



Validation Activities at SLAC

Koi, Tatsumi
SLAC / SCCS



Geant 4 collaboration workshop
Nov 8th 2005 Bordeaux, France

Overview

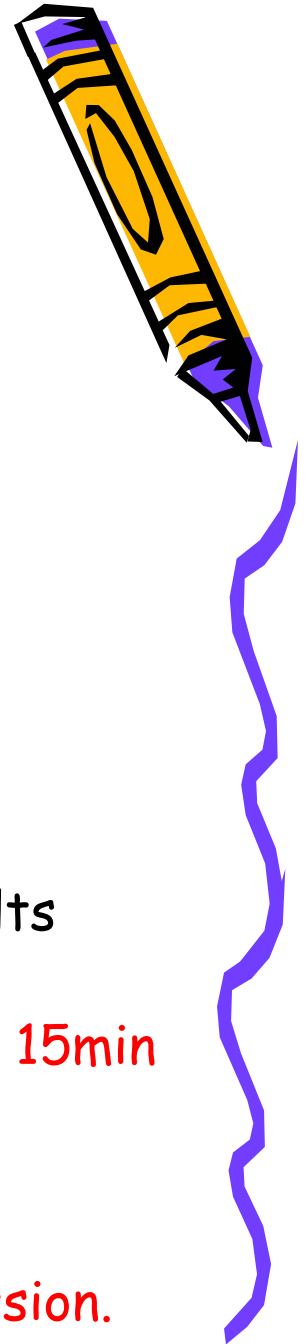
- Current and past Validation efforts
 - EM Physics
 - Multiple Coulomb Scattering
 - Others
 - Hadron Physics
 - pp interactions
 - nucleus-nucleus interactions
 - Medical related validations
 - Interfacing related validations
- Testing tool for Confidence Level of Monte Carlo results
- GRID related activities
- Summary

I have almost 50 slides for this 15min talks,

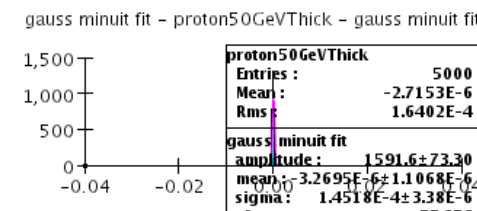
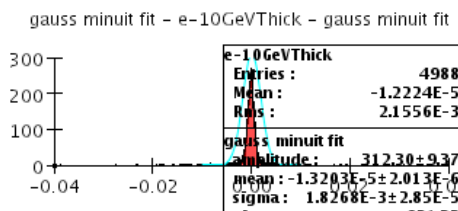
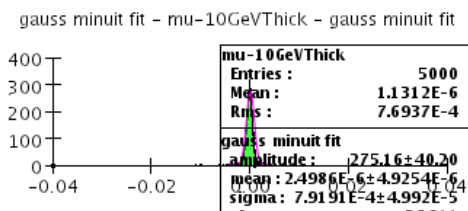
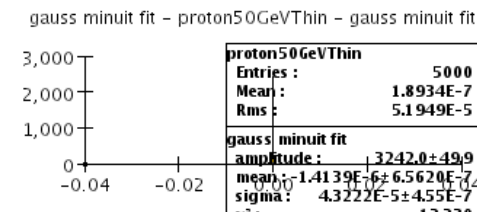
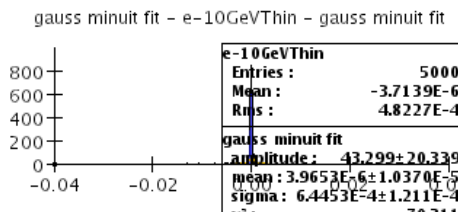
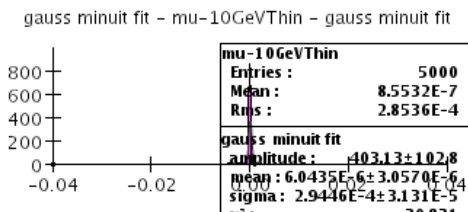
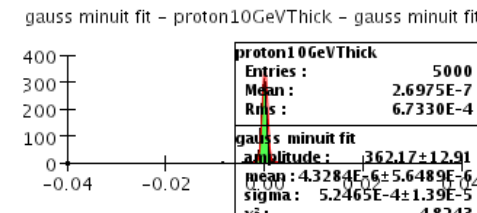
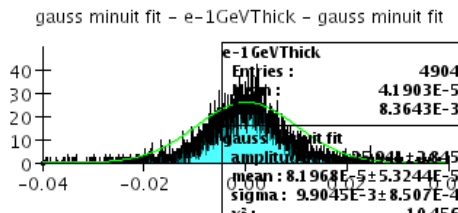
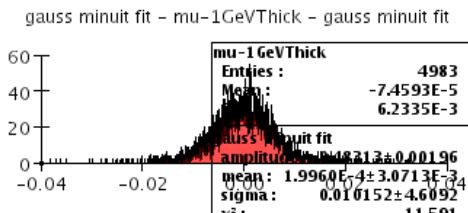
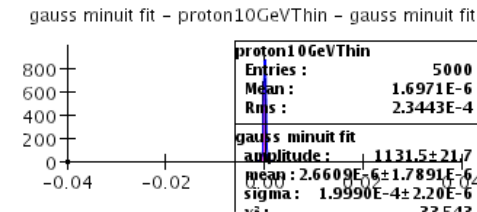
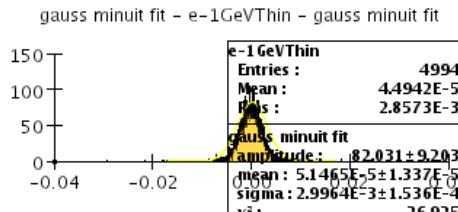
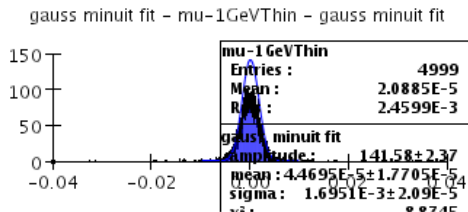
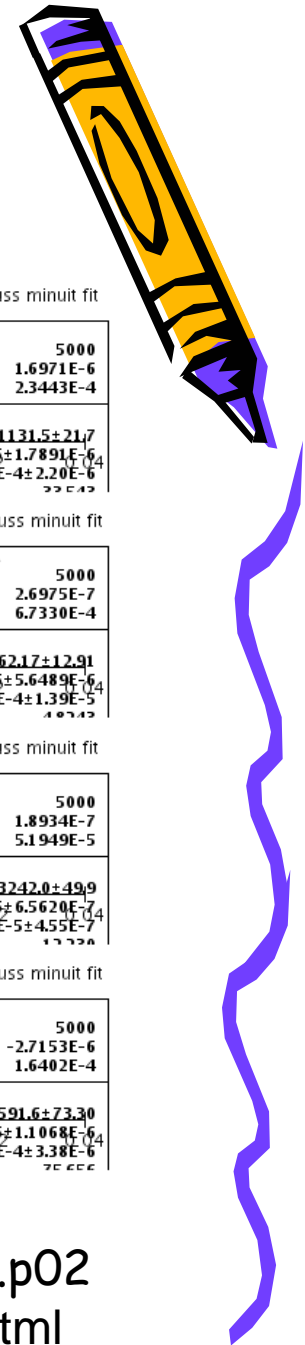
Any questions are welcome,

but please ask me after the session.

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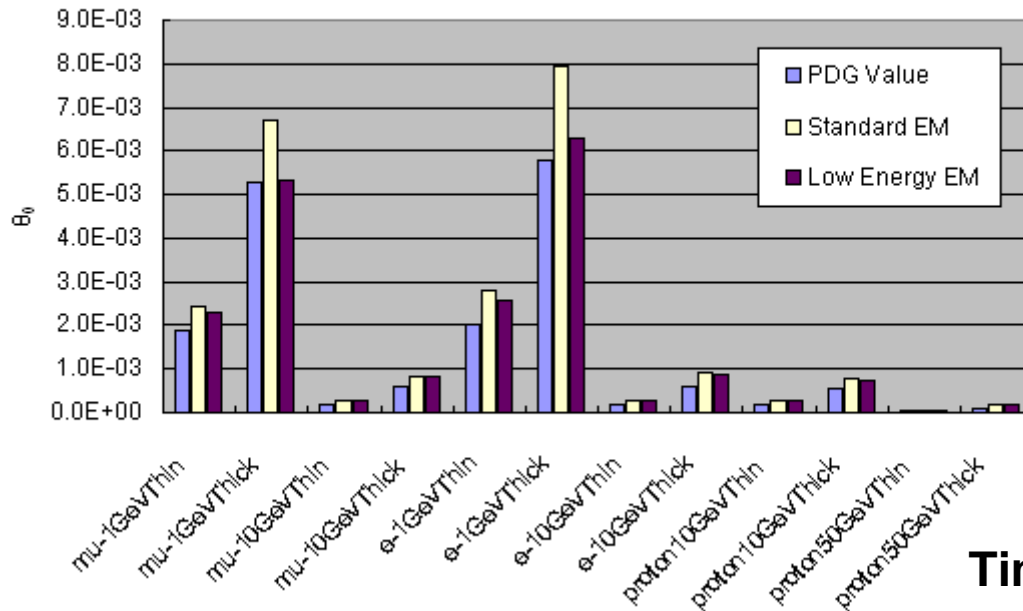
Multiple scattering widths Geant4 v7.1.ref04



Same plots are available since the version 4.2.p02
<http://www.slac.stanford.edu/~tkoi/G4MCStest.html>



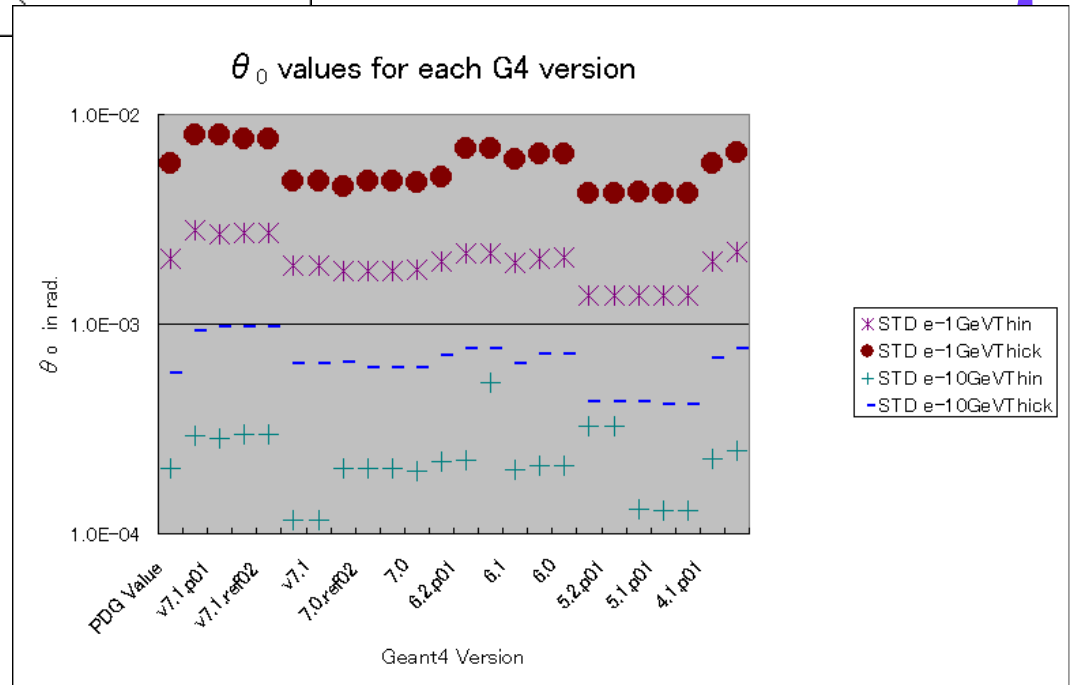
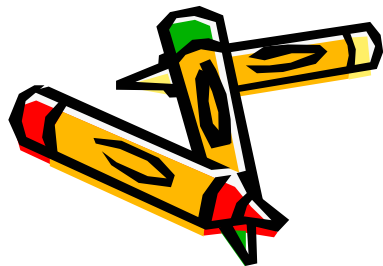
θ_0 of Multiple Scattering



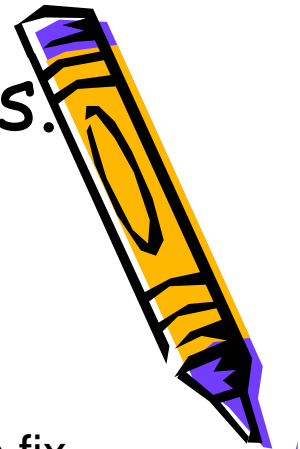
In future we also use TestEM5 for STDEM

Time profile since Geant4 v4.0p02

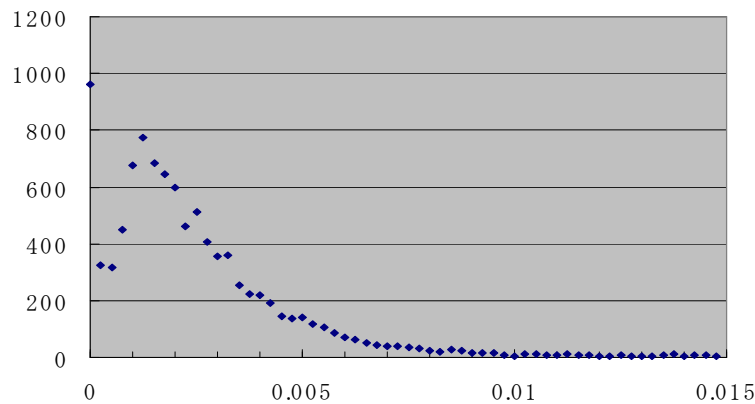
Result of Geant4 v7.1.ref04
 (Differences between Standard EM and Low Energy EM represents an uncertainty of this test, because they use the same multiple scattering model.)



Fluctuation of Energy Loss in Thin layers. Argon gas thickness of 2mm electron 235keV ($\gamma=1.5$)

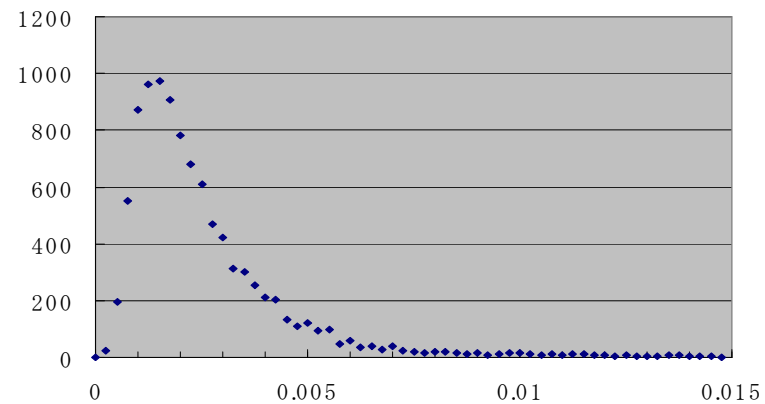


Geant4 v7.0



Energy loss [MeV/cm]

Geant4 v7.0 with fix



Energy loss [MeV/cm]

