

Current Status of the Odderon: Odderon in diffractive dip region

M.G. Ryskin

Odderon is the C-odd amplitude which does not die out (or die very slowly) with energy. We consider the constraints on the Odderon properties and the perturbative QCD odderon given at the lowest α_s order by the three gluon exchange. We discuss the Odderon contribution observed at the LHC at small $t \rightarrow 0$ and in the region of diffractive dip.

In both cases this contribution is hardly seen.

**The goal is not to prove
that the Odderon exists
(no reason to have *No* Odderon)
but to *measure* the Odderon exchange
amplitude.**

Theory

a) Constraints

At any impact parameter b

$$\text{Im}A_{\text{Odd}}(s, b) \leq \text{Im}A_{\text{even}}(s, b)$$

That is $\alpha_{\text{Odd}}(t=0) \leq \alpha_{\text{even}}(t=0)$ and $B_{\text{Odd}} \leq B_{\text{even}}$

b) pert. QCD

At the lowest α_s order (Born approx.)
Odderon = 3 gluon exchange

Properties: **C-odd**

1. Odderon does not couple to pion/meson
(due to C-parity)

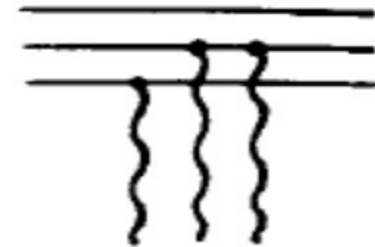
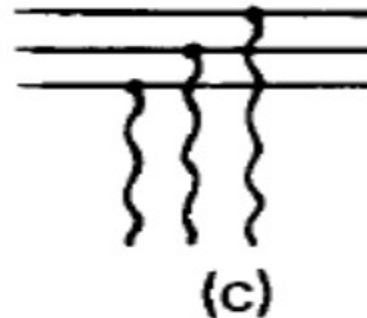
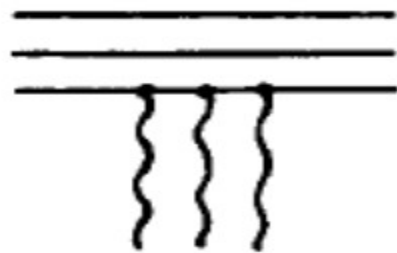
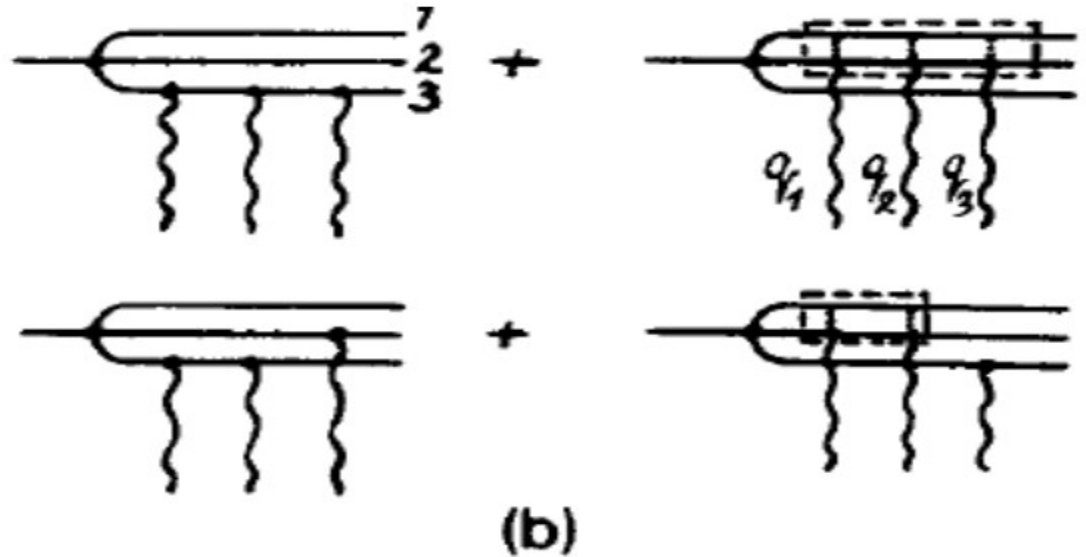
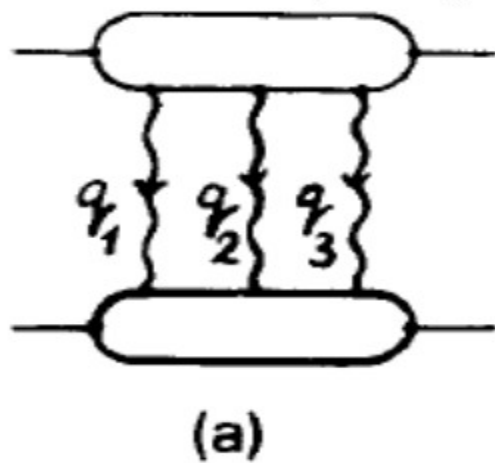
2. $\alpha(0)_{\text{Odd}} = 0.96 \rightarrow 1 \leq 1$

3. for $\alpha_{\text{Odd}} = 1$ C-odd amplitude A_{Odd} is **real**

Theory:

At the lowest α_s order (Born approx.)

Odderon = 3 gluon exchange



3. Odd. coupling is small

$$\sigma_{Odd} \sim \alpha_s^3 \cdot \langle r_{min}^2 \rangle \sim 1\text{mb} \otimes \text{BKP}$$

$$\sigma_{Pom} \sim \alpha_s^2 \cdot \langle r_{max}^2 \rangle \sim 40\text{ mb} \otimes \text{BFKL}$$

for $\alpha_{Odd} = 1$ C-odd amplitude A_{Odd} is **real**

$$A_{Odd} = \beta_O^2(t) \left(\frac{s}{s_0} \right)^{\alpha_{Odd}(t)} \sim \frac{s}{s_0} \beta_O^2(t)$$

$\beta_O(t) \equiv 0$ for π (π is C-even)

for K-meson $\beta_O(t=0) = 0$ but $\beta_O(t \neq 0) \neq 0$

for proton $\beta_O \propto \langle r_{min}(\text{qq separation}) \rangle$

in quark-diquark model (with point-like diquark)

$\beta_O(t=0) = 0$ as for K-meson

Dispersion relation

$$\text{Re}A(s, t = 0) = \frac{1}{\pi} \int_{-\infty}^0 \frac{ds' \text{Im}A(s', t)}{s' - s} + \frac{1}{\pi} \int_{4m^2}^{\infty} \frac{ds' \text{Im}A(s', t)}{s' - s}$$

$$\text{Im}A(s, 0) = \sigma_{tot}$$

$$\text{Re}A(s, t = 0) = \frac{1}{\pi} \int_{-\infty}^0 \frac{ds' \sigma(p\bar{p})(-s' + 4m^2)}{s' - s} + \frac{1}{\pi} \int_{4m^2}^{\infty} \frac{ds' \sigma(pp)(s')}{s' - s}$$

signature factor: If $A(s, t) \propto s^{\alpha(t)}$

$$\eta(t) = 1 \pm \exp(-i\pi\alpha(t)) = e^{-i\pi\alpha(t)/2} * f(t)$$

$$f(t) = \sin(\pi\alpha(t)/2) \quad \text{or} \quad \cos(\pi\alpha(t)/2)$$

for $\alpha_{Odd} \simeq 1$

$$\text{Re}A_{Odd} \sim \ln s \cdot \text{Im}A_{Odd} \text{ i.e. } \text{Re}A_{Odd} \gg \text{Im}A_{Odd}$$

$$\text{Re}A_{even} \ll \text{Im}A_{even}$$

$$\text{Re}A_{even}(s, t = 0) \simeq \frac{2s}{\pi} \int_{4m^2}^{\infty} \frac{ds' \sigma(pp)}{s'^2 - s^2} \simeq \frac{\pi}{2} \frac{\partial \sigma(s)}{\partial \ln s}$$

TOTEM 13 TeV $\sigma_{tot} = 110.6 \pm 3.4$ **mb**
 $(110.3 \pm 3.5)_{Coulomb} \Rightarrow 110.5 \pm 2.4$ **mb**
 $\rho = Re/Im = 0.10 \pm 0.01_{N=3}$ $(0.09 \pm 0.01_{N=1})$
arXiv: 1712.06153; 1812.04732

