P #322

Simulation of the background from (α, n) reactions in the JUNO scintillator

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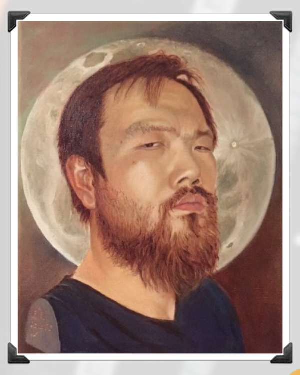
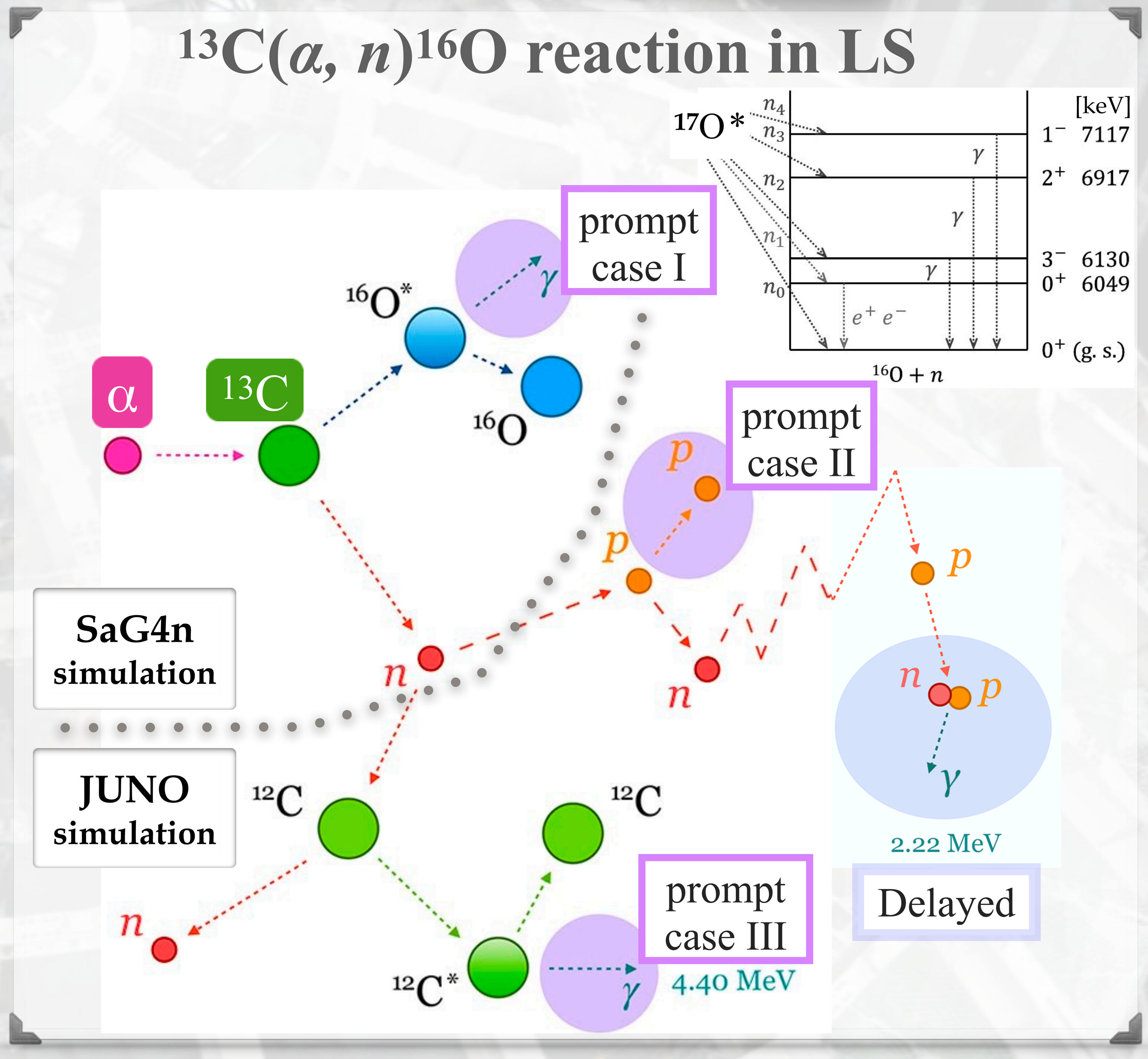
On behalf of the JUNO collaboration



