

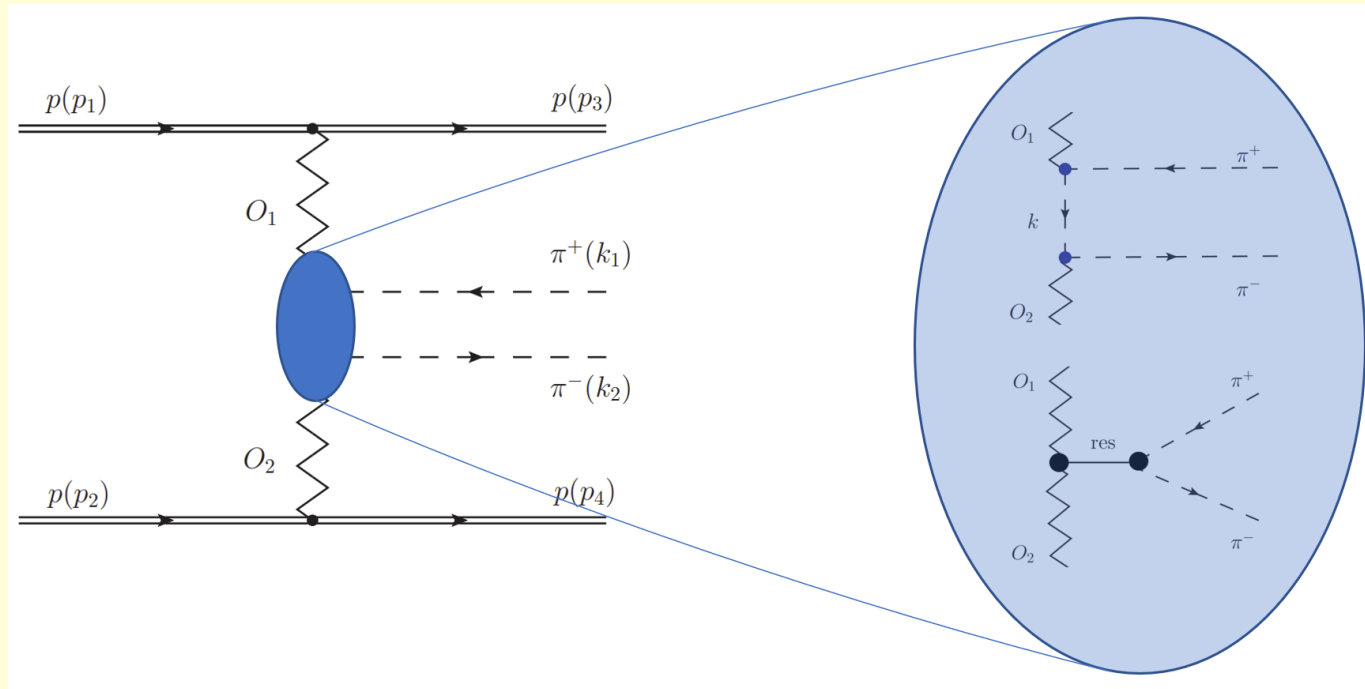
Exclusive pion pair production at $\sqrt{s} = 7$ TeV

