SNS - HYSPEC Instrument Development Team

MEMORANDUM

Date: May 7, 2012

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Subject: Prompt pulse contamination on HYSPEC

Contamination of the energy transfer range as a function of the incident neutron energy, resulting from the prompt source pulse on HYSPEC.

The prompt pulse, mainly consisting of high-energy neutrons is observed on HYSPEC as a significant source of time-structured background. This pulse reaches the detector array almost instantaneously, having an abrupt rise at the source burst time t = 0, and decaying within milliseconds as a function of time. While the efforts to eliminate this contamination by adding strategically positioned shielding are continuing, up to now only a modest reduction of about x3 has been achieved. Hence, it is important to analyze the limitations which such background imposes on HYSPEC experiments. In order to do so, we consider the arrival times of neutrons scattered from the sample with different energy transfer for several incident neutron energies of interest for typical experiments.

Instrument geometry and timing considerations.

1. The HYSPEC primary flight path (the distance from the source to the sample) is assumed to be L_i = 40.4 m. The secondary flight path (the distance from the sample to detector) is L_{SD} = 4.5 m.
2. For a neutron with the incident energy E_i ($v_i = 2200(m/s) \cdot \sqrt{E_i(meV)/25.3(meV)}$, it takes time $t_i = L_i/v_i$ to arrive at the sample position, and $t_{iD} = (L_i + L_{SD})/v_i$ to arrive at the detector. For a neutron that has reached the sample and scattered so that its energy became E_f ($v_f = 2200(m/s) \cdot \sqrt{E_f(meV)/25.3(meV)}$, it takes time $t_f = L_{SD}/v_f$ to reach the detector after the scattering. The total travel time for such neutron is $t = t_i + t_f$, and the energy transfer is $E = E_i - E_f$.

Figures 1 and 2 below, show the energy transfer E (left axis) and the corresponding scattered energy E_f (right axis) as a function of neutron's arrival time at the detector, t, for a number of neutron incident energies E_i. The bottom X-axis shows time in units of the source period T_s, $t = t^*\nu_s$ ($\nu_s = 1/T_s = 60$ Hz), while the top axis is in milliseconds. Neutrons from three frames (n = -1,0,1) are shown.

