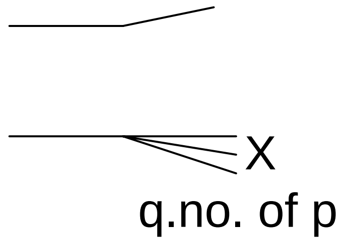
No unique definition of diffraction

1. Diffraction is elastic (or quasi-elastic) scattering caused, via s-channel unitarity, by the absorption of components of the wave functions of the incoming particles

   e.g. pp→pp,

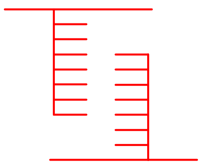
   pp→pX (single proton dissociation, SD),

   pp→XX (both protons dissociate, DD)



Good for quasi-elastic proc.

– but not high-mass dissoc^n



2. A diffractive process is characterized by a large rapidity gap (LRG), which is caused by t-channel Pomeron exch. (or, to be more precise, by the exchange corresponding to the rightmost singularity in the complex angular momentum plane with vacuum quantum numbers).

Only good for very LRG events – otherwise Reggeon/fluctuation contaminations

Why study diffraction ?

Intrinsic interest. The LHC should reach, for the first time, sufficiently HE to distinguish between the different theoretical asymptotic scenarios for HE interactions.

In HE pp collisions about 40% of σ_{tot} comes from diffractive processes, like elastic scatt., SD, DD. Need to study diffraction to understand the structure of σ_{tot} and the nature of the underlying events which accompany the sought-after rare hard subprocesses. (Note LHC detectors do not have 4π geometry and do not cover the whole rapidity interval. So minimum-bias events account for only part of total $\sigma_{inelastic}$.)

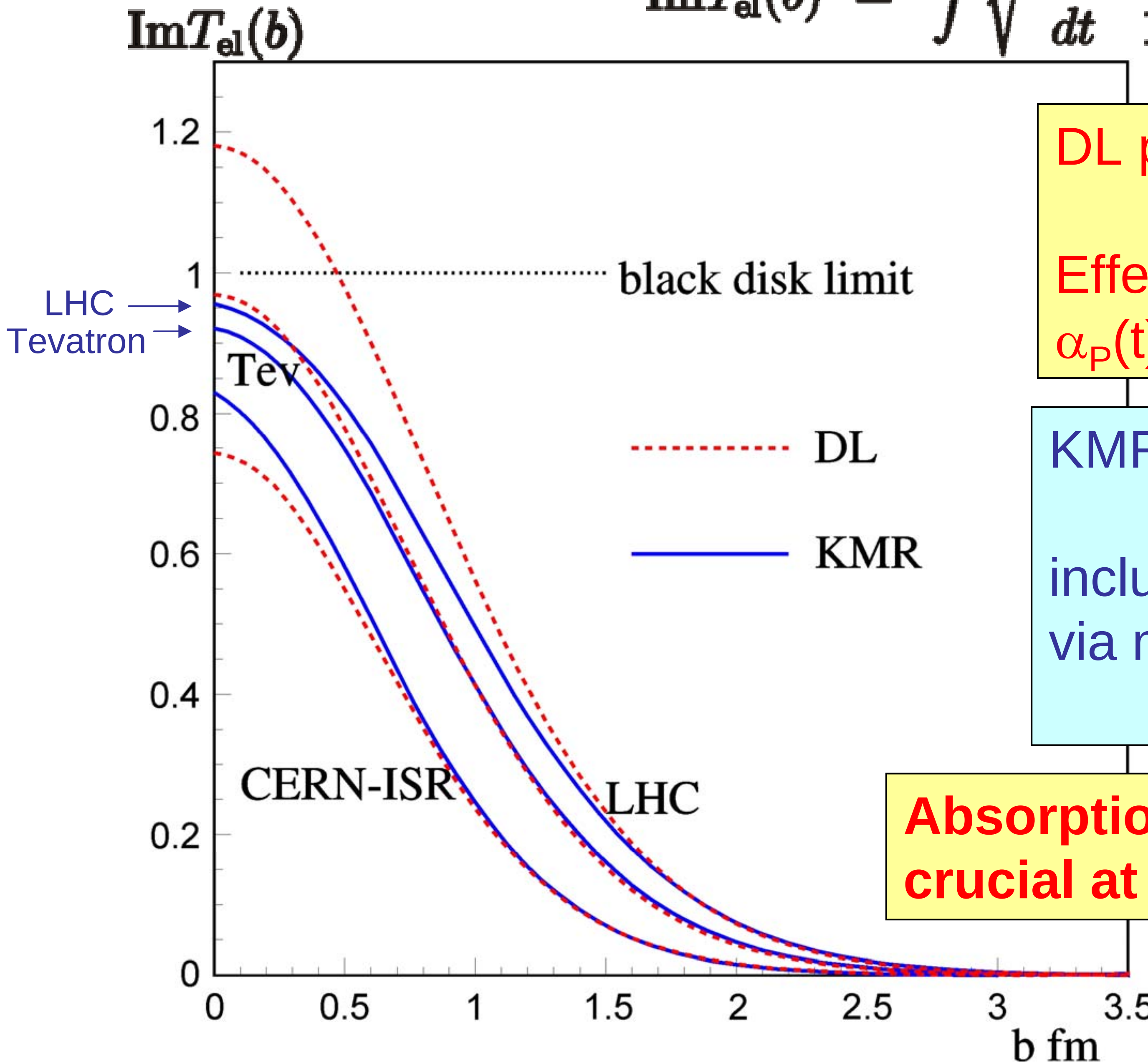
Study needed to estimate the survival probabilities of LRG to soft rescattering.

Recall “hard” exclusive diffractive processes (e.g., pp → p + Higgs + p) are an excellent means of suppressing the background for New Physics signals

Needed so as to understand the structure of HE cosmic ray phenomena (e.g. Auger experiment).

Finally, the hope is that a study of diffraction may allow the construction of a MC which merges “soft” and “hard” HE hadron interactions in a reliable and consistent way.

$$\mathrm{Im}T_{\rm el}(b) = \int \sqrt{\frac{d\sigma_{\rm el}}{dt}\,\frac{16\pi}{1+\rho^2}}\; J_0(qb)\,\frac{q\,dq}{2\pi}$$



DL parametrization:

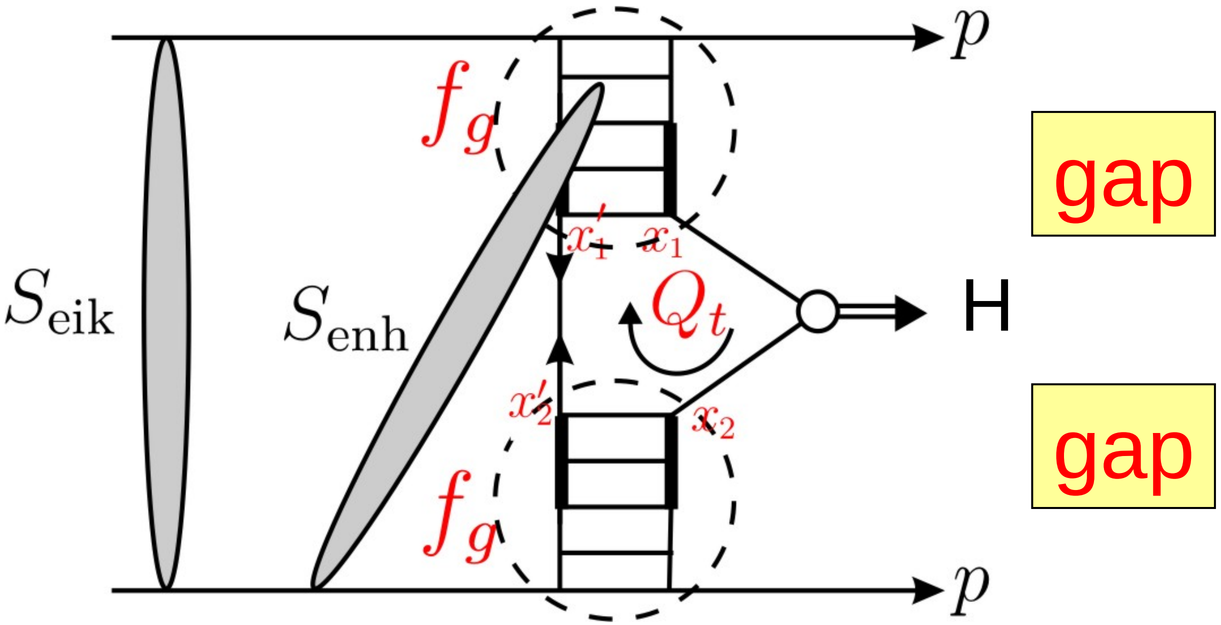
Effective Pom. pole
$\alpha_P(t) = 1.08+0.25t$

