

A CERN LHC TOTEM KÍSÉRLETÉNEK LEGÚJABB FELFEDEZÉSEI

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Bevezetés: Diffrakció

Hofstadter eredményei

Új képképzési módszer:
Lévy sorfejtésről dióhéjban

TOTEM/LHC p+p @ 7 és 13 TeV
p+p @ 23, 30, 45, 53, 62 GeV

Proton-proton és proton-antiproton
rugalmas ütközések

Páratlan felfedezés: Odderon
Páros felfedezés: struktúrák a protonban

[arxiv:1807.02897](https://arxiv.org/abs/1807.02897)

Ma (2018.07.10-én) jelent meg, 71 oldal, 41 ábra

Diffrakció – R. Hofstadter, Nobel-díj (1961)

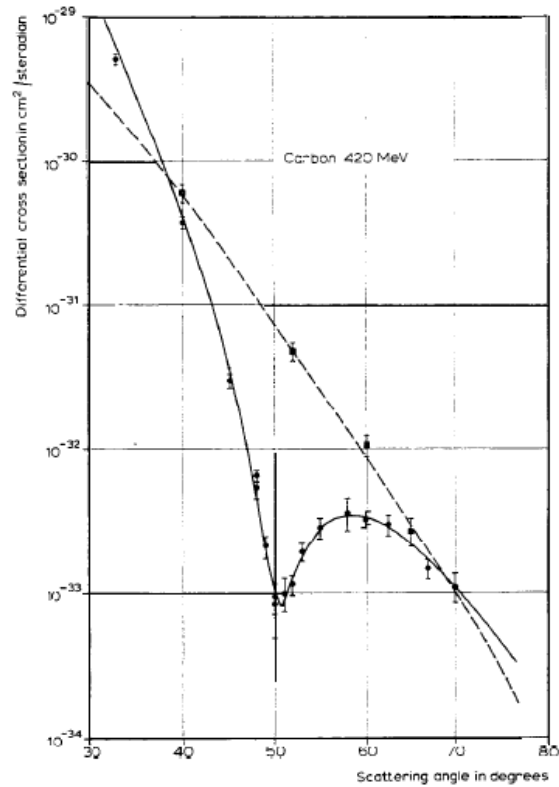
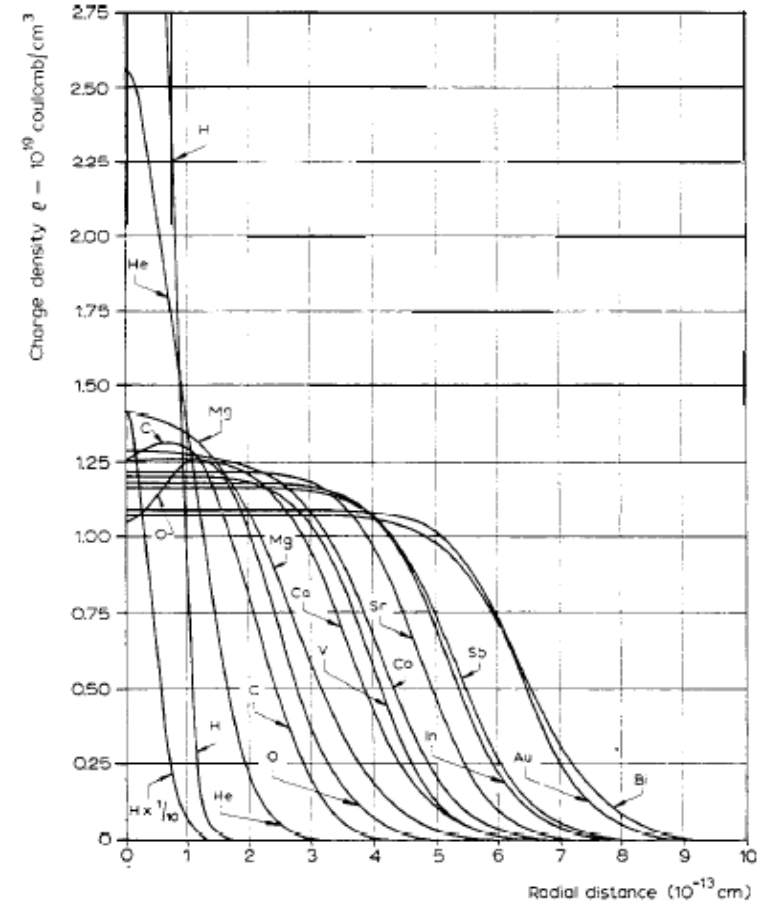


Fig. 5. This figure shows the elastic and inelastic curves corresponding to the scattering of 420-MeV electrons by ^{12}C . The *solid circles*, representing experimental points, show the elastic-scattering behavior while the *solid squares* show the inelastic-scattering curve for the 4.43-MeV level in carbon. The *solid line* through the elastic data shows the type of fit that can be calculated by phase-shift theory for the model of carbon shown in Fig. 8.

570

1961 R. HOFSTADTER



e+A: atommagokon rugalmasan szóródó elektronok szögeloszlásai

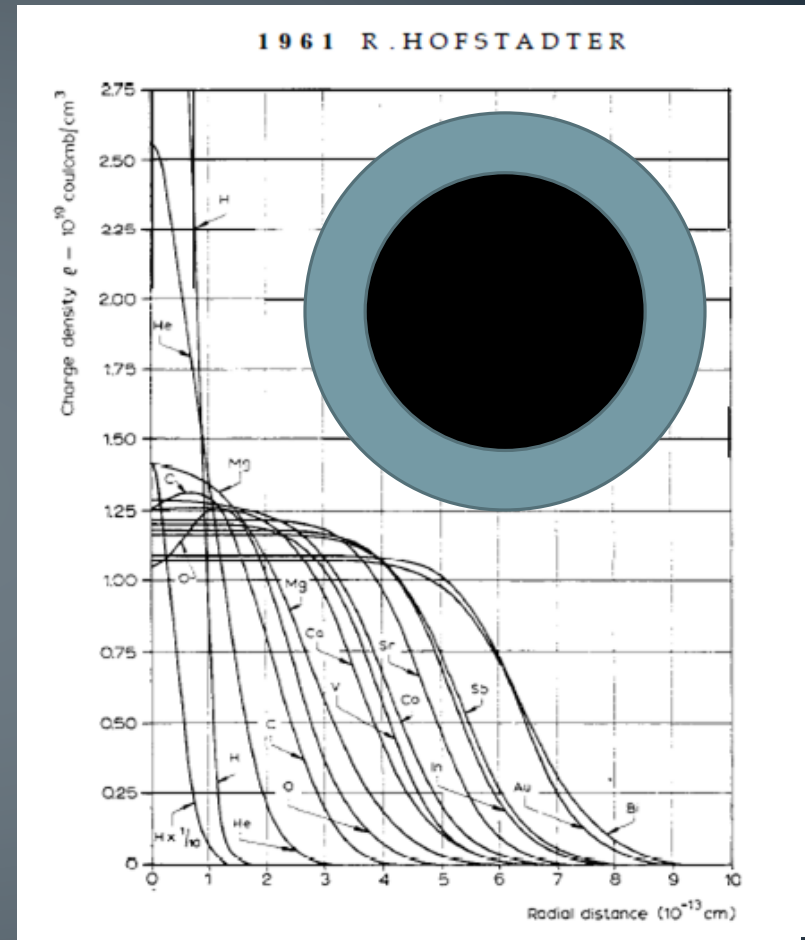
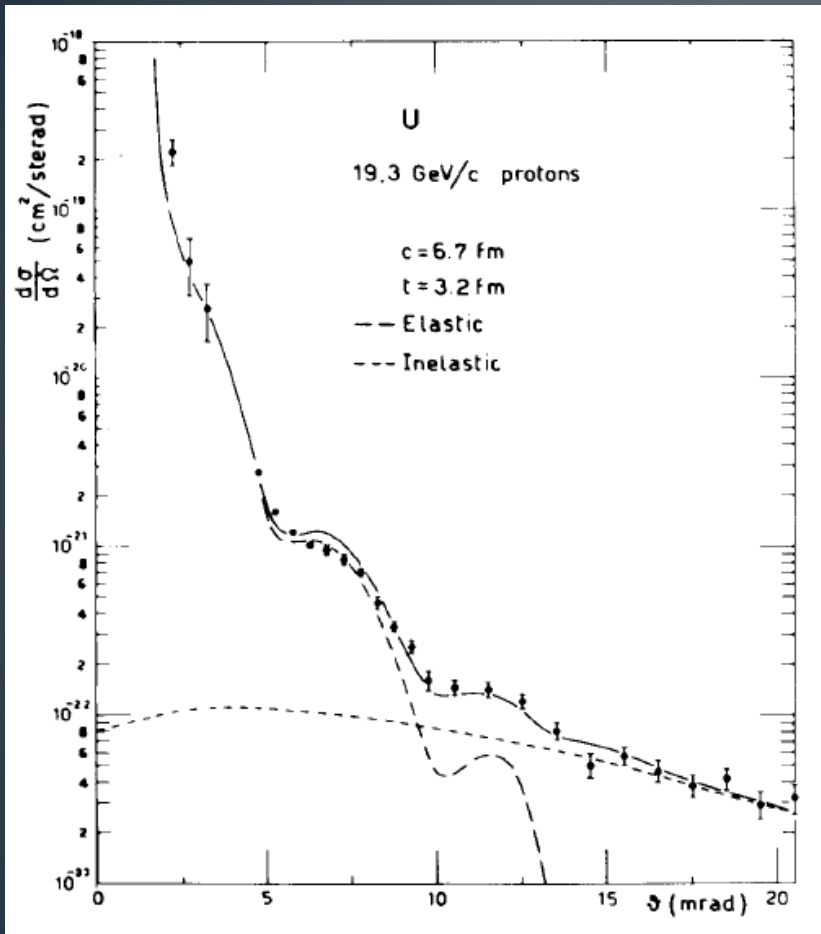


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Gömb alakú atommagok elektromos töltéseloszlásai

$p+A \rightarrow p+A$

Glauber és Matthiae, NPB21 (1970) 135

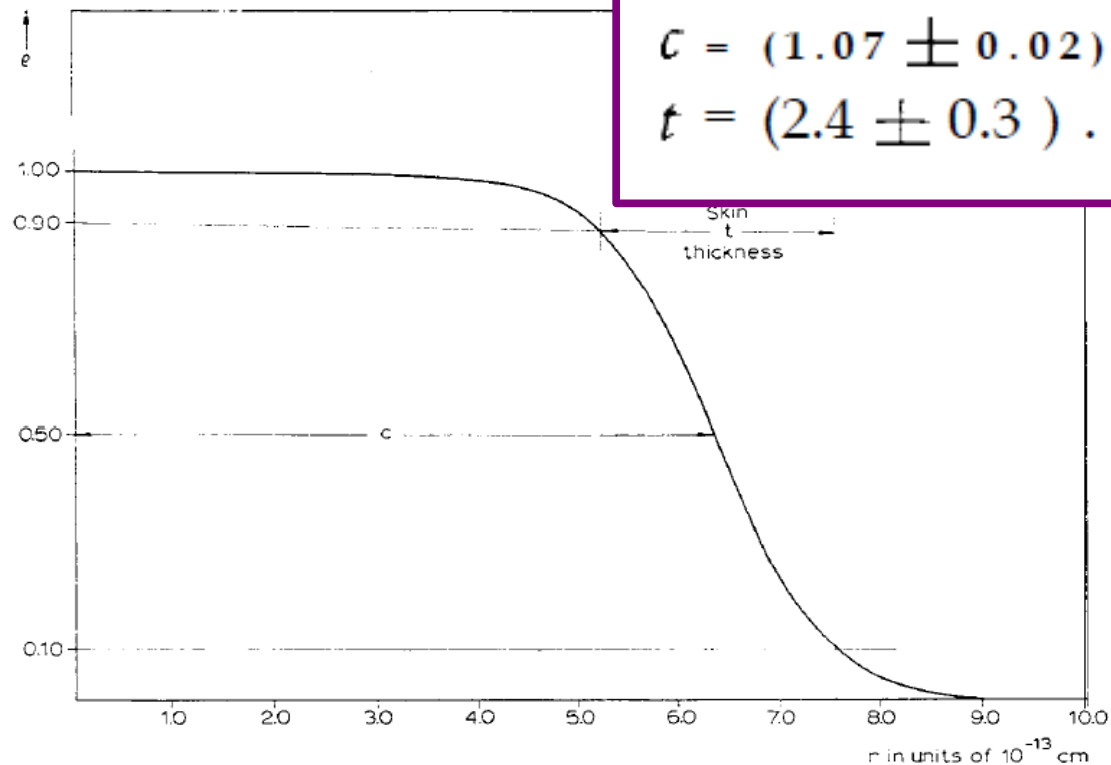


Az atommagok nukleon (p+n) eloszlása
 \sim az atommagok elektromos (p) töltéseloszlása

Diffrakció: mit tanultunk meg?