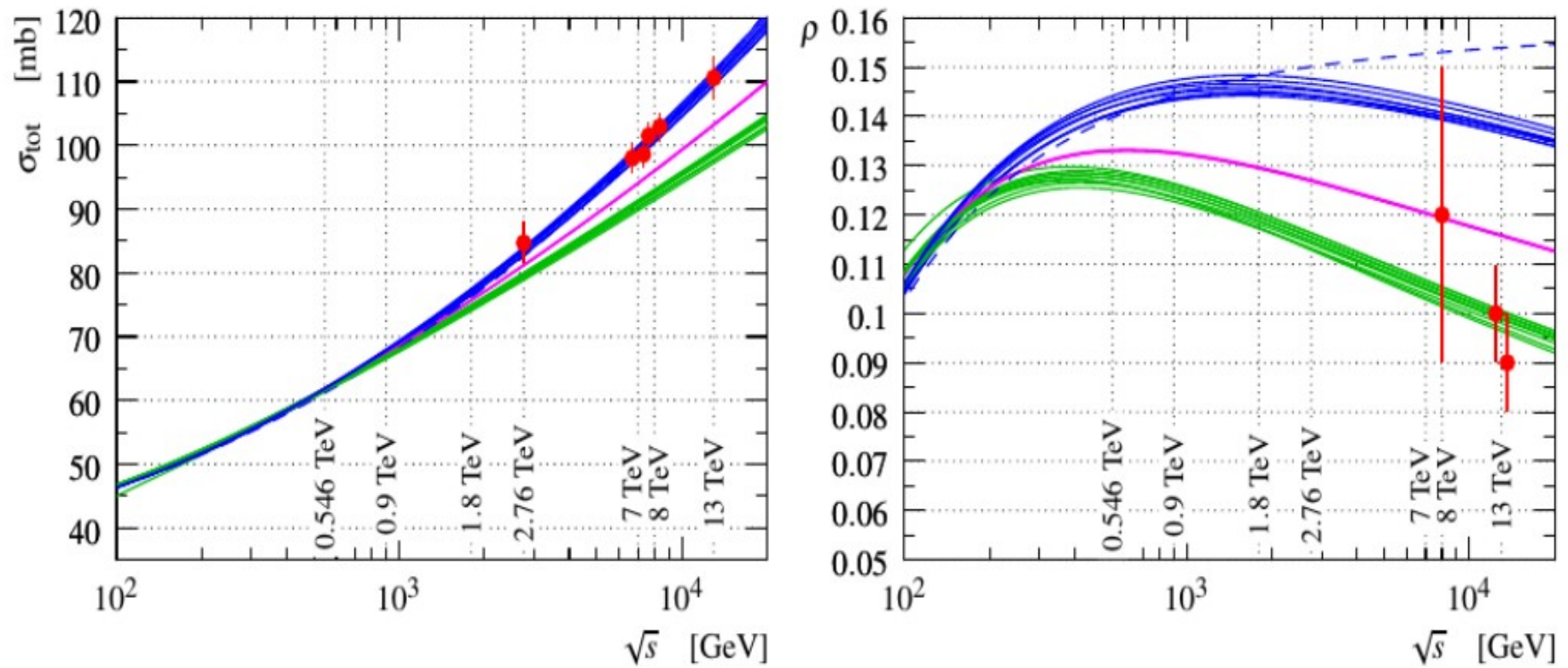


Fig. 18: Predictions of COMPETE models [32] for pp interactions. Each model is represented by one line (see

V.A. Petrov and N.P. Tkachenko,
PRD 106, 054003 (2022) accounts for
correlated errors and **normalization** factor

$$\rho = 0.11 \pm 0.01, \sigma_{tot} = 107.6 \pm 1.7 \text{ mb}, n = 0.92$$

normalization to Coulomb

NEW ATLAS/ALFA, EPJ C83, 441 (2023)

$$\sigma_{tot} = 104.7 \pm 1.1 \text{ mb}, \rho = 0.10 \pm 0.01$$

LRK fit E.G.S.Luna, M.G Ryskin, V.A.Khoze
2405.09385 $|t| < 0.1 \text{ GeV}^2, 50 \text{ GeV} < \sqrt{s} \leq 13 \text{ TeV}$

Two channel eikonal $A_N(s, b) = i(1 - e^{\Omega(s, b)/2})$

$$\Omega = \Omega_{Pomeron} + \Omega_{Odd}$$

$$A(s, t) = A_N + e^{i\alpha\phi} A_C$$

$$\mathcal{A}(s, t) = is \int_0^\infty b db J_0(bq) \left[1 - \frac{1}{4} e^{i(1+\gamma)^2 \Omega(s, b)/2} - \frac{1}{2} e^{i(1-\gamma^2) \Omega(s, b)/2} - \frac{1}{4} e^{i(1-\gamma)^2 \Omega(s, b)/2} \right]$$

TABLE I. Values of the parameters obtained in the global fits to Ensemble $A \oplus T$.

	Model I	Model II	Model II
$\beta_{\mathbb{P}}(0)$	2.247 ± 0.013	2.259 ± 0.016	2.307 ± 0.022
ϵ	0.1173 ± 0.0021	0.1180 ± 0.0020	0.1134 ± 0.0019
$\alpha'_{\mathbb{P}} \text{ (GeV}^{-2}\text{)}$	0.124 ± 0.024	0.128 ± 0.022	0.133 ± 0.023
$A \text{ (GeV}^{-2}\text{)}$	5.01 ± 0.20	4.78 ± 0.21	4.72 ± 0.21
$B \text{ (GeV}^{-4}\text{)}$	6.61 ± 0.99	6.7 ± 1.1	6.9 ± 1.2
$C \text{ (GeV}^{-6}\text{)}$	20.4 ± 5.7	17.7 ± 4.0	17.0 ± 4.2
$\beta_{\mathbb{O}}(0)$	$(0.15 \times 10^{-4}) \pm 39$	0.90 ± 0.18	0.88 ± 0.18
N_{546}	0.941	0.933	0.958
$N_{1.8[E]}$	0.923	0.912	0.944
$N_{1.8[C]}$	1.087	1.070	1.109
$N_{7[A]}$	1.015	1.015	1.056
$N_{8[A]}$	1.003	1.003	1.045
$N_{13[A]}$	1.009	1.009	1.052
$N_{7[T]}$	1.077	1.077	1.121
$N_{8[T]}$	1.121	1.121	1.167
$N_{13[T]}$	1.150	1.150	1.200
$\rho^{pp}(\sqrt{s} = 13 \text{ TeV})$	0.114	0.111	0.109
$\rho^{\bar{p}p}(\sqrt{s} = 13 \text{ TeV})$	0.114	0.119	0.116
Allowed N_i interval	[0.85,1.15]	[0.85,1.15]	[0.80,1.20]
ν	504	504	504
χ^2/ν	1.44	1.11	1.03

$\chi^2 = 560$ with Odderon
 $\chi^2 = 726$ without the Odderon

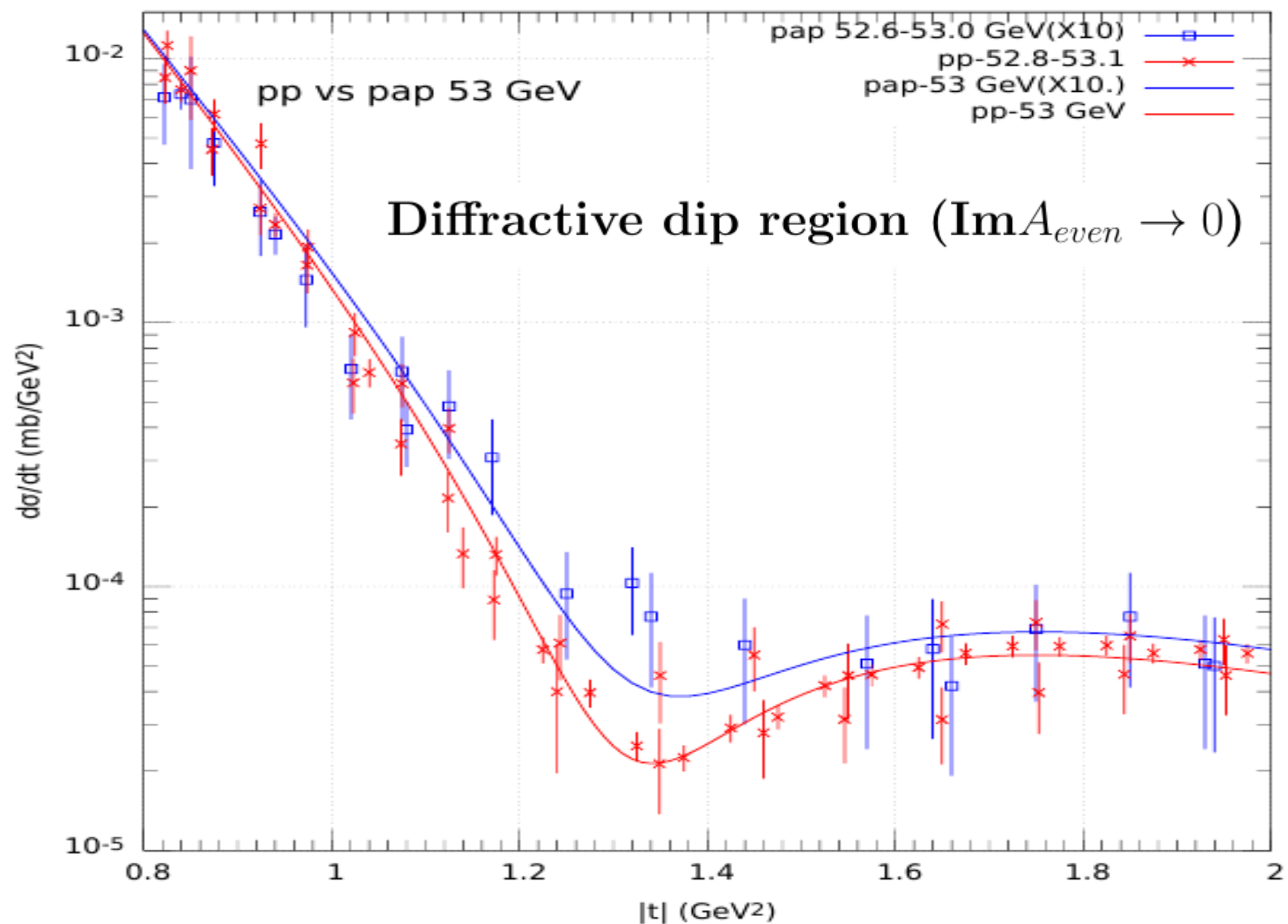
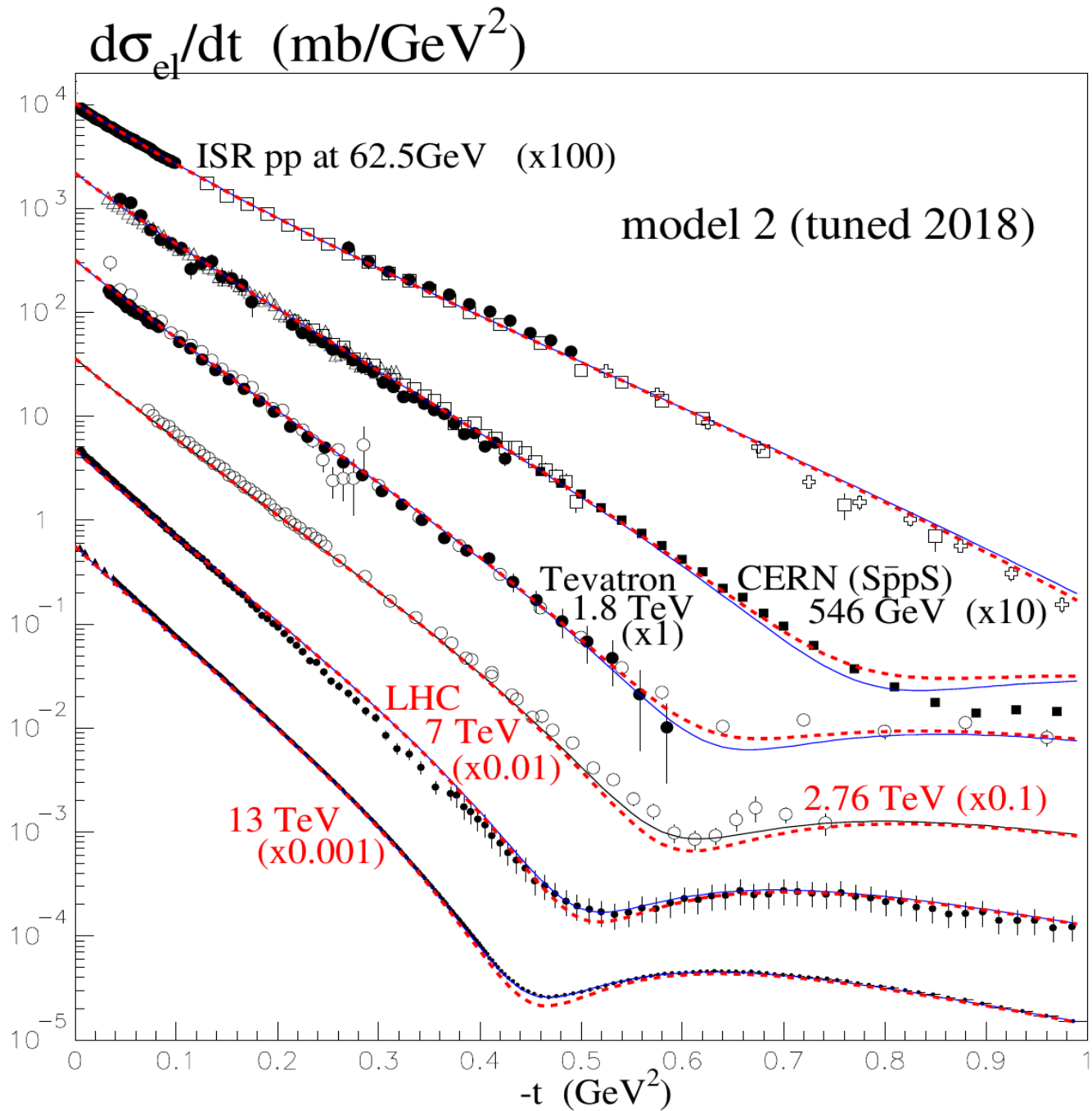


