Calculation of radiation hazard connected with the SAD spallation target replacement

Władysław Pohorecki

AGH-University of Science and Technology, Faculty of Physics and Applied Computer Science
Al. Mickiewicza 30, 30-059 Kraków, Poland

INTRODUCTION

The Subcritical Assembly in Dubna (SAD) is a installation (in design stage) coupled with existing 660 MeV proton accelerator (max beam current 3.2μA). The main characteristics of the subcritical core are: MOX fuel, keff=0.95,fission power 27.6 kW, Pb reflector. It includes necessary beam transport line ending on the heavy metal replaceable target (Pb, Pb/W) The SAD spallation target consists of one central and 18 hexagonal (36mm pitch) Pb prisms in 2 concentric layers.

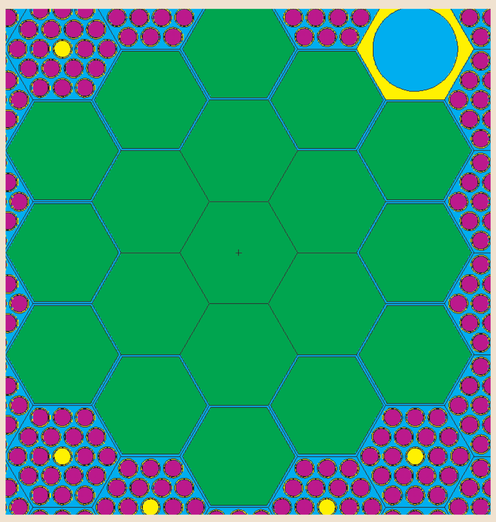

Fig.1.The perpendicular cross section of the spallation target with surrounding fuel elements and a vertical experimental channel.

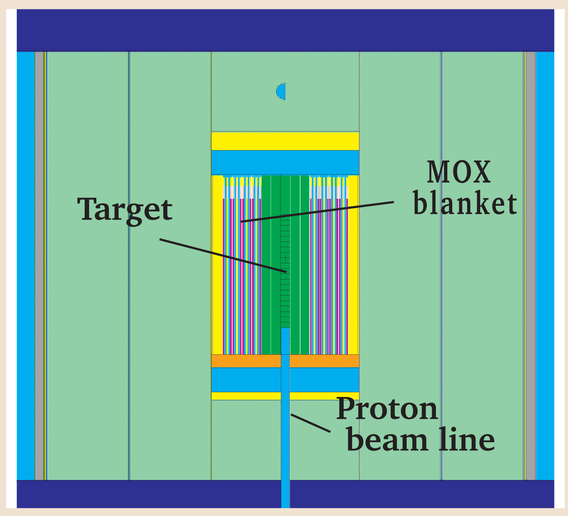

Fig.2.The longitudinal cross section of the SAD core.

The main goal of this work is to assess the radiation hazard connected with the replacement of the SAD target after planned six months operation period. As was shown in [1] ca 75% of the total activity mainly induced by high energy particles is concentrated in the single central element. Therefore only this moste hazardous part of the SAD Pb target has been chosed for detailed calculations.

METHODS and TOOLS

The residuals production rate per one source proton has been calculated with MCNPX [3] code. Then modified EvIzo [2] program has been used to calculate the time evolution of each possible production/decay path. Using the data from TORI database [4] the spectra of gammas, X-rays and betas in choosen time points after irradiation end have been produced and stored.

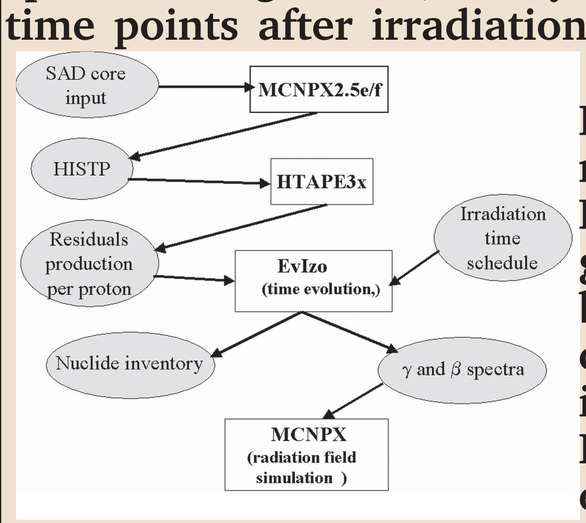

Fig.3. Scheme of the calculation process

In order to simulate the radiation field around the Pb rod the calculated gamma/beta spectra have been used for respective construction of source in MCNPX input. In each 2 cm prism element homogenous activity distribution is assumed. See Fig. 3.

