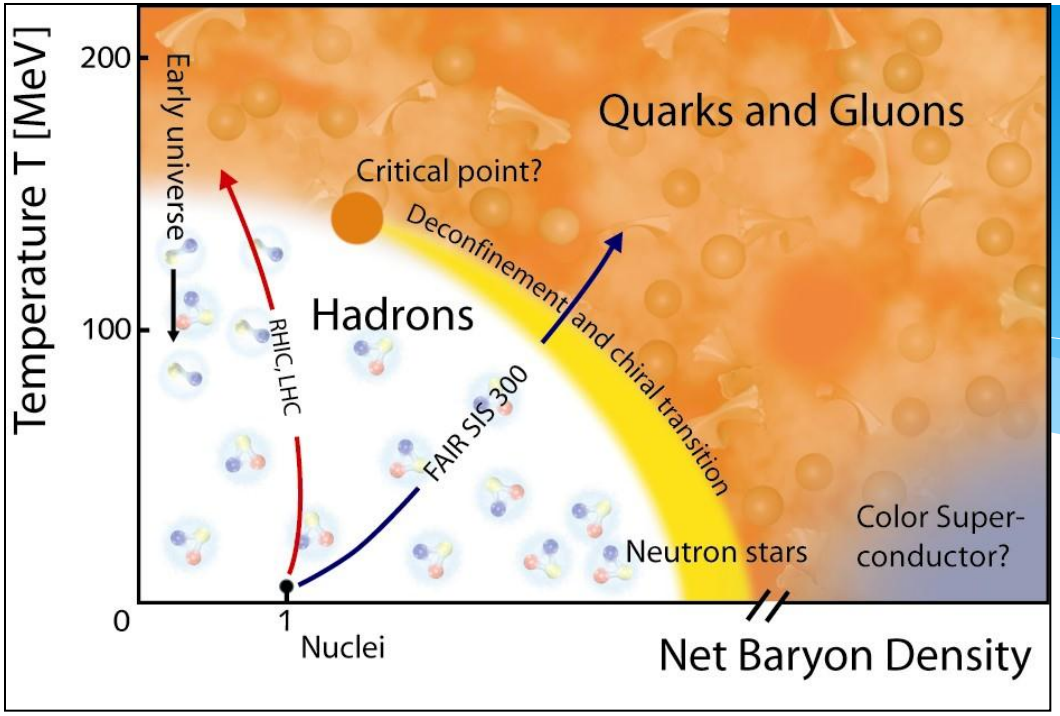
J/ψ reconstruction in the di-muon channel with CBM

Valentina Akishina*

[1] Goete Frankfurt University, Germany

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



CBM physics case

Exploration of the QCD phase diagram in regions of high baryon densities and moderate temperatures.

Physics Topics	Observables
In medium modifications of hadrons	$\rho, \omega, \phi \rightarrow \mu^+\mu^-$ (e^+e^-) D^0, $D^\pm$, $D^\pm_s$, Λ_c
Deconfinement phase transition, charm production at threshold	K, Λ, Σ, Ξ, Ω D^0, $D^\pm$ $J/\Psi, \Psi' \rightarrow \mu^+ \mu^-$ (e^+e^-)
Critical point	**Event by event fluctuations**

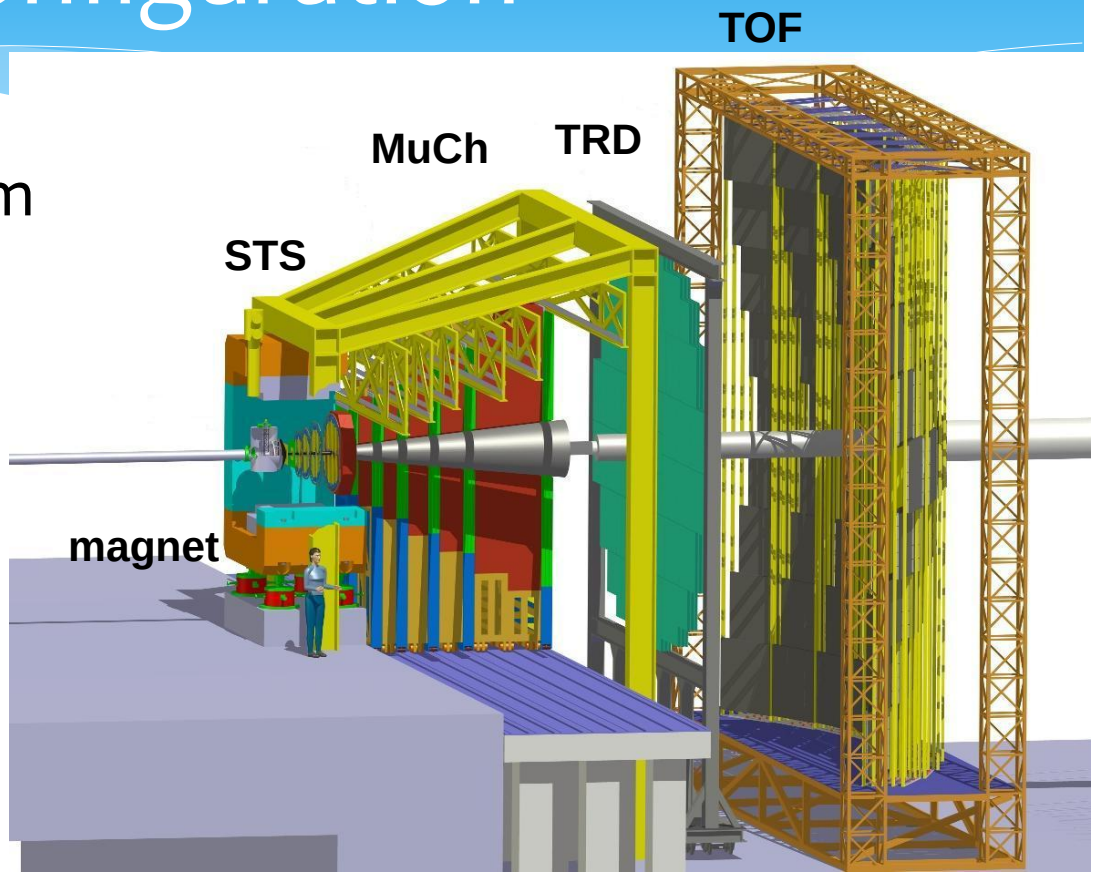
CBM experimental setup: muon configuration

