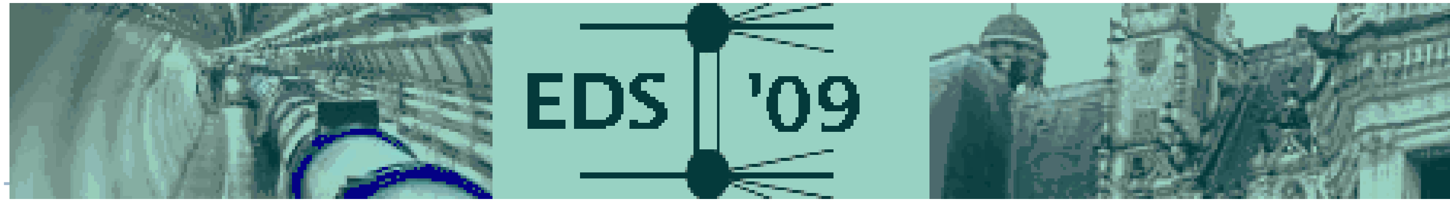

13th International Conference on Elastic & Diffractive Scattering
(13th "Blois Workshop")
CERN, 29th June - 3rd July 2009

GPDs and hadron elastic scattering

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Contents

Elastic scattering amplitude

$$pp \to pp \qquad\qquad p\bar{p} \to p\bar{p}$$

$$\frac{d\sigma}{dt} = 2\pi[|\Phi_1|^2 + |\Phi_2|^2 + |\Phi_3|^2 + |\Phi_4|^2 + 4|\Phi_5|^2]$$

$$\Phi_i(s,t) = \Phi_i^h(s,t) + \Phi_i^e(t)\, e^{i\alpha\varphi}$$

$$\varphi(s,t) = \mp [\,\gamma + \ln(B(s,t)\,|t|/2) + \nu_1 + \nu_2\,]$$

$\gamma = 0{,}577\ldots$ (*the Euler constant*)

ν_1 *and* ν_2 *are small correction terms*

Unitarity

Impact parameters dependence

$$T(s,t) = is \int_0^\infty b\, db\, J_0(bq)\ (1 - \exp[i\,\chi(s,b)])$$

Factorization

$$\chi(s,b) = h(s)\, f(b); \qquad h(s) \sim s^{\Delta}$$

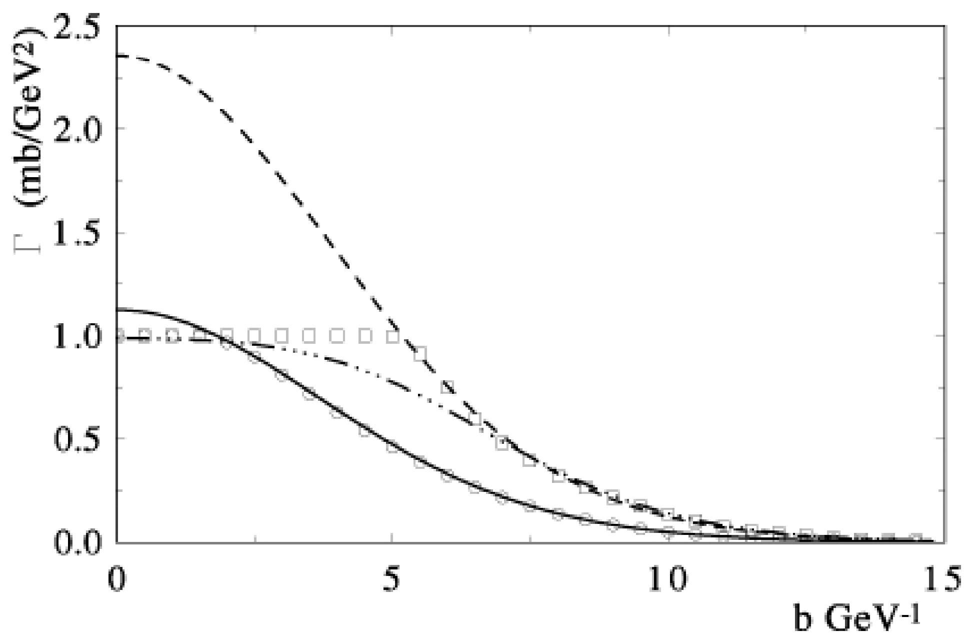
Soft and hard Pomeron

Donnachie-Landshoff model;

Schuler-Sjostrand model

$$T_1(s,t) = [h_1(\frac{s}{s_0})^{\Delta_1} e^{\alpha_1 t \ln(s/s_0)}$$

$$+ h_2(\frac{s}{s_0})^{\Delta_2} e^{\alpha_2 t \ln(s/s_0)}] F^2(t)$$



Second part of scattering amplitude

$$T_2(s,t) = [h_1(\frac{s}{s_0})^{\Delta_1} + h_2(\frac{s}{s_0})^{\Delta_2})\, A^{gr}(b)$$

ASSUMPTION

$$f_1(b) = F^{em}(b); \qquad f_2(b) = A^{gr}(b);$$

General Parton Distributions -GPDs

Electromagnetic form factors (charge distribution)

Energy momentum tensor form factors (matter distribution)

GPDs

Fallowing to A. Radyushkin

Phys.ReV. D58, (1998) 114008

limit $\xi = 0$

$$F_1^q(t) = \int_{-1}^{1} dx\, H^q(x,\xi,t); \qquad F_2^q(t) = \int_{-1}^{1} dx\, E^q(x,\xi,t);$$

$H^q(x;t) = H^q(x,0,t) + H^q(-x,0,t)$ $\qquad$ $E^q(x;t) = E^q(x,0,t) + E^q(-x,0,t)$

$$F_1^q(t) = \int_{0}^{1} dx\, \mathrm{H}^q(x,\xi,t); \qquad F_2^q(t) = \int_{0}^{1} dx\, \boldsymbol{\mathcal{E}}^q(x,\xi,t);$$

Energy-momentum tensor

$$\int_{-1}^{1} dx\, x[H^q(x,\xi,t)+E^q(x,\xi,t)] = A_q(\Delta^2)+B_q(\Delta^2);$$

$$A^q(t)=\int_0^1 dx\, x\, \mathrm{H}^q(x,t); \qquad B^q(t)=\int_0^1 dx\, x\, \boldsymbol{\mathcal{E}}^q(x,t);$$

