

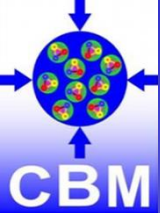
RPC 2020 – XV Workshop on Resistive Plate Chambers and Related Detectors

The FAIR Phase 0 program of the CBM Time-of-Flight project

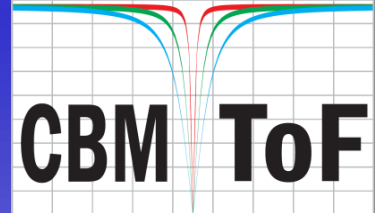
Ingo Deppner

Physikalisches Institut der Uni. Heidelberg





Outline

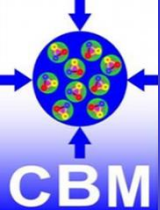


FAIR — Facility for Antiproton and Ion
Research in Europe

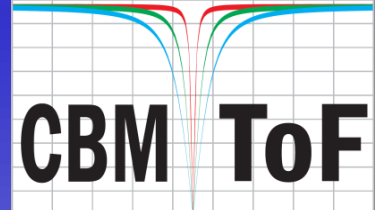


- **Introduction**
 - The Facility for Antiproton and Ion Research (FAIR)
 - The Compressed Baryonic Matter (CBM) Experiment
 - MRPC description being used for FAIR Phase 0 program
- **FAIR Phase 0 program of CBM-TOF**
 - The eTOF at STAR/BNL project (main topic)
 - The mTOF at mCBM/GSI project (a short introduction)
- **Summary**





The Facility for Antiproton and Ion Research (FAIR)

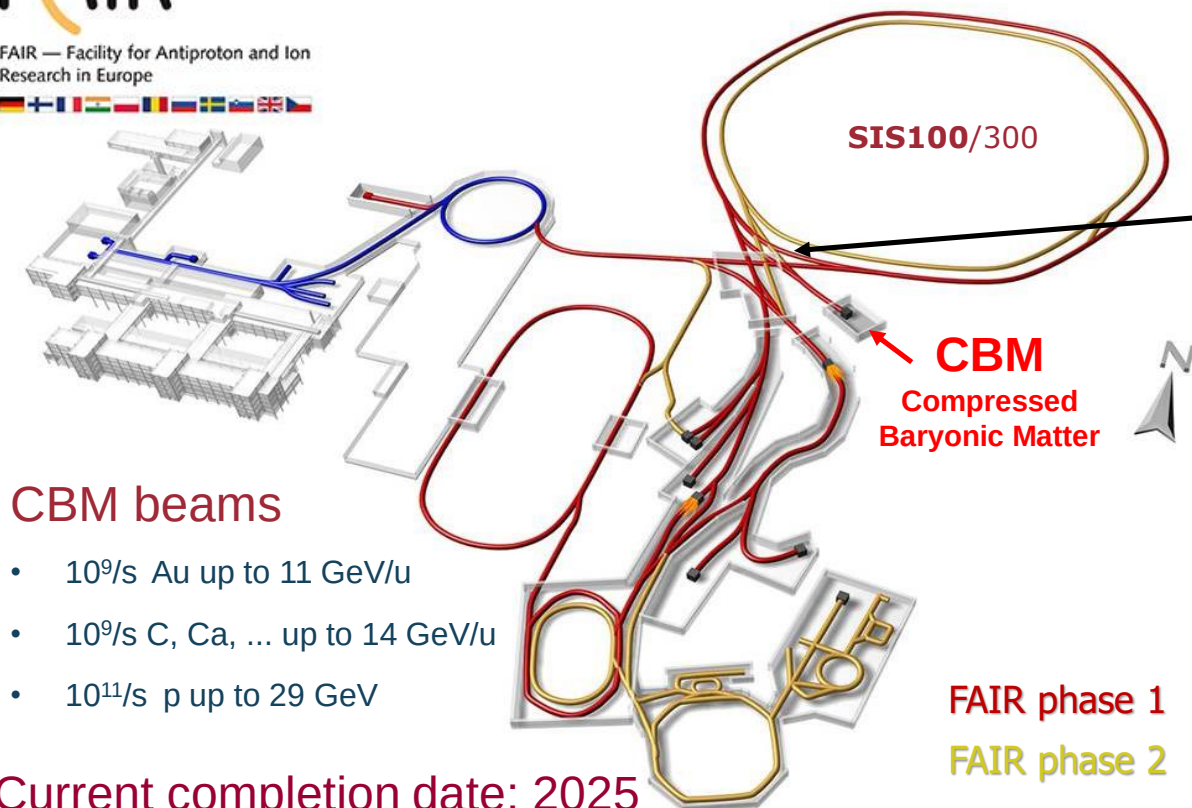


FAIR

FAIR — Facility for Antiproton and Ion Research in Europe



GSI and planned FAIR complex



CBM beams

- $10^9/s$ Au up to 11 GeV/u
- $10^9/s$ C, Ca, ... up to 14 GeV/u
- $10^{11}/s$ p up to 29 GeV

Current completion date: 2025

Drone video showing the construction progress

<https://www.youtube.com/watch?v=nS9yLm6PsZY>

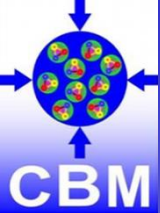


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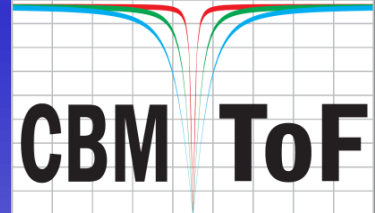
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View in the CBM cave



CBM cave status: June 2019

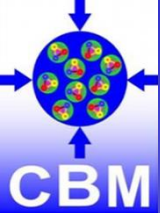


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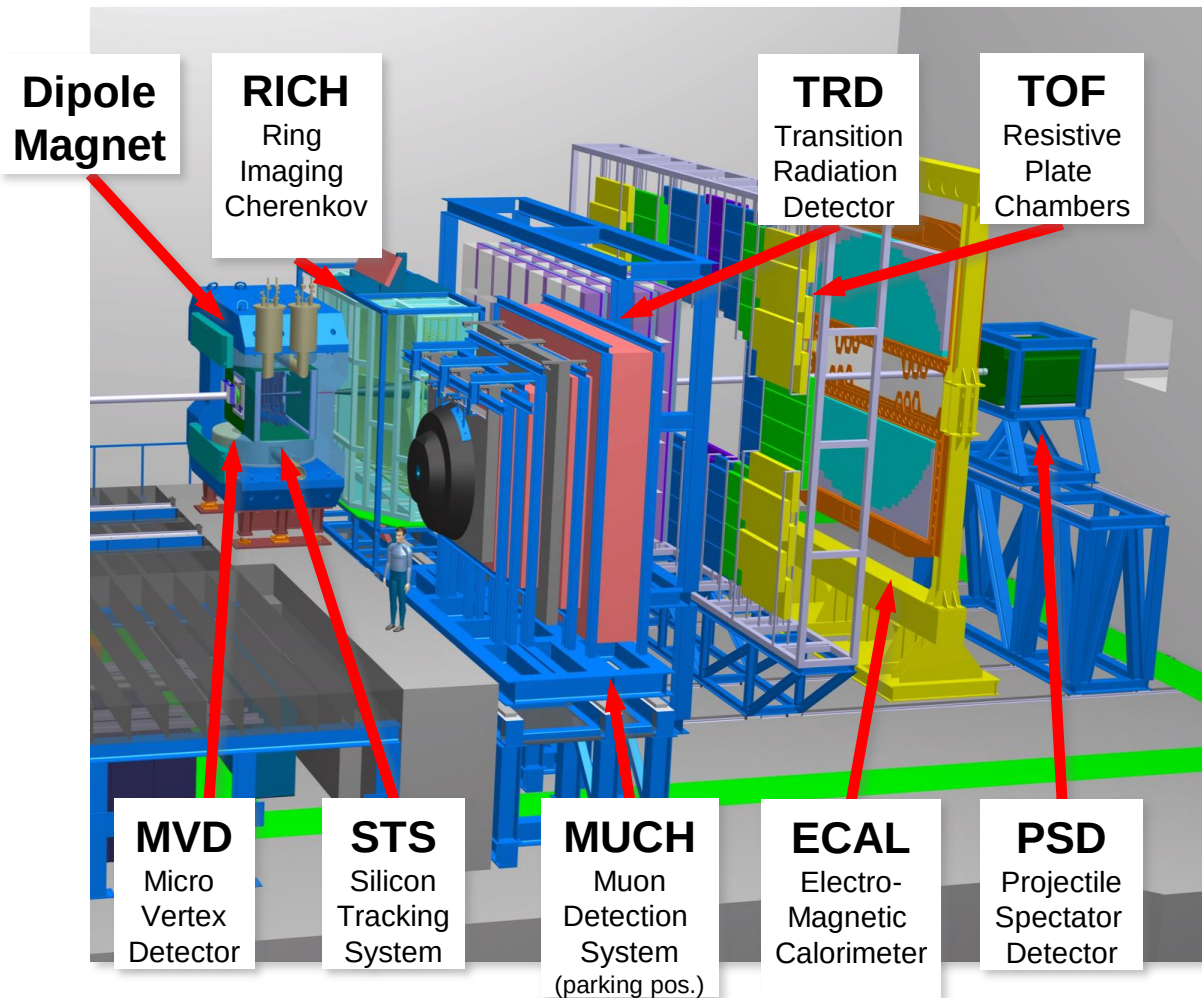
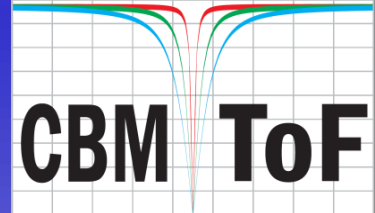
RPC 2020
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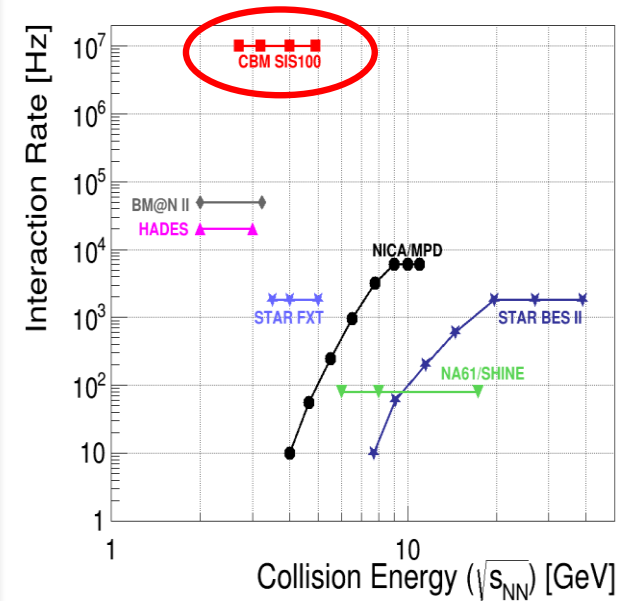


