Uncertainty propagation with AGS

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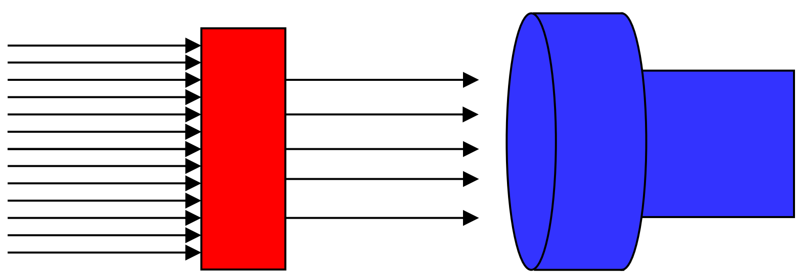
Contents

- Uncertainty propagation with AGS (Analysis of Geel Spectra)
- Examples
- Reporting of TOF-cross section data in EXFOR

Experimental observables

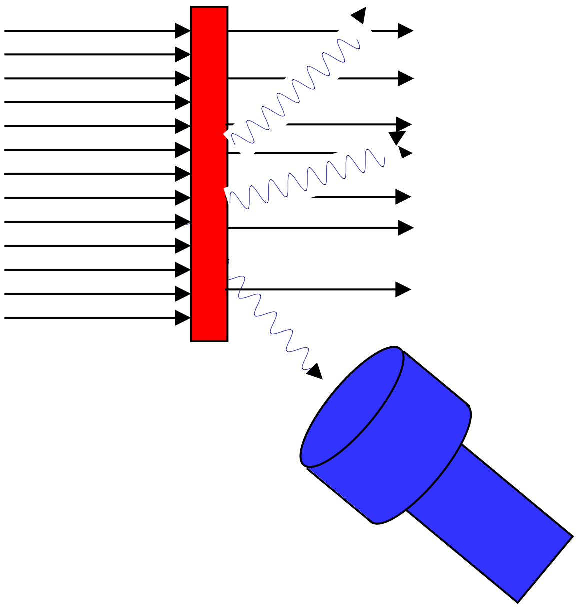
Transmission

$$T_{exp} = N \frac{C'_{in} - B'_{in}}{C'_{out} - B'_{out}}$$



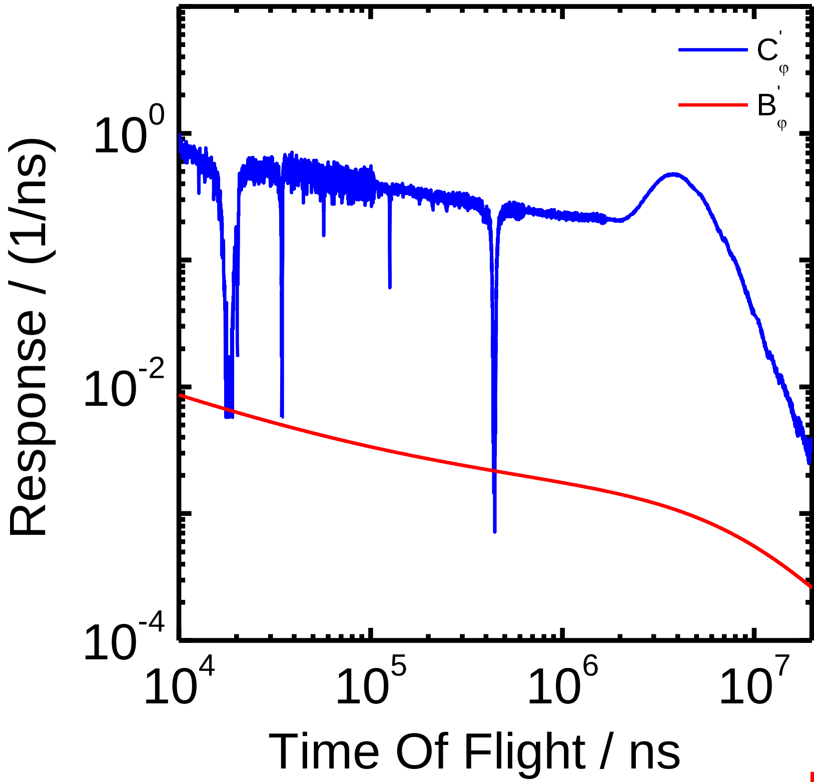
Reaction

$$Y_{exp} = N \frac{C'_{r} - B'_{r}}{C'_{\varphi} - B'_{\varphi}} Y_{\varphi}$$

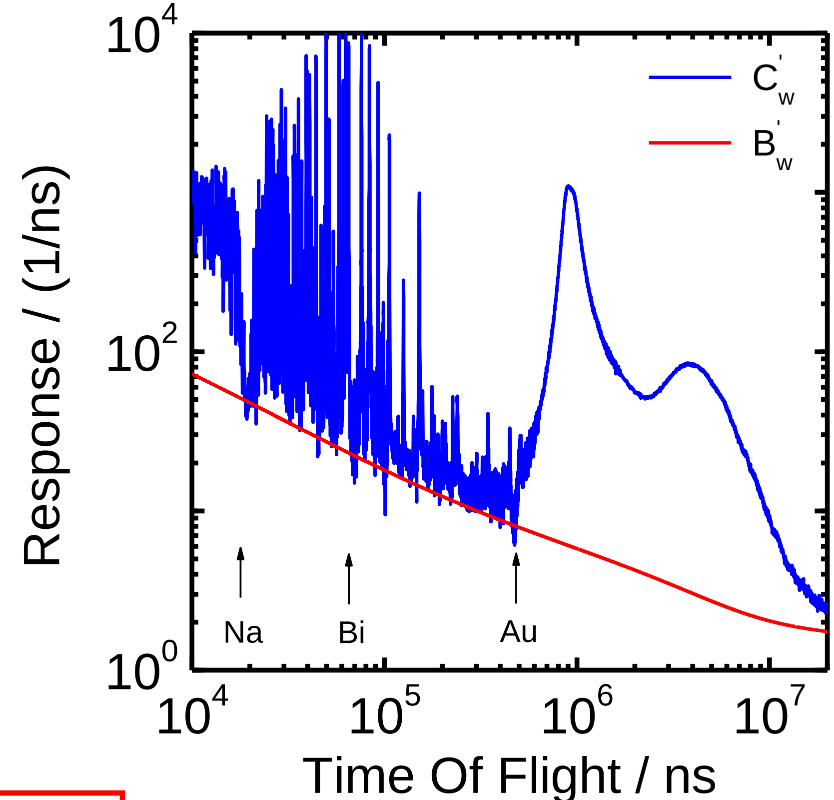


σ(n,γ) measurements: $^{103}Rh(n,\gamma)$

Flux measurement



Capture measurement



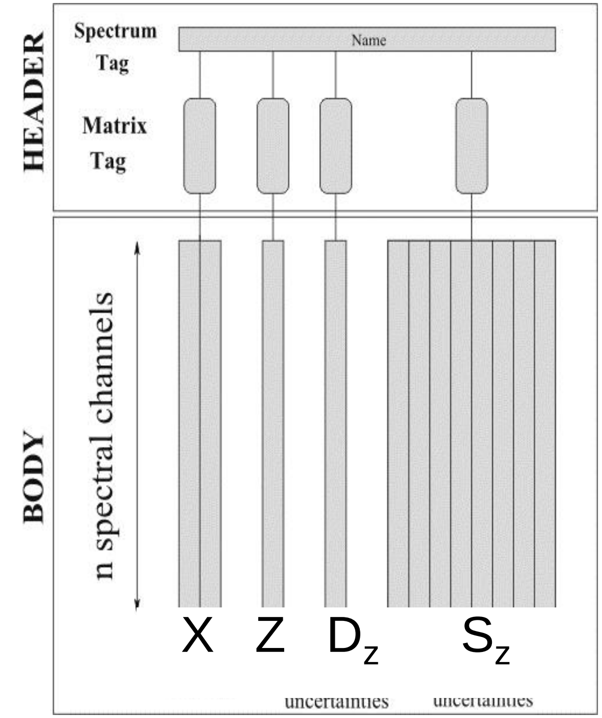
$$Y_{exp} = N \frac{C'_r - B'_r}{C'_\varphi - B'_\varphi} Y_\varphi$$

AGS – concept: full covariance information

Analysis of Geel Spectra (AGS)

- Transforms count rate spectra into observables (transmission, yields)
- Full uncertainty propagation starting from counting statistics
- Output: complete covariance matrix
- Special format for covariance matrix
  - Reduce space for data storage (EXFOR)
  - Document the sources of uncertainties due to each step in the data reduction process
  - Verify the contribution of each quantity introducing a correlated uncertainty component!

C. Bastian, Int. Soc. Optical Eng. 2867 (1997) 611



D_Z : uncorrelated part
n values

S_Z : correlated part
dim. (n x k)

Reliable experimental data and results (PS)

Requires

- Understanding of the measurement process (scientific background)
  - experimental observables
  - measurement model

- Well documented experimental observables, including

–all experimental details (input parameters, systematic effects)

–all uncertainty components (correlated and uncorrelated)

⇒Propagation of uncertainties (uncorrelated & correlated) not complicated

GLUP : $\underline{V}_Z = \underline{G}_X \, \underline{V}_X \, \underline{G}_X^T$

GLSQ: $(\vec{q} - \vec{q}\,') = \underline{V}_{\vec{q}\,'} \, \underline{G}_{\vec{q}\,'}^T \, \underline{V}_{\vec{z}}^{-1} \, (\vec{z} - h(\vec{q}\,'))$

