SLHC AND ATLAS, INITIAL PLANS

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Abstract

The recent developments in the plans and scenarios proposed by the LHC machine experts towards the SLHC, have triggered various concerns and reserves in the ATLAS community. In particular the eventual need to insert dipoles, quadrupoles and protection elements inside the detector creates major concerns, because of its complex logistics and the risk of reducing the effectiveness of the ATLAS internal radiation shielding. Justifications and constraints on how to best use this space are given.

CONCERNS AND STRATEGY

It took almost a decade to design and optimize, from the point of view of radiation and activation protection, the inside of the ATLAS detector. The main concerns are low- and high-energy neutral and charged particles, produced at the interaction point (IP) and capable of breaking down in a cascade of lower-energy particles, when interacting with the various detector elements. This in particular along the beam pipe region, where small angle and diffractive energy is copiously produced in the hadron interactions. The second source of concern comes from secondary particles produced in the various collimation and optical elements of the LHC beam line, particles that start showering when entering the experimental region.

The ATLAS muon spectrometer, which consists of thousands of gaseous detectors (~15000m^2) is particularly sensitive to such energy depositions, because they will generate a background that will obscure the detector readout, impacting directly on the physics performance of ATLAS.

Based on this strategy, various regions have been created inside the detector as pockets of energy absorption, in between active detection regions. The goal has always been to keep the active detector readout occupancy below a level where combinatorial effects can fake physics. All this took years of optimization, and all possible space was used to tune the detector for the LHC maximum design luminosity (ATLAS Note: ATL-GEN-2005-001)

ATLAS AND SLHC PLANS

ATLAS is starting to be prepared for the physics potential of the SLHC, knowing that some of its present detector components will suffer in performance when exposed to beam intensities beyond the LHC design luminosity as foreseen at SLHC. Some of the detector components are known to suffer from aging due to radiation, in such a way that they will need to be fully replaced and upgraded after about 300-400 fb^{-1} of integrated and delivered beam Luminosity. In particular, the inner detector, which is sitting inside the central 2T field solenoid, will need to be fully rebuilt with a new layout and technology, capable of coping with the new energy density and with a substantially better granularity in the readout geometry. This substantial high-technology part of the detector will need a vigorous R&D and design plan, before being ready for mass production and later integration inside ATLAS. The Collaboration has already started this new phase of the project very actively, with the goal of preparing for real construction around 2010-2011, when the physics potential of the LHC will be known and the SLHC project will be in its construction phase.

Other parts of ATLAS will need partial upgrades, in particular in their front-end electronics readout. Some of the very forward detection elements in the calorimeters and muon spectrometer will need a new fresh approach as well. The overall radiation protection strategy will also require to be fully reviewed and optimized.

To this complication we have now to add the possibility of inserting active beam elements inside the detector, which might directly impact on the overall performance and on the logistics of the various services and mechanical structures.

In general, ATLAS, when planning for SLHC, is interested in collecting as much as possible integrated luminosity on tape, while keeping the peak luminosity as low as possible to avoid excessively high densities of particles in the detector (detector pileup). Therefore it will welcome every attempt to increase the lifetime of the beams, the duty cycle of the overall machine and any new idea to effectively level the peak luminosity in favour of an increased integrated luminosity.

Where to place active beam elements in ATLAS?

Over the last 2 years we have explored various possible scenarios on how to effectively increase luminosity by a factor 10. Among this, is the idea of an early full or partial separation scheme, which adds dipoles and eventual quadrupoles in the detector region. Some of these plans have evolved with time with more and more realism on both sides. The bunch separation is kept at 25 or 50 ns in this phase of the project, the idea of inserting directly dipoles inside the inner detector (ID) cavity has been abandoned, new interesting techniques like wire compensation and crab cavities are discussed and are part of the future strategies.

Four regions have been identified in the detector capable in principle to host beam optics elements, as it is visible in figure 1 and table 1:

- The JF region: placed inside the bore of the endcap calorimeter cryostat. This region hosts today beam pipe elements (ion pumps, bellows, ..) and a neutron moderator. The region will need to be kept as transparent as possible to particles, in order to avoid adding substantial background to the inner detector and to the electromagnetic end cap calorimeter. Recently this region is becoming interesting as a possible solution to a potential problem related to the boiling of liquid Argon inside the forward calorimeter at SLHC beam intensity. At this stage of the project the uncertainties are such that we prefer to withdraw this location from the list of potential dipoles position. Bringing there the necessary cryogenics and power services, seems also to be a very difficult challenge

- The JD region: it hosts a SS-cylinder which today contains copper shielding elements. There, a small dipole could be hosted. The problem in this case is to avoid diluting the level of shielding protection to the muon spectrometer region just nearby. The typical distance to the IP is of about 7000-8000 mm. This region moves with the detector elements during the ATLAS access periods.

- The JTT region: inside the bore of the end cap toroid magnets, in a field-free region, placed at about 10000 mm in z. This region is more stable mechanically, but will move during access periods

- The JF region: the most far way solution (Z ~ 14000 mm), completely surrounded by a massive Fe shielding element. This region is the preferred one by the experiment and might be fully redesigned for SLHC, taking into account the shielding needs and the various mechanical and logistics constraints.

Optimizing for beam elements and for shielding protection at SLHC will in any case require a vigorous design and simulation effort over the next few years.

Table 1: possible available space for beam elements

Position	**Maximal radius**	**Zmin, Zmax position**
JF region	180 mm	3490 mm, 4580 mm
JD region	430 mm	6800 mm, 8660 mm
JTT region	870 mm	8690 mm, 12870 mm
JF region	1500 mm	12950 mm, 18600 mm

Today the JF region, among the four, is the preferred one by ATLAS. It will be the one offering most space, less services constraints and a bigger potential for shielding upgrades from the detector side. The only problem is that it will need to be full dismounted during shutdown periods, when the detector will have to be in its open configuration.

At this stage of the project, to pursue more realistic simulations we will need some detailed scenario. A full evaluation of such a layout is a major effort and involves several detector specialists.

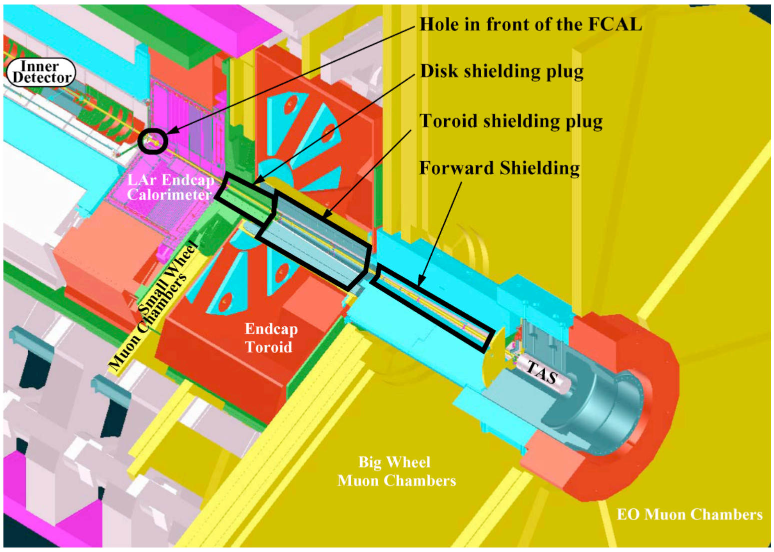

Figure 1: ATLAS longitudinal layout, showing possible position where additional beam elements can be hosted