Stopping Physics and Intermediate Energy Range Validation in Geant4.9.5-ref01 (status report – work in progress)

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Fermilab

Geant4 HAD Group meeting
2/22/2012

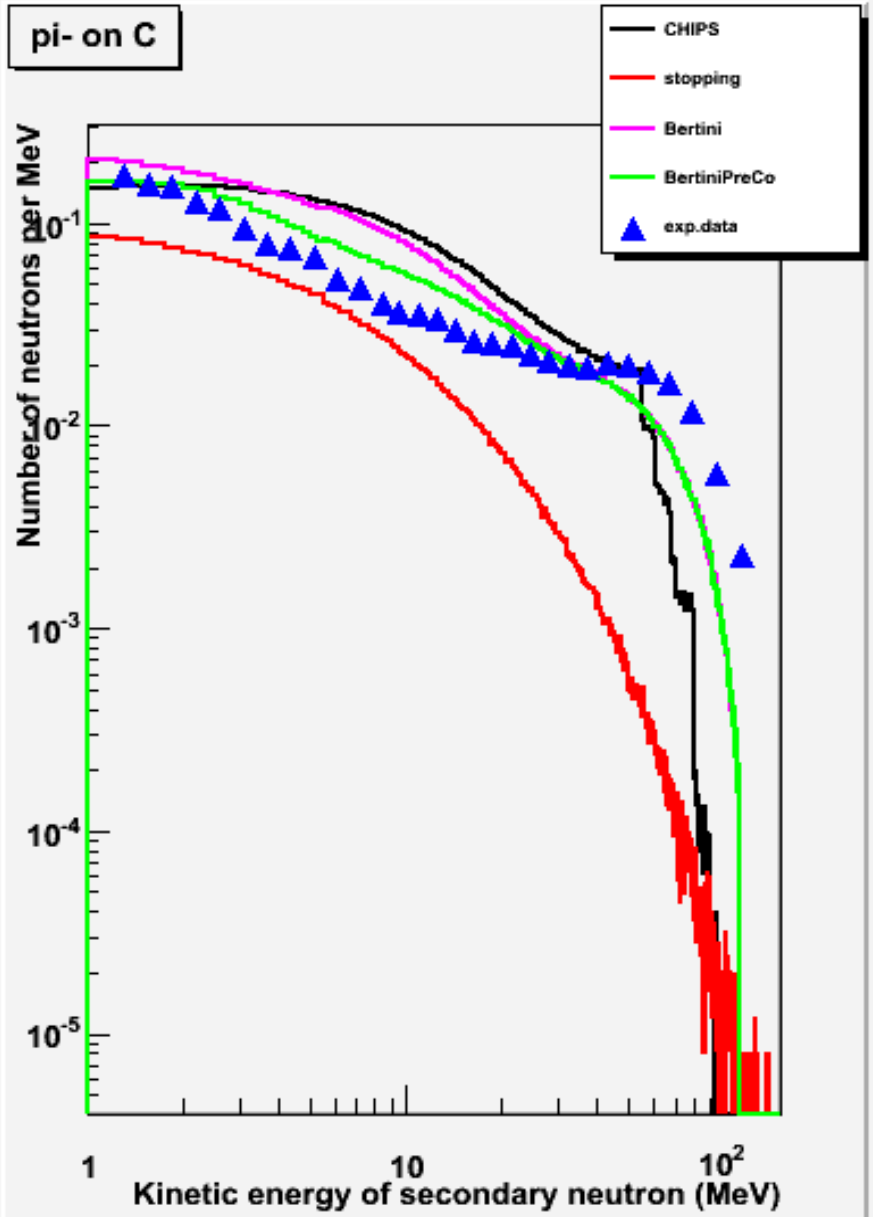
Outline

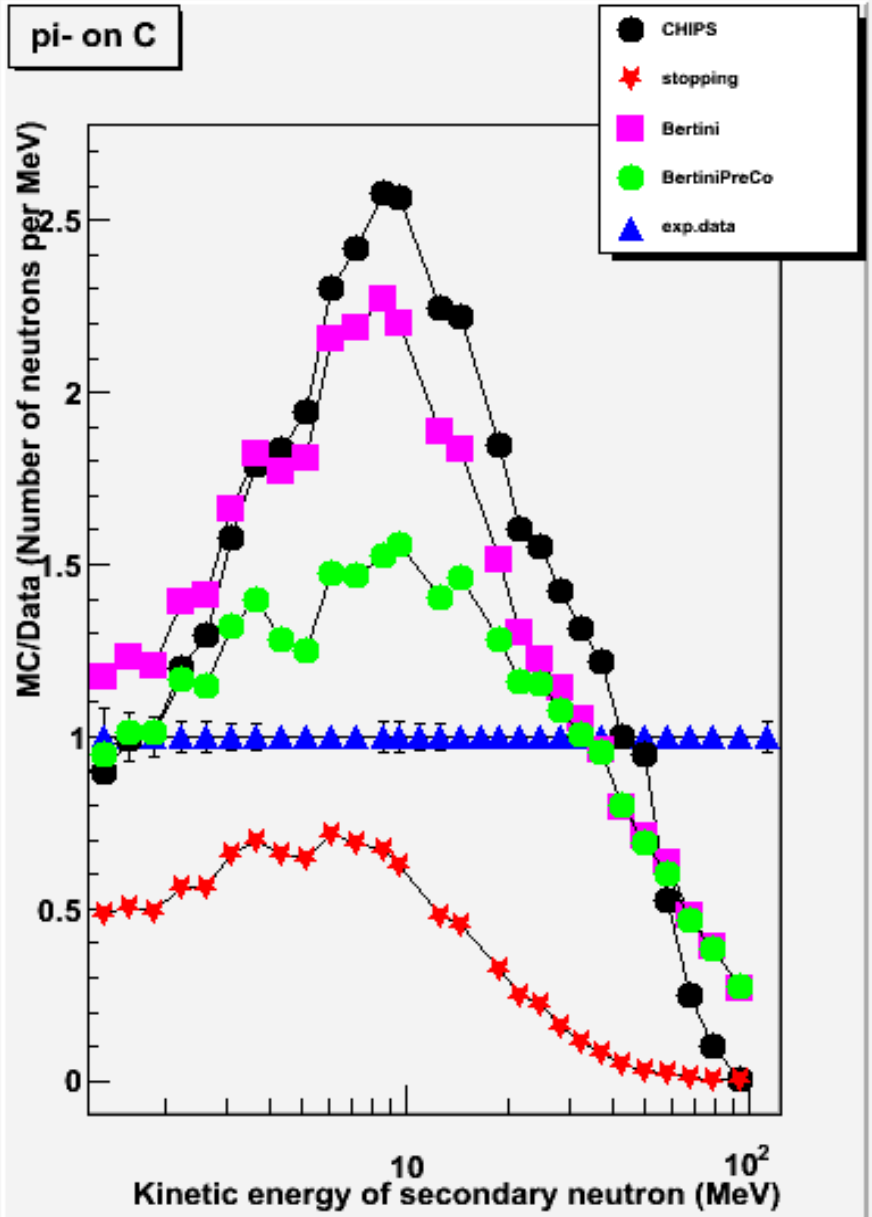
- Geant4: 9.5-ref01 & 9.5+9.4.ref10 (references)
- Stopping Physics:
  - Particles: pi-, K-, pbar
  - Models:
    - Traditional (Geisha) and CHIPS
    - Bertini, Bertini+Precompound
    - FTF – pbar
- Intermediate energy range (1.4-7.5GeV)
  - proton, pi+; pi- in progress
  - Models: Bertini; FTF and CHIPS to be finalized shortly

pi- capture

- Data set:
  - R.Madey et al.,Phys.Rev.C25,3050(1982)
- Targets: C, N, O, Al, Cu, Ta, Pb
- Models comparison (slides 4-10)
  - BertiniPreCo the closest fit to exp.data for all targets
- Regression test for CHIPS added (slides 11-16)
  - Changes in G4.9.5-ref01 do not seem right
  - Worrisome as CHIPS stopping physics used in many lists
  - Time to start replacing it with Bertini stopping physics ?
- Focus on Bertini
  - Regression test (slides 17-23)
  - 2 sets of nucl.struct. parameters tested for Pb (slide 24)

Geant 4


pi- on C
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
Number of neutrons per MeV
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
1
10
10^2
Kinetic energy of secondary neutron (MeV)


pi- on C
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
MC/Data (Number of neutrons per MeV)
2.5
2
1.5
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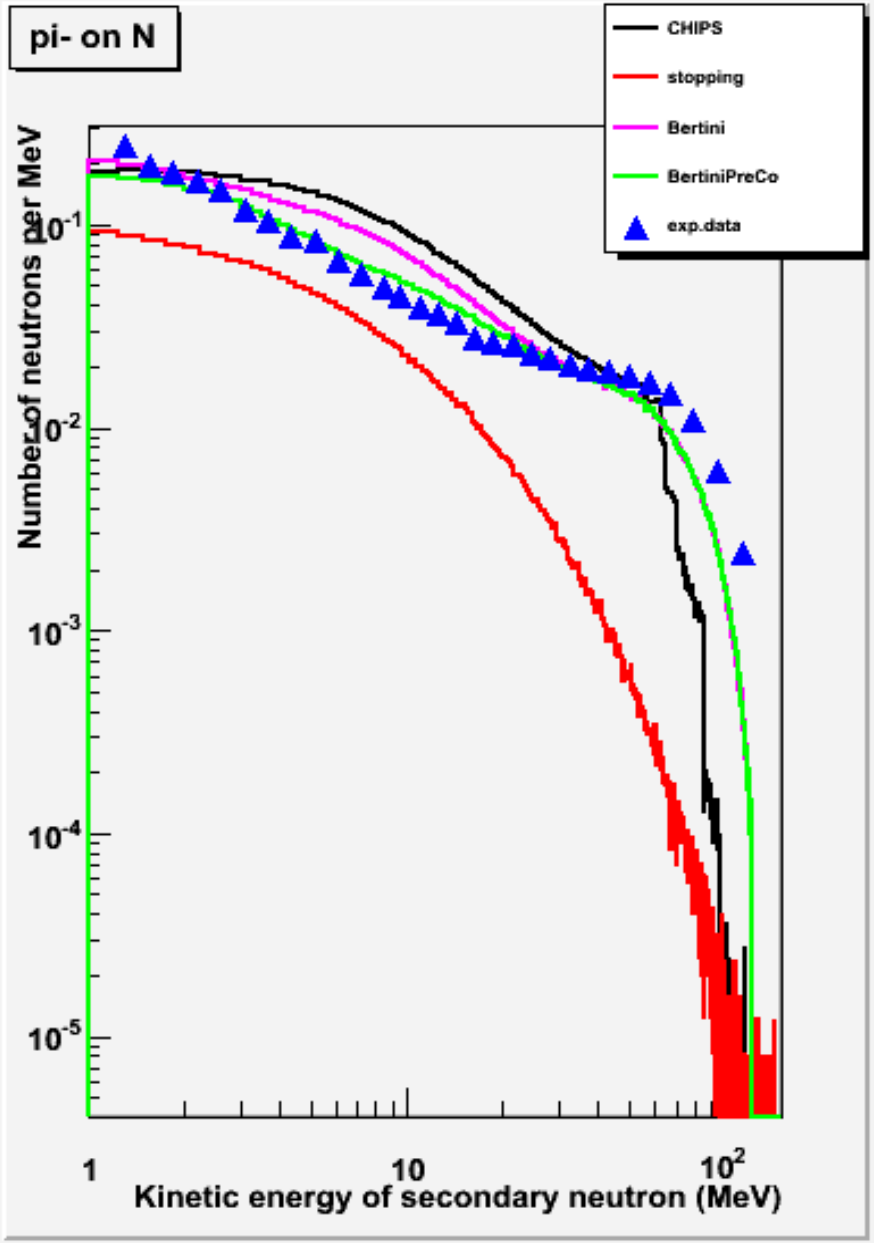
0
10
10^2
Kinetic energy of secondary neutron (MeV)

Geant 4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CHIPS
stopping
Bertini
BertiniPreCo
exp.data
Number of neutrons per MeV
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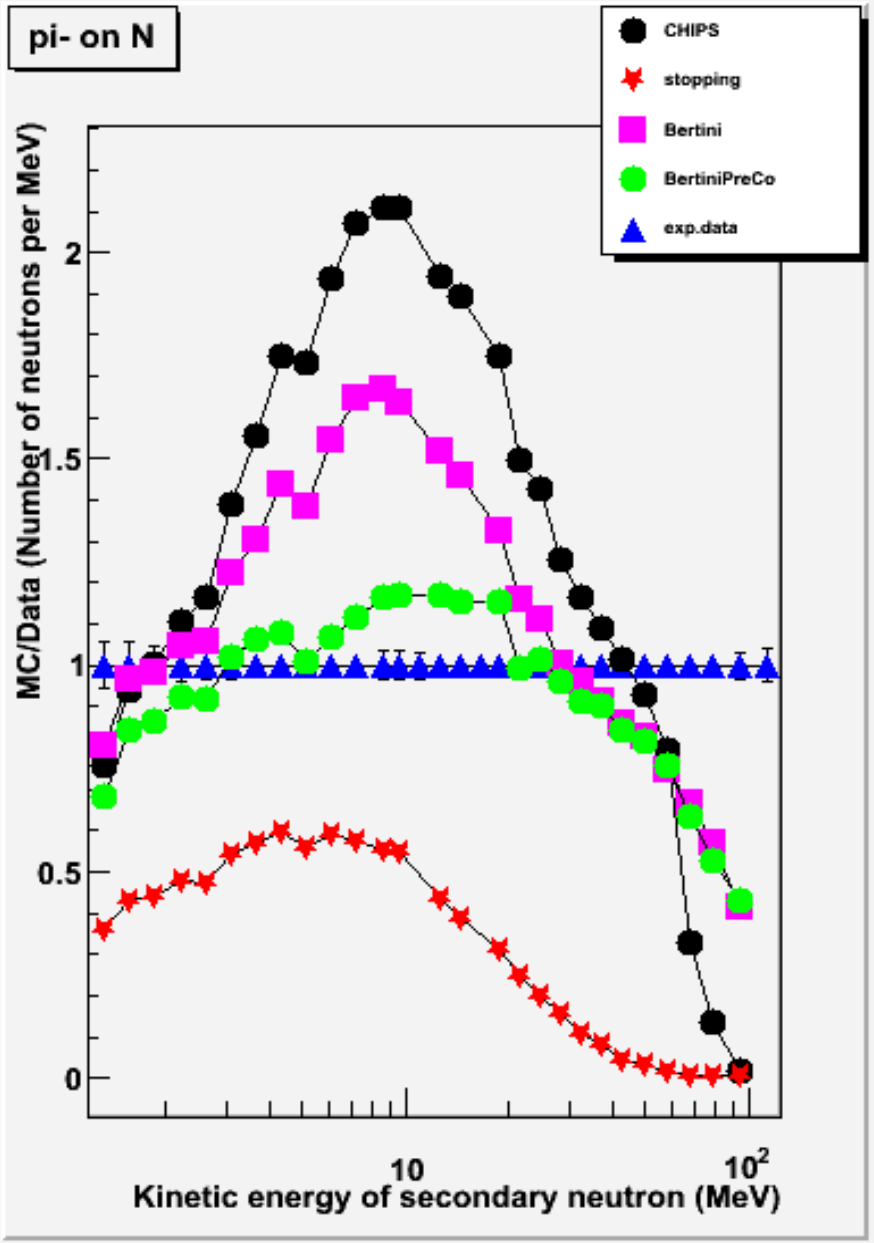
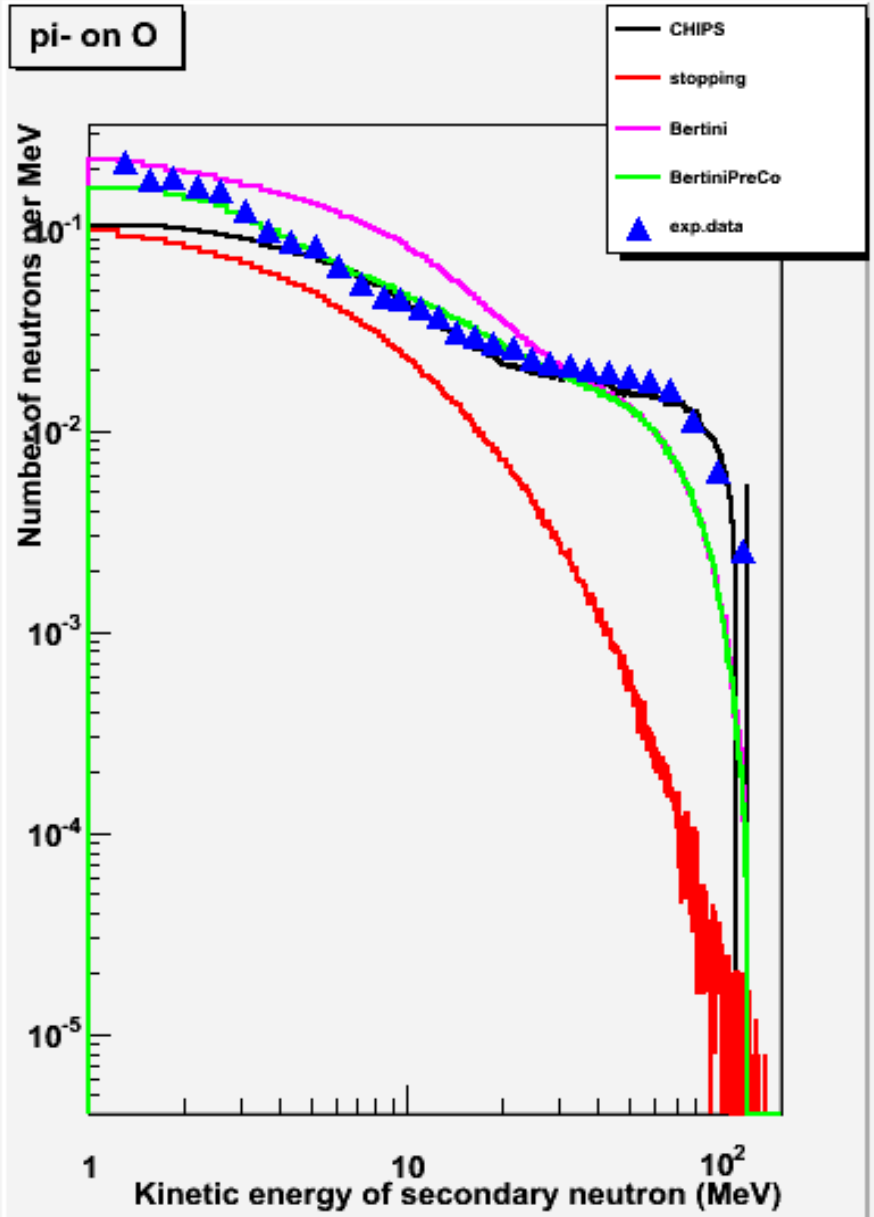
10^{-3}
10^{-4}
10^{-5}
1
10
10^2
Kinetic energy of secondary neutron (MeV)


pi- on N
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
MC/Data (Number of neutrons per MeV)
2
1.5
1
0.5
0
10
10^2
Kinetic energy of secondary neutron (MeV)

