ATLAS Roman Pots ALFA/AFP in Run-2

Rafał Staszewski

on behalf of the ATLAS Collaboration

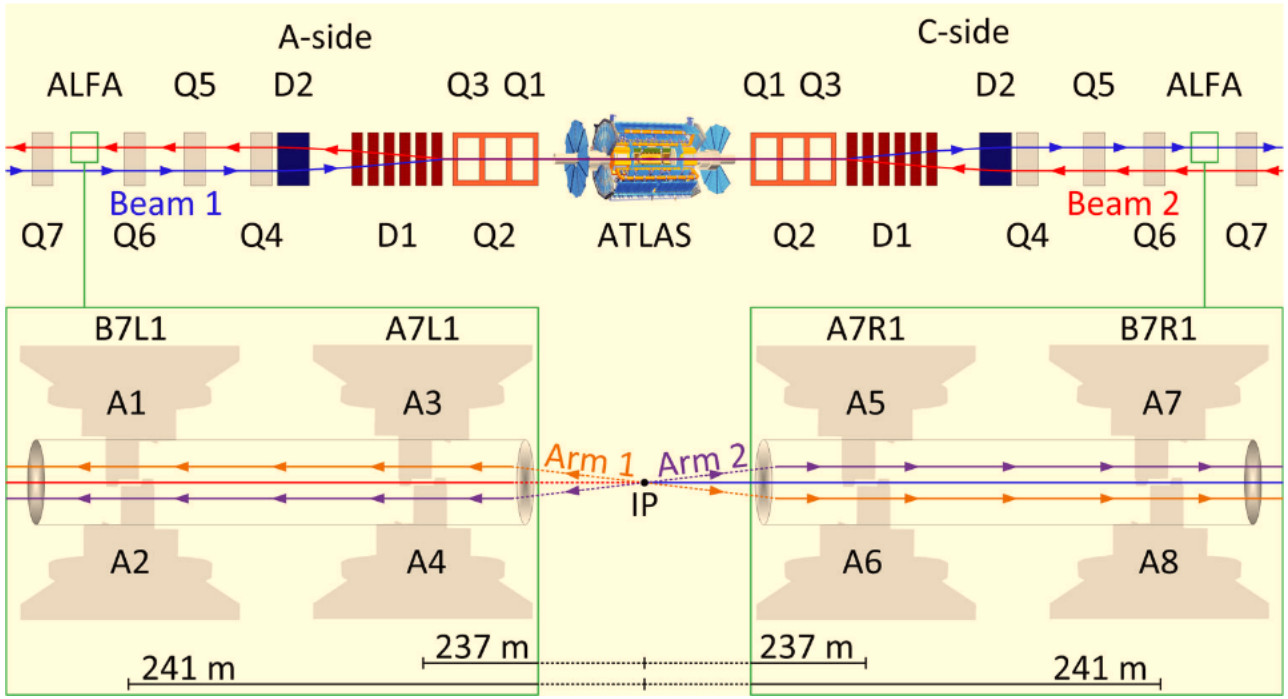
Henryk Niewodniczański
Institute of Nuclear Physics
Polish Academy of Sciences
(IFJ PAN Cracow)

