ALFA – RESULTS 2011 AND PLANS FOR 2012

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Abstract

The essential commissioning steps of the ALFA Roman Pot detectors in the LHC tunnel are described. First measurements of elastic proton scattering has been done with a high $\beta* = 90$m optics. The angular plots of elastically scattered protons are shown. Finally an outlook for physics data taking with $\beta*$ at 500m or slightly above is given.

INTRODUCTION

ALFA is a sub-system of the ATLAS experiment and located in the LHC tunnel to measure small angle proton scattering [1]. The ALFA detectors are placed in so-called Roman Pots which allow to move them close to the circulating beams. At smallest scattering angles the elastic cross section in the Coulomb-Nuclear Interference (CNI) region offers the opportunity to determine the luminosity and the total cross section only based on ALFA data. A verification of the ATLAS standard luminosity methods is important for all precision measurements which heavily rely on standard luminosity tools. For the total pp cross section ALFA is the counter part of TOTEM which also measure the total pp cross section with a similar approach but different tracking detectors [2].

The ALFA tracking detectors are multi-layer scintillating fiber structures. Two times 10 layers of 64 squared fibers of 0.5 x 0.5mm^2 cross section measure the transverse coordinates of the proton trajectories. The fibers are staggered and glued in stereo-geometry on thin Titanium plates. The scintillation signals of traversing protons are detected by 64 channels Multi-Anode-PhotoMultiplier Tubes (MAPMT) [3]. The typical efficiency to detect a traversing proton per layer is about 94%. Combining 10 layers results in a tracking efficiency close to 100%. The detector resolution was measured in test beams and values between 25μm and 35μm were obtained. The end face of a detector seen from the beam side is shown in fig.1. Each of the two Roman Pot (RP) stations on both sides of ATLAS is equipped with two detectors approaching the beam in the vertical coordinate. A detector consists of a Main Detector (MD) for proton tracking and a so-called Overlap Detector (OD) to determine the distance between upper and lower detectors. More details about the ALFA detectors can be found in [1].
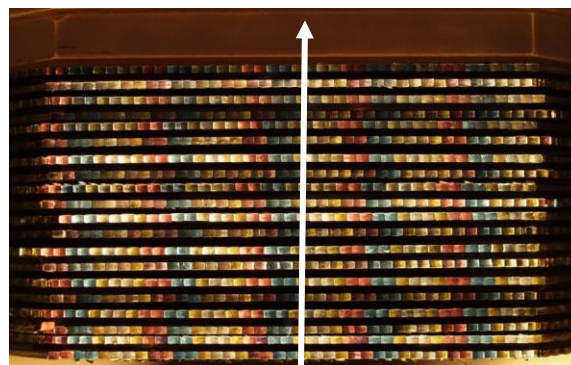

Fig.1: A view from the beam side on the fiber detector end face. Colored light was used for a fiber-to-MAPMT channel mapping check. A symbolic proton trajectory is indicated as arrow.

COMMISSIONING AND DATA TAKING

At the end of 2010 all four stations were mechanically installed in the LHC tunnel. The installation process was continued until March 2011 by the following activities: the insertion of the fiber detectors in the RPs, the installation of the MAPMT arrays with the PhotoMultiplier Front electronics (PMF) , the installation and cabling of the MotherBoards (MB), the connection of all cables to power supplies and crates in USA15, the laser survey for the calibration of the Linear Variable Displacement Transducers (LVDT), and finally the setup of the services like vacuum pumps, air cooling and radiation monitors. The next six months were devoted to the commissioning of the whole system. This included the functionality of the movement system, the time adjustment of the trigger signals, the test of the readout chain, the proof of the offline software by reconstruction of shower fragments with detector in garage position and halo particles with detectors in 25mm distance to the beam. The RPs are considered as movable beam line elements and have to pass similar safety tests as the collimators: checks of the interlock logic and no significant beam losses caused by the RPs in case of a beam dump. This is validated in special runs for so-called loss maps. For data taking ALFA can run in two modes: standalone or combined with ATLAS. In standalone mode only ALFA data with a minimum bias trigger are readout in a private data steam for calibration purposes.
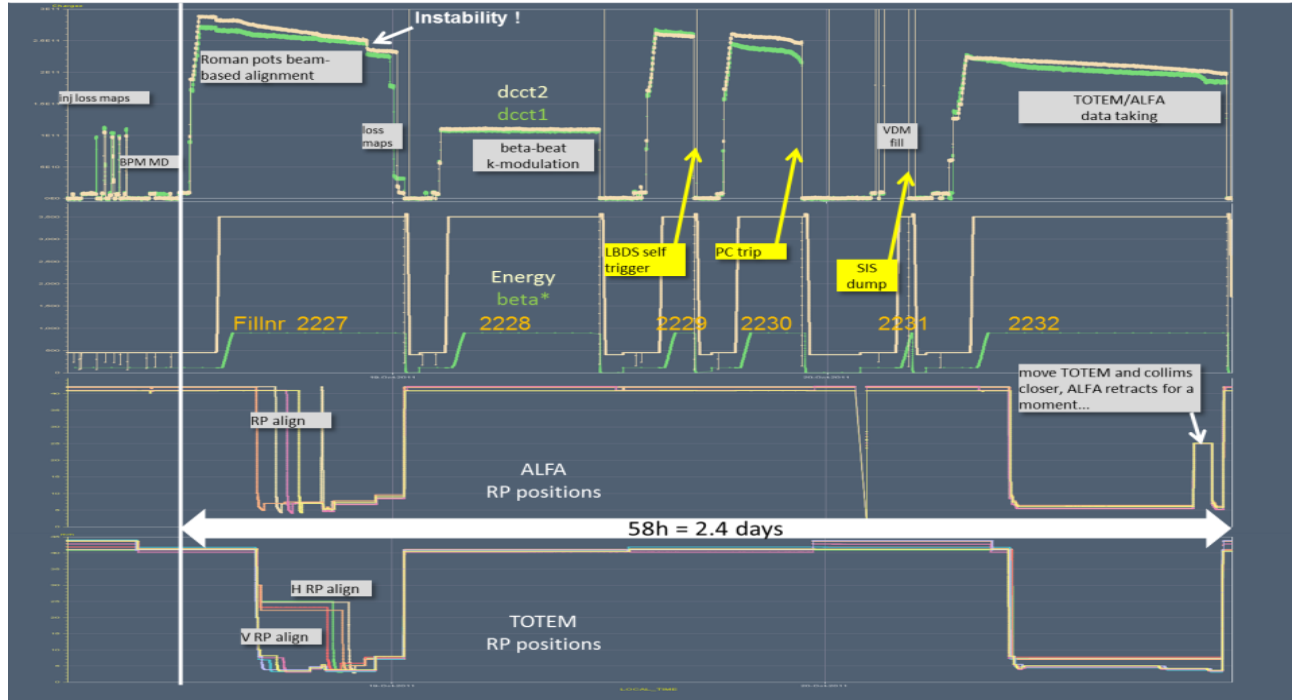
Fig.2: Beam intensity and energy, β* and ALFA, TOTEM RP positions during the β* 90m campaign in October 18-20, 2011.

