DUNE as the next-generation solar neutrino experiment

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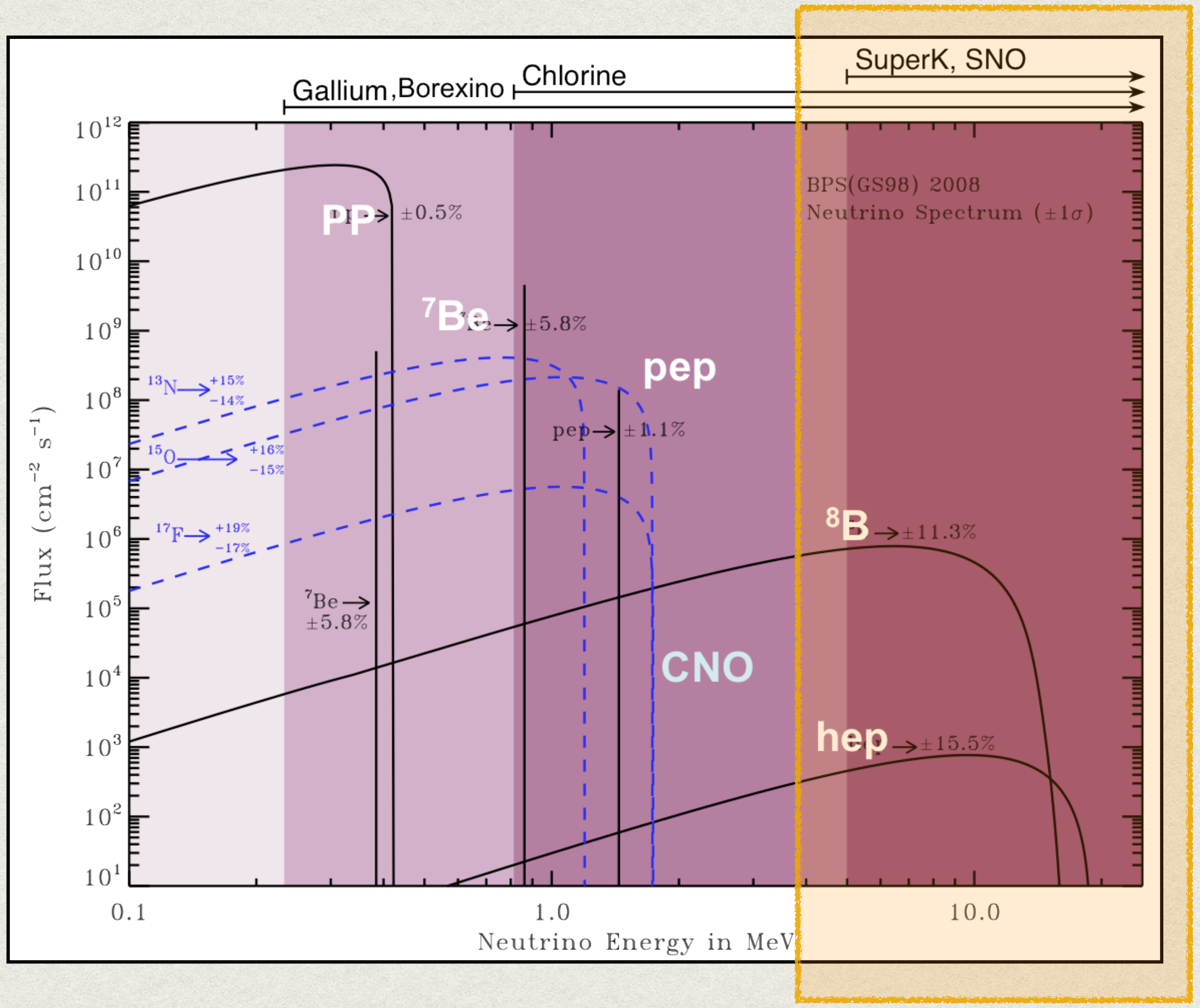
CCAPP

MeV Solar neutrinos (8B + hep)



Above few MeV

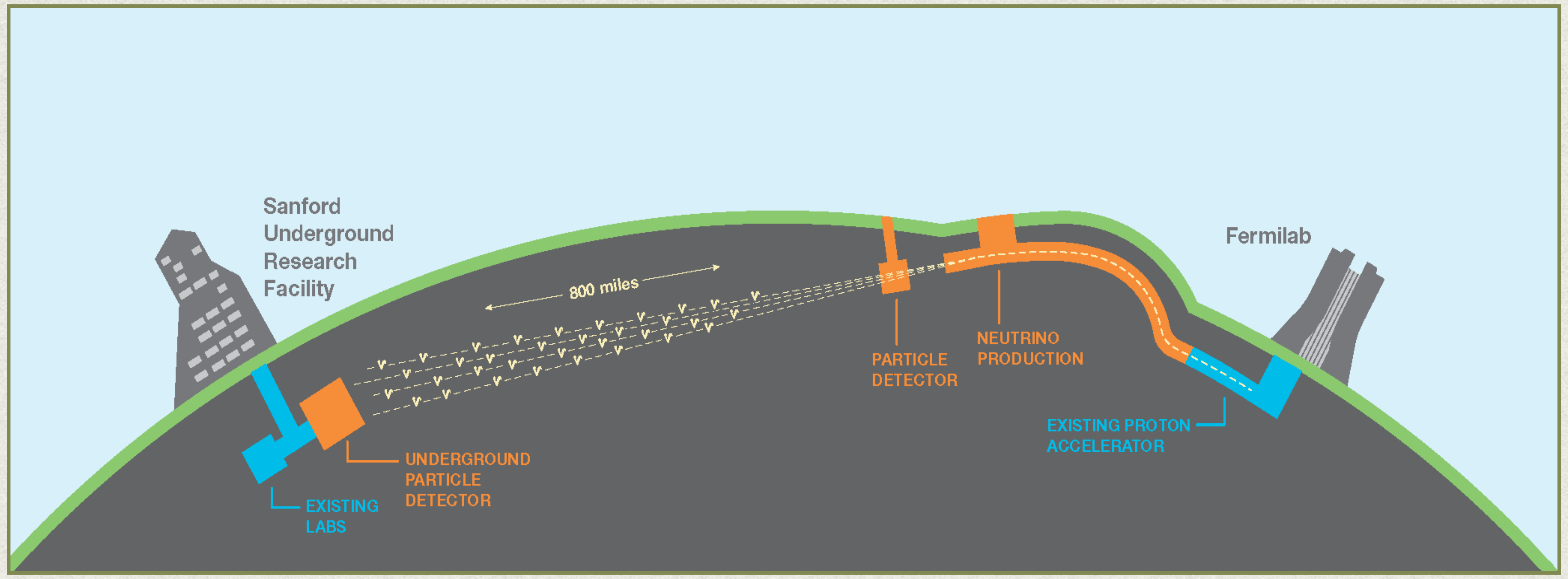
- 8B

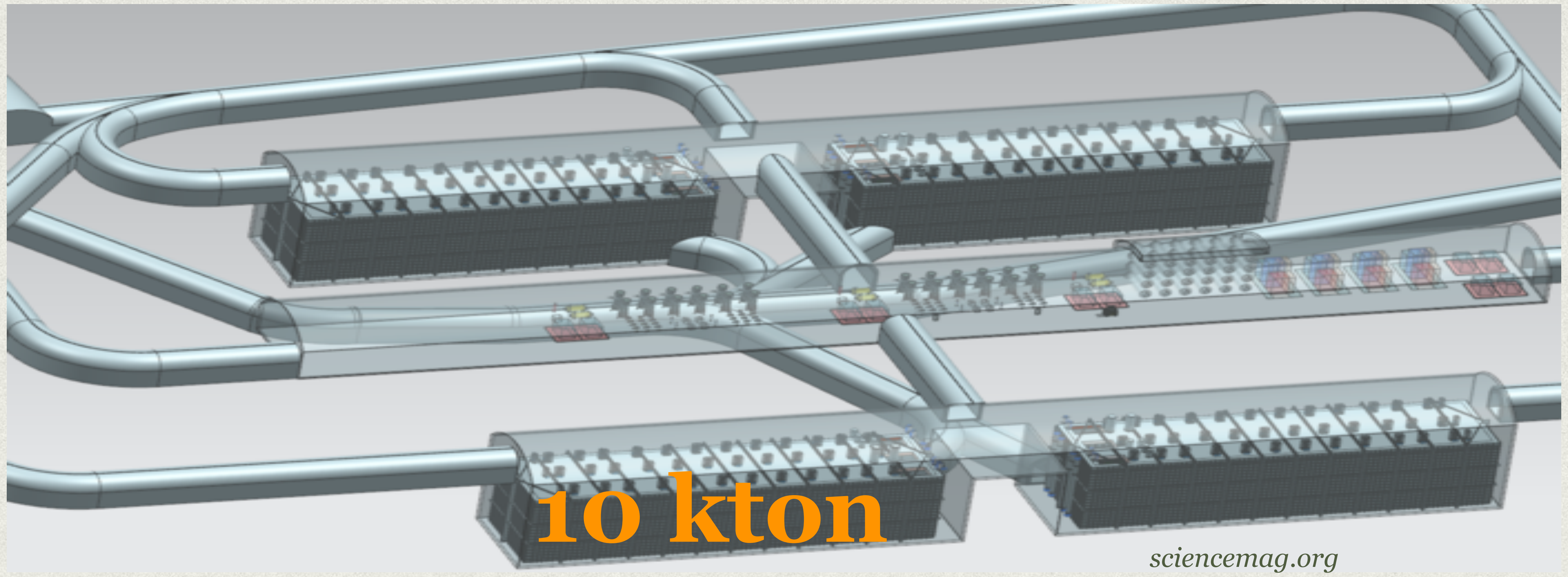
$$^8B \rightarrow \ ^8Be + e^+ + \nu_e$$

