The Full Bayesian Evaluation Technique

D. Neudecker, LANL, T-2 CSEWG covariance session, 11/08/2012

In collaboration with:
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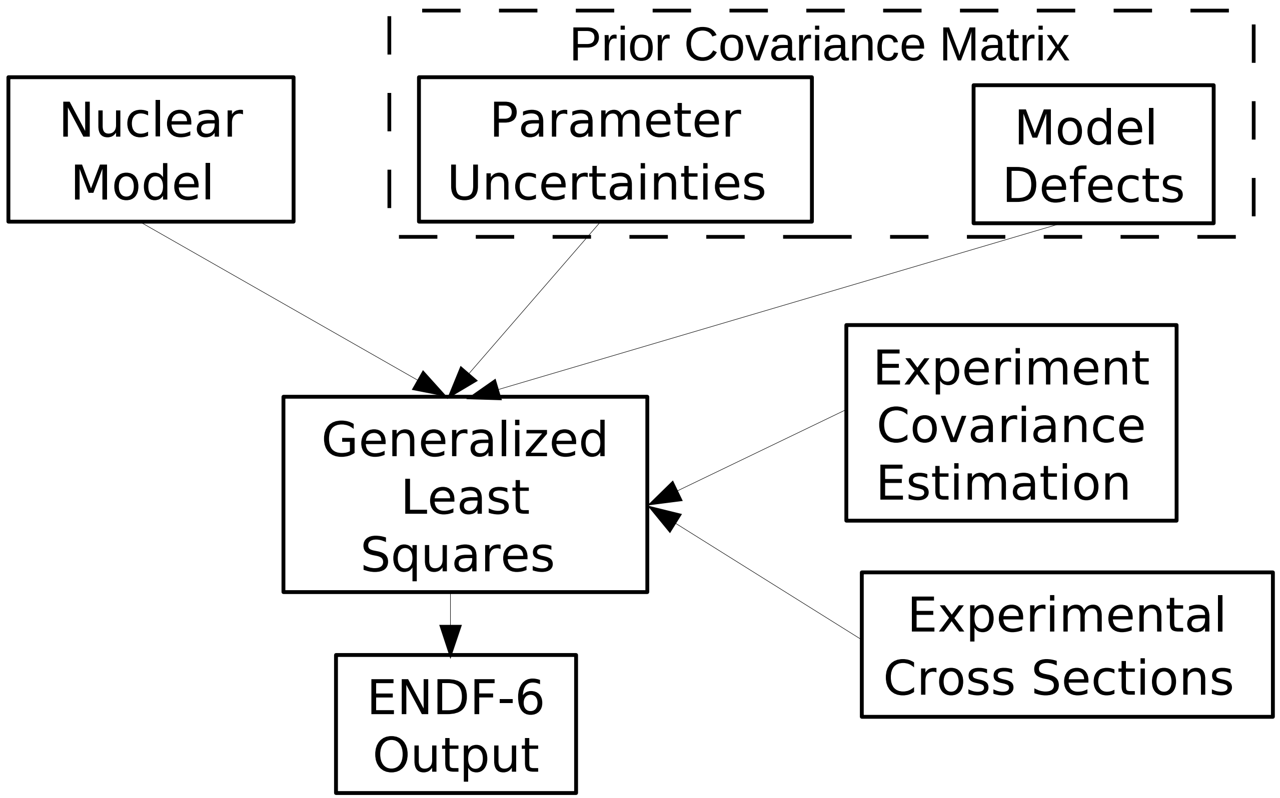
St. Gundacker – former Vienna Univ. of Technology, now Cern
R. Capote – IAEA Vienna

LA-UR-12-25848

The Full Bayesian Evaluation Technique provides cross sections and cov. mat. for structural materials.

