# Track reconstruction algorithms for the CBM experiment at FAIR

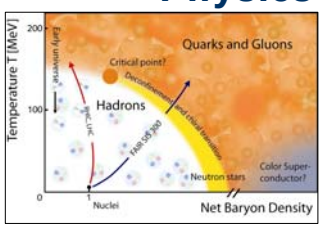
Andrey Lebedev[1,2], Gennady Ososkov[2] and the CBM collaboration

[1]GSI Helmholtzzentrum für Schwerionenforschung GmbH , Darmstadt, Germany

[2]Laboratory of Information Technologies, Joint Institute for Nuclear Research, Dubna, Russia

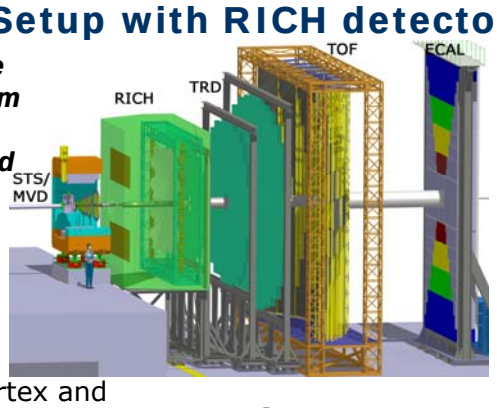
## CBM experiment

### Physics topics

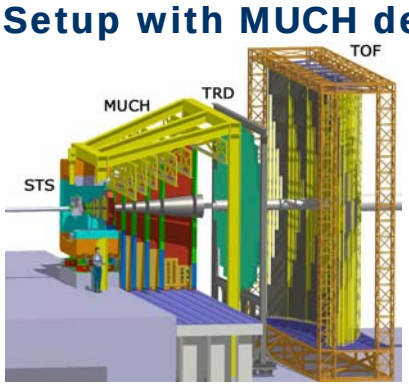



***Exploration of the QCD phase diagram in regions of high baryon density and moderate temperature***

### Setup with RICH detector




### Setup with MUCH detector




**STS** track, vertex and momentum reconstruction

**MVD** determination of secondary vertices

**RICH** electron identfication

**MUCH** muon identification

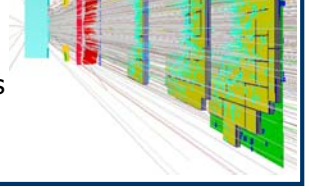
**TRD** identification of electrons

**TOF** time-of-flight measurement for hadron identification

**ECAL** measurement of photons and neutral particles

### CBM event

(only primaries are shown)



## Tracking challenges

### for CBM:

– high track multiplicity: up to 1000 charged particles per reaction

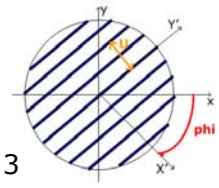
– high hit density

### Detector technologies:

– for high track density region **pad layout** is forseen (MWPC or GEM)

– for the detector stations further upstream in MUCH, **straw tube** chambers are under discussion

Straw tube

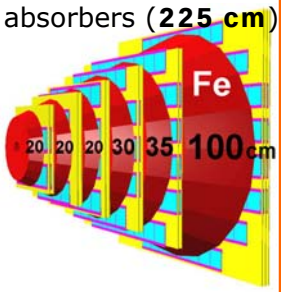



### MUCH layout:

– alternating absorber layers and detector stations

– low mass vector meosons: **5 Fe** absorbers (**125 cm**)

– charmonium: **6 Fe** absorbers (**225 cm**)




### TRD layout: 12 layers grouped in 3 stations

## Track propagation

**Extrapolation** Two models:

– Straight line in case of absence of magnetic field.

– Solution of the equation of motion in a magnetic field with the 4th order Runge-Kutta method, with a parallel integration of the derivatives.

### Material Effects

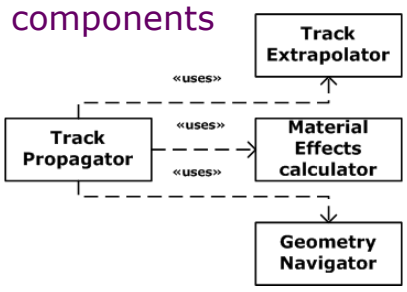
– **Energy loss** (ionization: Bethe-Bloch, bremsstrahlung: Bethe-Heitler, pair production)

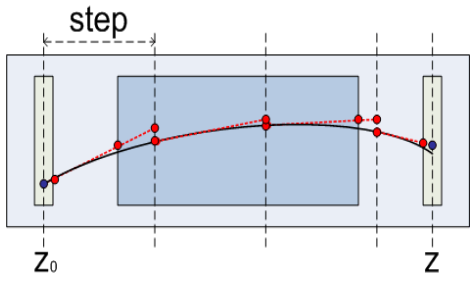
– **Multiple scattering** (Gaussian approximation)

### Navigation

– Based on the ROOT `TGeoManager` class.