Fig. 6 pp and $\bar{p}p$ differential cross sections at $\sqrt{s} = 53$ GeV



$$\begin{aligned}\mathcal{F}^{pp}(s,t) &= \mathcal{F}_+(s,t) - \mathcal{F}_-(s,t), \\ \mathcal{F}^{\bar{p}p}(s,t) &= \mathcal{F}_+(s,t) + \mathcal{F}_-(s,t).\end{aligned}\qquad \sqrt{s} > 500 \text{ GeV}, \qquad 0.2 < |t| < 1 \text{ GeV}^2.$$

$$\mathcal{F}(s,t) = \sum_{i=1}^{N_{\mathbb{P}}} \mathcal{F}_{\mathbb{P}_i}(s,t) + \tau \sum_{j=1}^{N_{\mathbb{O}}} \mathcal{F}_{\mathbb{O}_j}(s,t),$$

$$\begin{aligned}\mathcal{F}_{\mathbb{P}_i}(s,t) &= \eta_{\mathbb{P}_i}(t) \, \beta_{\mathbb{P}_i}(t) \, \tilde{s}^{\alpha_{\mathbb{P}_i}(t)} \\ \mathcal{F}_{\mathbb{O}_j}(s,t) &= \eta_{\mathbb{O}_j}(t) \, \beta_{\mathbb{O}_j}(t) \, \tilde{s}^{\alpha_{\mathbb{O}_j}(t)} \\ \beta_{\mathbb{P}_i}(t) &= \beta_{\mathbb{P}_i}(0) \, \exp(B_{\mathbb{P}_i} t).\end{aligned}$$

E.G.S. Luna, M.G. Ryskin, V.A. Khoze, arXiv: 2608.25713

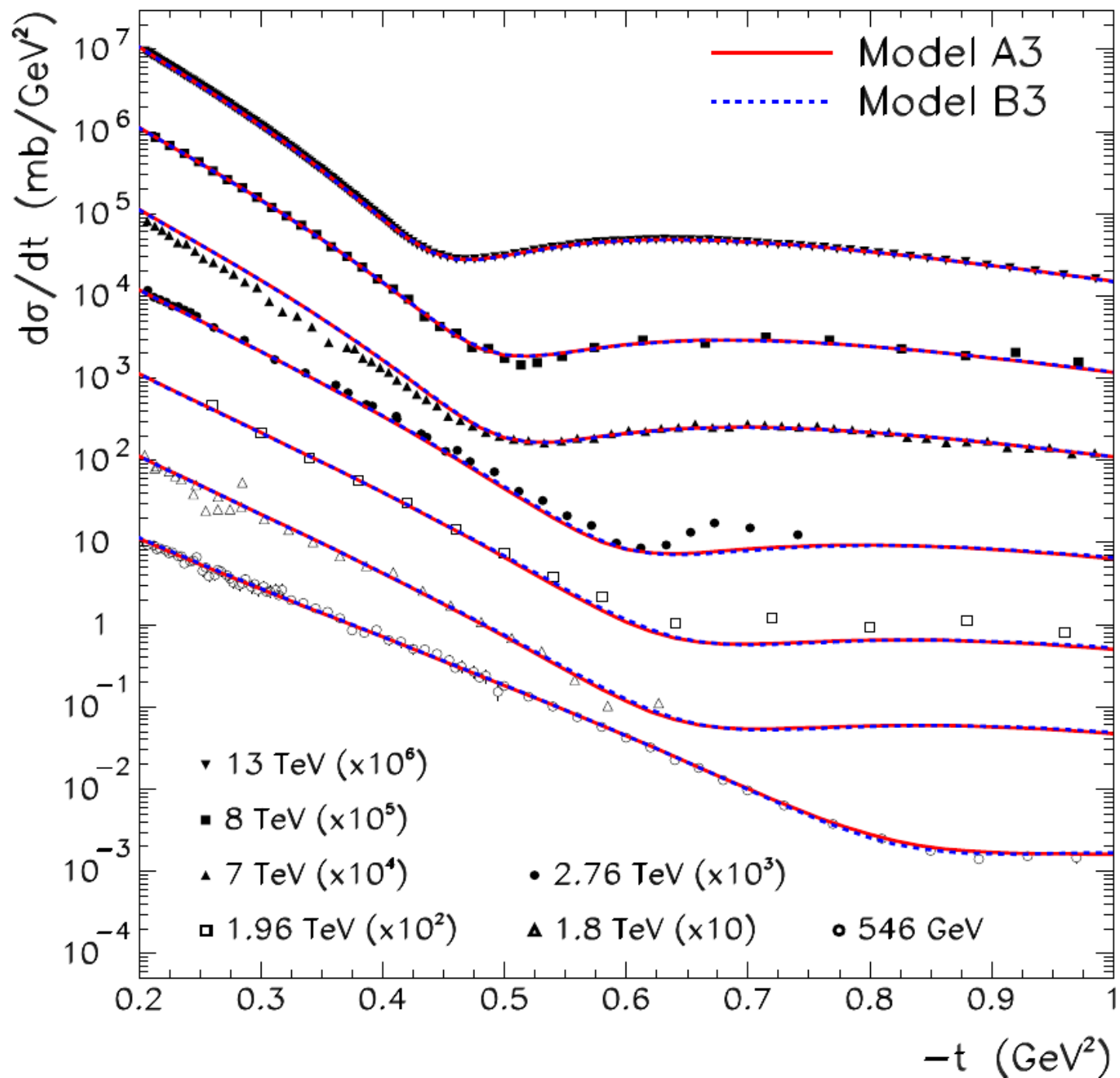
J.A. velazquez Corral, B.G. Giraud, R. Peschanski, C. Royon, e-Print:
2607.11286

No $\bar{p}p$ data

(but extra phase $e^{i\phi^+} \implies$ C-odd admixture to A^+)

TABLE V. Fit parameters and partial fit qualities for the A3/B3 family. In these fits the Odderon-like slope are also released, with $\alpha_0(t) = 1 + \epsilon_0 + \alpha'_0 t$. The reduced fits A3/13 and B3/13 are also shown.

