XIV-я Міжнародная школа-канферэнцыя "Актуальныя праблемы фізікі мікрасвету" (Гродна, Беларусь, 12-24 жніўня, 2018), прысвечаная памяці прафесара Н.М. Шумейка.

Diffraction at the LHC: Results and Problems

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Quickie history of the LHC: 2009 - 2018

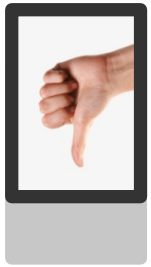
- **"Old Physics":**

- Completion of the SM with Higgs

- "Routine "measurements of cross-sections, life-times, masses, correlations…

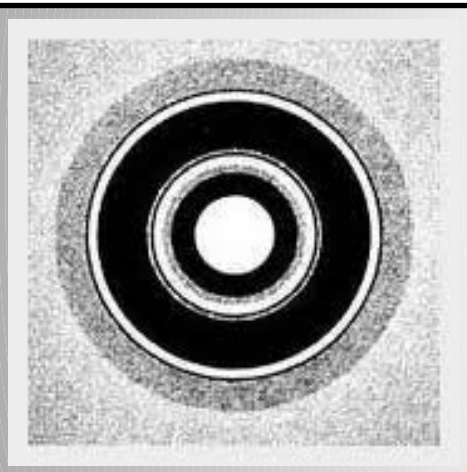
- **"New Physics":**

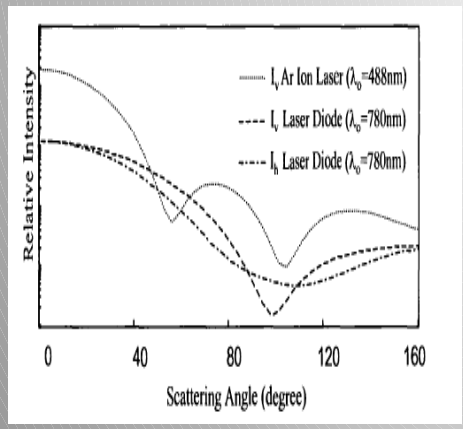
- Supersymmetry:
- "Stringy effects"
- Dark matter ("dark photons")
- Lepto-quarks
- Compositeness
- Extra dimensions
- Micro Black holes



What Is Diffraction Scattering ?

Light scattering off a polystirene latex particle

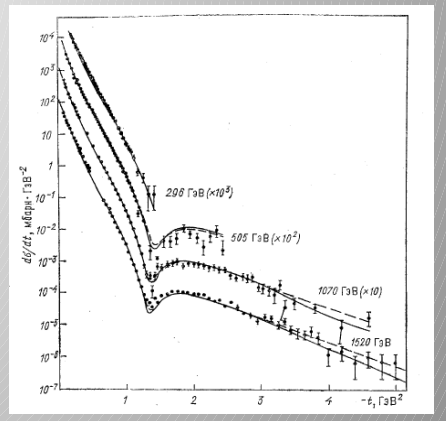




$E = 1.6 \div 2.5\ eV$

$R = 0.5\ \mu m = 5 \cdot 10^{-7} m = 5 \cdot 10^{8}\ fm$

Proton-proton scattering



$E = 2.96 \cdot 10^{11}\ eV \div 1.52 \cdot 10^{12} eV$

$R = 1.6 \cdot 10^{-15}\ m = 1.6 \cdot fm$

What to be measured

- “Global” Characteristics:

- cross-sections: total, elastic, single diffractive, doubly diffractive (integrated)

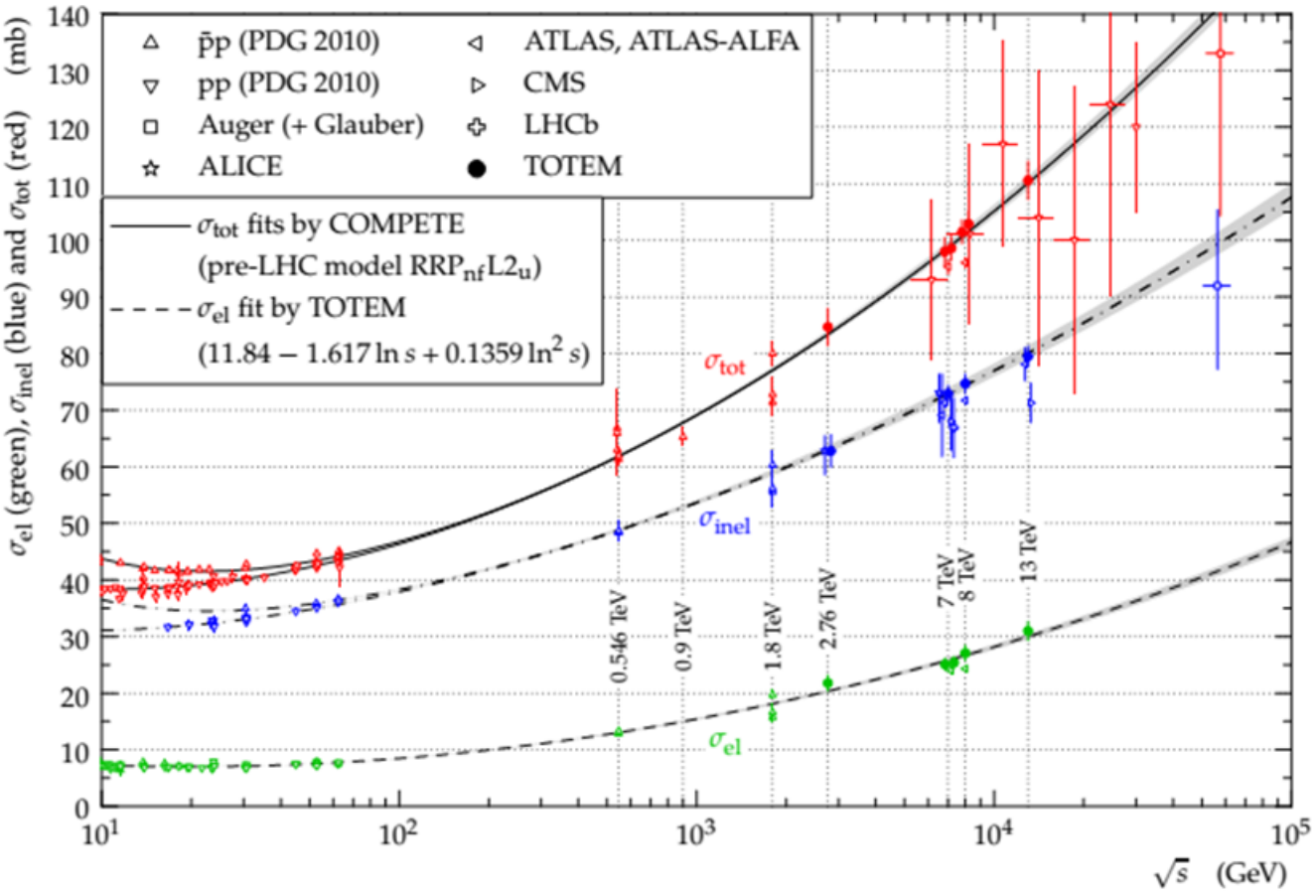
- Local Characteristics:

- Differential cross-sections (elatic & inelastic)
- The slope
- Real/Imaginary

Why?

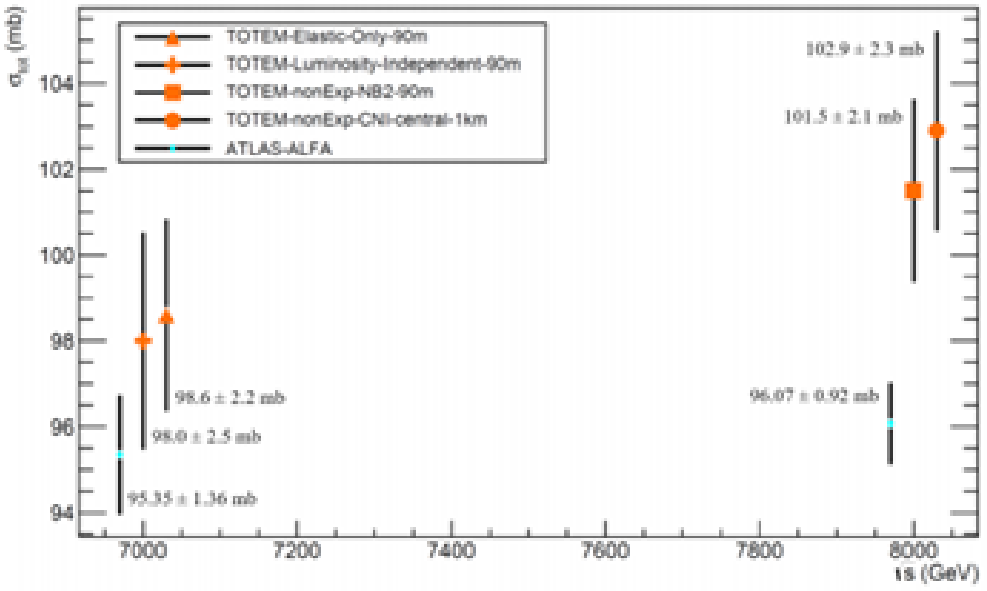
- To test general principles
- To test models
- To see spatial features of strong interactions

