Diamond detectors in the HADES-experiment

S. Spies\textsuperscript{1}, J. Pietraszko\textsuperscript{2}, W. Koenig\textsuperscript{2}, M. Träger\textsuperscript{2}, M. Kis\textsuperscript{2}, A. Rost\textsuperscript{3} and T. Galatyuk\textsuperscript{3} for the HADES Collaboration

\textsuperscript{1}Goethe University Frankfurt; \textsuperscript{2}GSI Helmholtzzentrum für Schwerionenforschung; \textsuperscript{3}Technical University Darmstadt

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

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\textbf{GOETHE UNIVERSITY FRANKFURT AM MAIN}
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\textbf{FAIR Phase 0 Research Program}
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\textbf{HADES}
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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 Acceptance Di Electron Spectrometer
The HADES Beamline

- START detector 5.27 cm in front of target
- VETO detector 54.68 cm 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 $\Delta t \approx 17\text{ps}$ and up to 10MHz readout rate

➢ After full calibration $\Delta t \approx 50\text{ps}$ 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: $\Delta t \approx 190\text{ps}$
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 $\pi^-$ on negative charge side of the spectrum
The Method

- Use negative Pions with $p > 300$ MeV/c

- $\beta$ 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 $\Delta t \approx 150\text{ps}$

➢ RPC, ToF, MDCs etc. not fully calibrated

➢ Momentum and Time of Flight precision will improve

➢ After final calibration of Au+Au beamtime from 2012 $\Delta t \approx 50\text{ps}$ 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!