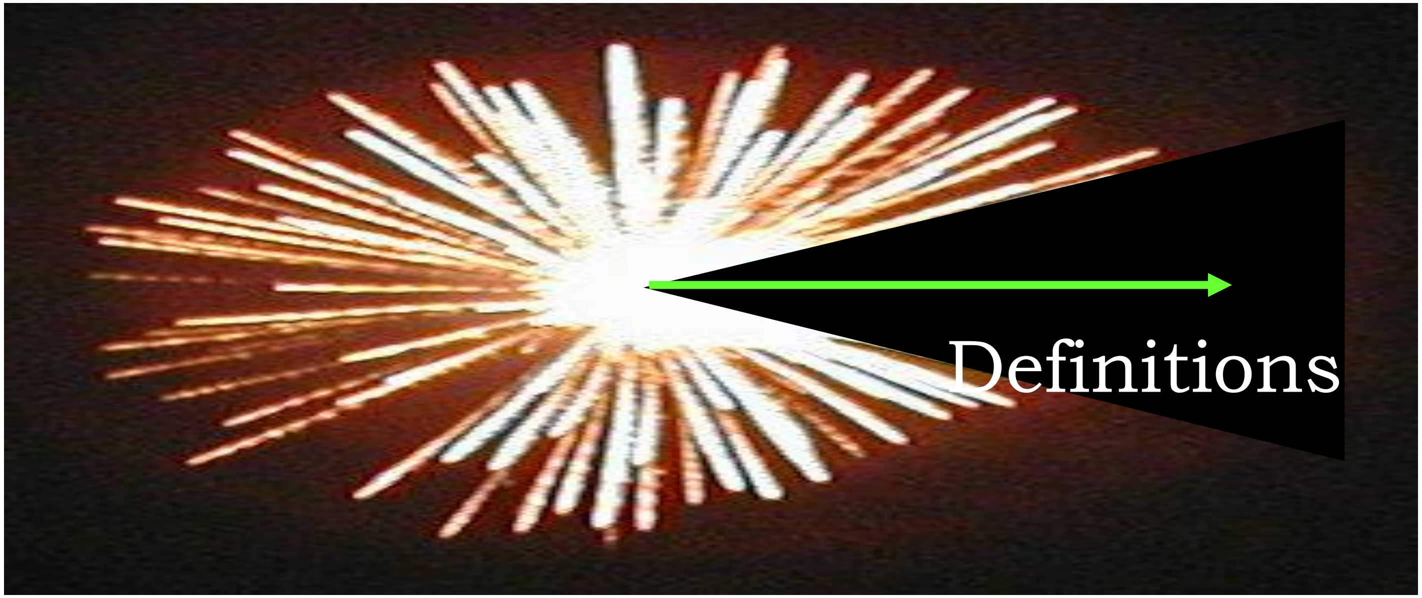
Zimányi School'12

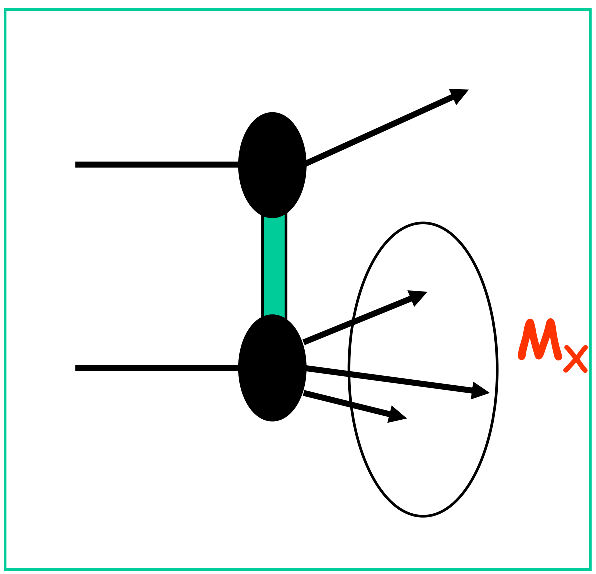
Budapest, December 2012

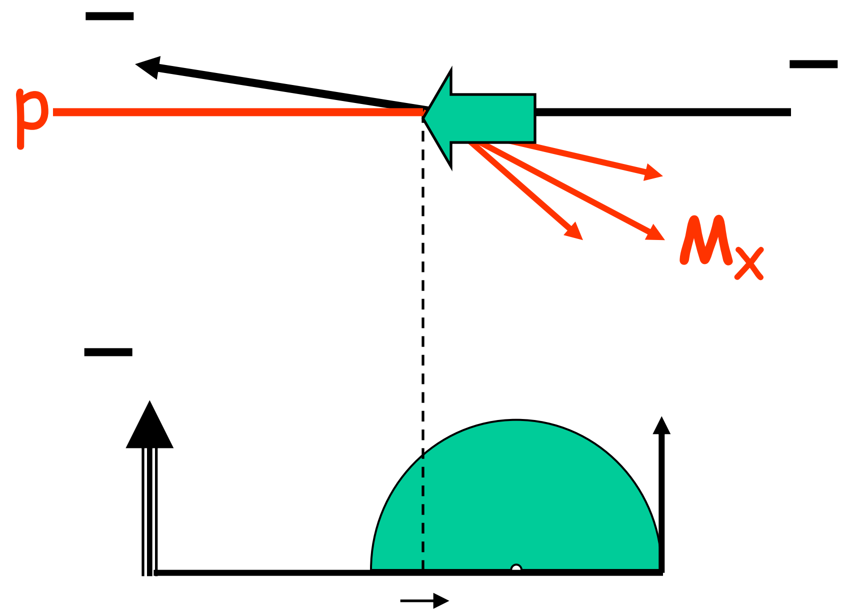
Elastic and inelastic diffraction at the LHC

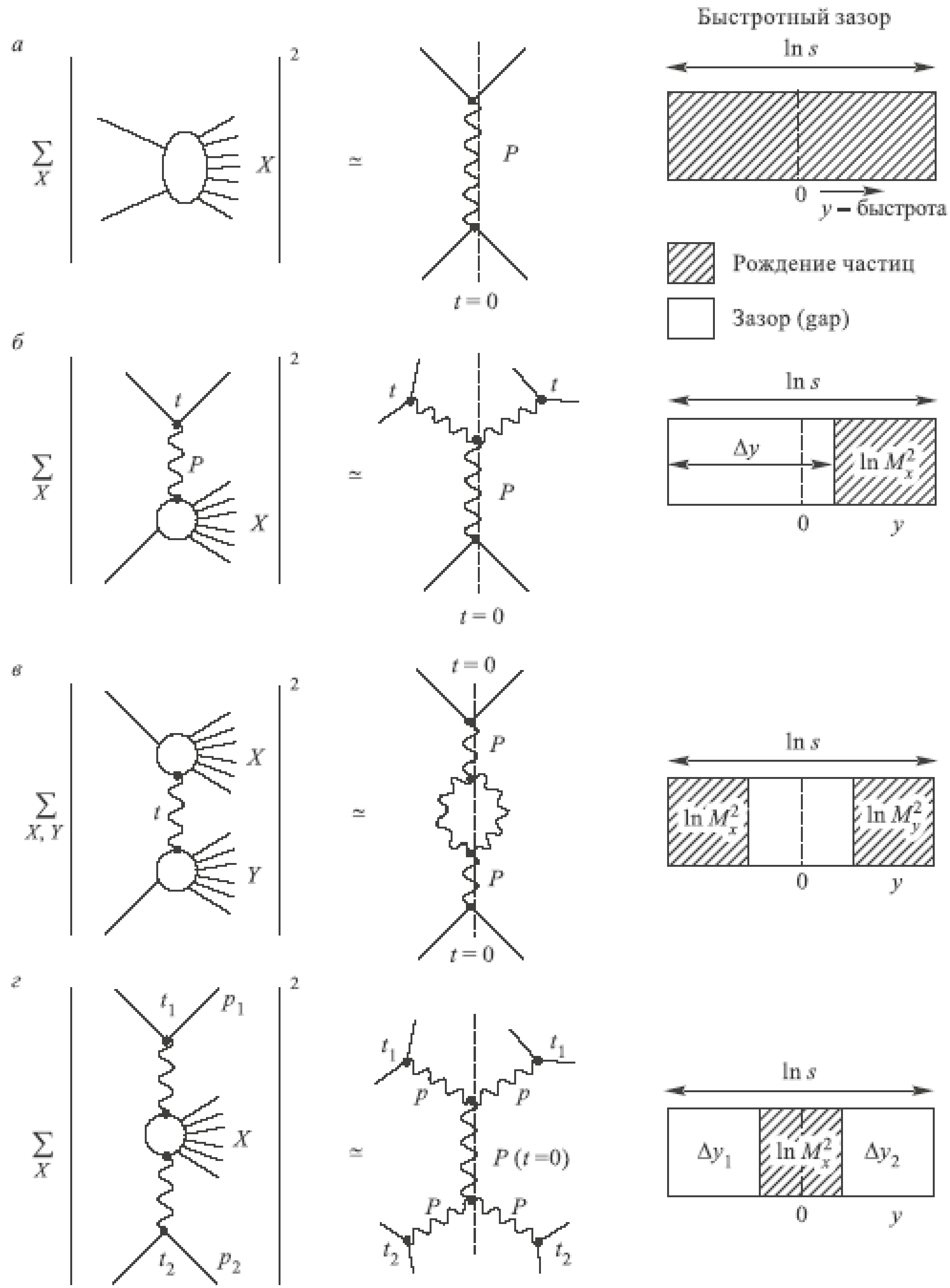
Jenkovszky László (in collab. with:

Oleg Kuprash, Risto Orava, and Andrii Salii)

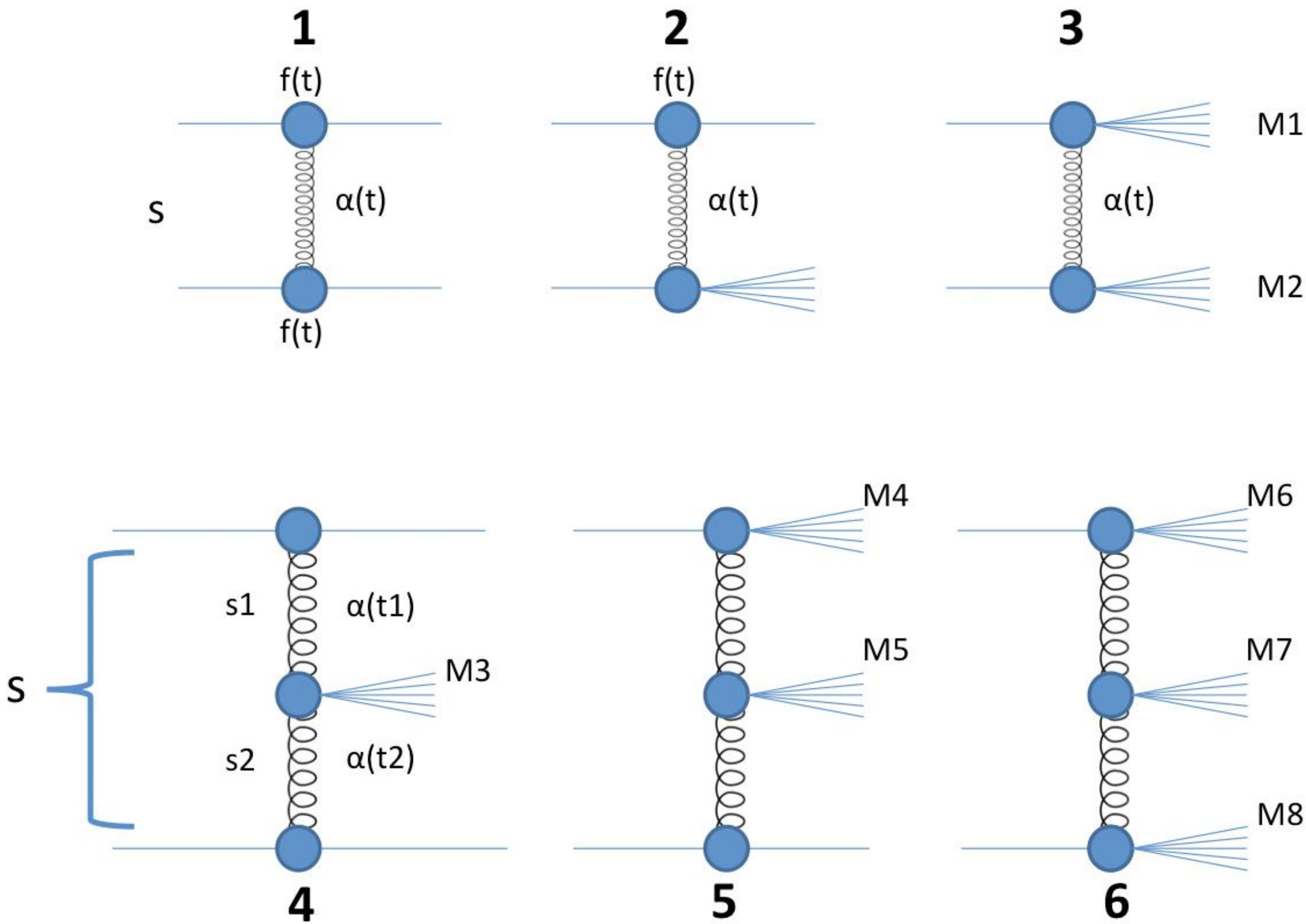

Definitions


Mx


p
Mx



а
б
в
г
Быстротный зазор
ln s
0
y – быстрота
Рождение частиц
Зазор (gap)
t = 0
P
X
Y
Δy
ln M²x
ln M²y
Δy1
Δy2
P (t = 0)


1
2
3
f(t)
f(t)
α(t)
s
f(t)
f(t)
α(t)
α(t)
M1
M2
M4
M6
s1
α(t1)
M3
M5
M7
S
s2
α(t2)
M8
4
5
6

Simple (but approximate) factorization relations

$$\frac{d^3\sigma_{DD}}{dt dM_1^2 dM_2^2} = \frac{d^2\sigma_{SD1}}{dt dM_1^2}\frac{d^2\sigma_{SD2}}{dt dM_2^2}\Big/\frac{d\sigma_{el}}{dt}. \qquad (1)$$

Assuming e^{bt} dependence for both SD and elastic scattering, integration over t yields

$$\frac{d^3\sigma_{DD}}{dM_1^2 dM_2^2} = k\frac{d^2\sigma_{SD1}}{dM_1^2}\frac{d^2\sigma_{SD2}}{dM_2^2}\Big/\sigma_{el}. \qquad (2)$$

where $k = r^2/(2r-1), \quad r = b_{SD}/b_{el}$.

$$\sigma_t(s) = \frac{4\pi}{s} Im A(s, t = 0); \quad \frac{d\sigma}{dt} = \frac{\pi}{s^2}|A(s,t)|^2; \quad \boldsymbol{n(s)};$$

$$\sigma_{el} = \int_{t_{min \approx -s/2 \approx \infty}}^{t_{thr. \approx 0}} \frac{d\sigma}{dt}; \quad \sigma_{in} = \sigma_t - \sigma_{el}; \quad B(s,t) = \frac{d}{dt} \ln\left(\frac{d\sigma}{dt}\right);$$

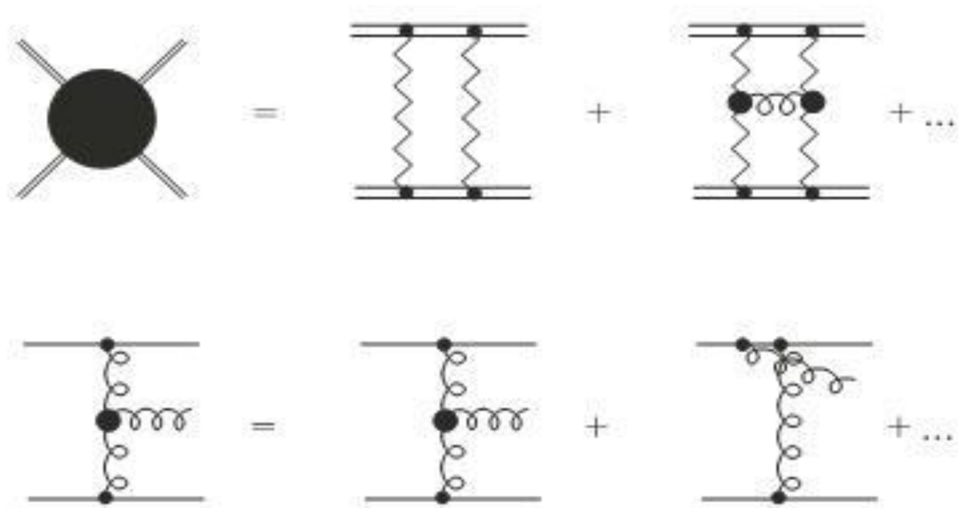
$$A_{pp}^{p\bar{p}}(s,t) = P(s,t) \pm O(s,t) + f(s,t) \pm \omega(s,t) \rightarrow_{LHC} \approx P(s,t) \pm O(s,t),$$

where P, O, f. ω are the Pomeron, odderon and non-leading Reggeon contributions.