LHCC Forward Proton Session

25 November 2014

Contents

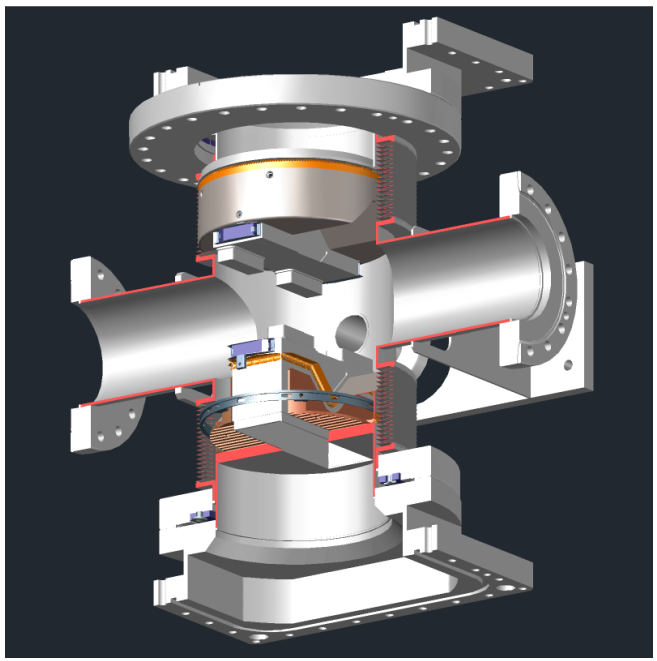
ALFA – introduction



- Vertical roman pots
- 8 detectors, 4 stations
- 237 and 245 m from IP
- Scintillating fibre technology
- UV geometry
- Designed for dedicated runs
- Neither detectors nor electronics are radiation hard

ALFA – activities during LS1

- Improve trajectory angle measurement – outer stations moved away from IP, distance between stations: 4 m $\rightarrow$ 8 m
- New trigger module ALFA_CTPIN – allows using ALFA trigger signals for ATLAS triggering
- Reduce RF losses – ring ferrites
- Improved heat distribution from roman pots to flanges
- Estimated heating reduction factor: 50 (should be safe)

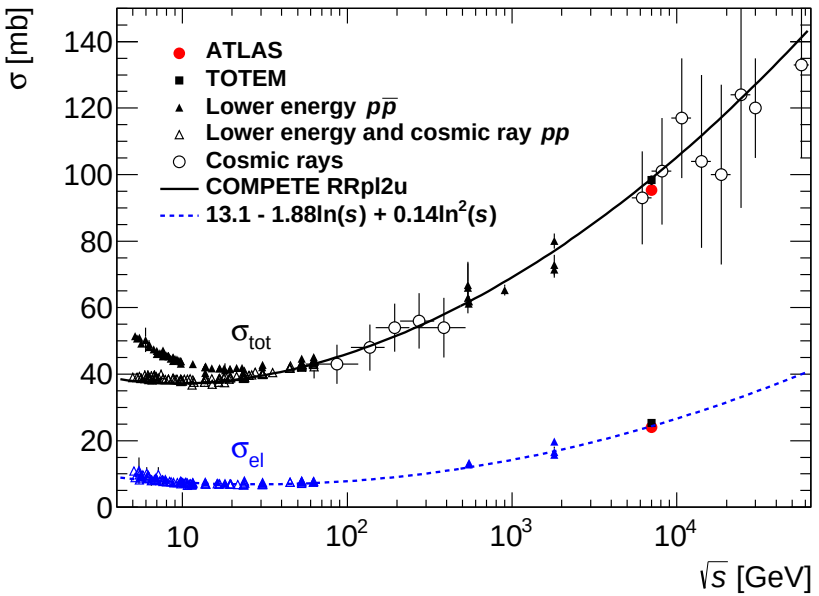


- Replacement of one detector (bad resolution, broken fibres, ...)
- Trigger front-end upgrade – reduces analog dead time from $\sim$550 ns to 87.5 ns. Now possible to run with 700 bunches (100 ns bunch spacing).

ALFA – physics status

1 Elastic scattering

- 7 TeV, 90 m optics: paper published JHEP 1410 (2014) 141
- 8 TeV, 90 m optics: analysis ongoing
- 8 TeV, 1 km optics: analysis started (more background, unfavourable phase advance)

