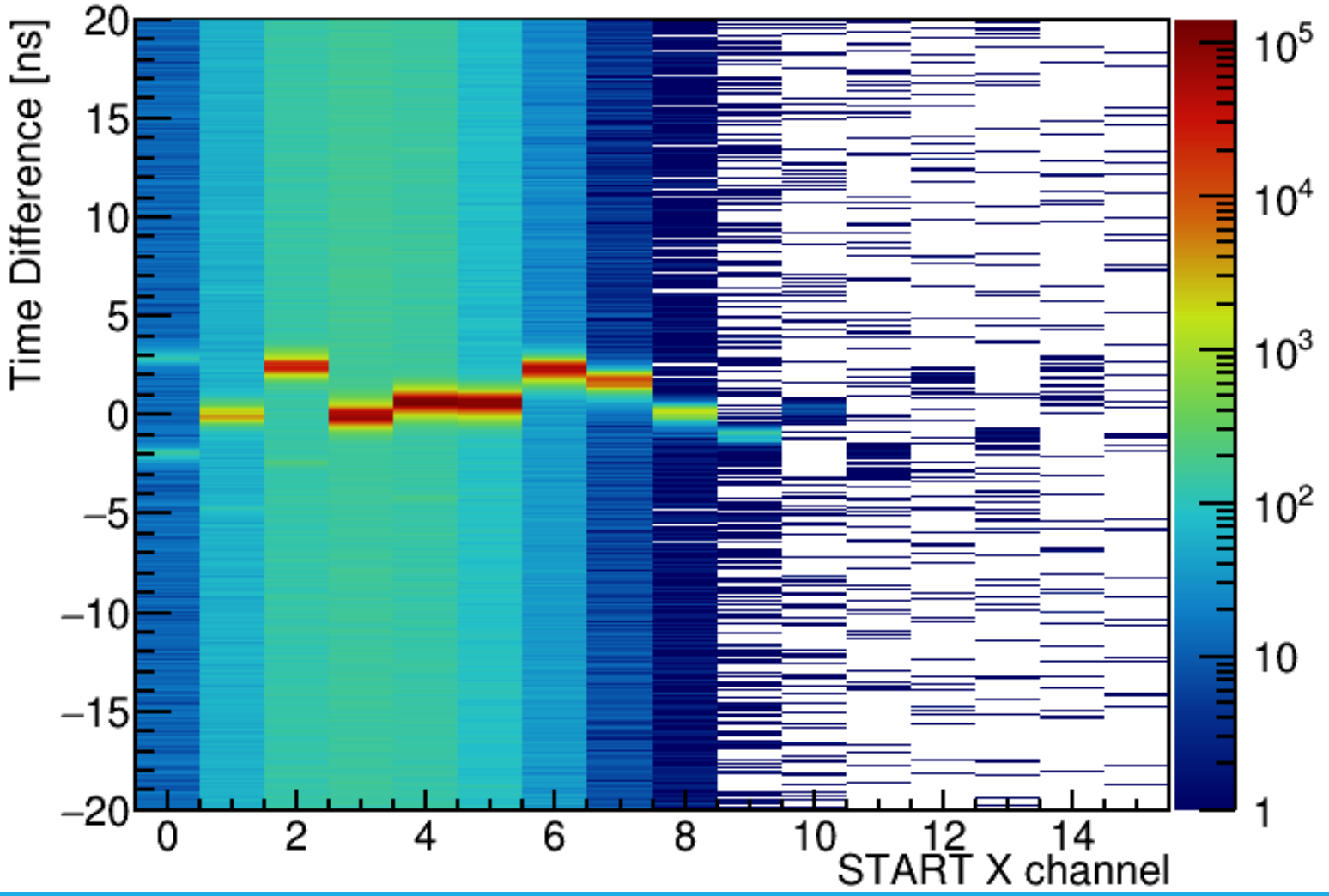
The Method

- Select most abundantly hit cell of VETO
- Calculate distribution of time difference between coincident hits in START and the selected VETO cell
- Define offset for each channel of START that the distributions peak at 0



