Weighting functions for the neutron capture measurements performed at nTOF-CERN in 2002-2003

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Abstract

For neutron capture measurements with C_6D_6 liquid scintillator gamma-ray detectors at the nTOF facility at CERN, we have calculated the response functions of the detectors by means of Monte Carlo simulations with the code MCNP. In total we simulated all 34 cases in 6 different sample-detector geometries as used in the capture measurements at CERN in 2002, and 23 cases in one single setup related to the 2003 campaign. From the response functions for each case we derived a weighting function, which is indispensable for the analysis of neutron capture measurements with C_6D_6 detectors. The parameters of all weighting functions are given together with their statistical uncertainties.

Introduction

In neutron capture cross section experiments one measures the gamma rays following the capture of incident neutrons on a sample and inducing a (n,γ) reaction. The cross section shows resonances since the compound nucleus formed by neutron capture is in an excited state at several MeV above the ground state due to the available neutron binding energy. Many decay paths via intermediate levels to the ground state are possible, especially for medium and heavy mass nuclei with a large level density.

The signature of a (n,γ) reaction is the subsequent gamma cascade, consisting of one or more gamma rays. The corresponding gamma-ray spectrum and gamma-ray multiplicity spectrum vary from one resonance to another but also from one isotope to another.

Only if all gamma rays from a cascade are detected, like in a detector with 100% efficiency and covering a 4π solid angle, the capture reaction yield can be determined in a straightforward way. With a gamma-ray detector covering a smaller solid angle or having a smaller efficiency, such as the C_6D_6 detectors used at nTOF-CERN, not all gamma rays of the cascade are detected.

To overcome this situation, one usually applies the pulse height weighting technique, allowing to make the detection efficiency of a capture event independent from the decay cascade.

The nucleus at its excitation energy E_c, decays by a gamma-ray cascade to the ground state. The sum of the gamma-ray energies $E_{\gamma,i}$ of the cascade corresponds to E_c

$$E_c = \sum_{i=1}^{n} E_{\gamma_i} \tag{1}$$

and the detection efficiency ϵ_c of the cascade can be expressed as:

$$\epsilon_c = 1 - \prod_{i=1}^{n} (1 - \epsilon_{\gamma_i}) \tag{2}$$

with ϵ_{γ_i}, the detection efficiency of the gamma-ray i of the cascade.

If the detection efficiency for a single gamma ray is small, $\epsilon_{\gamma_i} \ll 1$, then the previous equation can be approximated by:

$$\epsilon_c \approx \sum_{i=1}^{n} \epsilon_{\gamma_i} \tag{3}$$

If the detection efficiency of the detector were proportional to the gamma-ray energy,

$$\epsilon_\gamma = k \times E_\gamma \tag{4}$$

then the cascade efficiency would be proportional to the excitation energy

$$\epsilon_c = \sum_{i=1}^{n} \epsilon_{\gamma_i} = k \times \sum_{i=1}^{n} E_{\gamma_i} = k \times E_c \tag{5}$$

Real life detectors do not have this proportionality, except in approximation the Moxon-Rae detectors [1]. It is therefore convenient to change the efficiency artificially by applying a weight to the detected events in order to establish the proportionality of equation (4). The efficiency ϵ_γ for a gamma ray is related to the response function of the detector by:

$$\epsilon_\gamma = \int R_\gamma(E) dE \tag{6}$$

The response function is the probability distribution of the energy deposited in the detector for an incident gamma ray. For a detector with an infinite resolution and a 100% efficiency, the response function is a delta function. Detectors with a low resolution have broad response functions which can be measured [2] or simulated. A function $W(E)$ of the deposited energy has to be found in order to satisfy the relation:

$$\epsilon_\gamma = \int W(E) R_\gamma(E) dE = k \times E_\gamma \tag{7}$$

When the response function is known for several gamma rays, a parametrization of $W(E)$ can be obtained by minimizing the χ^2 quantity

$$\chi^2 = \sum_{i=1}^{n} \left(\frac{E_{\gamma_i} - \sum_j W(E_j) R_{\gamma_i}(E_j)}{\sigma_i} \right)^2 \tag{8}$$

where the proportionality constant has been taken $k = 1$ and where the continuous response function $R_\gamma(E)$ of a single gamma ray has been discretized in bins j as $R_\gamma(E_j)$. A relative weight or “data uncertainty” σ_i can be attributed to each response function $R_{\gamma_i}(E)$ in the fitting procedure.

1. Simulation for the capture measurements

At the nTOF facility at CERN [3], a measurement programme has been undertaken to measure neutron capture and fission cross sections. This facility offers two main advantages: a high instantaneous neutron flux, allowing capture measurements of radioactive samples, and a large neutron energy range combined with good resolution.

To detect the gamma rays from the (n,γ) reaction, we use C_6D_6-based liquid scintillator detectors. This material has a very low neutron capture cross section and is in this way little sensitive to neutrons scattered from the sample to the detector. Two types of C_6D_6 detectors have been used in the measurement campaign of 2002: an optimized commercial detector available from Bicron [4], and an in-house developed detector from FZK-Karlsruhe [5], with a carbon fibre housing optimized for an even lower neutron sensitivity. In 2003, we exclusively used the last type of C_6D_6.

In order to determine the weighting functions for the measurement setup, the detector response functions over a wide range of gamma-ray energies are necessary, typically from 0.1 to 15 MeV. Since nearly mono-energetic gamma-ray sources are not readily available above about 2.6 MeV, it is convenient to use simulations to calculate the response functions. We have used the Monte Carlo simulation code MCNP [6] to determine the detector response functions for each of the capture setups used at nTOF-CERN in 2002-2003.

The simulations include all 34 samples measured in the 6 different main geometries used in 2002, and 23 samples in the single setup used in 2003. The geometry description includes in detail : the sample, the sample holder, the detectors, and if needed, the canning and the sample changer beam pipes. For each sample, we simulated the energy spectrum deposited in the active C_6D_6 volume for a series of 20 mono-energetic and isotropic gamma rays of energies 0.1, 0.2, 0.5, 0.7, 0.8, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0 and 15.0 MeV, originating uniformly throughout the sample volume. The obtained spectra were broadened afterwards with a Gaussian broadening function with a variance of $\sigma^2 = 3.75E + 1.87E^2$ (σ and E in keV) in order to take into account the broadening due to the photomultiplier. An example of such a set of responses is shown in figure 1. Especially the double escape peaks due to pair creation are distinguishable.

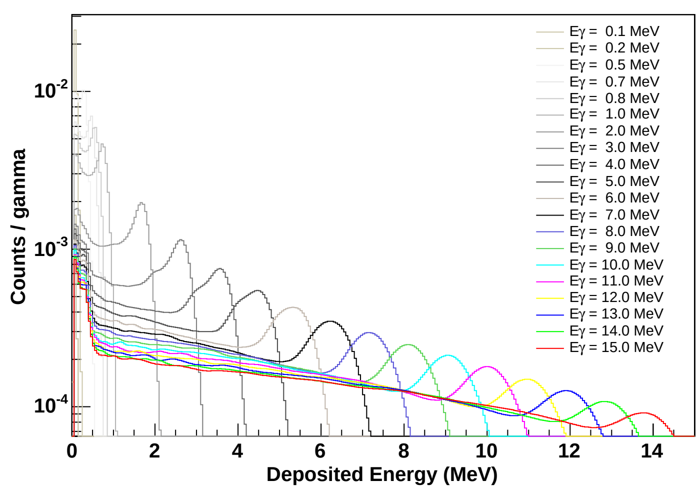

Figure 1: Broadened response functions for 2 detectors, for the case of Au (0.8 mm x 15 mm) used in TOF07.

