The LUCID detector

First 13 TeV collisions with new ATLAS luminosity monitor

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The LUCID detector

LUCID is a luminosity monitor with two detectors placed around the beam-pipe on both forward ends of ATLAS. Each detector consists of 16 photomultipliers (PMT) and 4 quartz fiber bundles. The PMTs detect charged particles that traverse their quartz windows, where Cherenkov light is produced. Cherenkov light is produced in the fiber bundles as well and carried to PMTs that are protected by shielding some 2 meters away (see Fig. 1). To increase the detector lifetime, only a subset of the PMTs is used at a given time, the others being available as spares. In additions, 4 PMTs have a reduced window to decrease their acceptance and thus avoid saturation of some luminosity algorithms.

New readout electronics have been built that consists of VME boards that digitize the PMT signals with FADCs. The electronics records hits if the pulseheight is above a threshold and integrate the pulses in each 25 ns interval that correspond to a LHC bunch crossing.

Luminosity measurement

Luminosity is measured by LUCID from a measurement of the number of PMT-hits, the number of bunch crossings with at least one PMT-hit and the integrated pulseheight (charge). These measurements are done over a time period called a luminosity block which are typically 1 minute long and they are done for each of the individual bunch crossings in the LHC.

The new electronics provides luminosity measurements using 124 different algorithms which take as input different combination of hits or charge from different tubes. Algorithms which are based on PMT hits from only one of the detector (either A or C), are calculated by the LUCROD cards, while algorithms which depends on combination of hits from both detectors are calculated by the LUMAT cards.

LUCID II uses R760 Hamamatsu PMTs, a smaller version of the previously used R762 model. A smaller PMT model has been chosen to reduce acceptance which will help to cope with the increased occupancy and to avoid saturation of the luminosity algorithms.

13 TeV collisions at LHC

LUCID can measure luminosity in many ways and Fig. 9 shows a comparison of the luminosity measured by an A and a C detector for different ATLAS data taking runs. The two measurements agree to better than 0.5%.

Figure 10 shows a measurement of the average number of inelastic pp collisions using different ATLAS luminometers and Figure 11 shows the ratio of this measurement with respect to a LUCID measurement. One of the detectors shows a deviation of up to 2% during this LHC fill but the other measurements are all in agreement with LUCID to better than 0.5%. The first month of data taking with the new detector therefore shows that LUCID can measure the relative luminosity with a precision of about 0.5%.

Fig. 1: Drawing of one of the two detectors.

Fig. 2: A quarter of one of the detectors.

Fig. 3: Typical PMT signal shape.

Fig. 4: The LUCID calibration system.

Fig. 5: Bi-207 calibration trending plot.

Fig. 6: Bloc diagram of the electronics.

The PMT pulseheight distribution in a physics run is shown in Fig. 8 (blue) together with the same distribution during a Bi-207 calibration run (red). In both distributions a peak due to Cherenkov photons is visible. The calibration distribution is cut due to the threshold in the electronics that define a PMT-hit.

Fig. 7: Bunch-by-bunch hit counts.

Fig. 8: Pulseheight distributions.

Fig. 9: Difference in luminosity measured by two LUCID detectors.

Fig. 10: Average number of inelastic pp collisions per bunch crossing during a 13 TeV fill.

Fig. 11: Comparison of measured luminosity by different luminometers in ATLAS wrt to LUCID.