Breaking the Neutrino Floor

Non-Directional Approach

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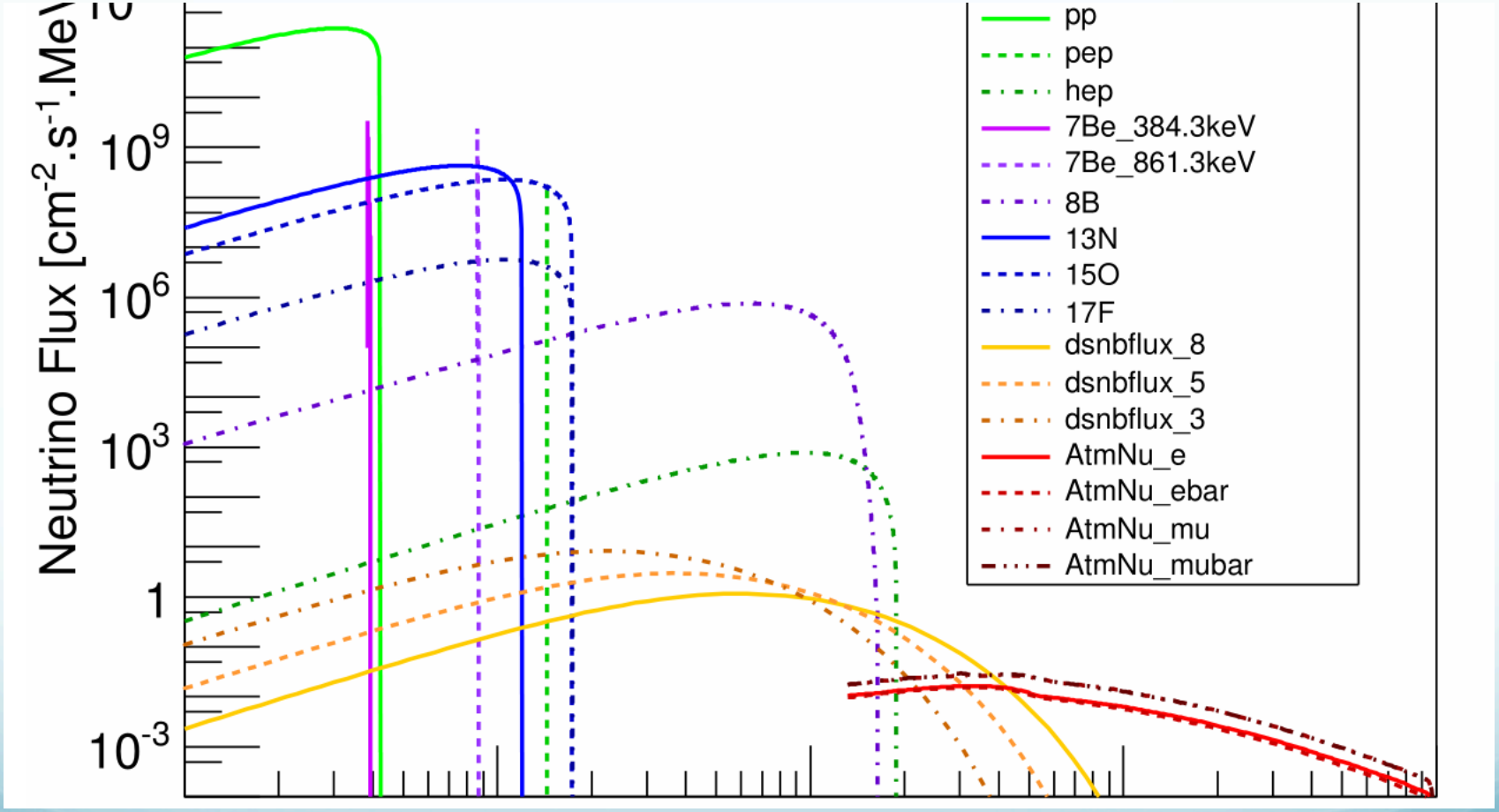
Background Fluxes



