Beam requirements of CBM & HADES

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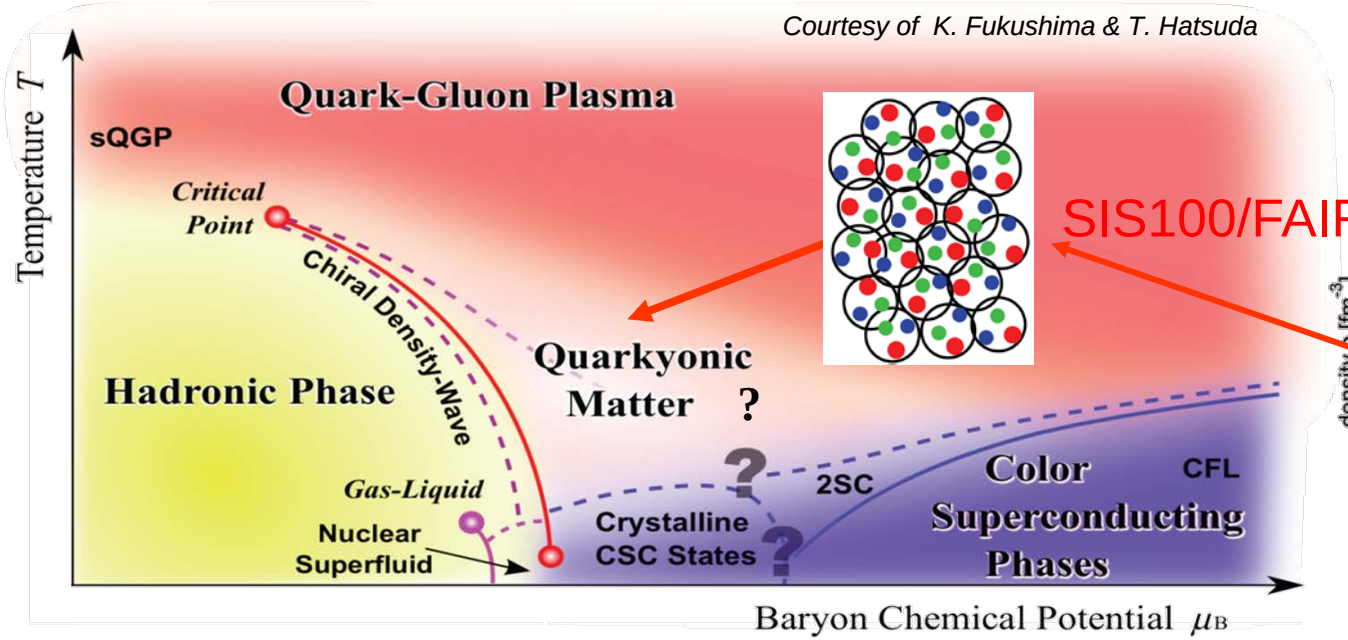
and
Jerzy Pietraszko

Outline

1. Running scenario @ SIS100 - *C. Sturm*
   - A brief introduction
   - CBM running scenario
   - CBM pre-commissioning phase
   - HADES running scenario

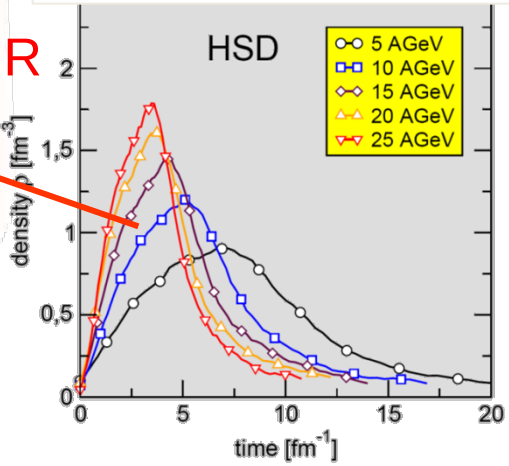
2. Beam quality requirements for CBM & HADES @ SIS100 - *J. Pietraszko*

Exploring the QCD phase diagram



SIS100/FAIR

Baryon density in central Au+Au collisions (HSD transport code)



Open questions at high net baryon densities:

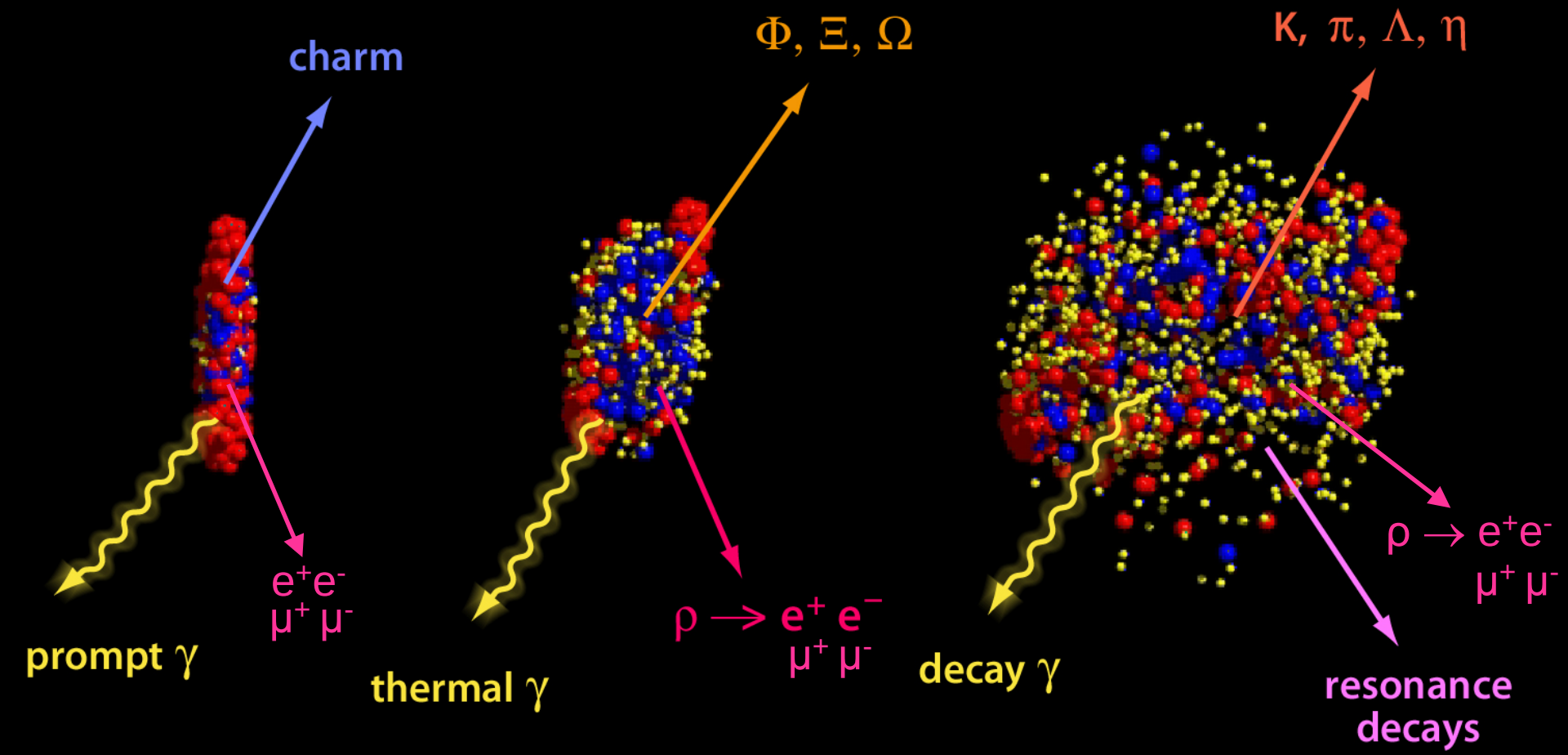
- Phase transition from hadronic matter to quarkyonic or partonic matter ?
- Chiral phase transition ? Chiral restoration ?
- In-medium modification of hadrons ?
- Nuclear Equation-of-State at neutron star core densities ?

