Cosmic Ray activation of Germanium in Geant4

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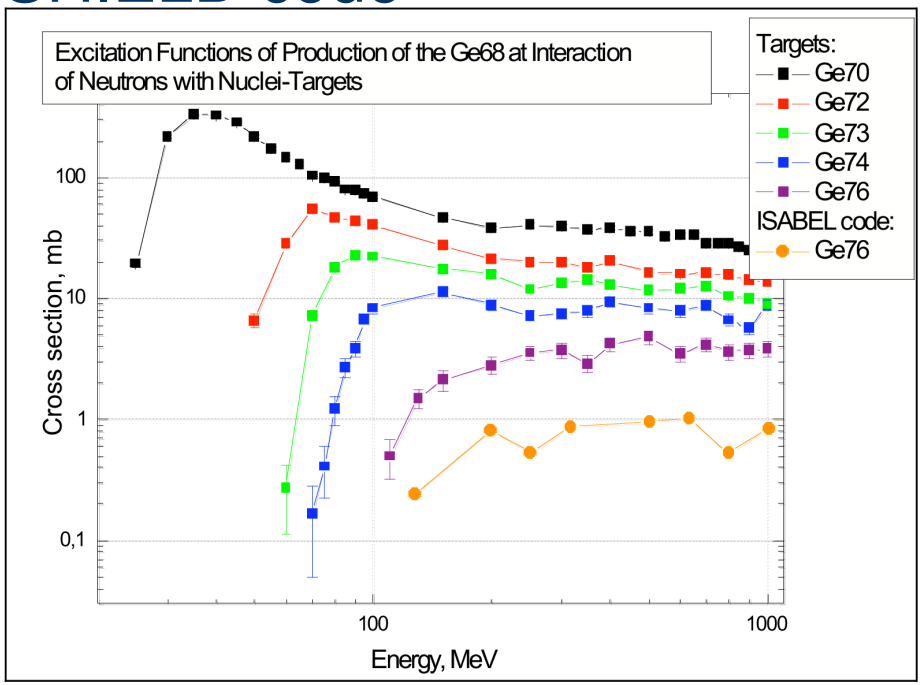
Introduction

- Since the release of geant4.9.0 is possible to simulate materials with different isotopic composition, the default behaivior of G4, is to identify elements based on A and Z
- Available data incomplete ...
- Several theory driven physics models available in G4 as well
- Geant4 is a general purpose MC, all detector simulations are based on, would be nice to do all in one MC
- My baseline for comparison: I. Barabanov et al., NIM B 251 (2006) 115-120 (and the simmilar internal note)

