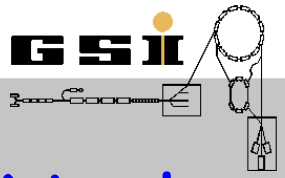
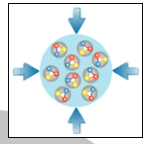




Nuclear Collisions at FAIR: The CBM Experiment

Volker Friese

Gesellschaft für Schwerionenforschung
Darmstadt

- CBM Physics
- CBM detector concept
- Feasibility studies
- R&D

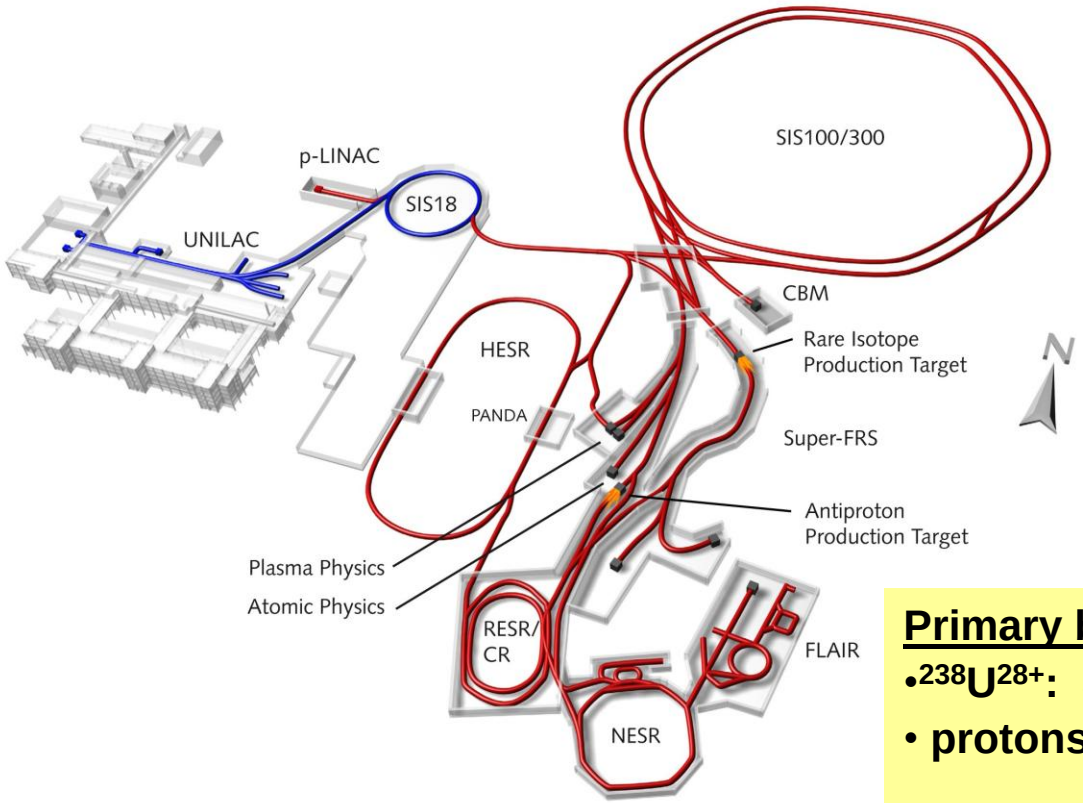
LINC 08 – Protvino – 18 June 2008

FAIR

Facility for Anti-Proton and Ion Research

At GSI,
Darmstadt

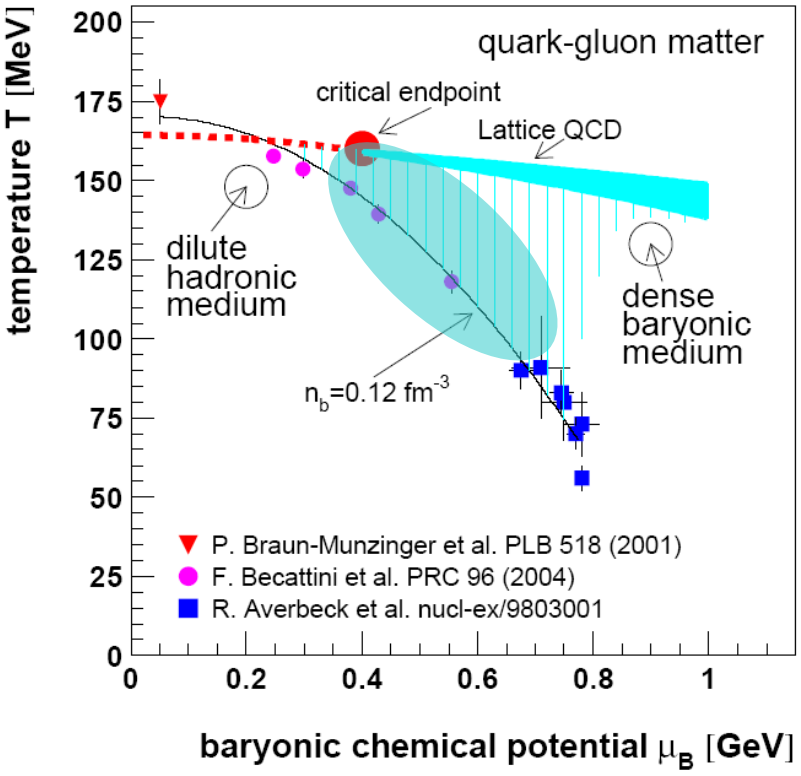
FAIR



Primary beams:

- $^{238}U^{28+}$: $3 \cdot 10^{11}$/s at 1.5-2 AGeV
- protons: 4×10^{13}/cycle at 30 GeV, 90 GeV max. energy
- $^{238}U^{92+}$: $2 \cdot 10^{9}$/s at 35 GeV/u (45 AGeV for Z=A/2)

