Prospects and Results from the AFP Detector in ATLAS

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on behalf of the ATLAS Collaboration

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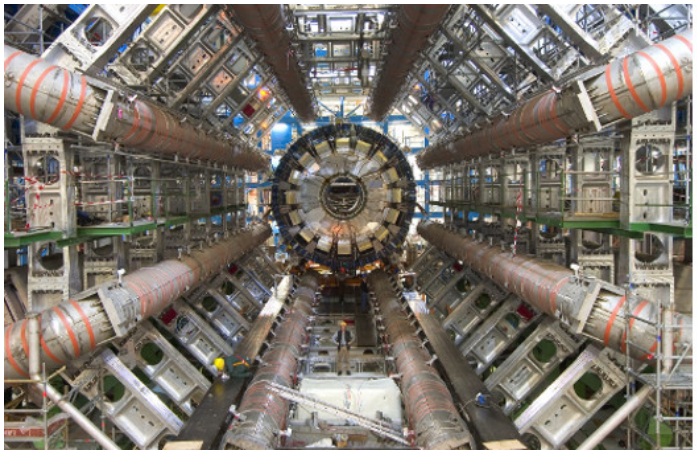
1 December, 2016

Multiple Partonic Interactions at the LHC 2016

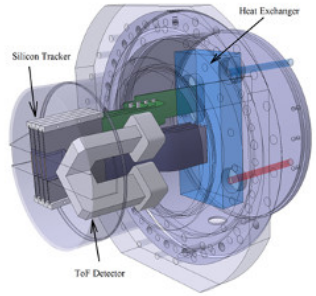
ATLAS Forward Detectors



ZDC

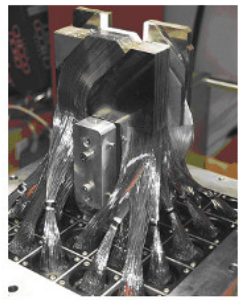
140 m

AFP



220 m

ALFA



240 m

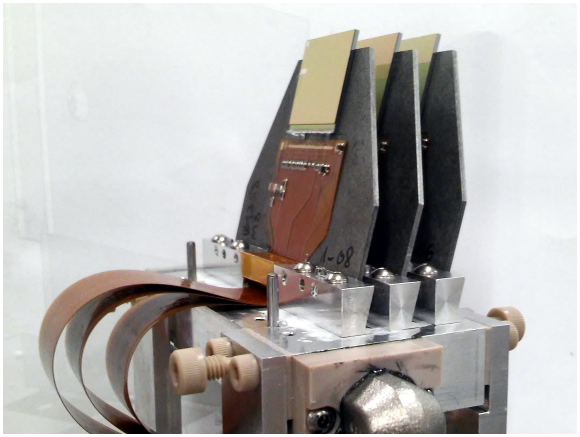
ATLAS Forward Proton

- detectors dedicated for diffractive processes measurements
- four stations — two on each side
- detectors mounted in horizontal roman pots
- 3D pixels and time-of-flight detectors
- acceptance in $\xi = (E - E')/E \approx (0.02, 0.12)$

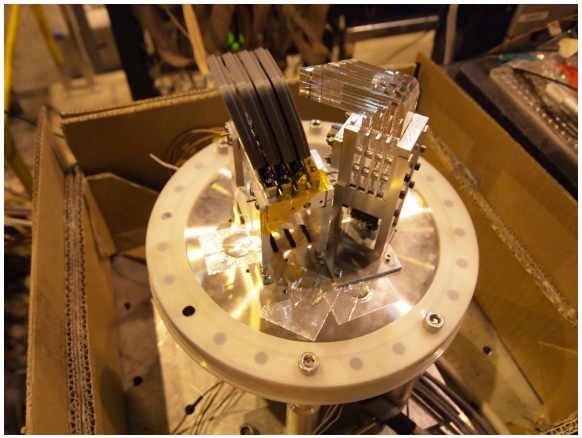
Possible Measurements

1. proton kinematics
2. rapidity gaps
3. gap survival probability
4. energy flow
5. event shapes
6. jets
7. jet–gap–jet
8. jet–photon
9. Pomeron structure
11. heavy quarks
12. Drell-Yan, W
13. exclusive jets
14. exclusive lepton production
15. photon–photon scattering
16. WW production
17. ZZ production
18. resonant production

