Models for quasi-elastic

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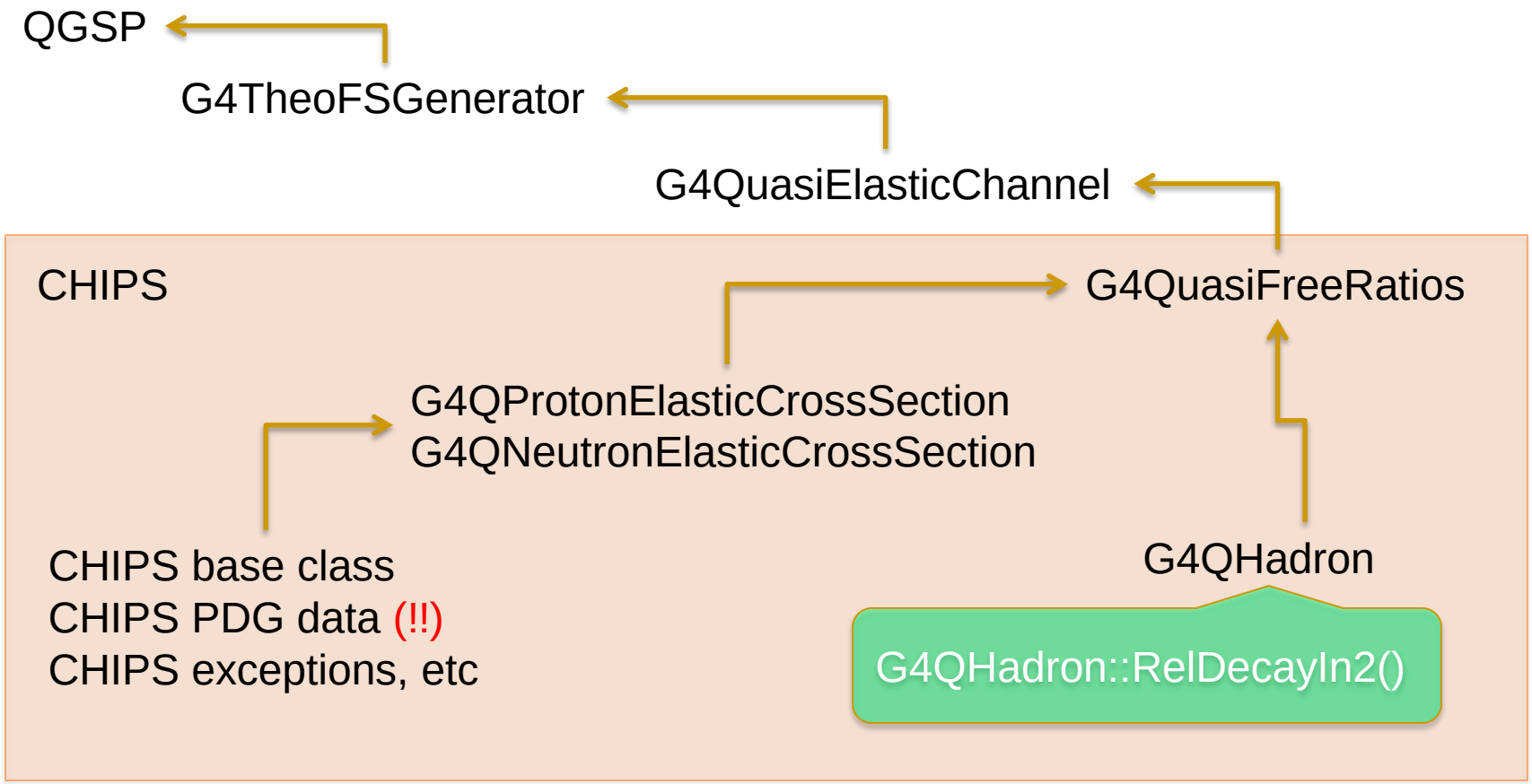
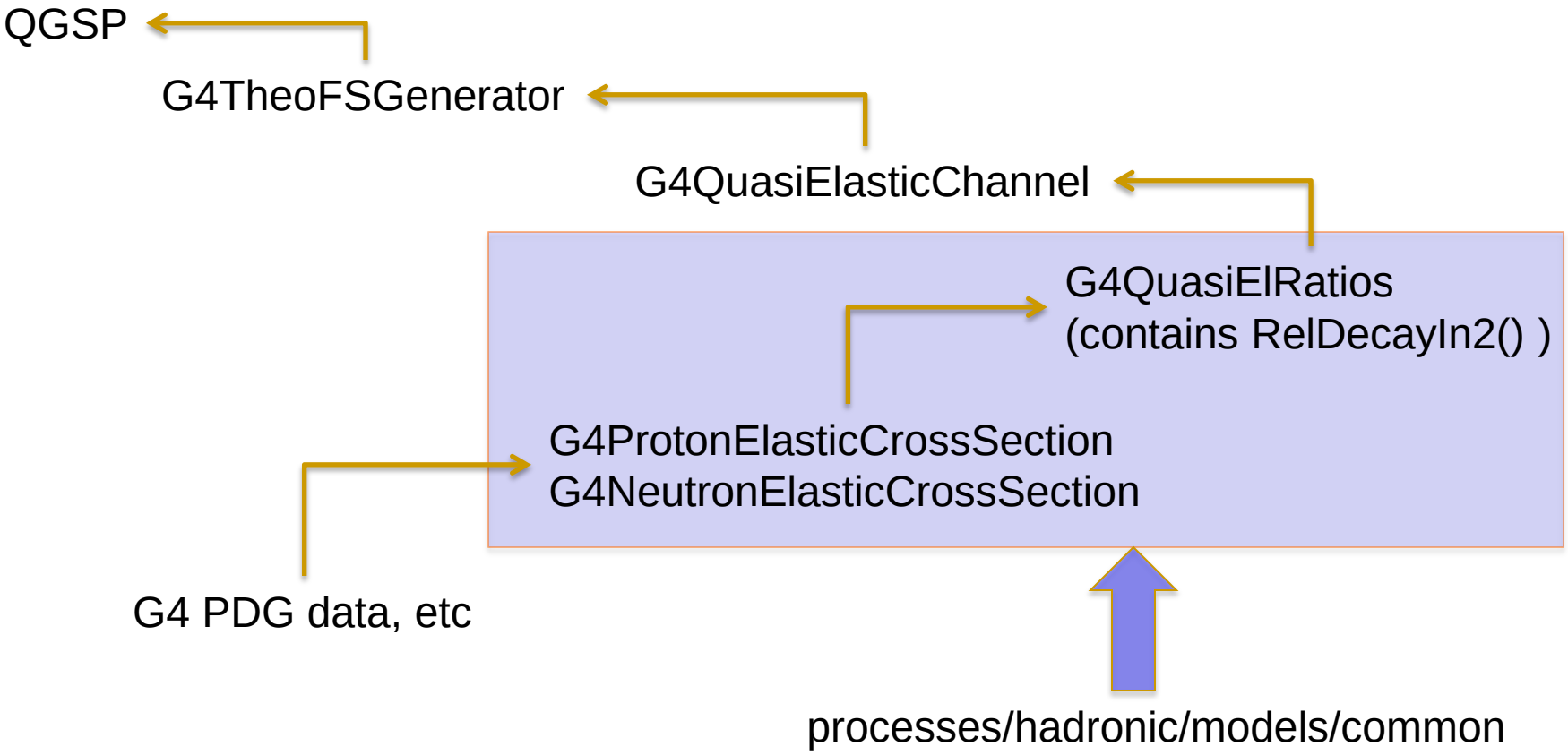
Introduction

