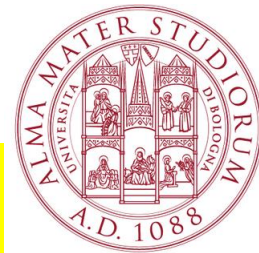# Low mass diffraction impact on total cross section

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- I have written a note about the impact of low mass diffraction which can be found on the ArXiv

Comments on low mass dissociation at the LHC in the context of the discrepancy between the ATLAS and TOTEM measurements of σ_{tot}

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Abstract

The cross section for low mass dissociation at LHC energies is estimated in a partly data driven approach. The result is compared to the Monte Carlo estimate from the QGSJET-II-03 model used by the TOTEM experiment in the determination of σ_{tot} via the luminosity-independent method. Significant differences are found and possible consequences are explored and discussed.

(I will follow my arXiv article in today's presentation)

What is low mass diffraction ?
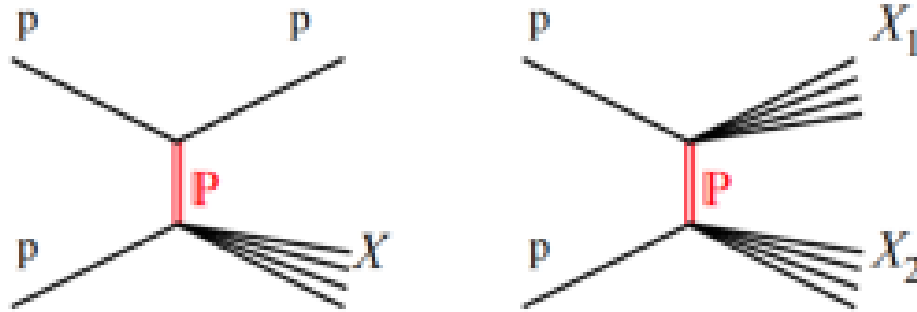
"Low" means :
SD: M_x <3-4 GeV
DD: M_{x1} and M_{x2} <3-4 GeV

Both difficult to:

- Measure

- Calculate theoretically

Low mass diffraction has of course an interest in itself…
..but also enters in the way TOTEM determines σ_{tot}.

Luminosity-independent method

$$\sigma_{tot} = \frac{16\pi}{1+\rho^2} \frac{(dN_{el}/dt)_{t=0}}{(N_{el}+N_{inel})}$$

TOTEM measures N_{inel} but not for Mx <3-4 GeV

the extrapolation to Mx < 3-4 GeV represents the biggest uncertainty in their measurement of σ_{tot}

Table 1: Corrections used by TOTEM for low mass dissociation

$\sqrt{s}$ TeV	Low mass limit GeV	Correction % of σ_{inel}	σ_{inel} mb	Correction mb
7	3.4	4	72.9	2.9
8	3.6	4.8±2.4	74.7	3.6±1.8
13	4.6	7.1±3.55	79.5	5.6±2.8

TOTEM uses Monte Carlo program QGSJET-II-03 |

TOTEM uses a Monte Carlo to estimate low mass dissociation

Is there another way??

Yes…try a partly data driven option

The main point for this approach:

It is theoretically easier to estimate
the diffractive cross section
above Mx= 3-4 GeV than below.

Above low mass diffraction i.e. above 3-4 GeV there is more or less a theoretical consensus that the triple Pomeron diagram dominates

a a

a a

R_1 R_2

R_3

b b
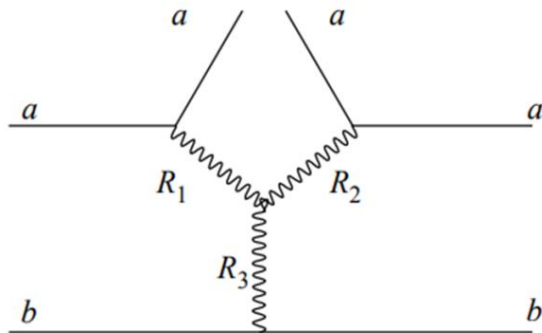
Below 3-4 Gev(low mass diffraction)
 estimates are more tricky

- Good-Walker formalism often used...but how many Good-Walker states are needed?
- Not clear if the triple pomeron vertex is also important here?
- Uncertainties related to the role of secondary Reggeons

What data is available ?