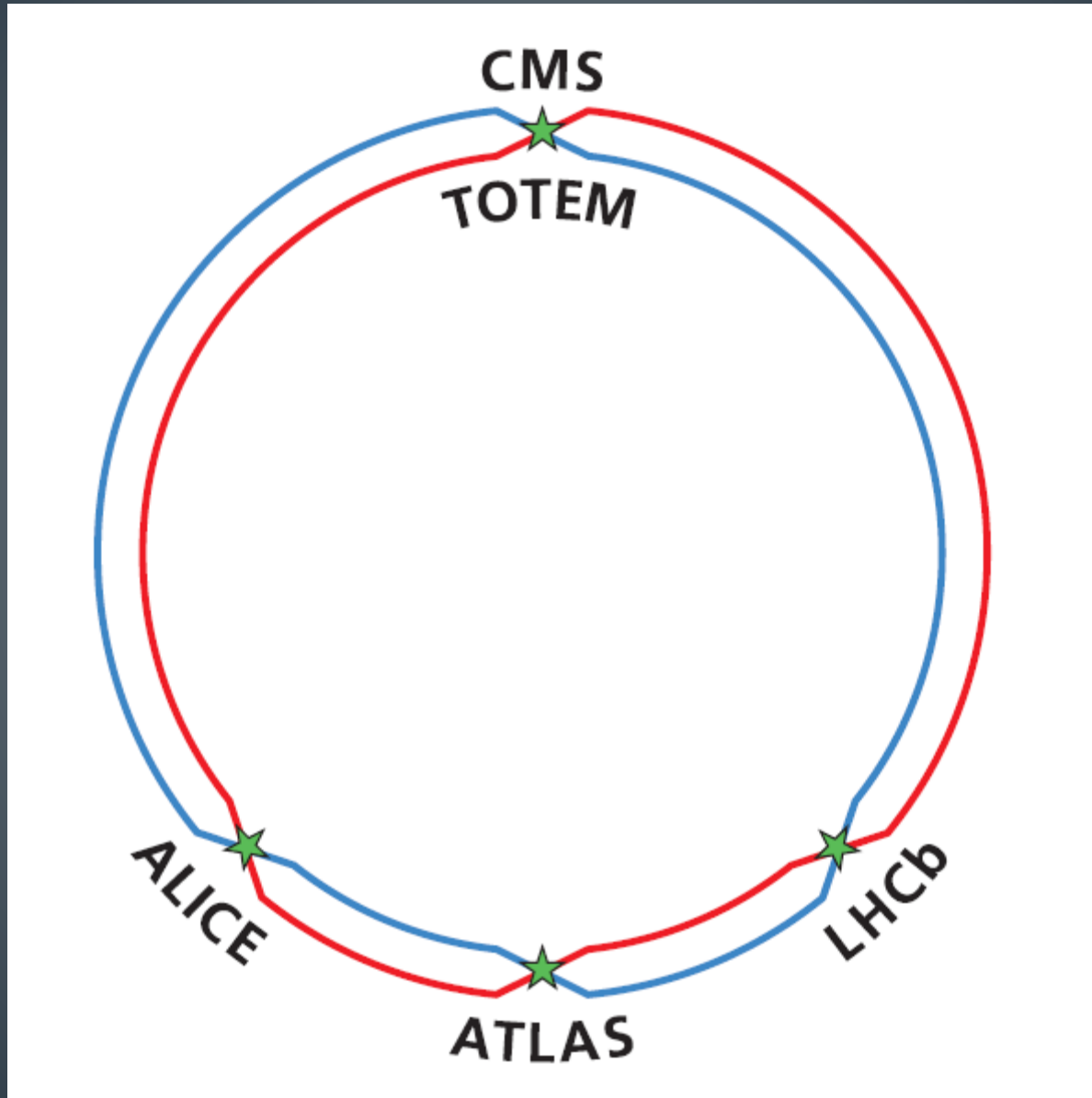
ELECTRON-SCATTERING METHOD

569

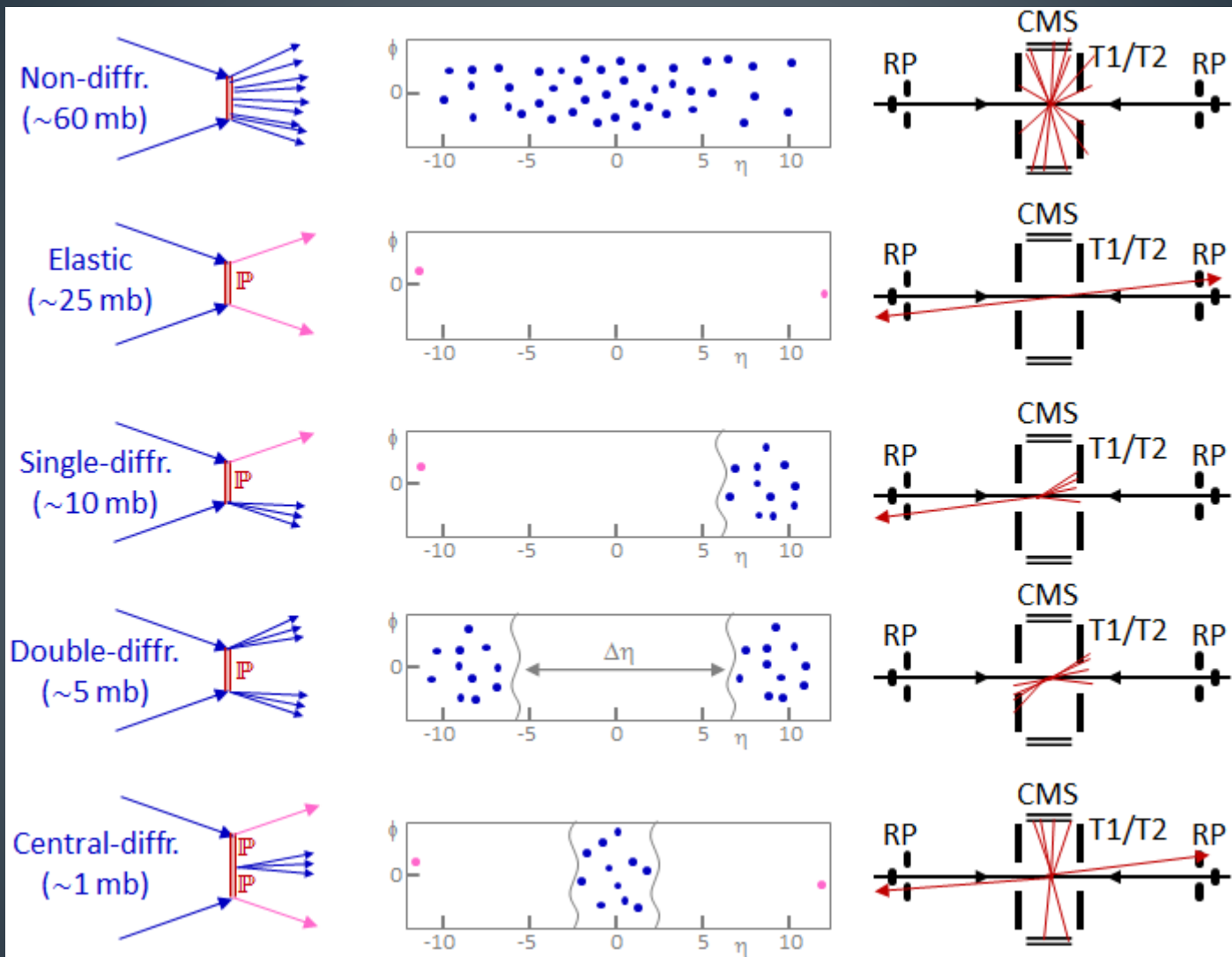


Gömb alakú atommagok térfogata $V \sim A$ (tömegszám)
A „bőrük” vastagsága független A -tól
→ Az atommagok központi sűrűsége A -tól független
R. Hofstadter, fizikai Nobel-díj előadása (1961)

A CERN LHC főbb kísérletei (RRB/LHCC)