Our ansatz

1. Simplest;

2. Not far from Gaussian representation

3. Satisfy the $(1-x)^n$ (n>= 2)

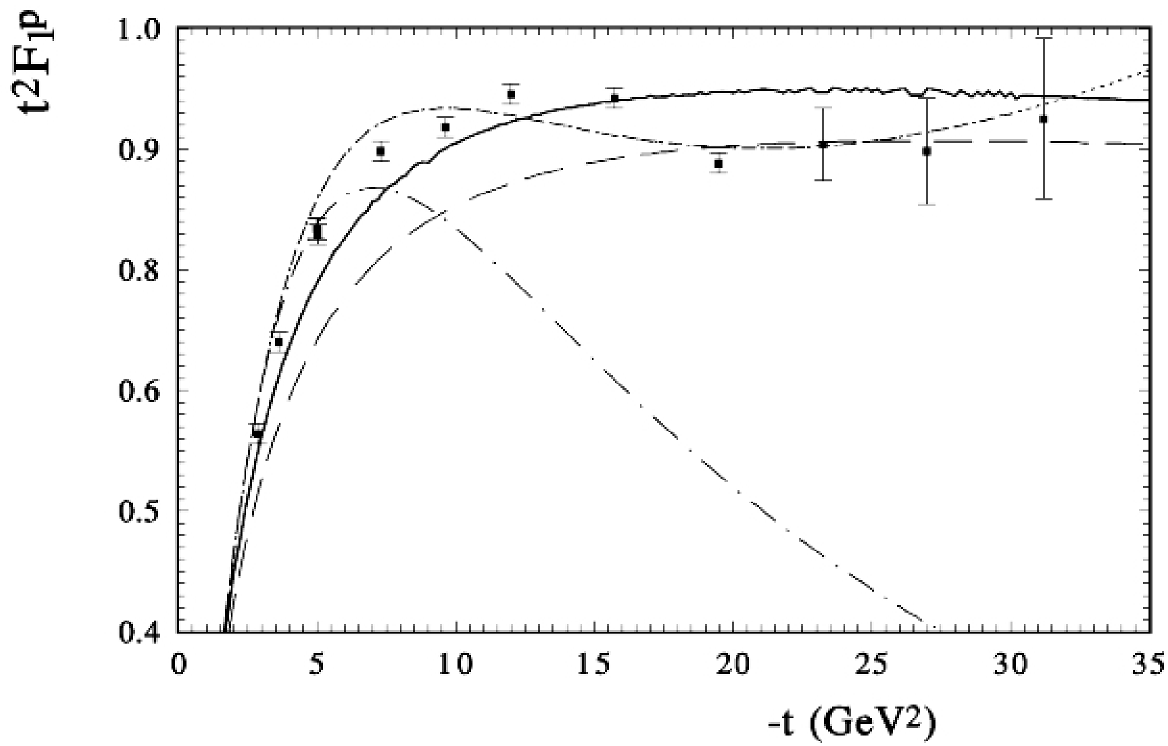
4. Valid for large t

$$H^q(x,t) \square q(x)\exp[a_+ \frac{(1-x)^2}{x^{0.4}} t];$$

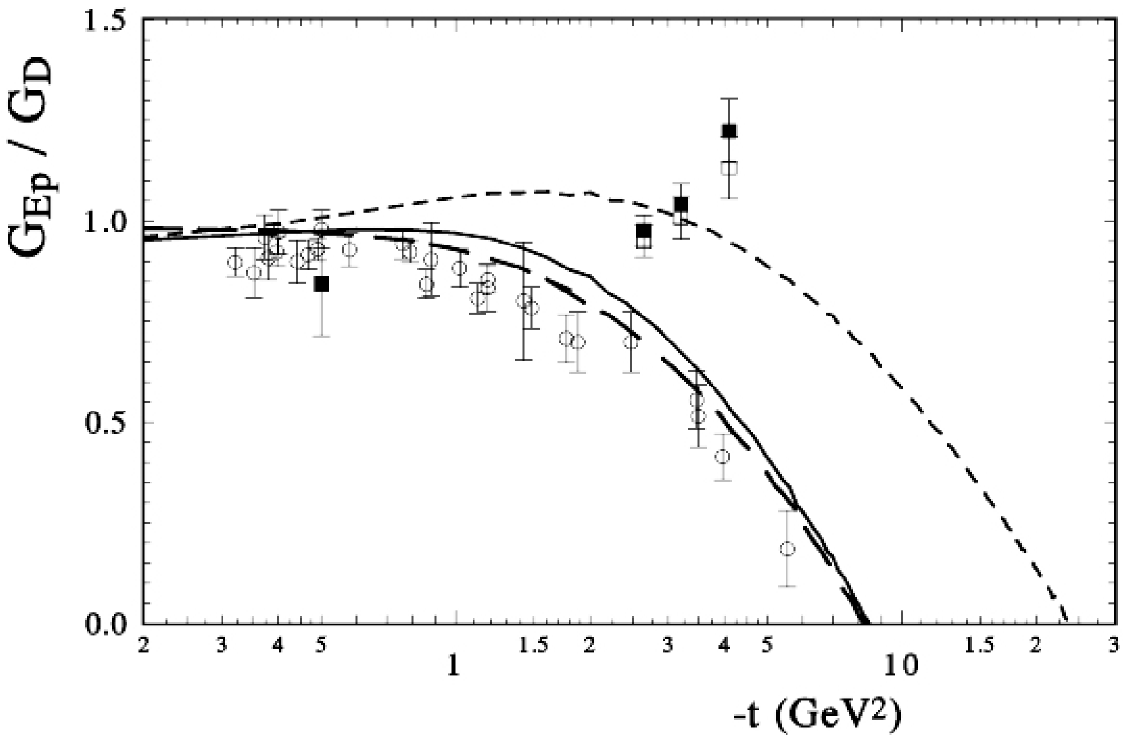
q(x) is based on the MRST2002 and A. Radyushkin (2005)

$$u(x) = 0.262 x^{-0.69} (1-x)^{3.50} (1+3.83 x^{0.5} + 37.65 x);$$
$$d(x) = 0.061 x^{-0.65} (1-x)^{4.03} (1+49.05 x^{0.5} + 8.65 x);$$

