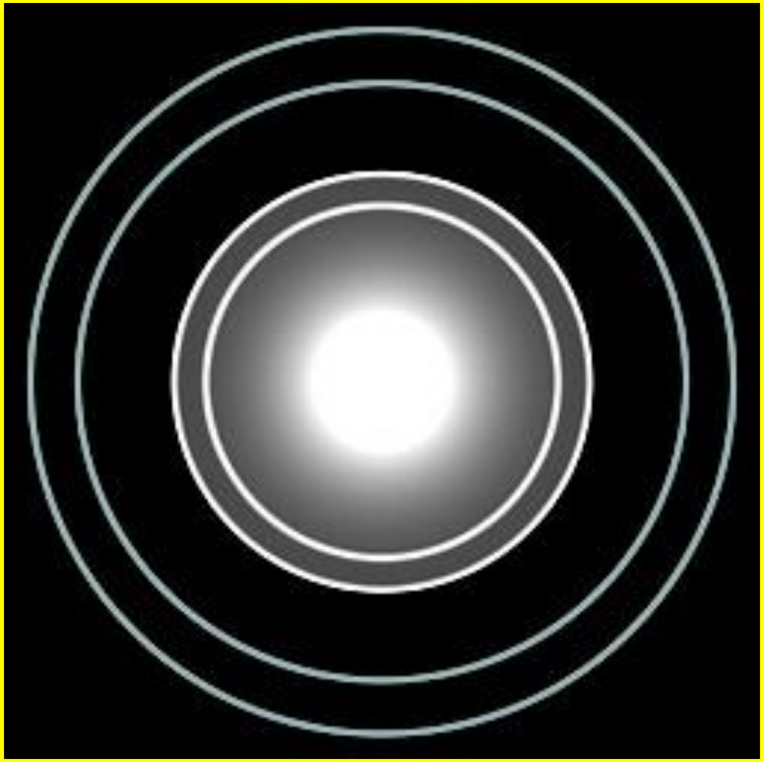
Diffractive Studies at the LHC : What Can We Learn (If Any) ?



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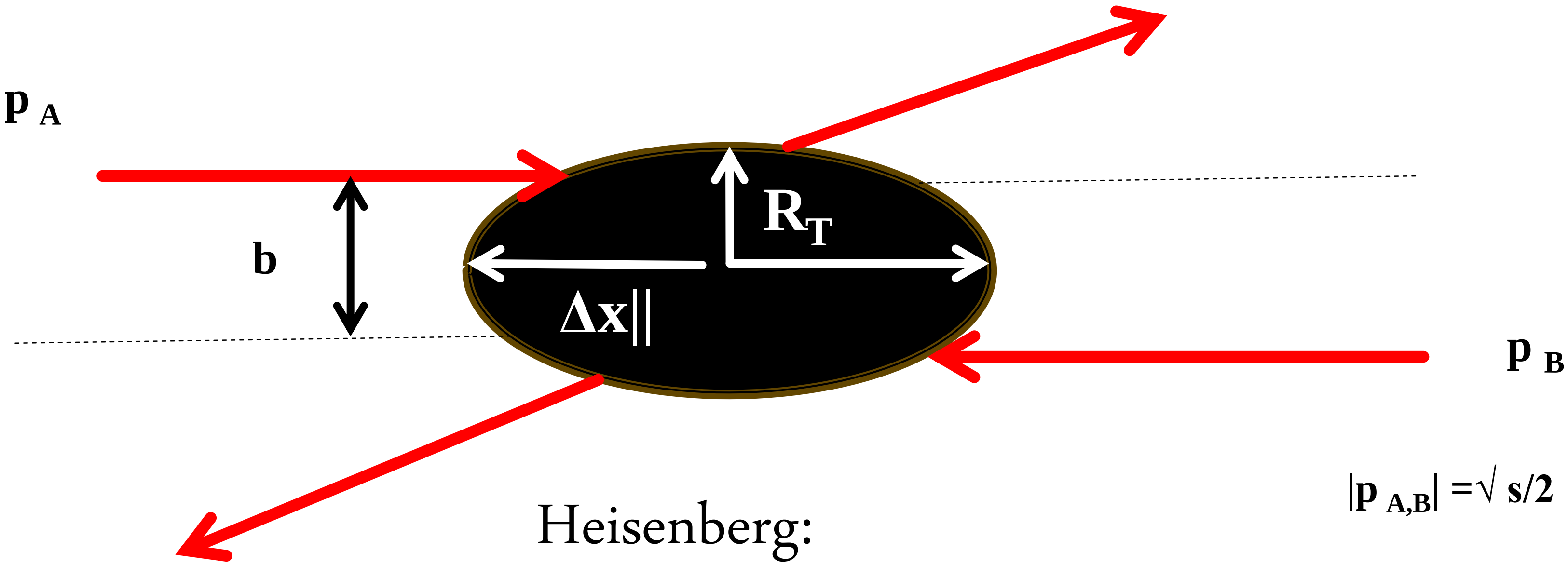
Characteristic Scales



