International workshop
Diffraction in High Energy Physics
("DIFFRACTION-2016")

Acireale (Italy)
September, 02-08

"The dispersion relations and analysis of the new LHC data"

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in collaboration with **J.-R. CUDELL**
FAGO, Univ. Liege

Contents

the new LHC data (elastic scattering) at 7 and 8 TeV

7 TeV (***TOTEM***) - t [0.00515 – 0.371] 17.08.2012

7 TeV (***ATLAS***) - t [0.0062 – 0.3636] 25.08.2014

8 TeV (***TOTEM***) - t [0.028500 – 0.1947] 12.09.2015

8 TeV (***TOTEM***) - t [0.000741 – 0.201] 11.12.2015

8 TeV (***ATLAS***) - t [0.01050 – 0.3635] 25.06.2016

Total cross sections

TOTEM ***ATLAS***

$$\sigma_{tot} = (98.3 \pm 2.8)\, mb;$$
$$(98.6 \pm 2.2)\, mb;$$
$$(99.1 \pm 4.3)\, mb;$$
$$(98.0 \pm 2.5)\, mb;$$

$$\sqrt{s} = 7000\, GeV;$$

$$\sigma_{tot} = (98.5 \pm 2.9)\, mb$$

$$\sigma_{tot} = (95.35 \pm 2.0)\, mb$$

$$\Delta = 3.15\ mb;$$

$$\sqrt{s} = 8000\, GeV;$$

$$\sigma_{tot} = (102.9 \pm 2.3)\, mb$$

$$\sigma_{tot} = (96.07 \pm 1.34)\, mb$$

$$\Delta = 6.7\ mb;$$

High Energy General Structure (HEGS) model O.V.S. - Eur. Phys. J. C (2012) 72:2073

Extending of model (HEGS1) – O.V. S. Phys.Rev. D 91, (2015) 113003

$$9 \leq \sqrt{s} \leq 8000\, GeV; \qquad \hat{s} = s / s_0 \, e^{-i\pi/2};$$

$$n = 980 \to 3416; \qquad 0.00037 < |t| < 15\ GeV^2; \qquad s_0 = 4m_p^2.$$

$$F_1^B(s,t) = h_2 G_{em}(t)\ (\hat{s})^{\Delta_1} e^{\alpha_1 t \ln(\hat{s})}; \qquad F_3^B(s,t) = h_3 G_A(t)^2\ (\hat{s})^{\Delta_1} e^{\alpha_1/4\, t \ln(\hat{s})}$$

$$F^B(\hat{s},t) = F_2^B(\hat{s},t)(1 + R_1/\sqrt{\hat{s}}\ )] + F_3^B(\hat{s},t)(1 + R_2/\sqrt{\hat{s}}\ )]$$

$$+ F_{odd}^B(s,t);$$

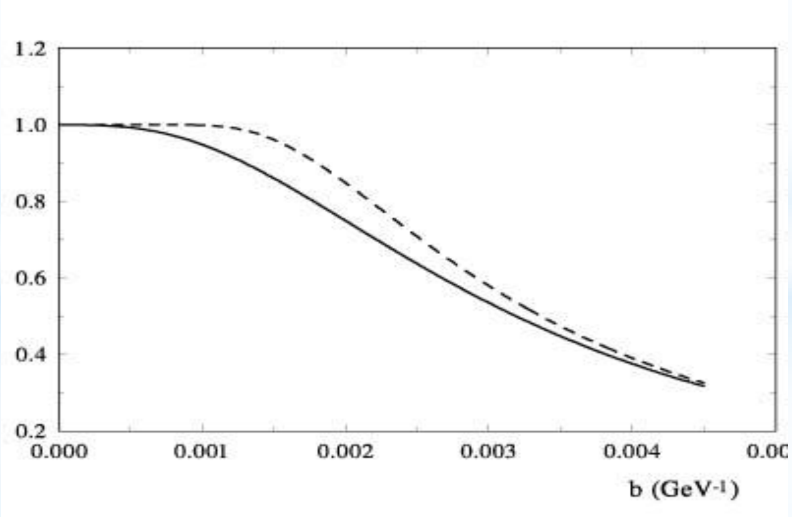
$$F_{Odd}^B(s,t) = h_{Odd}\ G_A(t)^2\ (\hat{s})^{\Delta_1} \frac{t}{1 - r_o^2 t} e^{\alpha_1/4\, t \ln(\hat{s})};$$

$$B(t) = (\alpha_1 + k_0\, q\, e^{k_0\, t\, ln\hat{s}}\ ) \ln \hat{s}.$$

UNITARIZATION → eikonal representation

$$\chi(s,b) = 2\pi \int_0^\infty q\ J_0(bq)\ F_B^h(s,q)\,dq \qquad \chi(s,b) = -\frac{1}{2k}\int_{-\infty}^{\infty} dz V[\sqrt{z^2+b^2}]$$

$$F^h(s,t) = \frac{1}{2\pi}\int_0^\infty b\ J_0(bq)\ [1-e^{-\chi(s,b)}]\,db$$



High energy parameters

$$\Delta_1 = 0.11; \quad \alpha_1 = 0.24; \ fixed;$$

$$h_1 = 0.82; \ h_2 = 0.31; \quad (h_{Odd} = 0.14 \ ; \ r_o^2 = 3.8); \ k_0 = 0.16 \ ;$$

