Online triggering of multi-strange hyperons in the CBM experiment

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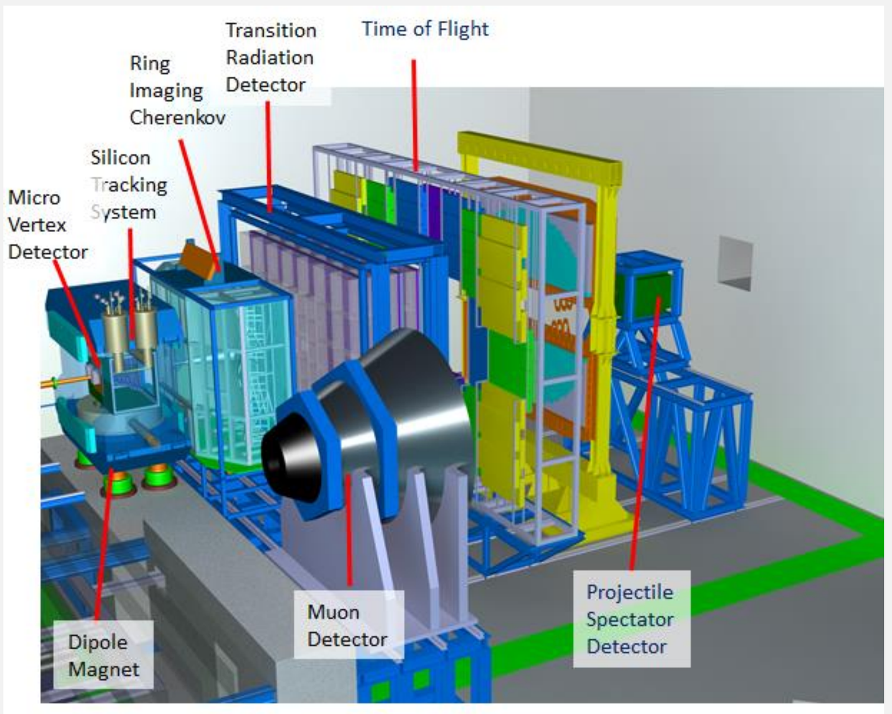
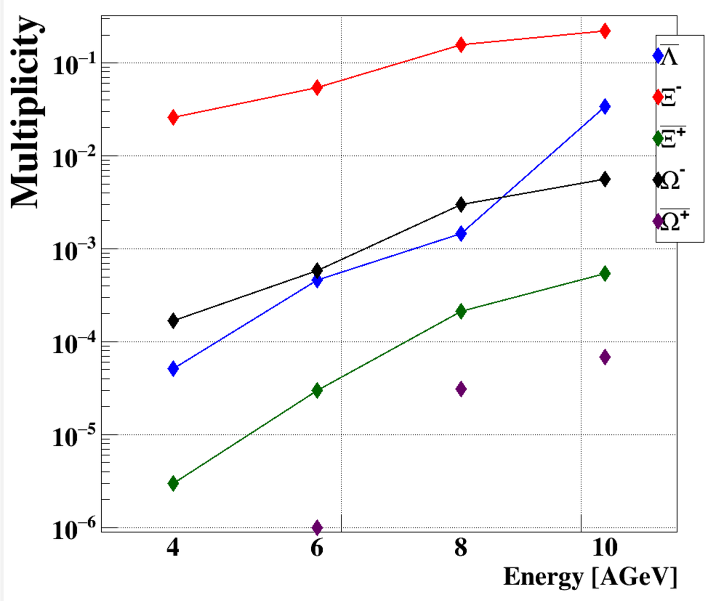
I. CBM Experiment

- The Compressed Baryonic Matter (CBM) experiment at the future Facility for Antiproton and Ion Research (FAIR) in Darmstadt is a fixed target experiment designed for precision measurements of observables using the high intensity heavy ion beams provided by the SIS 100/300 accelerators.
- CBM holds a wide and rich physics program and raises several experimental challenges such as the measurement of very rare probes.
- In order to explore the QCD phase diagram at high net baryon densities, the CBM experiment aims to run at extremely high interaction rates up to 10 MHz. [1]



