

Geant 4

ENDF/B-VII validation of G4 low energy neutron-nuclear elastic XS

Mikhail Kosov, Physics Validation,
31 March 2010

Introduction

■ The neutron elastic history

- **LHEP** cross-sections: only A -dependent
- **HP** cross-sections: isotope wise with many natural mixtures
- CHIPS old cross-sections: only A -dependent
- **CHIPS new** cross-sections: isotope wise 2010

■ CHIPS new versus HP

- CHIPS covers **381** isotope, while HP – only **157** (40%) isotopes
- CHIPS is working at all energies, while HP only below 20MeV
- CHIPS has a unique formula with 7 parameters, HP has tables
- CHIPS uses effective absorption bands, HP follows evaluations
- At high energy CHIPS is based on the CHIPS proton elastic
- The result: **78** of **157** HP isotopes (50%) should be updated

H2	N15	Si28	Ar40	Ti47	Fe57	Zn-nat	Se77
H3	O16	Si29	K39	Ti48	Fe58	Ga69	Se78
He3	O17	Si30	K40	Ti49	Co58	Ga71	Se79
He4	O18	P31	K41	Ti50	Co59	Ge70	Se80
Li6	F19	S32	Ca40	V-nat	Ni58	Ge72	Se82
Li7	Ne-all	S33	Ca42	Cr50	Ni59	Ge73	Br79
Be7	Na22	S34	Ca43	Cr52	Ni60	Ge74	Br81
Be9	Na23	S36	Ca44	Cr53	Ni61	Ge76	Kr78
B10	Mg24	Cl35	Ca46	Cr54	Ni62	As74	Kr80
B11	Mg25	Cl37	Ca48	Mn55	Ni64	As75	Kr82
C-nat	Mg26	Ar36	Sc45	Fe54	Cu63	Se74	Kr83
N14	Al27	Ar38	Ti46	Fe56	Cu65	Se76	Kr84

Kr85	Y90	Mo94	Ru101	Pd108	Cd114	Sn119	Te120
Kr86	Y91	Mo95	Ru102	Pd110	Cd115	Sn120	Te122
Rb85	Zr90	Mo96	Ru103	Ag107	Cd116	Sn122	Te123
Rb86	Zr91	Mo97	Ru104	Ag109	In113	Sn123	Te124
Rb87	Zr92	Mo98	Ru105	Ag110	In115	Sn124	Te125
Sr84	Zr93	Mo99	Rh103	Ag111	Sn112	Sn125	Te126
Sr86	Zr94	Mo100	Rh105	Cd106	Sn113	Sn126	Te127
Sr87	Zr95	Tc99	Pd102	Cd108	Sn114	Sb121	Te128
Sr88	Zr96	Ru96	Pd104	Cd110	Sn115	Sb123	Te129
Sr89	Nb94	Ru98	Pd105	Cd111	Sn116	Sb124	Te130
Sr90	Nb95	Ru99	Pd106	Cd112	Sn117	Sb125	Te132
Y89	Mo92	Ru100	Pd107	Cd113	Sn118	Sb126	I127

I129	Xe133	Ba134	Ce140	Nd145	Sm150	Gd152	Dy160
I130	Xe134	Ba135	Ce141	Nd146	Sm151	Gd153	Dy161
I131	Xe135	Ba136	Ce142	Nd147	Sm152	Gd154	Dy162
I135	Xe136	Ba137	Ce142	Nd148	Sm153	Gd155	Dy163
Xe123	Cs133	Ba138	Ce143	Nd150	Sm154	Gd156	Dy164
Xe124	Cs134	Ba140	Ce144	Pm147	Eu151	Gd157	Dy165
Xe126	Cs135	La138	Pr141	Pm148	Eu152	Gd158	Ho165
Xe128	Cs136	La139	Pr142	Pm149	Eu153	Gd160	Ho166
Xe129	Cs137	La140	Pr143	Sm144	Eu154	Tb159	Er162
Xe130	Ba130	Ce136	Nd142	Sm147	Eu155	Tb160	Er164
Xe131	Ba132	Ce138	Nd143	Sm148	Eu156	Dy156	Er166
Xe132	Ba133	Ce139	Nd144	Sm149	Eu157	Dy158	Er167

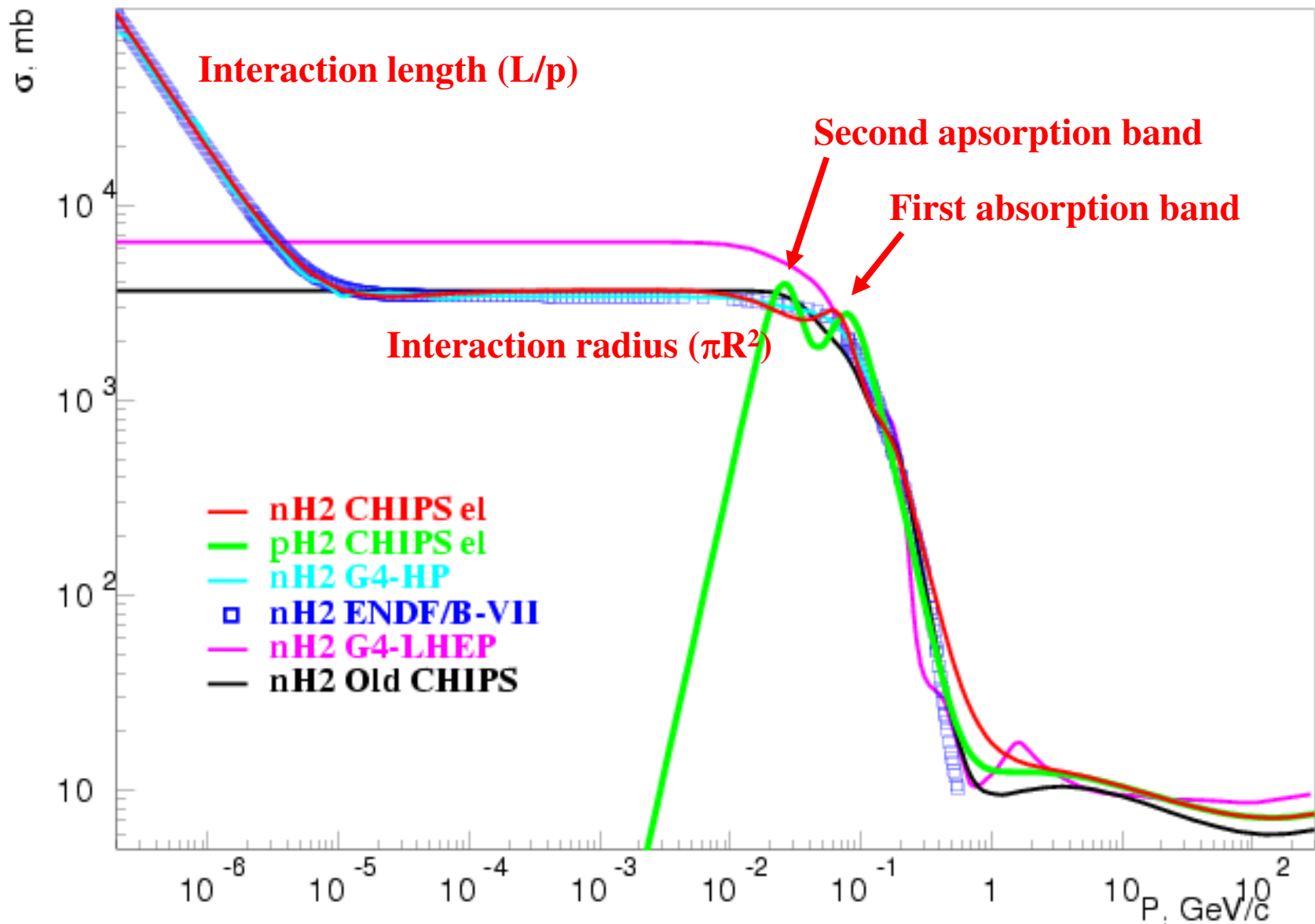
Er168	Ta181	Au197	Pb208	Ac227	U233	Np238	Am241
Er170	Ta182	Hg196	Bi209	Th227	U234	Np239	Am242
Tm-all	W182	Hg198	Po-all	Th228	U235	Pu236	Am243
Yb-all	W183	Hg199	At210	Th229	U236	Pu237	Am244
Lu175	W184	Hg200	Rn-all	Th230	U237	Pu238	Cm241
Lu176	W186	Hg201	Fr223	Th232	U238	Pu239	Cm242
Hf174	Re185	Hg202	Ra223	Th233	U239	Pu240	Cm243
Hf176	Re187	Hg204	Ra224	Th234	U240	Pu241	Cm244
Hf177	Os-all	Tl-all	Ra225	Pa231	U241	Pu242	Cm245
Hf178	Ir191	Pb204	Ra226	Pa232	Np235	Pu243	Cm246
Hf179	Ir193	Pb206	Ac225	Pa233	Np236	Pu244	Cm247
Hf180	Pt-all	Pb207	Ac226	U232	Np237	Pu246	Cm248

CHIPS parameterization for σ_{el} (nA)

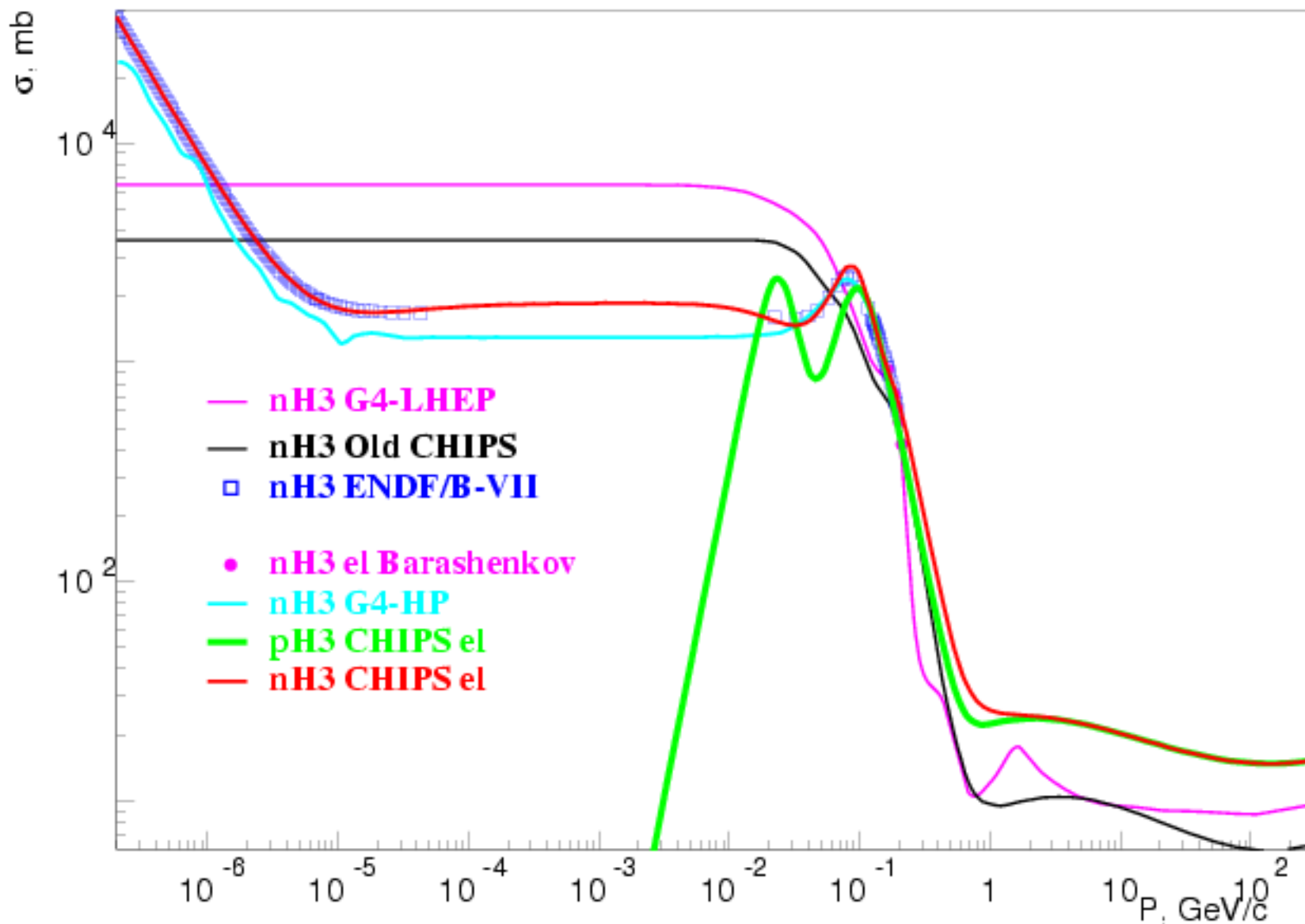
$$\sigma_{nA}^{el} = \frac{H_{Z,A}}{p^2 + \frac{K_{Z,A}}{p^2 + L_{Z,A}} + \frac{N_{Z,A}}{p^3}} + \frac{R_{Z,A}}{p^5 + \frac{S_{Z,A}}{p^2}} + \frac{T_{Z,A}}{p} + \frac{B(A) \cdot (\ln p - 5)^2 + C(A)}{1 + D(A)/p + \frac{E(A)}{p^4}} + \frac{F(A)}{p^3 + \frac{G(A)}{p^3}}$$

1. The high energy A-dependent parameters B(A), C(A), D(A), E(A) are equal to the **proton elastic CHIPS parameterization**.
2. The intermediate energy A-dependent parameters F(A) & G(A) (**the first absorption band**) are similar to the **proton elastic CHIPS parameterization**, but they have different A-dependence.
3. The 7 low energy parameters $H_{Z,A}$, $K_{Z,A}$, $L_{Z,A}$, $N_{Z,A}$, $R_{Z,A}$, $S_{Z,A}$, $T_{Z,A}$ are individual for each isotope:
 - $T_{Z,A}$ – the interaction length
 - $H_{Z,A} \cdot L_{Z,A} / K_{Z,A}$ – the interaction squared radius (πR^2)
 - $K_{Z,A}$, $L_{Z,A}$ – the effective absorption band (change both by the same factor)
 - $H_{Z,A}$ – the increase to low energies factor
 - $N_{Z,A}$ makes smooth transition from the interaction radius to the interaction length
 - $R_{Z,A}$, $S_{Z,A}$ – **the second absorption band** (similar to the **proton elastic CHIPS**)
4. Data: Compas, Barashenkov, ENDF/B-VII, Fits: Old CHIPS, LHEP, HP, CHIPS

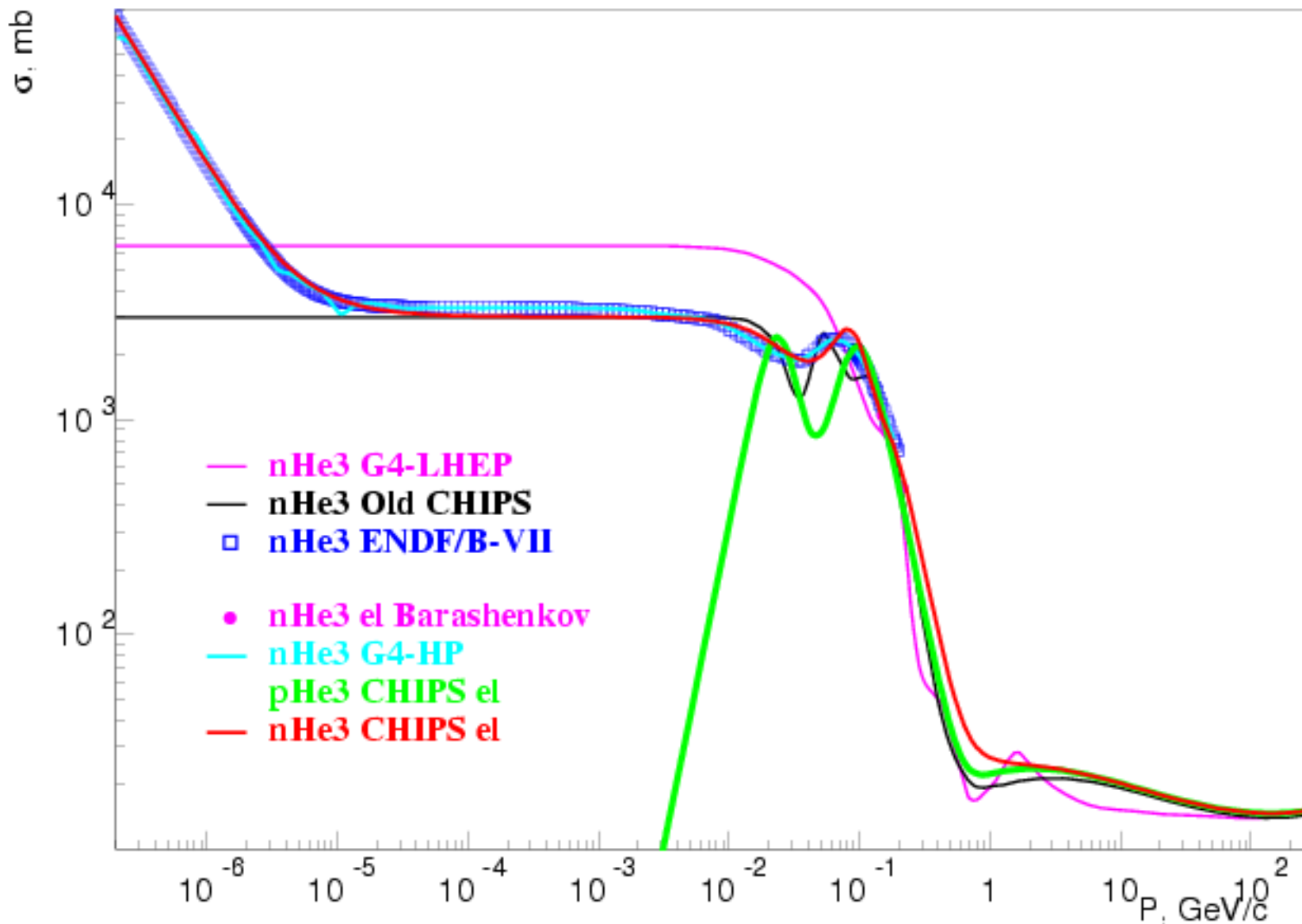
CHIPS improvement of nH2 elastic cross-section



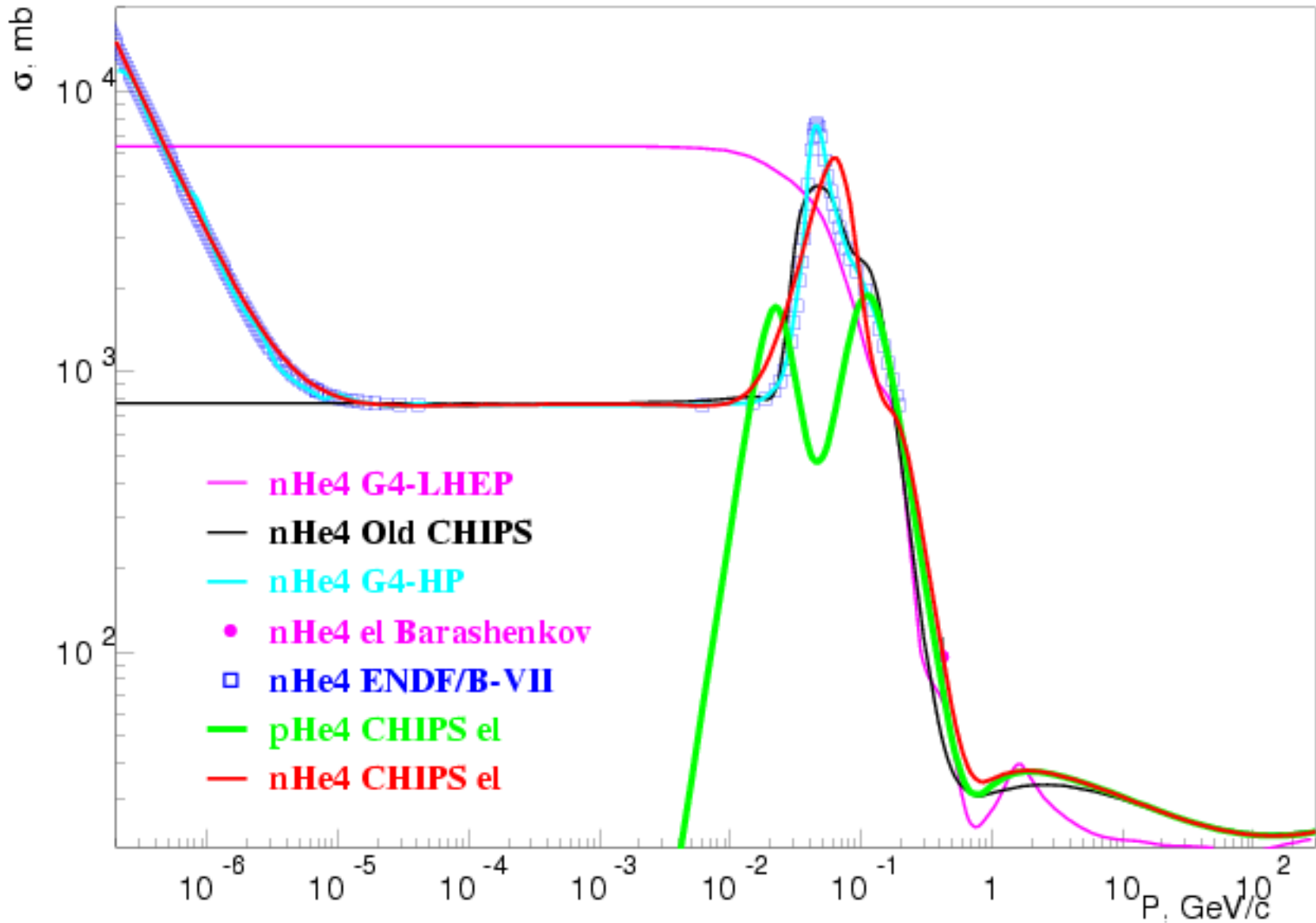
CHIPS improvement of nH3 elastic cross-section



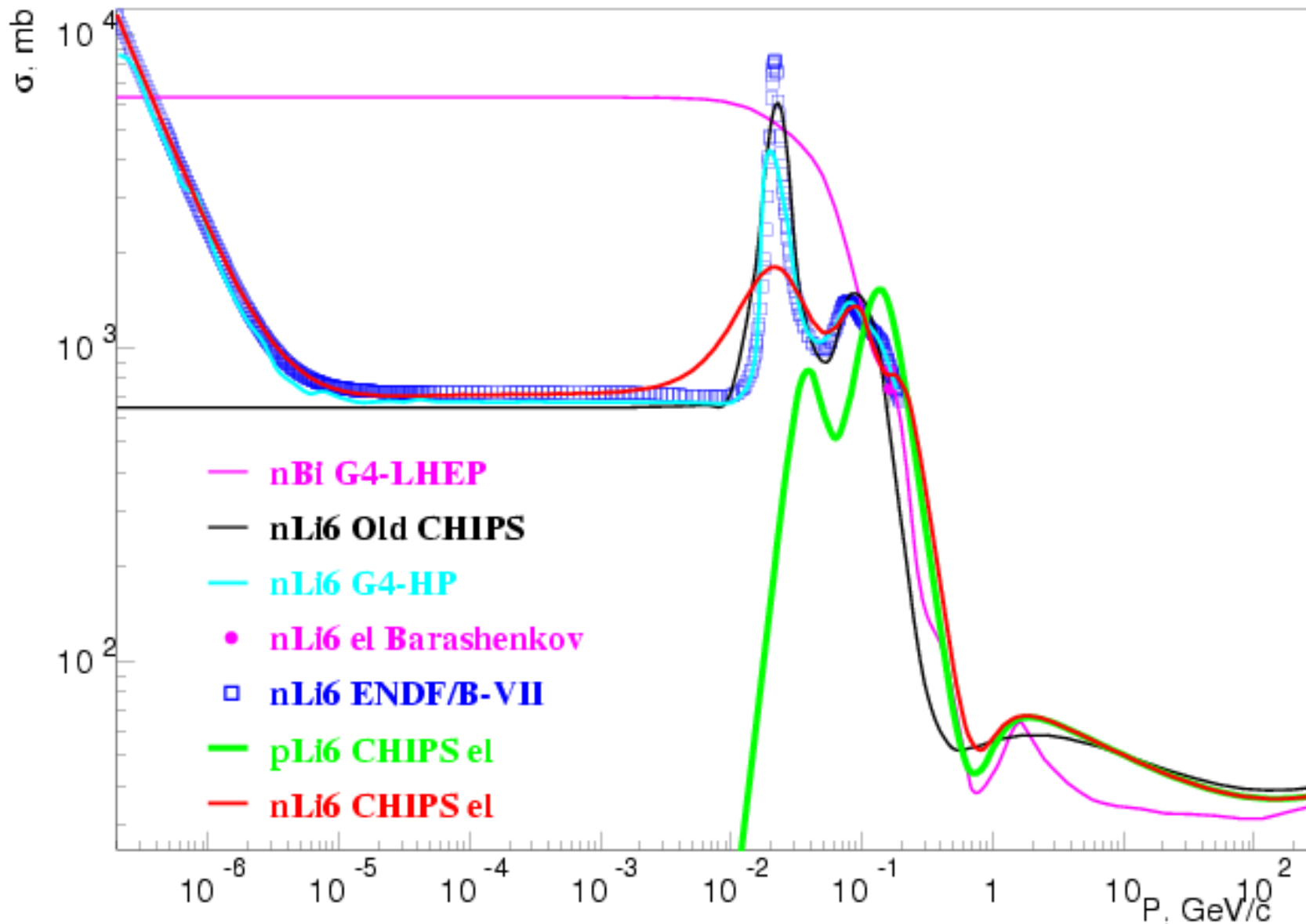
CHIPS improvement of nHe3 elastic cross-section



