The STS1 Detector for the FAIR Phase-0 Experiments with HADES

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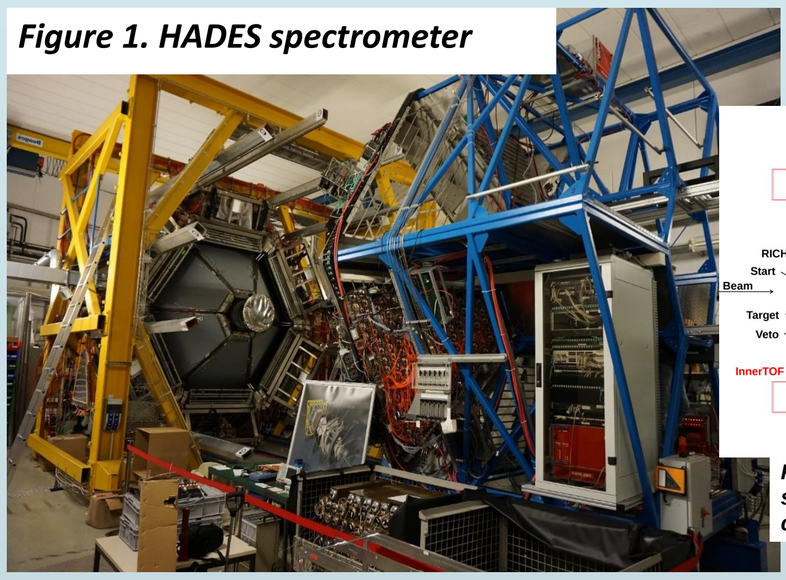
The HADES experiment

HADES (Fig. 1) studies the **properties of baryonic resonances** produced in proton or pion induced reactions [1]. The spectrometer is now being upgraded to enable the experiments included in the **FAIR Phase-0 program**, such as **measurements of hyperon radiative decays** [2].

The newly installed forward detectors are two **new Straw Tracking Stations (STS1 - STS2)** and a Forward Resistive Plate Chamber (FRPC). These increase the HADES angular acceptance to low polar angles between θ = 0.5 and 7^o (Fig. 2). The **STS1 was built at the IKP of the Research Center Jülich** and is described here.

Figure 1. HADES spectrometer



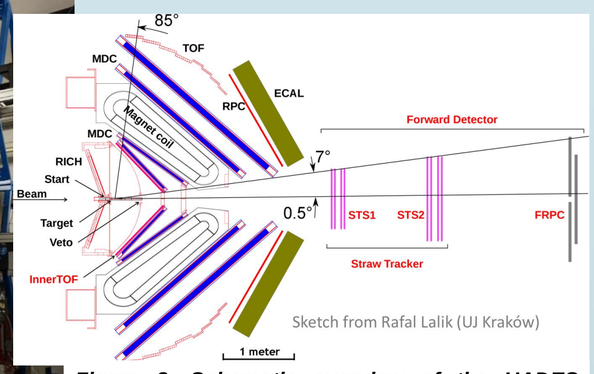


Figure 2. Schematic overview of the HADES spectrometer, including the newly added FD components. The STS1(2) shown in magenta.

STS1 detector system

Four double layers of **self-supporting gas-filled straws**. Each straw is made of 27µm thin Al-Mylar film tube with a 20 µm thin W/Re wire.

No. Straws	704
Straw length /diameter	76 cm / 10 mm
Gas Mixture	Ar/CO2(10%) @ 2 bar
ϕ orientation of straws in double layer	0 °, 90 °, 90 °, 0°
Beam opening	8 × 8 cm^2
Electronics	44x FEBv3, 88x PASTTRECv1
Distance to target (commiss. beamtime)	~ 3.50 m

A charged particle traversing a straw produces **ionization electrons** which drift towards the wire and generate an electric signal (Fig. 3) .

