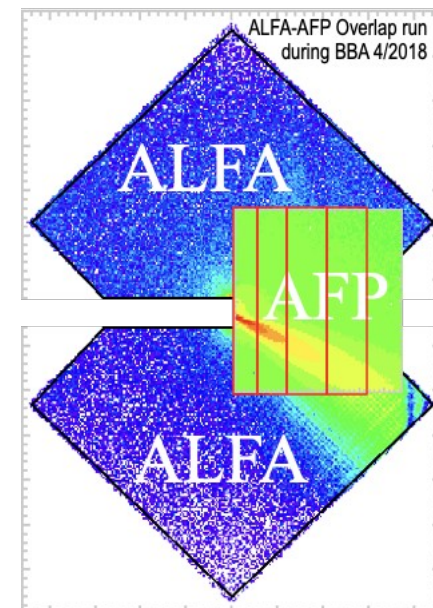
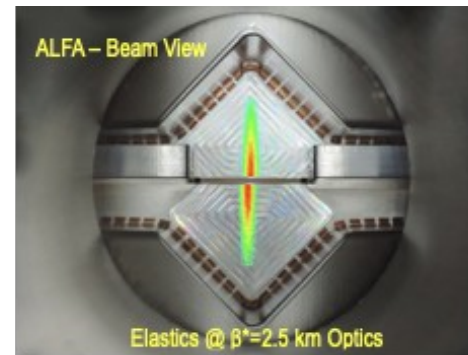
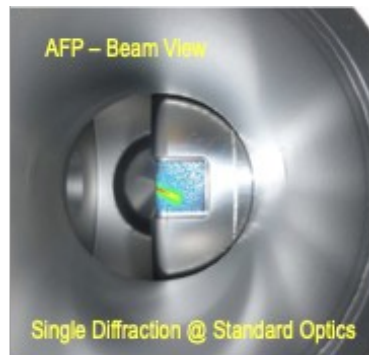
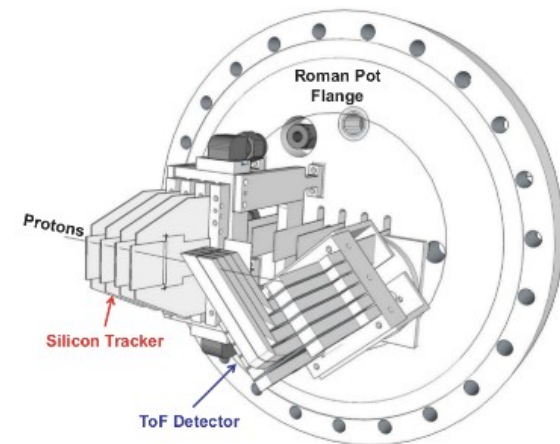
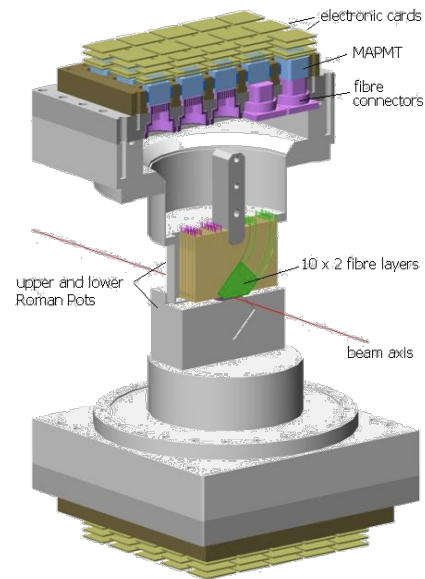


ARP Status

I. Lopez Paz on behalf of
ATLAS Forward Detectors
14th of December 2021
LHC Forward Working Group Meeting

14 December 2021

I. Lopez Paz
LHC Forward Physics meeting



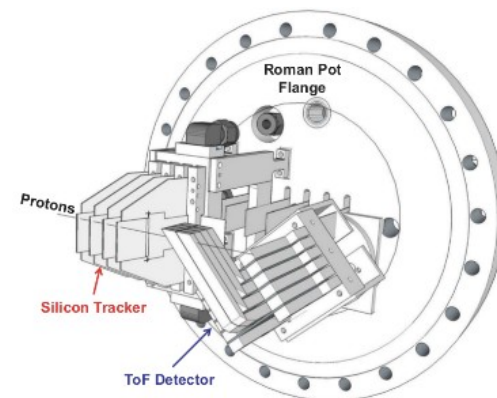
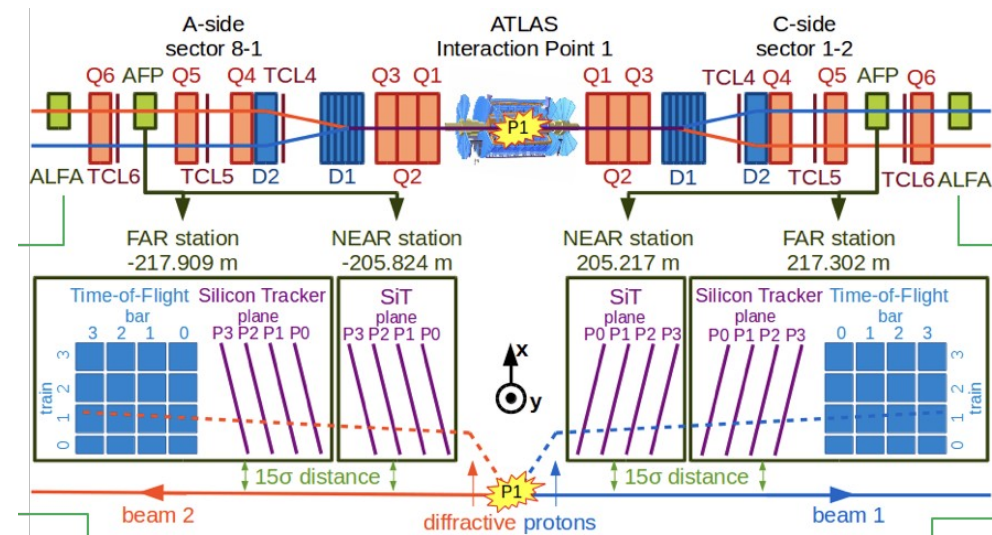
ARP: ALFA & AFP detectors

