AFP (ATLAS Forward Physics) Project

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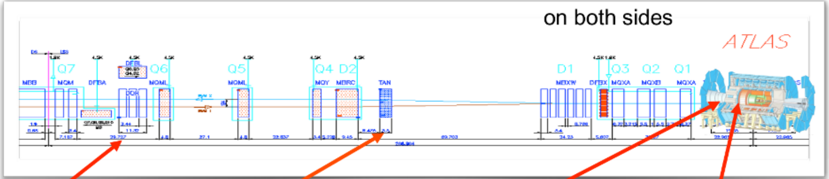
Outline

1. Existing forward detectors in ATLAS
2. Physical Motivation for New Forward Detectors
3. The AFP Project

Forward Physics

- Particle production mainly at central rapidities
- Most of the energy is emitted at very small angles
- Interesting physics:
    - Elastic scattering
    - Diffraction
    - Low-x QCD (saturation)
    - Photon-photon interaction
    - Central Exclusive Production

Existing Forward Detectors in ATLAS



ALFA at 240 m

ZDC at 140 m

LUCID at 17 m

MBTS at 3.6 m

Absolute Luminosity for ATLAS

Zero Degree Calorimeter

Luminosity Čerenkov Integrating Detector

Minimum Bias Trigger Scintillator

Existing Forward Detectors in ATLAS

MBTS

- Minimum Bias Trigger Scintillator
- only for low luminosity period (radiation destroys the scintillators)
- used for minimum bias studies
- 3.5 metres from the IP
- $2.1 < |\eta| < 3.8$

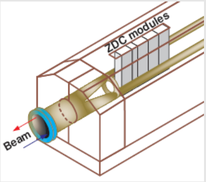
LUCID

- LUminosity measurement using a Cherenkov Integrating Detector
- gas tubes around the beampipe detect Cherenkov light due to charged particles
- 17 metres from the IP
- $5.6 < |\eta| < 5.9$

Existing Forward Detectors in ATLAS

ZDC

- **Z**ero **D**egree **C**alorimeter
- detects forward neutrons and photons
- 100 ps resolution (equivalent to about 3 cm)
- 140 metres from the IP
- $|\eta| > 8.3$



ALFA

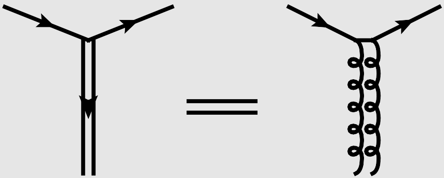
- **A**bsolute **L**uminosity **F**or **ATLAS**
- detect protons scattered into the beampipe (in particular elastic scattering)
- only for special, very low luminosity runs with dedicated LHC optics

Outline

Intact Proton

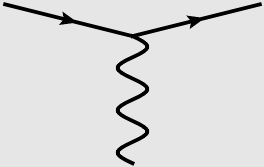
- Coherent interaction of all partons
- Proton is not broken

Strong interaction



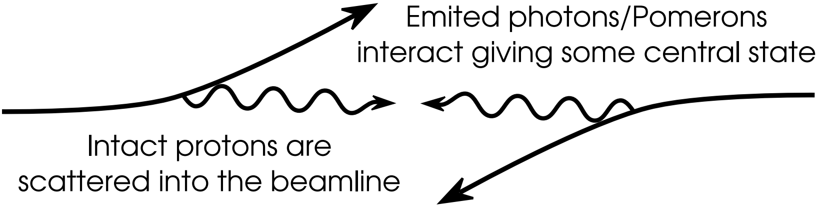
Pomeron exchange – color singlet exchange responsible for diffraction

EM interaction



Photon exchange

Central Exclusive Production



Central states

- dijets
- lepton pairs
- W/Z pairs
- Higgs boson
- pairs of SUSY particles

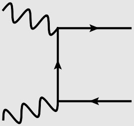
Advantages

+ clean events
+ constrained kinematics
+ good mass resolution

Interesting Physics Cases

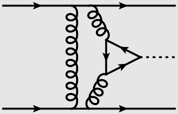
Anomalous couplings

- $\gamma\gamma \to W^+W^-$



- Anomalous couplings between γ and W/Z: effective description of BSM effects
- Non-zero anomalous parameters enhance W/Z pairs production