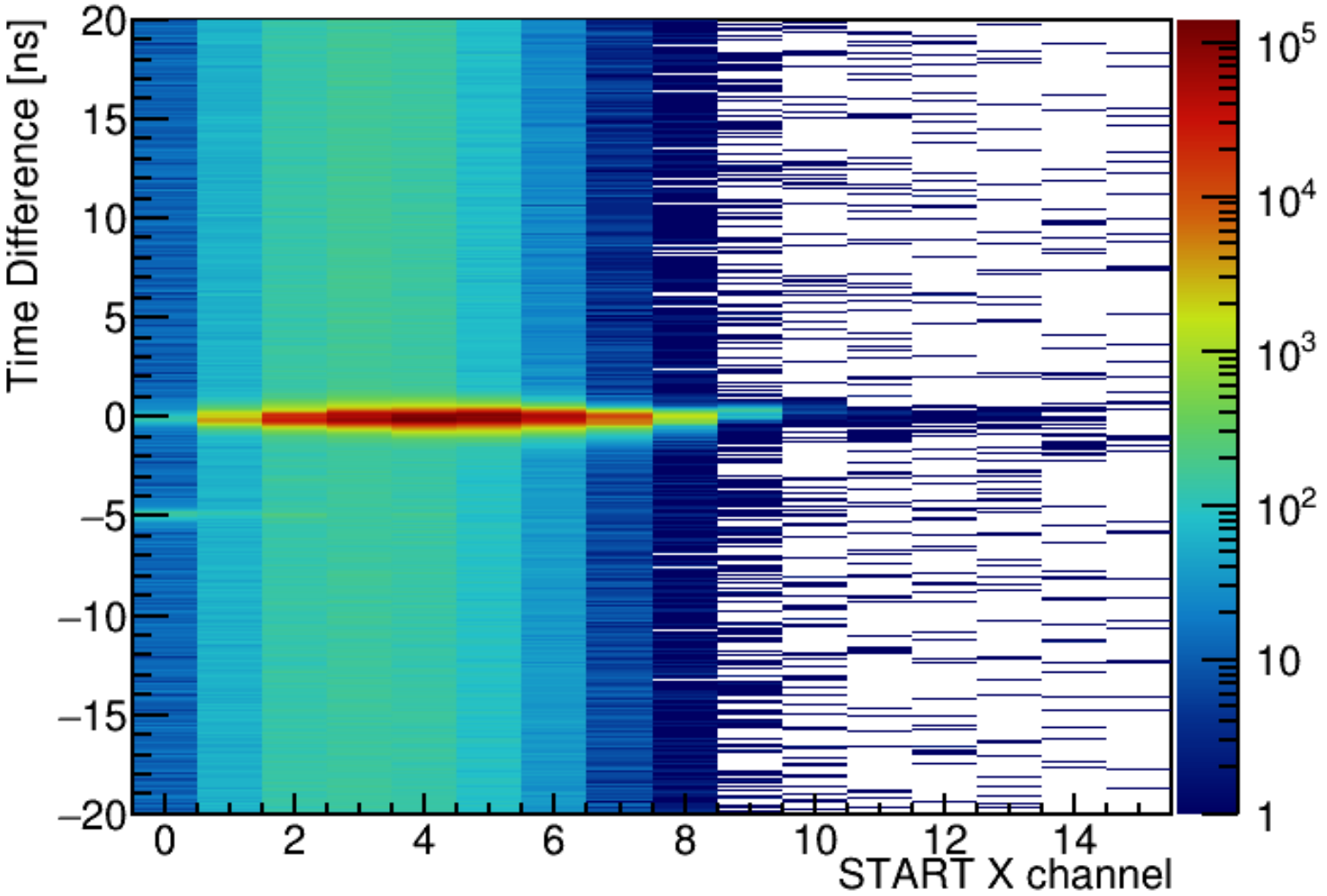
- Done for all 16 channels of both sides of the START detector individually
- Very first step of timing calibration in the experiment