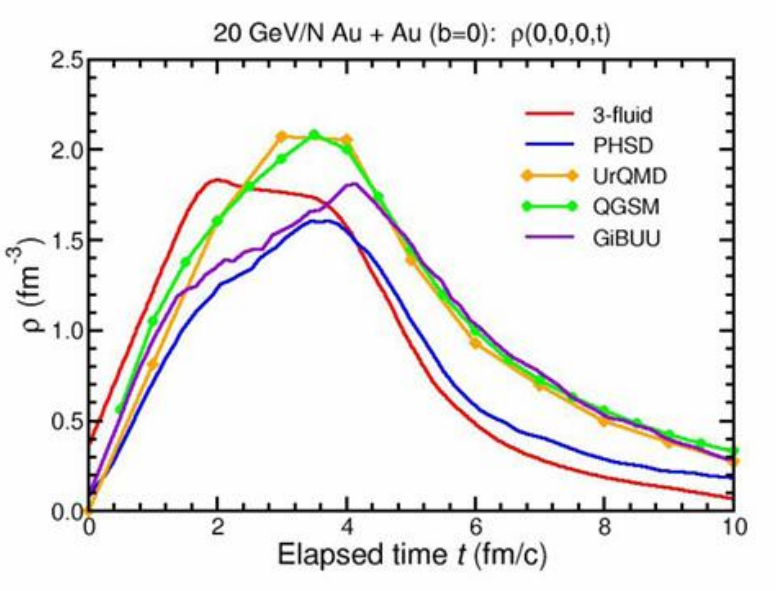
HI collisions and the QCD phase diagram

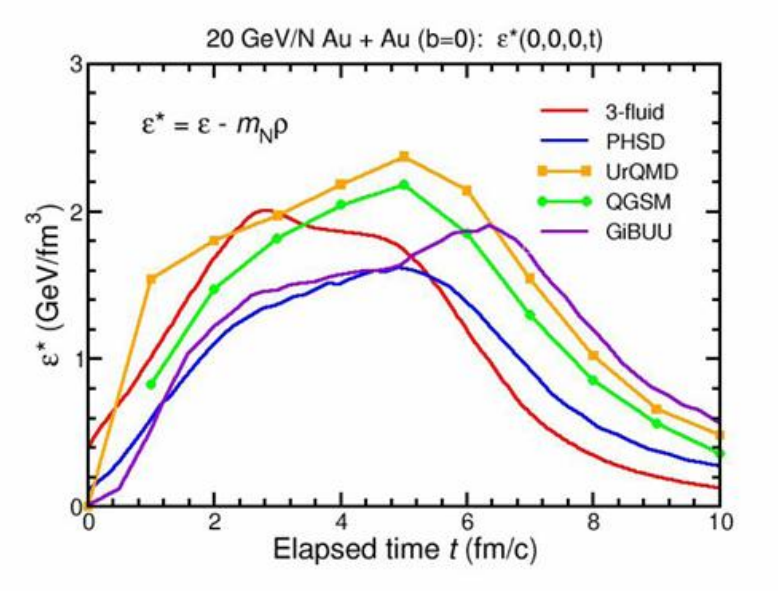


beam energies 10 – 45 AGeV give access to:

- highest baryon densities
- onset of phase transition (?)
- critical point (?)

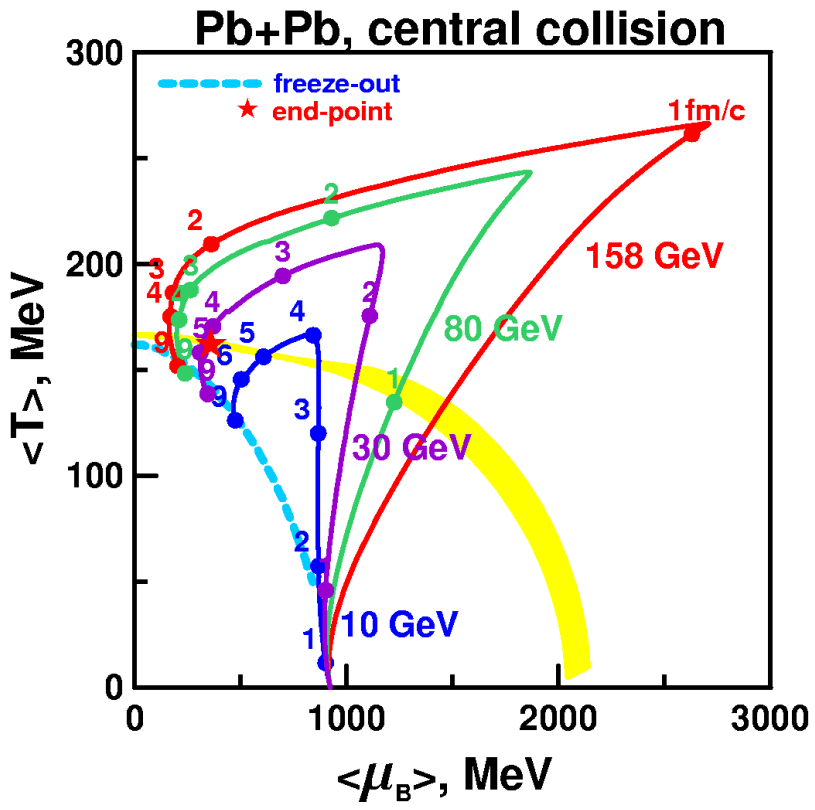
Matter at FAIR energies





Models agree: Extreme baryon density and energy density in heavy-ion collisins at FAIR energies

Trajectories in the QCD phase diagram



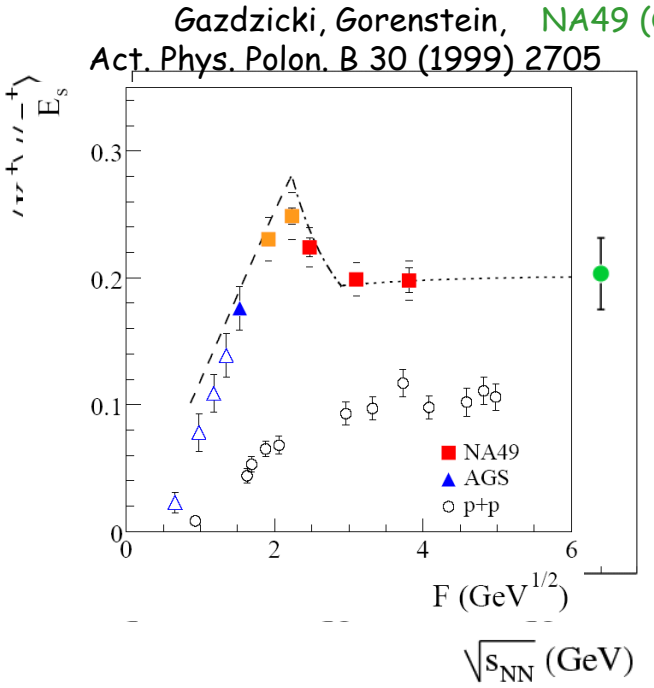
V.Toneev et al., nucl-th/0309008

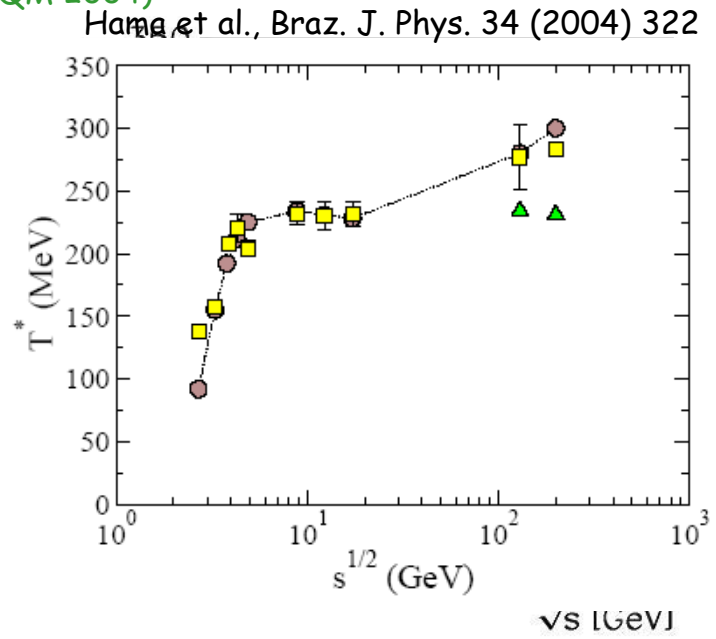
3 fluid hydro calculation with hadron gas EOS

