High Intensity Low Energy Electron Accelerators for Sub Critical Micro Nuclear Reactors

Kailash C Mittal* and Ganapati Myneni

BSCE Systems, Inc., 318 Quarter Track, Yorktown, Virginia 23693, US
* B 701, Lakhani Galaxy, Sector 15, CBD Belapur, Navi Mumbai 400614, India

Abstract

Accelerator Driven Subcritical (ADS) Reactor Systems are being considered for producing nuclear power that are proliferation free, clean, ultra safe. They are likely to be cheaper than the coal and generate very low quantity of radioactive spent fuel that needs to be stored for more than 300 years. Proton beams with 1 GeV energy and 1 to 10 MW of beam power are being proposed for producing neutrons by (p, n) reactions that will be injected in the nuclear reactor subcritical core to sustain chain reaction and produce power. GeV range proton accelerators are very large in size, expensive and can be coupled to nuclear reactors that can produce power in excess of 1000 MW. As an alternative, Electron Beams of 50 to 100 MeV are also proposed for ADS type of applicationswhere neutrons are produced due to (ϒ, n) reaction. Neutron production by (p, n) reaction is more efficient than (ϒ, n) reaction. However for ADS applications, proton beams are viable around 800 MeV where neutron yield saturates. In case of electron beam, neutron yield saturates at 100 MeV. Here, we present an alternate approach using low energy electron accelerators to produce X ray photons that are employed for neutron generations by (ϒ, n) reactions for injecting into Sub Critical Micro Nuclear Reactor.

Threshold energy for (ϒ, n) reaction is 1.67 MeV for Be, 2.23 MeV for D_2O and 5.4 MeV for Li. Neutron Yield is estimated for 8 to 20 MeV electron beam using Be, D_2O, LiD, CD_4/BeD_2 and W/Ta targets for 1 Ampere beam current. In comparison, neutron yield for W/Ta at 100 MeV with equal beam power is also estimated. The results are presented in the table below:

Table: Neutron Yield (n/s in 4π solid angle) for 1 Ampere Electron Beam Current for Beryllium, Deuterium and W/Ta Targets for Different Electron Energies

S. N0	Neutron Yield n/s in 4π solid angle for 1 Ampere x 10^{15}						Neutron Yield n/s (x10^{15}) at 100 MeV for W/Ta for Equal Beam Power
		Be	D_2O	LiD	CD_4 (liquid) /BeD_2	W/Ta	
1	8 MeV	2.1	4.4	7.5	11.5	-	-
2	10MeV	5.5	9.3	12.5	15.0	1	20
3	15MeV	10.2	**14.0**	**22.3**	**34.3**	**3.5**	**30**
4	20MeV	14.9	**20.0**	**28.6**	**44.8**	**20**	**40**

It can be seen that neutron yield at 10 to 20 MeV with low Z targets at 1A is 2 – 4 x 10^{16} n/s which is comparable with high Z targets at 100 MeV with equal beam power. Therefore, it is proposed to consider 10 to 20 MeV, 1 A electron accelerator for setting up micro reactors for power production.