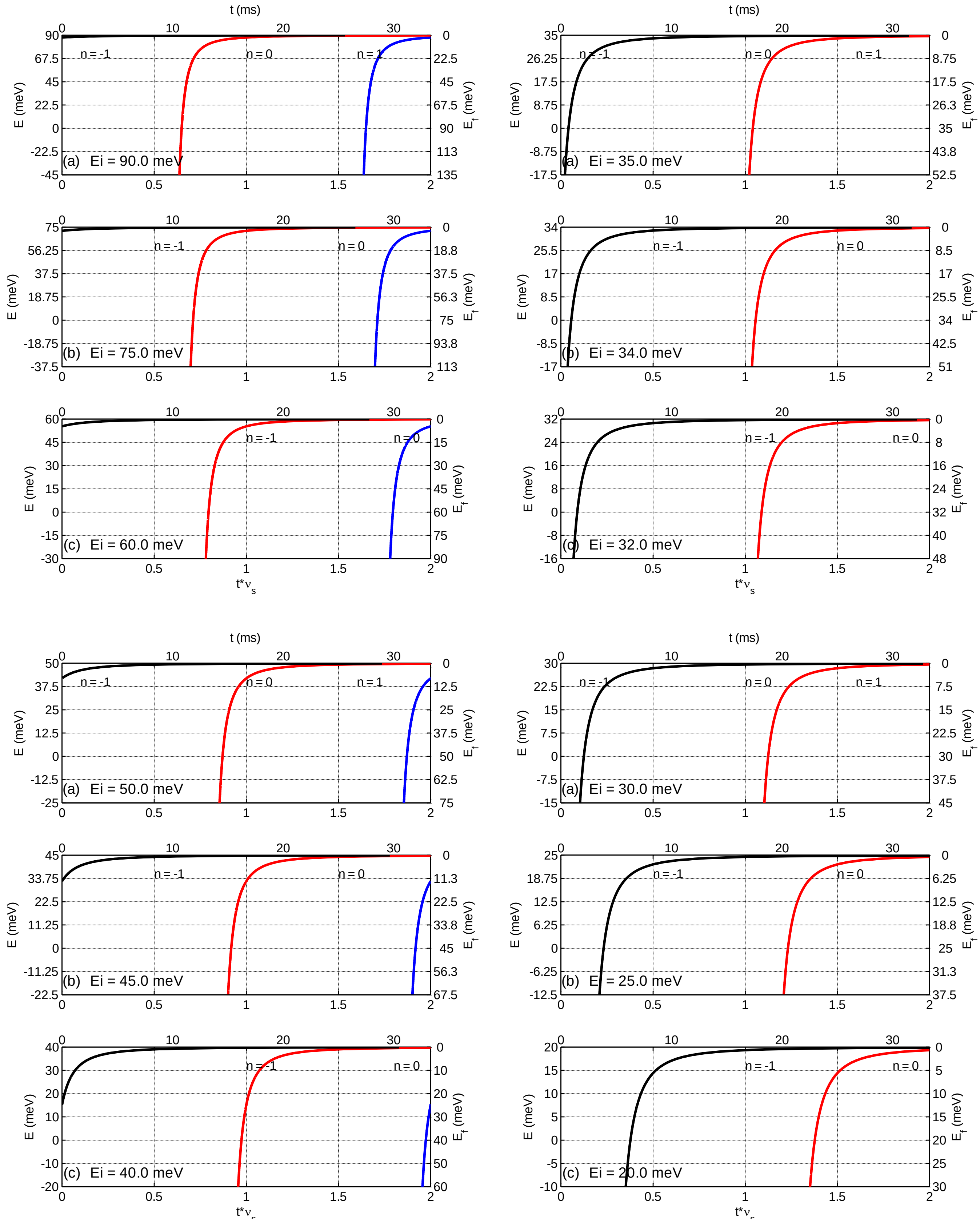

Figure 1. The arrival time at the detector for neutrons with incident energy E_i and energy transfer E (scattered energy E_f). Three frames, originating from the target at $\nu_s t$ = n = -1, 0, 1, are shown.

