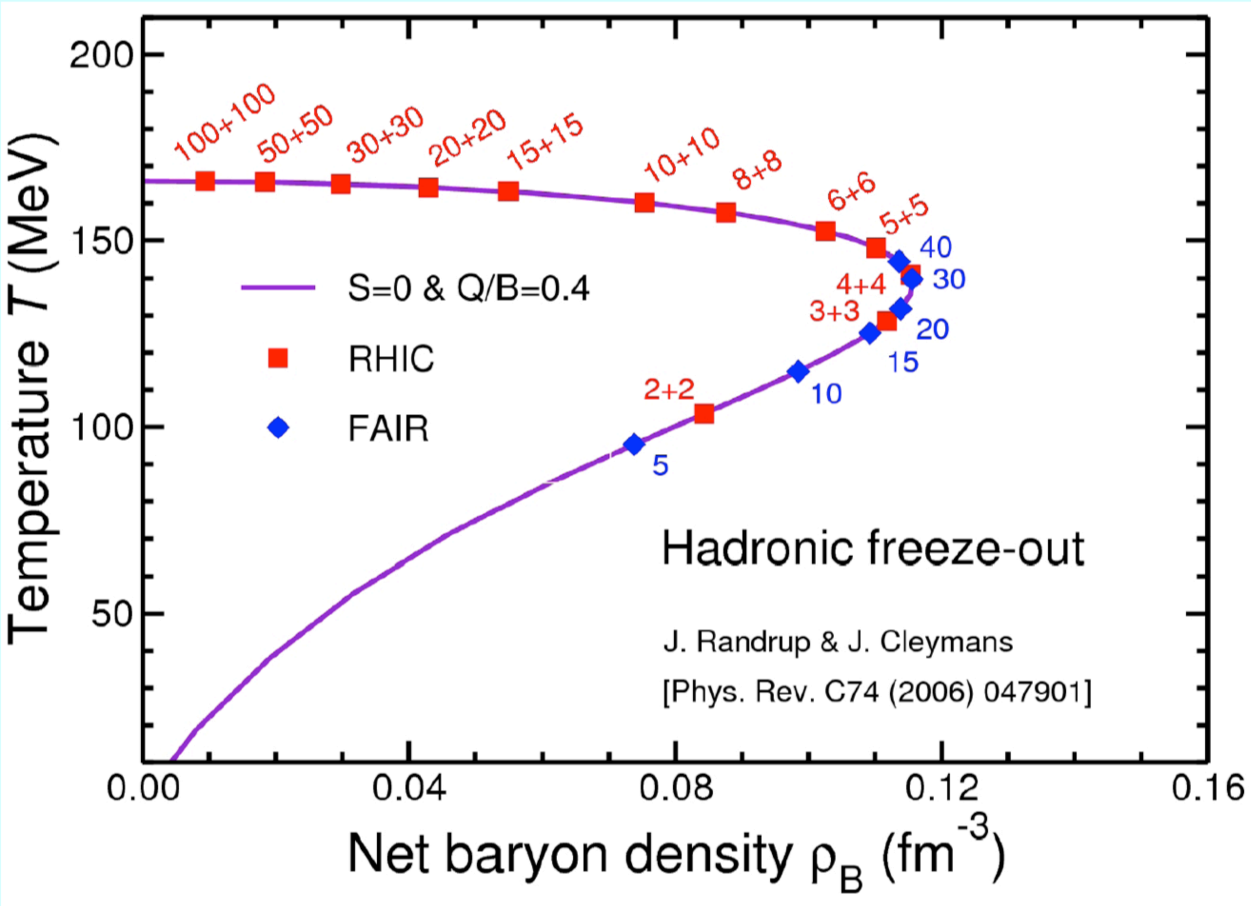
The CBM Experiment
- a status report -

Volker Friese
GSI Darmstadt

CPOD 2010, Dubna, 27 August 2010

Intro: QCD matter at high densities

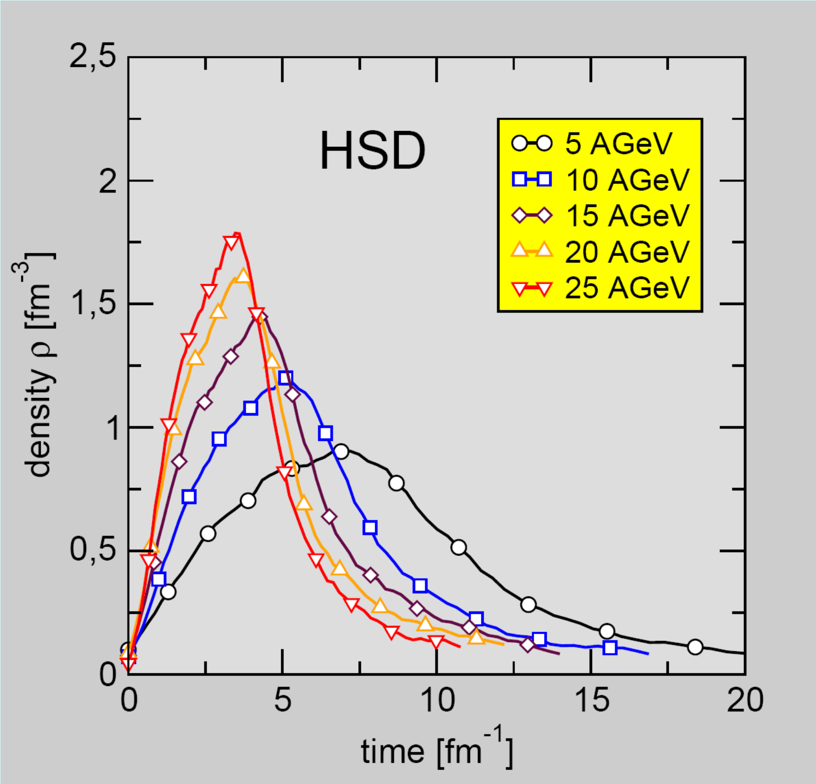


Points at chemical freeze-out (from stat. model fits to measured hadron abundances)

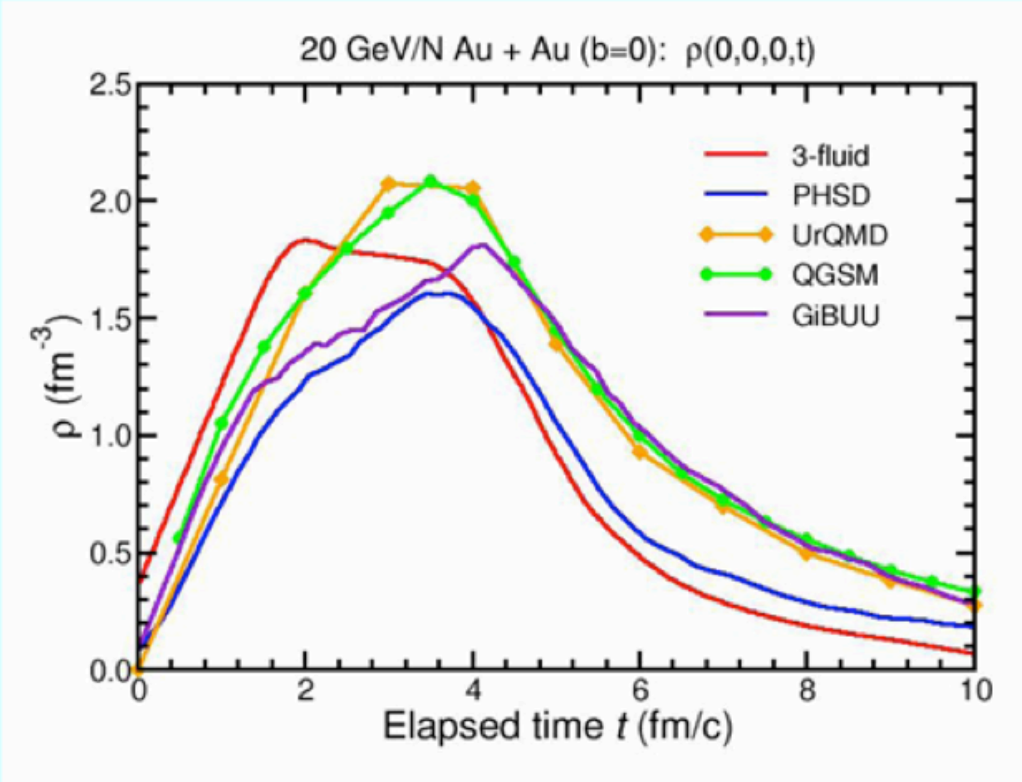
Maximal density for 30A GeV

The course of the collisions

E. Bratkovskaya, W. Cassing



from CBM Physics Book

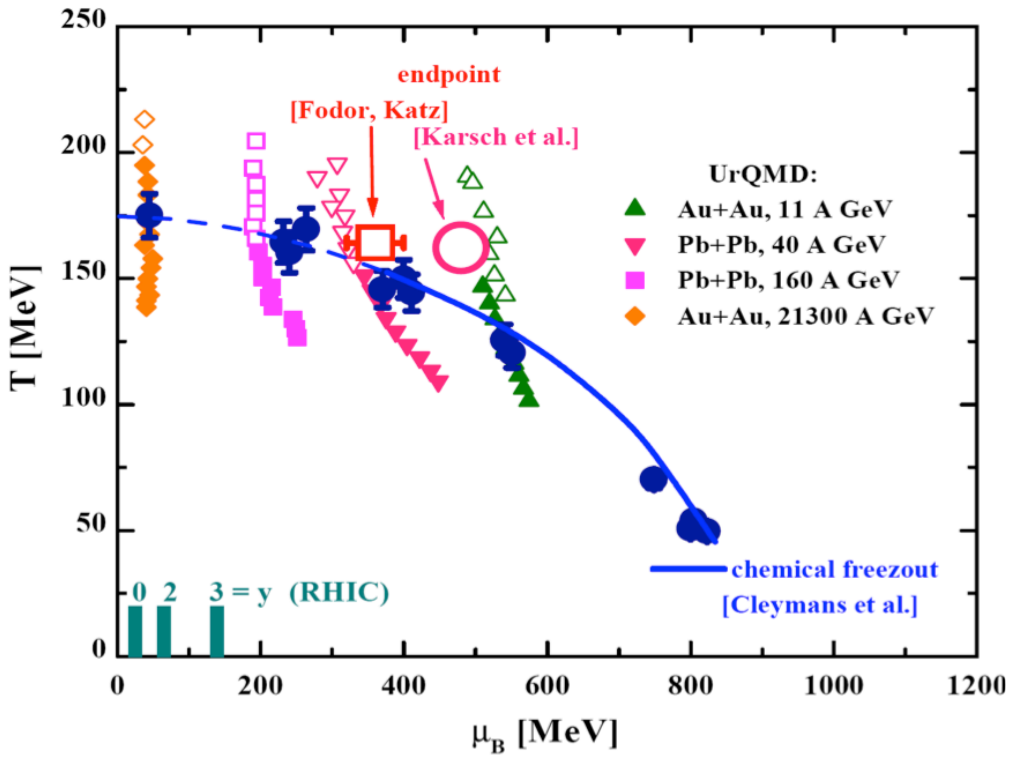


Transport models predict high densities for moderate collisions energies

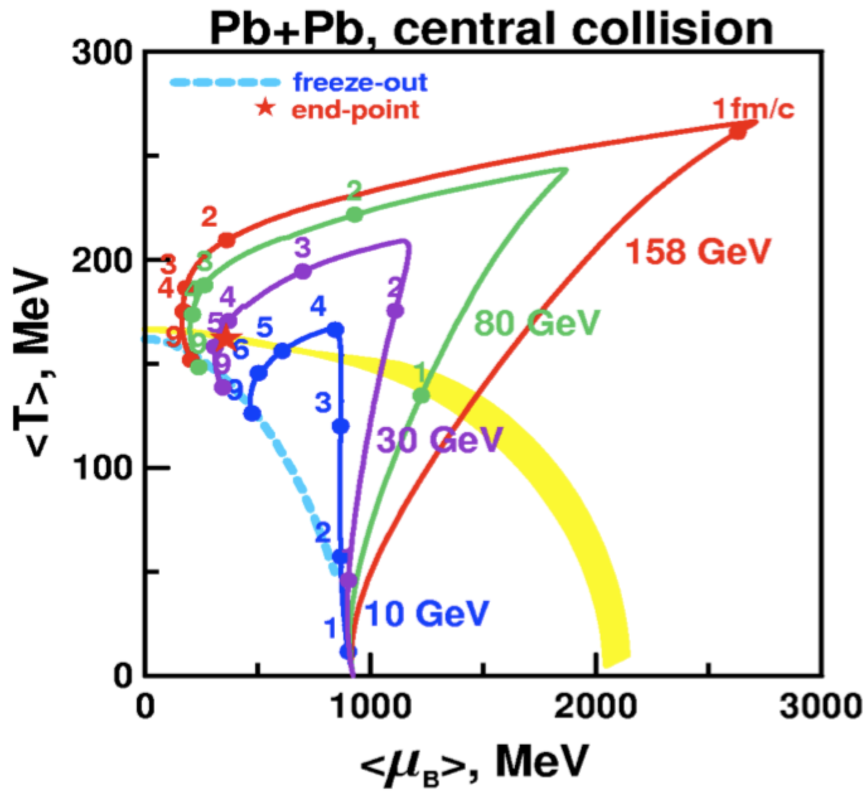
Different models agree qualitatively

The course of the collisions (2)

L.V. Bravina et al., Phys. Rev. C60 (1999) 044905



Y. Ivanov, V. Russkikh, V. Toneev,
Phys. Rev. C73 (2006) 044904



Nuclear collisions from 10 to 40 AGeV are the tools to look for the onset of deconfinement (and the critical point?)

