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The identification and treatment of unrecognized uncertainties and the impact on evaluated uncertainties– SG44

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Do we know how the evaluators treat experimental data?

- Estimation of exp. covariance paramount for the resulting evaluated co-variance
- Sometimes information is available in the file or in associate publication. Information often incomplete. No standardized format (within WPEC) on how to report on the use of experimental data and associate co-variance in connection to the evaluations.

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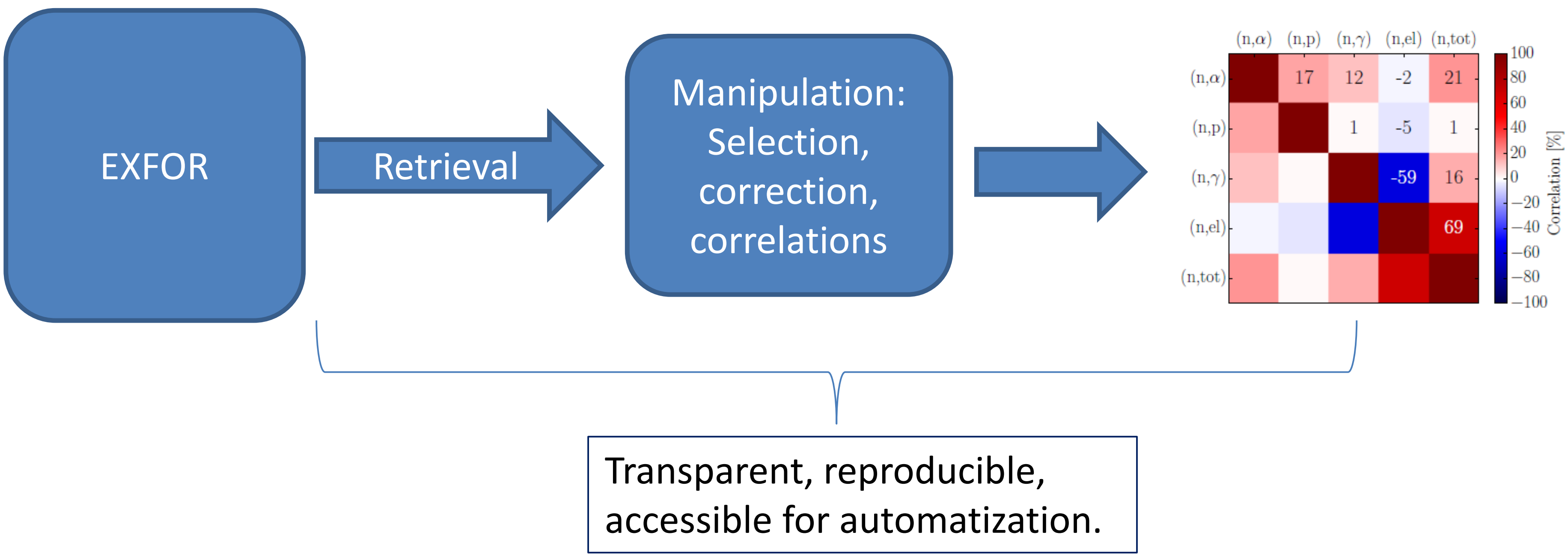
Recommendation

- To understand the evaluated co-variances and why it sometimes differ between libraries we need a standardized way/format to report how we treat experimental data in connection to the libraries.



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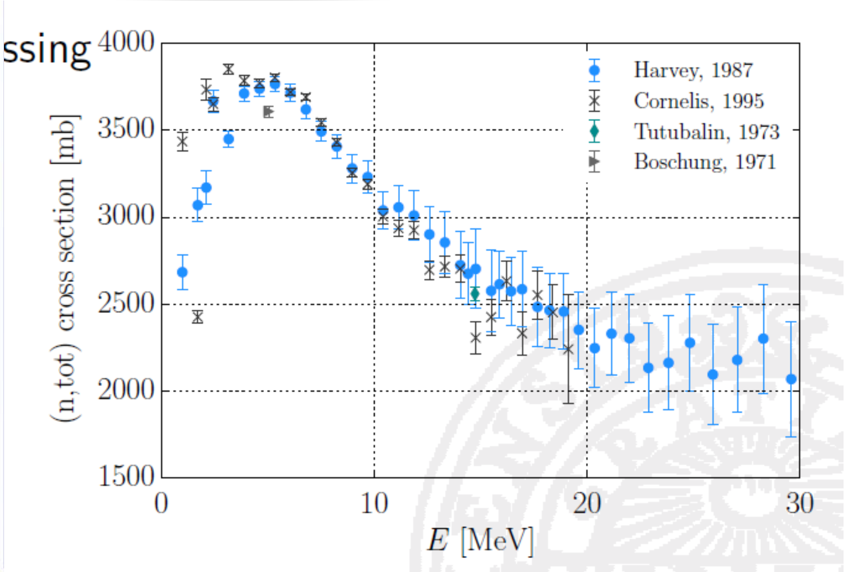
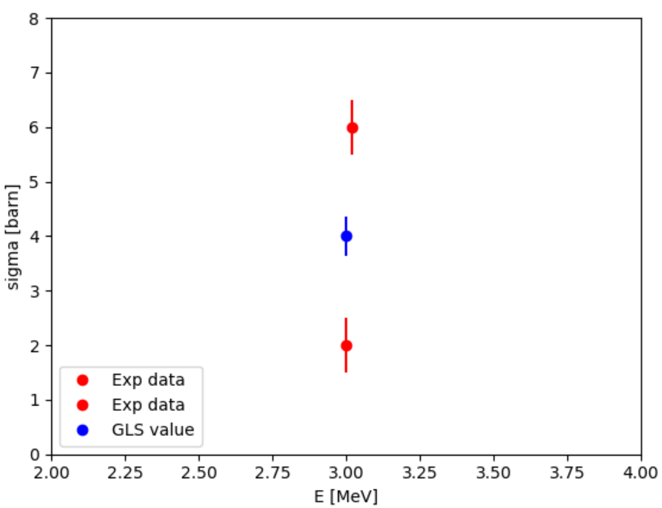
If the data is inconsistent?