Introduction

- goal of JUNO: precise measurement of reactor anti-neutrinos via **Inverse Beta Decay** (P #1)
  prompt signal energy spectrum to determine **Neutrino Mass Ordering** and **Oscillation Parameters** [1] (P #2, P #3)
- JUNO **Central Detector**: **20 kton** Organic Liquid Scintillator (**LS**)
  LS material: Linear Alkyl Benzene (**LAB**) *more details on LS* - P #4
  natural carbon has ~**1.1%** natural abundance of ^{13}C
- ***presented here: the first dedicated simulation for JUNO of $^{13}C(\alpha, n)^{16}O$ background shape and rate***
- important background for anti-neutrino detection with LS
  an example: **JUNO sensitivity to geoneutrino** - P #5

$^{13}C(\alpha, n)^{16}O$ reaction in LS



Sources of α in JUNO: radio impurities in LS

in equilibrium

^{238}U : 8, ^{232}Th : 6 } **daughter isotopes with dominantly α-decay**

out of ^{238}U chain equilibrium

^{210}Po **supported by ^{210}Pb**
^{210}Po **stand-alone**

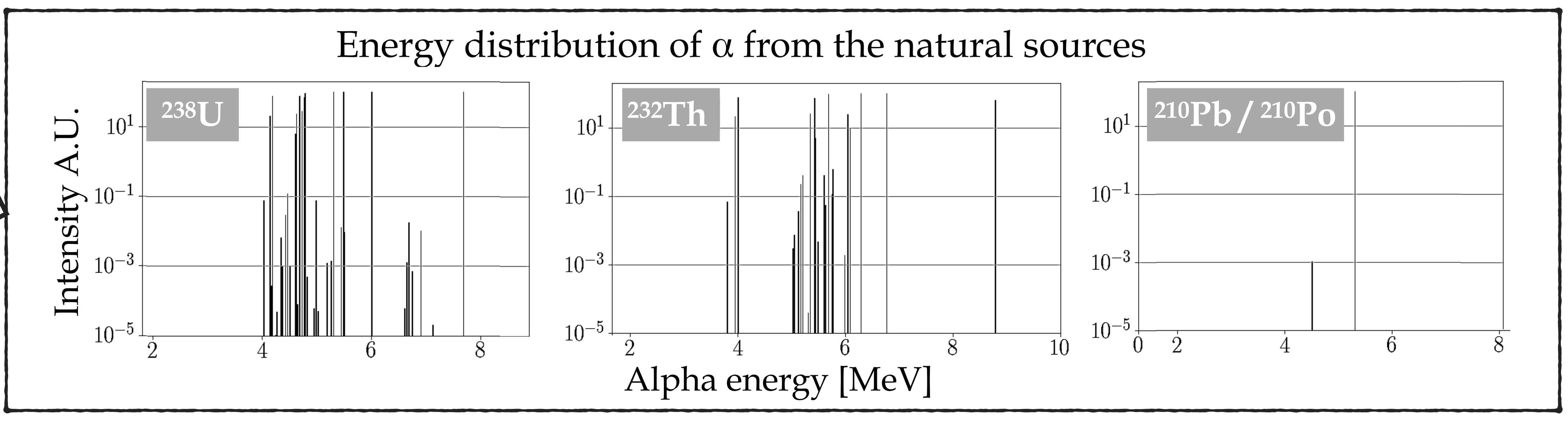
Simulation in 2 steps

step 1: SaG4n software[2]

to simulate final particles from the (α, n) reaction

- Geant4 based
- LAB as physical volume (< 1 m³)
- simulation of (α, n) reaction itself
- can augment x-sec to boost speed
- no optical simulation

