Changes in Multiple Scattering between G4 8.1 and 9.0

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All the G4 versions starting from 8.1 use some geometrical information, namely the safety. In 9.0 - if the step limit type 2 is activated, another geometrical quantity, the distance to the volume boundary - in the direction of the particle momentum- is used as well.

Stepping is the same INSIDE volumes, can be different around boundaries. Using the most precise step limit type 2 in 9.0:

small step(s) with single scattering just before/after boundary crossing, if the parameter $SKIN > 0$

size of small step(s) $= \lambda_{elastic}$

number of small steps : $SKIN/SKIN - 1$ before/after boundary

This kind of stepping can be used if there is no magnetic field.

Differences in the angular distribution:

In order to get better reproduction of the scattering data in 9.0 slightly different formula is used to compute the width of the CENTRAL PART

8.1:

$$\theta_0 = \frac{13.26MeV}{\beta cp} z_{ch} \left[\frac{t}{X_0}\right]^{0.54} \quad (1)$$

9.0:

$$\theta_0 = \frac{13.6MeV}{\beta cp} z_{ch} \left[\frac{t}{X_0}\right]^{0.5} \left[1 + 0.105y + 0.0035y^2\right]^{0.5} \quad (2)$$

where $y = log(\frac{t}{X_0})$.

different TAIL

motivation : to get better simulation results for the -not too many- experiments where the tail of the angular distribution was measured, e.g. 15.7 MeV e- in Au, muon scattering in low-Z materials (MUSCAT). The functional form in both versions

$$\frac{1}{[b - cos\theta]^c} \tag{3}$$

the value of the parameter c in 8.1:

$$3 - 0.85\frac{X_0}{\lambda par^2} \tag{4}$$

where $par = 13.6MeV/(\beta cp)$, λ is the transport mean free path, X_0 is the rad.length

in 9.0:

$$2.40 - 0.027Z^{2/3} \tag{5}$$

where Z is the atomic number.

Difference in results :

