LHCC Poster Session · CERN, 22 February 2016

The Forward Detectors of the ATLAS Experiment

The Forward Detectors are located in the most outer part of ATLAS along the beam line. Starting from the inside out, LUCID, ZDC, AFP and ALFA have been designed to determine luminosity and to study soft QCD and diffractive physics.

LUCID

LUCID is a Cherenkov detector specifically designed to measure ***luminosity***. It is composed of 2 modules symmetrically positioned at ±17 m from the Interaction Point (IP) around the beam pipe.

LUCID is the official ATLAS luminosity monitor since the beginning of Run 2.
The luminosity measurement precision achieved in 2015 data is 2.1%.

➤Sensors: 5 detectors on each side. Cherenkov medium
- 4+4 PMTs calibrated with ^{207}Bi
- 4+4 PMTs calibrated with LED signals
- 4+4 PMTs with reduced size window
- 4+4 PMTs as spare detectors
- 4+4 quartz fiber bundles read by PMTs

➤Electronics
- 4 custom-made VME boards (LUCROD) placed 15 m from the PMTs provide ***hit counting*** and ***charge measurement*** (insensitive to pile-up and proportional to luminosity) at each bunch crossing.
- 2 LUMAT boards correlate hits coming from the two sides of LUCID.

➤Calibration system
- electrons from ^{207}Bi internal conversion
- LED pulses (stability monitored by Pin Diode)

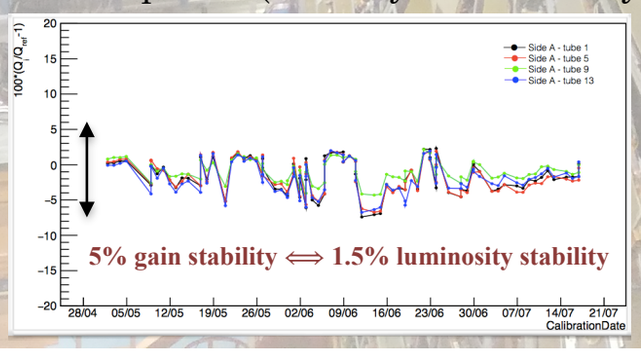


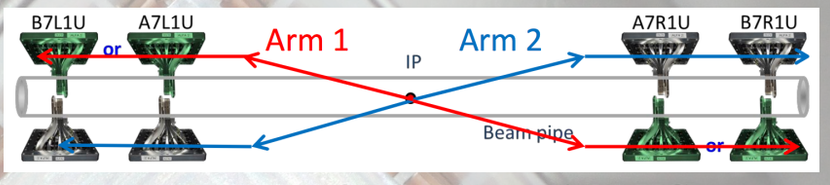
Fig.1 shows the mean charge in calibration runs.
The great precision of ^{207}Bi calibrations led to the equipment of all PMTs with ^{207}Bi source.

Fig. 1: ^{207}Bi calibration stability versus time
(ATL-FWD-PROC-2016-001)

ALFA

ALFA is a system of detectors dedicated to the measurement of ***elastic scattering*** at very small angles (down to Coulomb-Nuclear interference) for the total cross section determination and diffractive studies.

- Roman Pots to approach the beam (at ~1.5 mm) hosting 4 groups of scintillating fibres for particle tracking.



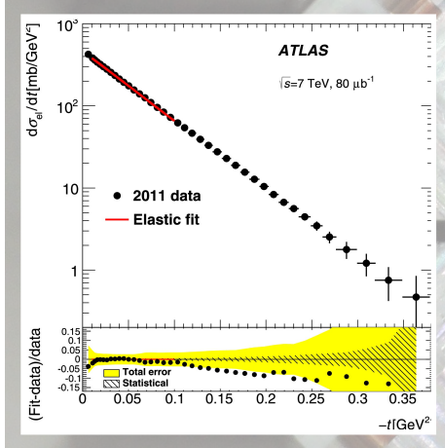


Fig. 2: $d\sigma_{el}/dt$ of pp collisions at $\sqrt{s}$=7 TeV
(*Nucl. Phys. B* 889 (2014) 486-548)

