§51. The Study of the Low Energy Neutron Spectrum in the Inertial Confinement Fusions

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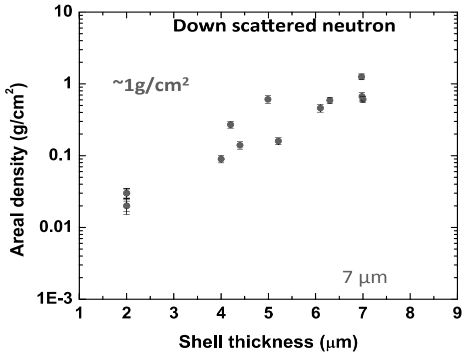
In the inertial confinement fusion a highly compressed fuel core is essential for the fusion ignition and burn. The areal density (here we infer ρR, the unit is g/cm^2) of the compressed core plasma is one of the most important parameter. The down-scattered neutron (DSN) method has been widely studied as a powerful method of ρR such as Omega [1], NIF[2], ILE, osaka. In this method, the low energy neutron created by the elastic scattering between the fusion neutron (primary neutron, PN) and fuel atom (D). The ρR can be measured from the ratio between PN and DSN, DS ratio = DSN/PN.

The experimental setup was described in [3]. The scintillator array was set at 16 cm from the target. 256-channel signals were recorded by fast AD-convertor array. Multi channel detection system allows us to detect small amount of the down scattered neutron in the large amount of primary neutron signals. The Monte Carlo simulation was conducted to study relation of the ρR and ratio of the number of the down scattered neutrons and primary neutrons. ρR was defined to be 7.1 × DS ratio.

The target used in this experiment was D2 gas filled CD plastic shell. The thickness of the shell target was varied from 2 μm to 7 μm to vary the ρR. The laser condition was fixed in the shots with the laser energy of 300J each for 12 beams on target with 527-nm wavelength, with the random phase plate.

Clear increment in the DSR was seen both in the separated signal (256 channel signals) and integrated signal. The ρR was summarized in the Fig 1 with the comparisons of the rR summary described in the previous study [4]. In the previous study they used various method to evaluate ρR (down scattered neutron was not included at that time), and mainly nuclear activation method was used to measure high ρR grater than 0.2 g/cm^2. A very similar trend with much smaller error-bar was obtained in this study. In the previous study they used 8 kJ of laser energy but we used only 3.6 kJ in this study. This caused the thickness for maximum compression was reduced from 9 μm to 7 μm. The 1D hydro dynamic simulation was conducted to verify our experimental result. The thickness of the shell for peak ρR was agreed with each other however no large drop in the thin target was seen. This is considered in the real experiment Rayleigh-Taylor instability which was not included in the 1D hydro dynamic simulation happens so that ρR was dropped in the experiment. For understanding this phenomenon at least 2D hydro dynamic simulation with taking account with the Rayleigh-Taylor instability. After the several years of the development on the diagnostics instrument, we finally obtained down scattered neutron signals from ICF fuel. The summarized ρR showed very similar trends with previous study by Azechi, et al., by using mainly nuclear activation methods.



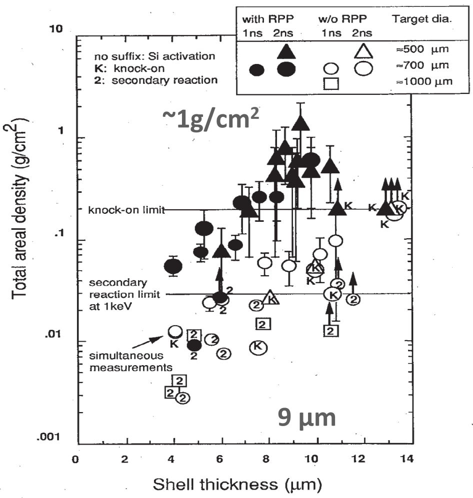


Figure 1 The summary of the ρR evaluated by down scattered neutron (up), the summary of the rR evaluated by H.Azechi ,et al. in the reference [4].

[1] J. Franje, et al., Rev. Sci. Instrum. 79, 10E502 (2008)

[2] O.A.Hurricane, et al., Nature 506, 343–348 (20 February 2014)

[3]Y.Arikawa, et al, Rev.Sci.Instrum, . 80, 113504 (2009),

[4] H.Azechi, et al., Laser and Particle Beams, 9, 2, 193-207, 2991