Performance studies for electron measurements with the CBM-TRD

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Etienne Bechtel
University of Frankfurt

Bundesministerium für Bildung und Forschung

HGS-HIRe for FAIR
Helmholtz Graduate School for Hadron and Ion Research

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Overview

The CBM experiment

Observables

The Experiment

Physics cases of the TRD

Dilepton channels

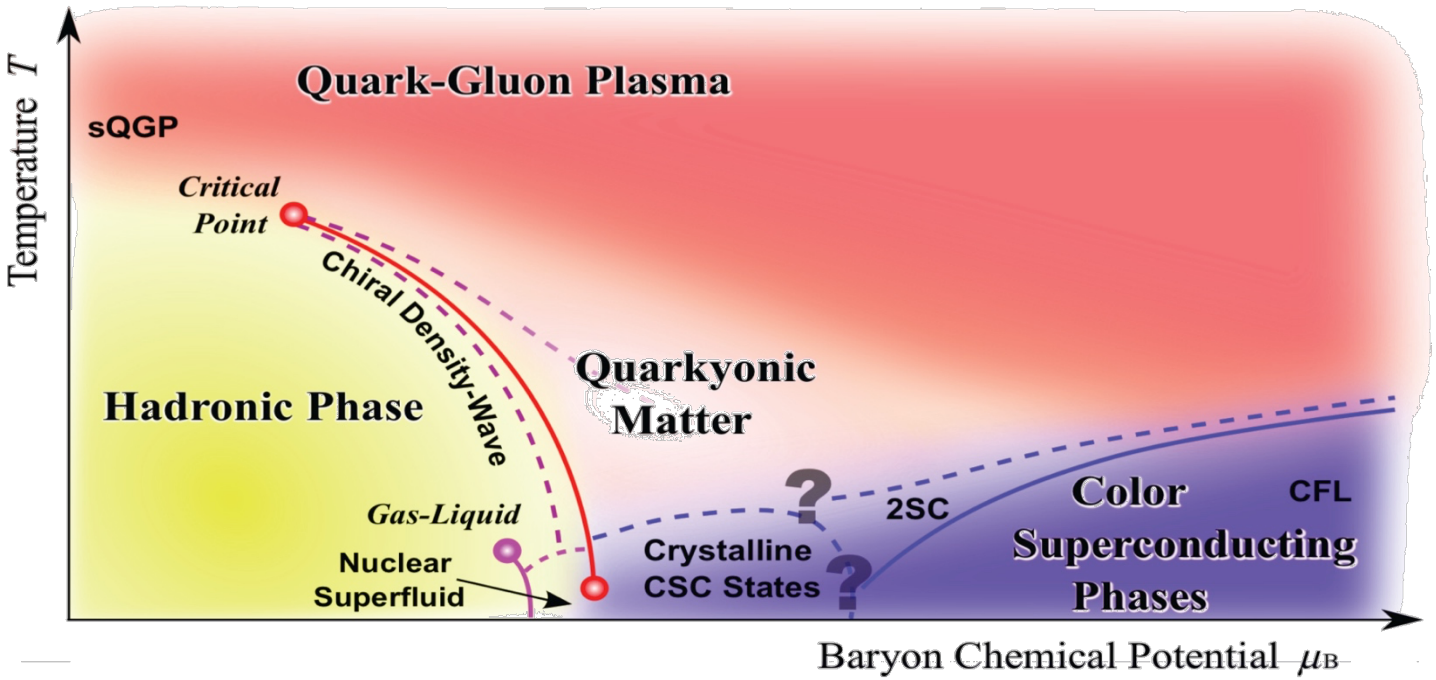
Fragment ID

New generation of performance simulations

TRD features

4D simulations

QCD Phase Diagram



Probing the QCD phase diagram with CBM