Geant 4


pi- on O
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
Number of neutrons per MeV
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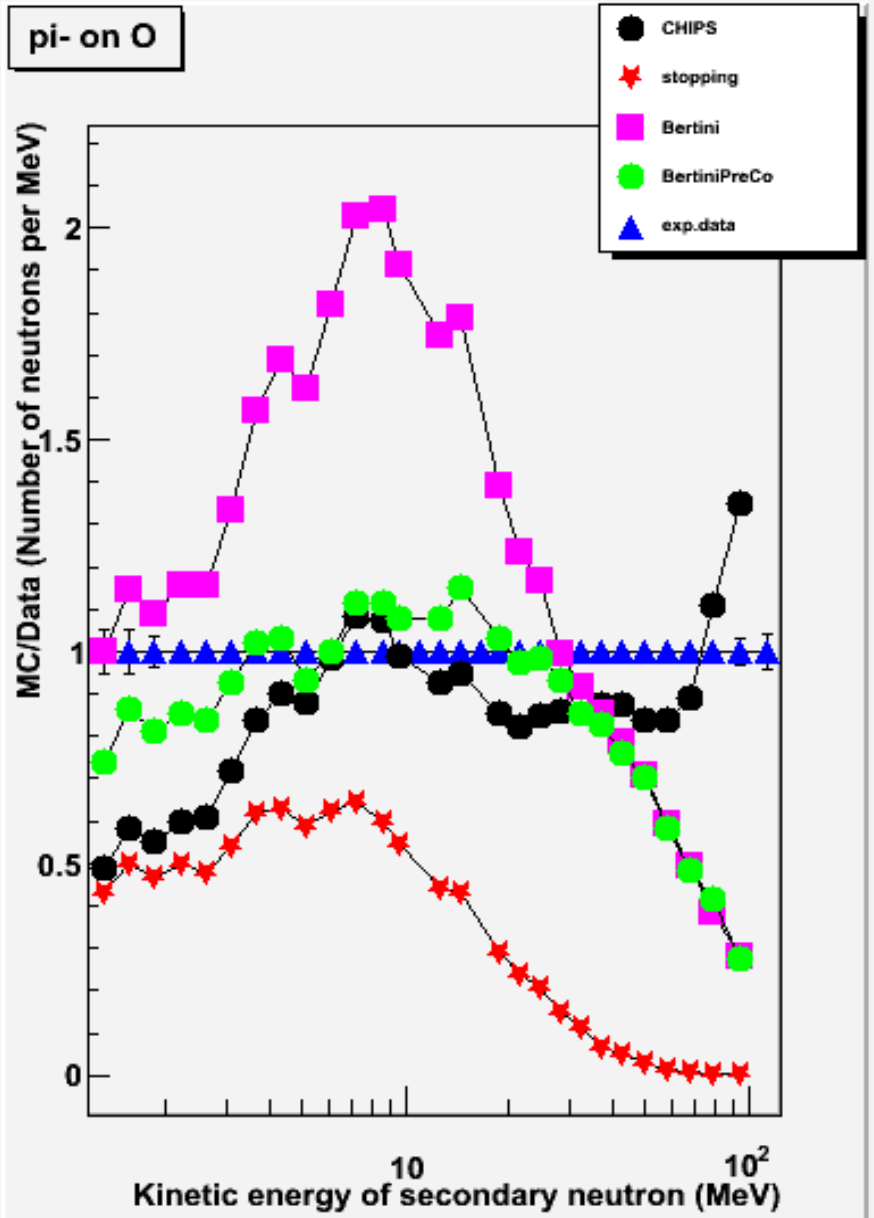
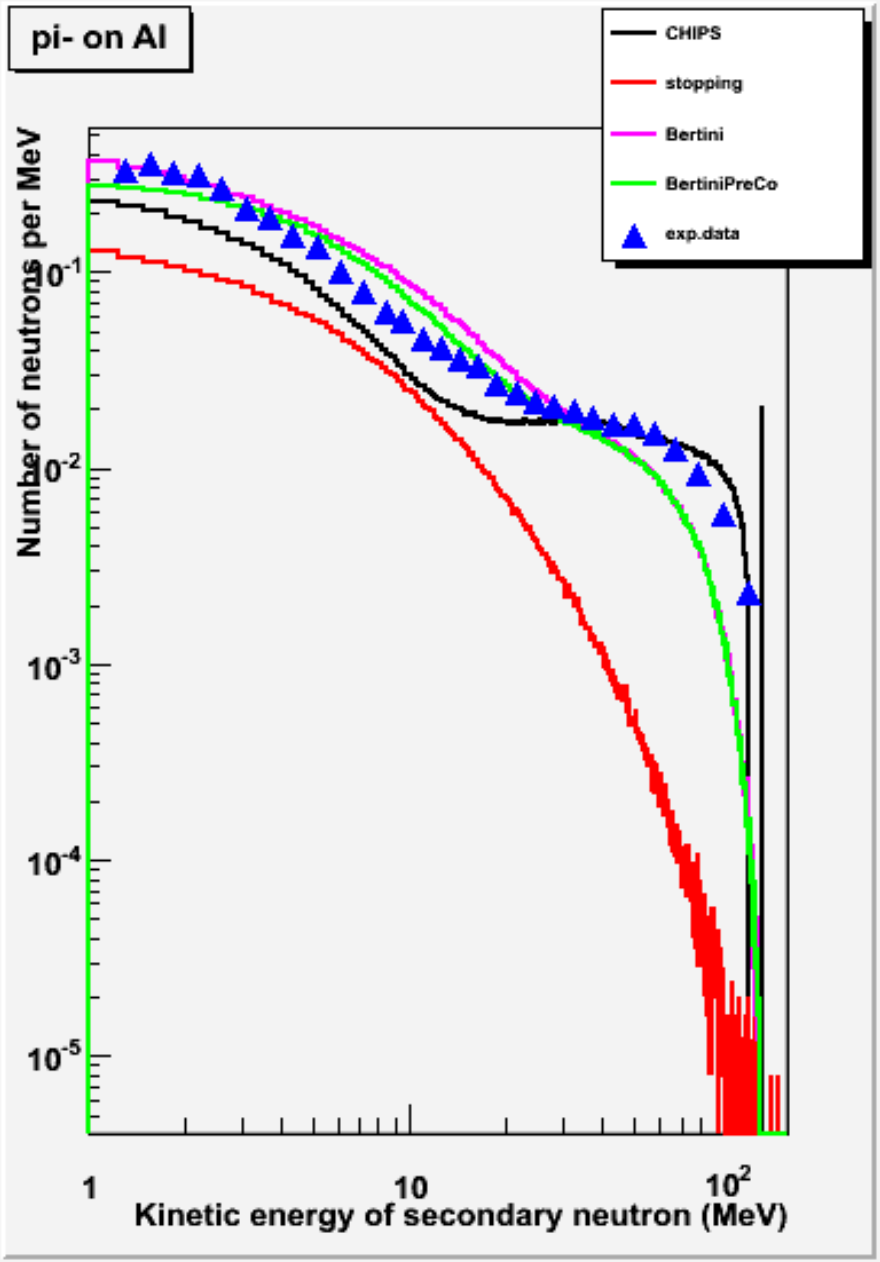
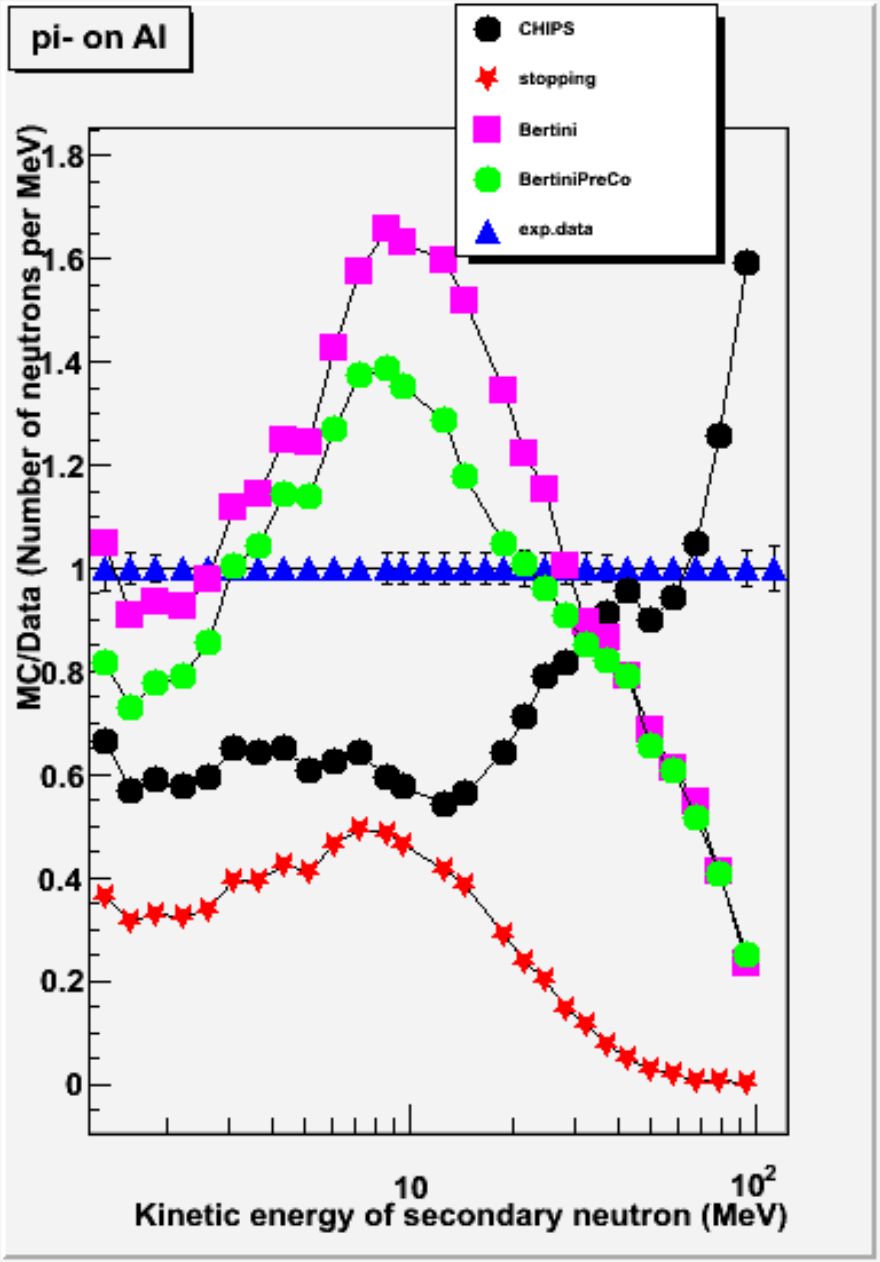
10^{-2}
10^{-3}
10^{-4}
10^{-5}
1
10
10^2
Kinetic energy of secondary neutron (MeV)

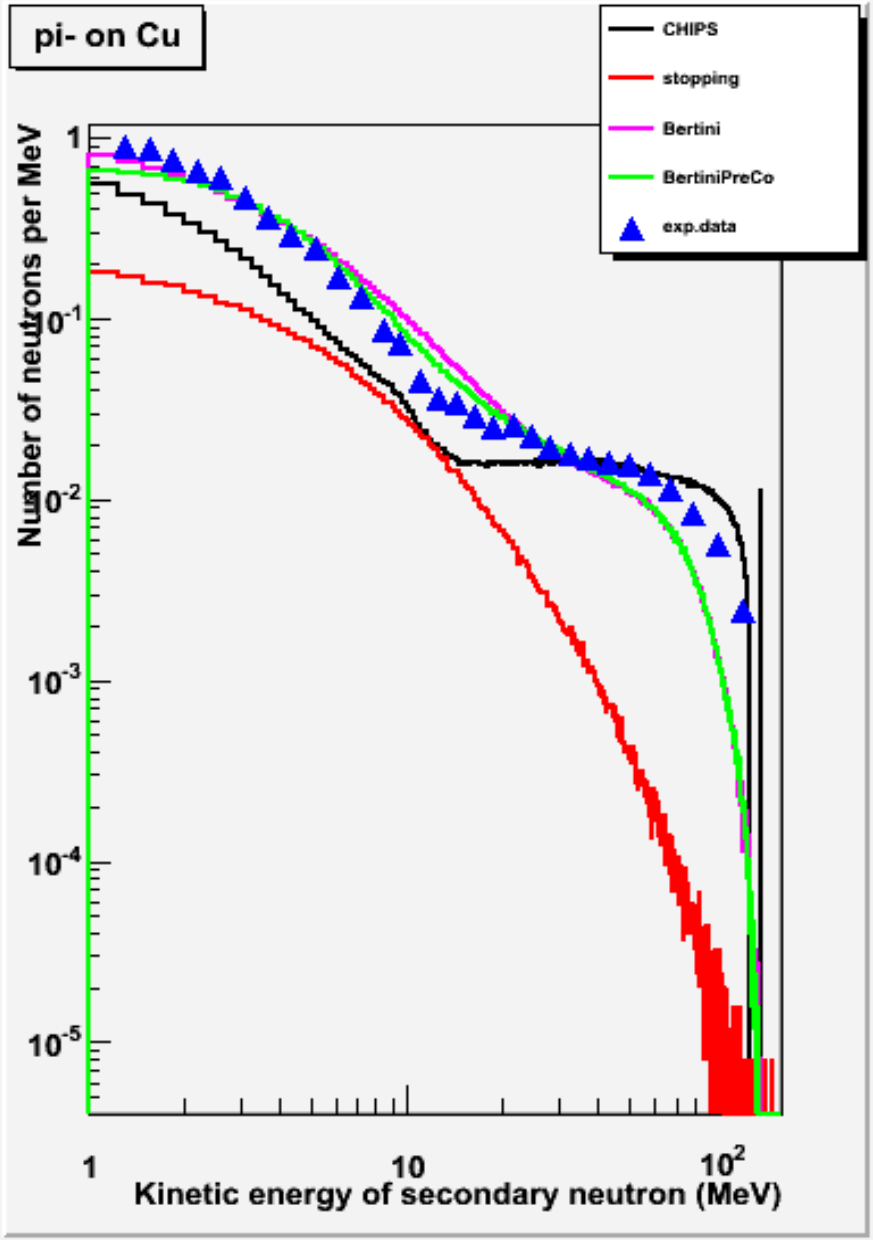

pi- on O
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
MC/Data (Number of neutrons per MeV)
2
1.5
1
0.5
0
10
10^2
Kinetic energy of secondary neutron (MeV)

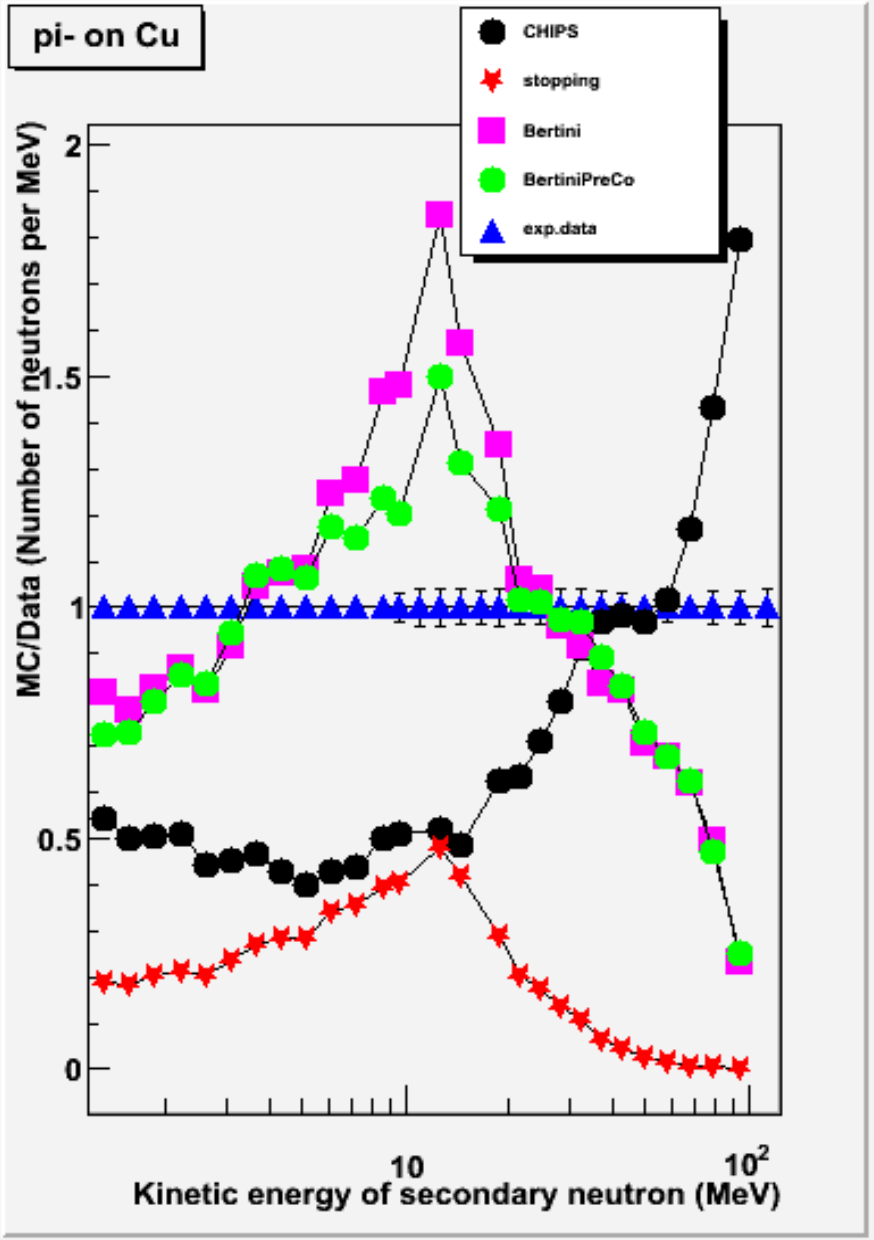
Geant 4


pi- on Al
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
Number of neutrons per MeV
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
1
10
10^2
Kinetic energy of secondary neutron (MeV)

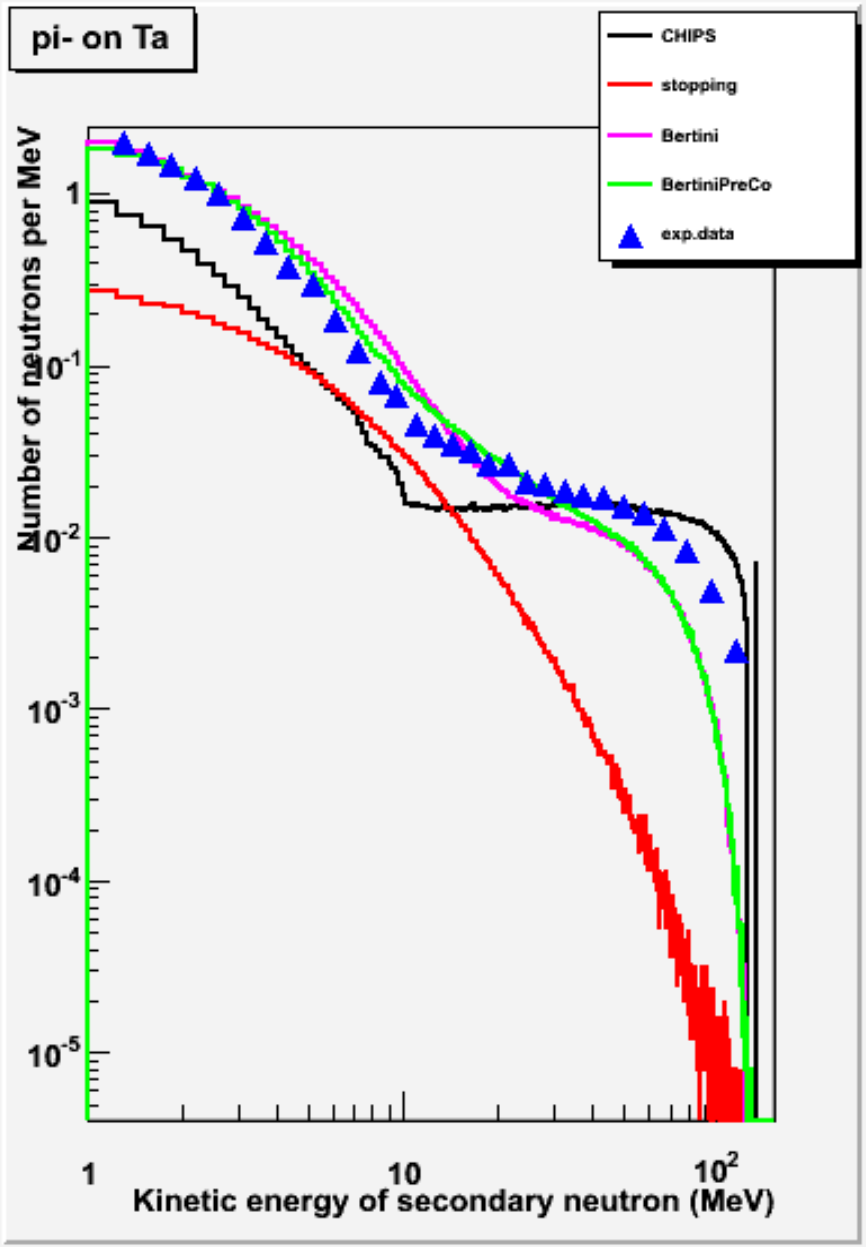

pi- on Al
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
MC/Data (Number of neutrons per MeV)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
10
10^2
Kinetic energy of secondary neutron (MeV)

