Status of the CBM Experiment at FAIR*

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The Compressed Baryonic Matter (CBM) experiment is designed to explore the QCD phase diagram in the region of high net-baryon densities using novel diagnostic probes. The layout of the CBM detectors is driven by the experimental requirements concerning reaction rates, radiation tolerance, particle densities, and selectivity. The experimental setup comprises the following components.

The superconducting dipole magnet

In 2012 the design of the CBM SC dipole magnet has been optimized. The magnet is of H-type with circular superconducting coils and with two cryostats (see figure 1). It has a large aperture (gap height 140 cm, gap width 260 cm) in order to host the Silicon Tracking System. The field integral is 1 Tm. The Technical Design Report has been submitted to FAIR in December 2012.

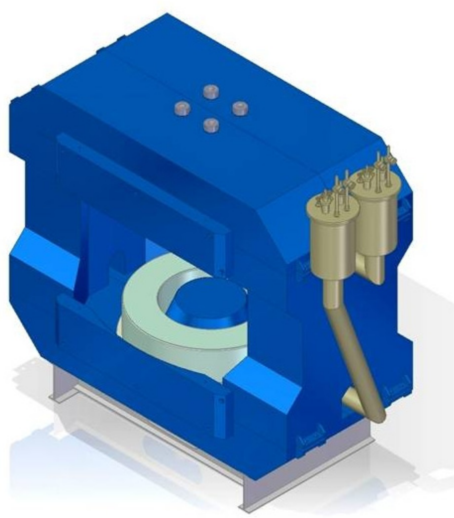

Fig.1: The CBM Superconducting Dipole Magnet.

The Micro-Vertex Detector

The precise determination of the secondary decay vertices of charmed particles requires a highly-granulated, fast, radiation-hard, and low-mass detector system. We will use silicon pixel stations which are based on ultra-thin “Monolithic Active Pixel Sensors” (MAPS). Sensors have been developed which exhibit a high signal-to-noise ratio even after an integrated neutron dose of 10^{13} n_{eq}/cm^2. Prototype detectors comprising sensors, a read-out-system, a cooling and support structure have been successfully tested with a 120 GeV pion beam at CERN.

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The silicon tracking system

The CBM Silicon Tracking System (STS) is based on double-sided micro-strip sensor with outer dimensions of 6.2x2 cm^2, 6.2x4 cm^2, and 6.2x6.2 cm^2. The front side strips are inclined by a stereo angle of 7.5^o. Short strips in the sensor corners will be interconnected to a strip in the opposite corner either via a second metallization layer, or via an additional micro-cable. Both options are under investigation. Each sensor (2048 strips) is read out via 16 low-mass micro cables (128 wires each) by 8 free-streaming ASICs (2 channels each). The cables will be tab-bonded at both ends. Several of these modules consisting of a sensor, the cables and the Front-End-Board carrying 8 ASICs will be mounted on a light-weight carbon ladder. Up to 16 of these ladders will be integrated into a detector station. The STS consists of 8 stations of increasing size and increasing granularity with increasing distance from the target (see figure 2). The STS will be operated in a thermal enclosure at about -10°. The Technical Design Report has been submitted to FAIR in December 2012.

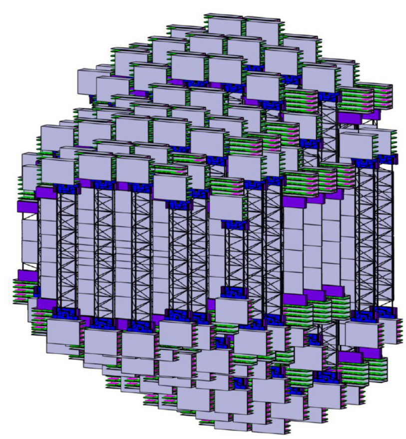

Fig.2: The CBM Silicon Tracking system

The Ring Imaging Cherenkov (RICH) detector

The RICH photo-detector exhibits an active area of 2.4 m^2 covered by multi-anode photomultipliers (MAPMTs).
Beam tests at GSI and CERN, and measurements with LEDs in the laboratory demonstrated that the Hamamatsu H8500 with 64 pixels is very well suited for the detection of single Cherenkov photons. Properties like the quantum efficiency (with and without wavelength shifting films), crosstalk and the performance of MAPMTs in the presence of magnetic fields have been successfully studied in 2010. The MAPMT signals were read-out with the self-triggered electronics using the nXYTER chip.