They Still Keep on Rising…



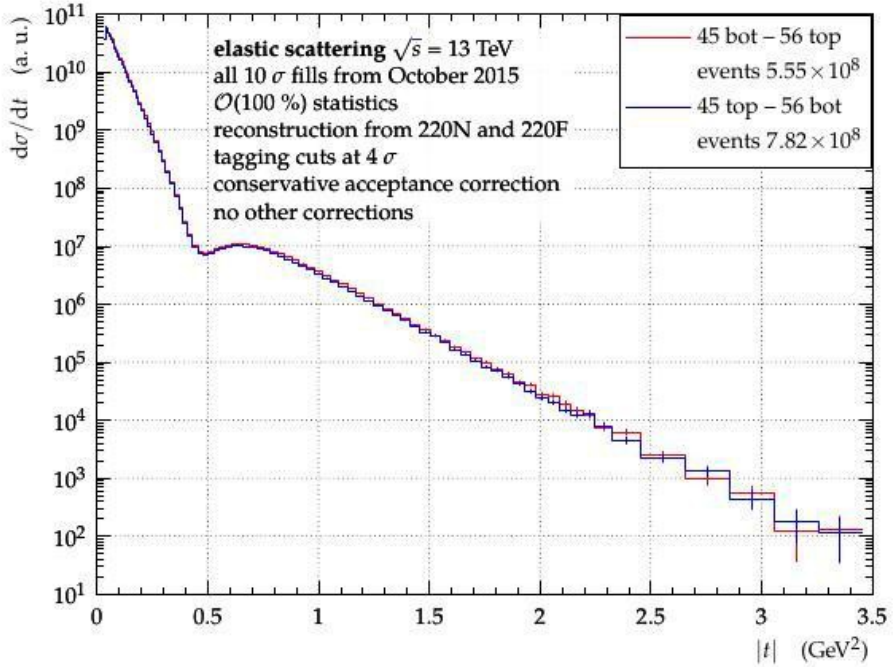
TOTEM vs ALFA/ATLAS

Startling gap

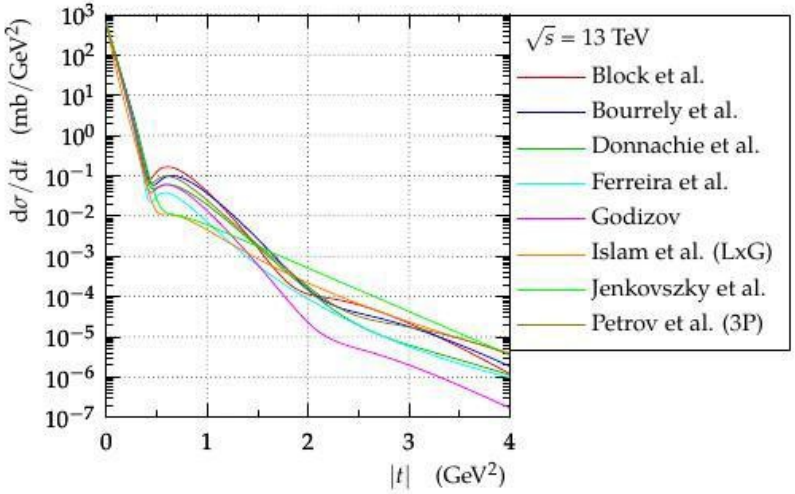


Elastic scattering : *Structures at high |t| ?*

- $\sqrt{s}$ = 13 TeV: very preliminary, but already very strong results

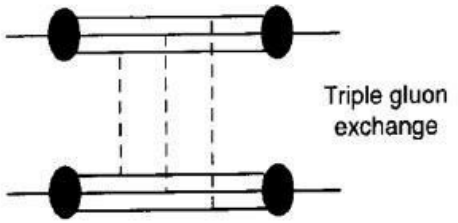


model predictions:

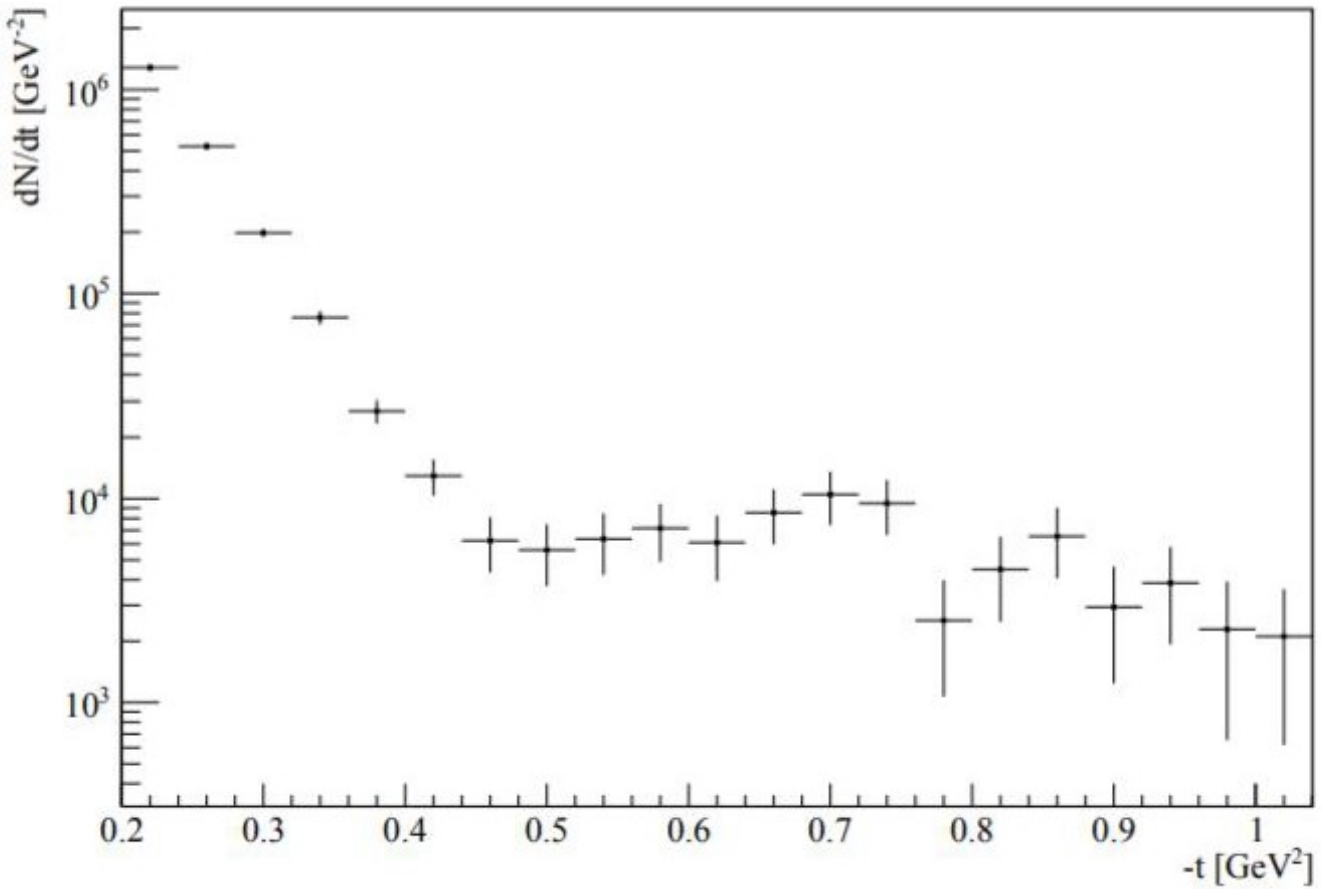


oscillations in almost each model

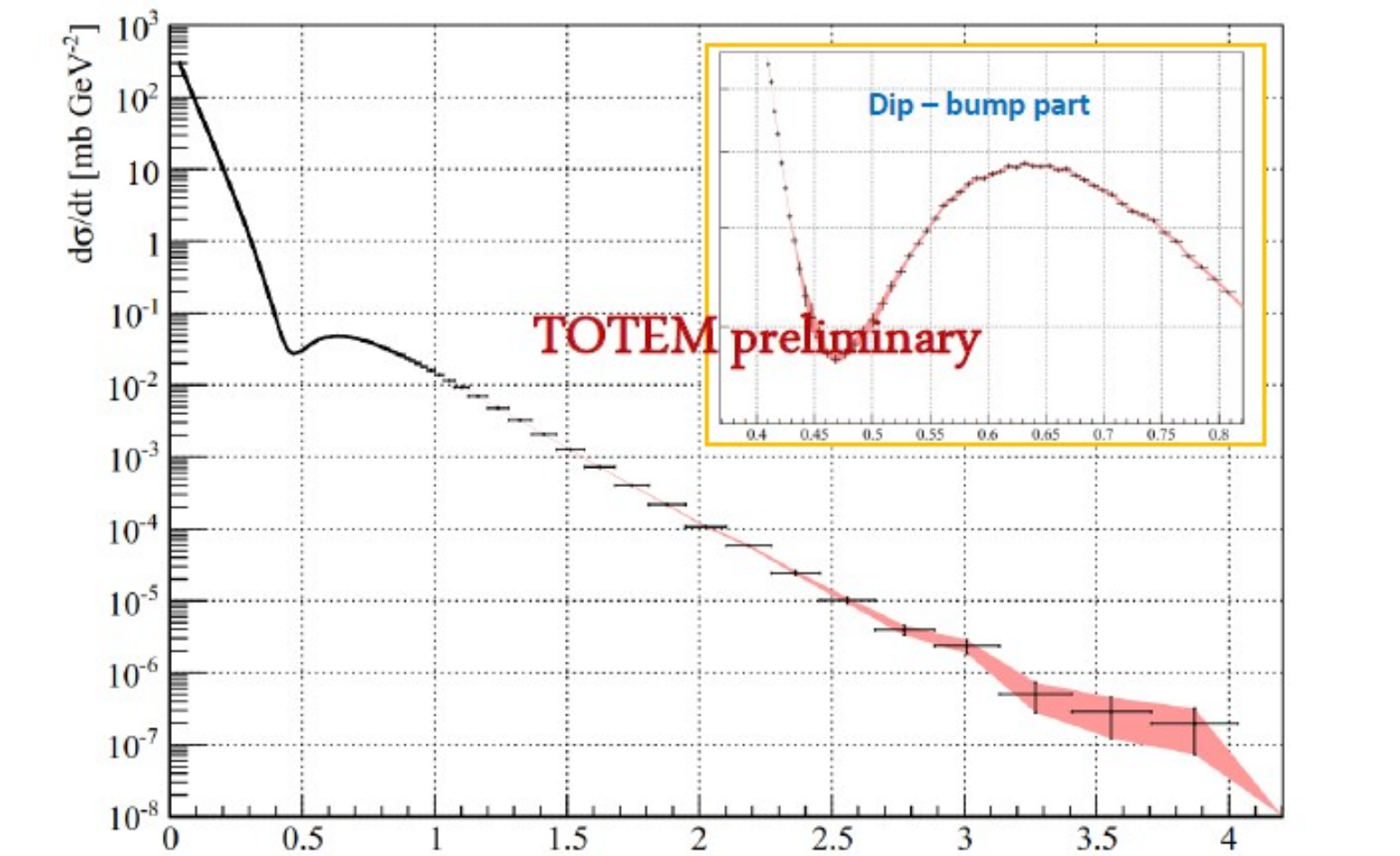
- *high-|t|: no structures!*
  - rules out many models
  - rules out physics mechanism: “optical” models
  - physics interpretation: transition between diffraction and pQCD? ⇒ e.g. Donnachie-Landshoff ⇒



