Covariances

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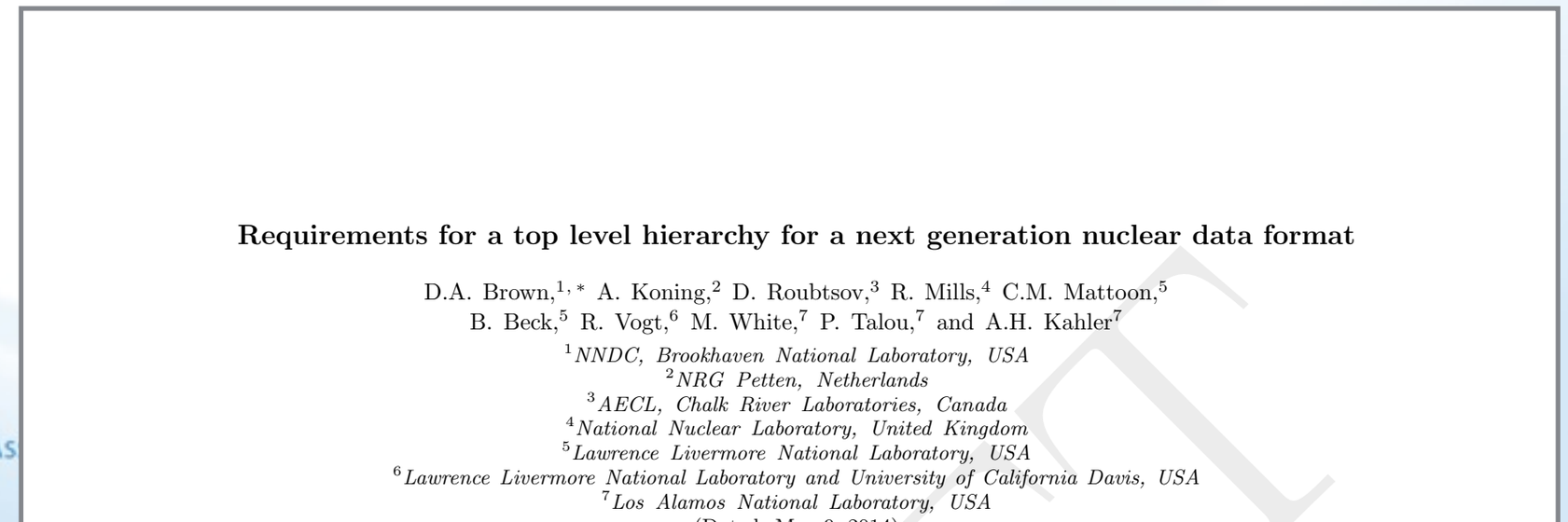
BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

U.S. DEPARTMENT OF ENERGY | Office of Science

I am trying to capture your view of how to arrange nuclear data

- **I will present the consensus view of required arrangement of nuclear data,**
  - presented at SG38 Meeting in Tokai, Japan, Dec. 2013
  - revised and presented at SG38 Meeting in Paris, France, Apr. 2014
  - revised again for this meeting
- **Element & attribute names are illustrative. They can be changed.**
- **From these discussions, I think we are OK with:**
  - approach to sensitivity matrix
  - linking concepts to unify the ENDF covariance data



Requirements for a top level hierarchy for a next generation nuclear data format

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B. Beck,[5] R. Vogt,[6] M. White,[7] P. Talou,[7] and A.H. Kahler[7]

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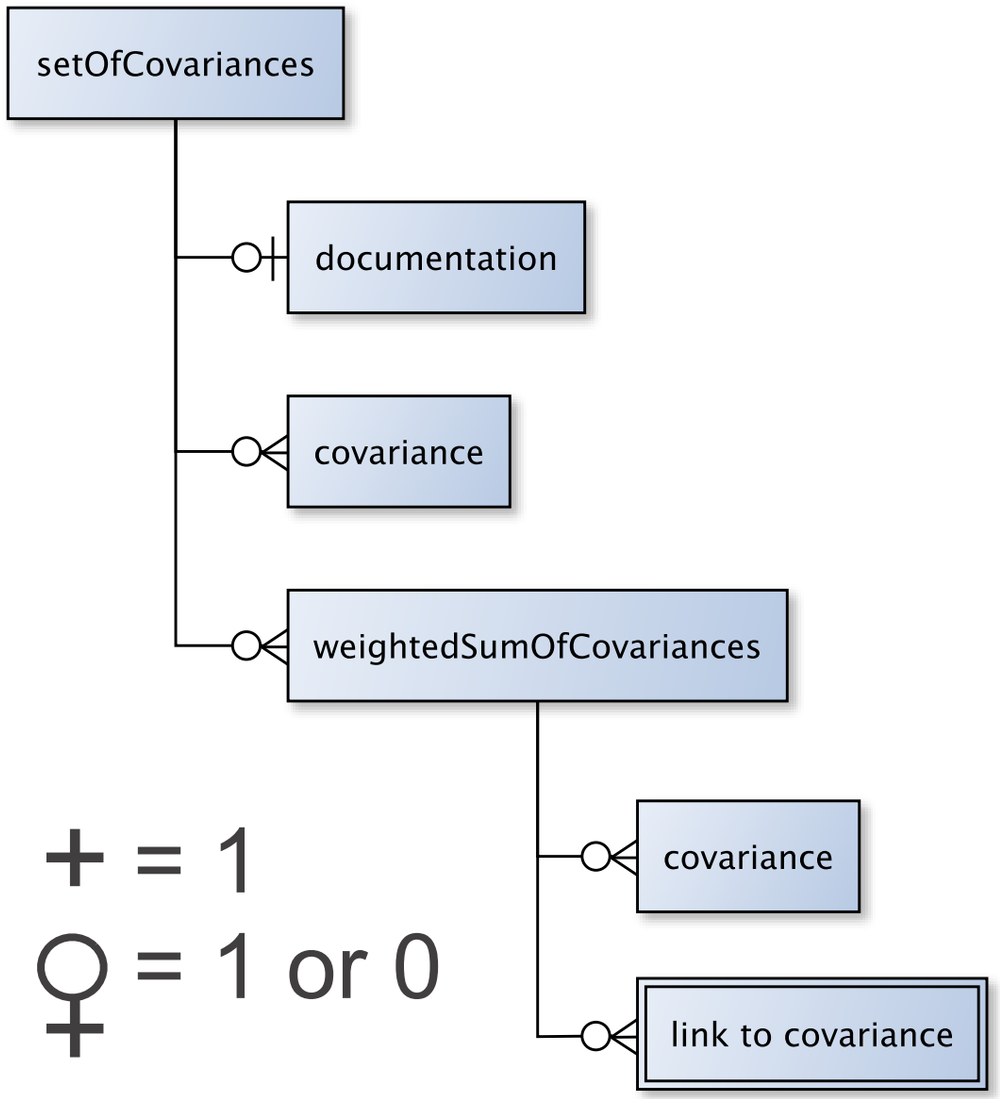
[2] *NRG Petten, Netherlands*
[3] *AECL, Chalk River Laboratories, Canada*
[4] *National Nuclear Laboratory, United Kingdom*
[5] *Lawrence Livermore National Laboratory, USA*
[6] *Lawrence Livermore National Laboratory and University of California Davis, USA*
[7] *Los Alamos National Laboratory, USA*