Low energy parameters

$$R_1 = 53.7; \ R_2 = 4.45; \quad h_{sf} = 0.05.$$

$$9 \leq \sqrt{s} \leq 8000 \, GeV; \quad N = 3416;$$

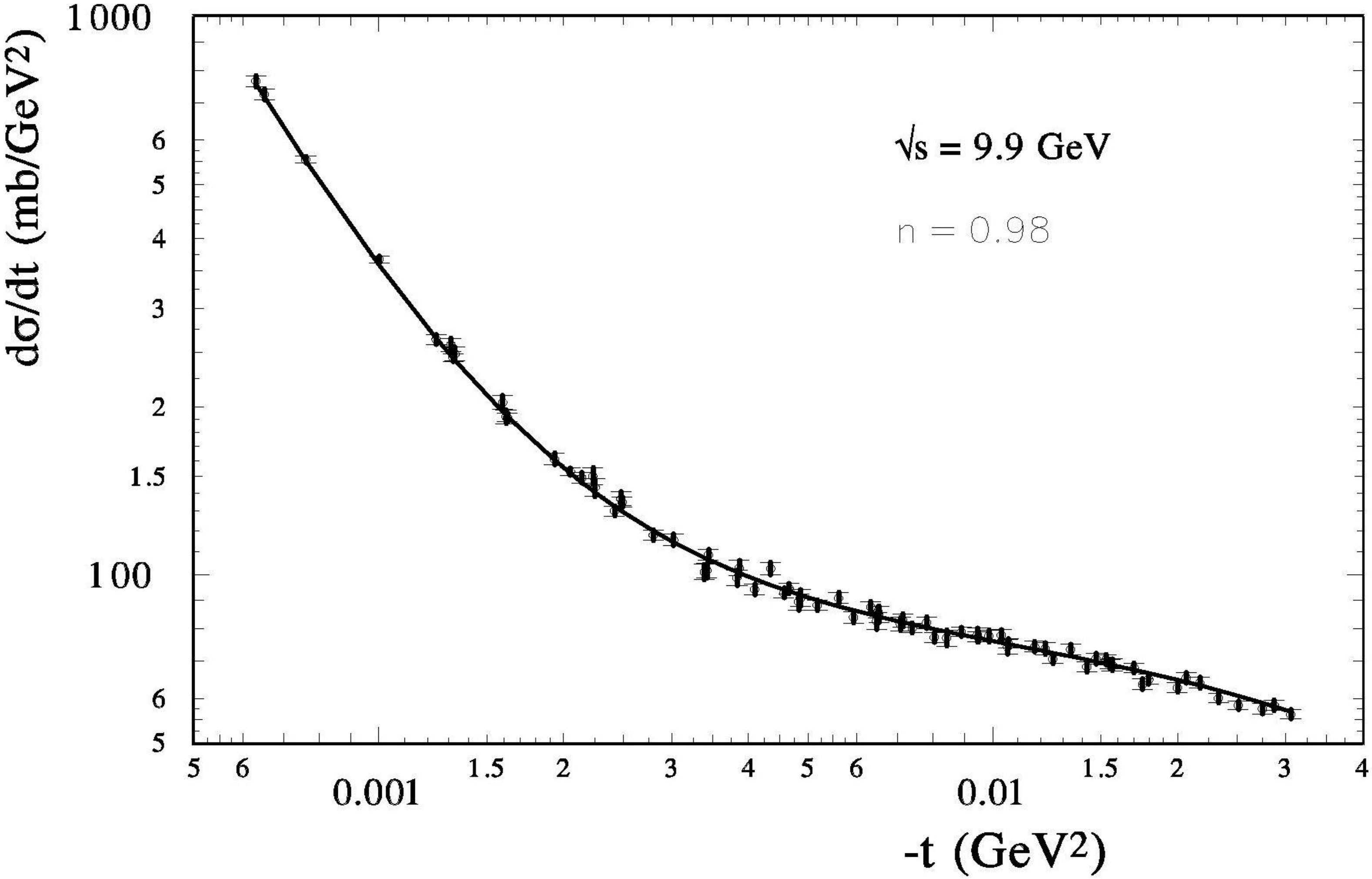
$$\sum \chi^2 / \mathrm{N} = 1.28$$

TABLE III: The proton-proton elastic scattering at small t

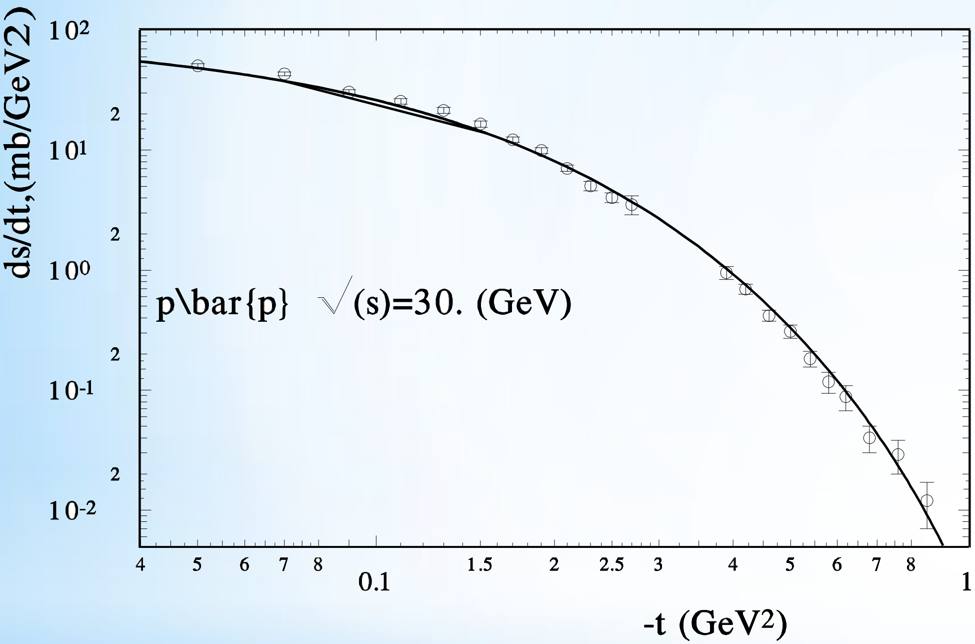
$\sqrt{s}$, GeV	$t_{\min}$, GeV	$t_{\max}$, GeV	N	$\sum_N \chi^2$	$\sum_N \chi^2/N$	n_k (norm.)
9.0	0.00193	0.04328	19	14.4	0.72	1.041
9.3	0.01268	0.1147	28	21	0.75	1.019
9.8	0.00115	0.115	64	87.6	1.35	1.013
9.8	0.0026	0.12	23	31.0	1.37	1.074
9.9	0.00063	0.0306	73	81.1	1.11	1.014
10.6	0.00079	0.01529	45	68.0	1.39	1.026
12.3	0.00066	0.02928	58	46.9	0.81	1.018
13.76	0.0023	0.0388	73	84.9	1.16	1.023
13.76	0.035	0.095	7	2.5	0.36	1.029
16.83	0.0022	0.0392	68	76.9	1.13	1.006
19.42	0.00066	0.0315	69	79.5	1.15	0.996
19.42	0.035	0.095	7	12.2	1.74	1.008
19.42	0.0206	0.12	42	19.9	0.47	1.038
21.7	0.022	0.039	64	50.1	0.78	0.996
22.2	0.0005	0.02978	64	55.6	0.87	1.007
23.5	0.00037	0.0102	30	58.5	1.95	1.008
23.8	0.0022	0.0388	60	69.1	1.15	1.001
23.9	0.00066	0.0316	66	76.5	1.16	0.988
27.4	0.00047	0.02579	61	66.1	1.08	0.987
30.6	0.016	0.11	48	53.1	1.10	1.005
30.8	0.0005	0.0176	31	75.7	2.36	1.009
44.7	0.00099	0.01856	40	51.	1.16	1.004
52.8	0.00107	0.05546	35	53.2	1.52	1.016
62.3	0.00543	0.05122	23	31.7	1.38	1.005
7000.	0.00515	0.356	84	173.4	2.04	0.943
7000.	0.006	0.36	40	31.4	0.77	1.0
8000.	0.028	0.195	30	20	0.7	0.9

TABLE IV: The proton-antiproton elastic scattering at small t

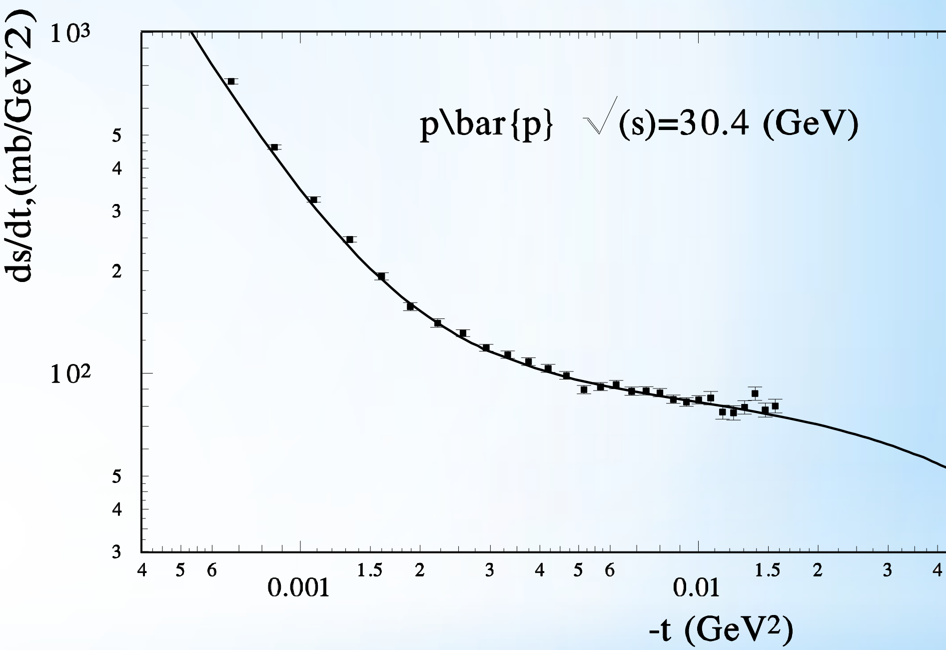
$\sqrt{s}$,	$t_{\min}$,	$t_{\max}$,	N	$\sum_N \chi^2$	$\sum_N \chi^2/N$	n_k
GeV	GeV	GeV				(norm.)
11.54	0.0375	0. 5	13	11.5	0.88	0.983
13.76	0.035	0.095	7	7.4	1.06	0.966
19.42	0.035	0.095	7	7.3	1.05	1.220
30.4	0.00067	0.01561	28	28.8	1.03	0.974
52.6	0.00097	0.03866	28	24.5	0.875	0.987
52.8	0.0109	0.0479	43	49.9	1.16	0.933
62.3	0.00632	0.03821	43	55.8	1.3	0.996
541.	0.000875	0.11875	99	164.7	1.65	unnorm.
546.	0.00225	0.03475	66	83.7	1.25	1.004
546.6	0.026	0.078	14	13.86	1.0	1.002
1800.	0.0339	0.285	28	28.8	1.03	1.024



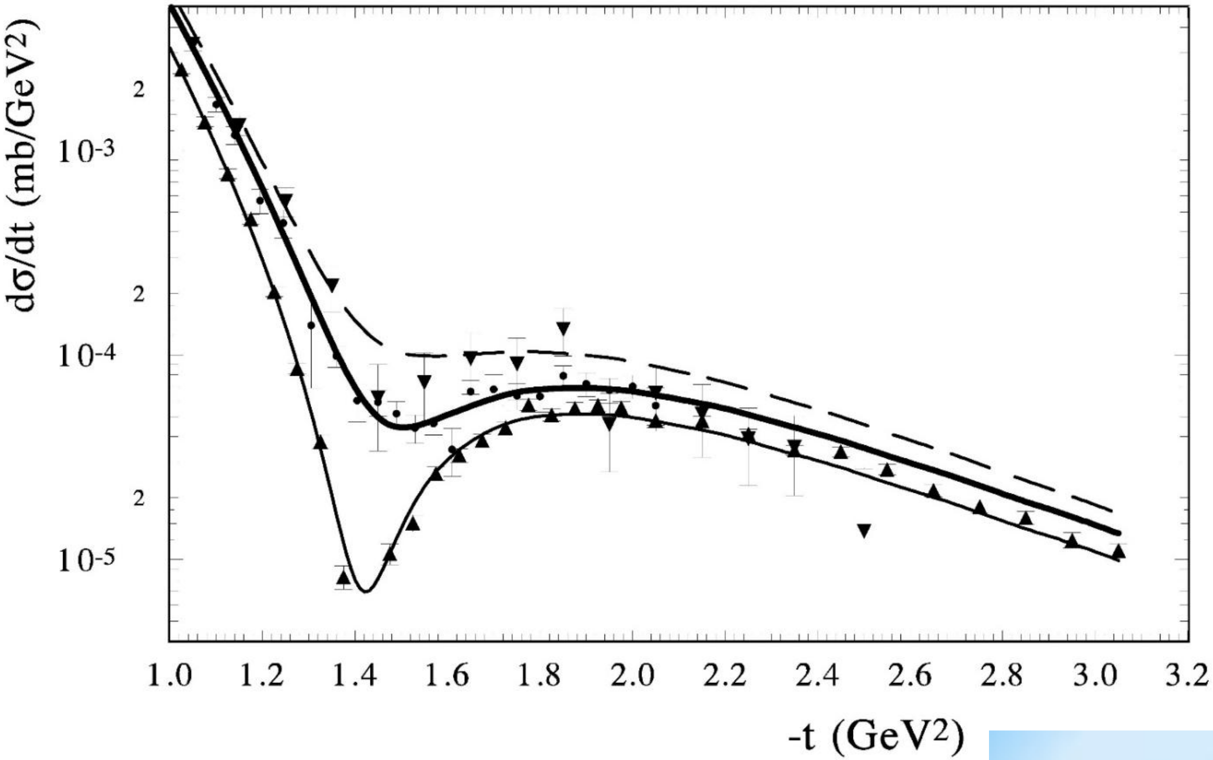
√s = 9.9 GeV
n = 0.98
dσ/dt (mb/GeV2)
1000
6
5
4
3
2
1.5
100
6
5
5
6
0.001
1.5
2
3
4
5
6
0.01
1.5
2
3
4
-t (GeV2)



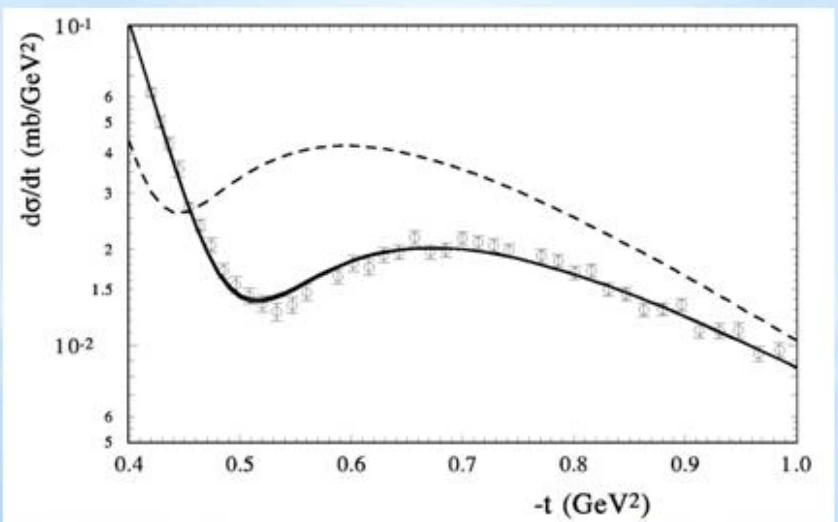
ds/dt,(mb/GeV2)
p\bar{p} √(s)=30. (GeV)
-t (GeV2)



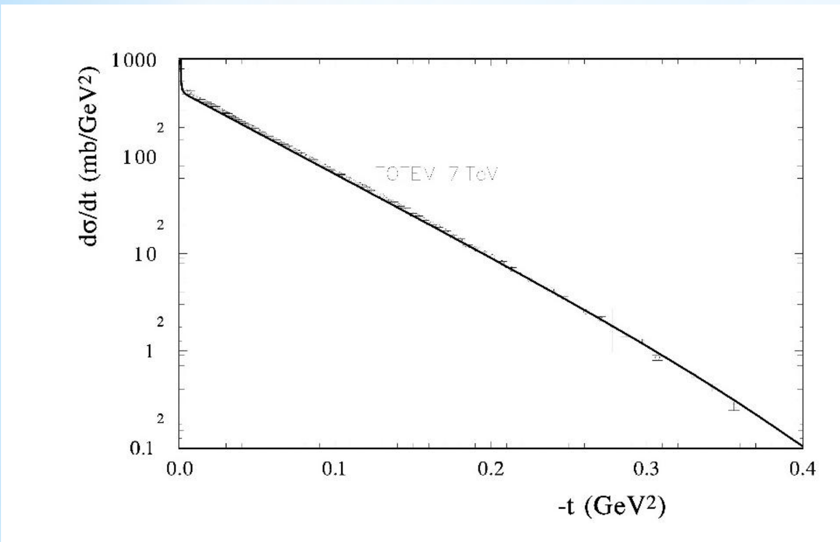
ds/dt,(mb/GeV2)
p\bar{p} √(s)=30.4 (GeV)
-t (GeV2)