Before first calibration step



After first calibration step

- Time precision after calibration: Δt ≈ 190ps



Time Calibration

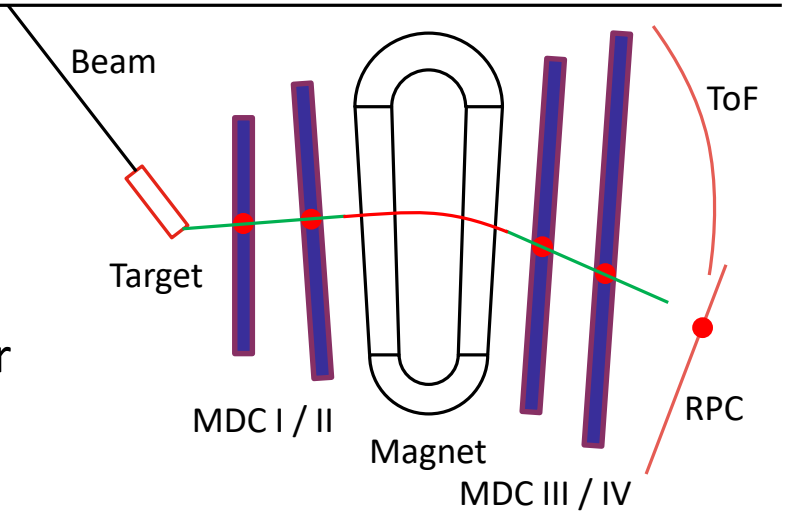
Calibrating START Times with negative Pions

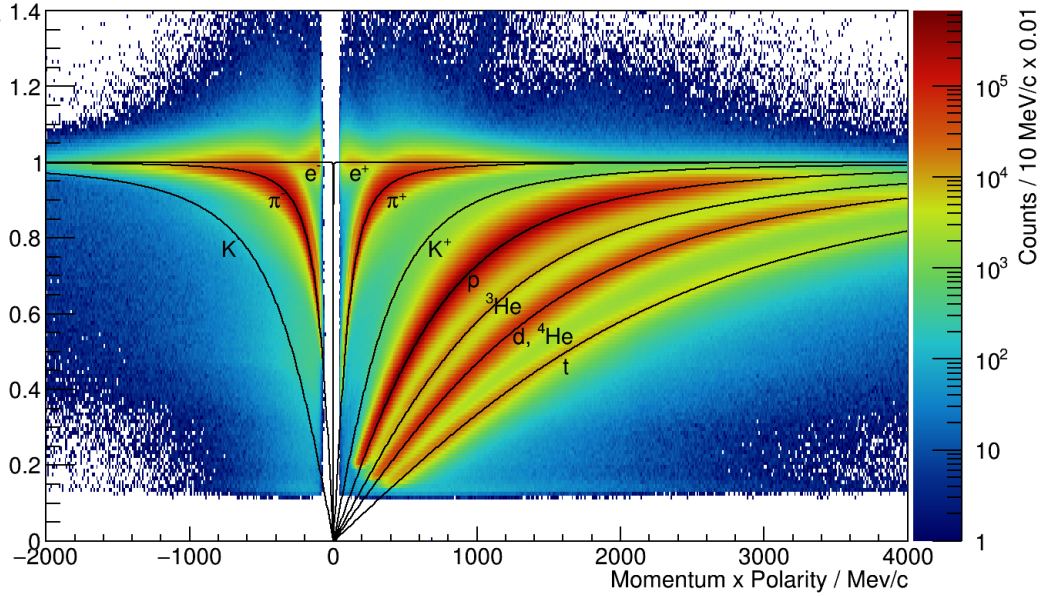
Excursion: Particle Identification

- Momentum reconstruction by deviation in magnetic field
- Time of Flight measurement by RPC / ToF and START detector
- Beta can be calculated from Time of Flight
- Mass measurement:

$$m = \sqrt{\frac{p^2}{\beta^2} - p^2}$$

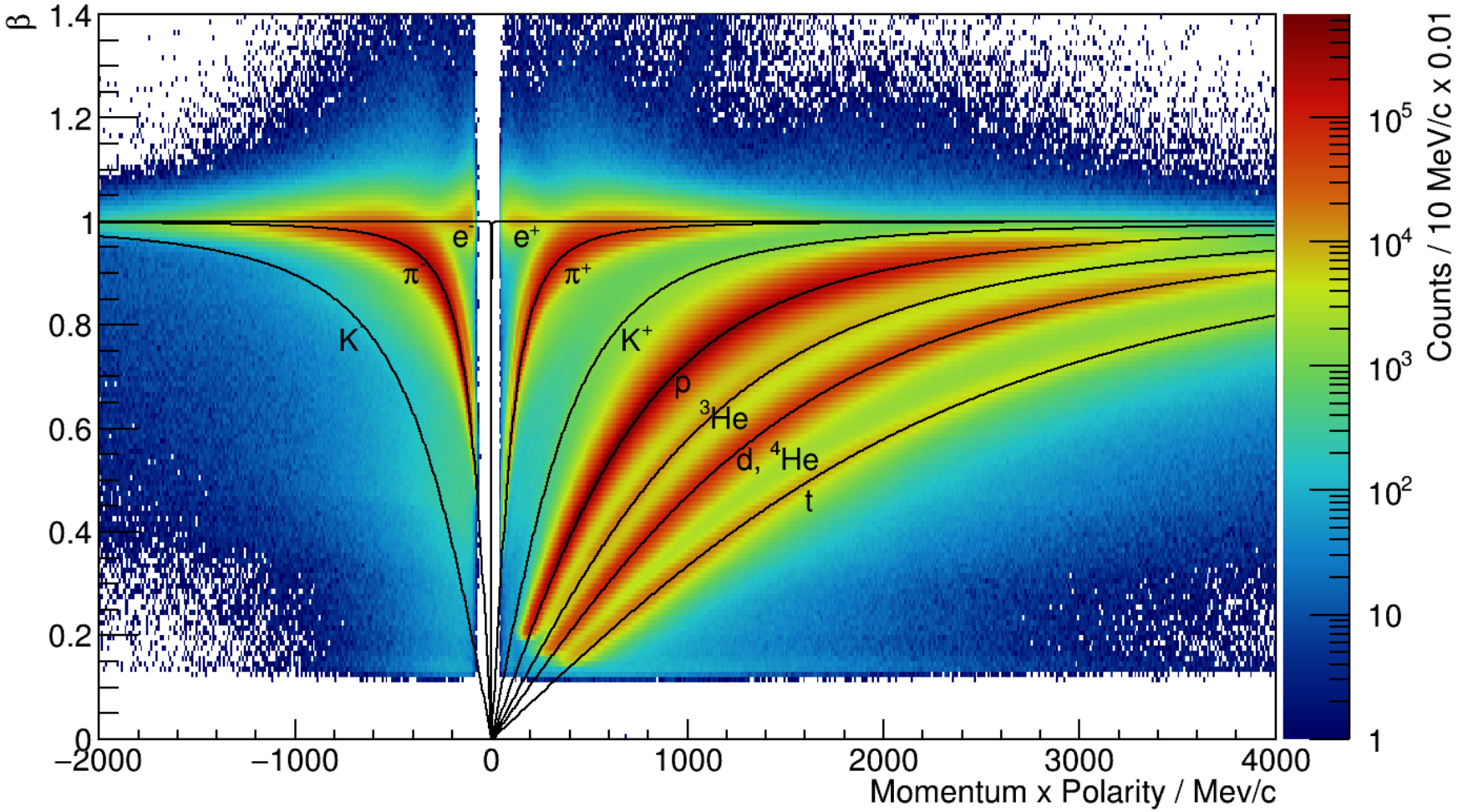
- Clear separation between particles





Excursion: Particle Identification

- Above 300 MeV/c almost purely π^- on negative charge side of the spectrum