α(0)\C	+	-
1	P	O
1/2	f	ω

“THEORY”:

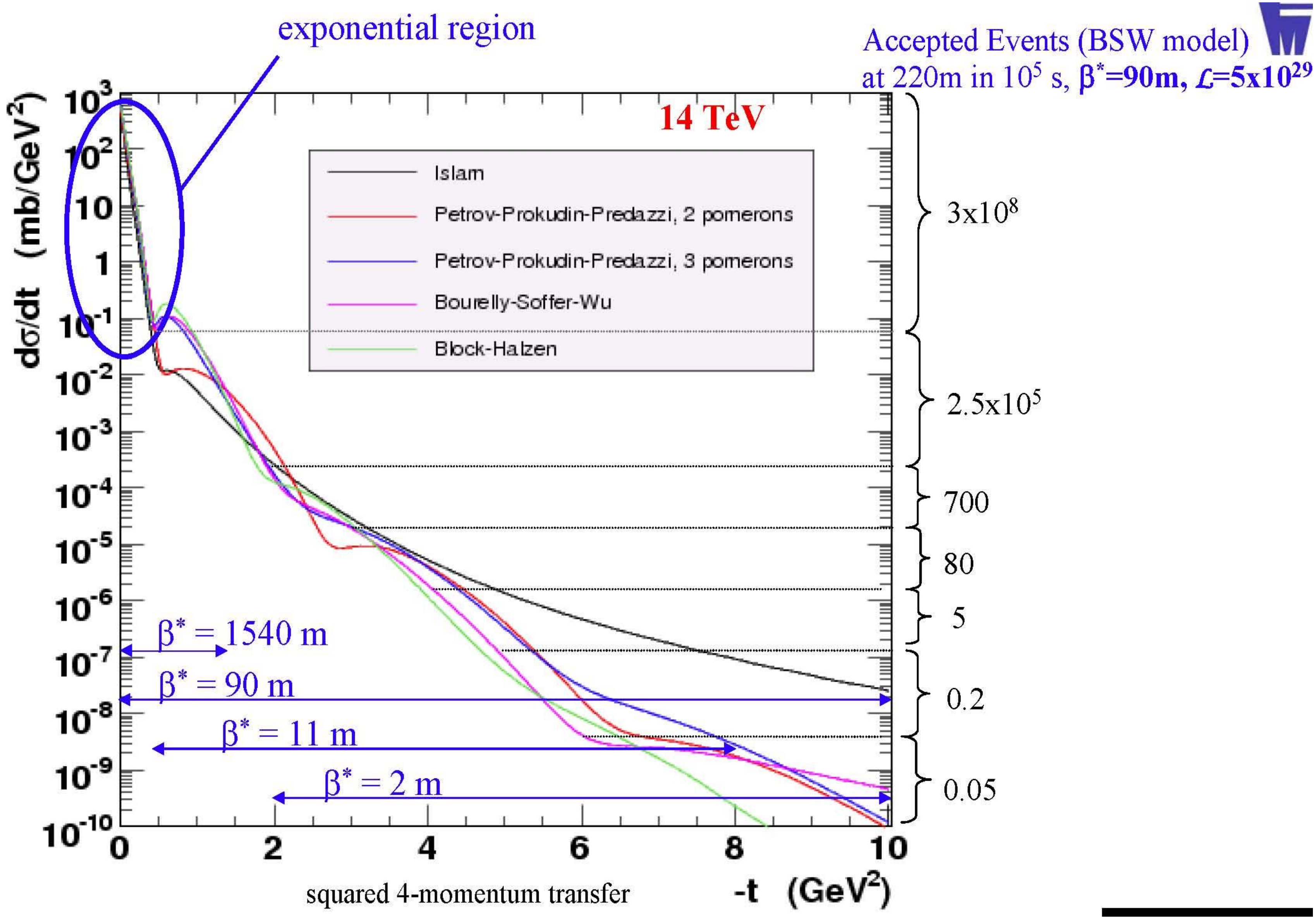
R. Fiore, L.L. Jenkovszky, E.A. Kuraev, A.I. Lengyel, ***Predictions for high-energy pp and \bar pp scattering from a finite sum of gluon ladders,*** **Phys. Rev. D81, #5 (2010) 056005; arXiv0911.2094/hep-ph**



$$\sigma_t^{(P)}(s) = \sum_{i=0}^{N} f_i \, \theta(s - s_0^i) \, \theta(s_0^{i+1} - s) \ , \qquad (1)$$

where

$$f_i = \sum_{j=0}^{i} a_{ij} L^j \ , \qquad (2)$$



exponential region
Accepted Events (BSW model)
at 220m in 10^5 s, β*=90m, L=5x10^29
14 TeV
Islam
Petrov-Prokudin-Predazzi, 2 pomerons
Petrov-Prokudin-Predazzi, 3 pomerons
Bourelly-Soffer-Wu
Block-Halzen
dσ/dt (mb/GeV²)
10³
10²
10
1
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
10⁻¹⁰
0
2
4
6
8
10
3x10⁸
2.5x10⁵
700
80
5
0.2
0.05
β* = 1540 m
β* = 90 m
β* = 11 m
β* = 2 m
squared 4-momentum transfer
-t (GeV²)

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

TOTEM 2011-01
22 June 2011

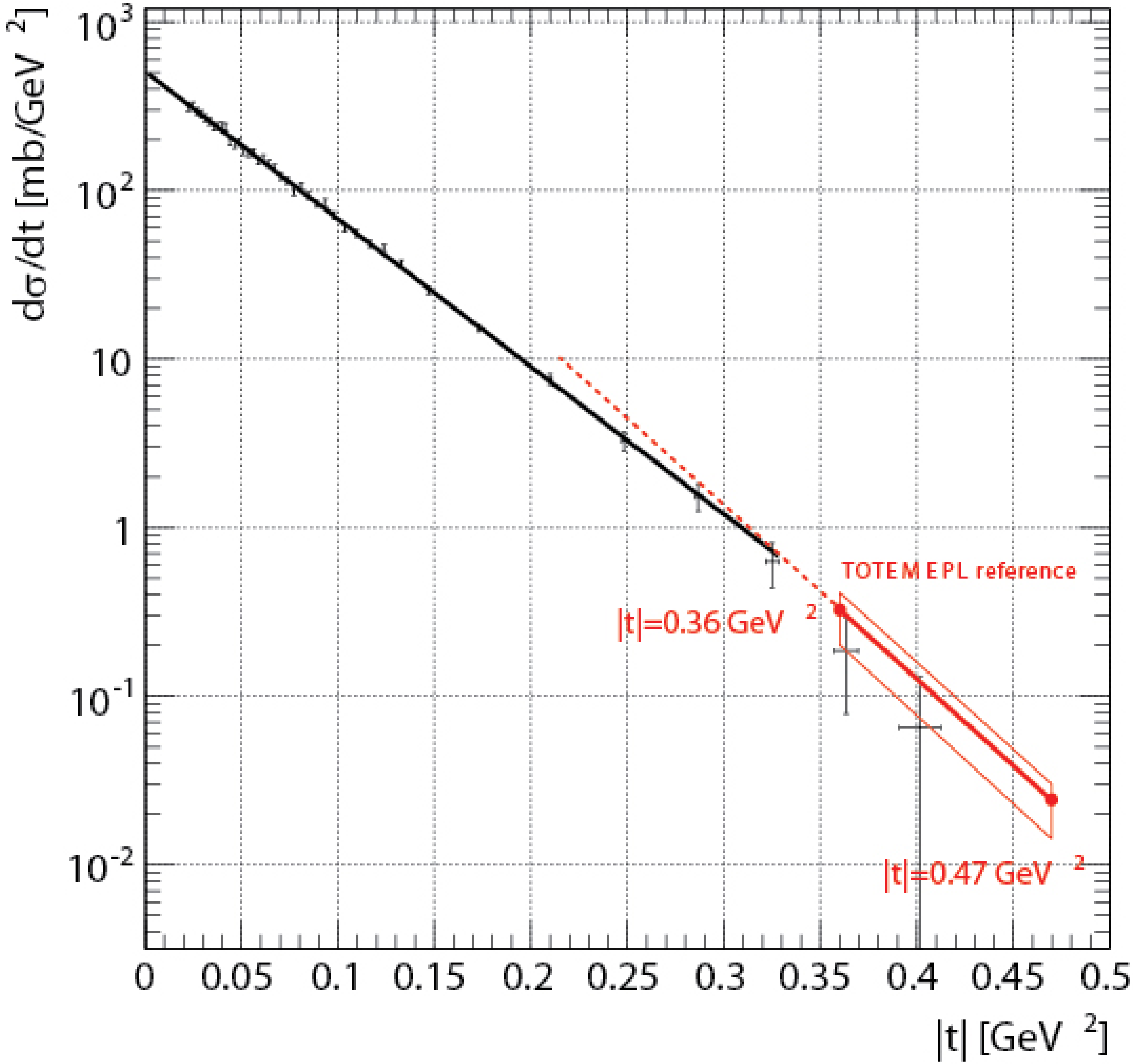
CERN-PH-EP-2011-101
26 June 2011

Elastic pp Scattering at the LHC at $\sqrt{s} = 7$ TeV.

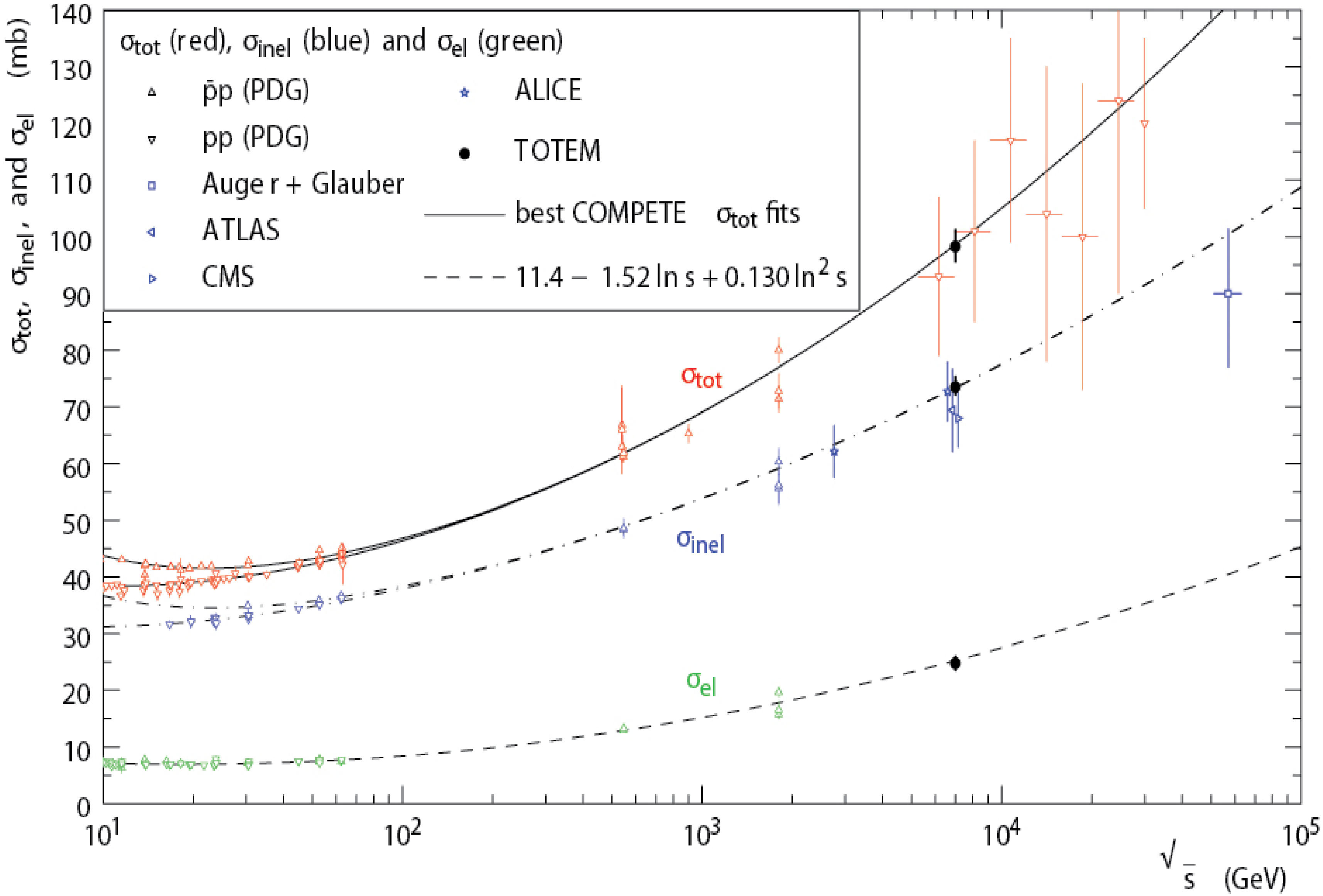
The TOTEM Collaboration
G. Antchev[*], P. Aspell[8], I. Atanassov[8,*], V. Avati[8], J. Baechler[8], V. Berardi[5b,5a], M. Berretti[7b], M. Bozzo[6b,6a], E. Brücken[3a,3b], A. Buzzo[6a], F. Cafagna[5a], M. Calicchio[5b,5a], M. G. Catanesi[5a], C. Covault[9], M. Csanád[4†] , T. Csörgö[4], M. Deile[8], E. Dimovasili[8], M. Doubek[1b], K. Eggert[9], V.Eremin[‡], F. Ferro[6a], A. Fiergolski[§], F. Garcia[3a], S. Giani[8], V. Greco[7b,8], L. Grzanka[8,¶], J. Heino[3a], T. Hilden[3a,3b], M. Janda[1b], J. Kašpar[1a,8], J. Kopal[1a,8], V. Kundrát[1a], K. Kurvinen[3a], S. Lami[7a], G. Latino[7b], R. Lauhakangas[3a], T. Leszko[§] E. Lippmaa[2], M. Lokajíček[1a], M. Lo Vetere[6b,6a], F. Lucas Rodríguez[8], M. Macrí[6a], L. Magaletti[5b,5a], G. Magazzù[7a], A. Mercadante[5b,5a], M. Meucci[7b], S. Minutoli[6a], F. Nemes[4,†] H. Niewiadomski[8], E. Noschis[8], T. Novak[4,‖], E. Oliveri[7b], F. Oljemark[3a,3b], R. Orava[3a,3b], M. Oriunno[8**], K. Österberg[3a,3b], A.-L. Perrot[8], P. Palazzi[8], E. Pedreschi[7a], J. Petäjäjärvi[3a], J. Procházka[1a], M. Quinto[5a], E. Radermacher[8], E. Radicioni[5a], F. Ravotti[8], E. Robutti[6a], L. Ropelewski[8], G. Ruggiero[8], H. Saarikko[3a,3b], A. Santroni[6b,6a], A. Scribano[7b], G. Sette[6b,6a], W. Snoeys[8], F. Spinella[7a], J. Sziklai[4], C. Taylor[9], N. Turini[7b], V. Vacek[1b], J. Welti[3a,b], M. Vítek[1b], J. Whitmore[10].

