Covariance Evaluation Work at LANL

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Introduction

Covariance Evaluations for ENDF/B-VI (V) at LANL

- GLUCS analysis for cross sections
  - full covariance data are given for ^{7}Li by Young
- Standards (R-matrix analysis)
  - light elements and their covariances for standards by Hale
- Covariance data processing capability in NJOY
- etc.

Covariance Evaluations for JENDL-3.2 and 3.3

- Covariance evaluation methodology developed at Kyushu, JAERI
  - least-squares fitting code SOK, Bayesian method KALMAN
- Sensitivity analysis, tools developed at JNC, JAERI, SAE
  - Reich-Moore R-Matrix, χ and P_1 covariances processing, ERRORJ
- JENDL-3.2 Covariance File (Shibata et al.)

Recent Development, Overview

Covariance Evaluations for ENDF/B-VII at LANL

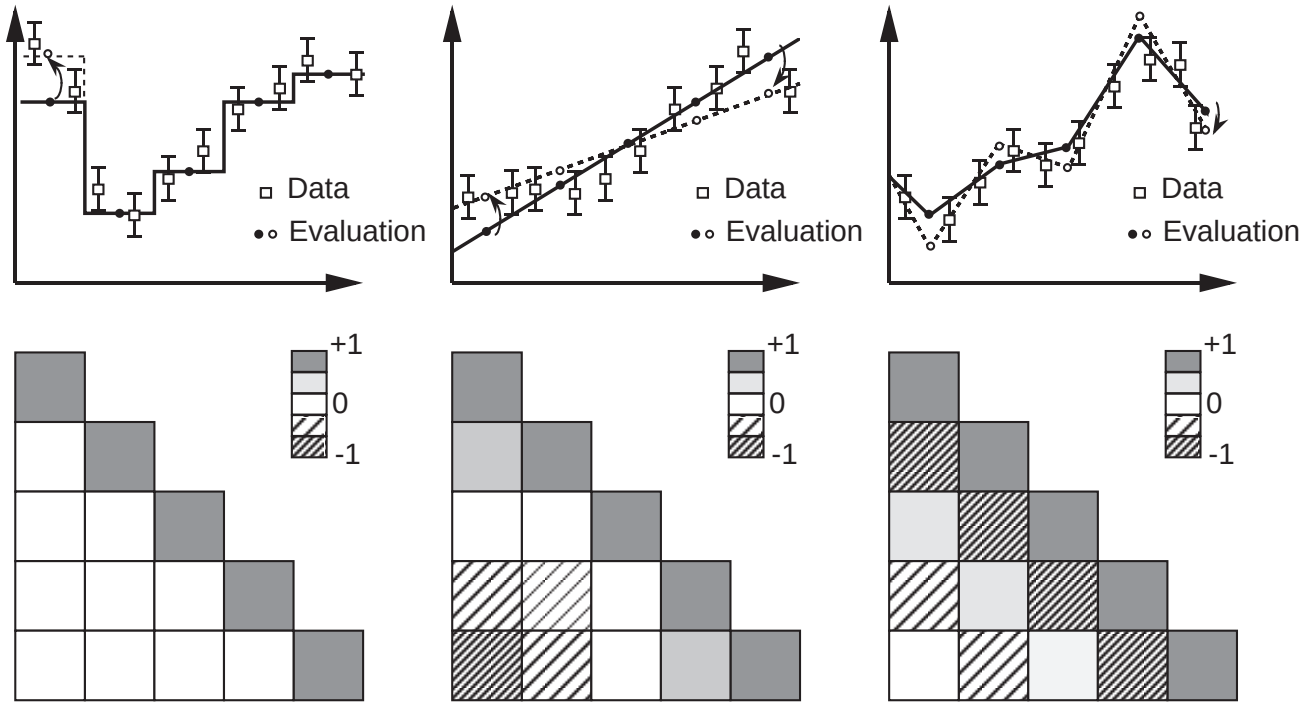
- KALMAN-GNASH calculations or GLUCS, SOK least-squares fitting
- GLUCS analysis for ^{239}Pu by Talou (ND2001)
- Covariances for actinides ^{233}U, ^{235}U, ^{238} and ^{239}Pu (ND2007 paper by Talou)
  - almost consistent with the cross section evaluations
- Standards evaluation included (IAEA CRP, LANL contributed)
  - some light elements, and fission of ^{235}U and ^{238}U
  - R-matrix analysis; talk by Hale
- χ evaluation under way by Talou
- ERRORJ became a part of NJOY package (Chiba visited LANL 2006)