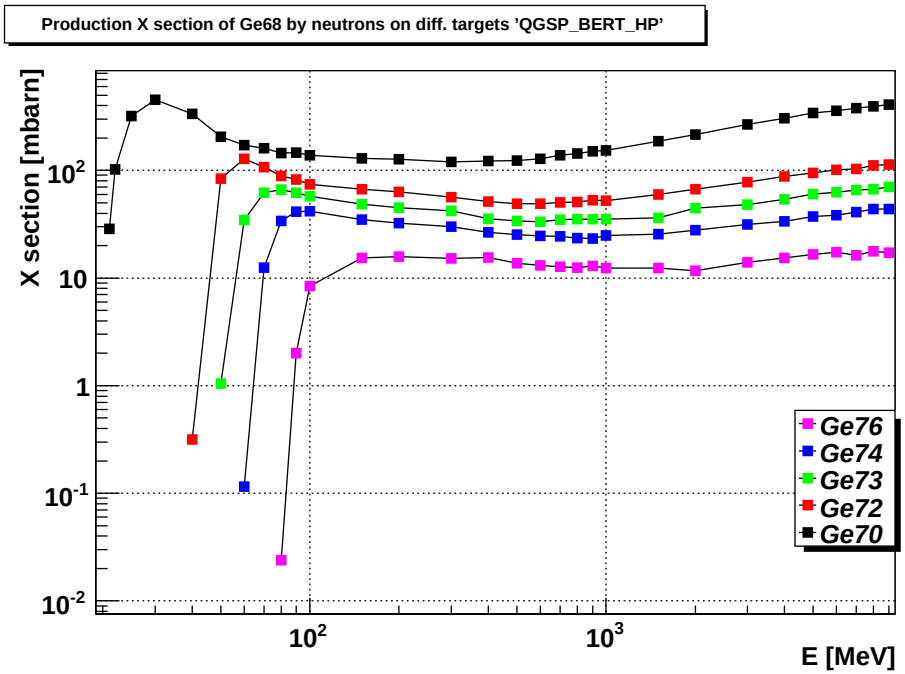
^{68}Ge

- First try with the Bertini-cascade: Production cross section of ^{68}Ge by neutrons on different Ge isotopes
- It works ...

