Dense baryonic matter in the CBM experiment at FAIR

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CBM collaboration

HIC for FAIR
Helmholtz International Center

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

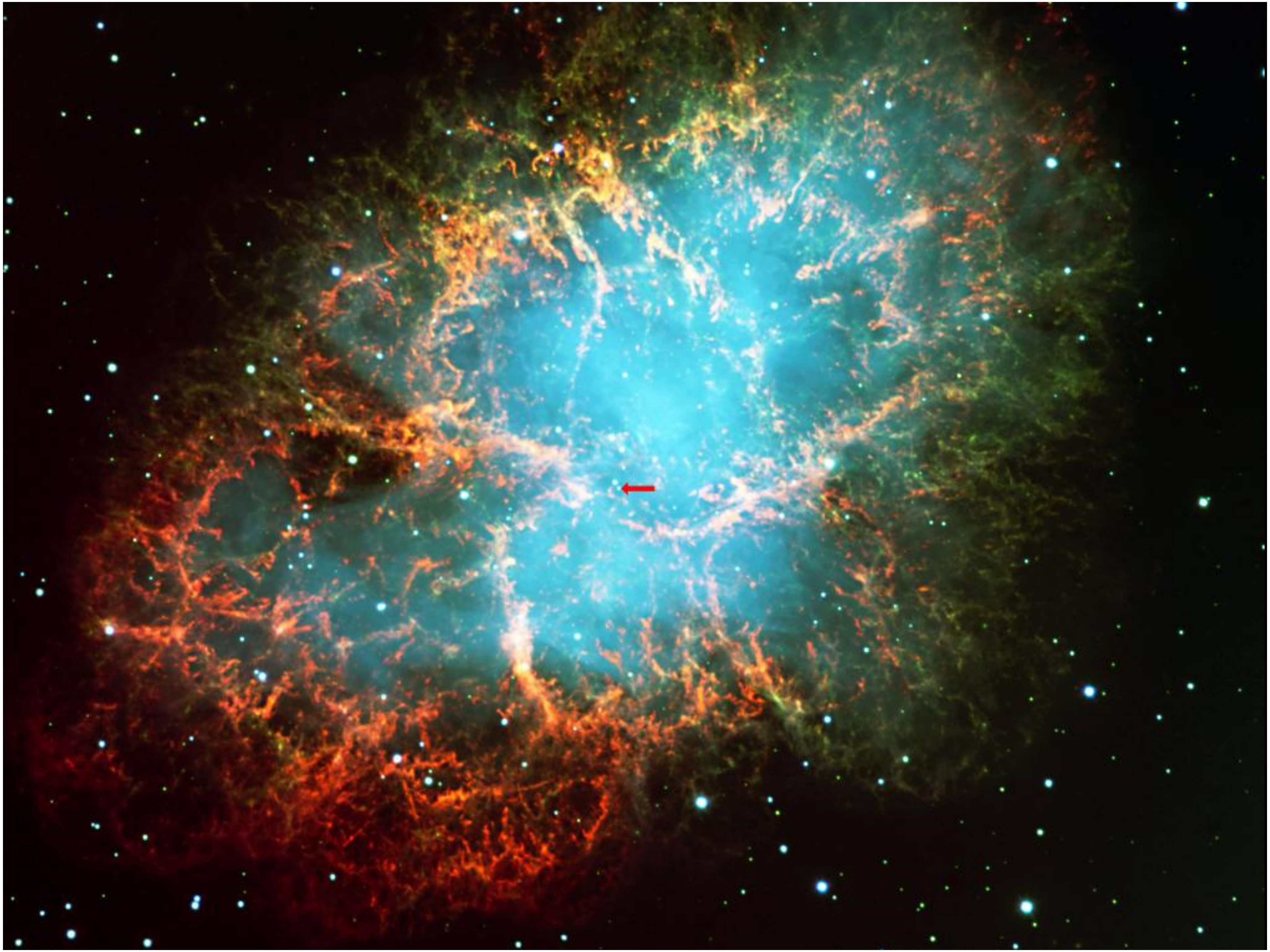
GSI

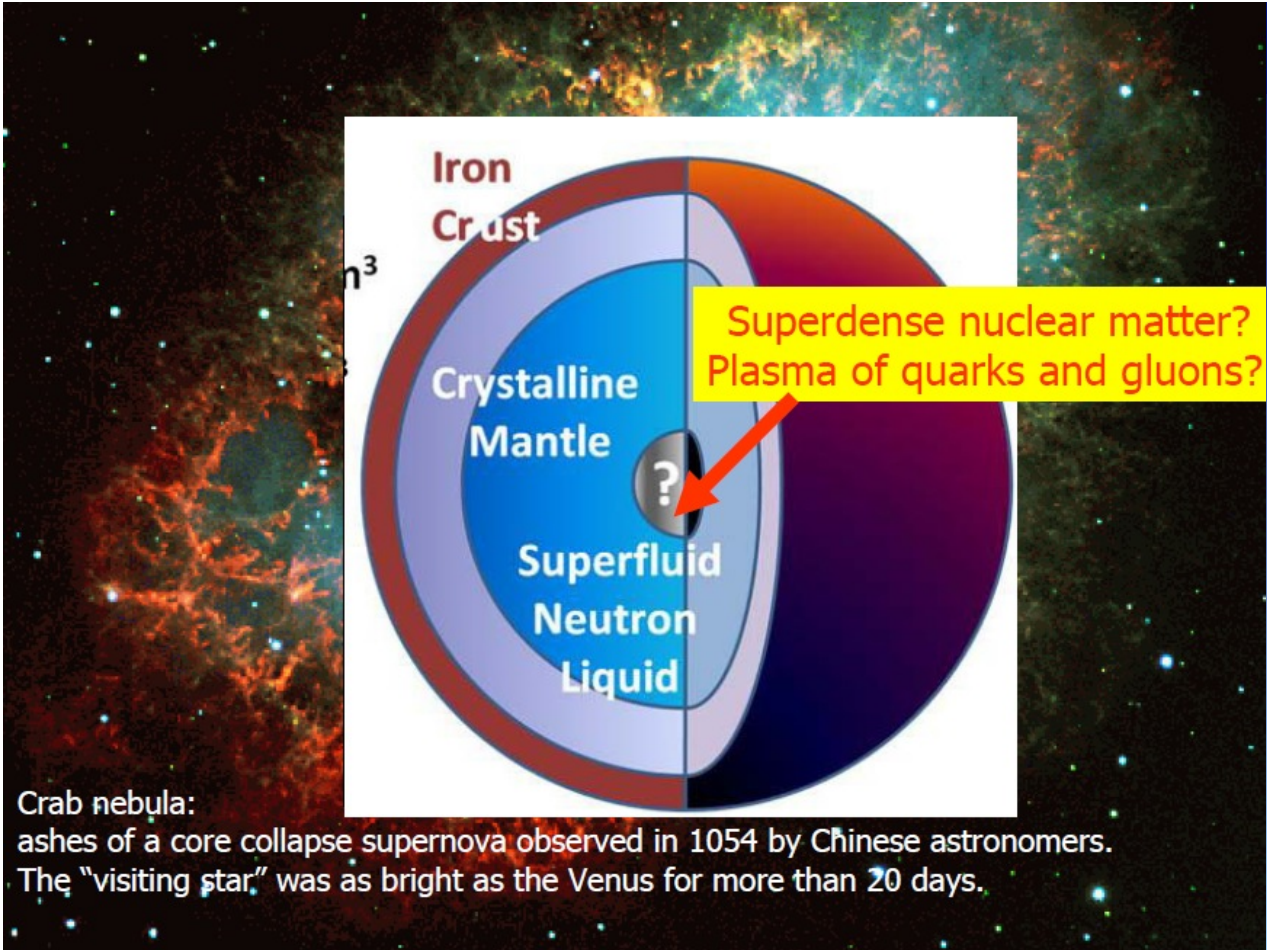
Outline

- **Introduction & Motivation**
  - Heavy-ion collisions
  - QCD phase diagram
  - Current and future experiments on dense baryonic matter
  - Signatures for phase transitions, CP, characterization of matter

- **CBM experiment at SIS-100 and SIS-300 at FAIR**

→ focus on rare probes (dileptons, open charm): unique feature of CBM
  - feasibility studies
  - detector R&D



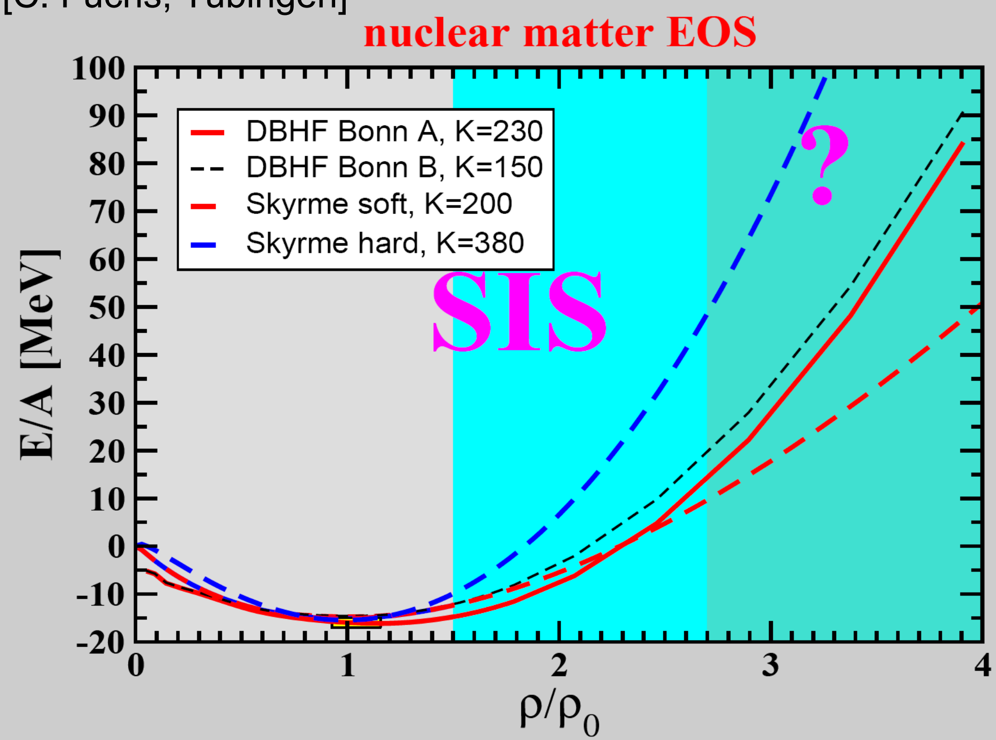

Iron
Crust
Crystalline
Mantle
?
Superfluid
Neutron
Liquid
Superdense nuclear matter?
Plasma of quarks and gluons?
Crab nebula:
ashes of a core collapse supernova observed in 1054 by Chinese astronomers.
The "visiting star" was as bright as the Venus for more than 20 days.

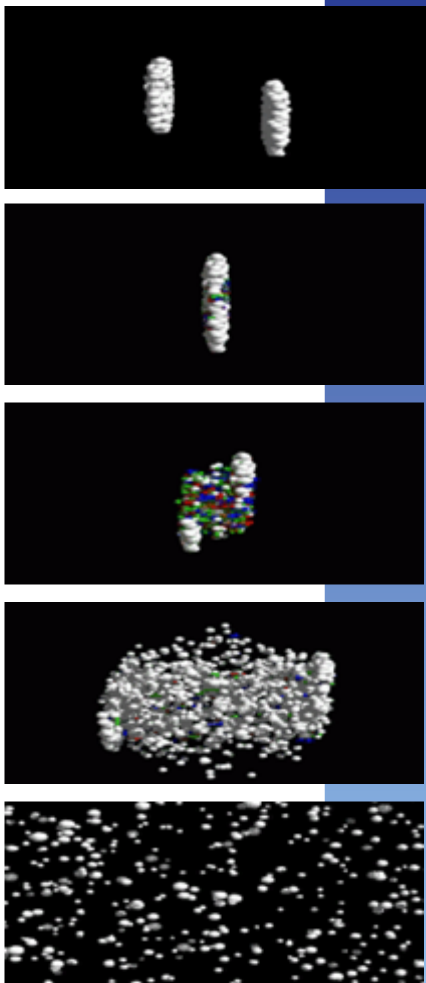
Equation of state at high baryon densities

- What is the equation of state at high baryon densities?
- New degrees of freedom?

→ use heavy-ion collisions in the lab to study this matter

[C. Fuchs, Tübingen]





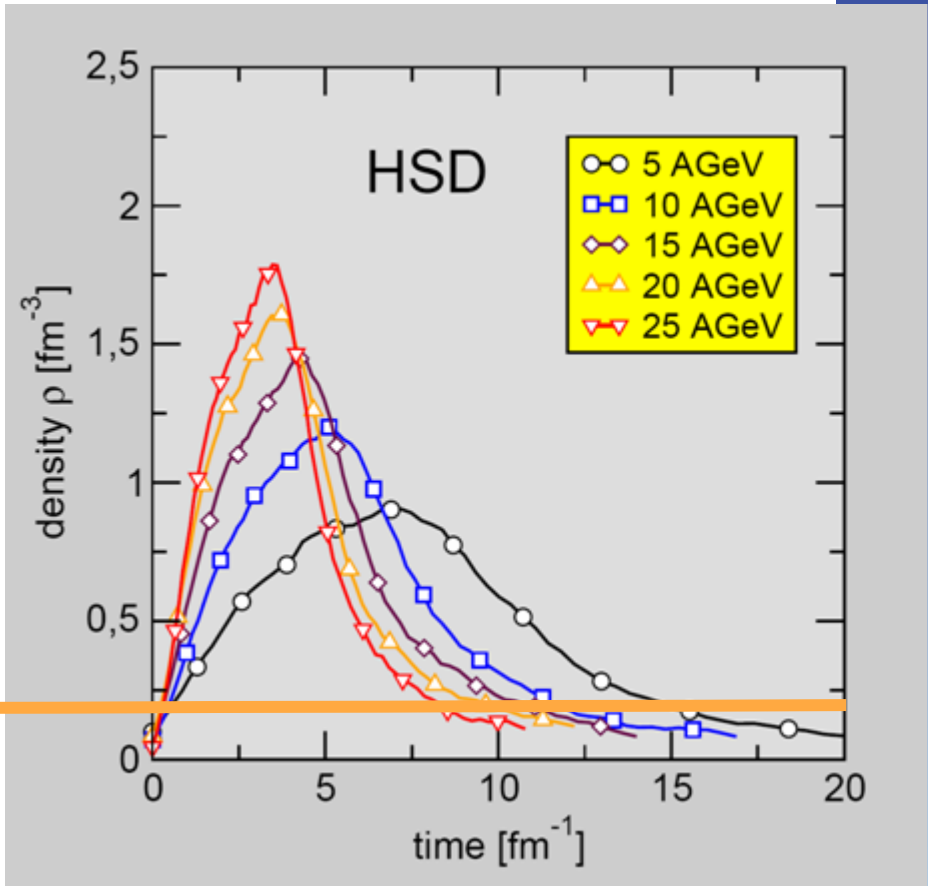
Transport calculations: heavy ion collisions

simulation of Au+Au collisions at different beam energies:

→ maximum baryon densities ρ increase with beam energy

→ several times normal nuclear matter density achieved prevailing for a few fm/c!

beam energy	max. ρ/ρ_0	time span ~FWHM
5 AGeV	6	~ 8 fm/c
25 AGeV	11	~ 4 fm/c
40 AGeV	12	~ 3.5 fm/c



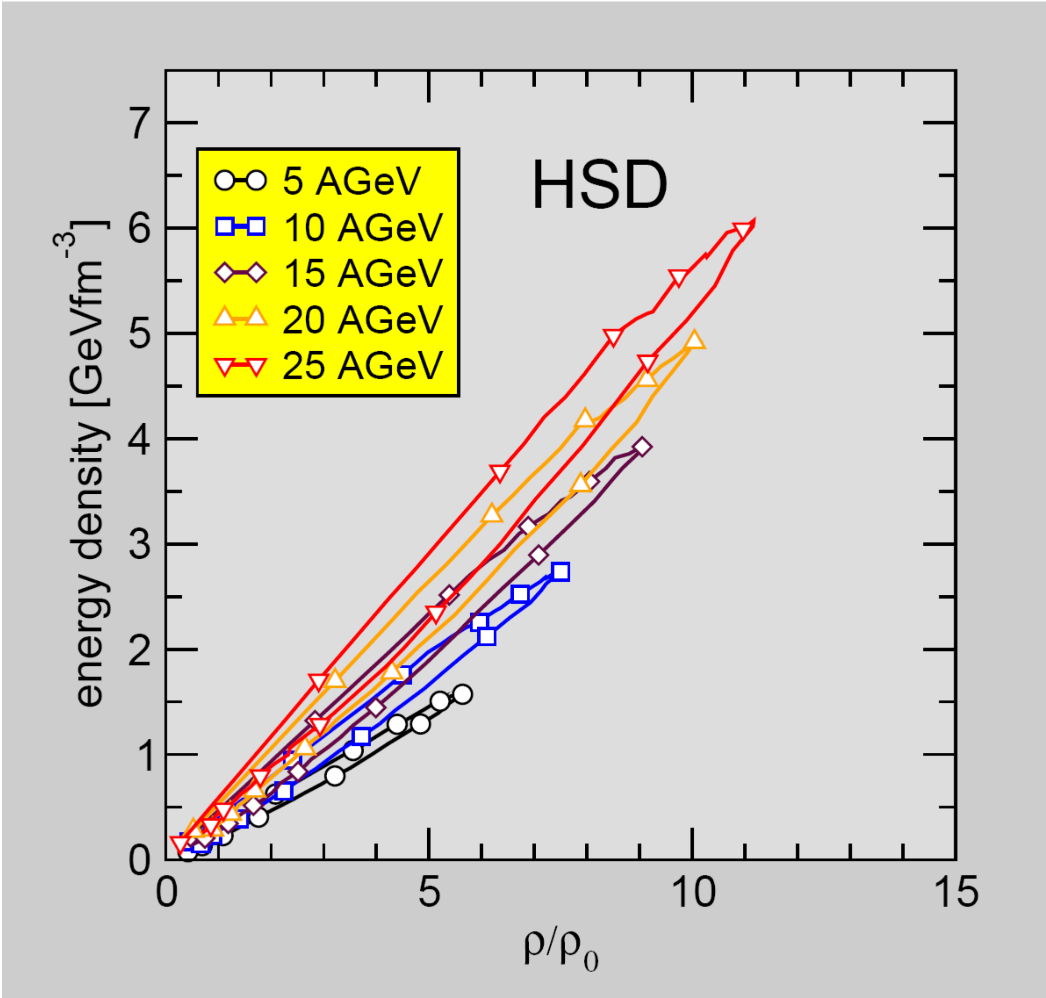
normal nuclear matter density

[CBM physics group, E. Bratkovskaya, C. Fuchs priv. com.]

Transport calculations: heavy ion collisions

Baryon and energy density in central cell (Au+Au, b=0 fm):

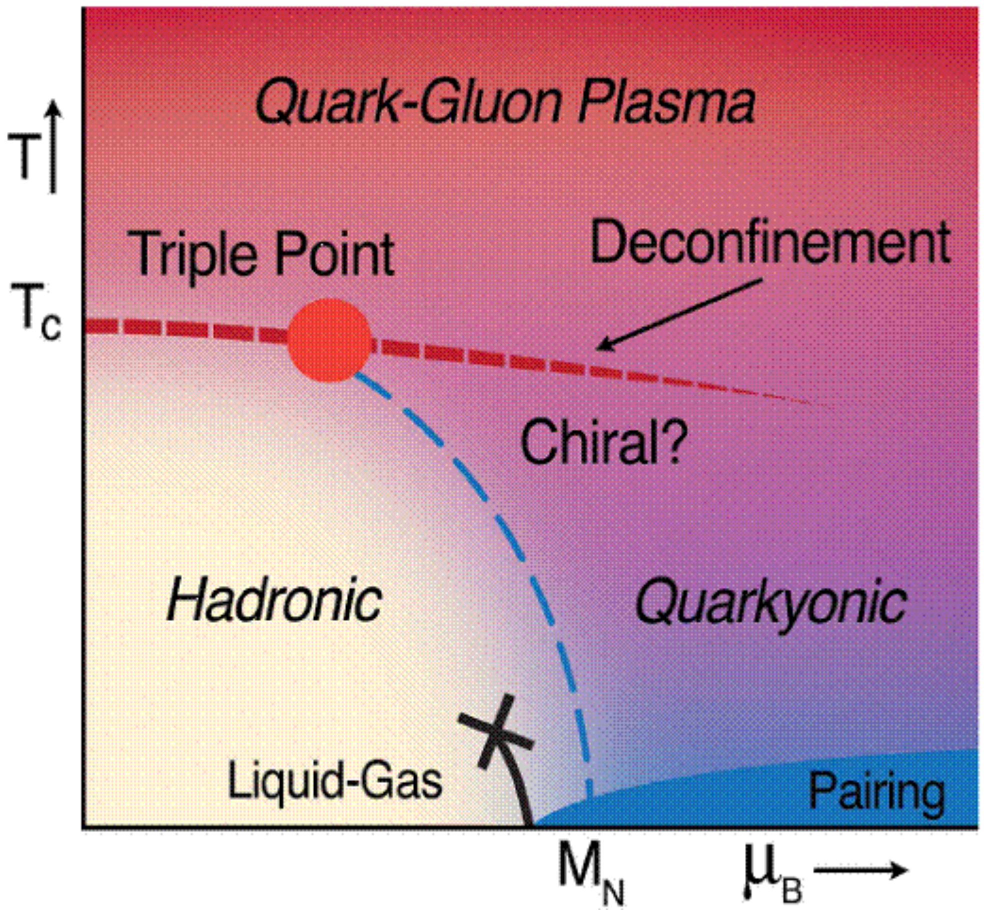
HSD: mean field, hadrons + resonances + strings



[CBM physics group, E. Bratkovskaya, C. Fuchs priv. com.]

The QCD phase diagram

→ use heavy-ion collisions to investigate the phases and degrees of freedom of strongly interacting matter at different baryon densities and temperatures!!



[A. Andronic et al., arXiv:0911.4806]

The QCD phase diagram

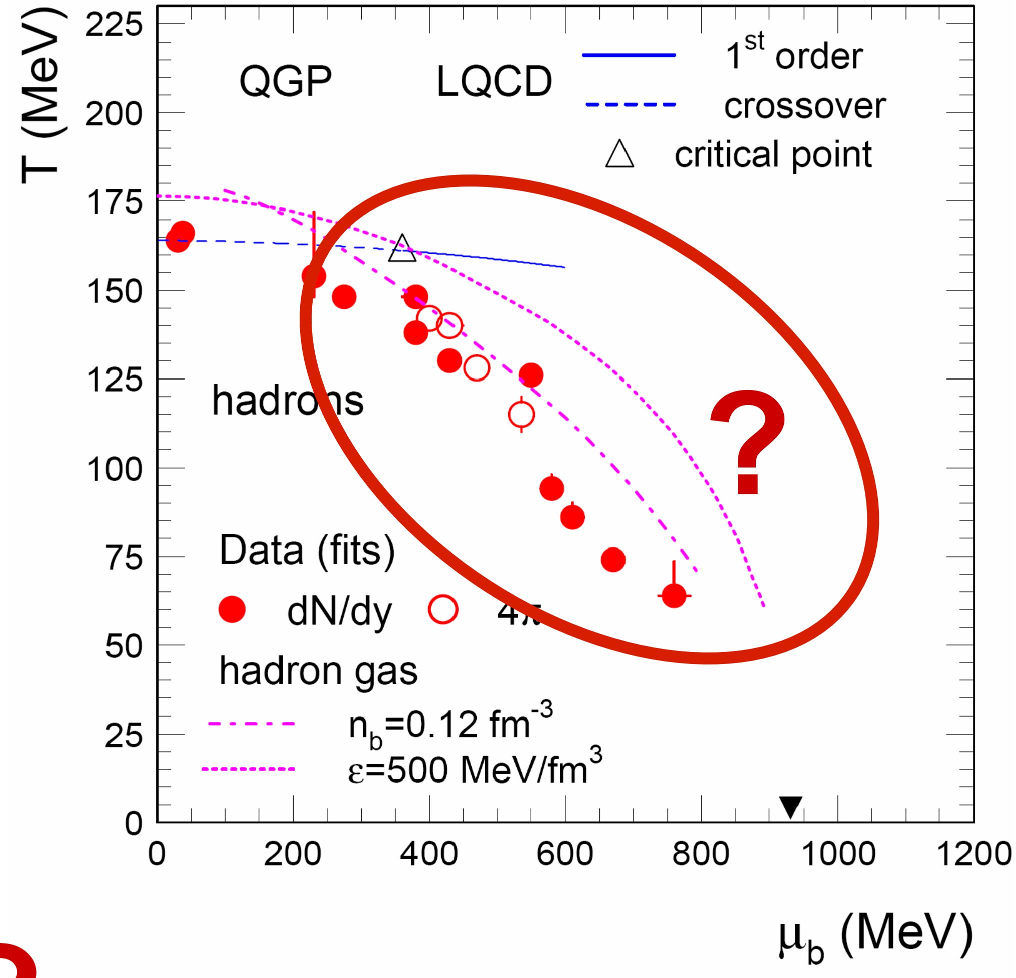
Experimental results:

- Freeze-out curve (T, μ_B) with $T_{ch} \approx$ 160 MeV at $\mu_B \approx 0$
- partonic matter at high T
- onset of deconf. at $\sqrt{s}$~8 GeV

L-QCD Predictions:

- T_C = 165±6 MeV (strange suscept.)
  S. Borsanyi et al., JHEP 1009 (2010) 073
  T_C = 154±9 MeV (chiral)
  A. Basavov et al., arXiv:1111.1710v1
- crossover transition at μ_B=0
  Y. Aoki et al., Nature 443 (2006) 675
- 1. order phase transition with critical endpoint at $\mu_B > 0$

A. Andronic et al., Phys. Lett. B 673 (2009).



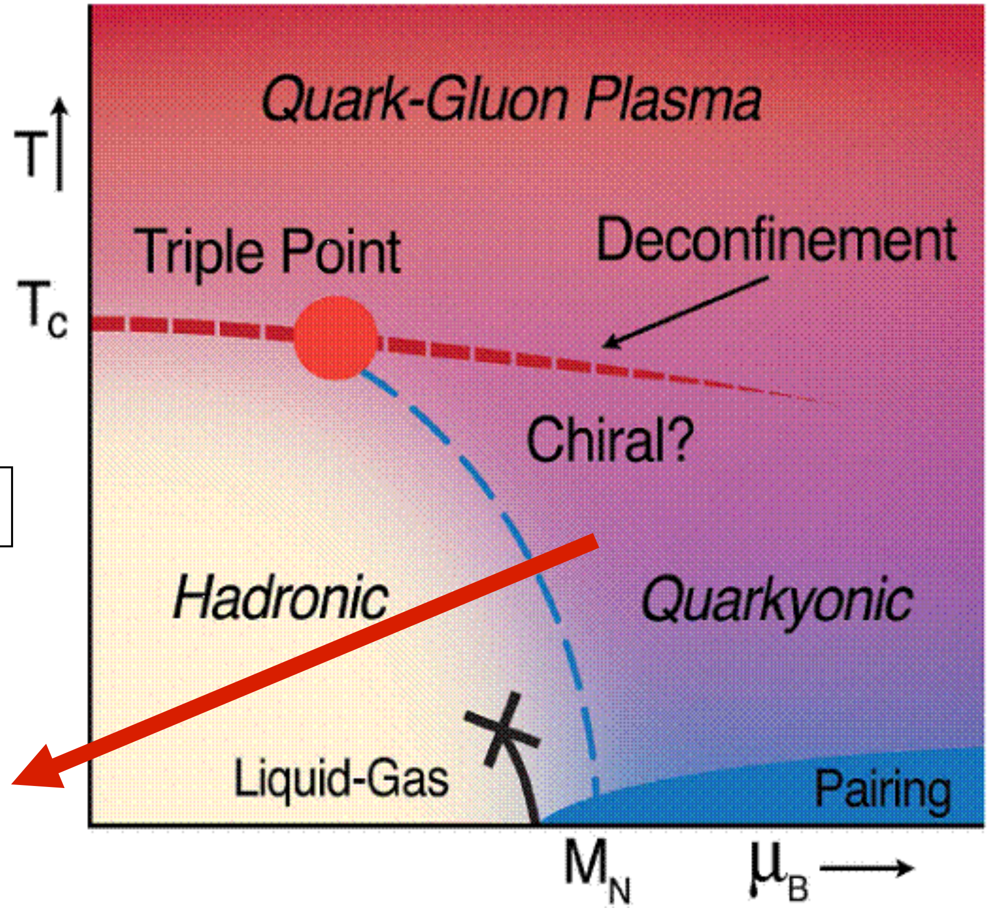
?