- Expert judgment
  - Time consuming
  - Reproducible?
  - Maybe not enough. Still inconsistent.
- Choose based on integral data.
  - Compensating errors.
- Based on the model.
  - Circular argument.
- GLS-fit.

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Using marginal likelihood optimization (MLO)

- Treat unrecognized systematic uncertainties in a systematic way.
- Ad an extra uncertainty component to the experiments.

$$\kappa_{tot}^2 = \kappa_{reported}^2 + \kappa_{extra}^2$$

- σ_{extra} found by maxzimizing[1] L:

$$L = \frac{1}{\sqrt{2\pi n \left| S A_0 S^T + \mathrm{cov}_{rep} + \mathrm{cov}_{extra} \right|}} e^{-\frac{\chi^2}{2}} e^{-\beta \sum \kappa_{extra}^2}$$

$A_0 =$ prior covariance

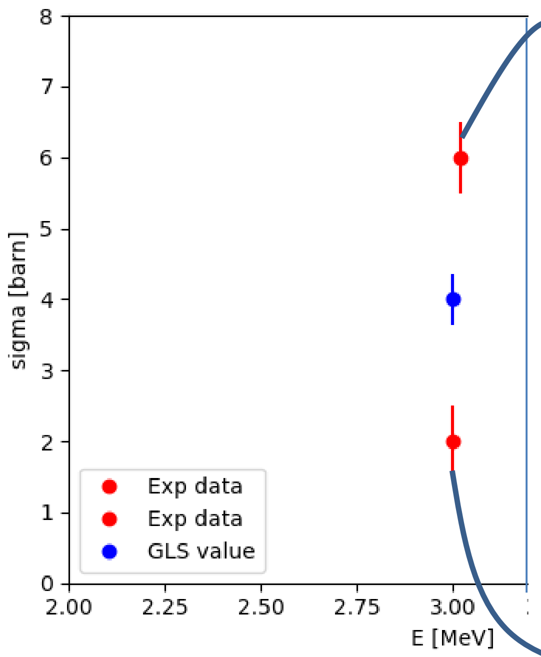
$n = number$ of experiments

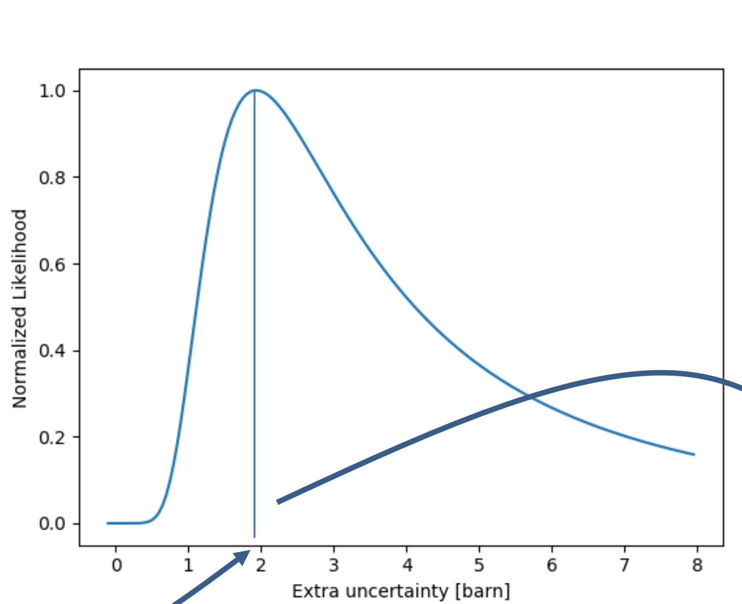
Agreement between GLS-value and original experiments

To favor small extra uncertainties. I.e., we believe what the experimentalists report.