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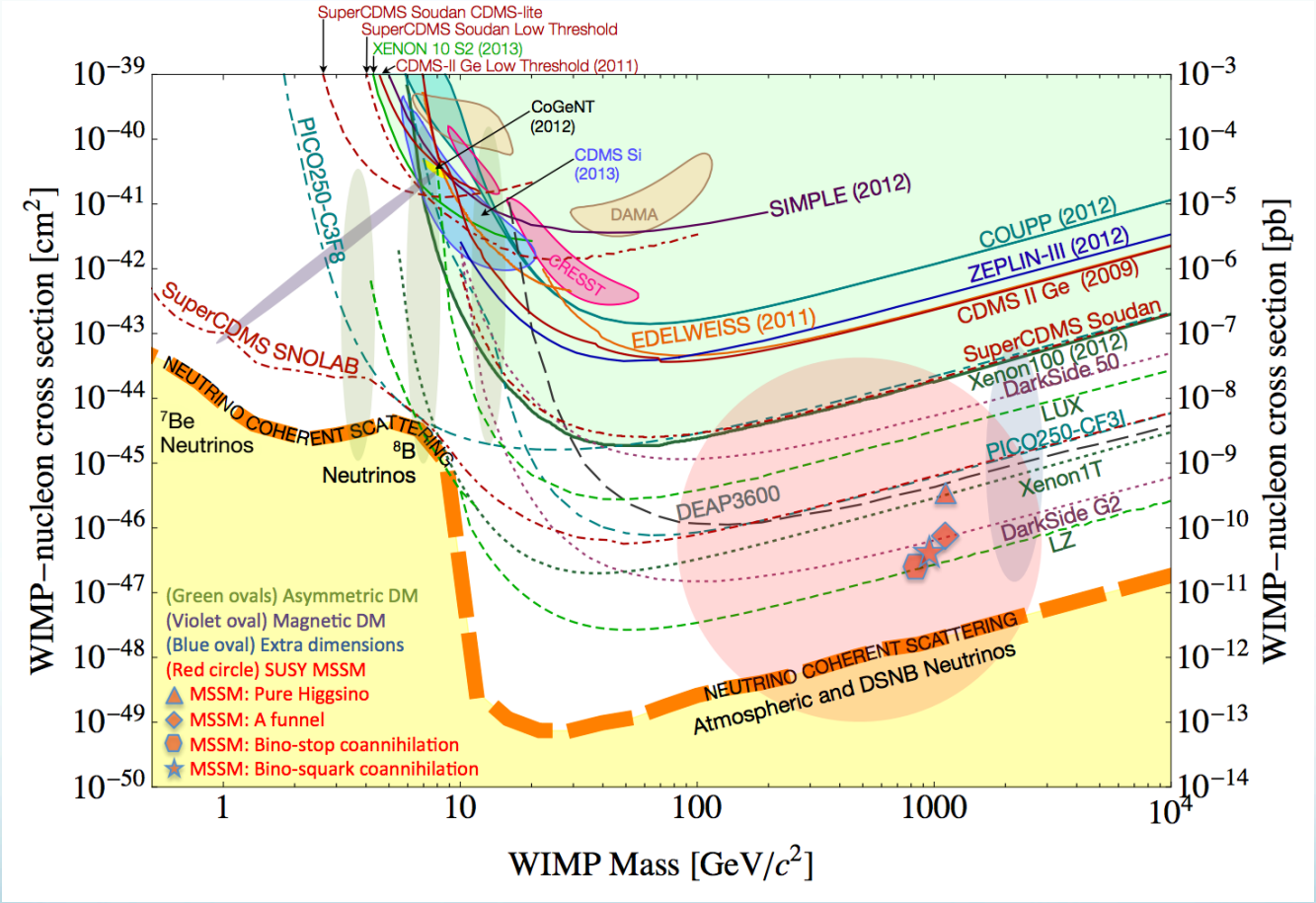
Neutrino Floor



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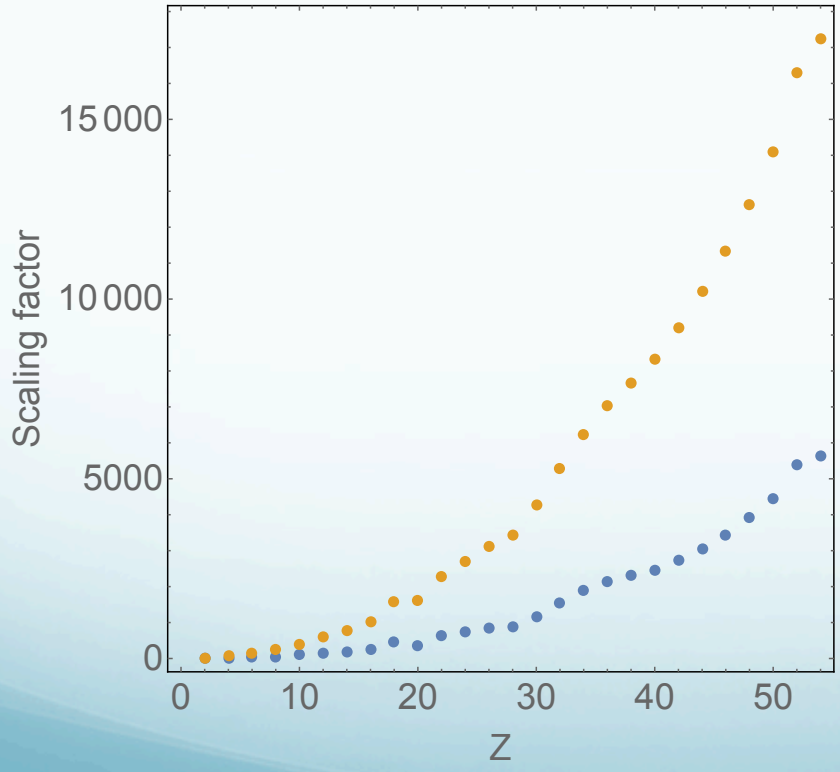
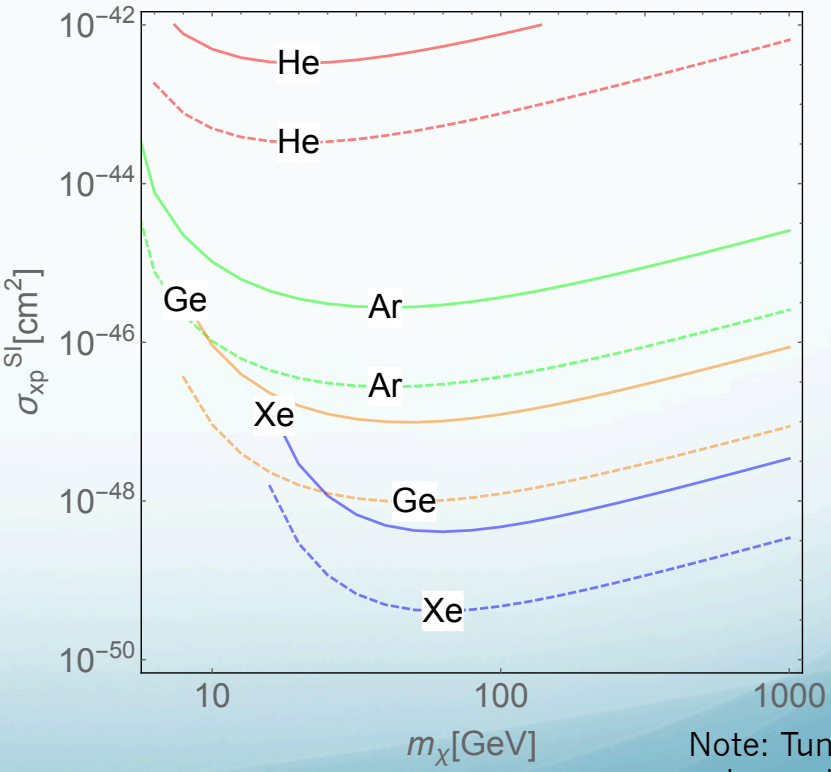
Target Dependence

