ALPHANSO

Open-Source Modeling of $(\alpha$,n) Neutron Source Terms

Divit Rawal[1,2] Anthony J. Nelson[2] William Zywiec[2] Daniel Siefman[1,2]
[1]University of California, Berkeley [2]Lawrence Livermore National Laboratory

ALPHANSO replaces legacy deterministic $(\alpha$,n) source-term tools with modern evaluated nuclear data, broader target coverage, ease of use/extension, and benchmark agreement closer to experiment.

Motivation

- Deterministic radiogenic neutron calculations remain essential in safeguards, nuclear assay, and low-background physics fast, interpretable, and required by regulators.
- SOURCES-4C is the industry standard but was built on 1980s nuclear data, a limited target library, and a hard 6.5 MeV E_α ceiling.
- Systematic biases of 30 to 50% are common in SOURCES-4C for key actinide mixtures, propagating into detector efficiency estimates and material accountancy.
- Modern evaluated libraries exist but have never been integrated into an open-source workflow until now.

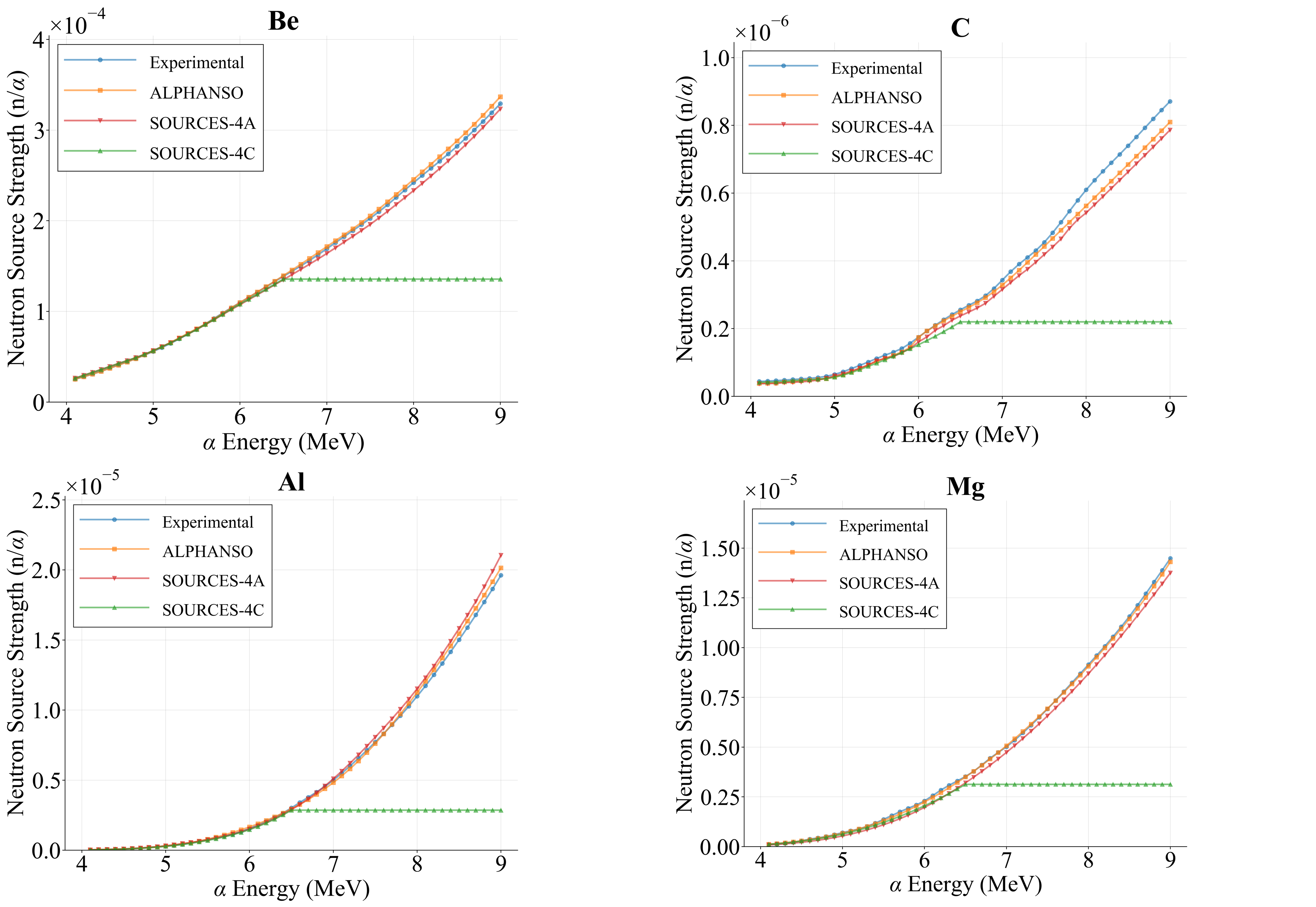
Why ALPHANSO

- Modern cross-section libraries: ENDF/B-VIII.1, JENDL-5, TENDL-2023, and the Parvu et al. (2025) optimized dataset all post-2020 evaluations.
- Broader stable-isotope target coverage (O, F, Na, Mg, Al, Si, Ca, Fe, and more) with no upper E_α energy limit.
- Open-source Python package with a scriptable API: define source geometries, emitter mixtures, and target compositions in code.
- Companion calculations for spontaneous-fission neutrons, γ-ray production, and layered geometries all in one framework.

