# The status and development of Neutron metrology in CIAE

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## 1. Preface

Recent activities on neutron metrology at China Institute of Atomic Energy (CIAE) have been focused on renewal of mono-energetic neutron reference fields using 5SDH-2 pelletron accelerator. This report describes the present status of the mono-energetic neutron reference fields. The research of monitoring method for neutron ambient dose equivalent and the neutron albedo meter are mentioned in this paper. In addition, the plans in the future is reported.

## 2. Renewal of neutron reference radiation field

In the past two years, measurements of mono-energetic neutron reference fields have been done at six energy points between 144 keV and 19 MeV. The fluence results reach good agreement within the uncertainty between different means and the efficiencies of the long counter have been calibrated at the energy range above. In this process, the Target scattering calculation has been finished by "Target" code and the various corrections of the results have been considered. In addition, the fluence measurement of about 20 keV neutron produced by the reaction $^{45}$Sc(p, n)$^{45}$Ti was attempted to be done with a H filled proportional counter, the resonance excited curve has been measured by a Long counter(see Figure 1). However, it is very difficult to measure absolute fluence by a H filled proportional counter due to too low neutron yield when the target proton current is less than 20μA. The measurement will be planned to be done with a long counter the efficiency of which will be calibrated by the reaction $^{7}$Li(p, n) when the beam current is increased after the accelerator pulsed upgrading. The research of above 20 MeV neutron fluence using $^{238}$U fission ionization chamber is in process, at present the design of the chamber construction has been finished.

In order to obtain neutron energy spectrum, the project that establishes a time of flight set planned in the past two years have been authorized. The parameters of pulsing system of 5SDH-2 have been determined suitable for 20 keV to 19 MeV neutron spectrum by the means of time of flight. Now the contracts are being signed for the pulsed upgrading and time of flight apparatus. The parameters of pulsed accelerator are as following:

a. Torvis ion source
b. base frequency 8 MHz
c. repetition frequency 4, 2, 1, 0.5, 0.25, 0.125, 0.0625 MHz
d. current: 150μA for D and H particle in DC mode
e. average current :4～5μA for D and H particle in pulsed mode

3. **Research of Monitor method for Neutron Ambient Dose Equivalent (Rate)**

By Monte Carlo MCNP4A program simulating and calculating the fluence energy response functions, the monitoring method for the neutron ambient dose equivalent (rate) with a sphere multi-counters(position sensitive $^{3}$He proportional counter) was designed and some radiation protection quantities were evaluated utilizing "few-channel" unfolding code. Fig.2 gives $^{241}$Am-Be and $^{252}$Cf neutron spectra unfolded by two different computer codes. Fig.3 shows a fluence-dose conversion factor curve functioned as neutron energy. Through the test in the reference radiation fields of both $^{252}$Cf and $^{241}$Am-Be sources, it shows that the deviations of the results of fluence rate, ambient dose equivalent rate, per fluence average ambient dose equivalent and dose equivalent average energy are less than 10% comparing with the reference values. This monitoring method could better improve dose response of monitor dependence on neutron energy.

**4. Neutron albedo dosimeter**

In the past years, the albedo TLD($^{6}$LiF and $^{7}$LiF) dosimeter have been developed and manufactured. The neutron personal dosimeter have been calibrated in the $D_2O$ moderated $^{252}$Cf and bare $^{252}$Cf fields respectively. The dosimetry characteristics are suitable for neutron personal dose monitoring.

**5.The plan in the future**

**1) Research of measurement method for neutron dose using TEPC**

TEPC technology has been emphasized for recent two decades because its advantage for area monitoring especially for mixed neutron and gamma fields. Using ½" and 1" ball TEPC which manufactured by the Far West corporation the measurement will be performed for mono-energetic neutron dose. A difference of quality factors between which will be measured by TEPC and recommended by ISO 8529 will be compared. Further more , the study and research will be developed in an n- ɣ mixed field.

**2) Simulated workplace reference field**

To establish simulated workplace field based on 5SDH-2 accelerator, first theory calculation will be done to optimize moderate material according ISO standard. Secondly, a reference field is to be established depending on one of all mono-energetic neutron field. Third, The energy spectrum of this reference field is measured with bonner sphere system.

**3) To establish a graphite pile**

Thermal neutron field based on radionuclide neutron source slowed down by graphite will be designed and structured. The neutron fluence will be expected to be up to $10^2 cm^{-2}s^{-1}$. Aim to establish this thermal pile is to meet the need to calibrate higher efficient thermal neutron detector. First, the structure optimization will be calculated by MCNP code. Secondly, the measurement results using gold activation foil will be compared with calculations. This is very important to fill lack of reference fields.

