Nuclear Data Needs for the National Security Program

Mark B. Chadwick,
Nuclear Physics Group T-16, LANL

- Overview of some important future directions
- Focus on a few cases

Presented at the 2003 LANSCE workshop

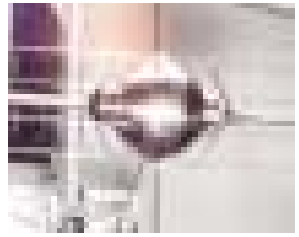
Summary overview of some future directions (1 of 2)

- **Nuclear reactions & nuclear reaction theory off stability**
  - **radchem chains**
  - **GEANIE (e.g. ^{193}Ir(n,n')^{193m}Ir, Y reactions, *etc*)**
  - **DANCE for neutron capture off stability**
  - **RIA: a major future facility**
  - **isomer physics (Hayes LDRD/DR)**
  - **light TN reactions**
  - **Chains of U, Pu, Np, Am isotope data**
- **New lumped fission product evaluation**
- **Fission cross sections**
  - **fission potential landscapes and barrier theory**
  - **synthesize fission model into Hauser-Feshbach code**
  - **new measurements needed**
- **Fission fragment physics & fission neutron spectra**
  - **FIGARO & new theoretical approach**

Summary overview of some future directions (2 of 2)

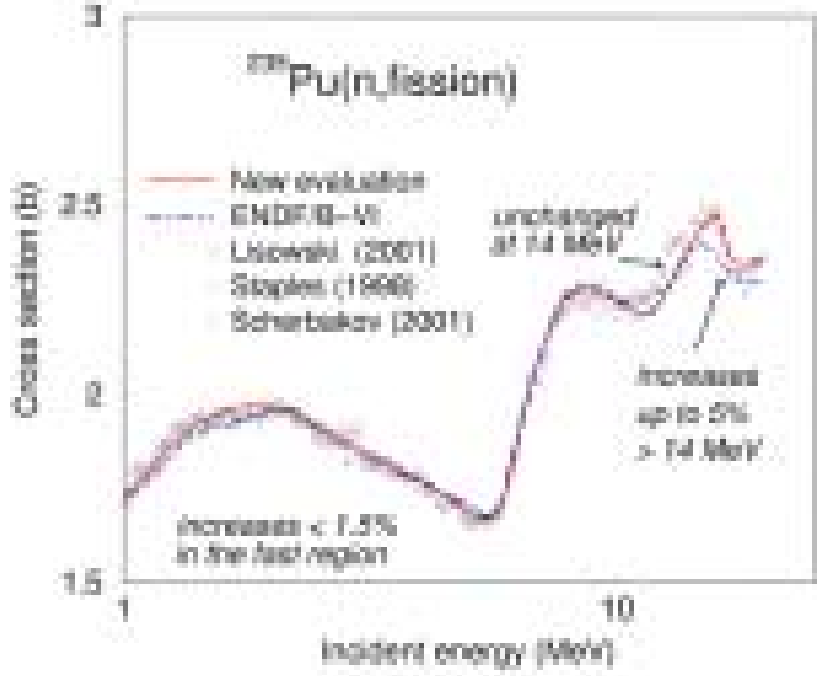
- Advanced nuclear reaction codes (McGNASH, EDA, NJOY)
  - New generation of codes involving enhanced models are being developed under ASC support
- Critical assemblies, alpha, reactivity
  - important for data testing
  - delayed neutrons (+ photofission SNM detection)
- Uncertainty Quantification
  - Evaluations of covariance uncertainty data needed
  - Work with X-5 to develop technology & identify test cases
- Data processing advances
  - NJOY remains the world's standard
  - work with X-5's NDI component for ASC and legacy codes
- Crucial feedback from X-2, X-4, X-5 on nuclear data
  - use in ASC, e.g. Dec '03 primary burn (Shevano/Blanca)
  - use in W88, W76, W78, W80, B61 certification