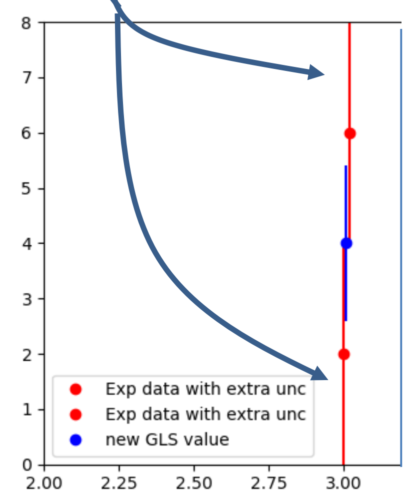
[1]G. Schnabel, Fitting and Analysis Technique for Inconsistent Nuclear Data, Proc. of MC2017, 2017

Toy example and L- function

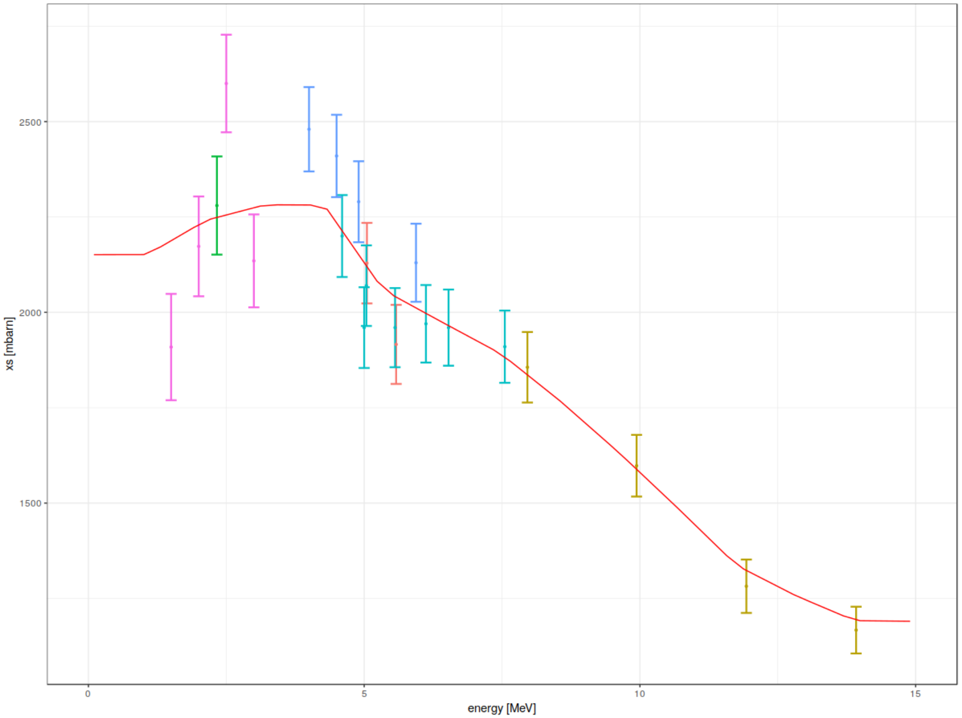


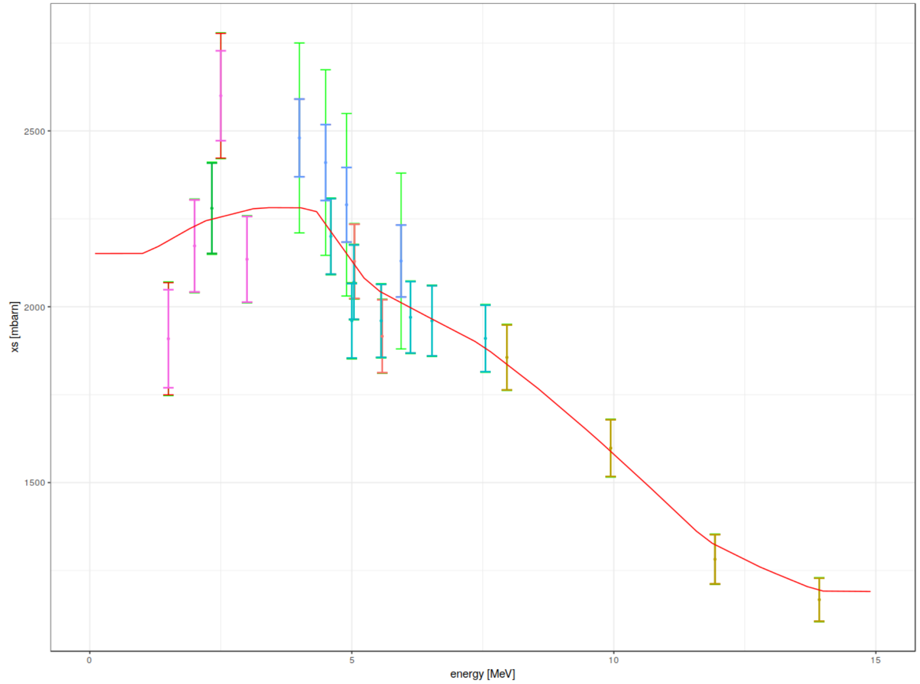


$$L = \frac{1}{\sqrt{2\pi n\left|SA_0S^T + \mathrm{cov}_{rep} + \mathrm{cov}_{extra}\right|}} e^{-\frac{\chi^2}{2}} e^{-\beta\sum\kappa_{extra}^2}$$