- hep

$$^3He + p \rightarrow \ ^4He + e^+ + \nu_e$$

Deep Underground Neutrino Experiment





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Detection channel in LAr

- Charge Current (CC)

$$\nu_e + {}^{40}Ar \to e^- + {}^{40}K^*$$

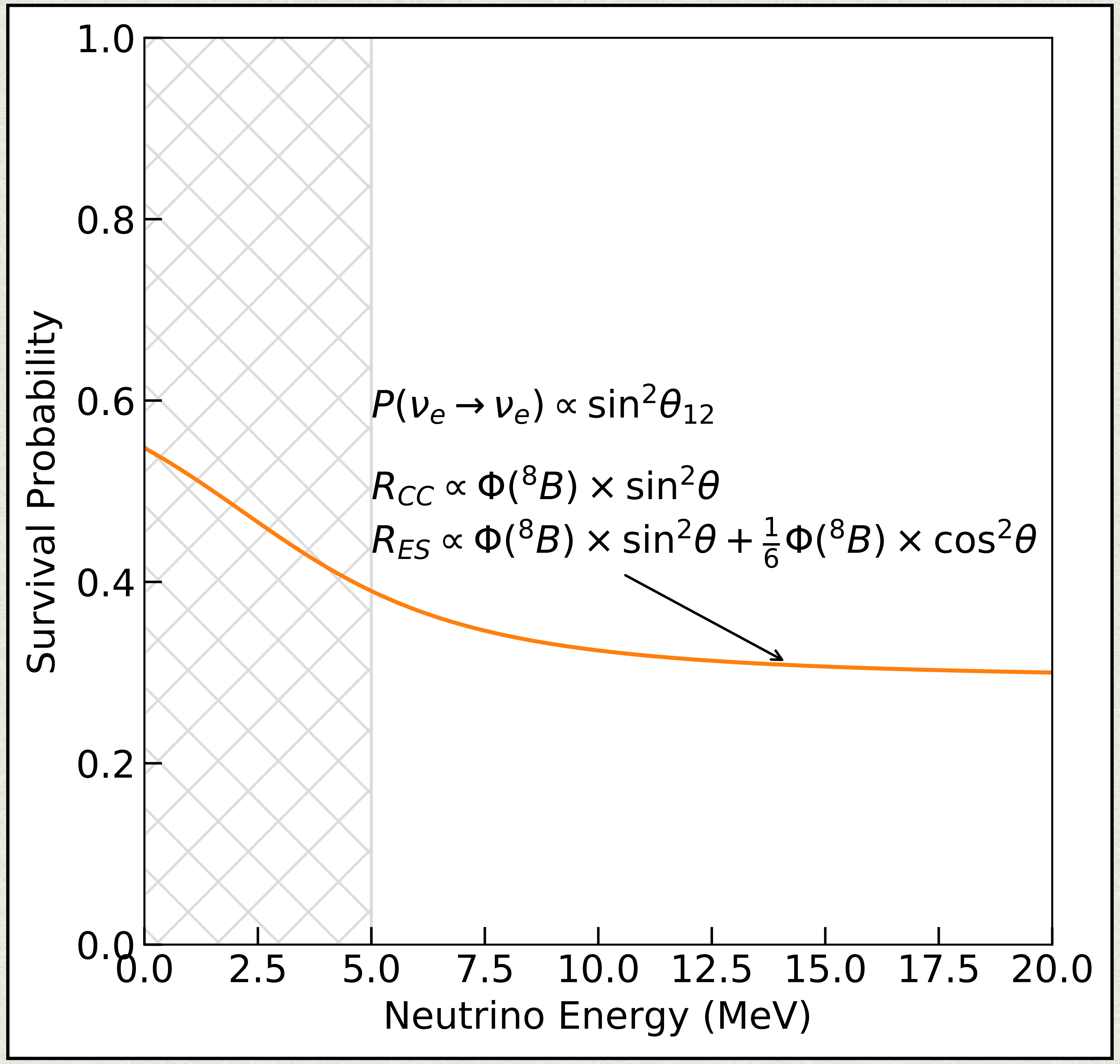
- Elastic Scattering (ES)

$$\nu_e + e^- \to \nu_e + e^-$$

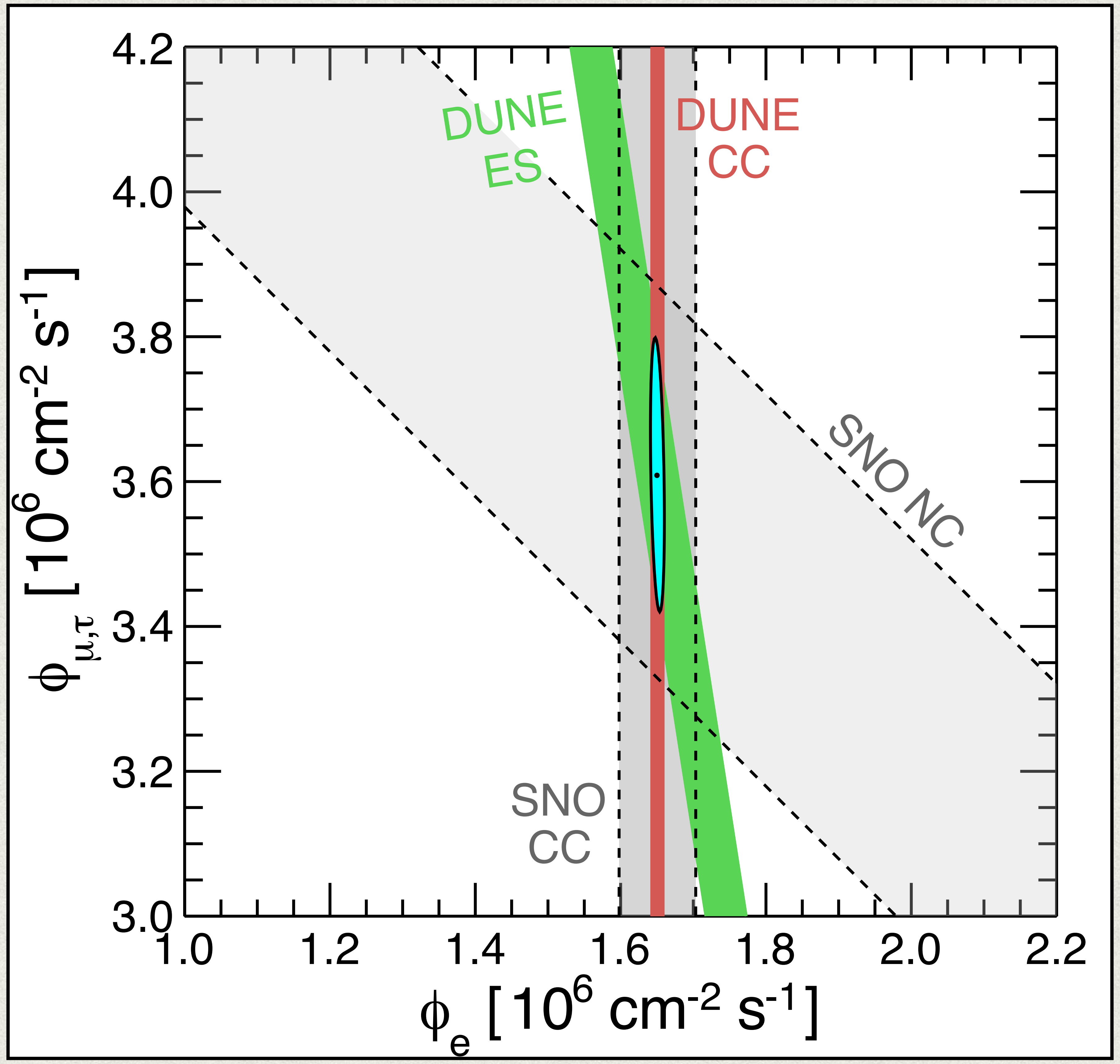
$$\nu_{\mu,\tau} + e^- \to \nu_{\mu,\tau} + e^-$$

$$\sigma(\nu_{\mu,\tau}) \sim \frac{1}{6}\sigma(\nu_e)$$

Power of DUNE for Solar: what and why?