The FAIR project

Facility for Anti-Proton and Ion Research At GSI, Darmstadt

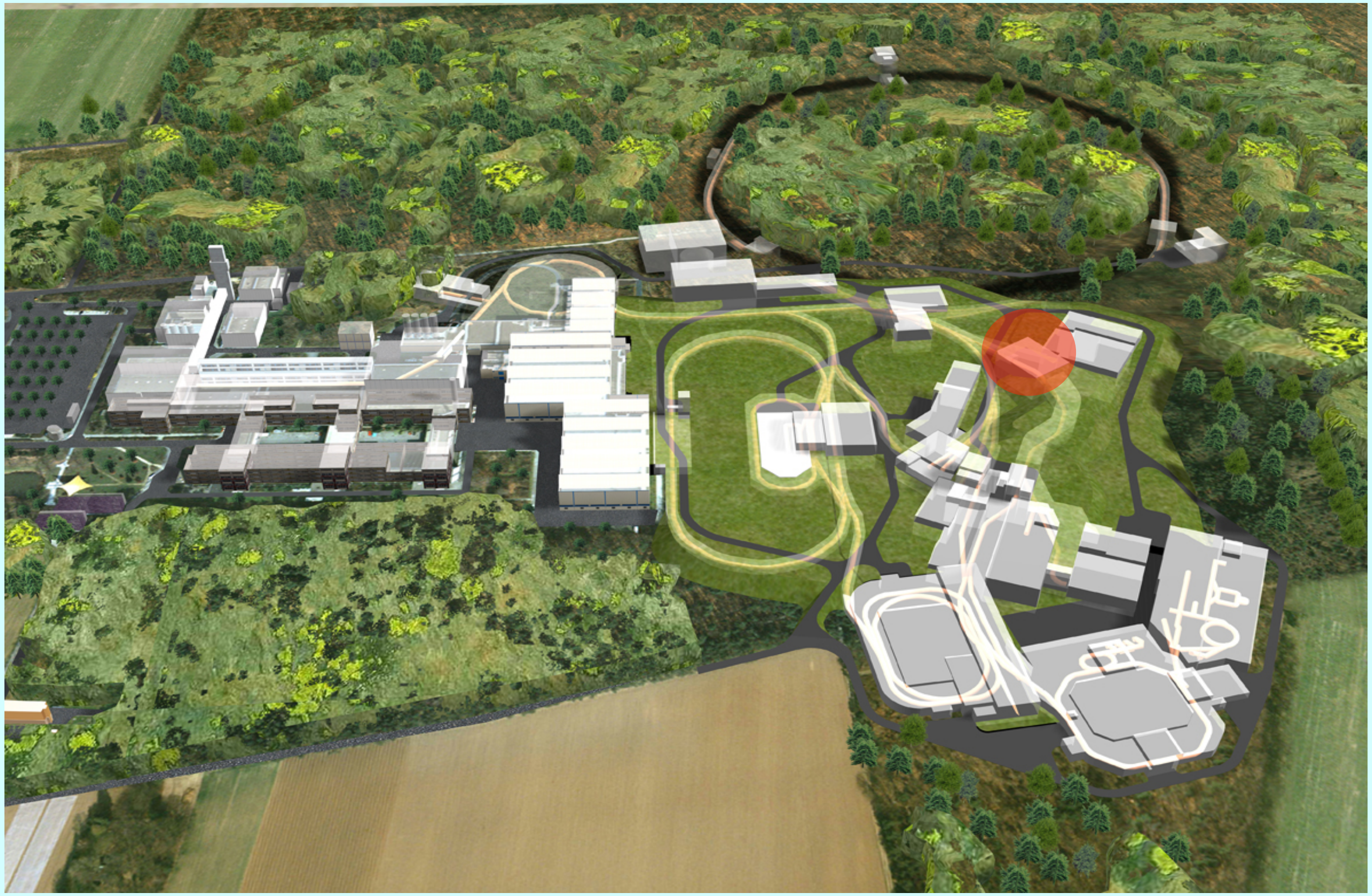
Hadron physics with anti-proton beams

Nuclear structure physics with rare isotope beams

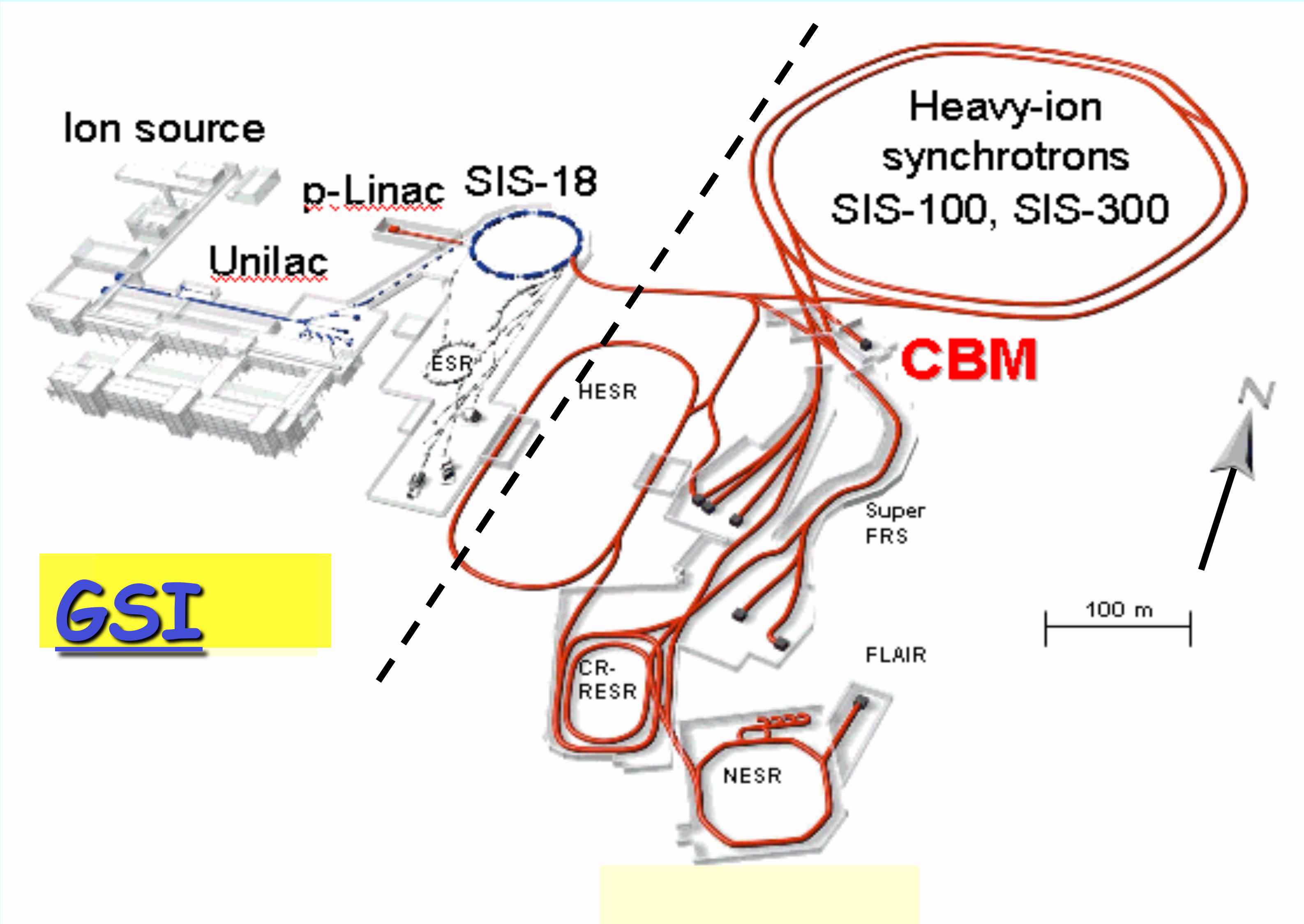
Plasma physics with short-pulsed heavy-ion beams

Atomic physics with highly charged ions and low-energy anti-protons

Nuclear collisions:
CBM
Ion beams 10^9/s
10 – 45 AGeV

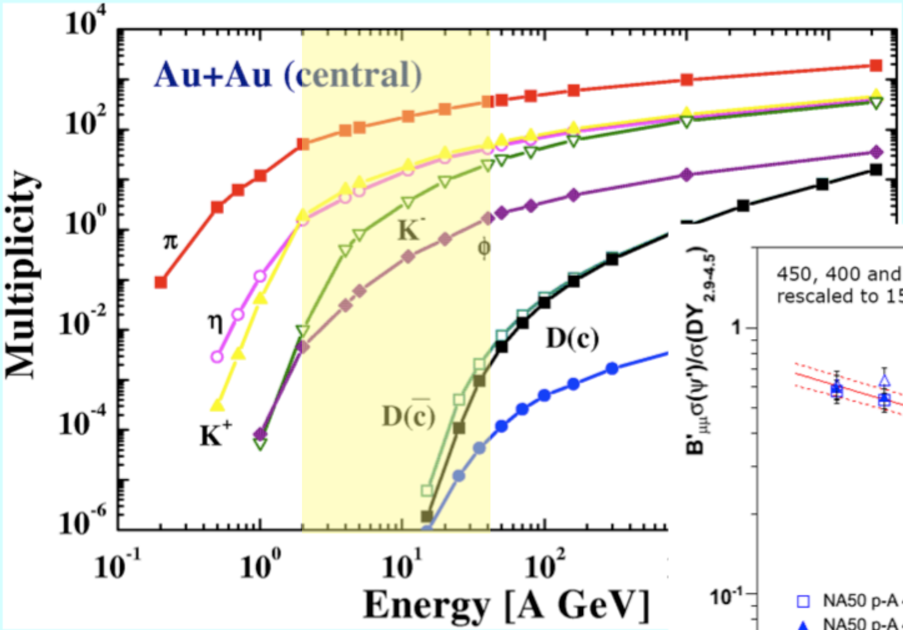


FAIR schematically

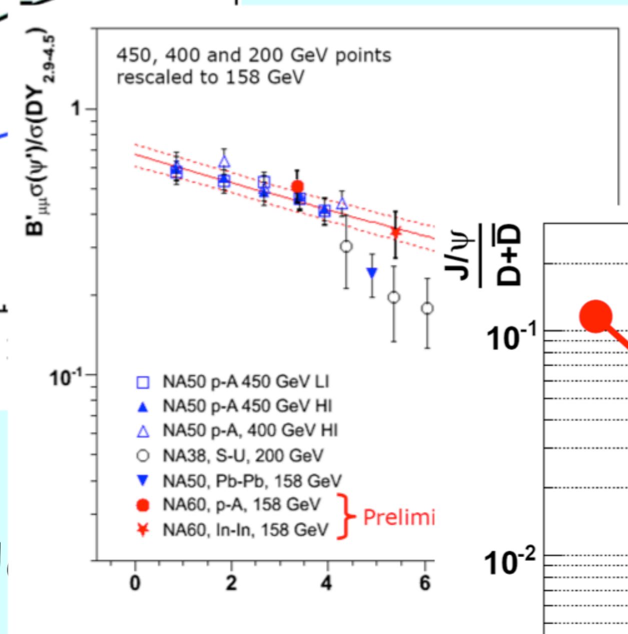


SIS-100/300:
protons:
max: 90 GeV
ions:
max. 45 GeV
up to Z/A=0.5
(35 AGeV Au)
intensities:
up to 10^9 ions
per second at
CBM

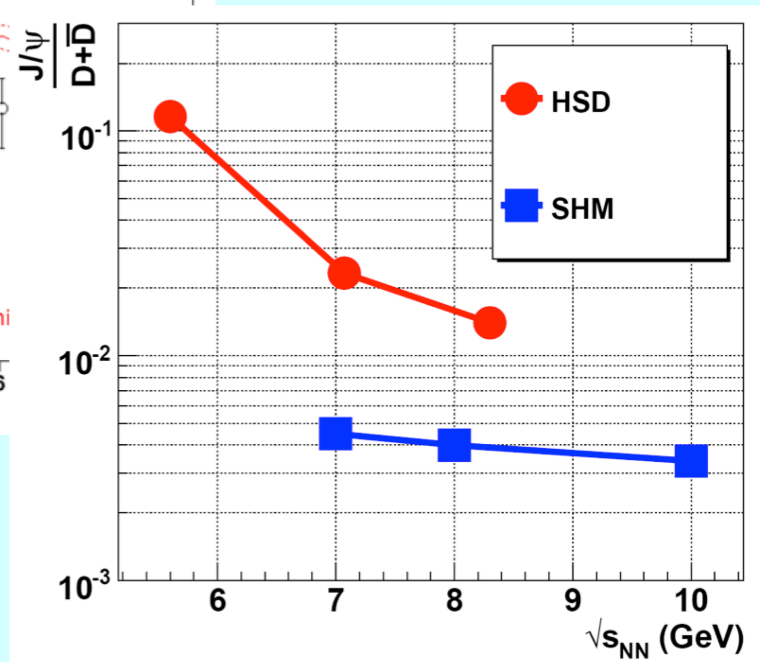
What to measure: charm



J/psi suppression: onset?



