Measurement of the zirconium-88 thermal neutron absorption cross section at EAR2

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$^{88}Zr(n,\gamma)^{89}Zr$ - Background

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- In 2019, ^{88}Zr was discovered to have a thermal neutron absorption cross section of 861,000 barns (measured) rather than 10 barns (expected).
  - Larger than ^{157}Gd, ^{10}B, ^{6}Li, ^{3}He
  - Smaller than ^{135}Xe
    - Both ^{88}Zr and ^{135}Xe are radioactive
- **n_TOF is uniquely positioned to measure a low energy resonance which explains the large cross section**.

LETTER

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The surprisingly large neutron capture cross-section of ^{88}Zr

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$^{88}Zr(n,\gamma)^{89}Zr$ – Motivation (Continued)

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- DICER at LANL is also searching for a resonance.
  - We have been expecting a 2023 publication.
    - There is a Nature scientific report on their sample prep.
  - Since DICER is transmission-based and we are direct capture-based, our n_TOF measurement will be relevant even if DICER publishes first.

www.nature.com/scientificreports

scientific reports

Check for updates

OPEN

Production of zirconium-88 via proton irradiation of metallic yttrium and preparation of target for neutron transmission measurements at DICER

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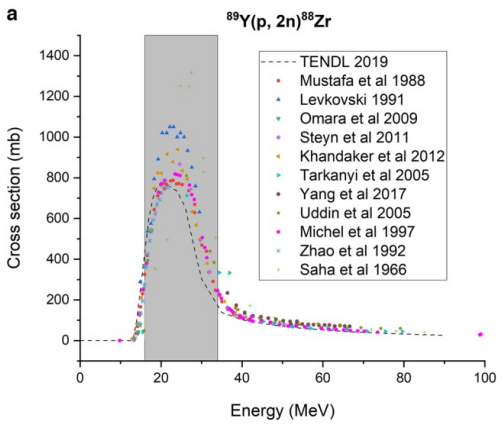

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DICER: a new instrument for nuclear data for nuclear security

Athanasios Stamatopoulos ✉, Artem Matyskin, Paul Koehler, Aaron Couture, Brad DiGiovine, Veronika Mocko, Gencho Rusev, John Ullmann & Christian Vermeulen

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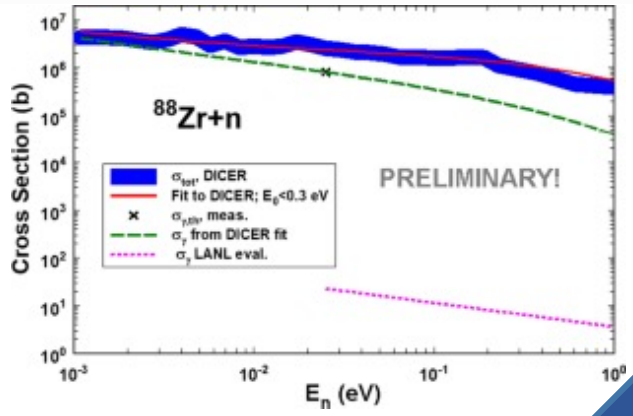

