

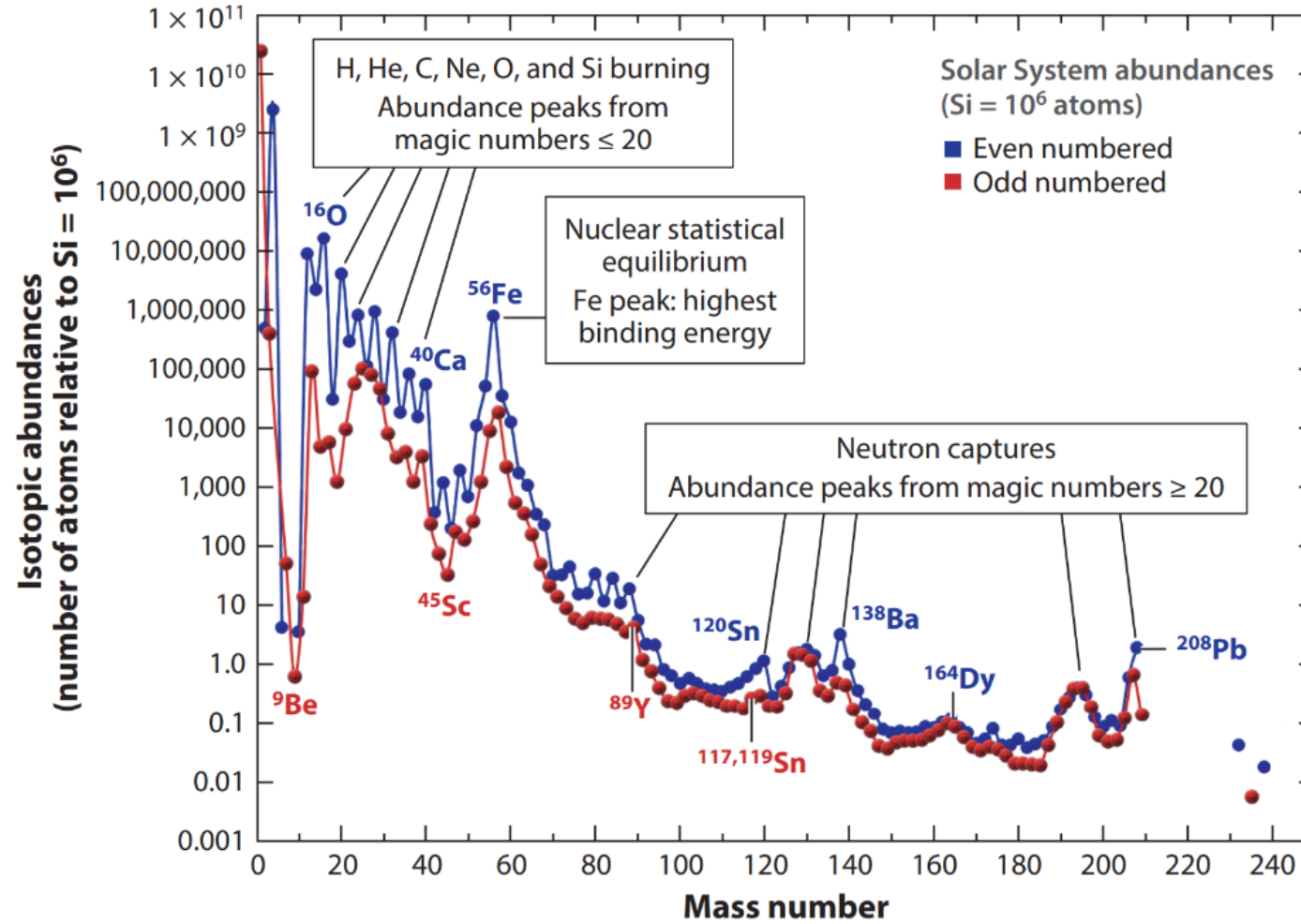
# Neutron Capture in a Plasma Environment – Towards an Excited State Measurement