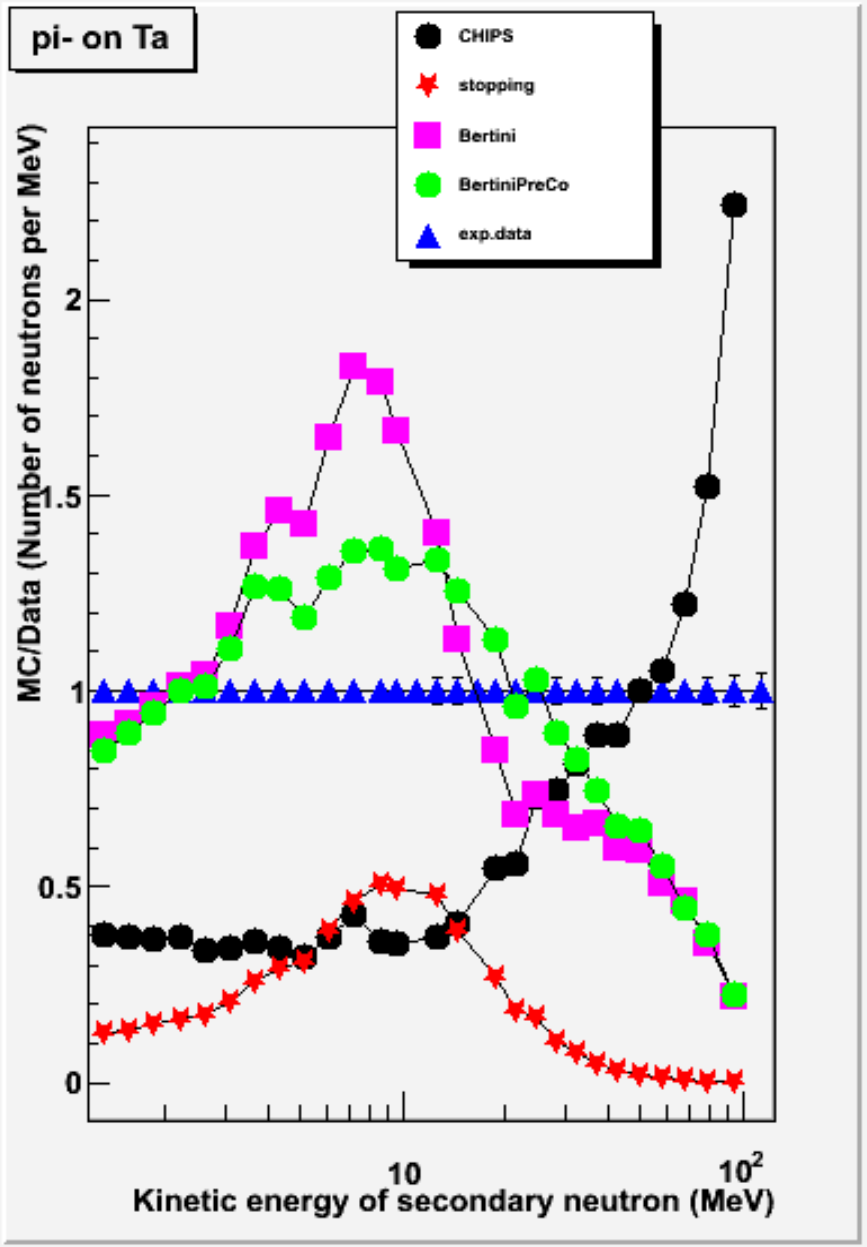
Geant 4


pi- on Cu
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
Number of neutrons per MeV
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
1
10
10^2
Kinetic energy of secondary neutron (MeV)

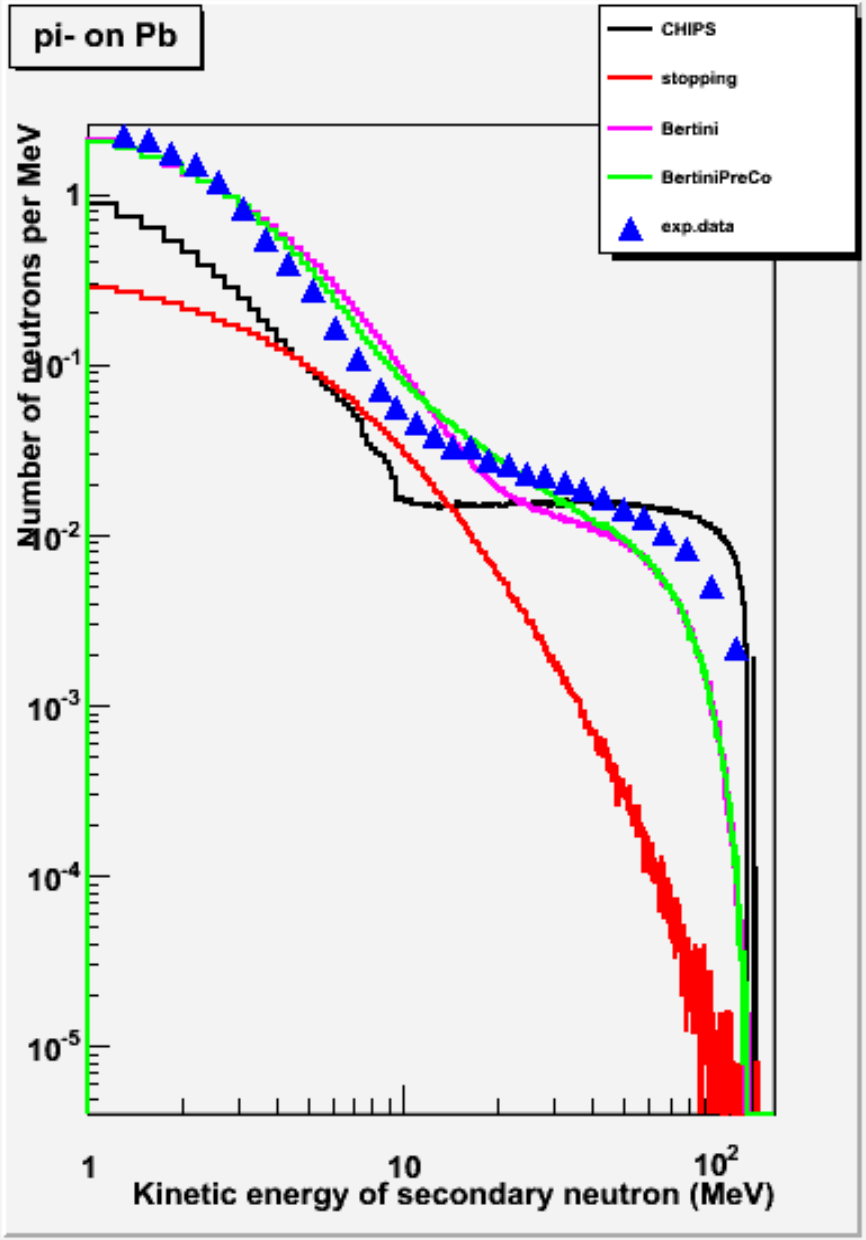

pi- on Cu
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
MC/Data (Number of neutrons per MeV)
2
1.5
1
0.5
0
10
10^2
Kinetic energy of secondary neutron (MeV)

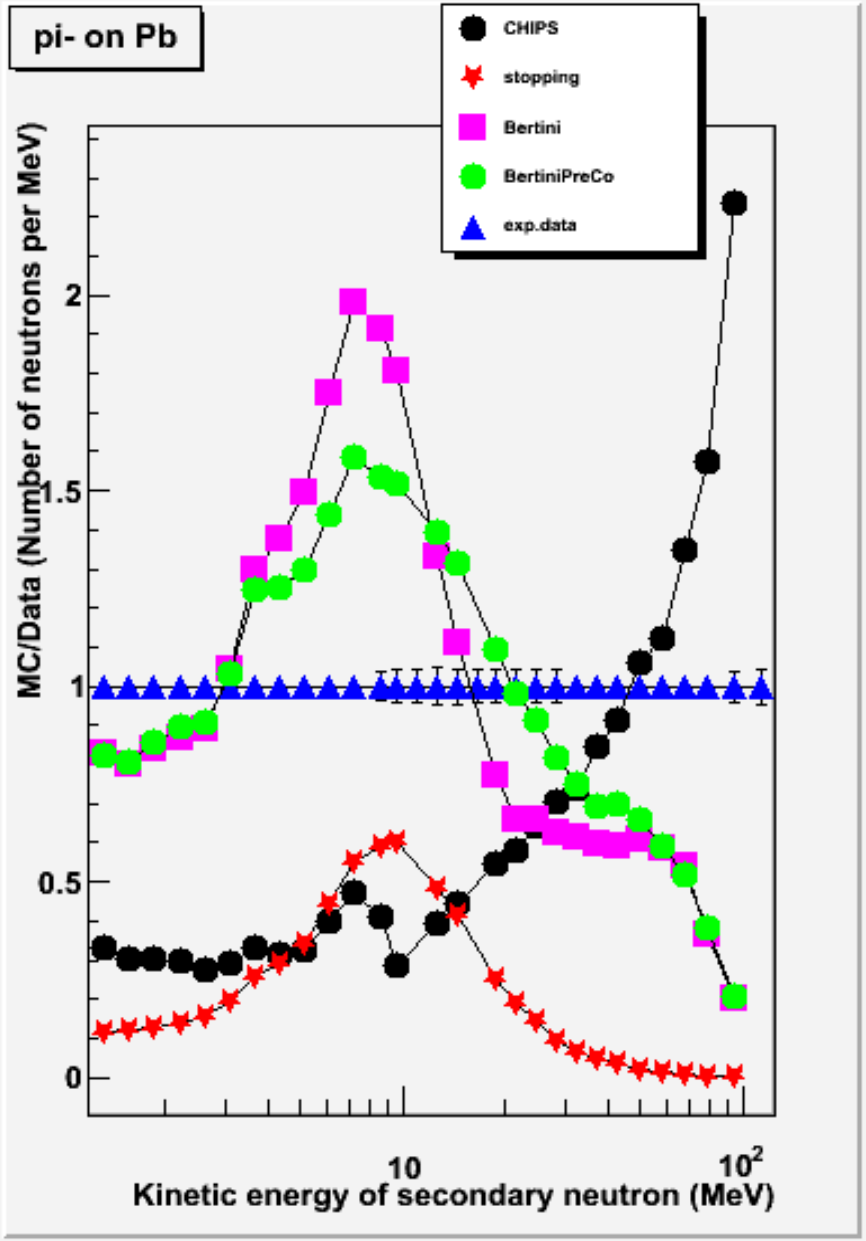
Geant 4


pi- on Ta
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
Number of neutrons per MeV
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
1
10
10^2
Kinetic energy of secondary neutron (MeV)

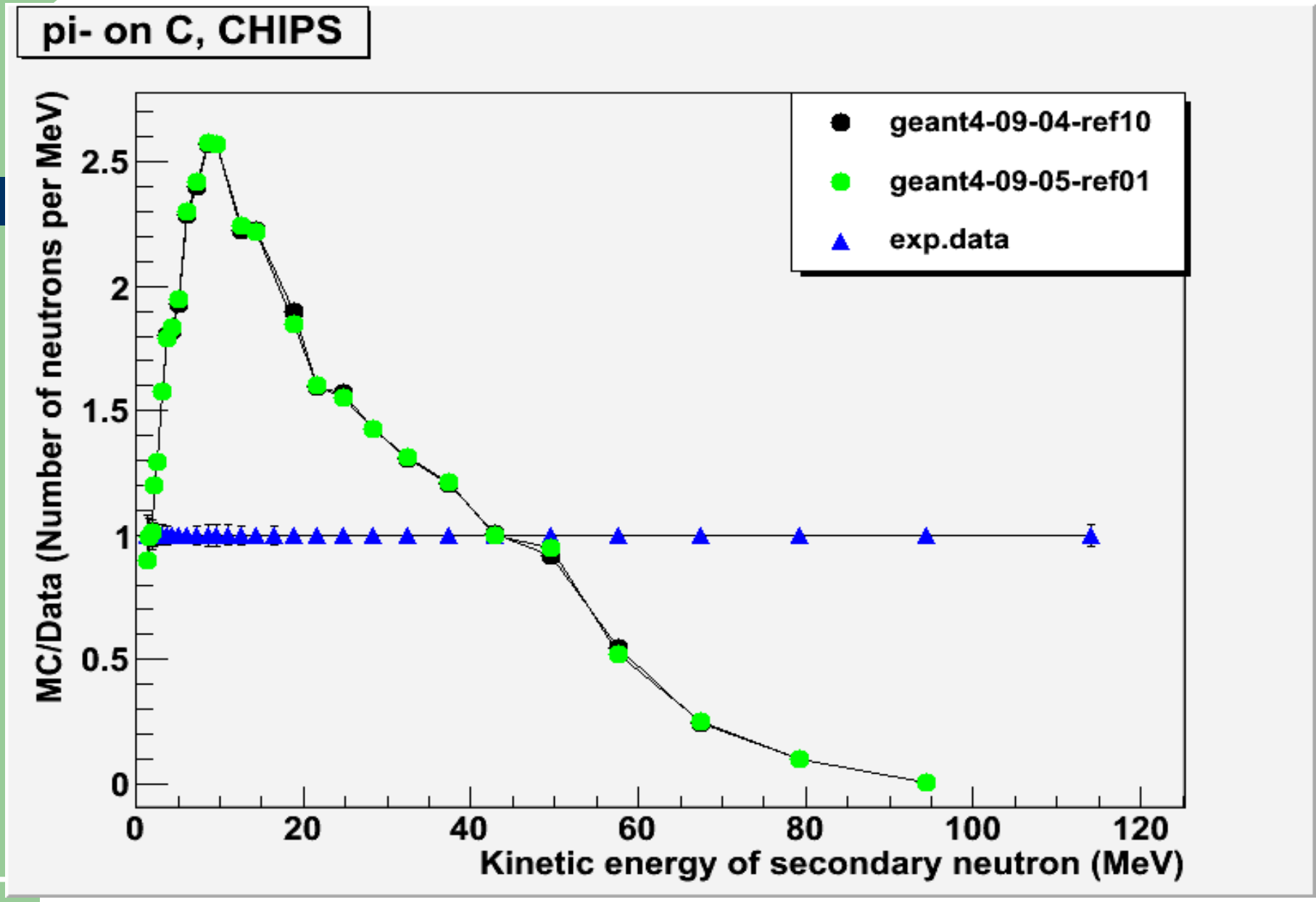

pi- on Ta
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
MC/Data (Number of neutrons per MeV)
2
1.5
1
0.5
0
10
10^2
Kinetic energy of secondary neutron (MeV)

Geant 4

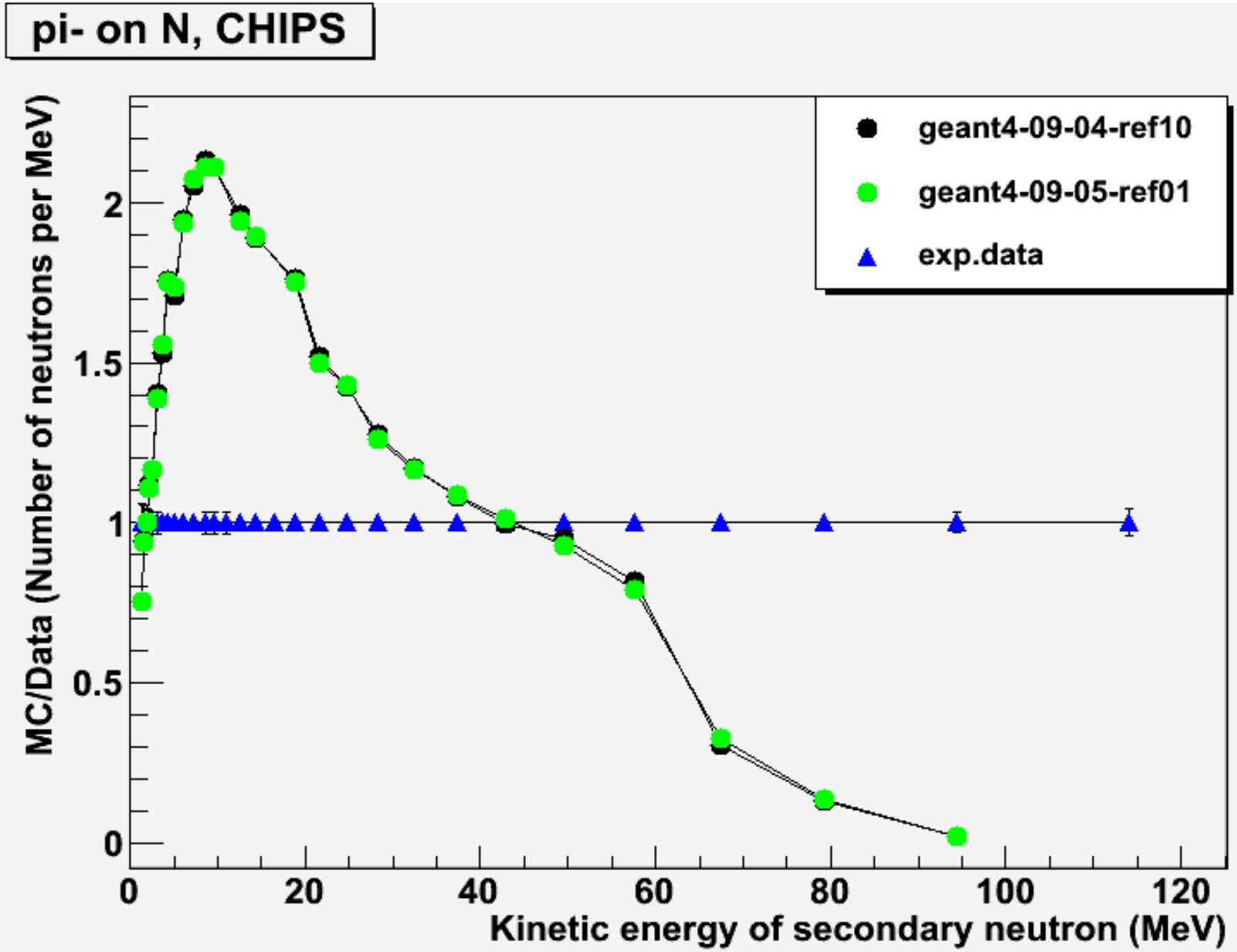

pi- on Pb
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
Number of neutrons per MeV
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
1
10
10^2
Kinetic energy of secondary neutron (MeV)


pi- on Pb
CHIPS
stopping
Bertini
BertiniPreCo
exp.data
MC/Data (Number of neutrons per MeV)
2
1.5
1
0.5
0
10
10^2
Kinetic energy of secondary neutron (MeV)

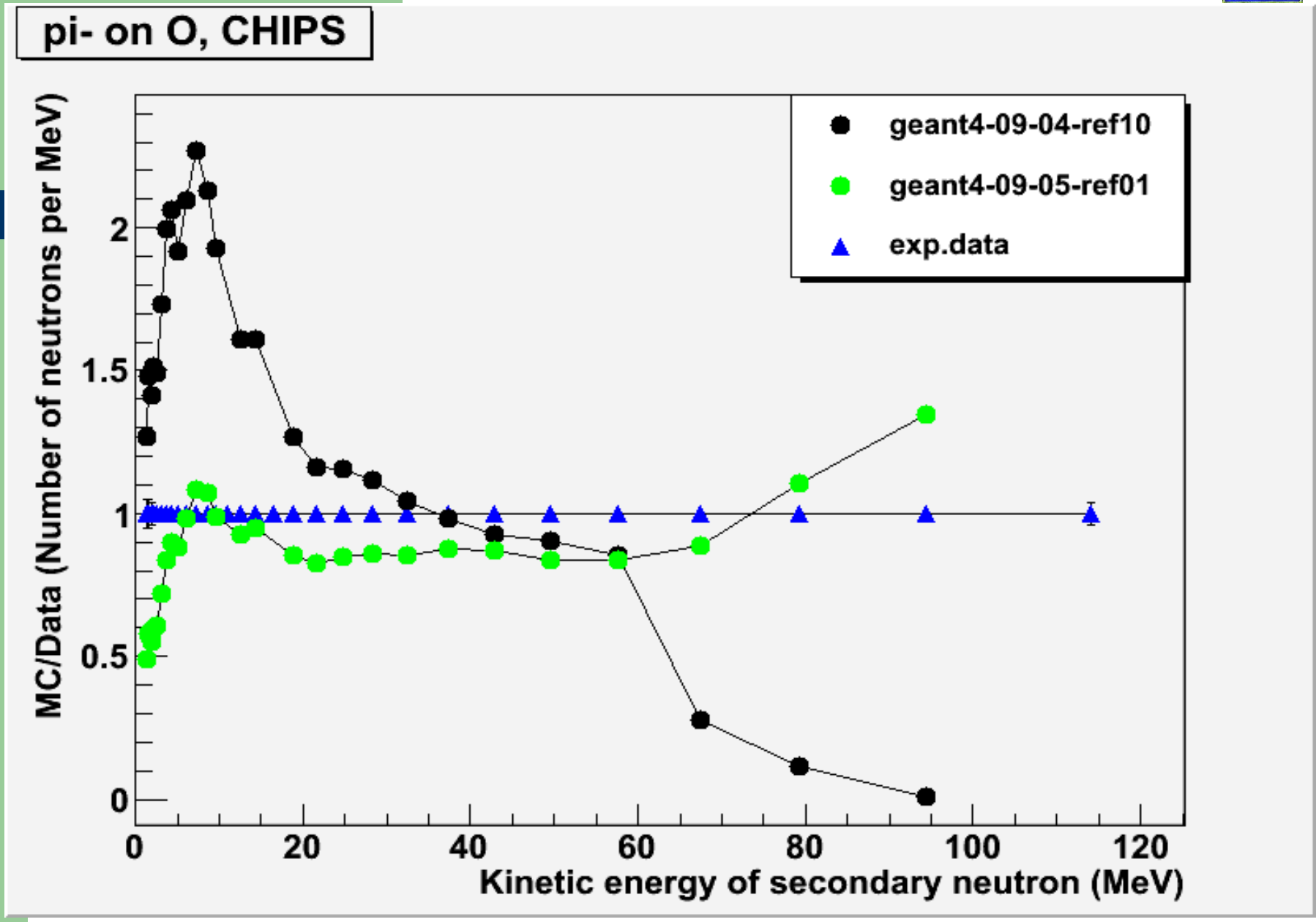
Geant 4


pi- on C, CHIPS
geant4-09-04-ref10
geant4-09-05-ref01
exp.data
MC/Data (Number of neutrons per MeV)
0
0.5
1
1.5
2
2.5
0
20
40
60
80
100
120
Kinetic energy of secondary neutron (MeV)

