STRONG-2020

Annual Meeting 2024

NA1 – QCD Physics at FAIR/GSI

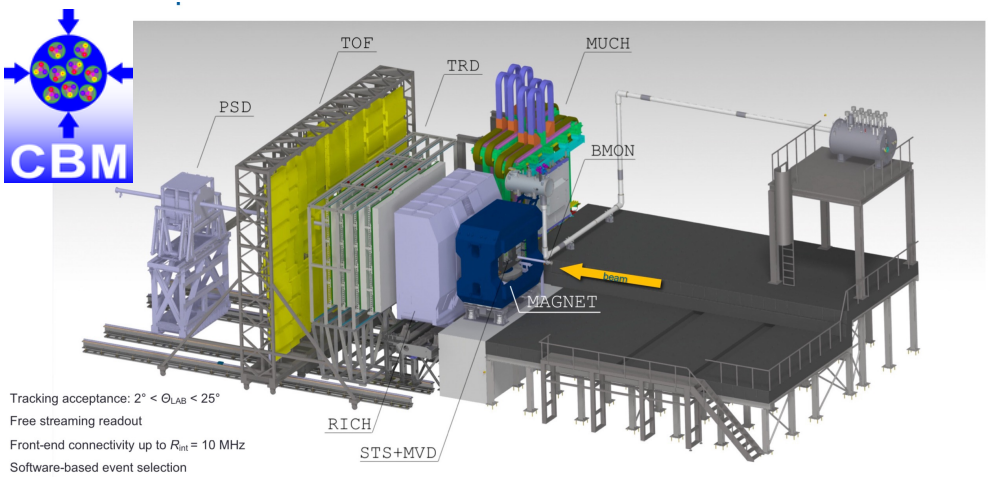
Fritz-Herbert Heinsius (RUB)

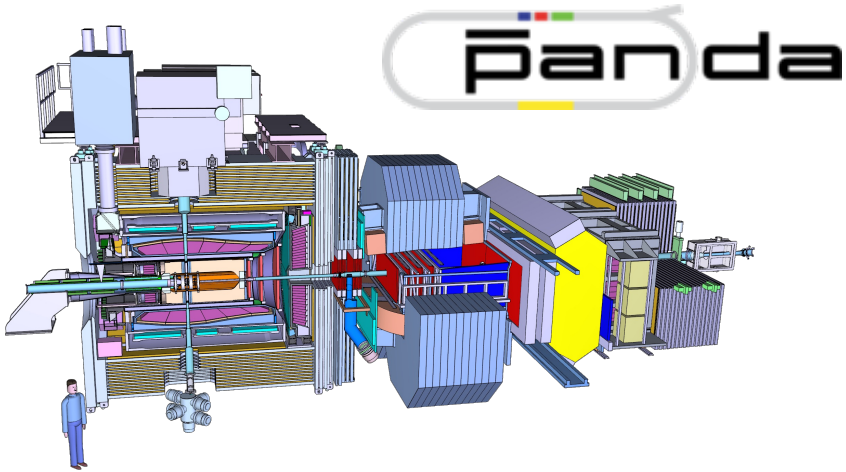
FAIR

RUB

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

NA1 – QCD Physics at FAIR/GSI





<u>Compressed Baryonic Matter</u>
Explore properties of strongly interacting matter under extreme conditions

<u>Antiproton Annihilation at Darmstadt</u>
Investigate the nature of the strong force at the quark level