Table 2: Measurements of the inelastic cross sections at 7 TeV

Experiment	σ_{inel} [mb]	Experiment	$\sigma_{inel}^{M_x>16 \text{ GeV}}$ [mb]	$\sigma_{inel}^{M_x<16 \text{ GeV}}$ [mb]
ATLAS-ALFA [7]	71.3±0.9	ALICE [1]	62.1±2.4	
TOTEM [3]	72.9±1.5	ATLAS [8]	60.3±2.1	
		CMS [9]	60.2±2.6	
Weighted mean	71.8±0.7		60.8±1.4	11.0±1.6

Table 3: Measurements of the inelastic cross sections at 13 TeV

Experiment	σ_{inel} [mb]	Experiment	$\sigma_{inel}^{M_x>13 \text{ GeV}}$ [mb]	$\sigma_{inel}^{M_x<13 \text{ GeV}}$ [mb]
ATLAS-ALFA [10]	77.4±1.1	ALICE		
TOTEM [5]	79.5±1.8	ATLAS [11]	68.1±1.4	
		CMS [12]	67.5±1.8	
Weighted mean	78.0±0.9		67.8±1.1	10.2±1.4

But we need the cross section for M_x<3-4 Gev (low mass diffraction) and not M_x<13-16 GeV !!

To use this data we have to estimate what happens in the region between 13-16 Gev and 3-4 GeV

The main point as expressed on previous slide is that such an estimate is easier than what happens below Mx=3-4 GeV

Start with 13 TeV

We have to estimate of the cross section between Mx=13 GeV and Mx=4.6GeV

Three different inputs

1. A CMS measurement for the cross section between Mx=13 Gev and 4.1 GeV giving 2.2 mb

2. Monte Carlo estimates for the same mass range indicates

Monte Carlo	% of σ_{inel}	One side [mb]	Two sides [mb]
EPOS-LHC	1.76	1.2	2.4
QGSJETII-04	2.36	1.6	3.2
PYTHIA8 MBR	2.32	1.6	3.2

3. Estimate from the KMR model (I have gotten outputs from their program) giving 2.4 mb

In the following we will use the 2.2 mb of the CMS measurement

Now 7 TeV

We have to estimate of the cross section between Mx=16 GeV and Mx=3.4GeV

Three different inputs also here

1.   No measurement for the cross section between Mx=16 Gev and 3.4 GeV exists. However a ATLAS measurement starting just above 16 Gev exists indicating 1 mb/unit of rapidity gap. Using this also below 16 GeV would give 3.1mb in the range 3.4 GeV to 16 GeV

2. Rough Monte Carlo estimates for the same mass range gives a couple of mb's

3. Estimate from the KMR model (I have gotten outputs from their program) giving 3 mb

In the following we will use 3 mb

Put it all together

13 TeV for 13 GeV > M_x > 4.1GeV:

Experiment CMS: 2.2 mb

Monte Carlo: 2-3 mb

KMR: 2.4 mb

7 TeV for 16 GeV > M_x > 3.4GeV:

Experiment ATLAS: 3.1 mb
(just above M_x=16GeV)

Monte Carlo: ≈ 1.5- 2.5 mb

KMR: 3 mb

Table 5: Partly data driven low mass dissociation cross section compared to the Mont-Carlo estimated used by TOTEM.

$\sqrt{s}(TeV)$	$M_x < (GeV)$	Low mass $\sigma_{inel}(mb)$	Used by TOTEM (mb)
7	3.4	8.0±1.6	2.9
8	3.6		3.6±1.8
13	4.6	8.2±1.4	5.6±2.8

Before using the table a couple of comments:

• The uncertainties given are just propagations of the uncertainties of the numbers used and do not include any uncertainties related to the different estimates used….thus the uncertainties are for sure underestimated

• No distinction between single and double dissociations. Double dissociation is thought to be down with an order of magnitude