LoFi Covariance under the DOE Criticality-Safety Program

- LANL provides data for minor actinides and light elements
- Very precise evaluation with R-matrix, but energy range and reactions limited
- Presentation by Little

Uncertainty Reduction by Interpolation

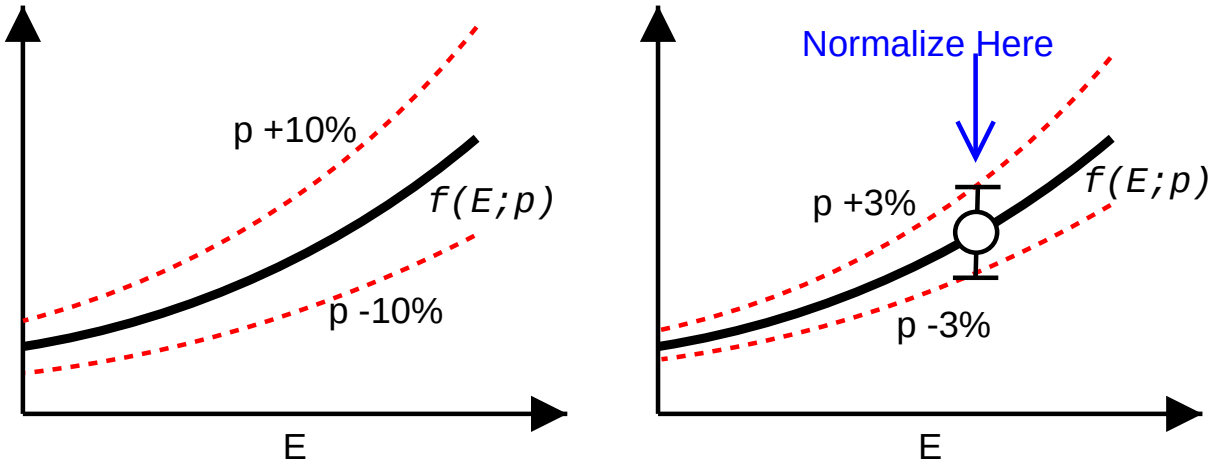
- Evaluated covariance depends on the interpolation method
  - 0-th order Spline — interval average
  - 1-st order Spline — data change smoothly like a linear function
  - functional forms — model calculation



The covariances are a consequence of error propagation from experimental data, however these are “collapsed” data by the fitting function adopted.

