U-238 neutron capture cross section measured with DANCE

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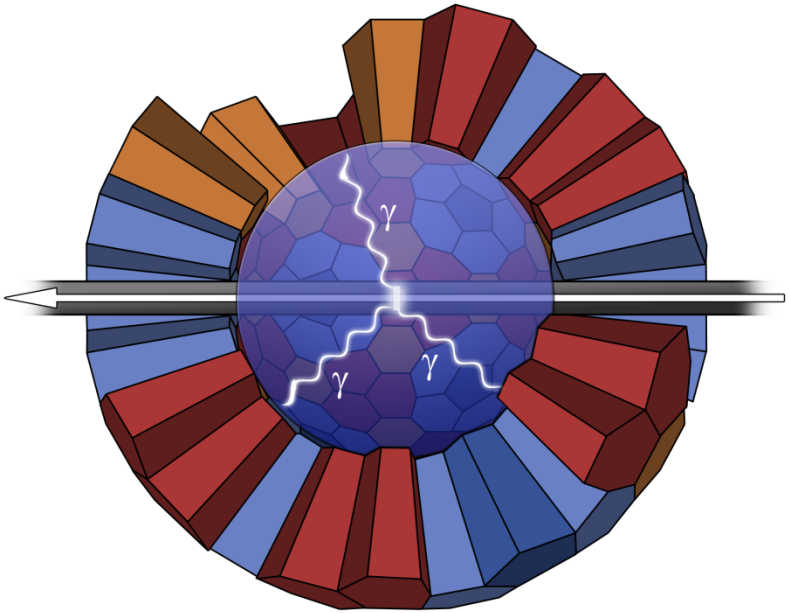
Introduction

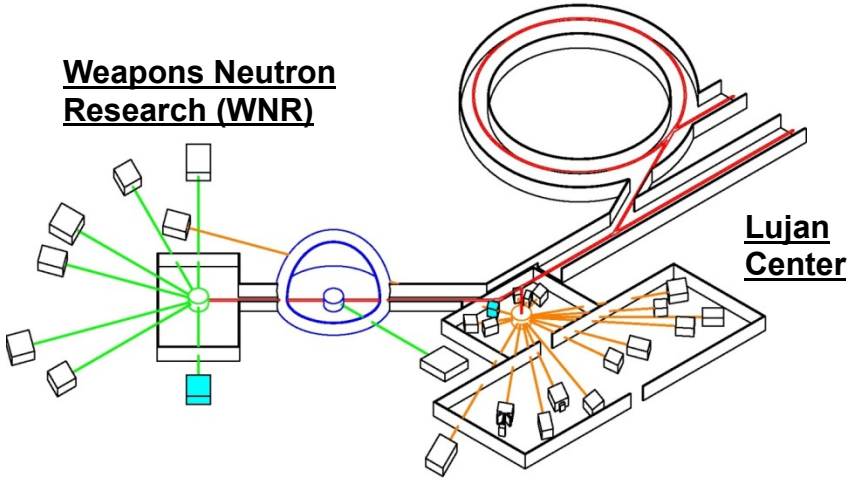
- New experiment intended to confirm U-238 neutron capture cross section in the unresolved resonance region from 1 to 500 keV
- Study of gamma ray cascades from capture and compared to theoretical predictions
- Measurement performed from 10 eV to 500 keV
- 48 ug/cm^2 depleted uranium target
- Cross section normalized to resonances around 100 keV

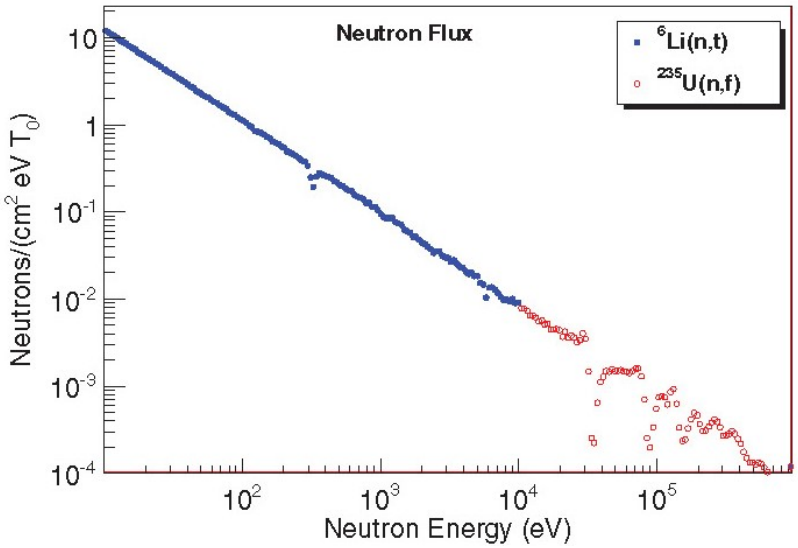
Detector for Advanced Neutron Capture Experiments (DANCE)

