

# Low Energy Neutron Propagation in Geant4 and MCNPX

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R. Lemrani et Al. NIM A 560-2 (2006) 454  
12th Geant4 Collaboration Workshop

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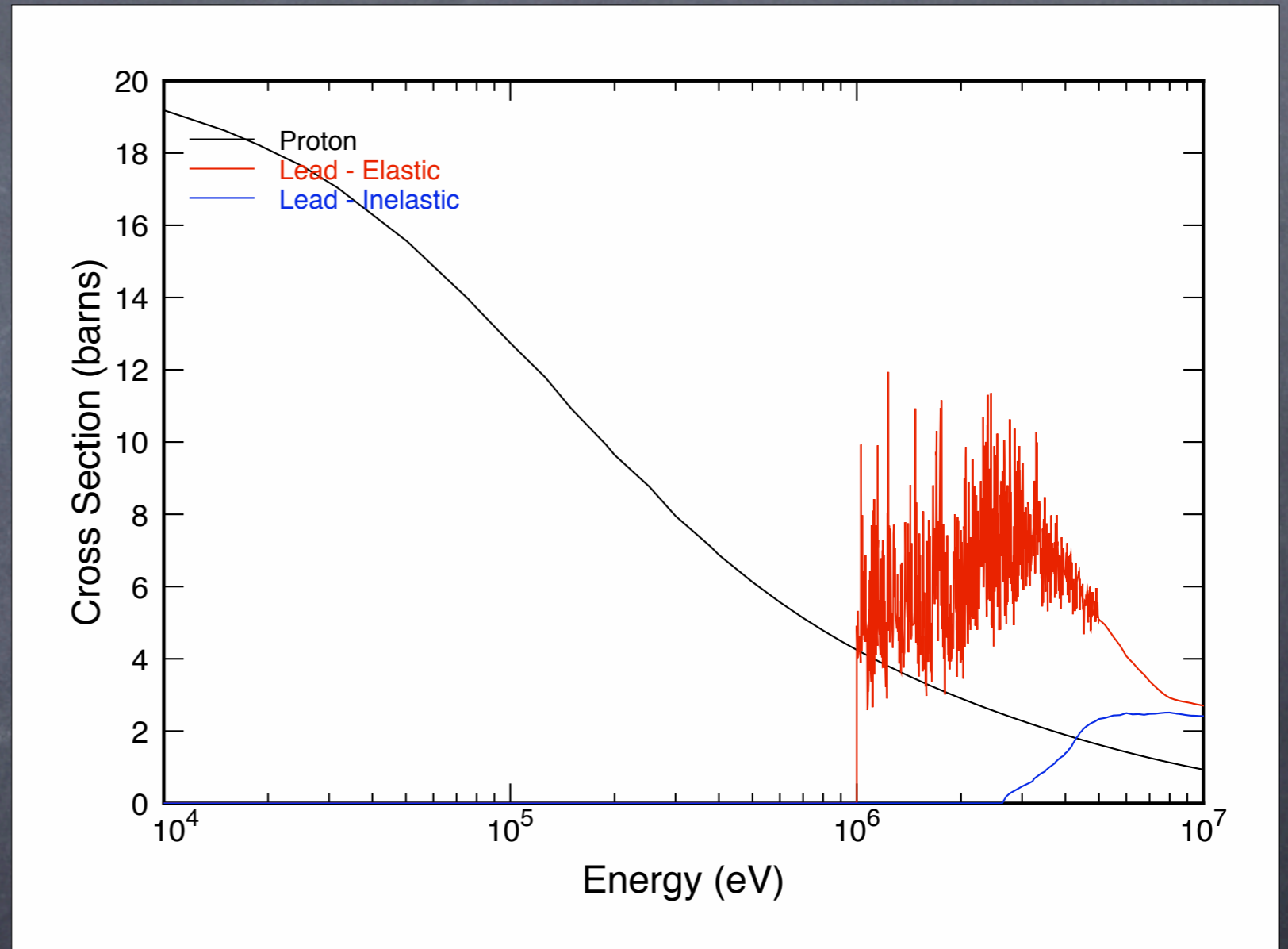
# Introduction

- Neutron Shielding design for ultra low background experiments
- Neutron Production Spectra
- Modane rock vs Boulby Rock
- Propagation through Lead and CH<sub>2</sub> shielding
- Neutron splitting
- Results
- Conclusions

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# Shielding Materials

- Combination of Metal and Hydrogenous shielding most effective.
- Metal softens spectrum and Hydrogen soaks it up.



