SUPPLEMENT

Additional Data

Table I shows the raw spectral temperatures, yields, emission history widths and CR ratios as measured for the analyzed implosions. Also included are the inferred values for the normalized equilibration time and Knudsen number (N_k) taken to be the ratio of the ion-ion mean free path to minimum radius. Figure 1 is a plot of the measured bang times vs DT gas fill density. The performance of hydrodynamic DUED simulations including real ion viscosity is summarized in Table II.

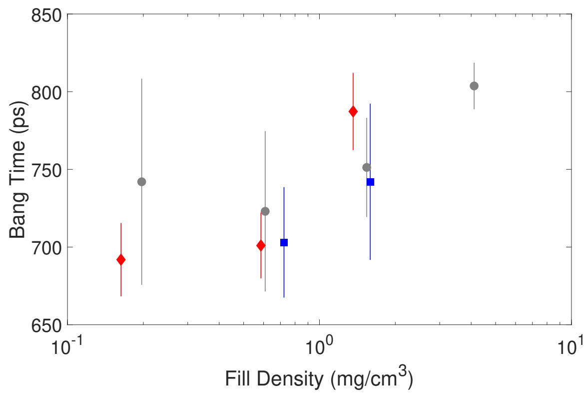

Figure 1. The measured DTn bang times in the DT gas filled implosions on OMEGA plotted versus fill density. Gray circles are 50:50 D:T gas fills, red are 97:3, and blue are 40:60. Each point is averaged over multiple implosions and the error bars include shot to shot variation.

Additional Monte Carlo Calculations

In order to infer apparent ion temperatures from the measured spectral temperatures the following relations were used.

$$T_D = T_{sDDn}, \tag{1}$$

$$T_T = T_{sDTn} + \frac{m_D}{m_T}\left(T_{sDTn} - T_{sDDn}\right) \tag{2}$$

Which come from the more general expression

$$T_{s12} = \frac{m_1 T_1 + m_2 T_2}{m_1 + m_2}. \tag{3}$$

Where subscripts 1 and 2 refer to the ion species. This expression come directly from Equation (10) in the paper on fusion neutron spectra by Brysk [1] and is a purely kinematic expression related to the average center of mass energy for a two species plasma. In addition to this kinematic correction there are also effects related to cross

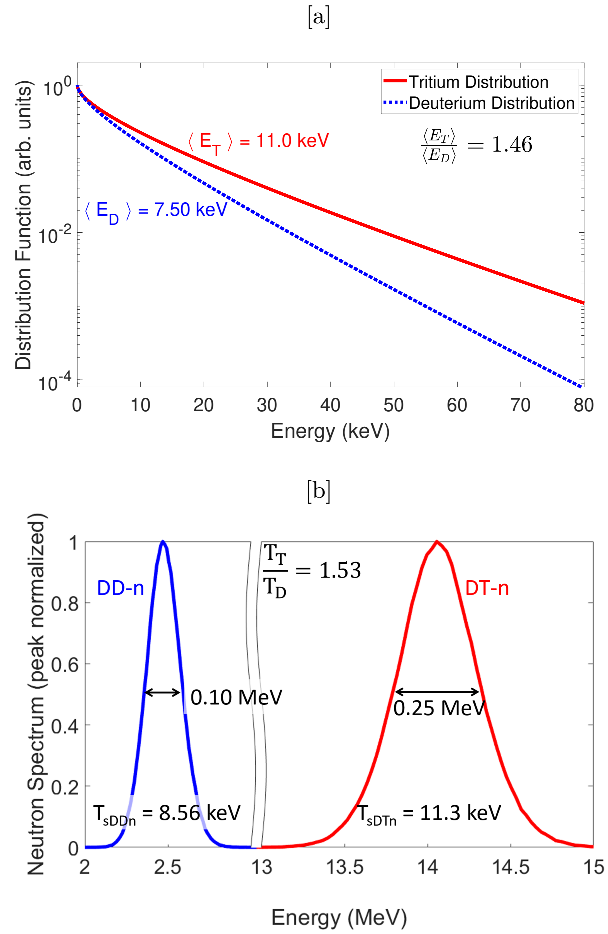

Figure 2. (a) Exponentially modified Maxwellian distribution functions used for the deuterium and tritium ions when calculating the fusion neutron spectra. The deuterium distribution is a 12 keV Maxwellian modified by $e^{-E_D/10keV}$ and the tritium distribution is a 20 keV Maxwellian modified by $e^{-E_T/10keV}$ where E_D and E_T are the deuterium and tritium energy. The ratio of the tritium to deuterium mean energy is 1.46. (b) Monte-Carlo simulated DD-n and DT-n spectra using the distribution functions in (a). The spectral ion temperatures inferred from the width of the neutron spectra are labeled next to each spectrum. The apparent tritium to deuterium temperature ratio is 1.53 for a 5% error compared to the input 1.46.