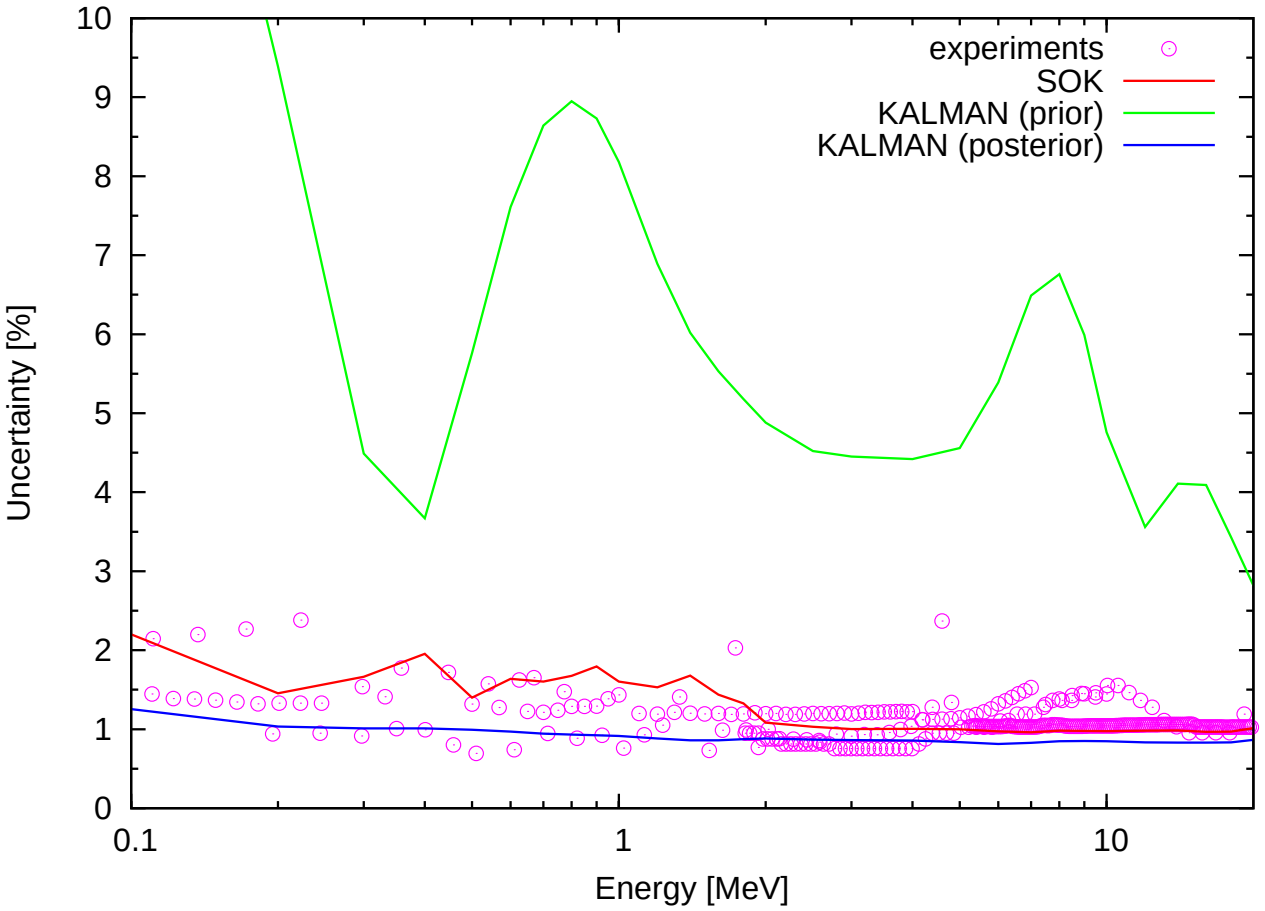
Model Parameters Fitting

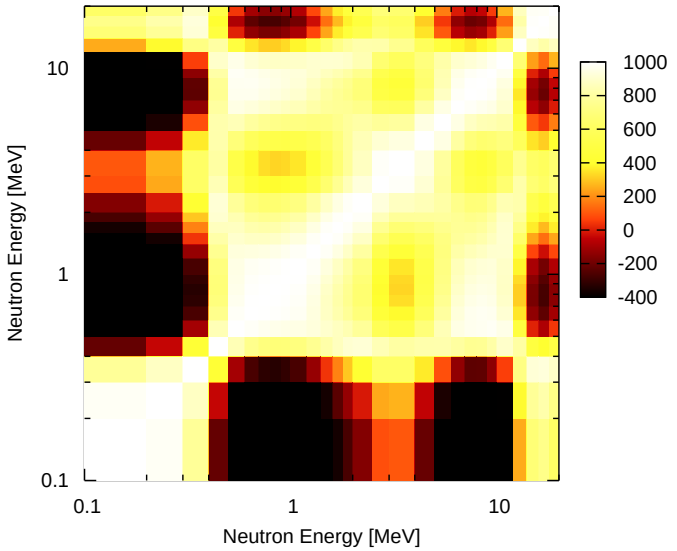
- Interpolation is made with some physical background
  - R-matrix, optical model, Hauser-Feshbach model, Madland-Nix etc.
- (*A Priori*) We know that the model describes all observable quantities well
  - uncertainties in the model calculation are ascribed to the model parameters — resonance parameters, optical model potentials, level densities, etc.
- Correlation exists even if experimental data are uncorrelated
  - the model tells us that a physical quantity varies continuously

