Glauber-Gribov Model for $\bar{p}$-Nucleus Cross-Sections (preliminary)

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Abstract

A model for $\bar{p}$-nucleus cross-sections based on the simplified Glauber-Gribov model is considered. The model uses Glauber-Gribov approach with Gauss-distributed point-like nucleons in nuclei. The model provides the total, inelastic, production, elastic and quasi-elastic cross-sections. Preliminary comparisons with experimental data are presented.

1 Glauber-Gribov model for $\bar{p}$-nucleus cross-sections

In the framework of simplified Glauber-Gribov model [1,2] the $\bar{p}$-nucleus cross sections read:

$$\sigma_{tot}^{\bar{p}A} = 2\pi R^2 \ln\left[1 + \frac{A\sigma_{tot}^{\bar{p}N}}{2\pi R^2}\right], \quad \sigma_{in}^{\bar{p}A} = \pi R^2 \ln\left[1 + \frac{A\sigma_{tot}^{\bar{p}N}}{\pi R^2}\right],$$

$$\sigma_{prod}^{\bar{p}A} = \pi R^2 \ln\left[1 + \frac{A\sigma_{in}^{\bar{p}N}}{\pi R^2}\right], \quad \sigma_{el}^{\bar{p}A} = \sigma_{tot}^{\bar{p}A} - \sigma_{in}^{\bar{p}A}, \quad \sigma_{qe}^{\bar{p}A} = \sigma_{in}^{\bar{p}A} - \sigma_{prod}^{\bar{p}A},$$

$$\sigma_{sd}^{\bar{p}A}(hA \rightarrow XA) = \pi R^2 \left\{\alpha - \ln\left[1+\alpha\right]\right\}, \quad \alpha = \frac{A\sigma_{tot}^{\bar{p}N}}{2\pi R^2 + A\sigma_{tot}^{\bar{p}N}}.$$

Where $\sigma_{tot}^{\bar{p}A}$, $\sigma_{in}^{\bar{p}A}$, $\sigma_{prod}^{\bar{p}A}$, $\sigma_{el}^{\bar{p}A}$, $\sigma_{qe}^{\bar{p}A}$ and $\sigma_{sd}^{\bar{p}A}(hA \rightarrow XA)$ are the total, inelastic, production, elastic, quasi-elastic and single-diffraction cross section of a antiproton on a nucleus A, respectively. They depend essentially on the $\bar{p}$-nucleon cross sections, $\sigma_{tot}^{\bar{p}N}$, and for the production cross section on $\sigma_{in}^{\bar{p}N}$. R is the RMS radius of nucleon distribution inside the nucleus.