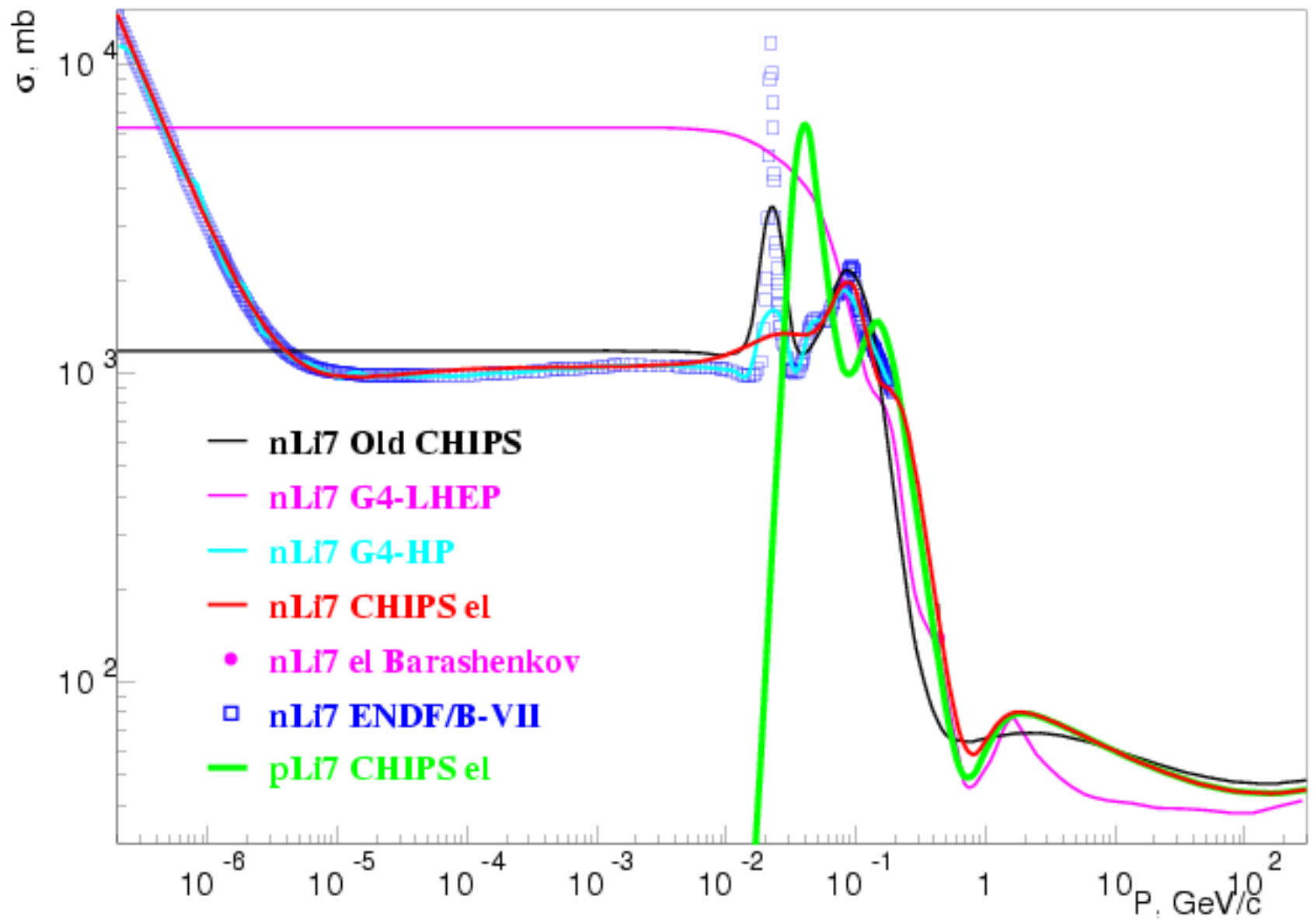
CHIPS improvement of nHe4 elastic cross-section



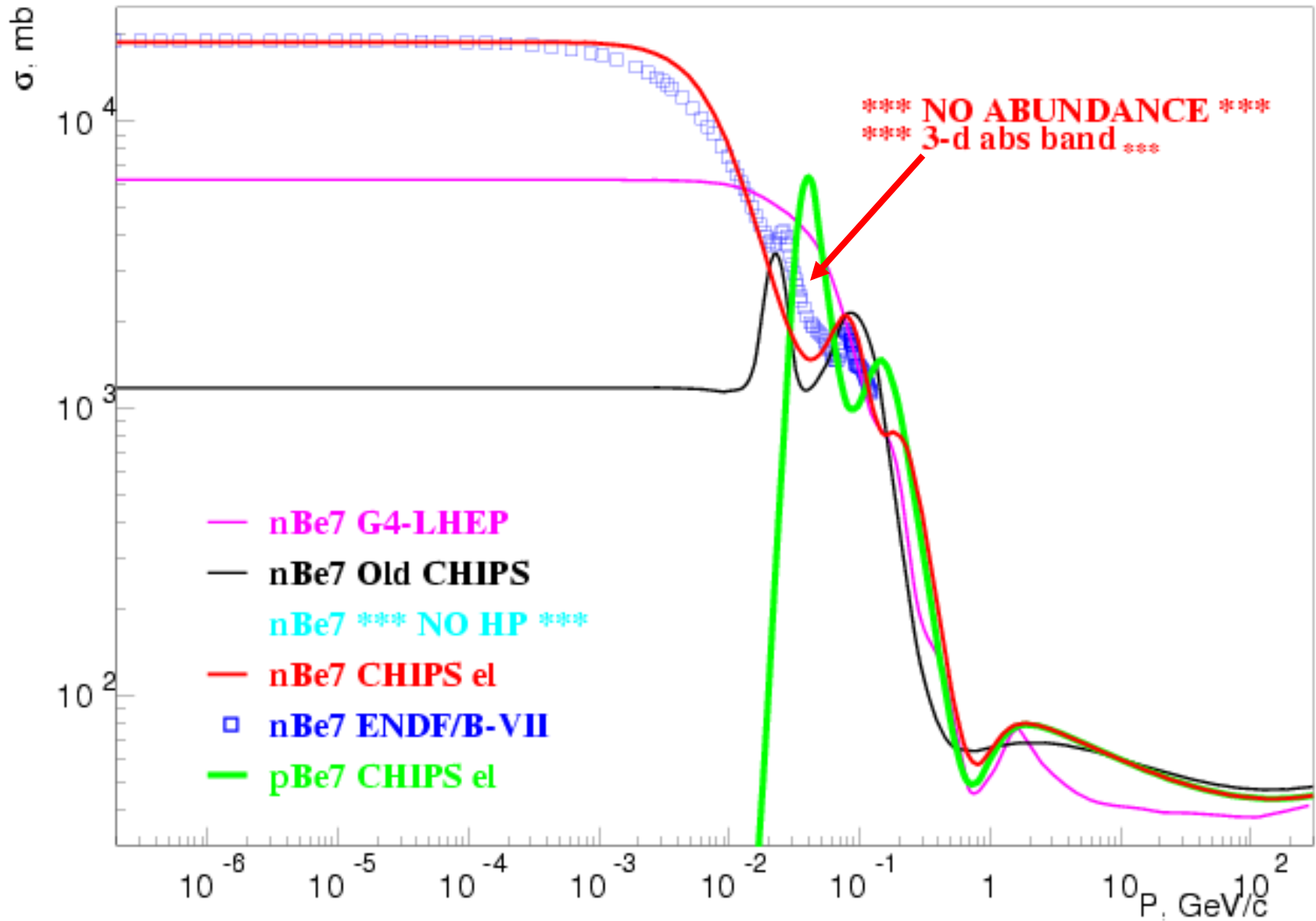
CHIPS improvement of nLi6 elastic cross-section



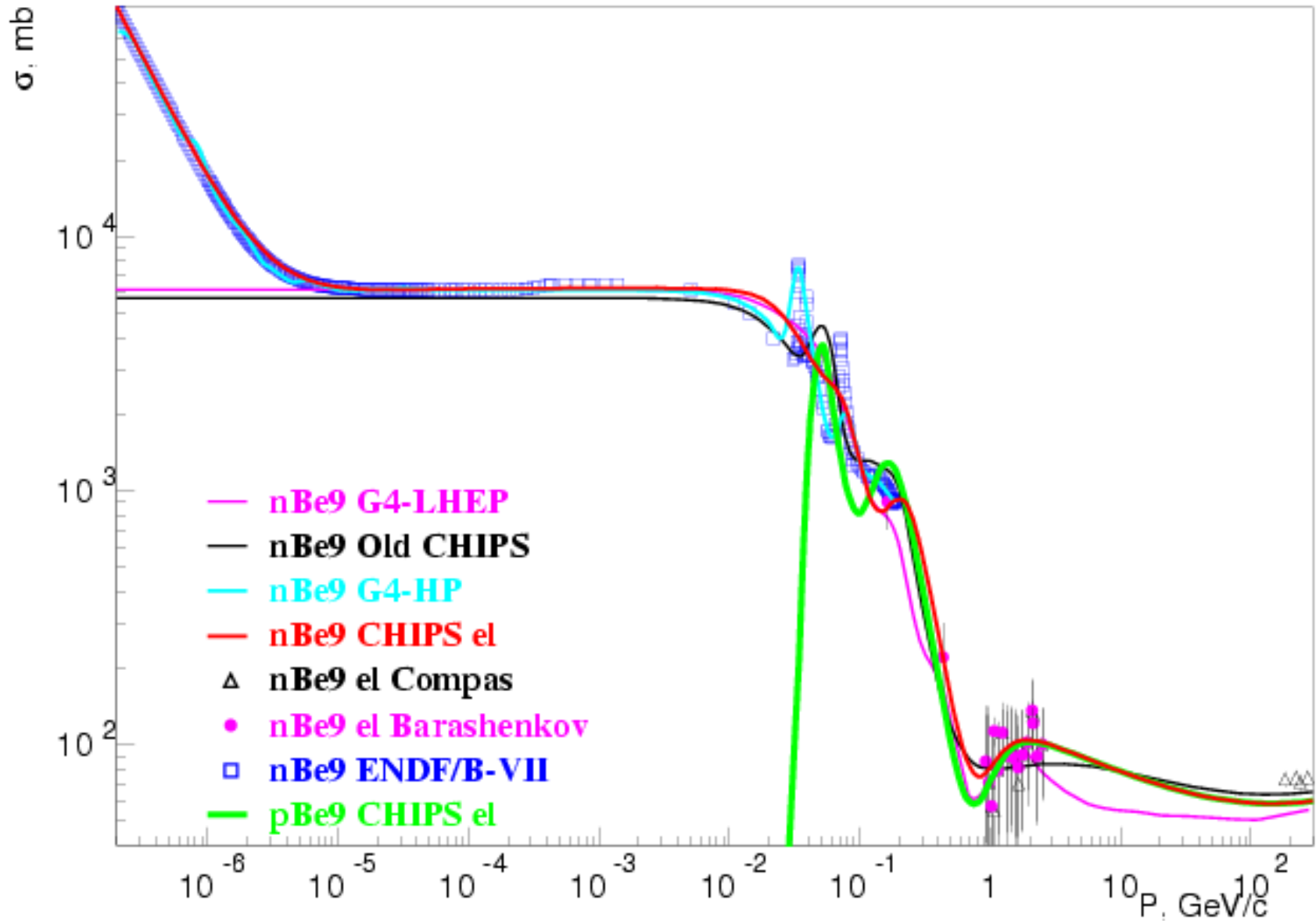
CHIPS improvement of nLi7 elastic cross-section



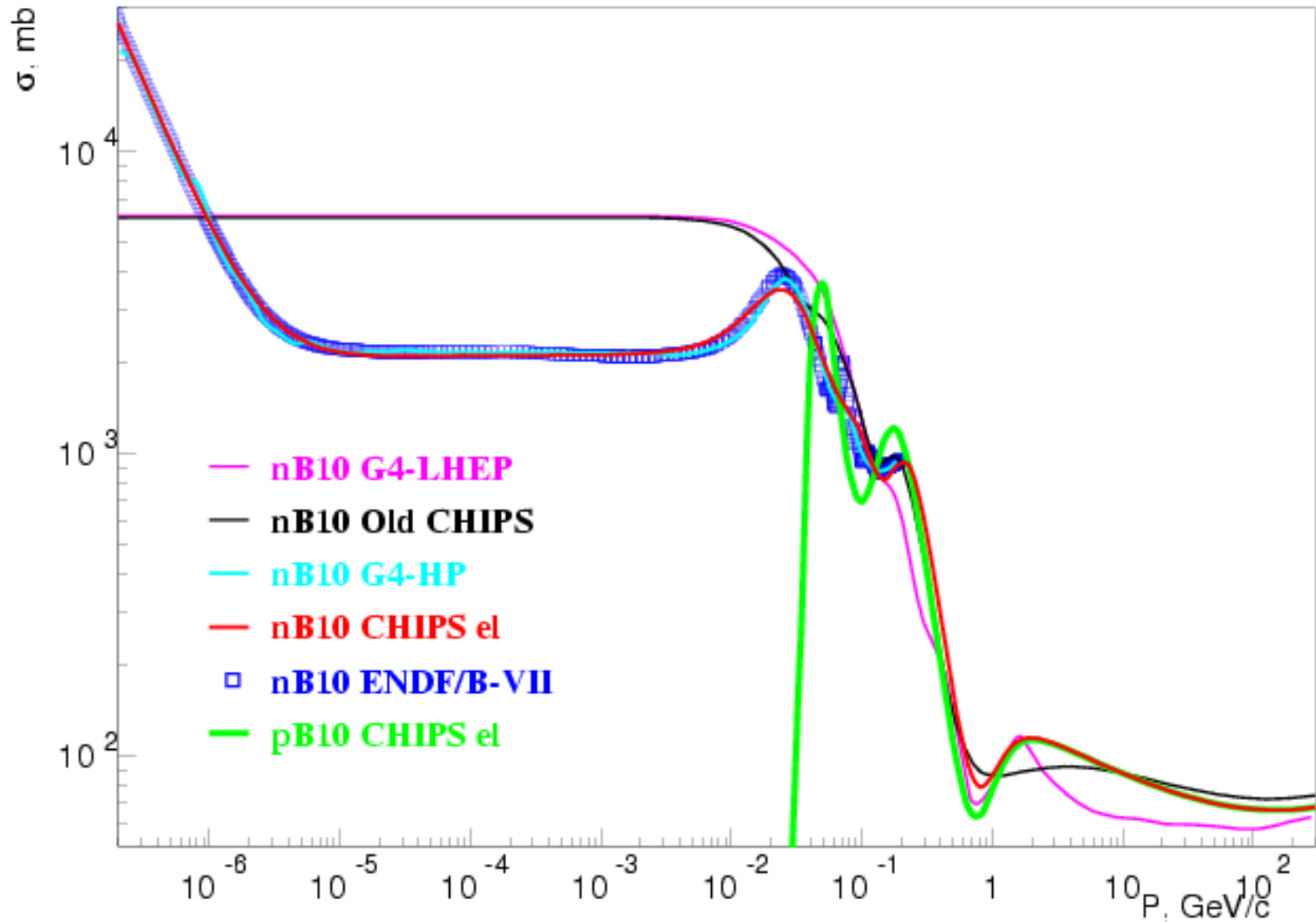
CHIPS improvement of nBe7 elastic cross-section



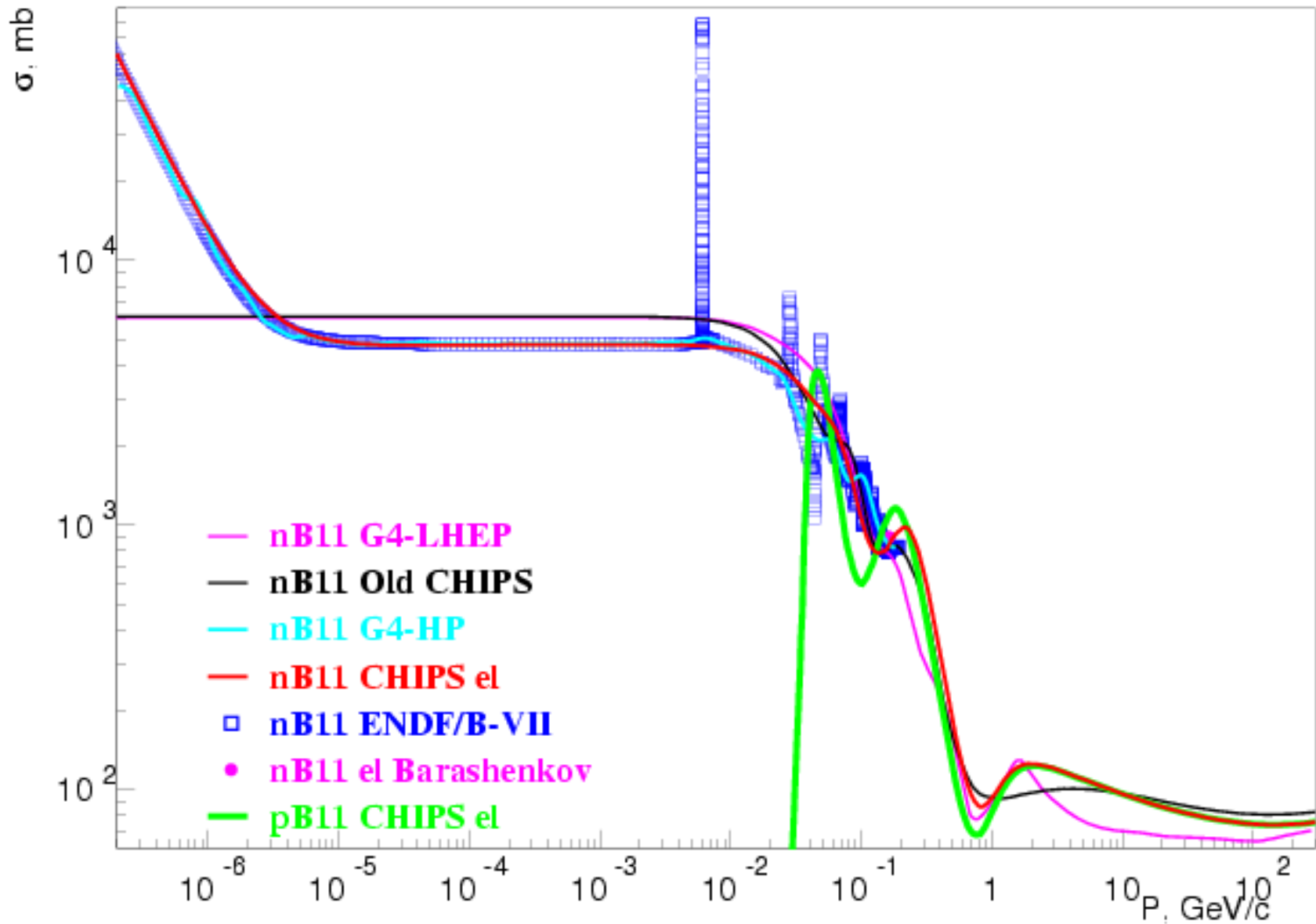
CHIPS improvement of nBe9 elastic cross-section



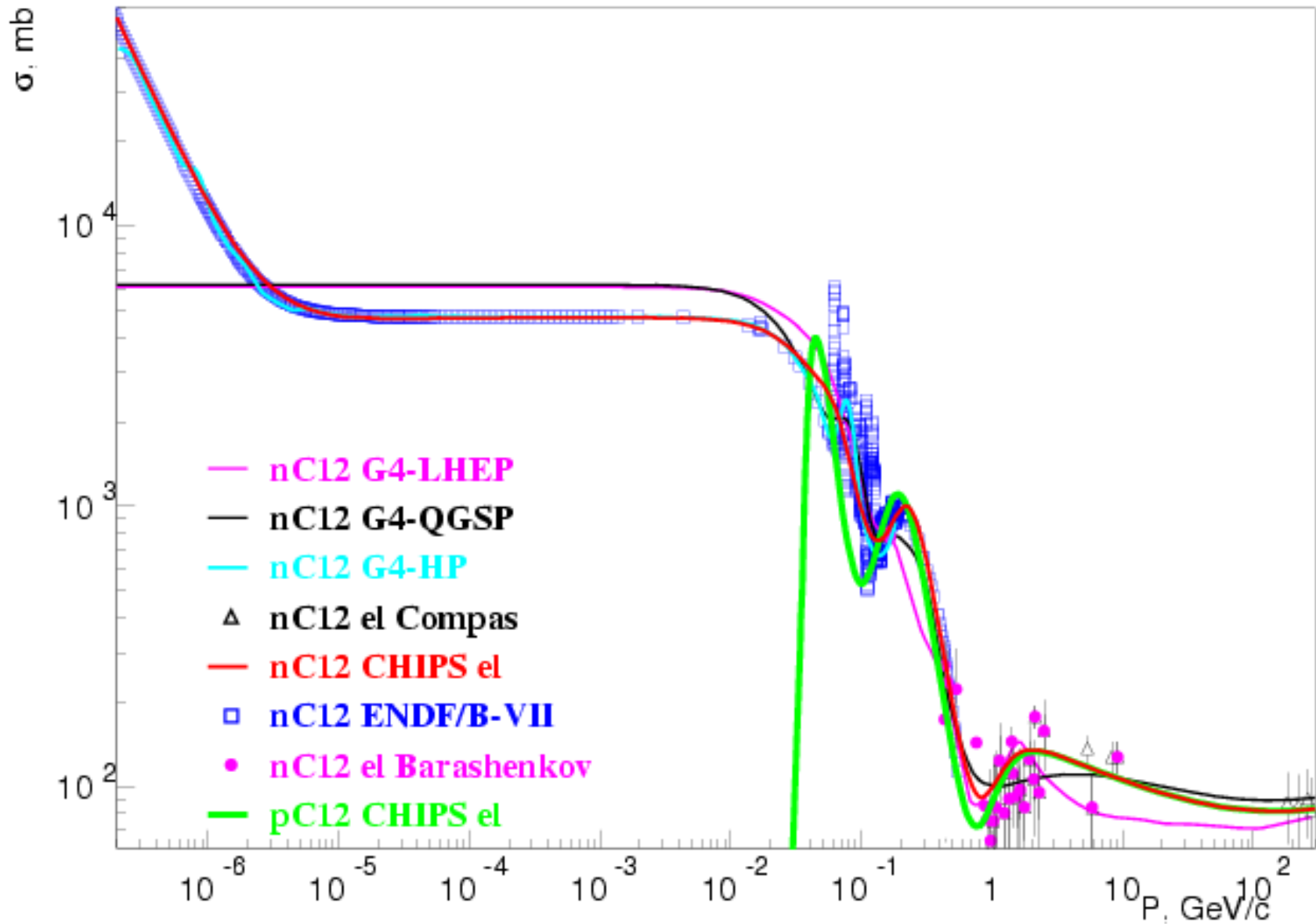
CHIPS improvement of nB10 elastic cross-section



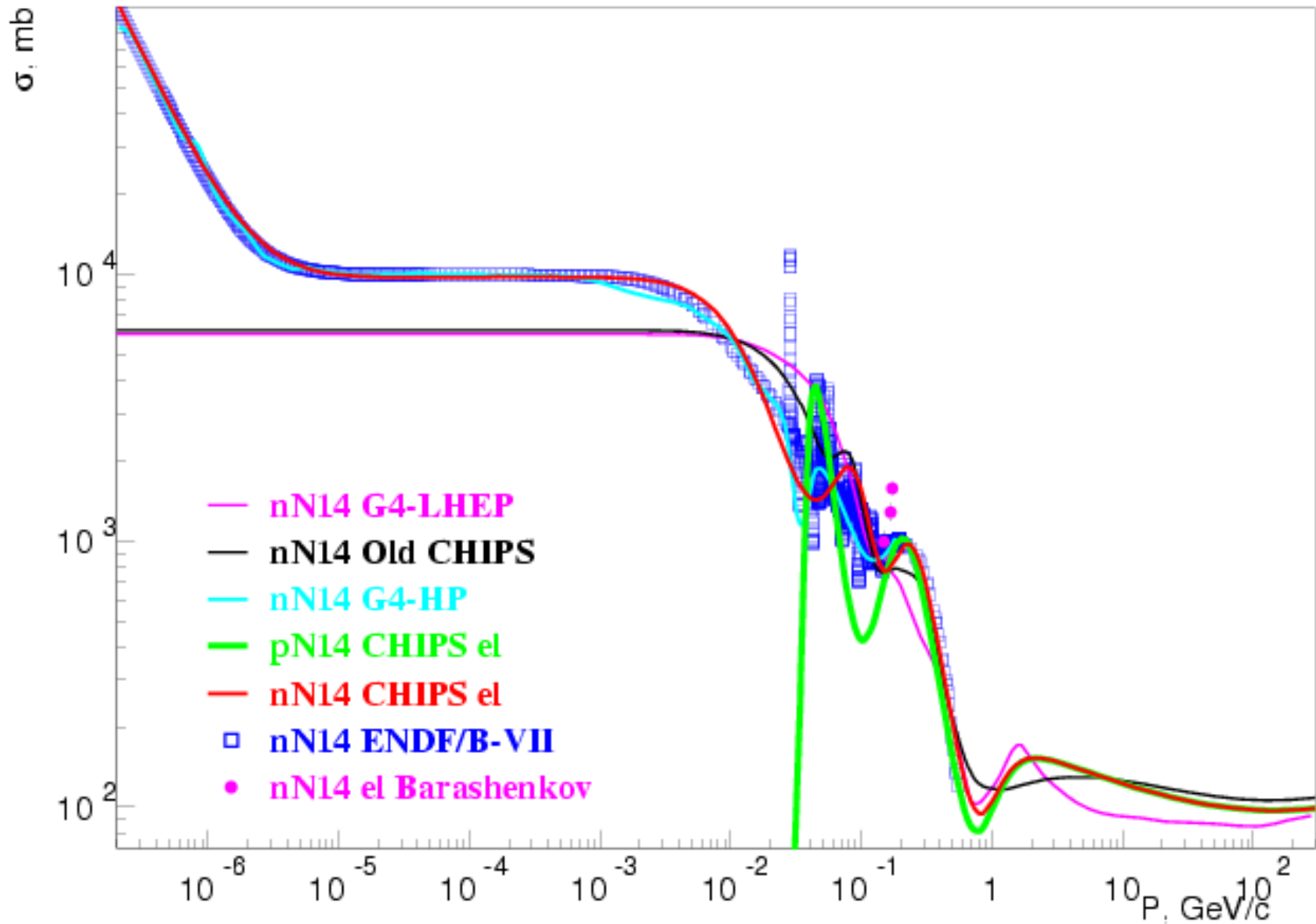
CHIPS improvement of nB11 elastic cross-section