predicts 30 AGeV to hit critical point

phase boundary reached already at 10 AGeV

Indications for onset of deconfinement at low SPS energies

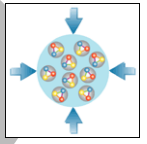




peak in strange/nonstrange yield ratio
plateau of kaon slopes at SPS
not satisfactorily explained in hadronic scenarios

can be modeled assuming 1st order phase transition

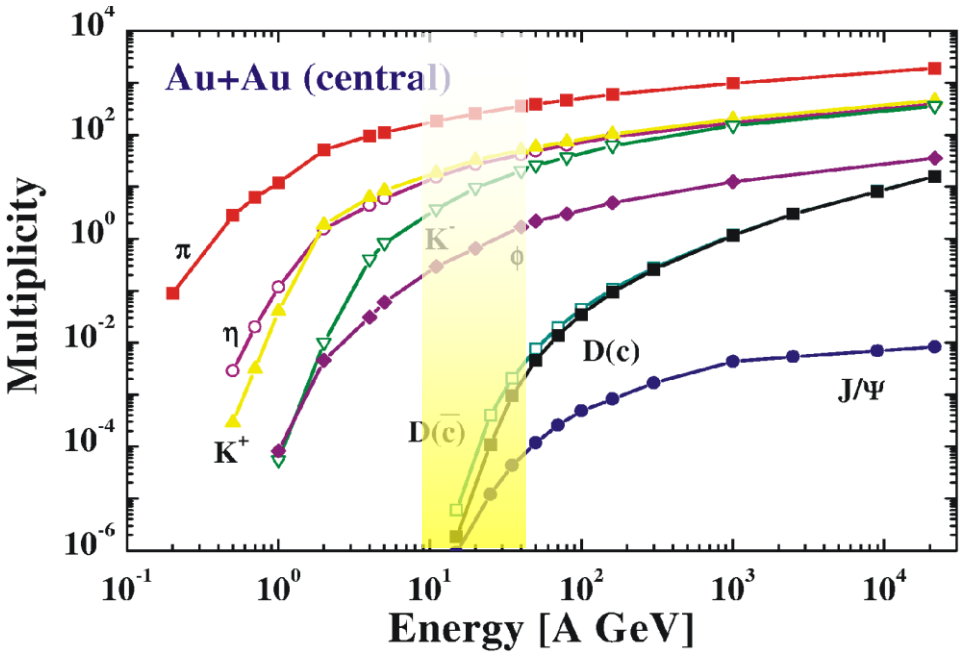
The physics of CBM



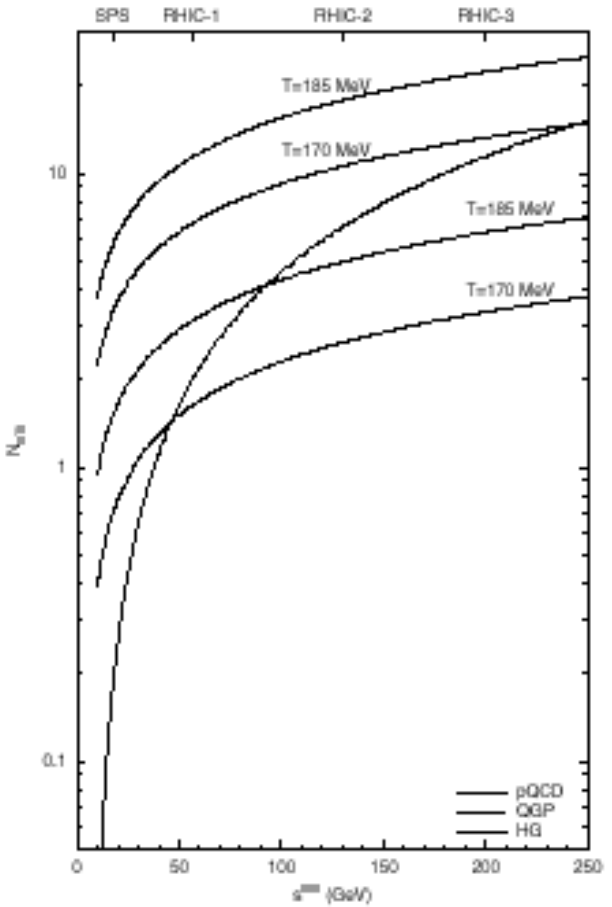
?		!
deconfinement at high ρ_B	→	strangeness (K, Λ, Σ, Ξ, Ω) charm (J/ψ, D) flow
in-medium properties of hadrons	→	$\rho, \omega, \varphi \rightarrow e^+e^-$ open charm
critical point	→	fluctuations

Charm production

[W. Cassing et al., Nucl. Phys. A 691 (2001) 753]

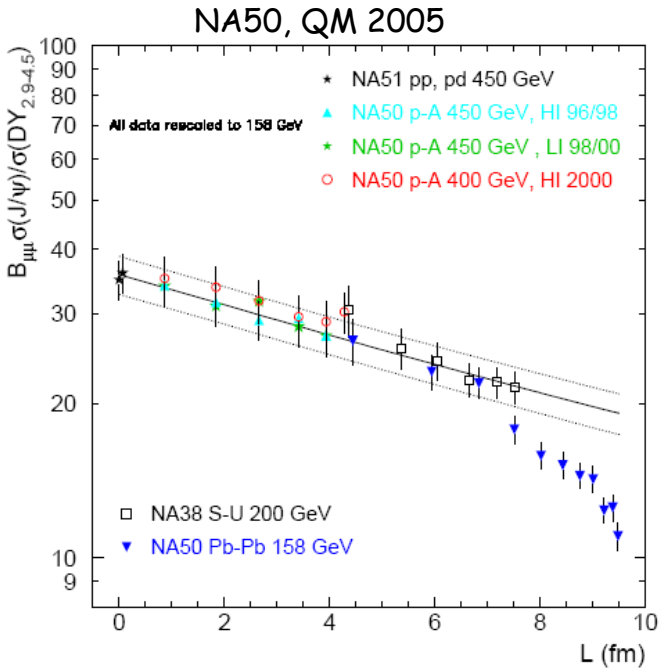


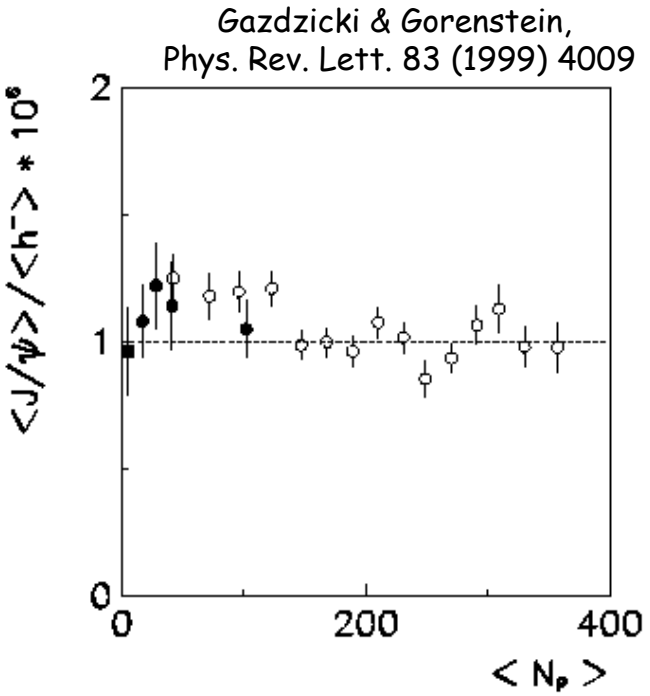
Charm production at threshold: Extremely low rates, but very sensitive to production scenario