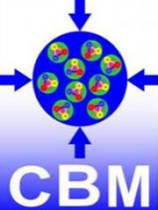


CBM experimental setup

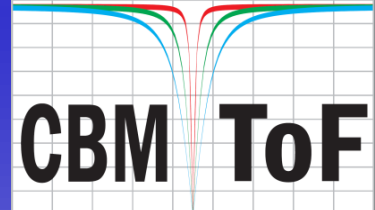


- ❖ Tracking acceptance: $2^\circ < \theta_{\text{Lab}} < 25^\circ$
- ❖ **Data driven DAQ**
- ❖ **Software based event selection**
- ❖ $R_{\text{int}} = 10 \text{ MHz (Au + Au)}$

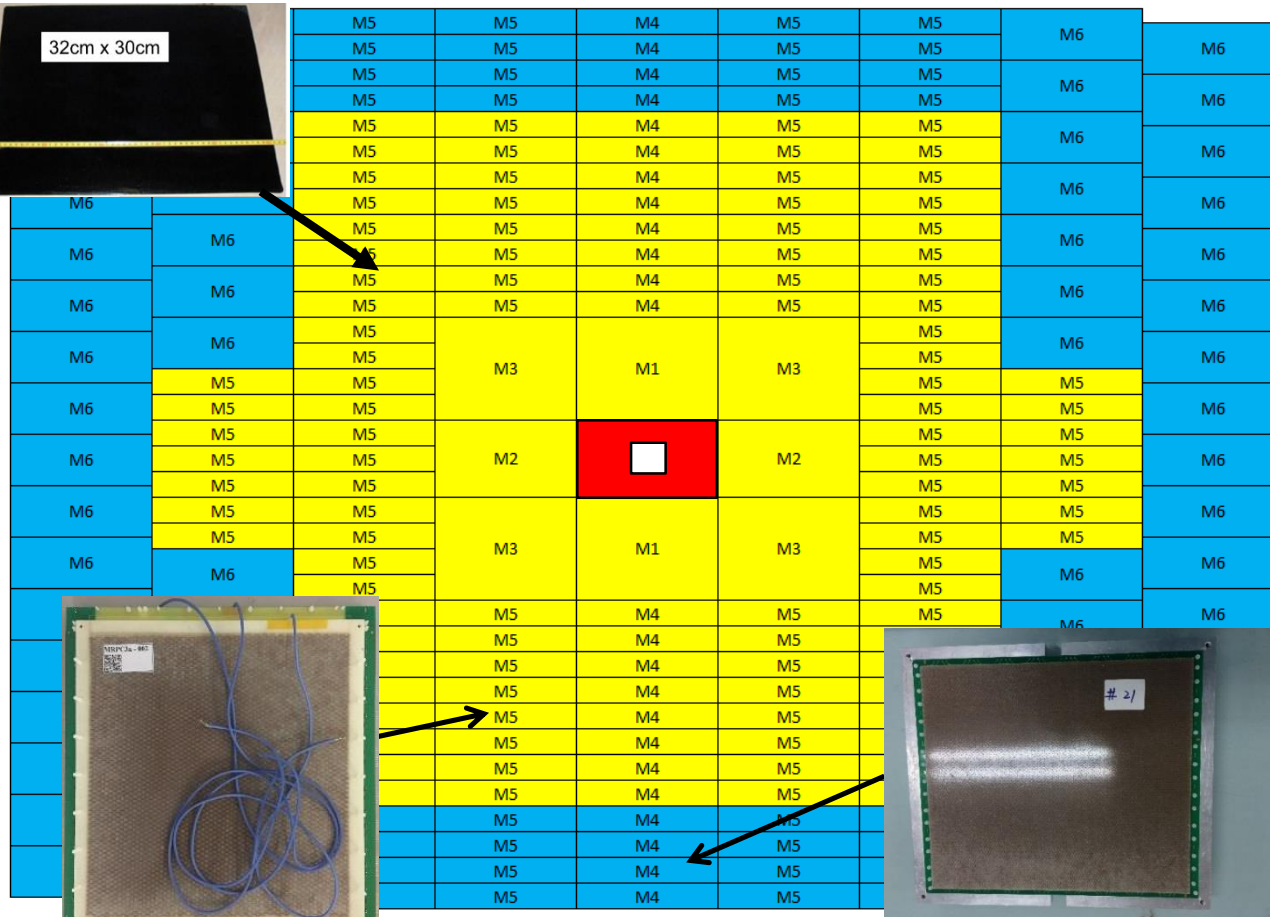
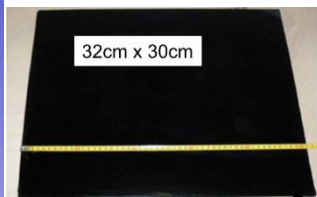




TDR ToF wall layout



Low resistivity glass



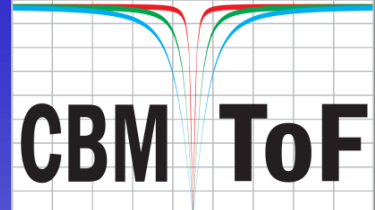
MRPC2 (Tsinghua)

MRPC3 (USTC)

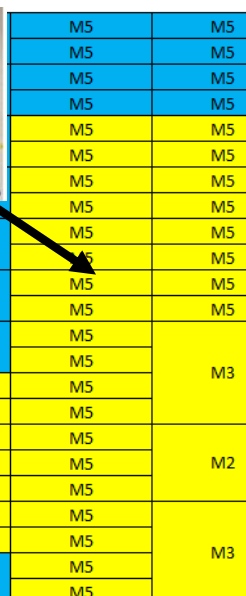
- A module contains several MRPC counters
- Region containing counters equipped with float glass
- Region containing counters equipped with low resistivity glass
- Region containing counters equipped with ceramic material

≈ 230 modules
 ≈ 1400 MRPCs
 ≈ 100000 channels

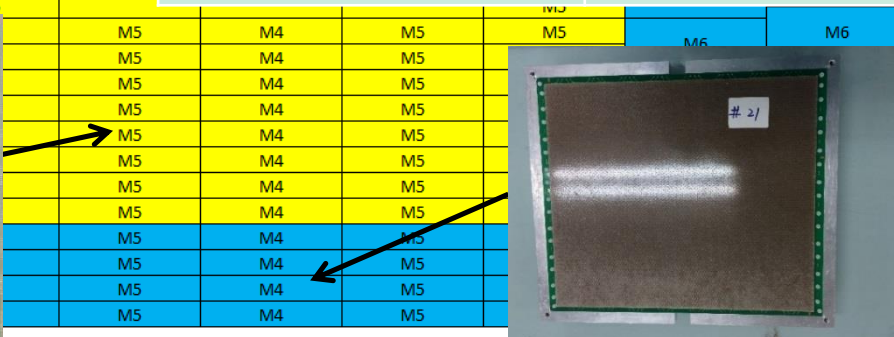




Low resistivity glass



	MRPC2	MRPC3
Active area	32 cm x 27 cm	32 cm x 27 cm
Strips	32	32
#gaps	2 x 4	2 x 5
Gap size	250 μm	230 μm
Glass type	Low resistivity	Soda-lime
Glass thickness	700 μm	270 μm
Operation voltage	± 5500 V	± 6300 V

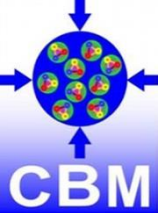


MRPC2 (Tsinghua)

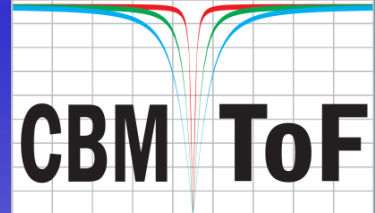
MRPC3 (USTC)

- ≈ 230 modules
- ≈ 1400 MRPCs
- ≈ 100000 channels





FAIR Phase 0 programs



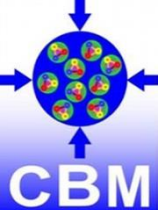
- FAIR Phase 0 is a bridge program until the start of FAIR in 2025
- It comprises the installation and testing of developed equipment in running experiments and analysis of obtained data



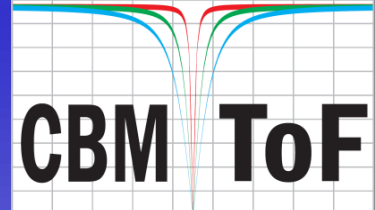
FAIR Phase 0 programs of CBM-TOF

1. **eTOF project at STAR@BNL (6912 channels)**
for long term stability test and physics results purpose
2. **mTOF project at mCBM@SIS18 (1600 channels)**
for high rate and system integration test purpose
(see Talk of Qiunan Zhang on Wed. 9:30)





FAIR Phase 0 – eTOF@STAR



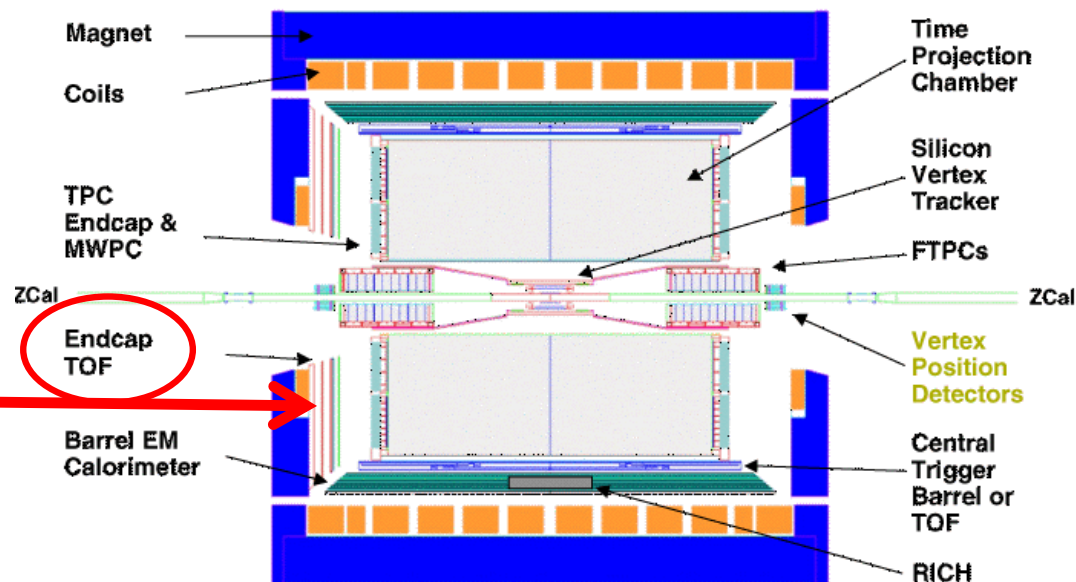
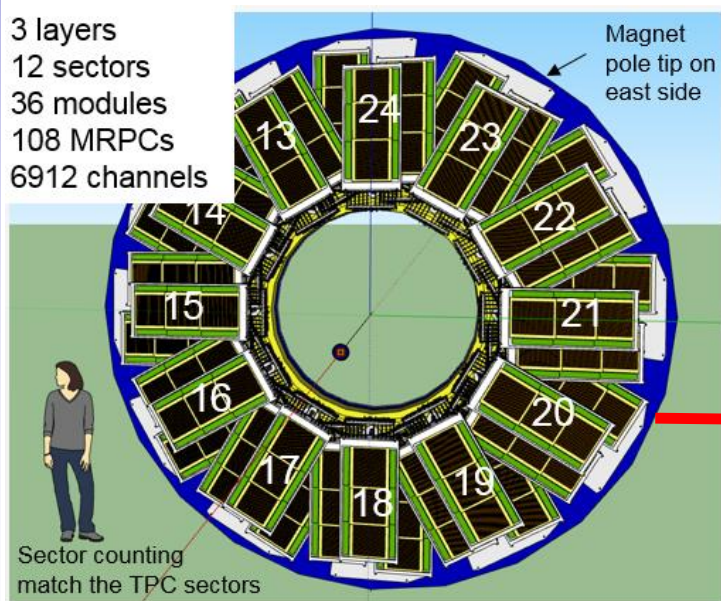
What is the eTOF project