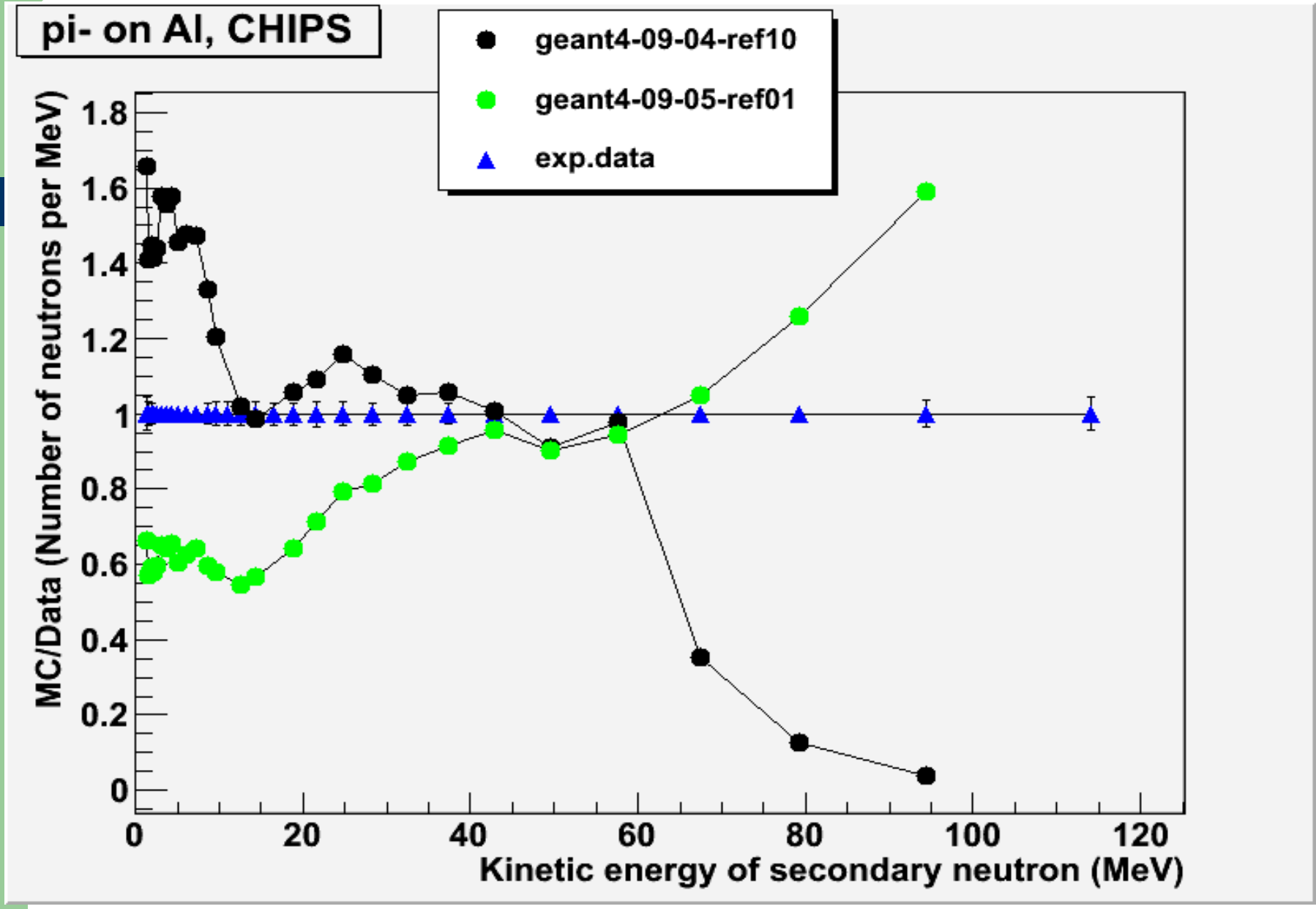
Geant 4


pi- on N, CHIPS
geant4-09-04-ref10
geant4-09-05-ref01
exp.data
MC/Data (Number of neutrons per MeV)
0
0.5
1
1.5
2
0
20
40
60
80
100
120
Kinetic energy of secondary neutron (MeV)

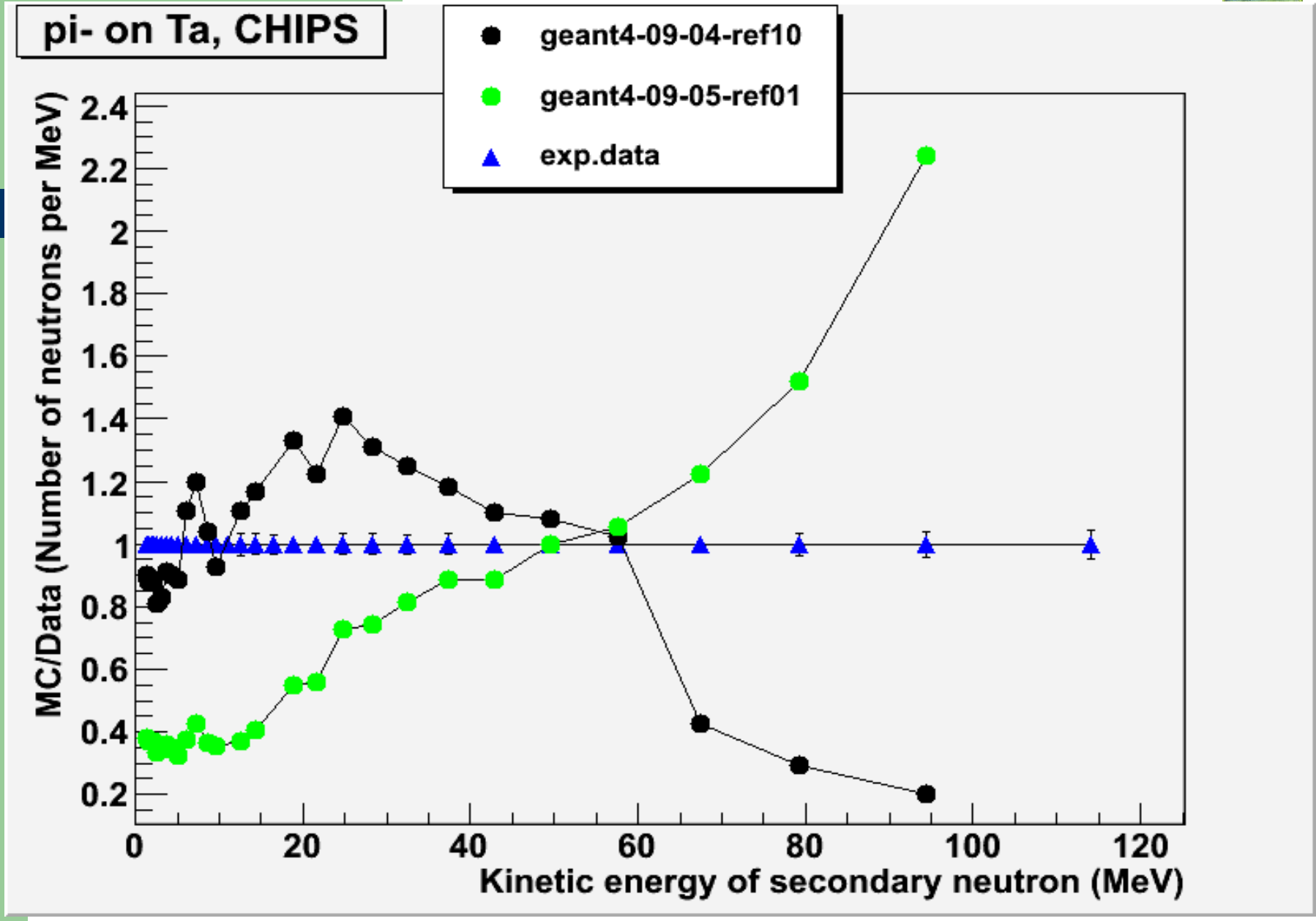
Geant 4


pi- on O, CHIPS
geant4-09-04-ref10
geant4-09-05-ref01
exp.data
MC/Data (Number of neutrons per MeV)
0
0.5
1
1.5
2
0
20
40
60
80
100
120
Kinetic energy of secondary neutron (MeV)

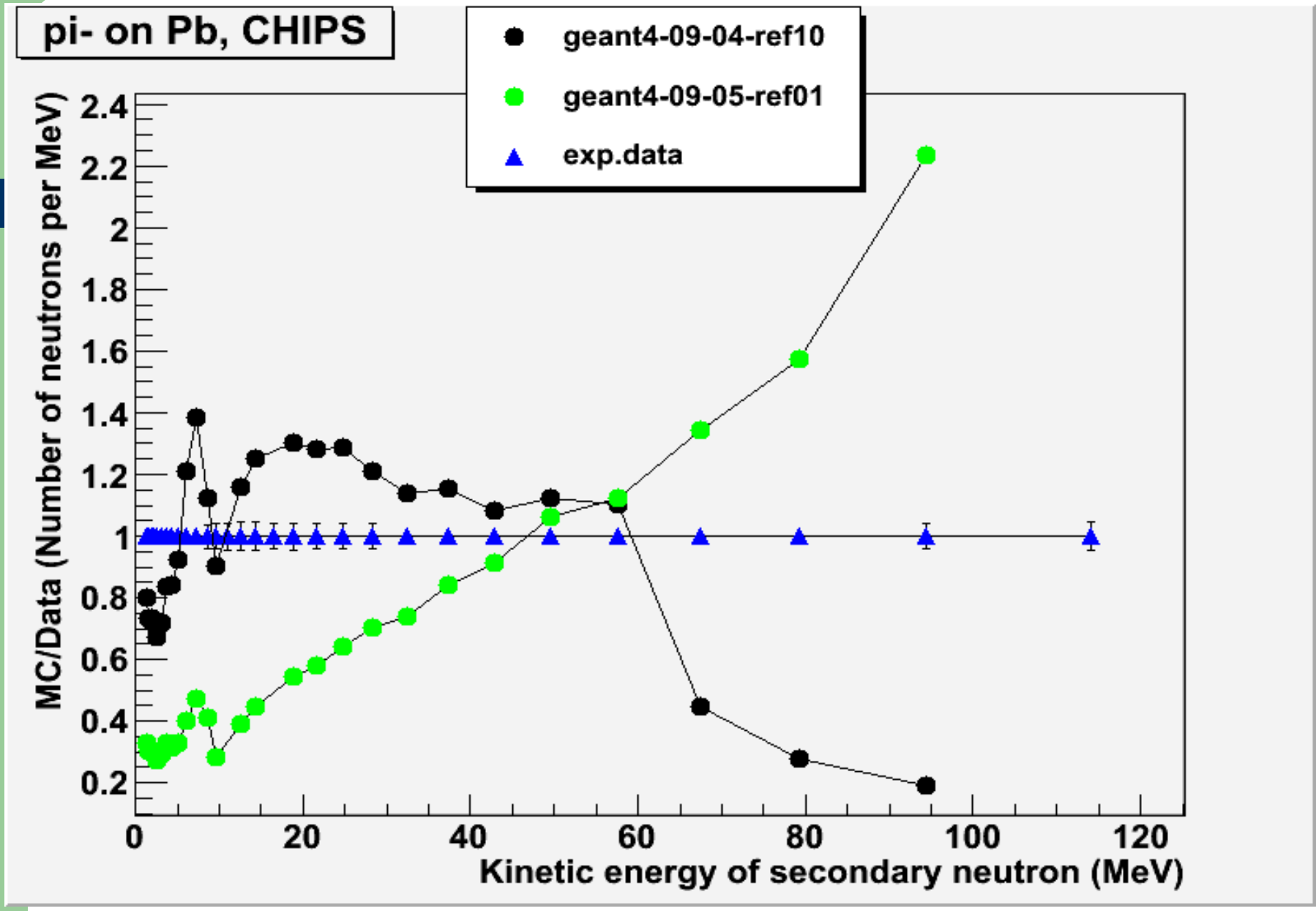
Geant 4


pi- on Al, CHIPS
geant4-09-04-ref10
geant4-09-05-ref01
exp.data
MC/Data (Number of neutrons per MeV)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
Kinetic energy of secondary neutron (MeV)

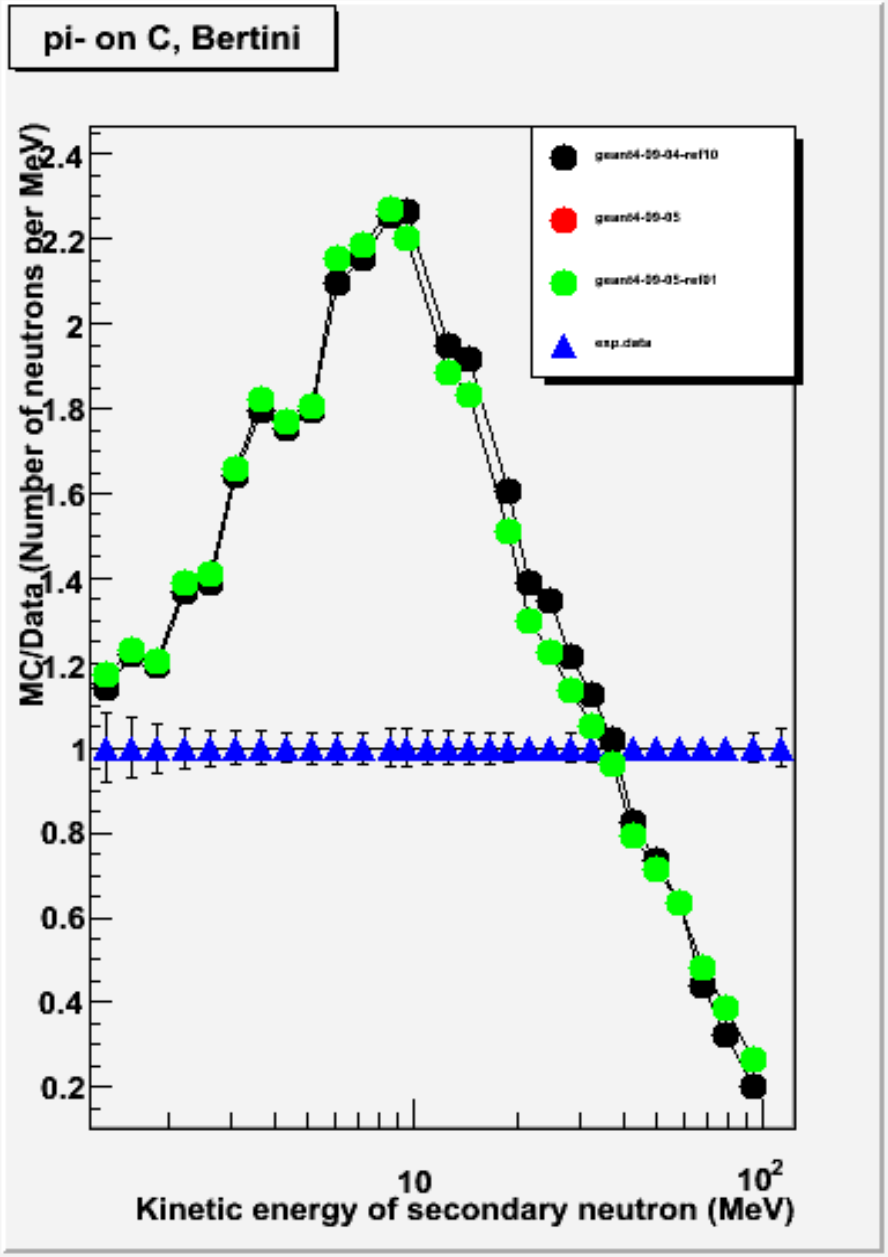
Geant 4

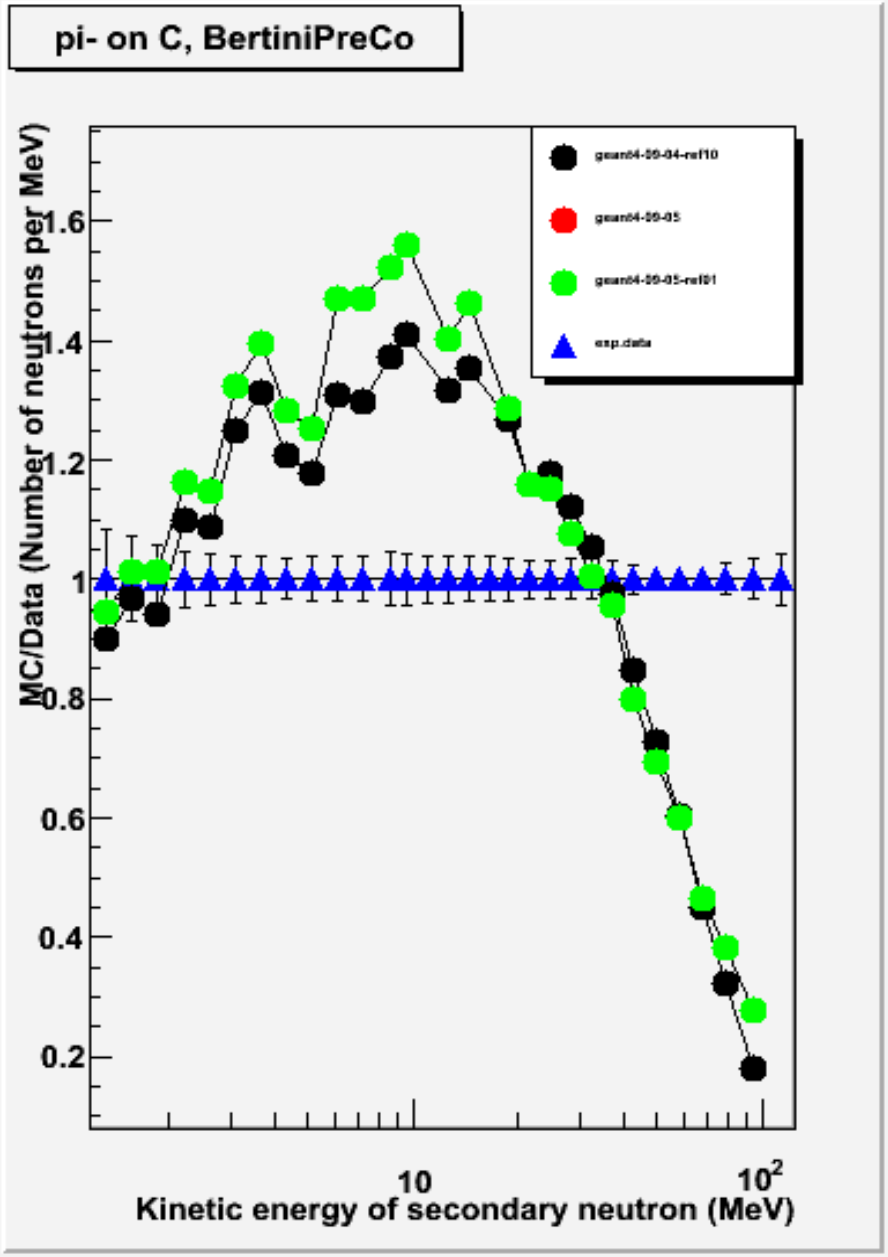

pi- on Ta, CHIPS
geant4-09-04-ref10
geant4-09-05-ref01
exp.data
MC/Data (Number of neutrons per MeV)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
20
40
60
80
100
120
Kinetic energy of secondary neutron (MeV)

Geant 4

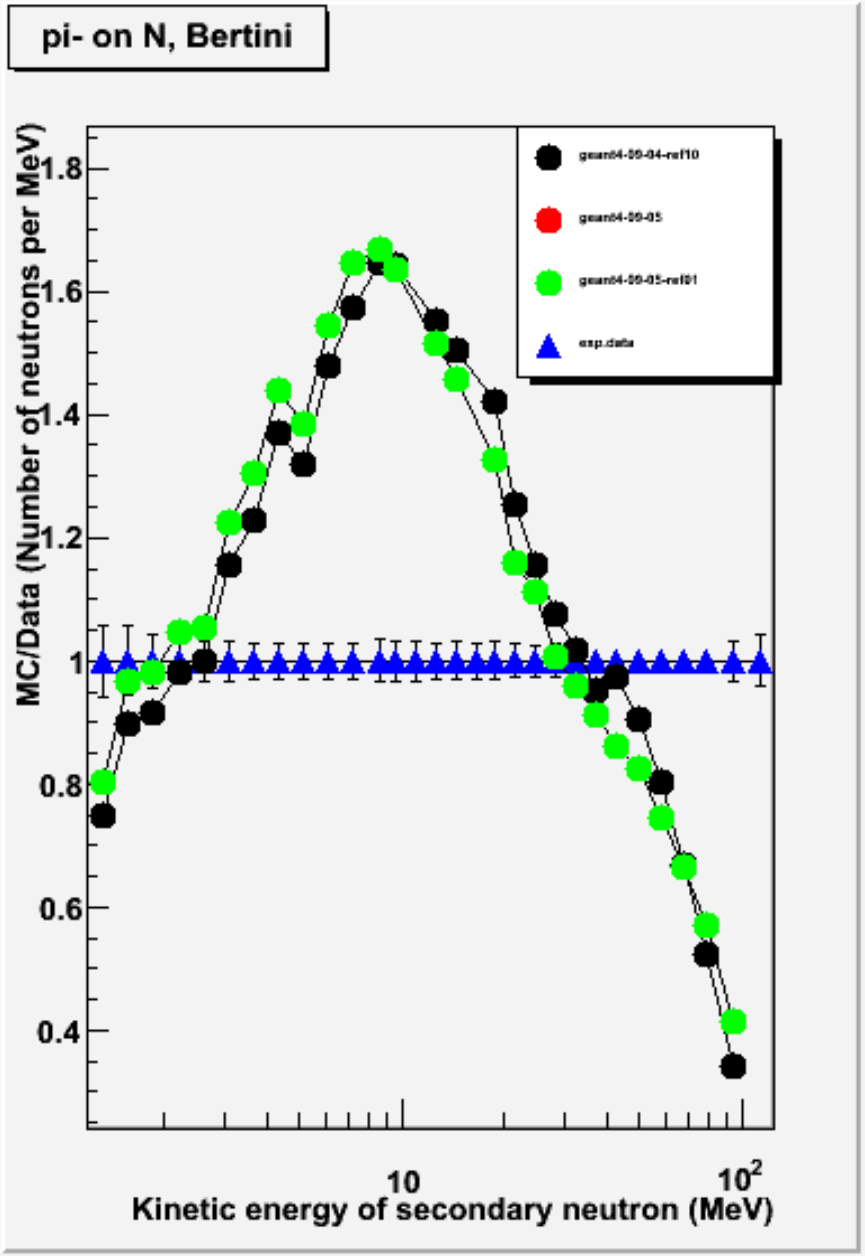

pi- on Pb, CHIPS
geant4-09-04-ref10
geant4-09-05-ref01
exp.data
MC/Data (Number of neutrons per MeV)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
20
40
60
80
100
120
Kinetic energy of secondary neutron (MeV)