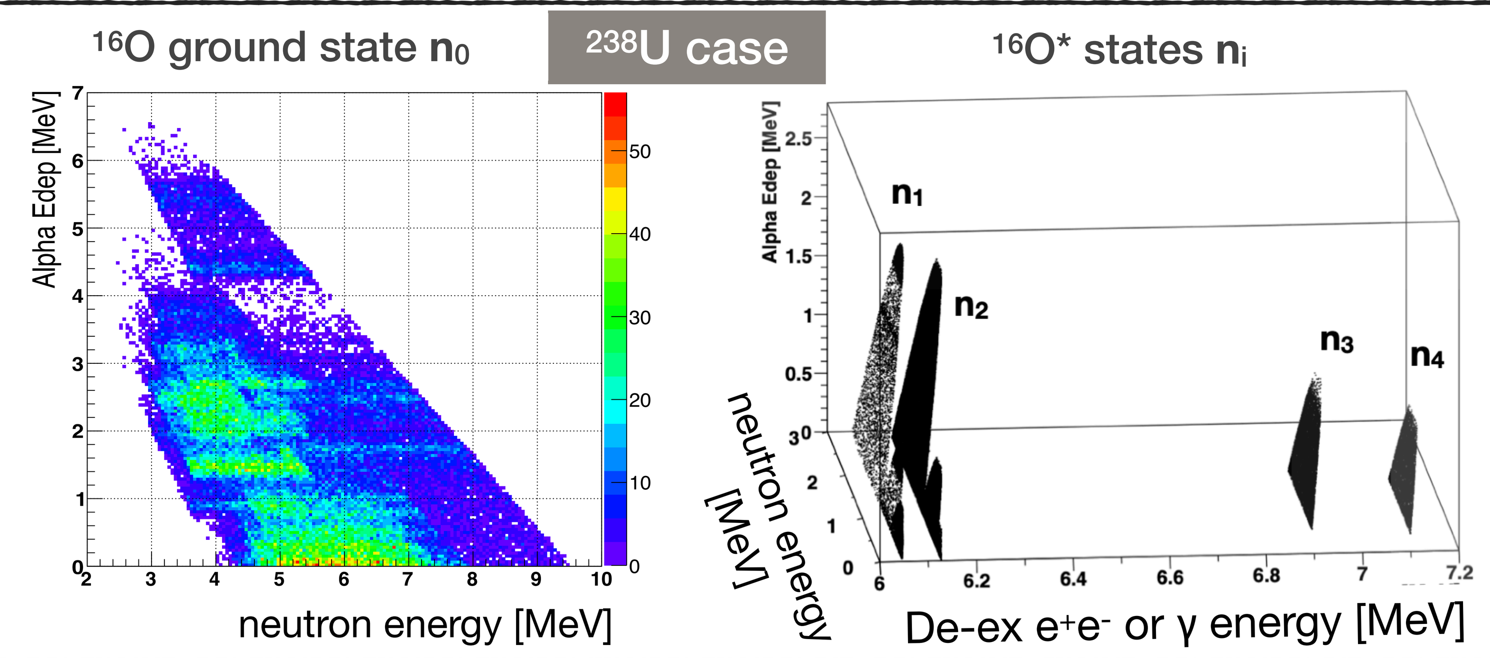
input:



output:

- neutron yields
- α energy deposit
- O* de-excitation
- neutron energy

defines initial particles for single event in JUNO CD uniformly



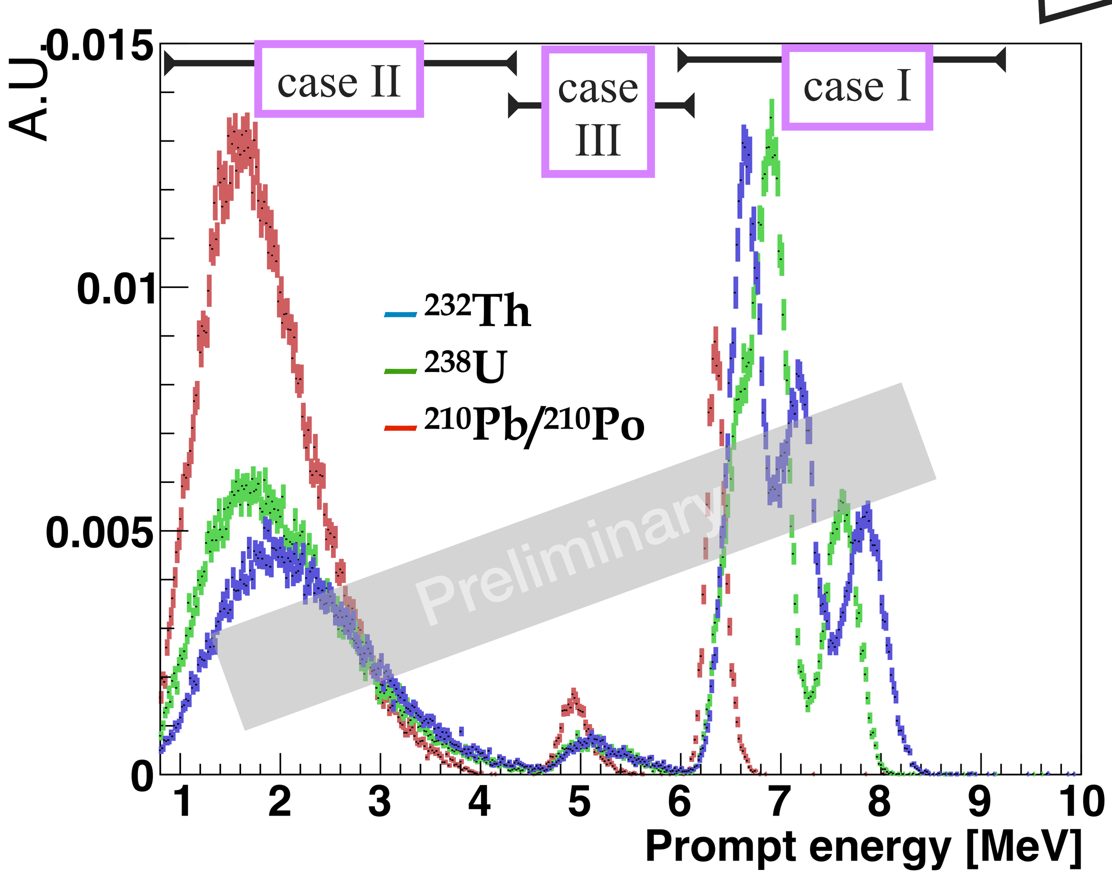
step 2: JUNO Software[3]

to simulate detector response

- Geant4 with full setup geometry
- optical properties of LS
- electronics response
- waveform reconstruction
- event reconstruction

IBD-like event selection using reconstructed vertices information

- prompt vertex radii (Fiducial Volume)
- prompt-delayed vertices: time difference; distance; energies



