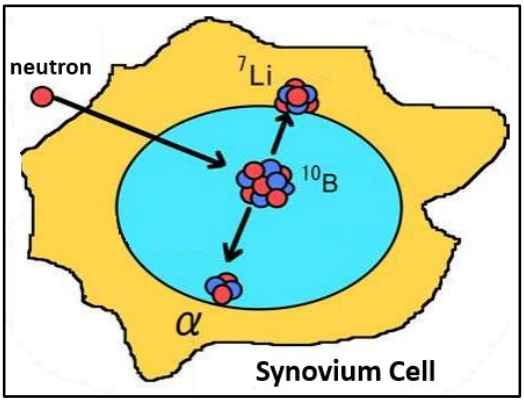
Feasibility study of accelerator-based Boron Neutron Capture Synovectomy.

Project Scope:

Rheumatoid arthritis (RA) is a chronic autoimmune disease that causes inflammation around the body and commonly presents with pain in the joints, mainly hands, wrists, feet, ankles, knees, shoulders and elbows are most often affected. Untreated, RA can lead to heart, lung or nervous system problems. Common symptoms include chronic pain, stiffness, tenderness, heat and swelling in the joints. RA can make it hard to move and perform daily activities.

As key facts should be considered that 18 million people worldwide are living with rheumatoid arthritis, while about 70% are women, and 55% are older than 55 years.

Boron Neutron Capture Synovectomy (BNCS) has been proposed as a possible treatment modality for rheumatoid arthritis. BNCS is a two-part modality, in which a compound containing an isotope (^{10}B) with an appreciable thermal neutron capture cross section is injected directly into the joint, followed by irradiation with a neutron beam. The $^{10}B(n,\alpha)^{7}Li$ reaction is also under development as a potential treatment modality for cancerous tumors.



Tasks: Use of modeling by the Monte Carlo method (MCNP6 and PHITS codes) to:

- ✓ Designing and optimization of accelerator based epithermal neutron beam obtained with the $^{7}Li(p,n)$ reaction.
- ✓ Calculation of the absorbed dose in the synovium using BNCS
- ✓ Estimation of treatment parameters for Boron Neutron Capture Synovectomy.
- ✓ Evaluation of clinical feasibility and prospects of BNCS.

Preliminary schedule by tasks (6 weeks):

Task 1: Weeks 1-2

Task 2: Weeks 3-4

Task 3: Week 5

Task 4 + Final Report: Week 6

Required skills and experience:

- ➢ Monte Carlo modeling using codes MCNP6 and PHITS.
- ➢ Knowledge of nuclear physics and particle transport.
- ➢ Solid knowledge about the interaction of radiation with living cells.

Acquired skills and experience:

- ❖ Designing and optimization of beam shaping assemblies (BSA).
- ❖ Dose calculation for treatment planning.
- ❖ Feasibility evaluation of therapeutic procedures.

Recommended literature:

1) Veronica A. Trivillin et al. , Radiat Environ Biophys. August/2026. DOI 10.1007/s00411-016-0664-3
2) D. P. Gierga and J. C. Yanch, R. E. Shefer, Med. Phys. 27 (1), January /2000
3) MCNP® Code Version 6.3.0 Release Notes LA-UR-22-33103 Rev. 1 January 10, 2023. Los Alamos National Laboratory. USA.
4) T. Sato et al., Recent improvements of the Particle and Heavy Ion Transport Code System - PHITS version 3.33, J. Nucl. Sci. Technol. 61, 127-135 (2024).