• The observant listener might have seen a difference at 13 TeV between the measurement with a limit of 4.1 Gev and the needed value at 4.6 GeV. The correction was estimated to be 0.2 mb.
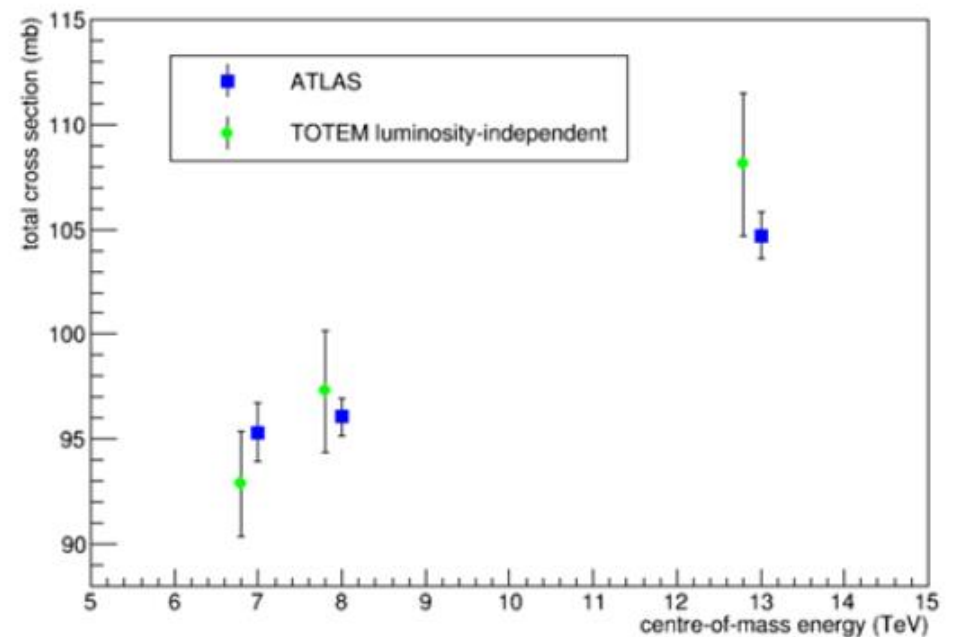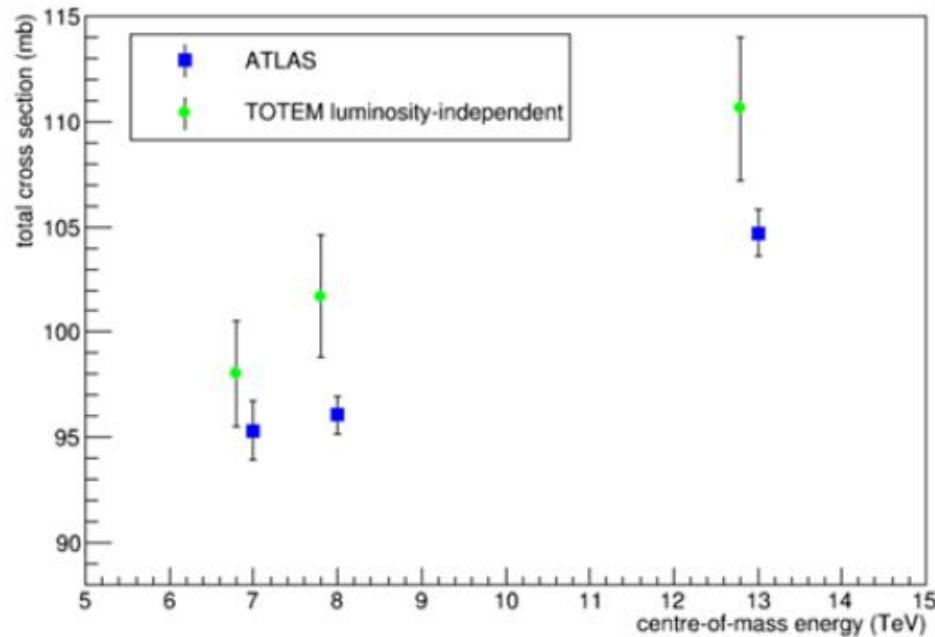
Result

Figure 3: Comparison of ATLAS and TOTEM measurements of σ_{tot}. To the left is shown the actual situation. To the right is shown what happens if the low mass estimates of this note are used.

TOTEM can raise at least three objections against this.

Below in order of increasing concern.

•   At 13 TeV TOTEM has used Coulomb normalization independently of the luminosity-independent method

•   At 7 TeV TOTEM also used the luminosity dependent method using a luminosity given to them from CMS with 4 % uncertainty.