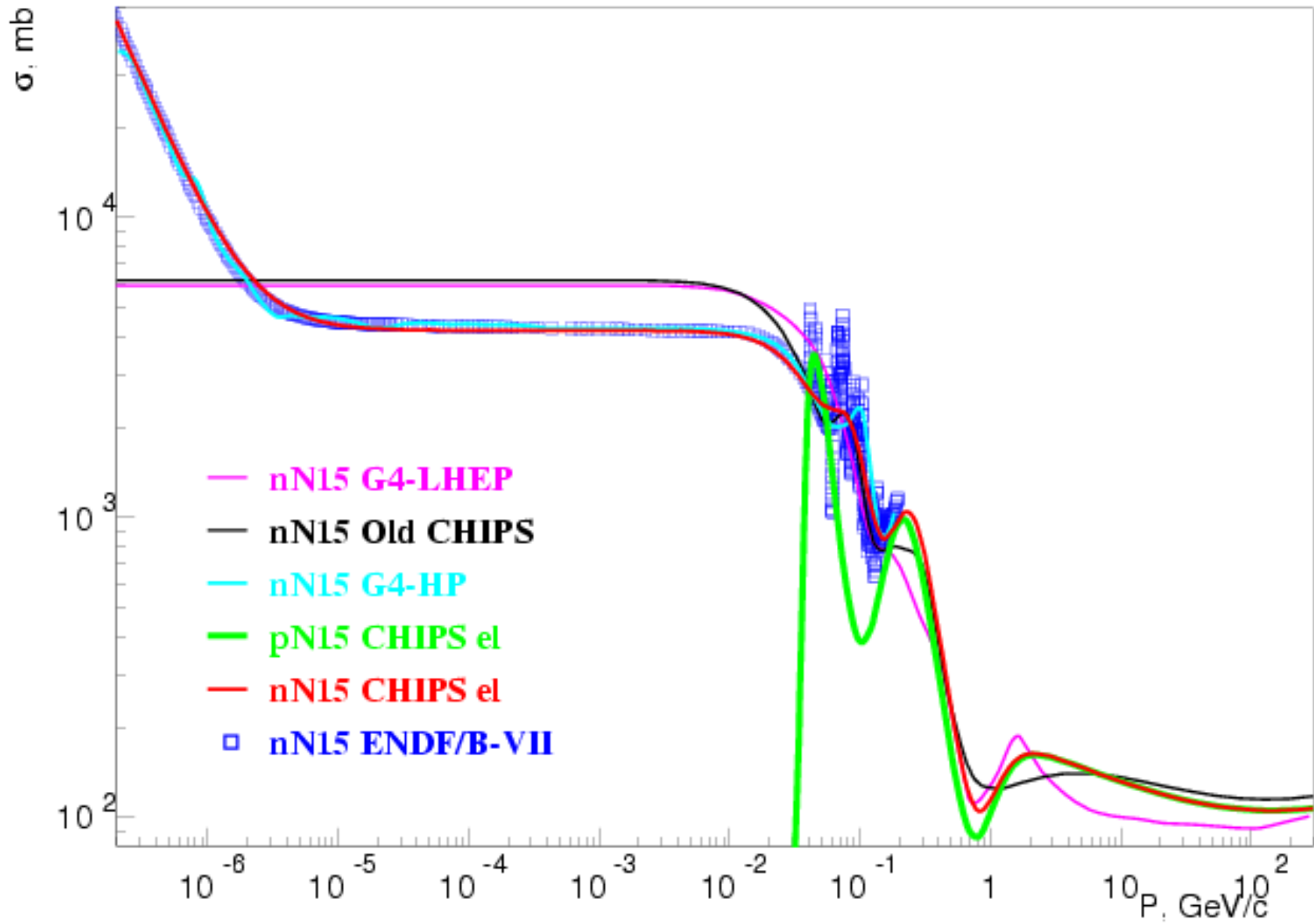
CHIPS improvement of nC12 elastic cross-section



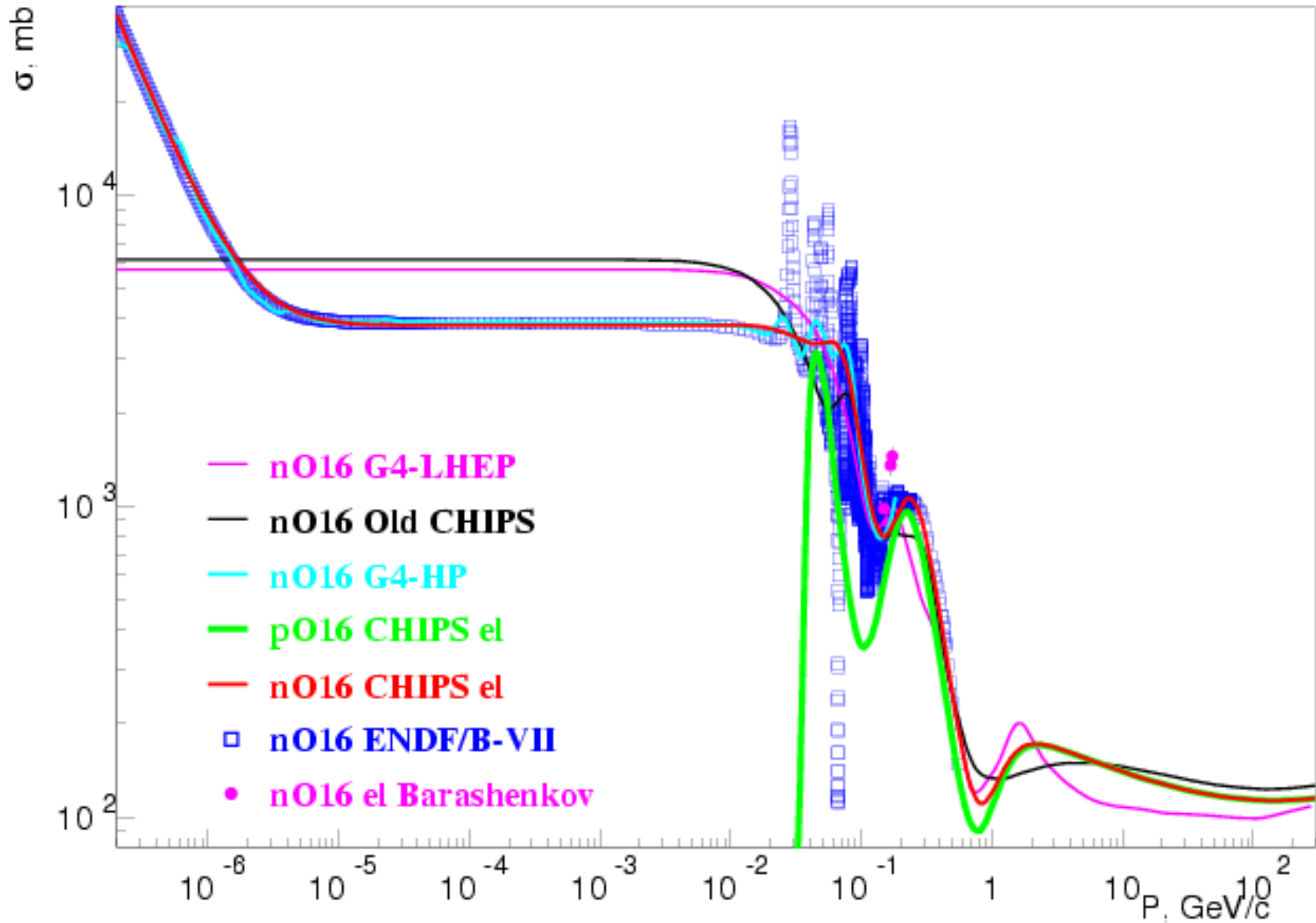
CHIPS improvement of nN14 elastic cross-section



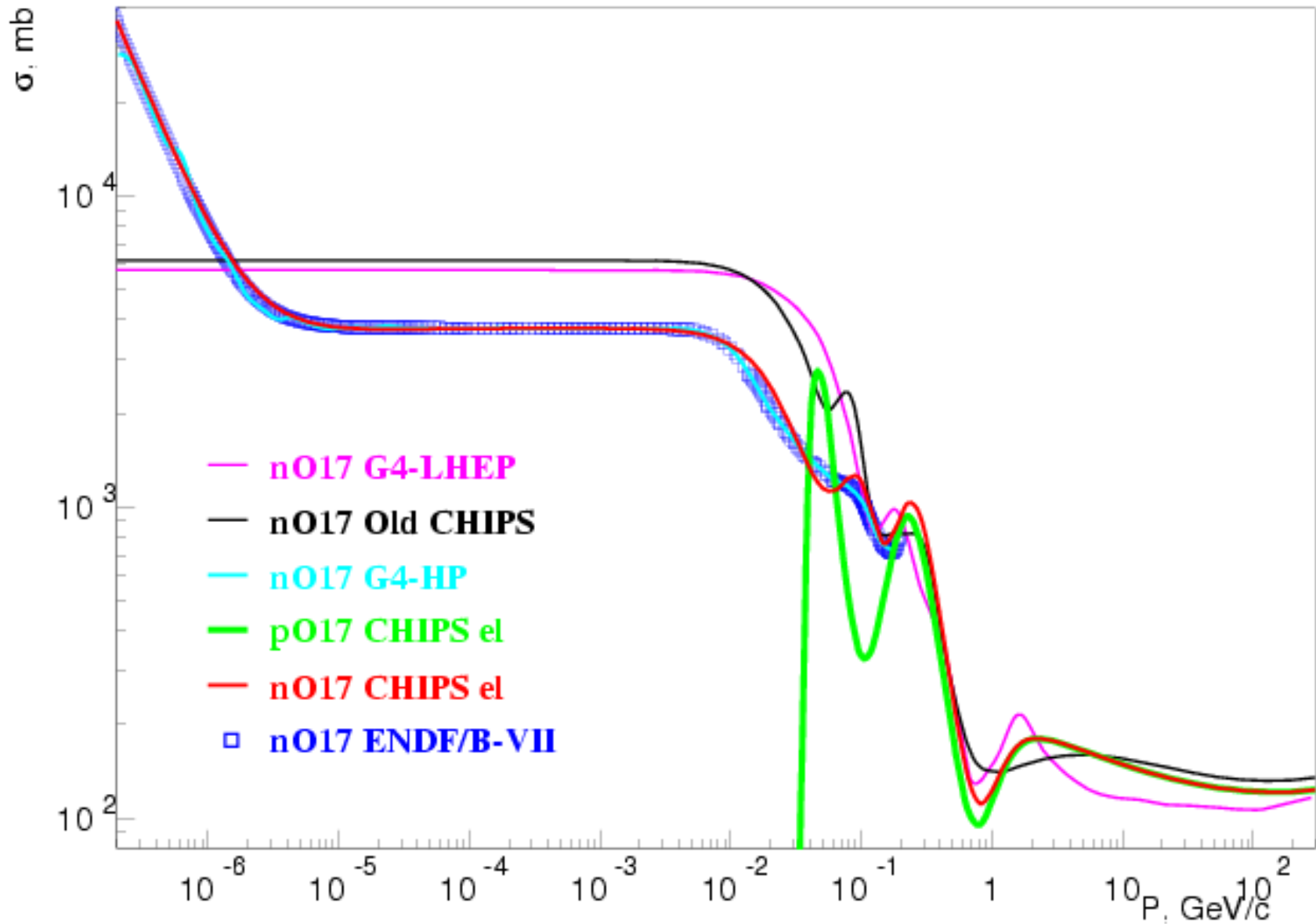
CHIPS improvement of nN15 elastic cross-section



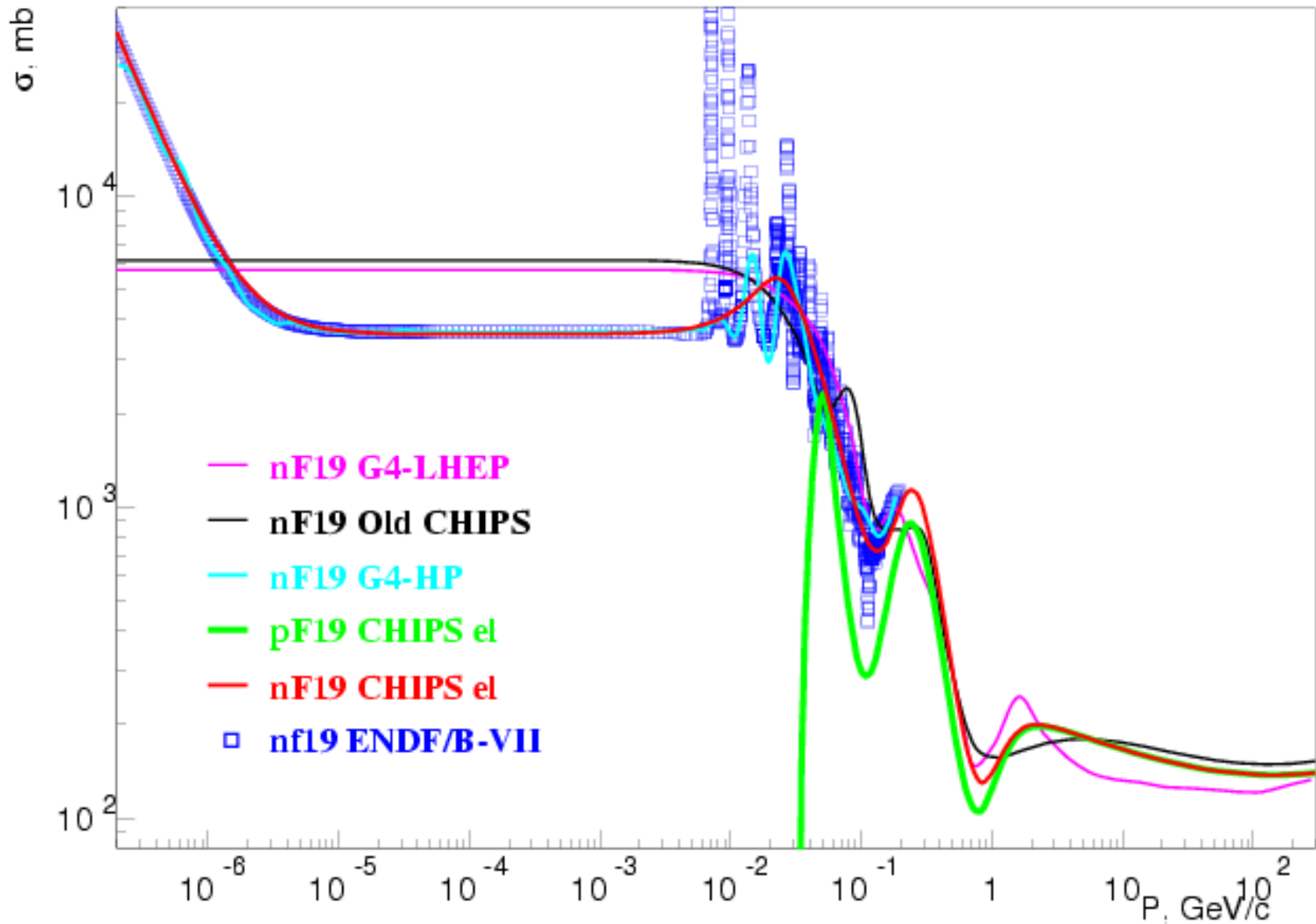
CHIPS improvement of nO16 elastic cross-section



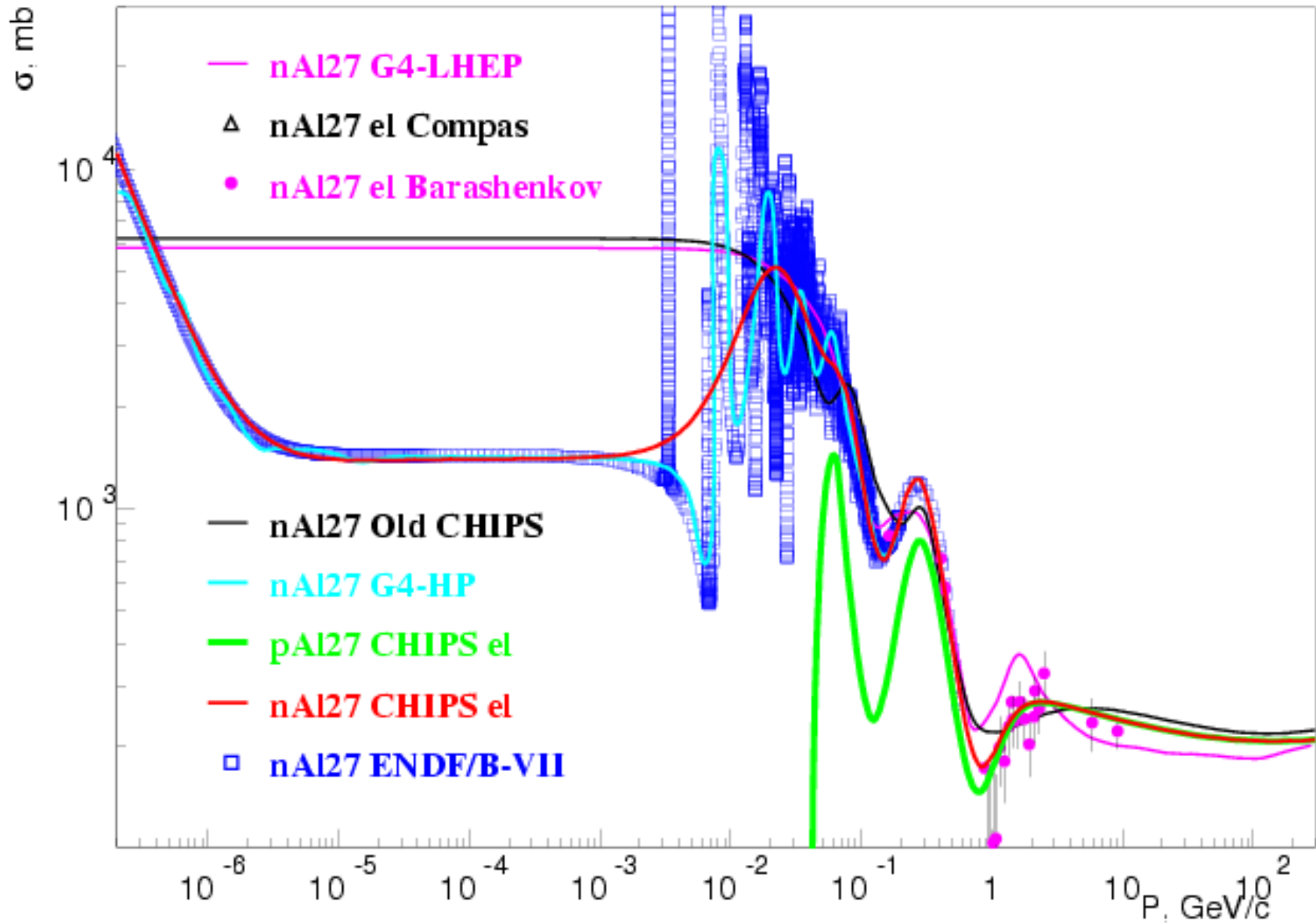
CHIPS improvement of nO17 elastic cross-section



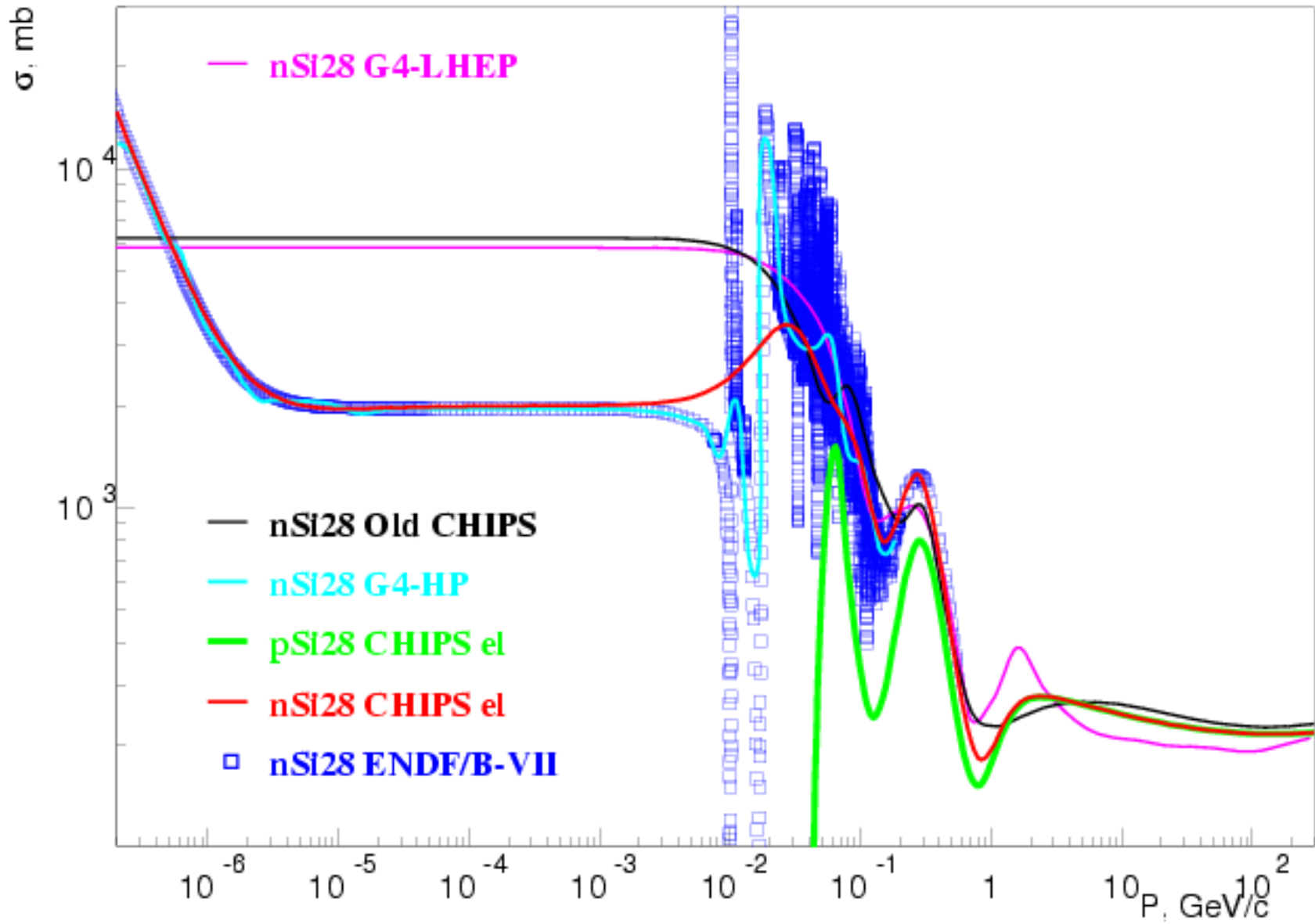
CHIPS improvement of nF19 elastic cross-section



