Wigner FK, RMI, Femtoscopy Research Group

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Emptiness of the proton — black ring limit instead of black disc limit

Recently we have developed a Lévy imaging method and in 2020 we have applied this method to extract an important physics information on proton structure at high energies and ultra-low momentum transfers directly from elastic proton-proton scattering data. Such a model-independent method was applied to probe the internal structure of the proton and quantify its inelasticity profile in the impact parameter space emerging in proton-proton collisions at the highest available colliding energy of √s=13 TeV. The inelasticity profile function and its error band for the proton and its substructure have been reconstructed at different energies and the proton hollowness (or "black-ring") effect with more than a 5σ discovery level significance has been found at 13 TeV, as illustrated on Fig. 1.

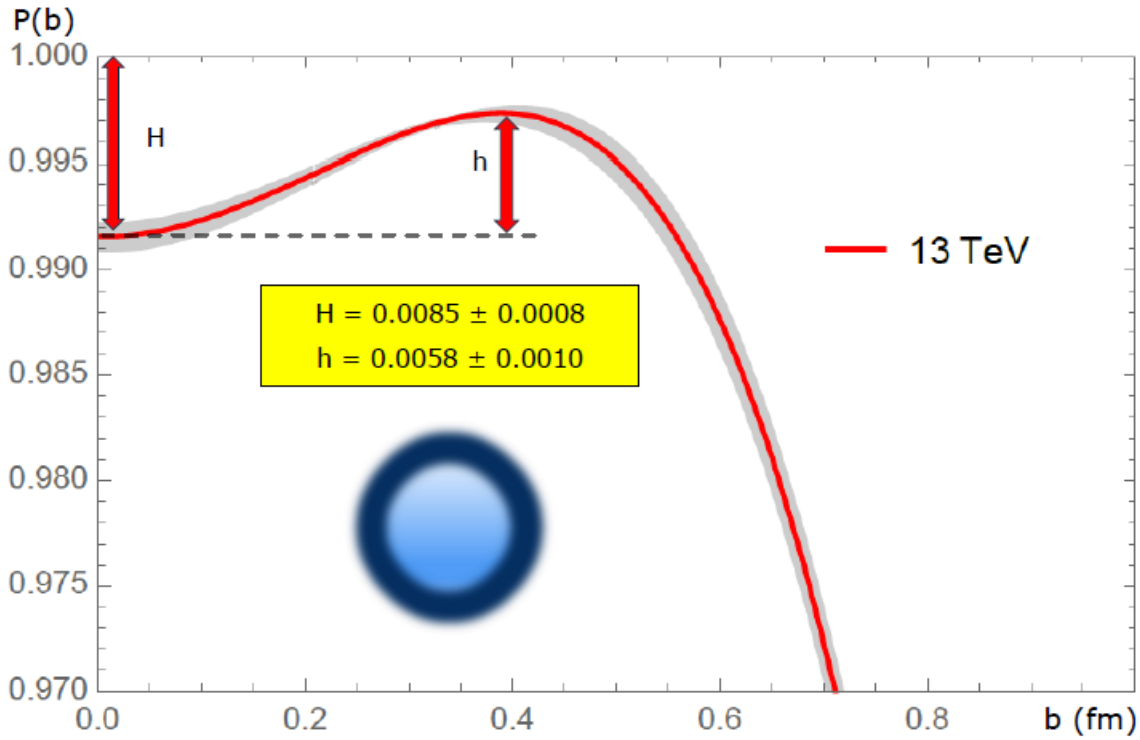

Figure 1. Protons appear as black rings at the top LHC energy of √s = 13 TeV. In a collaboration with the University of Lund, Lund, Sweden, we found a statistically significant, more than a 5 σ hollowness effect, namely that in the center of the protons at such a high collision energy becomes more transparent for inelastic collisions as compare to the edge of the protons at the same energies, for details see Ref. 1.

Other highlighted results of the Femtoscopy Research Group — Our group is active both in theoretical and in experimental investigations of both elementary particle physics and heavy ion physics. During 2020, our main focus was to prepare the discovery of the Odderon: a crossing-odd component of elastic proton-proton scattering at asymptotically high energies.

Together with the TOTEM Collaboration, we have published the differential cross-section of elastic pp collisions at √s = 2.76 TeV and observed a persistent diffractive minimum – maximum structure [2]. This paper concluded that the last step to be done to for a statistically significant Odderon discovery is to close the energy gap between 2.76 TeV proton-proton and 1.96 TeV proton-antiproton collisions. The experimenal as well as the theoretical papers that reveal this signal have been submitted for a publication during 2020. F. Nemes was a corresponding author for this important experimental milestone paper [2].

Honors received during 2020:

- For his innovative, original and careful determination of the LHC optics from the PPS data, a key ingredient for all analyses based on PPS information in CMS and TOTEM, F. Nemes received in the beginning of 2020 the **2019 CMS Achievement Award .**
- I. Szanyi has been awarded the title: Excellent Student of the Faculty of Sciences, Eötvös University, Budapest, Hungary
- T. Csörgő has been named, together with 9 other colleagues from Wigner RCP, by an international evaluation report to be among the top 1.5 % researchers of the world [3] .
- I. Szanyi received a Special Award of the Hungarian Academic Council of Subcarpathia

Grants:

- Principal Investigator NKFIH K 133 046 (PI: T. Csörgő, Wigner)
- Participation, NKTIH FK 123842 and 123959 grants (PI: M. Csanád, ELTE & A. László, Wigner)
- Participation, WG0839/2018 Circles of Knowledge Club – Wigner RCP sponsorship agreement

References:

[1] DOI: 10.1140/epjc/s10052-020-7681-8
[2} DOI: 10.1140/epjc/s10052-020-7654-y
[3] DOI: 10.1556/2065.181.2020.11.11