The Transition Radiation Detector

The CBM Transition Radiation detector (TRD) has to provide an electron/pion suppression factor of the order of 100 for momenta above 1 GeV/c at hit rates of 100 kHz/cm^2. A pion suppression factor of 100 (corresponding to a pion efficiency of 1 %), together with an electron efficiency of better that 90%, can only be achieved with 9 -12 layers of TRD chambers, resulting in an overall detector area of almost 1000 m^2. Several prototype detectors have been developed to fulfil the requirements. Prototype fast multi-wire chambers with and without drift section read-out by the self-triggered SPADIC chip have been developed. Moreover, a two-dimension position sensitive prototype TRD with diagonally split rectangular (i.e. triangular) read-out pads has been built. All prototype TRDs were successfully tested at CERN using a mixed beam of electrons and pions.

The Muon Detection System

In order to identify the soft muons from vector meson decays in a large combinatorial background the CBM we will use an instrumented hadron absorber. The detection system comprises 6 iron slabs of varying thickness from 20 cm to 100 cm, with detector triplets behind each iron absorber. The technology of the gaseous muon tracking detectors is matched to the hit density and rate: behind the first and second hadron absorber (particle density up to 500 kHz/cm^2) we will install Gas Electron Multiplier (GEM) Detectors. Prototype GEM detectors with single-mask foils have been successfully tested with particle beams at CERN. Further downstream, where the hit density is reduced, straw-tube detectors will be used. Full size prototype straw-tube detector modules have been built and tested.

Timing Multi-gap RPCs

An array of Multi-gap Resistive Plate Chambers (MRPCs) will be used for hadron identification via TOF measurements. The TOF wall covers an active area of about 120 m^2 and is located about 6 m downstream of the target for measurements at SIS100, and at 10 m at SIS300. The required time resolution is of the order of 80 ps. For 10 MHz minimum bias Au+Au collisions the innermost part of the detector has to work at rates up to 20 kHz/cm^2. Prototype MRPCs built with low-resistivity glass have been tested with a time resolution of σ = 40-60 ps at 20 kHz/cm^2. At small deflection angles the pad size is about 5 cm^2 corresponding to an occupancy of below 5% for central Au+Au collisions at 25 AGeV. In order to optimize the number of gaps, the pad layout, and the read-out electronics several prototype MRPCs have been tested with particle beams at CERN. At large polar emission angles, i.e. in most of the active area of the CBM ToF detector, the hit rate is of the order of 1 kHz/cm^2. At these low rates, a conventional MRPC in multi-strip configuration with thin standard float glass can be used. For this application, a fully differential prototype MRPC has been built and tested successfully at COSY with a proton beam.

Online Event selection

Measurements with high event rates require online event selection algorithms (and hardware) which reject the background events (which contain no signal) by a factor of 100 or more. The event selection system will be based on a fast on-line event reconstruction running on a high-performance computer farm equipped with many-core CPUs and graphics cards (GSI GreenIT cube).

Table 1: CBM subsystems, their status, and time of TDR submission

Subsystem	Status	TDR
Magnet	Design ready	Dec. 2012
Micro-Vertex Detector (MVD)	successful prototype tests with beams	2014
Silicon Tracking System (STS)	Design ready, successful prototyp tests with beams	Dec. 2012
Ring Imaging Cherenkov Detector	Design ready, successful prototyp tests with beams	Spring 2013
Time-of-Flight wall (Multi-gap RPCs)	Prototype MRPCs successfully tested with beams	2013
Transition Radiation Detector (TRD)	Prototype TRDs successfully tested with beams	2014
Muon Tracking Chambers (MUCH)	Prototype MUCH successfully tested with beams	End of 2013
Projectile Spectator Detector (PSD)	Design ready, established technology	Spring 2013
Electromagnetic Calorimeter (ECAL)	Design ready, established technology	2013/14
DAQ/FLES	Prototype tests with beams	2013 - 2016