Plan of presentation

01 Progress achieved by the WP during the last year

02 Important highlights of the performed work (last year + full project duration)

03 Tasks and achievements beyond the initial Work Program and/or tasks which could not be carried out

Task 1: Front-end electronics, DAQ and Online

Task 2: Demonstrator

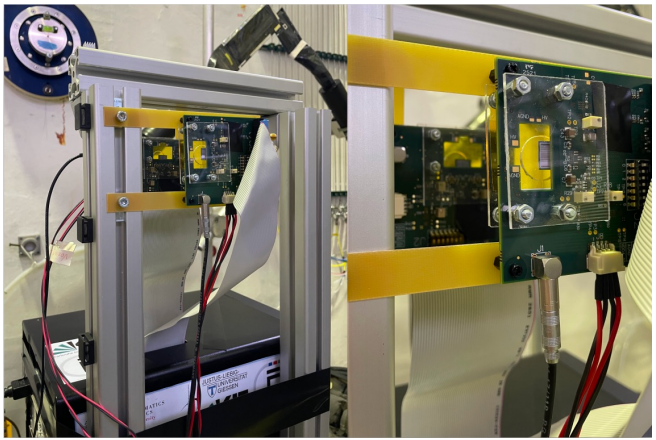
Task 3: Data analysis challenge

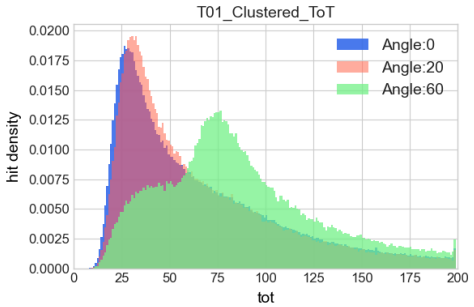
Task 4: Outreach and education

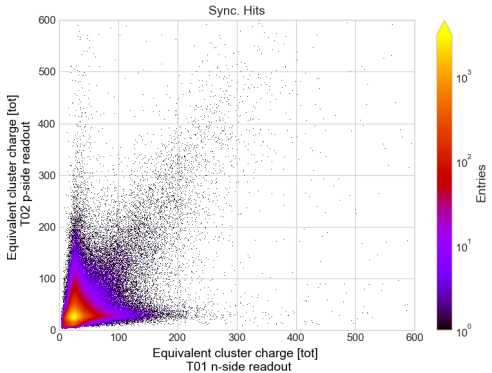
01 Progress: Task 1 – Front-end electronics, DAQ and Online: ToASt 64 channel ASIC for silicon strip detectors

Excellent results from beam tests at COSY in 2023

Presented at PISA Meeting on Advanced Detectors, May 2024, La Biodala, Italy and at TREDI Workshop on Advanced Silicon Radiation Detectors, Feb. 2024, Torino, Italy







Lab radiation tests showed a couple of weakness in the radiation tolerance of the ASIC.

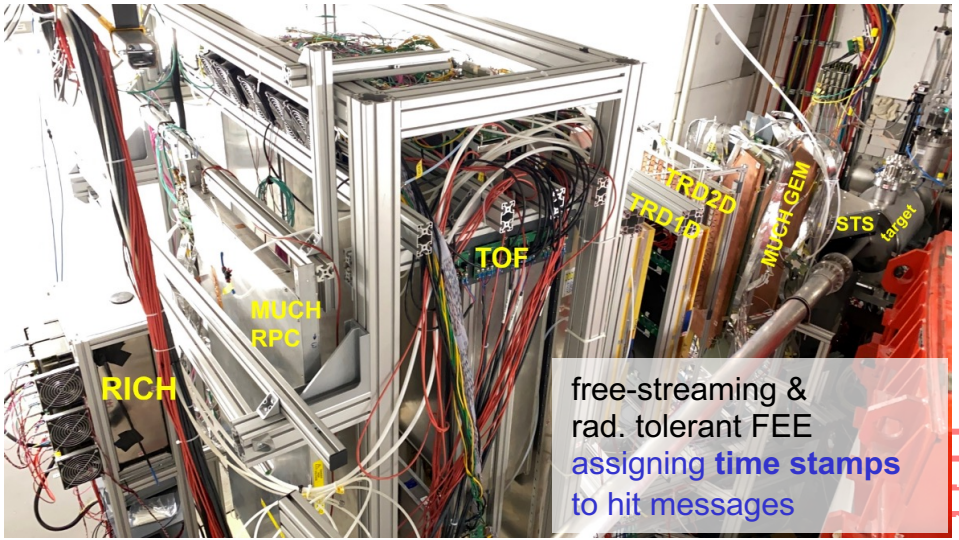
The issues has been identified and has been corrected in the second version, which has been submitted in March 2024.