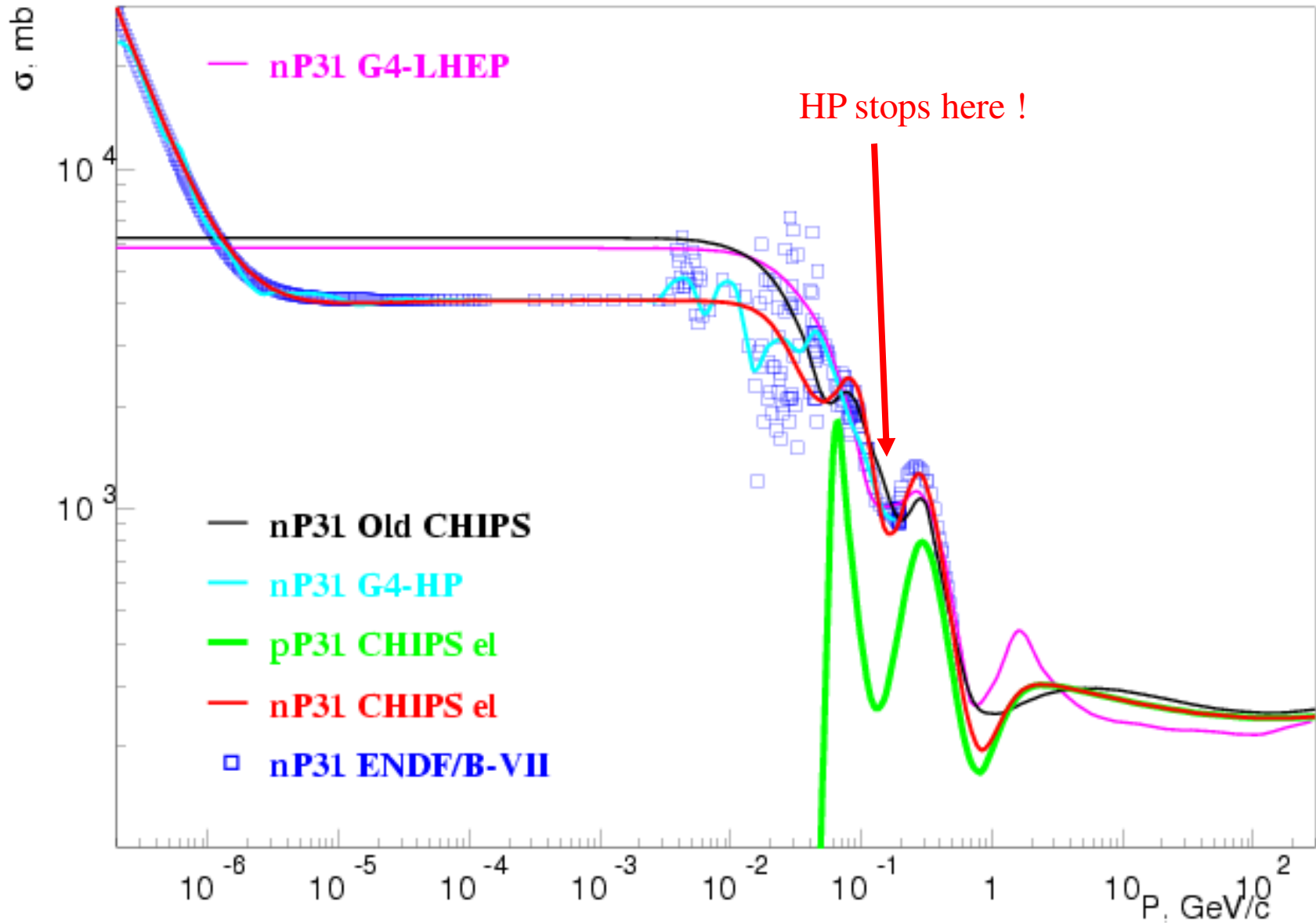
CHIPS improvement of nAl27 elastic cross-section



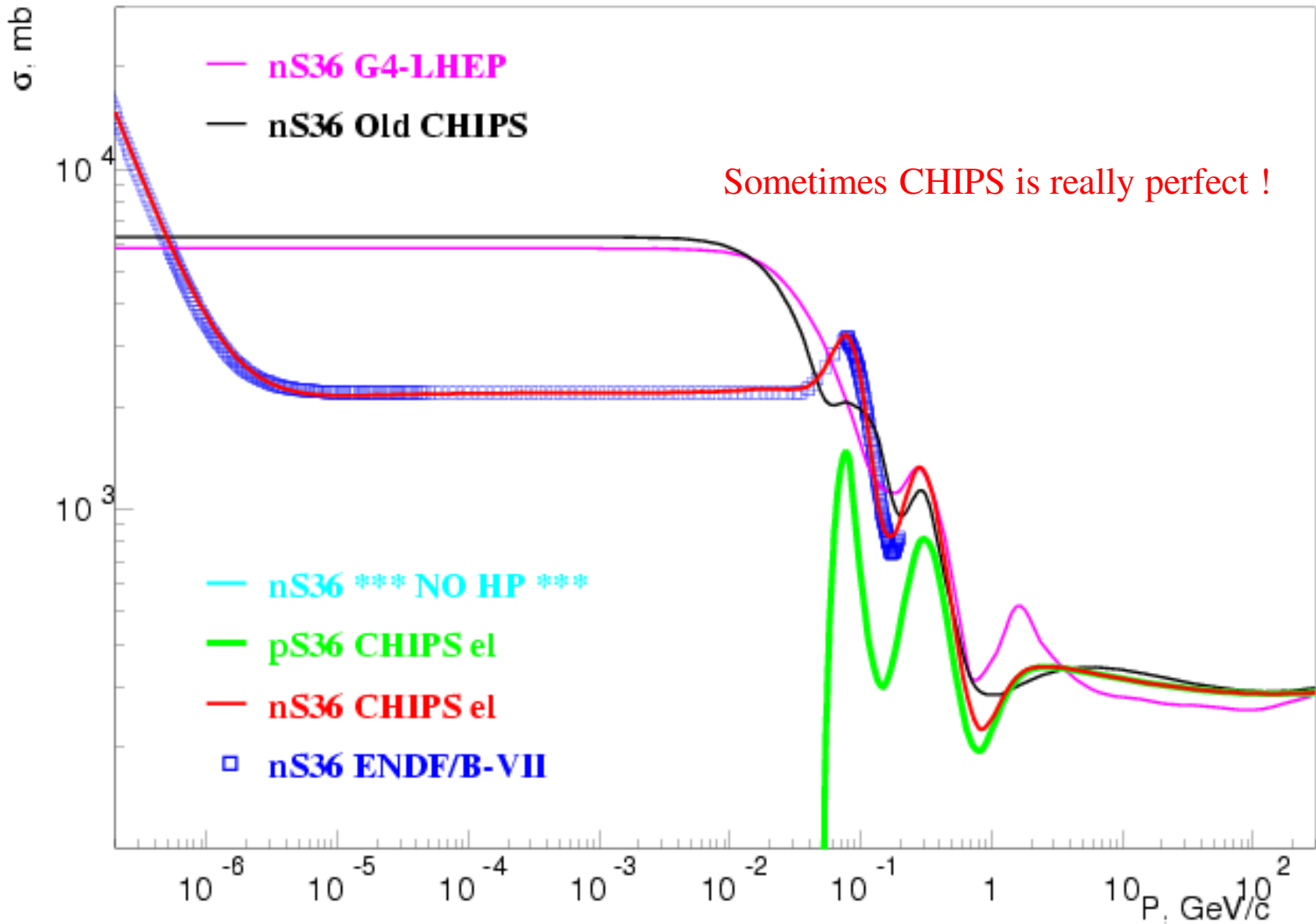
CHIPS improvement of nSi28 elastic cross-section



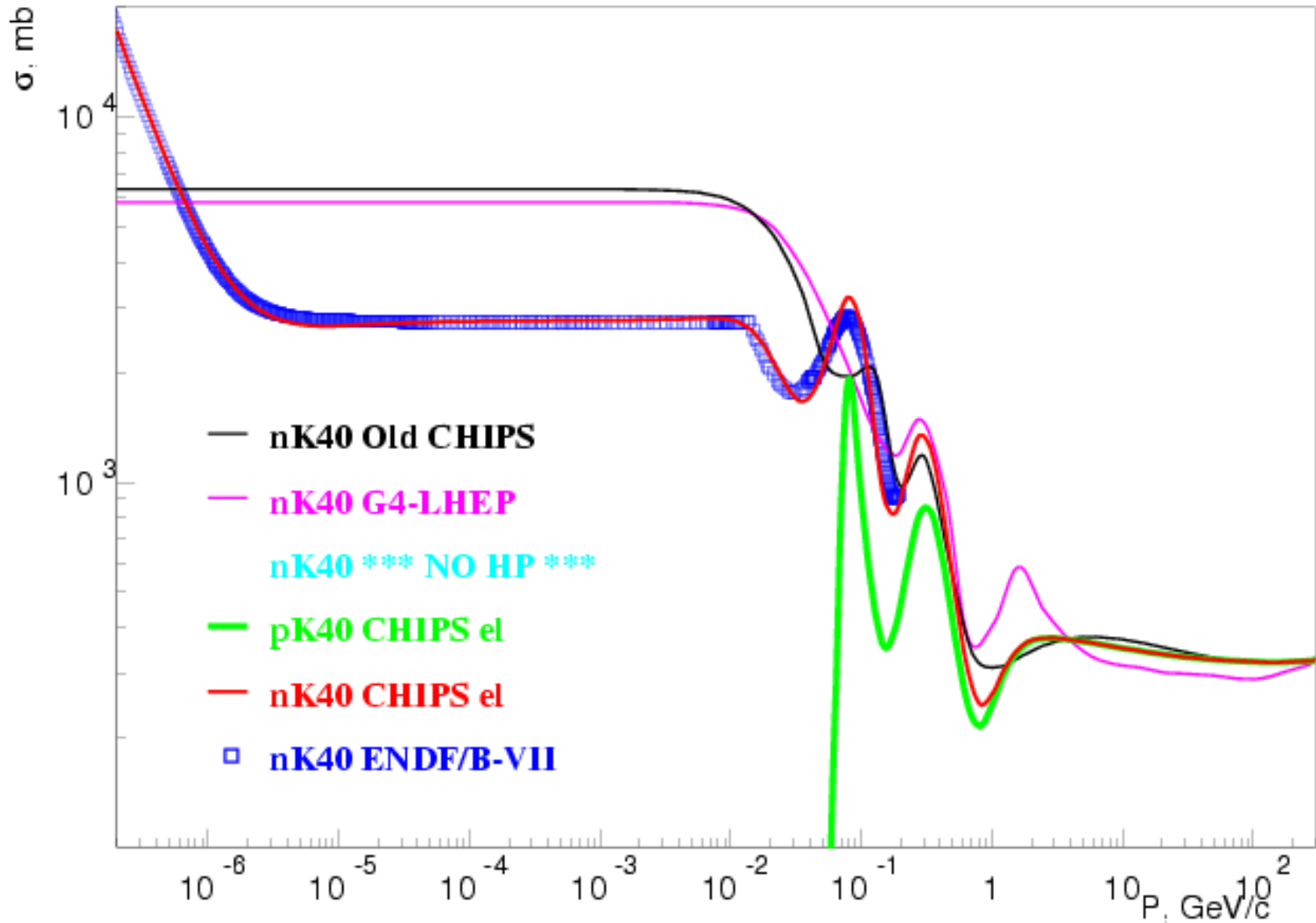
CHIPS improvement of nP31 elastic cross-section



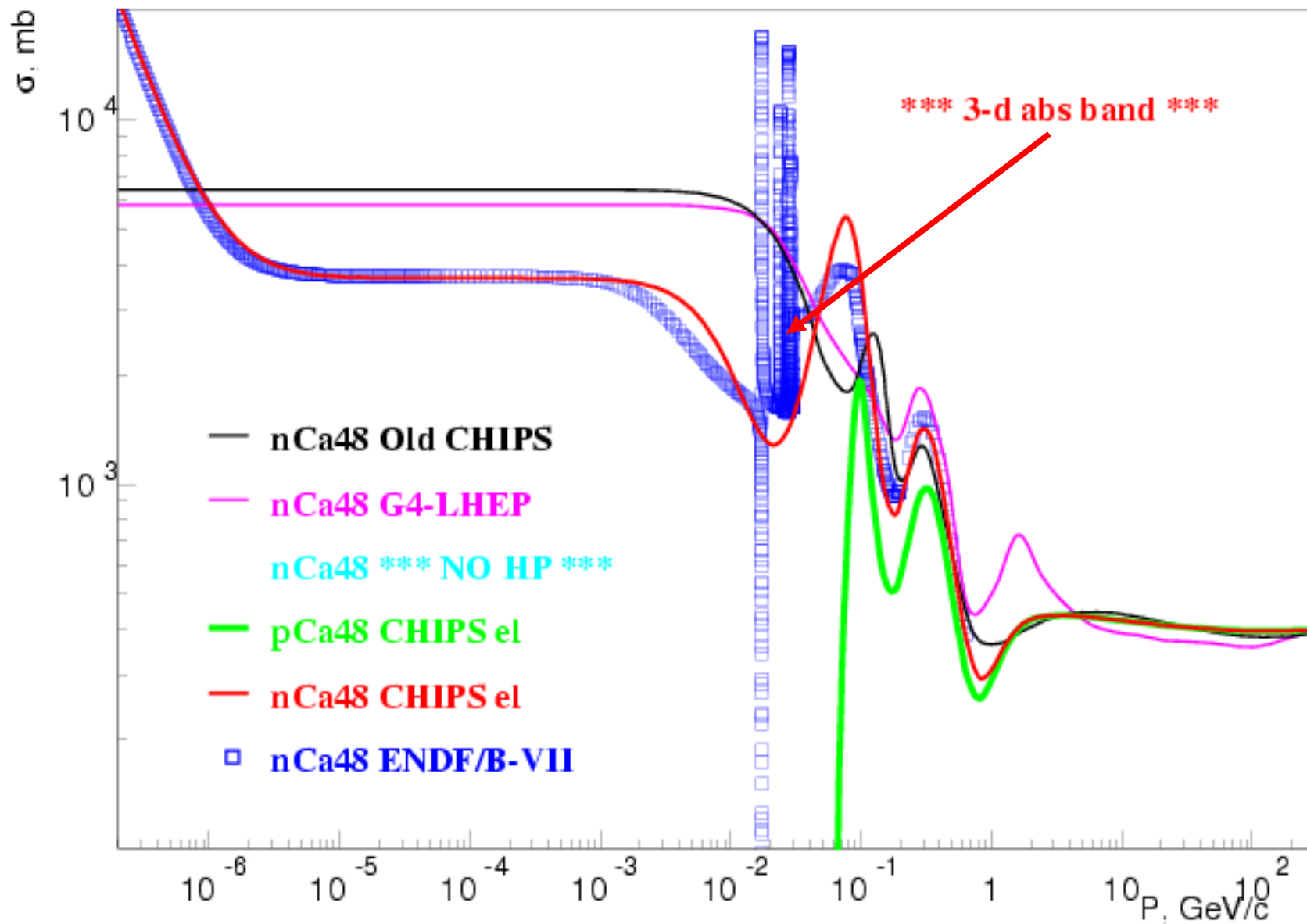
CHIPS improvement of nS36 elastic cross-section



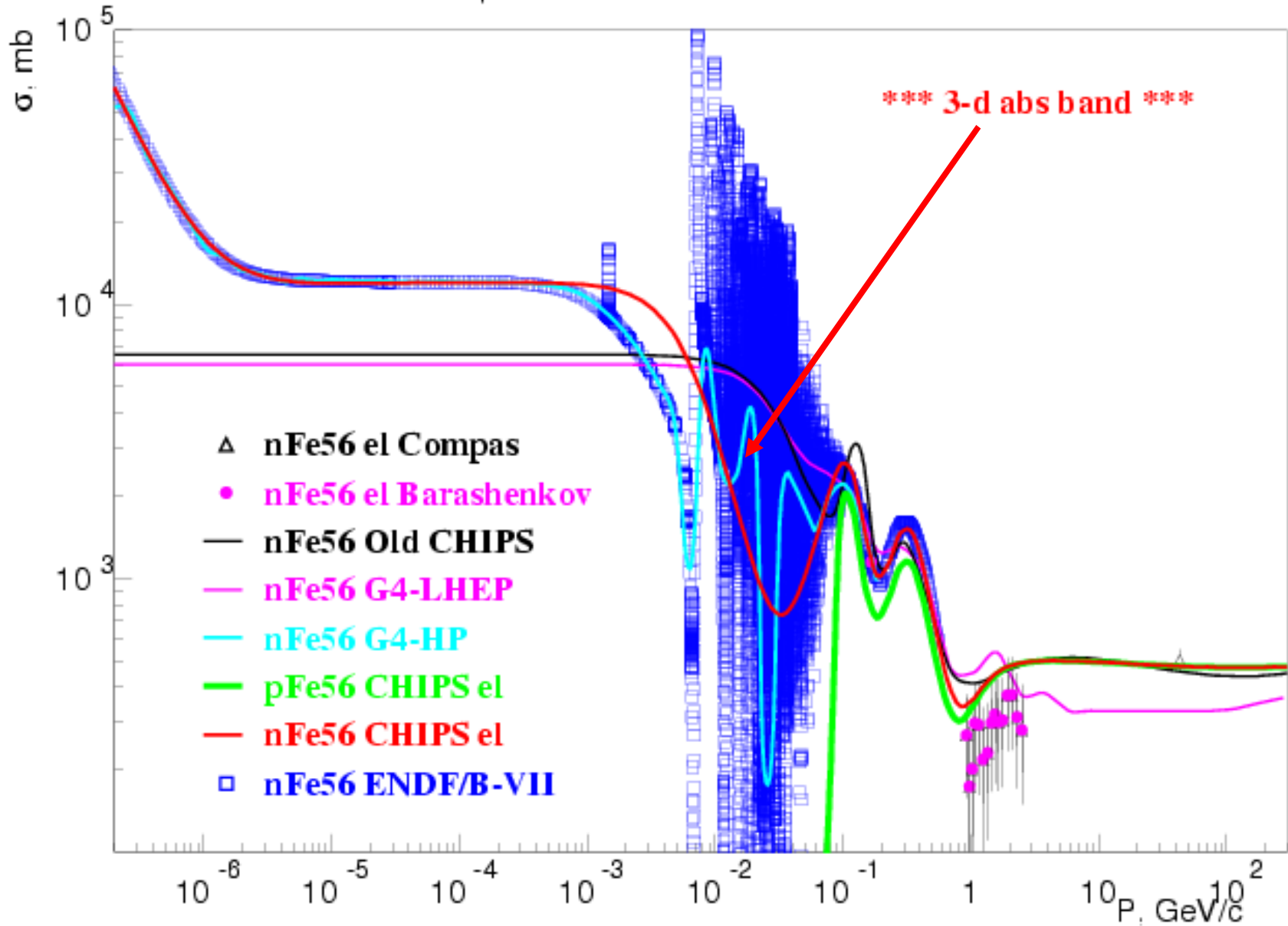
CHIPS improvement of nK40 elastic cross-section



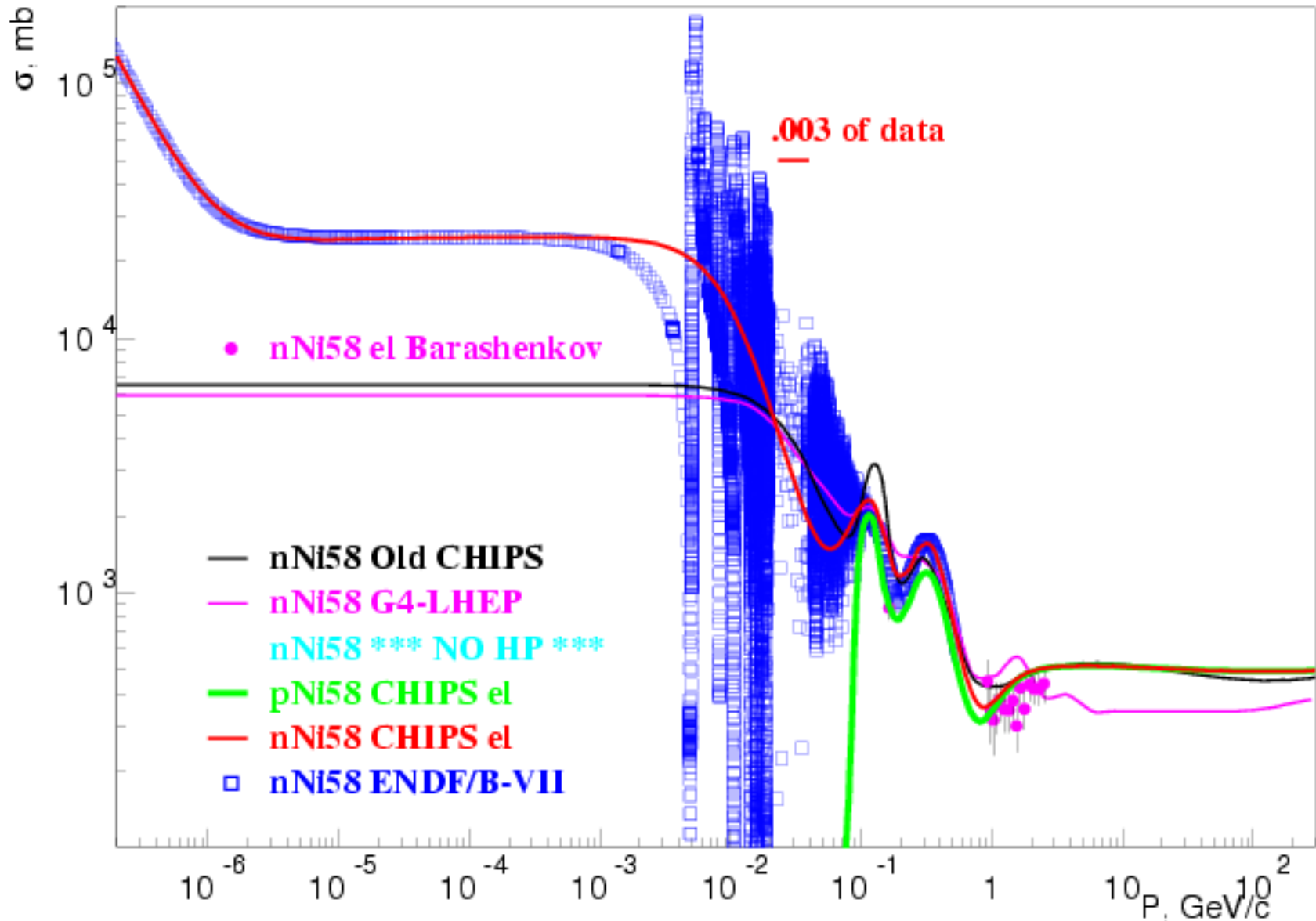
CHIPS improvement of nCa48 elastic cross-section



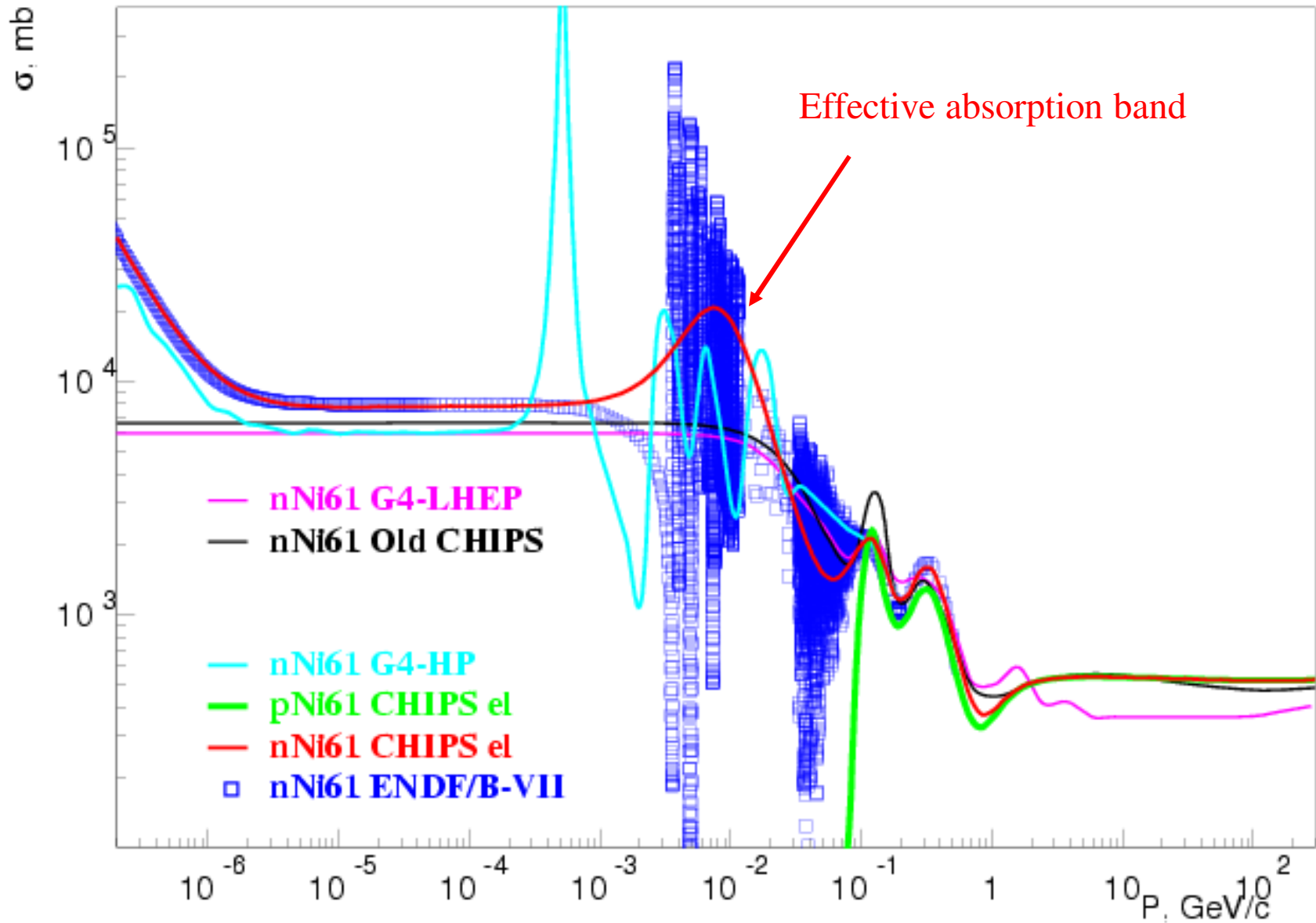
CHIPS improvement of nFe56 elastic cross-section