P. Aspell et. al. (TOTEM Collaboaration), *Proton-proton elastic scattering at the LHC energy 7 TeV*, Europhys. Lett. {\bf 95} (2011) 41001; arXiv:1110.1385.

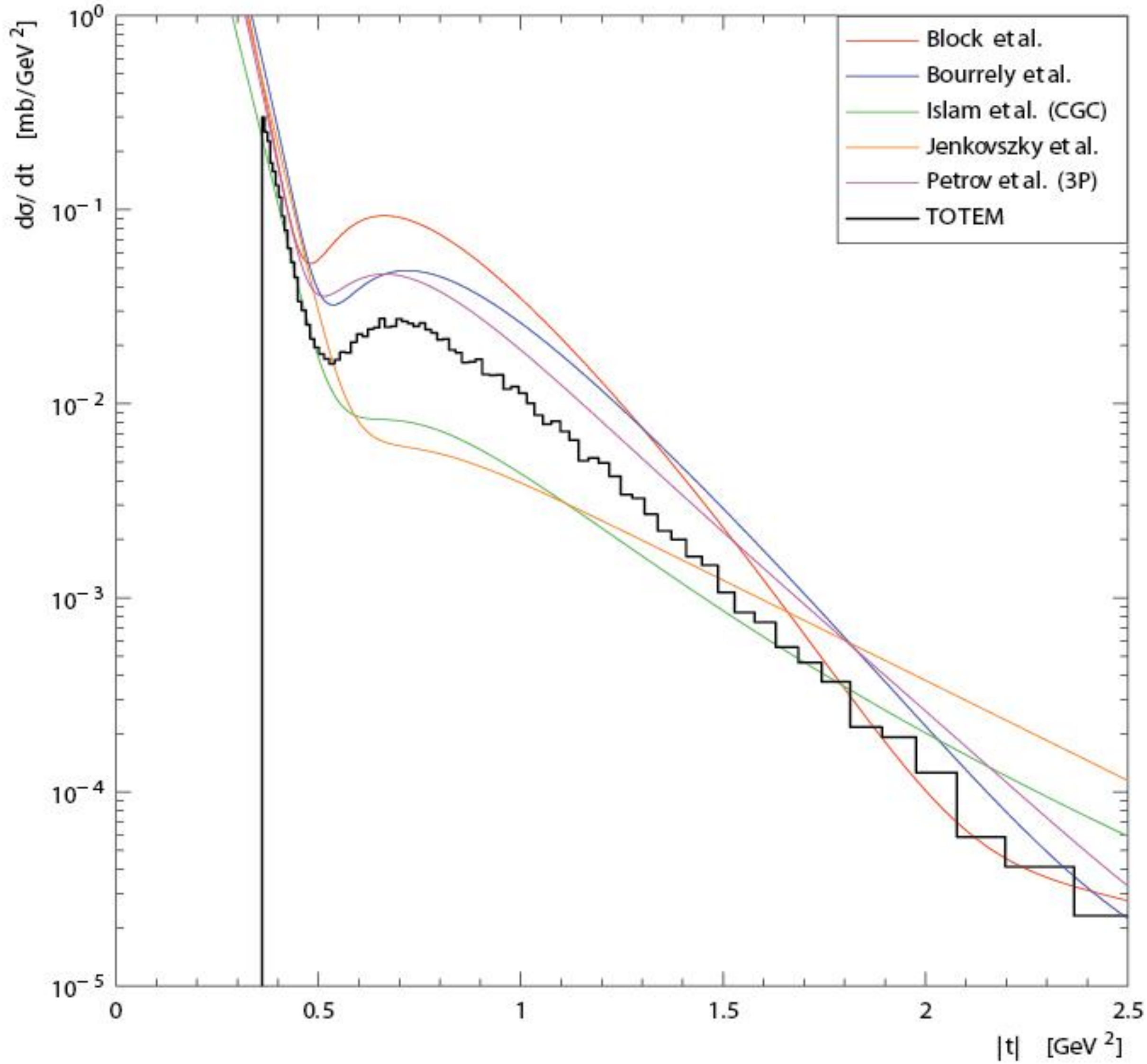
G. Antchev et al. (TOTEM Collab.*), First measurement of the total proton-proton cross section at the LHC energy of 7 TeV*, to be publ in EPL; arXiv:1110.1395.



dσ/dt [mb/GeV 2]
10^3
10^2
10
1
10^-1
10^-2
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
|t| [GeV 2]
TOTEM EPL reference
|t|=0.36 GeV 2
|t|=0.47 GeV 2



σtot (red), σinel (blue) and σel (green)
p̄p (PDG)
pp (PDG)
Auger + Glauber
ATLAS
CMS
ALICE
TOTEM
best COMPETE σtot fits
11.4 − 1.52 ln s + 0.130 ln² s
σtot
σinel
σel
σtot, σinel, and σel (mb)
√s (GeV)



dσ/ dt [mb/GeV 2]
10^0
10^−1
10^−2
10^−3
10^−4
10^−5
0
0.5
1
1.5
2
2.5
|t| [GeV 2]
Block et al.
Bourrely et al.
Islam et al. (CGC)
Jenkovszky et al.
Petrov et al. (3P)
TOTEM

R.J.J. Phillips and V. Barger, *Model independent analysis of the structure in pp scattering,* Phys. Lett. B 46 (1973) 412.

Phillips and Barger in 1973 [ ], right after its first observation at the ISR. Their formula reads

$$\frac{d\sigma}{dt} = |\sqrt{A}\exp(Bt/2) + \sqrt{C}\exp(Dt/2 + i\phi)|^2, \qquad (1)$$

where A, B, C, D and ϕ are determined independently at each energy.

Model building (input + unitarazation)

(analyticity, Regge behaviour (factorization), unitarity, GS)

$$A^{p\bar{p}}_{pp}(s,t) = P(s,t) \pm O(s,t) + f(s,t) \pm \omega(s,t) \rightarrow_{LHC} P(s,t) \pm O(s,t),$$

where P is the Pomeron contribution and O is that of the Odderon.

$$P(s,t) = i\frac{as}{bs_0}\left(r_1^2(s)e^{r_1^2(s)[\alpha_P(t)-1]} - \epsilon r_2^2(s)e^{r_2^2(s)[\alpha_P(t)-1]}\right),$$

where $r_1^2(s) = b + L - \frac{i\pi}{2}$, $r_2^2(s) = L - \frac{i\pi}{2}$ with $L \equiv \ln\frac{s}{s_0}$; $\alpha_P(t)$ is the Pomeron trajectory and a, b, s_0 and ϵ are free parameters.

Is A(s,t) ractorizable? **No, it is not!** (Regge poles, 60-ies)
The inclusion of the virtuality, Q^2, or the external mass is much more tricky.

$$A_P(s,t) = \frac{d}{d\alpha_P}\left[e^{-i\pi\alpha_P/2}G(\alpha_P)\Big(s/s_0\Big)^{\alpha_P}\right] = \qquad (1)$$

$$e^{-i\pi\alpha_P(t)/2}\Big(s/s_0\Big)^{\alpha_P(t)}\left[G'(\alpha_P)+\Big(L-i\pi/2\Big)G(\alpha_P)\right].$$

The Pomeron trajectory

The Pomeron trajectory has threshold singularities, the lowest one being due to the two-pion exchange, required by the $t-$channel unitarity. There is a constrain (Barut, Zwanziger; Gribov) from the $t-$ channel unitarity, by which

$$\Im\alpha(t) \sim (t - t_0)^{\Re\alpha(t_0)+1/2}, \quad t \to t_0,$$

where t_0 is the lightest threshold. For the Pomeron trajectory it is $t_0 = 4m_\pi^2$, and near the threshold:

$$\alpha(t) \sim \sqrt{4m_\pi^2 - t}. \qquad (1)$$

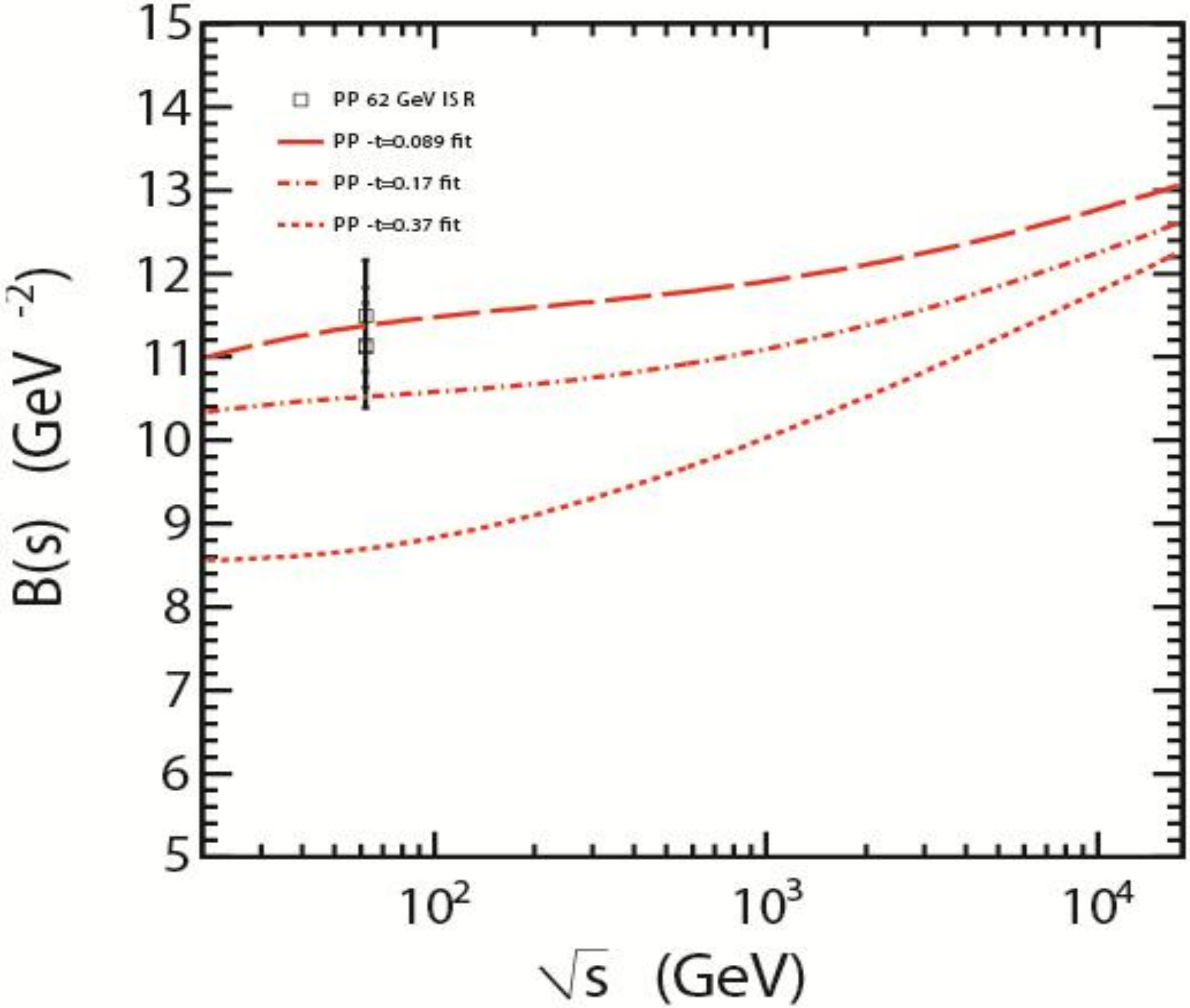
The observed nearly linear behaviour of the trajectory is promoted by higher, additive thresholds.

Asymptotically, the trajectories are logarithmic. This follows from the compatibility of the Regge behavior with the quark counting rules (Brodsky, Farrar; MMT), as well as from the solution of the BFKL equation. A simple parametrization combining the linear behaviour at small $|t|$ with its logarithmic asymptotic is:

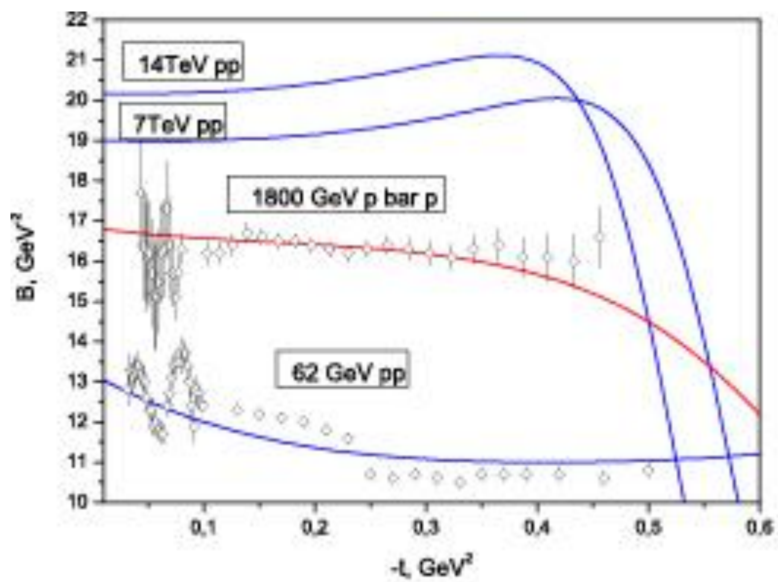
$$\alpha(t) = \alpha_0 - \gamma \ln(1 - \beta_1 t).$$