•   At 7 TeV TOTEM made a measurement for masses Mx >3.4 GeV

- At 13 TeV TOTEM has used Coulomb normalization independently of the luminosity independent method

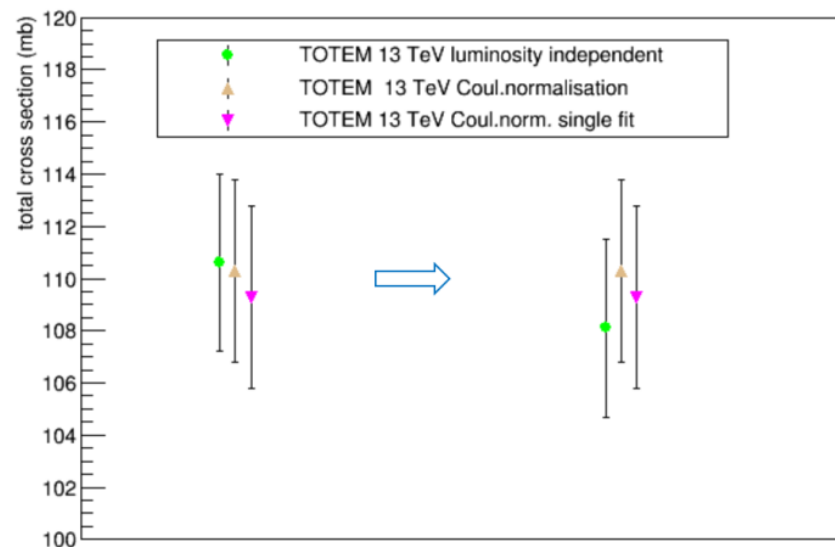Figure 4: Comparison of TOTEM measurements of σ_{tot} using Coulomb normalisation and using the luminosity-independent method. Two different approaches have been used to perform the Coulomb normalisation independently of the luminosity-independent method. Details are given in Ref. [19]. The figure shows, on the right side, the implications of the low mass corrections estimated in this note.
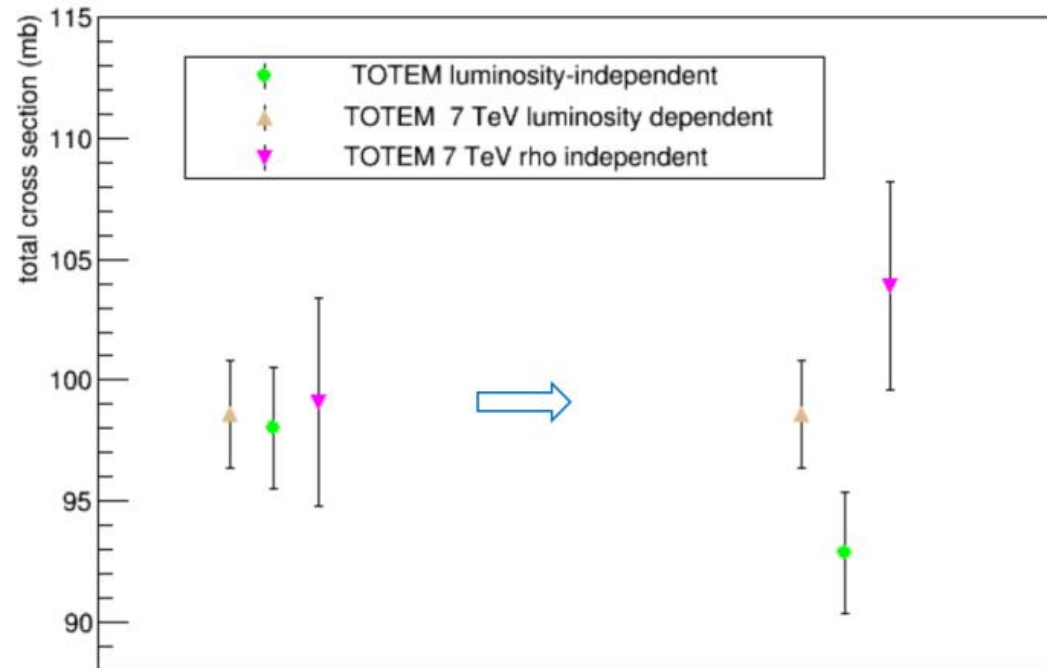
...not an issue

Figure 5: Comparison of TOTEM measurements of σ_{tot} using three different methods before and after adjusting the low mass correction.

- At 7 TeV TOTEM made a measurement for masses Mx >3.4 GeV

This measurement implied that TOTEM could put an upper limit for masses Mx<3.4 GeV of 6.3 mb at 95 % confidence level.

In contrast to 8.0 +-1.6 mb found here.

This and what is seen on the previous slide indicates some internal contradiction using the data driven estimate.

However the contradictions today between ATLAS and TOTEM is more striking...

Conclusion

If it turns out that the low mass dissociation at the LHC is somewhat underestimated then the discrepancy between the TOTEM and ATLAS measurement of σ_{tot} would not be as dramatic as now but rather acceptable.

Back up