Presented at 2nd Workshop “Trento Proton Beam Line Facility” this Monday

01 Progress: Task 2 – Demonstrator: mCBM Experiment at GSI/FAIR

Free-streaming CBM data transport

A full-system sandbox with detector prototypes / pre-series components
High-rate studies up to 10 MHz collision rate in nucleus-nucleus collisions
First runs 2021, 2022: no online processing, all data to disk
Development of online processing chain with re-play of archived raw data



FLES entry nodes
CRI FPGA
µSlice building
(DAQ container)

FLES processing nodes
time slice building
event reconstruction
& selection
archiving

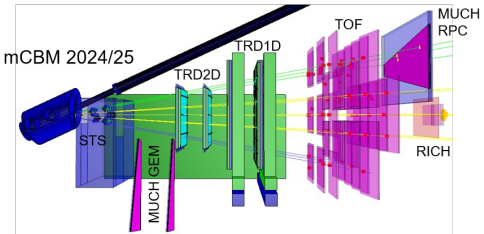
01 Progress: Task 2 – Demonstrator: mCBM Experiment at GSI/FAIR

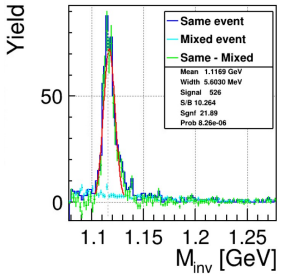
Free-streaming CBM data transport
A full-system sandbox with detector prototypes / pre-series components
High-rate studies up to 10 MHz collision rate in nucleus-nucleus collisions
First runs 2021, 2022: no online processing, all data to disk
Development of online processing chain with re-play of archived raw data

New in 2024: Applying online data selection

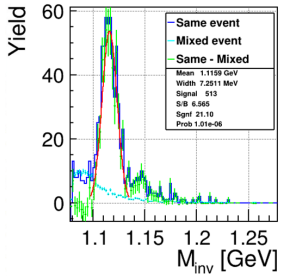
Commissioning beam time March 2024: applied online processing during data taking; minimum-bias trigger

Benchmark beam May 2024 (Ni+Ni): Application of full online reconstruction and trigger on displaced vertices (Lambda)



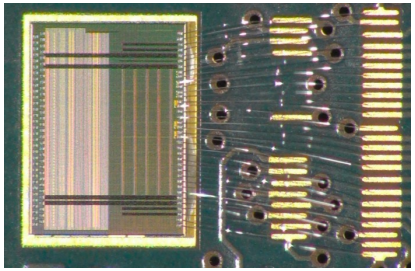


mCBM simulation
100 M events
10^5 events/s



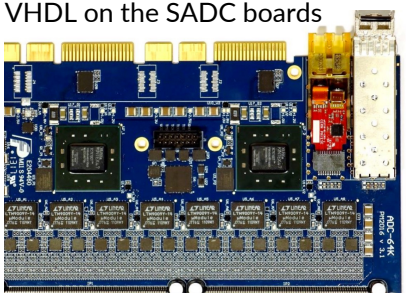
mCBM offline data analysis (preliminary)
Run 2391 (May 2022)
Av. rate 5 * 10^5 events/s
10^9 events

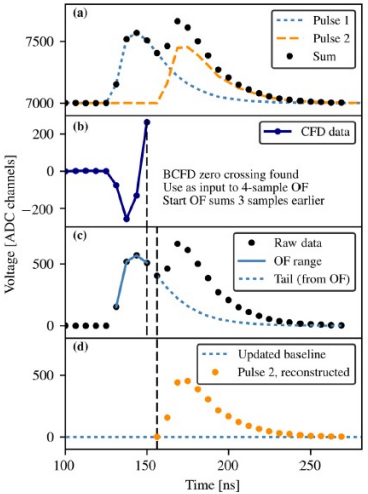
02 Important highlights:
Task 1 – Front-end electronics, DAQ and Online

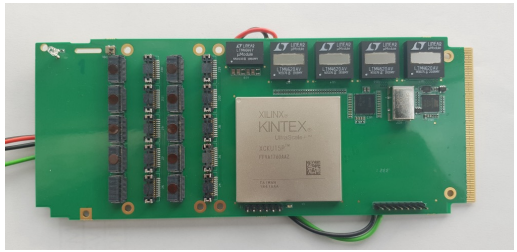


64 channel silicon strip detecor ASIC
time and energy via ToT
160 Mb/s serial link
Radiation tolerance (20 Gy)