**Brian Appelbe**<sup>1</sup>, Maria Gatu Johnson<sup>2</sup>, John Despotopoulos<sup>3</sup>, Kelly Kmak<sup>3</sup>, Daniel Pitman-Weymouth<sup>4</sup>, Jutta Escher<sup>3</sup>, Wei Jia Ong<sup>3</sup>, Charles Yeamans<sup>3</sup>, James Benstead<sup>4</sup>, Aidan Crilly<sup>1</sup>, Chad Forrest<sup>5</sup>, Warren Garbett<sup>4</sup>, Veronika Kruse<sup>3</sup>, Samantha Labb<sup>3</sup>, Andrew Lanzrath<sup>2</sup>, Claudia Lederer-Woods<sup>6</sup>, Mark Paris<sup>7</sup>, Andrew Ratkiewicz<sup>3</sup>, Ben Reichelt<sup>2</sup>, Nick Schwartz<sup>2</sup>, Ronnie Shepherd<sup>3</sup>, Will Taitano<sup>7</sup>

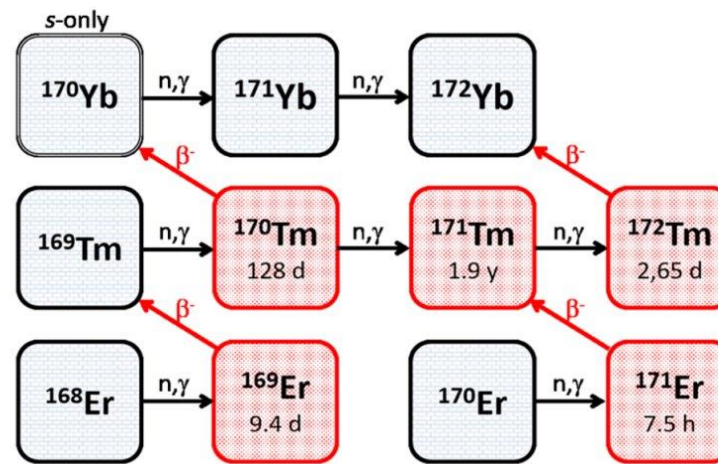
## The nyplasma Collaboration

<sup>1</sup>Imperial College London, <sup>2</sup>Massachusetts Institute of Technology, <sup>3</sup>Lawrence Livermore National Laboratory, <sup>4</sup>AWE Nuclear Security Technologies, <sup>5</sup>Laboratory for Laser Energetics, <sup>6</sup>University of Edinburgh, <sup>7</sup>Los Alamos National Laboratory