Heisenberg:

$$\langle b^2\rangle^{1/2} = R_T = \Delta x_\perp > 1/\sqrt{\langle -t \rangle} \approx 1 \text{ fm}$$

$$\Delta x_{||} > \sqrt{s} /(2 \sqrt{\langle t^2\rangle - \langle t \rangle^2}\,) \approx 10^4 \text{ fm at LHC}$$

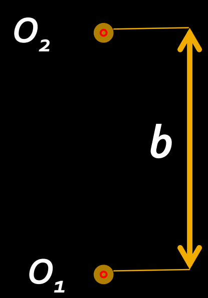
$$(\Delta x)^2 \equiv \langle x^2 \rangle - \langle x \rangle^2$$

$$r_{Compton}(\text{Higgs}) = 1.6\cdot 10^{-3} \text{ fm}$$

Elementary Geometry of Collision

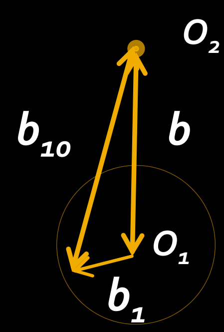
High Energies

Pointlike particle

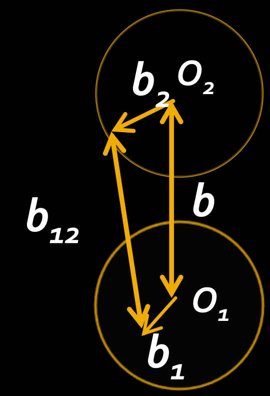


Pointlike particle

Pointlike particle



Extended particle

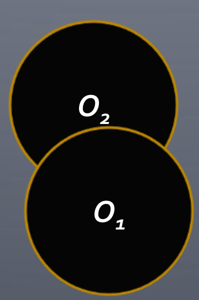


$<b_1 b_2> = <b_1 b_{12}> = <b_2 b_{12}> = 0$

$\mathbf{b} = \mathbf{b}$ $\qquad b = b_1 + b_{01}$ $\qquad b = b_1 - b_2 + b_{12}$