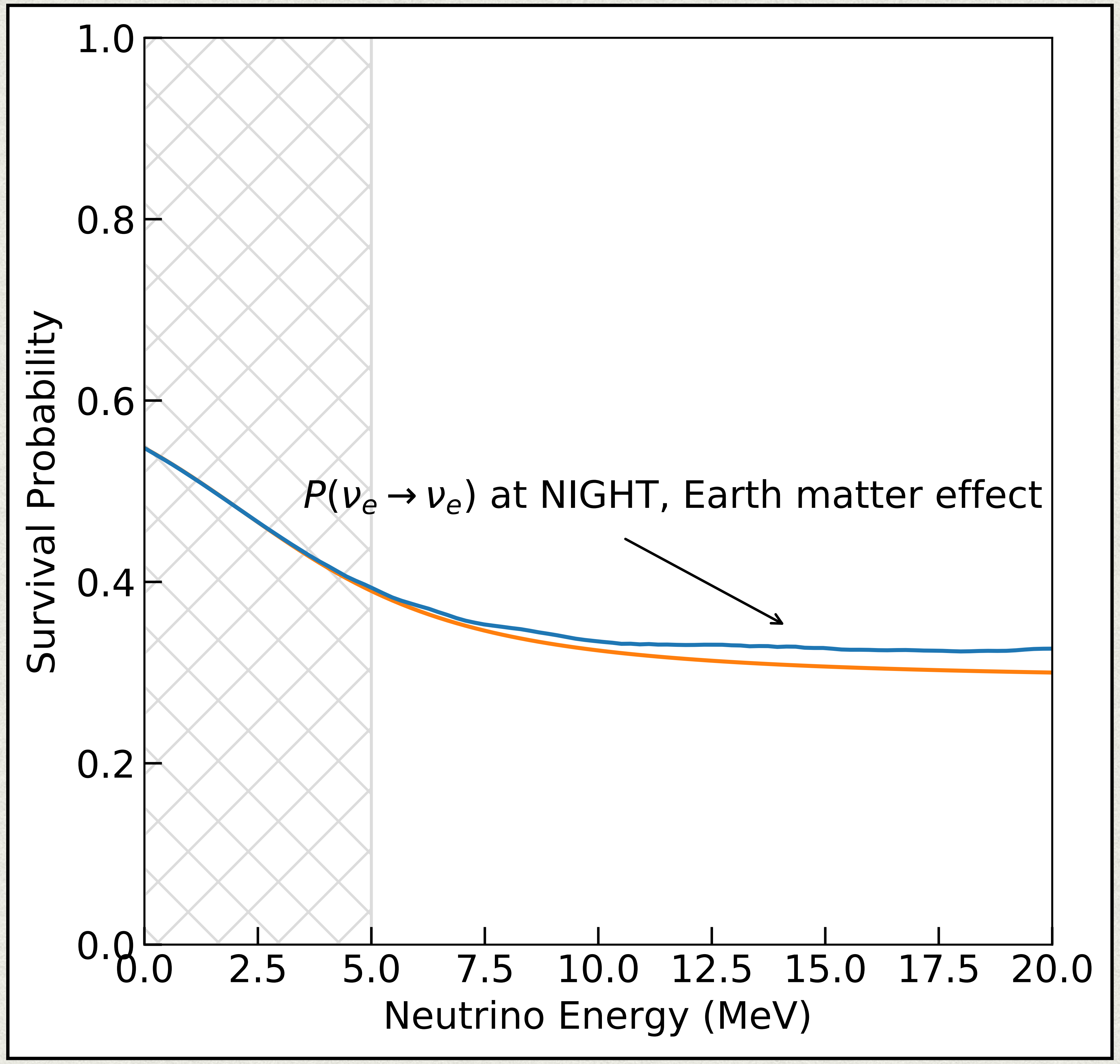


Isolate angle and flux with TWO channels

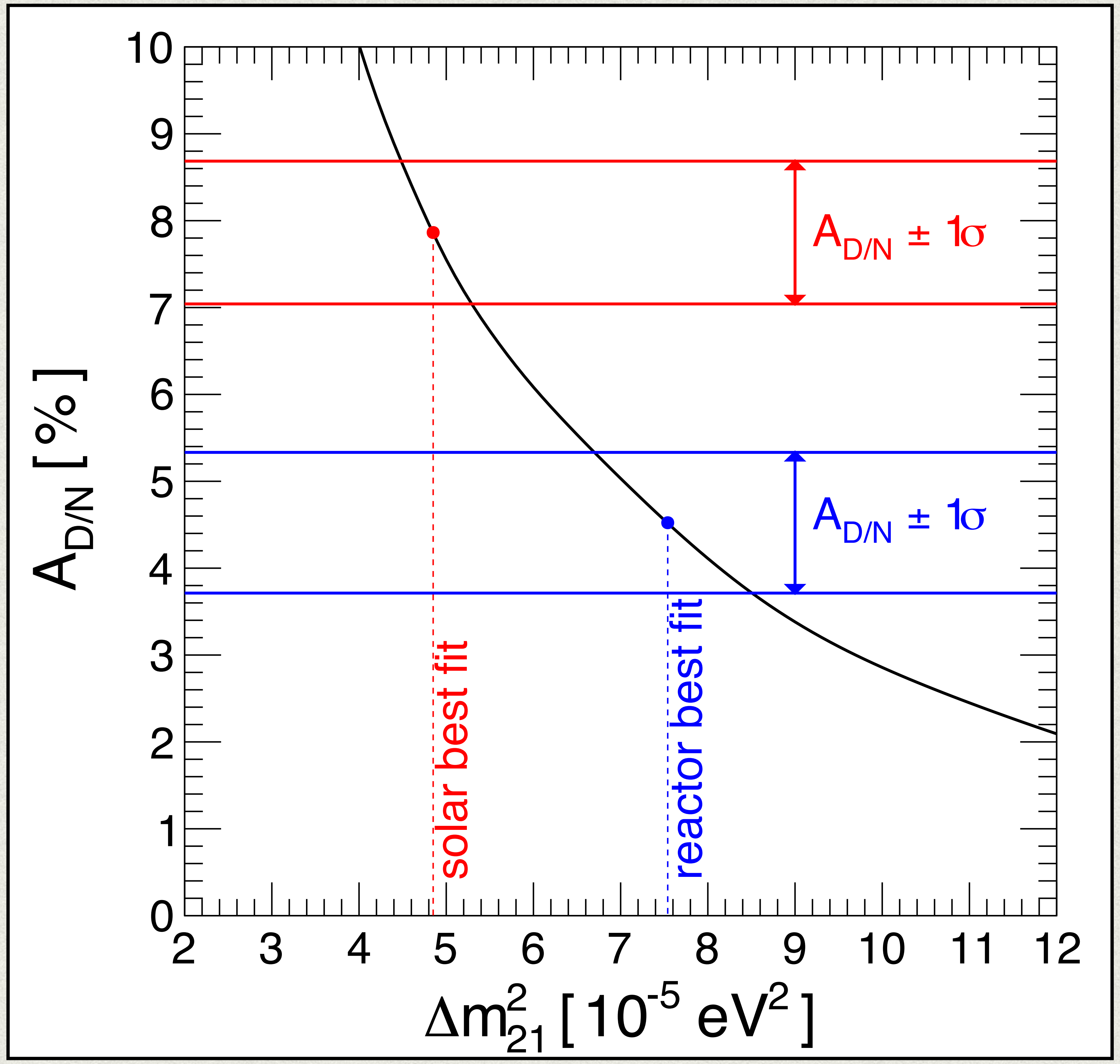


Capozzi et al, in prep

Power of DUNE for Solar: what and why?



