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KSTAR

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Neutron Spectrometers in the KSTAR Tokamak

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Introduction

Since the successful first operation in 2008, the plasma performance of KSTAR has been enhanced. At present, the duration of plasma operation is extended to over 100 seconds. The deuterium-deuterium (D-D) fusion reaction on the KSTAR tokamak generates mono energetic neutron with energy of 2.45 MeV from the reaction D (d, n) ^{3}He during operation cycles which lasts about 8 ~100 s. The total neutron yield at the KSTAR tokamak is about $10^{14\sim16}$ n/shot.

Hard X-rays (HXRs) due to runaway electrons and neutron-induced gamma rays are also produced from the KSTAR tokamak. Tokamaks are in such an environment with mixed radiation fields which are composed by different types and energies such as neutrons, gamma rays and HXRs. Neutron and gamma-ray diagnostics on KSTAR and other tokamaks is one of important tools for determining neuron emission rate related to fusion power as well as for understanding behavior of fast ions in plasma operations.

The status of neutron diagnostics in the KSTAR tokamak is described in the conference.

Material and Methods

To evaluate the mixed ratio of neutron-gamma radiations

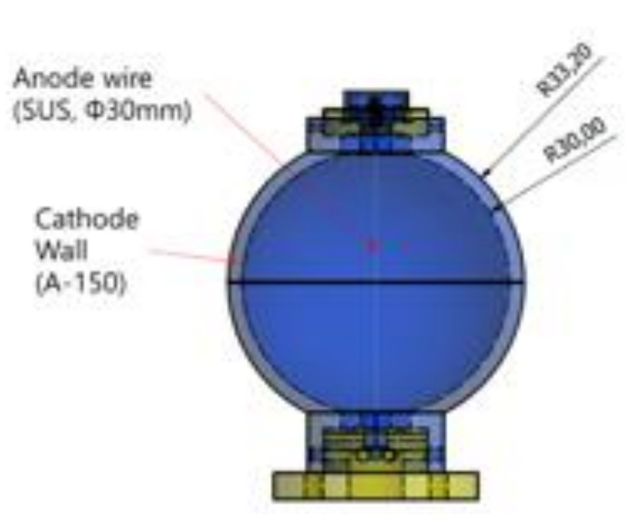


Fig 1 Cross-sectional drawing of Benjamin type of TEPC

A tissue equivalent proportional counter (TEPC) with the methane gas filled TEPC of a 5.69 cm diameter with a 0.318 cm tissue equivalent wall of A-150 plastic sphere, one of microdosimetric techniques have applied to detect and determine the contribution of mixed radiations by different types of particle on KSTAR.

Simultaneous measurements of the D-D fusion neutron energy and time-dependent neutron emission rate

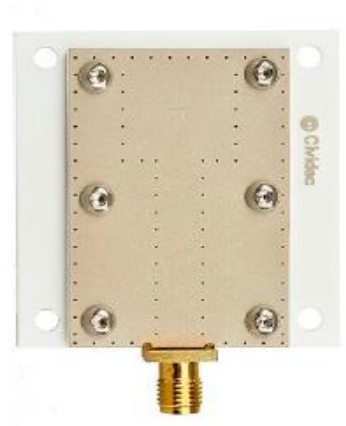
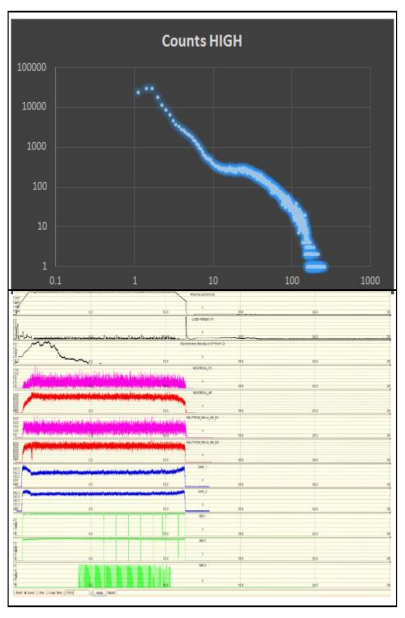


Fig 2 Photo of diamond fast-neutron detector.

They are detected directly through the ^{12}C (n, α) ^{9}Be, ^{12}C (n, n') 3α, ^{12}C (n, d) ^{11}B , and ^{12}C (n, el) ^{12}C* reactions [3]. The first three reactions have energy thresholds for incident neutrons of 6.17 MeV, 7 MeV, and 13.8 MeV respectively. The other reaction only gives rise to neutrons with energy lower than 6 MeV. In the case of a neutron energy of 2.45 MeV, the neutrons can mainly undergo elastic scattering in the ^{12}C (n, el) ^{12}C* reaction.

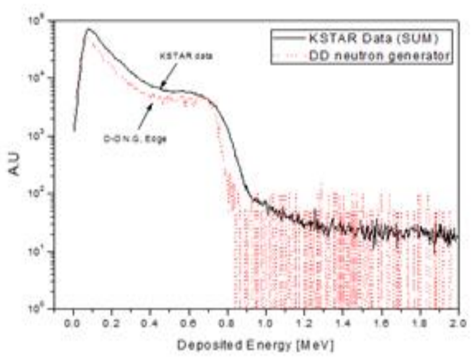
TEPC



The measurements of lineal energy spectra by the TEPC have recorded in every 100 ms during one days of plasma operations (from the shot No. 18847 to 188840). For the day, there were the plasma discharges of 25 times. In the Fig. 3, the discharge no. 18884, one of them, is compared with a measured lineal energy spectrum of TEPC.

Fig.3 Lineal energy spectrum of TEPC measured from the discharge No. 18884. The right side represents time traces of plasma current, loop voltage, electron line density, neutron emissions measured by He-3 counters and fission chamber, NBIs heating in the discharge No. 18884.

Diamond based Fast-Neutron Spectrometer



The broadening of the edge of the D-D fusion energy spectrum shown in Fig.4 is due to the Doppler effects of a moving plasma, the finite sensitive volume and energy resolution of the diamond detector used.

Fig.4 Comparison of neutron energy spectra measured at the KSTAR D-D plasma and the D-D compact neutron generator. The solid black curve is the energy spectrum obtained from the KSTAR D-D plasmas. The dashed red curve corresponds to the monochromatic 2.45 MeV neutron energy spectrum of the D-D compact neutron generator

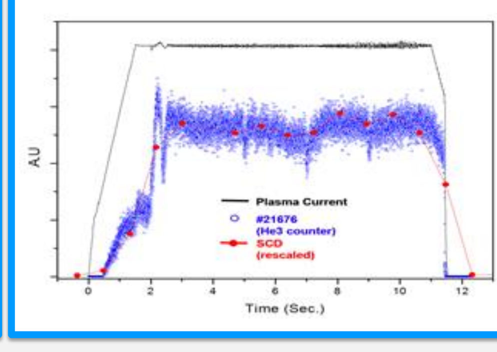


Fig.5 Comparison of time-dependent neutron emission rate measured with the diamond based neutron spectrometer (red solid circle), KSTAR He-3 counter (blue circle), and plasma current (black solid line) for discharges #21666, and #21676.

Summary

We have Introduced two neutron spectrometers of neutron measurement devices on KSTAR.
Consequently, the performance and capacity of the diamond-based neutron spectrometer as well as TEPC were verified by obtaining and analyzing neutron measurements of the D-D plasmas on KSTAR