KMR parametrization

includes absorption
via multi-Pomeron effects

Absorption/ s-ch unitarity crucial at small b at LHC

… "soft" scatt. can easily destroy the gaps



soft-hard factoriz^n

eikonal rescatt: between protons ← conserved

enhanced rescatt: involving intermediate partons ← broken

→ need a model for soft physics at HE, see later..

Recall the 2nd definition of diffraction

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

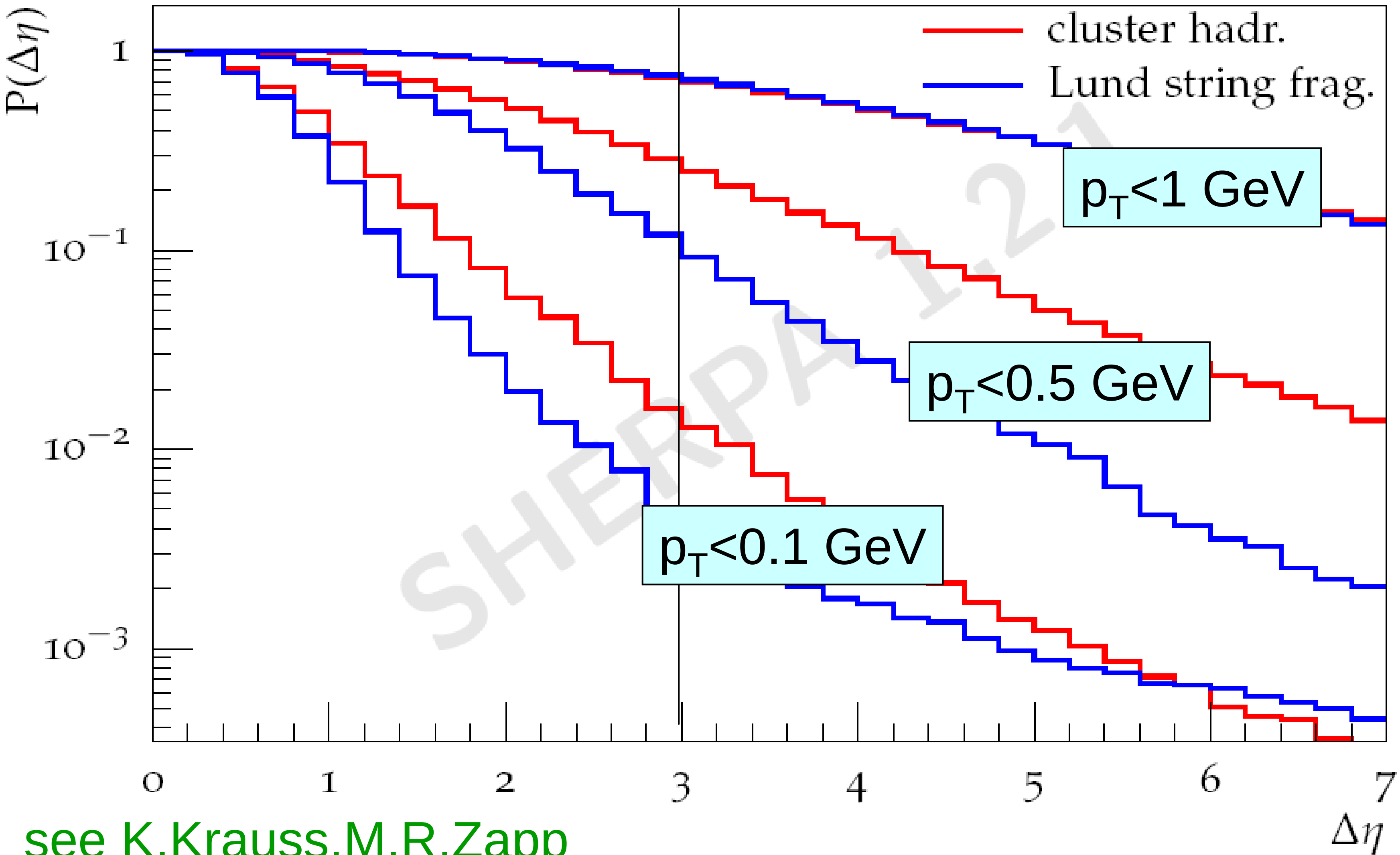
(a) Reggeon exchange

(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

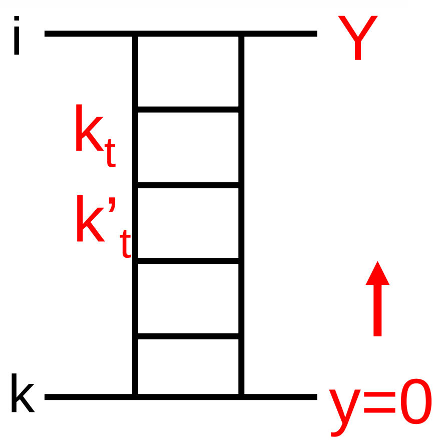
gap anywhere in $-5 < \eta < 5$, different threshold p_T



see K,Krauss,M,R,Zapp

Partonic structure of "bare" Pomeron

$$\Omega = \Omega_{ik}(y, k_t, b)$$



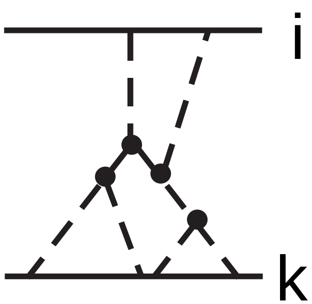
BFKL evol^n in rapidity generates ladder

$$\frac{\partial \Omega(y, k_t)}{\partial y} = \bar{\alpha}_s \int d^2 k_t' \, K(k_t, k_t') \, \Omega(y, k_t')$$

- At each step k_t and b of parton can be be changed – so, in principle, we have 3-variable integro-diff. eq. to solve
- **Inclusion of k_t crucial to match soft and hard domains. Moreover, embodies less screening for larger k_t comp^{ts}.**
- We use a simplified form of the kernel K with the main features of BFKL – diffusion in log k_t^2, $\Delta = \alpha_P(0) - 1 \sim 0.3$
- b dependence during the evolution is prop' to the Pomeron slope α', which is v.small ($\alpha' < 0.05$ GeV^{-2}) -- so ignore. Only b dependence comes from the starting evol^n distrib^n
- Evolution gives ⟶ $\Omega = \Omega_{ik}(y, k_t, b)$