Isolate dm^2 with day-night



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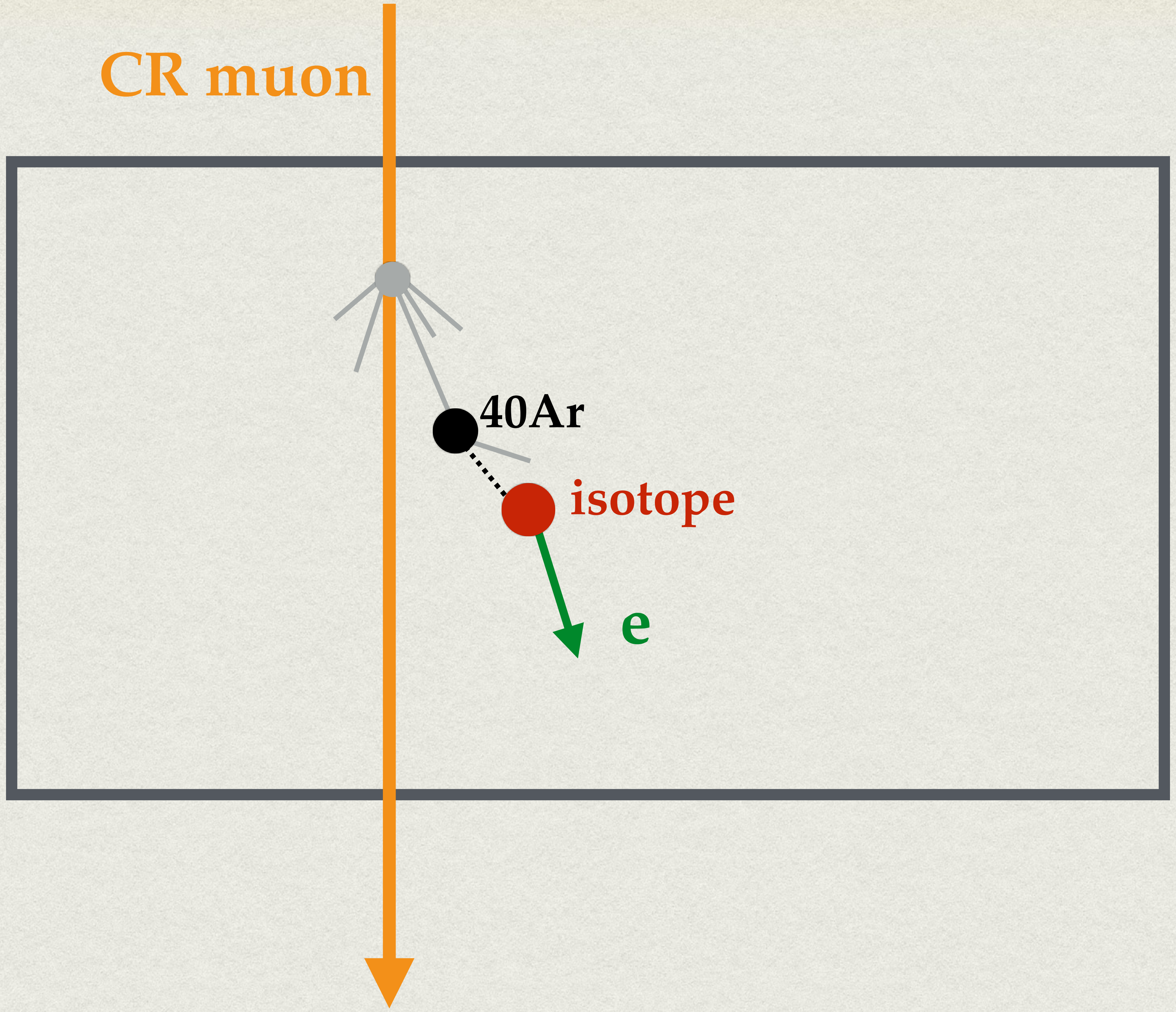
Background for solar detection I — spallation



