Neutron-induced reaction studies at the Los Alamos Neutron Science Center

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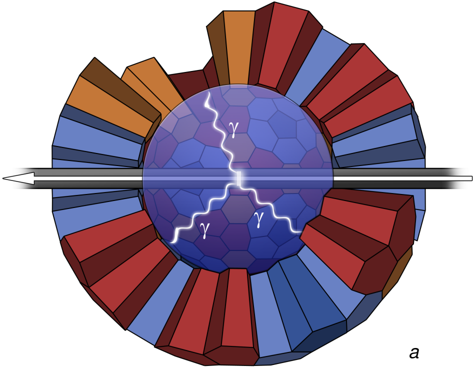
NSCL Special Seminar

A Detector for Advanced Neutron Capture Experiments

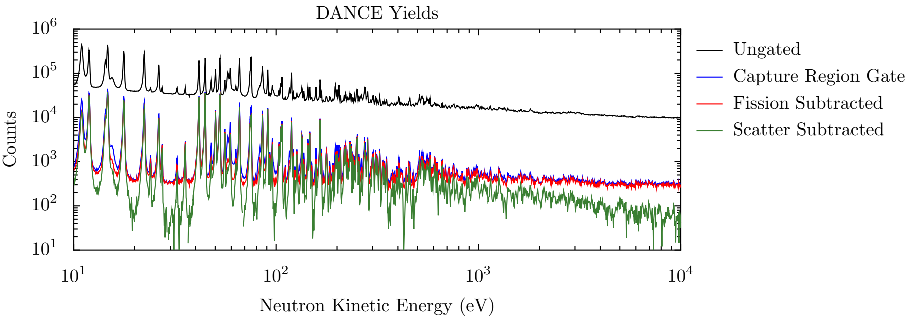
- 160 BaF_2 crystals w/ 4 crystal geometries
- 85% Efficiency - calorimeter
- 320 channels of digital DAQ
- Capable of high trigger rates: 250 kHz/ch or 1 MHz on array
- Radioactive / Rare targets (5 μg target in January)
- γ-ray energy / multiplicity information
- Capture identified by unique Q-value
- ^{6}LiH sphere reduces scattered neutron background

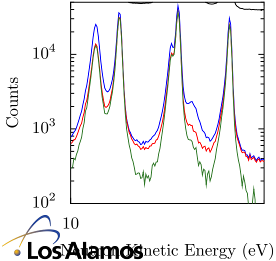


[a]

[a]M. Weigand, 2013

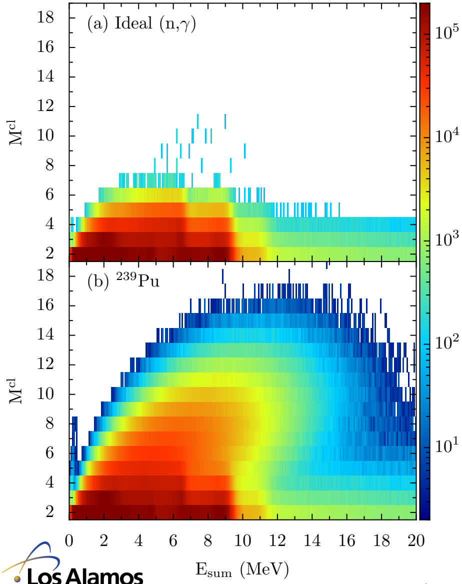
Data Analysis Overview

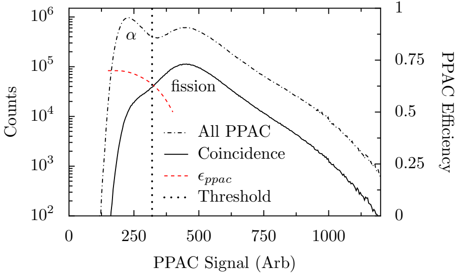




- Fission produces unwanted signals in DANCE
- Scattered neutrons moderate in DANCE crystals, produce light
- Primary challenge for this analysis: appropriately characterize, subtract off these backgrounds
- Old experiments provide limited disentanglement