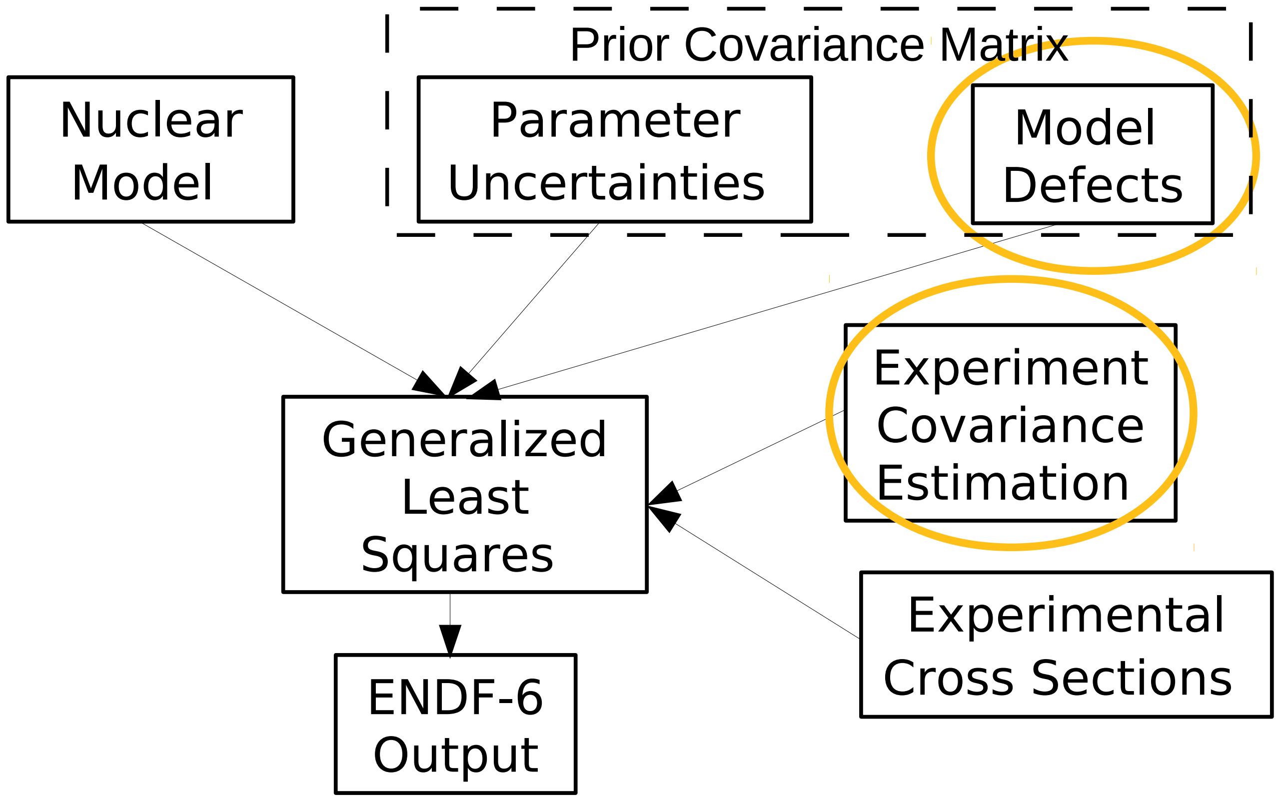


Model Defects

Covariance Matrices of Experiment

Summary/ Outlook

The Full Bayesian Evaluation Technique provides cross sections and cov. mat. for structural materials.



Model Defects

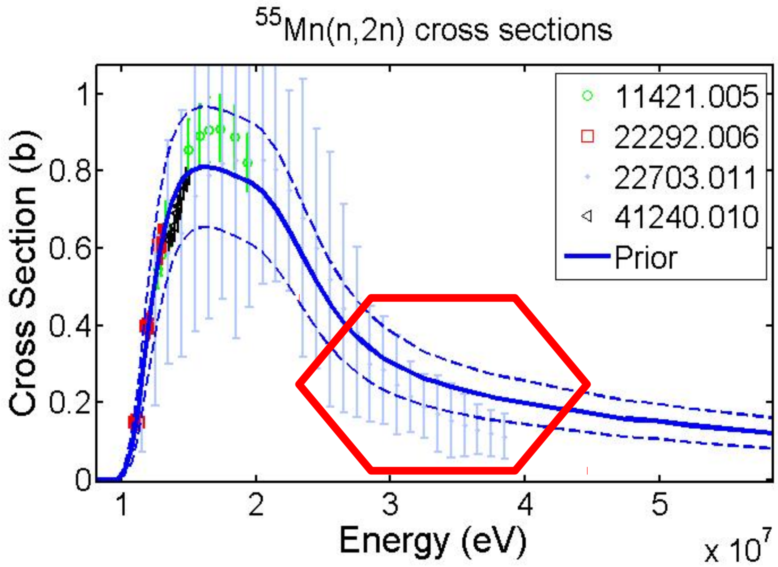
Covariance Matrices of Experiment

Summary/ Outlook

Model defect cov. mat. account for systematic deviations of the model from experimental data.

Model Defect:

A systematic deviation of the model from the experiment which can be observed for several isotopes in a similar energy regime within a selected model space.



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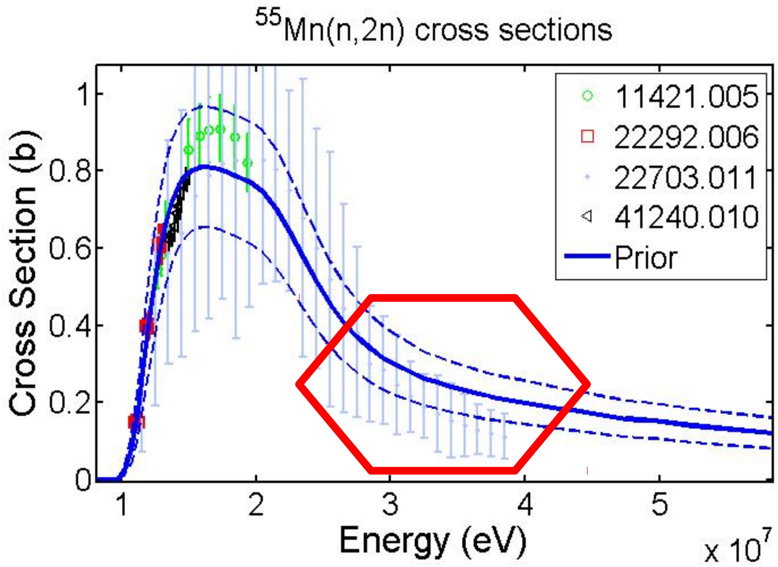


Model Defects

Covariance Matrices of Experiment

Summary/ Outlook

Constraints:

- Cannot be described exclusively within the insufficient model space.
- Experimental data employed in the evaluation should not be used.

