Pipeline: Users

Workshop for Applied Nuclear Data Activities 2020
Elliott School of International Affairs at The George Washington University

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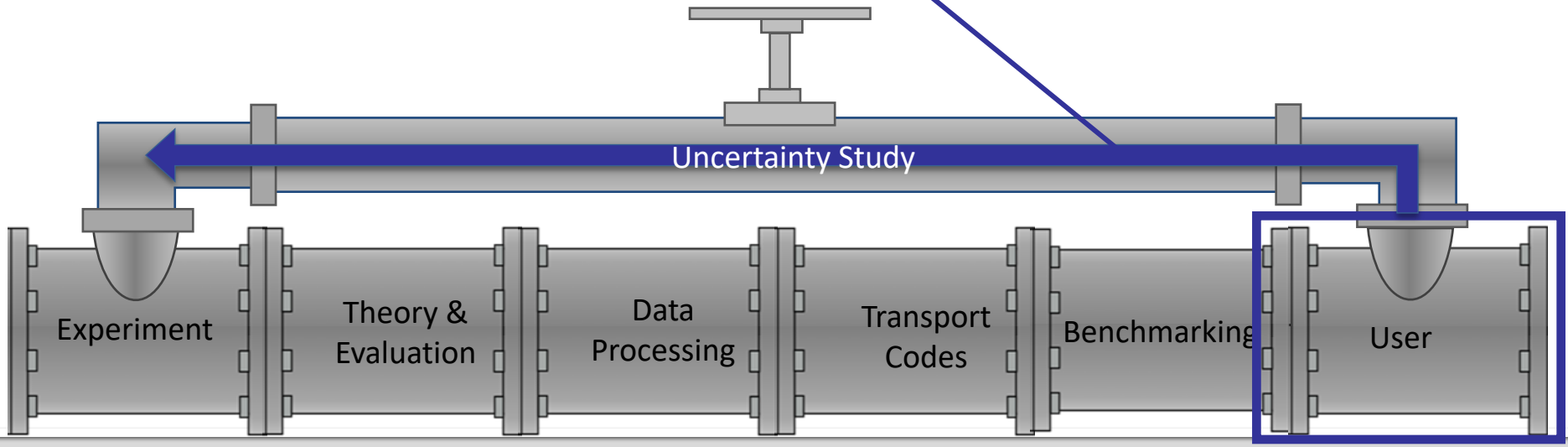
Users

Users determine impact of input distributions on applied quantities, and identify data required to reduce uncertainty.

Common Issues: Credibility and availability of input distributions, methods for disentangling correlated reactions, methods for identifying required experiments.



Why Quantify Uncertainties?

What's in the box?

Possibility A

Possibility B

Possibility C

What was in the box?

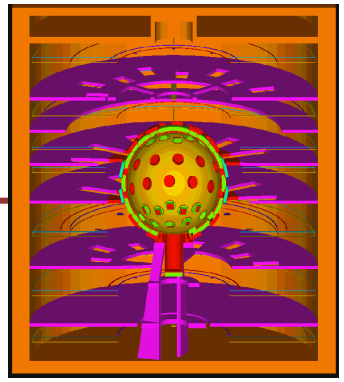
Possibility A

Possibility B

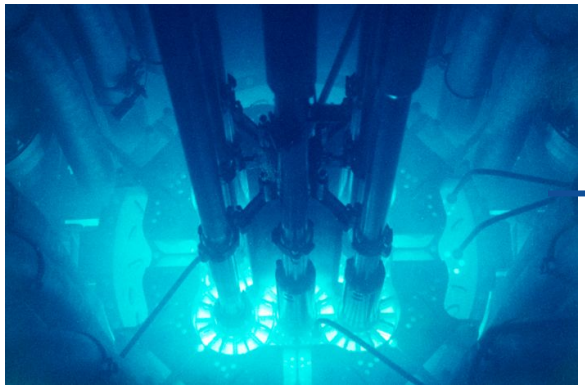
Possibility C

Will neutrons be shielded adequately?

Neutron Flux



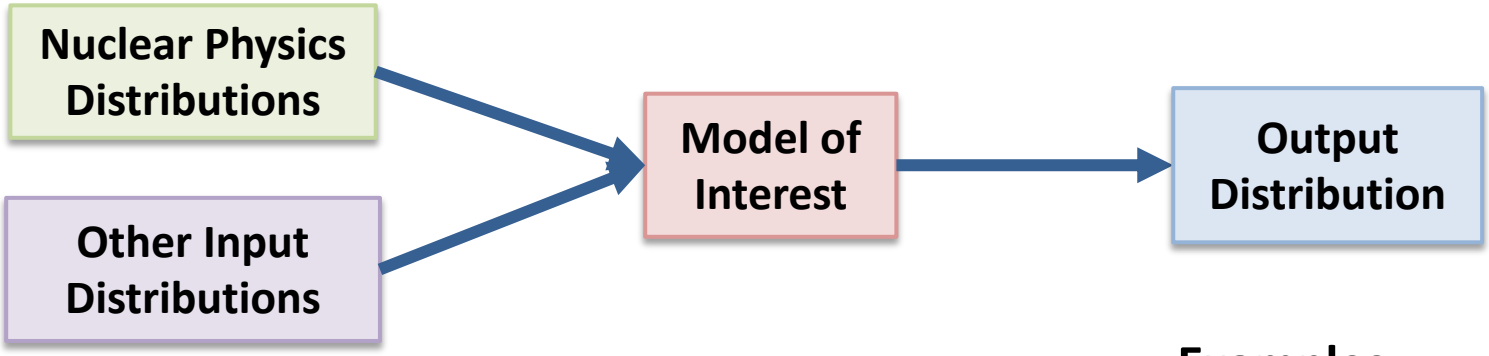
Will this perform to specification?



