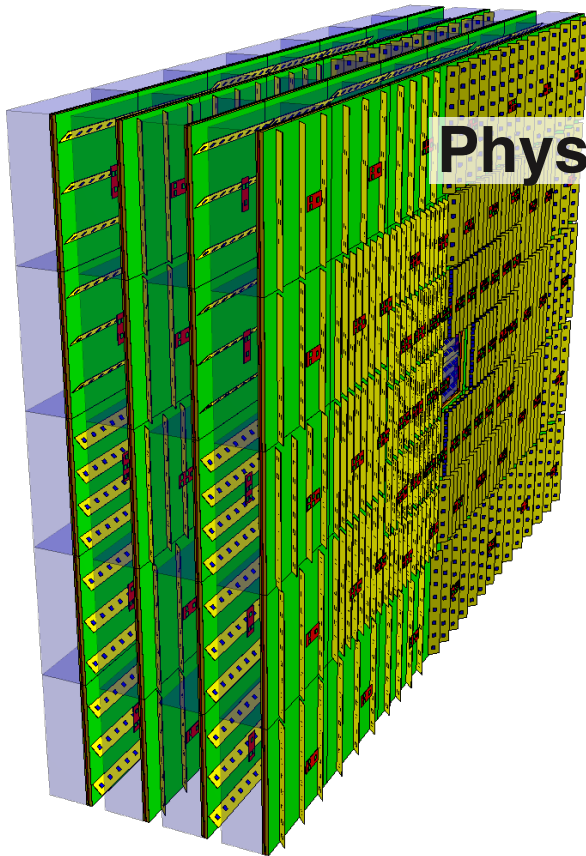




Physics Performance Studies with the CBM-TRD

DPG Spring Meeting 2016

Julian Book
Goethe University Frankfurt



Bundesministerium
für Bildung
und Forschung

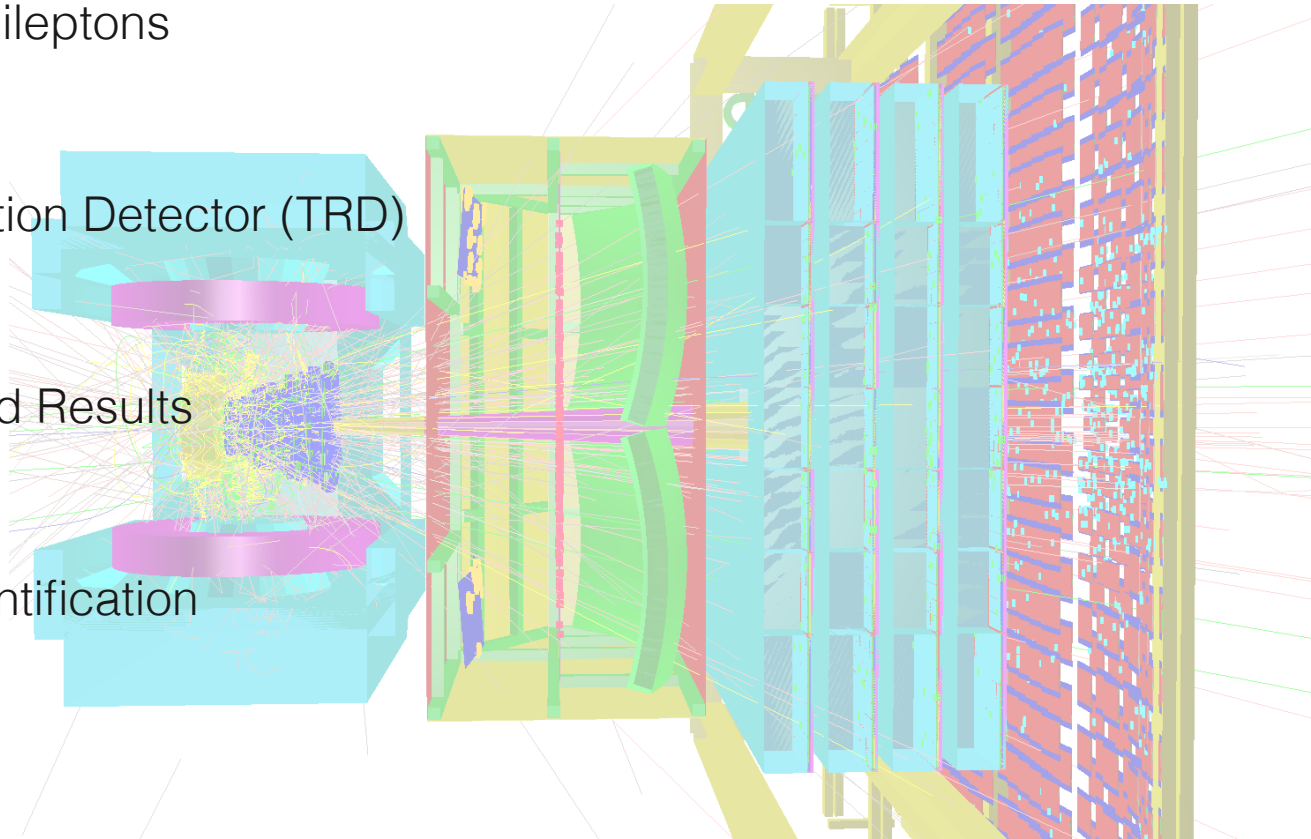
HIC | **FAIR**
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Helmholtz International Center

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FRANKFURT AM MAIN



Outline

- Intermediate Mass Dileptons
- The Transition Radiation Detector (TRD)
- Dilepton Analysis and Results
- Heavy Fragment Identification

