WANDA session on Covariances/ Sensitivity/ Uncertainties/ Validation and its Impact on Application

Denise Neudecker WANDA 2020

Speakers of session: D. Neudecker, A. Sonzogni, T. Bailey, B. Rearden, K. Parsons, B.J. Marshall, K. Wendt, M. Rising, F. Bostelmann, V. Sobes

The gist of this session:

Nuclear data uncertainties limit the precision and/ or accuracy of predictive application simulations. **If nuclear data uncertainties are wrong, so are the economic, safety and performance margins of our application simulations.**

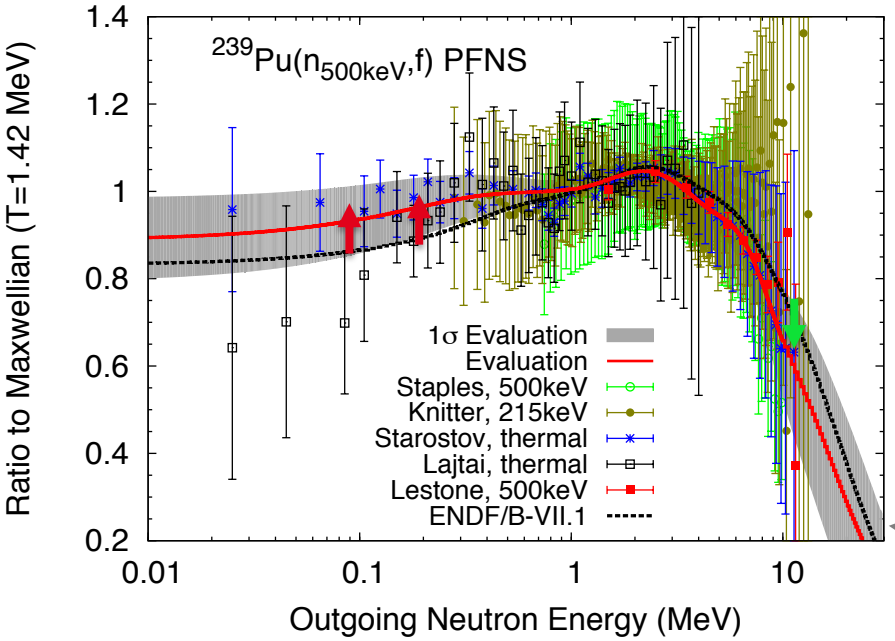
Questions here:

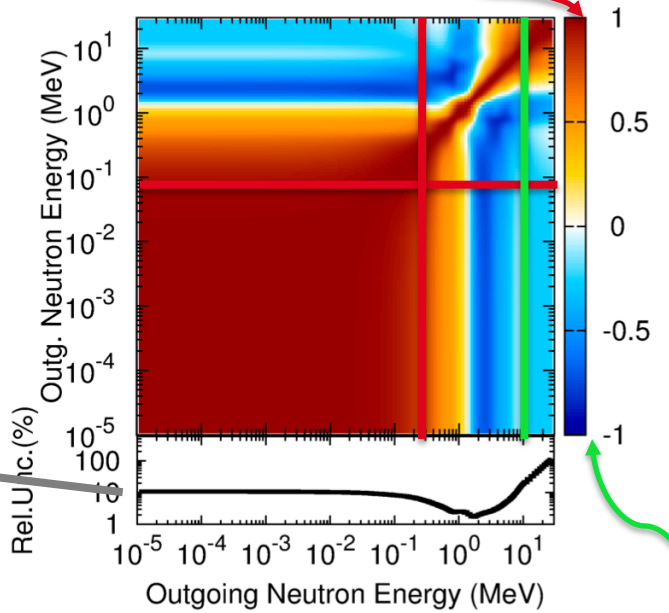
- Where do we have have problematic nuclear data uncertainties affecting many application areas leading to $$$ lost, too large or small margins, etc.?
- How can we solve these problems such that we provide more reliable application margins?

Structure of this introduction:

- What are covariances, uncertainties and sensitivities?
- Pipeline of nuclear data (covariances)
- Example: issues at the beginning of the nuclear data pipeline can impact applications at the end
- Session Structure
- Charge

What are covariances: the diagonal contains uncertainties, the off-diagonal correlations.