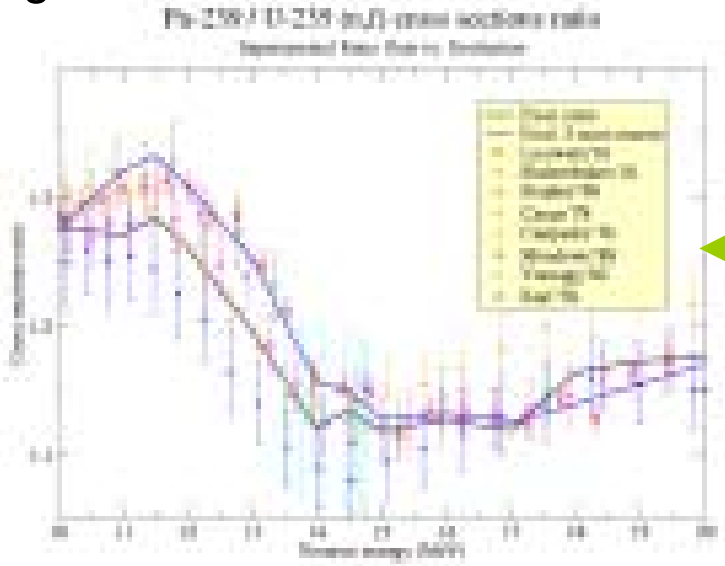
^{239}Pu fission cross section: More work may be needed



New evaluation completed

- Bayesian generalized least-squares analysis of measurements, including 3 recent experiments
- increase in (n,f) at fast energies (and Jezebel now modeled v. well)
- (n,f) unchanged in the10-14 MeV region





But, new measurement may be needed

- 3 most recent measurements 3-5% higher in the 10-14 MeV region
- Careful study of uncertainties in older, & recent, data is needed

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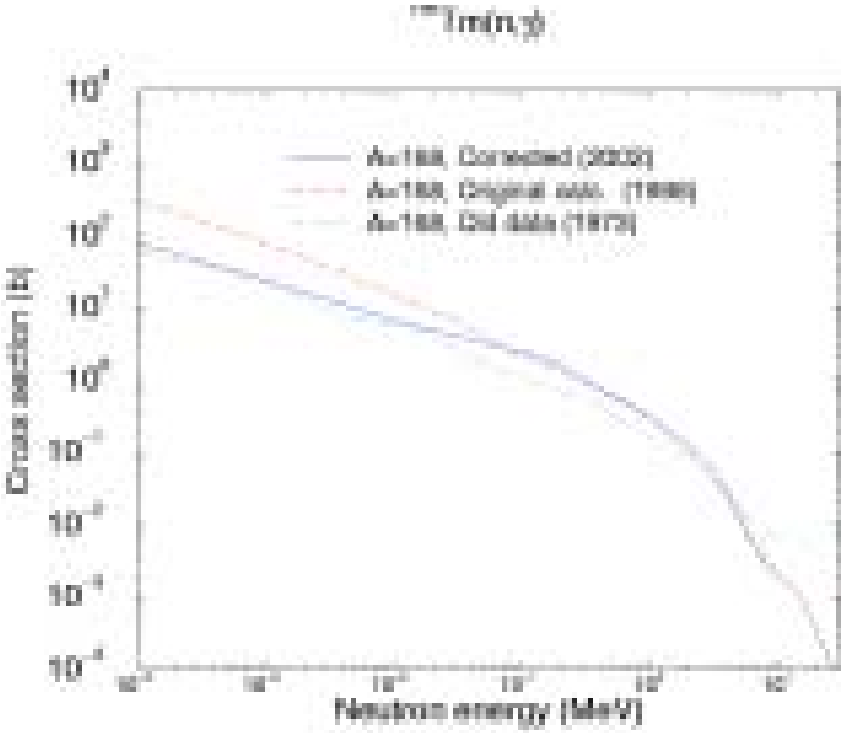
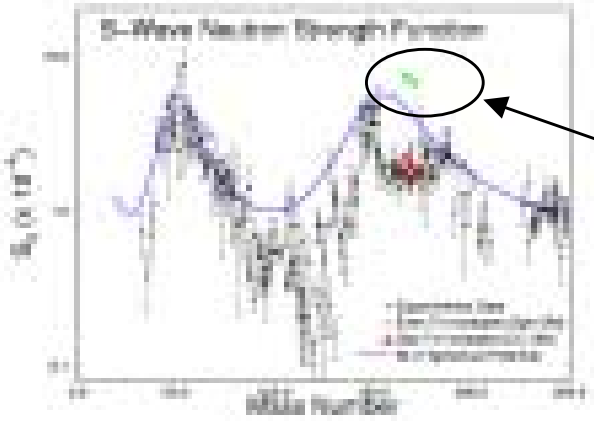
Thulium $^{166\text{-}174}$Tm isotopes evaluated for radchem: Even A isotopes recently recalculated accurately