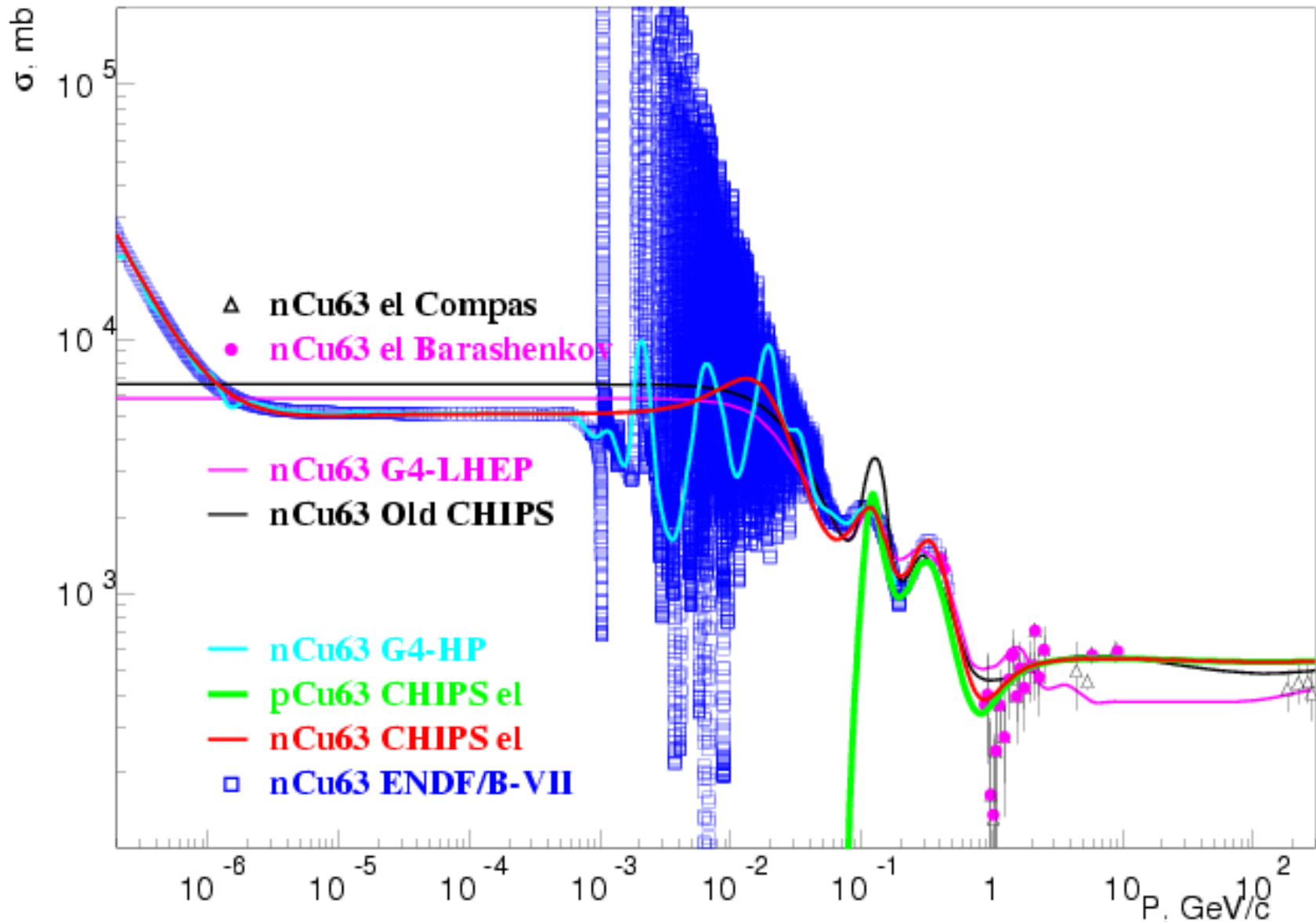
CHIPS improvement of nNi58 elastic cross-section



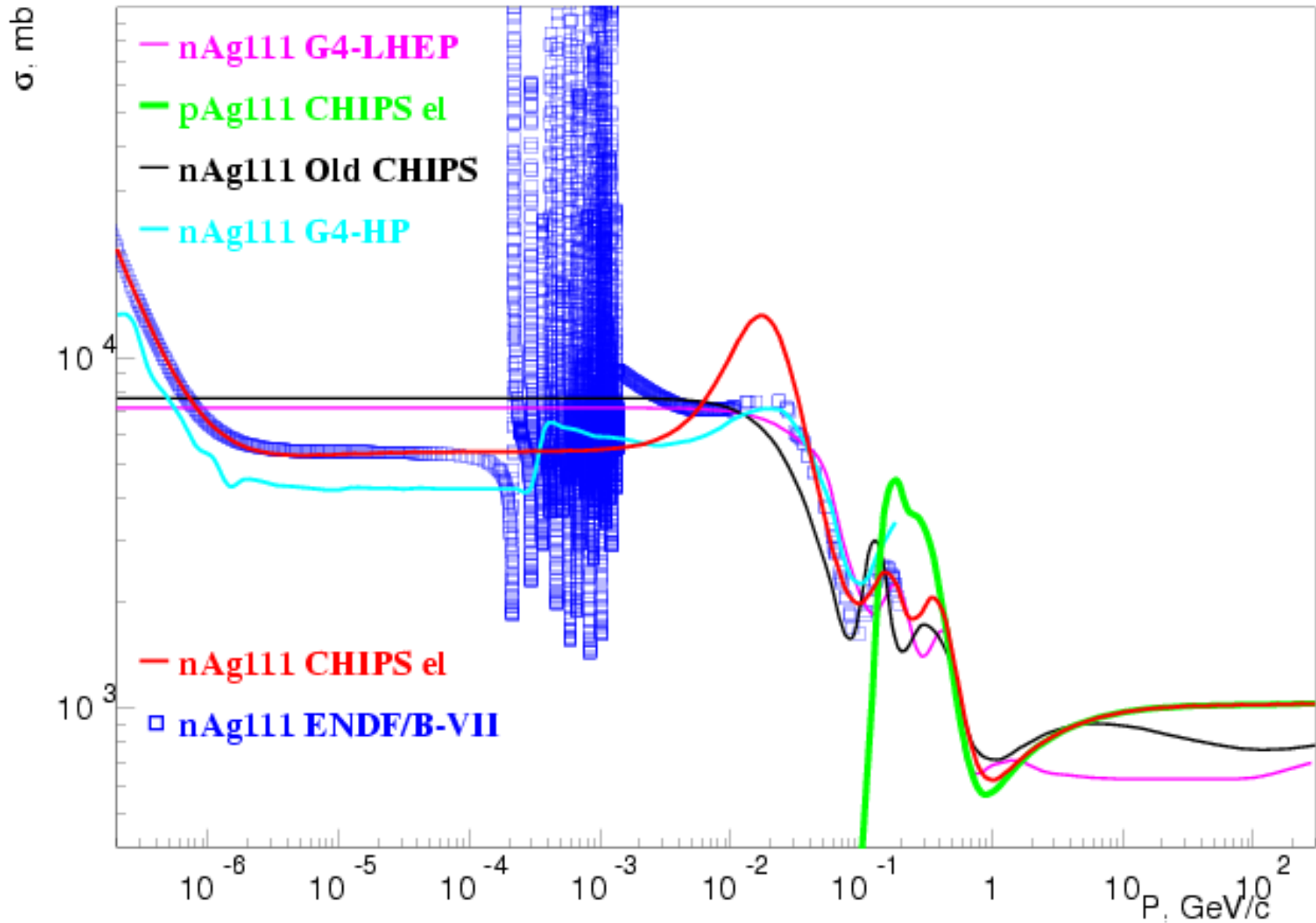
CHIPS improvement of nNi61 elastic cross-section



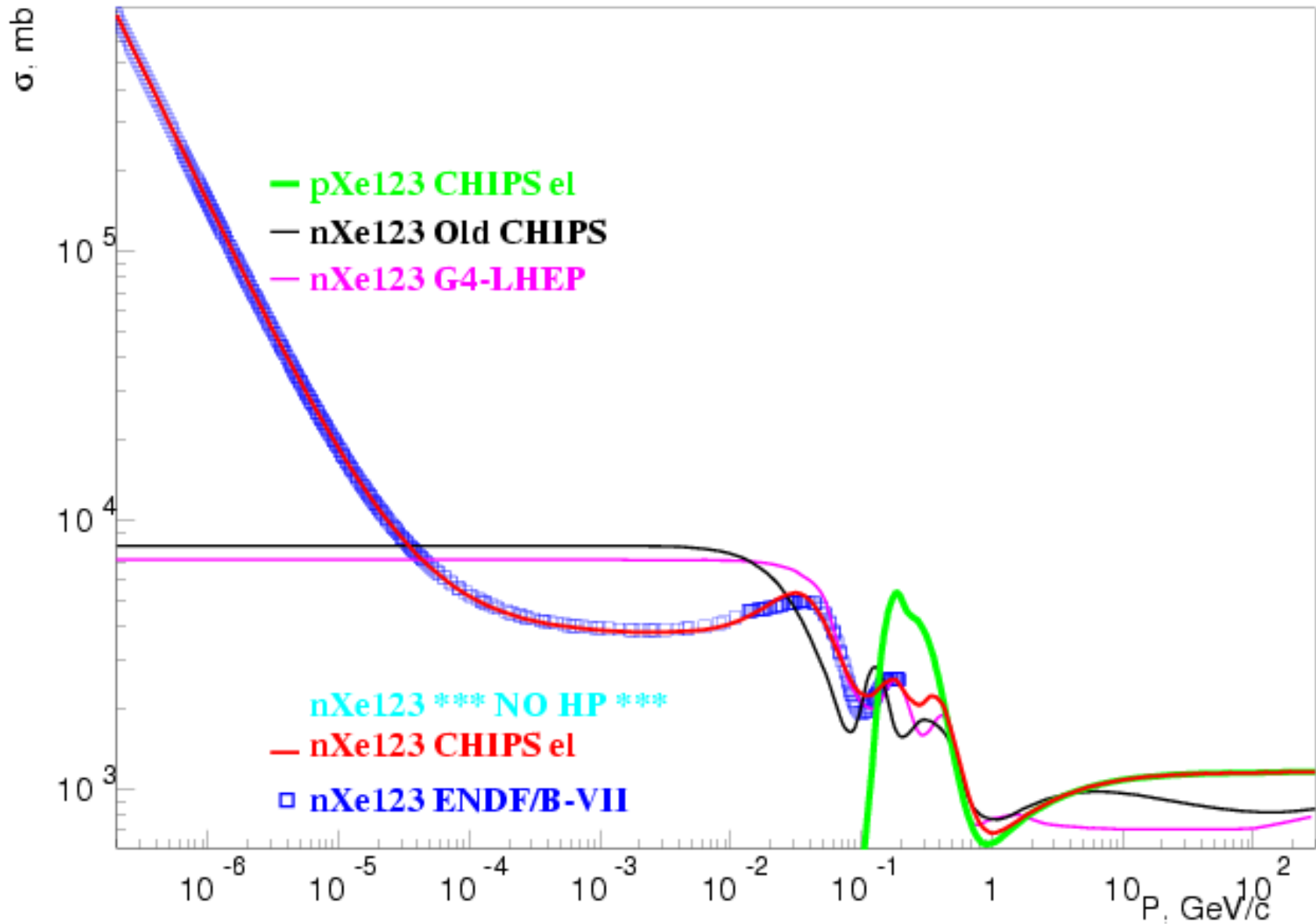
CHIPS improvement of nCu63 elastic cross-section



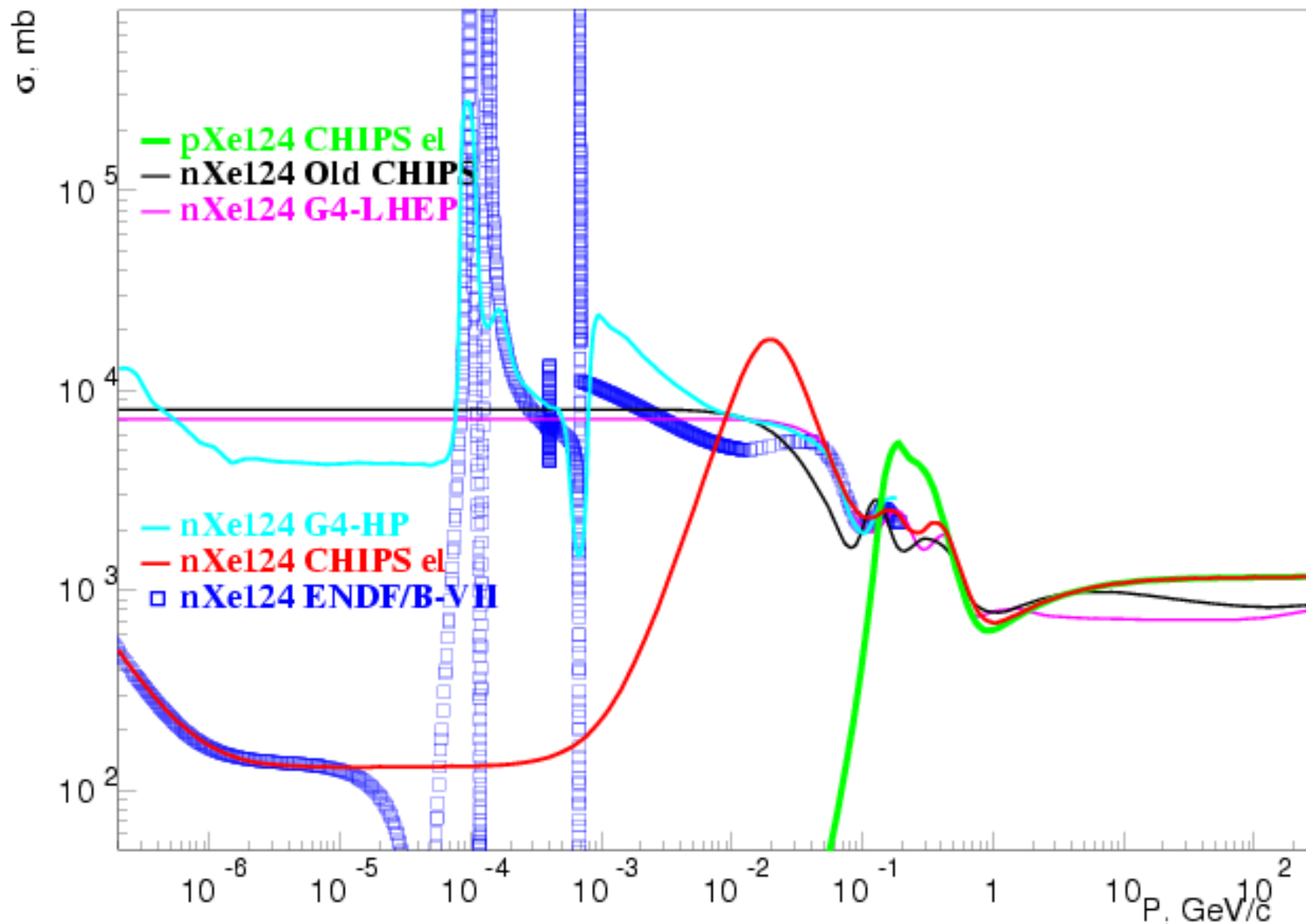
CHIPS improvement of nAg111 elastic cross-section



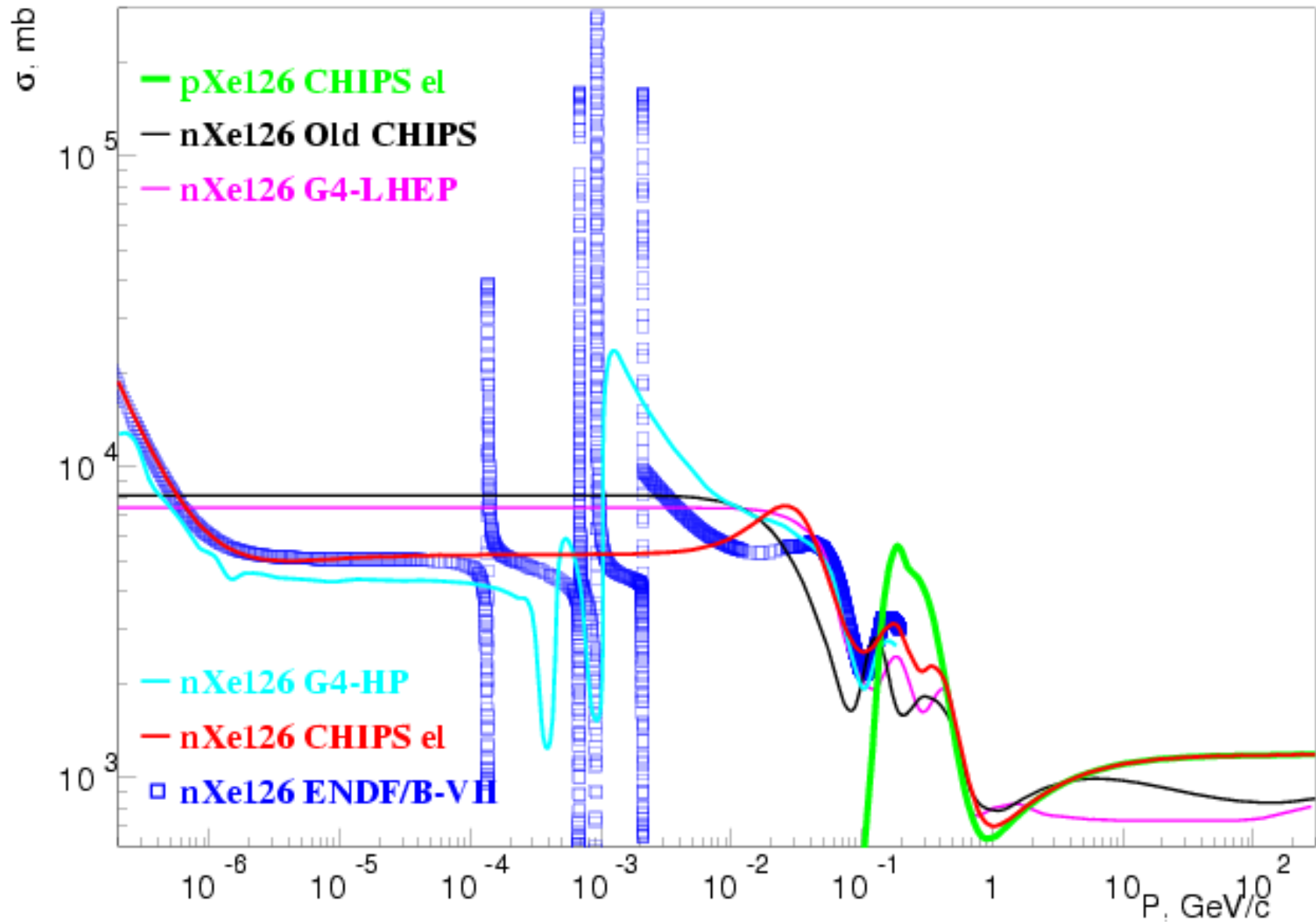
CHIPS improvement of nXe123 elastic cross-section



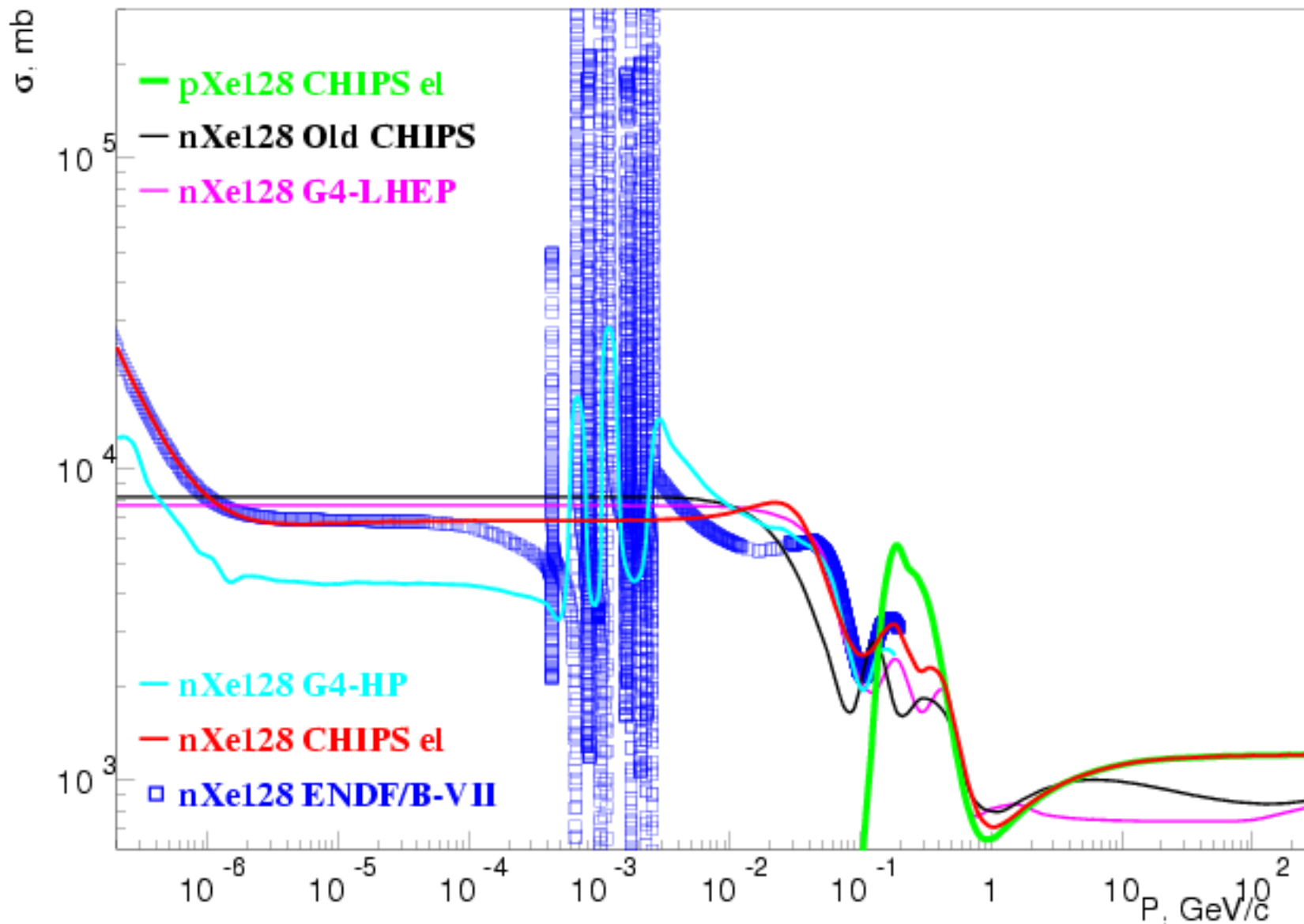
CHIPS improvement of nXe124 elastic cross-section



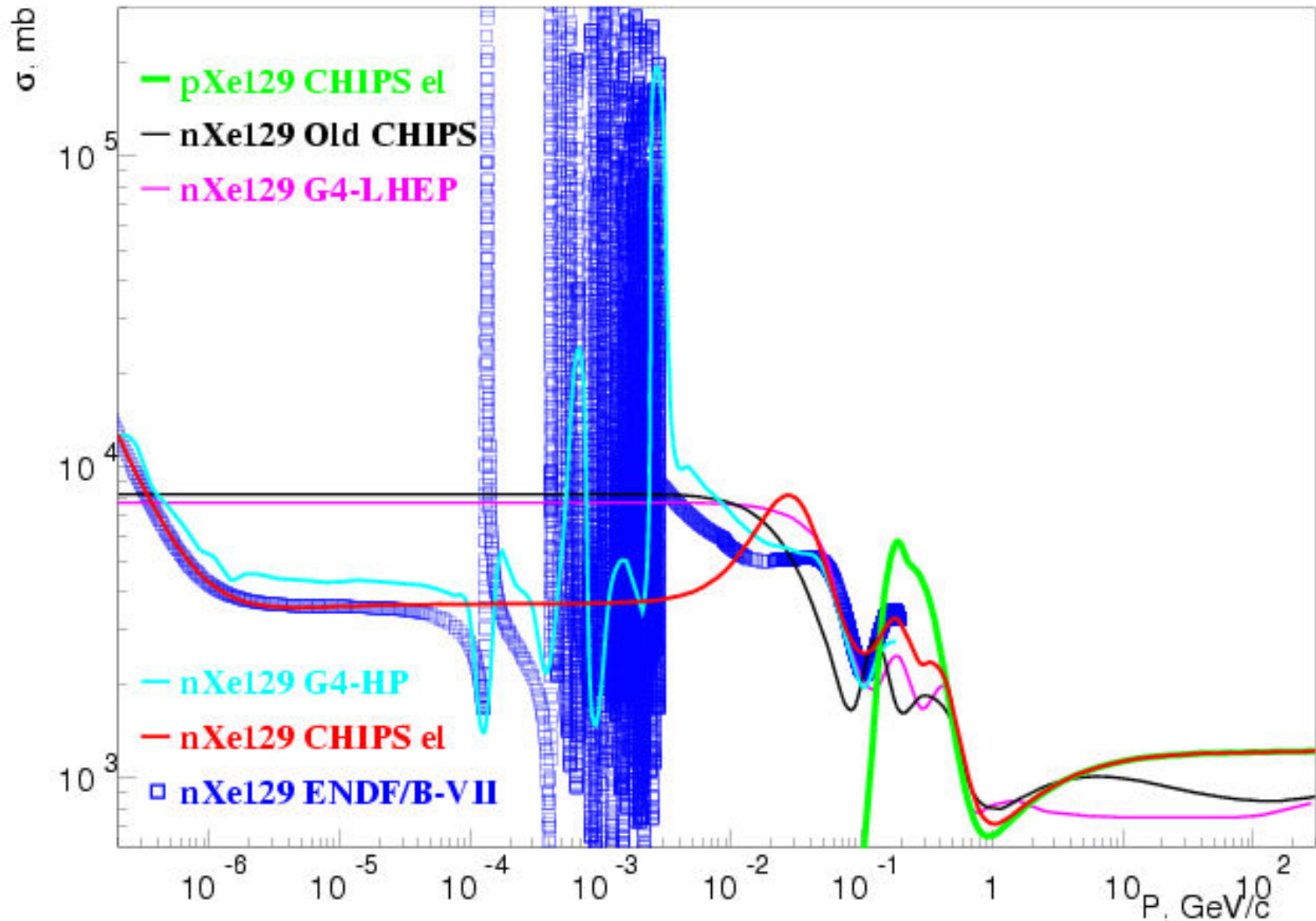
CHIPS improvement of nXe126 elastic cross-section