$$\underline{V}_{\vec{q}} = (\underline{G}_{\vec{q}\,'}^T \, \underline{V}_{\vec{z}}^{-1} \, \underline{G}_{\vec{q}\,'})^{-1}$$

Note : GLUP & GLSQ based on normal probability distributions

⇒ AGS-formalism (concept)

TOF - spectrum and parameter vector f(a,Y) only channel-channel operations

$(\vec{Y}, \underline{V}_{\vec{Y}})$ TOF – spectrum (counts) dim. n

$(\vec{a}, \underline{V}_{\vec{a}})$ $\vec{a} = (a_1, \ldots, a_k)$ parameter vector

$\Rightarrow \quad \vec{Z} = f(\vec{a}, \vec{Y})$

$$\underline{V}_{\vec{Z}} = \underline{G}_{\vec{a}} \underline{V}_{\vec{a}} \underline{G}_{\vec{a}}^T + \underline{G}_{\vec{Y}} \underline{V}_{\vec{Y}} \underline{G}_{\vec{Y}}^T$$

$$G_{\vec{a}} : \quad g_{a,ik} = \frac{\partial f_i}{\partial a_k}$$

$$G_{\vec{Y}} : \quad g_{Y,ik} = \frac{\partial f_i}{\partial y_k}$$

1) $\underline{V}_{\vec{Y}} = D_{\vec{Y}}$ diagonal elements $\sigma_{y_i}^2$

2) f only channel – channel operations

3) $\underline{V}_{\vec{a}}$: symmetric and positive definite $\boxed{\underline{V}_{\vec{a}} = L_{\vec{a}} L_{\vec{a}}^T}$ Cholesky transformation

TOF - spectrum and parameter vector
f(a,Y) only channel-channel operations

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$(\vec{Y}, \underline{D}_{\vec{Y}})$ TOF – spectrum(counts) dim. n

$(\vec{a}, \underline{V}_{\vec{a}})$ $\vec{a} = (a_1, \ldots, a_k)$ parameter vector

$\Rightarrow \quad \vec{Z} = f(\vec{a}, \vec{Y})$

$$\underline{V}_{\vec{Z}} = \underline{G}_{\vec{a}} \underline{V}_{\vec{a}} \underline{G}_{\vec{a}}^T + \underline{G}_{\vec{Y}} \underline{D}_{\vec{Y}} \underline{G}_{\vec{Y}}^T$$

dim (k,k) $\underline{V}_{\vec{a}} = \underline{L}_{\vec{a}} \underline{L}_{\vec{a}}^T$

dim (n,k) $\underline{G}_{\vec{a}}$

$\underline{V}_{\vec{Y}} = \underline{D}_{\vec{Y}}$ diagonal

f only channel – channel

$\underline{G}_{\vec{Y}}$: diagonal

$$\underline{S}_{\vec{Z}} = \underline{G}_{\vec{a}} \underline{L}_{\vec{a}}$$

dim (n,k)

$$\underline{D}_{\vec{Z}} = \underline{G}_{\vec{Y}} \underline{D}_{\vec{Y}} \underline{G}_{\vec{Y}}^T$$

$\underline{D}_Z$ diagonal, n - values

$$\underline{V}_{\vec{Z}} = \underline{S}_{\vec{Z}} \underline{S}_{\vec{Z}}^T + \underline{D}_{\vec{Z}}$$