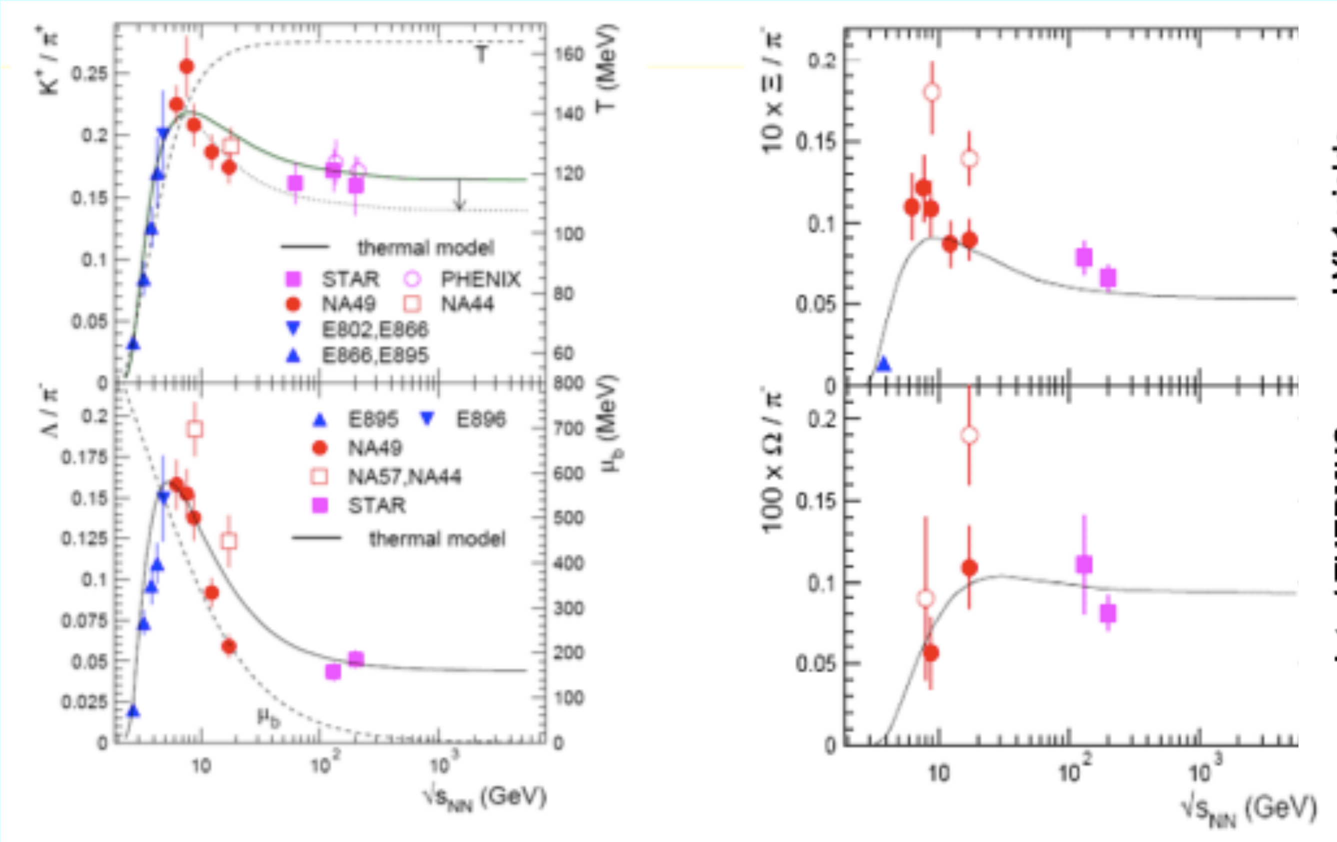
Promising:
open / hidden charm



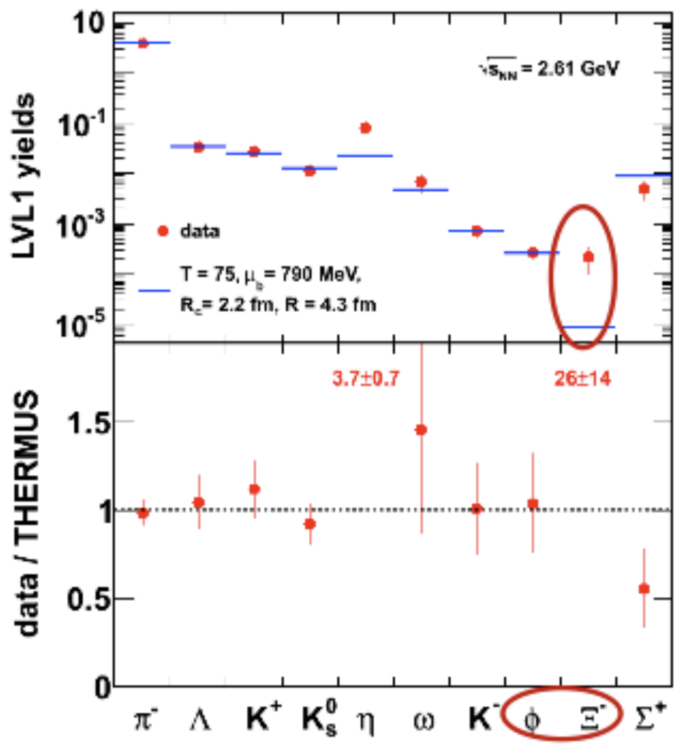
The unknown territory:
open charm near threshol

What to measure: strangeness

A. Andronic et al., PLB 673 (2009) 142



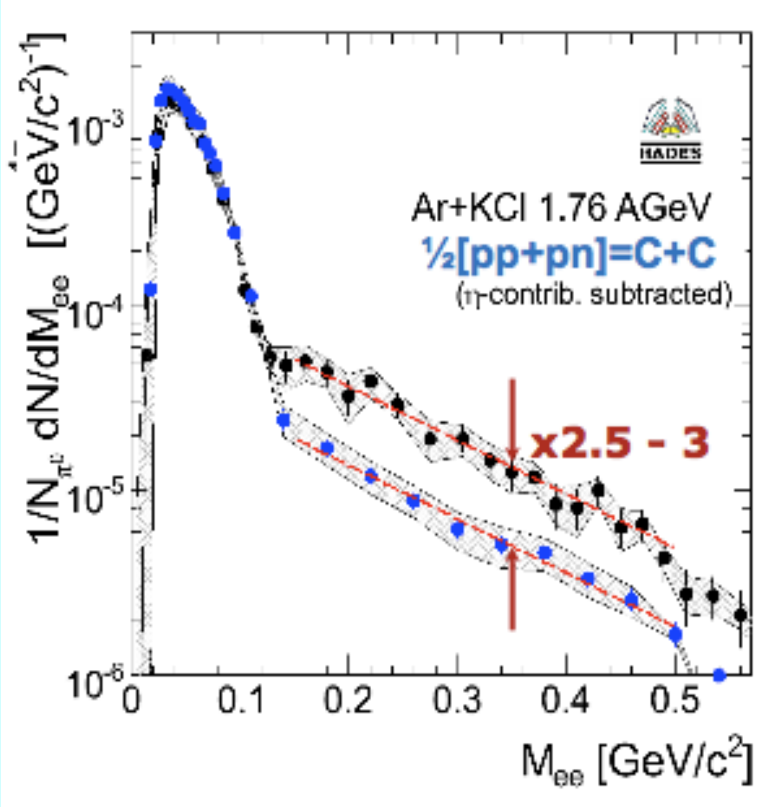
A. Rustamov (HADES), this conference



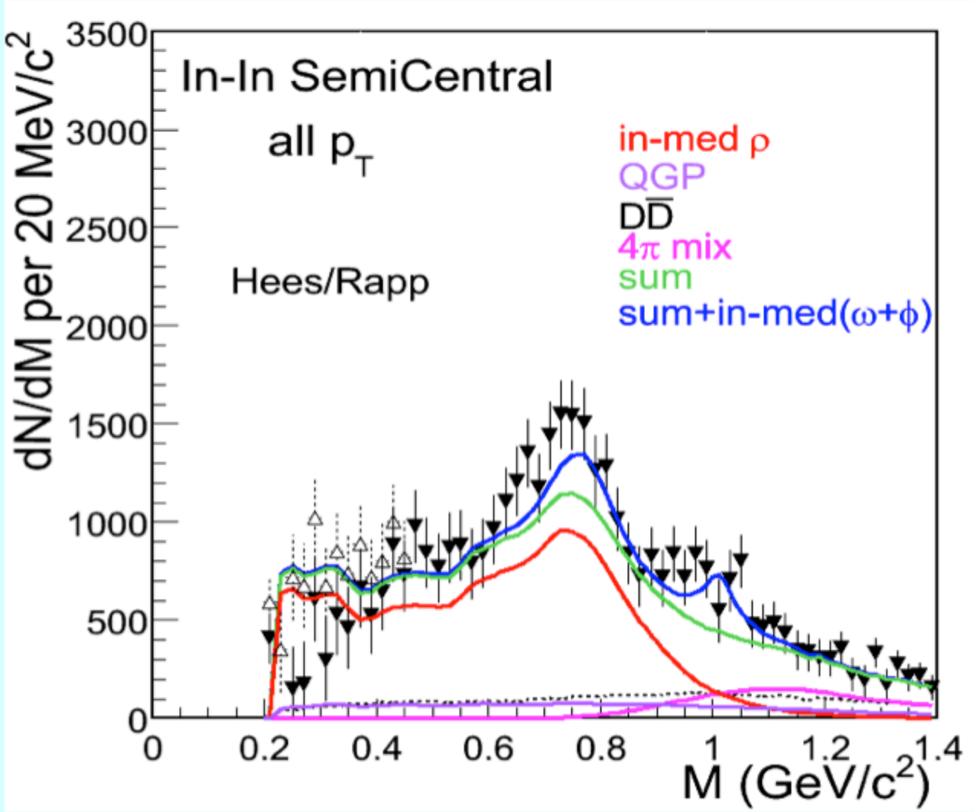
Everything understood by statistical model?
Data on multi-stranhe hyperons are scarce at low energies....

What to measure: low-mass dileptons

A. Rustamov (HADES), this conference



NA60, calc. by v. Hees / Rapp



Do we understand the observed excess?
Can we observe an onset of chiral restoration?
We need data between 2 and 40 AGeV!