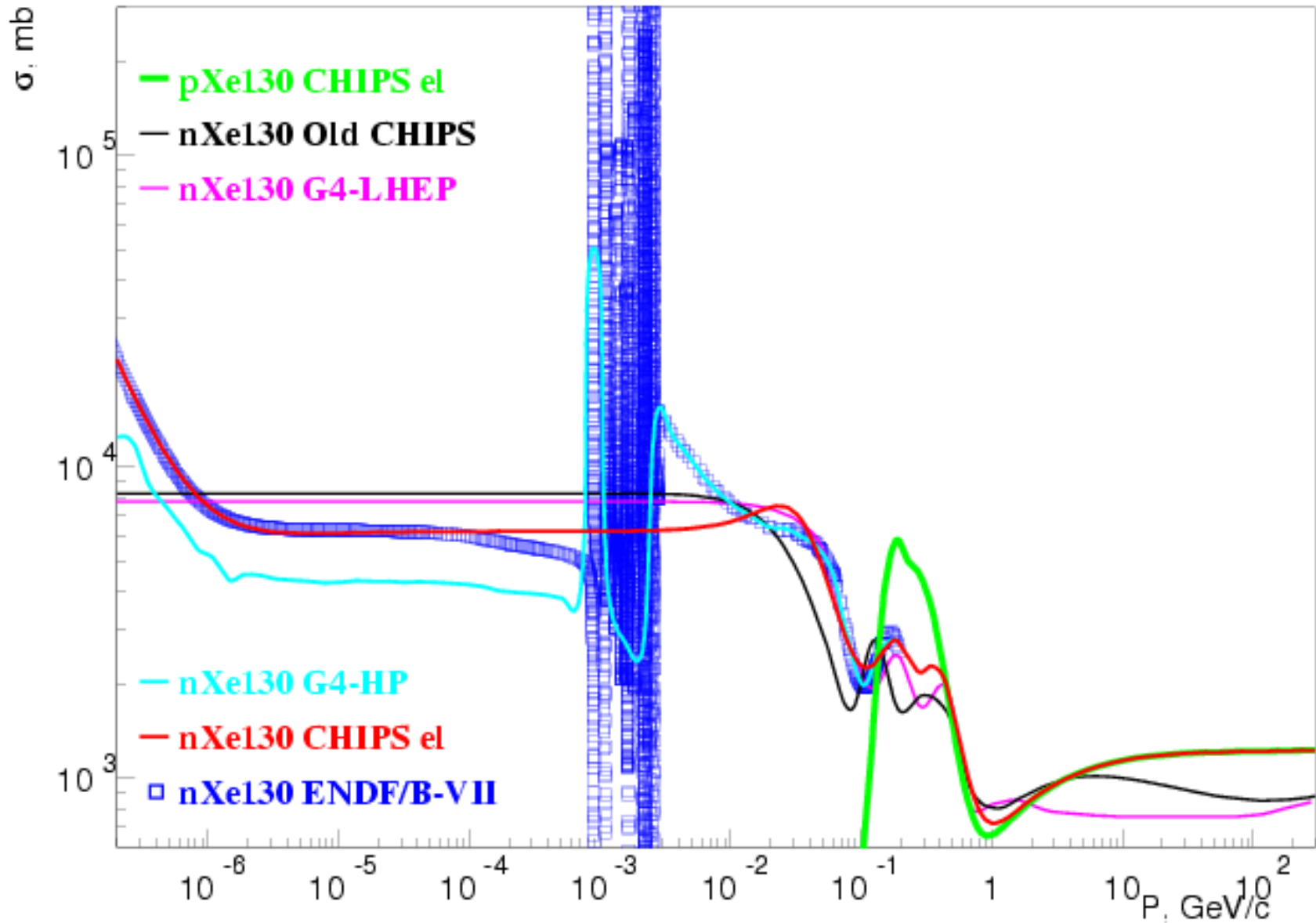
CHIPS improvement of nXe128 elastic cross-section



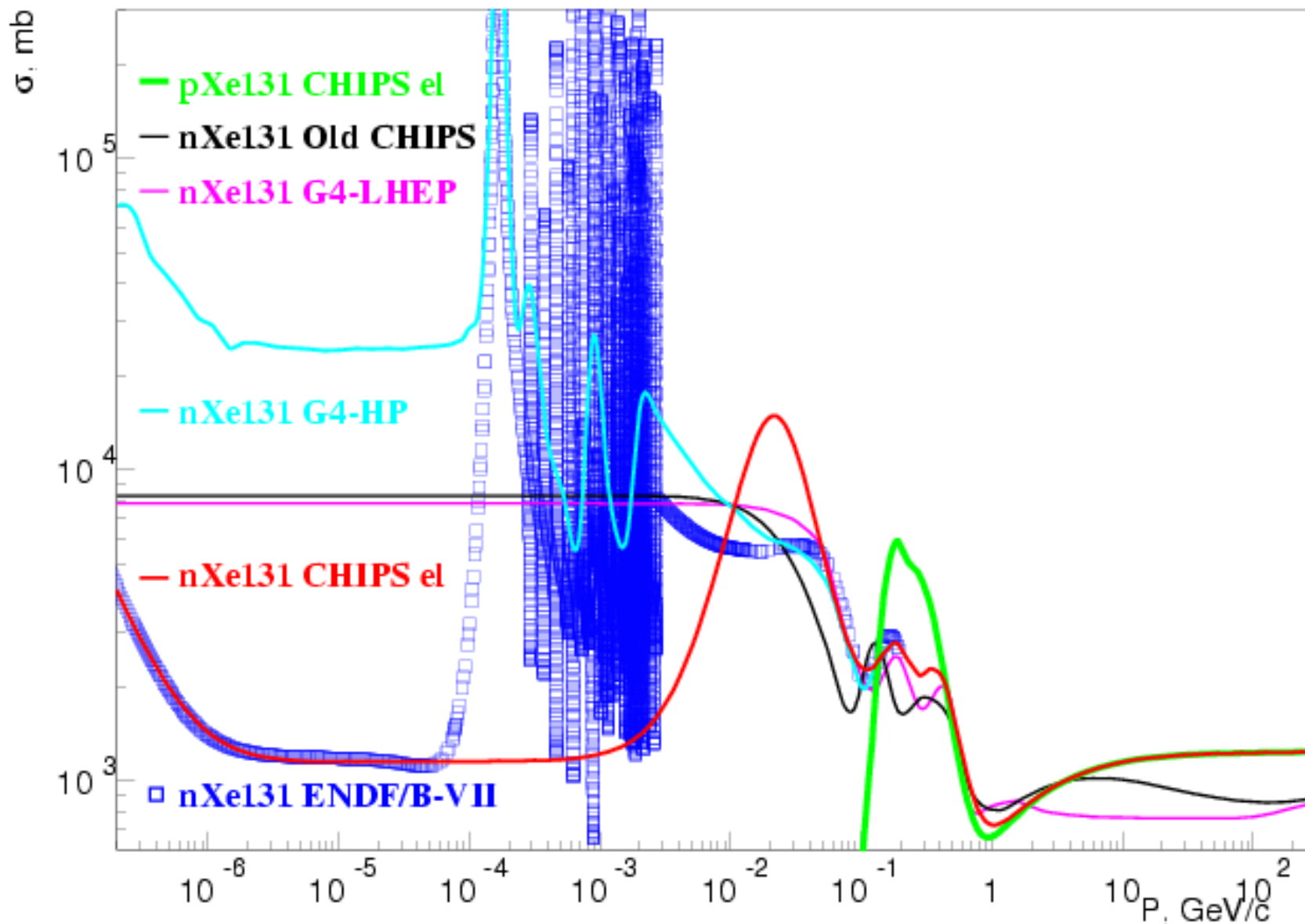
CHIPS improvement of nXe129 elastic cross-section



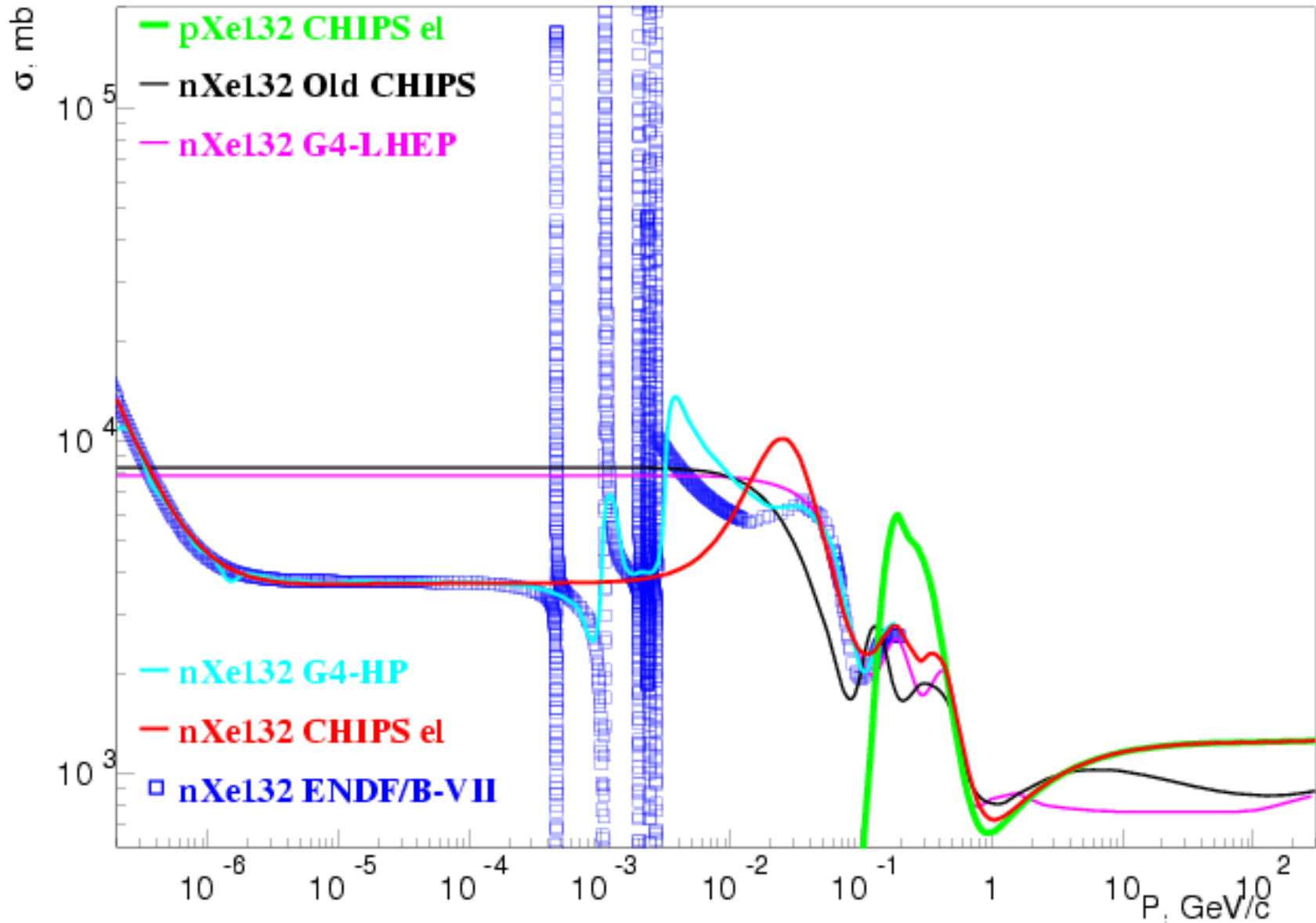
CHIPS improvement of nXe130 elastic cross-section



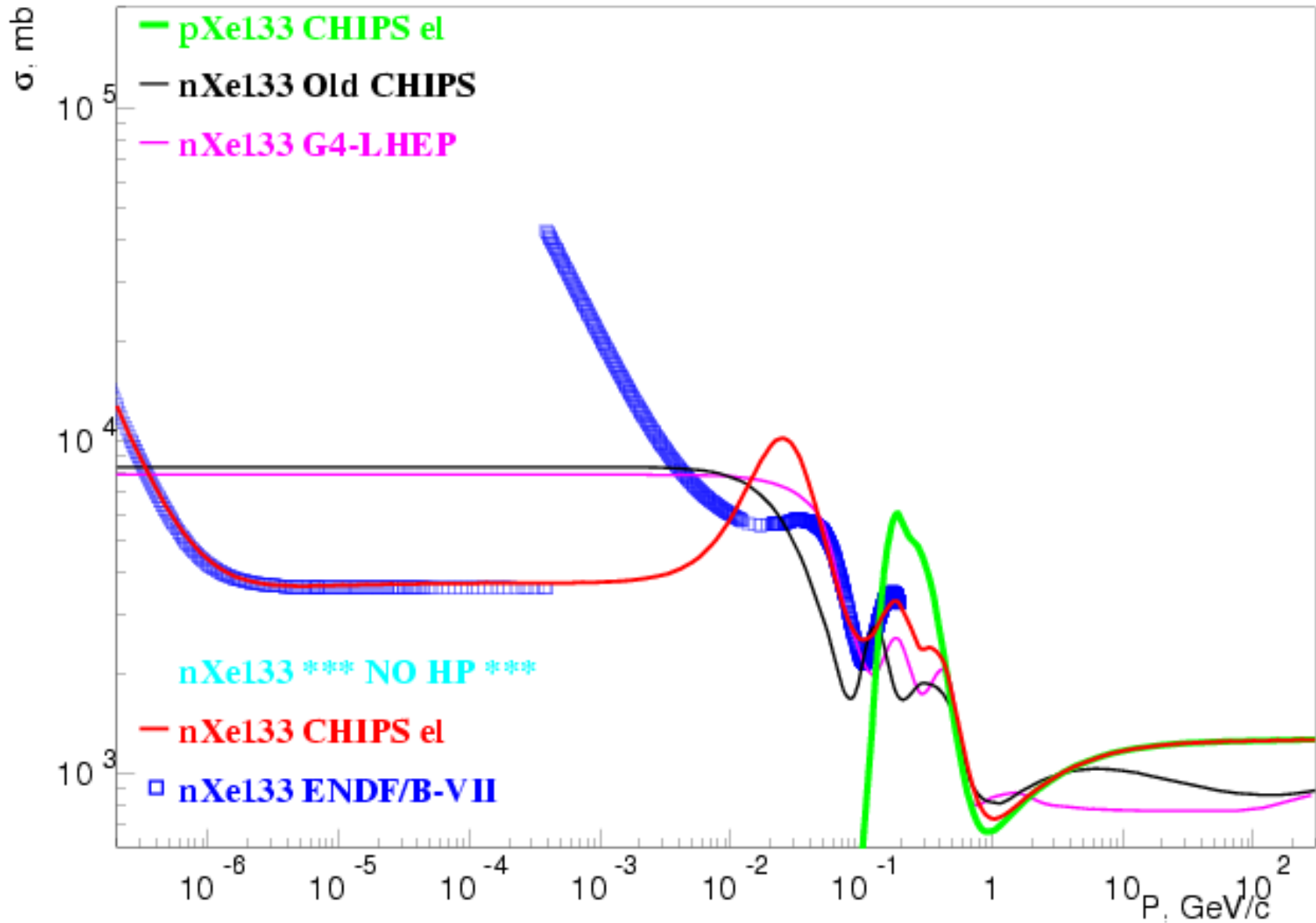
CHIPS improvement of nXe131 elastic cross-section



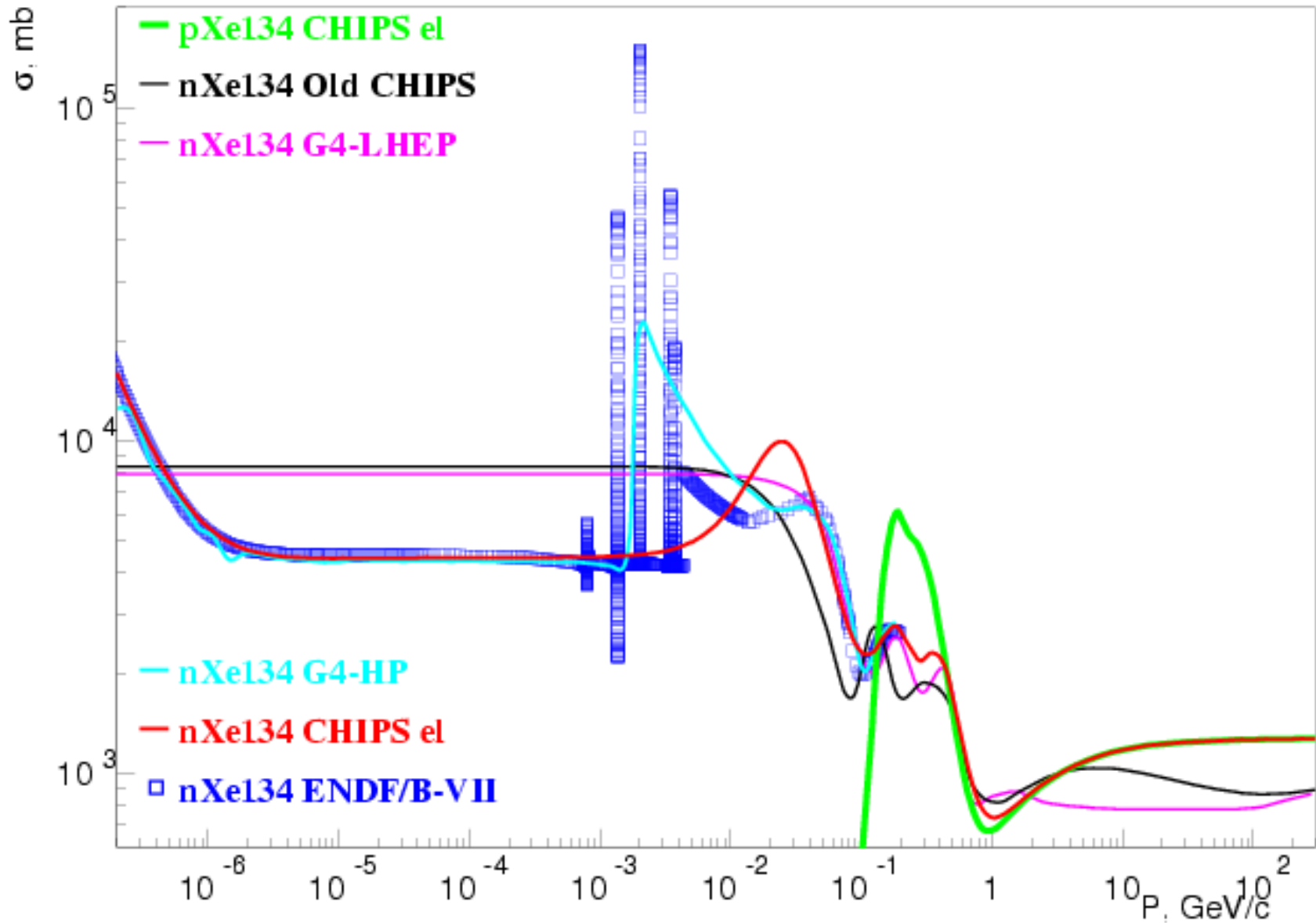
CHIPS improvement of nXe132 elastic cross-section



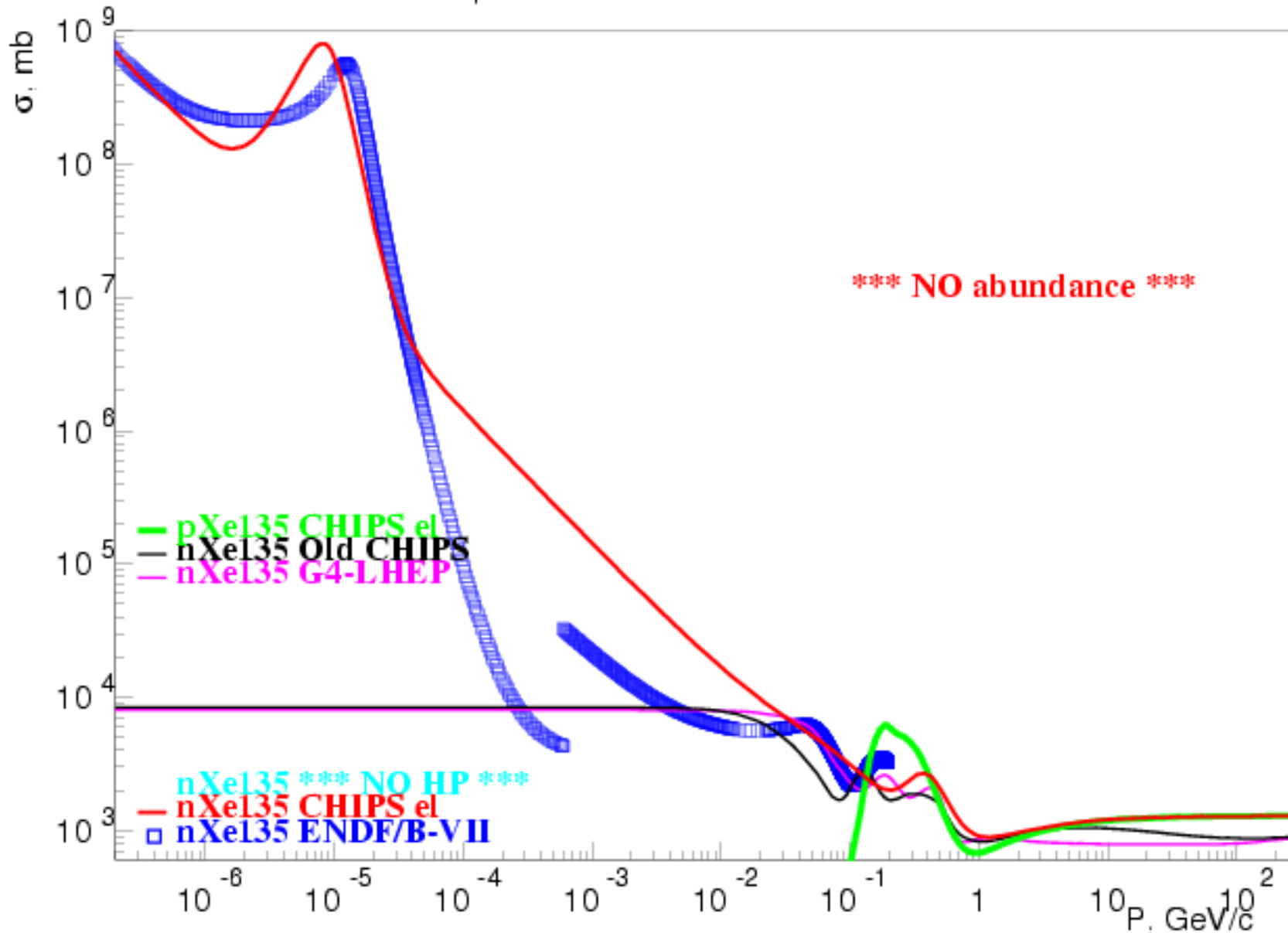
CHIPS improvement of nXe133 elastic cross-section



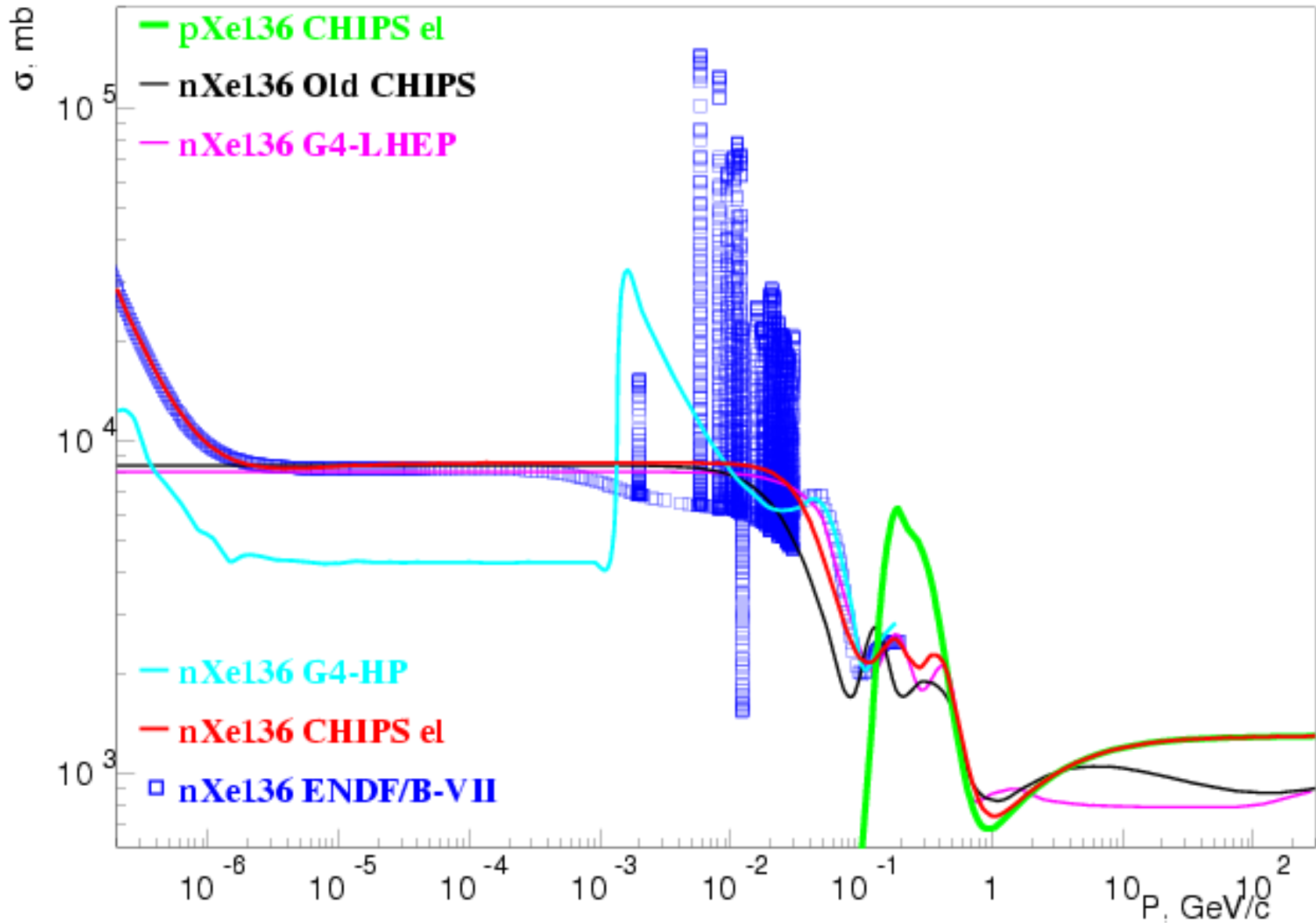
CHIPS improvement of nXe134 elastic cross-section



