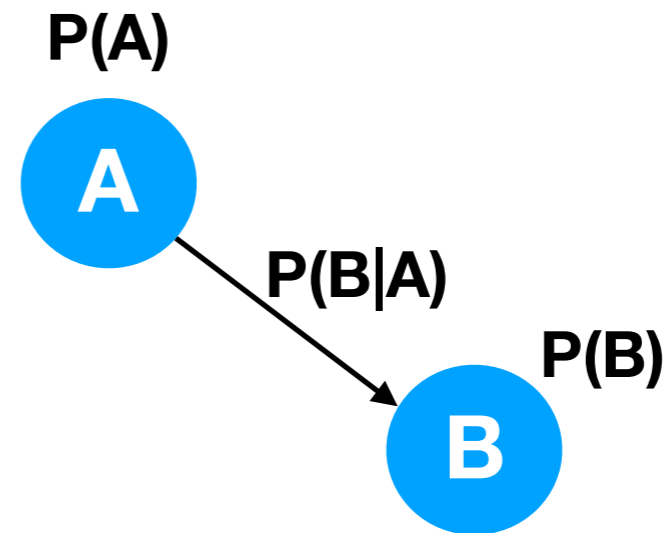


The Nuclear Data Belief Network

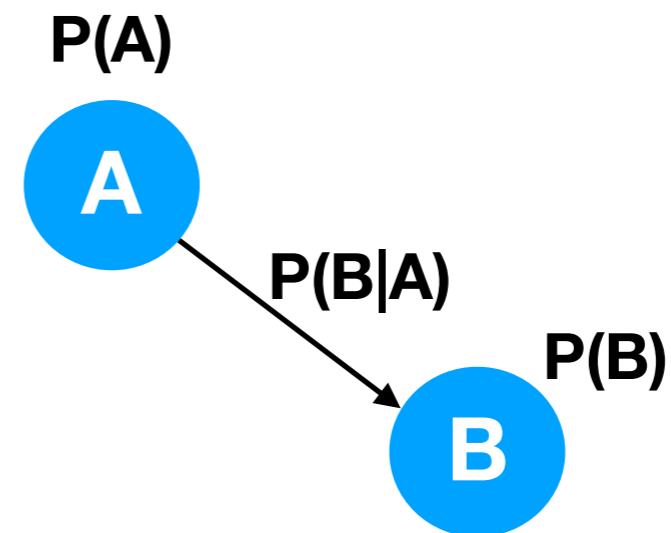
A belief network is a DAG that encodes probabilities

- Belief is the unconditional probability associated with a node, $P(A)$
- Forward problems follow arrows, associated with conditional probabilities, $P(A|B)$
- Inverse problems run against flow, use likelihood $L(A|B)$ gotten from Bayes' theorem
- Assimilation is an inverse problem, runs against flow



$$\begin{aligned} P(A|B) &= P(B|A)P(B)/P(A) \\ &= L(A|B) \\ &= \text{likelihood that B explains A} \end{aligned}$$

Bayesian update procedure tells us how to update belief as add nodes

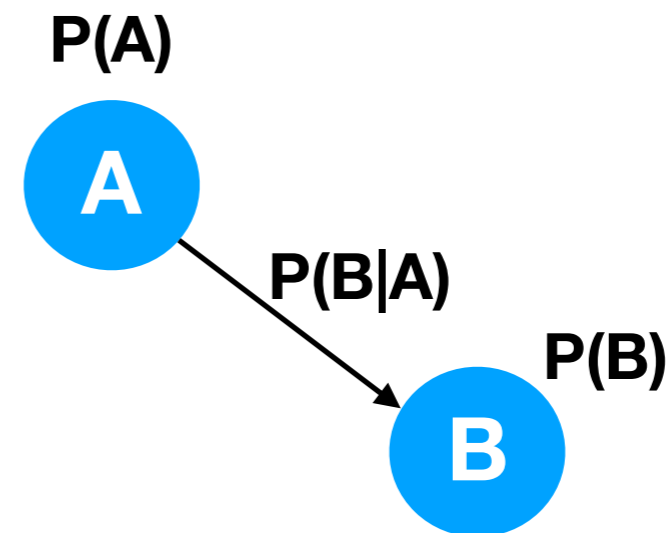


- Belief ...

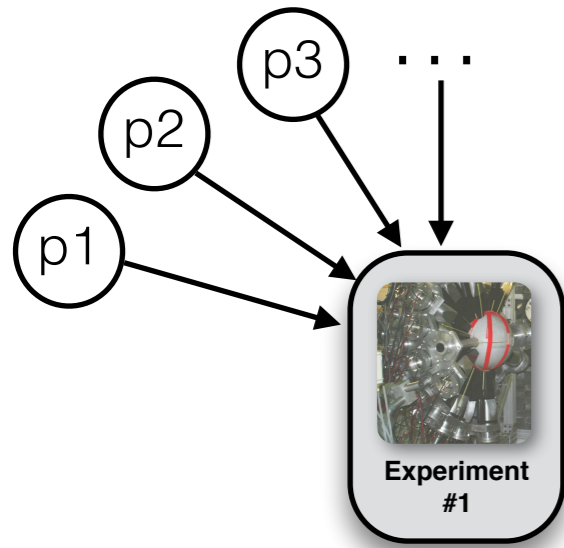
$$\begin{aligned} P(A|B) &= P(B|A)P(B)/P(A) \\ &= L(A|B) \\ &= \text{likelihood that B explains A} \end{aligned}$$

A Gaussian process regression (GPR) model assumes all probabilities are Gaussian

- A GPR is characterized with a set of mean values $\langle A \rangle$, $\langle B \rangle$ and covariance $\text{cov}(x)$ where vector x given by $x=(A,B)$
- Bayesian updates with Gaussians easy with Sandwich Formula, etc.



