Snowmass2021 - Letter of Interest

An accelerator based BNCT

NF Topical Groups: (check all that apply □/■)

■ (CEF1) Applications & Industry
□ (CEF2) Career Pipeline & Development
□ (CEF3) Diversity & Inclusion
□ (CEF4) Physics Education
□ (CEF5) Public Education & Outreach
□ (CEF6) Public Policy & Government Engagement
□ (Other) *[Please specify frontier/topical group(s)]*

Contact Information:
Name (Institution) [email]: Fujio Naito (KEK) [fujio.naito@kek.jp]
Collaboration (optional):
Ibaraki BNCT project (iBNCT)

Authors: (long author lists can be placed after the text)

Fujio Naito

Abstract: (maximum 200 words)
The boron neutron capture therapy (BNCT) is a kind of the cancer therapy. The principle of the BNCT is as follows: (1)Drug with ^{10}B is delivered to the cancer affected part; (2)Epithermal neutrons (0.5eV<Ek<10KeV) are irradiated from the outside; (3)Neutron reacts with ^{10}B through the reaction ^{10}B(n,α)^{7}Li; (4)Both of ^{7}Li and α stop in the cell and destroy it. At the beginning of the BNCT development, a nuclear reactor was used as the neutron source. Recently an accelerator based BNCT is being developed in order to install the system in the hospital. A low energy proton accelerator is used mainly to produce the neutron. IAEA report shows that the desirable minimum intensity of the epithermal neutron beam is 10^9 n/cm^2/s. It requires the beam average current of several mA. For spreading the accelerator based BNCT in the world, the size and the cost of the system must be reduced more. If HEP society want to show the usefulness of itself, the accelerator based BNCT is one of the adequate subject to take part in the activity. Since HEP society has built the almost intense accelerators, it should lead the development of the accelerator based BNCT.

LOI : An accelerator based BNCT

The boron neutron capture therapy (BNCT) is one of the candidates for the cancer therapy. The principle of the BNCT is as follows:

1. Drug which contains Boron ^{10}B is delivered to the cancer affected part;
2. Epithermal neutrons (0.5eV<E<10KeV) are irradiated from the outside to the affected part. (It is not the pinpoint irradiation like an ion beam therapy. Neutron beam must be wide so that the beam covers

the all patient part simultaneously);

3. Neutron reacts with Boron ^{10}B through the reaction ^{10}B(n,α)^{7}Li;
4. The range of both of the decayed particles (^{7}Li and α) in a cell are a few μm.;
5. Therefore, both stop in the cell. At that time, they loss the whole kinetic energy;
6. The cell affected by cancer is destroyed by the lost energy by particles.
7. The damage of the normal cells which has no boron is less than the permissible level.

At the beginning of the BNCT development, a nuclear reactor was used as the neutron source. However, the accelerator based BNCT is being developed recently because it is possible to install the system in the hospital. A low energy proton accelerator is used mainly to produce the neutron for BNCT. The neutron production target is made of Lithium or Beryllium. For Lithium target the proton energy of 2.3 MeV is adequate because (p, n) reaction cross section has a peak at the energy. An electro-static accelerator or RFQ linac is used. For Beryllium target the required proton energy is much higher ($>$ a few MeV). In this case, a cyclotron or RFQ+DTL is used.

IAEA report [1] shows that the desirable minimum intensity of the epithermal neutron beam is 10^9 n/cm^2/s. It requires the beam average current of several mA. In order to spread the accelerator based BNCT in the world, the size and the cost of the system must be reduced more. If HEP society want to show the usefulness of itself, the accelerator based BNCT is one of the adequate subject to take part in the activity. However, almost HEP laboratories has no interest in it because the project may be too small for them.

From the viewpoint of the spinoff from the HEP research for the intensity frontier, the developed accelerator is suitable for the BNCT. For instance, the design of the front-end part of J-PARC linac is used in the Ibaraki BNCT (iBNCT) project which is the collaboration among KEK, University of Tsukuba and several private companies in Japan.

IAEA has started the discussion to standardize the accelerator based BNCT. Thus, HEP society should commit positively to the discussion as the expert of the high intensity accelerator.

HEP society can transfer the accelerator technology to industry. However, the system must obtain pharmaceutical approval from the government for the installation in the hospital. Thus, the support from the university which has a hospital is suitable. Furthermore, the support from industries is important for the maintenance of the system in order to keep the performance for a long term.

The accelerator based BNCT is a relatively small project. However, it is very interesting and useful subject.

References

[1] IAEA-TECDOC-1223
(https://www-pub.iaea.org/MTCD/publications/PDF/te_1223_prn.pdf)