Gorenstein et al
J. Phys. G 28 (2002) 2151

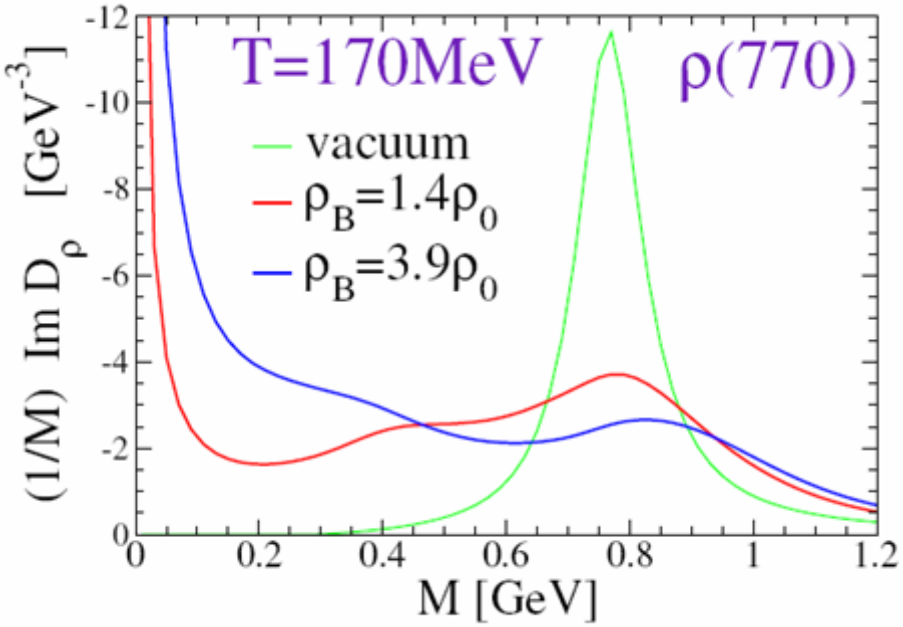
J/ψ suppression





anomalous suppression observed at top SPS in J/ψ / DY
suppression pattern similar at RHIC – why?
Is J/ψ production statistical?
onset of suppression at lower energies ?