Full positive correlation

Uncertainty on each value

Full negative correlation

Nuclear data covariances provide an estimate of fidelity of nuclear data mean values.

What are sensitivities: how does a simulated response change due to differences in nuclear data

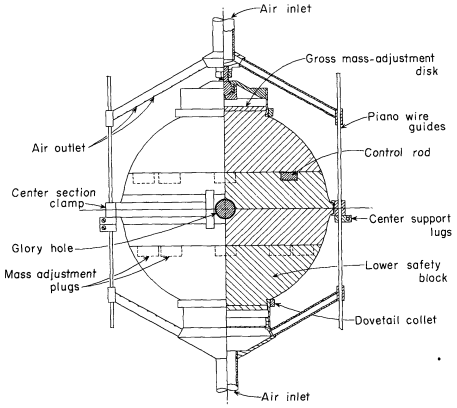
Sensitivities enable:

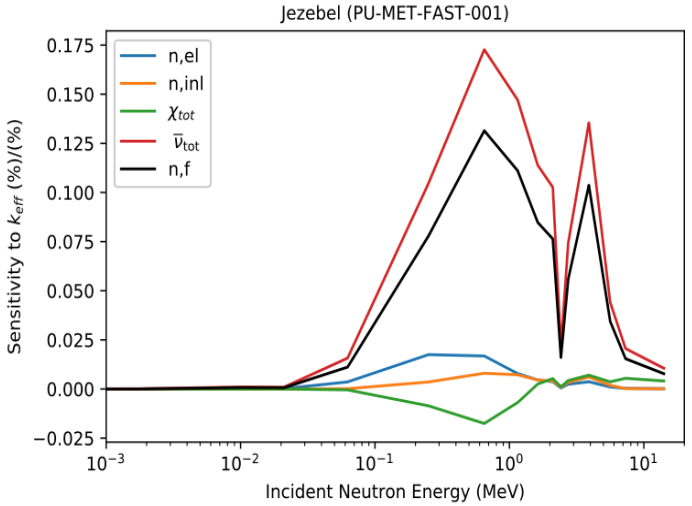
- Assessing impact of changes in nuclear data on application simulations.
- Forward-propagate nuclear data covariances to application quantity uncertainties.

Example

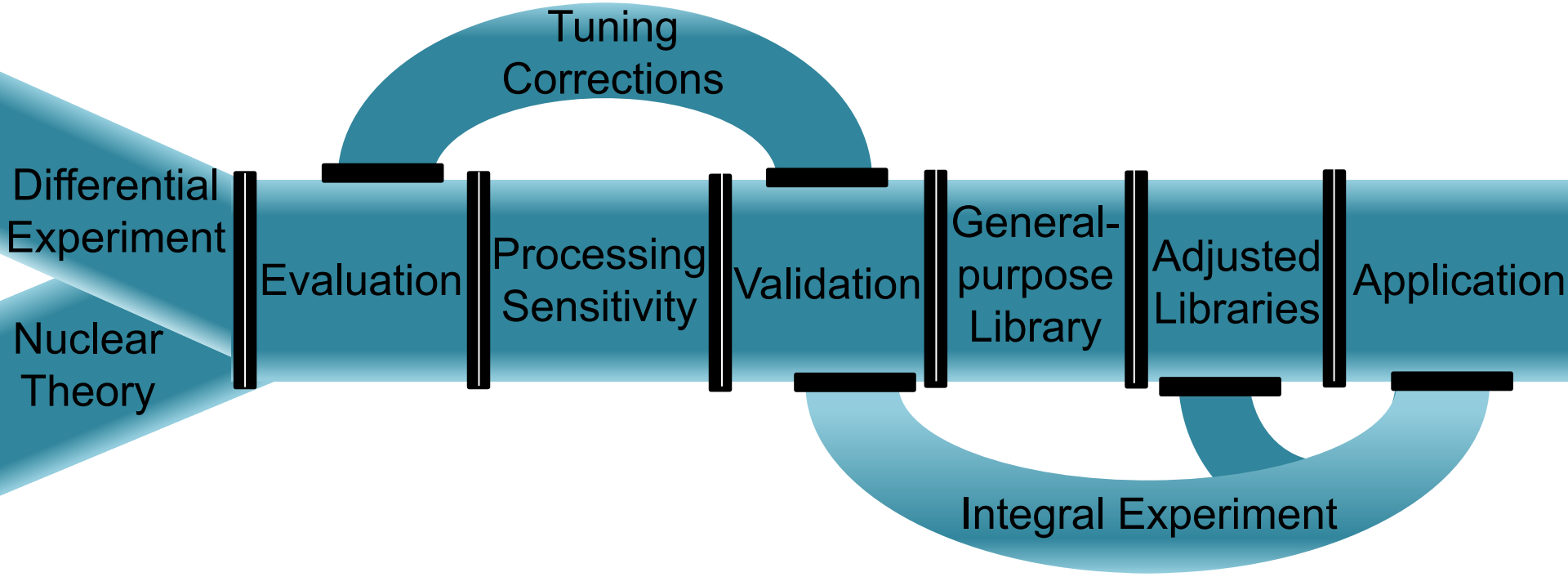
Sensitivity of criticality of Jezebel to nuclear data.