166 167 168 169 170 171 172 173 174

- ^{169}Tm & odd-A Tm used deformed optical model (coupled-channel calculation)
- Our original even-A calculations didn't properly account for deformation
- Becker's X-2 simulations discovered this
- Our subsequent study of s-wave strength functions verified this problem





This problem is now fixed
X-5 and X-2, T-6, working with us

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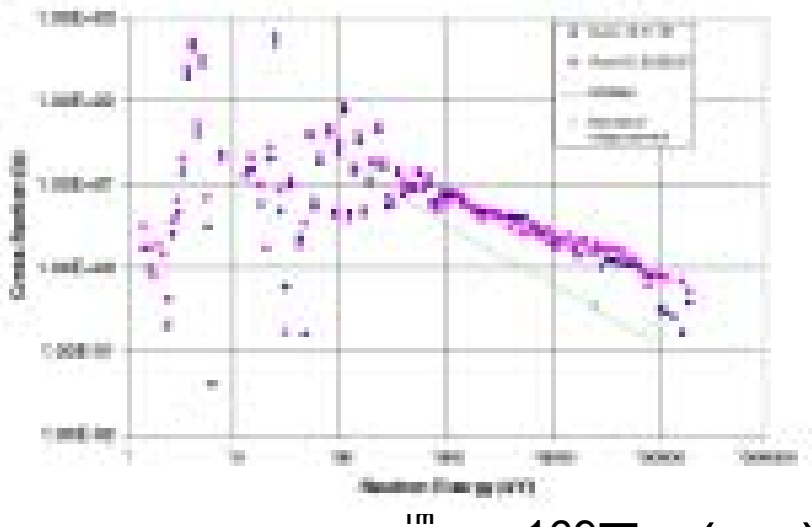
Thulium ^{171}Tm(n,γ) questions: DANCE will make vital contributions

- ^{171}Tm(n,γ) studied in T-16 & predicted by GNASH calculations
- Subsequent LANSCE data were higher
- Subsequent integral Karlsruhe data by Kappeler consistent with GNASH

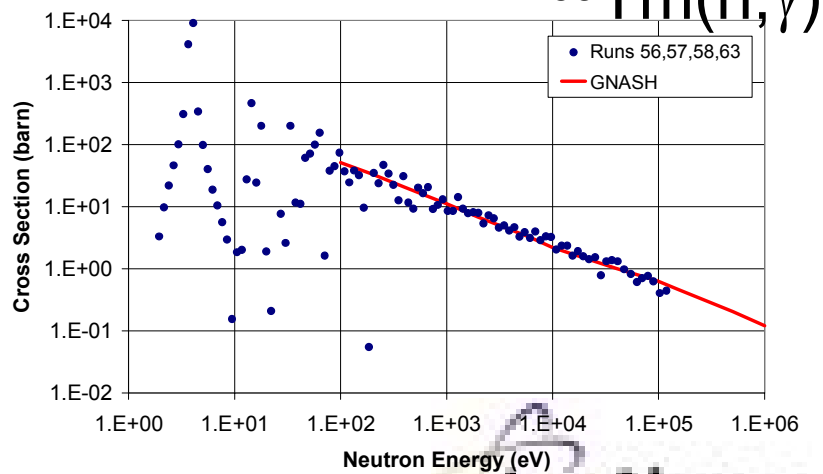
New DANSCE data Will be crucial

Future ^{170}Tm(n,γ) DANCE measurement also desirable!

^{171}Tm(n,γ)

