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Conceptual Design of Accelerator Driven Systems with Light Ion Beams

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The superior energy efficiency of light ion beams instead of proton beams for energy production in accelerator driven systems (ADS) is demonstrated. The energy efficiency is characterized by the energy gain calculated as the ratio of the energy released in the target to the energy spent for the beam acceleration. The energy deposited in the target is obtained via Geant4 simulation. The energy spent for the beam acceleration depends on the particle type and energy, beam intensity, and accelerator type (synchrotron, linac, cyclotron). A method to calculate the energy spent for the beam acceleration by scaling from the data for a reference beam is presented. For a given beam, the highest energy gain is obtained when the beam is accelerated in a synchrotron. A synchrotron, however, cannot ensure the beam intensities necessary for accelerator driven systems (ADS). Linacs are capable to produce the required beam intensities with good energy gain. For this reason, we consider the beams accelerated in a linac in the further analysis.
The influence of the target structure on the energy efficiency of 0.5-4 GeV proton beams and 0.25 –0.5 AGeV light ion beams is studied. The target consists of rods with different composition (metal, oxide, carbide) and different levels of enrichment in order to implement the target with a criticality coefficient of 0.96 -0.97, which ensure safe operation. The influence of the rod diameter and the distance between rods was investigated. The cooling with different metals (lead, lead-bismuth eutectic-LBE, and sodium) is compared. The use of convertors from heavy metals (uranium, lead, tungsten) and very light materials (lithium, beryllium, carbon) and their influence on the neutron spectrum and energy released are analyzed.
Our studies yield the conclusion that the best solution for ADS from the point of view of the energy efficiency and miniaturization is as follows: beams of Li-7 and Be-9 with energies of 0.35 - 0.4 AGeV, cooling with lead or LBE, and the use of convertors from Be or Li.

Selected session

Accelerators and INstrumentation

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