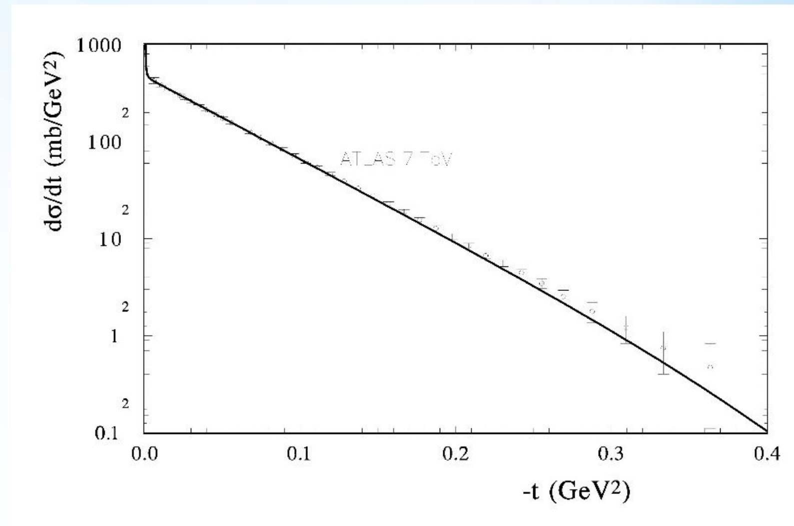
$\sqrt{s}$ = 7 TeV; 14 TeV.



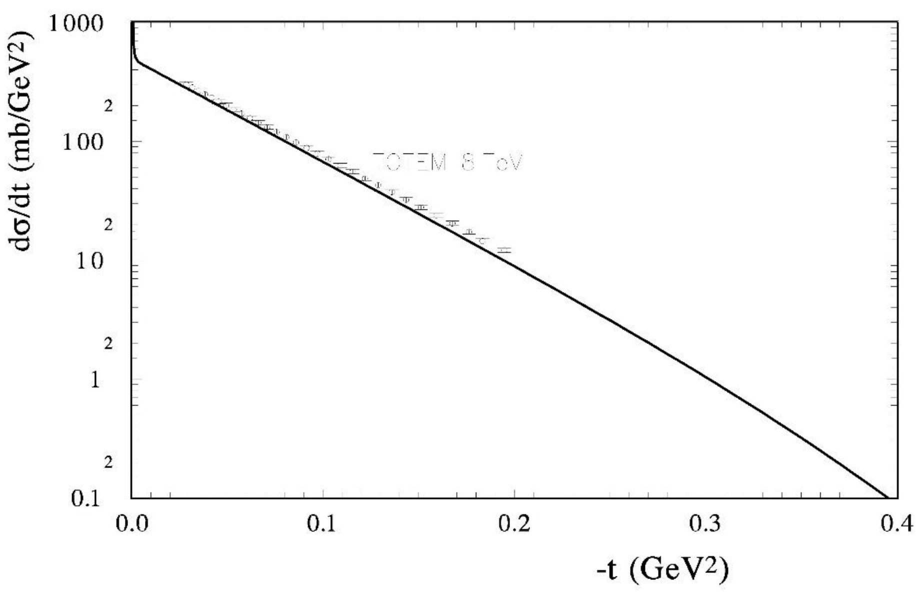
7 TeV (TOTEM) - t [0.00515 – 0.371]
n = 0.94



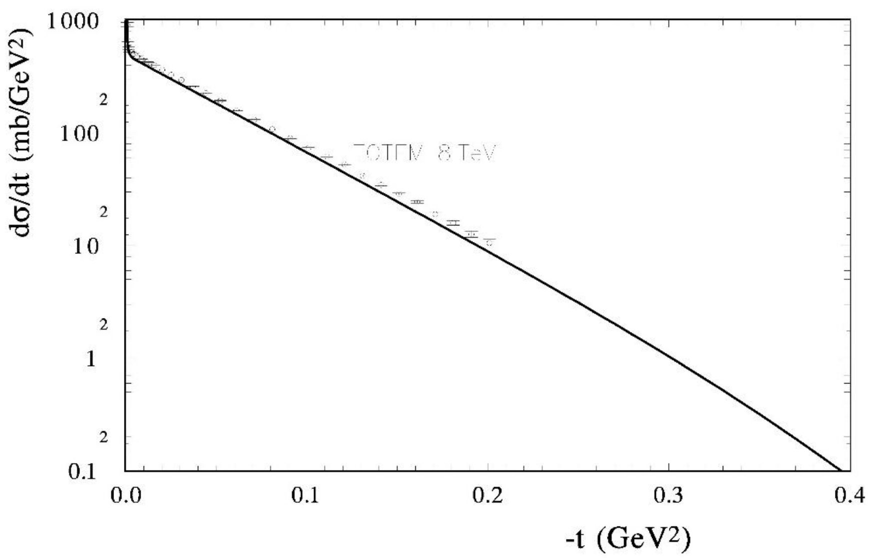
7 TeV (ATLAS) - t [0.0062 – 0.3636]
n=1.0



8 TeV (TOTEM) - t [0.0285 – 0.1947]
n=0.9

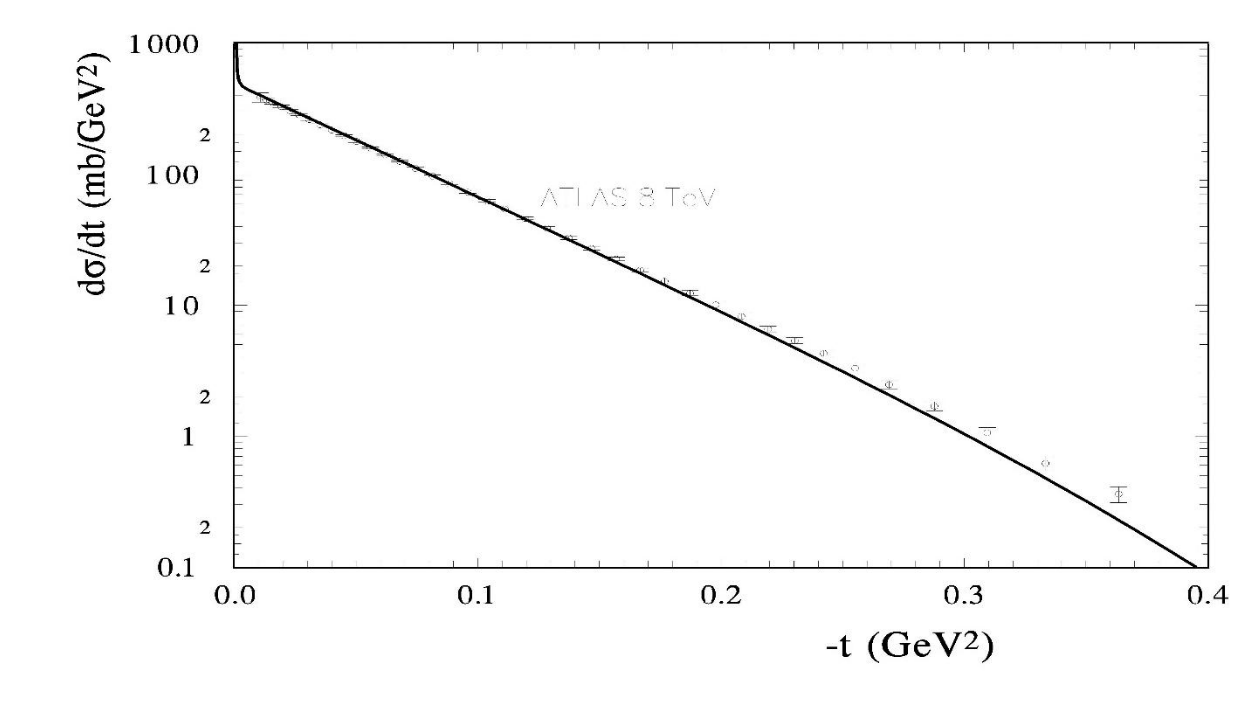


8 TeV (TOTEM) - t [0.000741 – 0.201]
n=0.9



8 TeV (ATLAS) - t [0.01050 – 0.3635]

n=1.0



Problems

$$CERN \quad \bar{p}p \to \bar{p}p \quad \sqrt{s} = 540 \;\; GeV$$

$\rho = 0.24 \pm 0.04$ (*UA4 Coll. M. Bozzo et al.*)

$\rho = 0.135 \pm 0.015$ (*UA4/2 Coll., C.Augier et al.*)

<u>*Comment*</u>

1992 $\rho = \not{0.24} \to 0.19 \pm 0.03$ (*O.V. Selyugin, Yad.Fiz.* 55, 841)

1995 $\rho = \not{0.135} \to 0.17 \pm 0.02$ (*O.V. Selyugin, Phys. Lett. B* 198, 583)

2009 $\rho = 0.172 \pm 0.009$

(*A.Kendi, E.Ferreira, T.Kodama, arXiv*: 0905.1955(*hep – ph*))

$$FNAL\ \bar{p}p \rightarrow \bar{p}p \qquad \sqrt{s} = 1800\ GeV$$

Problems

$$\sigma_{tot} = (80.03 \pm 2.24)\, mb \qquad CDF - Coll.$$

$$\sigma_{tot} = (71.42 \pm 1.55)\ mb \qquad SCINT\ Coll.$$

Comment

Very likely that this difference reflects the true errors of the fitting procedure of the experimental data obtained by the luminosity independent method.

ch I f

$$F_1^{em}(t) = \alpha f_1^2(t) \frac{s - 2m^2}{t}; \quad F_3^{em}(t) = F_1^{em};$$

and for spin-flip amplitudes:

$$F_2^{em}(t) = \alpha \frac{f_2^2(t)}{4m^2} s; \quad F_4^{em}(t) = -F_2^{em}(t),$$

$$F_5^{em}(t) = \alpha \frac{s}{2m\sqrt{|t|}} f_1(t) \ f_2(t),$$

where the form factors are:

$$f_1(t) = \frac{4m_p^2 - (1+k)\,t}{4m_p^2 - \ t} G_d(t);$$

$$f_2(t) = \frac{4m_p^2 \ k}{4m_p^2 - \ t} \ G_d(t);$$

$$\frac{dN}{dt} = \mathcal{L}\left[\frac{4\pi\alpha^2}{|t|^2} G^4(t) - \frac{2\alpha\left(\rho(s,t) + \phi_{CN}(s,t)\right)\sigma_{tot} G^2(t) e^{-\frac{B(s,t)|t|}{2}}}{|t|} + \frac{\sigma_{tot}^2 (1 + \rho(s,t)^2) e^{-B(s,t)|t|}}{16\pi}\right] \quad (\ $$