SHIELD code

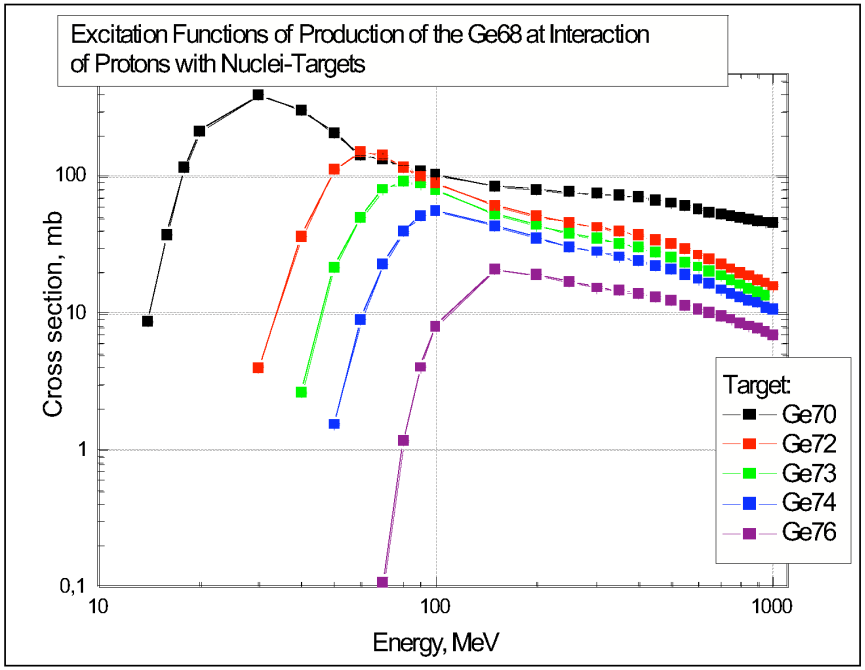


Geant4

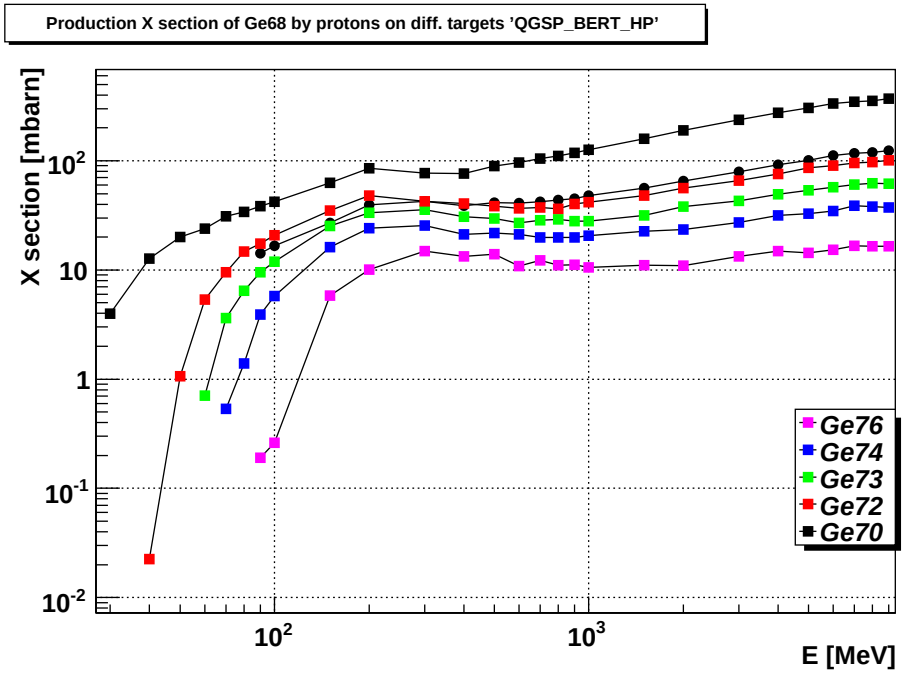


- Protons are a bit different. Don't get excited, the flux of cosmic protons is a few order of magnitudes smaller (than of the neutrons) in the relevant energy range