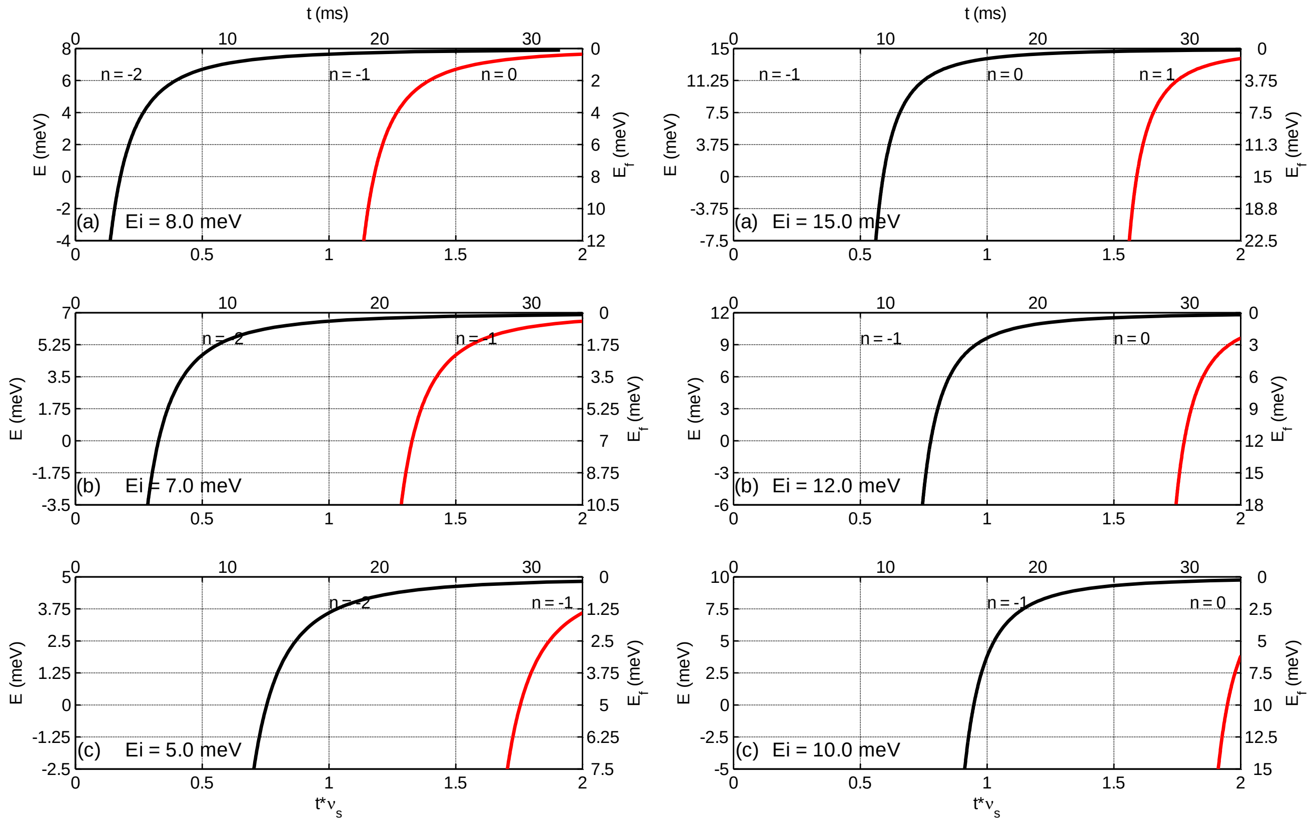

Figure 2. The arrival time at the detector for neutrons with incident energy E_i and energy transfer E (scattered energy E_f). Three frames, originating from the target at $\nu_s t$ = n = -1, 0, 1, or -2, -1, 0, are shown.

In order to understand the extent of the contaminated energy range as a function of the incident energy, we assume the duration (time extent) of the prompt pulse to be about 3 ms . Figure 3 shows at which energy transfer neutrons leaving the target up to 3 ms after the pulse would appear in the detector.

Conclusion.

In general, the prompt pulse contamination on HYSPEC appears to be of rather limited negative impact. It constrains measurements within several limited intervals of incident energy, where the prompt pulse arrives within the useful measurement time. In particular, these "dangerous" regions include Ei = 8 – 12 meV and Ei = 35 – 45 meV. However, outside these intervals, the prompt pulse arrives either very early in time, corresponding to large neutron energy gain, or rather late, corresponding to large energy transfers, E > 0.8 Ei, where the data is of very limited usefulness anyway.

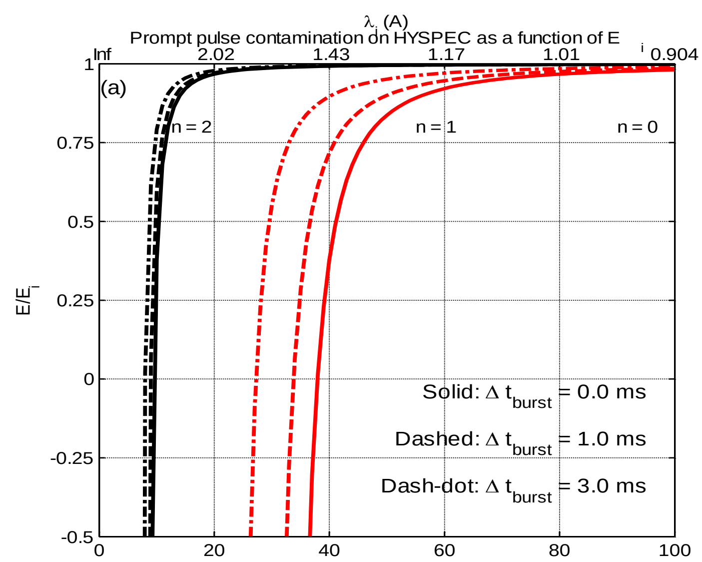

Figure 3. The apparent energy transfer relative to Ei for neutrons that left the target 0, 1 and 3 ms after t=0.