The QCD diagram at high μ_B

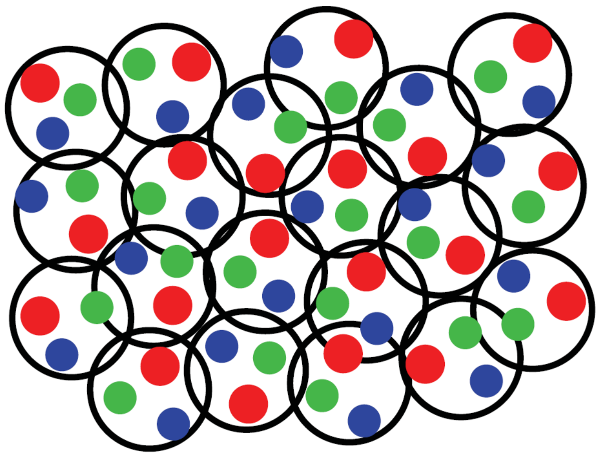
phase diagram at high μ_B ?

- quarkyonic phase?
- phase transition(s)?
- critical point/ triple point?
- **need for high precision data including rare probes!**

[A. Andronic et al., arXiv:0911.4806]



Field driven by experimental data!



Experiments on dense baryonic matter

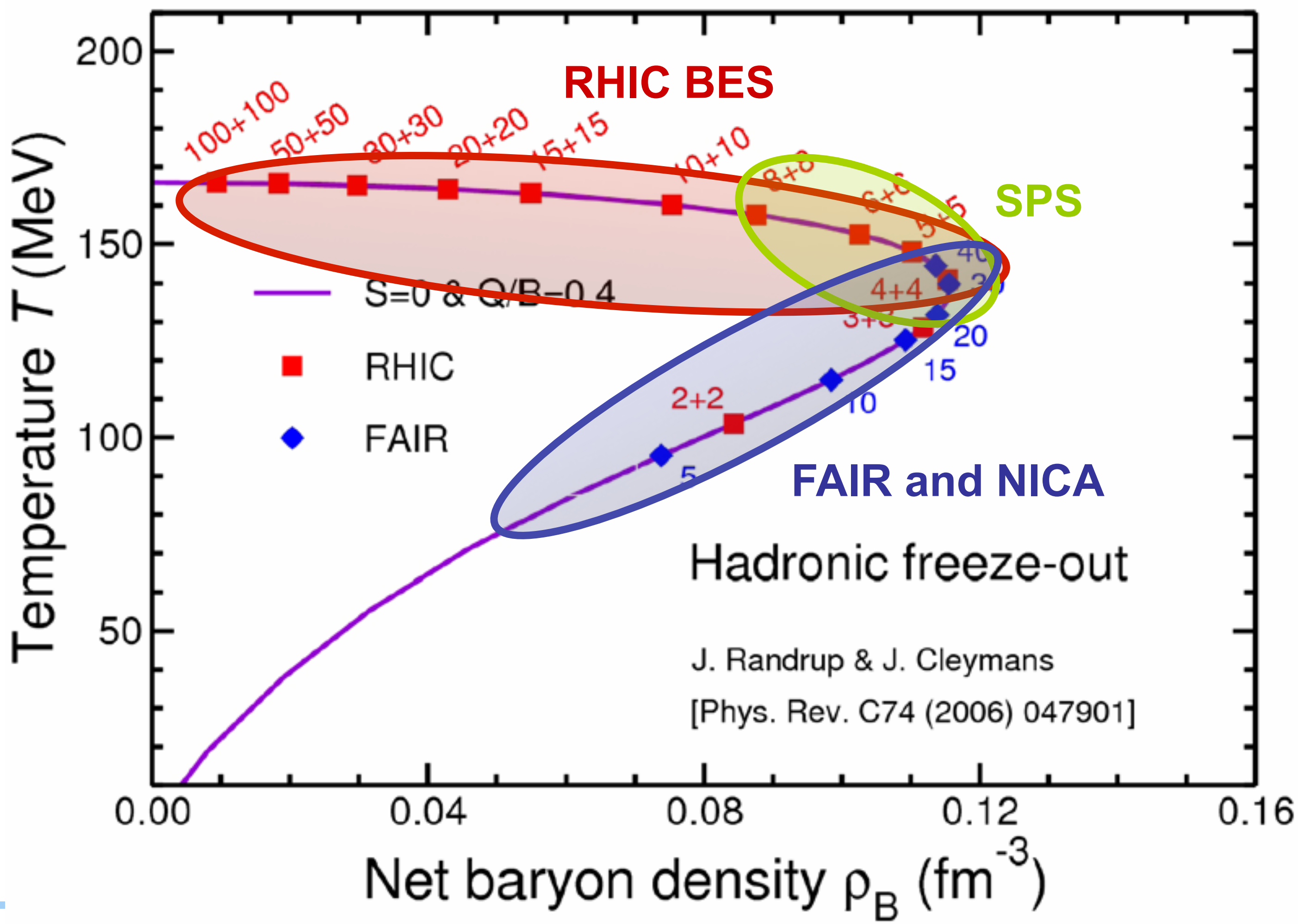
Experiment	Energy range (Au/Pb beams)	Reaction rates Hz
PHENIX & STAR @RHIC, BNL	$\sqrt{s_{NN}}$ = 7 – 200 GeV	1 – 800 (limitation by luminosity)
NA61@SPS CERN	E_{kin}= 20 – 160 A GeV $\sqrt{s_{NN}}$= 6.4 – 17.4 GeV	80 (limitation by detector)
MPD@NICA Dubna	$\sqrt{s_{NN}}$= 4.0 – 11.0 GeV	~1000 (design luminosity of 10^{27} $cm^{-2}s^{-1}$ for heavy ions)
CBM & HADES @FAIR, Darmstadt	E_{kin}= 2.0 – 35 A GeV $\sqrt{s_{NN}}$= 2.7 – 8.3 GeV	10^5 – 10^7 (limitation by detector)

Experiments on dense baryonic matter

Experiment	Observables for beam energies at about $\sqrt{s_{NN}}$ = 8 GeV (high baryon density region)			
	hadrons	correlations, fluctuations	dileptons	charm
PHENIX & STAR @RHIC, BNL	yes	yes	no (BES II ?)	no
NA61@SPS CERN	yes	yes	no	no
MPD@NICA Dubna	yes	yes	no	no
CBM & HADES @FAIR, Darmstadt	yes	yes	yes	yes

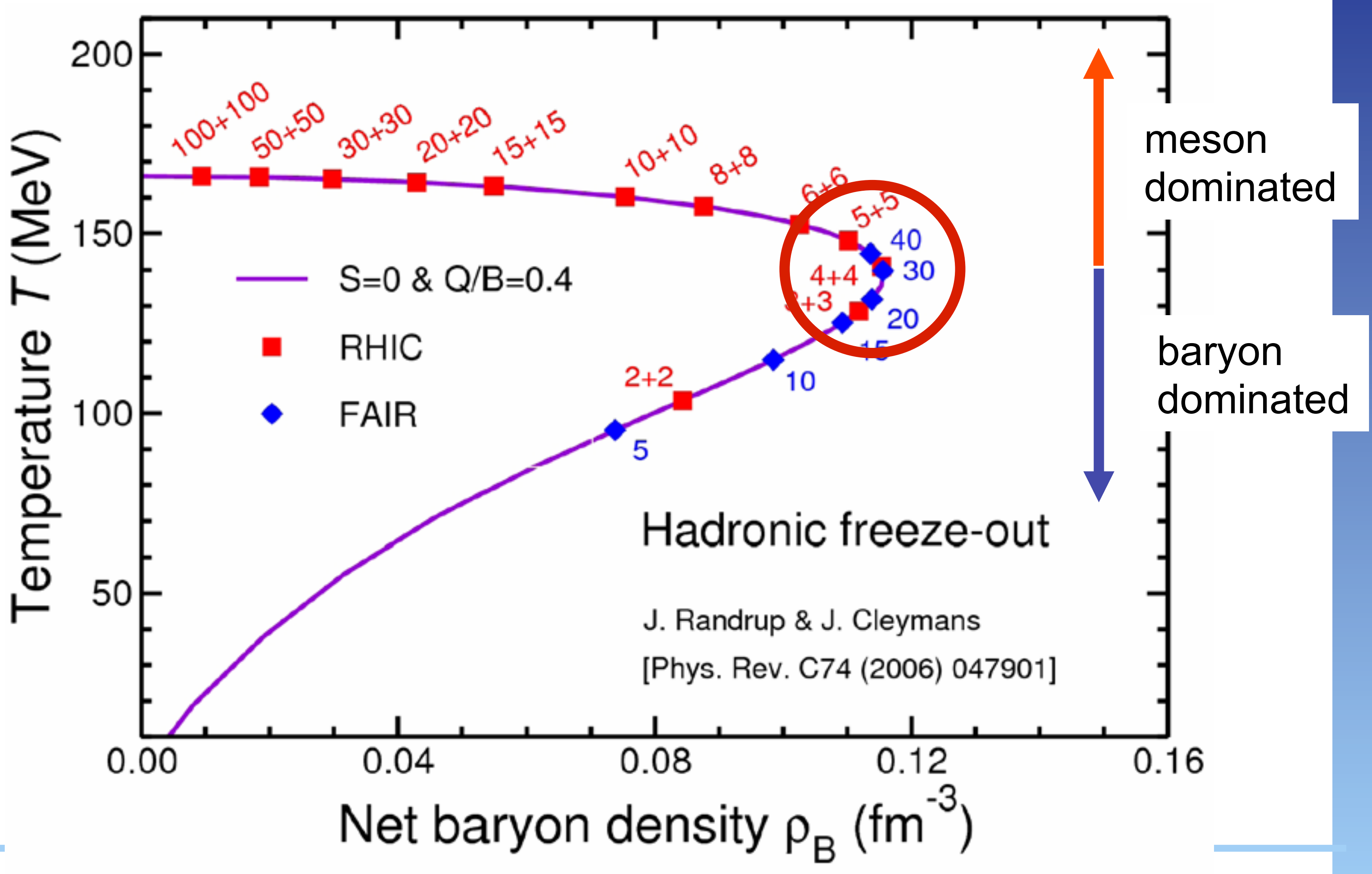
Chemical freeze-out: a different view

- high (net-)baryon and energy densities created in central Au+Au collisions
- different energy scans complementary!
- FAIR adding lots of new information due to accessibility of rare probes!



Chemical freeze-out: a different view

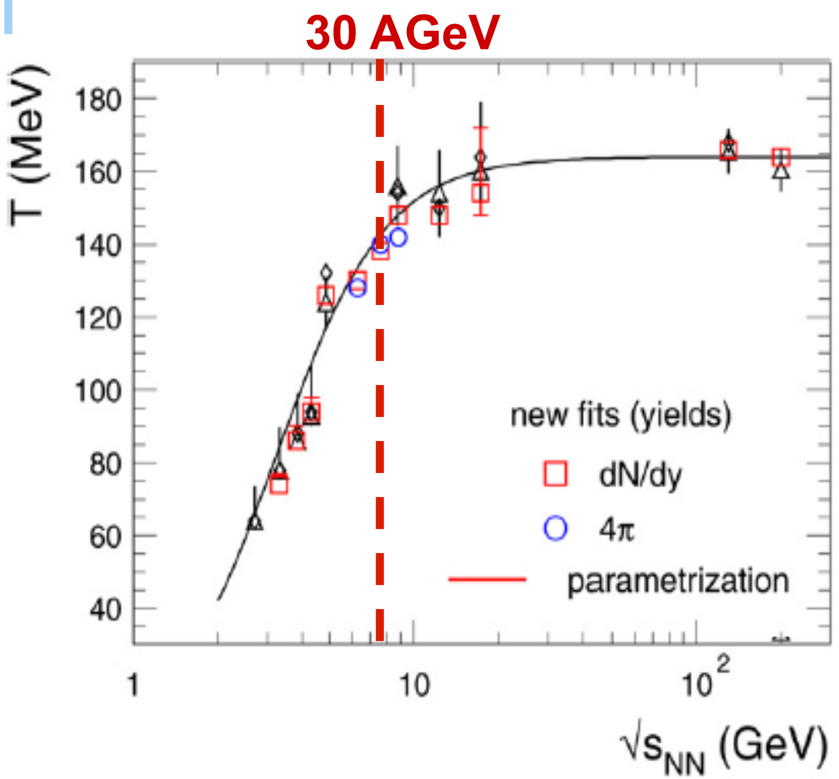
- indications for phase transition to partonic phase at about 30 AGeV beam energy ($\sqrt{s}$~8 GeV)!

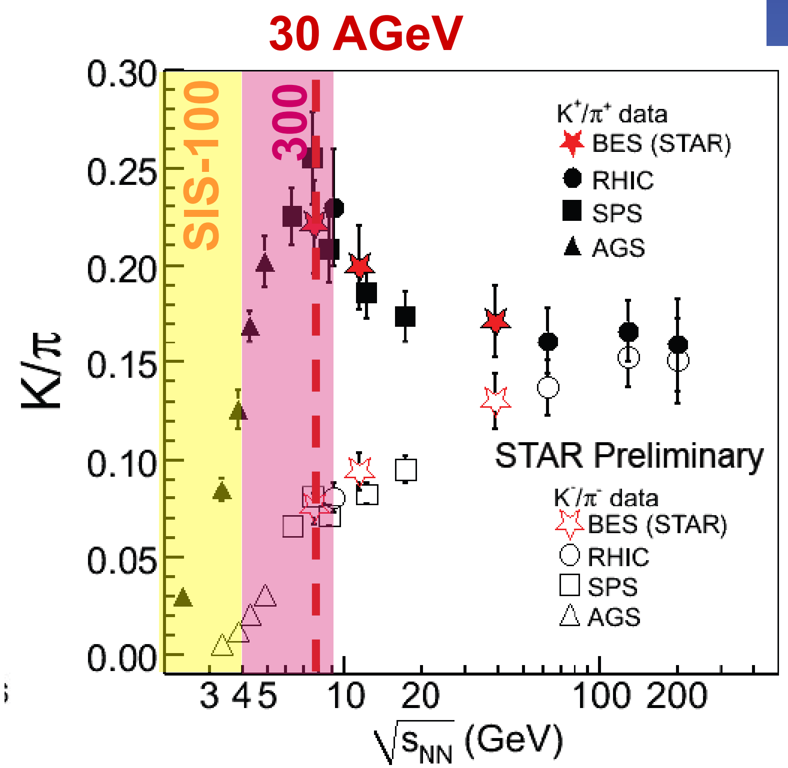


Phase transition at high μ_B?

- limiting chemical freeze-out temperature: hadronization at phase boundary
- other signatures showing changes at around 30 AGeV beam energy

SPS results nicely confirmed by RHIC BES!
CBM at FAIR will cover the lower energy side!





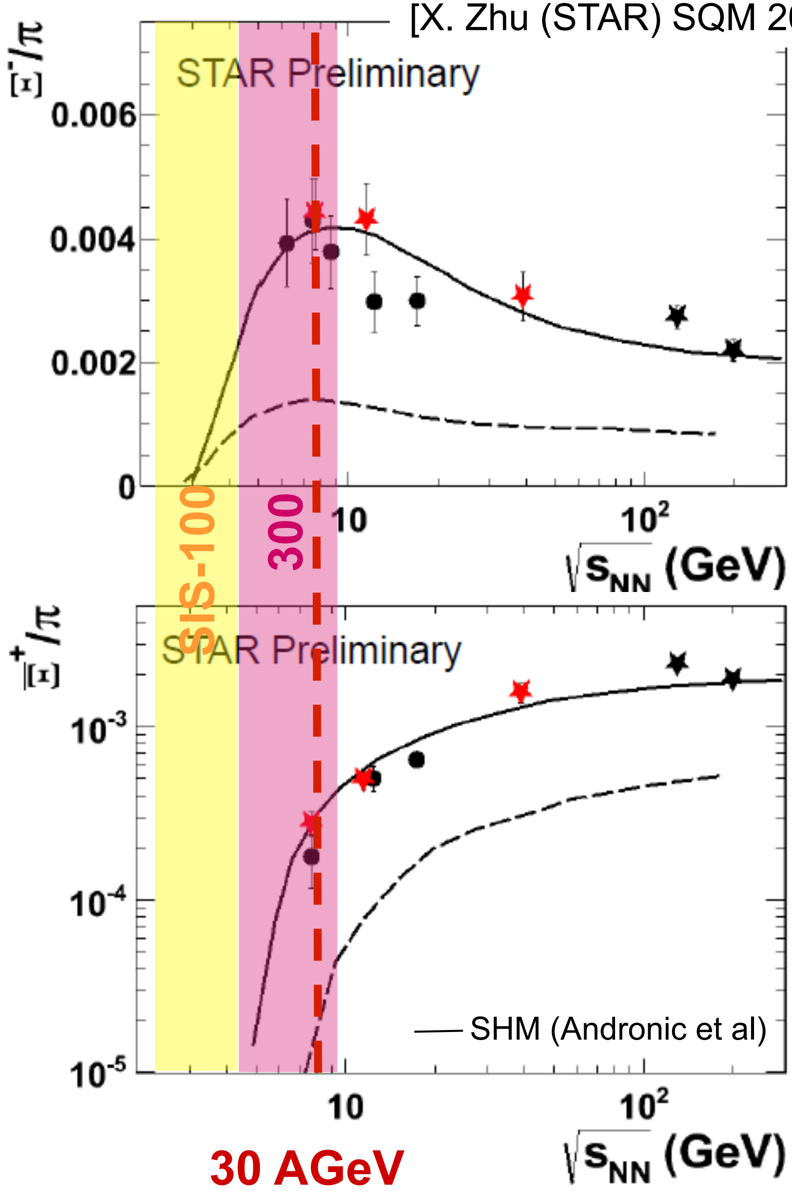
[L. Kumar (STAR) QM 2011]

[A. Andronic et al., Phys. Lett. B 673 (2009) 142]

(Multi-)strange particle production

- strangeness in equilibrium at low μ_B
- equilibration of strangeness at high μ_B?
$\rightarrow$ need multistrange particles!
- freeze-out at (another) phase boundary at high μ_B?

[X. Zhu (STAR) SQM 2011]

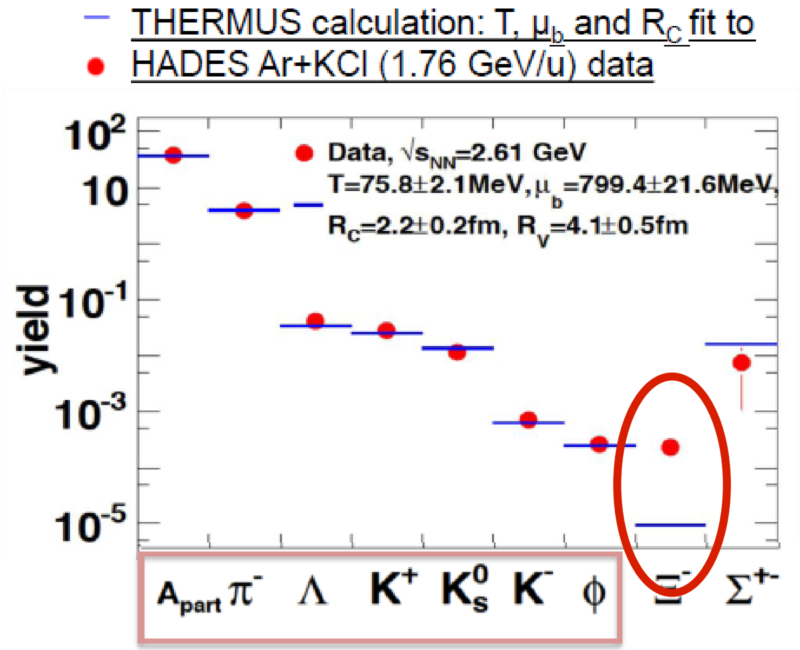


HADES: Sub-threshold Ξ^- production

Ar+KCl reactions at 1.76A GeV

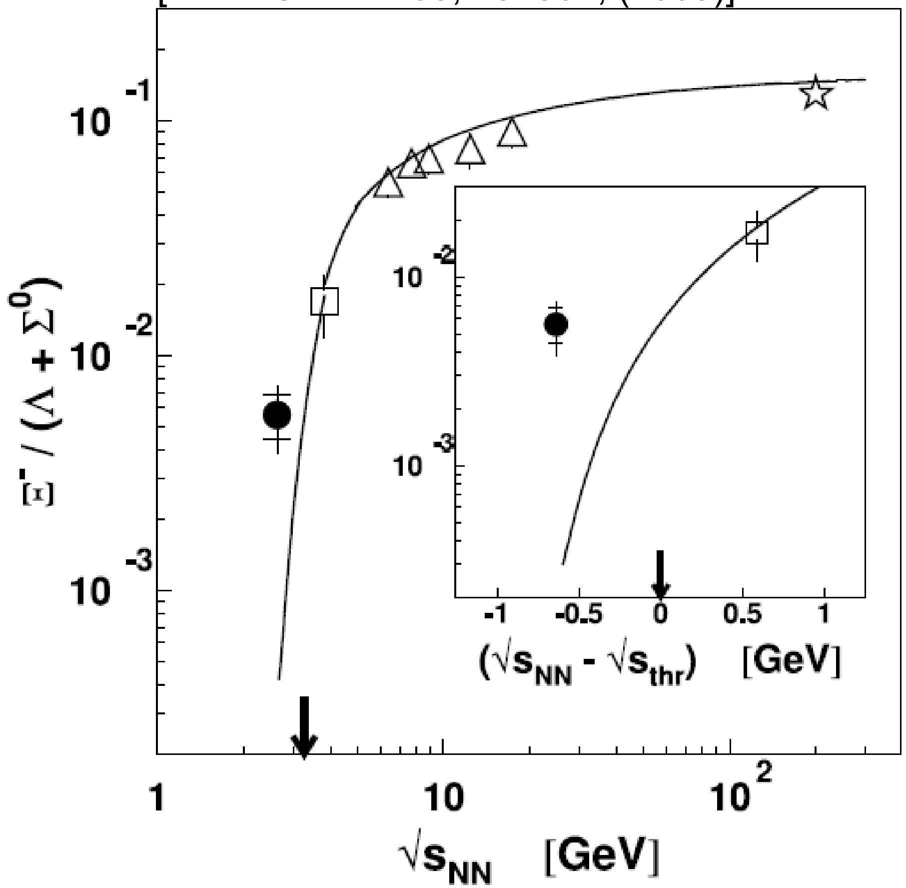
- Ξ^- yield by appr. factor 25 higher than thermal yield
- strangeness exchange reactions like

$\bar{K}Y \rightarrow \pi\Xi$ (Y=Λ,Σ) ?



THERMUS fit: J.Cleymans, J.Phys.G31(2005)S1069
HADES: Eur. Phys. J. A 47:21, 2011.

[HADES: PRL103, 132301, (2009)]



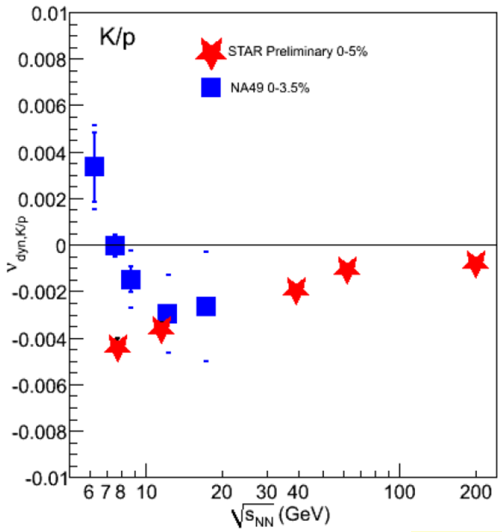
Search for fluctuations: CP – 1st order PT

open questions: CP? 1st order phase transition?

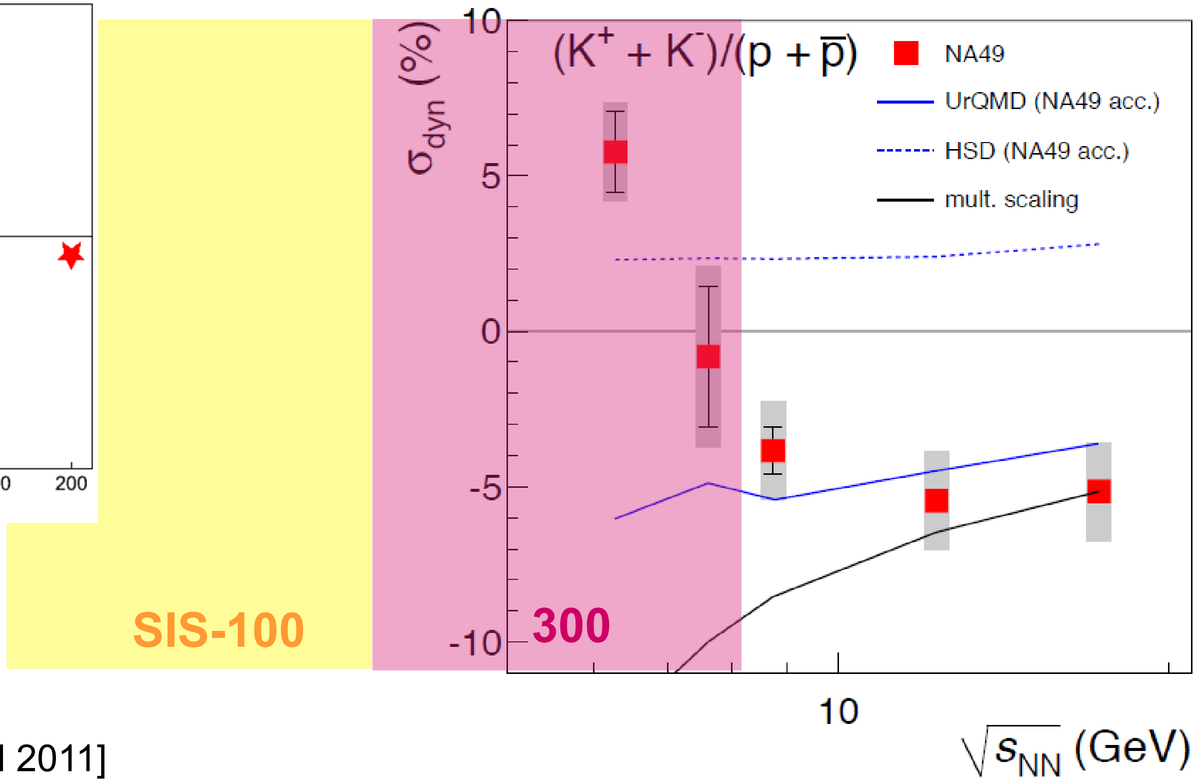
→ search for fluctuations, e.g. particle ratio fluctuations

- many results, no clear picture yet
- importance of systematic studies, e.g. energy & centrality dependencies!

NA49, arXiv:1204.2130: K multiplicity dependence in K/π fluctuations!