TOF - spectrum and parameter vector
f(a,Y) only channel-channel operations

$(\vec{Y}, \underline{D}_{\vec{Y}})$ TOF – spectrum (counts) dim. n

$(\vec{a}, \underline{V}_{\vec{a}})$ $\vec{a} = (a_1, \ldots, a_k)$ parameter vector

$\Rightarrow \quad \vec{Z} = f(\vec{a}, \vec{Y})$

$$\underline{V}_{\vec{Z}} = \underline{G}_{\vec{a}} \underline{V}_{\vec{a}} \underline{G}_{\vec{a}}^T + \underline{G}_{\vec{Y}} \underline{D}_{\vec{Y}} \underline{G}_{\vec{Y}}^T$$

$$\underline{V}_{\vec{a}} = \underline{L}_{\vec{a}} \underline{L}_{\vec{a}}^T$$

$$\underline{S}_{\vec{Z}} = \underline{G}_{\vec{a}} \underline{L}_{\vec{a}}$$

$$\underline{D}_{\vec{Z}} = \underline{G}_{\vec{Y}} \underline{D}_{\vec{Y}} \underline{G}_{\vec{Y}}^T$$

$$\underline{V}_{\vec{Z}} = \underline{S}_{\vec{Z}} \underline{S}_{\vec{Z}}^T + \underline{D}_{\vec{Z}}$$

dim (n,k)

$\underline{D}_Z$ diagonal, n - values

AGS - format

$\Rightarrow$ number of values to be stored dim. (n, k+1)

k = total number of correlated uncertainty components

TOF - spectrum and parameter vector f(a,Y) only channel-channel operations

$(\vec{Y}, \underline{D}_{\vec{Y}})$ TOF – spectrum (counts) dim. n

$(\vec{a}, \underline{V}_{\vec{a}})$ $\vec{a} = (a_1, \ldots, a_k)$ parameter vector

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$$\underline{V}_{\vec{Z}} = \underline{G}_{\vec{a}} \underline{V}_{\vec{a}} \underline{G}_{\vec{a}}^T + \underline{G}_{\vec{Y}} \underline{D}_{\vec{Y}} \underline{G}_{\vec{Y}}^T$$

$$\underline{V}_{\vec{a}} = \underline{L}_{\vec{a}} \underline{L}_{\vec{a}}^T$$

$$\underline{S}_{\vec{Z}} = \underline{G}_{\vec{a}} \underline{L}_{\vec{a}}$$

$$\underline{D}_{\vec{Z}} = \underline{G}_{\vec{Y}} \underline{D}_{\vec{Y}} \underline{G}_{\vec{Y}}^T$$

$\underline{S}_{\vec{Z}}$ – correlated components

$$\underline{V}_{\vec{Z}} = \underline{S}_{\vec{Z}} \underline{S}_{\vec{Z}}^T + \underline{D}_{\vec{Z}}$$

$\underline{D}_{\vec{Z}}$ – uncorrelated components

AGS - format

$\Rightarrow$ number of values to be stored dim. (n, k+1)

k = total number of correlated uncertainty components

TOF - spectrum and parameter vector

Example: $\vec{Z} = a\,\vec{Y}$

$(\vec{Y}, \underline{D}_{\vec{Y}})$ TOF – spectrum (counts) dim. n

$(a, V_a = \sigma_a^2)$ $\vec{a} = (a_1)$ parameter vector dim.1

$$\Rightarrow \quad \vec{Z} = f(\vec{a}, \vec{Y}) = \vec{a}\,\vec{Y}$$

$$\underline{V}_{\vec{Z}} = \underline{G}_{\vec{a}}\,\sigma_a^2\,\underline{G}_{\vec{a}}^T + \underline{G}_{\vec{Y}}\,\underline{D}_{\vec{Y}}\,\underline{G}_{\vec{Y}}^T$$

$L_a = \sigma_a = \sigma_a^T$

$\underline{V}_{\vec{a}} = L_{\vec{a}} L_{\vec{a}}^T$

$\underline{G}_{\vec{a}} = \vec{Y}$

$g_{a,i} = \dfrac{\partial f_i}{\partial a} = y_i$

$\underline{V}_{\vec{Y}} = D_{\vec{Y}}$ diagonal

f only channel – channel

$\underline{G}_{\vec{Y}}$: $g_{Y,ii} = \dfrac{\partial f_i}{\partial y_i} = a$

$\underline{S}_{\vec{Z}} = \underline{Y}\sigma_a$

dim (n,1)

$\underline{D}_{\vec{Z}} = a^2\,\underline{D}_{\vec{Y}}$

$\underline{D}_Z$ diagonal

$$\underline{V}_{\vec{Z}} = (\underline{Y}\sigma_a)(\underline{Y}\sigma_a)^T + a^2\,\underline{D}_{\vec{Y}}$$

TOF - spectra in AGS format and parameter vector

$\vec{Z} = g(\vec{b}, \vec{Z}_1, \vec{Z}_2)$ b, Z_1 and Z_2 not correlated

Input

$(\vec{b}, \underline{V}_{\vec{b}})$ dim. $\vec{b} = k_b$

$$\underline{V}_{\vec{b}} = \underline{L}_{\vec{b}} \underline{L}_{\vec{b}}^T$$

$(\vec{Z}_1, \underline{V}_{\vec{Z}_1})$ $\vec{Z}_1 = f_1(\vec{a}_1, \vec{Y}_1)$ dim. $\vec{a}_1 = k_1$

$$\underline{V}_{\vec{Z}_1} = \underline{S}_{\vec{Z}_1} \underline{S}_{\vec{Z}_1}^T + \underline{D}_{\vec{Z}_1}$$

$(\vec{Z}_2, \underline{V}_{\vec{Z}_2})$ $\vec{Z}_2 = f_2(\vec{a}_2, \vec{Y}_2)$ dim. $\vec{a}_2 = k_2$

$$\underline{V}_{\vec{Z}_2} = \underline{S}_{\vec{Z}_2} \underline{S}_{\vec{Z}_2}^T + \underline{D}_{\vec{Z}_2}$$

Output

$$\Rightarrow \quad \vec{Z} = f(\vec{b}, \vec{Z}_1, \vec{Z}_2)$$

$$\underline{V}_{\vec{Z}} = \underline{S}_{\vec{Z}} \underline{S}_{\vec{Z}}^T + \underline{D}_{\vec{Z}}$$