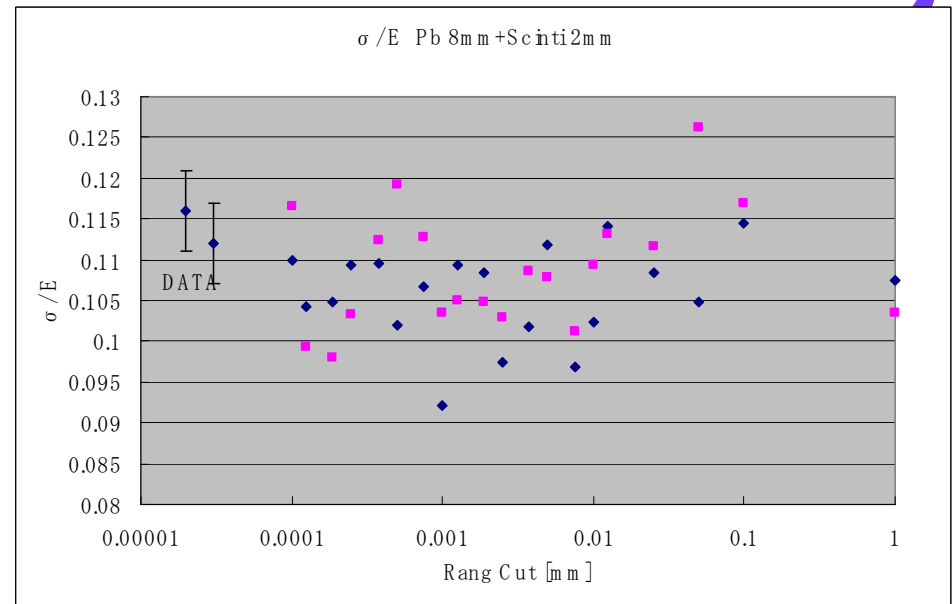
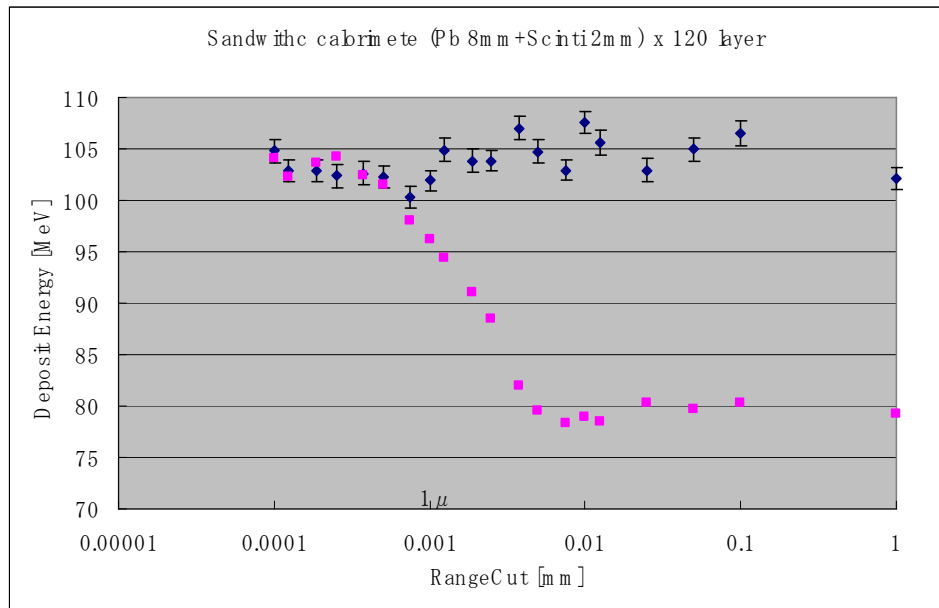


Sampling Calorimeter Pb+Scinti X 120 Layers Blue 7.1 + new MCS Tags Pink 7.0.p01



Observable energy

σ / energy

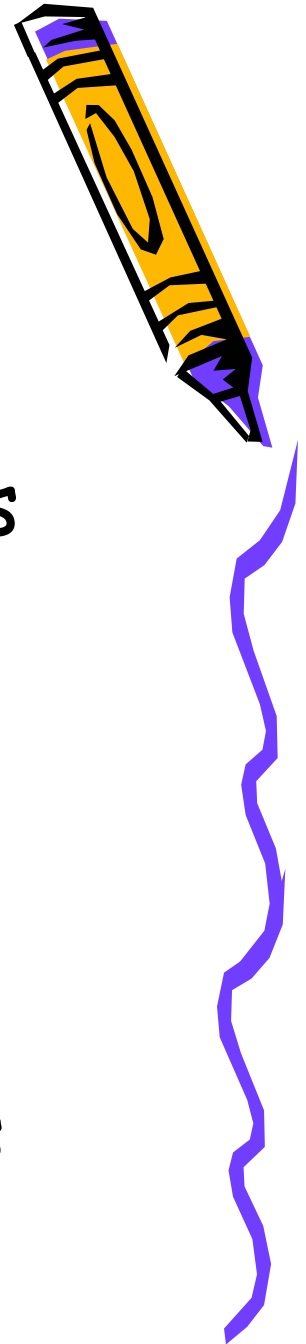


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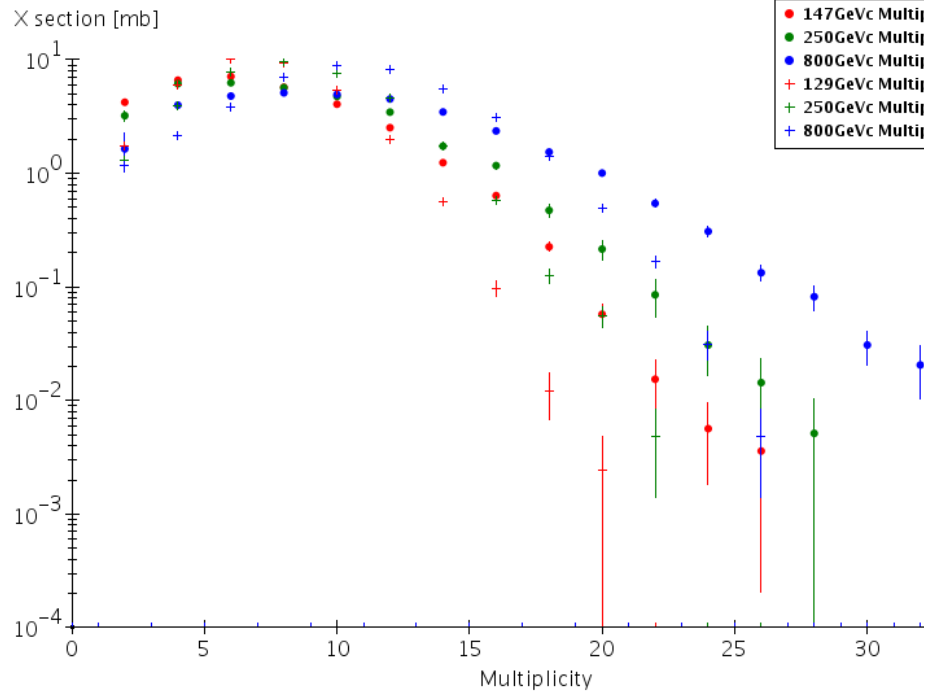
Hadron interaction validation

<http://www.slac.stanford.edu/~tkoi/G4HadInt.html>

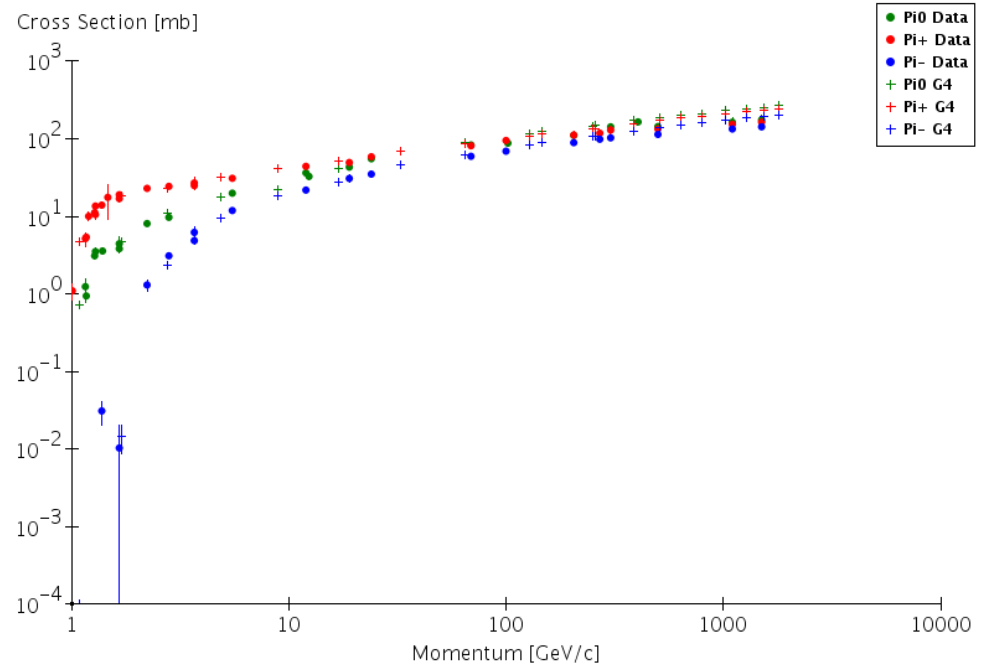
- For all major hadronic physics lists (Ex LHEP, QGSP, FTFP etc)
 - Gamma, Pion, and Kaon production spectra
 - Mean multiplicity distributions
 - Charged multiplicity distributions
 - Multi Layer Faraday Cup comparisons



pp Charged Multiplicity



Pions Production

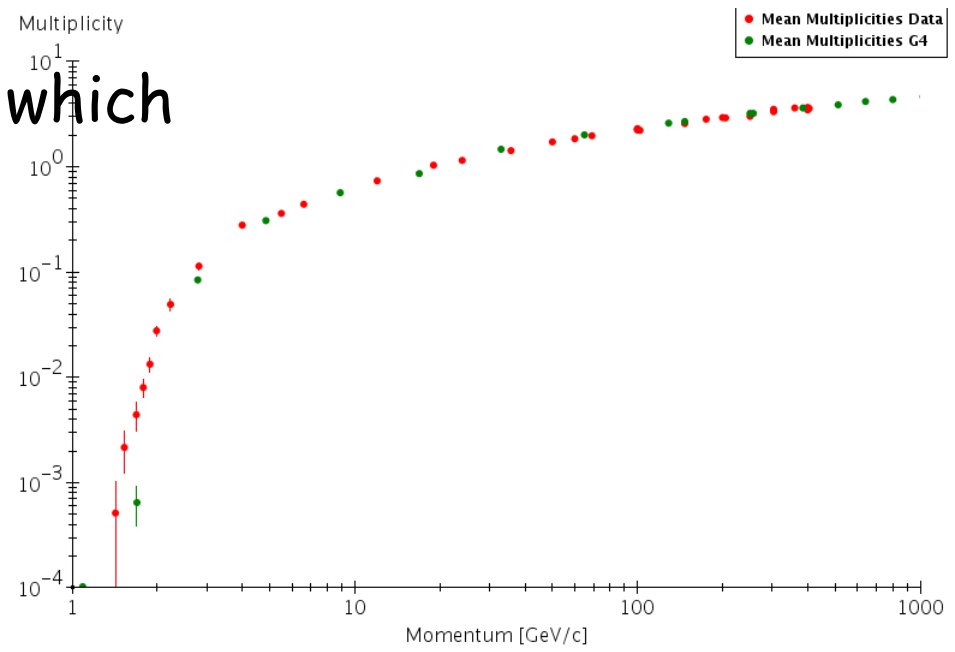


Validation of LC Physics Lists which SLAC provided

Geant4 v7.0.p01

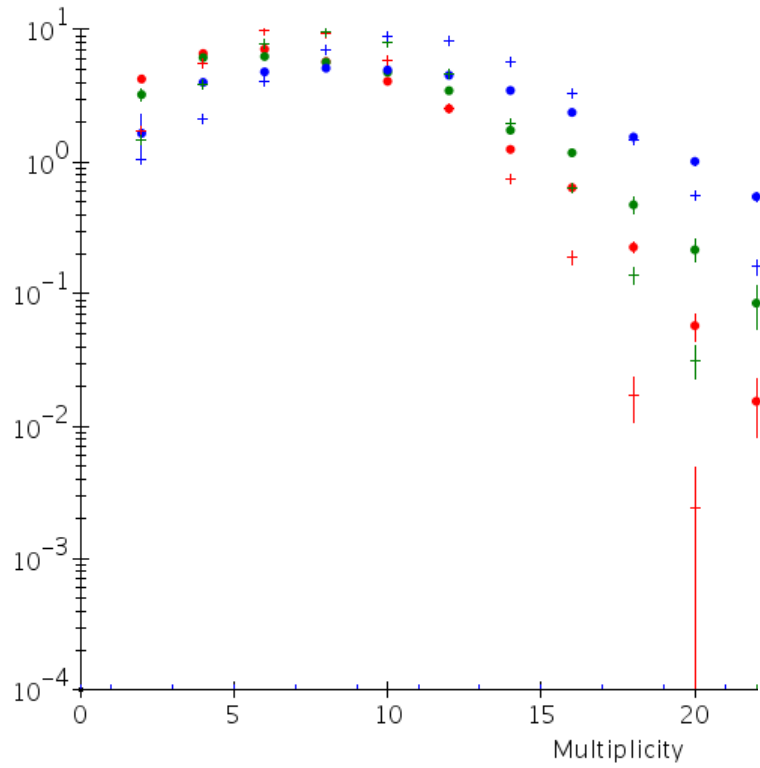


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pp Charged Multiplicity

X section [mb]

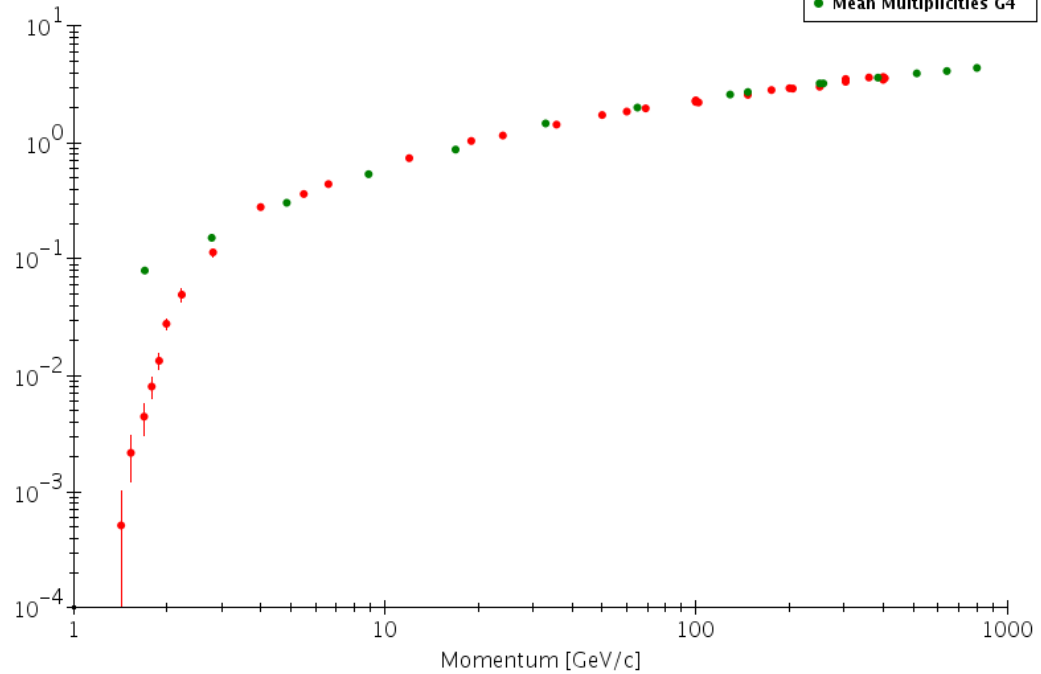


- 147GeVc Multiplicity Data
- 250GeVc Multiplicity Data
- 800GeVc Multiplicity Data
- + 147GeVc Multiplicity G4
- + 250GeVc Multiplicity G4
- + 800GeVc Multiplicity G4

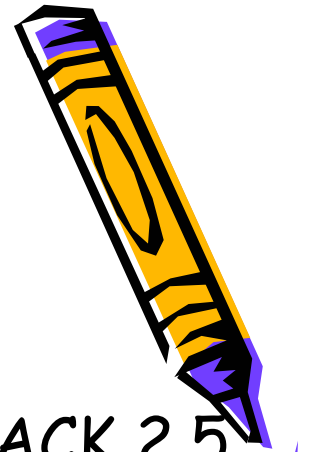
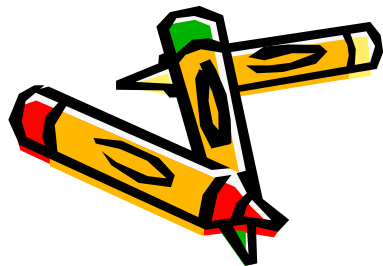
Geant4 v7.1.p01
QGSP Hadronic List PACK 2.5