[B. Mohanty (STAR) QM 2011]



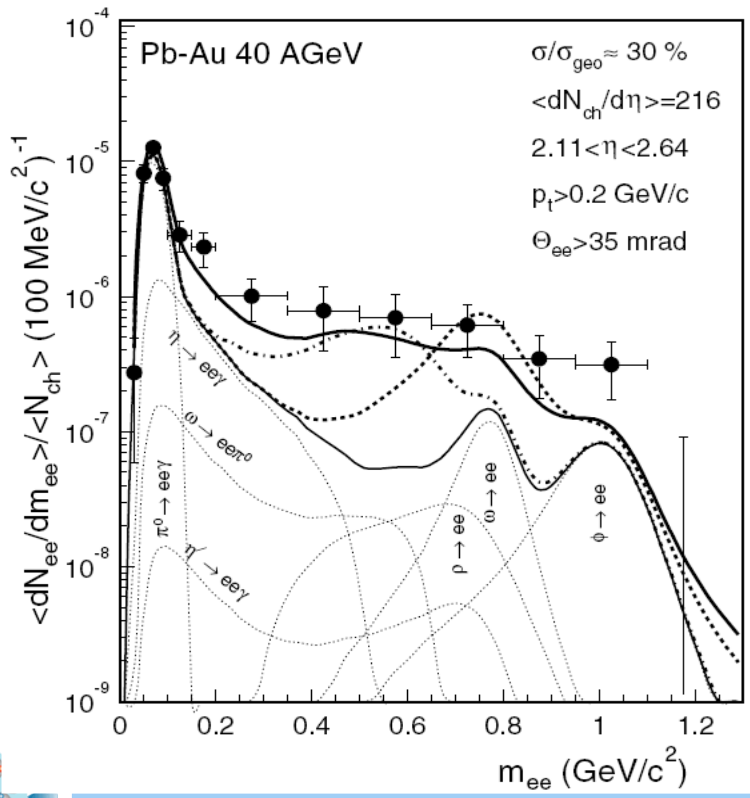
NA49: Phys.Rev. C83 (2011) 061902
T. Schuster, QM11

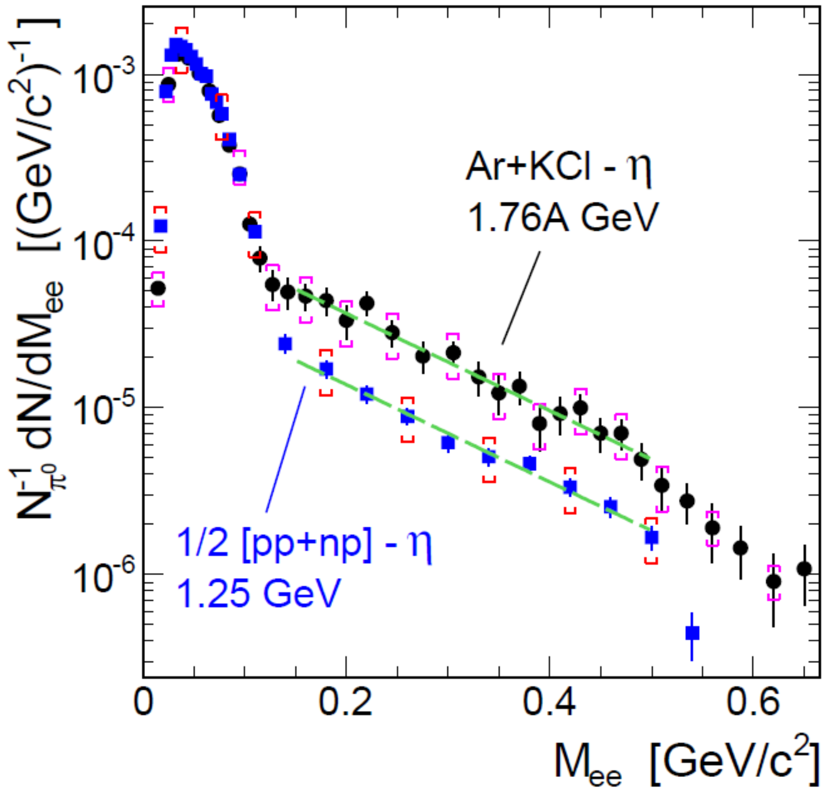
Dileptons as direct probe of high density phase

- CERES at 40 and 158 AGeV beam energy: excess higher at lower energy → importance of baryon density!
- HADES at SIS18: see strong coupling to baryons!

No data between 2 and 40 AGeV beam energy!

[CERES: Eur.Phys.J.C 41, 475 (2005)]





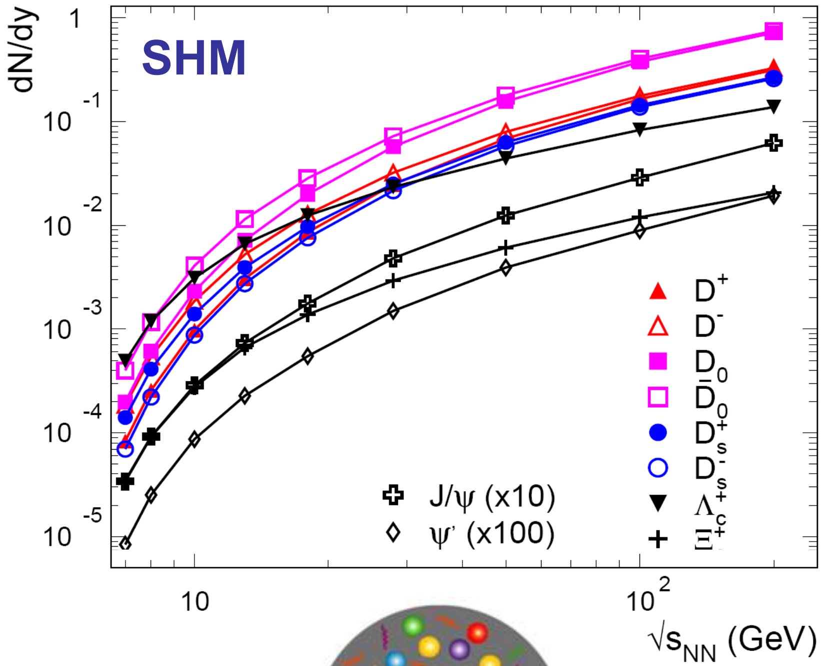
[HADES, Phys.Rev. C84 (2011) 014902]

Charm production in hadronic and partonic matter

→ probing dense baryonic matter on a higher energy scale and searching for the deconfinement phase transition

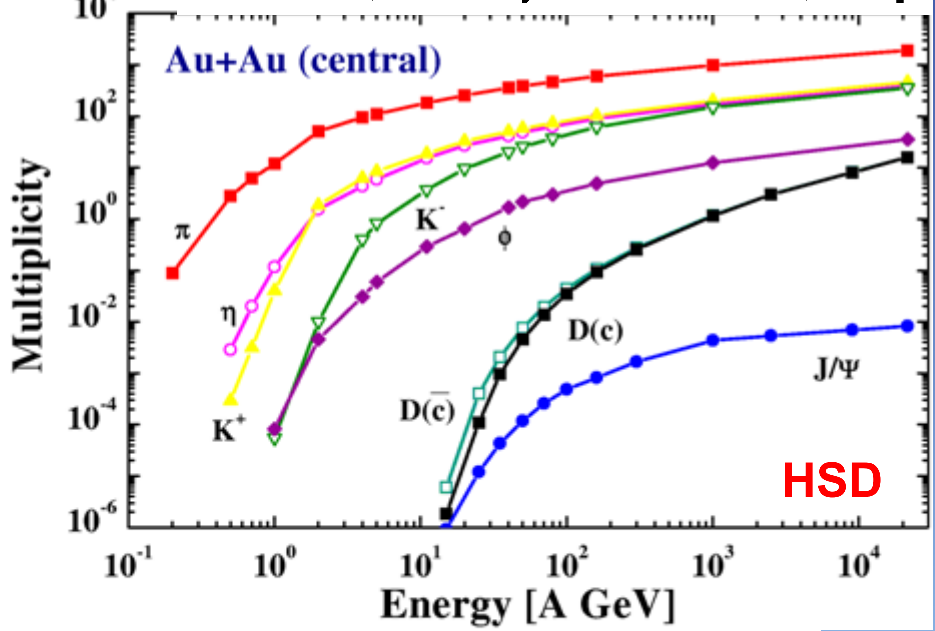
Statistical hadronization model (SHM)
(c-cbar in partonic phase)

[A. Andronic, P. Braun-Munzinger, K. Redlich, J. Stachel, arXiv:0708.1488]

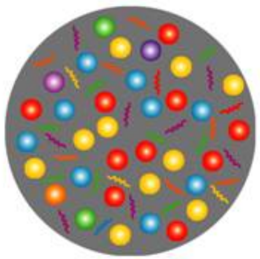


Hadronic model (HSD)

[O. Linnyk, E.L. Bratkovskaya, W. Cassing, H. Stöcker, Nucl.Phys.A786:183-200,2007]



NN → D Λ_c N
NN → DD NN
NN → J/ψ NN

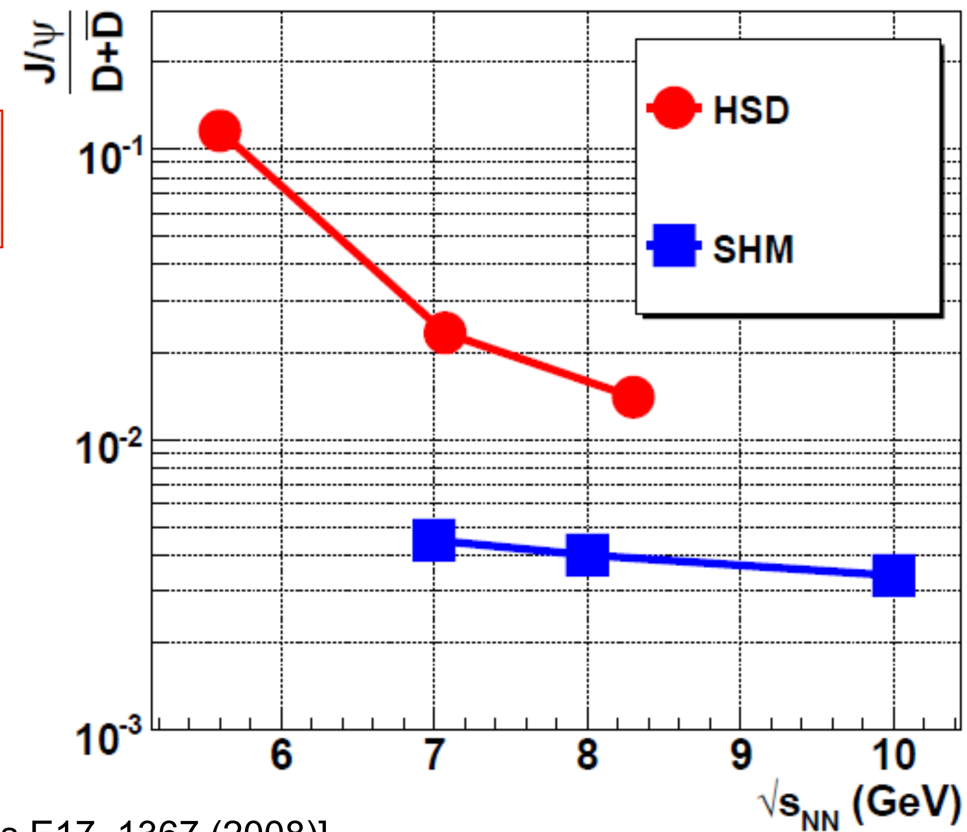


Charm propagation

$\frac{J/\psi}{(D+\overline{D})}$ **ratio for studying the propagation of produced charm quarks in dense matter: quark like or (pre-)hadron like?**

No data below 158 AGeV beam energy!

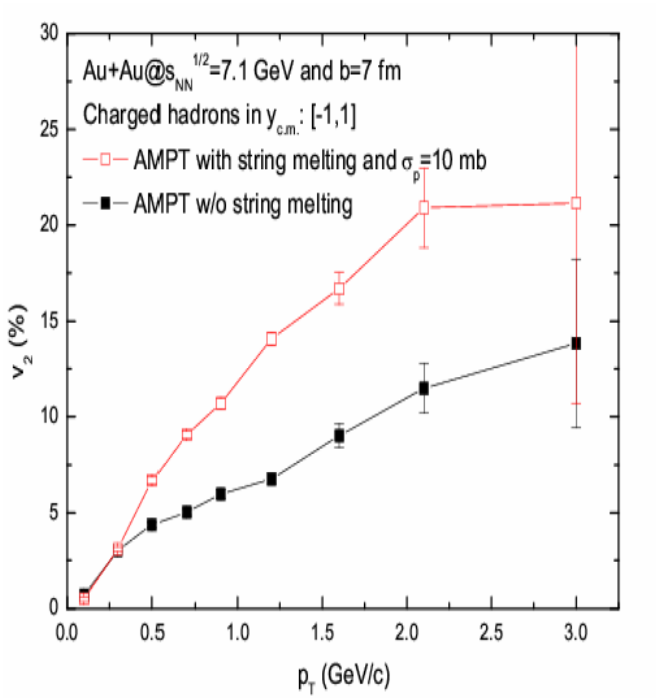
→ find onset of charmonium suppression?



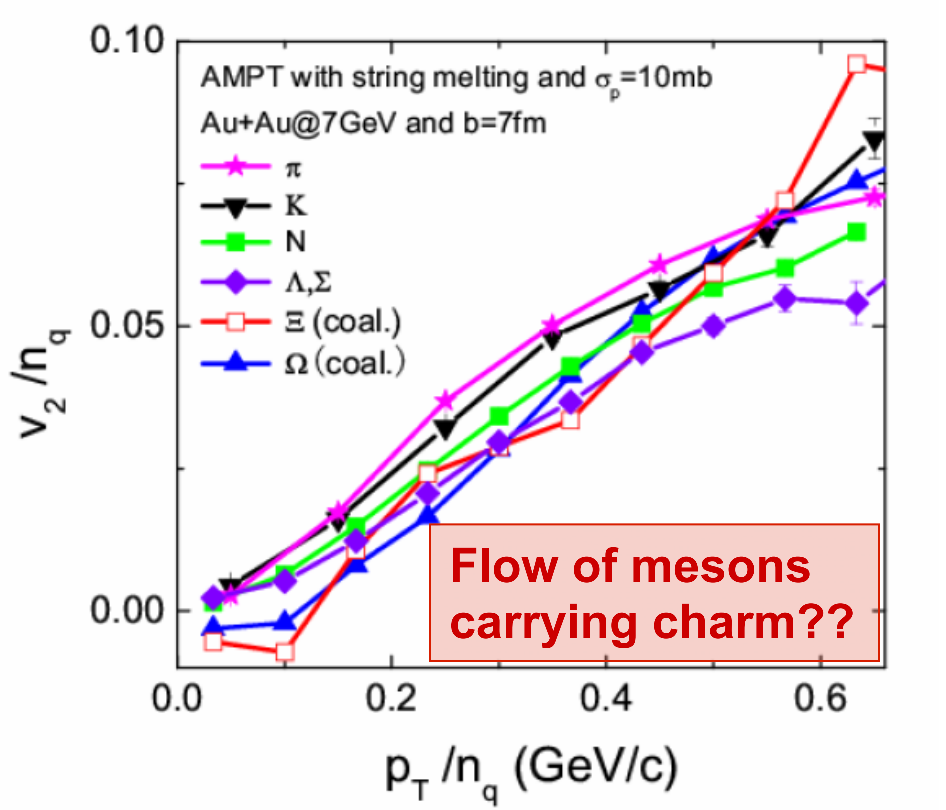
[HSD: O. Linnyk et al., Int.J.Mod.Phys.E17, 1367 (2008)]
[SHM: A. Andronic et al., Phys. Lett. B 659 (2008) 149]

Elliptic flow at FAIR

→ probe EOS!
- new data on identified particles from STAR BES!
- only scarce information for high net-baryon densities (2-40 AGeV)



Partonic scattering enhances elliptic flow



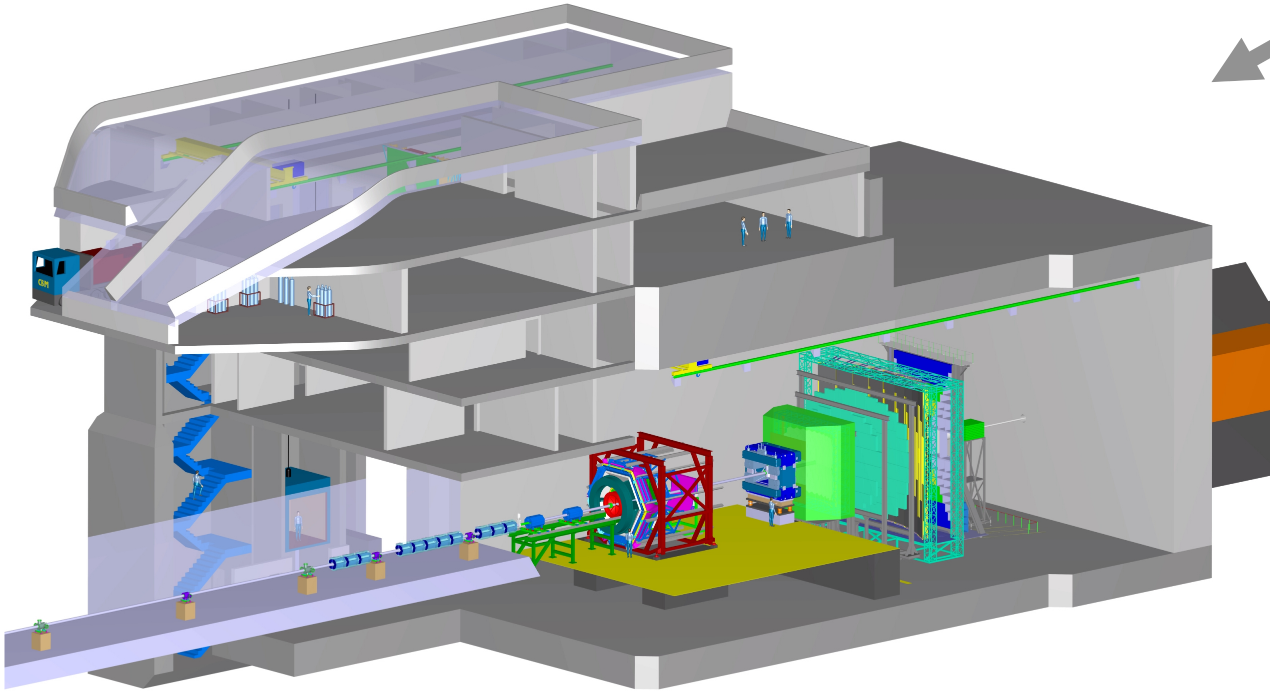
Approximate constituent quark number scaling !

[AMPT calculations: C.M. Ko at CPOD 2007]

The Facility for Antiproton and Ion Research

CBM and HADES at SIS-100 and SIS-300

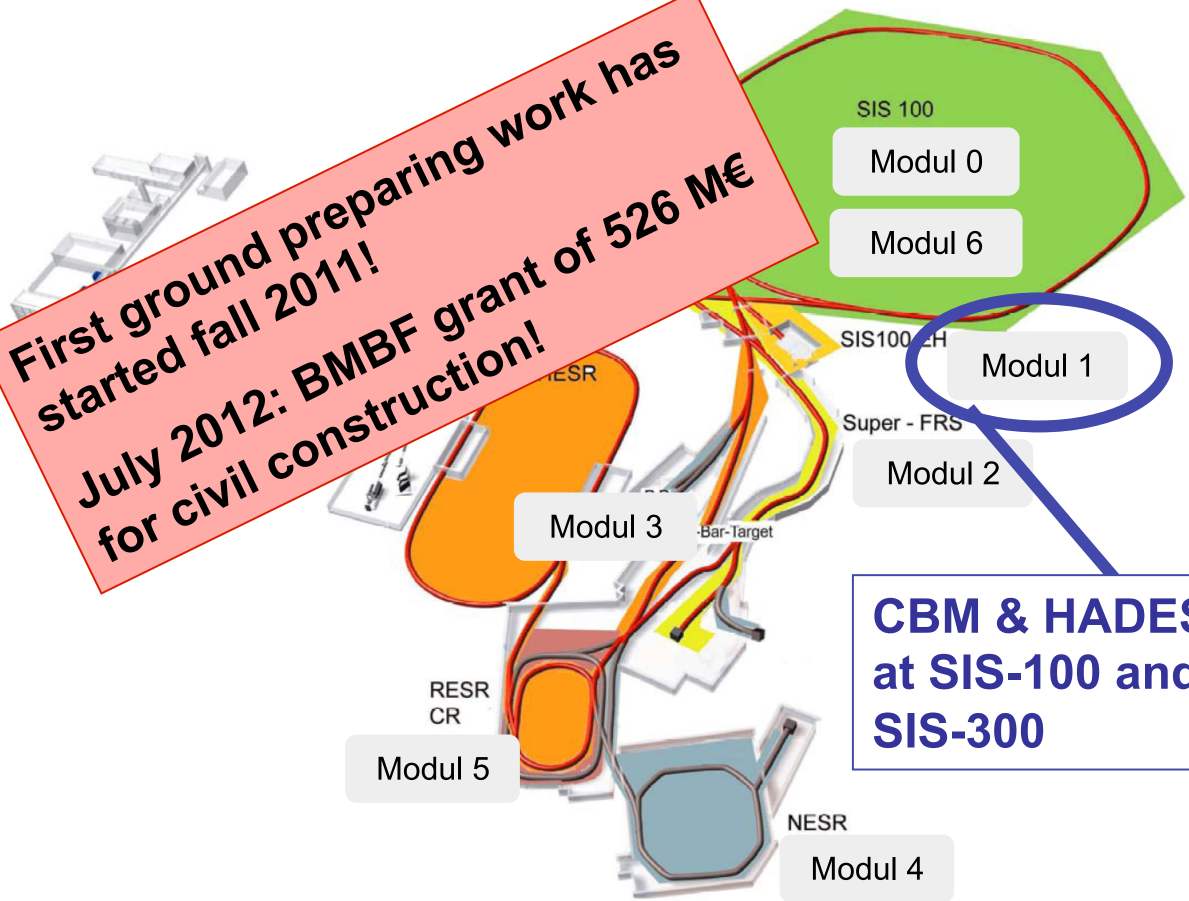
- systematic exploration of high baryon density matter in A+A collisions from 2 – 45 AGeV beam energy with 2nd generation experiments
- explore the QCD phase diagram, high baryon density matter, chiral symmetry restauration



FAIR: Modularized start version

First ground preparing work has started fall 2011!

July 2012: BMBF grant of 526 M€ for civil construction!



Module 0: SIS-100

Module 1: CBM cave, APPA hall

Module 2: Super-FRS and R3B

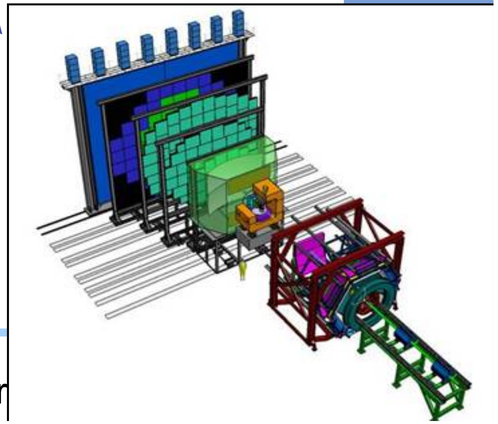
Module 3: Anti-proton facility

Module 4: LE-NuSTAR, NESR, FLAIR

Module 5: RESR

Module 6: SIS-300

CBM & HADES at SIS-100 and SIS-300



Modules 0 – 3:
Start of construction 2011, completion until 2017

Modules 4-6:
Start and completion of construction not fixed

CBM @ SIS-100

The first years of CBM operation will be at SIS-100 with a start setup

Beam	$p_{lab, max}$	$\sqrt{s_{NN, max}}$
heavy ions (Au)	11A GeV	4,7 GeV
light ions (Z/A = 0.5)	14A GeV	5,3 GeV
protons	29 GeV	7,5 GeV

Physics case at SIS-100:

- What are the equation of state and the degrees of freedom of strongly interacting matter at densities as present in the cores of neutron stars?
- What are the properties of hadrons in dense matter? Is chiral symmetry restored?
- Does strangeness exist in form of heavy, meta-stable objects?
- How is charm produced close to the threshold, and how does it propagate in cold nuclear matter?

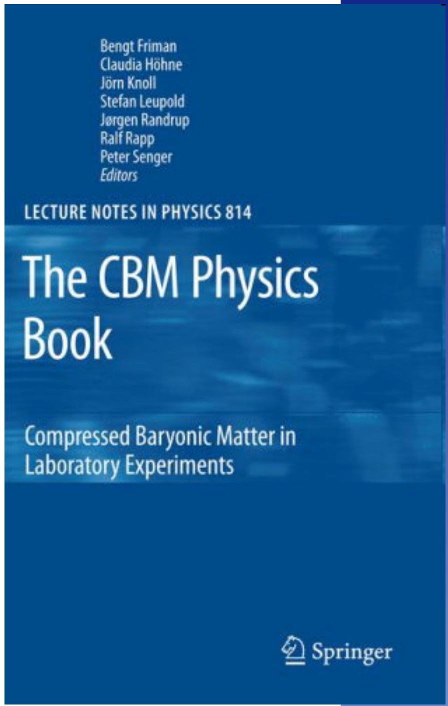
CBM: Physics topics and Observables

The equation-of-state at high ρ_B
- collective flow of hadrons
- particle production at threshold energies (open charm)

Deconfinement phase transition at high ρ_B
- excitation function and flow of strangeness (K, Λ, Σ, Ξ, Ω)
- excitation function and flow of charm (J/ψ, ψ', D^0, $D^{\pm}$, Λ_c)
- charmonium suppression, sequential for J/ψ and ψ' ?

QCD critical endpoint
- excitation function of event-by-event fluctuations (K/π,...)