$^{88}Zr(n,\gamma)^{89}Zr$ – Sensitivity Study

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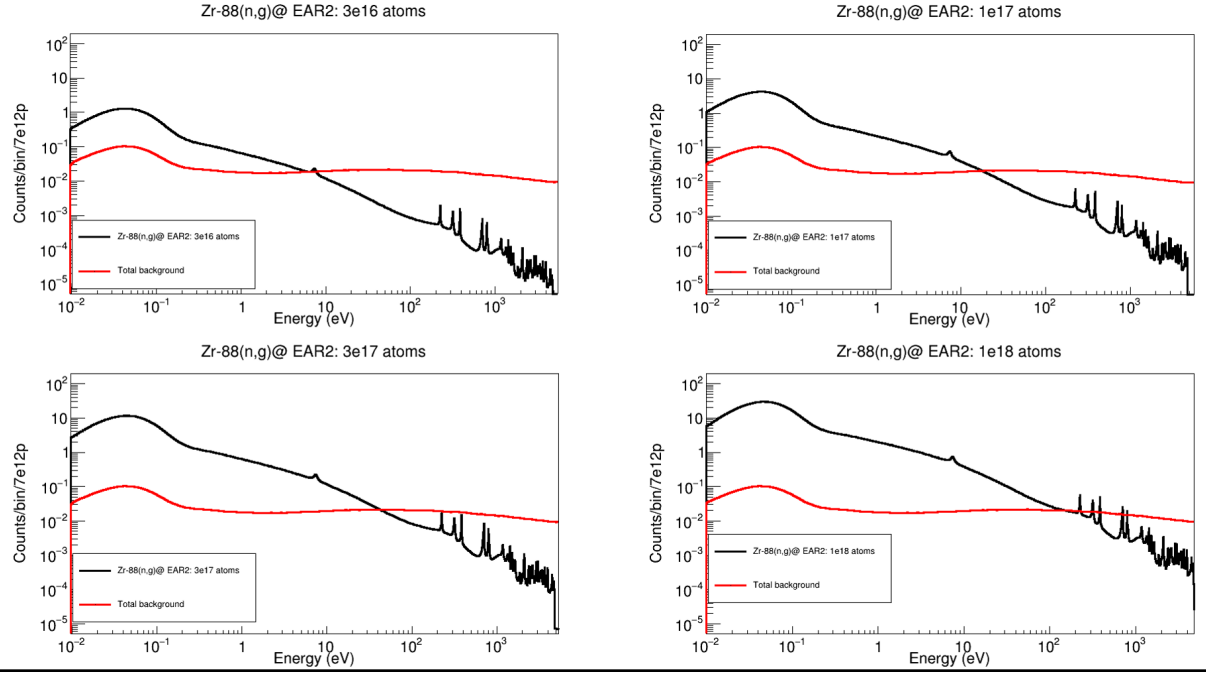
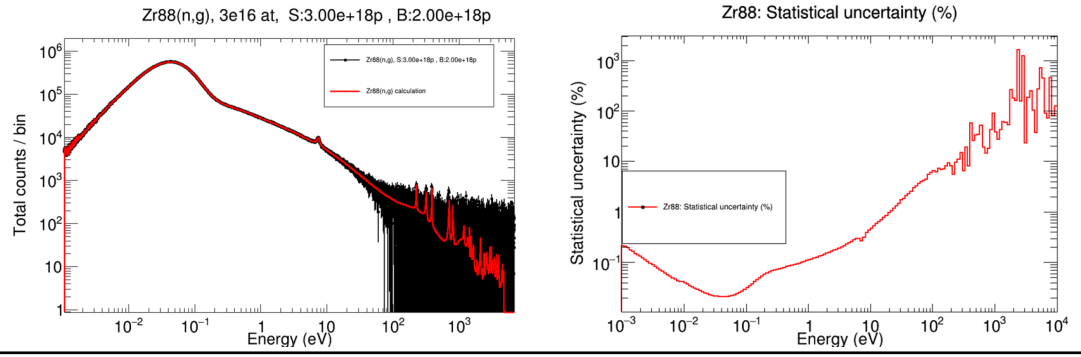
- Jorge did a sensitivity study in June.
  - https://docs.google.com/presentation/d/112T1jJfLVImO3u3At0SDTmkPzMqoOBUDSra5IwFfn3k/edit#slide=id.g24d657861bc_0_146





Background subtracted counts (left) and statistical uncertainty (right) for 100mCi $^{88}Zr(n,\gamma)^{89}Zr$ with 3×10^{18} protons on target for the sample and 2×10^{18} protons on target for background measurements.

Signal and background rate estimates at EAR2. The 100mCi sample proposed here corresponds to 3×10^{16} atoms, top left.

Signal-to-background above unity and sub-percent statistical uncertainty through 5 meV

$^{88}Zr(n,\gamma)^{89}Zr$ – 100 mCi Target Sample

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- Jorge's sensitivity study assumed 100 mCi
- The US DOE National Isotope Development Center (NIDC) offers ^{88}Zr
- The price is 2660 + 431.50/mCi
  - 1 mCi is 3092 USD
  - 100 mCi is 45811 USD
  - Includes a packing fee

- Funding
- A first attempt for funding with UD, LLNL, UAB, and Cerium did not succeed.
- Looking at another DOE STTR proposal due 3 JAN 2024 with grant starting 1 JUL 2024
- Considering other options and will bring a solution forward as soon as possible.

- NIDC purity quoted as >99%, radiopurity measured via ICP and gamma spectroscopy
- Claudia was quoted 1mCi in 1mL H_2O from Oak Ridge National Lab a few years back
  - 0.009 mCi/mL Y-88 and 6.07E-4 mCi/mL Zn-65
  - 0.22 Cu, 8.13 Fe, 0.44 Ni, 6.24 Zr (all ug/ml)
  - Ga and Nb >200 ug/ml

$^{88}Zr(n,\gamma)^{89}Zr$ – INTC Timeline

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- INTC LOI draft attached to agenda.
  - LOI not submitted. Claudia advised a full proposal rather than LOI.
  - We plan to submit to INTC in early January for the meeting in early February.

$^{88}Zr(n,\gamma)^{89}Zr$ – Repeat 2019 LLNL Result

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- We plan to repeat the LLNL total thermal cross section measurement early next year.
  - At University of Texas NETL TRIGA reactor
    - 3L facility with a thermal neutron flux of 4×10^{12} n/cm^2/s
  - Along with chemistry professor Dave Catlett
  - We have gold foils to place along with 1 mCi sample
  - With cross section of 861000 b, an 8 hour shift converts 10% of ^{88}Zr to ^{89}Zr
    - Few days of 'irradiation → HPGe overnight → irradiation' cycle

- This measurement is an opportunity to resolve any operational difficulties with a 1 mCi sample before coordinating the n_TOF 100 mCi sample.

- Also an opportunity to check purity and any unexpected hurdles.