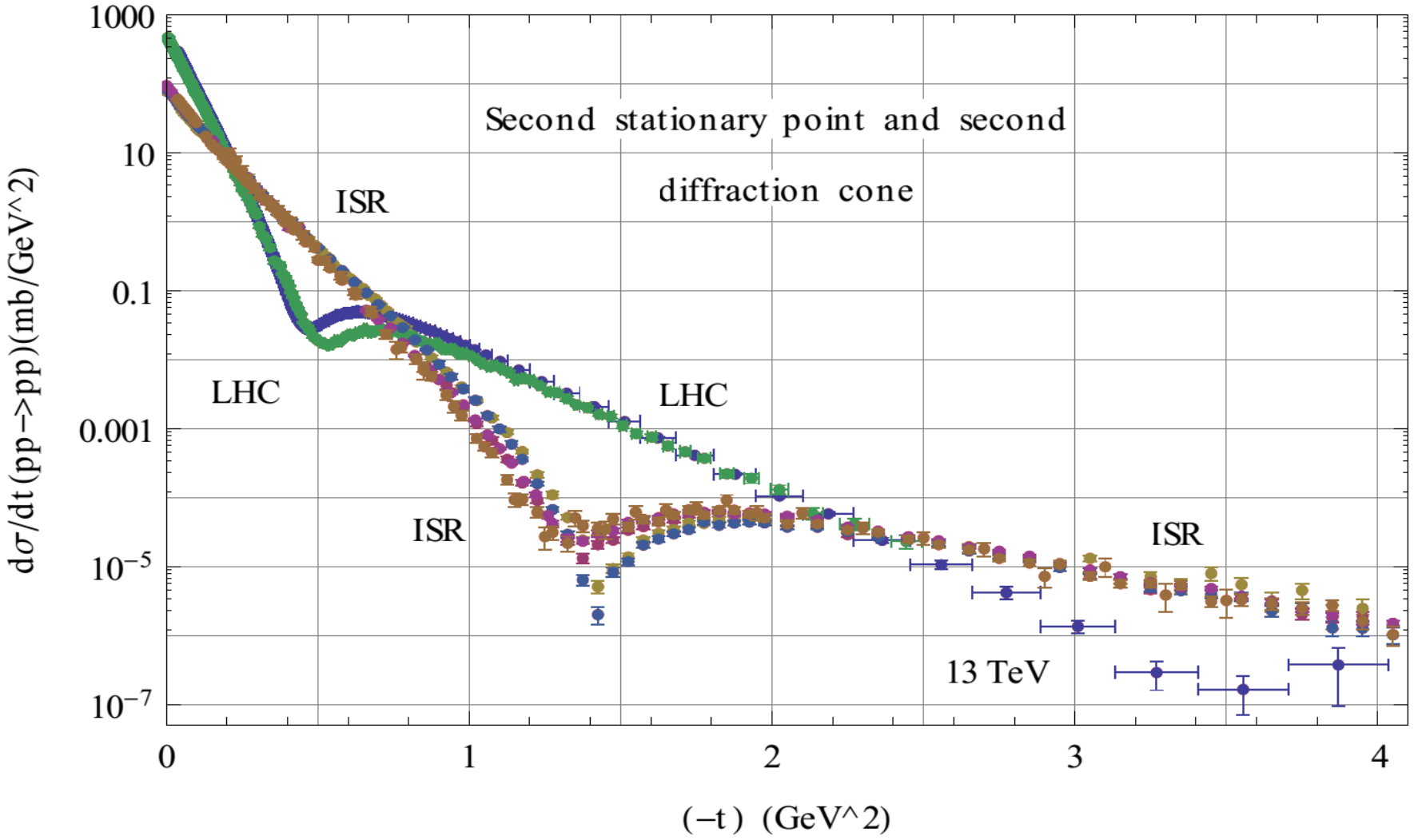
Large-t Focus



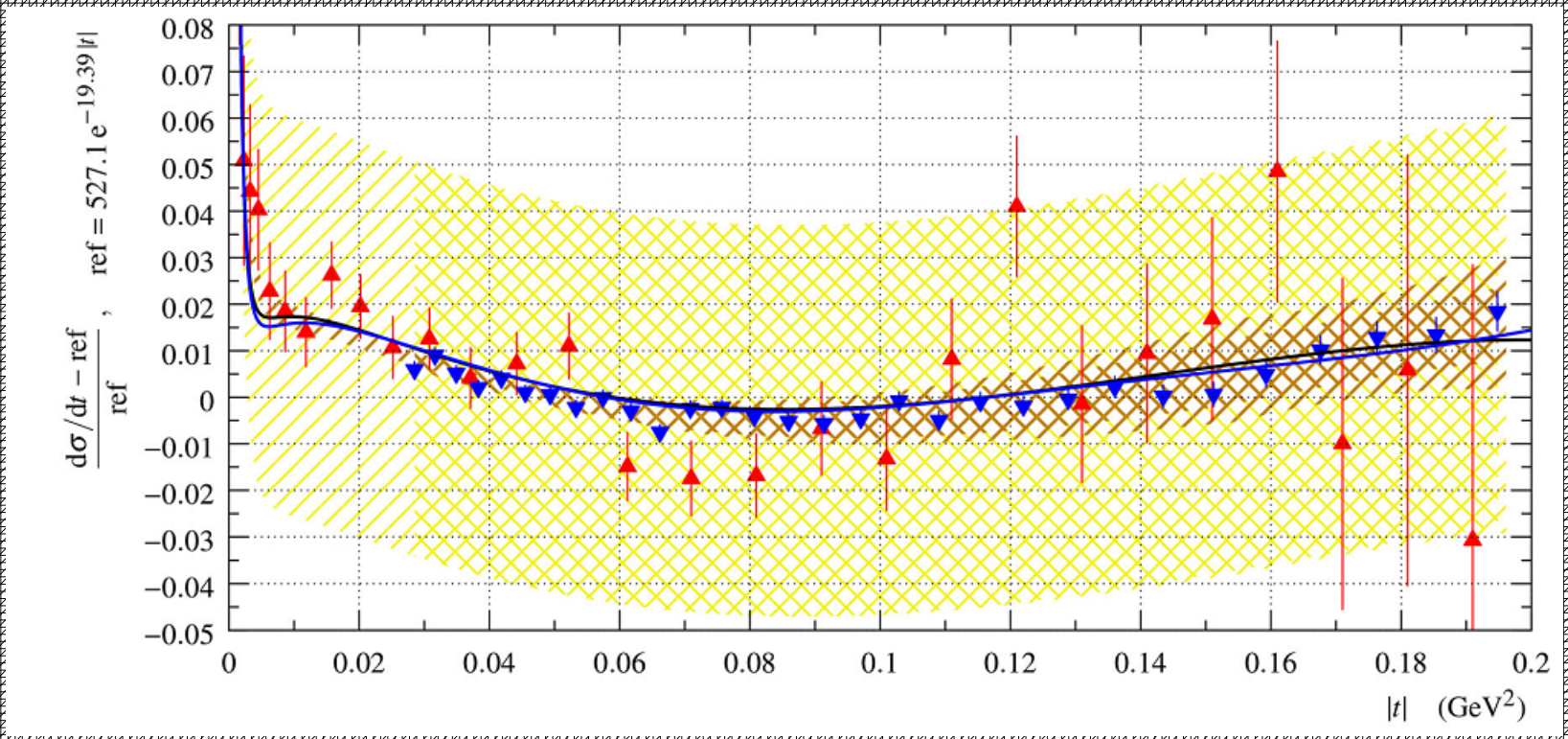
No Second Dip (?)