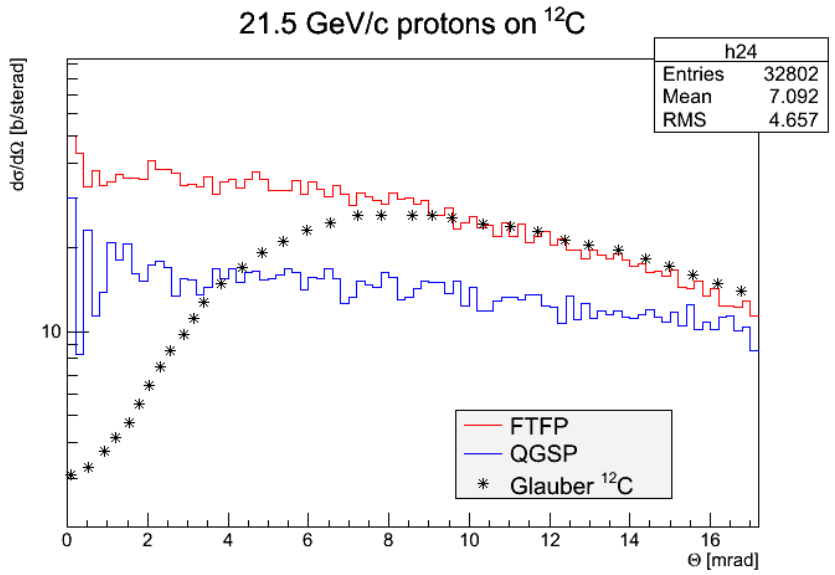
- two models for quasi-elastic exist in Geant4
  - FTF model
  - CHIPS model
- CHIPS model has been extracted and now can be used standalone (without CHIPS)
- extracted CHIPS model used by QGSP
  - can be used by any other physics list
- FTF model is an integral part of FTF
  - at the moment cannot be used outside it

