Simulation bi-weekly meeting
April 16, 2019, CERN

EM infrastructure update and New test for hadronic cross sections

Bagulya A.
(Lebedev Physical Institute, Moscow, Russia)

Outline

- Migration of EM testing suite from lxbatch to Condor
- Evaluation of the new ion ionization model
- Tuning of parameterization of pp elastic cross section to the data

EM testing suite

EM testing suite:

- important component for the software process of Geant4
- is applied monthly for each reference tag or by request
- consists of around 60 tests at present
- https://test-geant4-tools.web.cern.ch/test-geant4-tools/emtesting/ (29 tests, summary -14 tests)

EM testing suite history:

- started in 2005
- last years
  - migration of EM tests (source) to CVMFS
  - EM testing suite (results and web application) moved to EOS
  - running scripts were divided into 2 stages:
    i. Run test
    ii. Analysis of the results with ROOT6
  - several tests were updated

Some problems:

- a. LSF batch system is deprecated

HTCondor

- At present – the default batch system at CERN
- The current batch computing service currently consists of around 190,000 CPU cores - mostly deployed in the HTCondor based service
- To submit a task: to prepare a file with .sub extension

```
executable      = script.sh
arguments       = $(ClusterID) $(ProcId)
output          = output/hello.$(ClusterId).$(ProcId).out
error           = error/hello.$(ClusterId).$(ProcId).err
log             = log/hello.$(ClusterId).log
queue
```

HTCondor

There are problems to migrate to HTCondor because of

- complexity of some tests
- features of HTCondor

Individual approach for each test is required

Example: test Conversion

.cc file

```
Histo    histo;
 G4String hname = "test/conv_" + sz + "_" + se;
histo.SetFileName(hname);
histo.Book();
```

.csh script

```
mkdir -p test
```

If you submit such task to HTCondor -> no results , no message on errors because

- only executable is transferred to HTCondor system
- HTCondor knows nothing about “test” directory
- you don’t have permissions to create “test” directory

Decision: add lines to .sub file

```
transfer_input_files    = test
transfer_output_files  = test
```

HTCondor

condbatch.sub

```
FNAME          = conv
getenv         =  true
executable     = $ENV(G4BWORK)/Conversion
zz             = 26
output         = $(FNAME)_$(zz)_$(energy).out
error          = $(FNAME)_$(zz)_$(energy).err
log            = $(FNAME)_$(zz)_$(energy).log
request_cpus   = 2
requirements   = (OpSysAndVer =?= "CentOS7")
+JobFlavour    = "testmatch"
should_transfer_files = YES
when_to_transfer_output = ON_EXIT
transfer_input_files    = test
transfer_output_files   = test
arguments      = $(zz) $(energy) 100000
queue energy from (
    1.5  10  100 10000
)
```

get all environment variables

Set names of files to contain stdout/err

The following elements of the HTCondor submit file should not contain path pointing to EOS mount point (starting with /eos/)

Copy file *input.dat* to worker node (important if no shared storage)

Transfer output files from worker node back to submit host

very attractive feature of HTCondor: a possibility to use loops, task will be performed much faster

Results for migration to HTCondor

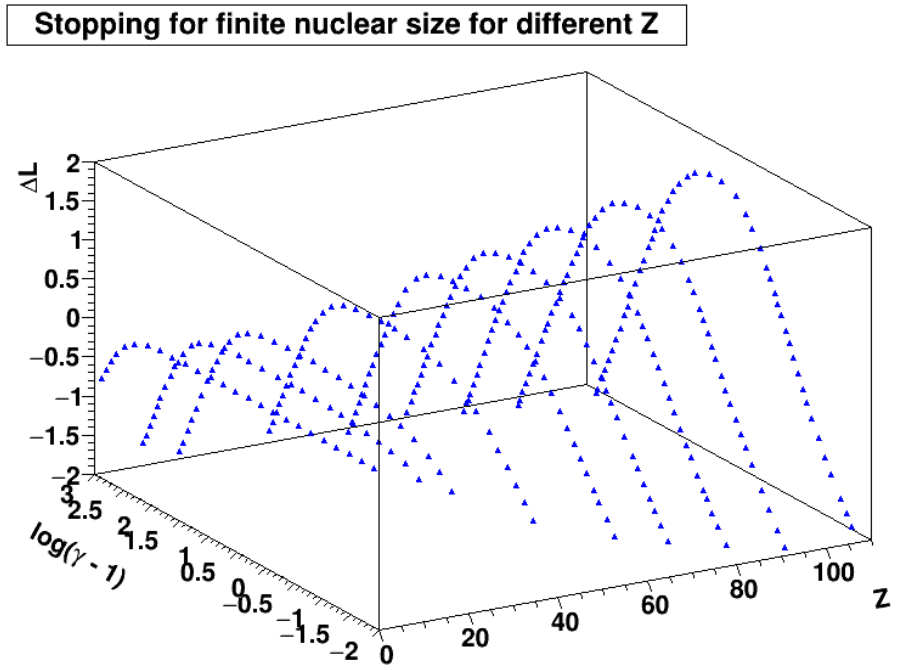
- submit files (condbatch.sub) were prepared for 22 tests
- all changes of tests were committed and accepted
- g4condbatch_all.csh ->
  - more than 200 jobs are performed at the same time
  - the most part of jobs are finished in 4 hours
- preparations for whole migration of EM testing suite to EOS were made
- new system was used for ref-03 validation
- now we need to collect experience of work with new system

Evaluation of the new ion ionization model

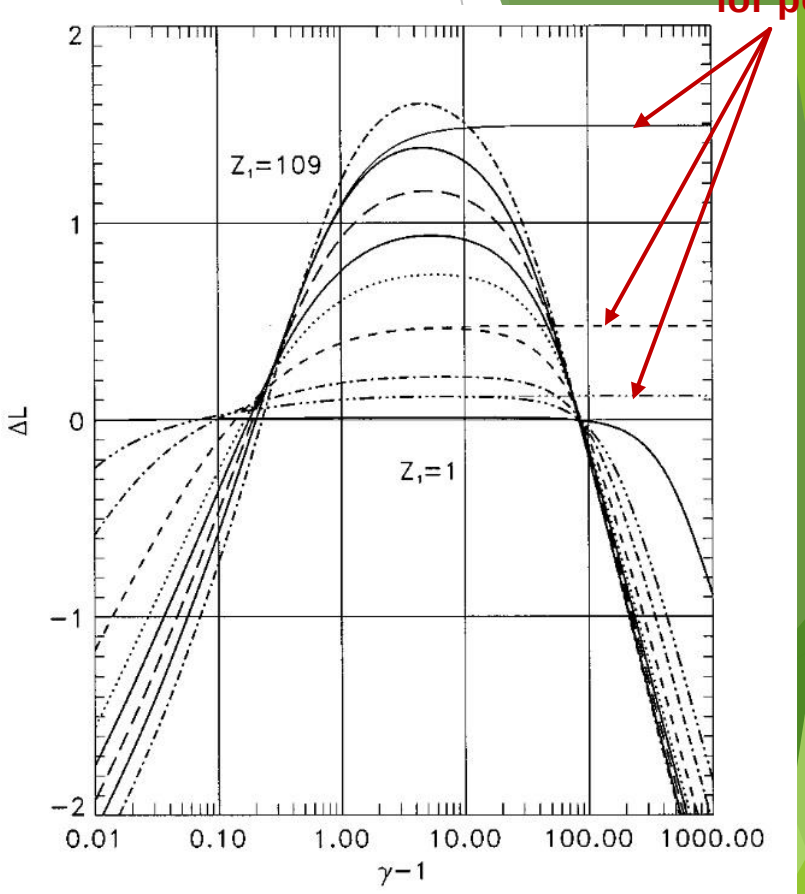
Lindhard J., Sorensen A.H. Relativistic theory of stopping for heavy ions. Phys. Rev. A 53 (1996) 2443

$$-\frac{dE}{dx} = \frac{4\pi Z_1^2 e^4}{mv^2} N Z_2 L\,, \qquad L_{stand} = ln\left(\frac{2mv^2}{I}\right) - \frac{v^2}{c^2} - \frac{1}{2}\delta$$