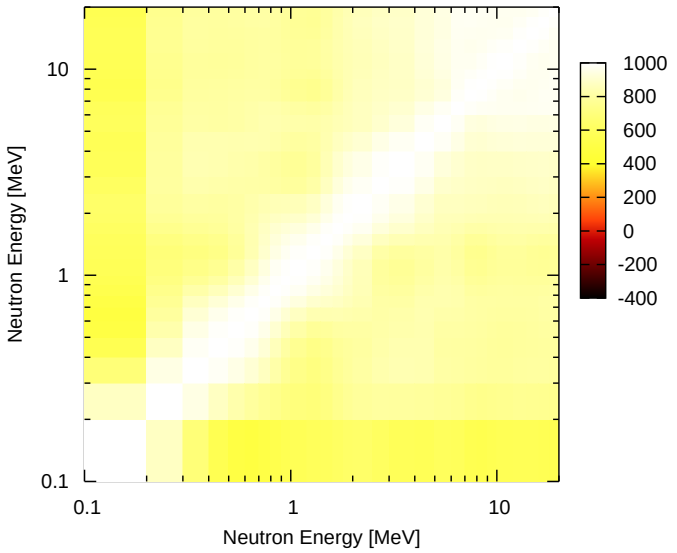


Example, KALMAN Calculation

Covariance for ^{232}Th total cross section







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Covariances for Actinides

Covariance Evaluation for Major Actinides

- Covariance evaluations for major U and Pu isotopes are consistent with the evaluation of cross sections for ENDF/B-VII
  - GNASH calculations performed for major actinides by Young et al.
  - sensitivity matrices are constructed by using the GNASH input data
  - CoH-KALMAN calculations: total and capture
  - GNASH-KALMAN calculations: (n,n'), (n,2n), (n,3n)
- Standards evaluation
  - covariances of fission cross sections
- Least-squares analysis (GLUCS, SOK)
  - for ν_p, a consistent set of data and covariance was obtained
  - covariances of fission, other than standards

LoFi Covariances for Minor Actinides

Covariance data for minor actinides from ^{225}Ac to ^{255}Fm were obtained with simplified methods; KALMAN calculations and simple guess-timates.

