

GEANT4 Hyperon-Nucleon Cross Sections (update)

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Abstract

The updated version of GEANT4 strange hyperon-nucleon (Λ , Σ , Ξ , Ω) cross-sections is discussed. Corrections for charm and beauty hyperons (mesons) are proposed. The cross sections can be used in GEANT4 hadronic models, especially in the Glauber-Gribov model, or directly for the description of hyperon(meson)-hydrogen hadronic interactions.

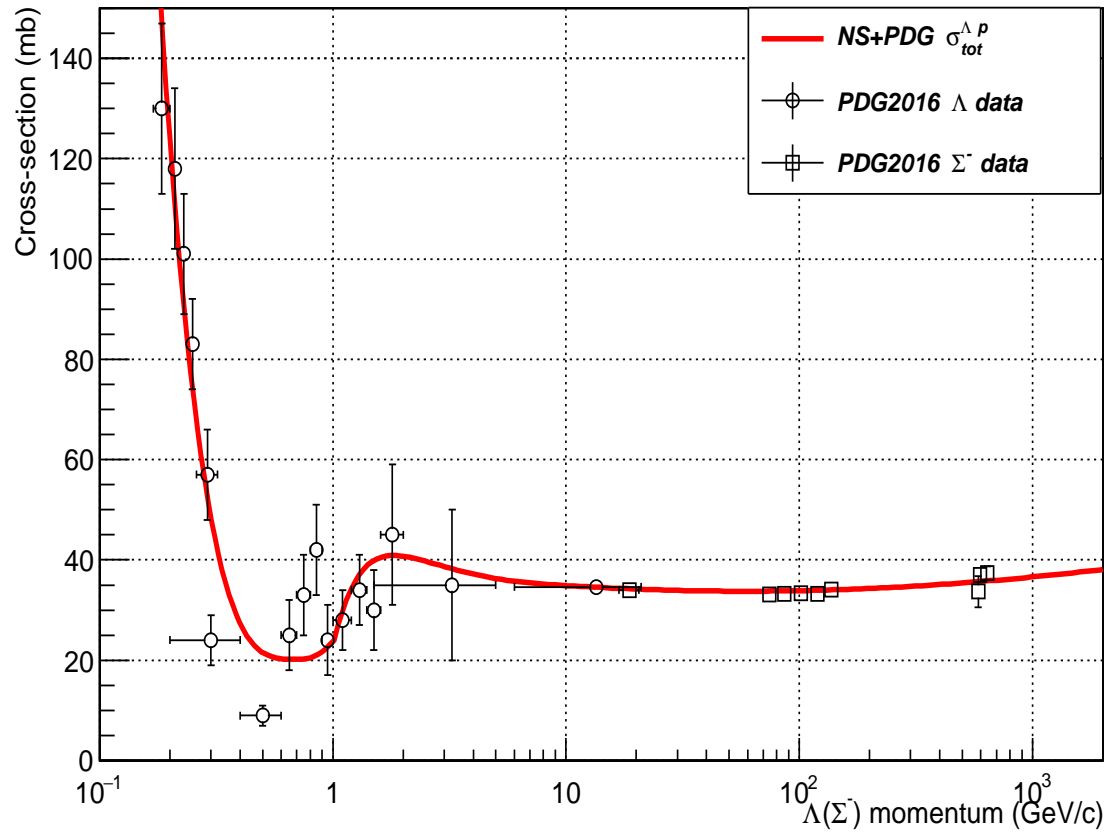
1 Method

In the framework of quark static scheme, hyperons are similar to nucleons, substituting one or more strange quarks for u, d ones:

$$\begin{aligned} & p(ud), \quad n(udd), \\ & \Lambda(uds), \quad \Sigma^+(uus), \quad \Sigma^0(uds), \quad \Sigma^-(dds), \\ & \Xi^0(uss), \quad \Xi^-(dss), \\ & \Omega^-(sss). \end{aligned}$$

Therefore, one can assume that their hadronic cross-sections could be similar to the nucleon cross-sections. Here updated results are shown concerning this assumption.