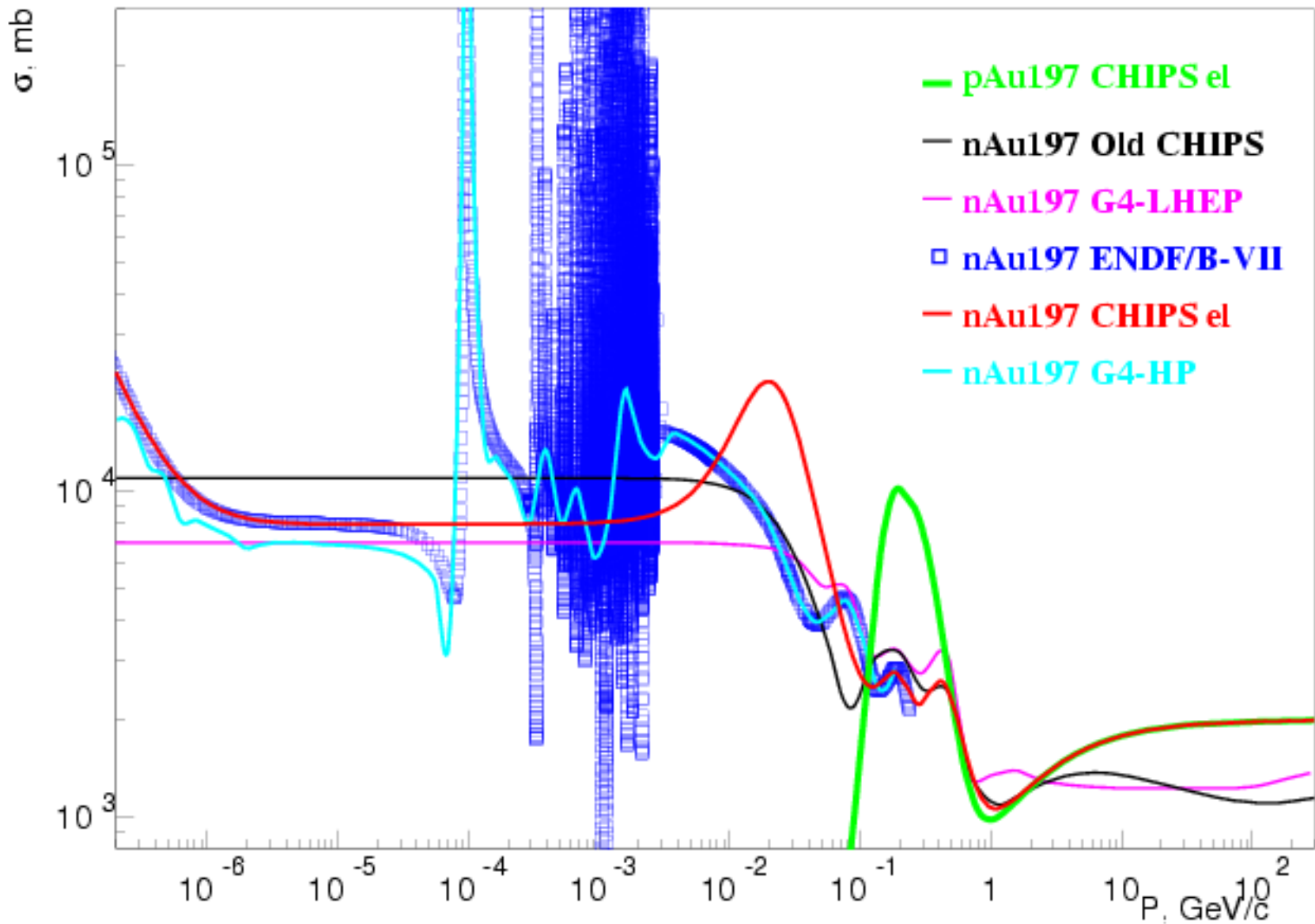
CHIPS improvement of nXe135 elastic cross-section



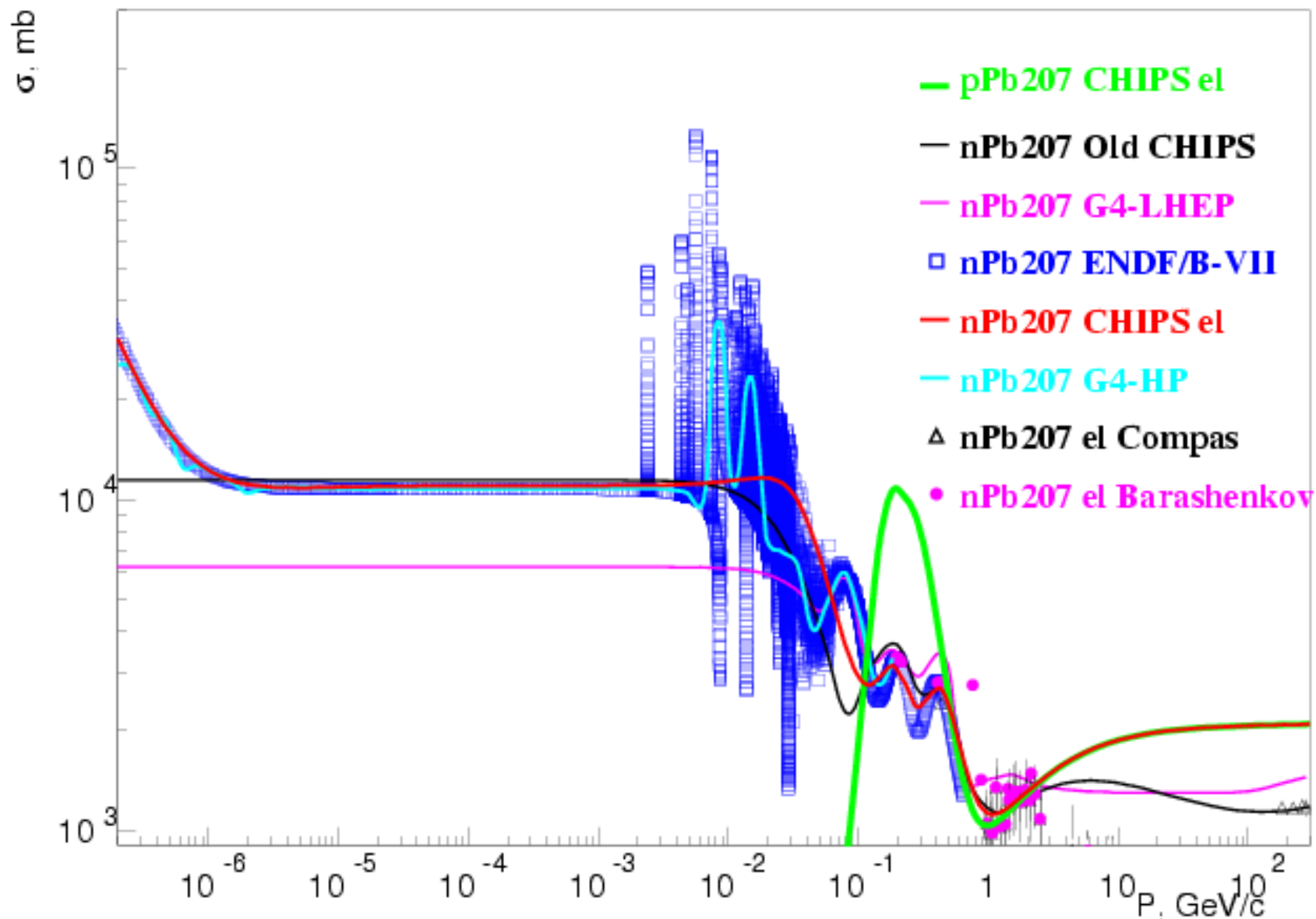
CHIPS improvement of nXe136 elastic cross-section



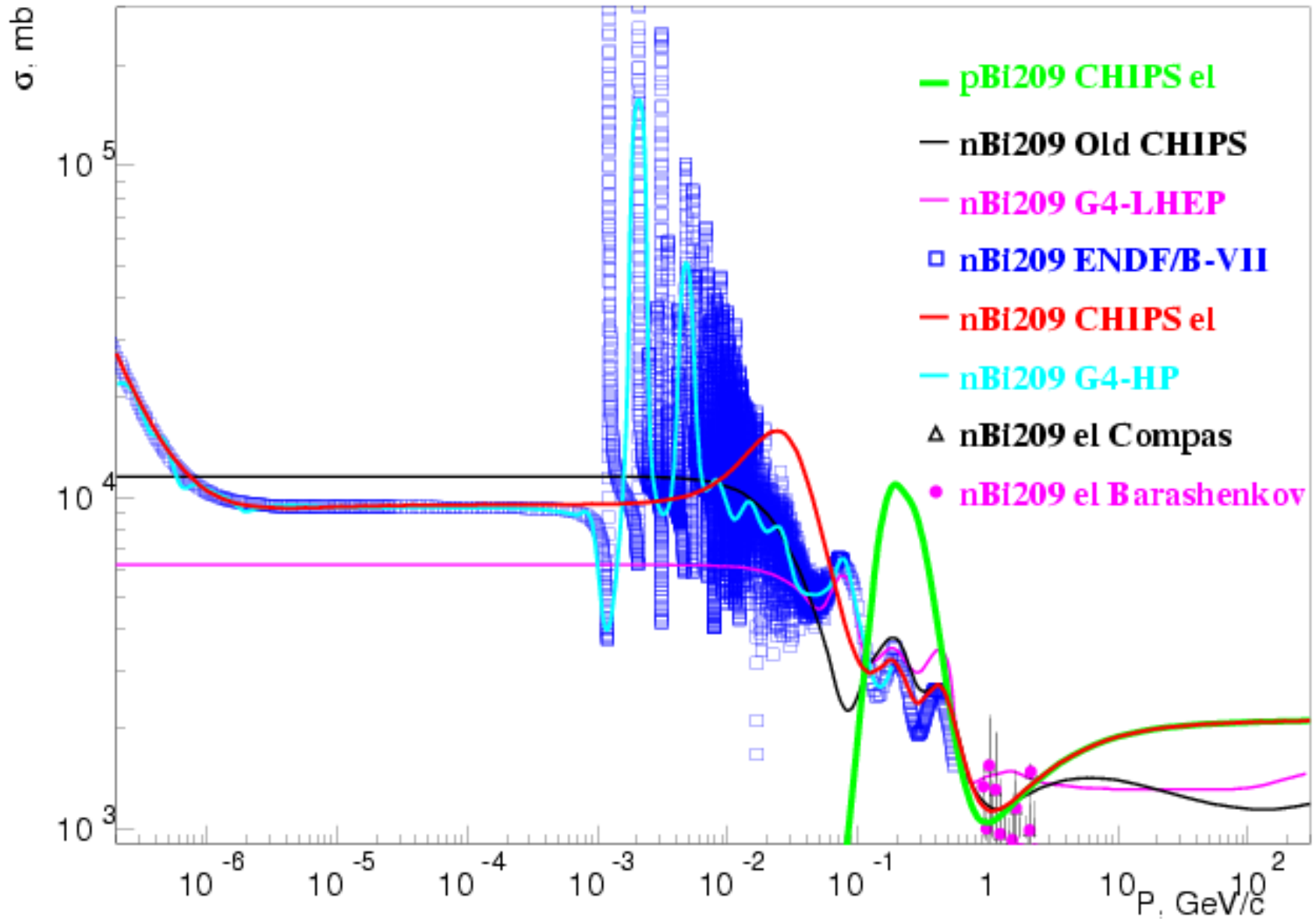
CHIPS improvement of nAu197 elastic cross-section



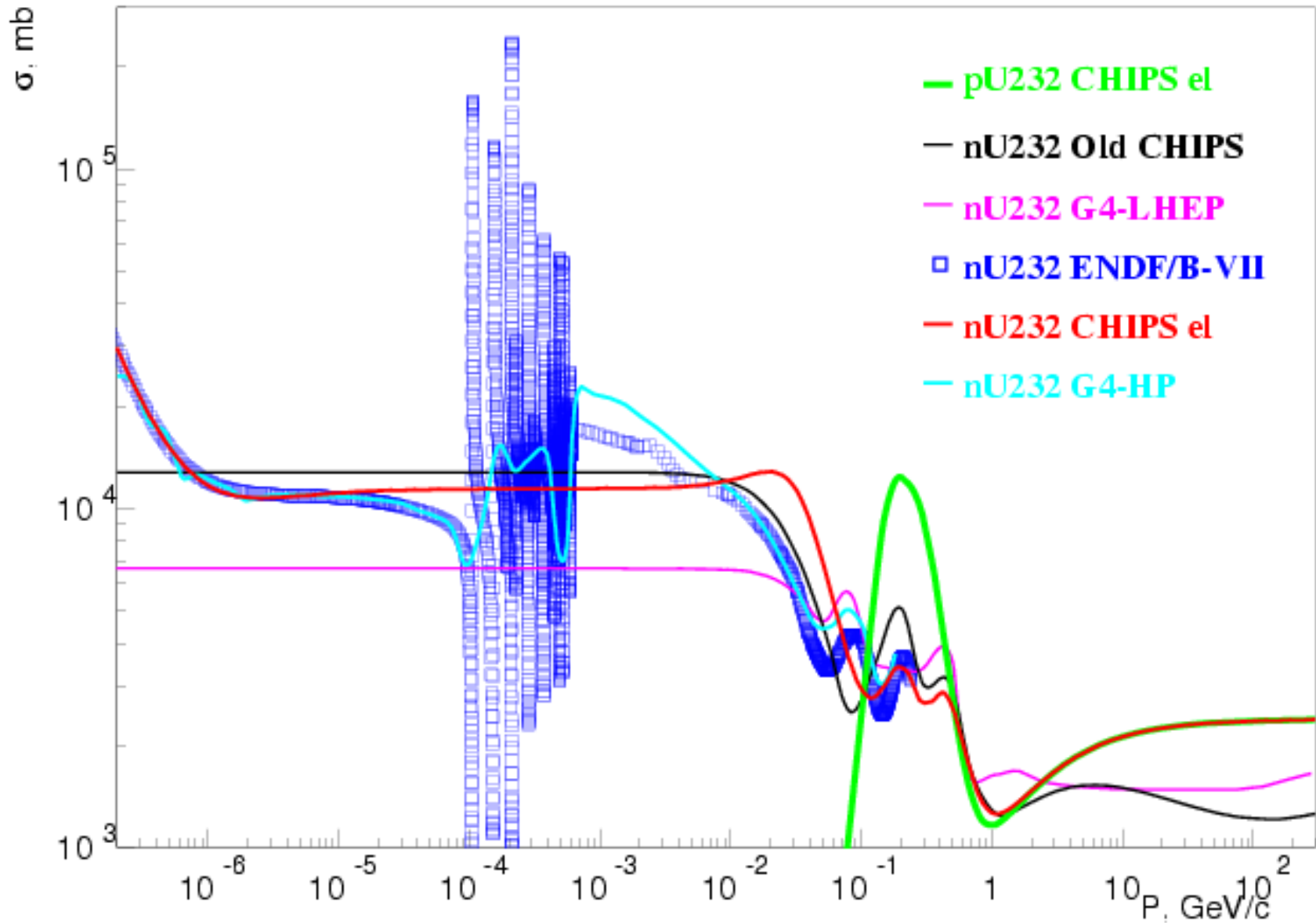
CHIPS improvement of nPb207 elastic cross-section



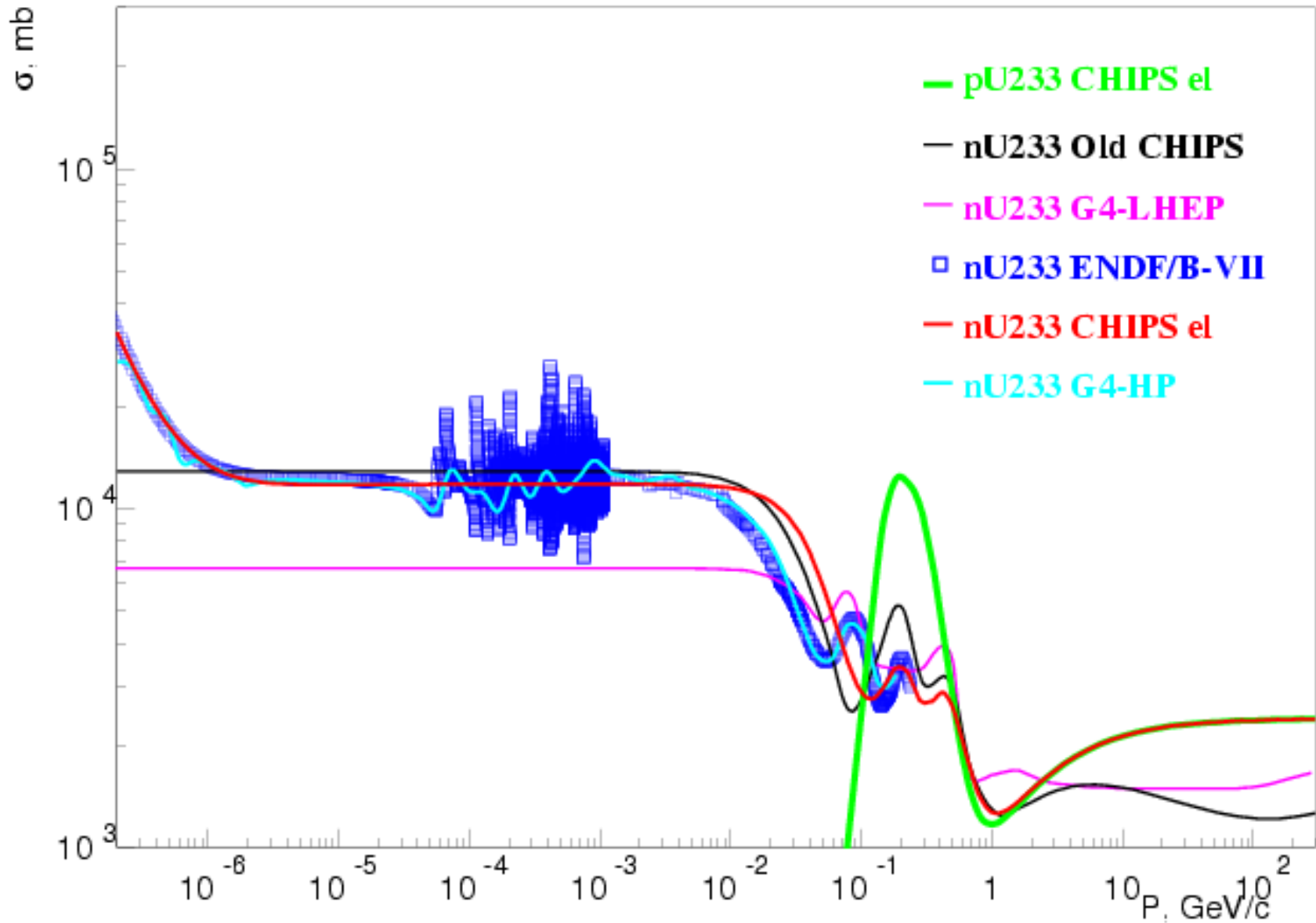
CHIPS improvement of nBi209 elastic cross-section



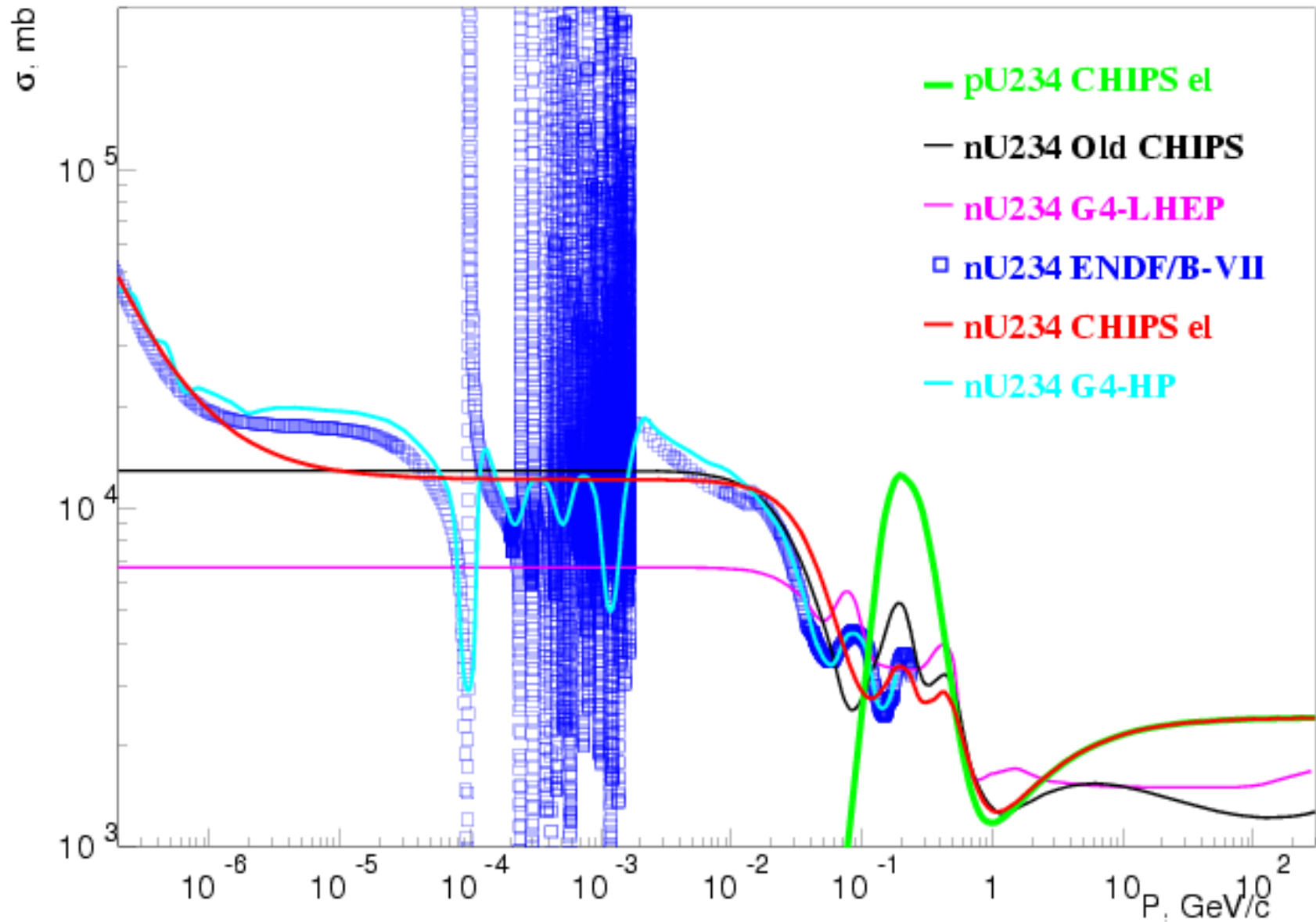
CHIPS improvement of nU232 elastic cross-section



