Reporting of experimental data in the resonance region

EC – JRC – IRMM
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Reporting of experimental data

Requirements:

- Experimental observables and relations to model parameters are defined ⇒ reporting of experimental conditions

- All uncertainty components (uncorrelated & correlated) are identified & quantified

- All uncertainty components are documented and reported

⇒ Proposal NDS-IAEA / IRMM based on AGS
Data reduction process

Reaction yield + Self-indication

\[ Y_{\text{exp}} = N \frac{\sigma_{\phi} \left( C'_w - B'_w \right)}{\varepsilon_r \left( C'_\phi - B'_\phi \right)} \]

- \( C' \): dead time corrected counts
- \( B' \): background contribution
- \( N \): normalization factor

Transmission

\[ T_{\text{exp}} = N \frac{C'_{\text{in}} - B'_{\text{in}}}{C'_{\text{out}} - B'_{\text{out}}} \]

Histogram operations + Covariance information

- \( Y_{\text{exp}} \) + covariance
- \( Y_{\text{SI,exp}} \) + covariance
- \( T_{\text{exp}} \) + covariance

input

Models
Analysis of Geel Spectra (AGS)

- Transform count rate spectra into observables (transmission, yield)
- Full uncertainty propagation starting from counting statistics
- Output: complete covariance information
- Special format for covariance information
  - Reduce space for data storage (EXFOR)
  - Document and report all sources of uncertainties due to each step in the data reduction process
  - Covariance matrix always well defined (positive definite)
Uncertainty propagation in AGS

Conditions:

(1) Data reduction starts from spectra subject only to uncorrelated uncertainties

(2) Additional computations using parameters with well defined covariance matrix

(3) Channel – channel operations (+, -, x, ÷) and log, exp, ...

\[ Z = F(\tilde{\alpha}, Y) \quad \text{e.g.} \quad Z(t) = Y(t) - (a_1 + a_2 t^{a_3}) \]

Covariance matrix \( V_\alpha \) well defined
⇒ symmetric and positive definite
⇒ Cholesky transformation

\[ V_\alpha = L_\alpha L_\alpha^T \]

\[ V_Y \] only diagonal terms:
⇒ \( D_Y = V_Y \)
⇒ \( v_{Y,i\neq j} = 0 \)

\[ V_Z = U_Z + S_\alpha S_\alpha^T \]

\( L_\alpha \) : lower triangular matrix
diagonal : \( n \) values
dimension: \( n \times k \)
Observable $Z$ (dimension $n$) with $k$ sources of correlated uncertainties

$$V_Z = D_Z + S_Z S_Z^T$$

$D_Z$ : uncorrelated part
$n$ values

$S_Z$ : correlated part
dim. $(n \times k)$
Data reduction of transmission: $T_{\text{exp}}$

\[ T_{\text{exp}} = N \frac{C_{\text{in}} - B_{\text{in}}}{C_{\text{out}} - B_{\text{out}}} \]

\[ \frac{\delta b_{\text{out}}}{b_{\text{out}}} = 5.0 \% \]

\[ \frac{\delta b_{\text{in}}}{b_{\text{in}}} = 10.0 \% \]
\( \delta \)B<sub>in</sub> / B<sub>in</sub> : 10.0 %  
\( \delta \)B<sub>out</sub> / B<sub>out</sub> : 5.0 %  
\( \delta K / K \) : 0.5 %