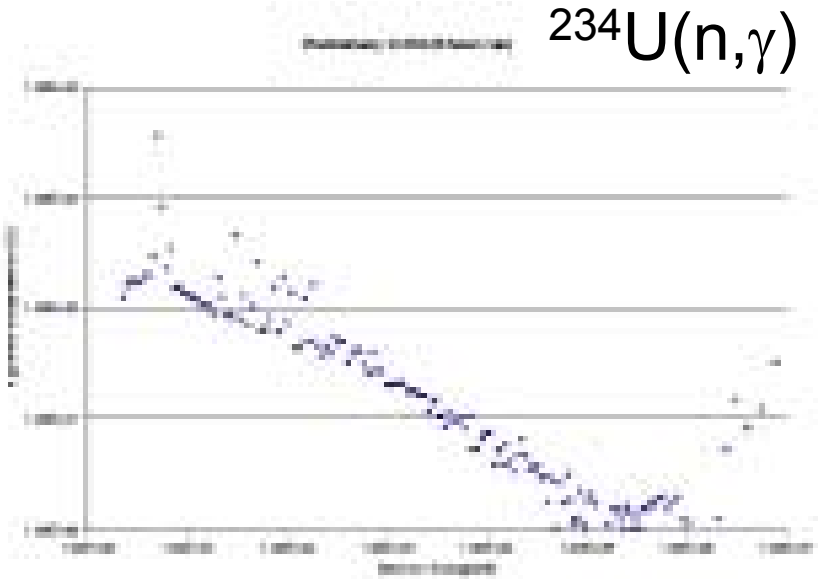


^{169}Tm(n,γ)



Uranium chain $^{232\text{-}241}$U evaluations: High-fidelity ASC modeling

- We are close to completing a new set of 11 uranium evaluations
- Feedback from X-2, X-5 crucial
- Capture measurements from LANSCE and C vital for our work (also applications in “Attribution”)



Preliminary LANSCE/C data using C_6D_6 detectors, Rundberg & Ulmann

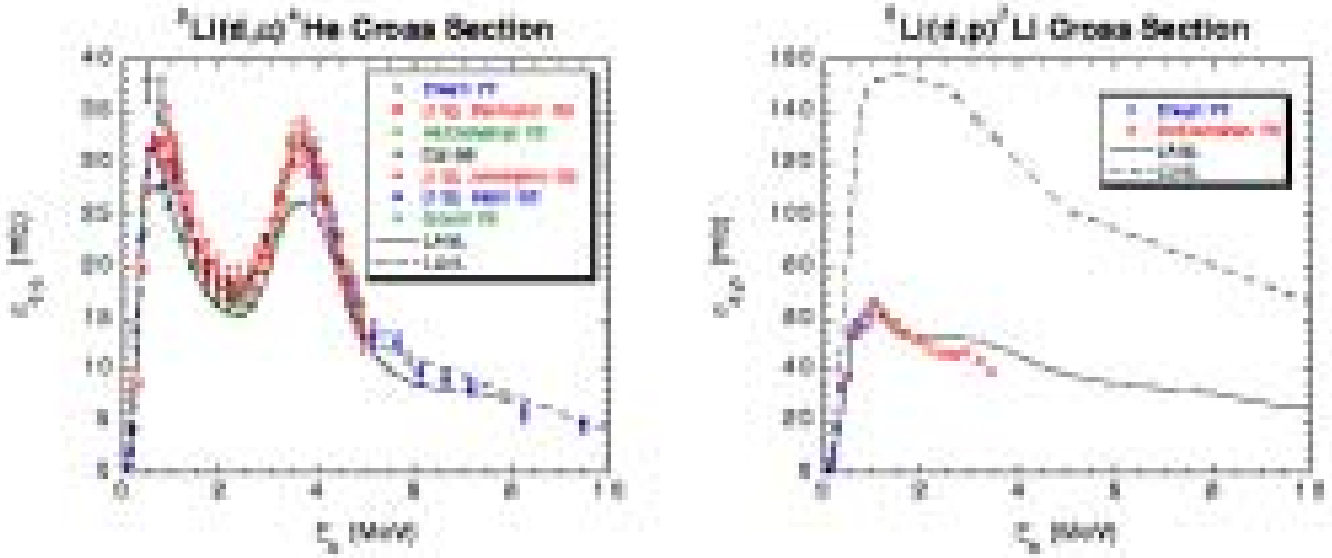
Status and outlook for TN data

- Data for A<8 generally in good shape from phenomenological R-matrix studies
- Data for A≥8 need more work, including:

- Extension of R-matrix analyses to higher energies

- Microscopic scattering calculations using GFMC, shell model, RGM, possibly within the framework of R-matrix theory