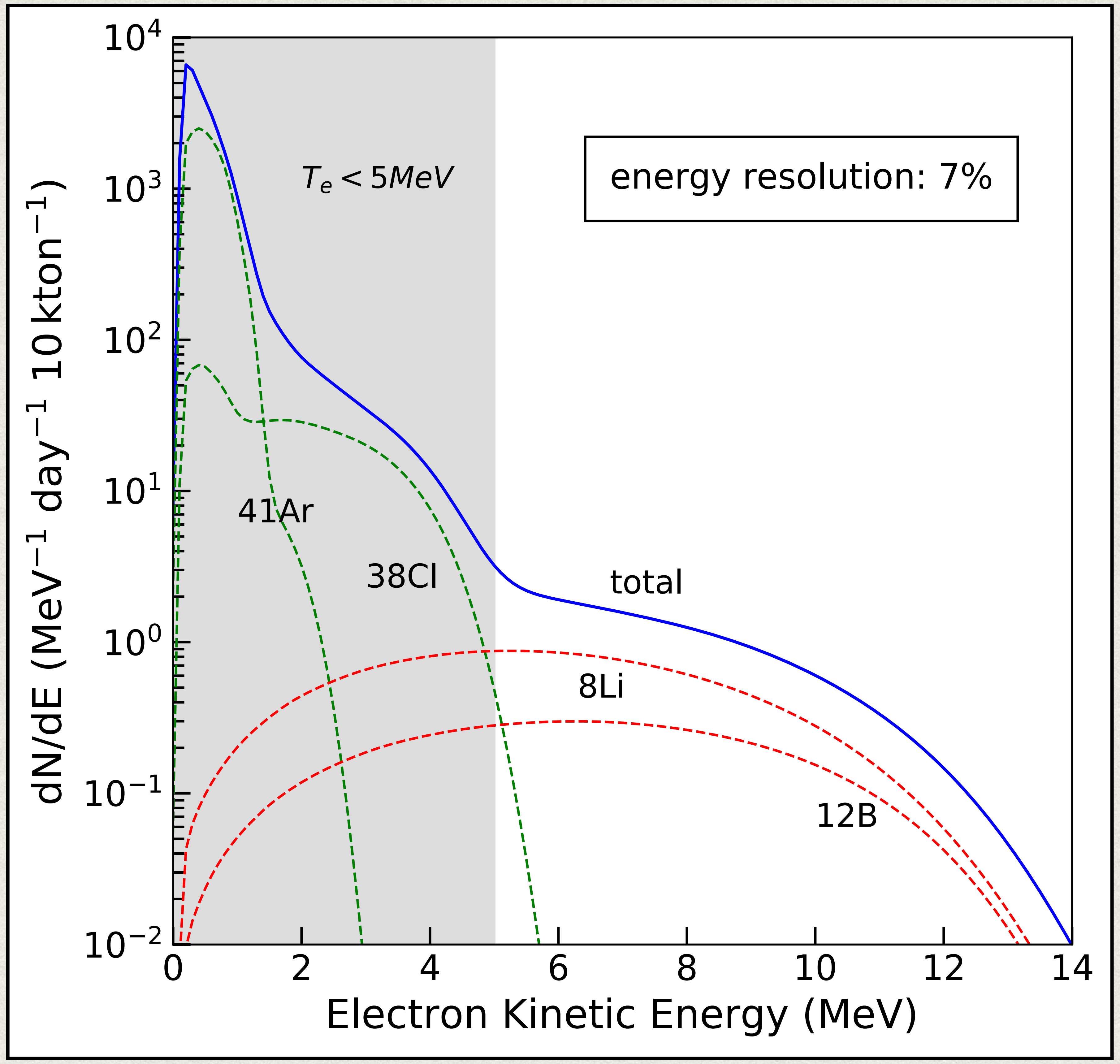
- delayed beta from radioactive decay

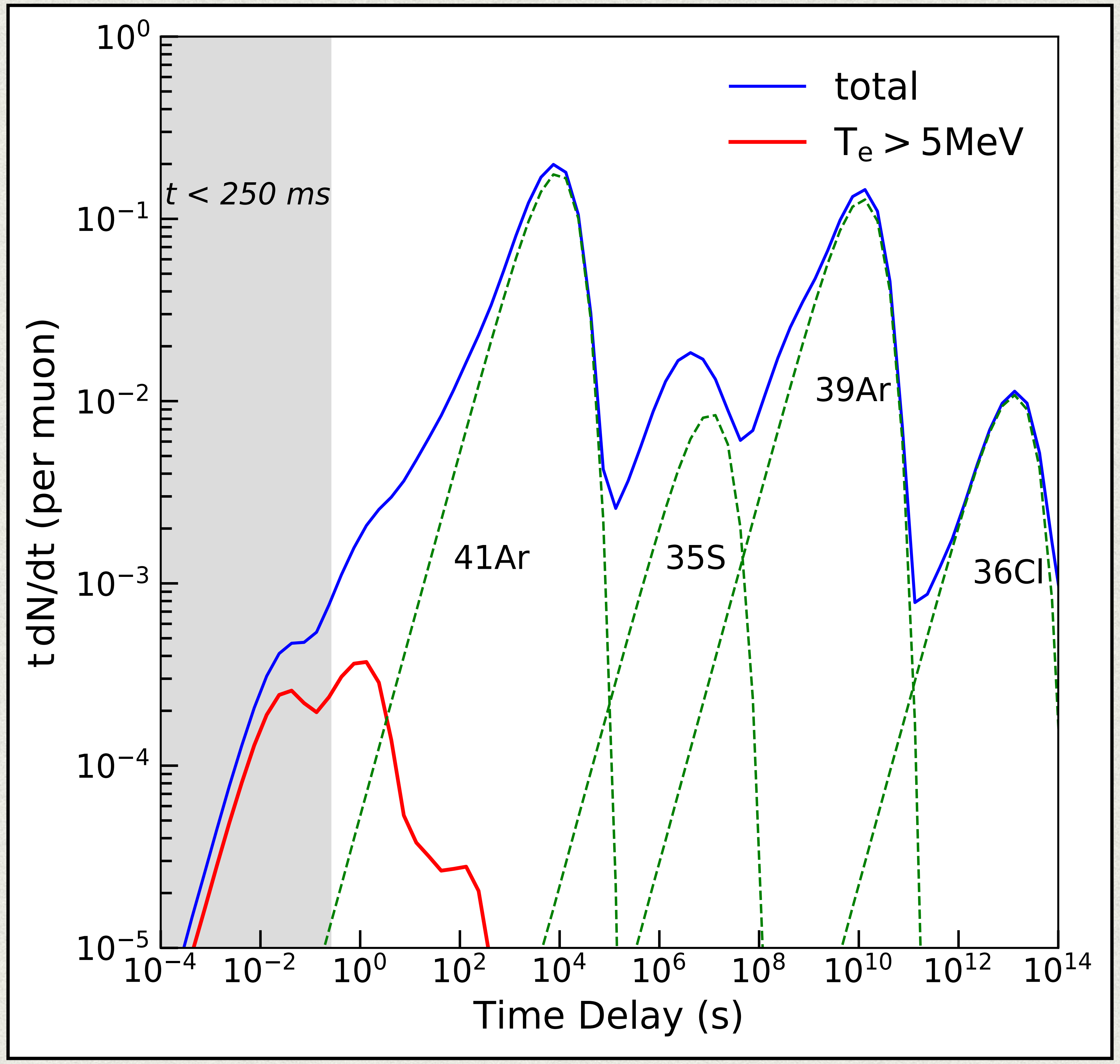
$$\mu \rightarrow \mu + secondary$$

$$secondary + X \rightarrow X'$$

$$X' \rightarrow e^{-} + others$$

Background for solar detection I — spallation





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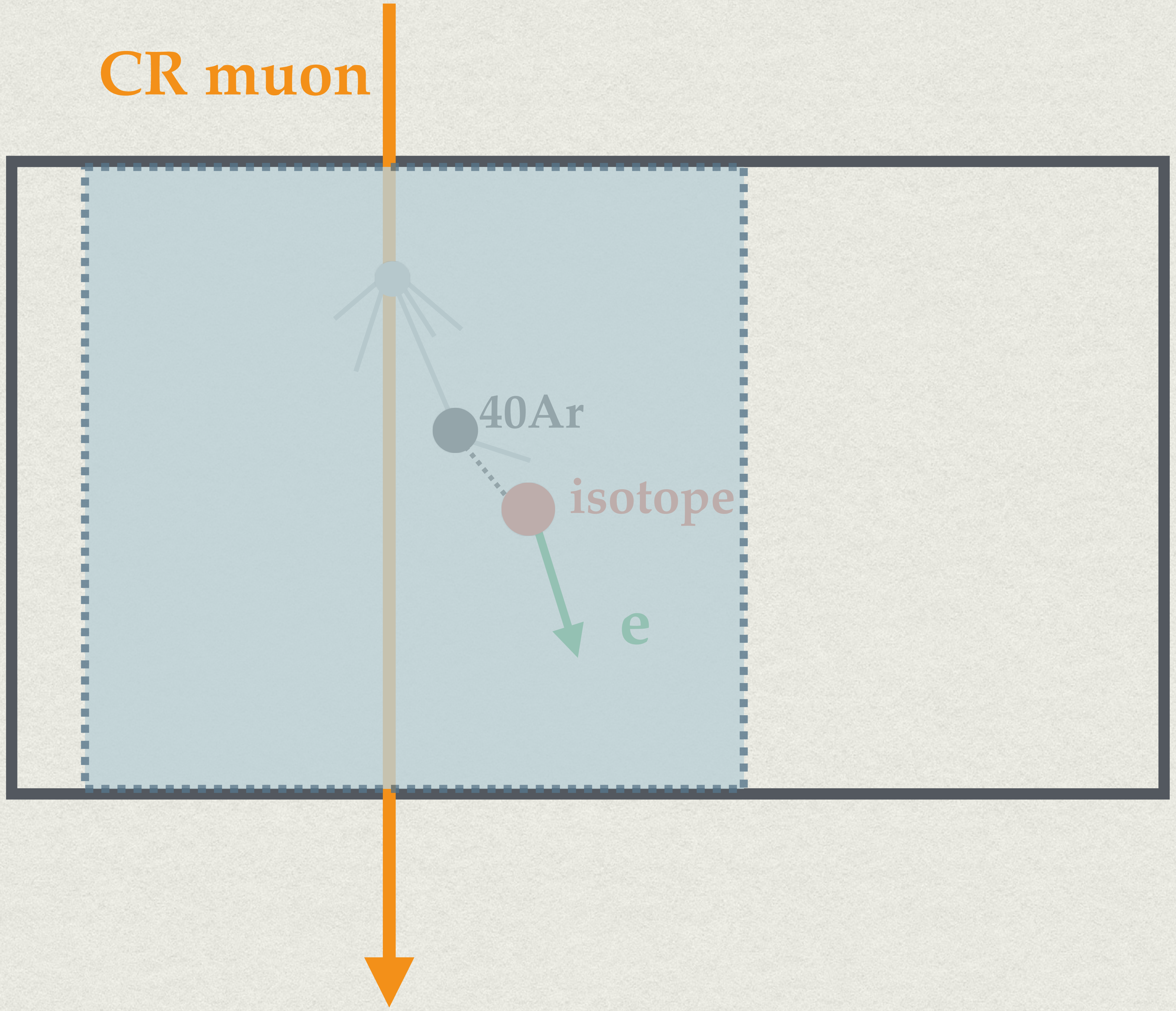
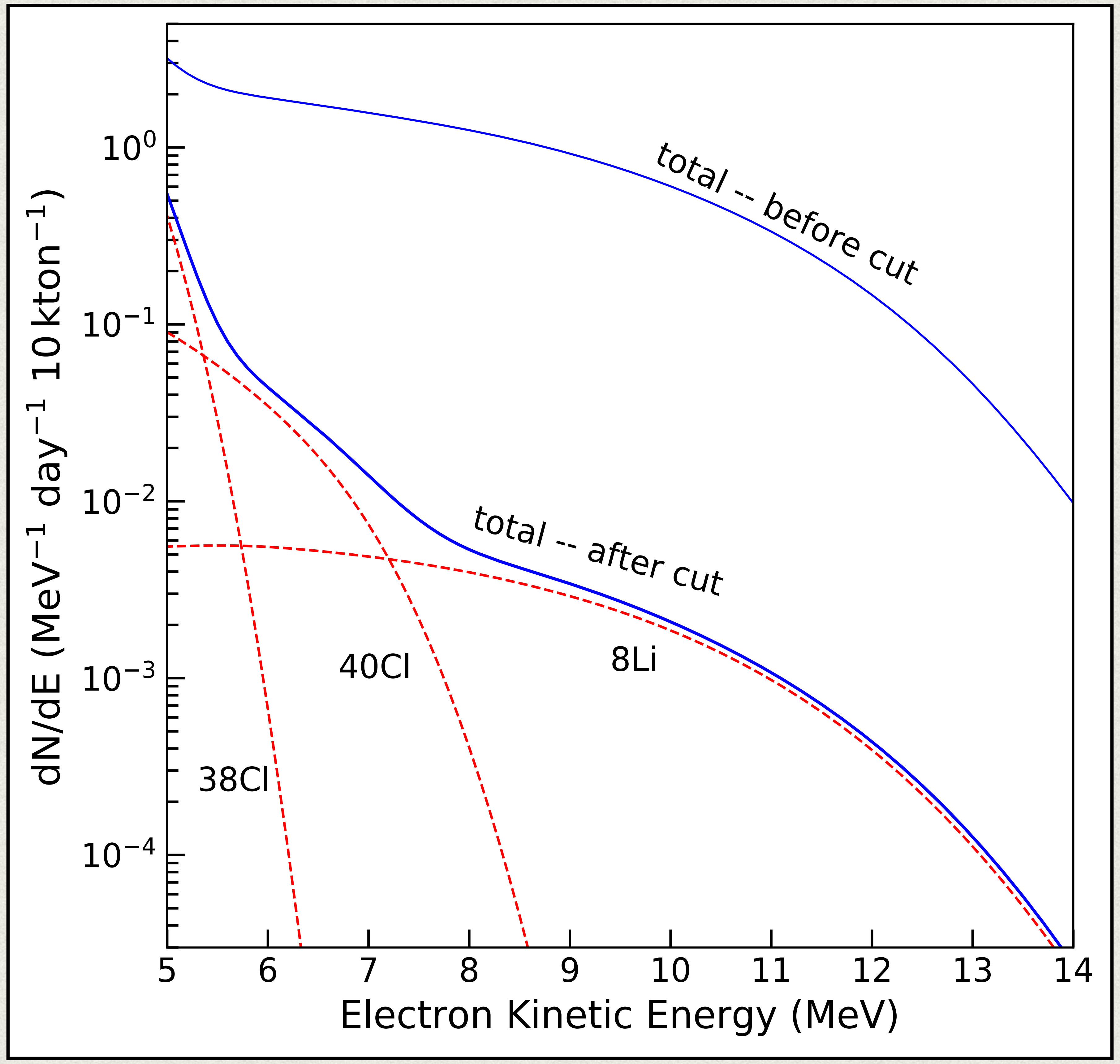
Background for solar detection I — spallation