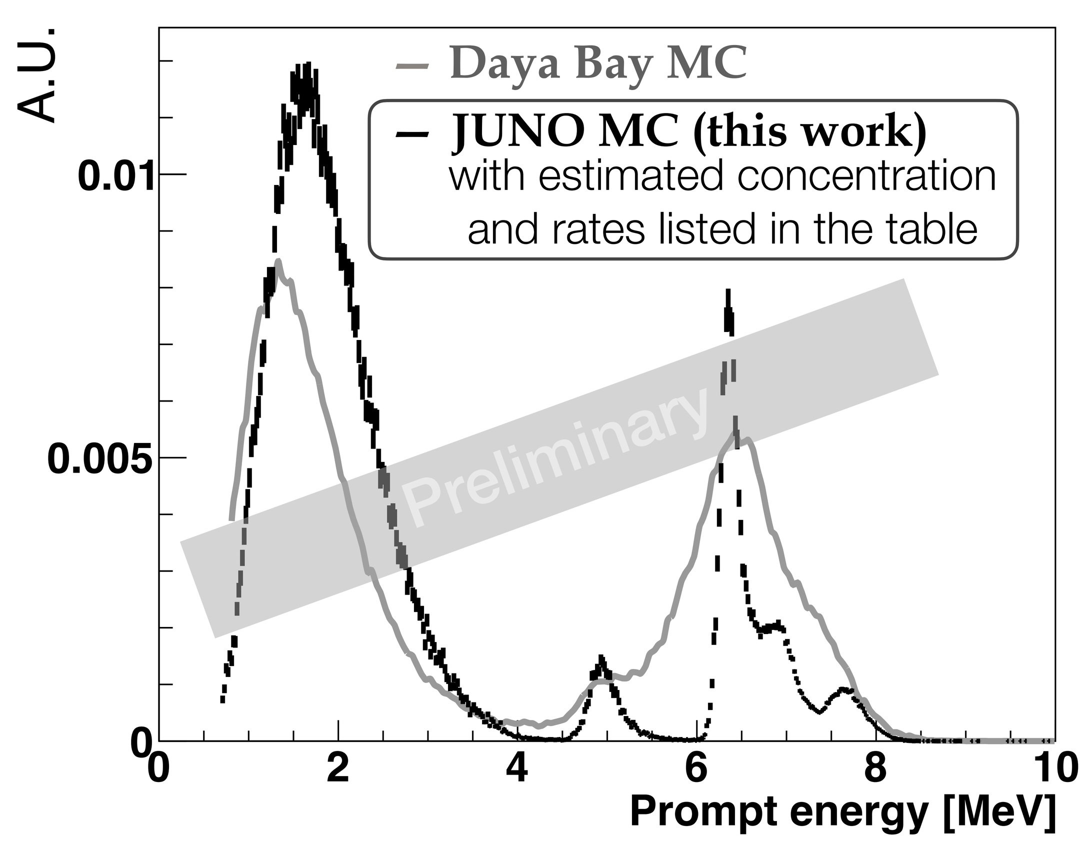
Normalised prompt energy spectra (PDFs)

summing PDFs of sources weighted by rate/total_rate

Results and Conclusion

ALPHA SOURCES	ESTIMATED CONCENTRATION	NEUTRON YIELD [N/CHAIN]	RATE COUNT PER DAY
^{238}U	< 10^{-15} [g/g]	6.4E-7	0.0123
^{232}Th	< 10^{-15} [g/g]	8.6E-7	0.0055
^{210}Po-^{210}Pb	< 5×10^{-23} [g/g]	5.1E-8	0.0114
^{210}Po	*7×10^4 [cpd/kt] **		0.0655
	Total rate [cpd]	0.095 (25%syst.)	

* Extrapolated from Borexino Phase-I condition [4]



$^{13}C(\alpha, n)^{16}O$ background shape in JUNO

References

[1] JUNO physics and detector, arXiv:2104.02565
[2] E. Mendoza, *et al*, NIM A 2020, 960, 163659
[3] T. Lin, *et al*, Eur. Phys. J. C (2023) 83:382
[4] M. Agostini, *et al*, Phys. Rev. D 2020, 101, 012009

P #1 X. Li: JUNO underground facility
P #2 D. Dolzhikov: JUNO NMO sensitivity
P #3 Y. Malyshkin : JUNO Oscillation parameters
P #4 X. Sun: LS mixing and purification
P #5 C. Morales : Geoneutrino in JUNO

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