Example 1 : 15.7 MeV e- scattering in thin gold layers

comparison: data - 8.1

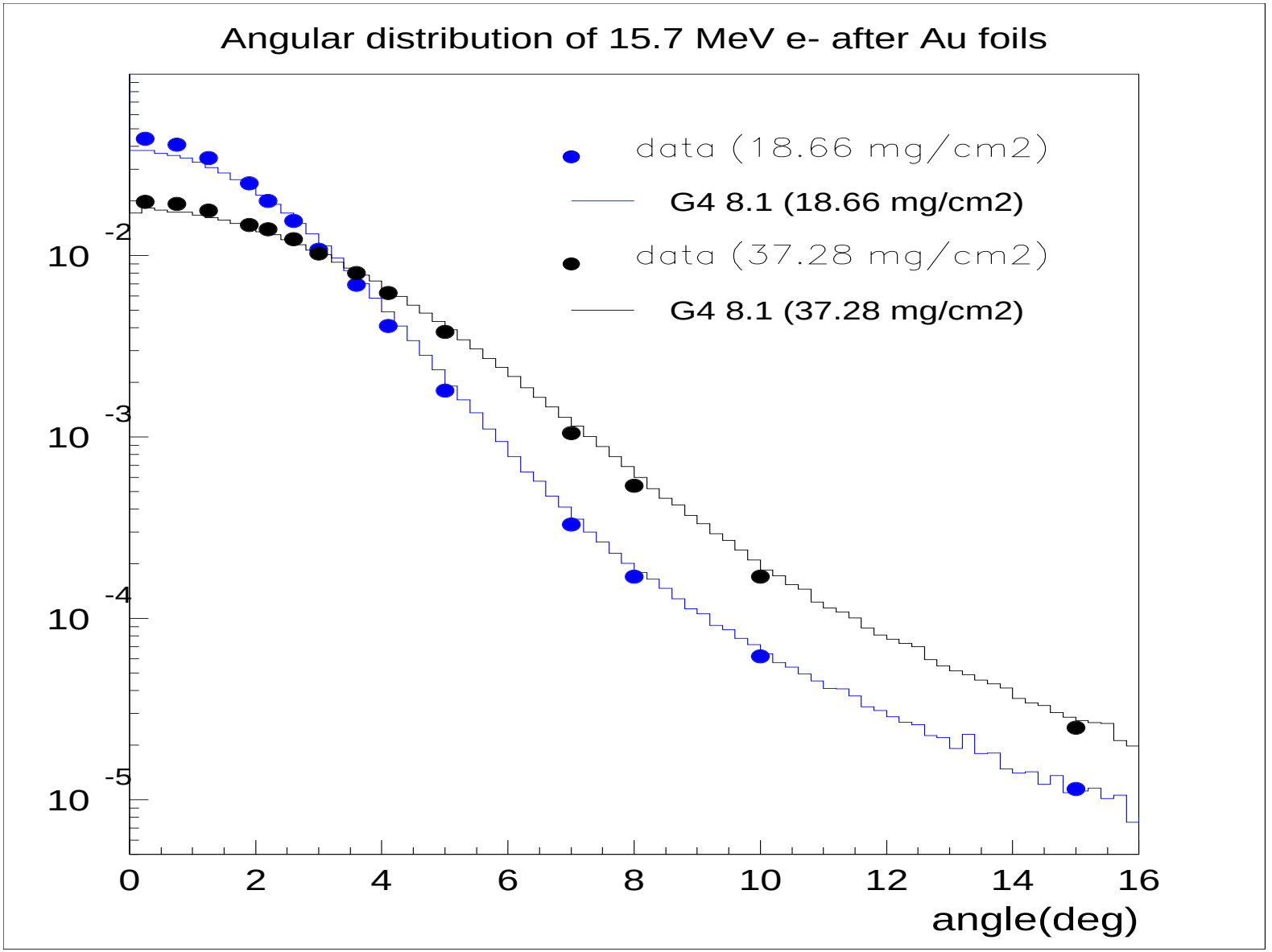
data - 9.0