- After a (R~2.5 m) & (t ~ 2 min) cylinder cut



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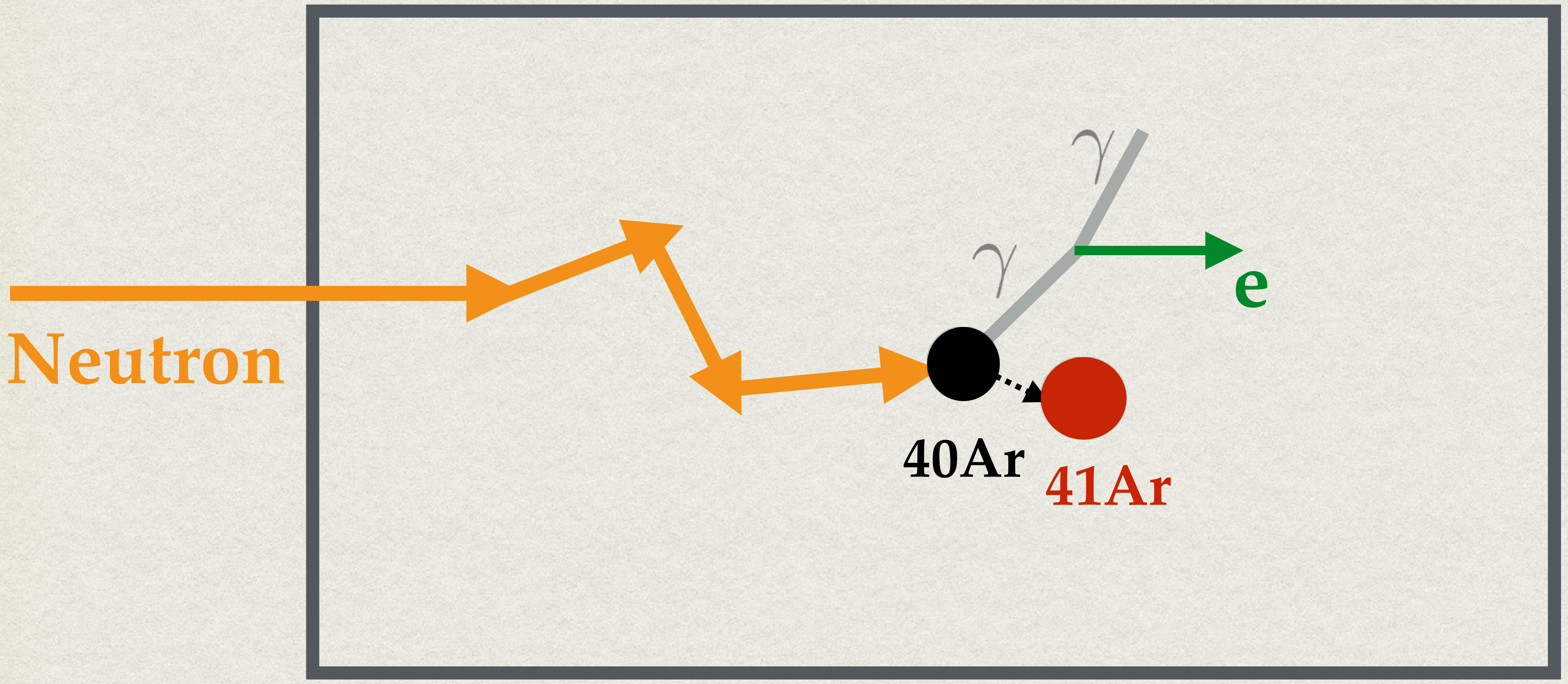
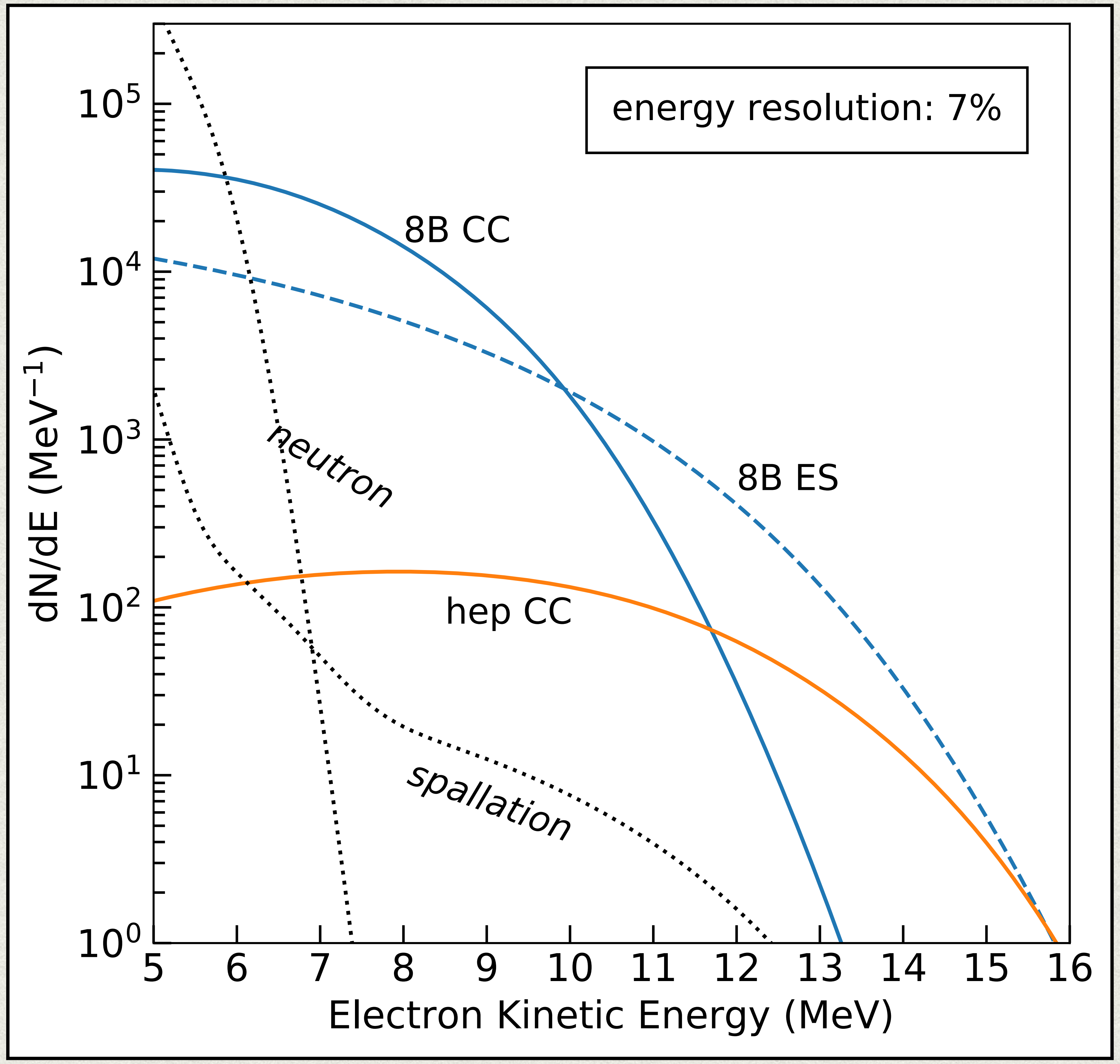
Background for solar detection II — neutron



- Where are neutrons from?
  - 238U/232Th alpha decay, (alpha, n) in the rock
  - 238U Spontaneous Fission -> n
- What do neutrons do in the detector?
  - Elastic scatter (ES) to lose energy
  - Eventually get captured and emit gamma

