# 3 - 16 Radiological Safety Analyses of Spallation Target in Designed China ADS

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Spallation target represents one of the most challenging components in accelerator driven systems (ADS) since it is the component coupling the accelerator and the sub-critical core. It is subjected to bombardment of intense proton beam and very high thermal load in a strong radiation field. The irradiated LBE target poses severe handling problems for the maintenance staff and other scientists due to its residual activity[1]. To assist the design of ADS, the general radiological safety aspects of lead, lead-bismuth eutectic (LBE) and tungsten spallation target were studied with MCNPX 2.7 code[2]. The spallation target was irradiated by a 250 MeV, 10 mA proton beam produced by a linear proton accelerator. The neutron yield, neutron spectrum, residual production and time evolution for the irradiated target were analyzed.

With MCNPX 2.7, Monte Carlo simulation study was conducted by using Bertini cascade and Dresner/RAL evaporation/fission models for three types of spallation target materials. The energy of the proton beam was simulated from 100 MeV to 1.0 GeV. The calculated neutron yields for lead, LBE and tungsten targets are presented in Fig. 1(a). It was found that the neutron production per primary proton increases almost linearly with proton energy in the low energy range. Then, the increase of the neutron production slows down with the proton energy. At high energy, the neutron production for tungsten target is relatively higher than the neutron production for lead and LBE targets. For instance, at 1 000 MeV, the neutron production is about 22.6 neutrons per proton for tungsten, while the neutron productions are about 19 neutrons per proton for lead and LBE. At 250 MeV, the neutron production is about 2.3 neutrons per proton for all these three kinds of target materials. Fig. 1(b) shows the neutron energy spectra for the neutrons produced in LBE target when proton beam energies are 250, 600, and 1 000 MeV. Except for the high energy portion, the distributions for different proton energies are similar and the maximum of neutron spectra occurs around 1.0 MeV.

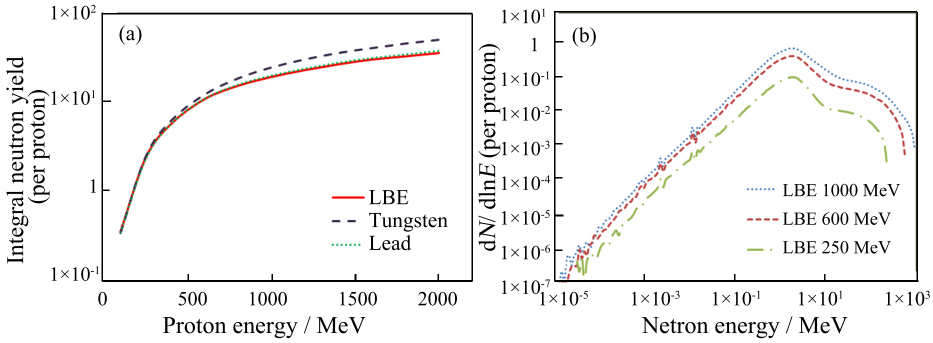


Fig. 1 (color online) (a) Integrated neutron yield for lead, LBE, and tungsten targets as a function of proton energy; (b) Neutron spectra in LBE target for proton energy at 250, 600 and 1 000 MeV.

As shown in Fig. 2, the residual products spread over two major regions. The upper right part corresponds to the target-like radionuclides that are produced by (p, $x$np) or (n, $x$np) reactions on Pb and Bi. The medium-mass residues are produced due to mechanisms such as fragmentation and fission reactions. It also can be seen that the valley of each curve moves to the left along the mass number axis when the incident proton energy becomes higher. It indicates that the reaction mechanisms become more complicated and more high-mass nuclides are produced as the incident proton energy increases.