	MODEL A3	MODEL B3	MODEL A3/13
$\epsilon_{\mathbb{P}_1}$	0.18942 $\pm$ 0.00036	0.18559 $\pm$ 0.00048	0.18970 $\pm$ 0.00034
$\alpha'_{\mathbb{P}_1}$ (GeV $^{-2}$)	0.086943 $\pm$ 0.00068	0.10750 $\pm$ 0.00090	0.08823 $\pm$ 0.00066
$\beta_{\mathbb{P}_1}(0)$	-0.04424 $\pm$ 0.00030	-0.06719 $\pm$ 0.00060	-0.04432 $\pm$ 0.00029
$B_{\mathbb{P}_1}$ (GeV $^{-2}$)	0.968 $\pm$ 0.013	0.846 $\pm$ 0.017	0.949 $\pm$ 0.012
$\epsilon_{\mathbb{P}_2}$	0.07707 $\pm$ 0.00021	0.02247 $\pm$ 0.00041	0.07609 $\pm$ 0.00020
$\alpha'_{\mathbb{P}_2}$ (GeV $^{-2}$)	0.31557 $\pm$ 0.00063	0.1812 $\pm$ 0.0011	0.31332 $\pm$ 0.00062
$\beta_{\mathbb{P}_2}(0)$	3.018 $\pm$ 0.012	4.972 $\pm$ 0.037	3.023 $\pm$ 0.011
$B_{\mathbb{P}_2}$ (GeV $^{-2}$)	1.443 $\pm$ 0.012	2.632 $\pm$ 0.020	1.450 $\pm$ 0.011
$\epsilon_{\mathbb{P}_3}$	0.0429 $\pm$ 0.0010	0.09088 $\pm$ 0.00084	0.04408 $\pm$ 0.00092
$\alpha'_{\mathbb{P}_3}$ (GeV $^{-2}$)	(0.0051$\times 10^{-1}$)$\pm$0.0065	(0.70$\times 10^{-2}$)$\pm$0.22	-
$\beta_{\mathbb{P}_3}(0)$	4.429 $\pm$ 0.082	2.813 $\pm$ 0.042	4.412 $\pm$ 0.075
$B_{\mathbb{P}_3}$ (GeV $^{-2}$)	12.162 $\pm$ 0.071	10.477 $\pm$ 0.052	12.080 $\pm$ 0.065
$\epsilon_{\mathbb{O}_1}$	(-0.13$\times 10^{-4}$)$\pm$0.19	-0.0084$\pm$0.0091	-
$\alpha'_{\mathbb{O}_1}$ (GeV $^{-2}$)	0.692 $\pm$ 0.069	0.66 $\pm$ 0.12	0.695 $\pm$ 0.057
$\beta_{\mathbb{O}_1}(0)$	1.95 $\pm$ 0.95	2.2 $\pm$ 1.7	1.98 $\pm$ 0.91
$B_{\mathbb{O}_1}$ (GeV $^{-2}$)	(2.2$\times 10^{-2}$)$\pm$7.4	(2.1$\times 10^{-3}$)$\pm$5.0	-
ν	436	436	439
$\tilde{\chi}^2_{total}$	1.86	1.50	1.84
$\tilde{\chi}^2 _{546 \text{ GeV}}$	0.48	0.52	0.49
$\tilde{\chi}^2 _{1.8 \text{ TeV}}$	1.19	1.24	1.19
$\tilde{\chi}^2 _{1.96 \text{ TeV}}$	3.59	3.20	3.58
$\tilde{\chi}^2 _{2.76 \text{ TeV}}$	2.23	2.08	2.23
$\tilde{\chi}^2 _{7 \text{ TeV}}$	4.46	4.30	4.46
$\tilde{\chi}^2 _{8 \text{ TeV}}$	0.69	0.69	0.69
$\tilde{\chi}^2 _{13 \text{ TeV}}$	1.42	0.62	1.42

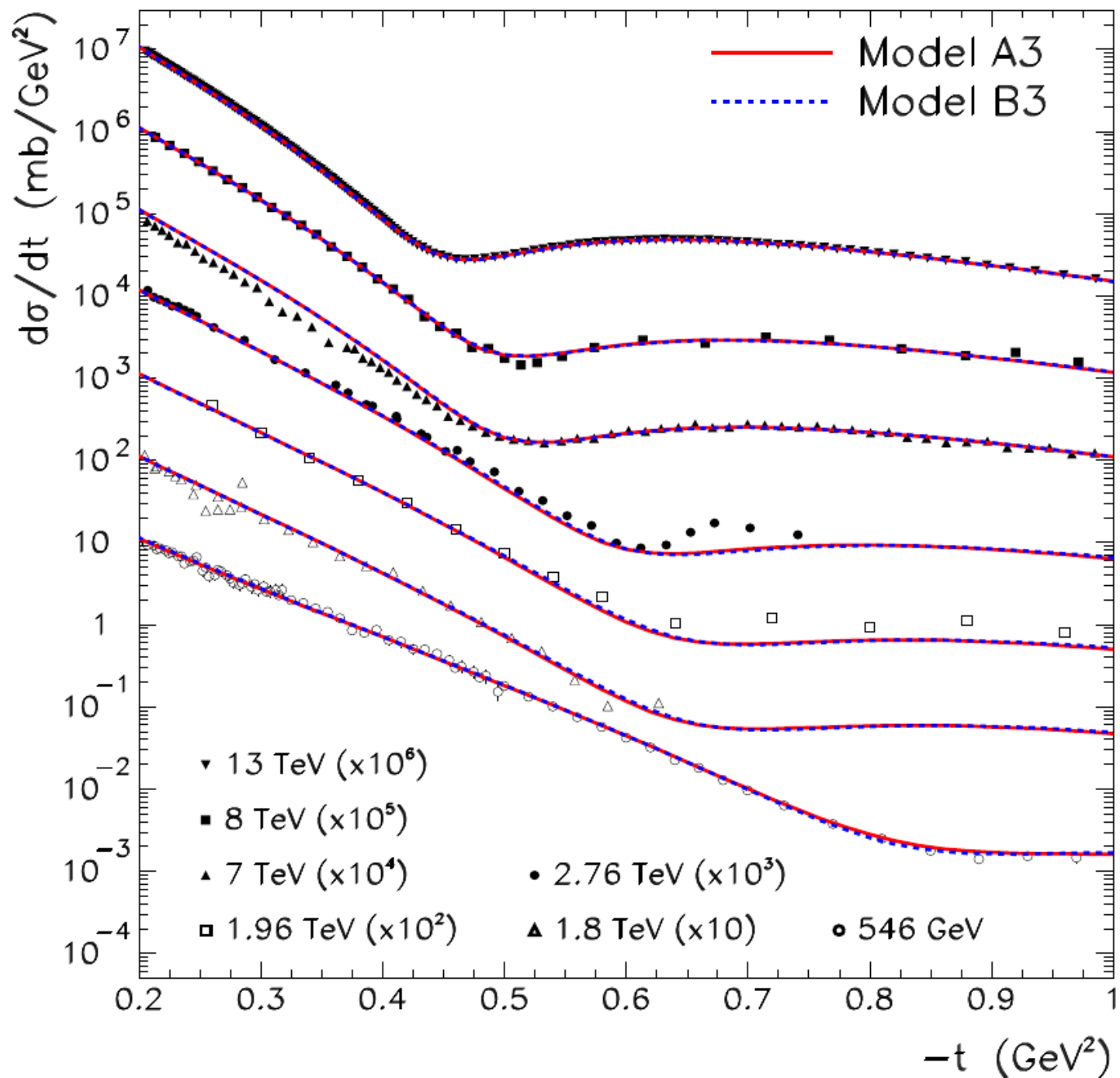


Odderon parameter are not sufficiently fixed
 $\epsilon_O = 0 \pm 0.19, \quad B_O = 0 \pm 7.4 \text{ GeV}^{-2}$
The uncertainty about two orders of magnitude for
 $\sqrt{s} = 13 \text{ TeV}$ and $t \sim -0.5 \text{ GeV}^2$.

Odderon contribution at dip can be compensated
by small variations of C-even amplitude parameters.

To improve the description of D0 (1.96) and TOTEM
(2.76) data we need an additional **C-even** term.

Adding the 4th C-even term improves χ^2 by 30
Adding an extra C-odd term improves χ^2 by 8.6.



Conclusion

- Odderon exists (i) in pert.QCD,
(ii) in experiment but the coupling is small
- It was observed experimentally
but number of $\sigma=???$
(accuracy is limited by systematics and not by statistics)
- Odderon can be observed in elastic
scattering at $t \rightarrow 0$ or in diffr. dip region
to exclude systematics we have to measure pp and $\bar{p}p$ in the
SAME experiment (LHC at 900 GeV)
- Odderon contribution to $Re/Im \simeq 0.004$
not 0.04 as TOTEM claimed
C-odd contribution to $Re\mathcal{A}(pp)$ in dip region
 $Re_{odd} < 0.05 Re_{even}$