Features

Feature	ALPHANSO	SOURCES-4C
Modern nuclear data	**Yes**	No
Broad target coverage	**Yes**	No
$E_\alpha > 6.5$ MeV	**Yes**	No
Open-source / Python	**Yes**	No
γ-ray production	**Yes**	No
Layered geometry	**Yes**	No

Thick-Target Beam Yields vs. West & Sherwood



Methodology

ALPHANSO integrates the (α, n) production rate over the full slowing-down spectrum of each alpha emitter, stepping from E_0 to threshold:

$$Y = \sum_i \int_{E_{\min}}^{E_0} \frac{\sigma_i(E)}{S(E)} \, \mathrm{d}E$$

where $\sigma_i(E)$ is the (α, n) cross section on target i and $S(E)$ is the stopping power. The key improvement is in $\sigma_i(E)$: modern evaluations cover more isotopes, higher energies, and are validated against recent measurements.

Alpha Decay Data

Alpha-emission energies and branching fractions from ENSDF, covering any alpha-emitting nuclide relevant to safeguards: ^{238}Pu, ^{241}Am, ^{244}Cm, and the full U/Th decay chains. Multi-line alpha spectra are treated exactly via individual level branching fractions.

Stopping Power

$S(E)$ from the ASTAR database using Bragg additivity self-consistent slowing-down for pure elements, compounds, and mixtures of arbitrary elemental composition. The same model is used in both the yield integral and spectral energy assignment steps.

Nuclear Data

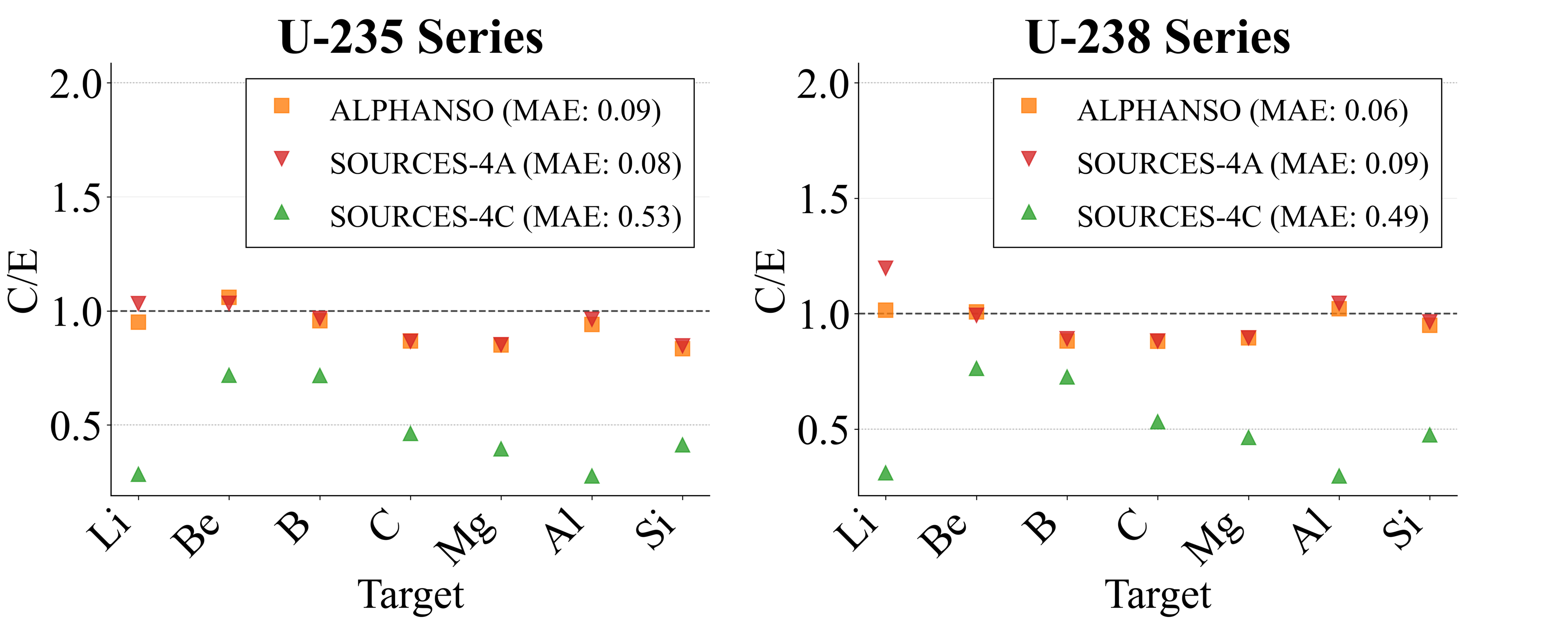
Cross sections cubic-spline interpolated and stored in GNDS format. Library priority: JENDL-5 where available; ENDF/B-VIII.1 for ^{6}Li, ^{9}Be, ^{17,18}O; Parvu et al. for light elements; TENDL-2023 otherwise. Users may override selection per target.

