XVI WORKSHOP ON HIGH ENERGY SPIN PHYSICS
DSPIN-17

Dubna, Russia, September 11 - 15, 2017

The momentum transfer dependence of the hadrons GPDs and Compton scattering at wide region of t

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Contents

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Hep-ph/0708.0162

"One doesn't know explicit form of the nucleon matrix element of the EM current"

$$J_\mu^{EM} = \frac{2}{3}\bar{u}\,\gamma_\mu u - \frac{1}{3}\bar{d}\,\gamma_\mu\, d - \frac{1}{3}\bar{s}\,\gamma_\mu\, s.$$

$$J_\mu(P',s';P,s) = \bar{u}(P',s')\,\Lambda_\mu(q,P)u(P,s) =$$

$$\bar{u}(P',s')(\gamma_\mu F_1(q^2) + \frac{1}{2M} i\,\sigma_{\mu\nu} q_\nu F_2(q^2))\,u(P,s).$$

Standard definitions

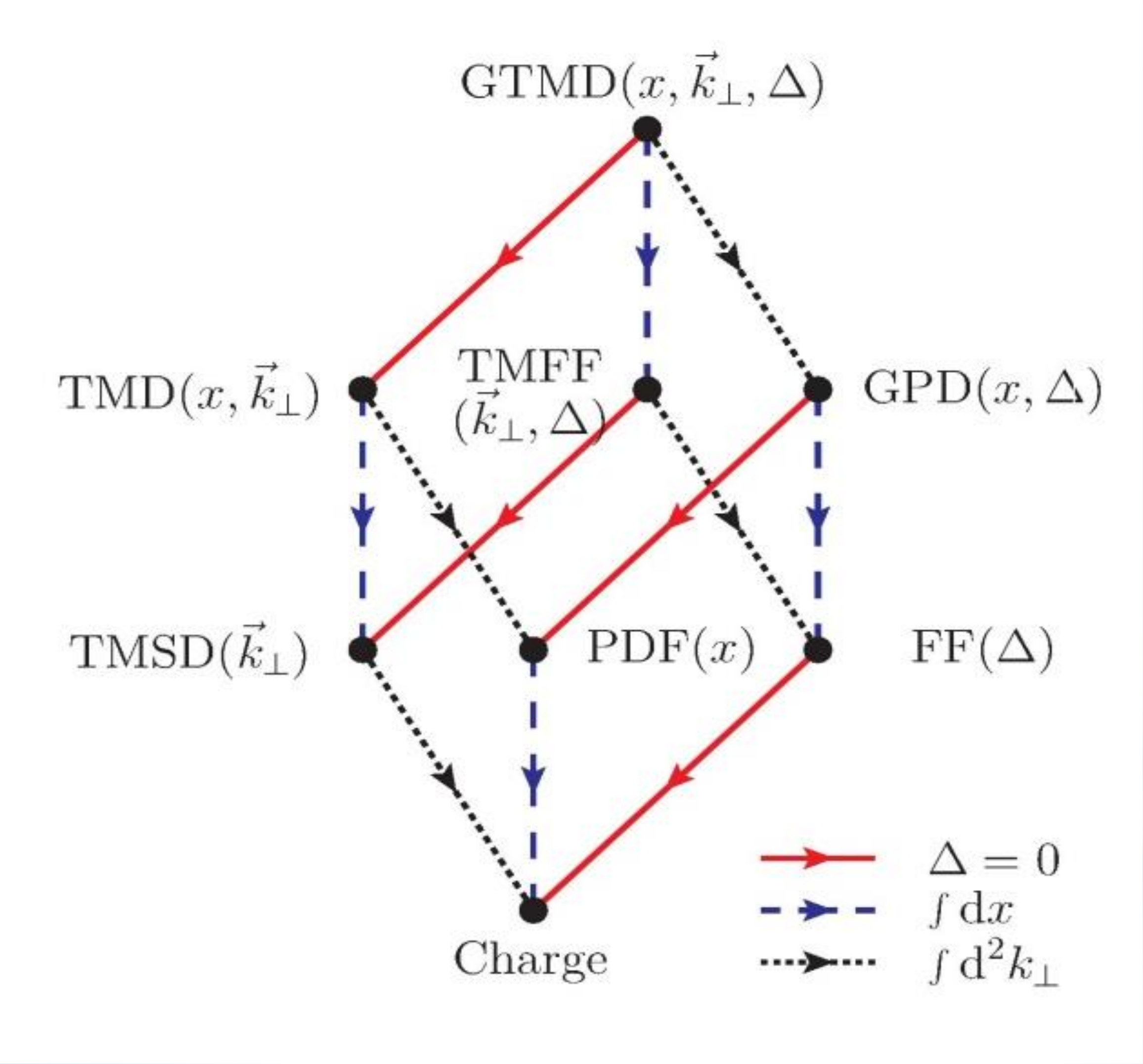
$$G_{Ep}(0) = 1;\ G_{En}(0) = 0; \quad G_M(0) = (G_E(0) + k) = \mu;$$

$$\mu_p = (1+1.79)\frac{e}{2M}; \qquad k_p = 1.79;$$

$$F_1^D(t) = \frac{4M_p^2 - t\,\mu_p}{4M_p^2 - t} G_D(t); \qquad F_2^P(t) = \frac{1}{1 - t/4M_p^2} G_D(t);$$

$$G_D(t) = \frac{\Lambda^2}{(\Lambda - t)^2}; \qquad \Lambda = 0.71 GeV^2;$$

M. Burkhardt, B. Pasquini, EPJ (2015)



General Parton Distributions (GPDs)

GPDs

$$limit\ \ Q_{\gamma}^{2}=0,\ \ and\ \ \xi=0$$

X.Ji Sum Rules (1997)

$\mathcal{F}_{\xi=0}(x;t) = \mathcal{F}(x;t)$

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

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

$\mathcal{H}^q(x;t) = H^q(x,0,t) + H^q(-x,0,t)$

$\mathcal{E}^q(x;t) = E^q(x,0,t) + E^q(-x,0,t)$

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

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

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

General Parton Distributions (GPDs)

Sanielevici-Valin (1984) –Valon model – Phys.Rev.D29 (1984).

“matter form factor” (MFF) measures the interaction of a gluonic probe with the excited matter of the overlapping hadrons and should incorporate the static matter distributions of the participating hadrons…”

$$M_{AB}(s,t) = K_A(q^2)\; K_B(q^2)\, V(s,q^2);$$

$$K_p(q^2) = \frac{1}{3}\int_0^1 dx\,[2L_p^U(x)\,T_p^U(\vec{k}) + L_p^D(x)\,T_p^D(\vec{k})];\; \vec{k} = (1-x)\vec{q}.$$

$$L_p^U(x) = 7.98x^{0.65}(1-x)^2;\; L_p^D(x) = 6.01x^{0.35}(1-x)^{2.3};$$

$$T_p^U(\vec{k}) = e^{-6.1k^2};\, T_p^U(\vec{k}) = e^{-3k^2}; \qquad k^2 = (1-x)^2 q^2.$$

Why it is need know the t-dependence of GPDs in the wide region of the momentum transfer?

•Form factors in the wide region of t (x^{n-1})

(Compton - zero momentum - x^{-1}
electromagnetic, - first momentum - x^{0}
gravitomagnetic - second momentum – x^{1}

* Tomography of the nucleons
(impact parameter representation)
require the integration on the whole region of t

Our ansatz

O.S., O. Terayev, Phys.Rev.D79:033003,2009
Found.Phys.40:1042,2010

1. Simplest;

2. Not fare from Gaussian representation

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

4. Valid for large t

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

q(x) is based on the MRST2002

$$u(x) = 0.262\, x^{-0.69} (1-x)^{3.50} (1 + 3.83\, x^{0.5} + 37.65\, x);$$

$$d(x) = 0.061\, x^{-0.65} (1-x)^{4.03} (1 + 49.05\, x^{0.5} + 8.65\, x);$$

TABLE I. The sets of the PDFs with its basic parameters.

N	Model	Reference	$g_2^q(x)$	Order, (Q_0^2)
1	ABKM09	[50]	Eq. (36)	NNLO (9.)
2a	JR08a	[46]	Eq. (32)	NNLO (0.55)
2b	JR08b	[46]	Eq. (32)	NNLO (2.)
3	ABM12	[51]	Eq. (37)	NNLO (9.)
4a	KKT12a	[48]	Eq. (34)	NLO (4.)
4b	KKT12b	[48]	Eq. (34)	NLO (4.)
5a	GJR07d	[52]	Eq. (32)	LO (0.3)
5b	GJR07b	[52]	Eq. (32)	NLO (0.3)
5c	GJR07a	[52]	Eq. (32)	NLO (2.)
5d	GJR07c	[52]	Eq. (32)	NLO (0.3)
6a	MRST02	[40]	Eq. (32)	NLO (1.)
6b	MRST01	[44]	Eq. (32)	NLO (1.)
7a	GP08a	[47]	Eq. (33)	NLO (0.5)
7b	GP08b	[47]	Eq. (33)	NNLO (1.5)
7c	GP08c	[47]	Eq. (33)	NLO (2.)
7d	GP08d	[47]	Eq. (33)	NNLO (0.5)
8a	MRST09	[43]	Eq. (32)	LO (1.)
8b	MRST09	[43]	Eq. (32)	NLO (1.)
8c	MRST09	[43]	Eq. (32)	NNLO (1.)
9	MRST02P	[49]	Eq. (35)	NLO (1.3)
10a	CJ12amin	[45]	Eq. (32)	NLO (1.7)
10b	CJ12am	[45]	Eq. (32)	NLO (1.7)
10c	CJ12bmid	[45]	Eq. (32)	NLO (1.7)
10c	CJ12cmax	[45]	Eq. (32)	NLO (1.7)
11	MRSTR4	[40]	Eq. (32)	NLO (1.3)

O.S. – Phys.Rev. (D 89) (2014)

Martin – 2002 // H. KHANPOUR..-2012 (1205.5194)

$$x q_v(x, Q_0) = A_0 x^{A_1}(1-x)^{A_2}(1 + A_3 x^{A_4} + A_5 x^{A_6})$$

Pumplin et al. 2002 (CTEQ6M)

$$x q_v(x, Q_0) = A_0 x^{A_1}(1-x)^{A_2 x} e^{A_3}(1 + e^{A_4 x} x)^{A_5}$$

Martin et al. 2002 (MRST02) .– Martin -2009 (LO, NLO, NNLO)

$$x q_v(x, Q_0) = A_0 x^{A_1}(1-x)^{A_2}(1 + A_3 x^{0.5} + A_4 x)$$

Gluck-Pisano 2008

$$x q_v(x, Q_0) = A_0 x^{A_1}(1-x)^{A_2}(1 + A_3 x^{0.5} + A_4 x + A_5 x^{1.5})$$

Alekhin et al. 2012 (ABM12)

$$x q_v(x, Q_0) = \frac{2\delta_{qu} + \delta_{qd}}{N_q^v} x^{a_q}(1-x)^{b_q} \, x^{\gamma_{1,q} x + \gamma_{2,q} x^2 + \gamma_{3,q} x^3}$$

TABLE II. Experimental data of the electromagnetic form factors.

N points	Proton	References
111	G_E^p	[53]; [55]; [56]; [57]; [58]; [59]; [54];
196	G_M^p	[53]; [55]; [60]; [56]; [61]; [62]; [59]; [54];
87	$\mu G_E^p/G_M^p$	[55]; [61]; [63]; [64]; [65]; [54];
	neutron	
13	G_E^n	[66]; [67]; [68]; [69]; [70]; [71]; [72]; [73]; [74];
38	G_M^n	[75]; [76]; [77]; [78]; [79];
6	$\mu G_E^n/G_M^n$	[80]; [68];

$$\mathcal{H}^u(x,t) \Box u(x)\exp[2\alpha_1(\frac{(1-x)^{p_1}}{(x_0+x)^{p_2}}t];$$

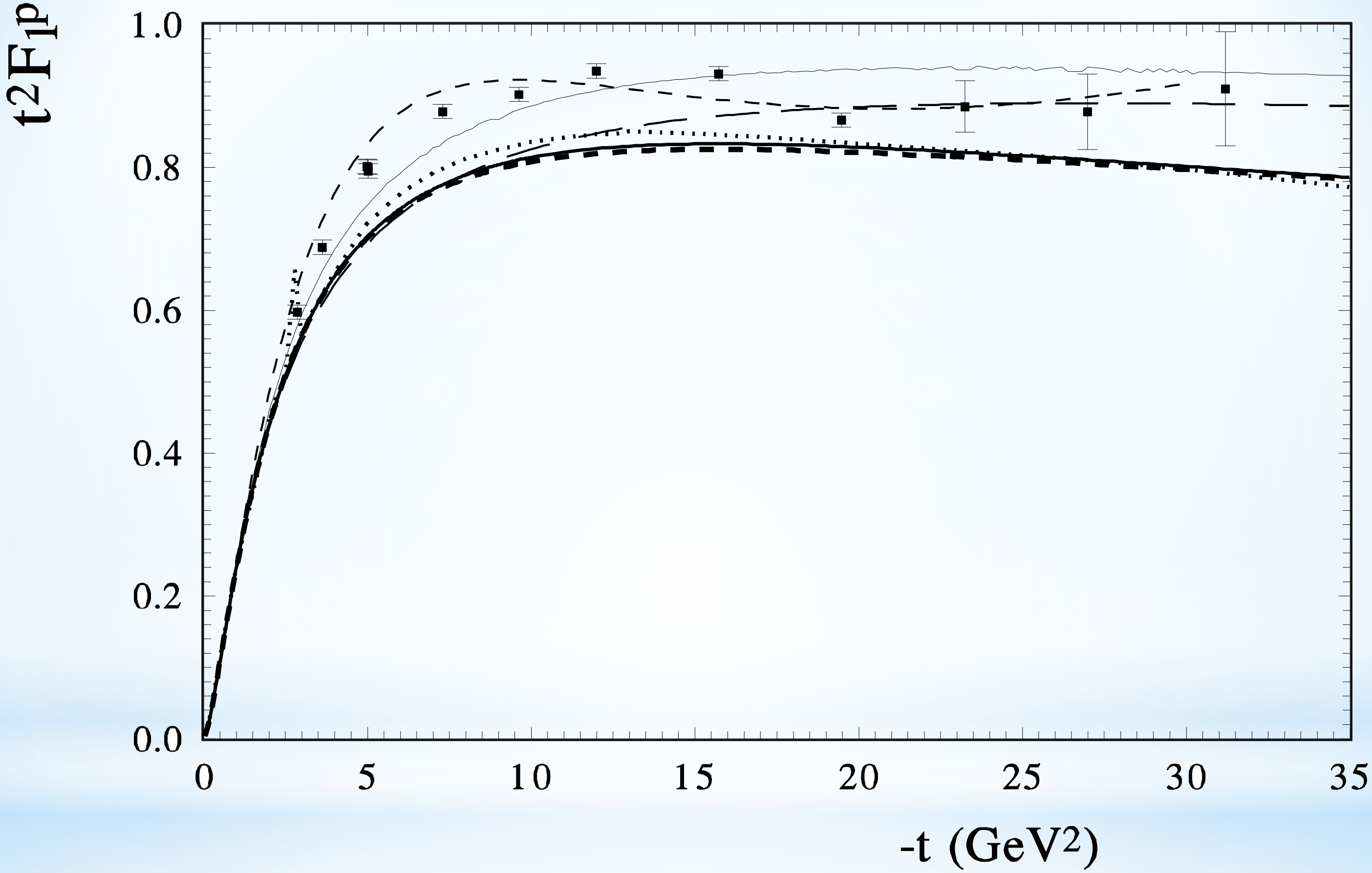
O.S., talk on Intern. Conf. "SPIN in High Energy Physics" (2012)

$$\mathcal{H}^d(x,t) \Box d(x)\exp[2\alpha_1(\frac{(1-x)^{p_1(*k_d)}}{(x_0+x)^{p_2}}+d*x*(1-x)t]$$