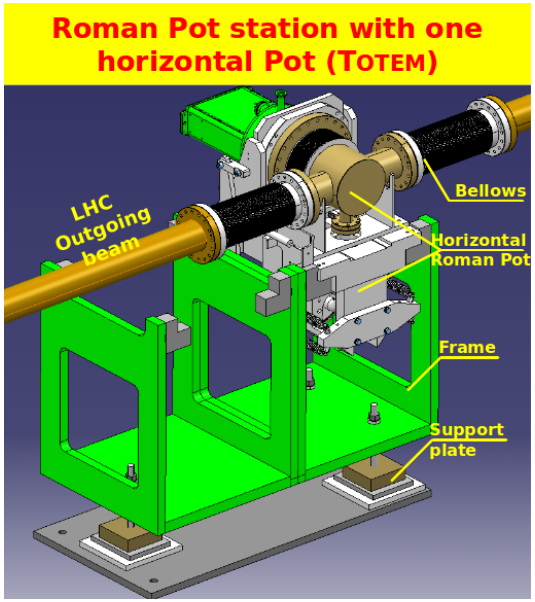


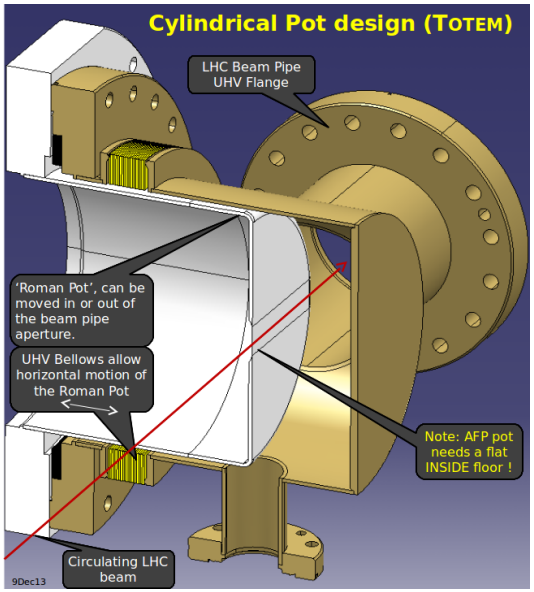
2 Diffraction

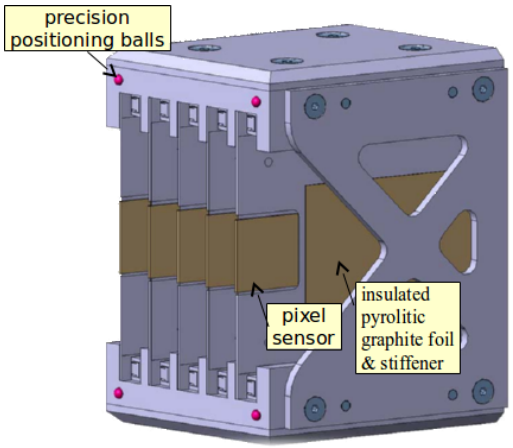
- 7 TeV, 90 m optics: analysis ongoing (low statistics)
- 8 TeV, 90 m optics: analysis started (promising)

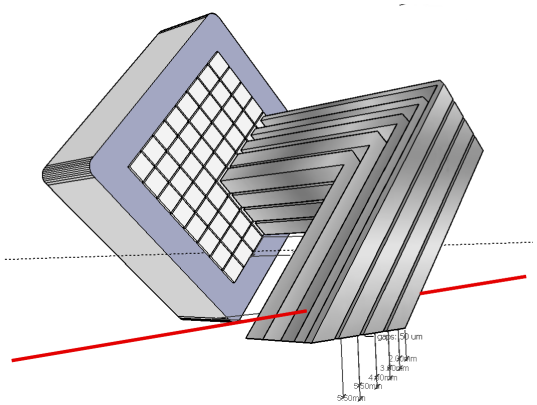
AFP – introduction

- 4 RPs: stations at 206 and 214 m from IP, on both outgoing beams
- Two stations on each side – trajectory position and direction
- Tracking detectors: IBL sensors + FEI4
- Timing detectors in stations at 214 m: precise timing for reconstructing longitudinal vertex position (needed for high μ)