Multiplicity: pp-->Charged- X

Multiplicity

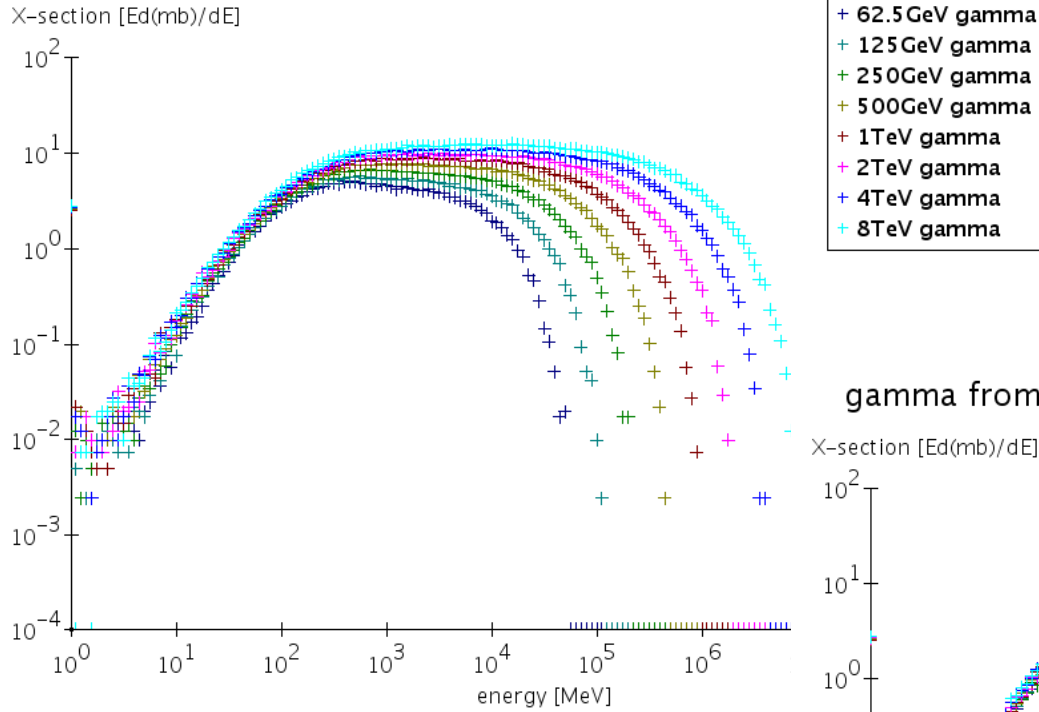


- Mean Multiplicities Data
- Mean Multiplicities G4



QGSP

gamma from p (62.5, 125, 250, 500 GeV 1, 2, 4, 8 TeV) on H



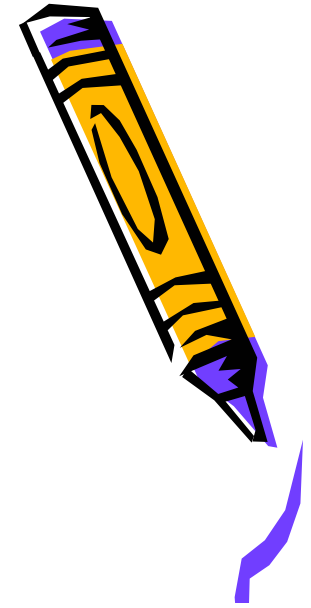
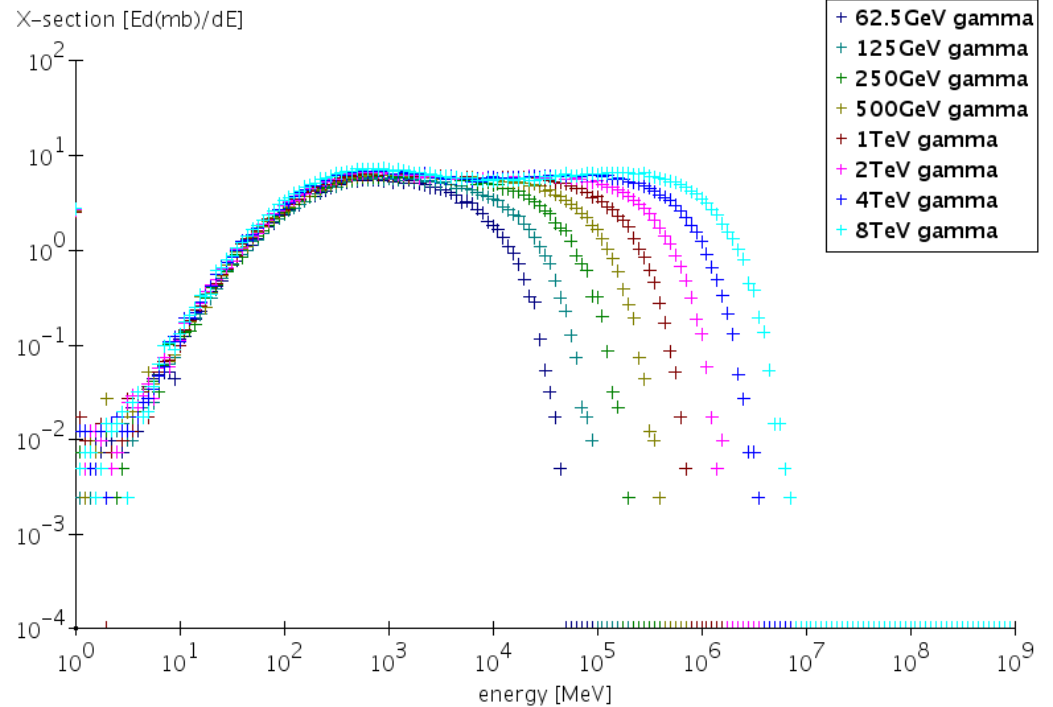
Geant4 v7.1.p01
Hadronic List PACK 2.5



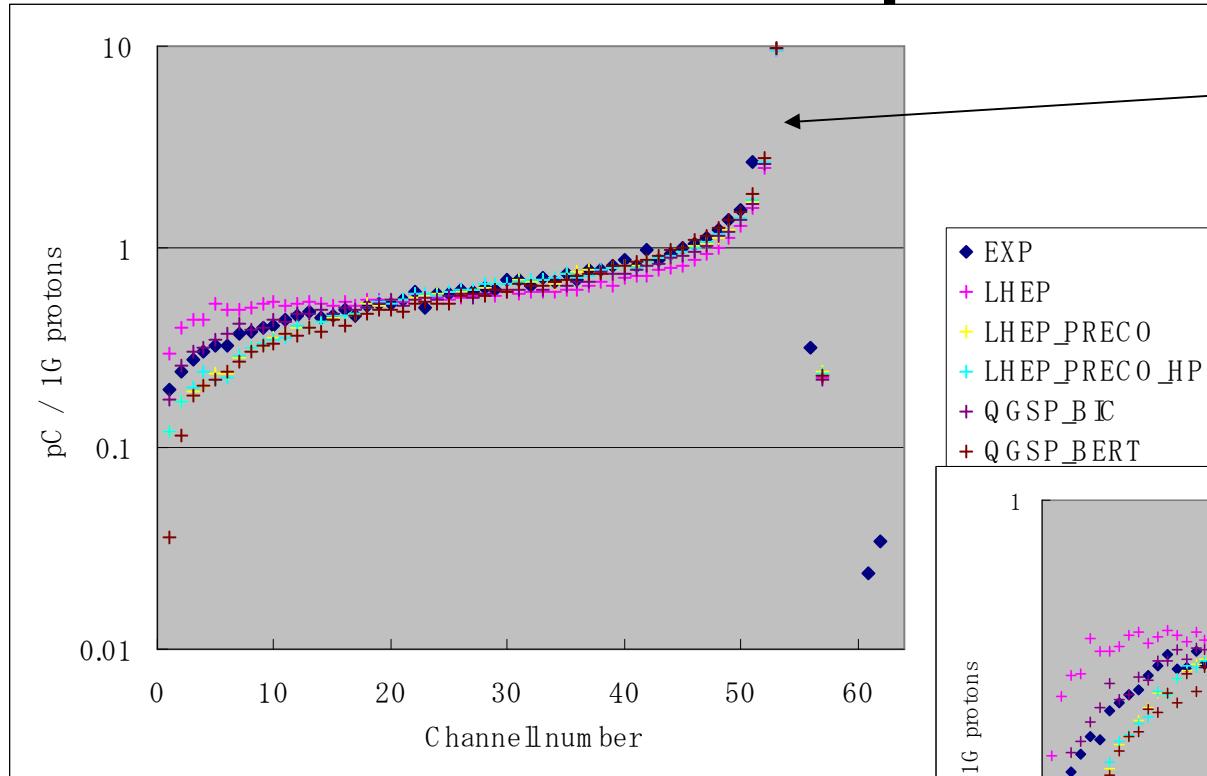
GeV
No

FTFP

gamma from p (62.5, 125, 250, 500 GeV 1, 2, 4, 8 TeV) on H

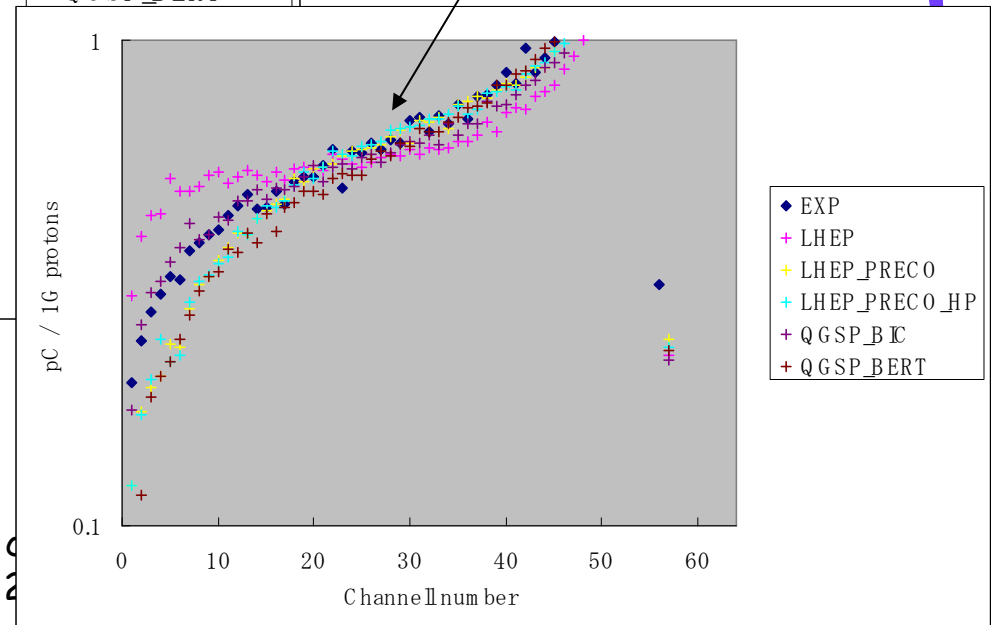


Multi Layers Faraday Cups ~160MeV protons



EM Physics Validation

Hadron Physics Validation



Kapton-Cu layers

Nuclear interactions of 160 MeV protons stopping in copper: A test of Monte Carlo nuclear models

[Bernard Gottschalk](#), [Rachel Platais](#), and [Harald Paganetti](#)

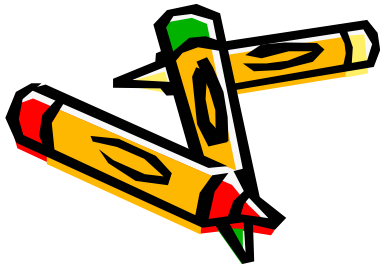
pp. 2597-2601 Med. Phys 26-12 (1999)

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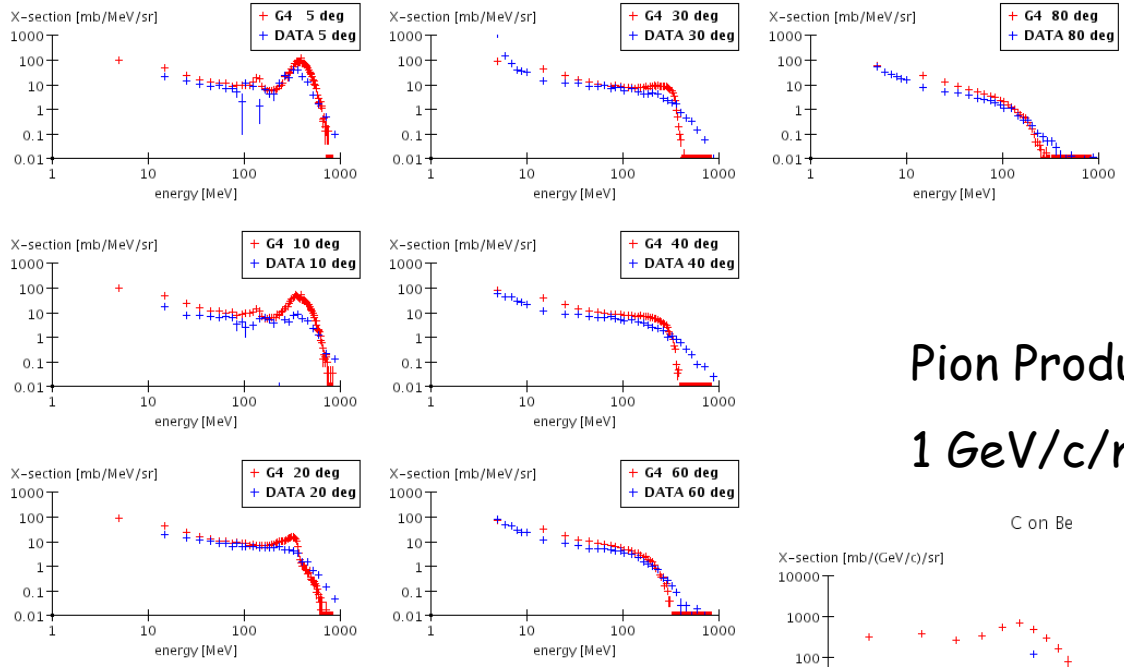
Ion interaction validation

<http://www.slac.stanford.edu/~tkoi/G4IonInteraction.html>

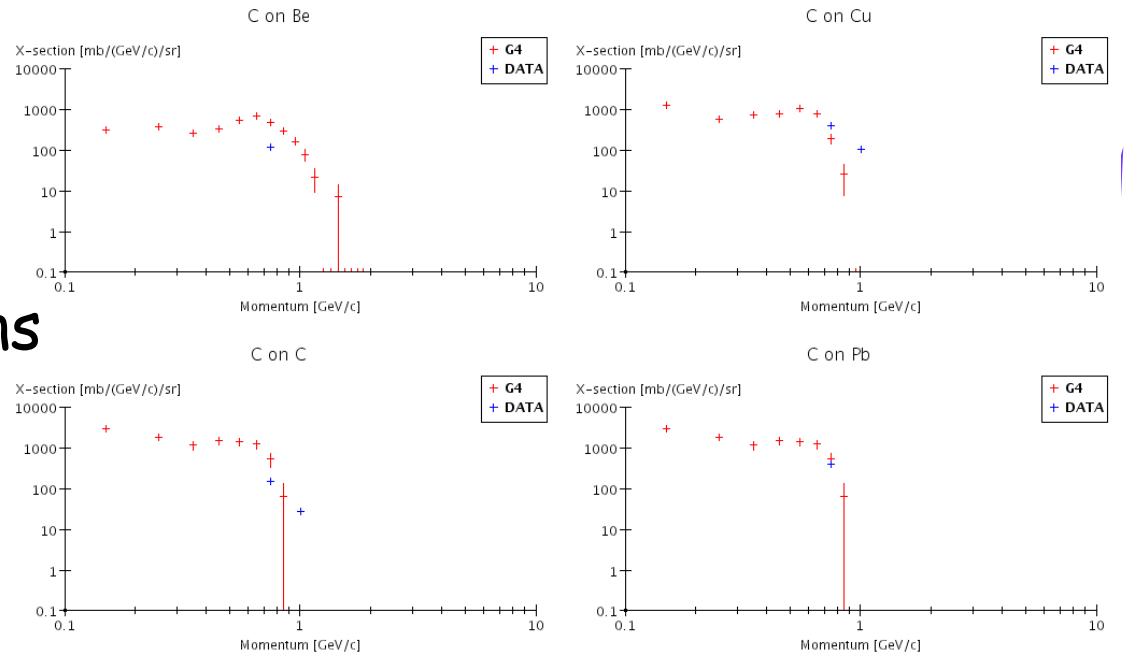
- Neutron double differential production cross sections
- Pion double differential production cross sections
- Neutron Yield from Thick Target
- Fragment particle production cross sections



Neutron Production 400 MeV/n Carbon on Copper



Pion Production 1 GeV/c/n Carbon on Be, C, Cu and Pn



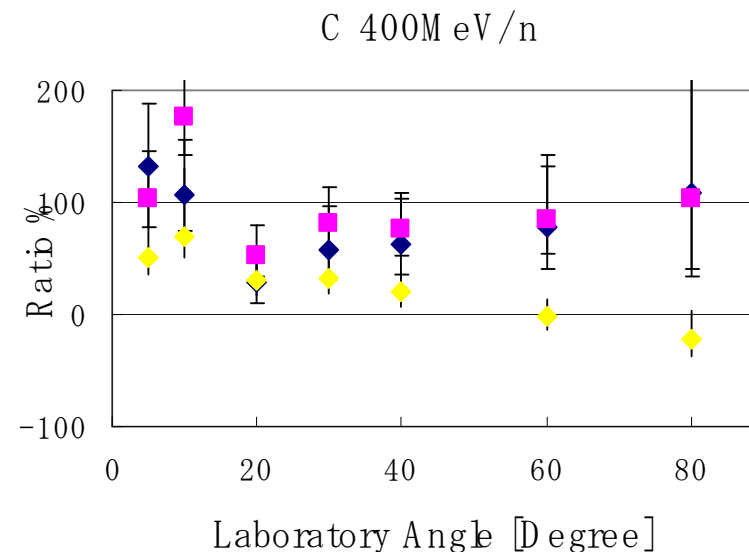
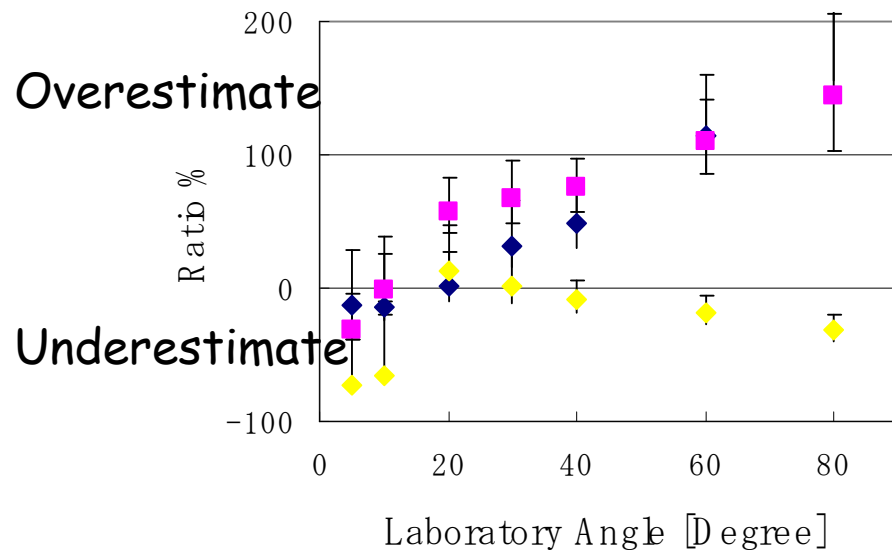
Geant4 6.2.p02
Binary Cascade Light Ions