$\Lambda(\Sigma^-)$ -p total cross section



GEANT4 $\Lambda(\Sigma^-)$ p combined total cross-section vs. PDG-2016 data

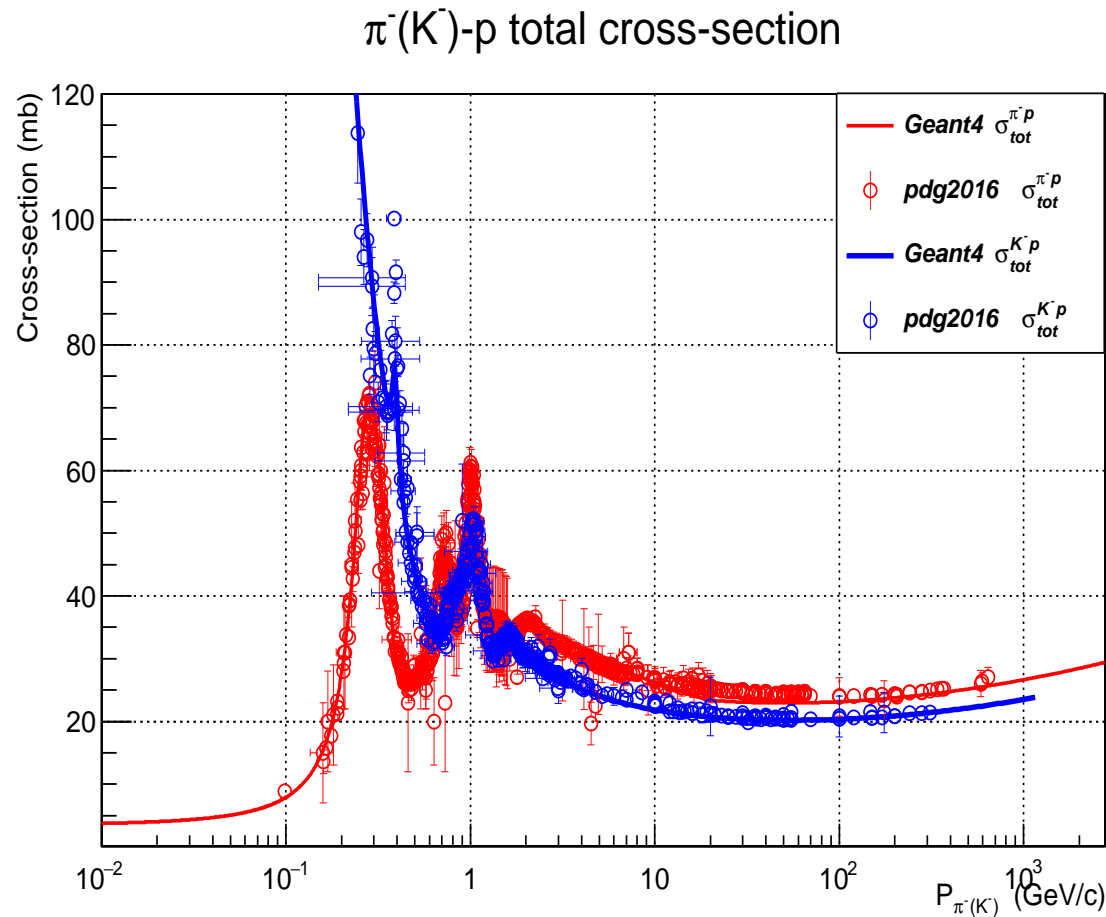
$$(\sigma_{tot}^{\Lambda p} \sim \sigma_{tot}^{\Sigma^- p} = 0.88 \cdot \sigma_{tot}^{pp}).$$

Ξ^- -p total cross-sections as $\sigma_{tot}^{\Xi^- p} / \sigma_{tot}^{pp}$ ratio		
Ξ^- momentum (GeV/c)	$\sigma_{tot}^{\Xi^- p} / \sigma_{tot}^{pp}$ (GEANT4)	$\sigma_{tot}^{\Xi^- p} / \sigma_{tot}^{pp}$ (experiment)
101.5	0.76	0.758
133.8	0.76	0.759

Table 1: Comparison of the GEANT4 Ξ^- -p total cross-sections based on the quark additivity considerations with experimental data ($\sigma_{tot}^{\Xi^- p} / \sigma_{tot}^{pp} = 0.76$, 0.76 is based on 0.88).

$\sigma_{tot}^{Hp} / \sigma_{tot}^{pp}$ ratio vs. the number of heavy quarks			
flavor	1	2	3
strange	0.88 (Λ)	0.76 (Ξ)	0.64 (Ω)
charm	0.784	0.569	0.353
beauty	0.74	0.481	0.222

Table 2: Hyperon-proton/proton-proton total cross-section ratios based on the quark additivity versus the number of heavy quarks.



GEANT4 $\pi^-(K^-)$ -p total cross-section vs. PDG-2016 data base. The cross-section ratio based on quark additivity is ~ 0.82 for momenta more 2 GeV/c in agreement with experiment.

2 GEANT4 Implementation

The parametrization was implemented in the GEANT4 class G4HadronNucleonXsc. The methods:

```
G4double GetHyperonNucleonXscNS(const G4ParticleDefinition*,
                                const G4ParticleDefinition*, Tkin);
G4double GetSCBMesonNucleonXscNS(const G4ParticleDefinition*,
                                  const G4ParticleDefinition*, Tkin);
```

calculate the total, elastic and inelastic cross sections and returns the total one for hyperons and mesons, respectively. The methods:

```
G4double GetElasticHadronNucleonXsc() { return fElasticXsc; };
G4double GetInelasticHadronNucleonXsc(){ return fInelasticXsc; };
```

return the elastic and inelastic cross sections respectively.

3 Summary and ToDo

1. The GEANT4 strange hyperon-nucleon cross sections were updated based on the existing parametrizations of nucleon cross-sections and the quark additivity considerations.
2. The GEANT4 charm (beauty) hyperon(meson)-nucleon cross sections were proposed based on the quark additivity considerations.
3. The cross-sections are in continuous progress to be used in the Glauber-Gribov model for the description of the strange (charm, beauty) hyperon-nucleus cross-sections as well as in other hadronic models.