In combined mode with ATLAS the information of all sub-detectors including ALFA is readout. This mode is foreseen for physics data taking using a special trigger menu to enhance elastic and diffractive processes. In September 2011 all ALFA readout components were integrated into the ATLAS central trigger and data acquisition systems and validated to be fully operational. In parallel to the ALFA commissioning the development and qualification of the 90m β* optics was performed in dedicated LHC fills. The details about this procedure can be found in [4].

The successful data taking happened from October 18 to 20. The time line of all fills and the related activities are shown in fig.2. The first fill 2227 was used for the beam-based alignment by scraping the edge of the collimated beam with the bottom window of each RP. The primary

collimators were at 4.5 σ. In the following text all RP position values in terms of σ were calculated with the nominal emittance of 3.5μm. Approaching the beam the PRs are moved in small steps of 10μm until an intensity spike appears in the beam loss monitors behind the ALFA stations. This procedure determines the beam edge with a precision of about 10μm. All edge positions measured by the LVDTs are compiled in table 1.

The values in table 1 indicate that beam1 is off by about -0.2mm and beam2 by +0.5mm in respect to the center of the beam pipe. The last 2 columns compare the half gap size in terms of σ in the vertical Y-coordinate measured by the LVDTs with the values extrapolated from the collimator settings to RP positions. The good agreement confirms that LVDTs are reliable on a scale of 100μm.

Table 1: Beam edges and gap sizes for all RP stations measured by scraping before data taking with β* 90m.

Beam 2	Y_up/mm	Y_low/mm	Y0/mm	σ_Y /mm	½ gap/σ_Y	coll/σ_Y
XRPV.B7L1.B2	3.960	-4.339	-0.190	0.856	4.85	4.78
XRPV.A7L1.B2	4.228	-4.671	-0.222	0.897	4.96	4.89
Beam 1						
XRPV.A7R1.B1	4.812	-3.658	0.577	0.897	4.72	4.82
XRPV.B7R1.B1	4.128	-3.151	0.489	0.856	4.25	4.38

After the scraping all RPs were retracted to 7mm and the beam was collimated to 4 σ. Then all RPs were moved to 5.5 σ and 8 σ for technical data taking in standalone mode. These runs were used to verify the elastic track pattern and to confirm the distance measurements with the ODs. At the end of this fill the RPs were moved to 10 σ and measurements for loss maps and the asynchronous dump were performed.

The next fill was used for the measurement of the β-beating and k-modulation. These measurements are used to minimize the errors of 90m optics parameters [5]. The following 2 fills were lost due to machine problems and also a van der Meer scan at β* 90m failed by premature beam dump.

The successful fill 2232 for physics data taking was on October 20. The filling scheme consists of 2 bunches of 7E10 protons (1colliding and 1non-colliding for background studies), and 12 smaller probe bunches with 1E10 protons for TOTEM. After the setup of the 90m optics the beam was collimated to 5 σ and all RPs were moved to 6.5 σ. Again, at the beginning a few technical runs were taken in standalone mode with subsequent fast processing to verify the data quality in MDs and ODs. Then the data taking was switched to combined mode with ATLAS for the physics run. After machine had declared a quiet period in beam mode ADJUST the ATLAS Silicon strip and pixel detectors were switched on (for standard data taking this is only allowed for STABLE beam mode). All ATLAS components apart from the Muon-detectors could accommodate to the increased latency of 20 bunch crossings caused by the late arrival of ALFA trigger signals. The physics run 191373 lasted about 5 hours and 8 million triggers were recorded with the ALFA trigger menu. The physics stream delivered 1.4 million triggers for elastic and 2
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million triggers for diffractive processes, 4 million minimum bias trigger plus more technical triggers. In the parallel Partial Event Building (PEB) stream 55 million triggers were recorded with the ALFA minimum bias trigger with data from ALFA and CTP. In total about 100 million triggers were recorded for physics, calibration and other systematic investigations. The information about all runs in the October period is compiled in table 2.