WIMP scattering rate scales as A^2

Neutrino rate scales as $(N-(1-4\sin^2\theta_w)Z)^2$





Note: Tungsten only small improvement over Xenon

Electron Recoil

- Ratio of cross sections≈

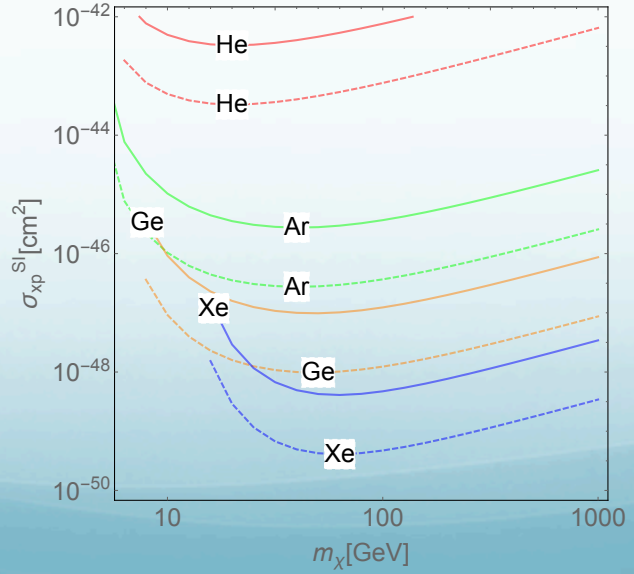
$$6.5 : 2.7 : 1 : 0.9$$
$$\nu_e : \overline{\nu} e : \nu_l : \overline{\nu}_l$$

- Unlike Nuclear Recoil, Electron Recoil cross-sections are flavor dependent
- We cannot extract the neutrino flux for each flavor from the electron recoil
- Would require assumption of the flavor and particle/ antiparticle percentage of the total flux
  - Possible to predict atmospheric neutrinos with some uncertainty
  - Not possible to predict neutrinos from diffuse supernovae

Our Approach

Take advantage of nuclear recoils in different targets to reduce background.