High net-baryon densities

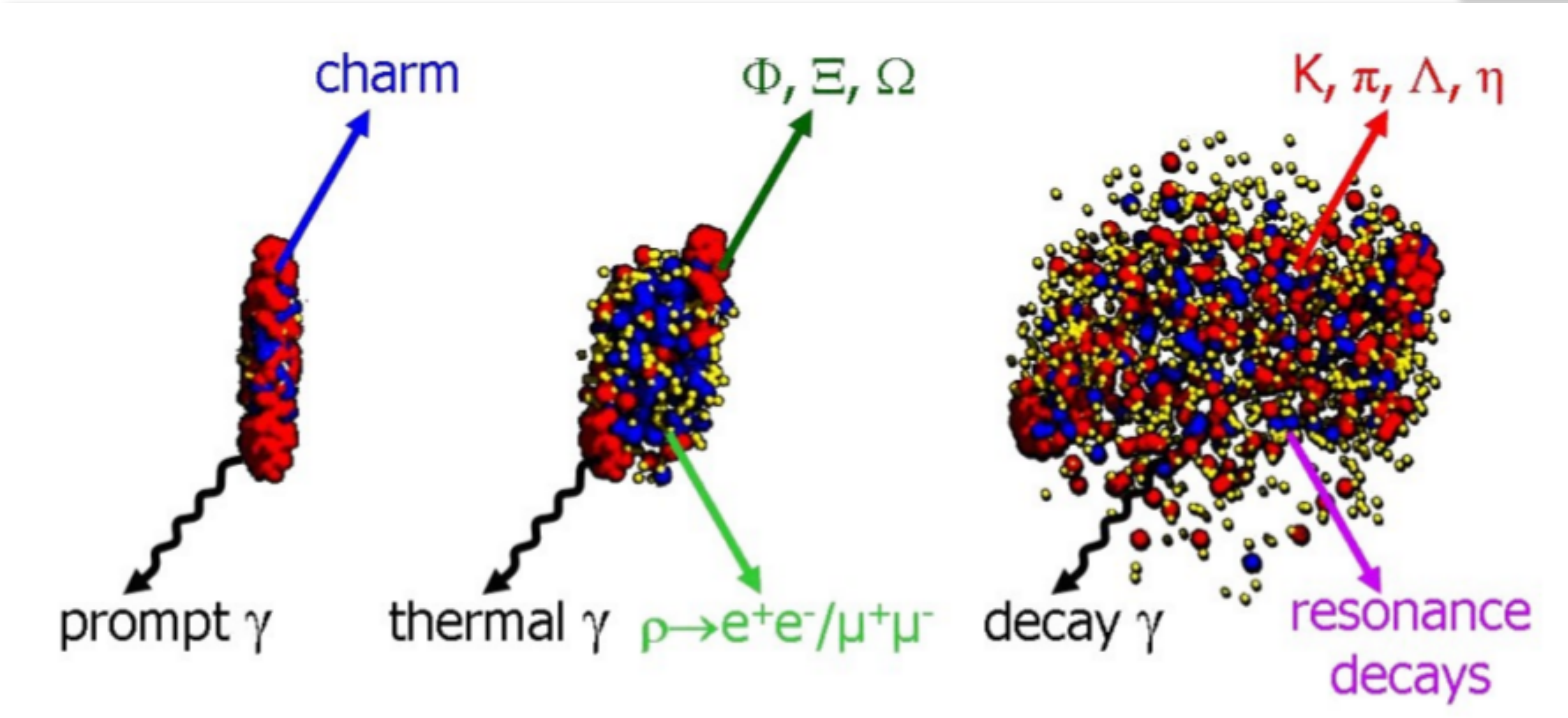
Moderate temperatures

Phase transitions: deconfinement + chiral symmetry

Critical end point

New phases (quarkyonic matter, …)

Observables



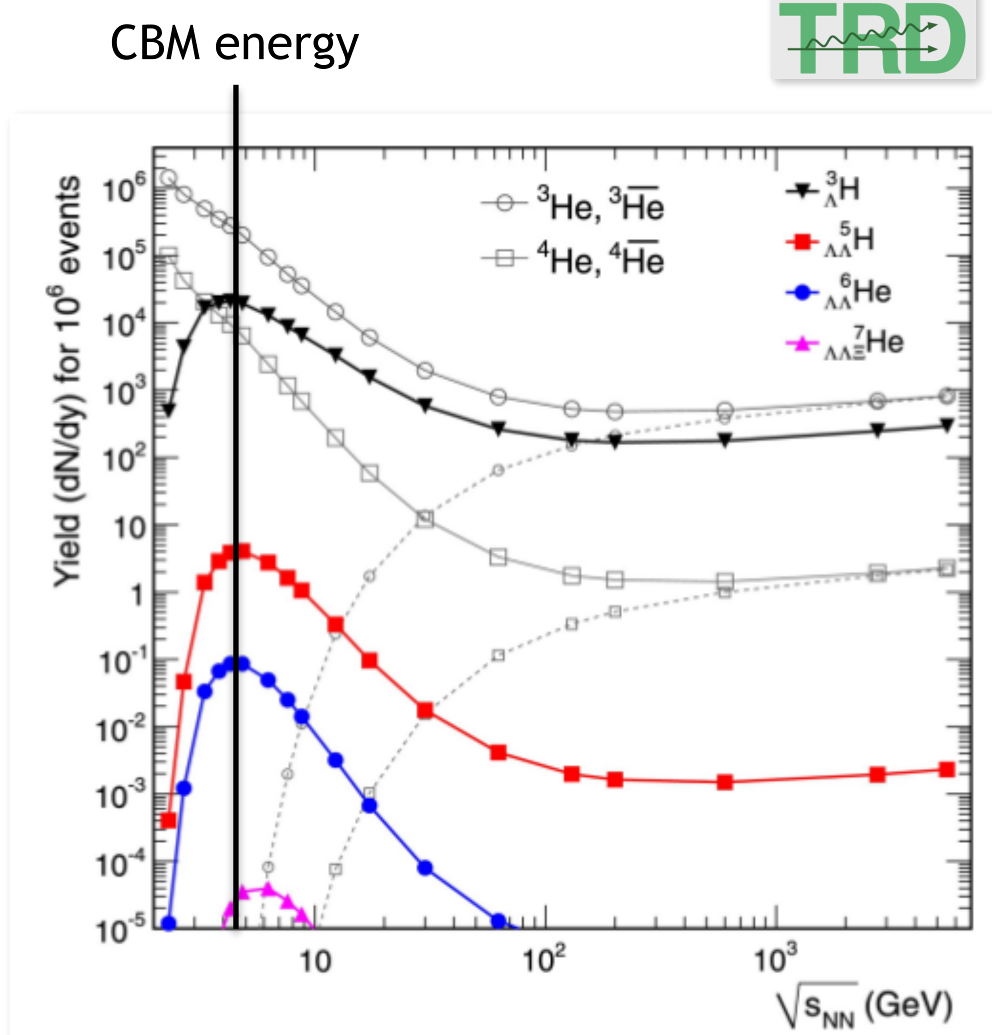
Heavy-Ion collisions

Di-leptons originate from all stages of the fireball development

They especially provide access to the early stages

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

Observables



Hypernuclei
Nuclei which contain at least one hyperon

Very exotic and rare probes

Useful to study hyperon-nucleon interaction and behaviour of strangeness in nuclear matter

