**Abstract**

GEANT4 predictions for the total and differential elastic cross-sections at the range $\sqrt{s} = 7-13$ TeV are presented and compared with recent TOTEM data.
1 Outline

1. The total p-p cross-section at 7-13 TeV.
2. GEANT4 hadron elastic (qQ-) model (history).
3. Differential elastic p-p cross-sections at 7-13 TeV.
4. Summary.
Geant4 simulation of p-p elastic scattering at the LHC energies

p-p total cross section

Proton energy (GeV) vs. Cross-section (mb)

- $\sigma_{tot}^{pp}$
- $h_n::NS+PDG$
- ihep-exp db data

G4HadronNucleonXsc::GetHadronNucleonXscNS(const G4DynamicParticle*, const G4ParticleDefinition*)

V. Grichine workshop, May 2018
13 TeV: Geant4 - 110.222 mb, TOTEM preliminary - 110.6 ± 3.6 mb.
(7 TeV: 98.8 and 98 ± 2.5 mb, respectively)
2 Geant4 hadron elastic model (history)

1. V.A. Tsarev [1] proposed the first version for pp-elastic scattering in quark-diquark (qQ-model) representation. Motivation was long uniform tail of $d\sigma_{el}/dt$ observed in FNAL and CERN experiments. The quark-quark models could not provide that.

2. The qQ-model was updated [2] to provide practical numerical simulation of pp-elastic scattering motivated by the TOTEM measurements at 7 TeV. The model was implemented in the framework of Geant4.

3. To describe better the dip part of the $d\sigma_{el}/dt$ spectrum, the scattering part of the Pomeron (reggeon-like) parameterization was increased [3]. The qQ-model was expanded to describe $pn$, $\pi p(n)$, $Kp(n)$, $\pi K$ etc use-cases.
Proton-proton differential elastic cross-section at $\sqrt{s} = 7$ TeV

$|t|$ (GeV$^2$)

$\frac{d\sigma^{el}}{dt}$ (mb/GeV$^2$)

Geant4 G4hhElastic and TOTEM 7 TeV data (2014)

V. Grichine

workshop, May 2018
Proton-proton differential elastic cross-section at $\sqrt{s} = 13$ TeV

**Geant4 G4hhElastic** and TOTEM 13 TeV preliminary data.
The qQ-model parameters at 7 ad 13 TeV for pp-elastic scattering

<table>
<thead>
<tr>
<th>$\sqrt{s}$</th>
<th>p radius ($GeV^{-1}$)</th>
<th>Pomeron elasticity</th>
<th>$\sigma_{qq}/\sigma_{tot}$</th>
<th>$\rho(0)$</th>
<th>$\rho(\text{dip} - \text{min})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 TeV</td>
<td>8.4</td>
<td>7.8</td>
<td>0.026</td>
<td>0.014</td>
<td>0.48</td>
</tr>
<tr>
<td>13 TeV</td>
<td>8.4</td>
<td>7.9</td>
<td>0.03</td>
<td>0.017</td>
<td>0.69</td>
</tr>
</tbody>
</table>

The main change is in the $\sigma_{qq}/\sigma_{tot}$ providing the increase (10%) of the $\sigma_{tot}$. The $\rho$-values are in conflict with other models and measurements.
3 Summary

1. GEANT4 predicts the total p-p cross section at 7-13 TeV with accuracy \( \sim 1\% \).

2. The differential elastic cross section at 7-13 TeV is described with reasonable accuracy.
References