Stationary points



Is the angular distribution Gaussian?



$$ref = 527.1e^{19.9\,t}$$

Central or Peripheral?

•• $S(b) = e^{2i\delta(b)}$

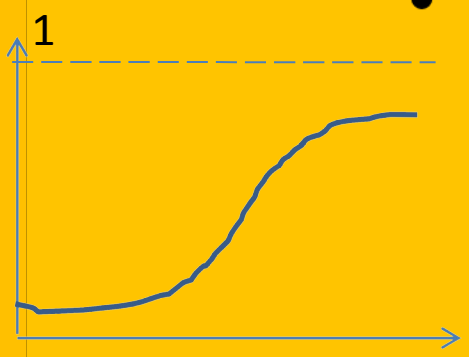
$$P(b) = |S(b)|^2 = e^{-2\Omega(b)}$$

Survival probability of the initial state

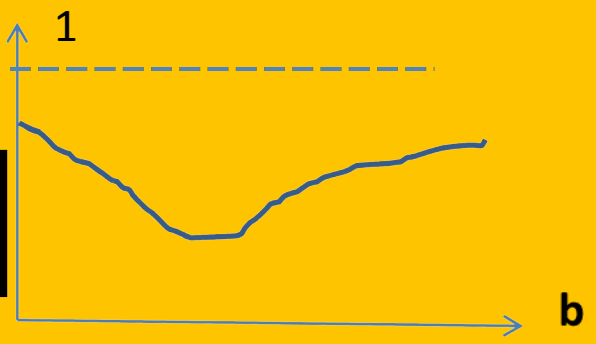
| Normal

Abnormal

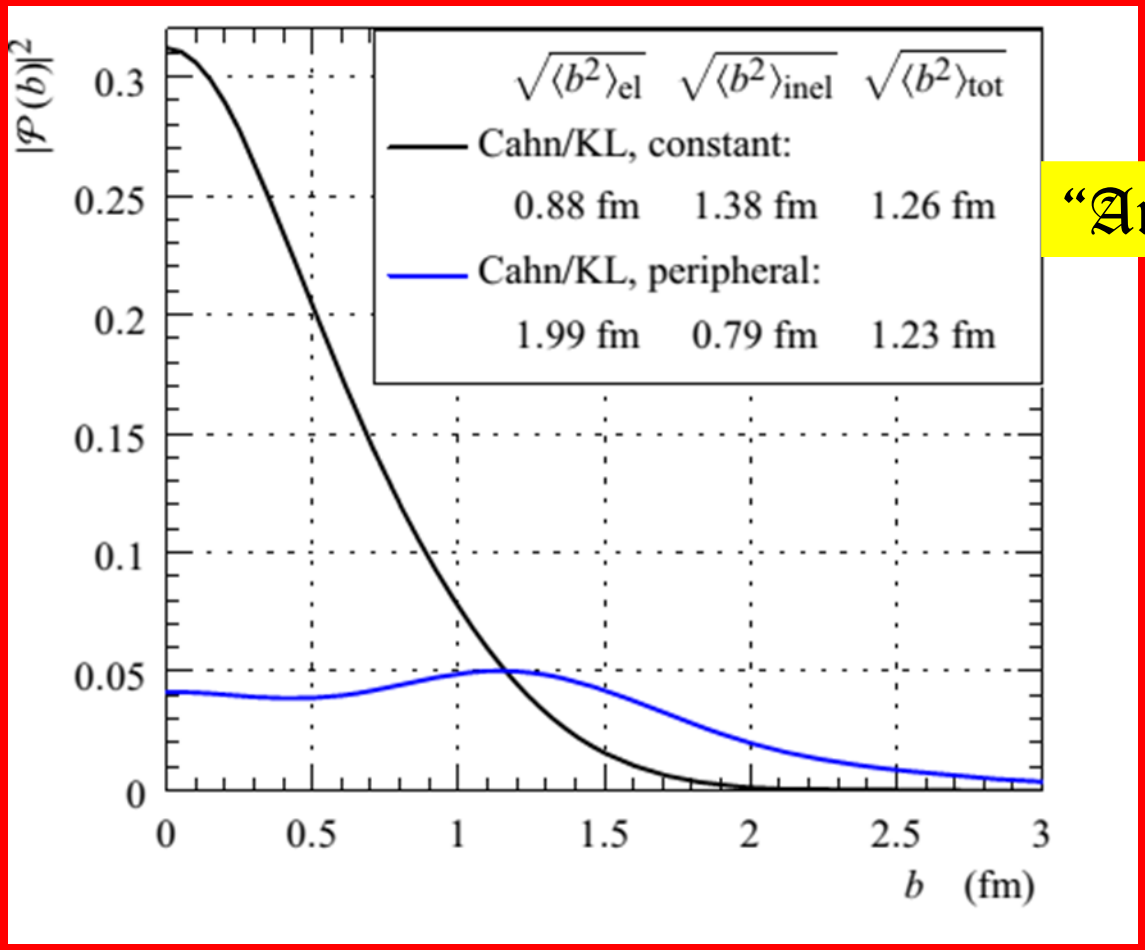
• $P(b) = |S(b)|^2$



Hollowness ?