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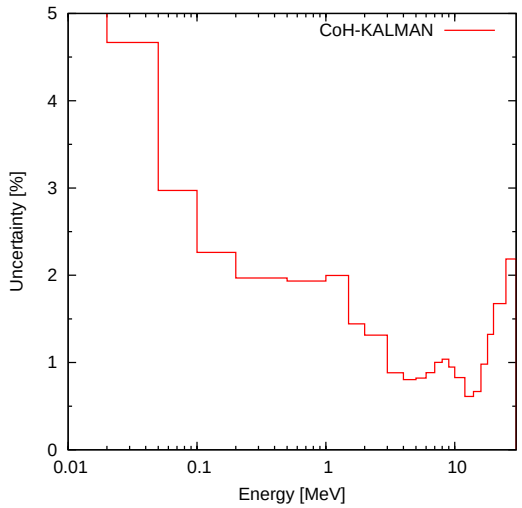
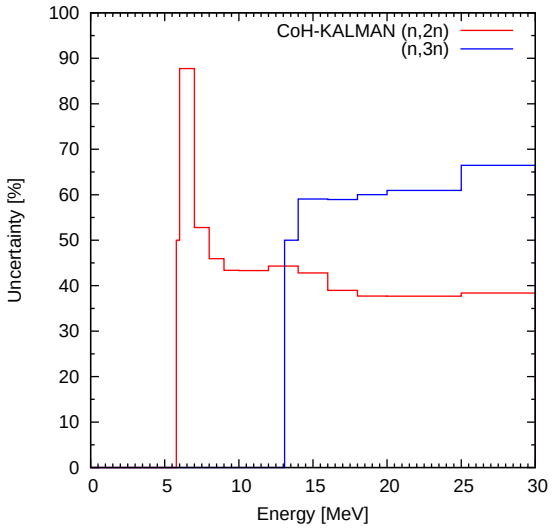
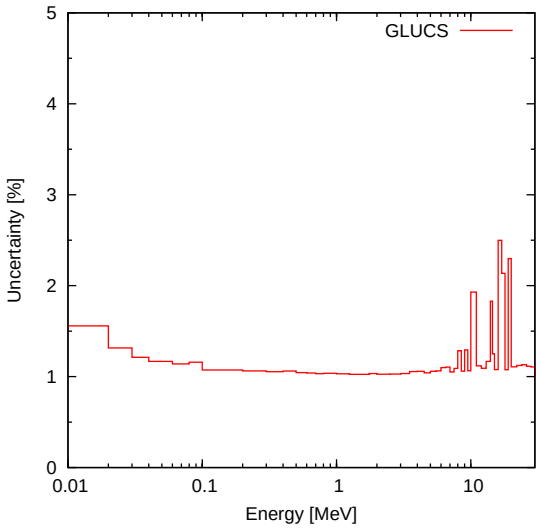
Example: U233 Covariances



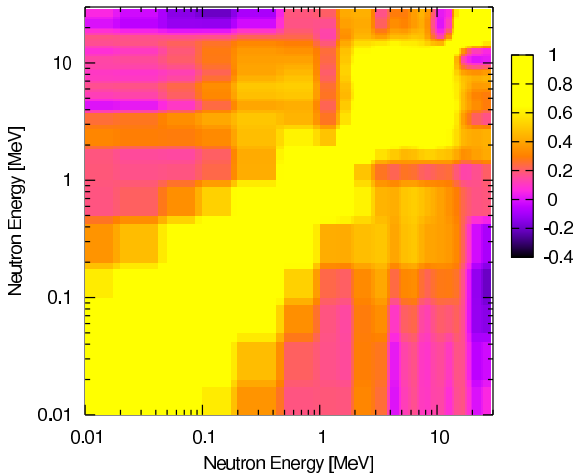
Total



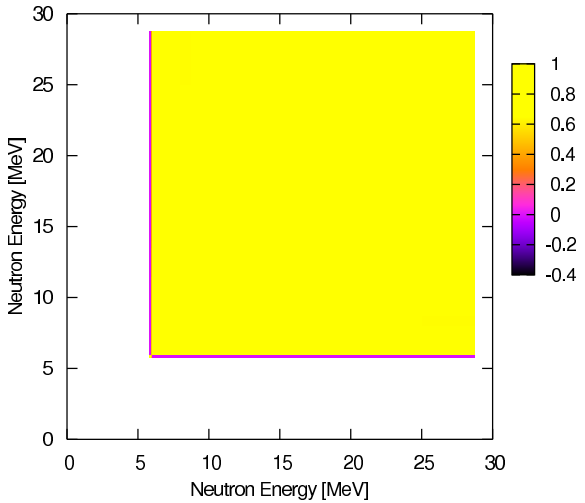
(n,xn)



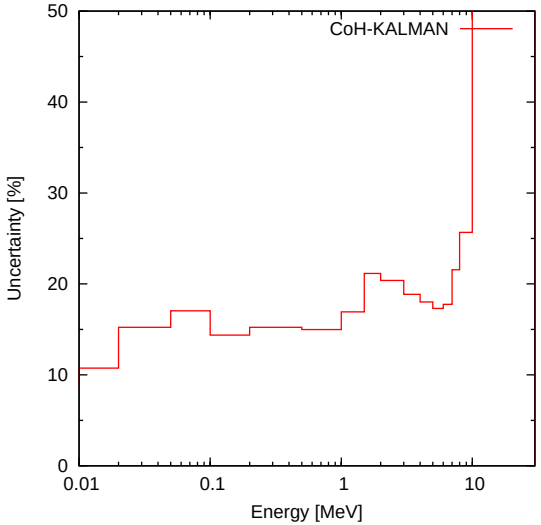
Fission



Total



(n,2n)