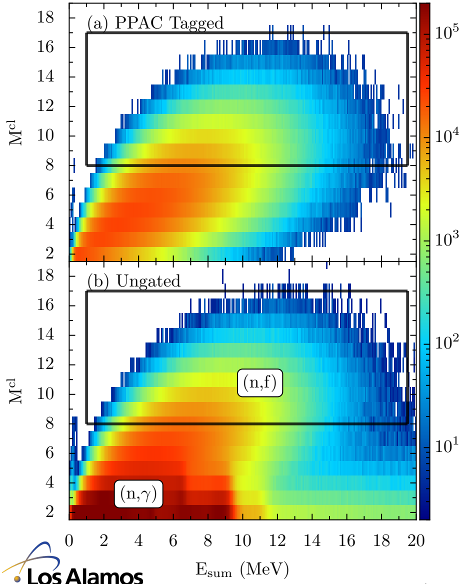
Prompt Fission γ-ray Background / PPAC

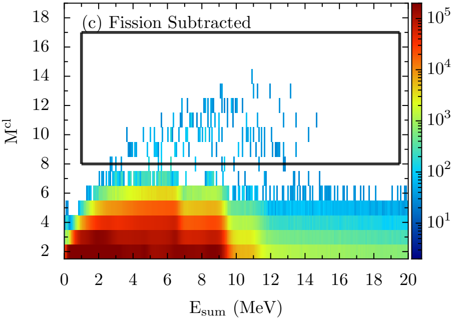




- Ideal (n,γ) spectrum occupies low multiplicity region
- ^{239}Pu γ spectrum contaminated by fission
- PPAC: tag fission by charged particles
- PPAC coinc with DANCE improves confidence

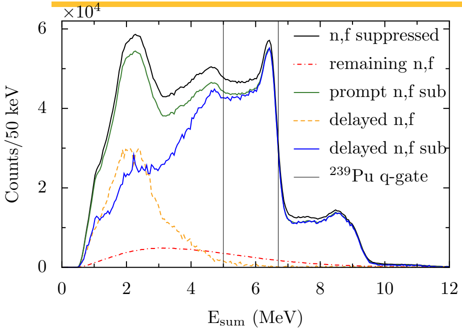
Prompt Fission γ-ray Background Subtraction

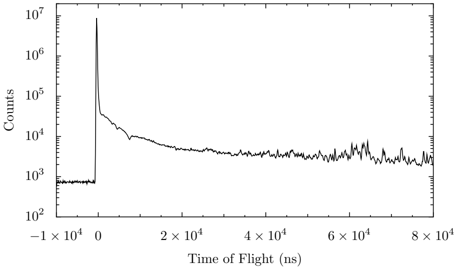




- PPAC / DANCE coincidences define fission γ-ray profile
- Only fission contributes to high M^{cl}/E_{sum} (boxed) region
- Normalize fission surface to data in boxed region and subtract

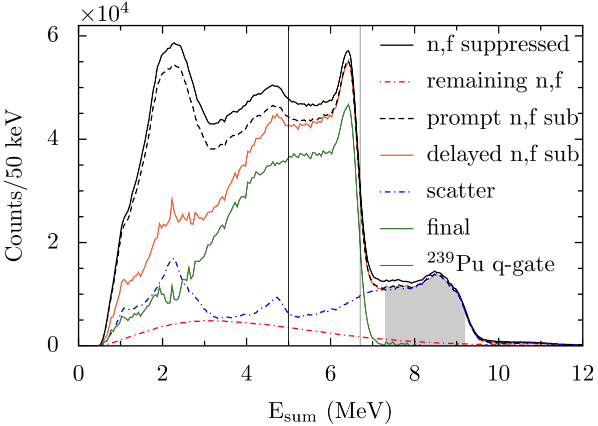
Delayed Fission γ-ray Background Subtraction





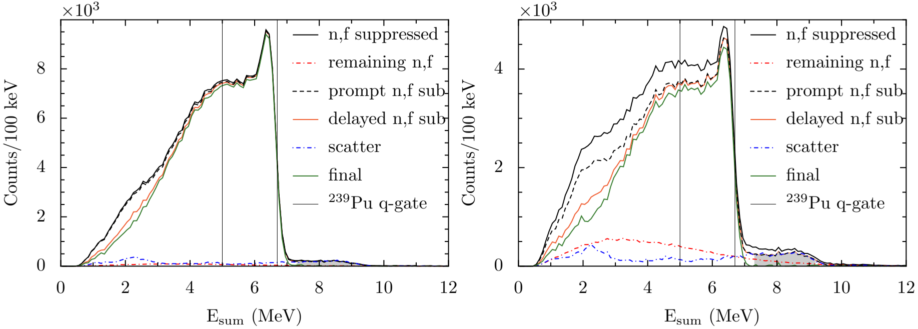
- Long lived fission products grow in and cause background that is constant in time
- “Look-back window” lets us see events prior to beam T0
- Background environment thus characterized - dominates spectrum below 3 MeV