A feature-extraction and pile-up reconstruction algorithm for the forward-spectrometer EMC of the PANDA experiment implemented in VHDL on the SADC boards







Data collected from front-end electronics and clock distribution to FEE

- 60 FireFly optical transceivers 12 Gbit/s
- 16 backplane links 12 Gbit/s

Further use: Evaluation of the firmware for the future DAQ for IceCube-Gen2 radio, which involves a neural network trigger

02 Important highlights:
Task 1 – Front-end electronics, DAQ and Online

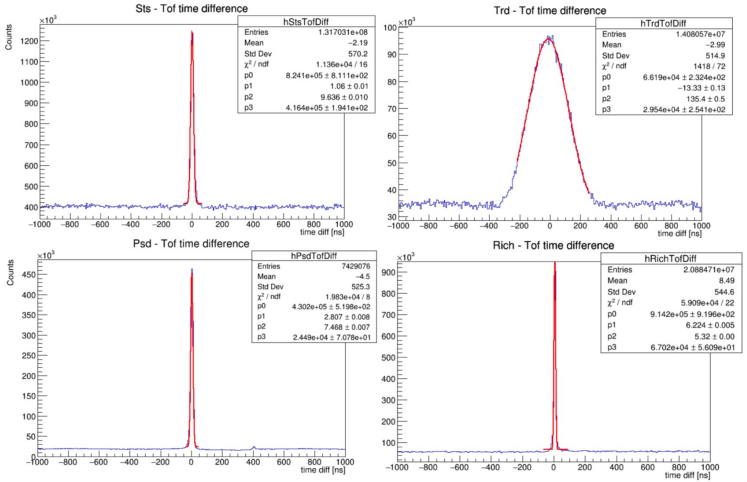
Common Readout Interface tested successfully at the mCBM experiment at GSI

Photo of the CRI1 board (BNL-712 v2). The Kintex UltraScale FPGA is hidden below the black fan. It is surrounded by 8 Avago MiniPod transceivers, which interface to the optical fibers. The optical coupler on the left hand side consists of two MTP-48 connectors. The mezzanine PCB in the top left holds the interface to the TFC system. A PCIe switch combines the two SLR of the FPGA to the PCIe Gen3 x16 interface. The board is powered by voltage converters located on the right hand side of the PCB.

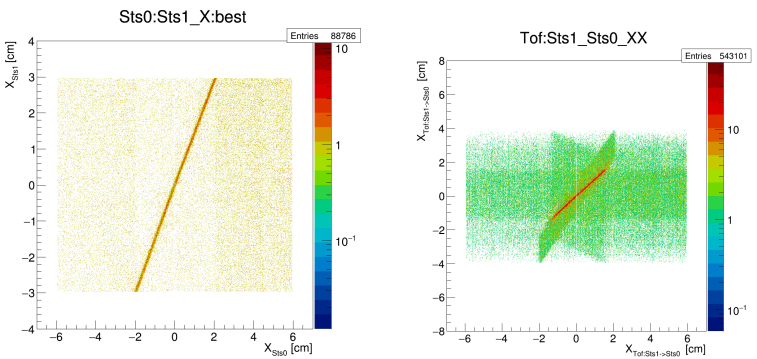
02 Important highlights: Task 2 – Demonstrator mCBM

mCBM experiment at GSI

- Multi-core parallelization (OpenMP) of all reconstructions steps (STS, TOF, tracking)
- STS unpacking and reconstruction ported to GPU and tested on VIRGO nodes
- Applied online data selection in 2024



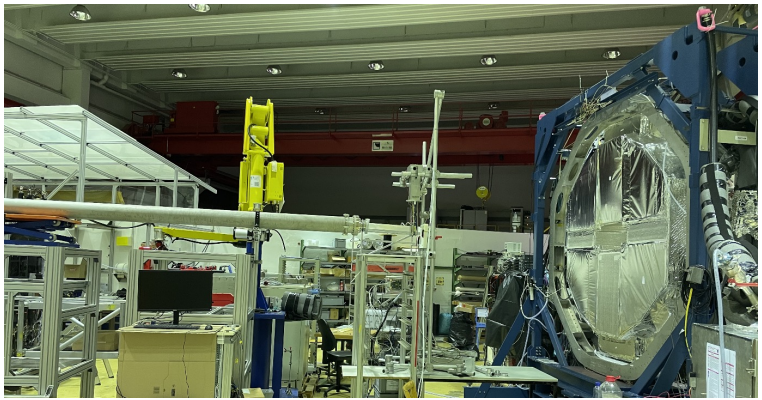
Stable timing: time difference measured by the detector subsystems STS, TRD, PSD, and RICH with respect to the TOF system (run 1588, O+Ni at 2.0AGeV, July 2021)