$\underline{D}_{\vec{Z}}$ – uncorrelated components

$\underline{S}_{\vec{Z}}$ – correlated components

AGS : $\vec{Z} = g(\vec{b}, \vec{Z}_1, \vec{Z}_2)$

b, Z_1 and Z_2 not correlated

Z_1 and Z_2 in AGS-format

$$\underline{V}_{\vec{b}} = \underline{L}_{\vec{b}} \underline{L}_{\vec{b}}^T \qquad \dim \vec{b} = k_b$$

$$\underline{V}_{\vec{Z}_1} = \underline{S}_{\vec{Z}_1} \underline{S}_{\vec{Z}_1}^T + \underline{D}_{\vec{Z}_1} \qquad \dim \underline{S}_{\vec{Z}_1} = (n, k_1)$$

$$\underline{V}_{\vec{Z}_2} = \underline{S}_{\vec{Z}_2} \underline{S}_{\vec{Z}_2}^T + \underline{D}_{\vec{Z}_2} \qquad \dim \underline{S}_{\vec{Z}_2} = (n, k_2)$$

$$\underline{V}_{\vec{Z}} = \underline{G}_{\vec{b}} \underline{V}_{\vec{b}} \underline{G}_{\vec{b}}^T + \underline{G}_{\vec{Z}_1} \underline{V}_{\vec{Z}_1} \underline{G}_{\vec{Z}_1}^T + \underline{G}_{\vec{Z}_2} \underline{V}_{\vec{Z}_2} \underline{G}_{\vec{Z}_2}^T$$

$$\underline{V}_{\vec{Z}} = \underline{G}_{\vec{b}} \underline{L}_{\vec{b}} \underline{L}_{\vec{b}}^T \underline{G}_{\vec{b}}^T + \underline{G}_{\vec{Z}_1} \underline{S}_{\vec{Z}_1} \underline{S}_{\vec{Z}_1}^T \underline{G}_{\vec{Z}_1}^T + \underline{G}_{\vec{Z}_1} \underline{D}_{\vec{Z}_1} \underline{G}_{\vec{Z}_1}^T + \underline{G}_{\vec{Z}_2} \underline{S}_{\vec{Z}_2} \underline{S}_{\vec{Z}_2}^T \underline{G}_{\vec{Z}_2}^T + \underline{G}_{\vec{Z}_2} \underline{D}_{\vec{Z}_2} \underline{G}_{\vec{Z}_2}^T$$

AGS : $\vec{Z} = g(\vec{b}, \vec{Z}_1, \vec{Z}_2)$

b, Z_1 and Z_2 not correlated
Z_1 and Z_2 in AGS-format

$$\underline{V}_{\vec{b}} = \underline{L}_{\vec{b}} \underline{L}_{\vec{b}}^T \qquad \dim \vec{b} = k_b$$

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$$\underline{V}_{\vec{Z}_2} = \underline{S}_{\vec{Z}_2} \underline{S}_{\vec{Z}_2}^T + \underline{D}_{\vec{Z}_2} \qquad \dim \underline{S}_{\vec{Z}_2} = (n, k_2)$$

$$\underline{V}_{\vec{Z}} = \underline{G}_{\vec{b}} \underline{V}_{\vec{b}} \underline{G}_{\vec{b}}^T + \underline{G}_{\vec{Z}_1} \underline{V}_{\vec{Z}_1} \underline{G}_{\vec{Z}_1}^T + \underline{G}_{\vec{Z}_2} \underline{V}_{\vec{Z}_2} \underline{G}_{\vec{Z}_2}^T$$

$$\underline{V}_{\vec{Z}} = \underline{G}_{\vec{b}} \underline{L}_{\vec{b}} \underline{L}_{\vec{b}}^T \underline{G}_{\vec{b}}^T + \underline{G}_{\vec{Z}_1} \underline{S}_{\vec{Z}_1} \underline{S}_{\vec{Z}_1}^T \underline{G}_{\vec{Z}_1}^T + \underline{G}_{\vec{Z}_1} \underline{D}_{\vec{Z}_1} \underline{G}_{\vec{Z}_1}^T + \underline{G}_{\vec{Z}_2} \underline{S}_{\vec{Z}_2} \underline{S}_{\vec{Z}_2}^T \underline{G}_{\vec{Z}_2}^T + \underline{G}_{\vec{Z}_2} \underline{D}_{\vec{Z}_2} \underline{G}_{\vec{Z}_2}^T$$

AGS : $\vec{Z} = g(\vec{b}, \vec{Z}_1, \vec{Z}_2)$

b, Z_1 and Z_2 not correlated

Z_1 and Z_2 in AGS-format

$$\underline{V}_{\vec{b}} = \underline{L}_{\vec{b}} \underline{L}_{\vec{b}}^T \qquad \dim \vec{b} = k_b$$

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$$\underline{V}_{\vec{Z}_2} = \underline{S}_{\vec{Z}_2} \underline{S}_{\vec{Z}_2}^T + \underline{D}_{\vec{Z}_2} \qquad \dim \underline{S}_{\vec{Z}_2} = (n, k_2)$$

$$\underline{V}_{\vec{Z}} = \underline{G}_{\vec{b}} \underline{V}_{\vec{b}} \underline{G}_{\vec{b}}^T + \underline{G}_{\vec{Z}_1} \underline{V}_{\vec{Z}_1} \underline{G}_{\vec{Z}_1}^T + \underline{G}_{\vec{Z}_2} \underline{V}_{\vec{Z}_2} \underline{G}_{\vec{Z}_2}^T$$

$$\underline{V}_{\vec{Z}} = \underline{G}_{\vec{b}} \underline{L}_{\vec{b}} \underline{L}_{\vec{b}}^T \underline{G}_{\vec{b}}^T + \underline{G}_{\vec{Z}_1} \underline{S}_{\vec{Z}_1} \underline{S}_{\vec{Z}_1}^T \underline{G}_{\vec{Z}_1}^T + \underline{G}_{\vec{Z}_2} \underline{S}_{\vec{Z}_2} \underline{S}_{\vec{Z}_2}^T \underline{G}_{\vec{Z}_2}^T + \underline{G}_{\vec{Z}_1} \underline{D}_{\vec{Z}_1} \underline{G}_{\vec{Z}_1}^T + \underline{G}_{\vec{Z}_2} \underline{D}_{\vec{Z}_2} \underline{G}_{\vec{Z}_2}^T$$

$$\underline{S}_{\vec{Z}} = \left[\underline{G}_{\vec{b}} \underline{L}_{\vec{b}} \quad \underline{G}_{\vec{Z}_1} \underline{S}_{\vec{Z}_1} \quad \underline{G}_{\vec{Z}_2} \underline{S}_{\vec{Z}_2} \right]$$