There were 7 different setups for part of the experiments of TOF02 [7], TOF03 [8], TOF04 [9], TOF05 [10], TOF07 [11] and TOF08 [12]. They are all described by the following figures (figure 2 to 8). At the start of the experiments in 2002, one Bicron and one FZK detector were in use (figure 2). Then the two FZK detectors were installed, and later progressively moved upstream, in order to reduce the sample-scattered photon background.

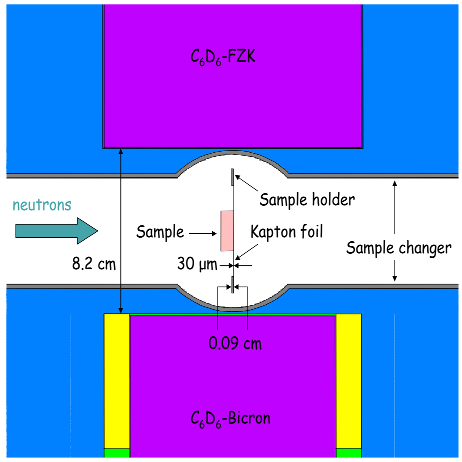

Figure 2: Setup #1, part of TOF02 measurement, 2002 campaign.

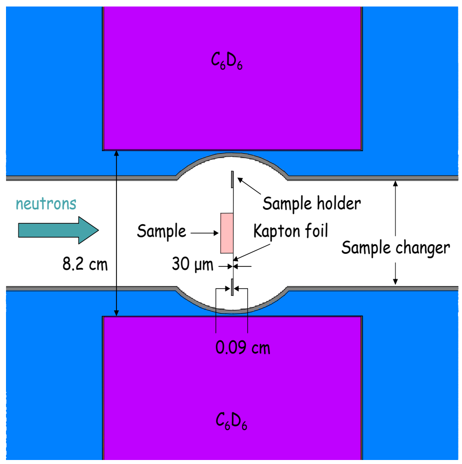

Figure 3: Setup #2, part of TOF02 measurement, 2002 campaign.

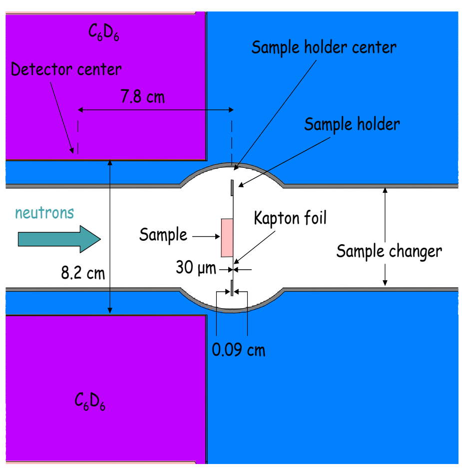

Figure 4: Setup #3, part of TOF02 measurement, 2002 campaign.

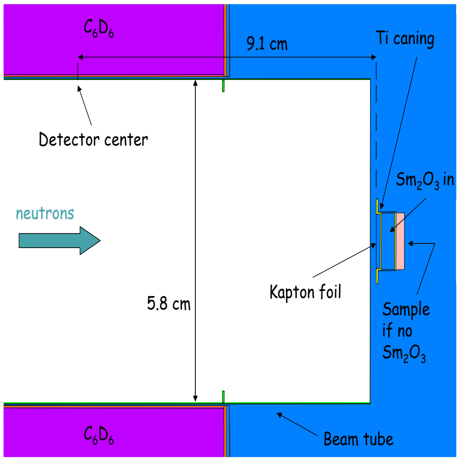

Figure 5: Setup #4, part of TOF03 measurement, 2002 campaign.

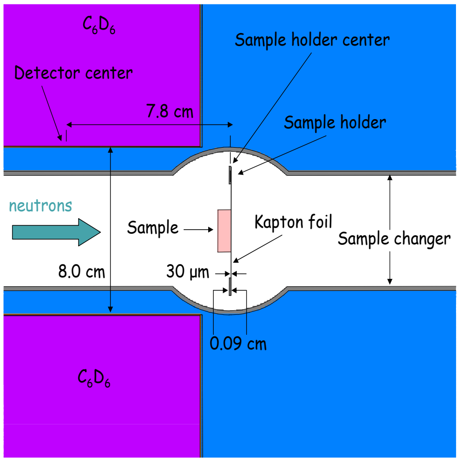

Figure 6: Setup #5, part of TOF05 measurement, 2002 campaign.

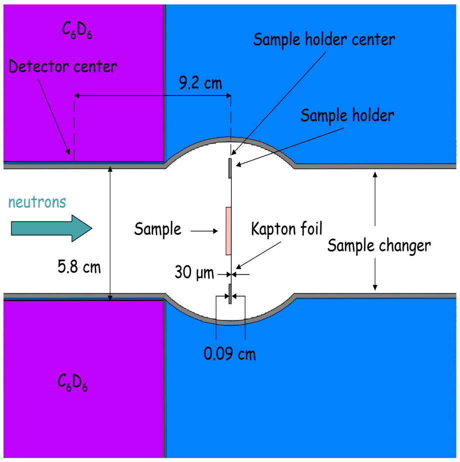

Figure 7: Setup #6, part of TOF05 and TOF07 measurement, 2002 campaign.

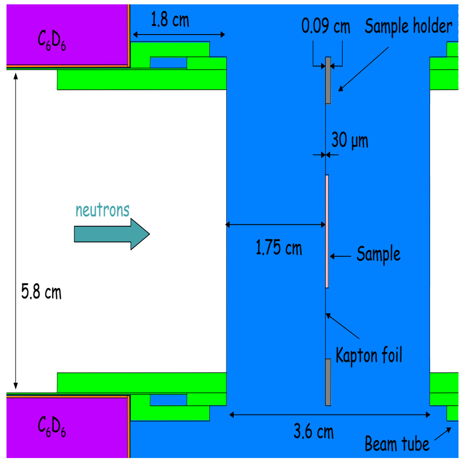

Figure 8: Setup #7, part of TOF03, TOF04 and TOF08 measurement, 2003 campaign.

Some of the measured samples were placed in cannings. One Ti canning and three types of Al canning have been used (figure 9). Their thicknesses have been adjusted in such way that the resulting simulated masses were the most accurate compared to the measured masses.

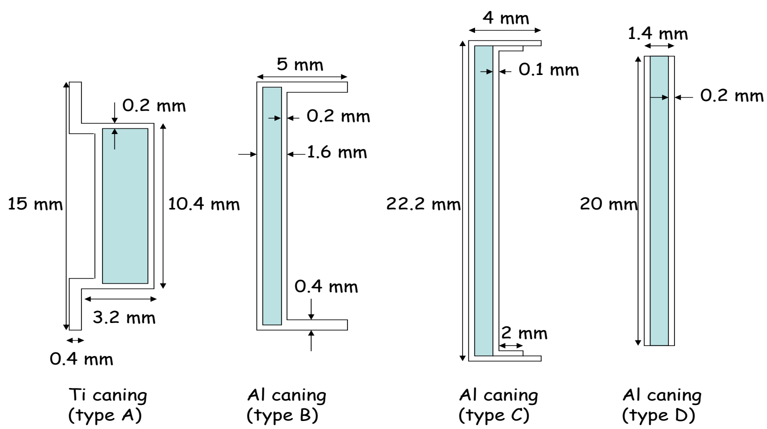

Figure 9: Schematic view of the different simulated cannings.