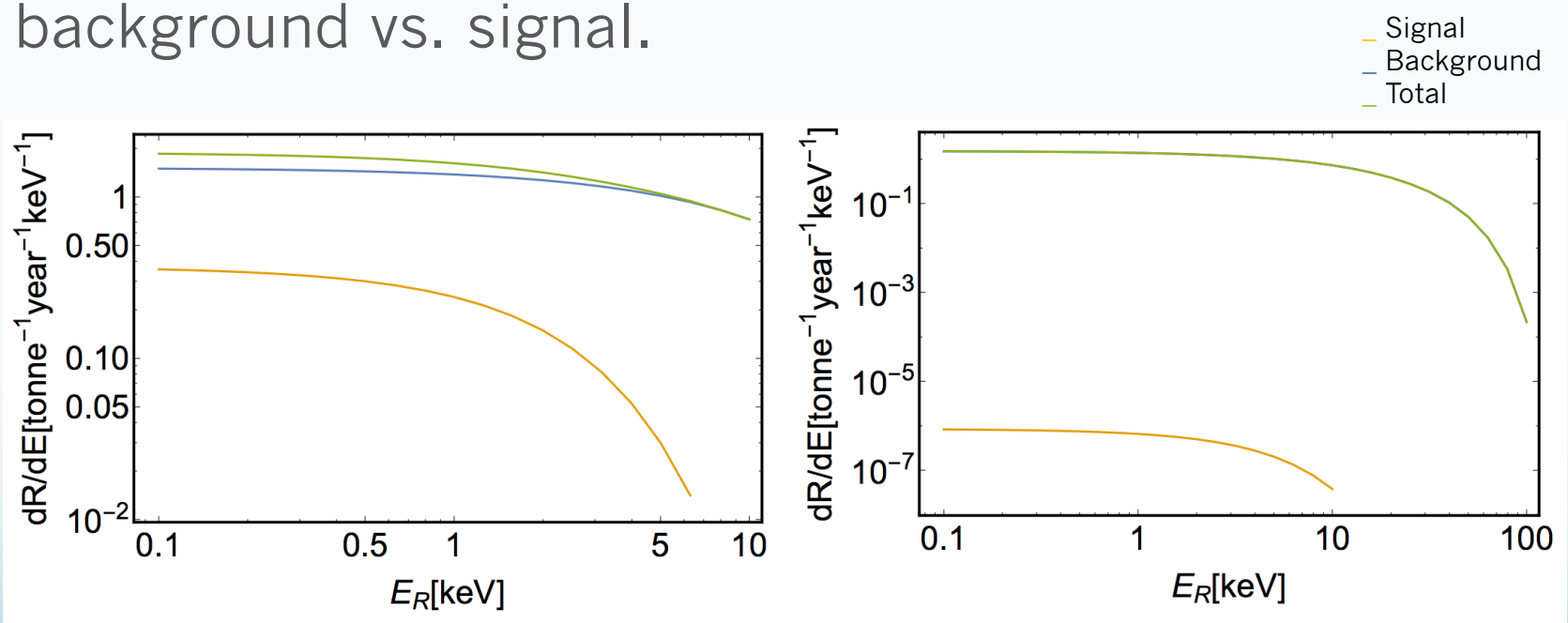
Ideally 2 experiments co-located



Our Approach

Run an experiment using a lighter target mass to measure background, due to higher ratio of background vs. signal.

Helium



Light WIMP (6 GeV)

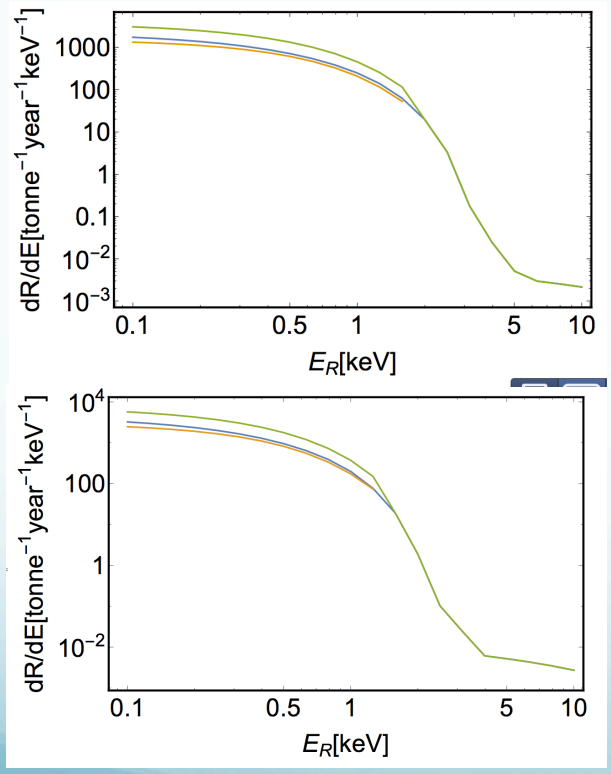
Heavy WIMP (100 GeV)

Our Approach

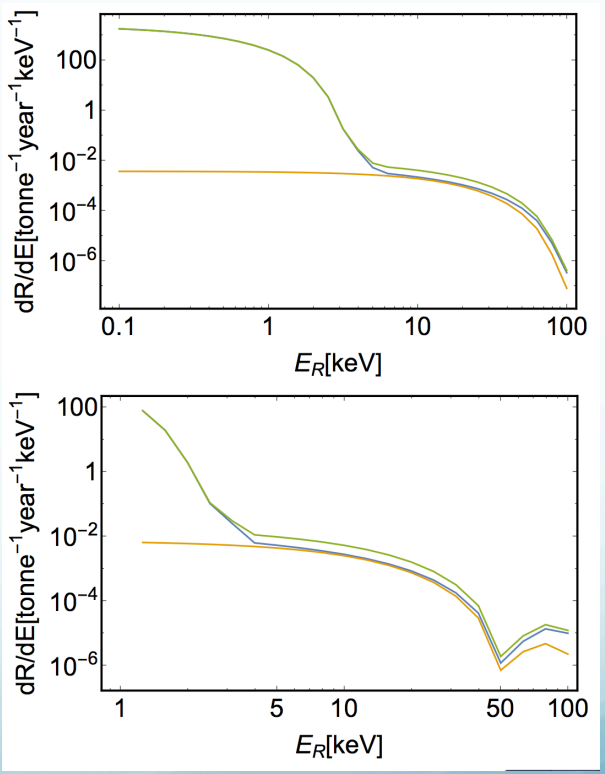
Run an experiment with a heavier target, where the ratio of background to signal is much lower, then subtract the background that has been previously measured and scaled.