STS: tracks, momentum reconstruction

MUCH: muon id

TRD: global tracking

TOF: time of flight measurement



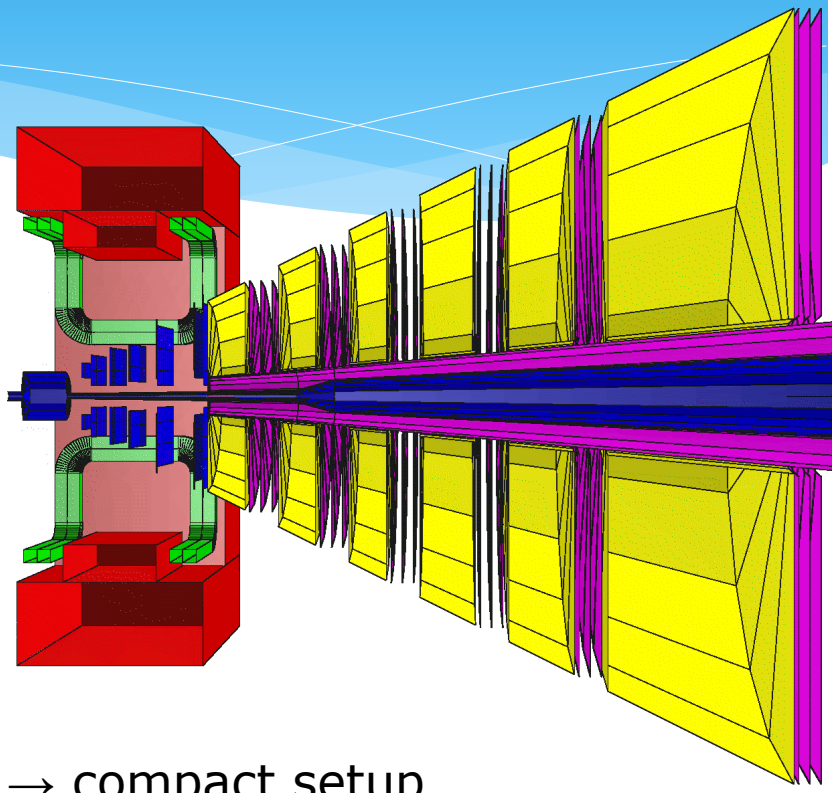
• comprehensive measurement of hadron and lepton production in *pp, pA* and *AA* collisions **8-45 AGeV** beam energy
• fixed target experiment

Muon identification challenges

standard: muon identification by absorber technique

however, for CBM:

* up to 1000 charged particles per central collision
* high hit density (up to 1 hit per cm^2 per event)
* high event rates (10^7 events/s)
* punch through hadrons
* track mismatches
* position resolution < 300 µm