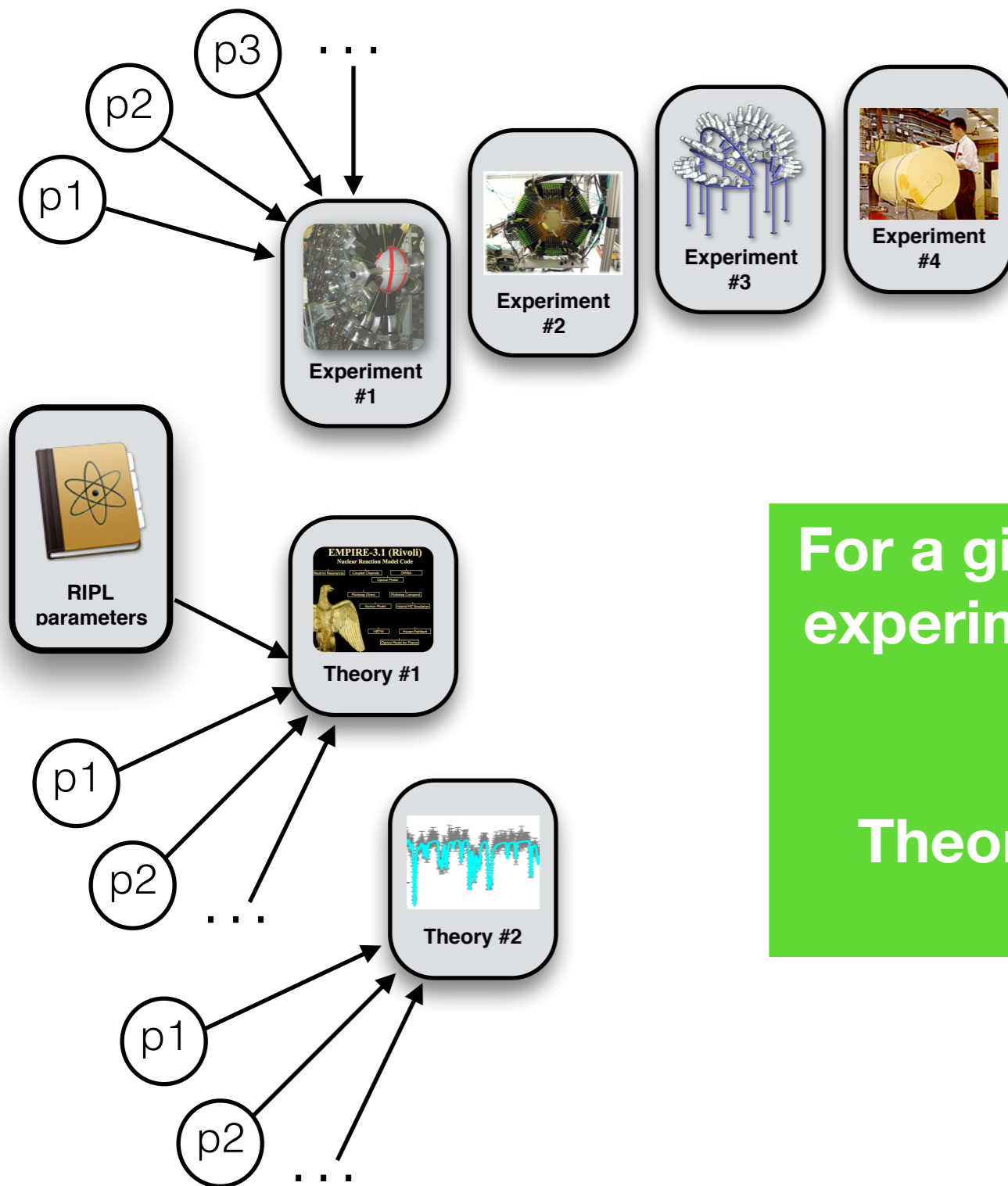
$$\begin{aligned} P(A|B) &= P(B|A)P(B)/P(A) \\ &= L(A|B) \\ &= \text{likelihood that B explains A} \end{aligned}$$



Experiments report a GPR model of say $\sigma(E)$
(at least this is what is reported in EXFOR)

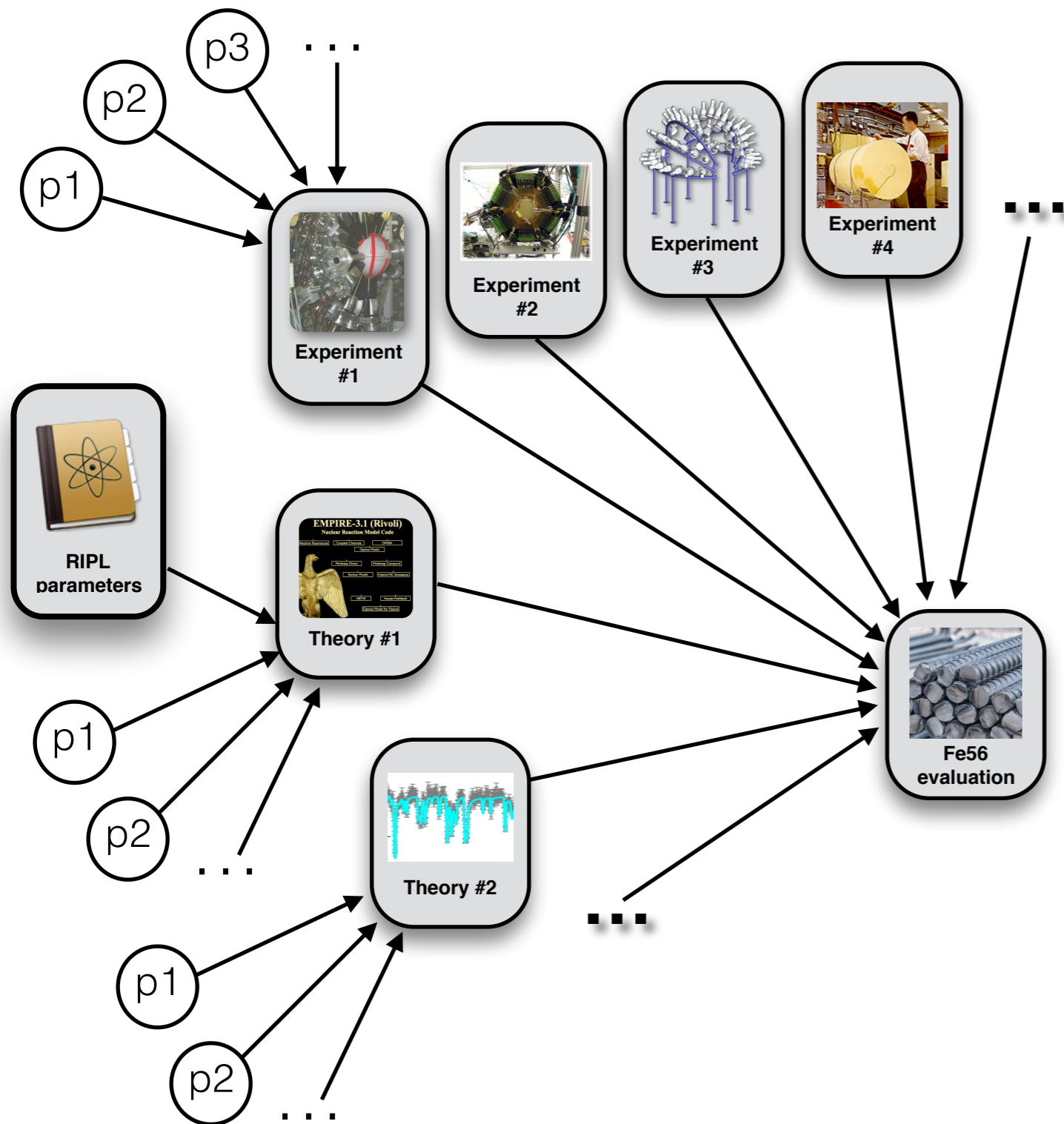
This model depends on a lot of parameters:

- Target thickness
- ToF corrections
- ...
- and data itself



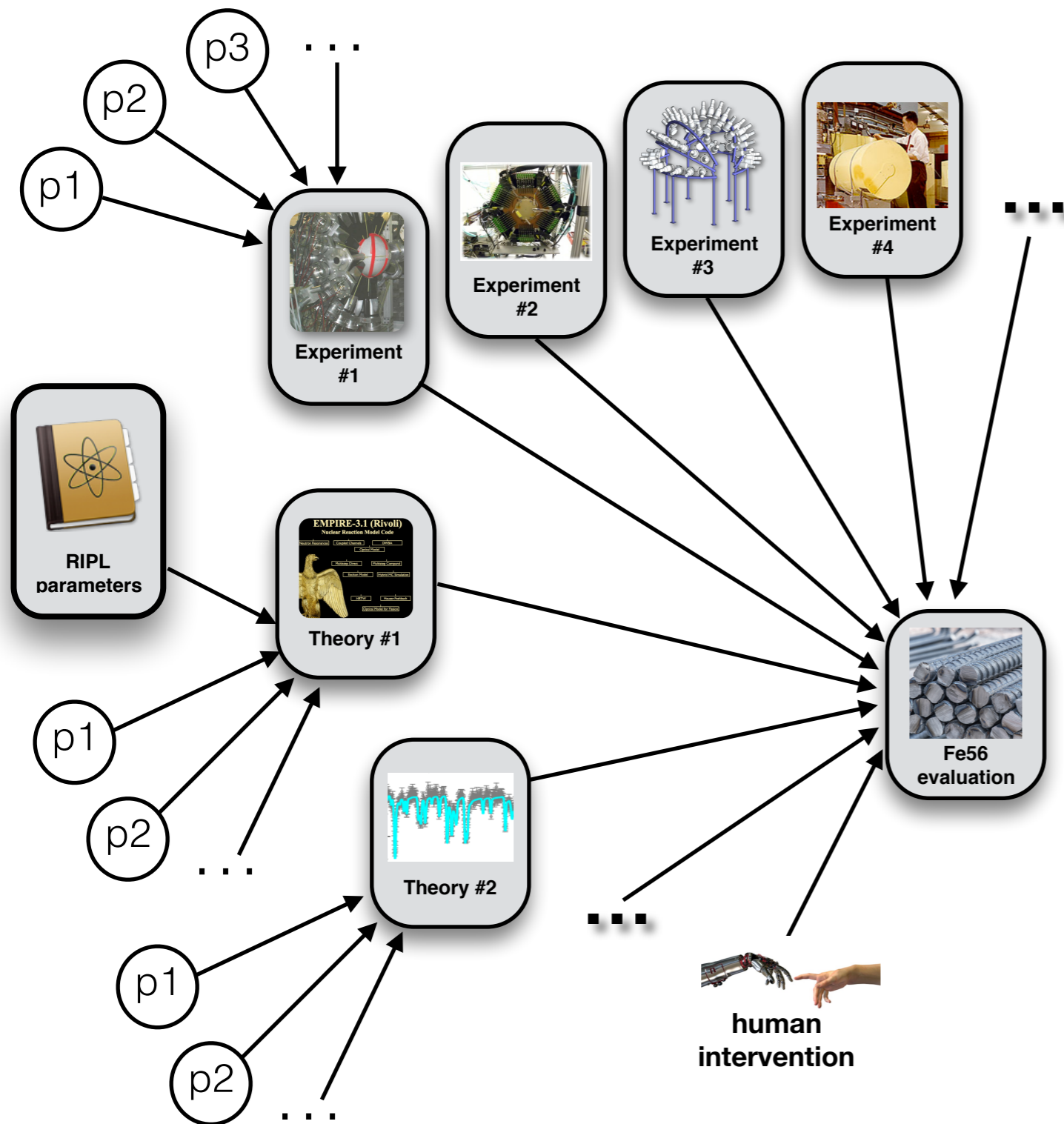
For a given observable, there are many experiments, and often several related observables

Theory aims to explain each with a parametric form



An evaluation is supposed to be a GPR model of observables required by a class of applications

Mean values & covariances determined by using theory as regression model of data



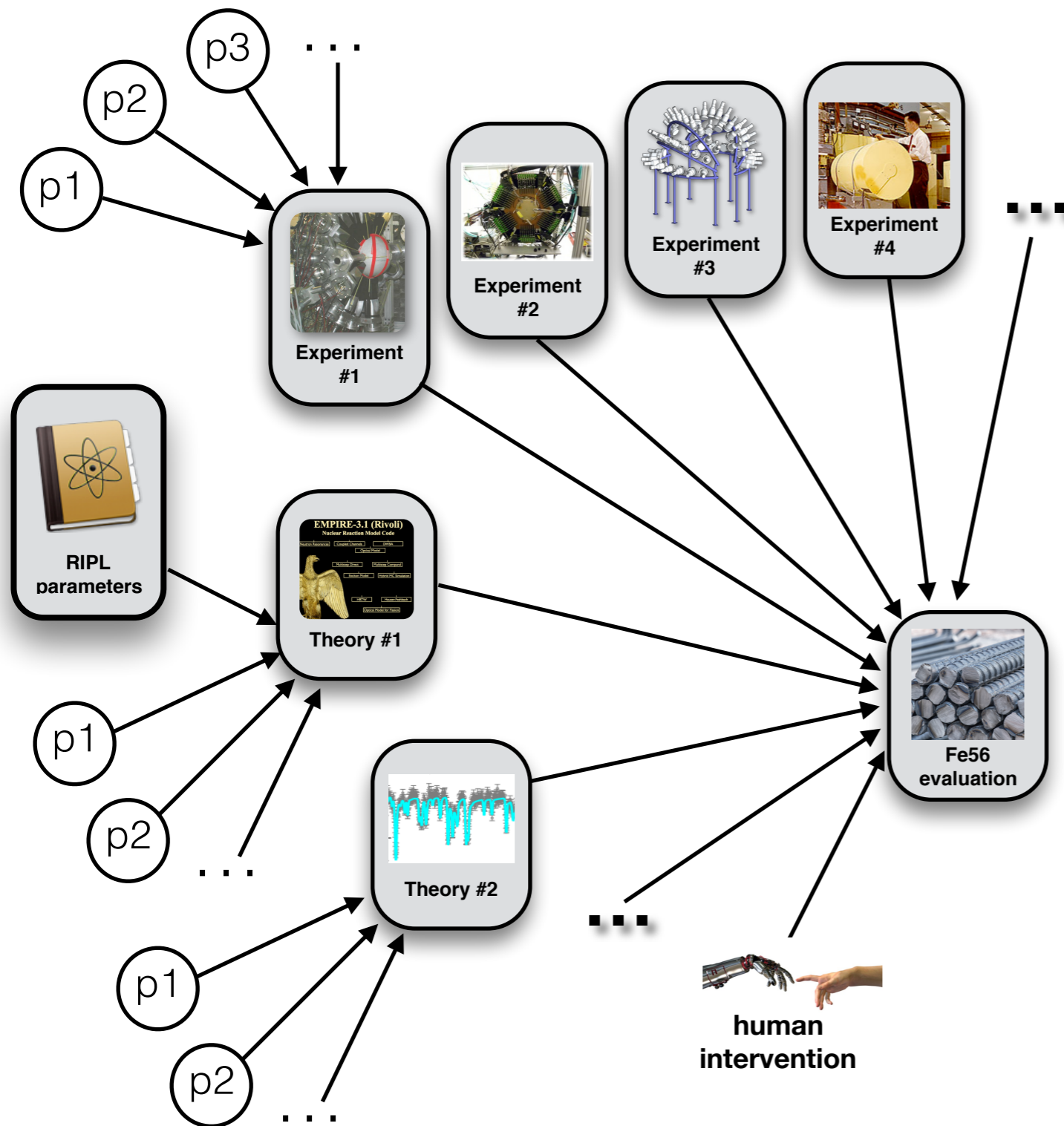
An evaluation is supposed to be a GPR model of observables required by a class of applications

