Facility for Antiproton and Ion Research (FAIR)

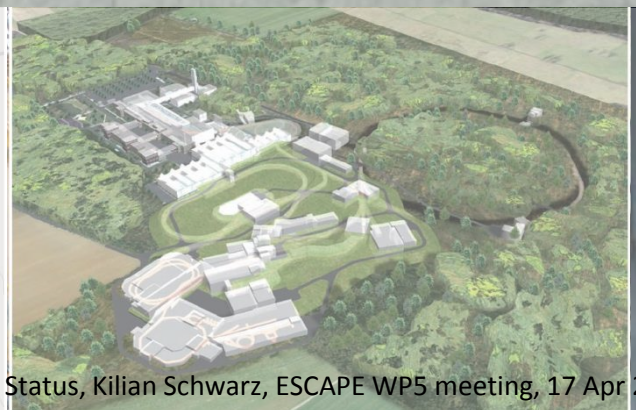
(under construction in Darmstadt, Germany)

Status of CBM

- challenges in data processing
in the context of EOSC and the *FAIR* principles

Kilian Schwarz
(with slides from J. Eschke and V. Friese)
GSI GmbH

ESCAPE WP5 meeting, Groningen, 16 April 2019


Facility for Antiproton & Ion Research

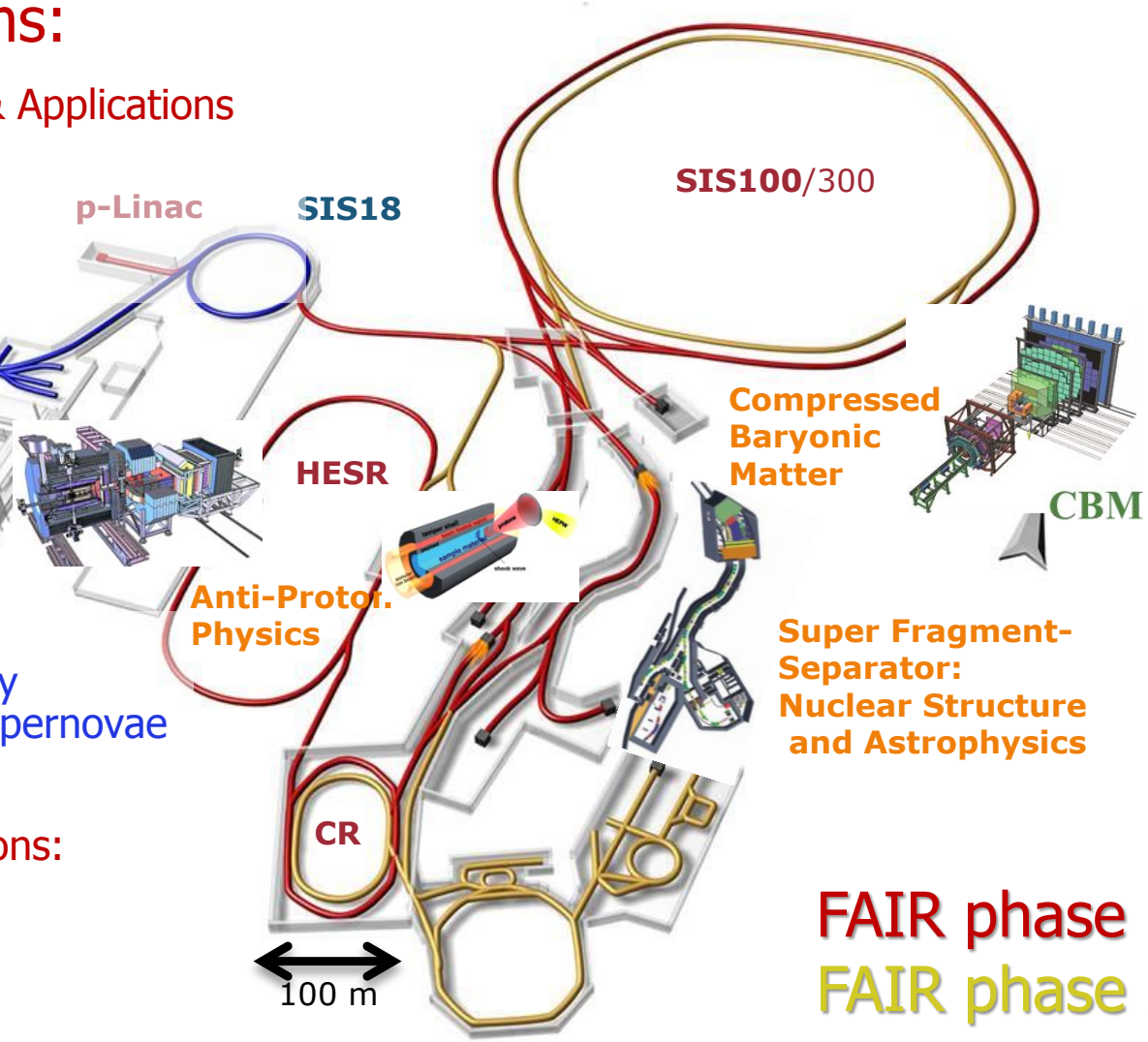
Experimental programs:

APPA: Atomic & Plasma Physics & Applications
- Highly charged atoms
- Plasma physics
- Radiobiology
- Material science

CBM: Nucleus-nucleus collisions
- Nuclear matter at neutron star core densities
- Phase transitions from hadrons to quarks

NUSTAR: Rare Isotope beams
- Nuclear structure far off stability
- Nucleosynthesis in stars and supernovae

PANDA: Antiproton-proton collisions:
- Charmed hadrons (XYZ)
- Gluonic matter and hybrids
- Hadron structure
- Double Lambda hypernuclei



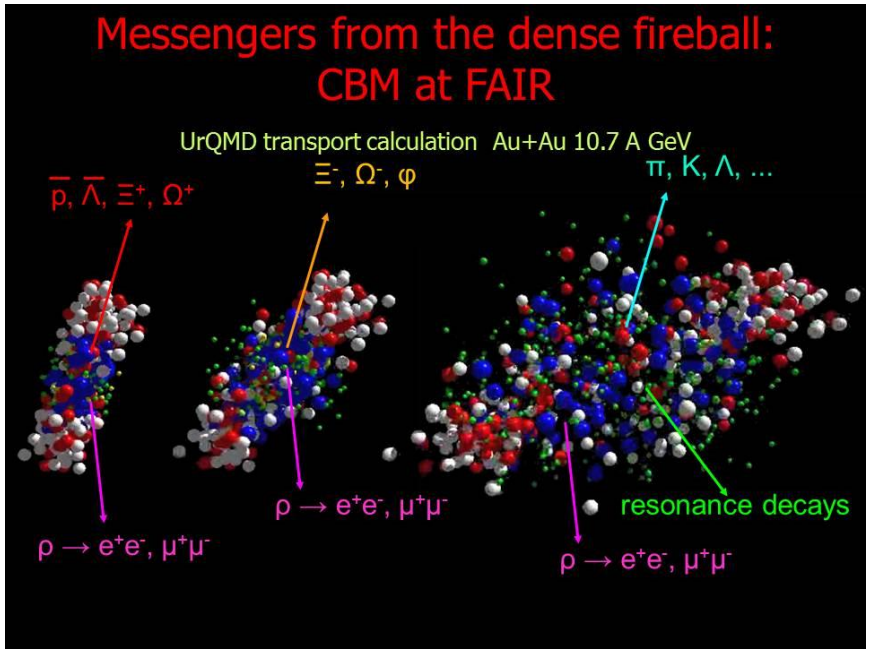
FAIR phase 1
FAIR phase 2

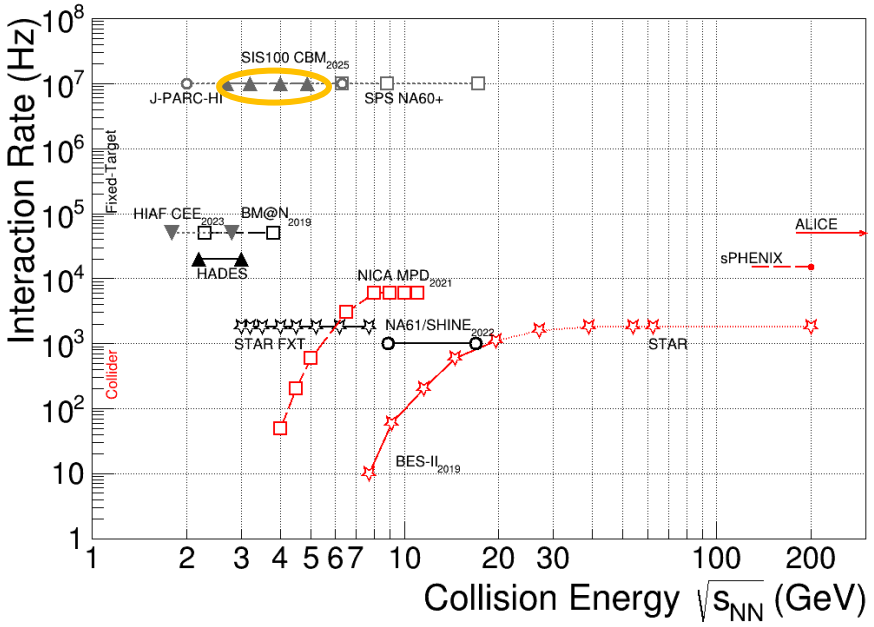
FAIR Collaborations

more than 2500 scientist from ~200 institutions in over 50 countries

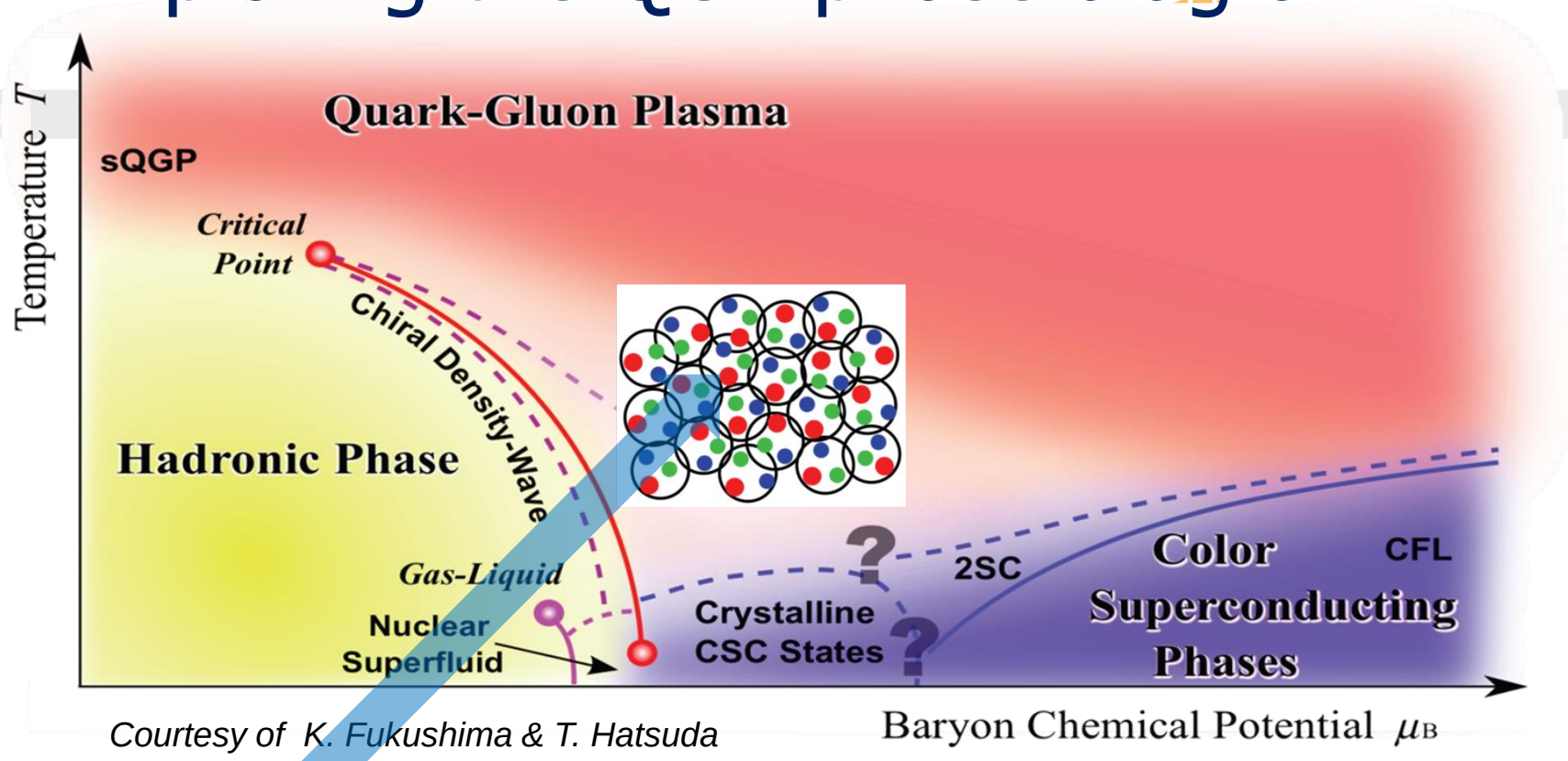
CBM - Compressed Baryonic Matter

CBM Experiment at FAIR: Systematically explore QCD matter at large baryon densities with high accuracy and rare probes, at highest interaction rates