AFP Installation



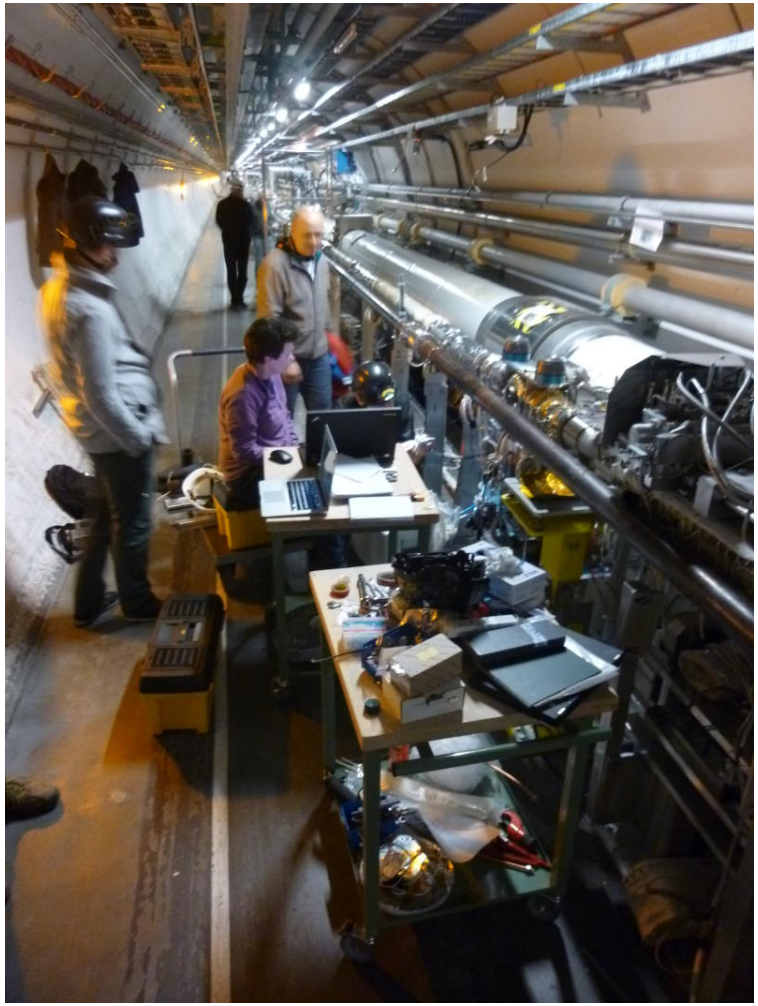
AFP 0+2 — 2016



AFP 2+2 — 2017

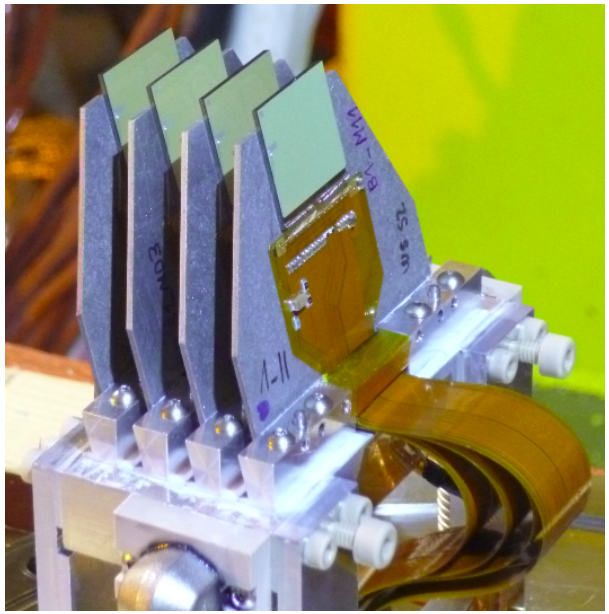
AFP 0+2 Installation

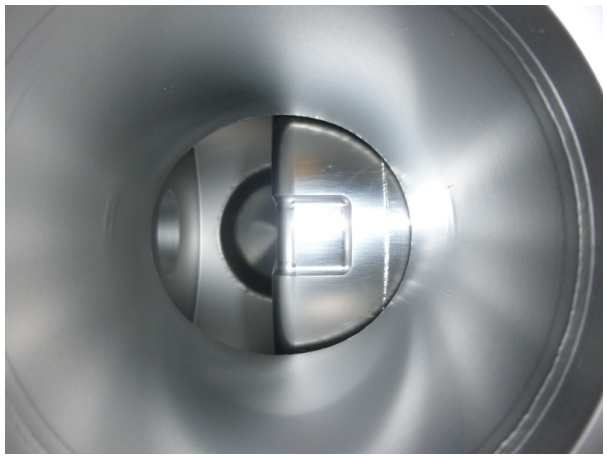
- ✓ installation of two stations on one side in the tunnel
- ✓ installation of tracking detectors in the stations
- ✓ LHC qualification
- ✓ integration with ATLAS DCS
- ✓ integration with ATLAS DAQ
- ✓ integration with ATLAS triggers
- ✓ data acquisition in special runs



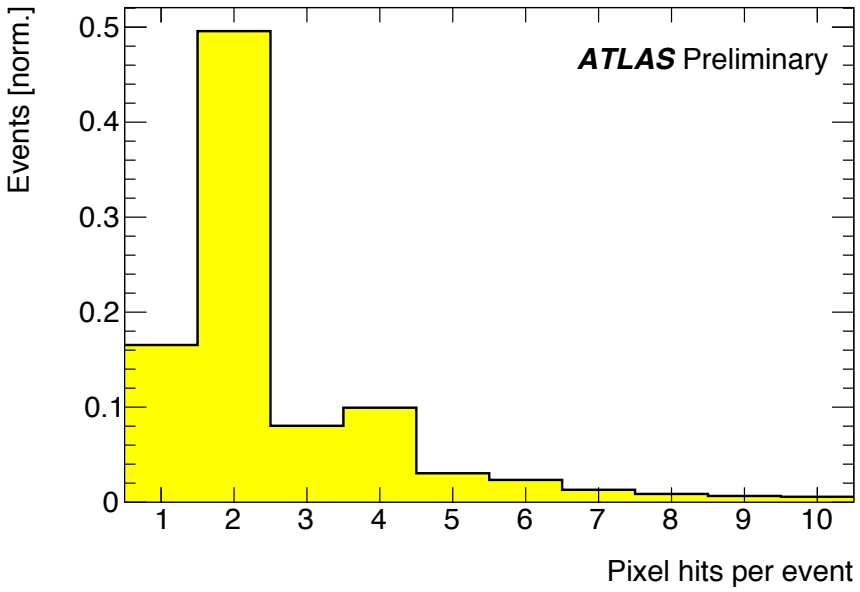
AFP 0+2

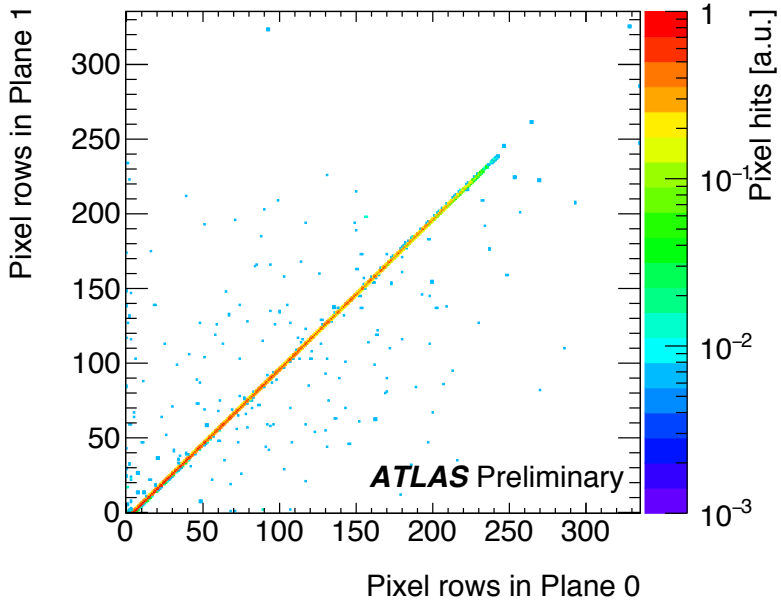
- 3(4) layers of pixel detectors in each station
- 336×80 pixels of $50 \times 250\,\mu m^2$
- pixel modules are similar to the ones used in ATLAS IBL with proven radiation hardness
- detectors are tilted by 14° with respect to vertical direction
- data collected in special low-μ runs with $\mathcal{L} \approx 500\,nb^{-1}$