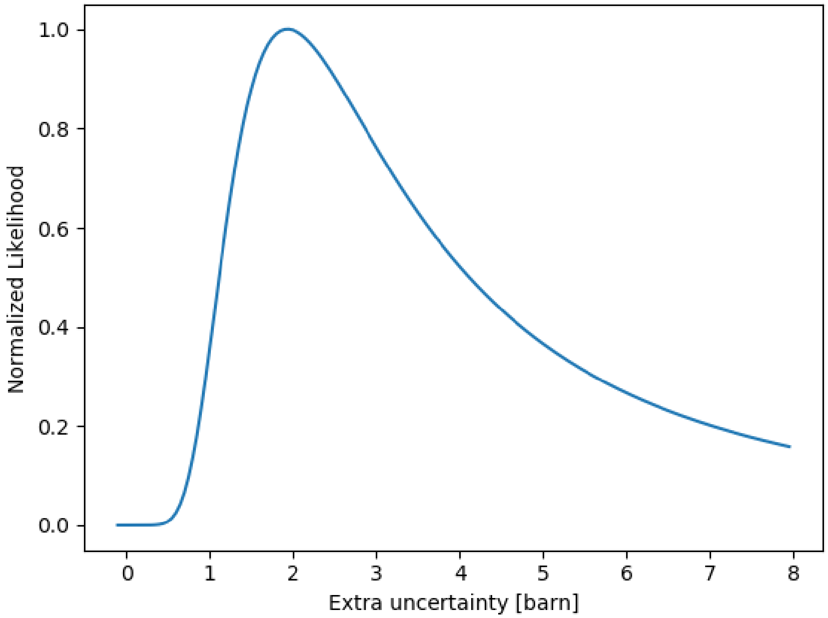
Fe56 results





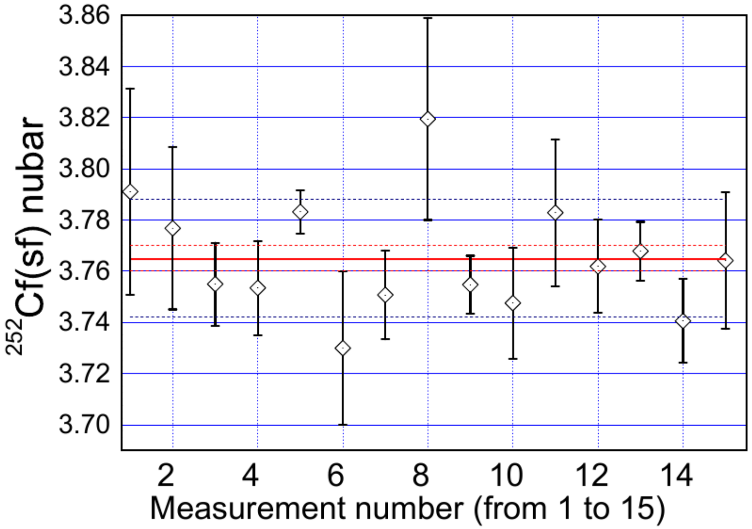
Fe56(n,el)

Next step: include the full likelihood functions.



- All values of the likelihoood functions is possbile, hence should be taken into account.
  - affects the best-estimate and normally increase the uncertainty.
- Can be achieved by e.g., sampling.

