Performance studies for electron measurements with the CBM-TRD

DPG
Münster, Germany
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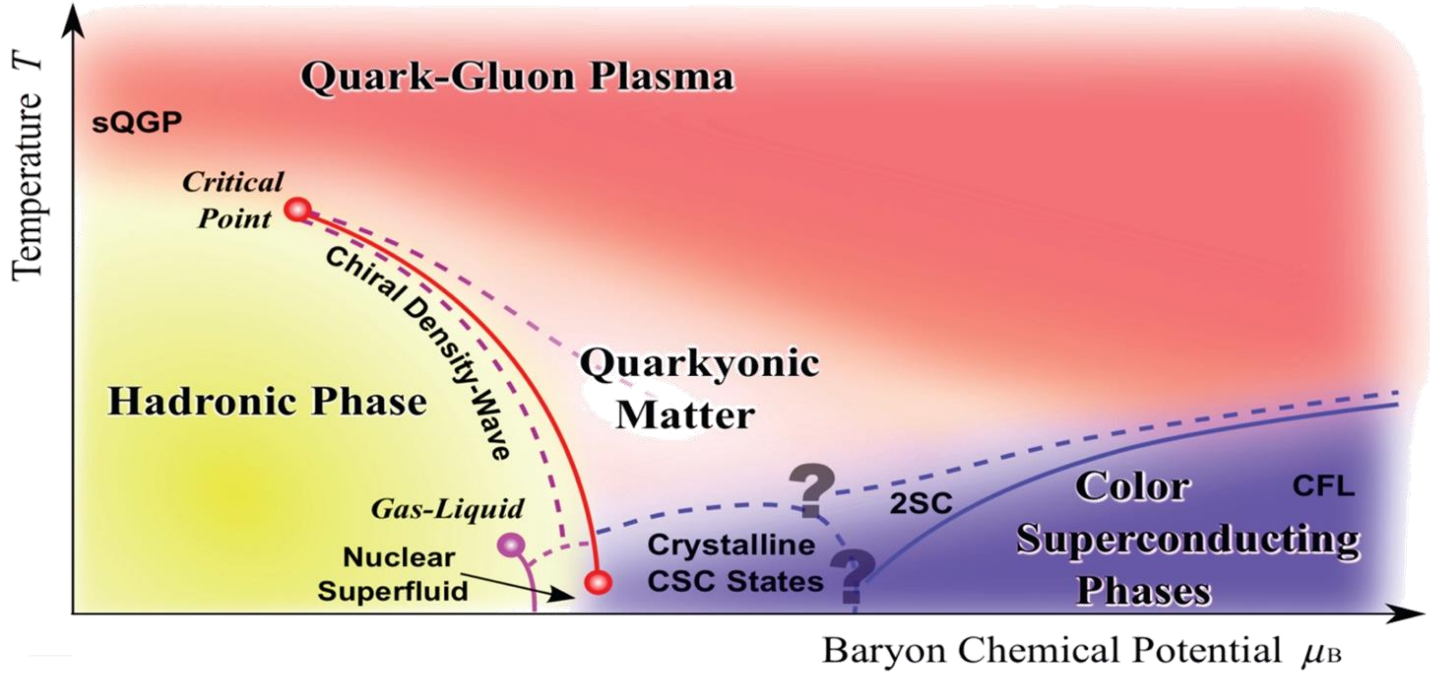
QCD Phase Diagram



Probing the QCD phase diagram

High net-baryon densities

Moderate temperatures

Phase transitions: deconfinement + chiral symmetry

Critical end point

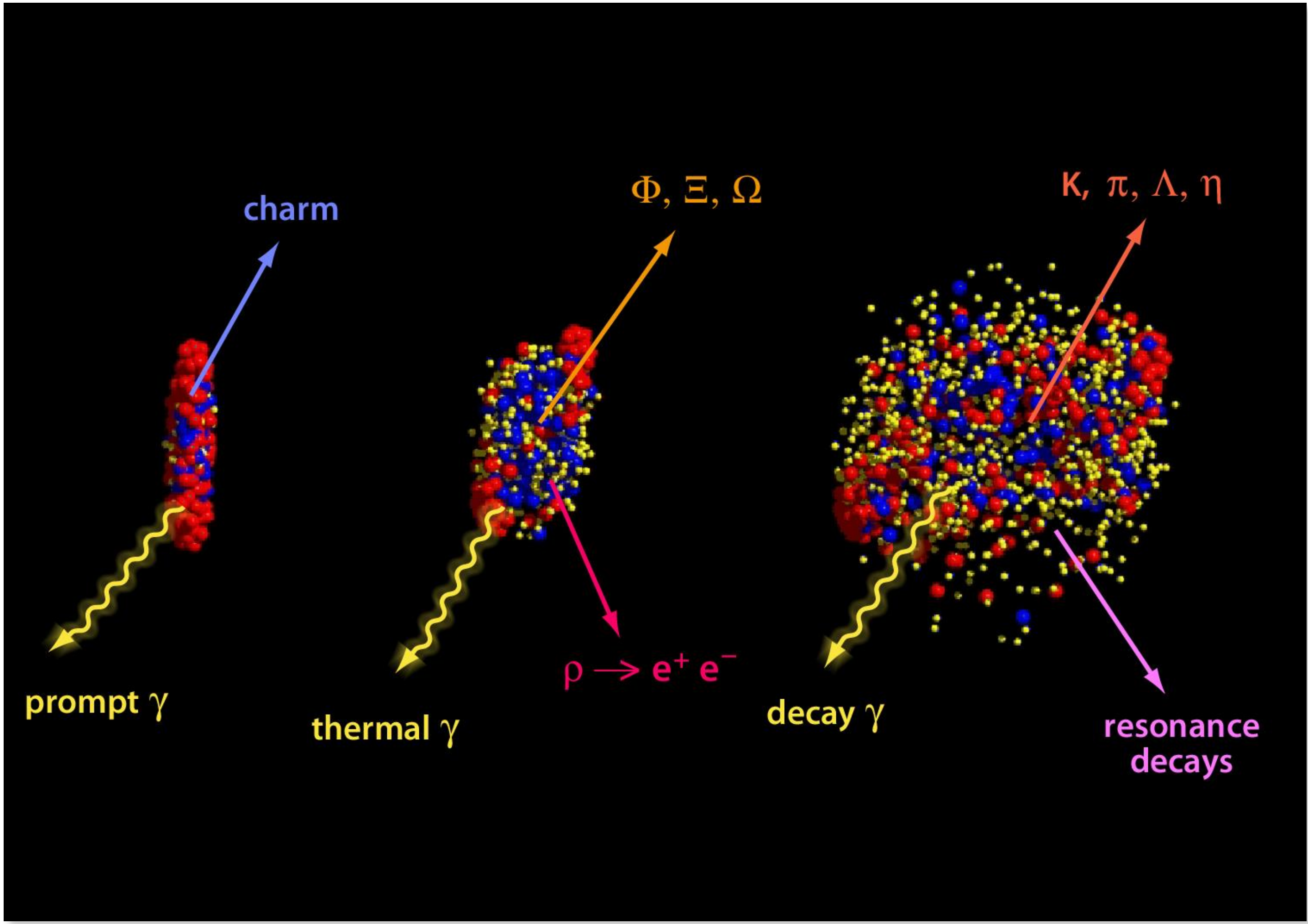
New phases (quarkyonic matter, …)