# Isotopic abundances in the Universe

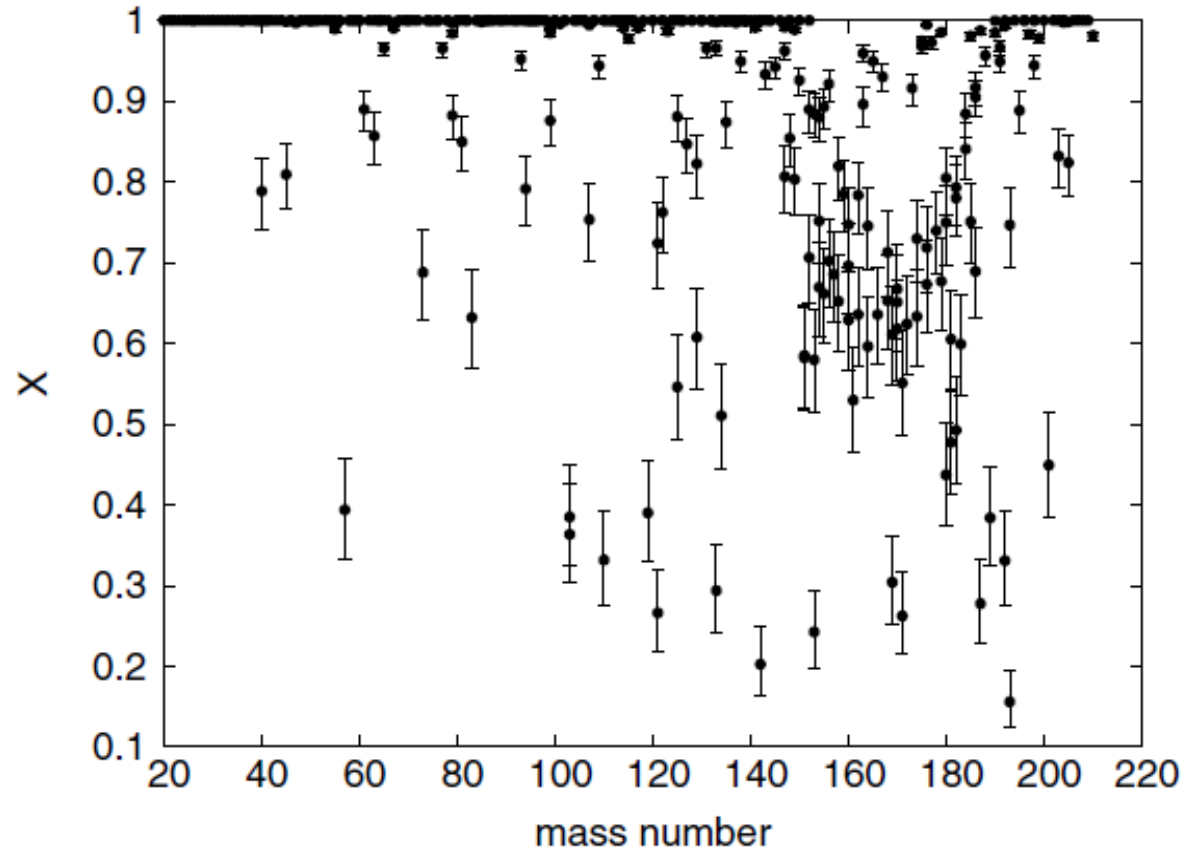


# The astrophysical $s$ process and stellar $(n,\gamma)$ rates

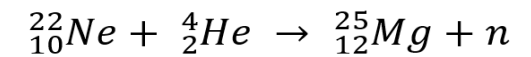
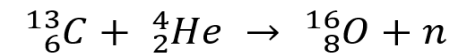


*An illustration of the  $s$  process in the region of the branch point nucleus  $\text{Tm}171$*

# Stellar $(n,\gamma)$ rates depend on nuclear excitation rates



Neutron source reactions:



*Estimated ground-state contributions  $X$  to stellar  $(n,\gamma)$  rate at 30 keV*