Multi-Pomeron contributions

Now include rescatt of intermediate partons with the "beam" i and "target" k

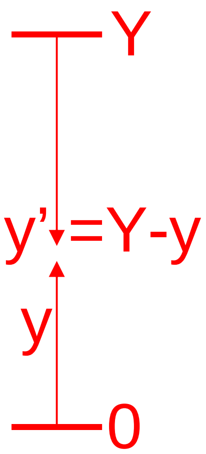


evolve up from y=0

$$\frac{\partial \Omega_k(y)}{\partial y} = \bar{\alpha}_s \int d^2k_t' \; \exp(-\lambda(\Omega_k(y)+\Omega_i(y'))/2) \; K(k_t,k_t') \; \Omega_k(y)$$

evolve down from y'=Y-y=0

$$\frac{\partial \Omega_i(y')}{\partial y'} = \bar{\alpha}_s \int d^2k_t' \; \exp(-\lambda(\Omega_i(y')+\Omega_k(y))/2) \; K(k_t,k_t') \; \Omega_i(y')$$



where $\lambda\Omega_{i,k}$ reflects the different opacity of protons felt by intermediate parton, rather the proton-proton opacity $\Omega_{i,k}$ $\lambda \sim 0.2$

solve iteratively for $\Omega_{ik}(y,k_t,b)$ **inclusion of k_t crucial**

Note: data prefer $\exp(-\lambda\Omega)$ → $[1 - \exp(-\lambda\Omega)] / \lambda\Omega$

Form is consistent with generalisation of AGK cutting rules

In principle, knowledge of $\Omega_{ik}(y,k_t,b)$ allows the description of all soft, semi-hard pp high-energy data:

σ_{tot}, $d\sigma_{el}/dt$, $d\sigma_{SD}/dtdM^2$, DD, DPE…

LRG survival factors S^2 (to both eikonal, enhanced rescatt)

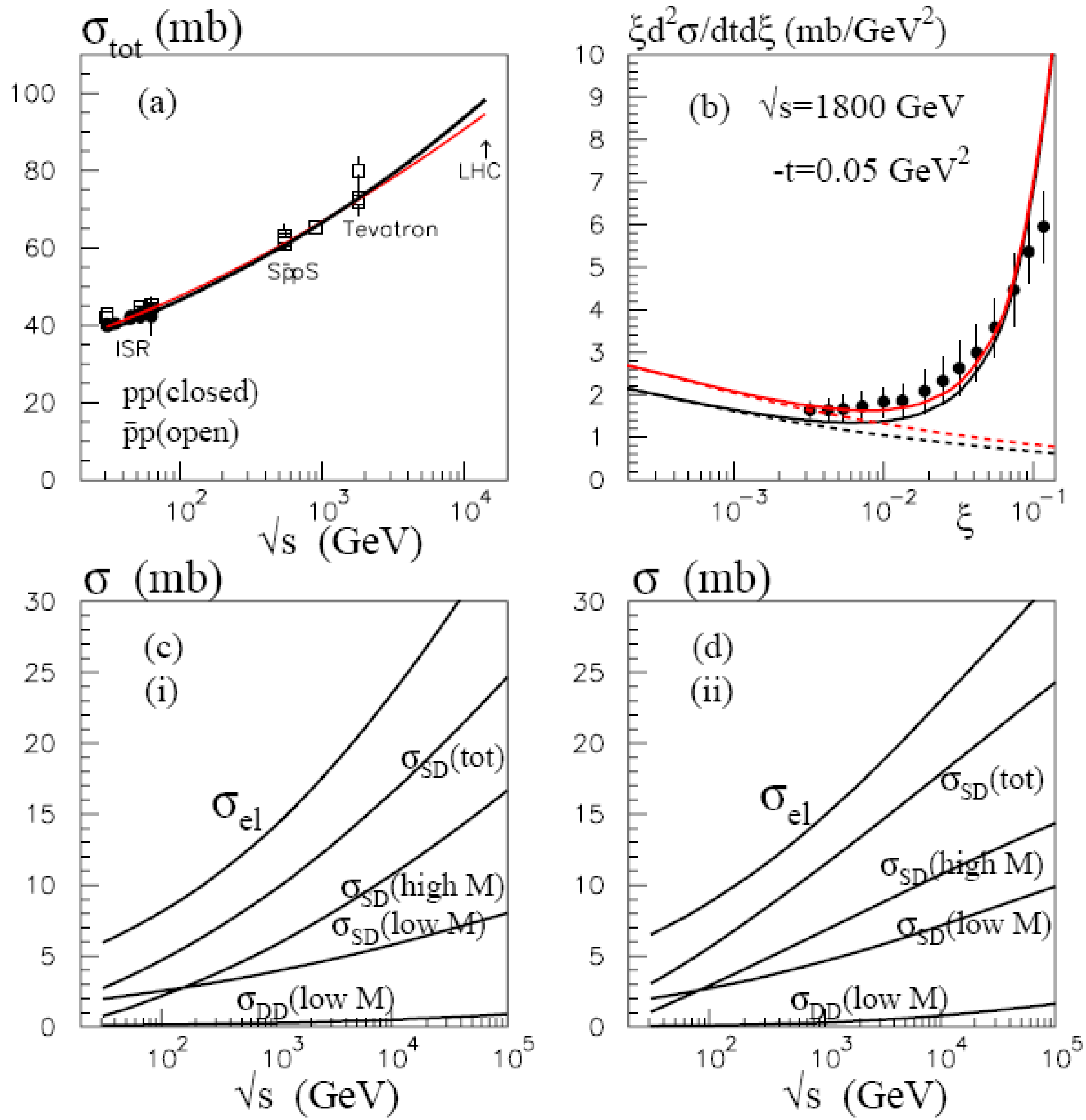
PDFs and diffractive PDFs at low x and low scales

Indeed, such a model can describe the main features of all the data, in a semi-quantitative way, with just a few physically motivated parameters.

energy	σ_{tot}	σ_{el}	σ_{SD}^{lowM}	σ_{SD}^{highM}	σ_{SD}^{tot}	σ_{DD}^{lowM}
1.8	72.8/72.5	16.3/16.8	4.4/5.2	8.3/11.1	12.7/16.3	0.8/1.7
7	89.0/86.8	21.9/21.6	5.5/6.7	12.0/14.4	17.5/21.1	1.4/2.8
14	98.3/94.6	25.1/24.2	6.1/7.5	14.0/15.9	20.1/23.4	1.8/3.6
100	127.1/117.4	35.2/31.8	8.0/9.9	20.6/20.0	28.6/29.9	3.4/6.2

$d\sigma/dy \sim s^{0.2}$ like the LHC data for 0.9 to 7 TeV

$S^2 = 0.010\text{-}0.016$ for gaps in pp → p + H + p (120GeV SM Higgs at 14TeV)



σ_tot (mb)
(a)
LHC
Tevotron
SppS
ISR
pp(closed)
p̄p(open)
√s (GeV)
ξd²σ/dtdξ (mb/GeV²)
(b) √s=1800 GeV
-t=0.05 GeV²
ξ
σ (mb)
(c)
(i)
σ_el
σ_SD(tot)
σ_SD(high M)
σ_SD(low M)
σ_DD(low M)
√s (GeV)
σ (mb)
(d)
(ii)
σ_el
σ_SD(tot)
σ_SD(high M)
σ_SD(low M)
σ_DD(low M)
√s (GeV)

Conclusions

- s-ch unitarity is important for quasi-elastic scatt or LRG events

- Multi-Pomeron exchange diagrams restore unitarity:
  (i) eikonal pp rescatt. (ii) enhanced with intermediate partons

- Altho' $g_{3P} \sim 0.2 g_N$, high-mass p dissoc^n is enhanced at the LHC

- Unitarity is restored for LRG by small survival prob. S^2 of gaps
  e.g. $S^2 \sim 0.015$ for pp → p + H + p (M_H=120 GeV at 14 TeV)

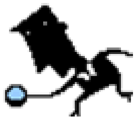
- LRG also from fluct^{ns} in had^n: study different p_T cuts and Δy
  also study long-range rapidity correlations at the LHC

- QCD/BFKL Pom. → Pomeron describing soft physics

- Partonic struct. of Pom, with multi-Pom contrib^{ns} can describe
  all soft ($\sigma_{tot,el,SD}$..) and semihard (PDFs, minijets..) physics-KMR

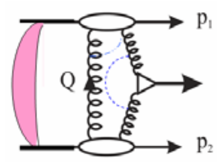
- Forms the basis of "all purpose" MC - Krauss, Hoeth, Zapp

CEP as a way to study old and new heavy resonances.