- 160 BaF2 crystals w/ 4 crystal geometries
- 320 channels of digital DAQ
- 85% Efficiency - calorimeter
- Radioactive / Rare targets (5 g target in January)
- γ-ray energy / multiplicity information for sophisticated data reduction
- Capture identified by unique Q-value
- ^{6}LiH sphere reduces scattered neutron background



DANCE is located at FP14 at Lujan Center

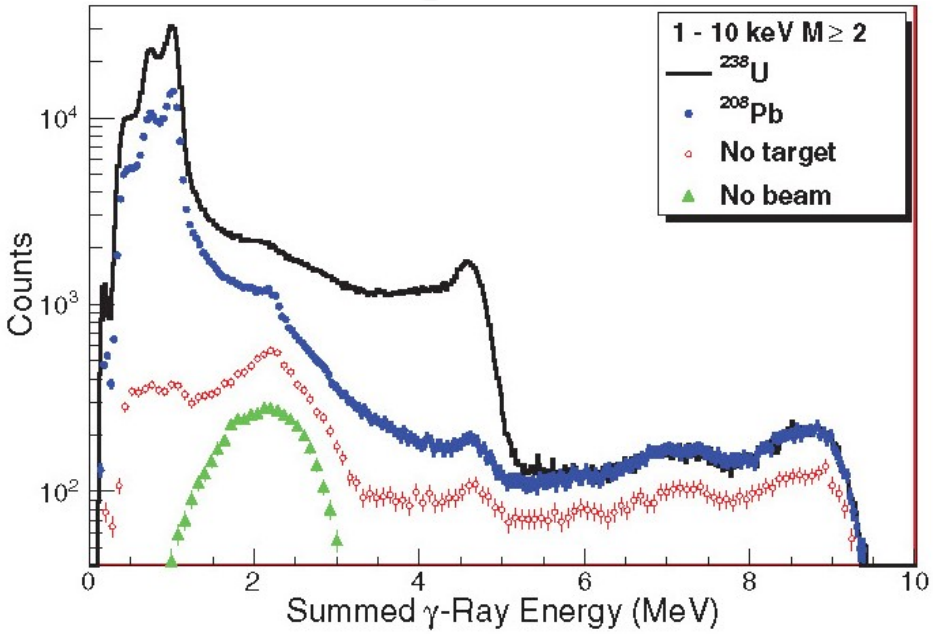




- DANCE sits 20 m from room-temperature water moderator at Lujan Center
- The neutron spectrum is soft, with low flux in the keV region
- Low intensity in the 1-500 keV region results in low statistics and low signal-to-background

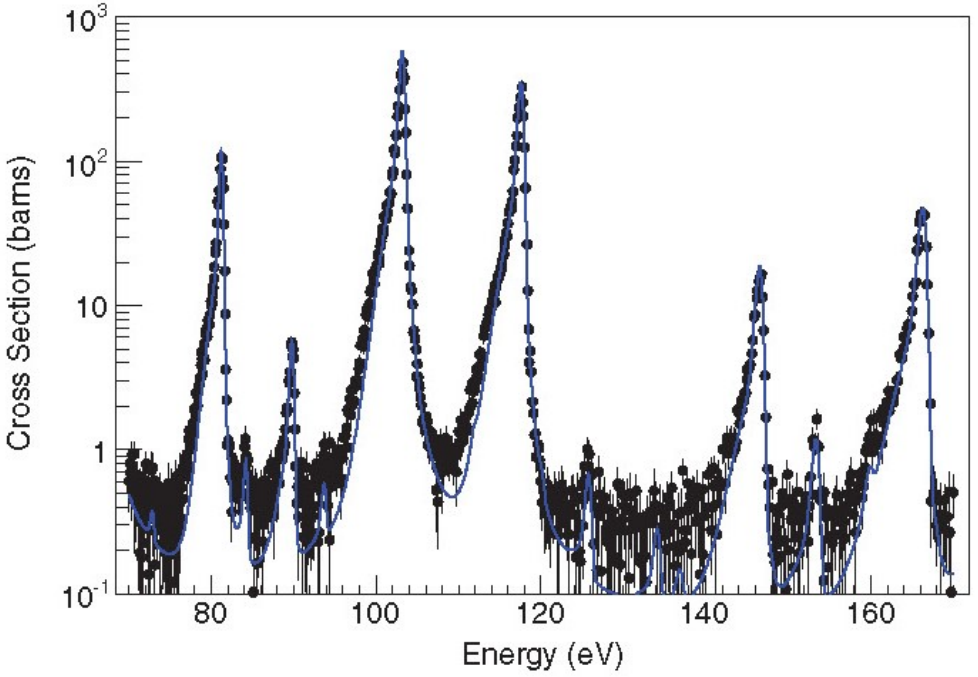
High precision measurement require accurate background subtraction