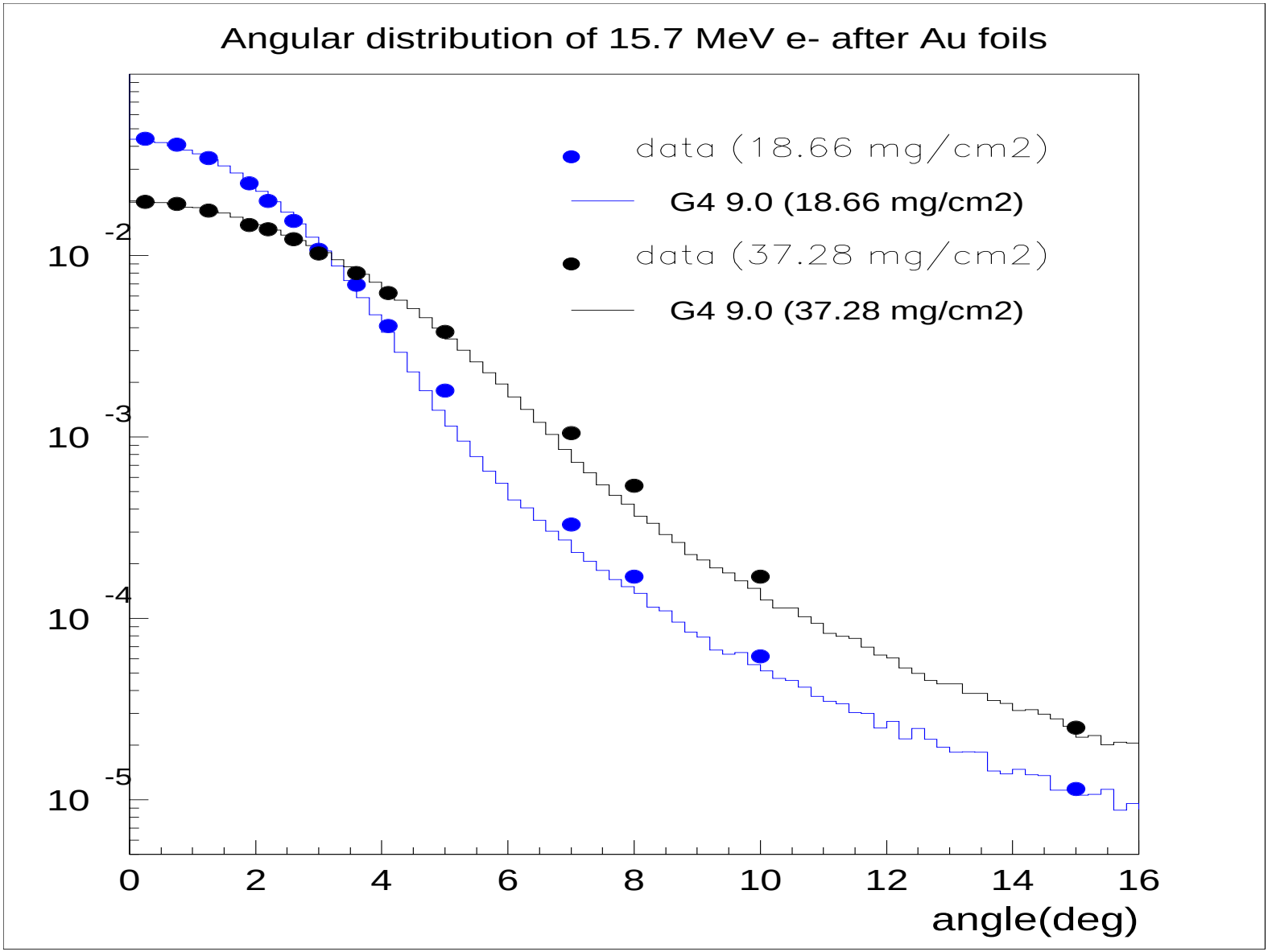
theory - 8.1 - 9.0 $\longrightarrow$

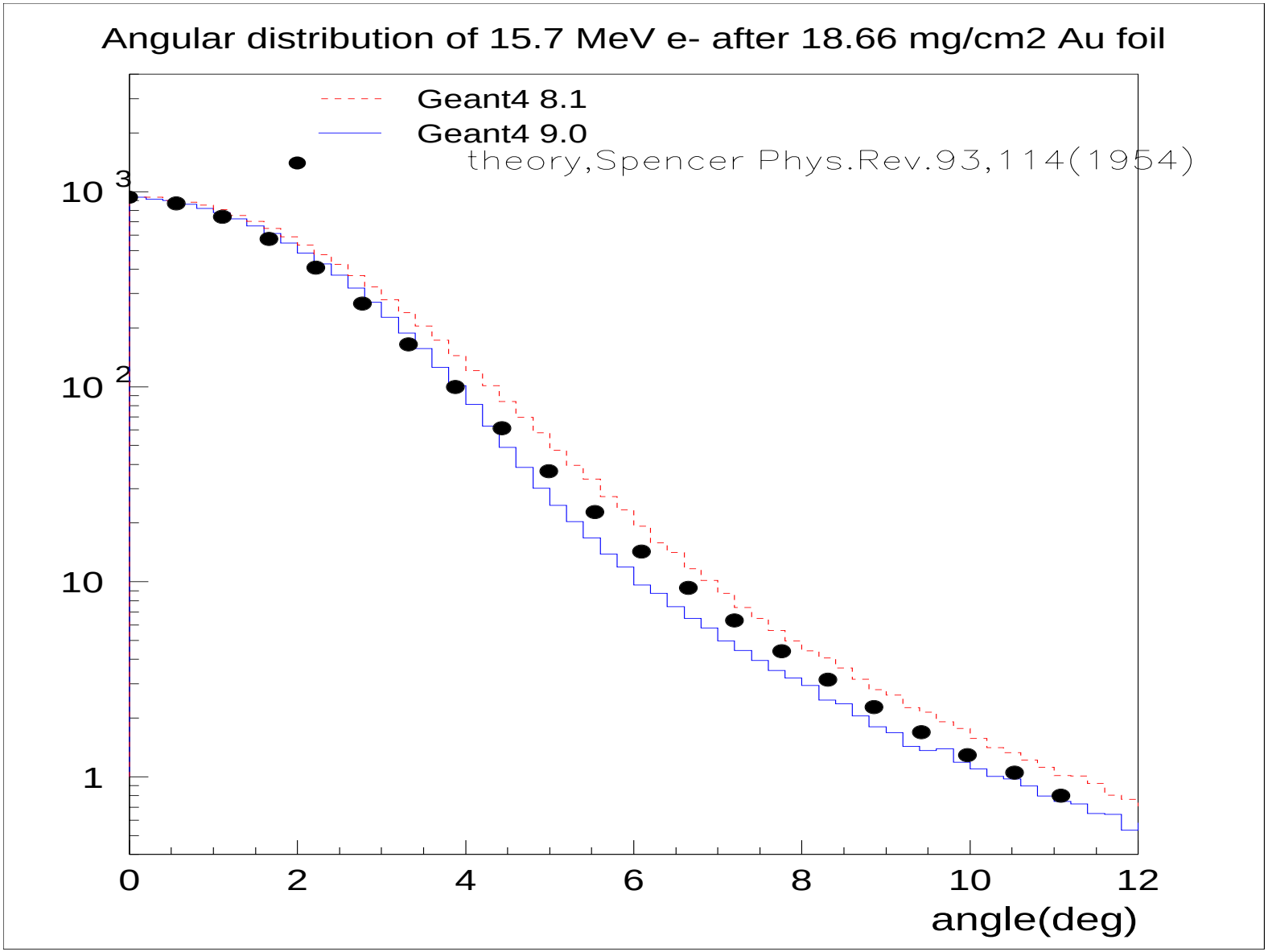
8.1 overestimates the scattering above 1 - 2 deg