2. Weighting functions

From the simulated and subsequently broadened response functions we derived a weighting function by minimizing equation (8). We got best results with a fourth order polynomial for $W(E)$:

$$W(E) = \sum_{k=0}^{4} a_k E^k \tag{9}$$

In the fitting procedure we used a relative weight or "data uncertainty" for each gamma response function i equal to

$$\sigma_i = E_{\gamma_i} \frac{\sqrt{\sum_j dR^2_{\gamma_i}(E_j)}}{\sum_j R_{\gamma_i}(E_j)} \tag{10}$$

From the fit are resulting the optimized parameters and the covariance matrix of the parameters. The variance of the weighting function with m parameters a_k is then given in a general form by

$$\mathrm{var}(W(E)) = \sum_{i=0}^{m} \sum_{j=0}^{m} \left(\frac{\partial W}{\partial a_i} \right) \left(\frac{\partial W}{\partial a_j} \right) \mathrm{cov}(a_i, a_j) \tag{11}$$

which becomes in the case of a polynomial

$$\mathrm{var}(W(E)) = \sum_{i=0}^{m} \sum_{j=0}^{m} E^i E^j \mathrm{cov}(a_i, a_j) \tag{12}$$

Instead of the covariance matrix it is sometimes easier to use the correlation matrix defined by

$$\rho(a_i, a_j) = \frac{\sqrt{\mathrm{var}(a_i)\mathrm{var}(a_j)}}{\mathrm{cov}(a_i, a_j)} \tag{13}$$

In the annexe we give the correlation coefficients in percent for ease of reading.

The uncertainty on the fitted function resulting from standard fitting procedures can be unrealistically small if the uncertainties on the data σ_i are small. Especially with Monte Carlo simulations it is easy to increase the number of events in order to improve the statistical counting errors. Although small uncertainties are then obtained, the goodness of the fit is characterized by the reduced chi-square value, the chi-square divided by the number of degrees of freedom, which should be in the order of 1 for a statistically coherent fit assuming Gaussian errors. A high value of the reduced chi-square may indicate that the chosen fitting function is not well adapted to the data.

A commonly used compromise for the situation of a fit with small parameter uncertainties and a high reduced chi-square value, is to scale the data uncertainties σ_i with a factor F in order to obtain a reduced chi-square of 1. The number of degrees of freedom corresponds to the number of gamma-ray spectra n minus the number of parameters k.

$$\frac{\chi^2}{n-k} = \sum_{i=1}^{n} \left(\frac{E_{\gamma_i} - \sum_j W(E_j) R_{\gamma_i}(E_j)}{F \times \sigma_i} \right)^2 = 1 \tag{14}$$

In table 1 we summarize the fitted parameters for the weighting functions of all cases. The masses and diameters are most accurate, the thicknesses are only approximate. The response functions below 160 keV were not included in the fit, which corresponds to the threshold typically used in the data analysis. For each case of weigting function result in this table, we specify: the measured sample, its nominal dimensions (adapted in the simulation to match the mass), the mass, the experiment to which it belongs, the related setup which has been described in the previous paragraph, the detector for which this weighting function is calculated, the type and mass of the canning if it was used, and finally, the parameters of the weighting function.

Table 1: The weighting functions for a single detector for the capture experiments at CERN in 2002-2003. The parameters correspond to a fourth order polynomial $\sum_k a_k E^k$. Uncertainties related to these parameters are given in the annexe.

sample	**t (mm)**	**d (mm)**	**mass (g)**	**exp**	**setup**	**det**	**can**	**WF parameters**
Au	1.0	20.0	5.91011	TOF02	1	FZK	-	a_0= 4.964 a_1= 19.135 a_2= 15.577 a_3= -1.434 a_4= 0.061
Au	1.0	20.0	5.91011	TOF02	1	Bicron	-	a_0= 7.319 a_1= 26.551 a_2= 22.830 a_3= -2.209 a_4= 0.094
Au	0.1	45.0	3.29	TOF02	1	FZK	-	a_0= 11.101 a_1= 10.148 a_2= 23.846 a_3= -2.780 a_4= 0.101
Au	0.1	45.0	3.29	TOF02	1	Bicron	-	a_0= 17.306 a_1= 11.505 a_2= 35.968 a_3= -4.161 a_4= 0.149

sample	t (mm)	d (mm)	mass (g)	exp	setup	det	can	WF parameters
C	6.3	20.0	3.93345	TOF02	1	FZK	-	a_0= 4.712 a_1= 20.457 a_2= 16.022 a_3= -1.582 a_4= 0.090
C	6.3	20.0	3.93345	TOF02	1	Bicron	-	a_0= 6.656 a_1= 29.681 a_2= 22.556 a_3=-2.274 a_4= 0.128
Pb	1.0	20.0	3.607	TOF02	1	FZK	-	a_0= 8.864 a_1= 12.970 a_2= 21.336 a_3= -2.445 a_4= 0.095
Pb	1.0	20.0	3.607	TOF02	1	Bicron	-	a_0= 13.593 a_1= 16.615 a_2= 31.543 a_3= -3.567 a_4= 0.135
Au	0.1	45.0	3.29	TOF02	2	FZK	-	a_0= 4.997 a_1= 18.976 a_2= 15.589 a_3=-1.420 a_4= 0.060
C	6.3	20.0	3.93345	TOF02	2	FZK	-	a_0= 4.817 a_1= 20.086 a_2= 16.108 a_3= -1.569 a_4=0.088
Fe	0.5	45.0	6.17	TOF02	2	FZK	-	a_0= 4.581 a_1= 20.111 a_2= 15.217 a_3= -1.404 a_4= 0.066
Fe	2.0	45.0	25.18933	TOF02	2	FZK	-	a_0= 5.686 a_1= 20.030 a_2= 16.971 a_3= -1.752 a_4= 0.070

sample	t (mm)	d (mm)	mass (g)	exp	setup	det	can	WF parameters
C	6.3	20.0	3.93345	TOF02	3	FZK	-	a_0= 7.343 a_1= 35.303 a_2= 24.582 a_3= -2.279 a_4=0.115
Pb	1.0	20.0	3.607	TOF02	3	FZK	-	a_0= 10.534 a_1= 28.680 a_2= 30.870 a_3= -3.693 a_4= 0.143
Fe	2.0	45.0	25.18933	TOF02	3	FZK	-	a_0= 7.909 a_1= 33.848 a_2= 27.188 a_3= -2.933 a_4= 0.119
Au	1.0	10.0	1.48556	TOF03	4	FZK	type A 0.40104g	a_0= 12.118 a_1= 29.343 a_2= 34.485 a_3= -4.114 a_4= 0.149
Sm_2O_3	2.4	10.0	0.2064	TOF03	4	FZK	type A 0.40104g	a_0= 8.396 a_1= 34.400 a_2= 28.071 a_3= -2.465 a_4= 0.113
C	1.5	10.0	0.23062	TOF03	4	FZK	type A 0.40104g	a_0= 8.463 a_1= 36.690 a_2= 28.464 a_3= -2.458 a_4= 0.117
Pb	1.0	10.0	0.95745	TOF03	4	FZK	-	a_0= 10.809 a_1= 31.812 a_2= 32.686 a_3= -3.796 a_4= 0.147
Au	1.0	20.0	5.91011	TOF05	5	FZK	-	a_0= 12.384 a_1= 24.360 a_2= 33.241 a_3= -4.089 a_4= 0.150