Model defects are estimated using experimental and model data of similar isotopes.

Model Defect:

A systematic deviation of the model from the experiment which can be observed for several isotopes in a similar energy regime within a selected model space.

Constraints:

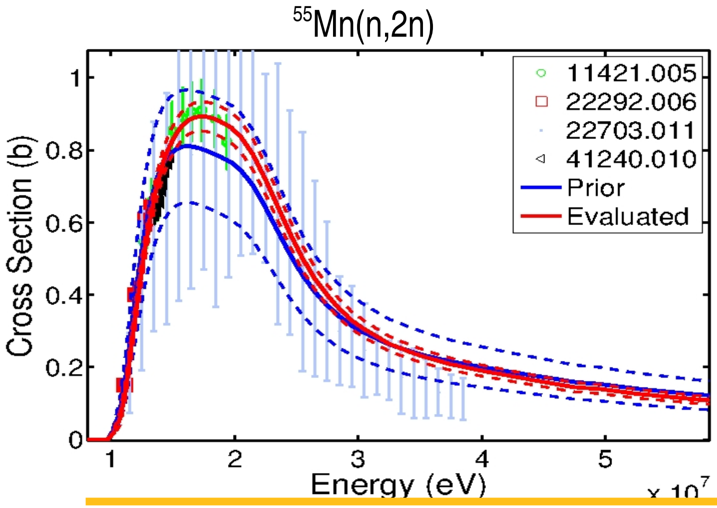
- Cannot be described exclusively within model space.
- Experiments employed in the evaluation should not be used.

Experimental data of similar isotopes are compared to model data in order to estimate model defect uncertainties.

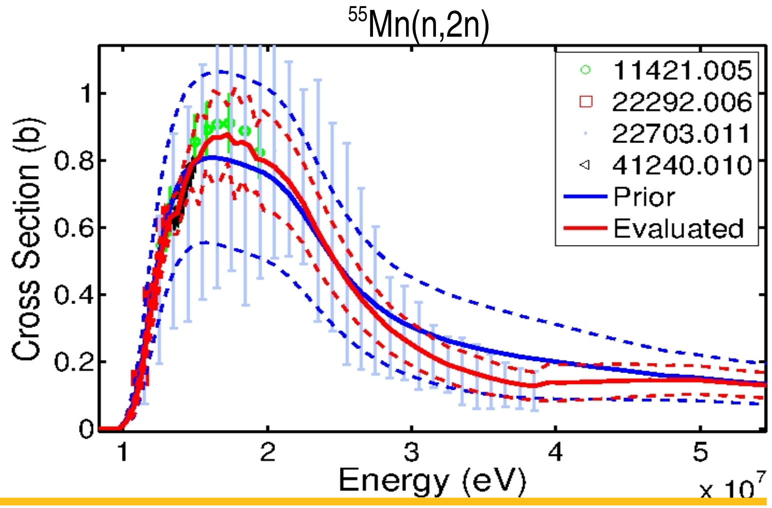
(see: H. Leeb, D. Neudecker, Th. Srdinko, Nucl. Data Sheets 109, Issue 12, 2762 (2008).)

Uncertainties due to model defects should be considered if model shows larger deficiencies.

Without model defect unc.



With mode defect unc.



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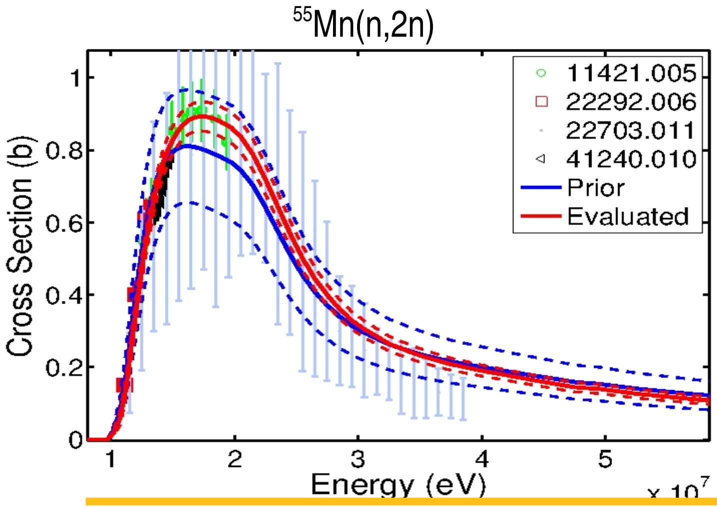
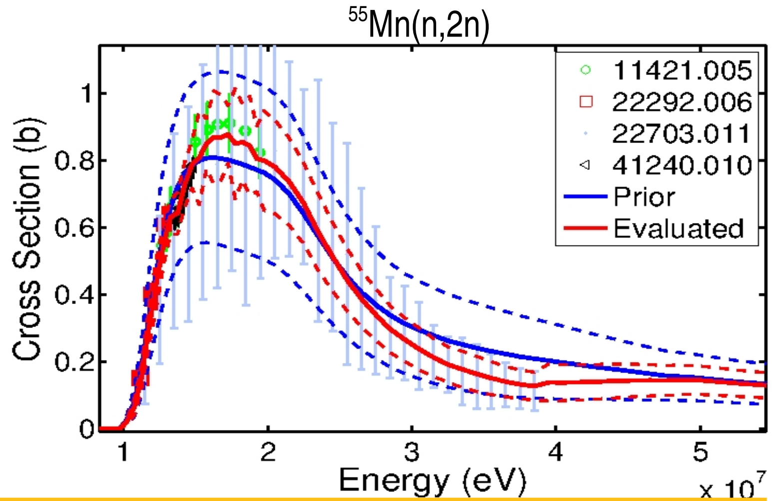


With mode defect unc.