Mean values & covariances determined by using theory as regression model of data

Humans are needed:

- model misfit
- discrepant data

Humans introduce bias and are not “automatable”



An evaluation is supposed to be a GPR model of observables required by a class of applications

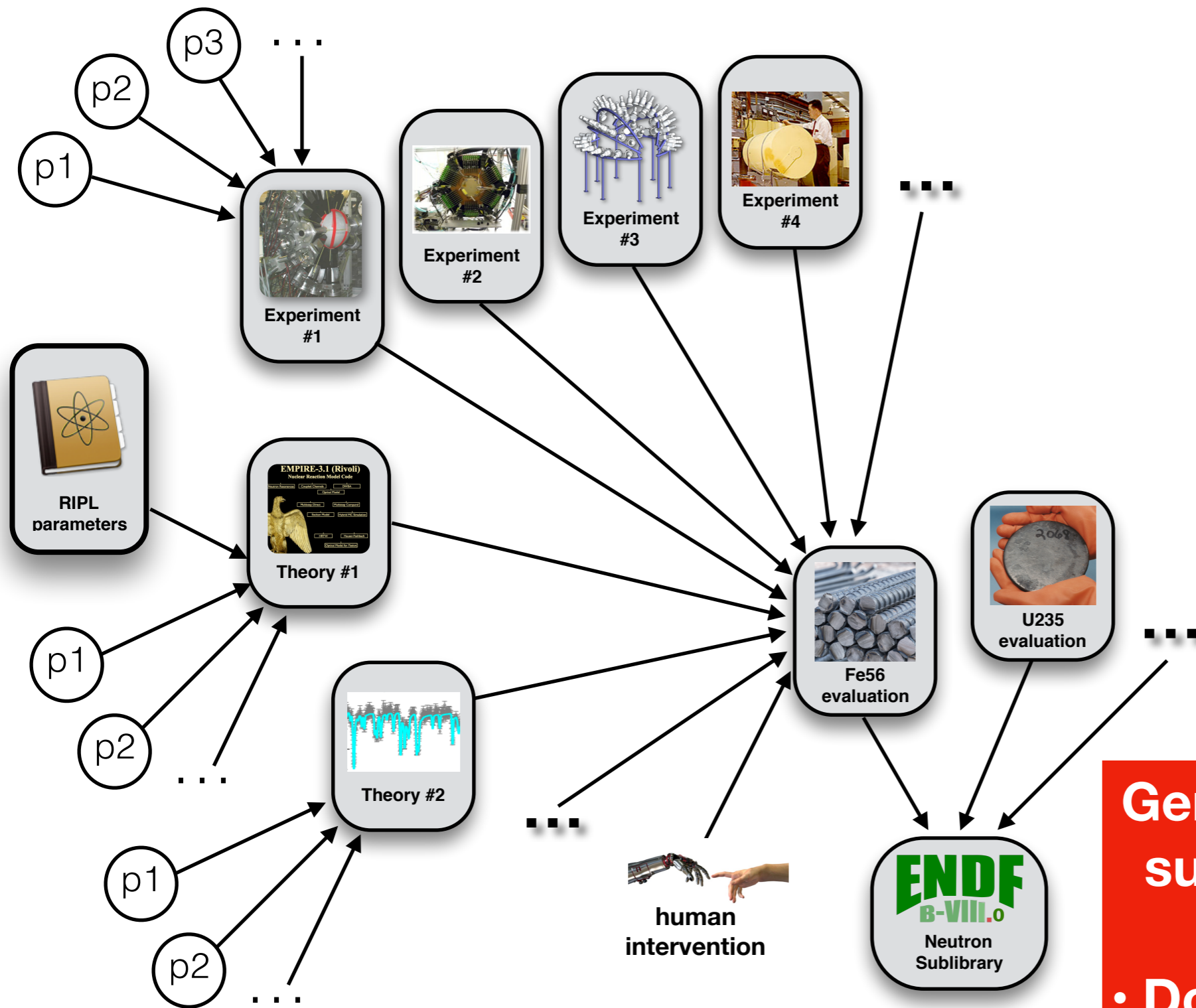
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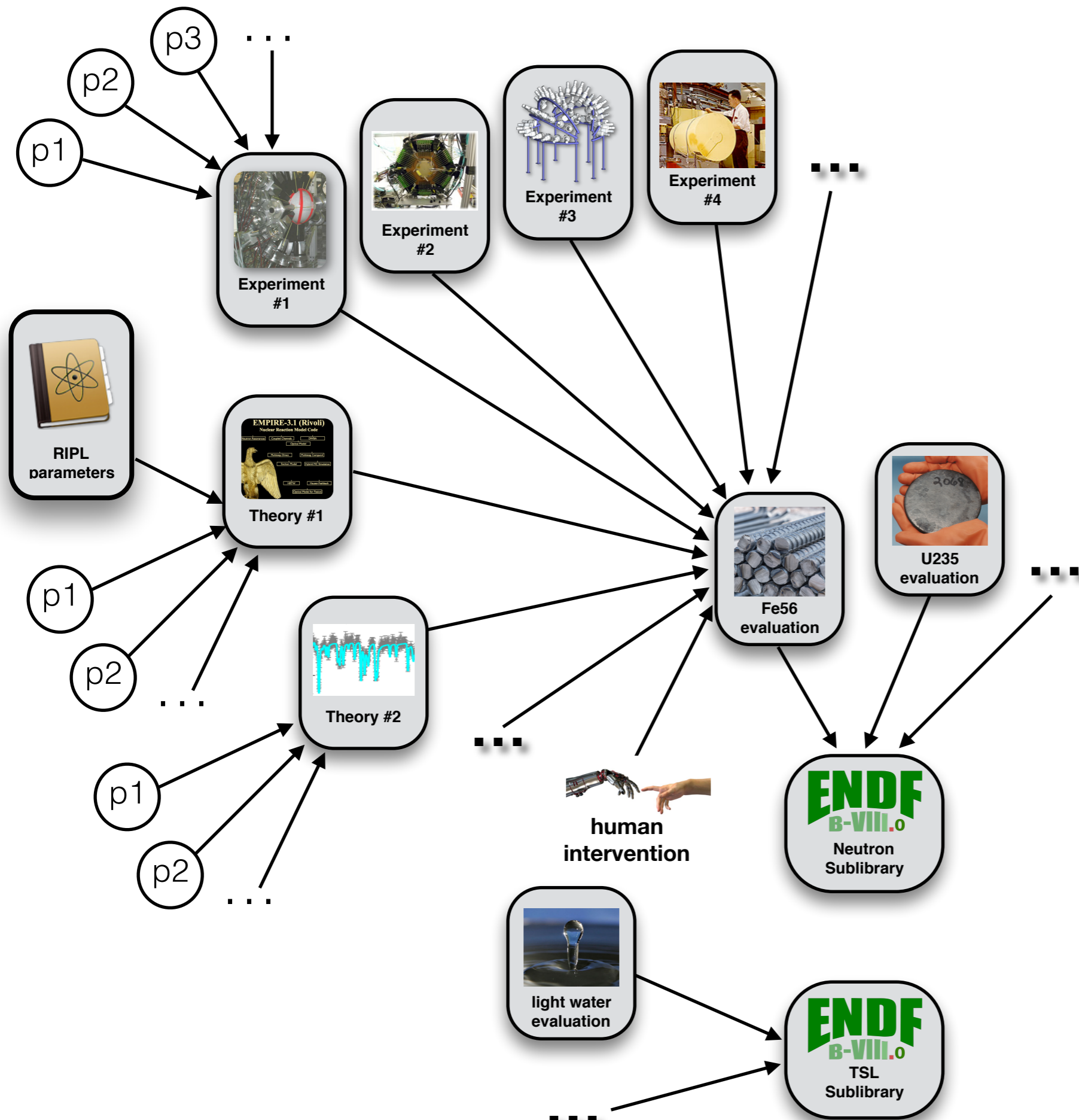
Humans introduce bias and are not "automatable"