Distribution of Rs Carbon Beams

$$R = (\sigma_{\text{calculate}} - \sigma_{\text{measure}}) / \sigma_{\text{measure}}$$

C 290M eV/n

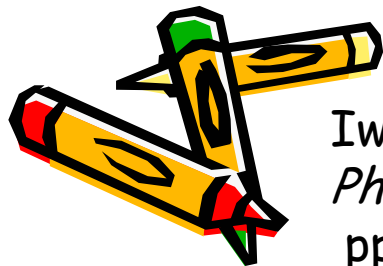


Target Materials

◆ Carbon

■ Copper

◆ Lead

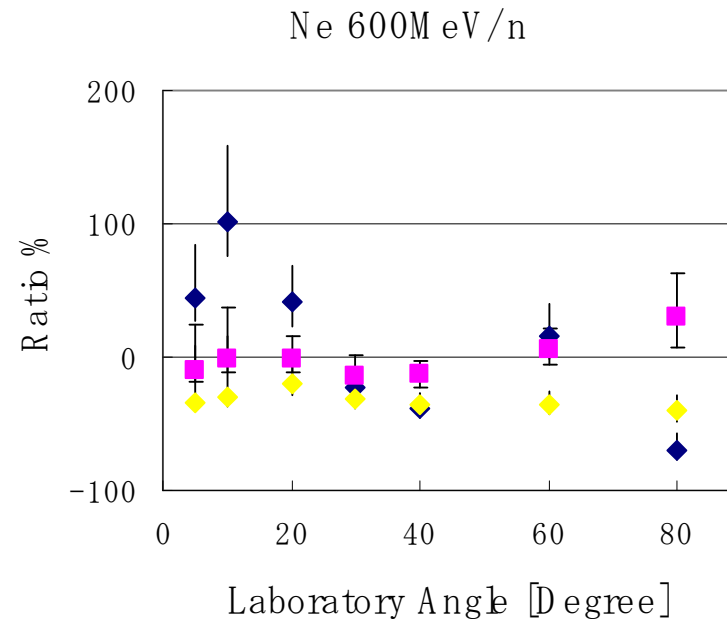
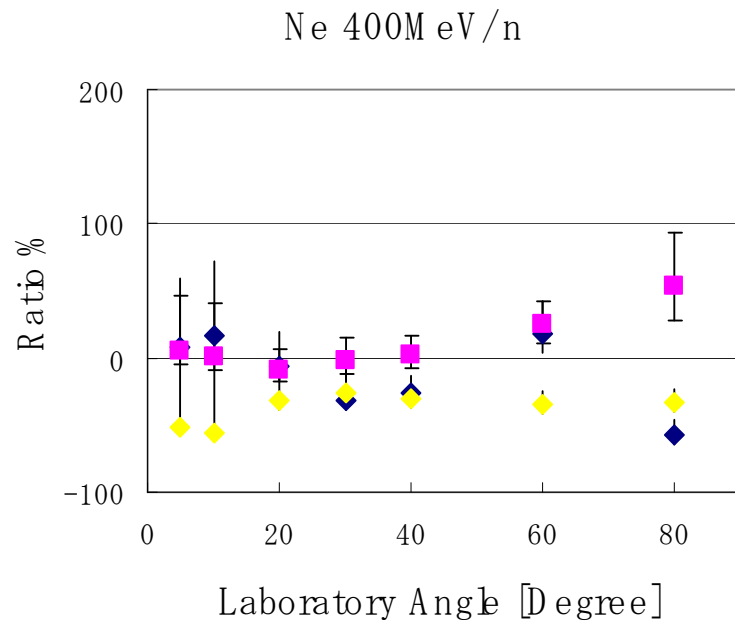
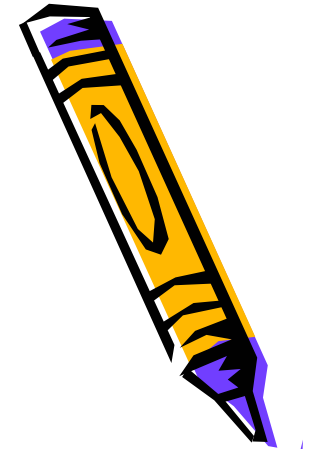


Iwata et al.,
Phys. Rev. C **64**

pp. 05460901(2001)

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Distribution of Rs Neon Beams

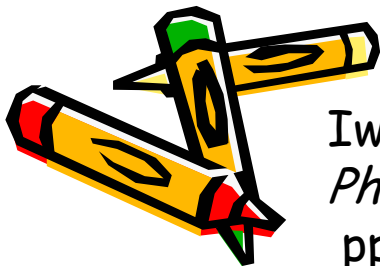


Target Materials

◆ Carbon

■ Copper

◆ Lead

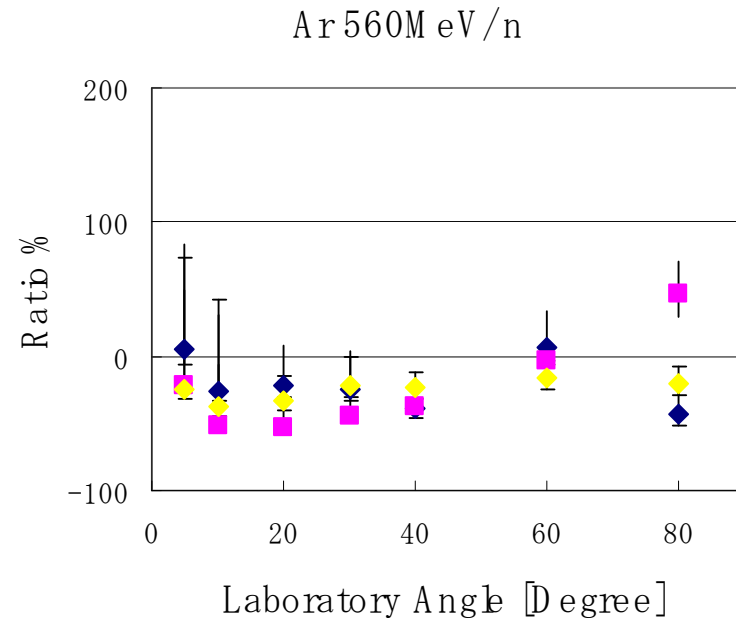
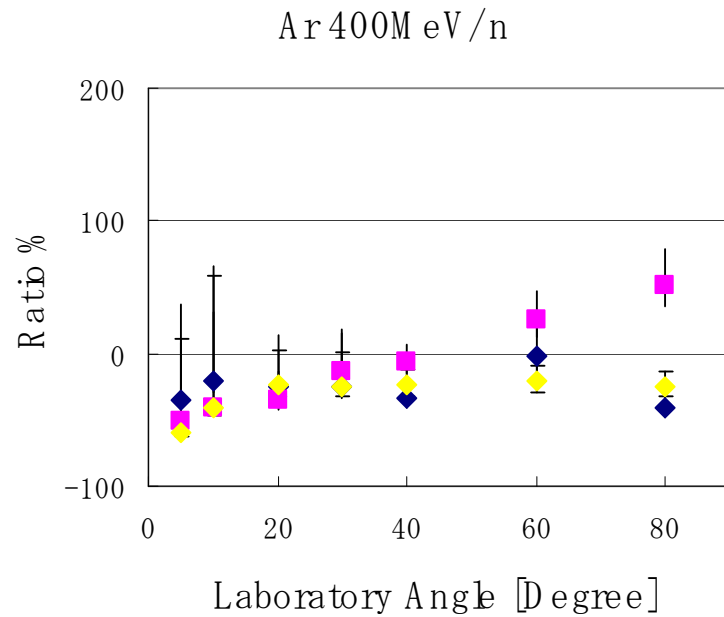
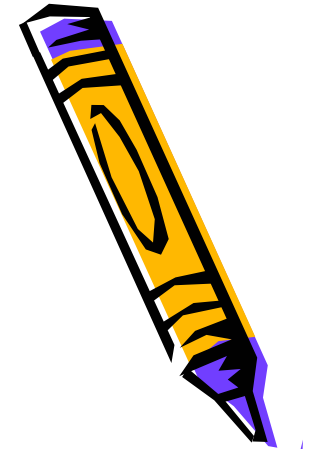


Iwata et al.,
Phys. Rev. C **64**

pp. 05460901(2001)

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Distribution of Rs Argon Beams

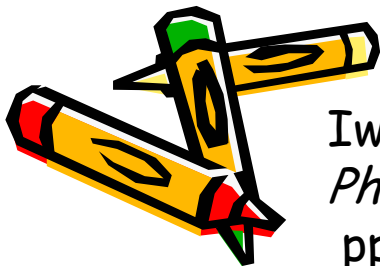


Target Materials

◆ Carbon

■ Copper

◆ Lead

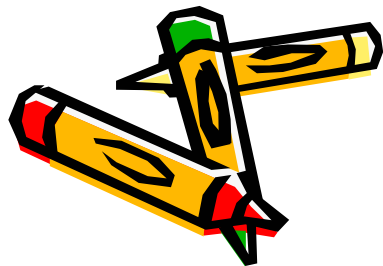
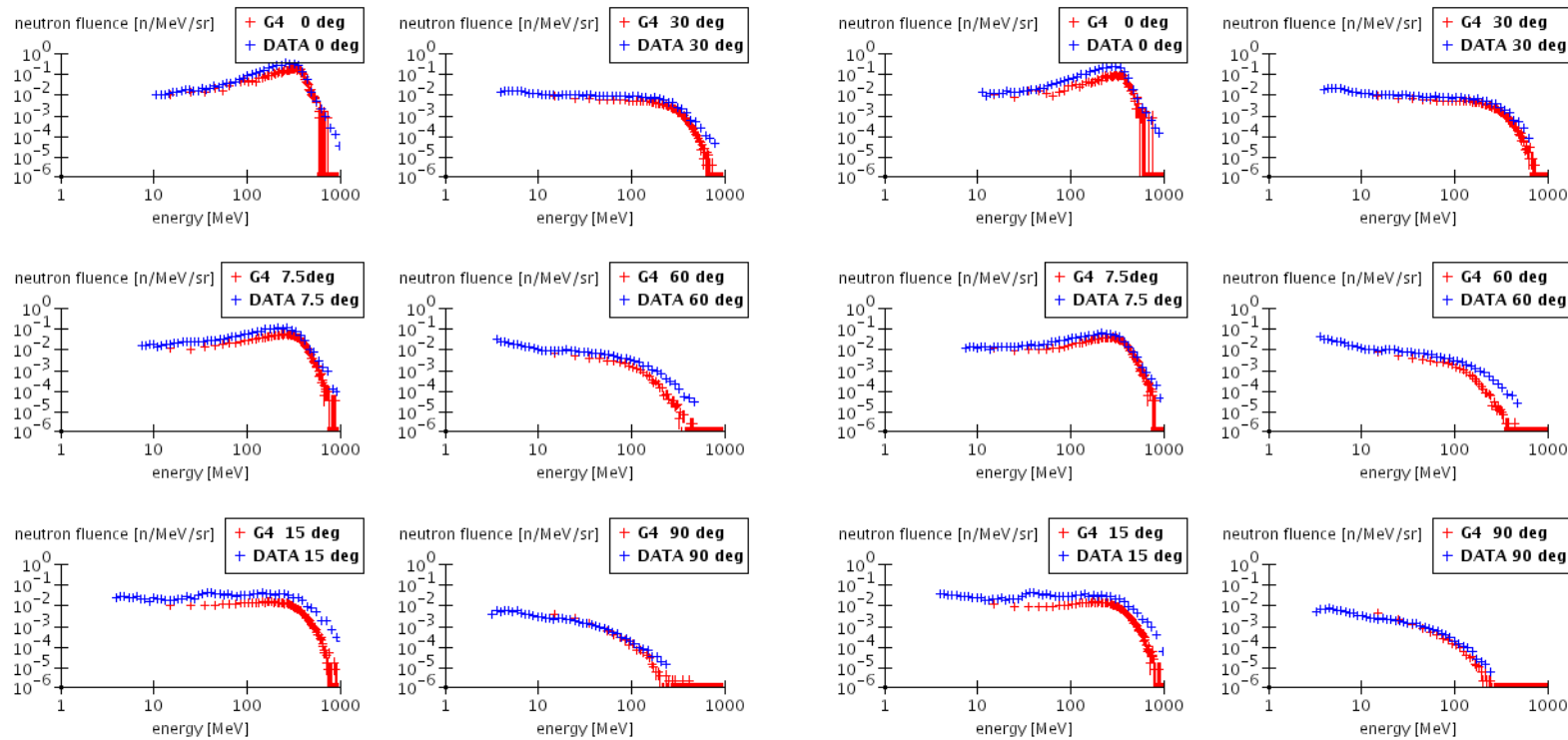


Iwata et al.,
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pp. 05460901(2001)

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Neutron Yield Argon 400 MeV/n beams



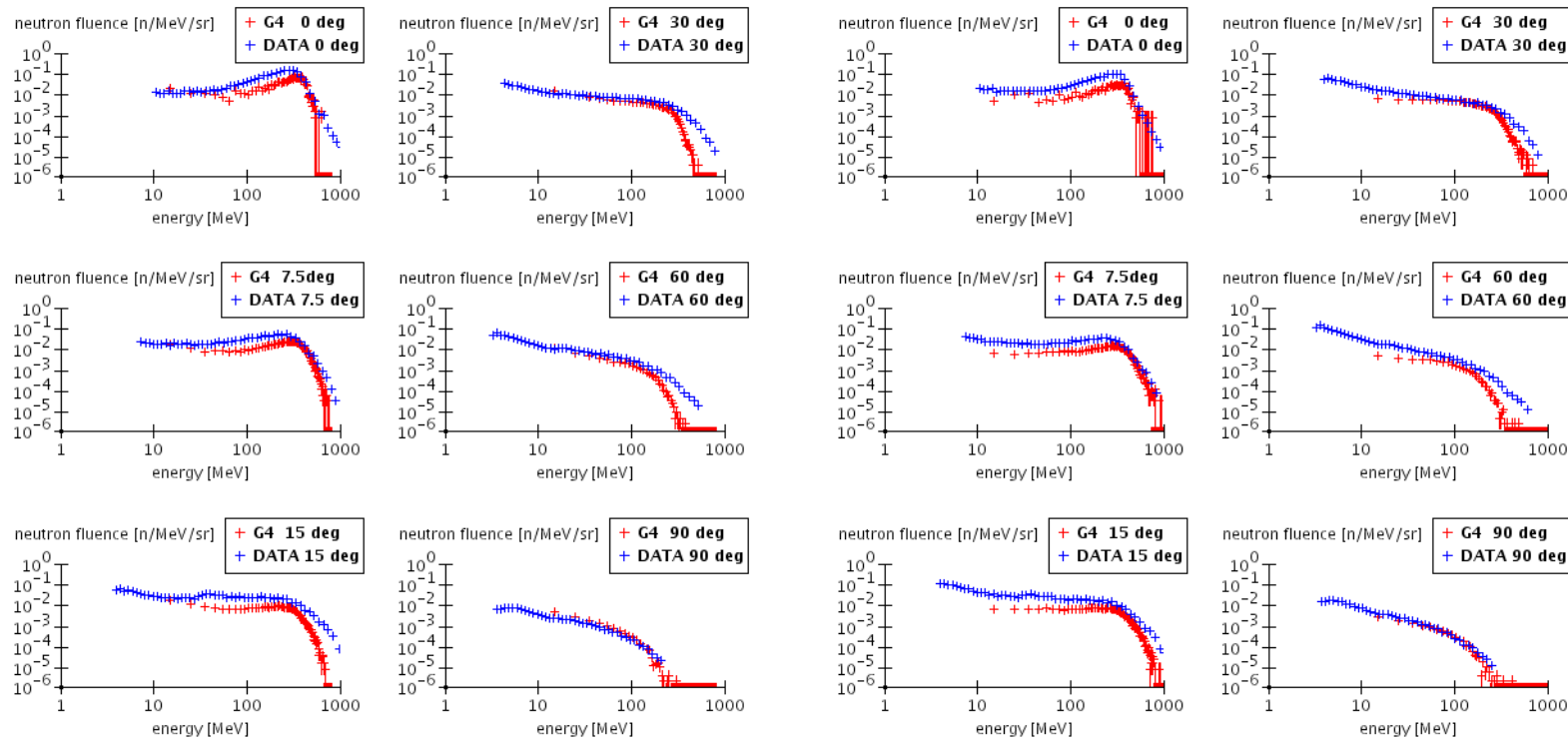
Carbon Thick Target

Aluminium Thick Target

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T. Kurosawa et al.,
Phys. Rev. C62
pp. 04461501 (2000)