Track propagation components




### The Algorithm:

Trajectory is divided into steps. For each step:

– – – Straight line approximation for finding intersections with different materials (geometry navigator)

——— Geometrical extrapolation of the trajectory

Material effects are added at each intersection point

## Tracking

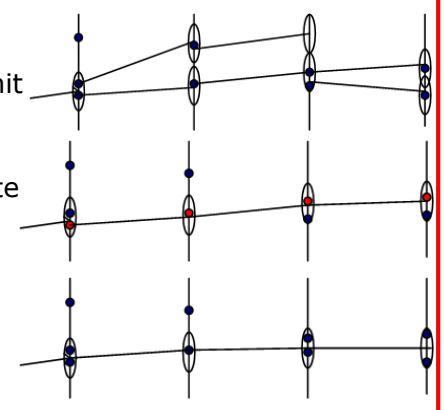
**Key concepts:** track following, Kalman Filter, validation gate, STS tracks as seeds

### 3 Methods:

– **branching**: branch is created for each hit in the validation gate

– **nearest neighbor**: the closest hit (statistical distance) from the validation gate is assigned to the track

– **weighting**: assign all hits from the validation gate and on the next step select appropriate hits



### Track selection

– aim: remove ghost and clone tracks

– tracks are sorted by their quality, obtained by chi-square and track length

– check of shared hits

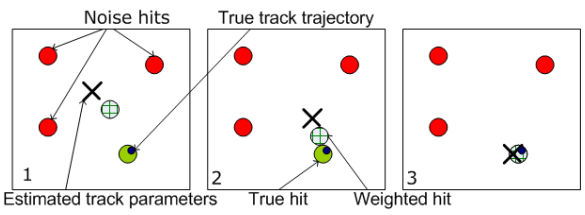
### Weighted track fit

– a weight is assigned to each hit, including temperature parameter T.

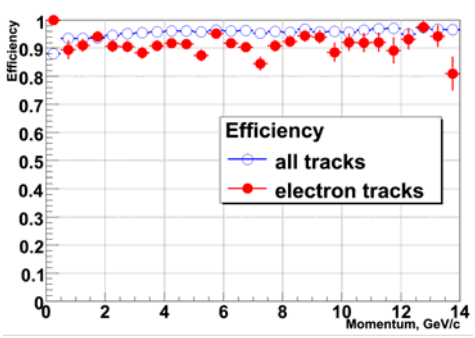
– weighted track is created as a collection of weighted mean hits from the same detector station

– Weighted track is fitted with standard KF

– Temperature is gradually decreased. Simulated annealing is applied



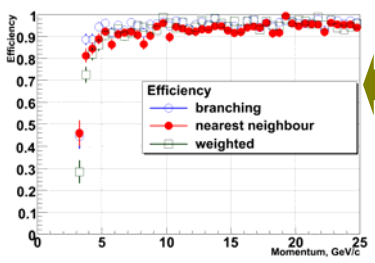

## Performance of the TRD tracking




**Events:** central Au+Au collisions at 25 AGeV beam energy from UrQMD + 5 electrons and 5 positrons embedded in each event + GEANT3 transport

| | |
|---|---|
| all | **94.7 %** |
| electrons | **91.0 %** |
| ghost | **6.0%** |

## Performance of the MUCH tracking

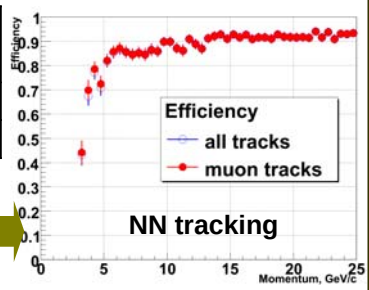



**Pad layout for all chambers**

| | Branching | NN | Weighting |
|---|---|---|---|
| all | **94.4 %** | **91.9 %** | **93.0 %** |
| muons | **94.7%** | **92.3 %** | **93.4 %** |
| ghost | **0.5%** | **1.1%** | **1.1%** |

**Events:** central Au+Au collisions at 25 AGeV beam energy from UrQMD + 10 muons embedded in each event + GEANT3 transport

| | |
|---|---|
| all | **89.2 %** |
| muons | **89.5 %** |
| ghost | **1.6%** |




**straw tubes**