Monitoring the CBM-TRD performance with a $^{55}$Fe - Source

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Testbeam Setup at DESY

The Compressed Baryonic Matter (CBM) experiment at FAIR is designed to investigate the properties of strongly interacting matter at highest net-baryon densities. The Transition Radiation Detectors (TRD) main purpose is the identification of electrons with momenta above 1 GeV/c, in order to enable dielectron measurements in the low and intermediate mass region. The second important contribution of the TRD to the CBM experiment is the measurement of the specific energy loss, in order to differentiate between nuclear fragments with the same m/Z-ratio but different Z. The TRD detector will consist of four layers of Multi-Wire-Propotional-Chambers (MWPC). To generate transition radiation, each layer will be equipped with a foam-foil radiator.

Testbeam at DESY

Fig. 1: Setup at DESY T22 in September 2017. From left to right: Two PMT’s, two small TRD chambers, one big TRD chamber rotated by 90° with radiator, three big TRD chambers with radiator. Beam from the right.

Beam:
- Pure electron beam
- Measurements with momenta of 1, 2, 3 and 4 GeV/c
- Differentiation between nuclear fragments with the same m/Z-ratio but different Z
- Ratio but different Z

Detectors:
- Four TRD chambers 95x95 cm\(^2\), gas volume 3.5x3.5x5 mm, equipped with full radiator, operated with \(\text{XeCO}_2\) 80:20 mixture.
- Radiators: 95x95x30 cm\(^3\), 146 sheets of 2 mm PE foam foil with 8 mm Rohacell housing.
- Two smaller MWPC as position reference, without radiator.
- Two Scintillators/PMT to confirm electron event selection.
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For further information, see HK 12.4 and HK 12.5

Front-End-Readout:
- With SPADIC v.2.0 ASICs
- One chip per detector in beam position
- One chip for gain monitoring with \(^{55}\text{Fe}\)-source at first detector
- One chip for PMT integration
- For further information, see HK 12.4 and HK 12.5

Fig. 2: Front-End-Board with SPADIC-chip, mounted to the backplane of the detector. KEL40-cable on the right side connecting the spadic with the AFCK board.

Iron Spectrum

The main goals of this test campaign were a performance test of the radiators and the readout electronics, a measurement of the spatial resolution and a calibration of the gain-gain for the new \(\text{XeCO}_2\) mixture. For the latter, a \(^{55}\text{Fe}\) source (100 MBq) was placed in front of one detector.

Fig. 3: Positioning of the \(^{55}\text{Fe}\)-source in front of the detector. The golden entrance-window-foil of the MWPC is visible, because radiators were removed in front of the source.

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Fig. 4: Signal shape of the pad in front of the iron source without correction.

- Baseline at approx. -220 ADC
- Signal of iron source clearly visible with maximum at ~50 ADC

Fig. 5: Signal shape of the pad in front of the iron source after correction.

- \(^{55}\text{Fe}\)-source recorded throughout the beamtime
- Raw control data like anode wire voltage, beam energy, gas flow, air temperature and atmospherical pressure also recorded
- Dependency of the iron spectrum on these variables can be tested
- Estimate on energy resolution of the TRD chamber can be done

Fig. 6: Heatmap of the padplane around the position of the iron source showing number of clusters measured at the given position.

- \(^{55}\text{Fe}\)-source at first detector
- Radiators: 95x95x30 cm\(^3\), 146 sheets of 2 mm PE foam foil with 8 mm Rohacell housing
- Two smaller MWPC as position reference, without radiator.
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Fig. 7: Spectrum of the \(^{55}\text{Fe}\)-source.

- Energy resolution of the TRD chamber can be estimated with this spectrum
- For this purpose: Gauß-fit is performed on the peak

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\Delta E_{rel} = \frac{\sigma}{\text{mean}}
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\sigma = 28.748 \pm 0.041
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\[
\text{mean} = 214.395 \pm 0.032
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\Rightarrow \Delta E_{rel} = 0.1374 \pm (1.91 \cdot 10^{-4})
\]

- Relative energy resolution is approximately 13.4%
- Energy of the Fe-K\textsubscript{α} spectral line is 5.9 keV, which should correspond to the peak position.

Fig. 8: Cluster Heatmap of SourceSpadic showing number of clusters measured at the given position.

- Iron source located in the lower pad-row at \(x \approx 8.5\) cm
- Other pads with many entries contain only noise
- Cut on the position of the source was added to the spectrum to filter out noisy pads.
- Charge of a cluster is estimated by taking the maximum ADC-value of the signalshape.