Exclusive Higgs

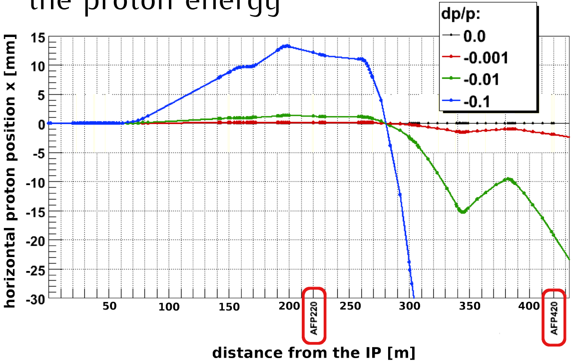


- possibility of quantum numbers determination
- $b\bar{b}$ background suppressed (conservation rules)
- small cross section in SM (greatly enhanced in MSSM)

Outline

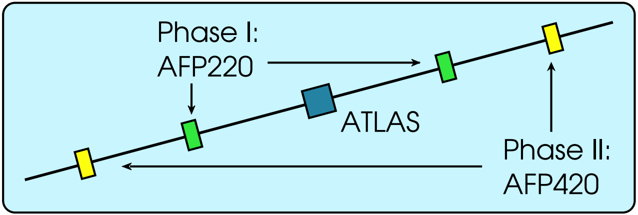
Proton Transport

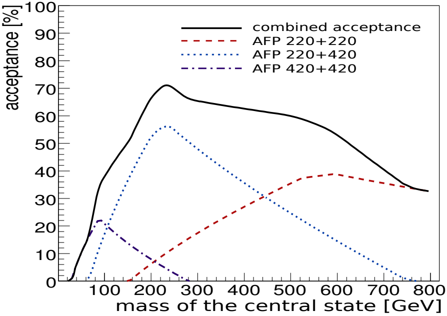
- Emission of photon/Pomeron – proton looses some part of its energy (of the order of the central state mass) and gains some transverse momentum (of the order of 1 GeV)
- Proton is scattered into the beampipe and traverses through the accelerator lattice
- Distance to the beam orbit is increasing and it depends on the proton energy



Detector stations

Tag protons scattered into the beamline.

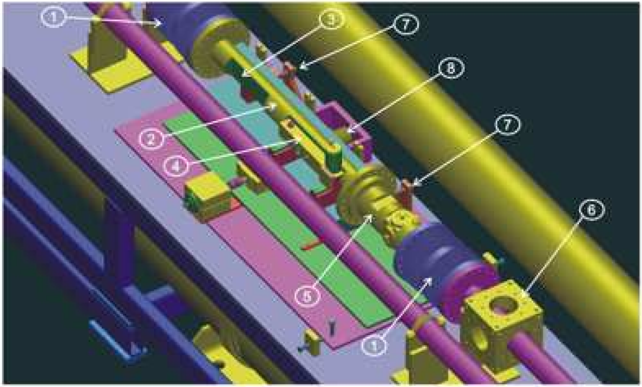




- Phase I (2013) – detectors at 220 m (warm vacuum)
- Phase II (2017) – detectors at 420 m (cold vacuum – cryostat bypass needed)

Hamburg Movable Beampipe

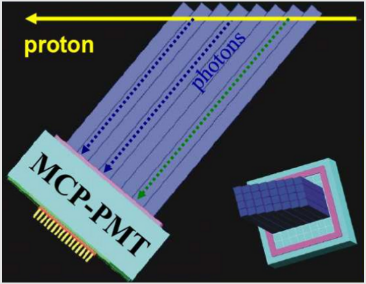
- Instead of moving the detectors inside the beampipe (roman pots) – move a part of the beampipe
- Successfully used at HERA
- Silicon pixel detector
- Timing detector inside



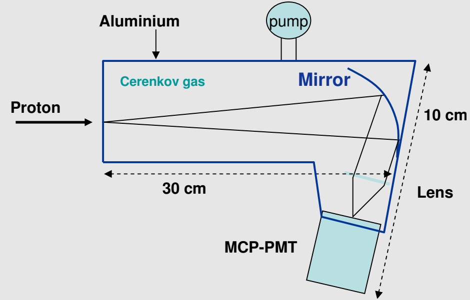
Fast Timing Detectors

- Measure proton TOF to calculate vertex position
- Reduction of pileup background (central state and forward proton originating from different interactions)
- Resolution 5 – 10 ps needed

QUARTIC



GASTOF



Conclusions

- Many interesting physics possible with the AFP detectors:
  1. insight into new physics with anomalus gauge boson couplings
  2. possibility of Higgs boson quantum numbers measurement
  3. diffraction and QCD physics
- Two phases of project – AFP220 and AFP420
- Hamburg movable beampipe – to place the detectors near the LHC beam
- Position detectors – to reconstruct proton position (and then the kinematics)
- Timing detectors – to reduce pileup background
- Status – currently the AFP project is being considered as a possible option for the future upgrade programme