Capture

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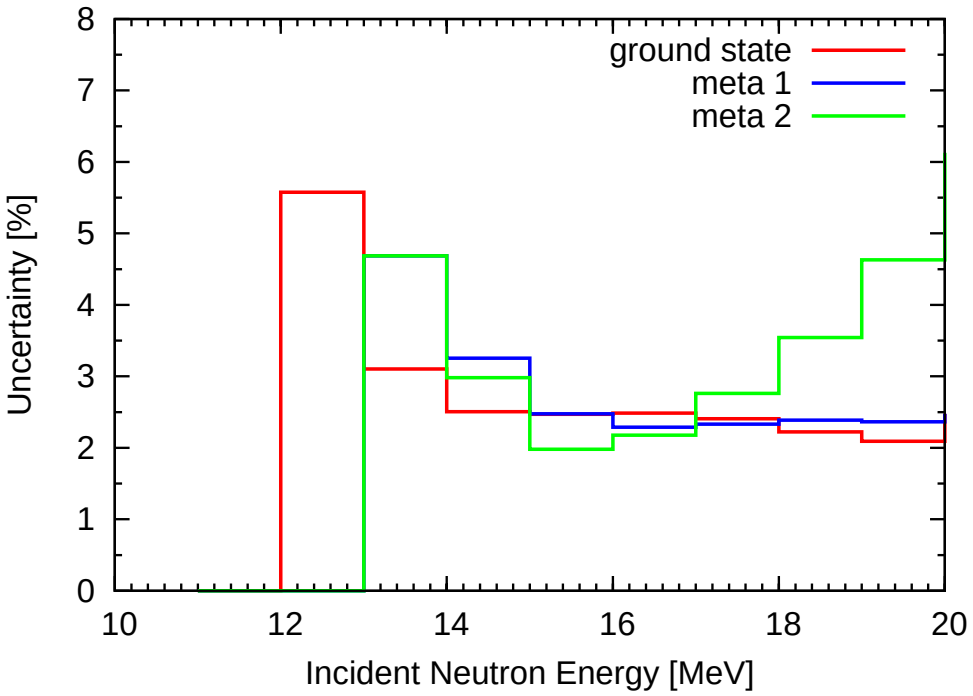
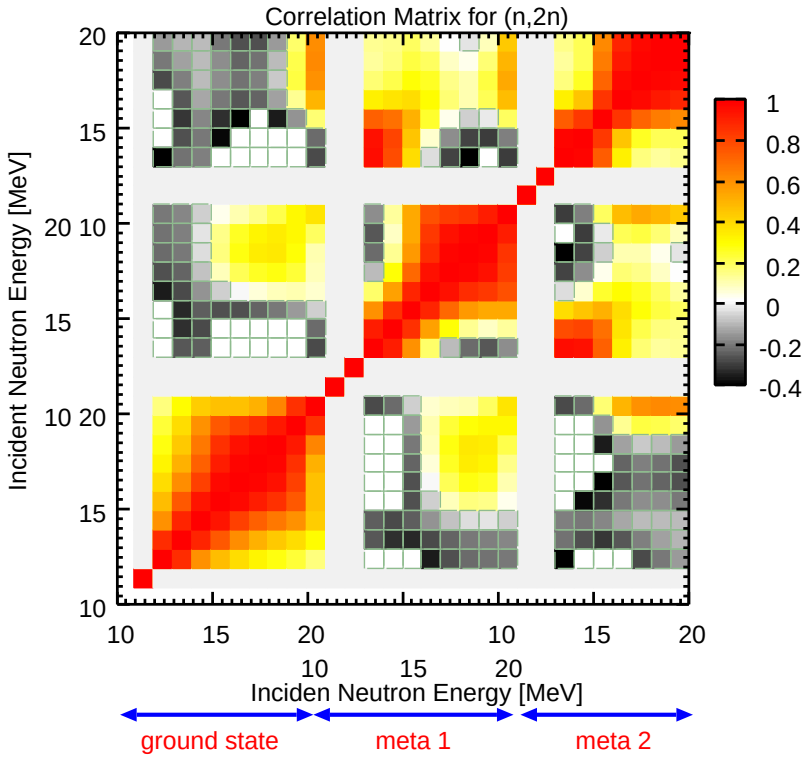
Covariances for Medium Mass Range