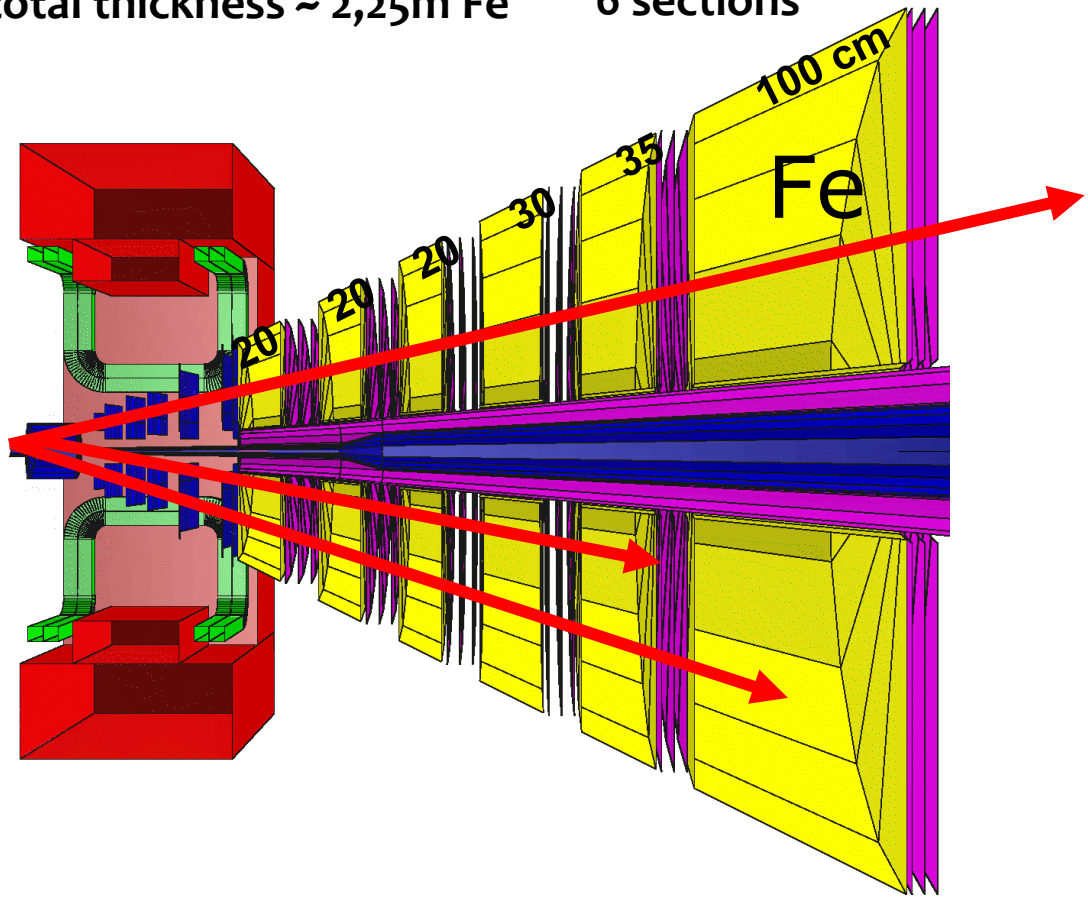


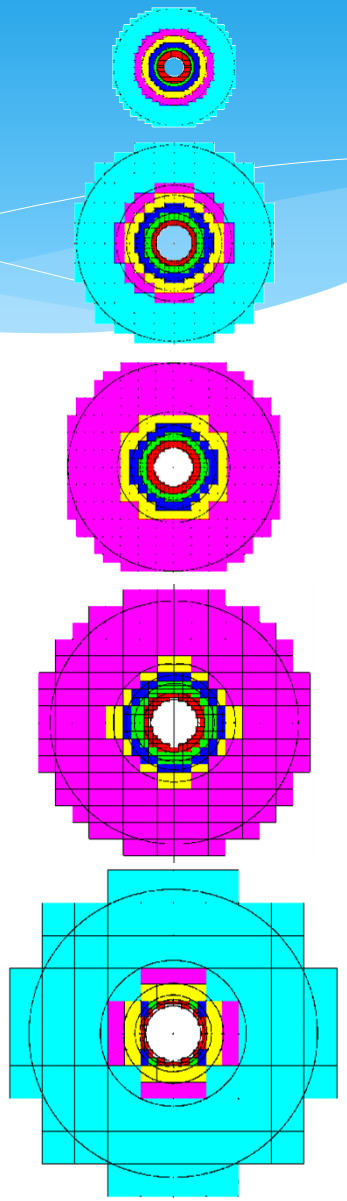
→ compact setup
→ absorber-detector sandwich for continuous tracking
→ use pad readout (e.g. GEMs)

Muon Chambers (MuCh) system: full version

- 6 Fe absorbers :
- increasing thickness
- total thickness ~ 2,25m Fe

- detectors:
- 3 layers between absorbers
- 6 sections





Input to the simulations

✓ **Background – UrQMD :**

$2 \cdot 10^5$ p + Au @ 30 GeV

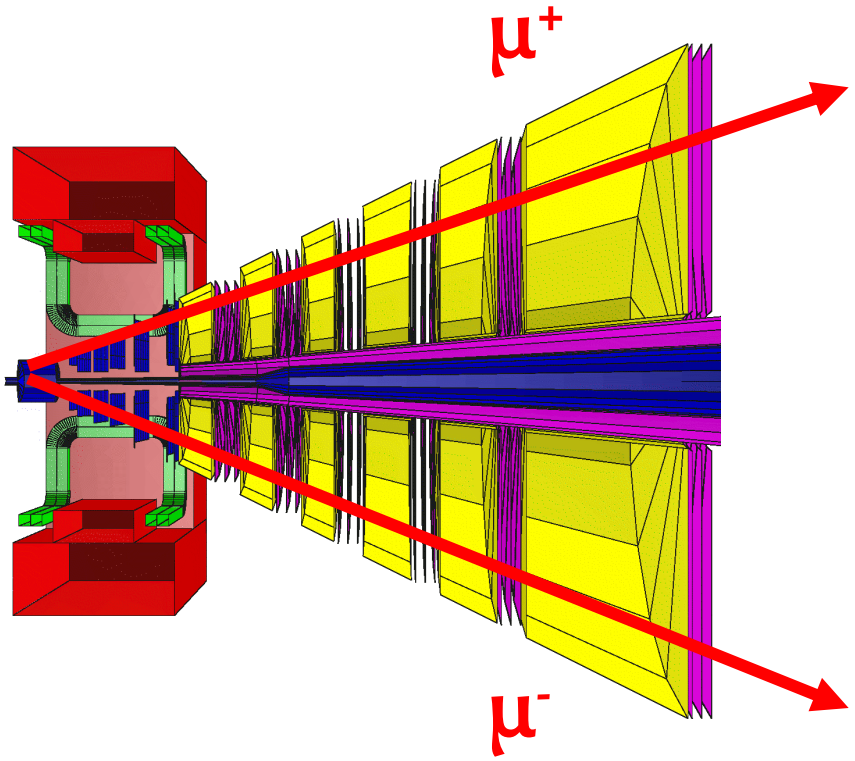
$2 \cdot 10^5$ p + C @ 30 GeV

✓ **Signal ($J/\psi \rightarrow \mu^+\mu^-$) – PLUTO generator**

✓ **Signal and background were transported through the CBM detector setup (STS + MUCH) GEANT3**

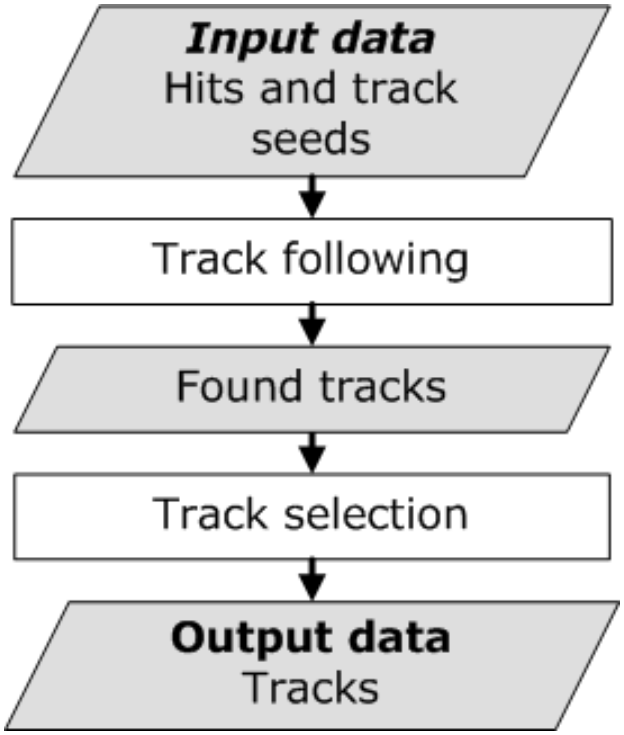
✓ **Realistic detector setup (digitization and clustering in the STS and MuCh)**