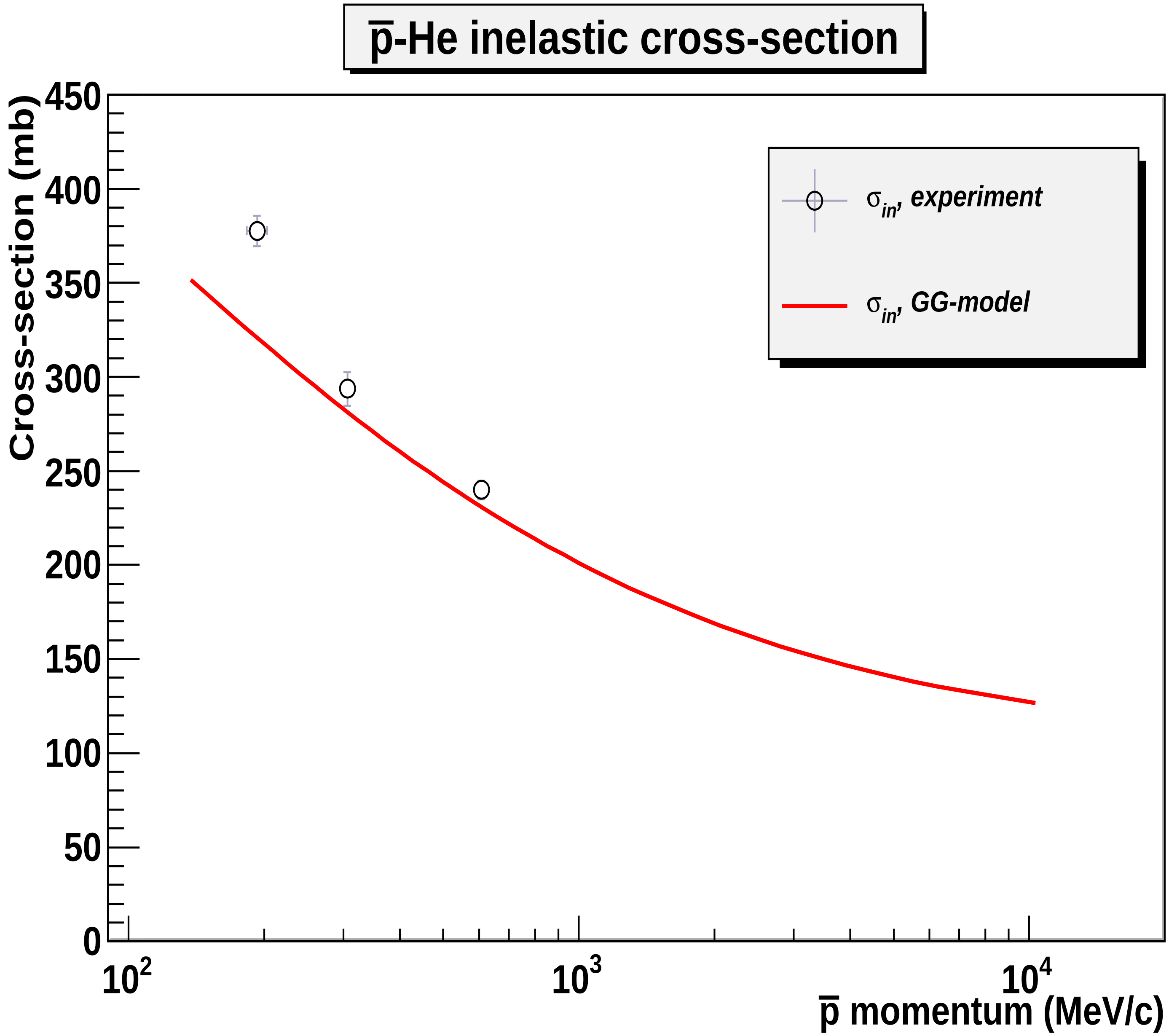
2 Gauss-Glauber model parameters

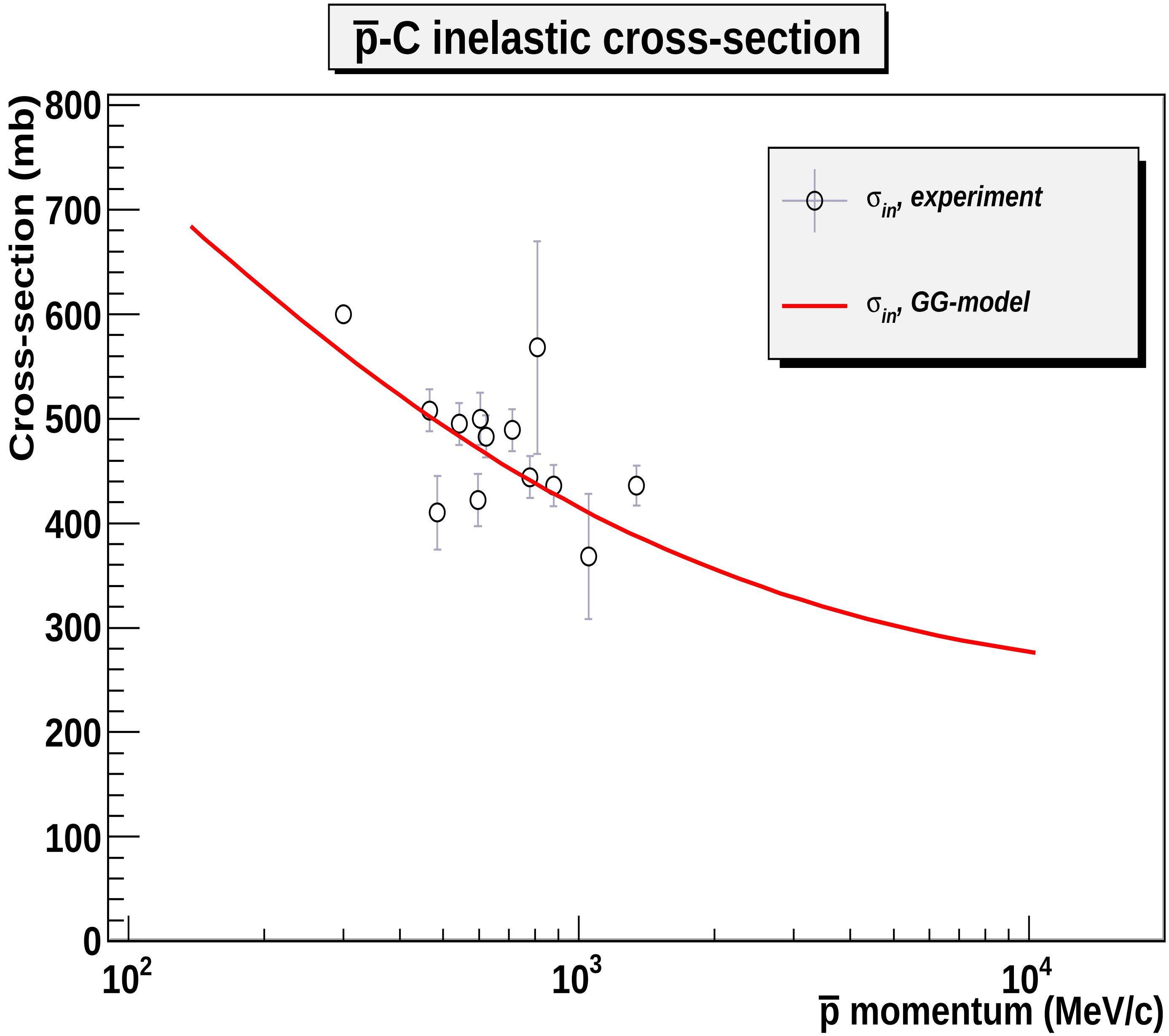
The $\bar{p}$-nucleon cross sections, $\sigma^{\bar{p}N}_{tot/in}$ are parameterised using the existing experimental data.