Xenon

Tungsten

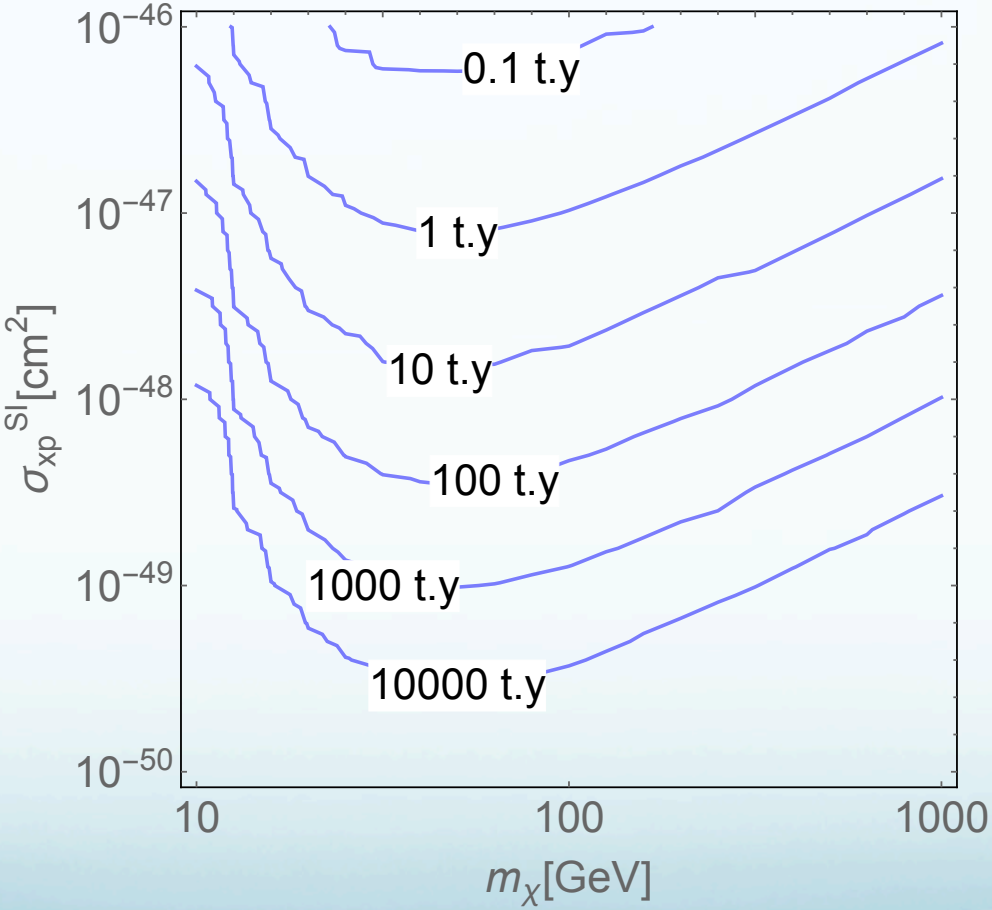


Light WIMP (6 GeV)



Heavy WIMP (100 GeV)