<setOfCovariances>

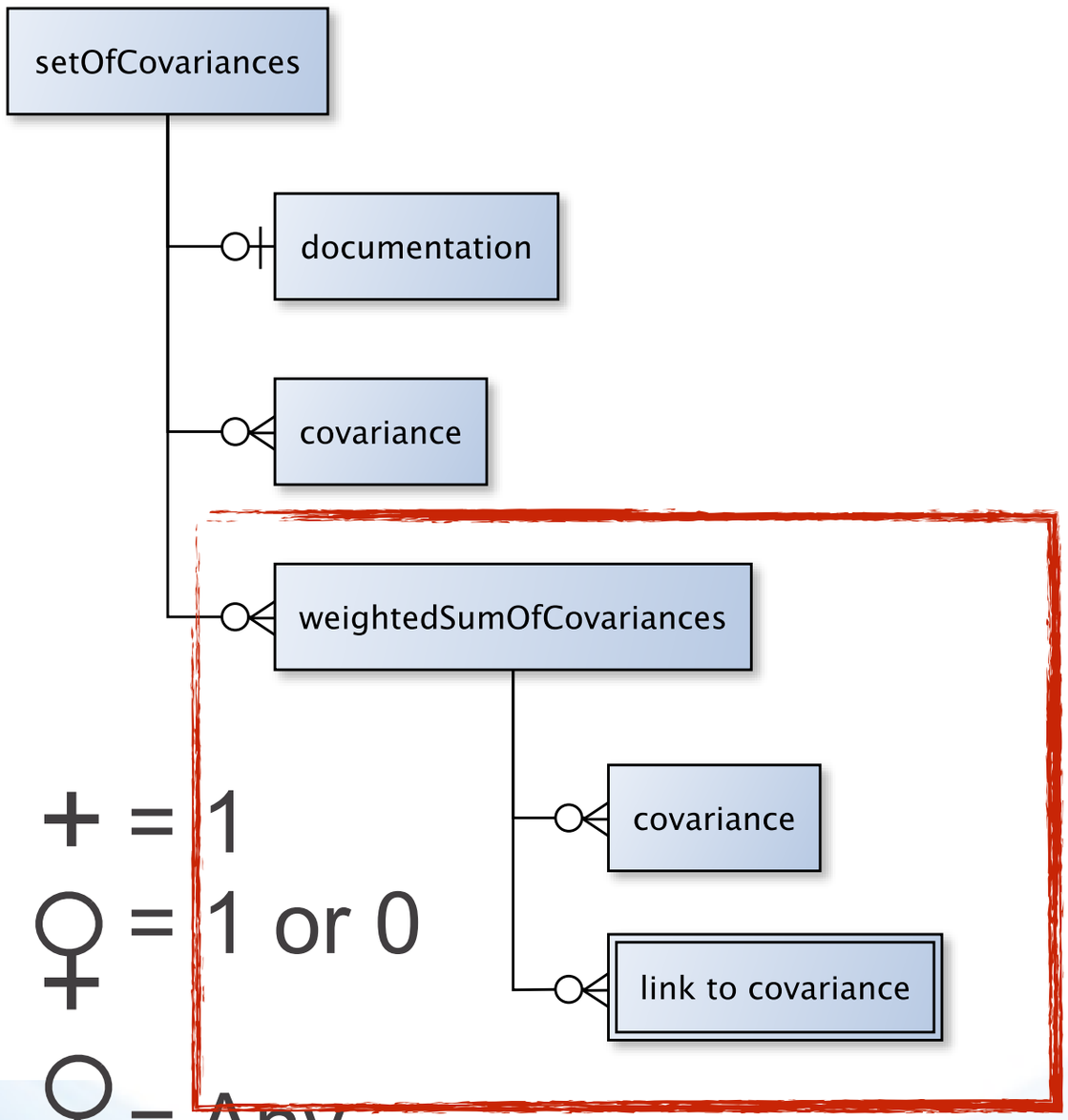


- Covariances can be big
- They can encode correlations across material, reaction, observable

However

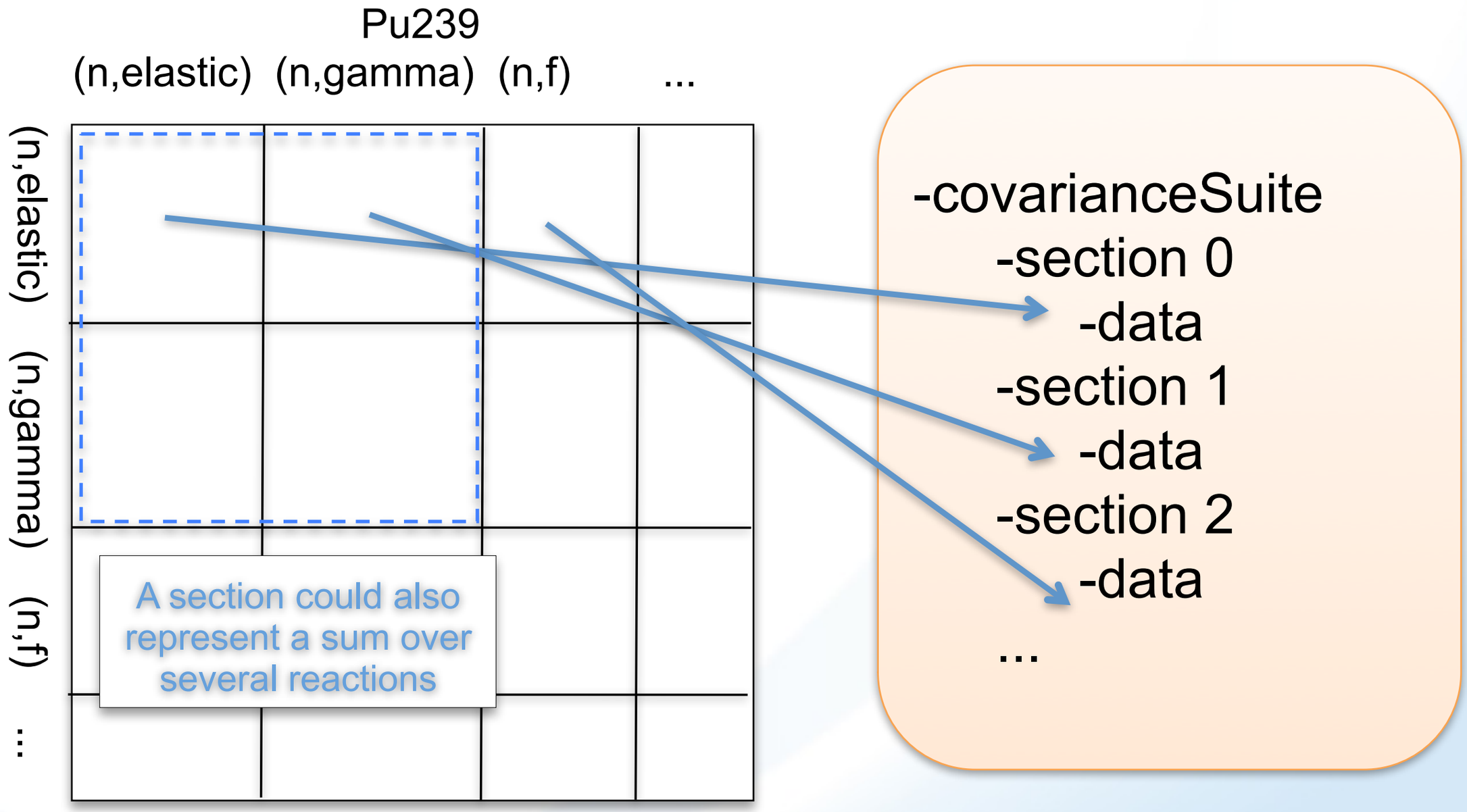
- They are **just matrices**
- You just have to know how to **pack them**
- **<setOfCovariances> is easy way to group them**
- Must allow to store separately