ARP (ATLAS Roman Pots) is the combination of all the Roman Pot detectors in the ATLAS experiment: ALFA and AFP

AFP (ATLAS Forward Proton, 2016):

- 4 horizontal stations at 210 m from the interaction point
- Focus on diffractive physics, for standard data taking
- Detectors:
 - **3D silicon pixel tracker detectors (SiT)**: for proton kinematics reconstruction
 - **L-shaped quartz cherenkov bars**: for time-of-flight (ToF) measurements → pile-up removal

ALFA (Absolute Luminosity For ATLAS, 2010)



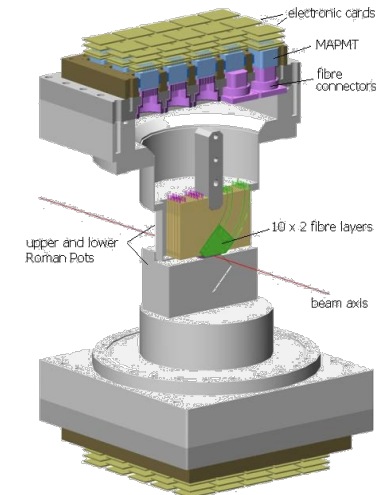
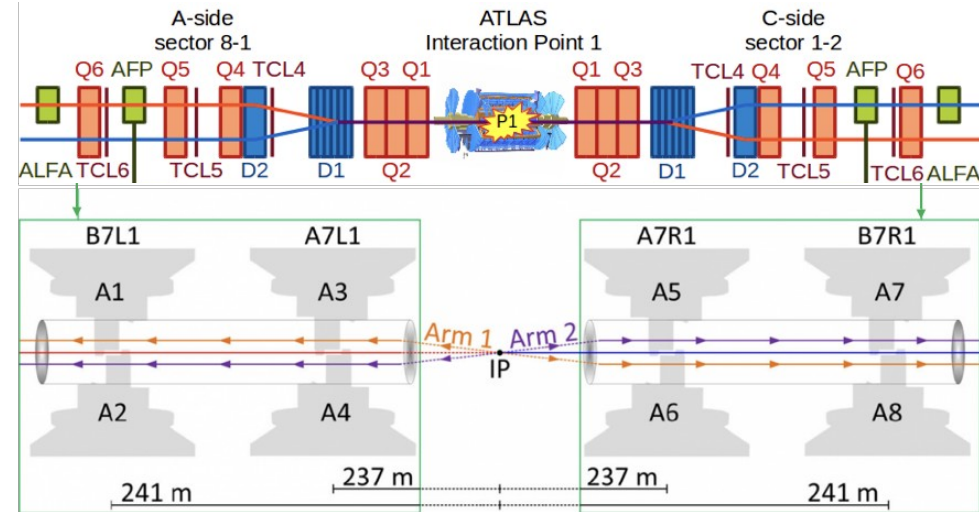
ARP: ALFA & AFP detectors

ARP (ATLAS Roman Pots) is the combination of all the Roman Pot detectors in the ATLAS experiment: ALFA and AFP

AFP (ATLAS Forward Proton, 2016)

ALFA (Absolute Luminosity For ATLAS, 2010):

- 4 vertical stations (8 pots) at 240 m from the interaction point
- Focus on pp total cross-section and elastic physics, special high β^* optics runs
- Detectors:
 - **Scintillating fibres** for proton kinematics reconstruction



AFP during LHC Run 2

In 2016 only one side populated with SiT detectors
→ low- μ runs only

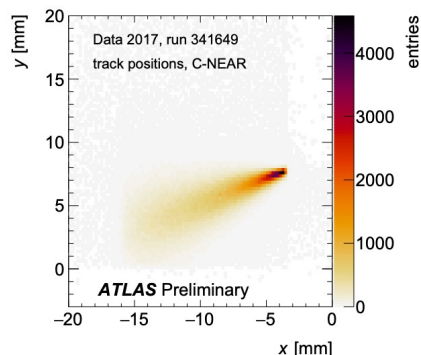
Full detector installed in the tunnel by 2017:
SiT+ToF in both sides of ATLAS

→ low- μ and standard data taking!