9.0 OK below 4 deg and above 10 deg, too small scattering between 4 and 10 deg

significant, but not very big difference here


Angular distribution of 15.7 MeV e- after Au foils
data (18.66 mg/cm2)
G4 8.1 (18.66 mg/cm2)
data (37.28 mg/cm2)
G4 8.1 (37.28 mg/cm2)
10^-2
10^-3
10^-4
10^-5
0
2
4
6
8
10
12
14
16
angle(deg)


Angular distribution of 15.7 MeV e- after Au foils
data (18.66 mg/cm2)
G4 9.0 (18.66 mg/cm2)
data (37.28 mg/cm2)
G4 9.0 (37.28 mg/cm2)
10^-2
10^-3
10^-4
10^-5
0
2
4
6
8
10
12
14
16
angle(deg)


Angular distribution of 15.7 MeV e- after 18.66 mg/cm2 Au foil
Geant4 8.1
Geant4 9.0
theory,Spencer Phys.Rev.93,114(1954)
10 3
10 2
10
1
0
2
4
6
8
10
12
angle(deg)

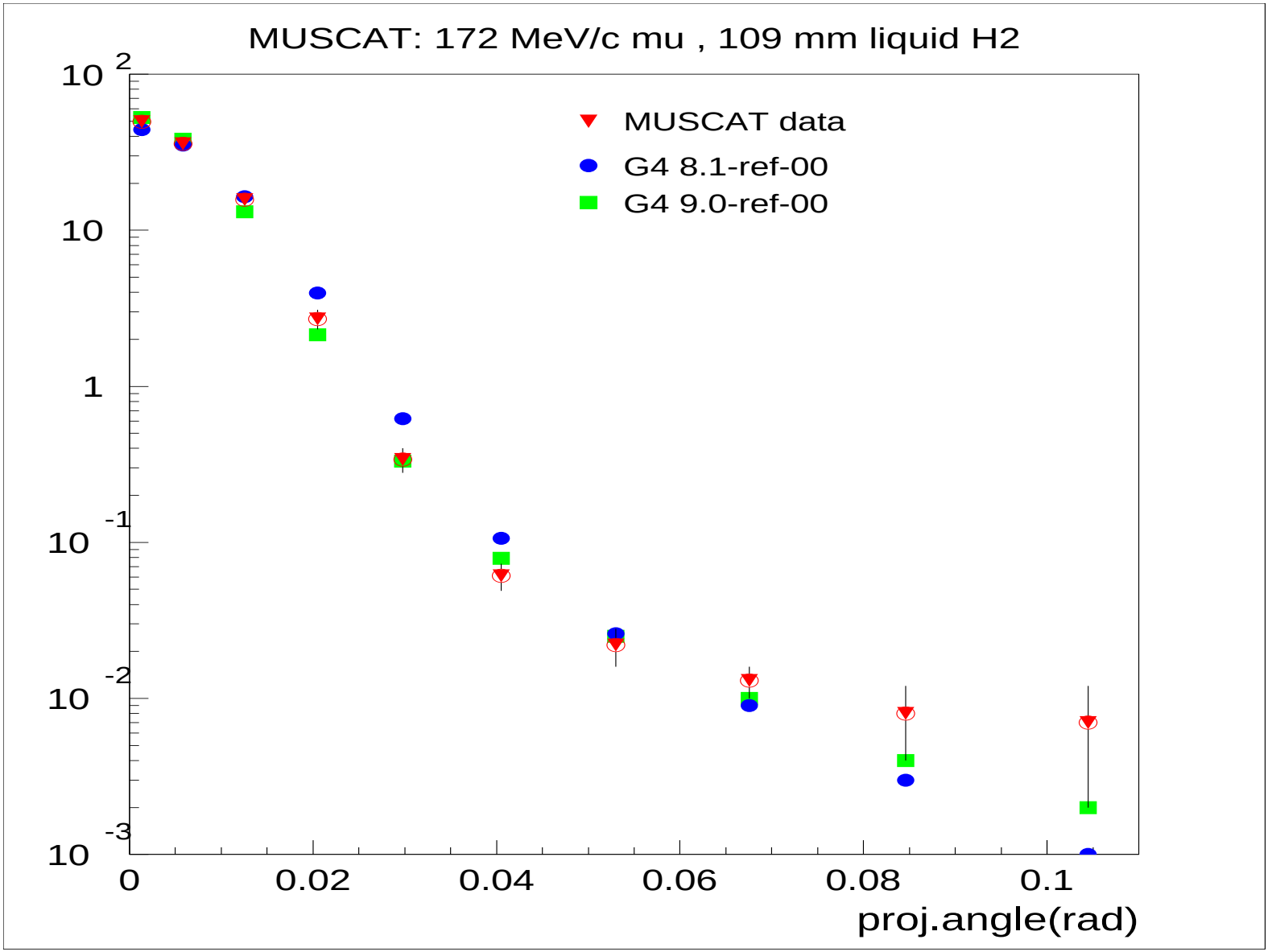
Difference in results :

