ACITADS (Assessment of the Consequences of the Irradiation of Targets in ADS)

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Objectives

The consequences of the high proton irradiation of an spallation target for ADS projects are systematically analyzed :

- Analysis of the spallation product yields
- Analysis of the long term radiation products inventories
- Gas production in the spallation target
- Material damages in the spallation target
- Energy deposition in the spallation target
- Investigation of the steady state feedback and the dynamic behavior between the ADS target and the sub-critical core

This project started in April 2005. Some of the results achieved are presented here.

Spallation products in a ^{181}Ta target

Based in the solid tantalum spallation target of the TRADE project, calculations of the spallation inventories have been made at 0.14, 0.3 and 1 GeV proton beam energies. In this calculations the spallation target was isolated and the low energy neutron flux was not very high ($6 \cdot 10^{12}$ n/s)

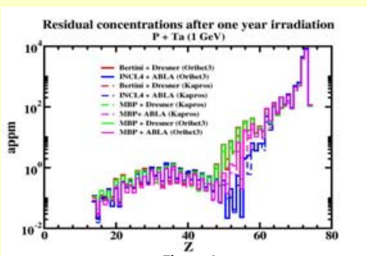

Figure 1

Fig.1: *Spallation residual concentrations (in appm) after one year of irradiation of 0.14 mA and 1 GeV proton beam in a solid ^{181}Ta target*

The residual production rate per one proton source has been calculated with different spallation models available in MCNPX2.5.f [1]. Then, two depletion codes were used to calculated the time evolution of each possible production / decay path: ORIHET3 [2] and the depletion module of KAPROS [3] which allows the inclusion of the low energy neutrons in the calculation. In *figure 1* the spallation residual concentration after one year of irradiation of a 1 GeV proton beam is presented. A comparison between the two depletion codes shows good agreement (generally less than 30%). Differences between the spallation models are evaluated to about 30% for the fission products between Bertini + Dresner and INCL4/ABLA [1] and achieved a factor of 40 for residual nuclei 50<Z<60. The MBP option falls between the two spallation models for intermediate evaporation residues.

Calculations of the activity of the target during irradiation and cooling have also been performed for the three energies of the proton beam (0.14, 0.3 and 1 GeV).

DPA Calculations in the ^{181}Ta target

Displacement Per Atom (DPA) were evaluated in the tantalum target using the NRT model for a 0.14 mA proton beam of 0.14, 0.3, 0.5 and 1 GeV.

Figure 2

Two spallation models were compared for the inelastic displacement cross-section evaluation showed in ***figure 2.*** The contribution to the total displacement cross-section of the elastic reactions is around 10-13% above 50 MeV.

References

[1] *Hendricks, J. S. et al.*, LA-UR-04-0570 (2004);

[2] *Atchison, F.; Schaal, H.* Orihet3 Users' Guide Version 1.12, 22. March (2001);

[3] *Broeders, C.H.M et al.*Proc. Reaktortagung, Düsseldorf (2004);

[4] W. Pohorecki *et al.* Proc. ICRS10 RPS May (2004);

[5] See http://sad.dubna.ru

Results for SAD benchmark

Recent experiments [4] were carried out in the frame of the SAD (Subcritical Assembly in Dubna [5] project in order to determine the spatial distributions of some identified nuclides and the activity induced in the lead spallation target. We show a comparison of our calculations with some of these experimental data as a part of the benchmark aiming to validate spallation codes and data libraries.

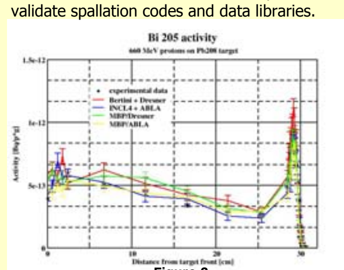

Figure 3

The existing JINR 660 MeV proton beam in Dubna was used to irradiate a solid spallation target of 31 lead samples during 8-9 hours. The total proton flux was $2.6 \cdot 10^{14}$ p. The ABLA de-excitation model seems to be in good agreement with experimental data. The shape of the activity peak is reproduced by the codes.

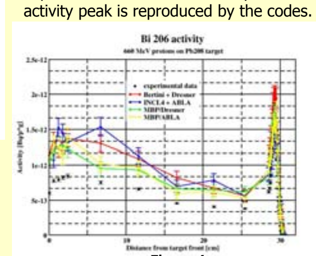

Figure 4

Figure 3,4*: Activity in the lead spallation target of the SAD project due to ^{205}Bi and ^{206}Bi versus depth in the lead target. Experimental data are compared to spallation models in MCNPX2.5.f. the KAPROS depletion model was used.*

Spallation products in the SAD target

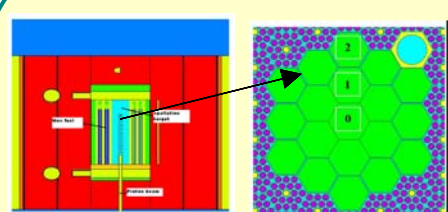

Figure 5

Figure 5*: The SAD spallation target consists of one central and 18 hexagonal (36 mm pitch) Pb prisms in concentric layers. In this project the JINR 660 MeV proton accelerator will be used.*

RESULTS

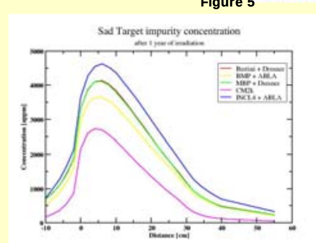

Figure 6

Figure 6*: Residual concentrations in the SAD lead target as a function of the distance to the proton beam entrance. Different spallation models available in MCNPX2.6 version are used. CM2k shows important differences in the total concentration .*

This difference is mainly due to three isotopes of lead (206, 207 and 208 Pb), that for embrittlement or corrosion problems are not considered as impurities (see for example ***figure 7***). On the other hand,^{209}Pb that comes from neutron absorption in the target, is more produced in the CM2k and MBP + ABLA spallation models.

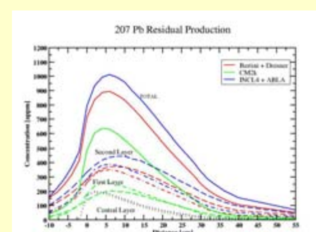

Figure 7

The β- decay of the ^{209}Pb→^{209}Bi (3.253h) is the main responsible for the activity of the target for CM2k and MBP + ABLA, while the β+ decay of the ^{203}Pb (51.9h) is the most important for the other spallation models (***figure 8***). It is also important to mention the contribution of the fuel to the total concentration that is more important for the Bertini + Dresner model than for CM2k (see ***figure 9***).

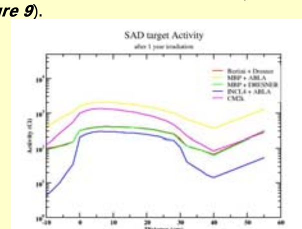

Figure 8

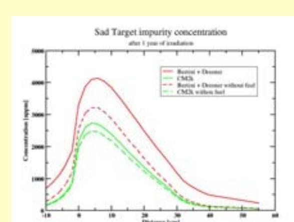

Figure 9