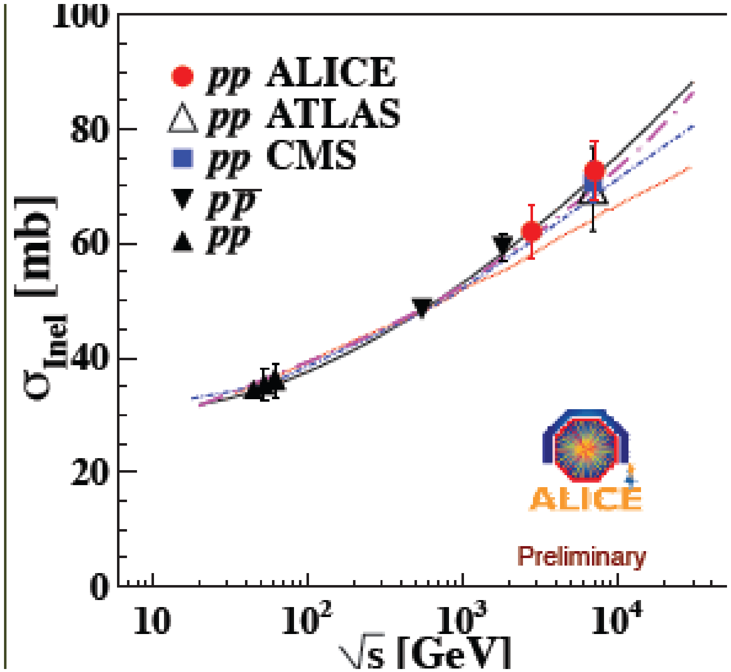
Recent LHC results



Gostman et al., arXiv:1010.5323, EPJ. C74, 1553 (2011)
Kaidalov et al., arXiv:0909.5156, EPJ. C67, 397 (2010)
Ostapchenko, arXiv:1010.1869, PR D83 114018 (2011)
Khoze et al., EPJ. C60 249 (2009), C71 1617 (2011)

ATLAS $\sigma_{inel}(\xi > m_p^2/s) = 69.4 \pm 2.4(\text{exp.}) \pm 6.9(\text{extr.})$ mb

CMS $66.8 \leq \sigma_t^{inel} \leq 74.8$ mb.

ALICE σ_{Inel} ($\sqrt{s}$ = 7 TeV) = 72.7 ± 1.1(model) ± 5.1(lum.) mb

$|\eta| < 2.$ $-3.7 < \eta < -1.7$ and $2.8 < \eta < 5.1.$

M.Poghosyan Quark Matter 2011

Can we measure σ_{inel} , σ_{SD}, σ_{DD} with high accuracy?

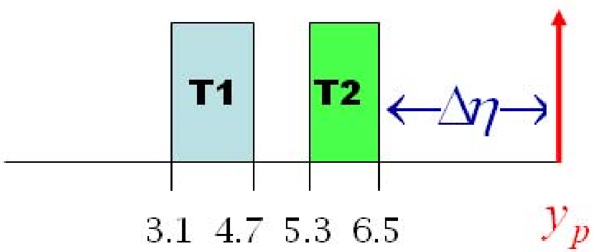
Achilles' Heel of 'inelastic' measurements : low mass SD,DD

Uninstrumented regions: (at least)

Totem-CMS : $M_X \le 2.5 - 3.5 GeV$

Atlas: $M_X \le 7 GeV$ **(<15.7 GeV)**

(Castor)

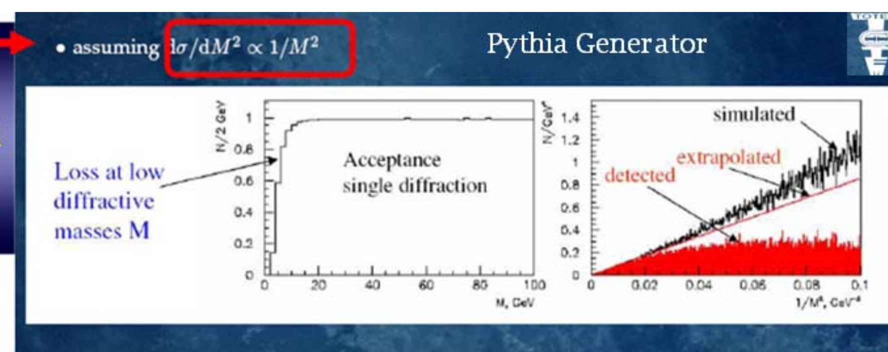


$$\eta = -\ln \tan \frac{\vartheta}{2}$$

$$y_p = \ln(\sqrt{s}/m_p), \Delta\eta \simeq (2.4 - 3.1)$$

Can we extrapolate from HM SD ?