Model Defects

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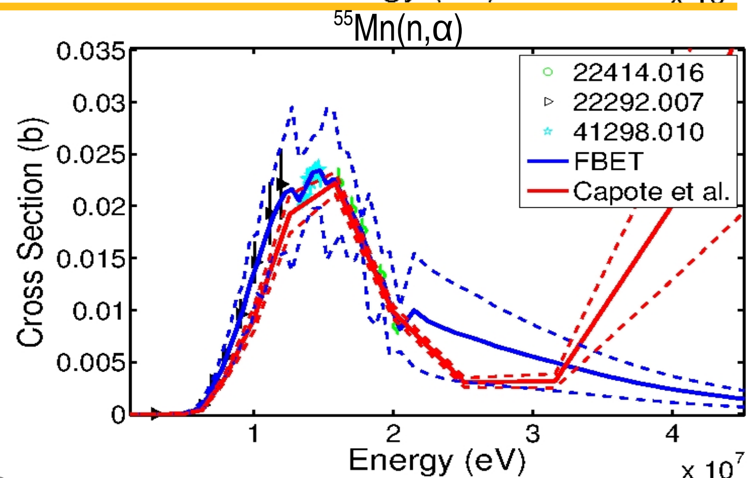
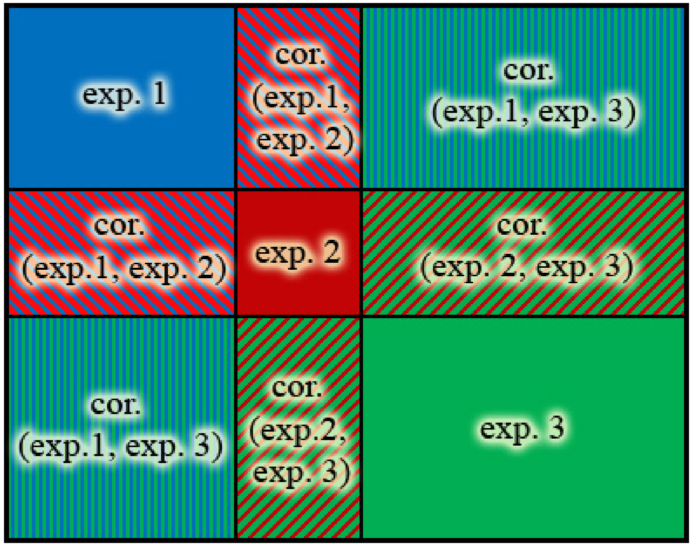
Summary/ Outlook

Open issue: Kinks occur in eval. cross sections which do not occur when using approach of Capote et al. (prior from A. Trkov et al., Nucl. Data Sheets 112, Issue 12, 3098 (2011).)



Correlations of systematic unc. of single and between different experiments are considered.

In the Full Bayesian Evaluation Technique, **correlations** of systematic uncertainties were considered for **single and between different experiments** leading to **evaluated uncertainties about the magnitude of the correlated systematic uncertainty.**



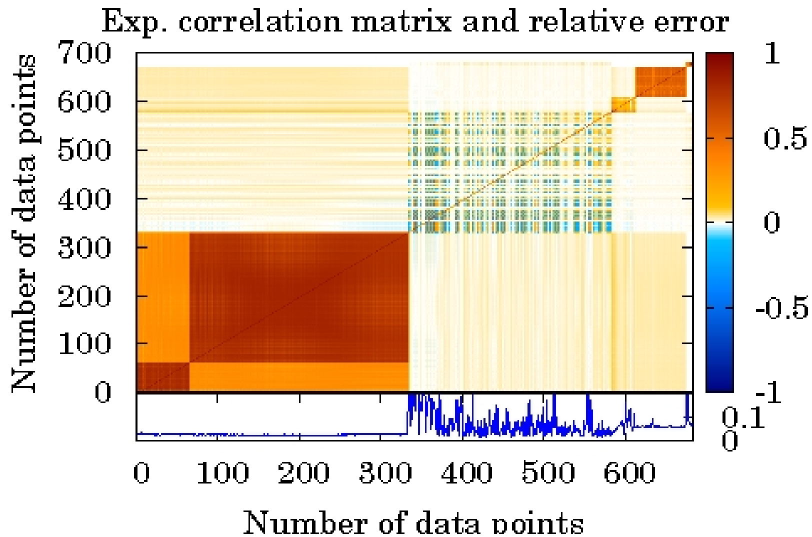
Model Defects

Covariance Matrices of Experiment

Summary/ Outlook

Correlations of systematic unc. of single and between different experiments were considered *roughly*.