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# Modane Rock vs Boulby Rock

- Boulby Rock

- NaCl

- 2.17 g/cm<sup>3</sup>

- 60 ppb U, 300 ppb Th

- Modane Rock (by Mass)

- 1% H, 6% C, 50% O, 1% Mg, 2% Al, 7% Si, 31% Ca, 2% Fe

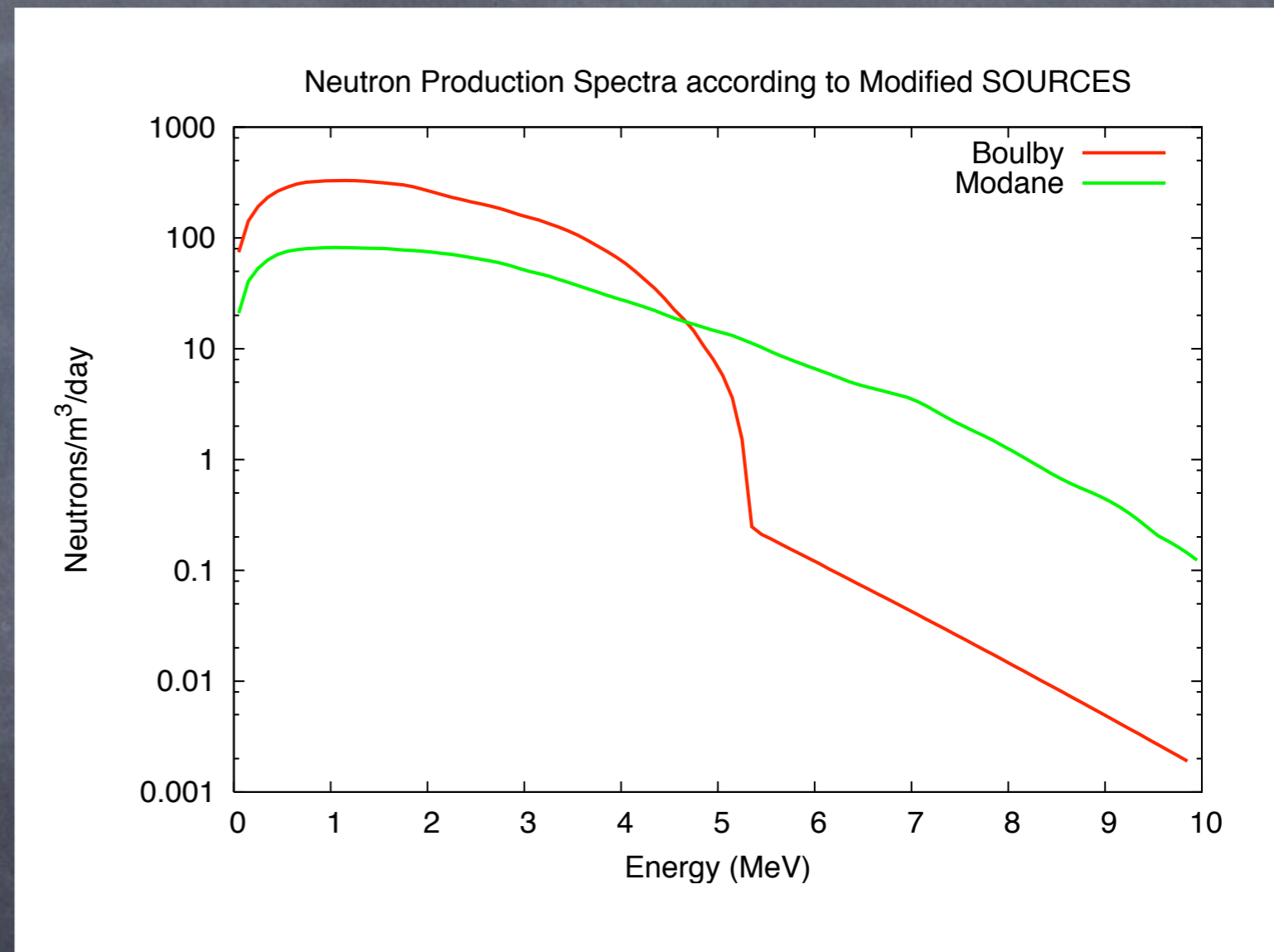
- 2.65 g/cm<sup>3</sup>

- 840 ppb U, 2450 ppb Th

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# Neutron Production Spectra

