Performance and Design of the Transition Radiation Detector for the CBM Experiment

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CBM

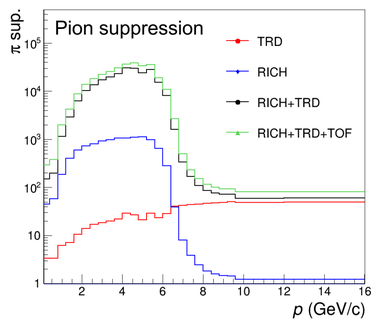
Compressed Baryonic Matter experiment at FAIR

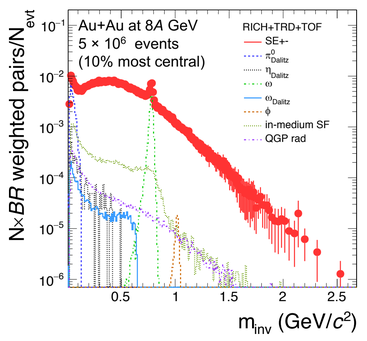
Physics Performance

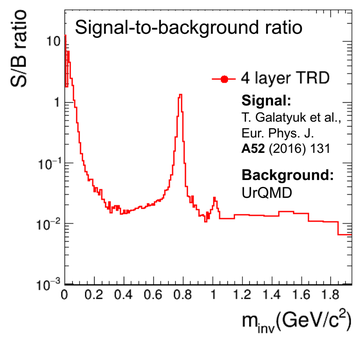
Dielectron Measurements

- Intermediate-mass dielectrons (s. figure)
- Quarkonia in pA (and AA)
- Photons via γ-conversion