CBM experimental setup:
- Superconducting dipole magnet
- Micro Vertex Detector (MVD)
- Silicon Tracking System (STS)
- Time-of-Flight (TOF)
- Ring Imaging Cherenkov (RICH)
- Transition Radiation Detector (TRD)
- Muon Chamber (MuCh) (alternating with RICH)
- Electromagnetic CALorimeter (ECAL)
- Projectile Spectator Detector (PSD)

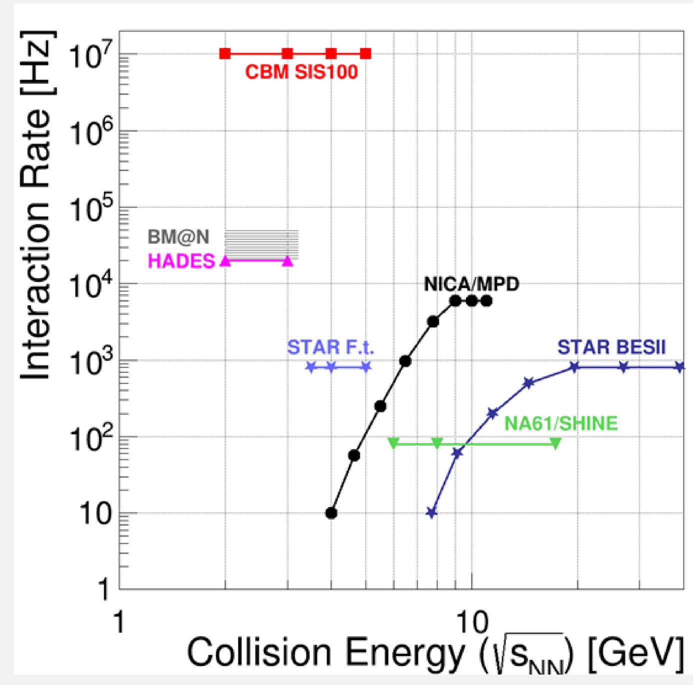
II. Multi-strange hyperons in CBM



- The study of strange and multi-strange hyperons production in relativistic heavy-ion collision is an important tool to investigate the properties of the strongly interacting matter.
- Multi-strange hyperons are rare probes with a low multiplicity as shown in the figure on the left with a UrQMD central Au+Au event at 10 AGeV.

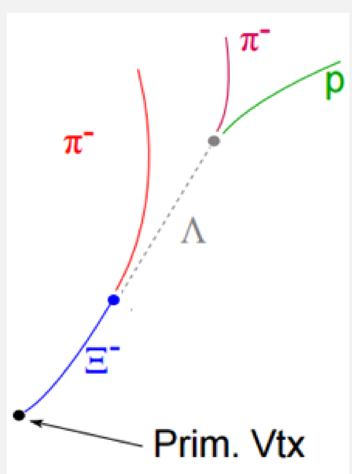
- High multiplicity of charged particles produced in heavy ion collisions
- Multi-strange hyperons have low cross section at low energies
- CBM experiment is designed to run at high interaction rate. See figure on the right
- Huge data rates up to 1 TB/s

CBM experiment requires:
- Free streaming data transport
- Online event selection
- Reduction factor of 400 or more



III. Online reconstruction

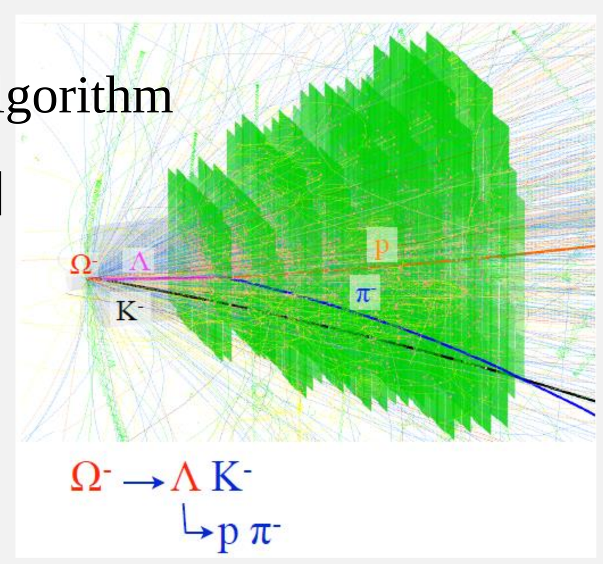
Multi-strange hyperons are reconstructed via their weak decay into charged hadrons in the Silicon Tracking System detector:
$\Lambda \rightarrow p\,\pi$; $\Xi \rightarrow \Lambda\pi$; $\Omega \rightarrow \Lambda\,K$