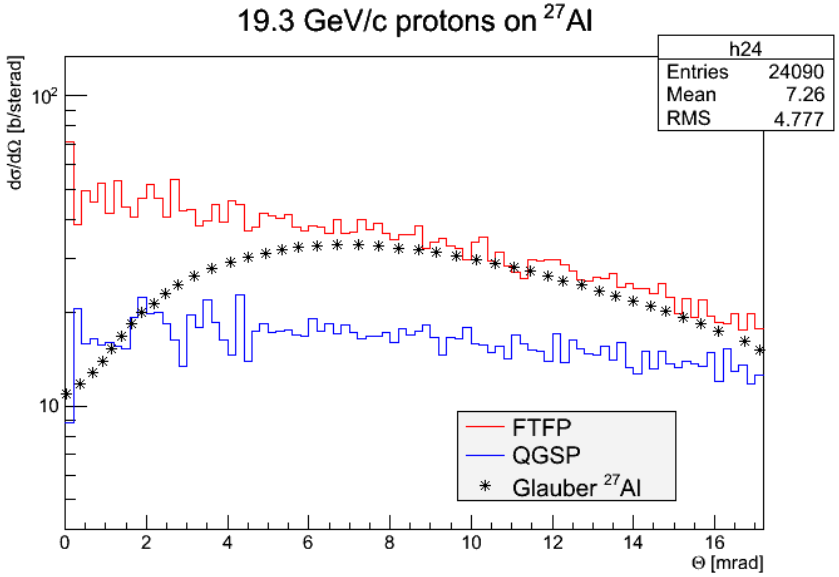
Former dependency on CHIPS

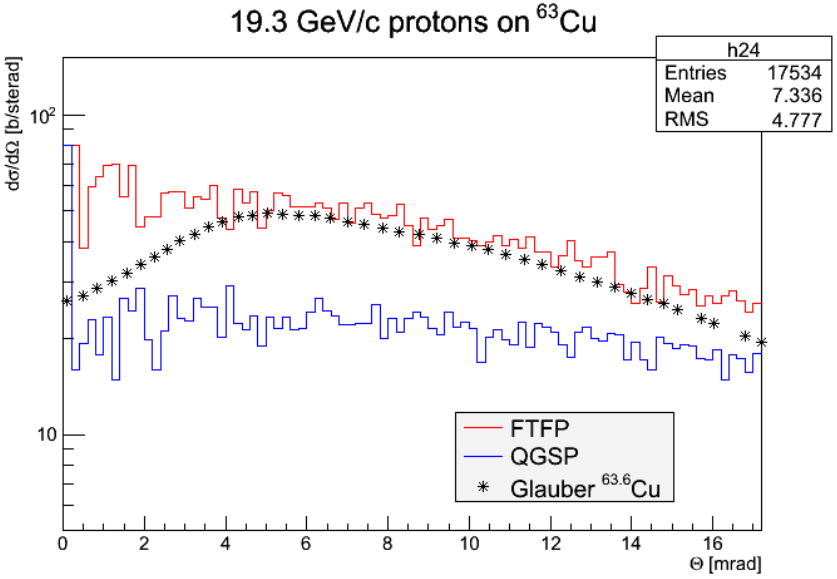


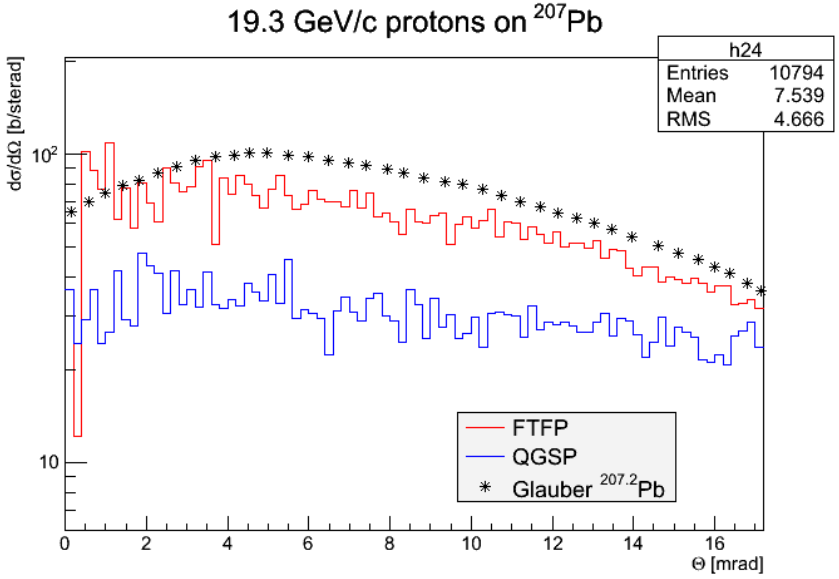