- Neutron background
  - Scattered neutrons:
    - Scatters on urnanium target
    - Major source of background
    - Effect measured with Pb-target (low (n,g) cross section)
  - Ambient neutrons
    - Present when shutter is opened
    - Measured with “sample out” runs
- Gamma background
  - Spalltion
  - Reactions in moderator (n+p)
  - Radon decay in BaF detectors



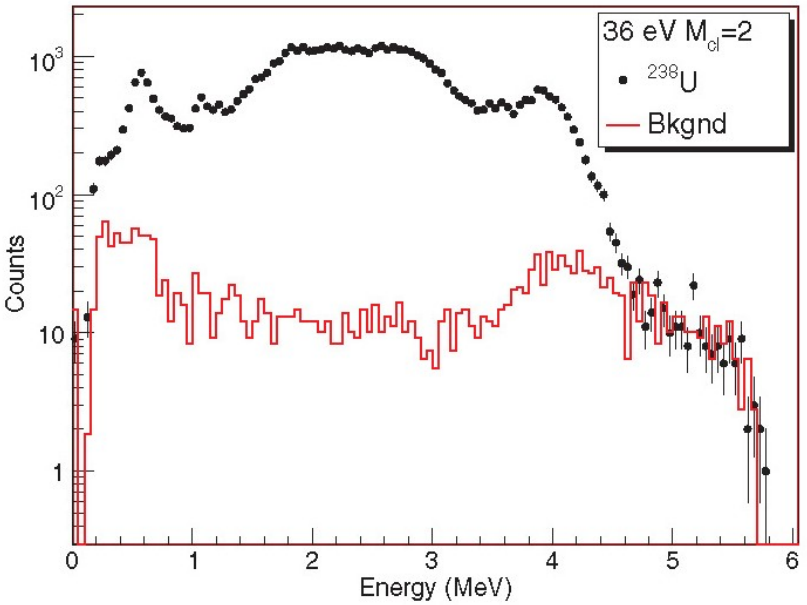
Cross section normalization

- Measurement includes resonance region down to 10 eV
- The resonance region has been extensively measured for U-238 and the evaluation is assumed to have low uncertainties for the resonance parameters
- Cross section normalization
  - ENDF/B-VII.1 resonance parameters
  - Normalize to resonance integrals
  - Takes into account self-attenuation and multiple scattering corrections (<1%)