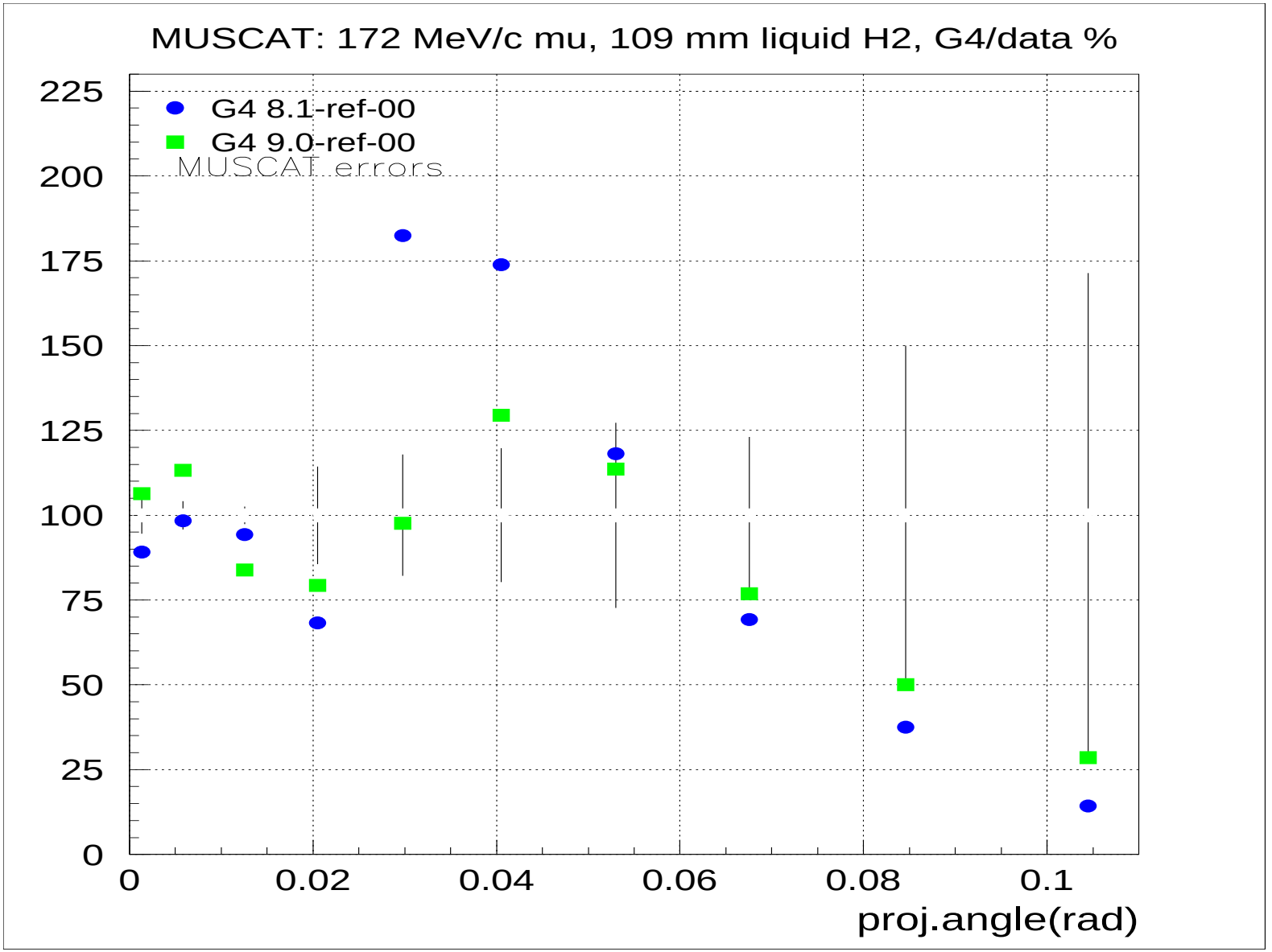
Example 2 : 172 MeV/c muon scattering in liquid hydrogen

comparison: (projected) angular distribution data - 8.1 - 9.0, simulation/data for 8.1 and 9.0

In this case the difference is big between 8.1 and 9.0, version 9.0 describes the data far better than 8.1.