<setOfCovariances>

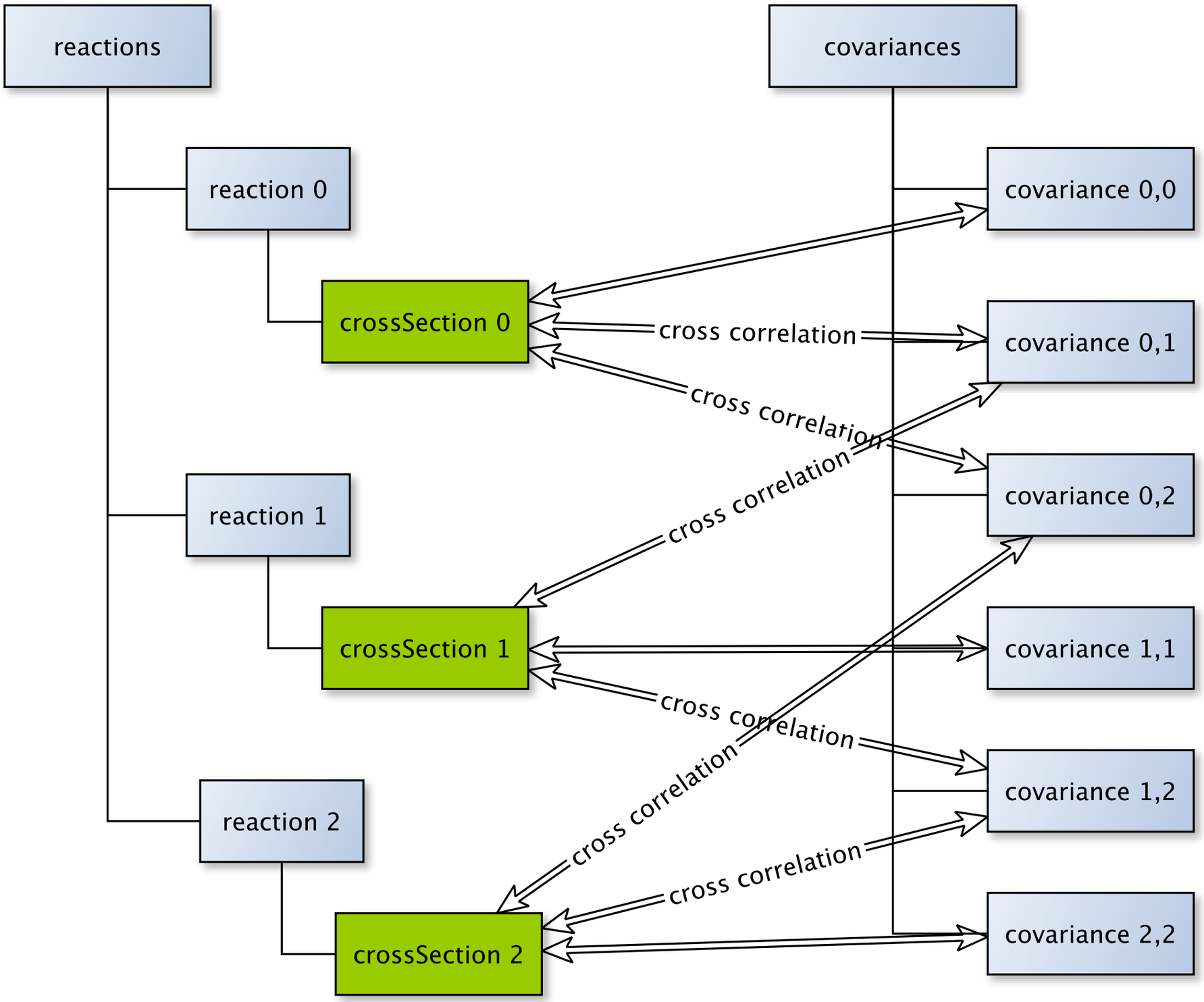


- **weightedSumOfCovariance is just list of covariance (or link to covariance) with a weight**
- **This is just ENDF LC-type covariances** (i.e. cov. for (n,tot) is sum of cov. for (n,el) and (n,g))
- **Can be "abused" to break out long-, medium- and short- range correlations**
- **Relies on <covariance>**

View covariances using block matrix construction



Blocks of a covariance have to be associated with the data



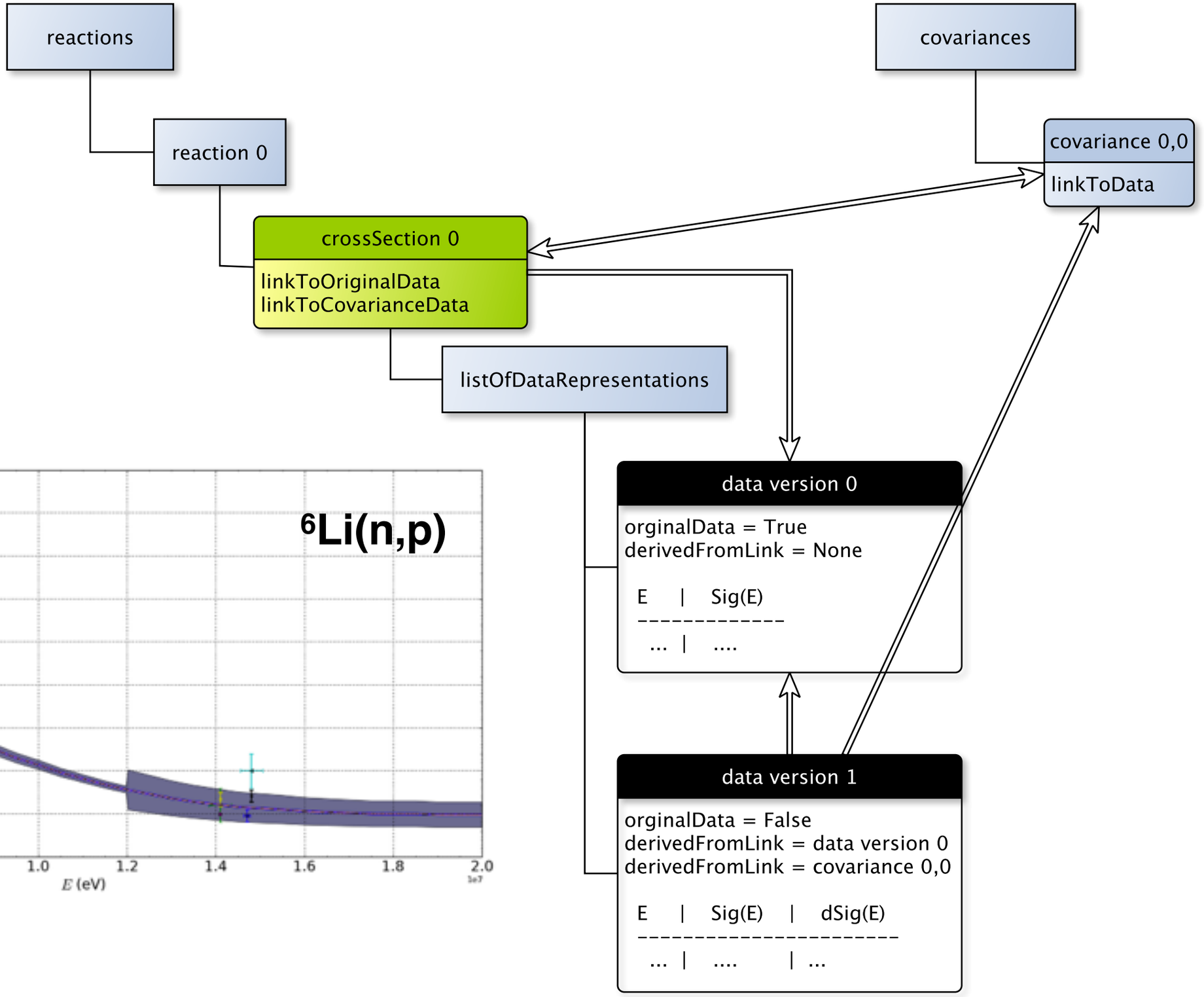
Should we put uncertainties with the data itself?

