# Development of database complex for the CBM experiment

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The results on the development of complex databases for the CBM experiment are presented. The set of basic structural characteristics of the required databases is provided. It is based on the analysis of databases used for data processing in high-energy physics experiments. The complex includes the following databases: Configuration DB, Condition DB, Geometry DB, TagEvent DB and Component DB. The description of the component database (Component DB) is given. The main principles of the functioning of the geometric database (Geometry DB) are considered.

Keywords: DBMS, component DB, geometry DB.

# Introduction

The CBM (Compressed Baryonic Matter) experimental facility that is being built at GSI (Darmstadt, Germany) at the accelerator complex of antiprotons and heavy ions FAIR (Facility for Antiproton and Ion Research) is intended for studying the properties of superdense baryonic matter generating in 8-45 GeV/nucleon proton-nuclear and nucleus-nucleus collisions [Friman, 2011].

Figure 1 presents a dielectron version of the CBM installation intended for research on short-living vector mesons and charmonium decaying into an electron-positron pair.
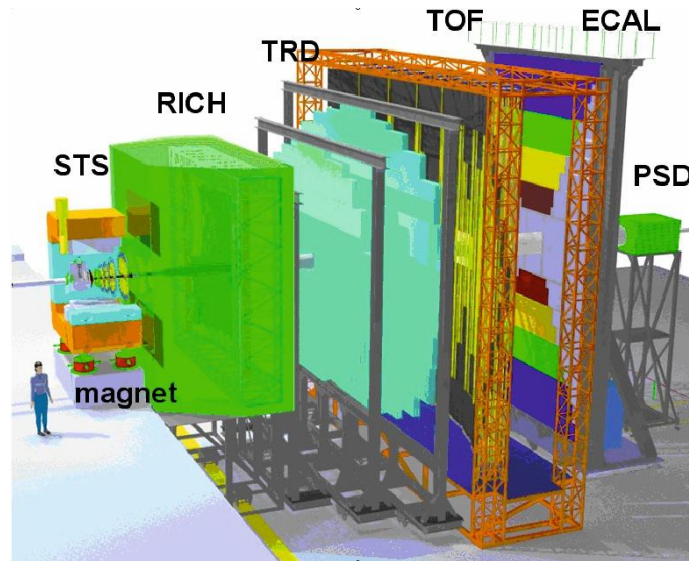


Figure 1: Dielectron version of the CBM experimental setup

Inside the dipole magnet there is a target and a coordinate tracking system STS (Silicon Tracking System) containing 8 stations of 300 mkm two-way strip detectors. Together with the dipole magnet, STS is used to reconstruct charged particle trajectories and to determine their momenta. The Cherenkov detector RICH (Ring Imaging Cherenkov) and the Transition Radiation Detector (TRD) should provide a reliable registration of electrons/positrons with the pulses of more than 1 GeV/s. The time-of-light detector (TOF) constructed on the basis of Resistive Plate Chambers (RPC) is intended for hadron identification in a wide energy range. The Electromagnetic Calorimeter (ECAL) is used for electron/photon identification. The Projectile Spectator Detector (PSD) is intended for the reaction plane determination.

Due to high beam intensity and high multiplicity of secondary particles, huge data is expected to be accumulated by the DAQ (Data acquisition) system for further analysis.

At the current moment the CBM collaboration moves from the stage of prototypes research and tests to detectors and their components production. The high level of control for manufacturing process is required because of the complexity and high price of the detector components.

As a result, there is a need for development of a database complex for the CBM experiment. This paper presents a complex of Database Management Systems (DBMS) for the CBM collaboration and describes a current status of its implementation. DBMS structure was designed based on the experience of using databases at the LHC and other experiments in high-energy physics [Akishina, 2014].

## Complex of DBMS

In the CBM databases the following data should be supported: detector production and installation, survey data, event data and metadata, detector geometry, online configuration, run conditions - DCS (Distributed Control System) and others, online calibrations and alignments data.

Below we present the list of main databases together with their brief description.

**Configuration database:** to store a large number of parameters describing the topology of the DAQ system, hardware and software components and run parameters. It only stores the parameters that are directly required to start and support in efficient operating conditions of all elements of DAQ system.

**Conditions database:** to store, retrieve and manipulate condition, alignment and calibration data. Condition data keep the state of the CBM setup at the time when events are collected. A subset of the data will be used both for online (FLES [Hutter,2015]) and offline computing.

**Tag Event database:** to store, retrieve and manipulate event data and corresponding metadata from all stages of data processing (Raw, Event Summary Data, Analysis Object Data, etc.).

**Geometry database:** to store, retrieve, manipulate and load the detector geometry that is stored as a set of well tested and versioned detectors geometry in a view of ROOT files and metadata.

**Component database:** to manage properties of detectors and electronic components obtained in QA (Quality Assurance) process after mass fabrication. Component database includes mechanical/engineering production data and electronics data (calibrations, chip thresholds etc) which are kept separately in general.

Most of the databases should be implemented as relational databases. The exclusion is the Configuration DB. It stores different types of data as hardware description, software description including programs with their run parameters etc. There should be a possibility to change data in easy and convenient way as such procedure is frequent one.  The possible solution for Configuration DB  is to use the object oriented database such as in the ATLAS experiment [Almeida, 2008].