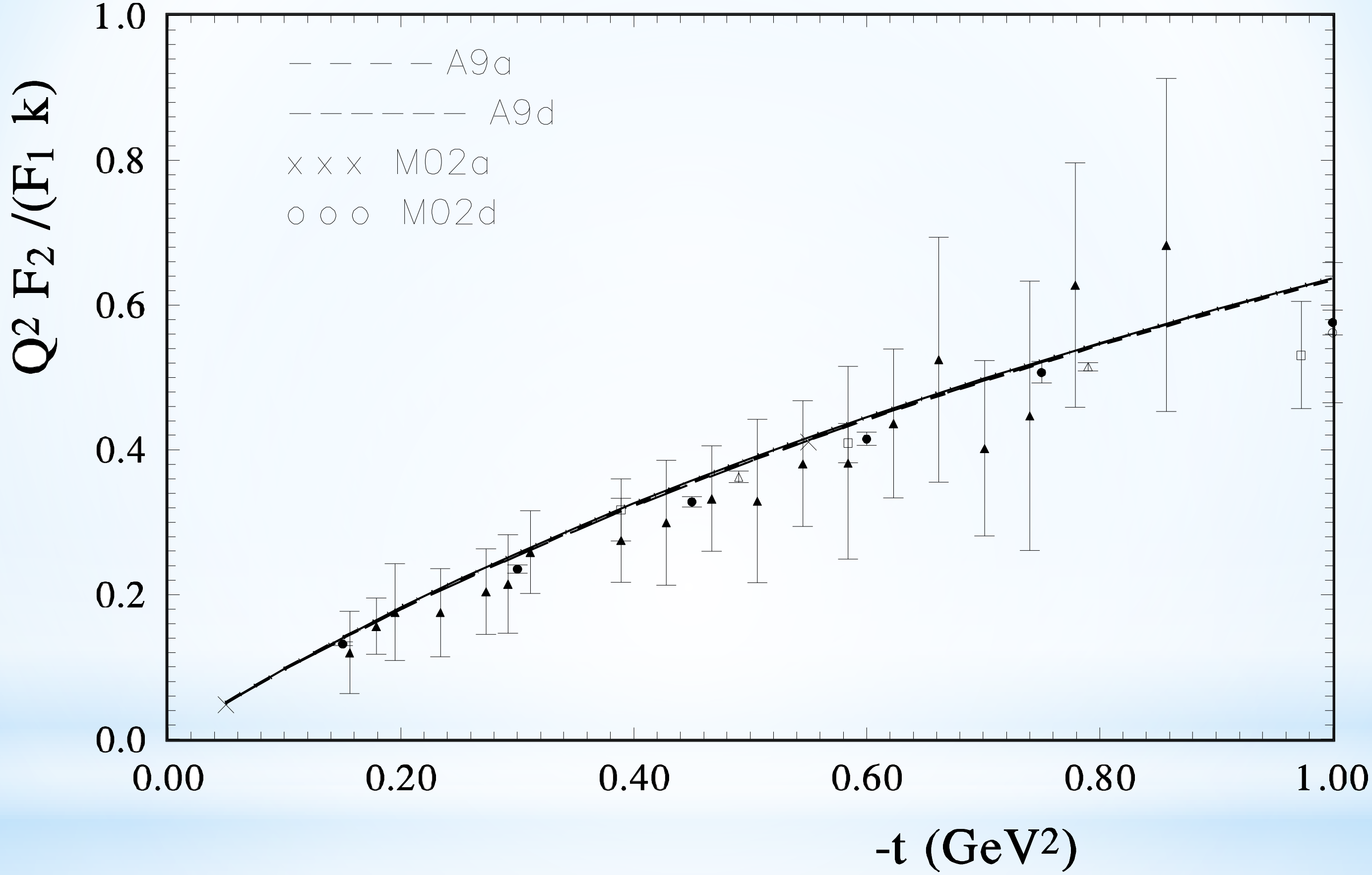
	a1	a2	a3	a4	a5	a6	a7	a8	a9
	p1	p2	♋🗁 ☎☝✆	♋🗎☎ ☜✆	du	dd	x0	k	d
Al-09	2.03	0.5	0.4	0.39	2.4	-0.14	0.006	0.41	-1.61
Al-09-0	2.-fix	0.5	0.38	0.39	2.6	0.03	0.007	1.-fix	------
G-07-a	1.88	0.43	0.6	0.6	1.7	-0.14	0.013	0.54	-1.
G-07-a0	2.-fix	0.34	0.68	0.73	1.7	-0.14	0.003	1 - fix	------
R4	1.89	0.51	0.5	0.43	2.6	0.5	0.01	0.35	-2.
R4-0	2.- fix	0.42	0.57	0.56	2.2	0.15	0.005	1 - fix	-------
M-09NN	1.92	0.4	0.57	0.66	0.93	-1.1	0.008	0.58	-0.61
M-09NN	2- fix	0.35	0.6	0.7	1.5	-0.5	0.003	1. fix	--------
G07NL	1.49	0.35	0.6	0.71	0.58	-1.05	0.007	0.89	0.46

TABLE III. The sum of χ^2 for the different PDFs sets and with different number of the fitting parameters.

N	Model	χ_0^2	χ_{+1p}^2	χ_{+1p}^2	χ_{+2p}^2	χ_{+3p}^2	χ_{+4p}^2
1	ABKM09	984	984	953	936	903	872
2a	JR08a	1119	861	891	861	860	857
2b	JR08b	1242	1242	880	868	868	864
3	ABM12	1036	1033	1031	1020	919	904
4a	KKT12a 8	1170	1133	1170	1108	934	888
4b	KKT12b	1074	1074	1064	1064	1036	988
5a	GJR07d	1772	1042	1553	936	884	878
5b	GJR07b	1172	1078	992	947	887	865
5c	GJR07a	1215	1214	1079	1024	940	894
5d	GJR07c	8423	1230	7279	1042	954	891
6a	MRST02	1089	1041	1035	1013	932	905
6b	MRST01	1167	1002	1129	999	898	873
7a	GP08a	2189	1575	1495	1017	886	879
7b	GP08b	1423	1382	1009	988	891	888
7c	GP08c	1278	1226	991	974	898	892
7d	GP08d	4587	2484	4575	3483	2388	2388
8a	MRST09a	1785	1184	1598	1107	974	887
8b	MRST09b	1382	1226	1149	1052	972	894
8c	MRST09c	1260	1168	1005	960	930	881
9	MR02P	1344	1187	1120	1044	946	875
10a	O12a	1523	1458	1080	1054	1007	932
10b	O12am	1534	1468	1077	1050	1007	932
10c	O12b	1377	1361	1134	1127	1052	958
10d	O12c	1366	1359	1192	1191	1085	981
11	MRST02R4	2360	2358	1879	1819	1786	1780

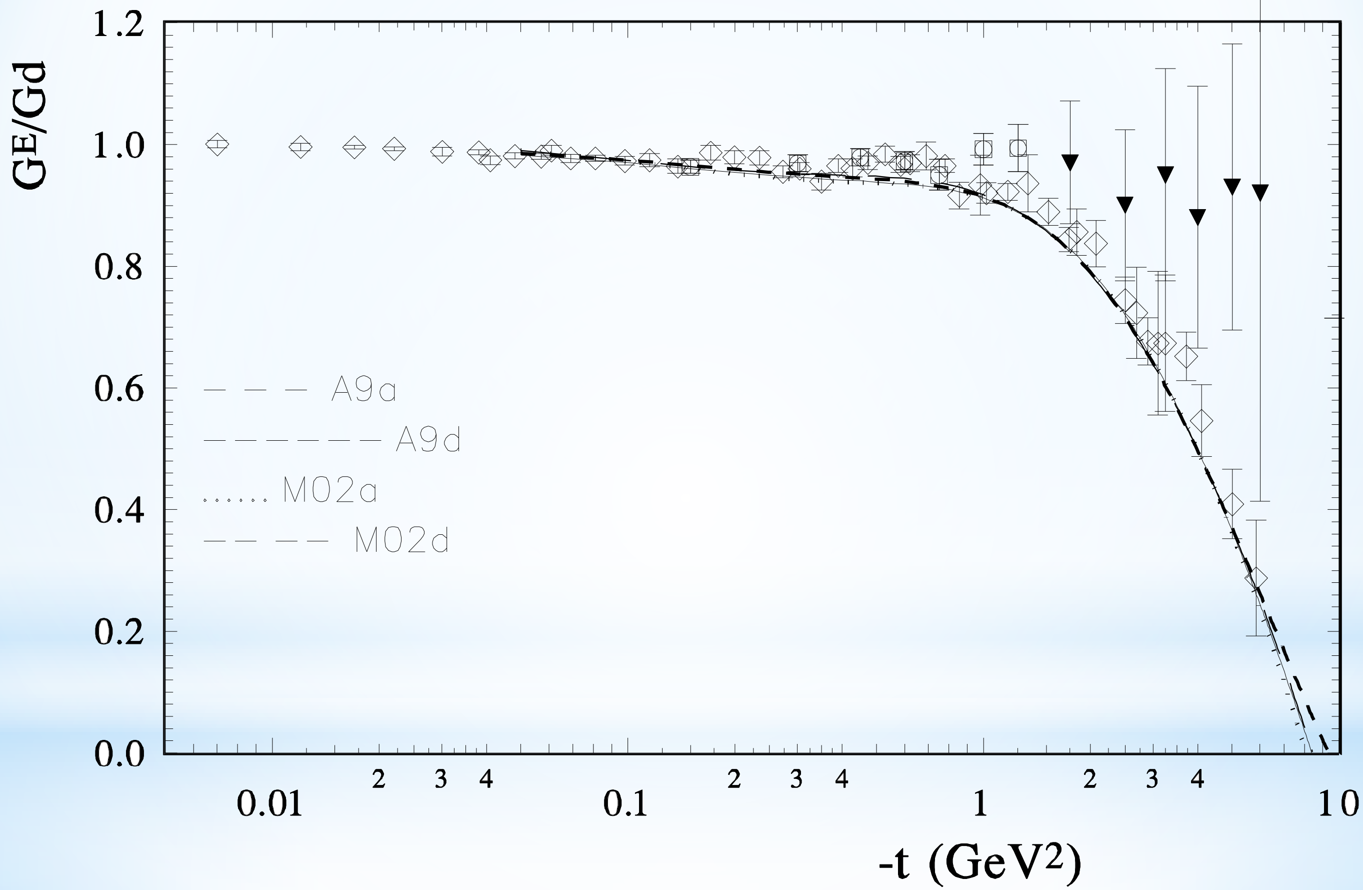


t2F1p
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
25
30
35
-t (GeV2)

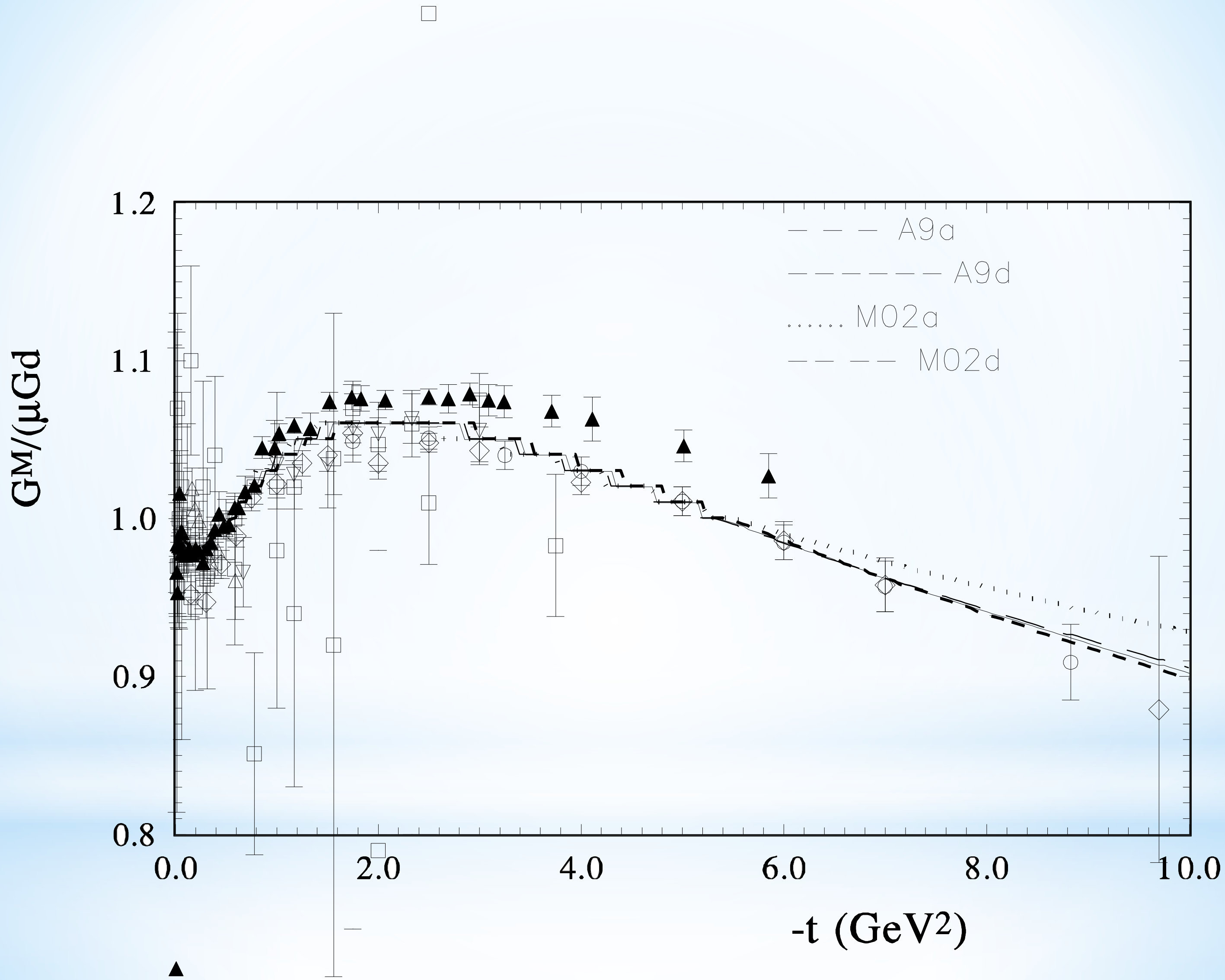


1.0
0.8
0.6
0.4
0.2
0.0
0.00
0.20
0.40
0.60
0.80
1.00
Q2 F2 /(F1 k)
-t (GeV2)
A9a
A9d
M02a
M02d