Restructured



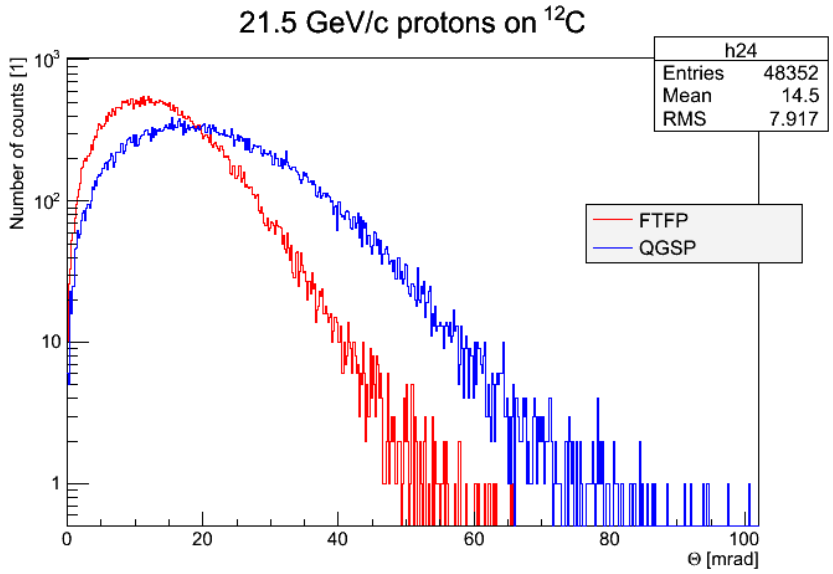


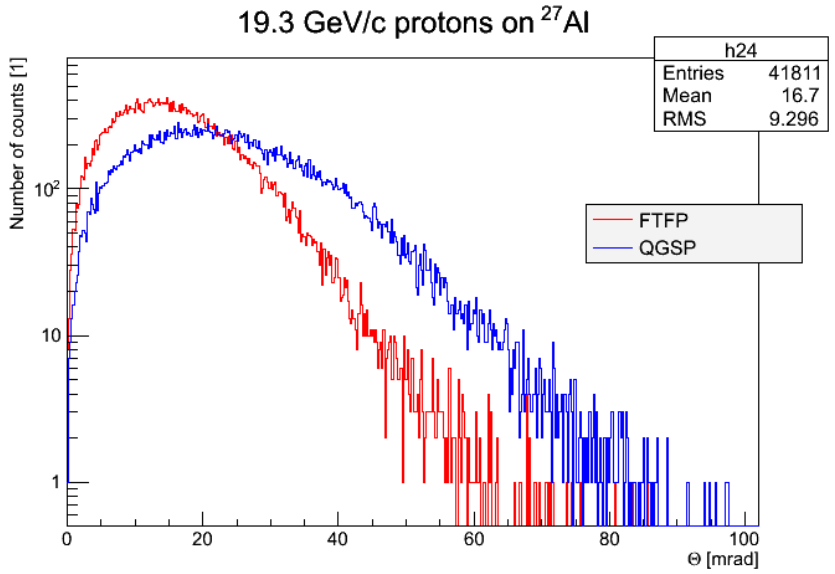