sample	t (mm)	d (mm)	mass (g)	exp	setup	det	can	WF parameters
C	6.3	20.0	3.93345	TOF05	5	FZK	-	a_0= 7.277 a_1= 34.647 a_2= 24.273 a_3=-2.252 a_4= 0.113
Fe	2.0	20.0	4.85285	TOF05	5	FZK	-	a_0= 7.828 a_1= 34.070 a_2= 26.644 a_3= -2.798 a_4= 0.117
^{209}Bi	6.1	20.0	18.90453	TOF05	5	FZK	-	a_0= 22.402 a_1= 9.160 a_2= 40.317 a_3= -4.487 a_4= 0.145
^{208}Pb	3.6	20.0	12.53146	TOF05	5	FZK	-	a_0= 18.225 a_1= 15.147 a_2= 37.680 a_3= -4.340 a_4= 0.146
Au	0.1	20.0	0.75506	TOF05	5	FZK	-	a_0= 7.466 a_1= 34.659 a_2= 25.479 a_3= -2.538 a_4= 0.114
^{207}Pb	2.2	20.0	8.00925	TOF05	5	FZK	-	a_0= 14.476 a_1= 21.221 a_2= 34.367 a_3= -4.024 a_4= 0.140
^{204}Pb	1.2	20.0	4.0389	TOF05	5	FZK	-	a_0= 10.813 a_1= 27.411 a_2= 30.947 a_3= -3.708 a_4= 0.141
^{206}Pb	2.3	20.0	8.12025	TOF05	5	FZK	-	a_0= 14.751 a_1= 20.529 a_2= 34.794 a_3= -4.077 a_4= 0.141

sample	t (mm)	d (mm)	mass (g)	exp	setup	det	can	WF parameters
^{204}Pb	1.2	20.0	4.0389	TOF05	6	FZK	-	a_0= 10.648 a_1= 30.266 a_2= 31.490 a_3= -3.782 a_4= 0.145
^{206}Pb	2.3	20.0	8.12025	TOF05	6	FZK	-	a_0= 14.158 a_1= 23.933 a_2= 34.533 a_3= -3.996 a_4= 0.135
Au	0.5	20.0	2.95236	TOF05	6	FZK	-	a_0= 9.629 a_1= 32.369 a_2= 30.378 a_3= -3.698 a_4= 0.148
Pb	1.1	15.0	2.0434	TOF07	6	FZK	-	a_0= 10.087 a_1= 31.602 a_2= 30.574 a_3= -3.597 a_4= 0.141
Au	0.8	15.0	1.3297	TOF07	6	FZK	-	a_0= 8.907 a_1= 34.342 a_2= 29.100 a_3= -3.415 a_4= 0.140
^{232}Th	1.3	15.0	2.8037	TOF07	6	FZK	-	a_0= 12.583 a_1= 26.525 a_2= 33.141 a_3= -3.907 a_4= 0.144
Au	0.3	22.0	1.871	TOF03	7	FZK	-	a_0= 11.080 a_1= 37.665 a_2= 32.521 a_3= -3.468 a_4= 0.143
C	2.3	22.0	1.541	TOF03	7	FZK	-	a_0= 10.691 a_1= 39.325 a_2= 32.569 a_3= -3.104 a_4= 0.135

sample	t (mm)	d (mm)	mass (g)	exp	setup	det	can	WF parameters
Pb	0.5	22.0	1.889	TOF03	7	FZK	-	a_0= 11.240 a_1= 37.442 a_2= 32.770 a_3= -3.475 a_4= 0.143
Pb	0.9	22.0	3.895	TOF03	7	FZK	-	a_0= 12.452 a_1= 35.727 a_2= 34.251 a_3= -3.736 a_4= 0.141
^{25}Mg	2.3	22.0	3.219	TOF03	7	FZK	-	a_0= 10.726 a_1= 39.742 a_2= 32.487 a_3= -3.198 a_4= 0.138
^{26}Mg	2.3	22.0	3.234	TOF03	7	FZK	-	a_0= 10.763 a_1= 39.568 a_2= 32.579 a_3= -3.215 a_4= 0.139
Mg	8.2	22.0	5.239	TOF03	7	FZK	-	a_0= 11.478 a_1= 41.714 a_2= 33.595 a_3= -3.245 a_4=0.137
Au	0.5	20.0	2.87333	TOF03 & TOF08	7	FZK	-	a_0= 11.956 a_1= 36.157 a_2= 33.794 a_3=-3.709 a_4= 0.142
Au	0.1	45.0	3.224	TOF04	7	FZK	-	a_0= 10.569 a_1= 38.788 a_2= 31.799 a_3= -3.203 a_4= 0.139
Pb	1.2	15.0	2.4	TOF04	7	FZK	-	a_0= 13.139 a_1= 34.956 a_2= 34.980 a_3= -3.704 a_4= 0.132

sample	t (mm)	d (mm)	mass (g)	exp	setup	det	can	WF parameters
Au	0.4	15.0	1.299	TOF04	7	FZK	-	a_0= 11.253 a_1= 37.838 a_2= 32.778 a_3= -3.475 a_4= 0.134
C	1.7	15.0	0.479	TOF04	7	FZK	-	a_0= 10.380 a_1= 39.585 a_2= 32.359 a_3= -3.017 a_4= 0.129
^{186}Os	1.2	15.0	1.9999	TOF04	7	FZK	type B 0.2927g	a_0= 12.312 a_1= 36.388 a_2= 33.786 a_3= -3.527 a_4= 0.130
^{187}Os	1.2	15.0	1.9212	TOF04	7	FZK	type B 0.3591g	a_0= 12.163 a_1= 36.835 a_2= 33.400 a_3= -3.452 a_4= 0.127
^{188}Os	1.2	15.0	1.9967	TOF04	7	FZK	type B 0.2636g	a_0= 12.301 a_1= 36.426 a_2= 33.726 a_3= -3.507 a_4= 0.128
C	6.3	20.0	3.93345	TOF08	7	FZK	-	a_0= 11.570 a_1= 40.642 a_2= 33.784 a_3= -3.281 a_4= 0.141
Pb	1.5	20.0	4.941	TOF08	7	FZK	-	a_0= 14.138 a_1= 32.808 a_2= 36.233 a_3= -3.951 a_4= 0.141
^{90}Zr	1.3	22.0	2.71689	TOF08	7	FZK	type C 0.31787g	a_0= 10.511 a_1= 39.695 a_2= 31.976 a_3= -3.164 a_4= 0.128

sample	t (mm)	d (mm)	mass (g)	exp	setup	det	can	WF parameters
^{91}Zr	0.6	22.0	1.40394	TOF08	7	FZK	type C 0.27729g	a_0= 10.347 a_1= 39.396 a_2= 31.661 a_3= -3.056 a_4= 0.127
^{92}Zr	0.6	22.0	1.34889	TOF08	7	FZK	type C 0.27354g	a_0= 10.378 a_1= 39.223 a_2= 31.765 a_3= -3.076 a_4= 0.128
^{94}Zr	0.9	22.0	2.0154	TOF08	7	FZK	type C 0.30554g	a_0= 10.459 a_1= 39.384 a_2= 31.923 a_3= -3.152 a_4= 0.130
^{96}Zr	1.5	22.0	3.39751	TOF08	7	FZK	type C 0.37274g	a_0= 10.799 a_1= 38.933 a_2= 32.897 a_3= -3.367 a_4= 0.136
La	1.0	20.0	1.9428	TOF08	7	FZK	type D 0.3522g	a_0= 10.558 a_1= 39.654 a_2= 32.057 a_3= -3.212 a_4= 0.128

Conclusion

This note contains the weighting functions obtained from simulations of detector responses with MCNP for all 34 detector-sample setups used in 2002 and 23 detector-sample setups used in 2003, at CERN. In parallel other groups (IFIC and INFN) have been working on weighting functions using different simulation codes. A comparison between the results of the different codes aims to validate all calculations. But it should be stressed that it is not necessary to have identical weighting functions for a correct analysis. Weighting functions with a different shape may give very similar weighted spectra. In addition, the weighted capture spectra are used relative to weighted spectra of a standard, which may minimize possible systematic uncertainties resulting from the applied weighting function. The original response functions for all setups are available at the ntof webserver (http://pceet075.cern.ch).