Ongoing work removing the humans:
G. Schnabl, H. Sjostrand,
H. Leeb, D. Neudecker, ...



Generating a processed sublibrary can change the GPR too:

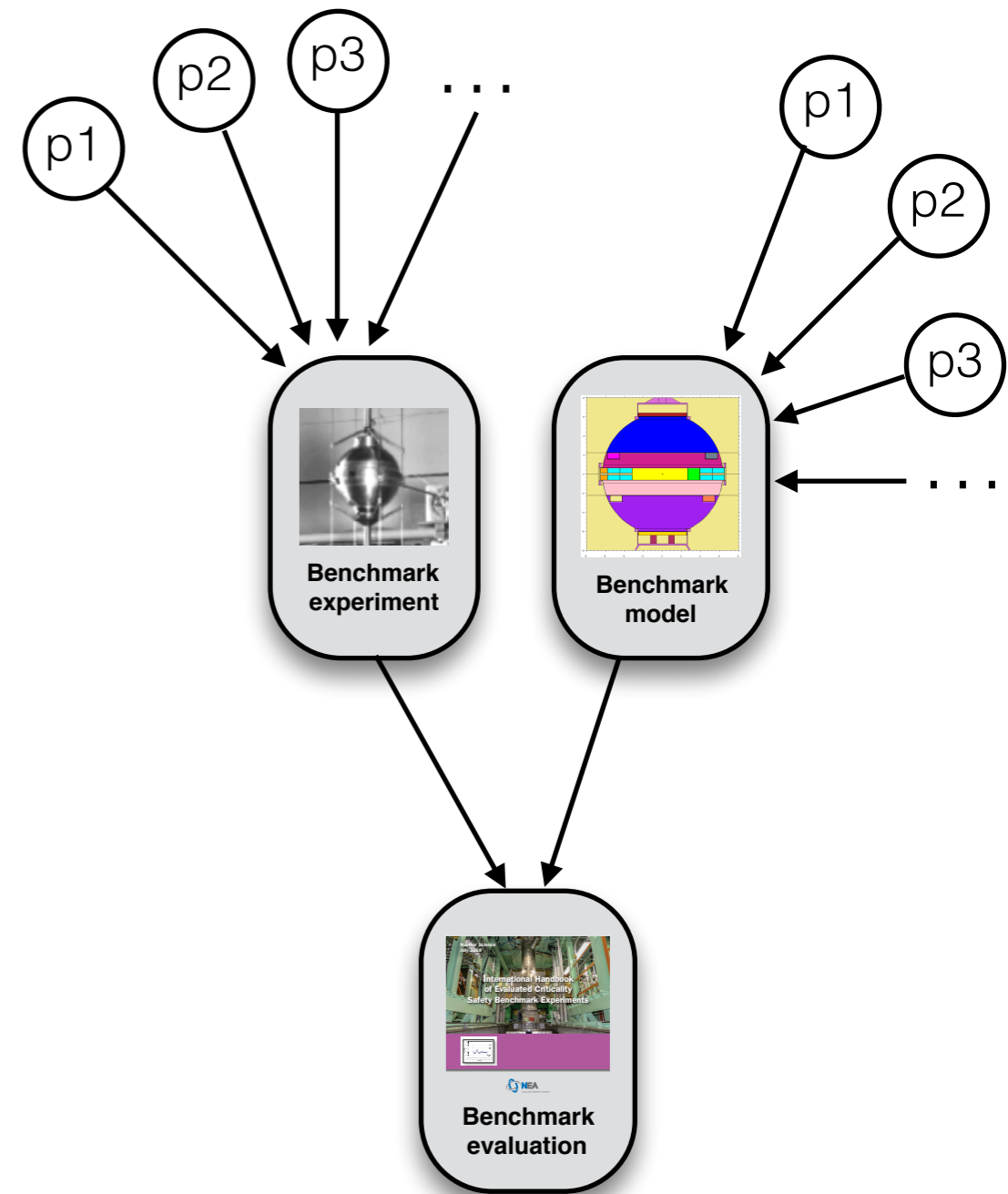
- Doppler broadening
- Grouping



Multiple processed sublibraries are needed in practice

Benchmarks have their own belief network

ICSBEP proves GPR model of fielded experiment and simplified GPR models

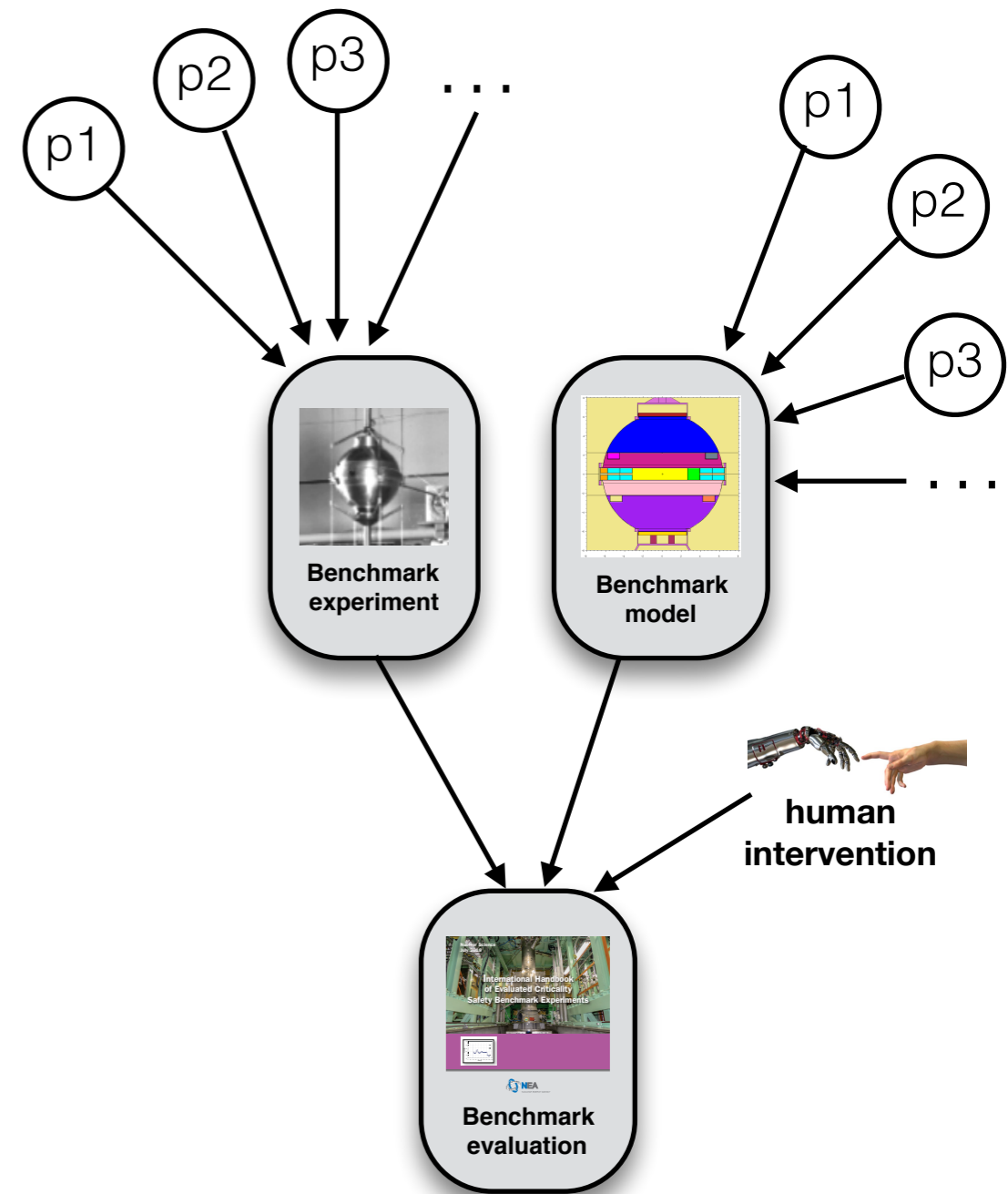


Benchmarks have their own belief network

ICSBEP proves GPR model of fielded experiment and simplified GPR models

Humans may have intervened too much too:

- model homogenization
- ...