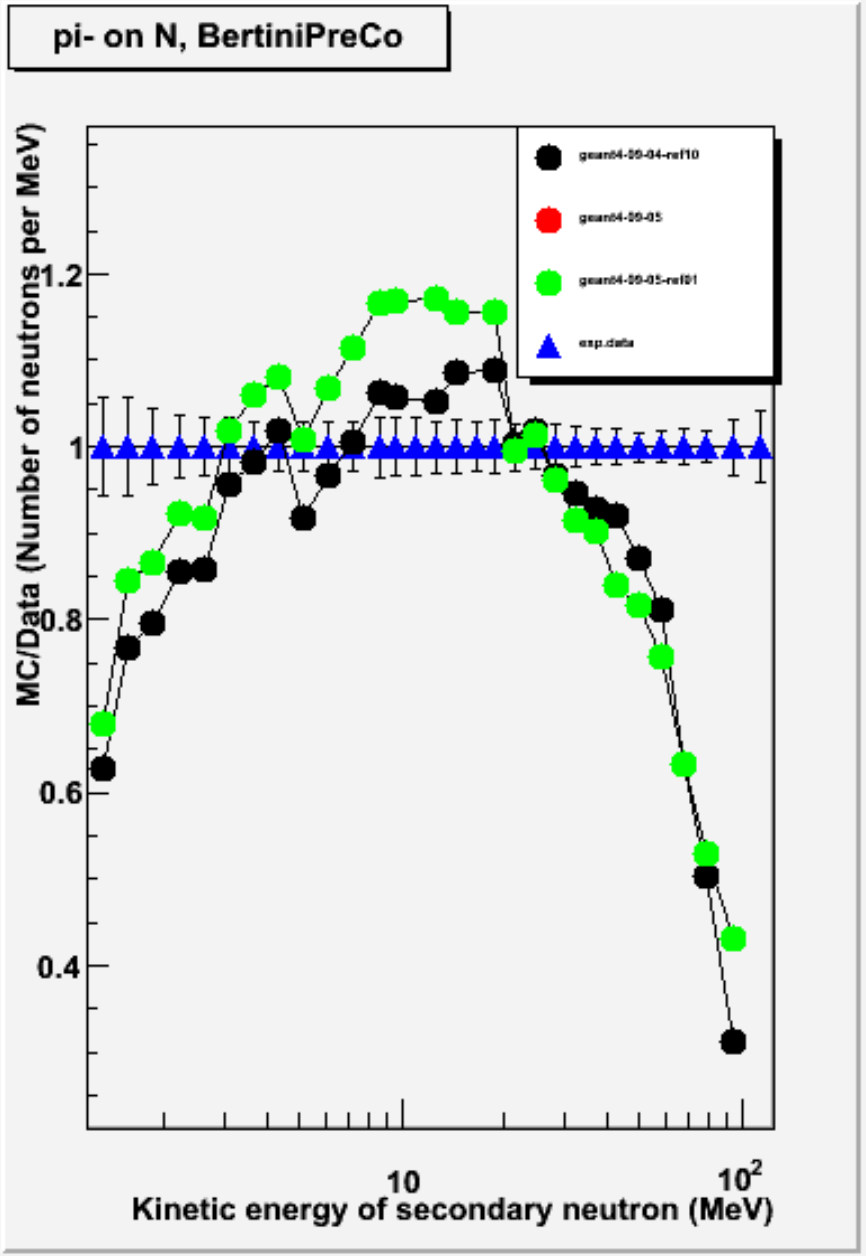
Geant 4


pi- on C, Bertini
MC/Data (Number of neutrons per MeV)
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data

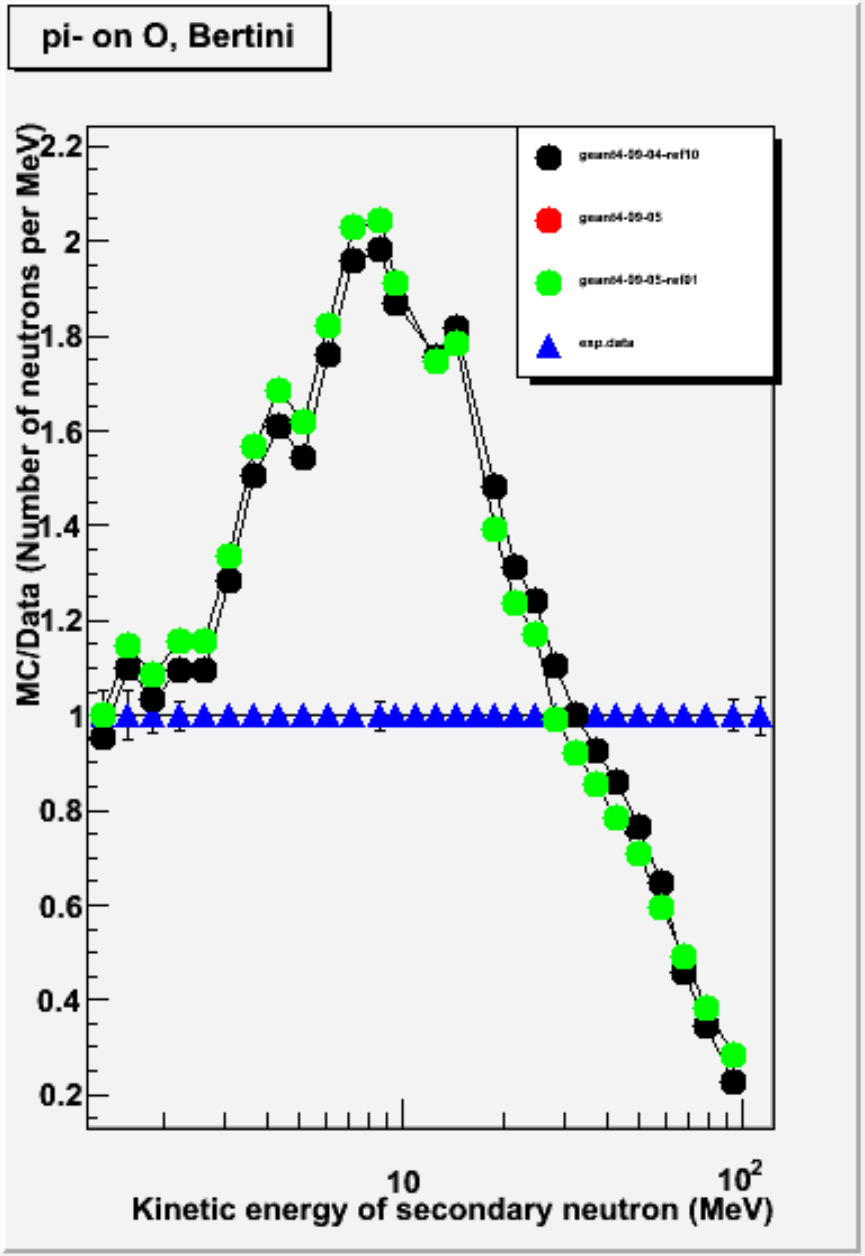

pi- on C, BertiniPreCo
MC/Data (Number of neutrons per MeV)
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data

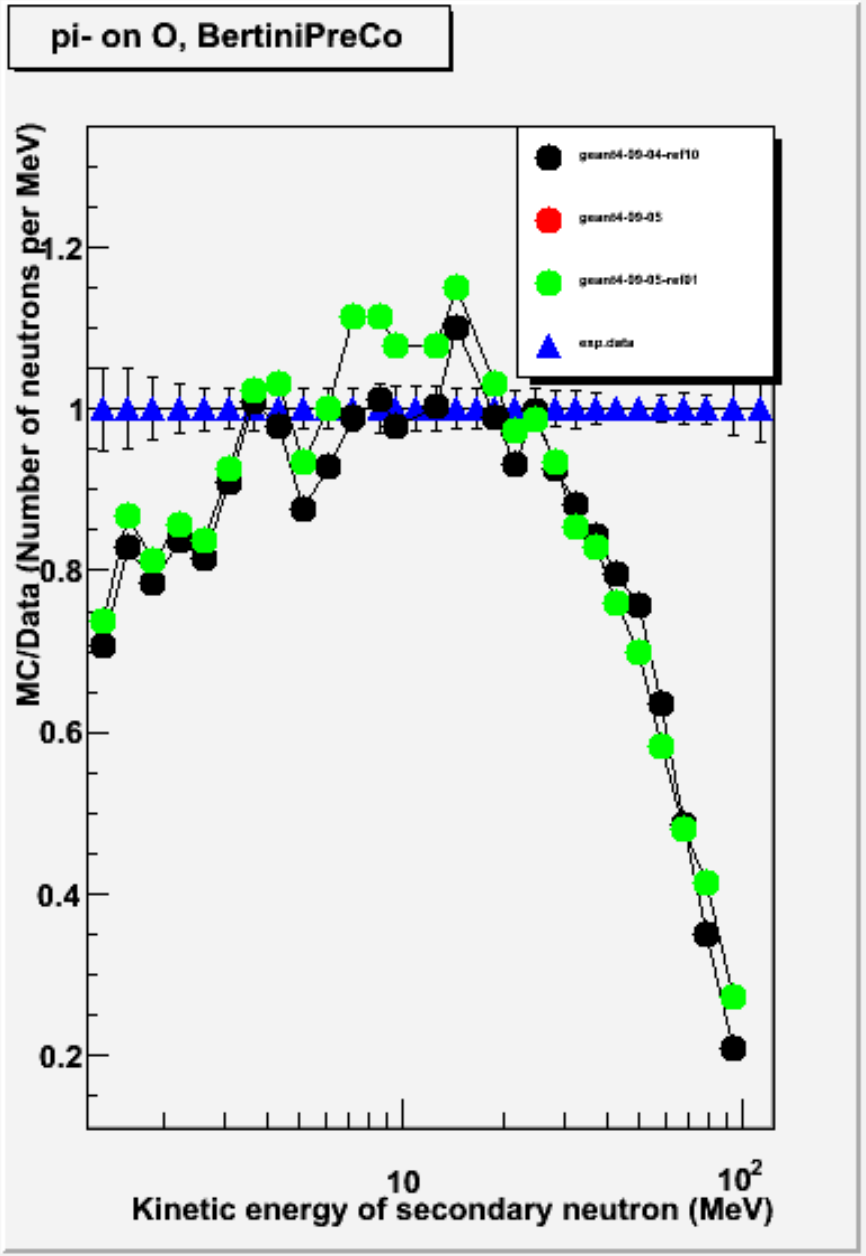
Geant 4


pi- on N, Bertini
MC/Data (Number of neutrons per MeV)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
10
10^2
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data

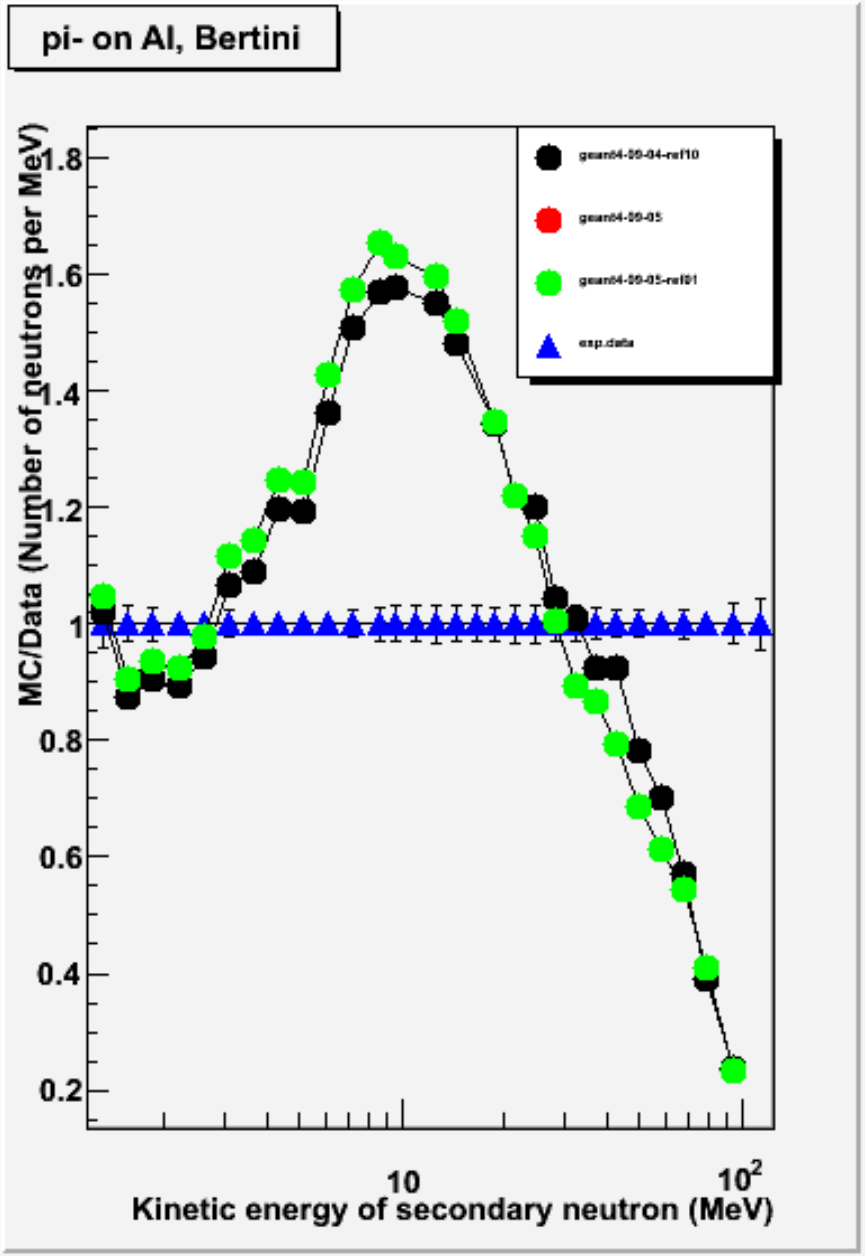

pi- on N, BertiniPreCo
MC/Data (Number of neutrons per MeV)
1.2
1
0.8
0.6
0.4
10
10^2
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data

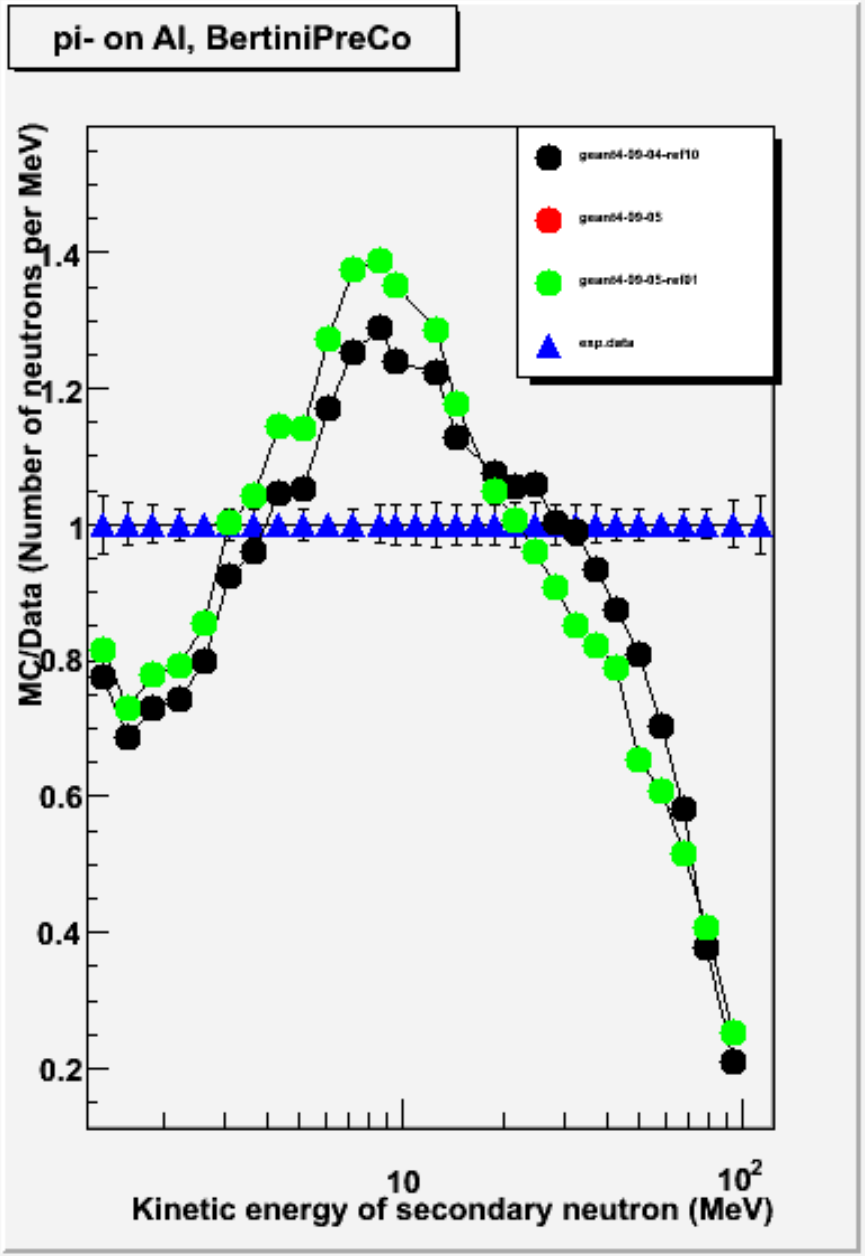
Geant 4


pi- on O, Bertini
MC/Data (Number of neutrons per MeV)
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data

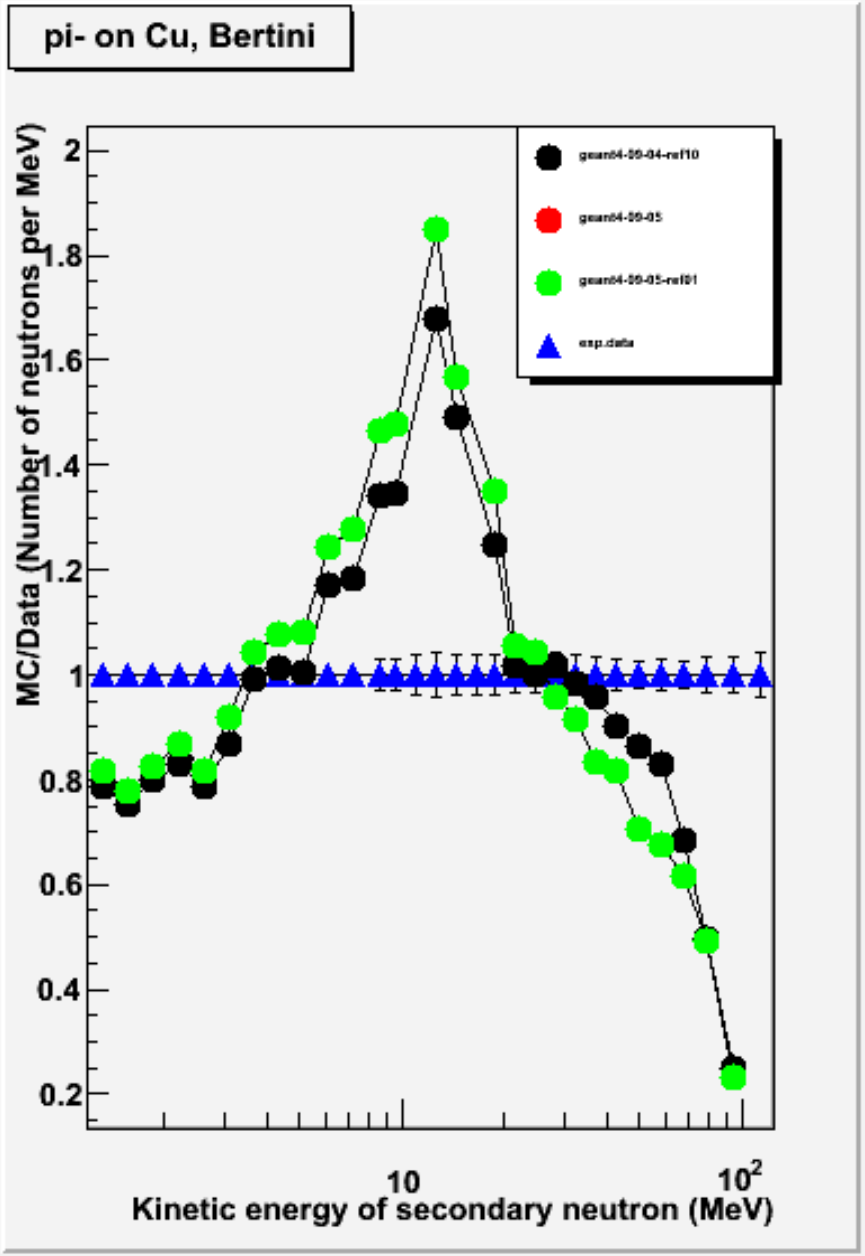

pi- on O, BertiniPreCo
MC/Data (Number of neutrons per MeV)
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data