Scattered Background



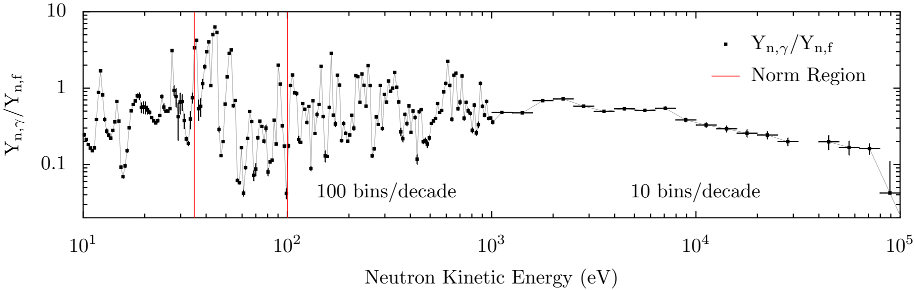
- Data taken with blank PPAC taken (no ^{239}Pu) to characterize scattering background - method depends on calorimetry
- Characterized as function of energy, normalized in high E_{sum} region
- Calorimetry allows gate on ^{239}Pu(n,γ) Q-value to select capture events

Subtraction Results On Resonance



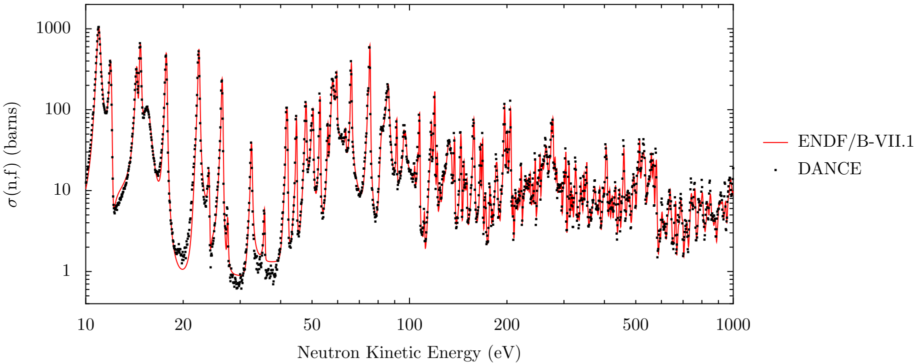
- On resolved resonances, backgrounds are fairly small but can change significantly
- Background subtraction as function of energy **important**

Cross Section Calculation



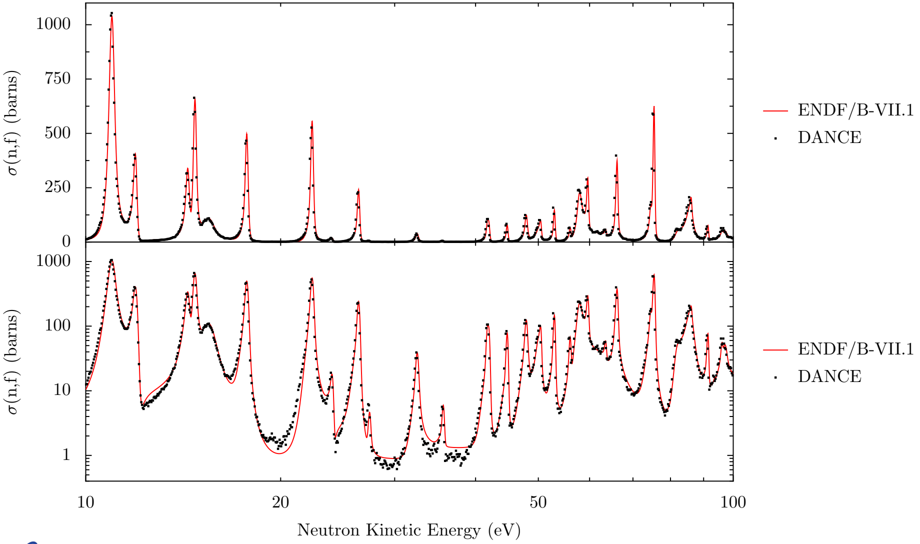
- $\sigma(\mathrm{n},\gamma) = A_{\mathrm{n}\gamma}\sigma_{\mathrm{n}f}\frac{Y_{cap}}{Y_{\mathrm{n,f}}}$ (ratio to fission measurement)
- $A_{\mathrm{n}\gamma} = \frac{I_{n\gamma}}{I_{nf}}\frac{Y_{integral\ \mathrm{n,f}}}{Y_{integral\ \mathrm{n},\gamma}}$ (scaling factor from ENDF integral cross sections)
- Signal/Background limits the 1 mg sample dataset to 1 keV
- Target Mass $\sim$ count rate - put 50 mg sample in Spring 2013