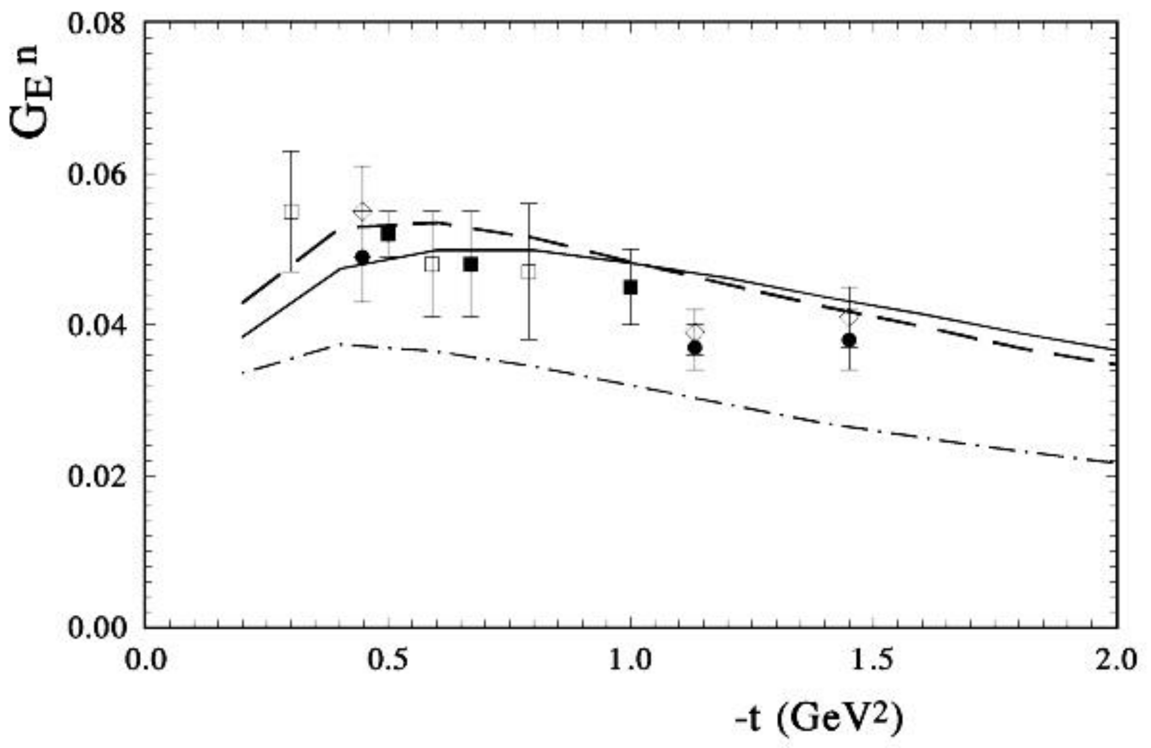
$$G_E^p(t)/Gd(t)$$

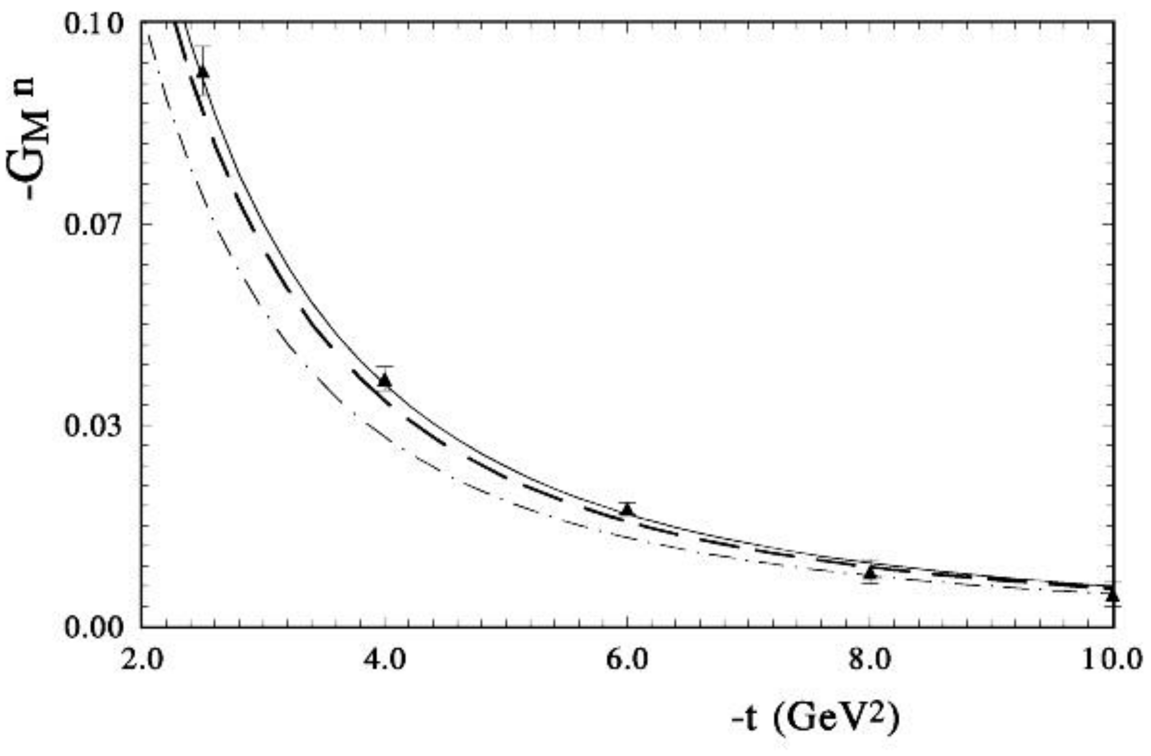


GE/Gd
1.2
1.0
0.8
0.6
0.4
0.2
0.0
A9a
A9d
M02a
M02d
0.01
2
3
4
0.1
2
3
4
1
2
3
4
10
-t (GeV2)


A9a
A9d
M02a
M02d
GM/(μGd
-t (GeV2)
1.2
1.1
1.0
0.9
0.8
0.0
2.0
4.0
6.0
8.0
10.0

* G_{En}

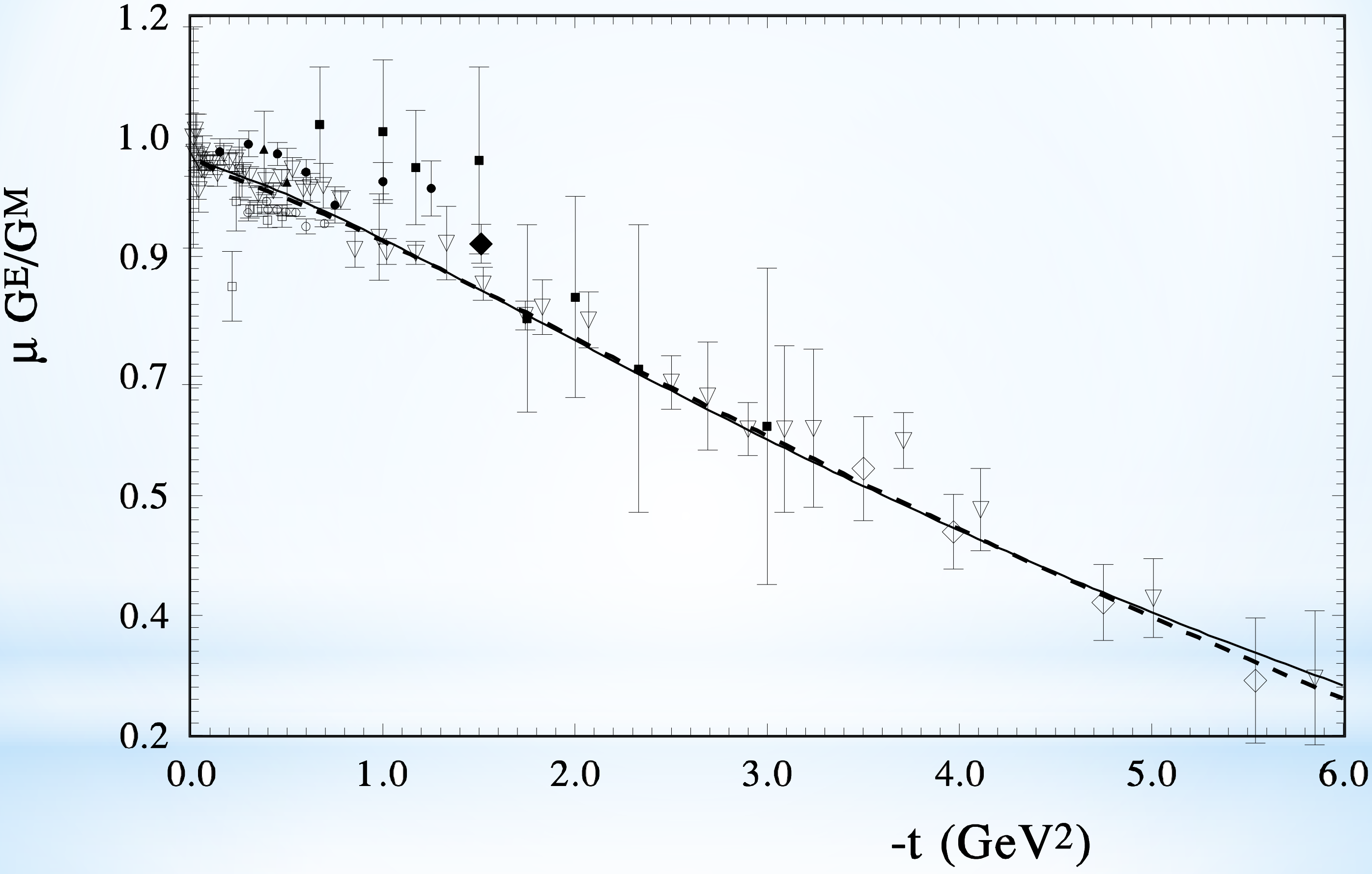




G_{Mn}

muG_{ep}/G_{Mp}

▽



- Form factors in the wide region of t
- (x^{n-1})

(Compton	- zero momentum	- x^{-1}
electromagnetic,	- first momentum	- x^{0}
gravitomagnetic	- second momentum	– x^{1}

Magnetic transition form factor $G_M^*(\gamma^* N\Delta)$

We can also be used to estimate N → Δ transition form factors, provided one can relate the N → Δ transition GPDs.
For the magnetic N → Δ transition form factor G∗M(t), in the large Nc limit, the relevant N → Δ GPD can be expressed in terms of the isovector GPD Eu − Ed, yielding the sum rule

$$G_M^*(t) = \frac{G_M^*(0)}{k_V} \int_{-1}^{1} dx \, \{E^u(x,\xi,t) - E^d(x,\xi,t)\};$$

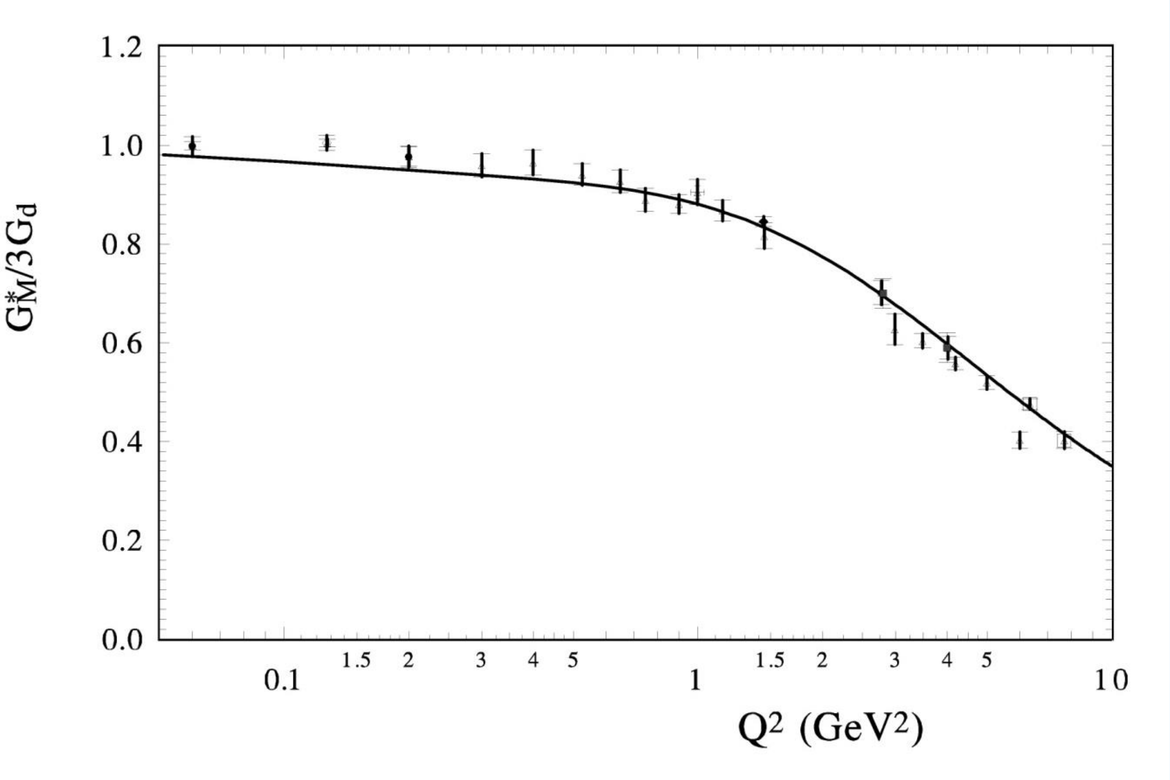
where $k_V = k_p - k_n = 3.70;$ *and* $G_M^*(0) = k_V / \sqrt{3};$

$$E^{u}\left(x,t\right)=u(x)_{E}\exp[2\alpha_{1}(\frac{(1-x)^{p_{1}}}{(x_{0}+x)^{p_{2}}}t];$$

$$E^{d}\left(x,t\right)=d(x)_{E}\exp[2\alpha_{1}(\frac{(1-x)^{p_{1}(*k_{d})}}{(x_{0}+x)^{p_{2}}}+d*x*(1-x)t]$$

All parameters are fixed

$$where\ \ k_{V}=k_{p}-k_{n}=3.70;$$



The Jones-Scadron convention is related to Ash conventional

$$G^{*}_{M,J-S}(Q^2) = G^{*}_{M,Ash}(Q^2)\sqrt{1+\frac{Q^2}{(M+m)^2}};$$

$\gamma p \to \gamma p$

The differential cross section for the unpolarized cross section that reaction can be written as

$$\frac{d\sigma}{dt} = \frac{\pi\alpha_{em}^2}{s^2}\frac{(s-u)^2}{-us}\;[R_V^2(t) - \frac{t}{4m^2}R_T^2(t) + \frac{t^2}{(s-u)^2}R_A^2(t)]$$

where $R_V((t)$, $R_T(t)$, $R_A(t)$ are the form factors given by the 1/x moments of corresponding GPDs $H^q(x,t)$, $E^q(x,t)$, $\tilde{H}^q(x,t)$.