Observables

Heavy-Ion collisions
Di-leptons can be found in all stages of the fireball development

They especially provide access to the early stages

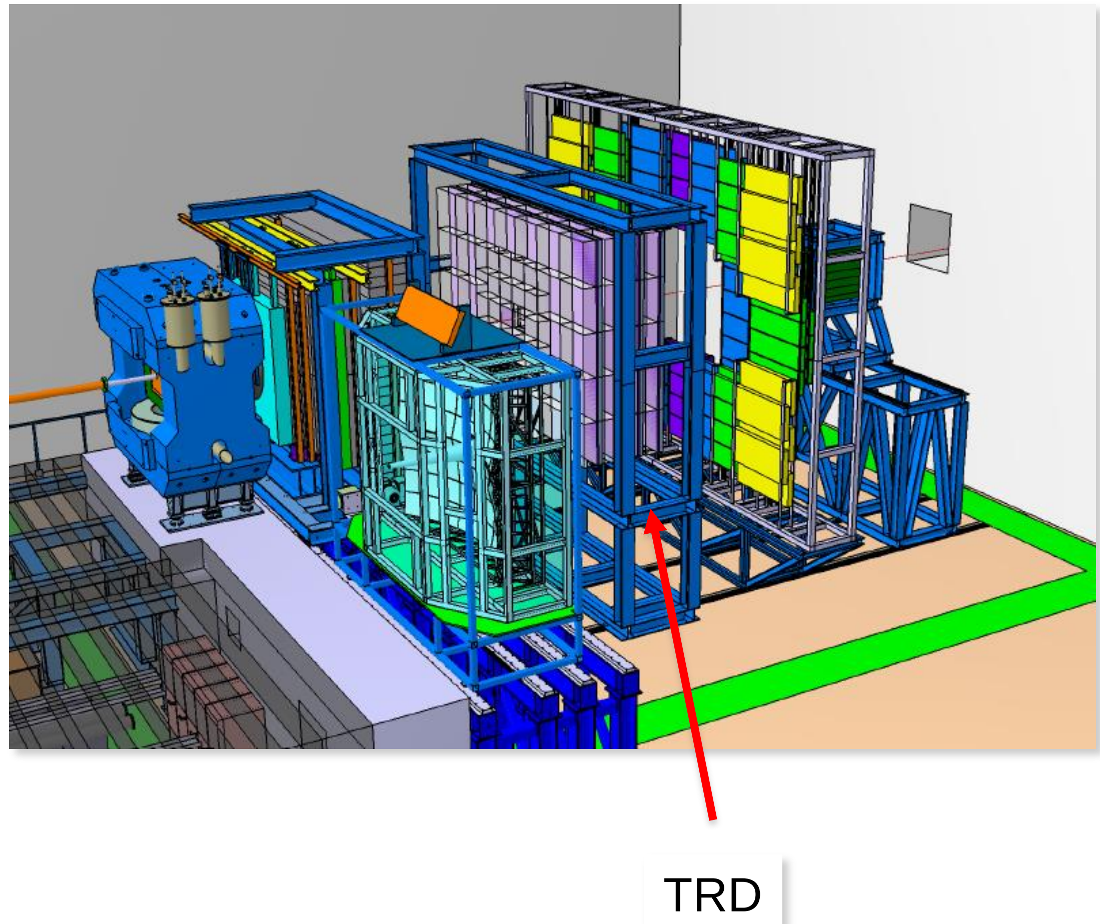
They do not interact strongly and therefore can carry information out of the fireball