The data

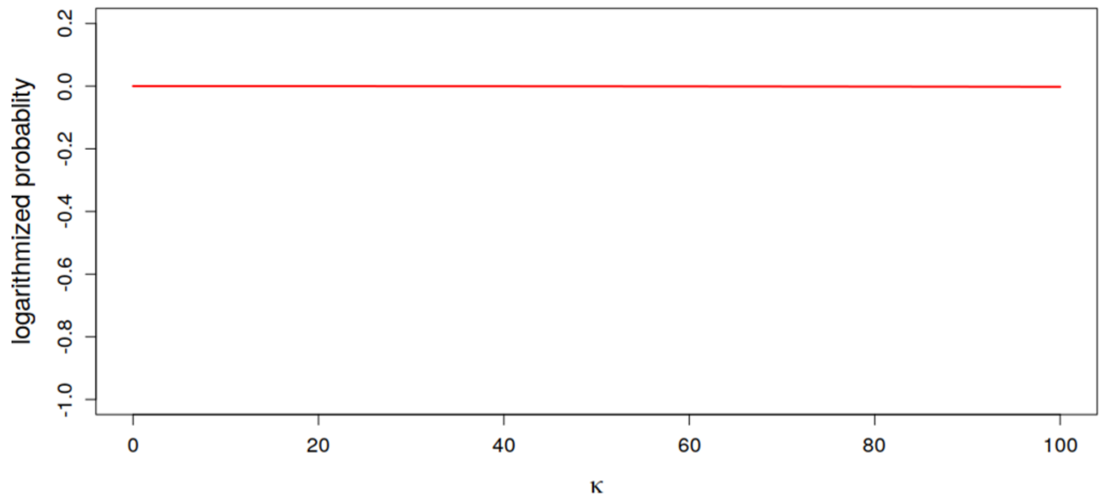


N°	Author	Year	Value (Uncert.)	Method
1	Asplund	1963	3.7910 (1.066%)	scintil.
2	Hopkins	1963	3.7767 (0.838%)	scintil.
3	Boldeman	1977	3.7549 (0.431%)	scintil.
4	Zhang	1981	3.7534 (0.490%)	scintil.
5	Spencer	1982	3.7831 (0.221%)	scintil.
6	Colvin/Axton*	1966	3.7299 (0.806%)	Mn-bath
7	DeVolpi	1970/72	3.7507 (0.463%)	Mn-bath
8	White*	1968	3.8194 (1.033%)	Mn-bath
9	Axton	1985	3.7547 (0.300%)	Mn-bath
10	Bozorgmanesh	1977	3.7475 (0.580%)	Mn-bath
11	Spiegel	1981	3.7828 (0.759%)	Mn-bath
12	Aleksandrov	1981	3.7618 (0.483%)	Mn-bath
13	Smith	1984	3.7678 (0.303%)	Mn-bath
14	Colvin/Ullo	1965	3.7405 (0.438%)	B-pile
15	Edwards	1982	3.7641 (0.711%)	B-pile

Figure and table from paper of R. Capote, D. Neudecker,
"How accurately we know the standard 252 Cf(sf) neutron multiplicity?"

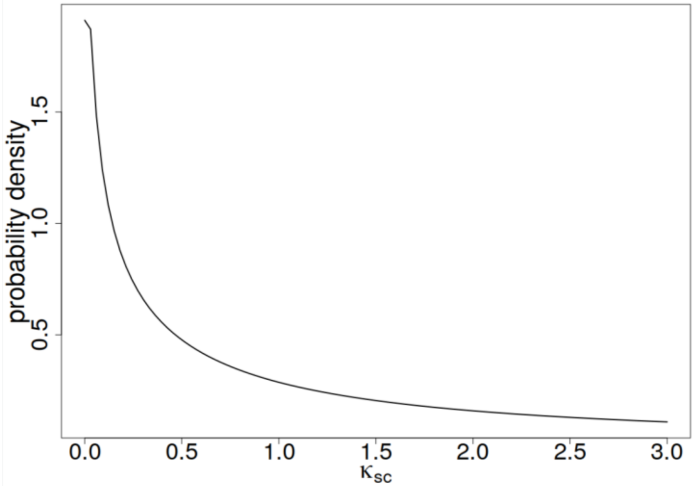
Scenario #1: flat prior, global normalization uncertainty

$$L = \frac{1}{\sqrt{2\pi n \left| S A_0 S^T + \mathrm{cov}_{rep} + \mathrm{cov}_{extra} \right|}} e^{-\frac{\chi^2}{2}} \cdot 1$$



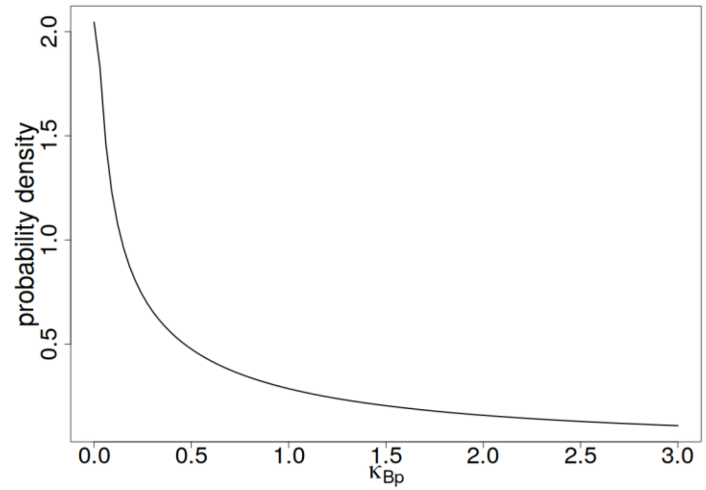
<u>Interpretation</u>:
If all measurement devices are wrong in the same way,
then it is impossible to infer the magnitude of this "universal" error from the data.