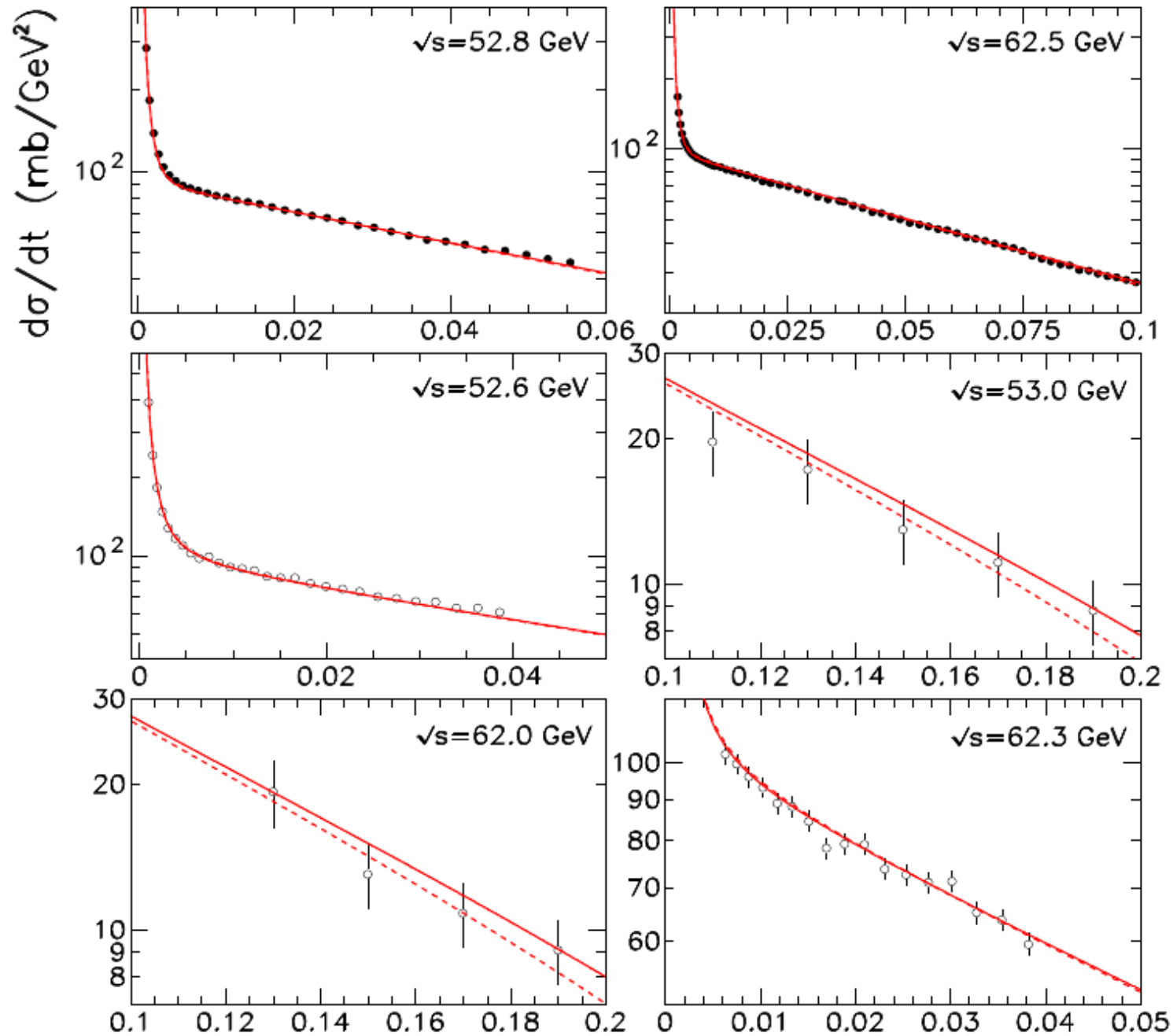
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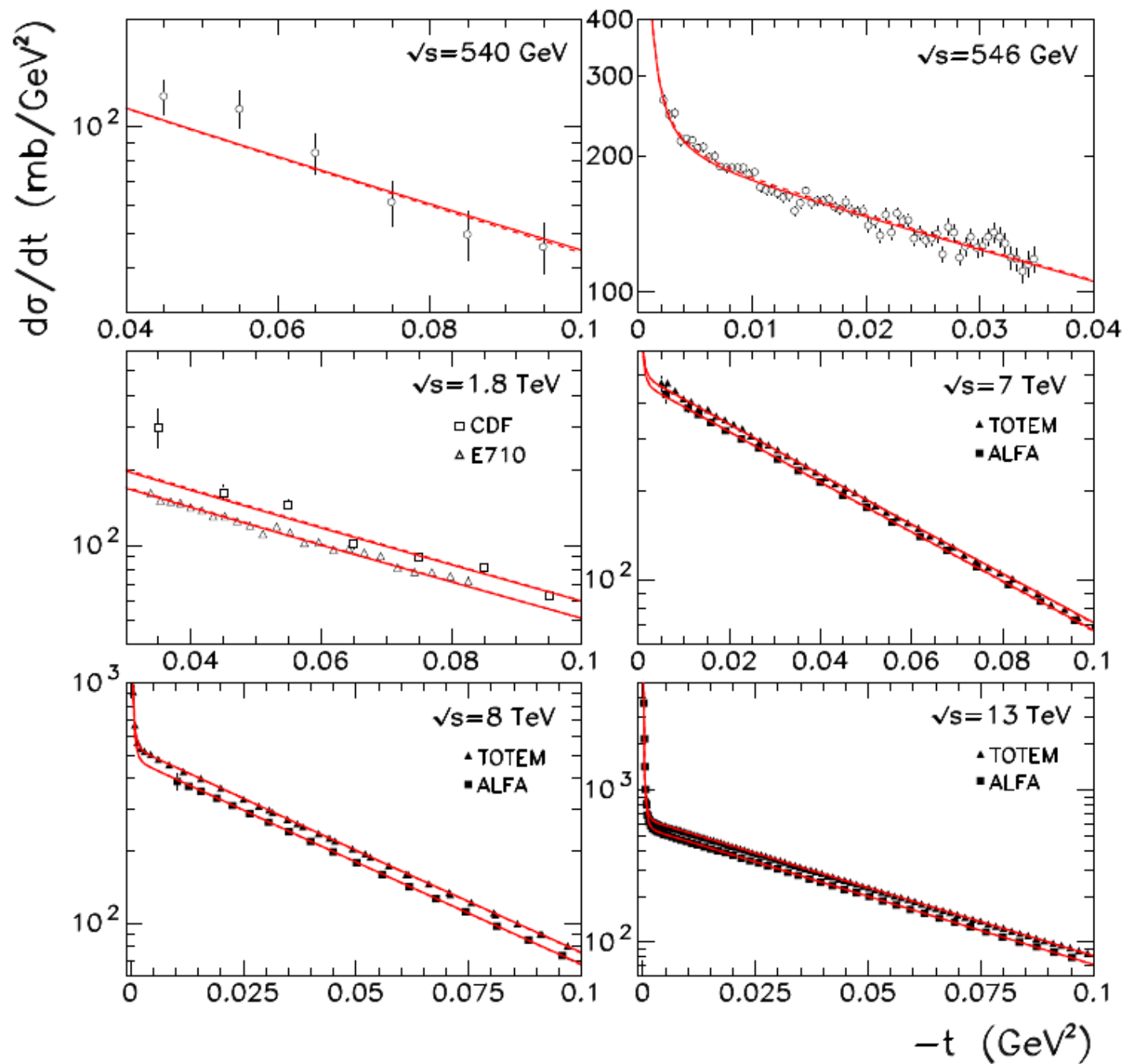
TABLE II. Predictions for $\sigma_{tot}^{\bar{p}p,pp}$, $\sigma_{el}^{\bar{p}p,pp}$, and $\rho^{\bar{p}p,pp}$ using Models I and II. These results were derived for the scenario with $D = A/2$.