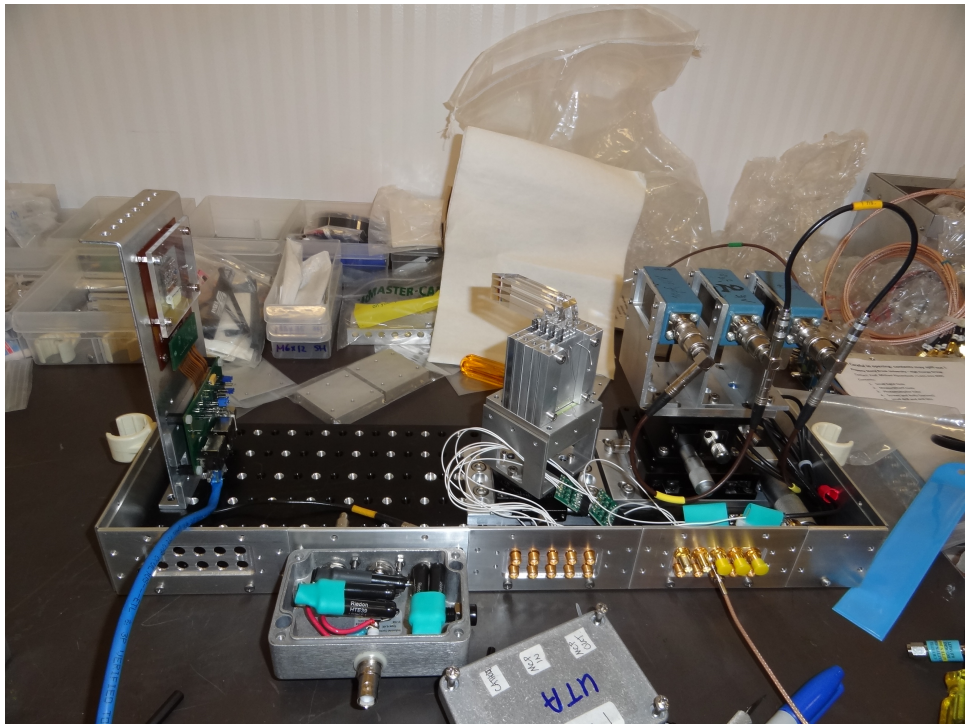


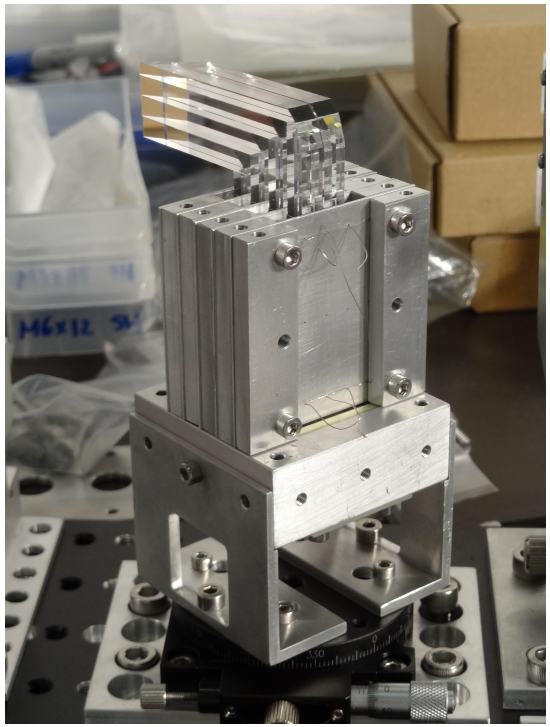


AFP status

1. Physics review (January 2014)
   - Physics case – diffractive and QCD topics to be studied in few days of data taken at low luminosity in special runs
   - Positive outcome – program appears achievable from the technical point of view, without strong demands on the timing precision and the alignment; running scenario to be agreed with TOTEM and ALFA;
   - High lumi program to be revisited when data on background in normal running conditions will exist
2. Technical review (April 2014)
   - The reviewers did not identify any substantial problem and therefore encourage the ATLAS Collaboration to approve the AFP project and go to the next stage with the submission of the TDR, provided that all the points mentioned will be addressed in due time.
3. Exec. Board approved AFP subject to finding resources (June 2014)
4. Combined test beam – this week
5. TDR – on the way …
6. Installation delayed to 2016/2017 because of lack of resources