SHIELD code

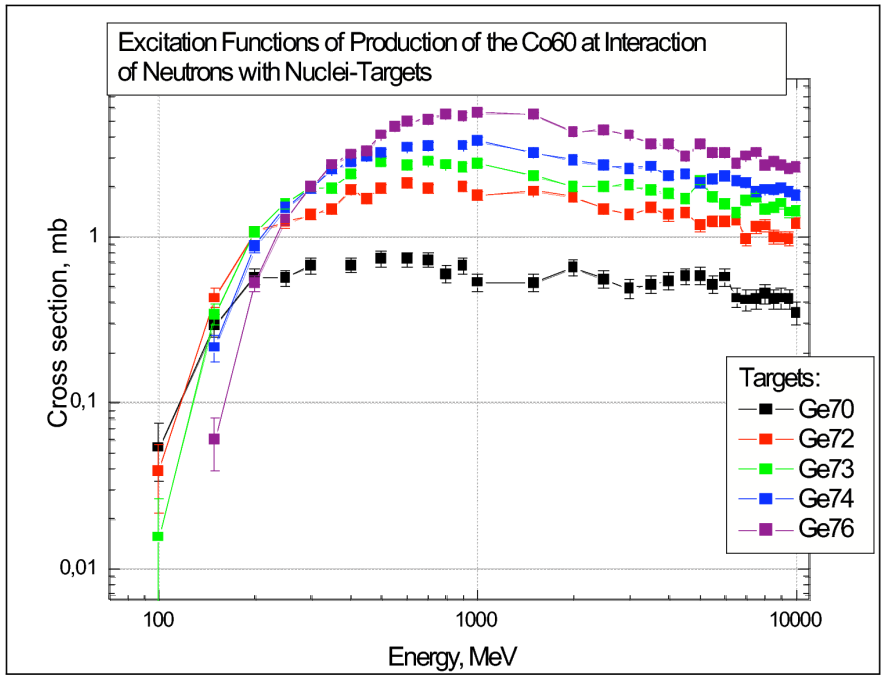


Geant4

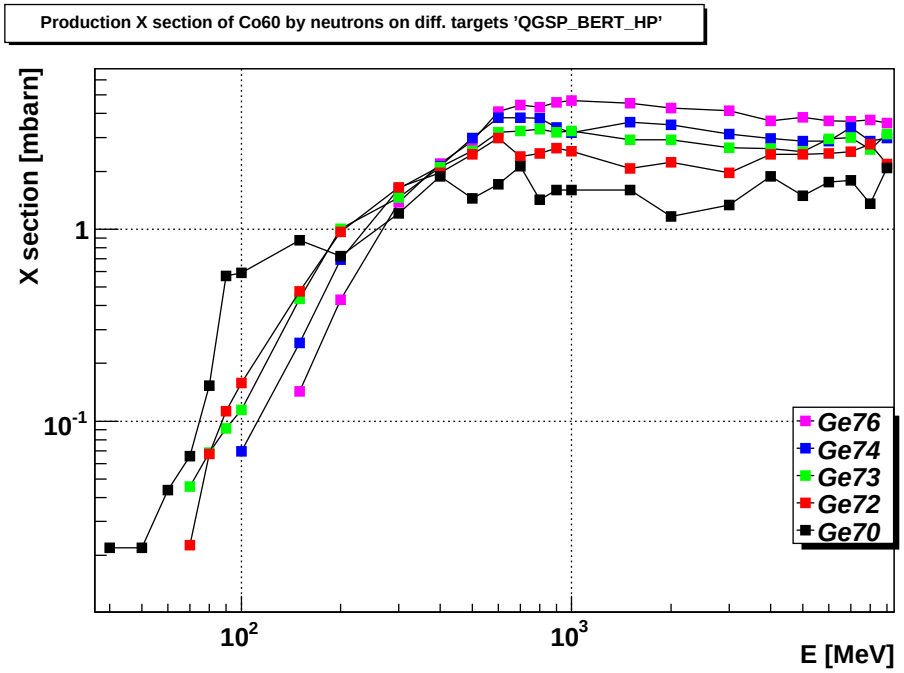


^{60}Co

SHIELD code