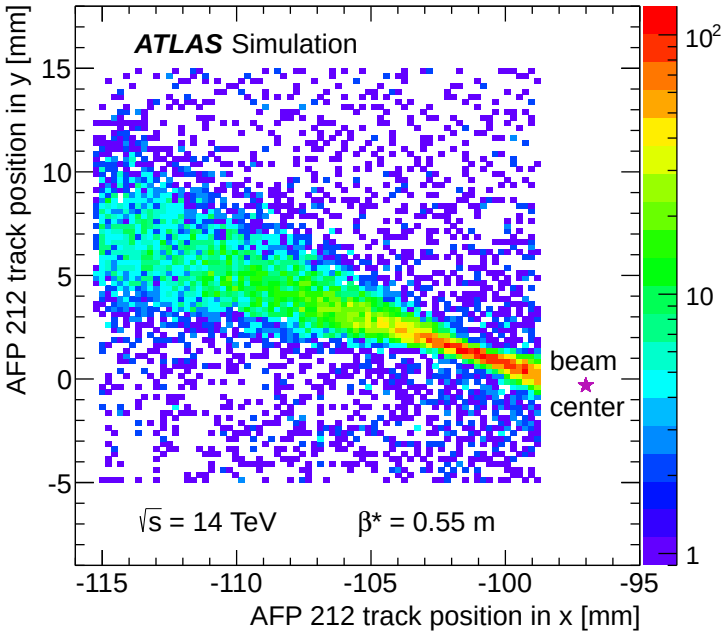
AFP 0+2 Performance

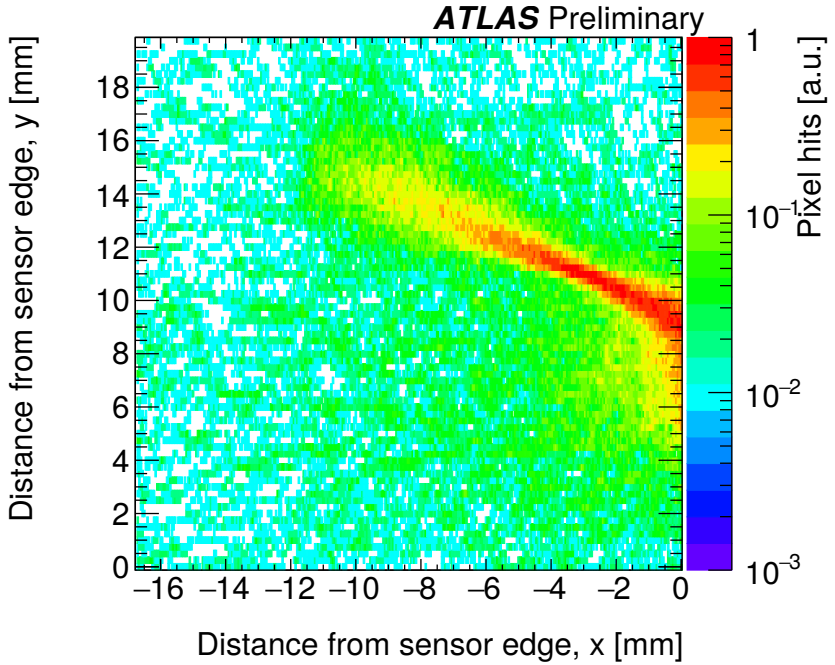




- in almost 50 % events 2 hits are observed in each plane
- very good correlation of hits between two planes (first and second)

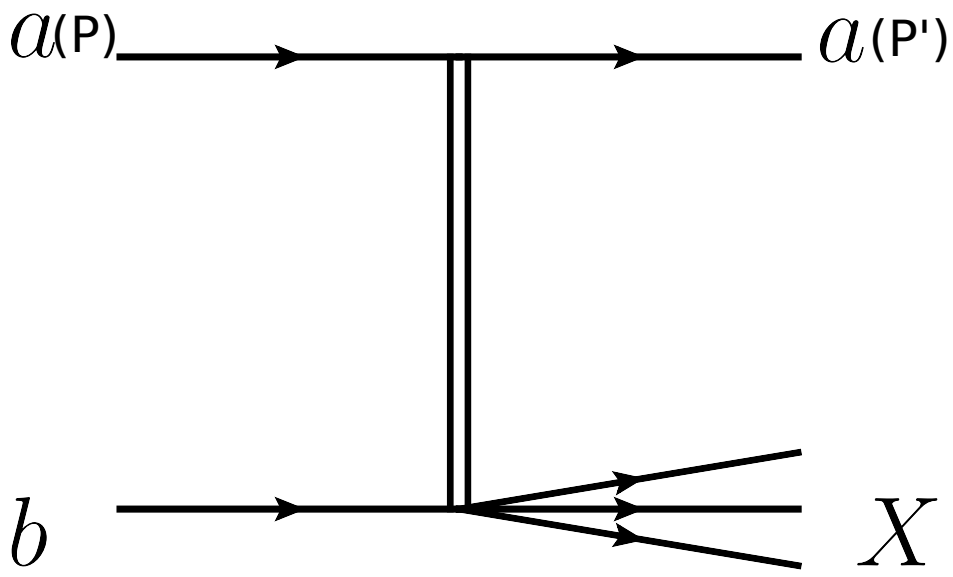
AFP 0+2 Performance





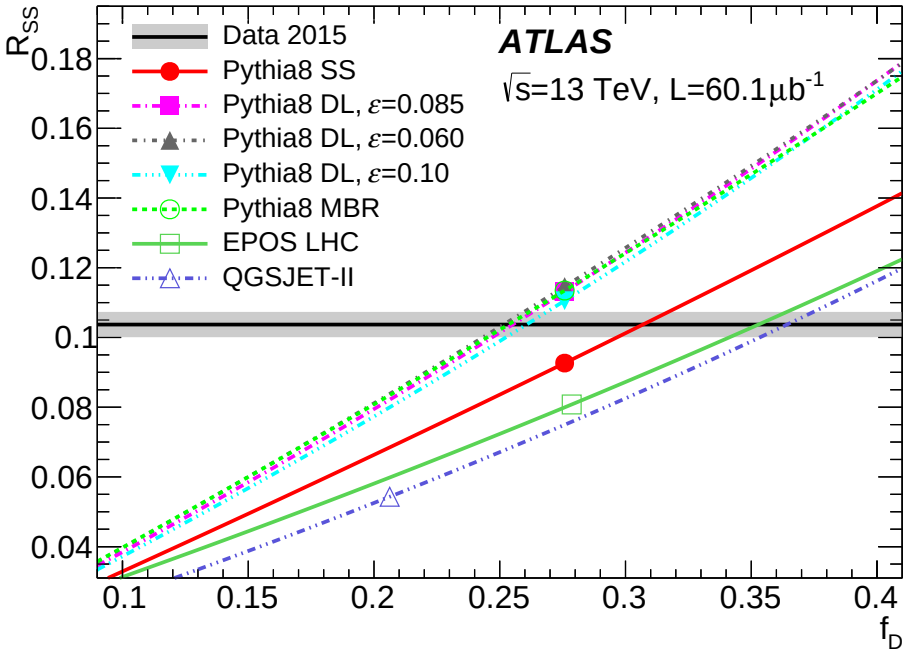
- hits in AFP near (205 m) station at $5\sigma + 400\,\mu$m from the beam centre
- visible pattern of diffractive protons