What to measure: ... and many more

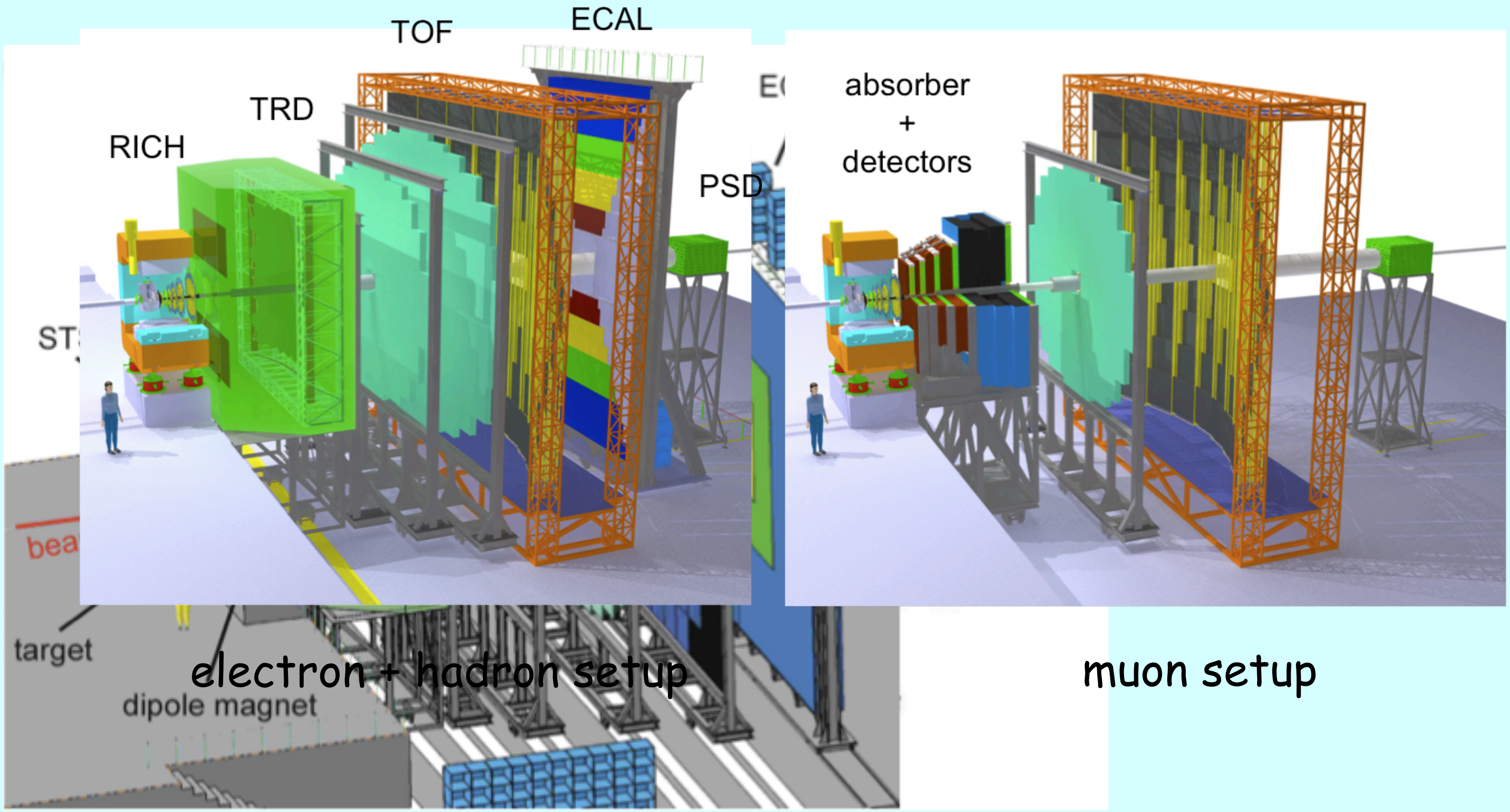
- flow excitation function (magnitude? onset of quark number scaling?)
- direct photons
- fluctuations
- ....

What do we need?

- Identification of hadrons: time of flight
- Identification of electrons: RICH, TRD
- Identification of muons: absorber system
- Measurement of neutrals: calorimeter
- Micro-vertex capabilities for open charm
- High rates for rare observables (charm, multi-strange hyperons)
- Large acceptance (forward rapidity, low and high pt coverage)

The CBM Geometry - Over The Years

2009



electron + hadron setup

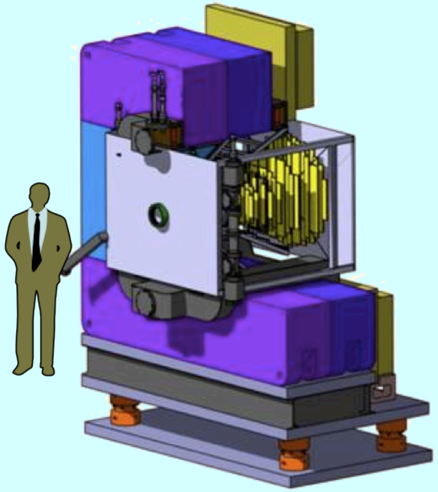
muon setup

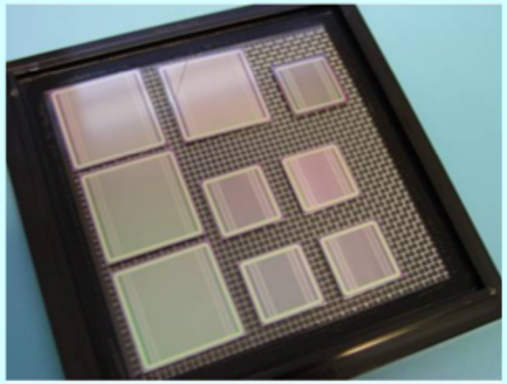
CBM: General status

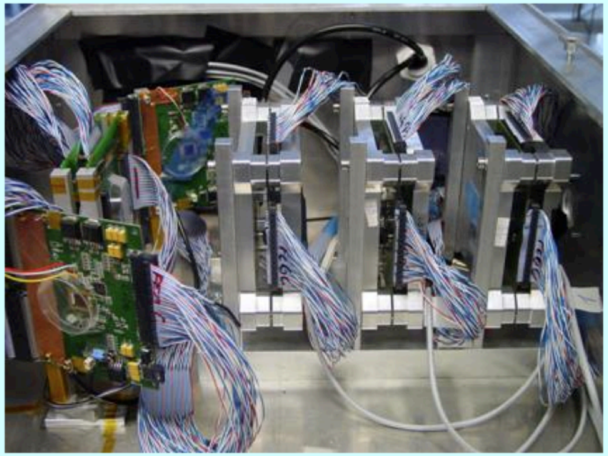
- Basic design consolidated
- Feasibility of the measurement of main observables shown
- Collaboration established (currently about 400 members)
- Activities now shift to development of detectors: in most cases, no off-the-shelf solution possible (rate capability, speed, material budget, radiation tolerance)

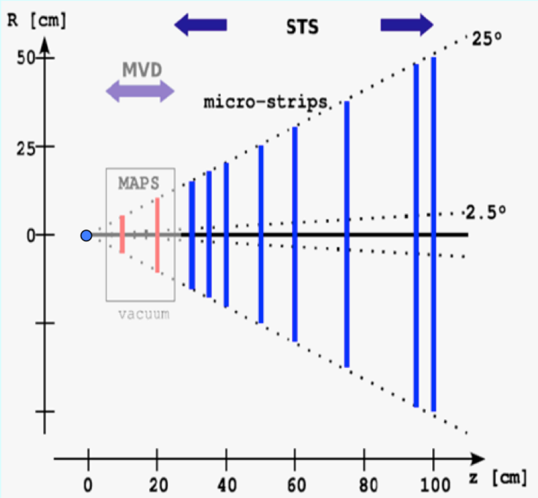
Silicon Tracking System

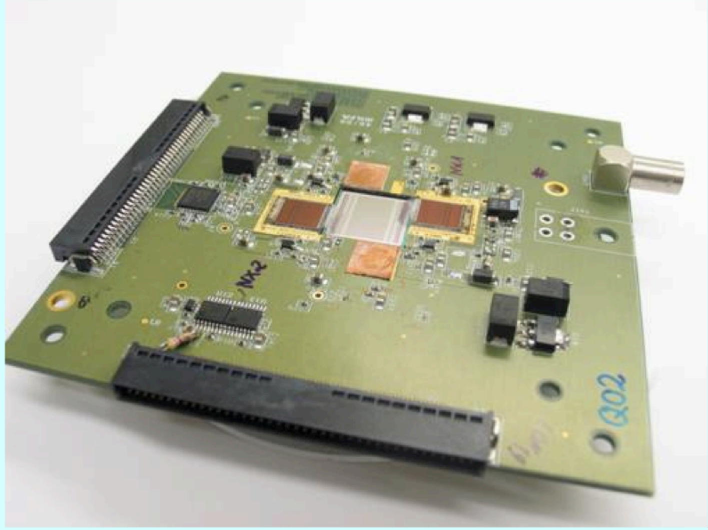
From first design to demonstrators, prototypes and beam tests

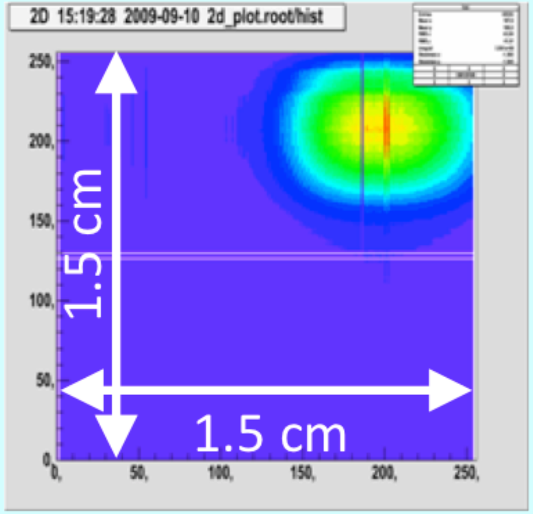




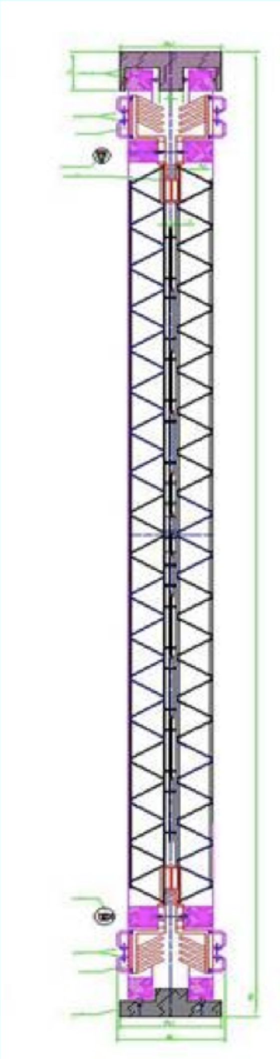


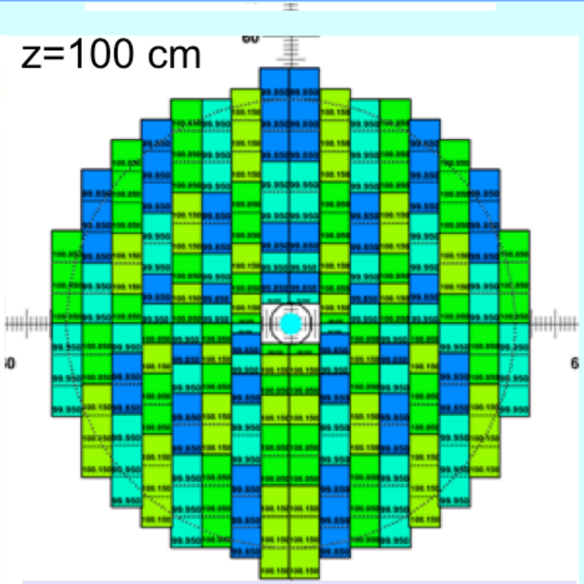


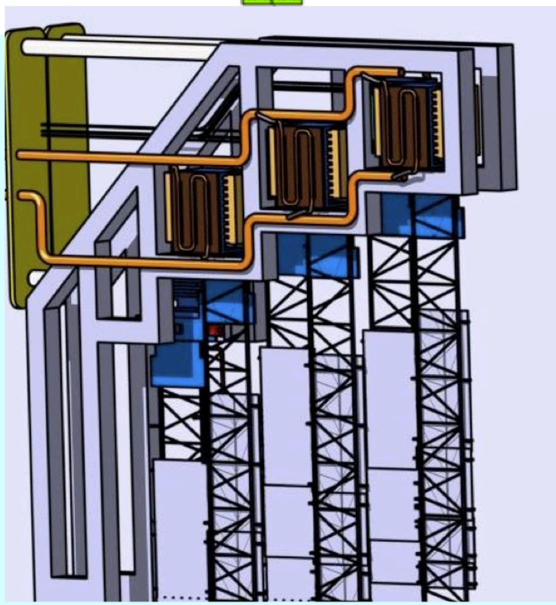


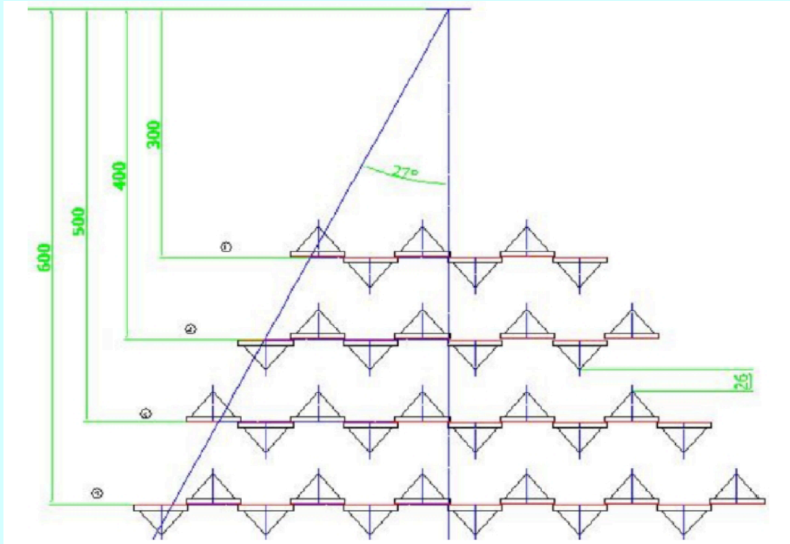


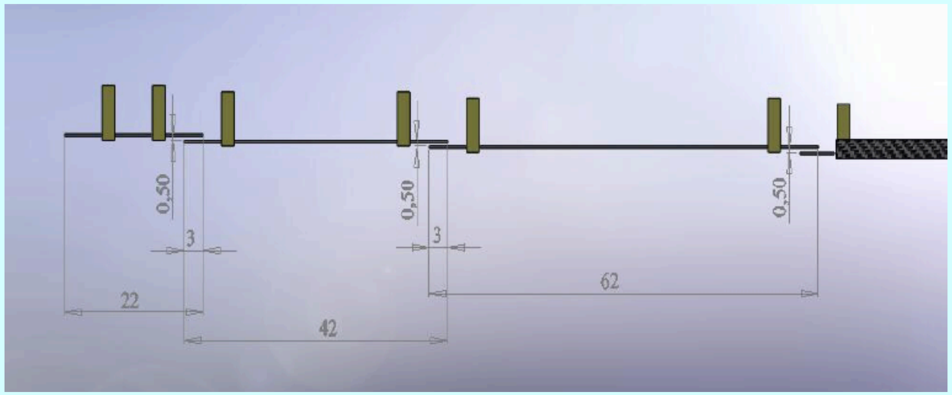
STS: detailed design and system integration