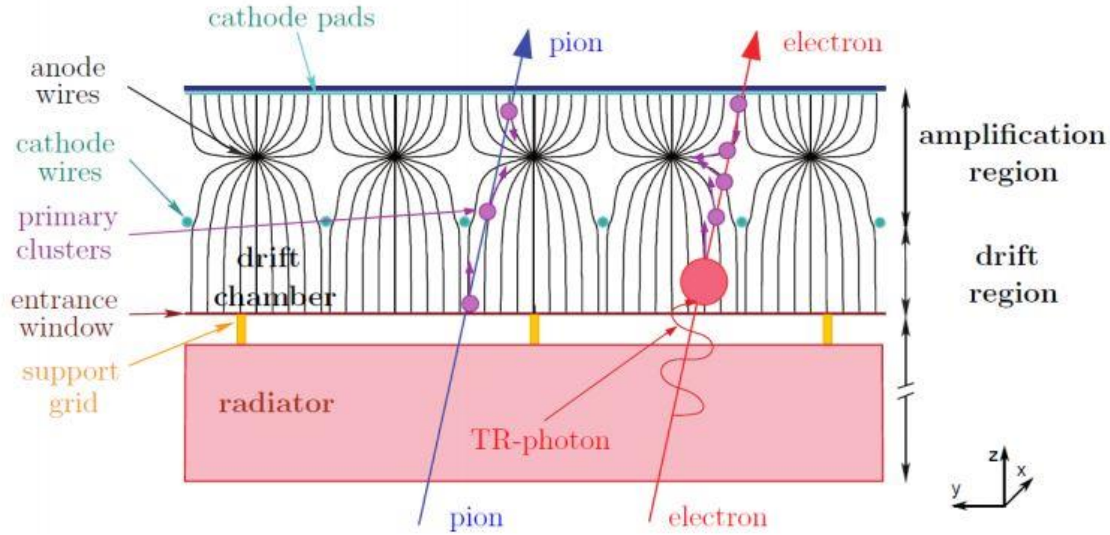
The CBM experiment

The CBM experiment

- Micro Vertex Detector (MVD)
- Silicon Tracking System (STS)
- Ring-Imaging Cherenkov (RICH) detector
- Transition Radiation Detector (TRD)
- Time-of-Flight (TOF) detector
- MUon CHamber (MUCH)
- Projectile Spectator Detector (PSD)

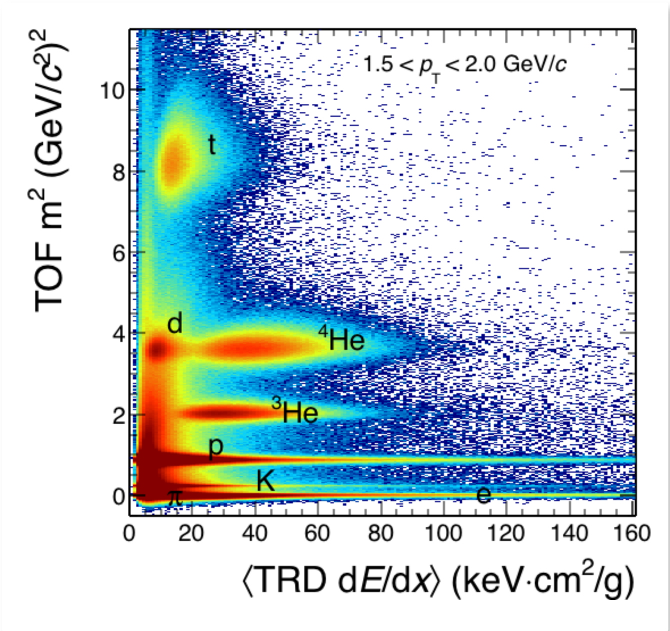


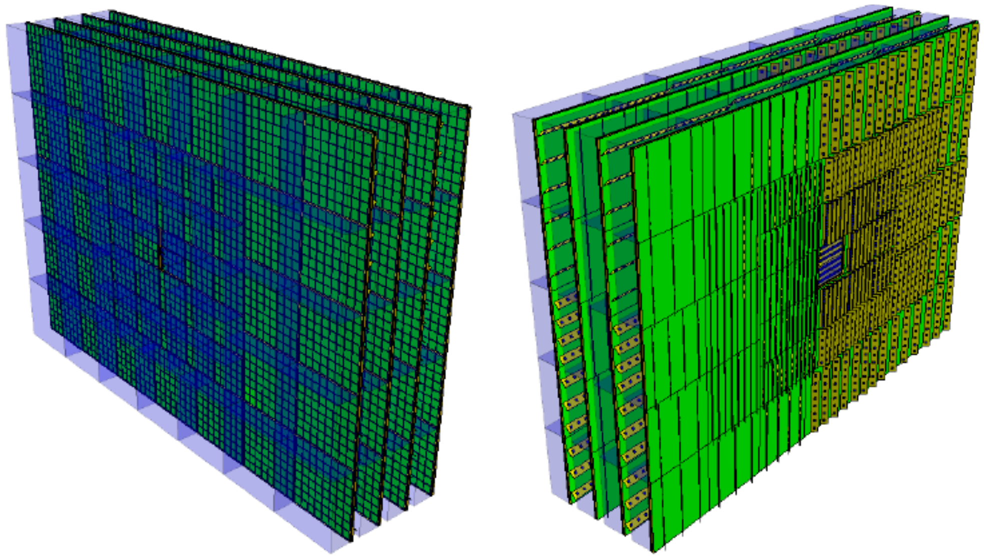
The TRD



TRD
Electron ID at high momenta (necessary to provide access to thermal radiation)

Second physics case: Fragment ID





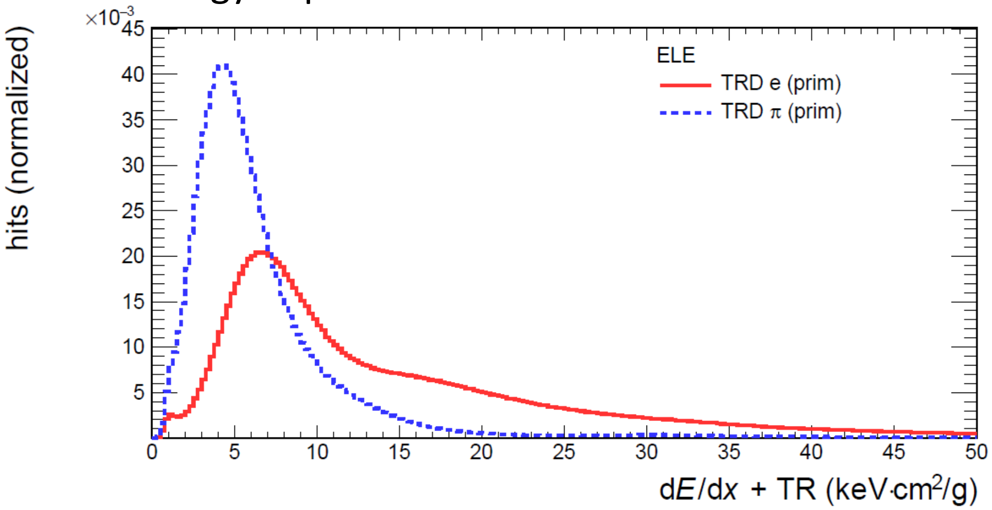
Likelihood method

Basic idea

Calculate the probabilty for a certain energy loss + transition radiation for both particles

