ATLAS Forward Proton detector status and future plans

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Instrumentation for Colliding Beam Physics Novosibirsk February 27th – March 3th, 2017





- physics case
 - design
 - station, pot
 - tracker
 - ToF
 - installation & commissioning
 - data taking
 - second arm & ToF

ATLAS-AFP Collaboration: Technical Design Report for the ATLAS Forward Proton Detector, CERN-LHCC-2015-009; ATLAS-TDR-024-2015

ATLAS IBL Collaboration, Prototype ATLAS IBL modules using the FE-I4A front-end readout chip, JINST 7 (2012) P11010 J. Lange et al., 3D silicon pixel detectors for the ATLAS Forward Physics experiment, JINST 10 (2015) C03031

LANGE, J. et al. Beam tests of an integrated prototype of the ATLAS Forward Proton detector, JINST 11 (2016), no. 09, P09005

NOZKA, L. et al. Design of Cherenkov bars for the optical part of the timeof-flight detector in Geant4, Optics Express, 2014, vol 22(23), pp 28984-28996

NOZKA, L. et al. Construction of the optical part of a time-of-light detector prototype for the AFP detector, Optics Express, 2016, vol 24(24), pp 27951-27960

see also talks of KOMAREK, T., Beam tests of the AFP Time-of-Flight subdetector and FOERSTER, F., Time resolution of 50 um thin LGAD before and after irradiation in beam tests at https://indico.desy.de/conferenceDisplay.py?confId=16161

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Properties of diffractive events:

- proton kinematics
- central tracks
- rapidity gaps
- energy flow
- underlying event
- Bose–Einstein correlations ...also studies of non-intact protons

Hard diffraction:

- jets, jet-gap-jet
- photon + jet
- heavy quarks
- Drell-Yan, W
- pomeron structure
- gap survival probability



inclusive (soft) diffraction







anomalous coupling





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Beam pipe

wwwwwwwww

Bellow

- cylindrical: good RF behavior (≲1% of LHC impedance)
- a flat inside bottom in the pot
- thin window machined on the beam side (different from TOTEM)





University Alberta at Edmonton









| CST | | dB -3.13 - -8.13 - -13.1 - -18.1 - |
|--|---|--|
| | | -23.1 - -28.1 - -33.1 - -40.0 |
| Type Monitor Component Plane at x Maximum-2D Sample Time | E-Field e-field (t=05(0.05);x=0) [pb] Abs 0 33276 V/m (= 0 dB) at -9.15168e-011 / -7.425 / -7.2646 6 / 101 0.25 | y La z |









- technology: slim-edge 3D ATLAS IBL pixel sensors bonded with FE-I4 readout chips
- pixel size: $50x250 \ \mu m^2$
- single layer resolution: \sim 6 μ m in x
- 3(4) detectors in NEAR(FAR) station
- trigger in 2016: majority vote (2 out of 3; two chips in FAR station are paired and vote as one)
- from 2017 our trigger will be based on ToF detectors (A and C side); our trigger menu will change

| Production run | Wafer Yield | Good Wafers | Sensor Yield | Good Sensors |
|------------------|----------------|----------------|-----------------|-----------------|
| AFP 1 (Jan 2015) | 38 % | 5 | 23 % | 9 |
| AFP 2 (Apr 2016) | 83 % | 10 | 94 % | 75 |











cooling - Czech Technical University in Prague

COLD OUTLET

AFP was inserted into beam position during LHC intensity rampup in each intensity step up to 600 colliding bunches Study detector performance and alignment **•** Understand beam background and AFP trigger Commission AFP trigger and data taking with ATLAS Successful integration with ATLAS TDAQ.