$$L - L_{stand} = \Delta L + \delta L_{shell} + L_{Barkas} + L_{scr}$$

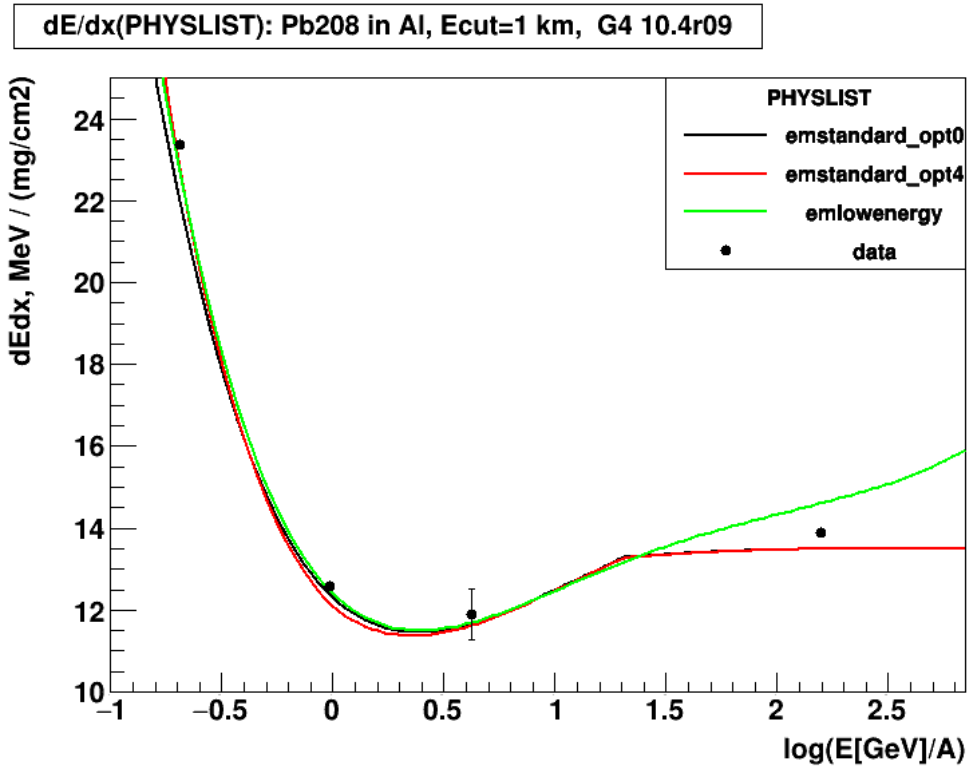


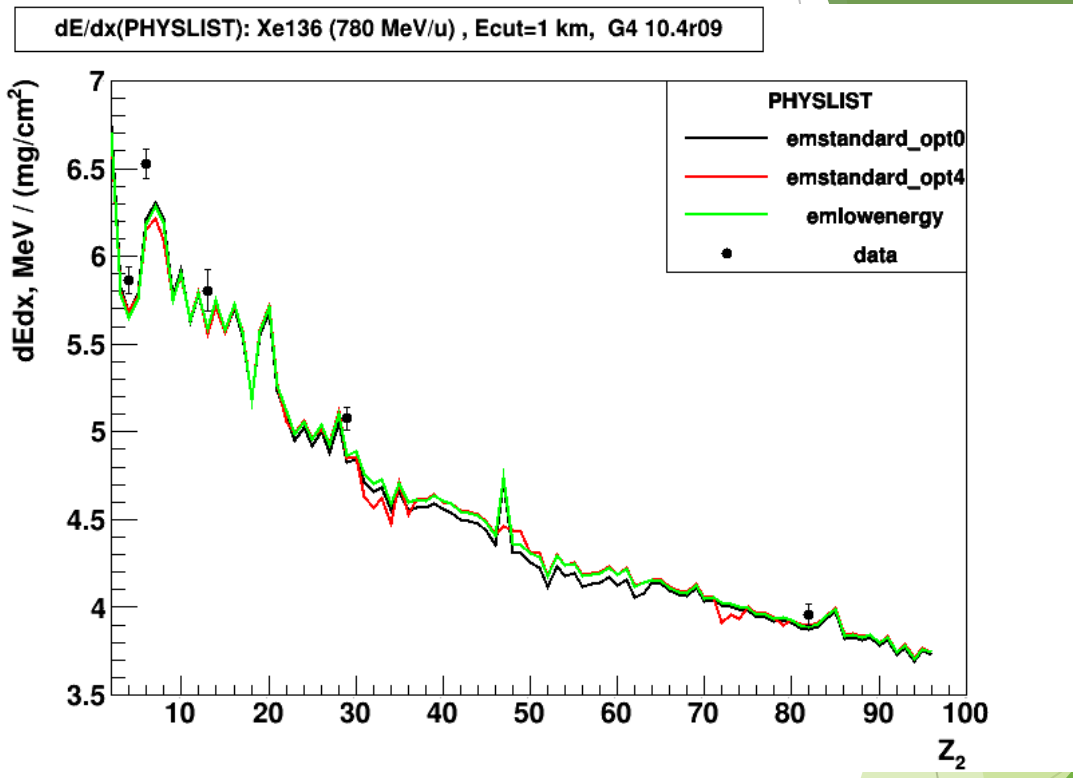
Stopping for finite nuclear size – 2d plot.
Z1 = 1, 10, 18, 36, 54, 66, 79, 92, 109



Stopping for finite nuclear size. The curves display the values of ΔL for atomic numbers Z1 = 1, 10, 18, 36, 54, 66, 79, 92, and 109

Evaluation of the new ion ionization model





^{208}Pb in Al

- Scheidenberger C. et al. Penetration of relativistic heavy ions through matter. NIMB135 (1998) 25-34
- Datz S. et al. Effect of Nuclear Size on the Stopping Power of Ultrarelativistic Heavy Ions. Phys. Rev. Lett. 77 (1996) 2925-2928

^{136}Xe 780 MeV/u in Be, C, Al, Cu, Pb

Scheidenberger C. et al. Direct Observation of Systematic Deviations from the Bethe Stopping Theory for Relativistic Heavy Ions. Phys. Rev. Lett. 73 (1994) 50-53

New hadronic test

Geant4 has several classes with elementary cross sections

These elementary cross sections are used to compute cross section off nuclei and are also used in hadronic models

In 2018 cross sections classes were revised but full validation was not done

The goal of this work is to identify accuracy of elementary cross sections versus PDG collection of data and to control the hydrogen cross section from cross sections classes

g4tests-verification/hadronic/HadrHN:

at the first stage we study pp, np, π^+p, π^-p elastic and total cross section

Projectile: proton, neutron, π^+, π^-

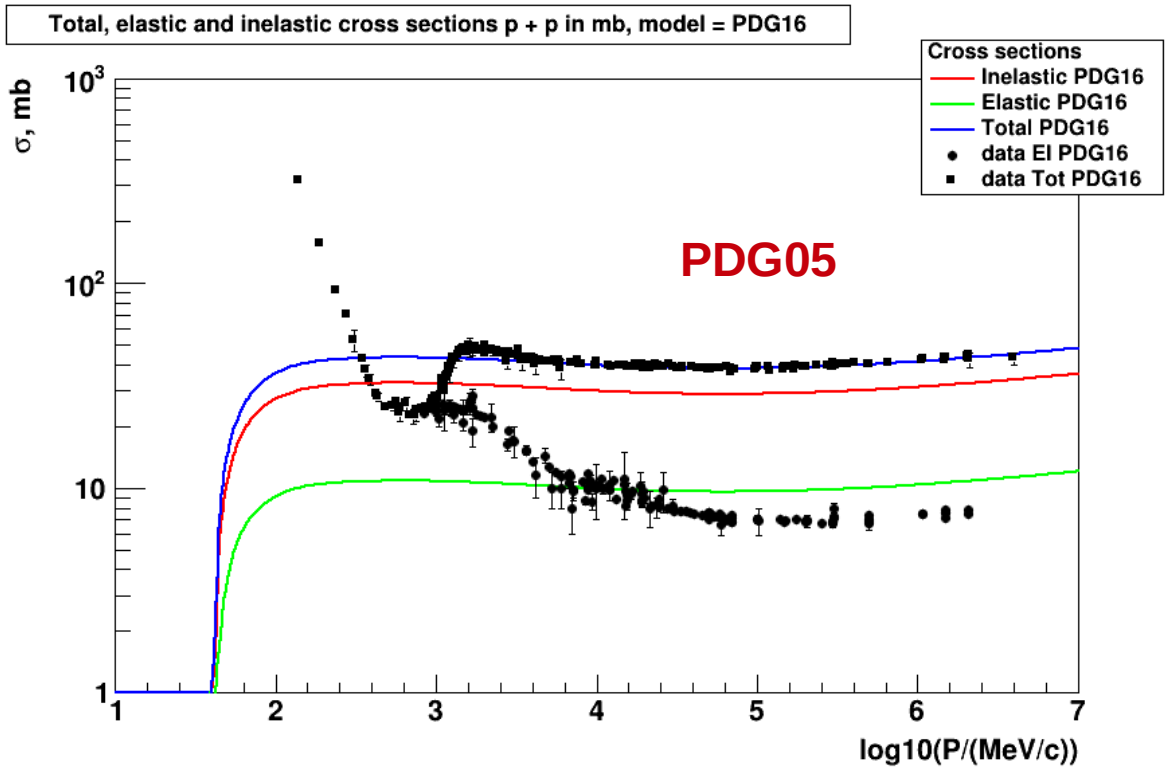
Elementary cross sections: “NS”, “PDG05”, “PDG16”, “SAID”

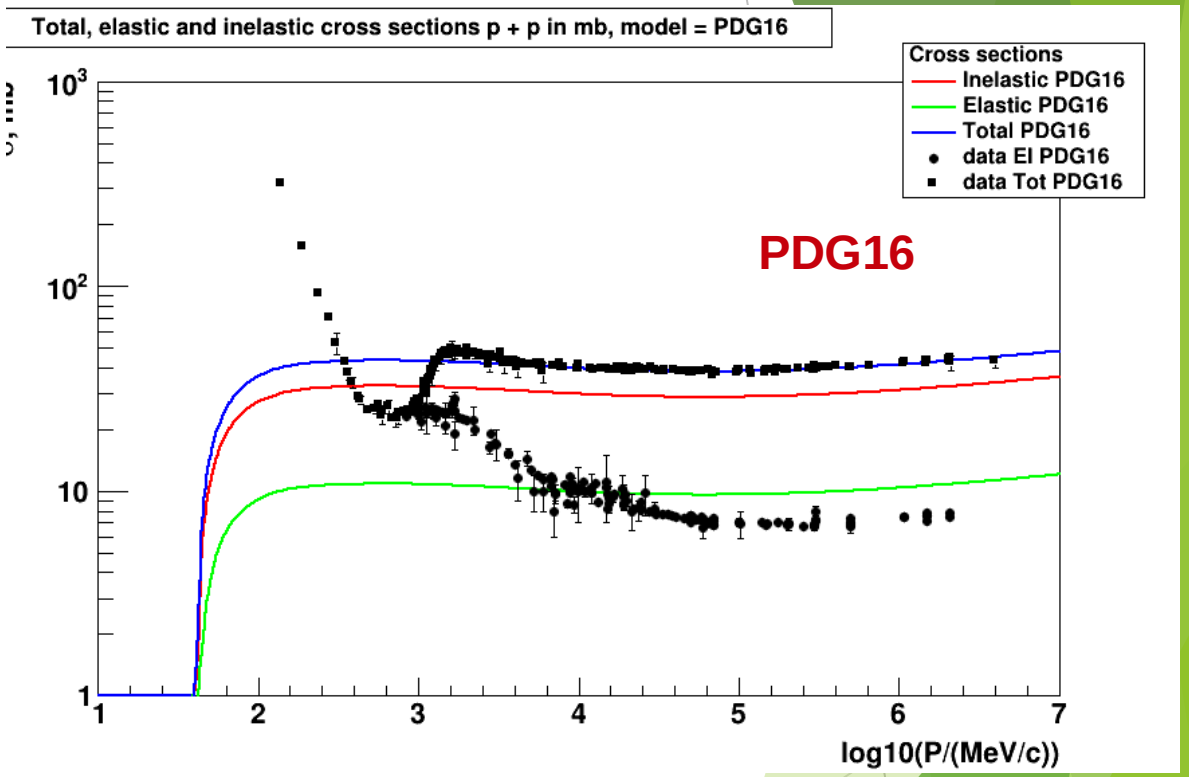
Cross sections classes: “CHIPS”, “BGG”, “XS”