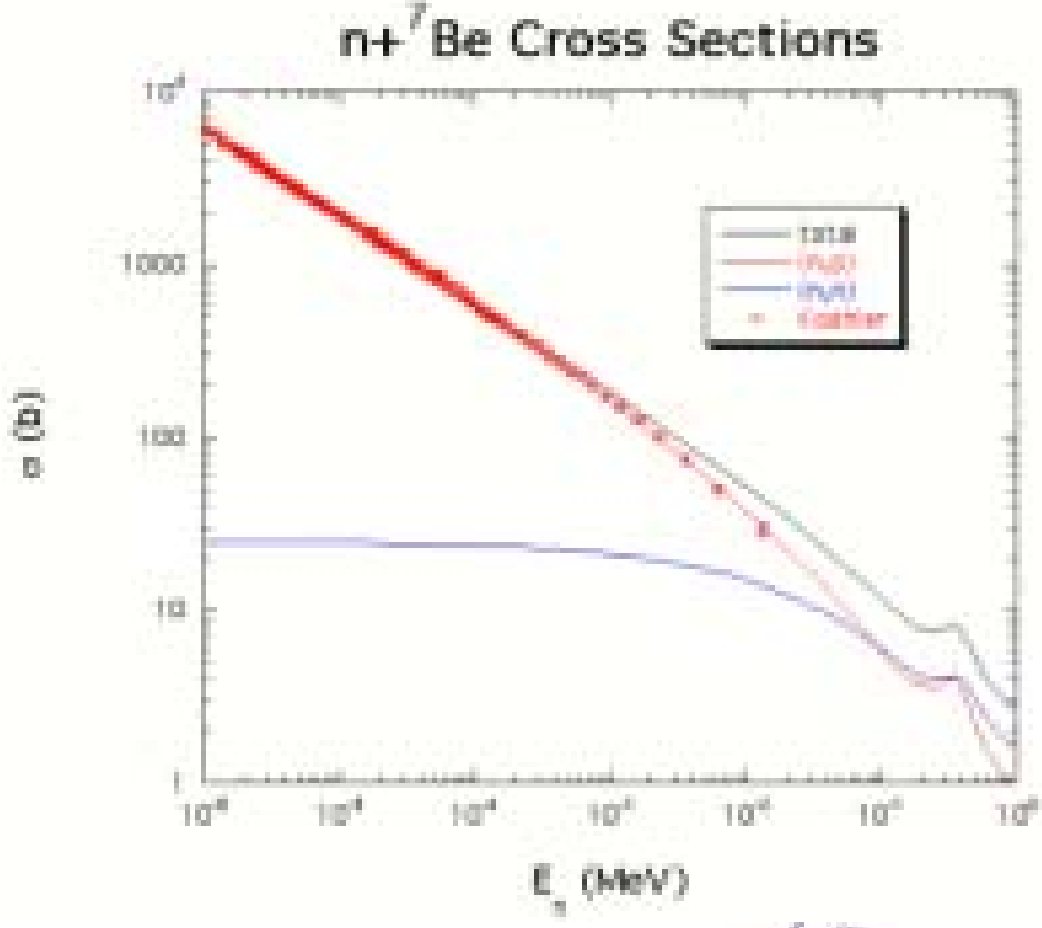
Thermonuclear reactions in ^{8}Be system ($n+^{7}Be$, $d+^{6}Li$):
Resolve discrepancies and perform enhanced R-matrix study



- We are searching for a complete set of exp. data
- Attempting to resolve discrepancies in data sets
- Undertaking a new R-matrix analysis, to higher energies

n+^{7}Be results from ^{8}Be analysis

- Measurements are for (n,p) and (p,n) reactions
- Predictions for (n,n) are Based on (p,p) data