- **Heavy Quarkonia**

- **Zoo of charmonium –like XYZ states**



M

- $\chi_{c,b}$ production is of special interest: **(star reactions!)**
  - Heavy quarkonium production can shed light on the physics of bound states (lattice, NRQCD$\cdots$).
  - Potential to produce different J^P states, which exhibit characteristic features (e.g. angular distributions of forward protons).
  - Could shed light on the nature of the various 'exotic' charmonium states observed recently. (X,Y,Z) charmonium-like states.

Spin-Parity Analyzer

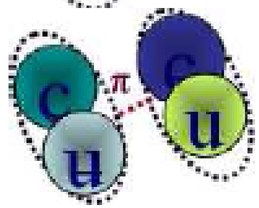
(KKMR-2003)

CDF & new LHCb measurements are all in good agreement (factor "few") with the Durham group predictions.

Zoo of charmonium –like XYZ states

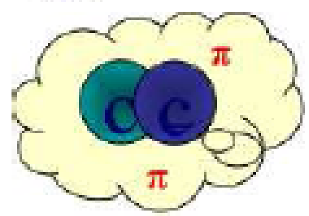
Tetraquark:
four tightly bound quarks

Molecular state:
two loosely bound mesons



Hybrid: states with
excited gluonic degrees of freedom

Hadrocharmonium: charmonium state,
"coated" by excited light-hadron matter



- X(3872) –
- XYZ(3940) & X(3915) –
- Y(4140)/Y(4280) & X(4350)

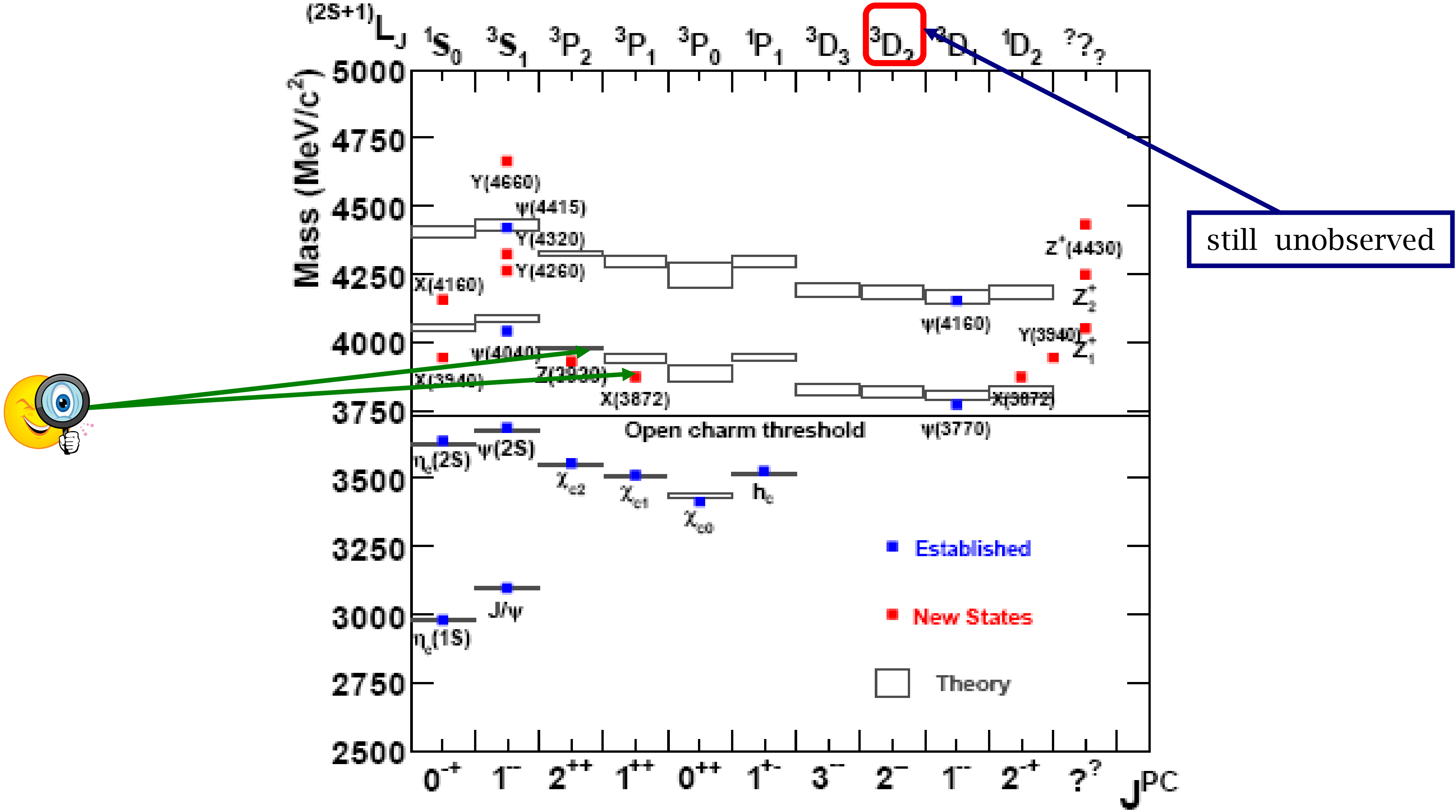
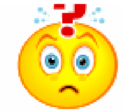


Figure 1: The mass versus the quantum numbers (J^{PC}) for the charmonium-like states. The boxes represent the predictions; blue boxes show the established states, and the red boxes indicate the new states discovered at the B-factories.

Overview of exotic/charmonium spectroscopy (2)

State	M, MeV	Γ, MeV	J^{PC}	Process
$X(3872)$	3871.52 ± 0.20	1.3 ± 0.6 (< 2.2)	$1^{++}/2^{-+}$	$B \to K(\pi^+\pi^- J/\psi)$ $p\bar{p} \to (\pi^+\pi^- J/\psi) + \ldots$ $B \to K(\omega J/\psi)$ $B \to K(D^{*0} D^0)$ $B \to K(\gamma J/\psi)$ $B \to K(\gamma \psi(2S))$
$X(3915)$	3915.6 ± 3.1	28 ± 10	$0/2^{?+}$	$B \to K(\omega J/\psi)$ $\gamma\gamma \to (\omega J/\psi)$
$X(3940)$	3942^{+9}_{-8}	37^{+27}_{-17}	$?^{?+}$	$e^+e^- \to J/\psi(D\bar{D}^*)$ $e^+e^- \to J/\psi\,(\ldots)$
$Y(4008)$	4008^{+121}_{-49}	226 ± 97	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^- J/\psi)$
$Z_1(4050)^+$	4051^{+24}_{-43}	82^{+51}_{-55}	?	$B \to K(\pi^+ \chi_{c1}(1P))$
$Y(4140)$	4143.4 ± 3.0	15^{+11}_{-7}	$?^{?+}$	$B \to K(\phi J/\psi)$
$X(4160)$	4156^{+29}_{-25}	139^{+113}_{-65}	$?^{?+}$	$e^+e^- \to J/\psi(D\bar{D}^*)$
$Z_2(4250)^+$	4248^{+185}_{-45}	177^{+321}_{-72}	?	$B \to K(\pi^+ \chi_{c1}(1P))$
$Y(4260)$	4263 ± 5	108 ± 14	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^- J/\psi)$ $e^+e^- \to (\pi^+\pi^- J/\psi)$ $e^+e^- \to (\pi^0\pi^0 J/\psi)$
$Y(4360)$	4353 ± 11	96 ± 42	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^- \psi')$
$Z(4430)^+$	4443^{+24}_{-18}	107^{+113}_{-71}	?	$B \to K(\pi^+ \psi(2S))$
$X(4630)$	4634^{+9}_{-11}	92^{+41}_{-32}	1^{--}	$e^+e^- \to \gamma(\Lambda_c^+ \Lambda_c^-)$
$Y(4660)$	4664 ± 12	48 ± 15	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^- \psi(2S))$

X(3872) — first and most puzzling state (observed in 2003 at Belle)



- Discovered by BELLE in 2003, confirmed by BaBar, CDF, D0
- Possible spin-parity assignment: 1^{++} or 2^{-+}
- May well be of exotic nature : loosely bound molecule, diquark-antidiquark, hybrid,….. but a conventional 2 P-wave charmonium interpretation is still on the table (recent renewal of interest).
- BaBar (2010) seems to favour 2^{-+} though various theory groups find this assignment highly problematic.
- According to PDG $\Gamma(\pi^+\pi^- J/\psi(1S))/\Gamma_{total}$ >2.6 % ; $\Gamma(\gamma\psi(2S))/\Gamma_{total}$ >3.0 %, Γ <2.3 MeV.