AFP Test Beam

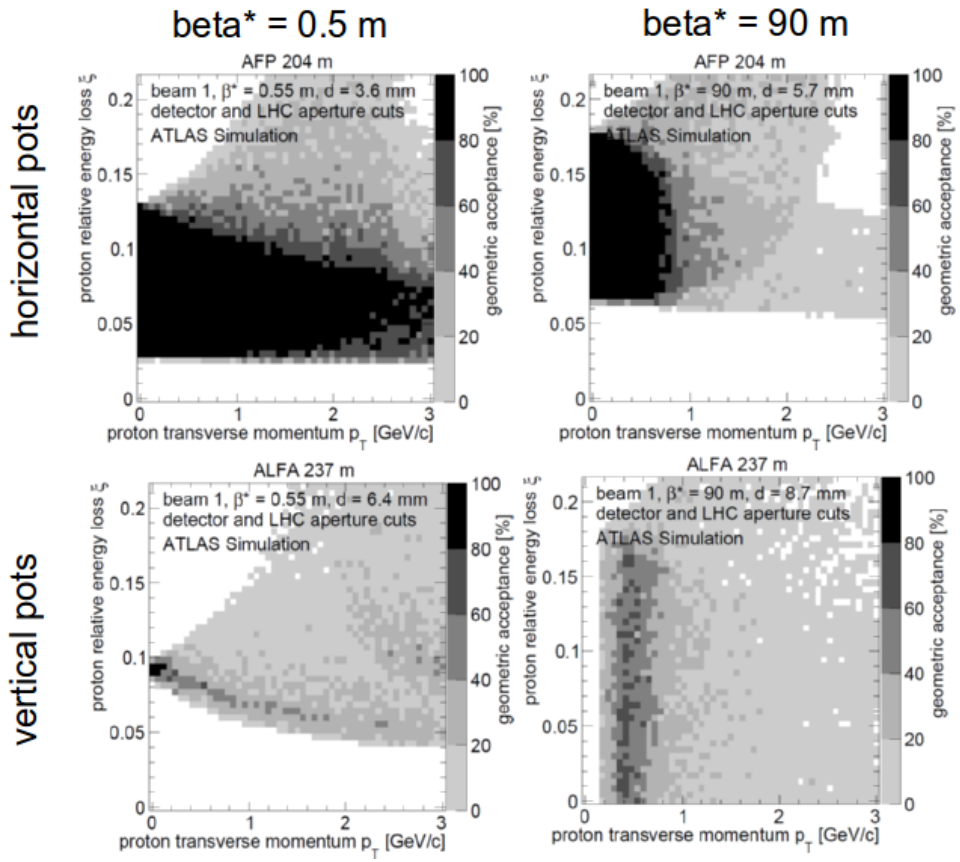




Contents

Optics scenarios

- Elastic scattering: $\xi = 0$, diffraction: $\xi < 0.2$
- In diffraction, coherent interaction of proton is soft $\rightarrow p_T \sim 1$ GeV



AFP – horizontal pots:

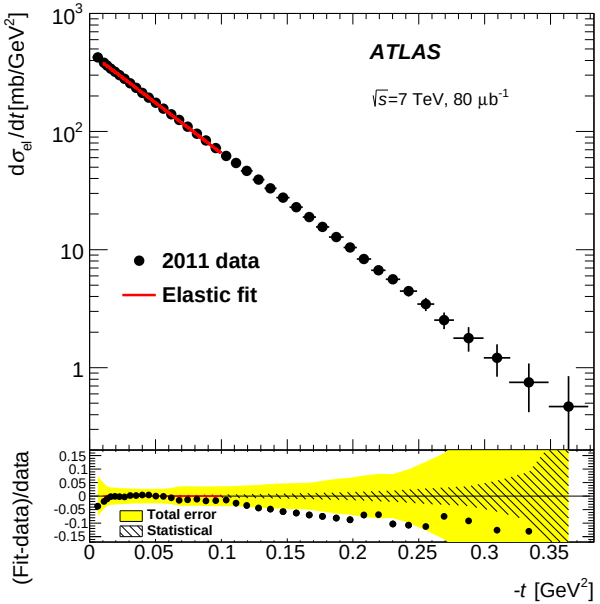
– 100% acceptance for small t
– ξ range depends on optics
– low and high luminosity
– low and high beta*