- Requires pion suppression at high p_t ⇒ TRD contribution



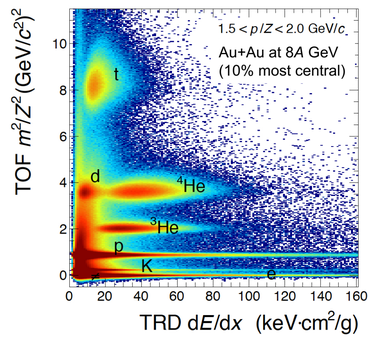


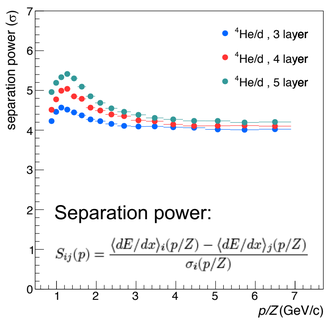


Hadron Identification

- 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



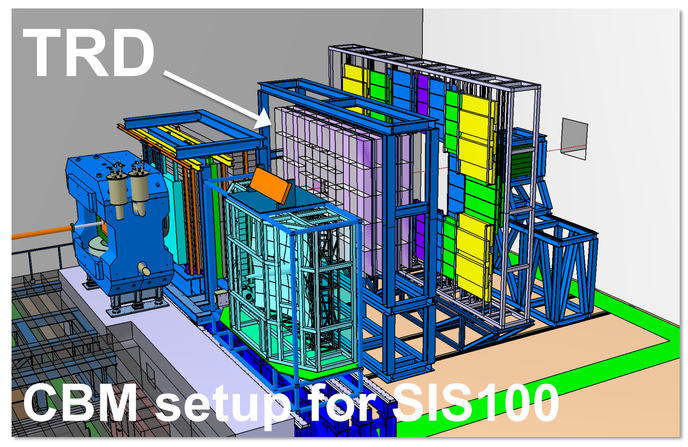


Detector Design

Requirements

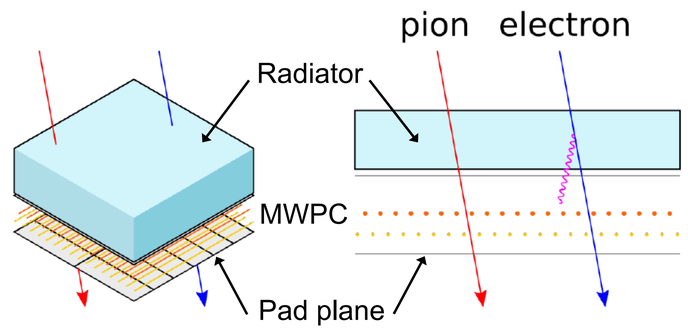
- 4-layer detector setup
- Modular structure
- Pion rejection factor ≈ 20
- Charged particle identification
- Tracking capabilities (STS → TOF)
- High interaction rates (up to 10 MHz)
- Muon tracking in MUCH setup

Design Parameters	Value
Pseudo-rapidity coverage	1.15 < η < 3.65
Max. height × width	5.15 m × 6.25 m
Gas volume	1.36 m^3
Active detector area	113.4 m^2
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, $p \geq 1.5$ GeV/c)	20
dE/dx-Resolution ($p > 1$ GeV/c)	≤ 30 %



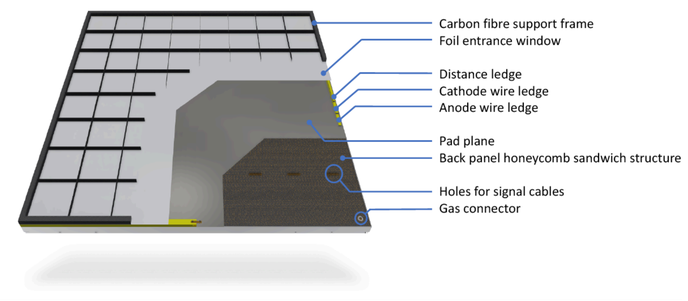
Working principle

- Radiator: boxes with stacks of PE foam foil
- Readout: Multi-Wire Proportional Chamber (MWPC) with segmented pad plane
- Counting gas: Xe/CO_2 (85/15) ⇒ high γ absorption cross section
- Thin MWPC (12 mm) ⇒ fast signal collection
- Drift region ⇒ high TR-photon absorption and stable gas gain



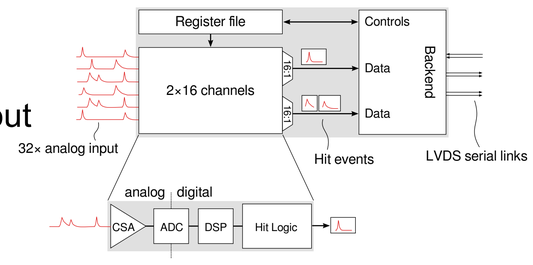
Module layout

- 4 different module types: 2 small (57×57 cm^2) and 2 large (99×99 cm^2) ones
- Thickness of gas volume: 5 mm (drift) / 3.5+3.5 mm (amplification)
- Carbon fiber support frame ⇒ stability of entrance window foil
- Front-end electronics mounted on back panel



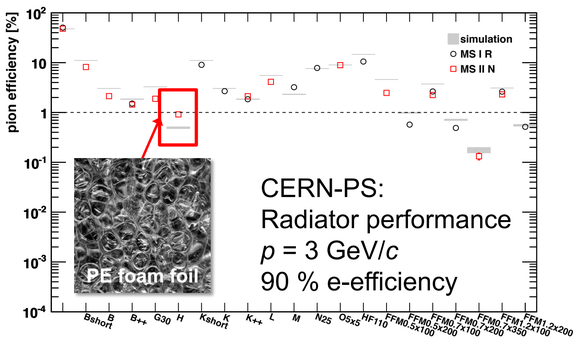
Readout

- SPADIC ASICs
- Self-triggered readout
- Forced neighbor readout
- 32 channels
- 9-bit ADC
- Digital shaper



SPADIC:
Self-triggered **P**ulse **A**mplification and **D**igitization AS**IC**

Test Measurements



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