  (maybe two different states X(3872), X(3875))

CEP as a spin-parity analyzer could help to resolve the $X(3872)$ puzzle.

$Z(3930) \equiv \chi_{c2}(2P)$

- Above DD threshold .
- Vertex detection at LHCb & RHIC→ exclusive open charm: $D^+D^-, D^0\bar{D}^0$,
- Roughly the same expectations for CEP as for χ_{c2}

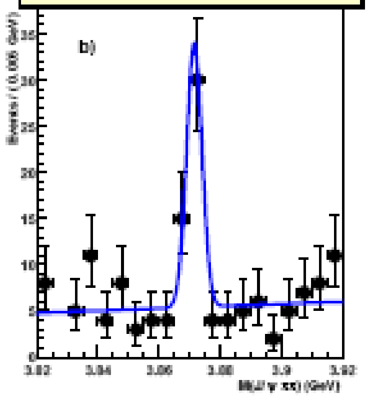
Triggering on J/ψ: M→ J/ψ+γ, J/ψ+ ρ….

$X(3872)$ ***properties***

Discovered by Belle in $B^{\pm} \to J/\psi\pi^+\pi^- K^{\pm}$ decays. Confirmed by D0, CDF, BaBar. What do we know about it?

$\sim 152\,\mathrm{M}\ B\bar{B}$ pairs

Belle, PRL 91, 262001 (2003)



$M(X) - (m_{D^0} + m_{D^{*0}}) = -0.32 \pm 0.35$ MeV

$X(3872) \to \pi^+\pi^- J/\psi$

$M(\pi^+\pi^-)$ is consistent with $\rho \Rightarrow$

large isospin violation;

$C = +1$.

$X(3872) \to \pi^+\pi^-\pi^0 J/\psi \Rightarrow$

$M(\pi^+\pi^-\pi^0)$ is consistent with ω, different isospin then $\rho J/\psi$.

Angular analysis: $J^{PC} = 1^{++}$ or 2^{-+}

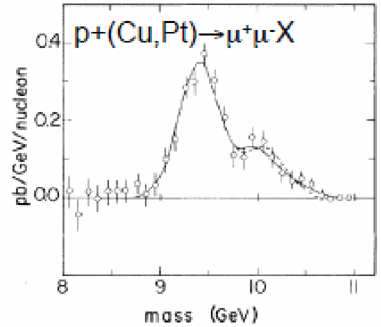
S-wave $D^0\bar{D}^{*0}$ molecular state?

E.S.Swanson, PLB 588, 189 (2004)

P-wave Bottomonia

Bottomonium history started 30 years ago

(PRL 39, 242 (1977) and PRL 39,1240 (1977))



FNAL, E288

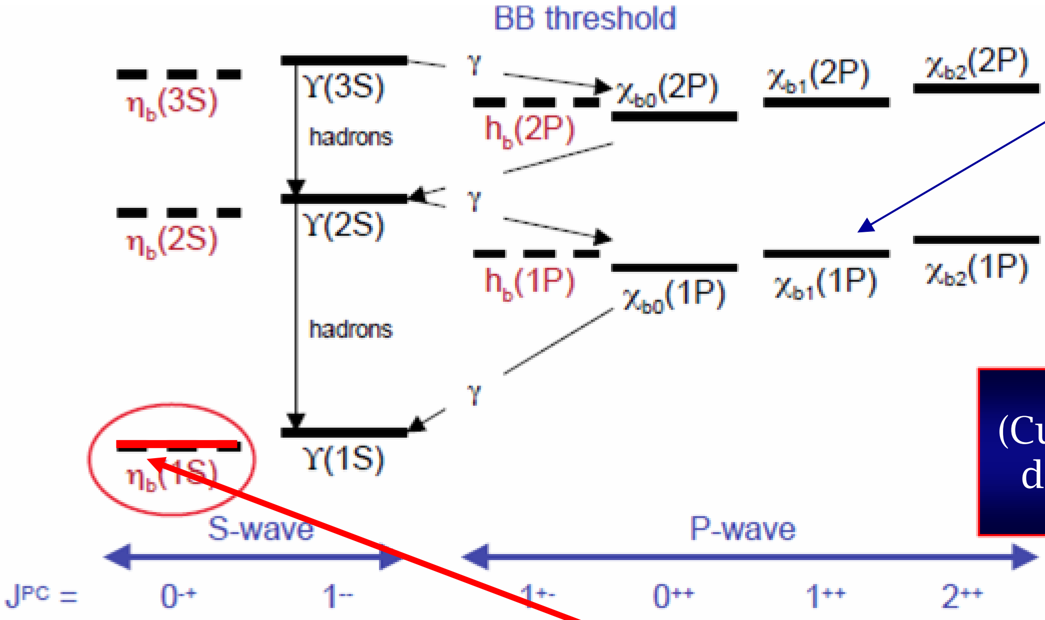
$M(\Upsilon)=9.40\pm0.013$

$M(\Upsilon')=10.00\pm0.04$

$M(\Upsilon'')=10.43\pm0.12$

(spins- still unconfirmed)

30 years later….



$\Upsilon(nS)$ confirmed and $\chi_{bJ}(1,2P)$ states observed

Below $B\bar{B}$, several states not yet observed: 3 S-wave (η_b), 2 P-wave (h_b), D-wave,etc…

(Currently no complete theoretical description of onium properties.)

(BABAR (2008))

(Still some puzzles)

The heaviest and most compact quark-antiquark bound state in nature

PDG particle data group Summary Tables

$\chi_{b0}(1P)$ [d]

$I^G(J^{PC}) = 0^+(0^{++})$

J needs confirmation.

Mass $m = 9859.44 \pm 0.42 \pm 0.31$ MeV

$\chi_{b0}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\gamma\,\Upsilon(1S)$	<6 %	90%	391

(Crystal Ball-1986)

$(1.73 \pm 0.35)\%$
CLEO-2011

$\chi_{b1}(1P)$ [d]

$I^G(J^{PC}) = 0^+(1^{++})$

J needs confirmation.

$\gamma\,\Upsilon(1S)$	(35 ± 8) %	423

$\chi_{b2}(1P)$ [d]

$I^G(J^{PC}) = 0^+(2^{++})$

J needs confirmation.

Mass $m = 9912.21 \pm 0.26 \pm 0.31$ MeV

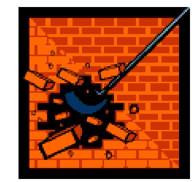
$\chi_{b2}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma\,\Upsilon(1S)$	(22 ± 4) %	442

Towards Full Acceptance Detector (bj- 1992)

CMS (& ATLAS) currently blind between $\eta = 6.4$ (CASTOR) and beam rapidity ($y_p = 8.9$ @ 7 TeV) except ZDC (neutrals). Cannot distinguish most diffractive/non-diffractive events.

IS THERE A WAY OUT ?

Yes, an addition of Forward Shower Counters around beam pipes at CMS!