Measurements performed in special LHC runs with high β* and low emittance

☑ **β* = 90m @ 7, 8 TeV(pub.) and 13 TeV (on-going)**
- access to transferred momenta of scattered proton in the region of Mandelstam $t > 10^{-2}$ GeV^2
- sensitive to ***nuclear scattering*** only (Fig. 2)
- σ_{tot} evaluated from elastic scattering in the forward direction via the Optical Theorem, using ATLAS *Luminosity* (Fig. 3).

☑ **β* = 1000m @ 8 TeV (on-going)**

➤**β*=2500 m @ 13 TeV (data collected)**
- access to $t < 10^{-2}$ GeV^2
- sensitive to interference between ***nuclear and coulomb scattering***
- σ_{tot}, ρ and *Luminosity* extracted from simultaneous fit on $d\sigma_{el}/dt$ in the low-t region.

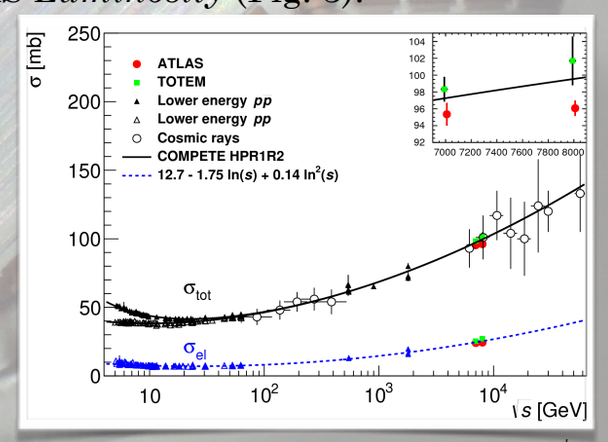
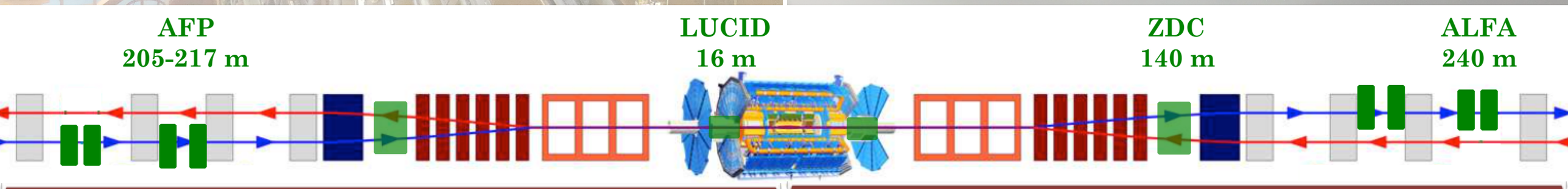


Fig. 3: σ_{tot} and σ_{el} of pp collisions versus $\sqrt{s}$
(*Phys. Lett. B* 761 (2016) 158-178)



AFP

AFP is designed to measure forward protons with Roman Pots for the study of ***soft and hard diffractive processes,*** together with the main ATLAS detector. It consists of 2 stations on each side: a tracker is placed at 205m and another tracker with a ToF detector is located 217m from the IP.