AFP 0+2 Physics Single Diffractive Dissociation

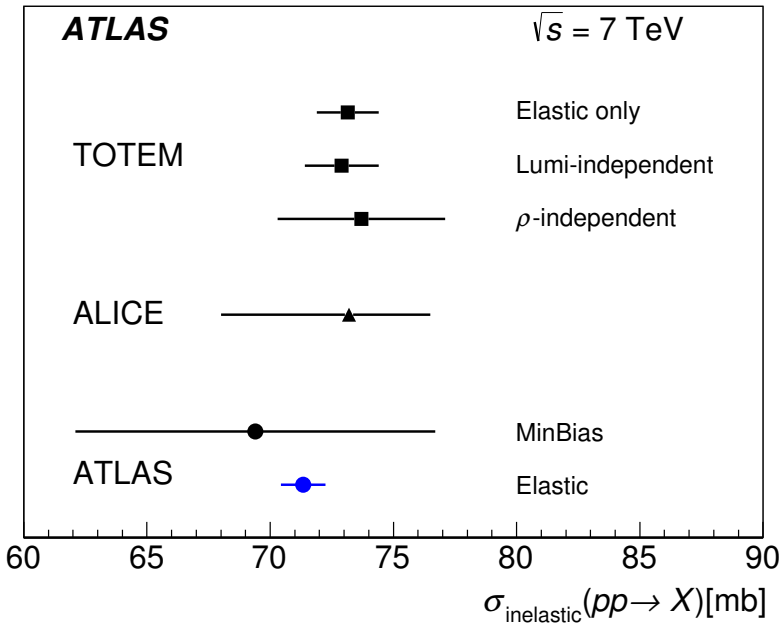


- relatively high cross section
- special runs with pile-up free environment provide clean events
- single proton detectable in AFP
- AFP provides access to so far non-measurable quantities like $\xi = (E - E')/E$ or $t = (\mathbf{P} - \mathbf{P}')^2$

AFP 0+2 Physics — Inclusive Single Diffraction



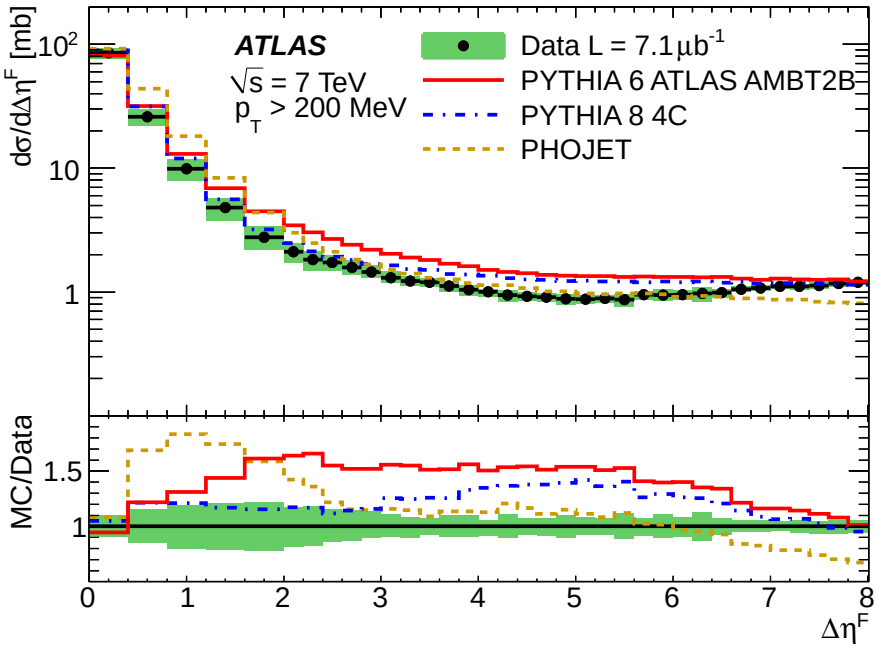
Phys.Rev.Lett. 117 (2016) 182002



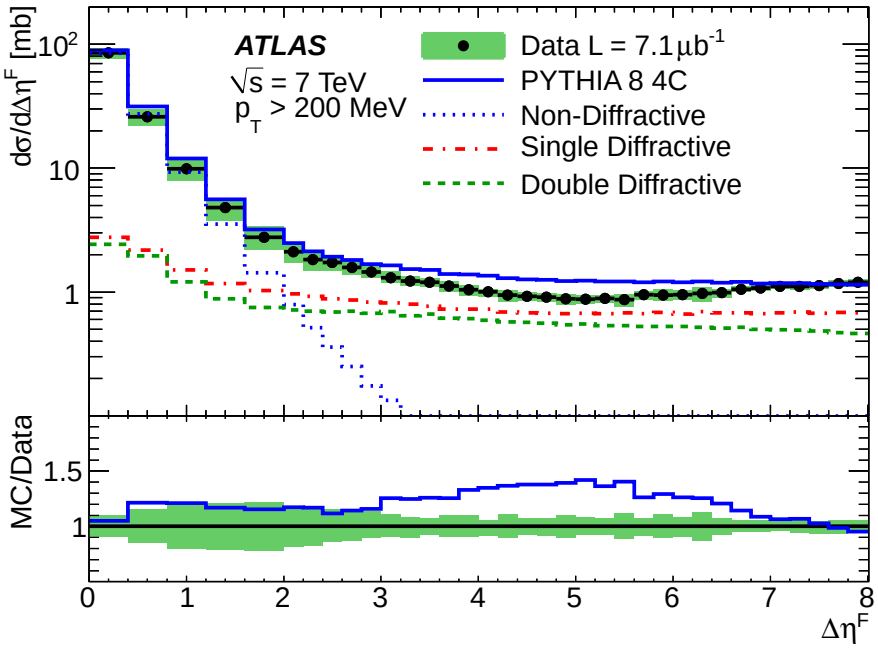
Nuclear Physics B (2014), 486-548

- $\sigma_{\mathrm{SD}\,+\,\mathrm{DD}}$ measured together with inelastic cross-section at 7 TeV and 13 TeV using MBTS signal on one side
- combination of ALFA and ATLAS $\sigma_{\mathrm{inelastic}}$ at 7 TeV gives σ_{SD} for $\xi < 5.1 \times 10^{-6}$