Neutron Yield Argon 400 MeV/n beams



Copper Thick Target

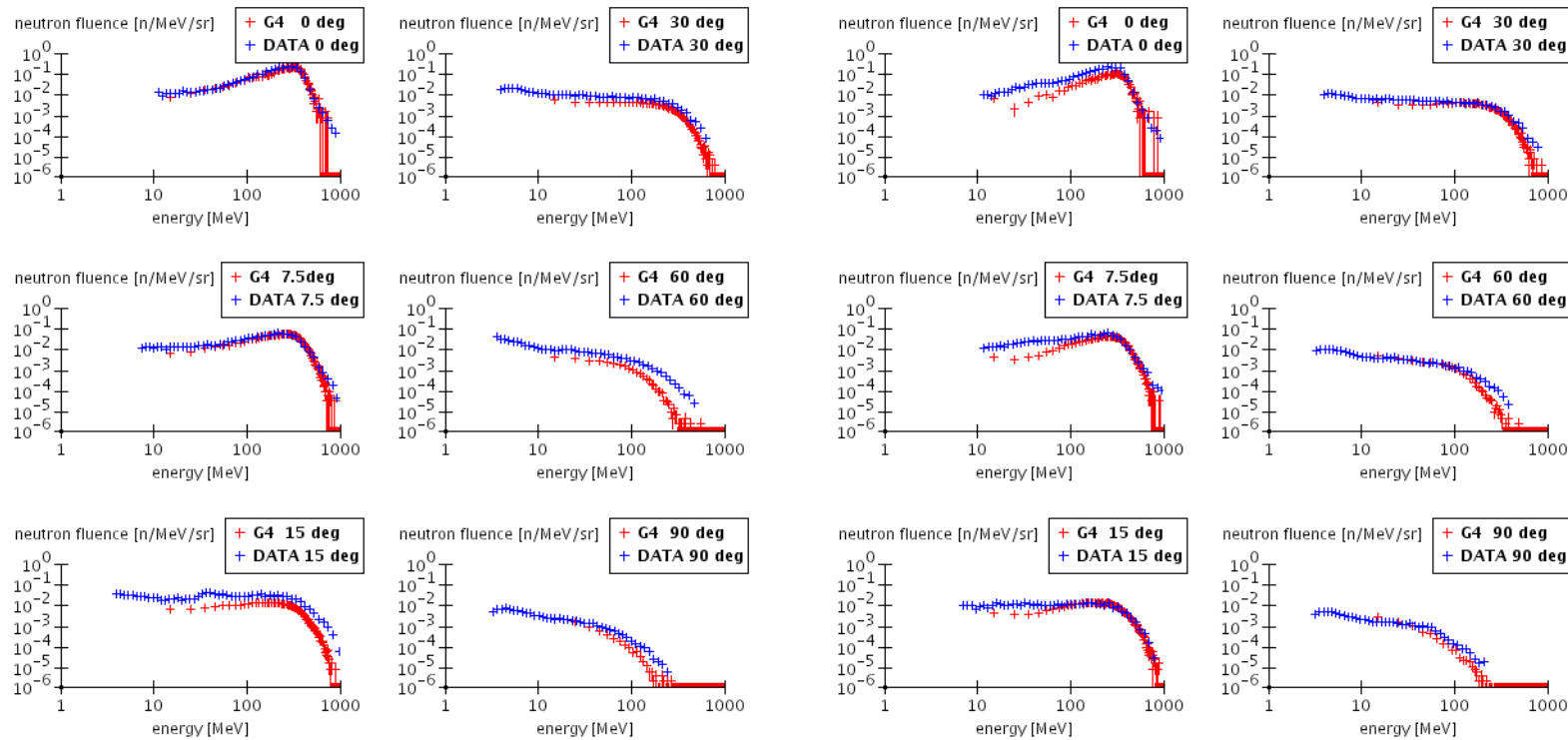
Lead Thick Target



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T. Kurosawa et al.,
Phys. Rev. C62
pp. 04461501 (2000)

Neutron Yield Fe 400 MeV/n beams



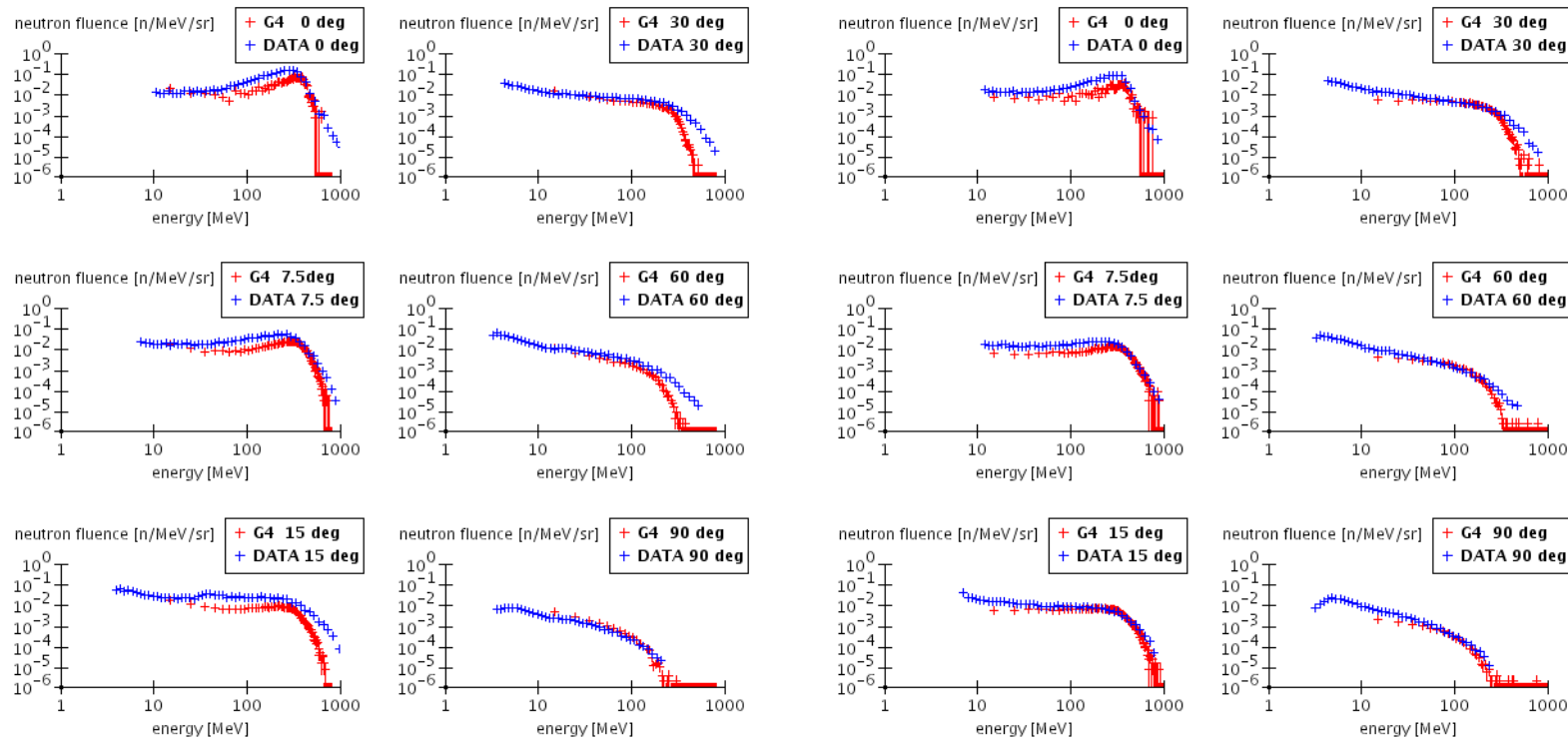
Carbon Thick Target

Aluminum Thick Target

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T. Kurosawa et al.,
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Neutron Yield Fe 400 MeV/n beams



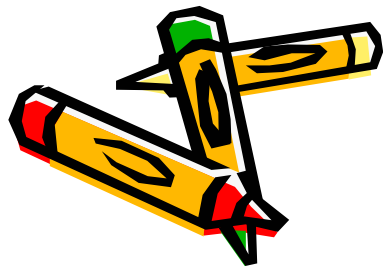
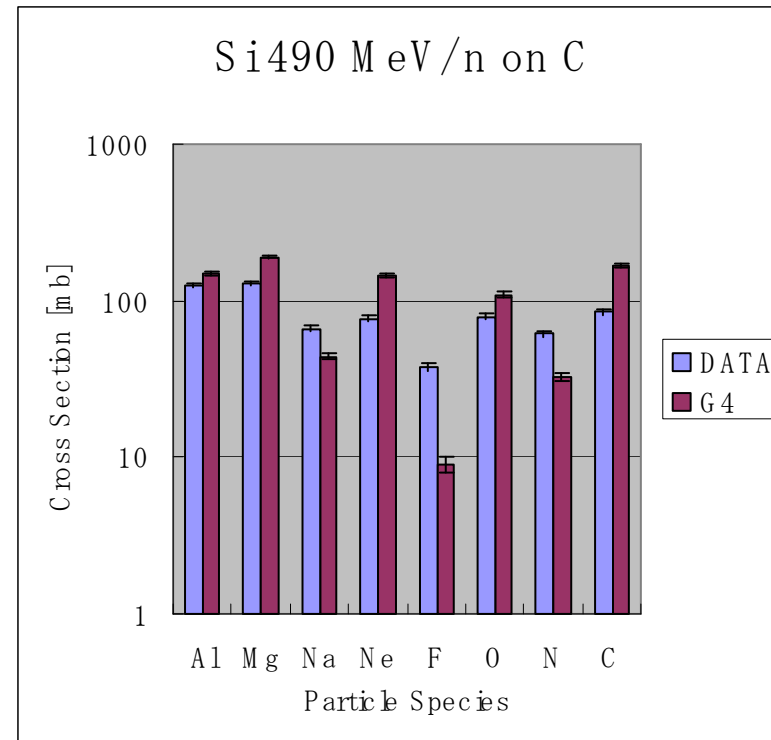
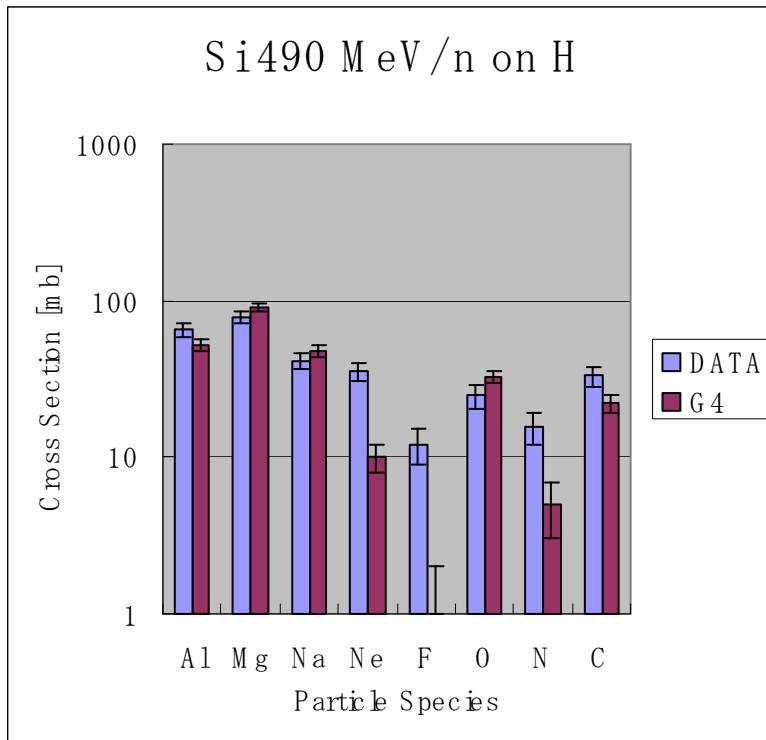
Copper Thick Target

Lead Thick Target

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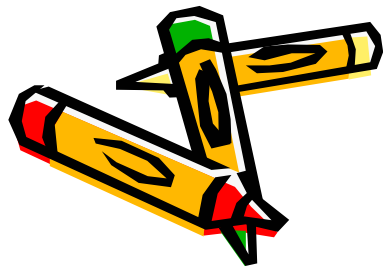
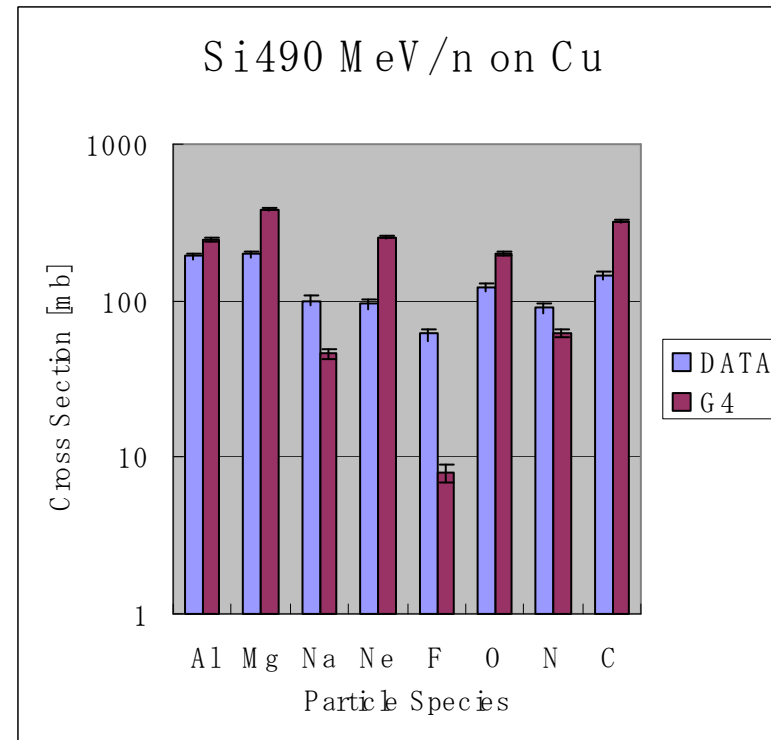
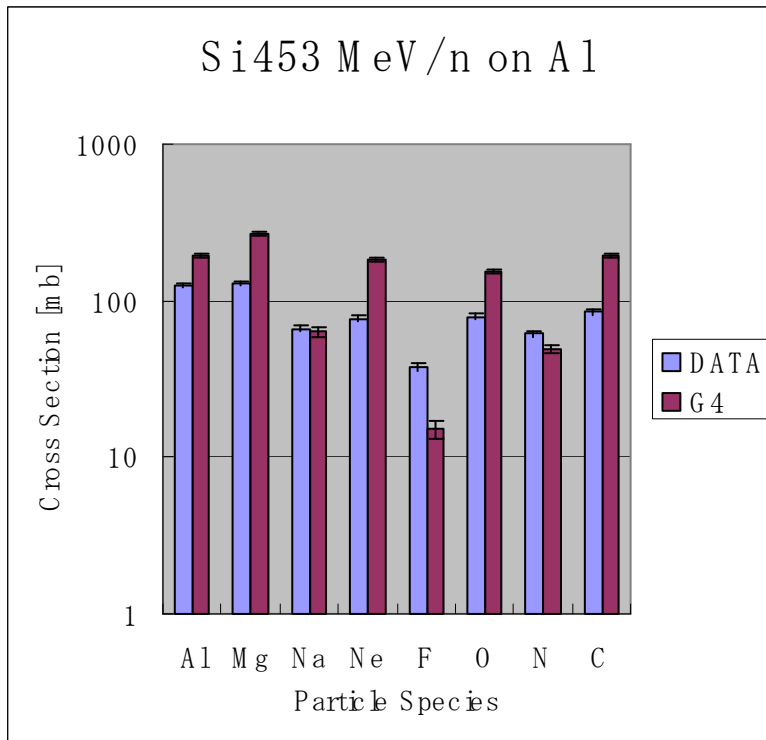
Fragmented Particles Productions



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F. Flesch et al.,
J, RM, 34 237 2001