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Annexe

Au (1.0 mm x 20.0 mm) - TOF02 - setup 1 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.11006E+01	2.46912E+00	22.2	100	-97	89	-79	72
1	1.01478E+01	8.36490E+00	82.4	-97	100	-95	88	-81
2	2.38459E+01	5.62183E+00	23.6	89	-95	100	-98	93
3	-2.77993E+00	1.10357E+00	39.7	-79	88	-98	100	-99
4	1.00748E-01	6.08615E-02	60.4	72	-81	93	-99	100

Au (1.0 mm x 20.0 mm) - TOF02 - setup 1 - Bicron

#	parameter	uncertainty	%	covariance matrix				
0	1.73061E+01	3.44340E+00	19.9	100	-97	89	-80	72
1	1.15048E+01	1.17665E+01	102.3	-97	100	-95	88	-81
2	3.59676E+01	7.96539E+00	22.1	89	-95	100	-98	93
3	-4.16137E+00	1.58189E+00	38.0	-80	88	-98	100	-99
4	1.48875E-01	8.83326E-02	59.3	72	-81	93	-99	100

Au (0.1 mm x 45.0 mm) - TOF02 - setup 1 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	4.96382E+00	2.94205E+00	59.3	100	-97	87	-77	69
1	1.91350E+01	1.03872E+01	54.3	-97	100	-95	86	-79
2	1.55772E+01	7.41170E+00	47.6	87	-95	100	-97	92
3	-1.43433E+00	1.51861E+00	105.9	-77	86	-97	100	-98
4	6.12294E-02	8.65402E-02	141.3	69	-79	92	-98	100

Au (0.1 mm x 45.0 mm) - TOF02 - setup 1 - Bicron

#	parameter	uncertainty	%	covariance matrix				
0	7.31933E+00	3.98443E+00	54.4	100	-97	88	-78	69
1	2.65513E+01	1.42154E+01	53.5	-97	100	-95	86	-79
2	2.28301E+01	1.02236E+01	44.8	88	-95	100	-97	92
3	-2.20945E+00	2.11885E+00	95.9	-78	86	-97	100	-98
4	9.39832E-02	1.22126E-01	129.9	69	-79	92	-98	100

C (6.3 mm x 20.0 mm) - TOF02 - setup 1 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	4.71210E+00	3.40558E+00	72.3	100	-97	87	-77	68
1	2.04571E+01	1.21970E+01	59.6	-97	100	-94	86	-78
2	1.60222E+01	8.83163E+00	55.1	87	-94	100	-97	92
3	-1.58237E+00	1.83827E+00	116.2	-77	86	-97	100	-98
4	9.03073E-02	1.06359E-01	117.8	68	-78	92	-98	100

C (6.3 mm x 20.0 mm) - TOF02 - setup 1 - Bicron

#	parameter	uncertainty	%	covariance matrix				
0	6.65624E+00	4.58324E+00	68.9	100	-97	87	-77	69
1	2.96811E+01	1.65375E+01	55.7	-97	100	-95	86	-78
2	2.25559E+01	1.19841E+01	53.1	87	-95	100	-97	92
3	-2.27409E+00	2.50565E+00	110.2	-77	86	-97	100	-98
4	1.27950E-01	1.45719E-01	113.9	69	-78	92	-98	100

Pb (1.0 mm x 20.0 mm) - TOF02 - setup 1 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	8.86358E+00	2.53751E+00	28.6	100	-97	88	-79	71
1	1.29704E+01	8.69863E+00	67.1	-97	100	-95	87	-80
2	2.13356E+01	5.96164E+00	27.9	88	-95	100	-98	93
3	-2.44493E+00	1.18759E+00	48.6	-79	87	-98	100	-99
4	9.46818E-02	6.62626E-02	70.0	71	-80	93	-99	100

Pb (1.0 mm x 20.0 mm) - TOF02 - setup 1 - Bicron

#	parameter	uncertainty	%	covariance matrix				
0	1.35928E+01	3.46930E+00	25.5	100	-97	88	-79	71
1	1.66151E+01	1.19987E+01	72.2	-97	100	-95	87	-80
2	3.15433E+01	8.27494E+00	26.2	88	-95	100	-98	93
3	-3.56704E+00	1.66494E+00	46.7	-79	87	-98	100	-99
4	1.34560E-01	9.38543E-02	69.7	71	-80	93	-99	100

Au (0.1 mm x 45.0 mm) - TOF02 - setup 2 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	4.99715E+00	2.93917E+00	58.8	100	-97	87	-77	69
1	1.89758E+01	1.02674E+01	54.1	-97	100	-95	86	-79
2	1.55886E+01	7.16704E+00	46.0	87	-95	100	-97	93
3	-1.42004E+00	1.43049E+00	100.7	-77	86	-97	100	-99
4	5.95498E-02	7.93886E-02	133.3	69	-79	93	-99	100

C (6.3 mm x 20.0 mm) - TOF02 - setup 2 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	4.81666E+00	3.35985E+00	69.8	100	-97	87	-77	69
1	2.00861E+01	1.19089E+01	59.3	-97	100	-94	86	-78
2	1.61085E+01	8.44535E+00	52.4	87	-94	100	-97	92
3	-1.56862E+00	1.71300E+00	109.2	-77	86	-97	100	-98
4	8.83048E-02	9.62575E-02	109.0	69	-78	92	-98	100

Fe (0.5 mm x 45.0 mm) - TOF02 - setup 2 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	4.58142E+00	3.27589E+00	71.5	100	-97	87	-77	69
1	2.01106E+01	1.15704E+01	57.5	-97	100	-94	86	-79
2	1.52171E+01	8.15853E+00	53.6	87	-94	100	-97	92
3	-1.40436E+00	1.64516E+00	117.1	-77	86	-97	100	-99
4	6.58311E-02	9.20371E-02	139.8	69	-79	92	-99	100

Fe (2.0 mm x 45.0 mm) - TOF02 - setup 2 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	5.68606E+00	3.32483E+00	58.5	100	-97	88	-78	70
1	2.00300E+01	1.17014E+01	58.4	-97	100	-95	87	-79
2	1.69710E+01	8.03688E+00	47.4	88	-95	100	-97	93
3	-1.75237E+00	1.58413E+00	90.4	-78	87	-97	100	-99
4	6.96335E-02	8.71065E-02	125.1	70	-79	93	-99	100