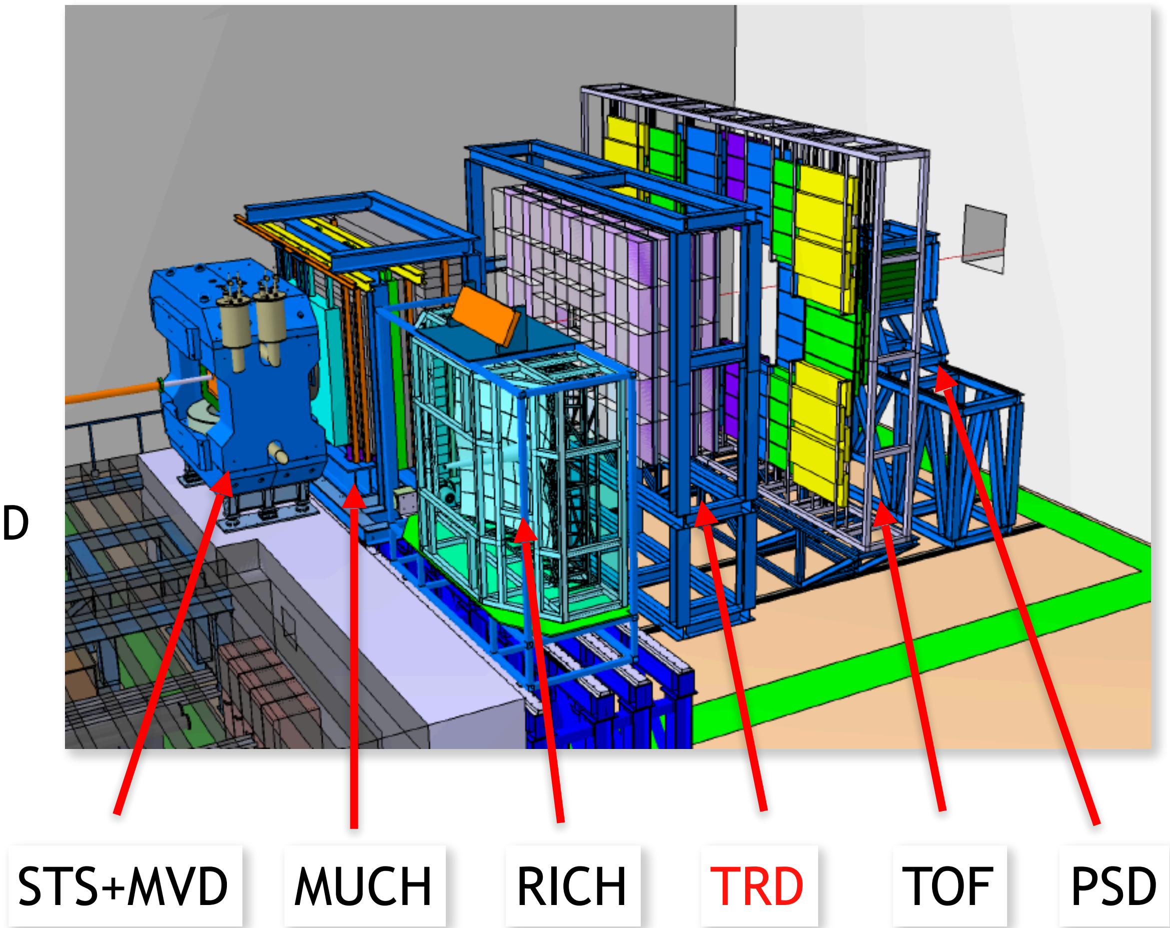
* (A. Andronic et al., Phys. Lett. B697 (2011) 203-207)

The CBM experiment

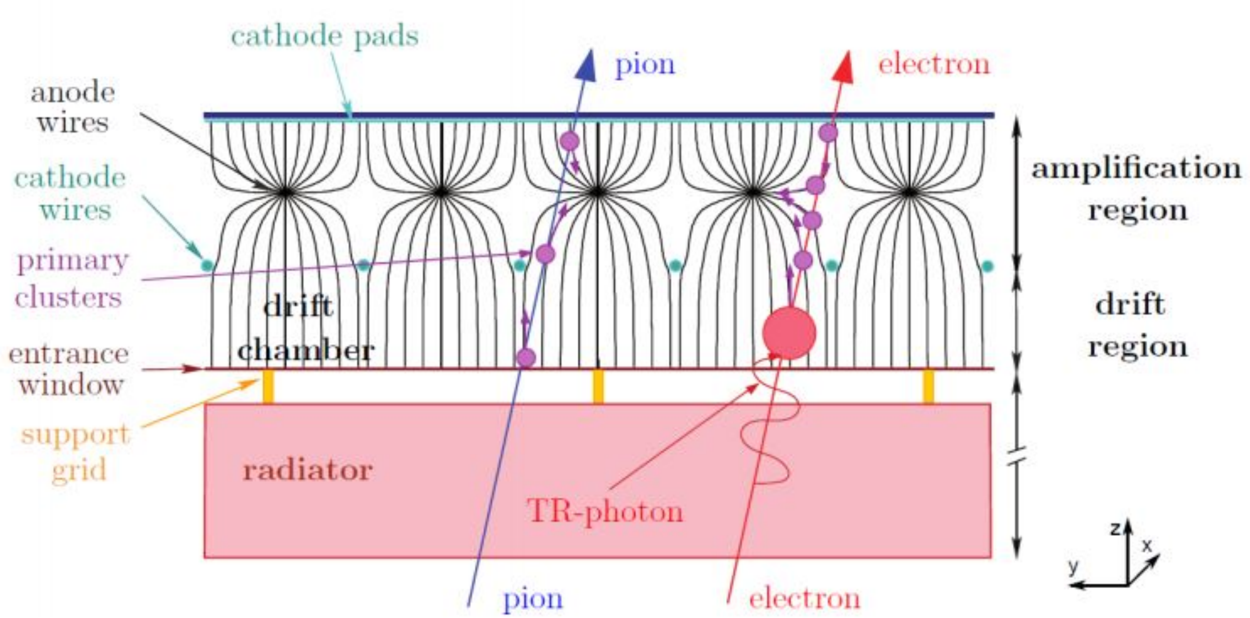
Acceptance
Forward rapidity
$p_T > 0$

Two experimental setups
- Electron setup with RICH
- Muon setup with MUCH

Hadron ID with TOF
Event characterisation with PSD
Tracking with STS and MVD



The TRD



Working principle

- Charged particles deposit energy in the detector gas
- Electrons create transition radiation in the radiator, which deposit additional energy

Requirements

- Very fast detector system
    - Thin chambers
    - Continuous read-out and trigger scheme

Simulation information

Central (10%) Au+Au at 5 GeV $\sqrt{s_{NN}}$
5×10^6 UrQMD background events

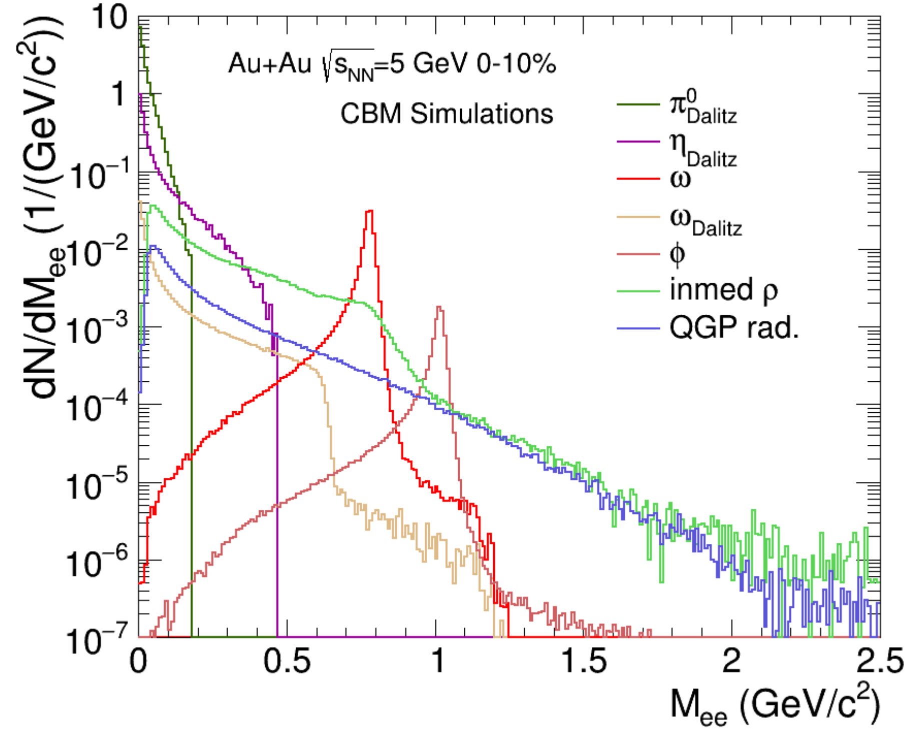
LMVM cocktail, yields according to HSD prediction
(W. Cassing et al., Nucl. Phys. A691 (2001) 753)