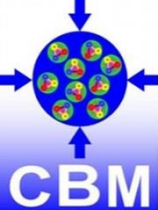
arXiv: 1609.05120



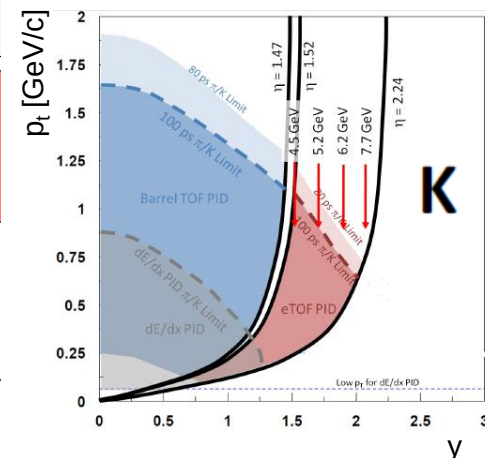
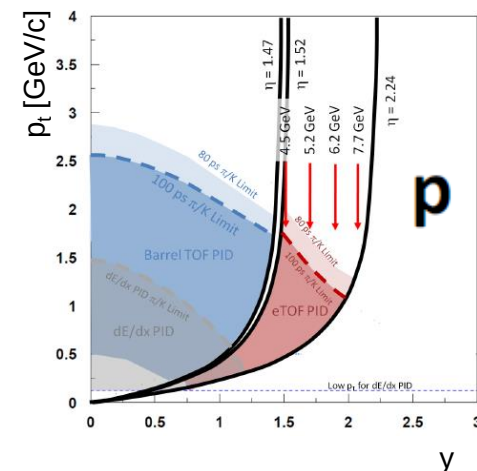
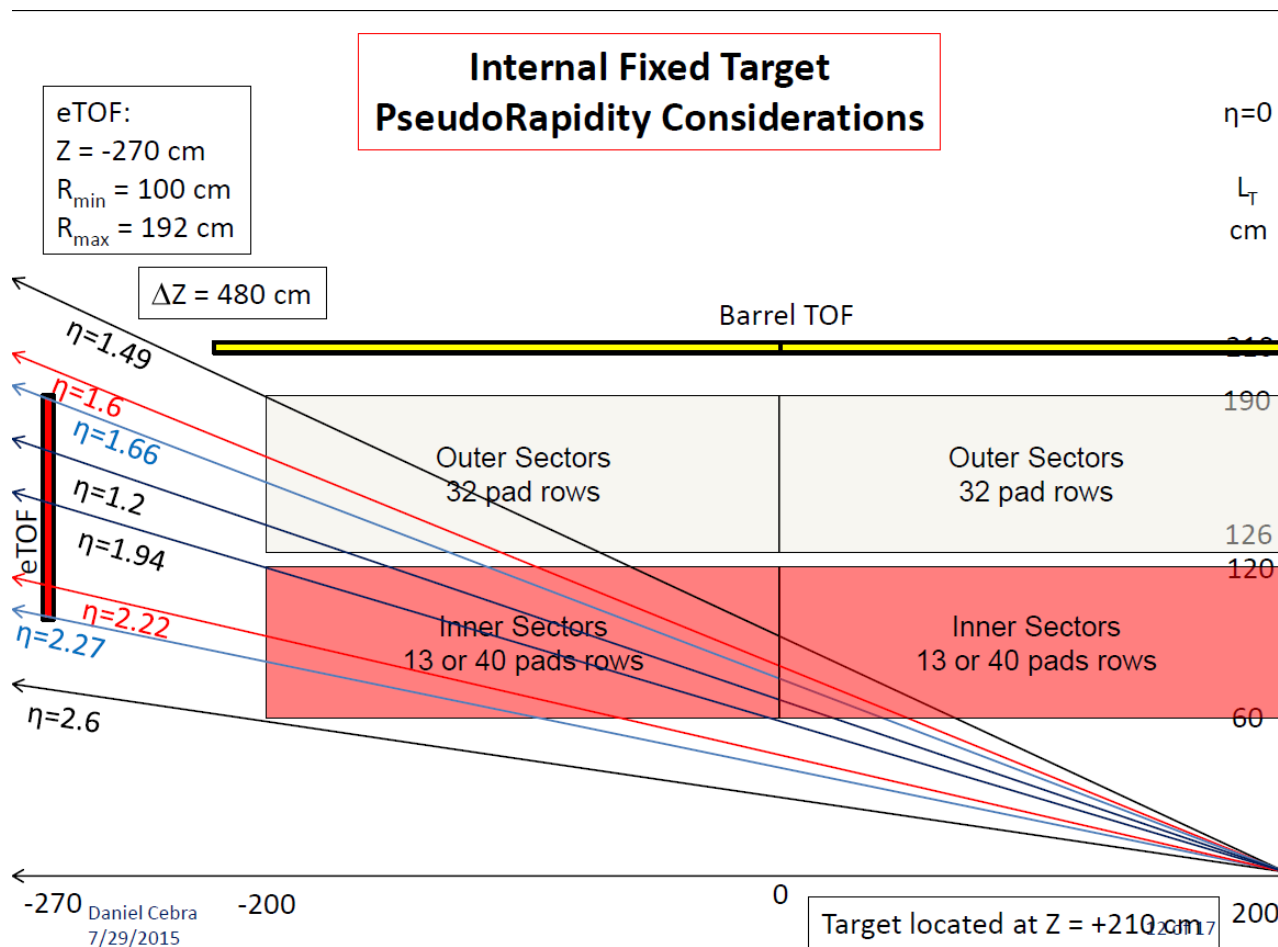
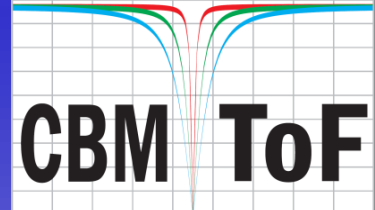
- eTOF project is a joint project between CBM and STAR
- eTOF project is part of the BESII detector upgrade at STAR
- It comprises the installation, commissioning and operation of CBM TOF modules positioned at the east pole tip of the STAR apparatus during the BESII campaign and physics analysis of data obtained with eTOF
- CBM institutions involved: CCNU, GSI, TSU, TUD, UHD, USTC

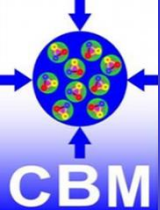
3 layers
12 sectors
36 modules
108 MRPCs
6912 channels



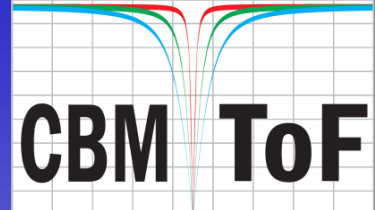


Phase space coverage of eTOF in the fix target mode





MRPC2 and MRPC3 mass production for eTOF



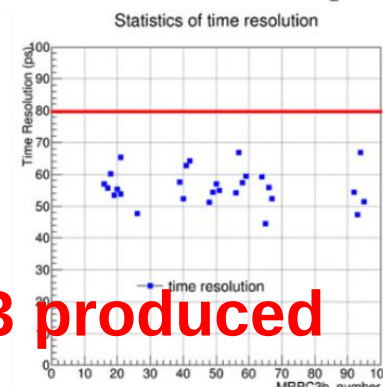
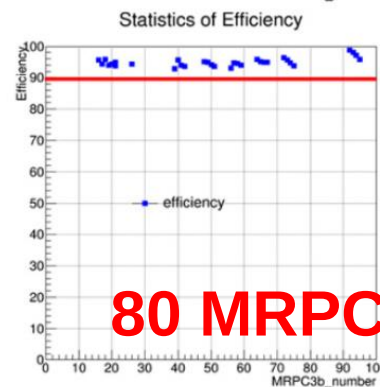
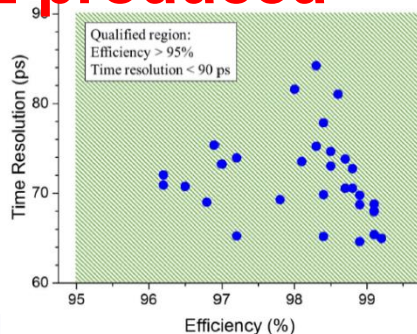
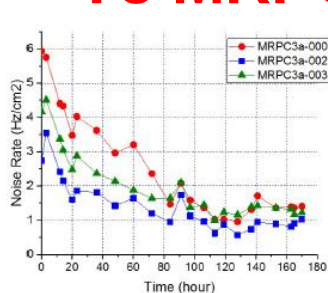
MRPC2 mass prod. at Nuctech, Beijing