RESULTS

In order to assess the time distribution of gamma and beta activity in the rod the calculations have been performed using 6-months-irradiation scenario. (25 working weeks - 1.5μA proton beam for 10 hours per day, 5 days in week). Total proton fluence equal 4.2x10^{19}. In order to calculate the longitudinal radioactivity distribution the 42cm long element has been divided in 2cm slices.

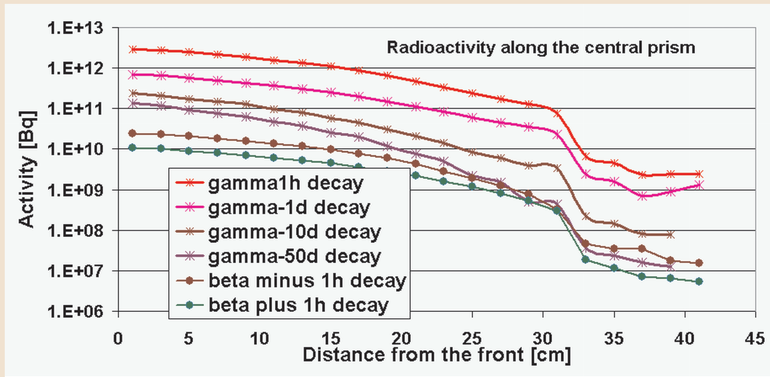

Fig.4.Gamma and beta activity distribution

The radioisotopes inventory was calculated independently in each of them. In Fig. 4 is shown the distribution of gamma and beta emission rate along target element surface

In fig. 5,7,8 one can see exemplary spectra for the most active slice Fig. 6 shows the shape of gamma radiation field one hour after shut down. Fig. 9,10 shows exemplary dose rates.

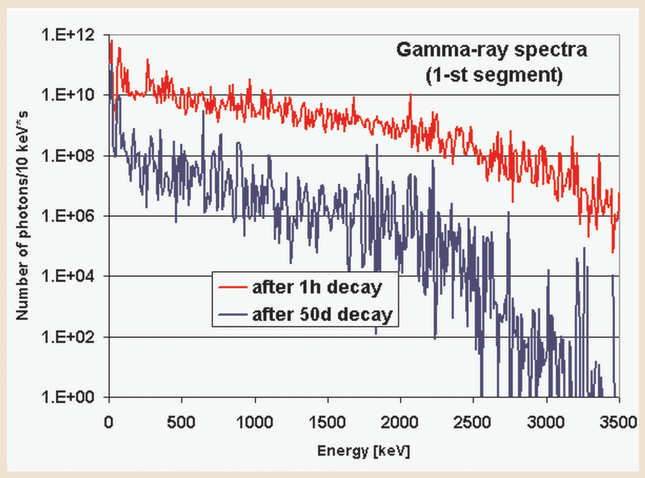

Fig.5 Gamma spectrum

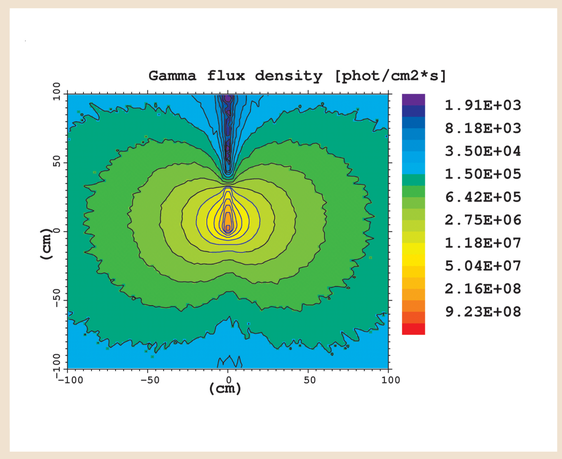

Fig.6 Gamma radiation field

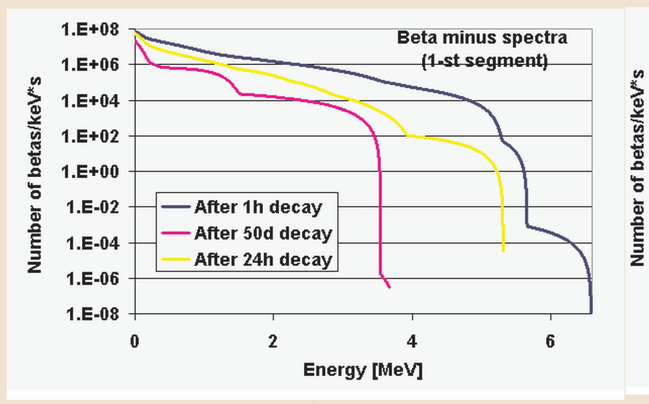

Fig.7. Beta minus spectrum.