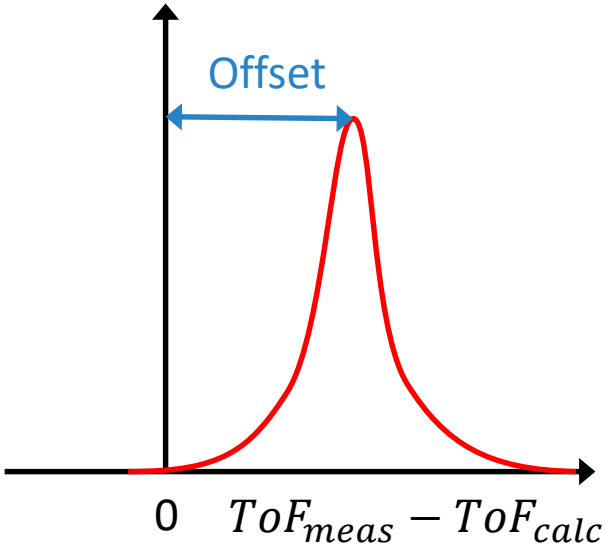


The Method

- Use negative Pions with p > 300 MeV/c
- β can be calculated from Momentum:

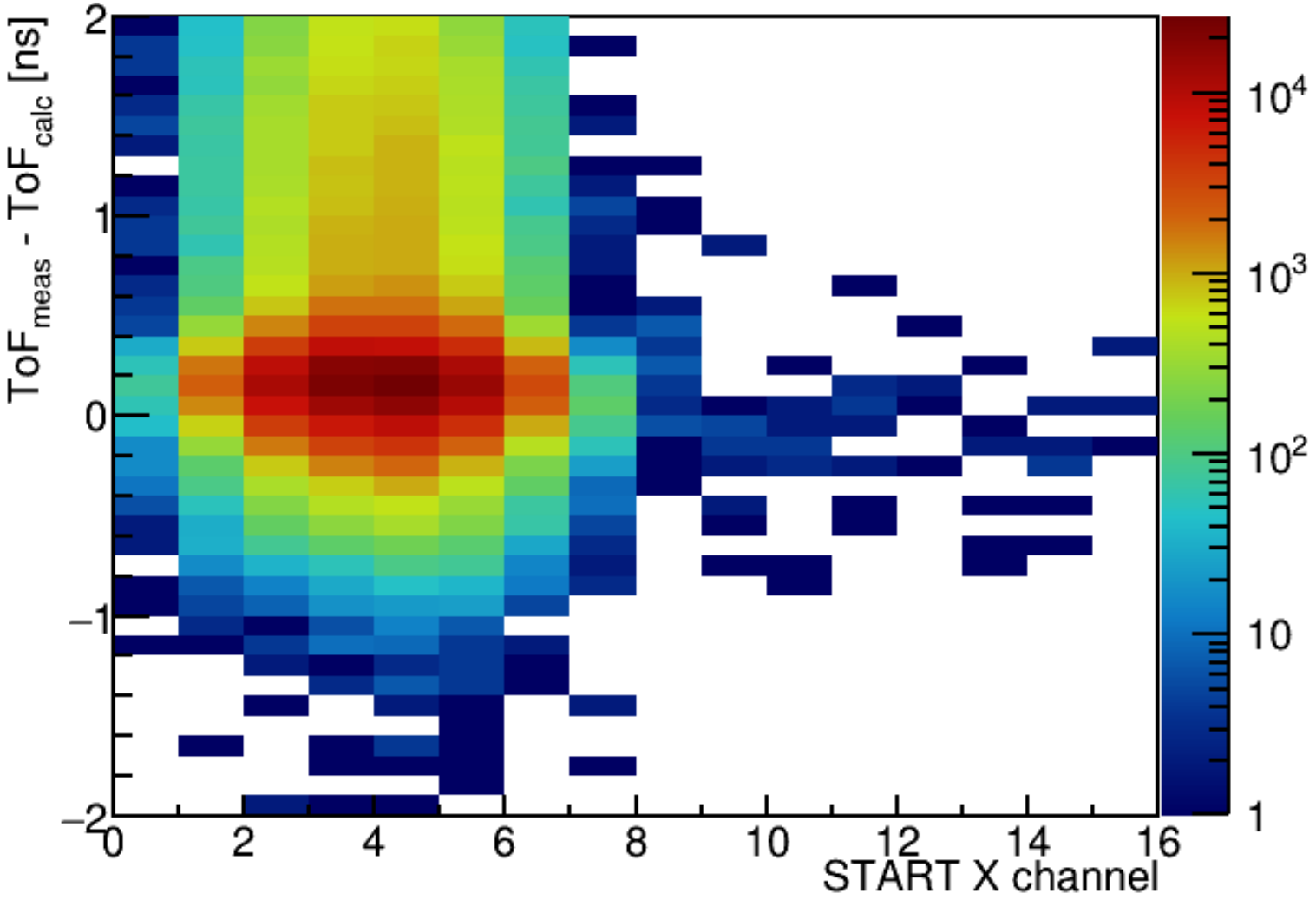
$$\beta_{calc} = \frac{p}{\sqrt{p^2+m_0^2}} \text{ and } ToF_{calc} = \frac{l_{Track}}{\beta_{calc}}$$