MRPC3 mass production at USTC/China



75 MRPC2 produced



80 MRPC3 produced

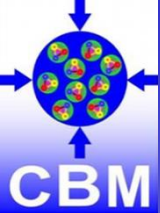


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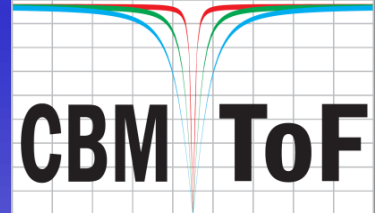
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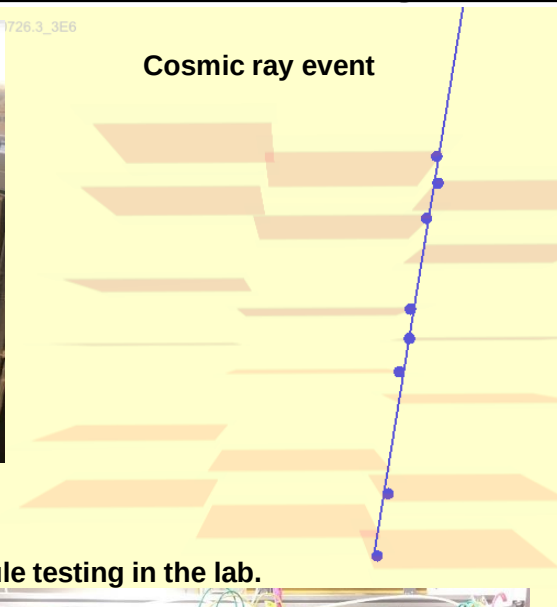
FAIR Phase 0 – eTOF@STAR



Module production and testing in HD (Jun – Oct. 2018)

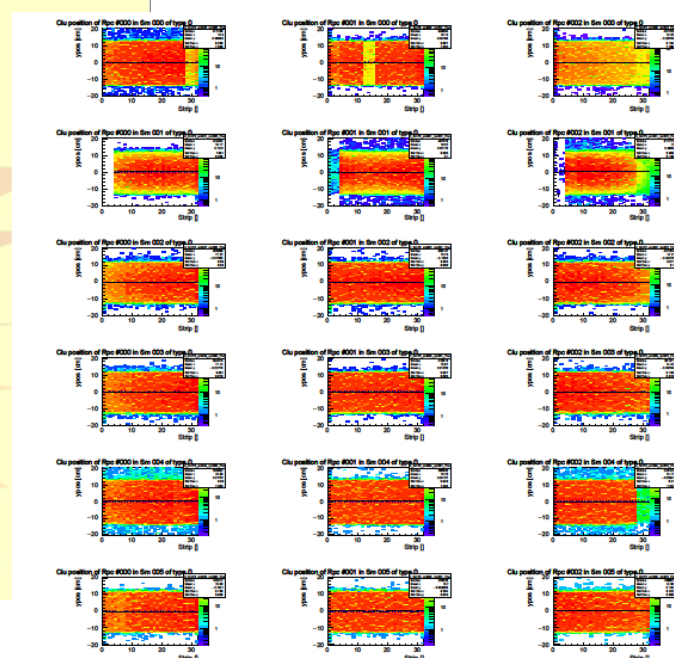
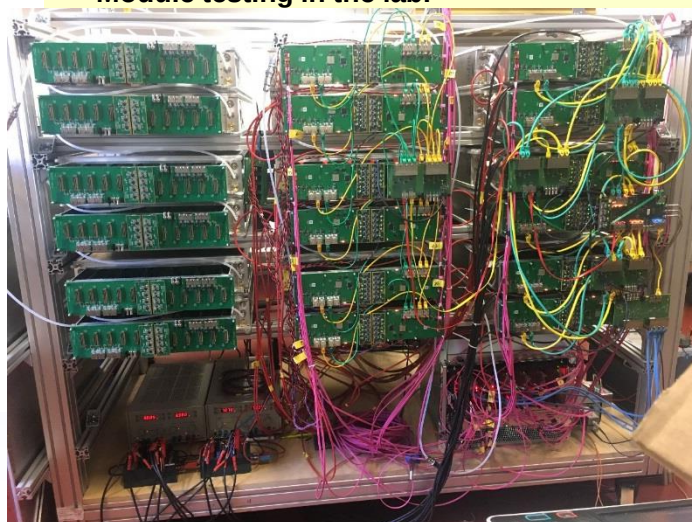


Module production in the clean room



Module testing in the lab.

36 modules
108 MRPCs
72 GBTX PCBs
216 GET4 PCBs
216 PADI PCBs
6912 channels



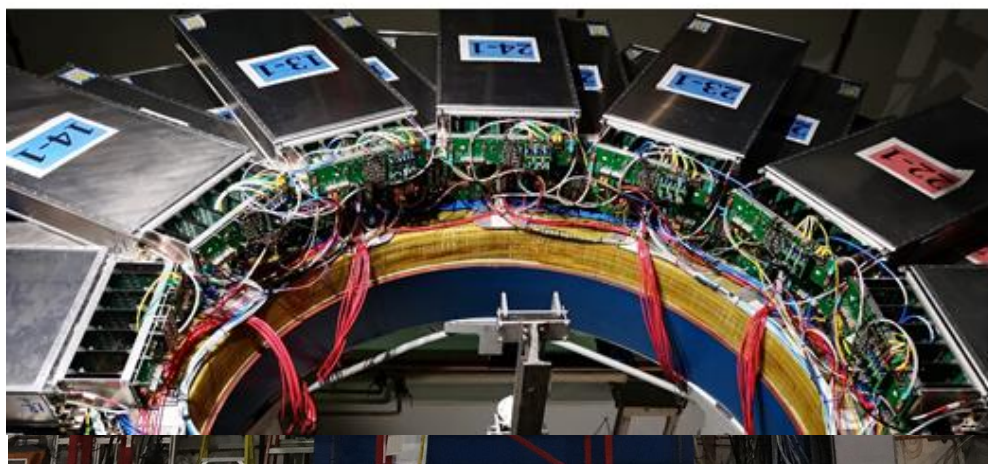
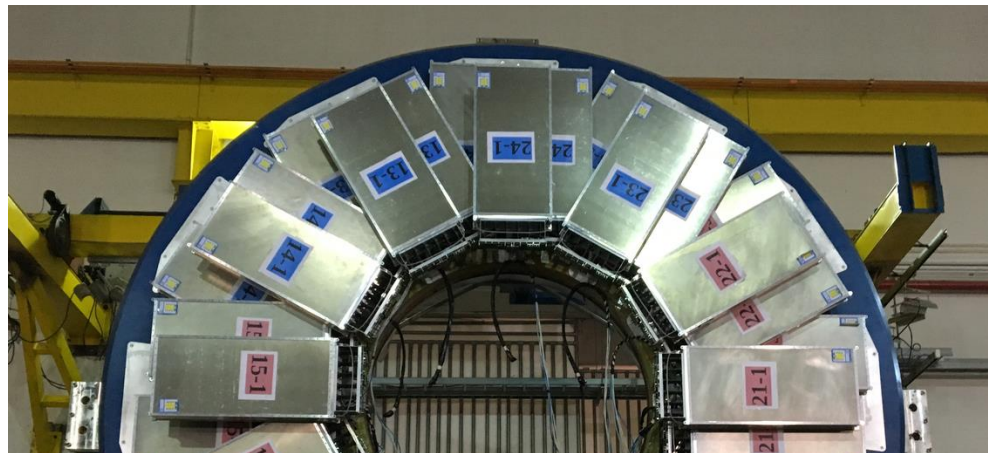
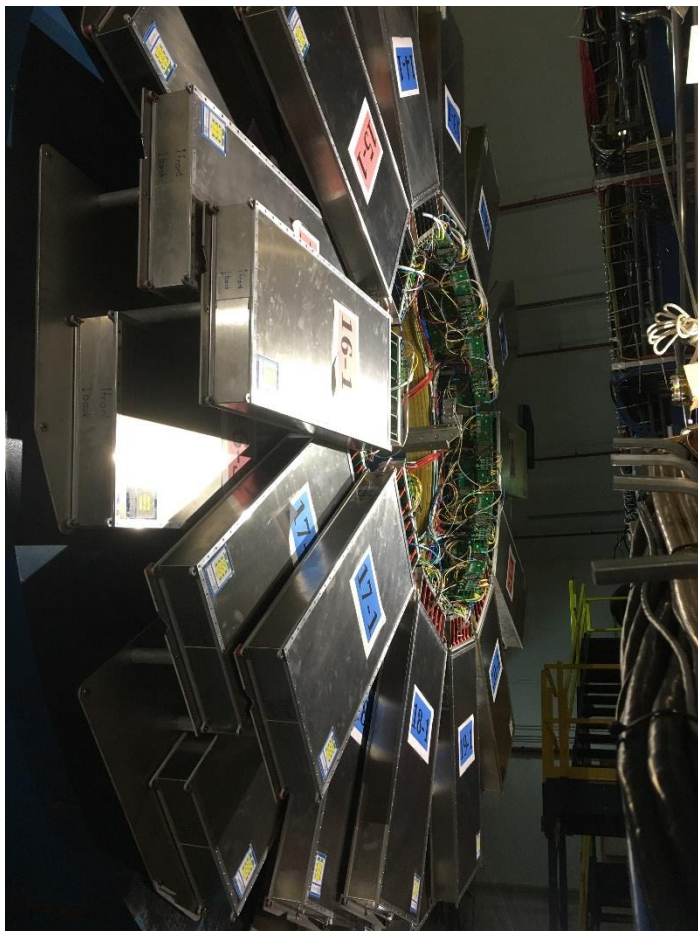
Preparation for transport



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Full installation in Nov. 2018



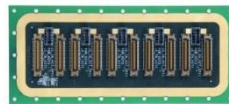
Readout chain (data driven)

- PADIX: Preamplifier board 32 ch

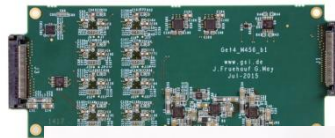


- Feed through PCB

On board are temperature, pressure and humidity sensors



- TDC board 32 ch.
(8 GET4 chips)



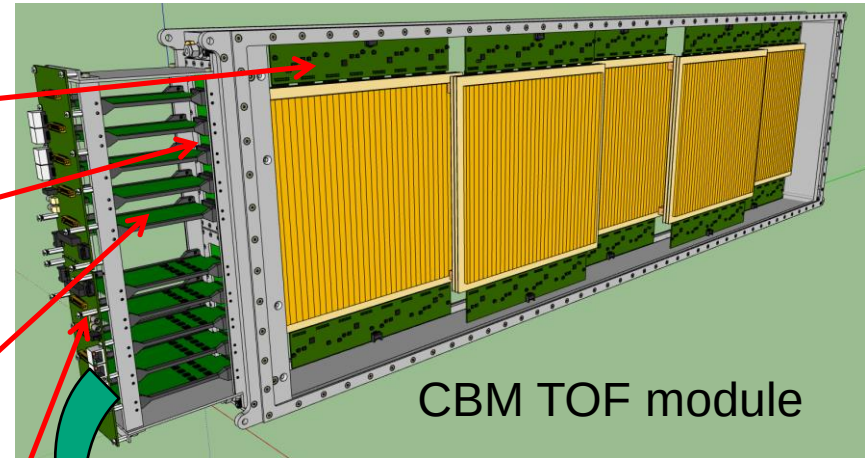
- Backplane with GBTx chip
(SCA chip for slow control)