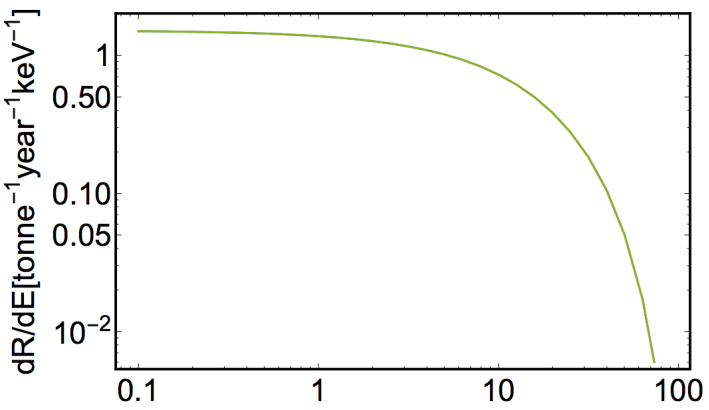
Necessary Exposure

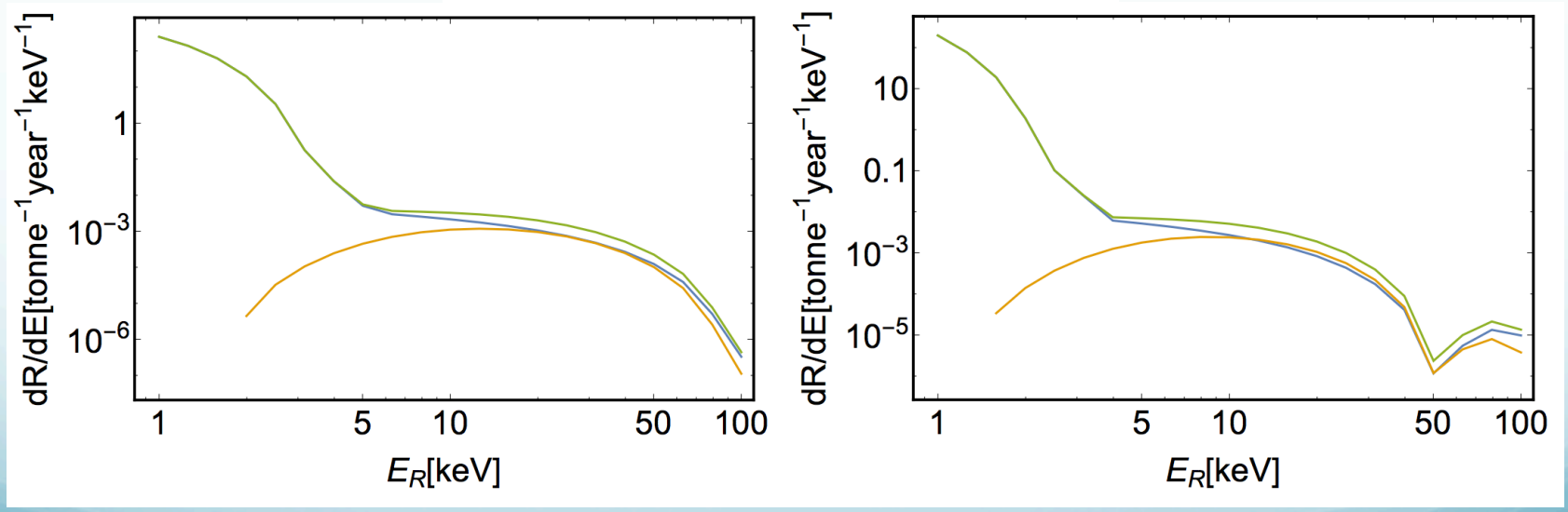


Alternatives

Inelastic Scattering

Helium

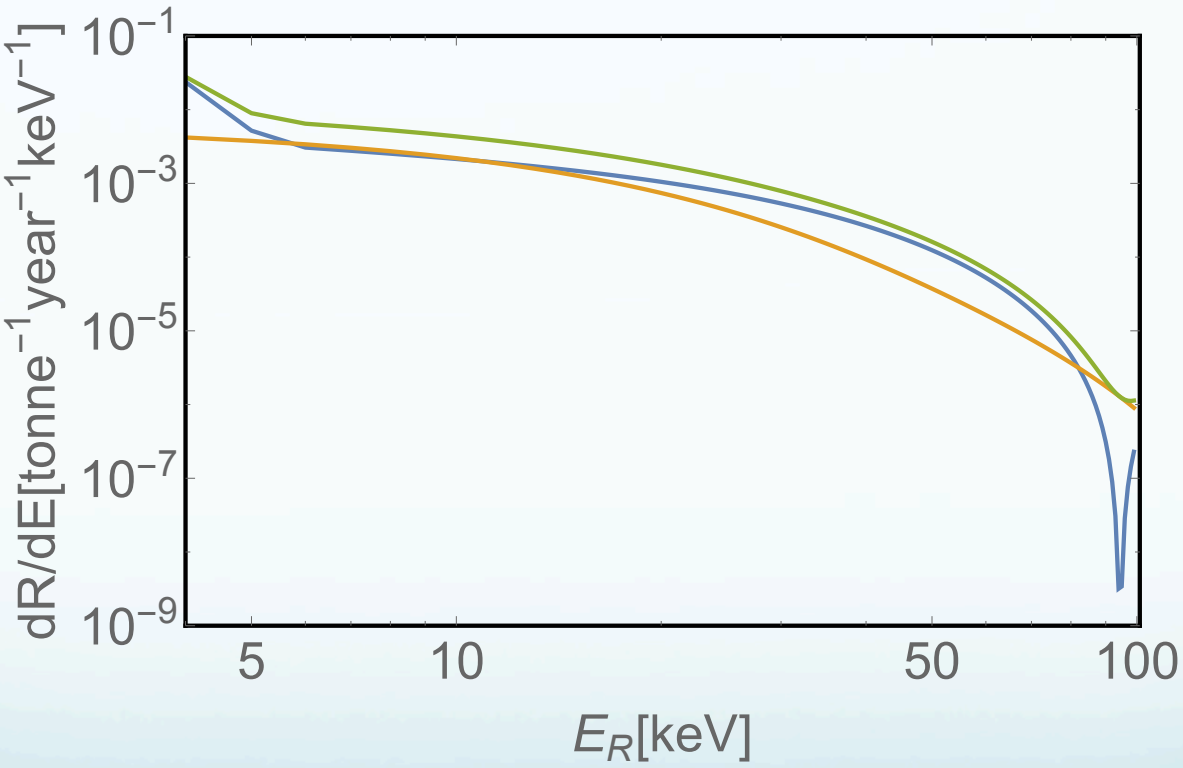




Xenon

Tungsten

Spin Dependence



Annual Modulation Simulation

Annual modulation “signature” of DM

Flat distribution expected for coherent neutrino background *

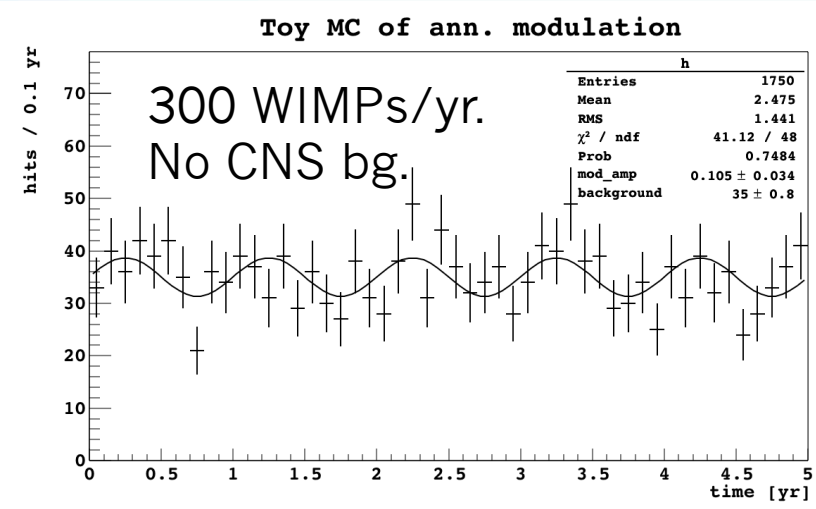
* Atmospheric neutrinos could have seasonal modulation