- $ToF_{meas} = t_{META} - t_{START}$

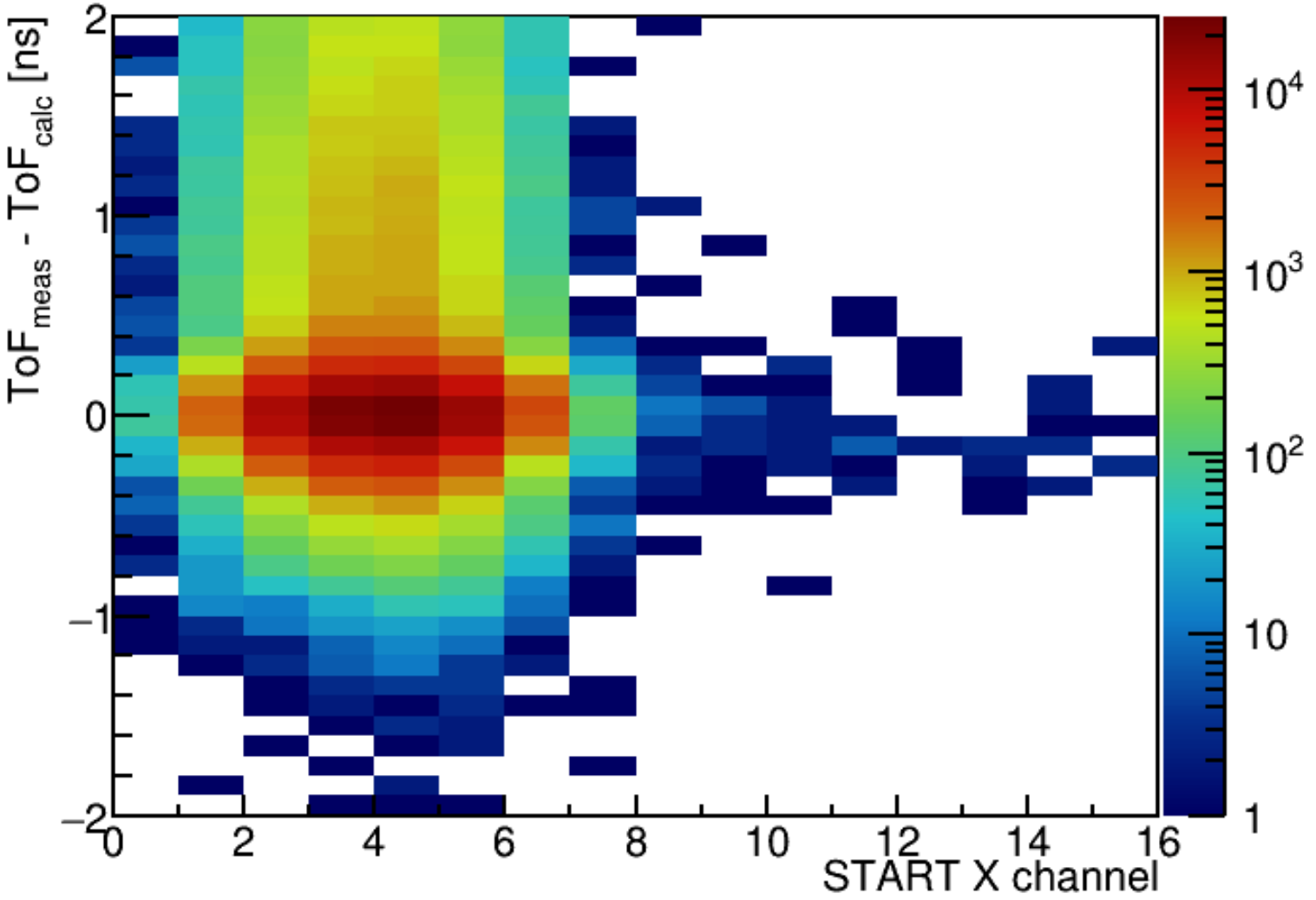


- Fill spectrum with difference between ToF_{calc} and ToF_{meas}
- Fit Gaussian and adjust START Offsets so that mean is 0
- Done individually for each START channel and bunches of roughly 500.000 events (≈ 1 minute beamtime)