- Theoretically unjustified
- Currently **NO** theoretically solid way to extrapolate HM to LM single diffraction

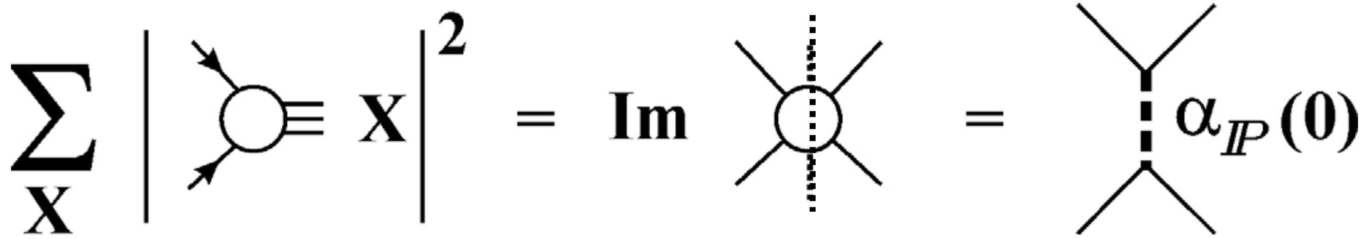


(UA4-experience ☞ factor of 2 for M<4 GeV)

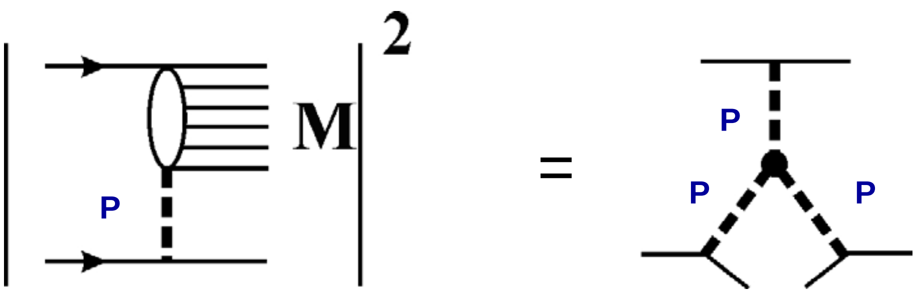
Optical theorem

A diffractive process is characterized by a large rapidity gap (LRG), which is caused by t-channel Pomeron exch.

σ_{total} =



High mass diffractive dissociation



PPP-diagram

$$d^2\sigma/dM^2dt|_{t=0} \sim \frac{s^{2\epsilon}}{(M^2)^{1+\epsilon}}\ S^2 \quad \sim 1/M^2$$

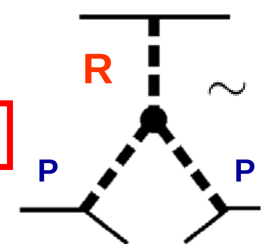
Screening is very important.
(semi) enhanced absorption ...

(t-dependence !?)

Low mass diffractive dissociation

introduce diff^{ve} estates ϕ_i, ϕ_k (comb^{ns} of p,p*,..) which only undergo "elastic" scattering (Good-Walker)

dual to



$$\sim \frac{s^{2\epsilon}}{(M^2)^{1.5+2\epsilon}}\ S^2 \ \sim 1/M^3$$

PPR-diagram

Model expectations for total inelastic cross-section

- Strong dependence of the longitudinal development of air showers on σ_{inel}

- Various MC generators are used by the CR community (some with full resummation of multi-Pomeron graphs)

For illustration purposes only

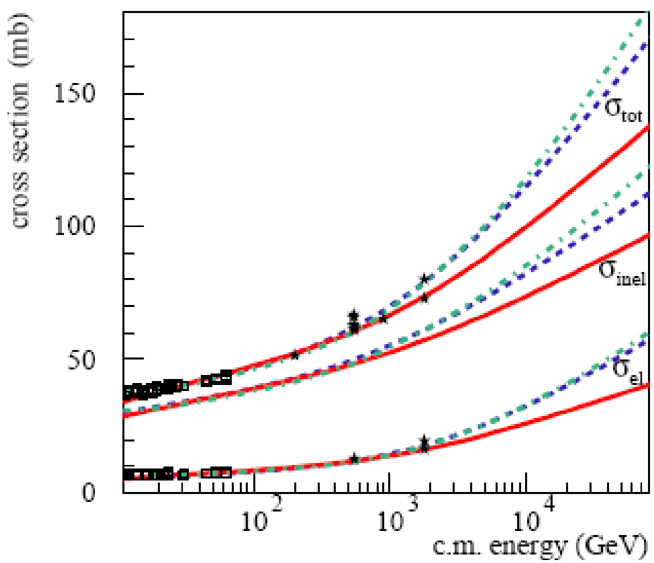


Figure 1: Model predictions for total, elastic, and inelastic proton-proton cross sections: QGSJET-II-4 - solid, QGSJET-II-3 - dashed, and SIBYLL - dot-dashed. The compilation of data is from Ref. [17].

