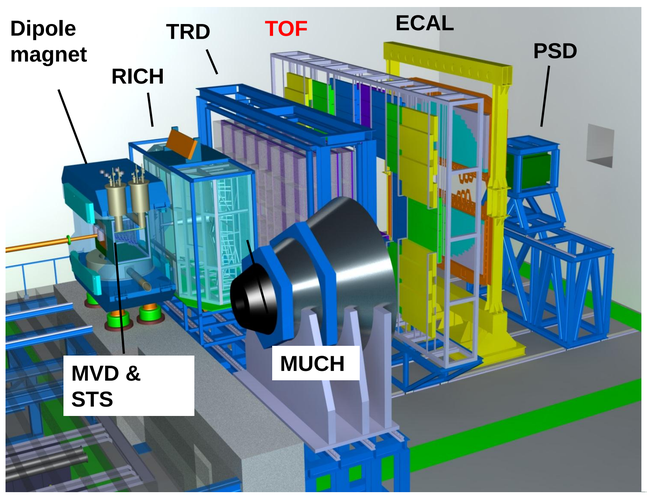
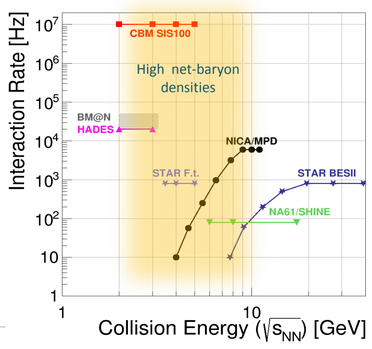
The CBM Time-of-Flight system

Abstract: The CBM experiment aims at exploring the QCD phase diagram at large baryon densities in the beam energy range from 2 A GeV to 11 (35) A GeV at the SIS100 (SIS300) accelerator of FAIR/GSI. For charged particle identification that is required by many observables that are sensitive to the phase structure like collective flow, phase space population of rare hyperons, fluctuations of conserved quantities, … a high performance Time-of-Flight (TOF) wall with a granularity of about 120.000 channels and a system timing resolution of better than 80 ps is being built. Part of the wall (~ 10.000 channels) will be installed in the forward hemisphere ($1.5 < \eta < 1.0$) of the STAR experiment at RHIC/ BNL during the beam energy scan (BES II) campaign planned for 2019/2020.

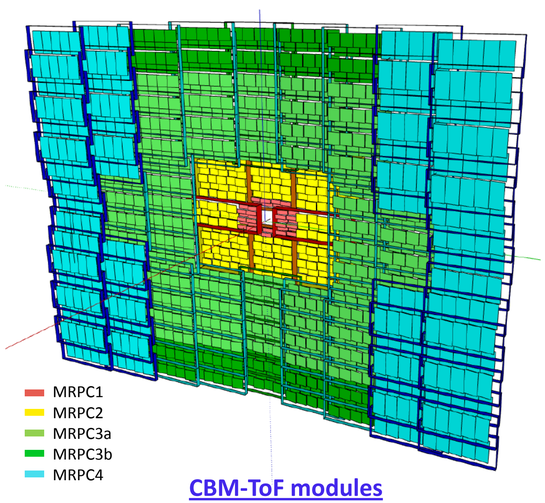
The Compressed Baryonic Matter (CBM) experiment



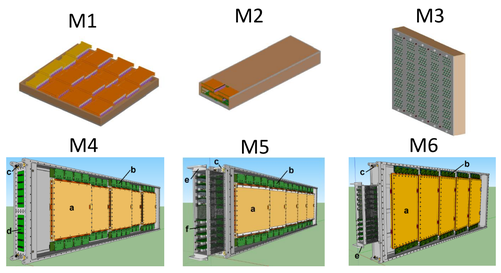
- Tracking acceptance: $2° < \theta_{Lab} < 25°$
- Free streaming DAQ
- Software based event selection
- R_{int} = 10 MHz (Au + Au)