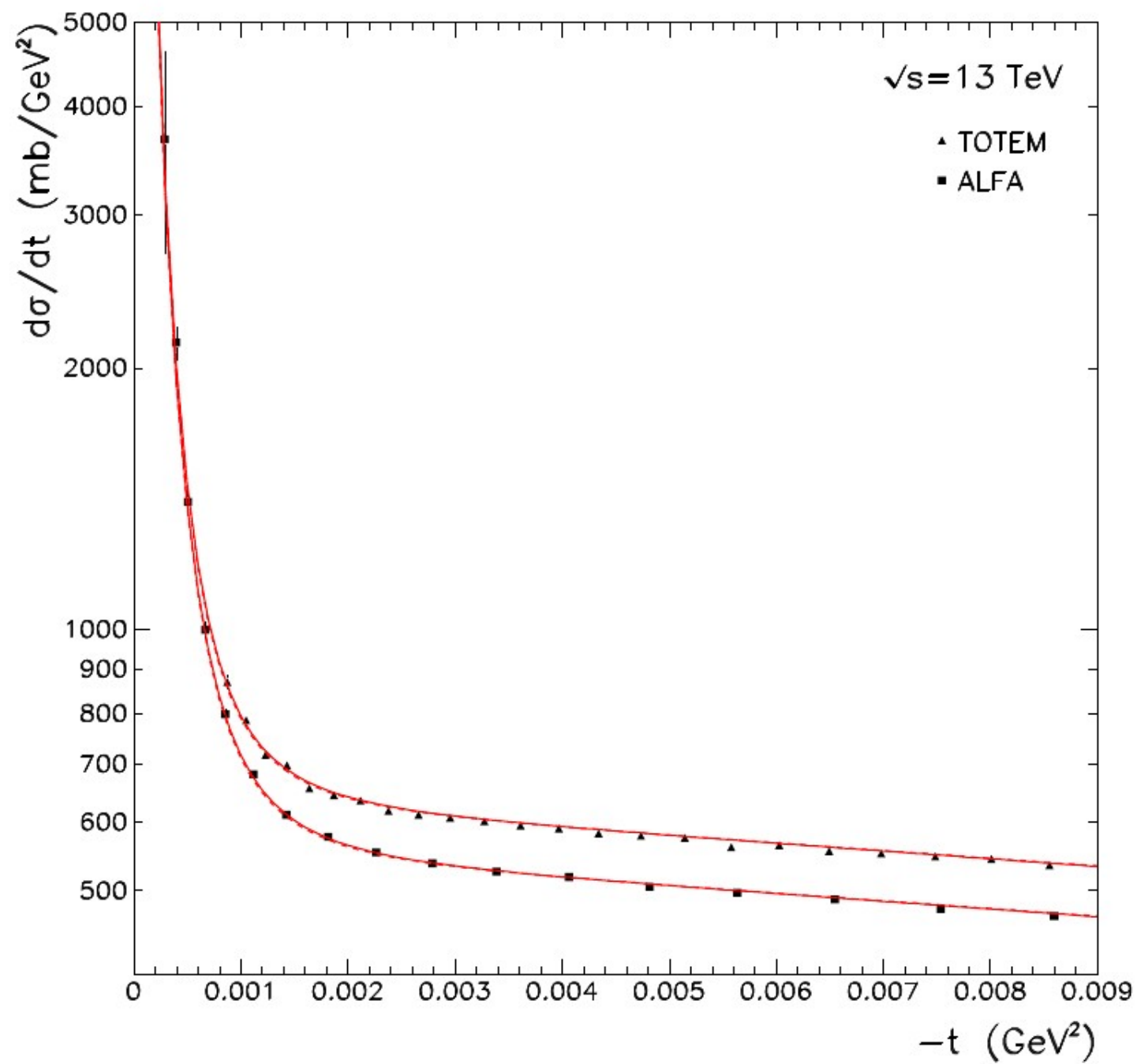
$\sqrt{s}$ (TeV)	Model I				Model II			
	$\sigma_{tot}^{pp} \sigma_{tot}^{\bar{p}p}$ (mb)	$\sigma_{el}^{pp} \sigma_{el}^{\bar{p}p}$ (mb)	$\rho^{pp} \rho^{\bar{p}p}$		$\sigma_{tot}^{pp} \sigma_{tot}^{\bar{p}p}$ (mb)	$\sigma_{el}^{pp} \sigma_{el}^{\bar{p}p}$ (mb)	$\rho^{pp} \rho^{\bar{p}p}$	
0.541	64.2 64.2	13.2 13.2	0.130 0.130		63.8 64.1	13.3 13.5	0.117 0.144	
1.8	78.0 78.0	17.6 17.6	0.124 0.124		77.6 77.8	17.7 17.9	0.116 0.133	
7	95.9 95.9	23.9 23.9	0.117 0.117		95.7 95.9	24.0 24.2	0.113 0.123	
8	97.9 97.9	24.5 24.5	0.116 0.116		97.6 97.8	24.7 24.8	0.113 0.122	
13	105.1 105.1	27.2 27.2	0.114 0.114		104.9 105.1	27.3 27.4	0.111 0.119	
Ensemble $A \oplus T$								
D (GeV $^{-2}$)	0.1A	0.3A	0.5A		0.7A	0.9A		
$\beta_{\mathbb{O}}(0)$	1.09 $\pm$ 0.24	0.95 $\pm$ 0.19	0.90 $\pm$ 0.18		0.86 $\pm$ 0.17	0.83 $\pm$ 0.16		
$\beta_{\mathbb{P}}(0)$	2.235 $\pm$ 0.023	2.257 $\pm$ 0.016	2.259 $\pm$ 0.016		2.258 $\pm$ 0.016	2.258 $\pm$ 0.017		
ν	504	504	504		504	504		
χ^2/ν	1.11	1.12	1.11		1.10	1.09		
$\rho^{pp}(\sqrt{s} = 13 \text{ TeV})$	0.112	0.112	0.111		0.111	0.110		
$\rho^{\bar{p}p}(\sqrt{s} = 13 \text{ TeV})$	0.119	0.118	0.119		0.119	0.120		
$\sigma_{tot}^{pp}(\sqrt{s} = 13 \text{ TeV})$ (mb)	104.9	104.9	104.9		104.9	104.9		
$\sigma_{tot}^{\bar{p}p}(\sqrt{s} = 13 \text{ TeV})$ (mb)	105.1	105.1	105.1		105.1	105.1		

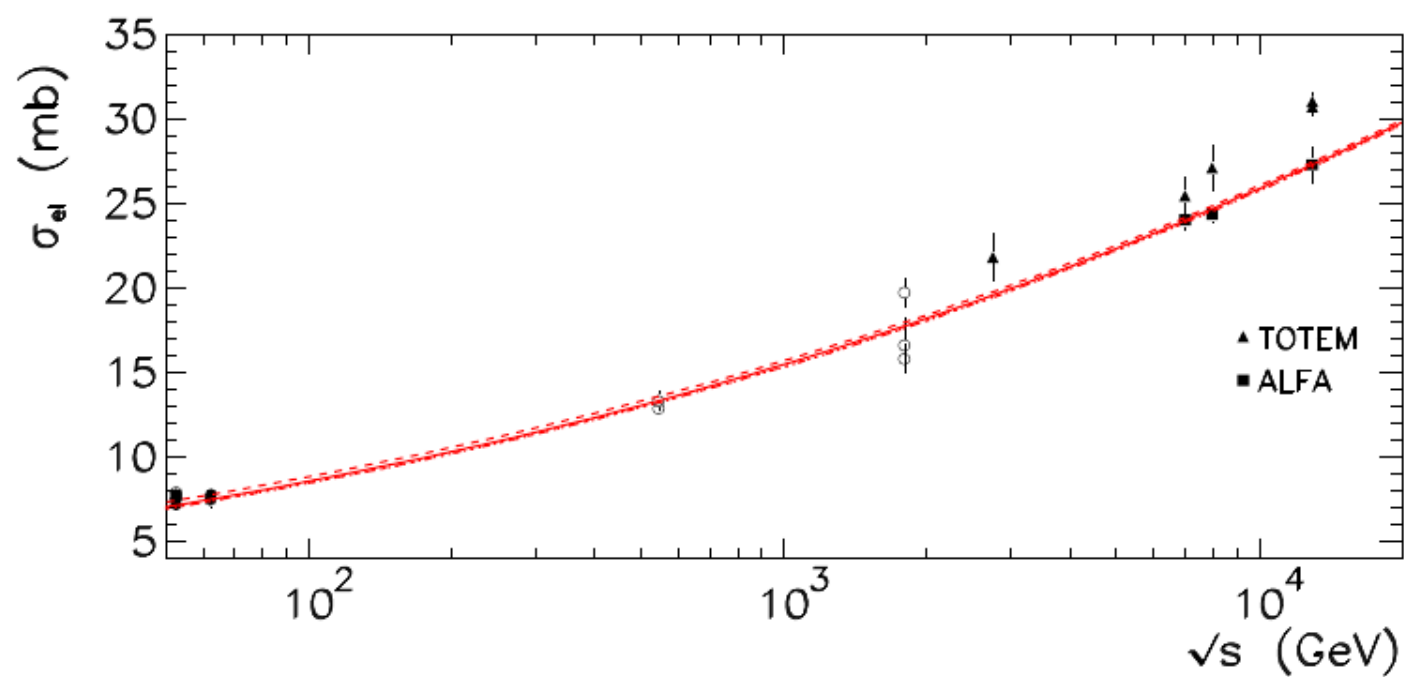
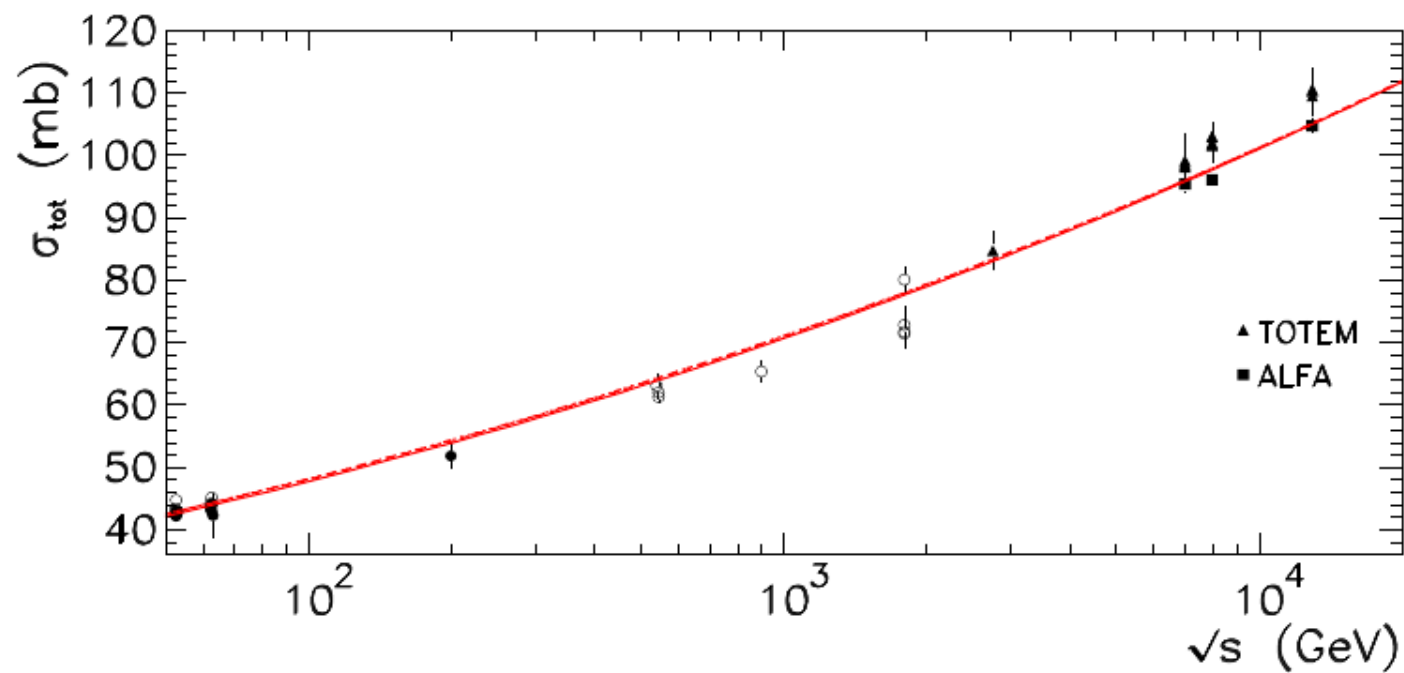
$$\beta_{\mathbb{O}}(t) = \beta_{\mathbb{O}}(0)e^{Dt/2}$$