# Can we measure $(n,\gamma)$ cross sections of excited state nuclei?

1. Observing  $n\gamma$  reactions in NIF implosion

2. Understanding nuclear excitation in plasmas

3. Measuring  $n\gamma$  cross section of excited state nuclei

4. Varying neutron spectra in plasma (moderation)

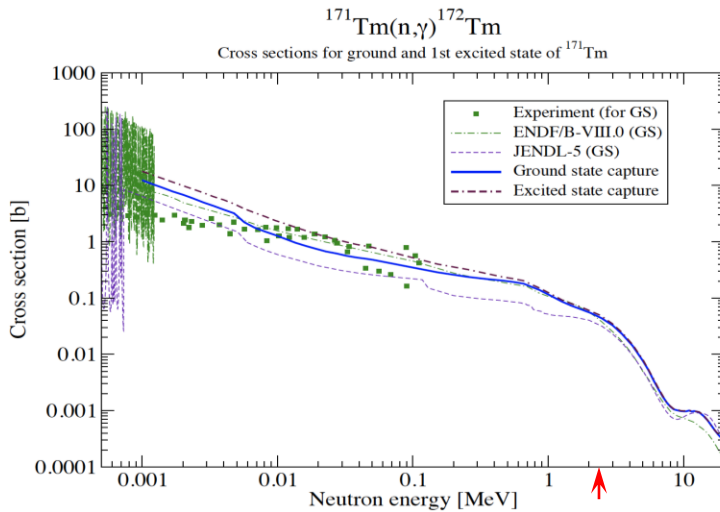
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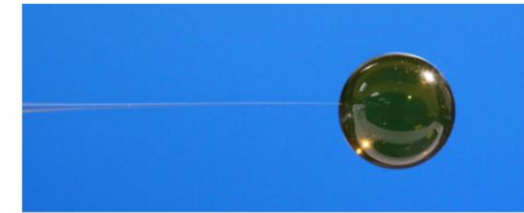
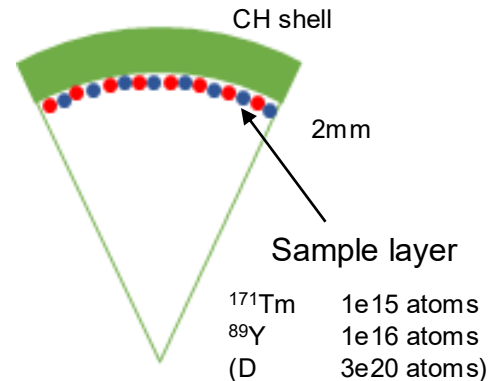
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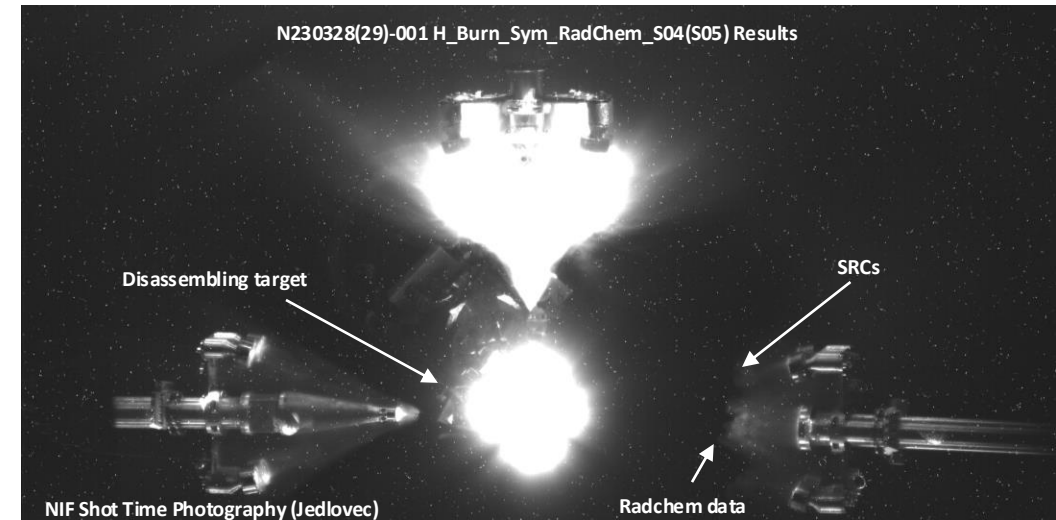


$\text{Tm}171$   $n\gamma$  cross section (gs and 1st exs)

- Experiment in Q4 FY26
- $\text{Tm}171(n,\gamma)\text{Tm}172$  at neutron energy of 2.45 MeV



Capsule and fill tube



SRC detectors on IDD shot

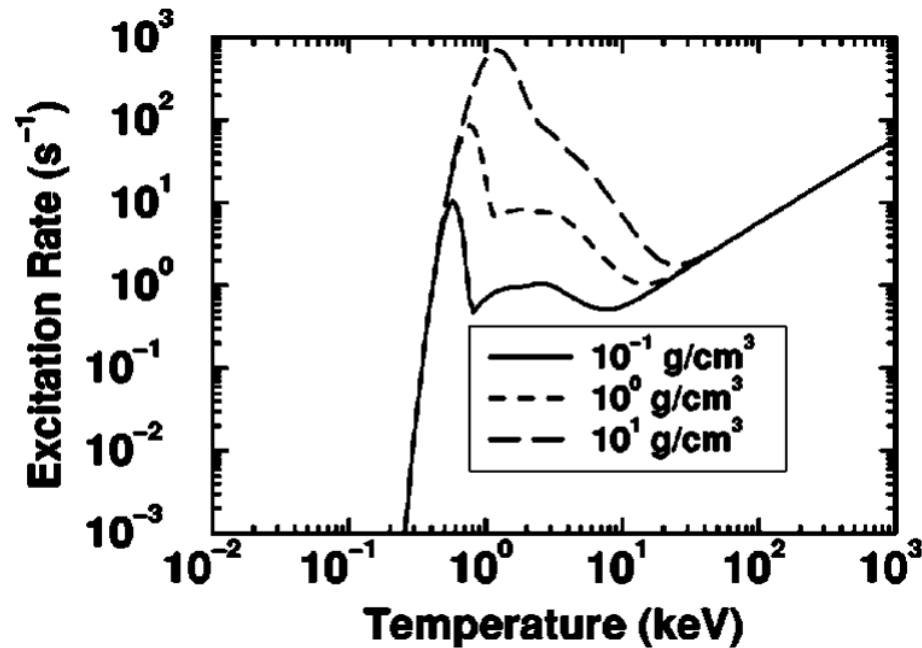
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*Excitation of Mo93 by NEEC and photon absorption*