- AFCK: FPGA board
(AMC FMC Carrier with Kintex)

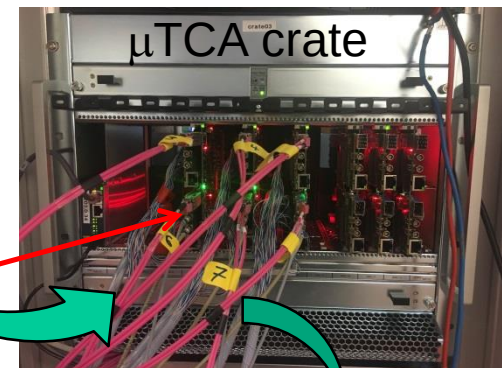


- FLIB: FPGA PCI express card



CBM TOF module

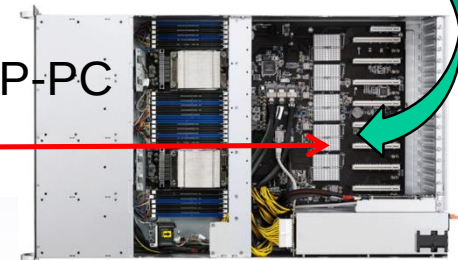
Optic fiber
20 m



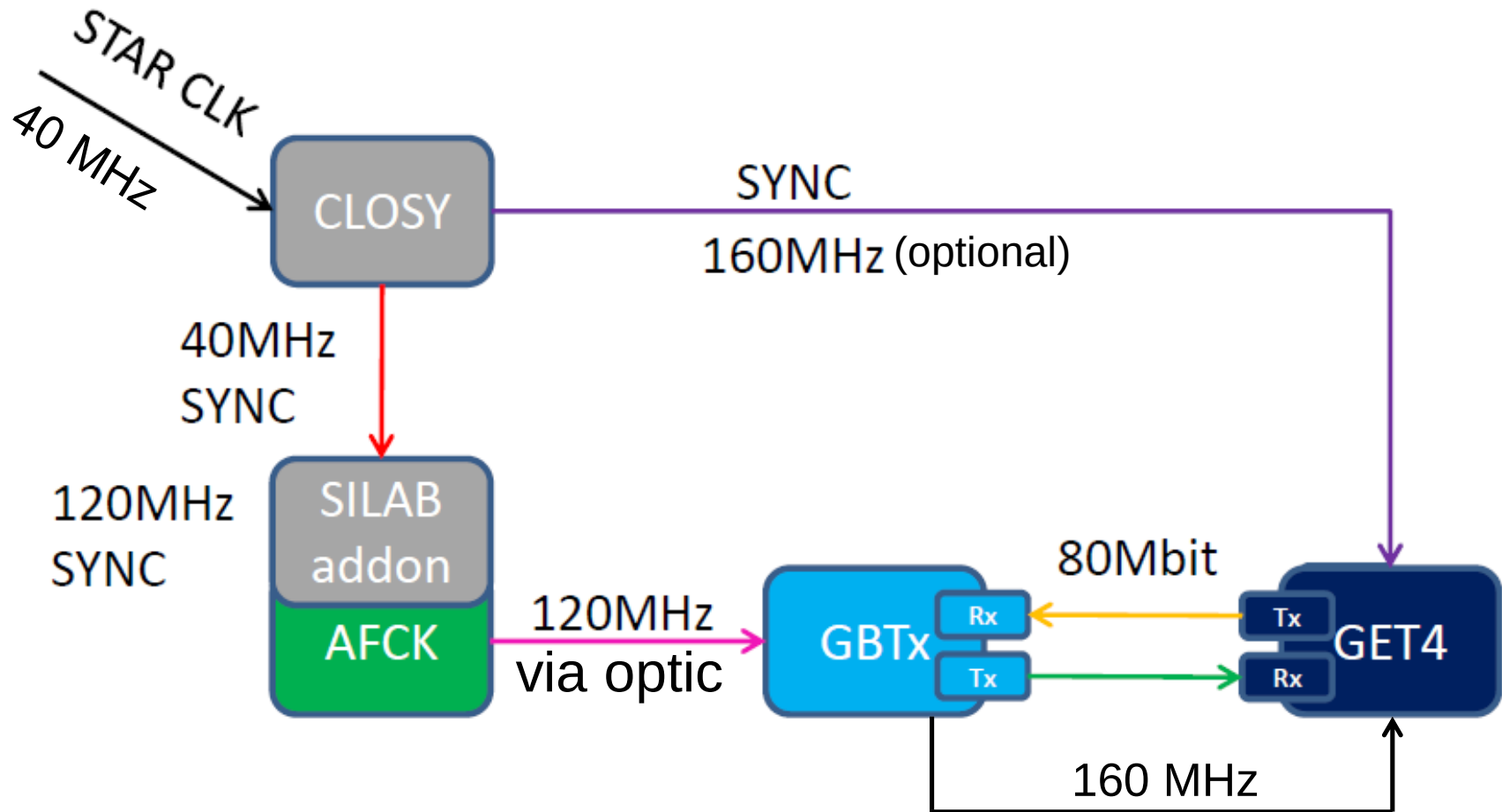
μTCA crate

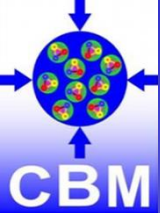
HP-PC

Optic fiber
100 m

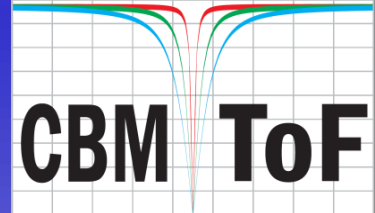


L4

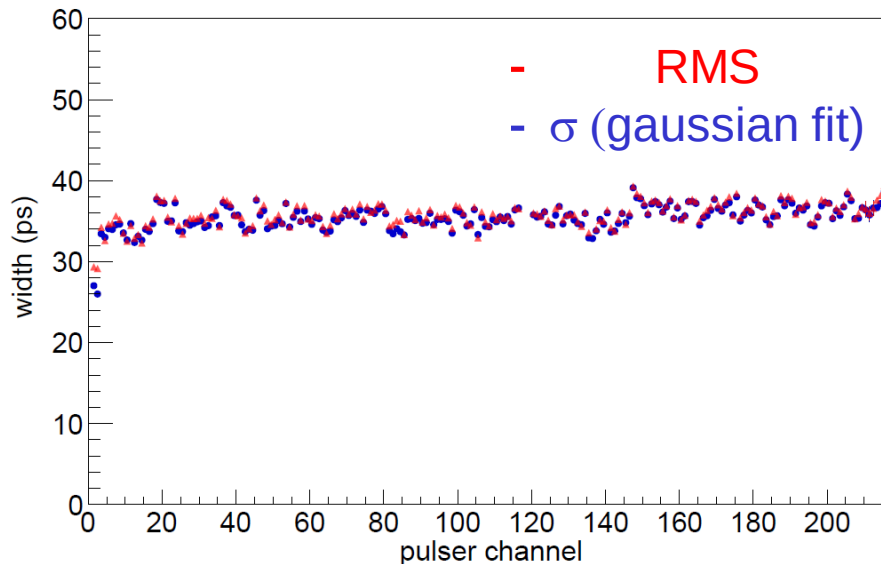




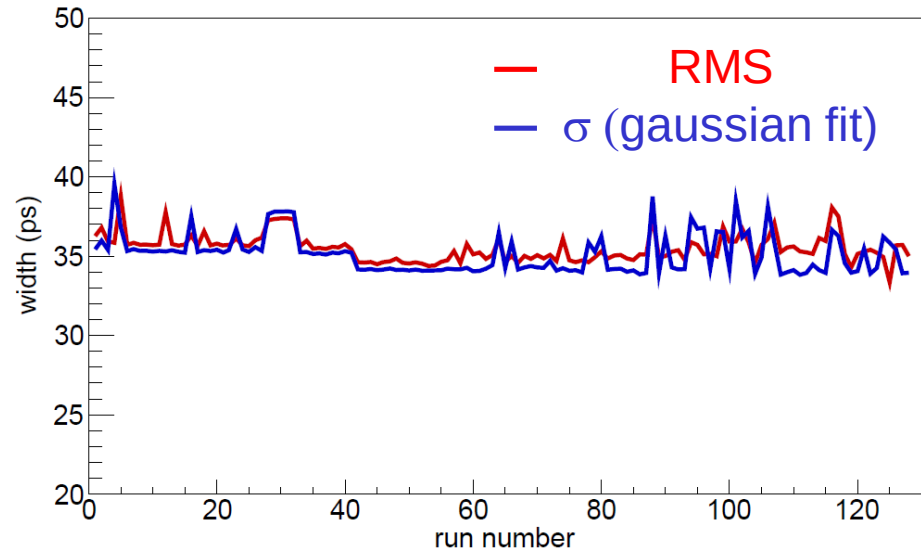
System time resolution of the readout chain



