Status of the ATLAS Forward Physics (AFP) Project

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Abstract. The ATLAS Forward Physics (AFP) project plans to add a set of detectors — silicon 3D pixel tracking detectors and QUARTIC time of flight detectors — in the forward region of the ATLAS experiment at the LHC. The AFP detectors will be placed around 210 m from the interaction point and are meant to detect protons produced at small angles. The detectors are to be housed in the so called Hamburg beam pipe — a movable beam pipe allowing horizontal movement of the detectors. The AFP is currently under approval with possible installation in 2014/15.

Keywords: 3D pixel sensor, anomalous coupling, exclusive production, Hamburg beam pipe, QUARTIC

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INTRODUCTION

The ATLAS Forward Physics project plans to add a set of detectors to both sides of the ATLAS experiment at the LHC. The final setup will consist of two 3D pixel tracking detectors and one high-resolution time of flight detector on each side of the forward region. These detectors will be placed around 210 m from the interaction point (IP).

The AFP detectors will allow to identify forward protons produced at small angles. With such capability, it will be possible to perform standard QCD physics measurements as well as explore new physics.

Concerning machine conditions, the AFP is designed to operate with high pile up and it will be able to collect data during standard high luminosity LHC runs.

PHYSICS MOTIVATION AND DETECTOR ACCEPTANCE

Two classes of measurements will be possible with high precision using the AFP [1, 2, 3]

- exploratory physics — anomalous couplings between γ and W or Z bosons, exclusive production (magnetic monopoles, Kaluza-Klein resonances or SUSY) etc.,
- standard QCD physics — double Pomeron exchange, exclusive production in the jet channel, single diffraction, $\gamma\text{-}\gamma$ physics etc. These measurements will extend HERA and Tevatron measurements to the LHC kinematical domain.

FIGURE 1. Calculated dependence of acceptance of the produced object in central production for different positions of the tracking detector relative to the beam as a function of the mass of the object.

The AFP is designed to detect protons which lost energy in diffractive processes. When a proton loses energy in an interaction, it is deflected from the nominal beam by dipole and quadrupole magnets in the forward region of the ATLAS. The acceptance and energy resolution therefore depends on the LHC optics and distance of the detectors from the beam. For the central production, it will be possible to measure the mass of a produced object independently of the ATLAS detector with better precision [1, 3]. Calculated dependence of acceptance of the produced object in central production for different positions of the tracking detector relative to the beam as a function of the mass of the object is shown in Fig. 1 [2].

AFP LAYOUT AND HOUSING

Figure 2 [1] shows the schema of the long straight section of the ATLAS forward region with marked positions of proposed AFP stations. The AFP will consist of two stations:

- AFP1 at 206 m instrumented with the 3D silicon tracking detector,
- AFP2 at 214 m instrumented with the 3D silicon tracking detector and the time of flight detector

The detectors will be housed in the so called Hamburg beam pipe. The Hamburg beam pipe (Fig. 3) is a detector housing designed to allow detector installation in limited space [1, 3]. The beam pipe wall is very thin (less than $300\ \mu\text{m}$) in area of the so called *floor* and *thin window* to minimize the interaction of beam particles with the wall material and the distance of the detectors to the beam. The Hamburg beam pipe will be used in two lengths — short (with 100 mm long detector pocket) for tracking detectors and long (700 mm long pocket) for timing detectors.

The Hamburg beam pipe will be installed on a moving table to allow horizontal movement of detectors. To ensure vacuum in detectors, the whole assembly of the

FIGURE 2. Schema of the long straight section of the ATLAS forward region with marked positions of the AFP stations at 206 and 214 m. D1 and D2 are dipole magnets and Q1–Q7 are quadrupole magnets.

FIGURE 3. Design of the Hamburg beam pipe with marked regions of the *thin window* and *floor*. In these regions, the wall thickness is very thin to minimize the interaction of beam particles with the wall material and the distance of the detectors to the beam.

Hamburg beam pipe and detectors will be placed in a secondary vacuum box.

DETECTORS

Tracking Detectors

Tracking detectors will consist of six layers of 3D pixel sensors with FE-I4 as the readout chip [1, 3]. These sensors will be cased in cooling plates and housed in the rectangular pocket of the short Hamburg beam pipe.

For the Phase-0 (possible installation in 2014/15), the sensors developed for the Insertable B-Layer [4] will be used. The sensors are radiation hard, have thin edge

(less than 100 μm dead zone) and resolution of 10 μm in horizontal axis and 30 μm in vertical. The angular resolution using two detectors in a distance of 8 m is 1 μrad .

For the Phase-I (installation in 2018), edgeless 3D sensors are planned.

Time of Flight Detectors

The time of flight detectors are needed to reduce the background coming from pile up by determining primary vertex of incoming protons [1, 3]. From difference of time of flight, it can be determined whether two protons originate from the same primary vertex.

For the Phase-0 (2014/15), QUARTIC detectors with resolution of 10–20 ps will be used. To achieve required time resolution the detectors consist of 4×8 quartz bars. In such configuration, it is possible to perform 8 measurements of the time of flight with 30–40 ps resolution each.

For the Phase-I (2018), better space resolution will be needed due to more incoming protons. Several possibilities are being considered — QUARTIC with quartz fibers instead of bars, MicroMegas detector, CVD Diamond detector, Avalanche photo-diode and Si-Pm detector. SAMPIC chip developed in Saclay is being considered for readout.

SUMMARY

The AFP is a new planned ATLAS forward detector system, which will add a set of detectors in the ATLAS forward region around 210 m from the IP. The AFP aims to extend ATLAS capabilities to study diffractive processes.

Detectors are to be fitted in the Hamburg beam pipe and should comprise two sets of 3D pixel sensors and one set of QUARTIC time of flight detectors on each side of the forward region of ATLAS.

The AFP is under approval with possible installation in 2014/15.

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