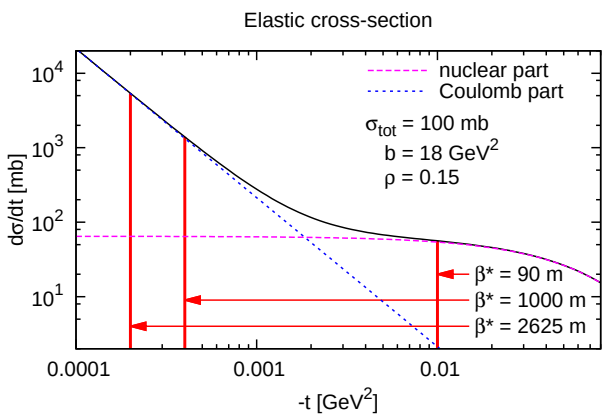
ALFA – vertical pots

– limited acceptance in t
– broad acceptance in ξ
– acceptance for elastics
– only high beta*
– only very small luminosity

Complementarity between AFP and ALFA

Elastic scattering and total cross section

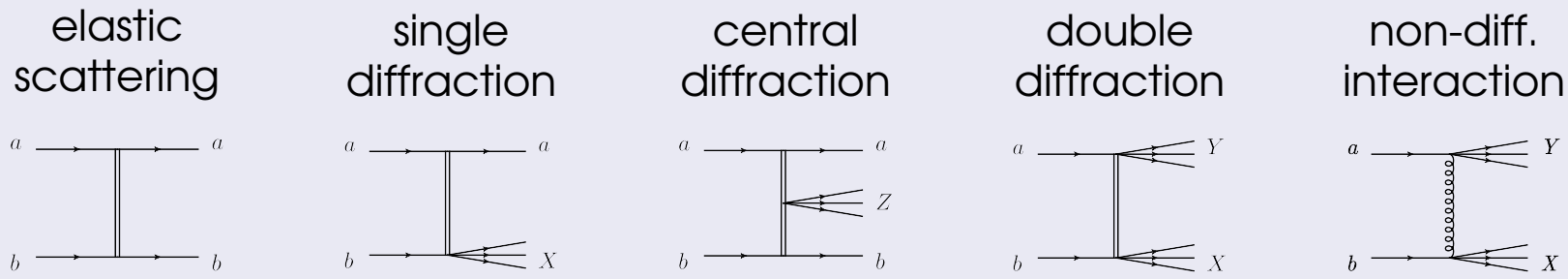




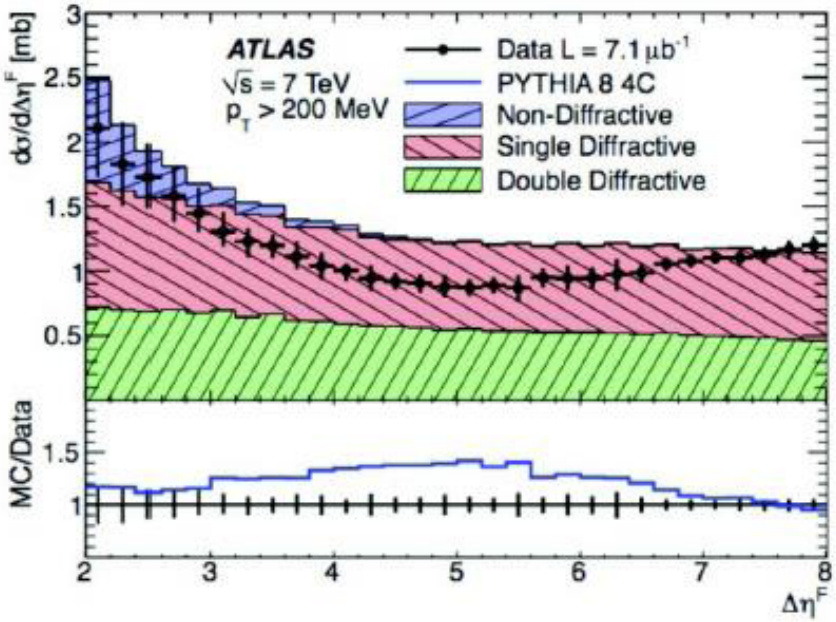
- Measurement at $\sqrt{s} = 7$ TeV published: JHEP 1410 (2014) 141
- Analysis of 8 TeV data ongoing
- Plan to measure at all available energies
- Minimal t depends on optics, emittance and detector position
- Ultimate goal: measurement in CNI region (2.5 km optics)
  - total cross section, elastic cross section, elastic slope, ρ
  - independent luminosity measurement