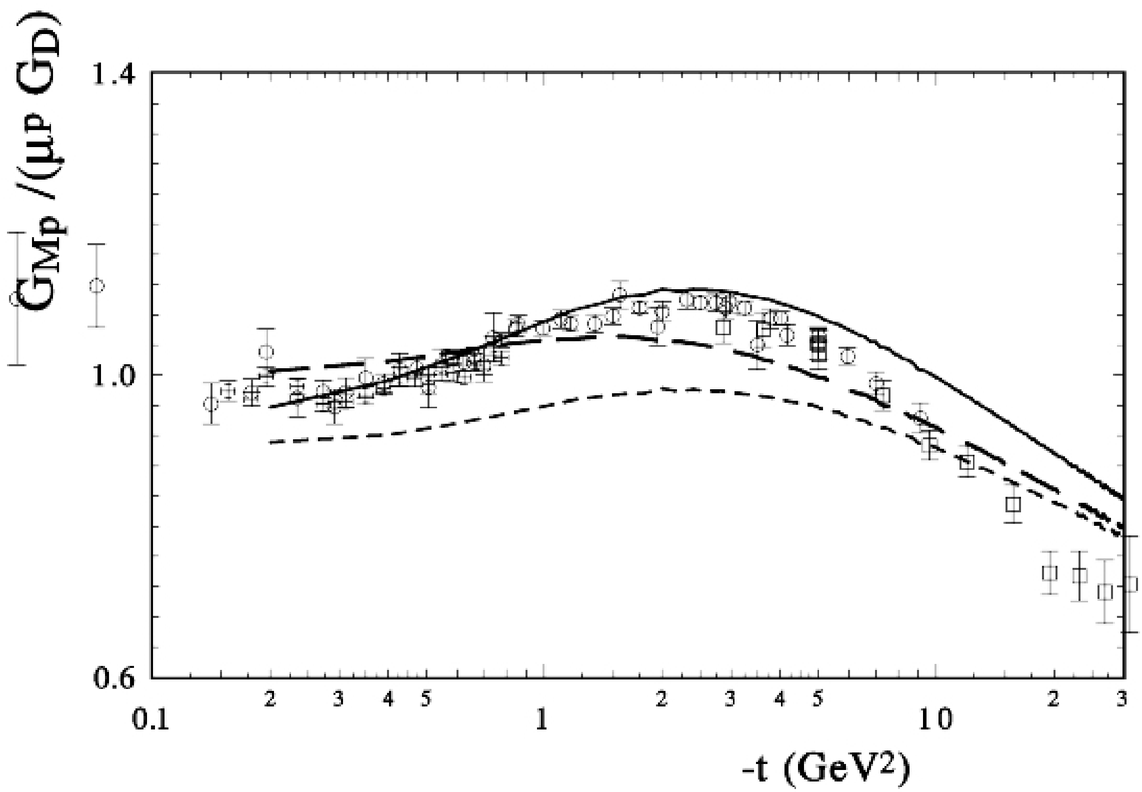
F_{1p} *t^2



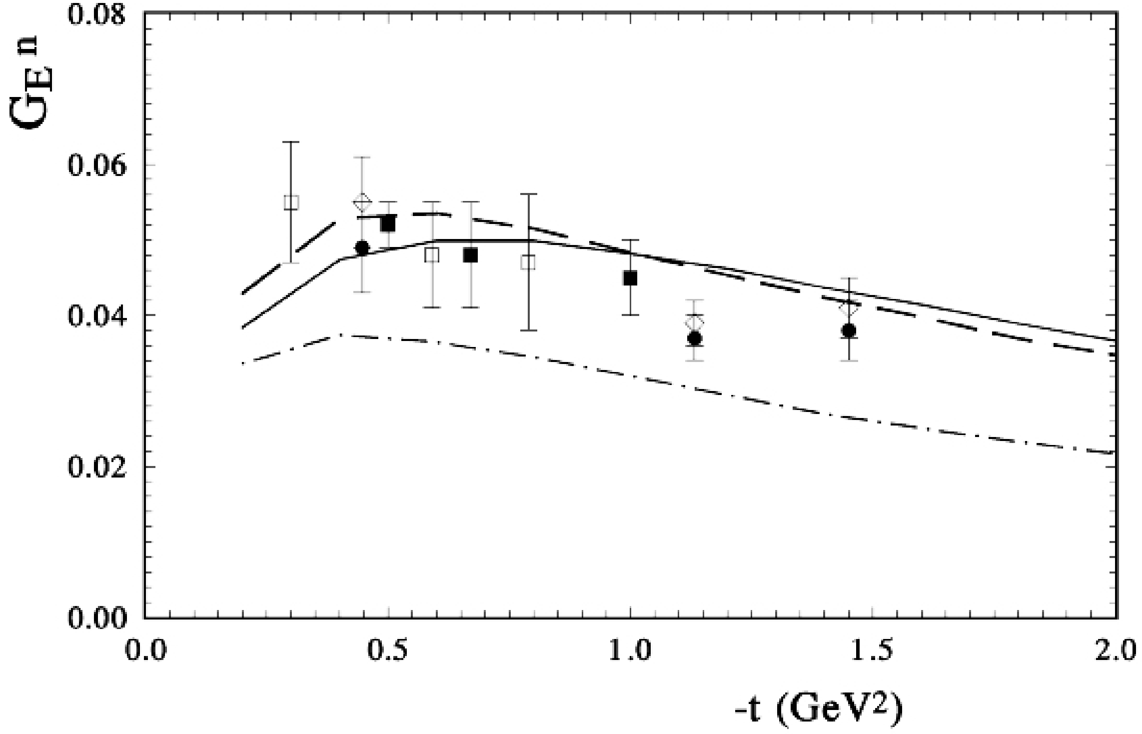
G_{ep}/Gd



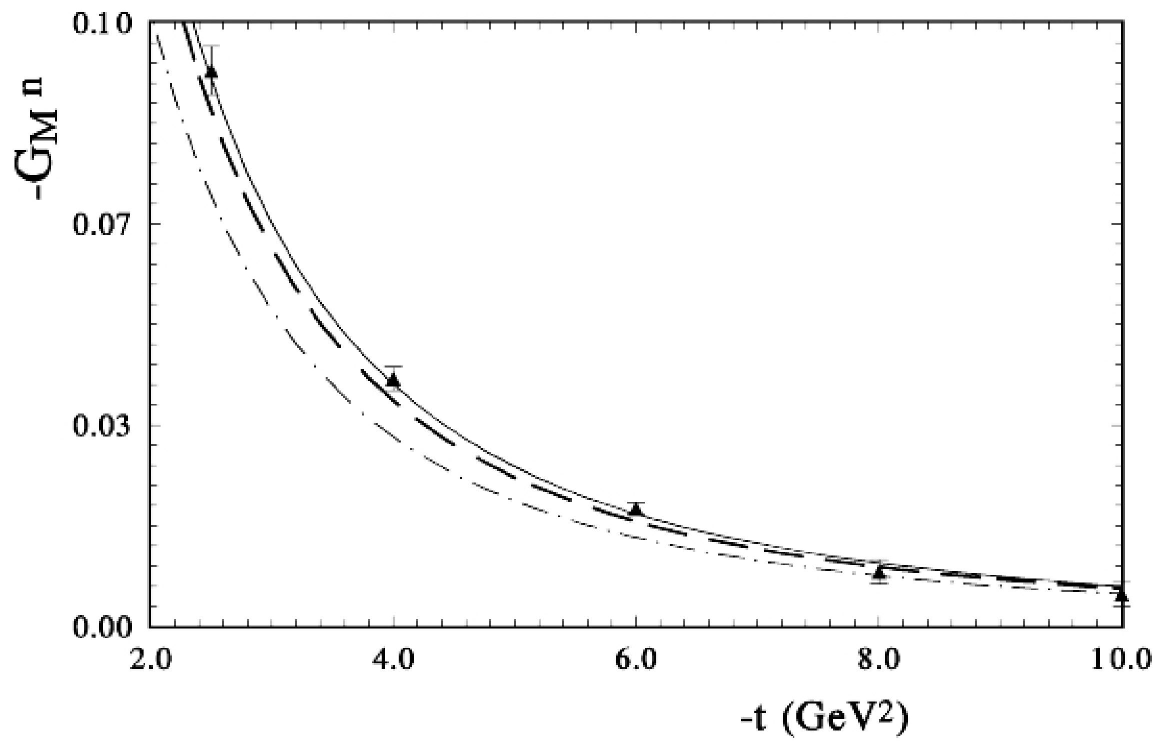
$G_{Mp}/(\mu_p Gd)$



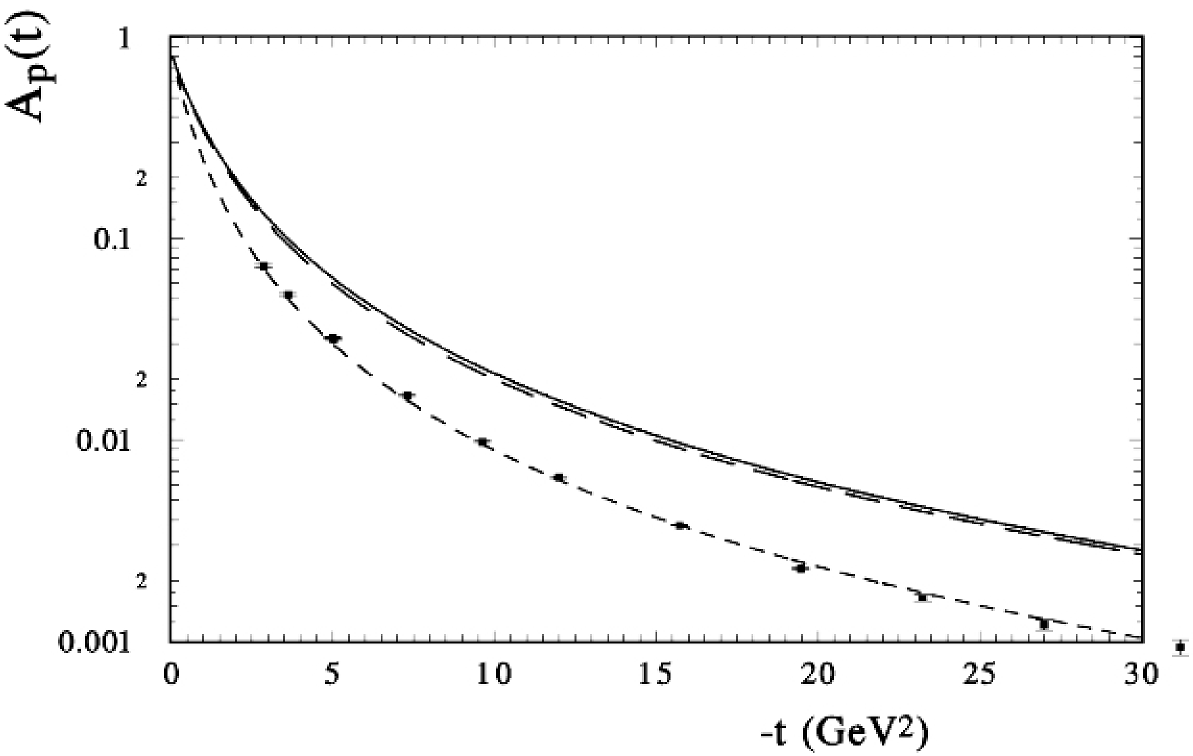
G_{En}



G_{Mn}



Gravitational and Dirac form-factors



$$A^q(t) = \int_0^1 dx\, x\, \mathrm{H}^q(x,t) \approx G_D(\Lambda^2 = 1.8, GeV^2)$$

$$f_2(b) = A^{gr}(b) = K_3(\Lambda b)$$

$$* (1 + \sqrt{r_1^2 + b^2}) / (\sqrt{r_2^2 + b^2});$$

PARAMETERS

