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→ New Challenges

Progamme & Abstracts

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Poster Session 2
Accelerator Neutron Sources and Physics (AC)

compressed monocusp, volume plasma proton ion source has been designed, fabricated and tested. It consists of a plasma generating chamber with a tungsten filament discharging against an anode within a plasma of relatively high density, surrounded by permanent magnets with their north poles facing the axis of the cylindrical chamber in order to generate a monocusp magnetic field. This longitudinal field, parallel to the axis, compresses and concentrates the electron discharge against the aperture connecting to a subsequent expansion cup. The magnetic field penetrates into that chamber further contributing to enhancing the hydrogen gas ionization efficiency of the electron discharge. The system is completed by a triode based extraction system with backstreaming electron suppression. Without transport through the line into the Faraday cup the ion source has been shown to deliver high proton currents up to 50mA with extraction voltages up to 40-50kV. In addition a beam of about 4mA, with a cross section of about 1cm diameter, has been accelerated and transported into the suppressed Faraday cup, 1m downstream. A diagnostic system based on the fluorescence induced in the residual gas is being developed. Extensive simulations of the source and extraction have been performed using both 2D and 3D selfconsistent codes.

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Accelerator Based Neutron Source for Boron Neutron Capture Therapy

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Introduction: Boron Neutron Capture Therapy (BNCT) has been developed greatly in curing Glioblastoma cells using dual modality boron compound and low energy neutron beam out of a reactor core. The principle of the technique is based on neutron $^{10}B(n,\alpha)^{7}Li$ reaction, which leads to dissipation of 2.79MeV energy in form of ions kinetic energies and excitation. The energy of each ion is proportional to the inverse of the particle mass, so $E_{\alpha} = 1471.27keV$ and $E_{^7Li} = 840.73keV$. In 93.7% cases, a gamma-ray with 478keV energy is emitted. It should be bear in mind that in practice, for deep seated brain tumors besides slow neutrons, there are many core gamma rays, capture gamma-rays by surrounding materials, recoil protons and $^{14}N(n,p)^{14}C$ reactions. Besides the above-mentioned constraints, research reactors operational safety procedures, make availability of the reactor for applications limited. Hence, accelerator based neutron sources have favored many applications including BNCT. In recent years, using electron linear accelerator (Linac) to produce photo-neutron has been considered as a favorable source of neutrons for BNCT application. In this project an electron linear accelerator, Varian 2300C/D with 23mA and 20MeV electron was considered. In the simulation, high-energy electrons impinge on a tungsten target to produce high-energy bremsstrahlung radiations. The gamma rays involving in (γ, n) reactions with lead and beryllium produce high-energy neutrons.

Materials and Methods: The high energy neutrons are slowed down as a result of scattering with light elements of polyethylene as a moderating material. The slow neutrons were collimated using Beam Shaping Assembly, BSA. To optimize the whole setup and maximize neutron flux at the target, the Monte Carlo code FLUKA simulated the system and neutron scattering. The results of our simulation by FLUKA code showed that the multiplying system creates neutron flux of $10^8 n/cm^2.s$, with a neutron energy spectrum extending in the range of 10^{-3} eV–5MeV. The spectrum peaking at $5\times10^{-2} eV$.

Results and Discussion: In deep seated brain tumors, epithermal neutron beam should be impinged on the patient's head. Human brain contains about 80% water. Therefore, before neutrons reach the tumor suffer many scattering collisions mainly with hydrogen nuclei of water molecules and other elements losing energy. Recoil protons may also receive nearly all the neutron energy. The epithermal flux drops as neutrons penetrate the brain and slows down. The calculated thermal neutron flux (below cadmium cutoff energy, 0.5eV) increases as move deep inside the brain and in deeper distance flux drops because of absorption and diffusion. In this project, we used high energy electron out of the accelerator with energy range up to 20MeV impinging on lead and tungsten target. Heavy elements are used as targets to produce bremsstralung high energy x-rays. The (γ, n) reactions with Pb and Be produce fast neutrons. Using simulation code variety of combinations examined to design a geometry that gives highest flux in experimental cavity. To shield the converter whole system is surrounded by borated paraffin and lead to limit the outside dose rate. The simulation showed that the neutron flux in the cavity was. $1.32\times10^8 n/cm^2.s \pm 4\%$. The gamma dose rate inside the cavity was estimated at $3.24\times10^{-1} Gy/s \pm 7\%$.

