A Measurement System Based on Activation Used in ICF Neutron Yield

C.B. Yang J Feng Y.Y.Zhang L.X. Bai
(National Key Laboratory for Laser Fusion,Reseach Center of Laser Fusion,China Academy of Engineering Physics, P.o.Box 919-986, Mianyang, Sichuan 621900, China
E-mail: ycb@lfcenter.ac.cn

The measurement of ICF(Inertial Confinement Fusion) neutron yield is one of the most basic test ways for the fusion products. The neutron yield is the most sensitive and direct index whether the conditions of the fusion reaction are satisfied. Activation is an important way to measure neutron yield, it used neutrons from DT or DD reaction to activate stable isotopes such ^{63}Cu, ^{207}Pb and ^{208}Pb, then produce radioactive nuclides. By measuring α, β or γ produced by these radioactive nuclides neutron yield can be calculated.

A system introduced in this paper is used in Cu and Pb activation. Copper activation is an effective and common method for measuring DT neutron, and more suitable for yields above 10^8 neutron per pulse than other ways. It used γ-γ coincidence counting technology to measure 2 gamma rays with opposite direction each , They come from annihilation of β^+ from $^{63}Cu(n,2n)^{62}Cu$ reaction of 14MeV fusion neutrons, and the half-life decay is about 9.7 min. The detection system consists of two NaI(Tl) detectors, two amplifiers, two single-channels and a multi-channel scaling counting system in computer. Copper disks are placed at the target chamber about 8 cm to target. After shooting, these copper disks are taken to detector system in measurement room. This way has been used for many years, but the drift of the peak of the pulse-height spectrum is unavoidable because of the NaI(Tl) detectors and the electronic system. The correct use of it is affected by this kind of drift. In this article a new method to adjust the peak of the multi-channel pulse height spectrum in time is presented. It used an embedded multi-channel pulse height analyzer in multi-channel scaling counting system. It is very easy and fast to adjustment the system by this way.

Lead(Pb) activation is used to measure very low yield of DT reaction, and it also can be applied to measure DD reaction neutrons(2.45MeV). These neutrons produce ^{207m}Pb radioactive nuclide by the reaction $^{208}Pb(n,2n)^{207m}Pb$ and $^{207}Pb(n,n)^{207m}Pb$ in Pb sheath that surrounds a NaI(Tl) detector or 1.5 cm thick Pb disks in front of NaI(Tl) detector. Using this detector, adding a amplifier, a single-channel and multi-channel scaling counting system in computer we can measure the 1.06MeV and 570KeV gamma rays from the ^{207m}Pb atoms with 0.8 s half-life decay, and then the yield may be calculated. Because the detection system is placed as close as 32 cm from the laser target, the X-rays burst from the laser irradiated target generates about 10^6 times more light intensity in NaI(Tl) detector than does an individual gamma ray from the ^{207m}Pb. To minimize this effect, a gate circuit removes the detector high voltage 200 ms to 1 s adjustable, and then restores it less than 100 ms after the shot. The drift of the peak is also adjusted by monitoring multi-channel pulse height analyzer embedded in multi-channel scaling counting system.