AFP 0+2 Physics — Inclusive Single Diffraction



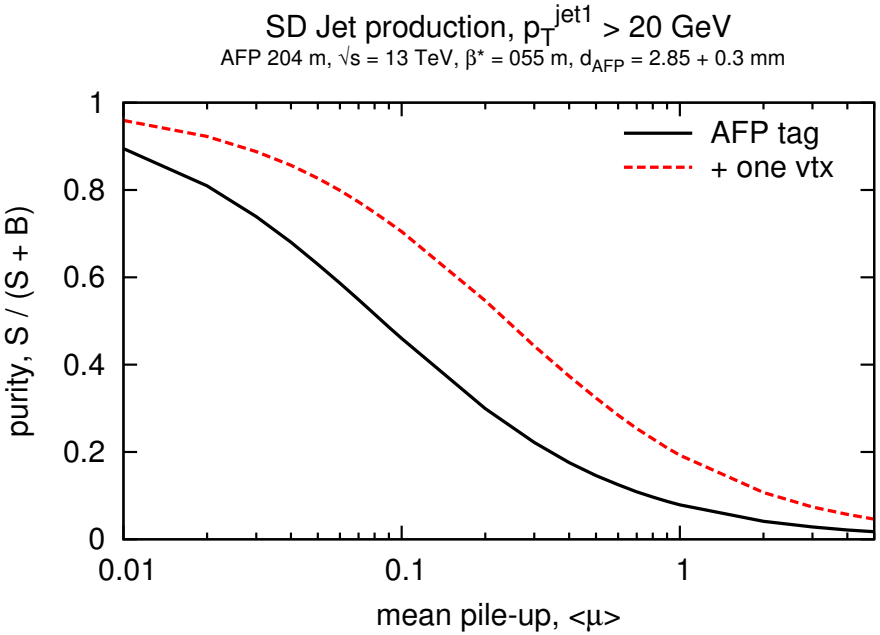
Eur. Phys. J. C72 (2012) 1926



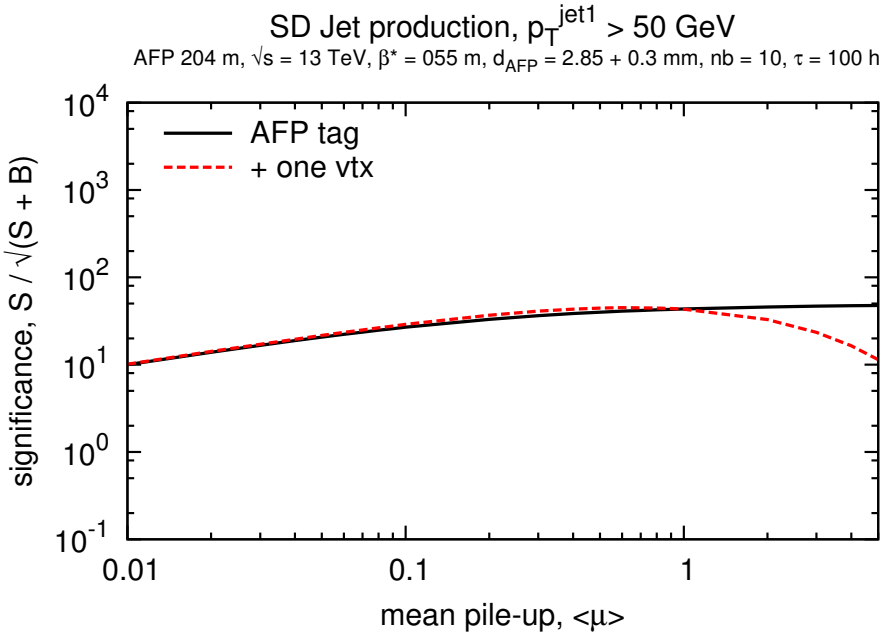
Eur. Phys. J. C72 (2012) 1926

- ATLAS dedicated measurement done only at $\sqrt{s} = 7\,\text{TeV}$
- possible large contribution of double diffraction background
- no measurement of differential cross sections $d\sigma/d\xi$ or $d\sigma/dt$
- improvement and extension of current measurements by tagging protons in 13 TeV

AFP 0+2 Physics — Single Diffractive Jets



ATLAS-TDR-024-2015



ATLAS-TDR-024-2015

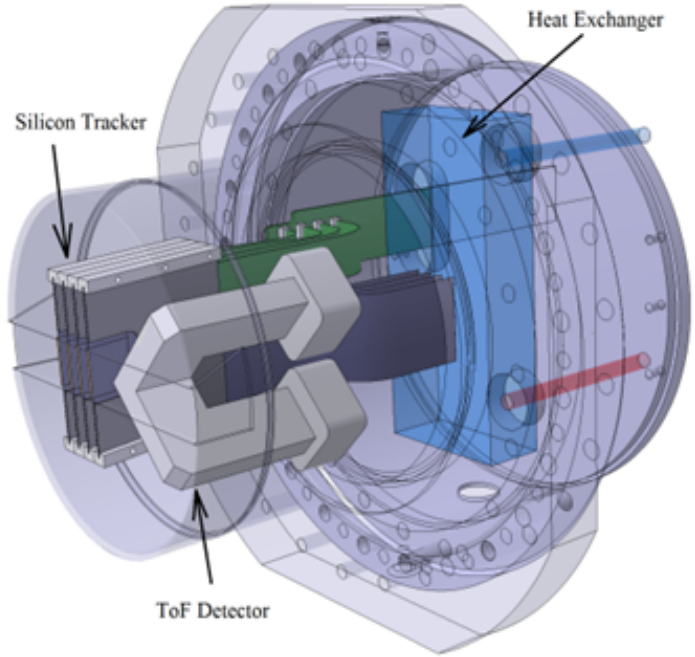
- probing Pomeron universality between ep and pp colliders
- measurement of gap survival probability
- Monte Carlo tuning

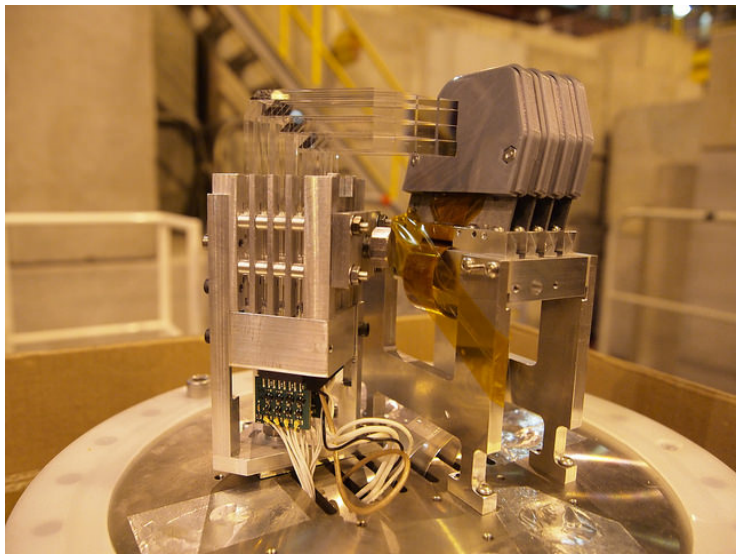
AFP 0+2 Summary

- ✓ despite challenging schedule the installation was successful
- ✓ very good detector performance
- ✓ collected more data than initially planned
- ✓ good data for soft diffraction analysis
- ✓ very good data for detector performance and background studies