In the Full Bayesian Evaluation Technique, **correlations** of systematic uncertainties were considered for **single and between different experiments** leading to **evaluated uncertainties about the magnitude of the correlated systematic uncertainty.**



EXFOR	method	neutron source	detector	monitor
3753.018 [13]	transmission time-of-flight	proton beam on tungsten target	BC404	none
10047.031 [28]	transmission time-of-flight	Li(d,n)	[illegible] iquid [illegible] or	none
11308.008 [29]	transmission	[illegible]	[illegible] parallel plate ioniz. chamber	none
20169.002	[illegible]	[illegible] $(d,n)^3$He	Emmerich det. Dario 5AVP	none
[illegible]	[illegible] measur. time-of-flight	$d(d,n)^3$He	NE213 liquid scintillator	none
[illegible] 0019.081 [32]	diff. measur. rel. to monitor	$t(p,n)^3$He (-4.6MeV) $d(d,n)^3$He(>4.6MeV)	NE102 scinti.	H(n,n)H

BUT ONLY VERY ROUGHLY

Model Defects

Covariance Matrices of Experiment

Summary/ Outlook

Work in progress: estimating exp. cov. mat. in a more reproducible and physical manner.

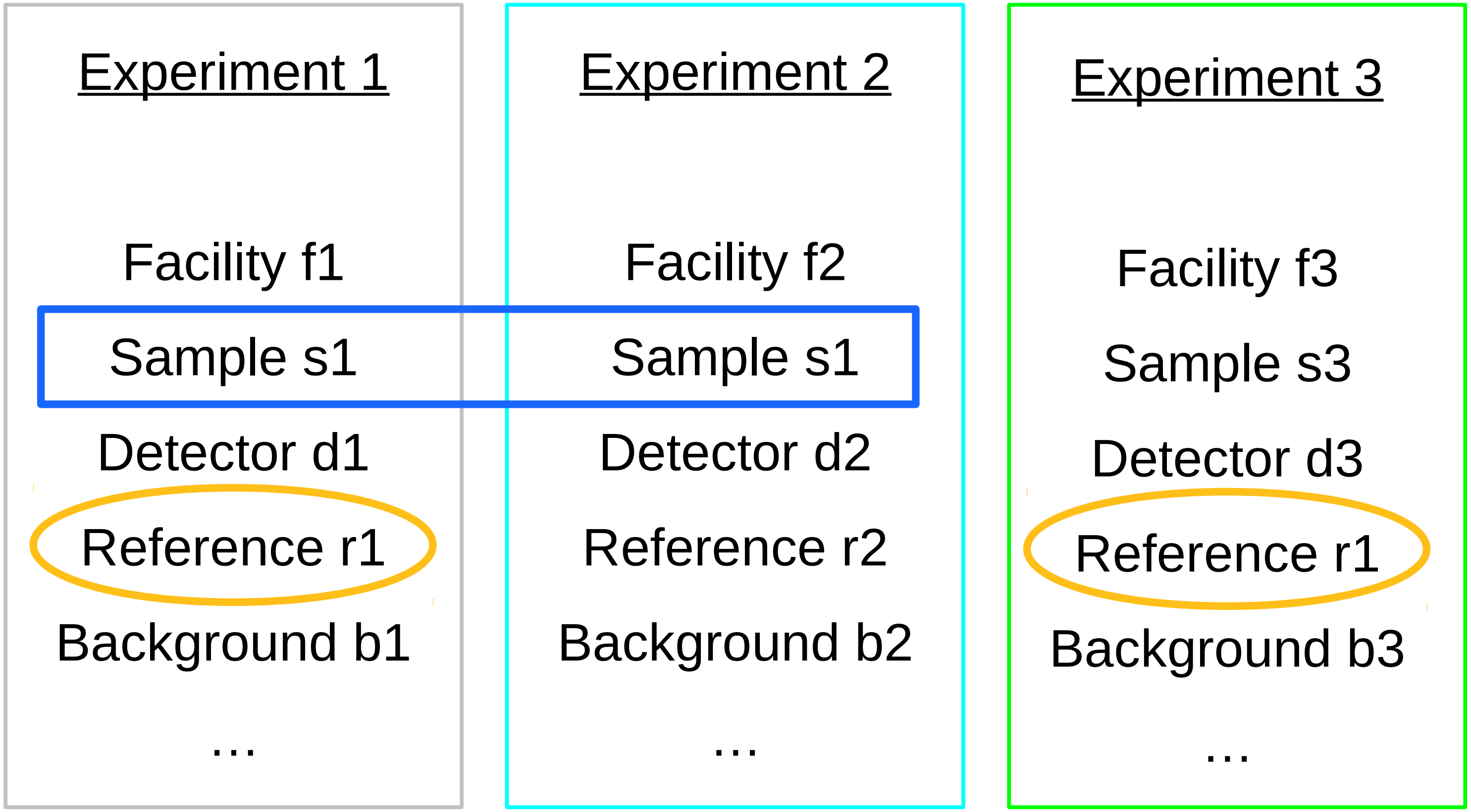
- Estimate covariance matrices for single and between different experiments.
- Store (xml) and use detailed information relevant for uncertainties of specific uncertainty components appearing in different experiments (e.g.: uncertainties due to reference reaction, specific sample)

  ⟶ Simplifies estimating uncertainties of experimental data with sparse uncertainty information and correlations between experiments

Why storing certain uncertainty components?