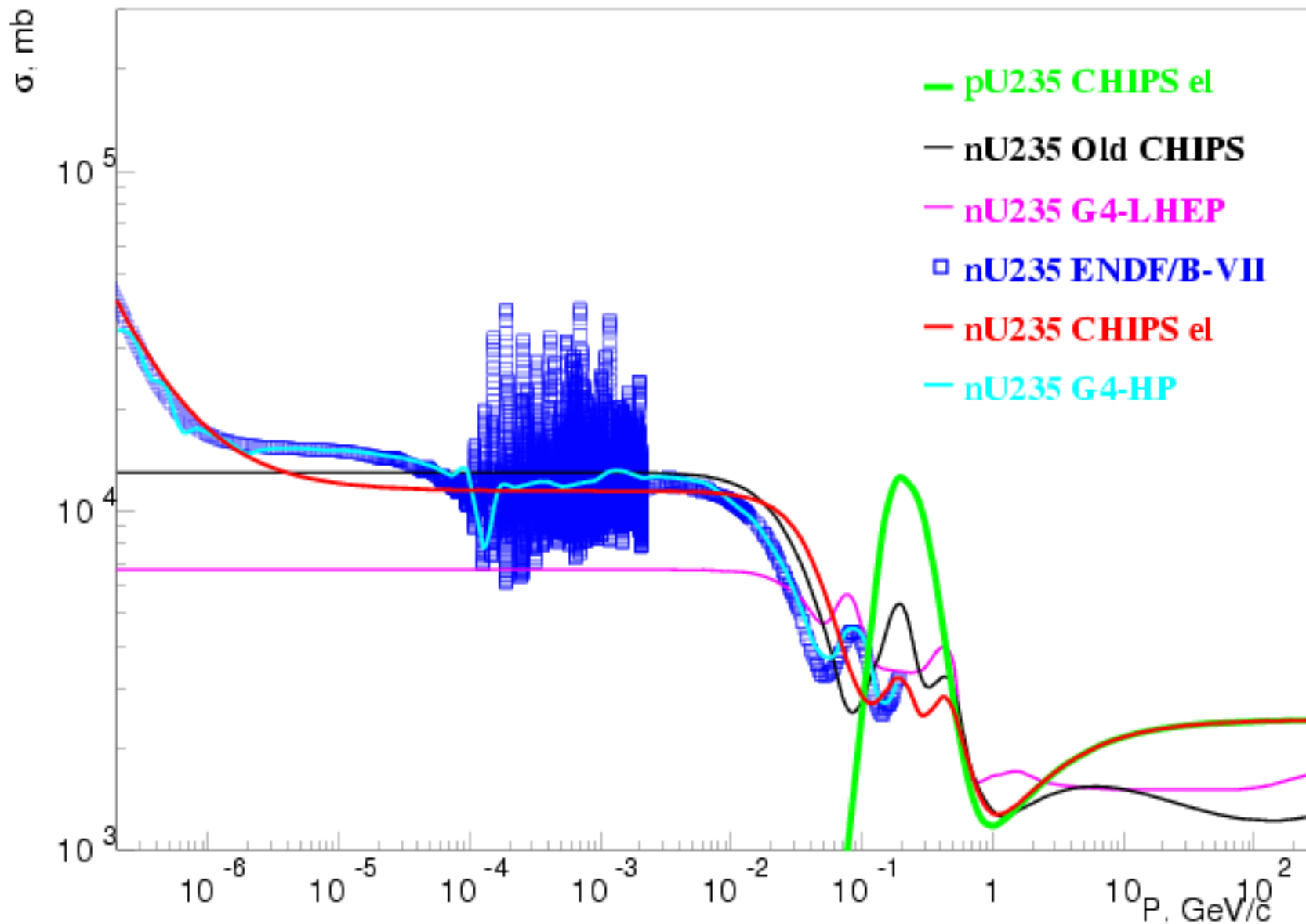
CHIPS improvement of nU233 elastic cross-section



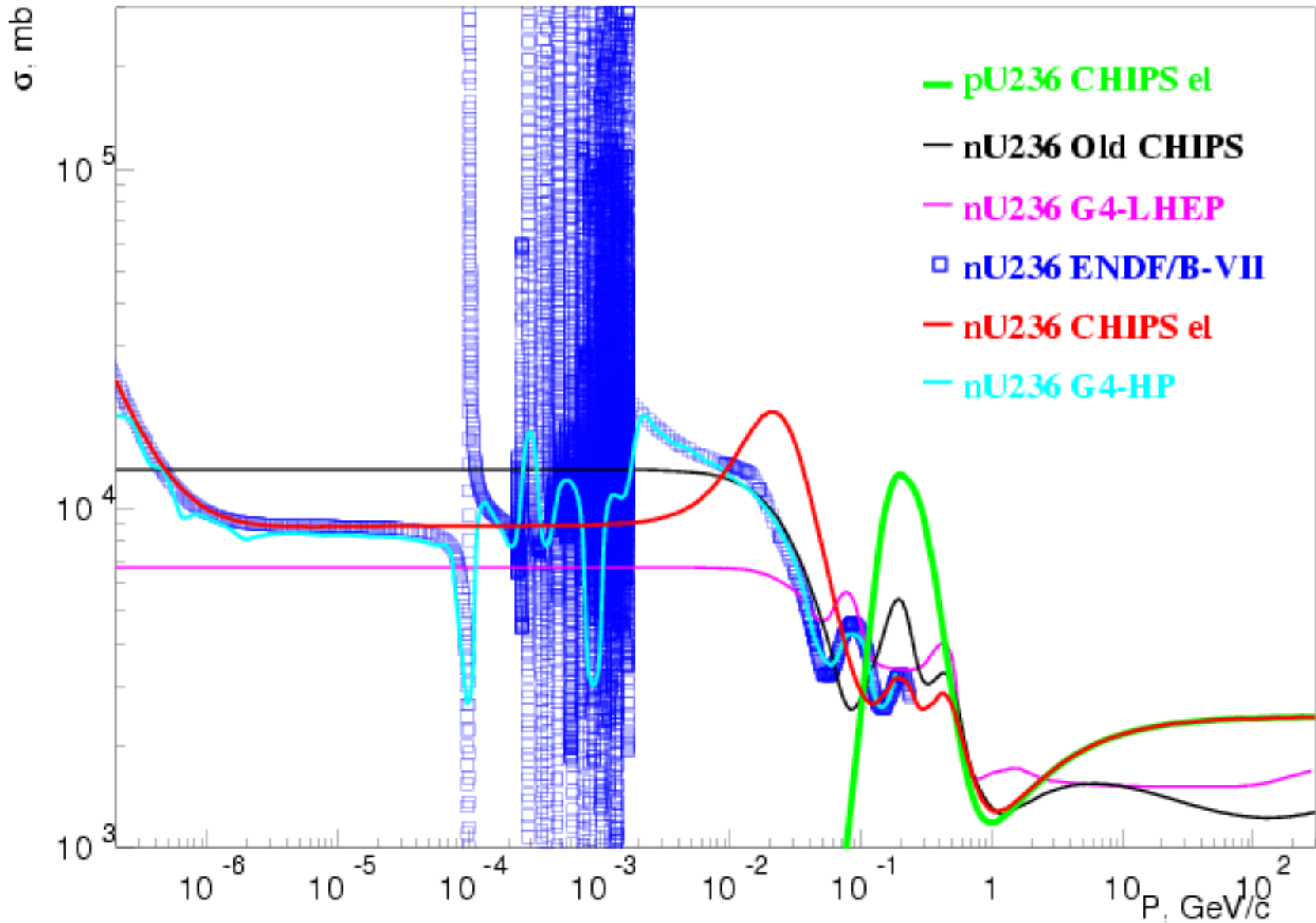
CHIPS improvement of nU234 elastic cross-section



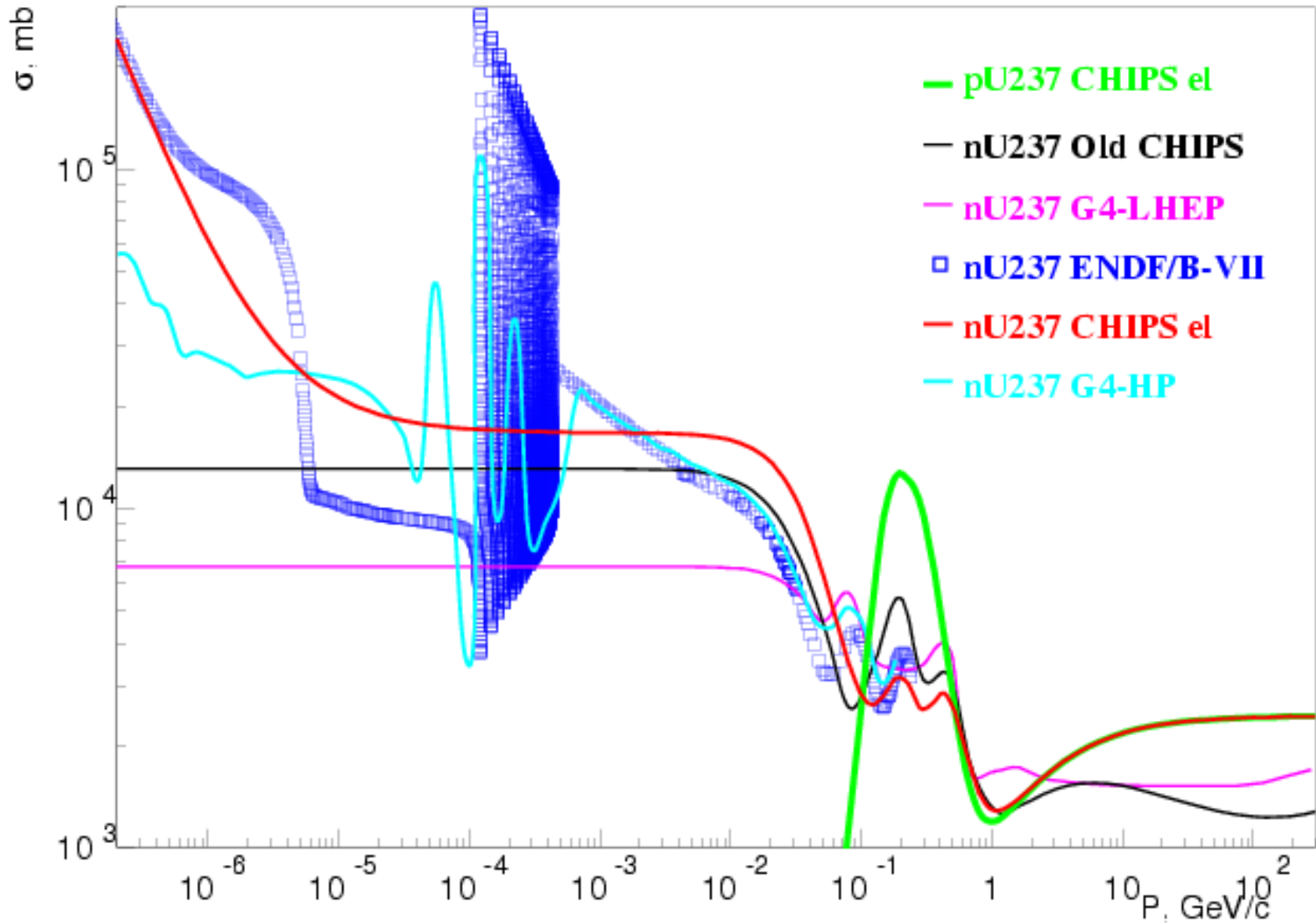
CHIPS improvement of nU235 elastic cross-section



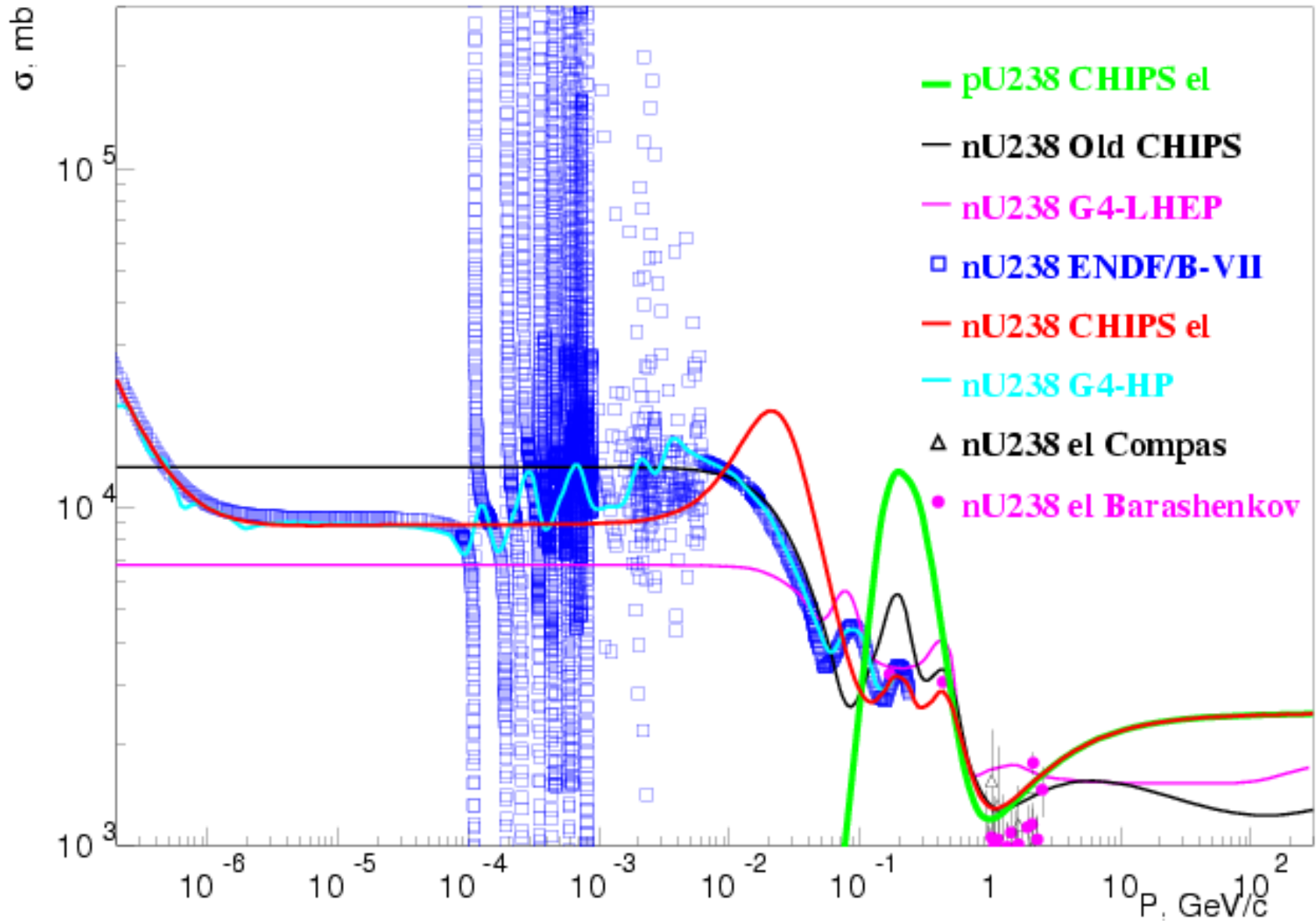
CHIPS improvement of nU236 elastic cross-section



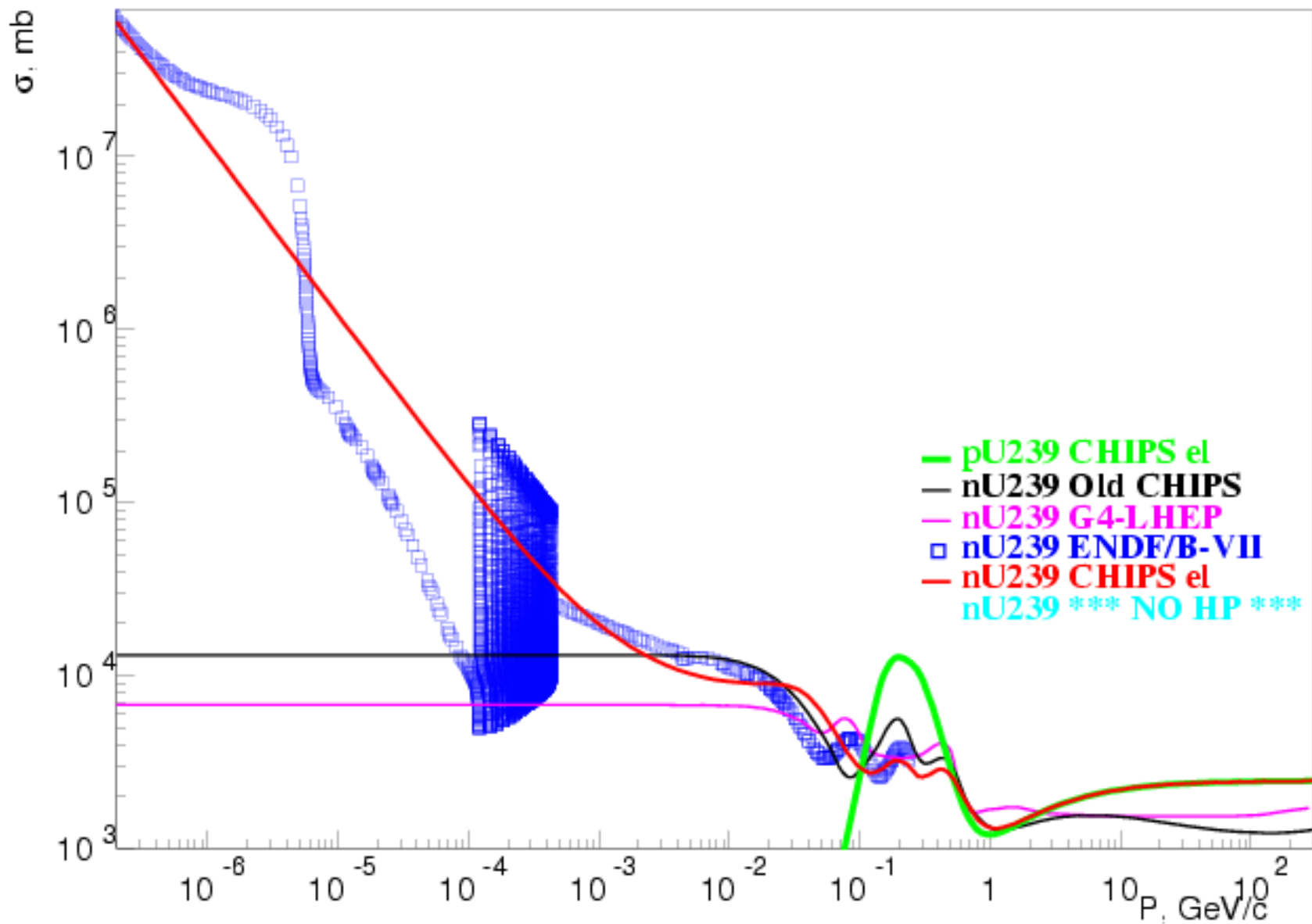
CHIPS improvement of nU237 elastic cross-section



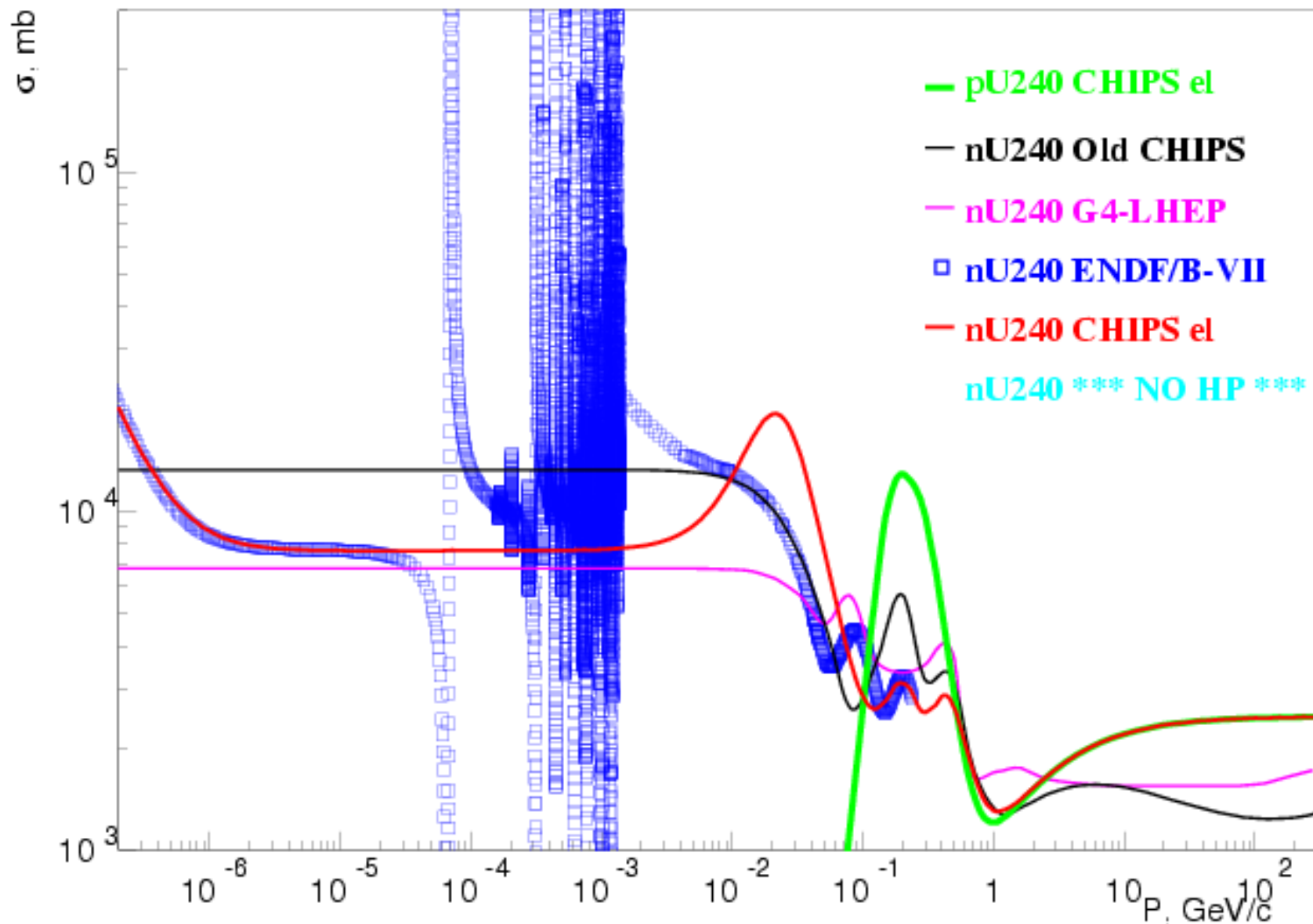
CHIPS improvement of nU238 elastic cross-section



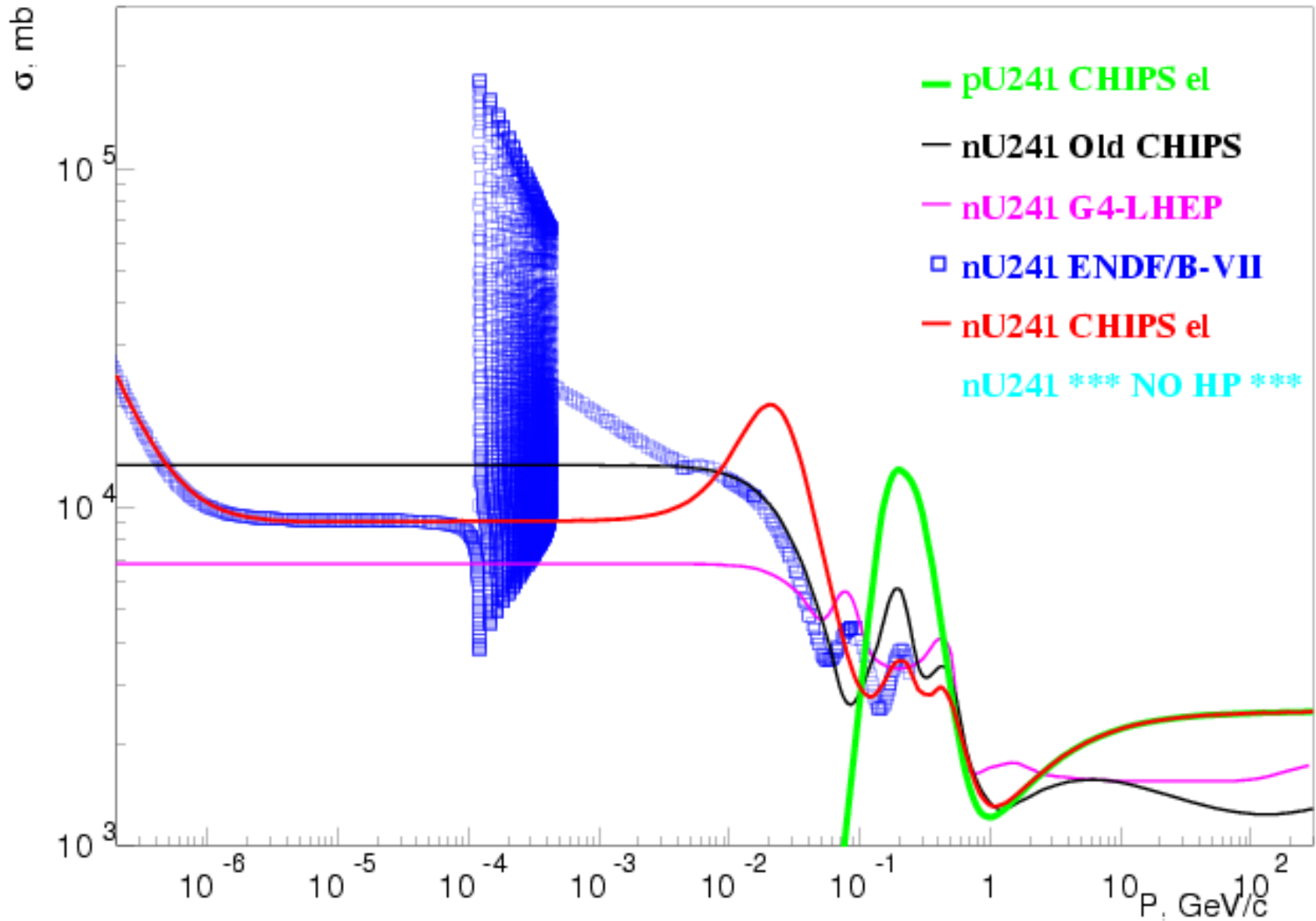
CHIPS improvement of nU239 elastic cross-section



CHIPS improvement of nU240 elastic cross-section



CHIPS improvement of nU241 elastic cross-section



Conclusion

- Now **all updated CHIPS elastic cross-sections** are ready for the CHIPS Physics List update
- By number of covered separate isotopes the new CHIPS is 2.5 times more detailed than HP, a half of covered by HP isotopes should be updated
- As a future work the CHIPS log-log tables for integrated XS can be made as an HP alternative
- As the next improvement step the **3-d absorption bands fit (9 parameters instead of 7)** can be done
- Further improvement can be caused only by the CHIPS Physics List applications (time-structure of the detector response, transmutation)



Thank you

Backup slides following