$$\chi(s,b) = k_1\,\chi_1(s,b) + k_2\chi_2(s,b);$$

Fixed:

$$\Delta_1 = 0.08;\ \Delta_2 = 0.45;\quad \alpha_1' = 0.25;\ \alpha_2' = 0.1;$$

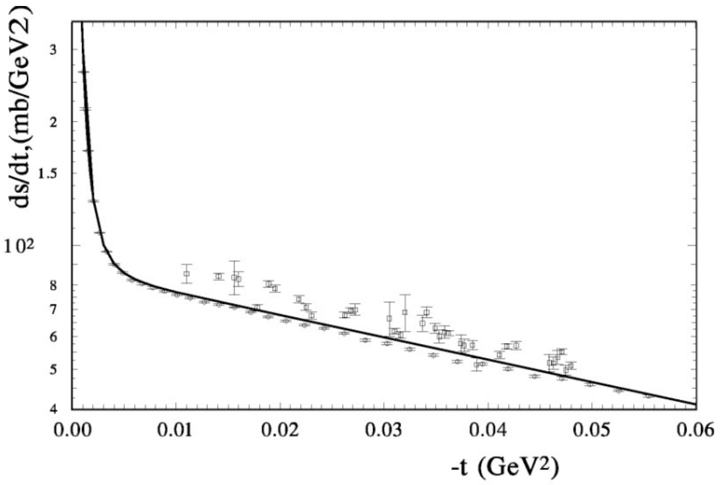
$$h_1 / h_2 = 0.008 / 4.47.$$

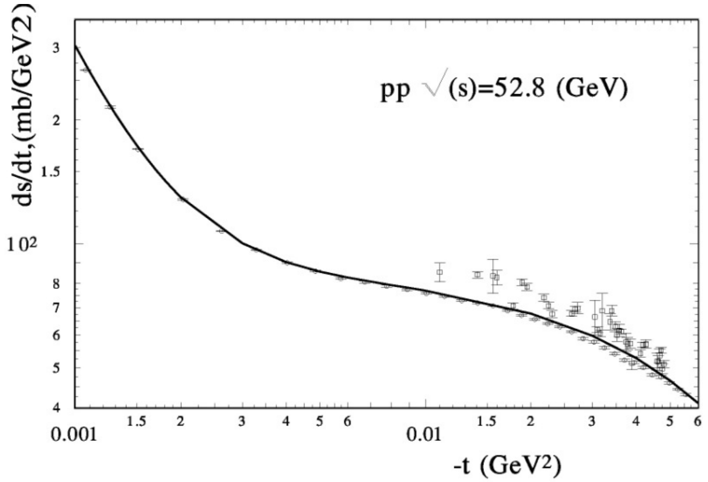
Free:

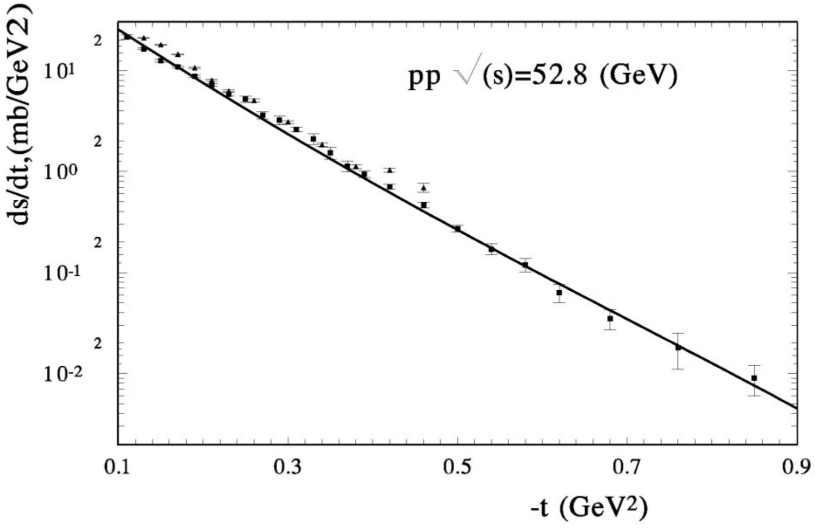
$$k_1 = 1.09;\ k_2 = 1.57;\qquad r_1 = 2.46;\quad r_2 = 30.9.$$

$$\chi^2 = 2731/947 \approx 3.$$

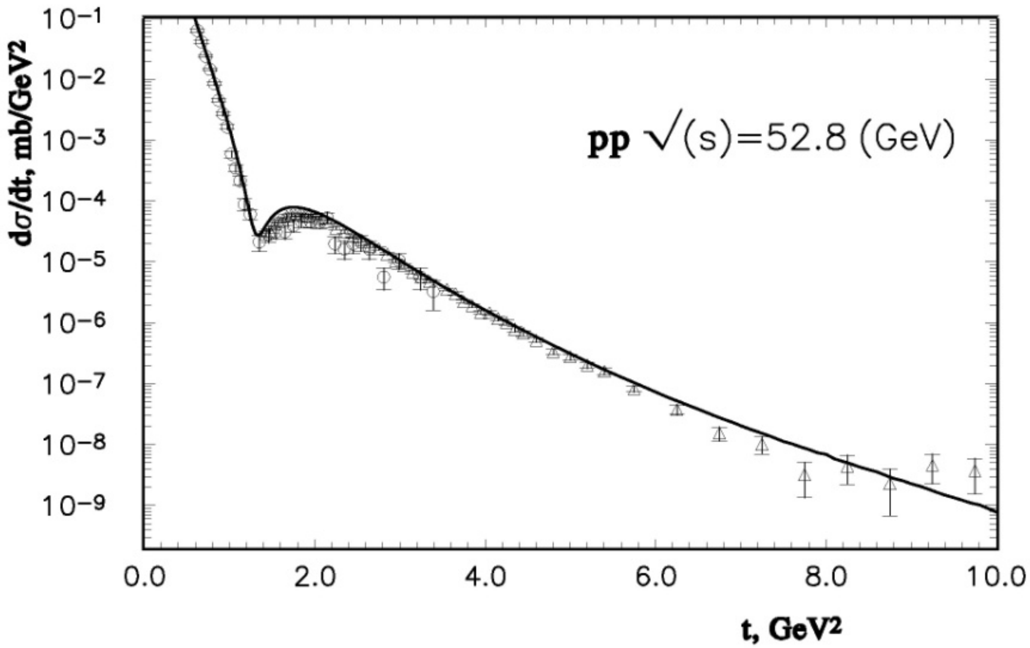
$pp \to pp$ $(\sqrt{s} = 52.8\ \text{GeV})$ *small t*