Data from http://pdg.lbl.gov

files with data were extracted and included into the test

HadrHN: p + p





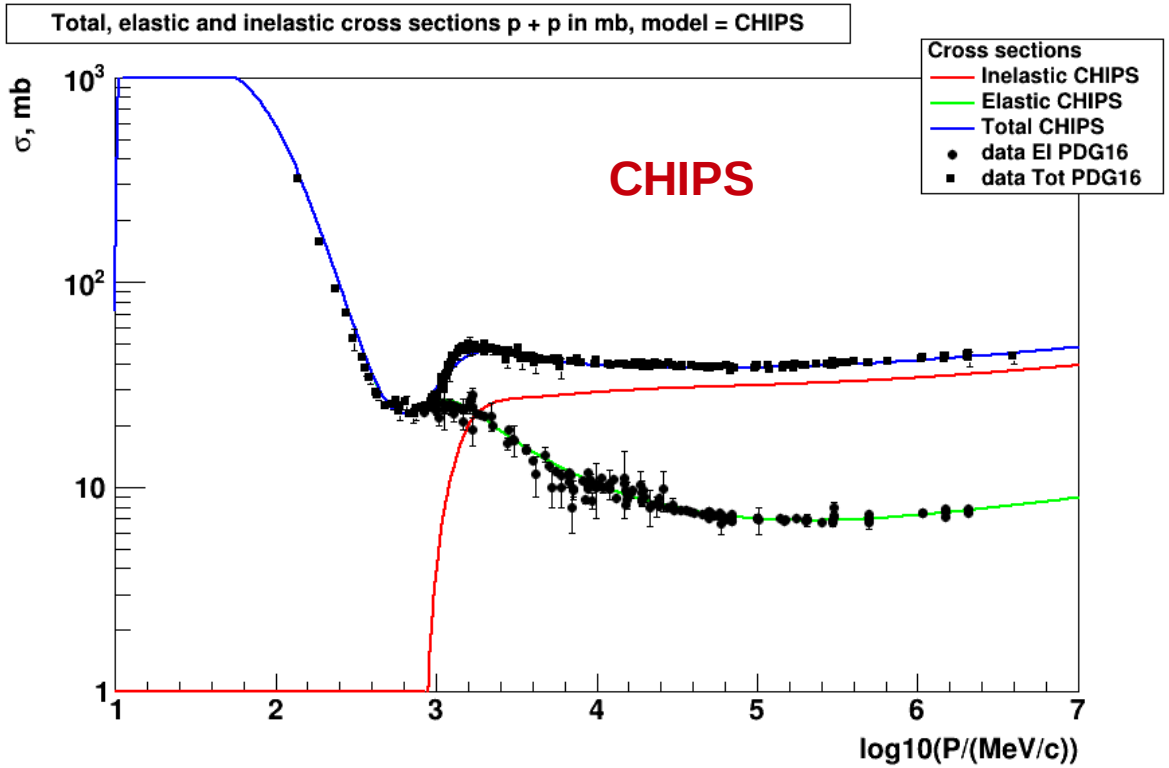
Total cross sections fit the data at high momentum:

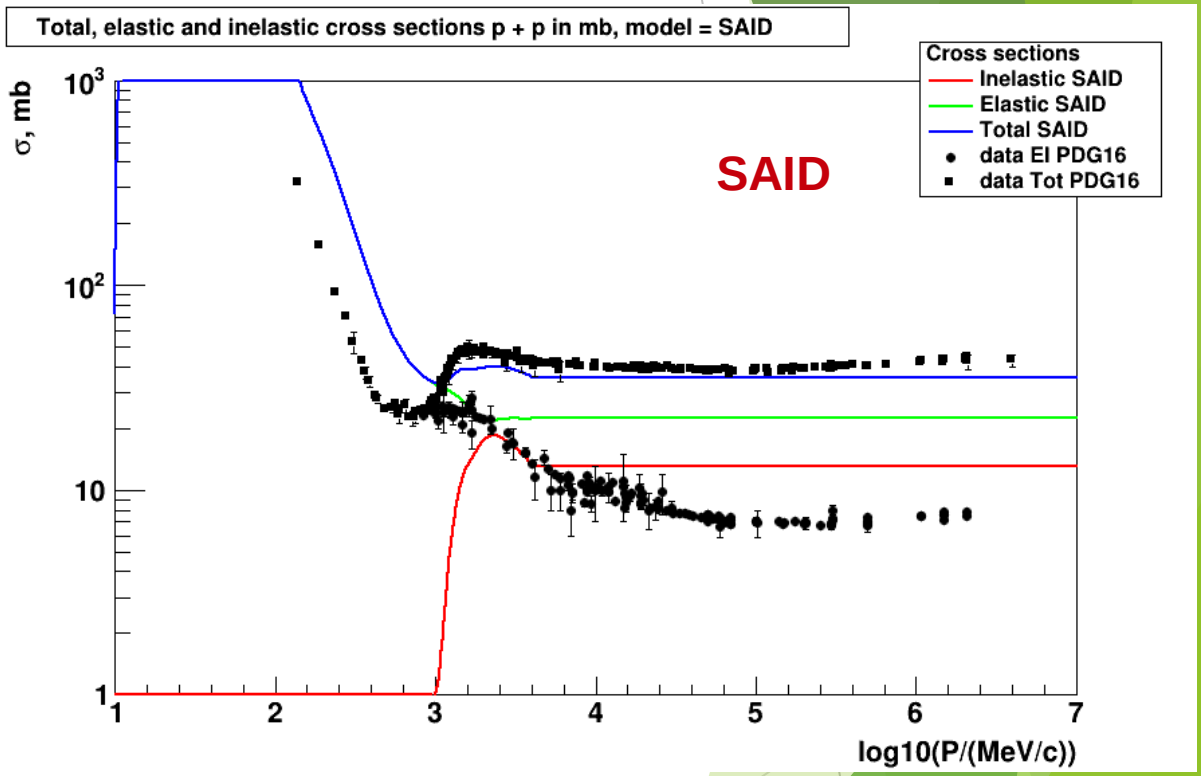
PDG05 – p > 20 GeV/c PDG16 – p > 5 GeV/c