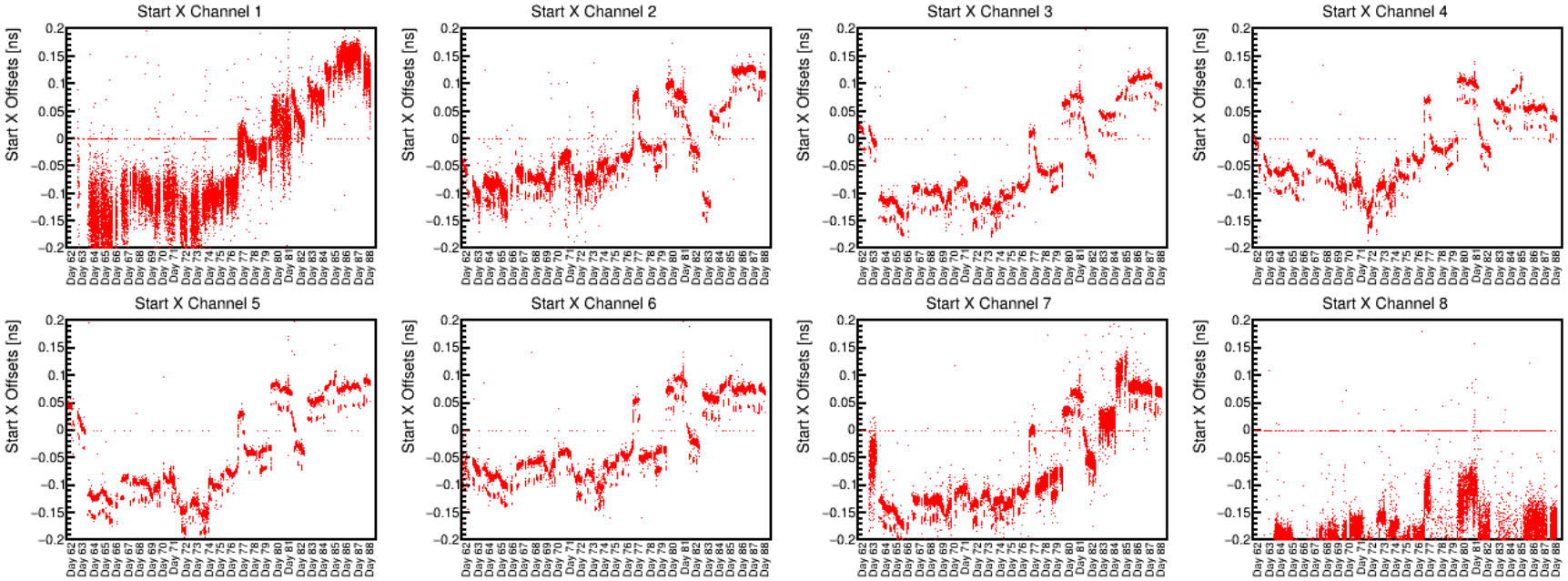
Before second calibration step



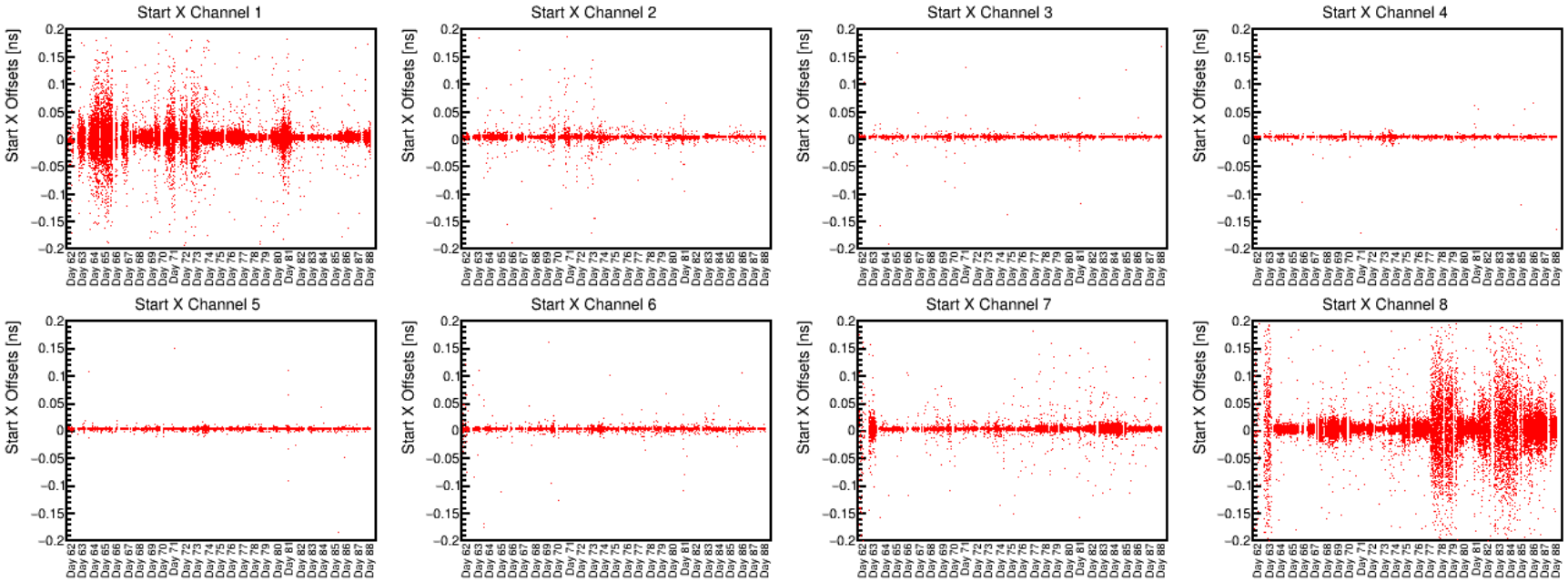
After second calibration step



Before calibration



After calibration



Summary and Outlook

- At the current stage of calibration Δt ≈ 150ps
  - RPC, ToF, MDCs etc. not fully calibrated
  - Momentum and Time of Flight precision will improve
- After final calibration of Au+Au beamtime from 2012
  Δt ≈ 50ps precision achieved
- The future: Ultra fast silicon detectors (UFSD) for HADES reaction time measurement?
  - Talk tomorrow noon (10.12.2019 12:00) by Jerzy Pietraszko
    “Performance of UFSD Strip sensors for timing applications”


Thank you
for your
Attention!
1500
1000
500
0
−500
−1000
−1500
−2000
−1500
−1000
−500
0
500
1000
1500
2000