Offline Event-Building with CBM-TRD Prototype FLES Data (CERN-SPS Beamtest 2015)

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The CBM-TRD in FAIR

- In construction: SIS100 (magnetic rigidity of 100 Tm)
- Compressed Baryonic Matter as one of the four pillars of FAIR
- Upgradeable: SIS300

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<tr>
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SIS100 energies
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Hadronic freeze-out

J. Randrup & J. Cleymans
The CBM-TRD in FAIR

- **MVD+STS**
  Micro-Vertex Detector + Silicon Tracking Station
  *magnetic field*

- **MUCH or RICH**
  MuonChambers/ Ring imaging Cherenkov Detector

- **TRD**
  Transition Radiation Detector

- **TOF**
  Time Of Flight

- **PSD**
  Projectile Spectator Detector
The TRD in CBM

- TRD in total:
  4 layers with 2 MWPCChamber sizes (central regions: higher rates)
  - Plus *radiator*: irregular type, foam (polyethylene)
CBM-TRD Readout: SPADIC

- Readout of the cathode pads with *Self-triggered Pulse Amplification and Digitization ASIC* (SPADIC)
- Charge-sensitive amplifier with 32 channels
- Free-streaming
- Digitising 32 samples, 40 ns each
- Forced neighbour readout (sensitivity despite high trigger thresholds)
- Digital filter implemented: time shortening by tail cancellation
- Ongoing development
- **Front End Board (FEB):** SPADIC
- **SysCore** boards streaming hit messages of 6 SPADICs to PC port
- **First Level Event Selector (FLES)** processes messages into data containers

*Scheme from Dirk Hutter, 23rd CBM Coll. meeting*
• Principle allows various microslice sources
• Ringbuffers minimize memory consumption, maximise throughput

Towards event-building:
• The SPADIC-unpacker extracts hit messages from the timeslices
• Full-time calculation currently in validation
• Let SPADIC A and SPADIC B be projective behind target
• Hits from one event to be correlated
Starts of Data Analysis: Spatial Correlation

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Starts of Data Analysis: Spatial Correlation

- Let SPADIC A and SPADIC B be projective behind target
- Hits from one event to be correlated
- Needed: Routines for message loss, e.g. caused by high-rate environment
Starts of Data Analysis:
Time Correlation

- Let SPADIC A and SPADIC B be projective behind target
- Hits from one event to be correlated
- Needed: Routines for message loss, e.g. caused by high-rate environment
- Needed: Routines for association in time
Starts of Data Analysis: SPS 2015 Testbeam

• Testbeam at the CERN-SPS, Nov. 2015
• Pb 30 AGeV beam on Pb target
• SPADICv1.0 readout on 3 diff. prototypes, 2 of them in line
• Interaction rates up to $10^5$ Hz

Measurements:
• SPADIC read-out
• HV-currents recorded with 2.5 Hz

Photo: David Emschermann
Starts of Data Analysis: Timing Validation

- Work in progress: Validation of time reconstruction

![Graphs showing real time vs. processing (recording) time]

- time is counted in the SPADIC as:
  - timestamp (12 bit, unsigned) with clock derived from outer frequency
  - timestamp periods are “epochs”
Starts of Data Analysis: Timing Validation

- Work in progress: Validation of time reconstruction

- time is counted in the SPADIC as:
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real time vs. processing (recording) time
• Work in progress: Correlations between 2 detectors

Thanks to Philipp Munkes for works on an efficient clusterizer
Outlook and Summary

• Next local steps:
  – Proceed in spatial and time correlation
  – Optimise SPADIC settings for high rate capabilities
  – Systematically analyse HV behaviour

• And more global:
  – Production of 4 large-sized prototypes
  – Release + test of the SPADICv1.1 chip

→ Fully equipped beamtime measurements with large acceptance (improved correlation)
The TRD in CBM

- **TRD in principle:**
  - Multi-wire proportional chamber-based
  - Transition radiation emitted at $\varepsilon$-transitions
  - Intensity of TR is $\sim \gamma$ (idealised)
  - e/π-sep. e.g. by likelihood
- **Regular and irregular radiators:** foil, foam, fibers

**Transition radiation at one $\varepsilon$-interface:**

$$
\left( \frac{d^2 N}{d \omega d \theta} \right)_{\text{interface}} = \frac{\alpha}{\pi} \cdot \frac{\vartheta}{\gamma^2 + \frac{9}{\omega_P,1^2/\omega^3} + \frac{9}{\omega_P,2^2/\omega^3}}
$$

- $\omega$: photon frequency
- $\omega_P,i$: plasma frequency of material $i$
- $\alpha$: fine structure constant
- $\vartheta$: emission wrt. particle motion
- $\gamma$: Lorentz factor
The TRD in CBM

Development in progress

- High-voltage wire geometries in comparison: different prototypes
- Proportional chamber: rate limits

→ short ion drifts (3.5+5 mm)

- Special conditions: flexible cathode (entrance window)

Favoured Anode+Drift HV geometry

Example: Field distortion by entrance window stretching (Garfield sim.)

from F. Sauli, CERN lectures 1977
The CBM-TRD in FAIR

• Physics objectives
  – Intermediate mass di-leptons ... continuum from thermal sources (1...3 GeV)
  – Fragments ... hyper- and anti-nuclei
  – Quarkonia ... are probes for deconfined matter
  – Low mass vector mesons ... medium-modified spectra
  – Direct Photons ... inverse slope fits as thermometer

• Design considerations
  – Pion rejection capability ... pion suppression up to 50 and $10^4$ with RICH
  – (Charged) Particle identification ... dE/dx resolution below 30%
  – Tracking capabilities ... track resolution below 300 µm (pad granularity)
  – High interaction rates ... optimised: $5 \times 10^6$ Hz & realistic multiplicities
  – Tracking of muons ... high track matching with the MUCH
The CBM-TRD in FAIR

**Physics objectives**
- Intermediate mass di-leptons
- Fragments
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- Low mass vector mesons
- Direct Photons

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- High interaction rates
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\[
\begin{align*}
^6\text{He} &\rightarrow ^5\text{He} + p + \pi^- \\
^5\text{He} &\rightarrow ^4\text{He} + p + \pi^- \\
^3\text{He} &\rightarrow d + p + \pi^-
\end{align*}
\]