REQUEST FOR EUDET SUPPORT TO LUCID TEST BEAM

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OTHER PARTICIPANTS:

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PERIOD: From July 1st to July 15th 2009.

SCIENTIFIC BACKGROUND AND PROGRAM

LUCID is the luminometer of the ATLAS experiment. It consists of two aluminium vessels located at about 17 meters from the interaction point on both sides of it, just around the beam pipe. Its goals are to measure the instantaneous and the integrated luminosity delivered by the LHC accelerator both for beam monitoring purposes and for cross section measurements. Its information are therefore crucial both to the machine experts for a fast feedback on the beam quality and to the experiment for any analysis involving the measurement of absolute cross sections.

The detector exploits the Cherenkov light production mechanism by particles travelling in a gas in order to detect pions, protons and electrons above few GeV. Each vessel is therefore filled with C4F10 radiator at about 1.2 bars. The total volume is subdivided into 20 tubes, 16 mm in diameter and about 1.5 meters long, each read-out either directly by a photomultiplier (PMT, 16 tubes) or by optical fibres plus one multi-anode PMT (4 tubes).

The complete detector is already installed in the ATLAS cavern since summer 2008 and it observed the first LHC events in September 2008, therefore proving its functionality. Despite this success, a complete understanding of the performances of the detector is still partially missing and it is crucial for a proper Monte Carlo description. Previous test beams, performed both at CERN and at DESY, did not allow to get a complete picture of all the parameters and some inconsistencies are still present, in particular for what concerns the total number of photoelectrons produced per crossing particle and the dependence of such number with the radiator pressure and with the particle path-length inside the tube. A precise knowledge of this latter dependence could allow to properly set the signals threshold on order to distinguish between primary particles – crossing the tube along its axis – and secondary particles – crossing the tube at an angle, with shorter path inside the gas.

One of the reasons for not having resolved all ambiguities in the previous test beams was the uncertainty in the beam control and detector alignment. In order to solve such a problem two strategies were believed to be needed and were therefore pursued:

1. to allow the maximum possible flexibility and precision in the movement of the detector on top of the support table, both in the horizontal and vertical directions. This was obtained with remotely controlled motors allowing translational motion and rotations around a fixed point in order to vary the angle between the beam and the detector tubes in a controlled and reproducible way.
2. to ask for the EUDET telescope so to have a precise knowledge of the beam direction and shape (beam profile) and, moreover, a high precision measurement of the direction of each particle crossing the LUCID tube under test. This will allow to select offline, in the analysis phase, particles with different directions (coaxial with the tubes, parallel/non-parallel to axis) and determine the LUCID response in the different cases.
   Another micro-strip telescope with lower space resolution will also be installed both in front and behind the LUCID detector in order to get redundant tracking information and confirm the passage of the particles all along the tube by measuring them also behind. Also 3 round scintillators of the same diameter of the tubes will be used for triggering purposes both in front and behind the detector.

The detector used for the test beam is equipped with 6 Cherenkov tubes, 3 of them equal to the ones in the vessels installed in the ATLAS cavern and 3 with slightly larger diameter and different reflecting surface.
One of these will be read out by a bundle of optical fibres, instead of the direct coupling to PMT. Additionally, we will also be testing a different technology of Cherenkov light production for a possible LUCID upgrade for LHC phase II. This consists in a quartz rod 30 cm long and few mm in diameter, directly coupled to a PMT, with the advantage, with respect to the gas detector, of a much higher light yield and simpler construction. Its small diameter compared to the standard tubes requires of course a much better knowledge of the beam direction and detector alignment.

We plan to use a 150-200 GeV pion beam with an intensity of about 1000 particles per second and with a beam spot at the detector of about 2x2 cm^2, the intensity being limited by the requirement of having no pile-up and not to saturate the acquisition. The beam size is defined by the geometry of the Cherenkov tubes.

The following steps and measurements will be made during the test beam:

1. Detector alignment to the beam using the EUDET telescope and the micro-strip chambers and beam scintillators information.
2. Detector calibration via LED signals. This will allow the determination of the response to single photoelectrons, crucial in order to determine the number of photoelectrons per crossing particle from the QDC spectra.
3. Light yield measurement in all tubes without radiator gas to determine the photoelectrons contribution due to the PMT quartz window.
4. Same measurement with increasing radiator pressure from 0 to about 2 bars (pressure scan).
5. measurement with varying inclinations between tubes and beam at the standard 1.2 bar radiator pressure (angular scan).
6. measurement with the quartz rod also with angular scan.

Additional to the detector study, the test beam will represent the first operation of the full LUCID DAQ and DCS system, which are the same as used in the ATLAS environment.

Requested EUDET financial support

We request the EUDET support for four participants to the test beam:

1. and 2.

   Sara Valentinetti and Riccardo Di Sipio are deeply involved in the DAQ and DCS development and operation. This is, as explained above, a crucial item not only for the test beam itself, but more in general for the training within the general ATLAS TDAQ.

3.

