Models of Elastic Diffractive Scattering to Falsify at the LHC

Anton Godizov

Institute for High Energy Physics, Protvino

The 14th EDS Blois Workshop

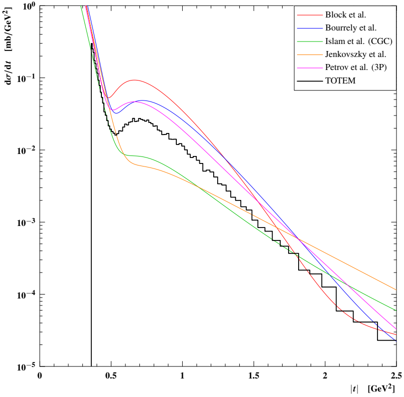
December 15-21, 2011, Qui Nhon, Vietnam

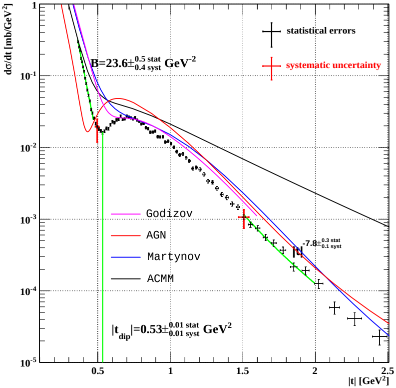
Models of Elastic Diffractive Scattering

P. Desgrolard, M. Giffon, and E. Martynov, Eur. Phys. J. C 18 (2000) 359
V.A. Petrov and A.V. Prokudin, Eur. Phys. J. C 23 (2002) 135
C. Bourrely, J. Soffer, and T.T. Wu, Eur. Phys. J. C 28 (2003) 97
R.F. Avila, S.D. Campos, M.J. Menon, and J. Montanha,
Eur. Phys. J. C 47 (2006) 171
M.M. Islam, R.J. Luddy, and A.V. Prokudin, Int. J. Mod. Phys. A 21 (2006) 1
E. Martynov, Phys. Rev. D 76 (2007) 074030
R.F. Avila, P. Gauron, and B. Nicolescu, Eur. Phys. J. C 49 (2007) 581
E. Martynov and B. Nicolescu, Eur. Phys. J. C 56 (2008) 57
C. Flensburg, G. Gustafson, and L. Lönnblad, Eur. Phys. J. C 60 (2009) 233
P. Brogueira and J. Dias de Deus, J. Phys. J 37 (2010) 075006
M.M. Block and F. Halzen, Phys. Rev. D 83 (2011) 077901
L.L. Jenkovszky, A.I. Lengyel, and D.I. Lontkovskyi,
Int. J. Mod. Phys. A 26 (2011) 4755
E. Gotsman, E. Levin, and U. Maor, Eur. Phys. J. C 71 (2011) 1553
M.G. Ryskin, A.D. Martin, and V.A. Khoze, Eur. Phys. J. C 71 (2011) 1617
S. Ostapchenko, Phys. Rev. D 83 (2011) 014018
D.A. Fagundes, E.G.S. Luna, M.J. Menon, and A.A. Natale,
arXiv: 1108.1206 [hep-ph]
A. Godizov, Phys. Lett. B 703 (2011) 331
A. Donnachie and P.V. Landshoff, arXiv: 1112.2485 [hep-ph]

Models vs. TOTEM. The *pp* Differential Cross-Section

The TOTEM Collaboration, Europhys.Lett. 95 (2011) 41001





Scattering Amplitude, Born Term ("Eikonal") and Regge Trajectories

$$T_{12\to12}(s,t) = 4\pi s\int_0^\infty db^2 J_0(b\sqrt{-t})\,\frac{e^{2i\delta_{12\to12}(s,b)}-1}{2i}\,,$$

$$\delta_{12\to12}(s,b) = \frac{1}{16\pi s}\int_0^\infty d(-t)J_0(b\sqrt{-t})\delta_{12\to12}(s,t) =$$