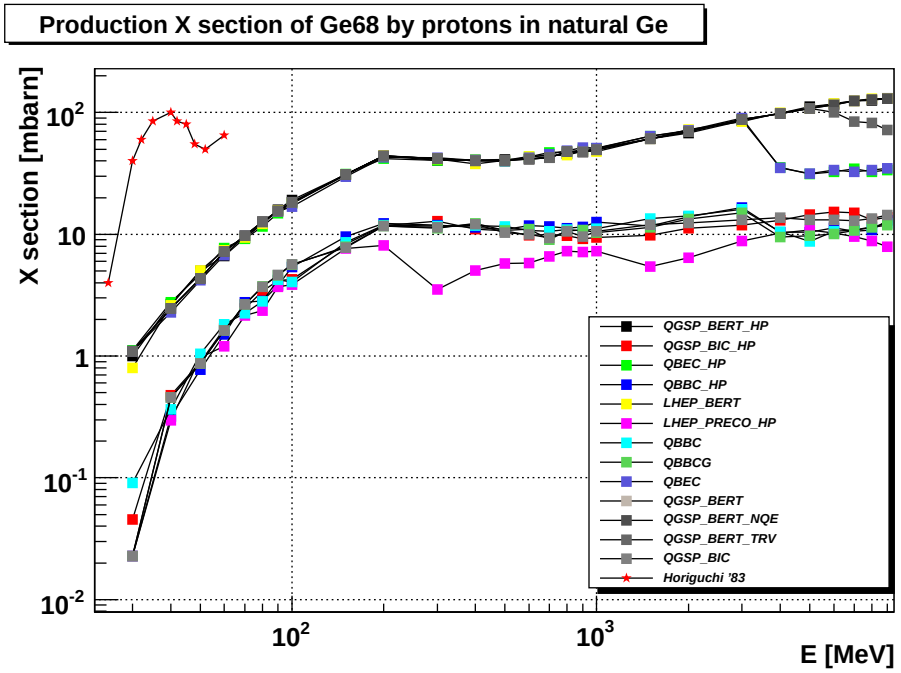


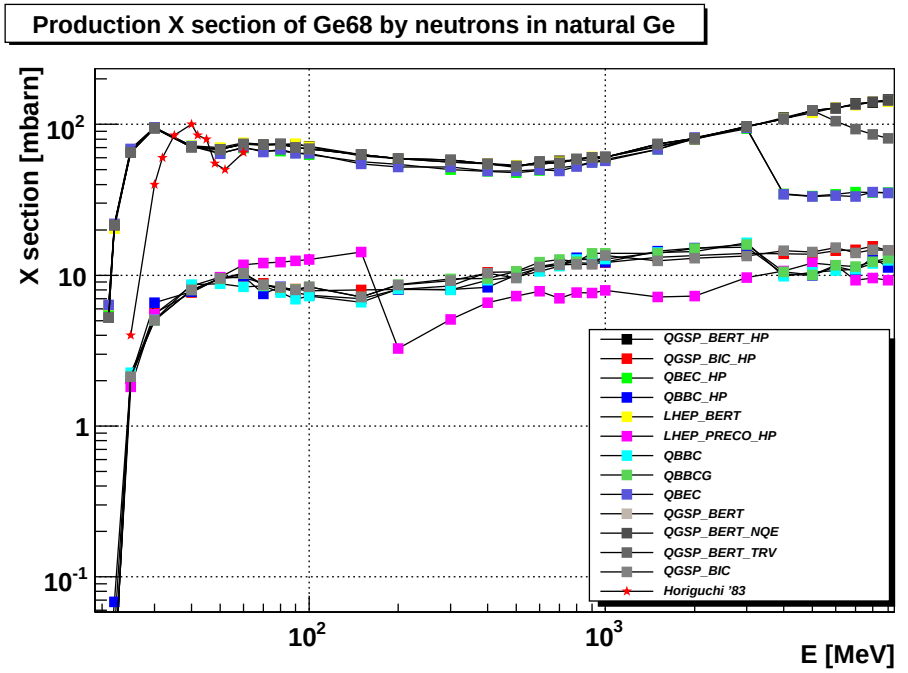
Geant4



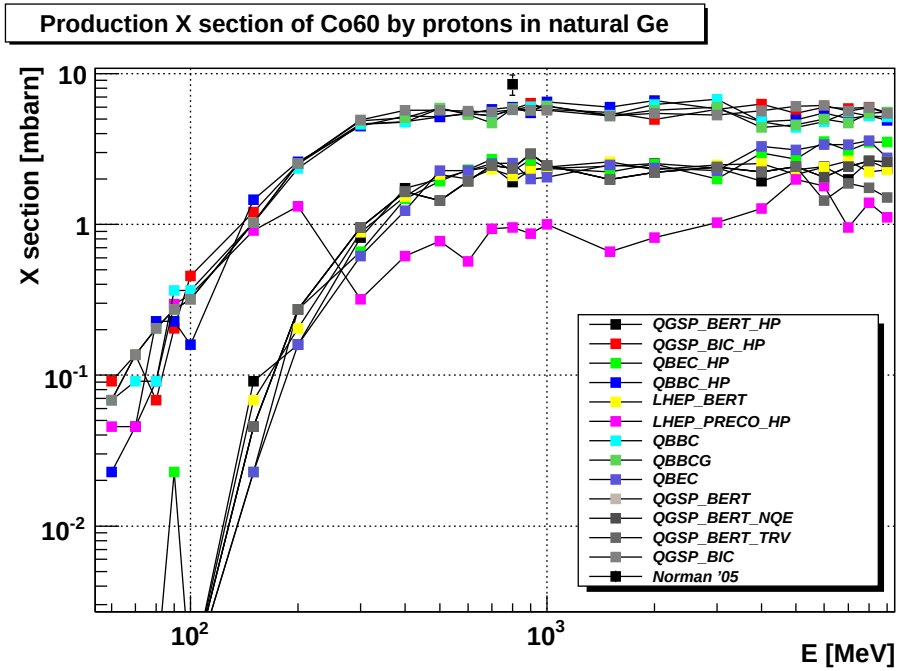