Elastic cross sections parameterizations are not implemented

Instead a short cuts are used

HadrHN: p + p



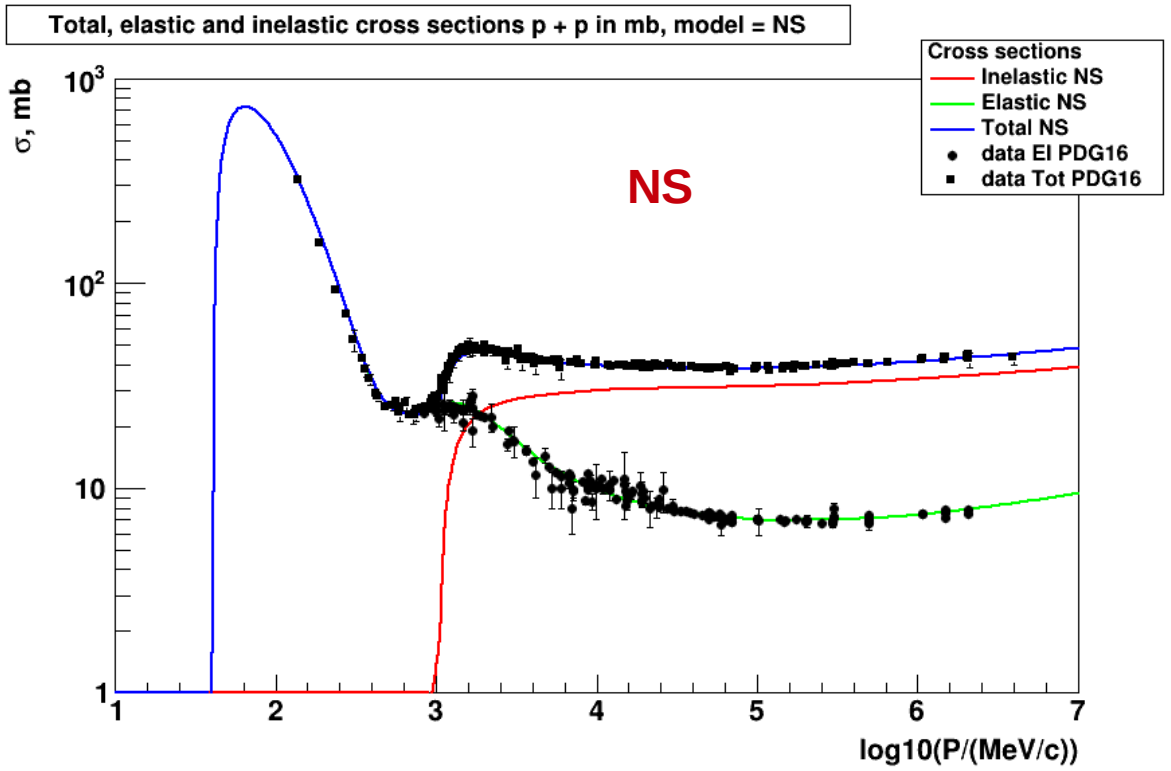


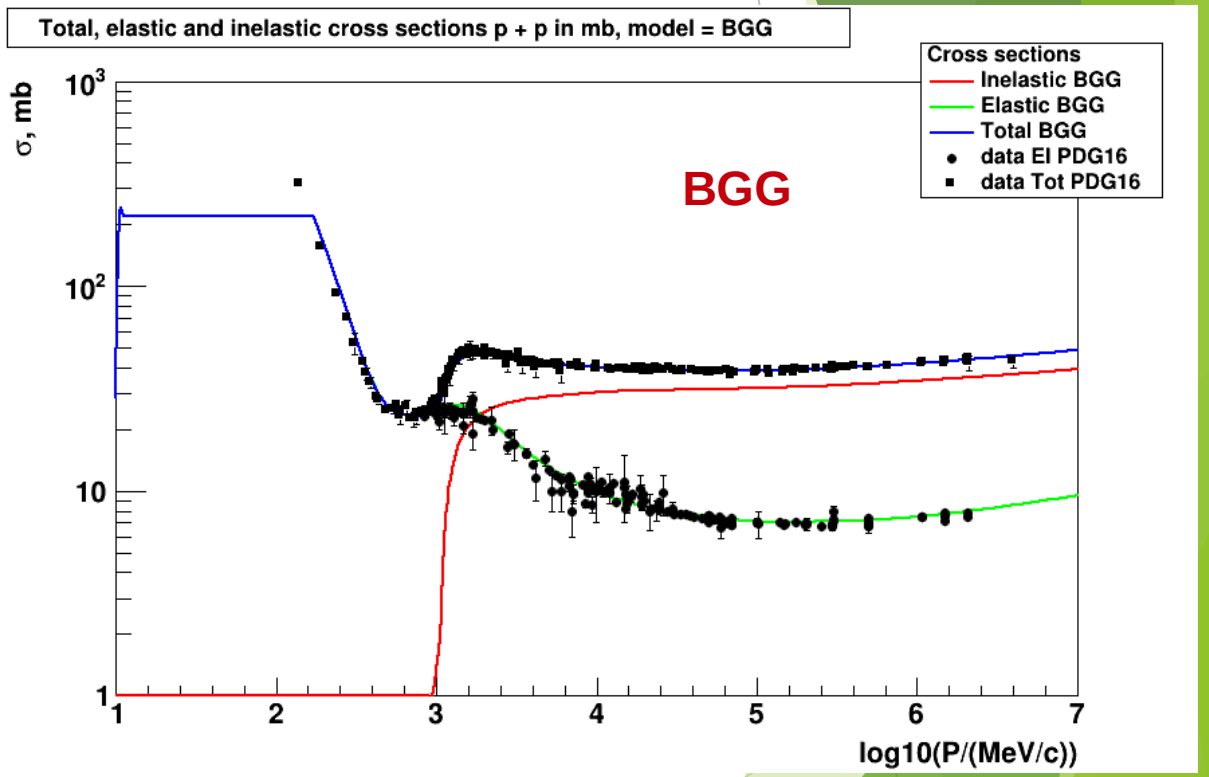
CHIPS in general fits the data

SAID has problems:

- total x-section is underestimated
- elastic is valid in narrow momentum interval

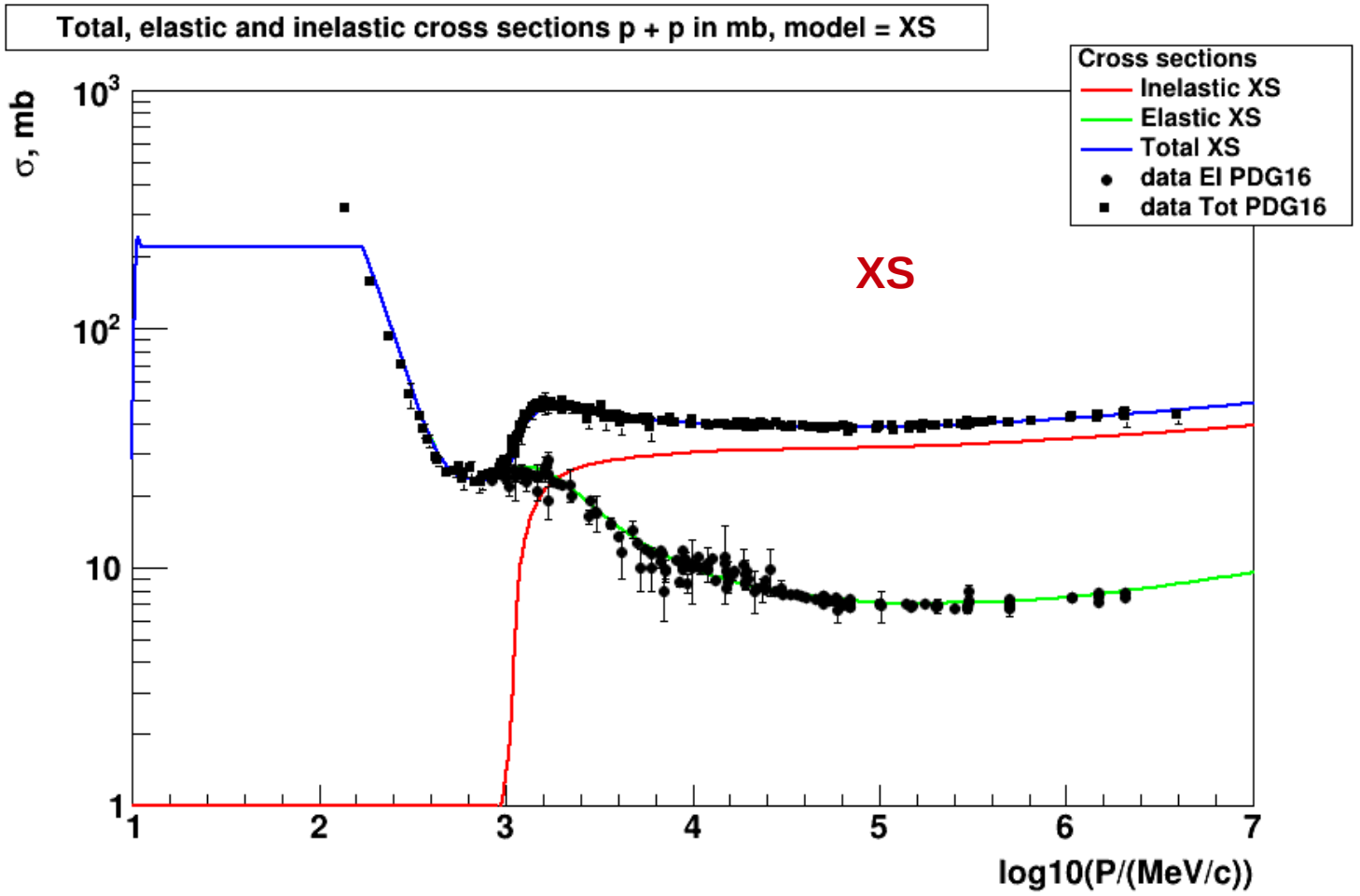
HadrHN: p + p





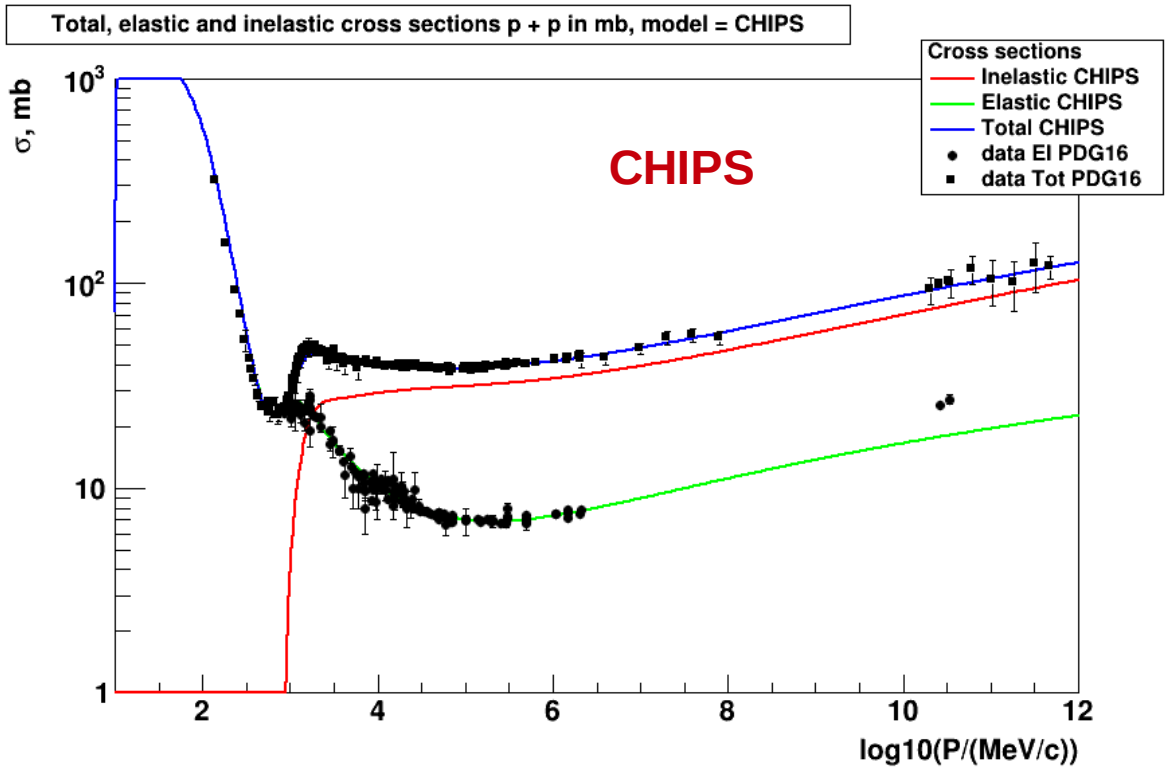
NS is the current recommendation for elementary x-section
BGG uses NS as an input