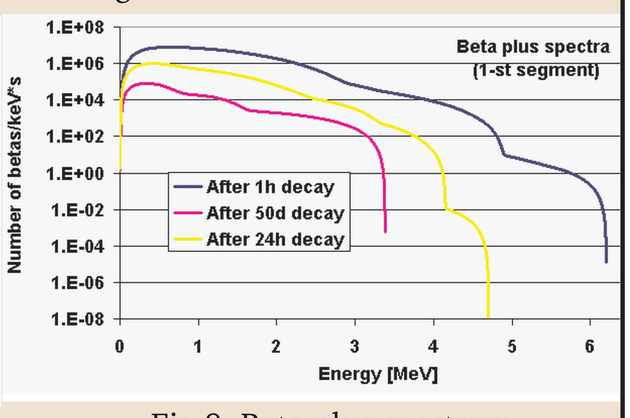

Fig.8. Beta plus spectrum

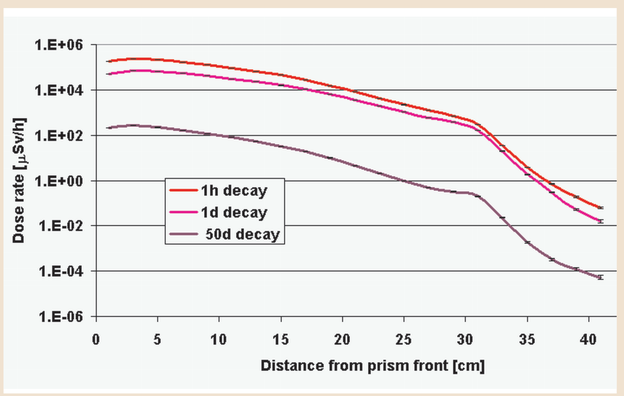

Fig.9.Surface gamma dose rate

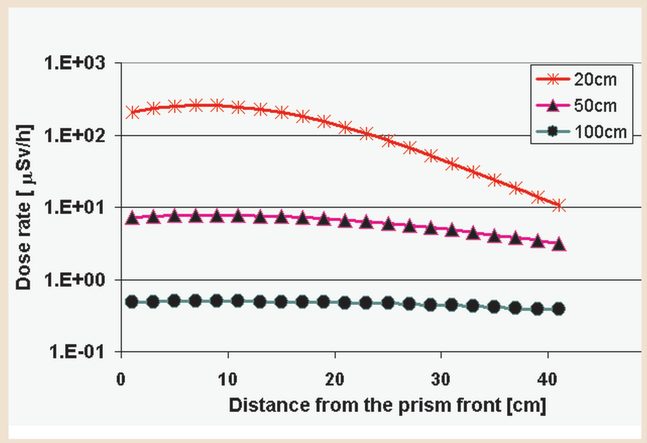

Fig.10.Gamma dose rate around(1h decay)

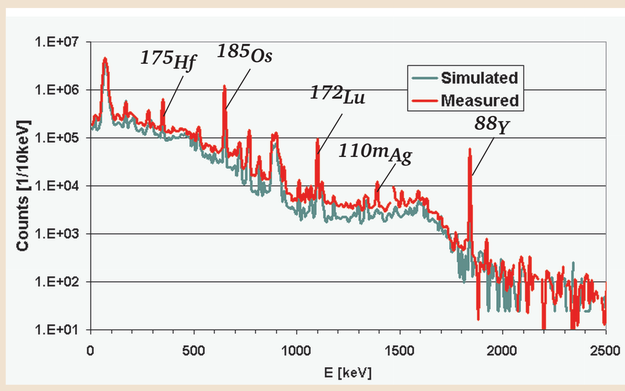

Fig.11.Measured and simulated gamma spectrum

In order to assess the calculations quality the experimental results from the experiment with bare 8 cm diameter Pb cylindrical target [3,5] are used. The gamma spectrum of the 1 mm thick target slice measured with HPGE detector after 200 days decay is compared with simulated one. The spectra are shown in Fig. 10. One can see good agreement of the spectra. Absolute total number of counts in spectrum agrees within 25% limit.

References

[1] W.Pohorecki, NIM A 562 (2006) 764.
[2] John S. Hendricks with Mcnpx Team," Mcnpx, version 2.5.d",
[3] L.P.Ekstrom and R.B. Firestone, WWW Table of Radioactive Isotopes, database version 2/28/99.
[4] W. Pohorecki, et al, NIM A 562 (2006) 750.

Summary

The radiation hazard connected with replacement of the most active part of the SAD target after planned six months operation period is estimated. The longitudnal distribution of radiosotopes produced in central target prism are presented. The exemplary gamma and beta spectra are shown as well. The results can be used for the SAD target maintenance end experiments designing. Methods and tools used for gamma calculations are tested with experimental results showing rather good agreement.