AFP 2+2 Installation

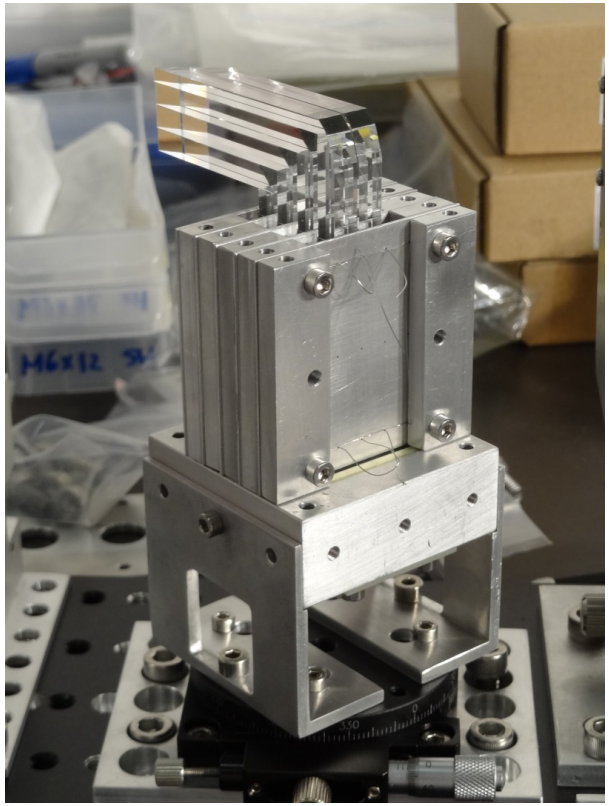
- installation of two missing stations on the other side in the tunnel
- installation of tracking detectors
- installation of timing detectors on both sides
- LHC qualification
- integration of timing detectors triggers with ATLAS
- data acquisition in special runs
- data acquisition in standard runs



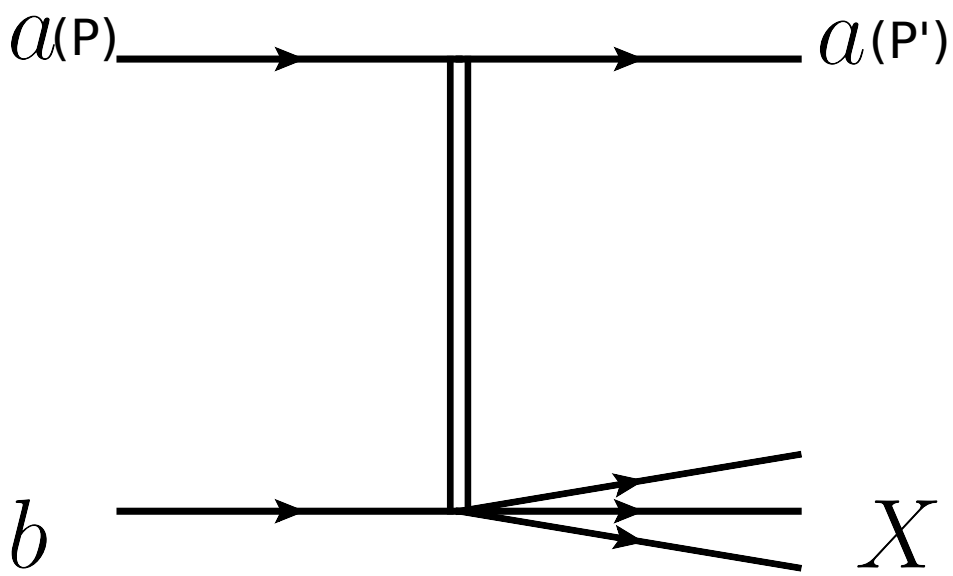


AFP 2+2 Time-of-Flight Detectors

- time resolution 10 ps or better
- efficiency not smaller than 90 %
- fast enough to provide trigger signal
- pile-up background reduction
- useful but not critical in special low-μ run
- necessary in standard runs with high pile-up