Results from the ALFA detector at ATLAS

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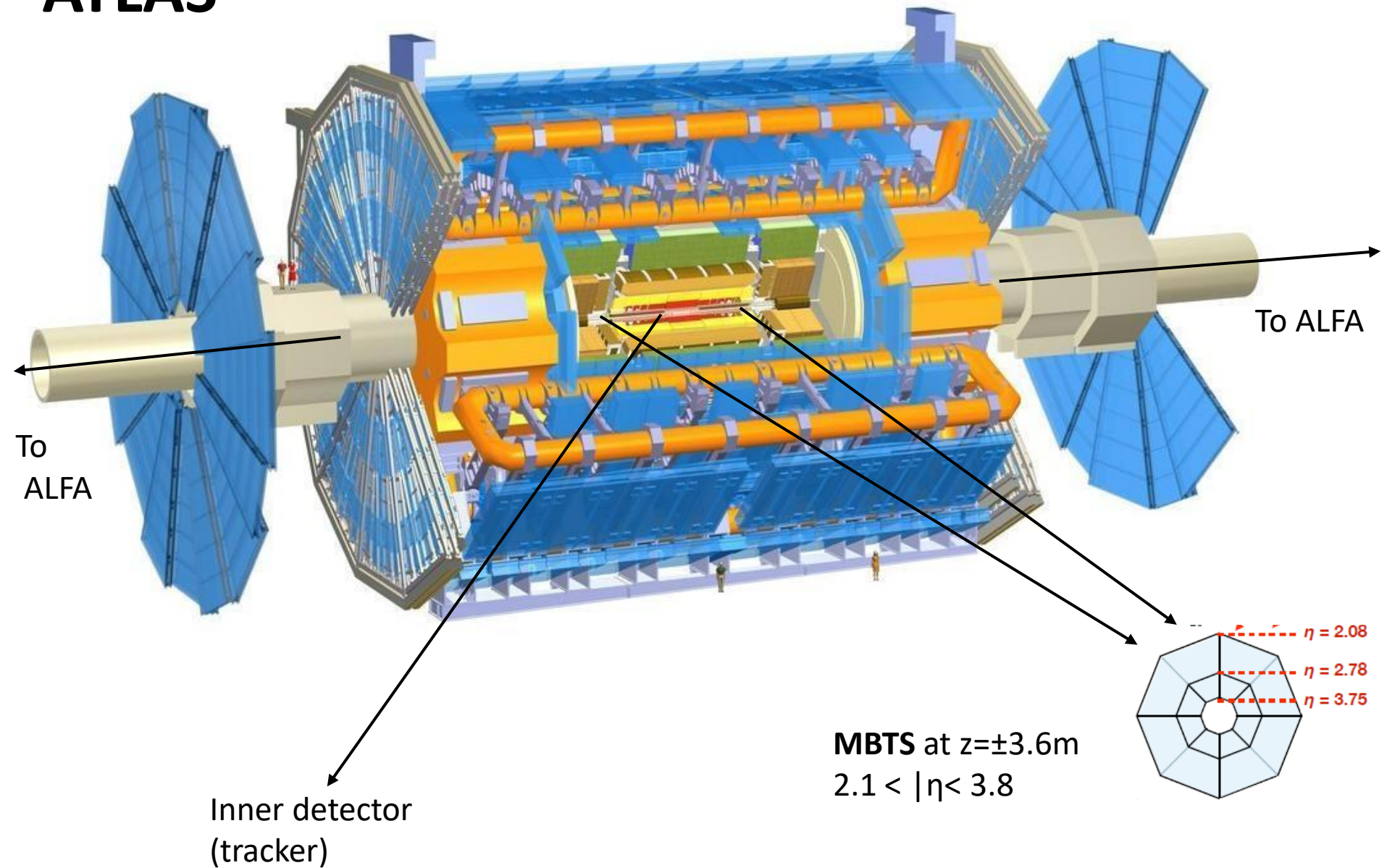