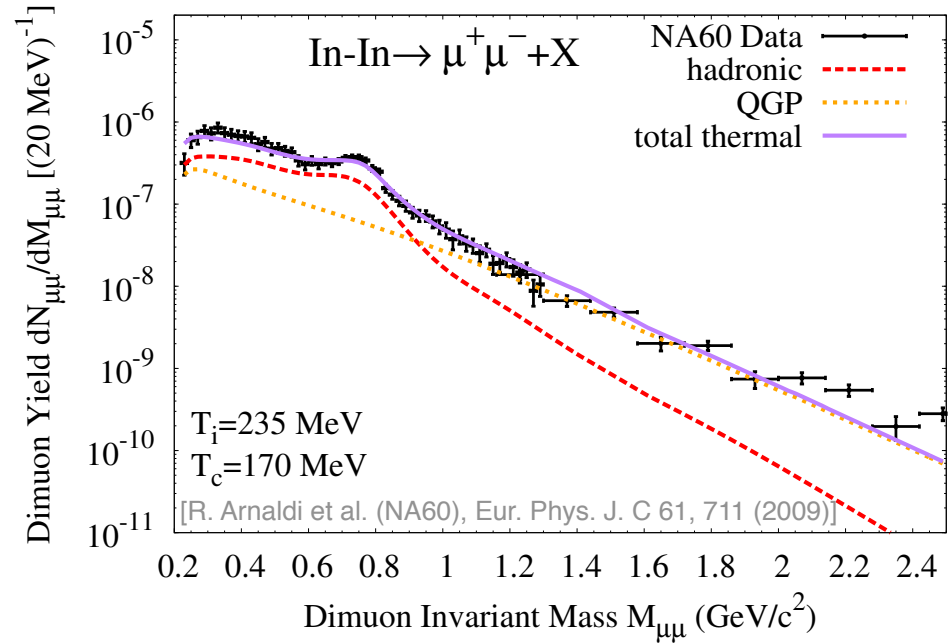


Intermediate mass dileptons ($1 < m_{ee} < 3 \text{ GeV}/c^2$) at SIS100

- Dilepton signal contains contributions from the whole collision evolution:

- pre-equilibrium
- thermalized medium
- meson-decays

- No strong final state interactions
- Probe the em. structure of the dense/hot hadronic matter

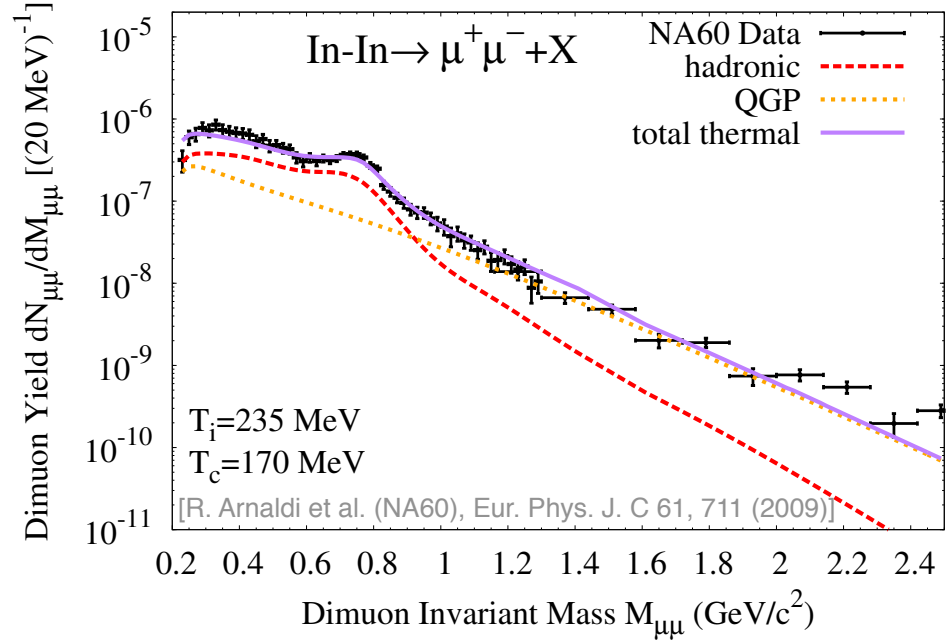


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Measurement

Large combinatorial background in e^+e^-

- Dalitz decays (π^0) & conversion pairs
- No correlated charm and negligible Drell-Yan

- Effective temperature T_{eff} and velocity evolution averaged over emission time
- Thermal contribution dominant for $m_{\text{inv}} > 1 \text{ GeV}/c^2$