The last is related with the axial form factors.

$$\frac{d\sigma}{dt} = \frac{2\pi\alpha_{em}^2}{s^2}\left[-\frac{u}{s} - \frac{s}{u}\right]\left\{\frac{1}{2}\left(R_V^2(t) + R_A^2(t)\right) - \frac{us}{s^2+u^2}\left(R_V^2(t) + R_A^2(t)\right)\right\}$$

A. Radyushkin (1998)

$$R_A(t) \approx R_V(t)$$

M. Diehle, P. Kroll

$$\frac{R_V(t)}{R_A(t)} = \frac{F_2(t)}{F_1(t)} \approx \frac{2m}{\sqrt{-t}}.$$

S. Alekhin, J. Blumlein, S. Moch, Phys.Rev. D86 (2012)

x q_u=4.649903*$x^{0.712}$)*(1.-x)$^{3.637}$ $x^{0.593*x-3.607*x**2+3.718*x**3}$

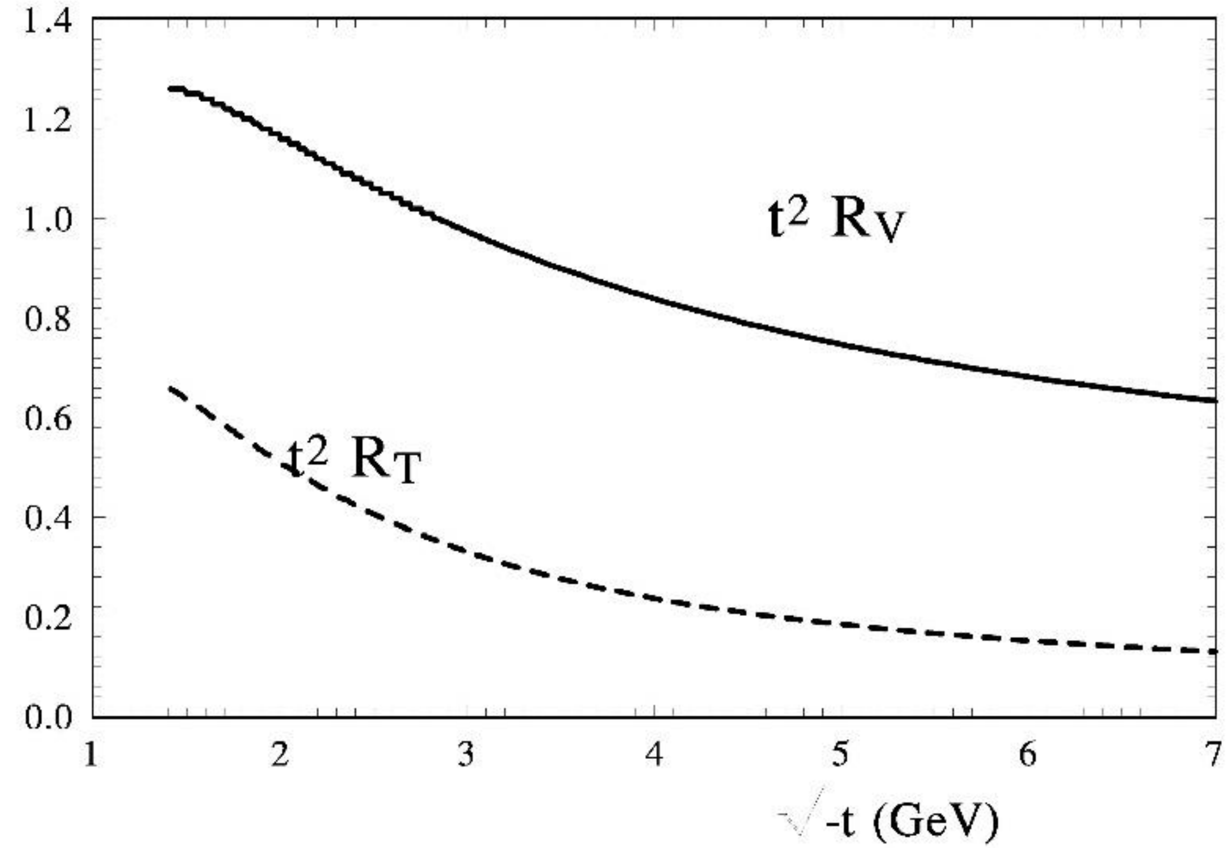
x q_d=3.424394*$x^{0.741}$ (1.-x)$^{5.123}$ $x^{(1.122*x-2.984*x**2)}$

$$R_V(t) = \sum_q e_q^2 \int \frac{dx}{x} dx\ H^q\left(x, \xi = 0, t\right)$$

$$= \frac{dx}{x}\{u(x)\exp[2\alpha_1(\frac{(1-x)^{p_1}}{(x_0+x)^{p_2}}t] + d(x)\exp[2\alpha_1(\frac{(1-x)^{p_1(*k_d)}}{(x_0+x)^{p_2}}t]$$

$$R_T(t) = \sum_q e_q^2 \int \frac{dx}{x} dx\ E^q\left(x, \xi = 0, t\right)$$

$$= \frac{dx}{x}\{u^e(x)\exp[2\alpha_1(\frac{(1-x)^{p_1}}{(x_0+x)^{p_2}}t] + d^e(x)\exp[2\alpha_1(\frac{(1-x)^{p_1(*k_d)}}{(x_0+x)^{p_2}}t]$$



1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1
2
3
4
5
6
7
t2 RV
t2 RT
√-t (GeV)

$$R_A(t) = \sum_q e_q^2 \int \frac{dx}{x} dx \;\tilde{H}^q\left(x, \xi = 0, t\right)$$

F.Taghavi-Shahri, H. Khanpour .. 1603.03157   NNLO Q^2_0=4 GeV^2

$$x\Delta_q(x, Q_0) = N_q\,\eta_q\, x^{\alpha_q}(1-x)^{b_q}(1+c_q x);$$

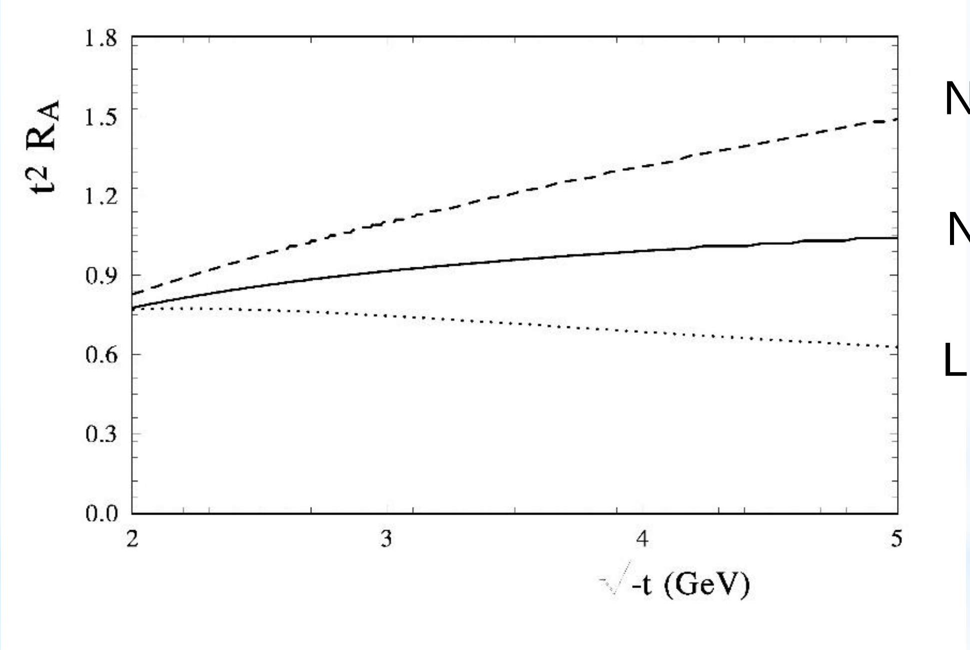
$$1/N_q = (1 + c_q \frac{a_q}{1+a_q+b_q}) B(a_q, b_q+1);$$

$$Euler \quad function \;\; B(a,b) = \Gamma(a)\Gamma(b)/\Gamma(a+b) = \int_0^1 t^{a-1}\,(1-t)^{b-1}\,d\,t;$$

$$SU(3)\; flawor\;\; symmetry \;\; \Delta\bar{q} \equiv \Delta\bar{u} = \Delta\bar{d} = \Delta\bar{s} = \Delta s;$$

$$R_A(t) = \sum_q e_q^2 \int \frac{dx}{x} dx \; \tilde{H}^q\left(x, \xi = 0, t\right)$$

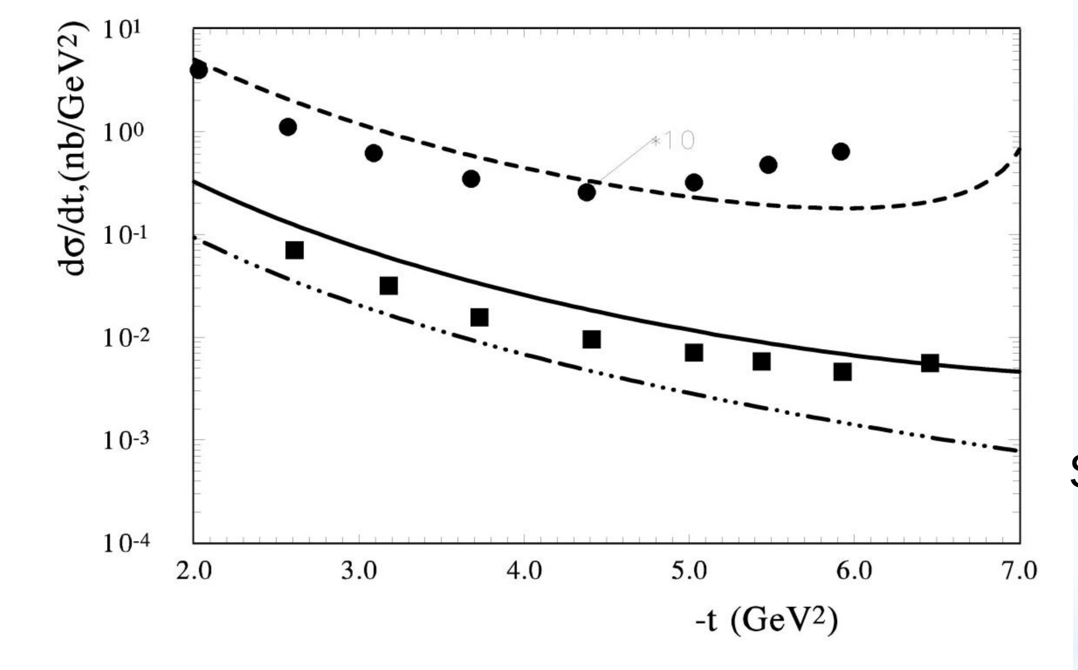
$$= \frac{dx}{x} \{\Delta u^e(x) \exp[2\alpha_1(\frac{(1-x)^{p_1}}{(x_0+x)^{p_2}} t] + \Delta d^e(x) \exp[2\alpha_1(\frac{(1-x)^{p_1(*k_d)}}{(x_0+x)^{p_2}} t]$$



NLO (2016)

NNLO (2016)

LO (2009)