- Dominated by Alpha-n, some spontaneous fission
- SOURCES code modified to add elements and extend energy spectrum beyond 6.5 MeV
- Spectra similar despite differences in rock



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# Physics

- pinched from examples/advanced/underground\_physics
- Problems with inelastic neutron cross-sections for Cl in G4NDL3.7
- Only neutron physics turned on. Fission, Elastic, Inelastic. HP below 19 MeV, LE above.
- Secondary particles not tracked

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# Propagation Studies

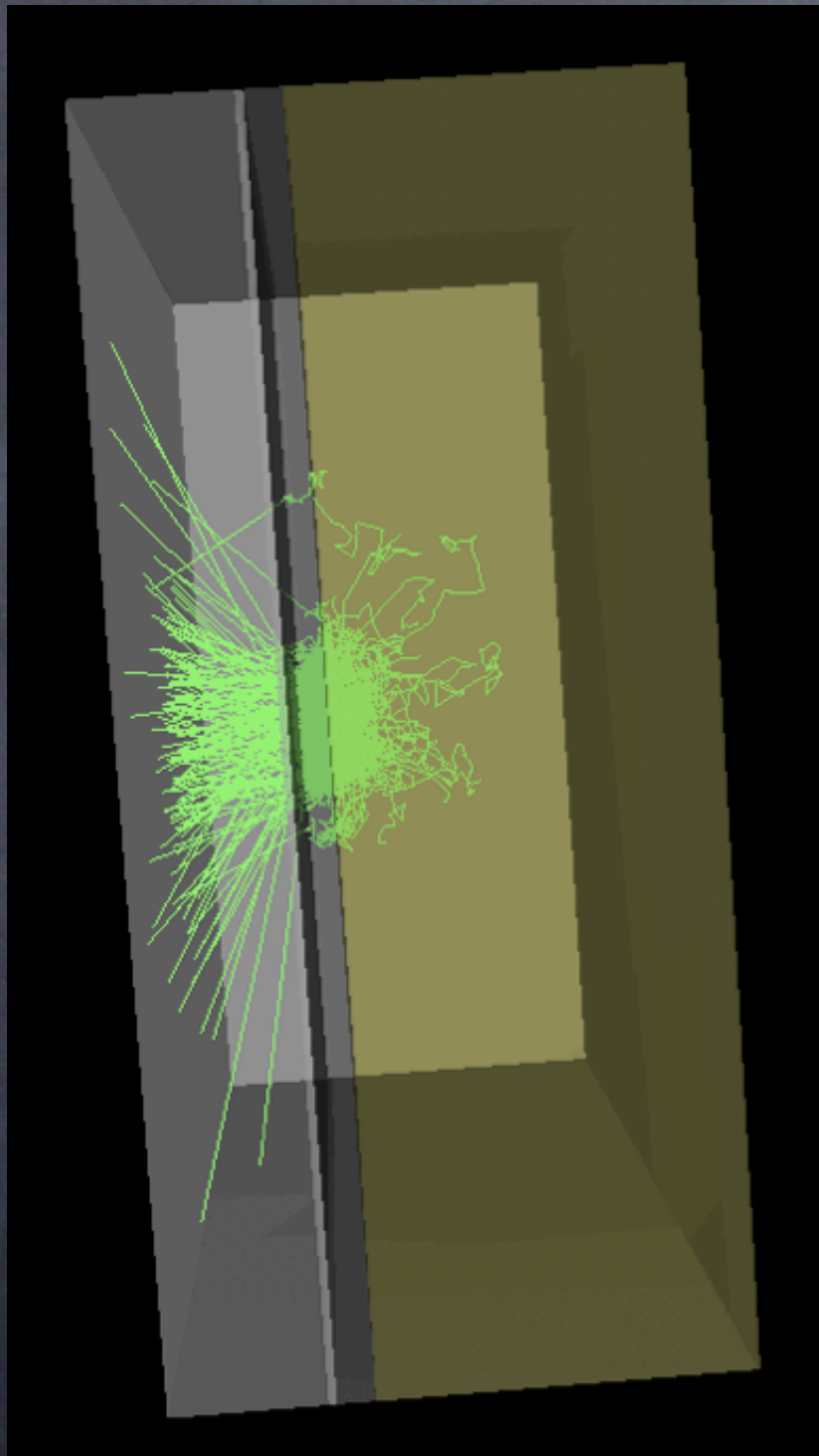
- Simple Geometry
  - 3 m depth of rock
  - Production in central area (1 m x 1 m) of rock
  - 30 cm of Lead
  - layers of  $\text{CH}_2$  10 g/cm<sup>2</sup> thick
  - Combination of Metal and Hydrogen most effective
  - Vacuum readout volume
  - Large area (100 m<sup>2</sup>)