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

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

TRD: Likelihood method, e-efficiency (80%)

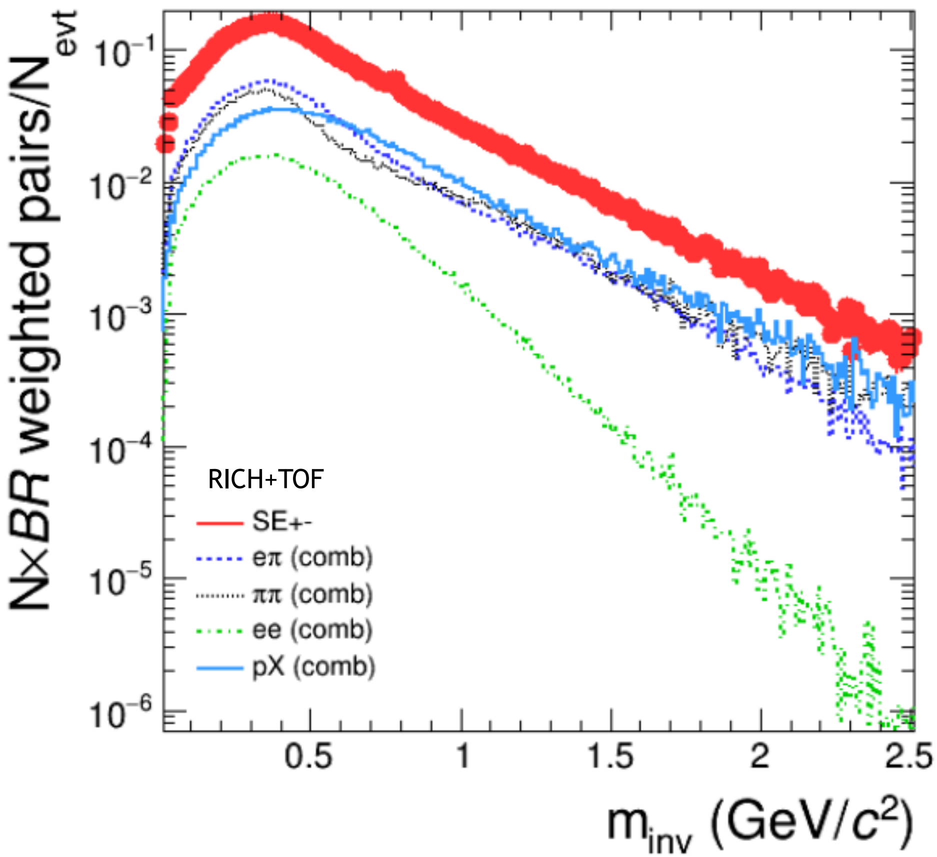
TOF: Cut on β_{meas} - β_e (± 1.65 σ)
⇒ ~ 90% e-efficiency



Invariant mass distribution without TRD PID

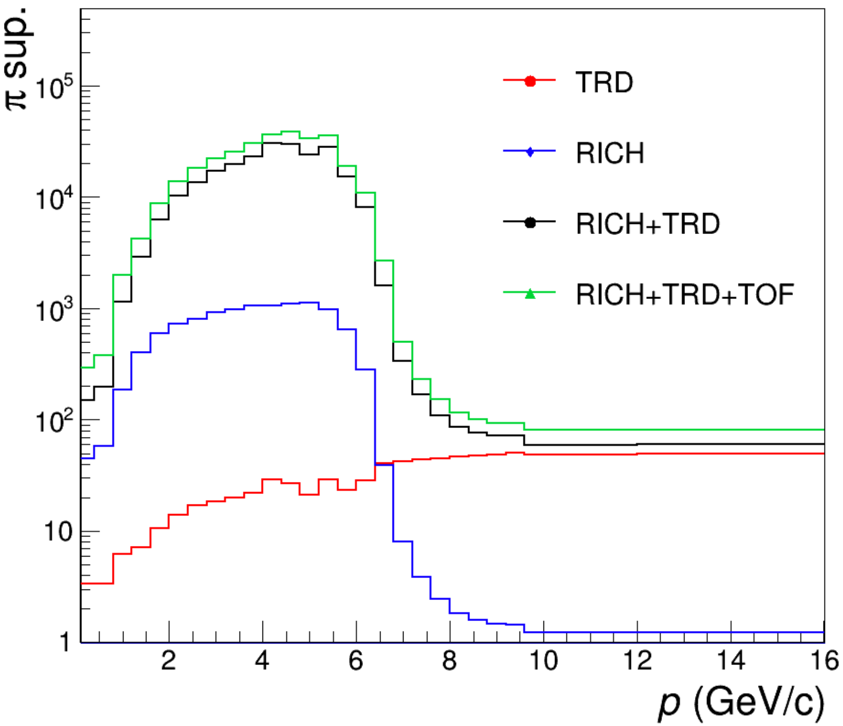
The selected unlike sign pairs contain a large amount of hadronic contributions