- **low- μ runs:** soft diffraction and (relatively low- p_T) hard diffraction,
- **high- μ runs:** photon induced processes

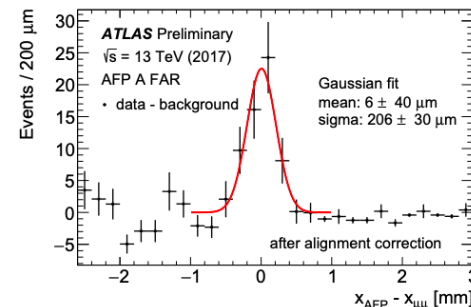
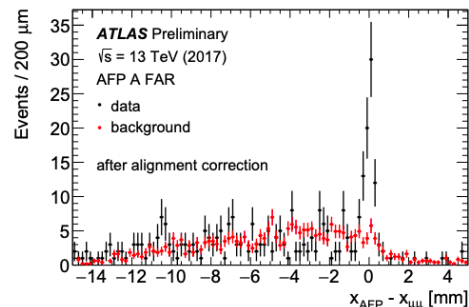
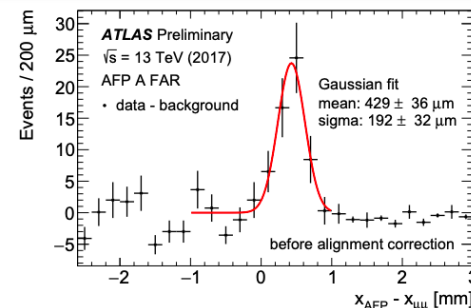
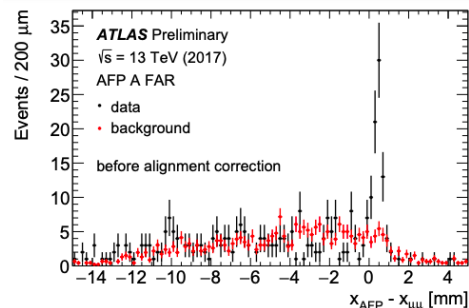
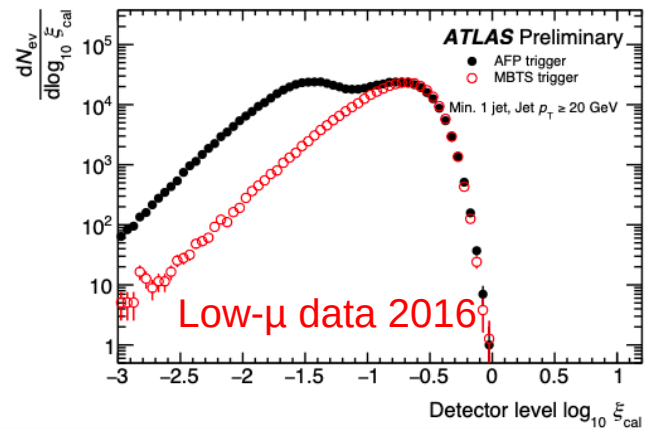
SiT operation and enough statistics:

- Allow for global alignment using exclusive $\mu\mu$ events



14 December 2021

I. Lopez Paz
LHC Forward Physics meeting



AFP during LHC Run 2 (cont)

ToF detector (2017) showed excellent time resolution

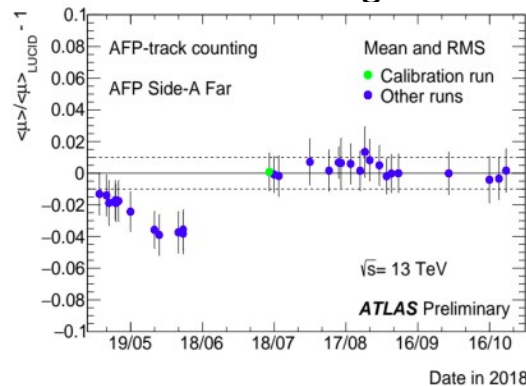
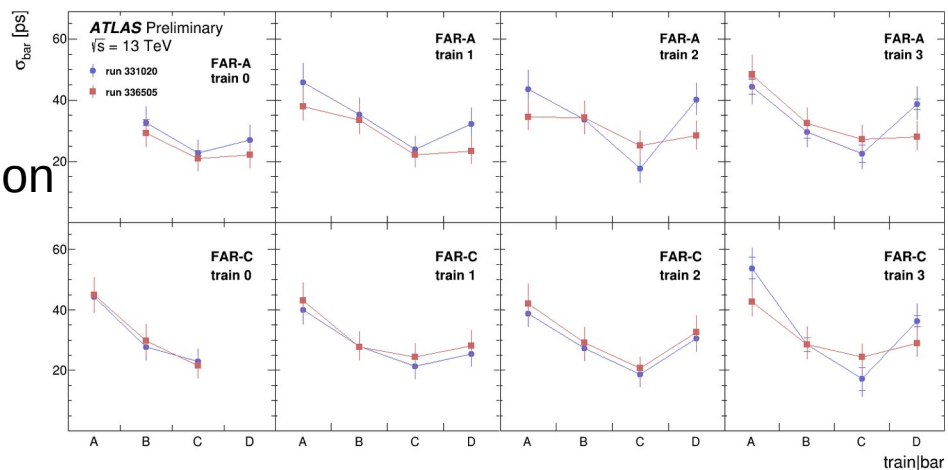
- Up to ~20 ps resolution
- Able to reach z-reconstruction resolutions of ~5 mm