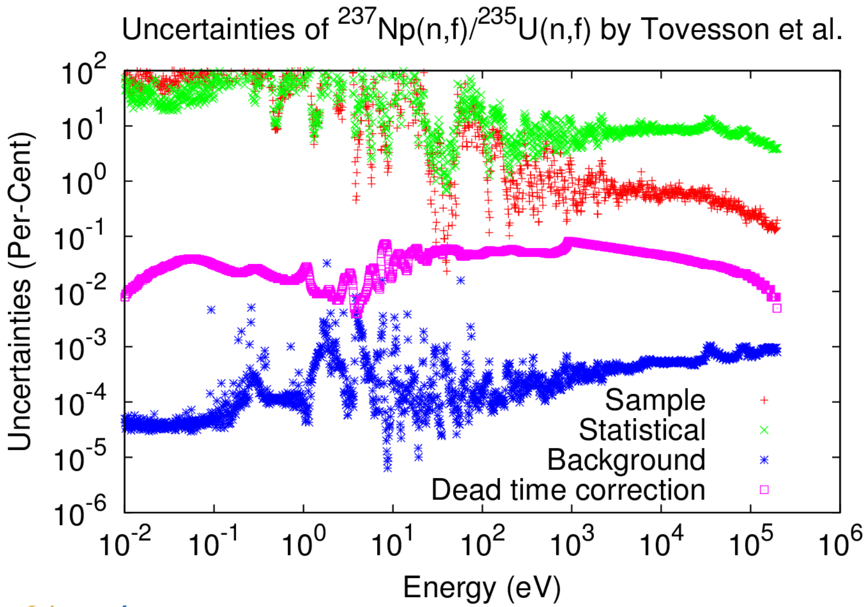
Experiment 1	Experiment 2	Experiment 3
Facility f1	Facility f2	Facility f3
Sample s1	Sample s1	Sample s3
Detector d1	Detector d2	Detector d3
Reference r1	Reference r2	Reference r1
Background b1	Background b2	Background b3
…	…	…

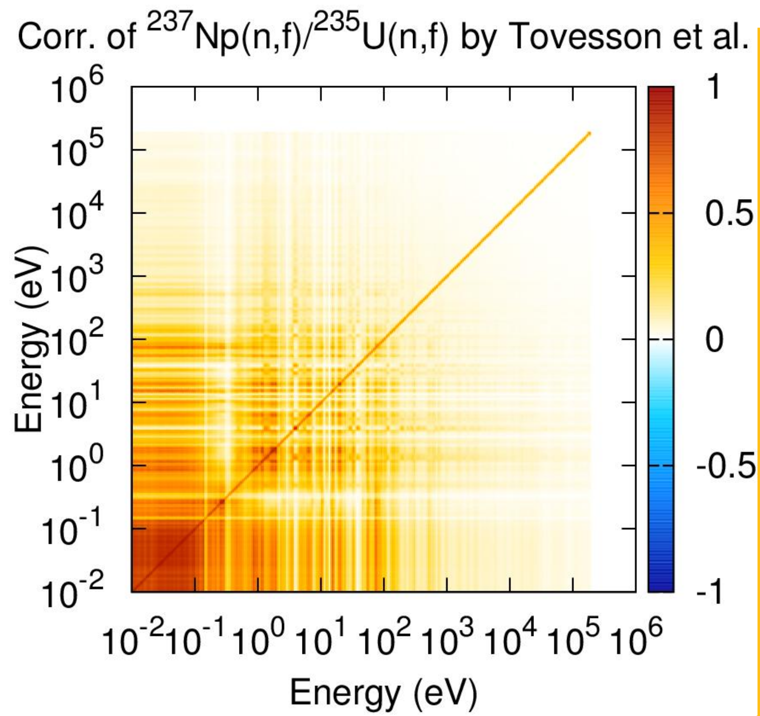
Why storing certain uncertainty components?



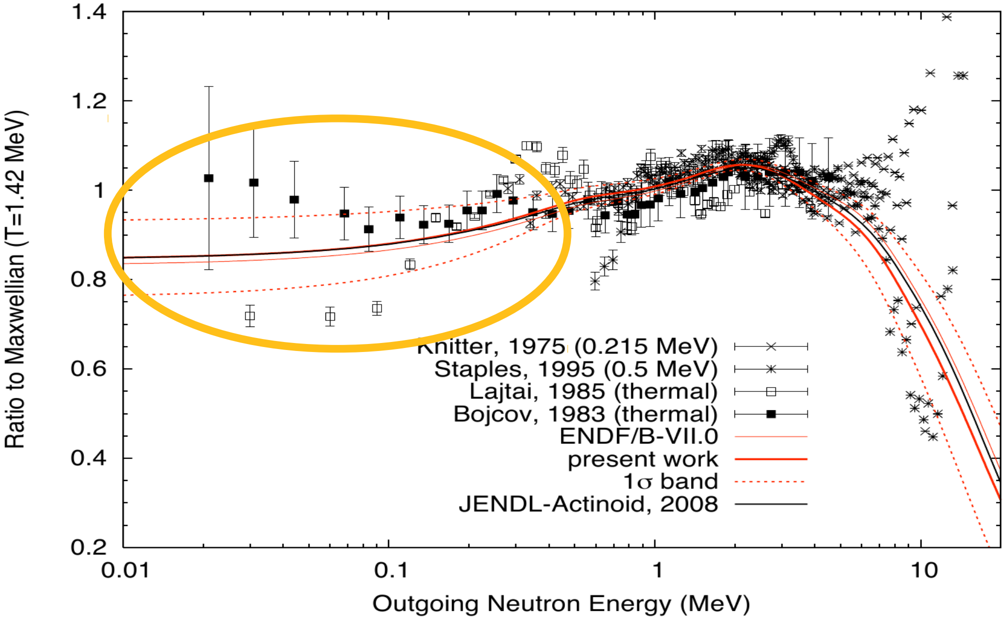
First steps: Reproducing a covariance matrix using detailed uncertainty information.

