LHC Working Group on Forward Physics and Diffraction
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On physical meaning of some diffractive observations at the LHC

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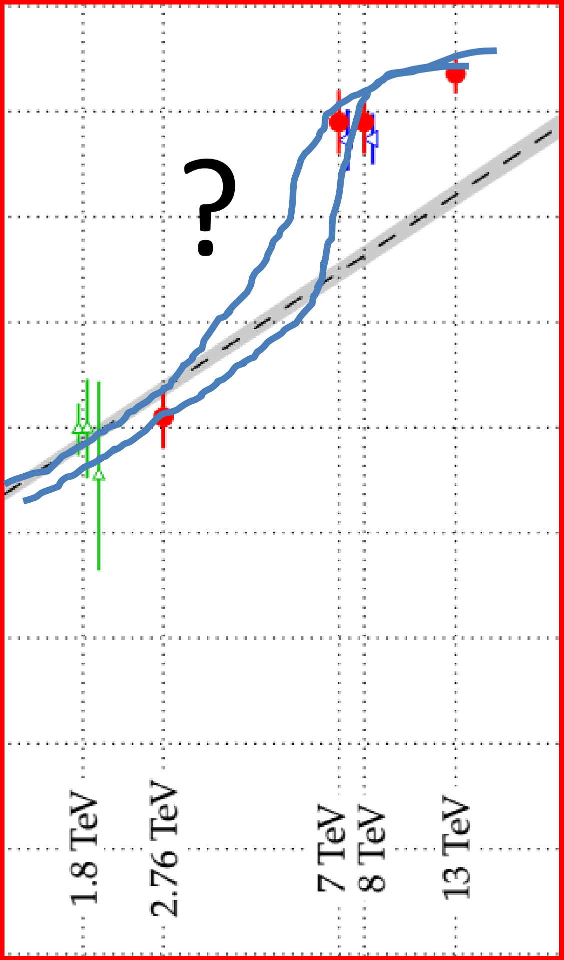
Forward Slope