Fission Cross Section Tests

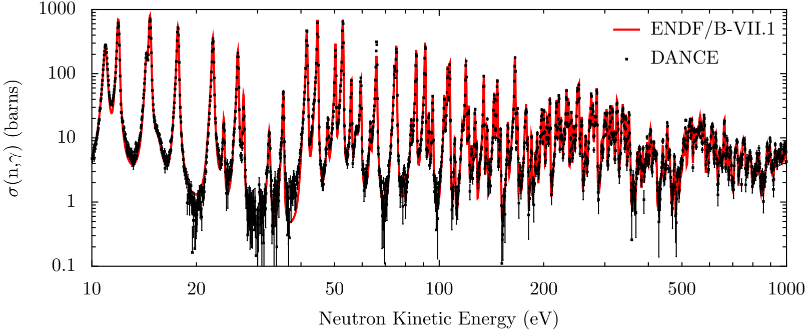


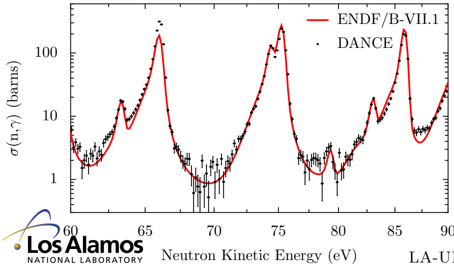
- Comparison to fission cross section serves as a check
- Good agreement with evaluations lends confidence to analysis