Solar neutrinos @ DUNE — Signal vs. Background



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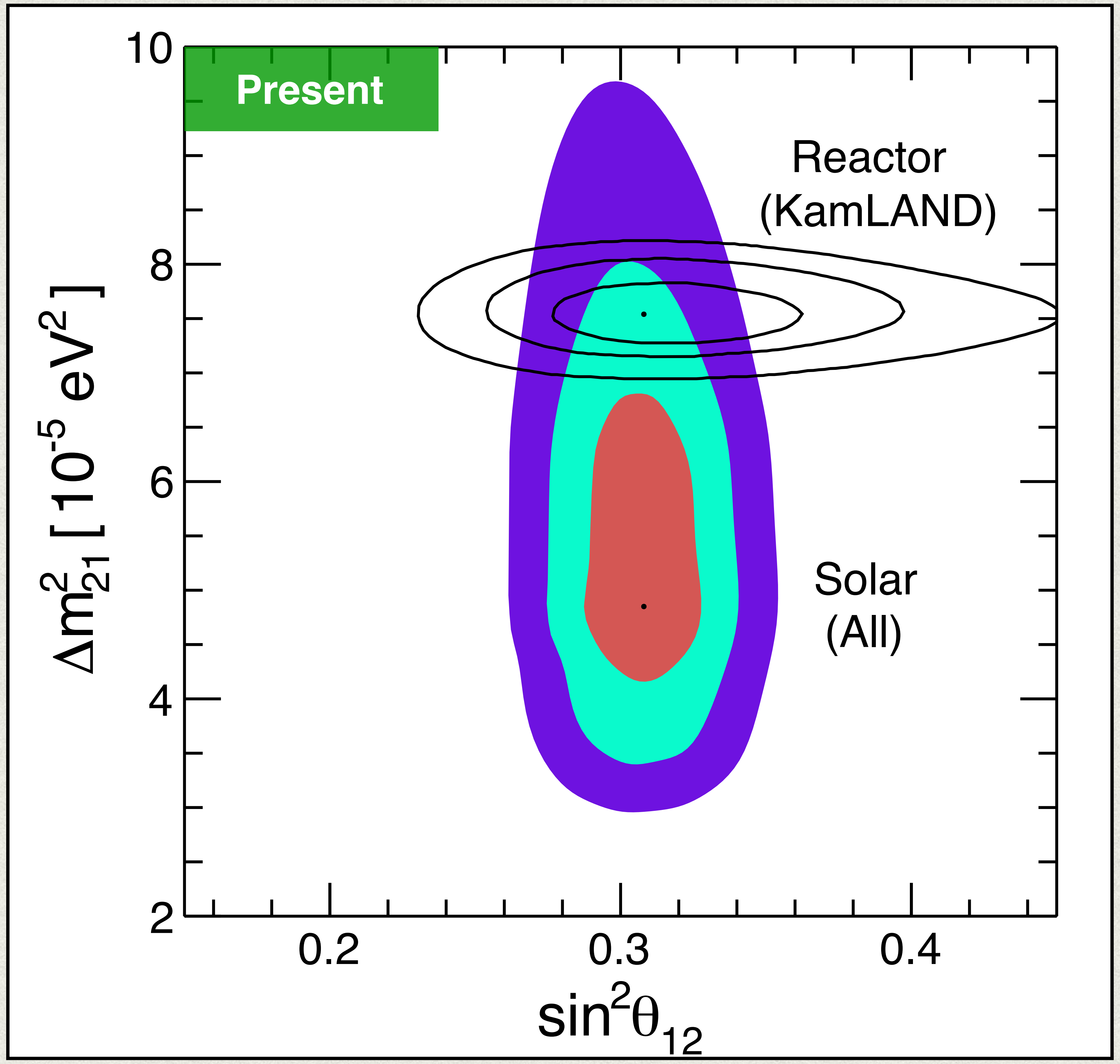
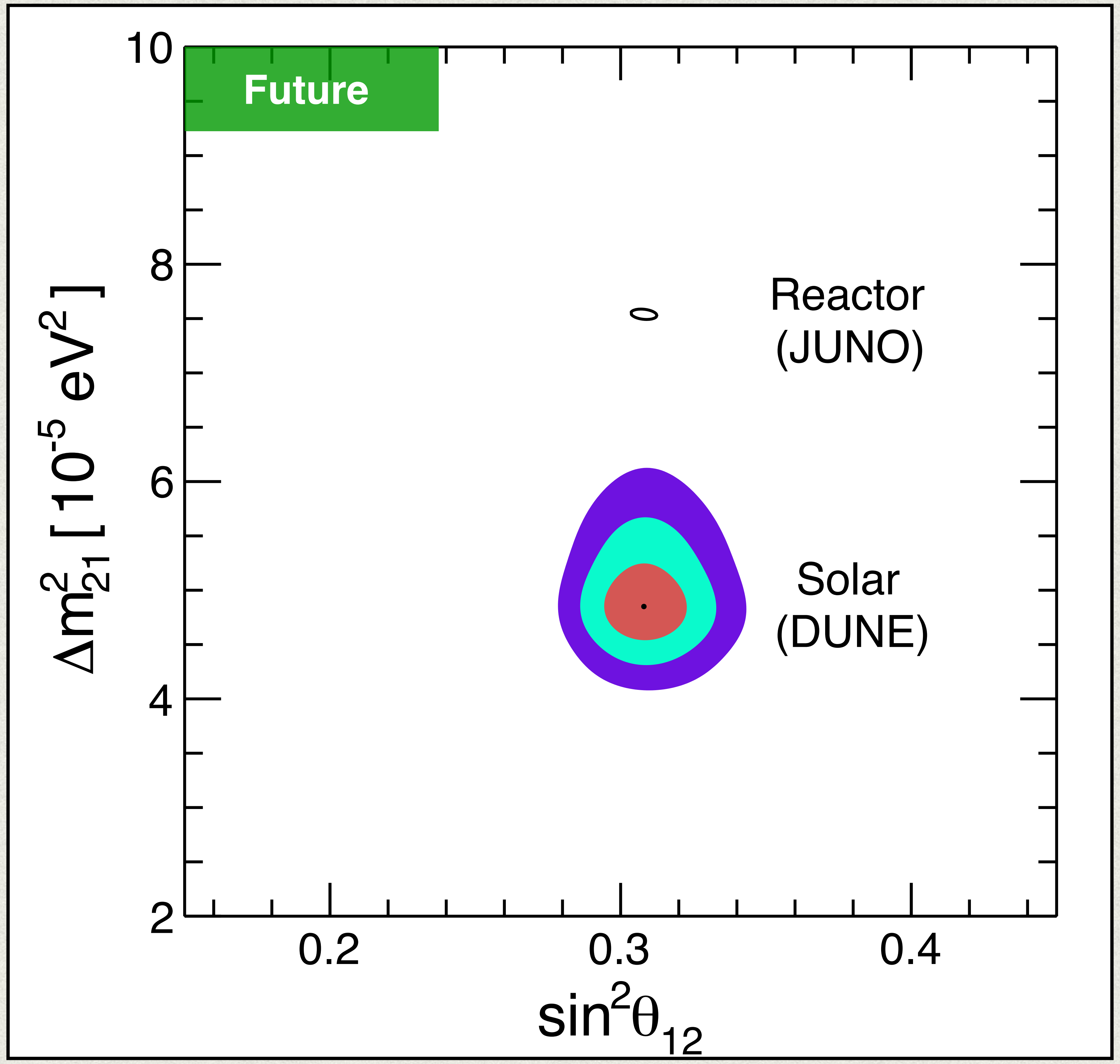
- Signal
  - 8B flux, ~2.5%
  - First detection of hep, ~11%
- Background
  - Spallation after cut is harmless
  - Neutron needs ~ 40 cm water shielding

DUNE is required





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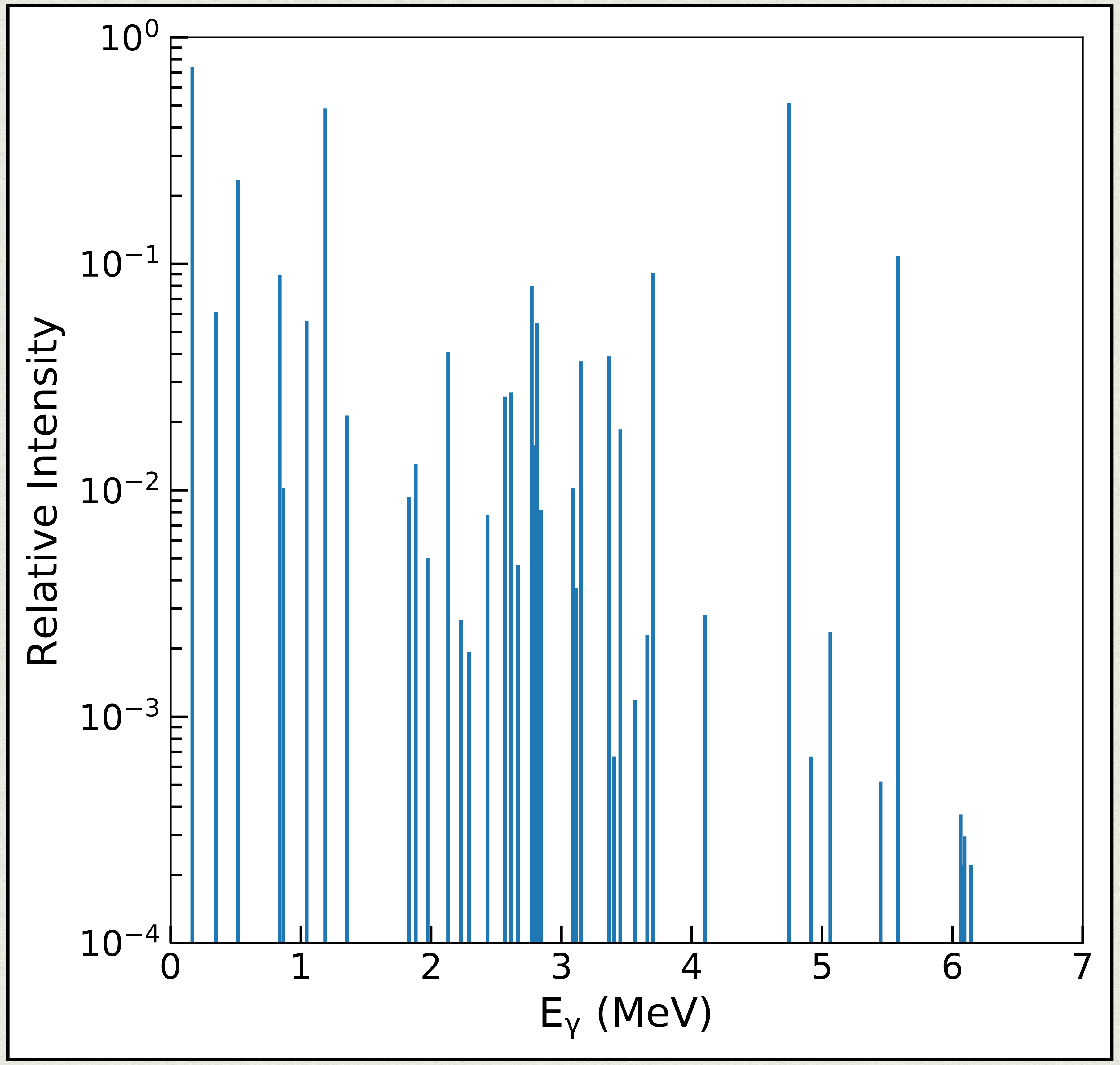
Summary

- Solar neutrinos @ DUNE: best sin^2, dm^2, Phi(8B); first detection of hep
- Background for MeV detection is manageable
  - Spallation — Low atomic number isotopes (Li, B, Be, …) matter most
  - Neutron — Prefer water shielding, if not, a longer exposure works fine
- We would learn more if MeV, GeV, TeV… are simultaneously making discoveries!