dim (n,k) $\quad (n,k_b) \quad (n,k_1) \quad (n,k_2)$

$(k = k_b + k_1 + k_2)$

$\underline{S}_{\vec{Z}}$ – correlated components

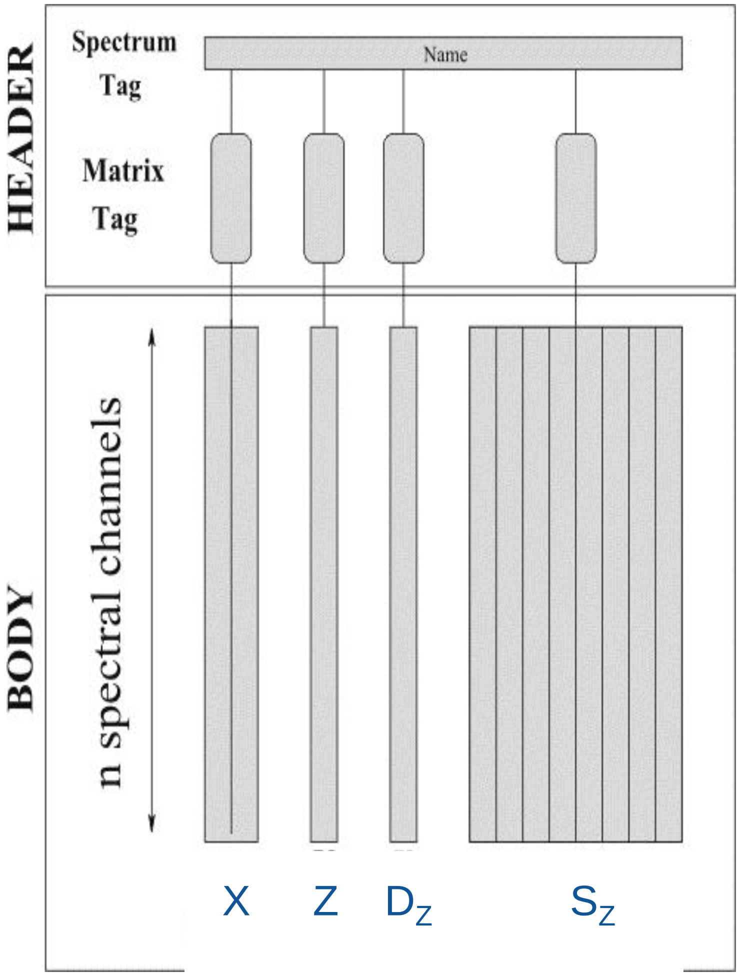
$$\underline{D}_{\vec{Z}} = \underline{G}_{\vec{Z}_1} \underline{D}_{\vec{Z}_1} \underline{G}_{\vec{Z}_1}^T + \underline{G}_{\vec{Z}_2} \underline{D}_{\vec{Z}_2} \underline{G}_{\vec{Z}_2}^T$$

dim n

$\underline{D}_{\vec{Z}}$ – uncorrelated components

$$\underline{V}_{\vec{Z}} = \underline{S}_{\vec{Z}} \underline{S}_{\vec{Z}}^T + \underline{D}_{\vec{Z}}$$

AGS File format



Observable Z (dimension n) with
k sources of correlated uncertainties

C. Bastian, Int. Soc. Optical Eng. 2867 (1997) 611

$$\underline{V}_{\vec{Z}} = \underline{S}_{\vec{Z}}\,\underline{S}_{\vec{Z}}^{T} + \underline{D}_{\vec{Z}}$$

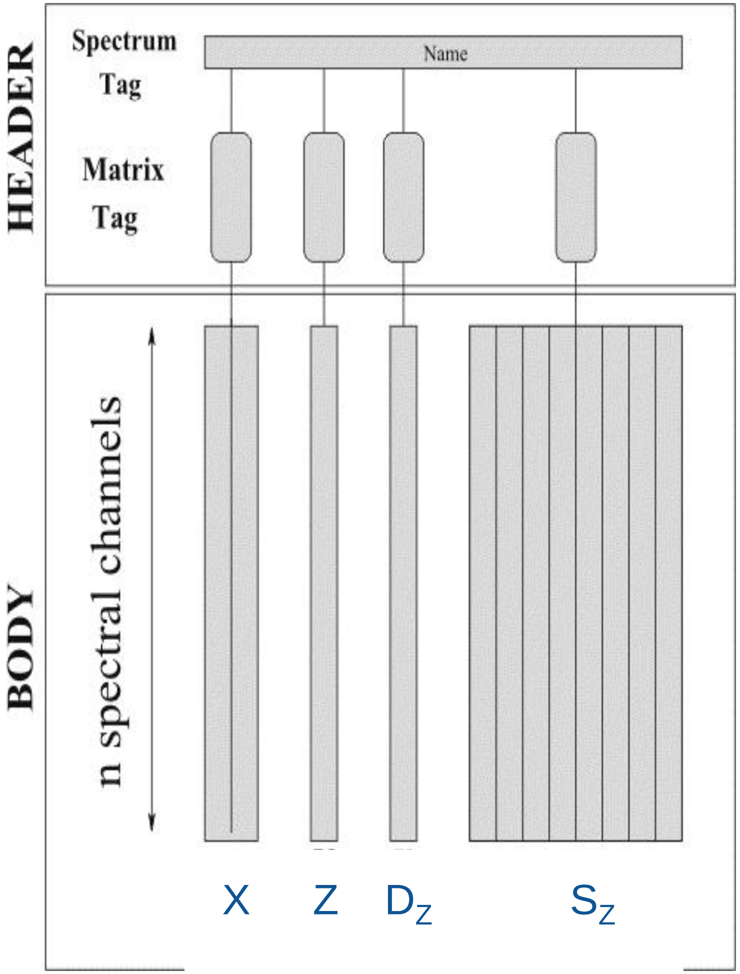
n : number of data points (TOF)

k : number of quantities introducing correlated uncertainty components

D_Z : uncorrelated part (n values)

S_Z : matrix dimension (n x k)
contains the contribution of each quantity creating a correlated uncertainty component

AGS File format



Observable Z (dimension n) with
k sources of correlated uncertainties

$$\underline{V}_{\vec{Z}} = \underline{S}_{\vec{Z}} \underline{S}_{\vec{Z}}^{T} + \underline{D}_{\vec{Z}}$$