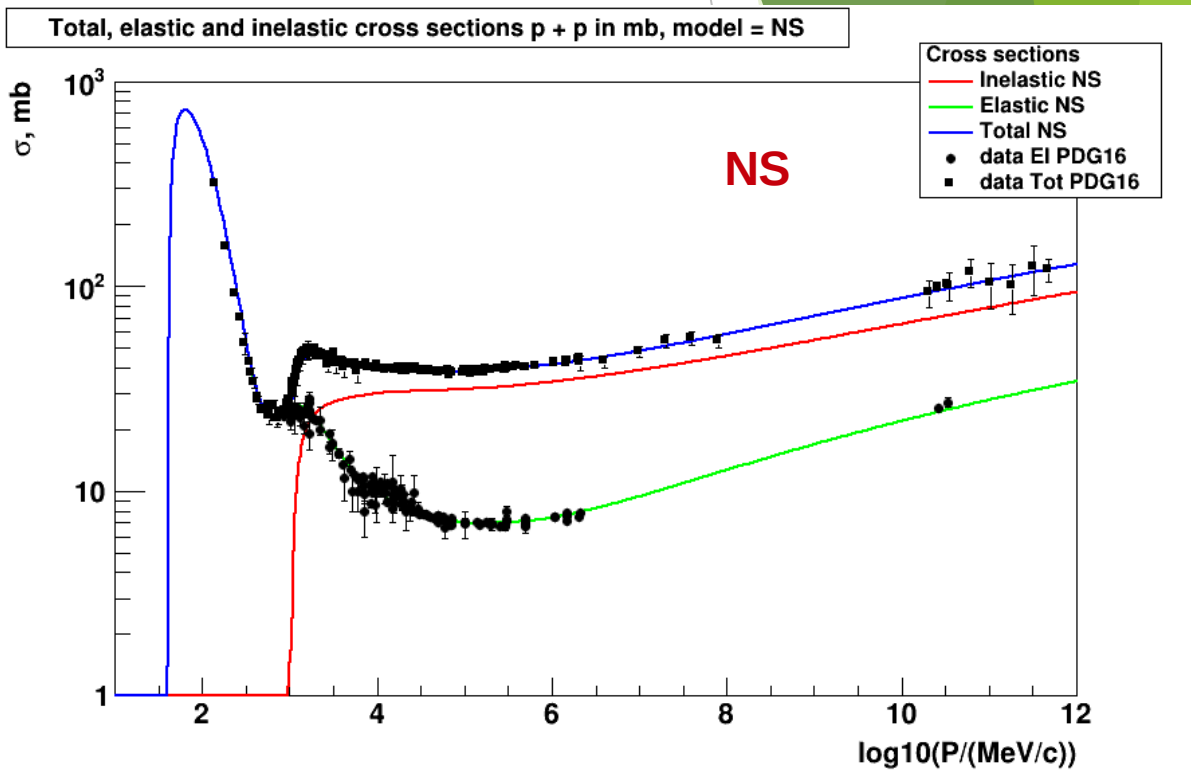
HadrHN: p + p



XS uses NS as an input at high energy

HadrHN: p + p, cosmic data

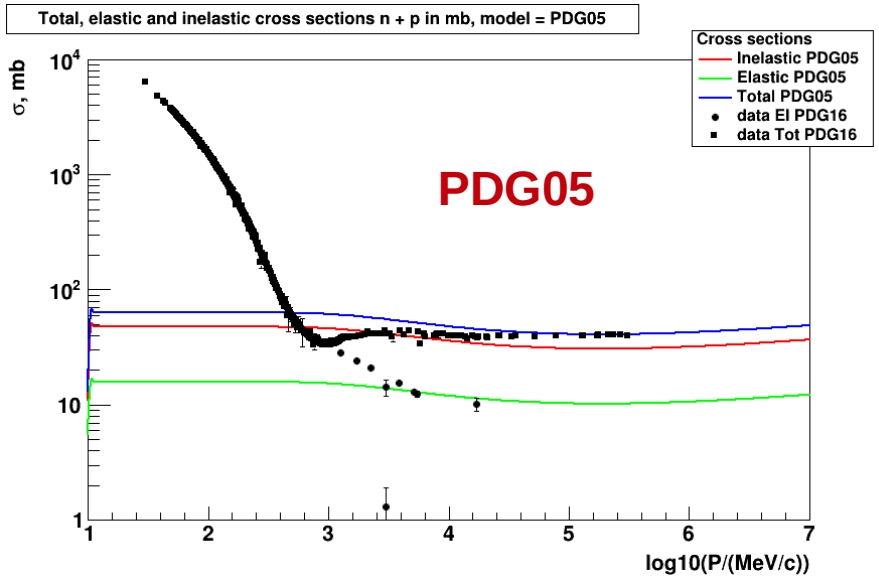


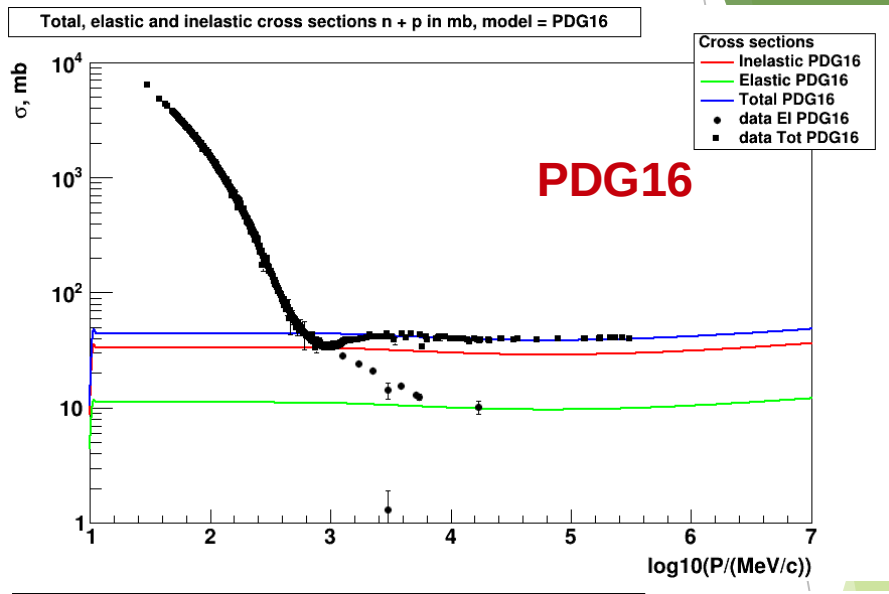


CHIPS elastic at high momentum is not valid
NS is much better for elastic

HadrHN: n + p

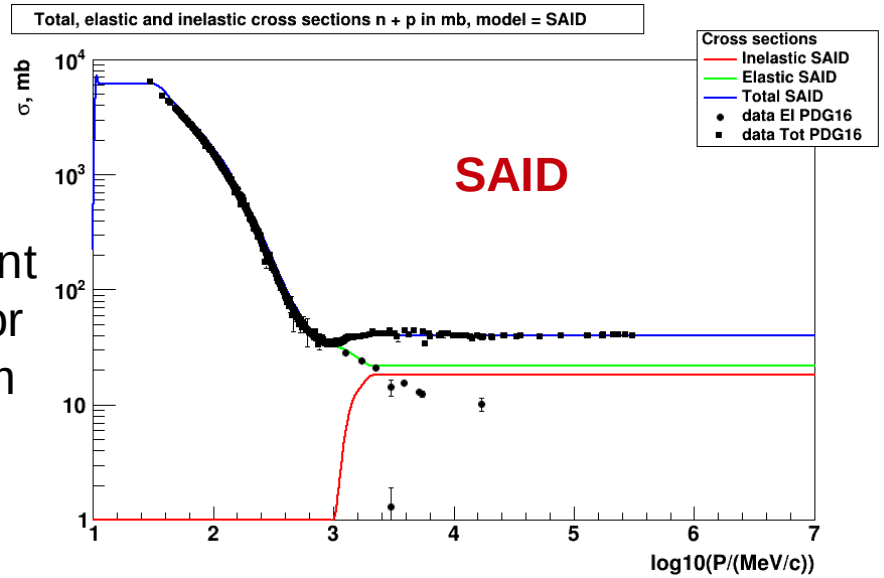
Total xs:
p > 25 GeV/c

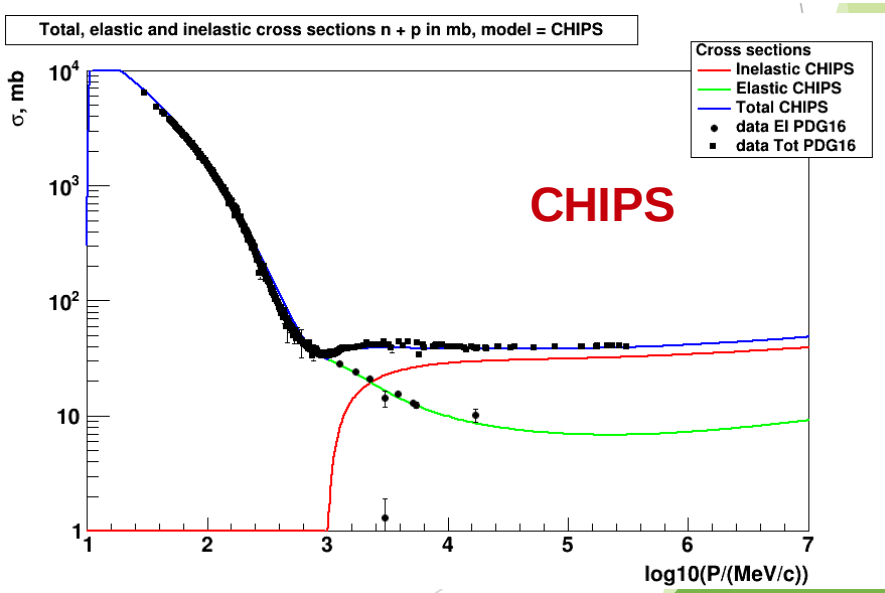




Total xs:
p > 5 GeV/c

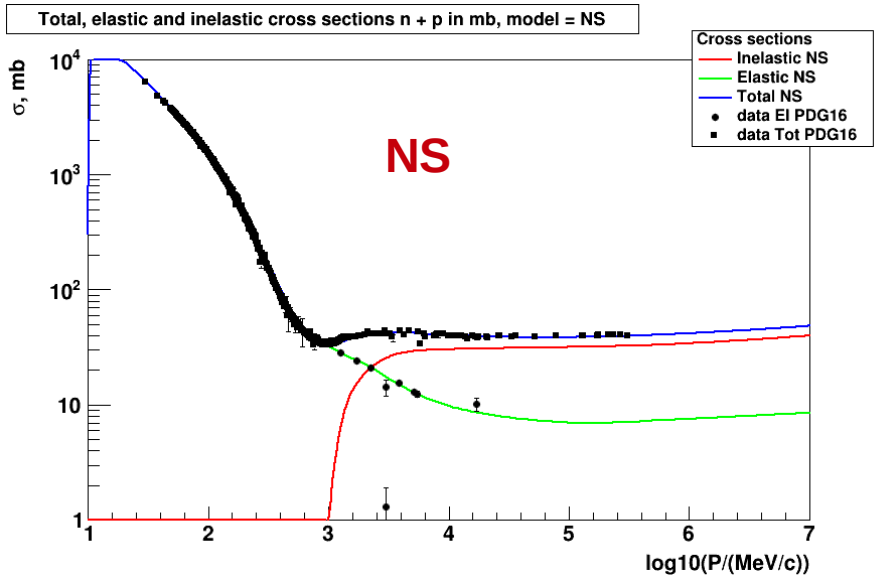
Total xs:
good agreement
Elastic: valid for low momentum