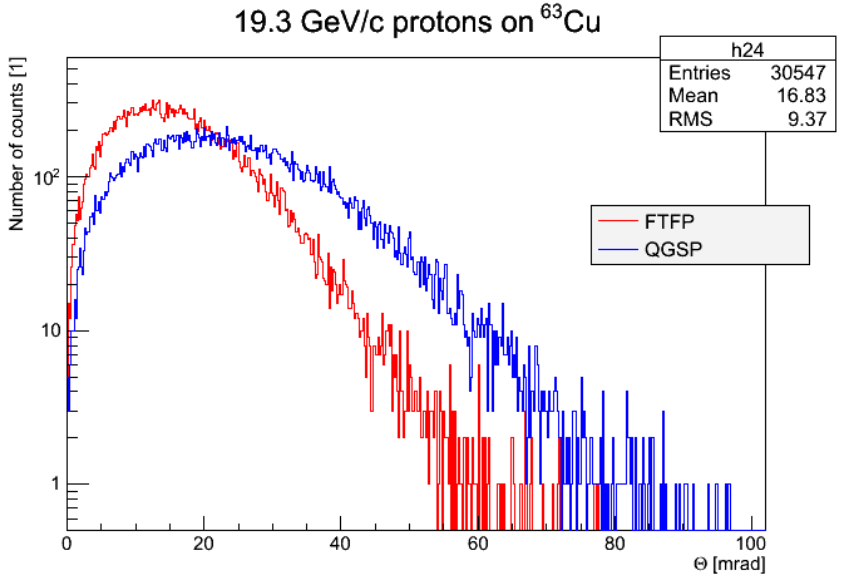


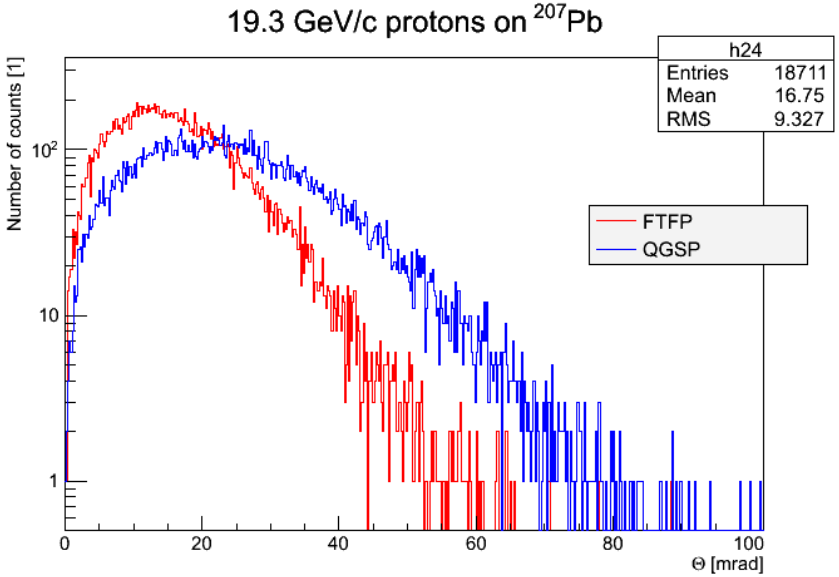


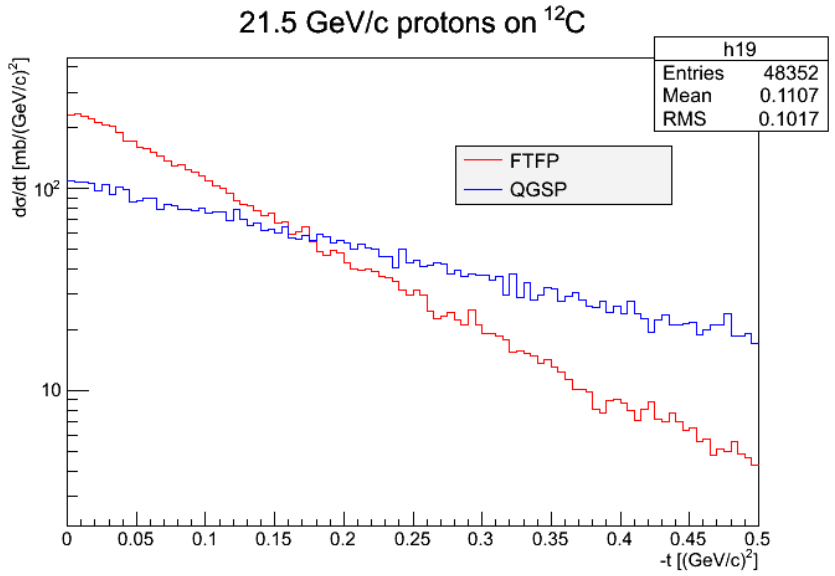
(Nucl.Phys B21 (1970), 135)