The results are about the same for every target used in MUSCAT.


MUSCAT: 172 MeV/c mu , 109 mm liquid H2
MUSCAT data
G4 8.1-ref-00
G4 9.0-ref-00
10 2
10
1
10 -1
10 -2
10 -3
0
0.02
0.04
0.06
0.08
0.1
proj.angle(rad)

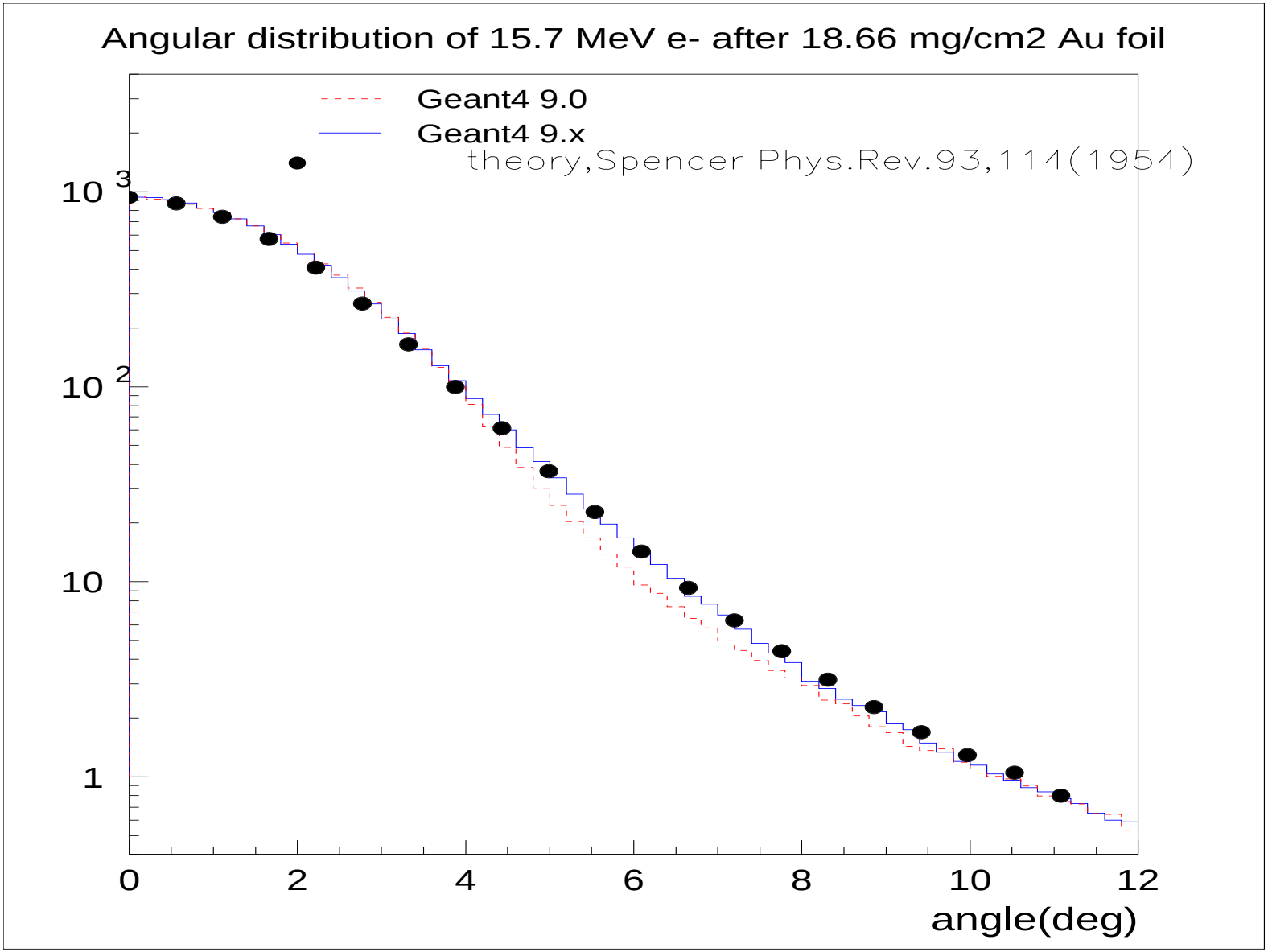

MUSCAT: 172 MeV/c mu, 109 mm liquid H2, G4/data %
G4 8.1-ref-00
G4 9.0-ref-00
MUSCAT errors
225
200
175
150
125
100
75
50
25
0
0
0.02
0.04
0.06
0.08
0.1
proj.angle(rad)