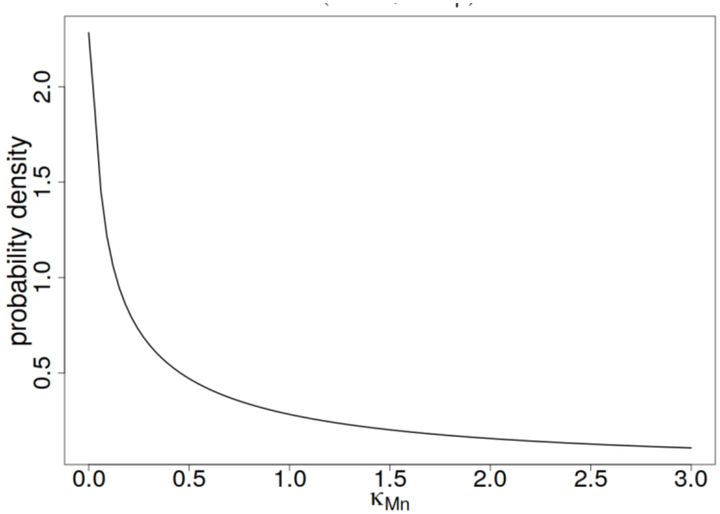
Scenario #2: flat prior, method uncs



Each method (scintill., Mn-bath, B-pile) has an individual systematic uncertainty

$$L = \frac{1}{\sqrt{2\pi n \left| S A_0 S^T + \mathrm{cov}_{rep} + \mathrm{cov}_{extra} \right|}} e^{-\frac{\chi^2}{2}} \cdot 1$$





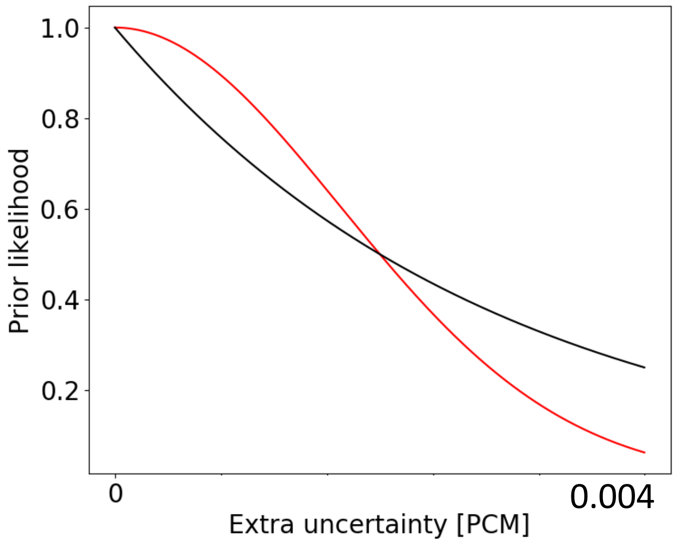
Heavy tails:
3.760 ± (0.39, 0.76, or Inf?)
Depending to the range of the sampling.
(GLS 3.765 ± 0.004)

Situation 3: Normal prior, method uncs

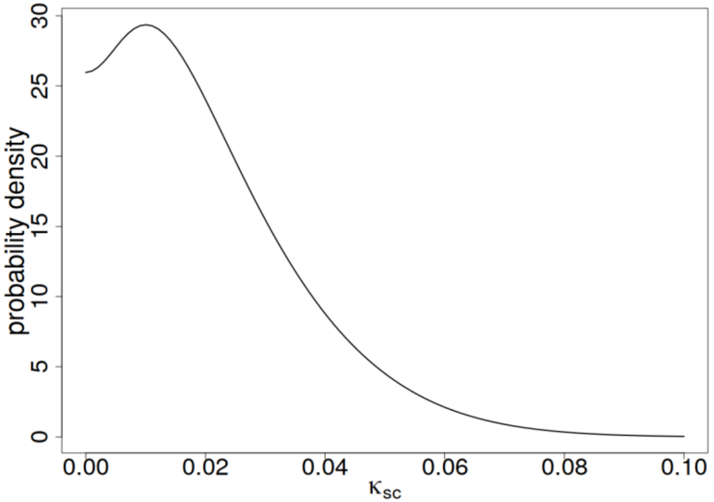
$$L = \frac{1}{\sqrt{2\pi n \left| S A_0 S^T + \mathrm{cov}_{rep} + \mathrm{cov}_{extra} \right|}} e^{-\frac{\chi^2}{2}} e^{-\beta \sum \kappa_{extra}^2}$$