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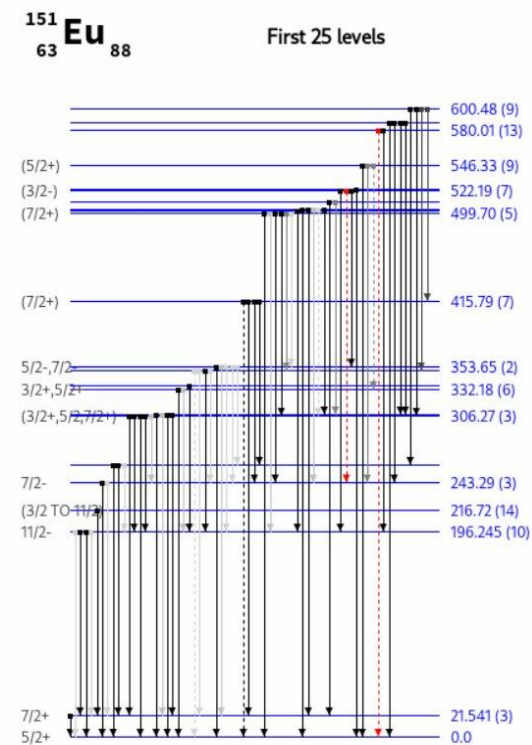
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| Isotope | cx GS [mb] | cx L1 [mb] | Ex Ener [MeV] | cx ratio |
|---------|------------|------------|---------------|----------|
| Eu151   | 30.28      | 34.40      | 0.022         | 1.136    |
| Zr88    | 39.04      | 28.52      | 1.057         | 0.730    |
| Nb93    | 6.01       | 5.35       | 0.031         | 0.890    |
| La139   | 5.25       | 4.25       | 0.166         | 0.809    |
| Sc45    | 1.35       | 1.14       | 0.012         | 0.842    |
| Cr50    | 2.64       | 3.68       | 0.783         | 1.391    |
| Co57    | 5.84       | 4.38       | 1.224         | 0.750    |
| Co59    | 2.54       | 2.15       | 1.099         | 0.847    |
| Zn64    | 10.33      | 8.88       | 0.992         | 0.860    |
| Mo98    | 3.52       | 2.17       | 0.735         | 0.616    |
| Cs133   | 19.35      | 16.72      | 0.081         | 0.864    |

*Candidate isotopes for measuring  $n\gamma$  cross section of excited states*



*Energy levels of  $Eu_{151}$  nucleus*

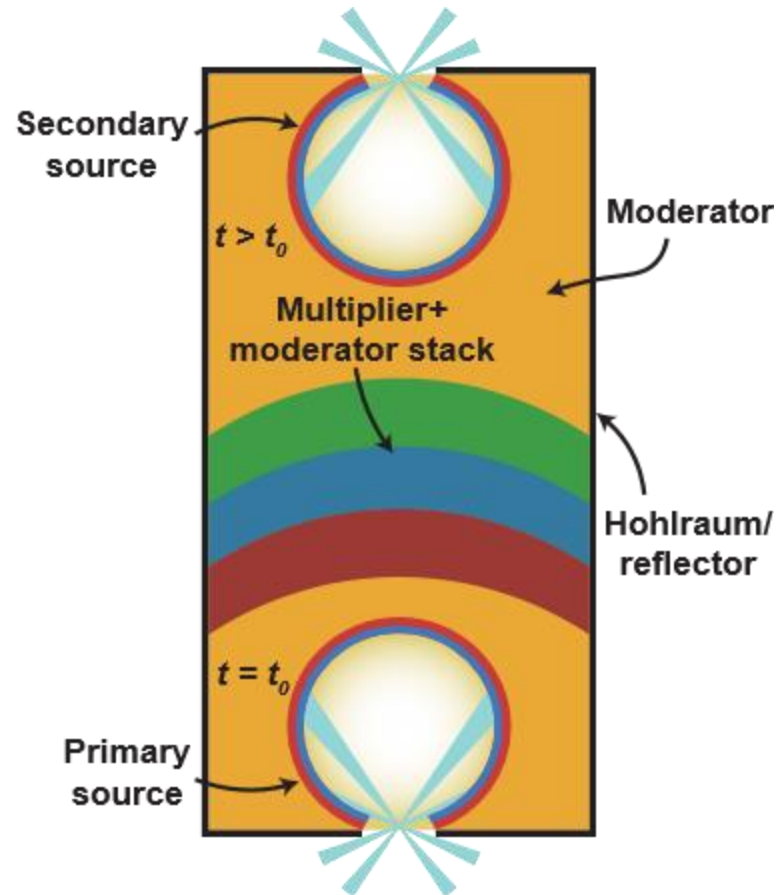
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Nick Schwartz, MIT, Poster Tuesday