Fragmented Particles Productions



Geant 4 collaboration workshop
Nov 8th 2005 Bordeaux, France

F. Flesch et al.,
J, RM, 34 237 2001

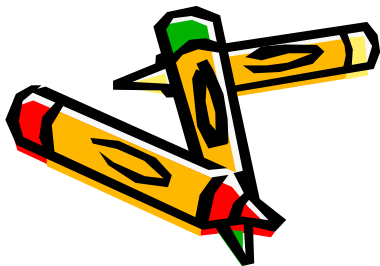
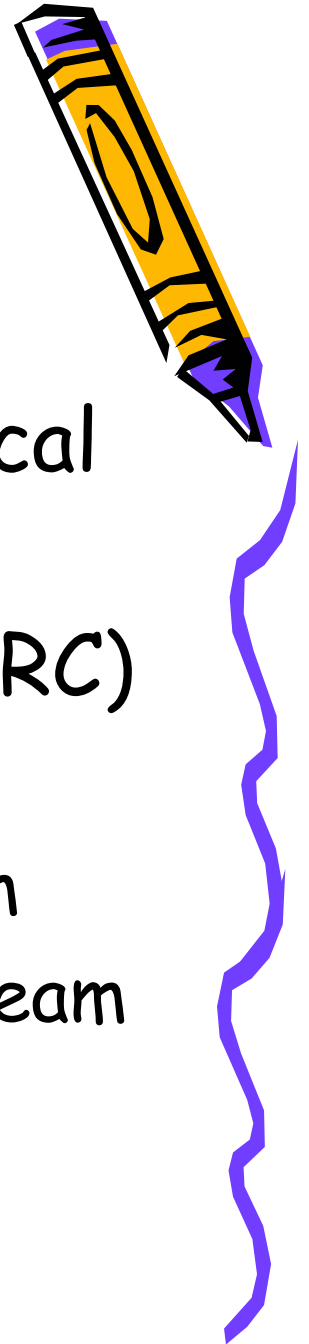
Medical use case validation

<http://www.slac.stanford.edu/~tkoi/G4Medical.html>

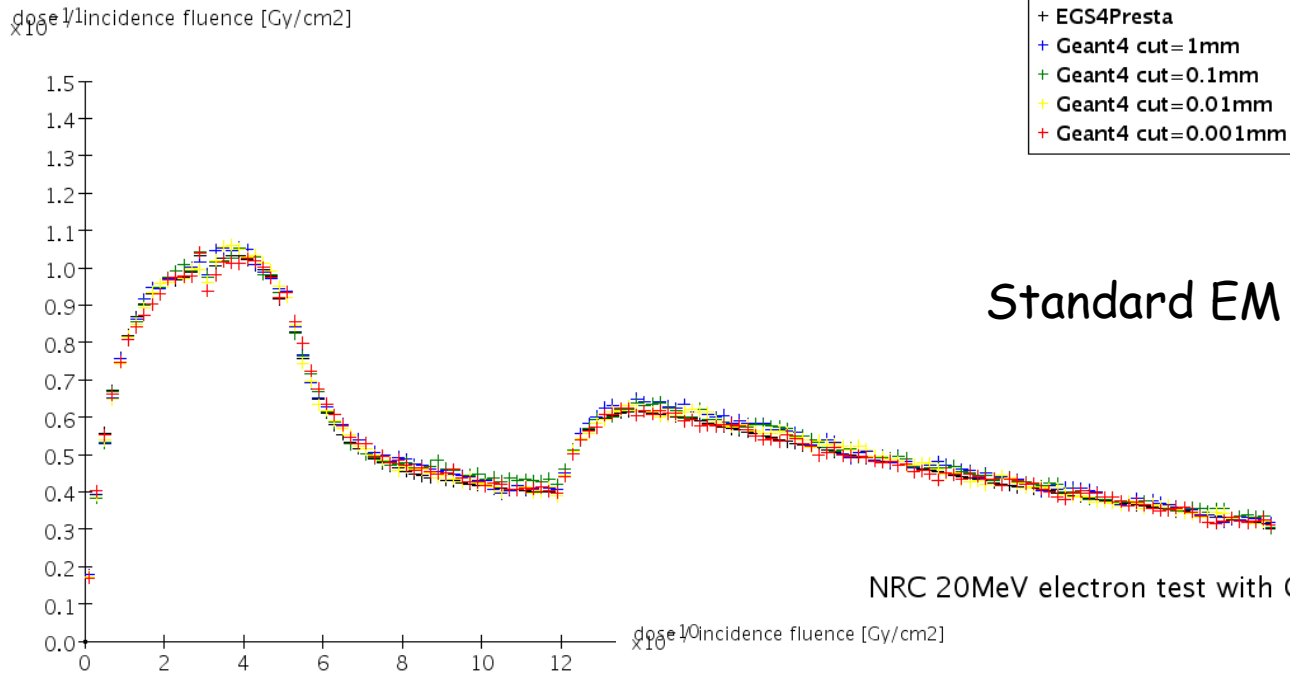
- "Questions for comparison of clinical Monte Carlo codes"

(D. W. O. Roger, Author of EGS-NRC)

- Speed test
- Accuracy test for 18MV photon beam
- Accuracy test for 20MeV electron beam



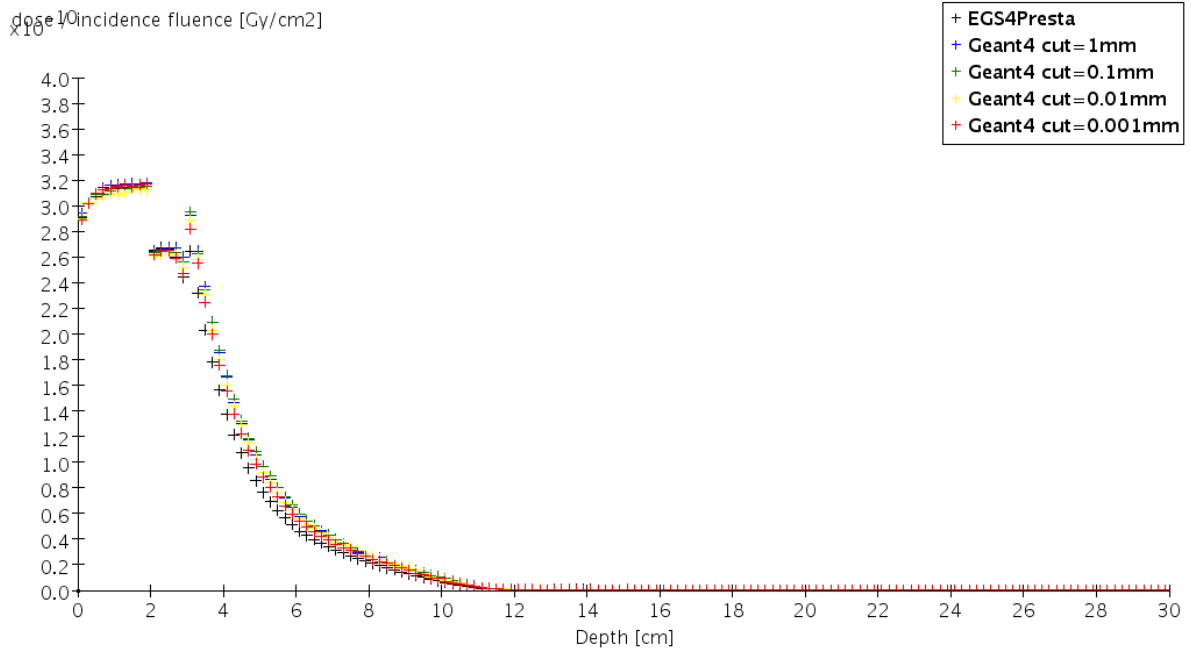
NRC 18MV photon test with Geant4 v6.2 patch02



Standard EM (ExN03PhysicsList)



NRC 20MeV electron test with Geant4 v6.2 patch02

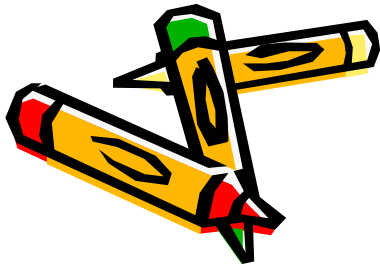
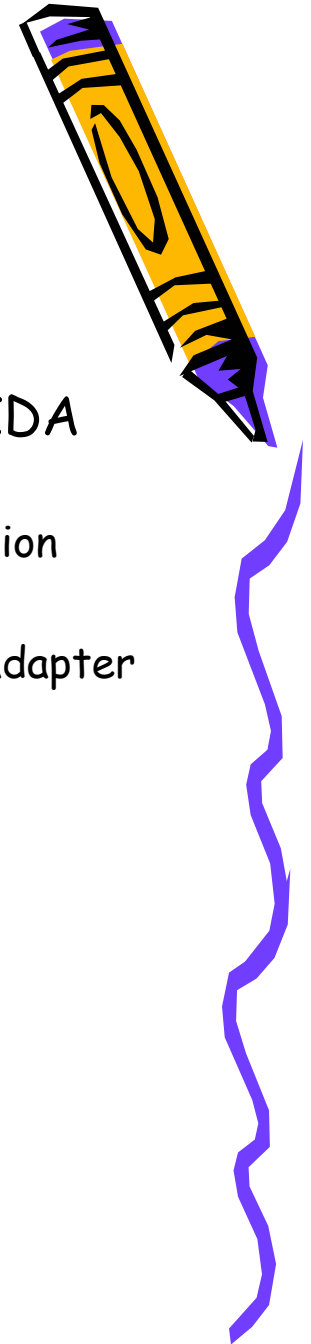


We also tests
Low energy EM
(DMXPhysicsList)



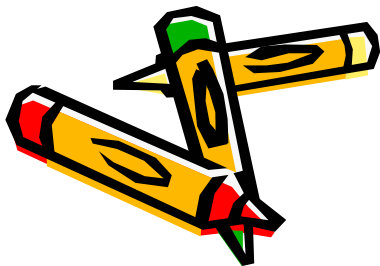
Testing Architecture

- Linux
 - Redhat Linux 7.2(Quit)
 - Enterprise Linux 3.0
- Compiler and libraries
 - GCC 2.95.3 and glibc-2.2.4 (RH7.2)(Quit)
 - GCC 3.2.3, glibc-2.3.2 (EL3.0)
 - JRE1.4.2
- Implementation of AIDA
 - JAIDA
 - JAVA implementation
 - AIDAJNI
 - AIDA C++-->Java adapter
- Analysis Sytem
 - JAS3
- Fitter
 - Uncimin
 - Minuit



These validations are carried
out for each release of
Geant4.

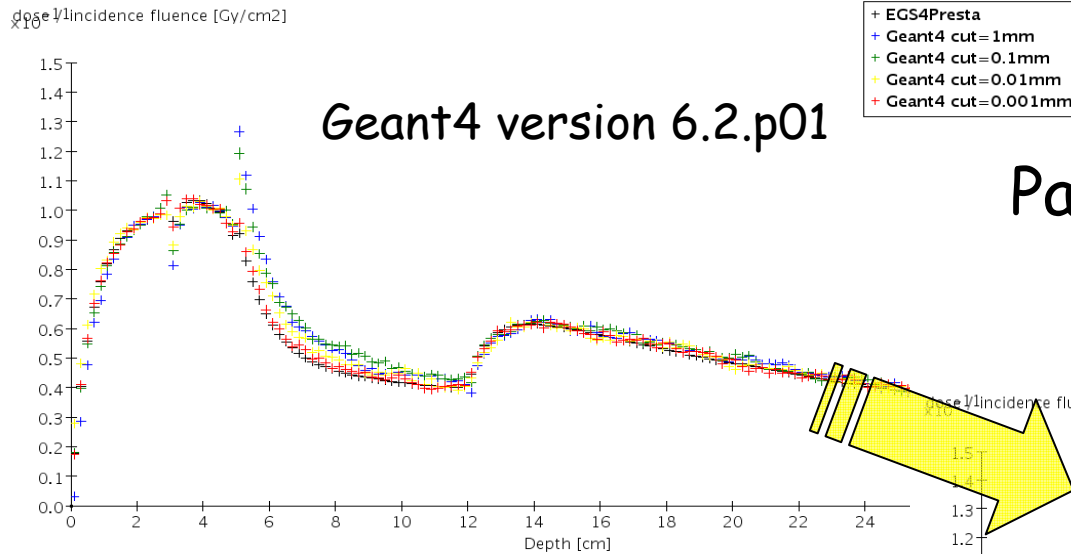
(Some of them are done for
each reference tag.)



Evidence of Geant4 improvement!

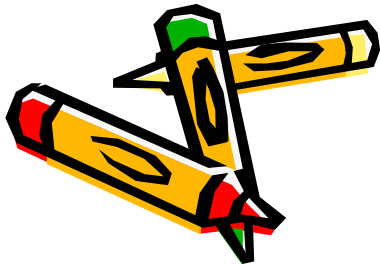
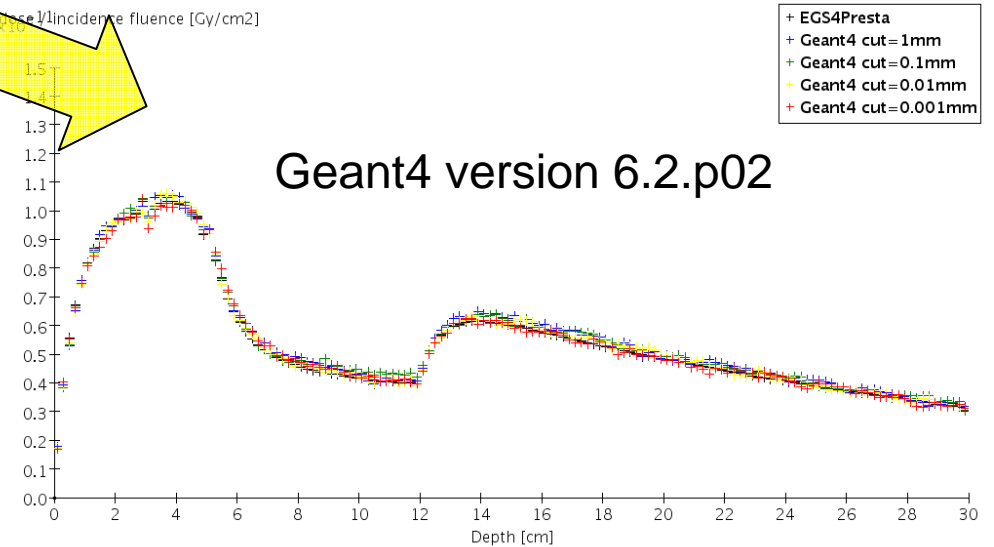


NRC 18MV photon test with Geant4 v6.2 patch01

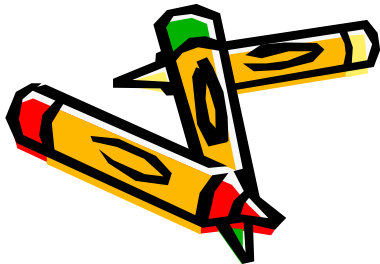
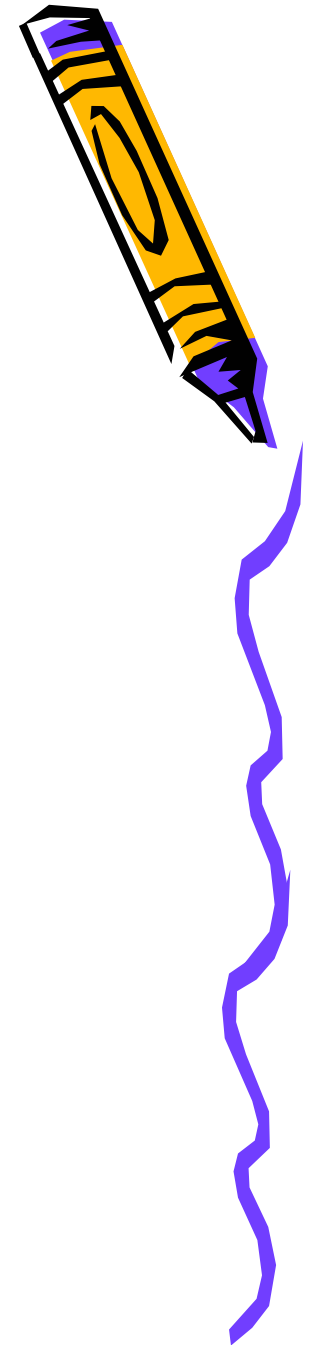


Bug fix of
Parameterization Materials

NRC 18MV photon test with Geant4 v6.2 patch02



We also do some
performance comparisons



Geant 4 collaboration workshop
Nov 8th 2005 Bordeaux, France

Comparison of Computing Speed and Memory consume among deferent implementation of Voxelized Geometries.