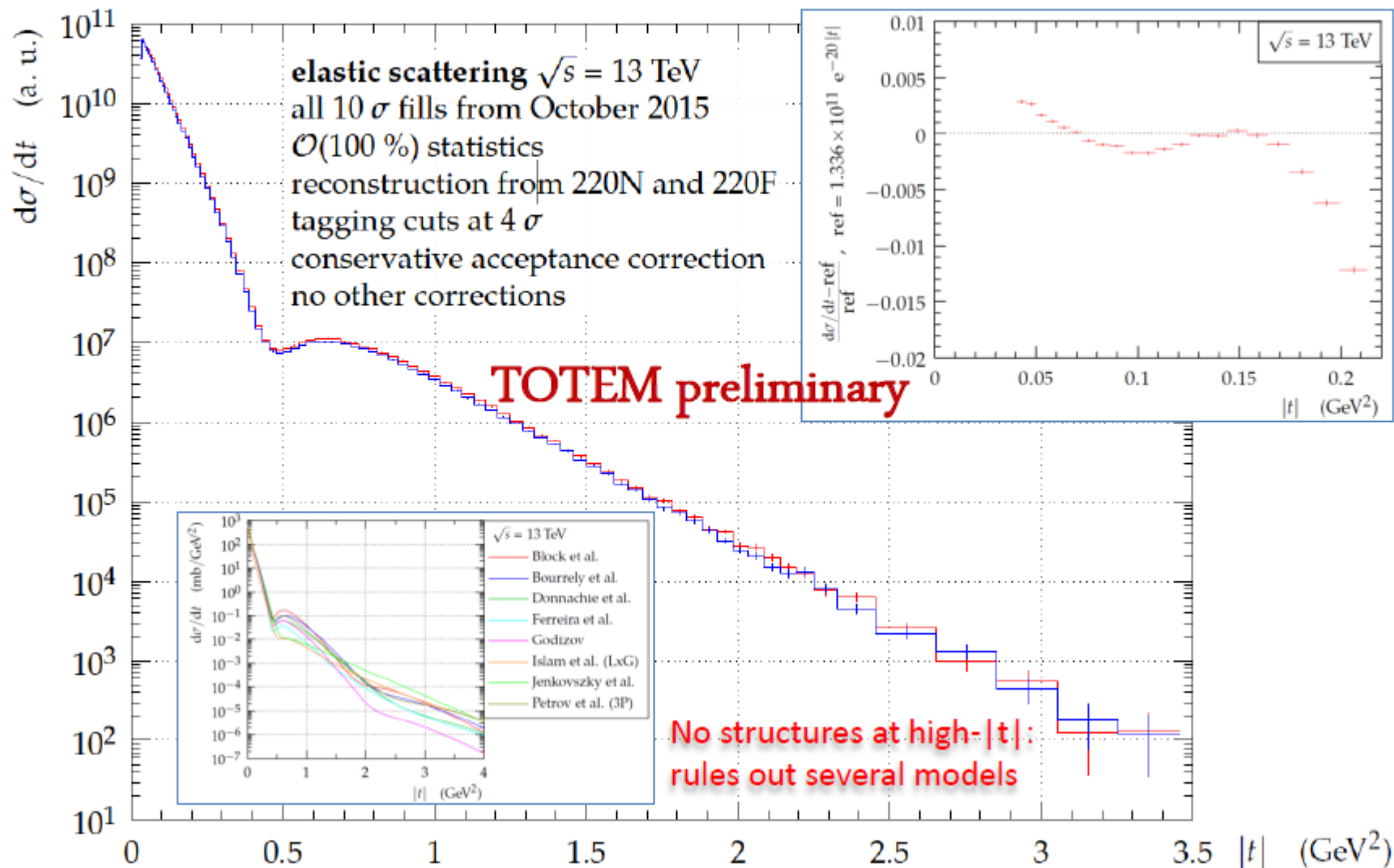
TOTEM fizika az LHC-nél



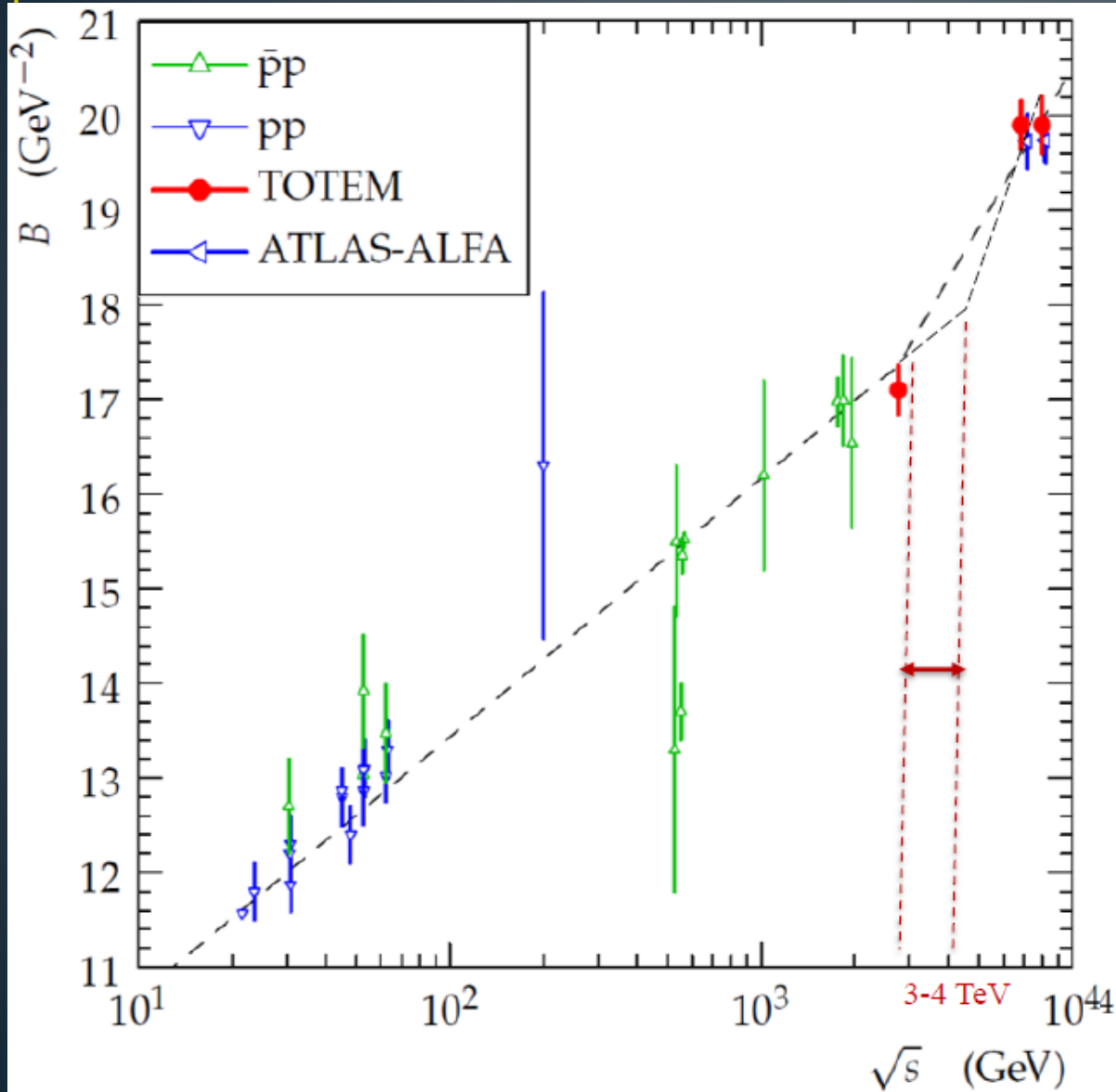
Rugalmas és diffraktív szórás: színtelen kvantum cseréje

TOTEM előzetes adatok, $\sqrt{s} = 13$ TeV

- Large amount of data (trigger rate **50x** w.r.t. Run I)



TOTEM preliminary at $\sqrt{s} = 13$ TeV



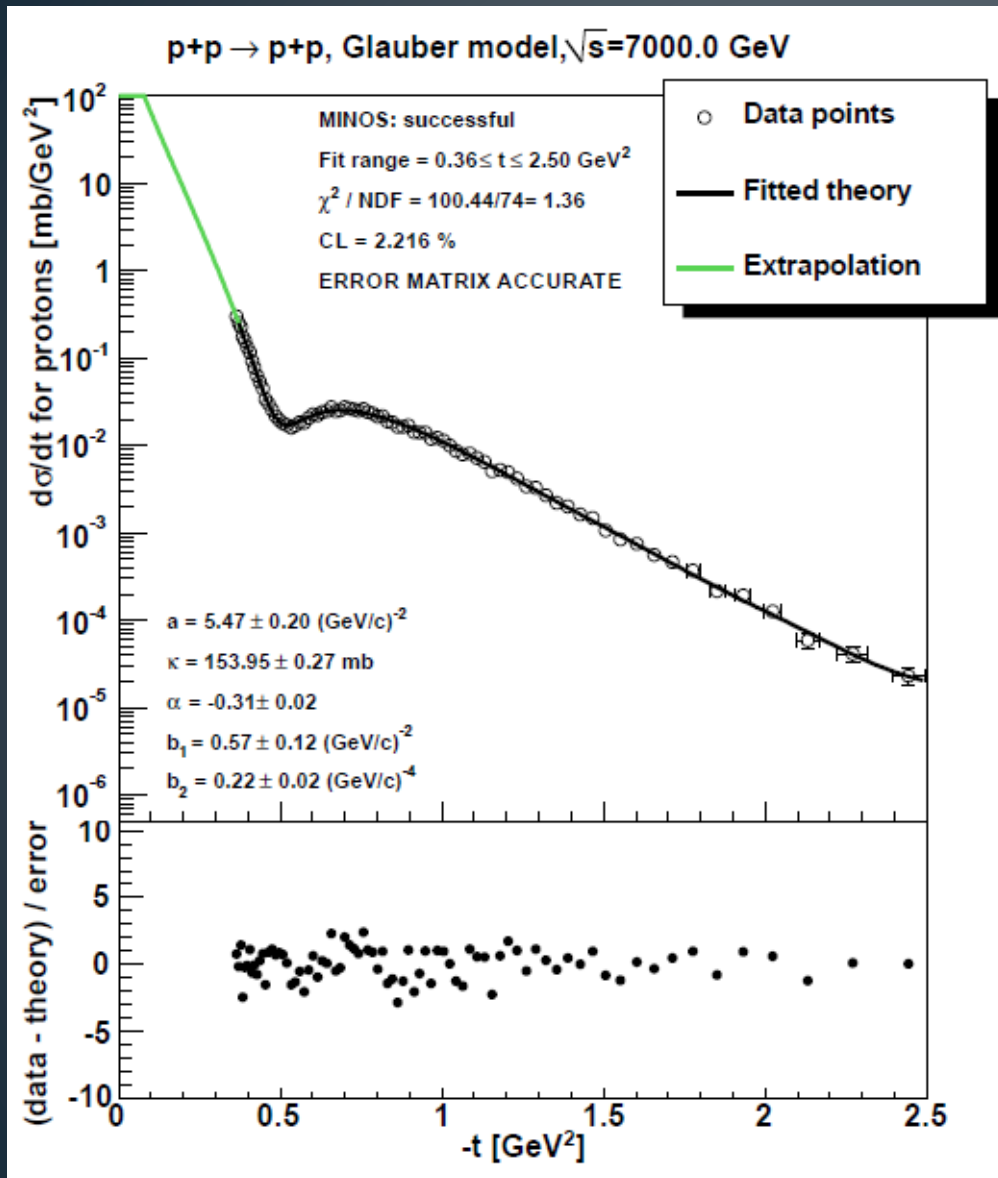
Growth of B:
Universal properties
of Pomeron

Acceleration of B:
Opening of an
additional physics
channel
from
TOTEM preliminary
2.76 and 13 TeV

threshold $\leq 3-4$ TeV
followed by
very sharp growth

Change of low- $|t|$
trend at LHC

First results @ Low-X 2013: GV works for $d\sigma/dt$ dip



Glauber-Velasco (GV)
(original)

describes $d\sigma/dt$ data
Both at ISR and
TOTEM@LHC
in the dip region

[arxiv:1311.2308](https://arxiv.org/abs/1311.2308)

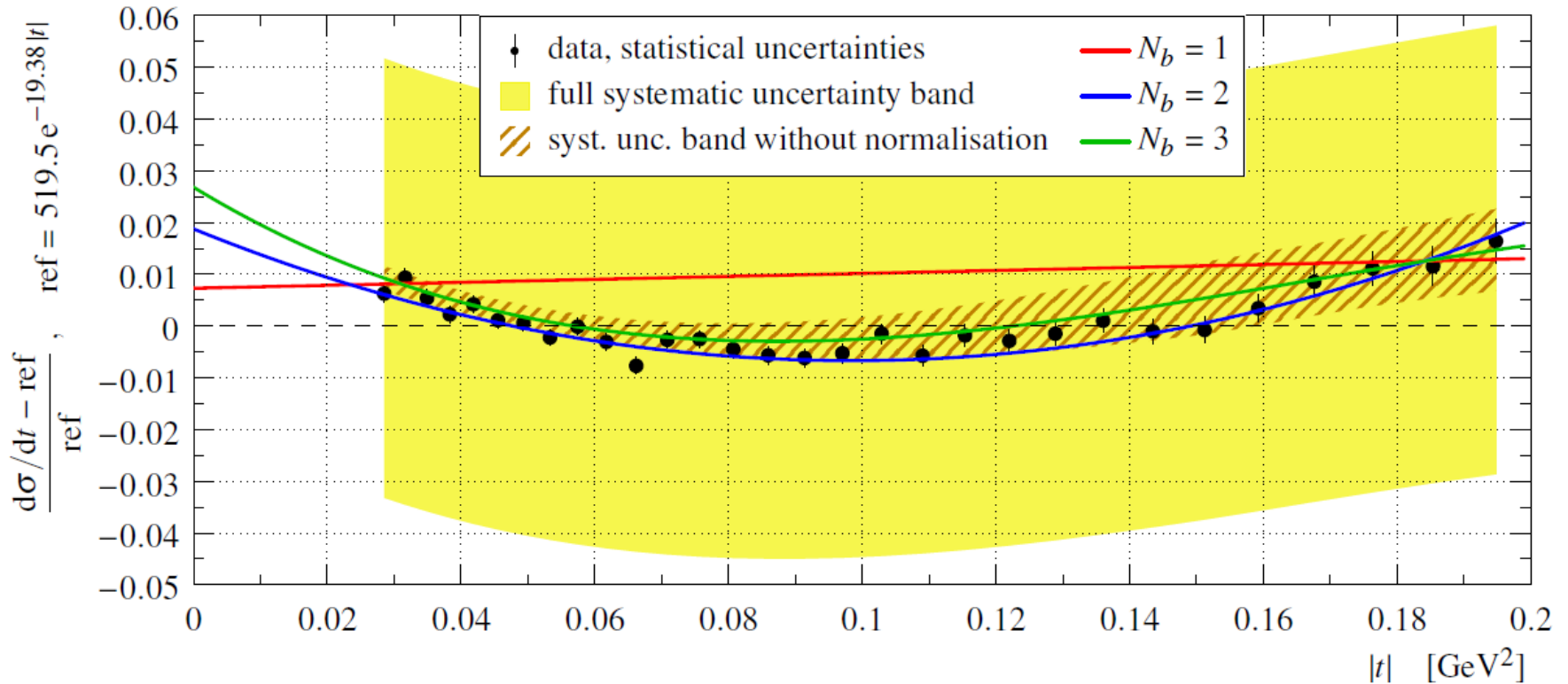
Note: at low- t
GV is \sim exponential

Really?
Lower energies?

TOTEM results @ 8 TeV, arxiv:1503.08111: d σ /dt non-exponential at low-t

Table 4: Fit quality measures for fits in Figure 11.

N_b	χ^2/ndf	p-value	significance
1	117.5/28 = 4.20	$6.1 \cdot 10^{-13}$	7.2σ
2	29.3/27 = 1.09	0.35	0.94σ
3	25.5/26 = 0.98	0.49	0.69σ