Non-exponential behavior (origins)

1. Non-linear Regge trajectory (L. Jenkovsky et al.)

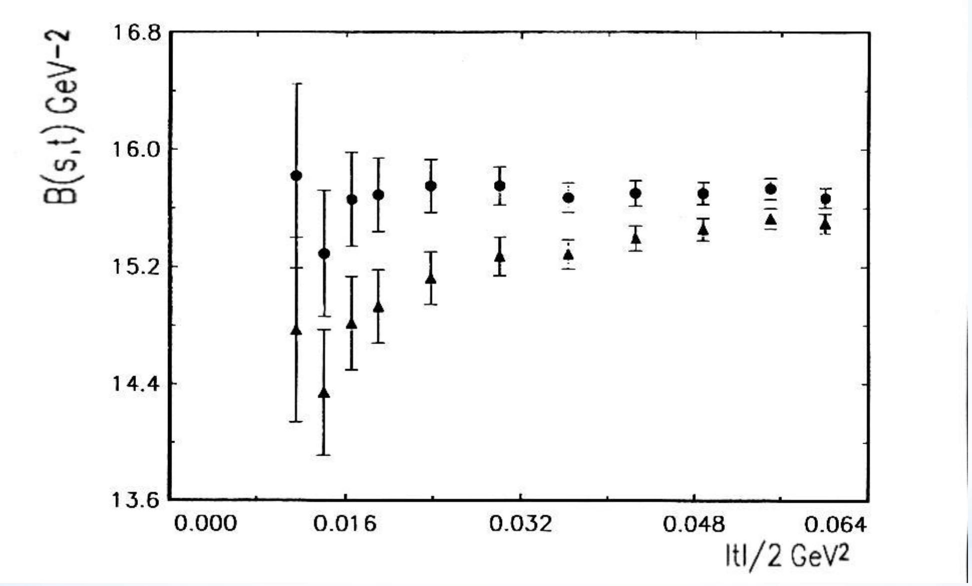
(Pion loops) Anselm, Gribov, G. Coken-Tannoudji et.al.; Khoze, Martin;

2. Different slopes of the other contributions
(real part, odderon, spin-flip amplitude)

3. Unitarization

O.V.S. Phys.Lett (1994)

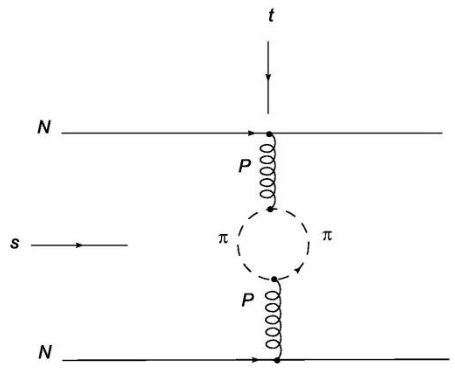
Dependence of the slope B(s,t) from the size of the examined interval t for UA4/2 experiment



triangles – exponential form of F

Circles - + additional term in the slope - sqrt(-t) k

Ch II



$$\alpha_P(q^2) = 1 - C_P q^2 - (\sigma_{\pi\pi} / 32\pi^2) h_1(q^2);$$

A.A. Anselm, V.N. Gribov, Phys.Lett. 40B, (1972).

$$h_1(q^2) = \frac{q^2}{\pi}\left[\frac{8\mu^2}{q^2} - \left(1 + \frac{4\mu^2}{q^2}\right)^{3/2} Ln\left(\frac{\sqrt{1 + (q^2/4\mu^2)} + 1}{\sqrt{1 + (q^2/4\mu^2)} - 1}\right) + Ln\left(\frac{m^2}{\mu^2}\right)\right];$$

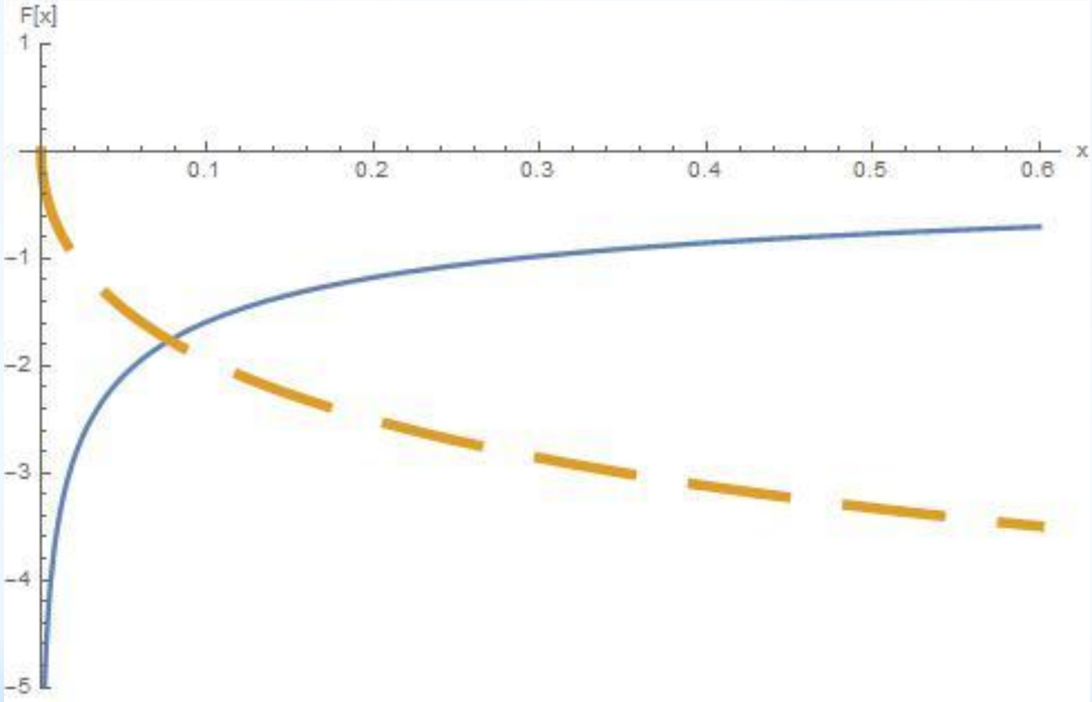
$$q^2 \ll 4\mu^2;$$

$$\frac{q^2}{\pi}\left[Ln\left(\frac{m^2}{\mu^2}\right) - \frac{8}{3}\right];$$

V.A. Khoze, A.D. Martin and M.G. Ryskin, J.Phys.G (2014)

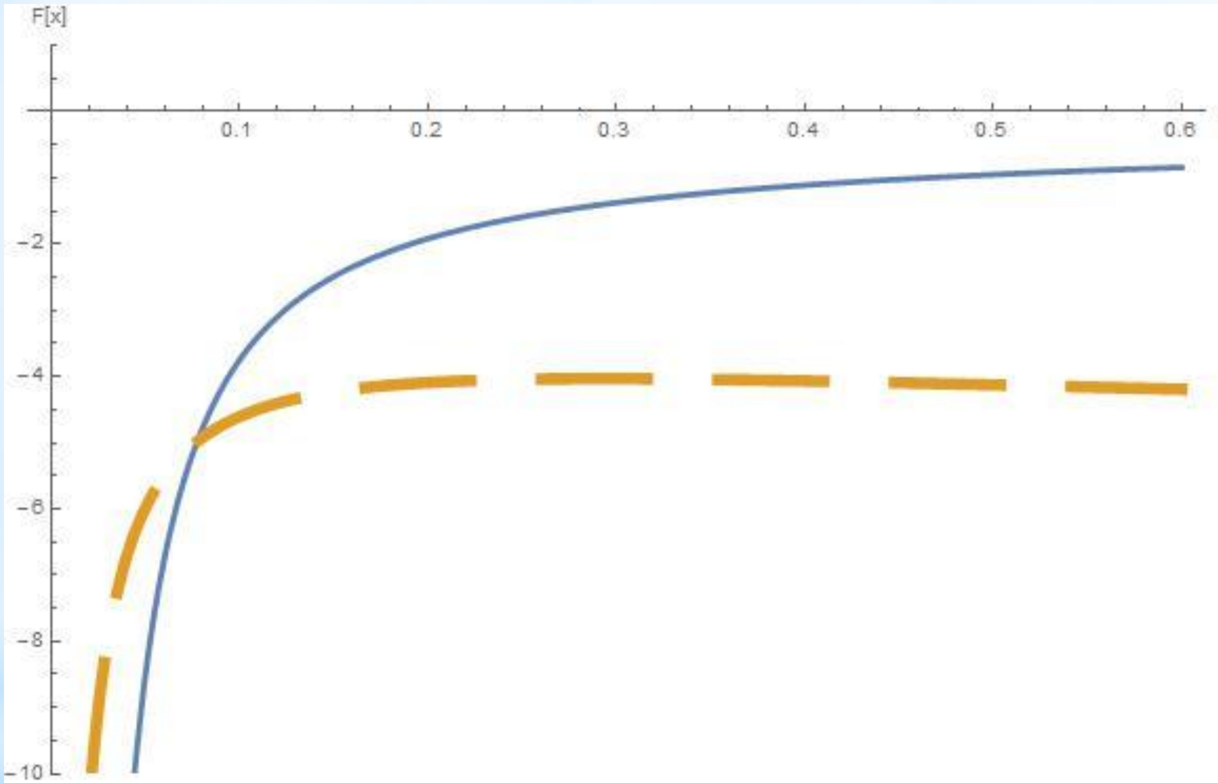
$$h_1(q^2) = \frac{q^2}{\pi}\left[\frac{8\mu^2}{q^2} - \left(1 + \frac{4\mu^2}{q^2}\right)^{3/2} Ln\left(\frac{\sqrt{1 + (4\mu^2/q^2)} + 1}{\sqrt{1 + (4\mu^2/q^2)} - 1}\right) + Ln\left(\frac{m^2}{\mu^2}\right)\right];$$

−Log[(Sqrt[(1. + 1./tau)] + 1.)/(Sqrt[(1. + 1.