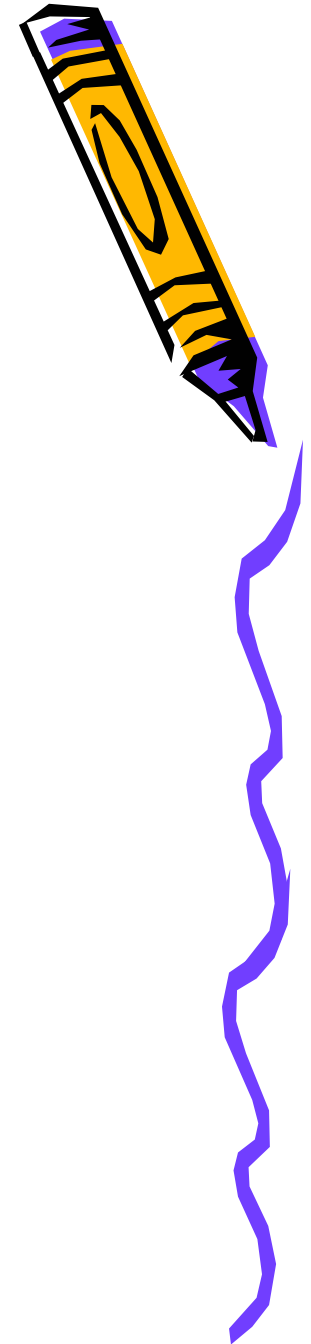
Geometry: Phantom 30x30x30 cubic cm.
Fill this Phantom by 216k voxels which have size of 0.5x0.5x0.5 cubic cm.
Incidence particle: 50MeV electron
Vertical incidence to a surface of Phantom
Uniform incidence to the surface.

Pattern of Phantom configurations
1, All voxels are place by G4Placement.
2, Configured a rod from voxels and placed these rods.
3, Configured a disk from rods and placed these disks.
4, Using G4VPVParameterisation
Results



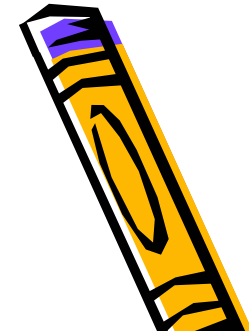
- Memory consume
 - 1, 47830k
 - 2, 572k
 - 3, 2k
 - 4, 42250k with kUndefined
4k with kXAxis
- Computing Speed
100k electrons incidence
 - 1, 433.99sec
 - 2, 410.69sec
 - 3, 427.97sec
 - 4, 446.85sec with kUndefined
44685 sec with kXAxis estimated
from 1k electrons (almost **100 times difference** with optimization option)
- If we changed the incidence surface of Phantom, there is no change in the results.

We have also activities of
interfacing to the reaction
codes from Geant4.

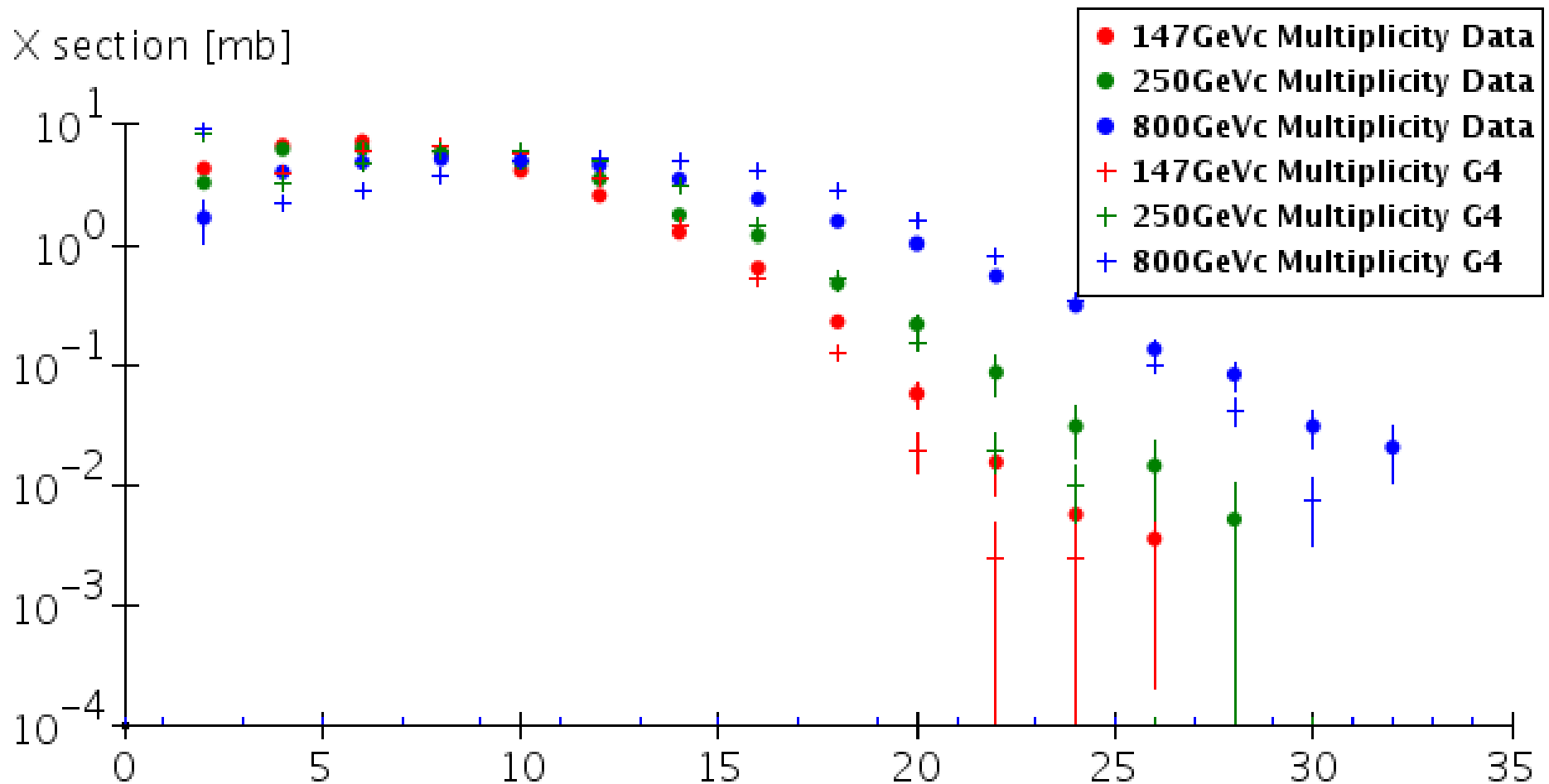


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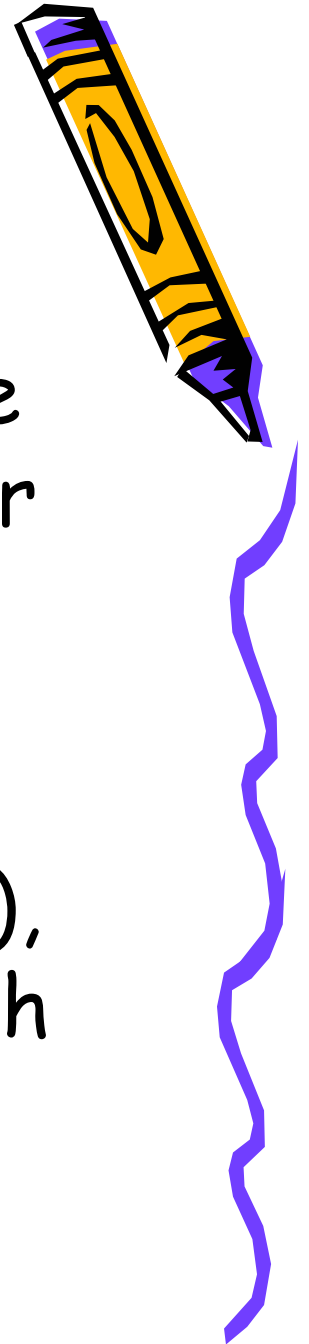
Validation of Interfaced reaction codes JAM



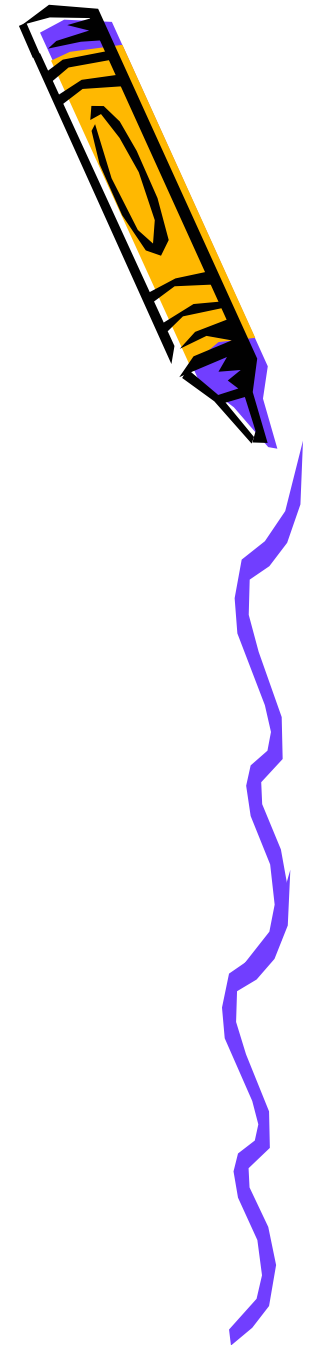
pp Charged Multiplicity



Of course,
there are quite many
validation activities and plots those
are strongly connected to the major
projects of SLAC
(Barbar, GLAST, LC, ...).
Because of limitation of time
(both presentation and preparation),
I should concentrate topics in which
general users are interested.



Testing tool for Confidence Level of Monte Carlo results



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Contents

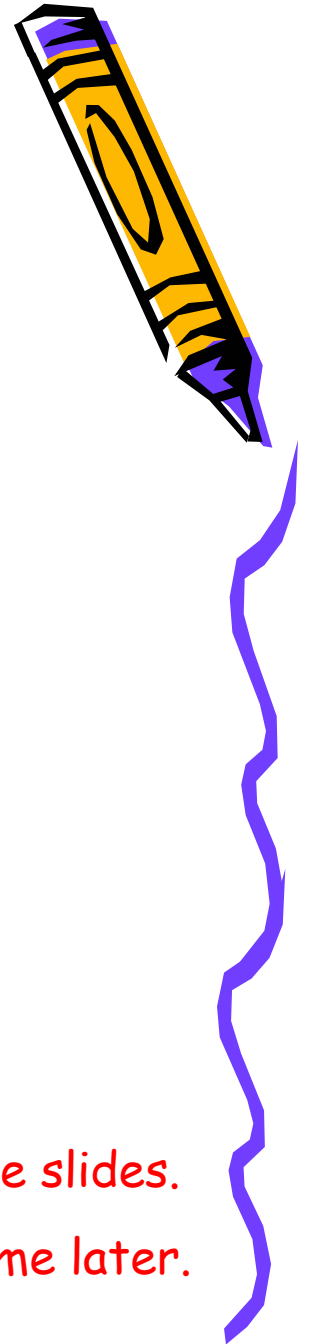
- Motivation
- Precision and Accuracy
- Central Limit Theorem
- Testing Method
- Current Status of Development
- Summary



I most like have not any time for these slides.

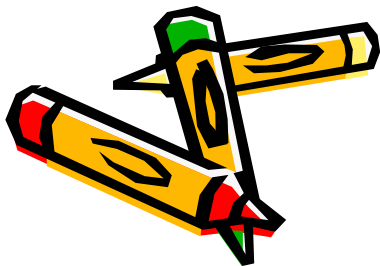
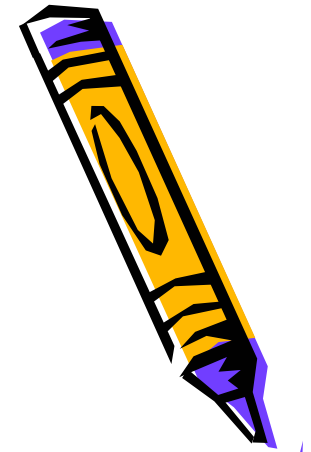
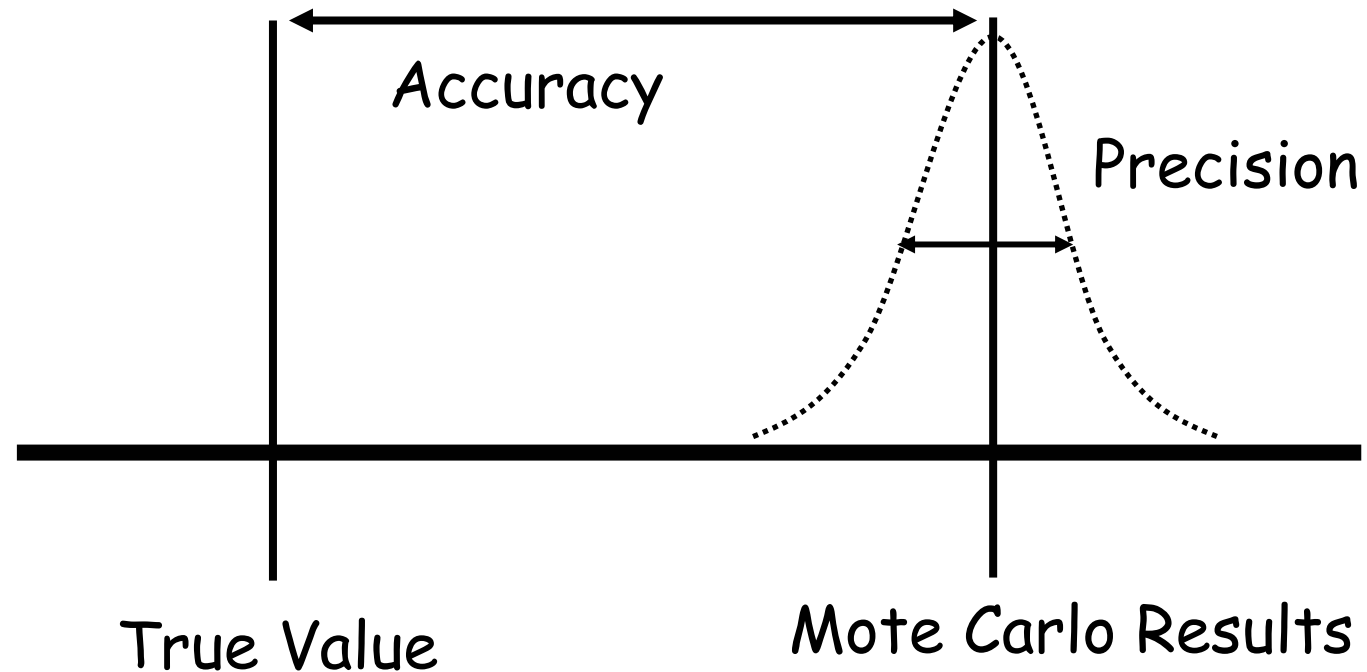
If you have interests, please contact me later.

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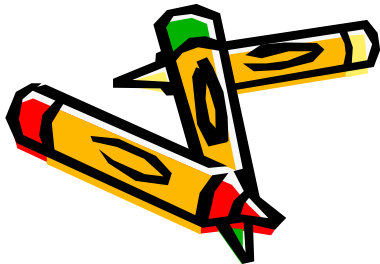
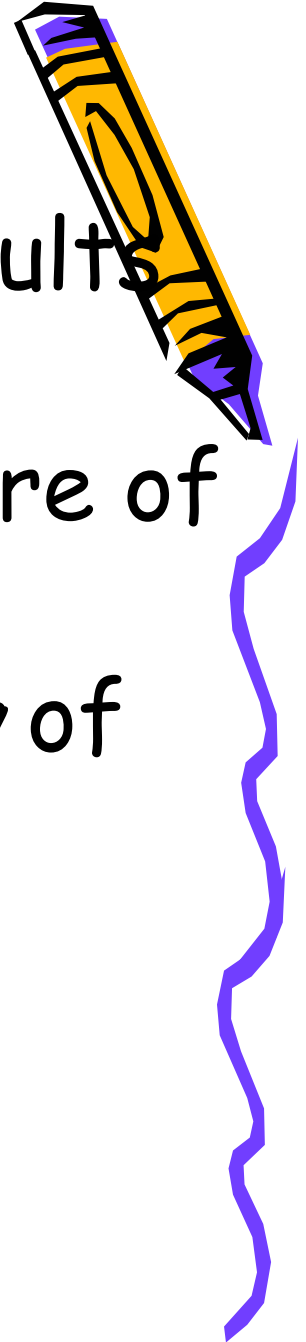


Precision and Accuracy

- Precision: Uncertainty caused by statistical fluctuations
- Accuracy: Difference between expected value and true physical quantity.

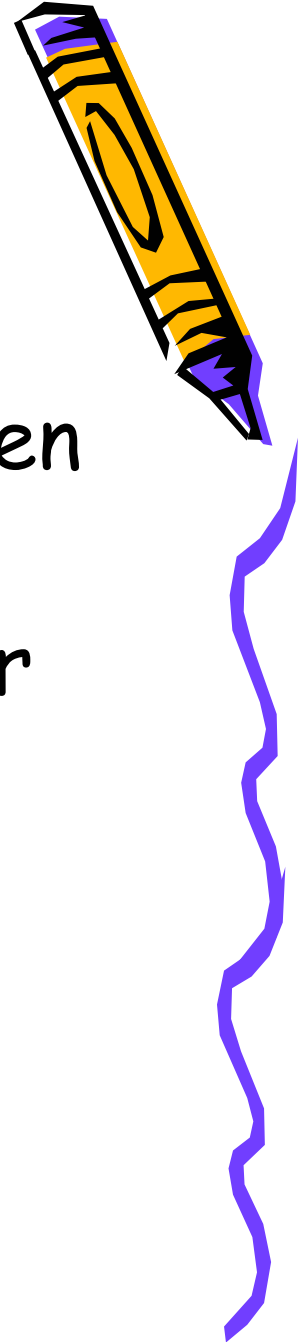


This is not
a simple static calculation of results
but
checking of the results from nature of
Monte Carlo simulations.
Checking the *complete sampling* of
interested phase spaces
has occurred or not.