Access to the thermal dielectron pairs above 1 GeV/c would not be possible



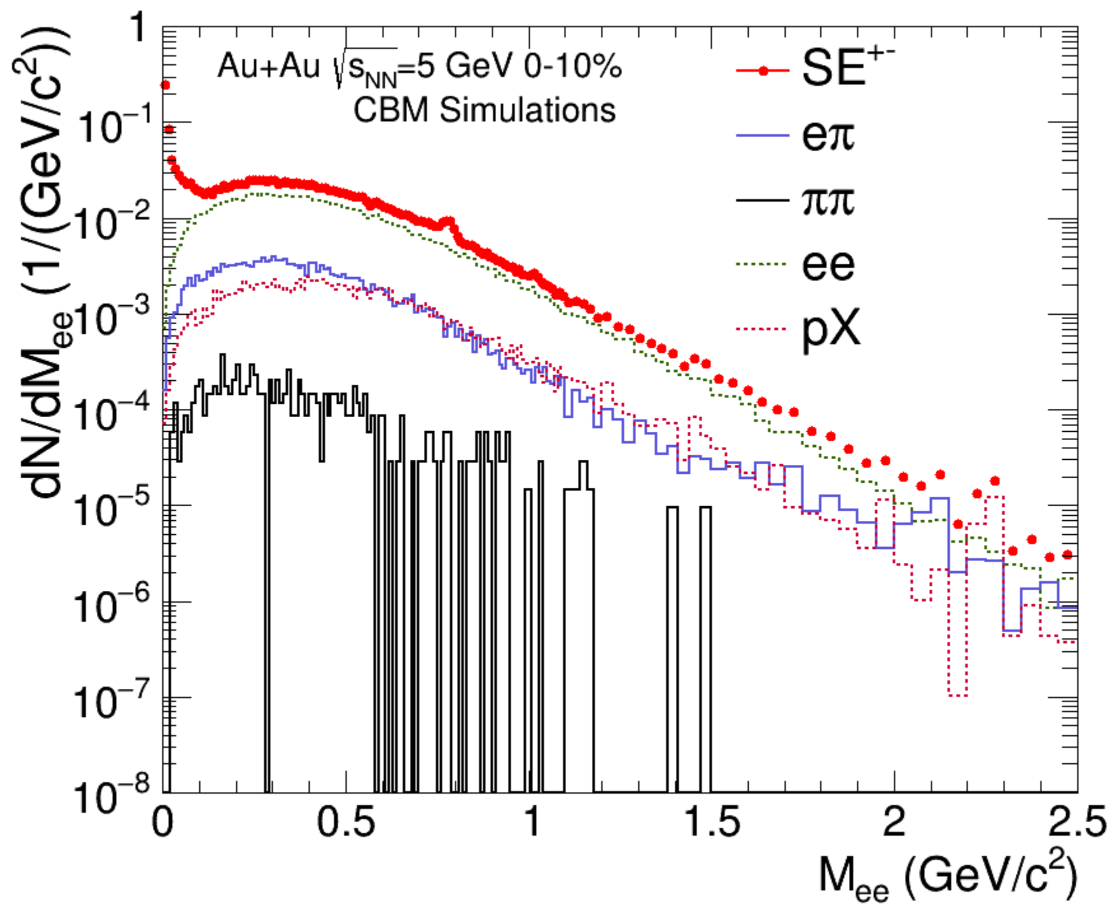
Pion suppression

The RICH provides it’s PID capabilities only up to 6 GeV/c
Above electrons will be identified by the TRD



Invariant mass distributions with TRD PID

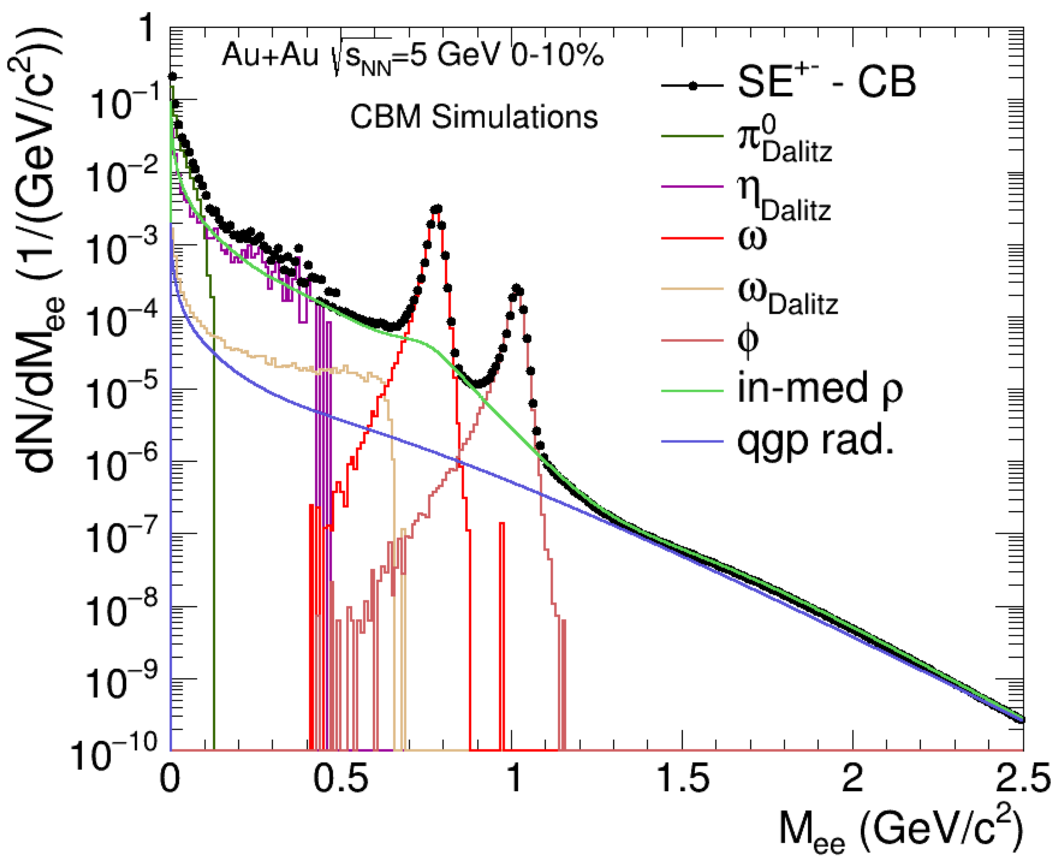
The hadronic background contributions are strongly suppressed



