# ATLAS Forward Proton detector status and future plans

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Instrumentation for Colliding Beam Physics Novosibirsk February 27<sup>th</sup> – March 3<sup>th</sup>, 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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28-Feb-2017

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  $\mu$ 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





![](_page_14_Picture_1.jpeg)

![](_page_15_Figure_0.jpeg)

![](_page_15_Figure_1.jpeg)

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 < $\mu$ > ~ 35, 15 hrs total, NO issues observed ...
- high- $\mu$  run 14 Oct
  - Insert AFP pots at "highest  $\mu^{\prime\prime}$
  - 100b, <µ>≈34 (at AFP insertion) 1 hr (~2 pb<sup>-1</sup>)

### low- $\mu$ runs for AFP – 1 Aug, 8 Oct

- 600b: AFP run < $\mu$ >=0.03,0.5 with ~5 $\sigma$  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!

![](_page_18_Figure_4.jpeg)

analysis still ongoing - alignment (optics)...

![](_page_19_Picture_0.jpeg)

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

![](_page_19_Picture_2.jpeg)

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![](_page_20_Figure_1.jpeg)

![](_page_21_Figure_1.jpeg)

- 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

![](_page_22_Figure_0.jpeg)

![](_page_23_Picture_1.jpeg)

![](_page_23_Picture_2.jpeg)

photos from last beam tests October 2016

![](_page_24_Figure_0.jpeg)

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)		

![](_page_25_Picture_2.jpeg)

miniPLANACON<sup>®</sup> XPM85112 https://www.photonis.com/uploads/datasheet/pd/Mini-PLANACON-4x4-datasheet.pdf

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

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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...