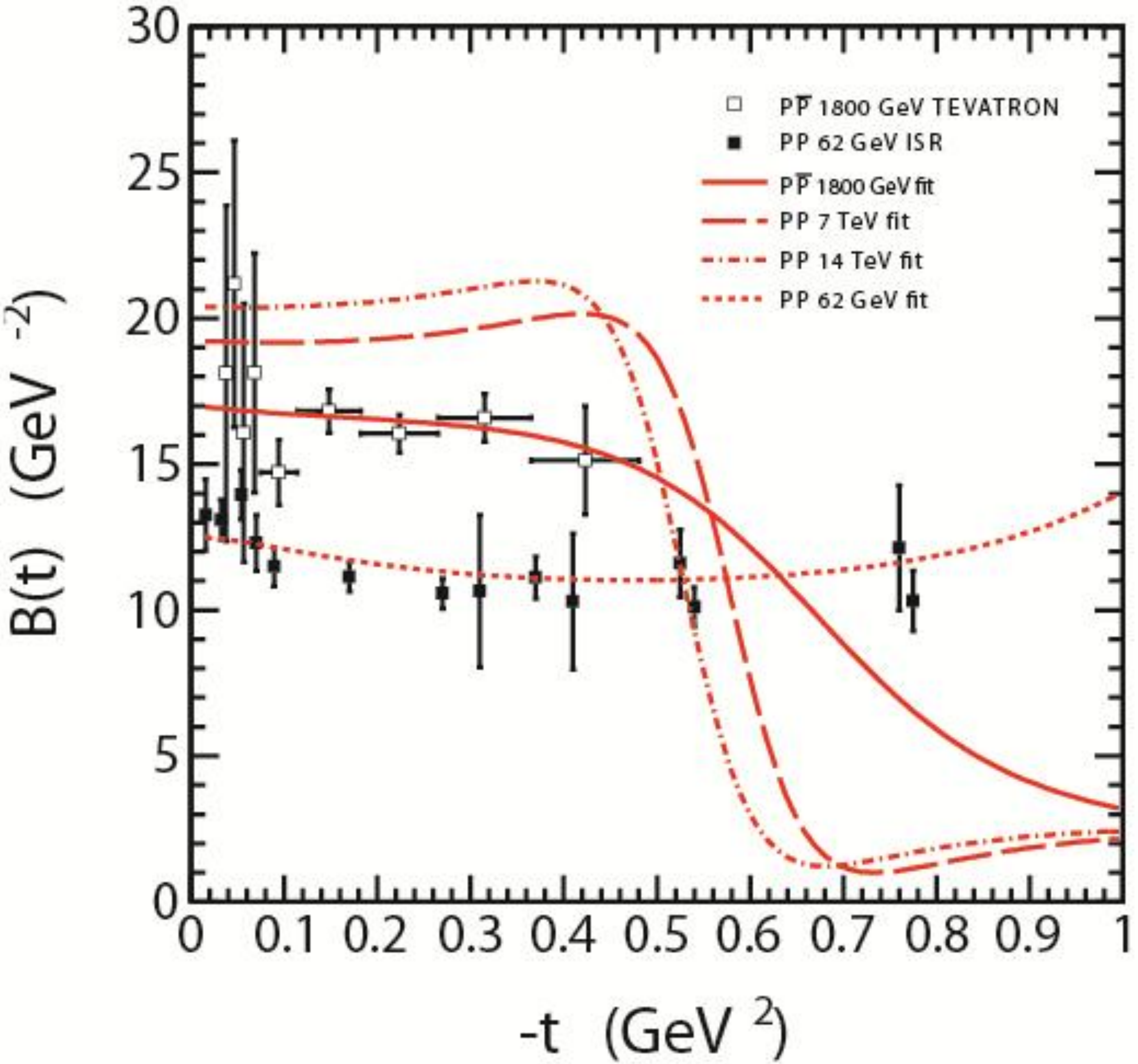
Nearly linear at small $|t|$, it reproduces the forward cone of the differential cross section, while its logarithmic asymptotic provides for the wide-angle scaling behavior. A combined form is:

$$\alpha(t) = \alpha_0 - \gamma \ln(1 + \beta_2 \sqrt{t_0 - t}).$$



PP 62 GeV ISR
PP -t=0.089 fit
PP -t=0.17 fit
PP -t=0.37 fit
B(s) (GeV -2)
√s (GeV)
15
14
13
12
11
10
9
8
7
6
5
10^2
10^3
10^4


14TeV pp
7TeV pp
1800 GeV p bar p
62 GeV pp
B, GeV⁻²
-t, GeV²
22
21
20
19
18
17
16
15
14
13
12
11
10
0,1
0,2
0,3
0,4
0,5
0,6



PP̄ 1800 GeV TEVATRON
PP 62 GeV ISR
PP̄ 1800 GeV fit
PP 7 TeV fit
PP 14 TeV fit
PP 62 GeV fit
B(t) (GeV -2)
-t (GeV 2)
0
5
10
15
20
25
30
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

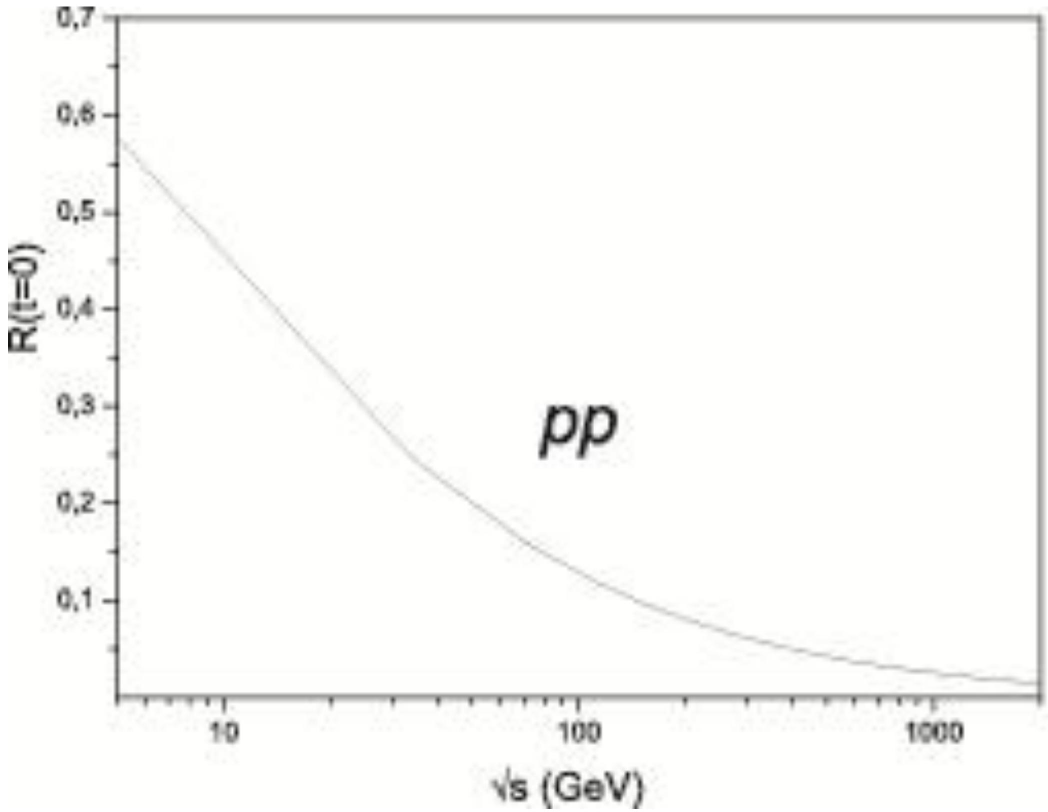
Energy variation of the relative importance of the Pomeron with respect to contributions from the secondary trajectories and the Odderon:

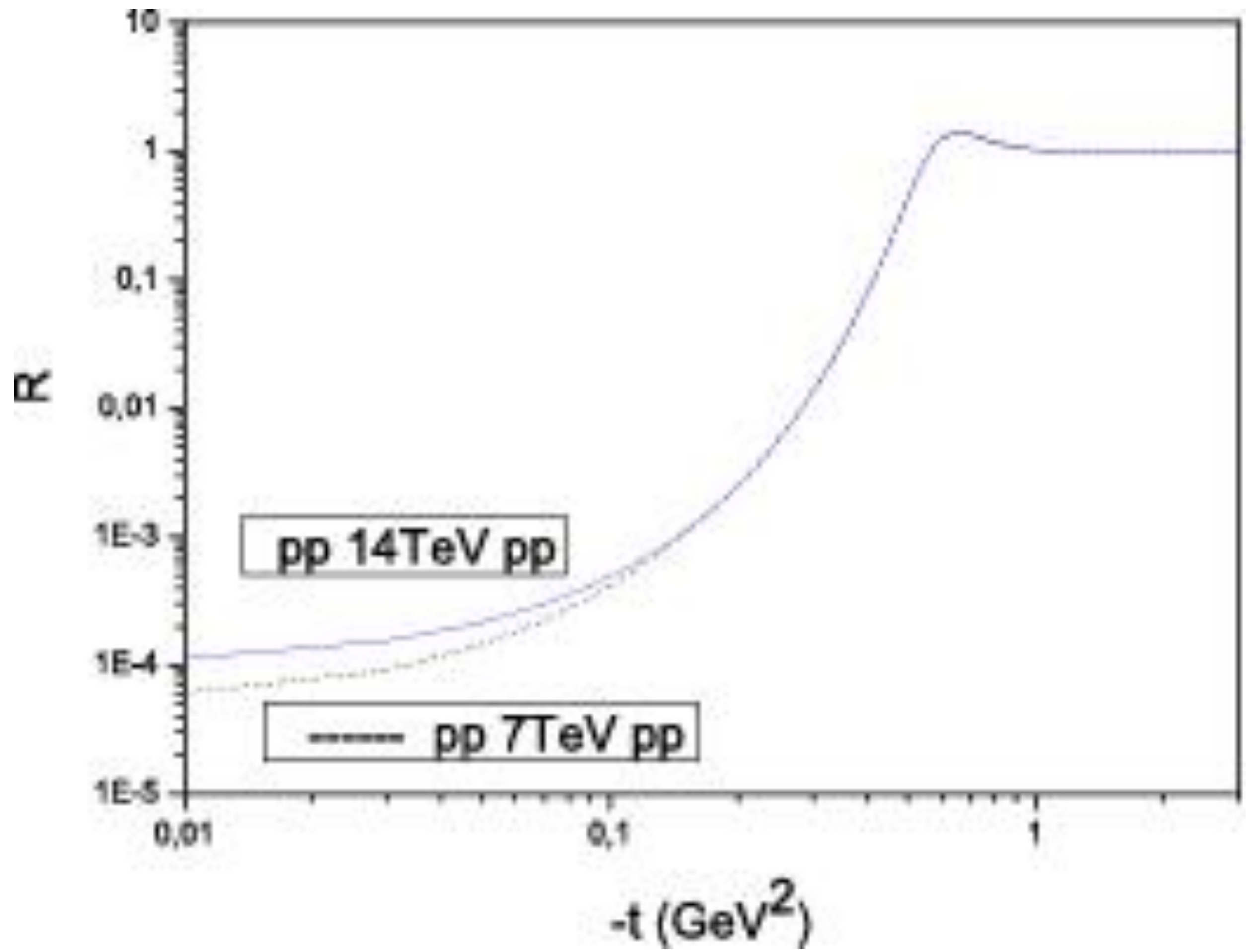
$$R(s, t = 0) = \frac{\Im m(A(s,t) - A_P(s,t))}{\Im A(s,t)}, \tag{1}$$

where the total scattering amplitude A includes the Pomeron contribution A_P plus the contribution from the secondary Reggeons and the Odderon.

Starting from the Tevatron energy region, the relative contribution of the non-Pomeron terms to the total cross-section becomes smaller than the experimental uncertainty and hence at higher energies they may be completely neglected, irrespective of the model used.

$$R(s, t) = \frac{|(A(s,t) - A_P(s,t)|^2}{|A(s,t)|^2}. \tag{2}$$


0,7
0,6
0,5
0,4
0,3
0,2
0,1
R(t=0)
pp
10
100
1000
√s (GeV)



10
1
0,1
0,01
1E-3
1E-4
1E-5
R
pp 14TeV pp
pp 7TeV pp
0,01
0,1
1
-t (GeV2)

Lessons:

1. Model predictions **for integral characteristics**, on the whole, are compatible with the data within about 10% (not too interesting!), diverging by orders of magnitudes (!) in the dip-bump region, that can be used to discriminate the existing (and future) models;

1. Any modes should describe various observables in a wide kinematical range with a unique set of adjustable parameters;

2. For any comparison and critical assasament, a ‘bank of models” should be created, in which different models would be tested on a unique set of the data. Who could do this?

4. Spin?!

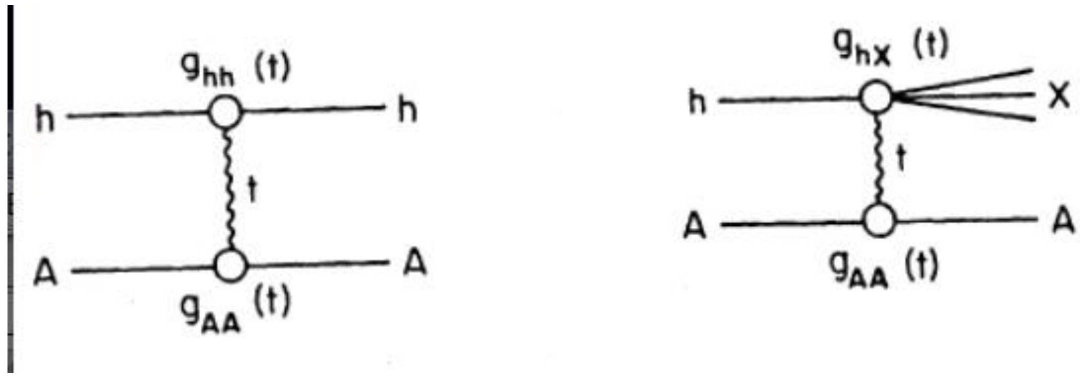
5. The Regge pole theory and QCD are progressing parallely, with little or no interference.

Low-mass diffraction dissociation at the LHC

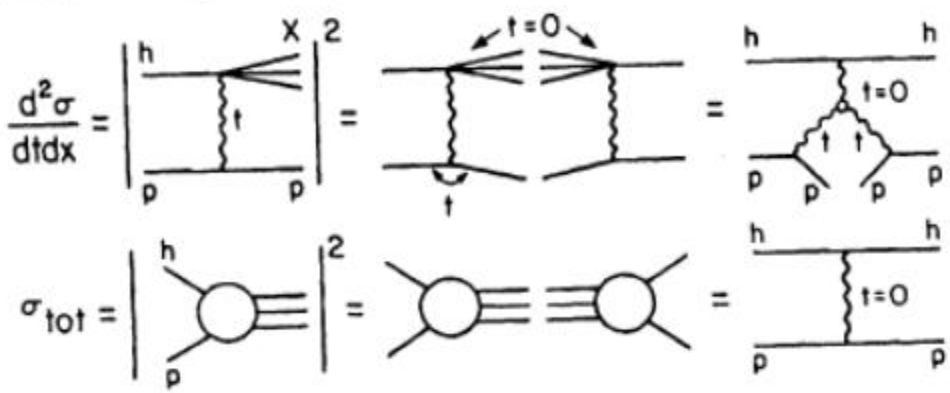
L. Jenkovszky, O. Kuprash, J. Lamsa, V. Magas, and R,. Orava:
Dual-Regge approach to high-energy, low-mass DD at the LHC,
Phys. Rev. D83(2011)0566014; hep-ph/1-11.0664.
L. Jenkovszky, O. Kuprash, J. Lamsa and R. Orava: hep-ph/11063299,
Mod. Phys. Letters A. **26**(2011) 1-9, August 2011.