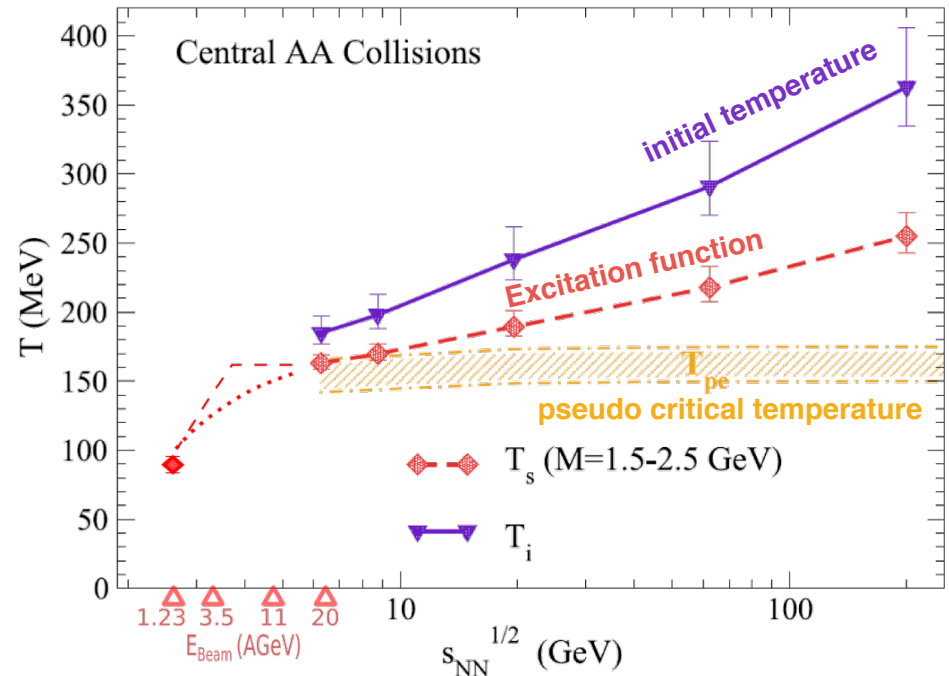
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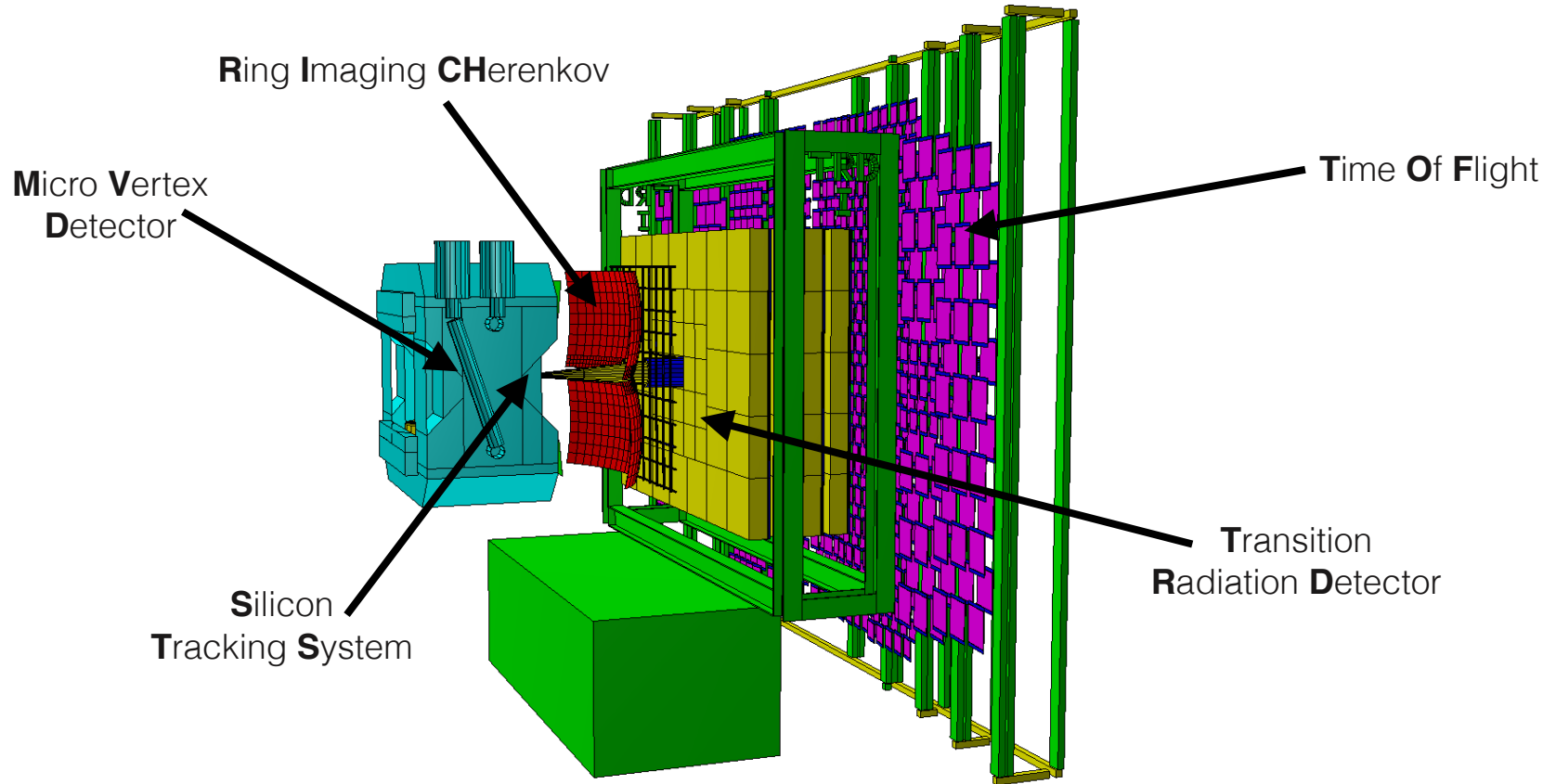
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[R.Rapp, H.Van Hees, Phys.Lett. B753 (2016) 586-590]