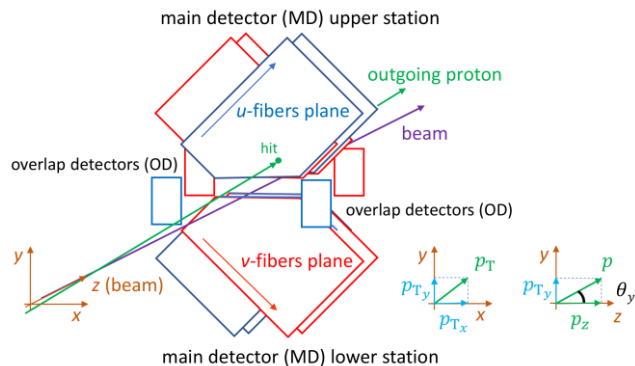
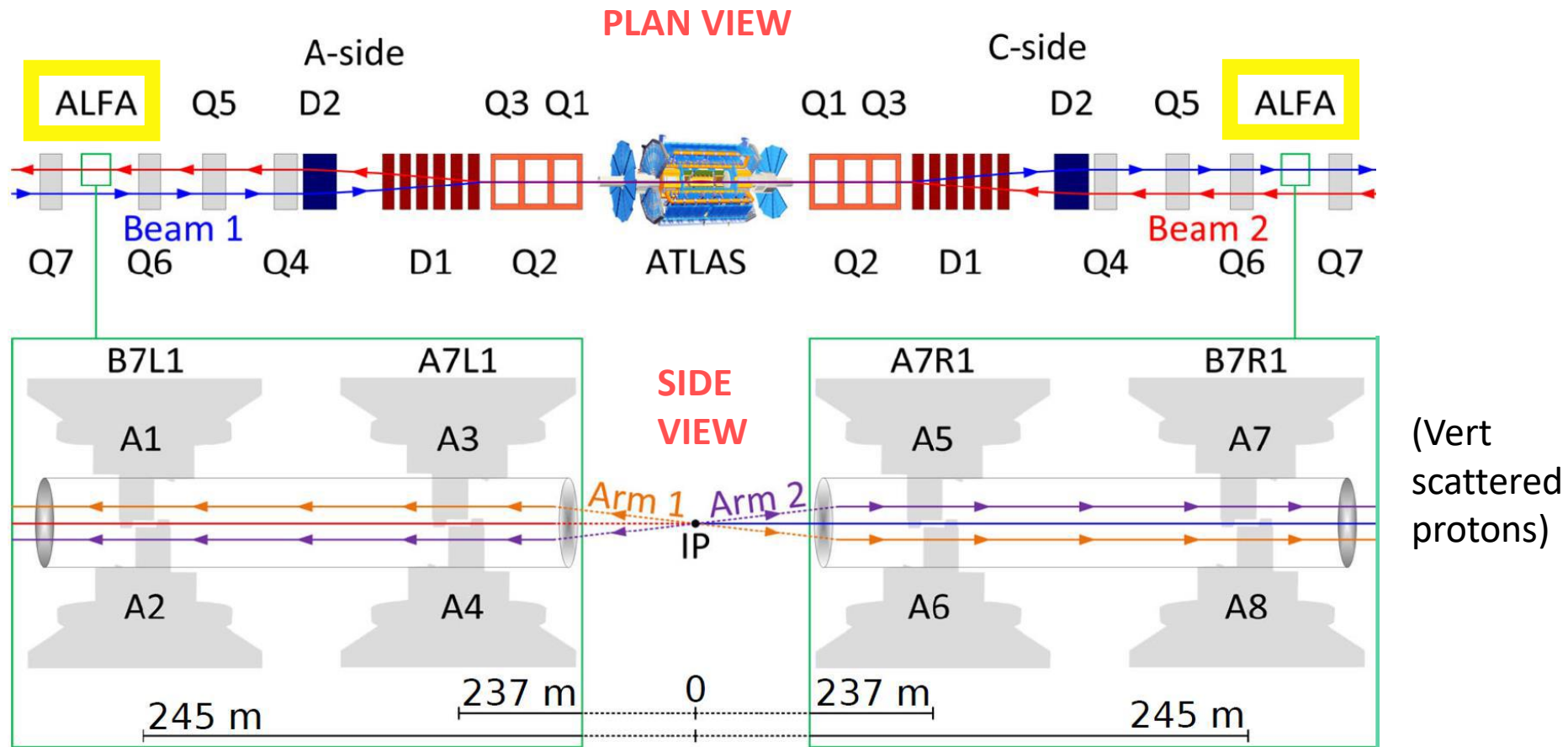
The exclusive diffractive dipion process at the LHC



We measure this by measuring the two pions in the ATLAS inner detector and both forward protons in the ALFA detectors. Proton excitation processes are excluded.

ATLAS





One proton in both ALFA stations on each side.

Elastic combinations: $A1+3+6+8$ and $A2+4+5+7$

Anti-elastic combs. $A1+3+5+7$ and $A2+2+6+8$

Measurement of exclusive process $pp \rightarrow pp\pi^+\pi^-$

Trigger:

Elastic - ALFA coincidence of detectors in an elastic combination.

Anti-elastic – signal in any ALFA detector, prescaled by 15

In ATLAS Inner Detector:

Two oppositely charged tracks, taken as pions,

satisfying $|\eta(\pi)| < 2.5$, $p_T(\pi) > 0.1 \text{ GeV}$, $2m_\pi < 2.0 \text{ GeV}$. (fiducial)

Quality requirements on the pion tracks were imposed.

In ALFA detectors:

One good quality track on each side (see later)

MBTS veto:

At most one hit in the combined inner MBTS scintillators, to remove diffractive-dissociative and non-diffractive events.