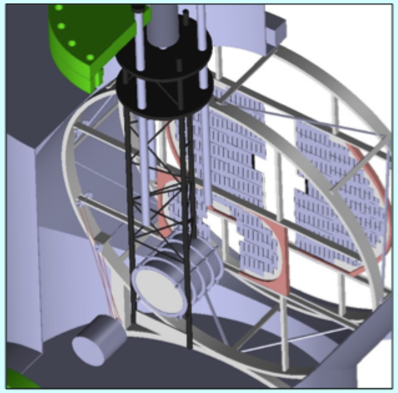


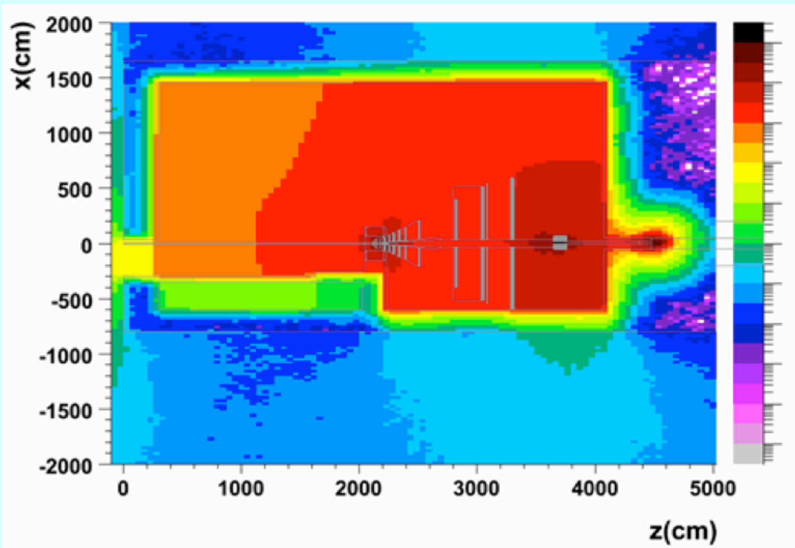




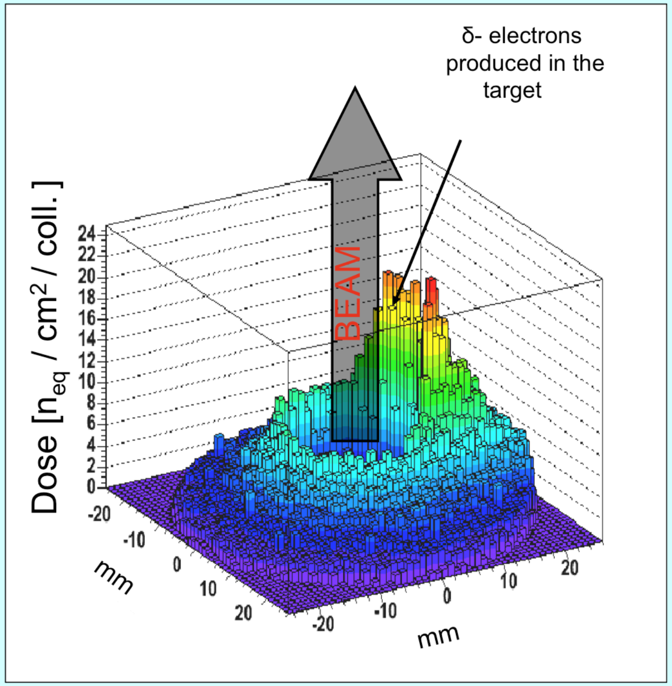
Micro Vertex Detector: The extreme challenge

- for open charm detection: very close to target; must be precise (low mass), fast (high rates) and stand the radiation environment

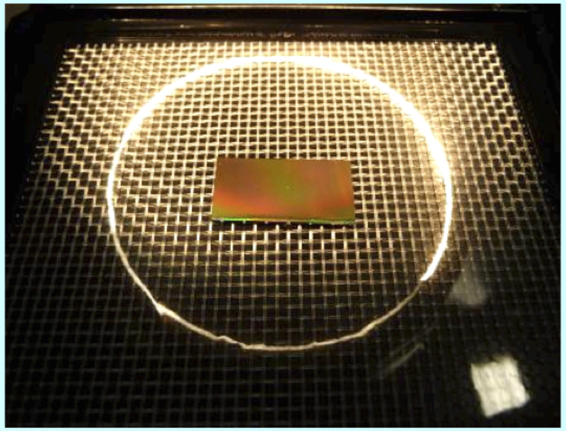


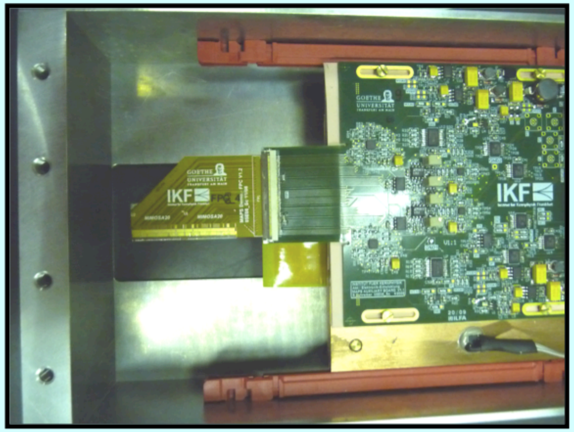


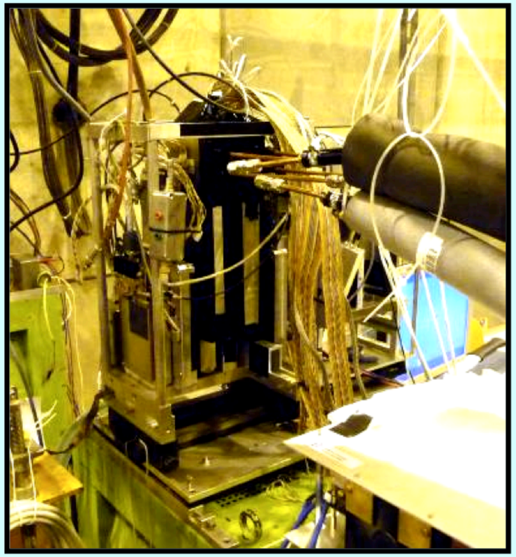
10^{13} - 10^{15} $n_{eq}/cm^2/year$



MVD: MAPS developments



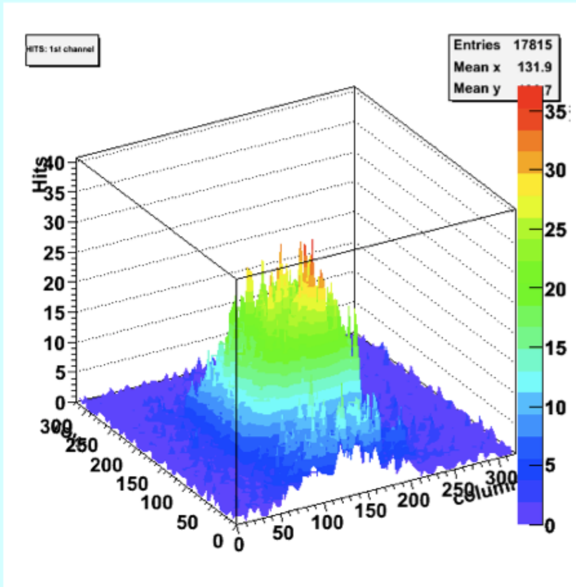




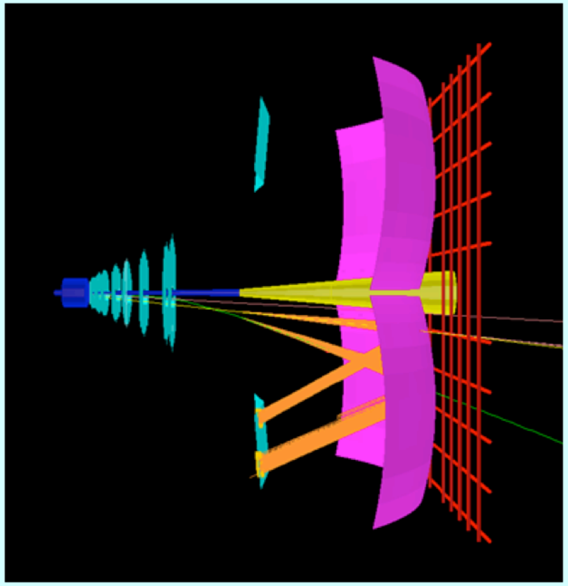
Monolithic Active Pixel Sensor:

- MimoSis 1 chip: 20 x 7.7mm^2
- pixels: 16 μm pitch
- rad tolerant: < $3x10^{12} n_{eq}/cm^2$
- 0-suppressed readout in 40μs

Chip thinned to 50 μm
Module: $\Rightarrow$ 0.3 % X_0

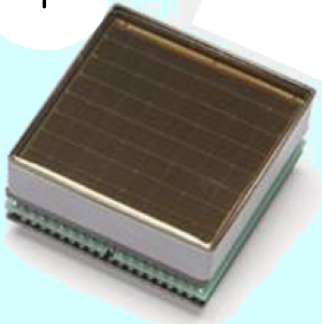


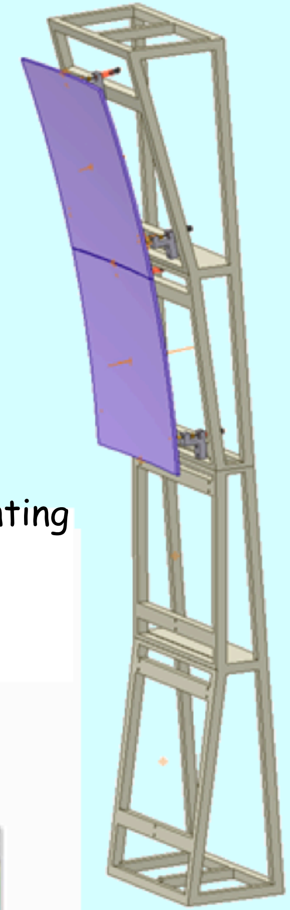
Huge improvement in r/o spead and rad. tolerance
Now close to specifications
First demonstrator successfully operated in beam