→ **substantial discovery potential with CBM at FAIR**

Field driven by experimental data !

Messengers from the dense fireball

UrQMD transport calculation



Charm, multi-strange (anti)particles, vector mesons (→dileptons) are rare probes at FAIR energies !

Experimental challenges

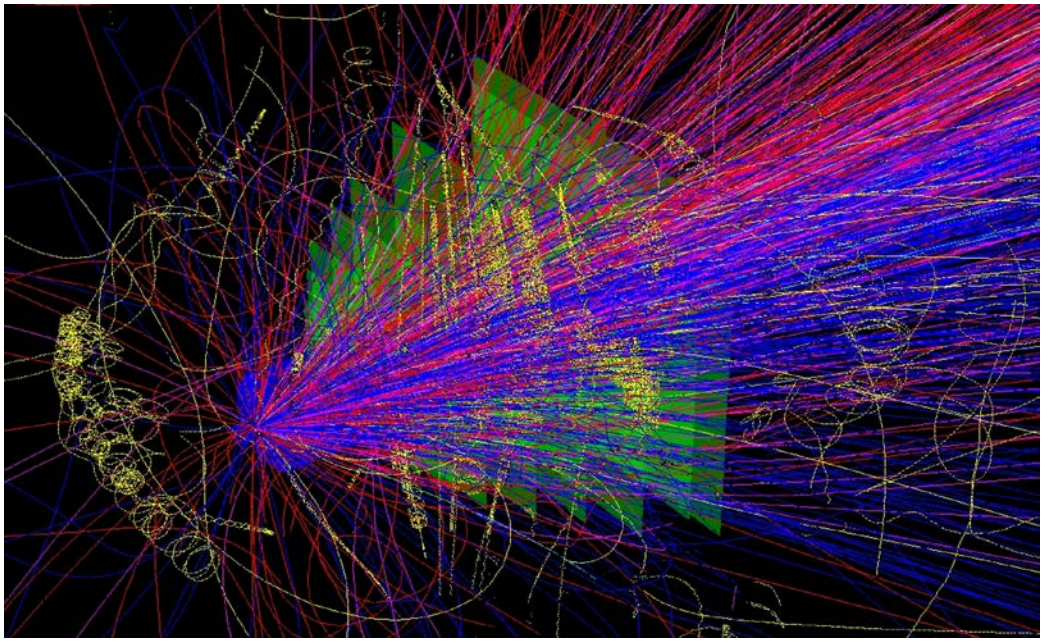
Perform measurements at unprecedented reaction rates

10^5 - 10^7 Au+Au reactions/sec

→ fast and radiation tolerant detectors

→ free-streaming read-out electronics

→ high speed data acquisition and high performance computer farm for online event selection



Central Au+Au at 25 A GeV / UrQMD+GEANT4
160 p, 450 $\pi^+ + \pi^-$, 44 K^+, 13 K^-

Identification
of leptons and hadrons

Determination of
(displaced) vertices ($\sigma \approx 50$ μm)

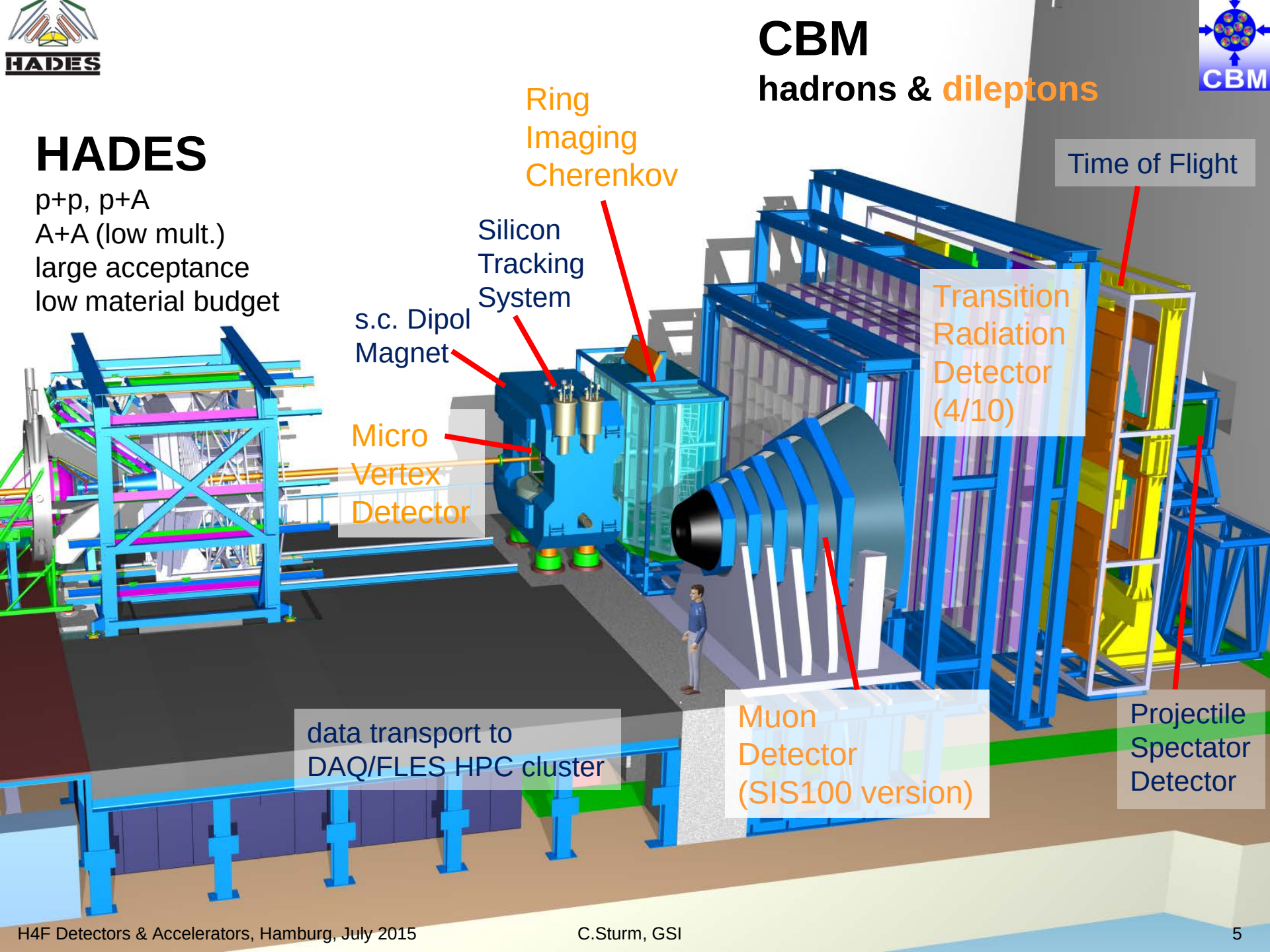
momentum resolution
$\delta p / p \cong 1\%$