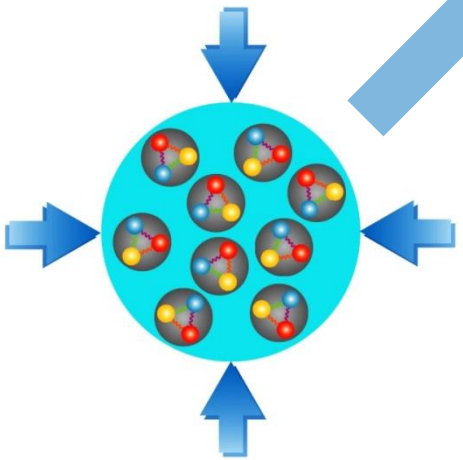




Exploring the QCD phase diagram



Courtesy of K. Fukushima & T. Hatsuda

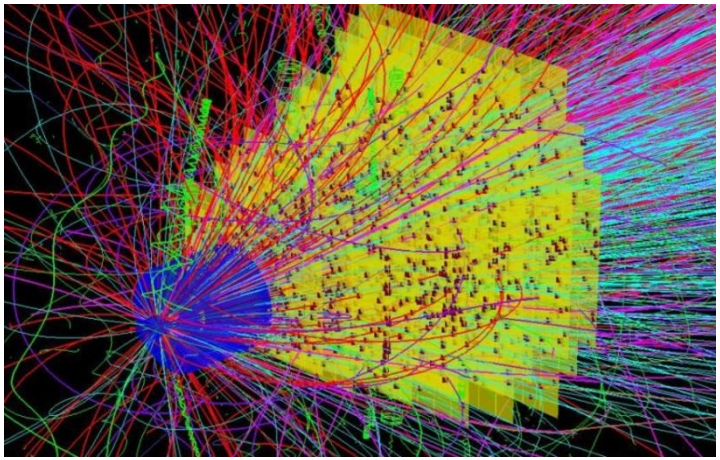


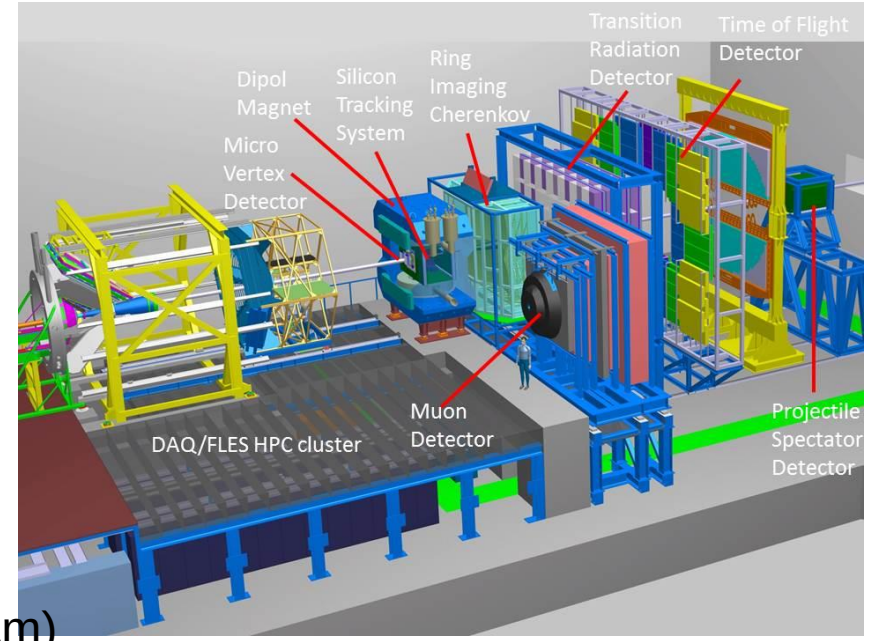
At high baryon density:

- N of baryons >> N of antibaryons
  Densities like in neutron star cores
- L-QCD not (yet) applicable
- Models predict first order phase transition with mixed or exotic phases
- Experiments: BES at RHIC, NA61 at CERN SPS, CBM at FAIR, NICA at JINR, J-PARC

CBM - Compressed Baryonic Matter experiment at FAIR

- typical collision system: Au + Au at 4 to 11 AGeV at SIS100
- MSV: beam intensity: 10^9 ions/sec; interaction rate 10 MHz



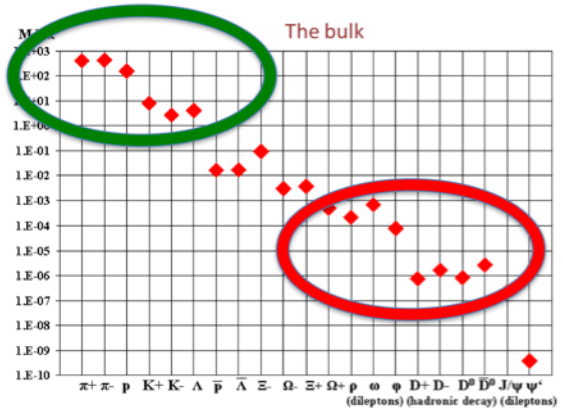


Experimental requirements:

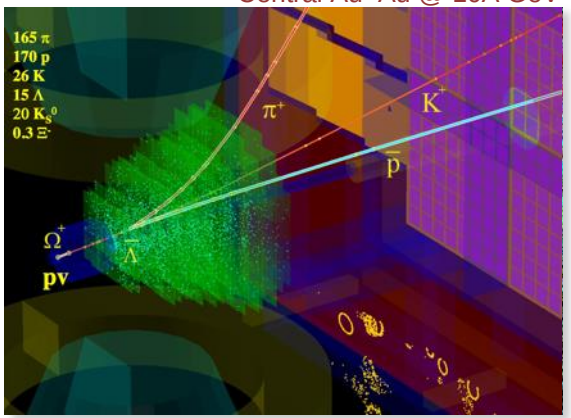
- 10^5 - 10^7 Au+Au reactions/sec
  → peak data flow 1 TByte/sec
- determination of displaced vertices (σ ~ 50μm)
- identification of leptons and hadrons
- fast and radiation hard detectors and FEE
- free-streaming readout electronics
- high speed data acquisition and high performance computer farm for online event selection
- 4-D event reconstruction

Needles in the Haystack

- CBM targets at extremely rare probes, which necessitates very high interaction rates (design rate 10 MHz).
- That entails a raw data rate of up to 1 TB/s.
- To be reduced online to a storage rate of several GB/s.
- Trigger signatures are mostly complex (e.g. weak cascade decays) and cannot be realized in hardware.
- Readout concept:
  - No hardware trigger
  - Self-triggered front-end electronics deliver time-stamped data
  - Data-push architecture to online compute farm
  - Event reconstruction and –selection to be performed on CPU