C (6.3 mm x 20.0 mm) - TOF02 - setup 3 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	7.34263E+00	5.18110E+00	70.6	100	-97	87	-76	68
1	3.53029E+01	1.81157E+01	51.3	-97	100	-94	85	-78
2	2.45823E+01	1.24338E+01	50.6	87	-94	100	-97	92
3	-2.27940E+00	2.43132E+00	106.7	-76	85	-97	100	-99
4	1.15179E-01	1.32141E-01	114.7	68	-78	92	-99	100

Pb (1.0 mm x 20.0 mm) - TOF02 - setup 3 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.05340E+01	4.16422E+00	39.5	100	-97	87	-78	70
1	2.86802E+01	1.41849E+01	49.5	-97	100	-94	86	-79
2	3.08704E+01	9.32248E+00	30.2	87	-94	100	-98	93
3	-3.69314E+00	1.75813E+00	47.6	-78	86	-98	100	-99
4	1.42942E-01	9.29591E-02	65.0	70	-79	93	-99	100

Fe (2.0 mm x 45.0 mm) - TOF02 - setup 3 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	7.90880E+00	5.03951E+00	63.7	100	-97	87	-77	69
1	3.38476E+01	1.76343E+01	52.1	-97	100	-94	86	-79
2	2.71885E+01	1.18374E+01	43.5	87	-94	100	-97	93
3	-2.93342E+00	2.26175E+00	77.1	-77	86	-97	100	-99
4	1.18824E-01	1.20535E-01	101.4	69	-79	93	-99	100

Au (1.0 mm x 10.0 mm) - TOF03 - setup 4 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.21179E+01	4.28870E+00	35.4	100	-97	87	-78	70
1	2.93429E+01	1.44897E+01	49.4	-97	100	-94	86	-79
2	3.44847E+01	9.37736E+00	27.2	87	-94	100	-98	93
3	-4.11399E+00	1.74386E+00	42.4	-78	86	-98	100	-99
4	1.48853E-01	9.10294E-02	61.2	70	-79	93	-99	100

Sm2O3 (2.4 mm x 10.0 mm) - TOF03 - setup 4 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	8.39566E+00	5.32016E+00	63.4	100	-97	86	-76	68
1	3.44002E+01	1.84592E+01	53.7	-97	100	-94	85	-77
2	2.80710E+01	1.27258E+01	45.3	86	-94	100	-97	92
3	-2.46502E+00	2.47967E+00	100.6	-76	85	-97	100	-98
4	1.13324E-01	1.33741E-01	118.0	68	-77	92	-98	100

C (1.5 mm x 10.0 mm) - TOF03 - setup 4 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	8.46257E+00	5.67963E+00	67.1	100	-97	86	-76	68
1	3.66902E+01	1.97160E+01	53.7	-97	100	-94	85	-77
2	2.84639E+01	1.36061E+01	47.8	86	-94	100	-97	92
3	-2.45789E+00	2.65603E+00	108.1	-76	85	-97	100	-98
4	1.17301E-01	1.43469E-01	122.3	68	-77	92	-98	100

Pb (1.0 mm x 10.0 mm) - TOF03 - setup 4 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.08087E+01	4.57590E+00	42.3	100	-97	87	-77	69
1	3.18119E+01	1.55299E+01	48.8	-97	100	-94	86	-79
2	3.26865E+01	1.01858E+01	31.2	87	-94	100	-97	93
3	-3.79635E+00	1.91283E+00	50.4	-77	86	-97	100	-99
4	1.46644E-01	1.00581E-01	68.6	69	-79	93	-99	100

Au (1.0 mm x 20.0 mm) - TOF05 - setup 5 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.23837E+01	3.83790E+00	31.0	100	-97	88	-78	71
1	2.43605E+01	1.29527E+01	53.2	-97	100	-95	87	-80
2	3.32409E+01	8.35829E+00	25.1	88	-95	100	-98	93
3	-4.08917E+00	1.55445E+00	38.0	-78	87	-98	100	-99
4	1.49569E-01	8.13140E-02	54.4	71	-80	93	-99	100

C (6.3 mm x 20.0 mm) - TOF05 - setup 5 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	7.27706E+00	5.07555E+00	69.7	100	-97	87	-76	68
1	3.46471E+01	1.77522E+01	51.2	-97	100	-94	86	-78
2	2.42731E+01	1.21778E+01	50.2	87	-94	100	-97	92
3	-2.25193E+00	2.37917E+00	105.6	-76	86	-97	100	-99
4	1.13276E-01	1.29204E-01	114.1	68	-78	92	-99	100

Fe (2.0 mm x 20.0 mm) - TOF05 - setup 5 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	7.82817E+00	5.07598E+00	64.8	100	-97	87	-77	69
1	3.40700E+01	1.77311E+01	52.0	-97	100	-94	86	-78
2	2.66438E+01	1.19538E+01	44.9	87	-94	100	-97	93
3	-2.79774E+00	2.29460E+00	82.0	-77	86	-97	100	-99
4	1.17151E-01	1.22823E-01	104.8	69	-78	93	-99	100

Bi (6.1 mm x 20.0 mm) - TOF05 - setup 5 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	2.24020E+01	3.51604E+00	15.7	100	-97	89	-80	73
1	9.16049E+00	1.13682E+01	124.1	-97	100	-95	88	-81
2	4.03172E+01	7.03598E+00	17.5	89	-95	100	-98	94
3	-4.48705E+00	1.27495E+00	28.4	-80	88	-98	100	-99
4	1.45196E-01	6.56347E-02	45.2	73	-81	94	-99	100

Pb208 (3.6 mm x 20.0 mm) - TOF05 - setup 5 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.82254E+01	3.49206E+00	19.2	100	-97	88	-79	72
1	1.51470E+01	1.14726E+01	75.7	-97	100	-95	88	-81
2	3.76797E+01	7.20427E+00	19.1	88	-95	100	-98	93
3	-4.33973E+00	1.31714E+00	30.4	-79	88	-98	100	-99
4	1.45739E-01	6.81828E-02	46.8	72	-81	93	-99	100

Au (0.1 mm x 20.0 mm) - TOF05 - setup 5 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	7.46649E+00	4.91011E+00	65.8	100	-97	87	-77	69
1	3.46594E+01	1.70424E+01	49.2	-97	100	-94	86	-78
2	2.54789E+01	1.15914E+01	45.5	87	-94	100	-97	92
3	-2.53827E+00	2.24422E+00	88.4	-77	86	-97	100	-99
4	1.14064E-01	1.20970E-01	106.1	69	-78	92	-99	100

Pb207 (2.2 mm x 20.0 mm) - TOF05 - setup 5 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.44757E+01	3.64651E+00	25.2	100	-97	88	-79	71
1	2.12207E+01	1.21763E+01	57.4	-97	100	-95	87	-80
2	3.43667E+01	7.79787E+00	22.7	88	-95	100	-98	93
3	-4.02438E+00	1.44426E+00	35.9	-79	87	-98	100	-99
4	1.40549E-01	7.54067E-02	53.7	71	-80	93	-99	100

Pb204 (1.2 mm x 20.0 mm) - TOF05 - setup 5 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.08133E+01	4.03737E+00	37.3	100	-97	87	-78	70
1	2.74110E+01	1.37166E+01	50.0	-97	100	-95	87	-79
2	3.09471E+01	8.97325E+00	29.0	87	-95	100	-98	93
3	-3.70811E+00	1.68545E+00	45.5	-78	87	-98	100	-99
4	1.41400E-01	8.88252E-02	62.8	70	-79	93	-99	100