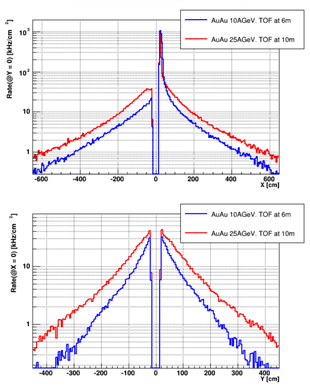
The CBM Time-of-Flight wall



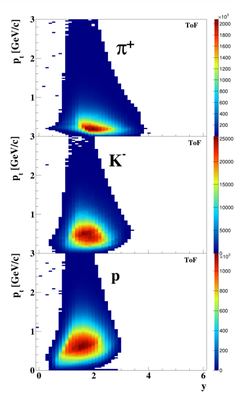
CBM-ToF modules



Anticipated rate



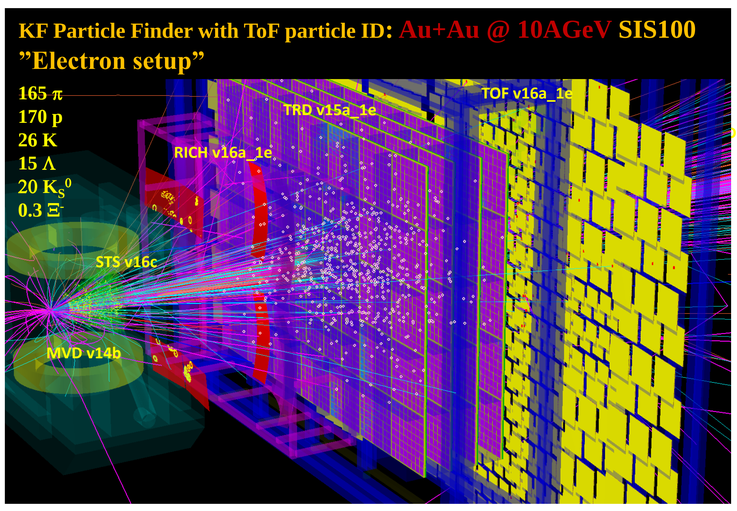
Phase space distribution



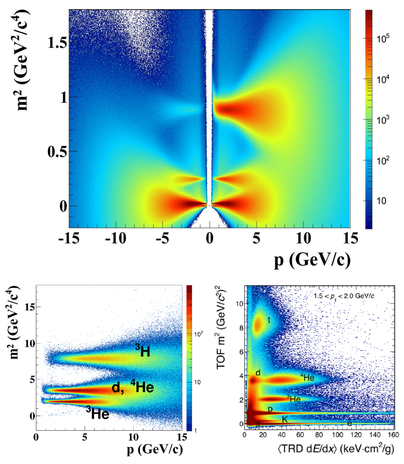
CBM-ToF Requirements

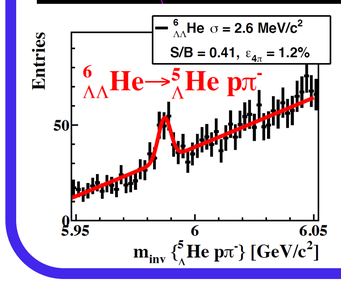
- Full system time resolution σ_T ~ 80 ps
- Efficiency > 95 %
- Rate capability ≤ 30 kHz/cm²
- Polar angular range 2.5° – 25°
- Active area of 120 m²
- Occupancy < 5 %
- Low power electronics
- (~120.000 channels)
- Free streaming data acquisition

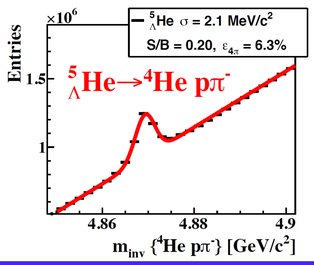
PID capability and an example of physics applications



Particle Identification





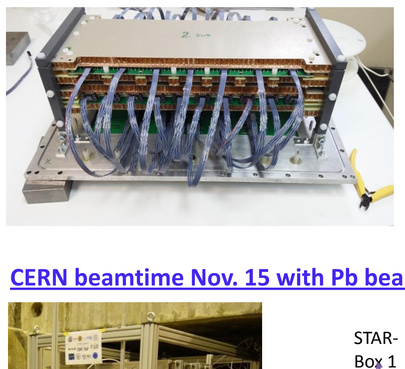


Reconstruction of double Λ-hypernuclei

- 10A GeV Au + Au
- 10^{12} central events
- High interaction rate is essential
- Large d background for ^{4}He
- ^{4}He can not be separated from d with TOF
- Additional dE/dx information is necessary