$$\text{Sensitivity} = \frac{\sigma}{k}\frac{dk}{d\sigma}$$

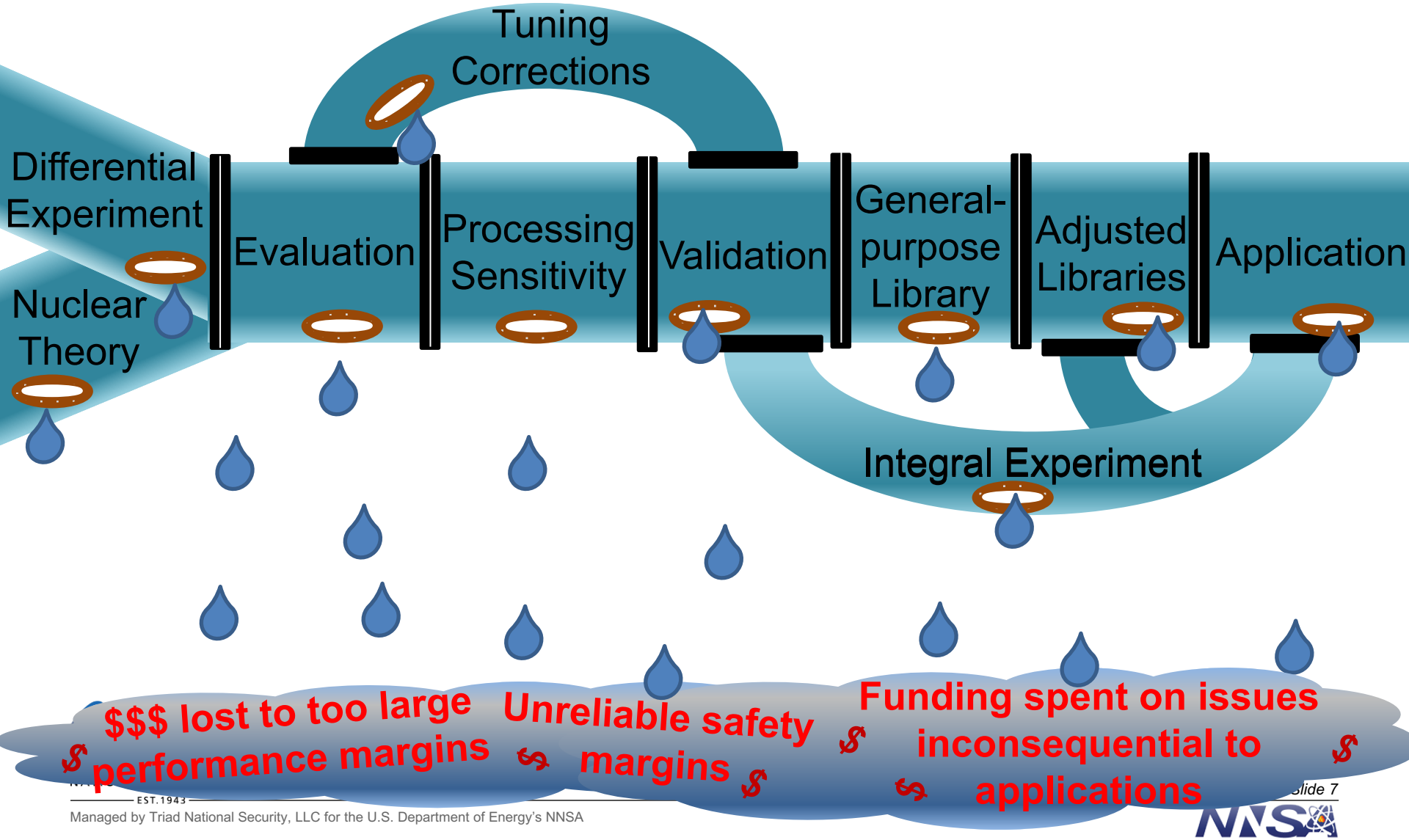




The nuclear data (covariance) pipeline.



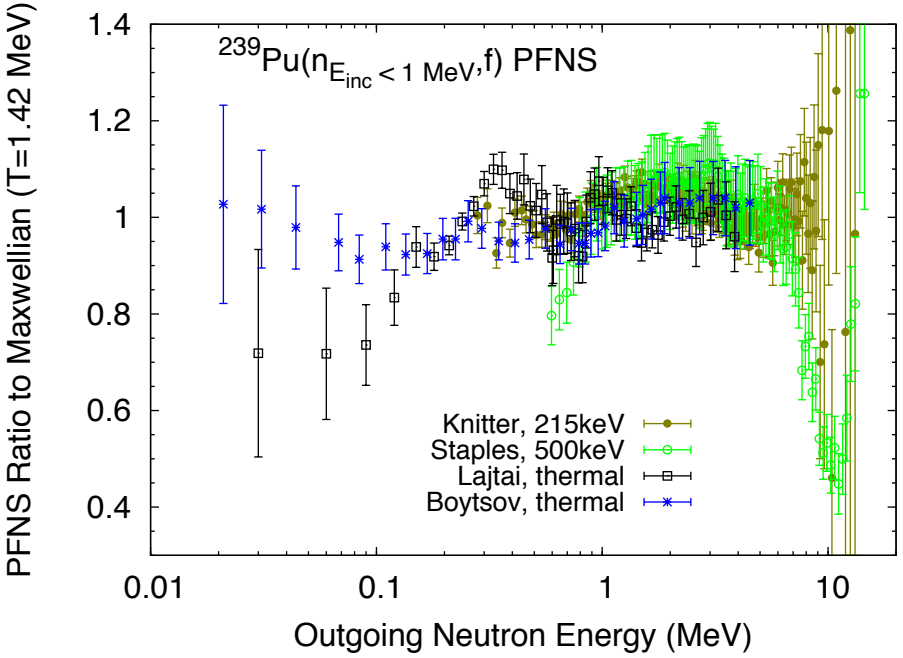