Fission Fragment Hauser-Feshbach Monte Carlo

+ Grand-challenge to model neutron reactions on all FP

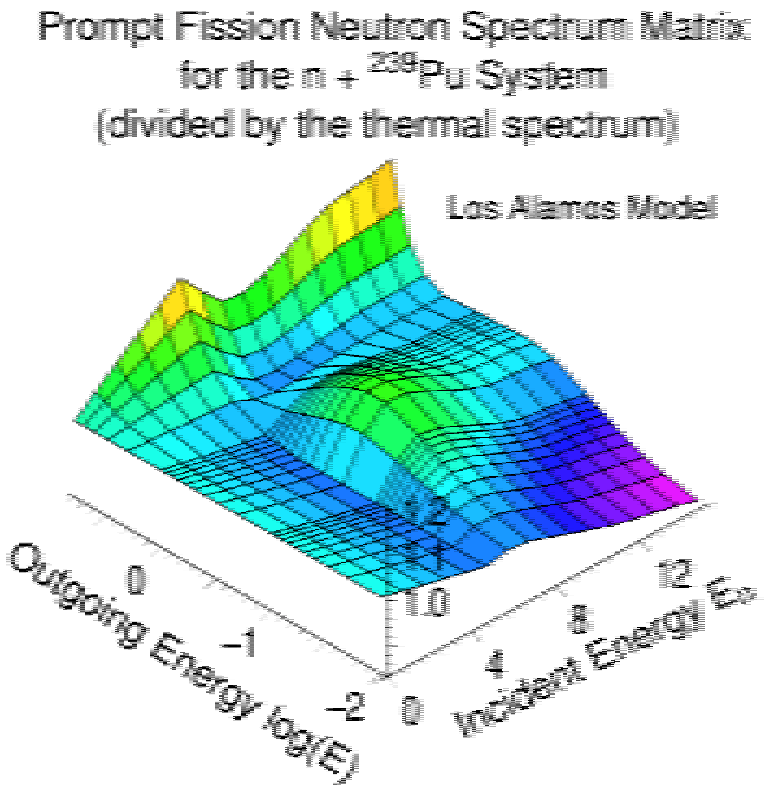
Fission fragments (upgrade of Los Alamos model)

- Use Hauser-Feshbach Monte Carlo methods
- Obtain detailed representations of:
  - Z, A distributions
  - kinetic energy distributions
  - neutron multiplicities, P(ν)
    (Homeland Security users)
  - prompt gammas obtained

Fission products as targets

- New evaluation urgently needed
- Model all possible n+FP reactions
- DANCE measurements needed

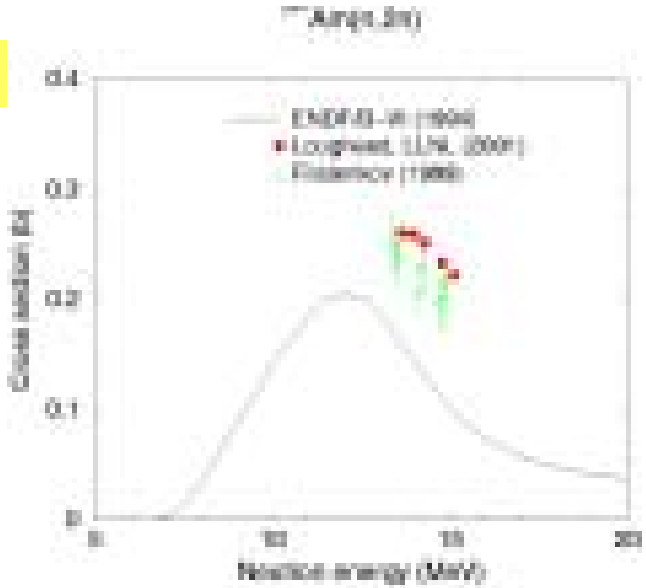
Prompt fission neutrons



^{241}Am ENDF data need to be improved

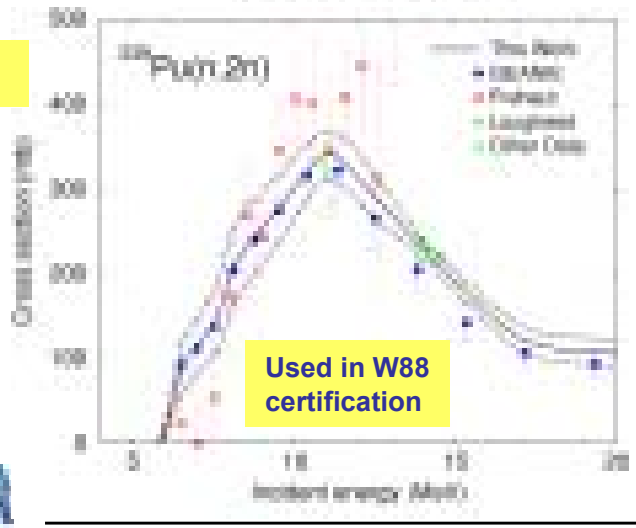
Integration of new experiments and theory

^{241}Am(n,2n)



- Existing ENDF data deficient (recently measured data available)
- Primary diagnostics
- Impacts isotopics for forensics
- New evaluation & model calc. needed
- Users in X-2 (MacInnes) and C
- Build on ^{239}Pu(n2n) experience (below)

^{239}Pu(n,2n)



- Successfully determined recently
- Primary diagnostics
- LANL-LLNL collaboration
- Theory & experiment important

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