Fission 10 - 100 eV



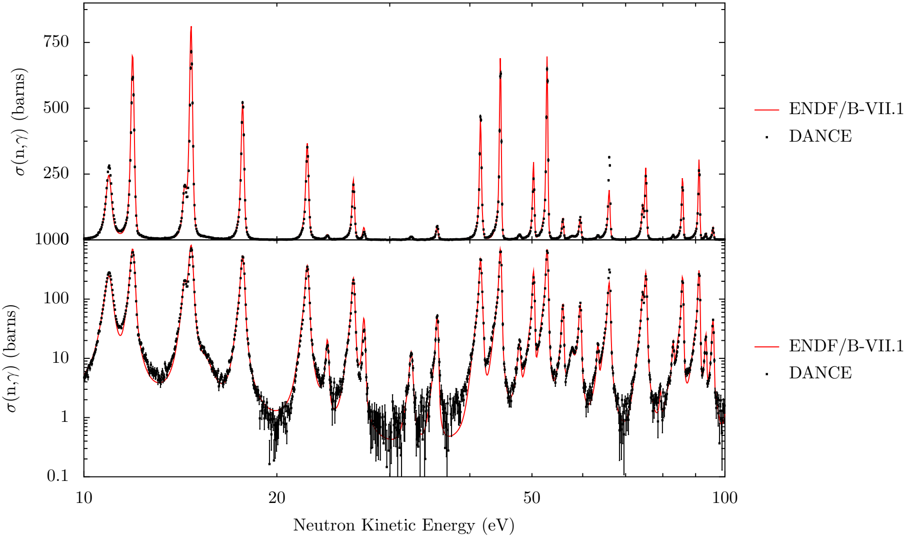
1 mg Sample Results



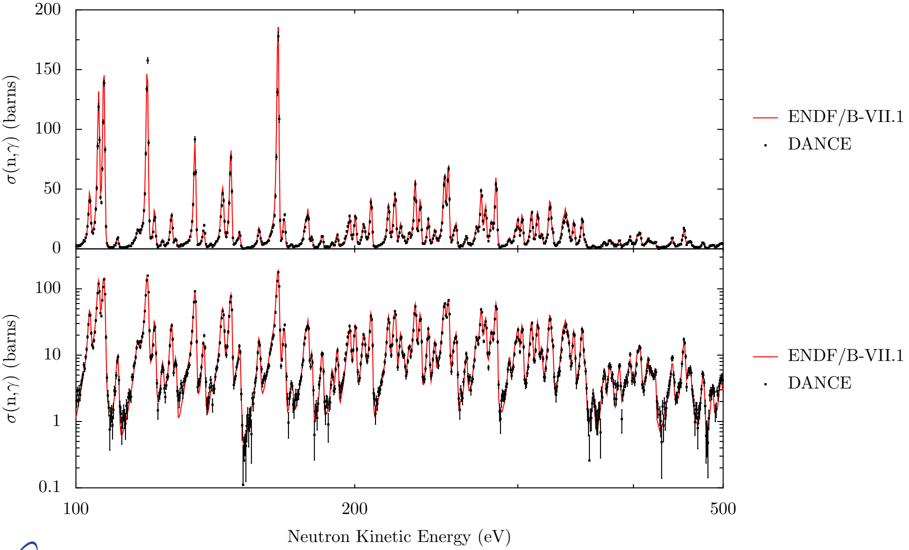


- Overall structure is similar to existing evaluation
- Individual resonance parameters appear to be different in some cases
- S. Mosby *et al*, PRC 89, 034610 (2014)

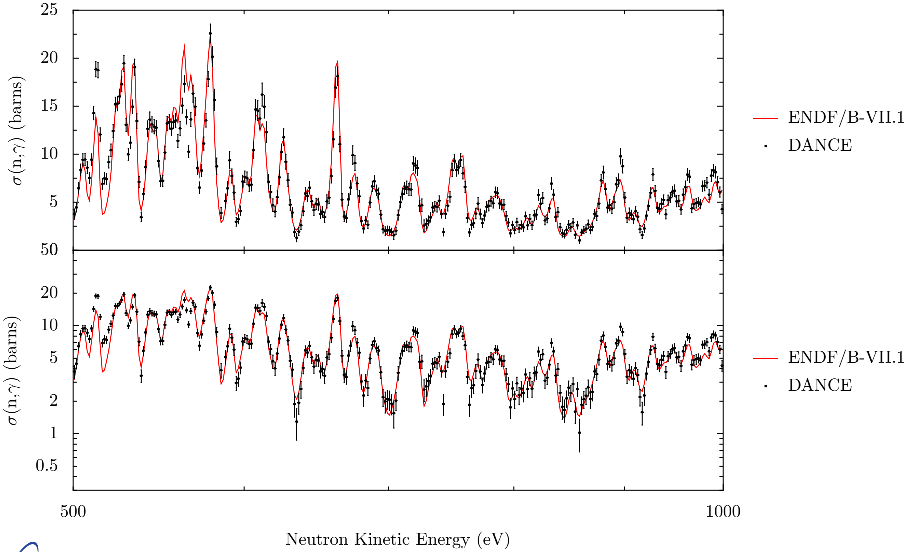
Capture 10 - 100 eV



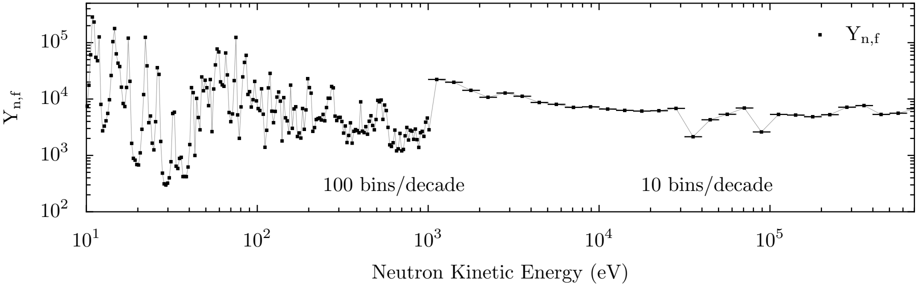
Capture 100 - 500 eV

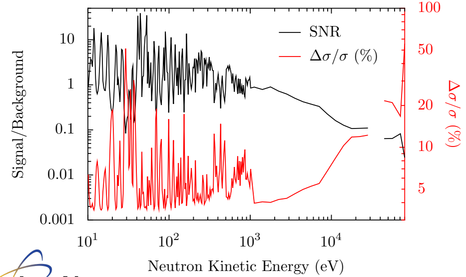


Capture 500 - 1000 eV



Extension to Higher Energies





- ^{239}Pu(n,f) PPAC coinc data extend to much higher energy than statistics-limited (n,γ)
- Thick sample precludes use of PPAC - different treatment
- (n,f) γ lineshape is known from thin-sample PPAC coinc and can be used for subtraction

