# A Prototype Compact Accelerator Driven Neutron Source for Canada Supporting Medical and Scientific Applications

D. D. Maharaj[a,b], M. Abbaslou[b,c], S. Tabbassum[d], [b,c]A. Gottberg[b,c], M. Marchetto[b], N. Muller[b], Z. Tun[e], D. Banks[e], Z. Yamani[f], V. Anghel[f], H. Fritzche[f], R. Rogge[f], X. Huang[f], M. Seydaliev[f], C. Song[f], L. H. Nie[d], O. Kester[b,c], D. Marquardt[a], R. Laxdal[b,c]

[a]Department of Chemistry and Biochemistry, University of Windsor, [b]Accelerator Division, TRIUMF, [c]Department of Physics and Astronomy, University of Victoria, [d]School of Health Sciences, Purdue University, [e]TVB Associates Inc. and [f]Canadian Nuclear Laboratories

## Neutron Beams for Canada

To address the neutron gap in Canada, the prototype Canadian compact accelerator driven neutron source (PC-CANS) has been proposed. This facility will facilitate neutron experiments, boron neutron capture therapy (BNCT) and F-18 isotope production. R&D efforts are geared towards three major topics,

- Accelerator design
- Target Design
- Target Moderator Reflector (TMR) optimization

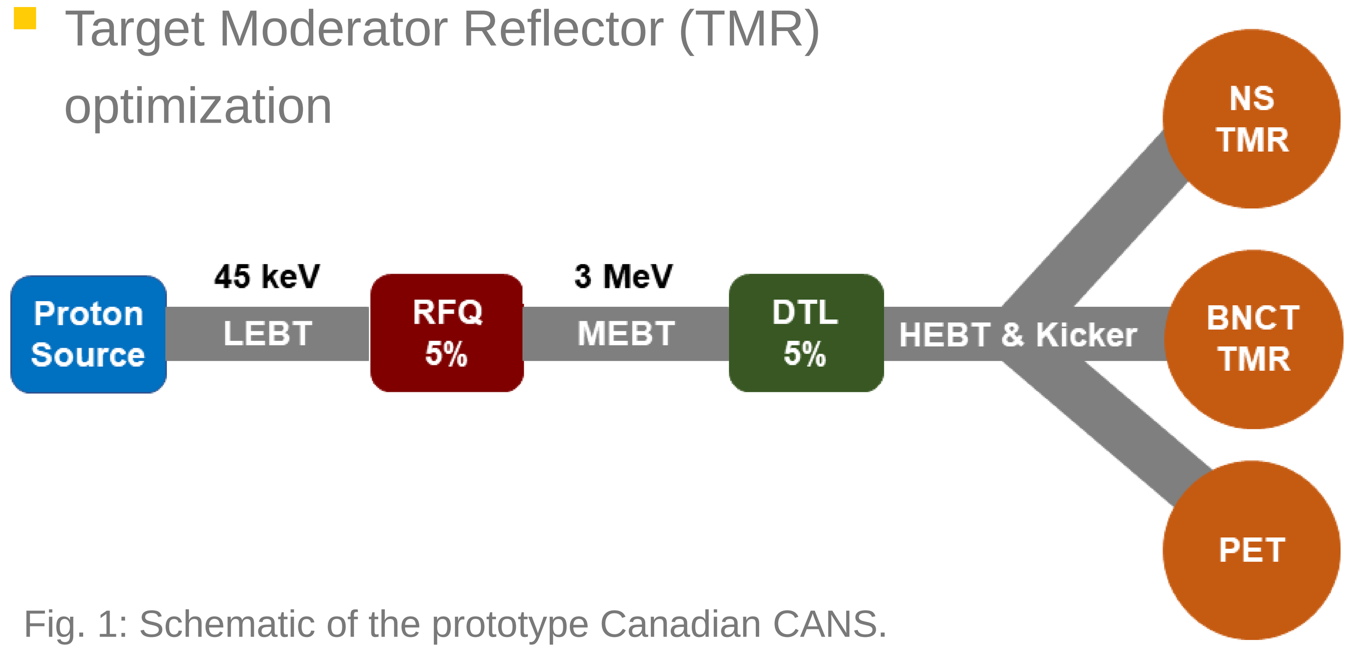


Fig. 1: Schematic of the prototype Canadian CANS.