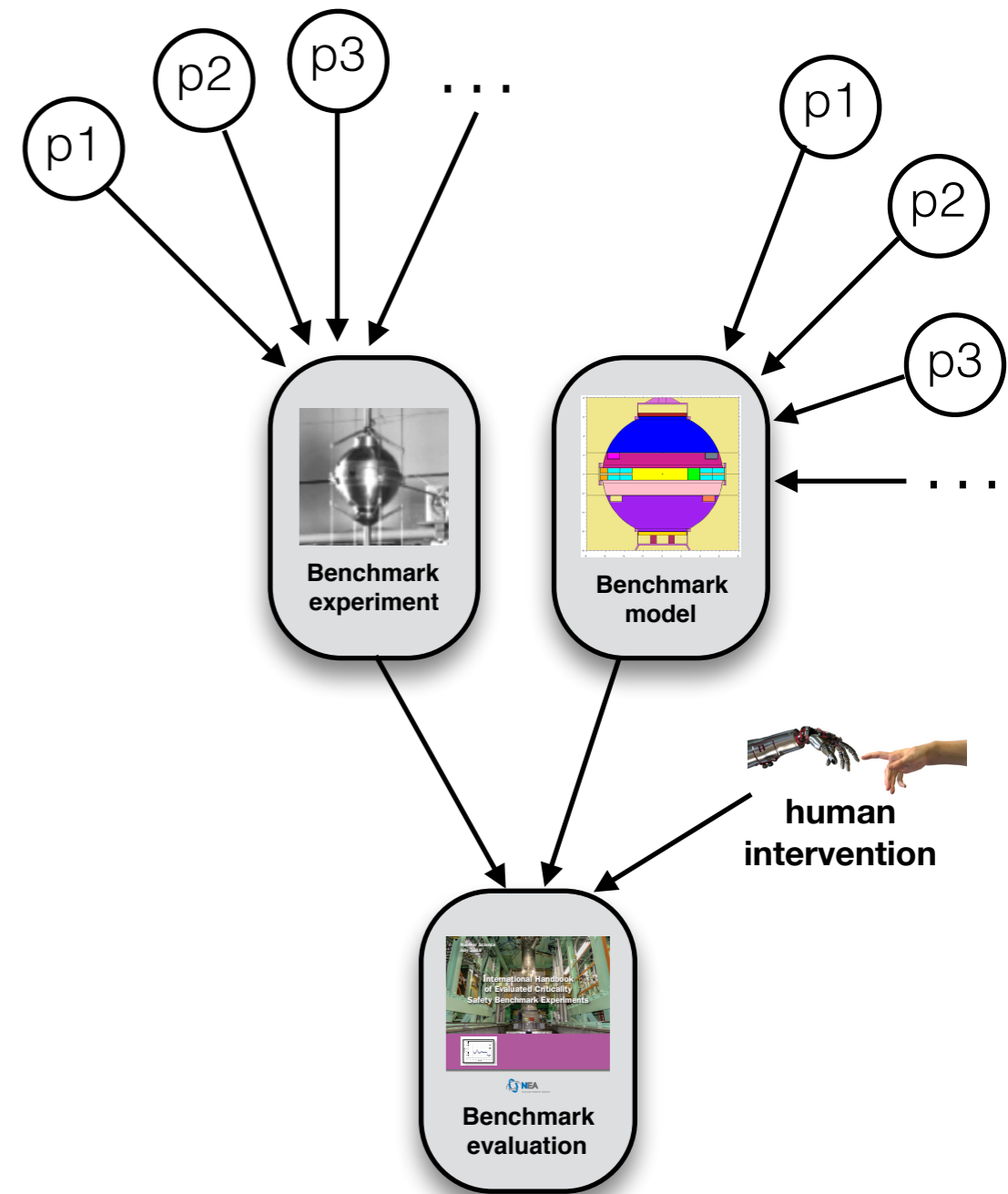
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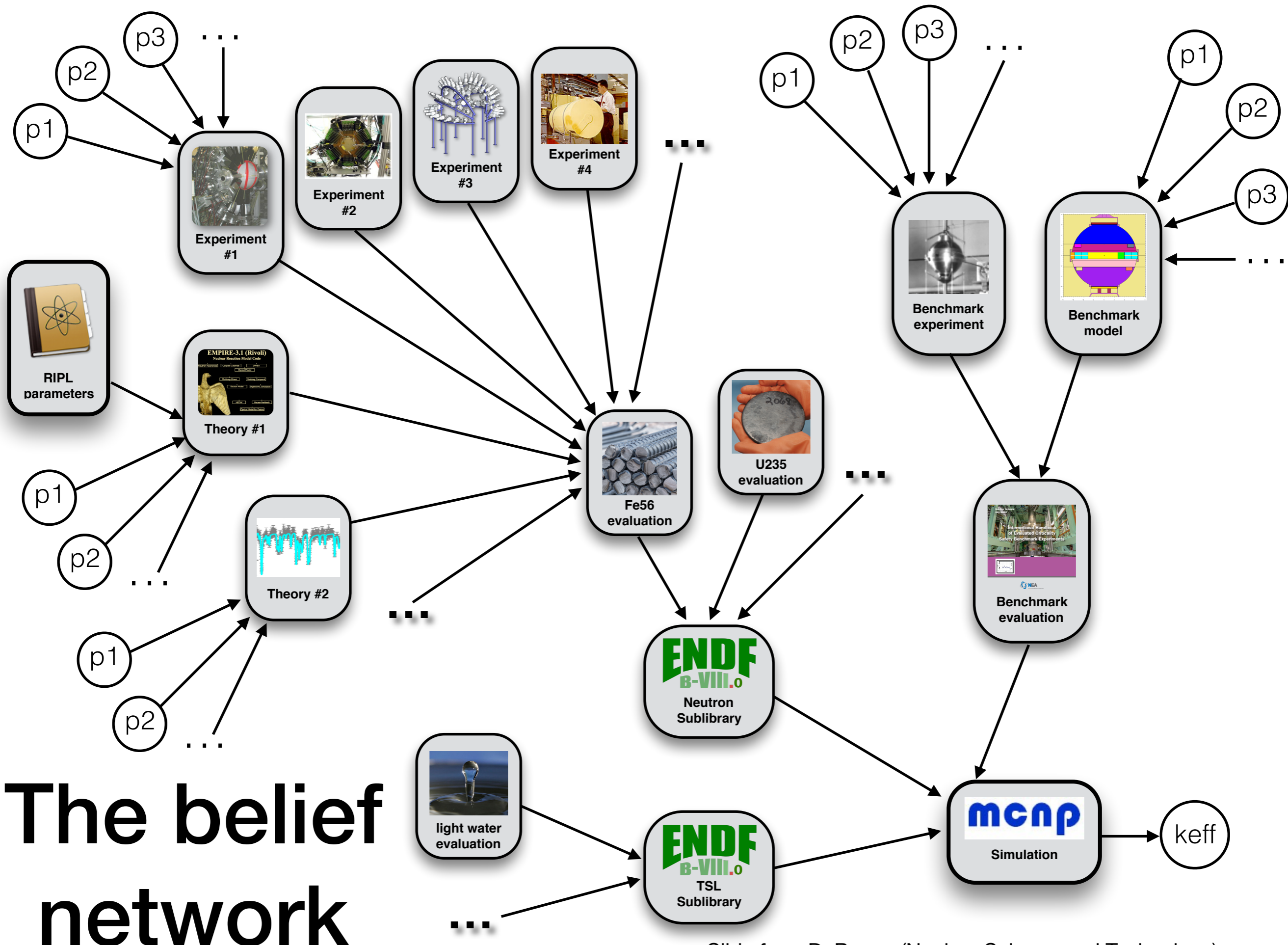