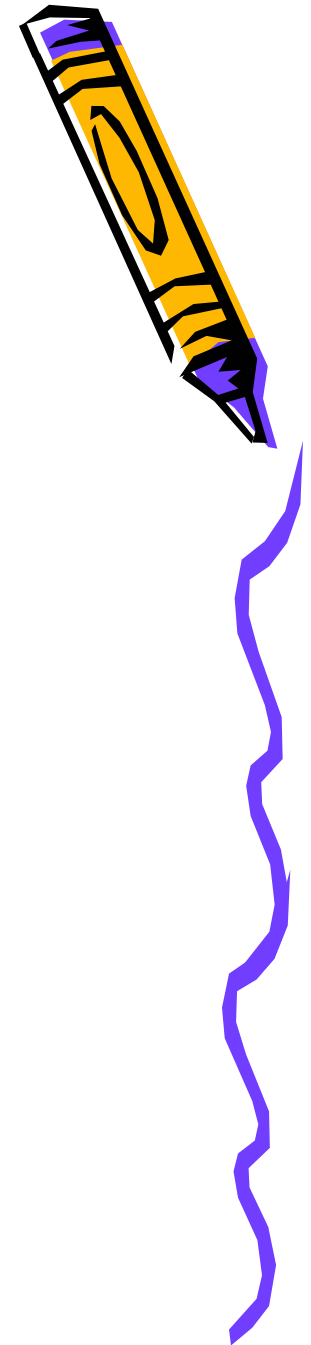
Current Status of Development

- Most part of developments has been done.
- Following items are remained under development.
 - Output of testing result
 - Class or function for minimization of multi dimensional functions



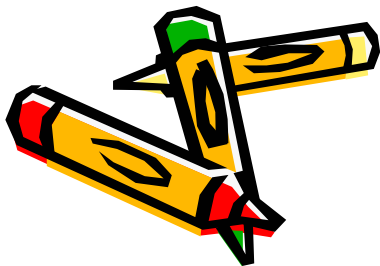
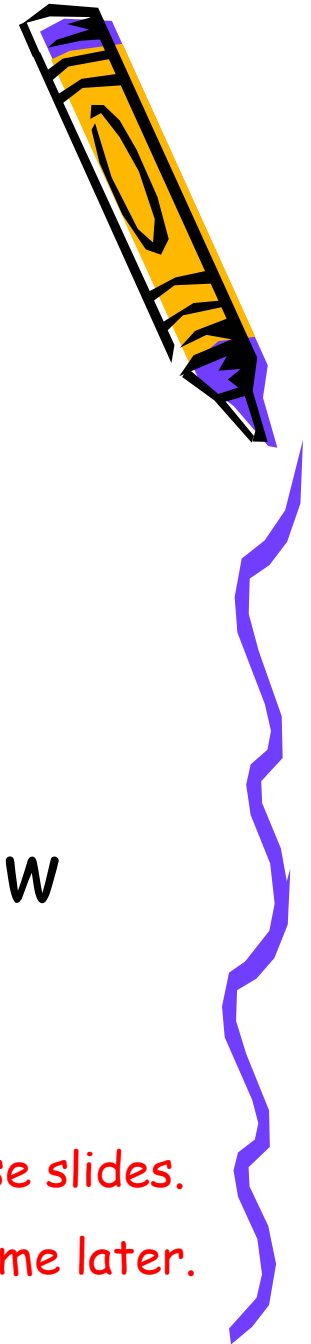
We want to include this tool in
Geant4
but
what category is suite for this
tool?

Run, SD, Hits and its collections,
Tally??



Summary

- We have successfully developed a general assistant tool for the checking the results from Monte Carlo simulations like MCNPs.
- Through this tool, users easily know the confidence intervals of their Monte Carlo results.

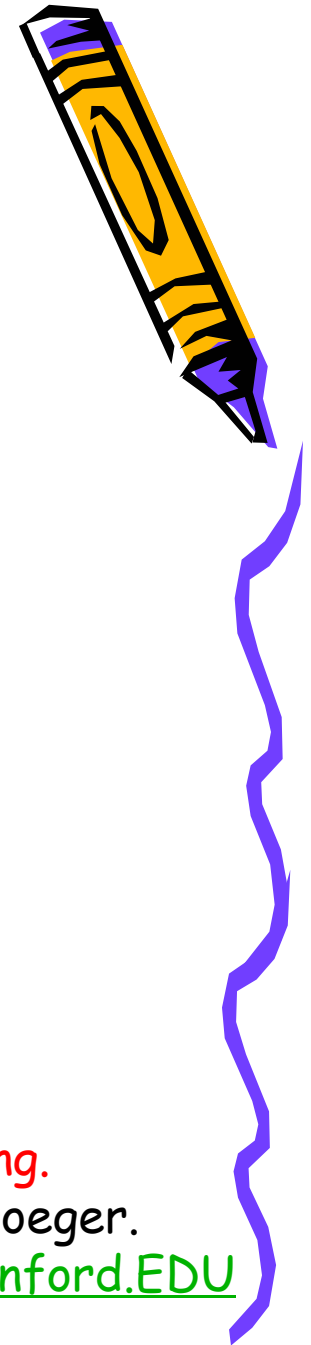


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Grid related Geant4 activities at SLAC



I am not GRID expert at all.
Most questions you might ask me,
I do not understand what you are asking.
Please have direct contact to Wilko Kroeger.

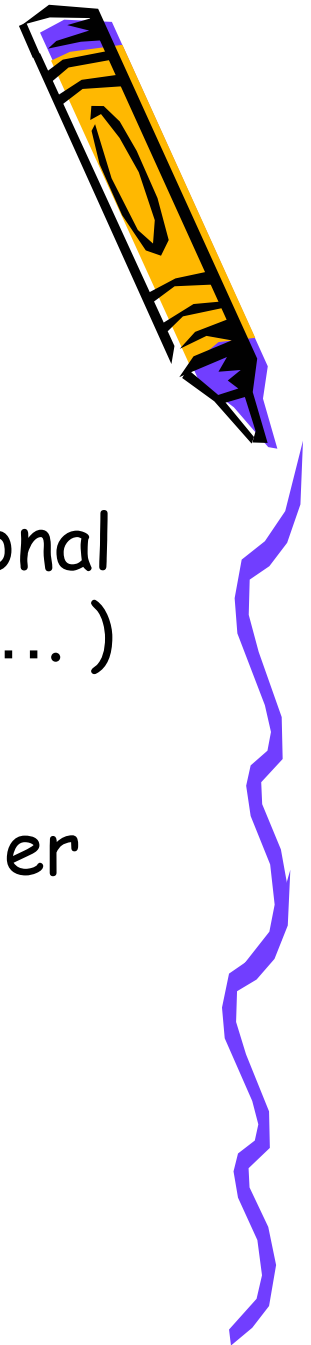
wilko@SLAC.Stanford.EDU

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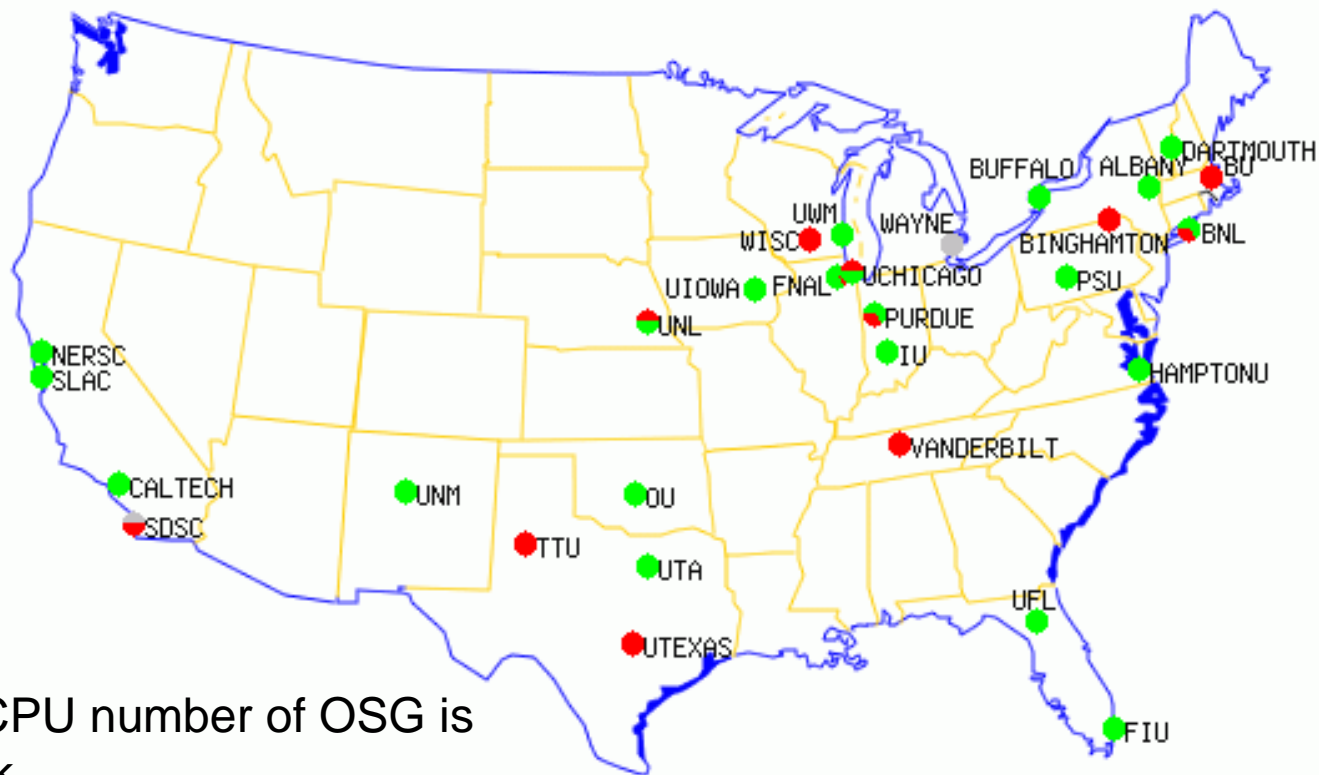


the Open Science Grid (OSG)

- US grid computing infrastructure
- Consortium of US University and National Laboratories (SLAC, Fermilab, BNL,)
- Driven by LHC
- Physics, Astrophysics, Biology and other Projects use the OSG



Status of OSG sites



Total CPU number of OSG is
10~15k.

Mon Oct 31 19:45:12 GMT 2005

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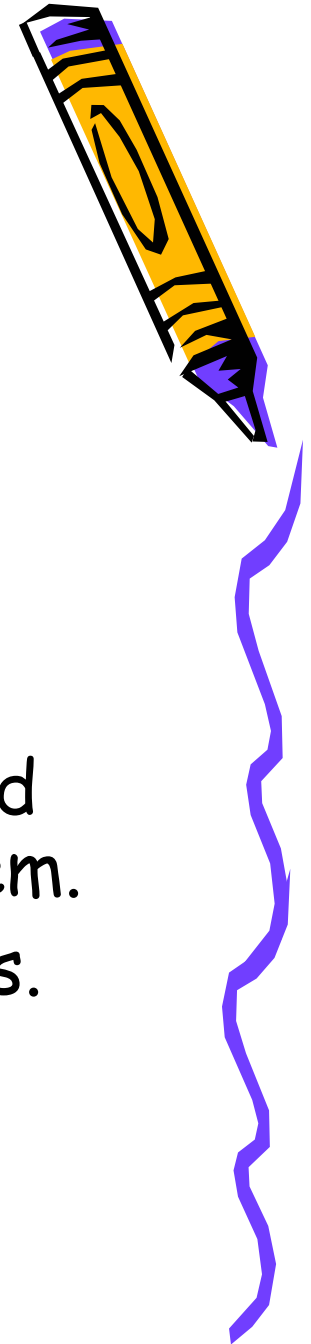
Geant4 Validation and OSG

- Validate each new Geant4 releases.
- Physics validation (e.g.: elm and had showers) is very computing intense in some cases.
- Using a Grid is a natural place to run these jobs.
- Validation with LCG has been successfully done. Now try to use OSG.

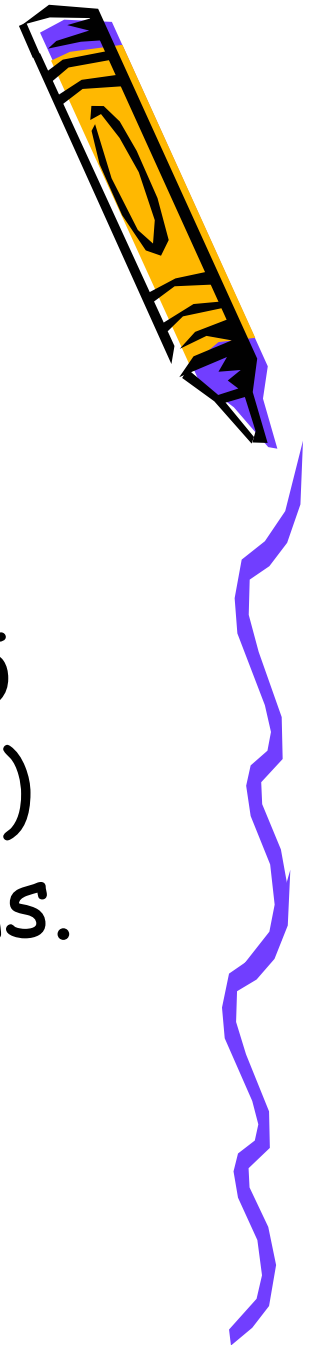


Geant4 Validation and OSG (Cont.)

- Follow ideas from Geant4 and LCG.
- Able to run Geant4 on OSG.
- Develop tools to install Geant4 release at OSG sites.
- Tools to manage many jobs, retrieve and compare results is also development item.
- Work closely other Geant4 grid efforts.
 - We are relatively new comer for this field.

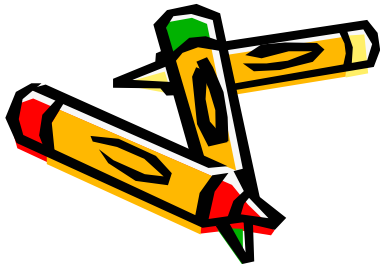
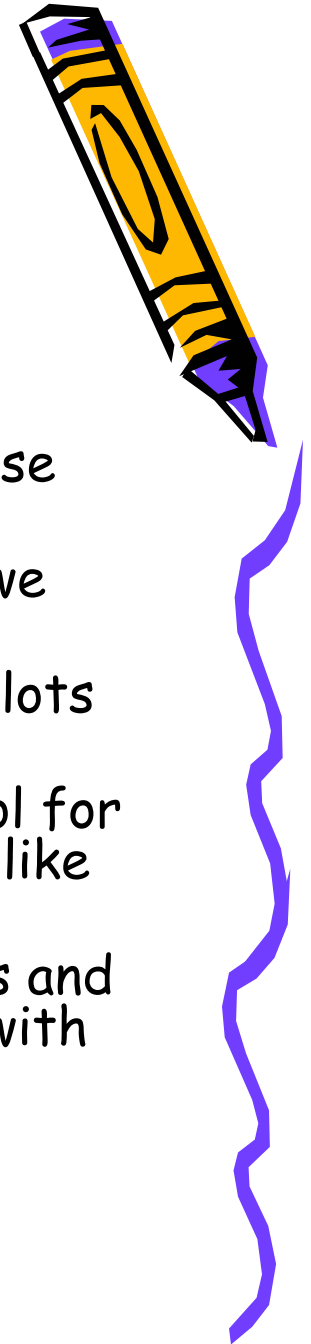


First results of
our Grid related activity
will be presented
by Wilko Kroeger
in the Super Computing 2005
(Nov 12-18 Seattle, WA USA)
at SLAC/Fermi lab exhibitions.
"Geant4 validation using the
Open Science Grid."



Summary

- Many validation plots are produced for each Geant4 release. You can get progresses of Geant4 through these plots.
- Thanks to the good users inside and outside of SLAC, we can achieve fruitful validations of Geant4.
- Thanks to the developers of Geant4, these validation plots have been effected improvement of Geant4.
- We have successfully developed a general assistant tool for the checking the results from Monte Carlo simulations like MCNPs.
- We just begin to use GRID for Geant4 validation works and we will continue to investigations. And collaborations with other Geant4 GRID efforts are most desirable.



Binary Cascade
Fragmented projectiles C12 on Water