−Log[(Sqrt[(1. +tau)] + 1.)/(Sqrt[(1. +tau)] f4

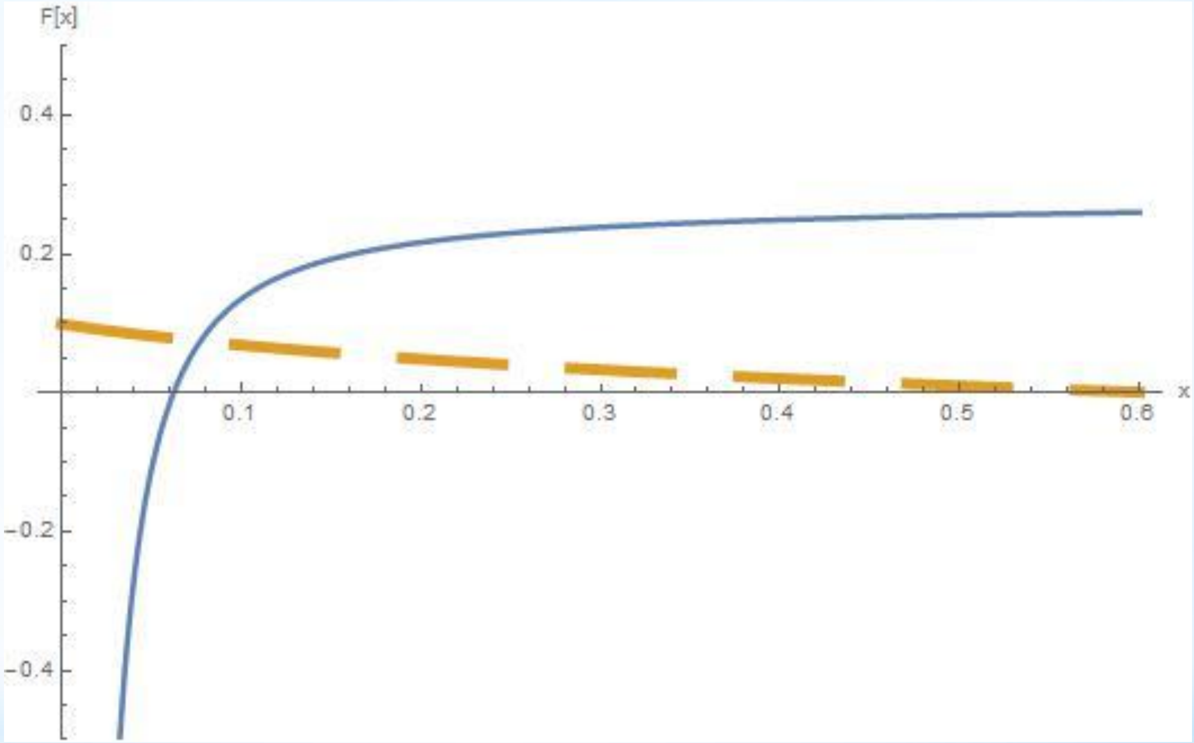
:= −(1.+tau)^(1.5)
∗ Log[(Sqrt[(1.+ 1./tau)] + 1.)/(Sqrt[(1.+ 1.



f5

:= −(1.+tau)^(1.5)
∗ Log[(Sqrt[(1.+tau)] + 1.)/(Sqrt[(1.+tau)]

```
4.* 0.139^2
* (2.* tau − (1. +tau)^(1.5) * Log[(Sqrt[(1. + 1./tau)] + 1. )/(Sqrt[(1. + 1./tau)] − 1. )]
+ Log[1./0.139^2]);
```




```
4.* 0.139^2
* (2.* tau − (1. +tau)^(1.5) * Log[(Sqrt[(1. +tau)] + 1. )/(Sqrt[(1. +tau)] − 1. )]
+ Log[1./0.139^2]);
```

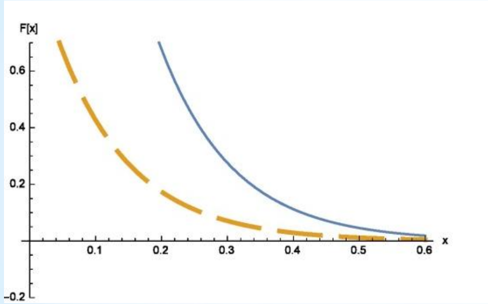
Regge representation

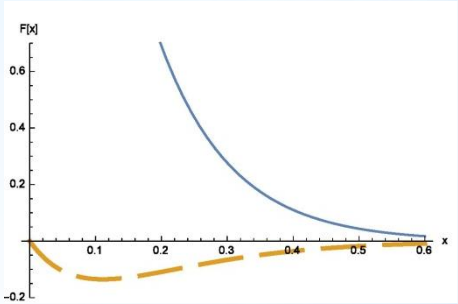
$$\hat{s} = s / s_0 \, e^{-i\pi/2} \; ;$$

$$F(s,t) = i \, (\hat{s})^{\Delta} \, e^{b \, Ln(s) \, t} \; ;$$

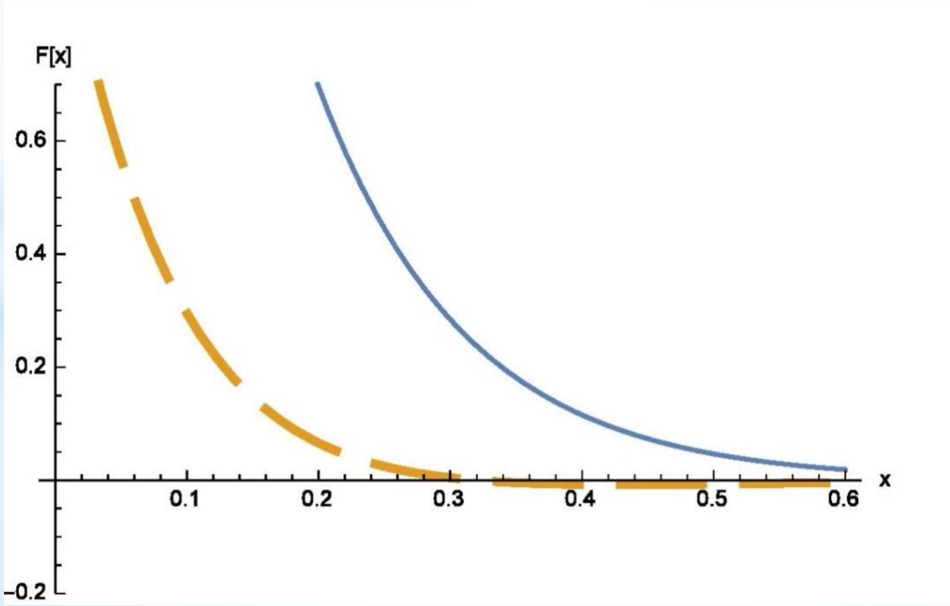
$$s_0 = 4m_p^2 .$$

$$F(s,t) = (s)^{\Delta} \, e^{b \, Ln(\hat{s}) \, t} \; ;$$





$$F(s,t) = (\hat{s})^{\Delta} \, e^{b \, Ln(\hat{s}) \, t} \; ;$$



Integral dispersion relations

$$s \to \infty$$

$$\rho_{\pm}(E)\,\sigma_{\pm}(E) = \frac{C}{P} + \frac{E}{\pi P}\int_m^{\infty} dE'\,P'\left[\frac{\sigma_{\pm}(E')}{E'(E'-E)} - \frac{\sigma_{\mp}(E')}{E'(E'+E)}\right].$$

Local DDR

COMPETE Collaboration

$$\mathrm{Re}\,F_{+}(E,0) = \left(\frac{E}{m_p}\right)^{\alpha}\tan\left[\frac{\pi}{2}\left(\alpha - 1 + E\frac{d}{dE}\right)\right]\mathrm{Im}\,F_{+}(E,0)/\left(\frac{E}{m_p}\right)^{\alpha}$$

S.M. Roy (2016)

$$\mathrm{Re}\,F_{+}(s,t) = \left(\frac{\pi}{\ln(s/s_0)}\right)\frac{d}{d\tau}[\tau\,\mathrm{Im}\,F_{+}(s,t)/\mathrm{Im}\,F_{+}(s,t=0)]\,\mathrm{Im}\,F_{+}(s,t=0), \quad as \quad s\to\infty, \quad \tau = t(\ln(s/s_0))^2.$$

$$\mathrm{Im}\,F_{+}(s,t) = he^{Bt}; \qquad \rho(s,t) \sim \rho(s,t=0)(1.+Bt).$$

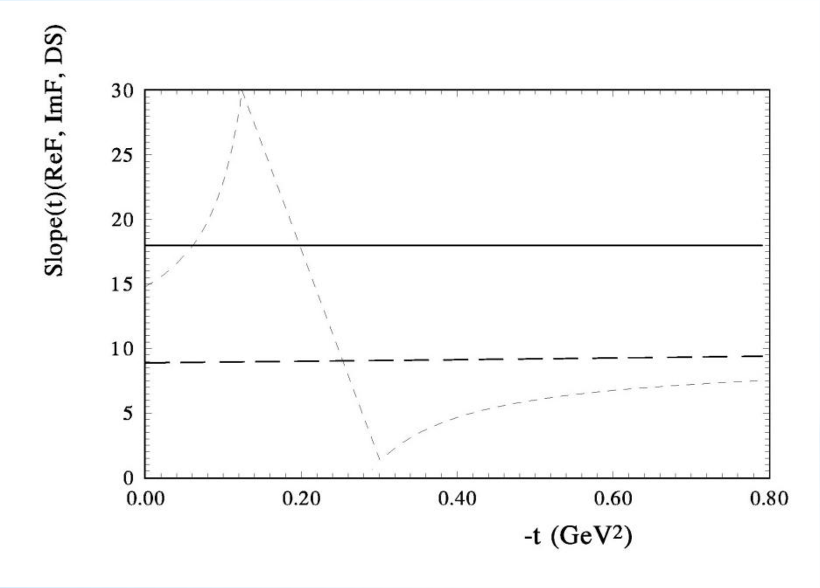
UNITARIZATION → eikonal representation

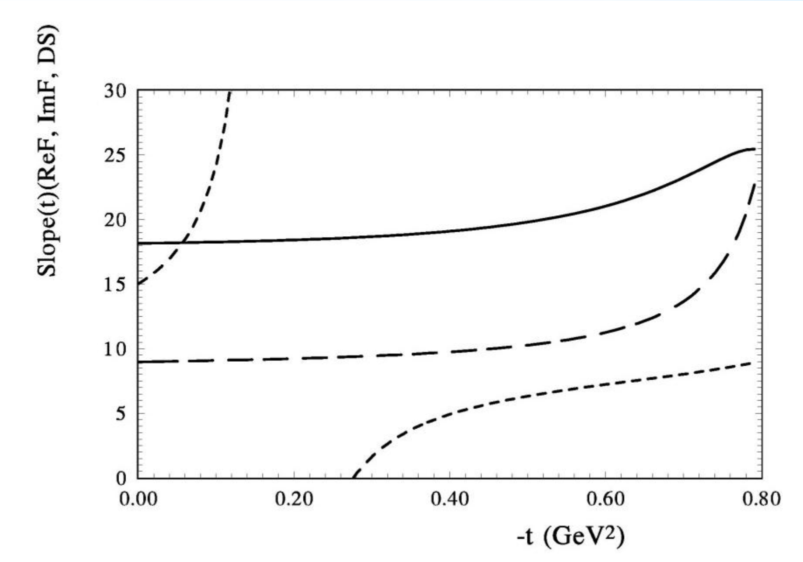
$$F^{Born}(s,t) = (\hat{s})^{\varepsilon}\, e^{btLn(\hat{s})};$$

$$\chi(s,b) = 2\pi \int_0^{\infty} q\; J_0(bq)\; F_B^h(s,q)\, dq$$

$$\chi(s,b) = -\frac{1}{2k} \int_{-\infty}^{\infty} dz V[\sqrt{z^2+b^2}]$$

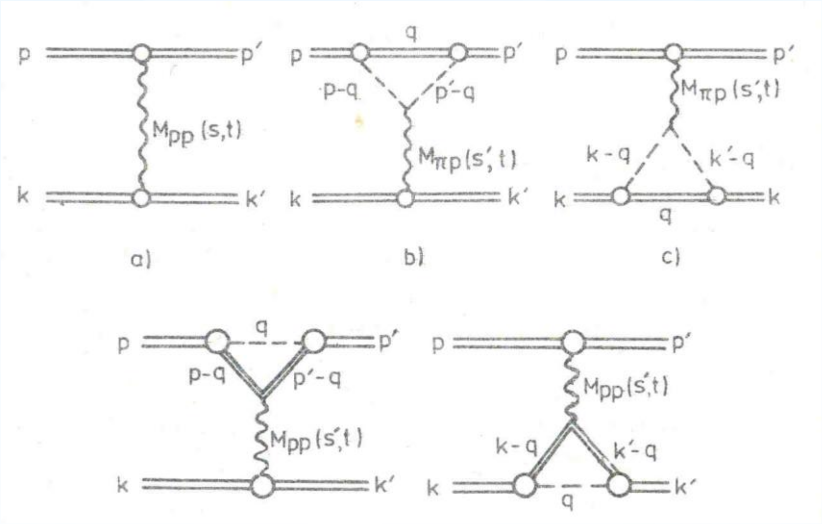
$$F^h(s,t) = \frac{1}{2\pi} \int_0^{\infty} b\; J_0(bq)\, [1-e^{-\chi(s,b)}]\, db$$