However, efficiencies were of <10%

- Solution: lower gain, better access to MCP-PMT for replacements

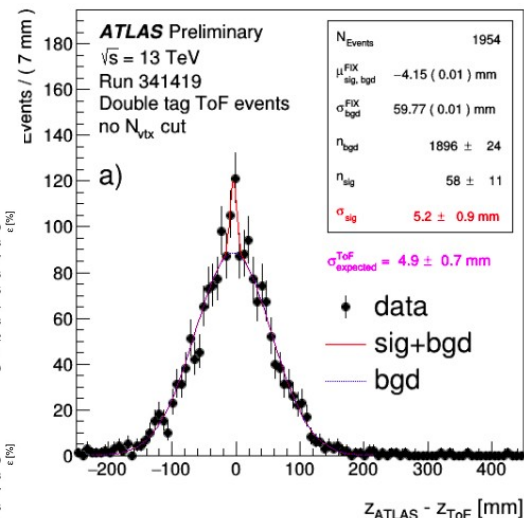
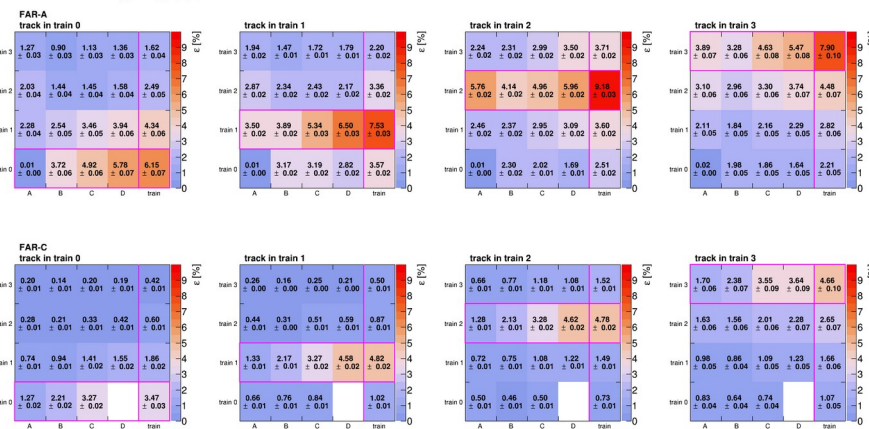
In 2018 AFP was running in the wrong BCID

- Data used for luminosity calibration
- Solution: more stringent tests



ATLAS Preliminary
 $\sqrt{s} = 13$ TeV

AFP/ToF efficiency in run 331020



14 December 2021

I. Lopez Paz
LHC Forward Physics meeting

AFP upgrades for Run 3

More accessibility to MCP-PMT for repairs

- **Out-of-Vacuum solution:** install Quartz bars in glass window and MCP-PMT outside the secondary vacuum
- Tested in testbeam campaigns at DESY (Sept. 2020) and CERN SPS (Aug. 2021)

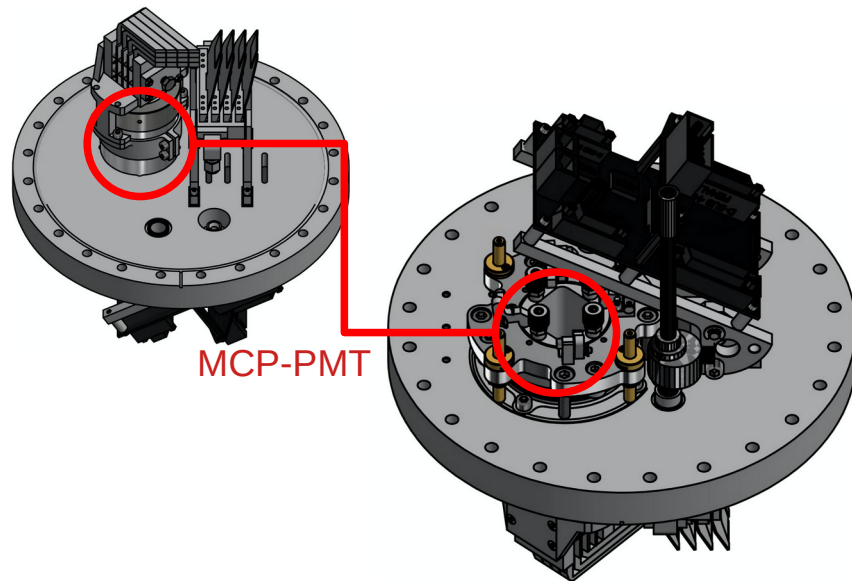
Low ToF efficiency was due to saturation in high gain – high rate regime:

- Studied ToF time resolution at lower MCP-PMT voltages/gains

A new TDC, the picoTDC, has been developed with improved timing resolution (\sim ps)

- Upgrade from High Precision TDC (HTDC, ~ 14 ps) to picoTDC

New digital trigger module with ToF pattern trigger capabilities, and pulser to test ToF outside collisions



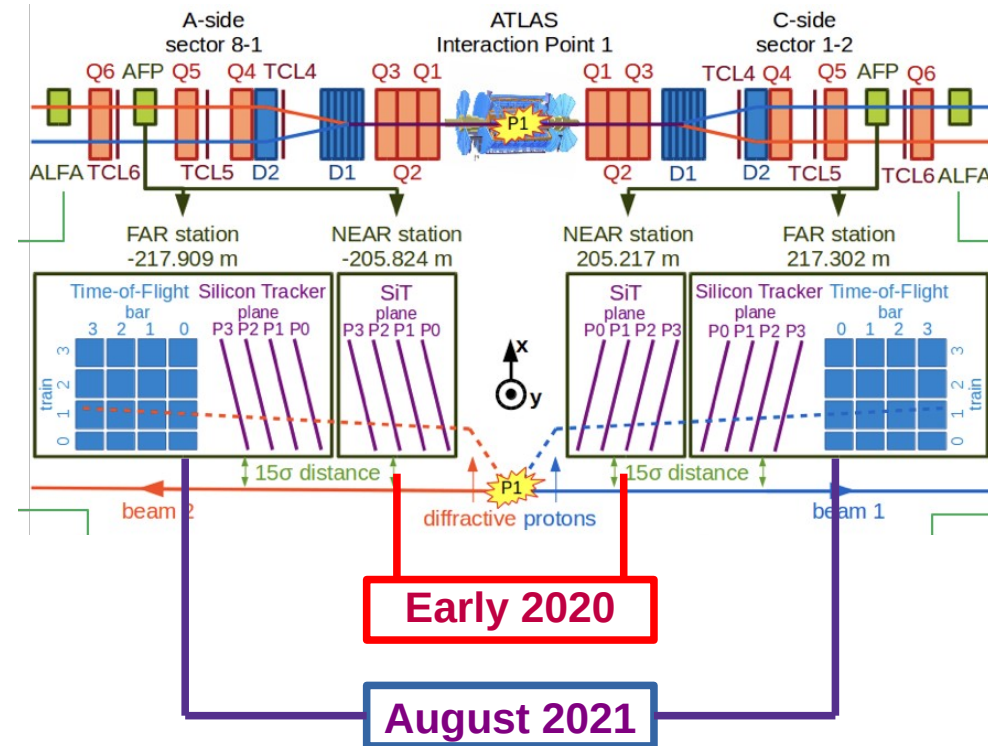
AFP installation in 2020/2021

Near stations were installed in early 2020, before lockdown

- Fresh un-irradiated SiT detectors to start Run 3

Far stations installed in August 2021 after ToF review passed

- New ToF detectors and OoV solution
- New ToF electronics
- Fresh un-irradiated SiT detectors
- 2 weeks of installation, many more of preparation!



AFP FAR station installation

Assembly of SiT and ToF:

- Individual detector packages assembled

Assembly of OoV solution:

- Finalised in mid-July and vacuum tests passed in both flanges

Electronics tests:

- Pulser was tested in the lab and trigger module was tested in the tunnel+USA15

SiT and ToF height calibration and installation in tunnel:

- Calibration done after repeating and passing vacuum tightness test
- Using CMM machine in b.180 thanks to NSW colleagues!
 - Installation of each station right after calibration

Survey and ToF crate installation:

- Survey was performed the week following the detector package installation in the tunnel thanks to survey team!
- Missing parts were installed the same week
- Pulser tests were done in tunnel, it works!

Many hiccups but a successful installation!
Thanks to everyone involved!

14 December 2021

I. Lopez Paz
LHC Forward Physics meeting



Metrology

Installation



Survey



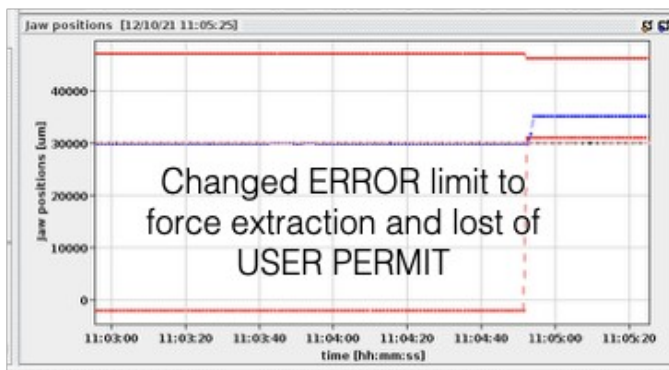
AFP BIS Validation

AFP to be moved to mid-way beam position during pilot beams (16 and 19 mm):

- Needs full Beam Interlock System validation for LHC safety

Interlock tests:

- **INJECTION PERMIT:** Removal of INJECTION PERMIT when out of HOME
- **LVDT box tests:** Safe self-retraction when PXI is down and recovery, HOLIDAY mode
- **USER PERMIT removal:** Removal of USER PERMIT when reaching an ERROR position, self-retraction in either WARNING or ERROR position
- **Interaction with beam modes:** similar, but LHC in STABLE BEAMS and ADJUST
- **DCS and Emergency button extraction**



LHC Control Favorites HWC General Diagnostics Print... Screenshot Stream Active Tasks					
CB 0515.01.02 - BIS Device Overview					
new History Buffer Expert View OBU Monitoring					
Permit	Timestamp	Visibility	Event type		
●	2021-10-12 11:04:52 009778	ALL	USER_PERMIT	3 B F-T	
●	2021-10-12 11:04:52 009778	ALL	USER_PERMIT	3 A F-T	
●	2021-10-12 11:04:52 009321	ALL	USER_PERMIT	3 A T-F	
●	2021-10-12 11:04:52 009321	ALL	USER_PERMIT	3 B T-F	
●	2021-10-12 11:04:52 008632	ALL	USER_PERMIT	3 B F-T	
●	2021-10-12 11:04:52 008632	ALL	USER_PERMIT	3 A F-T	
●	2021-10-12 11:04:52 008404	ALL	USER_PERMIT	3 A T-F	
●	2021-10-12 11:04:52 008404	ALL	USER_PERMIT	3 B T-F	
●	2021-10-12 11:04:52 008174	ALL	USER_PERMIT	3 B F-T	
●	2021-10-12 11:04:52 008174	ALL	USER_PERMIT	3 A F-T	
●	2021-10-12 11:04:52 007870	ALL	USER_PERMIT	3 A T-F	
●	2021-10-12 11:04:52 007869	ALL	USER_PERMIT	3 B T-F	
●	2021-10-12 11:04:52 007562	ALL	USER_PERMIT	3 B F-T	
●	2021-10-12 11:04:52 007562	ALL	USER_PERMIT	3 A F-T	
●	2021-10-12 11:04:51 837649	ALL	USER_PERMIT	3 A T-F	
●	2021-10-12 11:04:51 837649	ALL	USER_PERMIT	3 B T-F	

USER PERMIT was lost and recovered after retraction

BIS Validation passed before pilot beams!

AFP during pilot beams

New detectors in FAR stations installed, extra readout upgrades (VLDB and ALTI)

Survey and BIS validation done → pots inserted during stable beams (only after Loss Maps validation)

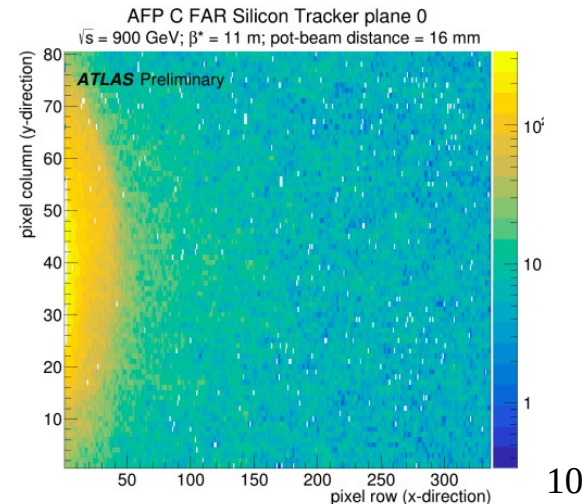
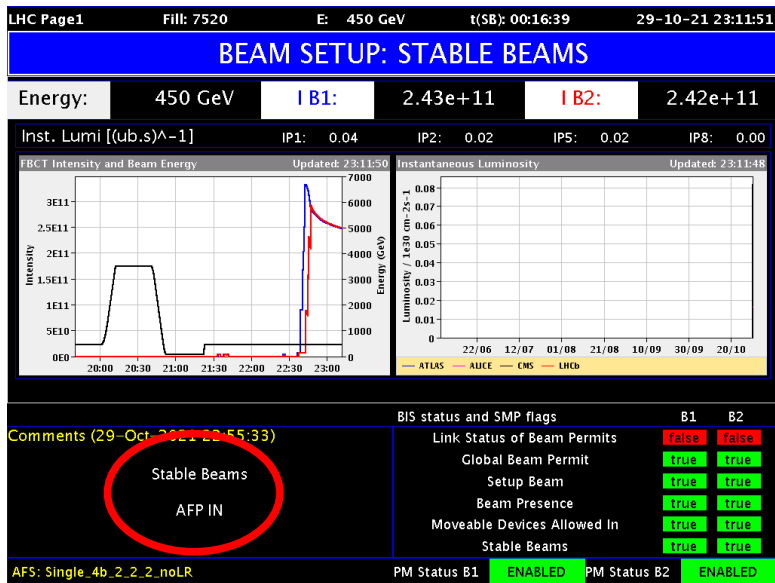
Goals:

- Timing-in SiT readout (in Standalone partition)
- Timing-in triggers
 - But will need to repeat for Run 3...
- Timing-in SiT readout (in Combined partition)
 - Problems with triggers, not enough statistics
- Tests with ToF detector and timing-in
 - Stuck in previous steps, no time for integration tests with beam

Useful exercise to repeat the process during the start of Run 3!