Identify electrons with their transition radiation (TR)

Energy deposition distribution for all momenta



Likelihood method

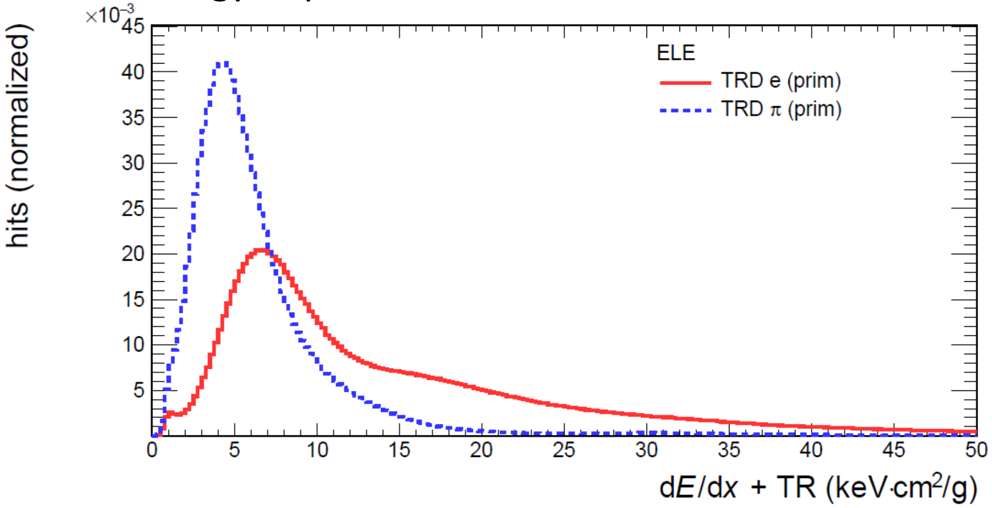
Calculation

$$L_e = \frac{p_e}{p_e + p_\pi}$$

With:

$$p_{e/\pi} = \prod_{i=1}^{n} p_{e_i/\pi_i}$$

Energy deposition distribution for all momenta



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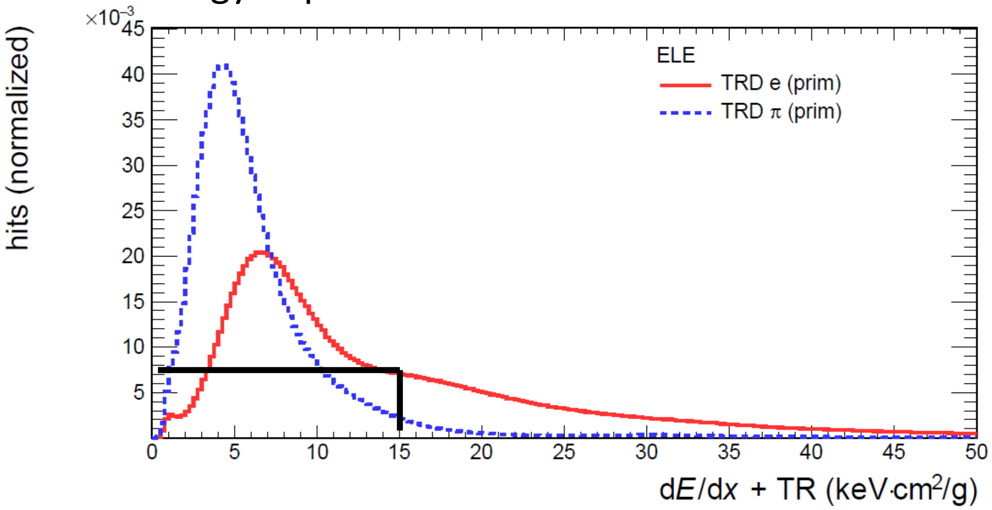


$$p_e = 7.5 \cdot 10^{-3}$$

Likelihood method

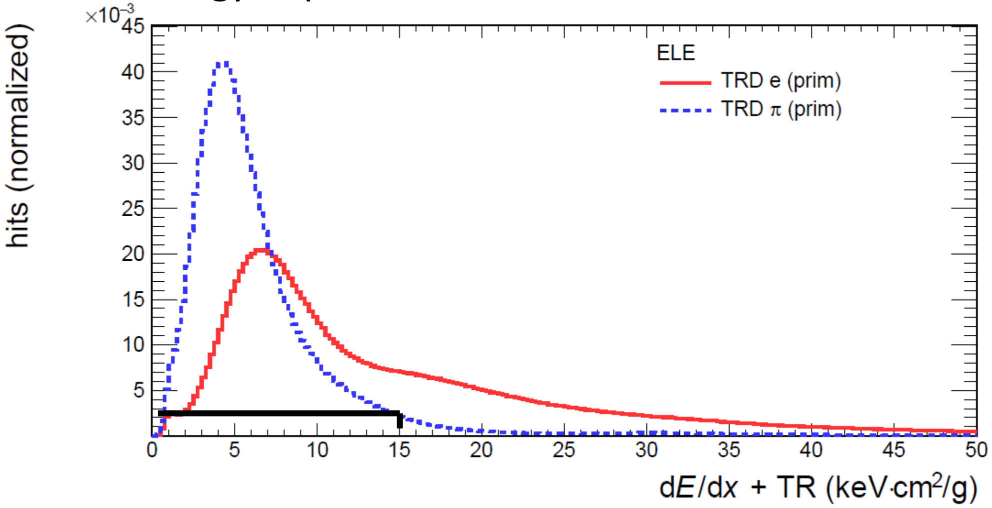
Calculation

$$L_e = \frac{p_e}{p_e + p_\pi}$$

With:

$$p_{e/\pi} = \prod_{i=1}^{n} p_{e_i/\pi_i}$$

Energy deposition distribution for all momenta



$$p_e = 7.5 \cdot 10^{-3}$$

$$p_\pi = 2.5 \cdot 10^{-3}$$

$$L_e = 0.75$$

Likelihood method

Calculation

$$L_e = \frac{p_e}{p_e + p_\pi}$$

With:

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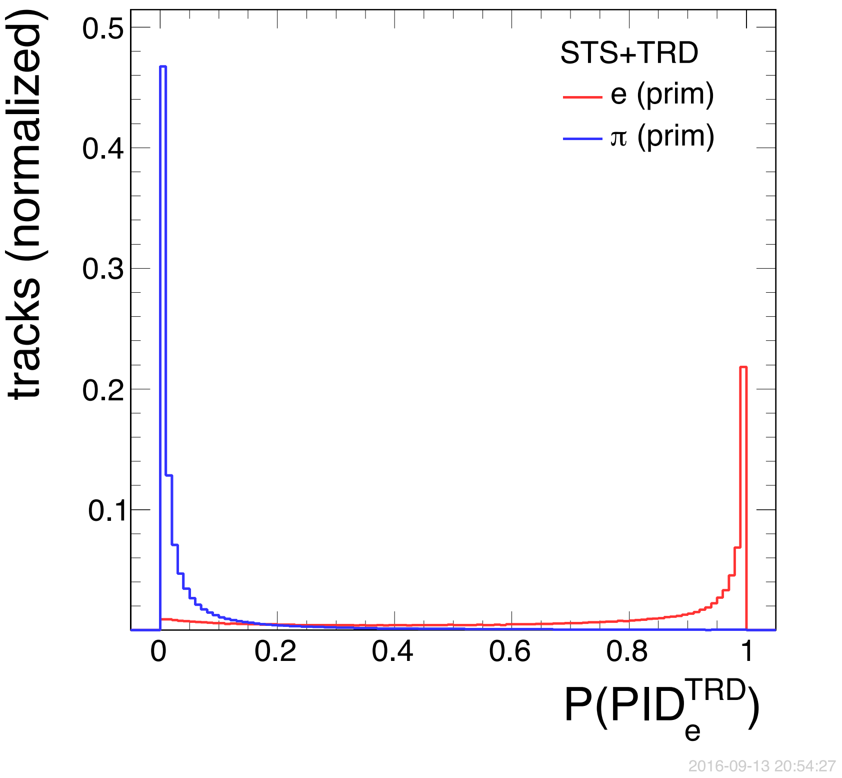


Simulation information

Software + Geometry

CbmRoot

TRD with four layers

Target thickness 25 µm

Central (10%) Au+Au at 8 *A*GeV

5×10^6 UrQMD background events

LMVM cocktail, yields according to HSD prediction

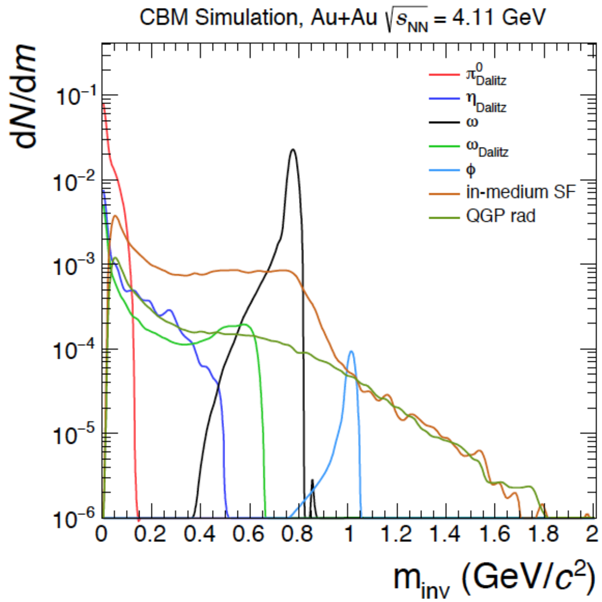
(W. Cassing et al., Nucl. Phys. A691 (2001) 753)

Thermal radiation

(T. Galatyuk et al., Eur. Phys. J. A52 (2016) 131)

Generated via PLUTO

and added to UrQMD events



Source	$BR_{e^+e^-}$	Total multiplicities	
		p + Au	Au + Au
ρ^0	$4.72 \cdot 10^{-5}$	$3.4 \cdot 10^{-3}$	9.0
ω	$7.28 \cdot 10^{-4}$	$5.7 \cdot 10^{-3}$	19.0
ϕ	$2.97 \cdot 10^{-4}$	$1.7 \cdot 10^{-4}$	0.12
$J/\psi(1S)$	$5.97 \cdot 10^{-2}$	$5.1 \cdot 10^{-8}$	—
$\psi(2S)$	$7.89 \cdot 10^{-3}$	$1.3 \cdot 10^{-9}$	—
In-medium radiation	—	—	$2.2 \cdot 10^{-2}$
QGP radiation	—	—	$5.8 \cdot 10^{-3}$

Di-electron reconstruction settings

Track quality
STS: $N_{hits} \geq 6$, RICH: $N_{hits} \geq 6$, TRD: $N_{hits} \geq 3$