section weighting that are not accounted for in a simple expression like this. To verify the validity of equation 2 Monte Carlo calculations were performed. For these calculations both the D and T ions were taken to have Maxwellian distribution functions. T_D was fixed at 10 keV and T_T was varied to produce many different temperature ratios in the range of 0.1 to 3. Resulting DDn and DTn spectra were computed using a relativistic Monte Carlo simulation [2]. The width of these spectra were then used to infer T_{sDTn} and T_{sDDn} as is done for NToF measured temperatures. Finally equation 2 was used to infer a simulated T_T to T_D temperature ratio. Figure 4 is

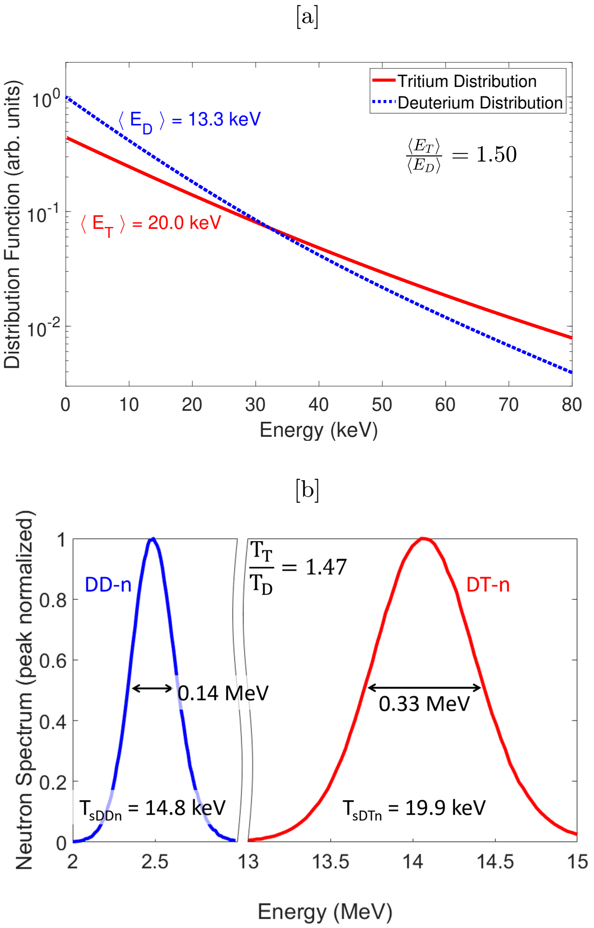

Figure 3. (a) Two temperature distribution functions used for the deuterium and tritium ions when calculating the fusion neutron spectra. The deuterium distribution is the sum of normalized 10 keV and 20 keV Maxwellians and the tritium distribution is the sum of normalized 15 keV and 30 keV Maxwellians. The ratio of the tritium to deuterium mean energy is 1.50. (b) Monte-Carlo simulated DD-n and DT-n spectra using the distribution functions in a. The spectral ion temperatures inferred from the width of the neutron spectra are labeled next to each spectrum. The apparent tritium to deuterium temperature ratio is 1.47 for a 2% error compared to the input 1.50.

a plot of the temperature ratio inferred using equation 2 vs the known input temperature ratio. It is clear that for moderate temperature ratios in the 0.5-2 range, equation 2 provides a reasonable estimate of the individual species temperatures. For temperature ratios outside this range the relation begins to break down substantially.

In addition to the single truncated Maxwellian example included in the main text, Monte Carlo simulation examples are shown here for an exponentially modified Maxwellian (Figure 2) and a two temperature distribution (Figure 3). The calculations shown here follow the same procedure as discussed in the letter and serve to demonstrate that significant modifications to the distribution functions cause deviations in the inferred temperature ratio of up to 20% when compared to the known input mean energy ratio.

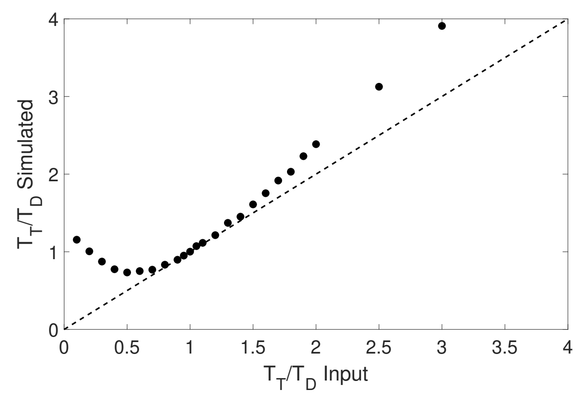

Figure 4. Black points show the temperature ratios inferred from Monte Carlo simulated neutron spectra plotted versus the input temperature ratio. The dashed black line is a reference showing equality between input and simulated values.

[1] H Brysk. Fusion neutron energies and spectra. *Plasma Physics*, 15(7):611–617, 1973.

[2] J. Eriksson, S. Conroy, E. Andersson Sundén, and C. Hellesen. Calculating fusion neutron energy spectra from arbitrary reactant distributions. *Computer Physics Communications*, 199:40–46, February 2016.

