III.C.2.a. Individual components of the ORR resolution function

1. Electron burst

The electron burst from ORELA is closely approximated by a square function in time:

$$I_1(t)=\begin{cases}1/p & \text{for } 0<t<p\\ 0 & \text{otherwise}\end{cases} \quad , \tag{III C2 a.1}$$

where p is the burst width in nanoseconds. The value $1/p$ for this function gives a normalization of unity.

2. Neutron sources

Experiments at ORELA can utilize neutrons from a tantalum target, or collimate on the water moderator surrounding the tantalum target. The two are modeled separately; experiments are assumed to use predominantly one or the other, rather than a mixture of both. (The implications to this representation if neutrons are emitted from both the tantalum target and the water moderator will be studied as time and funding permit.)

ORELA water moderator

The distribution of flight-path lengths of neutrons in the ORELA water moderator that has the most physical basis [SC92] is the chi-square distribution with $2(m+1)$ degrees of freedom, where m is an integer. (Originally m = 4 or 5, but any integer from 1 to 10 will now work; the default value is m = 4.)

$$I'_{2a}(l)=\frac{l^m}{m!\Lambda^{m+1}}\exp\left(-\frac{l}{\Lambda}\right) \quad , \tag{III C2 a.2}$$

where l is the flight-path-length variable and where the moderation distance Λ is a mean free path. The value of Λ varies with energy as $\Lambda=\Lambda_0+\Lambda_1\ln(E)+\Lambda_2(\ln(E))^2$ [CC83]. Default values for the Λ_i are chosen to give agreement with [SC92].

Tantalum target

The distribution of flight-path lengths for the tantalum target is somewhat more complicated: Monte Carlo calculations of F. G. Perey [FP92] have shown that this distribution function has the form

$$I'_{2b}(l) = \begin{cases} 0 & \text{for} \quad l < x'_1 \\ u'(l) + v'(l) & \text{for}\ x'_1 < l < x'_2 \\ u'(l) + w'(l) & \text{for}\ x'_2 < l < x'_3 \\ w'(l) & \text{for}\ x'_3 < l \quad , \end{cases} \tag{III C2 a.3}$$

where the functions $u'(l)$, $v'(l)$, and $w'(l)$ are defined as

$$u'(l) = N' \exp\left\{-\varepsilon'^2 \left(l - x'_0\right)^2\right\} \quad \text{for} \quad x'_1 < l < x'_3 \quad , \tag{III C2 a.4}$$

$$v'(l) = \frac{N'\alpha' l}{x'_2} \exp\left\{-\beta\left(l - x'_2\right)\right\} \quad \text{for} \quad x'_1 < l < x'_2 \quad , \tag{III C2 a.5}$$

and

$$w'(l) = N'\alpha' \exp\left\{-\beta'\left(l - x'_2\right)\right\} \quad \text{for} \quad x'_2 < l \quad . \tag{III C2 a.6}$$

The factor N' is a normalization, and α' determines the relative strengths of the pieces of the function I'_{2b}. The relative values of the x's are given by

$$x'_1 \le x'_0 \le x'_2 \le x'_3 \quad . \tag{III C2 a.7}$$

3. Time-of-flight channel width

Like the electron burst, the time-of-flight channel width may be modeled as a rectangular distribution of width c. This functional form ignores "electronic" time jitter, which is a reasonable approximation. The time distribution due to the finite channel width is therefore assumed to be

$$I_3(t) = \begin{cases} 1/c & \text{for} \quad 0 < t < c \\ 0 & \text{otherwise} \quad , \end{cases} \tag{III C2 a.8}$$

where the channel width c may be different for different energy regions.

4. Detectors

Two types of neutron detectors are commonly used for transmission measurements at ORELA: the NE110 (a recoil proton detector) and the lithium glass (for which moderation of neutrons in the detector plays an important role).

NE110 detector

If δ is the thickness of the NE110 detector, then the resolution function appropriate for that detector is

$$I'_{4a}(l) = \begin{cases} \Delta \exp(-\lambda \sigma l) & \text{for } 0 < l < \delta \\ 0 & \text{otherwise} \end{cases} . \qquad \text{(III C2 a.9)}$$

where λ is the number of molecules per volume (molecules per millimeter barn) of the detector (0.0047 for NE110), and $\sigma(E)$ is the total cross section of the detector material ($CH_{1.104}$ for NE110). The normalization factor Δ is found by setting the integral over all space of I'_{4a} equal to 1.

Lithium glass detector

For the lithium glass detector, the resolution function is assumed to have the form

$$I_{4b}(l) = \begin{cases} Dg & \text{for } 0 < t < d \\ D \exp(-f(t-d)) & \text{for } d < t \end{cases} , \qquad \text{(III C2 a.10)}$$

where *g*, *f*, and *d* are constants, and *D* is chosen to give an integral of unity.