Central Au+Au @ 10A GeV



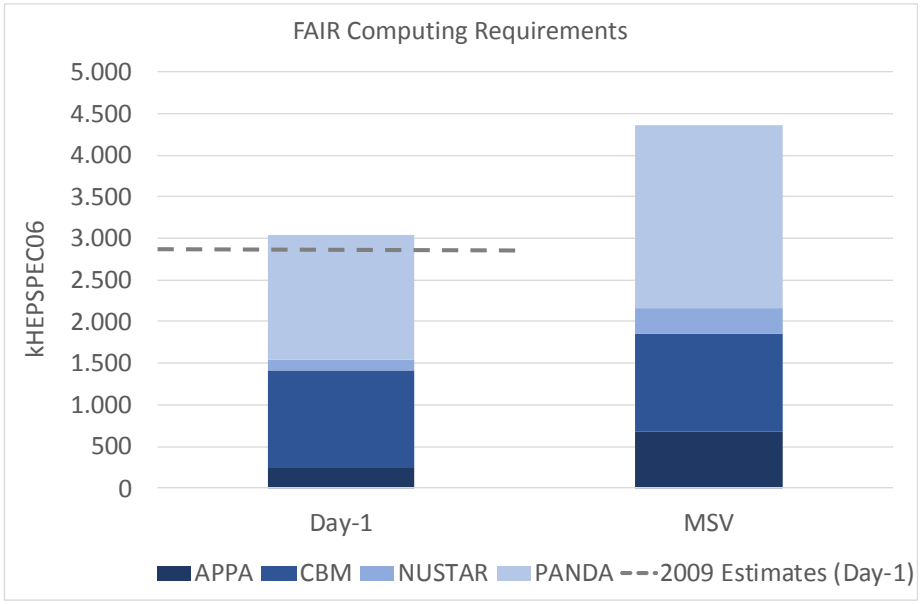
Data Rates

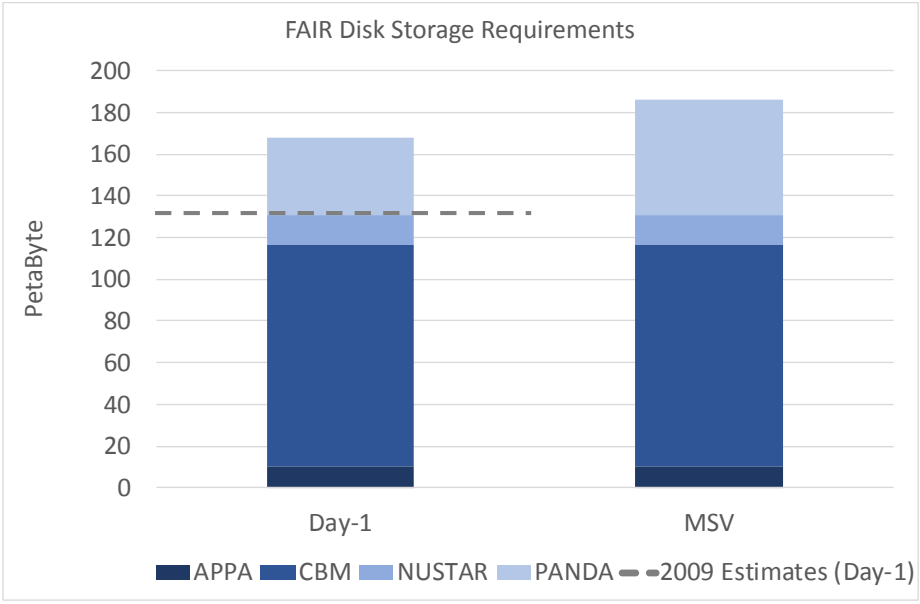
- Raw data event size: 50 - 100 kB / min. bias event (Au+Au)
- At 10 MHz event rate: raw data rate up to 1 TB/s

- Archival rate:
  - technologically possible are rates of 100 GB/s and above
  - limiting factor are the storage costs
  - typical runtime scenario 2 effective months / year (5×10^6 s)
  - At 1 GB/s: gives a storage volume of 5 PB/year

We aim at an data archival rate of a few GB/s, meaning that the raw data volume has to be suppressed online by factors 300 - 1000.