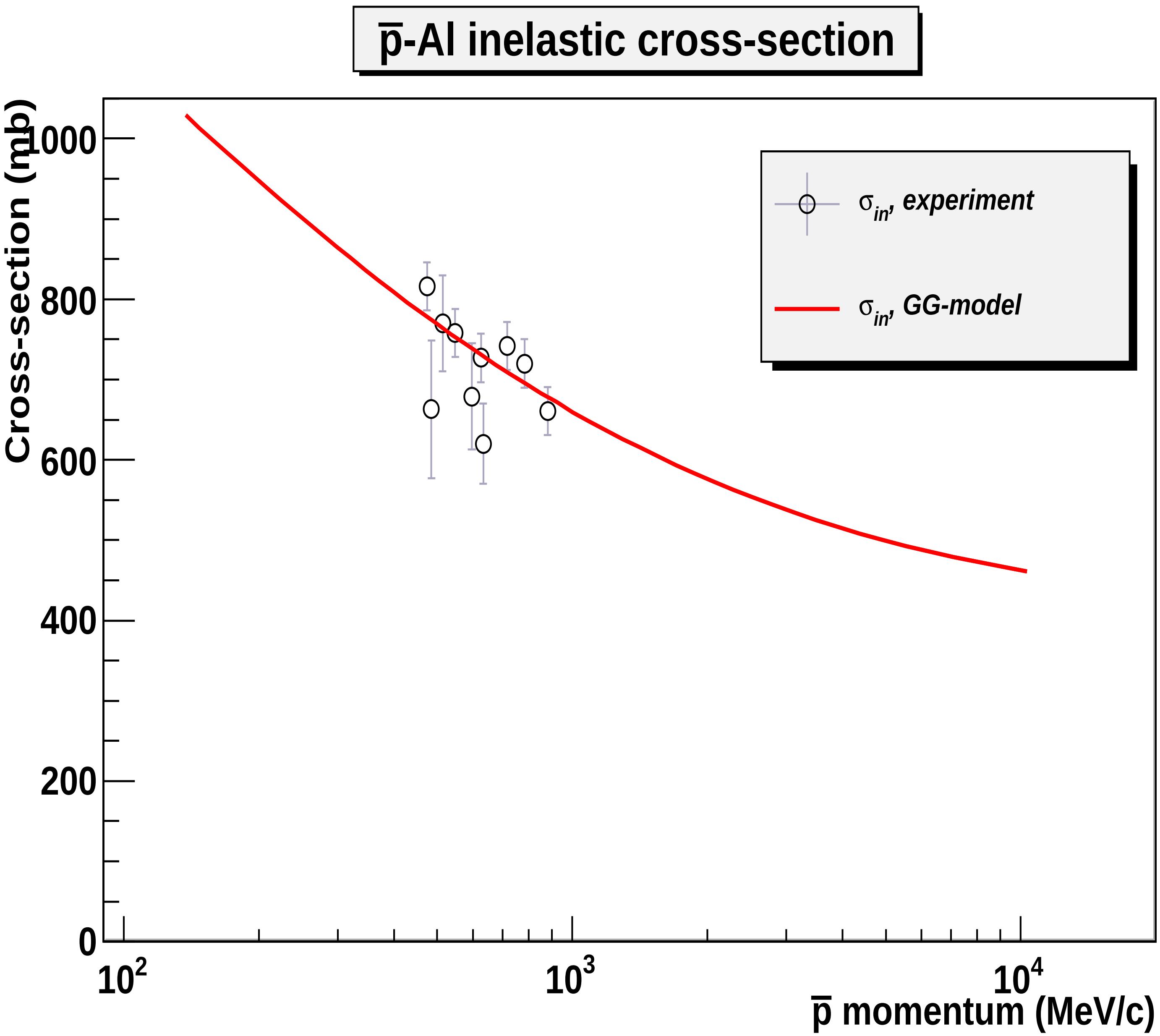
The RMS nuclear radius, R, is parametrized, as a function of A, by:
$R(A) = r_o A^{\frac{1}{3}} f(A)$, $r_o \sim 1.1$ fm, where the correction factor $f(A)$ reads:

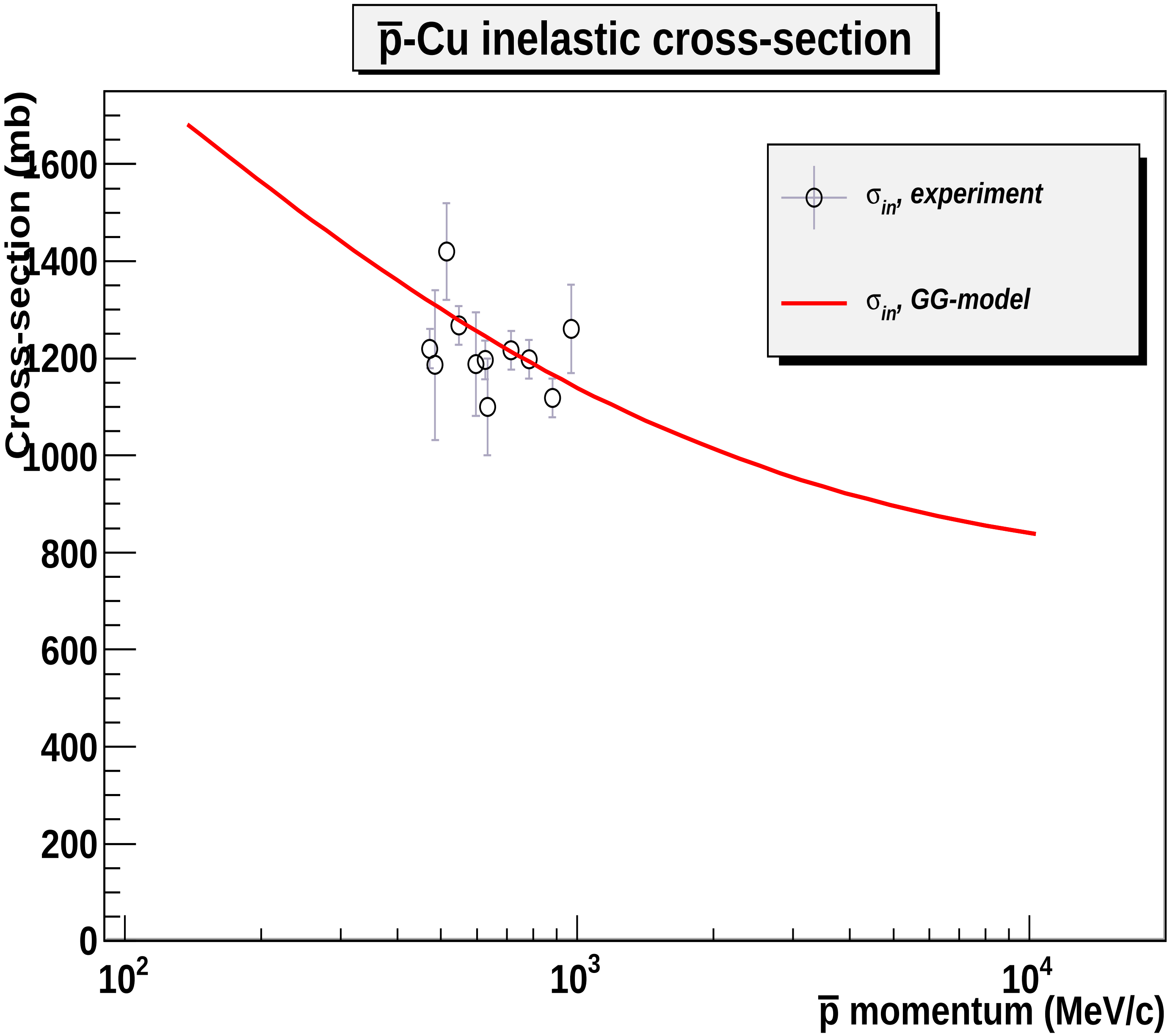
$$f(A) = \begin{cases} 0.8 + 0.2\exp\left(\dfrac{20-A}{20}\right), & A > 20, \\ 1 + 0.1\exp\left(\dfrac{A-20}{20}\right), & A \leq 20. \end{cases}$$