$$< b^2 > = < b_1^2 > + < b_2^2 > + < b_{12}^2 > \geq < b_1^2 > + < b_2^2 >$$

Low Energies

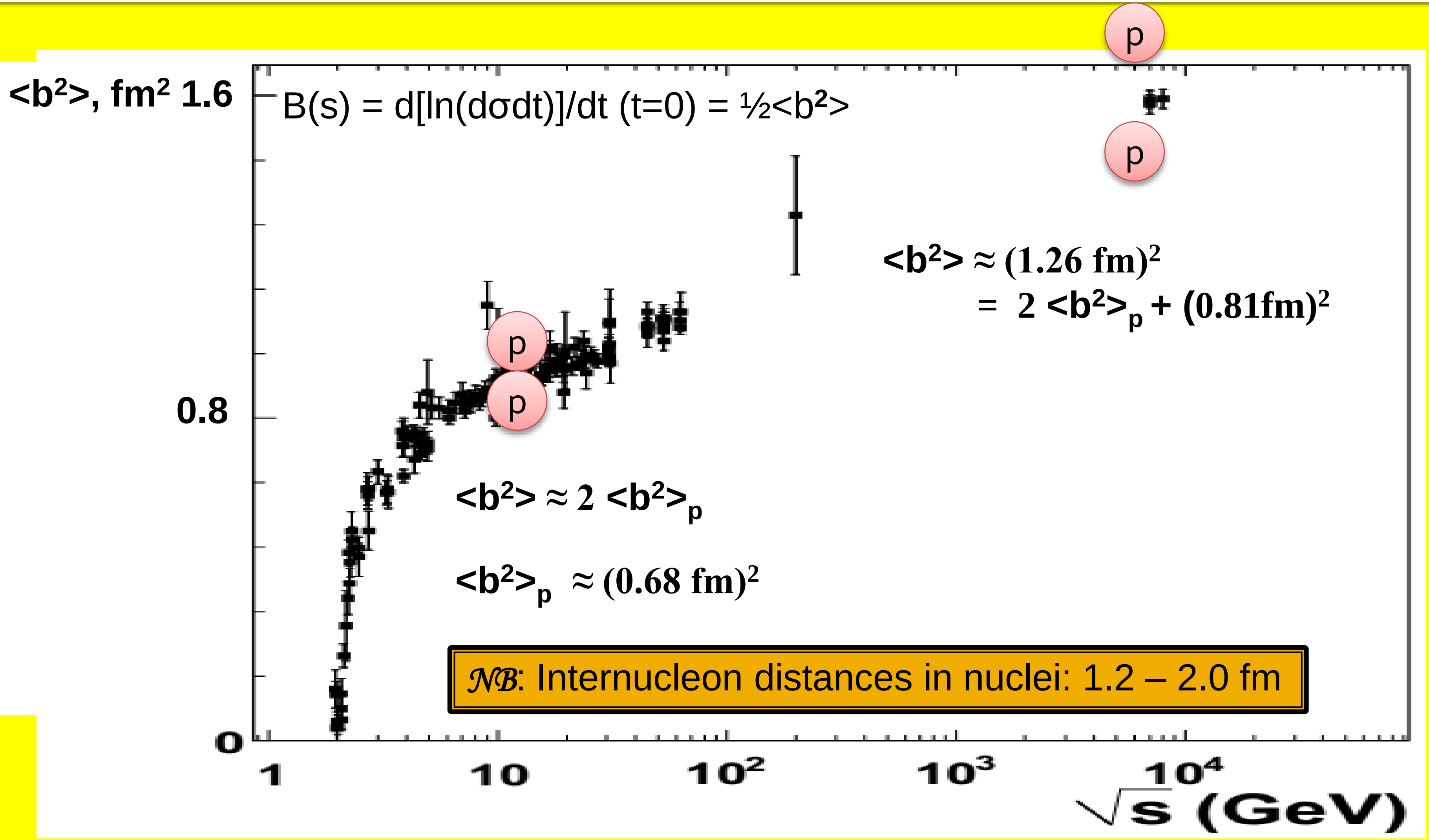


$< b_1 b_2 > \neq 0$

$< b_1 b_{12} > \neq 0$

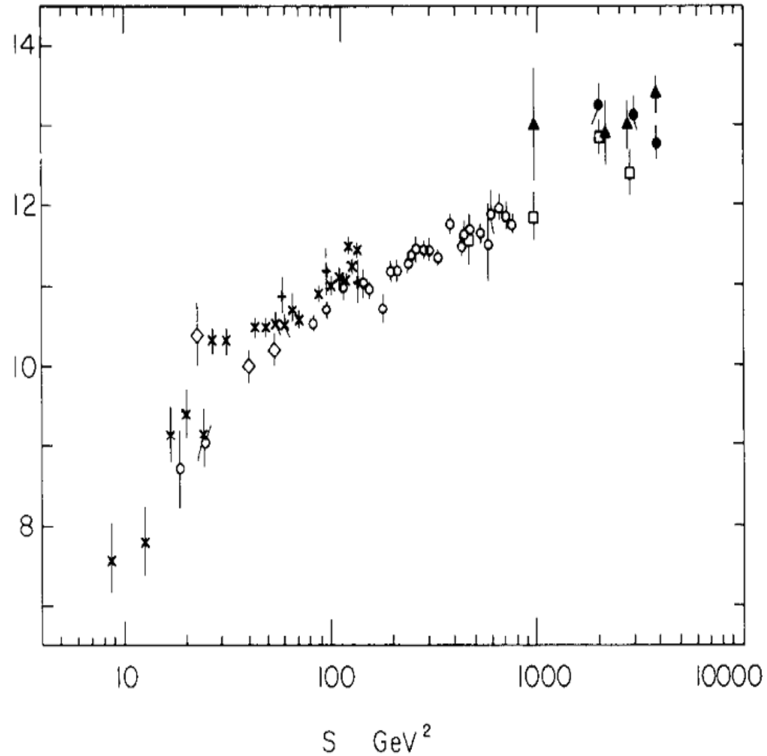
$< b_2 b_{12} > \neq 0$

Uneasy Separation



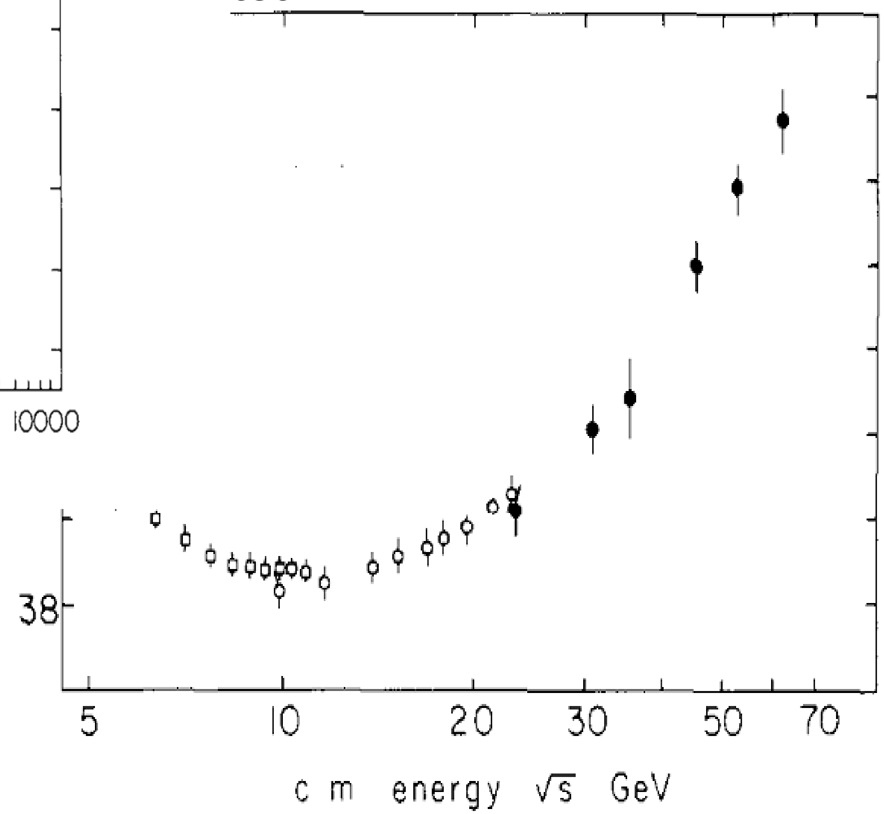
Two phenomena to be related