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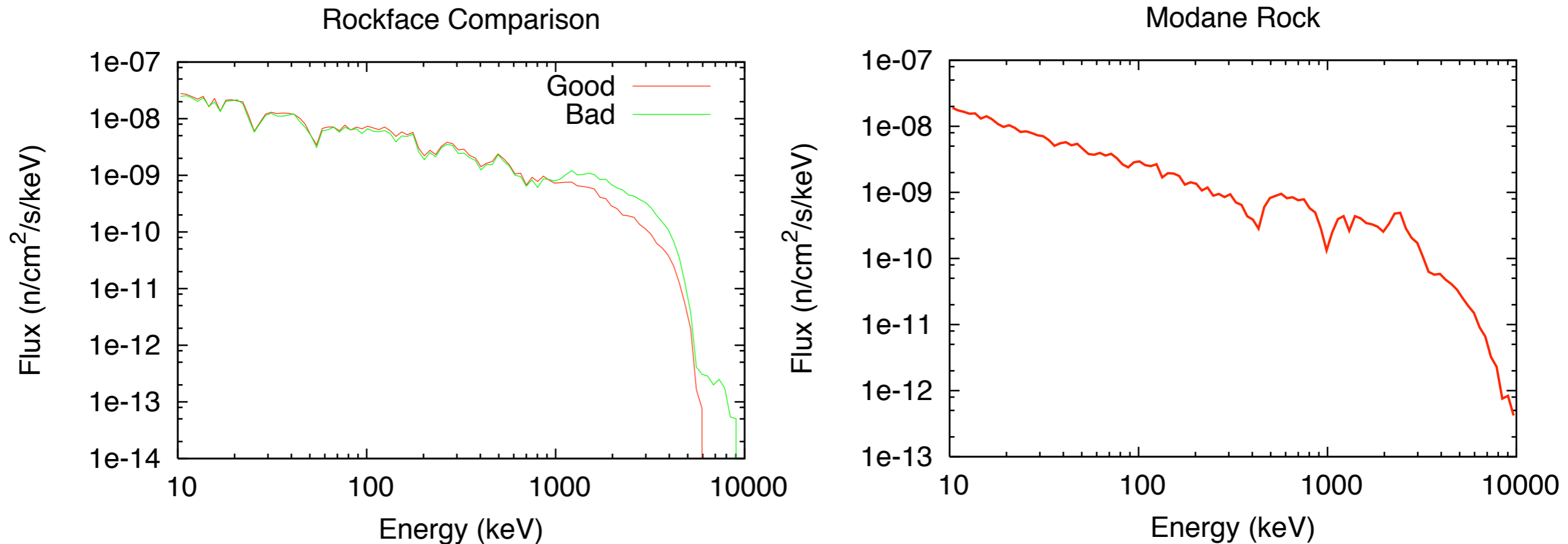
# Splitting

- CPU time reduced by dividing shielding into layers and using the result of 1 stage as the input to the next