STATUS OF PHYSICS ANALYSIS

Overlap Detectors and Alignment

The beam-based alignment allows to position the RPs in the vertical coordinate symmetric with respect to the beams. The horizontal detector position is constraint by the movement system and cannot be corrected during operation. The final precise alignment in both coordinates perpendicular to the beam is performed by offline analysis using the elastic track pattern in the detectors.

The essential input for the track-based alignment is the measurement of the distance between the upper and lower detector using tracks in the ODs. Each MD is complemented with two ODs on the left and right side. These ODs start to overlap if both detectors are about 8mm away from the beam center. The positions of the ODs with respect to the MDs were calibrated in test beam campaigns using the EUDET pixel telescope to allow a direct measurement of the distance [6]. After this calibration the ODs measure the distance of the detectors in the upper and lower RPs with a precision of 20μm. The distance measurements for the physics run with RPs at 6.5 σ are compiled in table 3.

. Table 2: Parameters of runs taken in October 2011, OD = Overlap Detector, MD = Main detector.

Date	Run	Triggers	Position	Trigger & Purpose
Oct 18	191291-191305	17 million	Various, 7mm	Scraping
Oct 18	191312-191313	0.5 million	7mm	OD only for distance
Oct 18	191321	2 million	5.5 σ	MD&OD standalone
Oct 18	191322	10 million	8.0 σ	MD&OD standalone
Oct 18	191323	0.5 million	8.0 σ	OD only for distance
Oct 20	191366	10 million	6.5 σ	MD&OD standalone
Oct 20	191367	1.2 million	6.5 σ	OD only for distance
Oct 20	191373	55 million 8 million	6.5 σ	ALFA PEB stream Full ATLAS stream
Oct 20	191377-191383	4 million	6.5 σ	OD only for distance
Oct 20	191386-191388	10 million	6.2 σ	MD&OD standalone

Table 3: Distances of detectors and RPs measured by tracks in the ODs and derived from LVDT values.

Distance /mm	B7L1	A7L1	A7R1	B7R1
Overlap Detector(+X)	12.048	12.453	12.402	11.853
Overlap Detector(–X)	11.882	12.405	12.346	11.780
Mean OD(+X), OD(-X)	11.965	12.429	12.374	11.817
RP from Mean OD	11.001	11.532	11.497	10.887
RP from LVDT	11.148	11.523	11.677	11.136
RP OD - LVDT	0.147	0.009	0.180	0.250

The mean of the inner (+X) and outer (-X) OD distance values is used to extrapolate to the distance of the outer RP windows to the beam. This distance is independently measured from the LVDTs which are calibrated by the laser survey. The differences in respect to values derived from the LVDT are in the range between 100μm and 200μm. They result mostly from the uncertainty of the LVDT calibration which combines the laser survey and the 3D measurement of the RPs. For the track-based alignment two offsets in the transverse coordinates and the rotation around the beam axis are taken into account. The alignment procedure is based on the track pattern of elastically scattered protons. A typical elastic track sample of a technical run with data taking in standalone mode is shown in fig.3. It covers a narrow range from -1mm to +1mm in the X-coordinate and extends to about 23mm in the Y-coordinate starting at the detector edge up to a limit set by the LHC beam screens.

For un-polarized scattering a symmetric shape of the track patterns in the upper and lower detectors of a RP station is expected. The alignment is based on this constraint and the distance measurement from the ODs. In a first step the horizontal offsets and the rotation angle of upper and lower detector are determined. In the horizontal coordinate the elastic track pattern is quite narrow what eases the patching of both half patterns. The alignment criterion is a profile connecting the track patterns in the upper and the lower detectors centered on a straight line. The alignment in the vertical coordinate is constraint by equal rates in the upper and lower detector at the same distance to the beam. A profile with a quadratic decrease of the rate in dependence on the distance to the beam is fitted to the vertical profile to determine the offset of the beam in respect to the detectors. To fix the absolute scale the most reliable distance measurement of station A7L1 is used as reference. The consistency of this assumption was investigated using the distance measurement in the all stations successively as reference value. The variation of the propagated values from four reference stations is about 60μm. Applying the beam optics this distance value of the reference station is propagated to the other stations and used for alignment. The final alignment parameters for the physics data taking at 6.5 σ are compiled in table 4.

Table 4: Alignment parameters of each detector for the physics run at 6.5 σ.

