

# *Covariances in GNDS*

WPEC SG44

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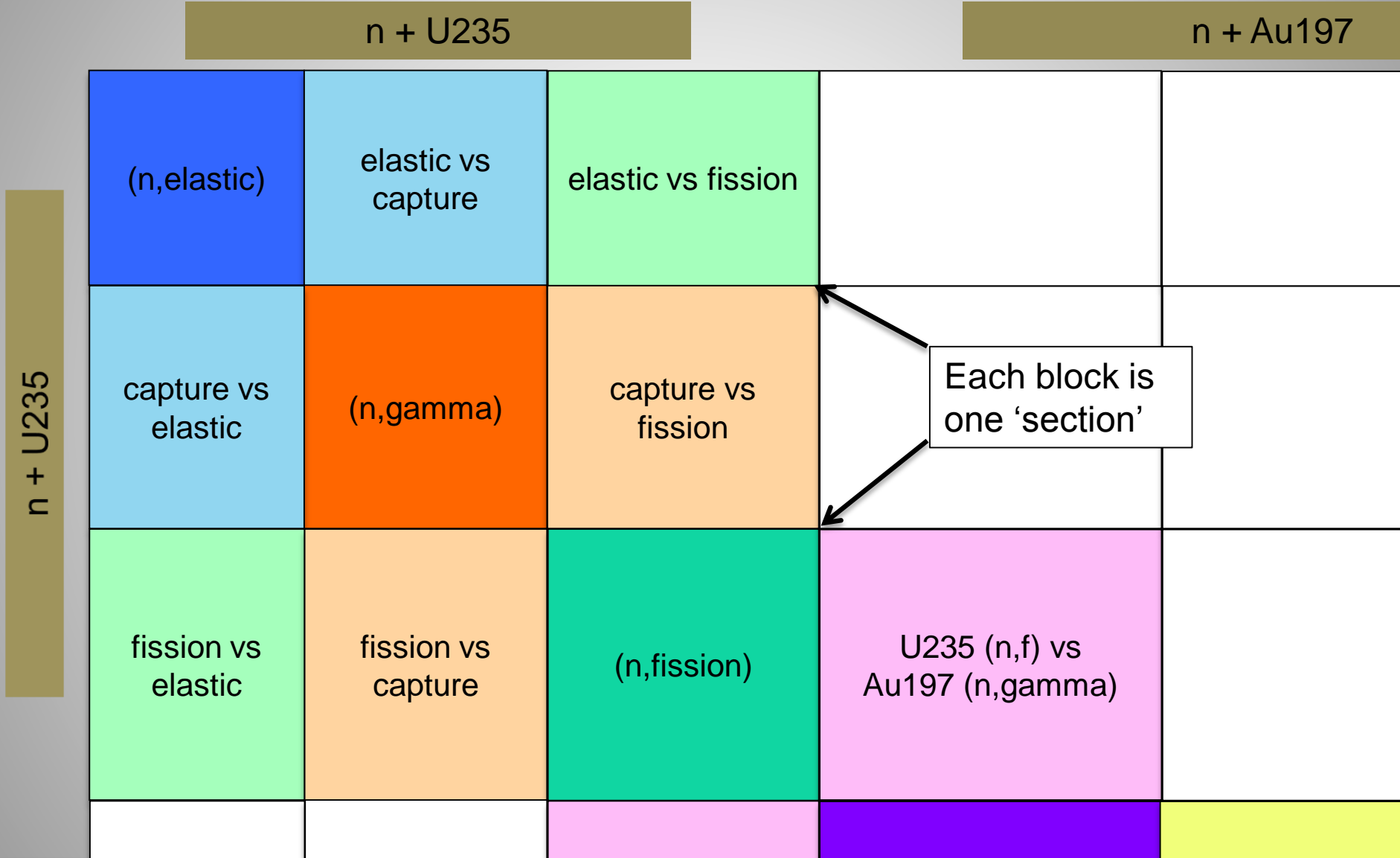
# New format specification nearly complete, will be used for ENDF-VIII

- Final meeting of SG38 is this week, main focus is on completing format specifications
  - GNDS: Generalized Nuclear Database Structure
- ENDF-VIII (expected December 2017) will be released in both ENDF-6 and GNDS
- Current version is GND-1.7, ENDF-VIII release will probably be in GNDS-1.9

# GND S covariances: support all ENDF-6 options, with more room to grow

- Covariance matrices can be stored along with the associated data (cross section, multiplicity, etc.), or can be put in a ‘suite’ of covariances along with a link
- covarianceSuite organized into sections

# Sample covariance matrix:



# GND 1.7 covarianceSuite overview

```
<covarianceSuite projectile="..." target="..." evaluation="..." version="GND 1.7">  
  <styles ... > evaluated, processed, etc. </styles>  
  <externalReactions> for cross-material covers </externalReactions>  
  <section label="...">  
    <rowData ENDF_MFMT="33,2" xlink="..."/>  
    <columnData ENDF_MFMT="33,16" xlink="..."/>  
    <covarianceMatrix> ... </covarianceMatrix></section>  
  <section label="...">...</section>  
  <section label="...">...</section>  
  ...  
</covarianceSuite>
```

# Each 'section' stores either a self-covariance or a cross term

```
<section label="...">  
  <rowData ENDF_MFMT="33,2" xlink="..."/>  
  <columnData ENDF_MFMT="33,16" xlink="..."/> (may omit for self-covariance)  
  <covarianceMatrix label="eval" type="relative">  
    <gridded2d>  
      <axes>  
        <grid label="rows" unit="eV" style="boundaries">  
          <values> ... (group boundaries along matrix rows) ... </values></grid>  
        <grid label="columns" unit="eV" style="boundaries">  
          <values> or <link> </grid>  
      <axis label="matrix elements" unit=""></axes>  
      <array shape="29,29"><values>...</values></array>  
    </covarianceMatrix>  
  </section>
```

Example shows a simple covariance matrix

# Other types of covariance matrix are supported:

- `<sum>`: matrix is composed by adding together other matrices
  - Could be links to other sections (like ENDF NC-type sections), or could be given explicitly (ENDF NI-type matrices)

# Parameter covariances (e.g. MF32):

```
<covarianceSuite projectile="..." target="..." format="...">
...
<parameterCovariance label="resolved" type="absolute">
  <parameters>
    <parameterLink label="0" xlink:href="..." nParameters="92"/>
    <parameterLink label="0" xlink:href="..." nParameters="220"/>
    ...</parameters>
  <array shape="1088,1088" compression="flattened" symmetry="lower">
    <values valueType="Integer32" label="starts">...</values>
    <values valueType="Integer32" label="lengths">...</values>
    <values>...</values>
  </array>
</parameterCovariance>
</covarianceSuite>
```

Example from n-017\_CI\_035 MF32  
Uses sparse array storage to save space

# MF=35 (PFNS) support:

- PFNS covariance relates  $P(E' | E)$  at two different outgoing energies  $E'_1$  and  $E'_2$
- Matrix may be broken into sections, where each section covers a range of incident energies.
- Cross-terms between incident energy ranges are allowed (in both ENDF and GND), but I haven't seen any evaluations using them yet

# What about higher dimensions?

- So far ENDF community has avoided MF=36 style covariances
  - Would require higher-dimension covariances: 1-d functions like cross section / multiplicity require 2-d matrix, 2-d function  $P(E' | E)$  requires 4 dimensions, 3-d function  $P(E', \mu | E)$  requires 6!
  - 'gridded' data container in GNDS can handle higher array dimensions (including sparse storage).
  - Not sure yet how to sample from higher-dimension covariance matrix, though



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