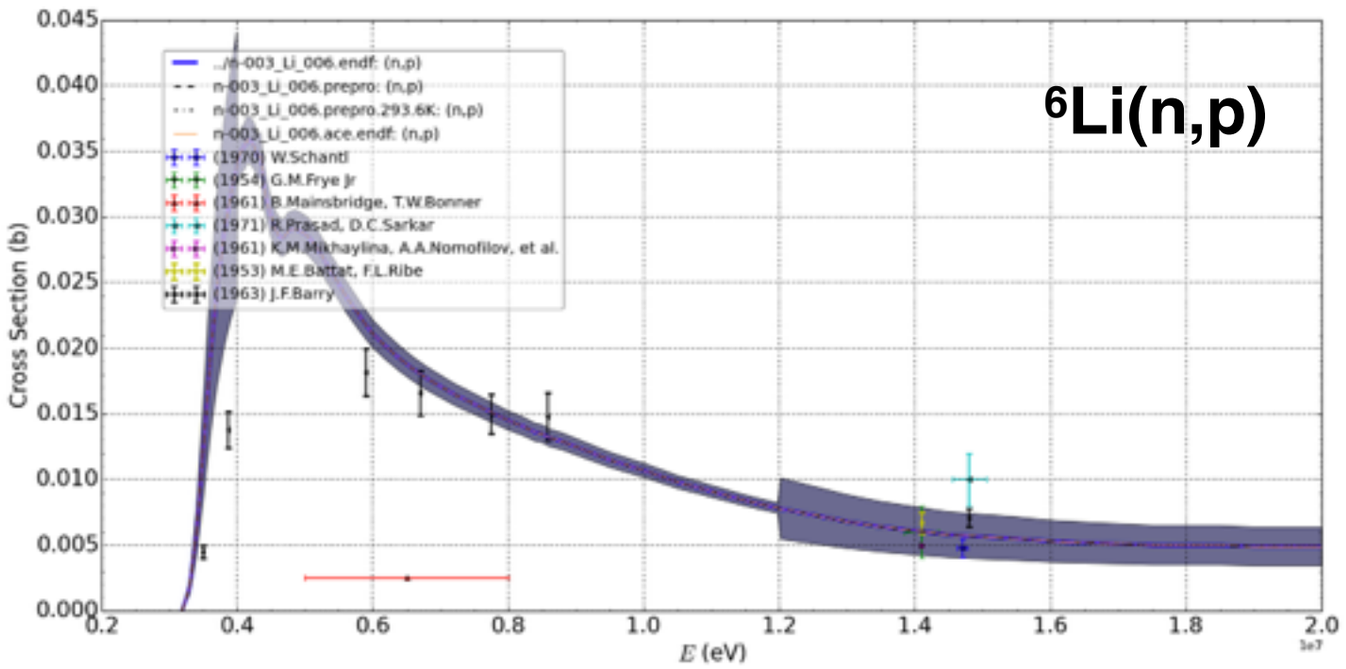
- **Very user friendly**
- **Simpler plotting**

but…

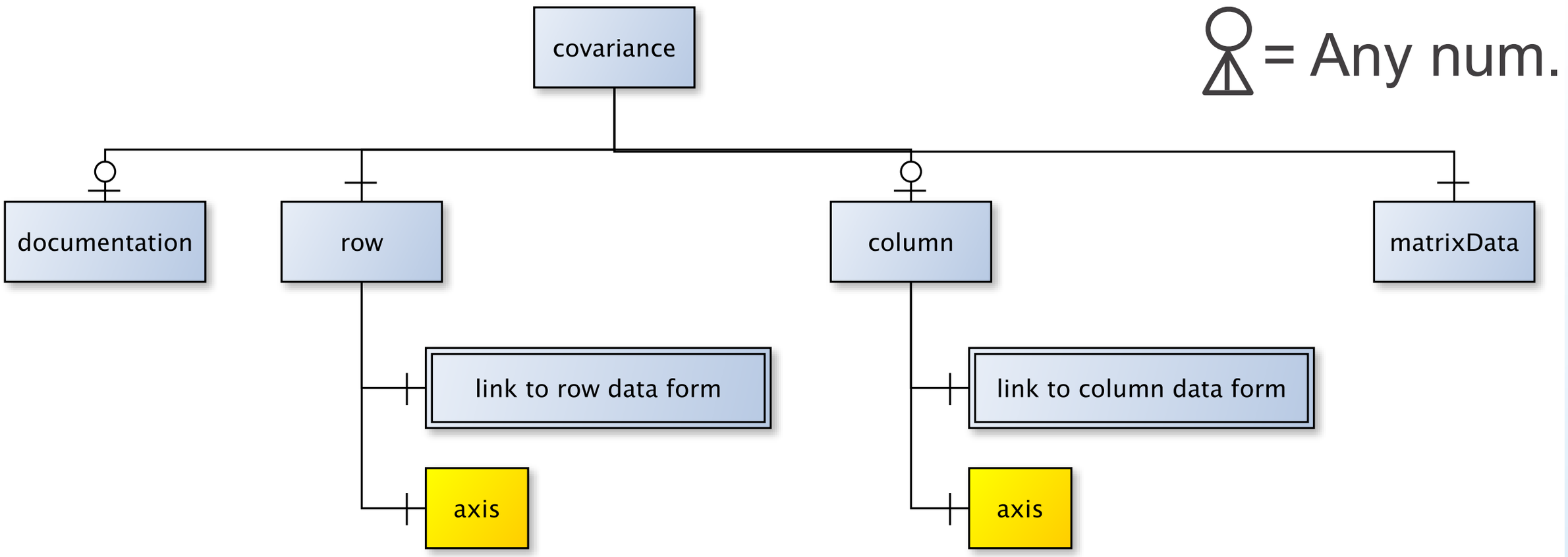
- **Not the whole story: *what about covariance*?**
- ***How do we keep uncertainty & covariance data synchronized?***