FAIR energy range is ideal to look for the onset of QGP radiation

Dilepton Measurements in the CBM Experiment

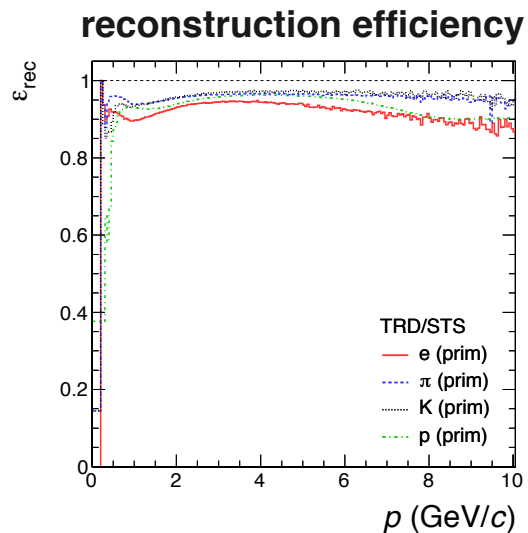
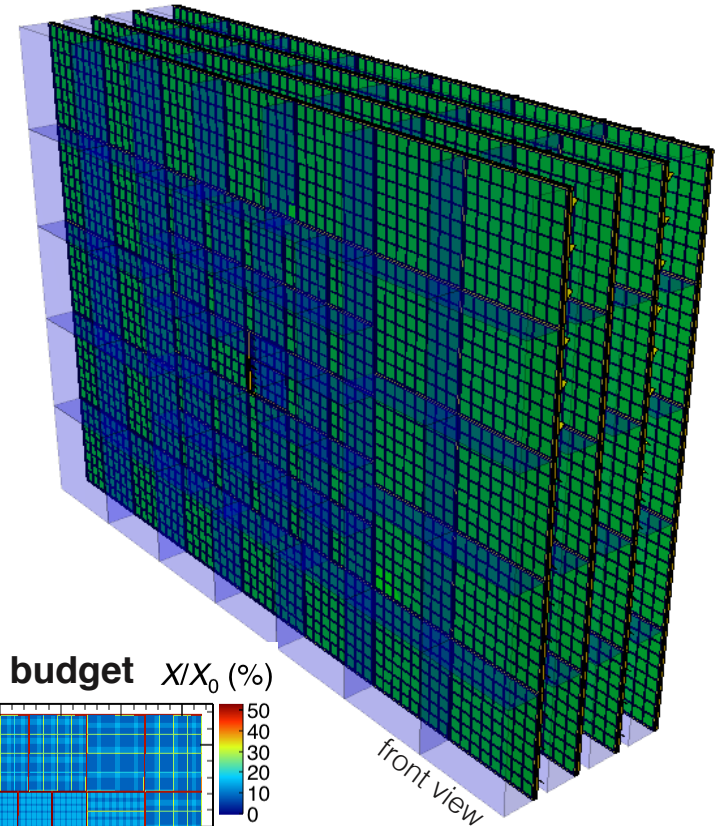


Kinematical Acceptance:	$2.5 < \theta < 25^\circ$, full azimuth
Tracking and Reconstruction:	4layer MVD + 10layer STS
Particle Identification:	RICH + TRD (+TOF)

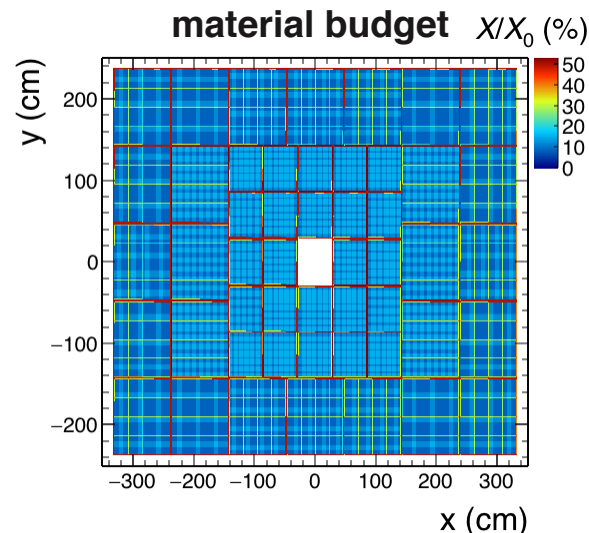
Transition Radiation Detector

Current design - focus on rate

- 4 layers of TRD detectors
- 50 modules and $\sim 72\text{k}$ channels per layer
- 25cm radiator material, Xe/CO₂ (15%) gas mixture
- Particle identification (PID) via specific energy-loss (dE/dx) and transition radiation (TR)
- only CBM-detector that provides charge measurement