CBM

hadrons & dileptons

HADES

p+p, p+A
A+A (low mult.)
large acceptance
low material budget



Anti-hyperon reconstruction

Input:
UrQMD 3.2
Au+Au 10 AGeV
central collision

π^+

K^+

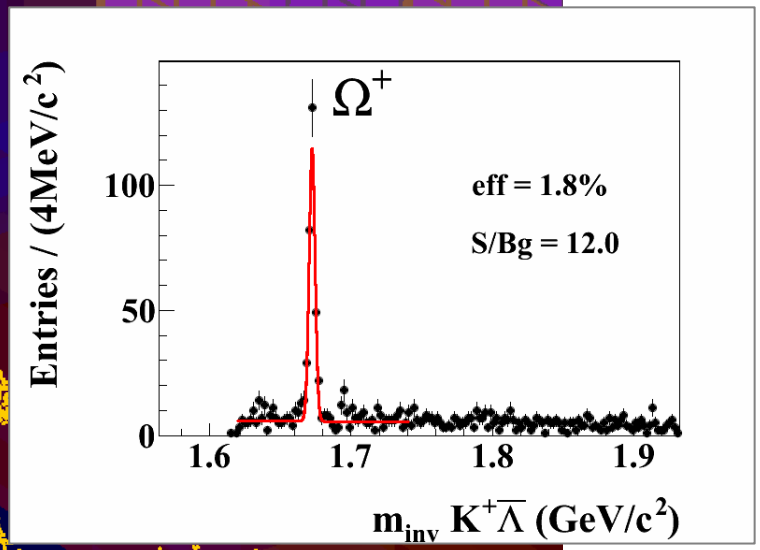
$\bar{p}$

$\Omega^+ \rightarrow \bar{\Lambda} K^+$

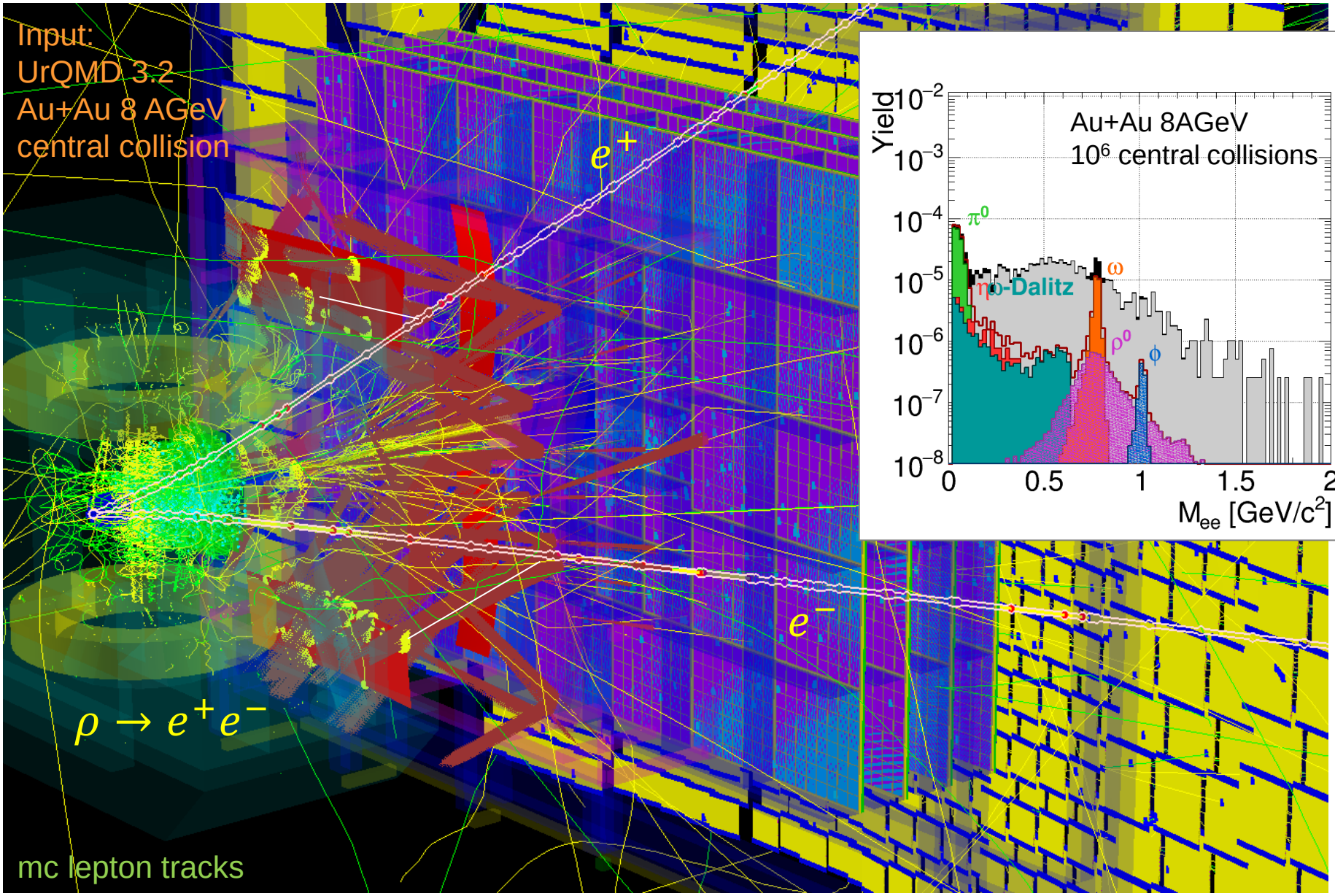
$\Omega^+(\bar{s}\bar{s}\bar{s})$

$M \cong 10^{-5}$

3D space points
in STS stations



Di-electron reconstruction



Di-muon reconstruction

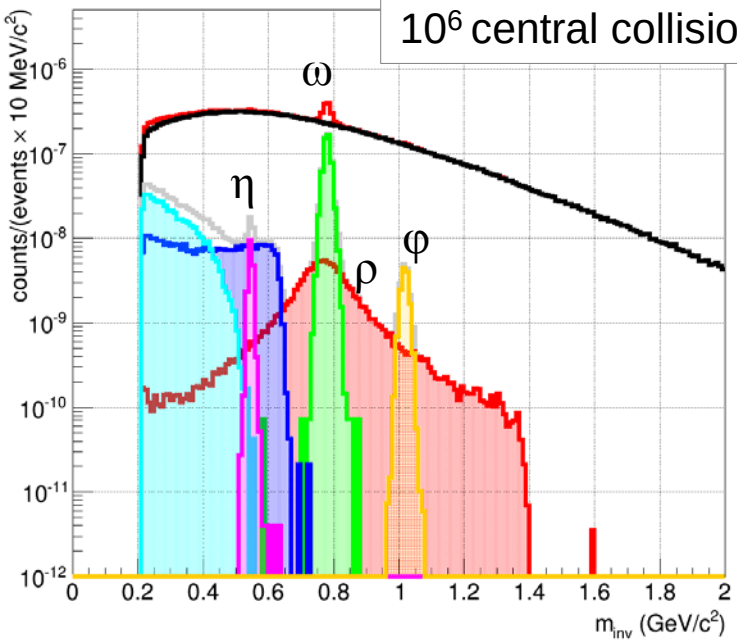
Input:
UrQMD 3.2
Au+Au 8 AGeV
central collision

$\omega \rightarrow \mu^+ \mu^-$

μ^+

μ^-

Au+Au 8AGeV
10^6 central collisions



Simulation: signal yields from HSD
background from UrQMD

CBM running scenario at SIS100 (preliminary)

Collision system	Projectile (intensity [s^{-1}])	Observable	CBM configuration of detector subsystems	Request [weeks]
A + A (C, Au) at 4, 6, 8, 11, (14) AGeV	C (10^8), Au (10^7)	▪ Hadrons ▪ Hypernuclei ▪ Di-electrons	MVD, STS, TOF, PSD, & RICH, TRD	6
p + A (C, Au) at 4, 6, 8, 11, 14 GeV	p ($5x10^8$)	▪ Hadrons ▪ Di-electrons	MVD, STS, TOF, (PSD) & RICH, TRD	6
p + p & p + A (C, Au) at 14, 20, 25, 29 GeV	p ($5x10^8$)	▪ Open charm	MVD, STS, TOF, (PSD) & RICH, TRD	12
A + A (C, Au) at 4, 8, 11, (14) AGeV	C (10^9), Au (10^9)	▪ Anti-baryons ▪ Multistrange (anti-)particles	STS, TOF, PSD	12
A + A (C, Ca, Au) at 4, 8, 11, (14) AGeV p + p & p + A (C, Ca, Au) at 14, 20, 25, 29 GeV	C (10^9), Ca (10^9), Au (10^9), p ($5x10^{10}$)	▪ Di-muons (incl. J/ψ)	STS, TOF & MUCH	12

preliminary estimations !

CBM running phases at SIS100 (preliminary)

Pre-commissioning phase

mCBM@SIS18, 2017 – 2021

- high intensity A+A, 1 week per year, main user
- several shifts per year, parasitic user

Commissioning phase – year 1

Technical runs for 3 configurations

- 3x 2 weeks, main user
- several shifts per year, parasitic user

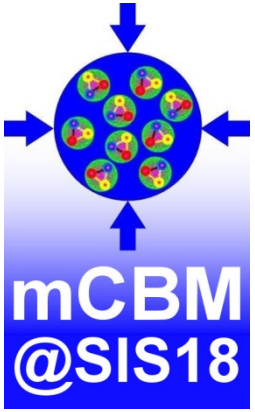
Production phase – year 2 - 7

- 1st block, 4 weeks
- break, $\geq$ 8 weeks
- 2nd block, 4 weeks
- break, $\geq$ 8 weeks
- 3rd block, 4 weeks

CBM pre-commissioning phase:

mCBM@SIS18

CBM full system test 2017 - 2021
in high-rate nucleus-nucleus collisions



Fixed set-up at the host lab

Test of final detector configurations

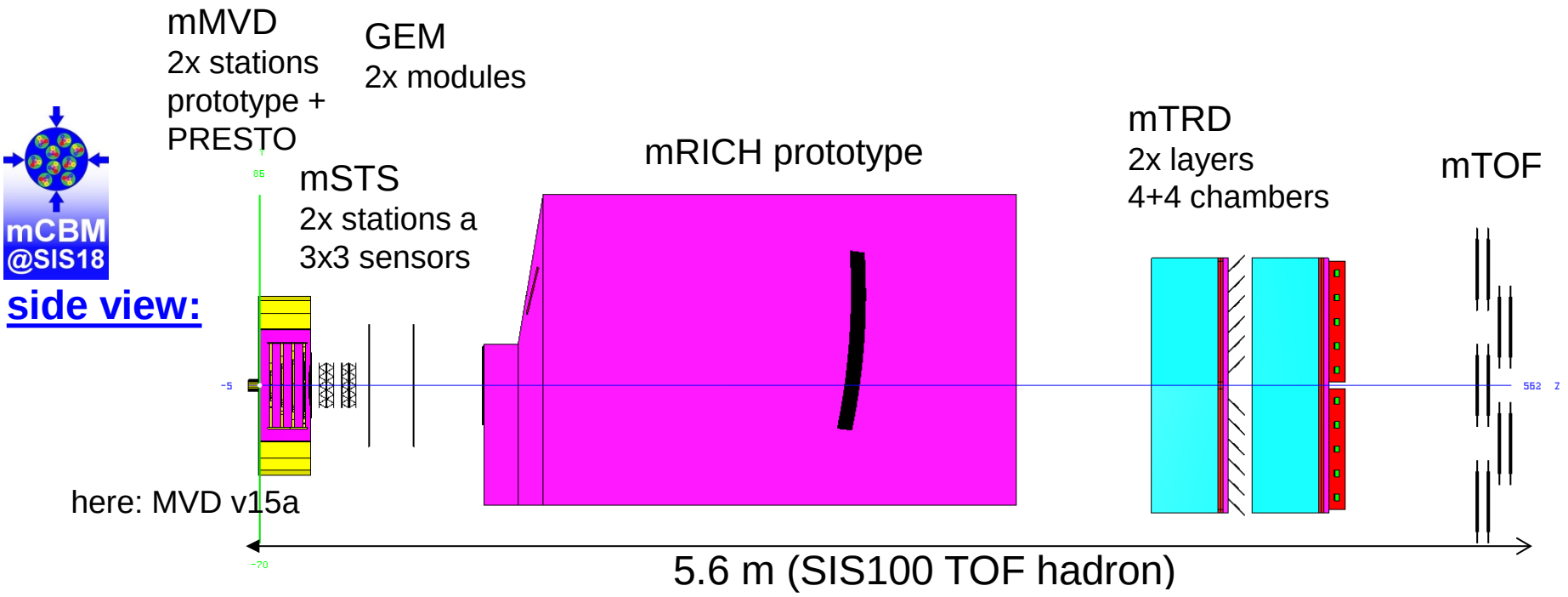
Test and optimization of the

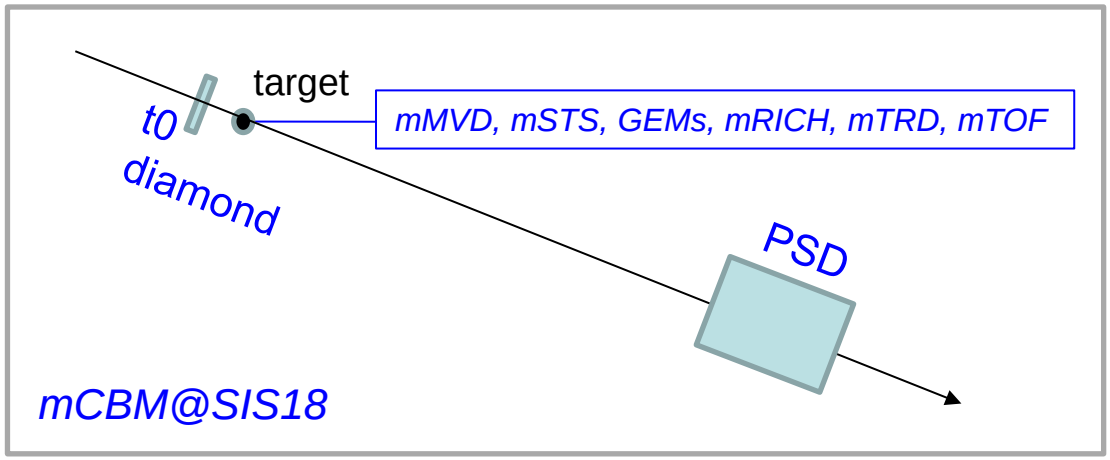
- free streaming data transport to a mFLES or to FLES
- online reconstruction
- offline data analysis

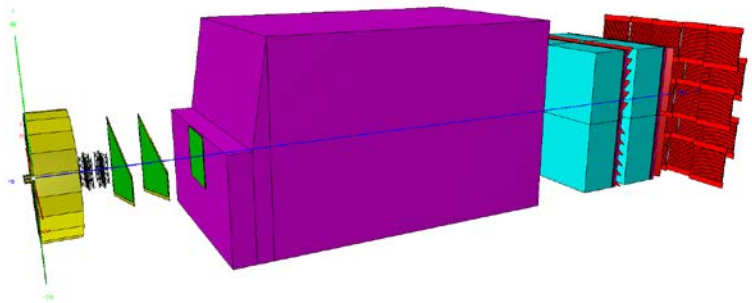
CBM pre-commissioning: *mCBM@SIS18*

mCBM @SIS18

side view:

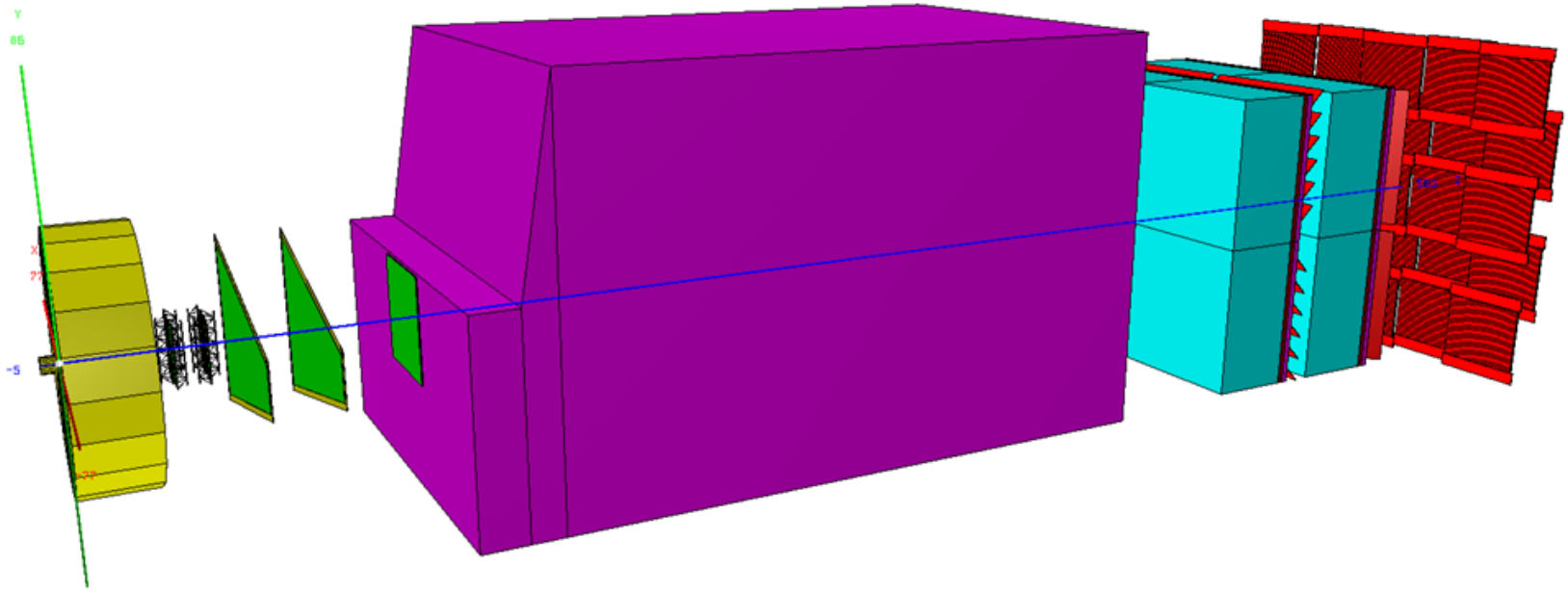


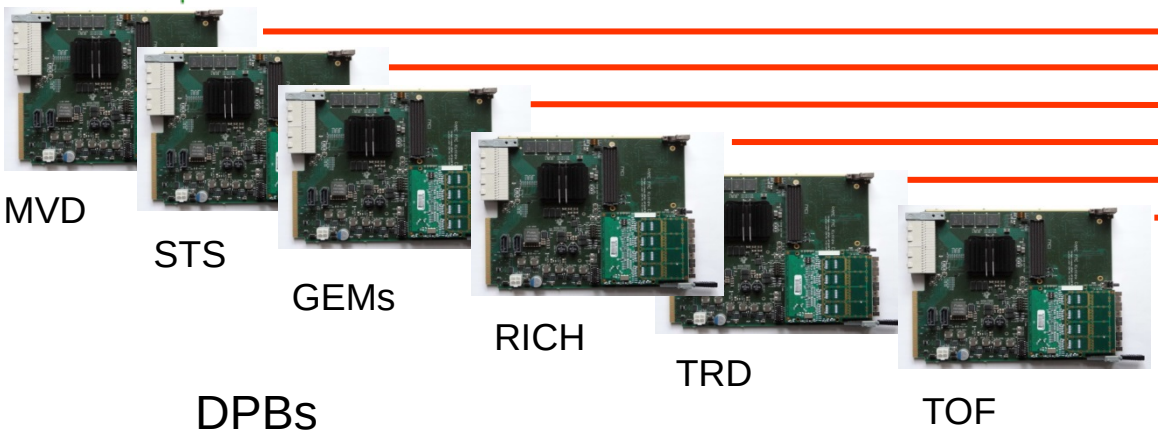




CbmRoot geometry v18a
by David Emschermann
(except MVD)

CBM pre-commissioning: mCBM@SIS18





Scientific output after first years of CBM running

Au+Au collisions, 4 – 11 A GeV

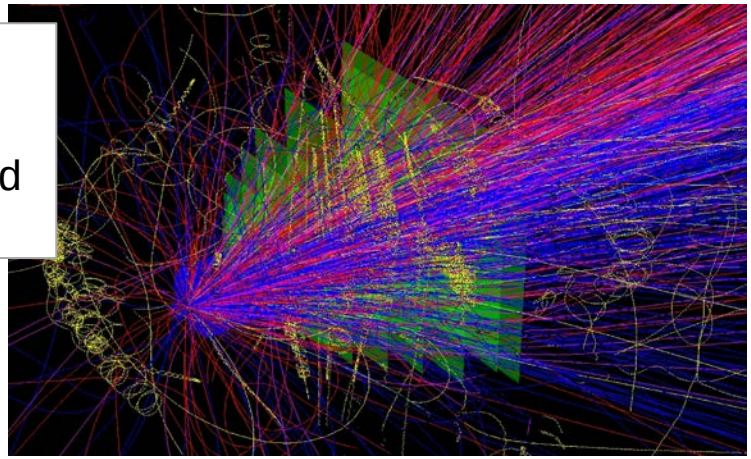
- Yield, p_T spectra and flow excitation functions of identified particles incl. multi-strange hyperons
- Excitation function of event-by-event fluctuations