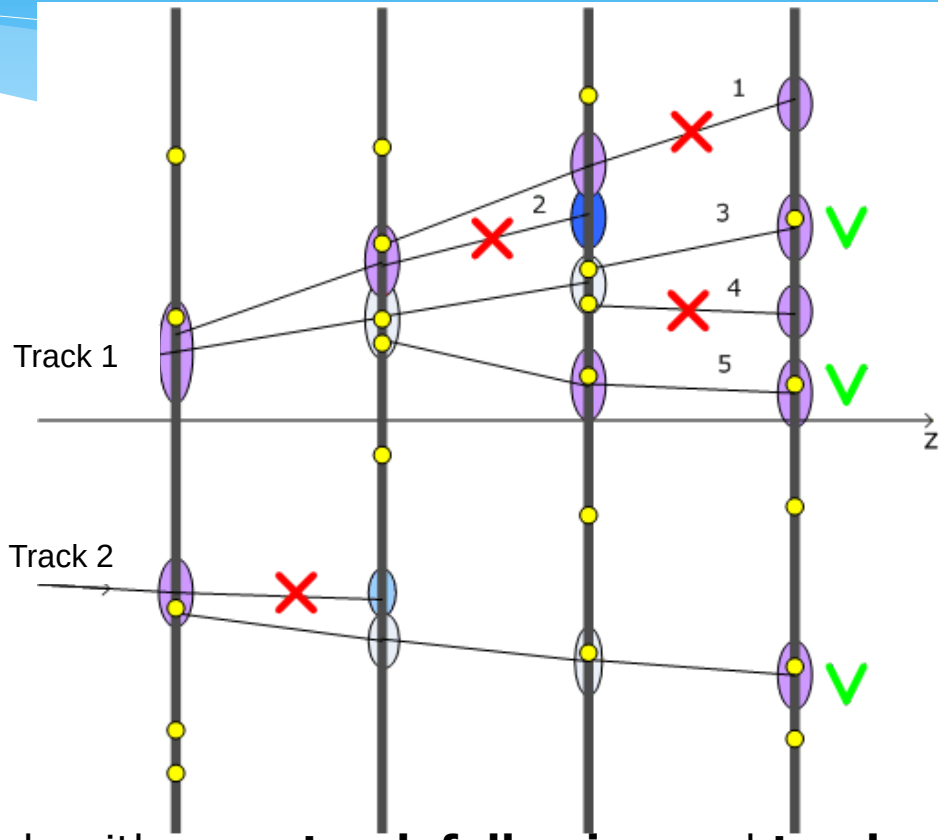
✓ **Track reconstruction and momentum determination with Silicon Tracking system (STS) in dipole magnet**



Track finding: LIT-tracking*

- Based on **track following** and the **Kalman filter**
- Uses **branching**: Branch is created for each hit, has to pass a test to be assigned to the track segment, check for missing hits.
- Initial seeds are tracks reconstructed in STS.





The main components of the track finding algorithm are **track following** and **track selection**.

* A.Lebedev, C.Höhne, I.Kisel, G.Ososkov, Fast parallel tracking algorithm for the muon detector of the CBM experiment at FAIR, PEPAN, Letters, V.7, No. 4(164) pp. 473-482

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)

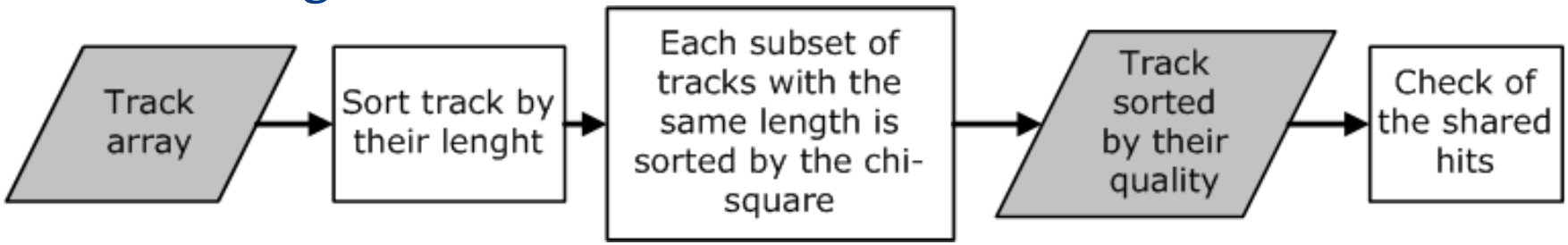
  – Multiple scattering (Gaussian approximation)

- ***Navigation***

  - Based on the ROOT TGeoManager.