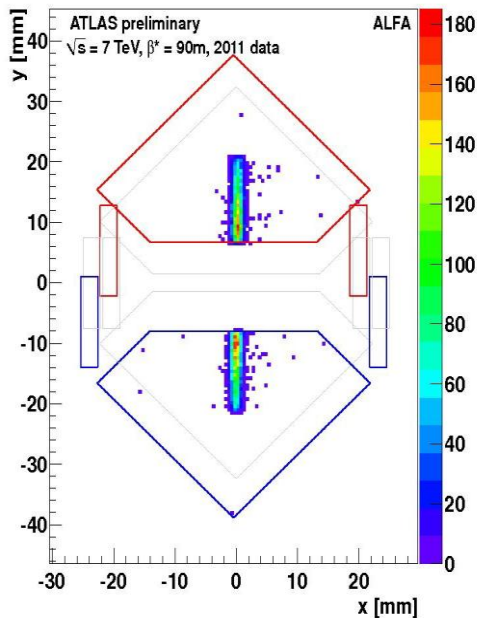| Station	Detector	Phi/mrad	ΔX/μm	ΔY/μm
B7L1	Upper	5	326	77
	Lower	0	-366	77
A7L1	Upper	3	629	7
	Lower	2	373	7
A7R1	Upper	0	263	12
	Lower	0	392	12
B7R1	Upper	4	415	58
	Lower	-2	493	58

Fig.3: An elastic track pattern in station A7L1 of an early technical run. For a better visibility the ODs left and right from the MDs are shown displaced with respect to their real position.
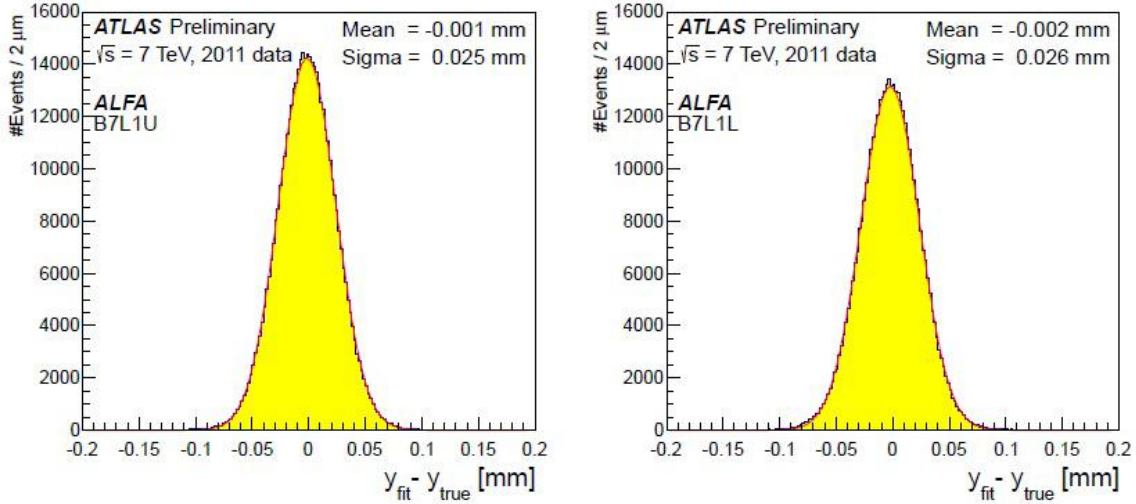
Fig.4: For the upper (left) and lower (right) detector of station B7L1 the residuals in the Y-coordinate for a global track fit combining local track points in all four stations.

The rotation corrections are at maximum 5mrad while the X-coordinates need rather large corrections up to half a millimeter. From variations of the selection cuts one can estimate the errors of the rotation correction and the X-offset to be smaller than 1mrad and 5μm, respectively. All the corrections in the vertical Y-coordinate are below 100μm indicating that the beam-based alignment works quite well. A quality check of the alignment is made by a straight line fit to the aligned track coordinates with the detectors artificially moved to positions which correspond to their effective length defined by optics.

This effective length represents the distance at which the scattered proton would be at the same transverse position as in absence of magnets. For an ideal case with perfect alignment the proton trajectory should be a straight line with a slope given by the scattering angle. The residuals fitting a global track trough all stations have offsets less than 5μm. For station B7L1 the residual plots are shown in fig.4. Combining all uncertainties we conclude that the absolute precision of the alignment in the vertical coordinate is about 20μm, taking into account the uncertainty from the OD measurement.

Angular Distributions of Elastic Processes

For the physics analysis only events from the colliding bunches with 7E10 protons are used. The reason for this restriction is that the luminosity measurement from

ATLAS is not reliable for lower bunch intensities. Also the beam-based background is much higher in the low-intensity pilot bunches. Out of 1.4 million triggers in total, 1.1 million triggers are from the colliding bunches with 7E10 protons. The next selection step is to request a local track in all four detectors which belong to one of the two arms consistent with the trajectory of an elastically scattered proton. About 884.000 triggers fulfill this criterion. But even this sample with at least four local tracks contains still contributions from diffractive processes in combination with beam-related backgrounds. To clean the sample the position correlation resulting from the elastic back-to-back scattering at the interaction point is used. Fig.5 illustrates the position correlation of track coordinates in RP detectors at both sides of ATLAS. Already in the trigger sample before any cleaning the correlation is visible. As expected the correlation band is much more pronounced in the Y-coordinate while the correlation in the X-coordinates is affected by the much smaller effective length in this projection.