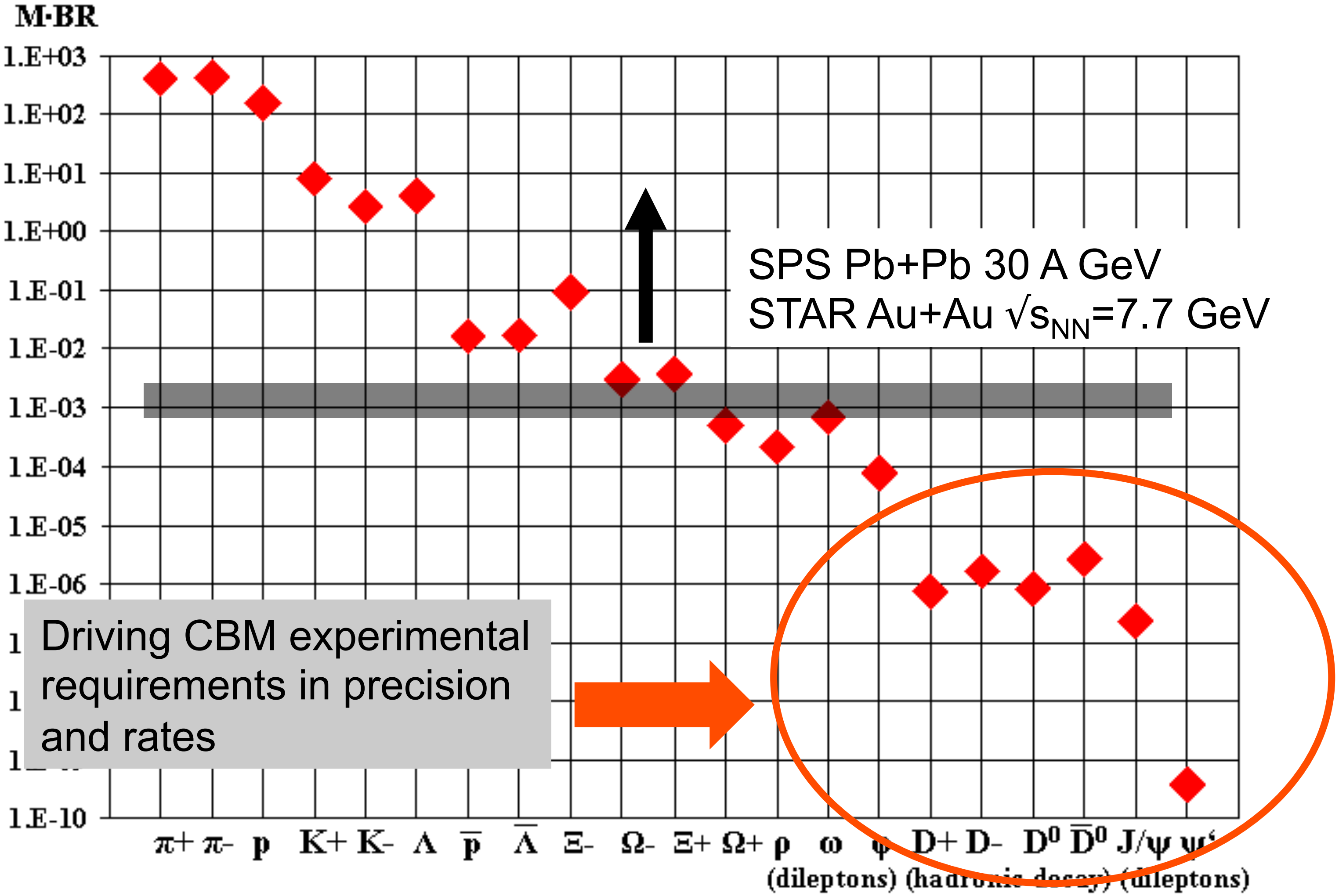
Onset of chiral symmetry restoration at high ρ_B
- in-medium modifications of hadrons ($\rho,\omega,\phi \rightarrow e^+e^-(\mu^+\mu^-)$, D)



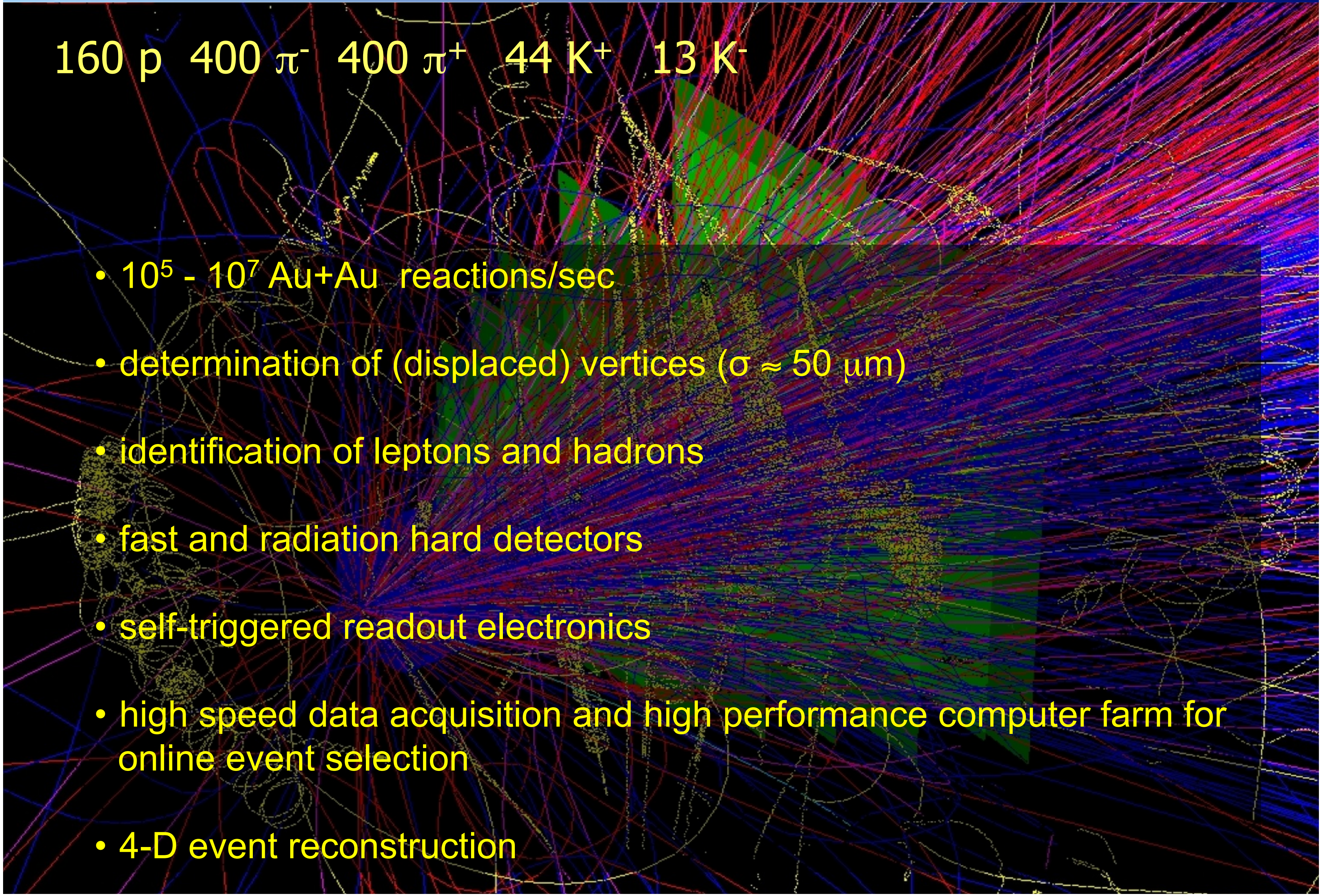
Systematics & precision!!
Rare probes as messengers from the medium!
→ characterization of the created medium!

Particle multiplicities & experimental challenges

Particle multiplicity · branching ratio for min. bias Au+Au collisions at 25 GeV (from HSD and thermal model)



Central Au+Au collision at 25 AGeV (UrQMD+GEANT)



160 p 400 π^- 400 π^+ 44 K^+ 13 K^-

- 10^5 - 10^7 Au+Au reactions/sec
- determination of (displaced) vertices ($\sigma \approx 50\ \mu$m)
- identification of leptons and hadrons
- fast and radiation hard detectors
- self-triggered readout electronics
- high speed data acquisition and high performance computer farm for online event selection
- 4-D event reconstruction

The CBM experiment

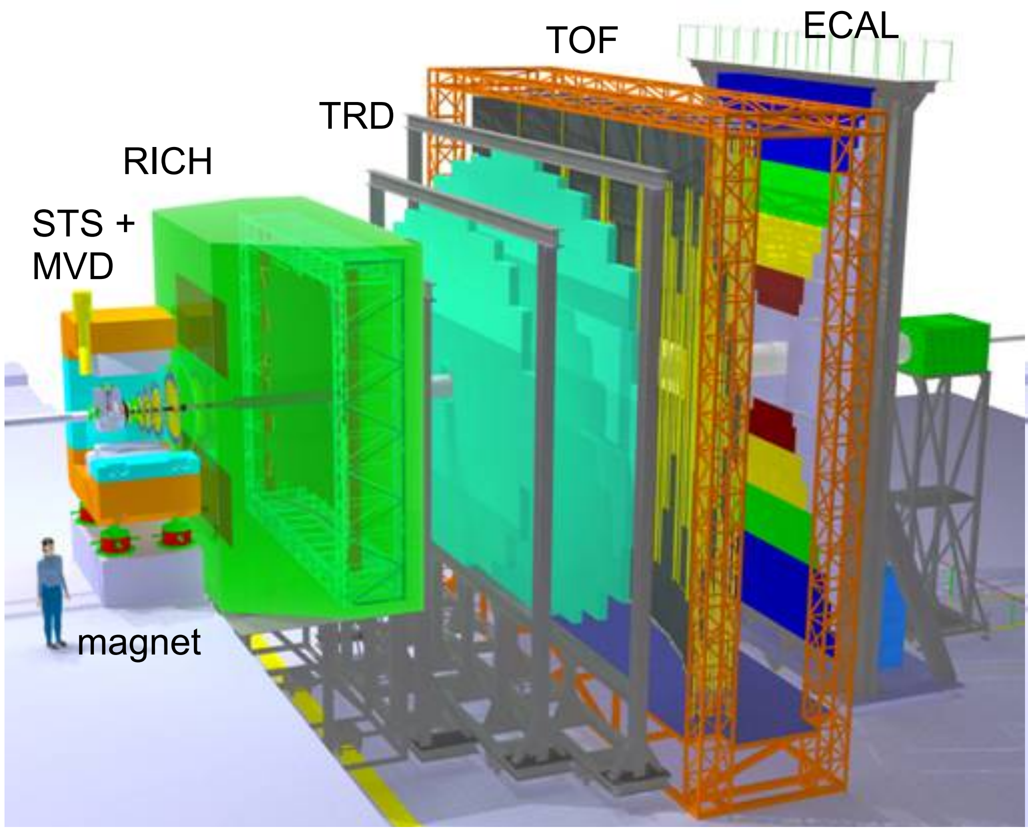
• tracking, momentum determination, vertex reconstruction: radiation hard silicon pixel/strip detectors (STS) in a magnetic dipole field

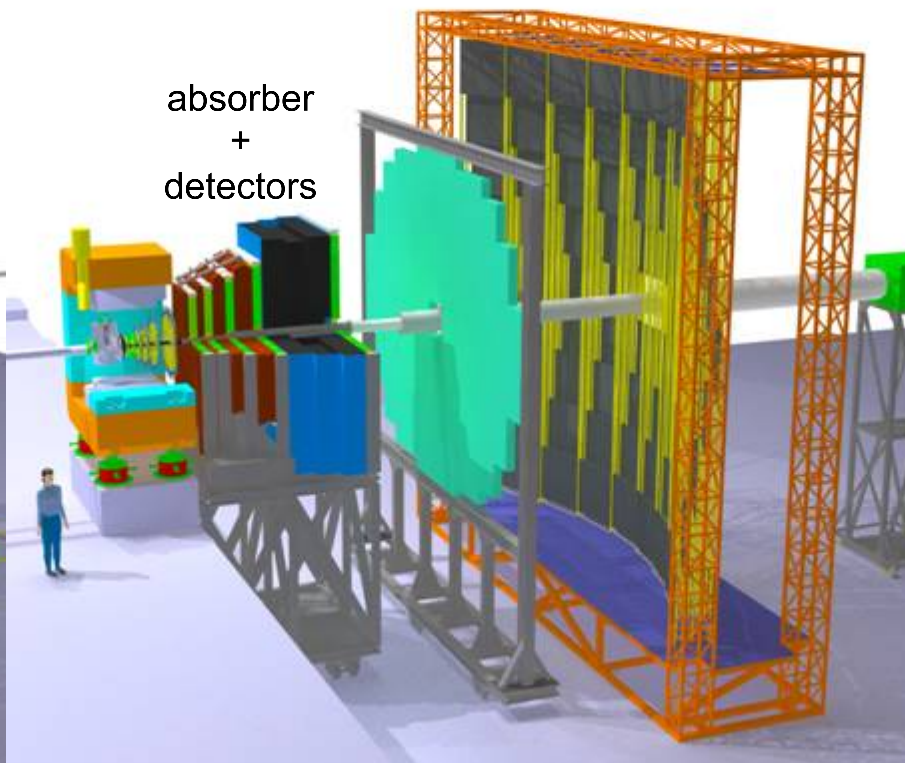
• hadron ID: TOF (& RICH)
• photons, π^0, η: ECAL

• PSD for event characterization
• high speed DAQ and trigger $\rightarrow$ **rare probes!**

• **electron ID**: RICH & TRD
  $\rightarrow$ π suppression $\geq 10^4$

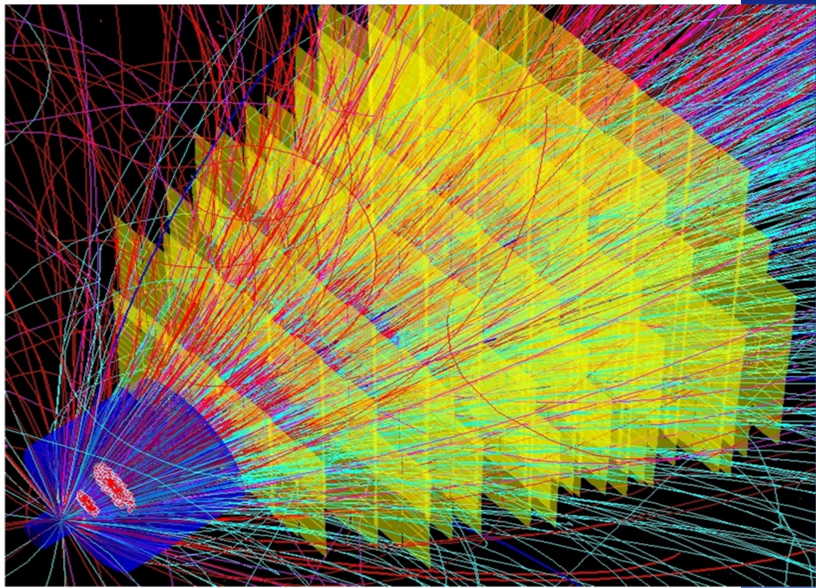
• **muon ID**: absorber + detector layer sandwich
  $\rightarrow$ move out absorbers for hadron runs

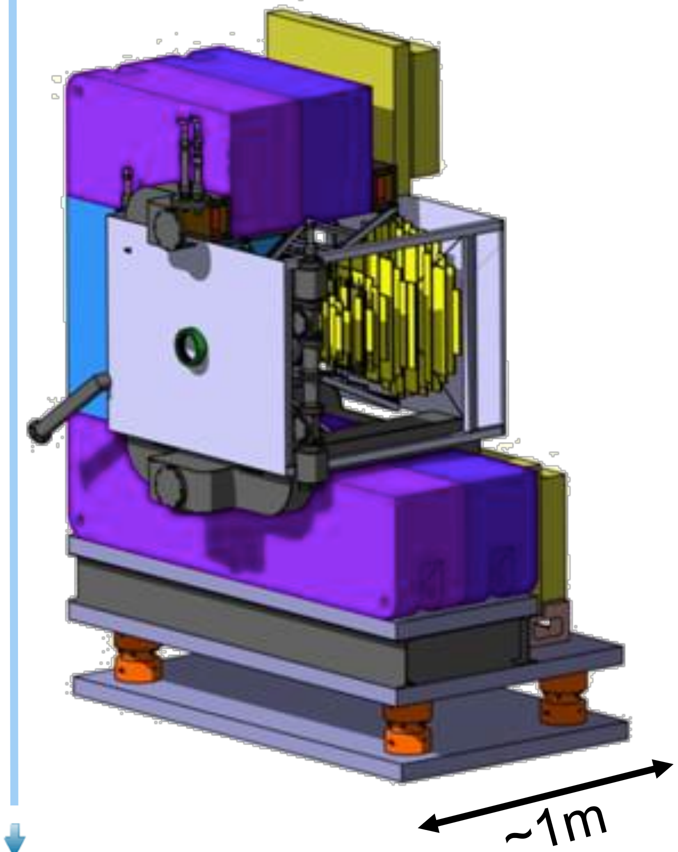


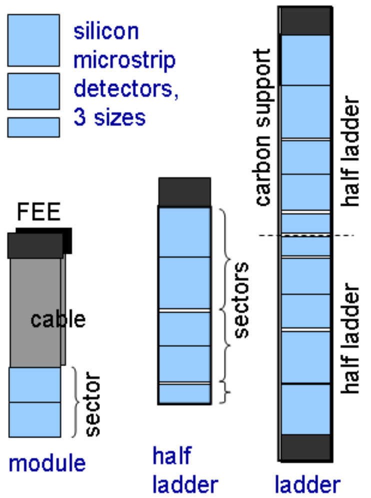


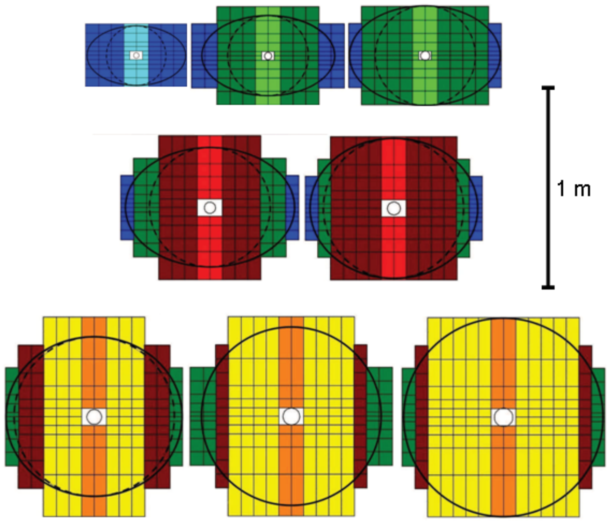
Silicon Tracking System

double sided silicon microstrip detector
7.5° stereo angle, 58 μm pitch, 300 μm thick, bonded to ultra-thin micro-cables, radiation hardness





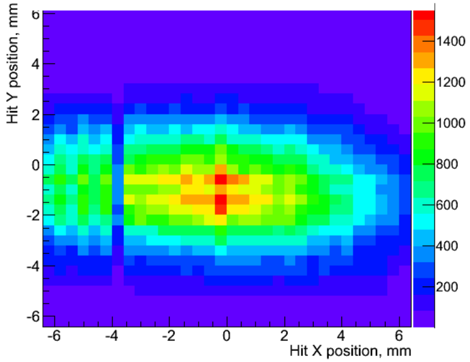


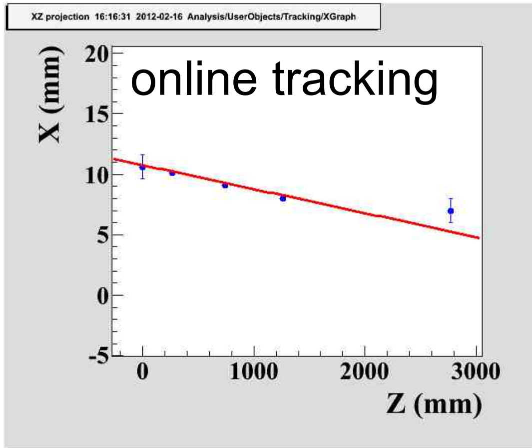


Silicon Tracking System

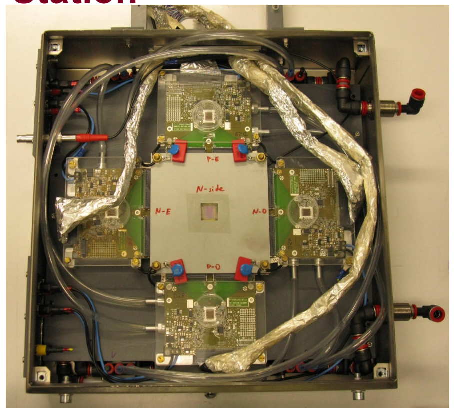
Results from last beam test, January 2012
proton beam at 2.4 GeV

beam spot,
1st STS station

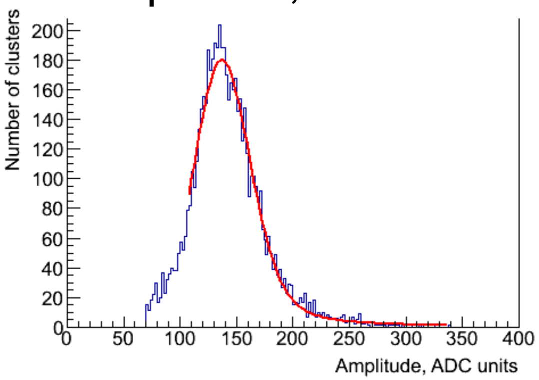


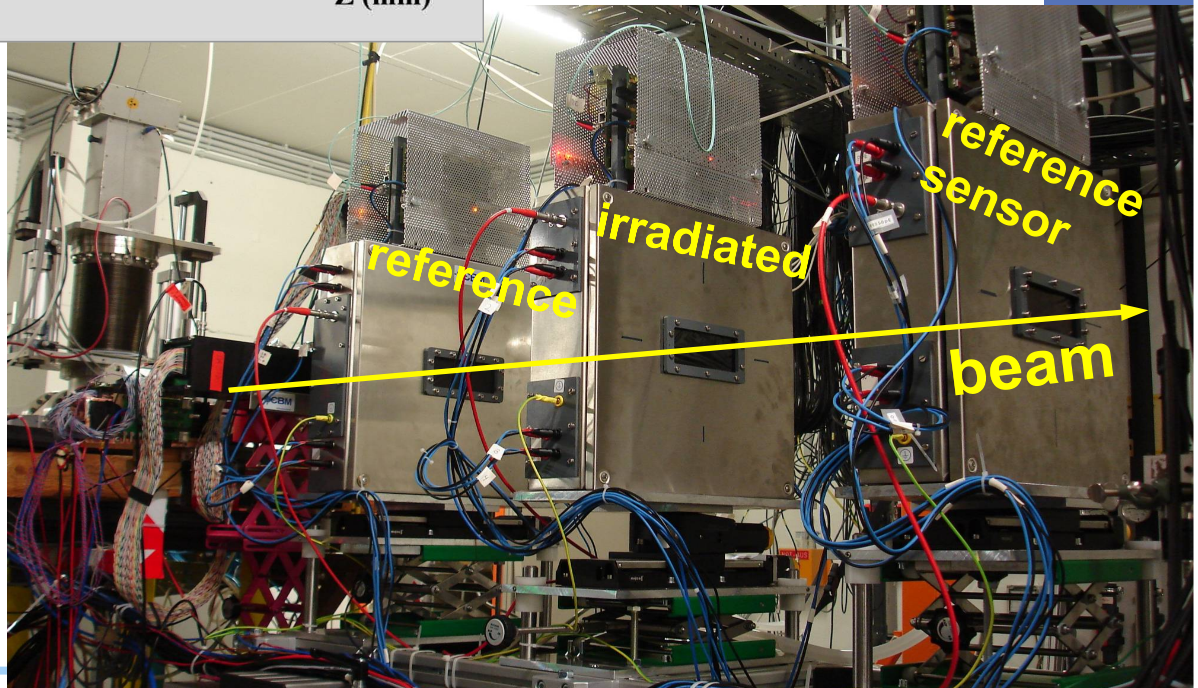


Station

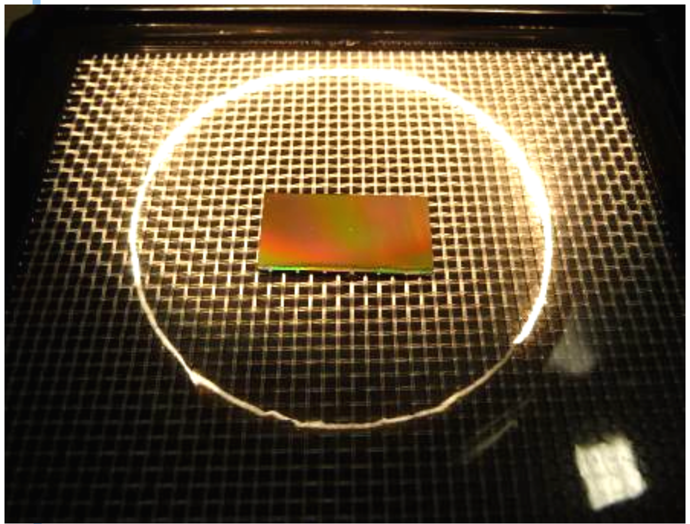


1-strip signal
amplitude, n-side





Micro Vertex Detector



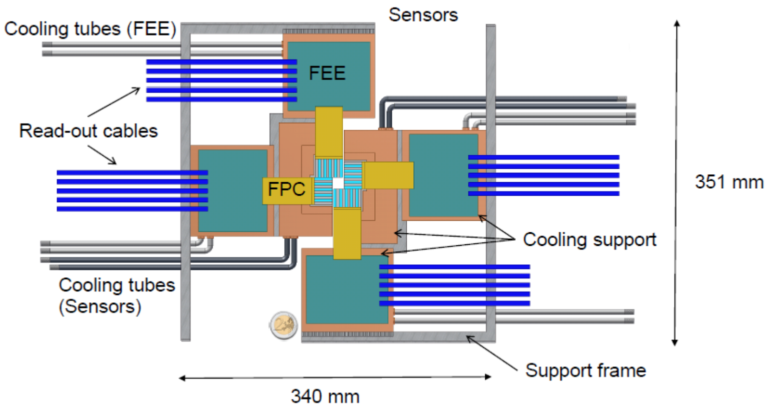
Monolithic Active Pixel Sensors (MAPS, also CMOS-Sensors)

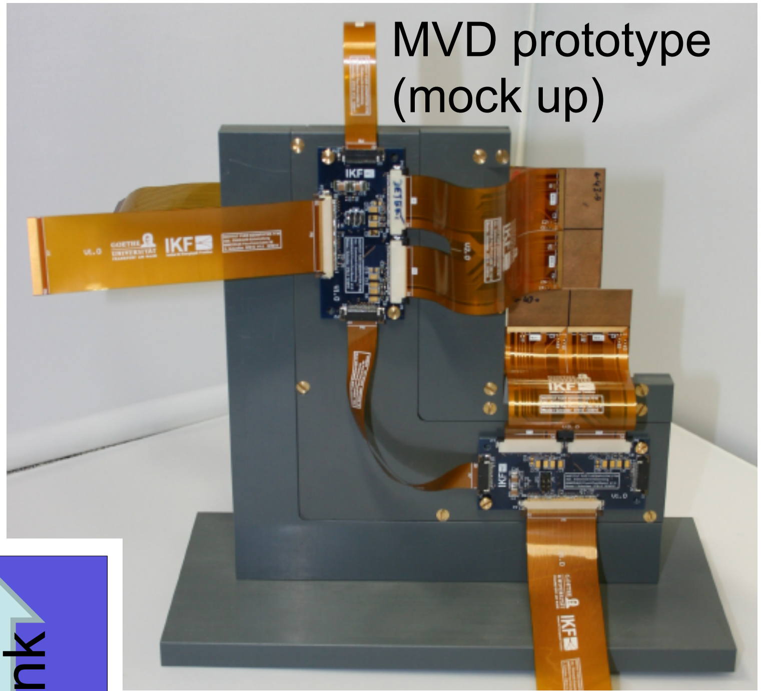
- Invented by industry (digital camera)
- Modified for charged particle detection since 1999 by IPHC Strasbourg
- Also foreseen for ILC, STAR, ALICE… => Sharing of R&D costs.