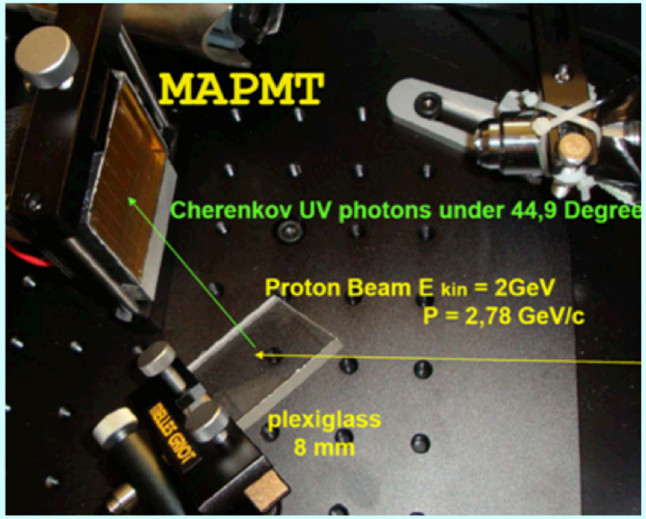
RICH layout

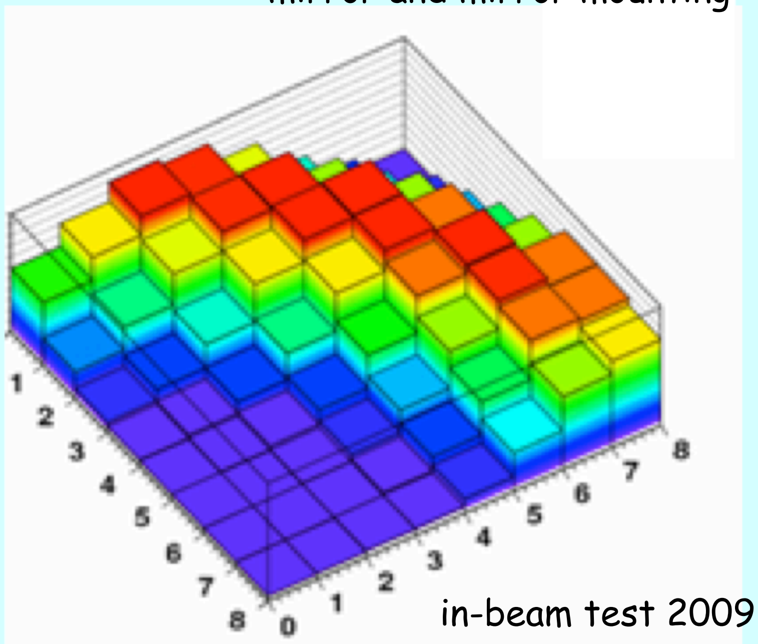
MAPMT for photodetection





mirror and mirror mounting

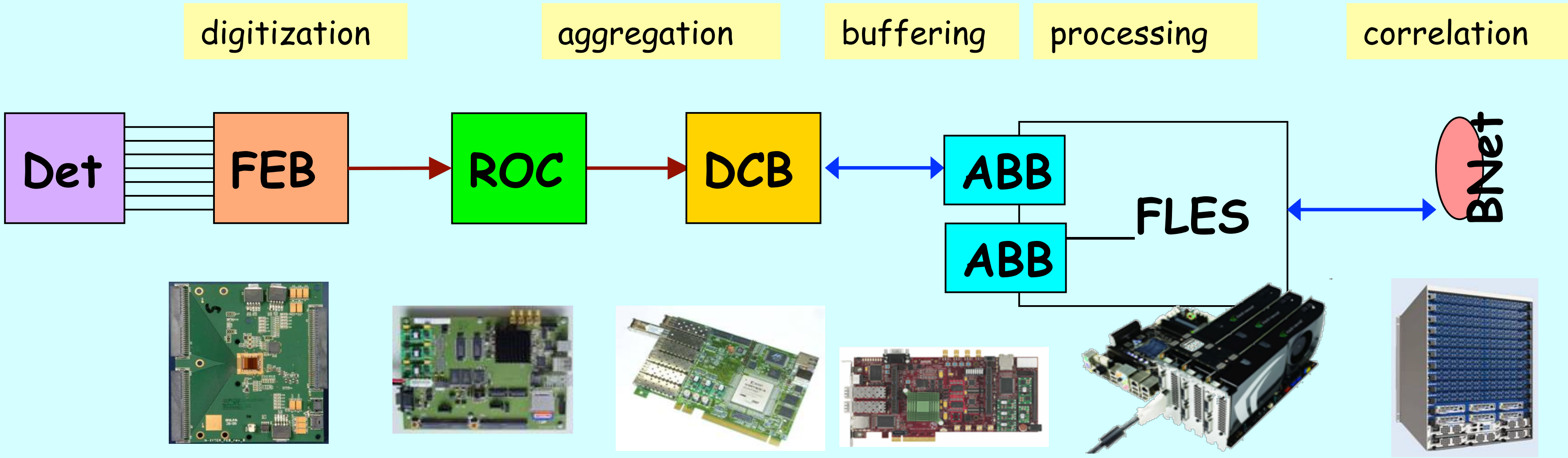




in-beam test 2009

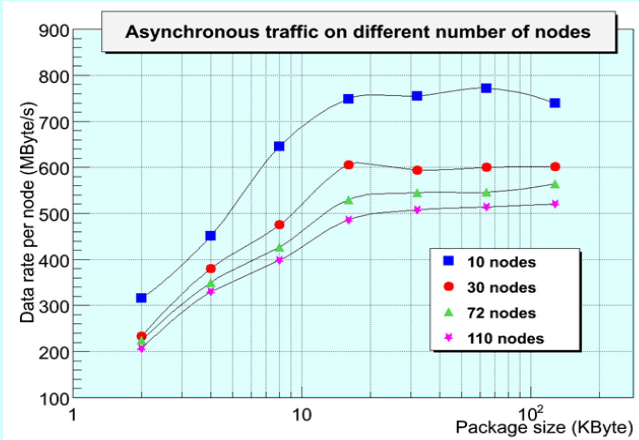
DAQ: a new paradigm

R&D challenge: High speed data transport and event building (1 TB/s)

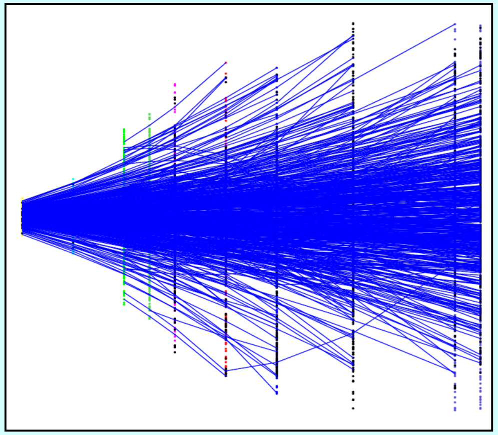


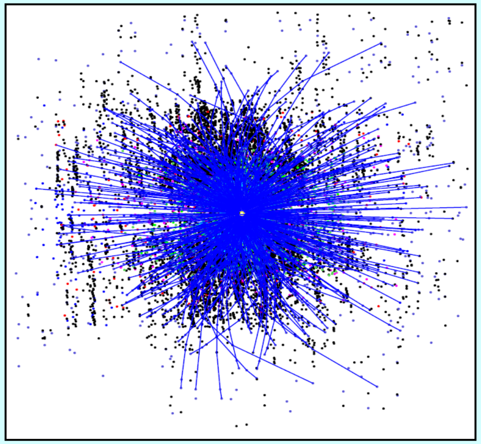
Ship 1 TB/s from front-ends
No conventional trigger: self-triggered FEE
Event association, (partial) reconstruction and selection in FLES

DAQ chain components developed and tested in-beam; operation successful



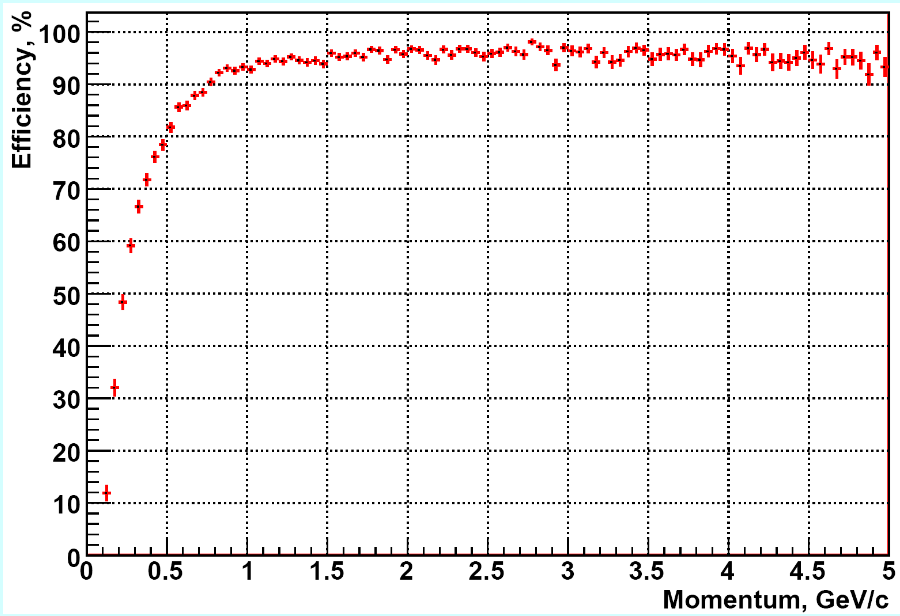
STS track reconstruction: Cellular Automaton



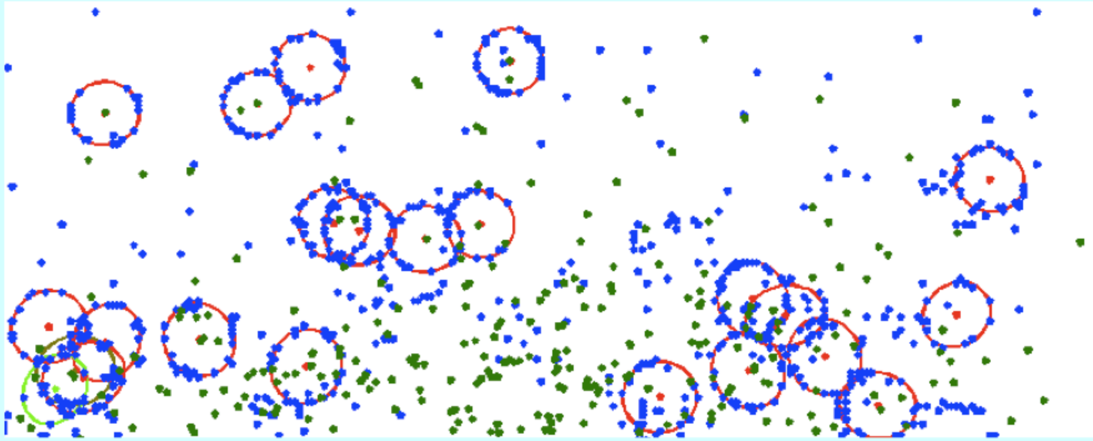


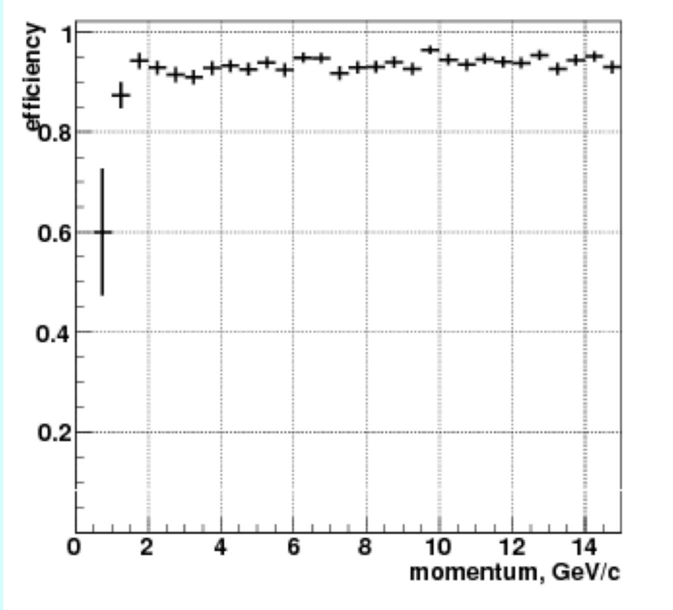
Track category	Efficiency, %
Reference set (>1 GeV/c)	95.2
All set (≥4 hits,>100 MeV/c)	89.8
Extra set (<1 GeV/c)	78.6
Clone	2.8
Ghost	6.6
MC tracks/ev found	672
Speed, s/ev	0.8