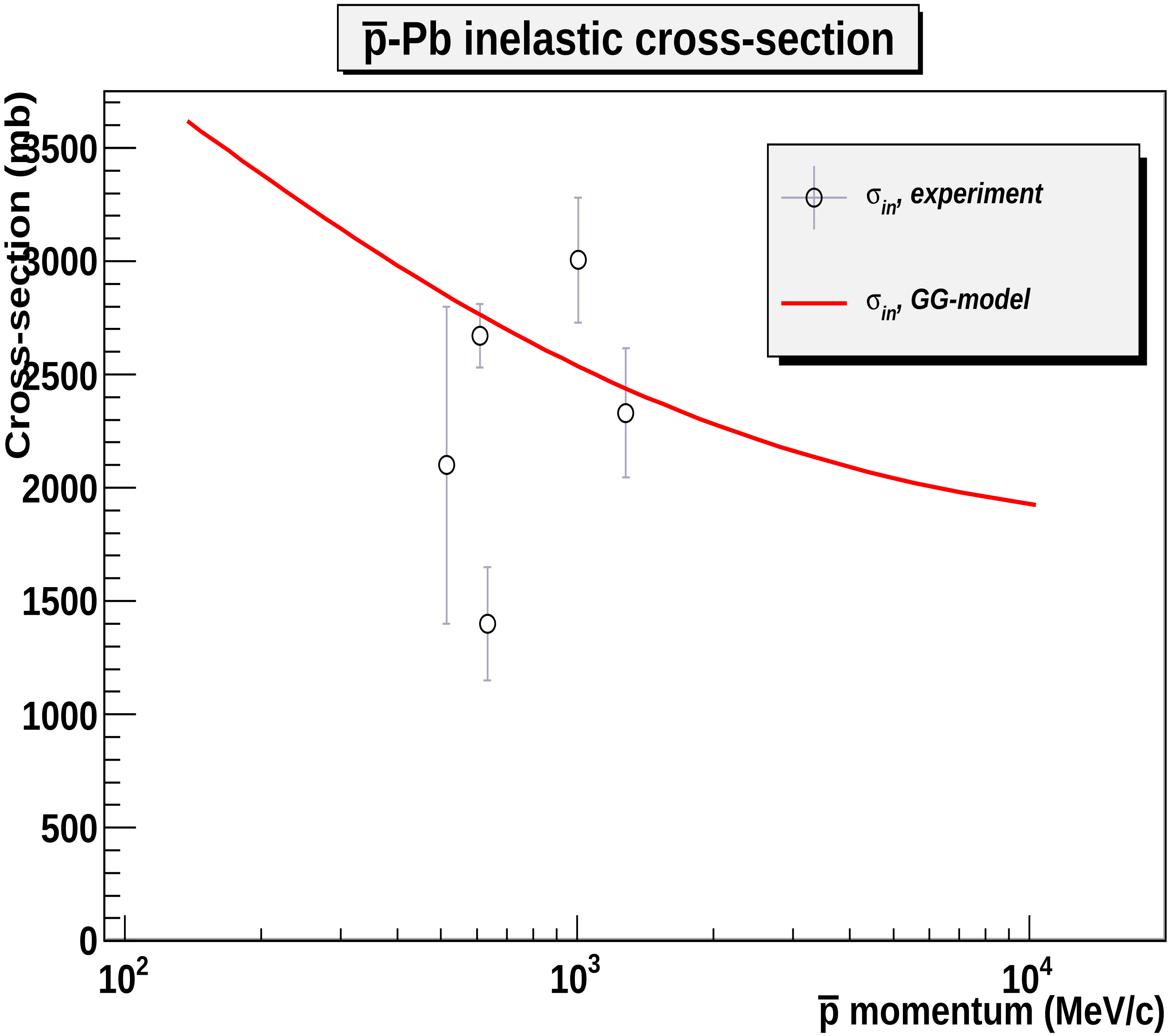
Some preliminary comparisons between the Glauber-Gribov model calculations and experimental data for $\bar{p}$-nucleus inelastic cross sections are shown for He, C, Al, Cu and Pb nuclei.