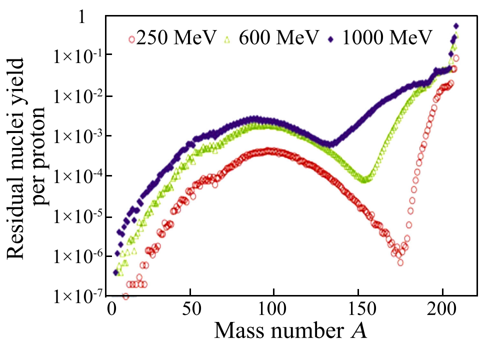


Fig. 2 (color online) Residual nuclei yield in LBE after 1 year irradiation by 250, 600, and 1 000 MeV proton beam.

The induced activities in LBE target irradiated for 1 year by 250 MeV proton beam are estimated and shown in Fig. 3. Since a large part of residues produced in LBE are short-lived, most of these short-lived radionuclides die away within 24 h as shown in the upper right con-

-tour plot in Fig. 3. After 5 years of decay, there are still a great number of radionuclides which have medium or long half-lives.

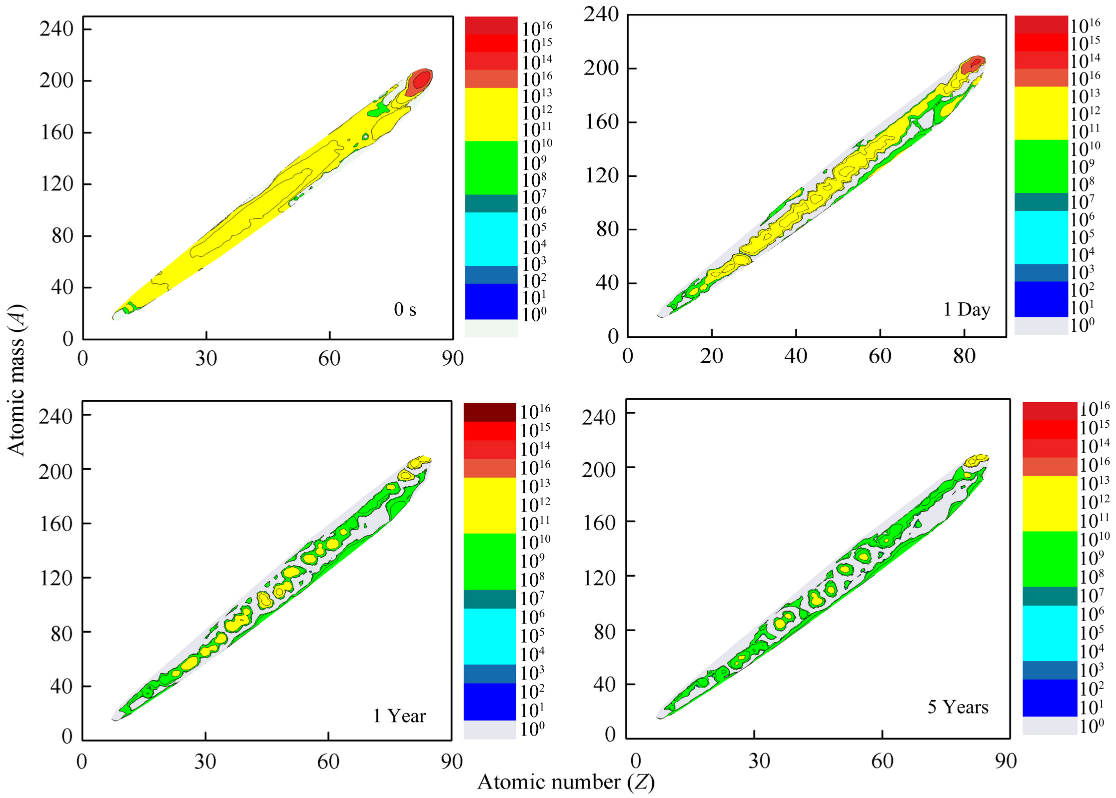


Fig. 3 (color online) Contour plots of the residual activity with different decay time in LBE target irradiated by 250 MeV proton beam for 1 year.

## References

[1] D. B. Pelowitz, LANL Report LA-CP-11-00438, (2011).

[2] C. Sunil, Radiation protection and Environment, 35(2012)145.