(8 FSC per side see showers from particles with $|\eta| = 7$-9)

(Alice is installing such counters, ongoing studies for LHCb)

(**FSC**→ at least a good foot in the door)

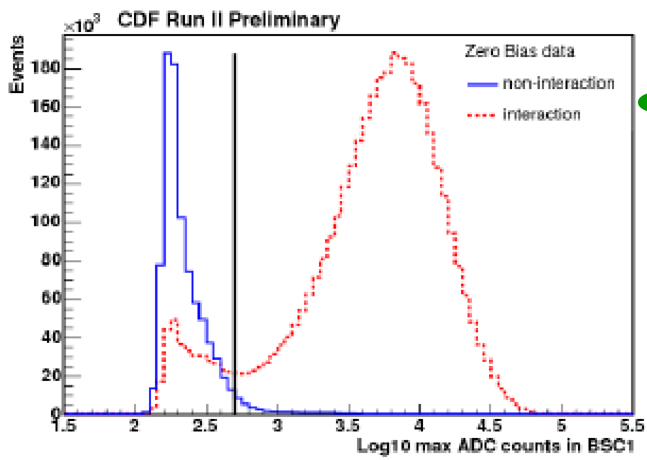
BSC very important as rap gap detectors.
All LHC experiments should have them!

FORWARD PHYSICS WITH RAPIDITY GAPS AT THE LHC

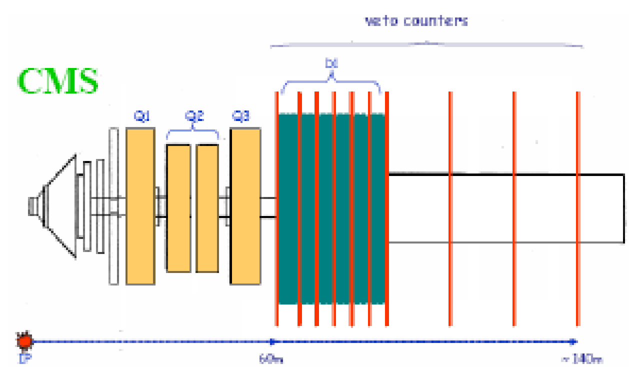
arXiv:0811.0120

JINST-09

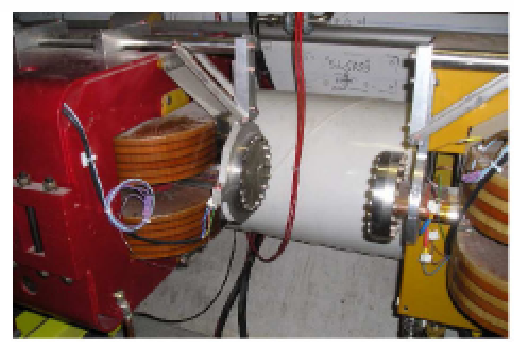
Michael Albrow[1], Albert De Roeck[2], Valery Khoze[3], Jerry Lämsä[4,5], E. Norbeck[6],
Y. Onel[6], Risto Orava[5], and M.G. Ryskin[7]
Sunday, November 09, 2008

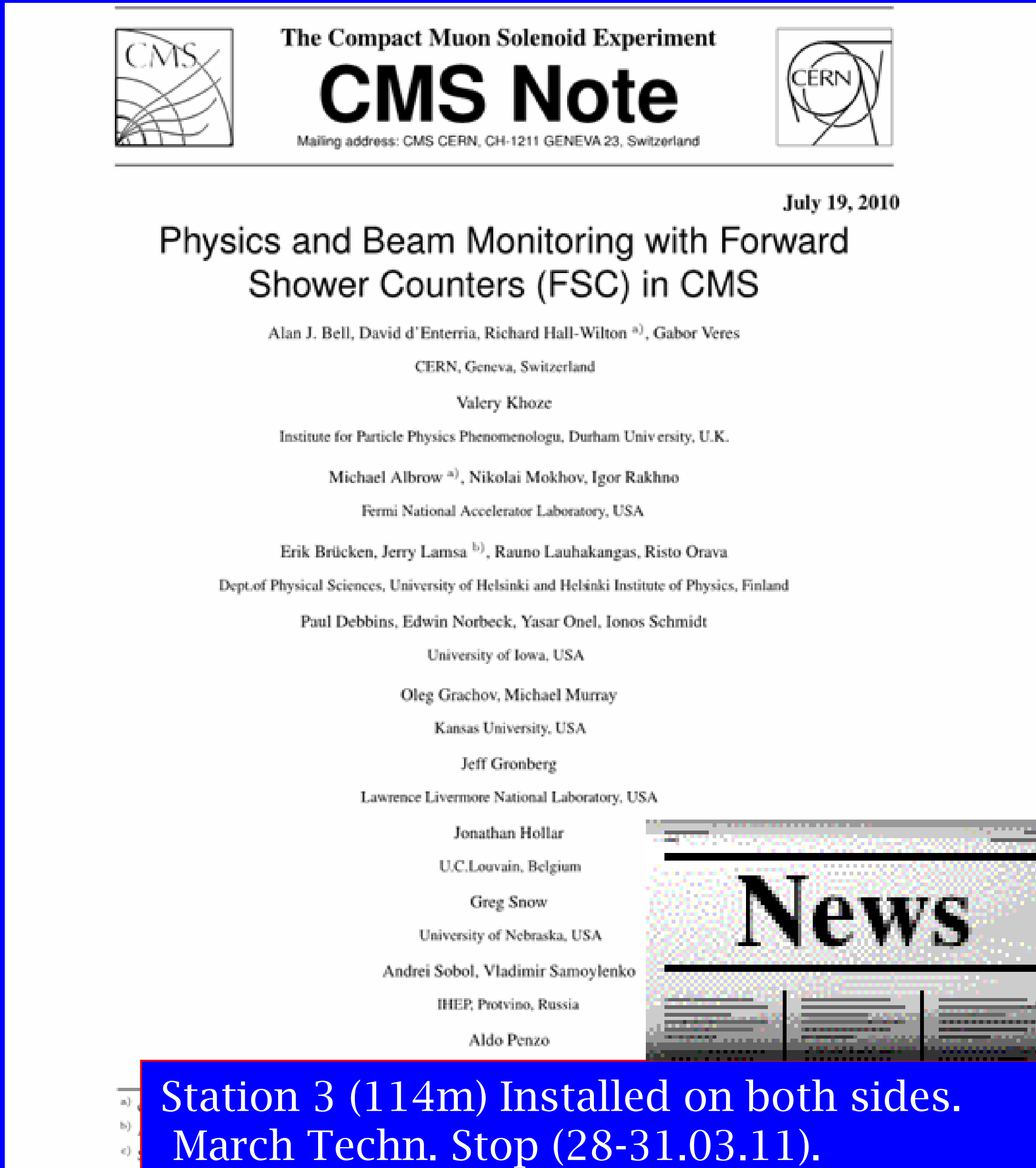


Warm accessible vacuum pipe (circular – elliptical)
~~Do not see primary particles, but showers in pipe ++~~
Simple scintillator paddles: **Gap detectors in no P-U events**



Take 0-bias events (Essential!)
{1} = prob no interaction
{2} = prob >= 1 interaction
Take hottest PMT of 8 BSC1
Plot log max ADC for {1} and {2}
Separates empty / not empty
Repeat for all detectors




The Compact Muon Solenoid Experiment

CMS Note

Mailing address: CMS CERN, CH-1211 GENEVA 23, Switzerland

July 19, 2010

Physics and Beam Monitoring with Forward Shower Counters (FSC) in CMS

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IHEP, Protvino, Russia

Aldo Penzo

a)

b)

c)

CMS NOTE-2010/015

Approved by CMS MB for Jan-Feb 2011 installation.

"Limited approval" :
Go ahead without detracting from necessary shutdown work.

Most value is 2011 running
& when <n/x> < ~ 5
(Do not expect to use > 2012)

Station 3 (114m) Installed on both sides.
March Techn. Stop (28-31.03.11).
Stations 1&2- installed during May Techn. stop. Commissioning with beam.