- (Double-) hypernuclei produced (discovered)
- Heavy strange objects discovered or excluded
- In-medium properties of light vector mesons at different fireball densities and temperatures
- Excitation function of the fireball temperature
- Flow of dileptons as function of p_T and m_{inv}

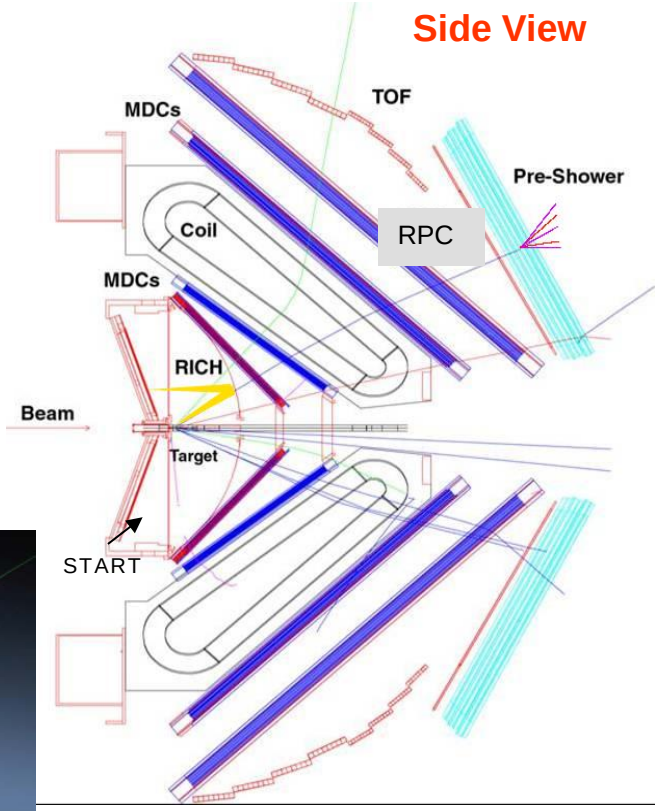
p+p and p+A collisions, 4 – 29 GeV

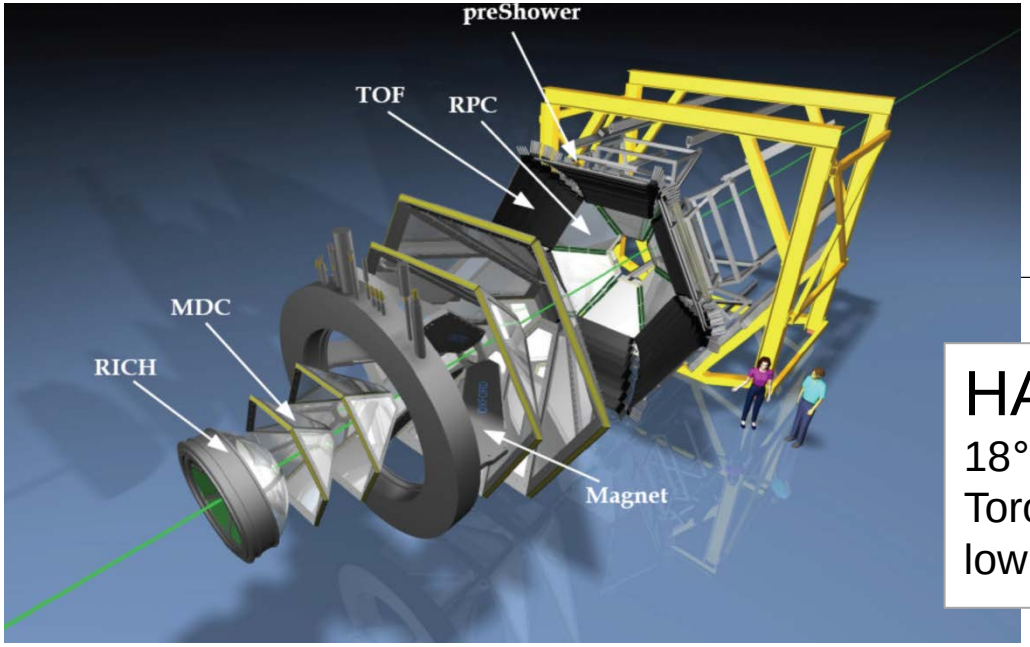
- Charm production and propagation in hadronic matter

