STUDY ON SPALLATION YIELDS PREDICTIONS IN AN ADS TARGET

H. Kobayashi, T. Sawada, M. Katsuma, V. Artisyuk, and T. Sasa

Importance of Simulations



A lot of the spallation produced isotopes are radioactive.

The Contribution to Toxicity accumulated would come from not only Po, but rare earth elements.

It is important to predict spallation produced isotopes yields precisely.

What is PHITS?

General Purpose Particle and Heavy Ion Transport code System - PHITS



NMTC/JAM MMTC/JAERI + JAM (*up to 200GeV*) + GEM + Modified Bertini model + Low Energy n, e, γ transport Jet AA Microscopic Transportation Model is a hadronic cascade model. Nara et al., 1999

PHITS

NMTC/JAM + Heavy Ion Reactions (Shen's formula) + Stopping Power (SPAR code) + JQMD *H. Iwase, K. Niita, and T. Nakamura* (2002)

Spallation reaction



Basic Validation of PHITS Code



Although basic physical quantities are reproduced well, we should investigate validation of the PHITS for an ADS.

Experiments related to ADS

Experiment

ITEP - p (1 GeV) + ²⁰⁸Pb, p (0.8 GeV) + ¹⁹⁷Au GSI - ²⁰⁸Pb (1 GeV/A) + p, ¹⁹⁷Au (0.8 GeV/A) + pZSR - p (1 GeV) + ^{nat}Pb, p (0.8 GeV) + ¹⁹⁷Au

We should investigate validity of the PHITS code to compare with these experiments.

Calculation by PHITS



- In the calculation of PHITS, we use Bertini model and GEM.
- The calculations are consistent with experimental data in factor 2-5.

Disagreement is LARGE in rare earth elements region.

Fragmentation Products



- In A > 70 and < 50, PHITS reproduce well.
- In rare earth elements, the results by PHITS are overestimated well.
- More accuracy is required for the prediction of toxicity.

Check the validity of PHITS in other calculation models !

Netron Number

Evaporation and Fission Models



Cascade Models



experiment

- JAM
- ISOBAR model
- Bertini model(PHITS)
- For the prediction of rare earth elements, JAM can reproduce the experimental data rather than the others.

ALL models did not reproduce experiment well

Discussion

- PHITS can reproduce experiments in factor 2-5.
 - For each rare-earths, the disagreement is larger.
- Using any calculation model, PHITS cannot reproduce experiment well.
 - More accuracy for the toxicity prediction!
- JAM is better than other cascade models in rareearths region.
 - JAM is not valid in the energy ~ 1GeV.
 - Excitation energy after cascade affect the results strongly !
 - It would be important to improve the cascade calculation in the PHITS code.

Future Work

- We should improve cascade models.
- ISOBAR model
 - This model is old.
 - LAHET has new ISOBAR model, ISABEL.
- Difference between ISOBAR and ISABEL.
 - Density profile,
 - Pauli principle,
 - reflection and refraction,
 -

Improve ISOBAR for the prediction of rare-earth!

Summary

- We investigate the validity of the PHITS code for toxicity prediction in an ADS target.
- The PHITS does not reproduce experiments in rare earth region.
- In future work, we will
 - Improve of ISOBAR in the other parts.
 - Introduce ISABEL to PHITS.

GEM + ISABEL

Mill in (b) p.t. 208Pb at 1GeV and intervalue of a set of the set

The product is A B A - C h M A - C

(Furihata 2003)

 GEM + ISABEL can reproduce the experimental data very well!