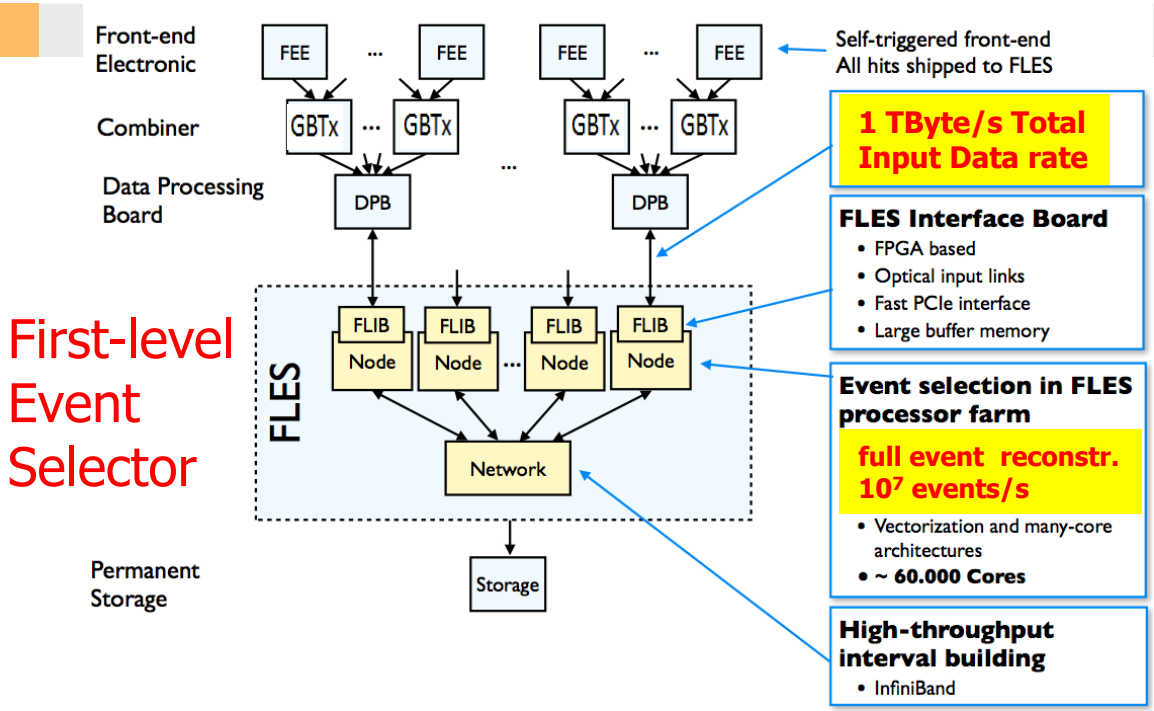
Computing – step 1: Experiment requirements determined





Assumptions for resource requirements:
Day-1 and MSV detector setups, nominal accelerator performance, multi-year integrated values (data lifetime)

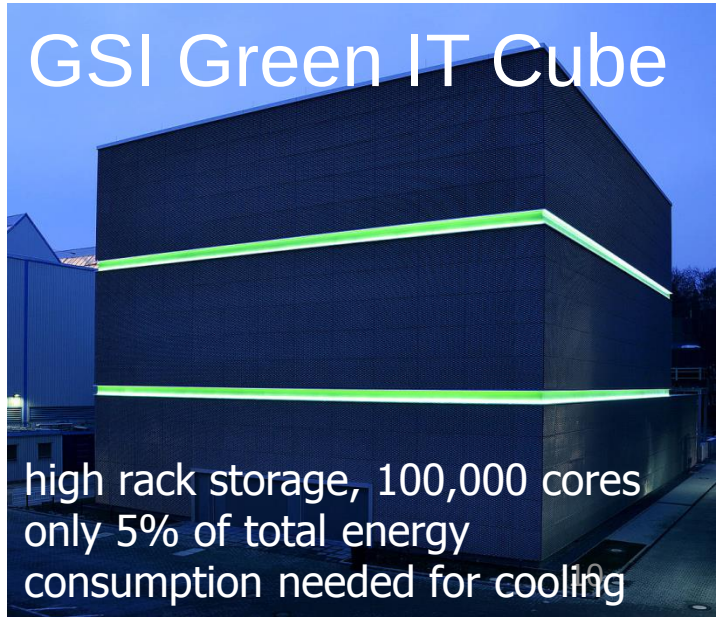
CBM DAQ and online event selection



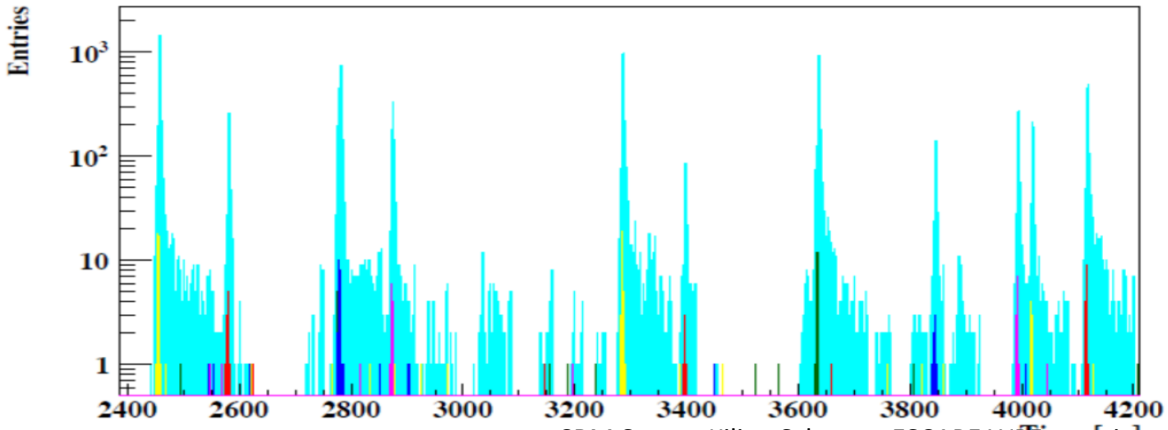
First-level Event Selector

Novel readout system:

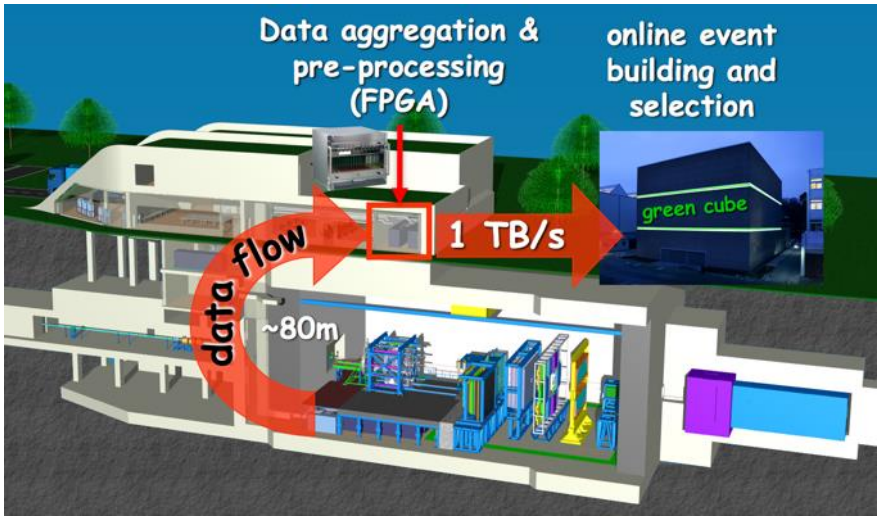
- no hardware trigger on events
- detector hits with time stamps
- full online 4-D track and event reconstruction.



Hit and track time distribution for Au+Au 10A GeV collisions at 10 MHz (UrQMD)



Online Data Flow

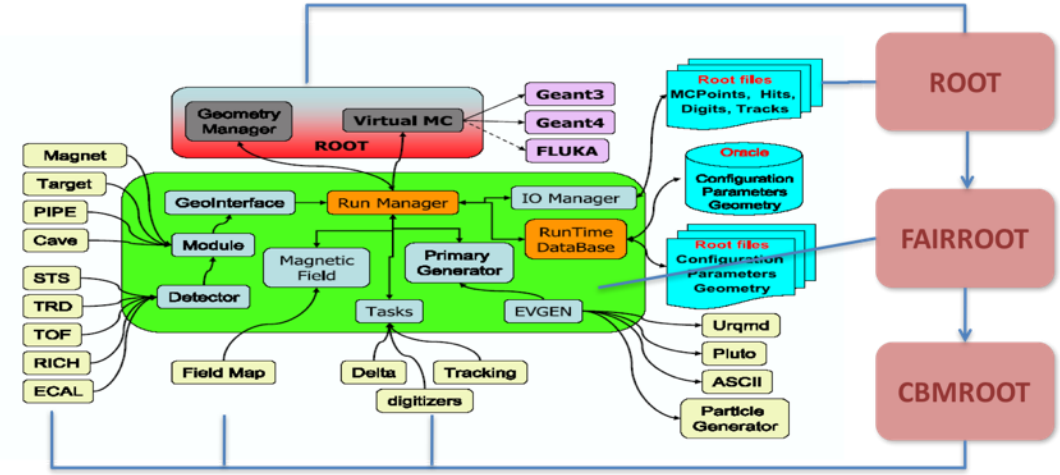


- Data are aggregated and pre-processed in an FPGA layer near the experiment.
- Time-slice building is performed on CPU (input nodes, in service building).
- Event reconstruction and –selection is performed in real-time on CPU (compute nodes) in the GSI ”Green Cube” (already existing at GSI).