Experimentally, diffraction dissociation in proton-proton scattering was intensively studied in the '70-ies at the Fermilab and the CERN ISR. In particular, double differential cross section $\frac{d\sigma}{dtdM_X^2}$ was measured in the region $0.024 < -t < 0.234$ $(\mathrm{GeV/c})^2$, $0 < M^2 < 0.12s$, and $(105 < s < 752)$ GeV^2, and a single peak in M_X^2 was identified.

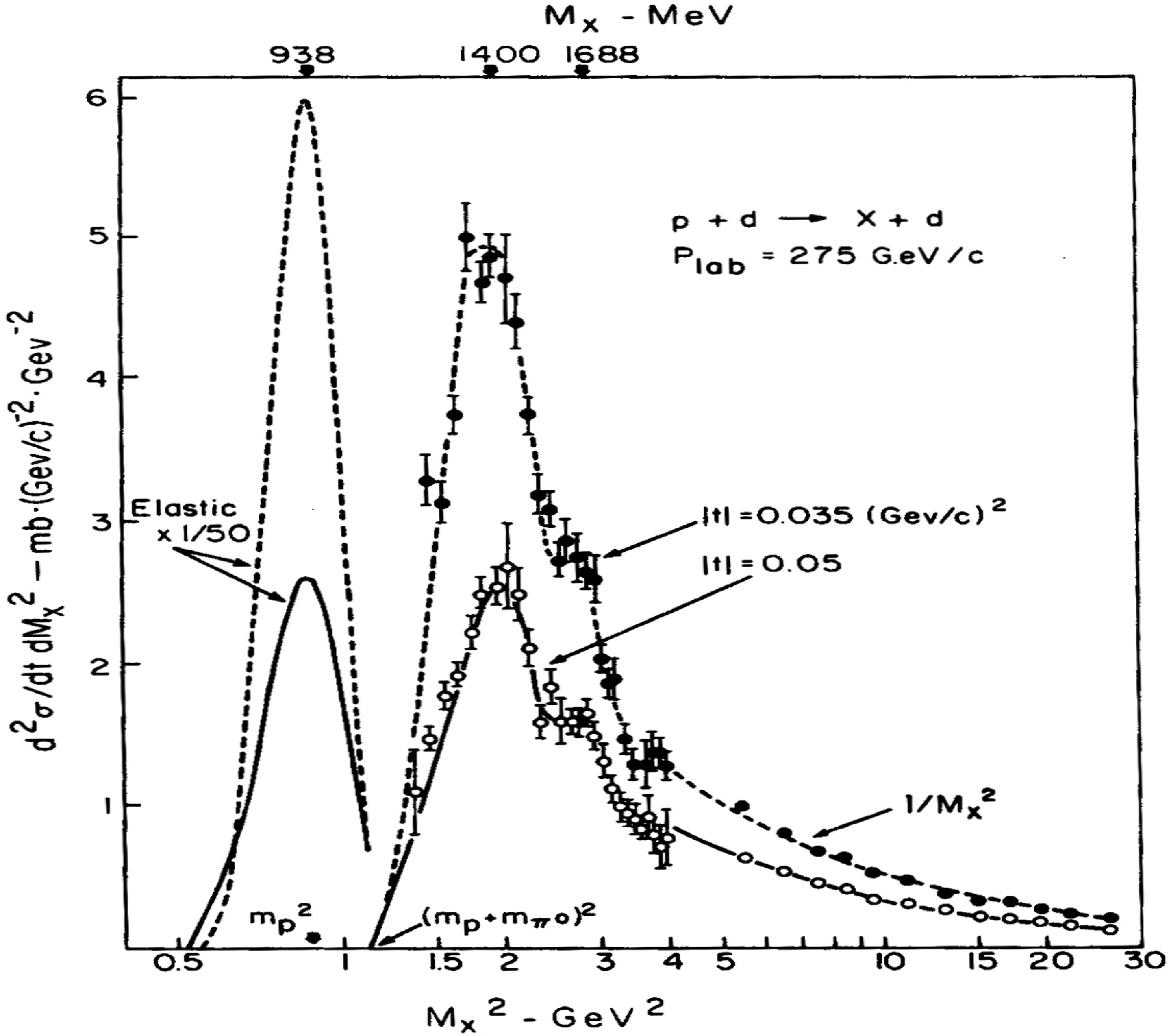
Low-mass single diffraction dissociation (SDD) of protons, $pp \to pX$ as well as their double diffraction dissociation (DDD) are among the priorities at the LHC. For the CMS Collaboration, the SDD mass coverage is presently limited to some 10 GeV. With the Zero Degree Calorimeter (ZDS), this could be reduced to smaller masses, in case the SDD system produces very forward neutrals, i.e. like a N^* decaying into a fast leading neutron. Together with the T2 detectors of TOTEM, SDD masses down to 4 GeV could be covered.



Triple Regge (Pomeron) limit::

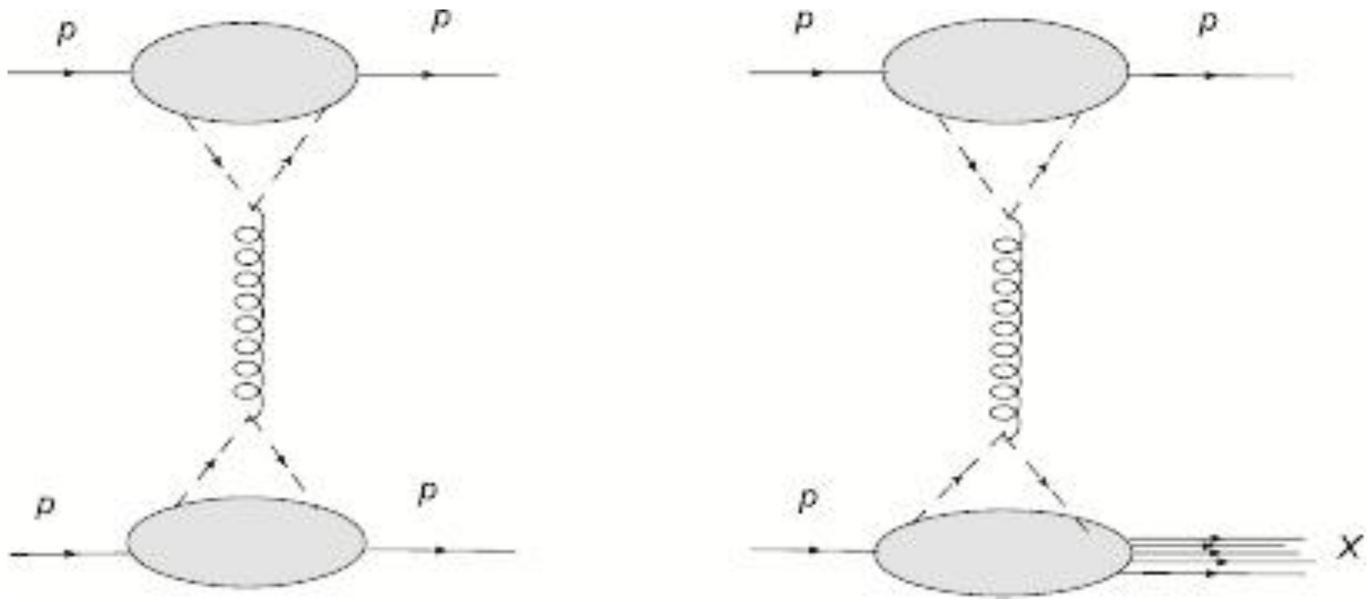


FNAL

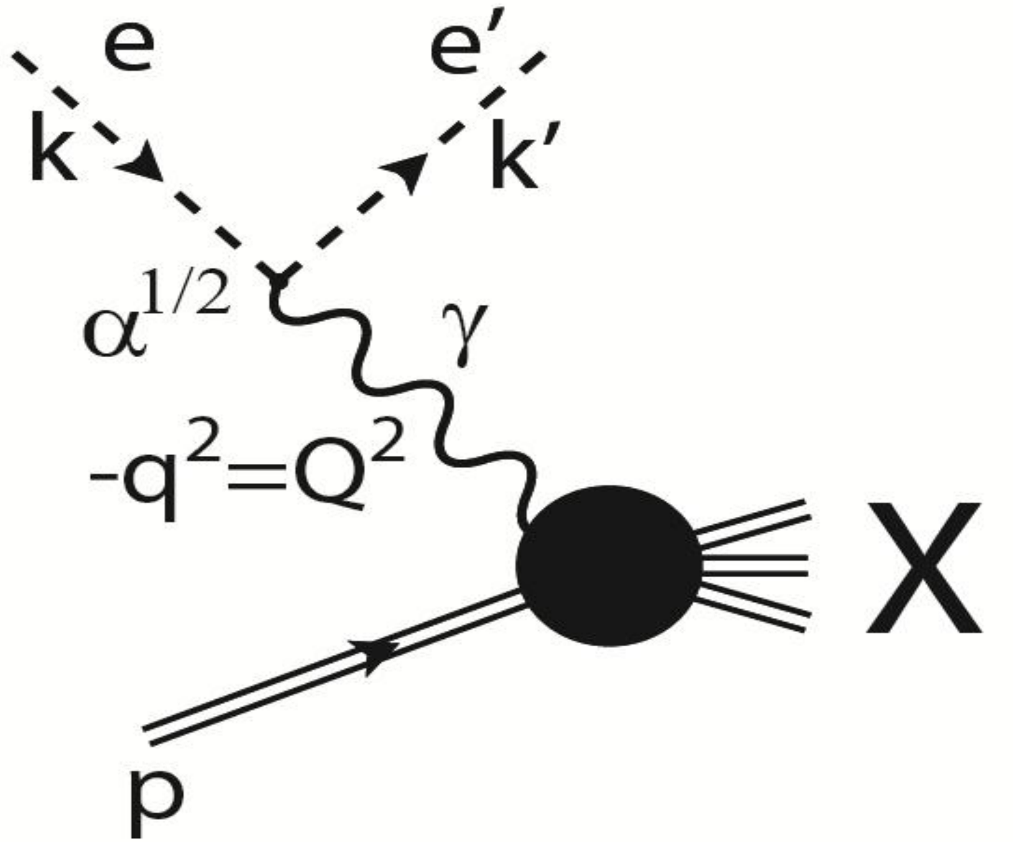


M_X - MeV
938
1400
1688
p + d → X + d
P_lab = 275 GeV/c
Elastic x 1/50
|t| = 0.035 (Gev/c)²
|t| = 0.05
1/M_X²
m_p²
(m_p + m_π0)²
d²σ/dt dM_X² — mb·(Gev/c)⁻²·Gev⁻²
M_X² - GeV²
0.5
1
1.5
2
3
4
5
10
15
20
30
1
2
3
4
5
6

Alternative (to the triple Regge) approach: Diffraction dissociation and DIS :



G.A. Jaroszkiewicz and P.V. Landshoff, Phys. Rev. 10 (1974) 170;
A. Donnachie, P.V. Landshoff, Nucl. Phys. B **244** (1984) 322.



JLAB → LHC; γ→ P; q^2→ t

R. Fiore {\it et al.} EPJ A **15** (2002) 505,hep-ph/0206027;.
R. Fiore {\it et al.} Phys. Rev. D **68** (2004) 014004, hep-ph/0308178.

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Pomeron dominance at the LHC

Energy variation of the relative importance of the Pomeron with respect to contributions from the secondary trajectories and the Odderon:

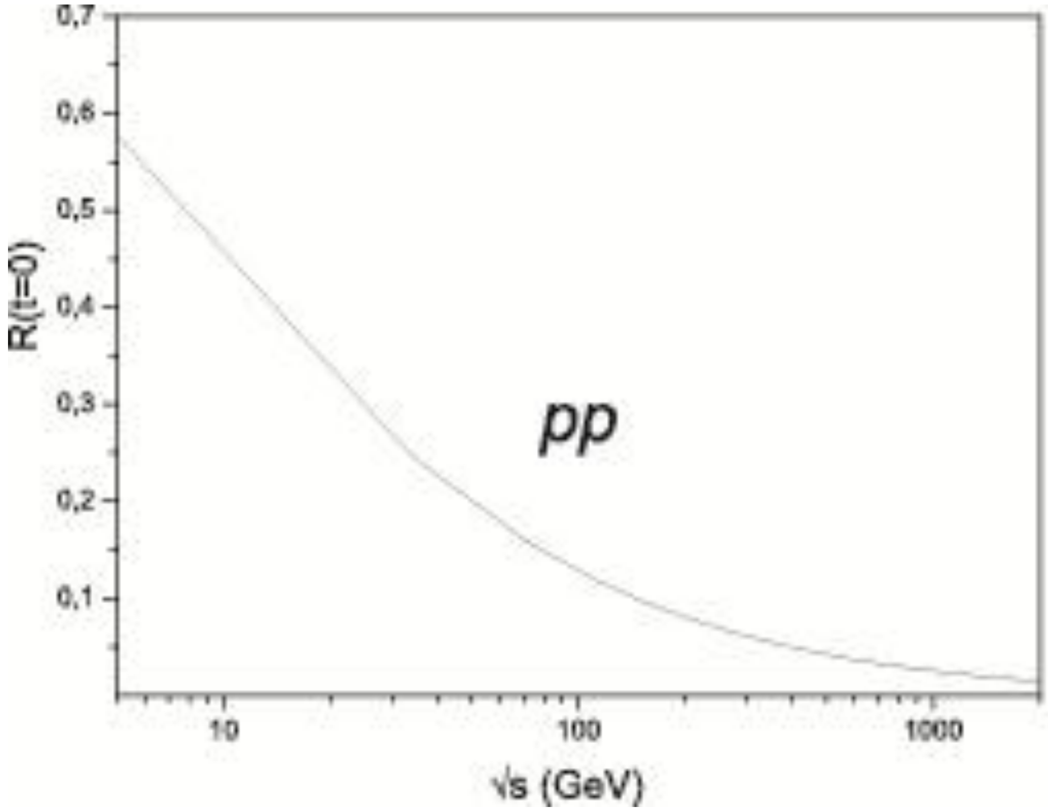
$$R(s, t = 0) = \frac{\Im m(A(s,t) - A_P(s,t))}{\Im A(s,t)}, \tag{1}$$

where the total scattering amplitude A includes the Pomeron contribution A_P plus the contribution from the secondary Reggeons and the Odderon.

Starting from the Tevatron energy region, the relative contribution of the non-Pomeron terms to the total cross-section becomes smaller than the experimental uncertainty and hence at higher energies they may be completely neglected, irrespective of the model used.

$$R(s,t) = \frac{|(A(s,t) - A_P(s,t)|^2}{|A(s,t)|^2}. \tag{2}$$

At the LHC, in the nearly forward direction, Pomeron exchange dominates; the rest, e.g. f-exchange, being negligible



The pp scattering amplitude

$$A(s,t)_P = \\ -\beta^2[f^u(t)+f^d(t)]^2\left(\frac{s}{s_0}\right)^{\alpha_P(t)-1}\frac{1+e^{-i\pi\alpha_P(t)}}{\sin\pi\alpha_P(t)}, \quad (1)$$

where $f^u(t)$ and $f^d(t)$ are the amplitudes for the emission of u and d valence quarks by the nucleon, β is the quark-Pomeron coupling, to be determined below; $\alpha_P(t)$ is a vacuum Regge trajectory. It is assumed that the Pomeron couples to the proton via quarks like a scalar photon.

