The Transition Radiation Detector in the CBM Experiment at FAIR

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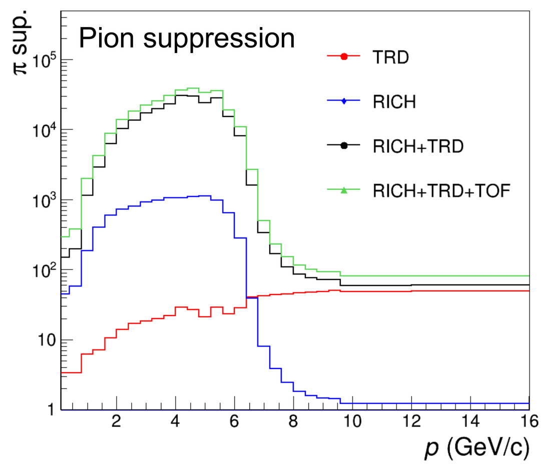
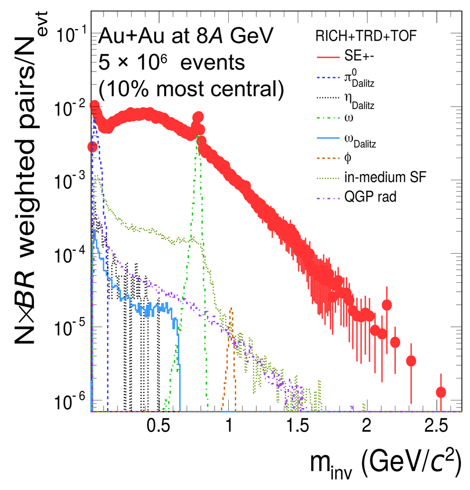
Compressed Baryonic Matter experiment at FAIR

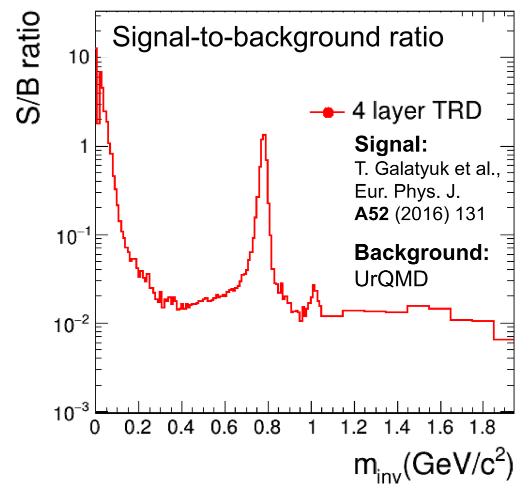
Physics Performance

Dielectron Measurements

- Intermediate-mass dielectrons (s. figure)
- Quarkonia in pA (and AA)
- Photons via γ-conversion
- Requires pion suppression at high p_t ⇒ TRD contribution

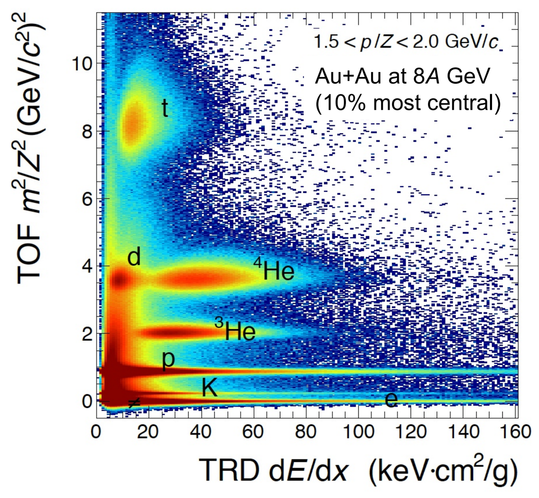


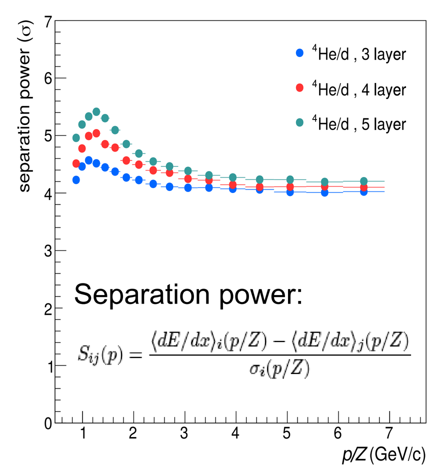




Hadron Identification

- Separation of light nuclei (e.g. d ↔ ^{4}He)
- Important for hypernuclei program (e.g. $^5_\Lambda$He → ^{4}He + p + π$^-$)
- Different charge states cannot be identified with TOF alone
- Additional hadron ID via *dE/dx*-measurement in the TRD