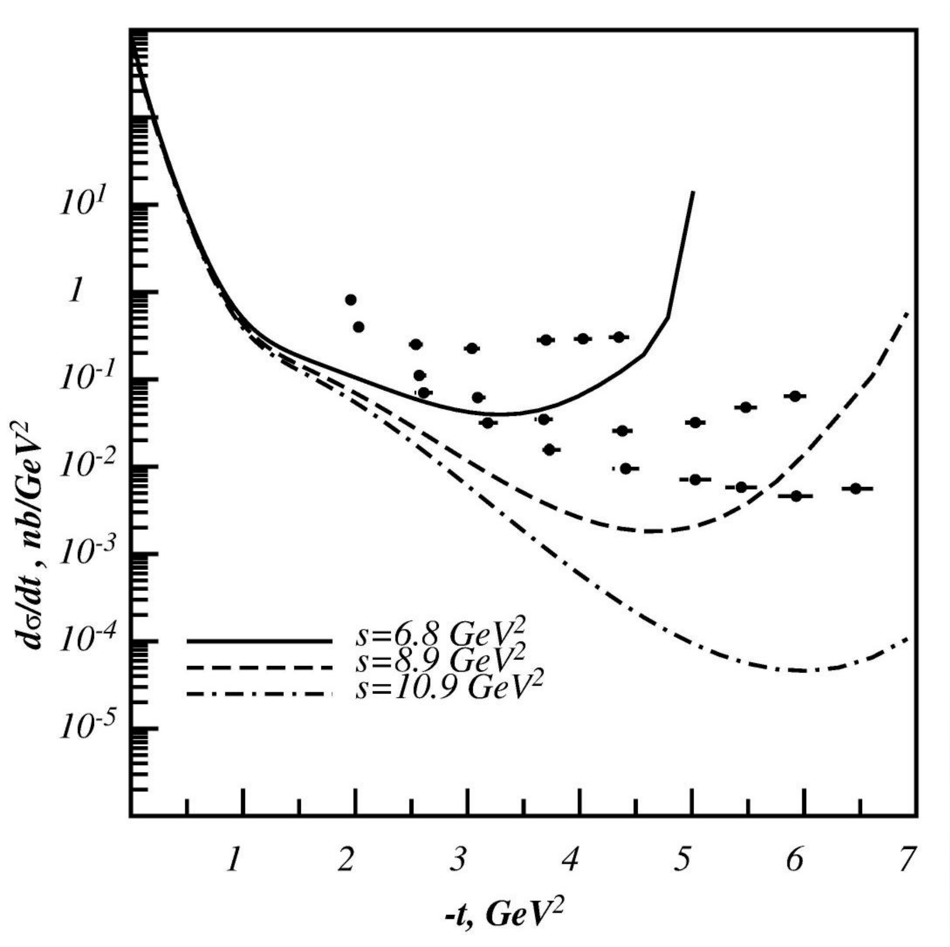


*10 S=8.7 GeV^2

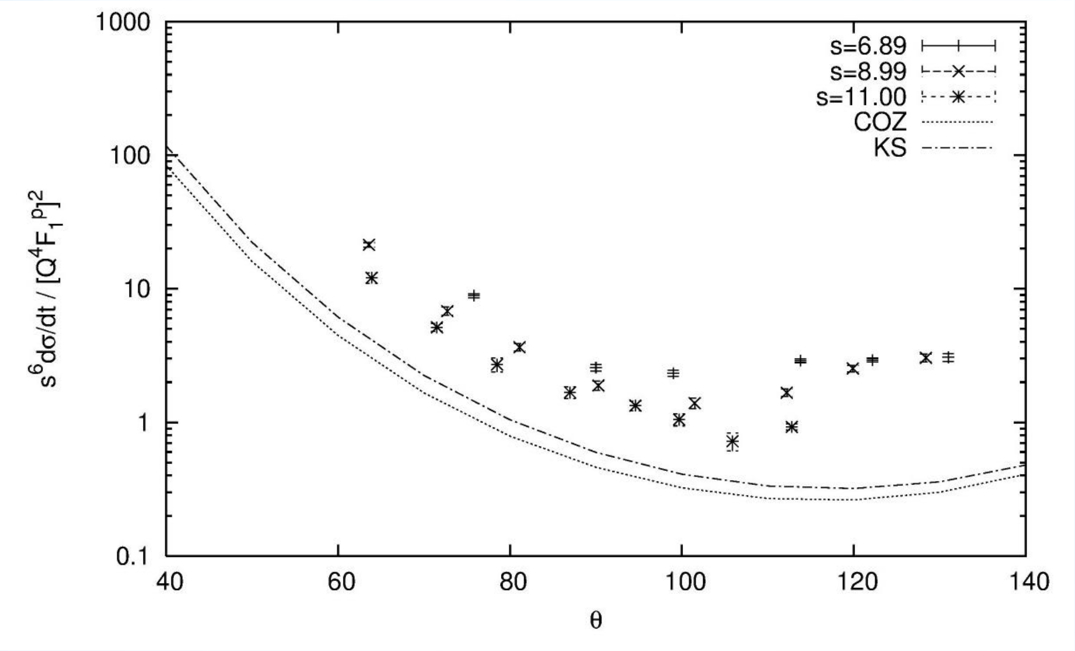
S=10.9 GeV^2

S=20. GeV^2

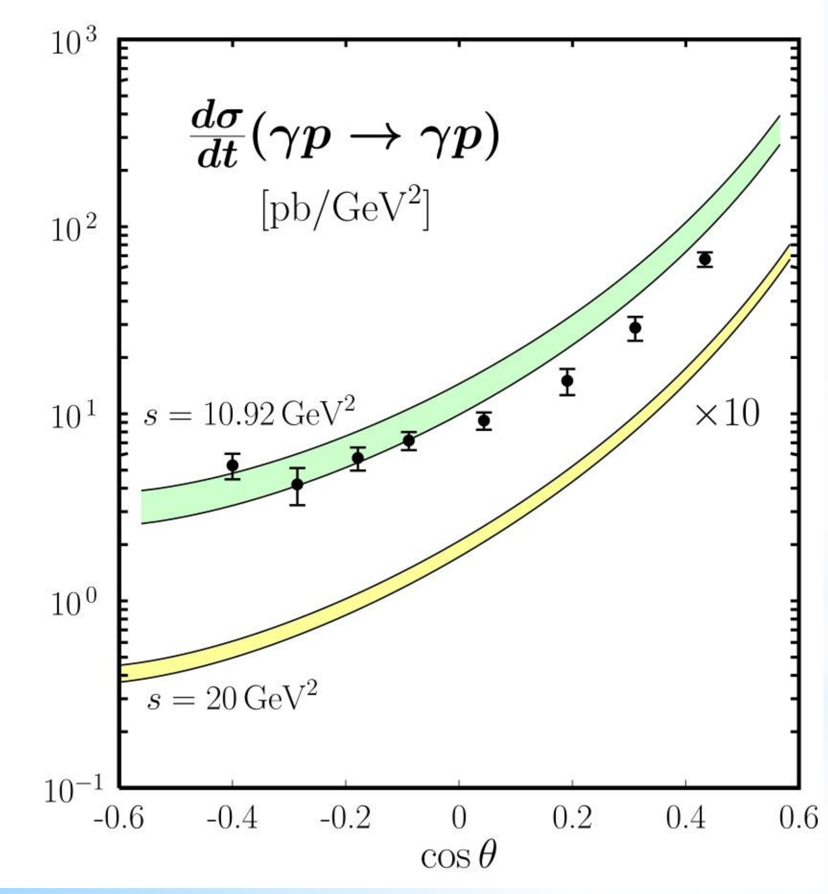
B. Kopeliovich,

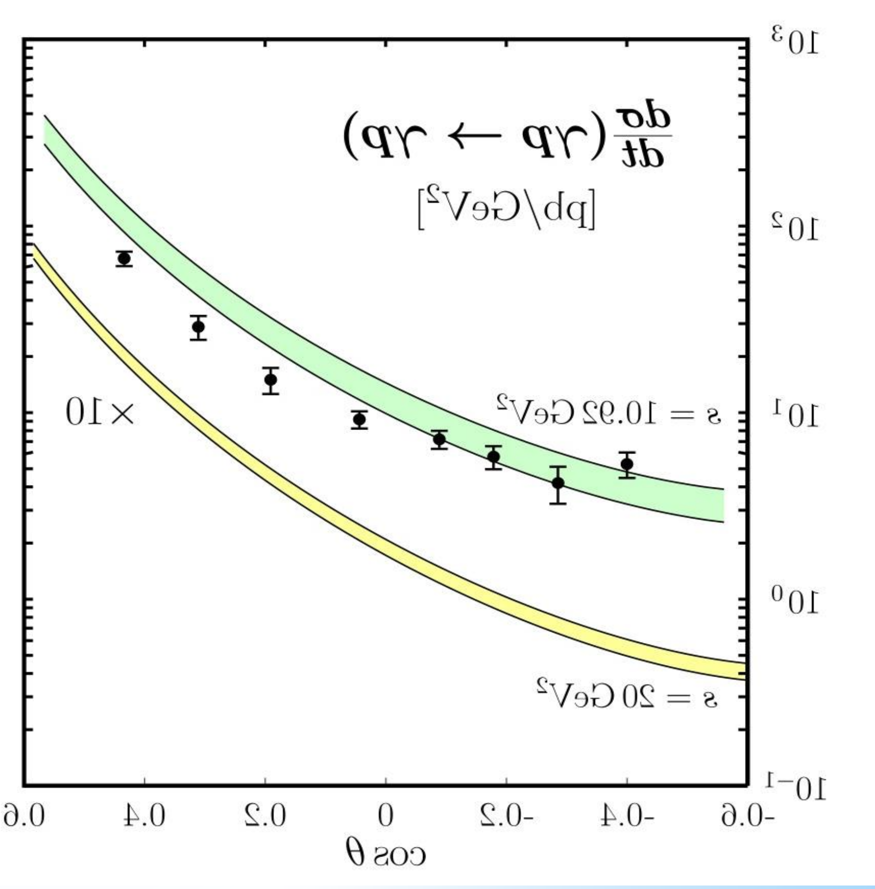


r. Thomson, A. Pang, Ch-R. Ji, Phys.ReV., D73 (2006)



Diehl, P. Kroll (2013)





$pp \to pp$

General Parton Distributions -GPDs

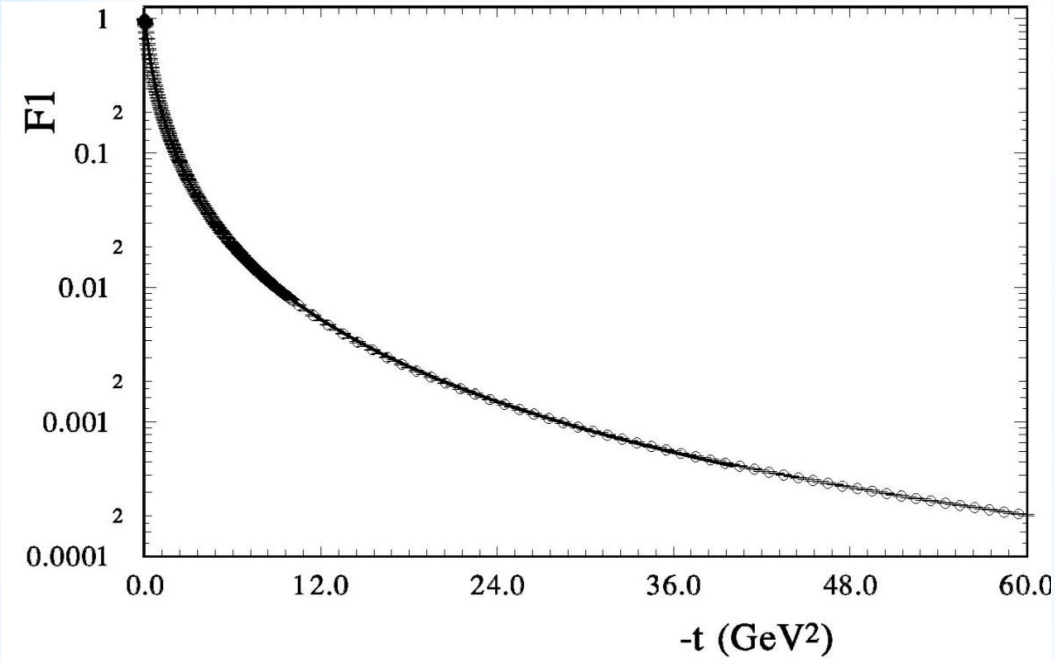
Electromagnetic form factors (charge distribution)

Gravitation form factors (matter distribution)

$$F_1^D(t) = \frac{4M_p^2 - t\,\mu_p}{4M_p^2 - t} G_D(t);$$

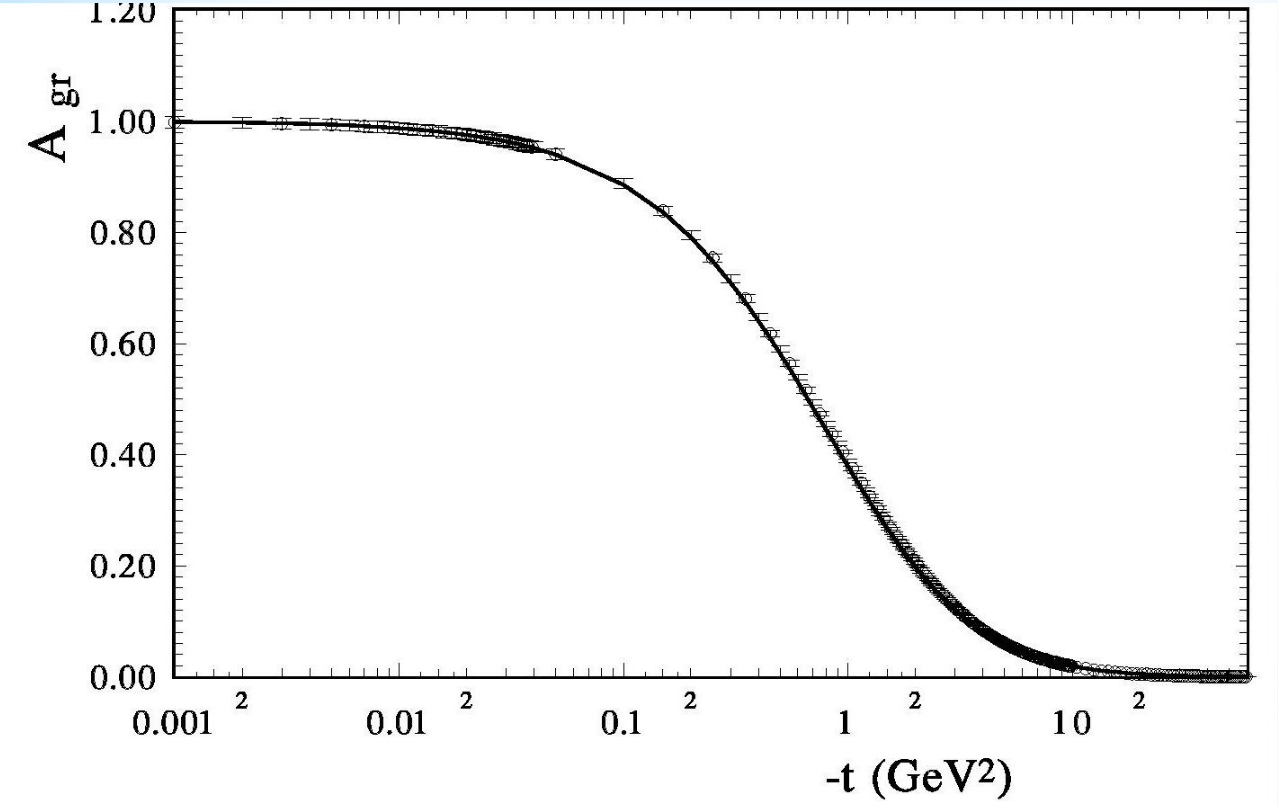
$$G_D(t) = \frac{\Lambda^4}{(\Lambda^2 - t)^2};$$

$$G_A(t) = \frac{\Lambda_A^4}{(\Lambda_A^2 - t)^2};$$



$$G_{em}(t) = \frac{\Lambda_{em}^4}{(\Lambda_{em}^2 + k_1\, q - t + k_2\, \mathrm{q}^3)^2};$$

$$\Lambda_{em}^2 = 0.775\, GeV^2;\ k_1 = 0.06\, GeV;\ k_2 = 0.08\, GeV^{-1};$$



$$G_A(t) = \frac{\Lambda_A^4}{(\Lambda_A^2 - t)^2}; \qquad \Lambda_A^2 = 1.6 \pm 0.05\ GeV^2;$$

Elastic scattering amplitude

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

$$\frac{d\sigma}{dt} = 2\pi[|\Phi|_1^2 + |\Phi|_2^2 + |\Phi|_3^2 + |\Phi|_4^2 + 4|\Phi|_5^2]$$