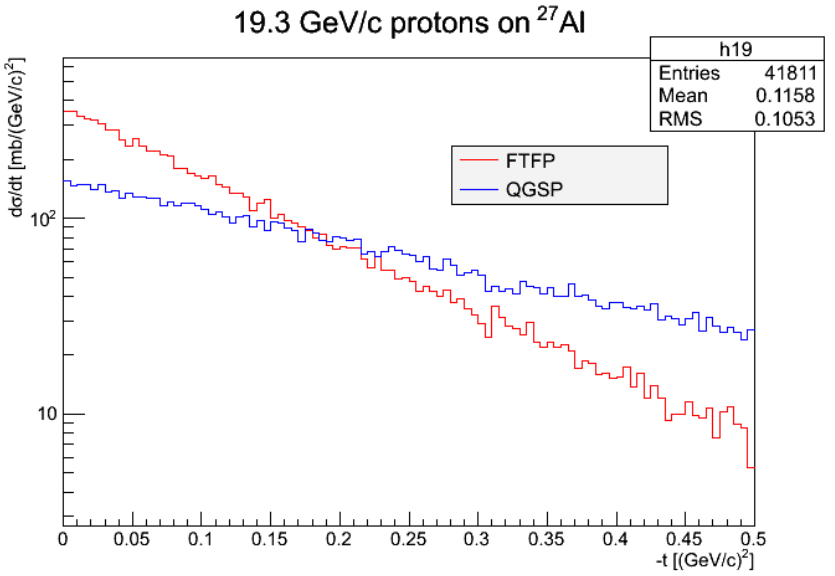

21.5 GeV/c protons on ^{12}C
h24
Entries 48352
Mean 14.5
RMS 7.917
FTFP
QGSP
Number of counts [1]
Θ [mrad]

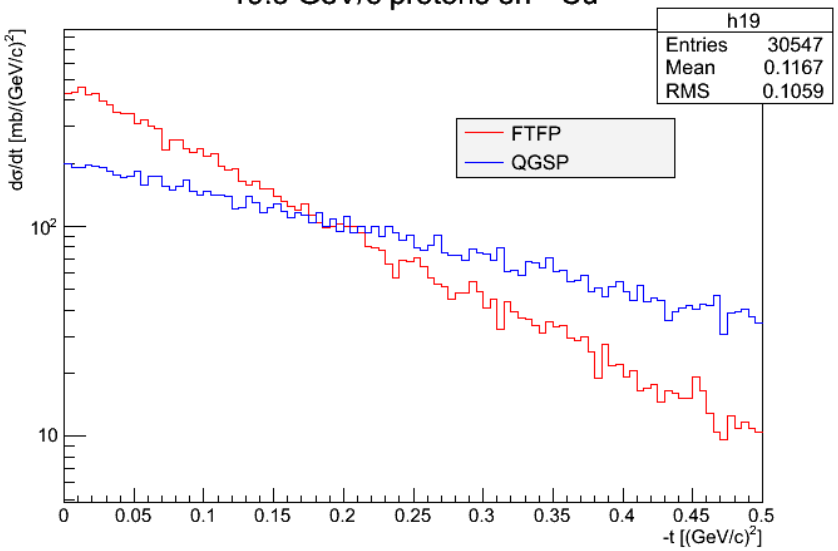

19.3 GeV/c protons on ^{27}Al
h24
Entries 41811
Mean 16.7
RMS 9.296
FTFP
QGSP
Number of counts [1]
Θ [mrad]

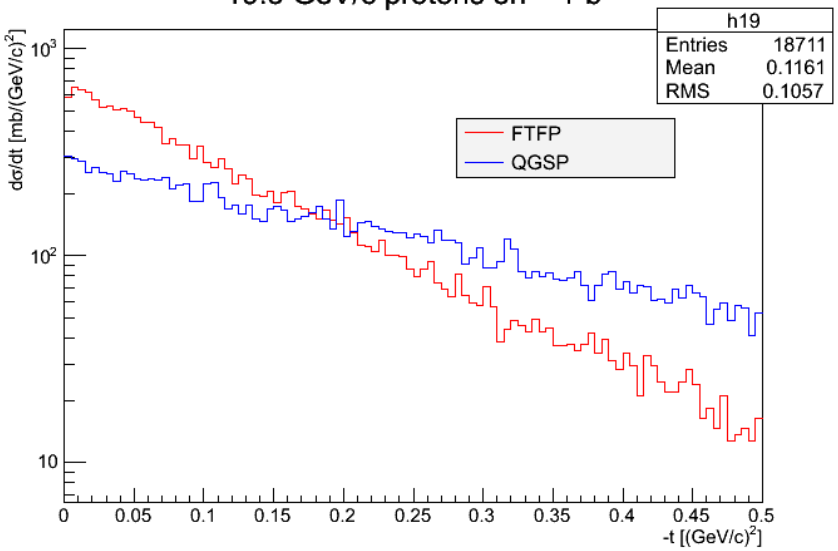

19.3 GeV/c protons on ^{63}Cu
h24
Entries 30547
Mean 16.83
RMS 9.37
FTFP
QGSP
Number of counts [1]
Θ [mrad]


19.3 GeV/c protons on ^{207}Pb
h24
Entries 18711
Mean 16.75
RMS 9.327
FTFP
QGSP
Number of counts [1]
Θ [mrad]


21.5 GeV/c protons on ^{12}C
h19
Entries 48352
Mean 0.1107
RMS 0.1017
FTFP
QGSP
dσ/dt [mb/(GeV/c)^2]
-t [(GeV/c)^2]


19.3 GeV/c protons on ^{27}Al
h19
Entries 41811
Mean 0.1158
RMS 0.1053
FTFP
QGSP
dσ/dt [mb/(GeV/c)^2]
-t [(GeV/c)^2]


19.3 GeV/c protons on ^{63}Cu
h19
Entries 30547
Mean 0.1167
RMS 0.1059
FTFP
QGSP
dσ/dt [mb/(GeV/c)^2]
-t [(GeV/c)^2]


19.3 GeV/c protons on ^{207}Pb
h19
Entries 18711
Mean 0.1161
RMS 0.1057
FTFP
QGSP
dσ/dt [mb/(GeV/c)^2]
-t [(GeV/c)^2]

Produced spectra

- FTF QE always (?) fragments the remaining nuclei
  - Alphas, D, etc produced
- CHIPS QE leaves the remaining (-1 nucleon) nuclei
  - is the excitation energy lost?

Bug in (ex)CHIPS QE fixed in 9.6.beta

- Alberto realized that physics lists which use quasi-elastic (extracted from CHIPS) violate the reproducibility
  - in some cases the events run with the same random number seed were history-dependent
    - QE process was giving history-dependent results
- the problem was traced down to the situation where QE was called in several events for the same target with different (in a specific way) incident particles (type or energy)

Code (1/2)

- problem comes from the method (omitting many details) :

```