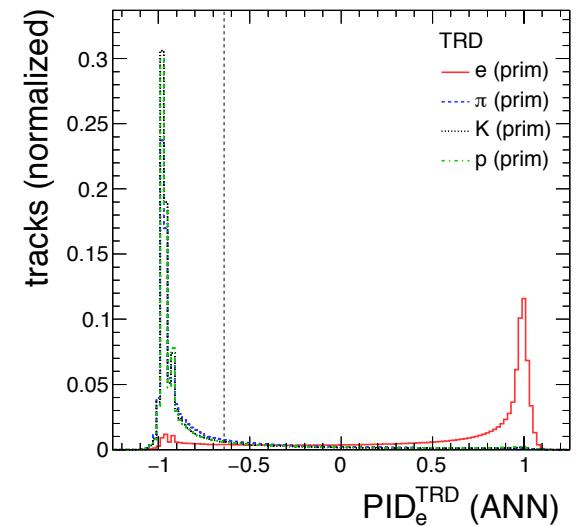
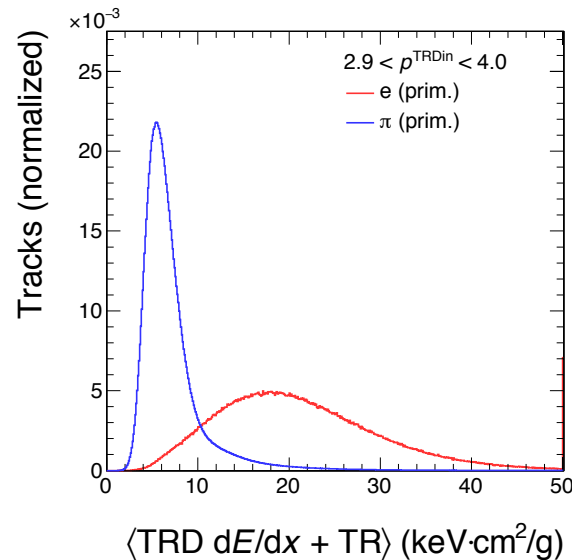
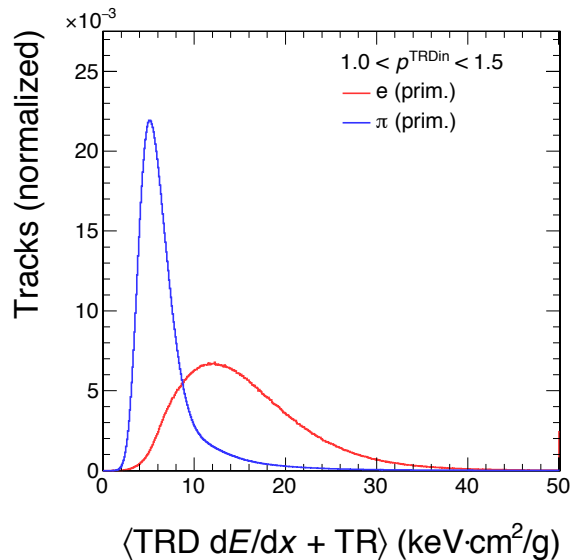
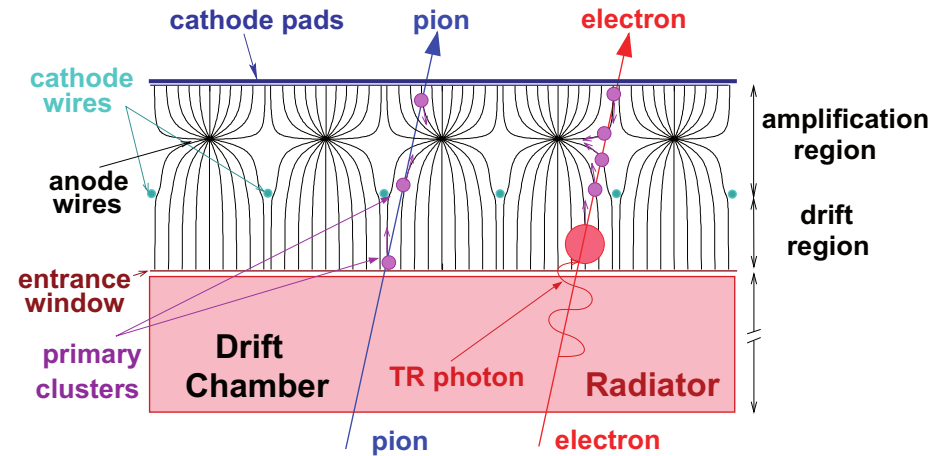
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Electron Identification with the TRD

Working Principle

- electrons with a large γ -factor crossing the radiator produce additional signal (**TR photon**)
- Artificial Neural Network (ANN) is used to identify leptons
- **potential:** pushing π -suppression by e.g. increased drift volume



Pion Suppression versus Momentum

Definition:

suppression = pions after rec. cuts / pions after add. PID cuts

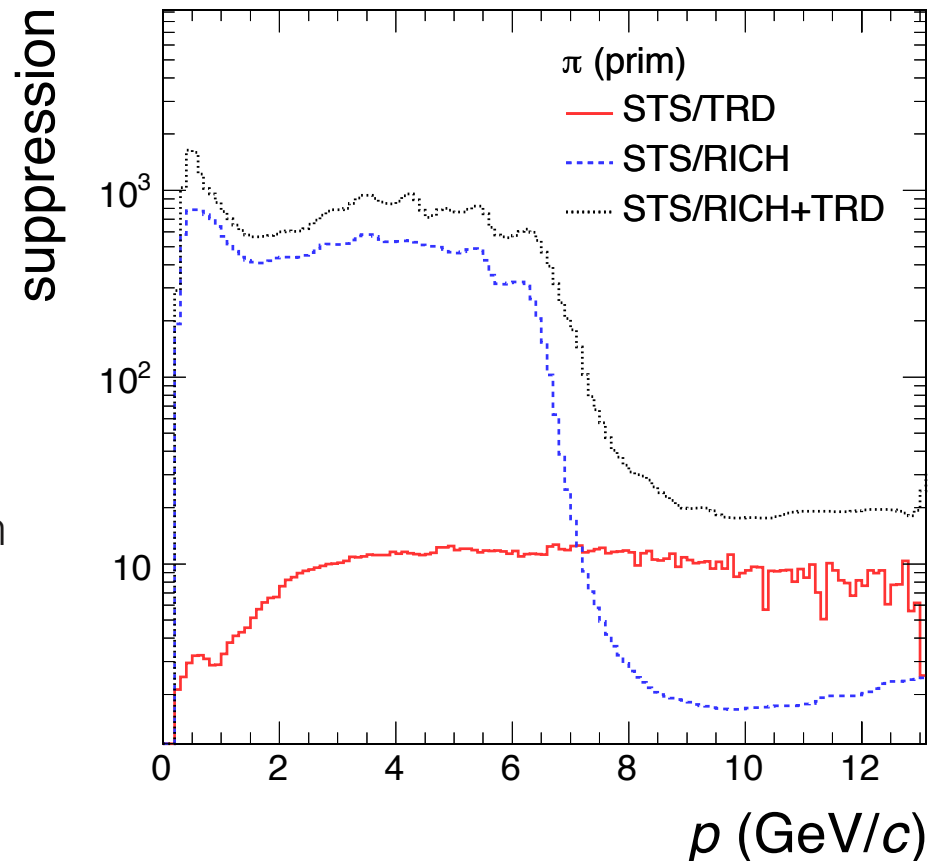
suppression power

RICH:

- Drops at $p=6.5$ GeV/c due to ring formation of pions

TRD:

- TR photon production grows to a factor ~ 10 π -suppression for $p > 3$ GeV/c
- Dominates the high- p region $\Rightarrow$ higher dilepton masses