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

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

$\gamma = 0,577...$ (*the Euler constant*) $\qquad$ ν_1 *and* ν_2 *are small correction terms*

Extending of model (HEGS)

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

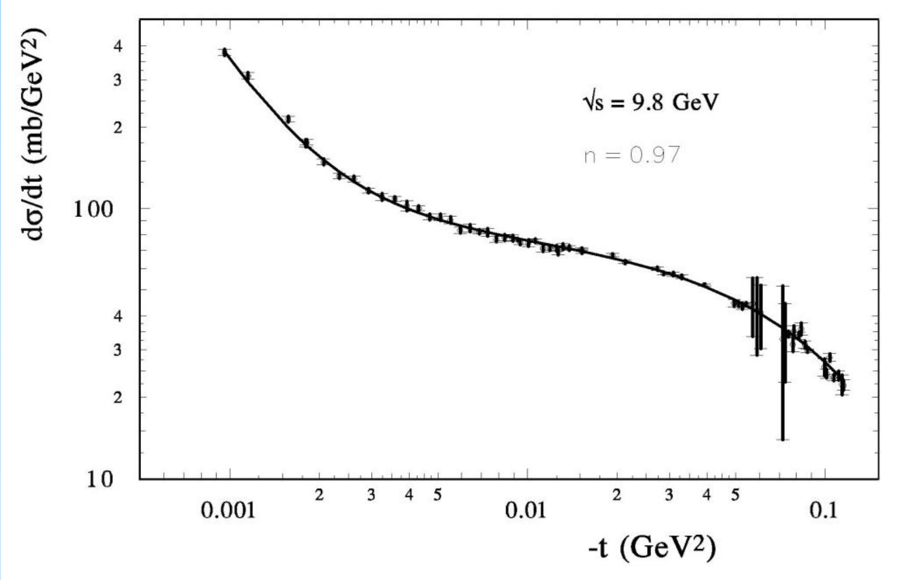
$$9 \le \sqrt{s} \le 8000\, GeV; \quad 0.00037 < |t| < 15\ GeV^2; \qquad s_0 = 4m_p^2.$$

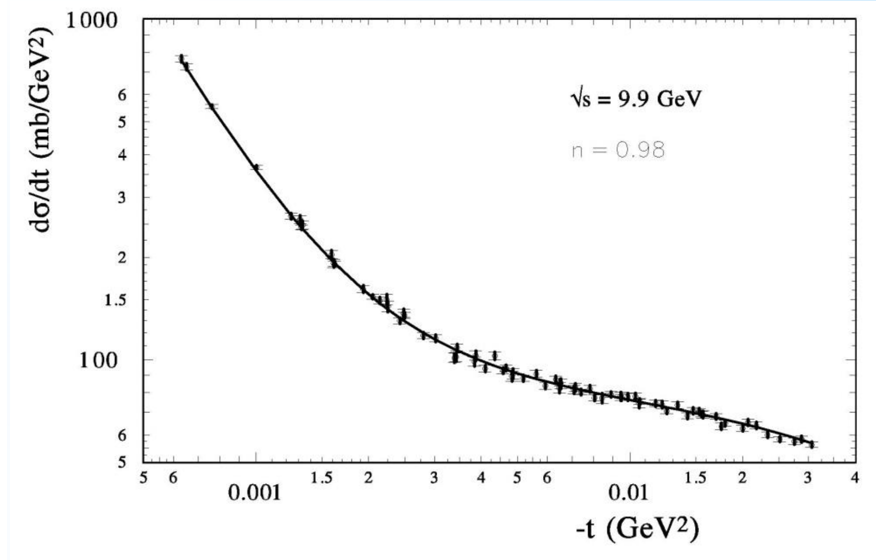
$$F_1^B(s,t) = h_2 G_{em}(t)\ (\hat{s})^{\Delta_1} e^{\alpha_1 t \ln(\hat{s})}; \quad F_3^B(s,t) = h_3 G_A(t)^2\ (\hat{s})^{\Delta_1} e^{\alpha_1/4t \ln(\hat{s})};$$

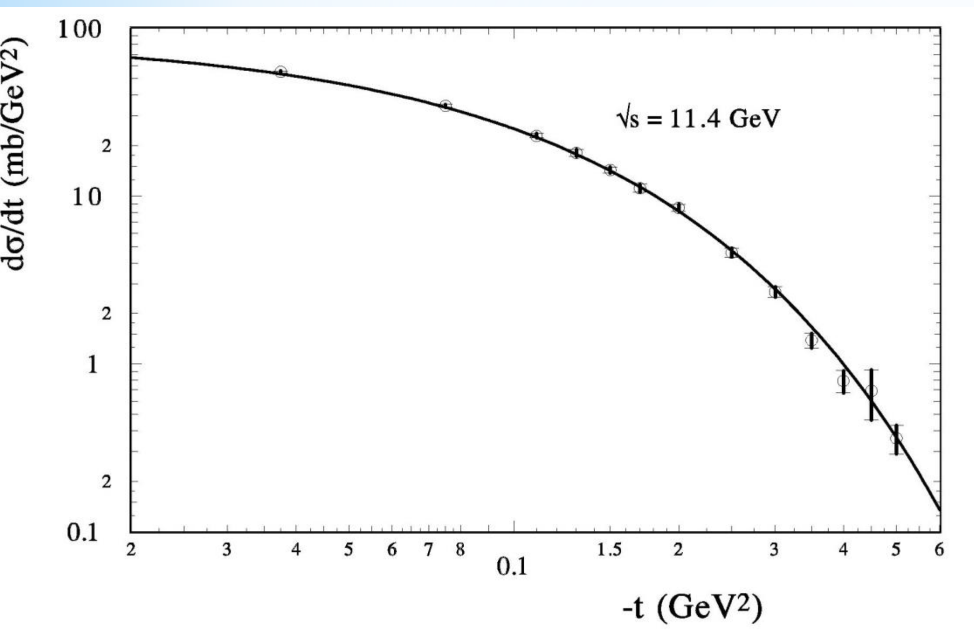
$$F^B(\hat{s},t) = F_2^B(\hat{s},t)(1 + R_1/\sqrt{\hat{s}}\ )]\ + F_3^B(\hat{s},t)(1 + R_2/\sqrt{\hat{s}}\ )]$$
$$+\ F_{odd}^B(s,t);$$

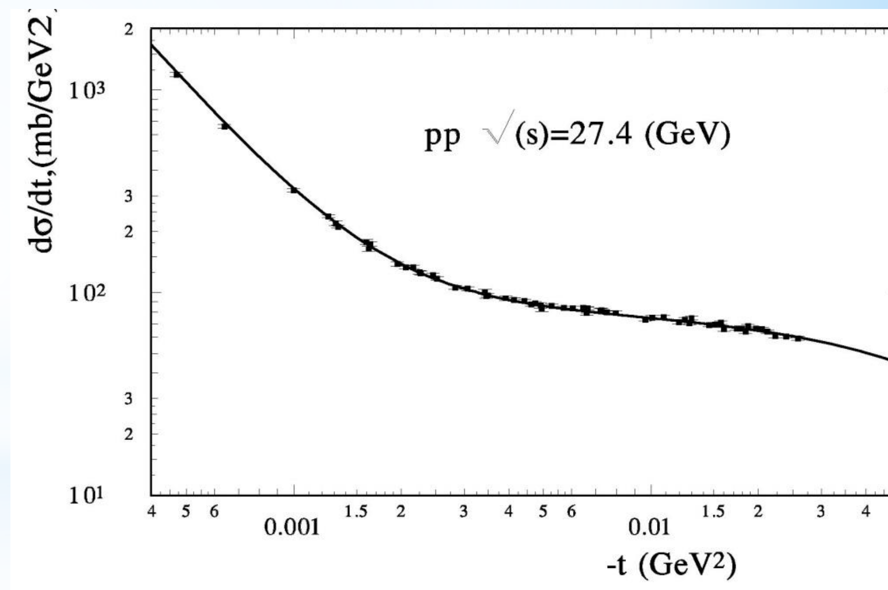
$$F_{Odd}^B(s,t) = h_{Odd}\ G_A(t)^2\ (\hat{s})^{\Delta_1}\ \frac{t}{1 - r_o^2 t} e^{\alpha_1/4t \ln(\hat{s})};$$

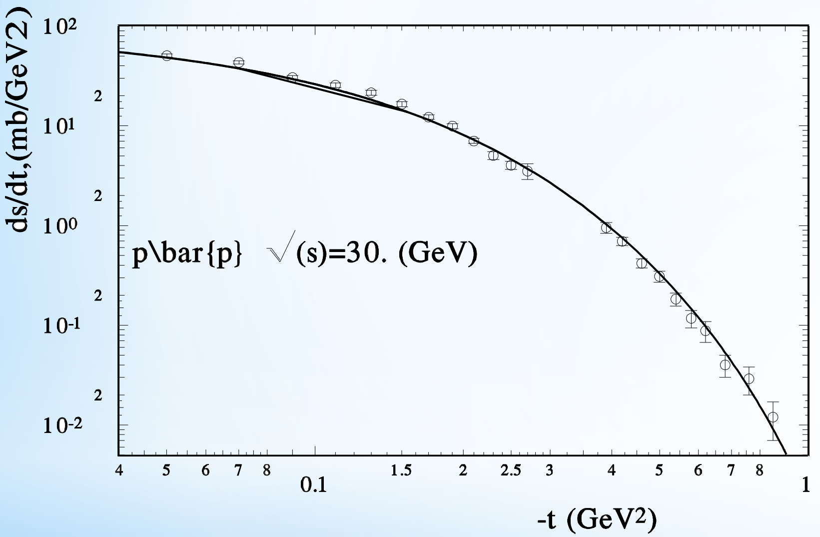
$$B(t) = (\alpha_1 + k_0\, q\, e^{k_0 t \ln\hat{s}}\ ) \ln \hat{s}. \qquad F^{+-}(s,t) = h_{sf}\ q^3\ G_{em}(t)^2;$$


dσ/dt (mb/GeV2)
√s = 9.8 GeV
n = 0.97
-t (GeV2)

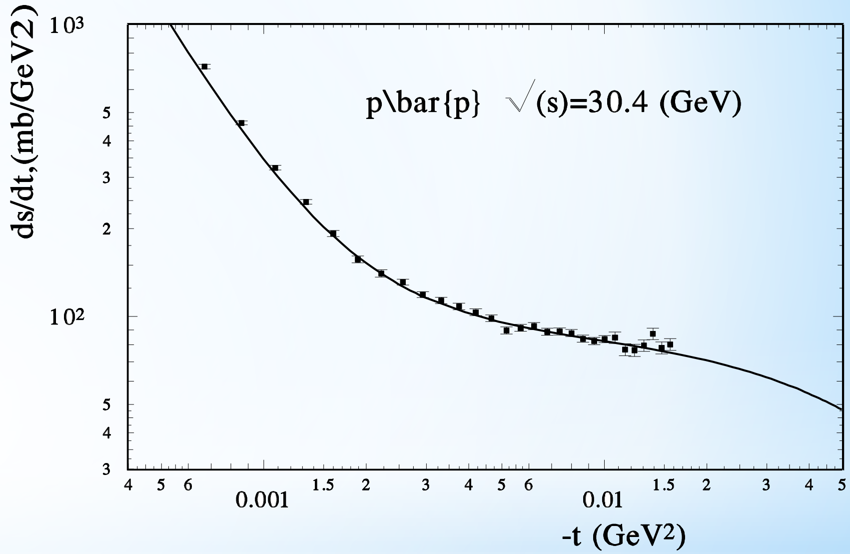

dσ/dt (mb/GeV2)
√s = 9.9 GeV
n = 0.98
-t (GeV2)


dσ/dt (mb/GeV2)
√s = 11.4 GeV
-t (GeV2)

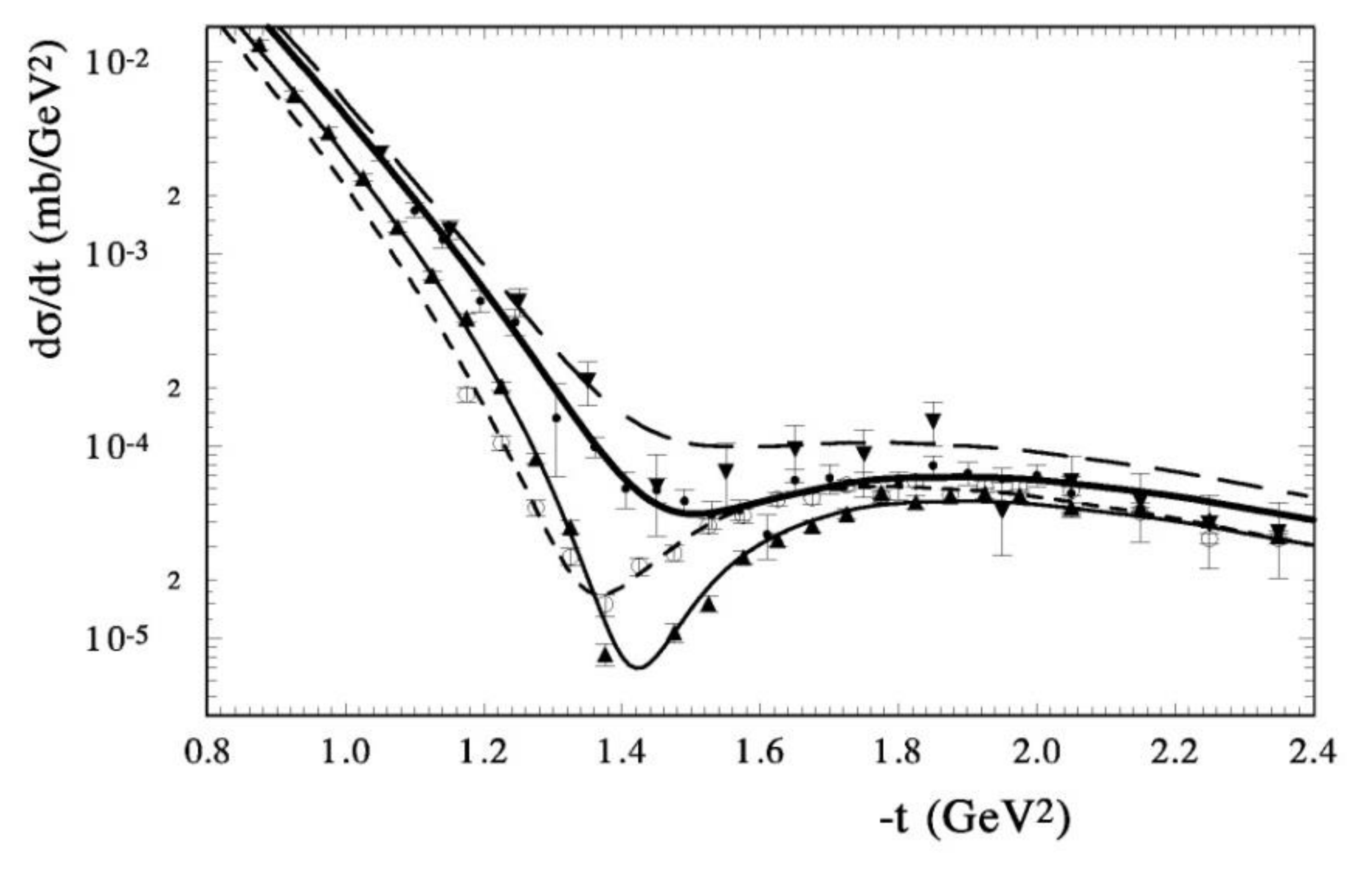

dσ/dt,(mb/GeV2)
pp √(s)=27.4 (GeV)
-t (GeV2)