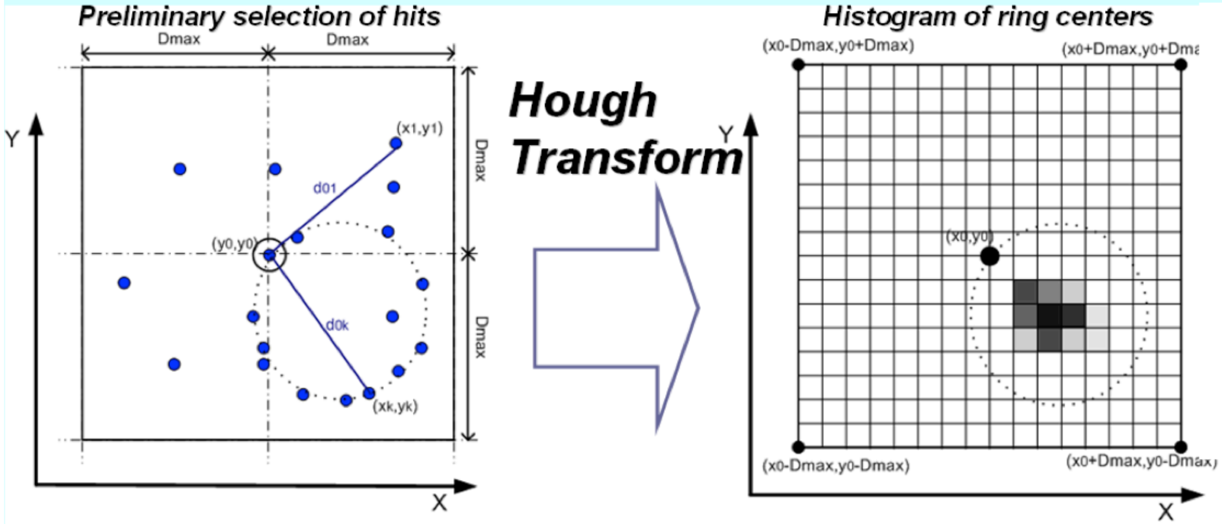
UrQMD, central Au+Au @ 25 AGeV

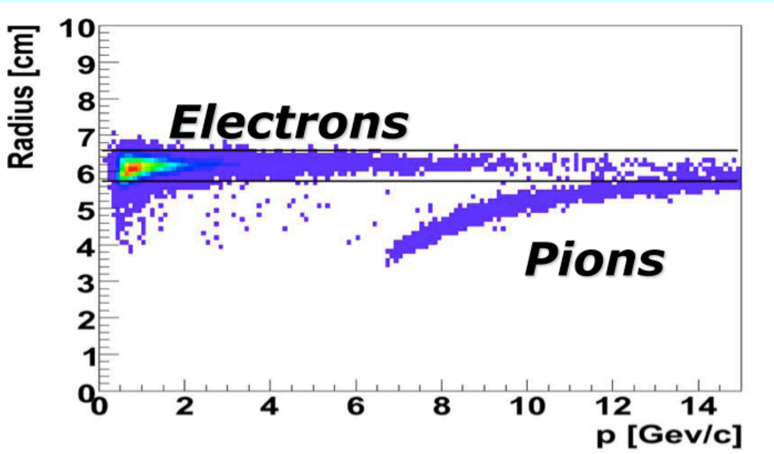


Reconstruction: RICH





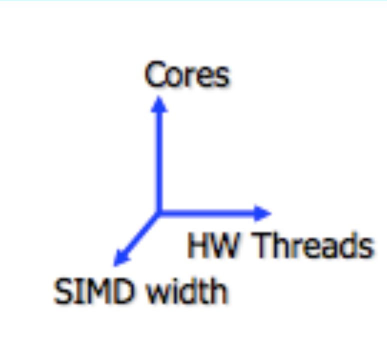




CBM: Running modes

- Untriggered: ≈ 10^4 events/s, 1 GB/s from FEE, 1 GB/s to archiv
  - pion, kaon, proton, hyperon yields, spectra and flow
  - low-mass dielectrons
- Medium rate: 10^5 – 10^6 events/s, < 100 GB/s from FEE, 1 GB/s to archiv
  - low-mass dimuons
  - open charm (limited by MAPS)
  - online event reduction 10 - 100
- High rate: 10^7 events/s, 1 TB/s from FEE, 1 GB/s to archiv
  - charmonium (electron or muon channel)
  - online event reduction 10^3

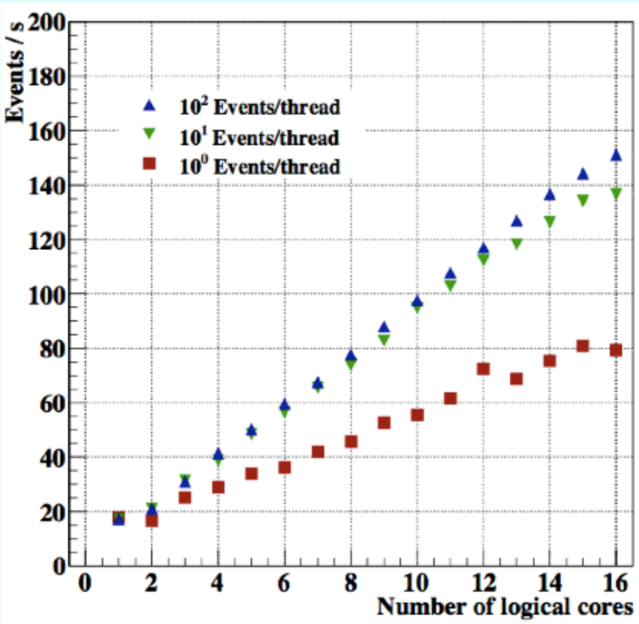
The challenge: fast online reconstruction



Make use of modern computer architectures:

- vector processing
- multithreading
- many core

CA track finder

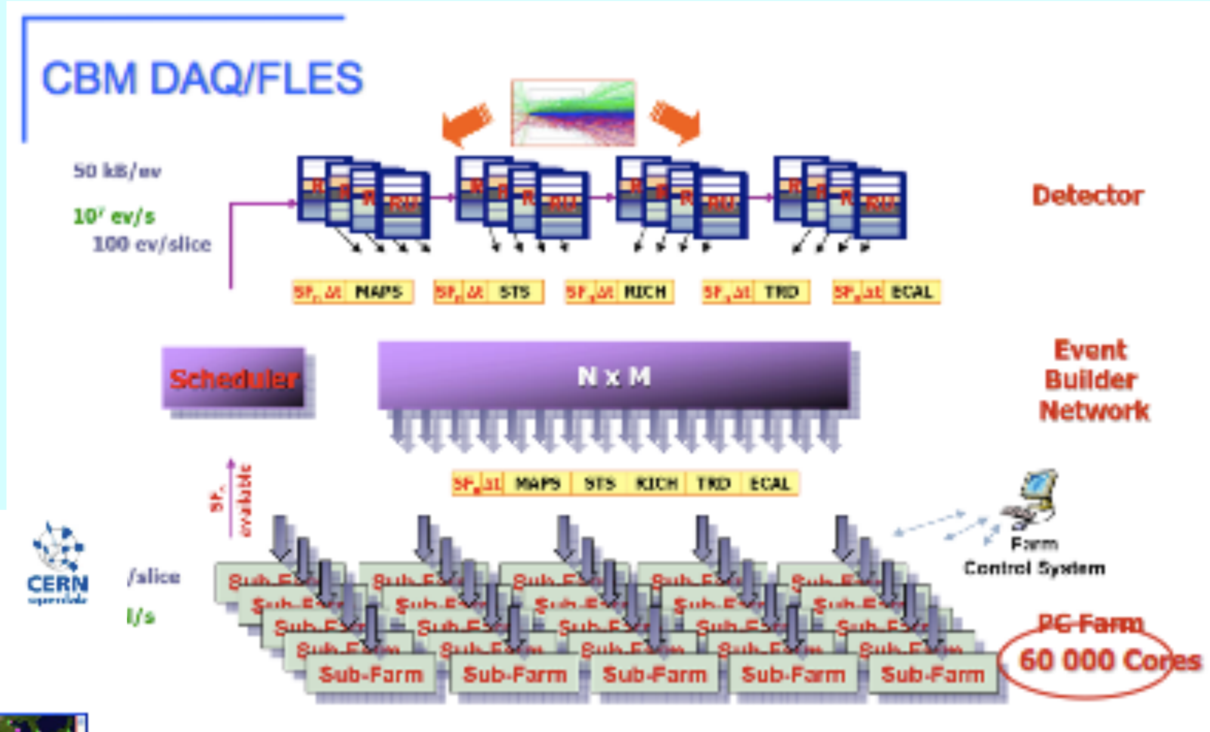


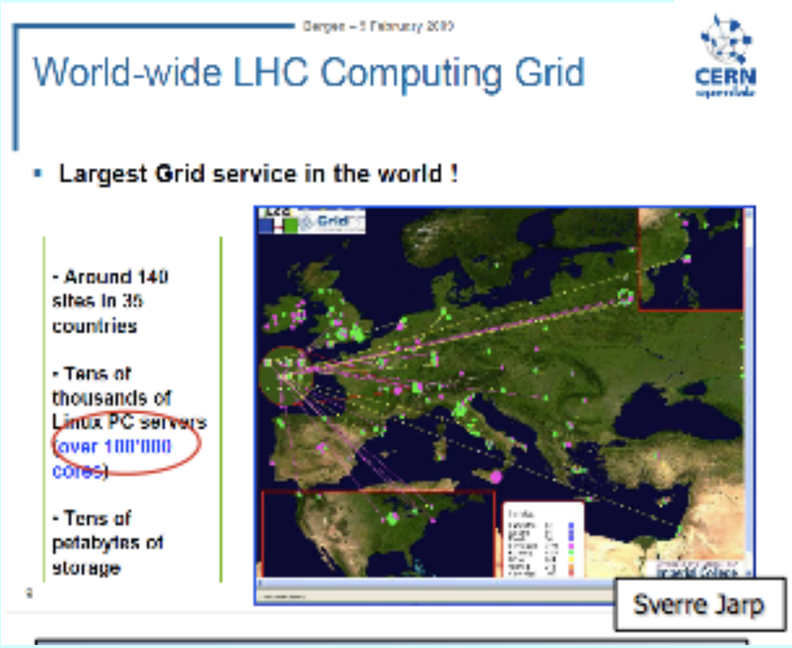
KF track fitter

	Stage	Description	Time/track	Speedup
Intel P4		Initial scalar version	12 ms	–
Intel P4	1	Approximation of the magnetic field	240 μs	50
Intel P4	2	Optimization of the algorithm	7.2 μs	35
Intel P4	3	Vectorization	1.6 μs	4.5
Cell	4	Porting to SPE	1.1 μs	1.5
Cell	5	Parallelization on 16 SPEs	0.1 μs	10
		Final simdized version	0.1 μs	120000

Similar activities ongoing for RICH, TRD and MUCH reco

FLES farm: estimates and ideas

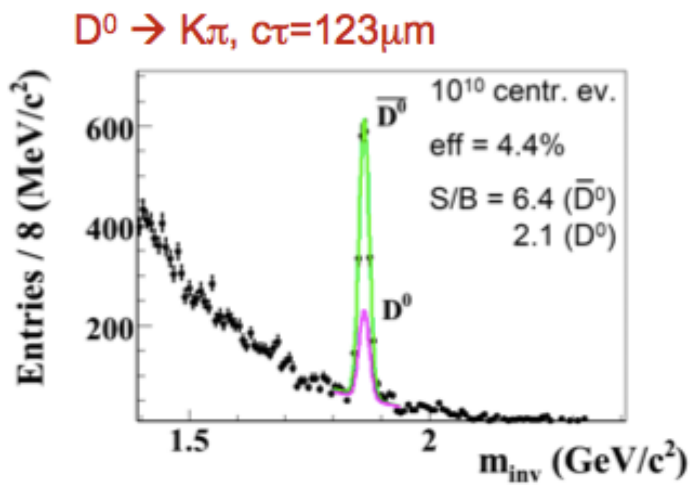


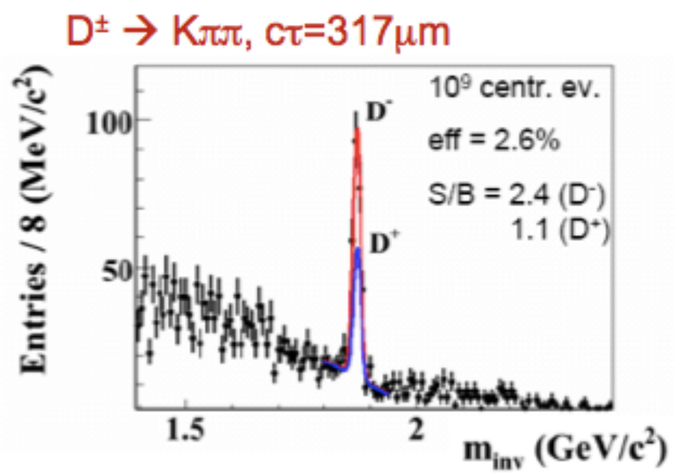


Online processing on/near experiment at GSI (new HPC centre)