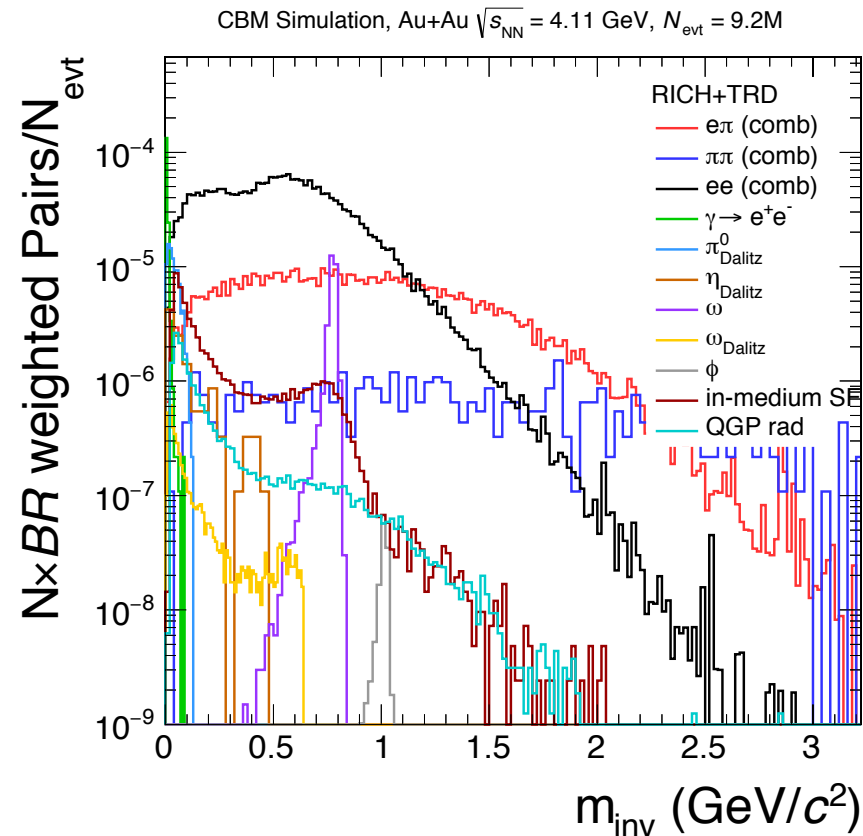


Invariant Mass Spectrum after PID Selection

Au+Au Collisions at $\sqrt{s_{NN}} = 4.11$ GeV

Background:

- mainly combinatoric from **physical sources**
- partially reconstructed **conversions** and **Dalitz decays**



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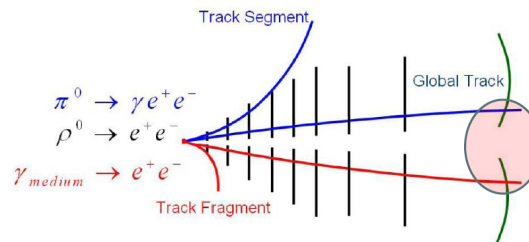
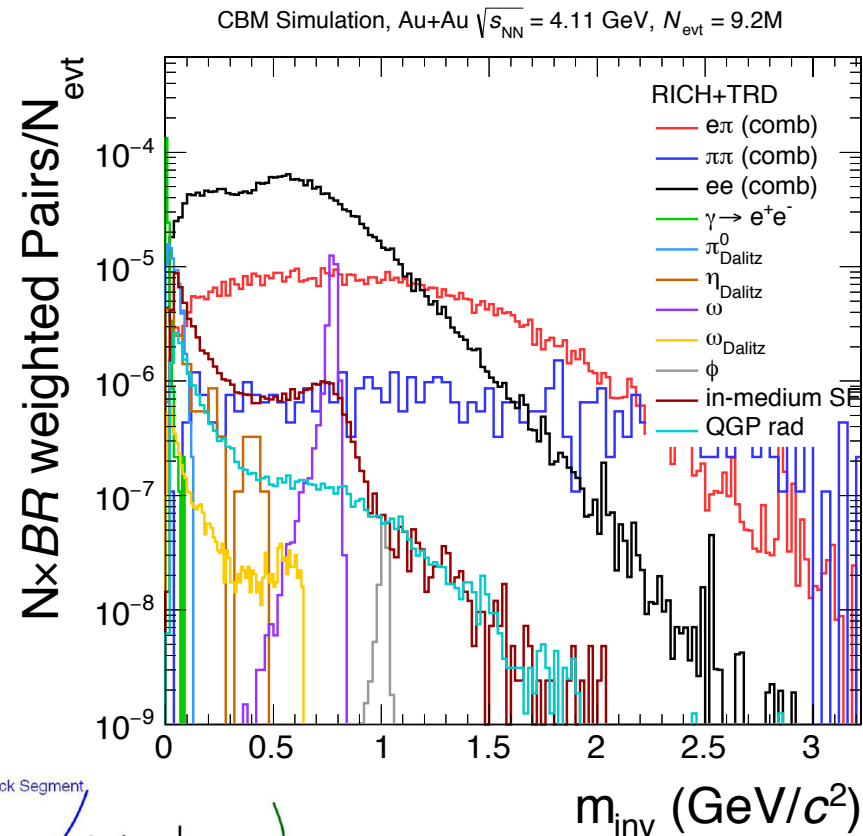
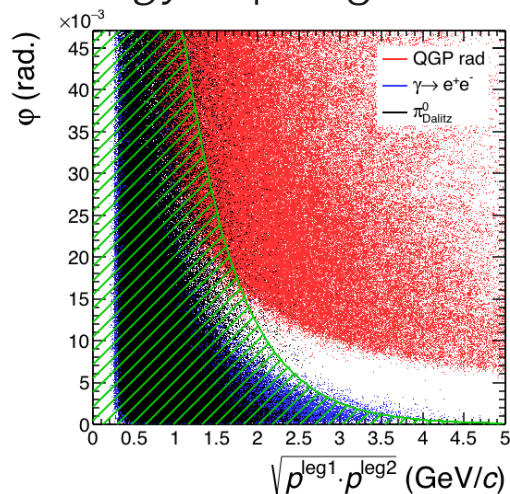
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Strategy: topological cuts using MVD