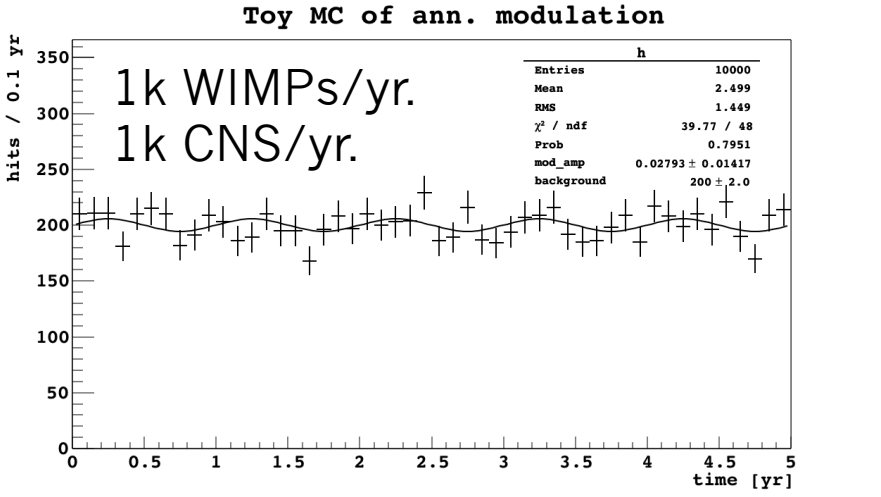
Two experiments located in opposite hemispheres to compare modulation.

Goal: given predicted CNS background, what’s the minimum WIMP signal necessary to use annual modulation as a signature?

Annual Modulation Simulation

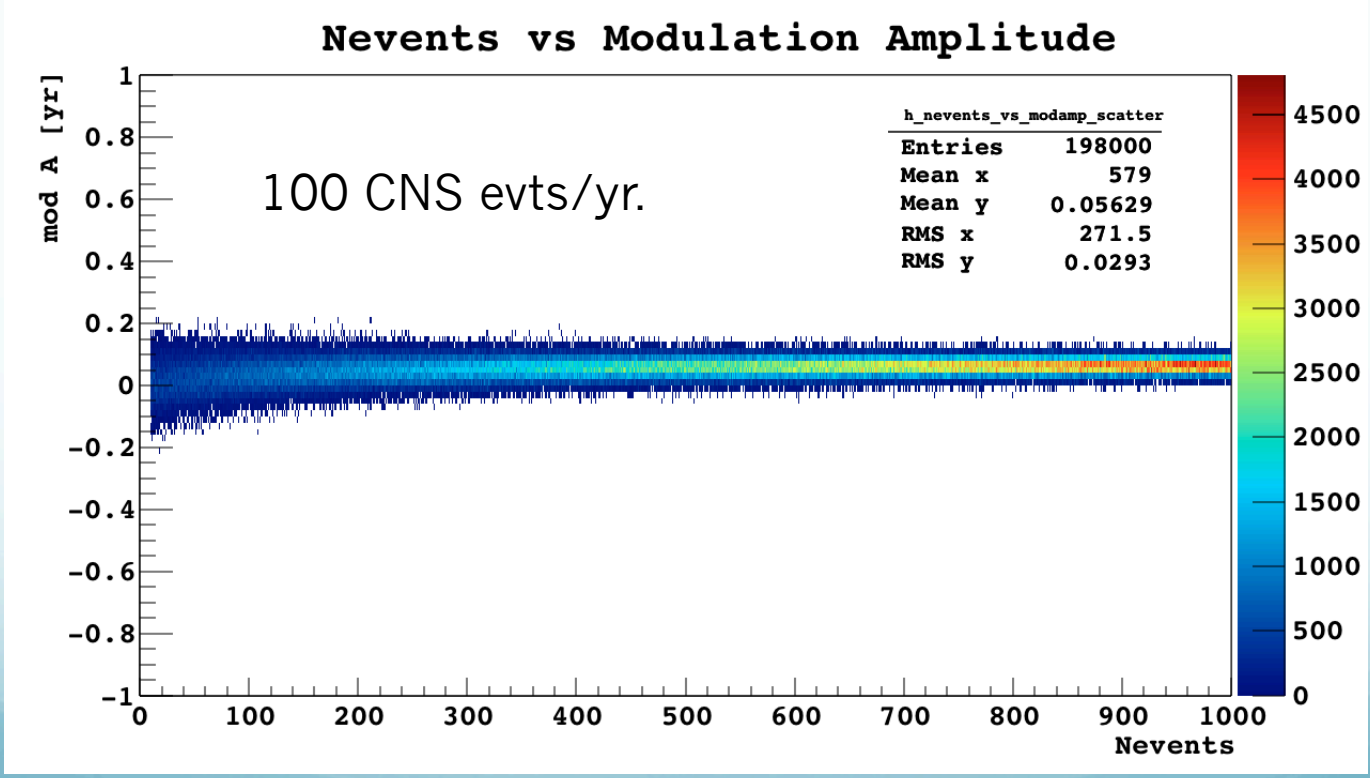
- Run a series of pseudo-experiments that detect increasing # of WIMPs.
- Uniformly distributed bg signal + WIMP signal with 7% modulation
- Each experiment runs for 5 years