Pi-meson cloud

J.Pumplin, G.L. Kane, 1975, Phys.Rev. D11; pi-mezon scattering
O.V.S., S. Goloskokov, 1980, Yad.Fiz. 31, pp-scattering



$$T(s,t) = -is\sum_{n=1}^{\infty}\frac{(-h)^n}{(n-1)!}\frac{\mu}{(n^2\mu^2-t))^{3/2}}(1-b\sqrt{n^2\mu^2-t})\,e^{-b\sqrt{n^2\mu^2-t}});$$

S.V. Goloskokov, O.V.S., Mod.Phys.Lett. A9 (1994)

Table rho, B 541 and 1800

$-t$ GeV^2	$\sqrt{s} = 541 GeV$		$\sqrt{s} = 1800 GeV$	
	$\rho(s,t)$	$B(s,t) GeV^{-2}$	$\rho(s,t)$	$B(s,t) GeV^{-2}$
.001	.141	16.8	.182	18.1
.014	.135	16.5	.178	17.7
.066	.112	15.5	.161	16.6
.120	.089	14.9	.143	15.9

Seminar in the TOTEM O.V.S. (2009) ; and
J.-R. Cudell, O.V.S. - Phys.Rev.Lett. (2009)

ch II f

$$F^h(s,t)=(i+\rho)\frac{\sigma_{tot}}{4\pi\, 0.38938}e^{Bt/2}$$

$$F^h(s,t)=(i+\rho)\frac{\sigma_{tot}}{4\pi\, 0.38938}e^{Bt/2-Ct^2}$$

$$F^h(s,t)=(i+\rho)\frac{\sigma_{tot}}{4\pi\, 0.38938}e^{Bt/2+D(\sqrt{4\mu^2-t}\;-2\mu)]}$$

$$F^h(s,t)=(i+\rho)\frac{\sigma_{tot}}{4\pi\, 0.38938}e^{D(\sqrt{4\mu^2-t}\;-2\mu)]}\quad f(t)^2_{em.};$$

$$F^h(s,t)=h\frac{\sigma_{tot}}{4\pi\, 0.38938}e^{Bt/2+i\varphi(t)}$$

ch III

O.V.S., Nucl.Phys. A922 (2014) 180

$$0.005 \leq |t| \leq 0.31 \;\; GeV^2; \quad N = 86 \, .$$ TOTEM 7TeV

i	N	$\sum_{i=1}^{N} \chi_i^2$	ρ	B	C	σ_{tot}, mb
1	86	287.	0.14 fix	20.	$0.fix$	98.87 ± 0.1
2	86	287	$0.05fix$	20.	$0.fix$	99.7 ± 0.1
3	86	287	0.146 ± 0.3	20.	$0.fix$	98.8 ± 0.4
4	86	220.5	$0.14fix$	21.7	-1.4 ± 0.2	97.9 ± 0.2
5	86	220.	0.05 ± 0.4	21.8	-1.4 ± 0.2	$98.76 \pm 4.$

Table 1: The basic parameters of the model are determined by fitting experimental data without the electromagnetic contributions and with free σ_{tot}.

TOTEM 7 TeV

N	$\sum_{i=1}^{N}\chi_i^2$	ρ	B	C	n	σ_{tot}, mb
47	77.84	0.14fixed	20.0	$0. - fix$	1.05	96.8 ± 0.1
47	71.65	$0.1ffix$	20.	$0.fix$	1.05	97.1 ± 0.1
47	66.3	$0.05fix$	20.	$0.fix$	1.05	97.2 ± 0.1
47	62.8	$0.fix$	19.4	$0.fix$	1.05	97.1 ± 0.1
47	63.1	0.14fixed	17.2	2.1 ± 0.5	1.05	97.56 ± 0.2
47	61.9	$0.1fix$	17.7	1.87 ± 0.5	1.05	97.7 ± 0.2
47	61.0	$0.05fix$	18.2	1.24 ± 0.5	1.05	97.7 ± 0.2
47	60.6	$0.fix$	18.8	0.8 ± 0.5	1.05	97.4 ± 0.2
47	60.8	$-0.05fix$	19.3	0.4 ± 0.5	1.05	96.9 ± 0.3
47	61.1	-0.064 ± 0.05	19.8	$0.fix$	1.05	96.57 ± 0.58
47	60.6	-0.011 ± 0.09	18.9	0.7 ± 0.9	1.05	97.3 ± 0.9

Table 10: The basic parameters of the model are determined by fitting experimental data.

O.S. – J. Nucl.Phys. (Yad.Phys.) v.55 (1992)

$$ReF^h(t) = -ReF_c(t) + [[\frac{d\sigma}{dt}|_{exp.} - k\pi * (ImF_c + ImF_h)^2]/(k\pi)]^{1/2}. \quad (9)$$

let us take the imaginary part of the hadron scattering amplitude in the simple exponential form with the parameters obtained by the TOTEM Collaboration

$$ImF^h(t) = \sigma_{tot}/(4k\pi)e^{Bt/2}, \quad (10)$$

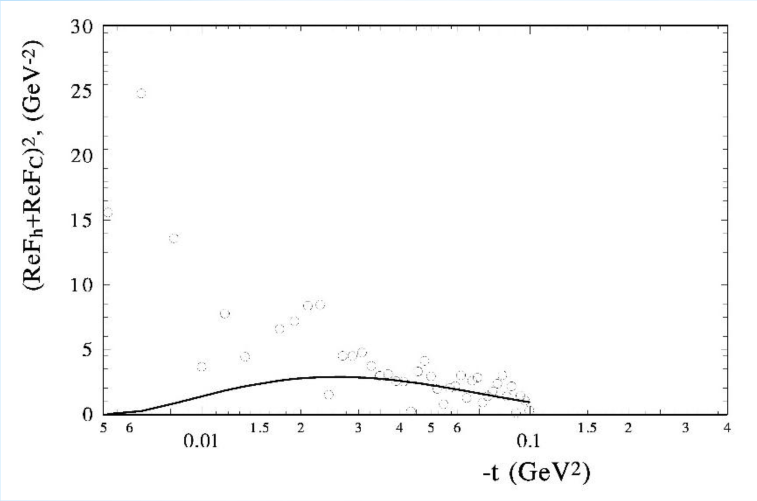
O.S. - New methods for calculating parameters of the diffraction scattering amplitude, "VI Intern. Conf. On Diffraction...", Blois, France,(1995).

O.S. "Additional ways to determination of structure of high energy elastic scattering amplitude" arxiv.org:[hep-ph/0104295]

P. Gauron, B. Nicolescu, O.S. "A New Method for the Determination of the Real Part of the Hadron Elastic Scattering Amplitude at Small Angles and High Energies" Phys.Lett. B629 (2005) 83-92

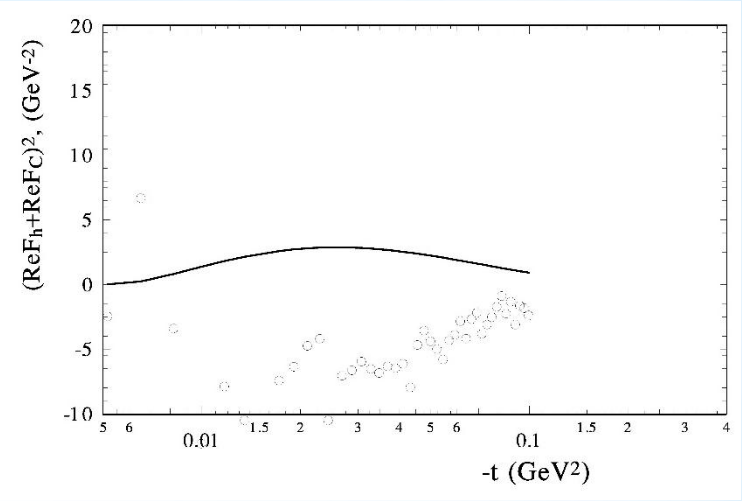
$$\Delta_R(t) = [\mathrm{Re}\, F^h(t) + \mathrm{Re}\, F^C(t)]^2 = [\frac{d\sigma}{dt}|_{\mathrm{exp.}} - k\pi(\mathrm{Im}\, F^h(t) + \mathrm{Im}\, F^C(t)]^2 / (k\pi)$$

n=1.



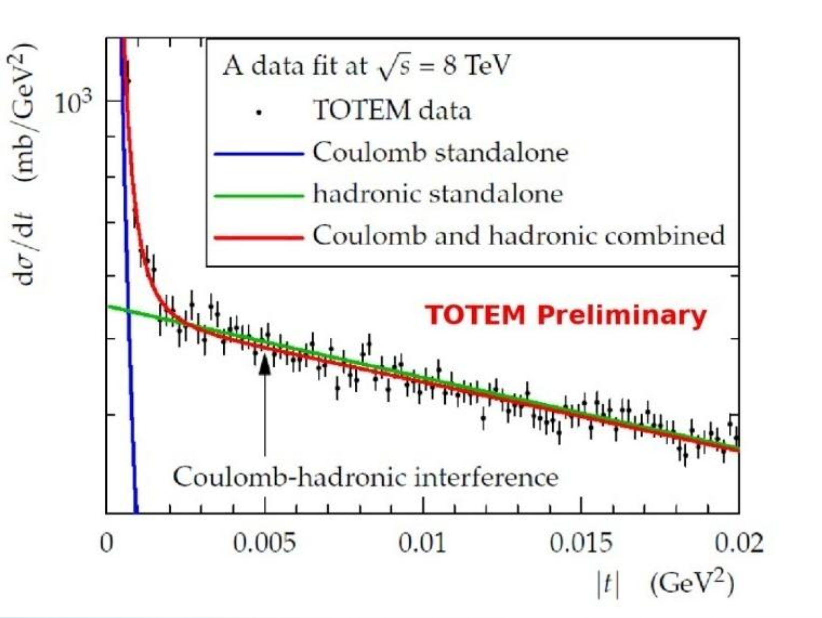
(ReFh+ReFC)2, (GeV-2)
30
25
20
15
10
5
0
5 6 0.01 1.5 2 3 4 5 6 0.1 1.5 2 3 4
-t (GeV2)

n=0.95
.