AFP running **ICHEP 2016**

BEAMS 1(82):

PS: 203.49

sics run:

7.11e+12

IP:

| Date | Fills with AFP inserted | TDAQ Mode | PROTON PHYSICS: STABLE BEAMS |
|-------------------------|--------------------------|-------------|--|
| 19-22 April | Alignment and Loss Maps | Stand-alone | Energy: 6499 GeV I(81): 7.09e+12 I(82) Inst. Lumi [(ub.s)A-1] #1: 190.37 #2: 0.22 #5: 20 Inft. humanity and frame frame Updated 120471 Instantaneous luminously |
| 23 April | 3 bunches | Stand-alone | 1403) 1403) 1403) 1403) 1403 1405 14 |
| 24-25 April | 12 bunches | Stand-alone | |
| 29 April - 5 May | LHC power cut -> TDAQ in | ntegration | 2012 003 1899 1298 1698 1698 1698 1698 1998 - 1918 - 665 - (00 - 1965 |
| 7 May | 49/86 bunches | Integrated | Comments (07-Mr-2016 19:59:50) stable beams AFP nots in |
| 9 May | 300 bunches | Integrated | All Jon Ab. 24 47 20-11 |
| 13 May | 600 bunches | Integrated | APE CONLINE, A. A. APPENDING AND APPENDING AND APPENDING AND APPENDING |
| 31 July - 1 Aug | 600 b. Low-µ physics run | Integrated | LOW-H Physi |
| | | | 3/st of lui |
| | | | Ist of Alla |
| Ivan Lopez – AFP poster | ; ICHEP 2017 | | ""SUSt |

• successful insertions in $\beta^*=40$ cm optics

- ≤600 bunch runs (to limit ALFA radiation dose)
- max < μ > ~ 35, 15 hrs total, NO issues observed ...
- high- μ run 14 Oct
 - Insert AFP pots at "highest $\mu^{\prime\prime}$
 - 100b, <µ>≈34 (at AFP insertion) 1 hr (~2 pb⁻¹)

low- μ runs for AFP – 1 Aug, 8 Oct

- 600b: AFP run < μ >=0.03,0.5 with ~5 σ separation at P1
 - Duration: 4 + 5.5 hours $\sim 0.54 \text{ pb}^{-1}$
 - L1: AFP 25 kHz
 - HLT: AFP ~2 KHz

| Run number | Filling scheme | Pile-up |
|------------|---------------------------------------|-------------|
| | distance from first BBA | |
| 298609 | 25ns_49b_49_36_36_12bpi_5inj | 17.1 - 17.3 |
| 298633 | 25ns_86b_74_47_49_12bpi_9inj | 12.3 - 17.5 |
| 298773 | 25ns_313b_301_276_276_72bpi_7inj | 21.1 - 22.8 |
| 299055 | 25ns_601b_589_552_552_72bpi_11inj_alt | 18.6 - 19.3 |
| 305293 | Single_3b_2_2_2 | 26.5 - 27.8 |
| | distance from second BBA | |
| 309311 | Single_4b_3_1_1_1bpi_4inj | 35.4 - 36.3 |
| 310210 | Single_10b_9_2_2_BSRT_Calib_RampUp | 27.2 - 27.6 |

so, after very long time, a lot of effort

a comparison by eye

* one arm

AFP installed* and running!



analysis still ongoing - alignment (optics)...



AFP 2nd arm approved by ATLAS, after the review October 27th 2016 new component - ToF



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- resolution 10 ps or better for higher pileup
 30 ps for 1-st phase
- acceptance over full range of tracker
- near 100% efficiency
- segmentation for multi-proton timing
- high rate capability (~ 5 MHz/segment)
- L1 trigger capability
- radiation hardness







photos from last beam tests October 2016



final resolution after trigger subtraction – 20.6 ps

| contributions to time resolution | | | |
|----------------------------------|---------------------|--|--|
| MCP-PMT | < 10 ps | | |
| PAa Pab | 3-4 ps | | |
| CFD HPTDC | 5 ps 15-17-25 ps | | |
| reference clock | 6 ps (conservative) | | |



miniPLANACON[®] XPM85112 https://www.photonis.com/uploads/datasheet/pd/Mini-PLANACON-4x4-datasheet.pdf

improvement on the way chance for significant upgrade (3 ps)

Tomas Sykora: ATLAS Forward Detector

AFP 2+0 operational, data analysis ongoing, tracker works well

AFP 2+2 – installation

up to March 24 – installation of detectors in the far stations up to April 14 – installation of electronics

ToF (trigger) – first experiences in the tunnel...