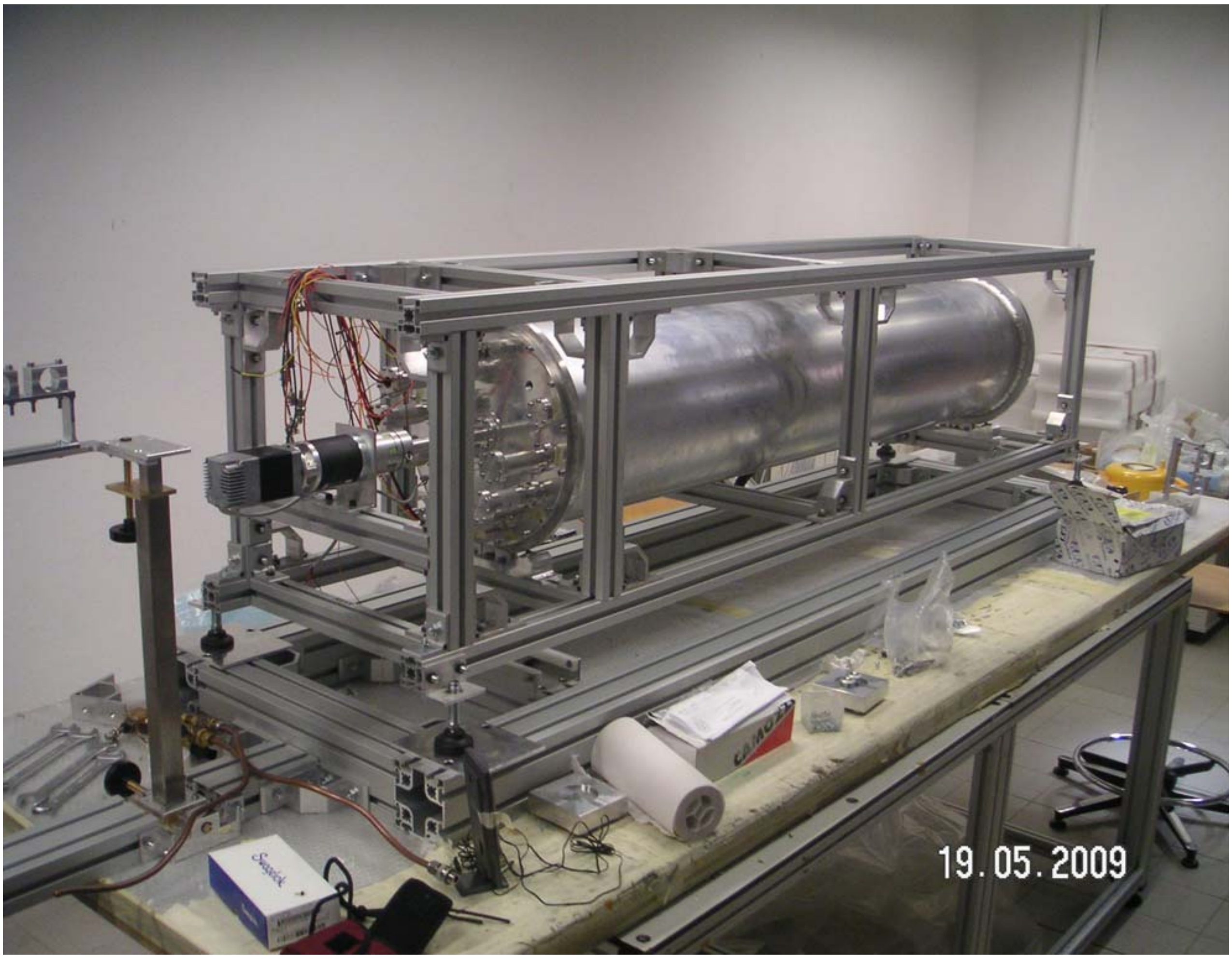
Simone Monzani is one of our experts on mechanics: his participation is, among other reasons, fundamental to ensure a proper installation of the complex detector and for the training of the motors operation.

4.

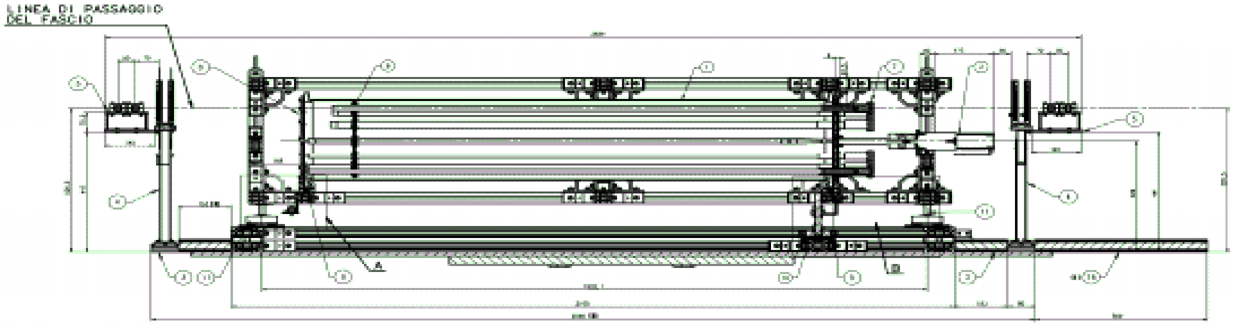
Richard Soluk (stay at the test beam from the 5-th of July until the 15-th) is our only expert for all concerning optical readout and LED fibres and PMT operation. As discussed, the LED signals will be used to calibrate the detector, in the same way as done for the LUCID installed in ATLAS. The readout fibre bundle is used to instrument one of the Cherenkov tubes: this type of readout is considered one the options for the LUCID upgrade for LHC phase II. We consider both items as crucial for the success of our measurement program.

Pictures:

1) The LUCID detector for test beam inside its movement system.



2) Mechanical drawing of the LUCID for test beam (side view)



3) Mechanical drawing of the LUCID for test beam (front view)