A single-Pomeron exchange is valid at the LHC energies, however at lower energies (e.g. those of the ISR or the SPS) the contribution of non-leading Regge exchanges should be accounted for as well.

Thus, the unpolarized elastic pp differential cross section is

$$\frac{d\sigma}{dt} = \frac{[3\beta F^p(t)]^4}{4\pi\sin^2[\pi\alpha_P(t)/2]}(s/s_0)^{2\alpha_P(t)-2}. \quad (2)$$

Similar to the case of elastic scattering, the double differential cross section for the SDD reaction, by Regge factorization, can be written as

$$\frac{d^2\sigma}{dtdM_X^2} = \frac{9\beta^4[F^p(t)]^2}{4\pi \sin^2[\pi\alpha_P(t)/2]}(s/M_X^2)^{2\alpha_P(t)-2} \times \left[\frac{W_2}{2m}\left(1 - M_X^2/s\right) - mW_1(t+2m^2)/s^2\right], \tag{1}$$

where $W_i, \quad i = 1,2$ are related to the structure functions of the nucleon and $W_2 \gg W_1$. For high M_X^2, the $W_{1,2}$ are Regge-behaved, while for small M_X^2 their behavior is dominated by nucleon resonances. The knowledge of the inelastic form factors (or transition amplitudes) is crucial for the calculation of low-mass diffraction dissociation.

In the LHC energy region it simplifies to:

$$\frac{d^2\sigma}{dtdM_X^2} \approx \frac{9\beta^4[F^p(t)]^2}{4\pi}(s/M_X^2)^{2\alpha_P(t)-2}\frac{W_2}{2m} \,. \qquad (1)$$

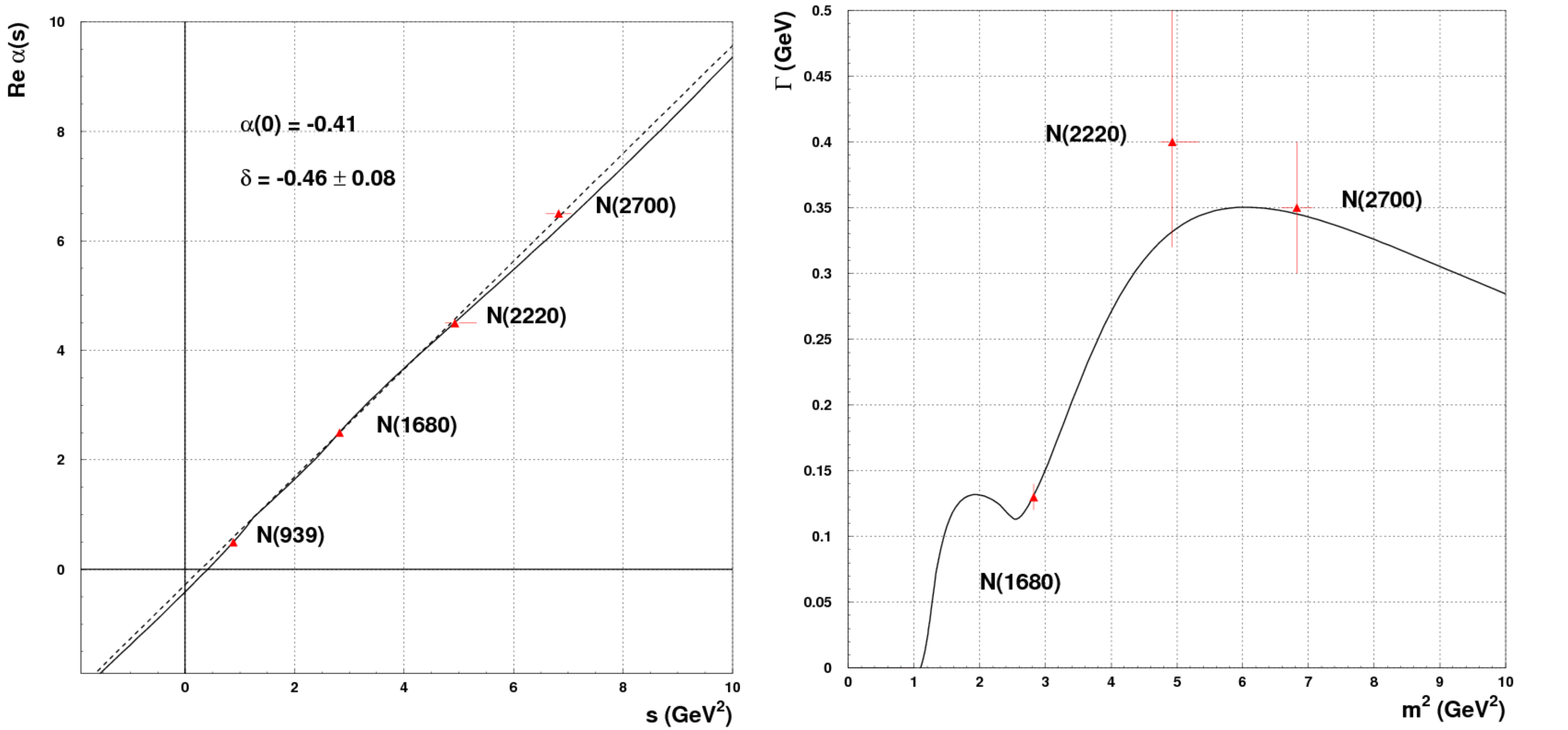
These expressions for SDD do not contain the elastic scattering limit because the inelastic form factor $W_2(M_X, t)$ has no elastic form factor limit $F(t)$ as $M_X \to m$. This problem is similar to the $x \to 1$ limit of the deep inelastic structure function $F_2(x, Q^2)$. The elastic contribution to SDD should be added separately.

At the lower vertex, the inelastic FF (transition amplitude) is the structure function

$$W_2(M_X^2, t) = \frac{-t(1-x)}{4\pi\alpha_s(1 + 4m^2x^2/(-t))} Im\, A(M_X^2, t)\,,$$

(here the Briorken variable $x \sim -t/M_X^2$), where the imaginary part of the transition amplitude is

$$Im\, A(M_X^2, t) = a \sum_{n=0,1,\ldots} \frac{[f(t)]^{2(n+1)} Im\, \alpha(M_x^2)}{(2n + 0.5 - Re\, \alpha(M_X^2))^2 + (Im\, \alpha(M_X^2))^2}.$$



The imaginary part of the trajectory can be written in the following way:

$$\mathcal{I}m\,\alpha(s) = s^{\delta} \sum_n c_n \left(\frac{s - s_n}{s} \right)^{\lambda_n} \cdot \theta(s - s_n)\,, \qquad (1)$$

where $\lambda_n = \mathcal{R}e\ \alpha(s_n)$.

The real part of the proton trajectory is given by

$$\mathcal{R}e\,\alpha(s) = \alpha(0) + \frac{s}{\pi}\sum_n c_n \mathcal{A}_n(s) \ , \tag{1}$$

where

$$\mathcal{A}_n(s) = \frac{\Gamma(1-\delta)\Gamma(\lambda_n+1)}{\Gamma(\lambda_n-\delta+2)s_n^{1-\delta}}\,{}_2F_1\left(1, 1-\delta; \lambda_n-\delta+2; \frac{s}{s_n}\right)\theta(s_n-s) +$$
$$\left\{\pi s^{\delta-1}\left(\frac{s-s_n}{s}\right)^{\lambda_n}\cot[\pi(1-\delta)] - \right.$$
$$\left.\frac{\Gamma(-\delta)\Gamma(\lambda_n+1)s_n^{\delta}}{s\Gamma(\lambda_n-\delta+1)}\,{}_2F_1\left(\delta-\lambda_n, 1; \delta+1; \frac{s_n}{s}\right)\right\}\theta(s-s_n) \ .$$

SD and DD cross sections

$$\frac{d^2\sigma_{SD}}{dt dM_x^2} = {F_p}^2(t) F(x_B, t) \frac{\sigma_T^{Pp}(M_x^2, t)}{2m_p} \left(\frac{s}{M_x^2}\right)^{2(\alpha(t)-1)} \ln\left(\frac{s}{M_x^2}\right)$$

$$\frac{d^3\sigma_{DD}}{dt dM_1^2 dM_2^2} = C_n F^2(x_B, t) \frac{\sigma_T^{Pp}(M_1^2, t)}{2m_p} \frac{\sigma_T^{Pp}(M_2^2, t)}{2m_p} \times \left(\frac{s}{(M_1 + M_2)^2}\right)^{2(\alpha(t)-1)} \ln\left(\frac{s}{(M_1 + M_2)^2}\right)$$

“Reggeized (dual) Breit-Wigner” formula:

$$\sigma_T^{Pp}(M_x^2,t) = Im\,A(M_x^2,t) = \frac{A_{N^*}}{\sum_n n-\alpha_{N^*}(M_x^2)} + Bg(t,M_x^2) =$$

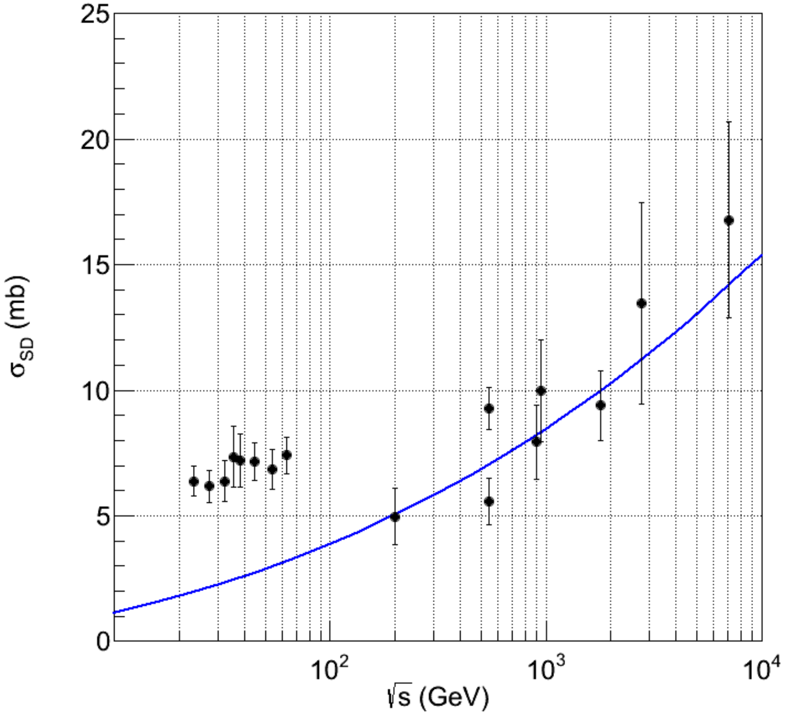
$$= A_n \sum_{n=0,1,\ldots} \frac{[f(t)]^{2(n+1)}\,Im\,\alpha(M_x^2)}{(2n+0.5-Re\,\alpha(M_x^2))^2 + (Im\,\alpha(M_x^2))^2} + B_n e^{b_{in}^{bg}t}\left(M_x^2 - M_{p+\pi}^2\right)^{\epsilon}$$

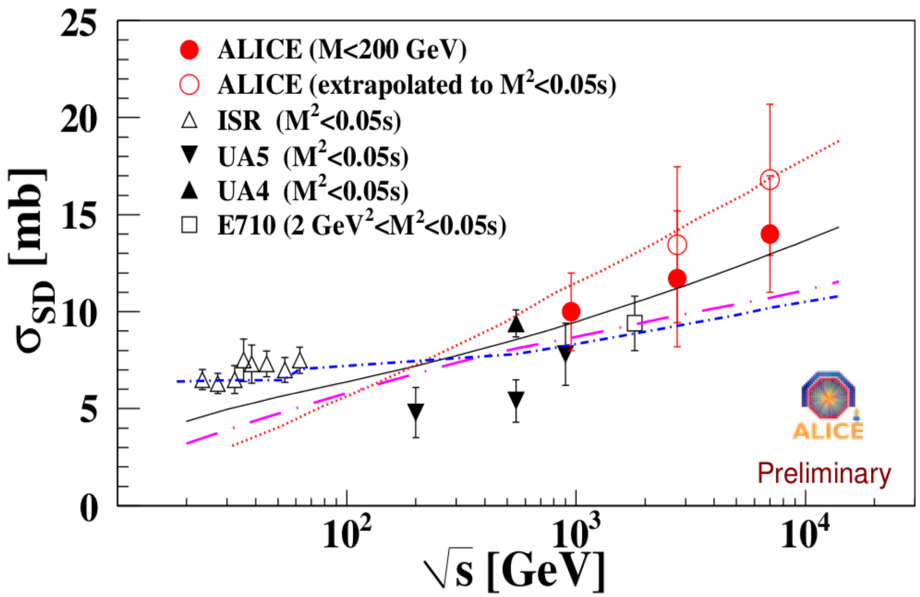
$$F(x_B,t) = \frac{x_B(1-x_B)}{\left(M_x^2-m_p^2\right)\left(1+4m_p^2x_B^2/(-t)\right)^{3/2}}, \quad x_B = \frac{-t}{M_x^2-m_p^2-t}$$

$$F_p(t) = \frac{1}{1-\frac{t}{0.71}}, \quad f(t) = e^{b_{in}t}$$

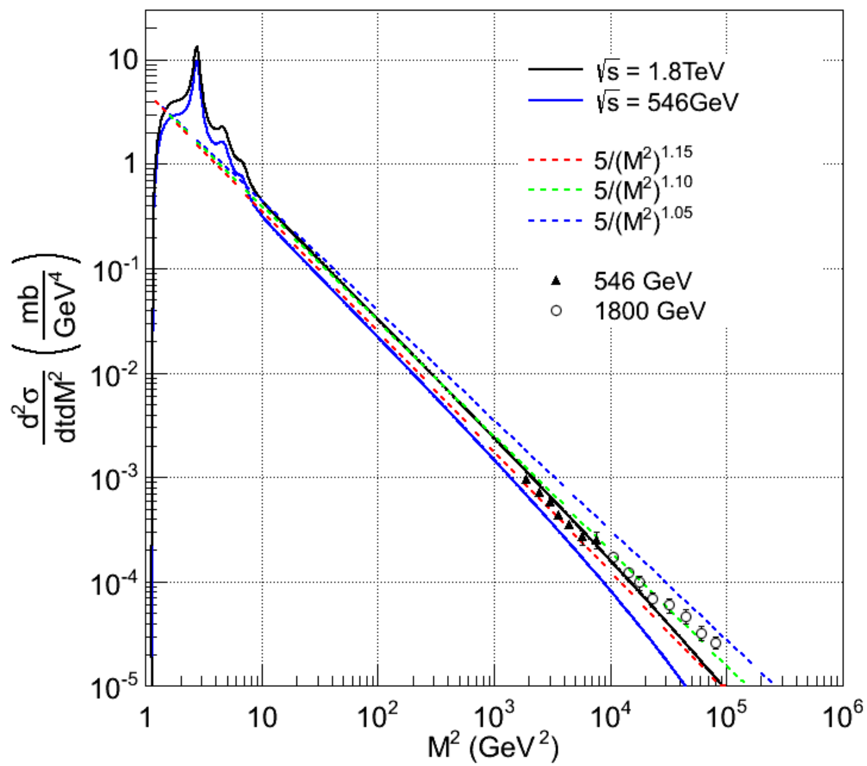
$$\alpha(t) = \alpha(0) + \alpha' t = 1.04 + 0.25t$$

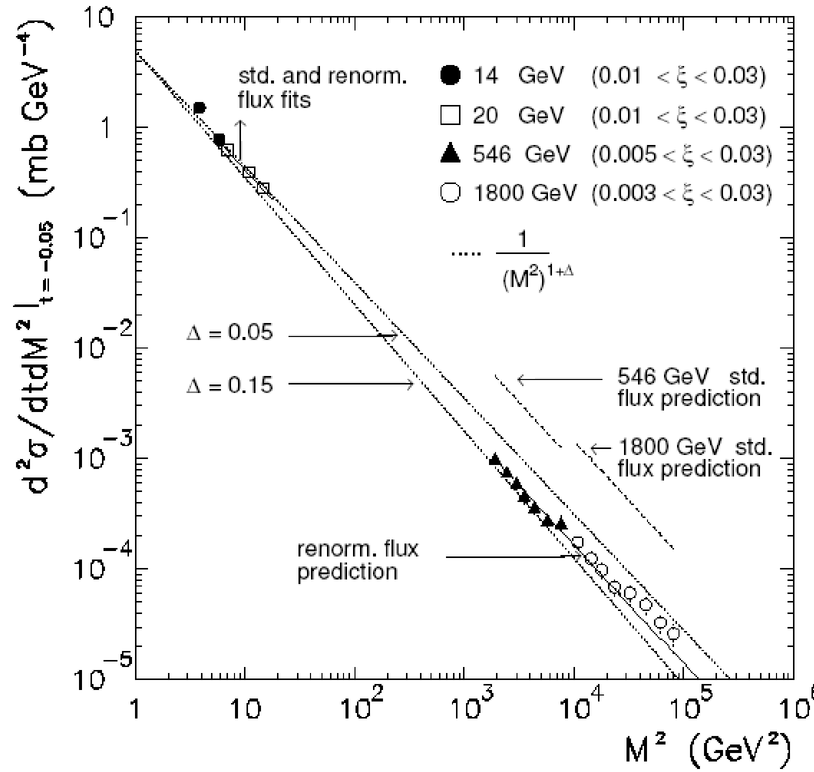
SDD cross sections vs. energy.