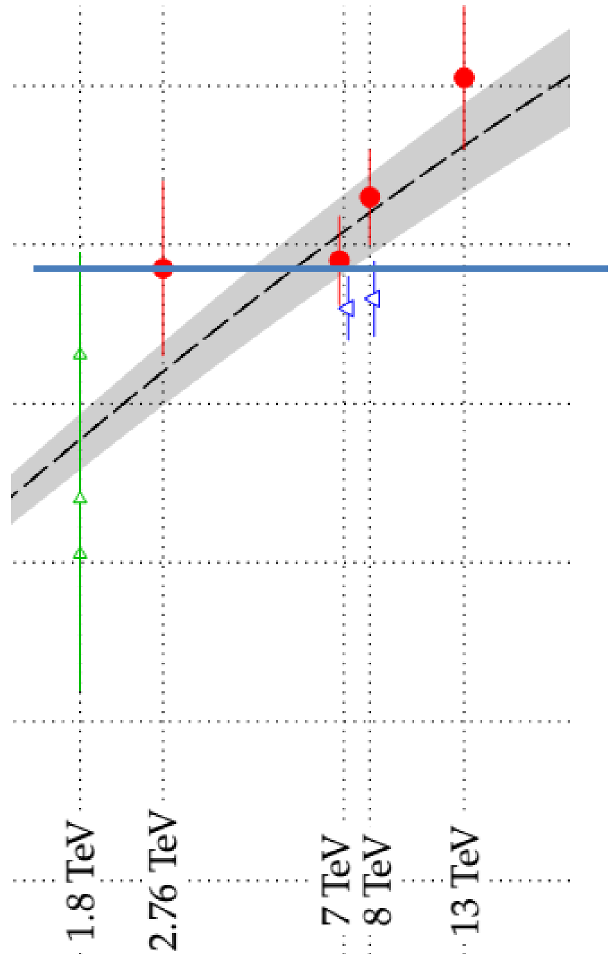
$$\langle b^2 \rangle \approx 2B(s)$$

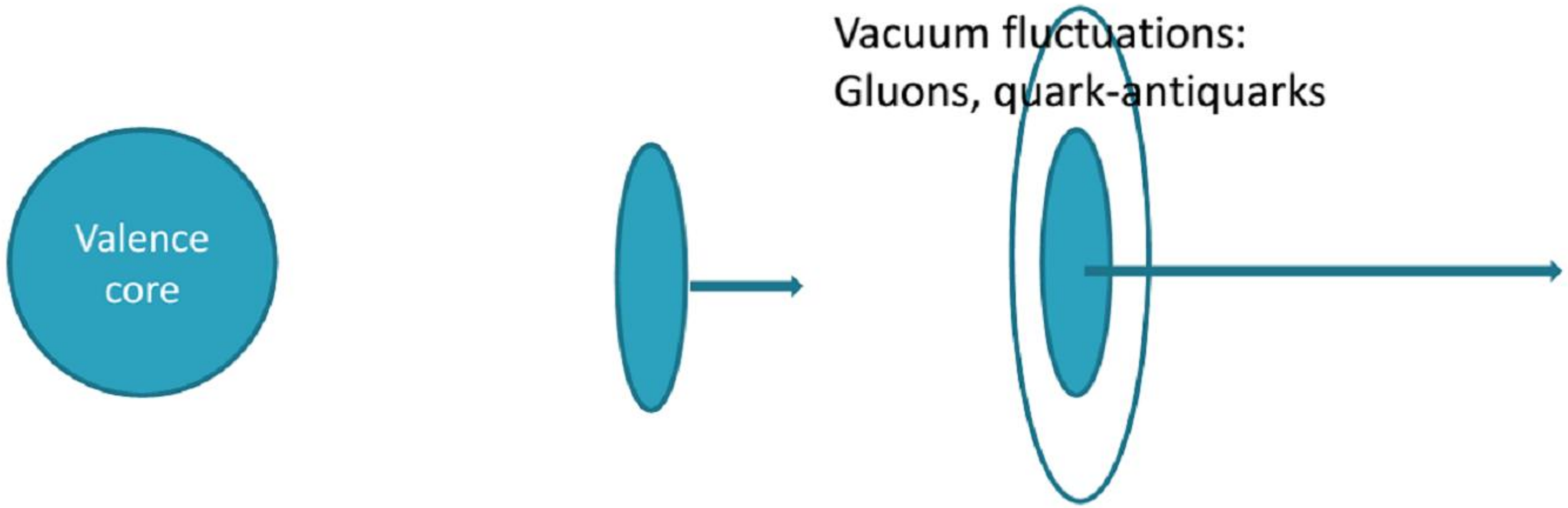


$<r^2> \approx 3\ B(s = (2760\ \text{GeV})^2\ ) \approx 1/m_\pi^2$!

$m_{\text{effective}}(\text{gluon}; \sqrt{s} = 2760\ \text{GeV}\ ) \approx m_\pi$