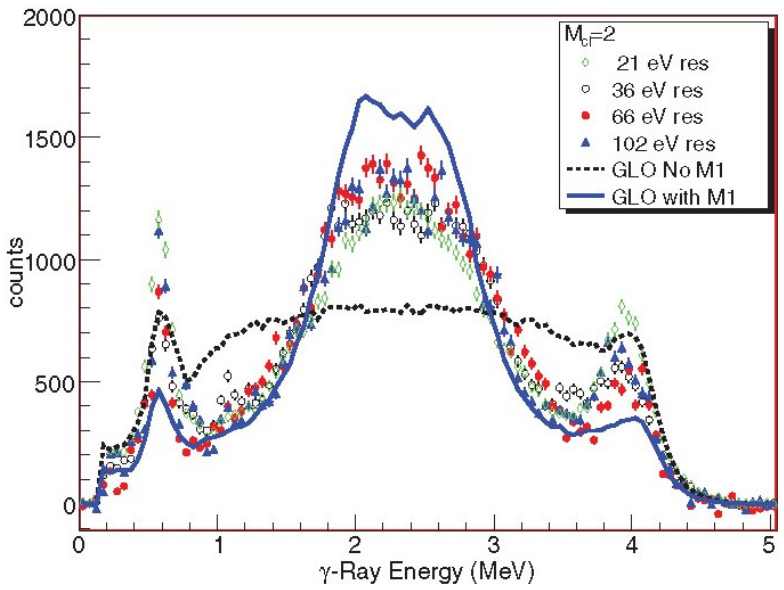


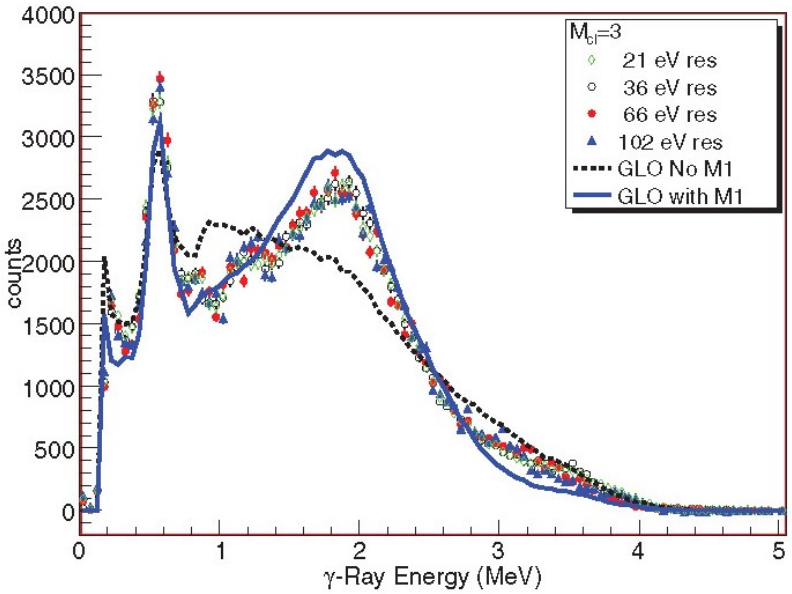
Gamma spectrum from capture was measured to compare with models

- Selected data in resonances where signal-to-background is high
- Gate of 4.2-5.5 MeV on total gamma ray energy
- DANCE response compared to DICEBOX calculations folded with MCNP calculation of detector response



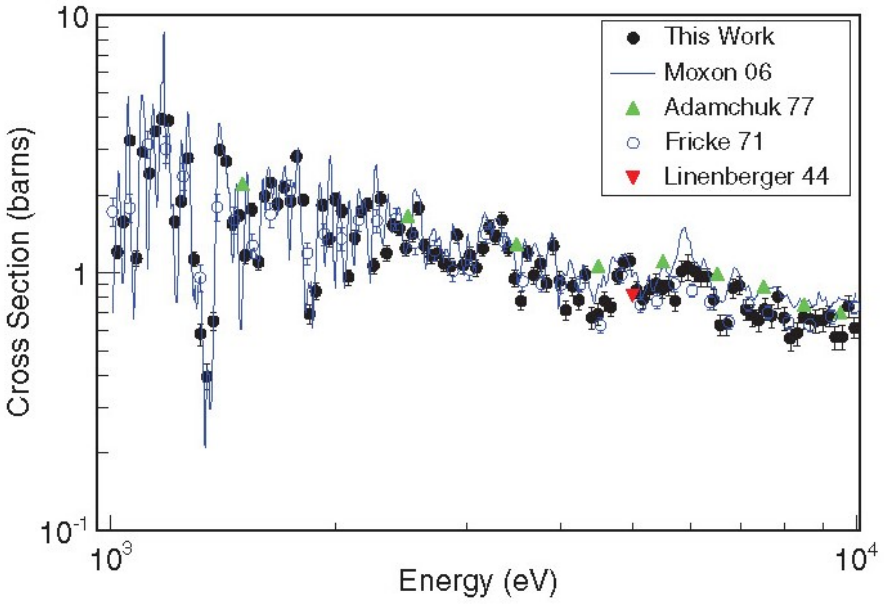
Calculated gamma-ray spectrum agrees well with measurements