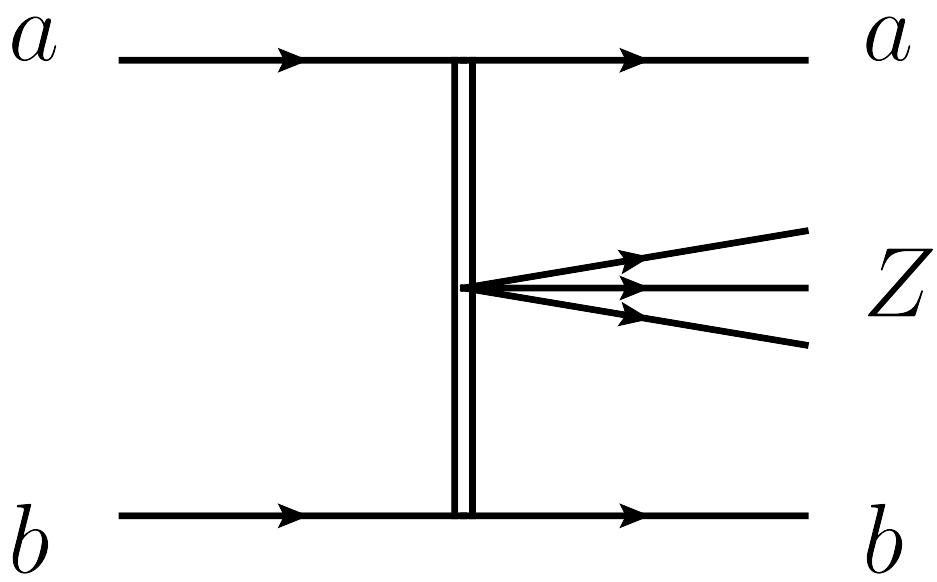


AFP 2+2 Physics — Single Diffractive Dissociation



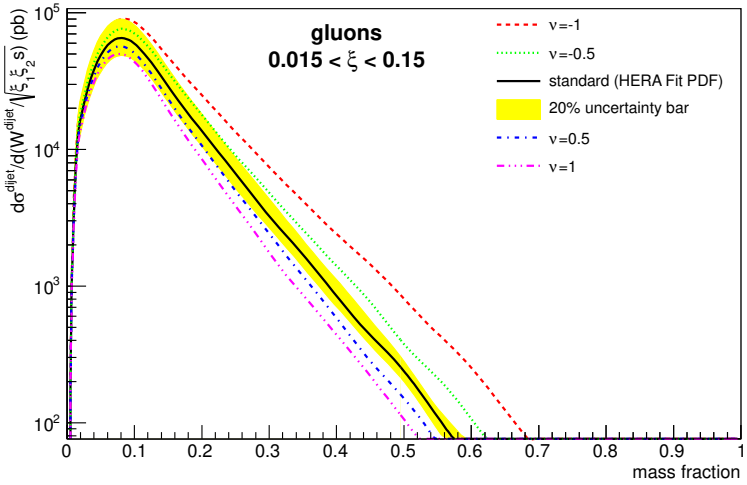
- only in special low-μ runs
- clean pile-up free environment
- doubled number of events with respect to AFP 0+2

AFP 2+2 Physics — Central Diffraction

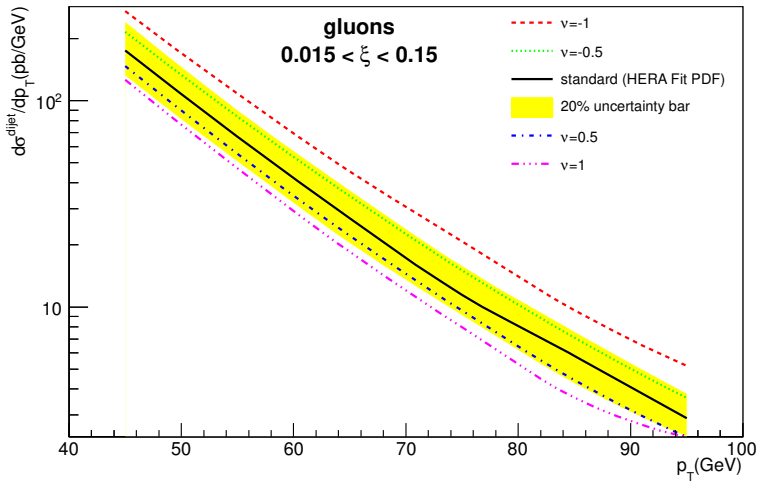


- special as well as standard runs give access to processes with medium and relatively small cross-sections
- double proton tag with time measurements allows direct observation of central diffraction with suppressed backgrounds (including pile-up)
- direct access to proton kinematics

AFP 2+2 Physics — Central Diffractive Jets



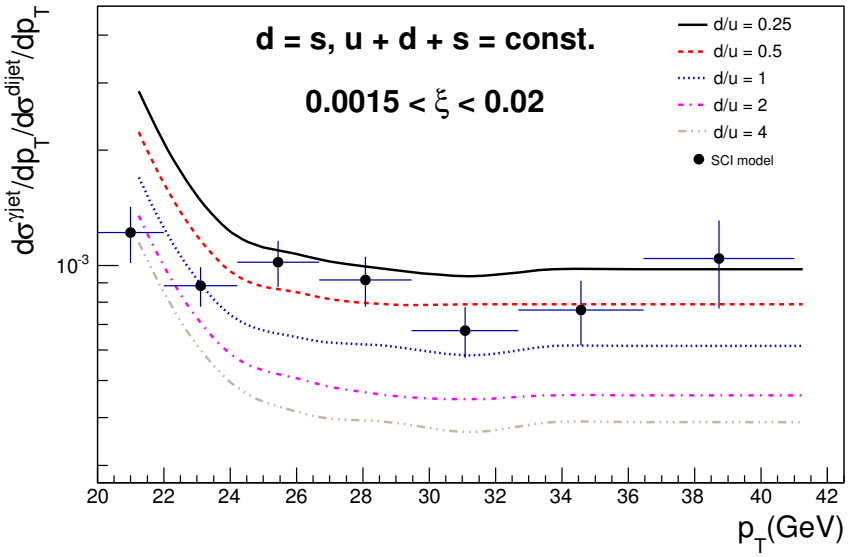
Phys.Rev. D88 (2013) no.7, 074029



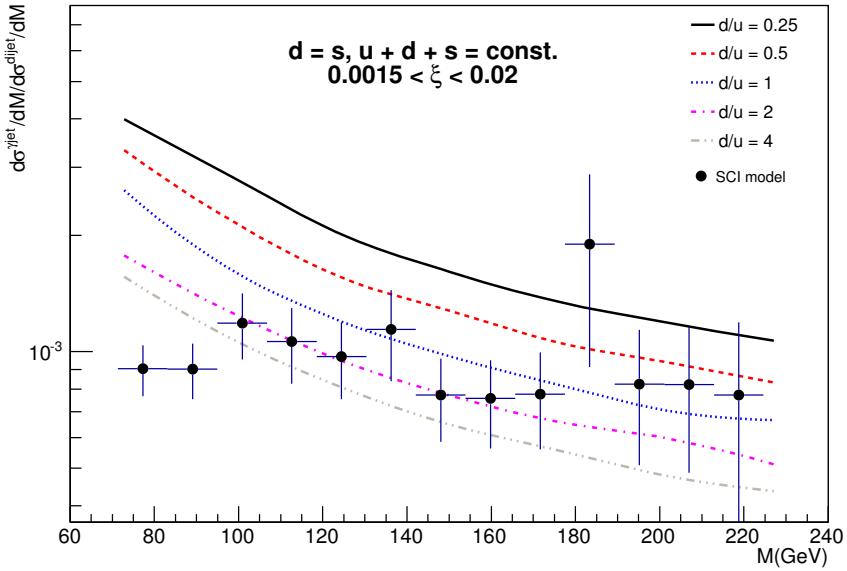
Phys.Rev. D88 (2013) no.7, 074029

- probing gluon structure of Pomeron
- sensitive to gap survival probability
- testing Pomeron universality between *ep*–*pp* colliders