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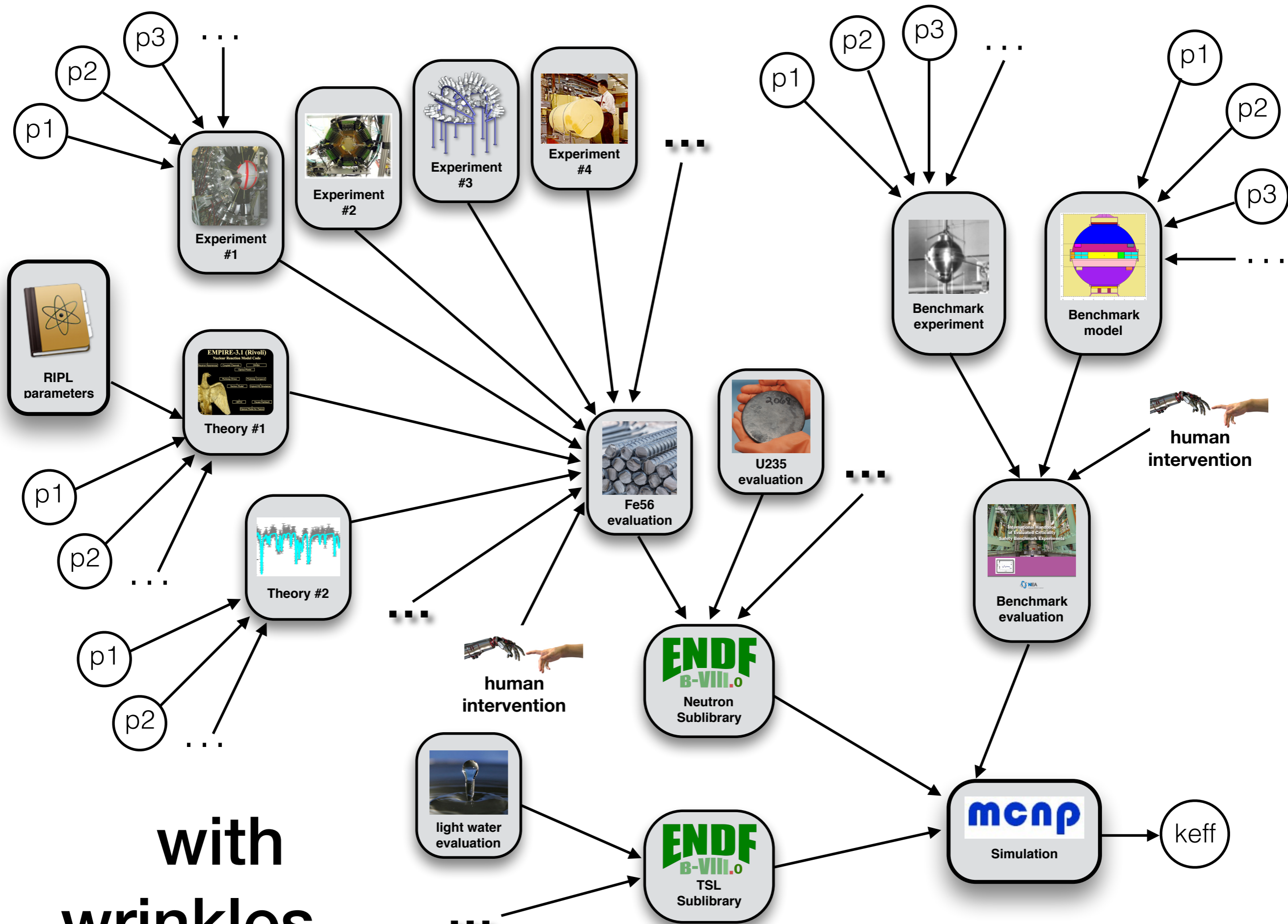
- model homogenization
- ...