The correlation of local track coordinates and angles is used to remove background contributions from the elastic trigger sample. After these cuts about 785.000 golden elastic events remain for physics analysis. The angular correlation plots after the selection cuts are shown in fig.6. The well-aligned correlation bands confirm the dominance of elastic events in this sample.
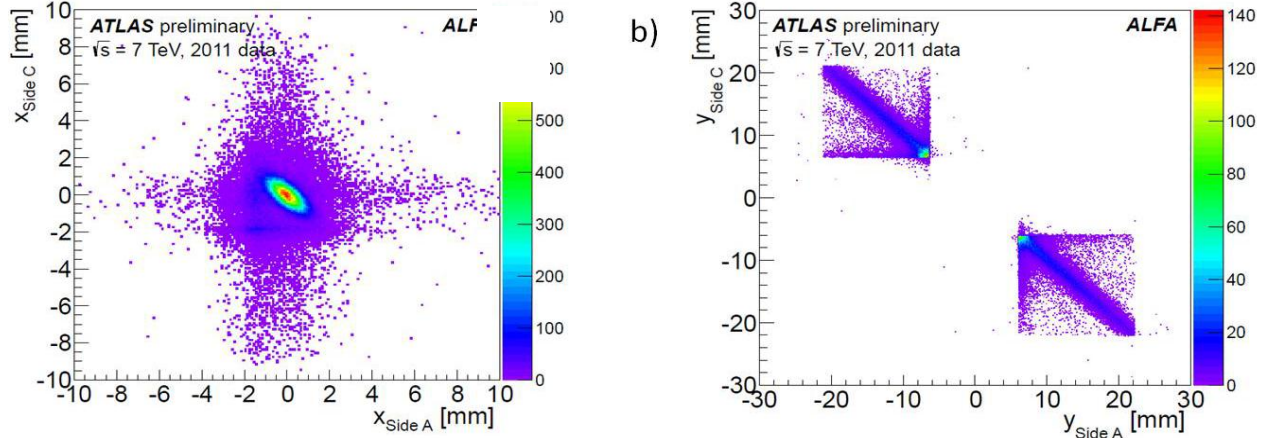
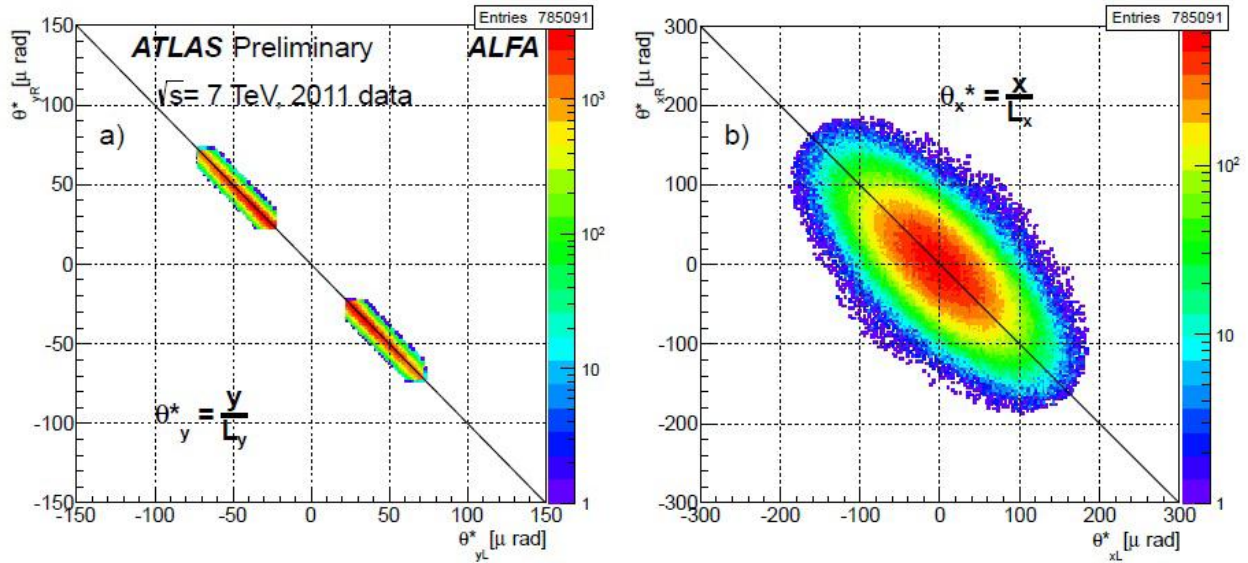Fig.5: The scatter plots of local track coordinates in both arms of ALFA for a sample of elastic triggers.

Fig.6: The angular correlation of the 90m physics run 191373 in both coordinates after selection cuts.

The 2-dimensional plot of scattering angles in both projections after the cleaning of the sample is shown in fig.7. Nicely visible is the rotation symmetry as it is expected for un-polarized elastic proton scattering.