Comparison of different models

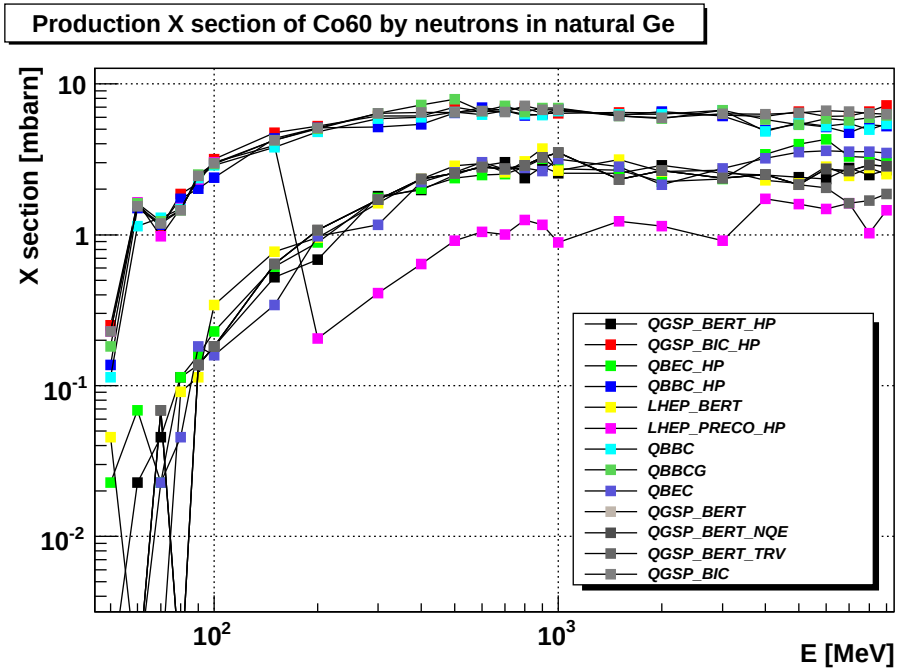
- I tried out all relevant models in Geant4.