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# Results – 2 rock types

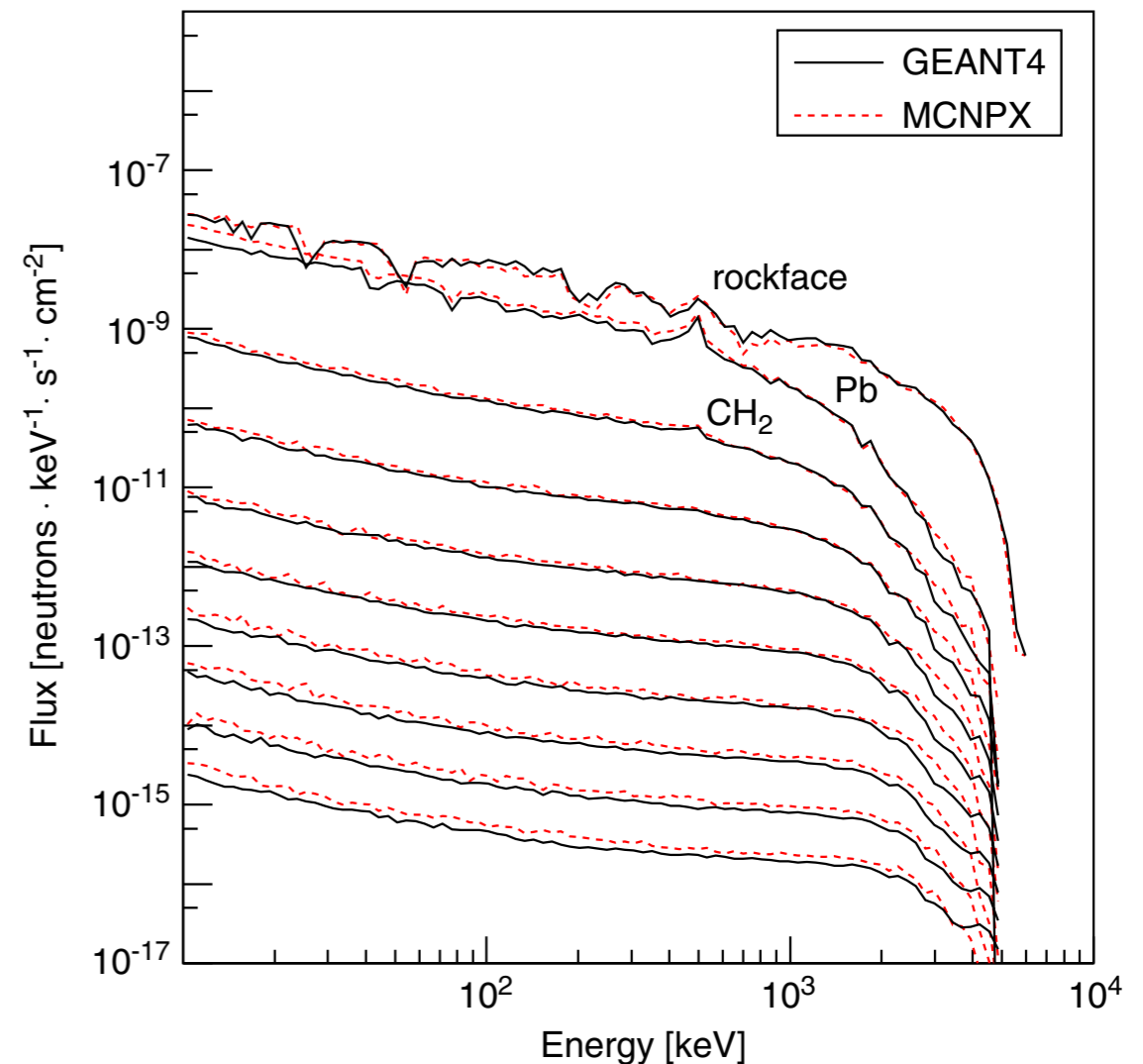


- Very small error in cross-section tables made a big difference in the results
- Despite differences in rock, similar spectra at rock-face