CBM & HADES: Complementary experiments

CBM
3° - 25°
Dipole field
high rate







HADES
18° - 85°
Toroidal field
low mass; high res

HADES running scenario at SIS100 (preliminary)

Collision system	**Projectile** (intensity [s^{-1}])	**Observable**	**Request [weeks]**
Phase I :			
p + p & p + A (C, Ca, Nb, Au) at 2, 3.5, 6, 8, 11, 14, 20 GeV	p ($5x10^6$)	▪ Di-electrons ▪ Strangeness	12
A + A (C, Nb, Au) at 1.5, 2, 3, 4, 6 AGeV	C ($5x10^6$), Nb ($2x10^6$), Au (10^6)	▪ Di-electrons ▪ Strangeness	12

Beam request: 1x 4 week block per year

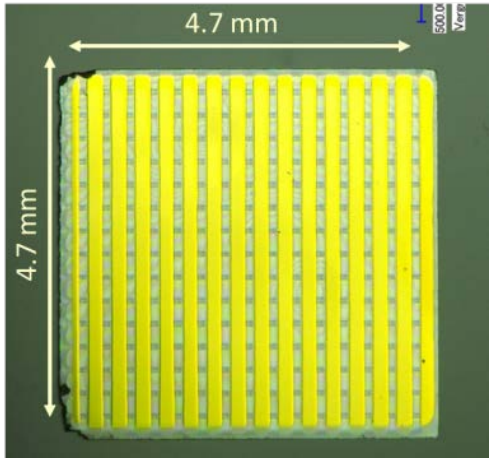
Phase II :			
π + p & π + A (C, Nb, Au)	N (10^{11}) at 14 AGeV	▪ Di-electrons ▪ Strangeness	16

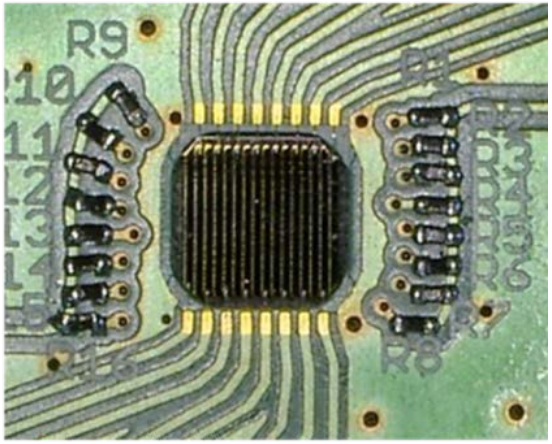
Pion beam campaign: taking full statistics in 2 years

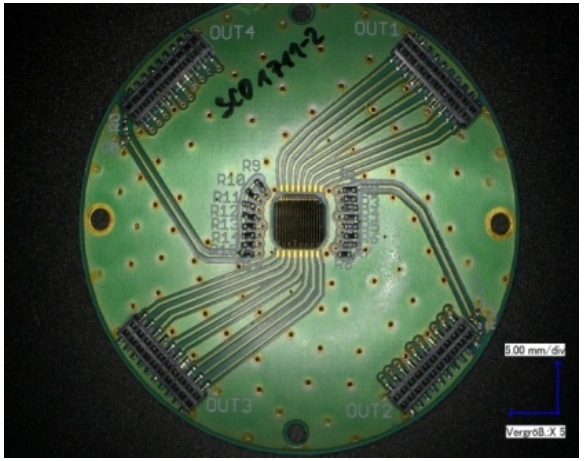
preliminary estimations !

Handover to *Jerzy Pietraszko :*

Beam quality requirements
for CBM and HADES @ SIS100







Backup

The CBM physics program

Physics case

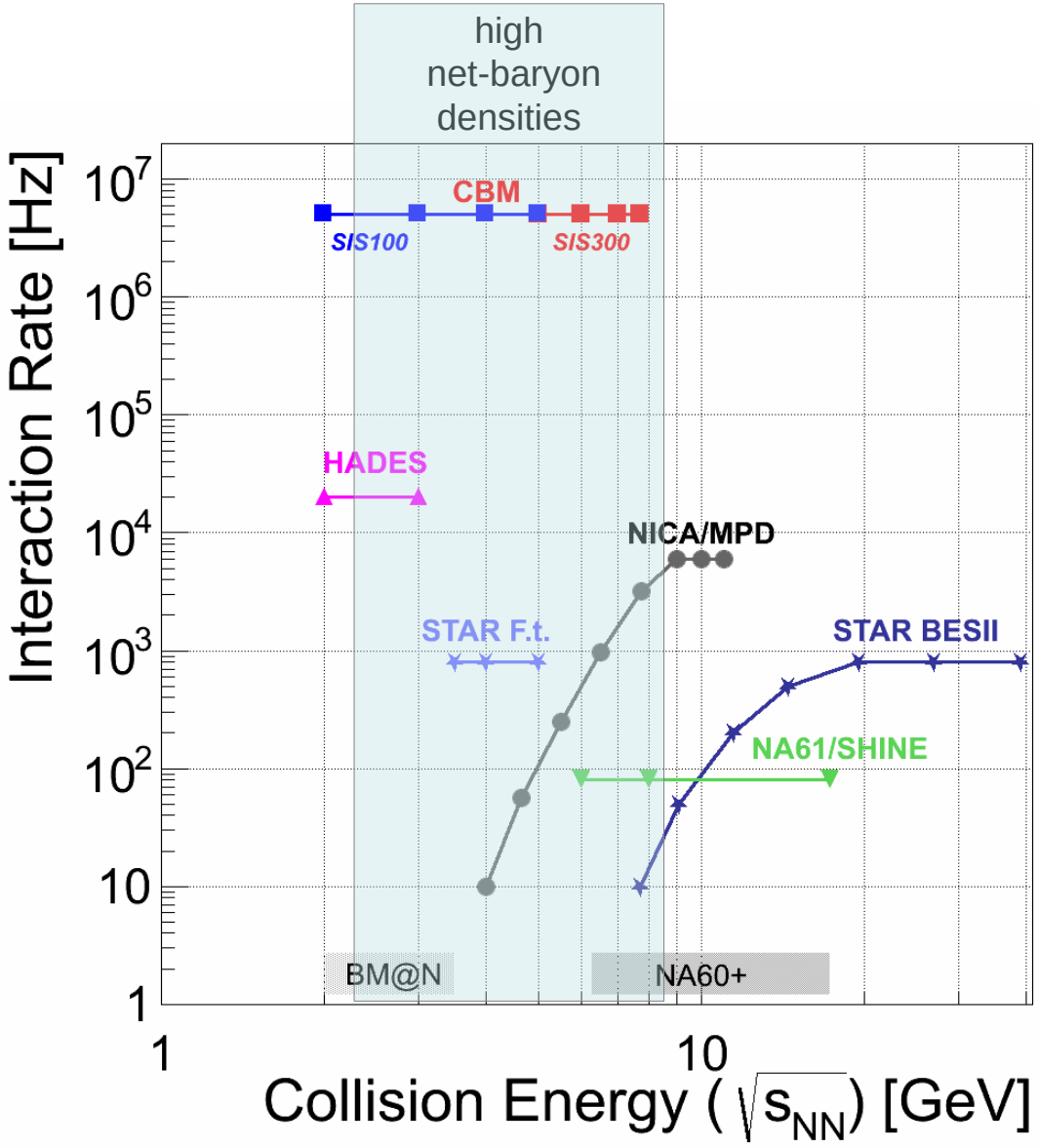
- Nuclear matter equation-of-state at high net-baryon densities
- Strangeness in nuclear matter and (multi-) strange objects
- Search for quarkyonic matter or for phase coexistence
- In-medium modifications of hadrons
- Exploring chiral symmetry restoration
- Charm production and propagation in cold nuclear matter and in dense QCD matter