There are some leaks in the (covariance) pipeline



Differential Experiment

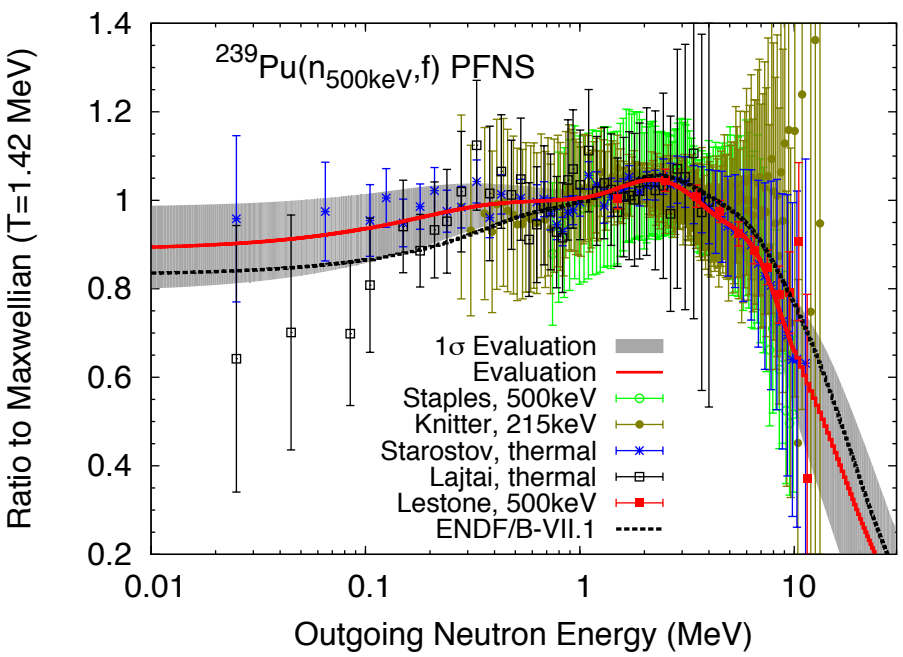
Problems at the beginning of the pipeline: EXFOR uncertainties can be misleading.