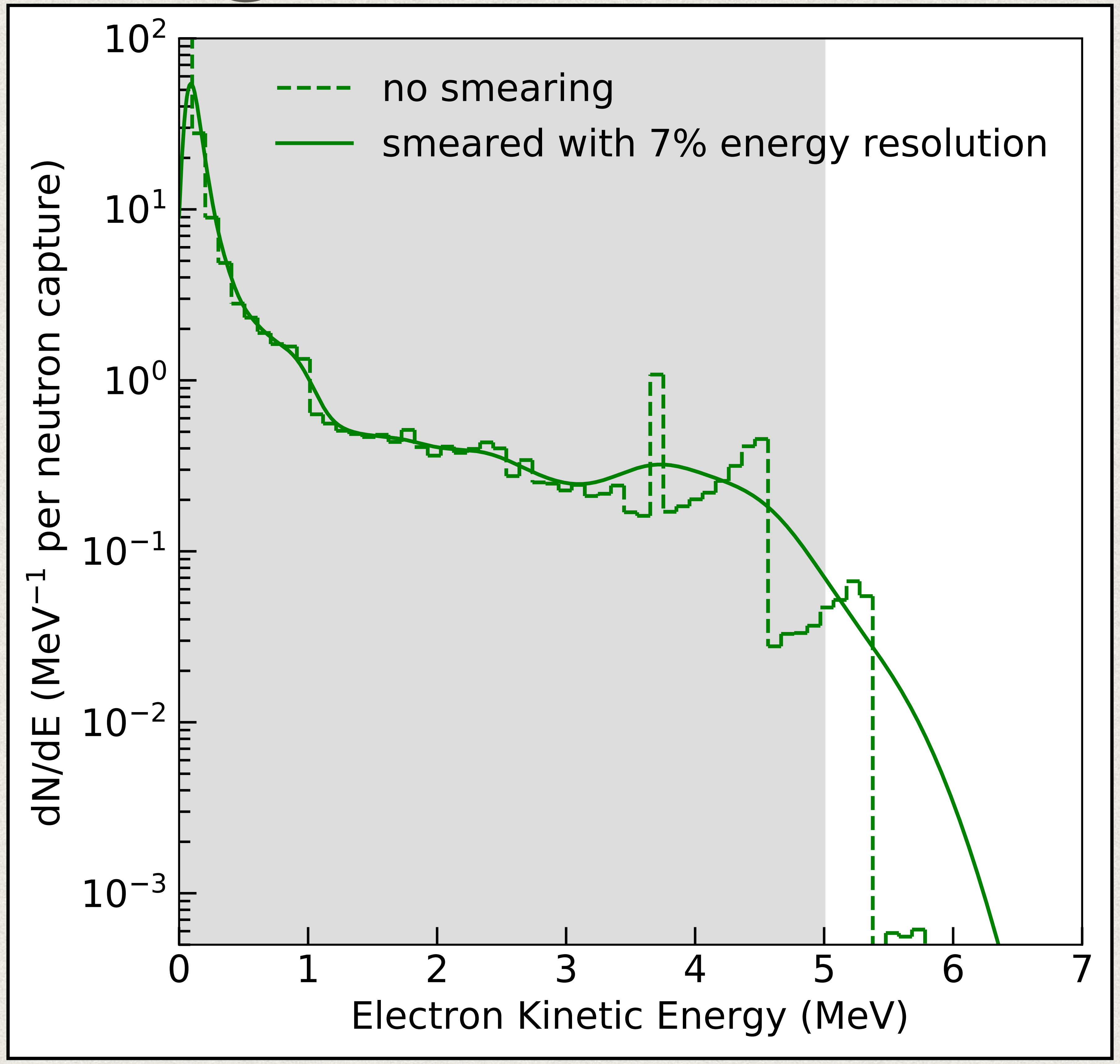
Back up

Background for MeV detection II — neutron

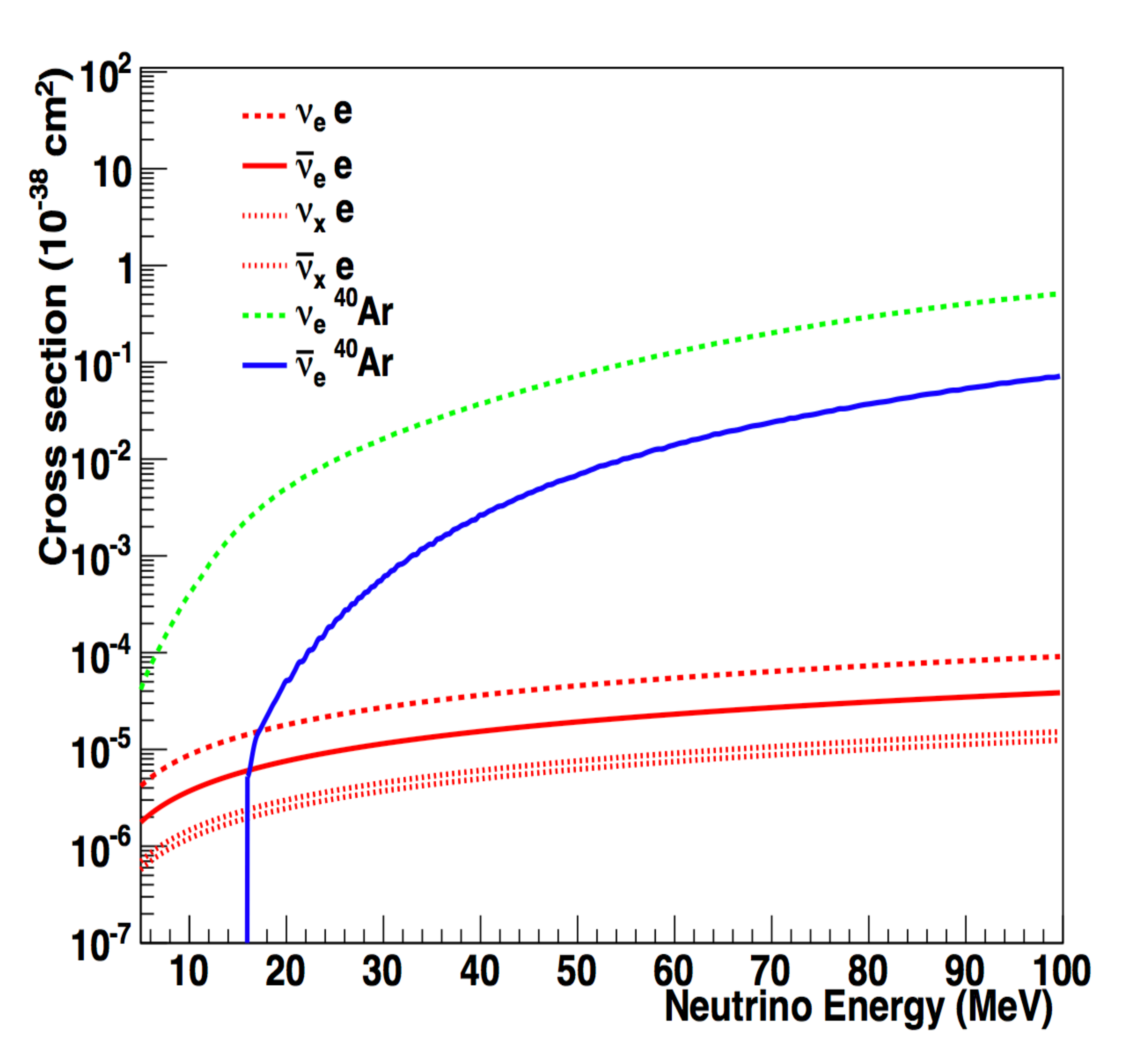
$n + {}^{40}Ar \rightarrow {}^{41}Ar + \gamma$



$\gamma + e^- \rightarrow \gamma + e^-$



Cross Section



DUNE, CDR Report, Volume 2