## Component database

The Component Database (DB) is the first database that was  designed and implemented as a part of the CBM databases project [Akishina, 2014] according to the User Requirements Document [Akishina, User Requirements…, 2015]. The Component DB is used to store and manage the properties of the detectors hardware and electronic components. It contains characteristics, statuses, test results, certificates and other parameters both numeric/strings and images. The current relational DB structure allows to use it for any CBM detector performing minor adjustments. The components of different detectors (STS, Magnet, PSD, RICH, ToF, MUCH, MVD, TRD, ECAL) will be stored in different databases. Data will be accessed through the common authorization service. The Component DB has a tree structure. The root of the tree has a name of the CBM facility part such as Magnet, MVD, STS, etc. The list of the detector components is stored in the tree. The tree leaf is connected to a table with corresponding names and values. The tests, certificates and statuses are stored in DB as the references. Testing results of the components are presented in form of images. The certificates details depend on the component and can be implemented for each detector. The catalog of different statuses can be defined for each detector separately.

The DBMS PostgreSQL v8.4.20 [PostgreSQL group] was used for implementation of Component DB. Basic services are supported for each CBM detector via WEB access to data bases: data viewing of detector components, search in navigation mode, inserting and editing components data, support of the catalogs, authorization services for system access. The authorization is based on affiliation to the detector's group.

The implementation is realized on the basis of client-server interaction. The same schema for all detectors was produced. Scripts and their usage in according html-pages were implemented. Figure 2 presents an example of the Magnet main page.

Figure 2: View Mode GUI Example for Magnet

The database structures for several detector systems (magnet, STS, MVD) were confirmed with the responsible persons. Currently, the Component DB includes eleven tables, six of which are the catalogs [Akishina, Component database…, 2015]. The tables were modified according to the needs of the various detector systems. The system of catalogs was refined. The following catalogs are currently approved: the catalog of production companies, the catalog of component categories, the catalog of component batches, the catalog of statuses, the catalog of the units of quality measurements, and the catalog of quality criteria.

## Geometry database

The Geometry Database is designed and implemented as a part of the CBM Databases project according to the User Requirements Document (URD) [Akishina, 2016].The CBM geometry describes the CBM setup on the detail level required for simulation of particles transport using GEANT [Agostinelli, 2003]. It represents an "ideal" geometry in the sense of the construction blueprint. Deviations from this ideal geometry, as e.g. obtained by optical surveillance after installation or by alignment procedures, will be described as additional datasets, which will be handled by Conditions DB.

The basic notations are defined in the URD. According the URD a geometry module is defined as some metadata and a file in ROOT format with content of detector geometry. Metadata includes module name, unique module index and other data. Geometry module linked with transformation matrix is the module setup. Complex of setup modules which represents the full CBM geometry is defined as setup.

Currently, the geometry ROOT files are stored and distributed through the CBM software repository. Setups as combinations of geometry files are defined on the ROOT macro level. Such a situation is rather complicated, error-prone and, thus, not ideal. Moreover, handling by the software repository does not match the requirement that a given geometry version must not change in time. The distribution of the module geometries as well as entire setups through a database thus appears as desirable solution.

The Geometry DB will store the CBM geometry and setup modules as well as setups as combination of setup modules. It provides appropriate interfaces to view, retrieve and update setup modules and setups. The URD also characterizes three categories of users of the Geometry DB: CBM user, Developer, and Lead Developer. The basic use cases for those categories are Load Geometry, Download Geometry, WEB View, Add Geometry, Add Setup Module, and Add Setup, the detailed description of which is in progress.

The prototype of the Geometry DB is implemented. It includes two parts: server and client. Server part is used to view and edit setup and its content. Figure 3 shows a content page of the Geometry

DB for a specific setup. Client part is used for loading the geometry into memory, for simulation and reconstruction. It also includes the ROOT macros to load the setup by a tag.



| | Tag | Date | Status | Author | Description |
|---|---|---|---|---|---|
| Setup | sis100_electron | 2016-06-23 | 0 | evgeny | desc sis100_electron |

| | Tag | Date | Author | Description |
|---|---|---|---|---|
| sts | sts v16c | 2016-06-20 | evgeny | |
| magnet | v15a | 2016-06-20 | evgeny | |
| pipe | pipe v141 | 2016-06-20 | evgeny | |
| mvd | mvd v15a | 2016-06-20 | evgeny | |
| rich | rich v16a 1e | 2016-06-20 | evgeny | |
| trd | trd v15a 1e | 2016-06-20 | evgeny | |
| tof | tof v16a 1e | 2016-06-20 | evgeny | |
| psd | psd geo xy | 2016-06-20 | evgeny | |
| Field | v12b | 2016-06-22 | evgeny | |
| Material | v1.10 | 2016-06-22 | evgeny | |

View Setup
View Setup Modules
View Files
View Materials
View Fields

Figure 3. View of the setup content

## Conclusion

The complex of databases is an important part of the software for the CBM experiment. The set of databases is defined and two first databases were designed and implemented. The Component DB stores all data on the CBM construction and it will be used intensively during CBM commissioning. Though the database is ready for use it is supposed that it will be upgraded on the base of experience of its usage. The Geometry DB has benefits both for employees and top management already in the current stage. This is a transparency and usability, reduced geometry loading code, business transparency, and advantages in monitoring of geometry. The beta version of the Geometry DB is ready for use.

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