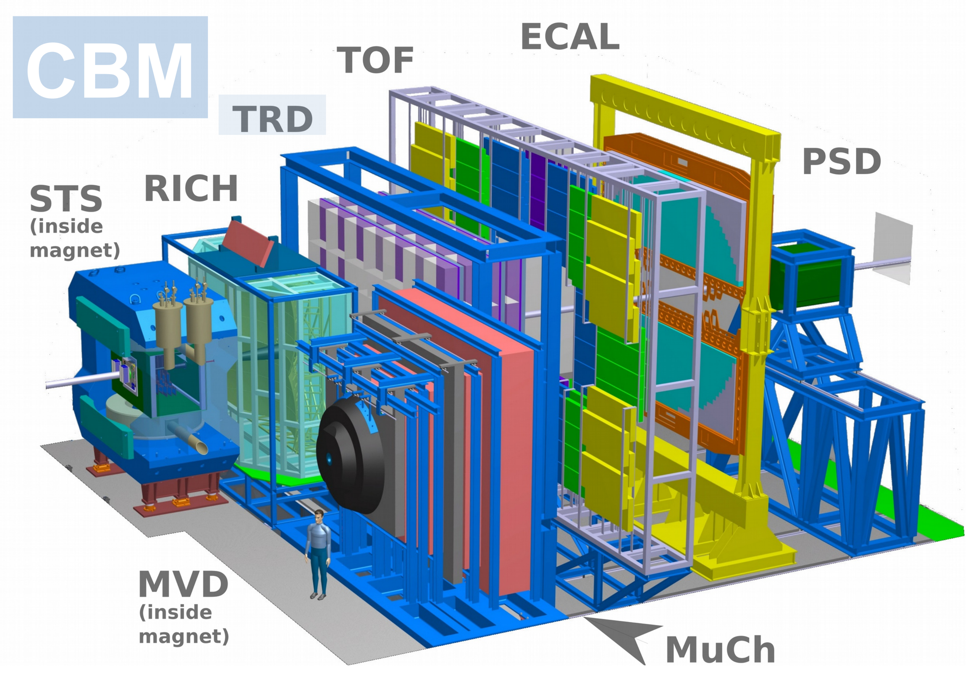
Picture reference in this section: The Transition Radiation Detector of the CBM Experiment at FAIR, Technical Design Report for the CBM, doi: 10.15120/GSI-2018-01091

Detector Design

Requirements and Setup

- High-rate capabilities (interaction rates of heavy systems: up to 10 MHz)
- Pion rejection factor ≈ 20
- Charged particle identification
- Tracking capabilities (STS → TOF)
- μ tracking in MUCH setup
- 4-layer detector geometry
- Modular structure

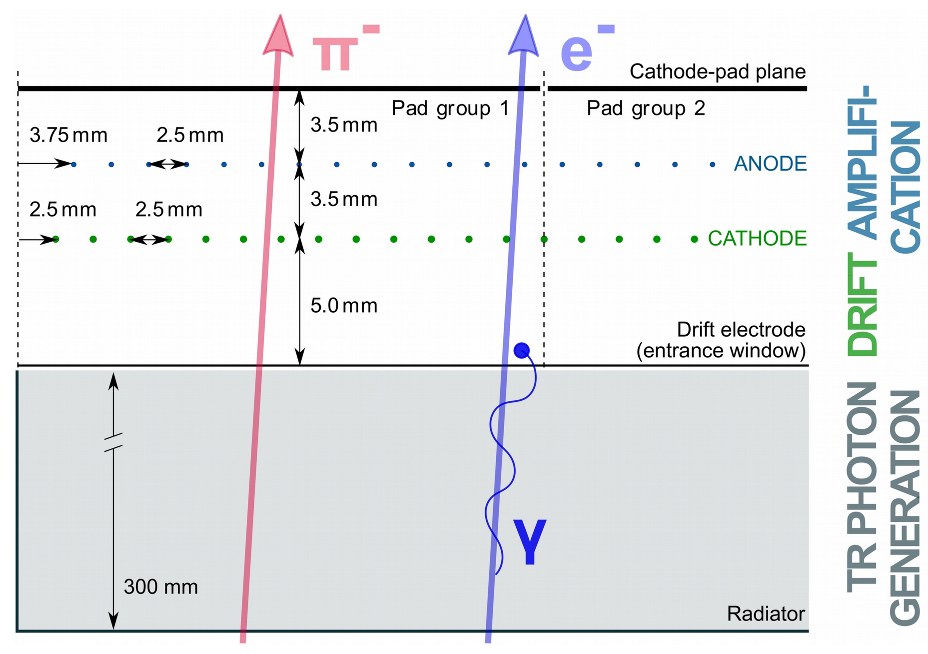
Design Parameters	Value
Pseudo-rapidity coverage	1.15 < η < 3.65
Max. height × width	5.15 m × 6.25 m
Gas volume	1.36 m³
Active detector area	113.4 m²
Material budget	< 5 % per layer
Number of modules	216
Number of readout channels	329728
Max. signal collection time	300 ns
Max. hit rate / channel (MB Au+Au at 10 *A*GeV)	≤ 100 kHz
Max. occupancy (cent. Au+Au at 10 *A*GeV)	< 10 %
Space point resolution	~ 300 μm
π-Suppression (90% e-efficiency, *p* ≥ 1.5 GeV/c)	20
dE/dx-Resolution (*p* > 1 GeV/c)	≤ 30 %