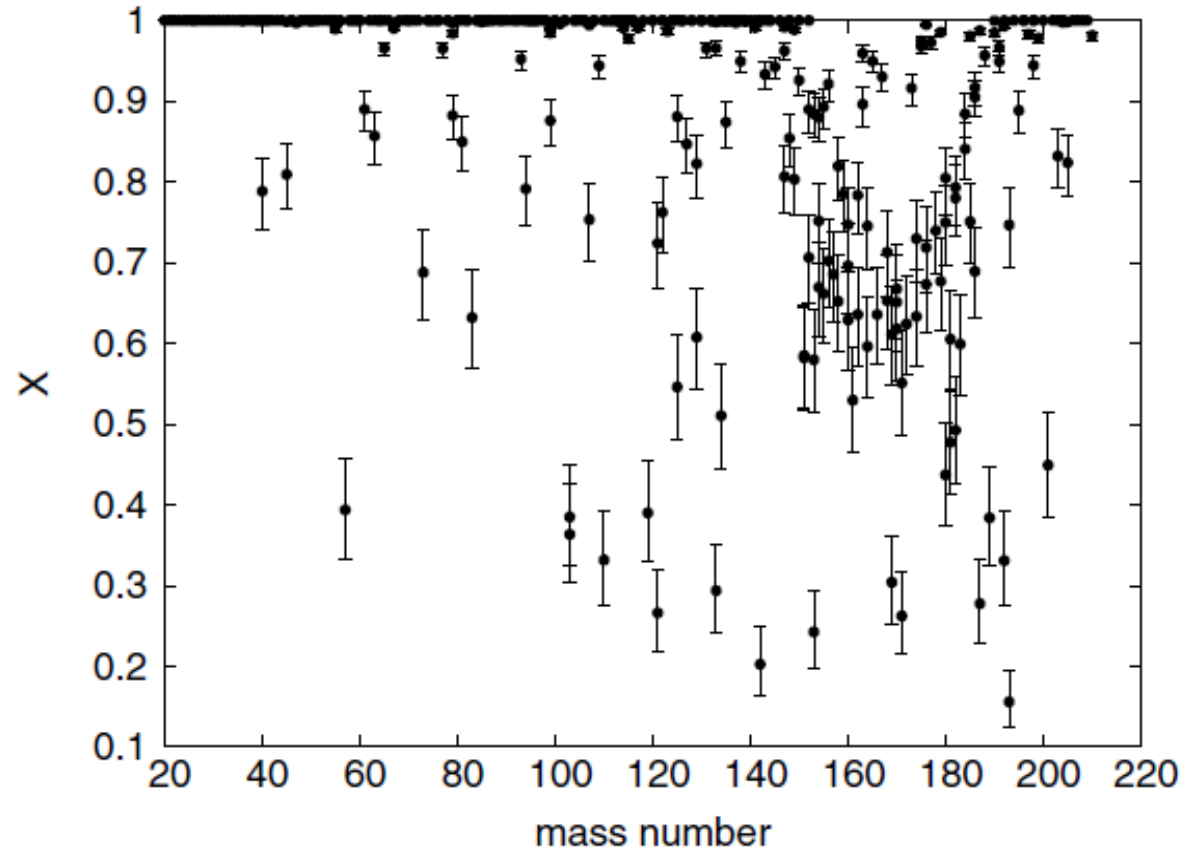
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