Covariance data can be used to generate “plottable” cross sections



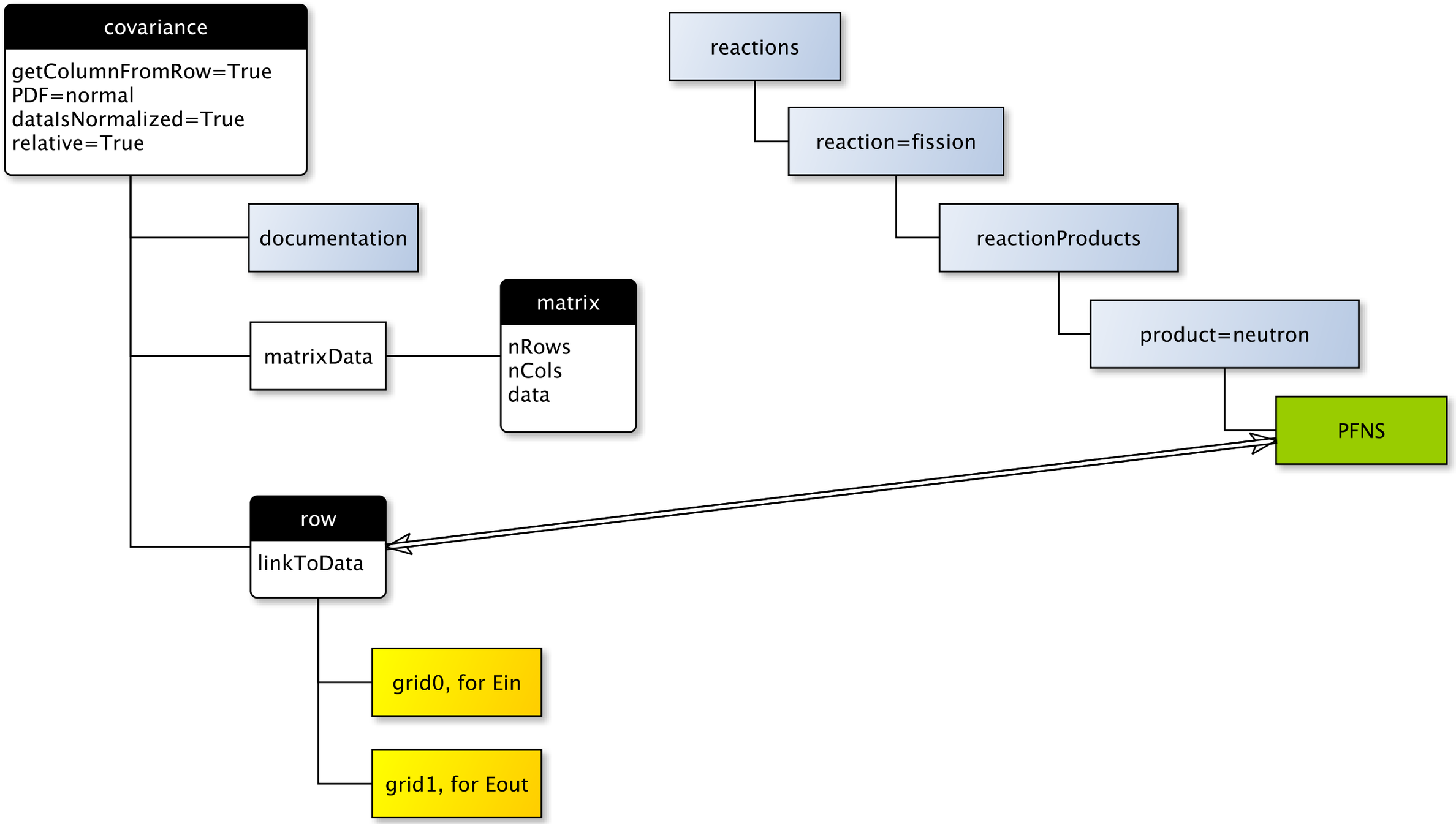


covariance



- Need <row> to describe the data↔<covariance> mapping
- If cross-correlation, need <column> too
- The matrix itself is in <matrixData>
- Covariance needs optional attribute to denote the PDF
- <axis> now called <grid>

PFNS “example”, detailing links to data & the grids in the row element



How to map the row with the matrix itself: the magic of <grid>

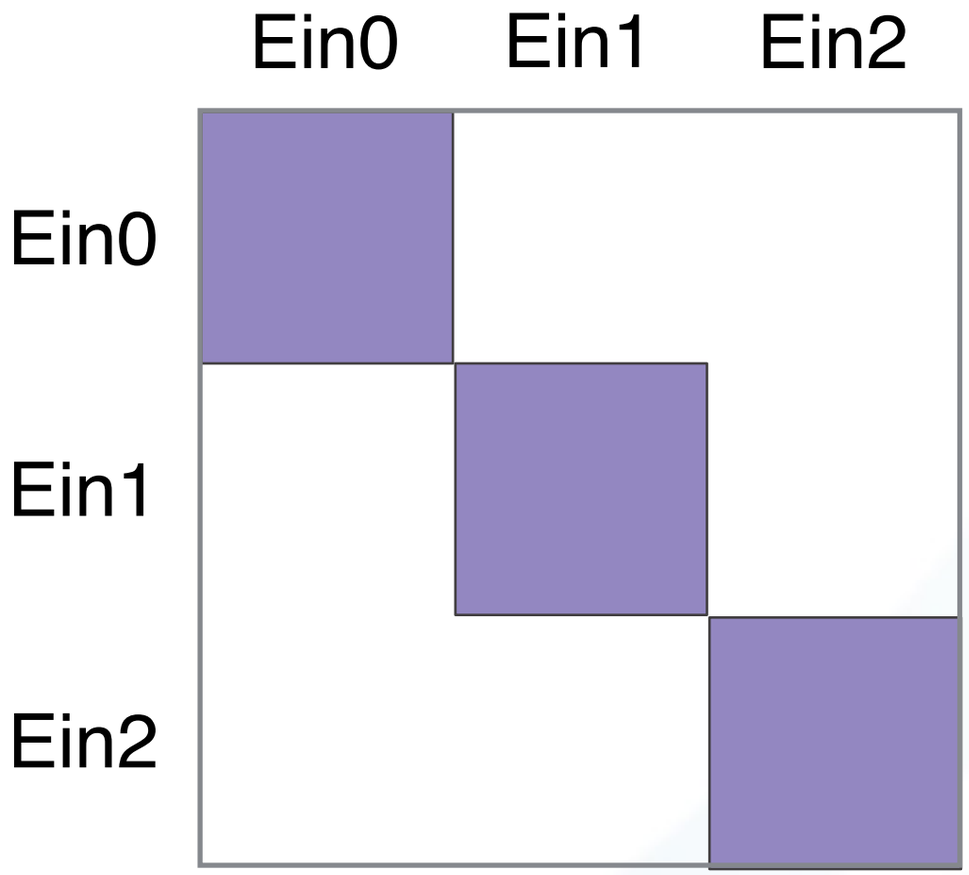
- **<grid> is list of "group boundaries" for covariance in ENDF, this defines the bins:**

```
<grid index="0" label="rows" unit="eV" length="3"> 1e-5 1e5 2e+7</grid>
```

- **For multiple grids in a row (column),**
  - loop though highest index grid bins first (in PFNS, this is Eout),
  - then the second last
  - …
  - finally the first (usually Ein)
- **nRows better equal nBins0 * nBins1 * nBins2 * …**
- **<grid> can have a "style" attribute with value "parameters". We'll use this later…**