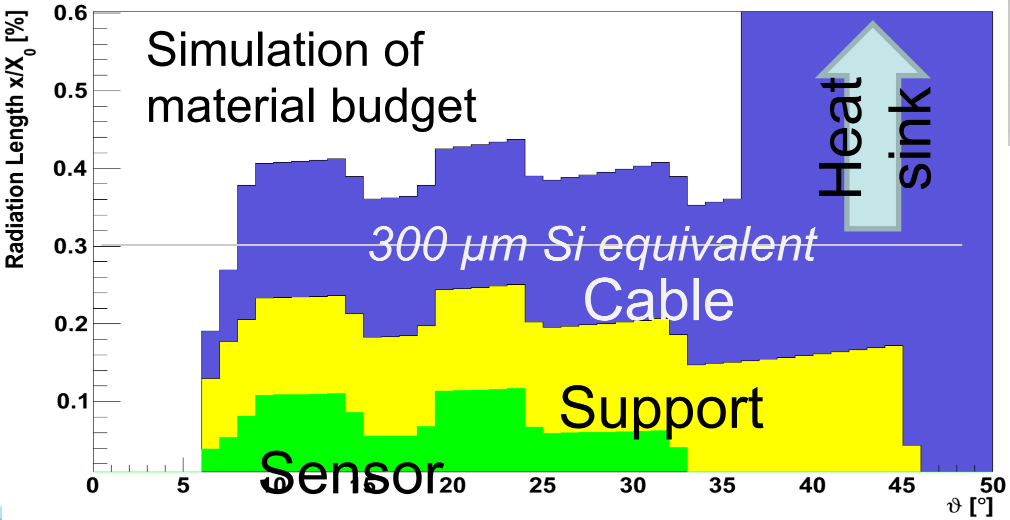
		Optimized for one parameter		Current compromise
	CBM SIS300	MAPS* (2003)	MAPS* (2012)	MIMOSA-26 Binary, Ø
Single point res.	**~ 5 µm**	**1.5 µm**	**1 µm**	**4 µm**
Material budget	**< 0.3% X_0**	**~ 0.1% X_0**	**~ 0.05% X_0**	**~ 0.05% X_0**
Rad. hard. non-io.	**>10^{13} n_{eq}**	**10^{12} n_{eq}/cm^2**	**>3x10^{14} n_{eq}**	**>10^{13} n_{eq}**
Rad. hard. io	**> 3 Mrad**	**200 krad**	**> 1 Mrad**	**> 500 krad**
Time resolution	**< 30 µs**	**~ 1 ms**	**~ 25 µs**	**110 µs**

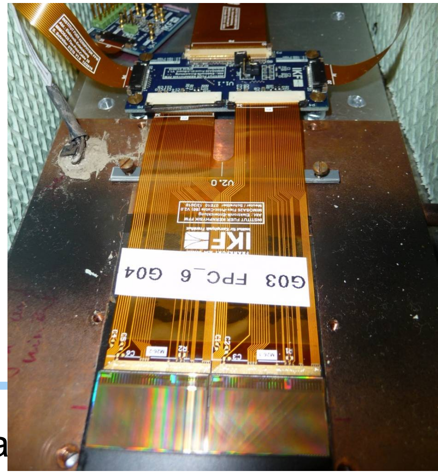
Micro Vertex Detector

Complete prototype under preparation to be tested in 2012





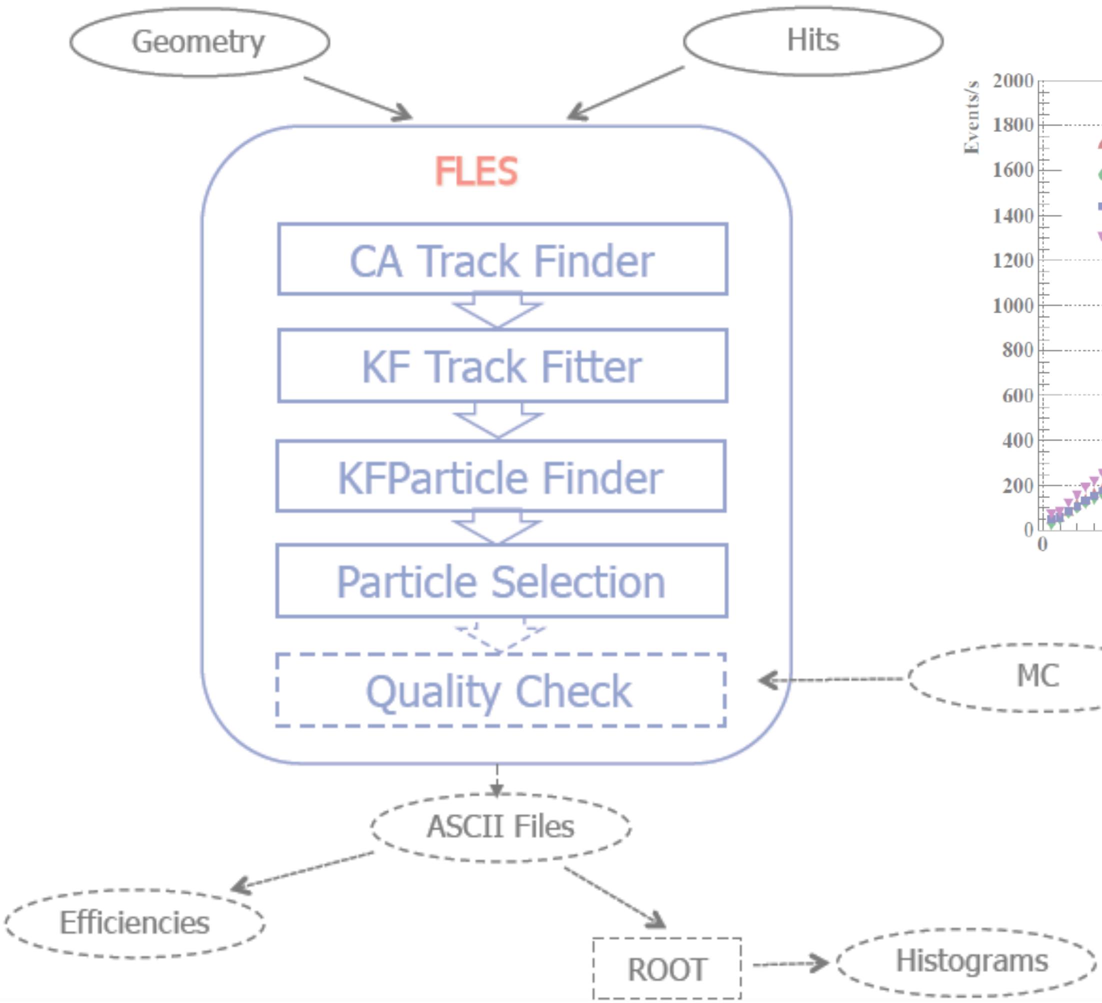


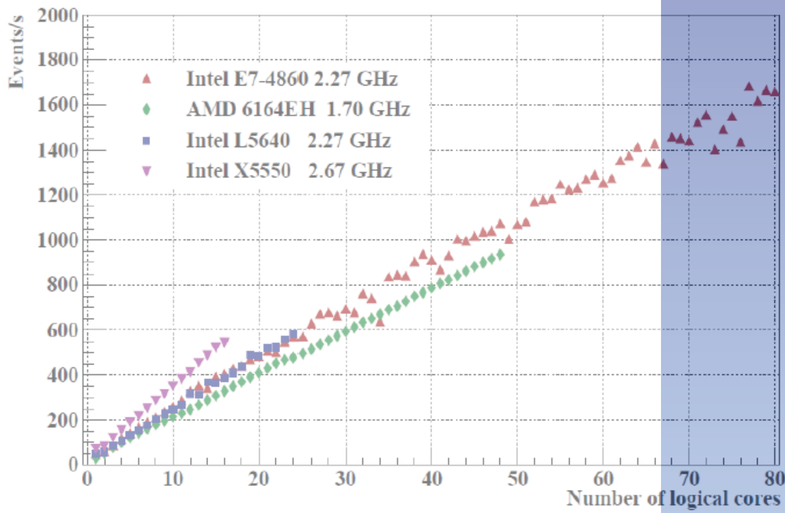


Standalone FLES package

FLES = First Level Event Selection

portable, effcient, SIMDized, parallelized





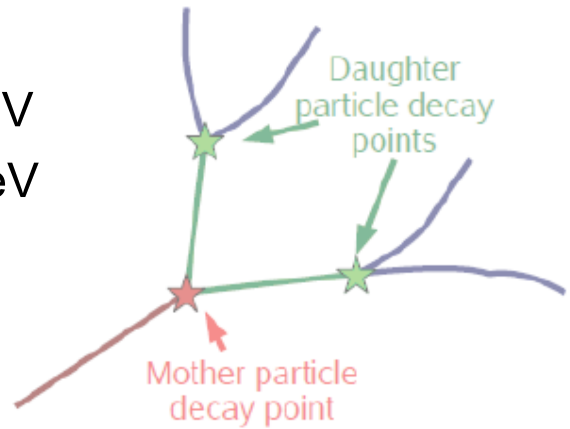
shows scalability up to 80 cores

KFParticle Finder

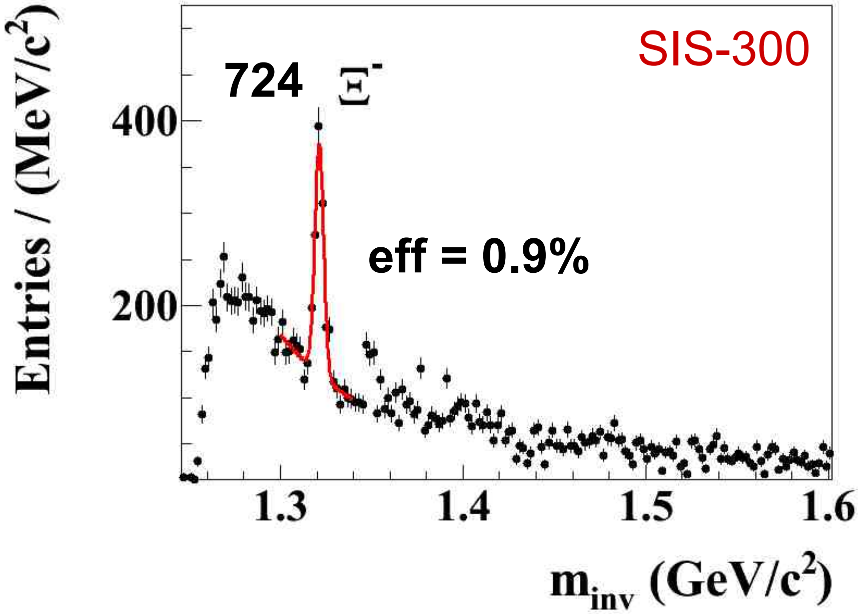
tracking + secondary vertex finder:

- 8 ms/core in minbias Au+Au events, 25 AGeV
- 62 ms/core in central Au+Au events, 25 AGeV

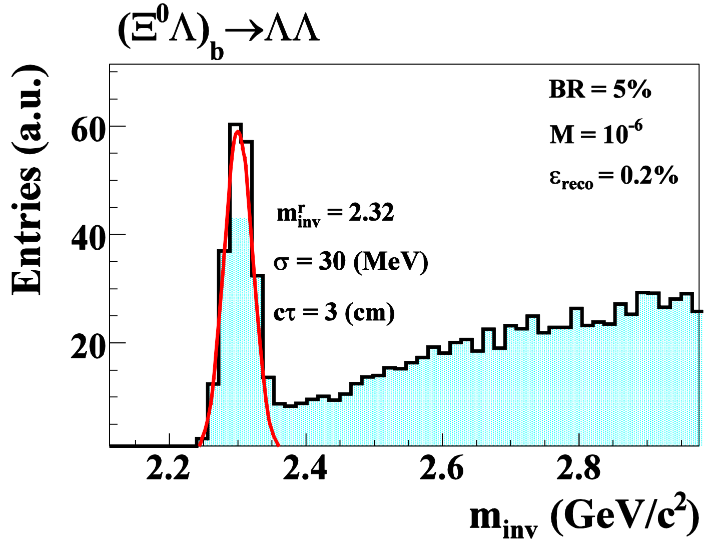
→ works as well for exoctics: measurable if existing, reasonable rates!



central Au+Au, 25 AGeV, 80k events



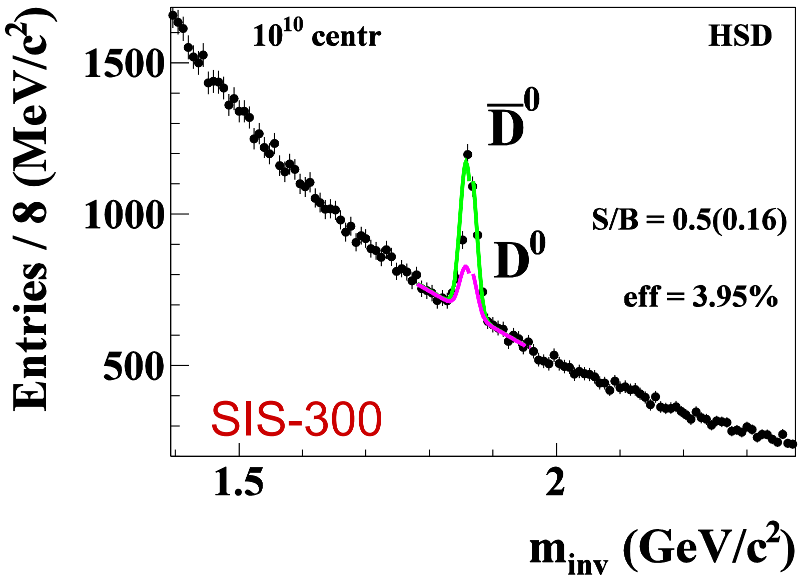
$(\Xi^0\Lambda)_b \rightarrow \Lambda\Lambda$ ($c\tau$=3cm)



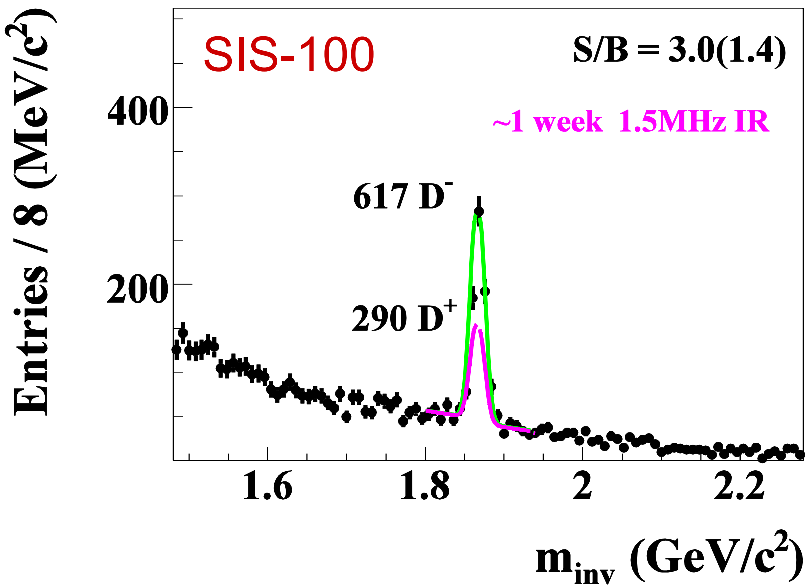
Open charm simulation at SIS-100 and 300

- secondary vertex reconstruction with a precision of 60 μm
- 2 MVD detectors at 5 and 10 cm from the main vertex
- realistic detector response
- 10^{12} minb. events 25 AGeV Au+Au: few 10k D_0 and about twice as much $D^{\pm}$

central Au+Au coll. at 25 AGeV (10^{10} events)



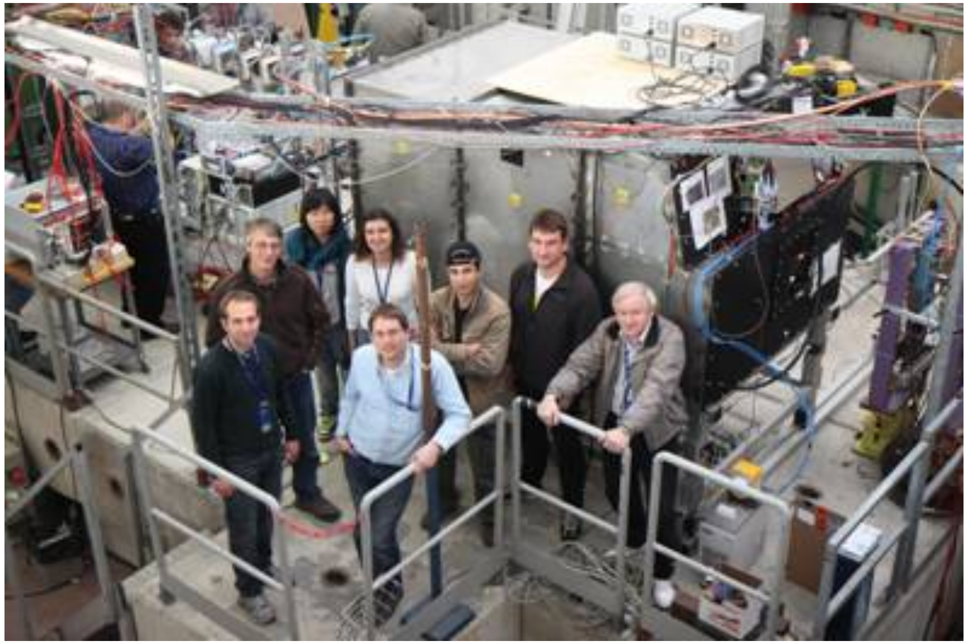
p+C collisions at 30 GeV (10^{12} events)



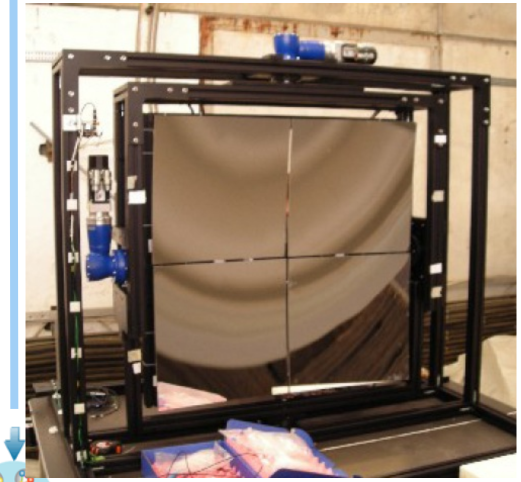
RICH Detector

RICH radiator box filled with CO_2

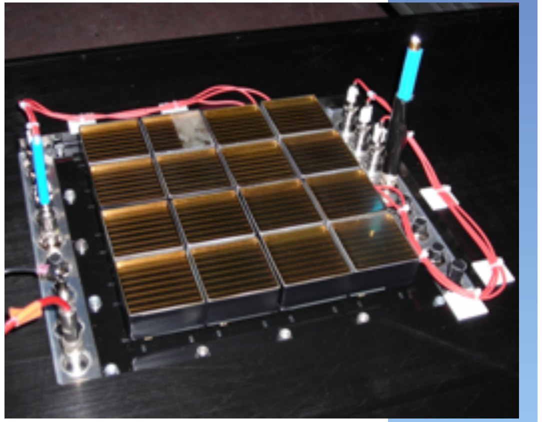
elaborated gas system



real dimension prototype in test beam at CERN, October 2011

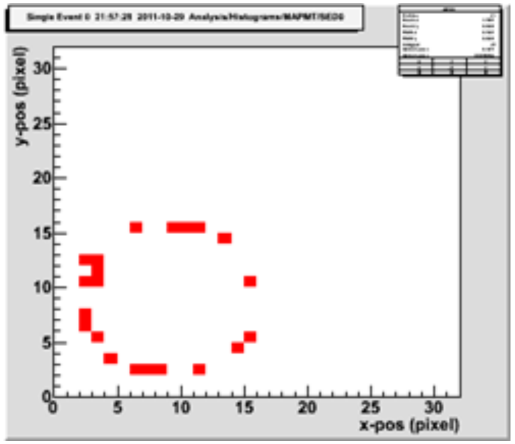


photocamera with 16 MAPMTs (H8500, H10966); 1024 channels; selftriggered n-XYter readout; w & w/o WLS coating

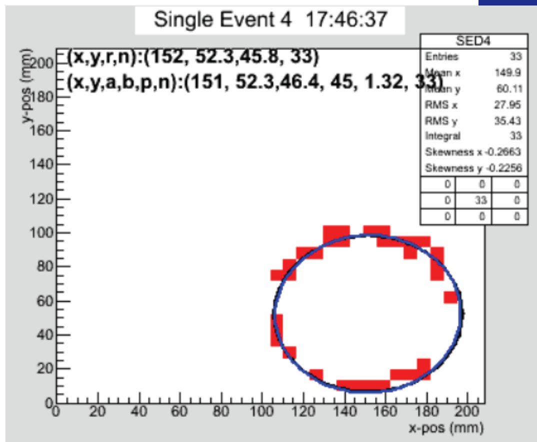


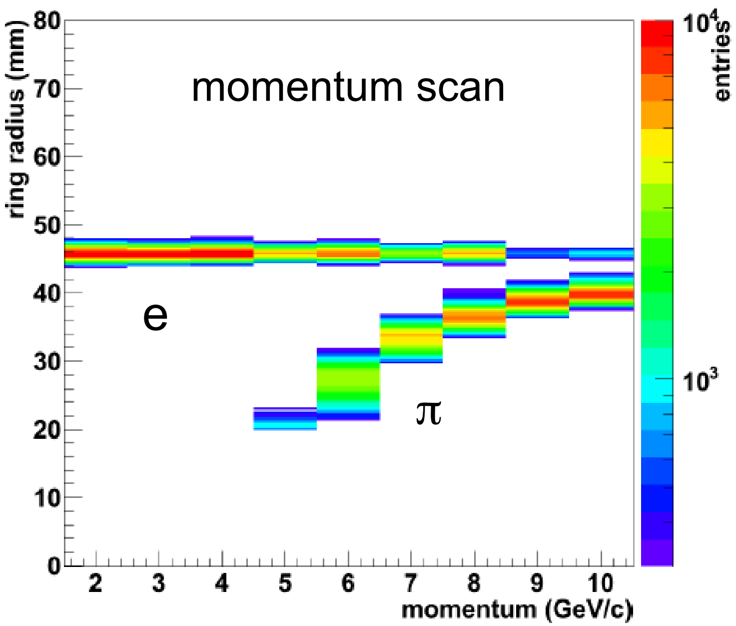
2x2 mirror array
scan of RICH camera
with movable mirror frames

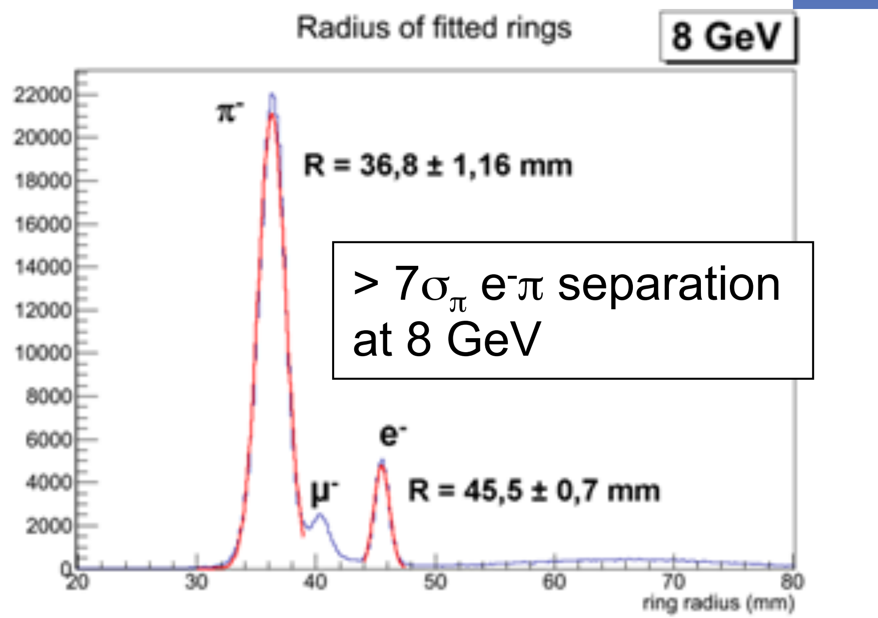
RICH Detector



typical single event display!
≥ 20 hits/ ring
noise/channel ~10Hz
online ring fit







> $7\sigma_\pi$ $e^-\pi$ separation at 8 GeV

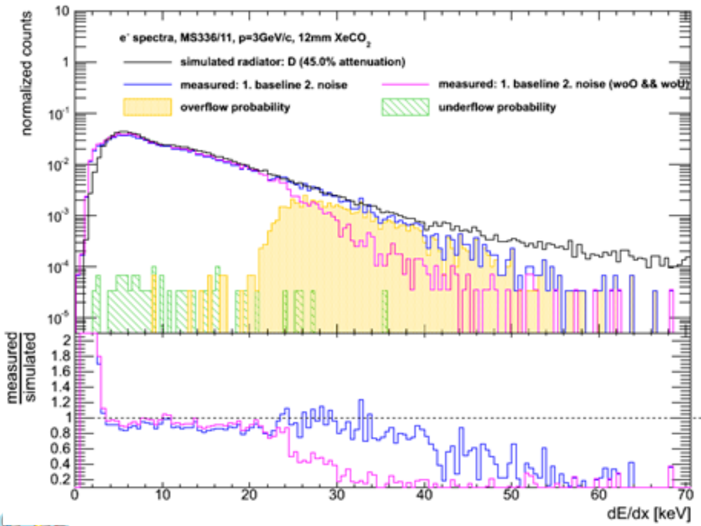
TRD

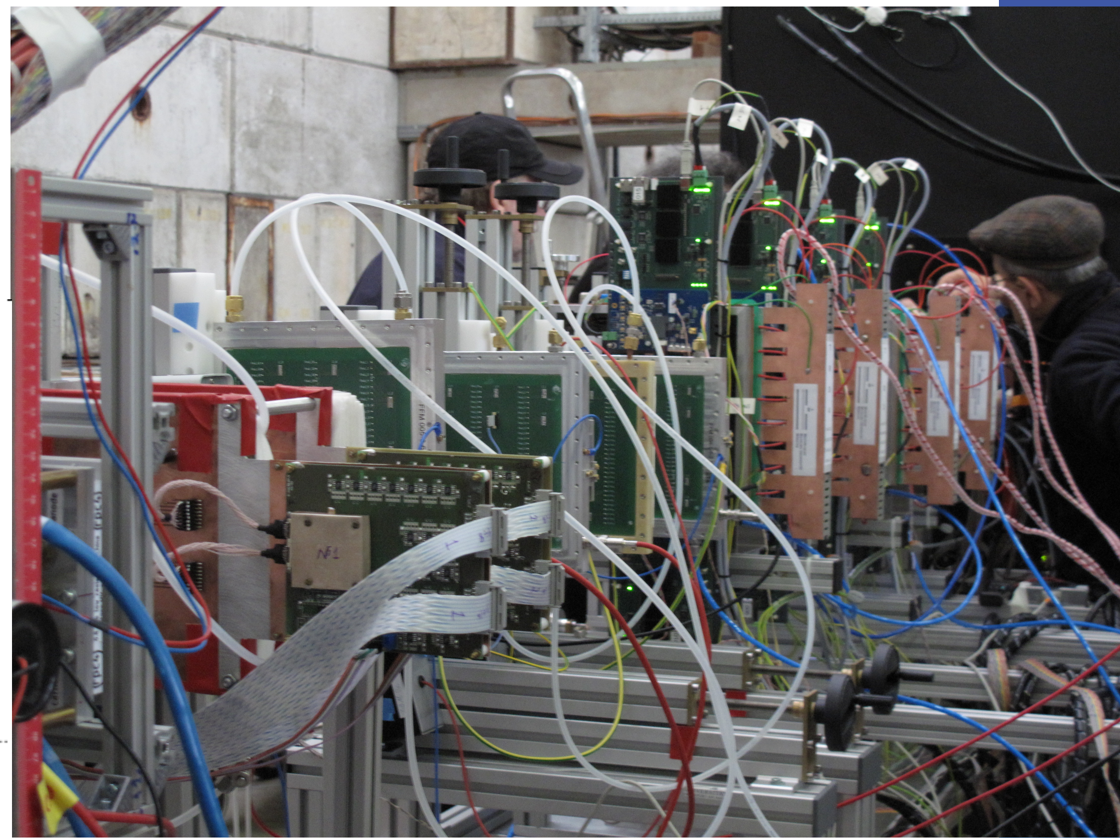
beamtest at CERN, October 2011:

- test 12 different chamber types (w & w/o drift, distances…)
- test different radiator types (fibers, foils,…)
- very nice agreement of simulated and measured data for the energy spectra

next: real dimension chamber (60x60)cm²

e-spectrum





Dilepton simulations: LMVM & charmonium

realistic detector response

electrons: 1‰ target

LMVM di-electrons:

background dominated by $e^{\pm}$ from π^0 Dalitz decays

statistics shown correspond to few s beamtim only!