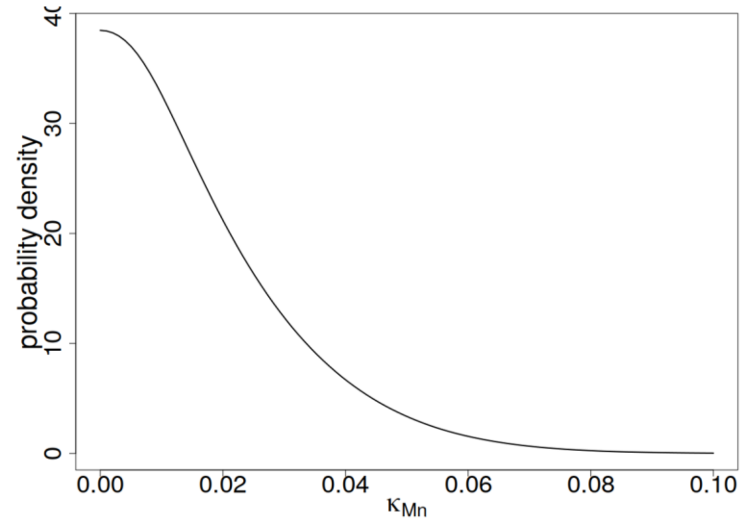
$$\beta = 555$$

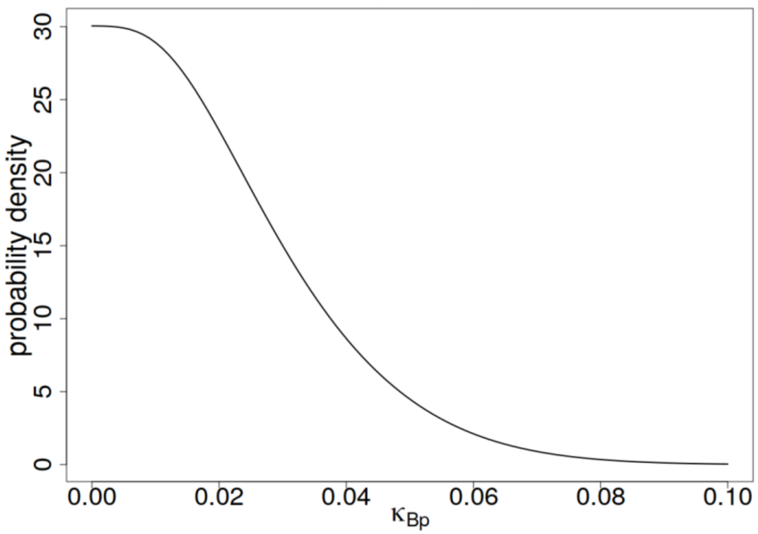
We say that the extra uncertainty needs to be within a reasonble range. beta of 555 means that an extra uncertainty of 0.004 has a 10 % probaility of no extra uncertainty.



1D marginal posterior pdfs







3.762 ± 0.011

(GLS 3.765 ± 0.004)