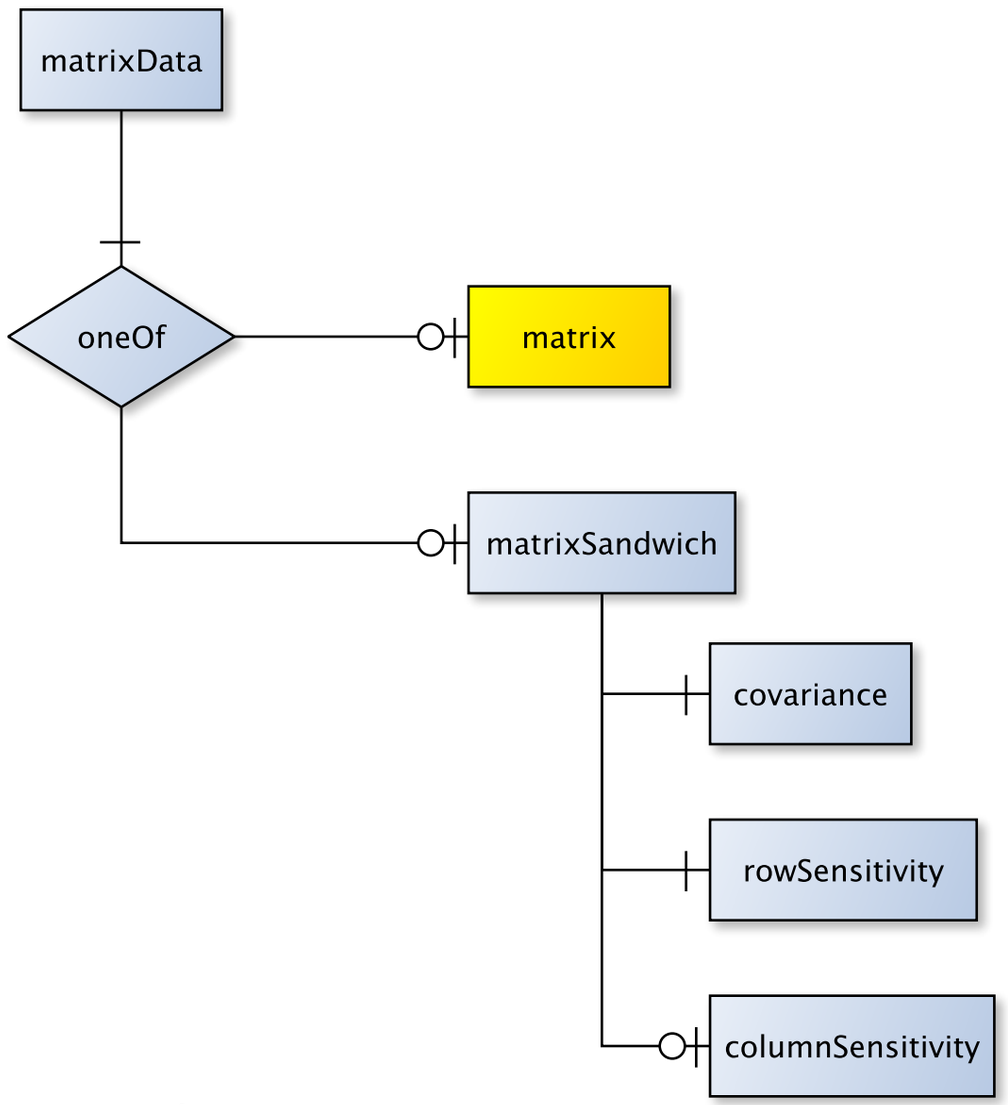
An aside on the PFNS example

- **ENDF PFNS covariances do not allow cross correlations between incident energies.**



- **Do we need “regions” here? Or is there an acceptable block matrix construction markup?**

matrixData



+ = 1
♀ = 1 or 0
⧋ = Any num.

We understand <matrix>, but what is a <matrixSandwich>?

It is just sandwich rule for propagating covariance:

$$f_i(\vec{x}) \approx f_i(\langle\vec{x}\rangle) + \sum_j \frac{\partial f_i(\langle\vec{x}\rangle)}{\partial x_j}(x_j - \langle x_j\rangle)$$

$$\mathrm{cov} f_{ij} = \sum_{i'j'} \mathrm{sens}_{ii'} \mathrm{cov} x_{i'j'} \mathrm{sens}_{j'j}$$

- **For cross-correlations, need two sensitivity matrices**

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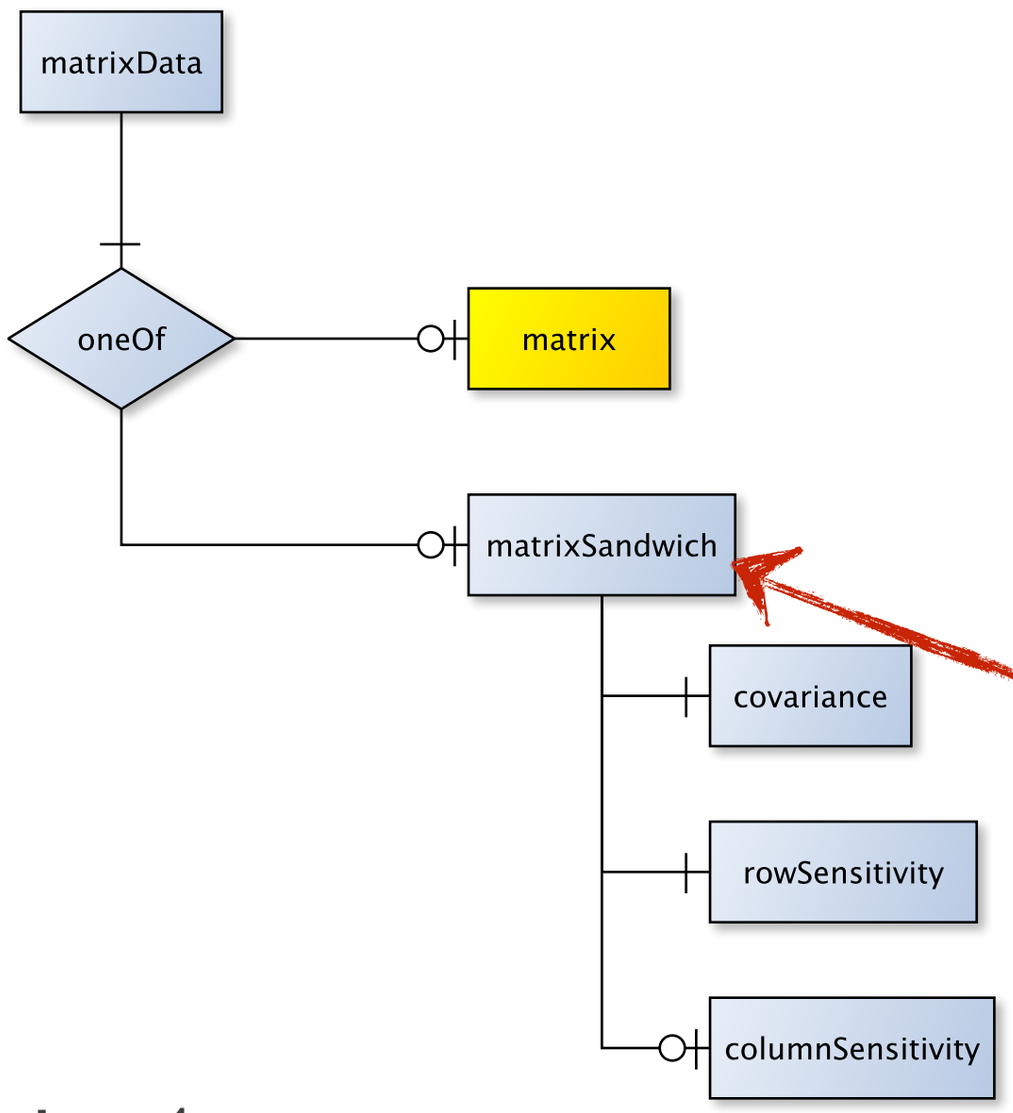