Attempts to build trustworthy suite of benchmarks should continue!





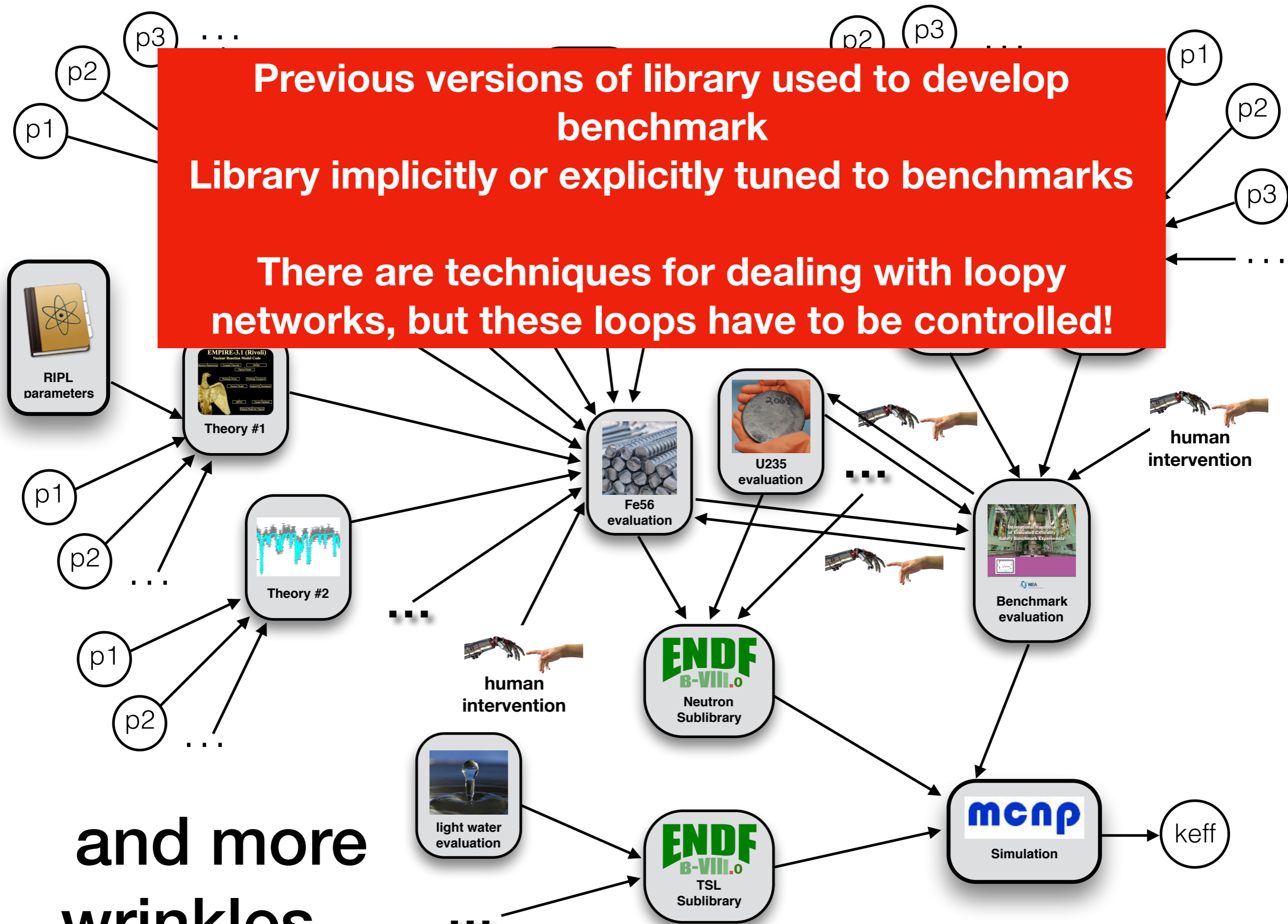
The belief network



with wrinkles...

Previous versions of library used to develop benchmark
Library implicitly or explicitly tuned to benchmarks

There are techniques for dealing with loopy networks, but these loops have to be controlled!



and more wrinkles...

Take-away messages

- The consensus nuclear data approach is built off a DAG containing various GPR models of important things (EXFOR, ENDF libraries, ICSBEP benchmarks)
- The nuclear data community is already engaged in machine learning: e.g. assimilation and adjusted libraries
- We are not ready for unsupervised learning : we need to get humans out of every step