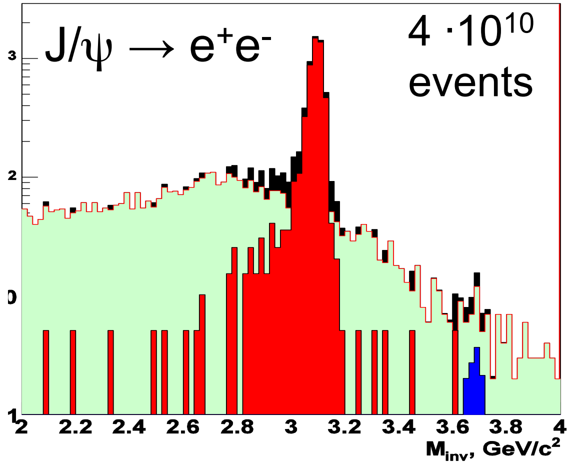
SIS-100: RICH only!

muons at SIS-100:

start setup for charmonium measurements

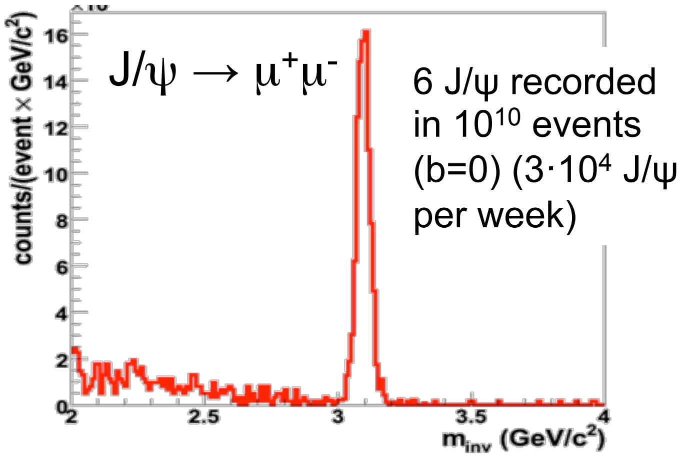
SIS-300

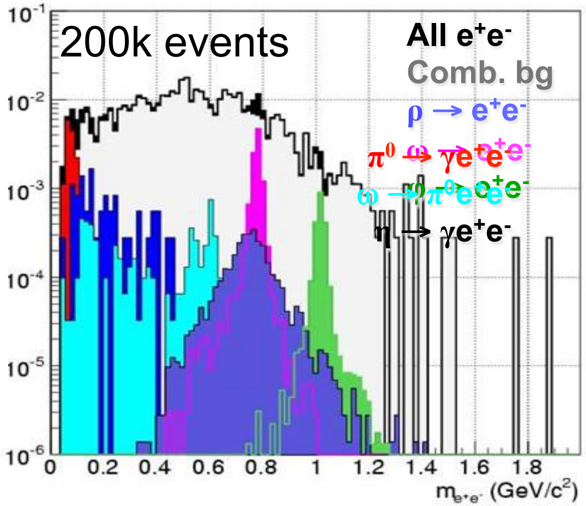
central Au+Au at 25 AGeV



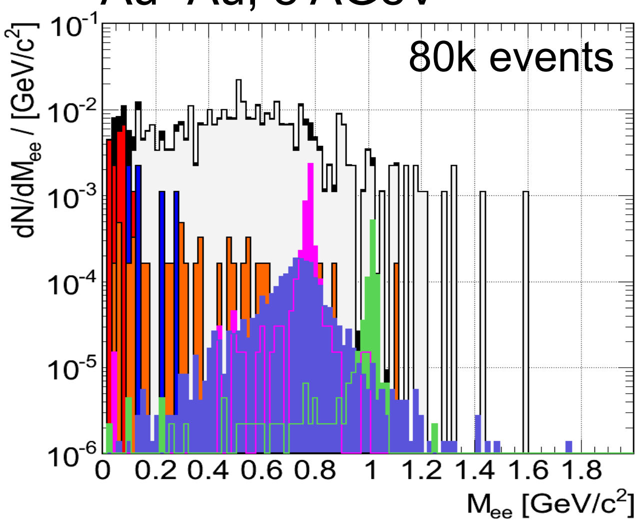
SIS-100

p+C at 30 GeV





Au+Au, 8 AGeV



Summary

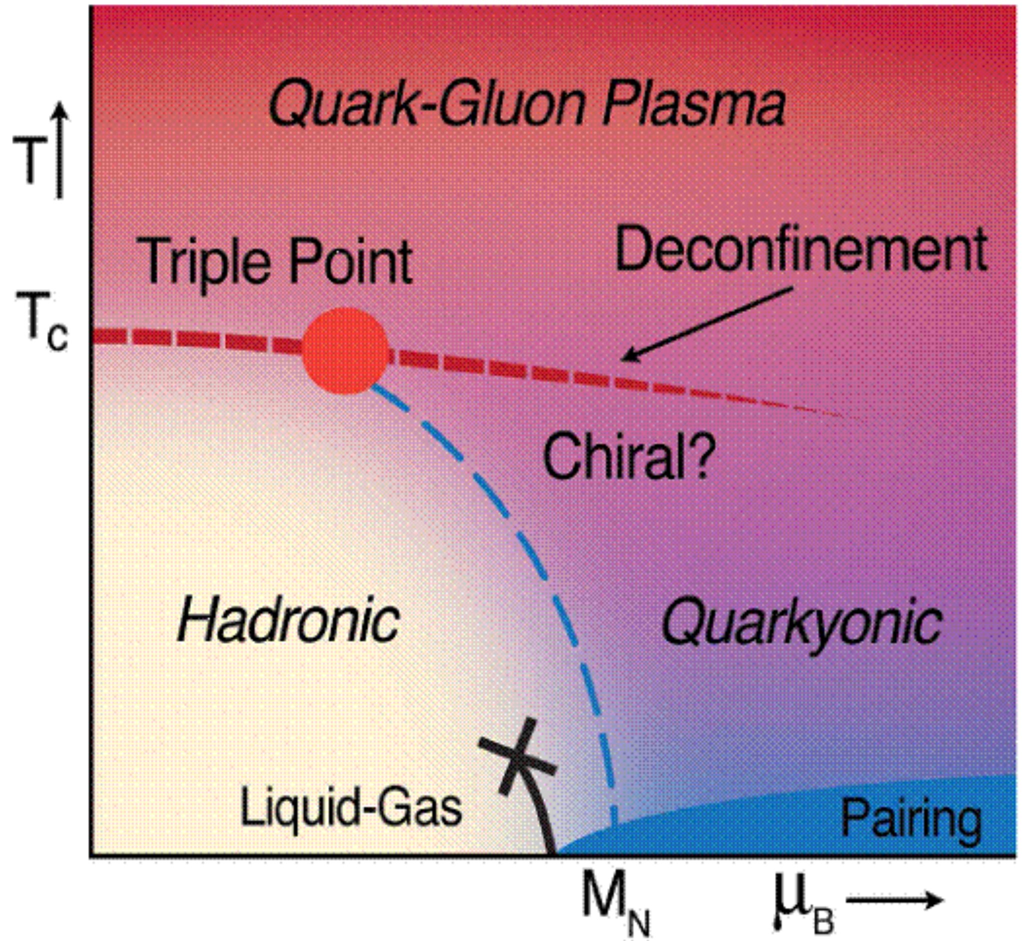
CBM@FAIR – high μ_B, moderate T:

- exploration of QCD phase diagram at high baryon densities at SIS-100 and SIS-300 (2-45 AGeV beam energy)

  → unique feature: rare probes!

- together with HADES unique possibility of characterizing properties of baryon dense matter
- implementation of increasingly realistic detector response in simulations, parallelization of event reconstruction, physics performance studies
- detector R&D, TDRs on the way

[A. Andronic et al., arXiv:0911.4806]



CBM collaboration

China:
Tsinghua Univ., Beijing
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. Gießen
Univ. Heidelberg, Phys. Inst.
Univ. HD, Kirchhoff Inst.
Univ. Frankfurt
Univ. Mannheim
Univ. Münster
FZ Rossendorf
GSI Darmstadt
Univ. Tübingen
Univ. Wuppertal

Hungaria:
KFKI Budapest
Eötvös Univ. Budapest

India:
Aligarh Muslim Univ., Aligarh
IOP Bhubaneswar
Panjab Univ., Chandigarh
Gauhati Univ., Guwahati
Univ. Rajasthan, Jaipur
Univ. Jammu, Jammu
IIT Kharagpur
SAHA Kolkata
Univ Calcutta, Kolkata
VECC Kolkata
Univ. Kashmir, Srinagar
Banaras Hindu Univ., Varanasi

Korea:
Korea Univ. Seoul
Pusan National Univ.

Norway:
Univ. Bergen

Poland:
Krakow Univ.
Warsaw Univ.
Silesia Univ. Katowice
Nucl. Phys. Inst. Krakow

Portugal:
LIP Coimbra

Romania:
NIPNE Bucharest
Bucharest University

Russia:
IHEP Protvino
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.

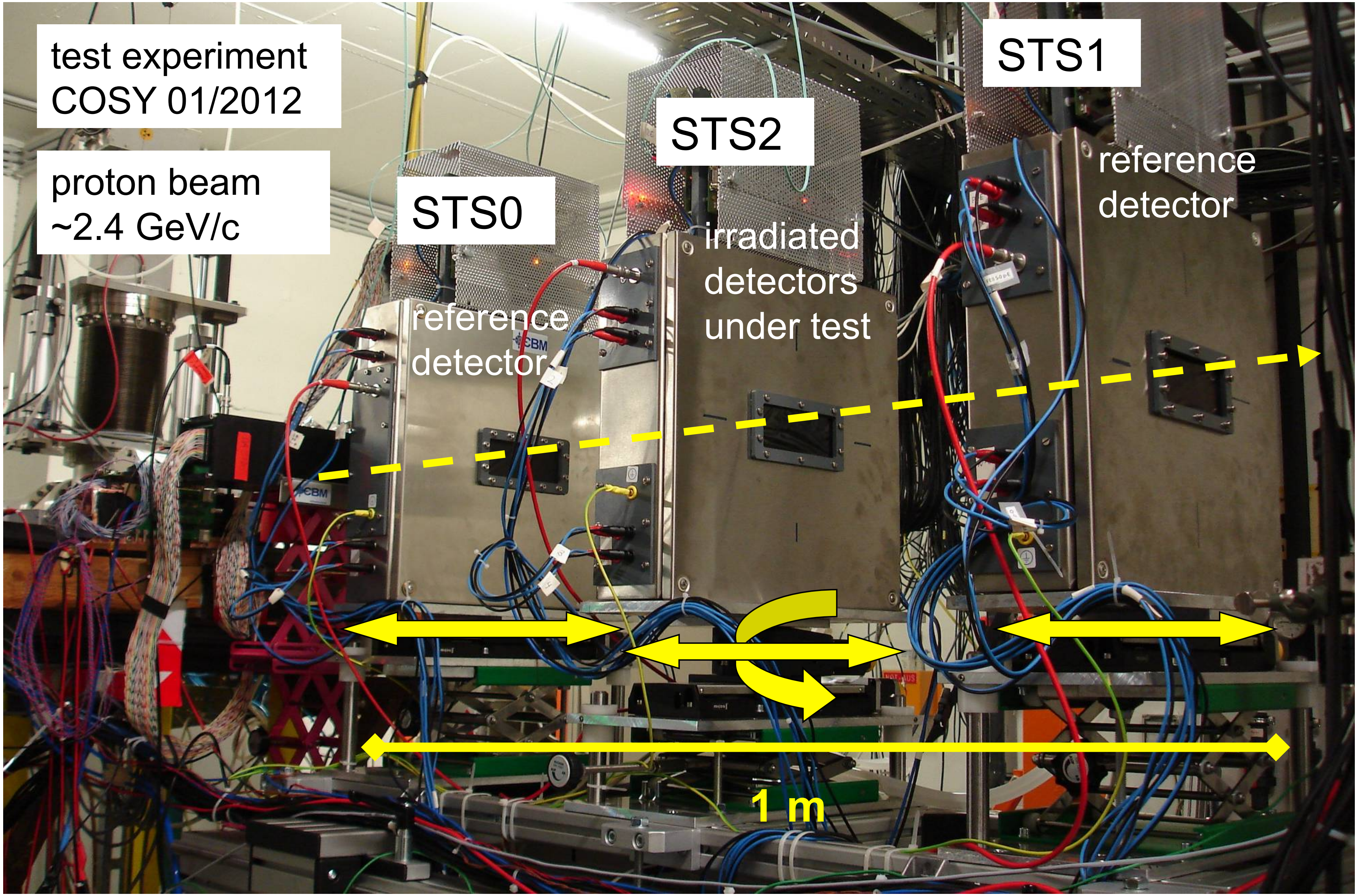
Ukraine:
INR, Kiev
Shevchenko Univ. , Kiev

56 institutions, > 400 members

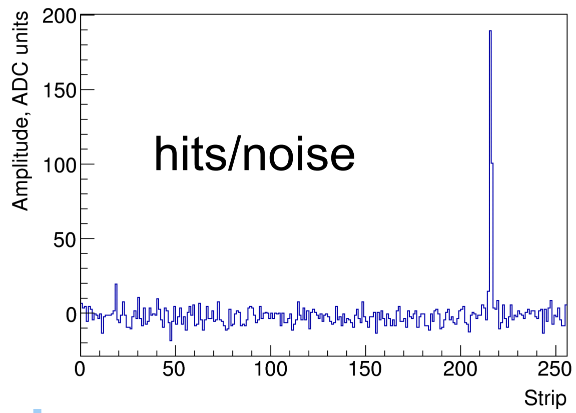
Split, Oct 2009

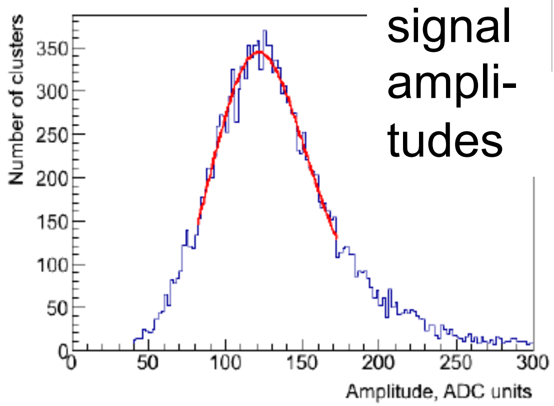
Silicon Tracking System:

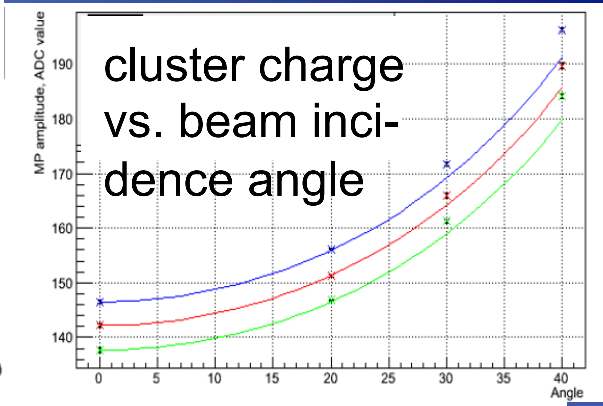
microstrip detectors + self-triggering readout electronics



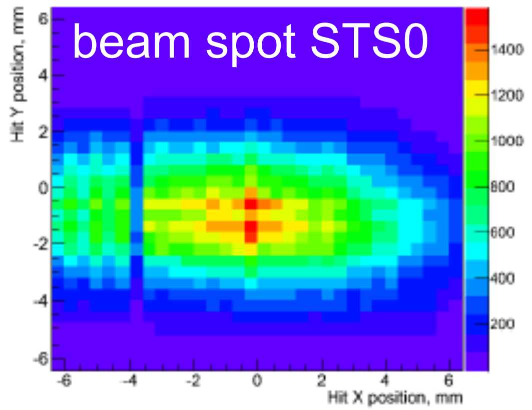
Detector response studies

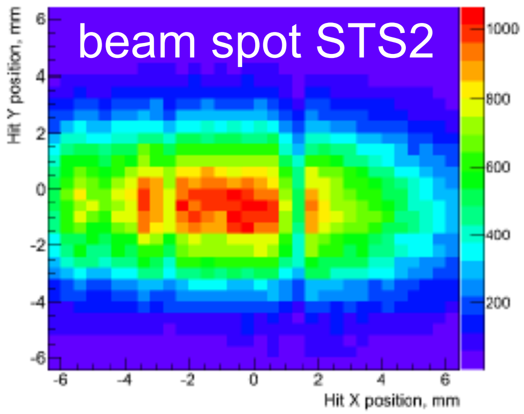


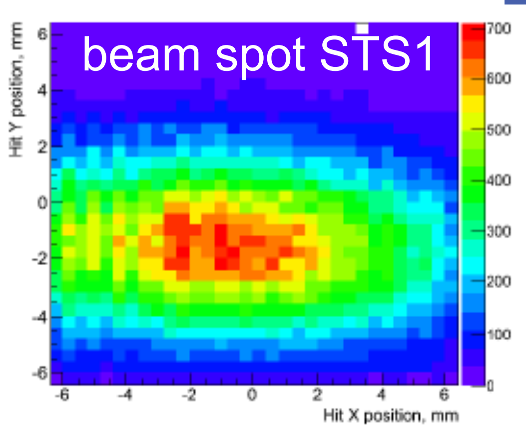




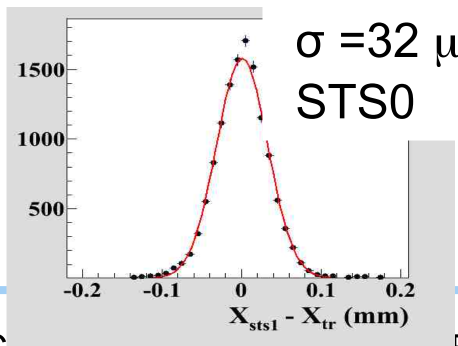
Hit reconstruction

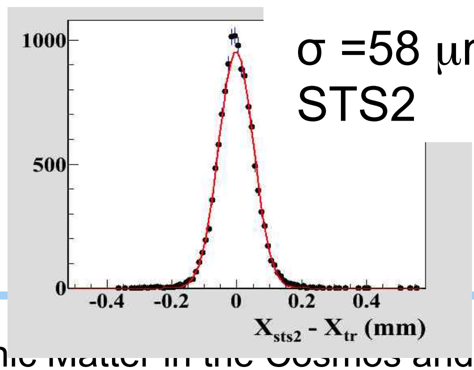


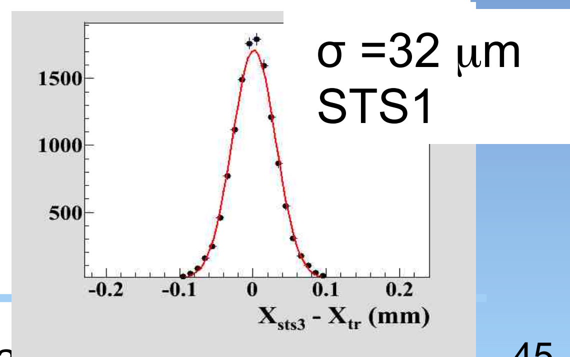




Track reconstruction

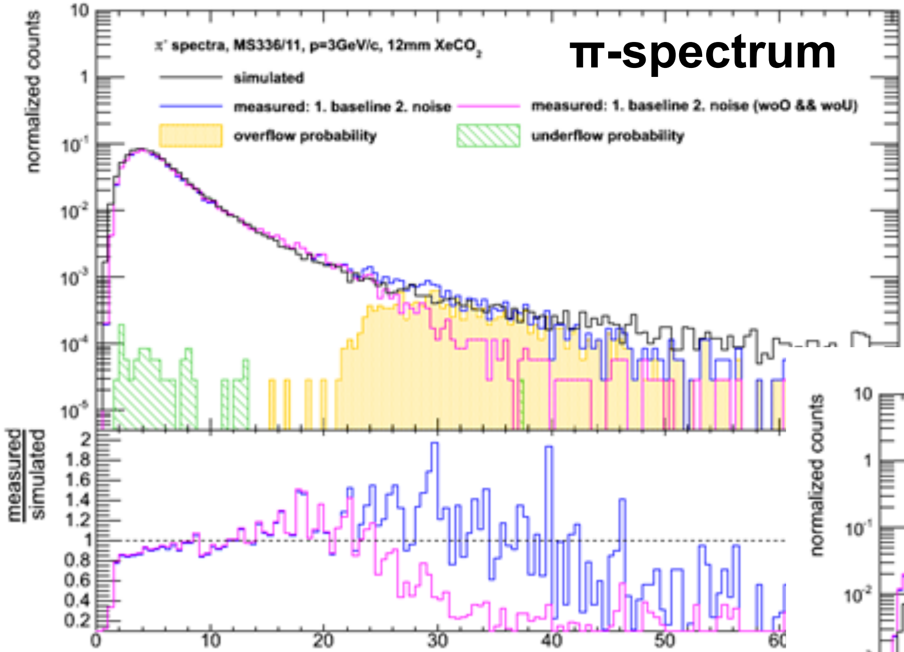




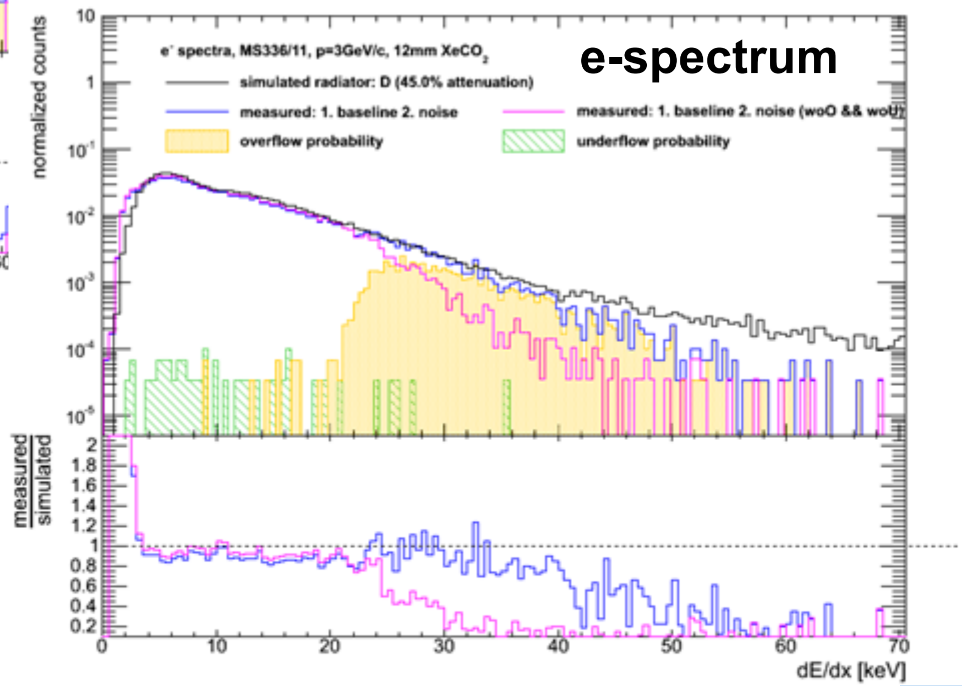


TRD R&D

energy loss spectra of e and π (here shown at 3 GeV/c):



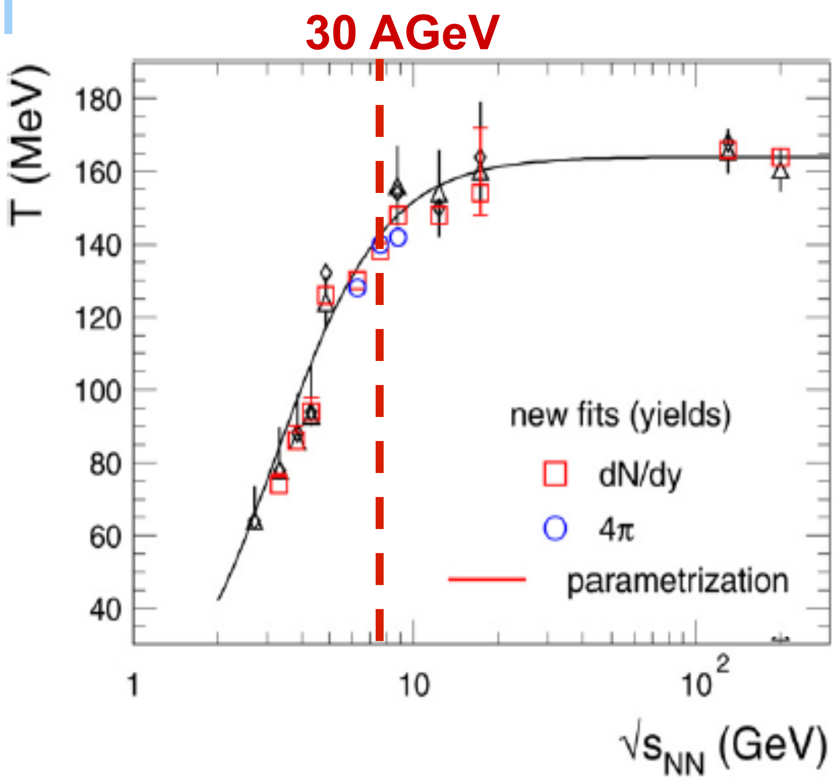
very nice agreement of simulated and measured data for the energy spectra



regular PE radiator
Spadic v0.3 readout

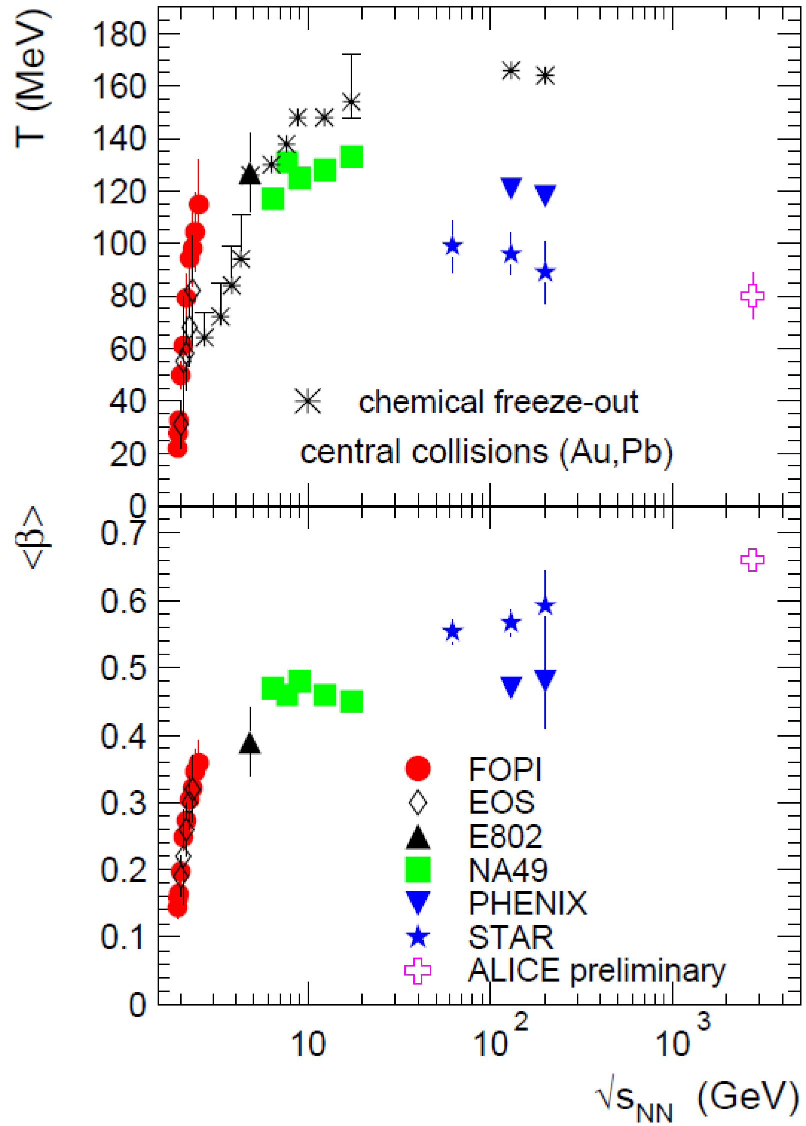
Phase transition at high μ_B?