➤3D silicon pixel detector (p-tracking)
high granularity (σ_x=10μm and σ_y=30μm) and radiation hard

➤ToF detector (pileup bkg reduction)
high time resolution $\sigma_t \leq$**30ps**, radiation hard, high rate

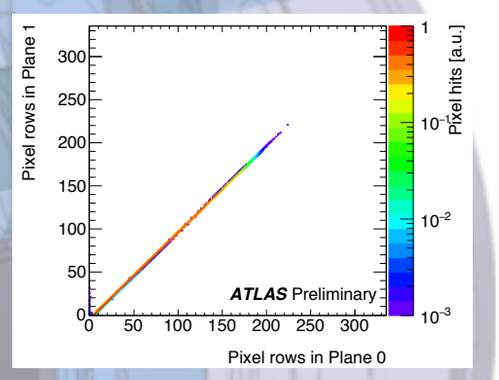
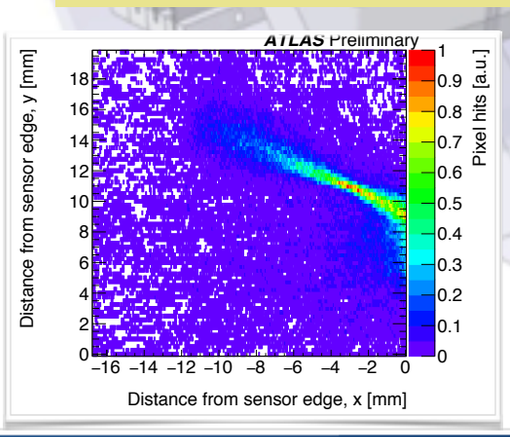


Fig. 4: Correlation of row pixel hits between consecutive layers in the 205 m station*

☑ **AFP 0+2 in 2016, installation of two trackers on one side.**
Data collected in special low-μ runs (L = 500 nb^{-1}).
➤**AFP 2+2 in winter 2017, *installation of the other arm* with ToF detectors included on both sides.**



Good pixel hit correlation between consecutive tracker planes in the 205m station observed (Fig. 4).

Band of ***diffractive protons*** clearly visible from the diagonal line in Fig.5.

Fig. 5: Number of row pixel hits in a tracker plane of the station at 205 m.
(*https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ForwardDetPublicResults)

ZDC

ZDC is designed to detect ***forward neutrons and photons in*** $|\eta|>8.3$ in p-p and heavy-ion collisions. It resides in transverse aperture of the neutral particle absorber (TAN) at ±140 m from the IP.

➤ZDC consists of 4 modules:
- 1 electromagnetic calorimeter
- 3 hadronic calorimeters

Each module consists of 11 tungsten plates with their faces perpendicular to the beam direction.

➤Read-out
System of quartz fibres (1.0mm diameter) coupled with PMTs.

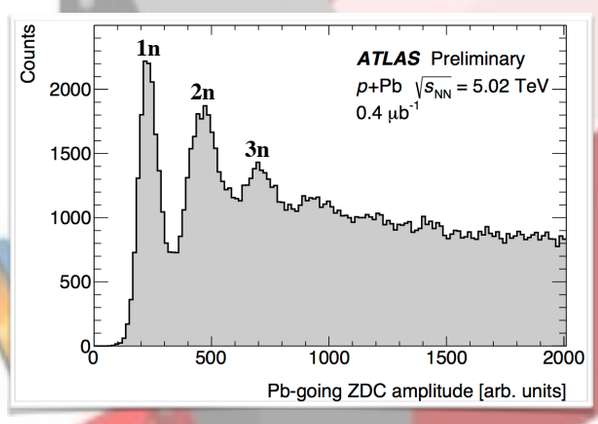


Fig. 6: ZDC signal amplitude in 2016 p-Pb runs
(https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PLOTS/HION-2016-002)

ZDC plays a key role in the determination of the **centrality** of heavy-ion collision, characterising the ***geometry of Pb+Pb and p+Pb collisions*** (Fig. 6).

ZDC is being used to study **ultra-peripheral** Pb+Pb collisions **(ATLAS-CONF-2017-011)**.

A refurbished ZDC was installed for 2015 heavy-ion runs.
An upgrade of the detector is underway with liquid radiator, improved position determination and faster readout.

Camilla Vittori, Università di Bologna and INFN