Pb206 (2.3 mm x 20.0 mm) - TOF05 - setup 5 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.47508E+01	3.63877E+00	24.7	100	-97	88	-79	71
1	2.05293E+01	1.21369E+01	59.1	-97	100	-95	87	-80
2	3.47936E+01	7.75692E+00	22.3	88	-95	100	-98	93
3	-4.07659E+00	1.43390E+00	35.2	-79	87	-98	100	-99
4	1.40723E-01	7.47464E-02	53.1	71	-80	93	-99	100

Pb204 (1.2 mm x 20.0 mm) - TOF05 - setup 6 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.06480E+01	4.31707E+00	40.5	100	-97	87	-78	70
1	3.02658E+01	1.46662E+01	48.5	-97	100	-94	86	-79
2	3.14904E+01	9.53926E+00	30.3	87	-94	100	-98	93
3	-3.78174E+00	1.78053E+00	47.1	-78	86	-98	100	-99
4	1.45227E-01	9.32251E-02	64.2	70	-79	93	-99	100

Pb206 (2.3 mm x 20.0 mm) - TOF05 - setup 6 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.41581E+01	3.84436E+00	27.2	100	-97	88	-78	71
1	2.39329E+01	1.28477E+01	53.7	-97	100	-95	87	-80
2	3.45326E+01	8.17157E+00	23.7	88	-95	100	-98	93
3	-3.99675E+00	1.50208E+00	37.6	-78	87	-98	100	-99
4	1.35489E-01	7.78427E-02	57.5	71	-80	93	-99	100

Au (0.5 mm x 20.0 mm) - TOF05 - setup 6 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	9.62887E+00	4.51948E+00	46.9	100	-97	87	-77	70
1	3.23687E+01	1.54383E+01	47.7	-97	100	-94	86	-79
2	3.03776E+01	1.00956E+01	33.2	87	-94	100	-98	93
3	-3.69820E+00	1.89327E+00	51.2	-77	86	-98	100	-99
4	1.47578E-01	9.95012E-02	67.4	70	-79	93	-99	100

Pb (1.1 mm x 15.0 mm) - TOF07 - setup 6 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.00875E+01	4.42810E+00	43.9	100	-97	87	-77	70
1	3.16019E+01	1.50849E+01	47.7	-97	100	-94	86	-79
2	3.05737E+01	9.86623E+00	32.3	87	-94	100	-98	93
3	-3.59743E+00	1.85001E+00	51.4	-77	86	-98	100	-99
4	1.41112E-01	9.72312E-02	68.9	70	-79	93	-99	100

Au (0.8 mm x 15.0 mm) - TOF07 - setup 6 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	8.90679E+00	4.70242E+00	52.8	100	-97	87	-77	69
1	3.43423E+01	1.61055E+01	46.9	-97	100	-94	86	-79
2	2.91001E+01	1.06074E+01	36.5	87	-94	100	-97	93
3	-3.41486E+00	1.99983E+00	58.6	-77	86	-97	100	-99
4	1.40432E-01	1.05519E-01	75.1	69	-79	93	-99	100

Th232 (1.3 mm x 15.0 mm) - TOF07 - setup 6 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.25827E+01	4.02481E+00	32.0	100	-97	87	-78	70
1	2.65247E+01	1.35261E+01	51.0	-97	100	-95	87	-80
2	3.31412E+01	8.70855E+00	26.3	87	-95	100	-98	93
3	-3.90718E+00	1.61398E+00	41.3	-78	87	-98	100	-99
4	1.44065E-01	8.40978E-02	58.4	70	-80	93	-99	100

Au (0.3 mm x 22.0 mm) - TOF03 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.10797E+01	5.56514E+00	50.2	100	-97	87	-77	69
1	3.76648E+01	1.90277E+01	50.5	-97	100	-94	86	-79
2	3.25212E+01	1.25206E+01	38.5	87	-94	100	-97	93
3	-3.46846E+00	2.35677E+00	67.9	-77	86	-97	100	-99
4	1.42628E-01	1.24154E-01	87.0	69	-79	93	-99	100

C (2.3 mm x 22.0 mm) - TOF03 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.06911E+01	6.21835E+00	58.2	100	-97	87	-76	68
1	3.93253E+01	2.15039E+01	54.7	-97	100	-94	86	-78
2	3.25694E+01	1.45169E+01	44.6	87	-94	100	-97	92
3	-3.10361E+00	2.78648E+00	89.8	-76	86	-97	100	-99
4	1.35419E-01	1.48970E-01	110.0	68	-78	92	-99	100

Pb (0.5 mm x 22.0 mm) - TOF03 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.12400E+01	5.52808E+00	49.2	100	-97	87	-77	69
1	3.74421E+01	1.88896E+01	50.5	-97	100	-94	86	-78
2	3.27704E+01	1.24425E+01	38.0	87	-94	100	-97	93
3	-3.47454E+00	2.34387E+00	67.5	-77	86	-97	100	-99
4	1.42715E-01	1.23551E-01	86.6	69	-78	93	-99	100

Pb (0.9 mm x 22.0 mm) - TOF03 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.24517E+01	5.10446E+00	41.0	100	-97	87	-77	70
1	3.57267E+01	1.73116E+01	48.5	-97	100	-94	86	-79
2	3.42515E+01	1.12172E+01	32.7	87	-94	100	-97	93
3	-3.73643E+00	2.08759E+00	55.9	-77	86	-97	100	-99
4	1.41396E-01	1.09042E-01	77.1	70	-79	93	-99	100

Mg25 (2.3 mm x 22.0 mm) - TOF03 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.07265E+01	6.15518E+00	57.4	100	-97	87	-77	69
1	3.97419E+01	2.13187E+01	53.6	-97	100	-94	86	-78
2	3.24866E+01	1.42858E+01	44.0	87	-94	100	-97	92
3	-3.19829E+00	2.72638E+00	85.2	-77	86	-97	100	-99
4	1.38377E-01	1.45183E-01	104.9	69	-78	92	-99	100

Mg26 (2.3 mm x 22.0 mm) - TOF03 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.07629E+01	6.15258E+00	57.2	100	-97	87	-77	69
1	3.95680E+01	2.13106E+01	53.9	-97	100	-94	86	-78
2	3.25791E+01	1.42846E+01	43.8	87	-94	100	-97	92
3	-3.21506E+00	2.72661E+00	84.8	-77	86	-97	100	-99
4	1.39027E-01	1.45206E-01	104.4	69	-78	92	-99	100

Mg (8.2 mm x 22.0 mm) - TOF03 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.14776E+01	6.47325E+00	56.4	100	-97	87	-77	69
1	4.17138E+01	2.23437E+01	53.6	-97	100	-94	86	-78
2	3.35946E+01	1.49113E+01	44.4	87	-94	100	-97	92
3	-3.24519E+00	2.83907E+00	87.5	-77	86	-97	100	-99
4	1.37170E-01	1.50946E-01	110.0	69	-78	92	-99	100

Au (0.5 mm x 20.0 mm) - TOF03-08 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.19563E+01	5.19999E+00	43.5	100	-97	87	-77	70
1	3.61575E+01	1.76856E+01	48.9	-97	100	-94	86	-79
2	3.37936E+01	1.14834E+01	34.0	87	-94	100	-97	93
3	-3.70903E+00	2.13918E+00	57.7	-77	86	-97	100	-99
4	1.42097E-01	1.11748E-01	78.6	70	-79	93	-99	100