Simulation includes:
- UrQMD event generator
- Au+Au collisions at different energies achievable with SIS100
- The magnet, STS and ToF from the CBM setup

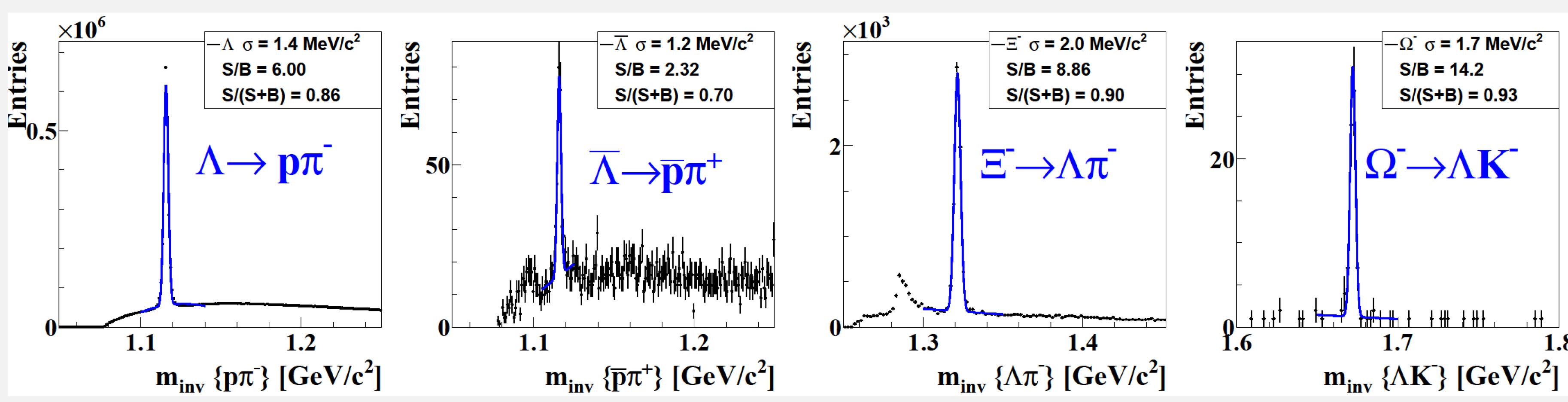
- CBM track finding based on Cellular Automaton algorithm
- KF Particle Finder package for physics analysis [2]

Online event reconstruction will be performed by the First Level Event Selector (FLES) a scalable high performance computer.



IV. Physics performance

Reconstructed invariant mass spectra of $\Lambda, \bar{\Lambda}, \Xi^{-}$ *and* Ω^{-} with 5 million central Au+Au collisions at 10 AGeV are shown. The blue line indicates the fit by the sum of a polynomial and a Gaussian function.