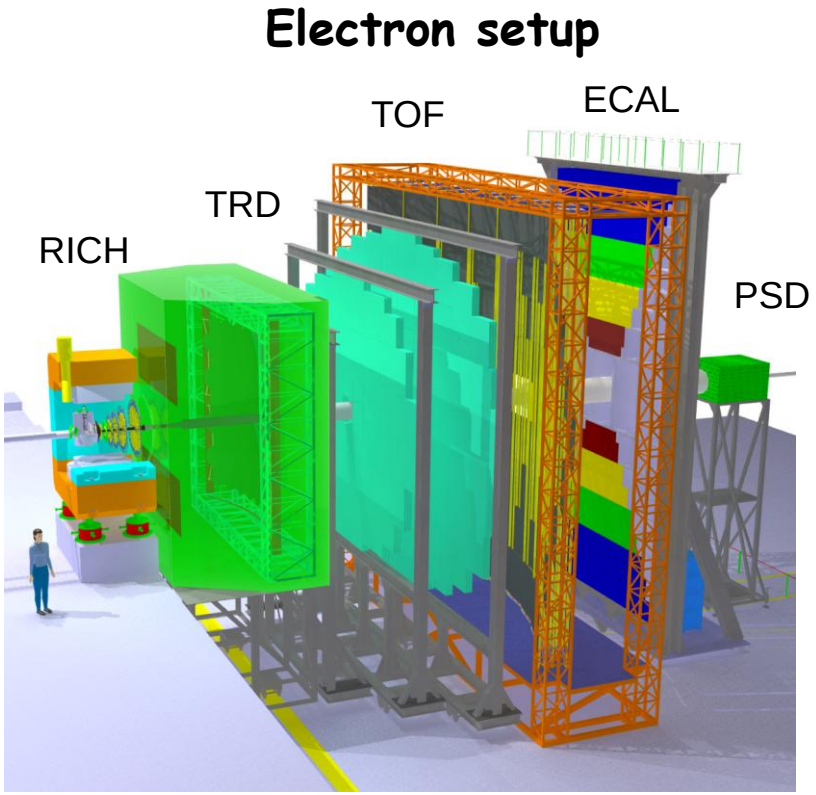
Hadrons in dense environment

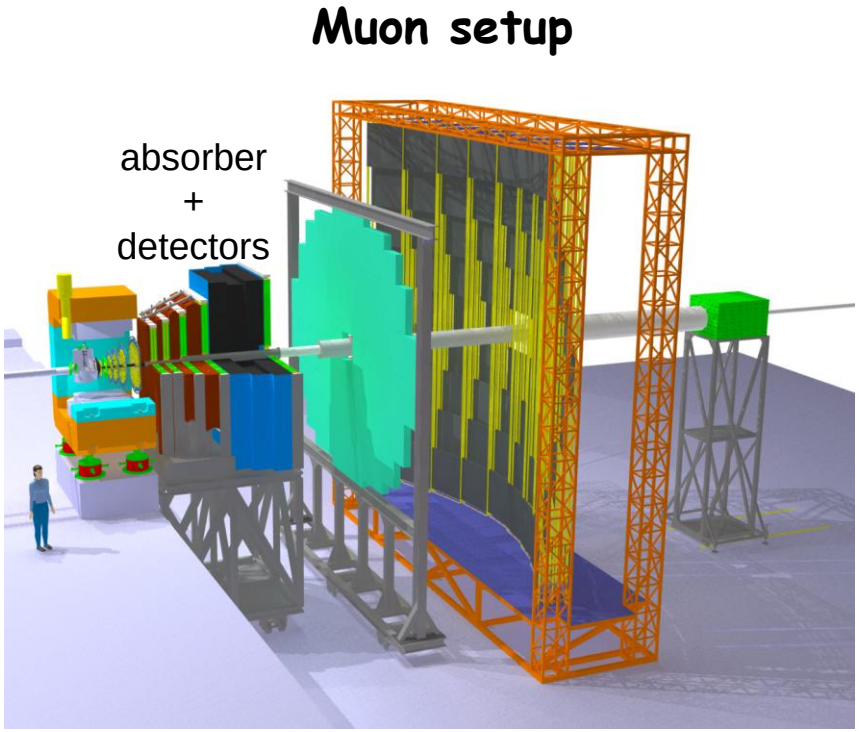


Spectral function of light vector mesons are sensitive to the baryon density

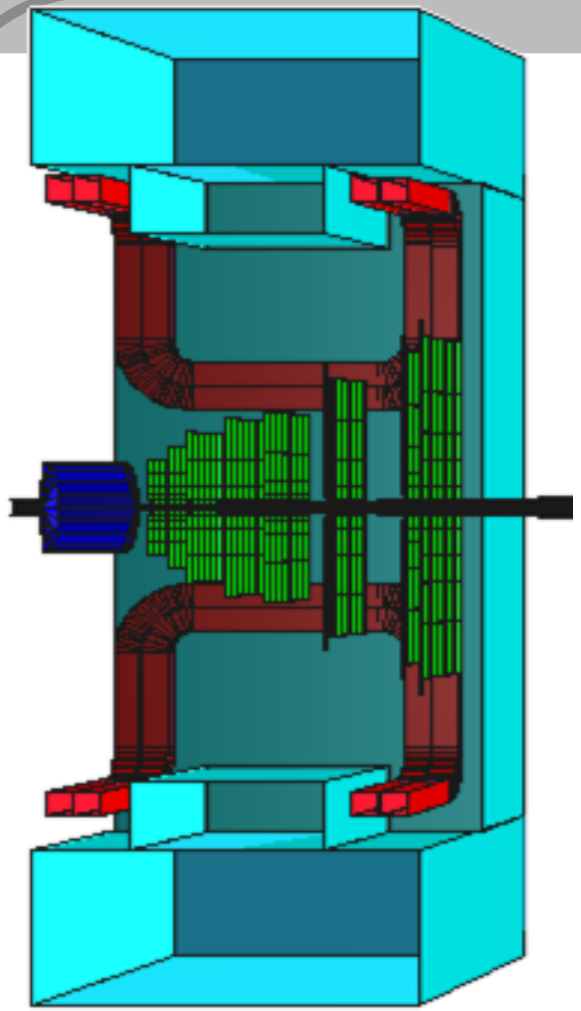
Chiral symmetry restoration ?

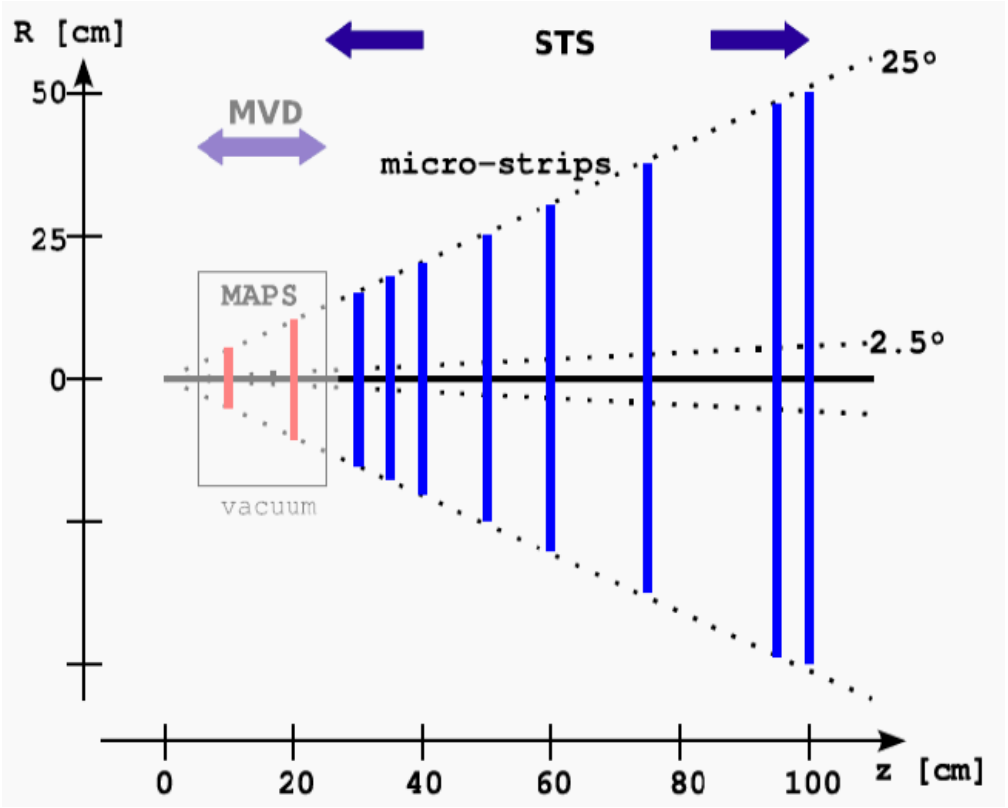
The CBM experiment





The core of CBM: Silicon Tracking System

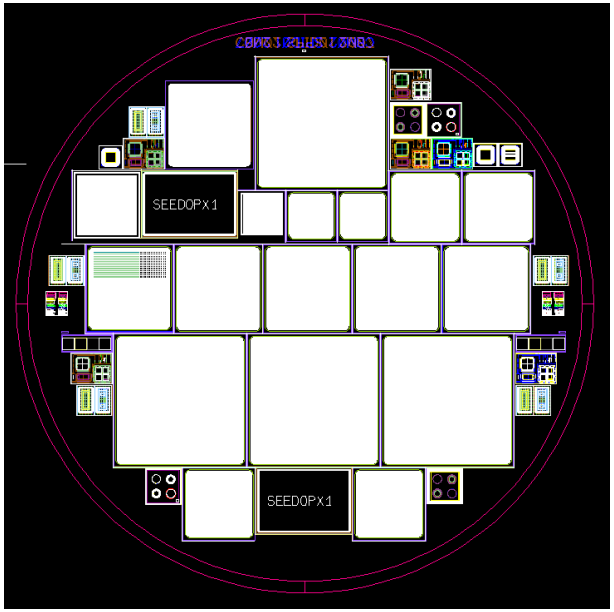




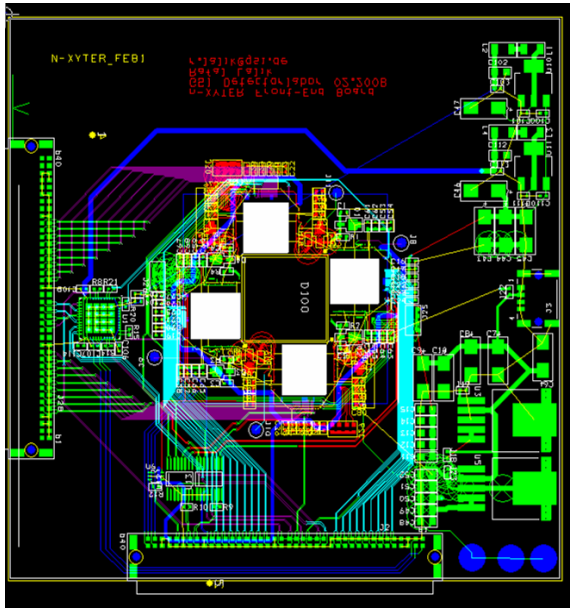
1 T dipole magnet

STS: 8 low-mass micro-strip station

R&D on STS



First waver with prototype sensors



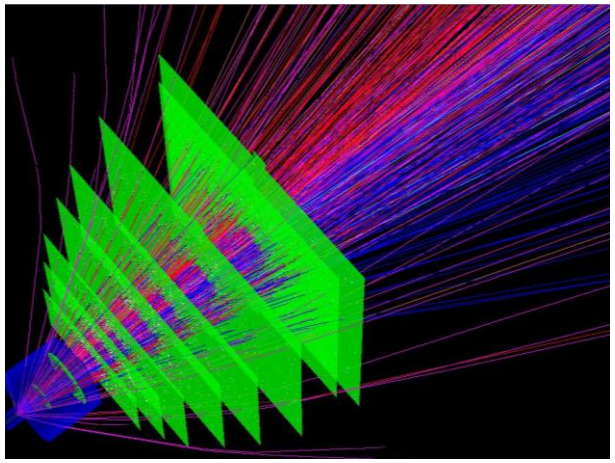
Testboard (reference station)