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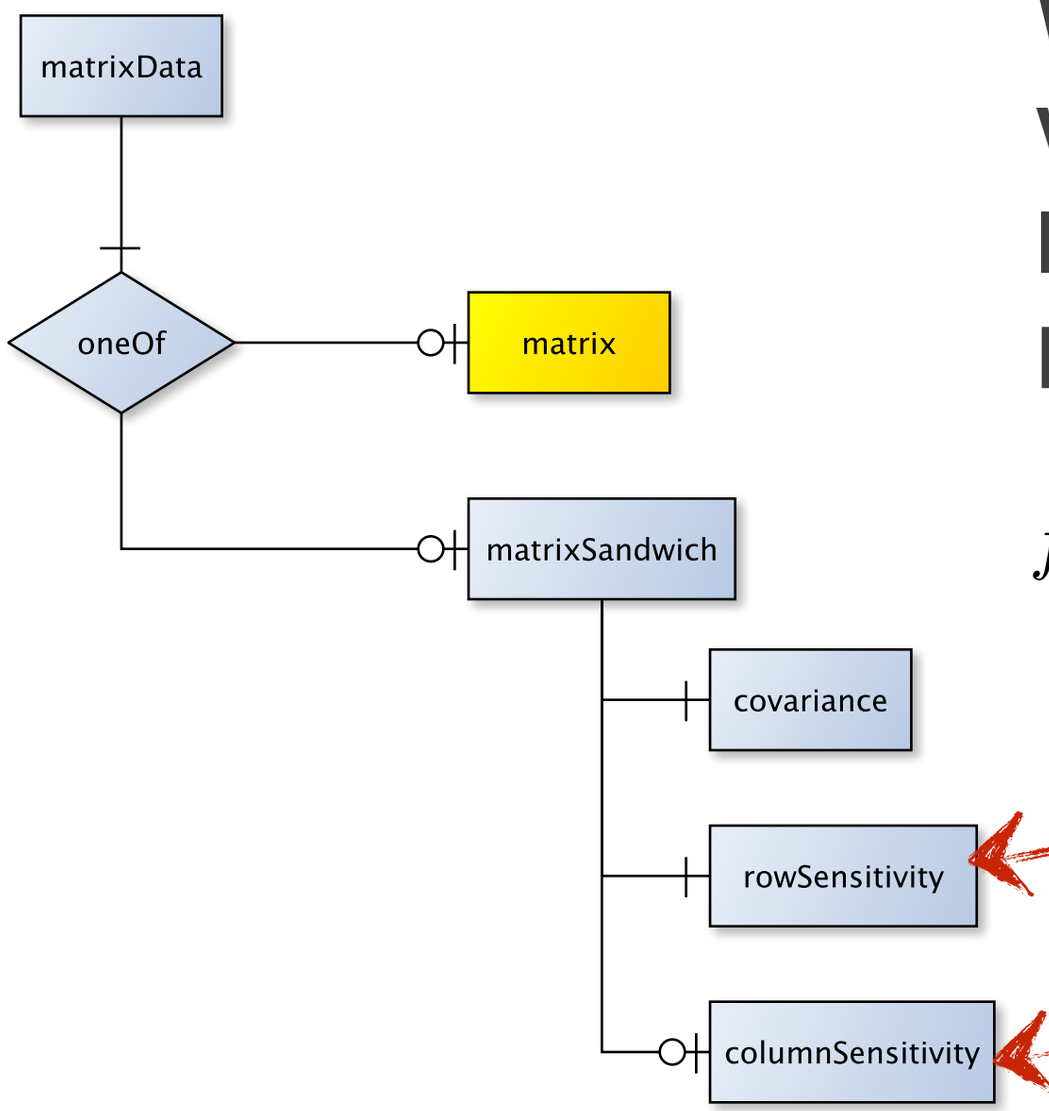

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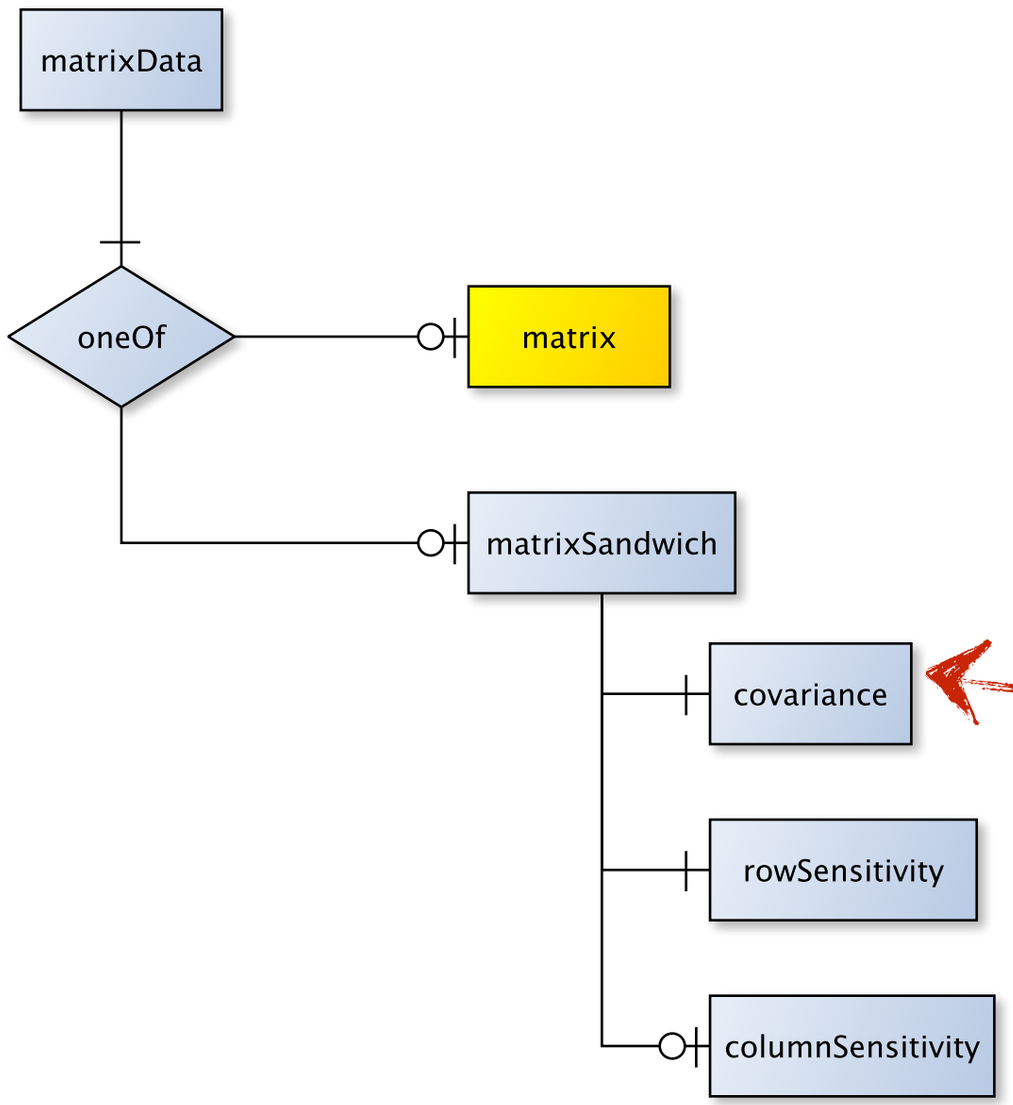