**Fig. 1 Neutron resonance excited curve functioned as proton energy**

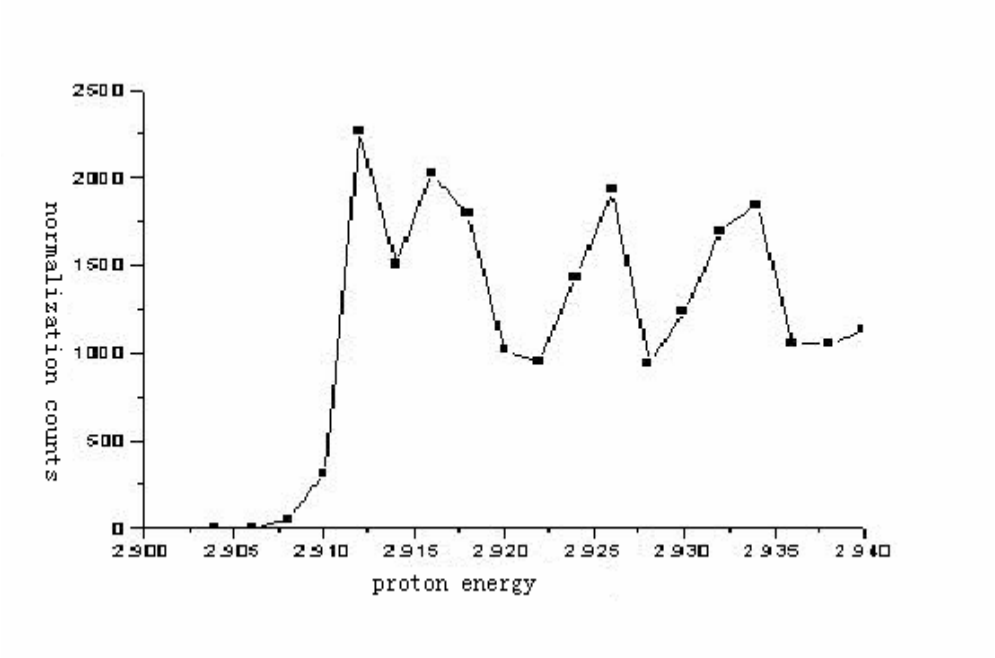

**Fig. 2 $^{241}$Am-Be and $^{252}$Cf source spectra unfolded by two computer codes**

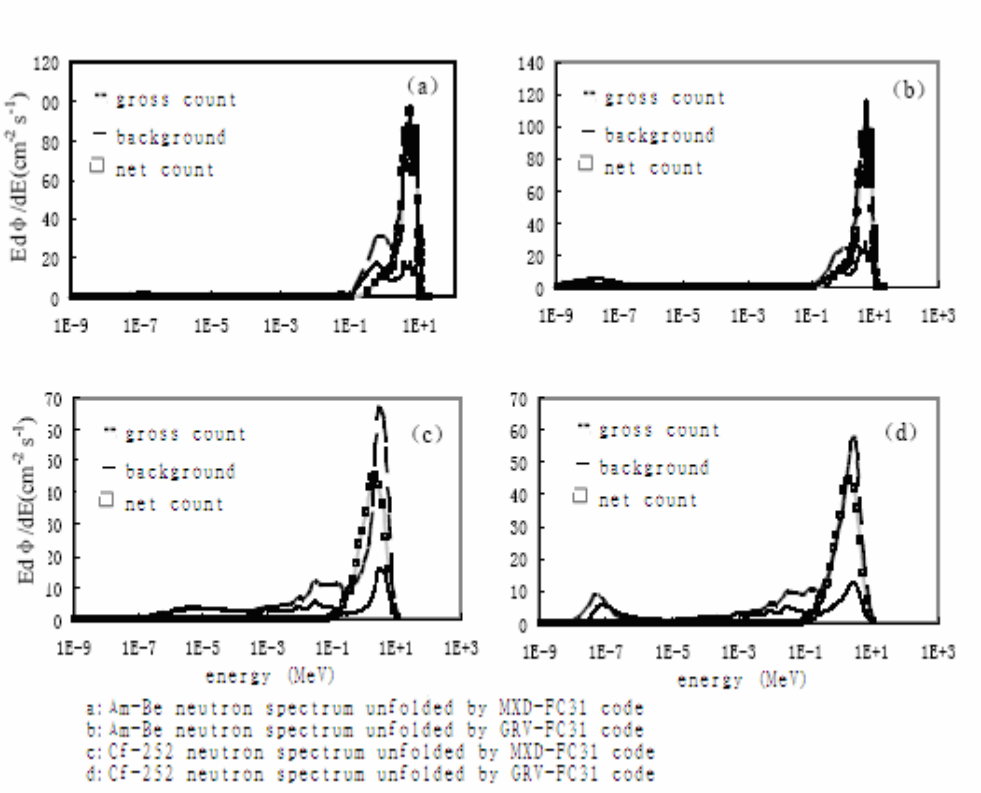


**Fig.3 Fluence-dose equivalent conversion factor functioned as neutron energy**