Track selection

* aim: remove clone and ghost tracks
* Tracks are sorted by their quality, obtained by chi-square and track length



* Check for shared hits
  * loop over tracks list which is sorted by quality
  * collect used hits
  * check for each new track the number of shared hits: if too many – reject track

	Reconst. Eff.
all	**97.5%**
ref	**97.6%**
prim	**97.5%**
muons	**97.5%**
ghost	**0.21%**
clone	**0.0%**

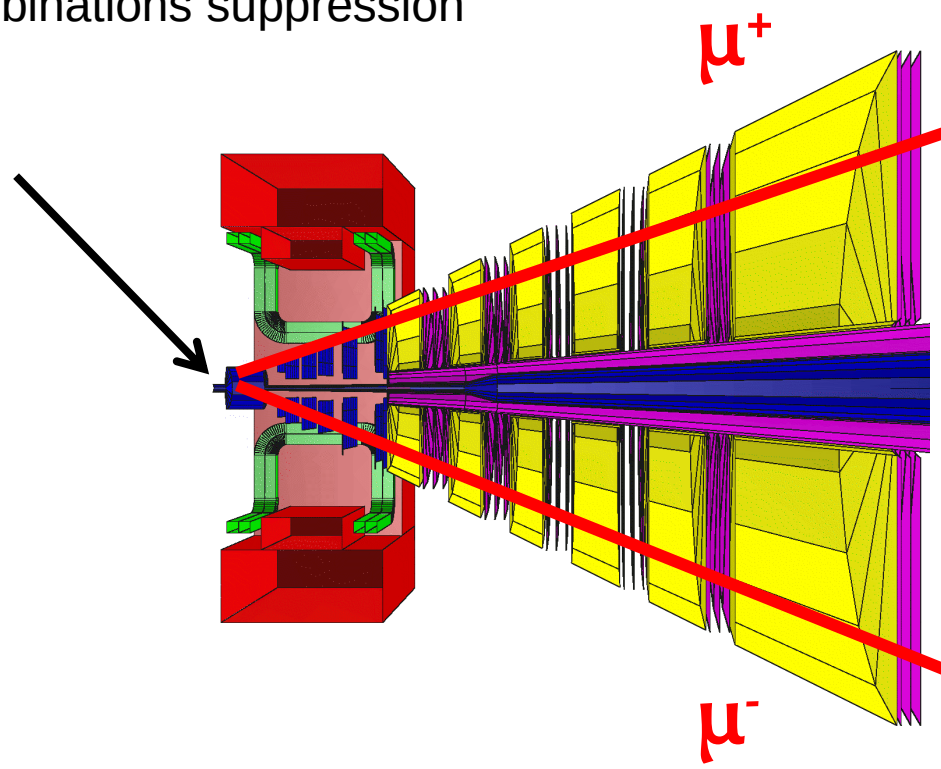
Performance of the track finder

J/ψ reconstruction challenges

- multiplicity of production $\langle J/\Psi \rangle \sim 10^{-6}$ for AuAu at 25 AGeV: signal muons are very rare
- major background: μ from π and K decays
- decays in primary vertex: large hit density from primary particles

Reconstruction strategy

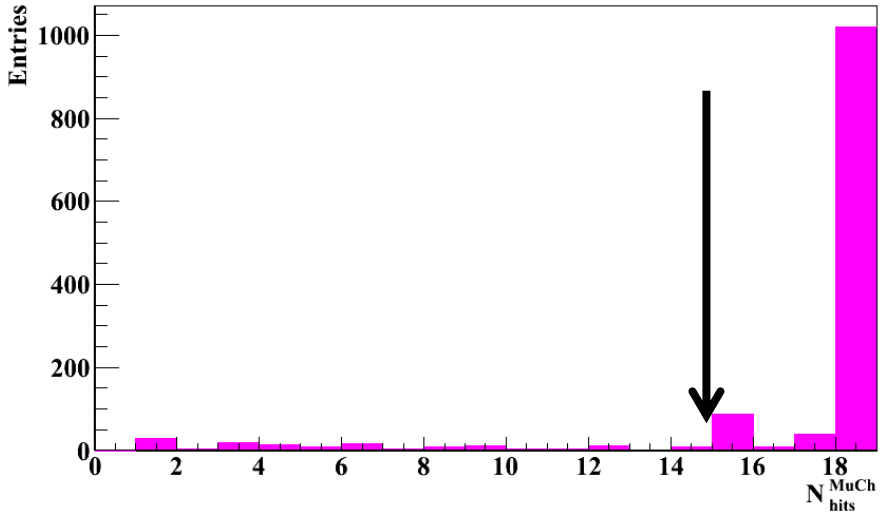
3. Secondary vertex quality check:
Random combinations suppression



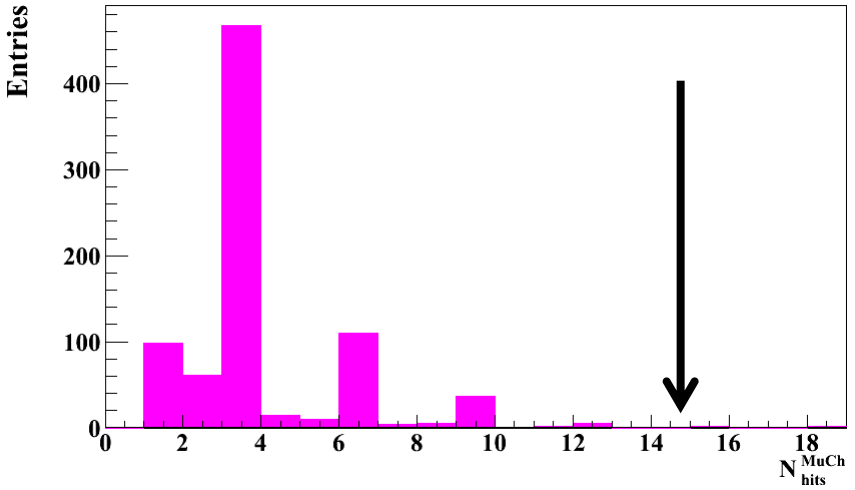
1. Hits in MuCh cut: muons only
2. Transverse momentum cut: J/ ψ decayed muons

N of hits in MUCH per track:

Signal muons



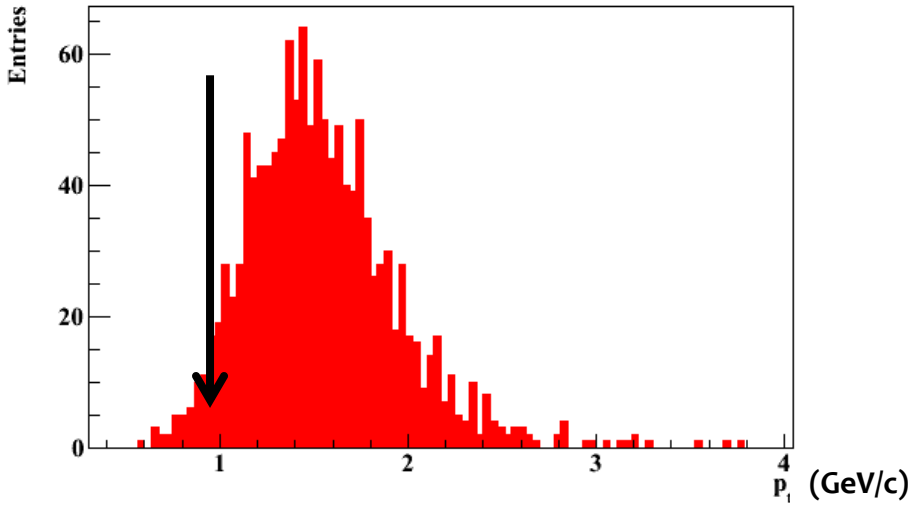
Background



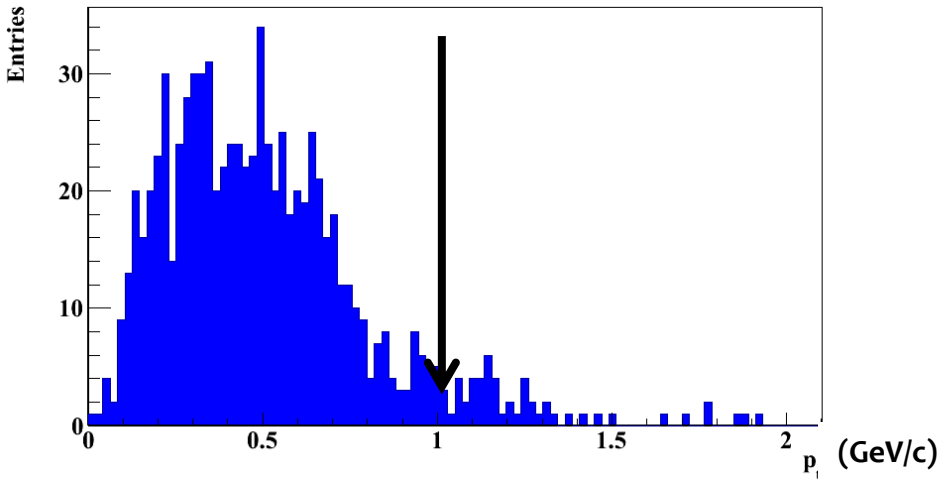
N of hits in MUCH ≥ 15

Transverse momentum cut:

Signal muons



Background



$p_t > 1$ GeV/c

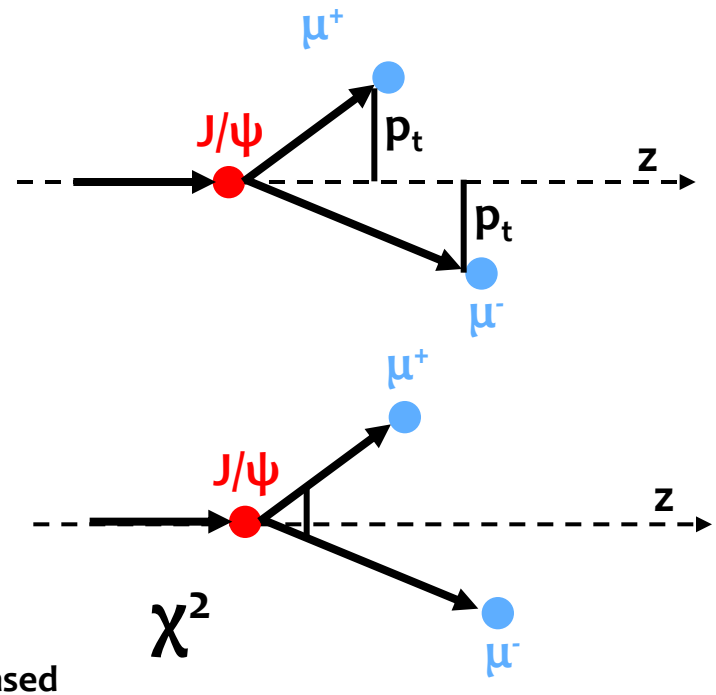
Cuts for background suppression:

Single particle cut:
N of hits in MUCH ≥ 15

Single particle cut:
transverse momentum p_t

p_t > 1 GeV/c

KFParticle*
Pair cut: secondary vertex
quality check $\chi^2 < 3$



*S. Gorbunov and I. Kisel: **Reconstruction of Decayed Particles Based on the Kalman Filter,** CBM-SOFT-note-2007-003