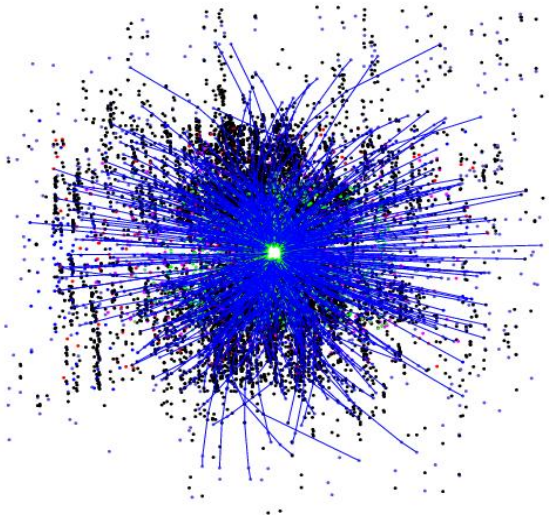
First in-beam tests:

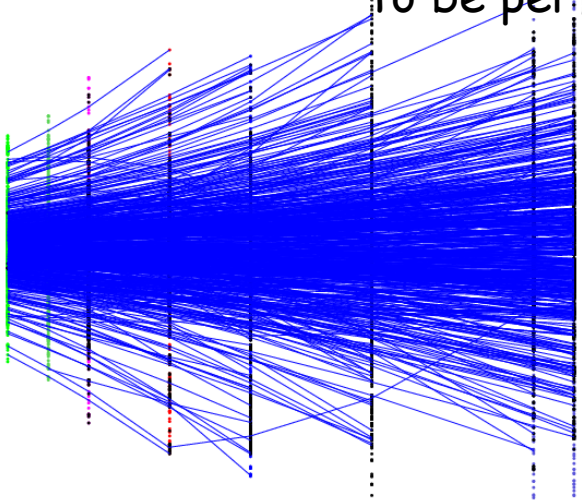
GSI, September 2008

Protvino, December 2008

Track reconstruction





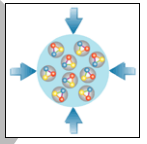


High track density
Many fake (conbinatorial) hits due to strip geometry

Several algorithms developed. Here: Cellular Automaton

to be performed online!

The challenge: Micro-Vertex Detector

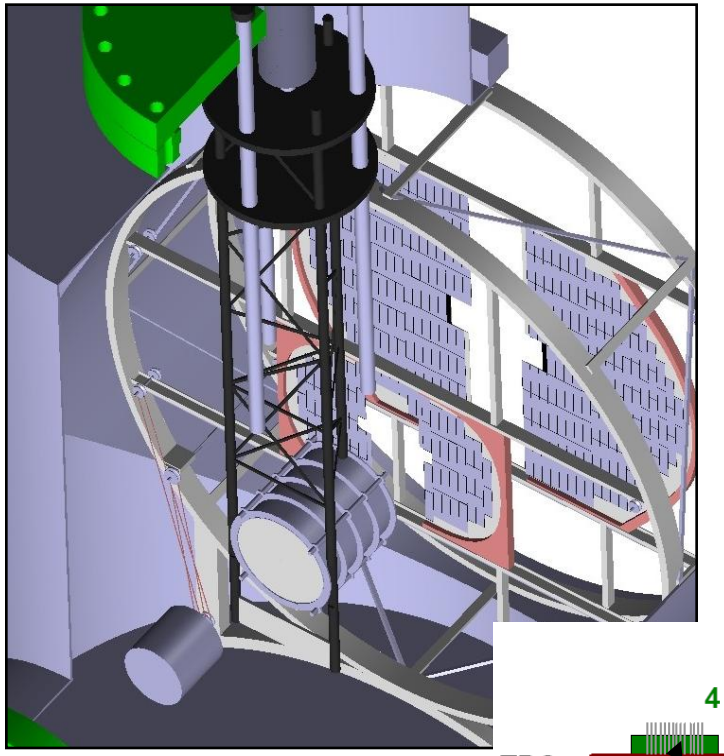


- Extreme radiation environment
- Fast response and readout
- High precision for open charm vertexing
- Ultra-low mass detector

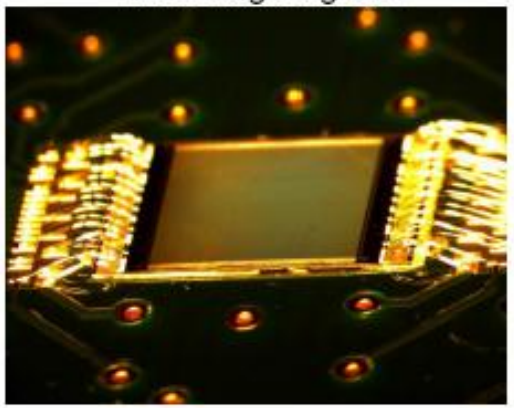
Current choice:
Monolothic Active Pixel Sensors (MAPS)
Low-mass: 150 μm Si equivalent
High precision: 3 μm coordinate resolution
Radiation hardness ?
Readout speed ?