^{89}Y(n,2n) Reactions, Meta-Stable State Production

- The KALMAN Method can be applied to any types of nuclear data whenever they can be calculated
- Covariance matrix of ^{89}Y(n,2n) reactions, including productions of two different meta-stable states





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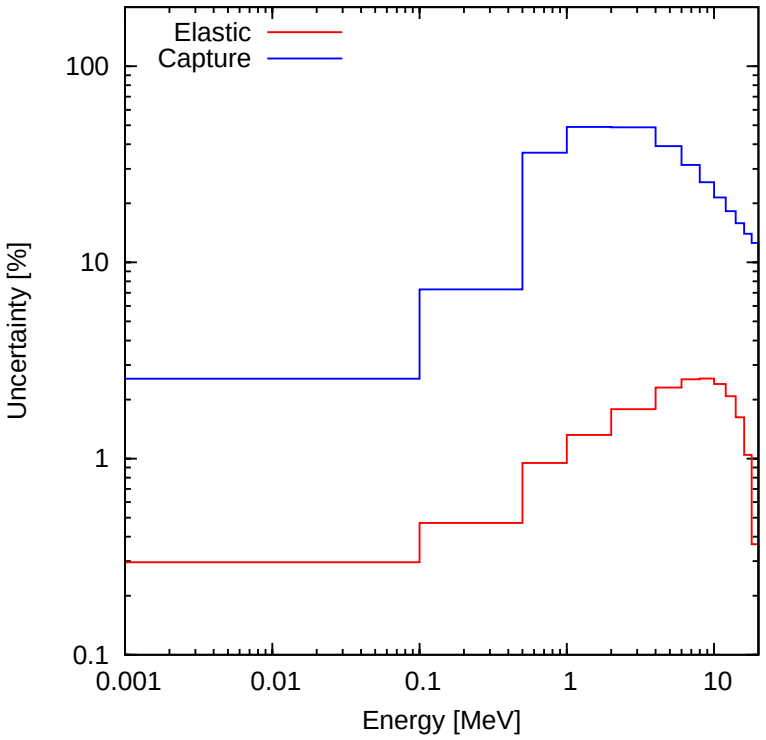
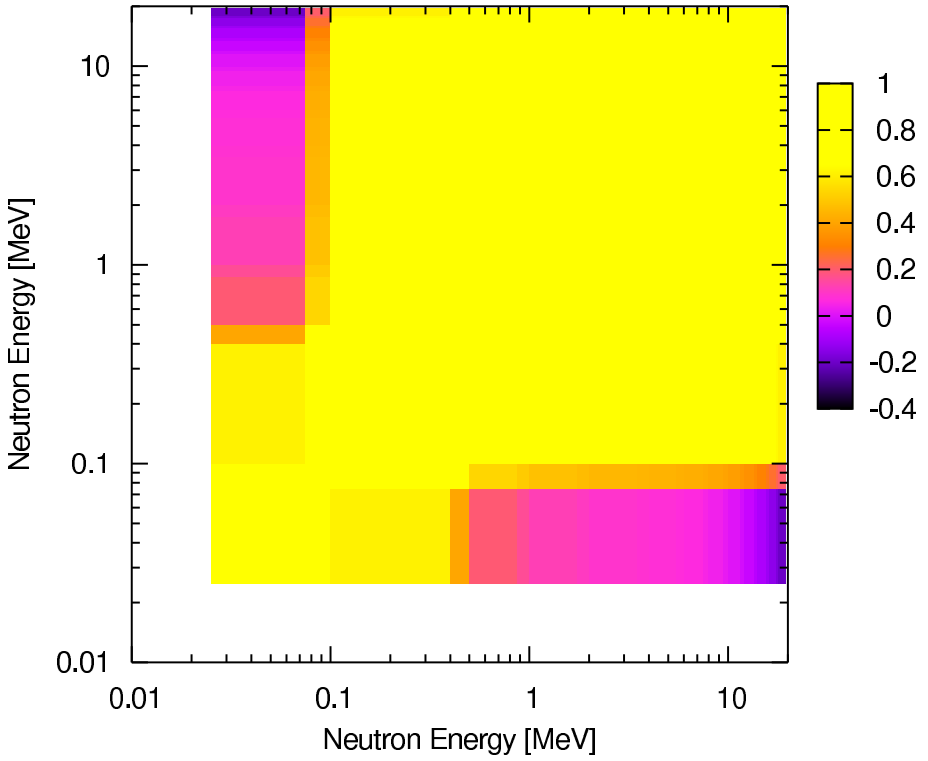
R-Matrix Fitting to Experimental Data