Soft diffraction

Minimum bias processes at the LHC:



- Gap measurement does not distinguish SD from DD
- Need forward proton tag
- High cross sections $\rightarrow$ low lumi needed $\rightarrow$ low pile-up possible
- Properties of SD – intact proton, multiplicities, gap, energy flow, ...
- Central diffraction (DPE)

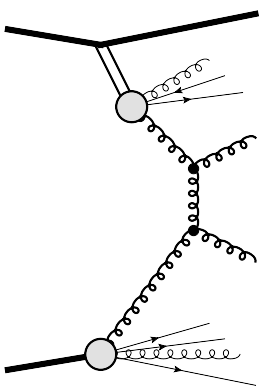


Eur. Phys. J. C72 (2012) 1926

Hard diffraction

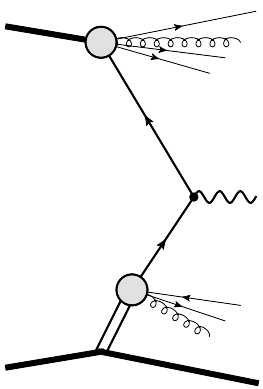
- Diffractive exchange + hard process
- Typical description – partonic Pomeron structure
- Alternative description – soft colour interactions
- Dominant background – non-diffractive hard interaction overlaid with soft pile-up process(es) giving a forward proton(s)