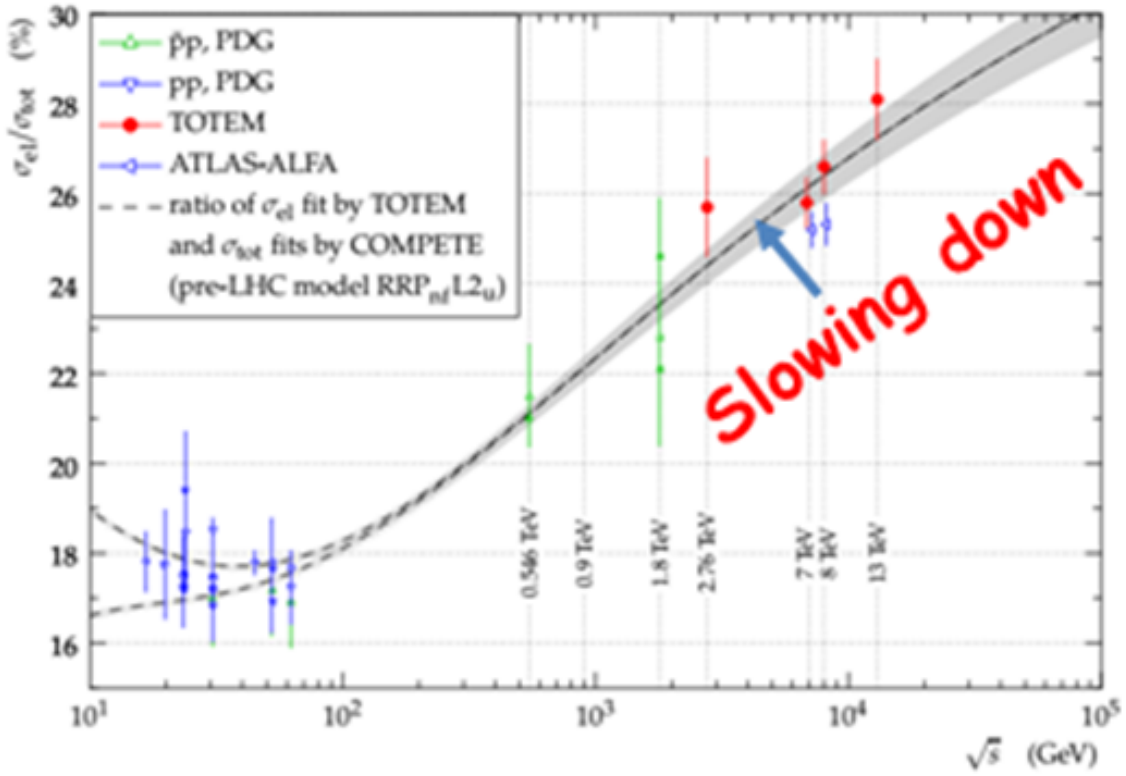


Central vs Peripheral: TOTEM is uncertain

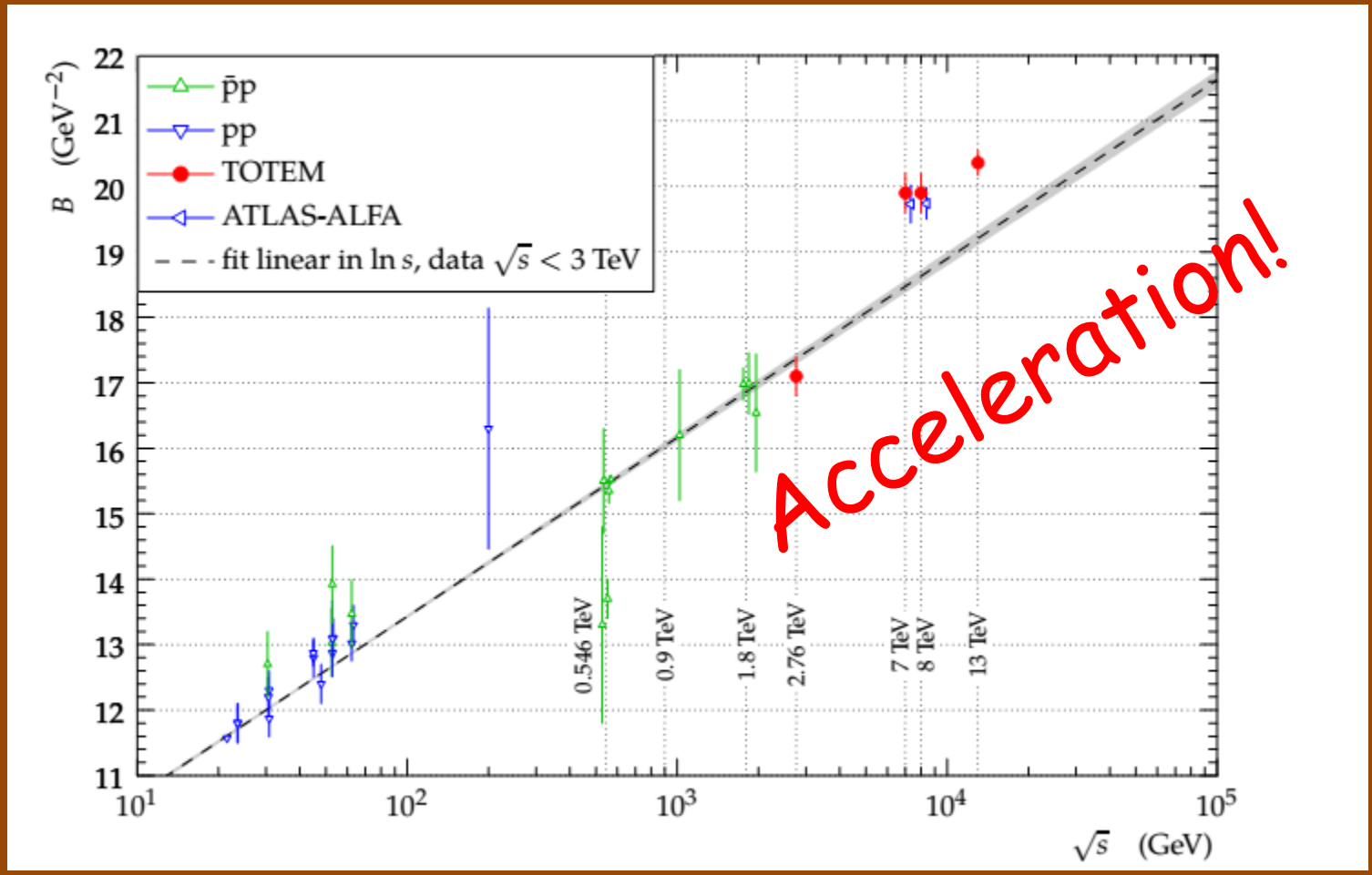


"Anti-ontological"

To be scattered or absorbed?