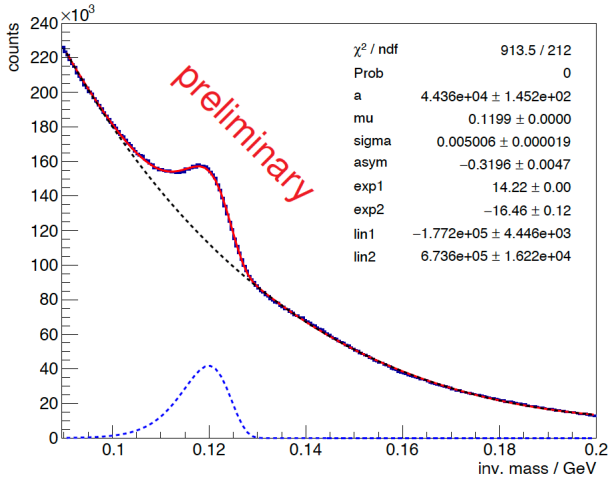
Correlation between spatial coordinates (x) of both STS stations STS 0 and STS 1 (left figure) and between both STS stations and TOF (right figure), run 1588, O+Ni at 2.0AGeV, July 2021

02 Important highlights:
Task 2 – Demonstrator: COSY

Combined test beam in 2023
Luminosity detector, micro vertex detector,
forward endcap electromagnetic calorimeter



Workshop February 2024
First discussion of results

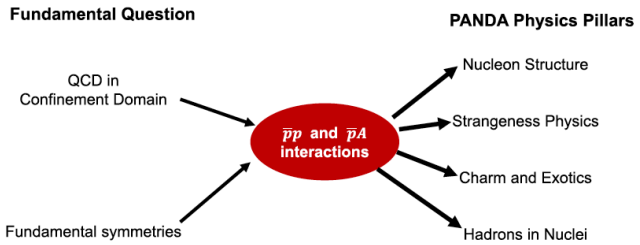


Without full calibration already $\mathrm{m}(\pi^0) = 5$ MeV

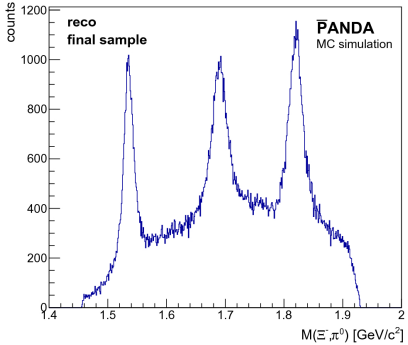
Presentation at CALOR 2024, Tsukuba, Japan, May 2024

02 Important highlights:
Task 3 – Data analysis challenge

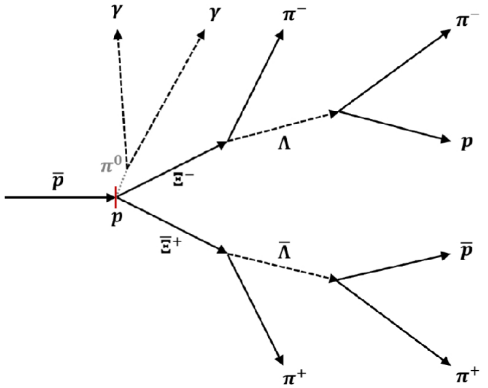
PANDA Phase One paper, Eur. Phys. J. A 57, 184 (2021)



Study of excited Ξ baryons with the PANDA detector, Eur. Phys. J. A 57, 149 (2021)

