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# DETECTOR DESCRIPTION OF THE ATLAS MUON SPECTROMETER

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The Muon Spectrometer of the ATLAS experiment is a large and complex system relying on several detector technologies. The simulation and reconstruction of muon events require a very careful description of these detectors, some of which provide a muon trigger while the others make precision measurements of tracks. A precise description of the passive materials, toroidal magnet systems and shield is also needed to account for Coulomb scattering and energy losses. Finally, the spectrometer performance is enhanced by the alignment of its precision chambers, so the detector description model must fully implement misalignments and deformations. We present the Detector Description chain employed in the Muon system and its integration in the ATLAS software framework. It relies on a database technology and a standard set of geometrical primitives common to all ATLAS subsystems. The Muon Detector Description has been used successfully in the context of the ATLAS Data Challenges, where it provides a unique and coherent geometry source for the simulation and reconstruction algorithms. It has also been validated in the context of the experimental program of the ATLAS testbeams, where analyses of the treatment of chamber alignment in track reconstruction relies crucially upon the detector description model.

*Keywords*: ATLAS; Detector Description; Geometry; Alignment; Deformations.

## 1. Introduction

High-momentum final-state muons are among the most promising and robust signatures of physics at the Large Hadron Collider. To exploit this potential, the ATLAS Collaboration [1] has designed a high-resolution muon spectrometer with standalone triggering and momentum measurement capability, aiming at the highest efficiency with momentum resolution of 2-3 % at 10-100 GeV/c and 10% at 1 TeV/c.

The spectrometer provides a three-point measurement of tracks in large superconducting air-core toroid magnets [2]. An optical alignment system controls the relative positioning of muon chambers at the 30 $\mu$m level. The layout of the detectors and their intrinsic design are optimized to give the best acceptance and resolution, taking into account the high-level background environment, the inhomogeneous magnetic field, and the large size of the apparatus (24 m diameter by 44 m length).

## 2. Challenges of the Detector Description

The geometry is complex, organized in Large and Small sectors associated with the eight coils of the toroidal magnets. Natural symmetries are broken by the feet structures supporting the detector (special sectors) and the appertures for access and services such as cables and cryogenics. The layout of chambers in the bending plane is designed to provide three points of precision and trigger measurements.

Four technologies of gaseous detectors are used. Monitored Drift Tubes chambers (MDT) and Cathod Strips Chambers (CSC) provide the measurement along the precision coordinate, while Resistive Plate Chambers (RPC) and Thin Gap Chambers (TGC) provide a 2nd coordinate measure and participate in the trigger.

The layout relies on a large number of chambers with different properties : 1200 MDT chambers are used, with various sizes, shapes, number of layers of tubes, and each layer made of 30 to 72 tubes.

Time-dependent misalignments and deformations of chambers are an important aspect of the detector description. Six parameters per chamber are used to describe the translations and rotations with respect to the nominal positions. The deformations are accounted for by the global temperature expansion plus 8 parameters (torsion, cross plate sags and elongations, longbeam sags, trapezoid effect).

Finally, a precise description of the passive materials is needed to account for the multiple Coulomb scattering and energy losses (magnets, supports,...) as well as radiation absorption (shields).

## 3. Implementation and integration in the ATLAS software chain

The full chain of simulation, reconstruction, and calibration packages depend upon the Detector Description. This requires a stable and robust implementation, flexible enough to answer the need of schema evolution and the requests for refinements from the various client applications. It must accomodate possible layout changes.

The primary source for the geometry parameters is the AMDB "Atlas Muon DataBase" ascii file specific to the Muon system. It is implemented as a structured organization of active elements (detectors) with indexing of objects mapping the offline identifier scheme, while passive elements are described using the AGDD "Atlas Generic Detector Description" XML scheme. The geometry is visualized using the Persint 3D viewing tool [3]. The AMDB parameters are made available to the detector description packages through the NOVA MySQL Database [4,5], which is common to all subsystems (calorimeters, inner detectors) and supports versioning.

The software packages retrieve the parameters from the DB and provide the geometrical informations to the clients in the software framework. The *MuonGeoModel* package [6] uses a geometry kernel [7], common with all other ATLAS subsystems, which provides a set of geometrical primitives together with volume operations. The *Amdcsimrec* package provides a set of methods to obtain all geometrical informations to build the internal geometry of the clients applications; complex volumes are described using boolean volume operations.

## 4. Achievements : Design phase, Data Challenges and Testbeams

The Detector Description was a key element in the process of optimizing the Spectrometer design [2], and for the Geant3-based evaluation of the ATLAS Physics performances using Muon Layout "M" [8]. Studies of realistic service and access holes [9] led to the implementation of Layout "P" in the Geant3-based Data Challenge 1.

In parallel, testbeams were engaged at the CERN-SPS to validate the concept of the Muon chambers alignment. The detector description played an important role in demonstrating that the geometry can be controlled at the 20 micron level [10].

## 5. Conclusions and Plans

A well established Detector Description has been in use for the optimization of the detector and throughout the evaluations of the Physics performance of ATLAS. Short term plans focus on Data Challenge 2 based on initial layout "Q" with some stageing of chambers, aiming at updated performance studies, using Oracle as distributed database [6]. Chambers description will account for properties measured by tomography. Longer term plans focus on Data Challenge 3, with the simulation of misalignments on all chambers, and the description of detectors as they are built.

A crucial test will come with the commissioning of the detector with cosmic rays and check of chambers alignment with the first tracks from collisions in 2007.

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## References

1. ATLAS Technical Proposal, CERN/LHCC/94-43, LHCC/P2, 15 December 1994.
2. ATLAS Muon Spectrometer Technical Design Report, CERN/LHCC/97-22 (1997).
3. D. Pomarède, M.Virchaux, proceedings of the CHEP03 Conference, La Jolla, California, March 24-28, 2003, eConf c030324 MOLT009, arXiv:cs.GR/0305057 (29 may 2003).
4. A. Vaniachine, *et al.*, proceedings of the CHEP03 Conference, La Jolla, California, March 24-28, 2003, eConf c030324 MOKT006, arXiv:cs.DB/0306103 (16 jun 2003).
5. A. Vaniachine, *et al.*, "ATLAS Detector Description Database Architecture", proc. of the CHEP04 Conference, Interlaken, Switzerland, Sept. 27-Oct.1, 2004, paper 212.
6. S. Spagnolo, *et al.*, "Description of the ATLAS Detector", proceedings of the CHEP04 Conference, Interlaken, Switzerland, Sept. 27-Oct. 1, 2004, paper 283.
7. J. Boudreau, V. Tsulaia, "The GeoModel Toolkit for Detector Description", proc. of the CHEP04 Conference, Interlaken, Switzerland, Sept. 27-Oct.1, 2004, paper 279.
8. ATLAS Detector and Physics Performance Technical Design Report, CERN/ LHCC/ 99-14 (1999).
9. D. Pomarède, *et al.*, ATLAS Internal Note ATL-MUON-2000-023 (2000).
10. S. Palestini, Nucl.Phys. B (proc. Suppl.) 125 (2003) 337-345