Bpp , GeV -2



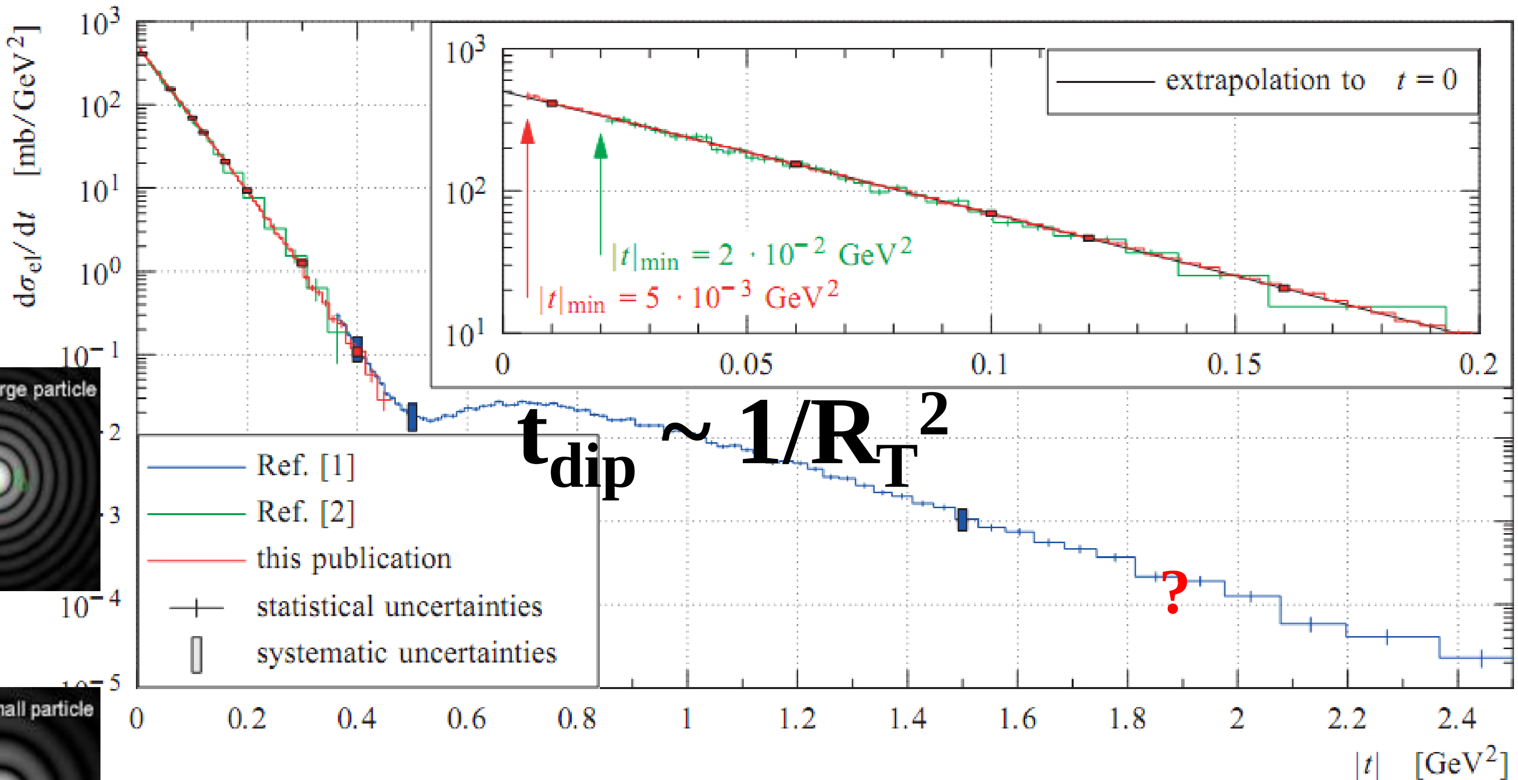
Stop of the decrease at ≈ 7 ÷15 GeV

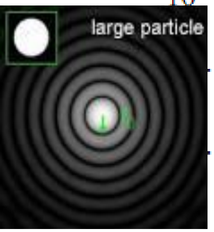
$\sigma_{tot}(pp)$

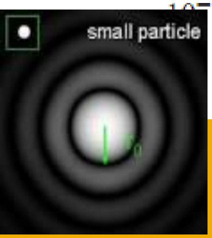


Change of the growth rate at ≈ 7 ÷15 GeV

Diffraction Pattern at the LHC

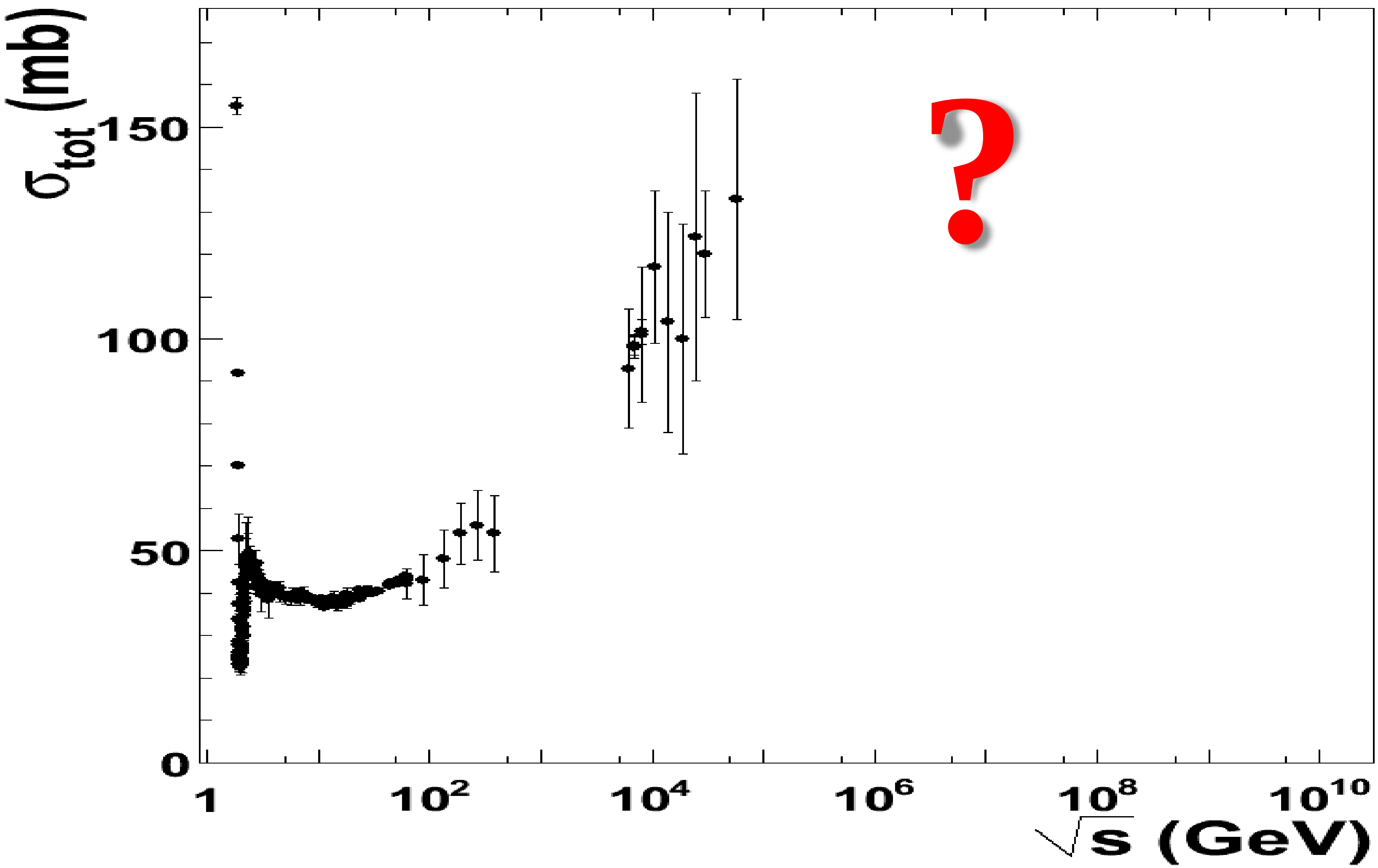






Straightforward optical analogy: a 2nd dip at t ≈ - 1.7 GeV^2.

Past, present ….



Where Lies the "Asymptopia"?

Sizes of nucleons

$$\langle r^2\rangle_{ch} = \sum_i e_i \langle r^2\rangle_i$$

Physical nucleon radius

$\langle r^2\rangle$(nucleon) = $\max_i \langle r^2\rangle_i$ = 0.711 fm^2

$\langle b^2\rangle$(nucleon) =(2/3) $\langle r^2\rangle$(nucleon) = 0.474 fm^2 = 11.85 GeV^{-2}

$B = B_{cr}$ = 11-12 GeV^{-2} at the "knee"

$\langle b^2\rangle$(7 TeV) = 40 GeV^{-2} = 2 $\langle b^2\rangle$(nucleon) + 16.3 GeV^{-2}

Asymptopia: $\langle b^2\rangle \gg 2\langle b^2\rangle(nucleon)$

$\langle b^2\rangle$ = 5$\langle b^2\rangle$(nucleon) (B = 27-30 GeV^{-2})

at O(>100 TeV) ?