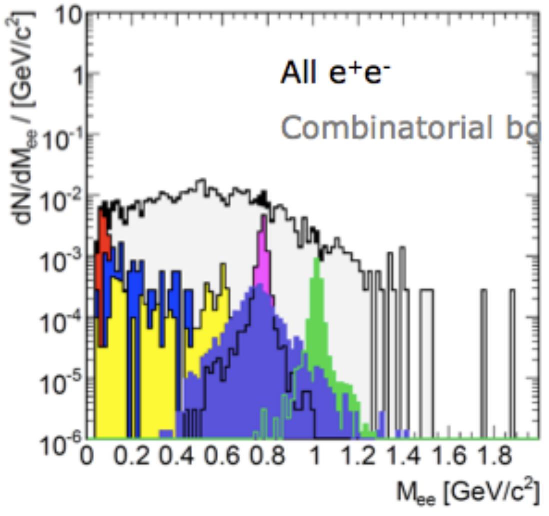
Performance (Au+Au, 25 AGeV)

open charm

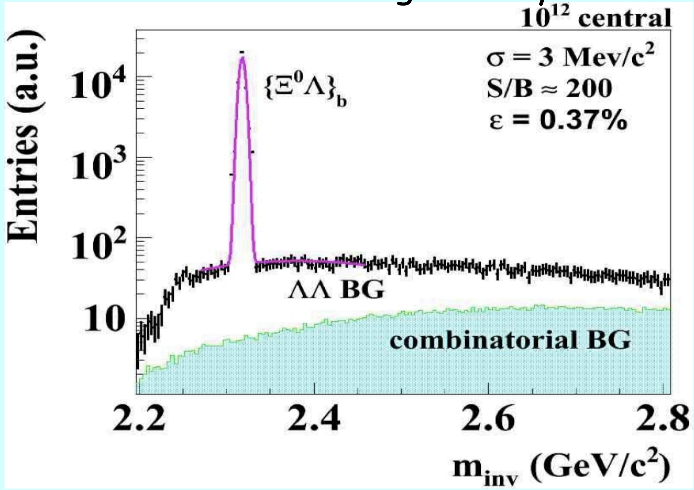




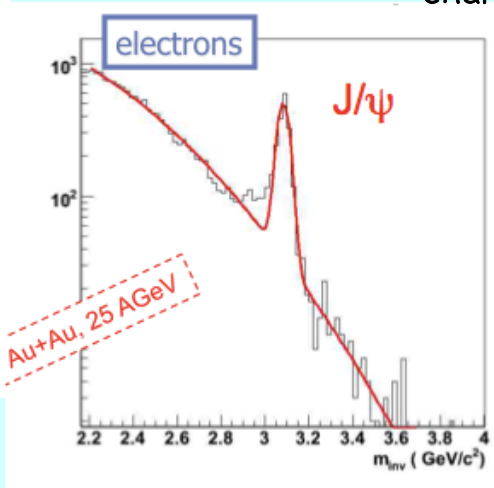
low-mass dielectrons

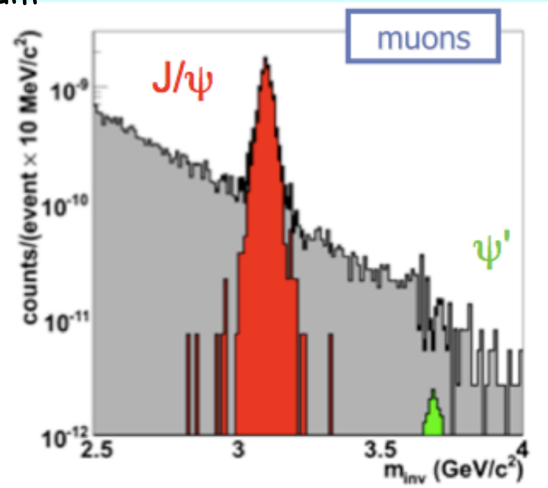


multi-strange dibaryons



charmonium





FAIR modules

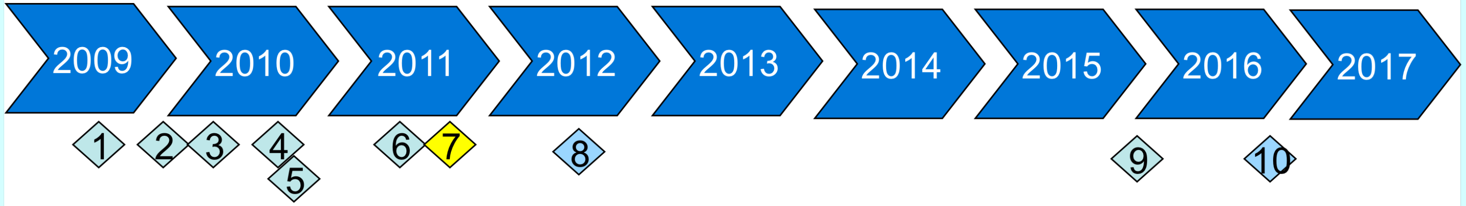
2003	**Recommendation by WissenschaftsRat – FAIR Realisation in three stages**						
2005	**Entire Facility** **Baseline Technical Report**						
2007	**Phase A**						**Phase B** SIS300
2009	**Module 0** SIS100	**Module 1** expt areas CBM/HADES and APPA	**Module 2** Super-FRS fixed target area NuSTAR	**Module 3** pbar facility, incl. CR for PANDA, options for NuSTAR	**Module 4** LEB for NuSTAR, NESR for NuSTAR and APPA, FLAIR for APPA	**Module 5** RESR nominal intensity for PANDA & parallel operation with NuSTAR and APPA SIS18 Proton Beamline	**Module 6** SIS300 HESR **Cooler** ER

Modularized Start Version (Modules 0–3)

B. Sharkov, director (des.) FAIR

FAIR roadmap

Road Map FAIR Site & Buildings

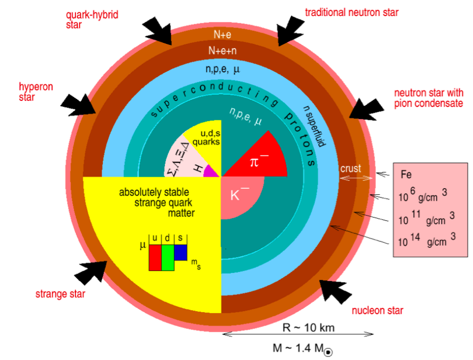


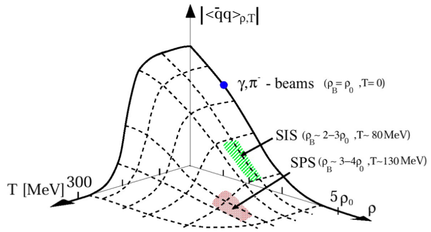
1. Handing in of preplanning documents to hbm
2. Clarification of user requirements Modularized Start Version (MSV)
3. Start revised preplanning for MSV
4. Expected approval of revised planning for MSV
5. Preparation of documents for building permit
6. Expected approval for (partial) building permit
7. Start site preparation (clearing trees)
8. Award contracts on civil construction work lot 1 … 4
9. Completion of civil construction work lot 1 … 4
10. Start installation of accelerators and detectors

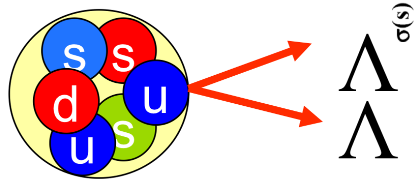
B. Sharkov, director (des.) FAIR

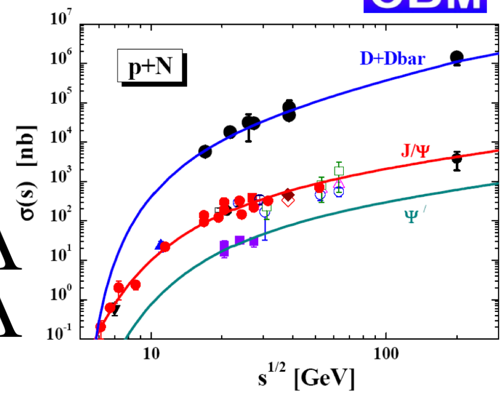
CBM @ SIS-100

CBM physics at SIS100





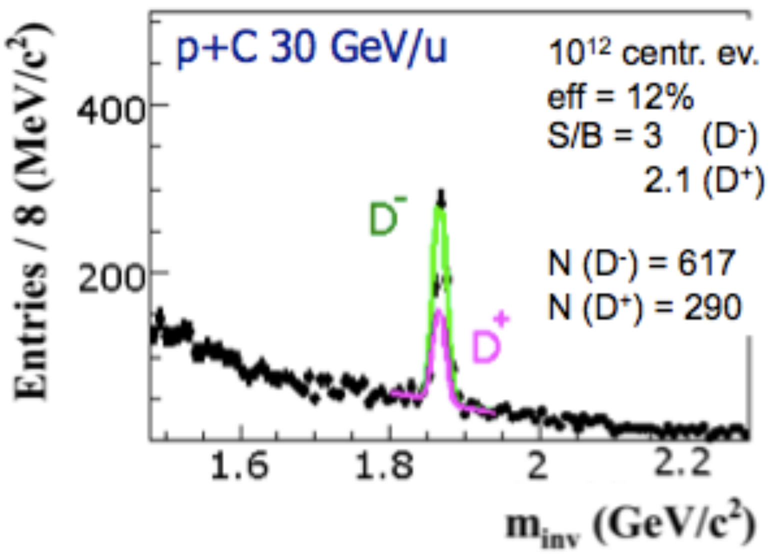


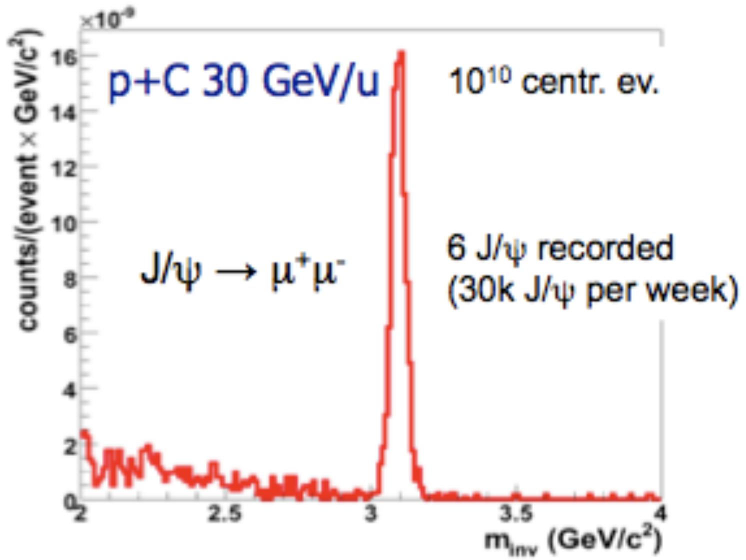


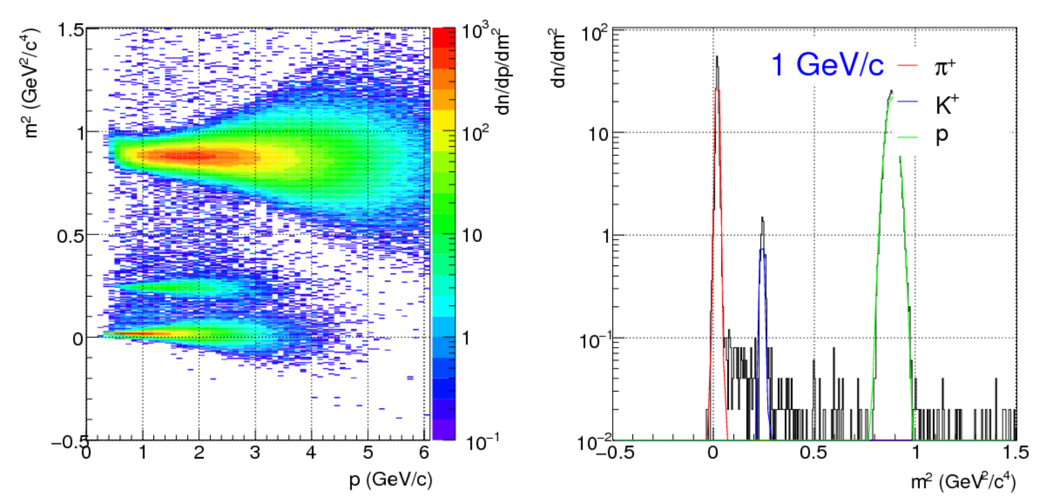
- Nuclear equation-of-state:
  What are the properties and the degrees-of-freedom of nuclear matter at neutron star core densities?
- Hadrons in dense matter:
  What are the in-medium properties of hadrons?
  Is chiral symmetry restored at very high baryon densities?
- Strange matter:
  Does strange matter exist in the form of heavy multi-strange objects?
- Heavy flavor physics:
  How ist charm produced at low beam energies, and how does it propagate in cold nuclear matter?

P. Senger

Performance at SIS-100







Simulations ongoing
First results: not much degradation of physics performance at lower beam energies

Summary

- CBM transited from the design / simulation phase to detector R&D and prototyping
- Progress in all major subdetector systems
- With simulations continuously adjusted to new insights on detector layout and detailed design: key observables demonstarted to be feasible
- Promising activties and first results towards fast algorithms for online event selection
- Will be ready for beam at SIS-100; valid (start) physics programme there identifiable
- Full physics to come with SIS-300

Progress towards SIS-300

R&D on SC magnets with curved coils

SIS-300 pre-consortium founded, March 2009, Protvino