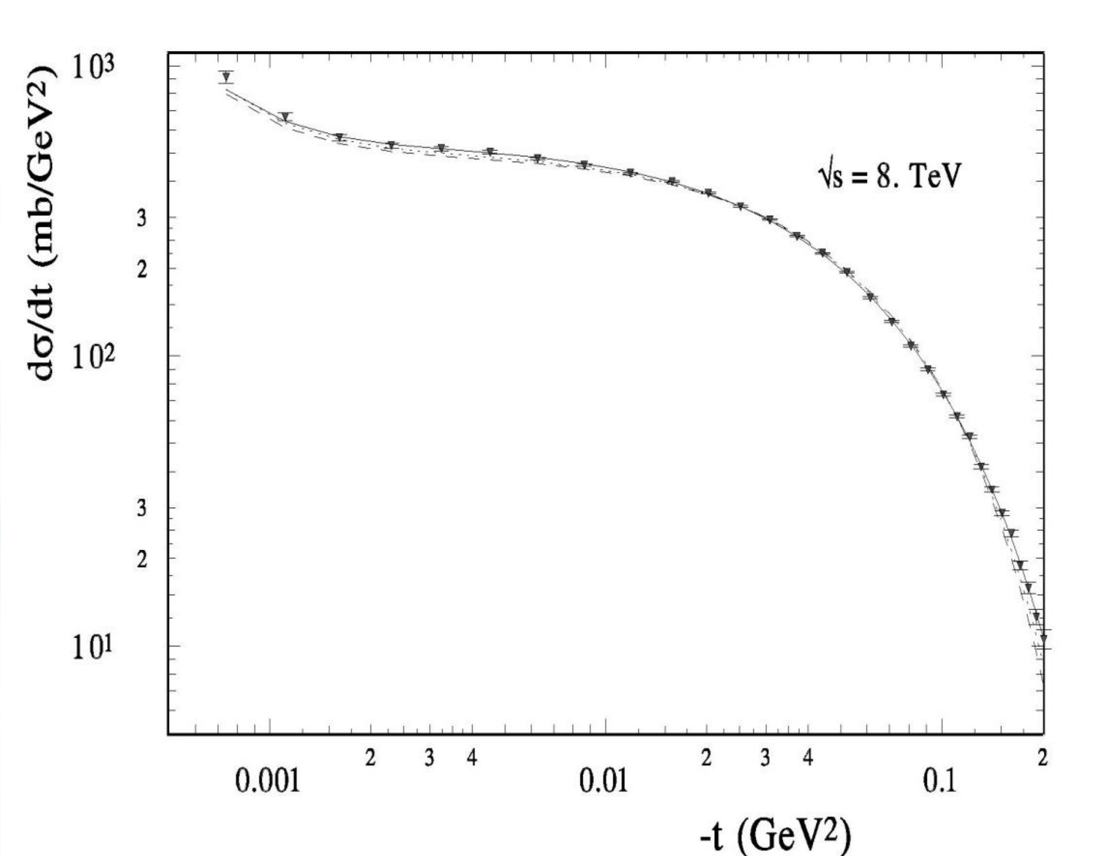


(ReFh+ReFC)2, (GeV-2)
20
15
10
5
0
-5
-10
5 6 0.01 1.5 2 3 4 5 6 0.1 1.5 2 3 4
-t (GeV2)

TOTEM – arXiv:1503



TOTEM – 12 (2015) CERN preprint



Ch III f

Like TOTEM analysis (N=223, 5 row)

Born case: $$F^{h}(s,t) = h\,\sigma_{tot}\,(i+\rho)\,Ln(s)^{2}\,e^{(B_1 t/2 + B_2 t^2 + B_3 t^3)Ln(s)}$$

n_{par}	k_{T7}	k_{A7}	k_{T8a}	k_{T8b}	k_{A8}	ρ	$\sigma_{tot(7)}$	$\sigma_{tot(8)}$	$\sum_1^N \chi_i^2$
5	1.	1.	1.	1.	1.	$0.b$	96.3	99.2	48212
5	0.93	0.98	0.9	0.9	$1._{fix}$	0.045	95.3	98.2	2872
5	1.14	1.18	1.1	1.1	1.2	0.025	106.1	109.3	1508

$$F^h(s,t) = i\,\frac{\sigma_{tot}}{4\pi\, 0.38938}\, Ln(\hat{s})^2\; f_1^{\,2}(t)\; e^{(D(\sqrt{4\mu^2 - t} - 2\mu)] + Ct^2)Ln(\hat{s})}$$

par	k_{T7}	k_{A7}	k_{T8a}	k_{T8b}	k_{A8}	ρ	$\sigma_{tot(7)}$	$\sigma_{tot(8)}$	$\sum^N \chi_i^2$
	1.	1.	1.	1.	1.	0.18	96.1	99.0	4774
	0.93	0.98	0.9	0.901	1.02	0.18	95.7	98.6	1327

$$F^h(s,t) = i\,\frac{\sigma_{tot}}{4\pi\, 0.38938}\, Ln(\hat{s})^{1.4}\; f_1^{\,2}(t)\; e^{(D(\sqrt{4\mu^2 - t} - 2\mu)] + Ct^2)Ln(\hat{s})}$$

3	0.95	1.0	0.9	0.903	1.02	0.12	97.1	99.1	1311

EIKONAL

$$F_B^h(s,t)=h\sigma_{tot}(i+\rho)(s)^{\Delta}\, e^{(B_1 t/2+B_2 t^2+B_3 t^3)Ln(s)}$$

n_{par}	$\rho(0)$	Δ	$\Sigma\chi^2$	k_{T7}	k_{A7}	k_{T8a}	k_{T8b}	k_{A8}	σ_{tot}^7	σ_{tot}^8
6	0.06	0.076	1797	0.966	1.015	0.9	0.91	1.02	96.7	98.5

$$F_B^h(s,t)=h\ \hat{s}^{\Delta}\ f_1(t)^2\,\sigma_{tot}\, e^{\alpha' t+\alpha_2'(\sqrt{4\mu^2-t}\ -2\mu)Ln(\hat{s})}$$

n_{par}	$\rho(0)$	Δ	$\Sigma\chi^2$	k_{T7}	k_{A7}	k_{T8a}	k_{T8b}	k_{A8}	σ_{tot}^7	σ_{tot}^8
4	0.09	0.075	1457	0.94	1.01	0.87	0.88	1.0	96.3	97.8

$C\ t^2$ – *does not* determined

EIKONALIZATION

$$F_B^h(s,t) = h\ \hat{s}^{\Delta}\ f_1(t)^2\ \sigma_{tot}\ e^{\alpha' t + \alpha_2' (\sqrt{4\mu^2 - t} - 2\mu) Ln(\hat{s})}$$

$\rho(0)$	Δ	$\Sigma\chi^2$	k_{T7}	k_{A7}	k_{T8a}	k_{T8b}	k_{A8}	σ_{tot}^7	σ_{tot}^8
0.11	0.087	382	1.047	0.99	1.1	1.097	0.99	97.7	99.45

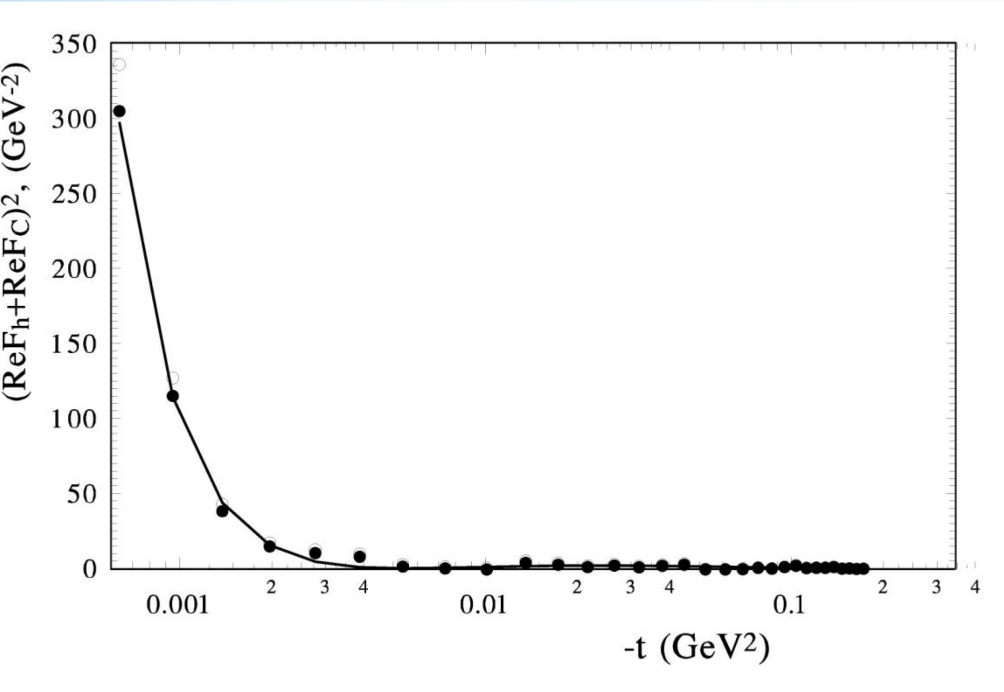
$$F_B^h(s,t) = h\, s^{\Delta}\ f_1(t)^2 \sigma_{tot} [i + \rho(1 + k_\rho\, t)] e^{[\alpha' t + \alpha_2' (\sqrt{4\mu^2 - t} - 2\mu)] Ln(\hat{s})};$$