p̄-He inelastic cross-section
Cross-section (mb)
450
400
350
300
250
200
150
100
50
0
10^2
10^3
10^4
p̄ momentum (MeV/c)
σ_in, experiment
σ_in, GG-model


p̄-C inelastic cross-section
Cross-section (mb)
800
700
600
500
400
300
200
100
0
10^2
10^3
10^4
p̄ momentum (MeV/c)
σ_{in}, experiment
σ_{in}, GG-model


p̄-Al inelastic cross-section
Cross-section (mb)
1000
800
600
400
200
0
σ_in, experiment
σ_in, GG-model
10^2
10^3
10^4
p̄ momentum (MeV/c)


p̄-Cu inelastic cross-section
Cross-section (mb)
p̄ momentum (MeV/c)
σin, experiment
σin, GG-model
0
200
400
600
800
1000
1200
1400
1600
10^2
10^3
10^4


p̄-Pb inelastic cross-section
Cross-section (mb)
3500
3000
2500
2000
1500
1000
500
0
10^2
10^3
10^4
p̄ momentum (MeV/c)
σ_in, experiment
σ_in, GG-model

3 Summary and To-Do

1. Glauber-Gribov approach provides the total, inelastic, production, elastic and quasi-elastic $\bar{p}$-nucleus cross-sections in a wide range of energies.
2. The model algorithm is fast and as robust as $\sigma^{\bar{p}N}_{tot/in}$ parametrization.
3. The model is in agreement with the experimental data for the inelastic cross-section. The model is applicable starting from ~ 10 MeV up to TeV range of the $\bar{p}$ kinetic energy. The both limits are defined mostly by the accuracy of the $\sigma^{\bar{p}N}_{tot/in}$ and the nucleus radius parametrizations.
4. The model can be extended for $\bar{n}$ and anti-nuclei.
5. More extended comparison with experimental data and other models, tuning of the model parameters (especially for light nuclei), testing and integration in physics lists are current plans.
6. The models will be implemented in the framework of the current redesign of the Geant4 hadron cross-sections.

4 References

1. V.M. Grichine, A simplified Glauber model for hadron-nucleus cross-sections, Eur. Phys. J., C62 (2009) 399.

2. V.M. Grichine, A simple model for integral hadron-nucleus and nucleus-nucleus cross-sections, Nucl. Instr. and Meth., B267 (2009) 2460.