First application: reproducing an experimental covariance matrix of F. Tovesson, T.S. Hill, K.M. Hanson, P. Talou, T. Kawano, R.C. Haight, L. Bonneau, Internal Report LA-UR-06-7318 (2006).

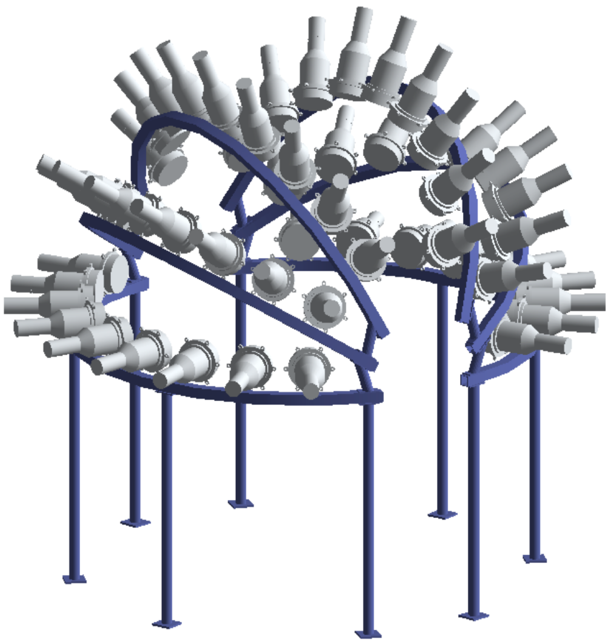




Outlook



New ^{239}Pu PFNS data will be coming from Chi-Nu at LANSCE.



Does Los Alamos model describe low energy range of PFNS?

→ model defect uncertainties?

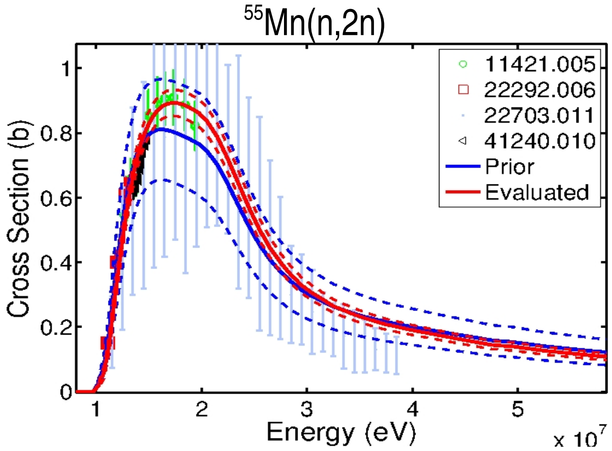
Model Defects

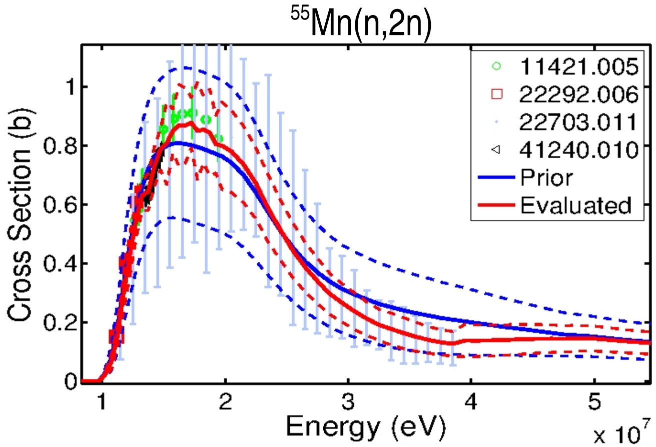
Covariance Matrices of Experiment

Summary/ Outlook

… and summary

- Considering model defect uncertainties is important if model deviates significantly from experimental data





- A new program is in development at LANL which estimates experimental covariance matrices in a more physical and reproducible manner and stores the underlying information in XML.

Selected literature

H. Leeb, D. Neudecker, Th. Srdinko, Nucl. Data Sheets 109, Issue 12, 2762 (2008).

F. Tovesson, T.S. Hill, K.M. Hanson, P. Talou, T. Kawano, R.C. Haight, L. Bonneau, Internal Report, LA-UR-06-7318 (2006).