Non-exponential $\bar{p}p$ in GV model

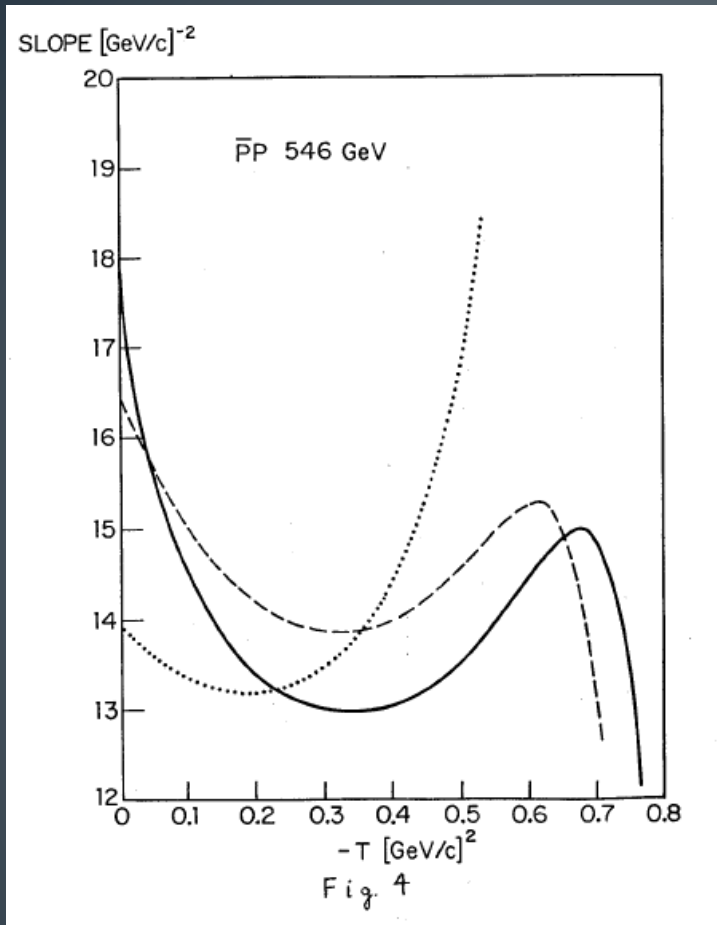


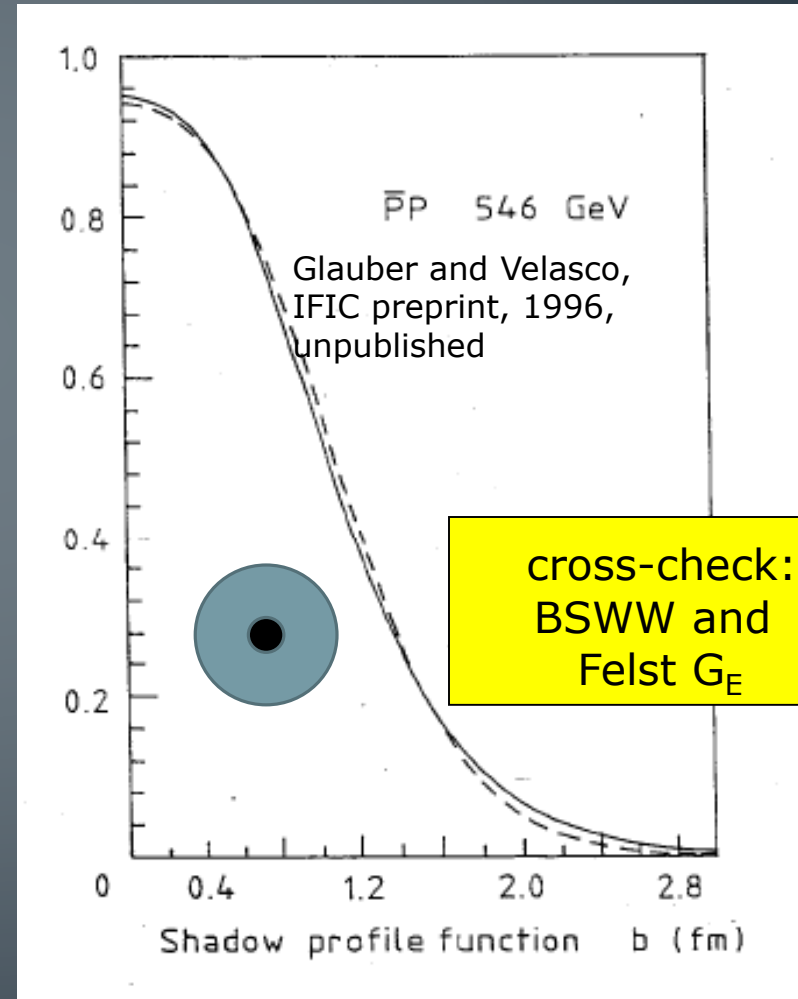
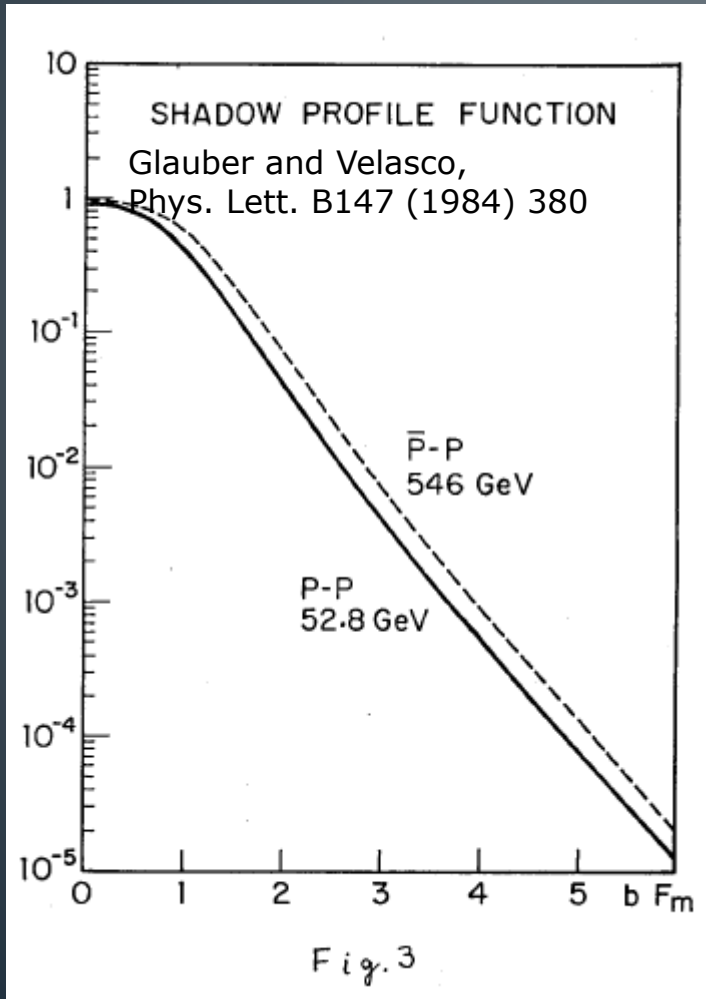
Figure 4 from
Glauber-Velasco
PLB 147 (1984) 380
Slope is not quite
exponential:

A non-Gaussian behaviour
of proton scattering
in coordinate space

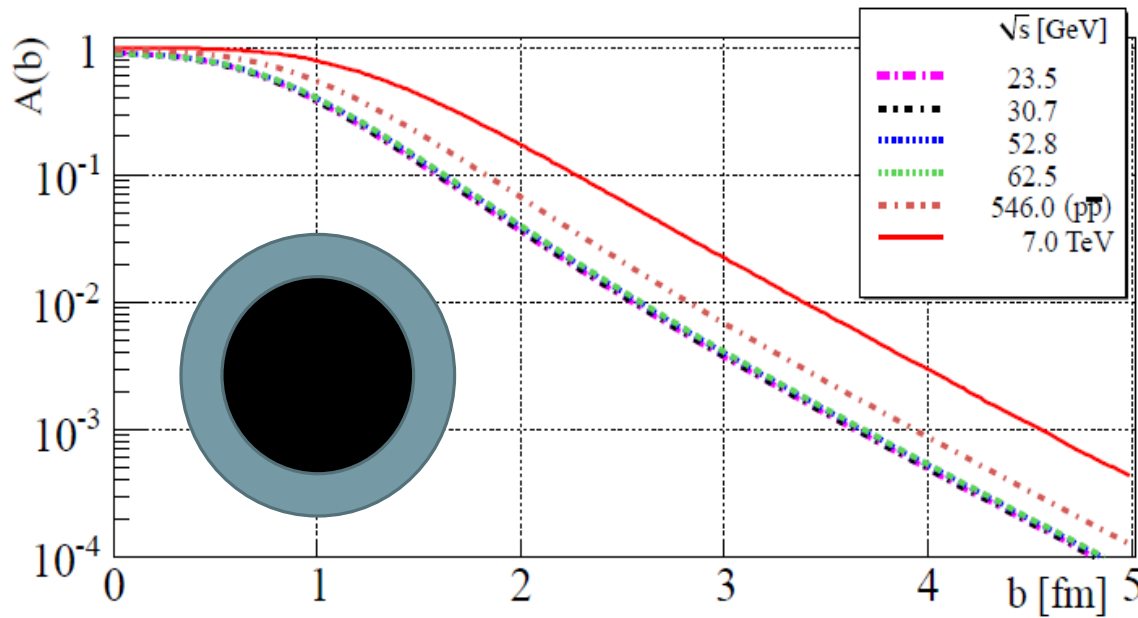
Fig. 4: Logarithmic slopes of the $\bar{p} - p$ differential cross-section at 546 GeV calculated according to: the *BSWW* form factor, which is accurate at small momentum transfers (solid wave), the Felst form factor, which accounts only for the data at larger momentum transfers (dashed curve) and the dipole form factor together with the Chou-yang scattering amplitude (dotted curve).

Imaging with shadow profile

$$A(b) = 1 - |e^{-\Omega(b)}|^2$$



Saturation from shadow profiles



at 7 TeV
proton becomes

Blacker, but
not Edgier,
and **Larger**

BEL \rightarrow **BnEL** effect
[arxiv:1311.2308](https://arxiv.org/abs/1311.2308)

$$A(b) = 1 - |e^{-\Omega(b)}|^2$$

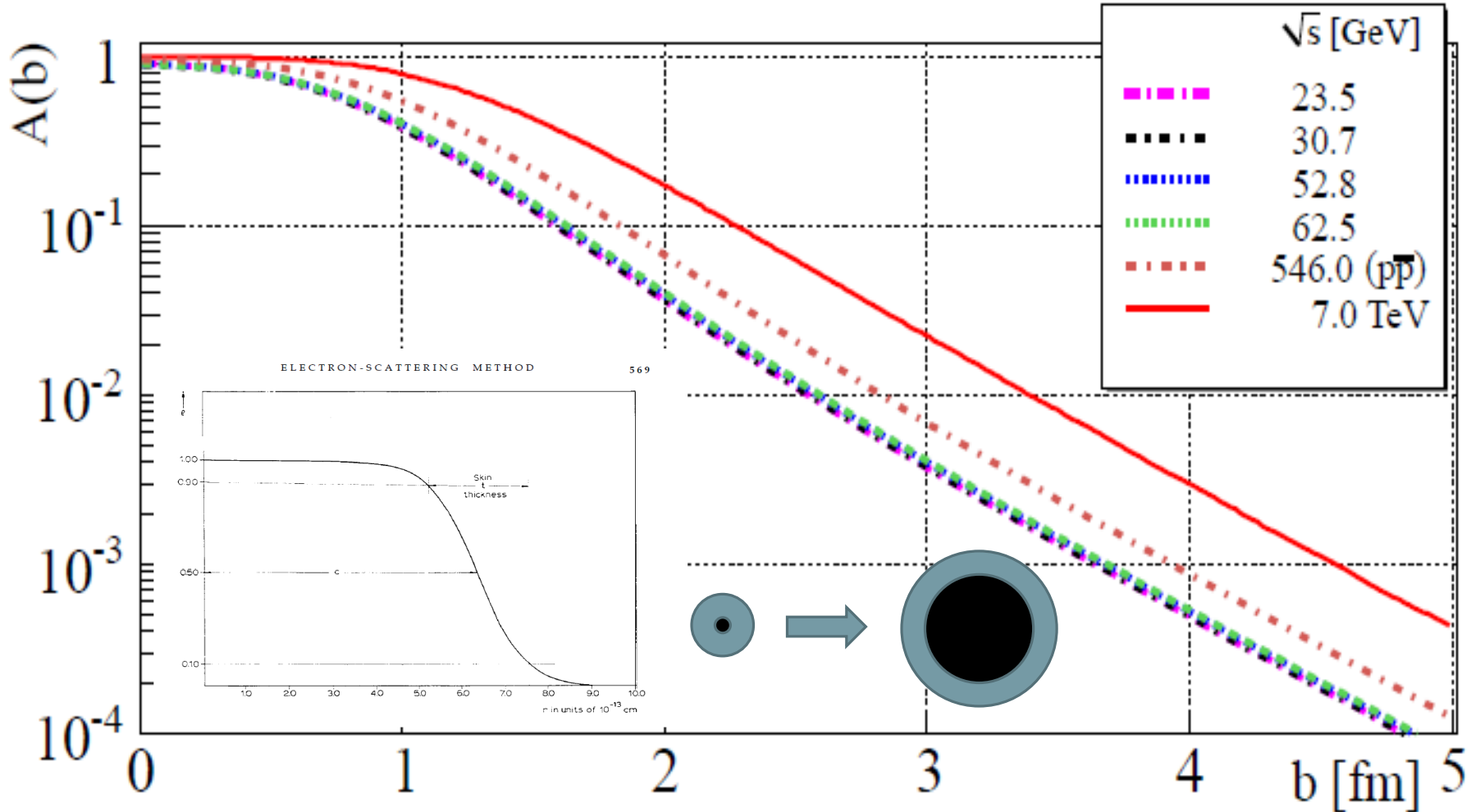
ISR and SppS:

R.J. Glauber and J.Velasco
Phys. Lett. B147 (1987) 380
 b_1, b_2 fixed

apparent saturation:
center of proton \sim black
at LHC, up to
 $r \sim 0.7$ fm

see also Lipari and Lusignoli,
[arXiv:1305.7216](https://arxiv.org/abs/1305.7216)