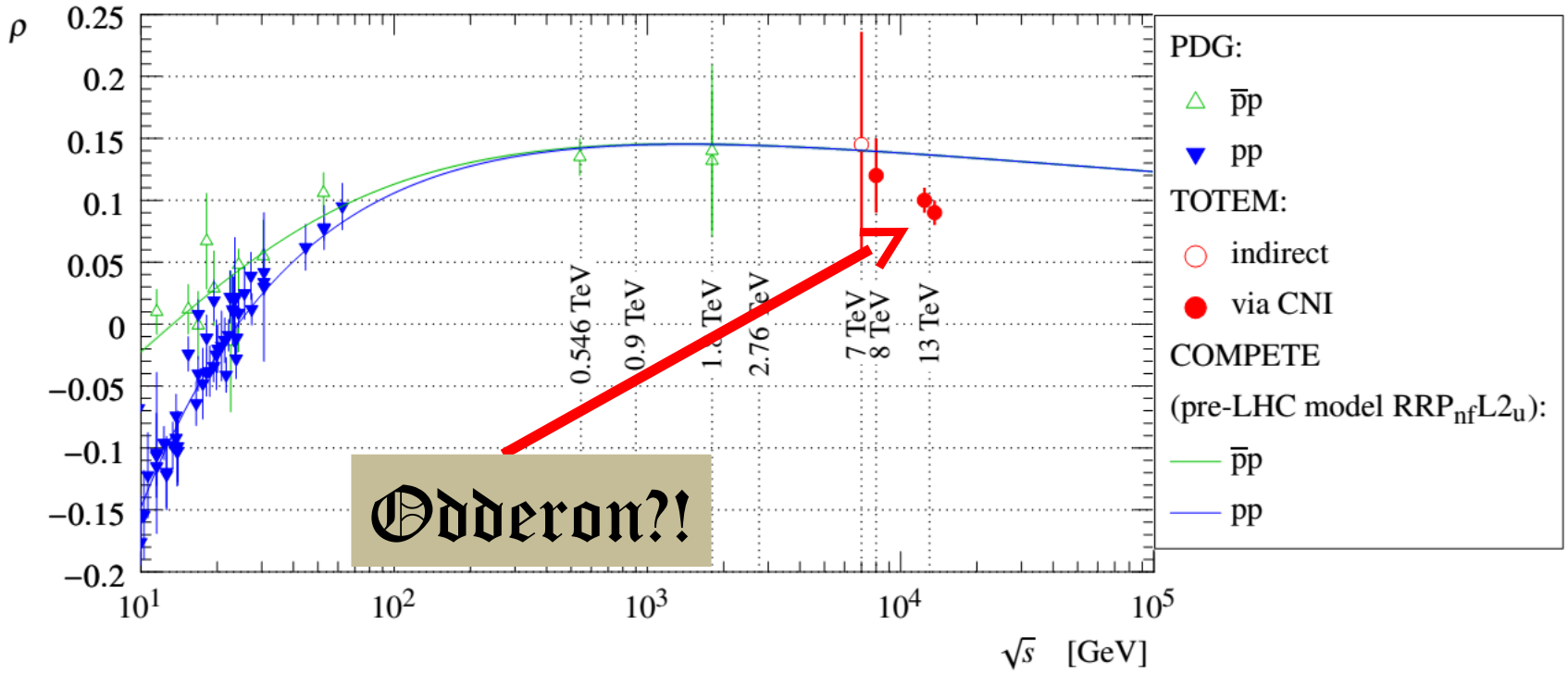


Transverse extent of the interaction radius: peculiar energy dependence.



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

$$\rho = \Re T(s,0)/\Im T(s,0) = \cot\Phi(s,0)$$



Longitudinal size: <z> = p <dΦ/dt>

Conclusions

- Diffractive studies at the LHC:
- Confirmed the growth of the total, elastic and inelastic pp cross-sections in 2-13 TeV region;
- Confirmed the growth of $\sigma_{el}/\sigma_{inel}$;
- Established a non Gaussian character of $d\sigma_{el}/dt$ at $-0.2\ GeV^2 \leq t \leq -0.02 GeV^2$
- Revealed a quasi-stationarity of $\frac{d\sigma_{el}}{dt}$ at $t = -\ 0.21 GeV^2$ and $t = -2.30 GeV^2$
- Ruled out stationarity of $\frac{d\sigma_{el}}{dt}\ at\ -t > 2{,}5\ GeV^2$.
- *Posed a bunch of problems to resolve*

Physics quantity	Value		Total uncertainty
	$\rho = 0.14$	$\rho = 0.1$	
B [GeV^{-2}]	20.36		$5.3 \cdot 10^{-2} \oplus 0.18 = 0.19$
σ_{tot} [mb]	109.5	110.6	3.4
σ_{el} [mb]	30.7	31.0	1.7
σ_{inel} [mb]	78.8	79.5	1.8
$\sigma_{\text{el}}/\sigma_{\text{inel}}$	0.390		0.017
$\sigma_{\text{el}}/\sigma_{\text{tot}}$	0.281		0.009