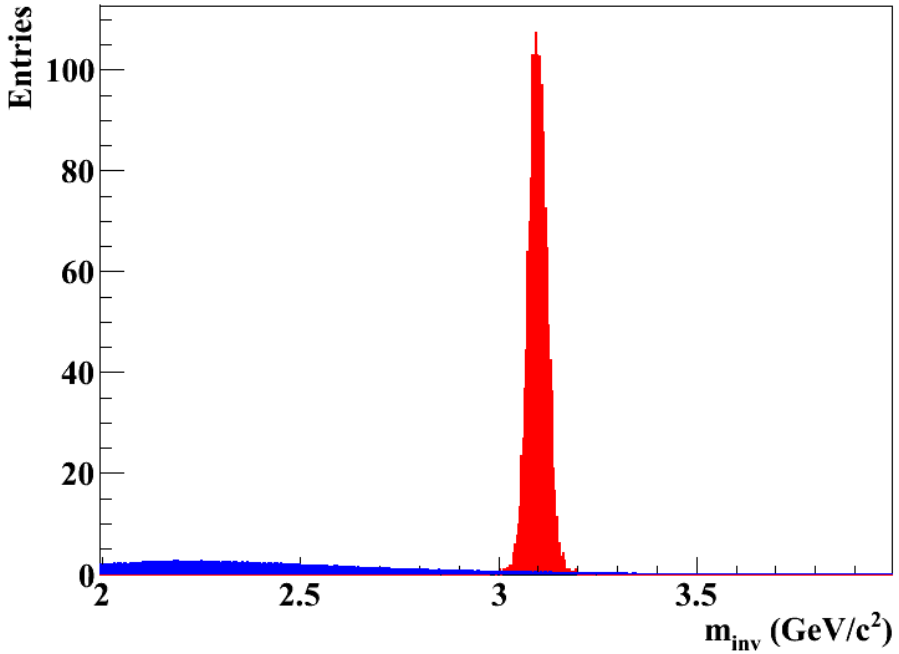
J/ψ Invariant mass spectra with full MuCh version

Mult. = $6 \cdot 10^{-8}$
Br.ratio = 5,93%
Eff. = 43,22%
S/B = 24,4

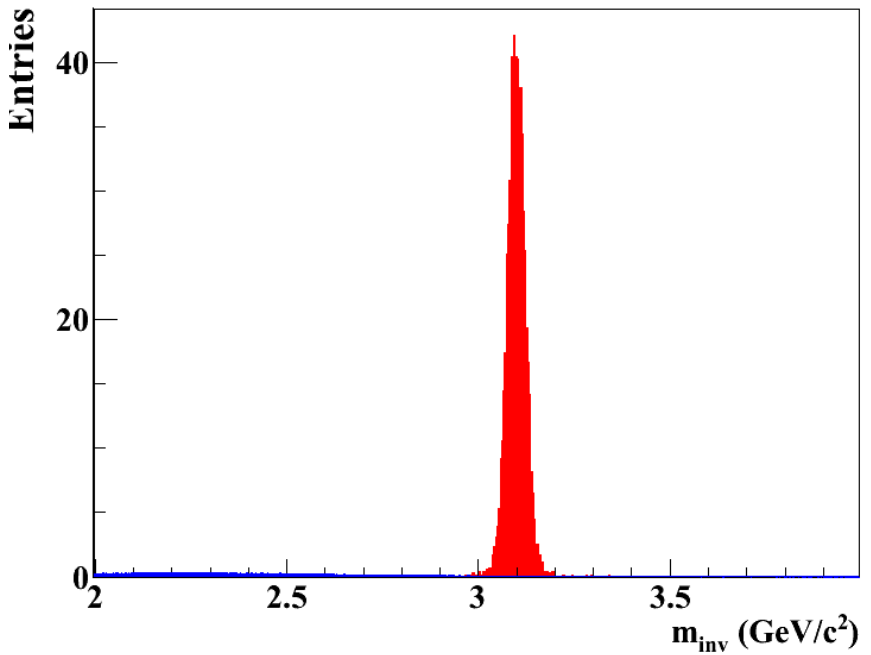
$4 * 10^{10}$ UrQMD
(event mixing technique)