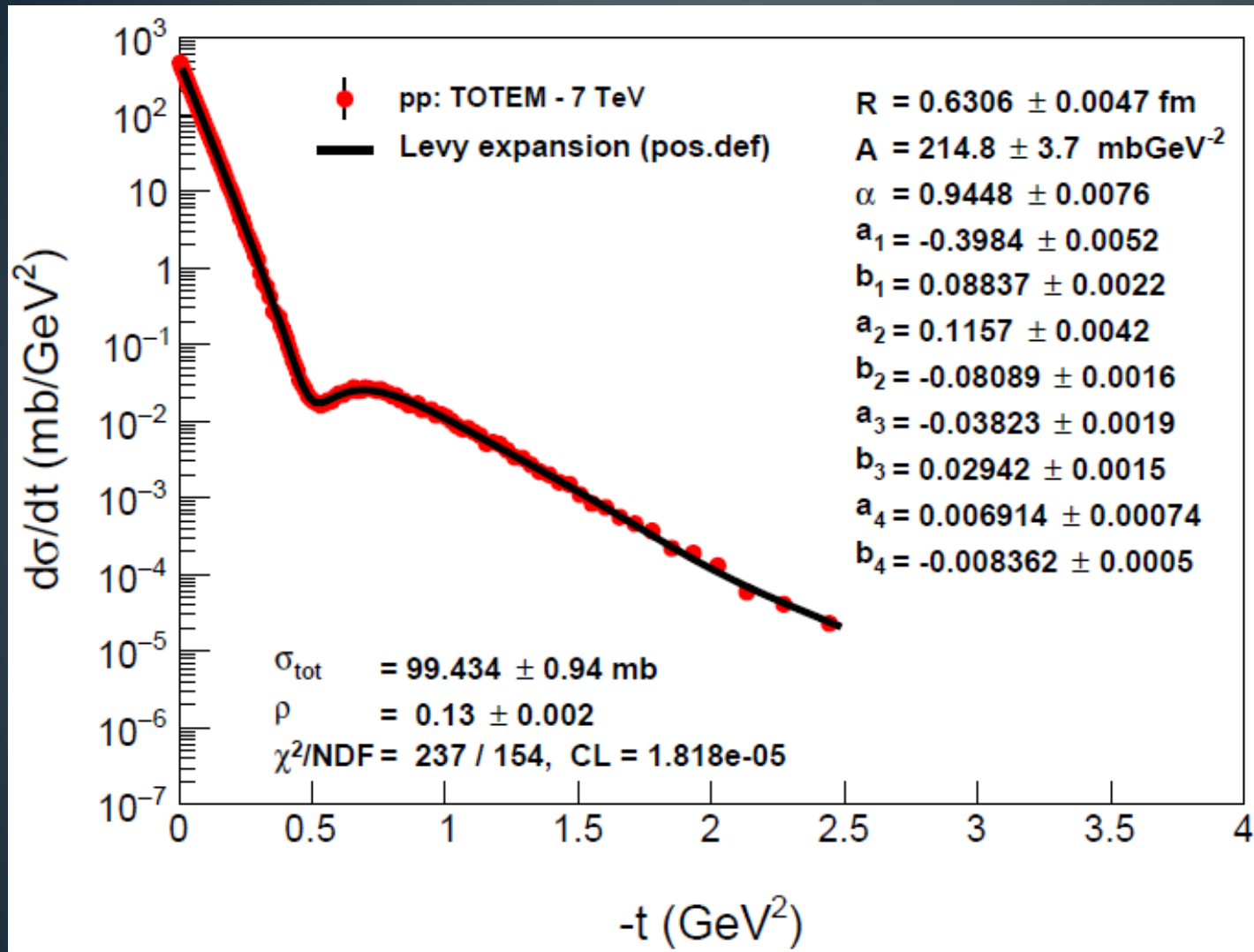
Shadow imaging in p+p at LHC



The **BnEL** effect.

Can it explain TOTEM data,
new trends of B at LHC?

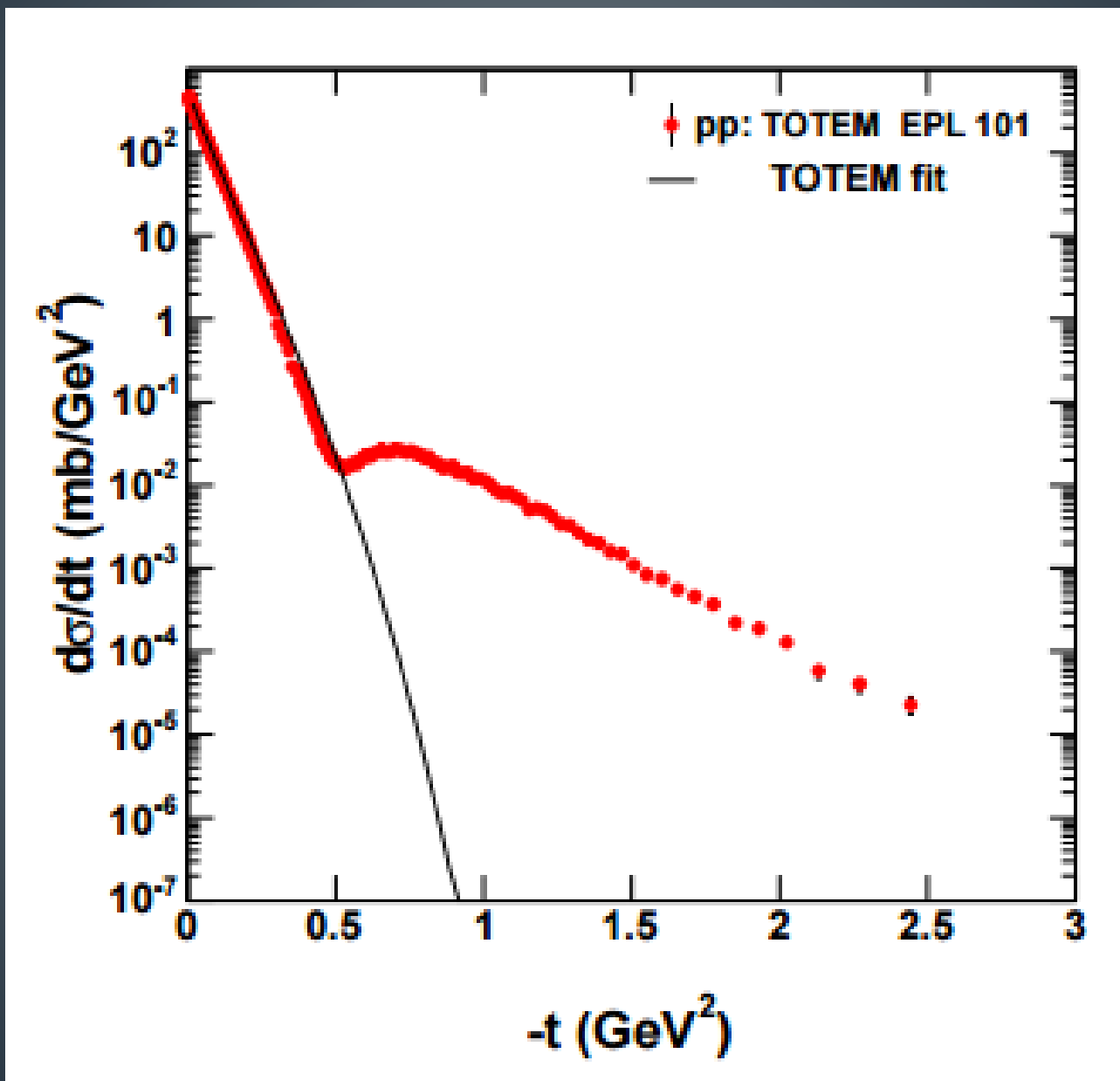
MODEL INDEPENDENT LEVY EXPANSION



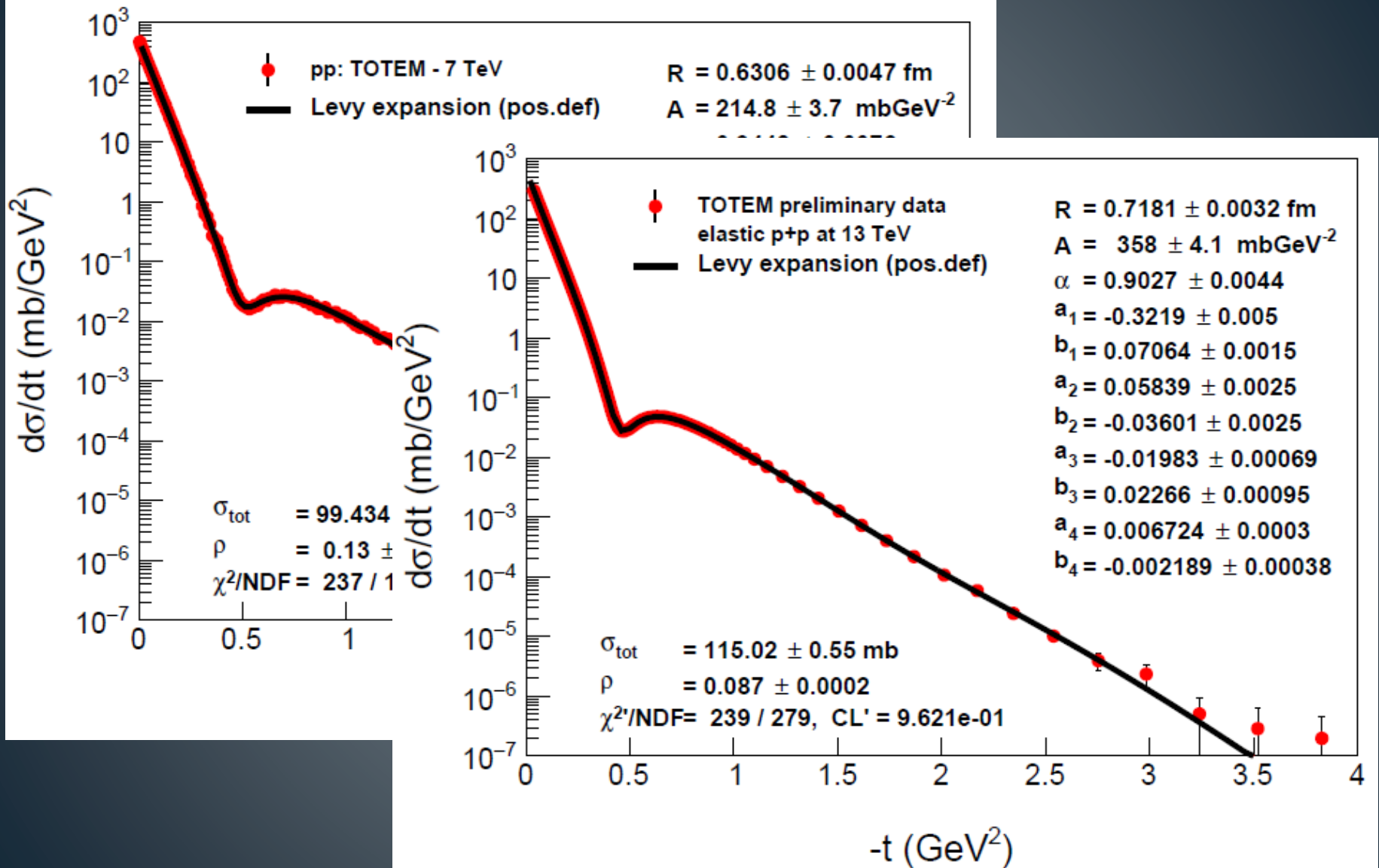
J. Chwastowski, Trento, 2016: Ez mit jelent?