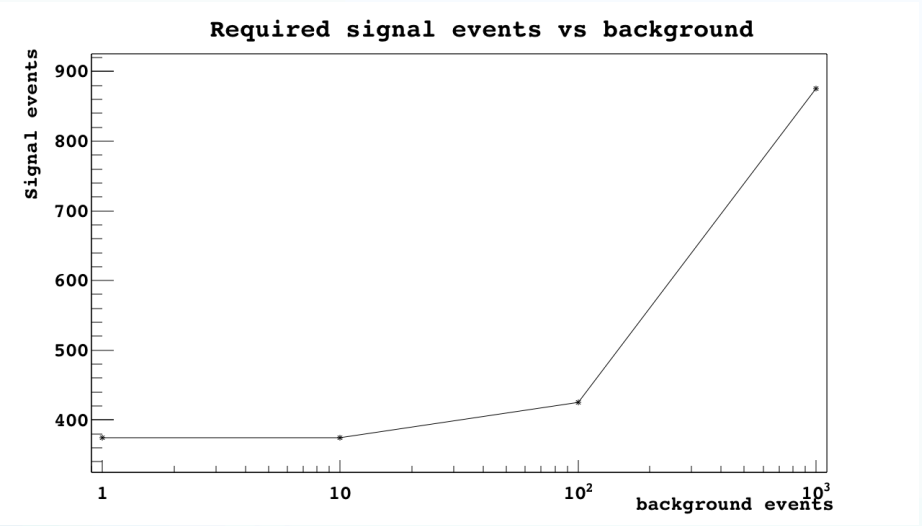
Annual Modulation Simulation

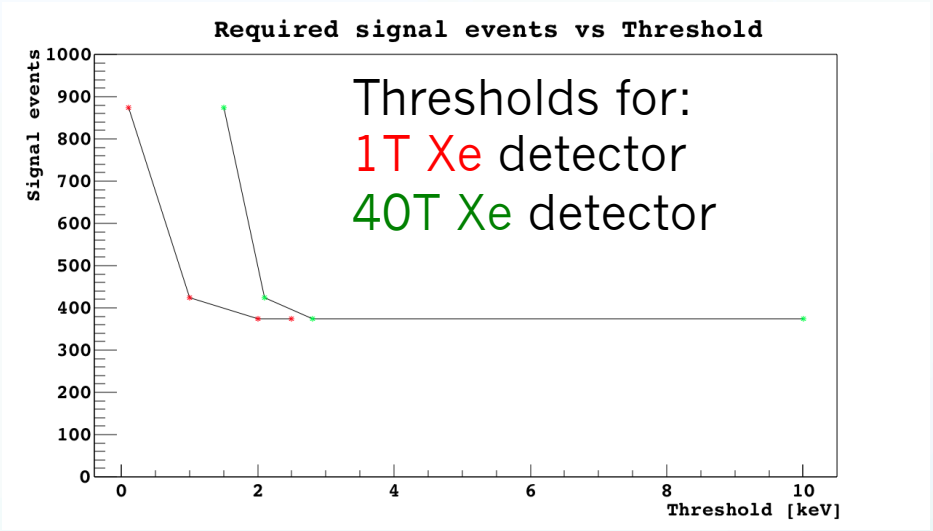
Repeat many times for increasing # signal events over various CNS backgrounds.



Annual Modulation Simulation

Required signal in 5 year running vs. CNS background





- 10 keV threshold achieved, 2 keV threshold reasonable
- For 100 GeV WIMP, $\sigma = 10^{-47}$ cm^2 , 1 keV threshold: expect 2.4 evts/ton/year

→ Annual modulation is unlikely to be useful in G2 or G3 experiments

- G4 or G5? Requires 200T Xe → ~$1 billion for Xe alone