Working Principle

- Radiator (irregular type: PE foam foils) mounted in front of the detector
- Electron identification by absorption of additionally generated TR photons
- Detector: Multi-Wire Proportional Chamber (MWPC) with segmented pad plane
- Thin design (3.5+3.5 mm / 5 mm drift) ⇒ fast signal collection, rate tolerance
- Counting gas: Xe/CO_2 (85:15) ⇒ high γ absorption cross-section
- Front-end electronics: analogue shaping, digitisation and self-triggered, free-streaming digital message building in highly integrated *SPADIC** chips

* for "*Self-triggered Pulse Amplification and Digitization asIC*"

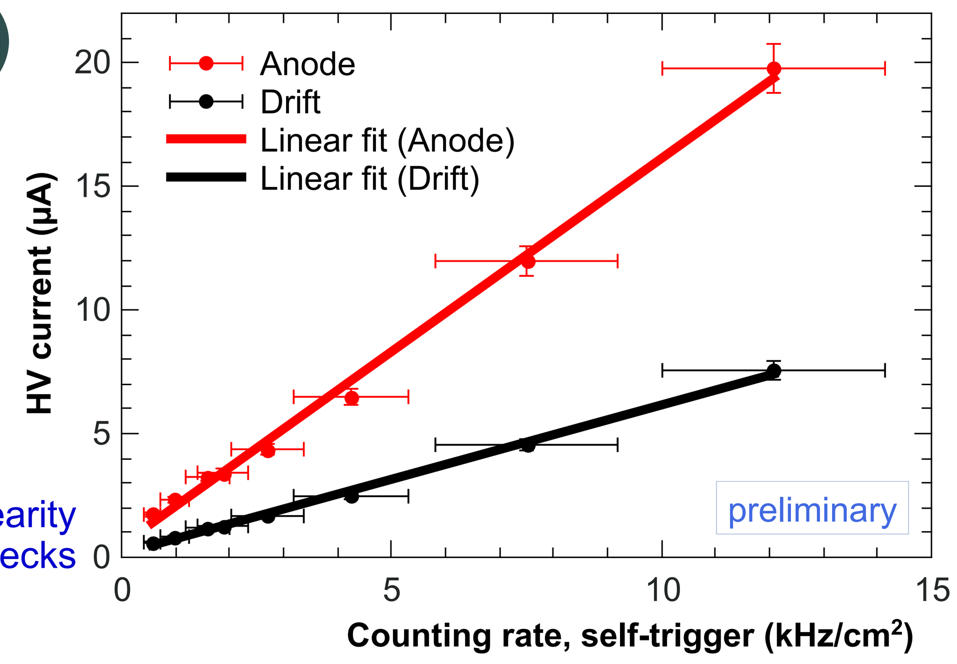


Recent Detector Performance

- Energy resolution in ^{55}Fe measurement: σ/μ down to 8.4 % – Master Thesis Johannes Beckhoff, Aug. 2018
- Overall detection efficiency (detector, front-end electronics, DAQ): (98.5 ± 2.0) % confirmed in e$^-$ beam – Master Thesis Adrian Meyer-Ahrens, Mar. 2019

High-Rate Tests at the CERN Gamma-Irradiation Facility (GIF^{++})

- In-beam test: MWPC and CBM-DAQ chain prototype with SPADIC read-out at the CERN-GIF, ionisation load up to CBM design values
- 14 TBq ^{137}Cs γ source as base load (flexible attenuation system) and μ beam from CERN-SPS, μ signal in DAQ
- Observable: μ detection efficiency w.r.t. detector load
- Analysis of data and detector behaviour ongoing: energy deposition processes, prevailing charge in detector gas cp. CBM events, ion back-flow



Load linearity checks

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