Invariant mass distributions with TRD PID

Clear access to low mass vector mesons and thermal radiation

Thermal radiation is scaled to expected yield at 4 weeks runtime



Hypernuclei identification

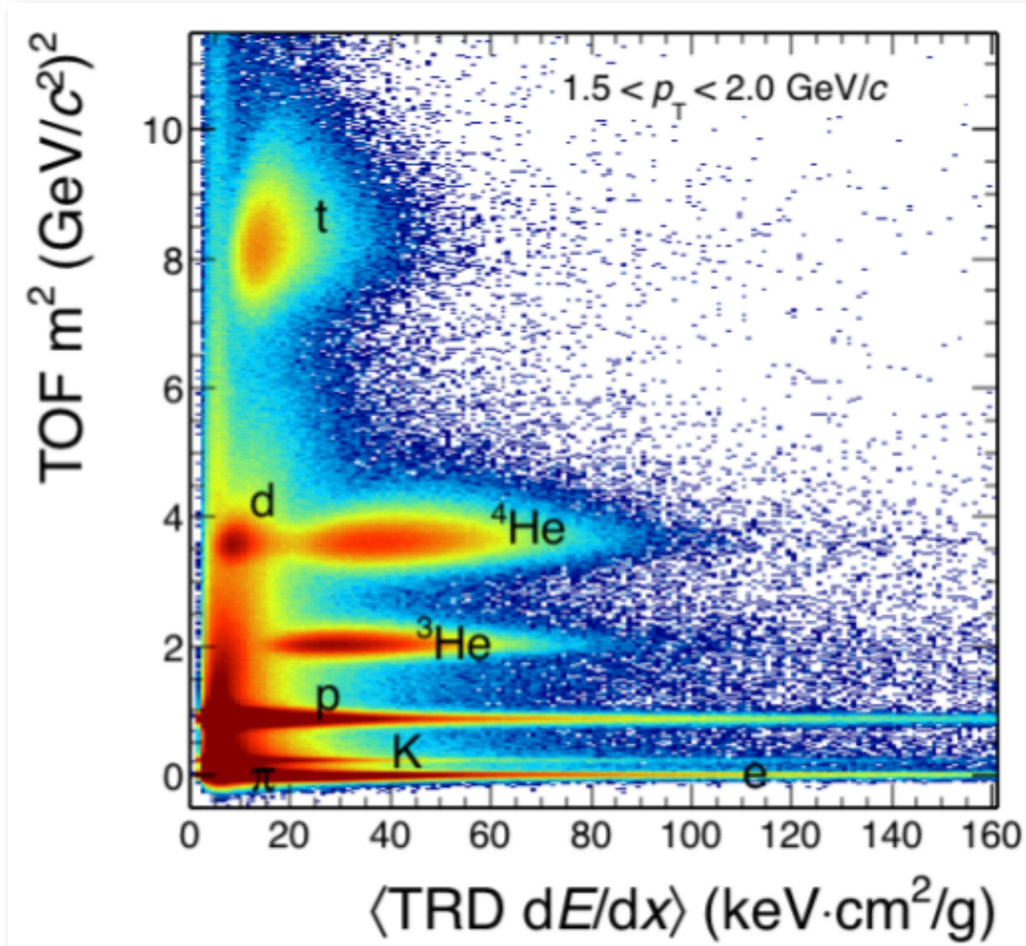
The TOF measurement cannot distinguish charge states

The energy loss measurement of the TRD can separate those fragments

$$^{6}_{\Lambda\Lambda}\mathrm{He} \rightarrow {}^{5}_{\Lambda}\mathrm{He} + p + \pi^{-}$$