// Calculation QuasiFree/Inelastic Ratio as a function of total hN cross-section (mb) and A
G4double G4QuasiElRatios::GetQF2IN_Ratio(G4double s, G4int A)
...
 G4double sv=0;
 for(G4int j=1; j<=lastN; j++)
      {
         sv+=ds;
         lastT[j]=CalcQF2IN_Ratio(sv,A);
      }
...
```

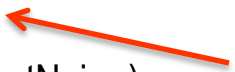
SV	lastT
1	QF2IN_Ratio(1,A)
…	…
s	QF2IN_Ratio(s,A)r_s

- values for sv=1 to s are calculated and put in the lastT table

Code (2/2)

- next time you call the GetQF2IN_Ratio (again, simplifying a lot)
  - you use the existing table if s < previous s
  - you (are supposed to) calculate the the remaining values if s > previous s

```
G4double sv=lastH;
for(G4int j=nextN; j<=lastN; j++)
        {
          sv+=ds;
          lastT[j]=CalcQF2IN_Ratio(sv,A);
        }
```



bug was here (it was set to lastM – wrong variable)

SV	lastT
1	QF2IN_Ratio(1,A)
…	…
s	QF2IN_Ratio(s,A)r_s
s+1	QF2IN_Ratio(1,A)r_s
…	…
s_new	…

Result of the bug

- table of Quasi-Free to inelastic ratio was calculated correctly for the first call (say for s=1 to 25 for 20GeV Pi+ on Fe)
- the second time it was called for a particle with higher s (say s=38 for 20GeV proton on Fe) the remaining part of the table was filled with incorrect values
  - in all the following calls to the method, the return value for s=26, 27,... was incorrect (was the one calculated for s=1, 2, ...)
    - the ratio of Quasi-Free to inelastic events was incorrect
- for instance, in our test, the return value for the Quasi-Free to inelastic ratio was 0.77 instead of 0.4
  - however, the overall result of this bug is most likely negligible

Conclusion

- Quasi-Elastic validation still requires work
- FTF QE seems to agree better with Glauber calculation
  - but still discrepancies
- proposal to make FTF QE standalone so it can be used in other physics lists