Approximation of background to reference points (t=-0.05)





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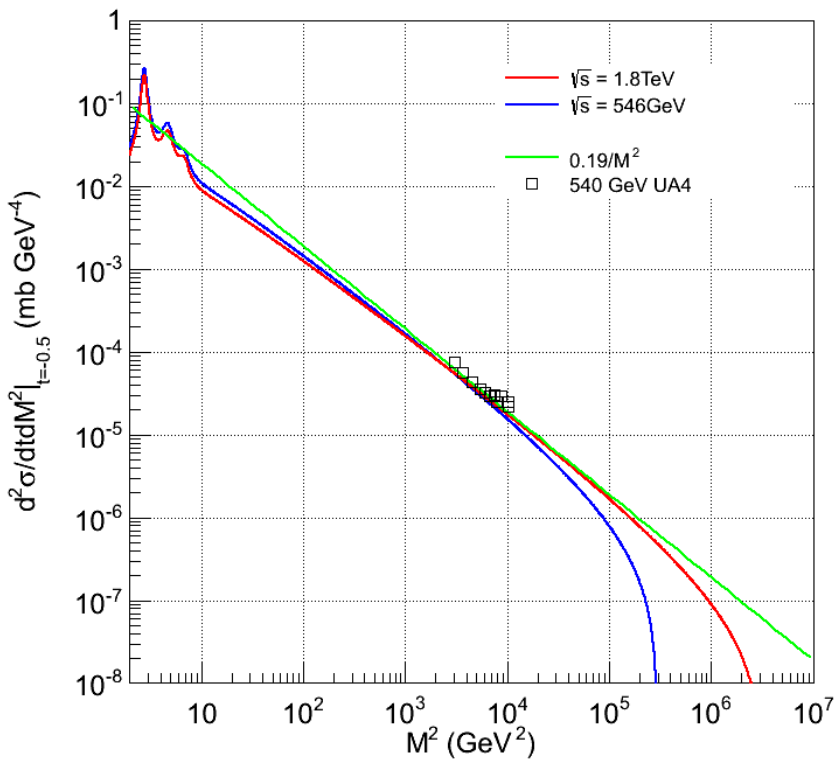
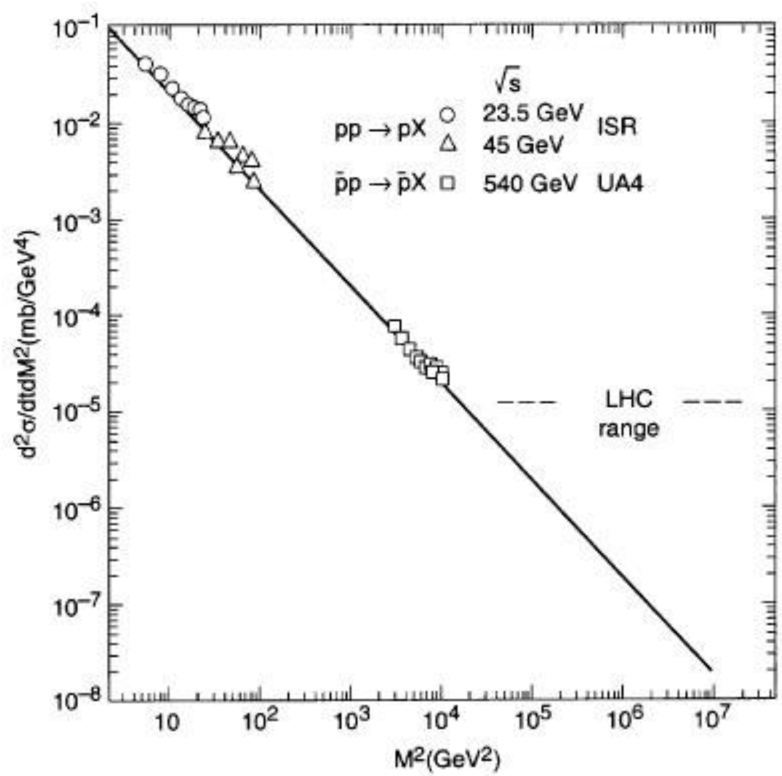
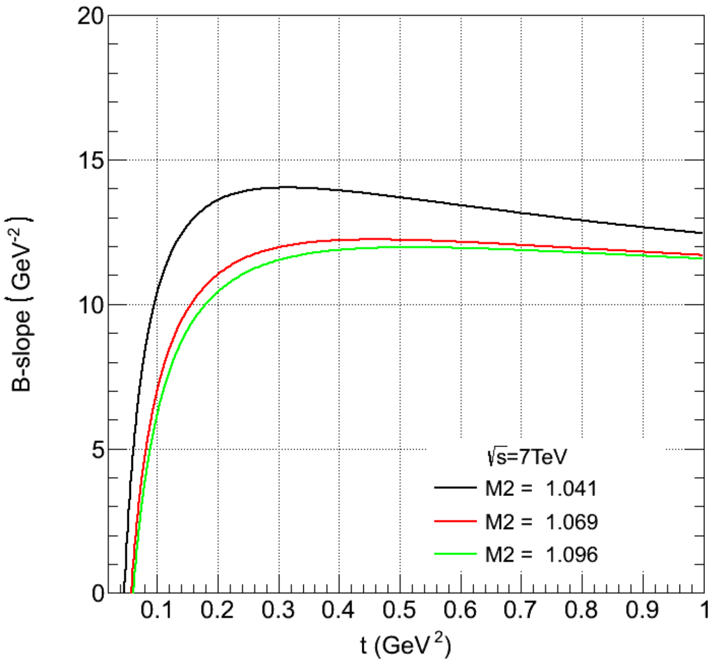
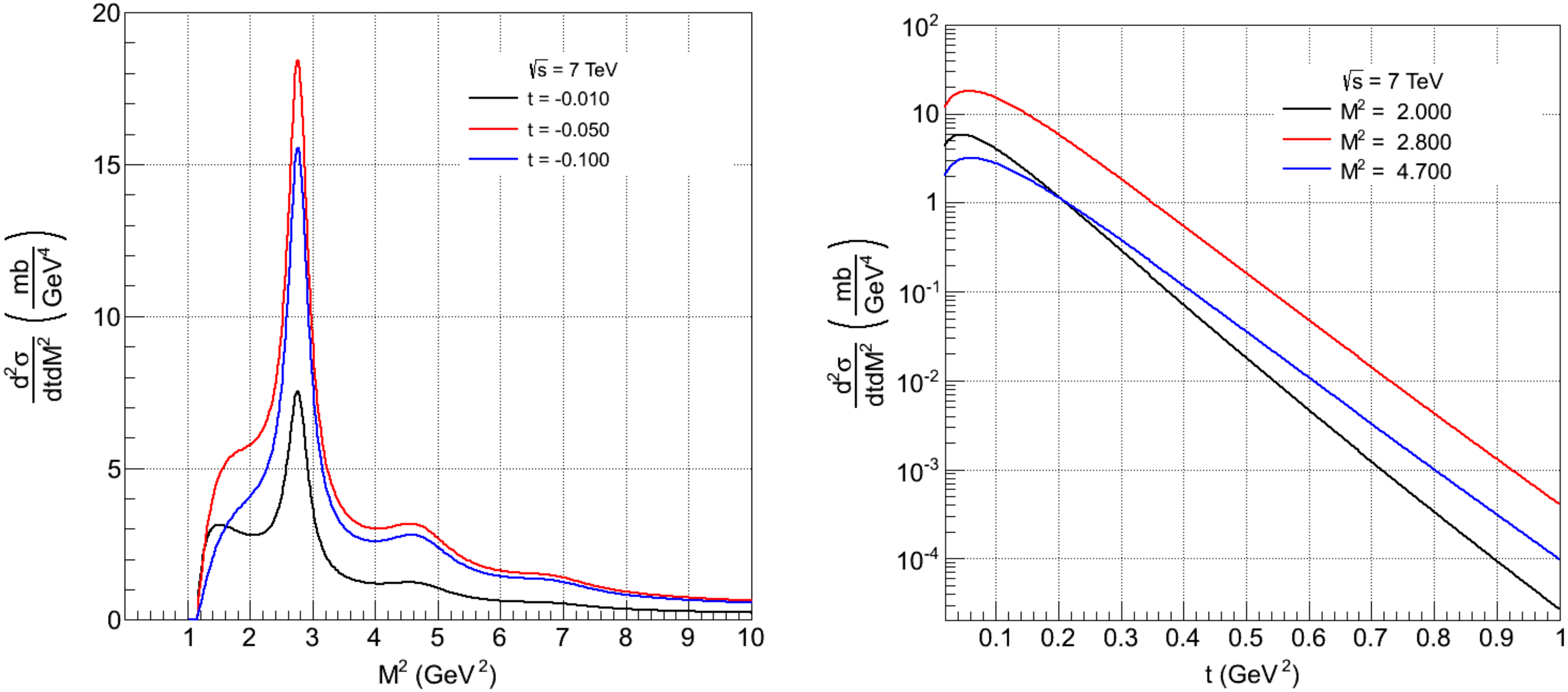