Asymptotic theory:

Asymptotic expectations (“ s $\rightarrow\infty$”) :

$$\sigma_{tot} \approx 8\pi\alpha'_P(0)(\alpha_P(0) - 1)\ln^2(s) + \ldots$$

$$\approx 8\pi\, B(s)$$

“Popular values”: $\alpha_P(0) = 0.08$,

$\alpha'_P(0) = 0.25\ \mathrm{GeV}^{-2}$

∞ =? 7 TeV $\rightarrow$ $\sigma_{tot} \approx 43$ mb, $B(s) \approx 4.3\ \mathrm{GeV}^{-2}$

LHC: $\sigma_{tot} \approx 100$ **mb**, $B \approx 20\ \mathrm{GeV}^{-2}$

$$\sigma_{tot} \ll 8\pi B$$

“Theory”

$$T(s,t) = \beta(t)s^{\alpha(t)}$$

$$\text{QCD}: \alpha(t) = A(t/\Lambda^2_{QCD}),$$

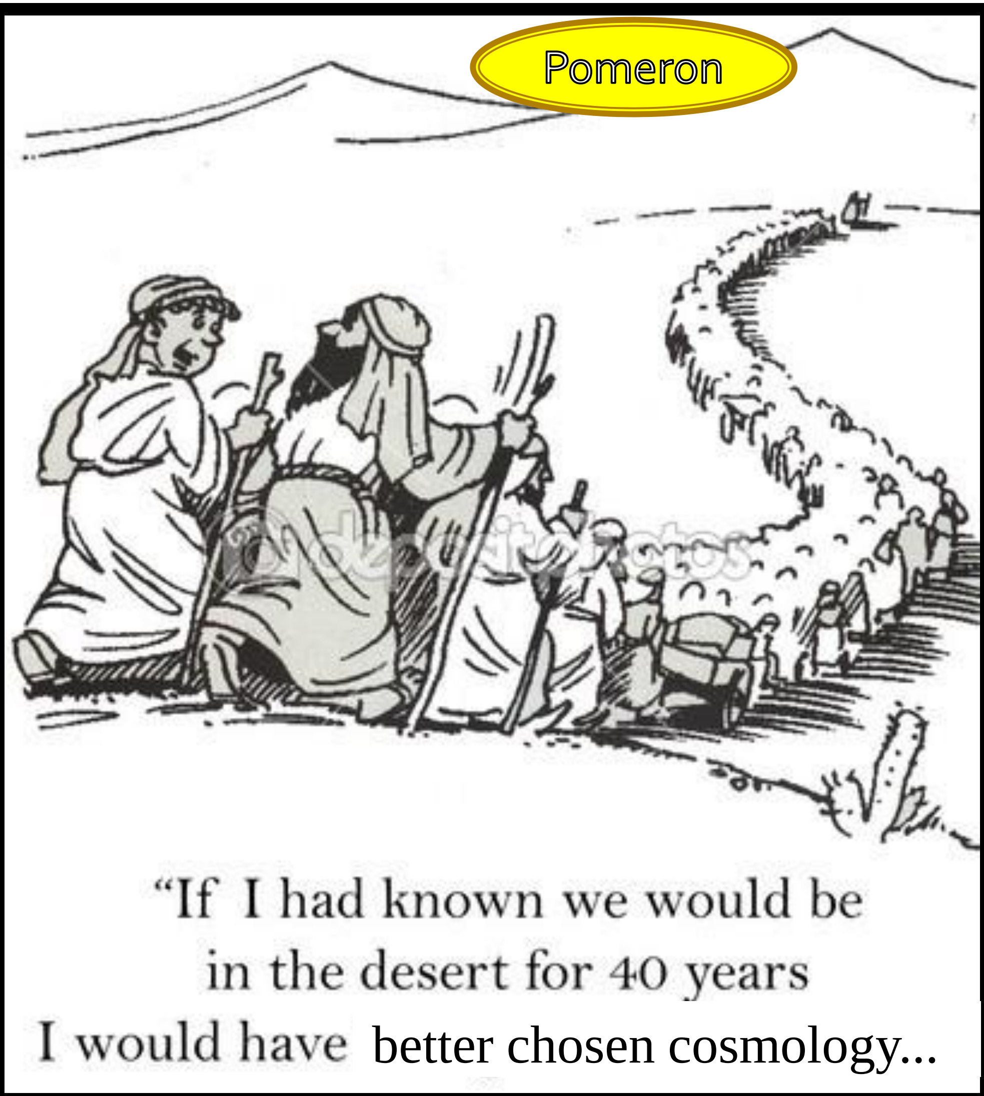
$$\Lambda^2_{QCD} = \mu^2 exp\left({}^{-1}/_{\beta_0\, g^2}\right).\ \alpha(0) = A(0).$$