Overall momentum balance:

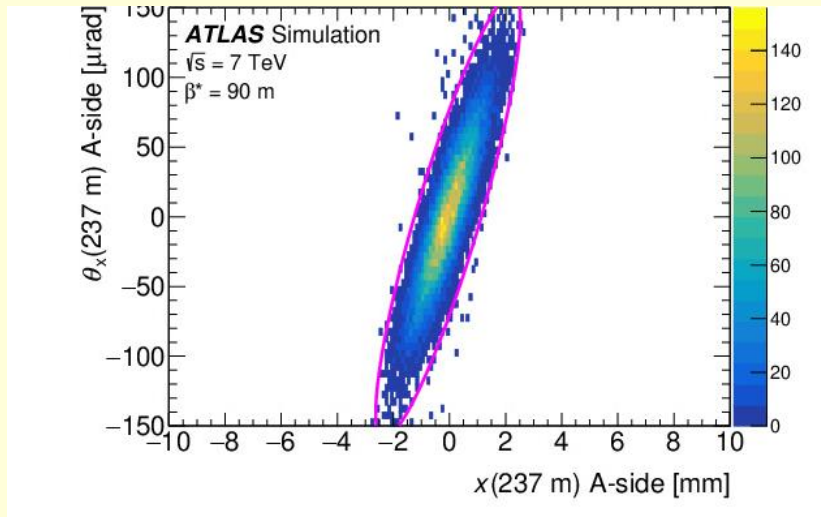
$pp\pi^+\pi^-$ momentum balance in x and in y consistent with zero ($\pm 3.5\sigma$)

Conditions on ALFA tracks

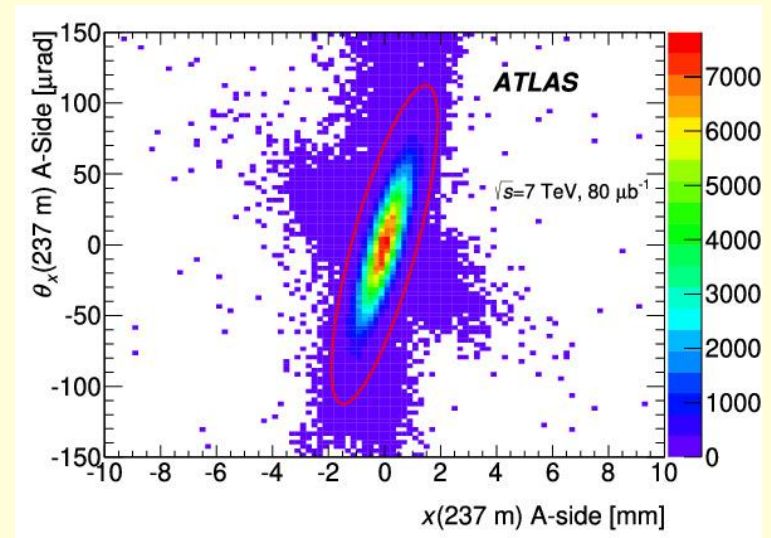
uv condition:

Track must have sufficient hits in u and v layers, with limit on number of multiple hits in a layer

Geometric condition:



(left) calculated x vs θ_x



(right) as seen in all protons.

This red ellipse is imposed on the ALFA tracks to reduce background.

Fiducial condition: cuts of typically $0.08 < |p_y| < 0.26 \text{ GeV}$ are imposed.

Monte Carlo simulations

GENEX:

(Model of Lebedowicz et al)

Exclusive production of pion and kaon pairs, Reggion exchange.

No absorption correction in MC, no rapidity-gap survival factor.

Used as the baseline generator for efficiency corrections

DIME (106):

Similar to GENEX but with more variant possibilities.

“Orear –like” meson form factor used here.

Used for systematics evaluation.