R&D on MVD

System integration

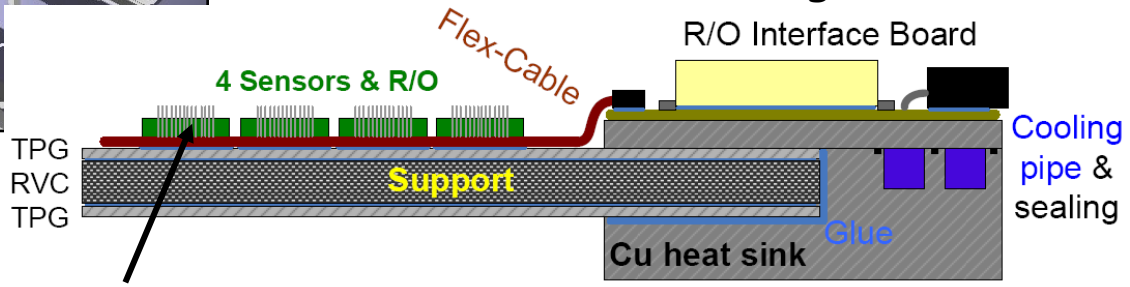


Second gluing trial



MIMOSA sensor

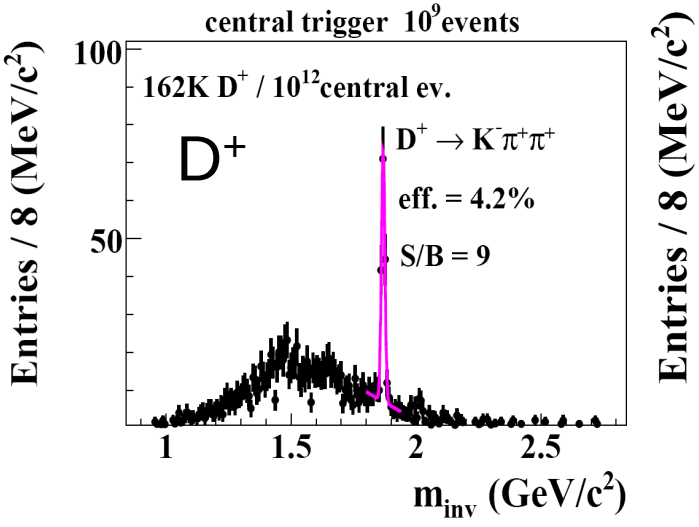
Station design

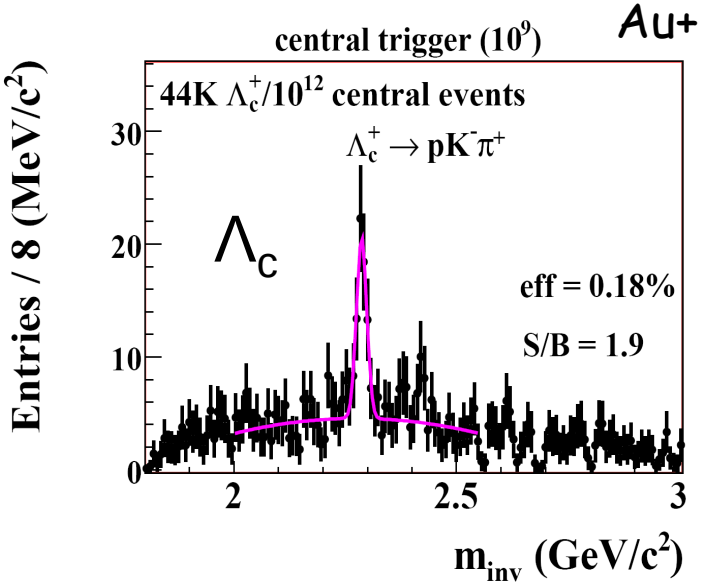


silicon pixel detectors (MAPS)

Detector performance: open charm

Au+Au, 25 AGeV



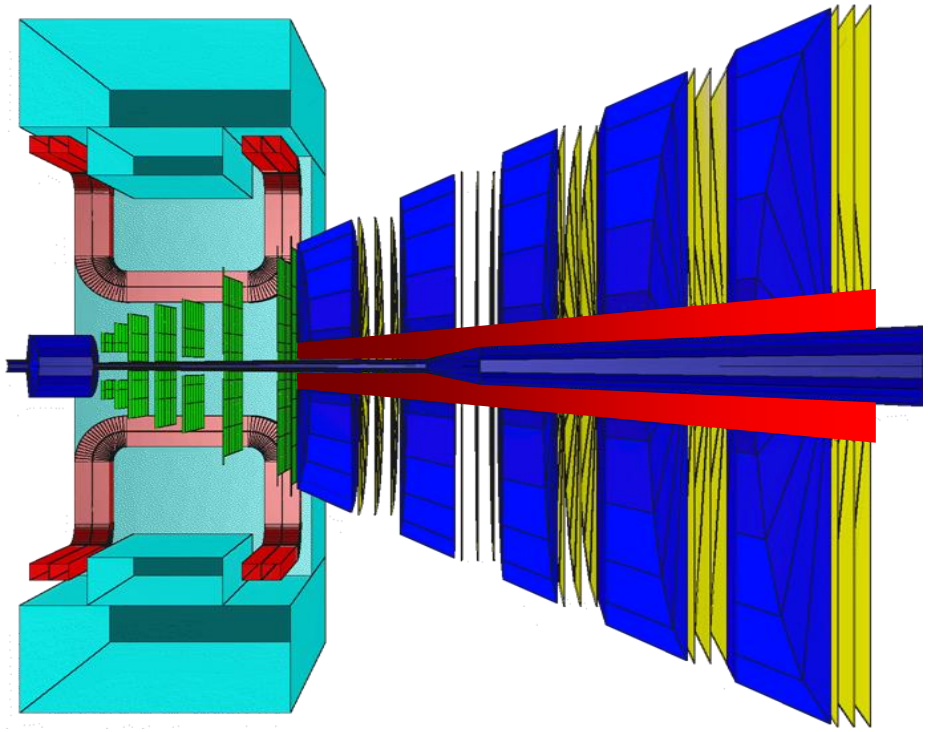


Open charm signals well detectable above background

$O(10^{12})$ events required for measurement

Challenge. Online reconstruction and event selection (suppression 10^3 required)

The muon system

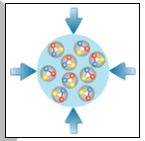


Need to connect (low-momentum) tracks before / after absorber

"Active absorber" concept: several absorber layers interlayed with 2-3 detector stations each

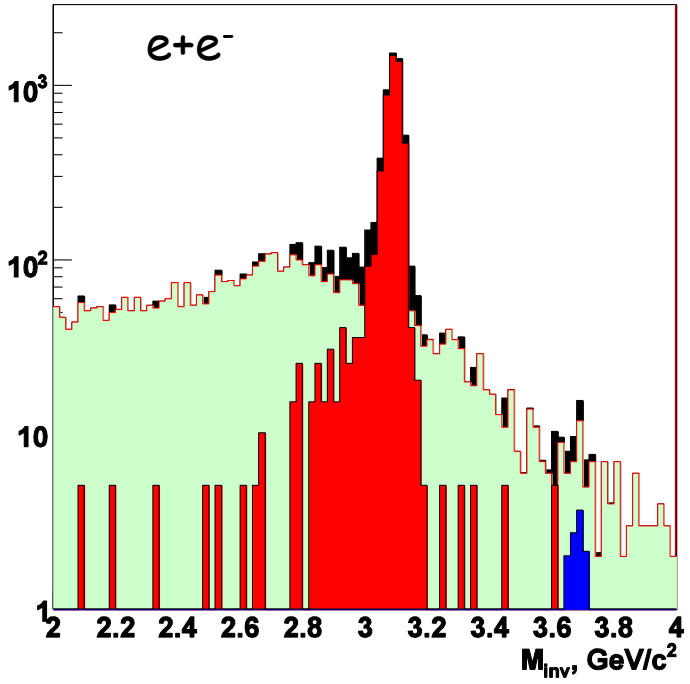
Detector options (depending on hit rates)
- Silicon
- GEM / Micromegas
- MWPC