A. Trkov, R. Capote, E.Sh. Soukhovitskii, L.C. Leal, M. Son, I. Kodeli, D.W. Muir, Nucl. Data Sheets 112, Issue 12, 3098 (2011).

P. Talou, P.G. Young, T. Kawano, M. Rising, M.B. Chadwick, Nucl. Data Sheets 112, Issue 12, 3054 (2011).

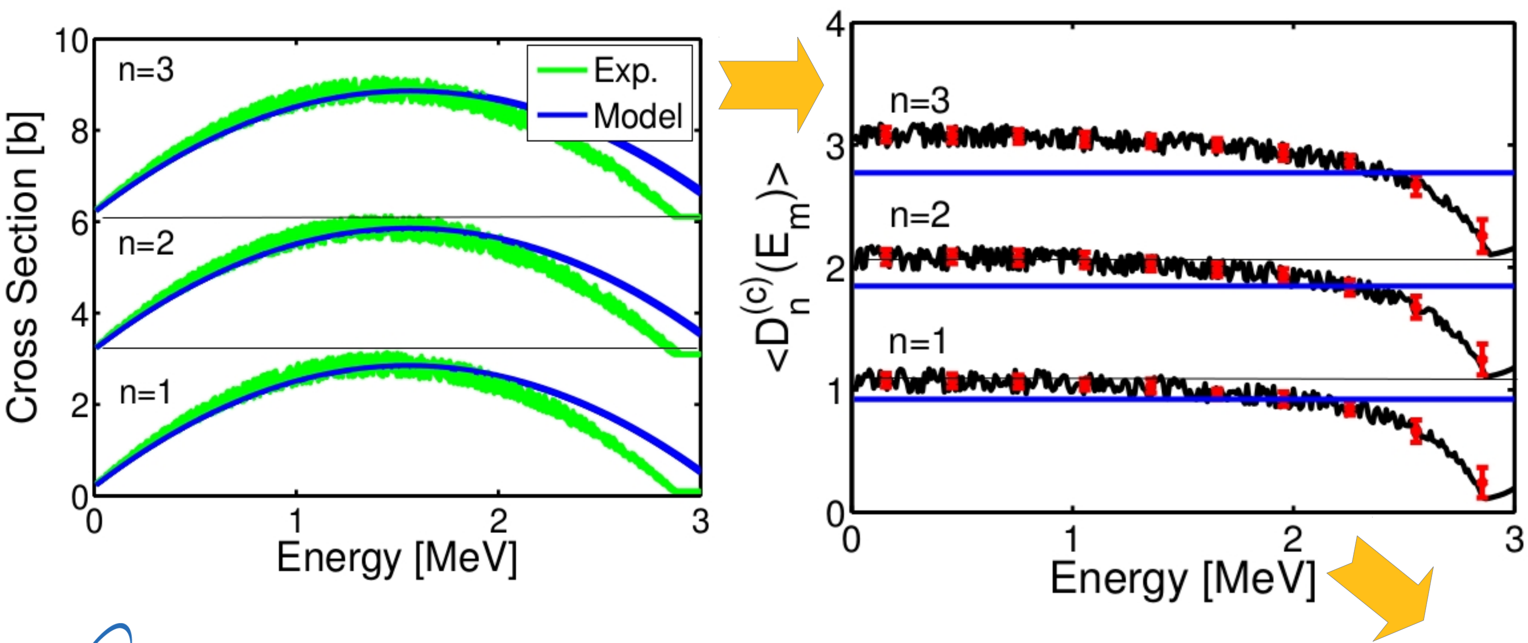
Thank you for your attention!

Model defects are estimated using experimental and model data of similar isotopes.

H. Leeb, D. Neudecker, Th. Srdinko, Nucl. Data Sheets 109, Issue 12, 2762 (2008).

$$D^c = \sum_{n=1}^{N^c} w^{c,n} \sum_{m=1}^{M} w_m^{c,n} \sum_{j\in Ebin} w_j^{c,m,n} \frac{\sigma_{ex}^{c,n}(E_j)}{\sigma_{th}^{c,n}(E_j)}$$

$$= \sum_{n=1}^{N^c} w^{c,n} \sum_{m=1}^{M} w_m^{c,n} \left\langle D_n^c(E_m) \right\rangle$$



$D^{(c)} = 0.902$

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Backup

Model defects are estimated using experimental and model data of similar isotopes.

H. Leeb, D. Neudecker, Th. Srdinko, Nucl. Data Sheets 109, Issue 12, 2762 (2008).

$$Cov^{cc'}(E_m, E_{m'}) = \frac{\sigma^{c}_{th}(E_m)\,\sigma^{c'}_{th}(E_{m'})}{\sqrt{N^{c}(E_m)}\sqrt{N^{c'}(E_{m'})}} \times \sum_{n=1}^{N^c} \left[\left\langle D^{c}_{n}(E_m)\right\rangle - D^{c}\right]\left[\left\langle D^{c'}_{n}(E_{m'})\right\rangle - D^{c'}\right] + \sum_{n=1}^{N^c} \delta_{cc'}\, g_{mm'} \sqrt{var\left(D^{c}_{n}(E_m)\right) var\left(D^{c'}_{n}(E_{m'})\right)}$$