width of pulser time distribution in run 21028013



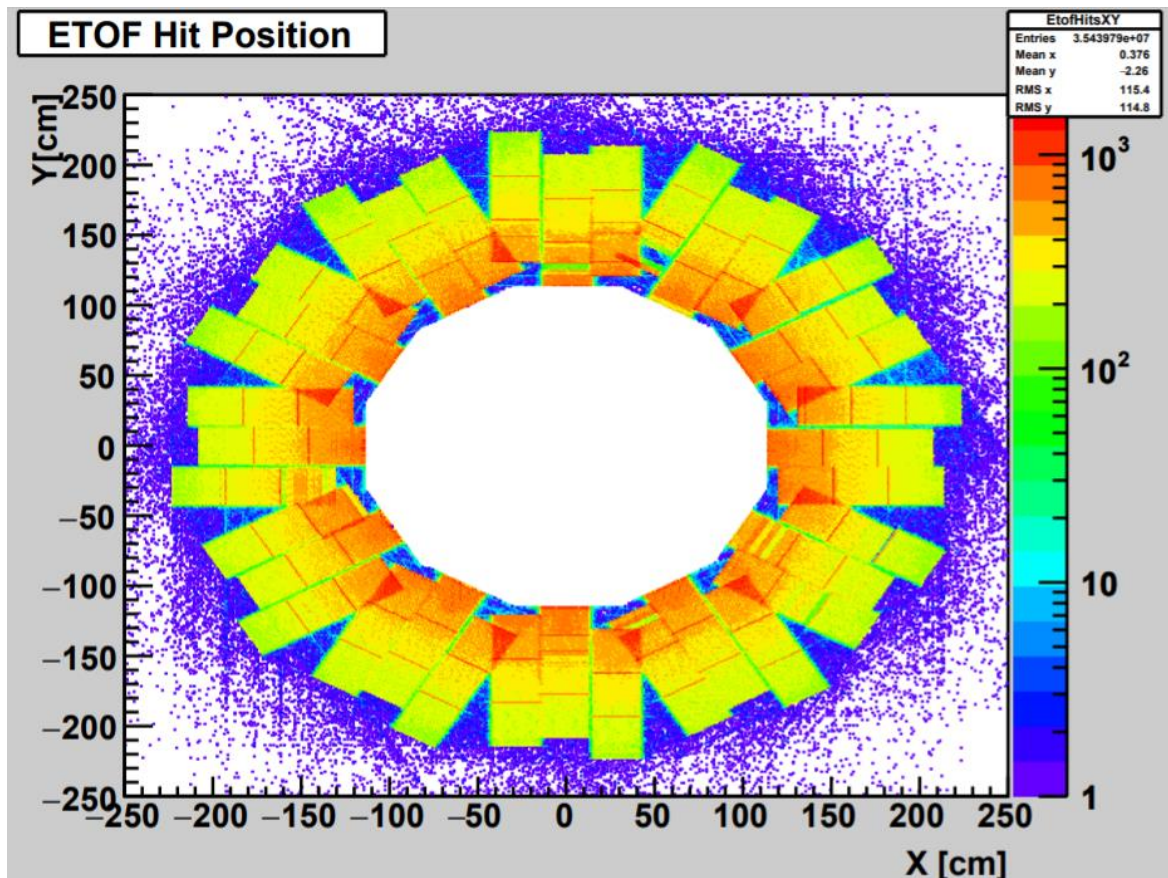
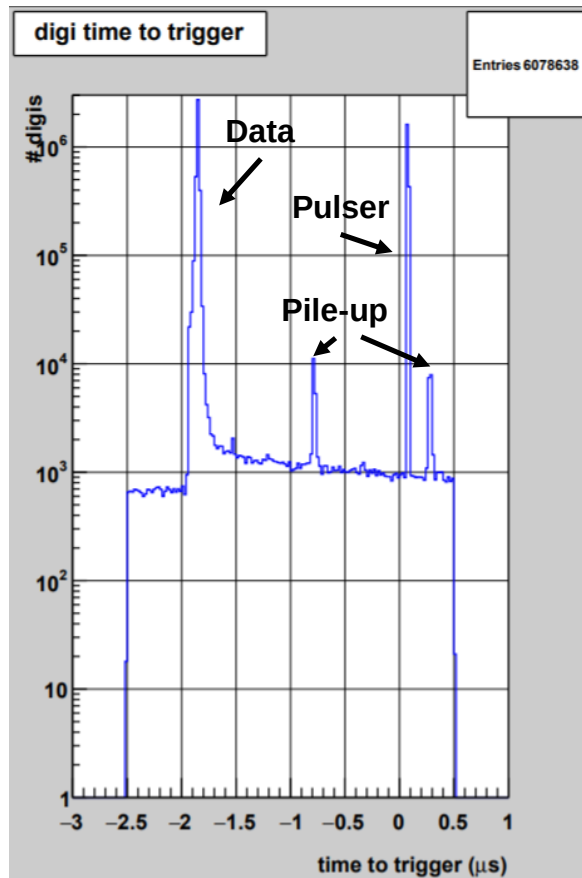
average width of pulser time distribution

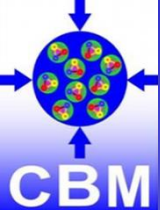


- In every first channel of all TDC cards (216) a pulser signal is injected when an trigger token from STAR is received
- The System time resolution of the readout chain is homogeneous for the full setup
- The System time resolution of the readout chain is in the order of 35 ps
- The stability of the system is demonstrated

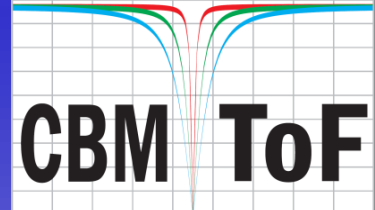


- A trigger token sent by STAR is imbedded in the free streaming eTOF data stream
- When a token word is found the data within a 3 μs window is sent to the STAR event builder