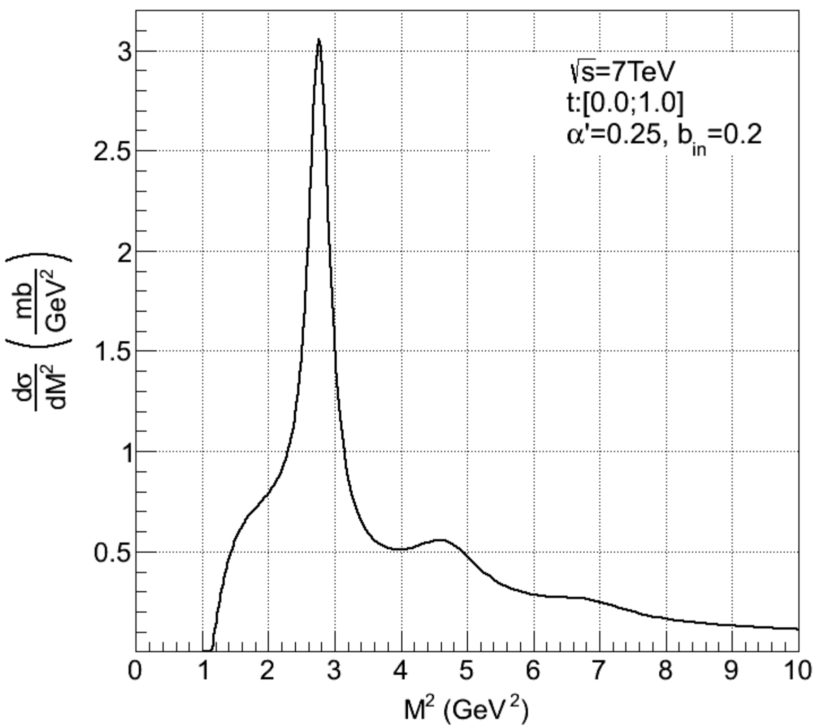
B-slopes for SD

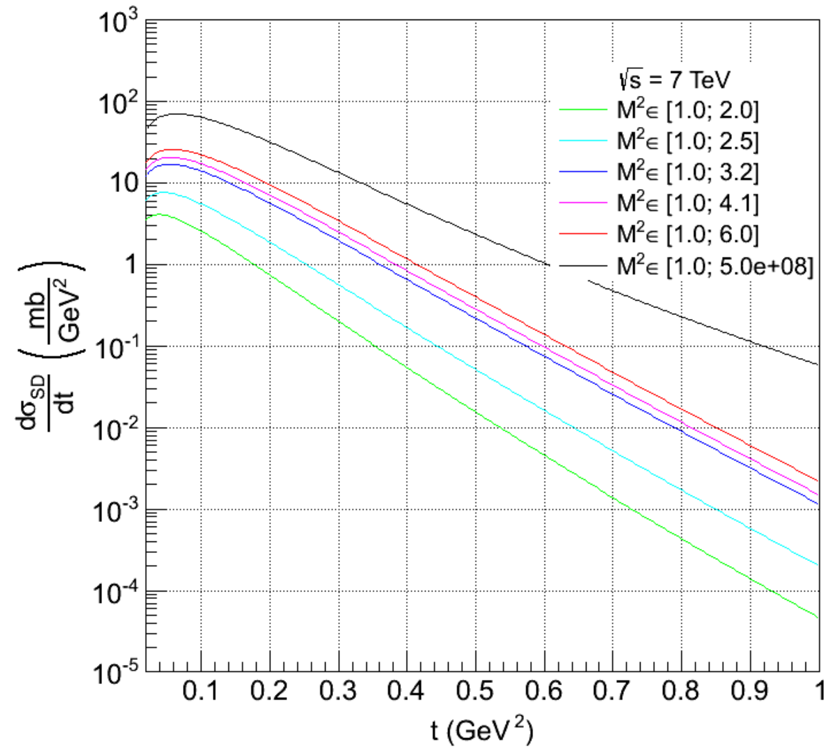


Double differential SD cross sections

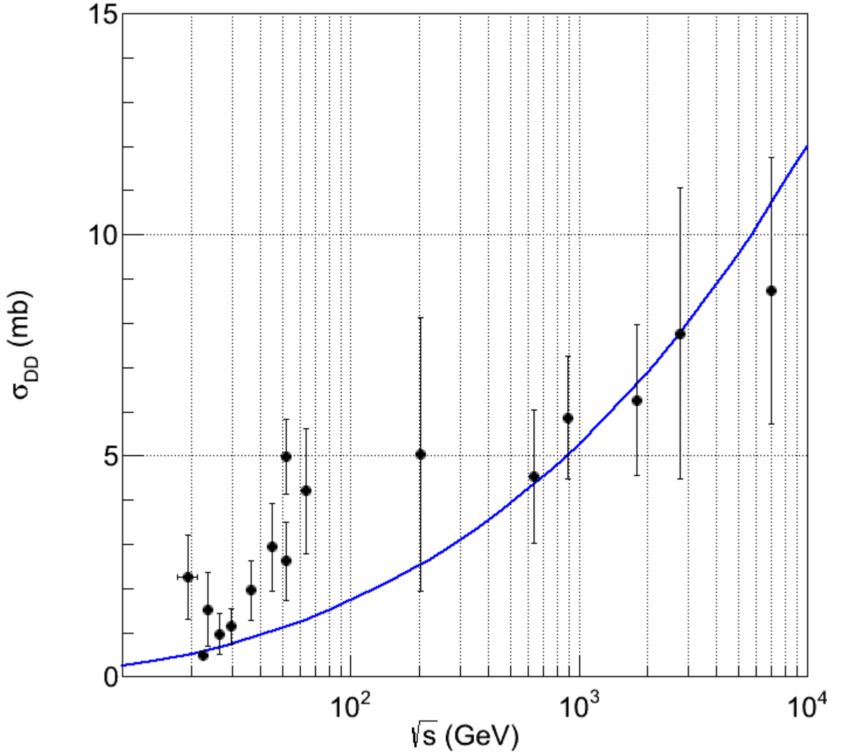


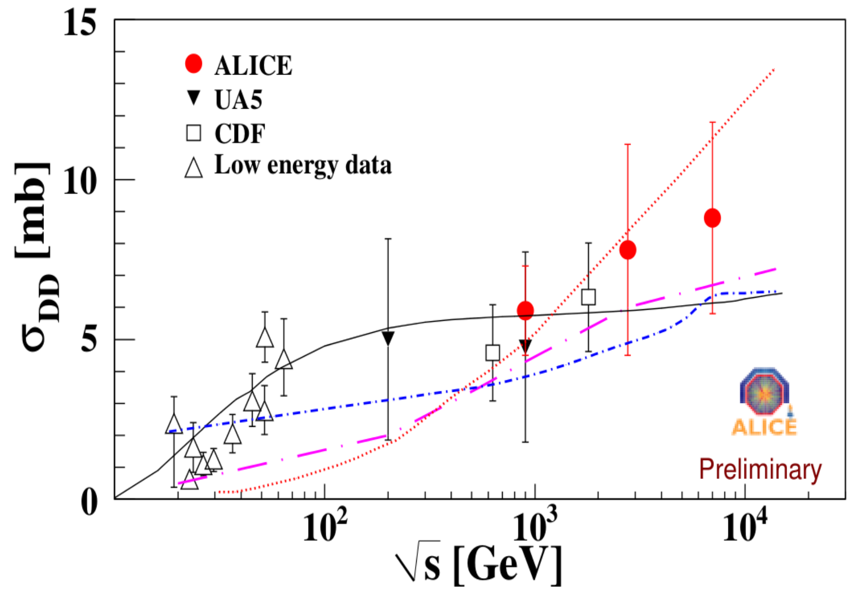
Single differential integrated SD cross sections



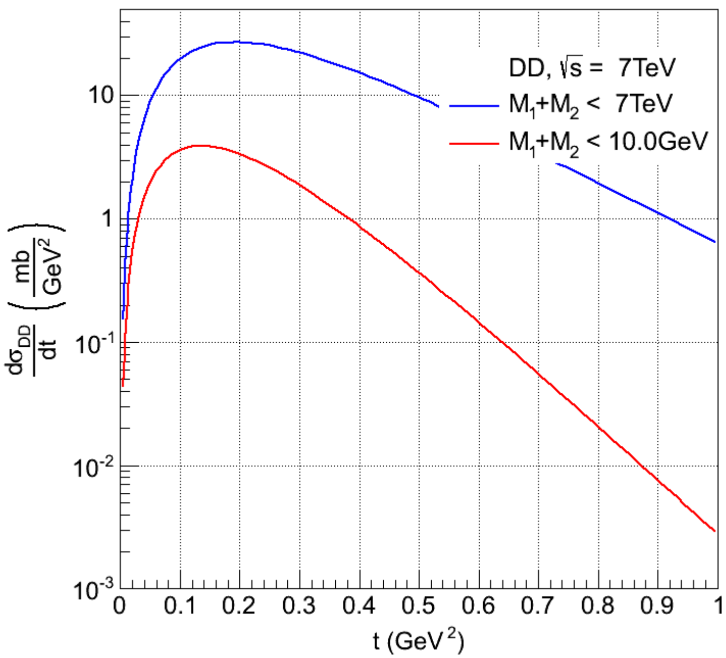


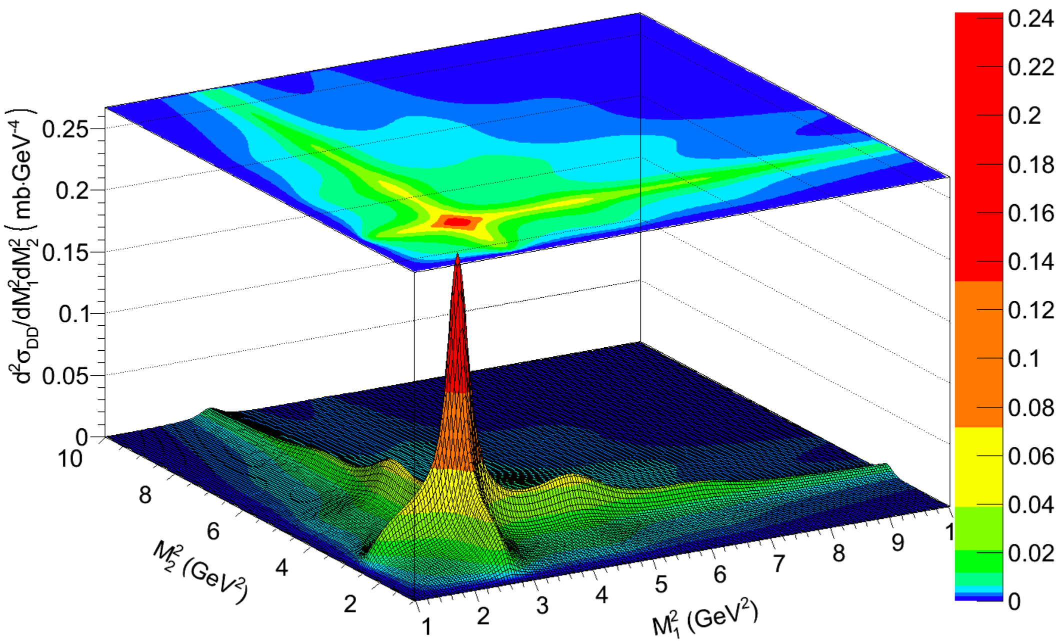
DDD cross sections vs. energy.



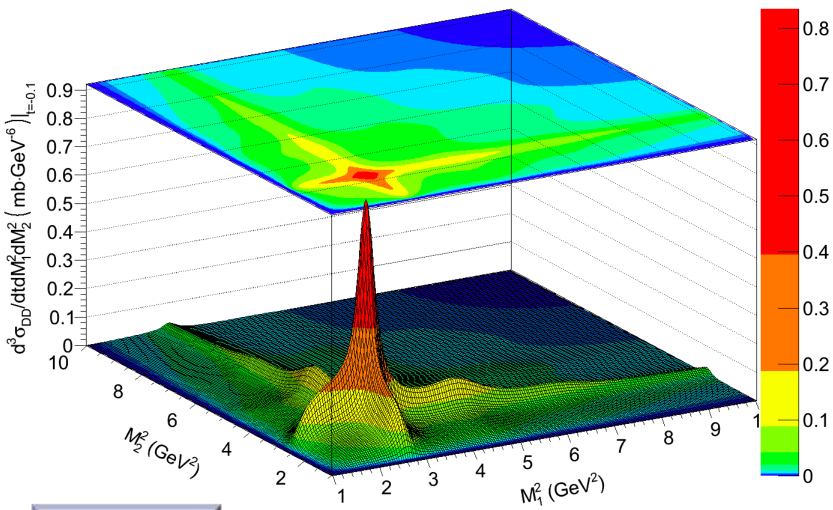


Integrated DD cross sections

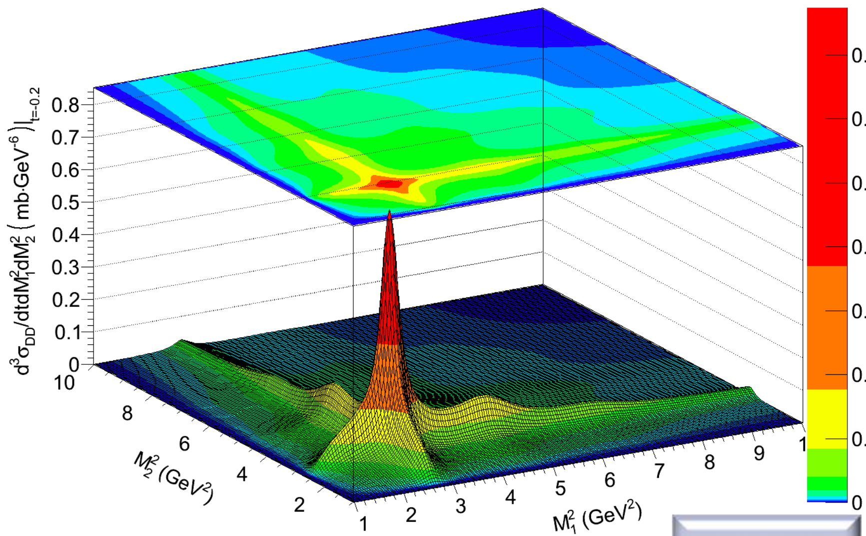




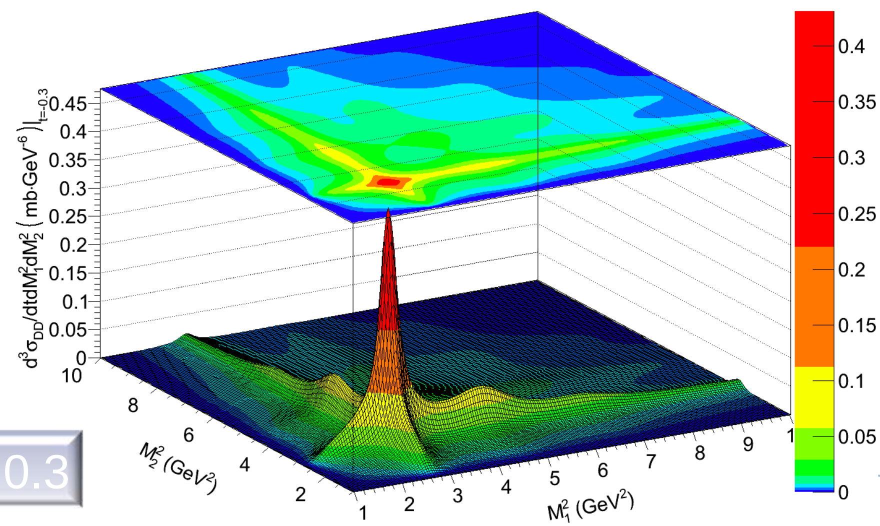
Triple differential DD cross sections



t = - 0.1



t = - 0.2



t = - 0.3

The parameters and results

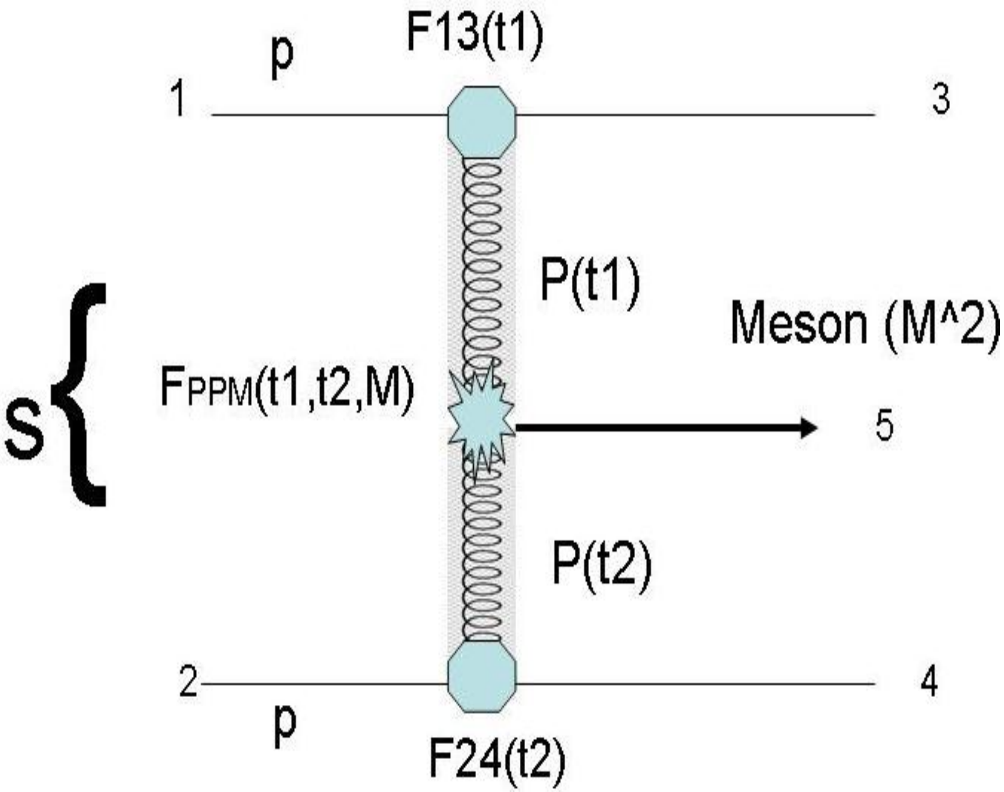
b_{in} (GeV^{-2})	0.2
b_{in}^{bg} (GeV^{-2})	3
α' (GeV^{-2})	0.25
$\alpha(0)$	1.04
ϵ	1.03
A_n	18.7
B_n	8.8
C_n	3.79e-2

σ_{SD} (mb)	14.13
$\sigma_{SD}(M < 3.5GeV)$ (mb)	4.68
$\sigma_{SD}(M > 3.5GeV)$ (mb)	9.45
σ_{Res}^{SD} (mb)	2.48
σ_{Bg}^{SD} (mb)	9.45
σ_{DD} (mb)	10.68
$\sigma_{DD}(M < 10GeV)$ (mb)	1.05
$\sigma_{DD}(M > 10GeV)$ (mb)	9.63

Open problems:

1. Interpolation in energy: from the Fermilab and ISR to the LHC;
2. Inclusion of non-leading contributions;
3. Deviation from a simple Pomeron pole model and breakdown of Regge-factorization;
4. The background (in M^2);
5. Finite-mass sum rules (duality), inerpolation in M^2).

Prospects (future plans): central diffractive meson production (double Pomeron exchange)



Thanks for your attention!