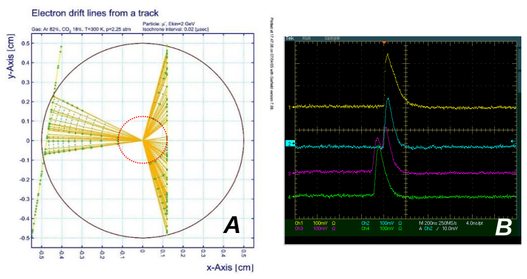


Figure 3. A) Path of drift electrons from ionization point to anode wire. B) Straw signals (in-beam)

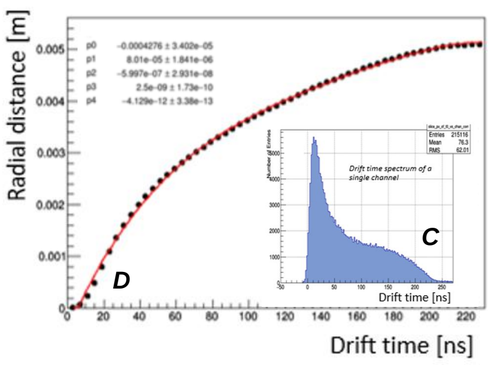


Figure 4. C) Typical single channel drift time spectrum D) Isochrone radius [m] versus electron drift ime [ns]. The data points (black) are fit with a fourth degree polynomial (red)

A **calibration curve** (Fig. 4) is generated to relate the isochrone radius $r(t_i)$ and the electrons drift time t_i :

$$r(t_i) = \sum P_i \times t^i$$

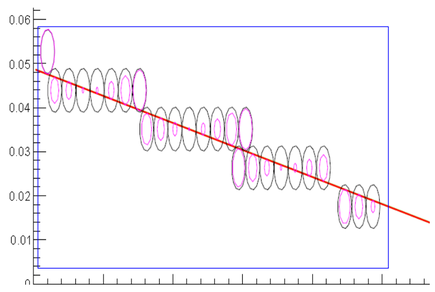


Figure 5. Typical track reconstruction with several layers of straws (testbeam data)

By collecting **all signals** delivered by the STS1 (and STS2) the particle **track is reconstructed**. A detailed explanation of the calibration/tracking is found in [2].

Pre-commissioning tests and installation

1. HV boxes & cables 2. LV cables 3. Gas lines
4. ASIC boards/cables

Figure 5. Photograph of the STS1 fully cabled at HADES

Full system tests (cabling, supply lines, ASIC-FEBs and TRB3-DAQ) focused in verifying that all components work properly. The individual **optimal signal baseline (BL)** to obtain **clean drift time spectra** and **aligned Time over Threshold (ToT) for all channels** (Fig 6) were determined.

1st tune of all ASIC baselines by noise scaler rate. 2nd precise BL-tune with **^{90}Sr source** signals (β-tracks, up to 2.2 MeV) by ToT alignment (Fig. 8).

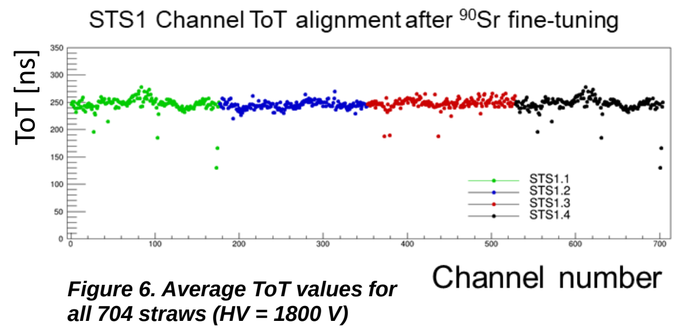


Figure 6. Average ToT values for all 704 straws (HV = 1800 V)

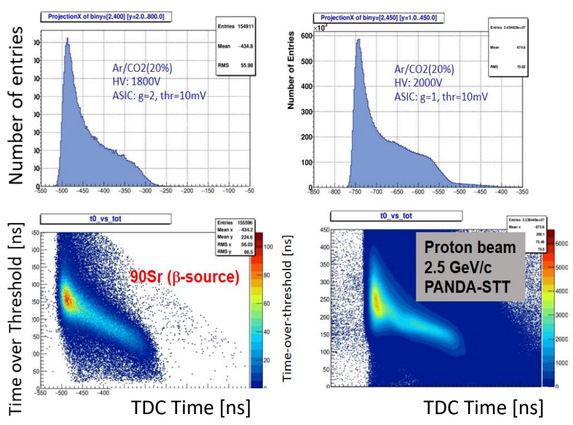


Figure 7. Similar spectra for ^{90}Sr β-tracks and (mip) proton beam tracks (~40% difference in dE/dx range between β and mip).