T. Csörgő, T. Novák and A. Ster

CUMULÁNS SORFEJTÉS: NAGY $-t$

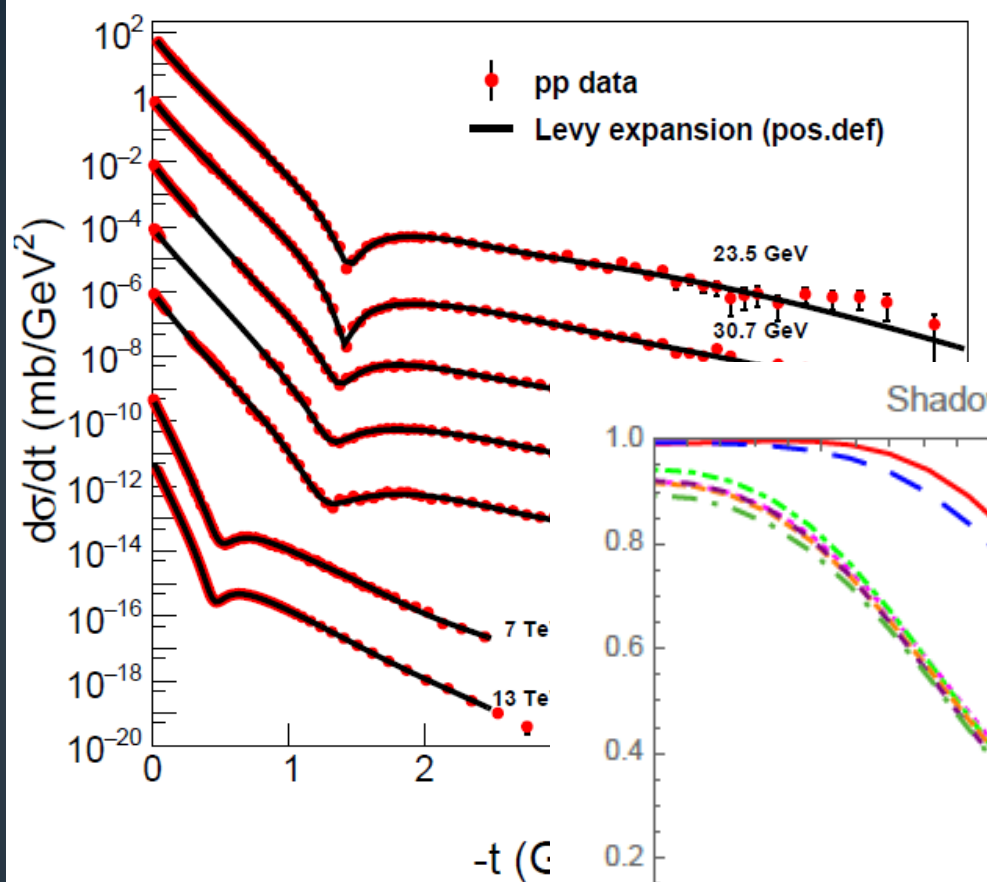


LEVY SORFEJTÉS, ISR ÉS LHC ENERGIÁN

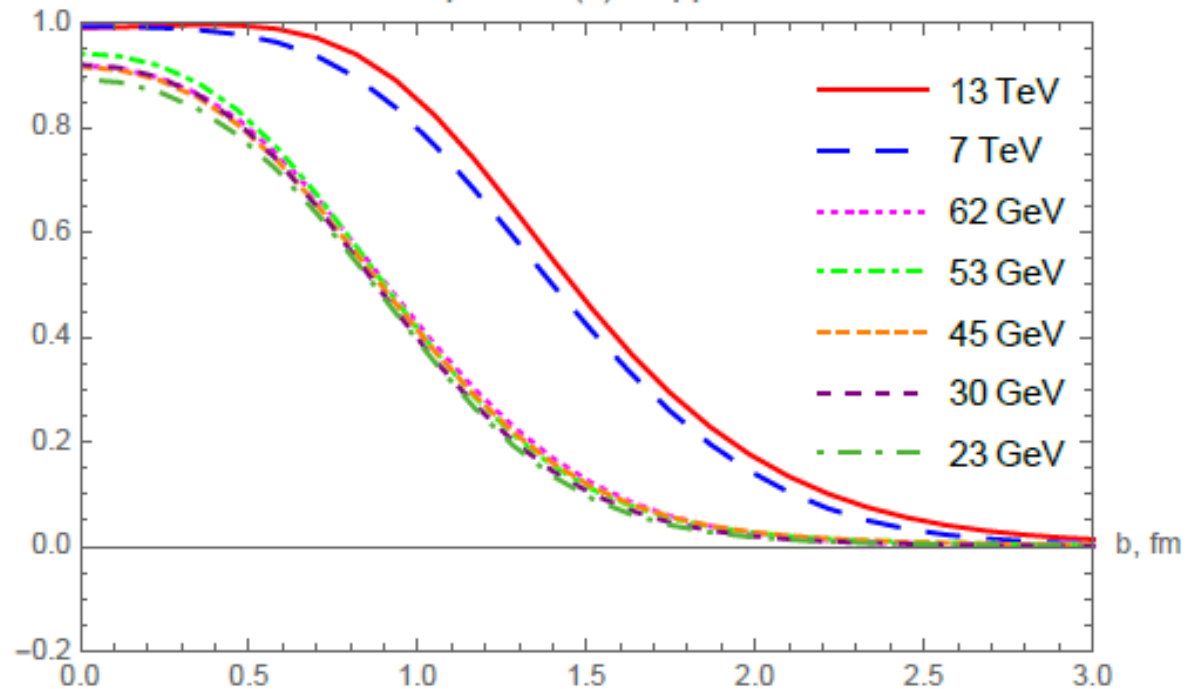


KÉPALKOTÁS ISR ÉS LHC ENERGIÁN

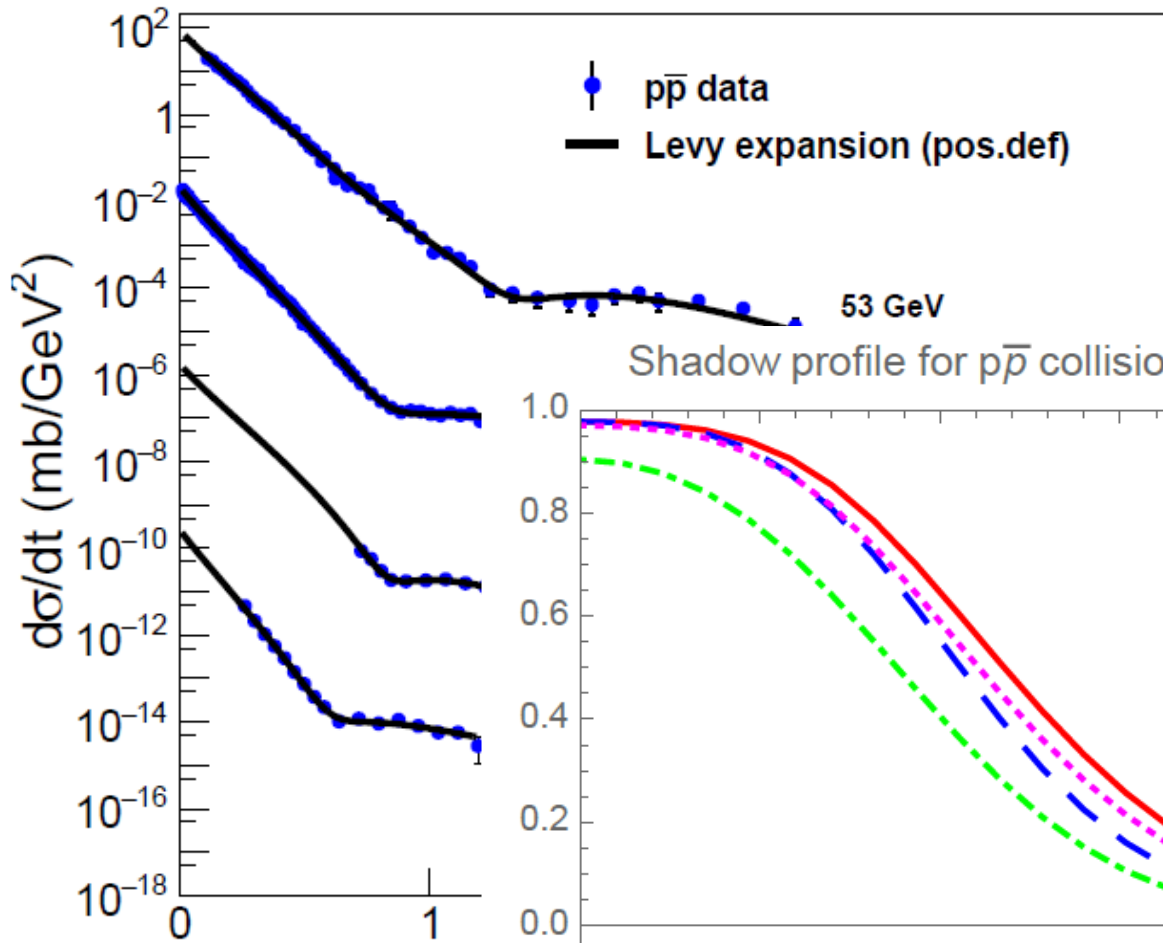
PP: PROTON+PROTON



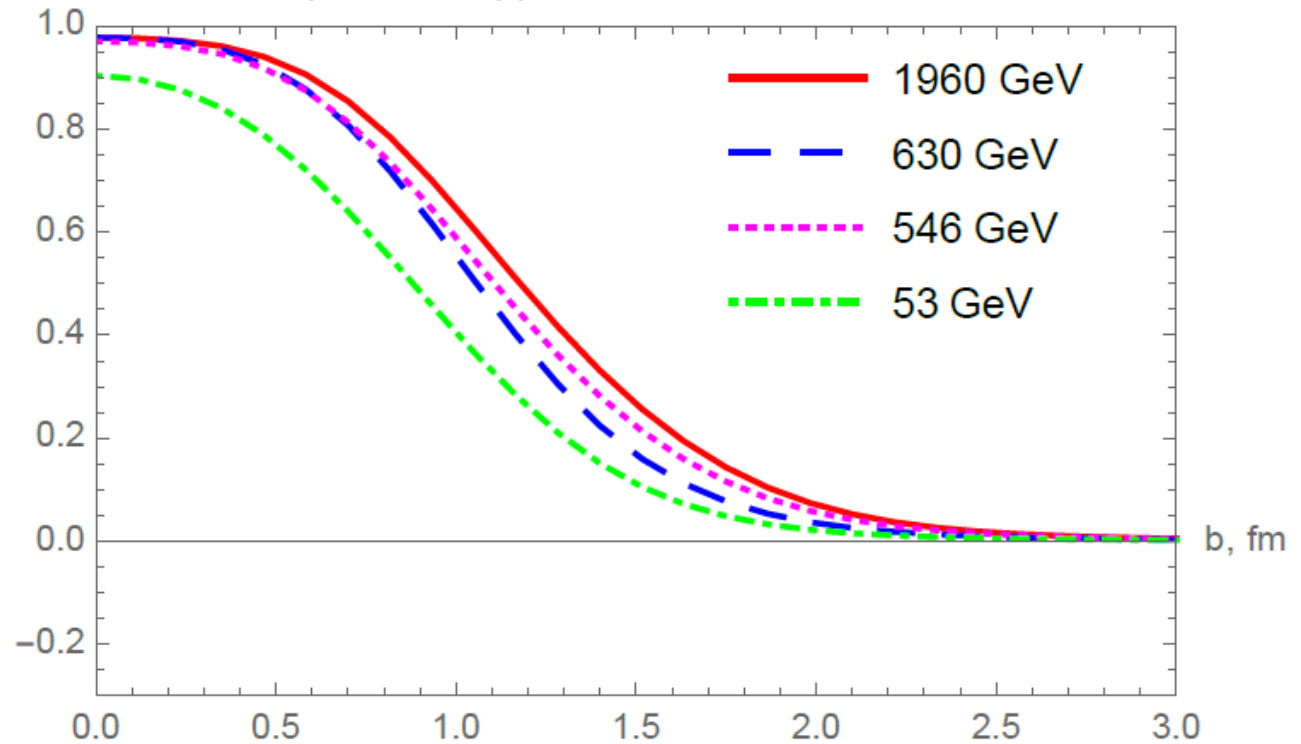
Shadow profile $P(b)$ for pp collisions



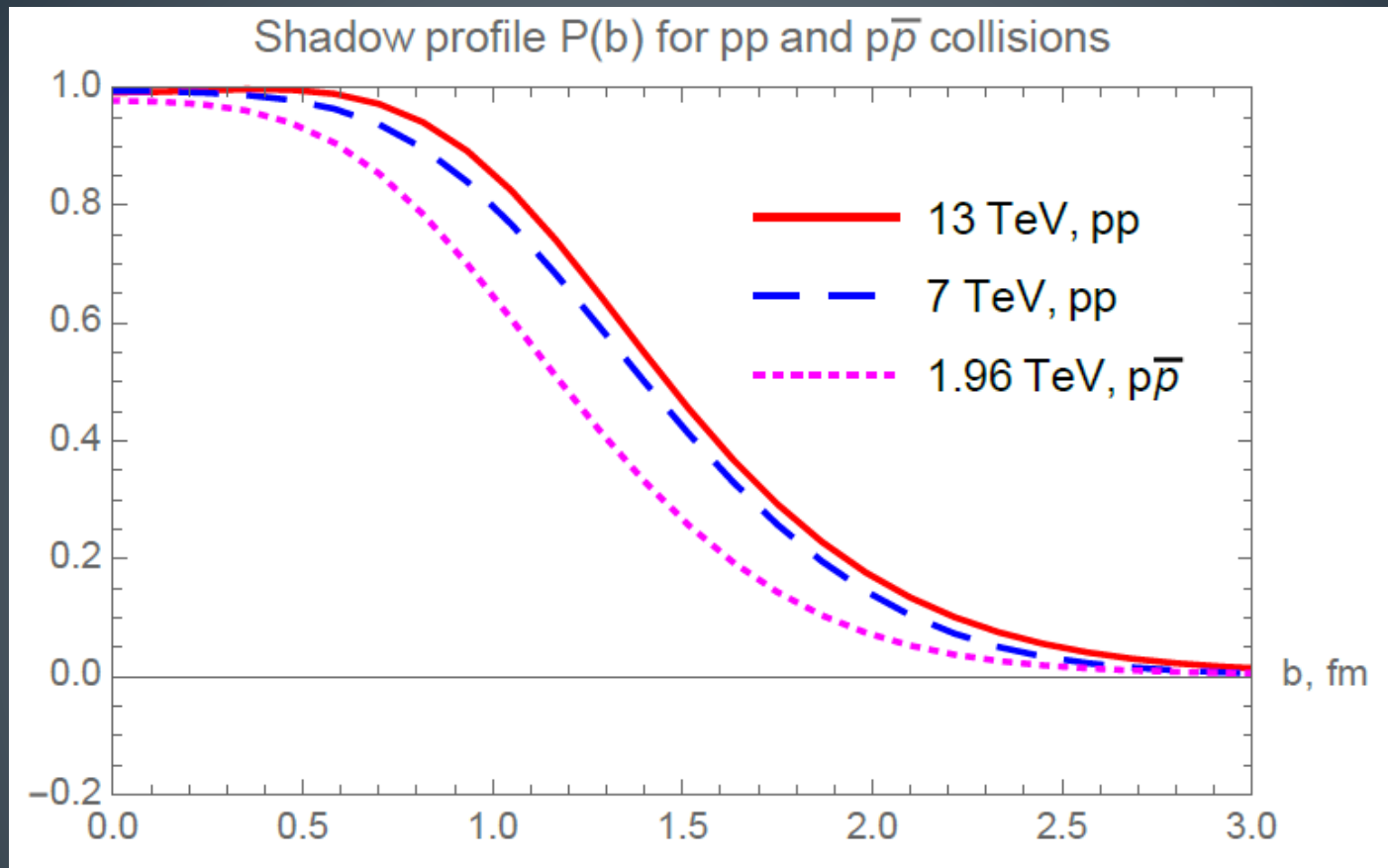