$$\beta_{\mathbb{P}}(t) = \beta_{\mathbb{P}}(0)e^{(At+Bt^2+Ct^3)/2}$$









Dispersion relation

$$\text{Re}A(s, t = 0) = \frac{1}{\pi} \int_{-\infty}^0 \frac{ds' \text{Im}A(s', t)}{s' - s} + \frac{1}{\pi} \int_{4m^2}^{\infty} \frac{ds' \text{Im}A(s', t)}{s' - s}$$

$$\text{Im}A(s, 0) = \sigma_{tot}$$

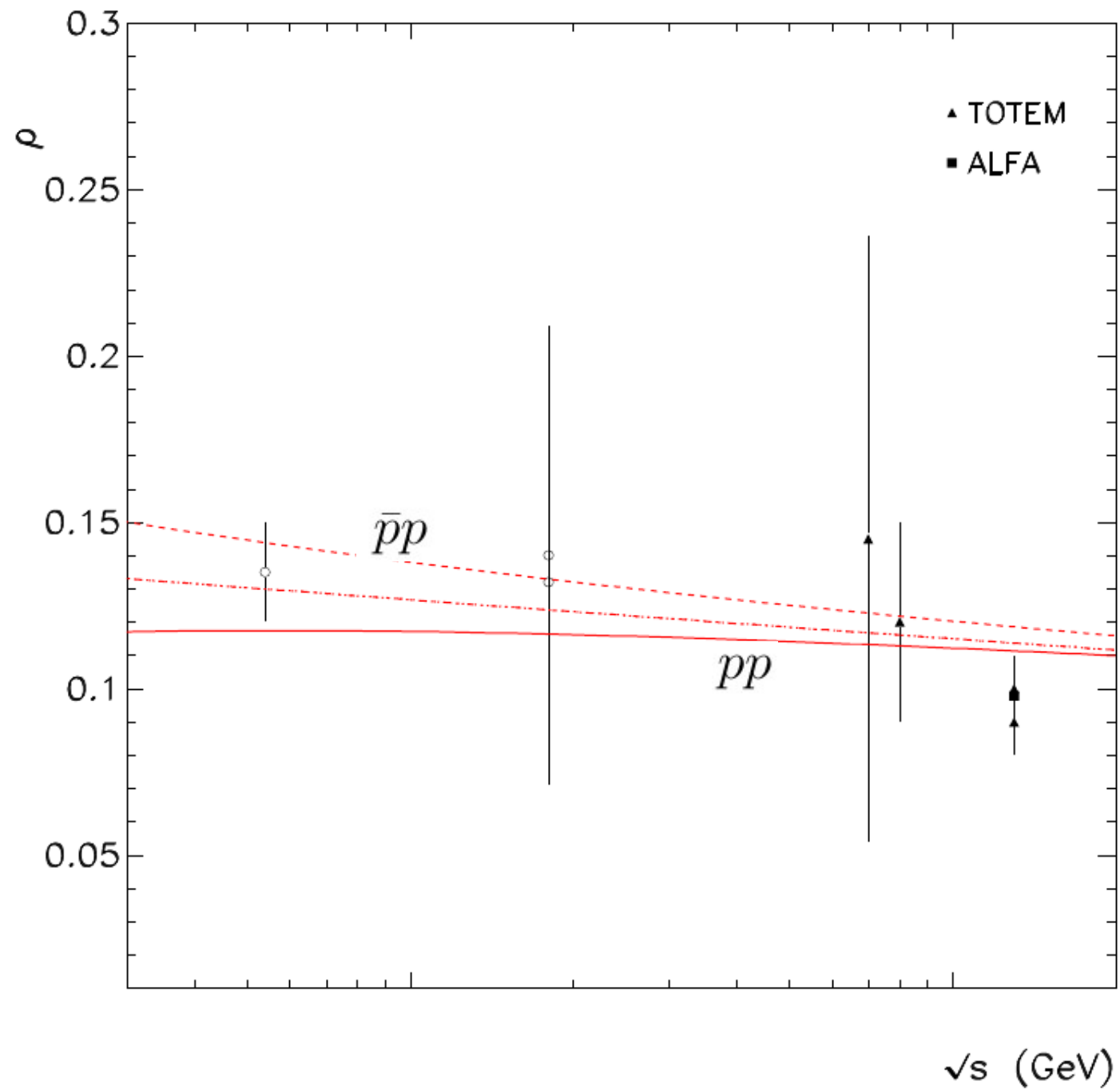
$$\text{Re}A(s, t = 0) = \frac{1}{\pi} \int_{-\infty}^0 \frac{ds' \sigma(pp)(-s' + 4m^2)}{s' - s} + \frac{1}{\pi} \int_{4m^2}^{\infty} \frac{ds' \sigma(pp)(s')}{s' - s}$$

for $\alpha_{Odd} \simeq 1$

$$\text{Re}A_{Odd} \sim \ln s \cdot \text{Im}A_{Odd} \text{ i.e. } \text{Re}A_{Odd} \gg \text{Im}A_{Odd}$$

$$\text{Re}A_{even} \ll \text{Im}A_{even}$$

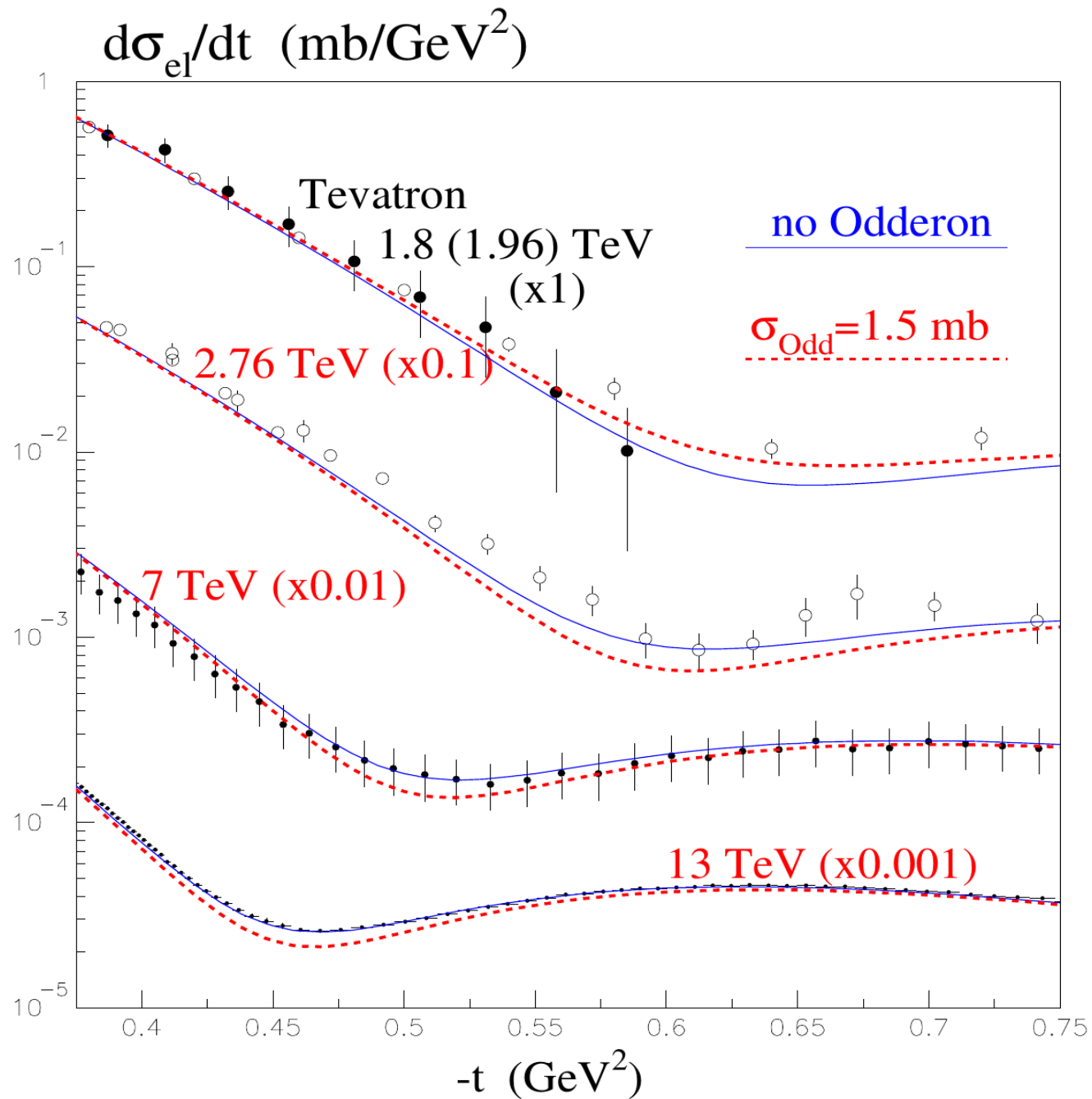
$$\text{Re}A_{even}(s, t = 0) \simeq \frac{2s}{\pi} \int_{4m^2}^{\infty} \frac{ds' \sigma(pp)}{s'^2 - s^2} \simeq \frac{\pi}{2} \frac{\partial \sigma(s)}{\partial \ln s}$$



The main lessons about the Odderon **at low $|t|$**

- The description using the Odderon improves the fit (the χ^2/ν is the lowest one).
- The sign of the Odderon amplitude needed to describe the very low $|t|$ data is opposite to that predicted by the perturbative QCD three-gluon exchange contribution **for "quark-diquark" proton** $\beta_O(t=0) = 0$
then at $t=0$ Pomeron-Odderon cut dominate
- The quality of the description weakly depends on the Odderon t -slope, D **leading to negative sign**
- The Odderon-proton coupling, $\beta_{\mathbb{O}}$, is smaller than that for the Pomeron, $\beta_{\mathbb{P}}$. For $D = A/2$ we get $\beta_{\mathbb{O}}/\beta_{\mathbb{P}} = 0.40$, however after accounting for screening by the Pomeron the final C -odd contribution to ρ at 13 TeV becomes quite small,

$$\delta\rho = (\rho^{\bar{p}p} - \rho^{pp})/2 \leq 0.004$$



C-even meson photoproduction

$$\sigma(\gamma p \rightarrow \pi^0 p) \sim 300 \text{ nb} \quad (< 39 \text{ nb} - \text{HERA})$$