- limiting chemical freeze-out temperature: hadronization at phase boundary
- flat mean m_t in SPS region → limiting transverse flow (?)



[A. Andronic et al., Phys. Lett. B 673 (2009) 142]

[A. Andronic, FAIR-NICA workshop, FIAS]



The QCD diagram at high μ_B

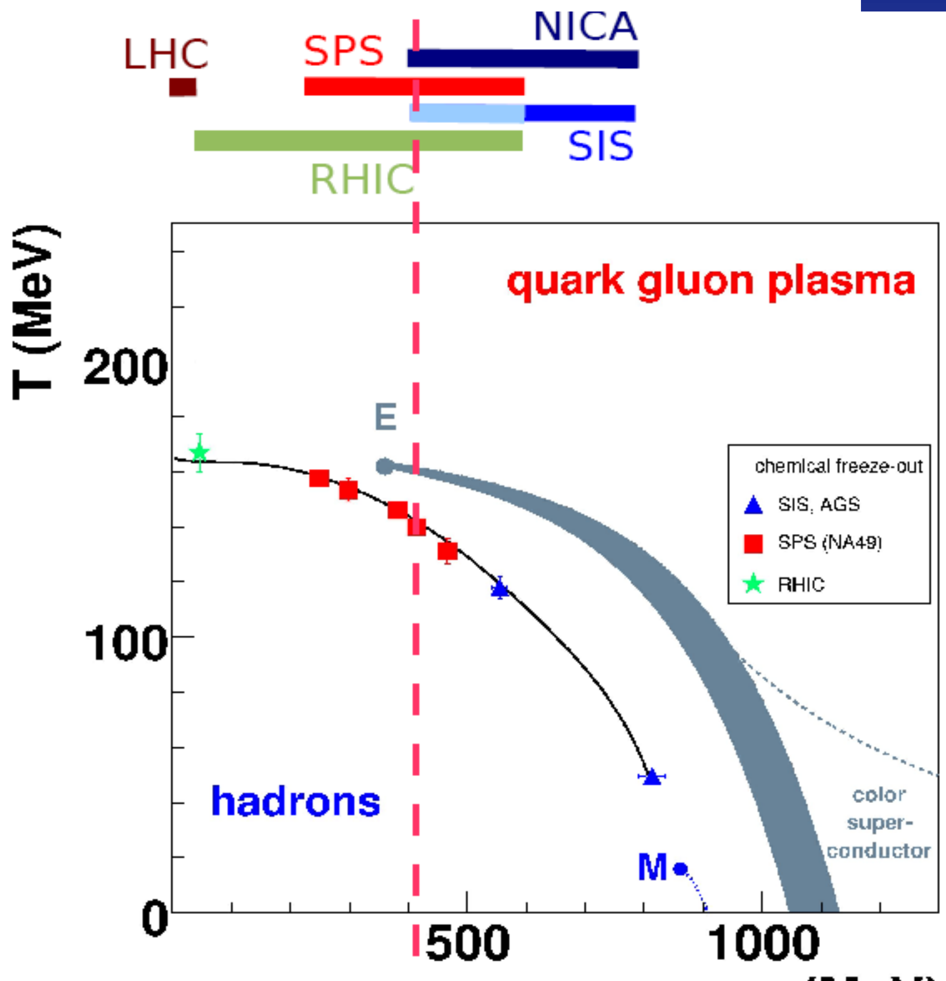
Experiments scanning the QCD phase diagram at high net-baryon densities:

RHIC low-energy scan →
bulk observables: yields, spectra, collective flow, fluctuations, and correlations of abundant hadrons

NA49/61@SPS → bulk observables

MPD@NICA → bulk observables

CBM@FAIR →
bulk and rare observables like multi-strange (anti-)hyperons, dileptons, open and hidden charm

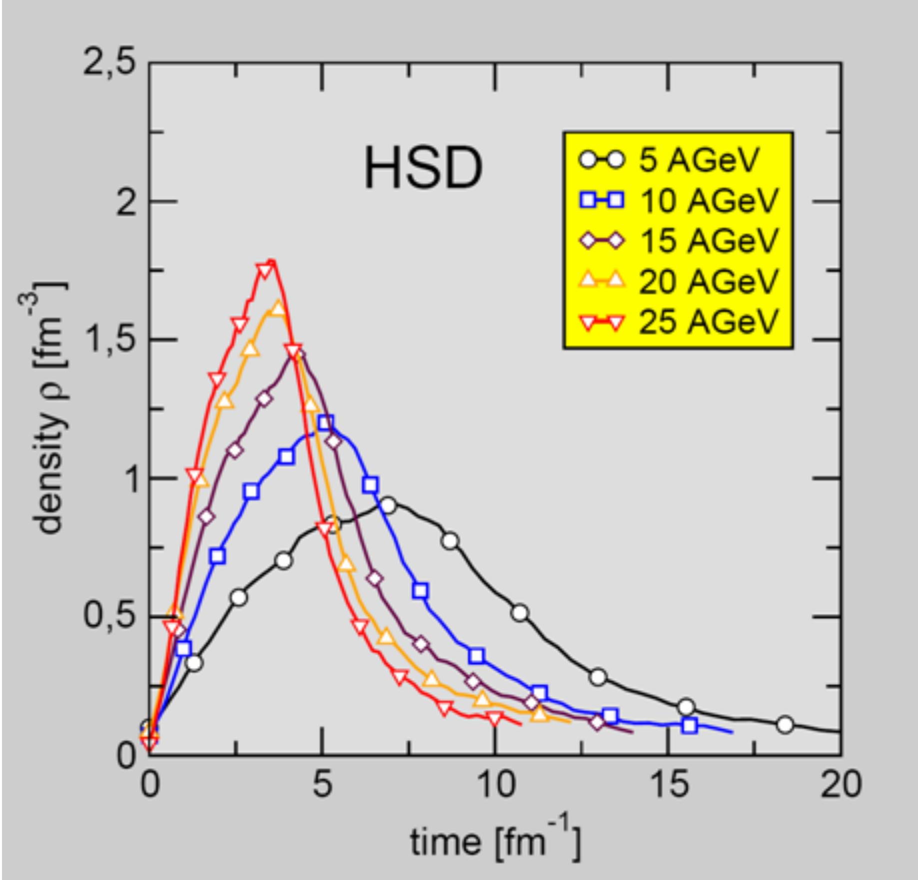


30*A* GeV beam energy

High net-baryon density matter at CBM

- **high baryon and energy densities created in central Au+Au SIS 100 and SIS 300 energies which prevail for a few fm/c!**
- agreement between different models (not shown)

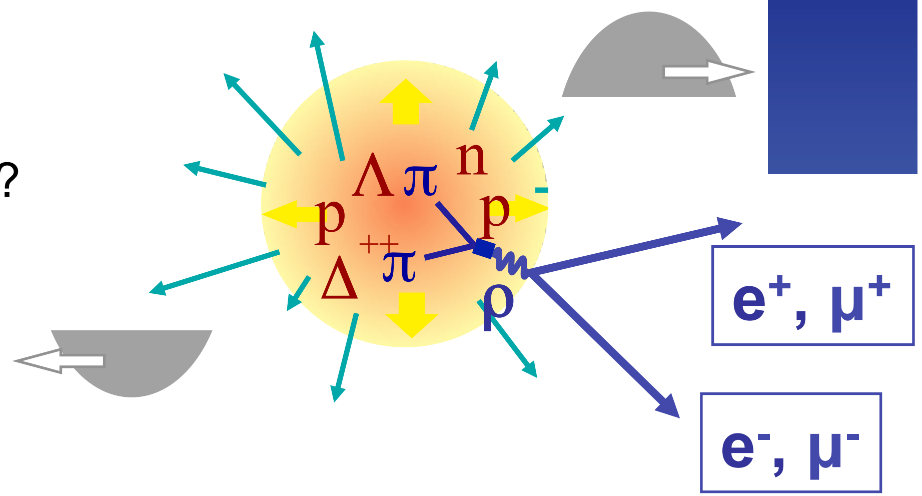
beam energy	max. ρ/ρ_0	max ε [GeV/fm^3]	time span ~FWHM
5 AGeV	6	1.5	~ 8 fm/c
40 AGeV	12	> 10	~ 3.5 fm/c

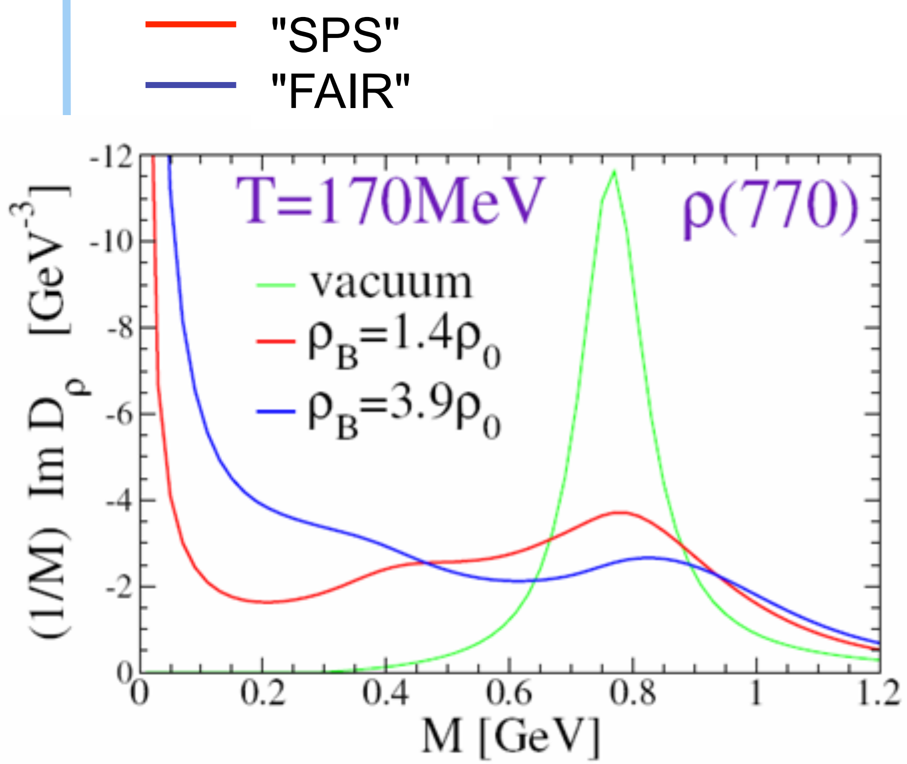


[CBM physics book, E. Bratkovskaya]

ρ-meson spectral function

- ρ-meson couples to the medium: "melts" close to T_c and at high μ_B
- vacuum lifetime τ_0 = 1.3 fm/c
- dileptons = penetrating probe
- connection to chiral symmetry restoration?
- no measurement between 2 and 40 AGeV

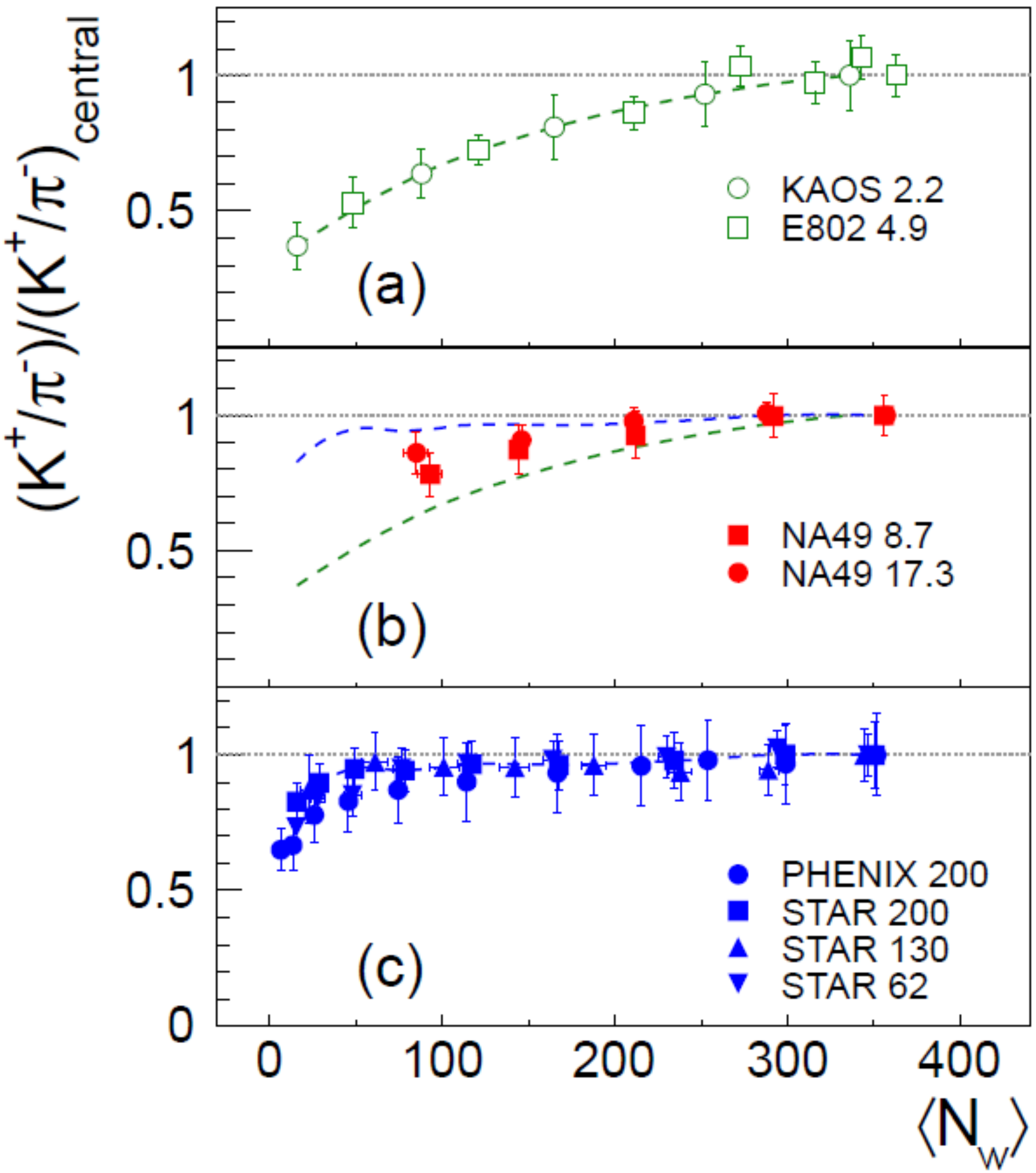




- particularly sensitive to baryon density
- region with m < 0.4 GeV/c^2 of special interest!

HADES + CBM offer the unique opportunity for measuring the complete excitation function of electromagnetic radiation in A+A collisions from 2 – 45 AGeV beam energy

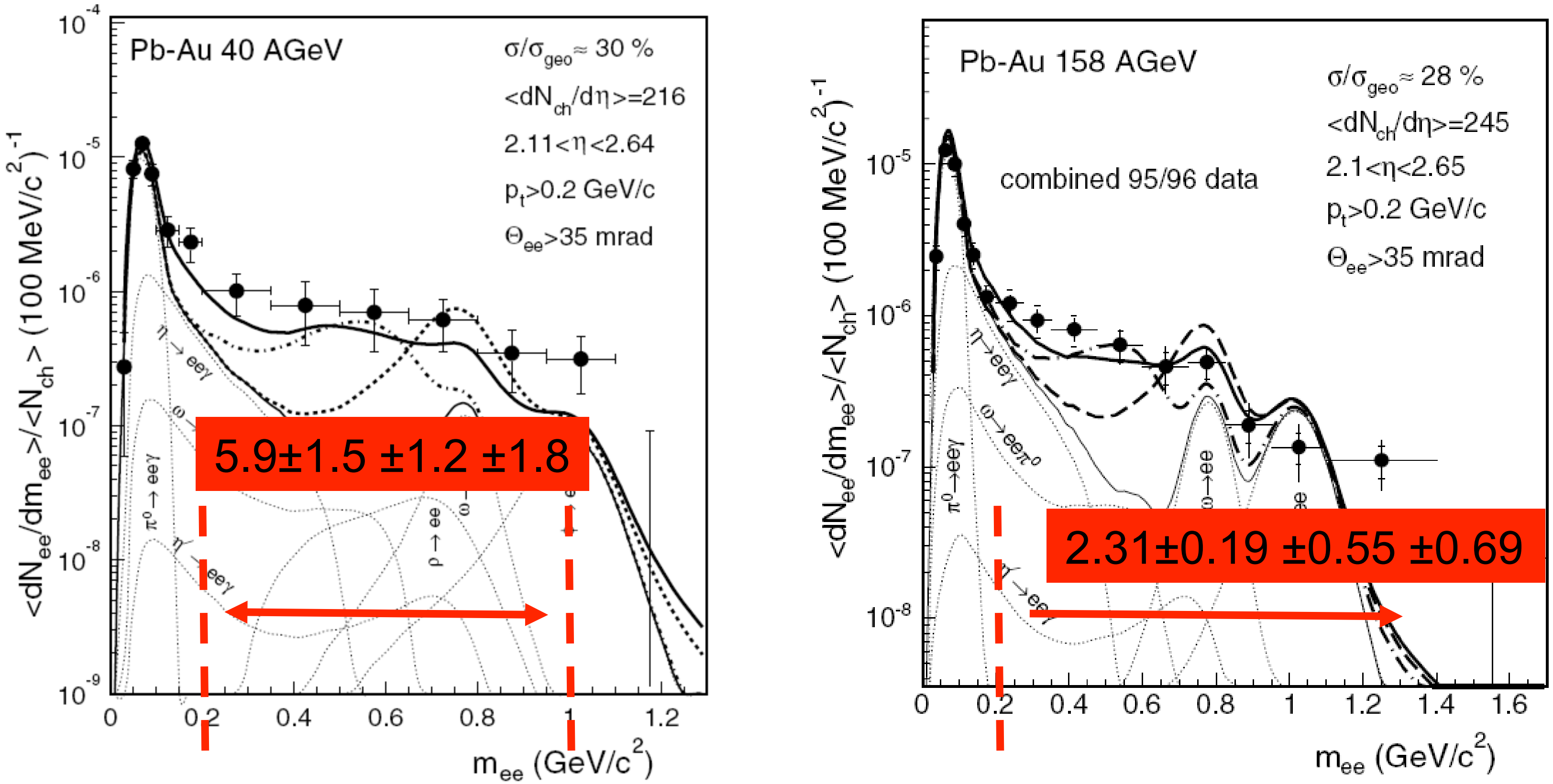
- K/π ratio [...]al model
- centrality [...]
- high ene[...] saturatio[...] understo[...] percolati[...] Corona [...]



[1] CH, F. F[...]
[2] K.Werne[...]

Dileptons

- dileptons as direct probe of the high density phase
- CERES at 40 and 158 AGeV beam energy: excess higher at lower energy → importance of baryon density!



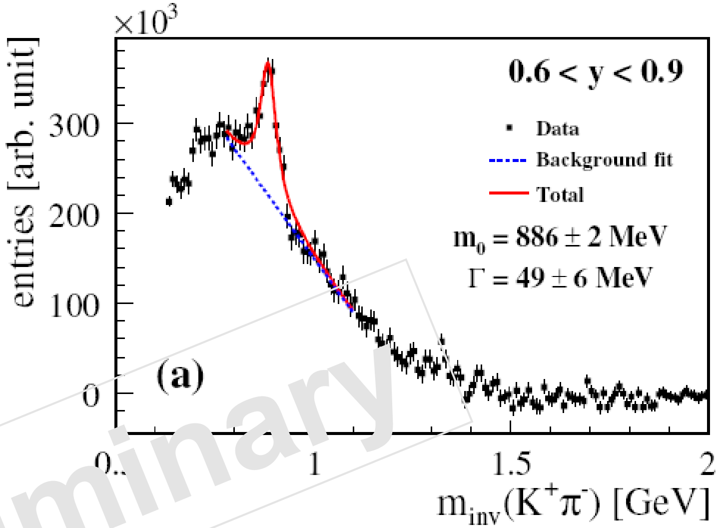
[CERES: Phys.Rev.Lett. 91, 042301 (2003); Eur.Phys.J.C 41, 475 (2005)]

Hadronic rescattering after freeze-out?

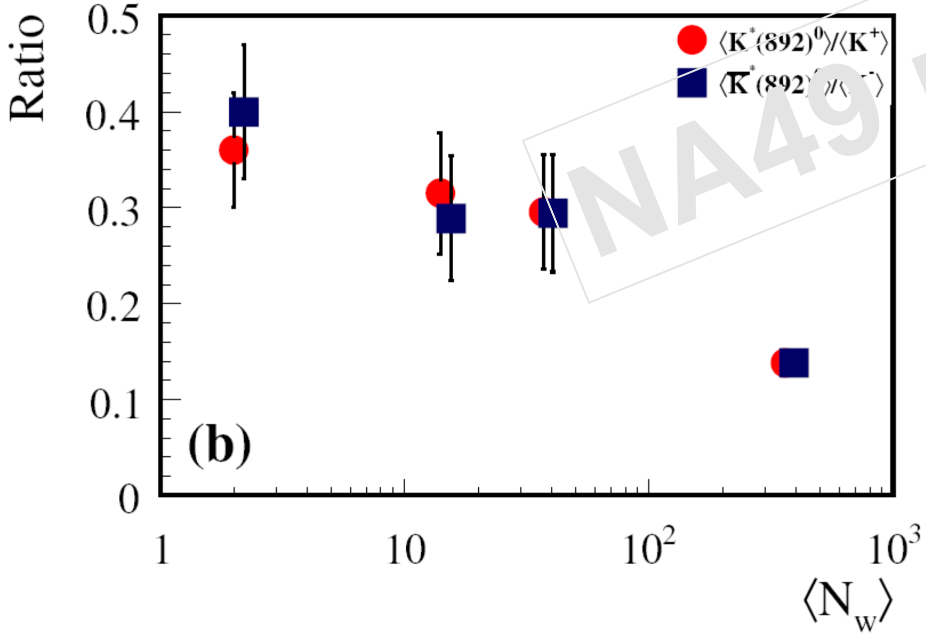
K* as probe for hadronic rescattering phase

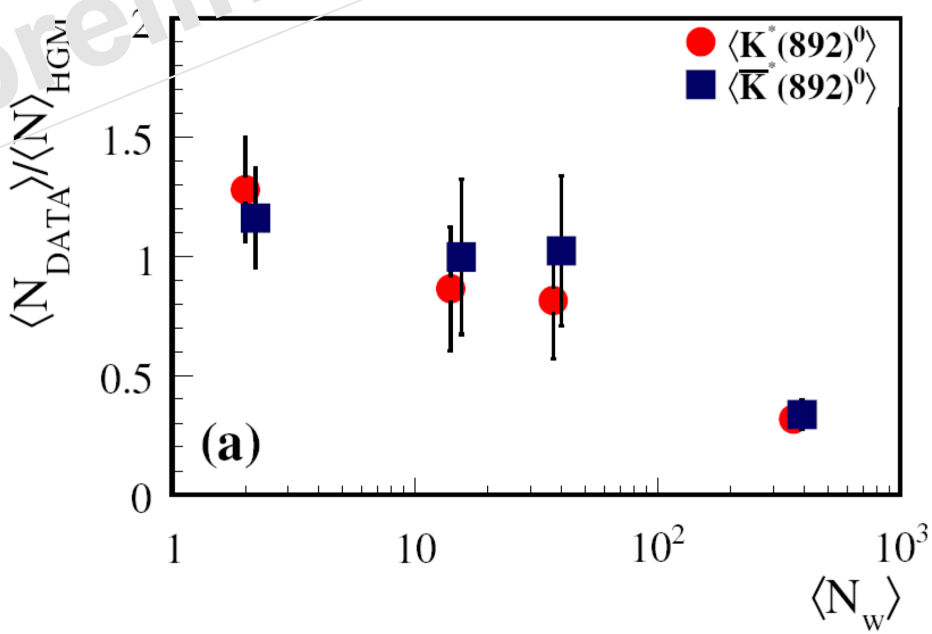
data: NA49 (158 AGeV), STAR (63, 200 GeV)