Mult. = $2{,}35 \cdot 10^{-8}$
Br.ratio = 5,93%
Eff. = 43,22%
S/B = 22,0

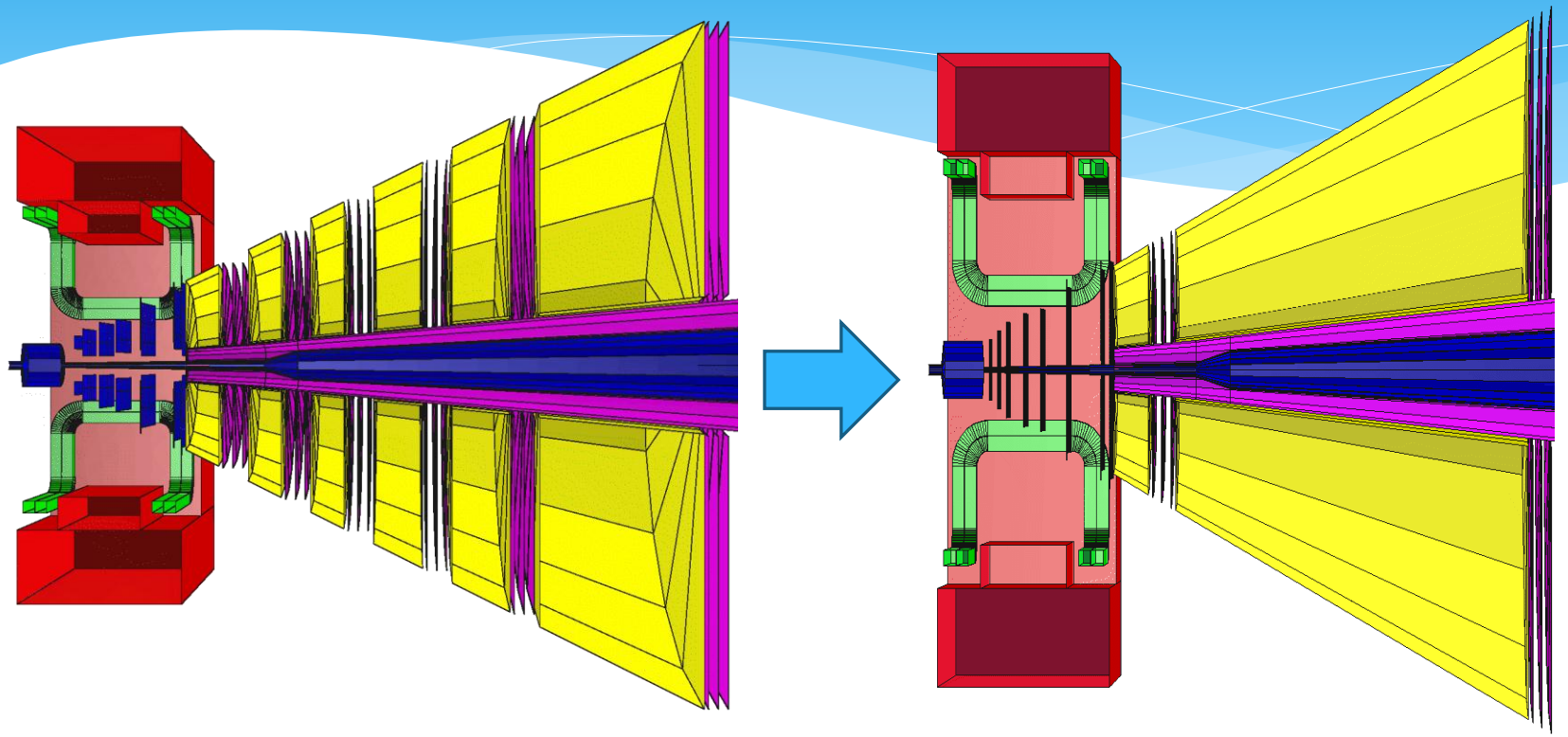
10^{12} UrQMD p + Au @ 30 GeV



10^{12} UrQMD p + C @ 30 GeV



MuCh detector: starting version



Full version

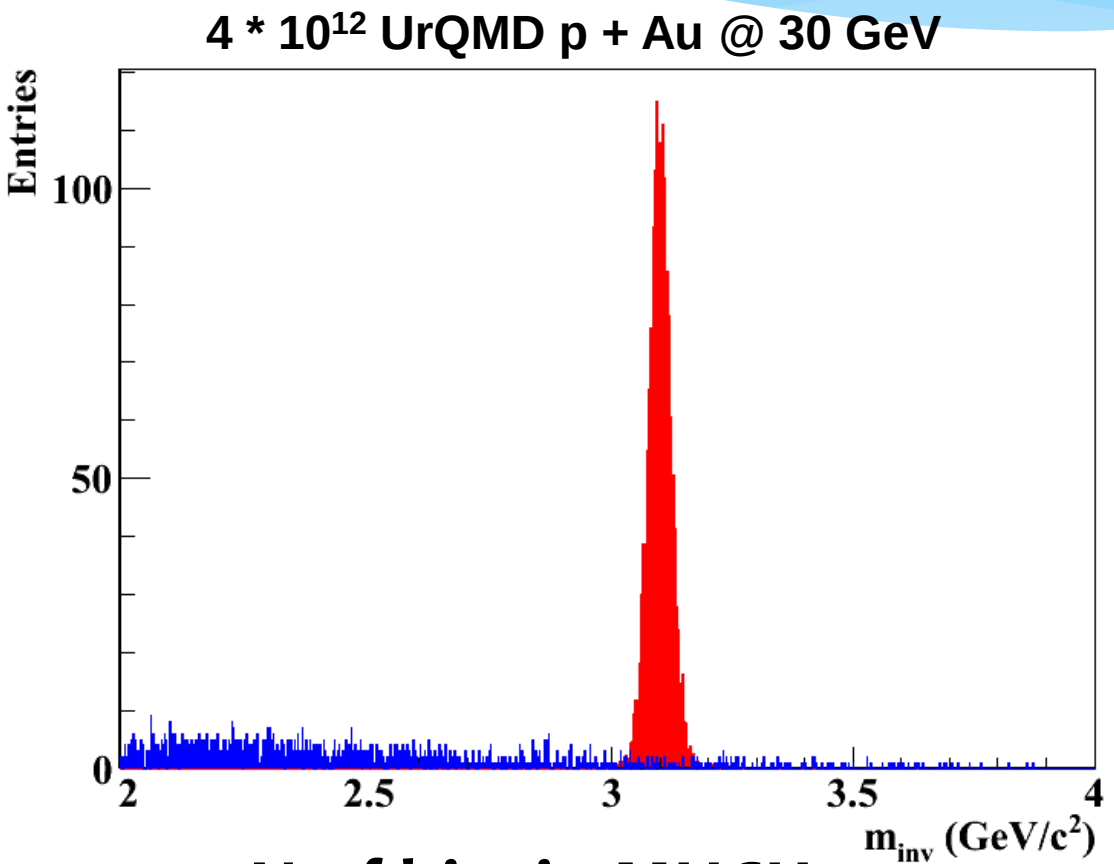
Iron absorber: 20+20+20+30+35+100 cm
6 detector triplets

Start version

Iron absorber: 20+205 cm
2 detector triplets

J/ψ Invariant mass spectrum with starting MuCh version

Mult. = $6 \cdot 10^{-8}$
Br.ratio = 5,93%
Eff. = 43,34%



N of hits in MUCH ≥ 4

Summary and Outlook:

1) Algorithm for J/ψ reconstruction based on the information from STS and Much detectors has been developed

2) The feasibility of J/ψ reconstruction in di-muon channel for proton-nucleus collisions at 30 GeV with the standard and the starting versions of the MUCH detector assuming realistic geometries and detector responses for STS and MUCH has been studied

3) Both starting and full version of MuCh detector allow to reconstruct J/ψ with high efficiency (Eff. ≈ 43 %)

Feasibility studies for J/ψ reconstruction with CBM looks promising

Future plans: Include detector inefficiency in MuCh detector

Thank you for your attention