## CANS Facilities Worldwide

A CANS is a viable solution to meet the demand for neutron beams because it is,

- Compact
- Cost effective
- A scalable technology

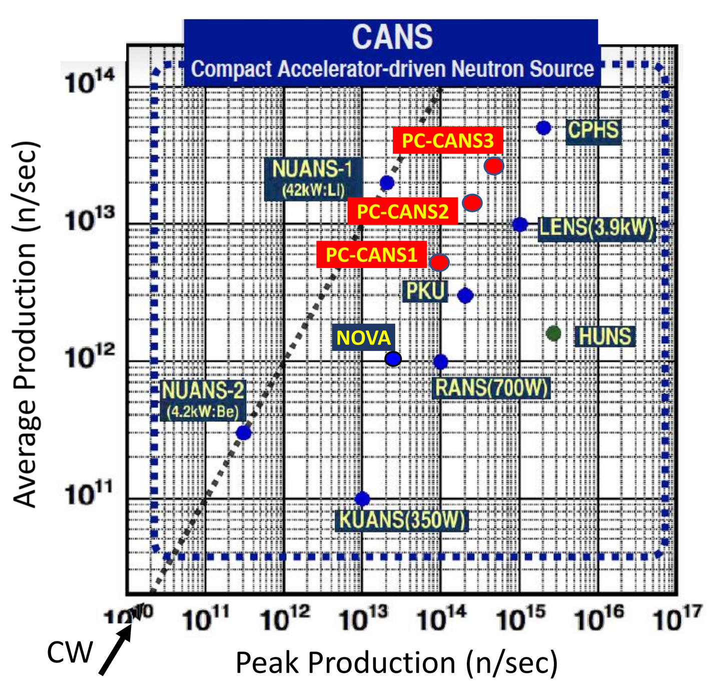


Fig. 2: Comparison of CANS facilities.

## Accelerator Parameters

The linac is based on a RFQ and DTL and will produce 10 MeV proton macropulses.

| Station | Energy (MeV) | $I_{ave}$ (μA) | DF (%) | $P_{ave}$ (kW) | $I_{peak}$ (mA) | $P_{peak}$ (kW) |
|---|---|---|---|---|---|---|
| Neutron | 10 | 200 | 5 | 2 | 4 | 40 |
| 18F | 10 | 100 | 5 | 1 | 2 | 20 |
| BNCT | 10 | 200 | 5 | 2 | 4 | 40 |
| Target totals | | 500 | 5 | 5 | 10 | 100 |
| Linac totals | 10 | 1000 | 5 | 10 | 20 | 200 |

Table I: A summary of the baseline design parameters of the PC CANS.

## Staged Approach

The neutron production targets will be based on beryllium and three performance milestones are envisioned.

**Stage 1**
- 2 kW to BNCT and NS
- 1 kW to PET

**Stage 2**
- 5 kW to BNCT or NS

**Stage 3**
- Max. power of 10 kW to BNCT or NS

## DTL Variants

- DTL variants based on CH and Alvarez structures are being considered.
- Final choice will depend on cost, ease of operation and reliability.

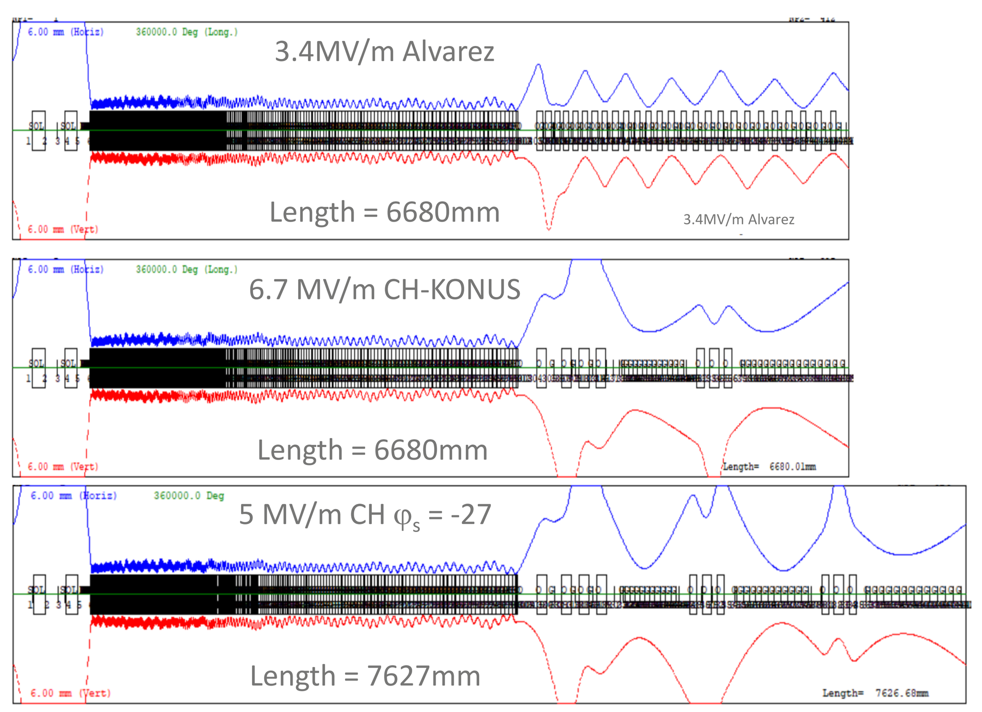


Fig. 3: Trace 3-D simulations of several DTL variants.