suppression increases for lower energies



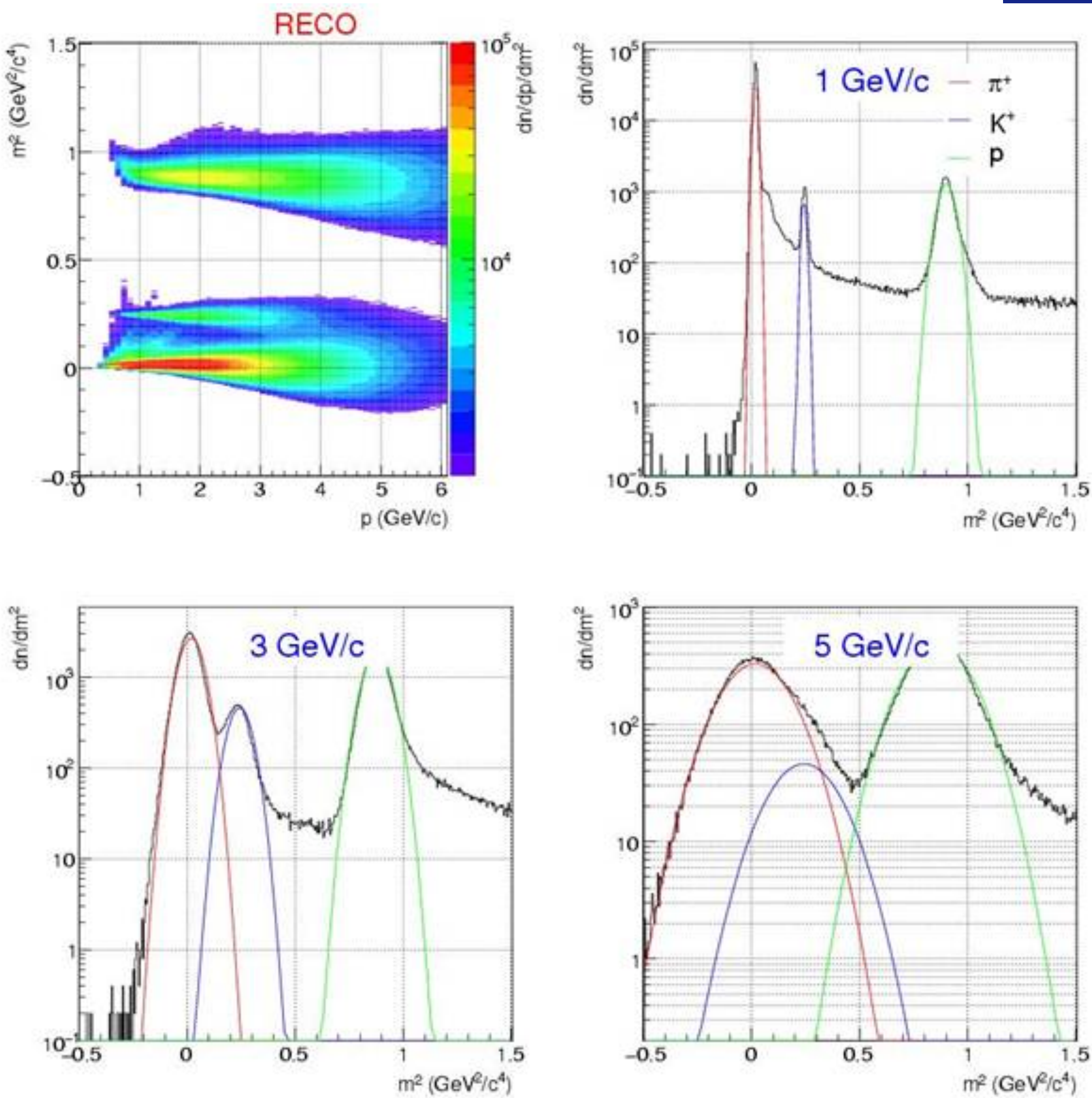
K* cτ = 4 fm/c



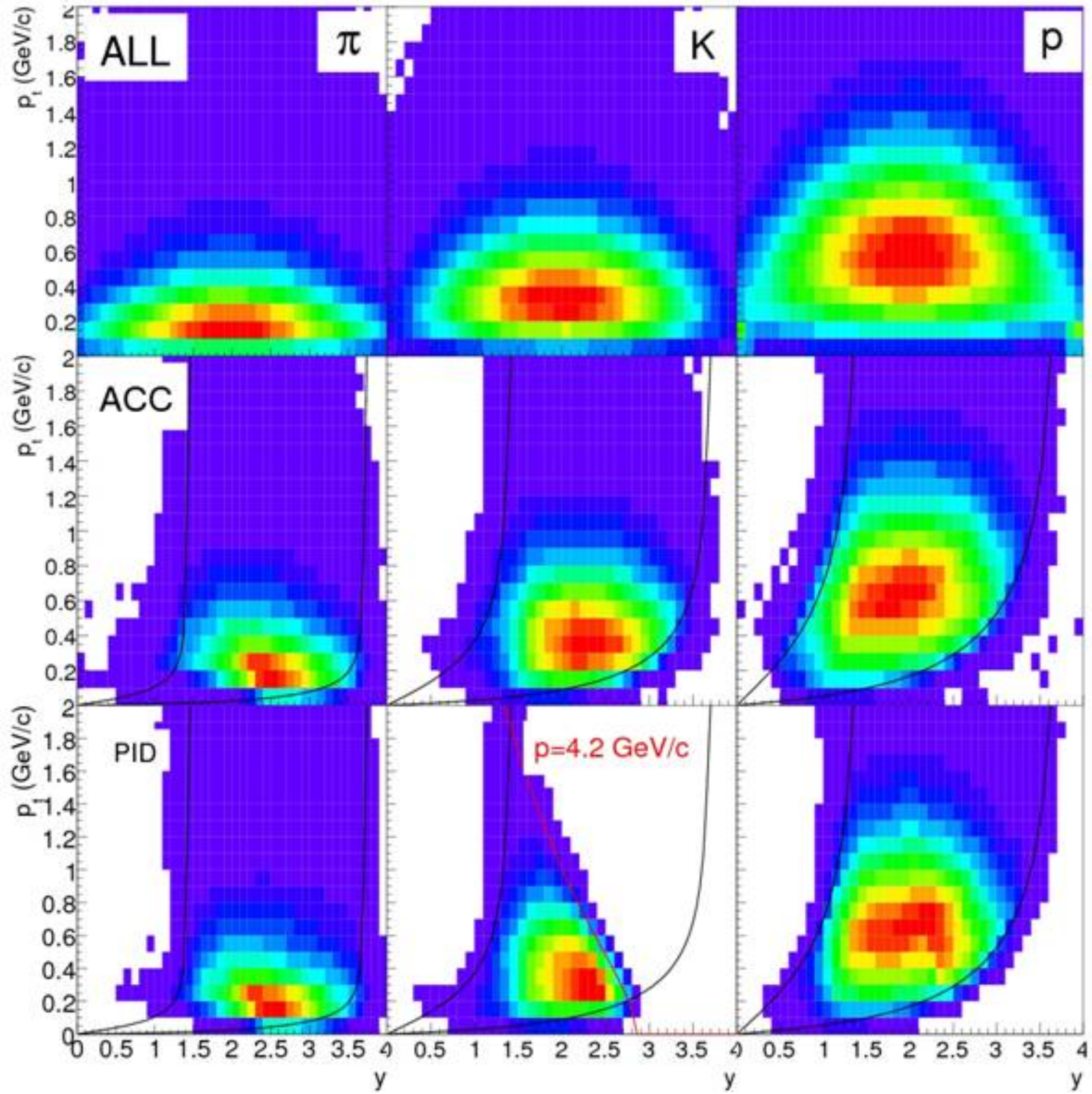


Hadron identification

- **hadron identification via time-of-flight (80 ps resl.)**
- **$2\sigma_m$ π-K separation up to p~3.2 GeV/c**
- **tails in mass spectra from track mismatches, double hits**



Hadron identification



90% kaon purity

Be prepared for exotica: multi-strange di-baryons

<u>Signal: strange dibaryon</u>

$(\Xi^0\Lambda)_b \rightarrow \Lambda\Lambda$ (cτ=3cm)

M= 10^{-6}, BR = 5%

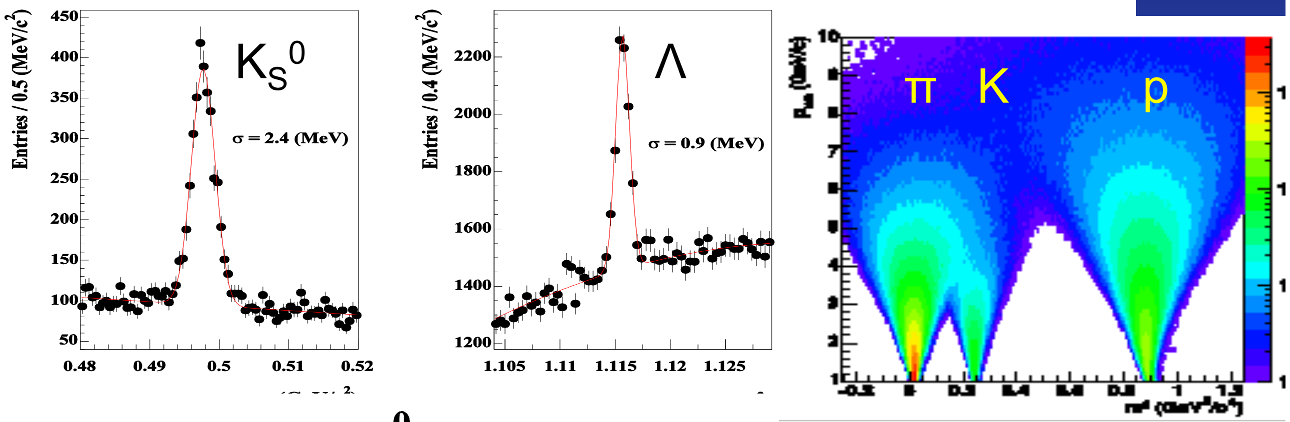
<u>Background:</u>

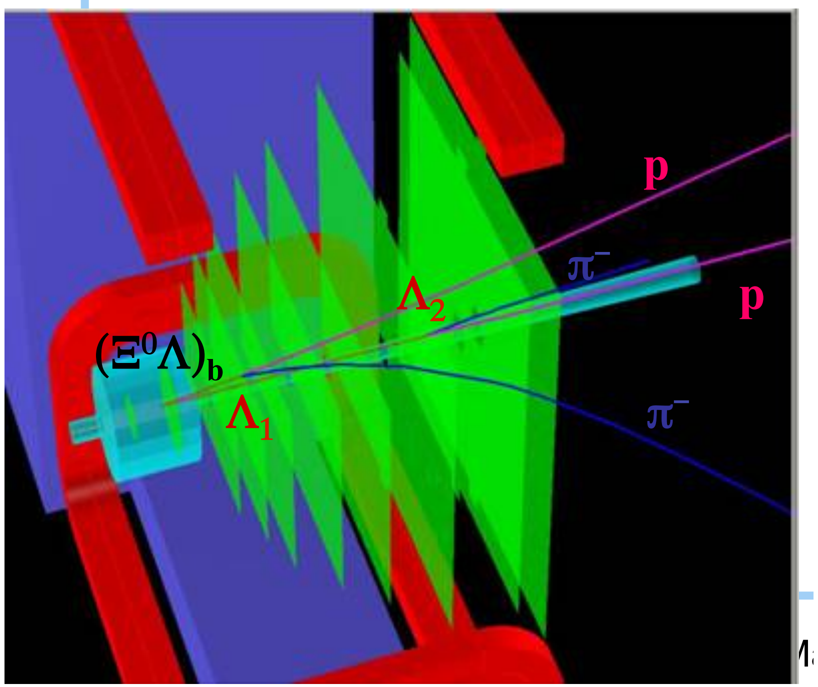
Au+Au @ 25 AGeV

32 Λ per central event

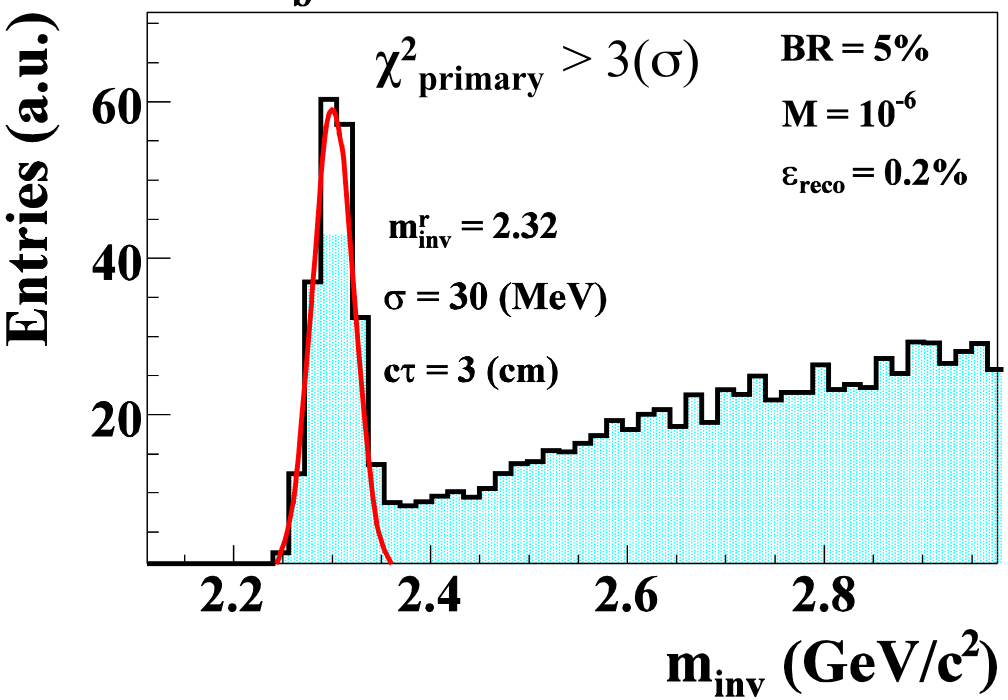
11 Λ reconstructable

Particle identification with CBM





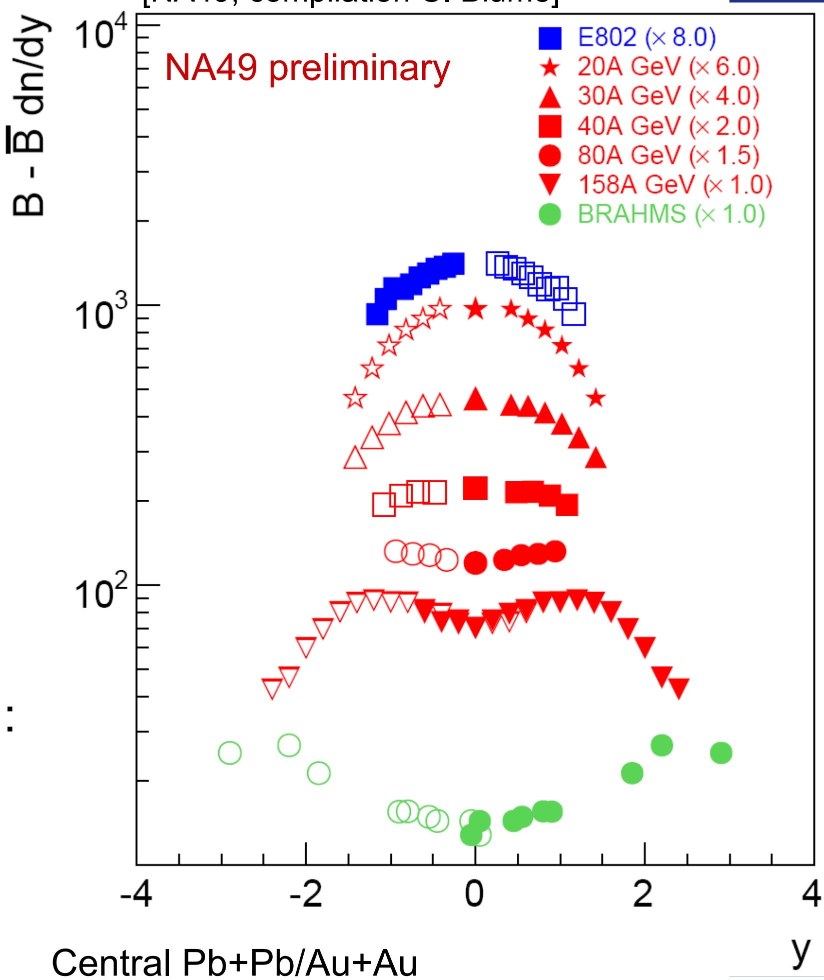
$(\Xi^0\Lambda)_b \rightarrow \Lambda\Lambda$



High net baryon densities at low SPS energies

- **low SPS/ AGS energies: high net-baryon densities at mid-rapidity**
- change to nearly net-baryon free region at RHIC
- change of shape most pronounced at SPS energies: peak → dip

[NA49, compilation C. Blume]



construction of total net-baryon distribution:

$$n(B-\overline{B}) = S_n(p-\overline{p}) + S_{\Sigma^\pm}(\Lambda-\overline{\Lambda}) + S_{\Xi^0}(\Xi^- - \overline{\Xi}^+)$$

S_x from stat. model fits

Statistical Model
F. Becattini et al., Phys. Rev. C73 (2006), 044905.

Central Pb+Pb/Au+Au

NA49 (158)
Phys. Rev. Lett. 82 (1999), 2471

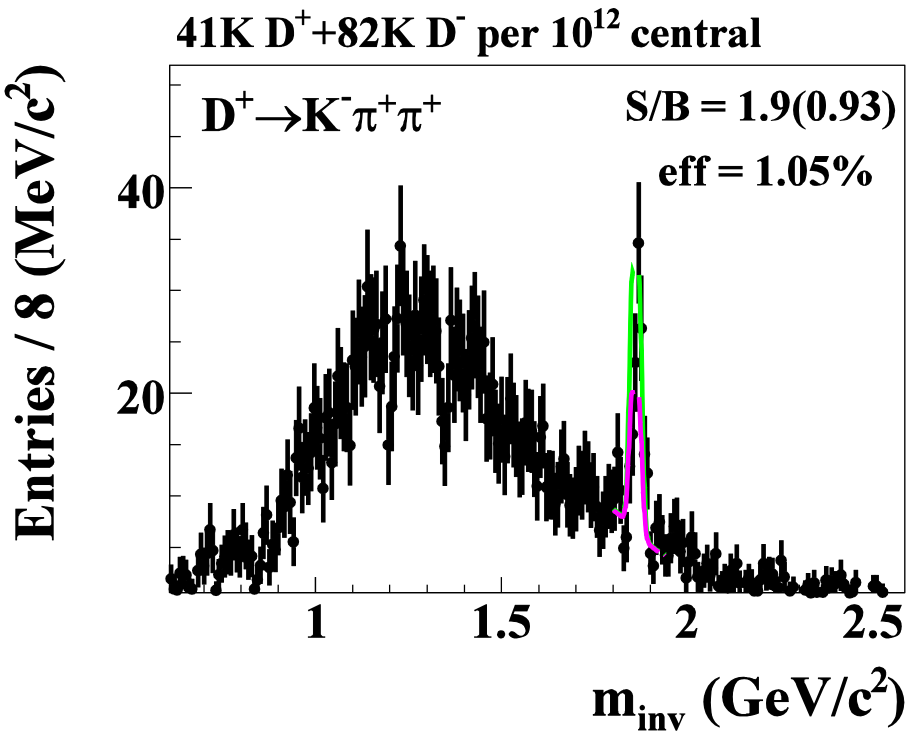
E802
Phys. Rev. C 60 (1999), 064901

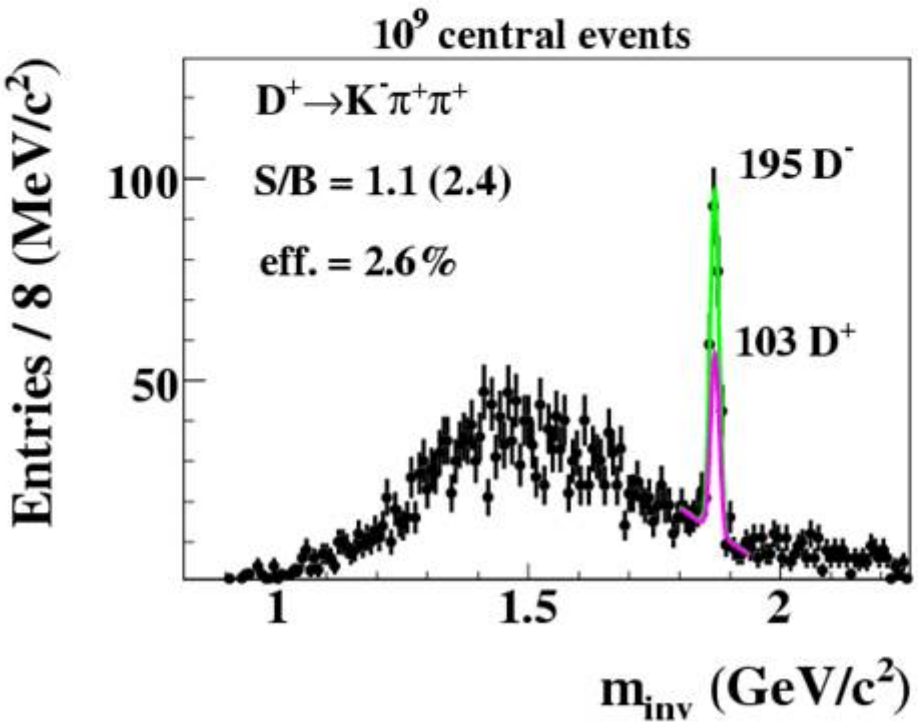
BRAHMS
Phys. Rev. Lett. 93 (2004), 102301

D meson reconstruction

- important layout studies: MAPS position and thickness !
- HSD: <D+> = 4.2 · 10^{-5}/ev
- 10^{12} central events ~ 8-10 weeks running time

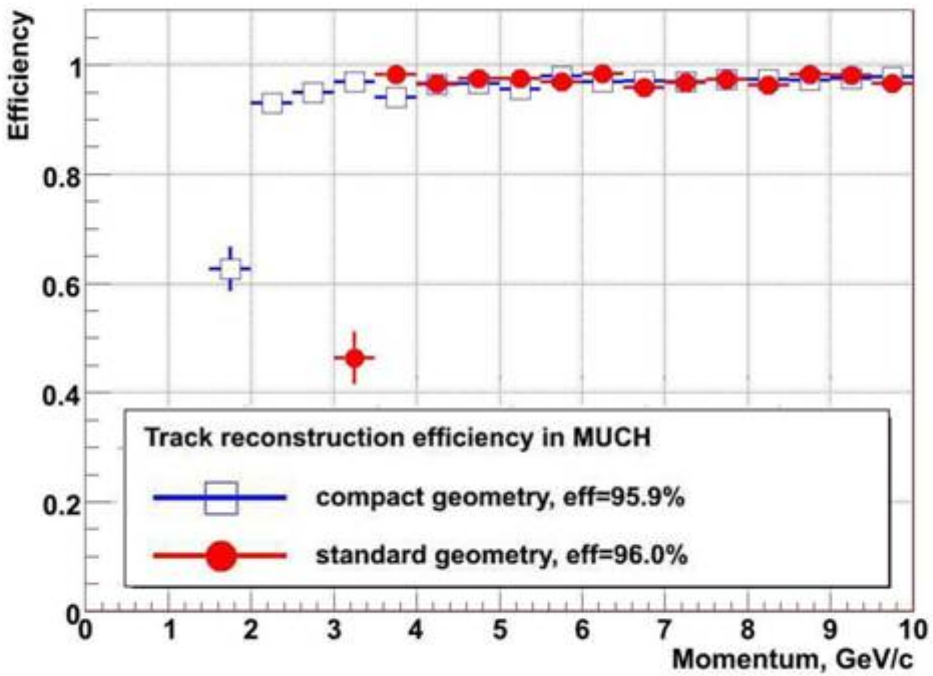
1st MAPS thickness	Position of 1st	D+ efficiency	D+ S/B (2σ)	D+ in 10^{12} ev.
150 μm	10 cm	4.2%	9	$162\cdot10^3$
500 μm	10 cm	1.05%	0.93	$41\cdot10^3$
300 μm	5 cm	2.6%	1.1	$103\cdot10^3$

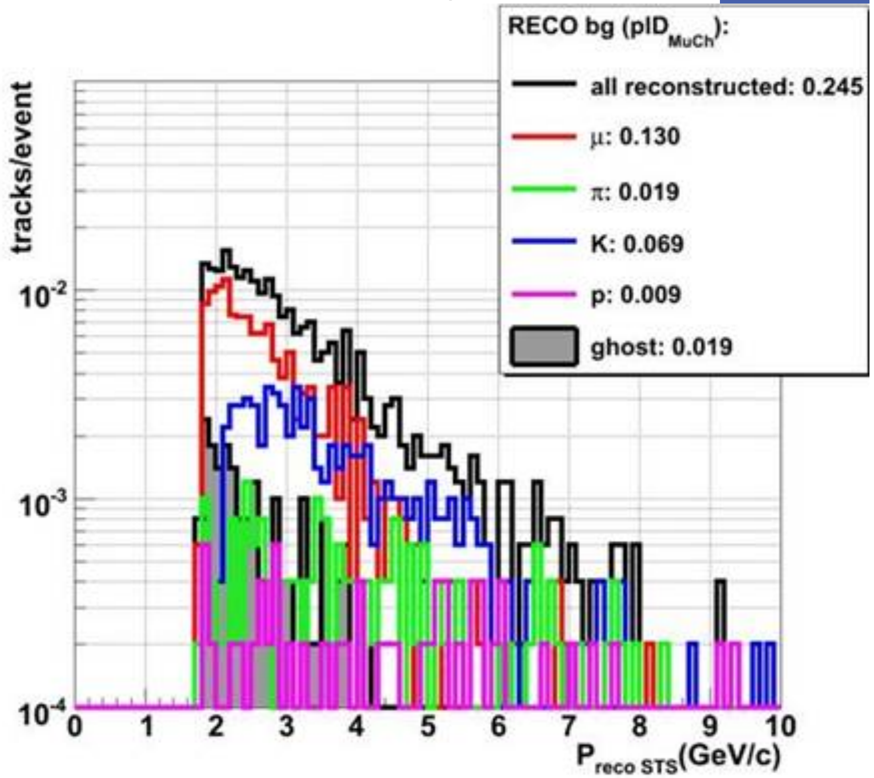




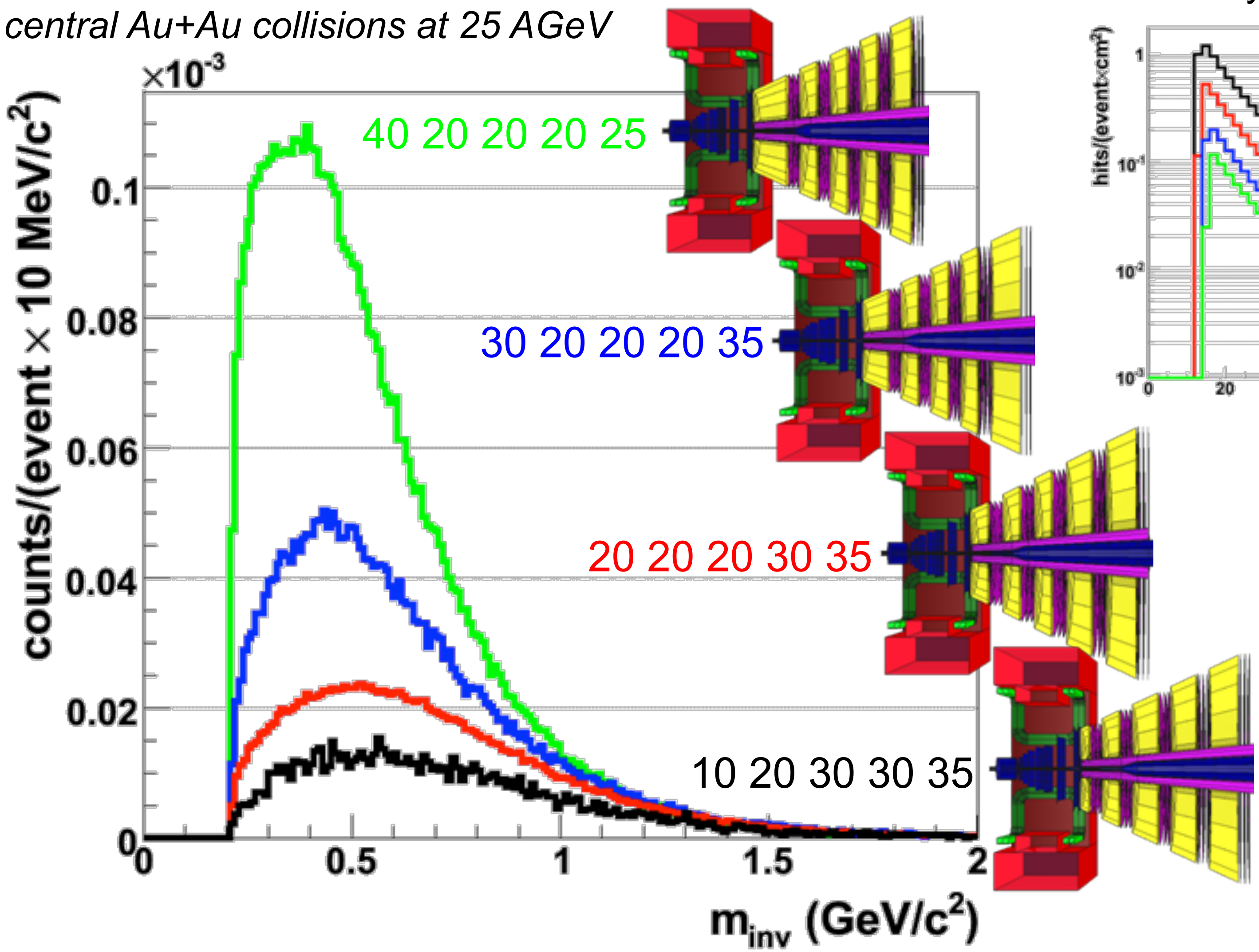
Muon identification

- alternating absorber-detector system allows efficient muon tracking
- central Au+Au collisions, 25 AGeV, absorber layout as (20+20+20+30+35) cm iron, 3 detector stations in between
- certain momentum cutoff depending on absorber length
- main part of remaining background: muons from π, K decays

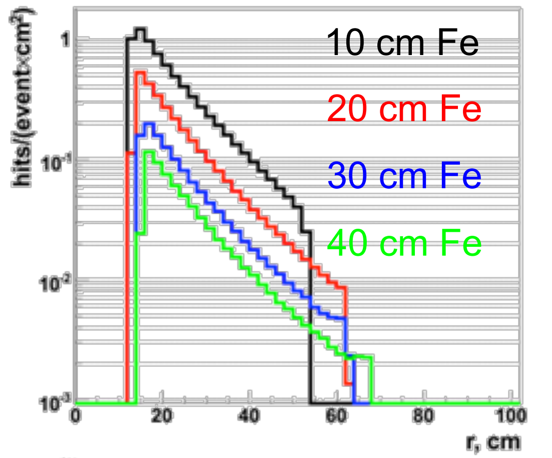




Detector layout optimization: Muon absorber



hit density after 1st absorber



total absorber length 125 cm = 7.5 λ_I