To convert the track points in the detectors to angles of elastic scattering the optics of the beam line between ATLAS and the RP stations has been used. The condense product of the optics is the so-called effective length L_{eff} which is a function of $\beta*$, the value of the β-function at

the RPs and the phase advance Ψ: $L_{eff} = (\beta*\beta)^{0.5} \sin(\Psi)$. For the transformation of track coordinates in angles the 90m design optics has been used. It was measured by k-modulations for the β-beating and globally using AC dipoles to generate orbit oscillation traced by the beam position monitors. A final optics check using the measured currents in the magnets indicates that L_{eff} deviates less than 1% from the value of the design optics. A detailed analysis for the 90m optics and related errors is described in these proceedings [ref: S.Cavalier].
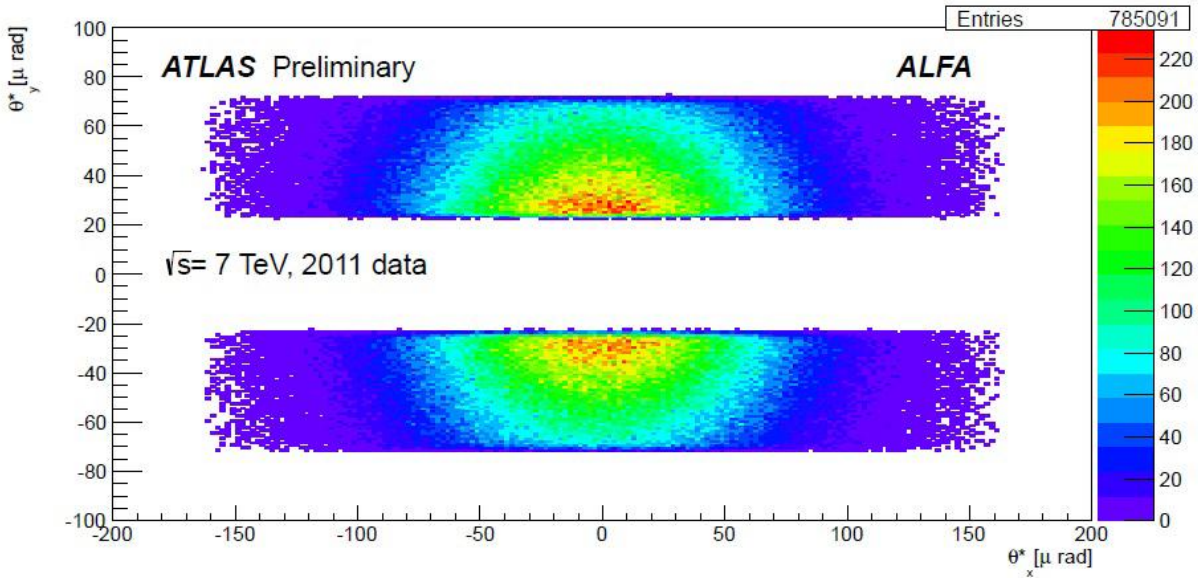
Fig.7: The 2-dimensional angular plot of protons scattered elastically at the interaction point.

Luminosity Analysis

The 90m optics and the detector positions at 6.5 σ do not allow to reach the CNI region. Hence for the total and elastic cross section measurement the external luminosity from ATLAS has to be used. The calibration of the luminosity measurement is performed in so-called van der Meer scans. These scans measure the area of the overlapping beam profiles which, together with the counting rate at zero beam separation and with the bunch current measurement, gives the absolute luminosity scale. The van der Meer scans are also used to cross calibrate specific ATLAS detectors for absolute luminosity measurements.

The ALFA run with very low luminosity is characterized by a corresponding low μ-value between 0.03 and 0.04, where μ is the number of interactions per bunch crossing. The instantaneous luminosity per bunch was 6-7E27 $cm^{-2}sec^{-1}$, more than two orders of magnitude lower than in standard fills. The ATLAS detectors available for luminosity measurement at low luminosities are LUCID, BCM and the inner tracking detector for vertex-based methods. For the calorimeters the luminosity was below the sensitivity threshold; the MBTS scintillator wheels lost calibration from the high accumulated radiation dose. Various algorithms based on event and hit counting in coincidence on both sides of ATLAS (AND) or just from any side (OR) can be used for consistency checks and studies of systematic errors. A critical point in the luminosity measurement of the ALFA run is the extrapolation of algorithms from standard run conditions over two orders of magnitude to very low μ-values. Fig. 8 demonstrates the μ-dependence of various algorithms for a special μ-scan. While at standard μ-values > 2 the algorithms agree mostly in a band of +- 1%, at lower μ a clear indication of systematic effects of up to a few % is visible.
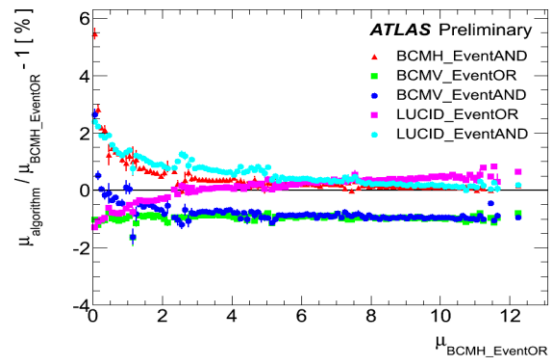

Fig.8: The μ-dependence of various BCM and LUCID luminosity algorithms from a special μ-scan.

The key to the understanding of the luminosity in the ALFA run was vertex-based event counting, which yields an integrated luminosity consistent with the BCM_OR event counting at the 0.6% level. The results are highly insensitive to the event-selection cuts e.g. the minimum of tracks required to form a vertex.