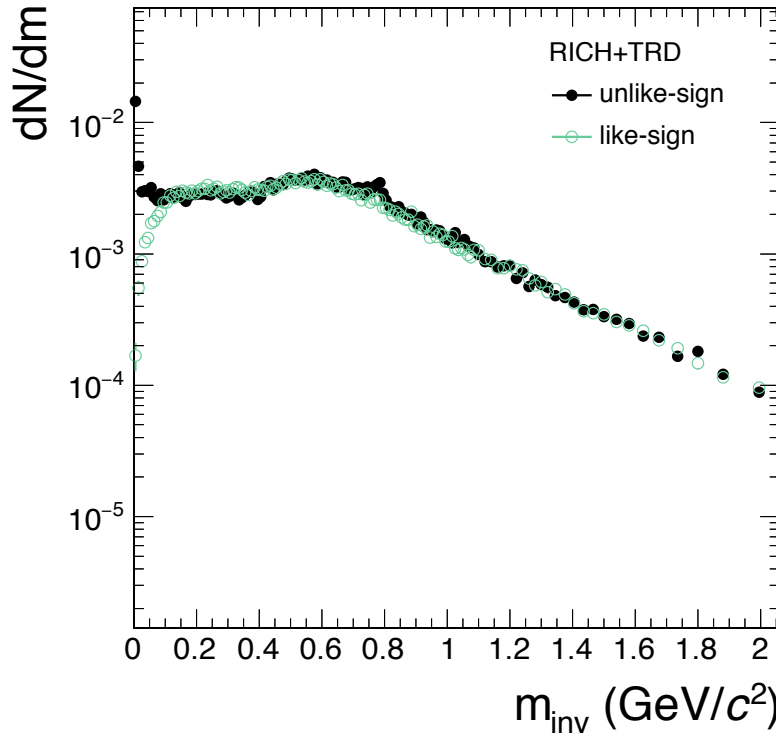


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Signal Extraction

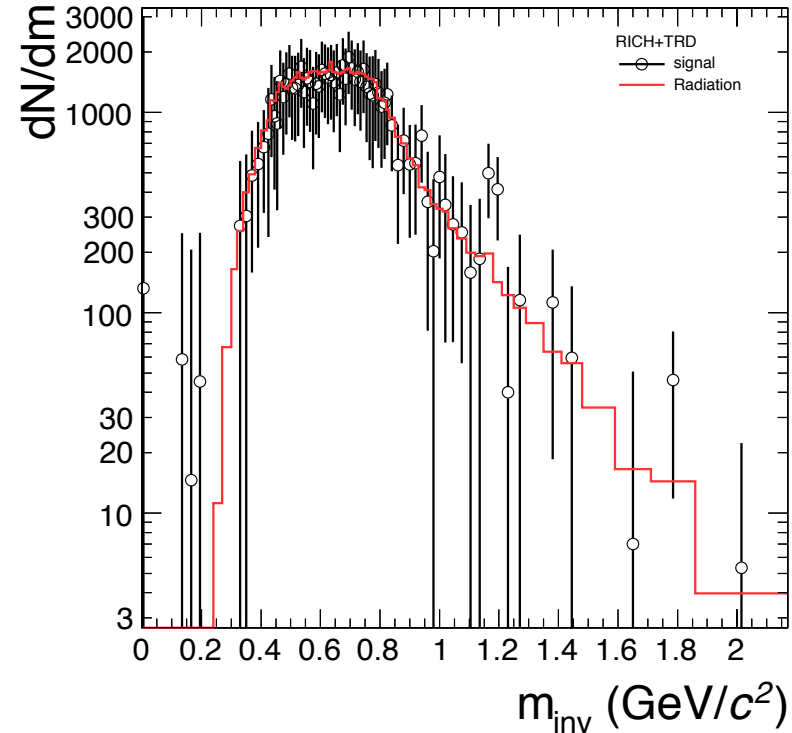
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CBM Simulation, Au+Au $\sqrt{s_{NN}} = 4.11$ GeV, $N_{evt} = 9.2M$