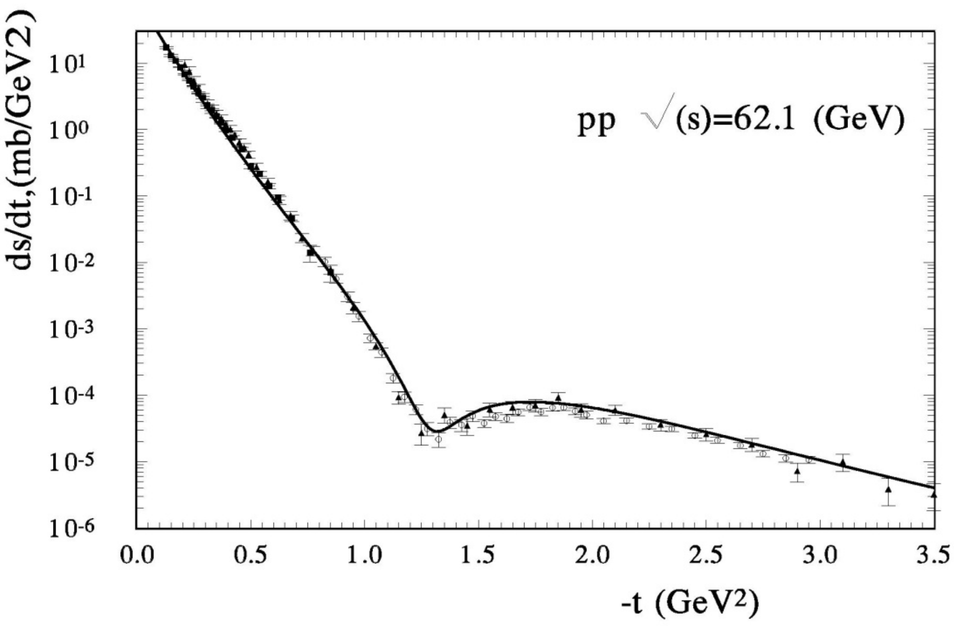




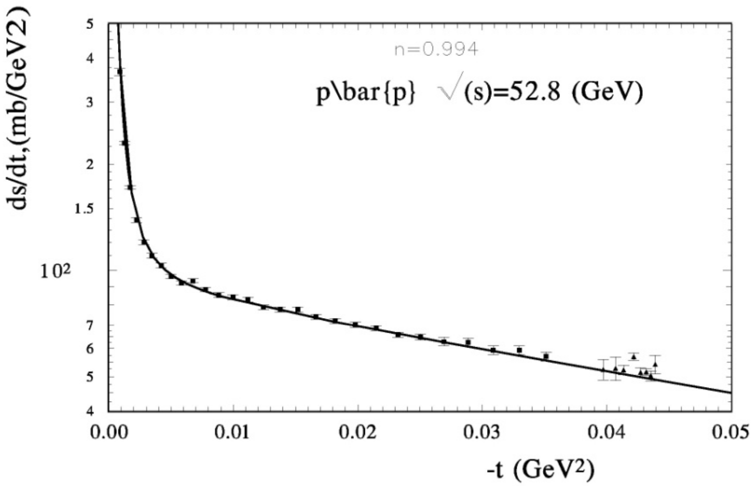
$pp \rightarrow pp \quad (\sqrt{s} = 52.8\ \text{GeV})\ \ large\ t$