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)



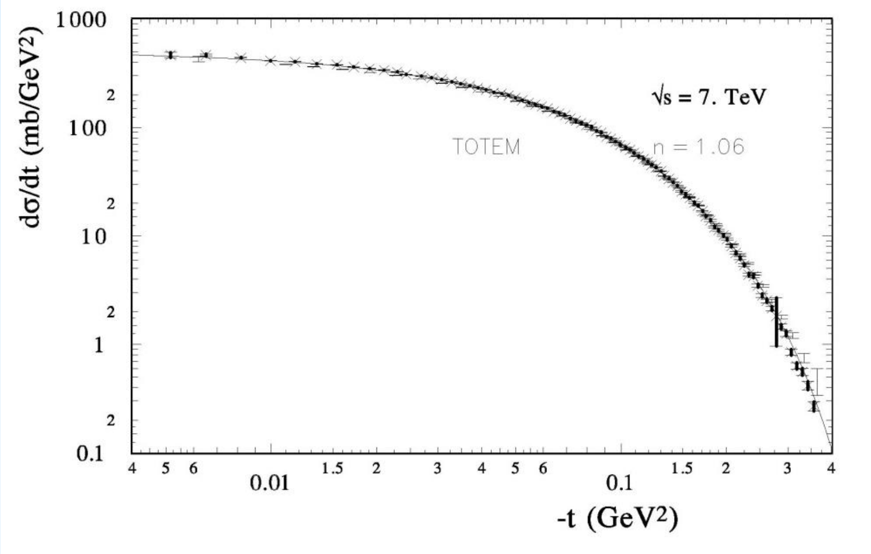
$\sqrt{s} = 9.8\,GeV$

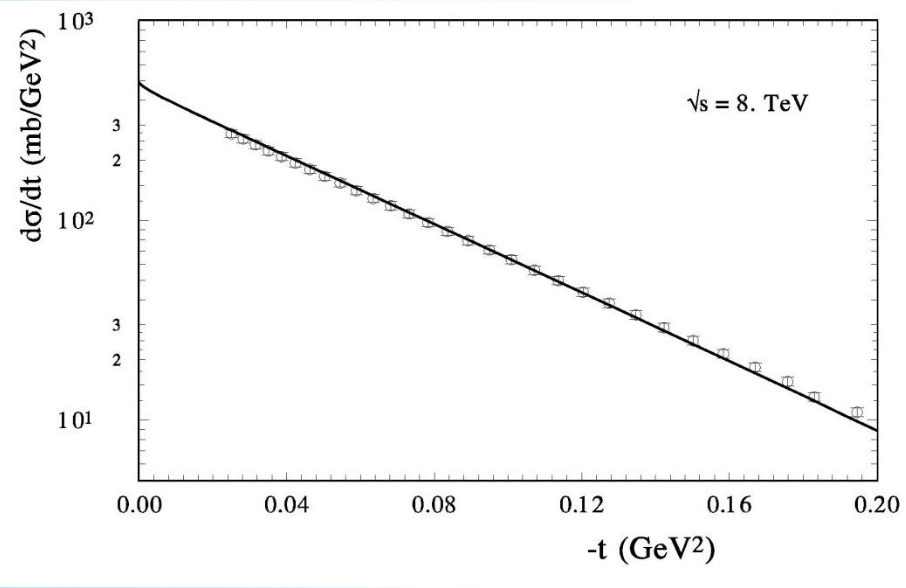
$\sqrt{s} = 13.7\,GeV$

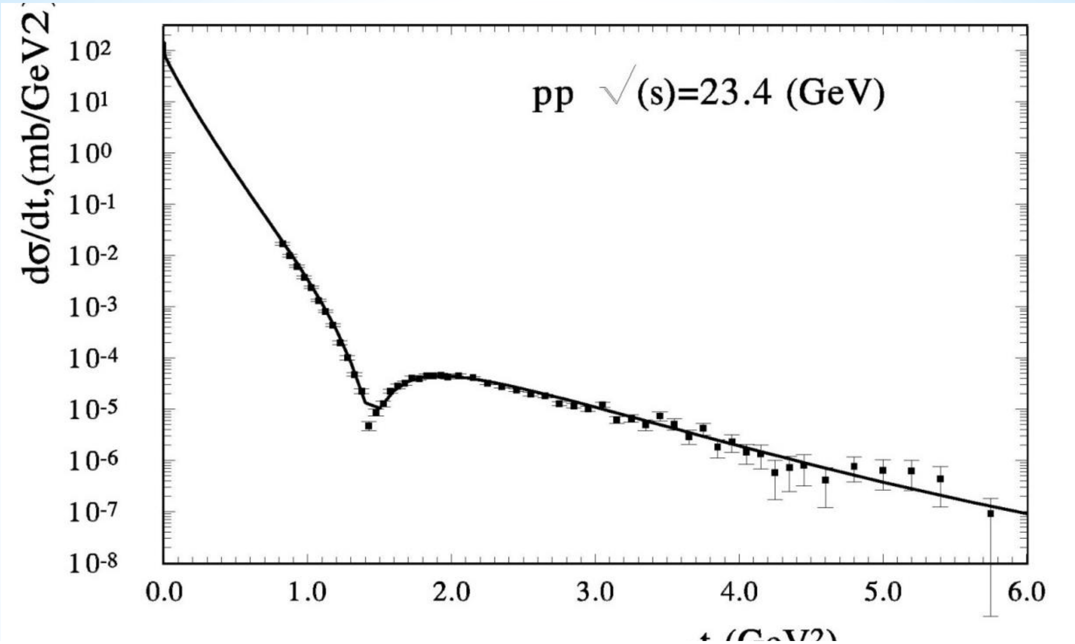
$\sqrt{s} = 30.4\,GeV$

$\sqrt{s} = 44.8\,GeV$

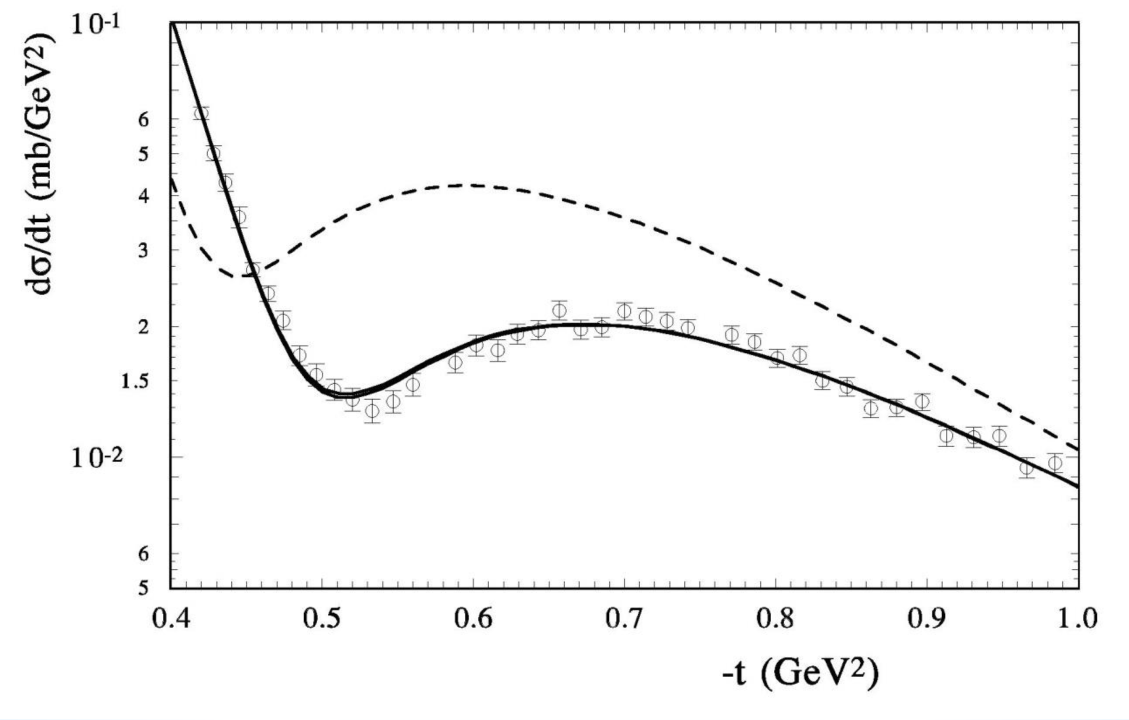
TOTEM 7TeV







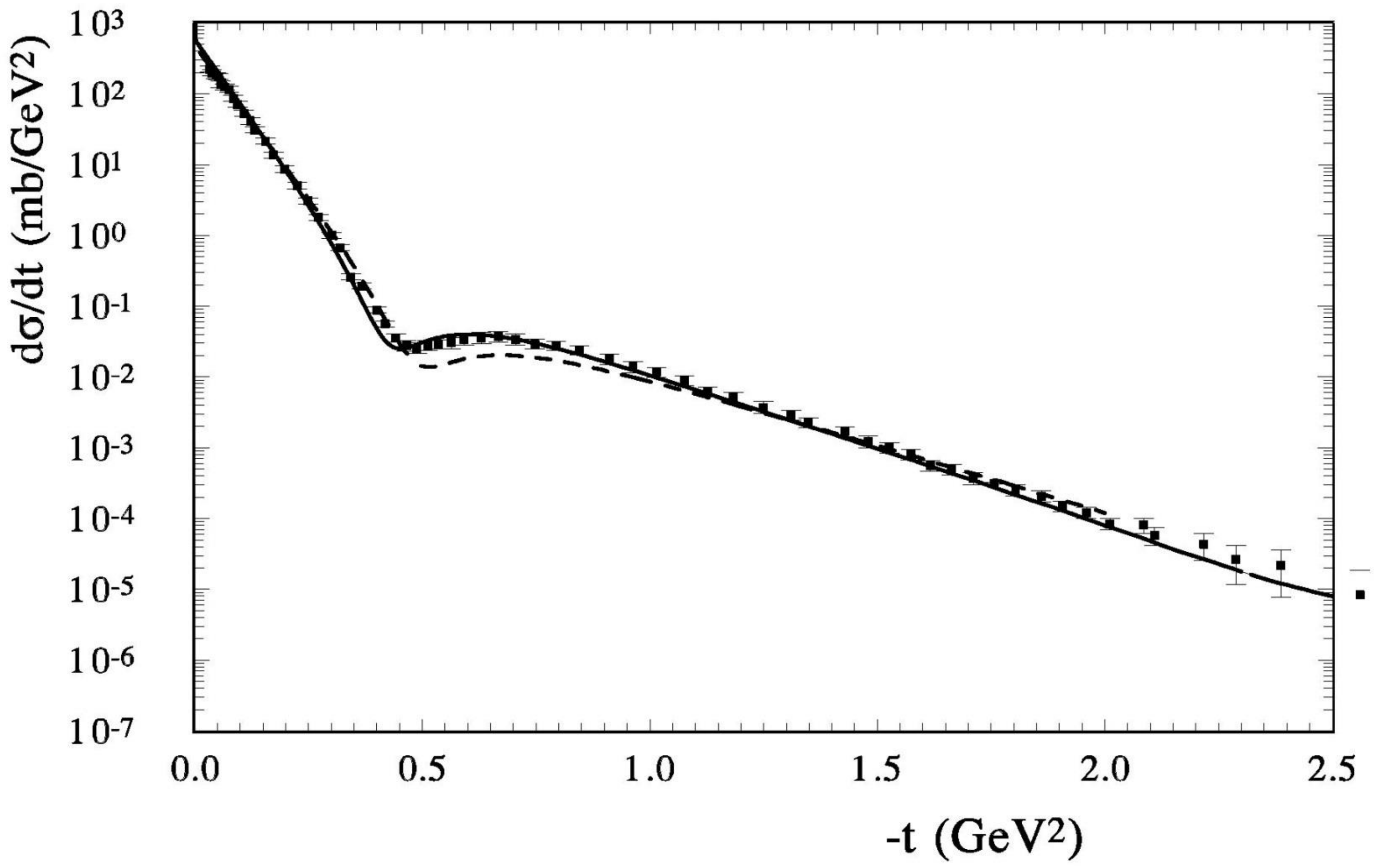
pp √(s)=23.4 (GeV)
dσ/dt,(mb/GeV2)
-t (GeV2)



dσ/dt (mb/GeV2)
-t (GeV2)