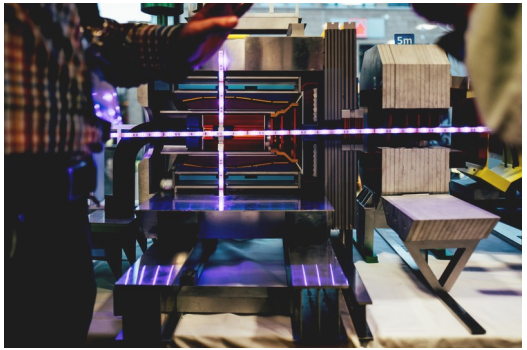


The potential of Λ and $\Xi-$ studies with PANDA at FAIR, Eur. Phys. J. A 57, 154 (2021)



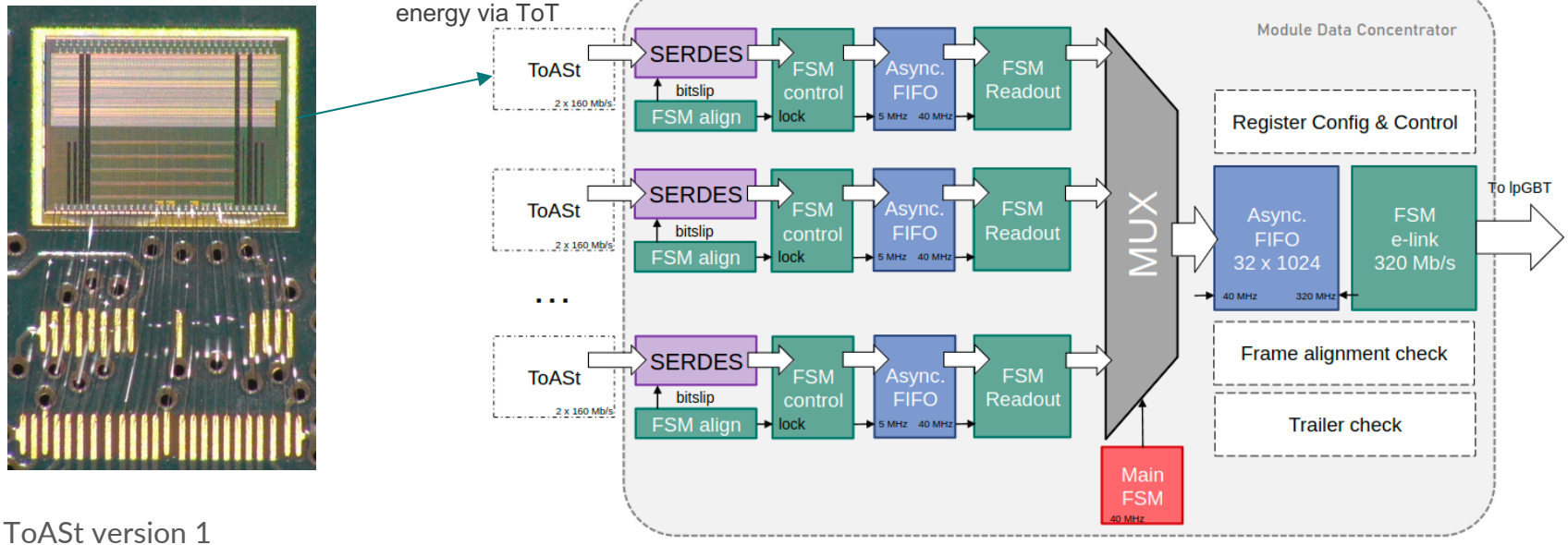
02 Important highlights:
Task 4 – Outreach and education

Model of linear accelerator as a game



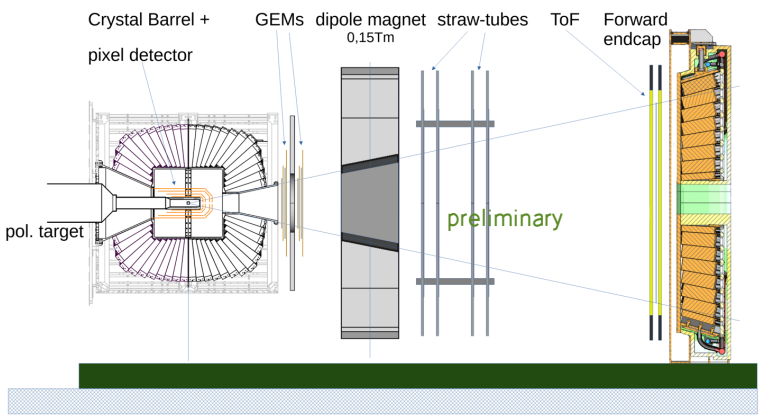
03 Tasks and achievements beyond the initial Work Program : ToASt 64 channel ASIC for silicon strip detectors

Design of an data concentrator ASIC in CMOS 110 nm technology. To be submitted in September 2024.