(Rueter, Dosch, Nachtmann Ph.Rev. D59 (1999) 014018)

C-even meson (M)	Odderon Signal		Backgrounds		
	Upper Limit	QCD Prediction	$\gamma\gamma$	Pomeron- Pomeron	$V \rightarrow M + \gamma$
π^0	7.4	0.1 - 1	0.044	–	30
$f_2(1270)$	3	0.05 - 0.5	0.020	3 - 4.5	0.02
$\eta(548)$	3.4	0.05 - 0.5	0.042	negligible	3
η_c	–	$(0.1 - 0.5) \cdot 10^{-3}$	0.0025	$\sim 10^{-5}$	0.012

Table 3: The expected cross sections ($d\sigma/dY_M$ at $Y_M = 0$ in μb) of the Odderon signal and backgrounds in the CEP* ultraperipheral production of C-even mesons (M) in high-energy proton-lead collisions ($Pb + p \rightarrow Pb + M + P$) integrated over the interval $0.2 < p_\perp < 1$ GeV. In the η_c case a total branching ratio of 0.05 has been applied, i.e. summing over the channels discussed in

The goal is not to proof
that the Odderon exists
(no reason to have *No* Odderon)
but to *measure* the Odderon exchange
amplitude.

Maximum odderon ($A_{Odd} \propto \ln^2 s$) is another story.
Max. Odderon contradicts unitarity
(taking s- and t- unit. together)

THANK YOU

Maximal Odderon Violates unitarity

$$2\text{Im}A_{el}(b) = |A_{el}(b)|^2 + G_{inel}(b) \text{ (s-unit.)}$$

Solution:

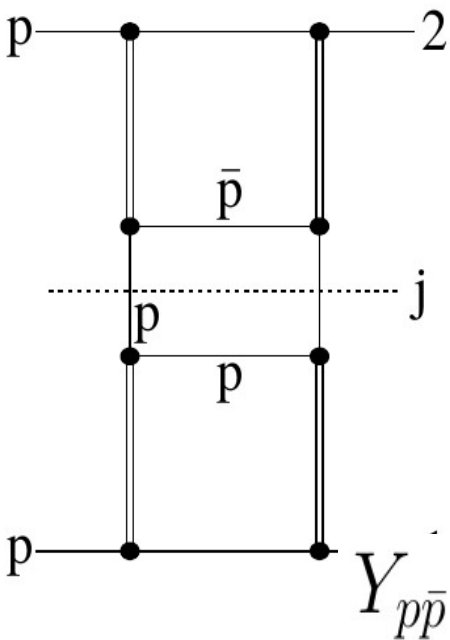
$A_{el}(b) = i(1 - e^{2i\delta(b)})$
 $l = b\sqrt{s}/2$

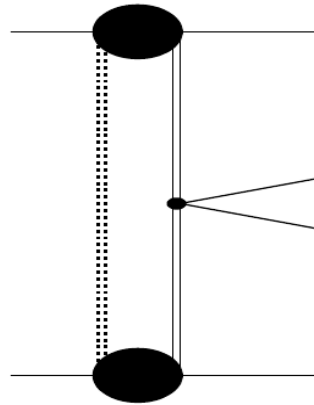
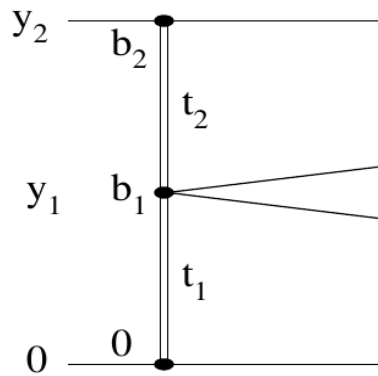
$$\delta(b) = \delta_{even} + \delta_{Odd} \quad \text{Im}\delta_{even}(b) > 0$$

Max.Odd. assume $A_{Odd} = a\theta(c \ln s - b)$

Then $\sigma(pp \rightarrow p + p\bar{p} + p)(b) \geq c' \ln s$

i.e. $\text{Im}\delta_{even}(b) \propto \ln s \implies A_{el} = i$



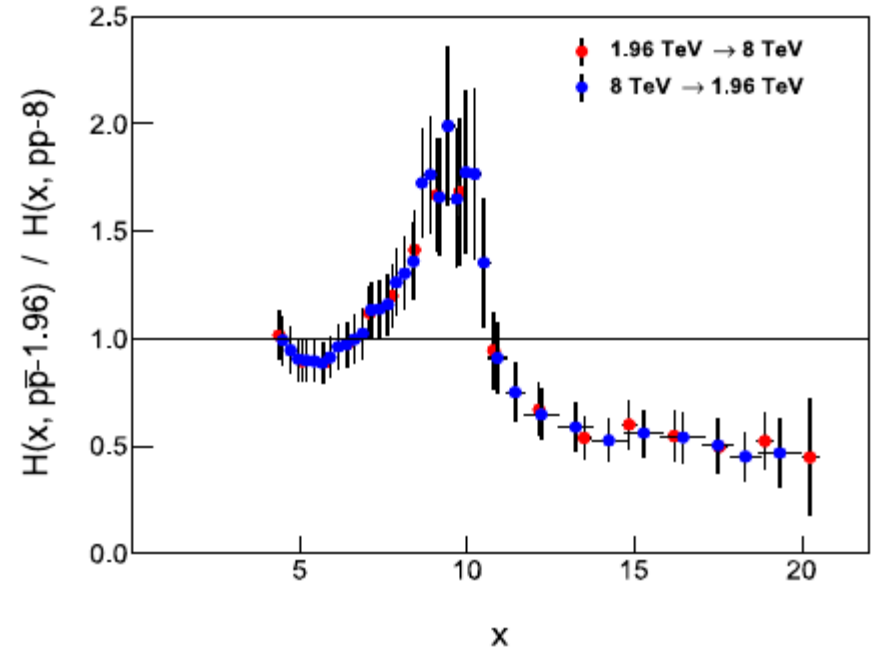
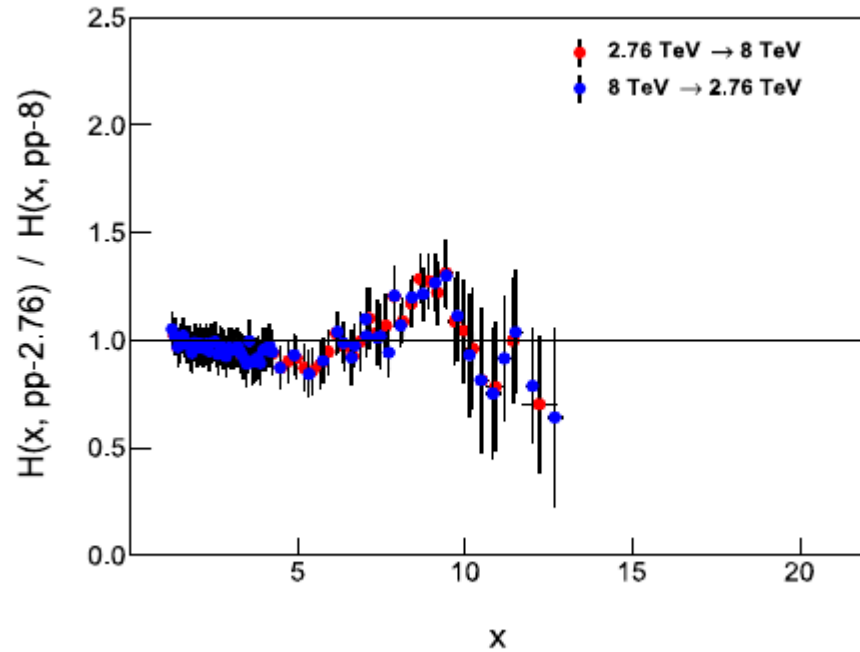


$$S(b) = 1 + iA_{el}(b) \rightarrow 0!$$

Max. Odderon screens himself to zero

Evaluating the $H(x, s|pp)$ scaling function of elastic proton-proton (pp) collisions from recent TOTEM data at $\sqrt{s} = 8$ TeV and comparing it with the same function of elastic proton-antiproton ($p\bar{p}$) data of the D0 collaboration at $\sqrt{s} = 1.96$ TeV, we find, signal of Odderon exchange.

$$H(x, s|pp) = \frac{1}{B\sigma_{\text{el}}^{pp}} \frac{d\sigma^{pp}}{dt}, \quad x = -tB$$



Bethe phase $\phi = \ln \frac{B|t|}{2} + \gamma + \text{const}$

ρ depends on **const**. For $\phi = 0$

Kohara-Ferreira-Rangel (Ph.Lett. B789, p.1)

got $\rho = 0.131$ with $\chi^2/ndf = 0.94$

$\rho = 0.112 \pm 0.005$ for **const**=2 ($\chi^2/ndf = 0.96$)

Cudell-Selyugin (1901.05863) accounts for correlated errors and **normalization** factor n .

They got (**const**=0):

$\sigma_{tot} = 106.4 \pm 2.2$ mb, $\rho = 0.098 \pm 0.008$,

$n = 0.91 \pm 0.04$ ($\chi^2/ndf = 0.81$)

(79 points $0.0008 < |t| < 0.07$ GeV²)