^{60}Co

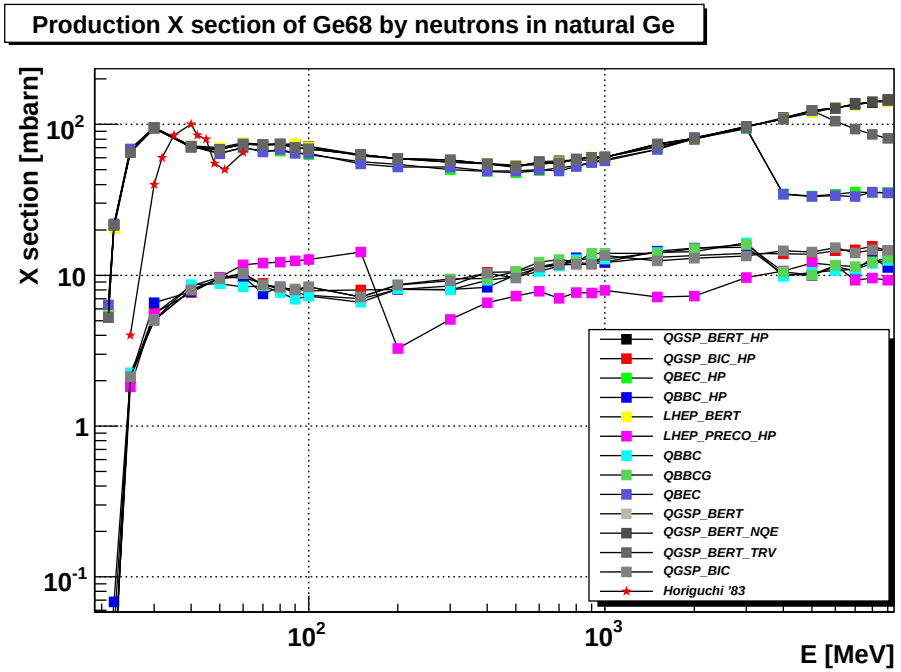


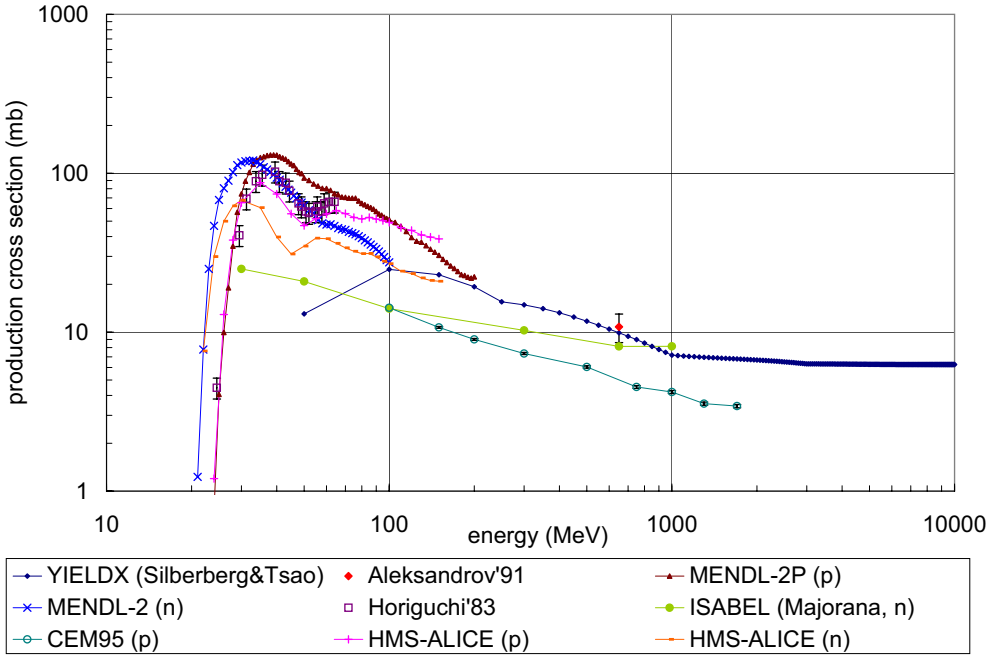


Conclusion: BERT is OK for ^{68}Ge (and below 1 GeV), BIC (BinaryCascadeModel) better for ^{60}Co and in general, above 1 GeV