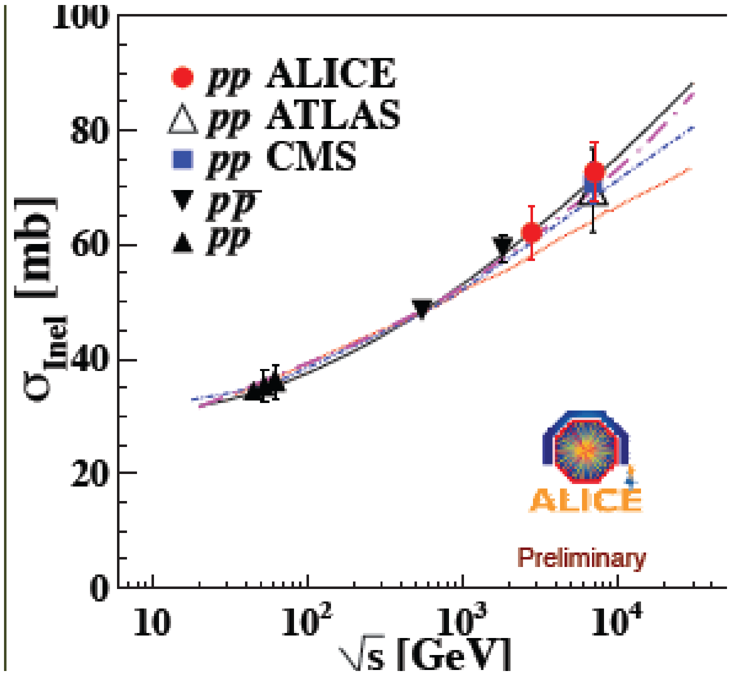
The FSC- these are for real !

- The installation and commissioning phase of FSC during the March Technical Stop.
- Main concern- lumi per bunch crossing might be too high.

What about precise measurement of SD?

Don't hold your breath, Valery.
This certainly needs all the counters and some low lumi run, or at least bunches. (Mike Albrow)

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 $2.8 < \eta < 5.1.$

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

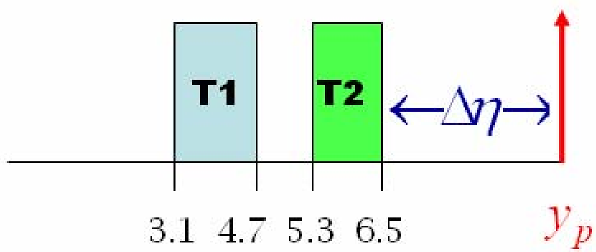
Achilles' Heel of 'inelastic' measurements : low mass SD,DD

Uninstrumented regions: (at least)

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

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

(Castor)

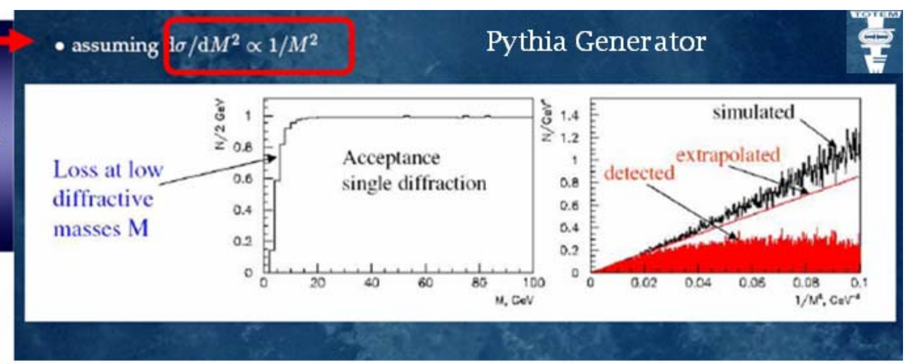


$$\eta = -\ln \tan \frac{\vartheta}{2}$$

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

Can we extrapolate from HM SD ?

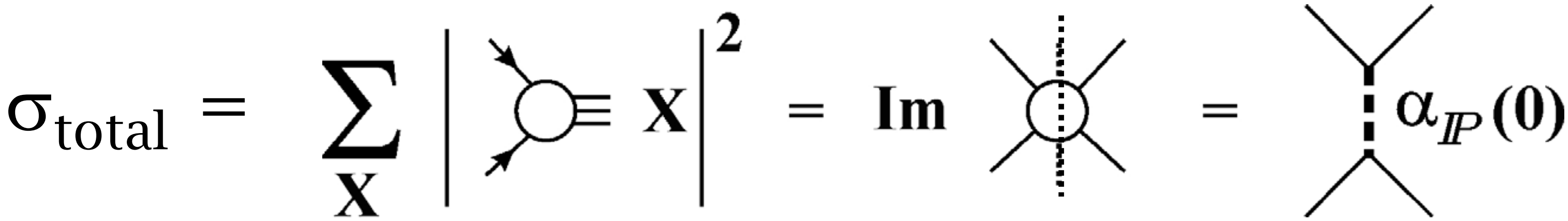
- Theoretically unjustified
- Currently **NO** theoretically solid way to extrapolate HM to LM single diffraction



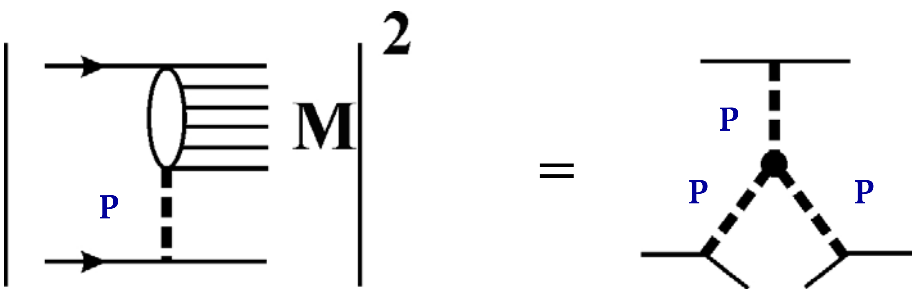
(UA4-experience ☞ factor of 2 for M<4 GeV)

Optical theorem

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



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

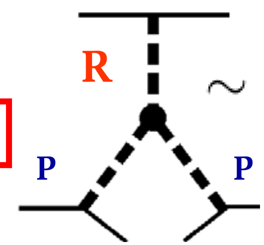
…

(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

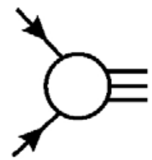
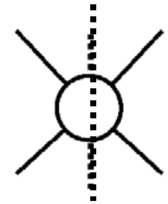
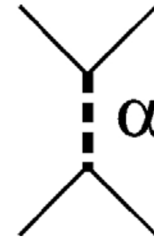


$$\sim \frac{s^{2\epsilon}}{(M^2)^{1.5+2\epsilon}}\ S^2 \quad \sim 1/M^3$$

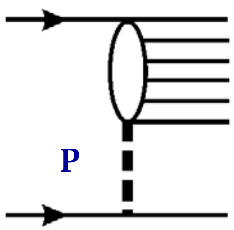
PPR-diagram

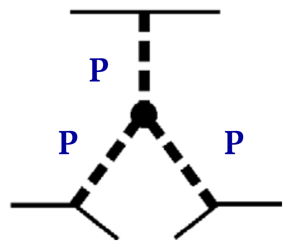
Optical theorem

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

$\sigma_{total} = \sum_X \Big|$  $X \Big|^2 =$ Im  $=$  $\alpha_{I\!P}(0)$

High mass diffractive dissociation

$\Big|$ 

$M \Big|^2 =$ 

PPP-diagram

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

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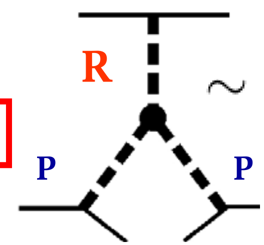

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PPR-diagram

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)

