Report on the Forward Tracker

- Straws for HADES/PANDA Phase-0
- Planned test at COSY
- Study of the space charge effect and cross-talk

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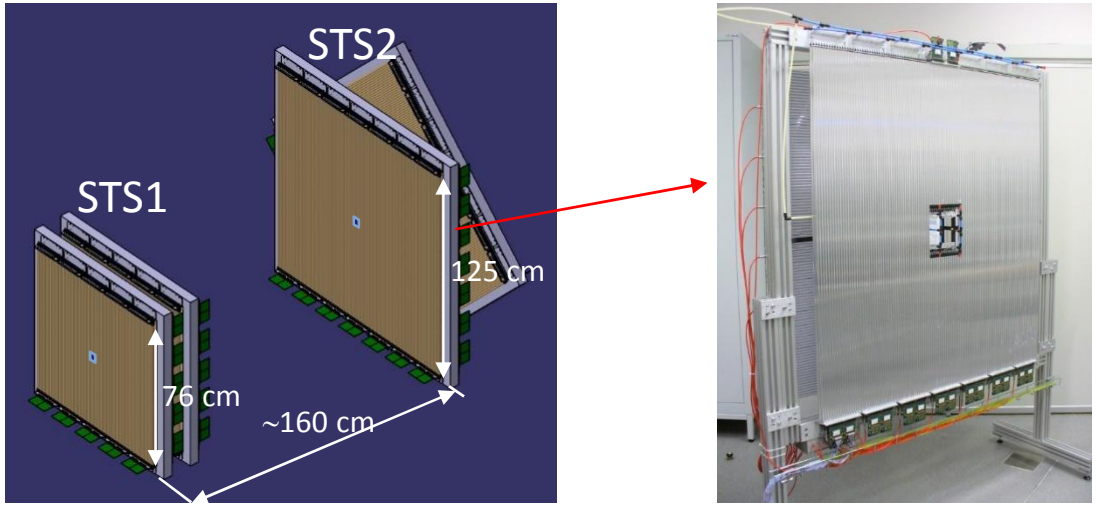
Straws for the HADES Forward Tracker (PANDA-Phase 0)

- 8 vertical + 8 horizontal modules for ½ of HADES STS2 are ready (compatible with PANDA FT5, FT6)
- 16 modules for the second half of STS2 are being built in Krakow and 20 modules for HADES STS1 (compatible with FT3) are being built in Juelich

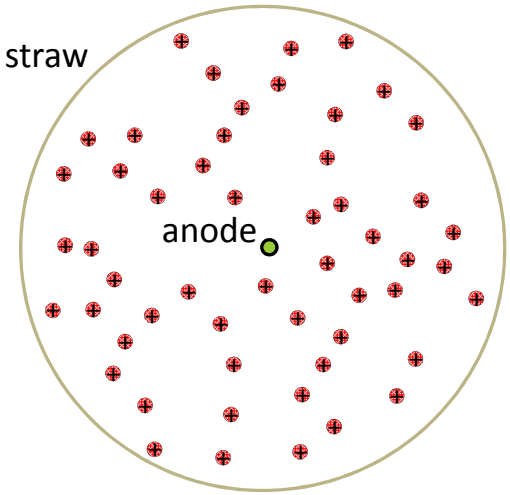


Request for the COSY beam

- „**Beam request** for PANDA FT and PANDA DAQ prototype set-up test" submitted to the COSY Beamtime Advisory Committee in May 2018
- **Requested:** one week of 2.5 GeV/c proton beam, intensity 20-400 kHz
- **Setup**: 8 straw tube modules arranged in the beam one after the other, inclined at (0°, +5°, −5°, 0°, 0°, +5°, −5° , 0°) as in (FT1, FT2) or (FT5, FT6)
- **Main goals:**
  - checking the reconstruction of straight tracks in (FT1, FT2) / (FT5, FT6)
  - finding the optimal FEE setting and the lowest anode wire voltage that meets the FT requirements

Space charge effect

- Accumulation of positive ions in the straw tube volume resulting in reduction of the gas gain