LEVY SORFEJTÉS, ISR ÉS LHC ENERGIÁN



Shadow profile for $p\bar{p}$ collisions for $\alpha=0.9$, $R=0.65$ fm

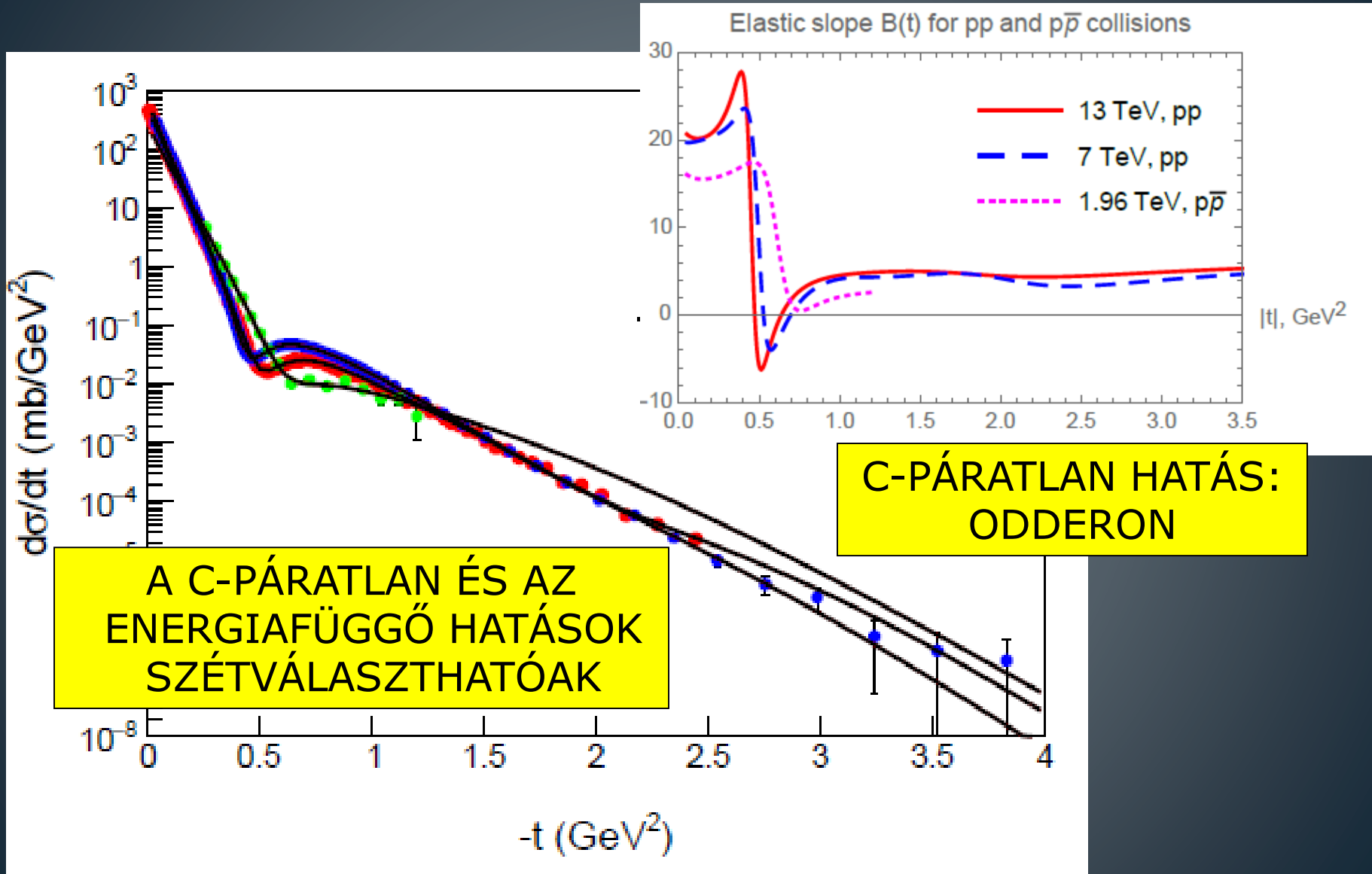


C-PÁRATLAN : (P,P) - (P,ANTIP)



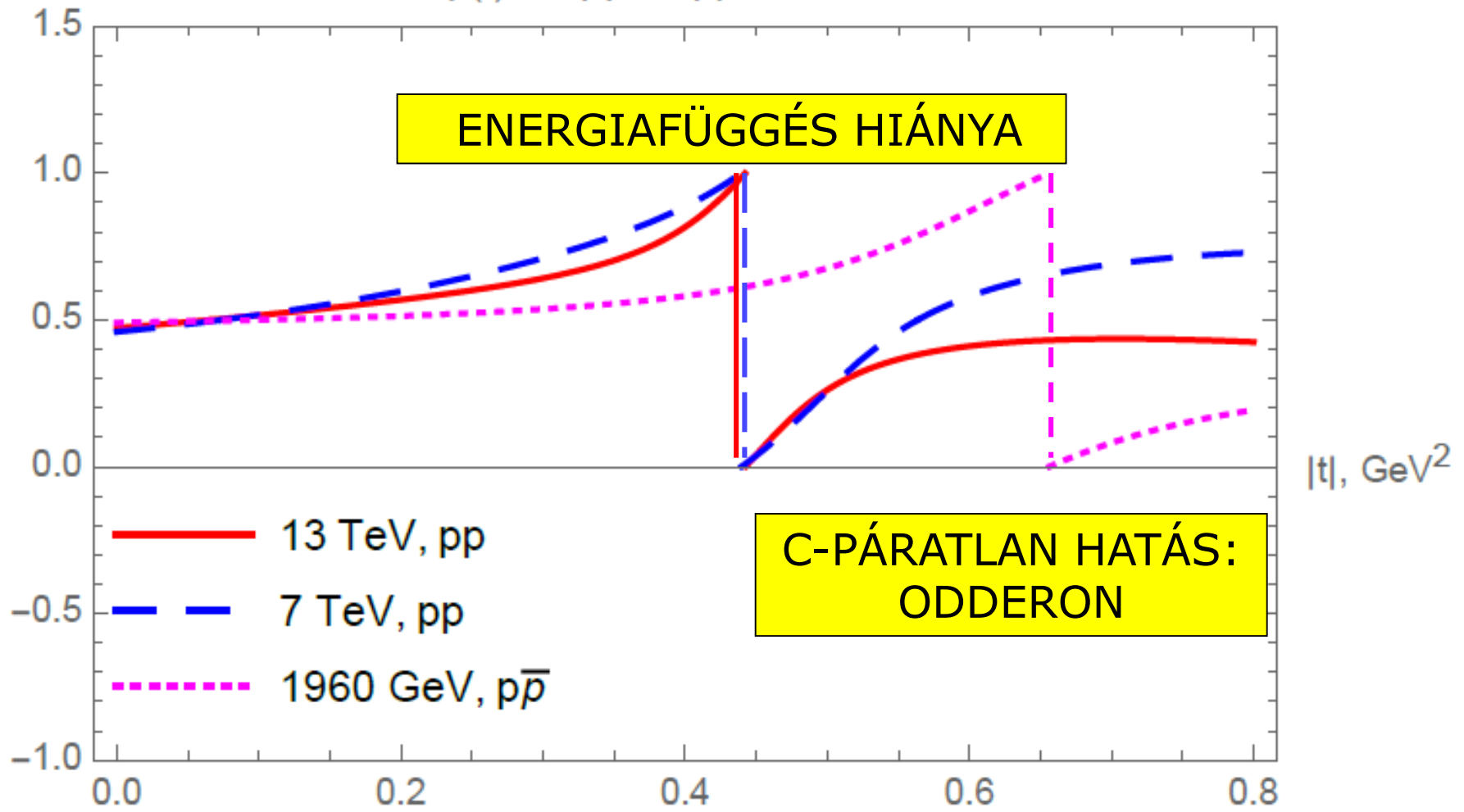
A C-PÁRATLAN ÉS AZ
ENERGIAFÜGGŐ
HATÁSOK
KEVEREDHETNEK

C-PÁRATLAN : (P,P) - (P,ANTIP)

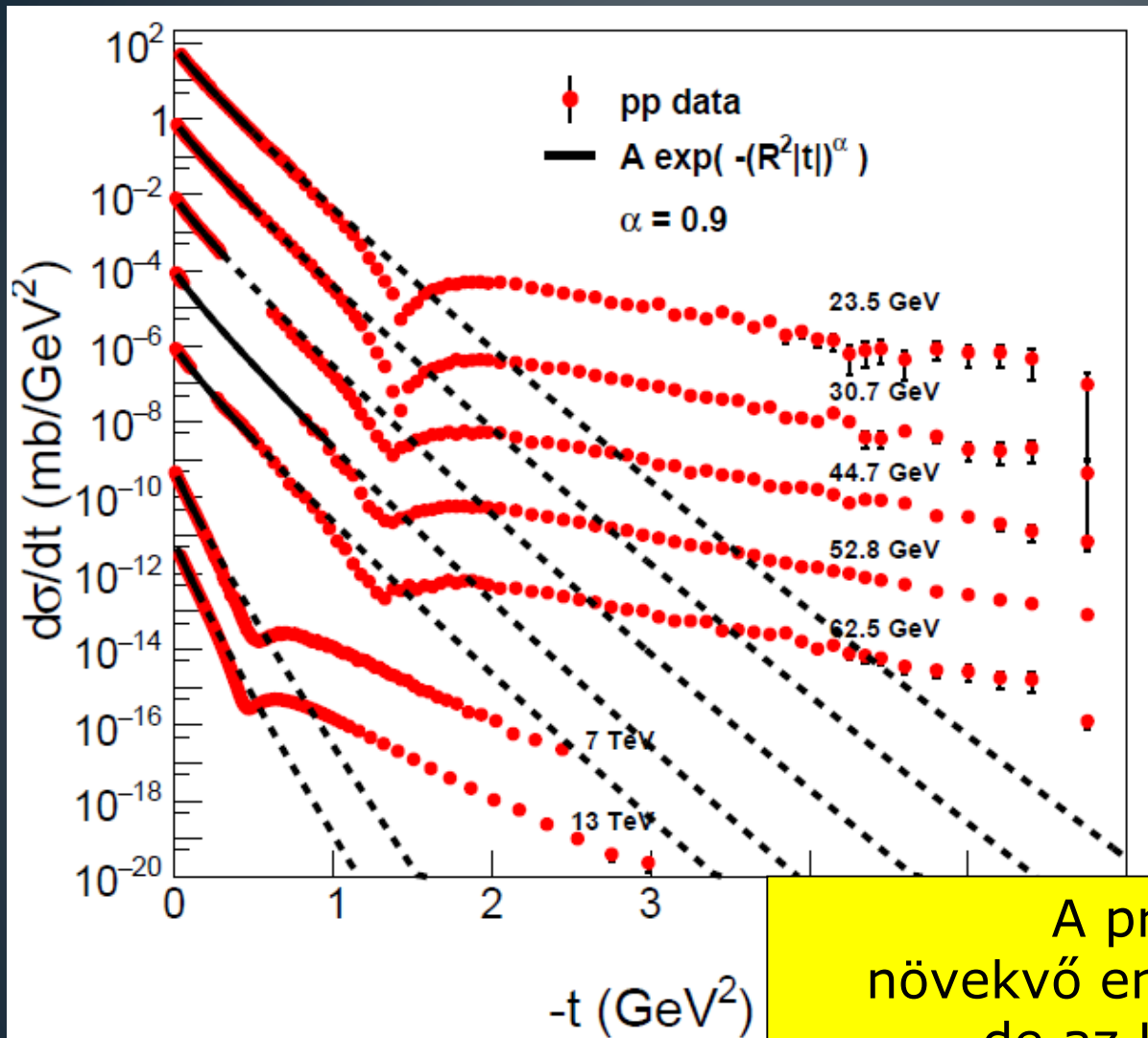


C-PÁRATLAN : (P,P) - (P,ANTIP)