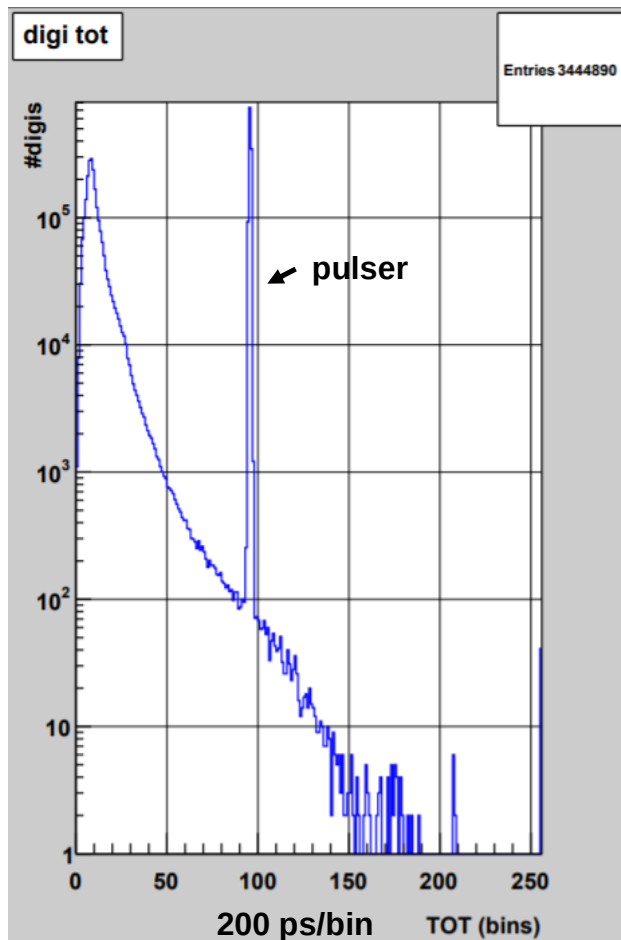




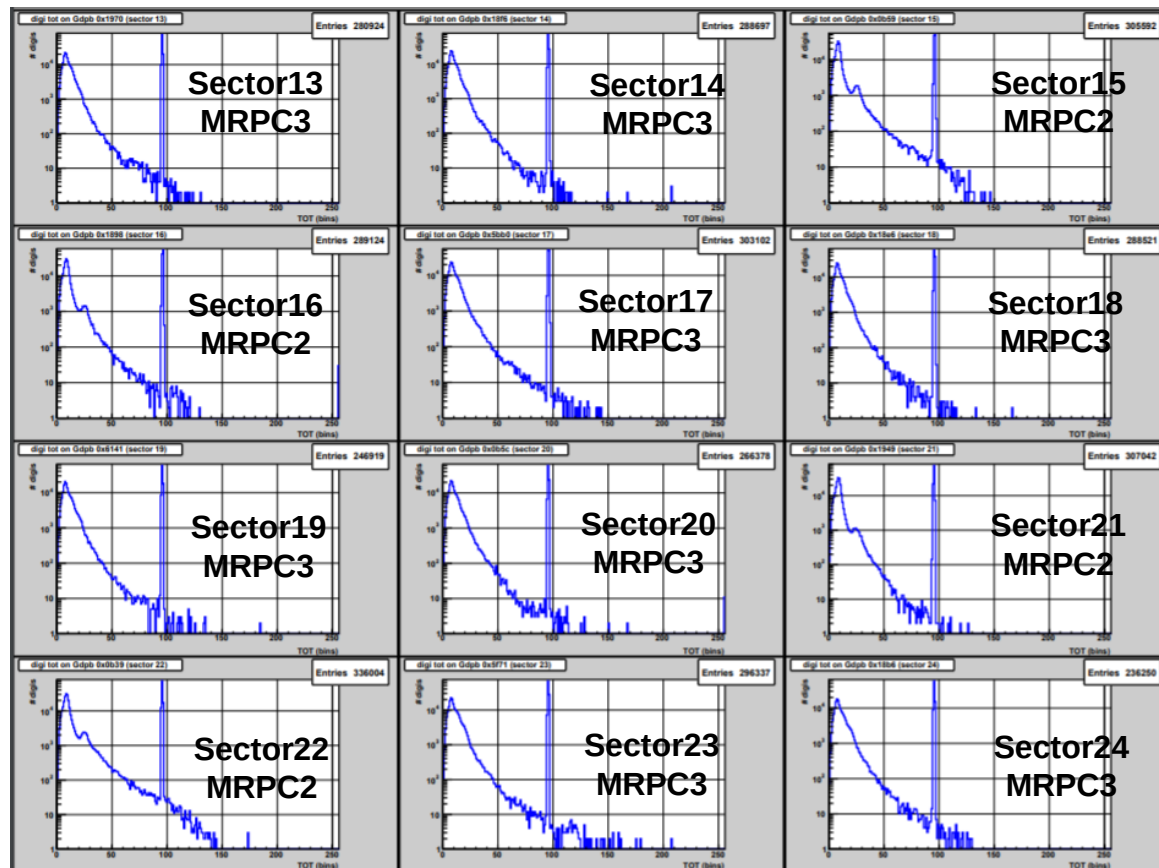
Time over Threshold distribution



TOT of all sectors



TOT of each sector

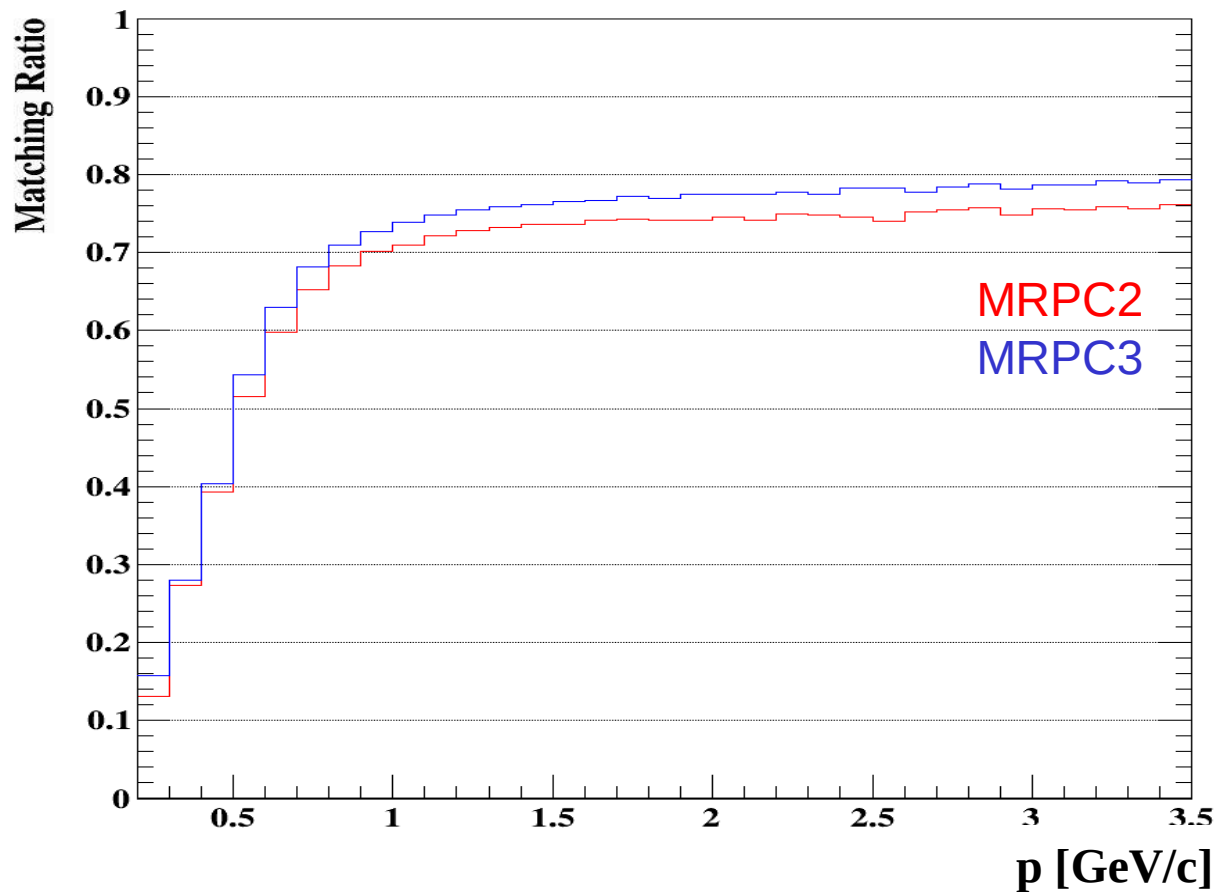


TOT distribution almost exponential over 5 order of magnitudes
Gas Mixture: 94 % R134a, 5% iso-Butane, 1% SF₆



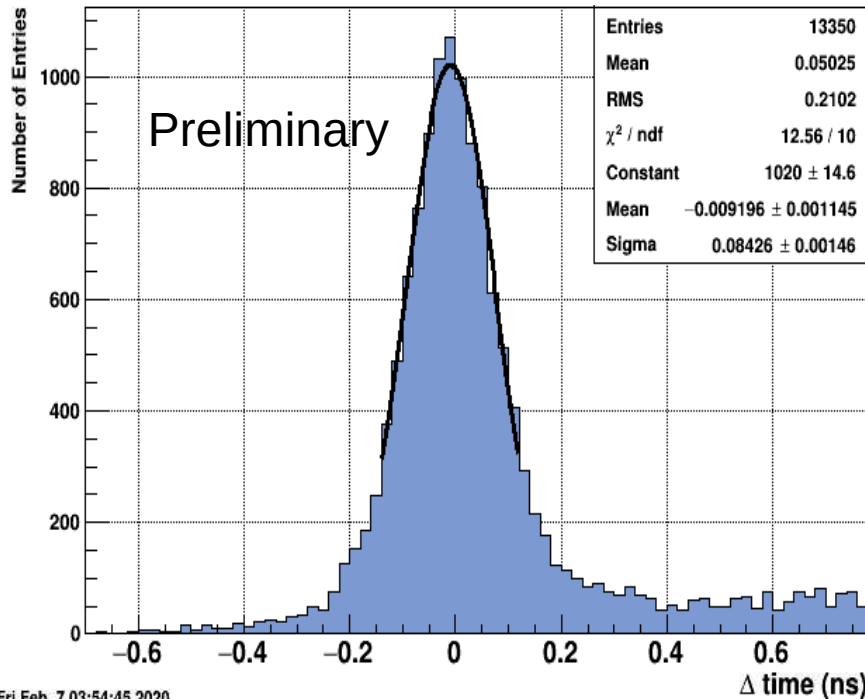
Matching efficiency with TPC tracks

Matching efficiency as function of momentum

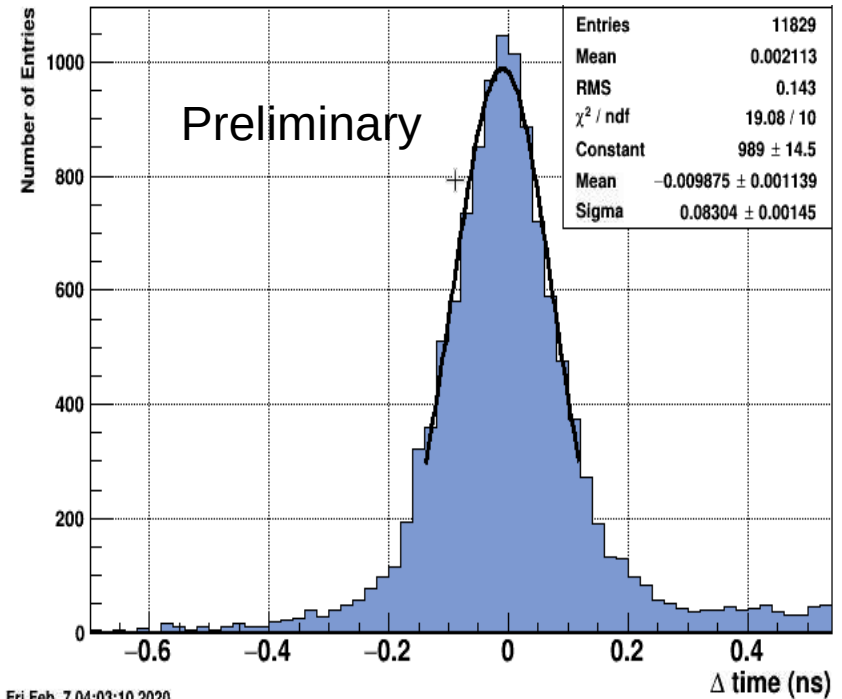


- Matching efficiency with TPC tracks on the order of 75 % above 1.2 GeV/c

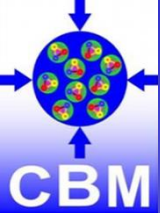
Time resolution MRPC2



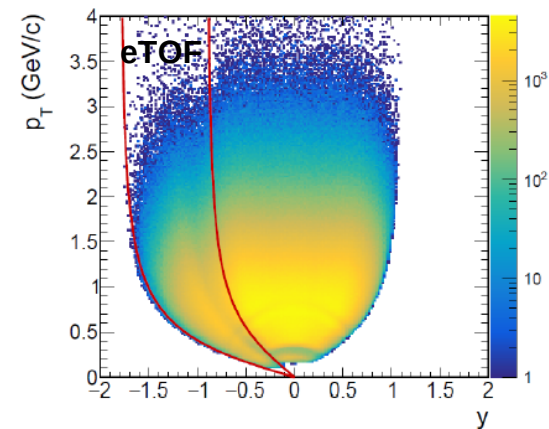
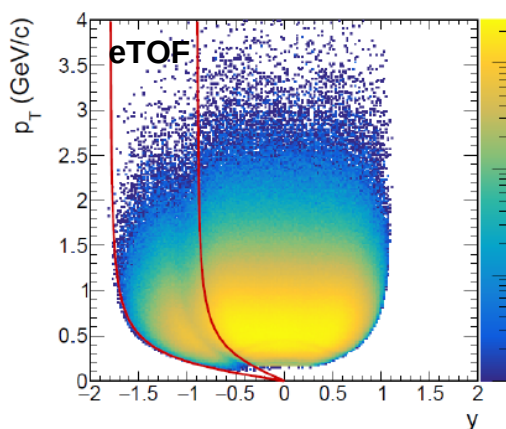
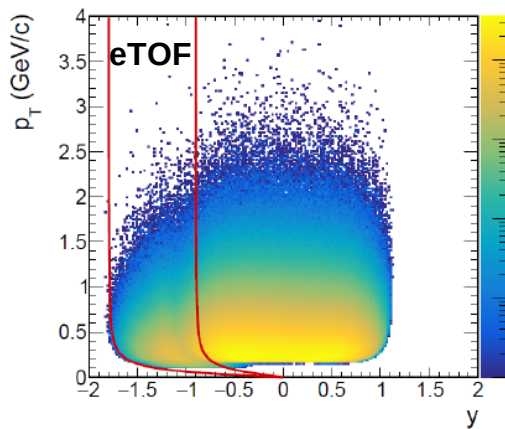
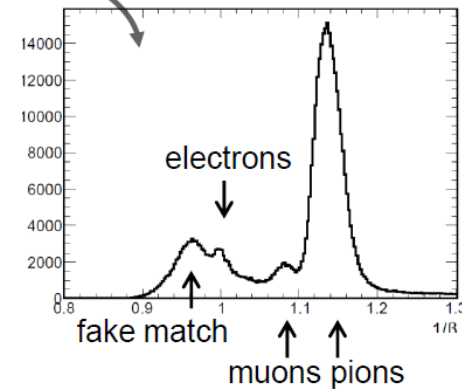
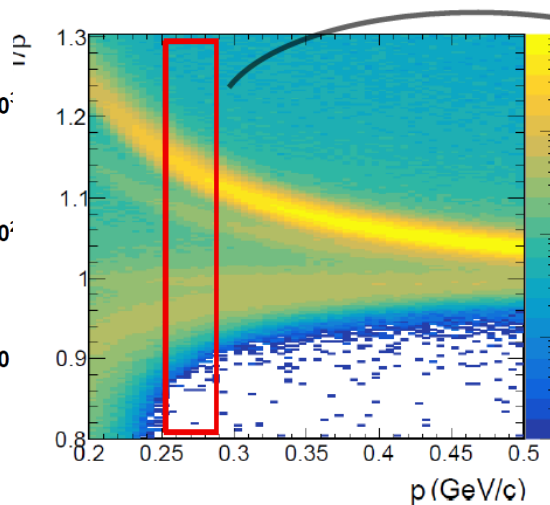
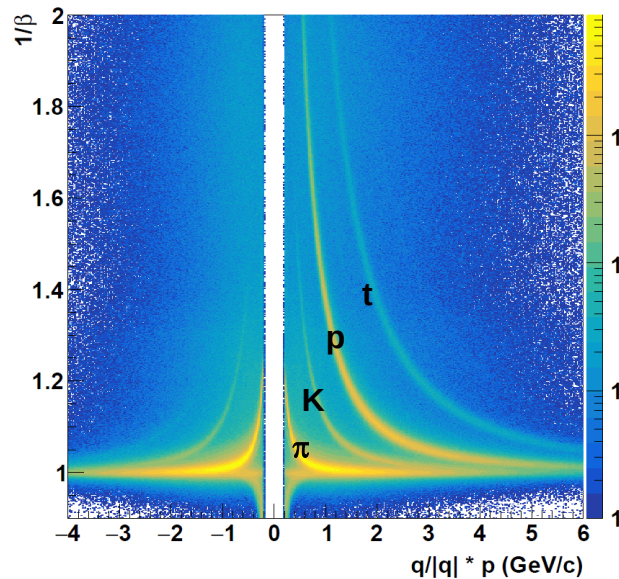
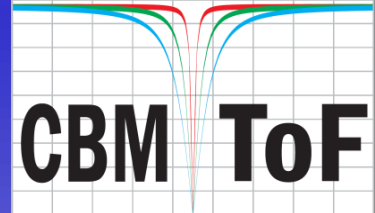
Time resolution MRPC3