Electric field $E \sim \frac{1}{r}$

Drift velocity of ions $v = \mu E$ ⇒ $v \sim \frac{1}{r}$

⇓

Uniform density of ions

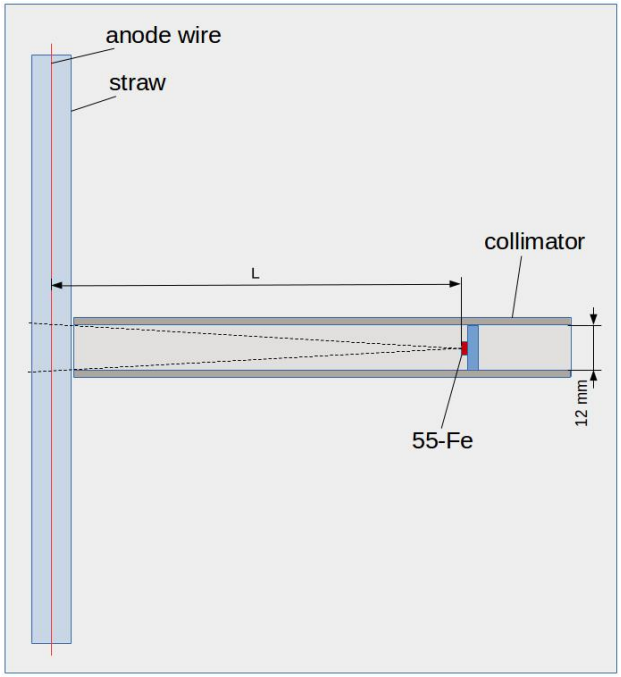
$$V = \int_a^b E_w(r)\,dr + \int_a^b E_s(r)\,dr$$

anode wire field — space charge field

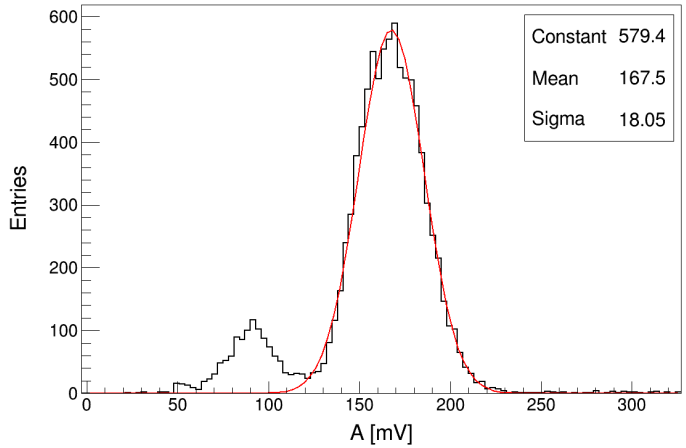
E_w (and gas gain) reduced if the 2nd integral > 0

Amplitude of pulses vs. rate

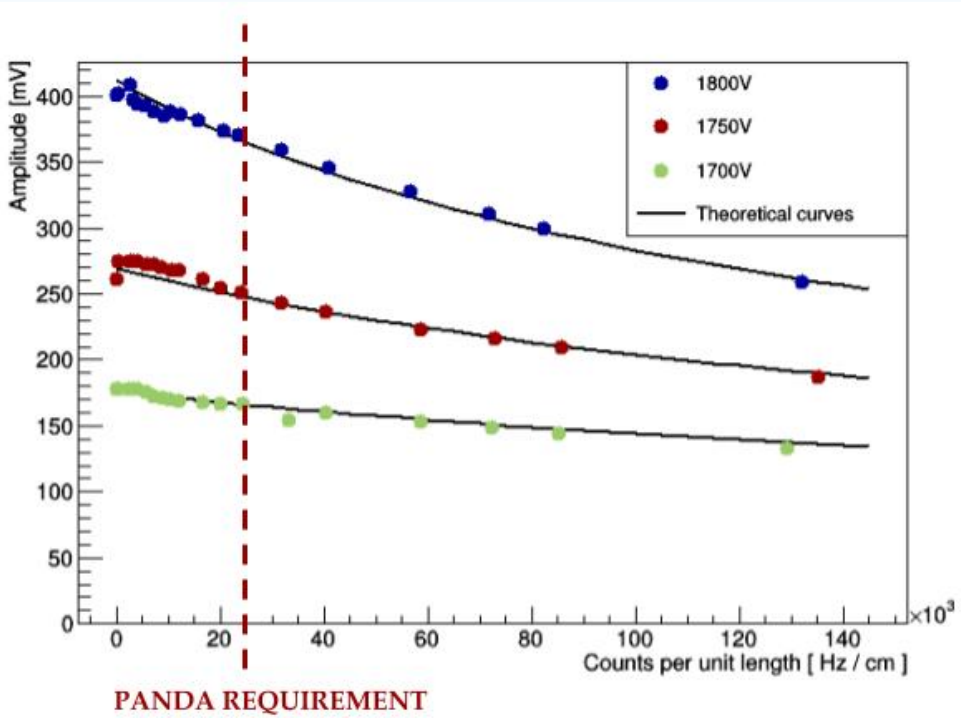
Varied distance between collimated ^{55}Fe source and the straw