Criticalilty

Uncertainty Quantification helps inform decision makers, and identifies sources of uncertainty that could be reduced.

What is Uncertainty Quantification?



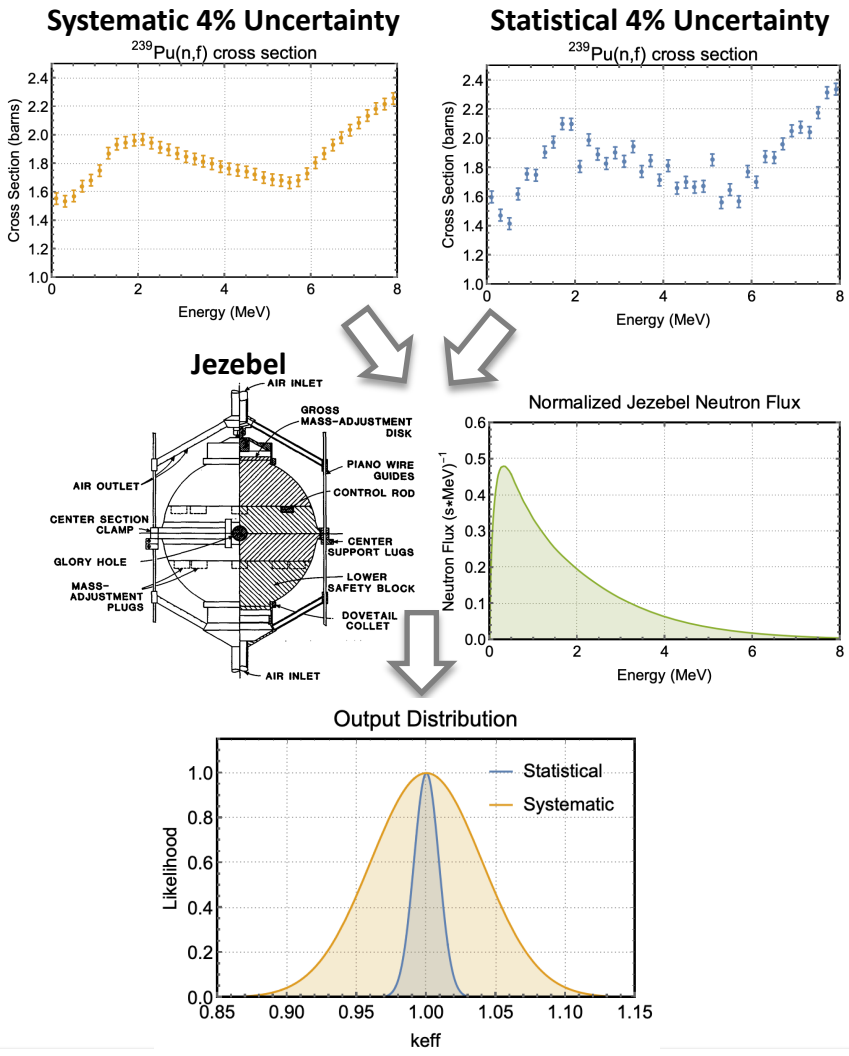
Forms of Uncertainty Propagation

- UQ involves propagation of uncertainties through models of interest, and analysis of output distributions.
- Sensitivity studies useful as an intermediate step.
- Inverse UQ using experimental output data is relevant to some applications, and can produce constrained input distributions.

Examples

- Sensitivity analysis of output: $\frac{\partial y}{\partial x_i}$
  - One-at-a-time, adjoint methods, regression.
- Uncertainty propagation:
  - Linear: $\sigma_y^2 = \sum_{ij} \frac{\partial y}{\partial x_i} \Sigma_{ij} \frac{\partial y}{\partial x_j}$
  - Monte Carlo sampling:
    - $\Sigma = C^T C$ (e.g. PCA: $C = \sqrt{D}V$)
    - $s = \mu + C^T g$ where g is random Gaussian vector.

Example of Covariance in Nuclear Physics



Nuclear Physics Distributions

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Model of Interest

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Output Distribution

- Uncertainties in nuclear data libraries stored using covariance matrices, which includes correlations between energies.
- For applications where neutron flux is broad distribution, correlated uncertainties can have larger contribution than uncorrelated.
- Properly quantifying correlations in experiment and evaluation is very important (e.g. templates).

User Issues

- Requires credible uncertainties, otherwise garbage-in/garbage-out or nothing-in/nothing-out.
  - How best to validate covariances?
  - How best to fix bad or missing covariances?
- Challenging to quantify impact of individual reactions when sampling from correlated reactions.
- Best method to define required experiment.
  - Replace existing evaluation with hypothetical experiment?
  - Trust existing evaluation and identify constraints that most impact applications?
  - Work with evaluator?