$\sqrt{s} = 7$ TeV

S.Ostapchenko, ArXiv:1103.5684)

(in mb)	σ_{inel}	$\sigma_{\text{SD}}^{\text{LM}} + \sigma_{\text{DD}}^{\text{LM}}$
QGSJET II-04	69.7	7.1
QGSJET II-03	77.5	3.3
SIBYLL	79.6	0
PYTHIA	71.5	0
KMR-11	**65.2/67.1**	**6/7.4**
Dino-11	71 ± 6	
MPS-11	73.4	
KP-10	**71.6**	

What about current theoretical uncertainties ?

$\sqrt{s} = 14$ TeV.

	σ^{tot}	σ^{el}	σ^{SD}	σ^{DD}	σ^{SD}_{LM}	σ^{SD}_{HM}	σ^{DD}_{LM}	σ^{DD}_{HM}
Set (A)	128	37.5	12.1	4.61	8.48	3.62 (3.54)	1.15	2.06
Set (B)	126	37.3	12.4	5.18	8.22	4.24 (4.14)	1.08	2.50
Set (C)	114	33.0	11.0	4.83	5.58	5.22 (5.12)	0.47	3.15
KMR-08	91.7	21.5	19.0		4.9	14.1		
GLMM-08	92.1	20.9	11.8	6.08	10.5	1.28		
KP-10	108	29.5	14.3					

For illustration purposes only

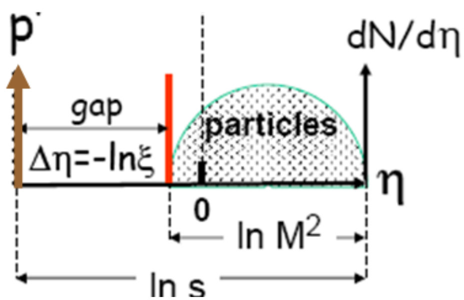
(A,B,C) S. Ostapchenko, Phys.Rev.D81:114028,2010.
KMR-08: KMR, EPJ C54,199(2008); ibid C60,249 (2009).
GLMM-08: GLMM,EPJ C57,689 (2008).
KP-10 A.B. Kaidalov, M.Poghosyan

Large variation of σ^{SD}_{LM} in the range 5- 10.5 mb

5. A flavour of diffraction in the first LHC runs.

- First measurement of σ_{inel} at 7 TeV.

(arXiv:1104.0326 [hep-ex] , 2 Apr. 2011)



$$\xi = M_X^2/s > 5\times10^{-6}$$

$M_X > 15.7$ GeV for $\sqrt{s} = 7$ TeV

$\sigma(\xi > 5\times10^{-6})$ [mb]	
ATLAS Data 2010	$60.33 \pm 2.10(\text{exp.})$
Schuler and Sjöstrand	66.4
PHOJET	74.2
Ryskin *et al.*	51.8 / 56.2
$\sigma(\xi > m_p^2/s)$ [mb]	
ATLAS Data 2010	$69.4 \pm 2.4(\text{exp.}) \pm 6.9(\text{extr.})$
Schuler and Sjöstrand	71.5
PHOJET	77.3
Block and Halzen	69
Ryskin *et al.*	65.2 / 67.1
Gotsman *et al.*	68
Achilli *et al.*	60 – 75

(model dependence in the definition of ξ)

$$\Delta\eta = \ln 1/\xi + \ln \langle p_\perp \rangle / m_p$$

Can we measure $\frac{d\sigma_{el}}{dt}$, σ_{el} and σ_{tot} with a good accuracy ?

YES WE CAN

- $\frac{d\sigma_{el}}{dt} = \frac{\pi}{sp^2}|F_{el}(t)|^2$
- optical theorem: $\sigma_{tot} = \frac{4\pi}{p\sqrt{s}} \,\mathrm{Im}\, F_{el}(s, t=0)$

With known lumi (3.5% VdM)

- $L\sigma_{tot} = N_{el} + N_{inel}$
- Need to separate the Coulomb and hadron scattering

TOTEM

(Lumi independent)

$$\sigma_{tot} = \frac{16\pi}{1+\rho^2} \frac{\left.\frac{dN_{el}}{dt}\right|_{t=0}}{N_{el}+N_{inel}}; \qquad L = \frac{1+\rho^2}{16\pi} \frac{(N_{el}+N_{inel})^2}{\left.\frac{dN_{el}}{dt}\right|_{t=0}}$$

Model	ρ
Islam et al.	0.123
Petrov et al. 2P	0.0968
Petrov et al. 3P	0.111
BSW	0.121
Block-Halzen	0.114
COMPETE	0.1316

- measure $\frac{dN_{el}}{dt}$ and extrapolate it to $t = 0 \rightarrow$ needs RP acceptance at small small beam divergence $\rightarrow$ high β^* (parallel to point focusing)

- ALFA- measurement of elastic scattering in the Coulomb interference region

- Will require special LHC runs at high β^* and low $\mathcal{L}_{inst}$: 90m (2011), 2km (2013+)

How Large is Large ?