Au (0.1 mm x 45.0 mm) - TOF04 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.05686E+01	5.85484E+00	55.4	100	-97	87	-77	69
1	3.87880E+01	2.01240E+01	51.9	-97	100	-94	86	-78
2	3.17991E+01	1.34473E+01	42.3	87	-94	100	-97	92
3	-3.20289E+00	2.56277E+00	80.0	-77	86	-97	100	-99
4	1.38618E-01	1.36285E-01	98.3	69	-78	92	-99	100

Pb (1.2 mm x 15.0 mm) - TOF04 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.31390E+01	4.98716E+00	38.0	100	-97	87	-78	70
1	3.49564E+01	1.68697E+01	48.3	-97	100	-94	86	-79
2	3.49801E+01	1.08986E+01	31.2	87	-94	100	-97	93
3	-3.70447E+00	2.02349E+00	54.6	-78	86	-97	100	-99
4	1.32223E-01	1.05510E-01	79.8	70	-79	93	-99	100

Au (0.4 mm x 15.0 mm) - TOF04 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.12527E+01	5.41005E+00	48.1	100	-97	87	-77	69
1	3.78382E+01	1.84556E+01	48.8	-97	100	-94	86	-79
2	3.27779E+01	1.20685E+01	36.8	87	-94	100	-97	93
3	-3.47536E+00	2.26046E+00	65.0	-77	86	-97	100	-99
4	1.34255E-01	1.18610E-01	88.3	69	-79	93	-99	100

C (1.7 mm x 15.0 mm) - TOF04 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.03801E+01	6.20515E+00	59.8	100	-97	87	-77	69
1	3.95847E+01	2.14640E+01	54.2	-97	100	-94	86	-78
2	3.23589E+01	1.45262E+01	44.9	87	-94	100	-97	92
3	-3.01708E+00	2.79246E+00	92.6	-77	86	-97	100	-99
4	1.29459E-01	1.49426E-01	115.4	69	-78	92	-99	100

Os186 (1.2 mm x 15.0 mm) - TOF04 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.23123E+01	5.21772E+00	42.4	100	-97	87	-77	70
1	3.63884E+01	1.77713E+01	48.8	-97	100	-94	86	-79
2	3.37863E+01	1.15689E+01	34.2	87	-94	100	-97	93
3	-3.52661E+00	2.16034E+00	61.3	-77	86	-97	100	-99
4	1.29703E-01	1.13135E-01	87.2	70	-79	93	-99	100

Os187 (1.2 mm x 15.0 mm) - TOF04 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.21631E+01	5.26262E+00	43.3	100	-97	87	-77	70
1	3.68347E+01	1.79323E+01	48.7	-97	100	-94	86	-79
2	3.33998E+01	1.16860E+01	35.0	87	-94	100	-97	93
3	-3.45181E+00	2.18448E+00	63.3	-77	86	-97	100	-99
4	1.26836E-01	1.14487E-01	90.3	70	-79	93	-99	100

Os188 (1.2 mm x 15.0 mm) - TOF04 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.23007E+01	5.22046E+00	42.4	100	-97	87	-77	70
1	3.64258E+01	1.77820E+01	48.8	-97	100	-94	86	-79
2	3.37257E+01	1.15799E+01	34.3	87	-94	100	-97	93
3	-3.50725E+00	2.16255E+00	61.7	-77	86	-97	100	-99
4	1.28304E-01	1.13234E-01	88.3	70	-79	93	-99	100

C (6.3 mm x 20.0 mm) - TOF08 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.15703E+01	6.44281E+00	55.7	100	-97	87	-77	69
1	4.06422E+01	2.22362E+01	54.7	-97	100	-94	86	-78
2	3.37844E+01	1.48748E+01	44.0	87	-94	100	-97	92
3	-3.28121E+00	2.83717E+00	86.5	-77	86	-97	100	-99
4	1.41257E-01	1.51045E-01	106.9	69	-78	92	-99	100

Pb (1.5 mm x 20.0 mm) - TOF08 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.41382E+01	4.77074E+00	33.7	100	-97	87	-78	70
1	3.28085E+01	1.60778E+01	49.0	-97	100	-95	86	-79
2	3.62331E+01	1.03126E+01	28.5	87	-95	100	-97	93
3	-3.95106E+00	1.90449E+00	48.2	-78	86	-97	100	-99
4	1.41233E-01	9.88857E-02	70.0	70	-79	93	-99	100

Zr90 (1.3 mm x 22.0 mm) - TOF08 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.05106E+01	6.01498E+00	57.2	100	-97	87	-77	69
1	3.96954E+01	2.07622E+01	52.3	-97	100	-94	86	-78
2	3.19760E+01	1.38189E+01	43.2	87	-94	100	-97	92
3	-3.16421E+00	2.62130E+00	82.8	-77	86	-97	100	-99
4	1.27521E-01	1.38866E-01	108.9	69	-78	92	-99	100

Zr91 (0.6 mm x 22.0 mm) - TOF08 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.03468E+01	6.09319E+00	58.9	100	-97	87	-77	69
1	3.93965E+01	2.10201E+01	53.4	-97	100	-94	86	-78
2	3.16612E+01	1.40798E+01	44.5	87	-94	100	-97	92
3	-3.05578E+00	2.68574E+00	87.9	-77	86	-97	100	-99
4	1.27047E-01	1.42888E-01	112.5	69	-78	92	-99	100

Zr92 (0.6 mm x 22.0 mm) - TOF08 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.03783E+01	6.09038E+00	58.7	100	-97	87	-77	69
1	3.92230E+01	2.10044E+01	53.6	-97	100	-94	86	-78
2	3.17655E+01	1.40678E+01	44.3	87	-94	100	-97	92
3	-3.07640E+00	2.68288E+00	87.2	-77	86	-97	100	-99
4	1.28471E-01	1.42717E-01	111.1	69	-78	92	-99	100

Zr94 (0.9 mm x 22.0 mm) - TOF08 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.04589E+01	6.05976E+00	57.9	100	-97	87	-77	69
1	3.93839E+01	2.09023E+01	53.1	-97	100	-94	86	-78
2	3.19227E+01	1.39426E+01	43.7	87	-94	100	-97	92
3	-3.15153E+00	2.64989E+00	84.1	-77	86	-97	100	-99
4	1.30041E-01	1.40599E-01	108.1	69	-78	92	-99	100

Zr96 (1.5 mm x 22.0 mm) - TOF08 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.07994E+01	6.03743E+00	55.9	100	-97	87	-77	69
1	3.89333E+01	2.08327E+01	53.5	-97	100	-94	86	-78
2	3.28973E+01	1.38257E+01	42.0	87	-94	100	-97	92
3	-3.36685E+00	2.61556E+00	77.7	-77	86	-97	100	-99
4	1.35919E-01	1.38272E-01	101.7	69	-78	92	-99	100

La (1.0 mm x 20.0 mm) - TOF08 - setup 7 - FZK

#	parameter	uncertainty	%	covariance matrix				
0	1.05577E+01	5.87302E+00	55.6	100	-97	87	-77	69
1	3.96545E+01	2.02182E+01	51.0	-97	100	-94	86	-78
2	3.20567E+01	1.34217E+01	41.9	87	-94	100	-97	92
3	-3.21217E+00	2.54122E+00	79.1	-77	86	-97	100	-99
4	1.28344E-01	1.34416E-01	104.7	69	-78	92	-99	100