Depth & Shielding Considerations for a Massive LAr Detector of Dark Matter

Andrew Hime

Pacific Northwest
NATIONAL LABORATORY

AARM Workshop
Rapid City, SD, May 2015

Some Context and Perspective

- It is plausible to consider a large (~100 to 200 tonne) LAr detector capable of extending sensitivity to high mass WIMPs (> 50 GeV) into the background floor imposed by the coherent scattering of atmospheric neutrinos.

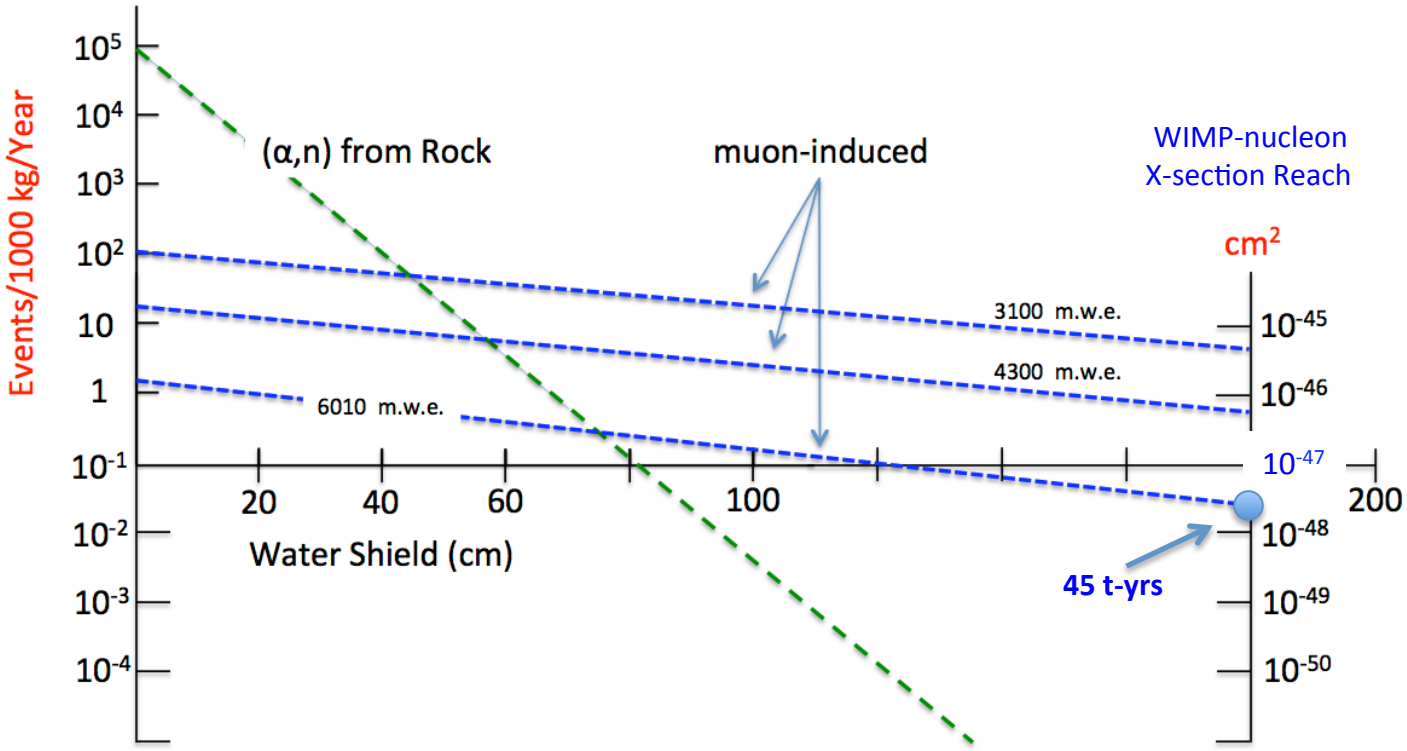
- I have been considering some of the challenges regarding background rejection and have returned, recently, to those "pesky neutrons".