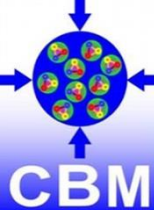


- Time resolution measured with fast pions
- Time resolution in the order of 85 ps

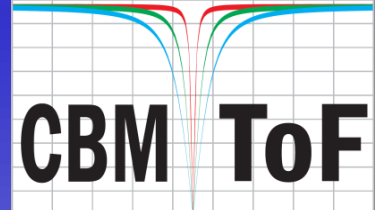


Particle identification and phase space coverage





FAIR Phase 0 – mCBM@SIS18



mCBM is a CBM full system test setup at GSI

mTOF setup

- 25 MRPC3a counters
- 5 M4 modules + 10 CROB(GTBx)
- Active area: $150 \times 120 \text{ cm}^2$
- # of readout channels: 1600
- T0 diamond counter (8 channels)
- **Intended interaction rate: 10 MHz**

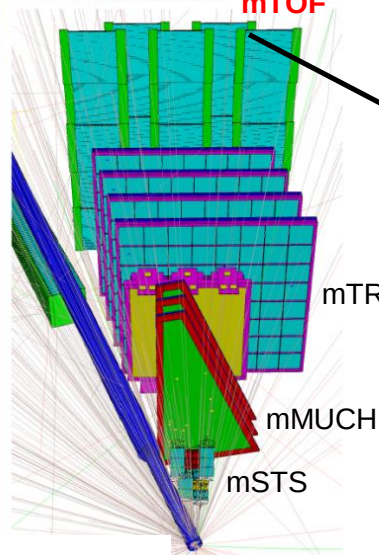
mCBM program:

- Q1 2019 detector & daq commissioning
- Q1 2020 high rate test for subsystems/detectors
- Q1 2021 high rate full system test
- Q1 2022 physics benchmark (Λ – prod)
- Q1 2023 Λ – excitation function**

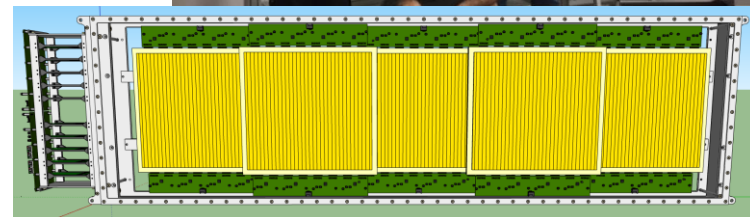
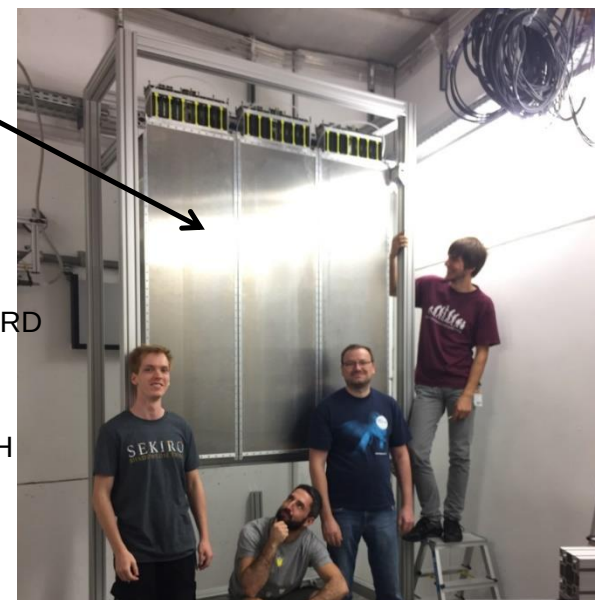


mCBM@SIS18

The CBM Collaboration **mTOF**

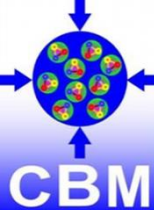


mTOF-wall

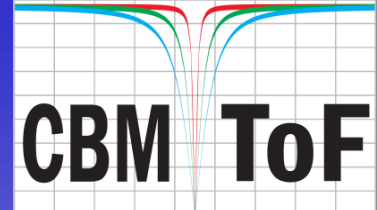


M4 module: 5 MRPC3a counters, 10 PADI, 2 Feed-through PCBs, 10 Get4, 2 backplane PCBs (with GTBx)

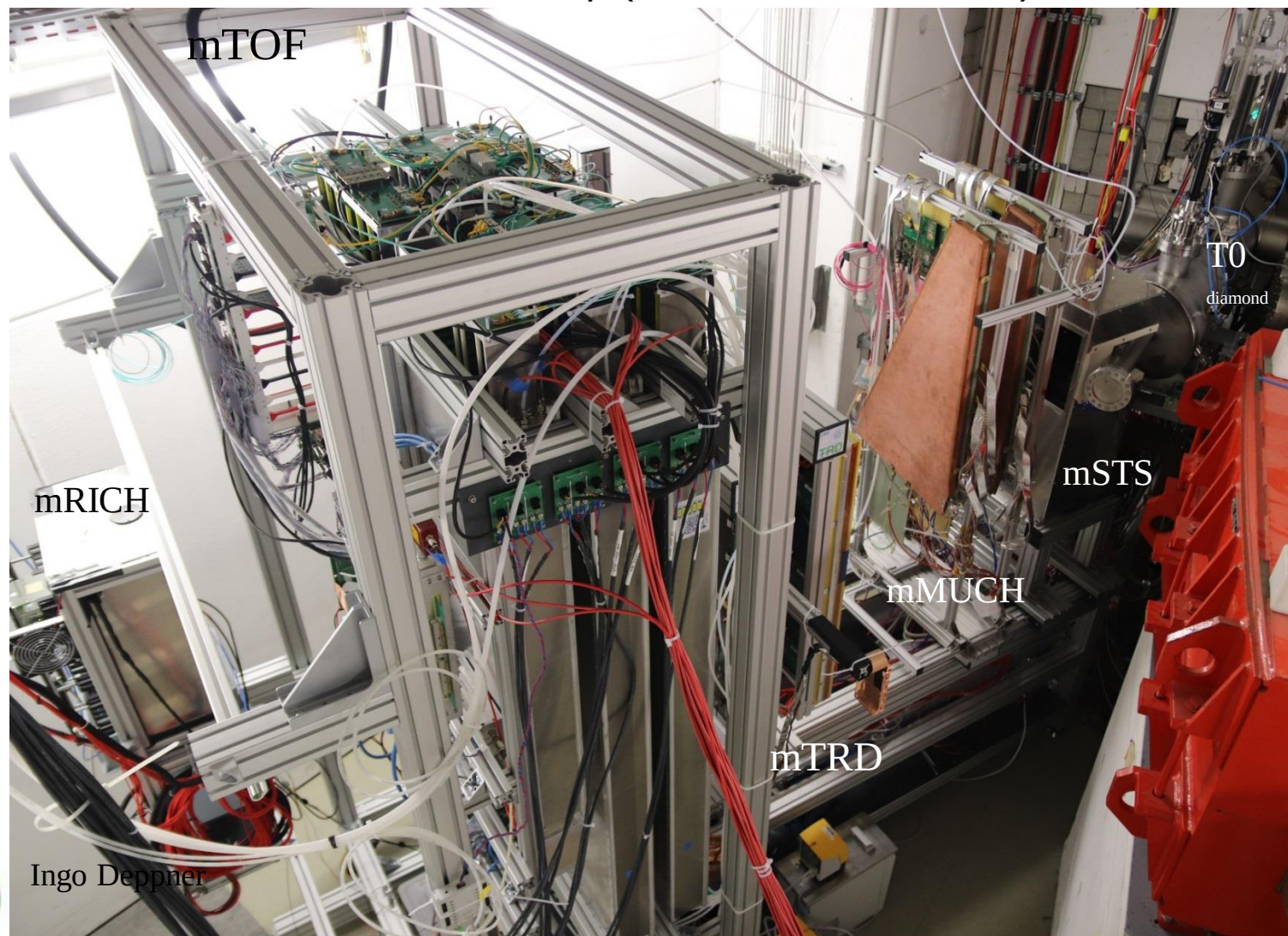




FAIR Phase 0 – mCBM@SIS18

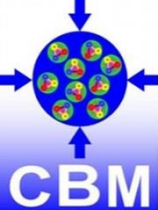


mCBM Setup (as of March 25, 2019)

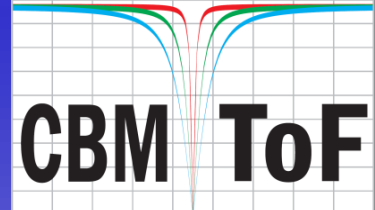


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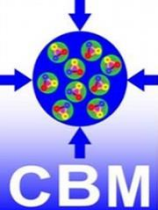


Summary

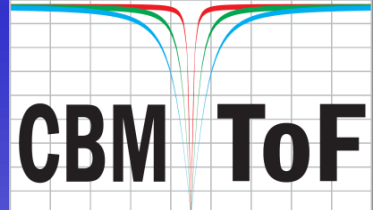


- FAIR construction started
- CBM TOF ready for beam in 2024
- Preproduction for MRPC2 and MRPC3 finished
- CBM-TOF FAIR phase 0 projects in full swing
- Counter fulfill the specs
- eTOF system time resolution about 85 ps
- Matching efficiencies with TPC tracks in the order of 75%
- PID capability demonstrated





Thank you for your attention



Contributing CBM institutions:

Tsinghua Beijing,
NIPNE Bucharest,
GSI Darmstadt,
TUD Darmstadt,
FIAS Frankfurt,
USTC Hefei,
PI Heidelberg,
ITEP Moscow,
HZDR Rossendorf,
CCNU Wuhan,

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bmb+f

Großgeräte
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Grundlagenforschung



FAIR — Facility for Antiproton and Ion
Research in Europe



Ingo Deppner

RPC 2020

Tor Vergata, 10 - 14.02.2020

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