Taking Unc. from our ND experimental database



EXFOR is great but data should not be blindly adopted!

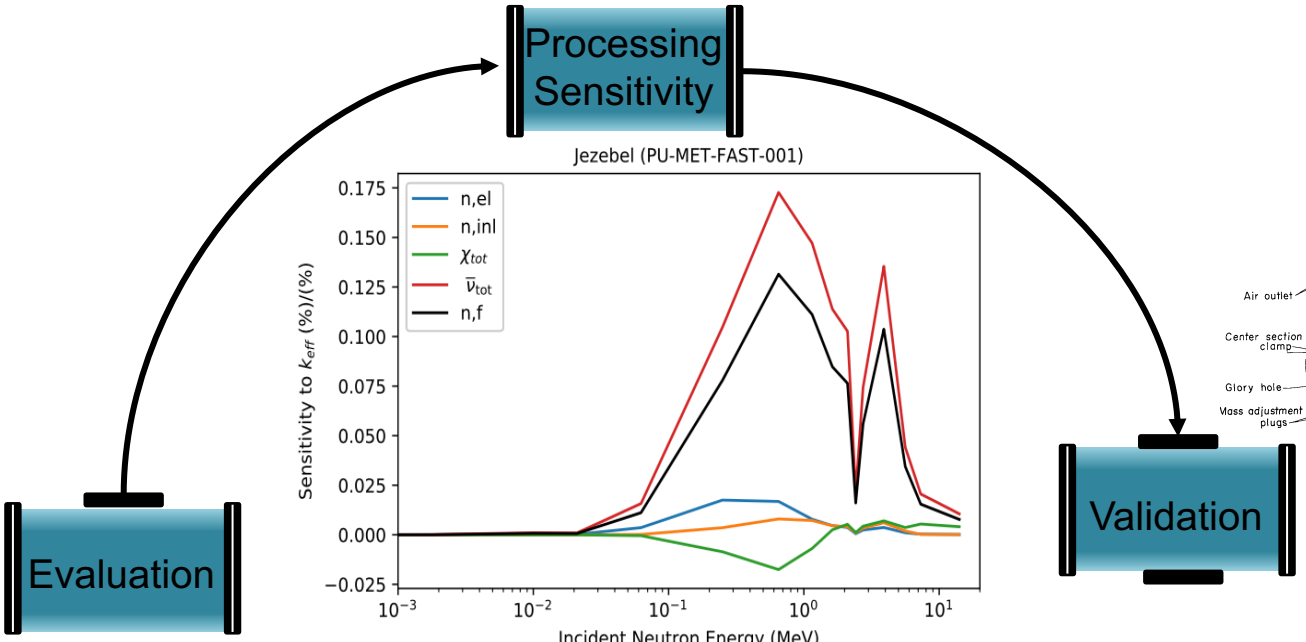
Detailed uncertainty estimate

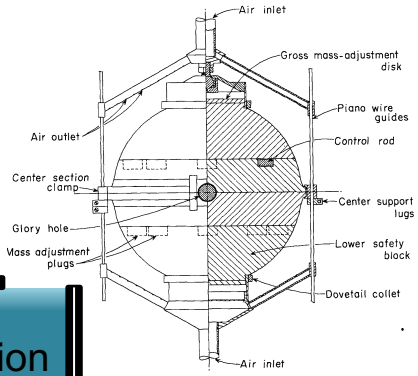


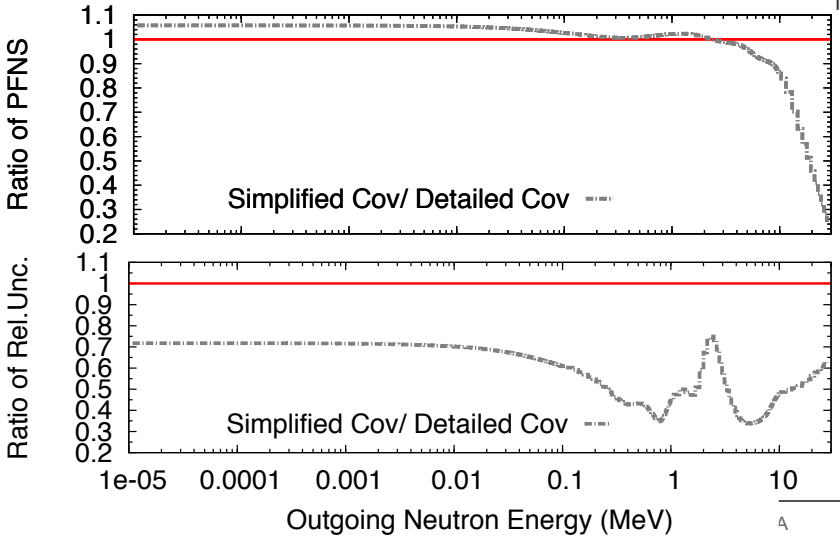
Experimentalists and evaluators analyzed unc.

PFNS: energy distribution of prompt neutrons released after fission.

Lesson learned: Issue in any part of pipeline can critically impact application simulations!