$\phi(t)$ for pp vs $p\bar{p}$ collisions

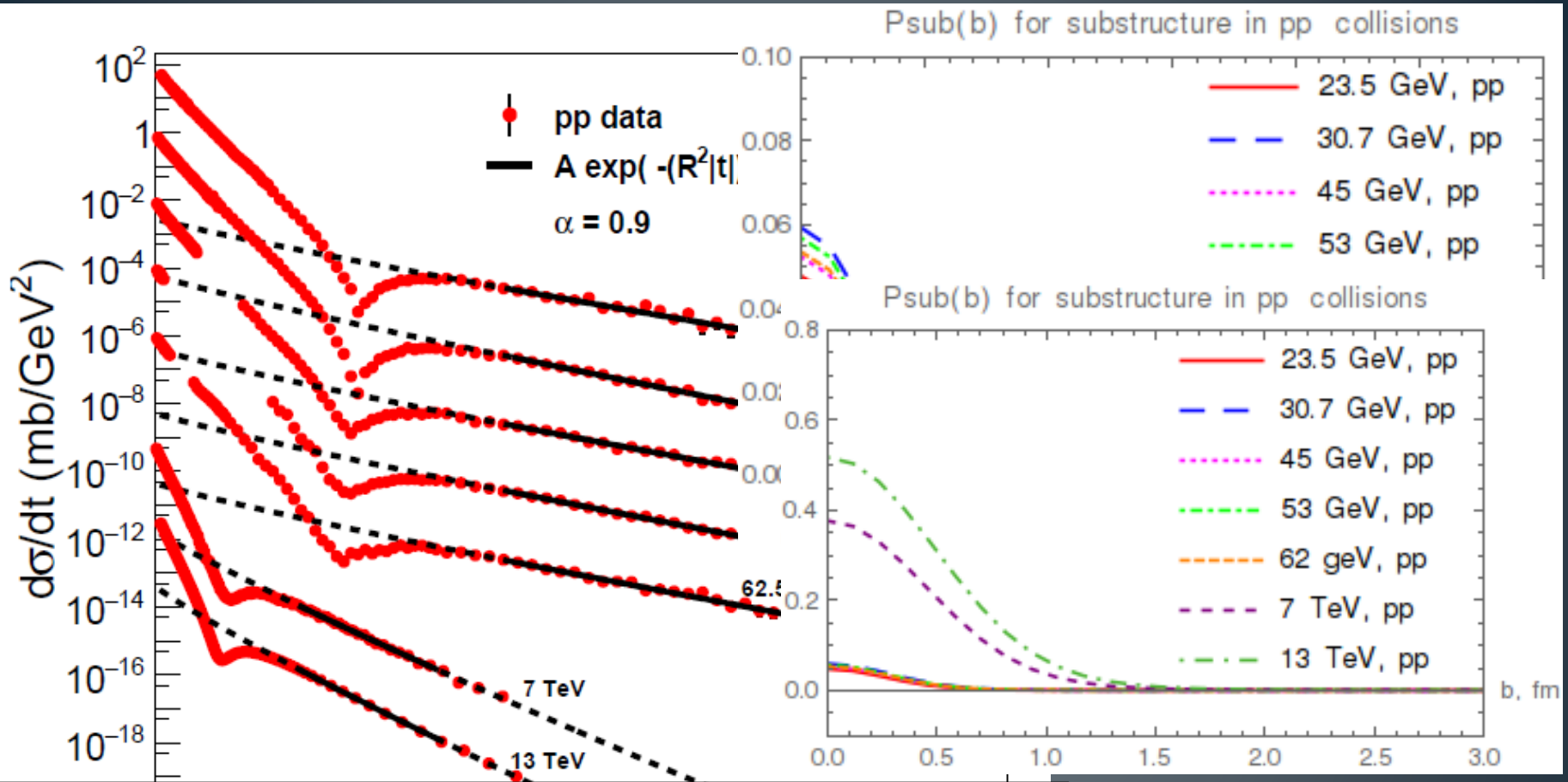


LEVY ILLESZTÉS: DURVA SZERKEZET



A proton mérete
növekvő energiával növekszik:
de az LHC energiákon
az alakjuk is megváltozik!

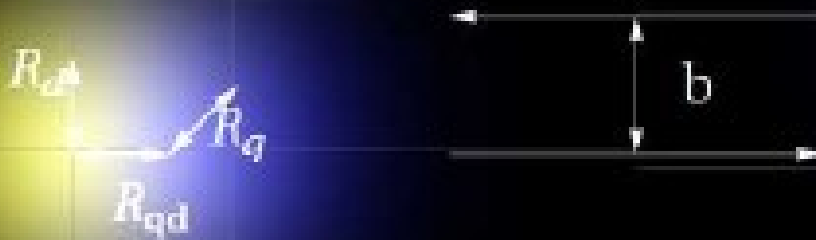
LEVY ILLESZTÉS: FINOM SZERKEZET



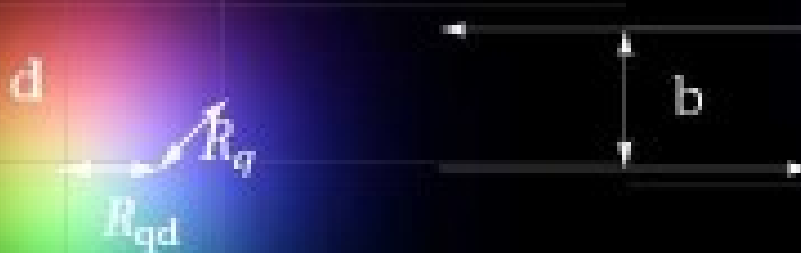
A protonban két belső szerkezet,
 növekvő energiával növekszik:
 de a kisebb energiákon a kisebb, q
 Az LHC energiákon a nagyobb, $d=(q,q)$

LEVY ILLESZTÉS: FINOM SZERKEZET

Model $p=(q,d)$

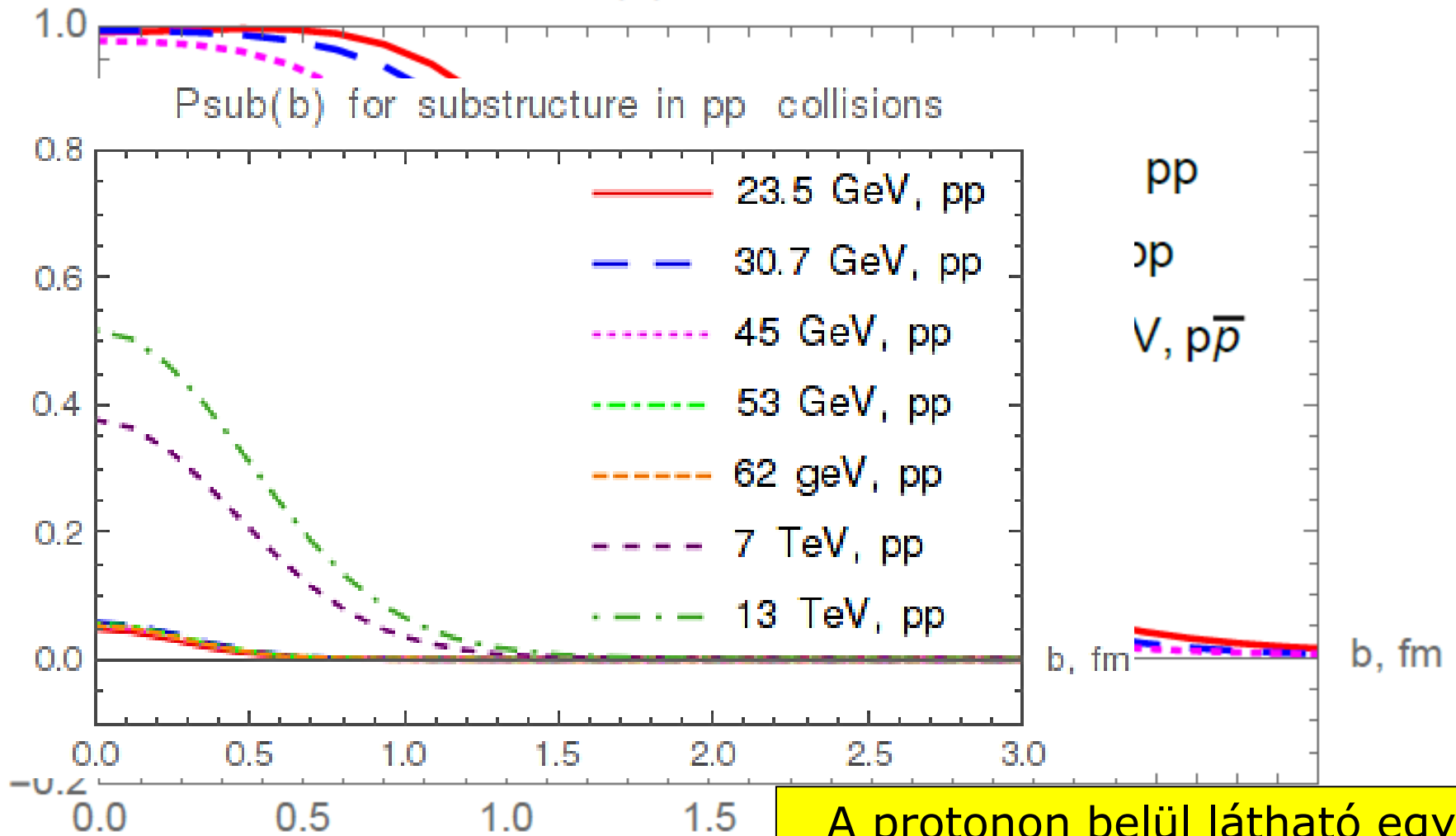


Model $p=(q,(q,q))$



$$P = (q,d)$$

Shadow profile $P(b)$ for pp and $p\bar{p}$ collisions



A protonon belül látható egy nagyobb (dikvark) és egy kisebb (kvark) szerkezet is !!

ÖSSZEFOGLALÁS

Az LHC energiákon
a proton megváltozik

Blacker, but not Edgier, and Larger: BnEL

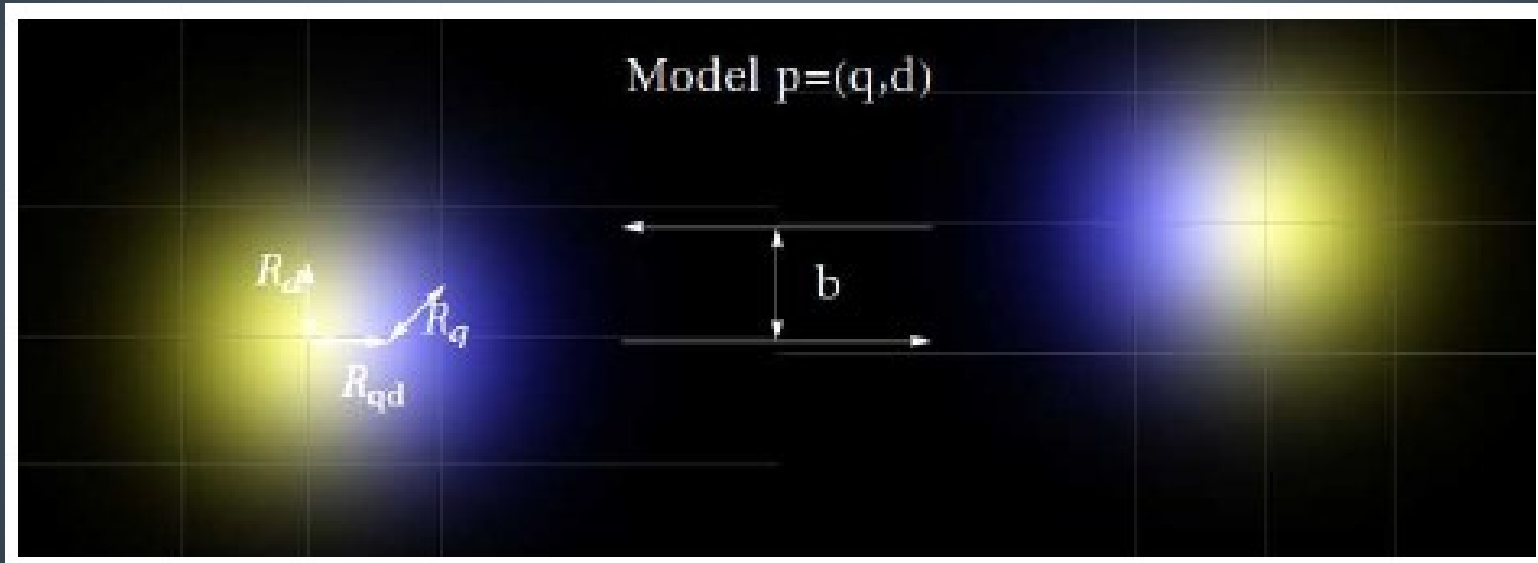
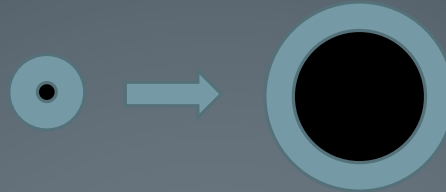
Minél gyorsabban megy, annál nagyobb a proton

ODDERONT KERESTÜNK ÉS ...
ODDERONT TALÁLTUNK

Továbbá még találtunk két új struktúrát

„Felöltözött” kvark és dikvark
 $P=(q,d)$

Köszönöm a figyelmet!



Kérdések?