$$= \frac{1}{16\pi s}\int_0^\infty d(-t)J_0(b\sqrt{-t})\times$$

$$\times\left\{\sum_n\left(i+\mathrm{tg}\frac{\pi(\alpha_n^+(t)-1)}{2}\right)\Gamma_n^{(1)+}(t)\Gamma_n^{(2)+}(t)s^{\alpha_n^+(t)}\mp\right.$$

$$\left.\mp\sum_n\left(i-\mathrm{ctg}\frac{\pi(\alpha_n^-(t)-1)}{2}\right)\Gamma_n^{(1)-}(t)\Gamma_n^{(2)-}(t)s^{\alpha_n^-(t)}\right\}.$$

Regge Trajectories and QCD. The BFKL Approach

J. Kwiecinski, Phys. Rev. D **26** (1982) 3293:

$$\alpha_{\bar{q}q}(t) = \sqrt{\frac{8}{3\pi}\alpha_s(\sqrt{-t})} + o(\alpha_s^{1/2}(\sqrt{-t}))$$

R. Kirschner and L.N. Lipatov, Z. Phys. C **45** (1990) 477:

$$\alpha_{gg}(t) = 1 + \frac{12\ln 2}{\pi}\alpha_s(\sqrt{-t}) + o(\alpha_s(\sqrt{-t}))$$

V.S. Fadin and L.N. Lipatov, Phys. Lett. B **429** (1998) 127,
M. Ciafaloni and G. Camici, Phys. Lett. B **430** (1998) 349:

$$\alpha_{gg}(0) = 1 + \frac{12\ln 2}{\pi}\alpha_s(\mu)\left(1 - \frac{20}{\pi}\alpha_s(\mu)\right) + o(\alpha_s^2(\mu))$$

Regge Trajectories and QCD. The Lovelace Approach

C. Lovelace, Nucl. Phys. B **95** (1975) 12:

$$(\alpha^{(k)}_{\phi\phi}(0)+1)(\alpha^{(k)}_{\phi\phi}(0)+2)(\alpha^{(k)}_{\phi\phi}(0)+3)=\frac{16}{3(2k+1)}$$

D. Heckathorn, Phys. Rev. D **18** (1978) 1286:

$$\alpha^{(k)}_{gg}(0)(\alpha^{(k)}_{gg}(0)+1)(\alpha^{(k)}_{gg}(0)+2)=\frac{24N_c}{(2k+1)(11N_c-2n_f)}$$

A. Godizov, Phys. Rev. D **81** (2010) 065009:

$$\alpha^{(k)}_{\bar{q}q}(0)=\frac{9(N_c^2-1)}{(2k+1)N_c(11N_c-2n_f)}-1$$

Reggeon Models

Single-reggeon exchanges + eikonalization:

C. Bourrely, J. Soffer, and T.T. Wu, Eur. Phys. J. C 28 (2003) 97

V.A. Petrov and A.V. Prokudin, Eur. Phys. J. C 23 (2002) 135
A. Godizov, Phys. Lett. B 703 (2011) 331

Models without eikonalization:

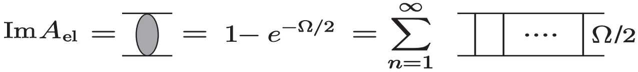
A. Donnachie and P.V. Landshoff, arXiv: 1112.2485 [hep-ph]

P. Desgrolard, M. Giffon, and E. Martynov, Eur. Phys. J. C 18 (2000) 359
E. Martynov, Phys. Rev. D 76 (2007) 074030
L.L. Jenkovszky, A.I. Lengyel, and D.I. Lontkovskyi, Int. J. Mod. Phys. A 26 (2011) 4755

R.F. Avila, P. Gauron, and B. Nicolescu, Eur. Phys. J. C 49 (2007) 581
E. Martynov and B. Nicolescu, Eur. Phys. J. C 56 (2008) 57