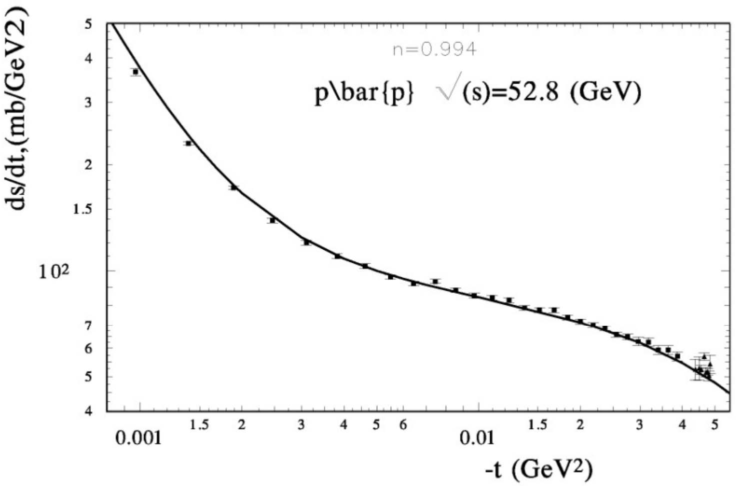


$$pp \rightarrow pp \qquad (\sqrt{s} = 62.1\ \text{GeV})$$

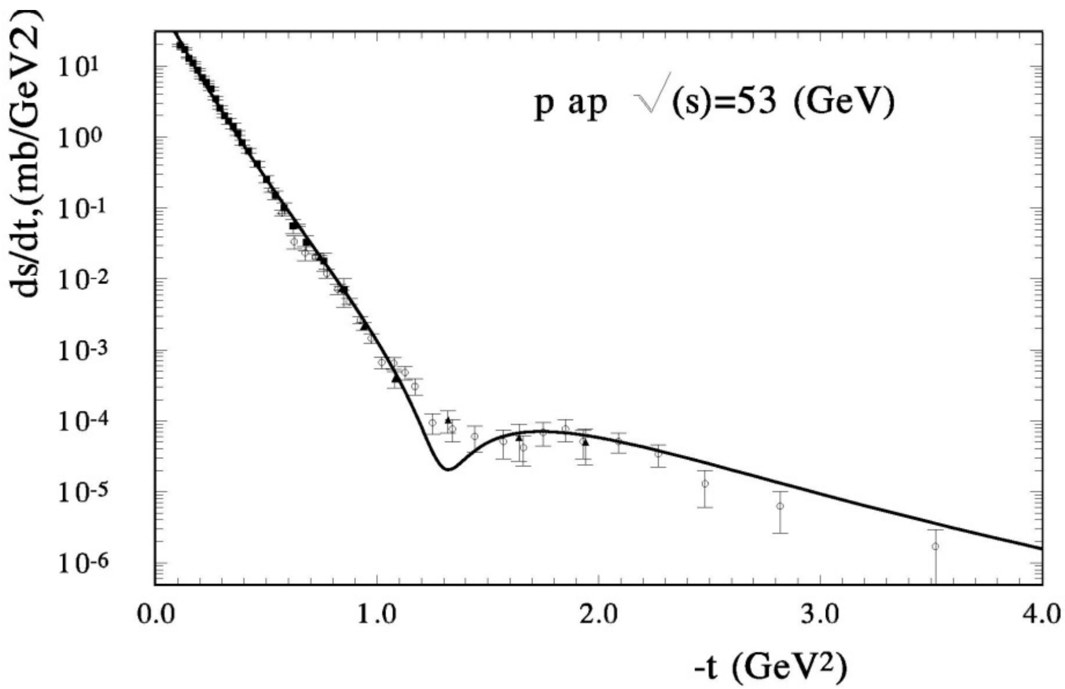


$p\bar{p} \rightarrow p\bar{p}$ $(\sqrt{s} = 52.8 \text{ GeV})$ *small t*

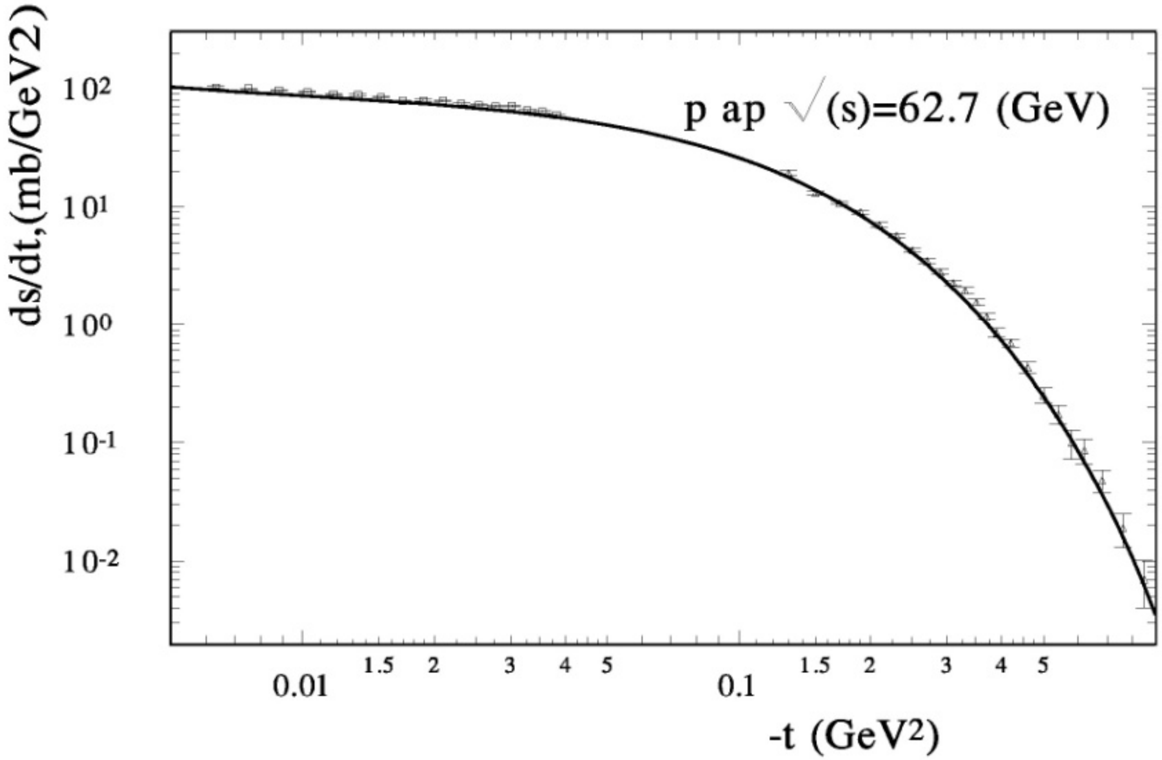




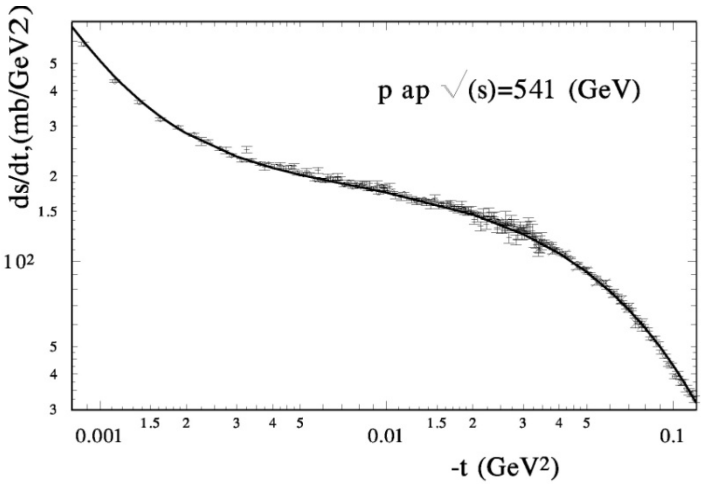
$p\bar{p} \rightarrow p\bar{p}$ $(\sqrt{s} = 53\ \mathrm{GeV})$

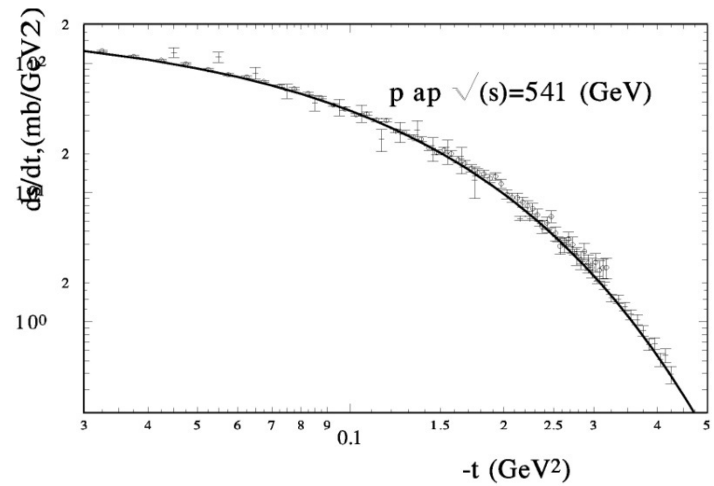


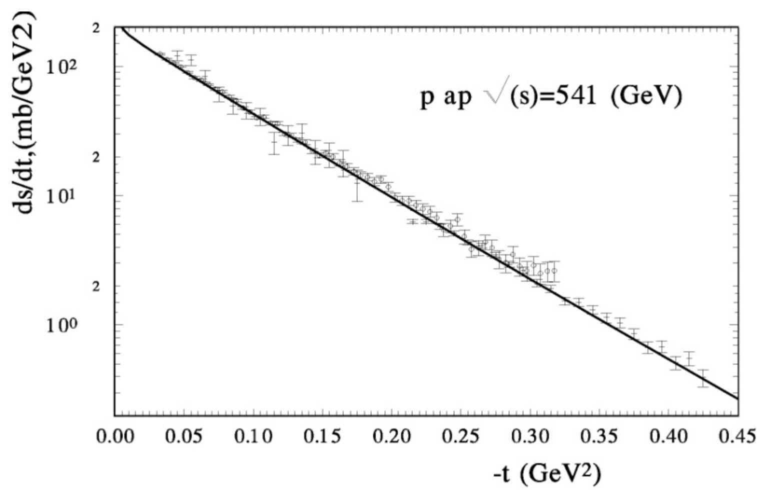
$p\bar{p} \rightarrow p\bar{p}$ $(\sqrt{s} = 62.7 \text{ GeV})$



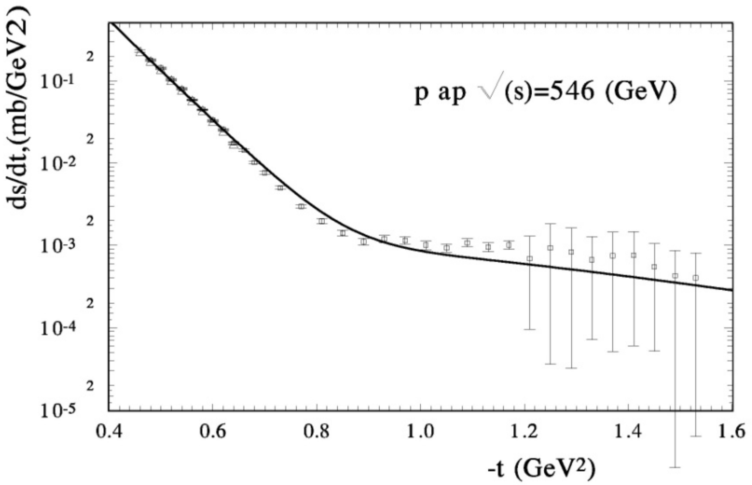
$p\bar{p} \to p\bar{p}$ $(\sqrt{s} = 541\ \text{GeV})$