Storage space

- Covariance matrix
  - n^2 elements (e.g. 32k x 8 bytes → 8 Gb)
- AGS representation
  - n (k+1) elements (32k, 20 corr. → 5 Mb)

Information

- Covariance matrix
  - no separation between components
- AGS representation
  - separates uncorrelated and correlated components (avoid PPP)
  - verify impact of each individual component

AGS commands

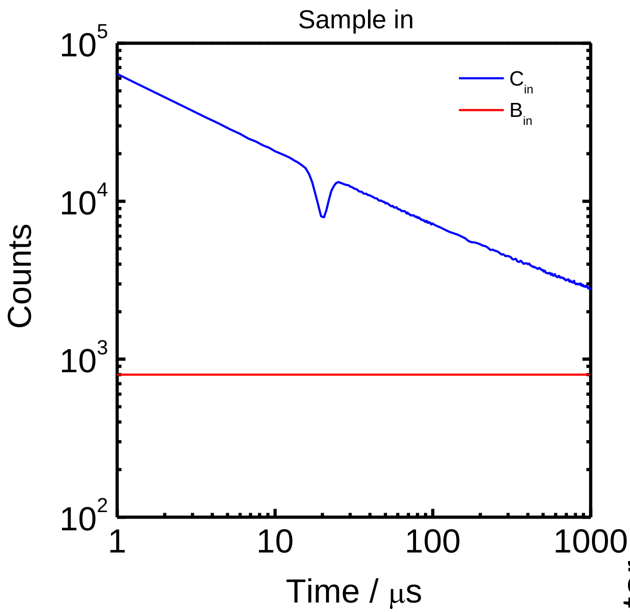
Creation of AGS library file and data import	
ags_getA	Import a spectrum from an AGS archive file
ags_getE	Import cross section data from an ENDF formated file (file 3) in energy
ags_getET	Import cross section data from an ENDF formated file (file 3) in TOF
ags_getH	Import a histogram (integers)
ags_getW	Import a weighted histogram
ags_getXY	Import a spectrum
ags_getY	Import a histogram
ags_mpty	Creation of an empty AGS archive file
Basic channel-to-channel, arithmetic operations	
ags_addval	Add a constant to a spectrum
ags_divval	Division of a spectrum by a constant
ags_multval	Multiplication of a spectrum with a constant
ags_subval	Subtraction of a constant from a spectrum
Channel-to-channel, spectrum operations	
ags_avrg	Division of spectrum by bin widths
ags_divi	Division of two spectra
ags_dtco	Dead time correction
ags_ener	Conversion of bin boundaries from TOF to energy
ags_exp	Exponential of a spectrum
ags_fit	Fitting a spectrum
ags_fpa	Flight path adjustment
ags_func	Generate spectrum using a function
ags_fxyp	Special spectrum operation
ags_inv	Inverse a spectrum
ags_lico	Linear combination of spectra
ags_lift	Interpolate spectrum on different grid
ags_log	Natural logarithm of a spectrum
ags_mult	Multiplication of two spectra
ags_shift	Shift grid boundaries
ags_tof	Conversion of bin boundaries from energy to TOF
ags_unav	Multiply spectrum with bin widths
Output operations	
ags_putCM	Print covariance matrix
ags_putX	Print spectra and uncertainty components
ags_scan	Print content of AGS archive file
ags_title	Print title of AGS archive file

AGS, Script for transmission data

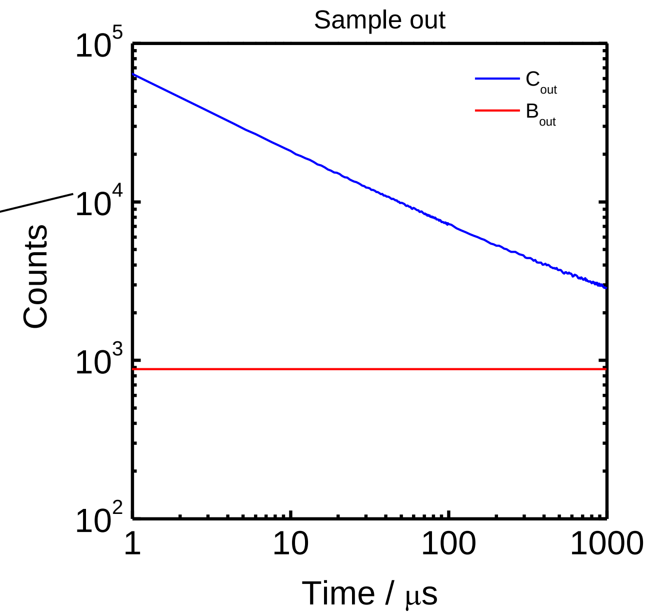
$$T = N \frac{C'_{in} - B'_{in}}{C'_{out} - B'_{out}}$$

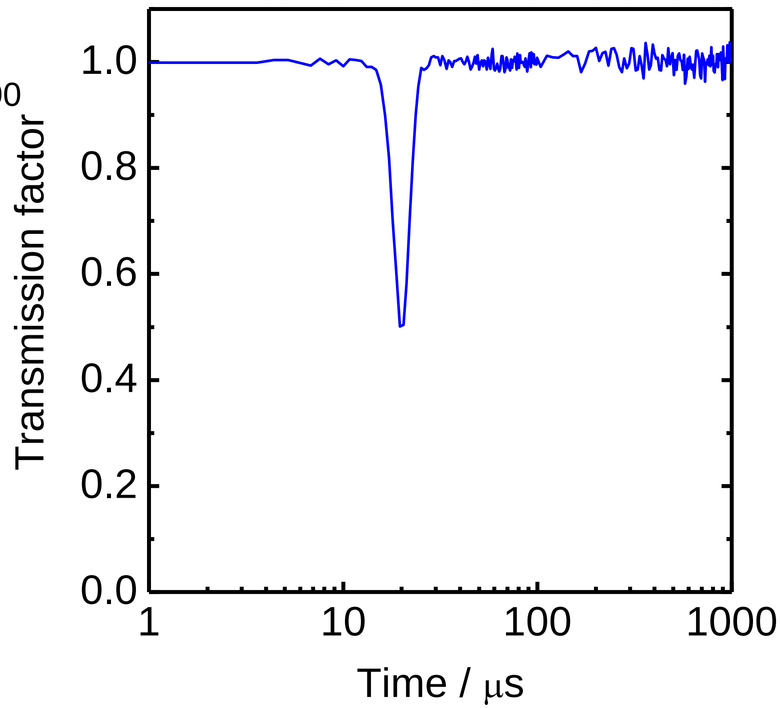
```
# create ags-file
ags_mpty TRFAK

# read sample out
scaler=TOout,CMout
ags_getXY TRFAK /SCALER=$scaler /FROM=spout.his /ALIAS=SOUT

# read sample in
scaler=TOin,CMin
ags_getXY TRFAK /SCALER=$scaler /FROM=spin.his /ALIAS=SIN /LIKE=A01SOUT

# dead time correction
dtcoef=DTCOEF
ags_idtc TRFAK,A01SOUT /DTIME=$dtcoef /LPSC=1
ags_idtc TRFAK,B01SIN /DTIME=$dtcoef /LPSC=1

# normalize to central monitor and divide by bin width
ags_avgr TRFAK,C01SOUT /CMSC=2
ags_avgr TRFAK,D01SIN /CMSC=2

#calculate background contribution
ags_func TRFAK /FUN=f01 /PARFILE=PAROUT /ALIAS=SBOUT /LIKE=A01SOUT
ags_func TRFAK /FUN=f01 /PARFILE=PARIN /ALIAS=SBIN /LIKE=A01SOUT

#subtract background
ags_lico TRFAK,E01SOUT,G01SBOUT /ALIAS=SOUTNET /PAR=1.0,-1.0
ags_lico TRFAK,F01SIN,H01SBIN /ALIAS=SINNET /PAR=1.0,-1.0

#create transmission factor
ags_divi TRFAK,I01SOUTNET,J01SINNET /ALIAS=TRFAK
```