\[
\begin{array}{|c|c|c|c|c|c|}
\hline
X_L & X_H & Z & \delta Z & \delta Z_u & C_Z = D_Z + S S^T \\
\hline
800 & 1600 & 0.999 & 0.79E-2 & 0.59E-2 & 0.35E-4 0.14E-2 -0.08E-2 0.50E-2 \\
1600 & 2400 & 0.999 & 0.86E-2 & 0.67E-2 & 0.45E-4 0.16E-2 -0.10E-2 0.50E-2 \\
2400 & 3200 & 0.999 & 0.92E-2 & 0.73E-2 & 0.54E-4 0.21E-2 -0.12E-2 0.50E-2 \\
3200 & 4000 & 0.999 & 0.97E-2 & 0.78E-2 & 0.61E-4 0.24E-2 -0.13E-2 0.50E-2 \\
16000 & 16800 & 0.899 & 1.30E-2 & 1.07E-2 & 1.15E-4 0.51E-2 -0.25E-2 0.45E-2 \\
16800 & 17600 & 0.818 & 1.24E-2 & 1.02E-2 & 1.04E-4 0.53E-2 -0.24E-2 0.41E-2 \\
17600 & 18400 & 0.701 & 1.15E-2 & 0.93E-2 & 0.86E-4 0.54E-2 -0.21E-2 0.35E-2 \\
18400 & 19200 & 0.594 & 1.06E-2 & 0.84E-2 & 0.71E-4 0.55E-2 -0.18E-2 0.30E-2 \\
19200 & 20000 & 0.501 & 0.98E-2 & 0.76E-2 & 0.57E-4 0.56E-2 -0.15E-2 0.25E-2 \\
20000 & 20800 & 0.504 & 1.00E-2 & 0.77E-2 & 0.59E-4 0.57E-2 -0.16E-2 0.25E-2 \\
20800 & 21600 & 0.581 & 1.09E-2 & 0.85E-2 & 0.73E-4 0.58E-2 -0.19E-2 0.29E-2 \\
21600 & 22400 & 0.707 & 1.22E-2 & 0.98E-2 & 0.97E-4 0.60E-2 -0.23E-2 0.35E-2 \\
964000 & 972000 & 0.999 & 5.91E-2 & 3.75E-2 & 14.06E-4 3.98E-2 -2.18E-2 0.50E-2 \\
972000 & 980000 & 1.037 & 6.09E-2 & 3.89E-2 & 15.13E-4 4.04E-2 -2.31E-2 0.52E-2 \\
980000 & 988000 & 1.001 & 6.01E-2 & 3.80E-2 & 14.46E-4 4.05E-2 -2.23E-2 0.50E-2 \\
988000 & 996000 & 1.010 & 5.92E-2 & 3.77E-2 & 14.23E-4 3.96E-2 -2.20E-2 0.50E-2 \\
\hline
\end{array}
\]

![Graph showing time-of-flight distribution with color gradients representing intensity.](image-url)
Reporting of results + experimental conditions

- Facility
- Neutron production
- Experimental details
- Sample
- **Flux (reaction cross section data)**
- Normalization (TOF-independent)
- Data
- Uncertainties (AGS-concept)
Facility + Neutron production

- Facility + Reference
  (GELINA/nTOF/ORELA/POHANG/KAERI/RPI)

- Neutron production
  - Primary beam: Electron
  - Time resolution primary beam (ns): 1 ns
  - Frequency: 800 Hz
  - Overlap filter: $0.002 \text{ at/b } ^{10}\text{B}$
  - Primary neutron production target: Uranium
  - Moderator material: $\text{H}_2\text{O}$
  - Moderator surface dimensions: 2 containers 100 x 100 mm
  - Moderator thickness: 40 mm
  - Response functions: Ref. 4
Experimental details

- **Measurement type**: transmission
- **Method**: sample in / sample out
- **Flight path length**: 9.340 +/- 0.006 m (moderator – target detector: face to face)
- **Angle**: 18° (moderator – target detector: face to face)
- **Beam dimensions on sample**: 25 mm diameter (mm x mm or diameter)
- **Detector**
  - **Type**: Li-glass scintillator
  - **Material**: NE905
  - **Dimensions**: 120 mm diameter & 12.7 mm thick
  - **Geometry in neutron beam**
**Sample details**

- **Type (metal, powder, preparation)**: metal disc
- **Composition**: 100% nat Cd
- **Weight**: 1.2814 +/- 0.0001 g
- **Area**: +/- mm²
- **Area density**: 0.02547 g/cm²
- **Number area density of main component**: 1.3643 \(10^{-4}\) at/b nat Cd
- **Geometry**
  - **Surface dimensions**: (80.004 +/- 0.03) mm diameter
  - **Thickness**: 0.03 mm
- **Backing**: none
- **Containment**: none
- **Temperature**: 120 mm diameter & 12.7 mm
Reporting results

- **Normalization**
  - method
  - uncertainty beam monitors

- **Background**
  - method saturated resonance
  - Fixed filters S

- **Data**
  - Energy (L = m) column 1
  - TOF (low) column 2
  - TOF (high) column 3
  - Transmission (yield) column 4
  - Correction -

- **Uncertainty components (AGS concept)**
  - Total column 5
  - Uncorrelated uncertainty column 6
  - Correlated components
    - Dead time sample in column 7
    - Background sample in column 8
    - Dead time sample out column 9
    - Background sample out column 10