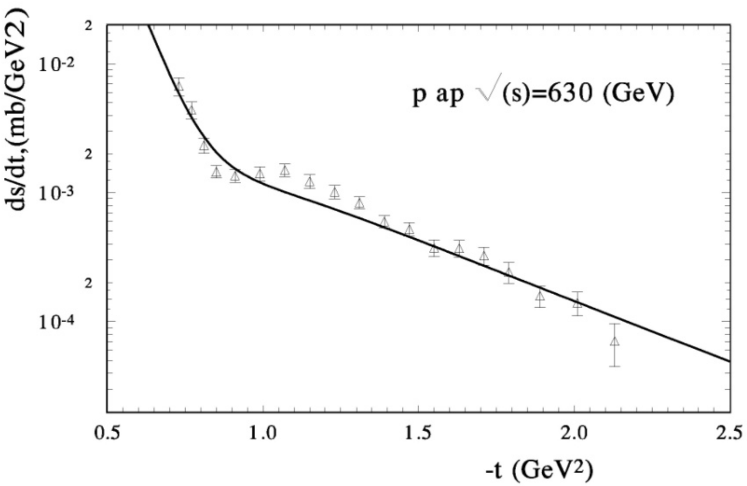




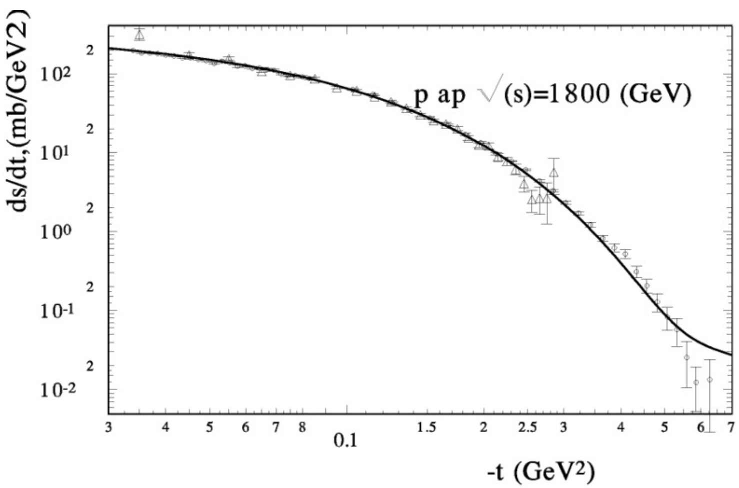


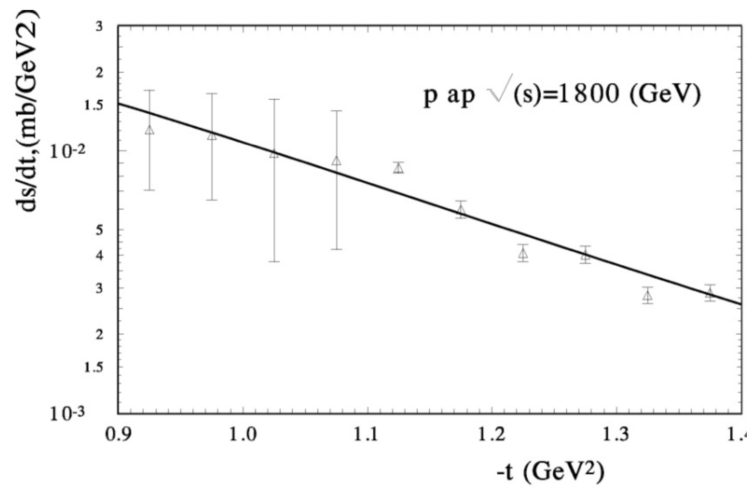
$p\bar{p} \rightarrow p\bar{p} \quad (\sqrt{s} = 541 \ \mathit{and} \ 546 \text{ GeV})$