Calculation of transmission



$$T_{exp} = N\frac{C'_{in} - B'_{in}}{C'_{out} - B'_{out}}$$



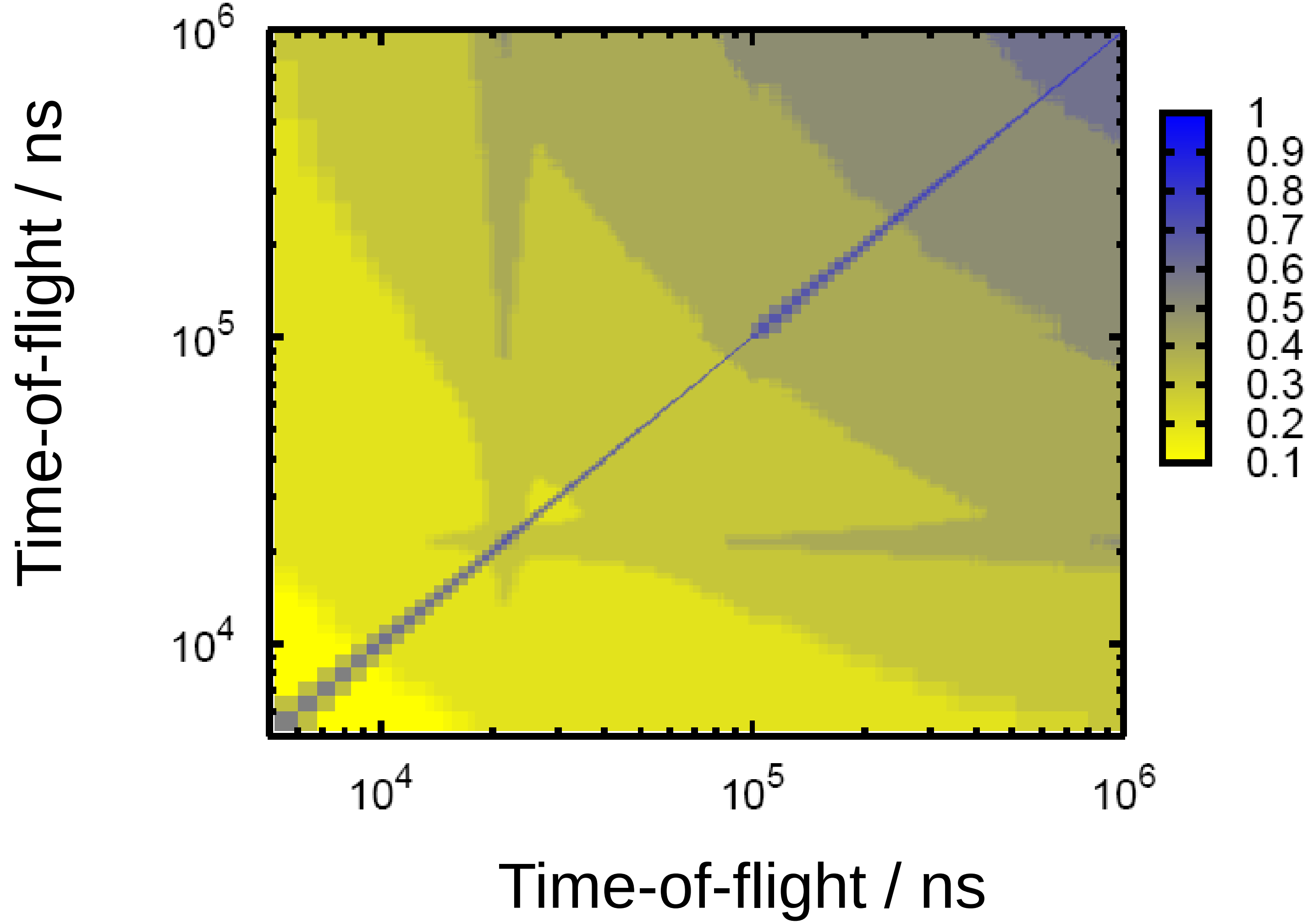


Output AGS_PUTX

$\delta B_{in} / B_{in}$: 10.0 %
$\delta B_{out} / B_{out}$: 5.0 %
$\delta N / N$: 0.5 %

X_L	X_H	Z	δZ	δZ_u	$V_Z = D_Z + S\,S^T$: D_Z (δZ_u^2)	S: B_{in}	S: B_{out}	S: N
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	0.18E-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

AGS Output -> Covariance matrix



Reliable model parameters from experiment

Requirements:

Well documented experimental observables in EXFOR

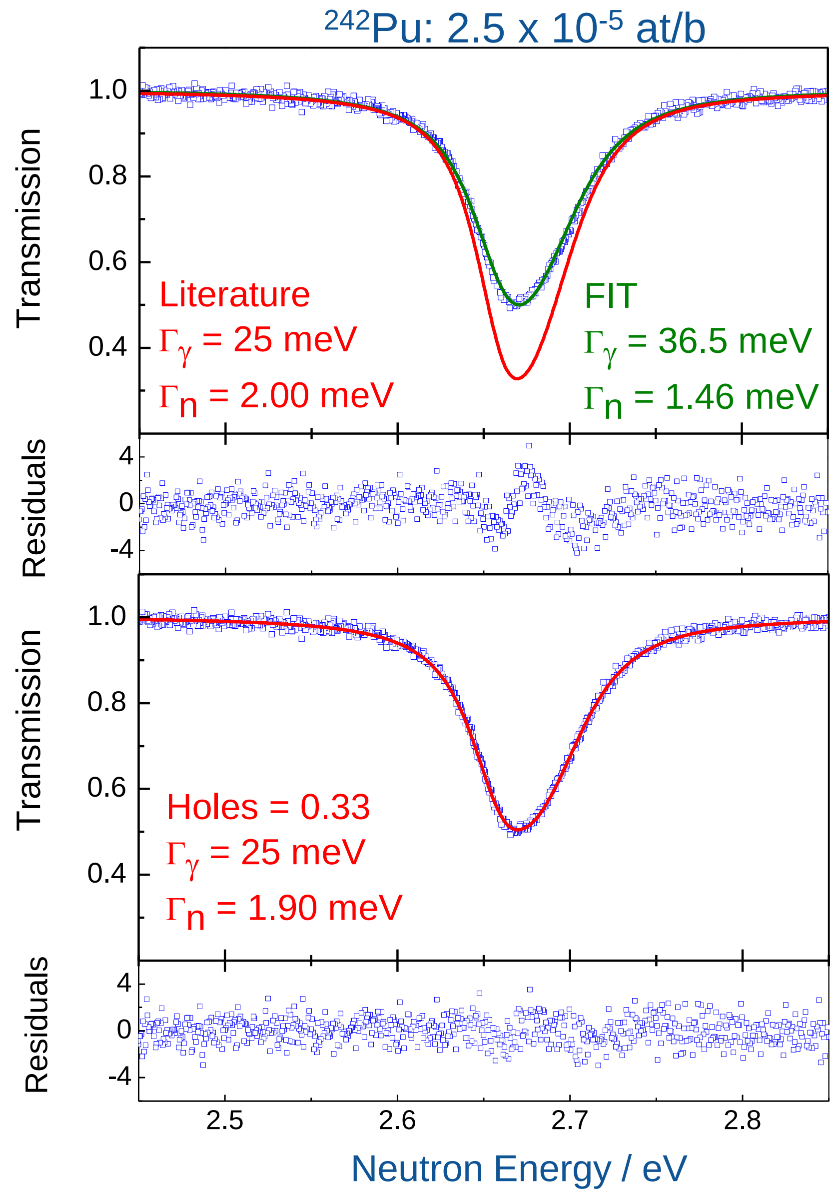
Including:

- experimental details (T_D, n, N, …)
- all uncertainty components (correlated and uncorrelated, AGS-format)
- response function of TOF-spectrometers

$\Rightarrow$ Recommendation IAEA / IRMM based on the AGS – system

Specify target characteristics

- Powder/metal sample
- Areal density + uncertainty
- Grain size of powder sample
- Homogeneity



Capture measurements

Specify how data reduction was done and use a proper reference

1) Weighting function

- with threshold — e.g. Borella et al., NIM A577 (2007) 626
- without threshold — e.g. Abbondannno et al. NIM A521 (2004) 454

2) Correction for γ-ray attenuation

3) Normalization

- internal/external
- saturated resonance
- neutron flux monitor

4) Background

- fixed background filters

Template for cross section data in EXFOR

Main Reference		**1**
Facility	**GELINA**	**2,3**
Neutron production		**4**
Primary neutron production target	Uranium	
Time resolution primary beam (ns)	4 ns	
Moderator material	H_2O	
Surface Dimensions (mm x mm or diameter in mm)	2 containers 100 x 100 mm	
Thickness (mm)	40 mm	
Experimental details		
Measurement type	Fission	
Flight path length (m) (moderator – target (detector): face to face distance)	(8.218 +/- 0.006) m	
Angle (with respect to normal of moderator)	18 deg	
Beam dimensions (mm x mm or diameter in mm)	Diameter 55 mm	
Sample		
Type (metal, powder)	Electrodeposition	
Chemical composition	UO_2	
Atomic abundance of main element	99.9732 at% ^{236}U	
Weight per unit area (g/cm^2)	(209.9 +/- 1.3) Uμg/cm^2	
Geometry		
Surface dimensions (mm x mm or diameter in mm)	Diameter (50.0 +/- 0.1) mm	
Thickness of main element (at/b)	5.354 10^{-6} at/b ^{236}U	
Backing	20 μm aluminium	
Containment description	No container	
Temperature	25 meV	

[1] NSE 160 (2008) 200 - 206
[2] NIM A 179 (1981), 13
[3] NIM A 228 (1985), 217
[4] NIM A 531 (2004), 392

Recommendation
IRMM & NDS - IAEA

Template for cross section data in EXFOR

Detector	
Type	Frisch gridded ionisation chamber
Material	CH_4 (100%)
Gas pressure	Gas flow at 1 atm
Geometry	2π
Flux normalization	
Reaction	$^{10}B(n,\alpha)$
Cross section from	ENDF/B-VI.8
Atomic abundance of main element	93.0 at% ^{10}B
Target thickness	(8.05 +/- 0.10) ^{10}B $\mu g/cm^2$
Surface dimensions	Diameter (50.0 +/- 0.1) mm
	(^{236}U- ^{10}B : back to back)
Normalization uncertainty (TOF-independent)	**1.5 %**
Data	
Time-of-flight of first channel	3000 ns
Time-of-fligth bin width / ns	Column 1
Energy (relativistic formula, L = 8.238 m) eV	Column 2
Yield in barn/at	Column 3
Uncertainties (at 1 sigma level)	
Total (normalization not included)	Column 4
Uncorrelated contribution (variance)	Column 5
Other sources creating correlated uncertainty components	Dead time ^{10}B [col 6]
	Background ^{10}B [col.7, 8,9]
	Dead time ^{236}U [col. 10]
	Background ^{236}U [col.11,12,13]

Description of
AGS
Output

IAEA recommendation

IAEA
International Atomic Energy Agency

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INDC International Nuclear Data Committee

Summary Report of the Consultants' Meeting on

EXFOR Data in Resonance Region and Spectrometer Response Function

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