40 years of a hard work

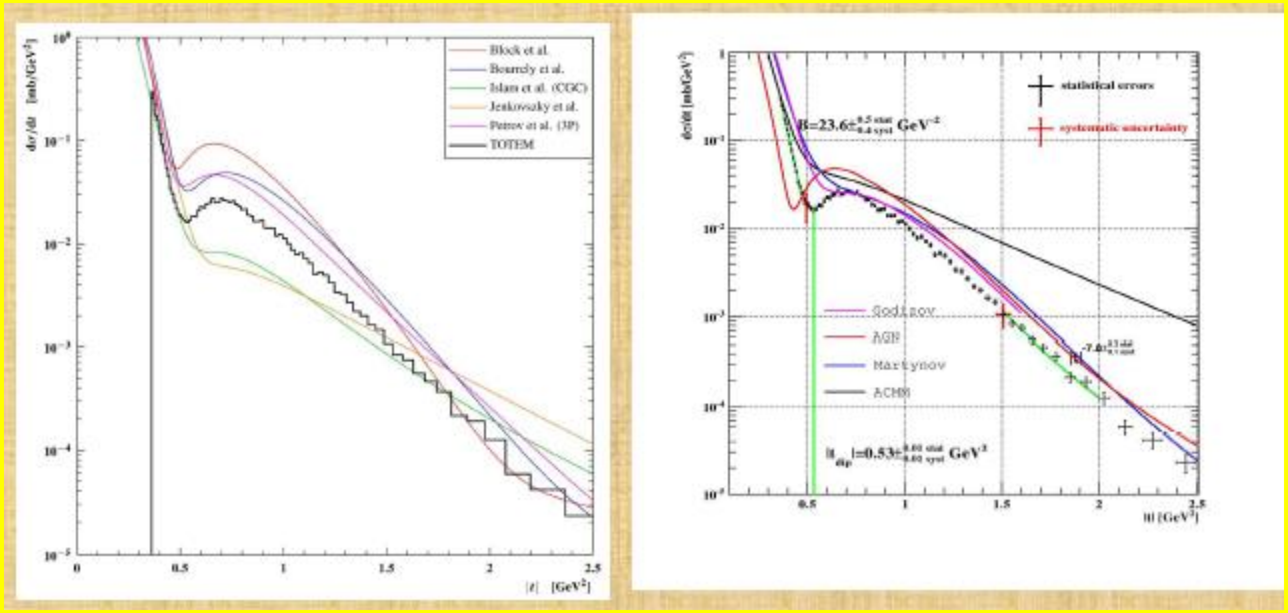
$$\alpha(t) \to \alpha_k(t) > \mathbf{1}, k = 1,2,\dots,\infty$$

$$\alpha_k^{\mathbb{P}}(t) \to \mathbf{1}, -t \to \infty;\ \ \alpha(0)^{\mathbb{P}}_{\infty} = \mathbf{1}$$

A la recherche du Pomeron perdu



LHC against models



General Failure…

QCD against the Diffraction Data

Damned Questions

- Why do cross-sections rise?
- Where are other dips?
- Where the Asymptopia lies?
- Etc, etc…

Conclusions
(1st movement. Lamentation)

- 1. All the models gave wrong predictions for the diffractive picture at the LHC (7 TeV)
- 2. Some models gave good predictions for " global" characteristics (σ_{tot} , σ_{el} , B, t_{DIP})
- No consequences for QCD ! No commonly significant consequences at all.

Outlook:

- Stop arbitrary modelling!
- Go deep into QCD at large distances!

Conclusions
(2nd Movement. Consolation)

At the LHC we seem to be still far from the "truly asymptotic" region but

"There is still plenty of good music to be written in C major."

Arnold Schönberg