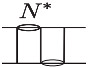
E. Gotsman, E. Levin, U. Maor, Eur. Phys. J. C 71 (2011) 1553
M.G. Ryskin, A.D. Martin, V.A. Khoze, Eur. Phys. J. C 71 (2011) 1617
S. Ostapchenko, Phys. Rev. D 83 (2011) 014018

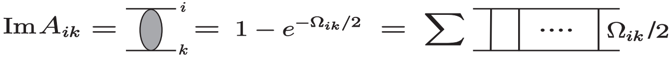
(a) Elastic amplitude



$$\mathrm{Im}\,A_{\mathrm{el}} = 1 - e^{-\Omega/2} = \sum_{n=1}^{\infty} \ldots \Omega/2$$

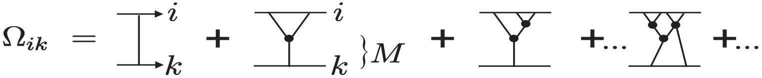
(b) Inclusion of low-mass dissociation





$$\mathrm{Im}\,A_{ik} = 1 - e^{-\Omega_{ik}/2} = \sum \ldots \Omega_{ik}/2$$

(c) Inclusion of high-mass dissociation



Non-Reggeon Models

Models not appealing to QCD:

R.F. Avila, S.D. Campos, M.J. Menon, and J. Montanha,
Eur. Phys. J. C 47 (2006) 171

P. Brogueira and J. Dias de Deus, J. Phys. J 37 (2010) 075006

"QCD-inspired" models:

M.M. Islam, R.J. Luddy, and A.V. Prokudin,
Int. J. Mod. Phys. A 21 (2006) 1

C. Flensburg, G. Gustafson, and L. Lönnblad,
Eur. Phys. J. C 60 (2009) 233

M.M. Block and F. Halzen, Phys. Rev. D 83 (2011) 077901
D.A. Fagundes, E.G.S. Luna, M.J. Menon, and A.A. Natale,
arXiv: 1108.1206 [hep-ph]

Models vs. TOTEM. The Total *pp* Cross-Section

The TOTEM Collaboration, Europhys.Lett. 96 (2011) 21002:

$$\sigma_{tot}^{pp}(7\ TeV) = (98.3 \pm 0.2^{stat} \pm 2.8^{syst})\ mb$$

The Model	$\sigma_{tot}^{pp}(7\ TeV)$, mb
P. Desgrolard, M. Giffon, E. Martynov, Eur. Phys. J. C 18 (2000) 359	95
V.A. Petrov, A.V. Prokudin, Eur. Phys. J. C 23 (2002) 135	97 ± 4
C. Bourrely, J. Soffer, T.T. Wu, Eur. Phys. J. C 28 (2003) 97	93
R.F. Avila, S.D. Campos, M.J. Menon, J. Montanha, Eur. Phys. J. C 47 (2006) 171	94
M.M. Islam, R.J. Luddy, A.V. Prokudin, Int. J. Mod. Phys. A 21 (2006) 1	97.5
E. Martynov, Phys. Rev. D 76 (2007) 074030	91
R.F. Avila, P. Gauron, B. Nicolescu, Eur. Phys. J. C 49 (2007) 581	108
E. Martynov, B. Nicolescu, Eur. Phys. J. C 56 (2008) 57	95
C. Flensburg, G. Gustafson, L. Lönnblad, Eur. Phys. J. C 60 (2009) 233	98 ± 9

Models vs. TOTEM. The Total *pp* Cross-Section

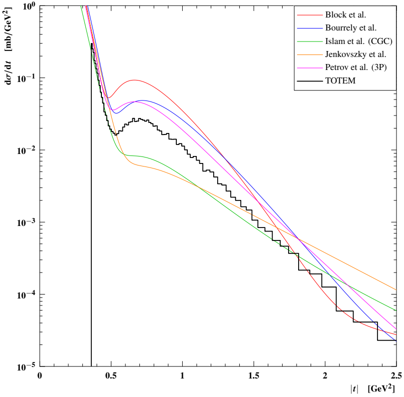
The TOTEM Collaboration, Europhys.Lett. 96 (2011) 21002:

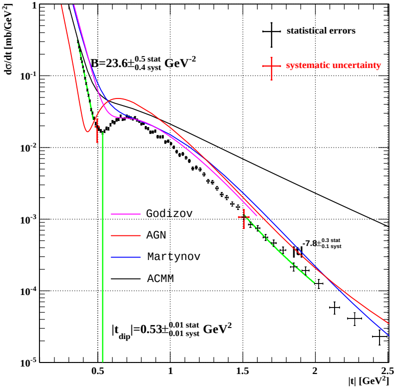
$$\sigma_{tot}^{pp}(7\ TeV) = (98.3 \pm 0.2^{stat} \pm 2.8^{syst})\ mb$$

The Model	$\sigma_{tot}^{pp}(7\ TeV)$, mb
P. Brogueira, J. Dias de Deus, J. Phys. J 37 (2010) 075006	110
M.M. Block, F. Halzen, Phys. Rev. D 83 (2011) 077901	95.5 ± 1
L.L. Jenkovszky, A.I. Lengyel, D.I. Lontkovskyi, Int. J. Mod. Phys. A 26 (2011) 4755	98 ± 1
E. Gotsman, E. Levin, U. Maor, Eur. Phys. J. C 71 (2011) 1553	91
M.G. Ryskin, A.D. Martin, V.A. Khoze, Eur. Phys. J. C 71 (2011) 1617	89
S. Ostapchenko, Phys. Rev. D 83 (2011) 014018	93
D.A. Fagundes, E.G.S. Luna, M.J. Menon, A.A. Natale, arXiv: 1108.1206 [hep-ph]	97
A. Godizov, Phys. Lett. B 703 (2011) 331	110
A. Donnachie, P.V. Landshoff, arXiv: 1112.2485 [hep-ph]	91

Models vs. TOTEM. The *pp* Differential Cross-Section

The TOTEM Collaboration, Europhys.Lett. 95 (2011) 41001





Conclusion

We need deeper interrelation of phenomenological models with QCD. This requires developing powerful non-perturbative QCD techniques which should allow to deal with diffractive (large distance) domain of strong interaction.

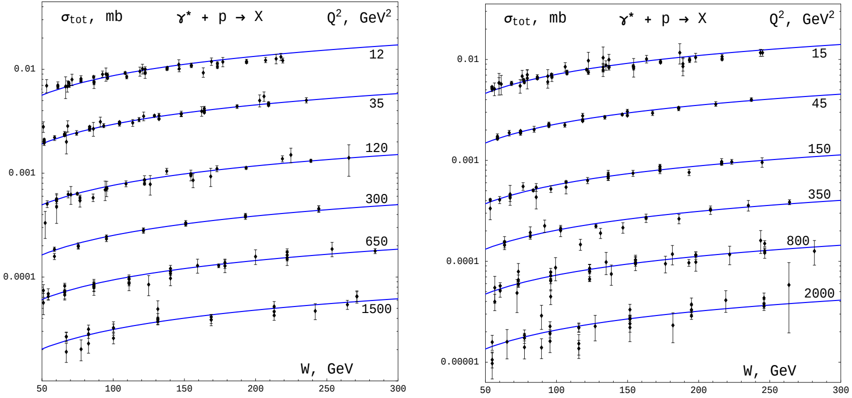
Thank You for Attention!

Extraction of the Pomeron Intercept from the DIS Data

At 50 GeV $< W <$ 300 GeV and 25 GeV$^2 < Q^2 \ll W^2$ the $\gamma^* p$ total cross-sections can be well-described by simple formula

$$\sigma_{tot}^{\gamma^* p}(W^2, Q^2) \approx \beta(Q^2) W^{2\delta}$$

with $\delta \approx 0.31$



Extraction of the Pomeron Intercept from the DIS Data

This universal parameter can be associated with the intercept of the pomeron trajectory:

$$\alpha_{\mathrm{P}}(0) - 1 = \delta \approx 0.31$$