Observables

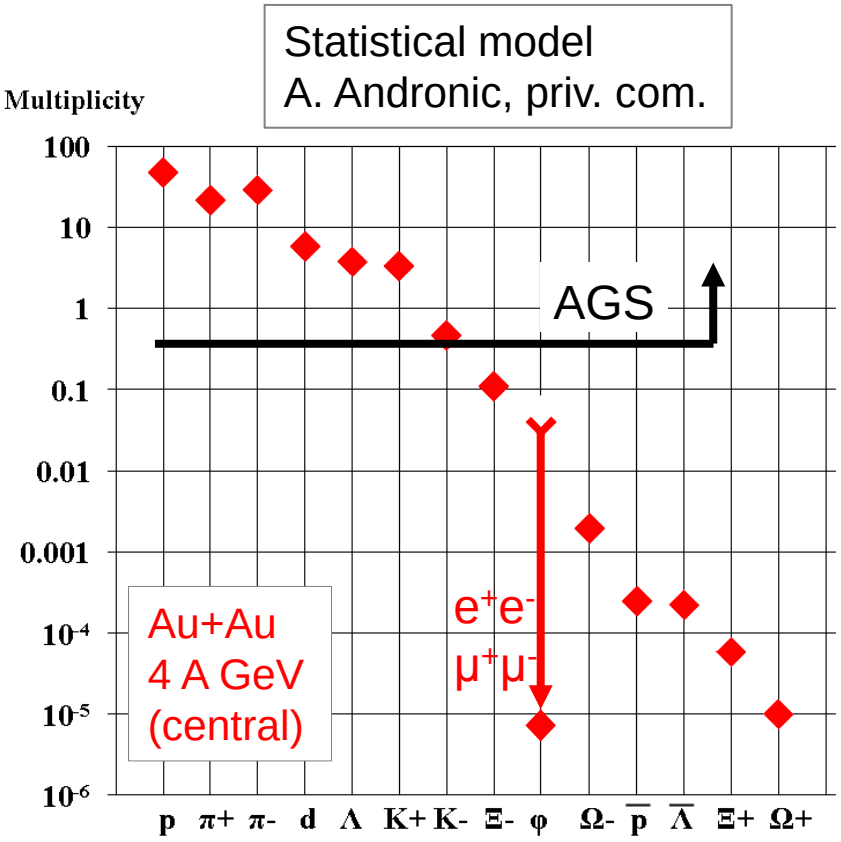
- Strangeness
- Dileptons
- Collective flow, correlations, fluctuations
- Charm
- Hypernuclei

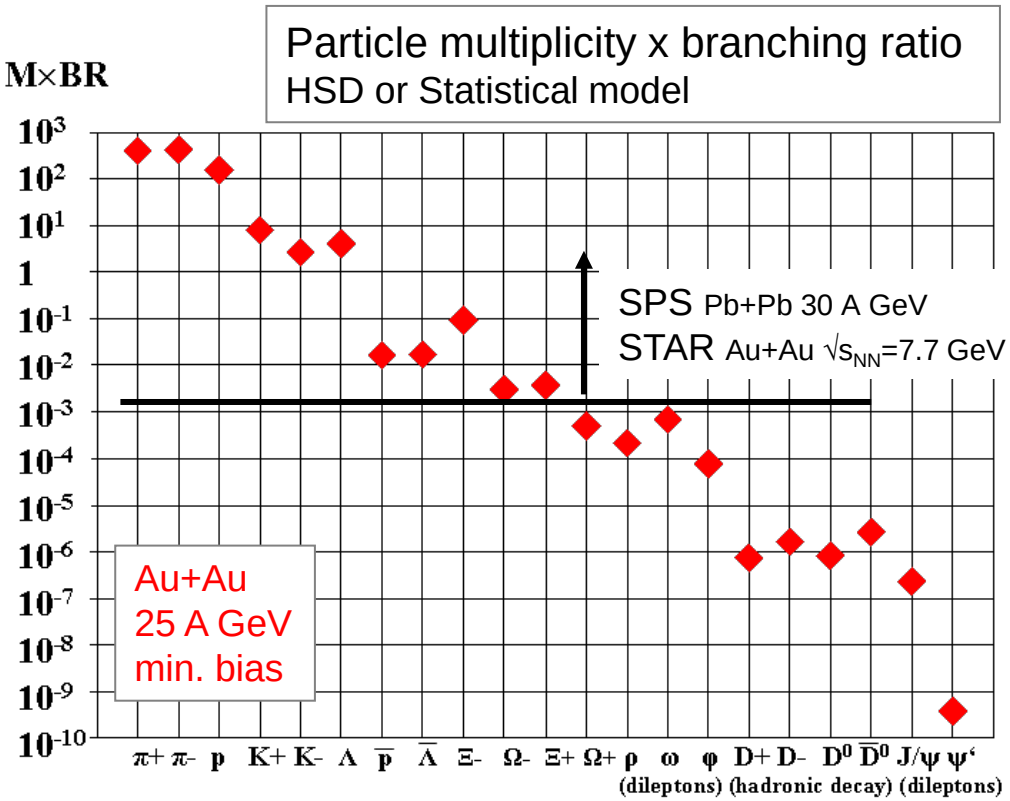
Experiments exploring dense QCD matter

Rate capabilities



Experimental challenges





rare probes → extremely high interaction rates required !

Particle identification