Annual fast neutron emission of KSTAR

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1. Introduction

KSTAR shows high performance in neutron generation as well as plasma performance. Based on beam-target fusion reaction of deuterium-deuterium, it shows the characteristics of beam target fusion[1]. 2.45 MeV fast neutron was measured by diamond detector[2]. For the nuclear safety of the machine and improvement of the plasma performance, neutron emission monitoring is very important. In this article, we will show the annual accumulated dose of KSTAR and its distribution with plasma performance.

2. Methods and Results

In this section some of the techniques used to calculate annual is introduced and beam-target fusion reaction characteristics are discussed.

2.1 Annual dose calculation

On the accumulated dose, nickel sample is installed at the inner PFC in many places. When the decay time is comparable to experimental time, the total fluence can be described as follows,

$$\sum \Phi t_N = \frac{S_{total}}{N_a \sigma \lambda \eta t_3} \qquad (1)$$

Where Stotal is the measured activity of the sample, t_3 is measurement time of gamma ray, σ is the summation of the cross section of a 2.45-MeV neutron on ^{58}Ni(n, p)^{58}Co and ^{58}Ni(n, p)^{58m}Co, λ and λ_m is the decay constant of ^{58}Co, η is the detection efficiency of HPGe detector for a 811-keV gamma ray, and N_a is the number of the target nuclei.

It was known that total the neutron fluence during 2016 campaign is estimated about $2*10^{19}$. KSTAR tokamak operation is licensed by annual total neutron dose in term of nuclear safety. Fig. 1 shows the neutron fluence at the sample of the poloidal limiter and the stabilizer plate for 5 years. As expected, the total neutron fluence is proportional to the plasma operation time. The weight of the Ni sample is about 0.2 g. Presently the annual neutron budget is licenced by 1.2E+20 per year and 3.0E+18 per shot.

2.2 distribution and annual dose

The radial distribution is checked for samples around torus where the sample is located about 90 degree around the graphite tile on the passive stabilizer as shown in Fig.2. On the contrary to 2016 result, as plasma current is increased, no anisotropy is shown in toroidal distribution in both 2017 and 2018.

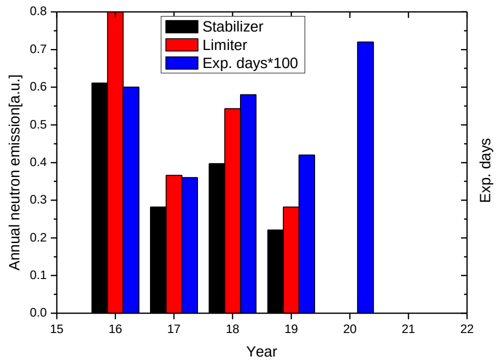

Fig. 2. Annual neutron fluence and experimental days per year.

2.3 plasma performances

KSTAR recently reported 10 keV ion temperature over

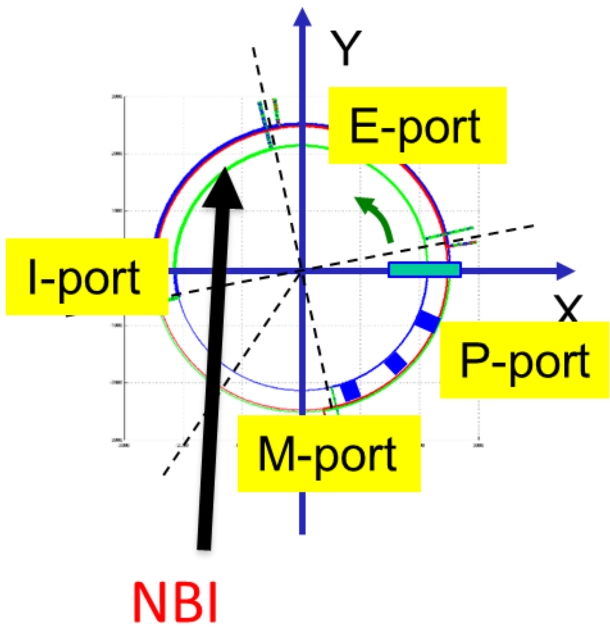

Fig. 2. Bird view of KSTAR tokamak.

10 s as well as long pulse discharge up to 90 s where injected heating power is about 350 MJ.

2.4 Beam-target dependency

The fast neutron is coming from beam-target, thermal and beam–beam reaction in tokamak discharge. Under the present KSTAR DD plasma discharge condition, it is well known that beam-target fusion neutron is dominant process. And it is very clear that electron temperature dependency via beam slowing down time is clearly seen. The figure 3 shows the neutron vs. stored energy.

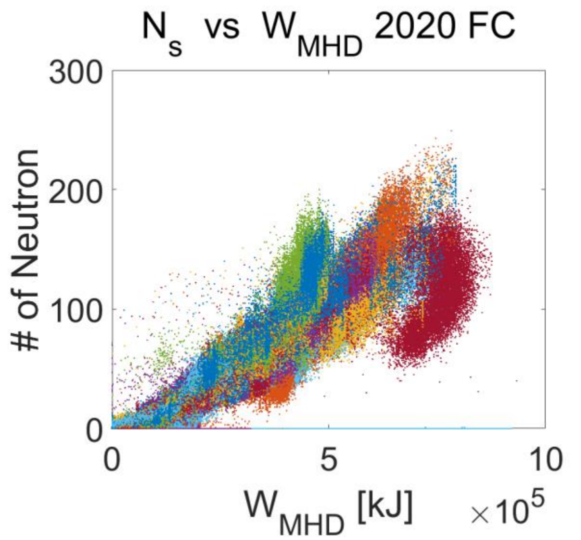

Fig. 3. Neutron vs. the stored energy for 2020 campaign.

Table I: Toroidal distribution of neutron emission in passive stabilizer where P, E, I and M is the port number and each is located 90 degree apart.

	PS2(P)	PS4(E)	PS6(I)	PS8(M)
17y	0.272	0.282	0.283	0.245
18y	0.386	0.397	0.389	0.382

3. Summary

KSTAR shows the high performance in neutron generation as well as plasma performance. Based on beam-target fusion reaction of deuterium-deuterium, it shows the typical characteristics of beam target fusion. As the neutral beam injection time is proportional to tokamak shot time or operation time, the accumulated neutron per year is proportional to the operation time. In term of the nuclear safety, the accumulated neutron budget per year is under licensed value.

REFERENCES

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