Geant 4


pi- on Al, Bertini
MC/Data (Number of neutrons per MeV)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
10
10^2
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data


pi- on Al, BertiniPreCo
MC/Data (Number of neutrons per MeV)
1.4
1.2
1
0.8
0.6
0.4
0.2
10
10^2
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data

Geant 4


pi- on Cu, Bertini
MC/Data (Number of neutrons per MeV)
Kinetic energy of secondary neutron (MeV)
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geant4-09-05
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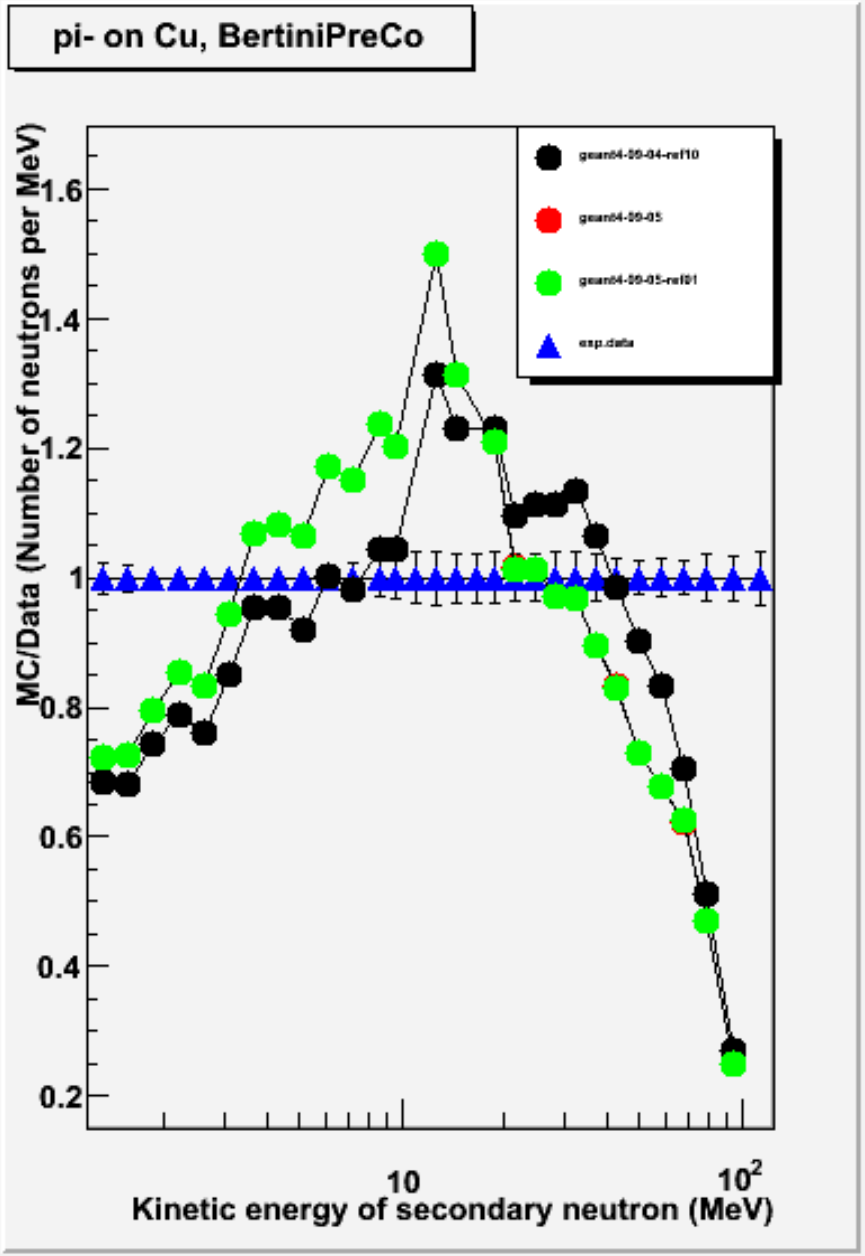
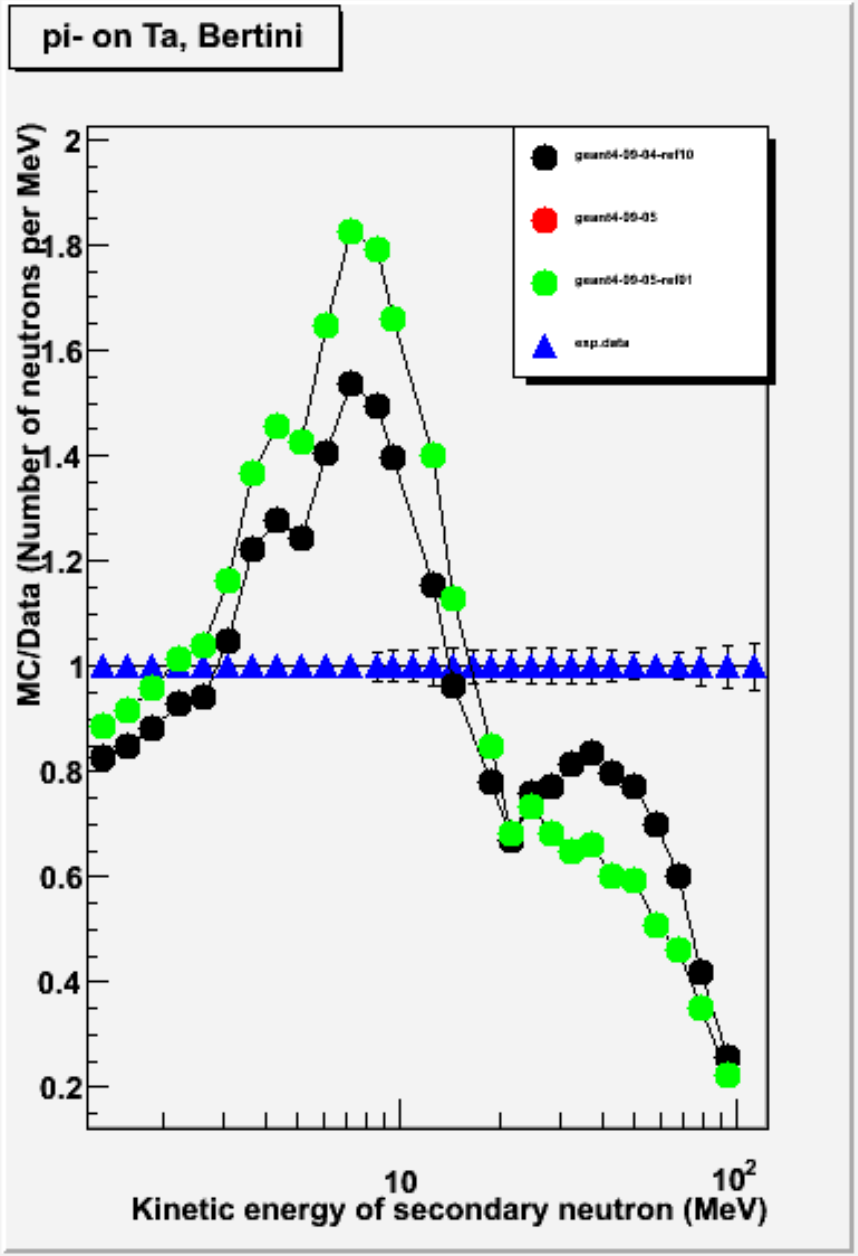
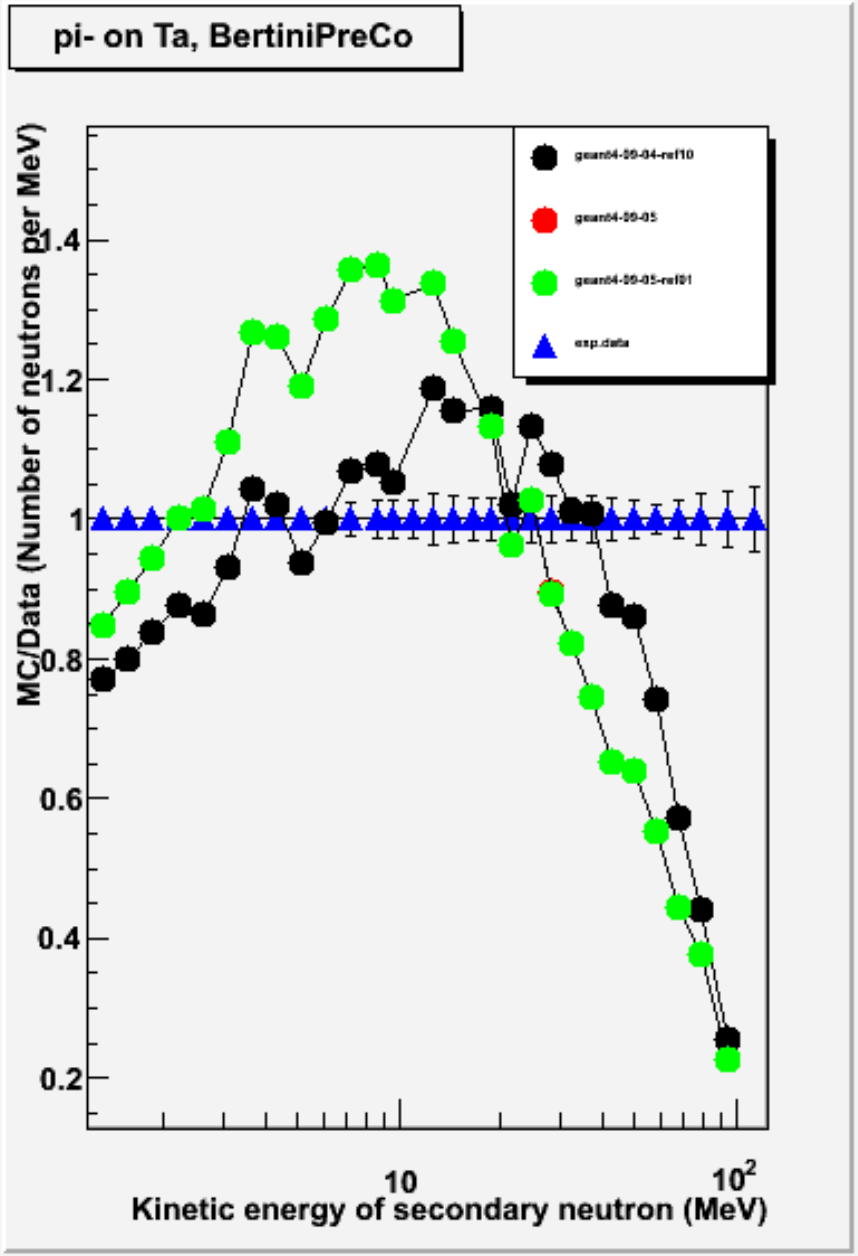
exp.data

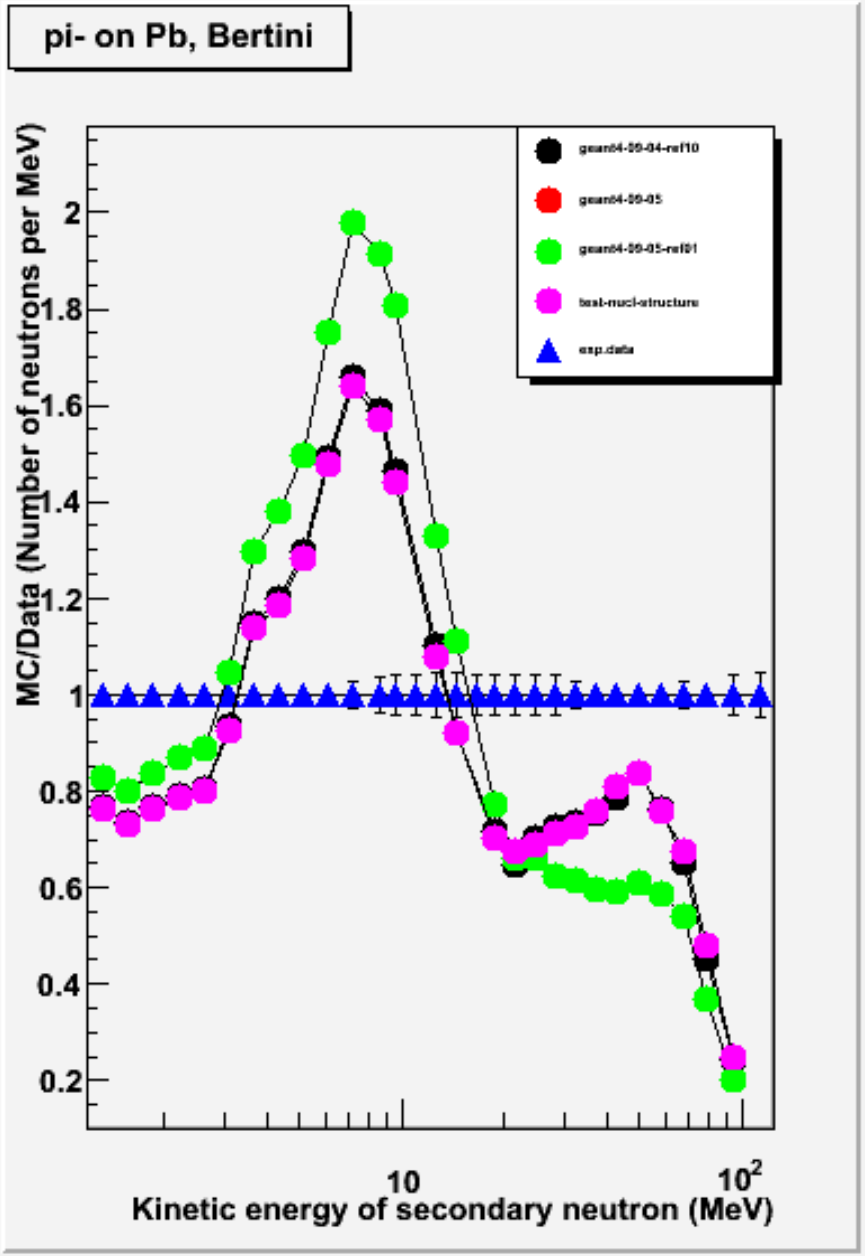

pi- on Cu, BertiniPreCo
MC/Data (Number of neutrons per MeV)
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data

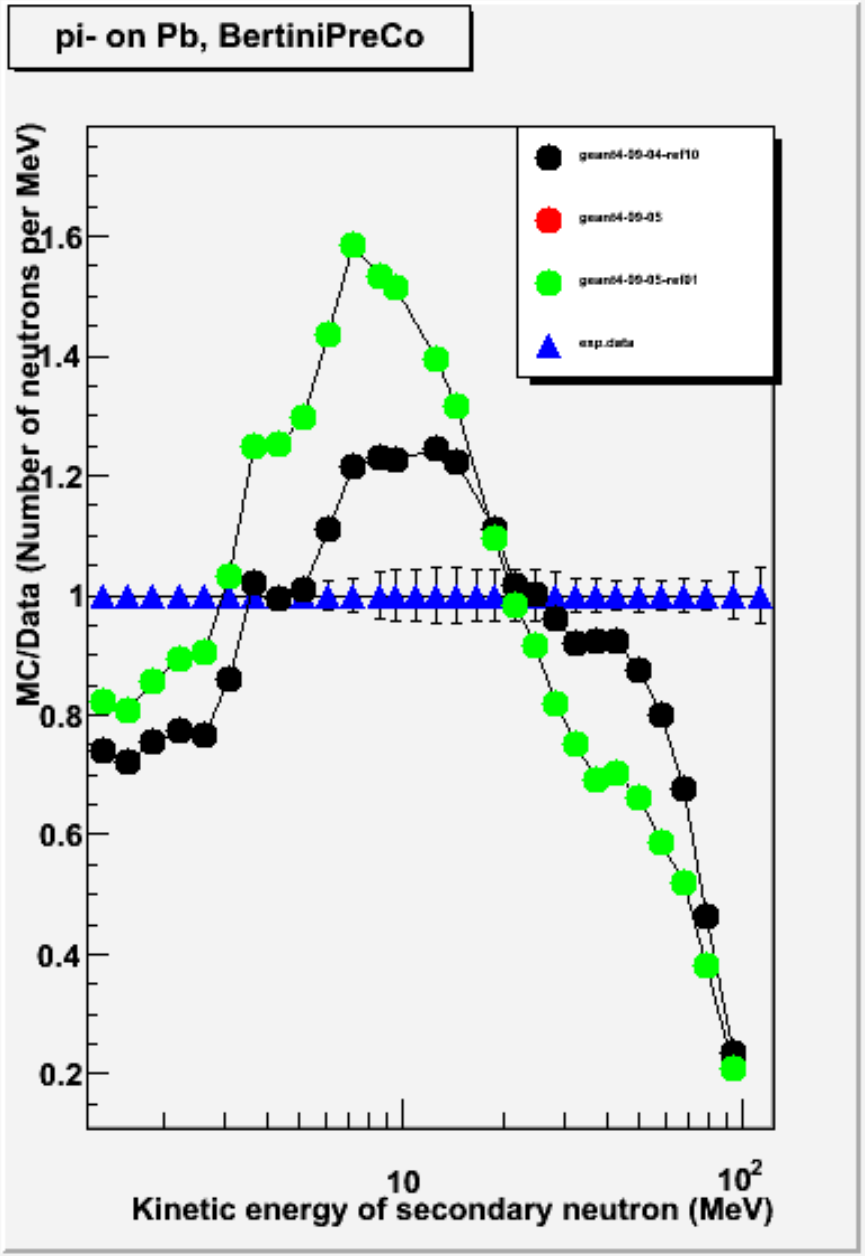
Geant 4


pi- on Ta, Bertini
MC/Data (Number of neutrons per MeV)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
10
10^2
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data


pi- on Ta, BertiniPreCo
MC/Data (Number of neutrons per MeV)
1.4
1.2
1
0.8
0.6
0.4
0.2
10
10^2
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data

Geant 4

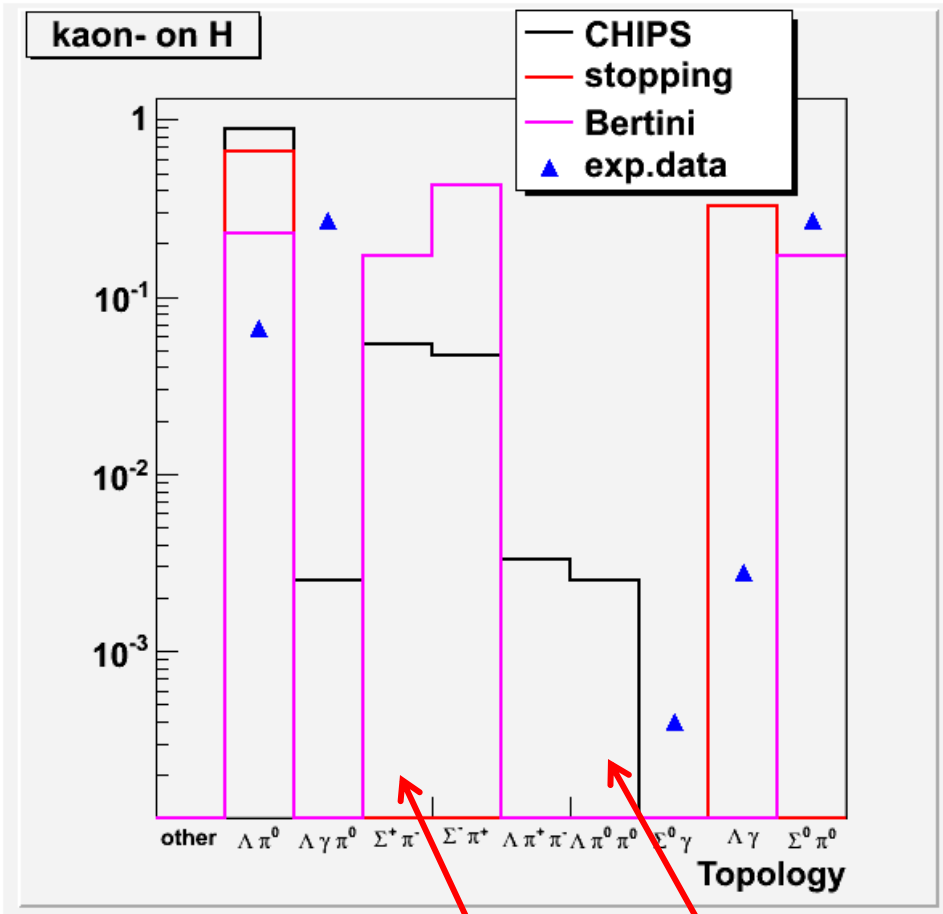

pi- on Pb, Bertini
MC/Data (Number of neutrons per MeV)
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
test-nucl-structure
exp.data