MIND THE GAP

Diffraction is any process caused by Pomeron exchange.

(Old convention was any event with LRG of size $\delta\eta>3$, since Pomeron exchange gives the major contribution)

However LRG in the distribution of secondaries can also arise from

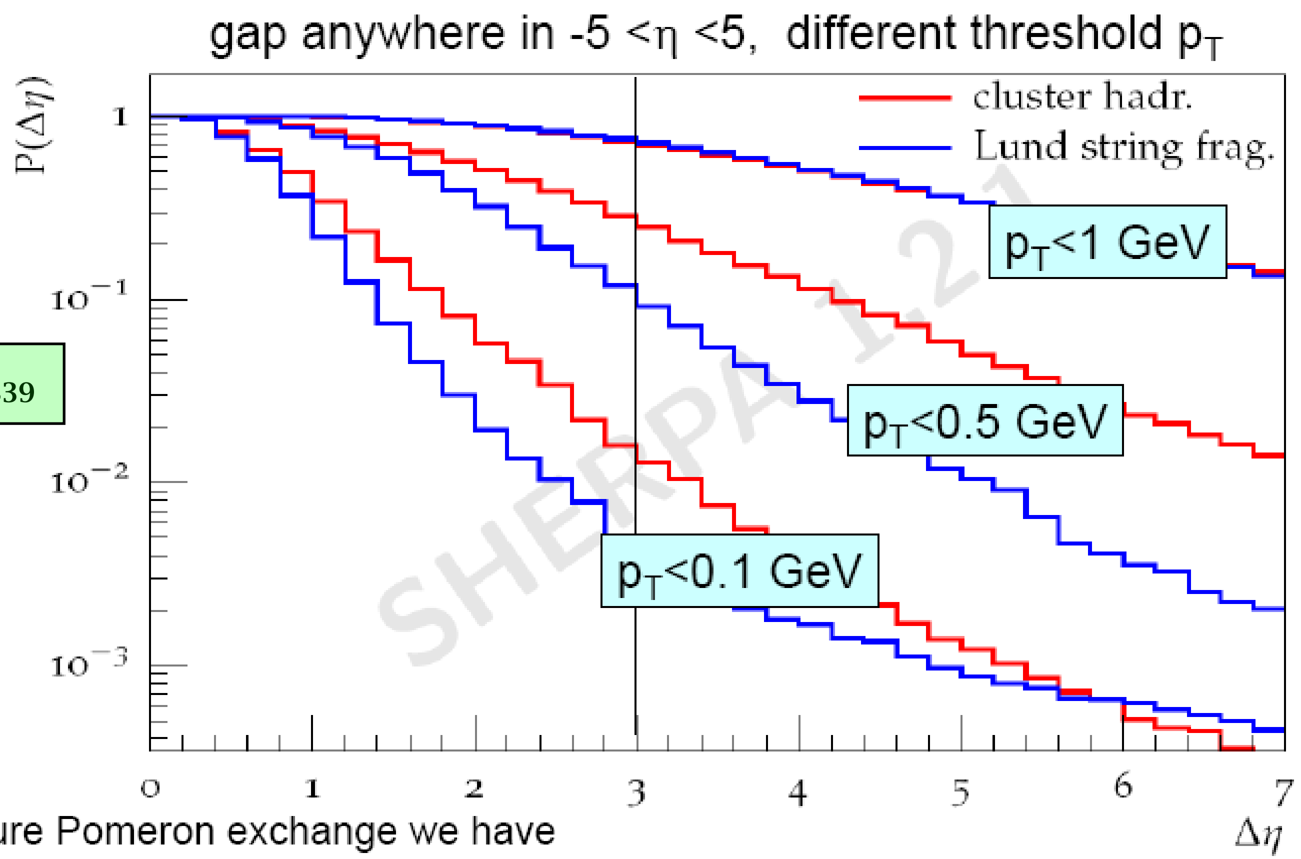
(a) Reggeon exchange

(b) fluctuations during the hadronization process

Indeed, at LHC energies LRG of size $\delta\eta>3$ do not unambiguously select diffractive events.

Prob. of finding gap larger than $\Delta\eta$ in inclusive event at 7 TeV due to fluctuations in hadronization

KKMRZ, arXiv:1005.4839



So to study pure Pomeron exchange we have

either to select much larger gaps

or to study the Δy dependence of the data, fitting so as to subtract the part caused by Reggeon and/or fluctuations.