Measured amplitude of pulses for the 5.9 keV X-rays



Amplitude drop due to space charge



- The amplitude drop at a rate 25 kHz/cm – the highest expected in the FT – is about 10%
- The corresponding time walk for pulses produced by MIPs and the foreseen FEE setting is about 0.1 ns and is significantly smaller than the required drift time resolution of ~1 ns

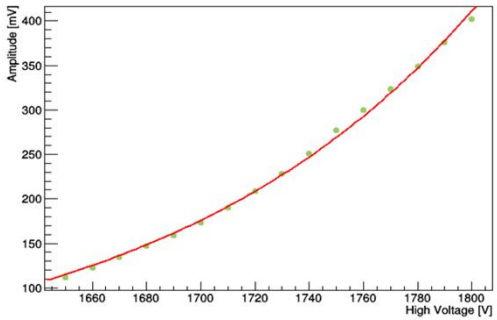
Drop of pulse amplitude due to space charge

- Drop of anode voltage

$$\Delta V = \frac{b^3 q \Phi \ln \frac{b}{a}}{4\pi\varepsilon_0 \mu V_0}$$

Φ - particle flux per unit area
a - anode wire radius
b - straw tube radius
q - total avalanche charge per particle
V_0 - voltage at low rate
μ - ion mobility

- Corresponding change of pulse amplitude is determined based on measurement of the amplitude dependence on the anode voltage at low rate

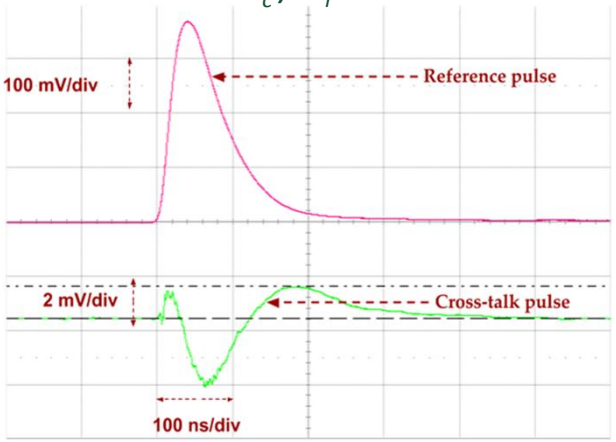


Cross-talk

- Reference straw illuminated with ^{55}Fe – amplitude of pulses A_r
- Cross-talk pulses observed in neighboring straws – amplitude A_c

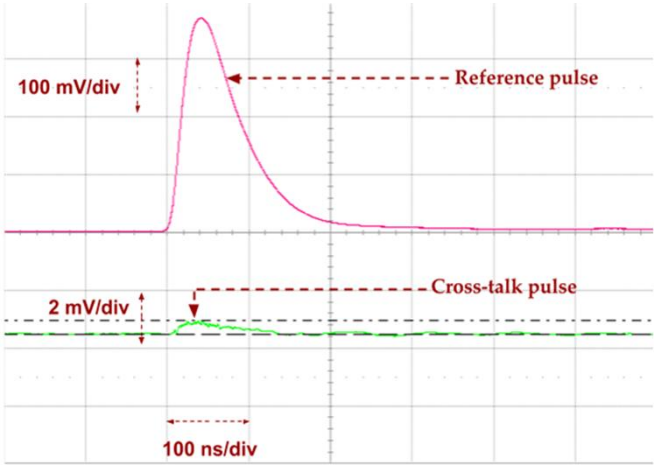
straws connected to the same FEE chip

cross-talk level A_c / A_r ~ 0.6%



two different chips, the same FFE card

cross-talk ~ 0.2%



Two neighboring straws connected to two different FEE cards

cross-talk ~ 0.1%

Conclusions (cross-talk)

- The cross-talk between two neighboring straws due to the capacitive coupling between them is only ~0.1%.
- Higher cross-talk of 0.6% occurs due to coupling between electronic channels in the PASTTREC chip. This was also observed with a pulse generator connected to the FEE instead of the straws.
- The observed cross-talk level is acceptable since for pulses produced by MIPs (~200 mV at HV=1800 V) and the typical discrimination threshold in the FEE of ~10 mV, the cross-talk pulses of ~1 mV are below the threshold.

Backup slides

Tests in preparation

- Measurement of aging of the straws with ^{55}Fe
- Measurement of positions of straws and wires in the module using X-rays, digital microscope, laser distance sensor – choice of the optimal method(s)

Particle fluxes expected in the FT

pbar-p interaction rate: $2 \times 10^7\ s^{-1}$, p_{beam} = 15 GeV/c, simulations based on the DPM