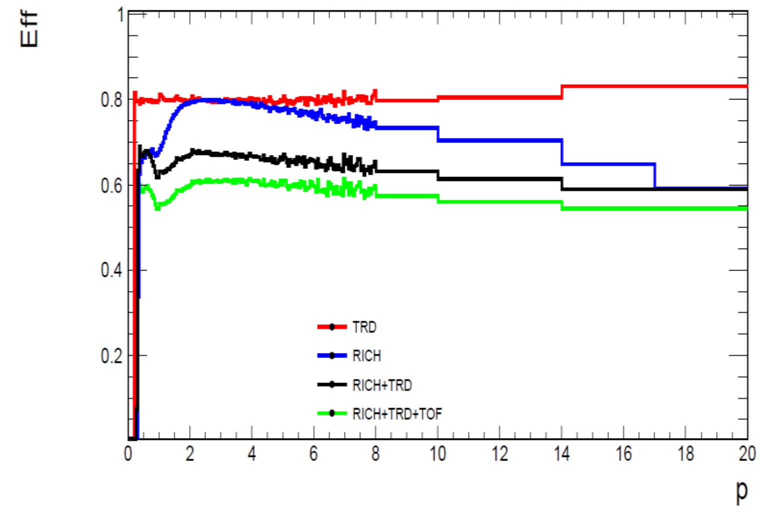
χ^2/ndf < 3 to primary vertex

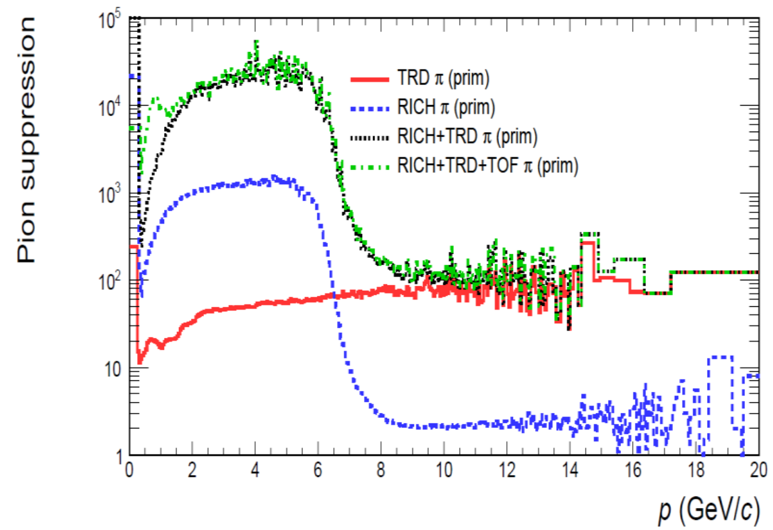
Refit under electron assumption

Electron identification
RICH: ANN output, e-efficiency (~ 90%)

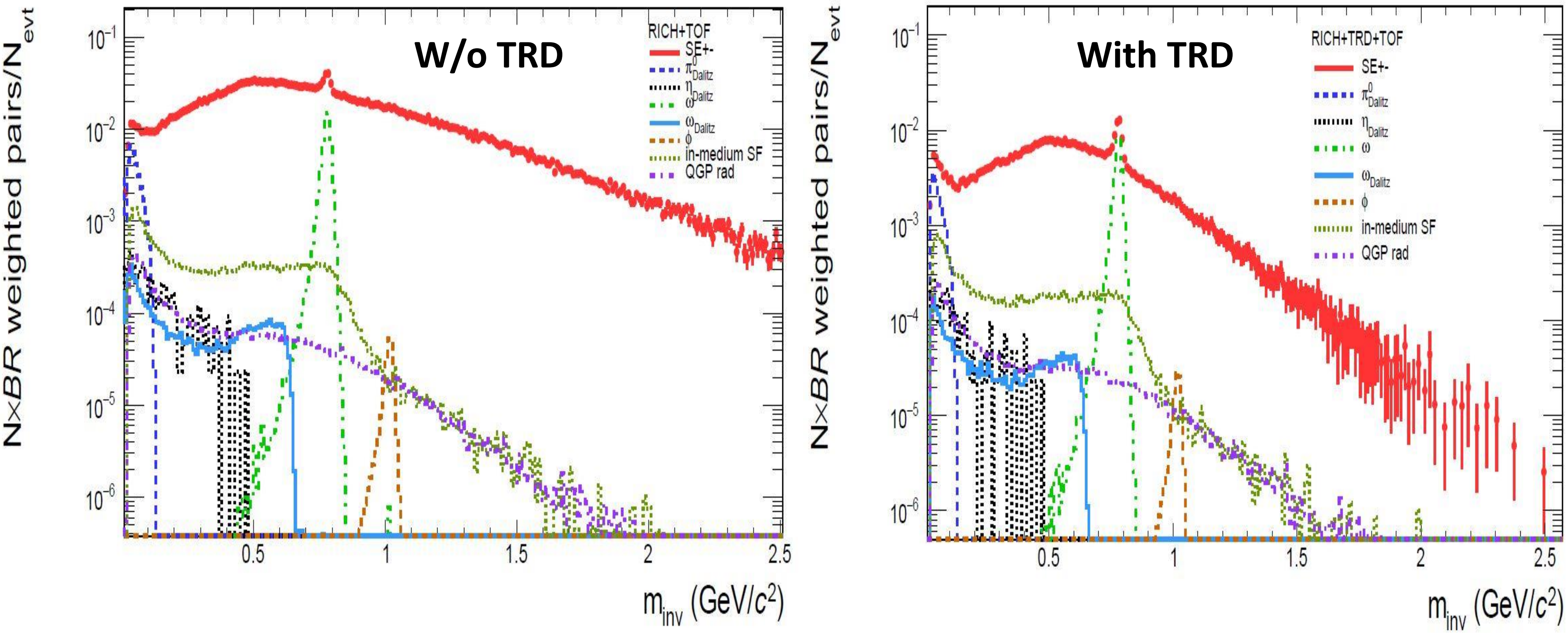
TRD: Likelihood method
Cuts tuned to different p-dep e-efficiency (70% / 80% / 90%)