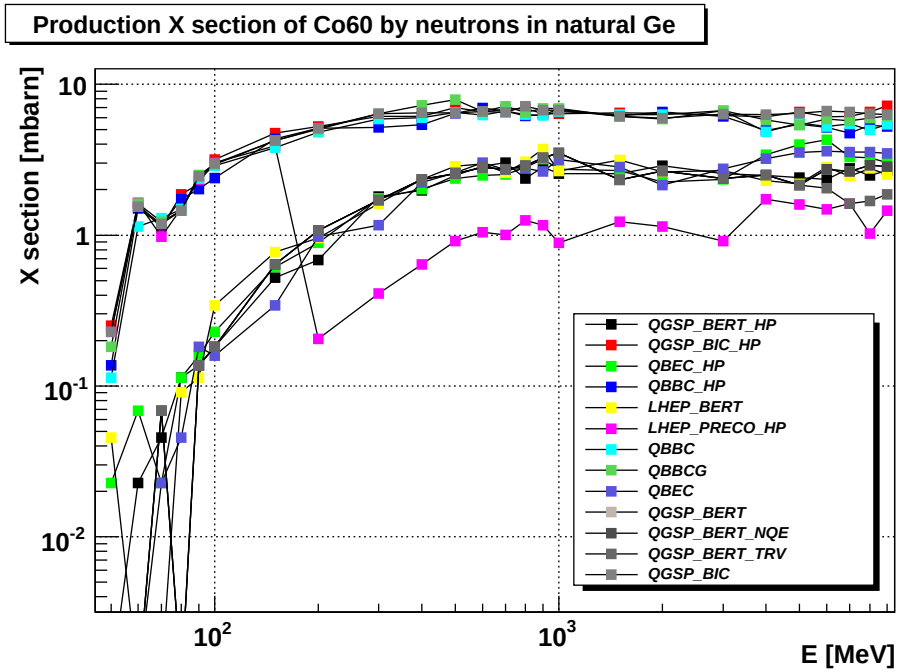
Comparison with other MC

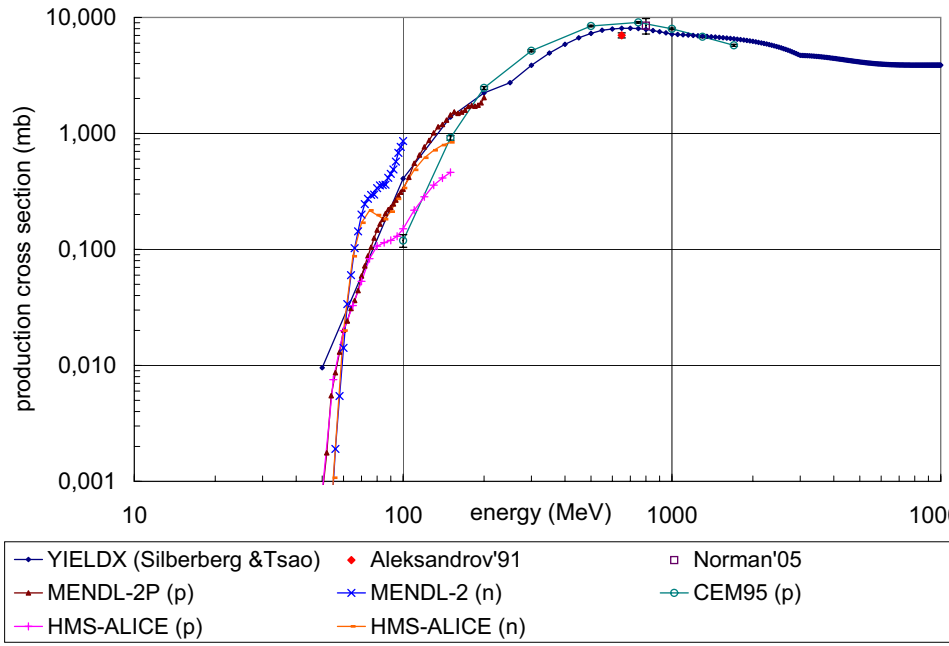
- See: H. Gomez et al. arXiv:0708.3987v1 nucl-ex, IDEA report etc.





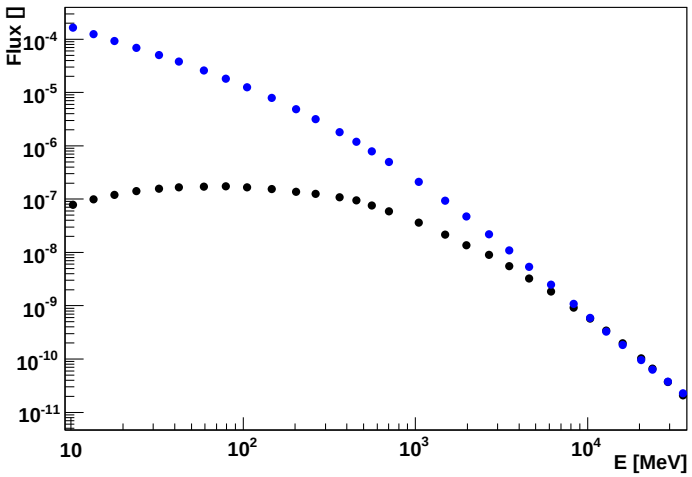
Comparison with other MC 2.





Conclusion: Geant4 in *principle* can reproduce these plots (and accomodate all data points). Hybrid physics list shows strange behaivior, under investigation ...

Cosmic nucleons



- Flux of neutrons and protons drops fast above 1 GeV.
- One order of magnitude differences between MC codes might be supressed by larger variations of the cosmic ray flux

	nat Ge		enr Ge	
	^{68}Ge	^{60}Co	^{68}Ge	^{60}Co
QGSP_BERT_HP	**105.01**	1.09	**14.48**	1.03
QGSP_BIC_HP	14.37	**5.1**	0.19	**2.33**

Total production rates computed with the isotopic abundance of nat. and enr. Ge (/kg/day)

Summary

	nat Ge		enr Ge	
	^{68}Ge	^{60}Co	^{68}Ge	^{60}Co
G4	105.01	5.1	14.48	2.33
Shield	83.92	2.86	5.8	3.31
Ref.[1]	89	4.8	13	6.7
MC Ref.[2]	29.6	-	0.94	-
Data Ref.[2]	30+-7	-	-	-

Summary of all known estimates (/kg/day)

[1] H. Gomez et al. arXiv:0708.3987v1 nucl-ex

[2] F.T. Avignone et al., Nucl.Phys.B (Proc Suppl.)28A,1992

Conlusion

- Despite some discrepancies, Geant4 agrees with other MC codes within the error (uncertenity) of those
- In principle Geant4 can be tuned to reproduce the data points shown in H. Gomez et al. arXiv:0708.3987v1 nucl-ex
- You can use it with the predefined physics lists if you know what are you doing
- Is impossible to accomodate the data of Horiguchi'83 and Avignone'92 in the same estimate. Choose one, (G4 can do both)