$$^{5}_{\Lambda}\mathrm{He} \rightarrow {}^{4}\mathrm{He} + p + \pi^{-}$$

$$^{3}_{\Lambda}\mathrm{He} \rightarrow d + p + \pi^{-}$$



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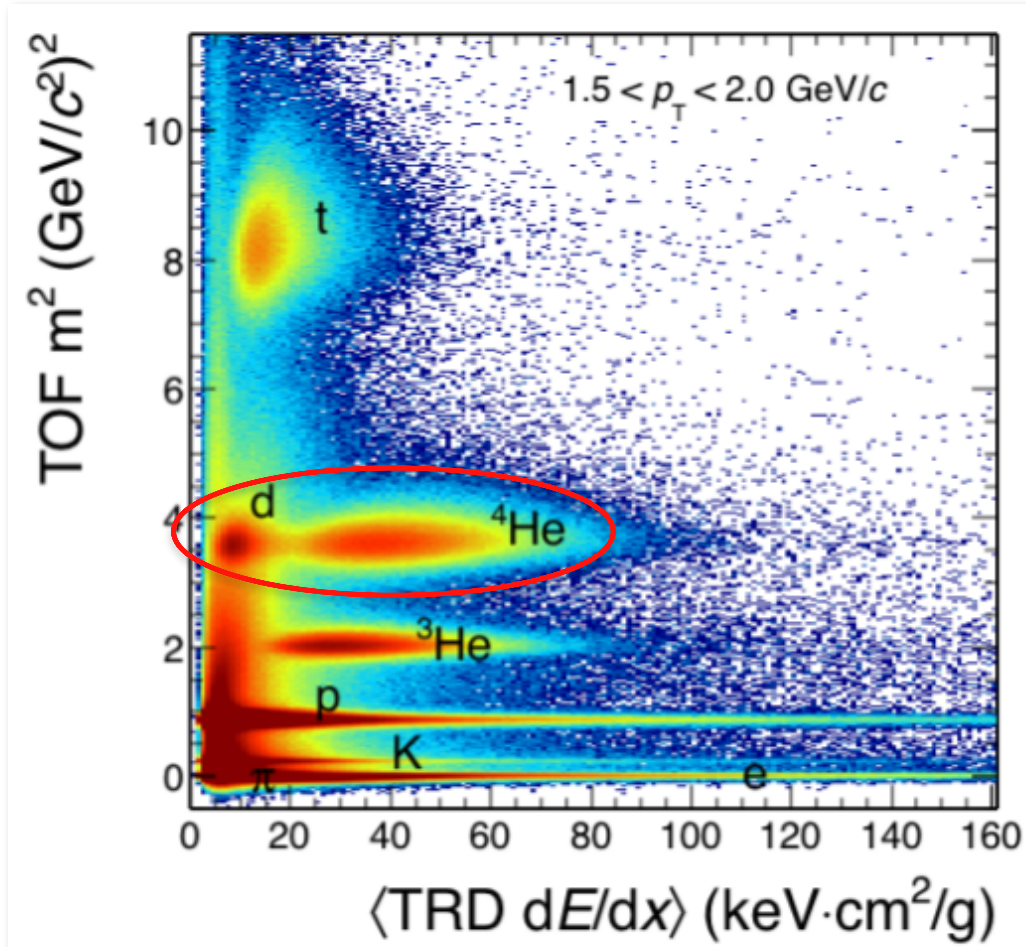
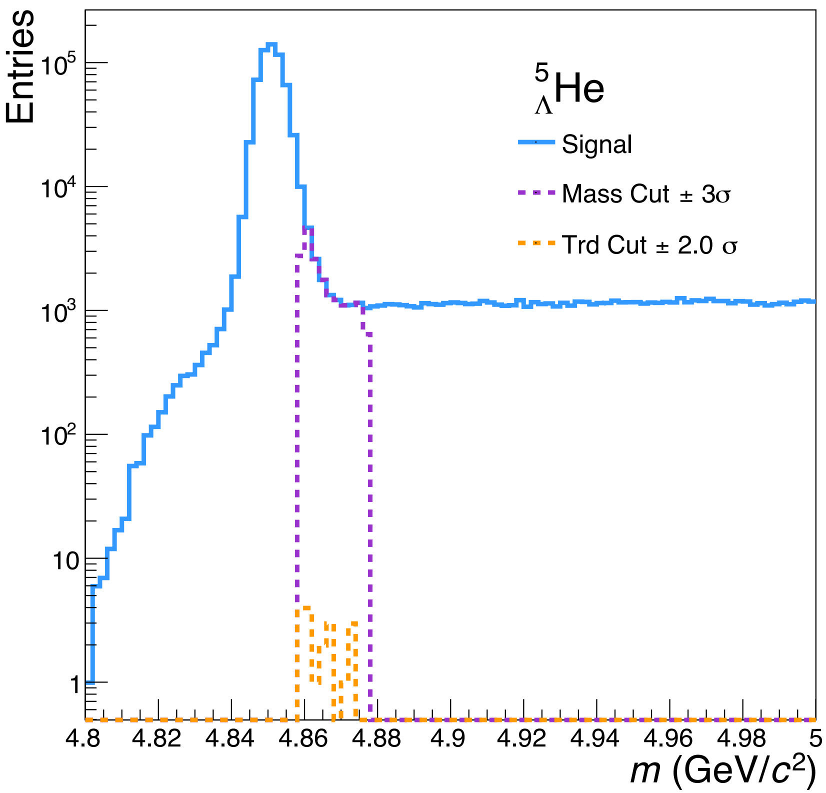
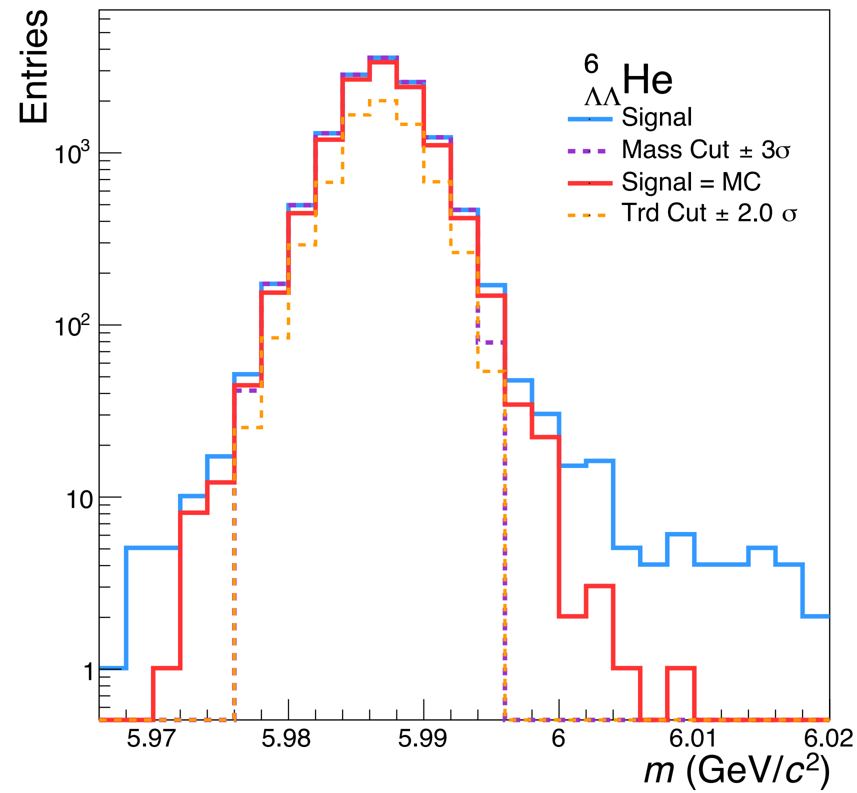


Invariant mass distributions with TDR PID



Deuterium and ${}^{3}_{\Lambda}\mathrm{He}$ embedded + UrQMD background events

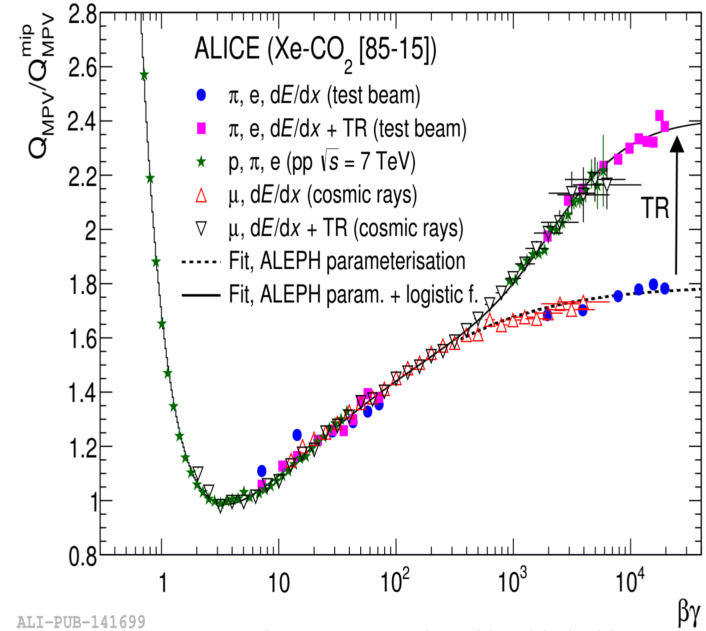
Wrongly identified as ${}^{5}_{\Lambda}\mathrm{He}$