Table I. Measured and inferred quantities from DT gas-filled shock driven implosions with a variety of fill densities and fill fractions, including the spectral DDn ion temperature, the spectral DTn ion temperature, the DDn yield, the DTn yield, the DTn emission FWHM, convergence ratio, the ratio of the DTn emission FWHM to ion-ion equilibration time, and the Knudsen number (ratio of ion-ion mean free path to minimum radius). Implosions of capsules with similar gas fills have been grouped, the number in each group is listed in the column labeled num. Listed uncertainties include the shot to shot variation within a group.

fill density (mg/cm^3)	f$_D$	num.	T_{sDDn}(+/-) (keV)	T_{sDTn}(+/-) (keV)	Y_{DDn}(+/-)	Y_{DTn}(+/-)	τ_{DTn}(+/-) (ps)	CR	τ_N(+/-)	N_k
0.16	0.97	4	17.3 (0.5)	21.9 (1.2)	3.45E9 (4.5E8)	4.46E10 (7.8E9)	145 (46)	5.25	0.13 (0.04)	18
0.59	0.97	3	15.4 (0.4)	18.7 (0.4)	3.33E10 (2.1E9)	4.87E11 (3.4E10)	92 (25)	4.17	0.18 (0.03)	6.4
1.36	0.97	4	11.7 (0.3)	13.5 (0.3)	1.50E11 (2.4E10)	2.42E12 (2.8E11)	97 (14)	3.40	0.40 (0.06)	2.1
0.20	0.49	3	17.0 (0.7)	19.7 (1.6)	1.25E9 (3.6E8)	5.02E11 (1.8E11)	123 (16)	5.05	0.13 (0.02)	15
0.61	0.49	4	14.6 (0.5)	18.4 (0.5)	9.44E9 (2.1E9)	3.95E12 (9.6E11)	115 (15)	4.31	0.22 (0.03)	6.3
1.54	0.49	4	11.3 (0.4)	13.3 (0.5)	3.50E10 (3.1E9)	1.72E13 (1.5E12)	132 (11)	3.56	0.54 (0.05)	2.0
4.11	0.50	3	8.57 (0.4)	9.11 (0.3)	6.64E10 (7.3E9)	3.09E13 (3.2E12)	132 (12)	2.79	1.25 (0.13)	0.60
0.72	0.40	3	14.2 (0.4)	19.0 (0.3)	4.80E9 (7.7E8)	3.81E12 (1.1E11)	102 (15)	4.20	0.20 (0.03)	5.8
1.59	0.40	3	12.0 (0.5)	13.9 (0.6)	1.94E10 (5.1E9)	1.73E13 (4.4E12)	128 (14)	3.57	0.49 (0.05)	2.3
1.69	0.49	1	5.24 (0.14)	5.76 (0.14)	1.31E12 (5.2E10)	4.29E14 (1.32E13)	374 (30)	5.5	18.7 (1.5)	0.037
7.32	0.48	1	4.19 (0.19)	4.64 (0.16)	1.54E12 (1.5E11)	5.10E14 (9.46E12)	340 (50)	4.8	62.1 (9.1)	0.0078
7.64	0.49	3	4.52 (0.08)	5.27 (0.08)	1.56E12 (4.1E10)	5.21E14 (9.22E12)	275 (60)	3.5	17.9 (4.2)	0.015
12.2	0.49	2	4.21 (0.10)	4.93 (0.09)	1.79E12 (6.7E10)	5.41E14 (1.04E13)	329 (70)	3.0	25.2 (5.4)	0.012

Table II. Comparison of DUED simulated values to measured values in select 50:50 DT gas filled OMEGA implosions. Information about the experiments given, including OMEGA shot ID, fill density, shell outer diameter (OD), shell wall thickness (Δ), and laser energy (E_{laser}). Experimental and simulation results for the DTn bang time (BT), DD and DT spectral temperatures and yields are given. Simulated yields are listed at yield over clean (YOC), the measured yield divided by the simulation value.

Experiment Parameters					Measured Values					DUED Simulated Values				
ID	fill density (mg/cm^3)	OD (μm)	Δ (μm)	E_{laser} (kJ)	DTn BT(+/-) (ps)	T_{sDDn}(+/-) (keV)	T_{sDTn}(+/-) (keV)	Y_{DDn}(+/-)	Y_{DTn}(+/-)	DTn BT (ps)	T_{sDDn} (keV)	T_{sDTn} (keV)	YOC_{DDn}	YOC_{DTn}
86660	0.20	866	2.2	15.2	703(20)	17.55(0.88)	21.86(1)	1.01E9(9.05E7)	3.71E11(1.86E10)	725	59	51	0.016	0.044
86663	0.61	843	2.4	15.1	799(20)	14.75(0.74)	18.01(1)	1.18E10(1.06E9)	5.16E12(2.58E11)	770	25	25	0.091	0.129
86639	1.54	851	2.2	15.5	738(20)	11.26(0.56)	13.48(0.5)	3.53E10(3.18E9)	1.72E13(8.60E11)	767	15.8	16.3	0.299	0.382
89931	4.11	855	2.1	14.4	794(20)	8.50(0.65)	9.16(0.5)	5.74E10(5.17E9)	2.68E13(1.34E12)	787	9.0	9.2	0.683	0.912