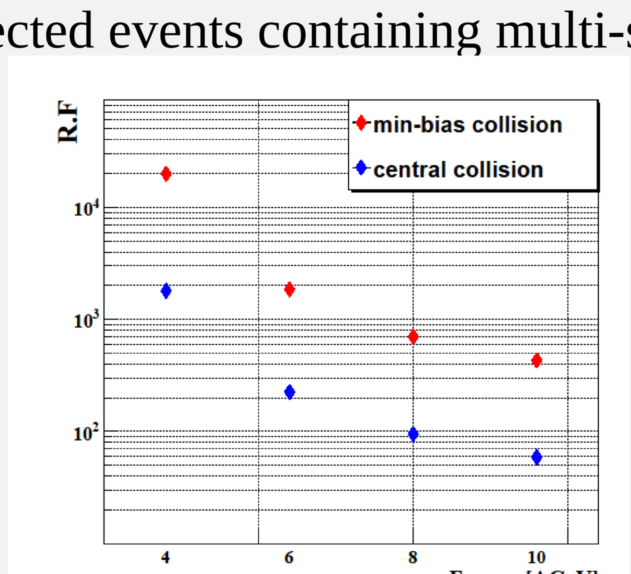
CBM experiment maintain a high reconstruction efficiency for mutli-strange hyperons:

	Λ	$\bar{\Lambda}$	Ξ^{-}	$\bar{\Xi}^{+}$	Ω^{-}	$\bar{\Omega}^{+}$
(a) : KF Particle Finder efficiency (%)	70.7	43.6	47.6	30.6	15.9	12.9
(b) : 4π efficiency (%)	26.6	16.5	10.2	6.8	4.6	3.9

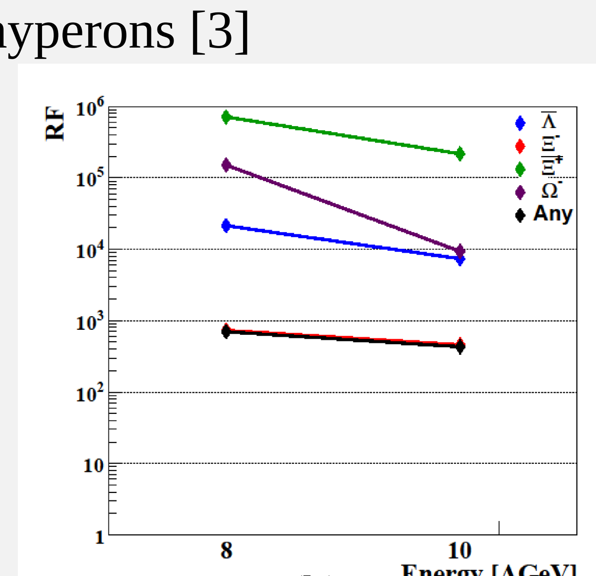
(a) : The efficiency of the particle reconstruction and cuts on the candidates including PID in ToF.
(b) : The total efficiency which take into account the acceptance of the detector and the inefficiencies of track reconstruction and PID algorithms [2]

V. Software trigger

- The huge data rate need a software trigger in order to select interesting events
- Selection of events containing multi-strange hyperons : $\bar{\Lambda}$, Ξ^{-}, $\bar{\Xi}^{+}$, Ω^{-}, and $\bar{\Omega}^{+}$ or any other combination.
- "Combined trigger" : select event with any of the list above
- A Reduction Factor (RF) of 400 or more is required
- The RF is calculated by dividing the total number of events by the number of selected events containing multi-strange hyperons [3]



(a)



(b)

Figure a: RF for the combined trigger calculated for central and minimum bias collisions at different energies
Figure b: RF calculated for trigger on individual hyperon compared to the RF for the combined trigger in minimum bias Au-Au collisions at 8 and 10 AGeV

VI. Summary

- ✓ The CBM experiment is designed to perform measurements at high interaction rate to explore a new area in the QCD phase diagram at high net baryon densities and moderate temperature
- ✓ CBM measurements are performed with a high performance computing cluster for online event selection
- ✓ CBM reaches the reduction factor required with the selection of mutli-strange hyperons

References:

[1] *CBM Collaboration, Challenges in QCD matter physics The Compressed Baryonic Matter experiment at FAIR, arXiv:1607.01487 [nucl-ex]*
[2] *M. Zyzak (2016), Online selection of short lived particles on many core computer architectures in the CBM experiment at FAIR.(Doctoral thesis, Goethe University Frankfurt am Main)*
[3] *H.Cherif, A.Toia and I.Vassiliev Online reconstruction of multi-strange hyperons at SIS-100, GSI Scientific Report 2015, p.16.*