Correctly identified ${}^{6}_{\Lambda\Lambda}\mathrm{He}$

*simulation done by Susanne Glaessel

Advanced simulations



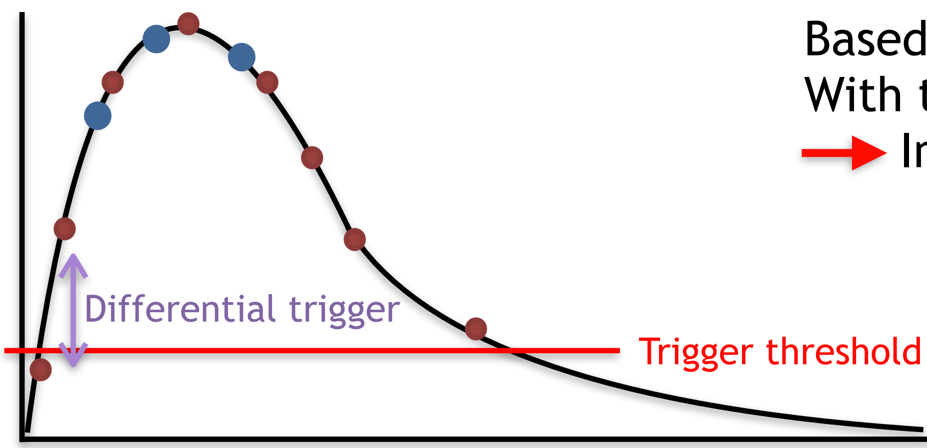
*Nucl. Instrum. Meth. A 881 (2018) 88

Charge distribution in the chamber

$$P(s) = \frac{1}{D} exp(-\frac{s}{D})$$

$$D = \frac{1}{< N_{prim} > \cdot f(\beta\gamma)}$$

Pulses in the electronics

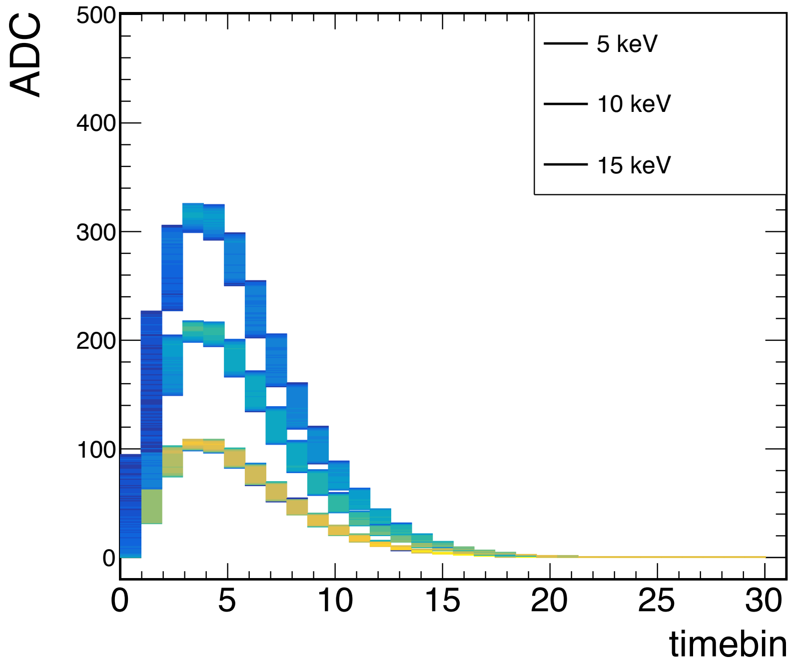


Based on the shaping function
With two possible trigger modes
→ Important for time based simulations

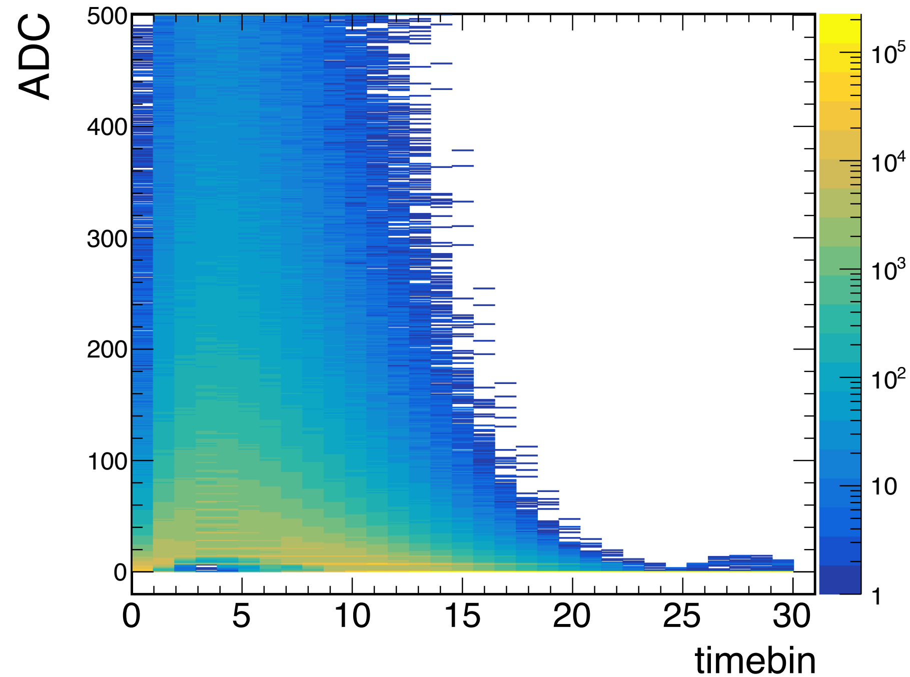
See also HK.24.2

Simulated signal pulses

Selected energies



Full spectrum



With this we can now study:

- Trigger behaviour at high rates
- Timeshifts in comparison to the front-end clock
- Compare different feature extraction methods
- Check for noise and clipping effects on ADC level

Conclusion

Fragment ID

The TRD measurement is crucial for the hypernuclei program of CBM

Di-electron channels

Sufficient pion suppression can be achieved in the complete momentum range

→ Thermal radiation can be accessed

New simulation features

Simulation can be done in 4D

Detector behaviour can be studied in detail