14 December 2021

I. Lopez Paz
LHC Forward Physics meeting



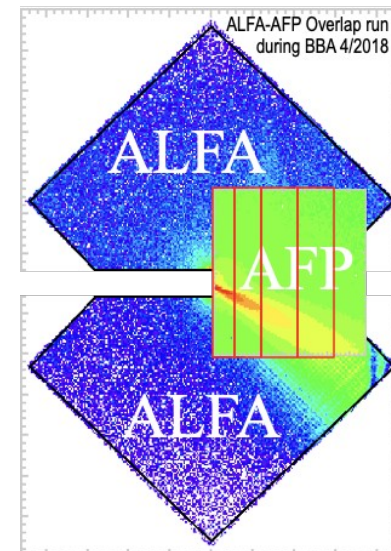
10

AFP preparations for Run 3

Next steps in preparation :

- Repeat BIS validation in 2022 (together with ALFA)
- Digital Trigger Module Decoder installation
- PicoTDC installation and integration
 - Subject to availability
- Commissioning of AFP before the LHC intensity ramp-up
 - Beam-based alignment with ALFA for insertion during stable beams
 - Timing in of triggers and readout during Loss Maps and BBA runs (experience from pilot beams)

Regularly participate in standard pile-up runs, low- μ run somewhere around 600 bunch step



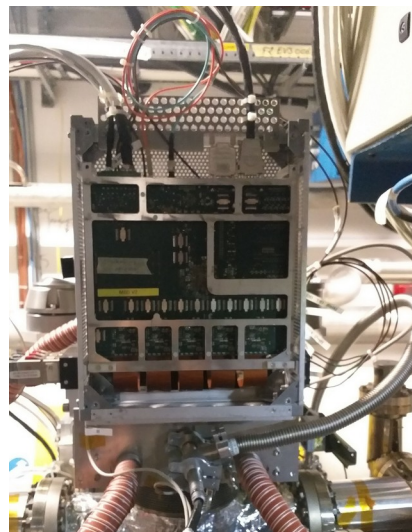
ALFA after Run 2

ALFA has been in operation since 2010

- End of ALFA life-time was planned by end of Run 2
 - However:
 - Detectors still surviving from radiation damage
 - New high β^* run for physics expected in early 2023
- Chances to extend ALFA life-time!

Preparations needed for Run 3:

- Replace rad. damaged read-out electronics (ongoing)
- Vacuum pumps close to end of life-cycle → refurbish and replace pumps (ongoing)
- Survey of Roman Pot stations (done)
- Re-commissioning of ALFA detector trigger and readout
 - During start of Run 3



Lots of work to do, but worth the effort

ALFA preparations for pilot beams: BIS pre-validation

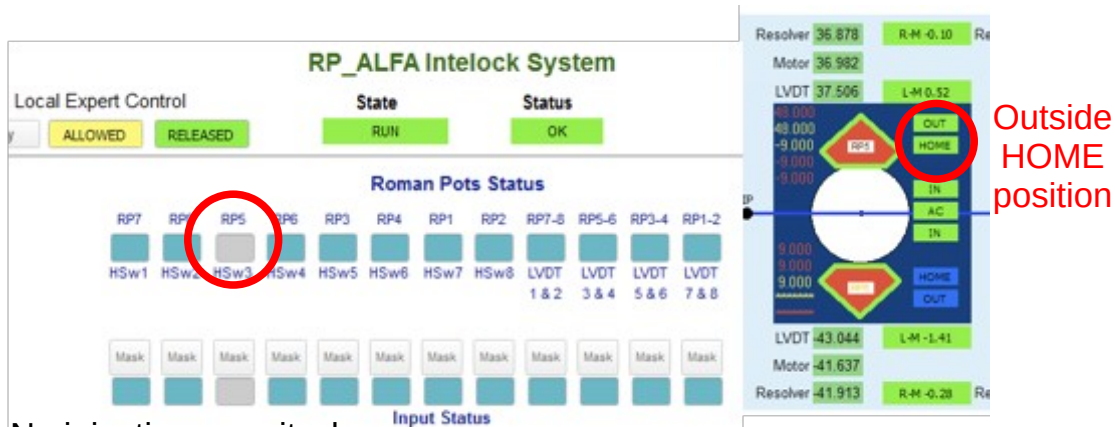
ALFA stays in HOLIDAY mode, i.e. impossible to move from garage for everybody (including LHC)

- Survey was not performed before pilot beams → insertion not possible
- Not full BIS validation needed

Partial Beam Interlock tests for safety:

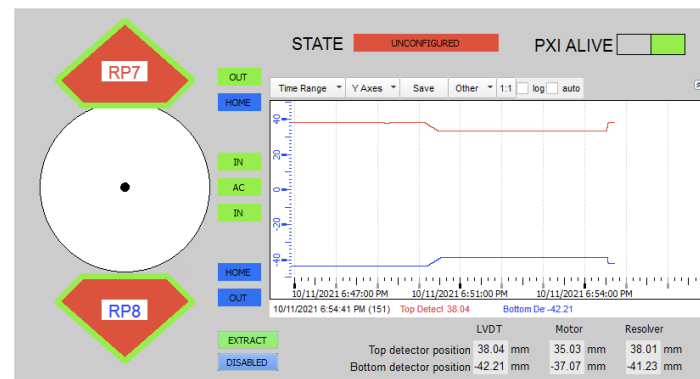
- **INJECTION PERMIT:** Removal of INJECTION PERMIT when out of HOME
- **LVDT box tests:** Safe self-retraction when PXI is down and recovery, HOLIDAY mode
- **DCS and Emergency button extraction**

Note that the full validation will need to be done after survey, in 2022



No injection permit when
outside from HOME position

Tests passed before pilot beams → safe in HOLIDAY mode!



ALFA during pilot beams

Partial Beam Interlock System Validation in week 41

→ Assure safety LHC operation when in garage

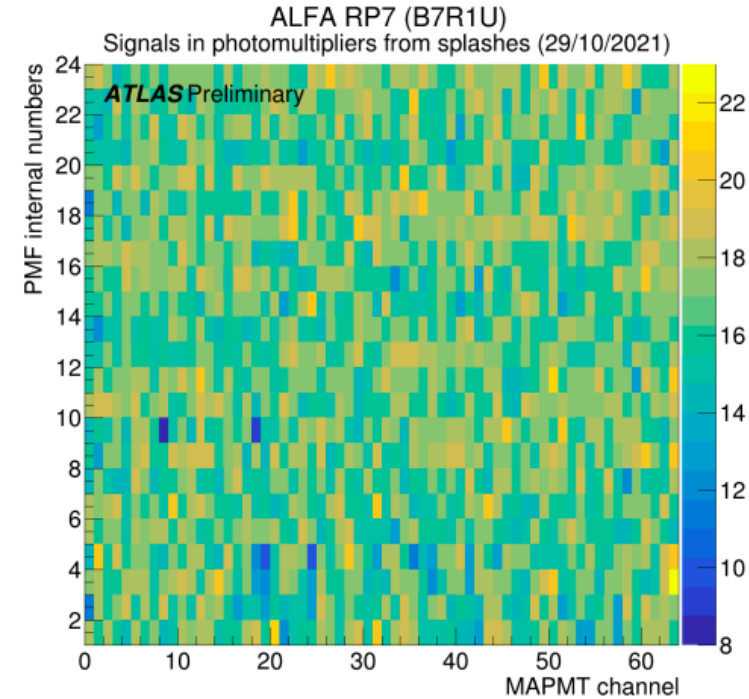
In garage position during the pilot, but with detectors powered on.

Successful participation in splashes

→ signal registered in all PMTs

→ Able to test a new read-out electronics motherboard with beam!

Successful participation in ATLAS combined runs → no major problems observed.



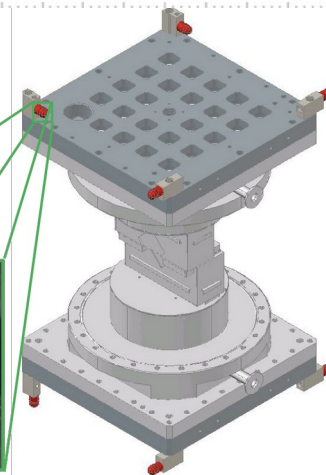
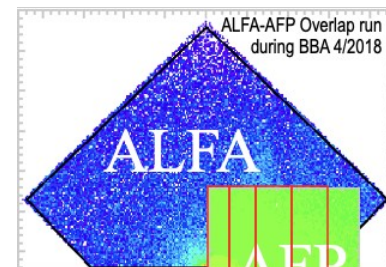
New motherboard installed
before pilot beams

ALFA survey and next steps

Survey was performed over 2 weeks after pilot beams → full BIS validation now possible!

Next steps:

- Full BIS validation in 2022 (together with AFP)
- Commissioning of ALFA with 2 new readout motherboards
 - Beam-based alignment with AFP for commissioning with stable beams
 - Timing in of triggers and readout over the beginning of Run 3
- Finish replacement of motherboards, commission new ones during a Technical stop
- Final testing of ALFA detector during 2022 high- β^* run
- Ready for physics run in 2023!



Conclusions and Outlook

AFP and ALFA are getting ready for Run 3

- AFP will run in low- μ and standard data taking runs
- ALFA will take physics data in its last high β^* run in 2023

AFP status

- All stations have been re-populated with detectors:
 - Near stations with new SiT detectors
 - Far stations with new SiT detectors, ToF detectors, upgraded mechanics and electronics
- AFP participated in the pilot beam being inserted out of home position
- Commissioning of SiT and ToF still to be finalised during start of Run 3

ALFA status

- ALFA getting ready for last high β^* physics run optics in 2023
- New read-out electronics boards have been tested in the lab, and are being installed to replace irradiated ones
- Commissioning of ALFA detector to be done over 2022

Back-up