Although LUCID had been absolutely calibrated by the van der Meer method at the same time as the BCM and the vertex-based methods, ageing effects in the LUCID phototubes during the intervening high-luminosity running periods cast doubt on the continuing validity of this absolute calibration. A two-step calibration-transfer procedure was therefore adopted. The currents drawn by the phototubes of the hadronic (TILE) calorimeter were cross-calibrated to the absolute LUCID luminosity during the May 2011 van der Meer calibration fill. The resulting TILE-based luminosity measurement remained consistent, at the 1% level and throughout the 2011 high-luminosity pp running, with that of the BCM algorithms [ref: M. Tibbetts, these proceedings], suggesting that the TILE luminosity calibration remained stable at that level. LUCID was then cross-calibrated back to the TILE luminosity measurement in a high-luminosity fill a few days after the ALFA data-taking at β* 90 m. This allowed LUCID to perform a luminosity measurement, additional to and independent from those provided by the BCM and vertex methods, during the ALFA run where the TILE sensitivity was inadequate. This came, however, at the cost of moderate additional systematic uncertainties, associated with the LUCID-TILE calibration transfers and with the empirical corrections to the LUCID phototube response between the low- and high-luminosity regimes.

At this stage it seems that the luminosity of the 90m ALFA run has an overall uncertainty between 3 and 4%. The final values will be published in an upcoming cross-section publication.

PLANS FOR 2012

A couple of upgrades have been performed after the 2011 data taking during the winter shut down. The most important ones are the trigger modifications and improved temperature monitoring. The ALFA movement control was modified for more save operation. The attenuation factors for the trigger signals on the adapter boards were modified to cope better with the PMT signals. A new MB firmware was uploaded which in special runs allows an analogue readout of the fiber signals. Also the trigger modifications required some changes in the firmware. The DCS was improved in the handling, especially the extensive temperature monitoring and more radiation sensors were included. Finally the DAQ was adapted to the latest version of the central ATLAS DAQ including the new analogue readout.

Combined MD-OD Triggering

According to the TDR only the MD trigger signals are sent to CTP for physics data taking in special very fast air-core cables. The OD trigger signals which are used to trigger particles in the OD trackers are sent separately by standard cables. The consequence of this separation is that the beam time has to be split for two tasks: the run with OD triggers for distance measurements in standalone mode, and the run combined with ATLAS for physics. The basic idea for the modification is to send MD and OD trigger signals both trough the air-core cables and distinguish them by different signal length. The modified firmware delivers 50ns pulses for the MD triggers and 25ns pulses for the OD triggers. The different pulse lengths are used to identify the source. The logic scheme arranged by 8 NIM modules is shown in fig.9. Altogether 12 combinations for the OD trigger signals are in the new ALFA trigger menu. Also some of the ALFA physics triggers are combined with MBTS, LUCID and ZDC signals and were included in the new ALFA trigger menu.
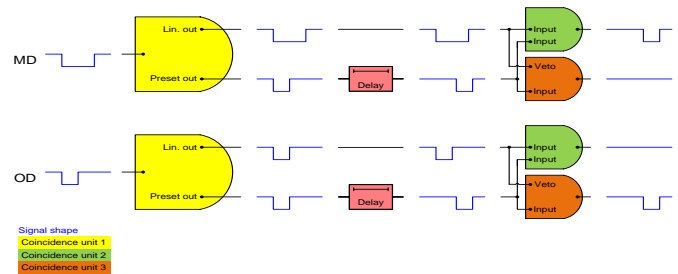

Fig.9: Logic scheme to separate MD and OD trigger signals of different pulse length.

Temperature Monitoring

The ALFA detectors and electronic components are equipped with a couple of PT100 temperature sensors for monitoring. In the 2011 standard fills with high beam intensities of 1380 bunches with 1.3E11 protons a typical temperature increase between 10 and 15 degrees was observed on the Titanium plates with the fiber layers. The temperature profiles of all ALFA detectors in a typical high intensity run are shown in fig.10. The values for beam1 are systematically about 3 degrees higher than those for beam2. The temperatures maximum is reached about 3 hours after injection and follows later the decrease of the beam intensities. The sensors were not calibrated and only the increase in respect to periods without beam was accessible. Assuming a base temperature in the tunnel of 20 degrees the temperatures on the detectors ranged roughly between 30 and 40 degrees.
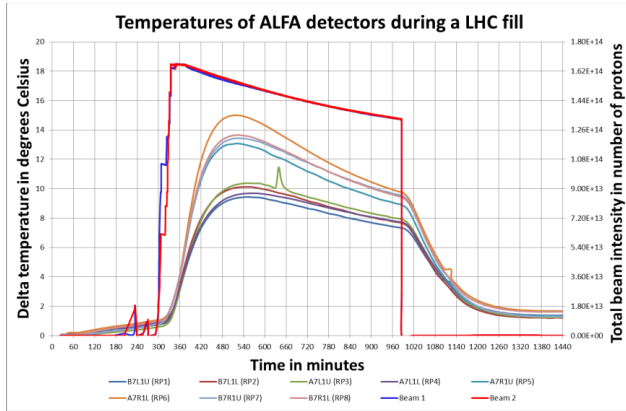
Fig.10: The temperatures of all ALFA detectors measured on the Titanium plates in a typical 2011 high intensity fill.

To trace possible impacts of high temperatures on the detectors ALFA2 was taken out from station B7L1 and visually inspected. A comparison of the fiber structure with photos before the detector insertion was made. No obvious changes in fiber positions or the consistency of the glue have been observed.