- very precise analysis with the EDA code
  - elastic and capture on ^{1}H evaluated in the entire energy range
  - standards evaluation: small uncertainties and strong correlation
  - this is an ideal case for the covairance evaluation





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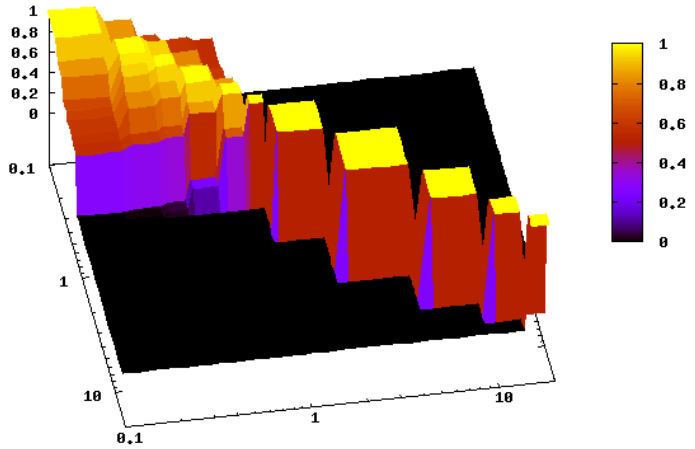
Issues Regarding LE Covariance Evaluations

Complicated Procedure for the Light Element Evaluations

- Evaluation performed in different ways
  - R-matrix, least-squares fitting to experimental data, simple interpolation, guess ...
  - often resonance parameter covariances are not available
  - many "derived" cross sections: $(n, \alpha) = (n, \alpha_0) + (n, \alpha_1) + \ldots$ etc.
  - we often see a scary word adjusted in the document
- HiFi R-matrix covariance supplemented by LoFi covariances is only possible



Lo-Fi Covariance Evaluations for Light Elements

LANL generated the LoFi covariance data for light elements (from ^{1}H to ^{19}F, except for ^{7}Li), which include HiFi R-matrix covariances of ^{1}H, ^{6}Li, and ^{10}B.

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Concluding Remarks

Actinide Evaluation

- LANL evaluates covariance data for major actinides, which are in consistent with the ENDF/B-VII evaluations.
- For minor actinide data, from ^{225}Ac to ^{255}Fm, so called LoFi evaluations are available.

Light Element Evaluation

- LANL generated the covariance data for light elements, from ^{1}H to ^{19}F, including the R-matrix covariances.
- We have seen several issues regarding the light element covariance evaluation. It seems there is no easy way to generate the covariance data automatically.

Future Work Needed

- Extend the HiFi actinide evaluations, and upgrade the LoFi data
  - Prioritize important materials for covariance data needs
- Complete the covariance data evaluation for χ
- Living with the covariance files

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