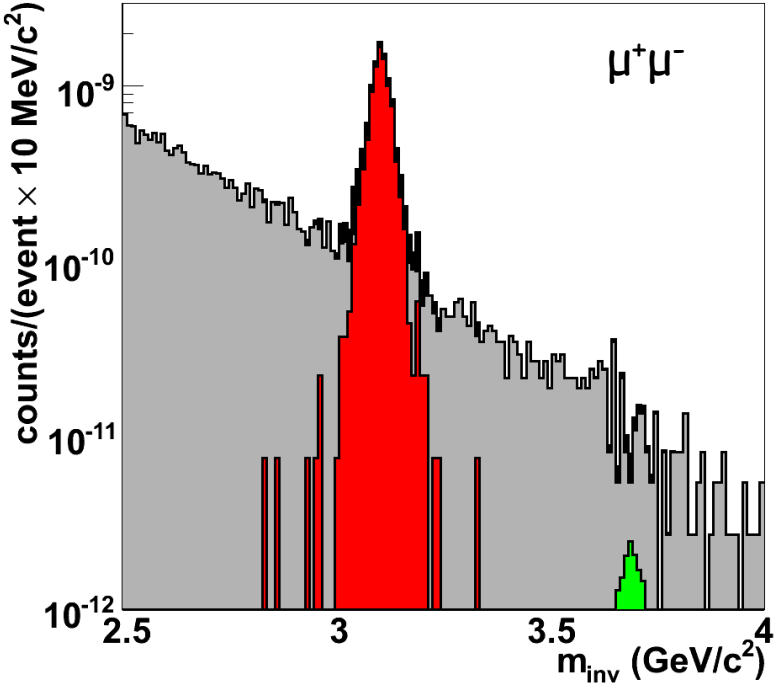
Electrons vs muons



- Electrons:
  - Identification RICH + TRD + TOF + ECAL
  - Background:
    - π^0, η Dalitz decays
    - γ conversion in target
    - mis-identified hadrons
- Muons:
  - Identification by absorber
  - Background:
    - muons from weak decays before absorber
    - punch-through hadrons
    - track mismatches
  - No access to $m < 2\, m_\mu$

Performance: Charmonium

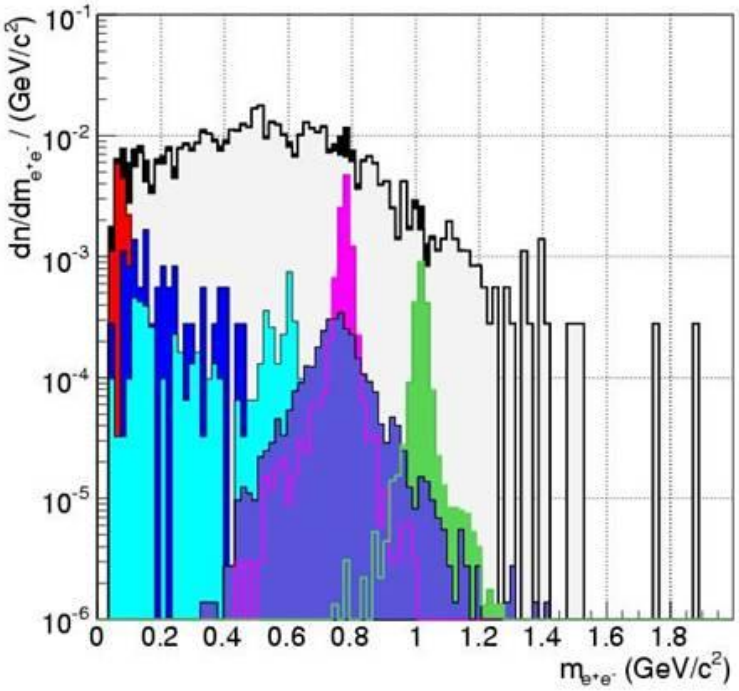


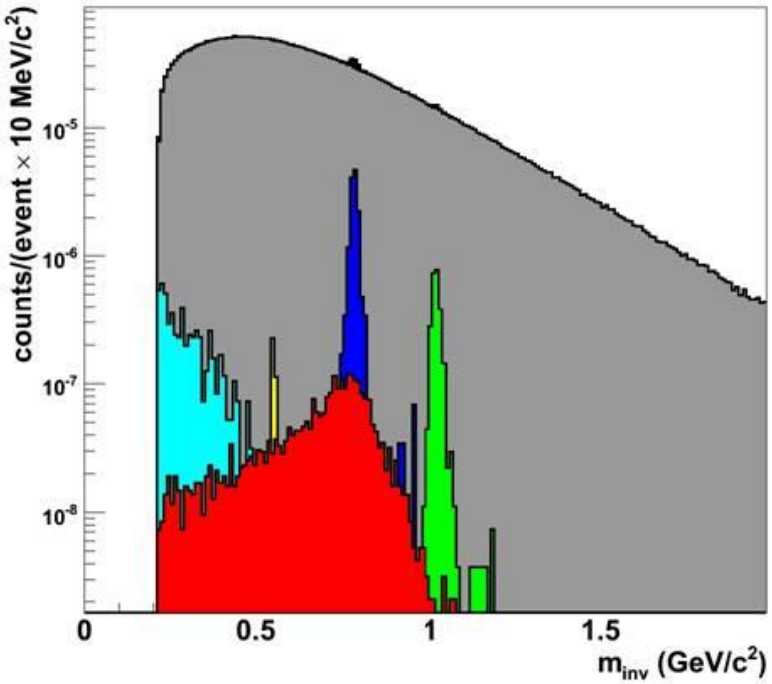


Similar performance for charmonium in electron and muon channels

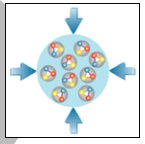
Performance: Low-mass vector mesons

Au+Au, 25 AGeV





Russian participation in CBM



- IHEP, Protvino: ECAL, PSD, RICH, RPC
- ITEP, Moscow: ECAL, PSD
- JINR, Dubna: Magnet, TRD, Software, Tracking
- PNPI, St. Petersburg: MUCH
- SPbSU, St. Peterburg: MUCH, TRT
- STS-MPD Consortium:
  - MSU, Moscow
  - SPbSU, St. Petersburg
  - KRI, St. Petersburg
  - JINR, Dubna
  - MEPhi, Moscow
  - ITEP, Moscow
  - IHEP, Protvino

CBM collaboration

China:
CCNU Wuhan
USTC Hefei

Croatia:
University of Split
RBI, Zagreb

Cyprus:
Nikosia Univ.

Czech Republic:
CAS, Rez
Techn. Univ. Prague

France:
IPHC Strasbourg

Germany:
Univ. Heidelberg, Phys. Inst.
Univ. HD, Kirchhoff Inst.
Univ. Frankfurt
Univ. Mannheim
Univ. Münster
FZ Rossendorf
GSI Darmstadt

Hungaria:
KFKI Budapest
Eötvös Univ. Budapest

India:
Aligarh Muslim Univ., Aligarh
IOP Bhubaneswar
Panjab Univ., Chandigarh
Univ. Rajasthan, Jaipur
Univ. Jammu, Jammu
IIT Kharagpur
SAHA Kolkata
Univ Calcutta, Kolkata
VECC Kolkata
Univ. Kashmir, Srinagar
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Silesia Univ. Katowice
Nucl. Phys. Inst. Krakow

Portugal:
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Romania:
NIPNE Bucharest

Russia:
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INR Troitzk
ITEP Moscow
KRI, St. Petersburg
Kurchatov Inst. Moscow
LHE, JINR Dubna
LPP, JINR Dubna
LIT, JINR Dubna
MEPHI Moscow
Obninsk State Univ.
PNPI Gatchina
SINP, Moscow State Univ.
St. Petersburg Polytec. U.

Ukraine:
Shevchenko Univ. , Kiev

51 institutions, > 400 members