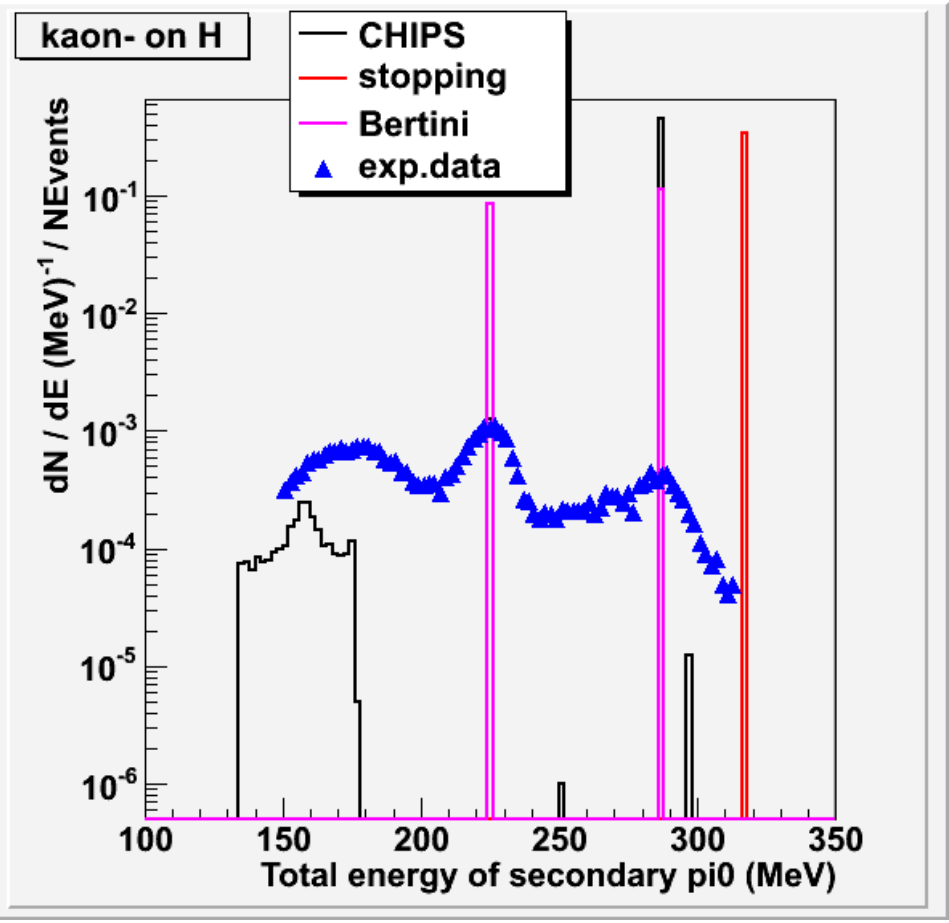

pi- on Pb, BertiniPreCo
MC/Data (Number of neutrons per MeV)
Kinetic energy of secondary neutron (MeV)
geant4-09-04-ref10
geant4-09-05
geant4-09-05-ref01
exp.data

K- capture

- Data sets:
  - K.Larson et al., Phys.Rev.D47,799(1993) + ref.materials
- Models: traditional, CHIPS, Bertini
- Observable: final state topology, pi0 production
  - Several data points for final state BR's added to the plot
- No change vs g4.9.4-ref10
- Traditional is too simplistic
- Both CHIPS and Bertini produce sensible output

Geant 4





Channels near threshold, not observed

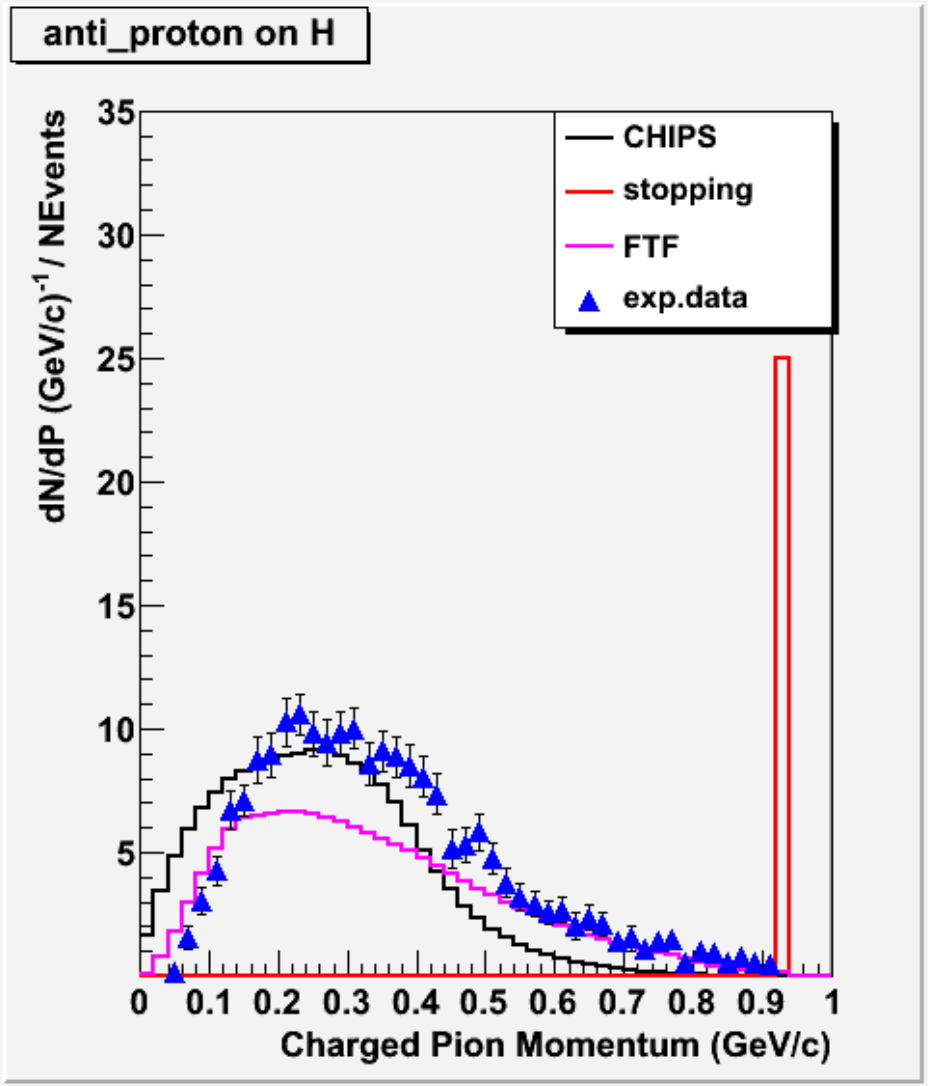
Exp.data to be added shortly

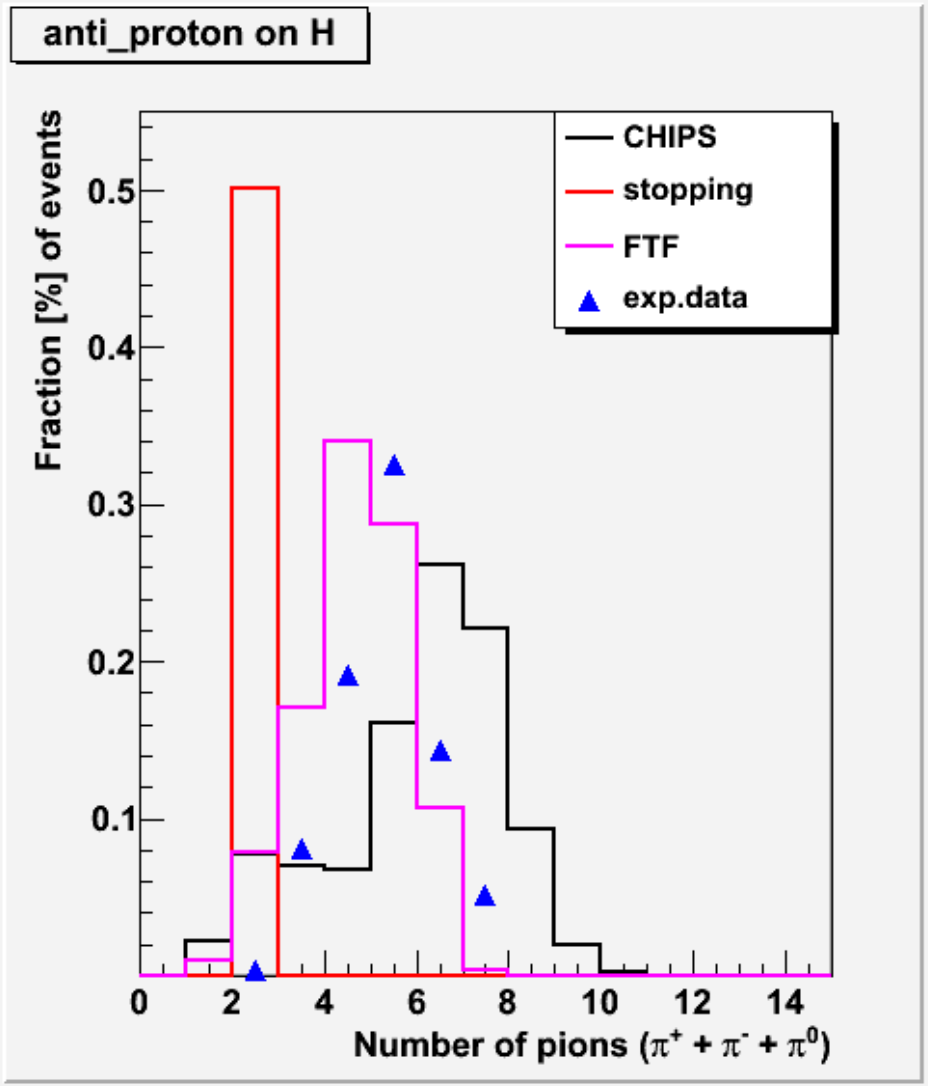
$\Lambda\gamma\pi^0$ (CHIPS) == $\Sigma^0\pi^0$ (Bertini) ???

pbar anihillation

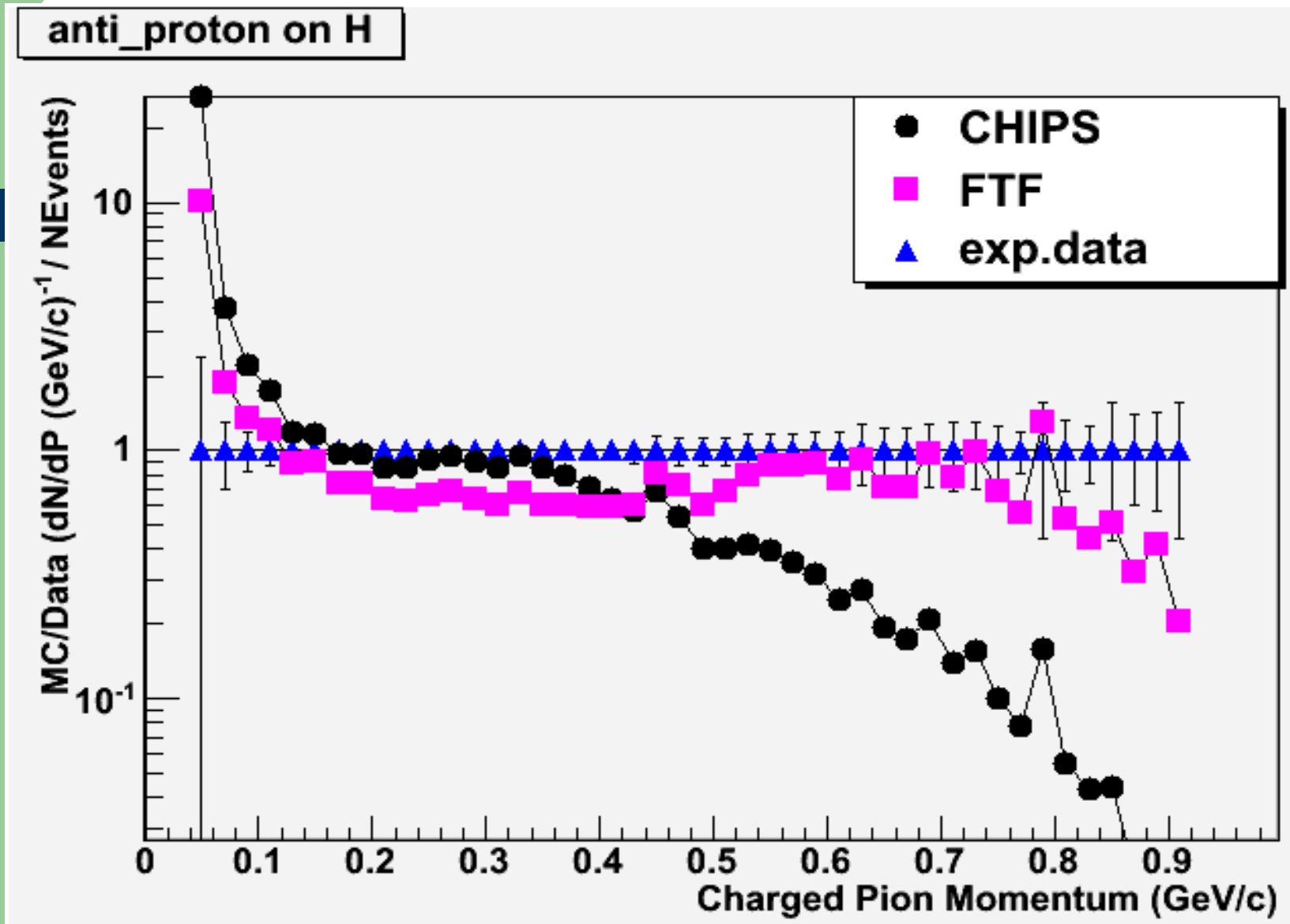
- Data sets:
  - C. Amsler, Rev. Mod. Phys. 70, 1293 (1998)
  - C.B. Dover et al., Prog. Part. Nucl. Phys., Vol.29, pp.87-173 (1992)
- No changes vs G4.9.4.ref10
- Charged pion momentun spectrum – added MC/data plot
- Still the same overall observations (also next slide)
  - In general, good performance, 20x faster than CHIPS
  - Slightly underestimates overal pion multiplicity
  - Charged pion momentum somewhat off vs experimental data

Geant 4


anti_proton on H
CHIPS
stopping
FTF
exp.data
dN/dP (GeV/c)$^{-1}$ / NEvents
Charged Pion Momentum (GeV/c)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
5
10
15
20
25
30
35


anti_proton on H
CHIPS
stopping
FTF
exp.data
Fraction [%] of events
Number of pions ($\pi^+ + \pi^- + \pi^0$)
0
2
4
6
8
10
12
14
0.1
0.2
0.3
0.4
0.5

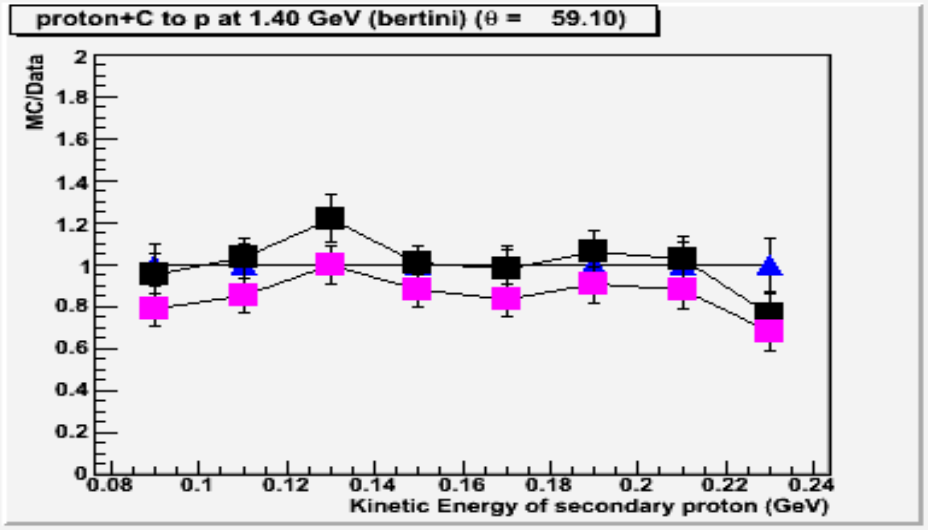
Geant 4

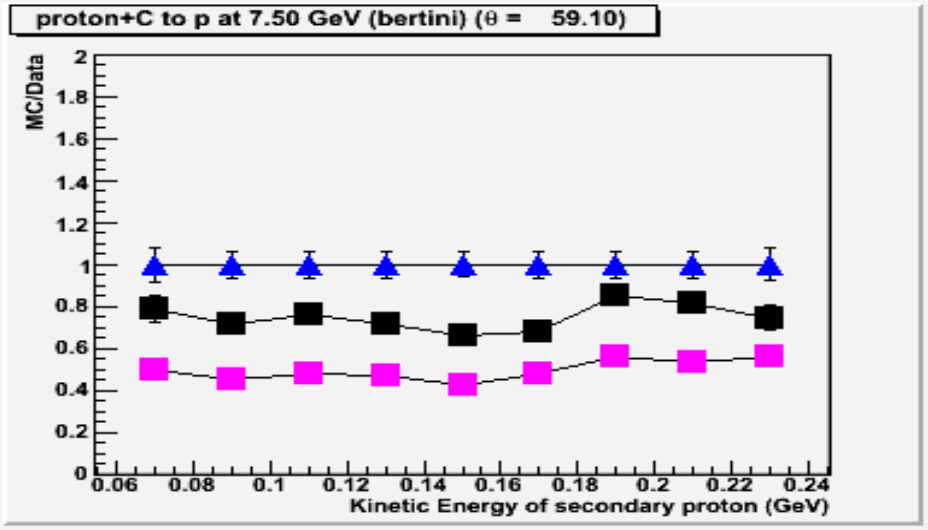

anti_proton on H
CHIPS
FTF
exp.data
MC/Data (dN/dP (GeV/c)$^{-1}$ / NEvents)
10
1
10^{-1}
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Charged Pion Momentum (GeV/c)

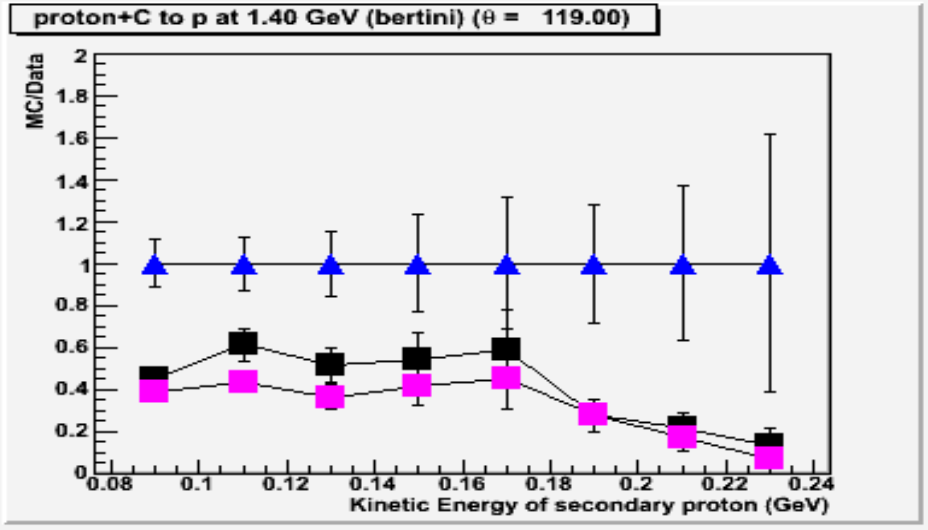
Intermediate Energy Range

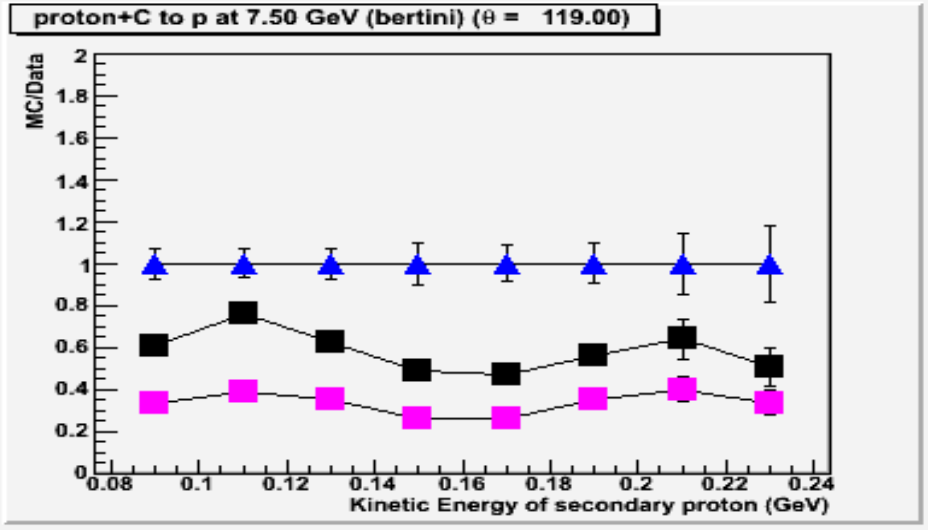
- WORK IN PROGRESS !!!
- Data set (aka ITEP data):
  - Yu.D. Bayukov et al., Sov.J.Nucl.Phys.42:116-121,1985
- Energy: 1.4, 5.0, 7.5GeV
- Various targets
- Particles: proton (slides 30-31), pi+ (slides 32-33);
  pi- in progress
- Models:
  - Focus on Bertini, 2 sets of nucl.struct. params tested – following concerns from g4.9.4-ref09
  - FTF, CHIPS also done, but need to finalize analysis
- Misc: need to slightly restructure analysis scripts in /test47

p + C -> p + X, Bertini
Black – g4.9.5-ref01
Magenta – "new" nucl.struct.parameters