- Independent of overburden (i.e. depth), an active neutron veto with an efficiency of about 92 to 95% is likely required to reject single-scatter neutrons from internal detector materials produced by radioactivity and (alpha, n) reactions.

- Fast neutrons produced by cosmic ray muons can be challenging, depending on the depth that the detector is located and the requirement for active neutron veto efficiency. The initial estimates provided here indicate the challenge and the need to perform dedicated and detailed simulations for a new detector.

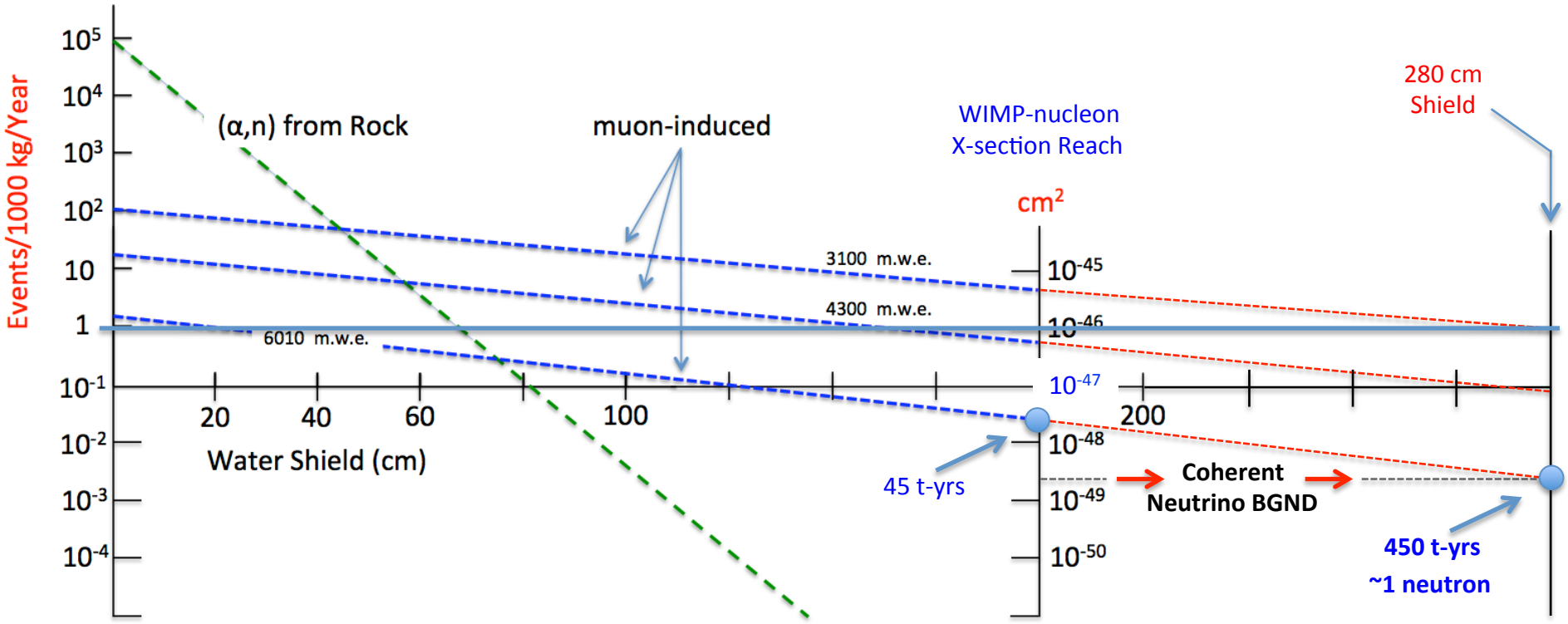
Muon-Induced Neutrons

Past work from Mei & Hime



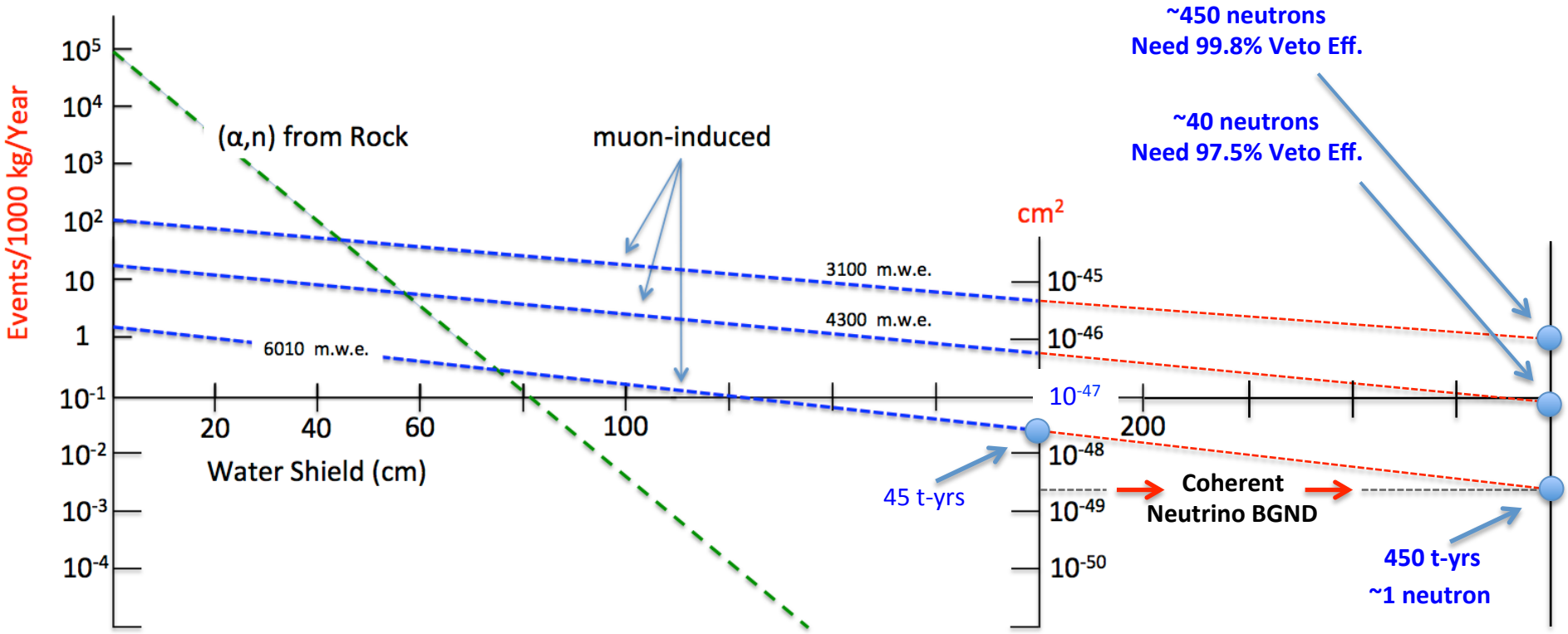
Muon-Induced Neutrons

** Preliminary Extrapolations **



Muon-Induced Neutrons

** Preliminary Extrapolations **



Conclusions

- Fast neutrons produced by cosmic ray muons can be challenging, depending on the depth that the detector is located and the requirement for active neutron veto efficiency. The initial estimates provided here indicate the challenge and the need to perform dedicated and detailed simulations for a new detector.

- The veto efficiency requirement can be reduced (perhaps as much as a x10) using data cuts that identify multiple-scatter events from single-scatter events.

- There must be a limit to the effective veto efficiency achievable owing to the fact that some of the single-scatter events will capture in detector material before finding their way to the veto. Initial (and crude) estimates indicate that this could be of order ~2 to 5%.

- If veto efficiency is fundamentally limited (to say 95%) then the only cure is depth and/or significantly more external shielding (beyond 3m). Roughly speaking, the muon flux is reduced by ~x10 for additional overburden of 1500 m.w.e. At a given depth, the fast neutron flux can be attenuated by ~x10 for an additional shield thickness of 100 cm.