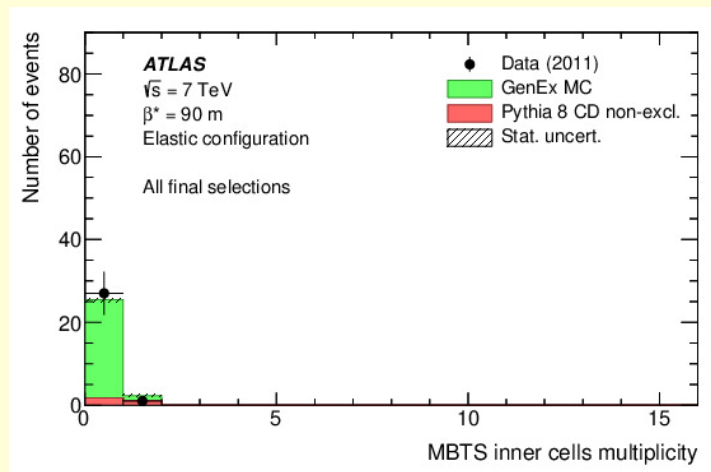
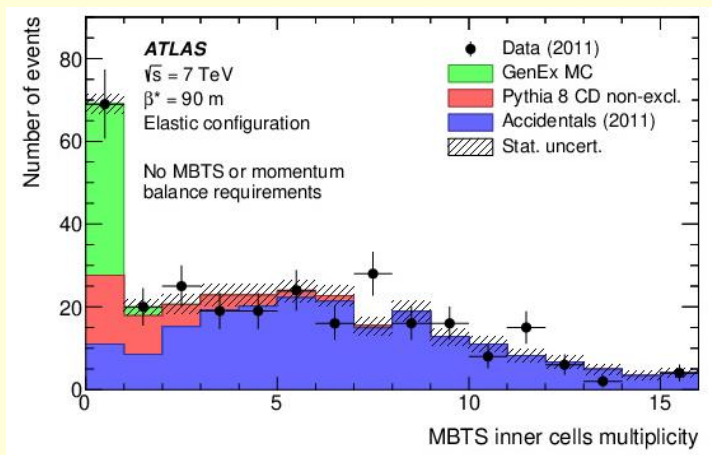
Absolute normalisation not required in either case.

PYTHIA 8

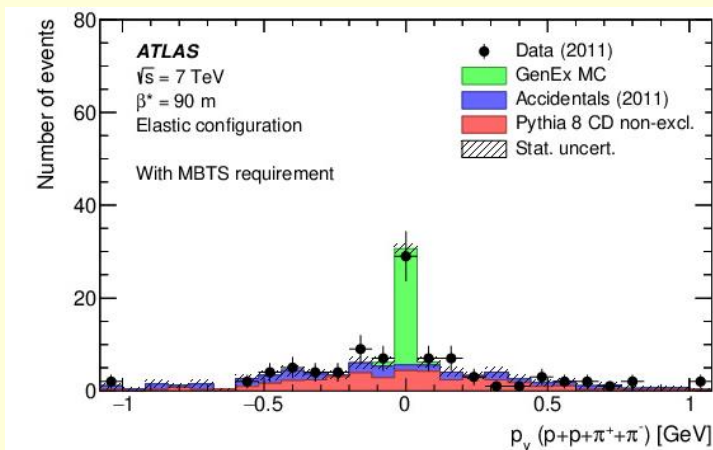
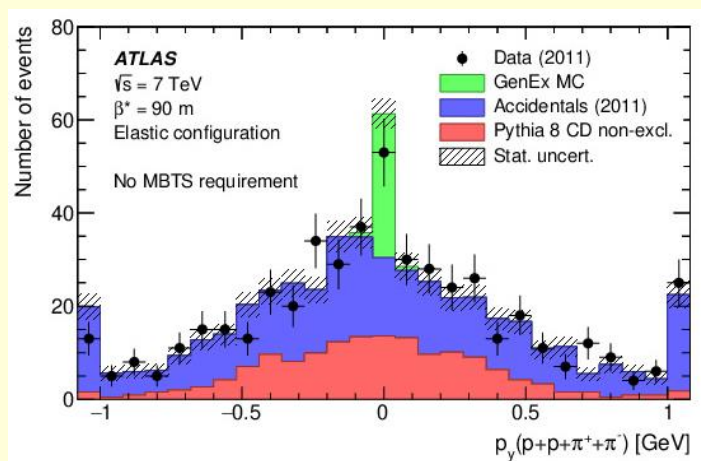
Used for central diffractive background calculations

Background removal and evaluation of results. Elastic configuration

Background modelled in terms of PYTHIA 8 and “accidentals” formed from central pion pairs + ALFA proton pairs from random events.