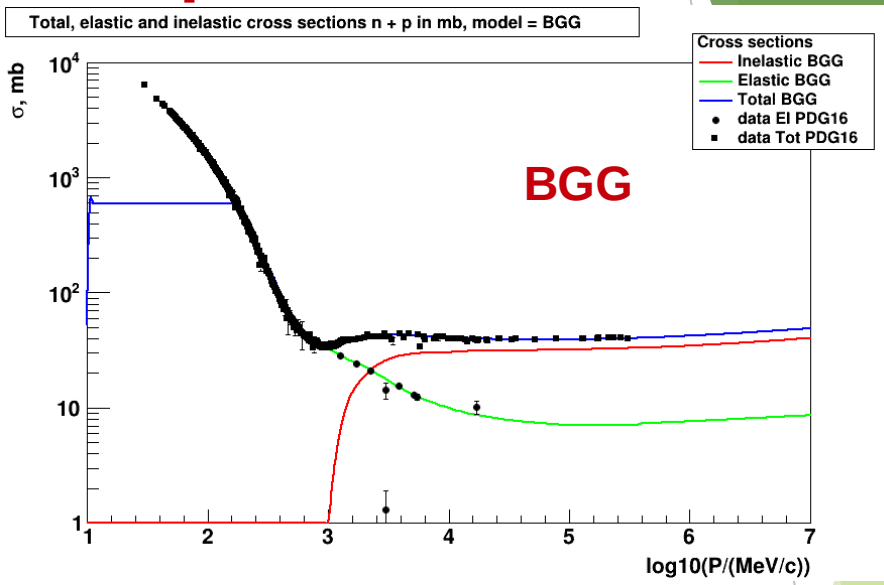




good agreement

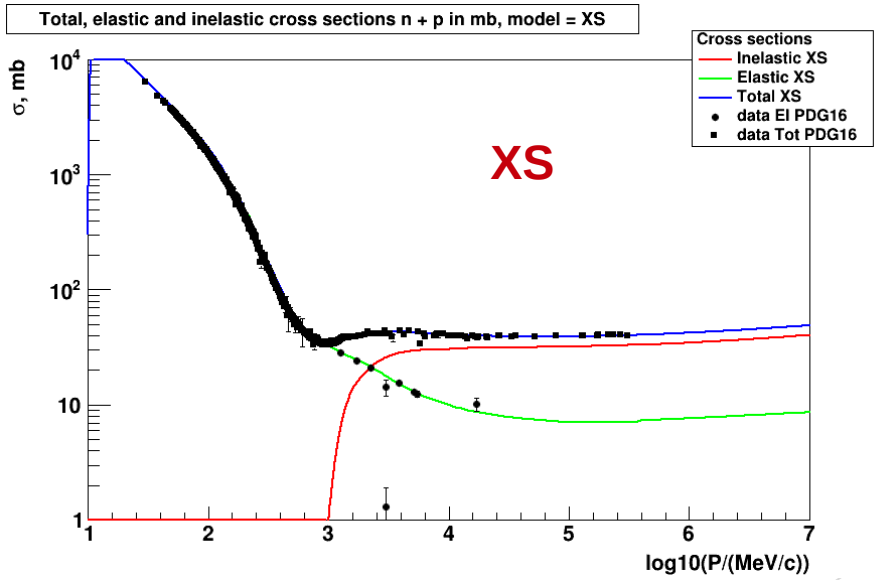
HadrHN: n + p





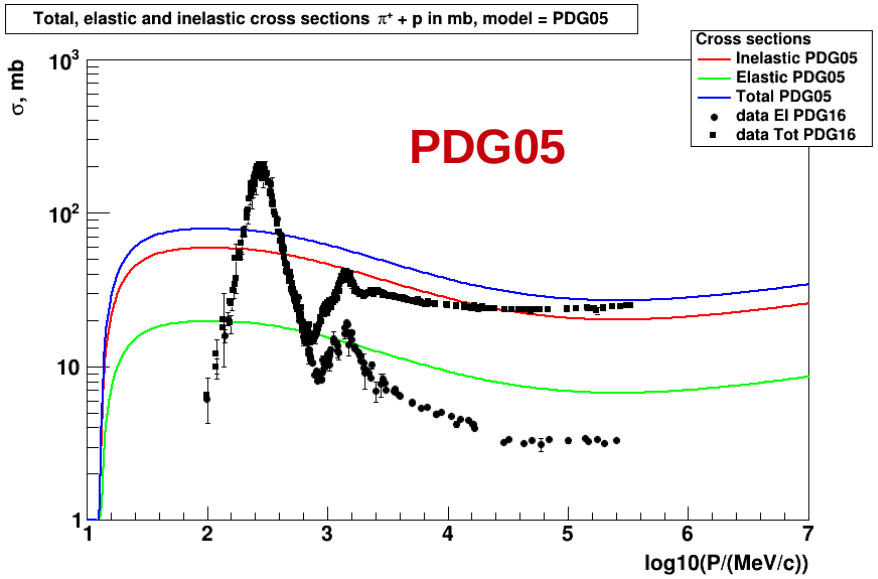
p > 0.2 GeV/c

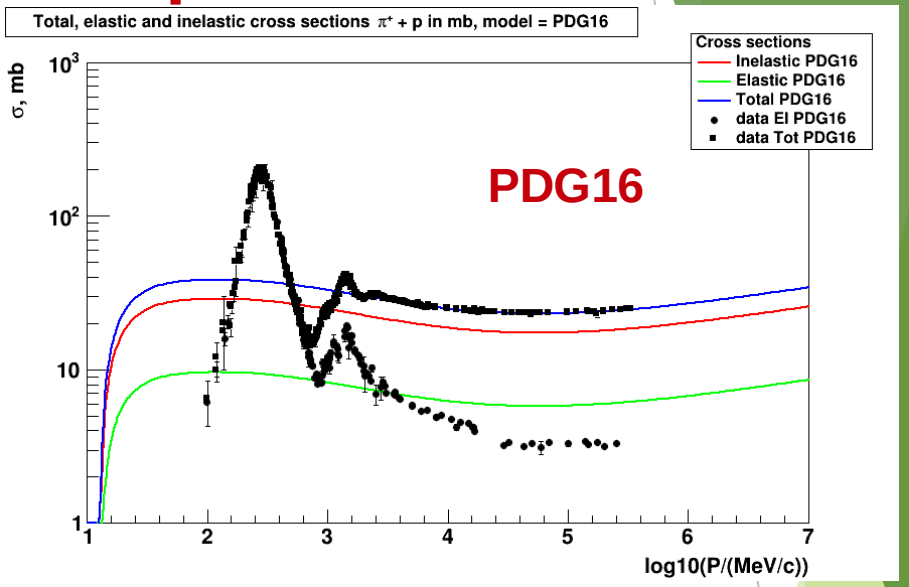
NS and XS: good agreement



HadrHN: $\pi^+ + p$

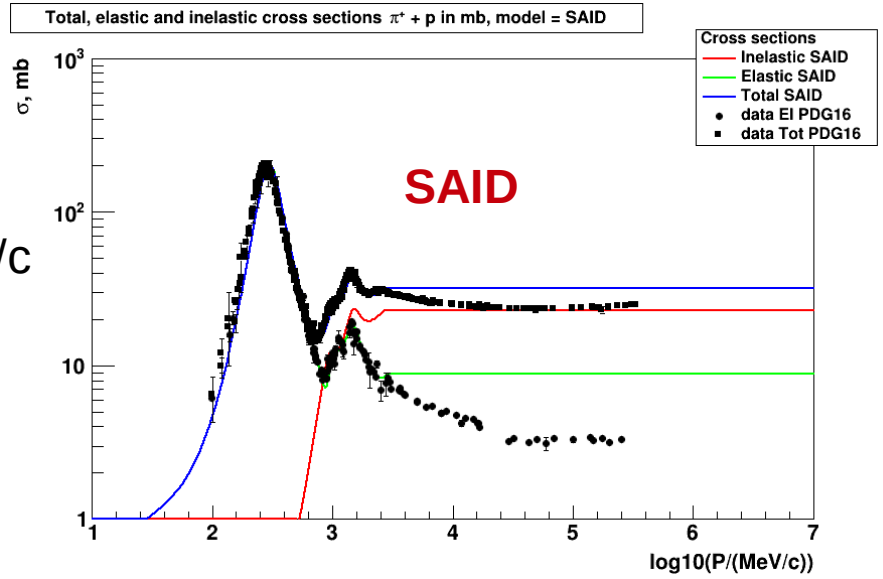
bad agreement

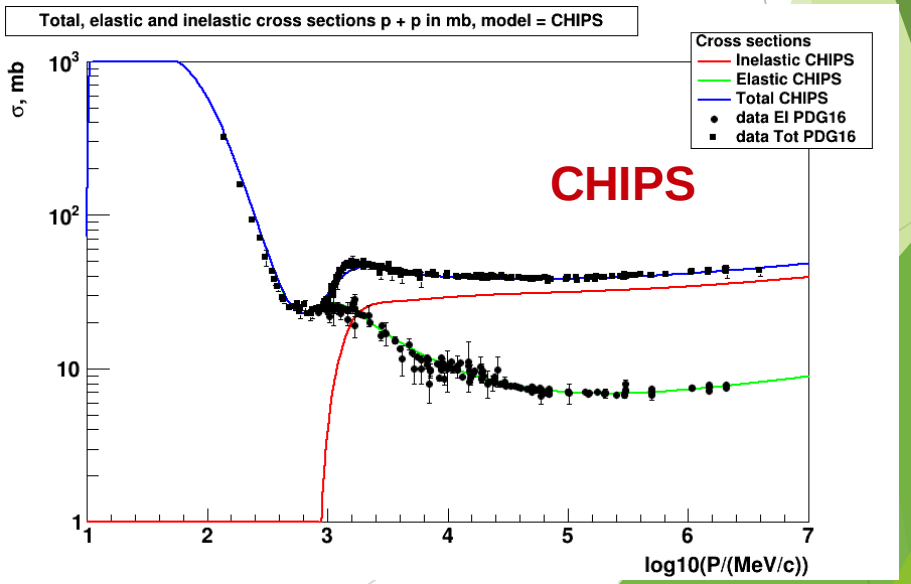




Total xs:
p > 2 GeV/c

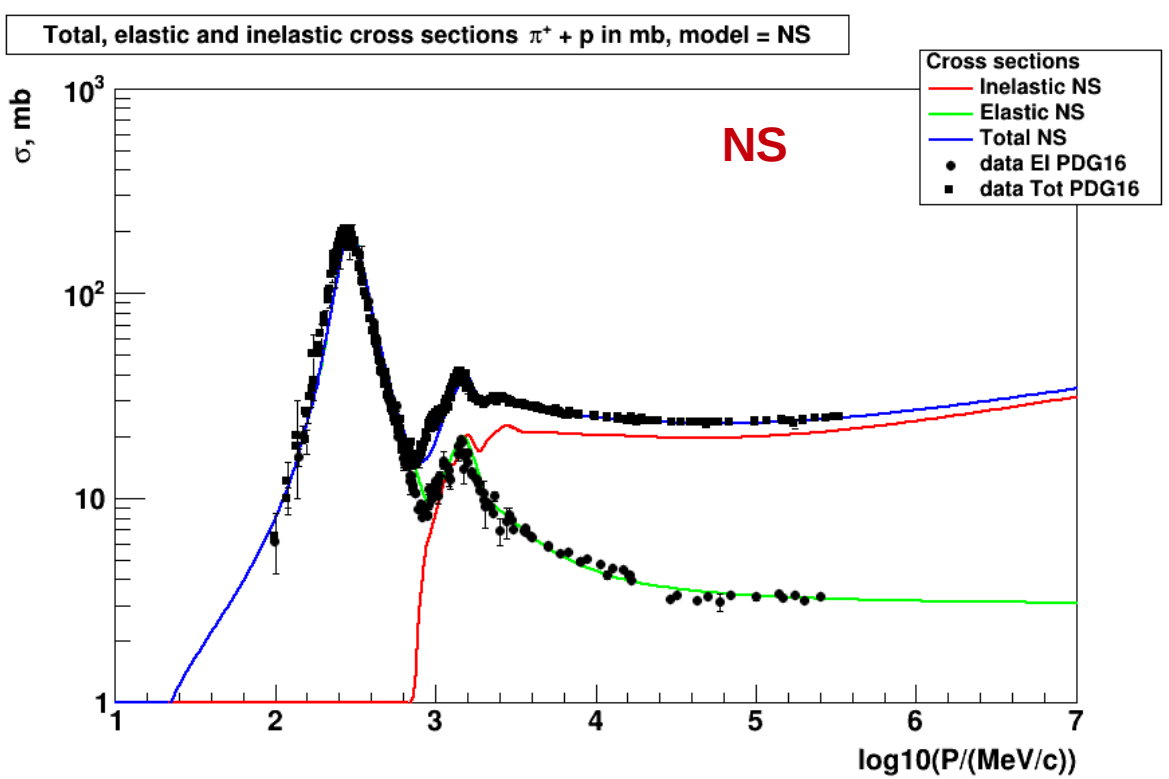
p < 0.2 GeV/c

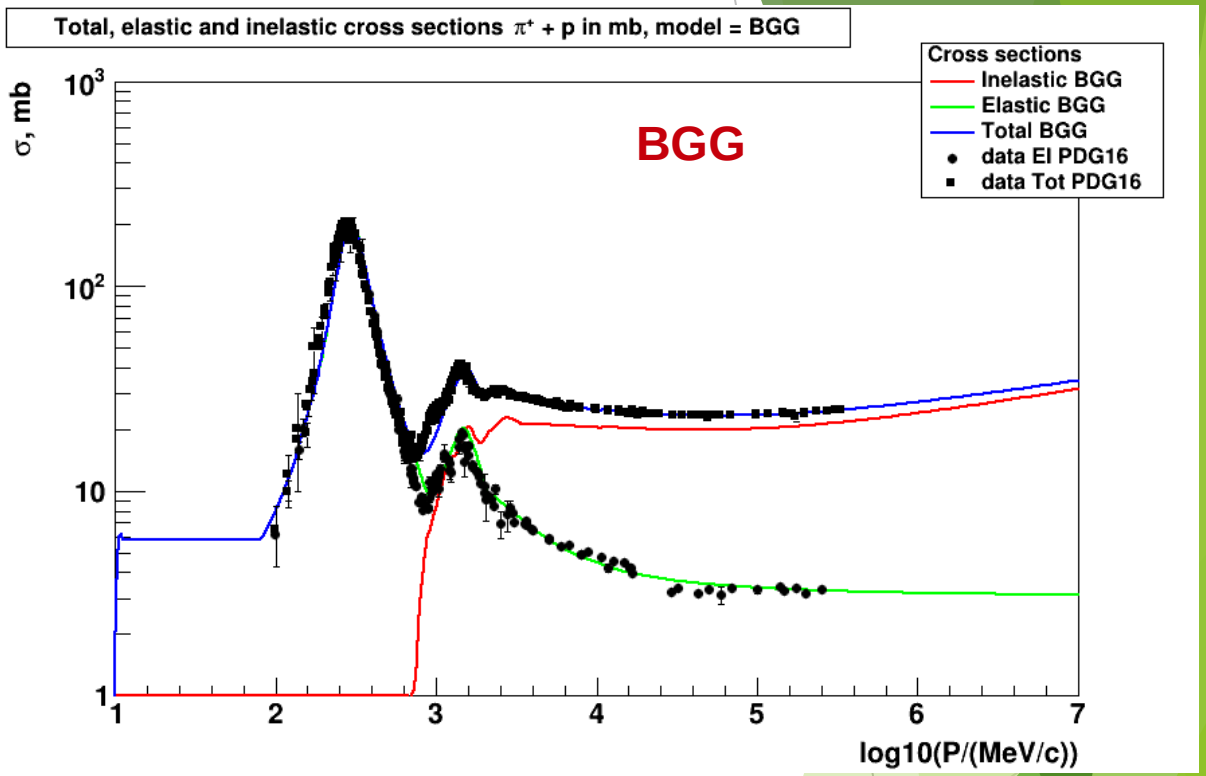




good agreement

HadrHN: $\pi^+ + p$