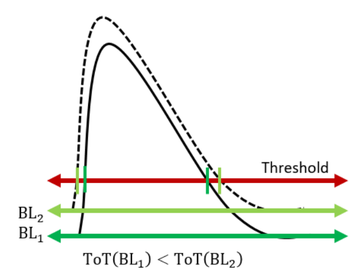


Figure 8. The ToT gives information about signal width. It can be used to adjust the BL values of the individual channels: the closer the baseline is below the threshold, the higher the measured ToT and vice versa.

Pre-commissioning summary

- All straws without failure (*e.g.* no broken wire, …).
- Several months of **stable detector operation** in Jülich.
- The **STS1** was **installed at HADES** at the **end of 2020** (Figs. 5,9).

HADES Commissioning Beamtime (February 2021):

- SIS18 delivered **proton beam** with 2 GeV and 4.2 GeV kin. energy
- STS1 **operation** was **stable** and **no self-sustaining currents** were observed even at the highest beam intensities (10^5 p/s per straw)
- Several data takings for different ASIC settings were completed.
- **Very low noise** was observed, raw data shows **clean ToT spectra**

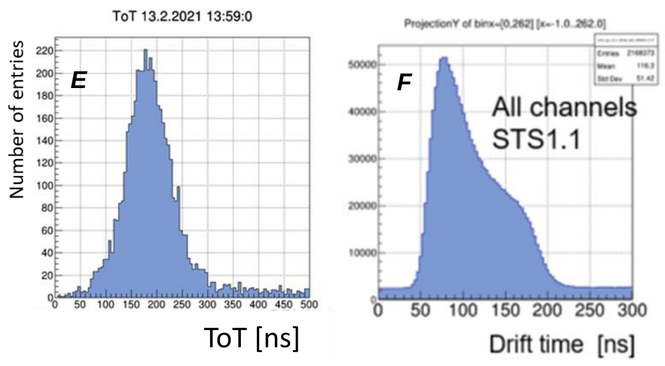


Figure 10. E) ToT online check of STS1, F) Drift time spectrum from first double layer of STS1

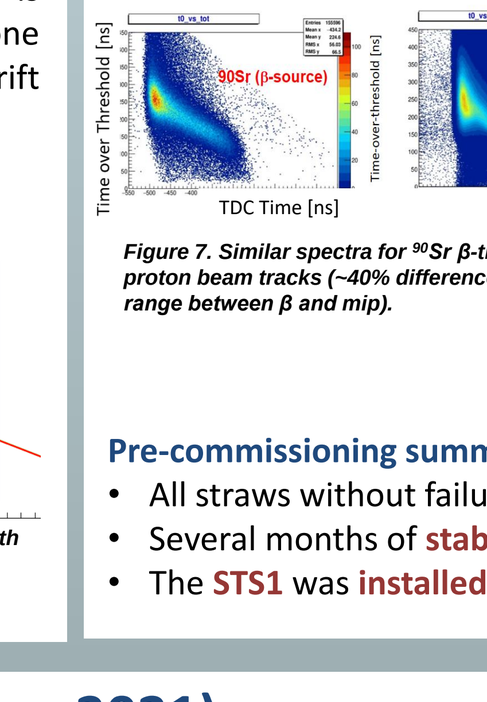


Figure 9. STS1 station installed at HADES

Summary and outlook

- STS1 **station and readout** system was **successfully tested** under experiment conditions
- A **rich data base** is **now available** for analysis
- Data offline analysis, development of calibration and tracking algorithms for STS is in progress.
- A four week experiment beamtime with the **upgraded HADES** is scheduled for **early 2022.**

References

[1] Agakichiev, G., et al. The high-acceptance dielectron spectrometer HADES. Eur. Phys. J. A 41, 243{277 (2009).
[2] Adamczewski-Musch, J., et al. "Production and electromagnetic decay of hyperons: a feasibility study with HADES as a phase-0 experiment at FAIR." *The European Physical Journal A* 57.4 (2021) 1.
[3] G. Perez-Andrade et al., Self-calibration Method for the In-Beam Test of the PANDA STT, Annual Report 2019 Institut für Kernphysik/ COSY.

Annual Matter and Technology meeting (2021)