AFP 2+2 Physics — Central Diffractive γ–jet



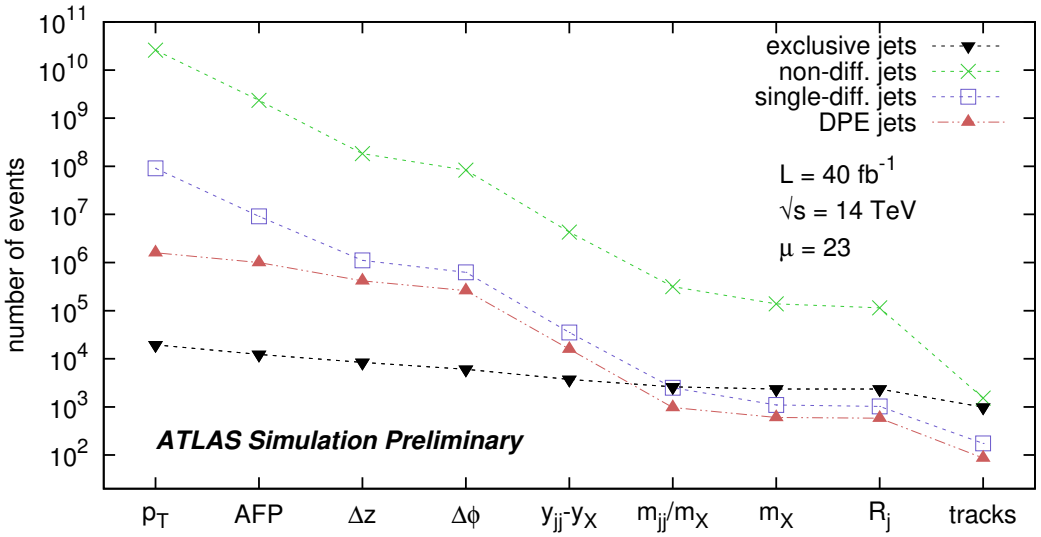
Phys.Rev. D88 (2013) no.7, 074029



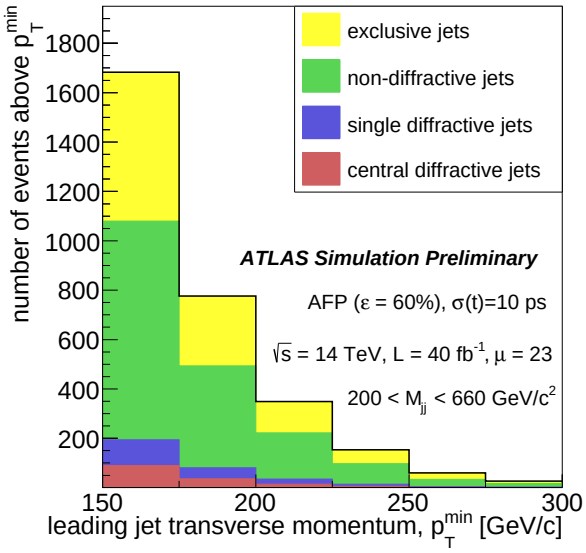
Phys.Rev. D88 (2013) no.7, 074029

- probing quark structure of Pomeron
- testing Pomeron universality between ep–pp colliders
- interesting variables p_T and $M = \sqrt{s\xi_1\xi_2}$

AFP 2+2 Physics — Exclusive Dijets



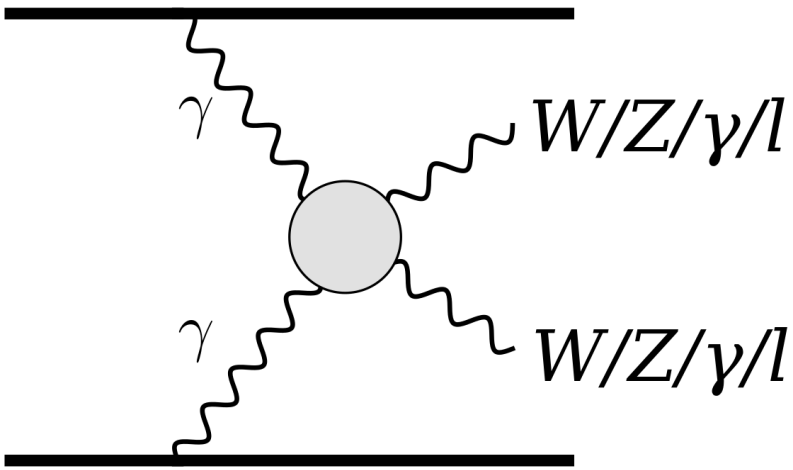
ATL-PHYS-PUB-2015-003

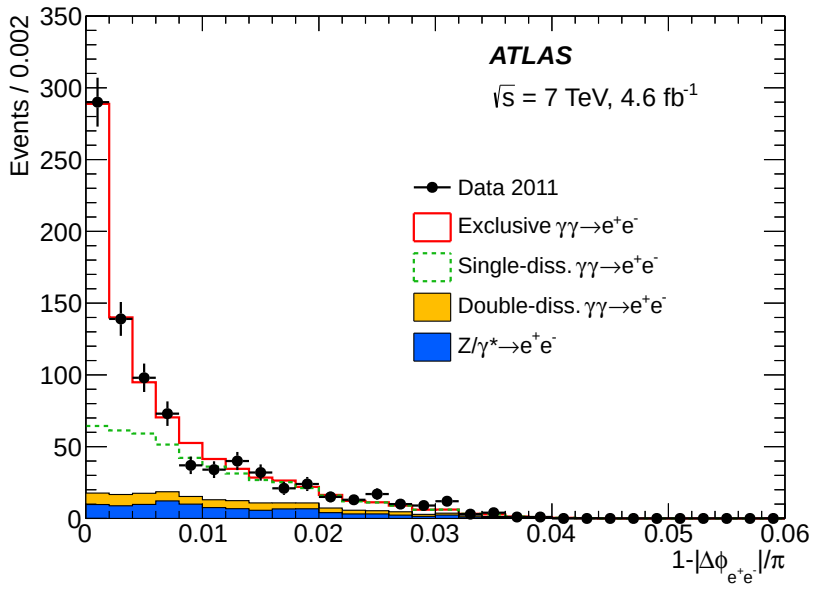


ATL-PHYS-PUB-2015-003

- calculations can be done using QCD without Pomeron
- no Pomeron remnants
- sensitive to unintegrated gluon PDF
- sensitive to rescattering corrections
- analysis inspired by Khoze, Martin, Ryskin publications

AFP 2+2 Physics — γ–γ Processes





Physics Letters B 749 (2015) 242-261

- improvement and extension of existing measurements
- exclusive lepton production with tagged protons
- possible new physics with anomalous quartic couplings (W and Z production)
- very good background rejection for $\gamma\gamma$ production

Summary

- very successful first stage of AFP installation AFP 0+2
- data collected in 2016 are interesting not only from detector performance point of view but also physics
- next year final installation stage AFP 2+2 will be completed
- reach physics program for special low-μ focused mainly on soft diffraction
- timing detectors open access to measuring protons in high pile-up conditions and allow measuring processes with small cross sections