O.V. S. Nucl.Phys. A,959 (2017); arxiv: 1609.08847

13 TeV (line and points) and 7 TeV – dashed line

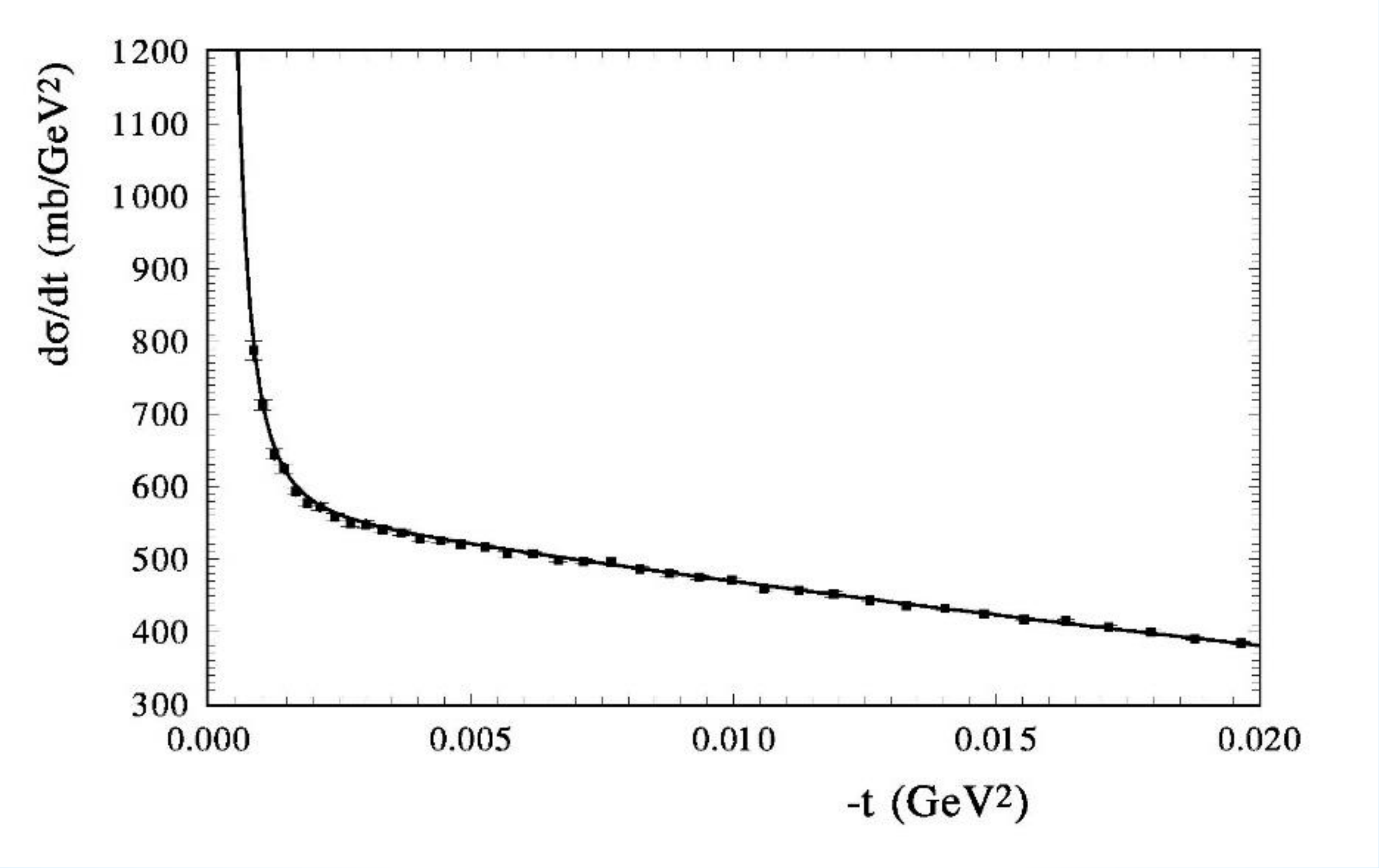


(The normalization of the 13 TeV data on the model calculations)

13 TeV (TOTEM) - (**Mario Deile** "EDS(Blois)-17, Prague, *June 26-30, 2017*)
+ HEGS model predictions O.V. S. Nucl.Phys. A,959 (2017); arxiv: 1609.08847

t [0.0008 – 0.019] n=0.9

$\sqrt{s}$ = 13 TeV, β* = 2500 m



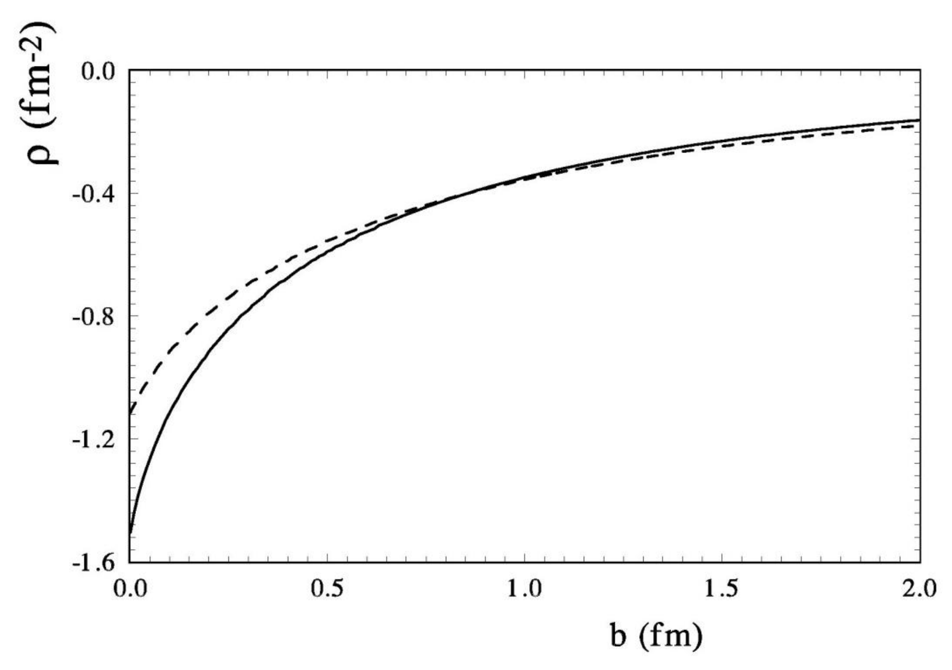
M. Burkardt, Phys.Rev. D74 (2006)

O.V.S., O. Terayev, Phys.Rev.D79:033003,2009

$$\rho(\vec{b}) = \sum_q e_q \frac{1}{2\pi} \int_{\infty}^{0} d^2 q \exp[i \vec{q}\, \vec{b}] \int_0^1 d x\, H_q(x, t, \xi = 0).$$

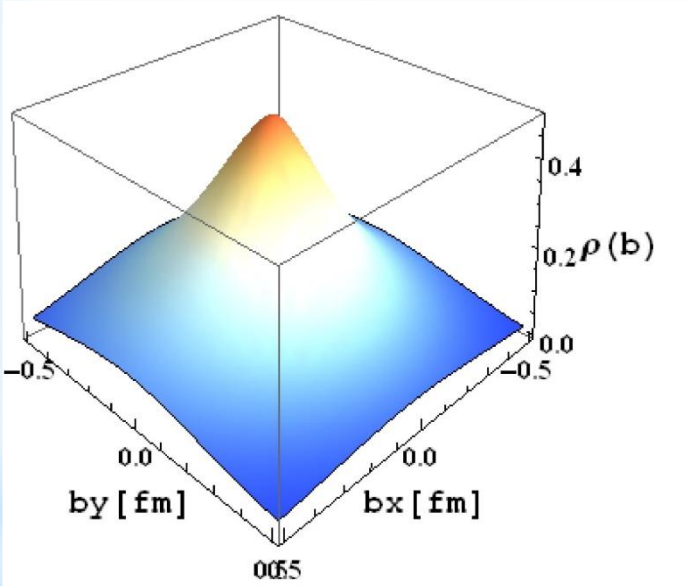
$$\rho_{G_E}(\vec{b}) = \frac{1}{2\pi} \int_0^{\infty} q\, d q\, J_0(q\, b) G_E(q^2)$$

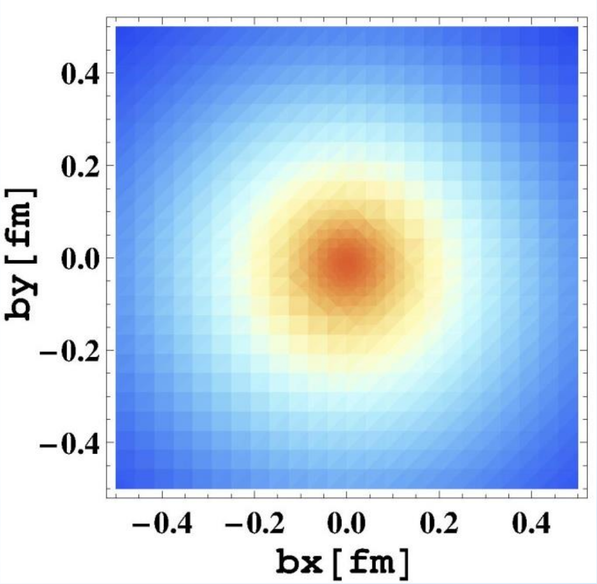
The contribution in the density of the neutron
u-quark (hard line) and (- d) – quark (dashed line)



Quark transverse charge density of the proton

$$\rho_T^N(\vec{b}) = \rho_0^N(\vec{b}) + Sin(\phi)\frac{1}{2\pi}\int_0^\infty dq\,\frac{q^2}{2M_N}J_1(qb)\;F_2(q^2))$$

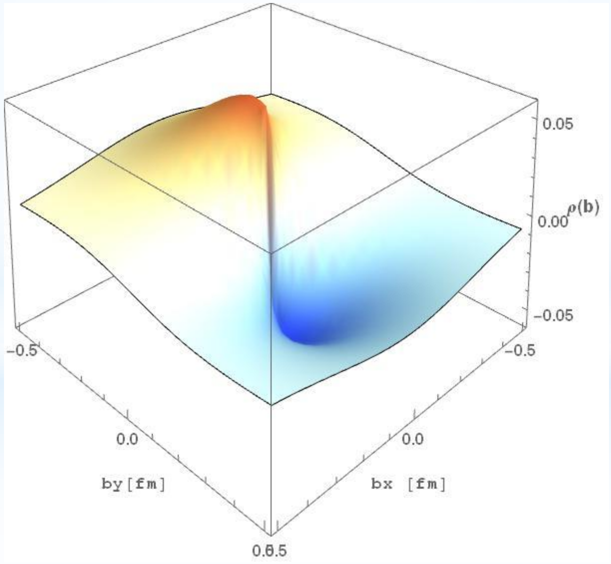


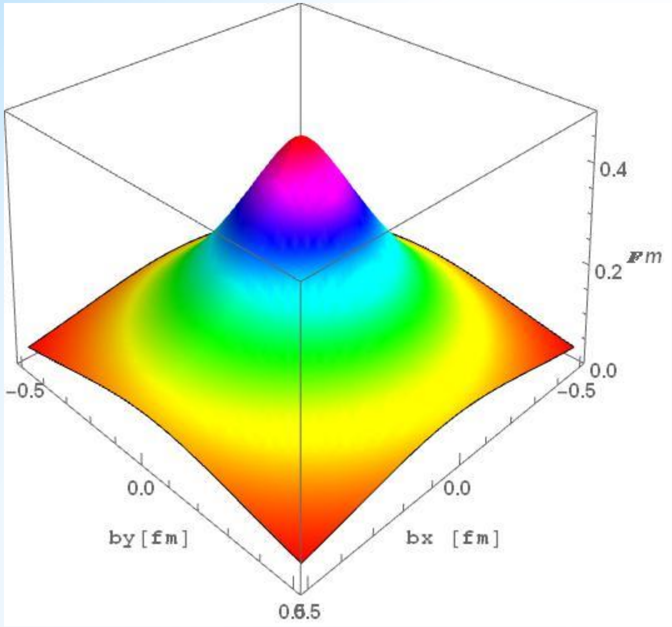


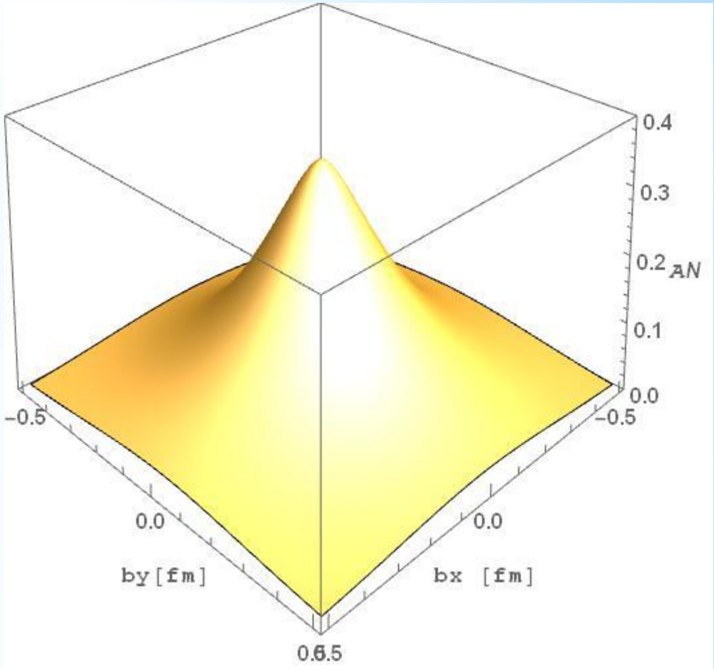
Angular-dependent contribution to quark transverse density of the proton

$$\Delta\rho(\vec{b}) = \rho_T^p(\vec{b}) - \rho_0^p(\vec{b});$$

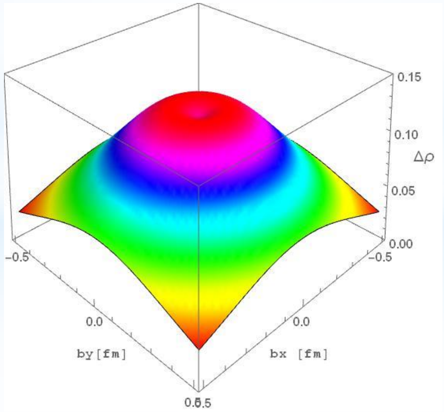
$$Sin(\phi)\frac{1}{2\pi}\int_0^\infty dq\,\frac{q^2}{2M_N}J_1(qb)\;F_2(q^2)\bigg)$$







$$\Delta\rho(\vec{b}) = F_1(\vec{b}) - A(\vec{b});$$



$$\langle r_{em}^2 \rangle \approx -\frac{6}{G(0)}\frac{dG}{dt} \approx \frac{1}{L_{em}^2}; \qquad \langle r_{gr}^2 \rangle \approx -\frac{6}{A(0)}\frac{dA}{dt} \approx \frac{1}{L_{gr}^2};$$

$$L_{em}^2 = 0.71 \ GeV^2; \quad L_{gr}^2 = 1.6 \ GeV^2$$

$$\frac{r_{em}}{r_{gr}} \approx \sqrt{\frac{1/L_{em}^2}{1/L_{gr}^2}} \approx 1.5;$$

Summary

* The GPDs reflect the basic properties of the hadron structure and gave some bridge between the many different reactions.

- The new form of the t-dependence of GPDs allow to obtain the different form factors, including Compton form factors, electromagnetic form factors, transition form factor, gravitomagnetic form factor.

- The our model GPDs leads to the well description of the proton and neutron electromagnetic form factors simultaneously.

* The compare the calculations and full row of the data shows the preference the "Polarization" case.

Summary

- In result, the description of the different reaction based on the same representation of the hadron structure.

- Especially it is concern the high energy elastic hadron scattering

* 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.

  The predictions of the model based on the obtained electromagnetic and gravitomagnetic form factors, good coincide with the preliminary data at 13 TeV.

- The investigation of the nucleon structure show that the density of the matter more concentrated into nucleon than the charge density.

* The model open the new way to determine the true form of the GPDs and standard parton distributions

Thanks for your attention