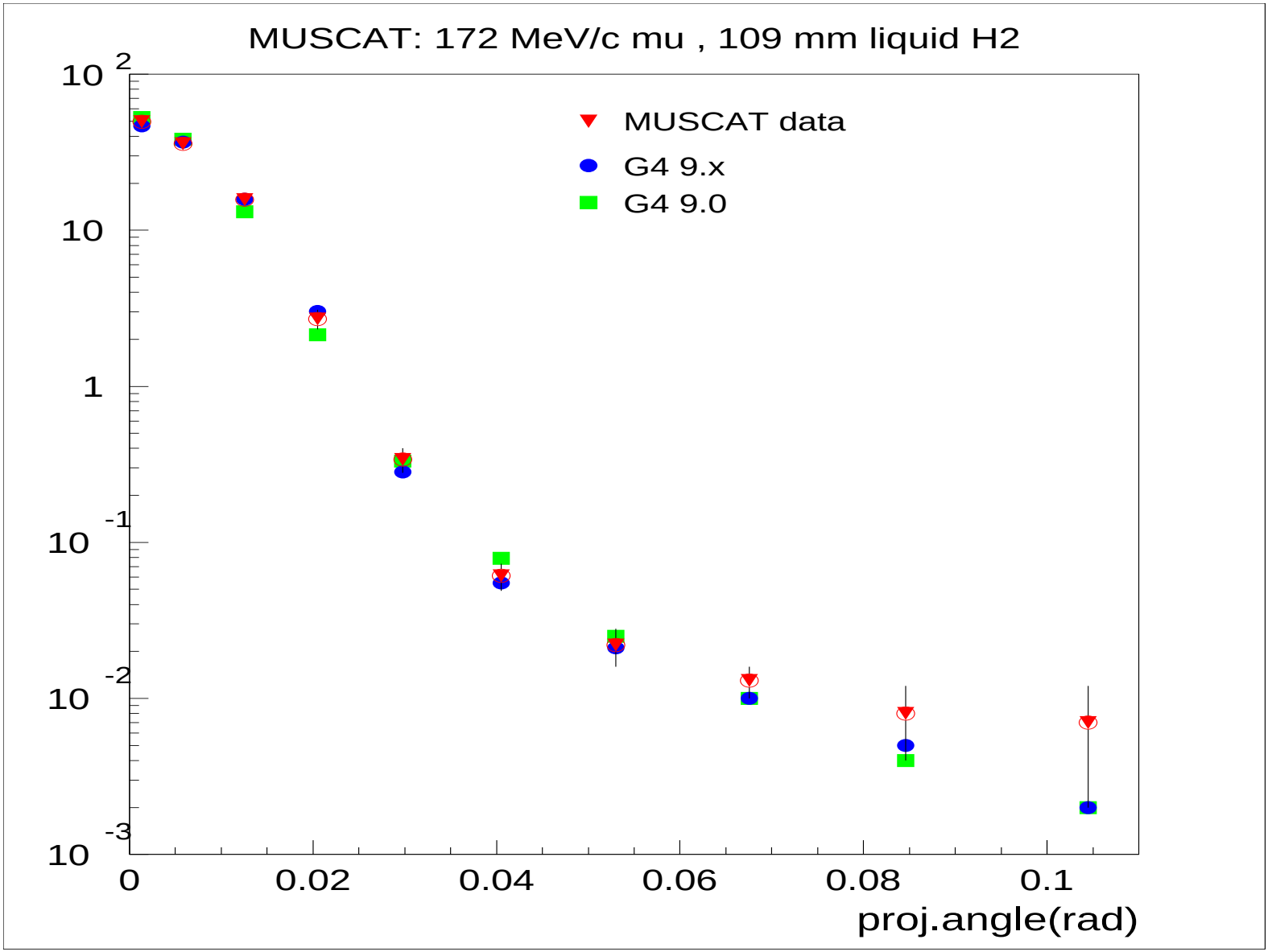
latest developments (very preliminary)