ToASt version 1

03 Tasks and achievements beyond the initial Work Program: Transfer of knowledge
Intermediate operation of the PANDA forward endcap EMC at ELSA, Bonn



4π measurement of photons and detection of charged particles

$\sqrt{s_{max}} = 2.6$ GeV

+ polarisation measurements

Non-strange baryon spectroscopy:

Gain a complete picture of the light-quark N^*, Δ^*- baryon spectrum:

- **Polarized photoproduction off the polarized proton and neutron!**

⇔ unambiguous PWA not possible without the measurement of polarization observables

- **Multi-meson photoproduction**

Strange baryon spectroscopy (Λ^*, Σ^*):

More states expected than in the u, d-sector but much less states found so far!

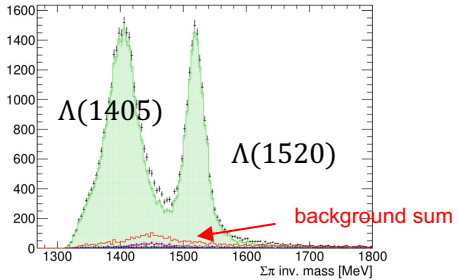
⇔ Do they exist ?

⇔ Are they consistent with SU(6)xO(3)- symmetry?

⇔ Nature of the observed states=?

e.g. Λ(1405), 2-pole structures / multiquark-states?

PDG'2022: "., the field is starved for data"



- **Transfer of knowledge from PANDA to another hadron physics experiment.**
- Next week DAQ meeting with discussion of integration of DAQ

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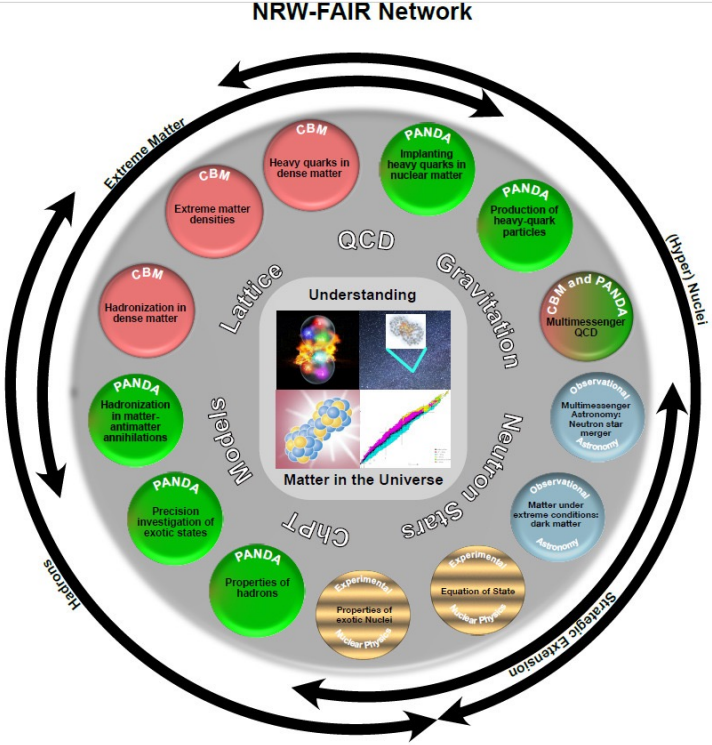
NRW-FAIR: State funded network in North Rhine-Westphalia, Germany



Total: 16.5 Mio € over 4 years

FAIR experiments: CBM, PANDA (1.8.22), and NUSTAR (added 1.8.24)

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Application of experience with mCBM to CBM, start of operation in 2028

Shell construction of accelerator tunnel finished

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