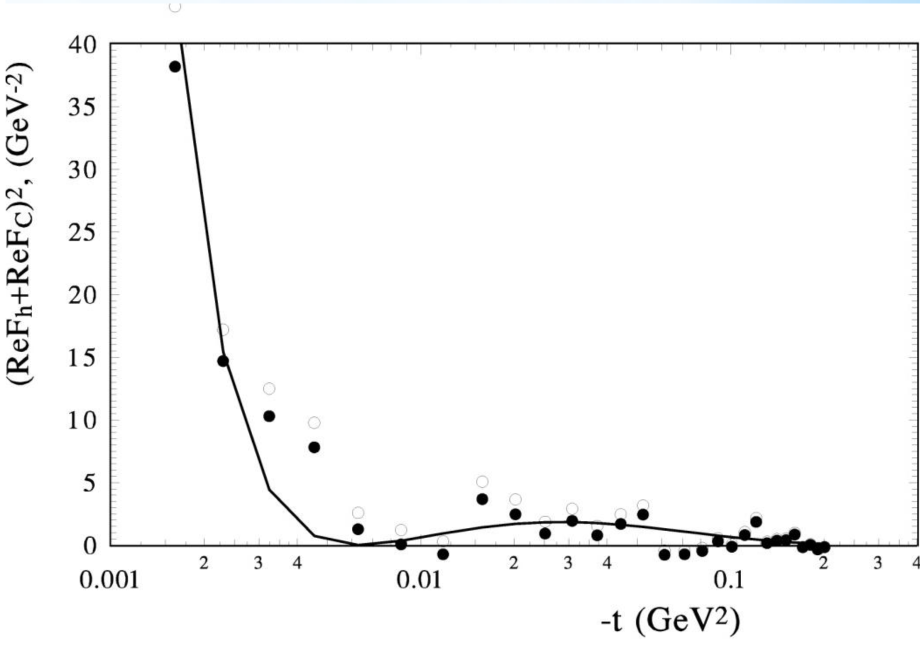
$\rho(0)$	Δ	$\Sigma\chi^2$	k_{T7}	k_{A7}	k_{T8a}	k_{T8b}	k_{A8}	σ_{tot}^7	σ_{tot}^8
0.15	0.07_{fix}	332	1.076	1.027	1.14	1.13	1.02	95.9	97.3
0.14	0.08_{fix}	341	1.05	$1._{fix}$	1.11	1.10	0.99	97.1	98.8

TOTEM 8 TeV $\sigma_{tot}^{8} = 102.9\, mb$

$$F^h(s,t) = a\,(0.9927i + 0.11915)\; e^{20.47/2t + 8.8/2t^2 + 20/2t^3}$$

$\Delta_R^{th}(t) = [\mathrm{Re}\, F^h(t) + \mathrm{Re}\, F^C(t)]^2$; $\Delta_R^{Exp}(t) = [\frac{d\sigma}{dt}|_{exp.} *n - k\pi\,(\mathrm{Im}\, F^h(t) + \mathrm{Im}\, F^C(t)]^2 \,/\, (k\pi)$



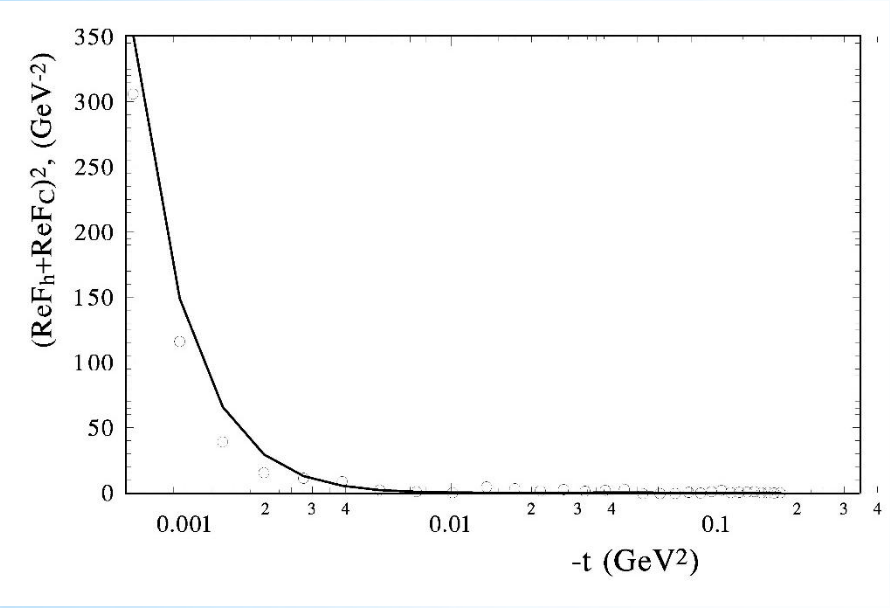


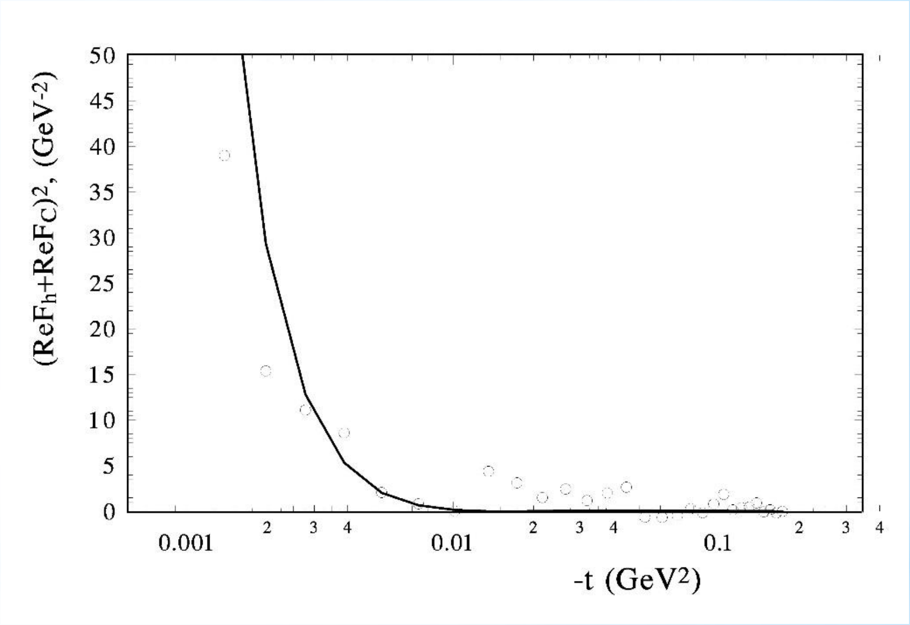
Empty circles: n=1

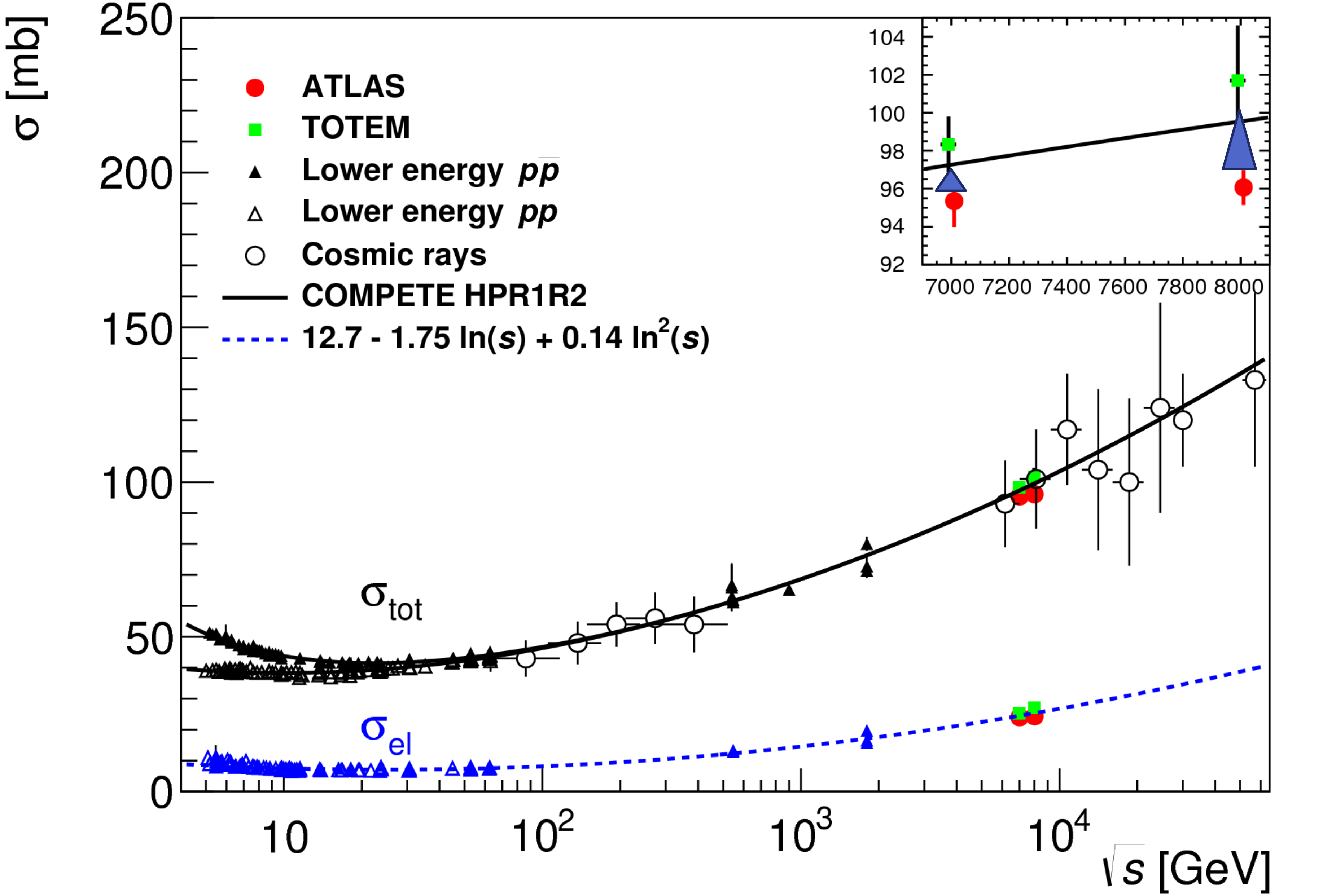
Closed circles: n=0.9

dq3b1227

$$F^{h}(s,t)=i\frac{\sigma_{tot}}{4\pi\,0.38938}Ln(\hat{s})^{2}\ f_{1}^{2}(t)\ e^{(D(\sqrt{4\mu^{2}-t}\ -2\mu)]+Ct^{2})Ln(\hat{s})}$$







σ [mb]
250
200
150
100
50
0
ATLAS
TOTEM
Lower energy $p\bar{p}$
Lower energy pp
Cosmic rays
COMPETE HPR1R2
12.7 - 1.75 ln(s) + 0.14 ln²(s)
σ_{tot}
σ_{el}
104
102
100
98
96
94
92
7000 7200 7400 7600 7800 8000
10
10^2
10^3
10^4
$\sqrt{s}$ [GeV]

(a)

LHC Final results (or) the beginning new story

* The new data bounded the different models essentially.

The new High Energy Generalized Structure model (HEGS) gives the quantitatively description of the elastic nucleon scattering at high energy with only 6 fitting high energy parameters. Is is shown the discrepancy

in the normalization of the TOTEM and ATLAS data.

Phenomenological analysis

The problems of the determination of $\sigma_{tot}(s)$ *and* $\rho(s,t)$

- The thin structure of the slope - B(s,t), (non-exponential, oscillations)
- The term ct^2 mimic the unitarization procedure –> it is better use the eikonal representation
- The term $D(\sqrt{4\mu^2-t} - 2\mu)$ (or like it) play important value;
- It is need taking into account the form factors of hadrons
- The slope of Re F(s,t) exceeded the slope of Im F(s,t);
- The new LHC data show the problem with the normalization.

It is need obtain the data in CNI region.

Wait the high precision new data at small t and 13 TeV

Thanks for your attention