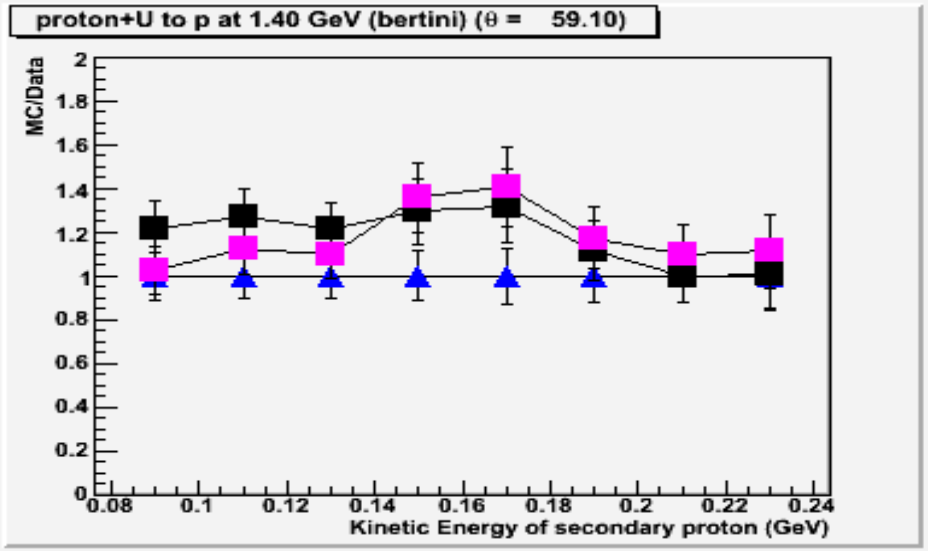


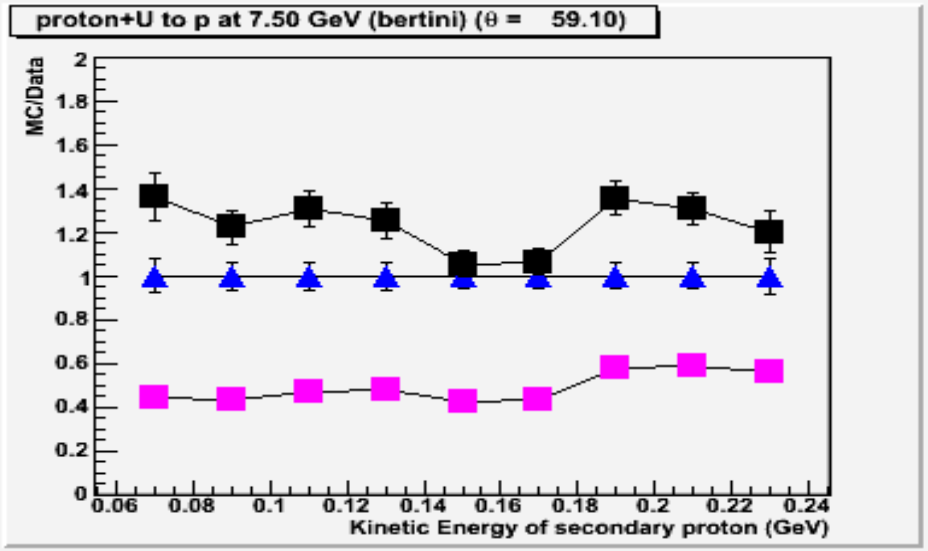


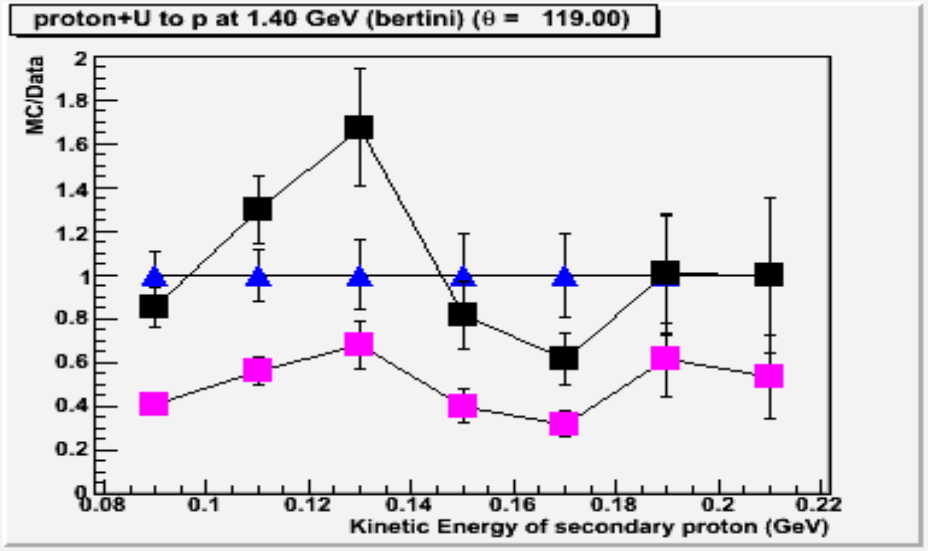


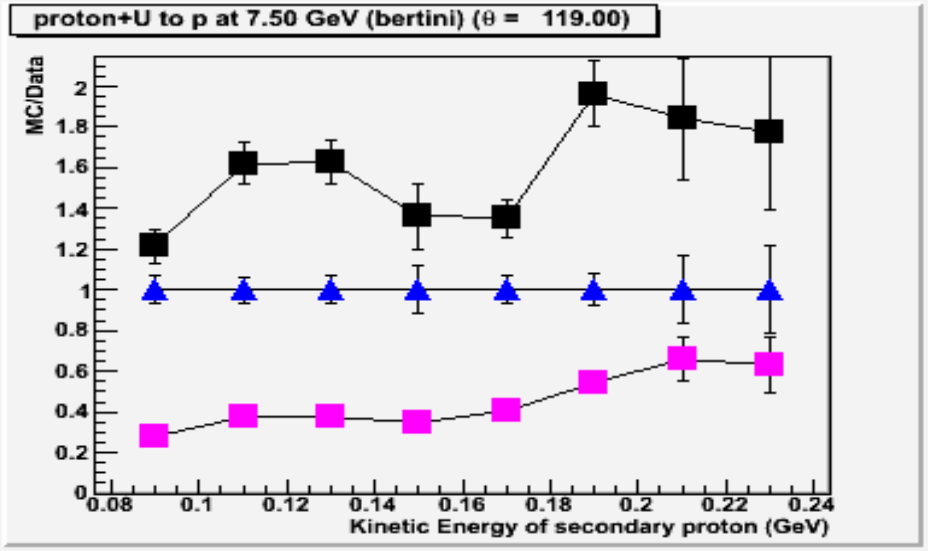
Geant 4

p + U -> p + X, Bertini
Black – g4.9.5-ref01
Magenta – "new" nucl.struct.parameters





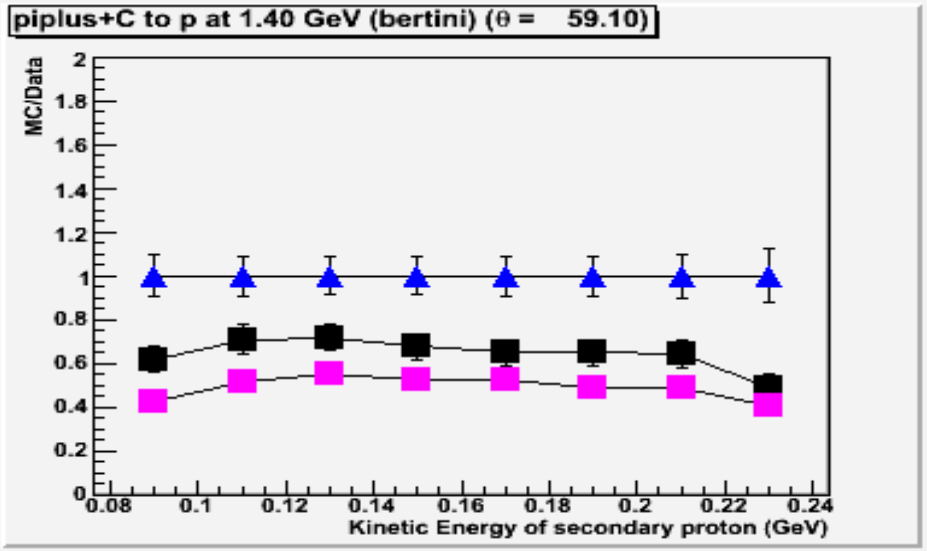


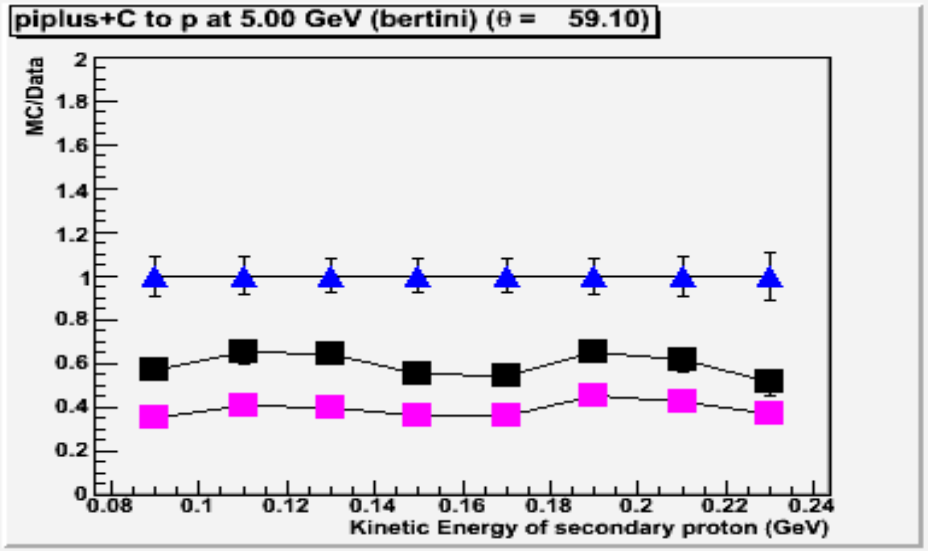


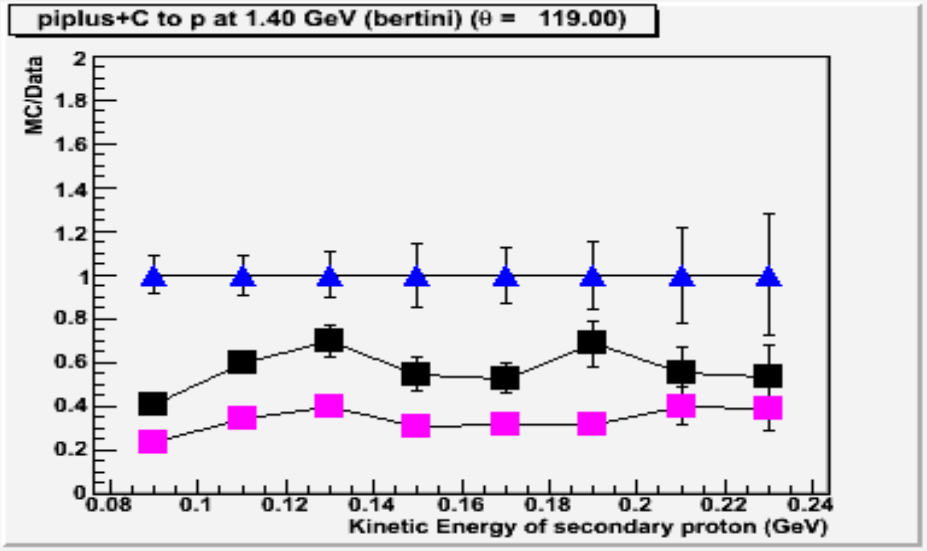
π^+ + C -> p + X, Bertini

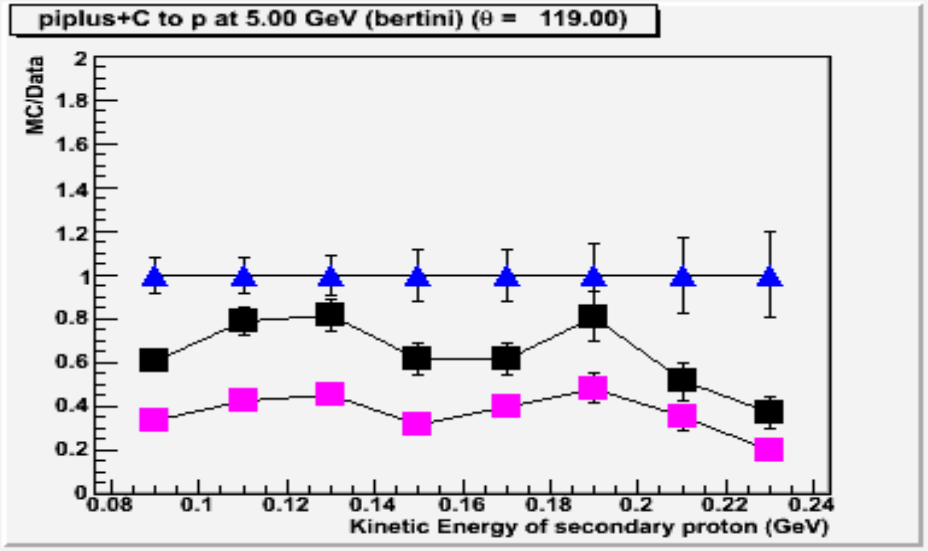
Black – g4.9.5-ref01

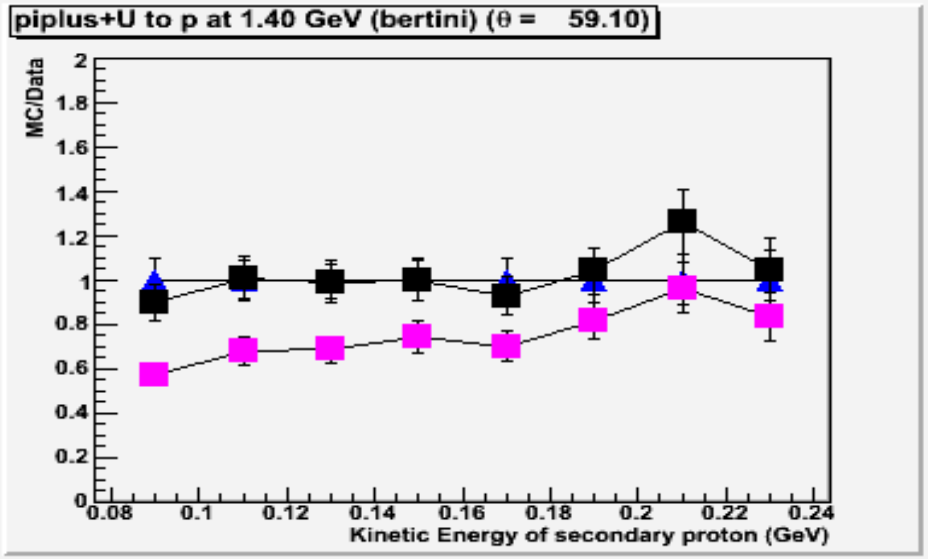
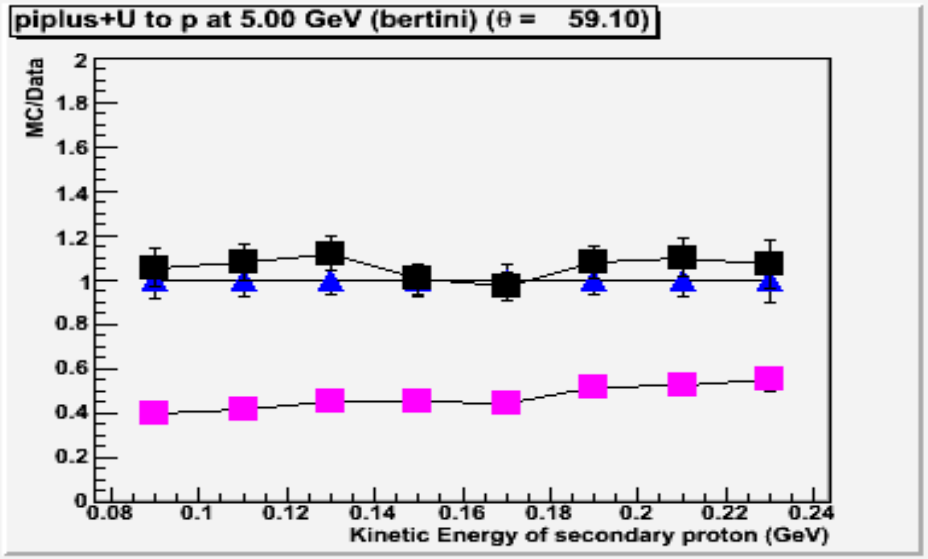
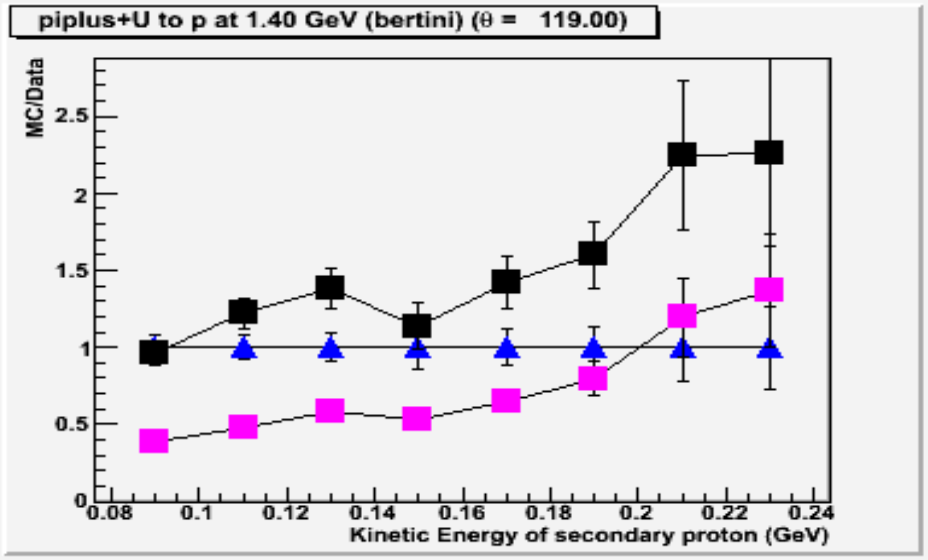
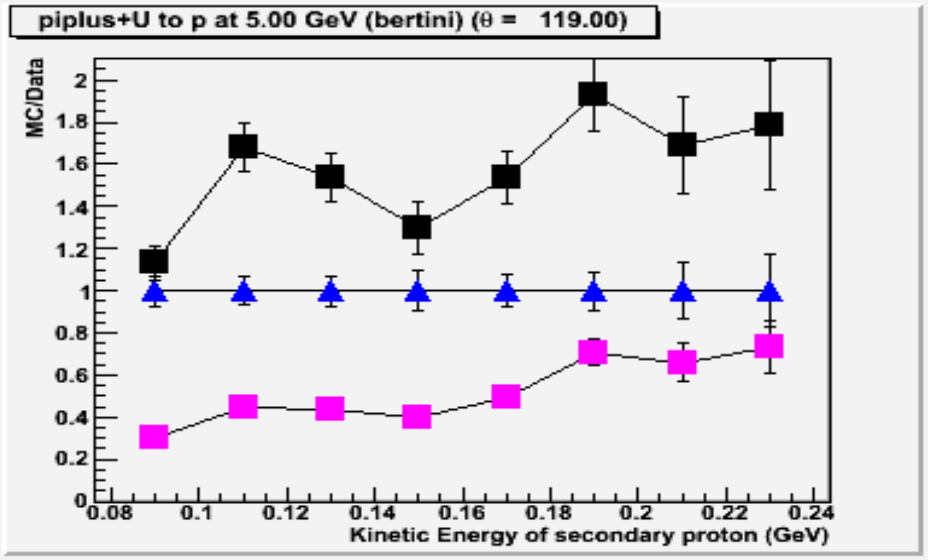
Magenta – "new" nucl.struct.parameters









Geant 4

π^+ + U -> p + X, Bertini
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