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A protective subsurface container for activated target holding and temporary storage

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Introduction: An accelerator-driven source of epithermal neutrons developed for neutron capture therapy studies has been put into operation at Budker Institute of Nuclear Physics. One of the problems arising from the use of the reaction $^7Li(p,n)^7Be$ for neutron generation is lithium activation by the radioactive isotope beryllium-7. Proton beams, whose power

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reaches 25 kW heat lithium, but the effective heat removal helps keep it in the solid state thus retaining the radioactive isotope within the lithium layer and preventing its spread with vapor over the entire facility. It is proposed that the target should be removed after its activity becomes prohibitively high or its life runs out, and put into a protective subsurface container for holding and temporary storage. Such a procedure seems optimal because the 53-days-long half-life of beryllium-7 is long enough to allow target removal operations near the source to be accomplished and short enough to allow the natural deactivation of the target.

Results and discussion: The maximum activity of targets in the container was determined. Gamma transport simulations by the Monte Carlo method were done with the code PRIZMA to determine the optimal size of the container which must ensure radiation safety for personnel. Their results were used to develop and adjust the detailed design of the container. Later the container was constructed and put into operation.

Thus, with the constructed container for activated target holding and storage, it becomes possible to implement sustained neutron generation on the facility designed for systematic research in boron-neutron-capture therapy.

AC - 5
New technical solution for use the time-of-flight technique to measure neutron spectra

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Introduction: An innovative accelerator-based neutron source for boron neutron capture therapy has started operation at the Budker Institute of Nuclear Physics, Novosibirsk. This facility is based on a compact vacuum insulation tandem accelerator designed to produce proton current up to 10 mA. Epithermal neutrons are proposed to be generated by 1.915 MeV protons bombarding a lithium target using $^7Li(p,n)^7Be$ threshold reaction.

Results and discussion: New technical decision is proposed for use the time-of-flight technique to measure neutron spectra. For a short interval of time the energy of proton increases from 1.865 MeV (lower than the threshold of the $^7Li(p,n)^7Be$ reaction that is 1.882 MeV) up to 1.915 MeV. The energy increase is performed by supplying the square pulse of 50 kV for 200 ns on neutron-generating target that is isolated from facility body. During these 200 ns the generation of neutrons is performed. The registration of neutrons is made with neutron detector Saint-Gobain, consisting of cerium activated lithium silicate glass scintillator GS20. This detector enhances the region of effective neutron registration up to 500 keV. The neutron spectrum is detected according to time of delay in its registration. The high voltage modulator for time-of-flight technique has been created. It consists of: the high-voltage pulse commutator on the base of industrial thyratron with hollow cathode TPI-1 10 kA/50 kV, unit for creation of heater voltage, triggering unit and double pulse forming line. The result of measuring the high-voltage pulse of the modulator on matched load of pulse forming line R = 150 Ohm at test frequency 50 Hz is shown that this pulse possesses practically rectangular shape with duration 200 ns at the leading and falling edges durations 18 ns and 25 ns respectively. The amplitude of the pulse in this testing experiment was 40 kV.

So, the time-of-flight technique proposed is ready for measurements of epithermal neutron spectra. First experiments on neutron detection were performed. The count rate was measured as depending on the proton beam energy. Continuous neutron generation and spectrum measurement by time-of-flight technique are in short-range plans.

AC - 6
Accelerator tube construction and characterization for a Tandem-Electrostatic-Quadrupole for Accelerator-Based Boron Neutron Capture Therapy

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Introduction: Within the frame of an ongoing project to develop a folded Tandem-Electrostatic-Quadrupole (**TESQ**) accelerator facility for Accelerator-Based Boron Neutron Capture Therapy (AB-BNCT) we discuss here the ongoing construction and characterization of the accelerator tubes for the transport and acceleration of 30mA proton or deuteron beam.

Materials and Methods: The tubes are essential components of the accelerator. Their function is to transport and accelerate an intense proton or deuteron beam (30mA) through the machine, from the ion source to the neutron production target, without significant losses. In this contribution we discuss the materials selected for the tube construction, the procedures used for their assembly and the testing performed to meet the stringent requirements to which it is subjected. The tubes have to withstand non-negligible mechanical stresses, they have to be completely tight since they separate the ambient air from the high vacuum (less than 10^{-6} Torr) through which the beam is transported and the materials from which they are made of have to be appropriate for this high vacuum. In addition the tubes have to withstand the high electric fields necessary to focus and accelerate the beam

Results and Discussion: The present form of the tube prototype will be discussed in this presentation. It consists