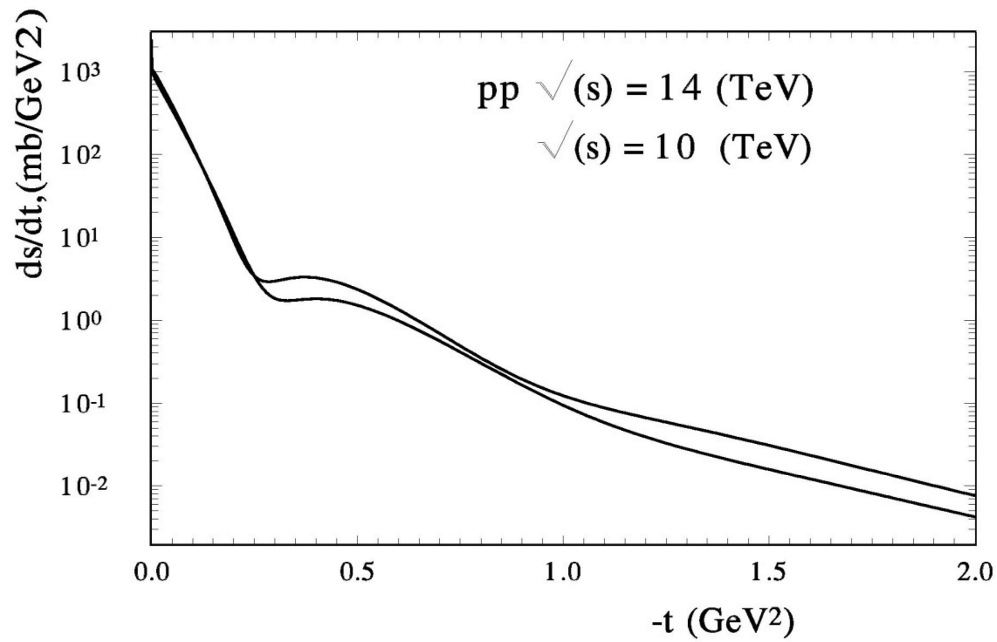


$p\bar{p} \rightarrow p\bar{p} \quad (\sqrt{s} = 1800 \text{ GeV})$





PREDICTIONS $pp \rightarrow pp \quad (\sqrt{s} = 10,\ 14 \quad \text{TeV})$

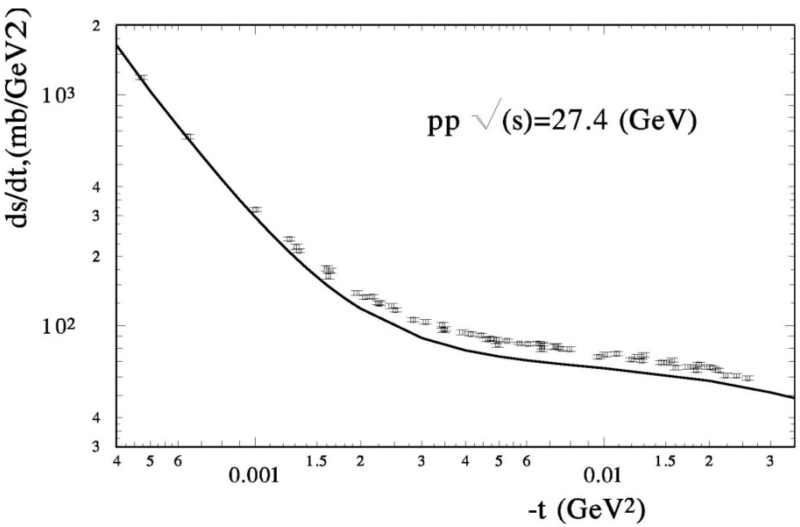


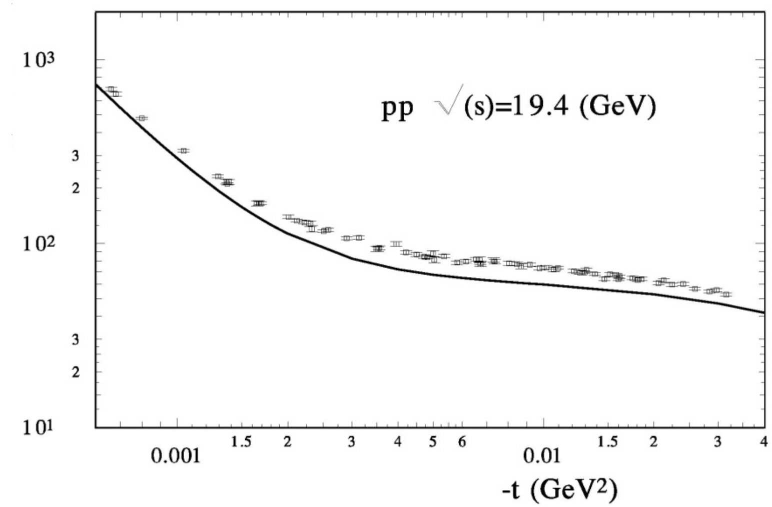
$\sqrt{s}$ □ 1.8 TeV; $\quad \rho(0) = 0.208;\ \sigma_{tot} = 80.3\, mb;$

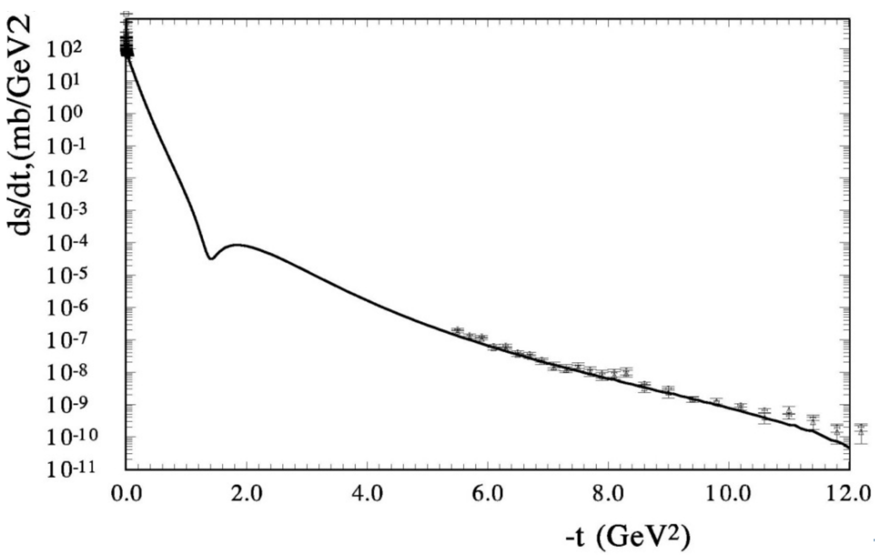
$\sqrt{s}$ □ 10 TeV; $\quad \rho(0) = 0.238;\ \sigma_{tot} = 132\, mb;$

$\sqrt{s}$ □ 14 TeV; $\quad \rho(0) = 0.235;\ \sigma_{tot} = 146\, mb;$

Lower energy







There is a small place for the secondary reggeons (with the intercept > 0,5)

Non-linear equation (K-matrix)

$$\frac{dN}{dy} = \Delta N(1 - N); \qquad N[y] = \Gamma(s,0); \quad y = \ln(s/s_0);$$

$$N[y] = \frac{s^{\Delta y} f(b)}{1 + s^{\Delta y} f(b)}; \qquad N[y] = \frac{i\,\chi(s,b)}{1 + \chi(s,b)};$$

$$\chi^2 = 5400/947 \approx 6;$$

$$\frac{dN}{dy} = \gamma\,(1 - [1 - N]^{1/\gamma}\,)\;(1 - N);$$

Interpolating form of unitarization

$$G(s,b) = i/\omega\,[1 - (1 + \omega\,\chi(s,b)/\gamma)^{-\gamma}\,];$$

$$\gamma = 1; \qquad G(s,b) = 1 - \frac{1}{(1 + \chi(s,b))} = \frac{\chi(s,b)}{1 + \chi(s,b)};$$

$$\gamma \to \infty; \qquad G(s,b) = 1 - exp(-\chi(s,b);$$

Fit: $\gamma \to \infty.$

Experiment data choose the eikonal form

Summary

1. Proposed a new simple model of proton-proton and proton-antiproton elastic scattering .

2. The model is based on the assumption that the scattering amplitude is a sum of terms proportional to the charge distribution of the hadron (dominant at small t) and terms proportional to the matter distribution of the hadron (dominant at large t).

3. Both distributions are obtained from our model of GPDs of the hadrons. The corresponding electromagnetic and gravitational form factors of the proton are calculated with our proposed t-dependence of the GPDs.

Summary

4. The model includes the contributions of the soft and hard pomerons with intercepts = 1+0.08 and 1+0.45 and slopes = 0.25 and 0.1 GeV^{-2}.

5, The model describes all high-energy experimental data beginning from sqrt(s)=52.8 GeV in the Coulomb hadron interference region and at large $|t| = 10$ GeV^2.

(with 4 free parameters , ♍ ^{2} = 3 per point)

6. We note the essential contribution of the hard pomeron at the LHC energy at small and large t. This leads to a large value of rho at small t.

7. We do not see the odderon contribution at small and large t.

END

END

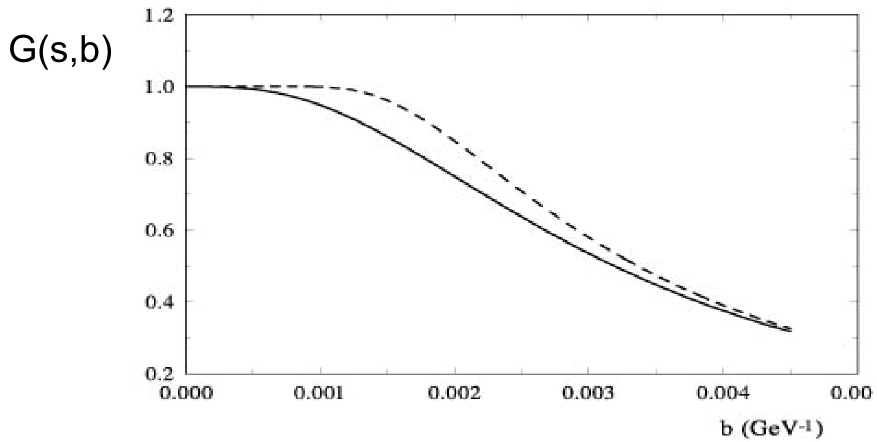
THANKS

FOR YOUR ATTANTION

Saturation bound

$$\chi(s,b) = 2\pi \int_0^\infty q\, J_0(bq)\, M_B(s,q)\, dq$$

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



$$\chi(s,b) = k_1\, \chi_1(s,b) + k_2 \chi_2(s,b);$$

$$\chi_1(s,b) = h(s,b)\, f_1(b); \quad \chi_2(s,b) = h(s)\, f_2(b);$$

$$h(s) = [h_1 (\frac{s}{s_0})^{\Delta_1} + h_2 (\frac{s}{s_0})^{\Delta_2}]$$