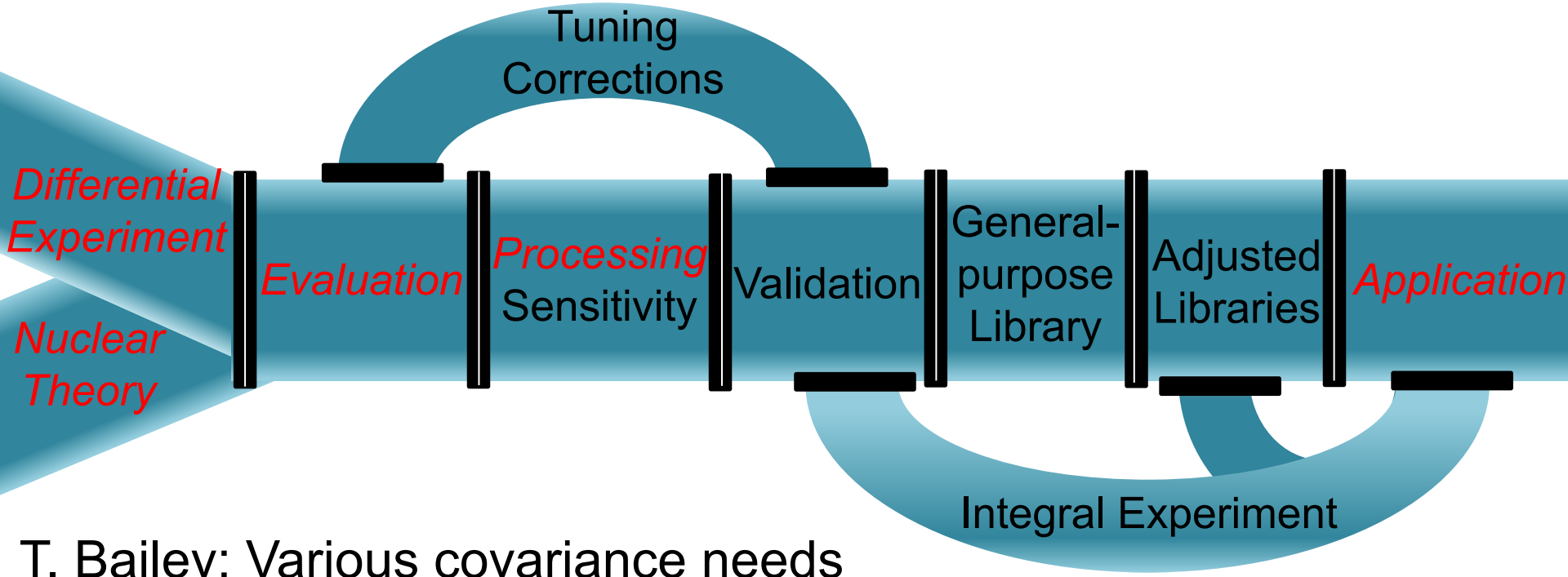


Change in Jezebel k_{eff} *195 pcm!!!* *(2/3rd of difference between delayed and prompt critical)*

Drop in Jezebel k_{eff} unc. due to PFNS uncertainty: -69% !!!

National Nuclear Security Administration

Topic 1: Which covariances in current US libraries are unrealistic *and* impact various applications?