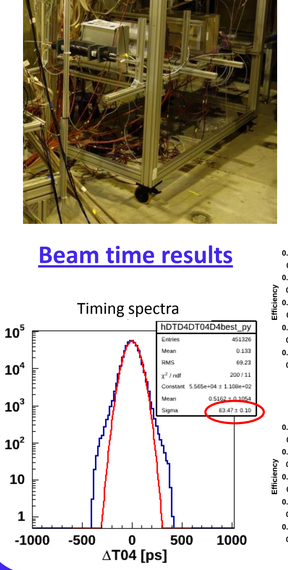
CBM MRPC prototypes and test beam performance

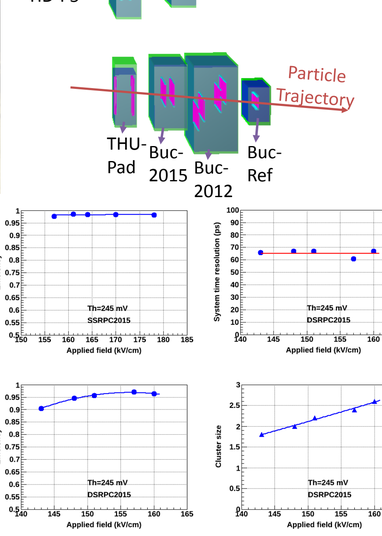
CBM MRPC prototypes (MRPC2 and MRPC3a)

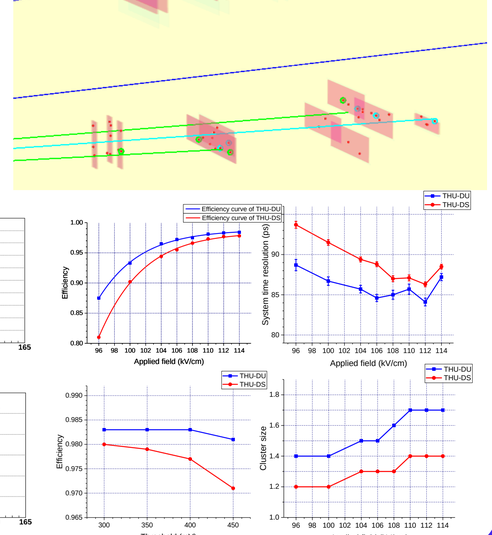


- Active area 300 – 864 cm²
- Granularities 10 – 27 cm²
- Low resistive glass
- Rate capability > 30 kHz/cm²
- Time resolution about 50 ps
- Efficiencies above 95 %
- Cluster size about 1.4 - 2