Subtract combinatorial background
via like-sign (LS) method

$$LS = \sqrt{N_{++} \cdot N_{--}}$$

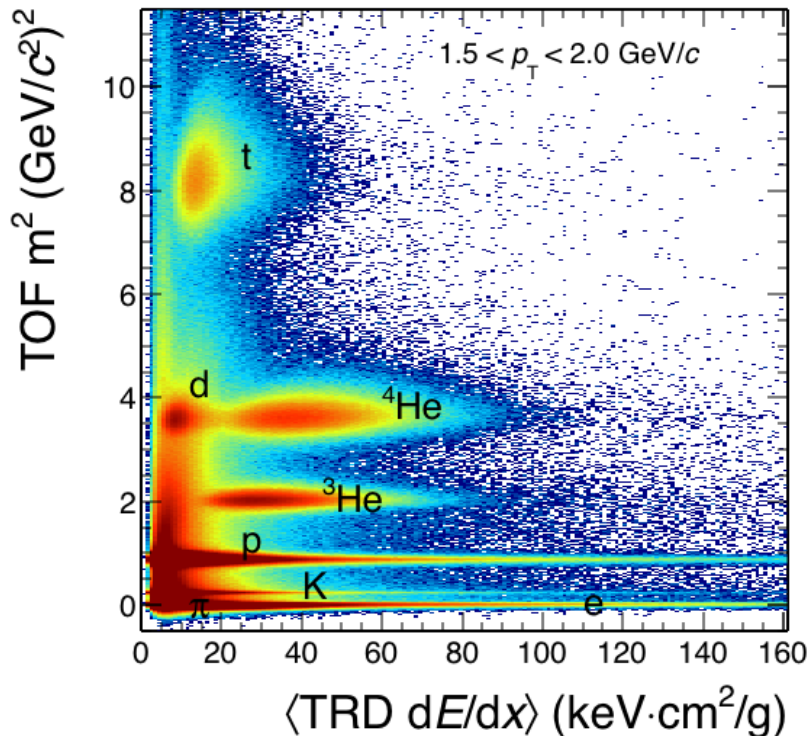


Extract effective temperature via
exponential fit: $N \sim \exp(-m_{inv}/T)$

Fragment Identification with the TRD

Crucial for ^4He -, d -separation and e.g. identification double- Λ hyper-nuclei

Example: $^6_{\Lambda\Lambda}\text{He} \rightarrow ^5_{\Lambda}\text{He} + p + \pi^- \rightarrow ^4\text{He} + 2p + 2\pi^- \iff ^3_{\Lambda}\text{He} \rightarrow d + p + \pi^-$



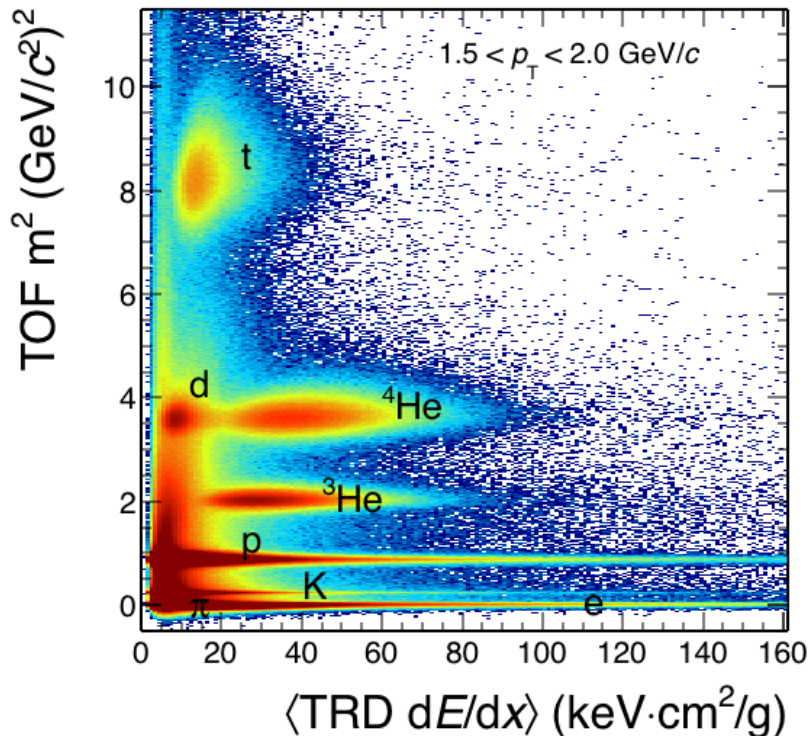
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No separation of deuteron and ^4He
with TOF measurement alone

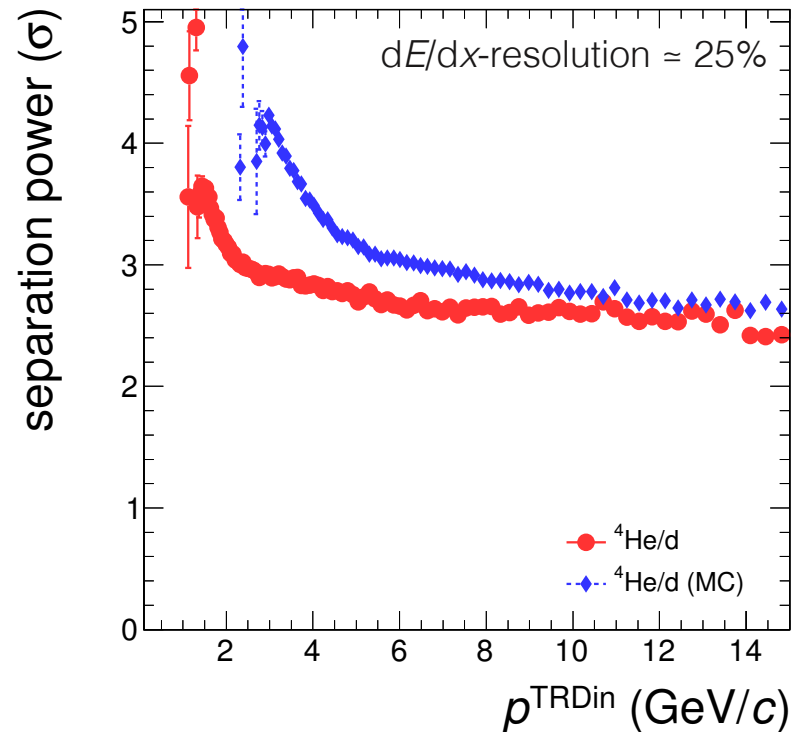
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separation power $> 2.5\sigma$
charge determination can be applied in tracking

Summary

Main physics case for the TRD: Intermediate mass dileptons

- first performance studies for Au+Au at $\sqrt{s_{NN}} = 4.11$ GeV
 - CBM electron setup with 4 layers of TRD detectors
 - optimizing radiator/ drift volume to improve π -suppression
- TRD provides electron Identification at intermediate dilepton masses
 - very good reconstruction efficiency ($\epsilon_{rec} > 90\%$)
 - best pion suppressor for track momenta above 7 GeV/c
- TRD provides information for fragment identification
 - allows to study hyper-nuclei e.g. ${}^6_{\Lambda\Lambda}\text{He}$
 - charge separation can be applied in the track reconstruction