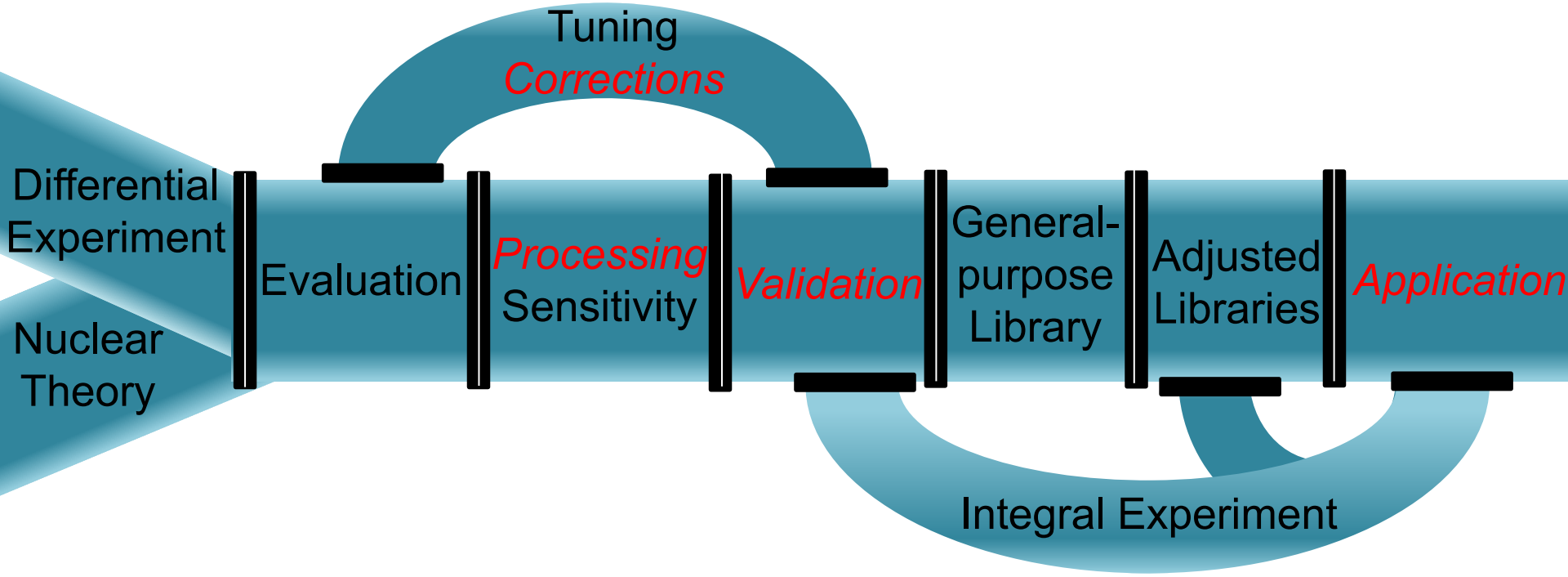


T. Bailey: Various covariance needs

B. Rearden: Covariance needs for nuclear energy, reactor physics, etc.

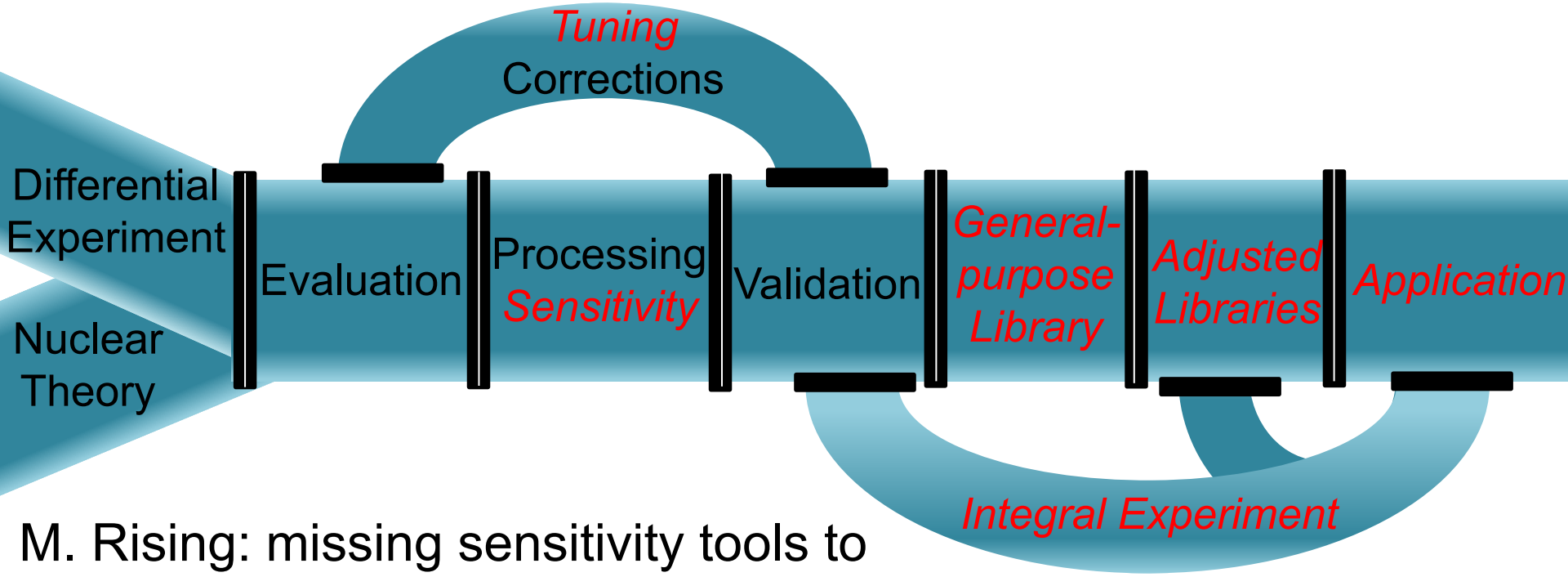
K. Parsons: angular distribution covariances.

Topic 1: Which tools are missing to find problematic covariances early on and correct?



BJ Marshall: Tools for finding problematic covariances
K. Wendt: Correcting covariances

Topic 2: How do we deliver nuclear data and covariances tailored to the needs of applications?



M. Rising: missing sensitivity tools to propagate covariances to applications.

F. Bostelmann: ENDF/B-VIII.0, the tuned general-purpose library

BJ Marshall: Adjusting nuclear data to application needs

V. Sobes: Missing integral experiments representing applications

Charge: discuss the following questions

- Which nuclear data covariances/uncertainties are clearly wrong in the current US-library *and* impact many application areas?
- Which tools are missing that help us pint-point such wrong covariances/ uncertainties early on and correct them?
- Which tools are missing enabling us to propagate nuclear data covariances to application bounds?
- Which tools and validation experiments are missing to produce nuclear data libraries representing specific application spaces?

Reminder: discussion should be collaborative.

Next talk by A. Sonzogni:

Example how FOA funds are currently enabling critically advancing our fission yield covariance capabilities:

- Before the FOA, we had **no fission yield covariances** in US nuclear data libraries.
- Now, we can even **predict their impact on applications**.