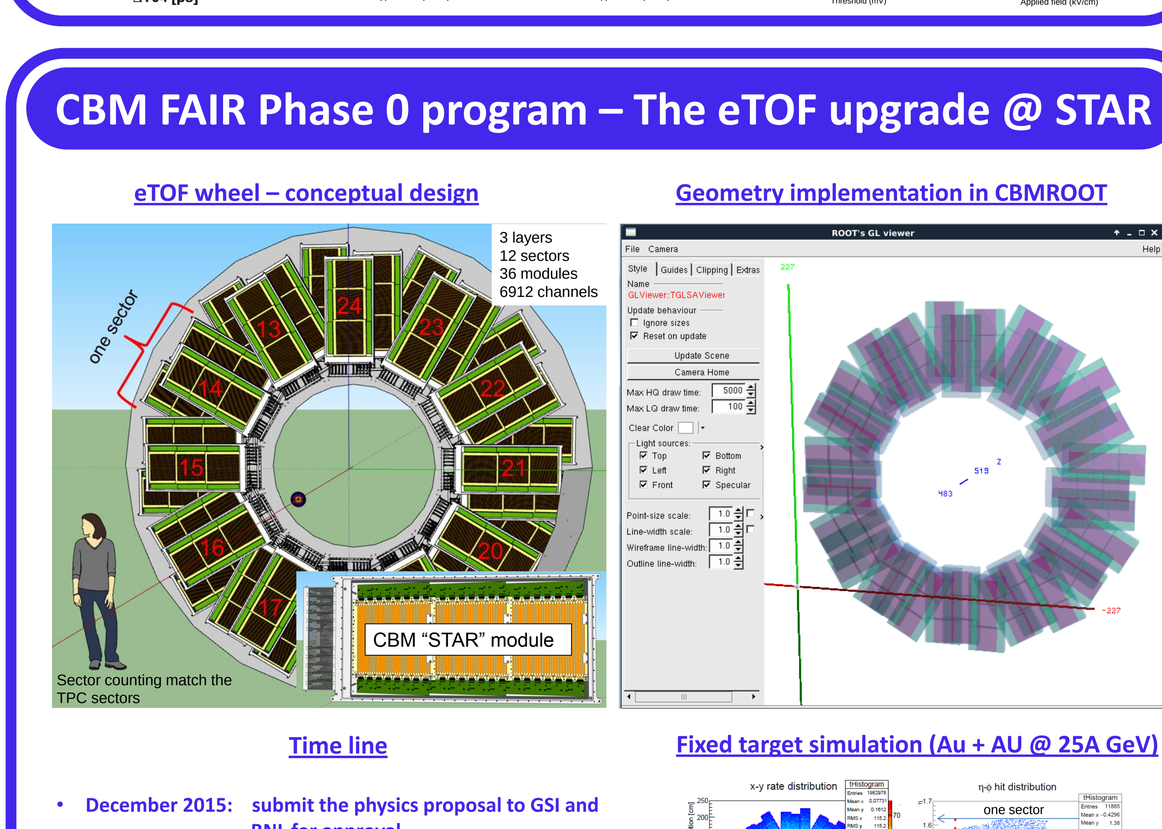
CERN beamtime Nov. 15 with Pb beam of 30A GeV on a Pb target







Beam time results



CBM FAIR Phase 0 program – The eTOF upgrade @ STAR

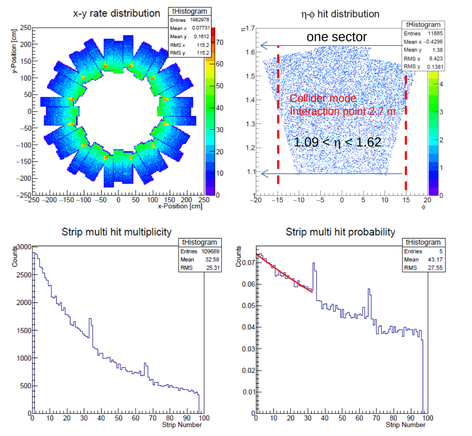
eTOF wheel – conceptual design

Geometry implementation in CBMROOT

Time line

- December 2015: submit the physics proposal to GSI and BNL for approval
- October 2016: shipping a real size module to BNL and installing it on the east side pole of STAR
- Feb. 2017: 1st system integration test with one module by participating on the Run17 beam time in STAR
- June 2017 : submit the plan and schedule for the endcap TOF installation to STAR operations.
- Feb. 2018: 2nd system integration test with one module by participating on the Run18 beam time in STAR
- Summer 2018: shipping all 36 modules including infrastructure (gas system, LV-, HV-power supply) to BNL
- Fall 2018: Installation and commissioning
- Feb 2019: Start of the BES II campaign
- Summer 2020: Decommissioning and shipping of all modules including infrastructure to FAIR

Fixed target simulation (Au + AU @ 25A GeV)



Beam energy	4A GeV	10A GeV	25A GeV
Max. rate of all particles [Hz/cm²]	15	30	45
Max multi-hit prob. of all part. [%]	3.4	5.8	7.4
Max rate of prim. particles [Hz/cm²]	12	20	25
Max multi-hit prob. of prim. part [%]	1.3	2.4	3.6

Summary: The CBM Time-of-Flight system is developed by 9 institutions from China, Germany, Romania and Russia. It comprises about 120000 channels and a rate capability up to 30 kHz/cm². The targeted system time resolution is 80 ps at an efficiency above 95%. Test beam experiments have demonstrated counter resolutions in the order of 50 ps. CBM-TOF will participate as part of the FAIR phase 0 program in the BESII campaign of STAR@RHIC. The CBM-TOF wall will be ready to take beam at FAIR in 2023.

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