$$\frac{\sigma_{el}}{\sigma_{tot}}(s)$$

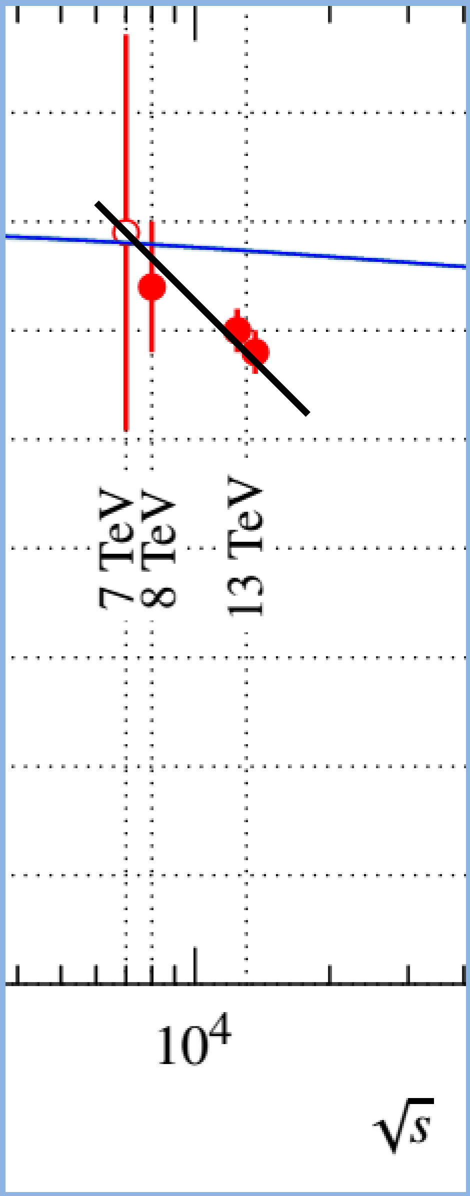



Valence core
Vacuum fluctuations:
Gluons, quark-antiquarks

$$\rho\,(s) = \cot[\Phi(s, t = 0)]$$

$$\langle \Delta T^* \rangle = \partial\Phi(s, t = 0)/\partial E^*$$

$$\langle \Delta T^* \rangle = \frac{2}{1 + \rho^2(s)} \left| \frac{\partial \rho(s)}{\partial \sqrt{s}} \right|$$



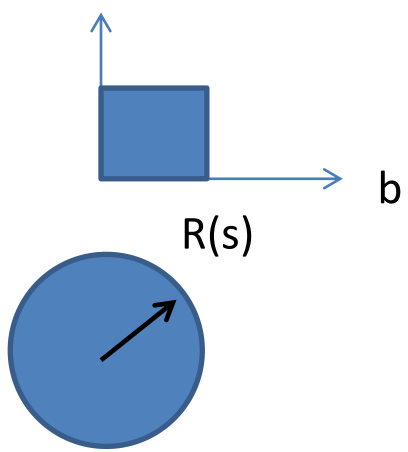
CNI

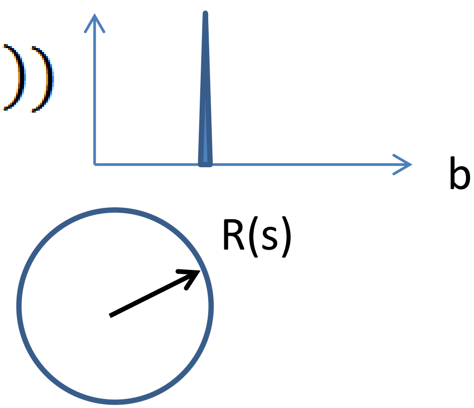
$$F^{\mathrm{C+N}}(s,t) = F^{\mathrm{C}}(s,t)\,\mathrm{e}^{\mathrm{i}\alpha\phi(s,t)} + F^{\mathrm{N}}(s,t)$$

"90% of rigour"

$$\tilde{F}^{N}(s,b) = \frac{1}{16\pi s}\int dt\, J_0\left(b\sqrt{-t}\right) F^{N}(s,t)$$

$$\tilde{F}^{N}(s,b) \sim \delta\left(b - R(s)\right)$$





What for t-dependence of nuclear phase?

$$F^N(s,t) = |F^N(s,t)| e^{i\Phi(s,t)}$$

$$< b^2 >_{el} = < (-t) B^2(s,t) + 4(-t) [\frac{\partial \Phi(s,t)}{\partial t}]^2 >$$ (V. Kundrat et al.)

$$\left\langle x_{||} \right\rangle = \left\langle \frac{\partial \Phi}{\partial p_{||}} \right\rangle = \sqrt{s - 4m^2} \left\langle \frac{\partial \Phi(s,t)}{\partial t} \right\rangle$$