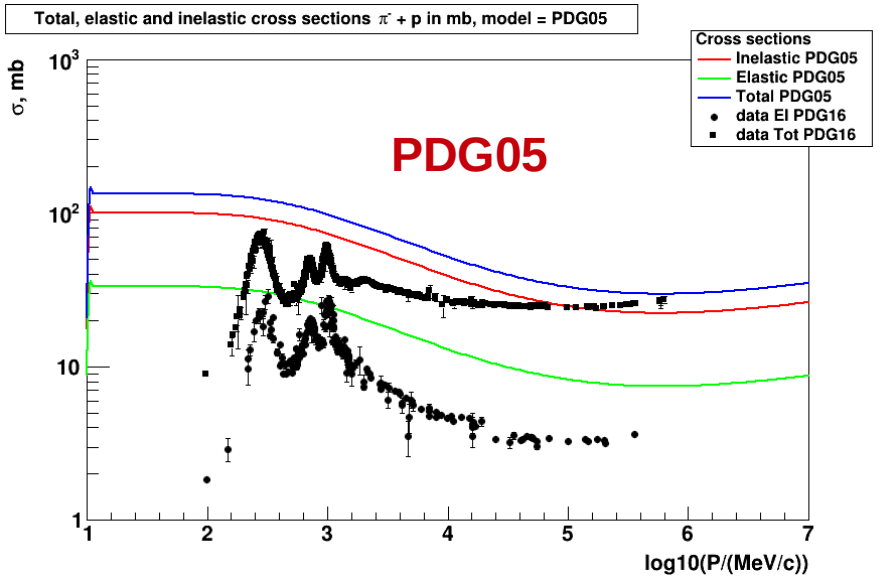


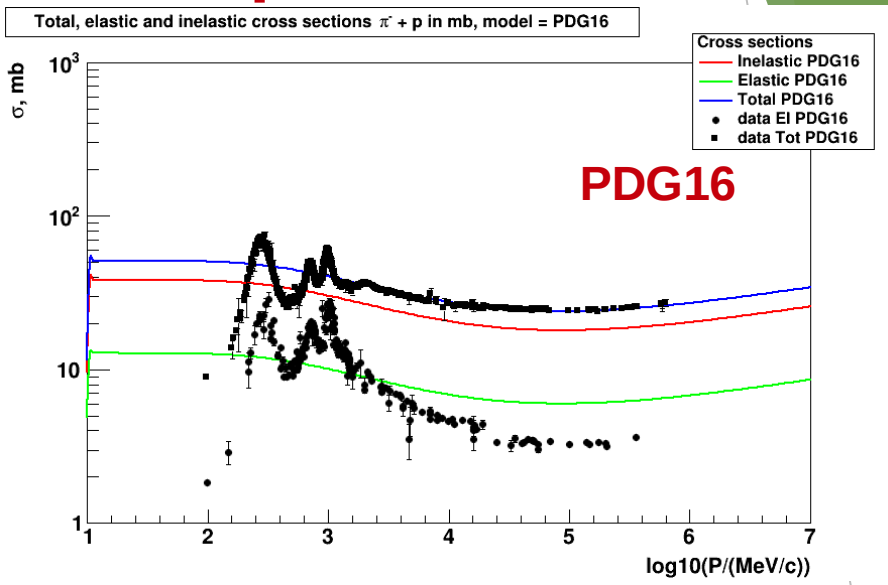


NS and BGG in general fit the data
There is a problem at 0.6-0.8 GeV/c

HadrHN: π^- + p

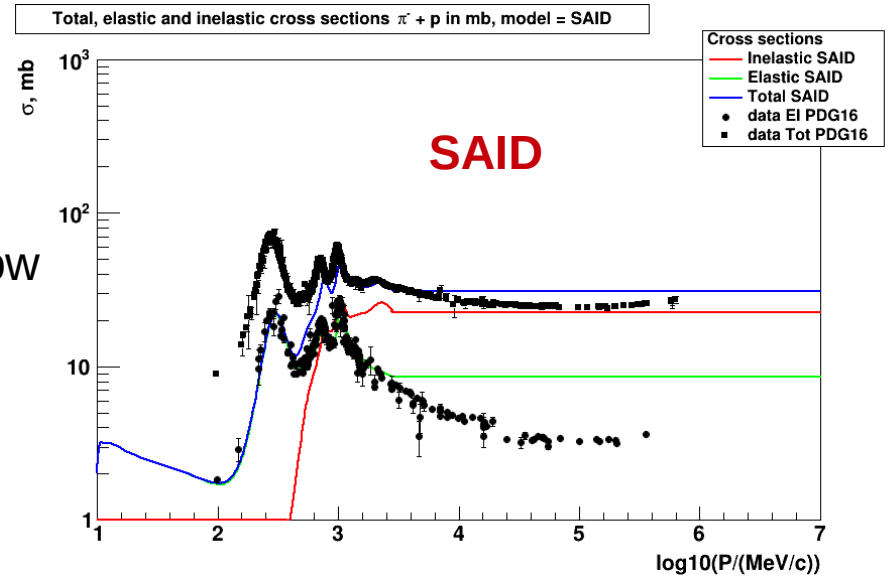
is not valid

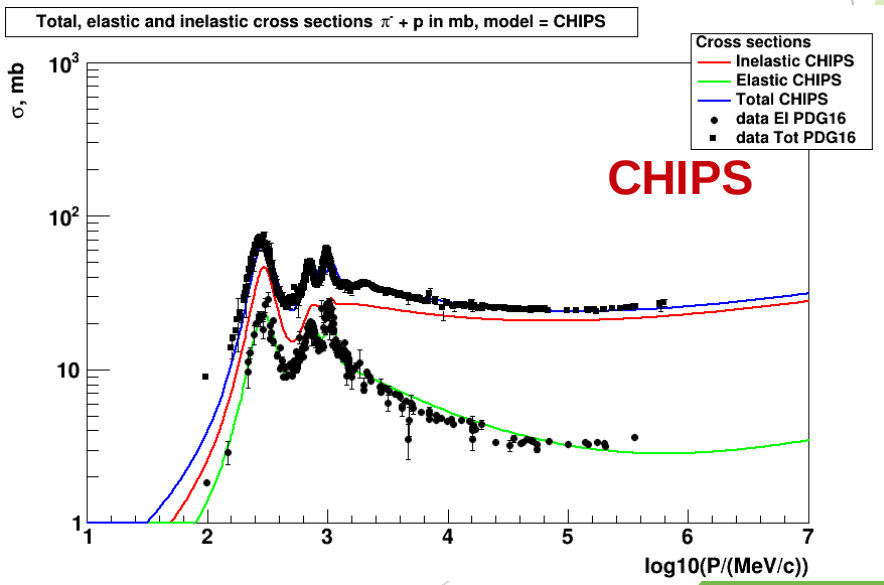




Total xs:
p > 2 GeV/c

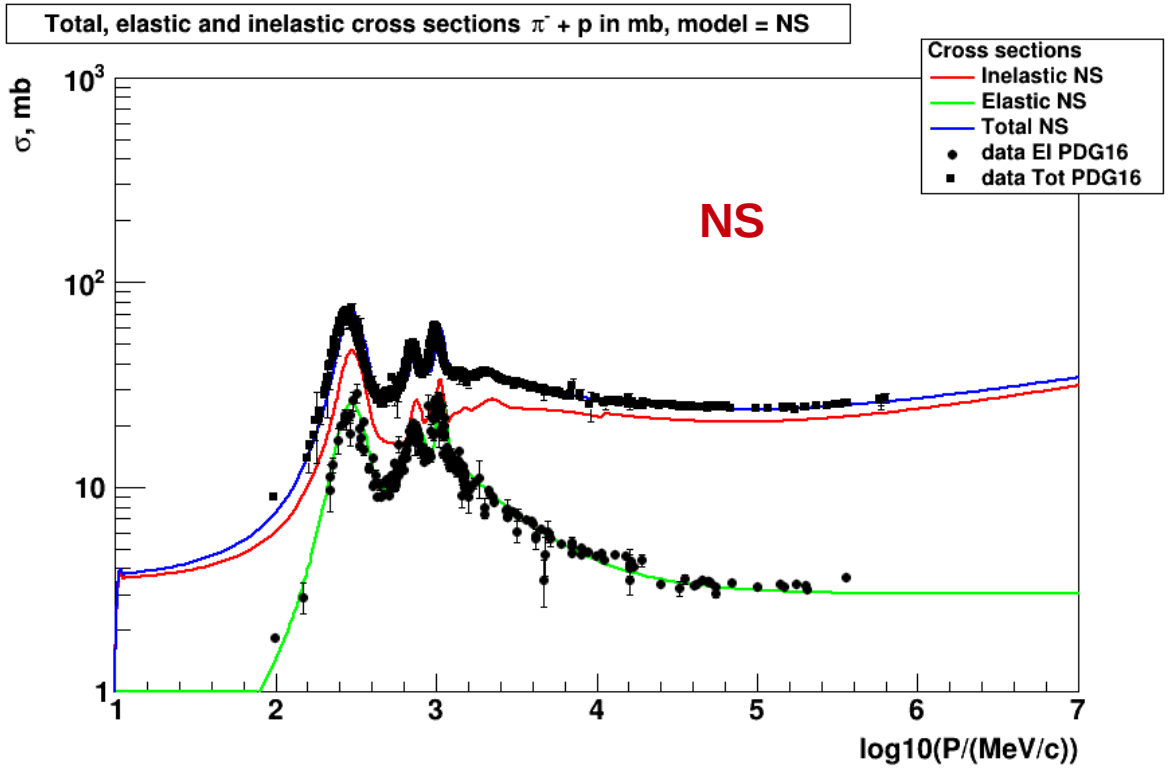
valid in narrow momentum interval

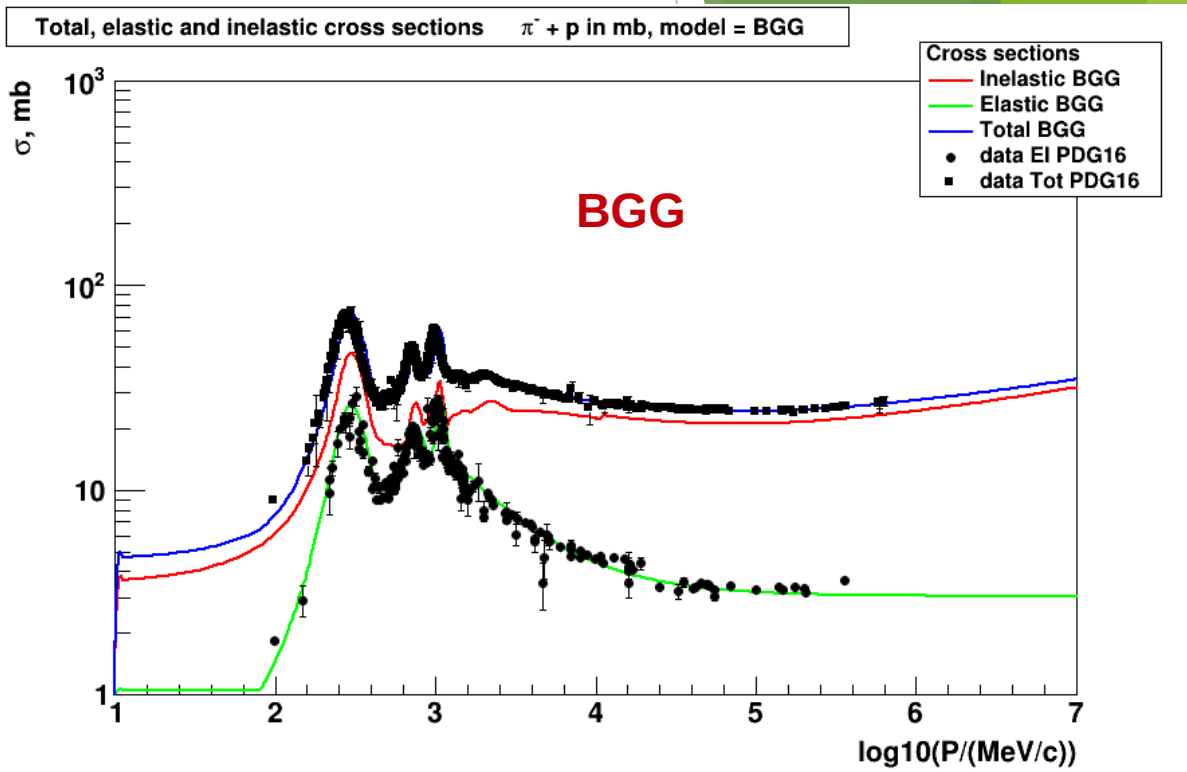




Total xs:
good agreement excluding low p
Elastic: fits in general, 4- 60 GeV/c overestimation, > 100 GeV/c underestimation

HadrHN: π^- + p





NS and BGG:
both total and elastic xs are good

New hadronic test

Results

- BGG, NS, XS, CHIPS x-sections in general fit the data
- PDG05 should be removed
- PDG16 for today has only total x-section parameterization
- SAID in some cases contradicts to the data
- 15 MeV internal limit in BGG elastic x-sections should be reduced
- NS has non-ideal parameterization for total x-section π + p 0.6-0.8 GeV/c

Plans

- Add projectile kaons and hyperons to the test
- Add recent TOTEM data
- Prepare scripts for an automation of the test