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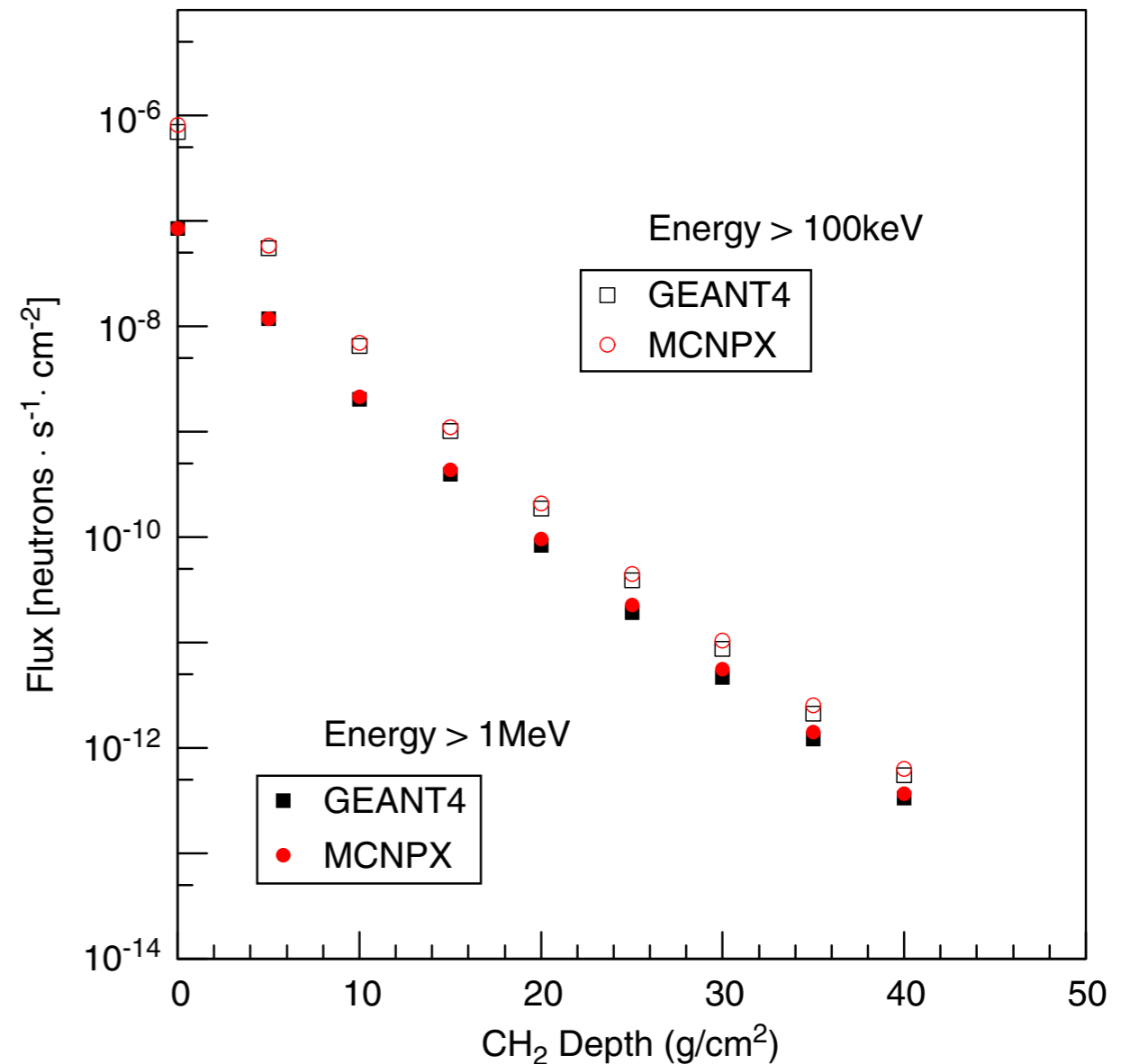
# Results

- Neutron suppression (Boulby spectrum) as a function of shielding depth.
- Factor of  $>10^6$  suppression achieved with 30 cm Lead and 40 g/cm<sup>2</sup> CH<sub>2</sub>



# Results

- Total neutron flux (Boulby Rock) as a function of depth of  $\text{CH}_2$  shielding
- Maximum observed difference in integrated neutron flux after  $40 \text{ g/cm}^2$  (55 cm)  $\text{CH}_2$  ~50%



# Conclusions

- 30 cm Lead + 55 g/cm<sup>2</sup> CH<sub>2</sub> is sufficient to suppress neutron flux by 6 orders of magnitude
- Geant4 is sound for low energy (>10 keV) neutron propagation
- Geant4 may be used to test neutron shielding designs for low background (e.g. Dark Matter) detectors.