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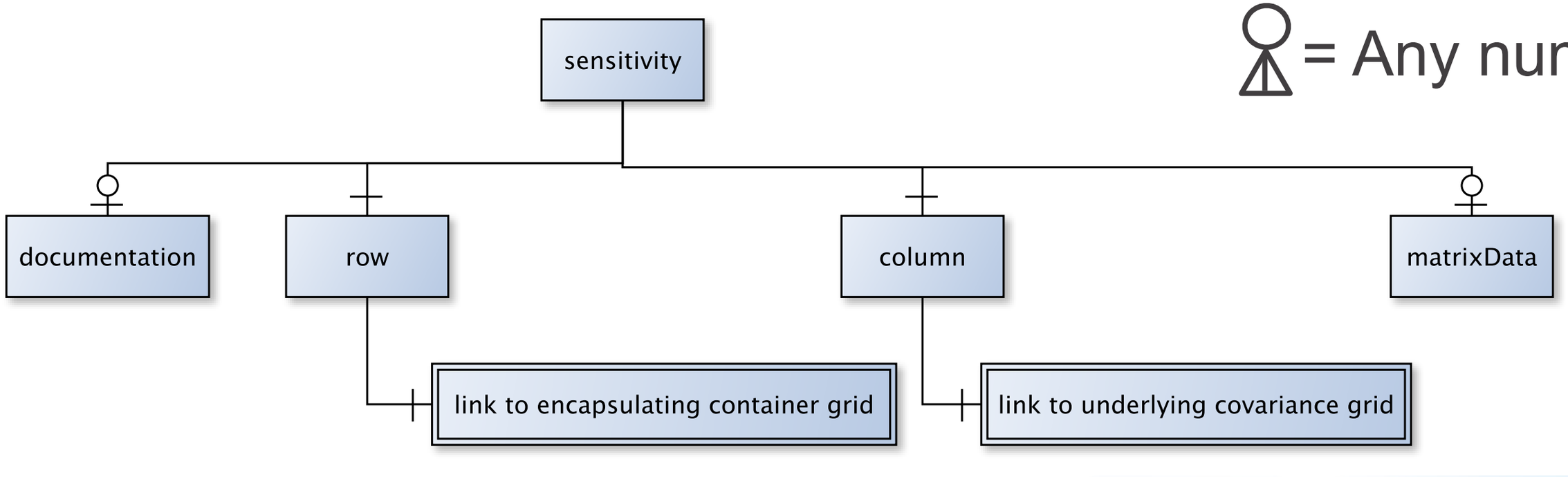
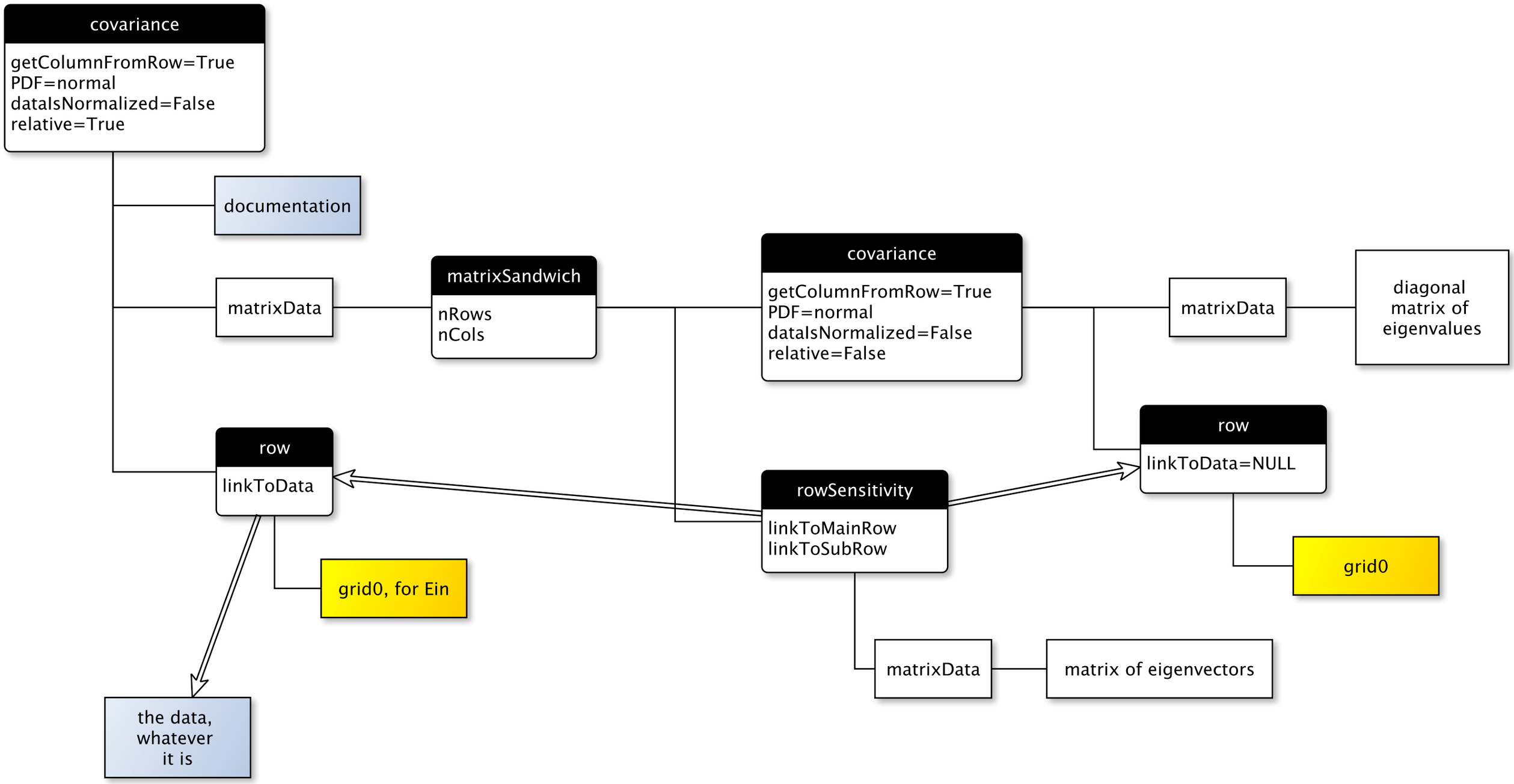
sensitivity



- Sensitivity can be given by equation (e.g. RRR)
- Or can be a matrix
- <row> links to data grid
- <column> links to parameter covariance grid
- Both row and column must be specified
- For RRR's MF=32 data, matrixData optional, since covariance is parameterized

Using sensitivity matrix to encode eigenvalue decomposition



RRR parameter covariances require sensitivity matrix