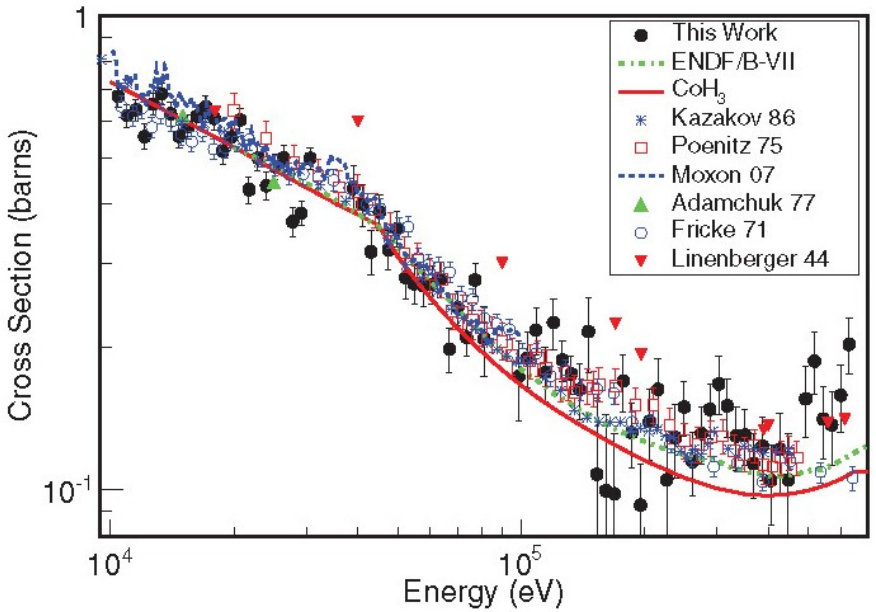




- The DICEBOX calculations reproduces the measured data when including M1 scissor mode strength

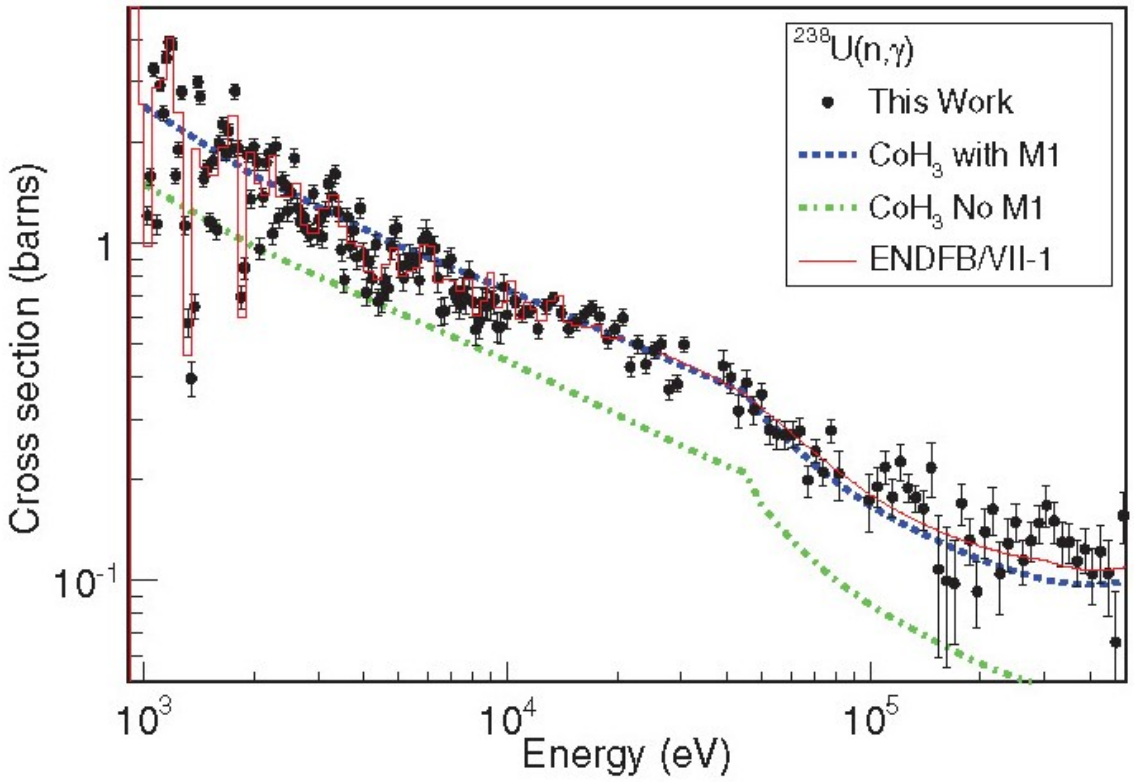
Cross section result





- DANCE measurement confirms current evaluation

Cross section result



Summary and outlook

- DANCE provide is a unique instrument for neutron capture measurements
- New technique for capture measurements of fissile isotopes significantly improves accuracy (see Bob Haight's presentation)
- Modifications to the Lujan Center target could significantly increase the neutron flux in the 1-500 keV region to improve accuracy. This would provide better data for nuclear astrophysics, defense and fast reactor systems