TOF: Cut on $\beta_{meas} - \beta_e$ ($\pm$ 1.65 σ)
⇒ ~ 90% e-efficiency





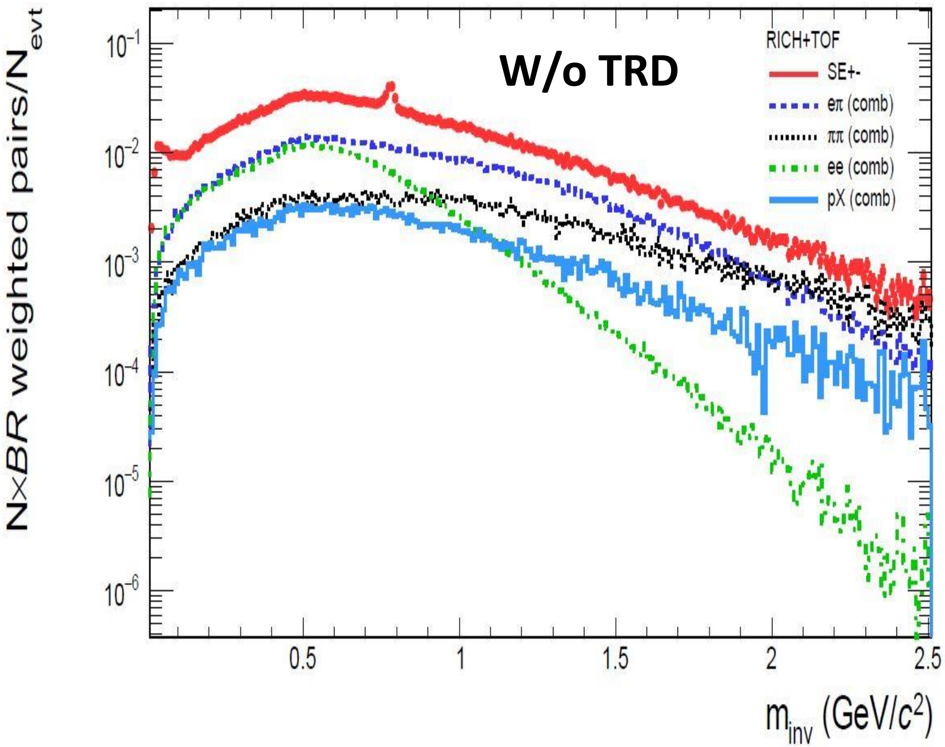
Di-lepton yield with and w/o TRD

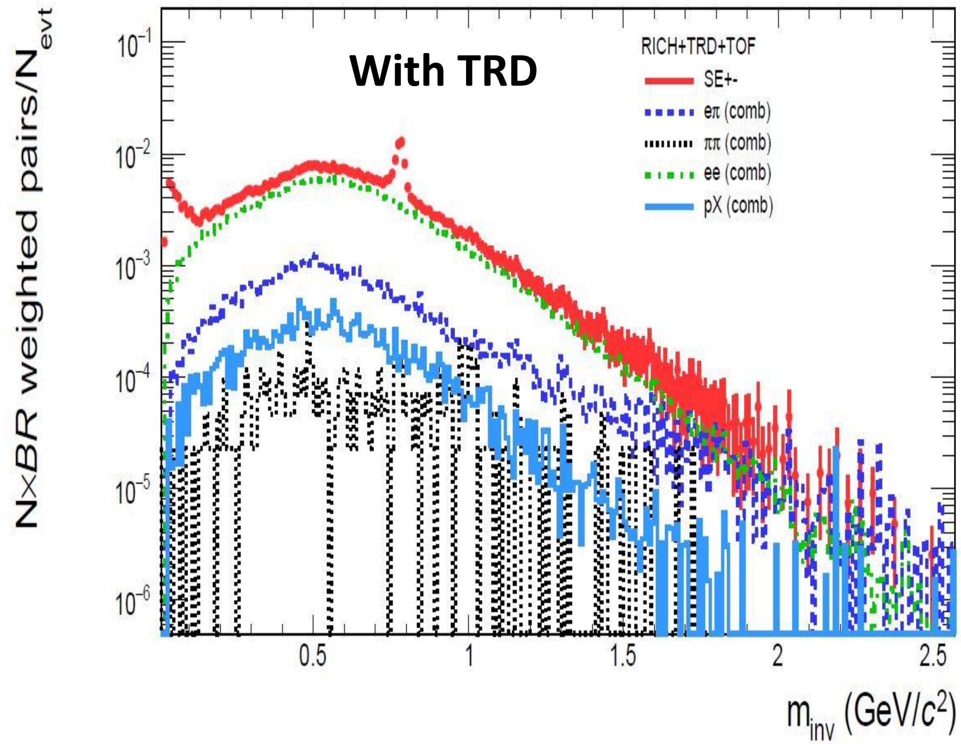


Dilepton yield

No significant change in the signal yield, but much higher total yield of unlike-sign pairs (SE+-)

Combinatorial background with and w/o TRD





Combinatorial background

Much higher total yield of unlike-sign pairs due to a much larger amount of pion signals

Conclusion

Di-electron simulations

A sufficient pion suppression can be achieved to provide access to the thermal radiation

The TRD is mandatory for this physics case

The PID of the TRD increases the signal-to-background ratio in the higher invariant mass region by about two orders of magnitude