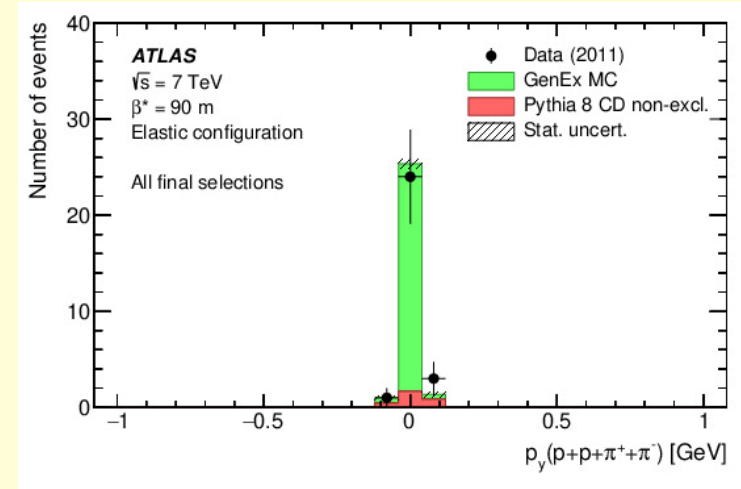
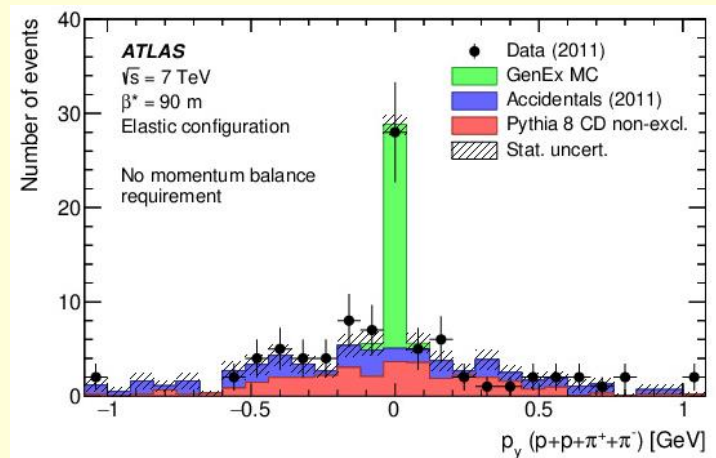


Effect of MBTS cut and other final requirements on MBTS count.



Effect of MBTS requirement on p_T distribution

Final results for elastic combination.



Before and after final momentum balance cut.

To note:

- The cuts are *very* effective at removing background.
- All backgrounds data-driven or fitted to data.
- Low statistics from this very short run in 2011 at 7 TeV (4 hours at high β^* , $\mu = 0.035$)
- Cross sections calculated using GENEX for acceptances.
- Feasibility of the measurement has been demonstrated.

Uncertainties

Source of uncertainty %	elastic	anti-elastic
Systematic:		
Trigger efficiency ϵ_{trig}	± 0.1	± 0.3
Background determination	± 3.5	± 3.5
Signal and background corrections:		
Beam energy	± 0.1	± 0.1
Inner Detector material	+4.8	+4.1
Veto on MBTS signal	± 1.3	± 2.0
ALFA single-track selection	± 0.9	± 0.9
ALFA reconstruction effic.	± 0.9	± 0.8
ALFA geometry selection	± 0.5	± 0.5
Optics	± 1.1	± 1.0
Overall syst uncertainty		
	+6.4 -4.2	+6.0 -4.4
Statistical uncertainty	± 21.2	± 61.6
Theoretical modelling	± 2.8	± 8.0
Luminosity	± 1.2	± 1.2

All systematics quite small but ID material is biggest.

Statistics on anti-elastic are poor and our result is purely indicative. (Prescaling factor)

Results

Exclusive $\pi^+\pi^-$ cross-section [μb]

Elastic configuration

Measurement	4.8 ± 1.0 (stat) $^{+0.3}_{-0.2}$ (syst) ± 0.1 (lumi) ± 0.1 (model)
GENEX $\times 0.22$ (absorptive correction)	1.5
DIME	1.6

Anti-elastic configuration

measurement	9 ± 6 (stat) $^{+1}_{-1}$ (syst) ± 1 (lumi) ± 1 (model)
GENEX $\times 0.22$ (absorptive correction)	2
DIME	3

Comments:

- The absorptive correction included here was recommended by the author
- These are just first measurements,
- The MC appears a little low but there are parameters that could be varied.

Summary

First completely exclusive measurements of diffractive pion pair production at LHC have been performed.

7 TeV LHC energy, using ALFA system at ATLAS

The method is shown to work well

Much more statistics are wanted

Then we can start to look at e.g. resonance production and maybe search for glueballs.