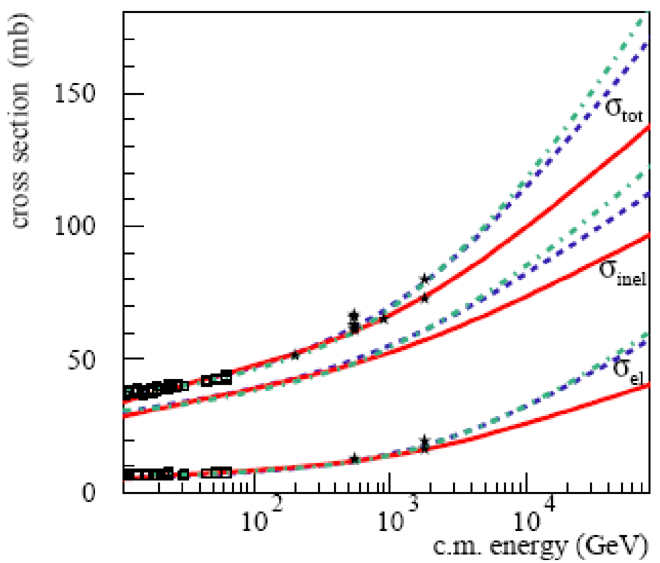

Figure 1: Model predictions for total, elastic, and inelastic proton-proton cross sections: QGSJET-II-4 - solid, QGSJET-II-3 - dashed, and SIBYLL - dot-dashed. The compilation of data is from Ref. [17].

S.Ostapchenko, ArXiv:1103.5684)

$\sqrt{s} = 7$ TeV

(in mb)	σ_{inel}	$\sigma_{\mathrm{SD}}^{\mathrm{LM}} + \sigma_{\mathrm{DD}}^{\mathrm{LM}}$
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**	

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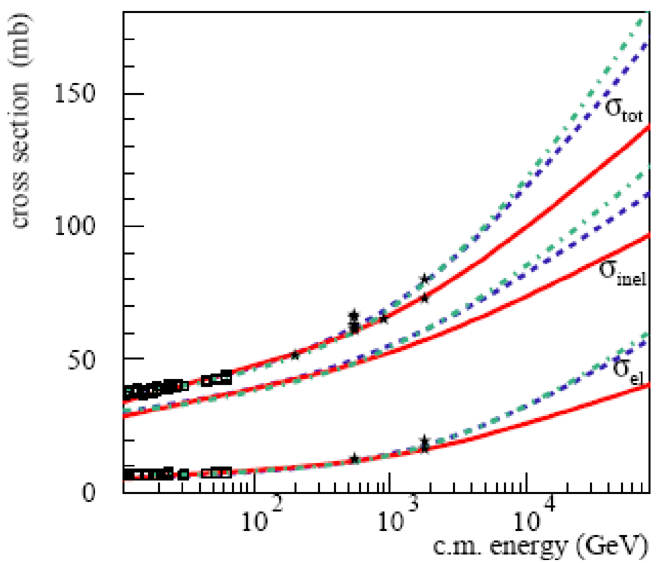

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For illustration purposes only

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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.[illegible]2 (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.[illegible]6	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

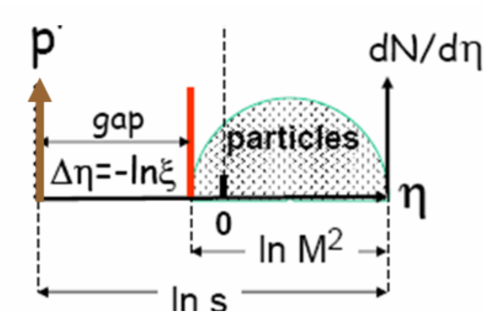
(A,B,C) S. Ostapchenko, Phys.Rev.D81:114028,2010.
KMR-08: KMR, EPJ C54,199(2008); ibid C60,249 (2009).
GLMM-08: GLMM,EPJ C57,689 (2008).
KP-10 A.B. Kaidalov, M.Poghosyan

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   at 7 TeV.

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



$$\xi = M_X^2/s > 5 \times 10^{-6}$$

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

$\sigma(\xi > 5 \times 10^{-6})$ [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]	
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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 $\frac{d\sigma_{el}}{dt}$, r σ_{el} wit σ_{tot} ood accuracy ?

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

With known lumi (3.5% VdM)

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

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

(Lumi independent)

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.

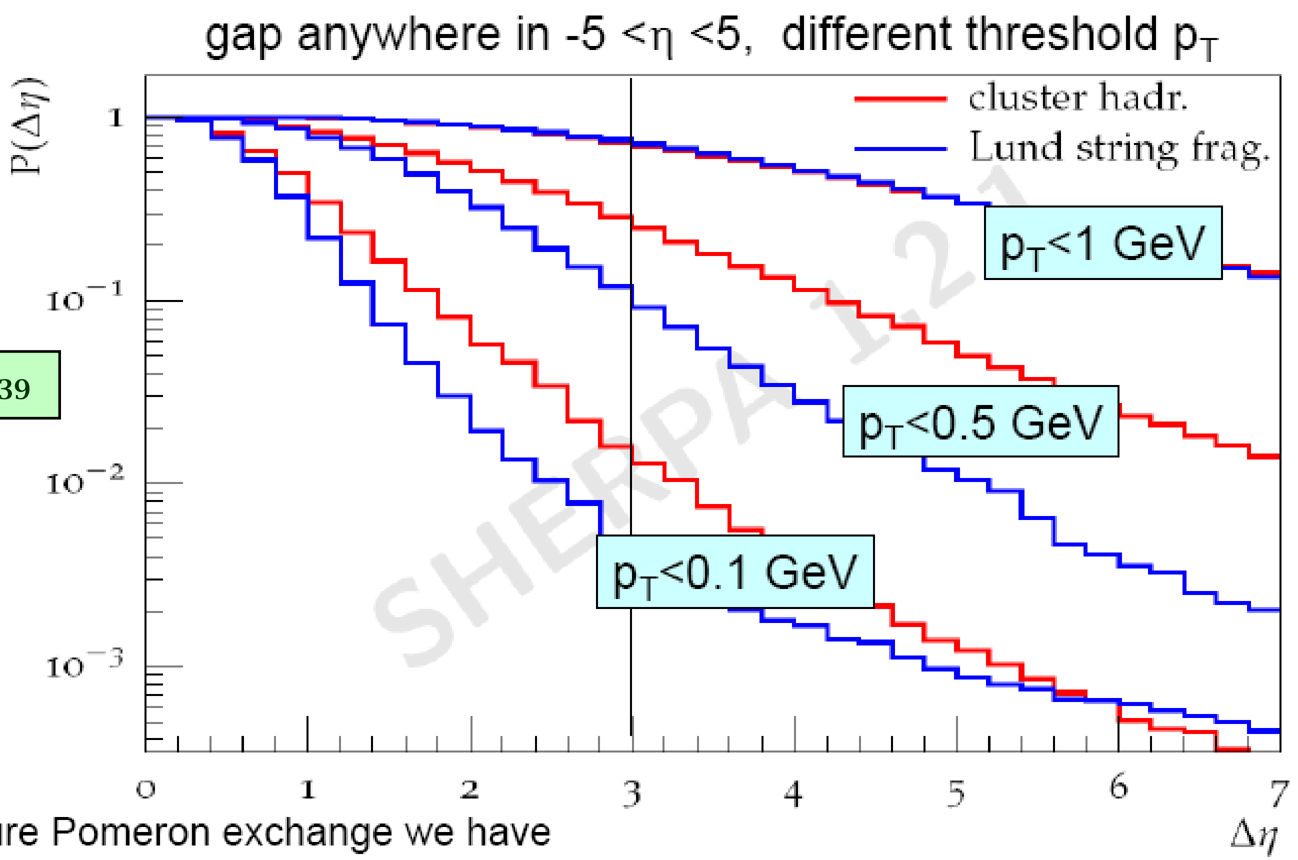
(Old convention was any event with LRG of size $\delta\eta>3$, since Pomeron exchange gives the major contribution)

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.