See also H.K. 27.24 – Poster by Daniel Giang

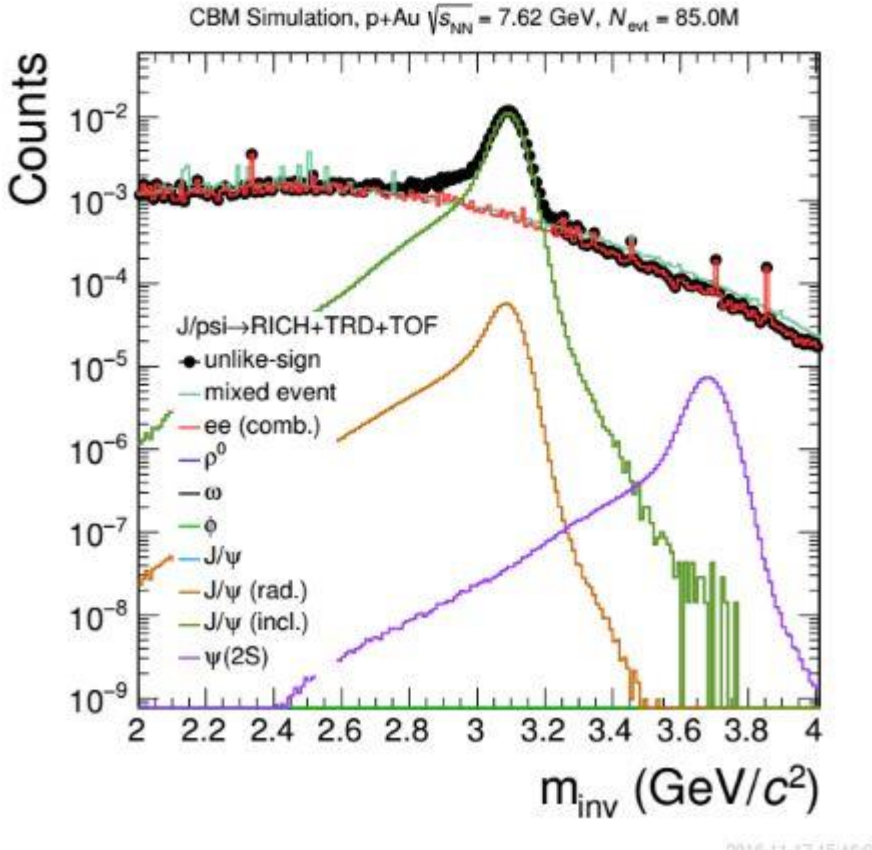
Performance studies for J/ψ measurements in p+A collisions with CBM

p+AU collisions

Reconstruction aspects

J/ψ efficiency

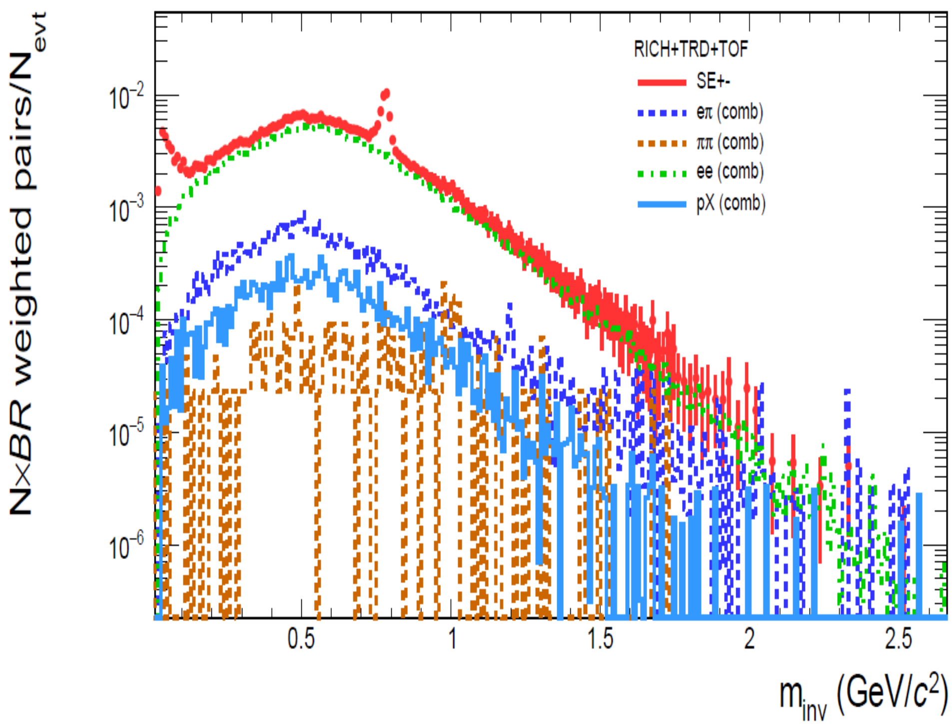
Fast simulation



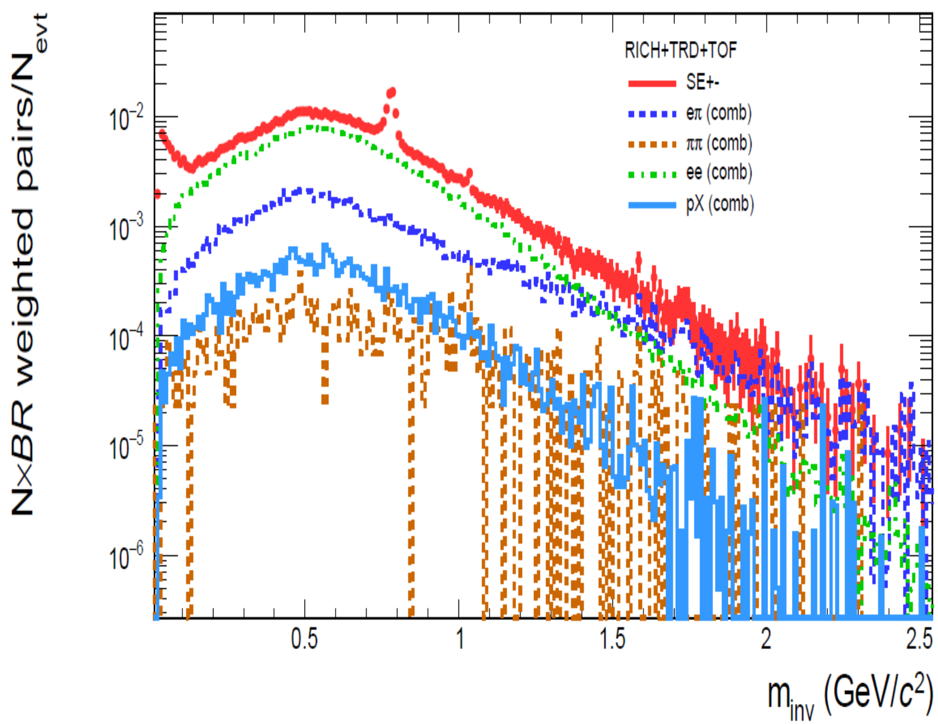
Thank you for your attention

Background combinatorics for different electron efficiencies

70% efficiency



90% efficiency



Combinatorial background

Larger contribution of the $e\pi$ channel especially for invariant masses larger than 1 GeV/c