Data Processing Framework

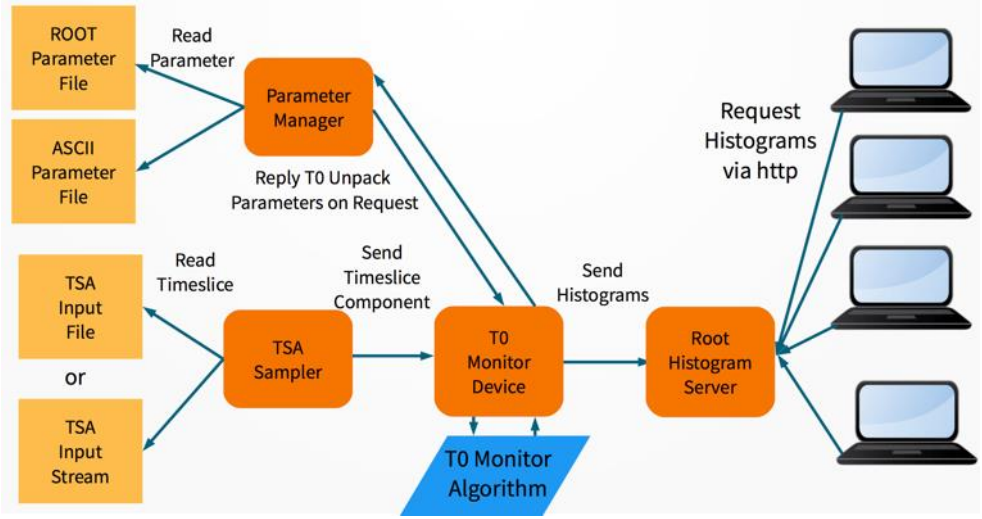
DPF
PL: F. Uhlig, GSI

- Mission: to provide a flexible and efficient environment for data analysis and simulation (regulate data model, I/O, run configuration, execution of processing graph)
- For both offline and online purposes
- Since many years, the CbmRoot framework is used, using ROOT as a platform and the FairRoot software layer (synergy with PANDA, ALICE, ...)



Data Processing Framework

- Shortcoming of the current framework: linear task queue, no concurrency features -> not well suited for online data processing
- Moving to message-queue-based system (FairMQ); intra-node and inter-node data transport possible
- First deployment (proof-of-principle): online monitoring for mCBM

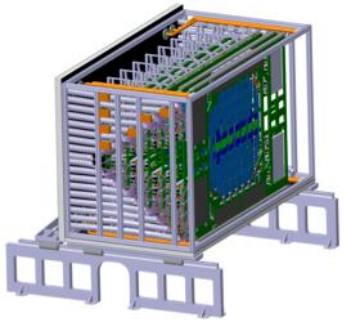


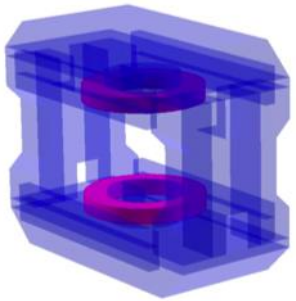
- Progress is moderate; project suffers from serious understaffing

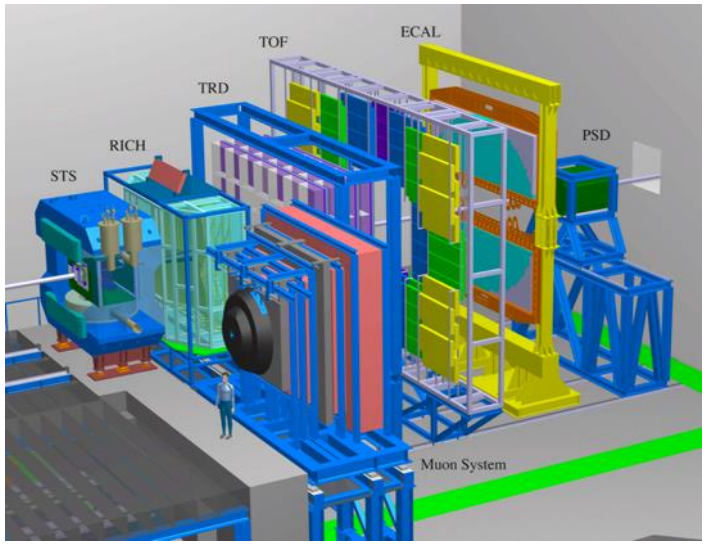
Simulation Software

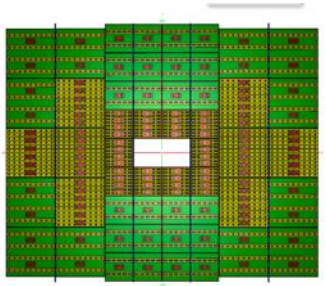
SIM
PL: V. Friese, GSI

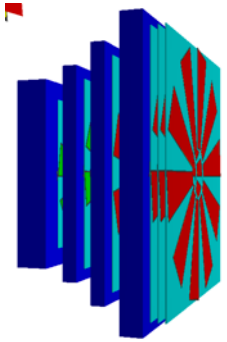
- Detector geometry model
  - according to current technical planning
  - comprising all relevant contributors to the material budget
  - format: TGeo
  - subject to continuous adjustments / improvements











Volker Friese

CBM status/requirements computing/ESCAPE WP5/questionaire:

- 400 GB/s into online farm, 8 GB/s on disk
- no hardware trigger on events, detector hits with time stamps
- simulated event size (CBM): 250 kB
- meta data are planned to be made VO compliant
- access rights to data: proprietary period after which public
- at least parts of the data will be geographically distributed
- data will have replicas
- offline data processing will to some extent be geographically distributed
- currently data are stored and processed mainly at GSI
- software visualisation tools should be integrated into science platform
- building blocks for standard processing pipeline are available

CBM interest in ESCAPE

- ESCAPE takes place right before the official start of CBM.
- within ESCAPE essential IT ingredients are being developed, especially infrastructures for distributed data management and computing, which are needed by CBM.
- CBM hopes to profit from taking part in ESCAPE by getting important support and ideas for setting up their own infrastructure for distributed computing.