Outputs

- Total neutron yield (n/s/g)
- Neutron energy spectrum
- Per-target contributions
- γ-ray production rates
- Spontaneous-fission companion

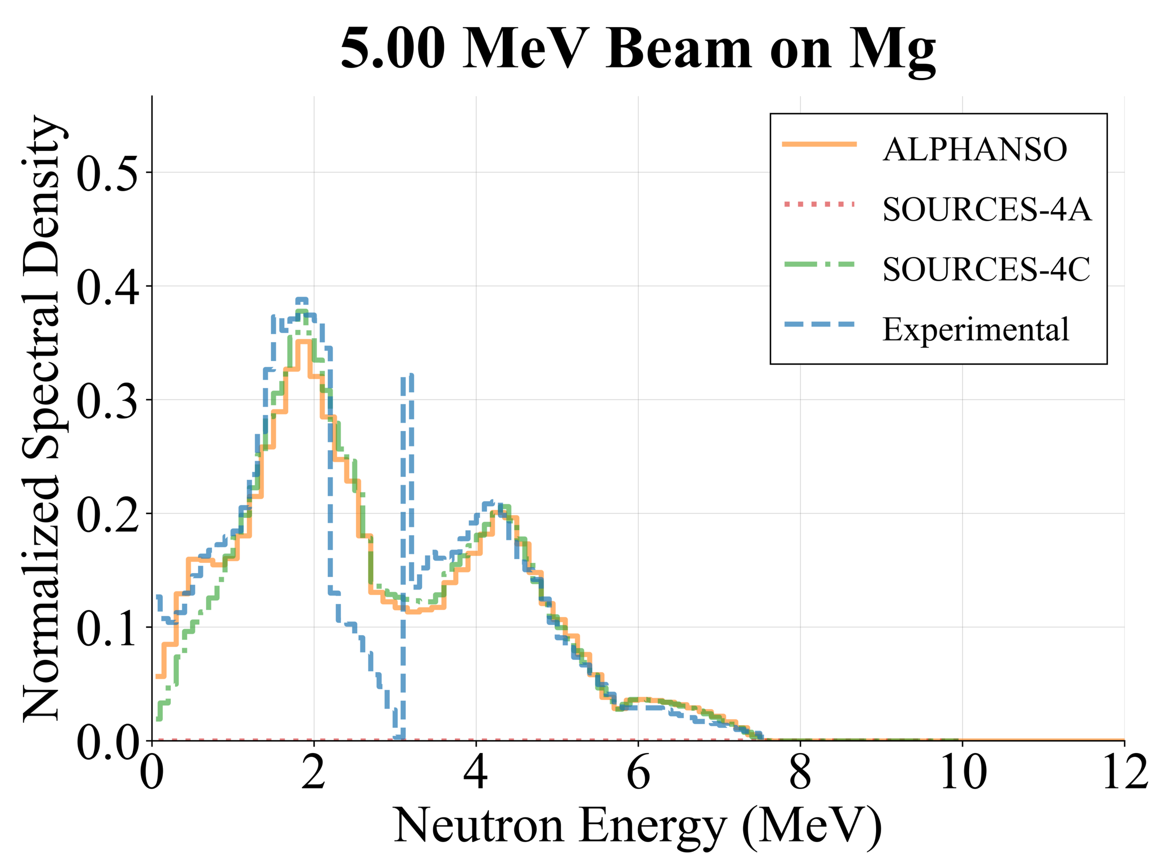
Homogeneous Actinide Mixtures

C/E ratios for U-235 and U-238 decay-series mixtures. ALPHANSO removes the systematic underprediction seen in SOURCES-4C, moving calculated yields substantially closer to measurement across all targets.



Neutron Spectra

Spectral validation at 5.0 MeV on Mg. ALPHANSO reproduces the measured spectral shape with accuracy comparable to the best modernized SOURCES datasets.



Get ALPHANSO

`pip install alphanso`

github.com/alphanso-org/alphanso

Supported Libraries

ENDF/B-VIII.1 JENDL-5
TENDL-2023 Parvu et al. (2025)

Supported in part by NNSA through the Nuclear Science and Security Consortium under Award No. DE-NA0003996. Work also performed under the auspices of the U.S. Department of Energy by LLNL under Contract DE-AC52-07NA27344.

References: Wilson et al. (2002), Parvu et al. (2025), West & Sherwood (1982), Jacobs/Liskien beam-spectrum benchmarks.