Physics interpretation: on-going work in the theory community

- t-channel exchange of a colourless 3-gluon bound state ($J^{PC} = 1^{--}$) could decrease ρ in pp collisions at large $\sqrt{s}$
  - originally predicted as “Odderon” in axiomatic theory [Lukaszuk, Nicolescu]
  - confirmed in QCD [Vacca, Braun, Lipatov et al.]: colourless 3-gluon bound state with stronger internal coupling than external
  - “vector glueball“ in lattice calculations [Luscher, Morningstar et al.]
- other manifestations
  - difference of depth of “diffractive dip“ between pp and p$\bar{\text{p}}$ collisions
  - faster increase of σ_{tot} with $\sqrt{s}$
  - non-constant hadronic phase and low-$|t|$ deviation from pure exponential
  - no oscillatory effects at large $|t|$
- 2 models in agreement with TOTEM data [Nicolescu, Durham]
  - *agreement improved when included exchange of 3-gluon bound state*

On “ Maximal Odderon”

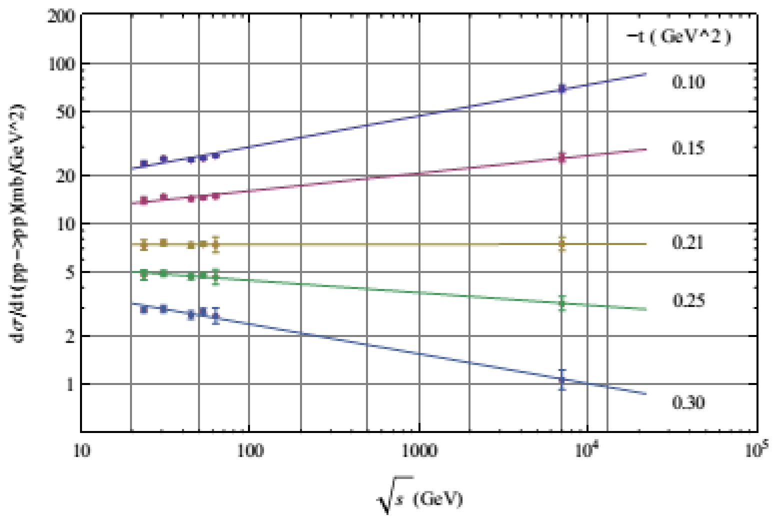
$$F^{MO}(s,t) = \int \frac{dj}{2i\pi}\, s^j F_{-}^{MO}(j,t) \sim s(lns - \frac{i\pi}{2})^2$$

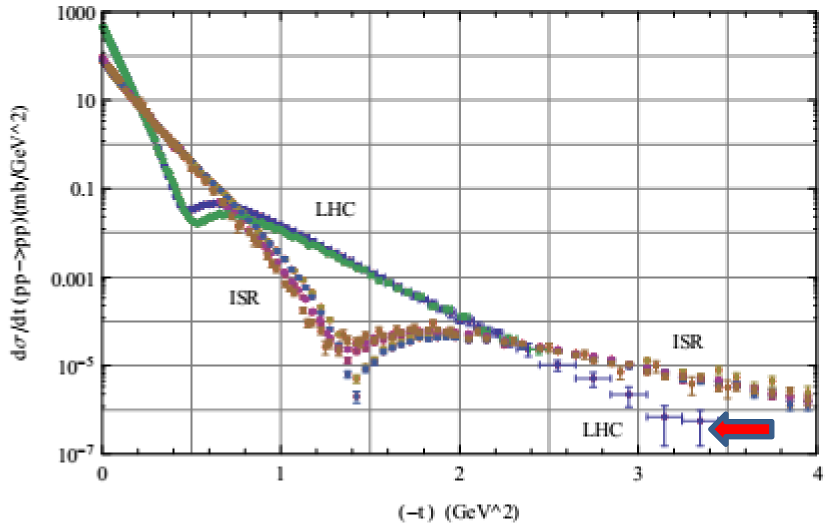
$$F_{-}^{MO}(j,t) \sim \frac{1}{(j-1)^2 - R^2 t}$$

Massless vector in t-channel p-wave

$$F_{-}^{MO}(1,t) \sim \frac{1}{-t}$$

Stationary Points ?





DL 3-gluon exchange ruled out