SD jets



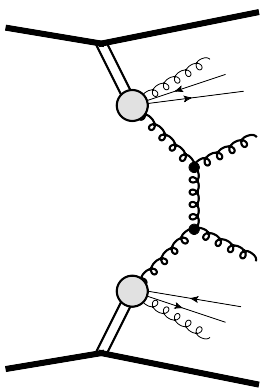
$\sigma_{\text{vis}} \sim 10^5$ pb

SD W/Z



$\sigma_{\text{vis}} \sim 10$ pb

CD (DPE) jets



$\sigma_{\text{vis}} \sim 5 \cdot 10^3$ pb

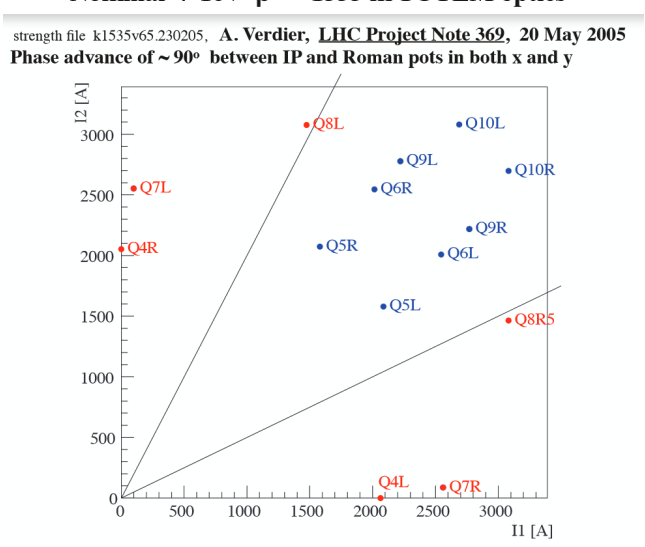
Contents

Priorities for elastic scattering programme

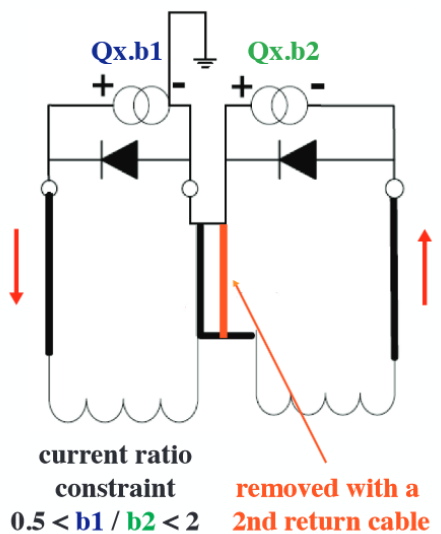
1. $\beta^* = 90$ m
   (one good fill for measurements + setup time $\sim$ days)
   - primary goal
   - total cross section, elastic cross section, elastics slope
   - nuclear dominance region
   - requires external luminosity measurement
2. $\beta^* = 2.5$ km
   (similar duration as for 90 m + optics qualification in MD)
   - ultimate goal, ALFA golden optics
   - CNI region
   - absolute luminosity measurement
   - total cross section, elastic cross section, elastics slope
   - return cables needed for Q4 and Q7 magnets!

Cables

- Technical limitation for current in quadrupole magnets:
  0.5 < B1/B2 < 2.0 (single return cable)
- To get the right phase advance and high β^* > 2 km some Q-poles are outside current limits
  (see TOTEM case for 1.5 km)
- Solution: equip Q4 and Q7 with a second return cable



- Solution discussed in meetings, finally approved by LMC 14/10/2009 (link)
- Installation postponed to 2015/2016 winter shutdown by Directorate
- **W/o new cables the goal of ALFA to measure total cross section AND luminosity independently from ATLAS standard methods (VdM based) cannot be achieved!**



Interest in diffractive programme

1. Interest before AFP installed
   - β^* = 90 m , $\mu \sim 0.1$, $\mathcal{L}$: 1 to few pb^{-1}
   - interest in such data for soft diffraction with ATLAS
   - if data are taken for TOTEM, we would run parasitically
   - given other LHC goals, ATLAS does not request such data in 2015
2. Interest after AFP installed
   - default low β^*, $\mu \sim 0.1 - 3$, $\mathcal{L}$: 10 to 100 pb^{-1}, $t \sim 2$ weeks
   - hard diffraction
   - will be an ATLAS request when AFP is there
   - possibly some fills at 90 m
3. Longer-term, ultimate AFP programme
   - default low β^*, $\mu \sim 50$, $\mathcal{L} \sim 10$ fb^{-1} , $t \sim$ year
   - normal running
   - exclusive processes
   - performance to be proven

Other possibilities to consider

1. Low luminosity pp runs at the beginning of Run-2 ("LHCf run")
   - ALFA recommissioning
   - possibility to measure background for AFP
2. pp run at $\sqrt{s} \sim 5$ TeV
   - part of the HI programme
   - could consider taking a few hours of data with 90 m optics in order to measure total cross section
   - but: 90 m setup time
3. ZDC could enhance physics programme (forward going neutrals)

Summary

- Successful ALFA elastic programme during Run-1 was demonstrated: σ_{tot} to $\pm 1.5\%$
- Highest priority continues to be ALFA elastic programme, with 90 m and eventually 2.5 km (cables!)
- Diffractive programme – highest priority is the low β^* run with AFP, plan parasitic data-taking in other runs

Contents

ZDC

- ZDC is being upgraded for Run-2
- It is not likely that the new ZDC will run before 2016
- ZDC employment in special runs (also pp high β^*) is presently discussed
- Potential physics interest:
  - Electromagnetic bremsstrahlung ($pp \to pp\gamma$)
  - Diffractive bremsstrahlung ($pp \to pp\gamma$)
  - π^0-strahlung ($pp \to pp\pi^0$)
  - Optics calibration