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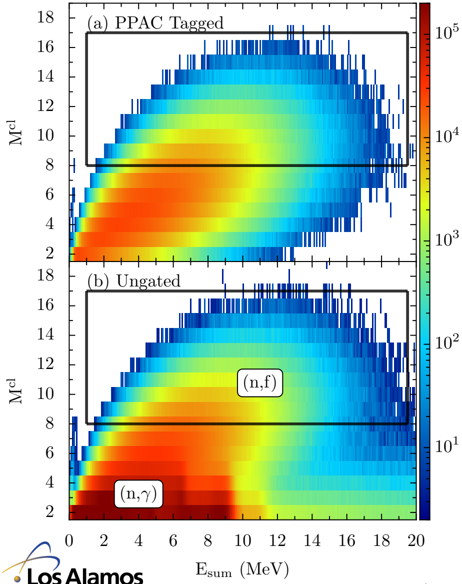
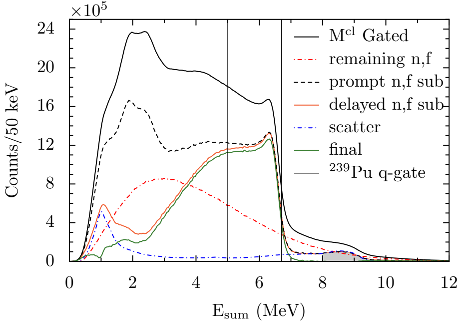
Thick Target (n,f) Treatment



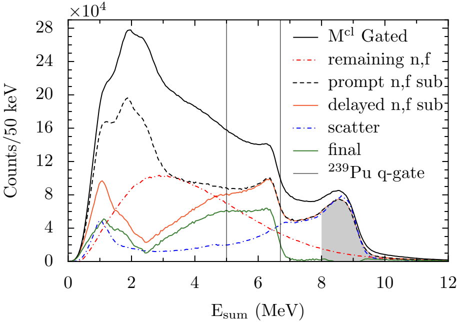
- High M^{cl} region only has (n,f)
- With (n,f) lineshape known from present data, thick-target background can be calculated as $N_{fis} = \epsilon_{fis} Y_{mcl>8}$
- ϵ_{fis} is "fission efficiency" scaling factor from high M^{cl} region to Q-value gate

Background at High Neutron Energy

NKE 200 eV - 10 keV

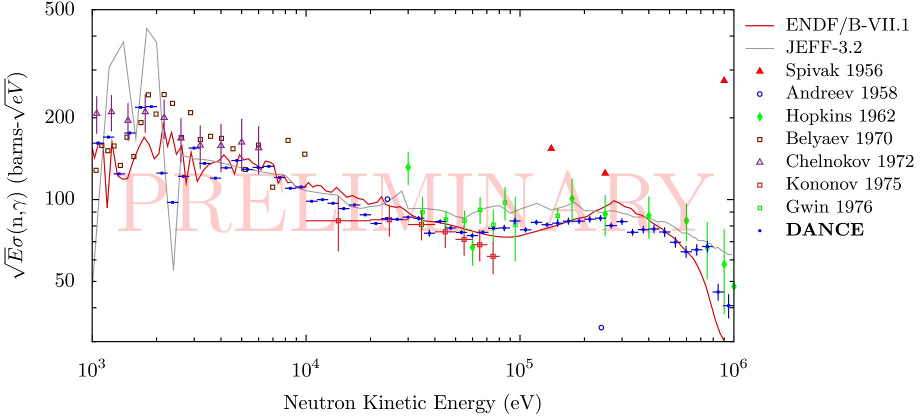


NKE 10 keV - 100 keV



- Signal-to-noise crosses through 1 in 10 keV - 100 keV energy decade
- Fission is dominant background - **absolutely critical** to get this right

Thick Target Preliminary Results



- Closer consistency with ENDF at highest energies
- Looking into details of the keV region

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