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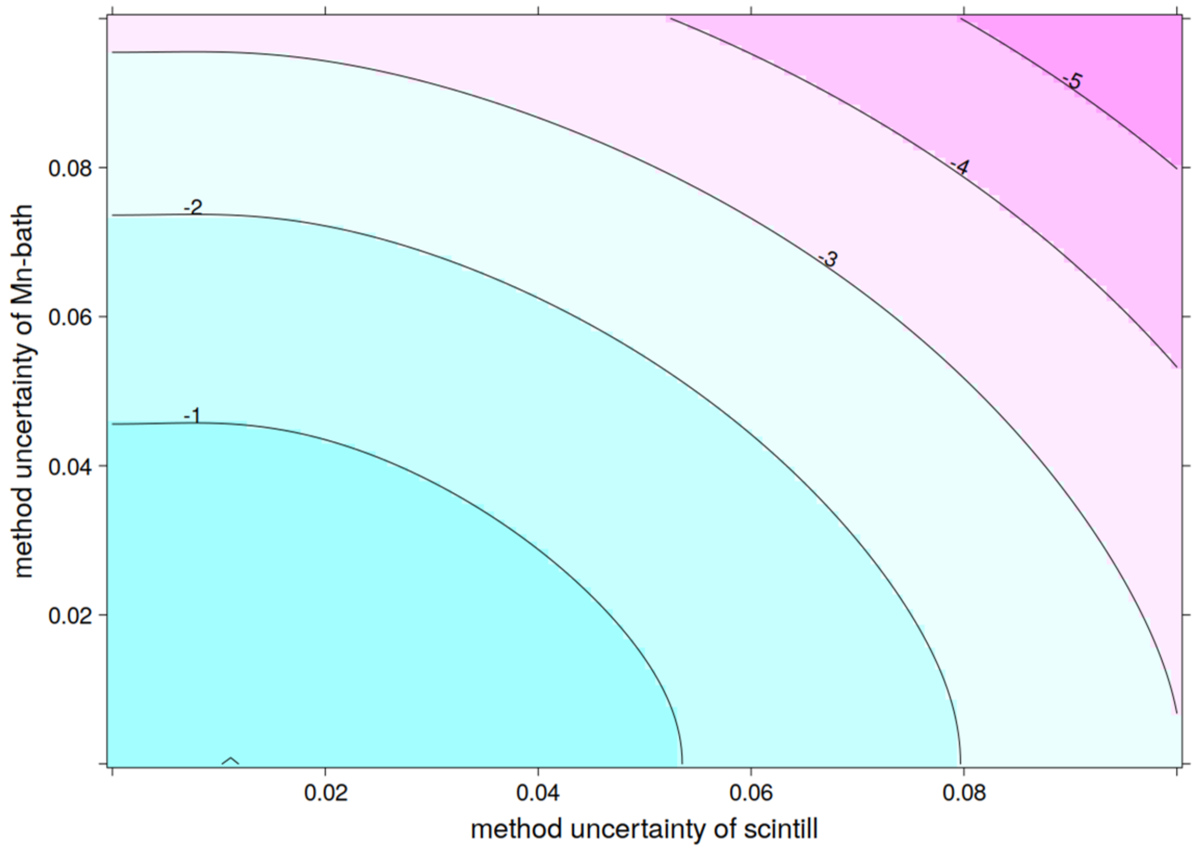
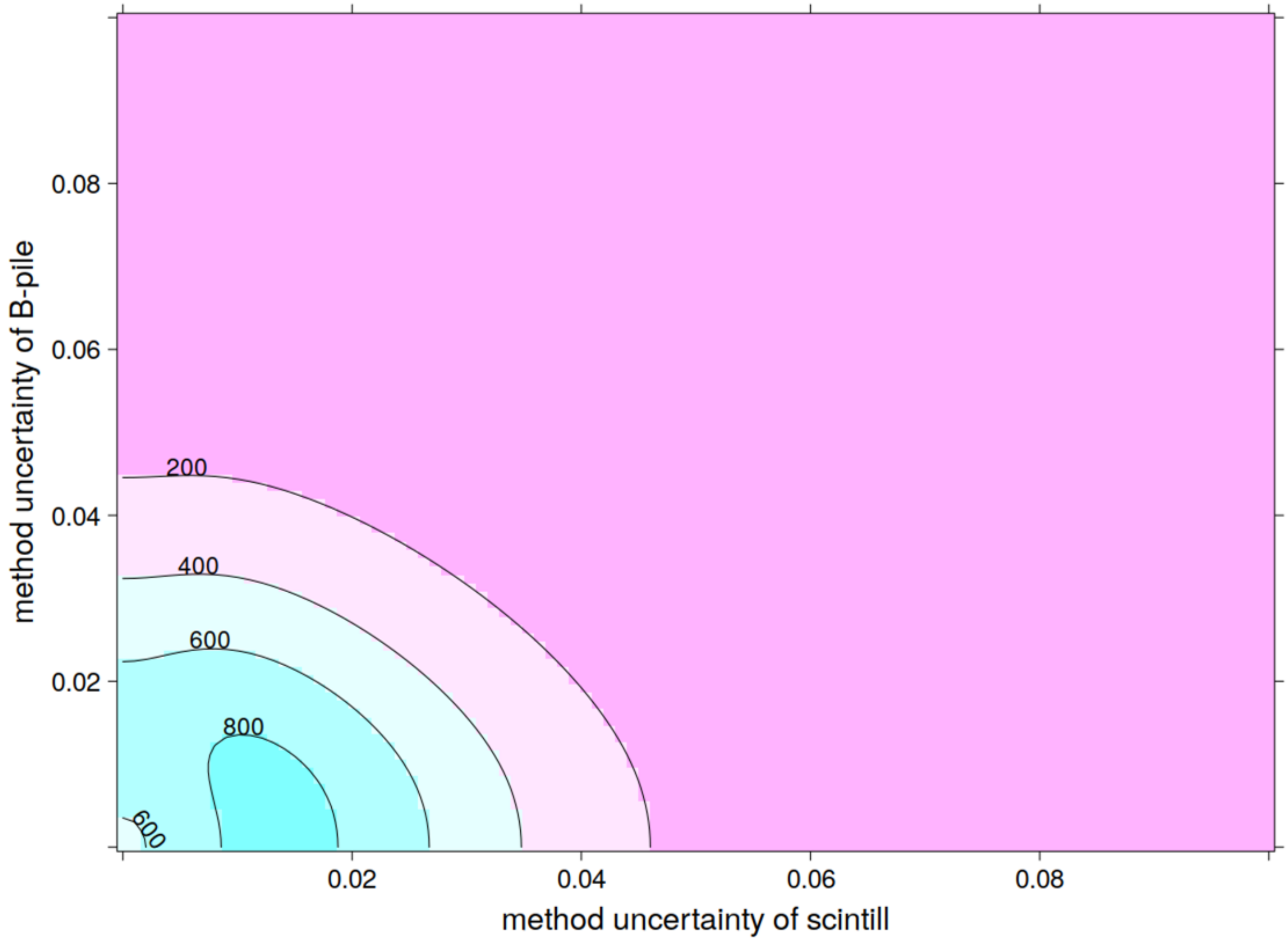
Situation 3: in two dimensions



Local non-normal features



Conclusions

- The treatment of cov_{exp}. is paramount for the resulting cov_{eval}.
- Wanted: A standardized way to report how experimental data is treated.
- A MLO technique to handle experimental data is presented. Can be used
  - to treat inconsistent experimental data
  - set limits to unrecognized systematic uncertainties.
  - Statistical well-founded
  - Transparent
  - Complements expert judgement
- The assumptions on the prior and type of uncertainties can be important.
  - Expert knowledge still important.

References

- P. Helgesson et al. "Assessment of Novel Techniques for Nuclear Data Evaluation"; Conference: 16th International Symposium of Reactor Dosimetry (ISRD16); (2017)
- G. Schnabel, Fitting and Analysis Technique for Inconsistent Nuclear Data, Proc. of MC2017, 2017