To estimate the expected increase of temperature for 2012 conditions simulations of heating by RF losses have been performed. Including the uncertainties of the models for the 2012 conditions with 1380 bunches of 1.6E11 particles and 50ns operation an increase in the range from 20 to 30 degrees has to be expected. This corresponds to a maximum temperature of 50 degrees.

To study the impact of heating on the structure one MD plate was temperature cycled in an oven. Temperatures of 45 and 60 degrees were simulated for about 4 hours and repeated many times. The fiber positions at the end faces were measured by microscope and no systematic offset was found. However at 60 degrees at one side of the plate the fibers in the central part lost contact to the Titanium indicated by an air gap. Unfortunately the fiber positions on that side were not measured by microscope but the loose contact can result in a shift of the fiber positions. Another critical effect was observed for the trigger tiles glued to the Titanium structure. After 60 degrees heating the glue lost adherence and the tiles have been fallen off or were easy to remove.

From the investigation on can conclude that the detectors do not harm at 45 degrees while 60 degrees is a dangerous value. More details are summarized on an ATLAS note [7]. The studies are going on in steps of 5 degrees and with vacuum conditions as for the detectors installed in the tunnel.

To reduce the temperature during 2012 running the bake-out jackets were removed from the beam pipe at the RP stations. Another option presently under investigation is an additional external air cooling of the stations. For long terms an active cooling of the detectors inside the RPs will be investigated. To study possible heat sources and propagation on each station 32 PT100 sensors were mounted close to electronic components, the detectors and the beam pipe.

Preparation of Physics Data Taking

After the startup of LHC at 4 TeV a couple of runs for commissioning of ALFA are foreseen. The goal of these runs is to verify the upgrade modifications and the complete read out chain up the offline reconstruction.

Some activities under discussion for the near future are: the scraping at collision optics with β* 0.6m, the participation in the loss maps and the early low-μ run for Monte Carlo calibration. The scraping is basically a measurement of the beam center and is needed to move the detectors safely closer to the beam during standard collision runs. During loss maps the detectors will be moved to 20 σ (about 7mm) and the feedback from beam loss monitors verifies that there is no impact on the beam. These values define the innermost detector positions during stable beam conditions. If scraping is done before the loss maps the minimum distance for safe operation can may be decreased to 14 σ. In the low-μ run ALFA will record data in combined mode with ATLAS at collision optics with detectors as close as possible to the beam.

The physics goal of 2012 data taking is to reach the CNI region. The interplay of 3 parameters is relevant for this purpose: β*, the emittance and the distance of detectors to the beam. The dependence of the minimum accessible momentum transfer on β* for different combinations of emittance and detector position is illustrated in fig.11. At $t = 0.0006$ GeV^2 (horizontal black line) Coulomb and Nuclear scattering contribute roughly equally to the elastic cross section. In the plot three scenarios are described: emittance 2μm and detectors at 6.5 σ (green), an aggressive scenario with 1μm and 5 σ (red), and a pessimistic scenario with 3μm and 8 σ positions (blue). For the dashed lines the full acceptance range is used while the full lines are for the realistic case with the condition of at least 50% acceptance. For 2μm emittance and detectors at 6.5 σ at least β* of 900m is needed to touch the CNI region. For the aggressive scenario with 1μm and 5 σ (red) a minimum β* of 300m is necessary, while the relaxed scenario (blue) requires a very high β* close to 2000m. For the physics case one should remind that an essential part of the data in the Coulomb branch is needed to constrain luminosity and total cross section from ALFA data without external input.

The prospects for higher β* in 2012 are described in these proceedings [ref: H. Burkhardt]. From these

considerations a value in the range between 500m and 800m seems to be possible. Much higher values are not realistic due to the tight LHC schedule of this year. For β* of 500m a combination of emittance and position in the ranges 1-2μm and 4-5 σ would allow to measure in the CNI region. This is a very challenging goal but if a tight and clean beam can be delivered it is not unrealistic. The commissioning of the high β* optics will happen in machine development periods until summer. The physics data taking is presently planned for late summer to autumn.

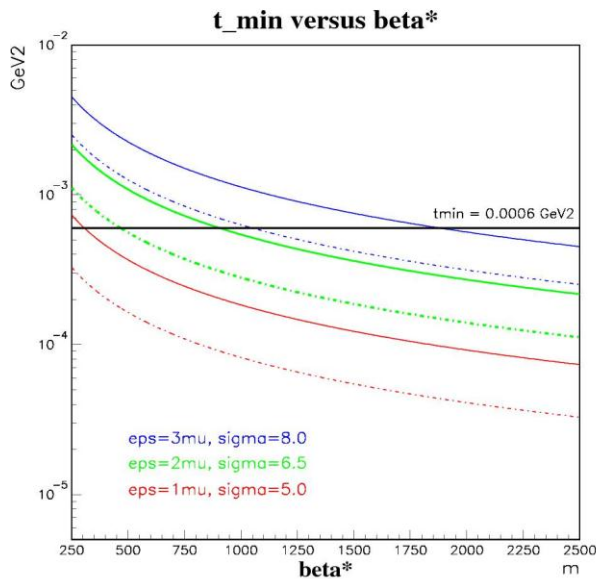
Fig.11: The minimum momentum transfer to reach the CNI region in dependence on β* for three combinations of emittance and detector positions. The full lines are for 50% acceptance, dashed lined assume no acceptance cut.

ACKNOWLEDGMENT

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