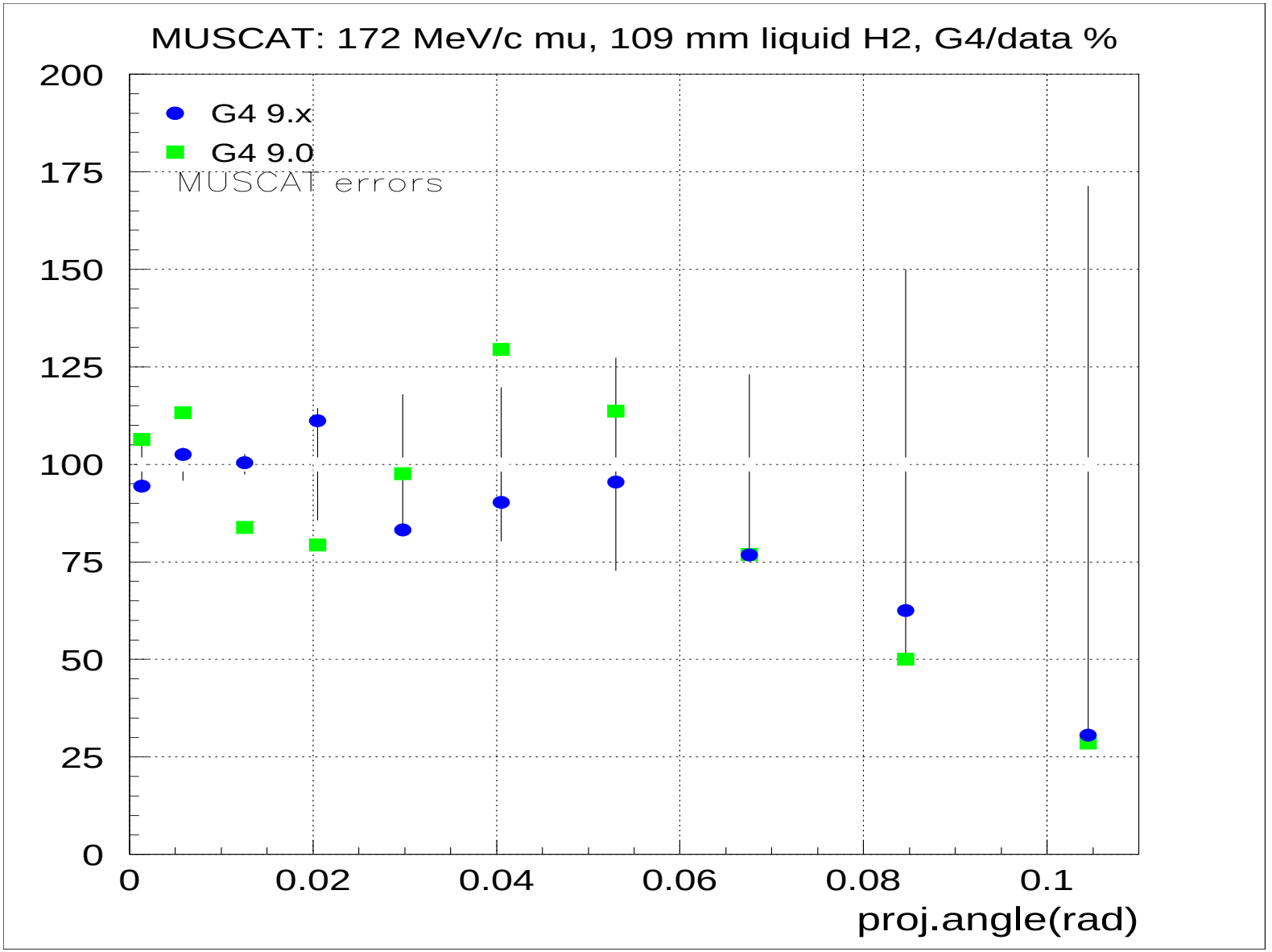
- simpler model functions for the angle distribution part $\longrightarrow$ MSC is slightly faster, step dependence smaller than in 9.0

- same small angle and tail behaviour than in 9.0, but some modification in the region between the small angle part and the tail $\longrightarrow$ see next slide

- improvement in muon-H2 scattering too – slides.


Angular distribution of 15.7 MeV e- after 18.66 mg/cm2 Au foil
Geant4 9.0
Geant4 9.x
theory,Spencer Phys.Rev.93,114(1954)
10 3
10 2
10
1
0
2
4
6
8
10
12
angle(deg)


MUSCAT: 172 MeV/c mu , 109 mm liquid H2
MUSCAT data
G4 9.x
G4 9.0
10 2
10
1
10 -1
10 -2
10 -3
0
0.02
0.04
0.06
0.08
0.1
proj.angle(rad)


MUSCAT: 172 MeV/c mu, 109 mm liquid H2, G4/data %
G4 9.x
G4 9.0
MUSCAT errors
200
175
150
125
100
75
50
25
0
0
0.02
0.04
0.06
0.08
0.1
proj.angle(rad)