## Target-Moderator-Reflector (TMR) for Neutron Sciences

TMR optimization goals are to (I) maximize the cold and thermal neutron yield for SANS and imaging by varying material and geometry (II) tailor the neutron time structure to the instruments.

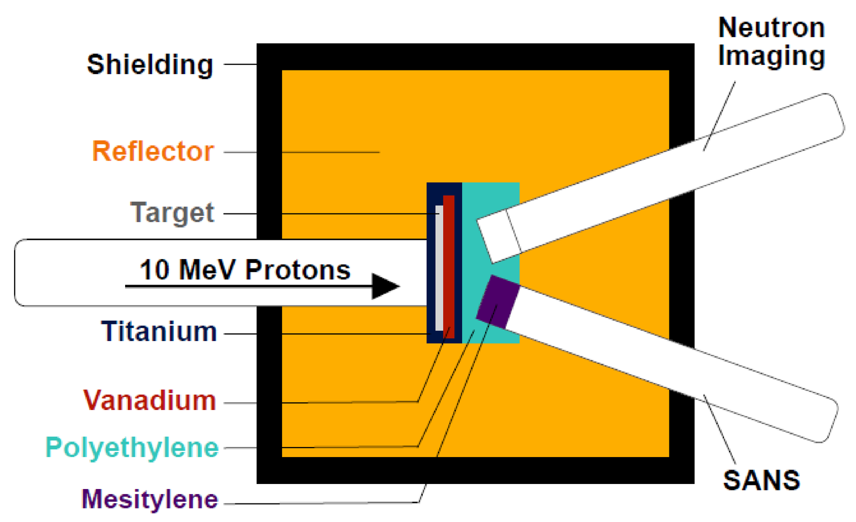


Fig. 4: Illustration of baseline TMR Design

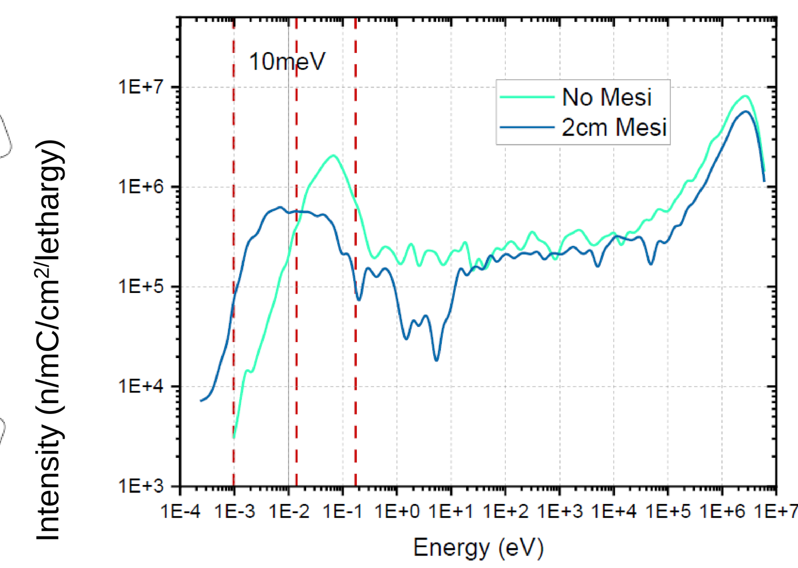


Fig. 5: Neutron spectrum at end of SANS and imaging beam tubes at 2m from target

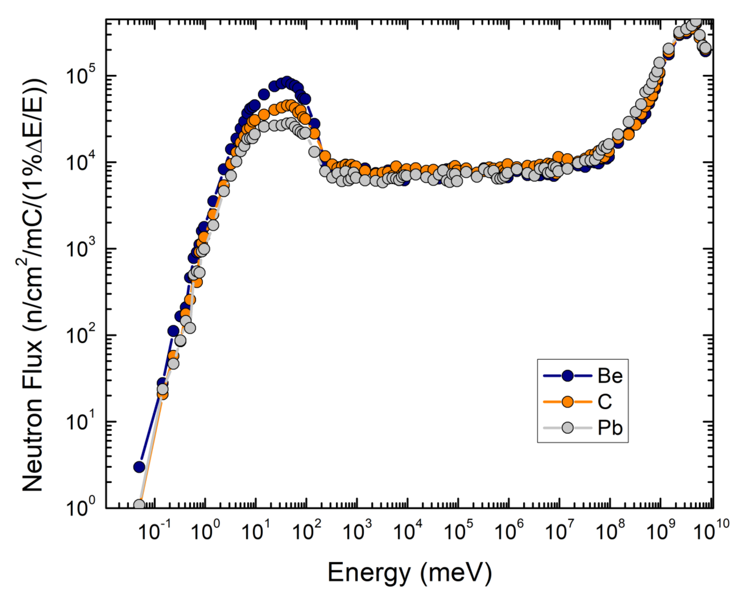


Fig. 6: Neutron spectrum obtained from reflector materials Be, C and Pb

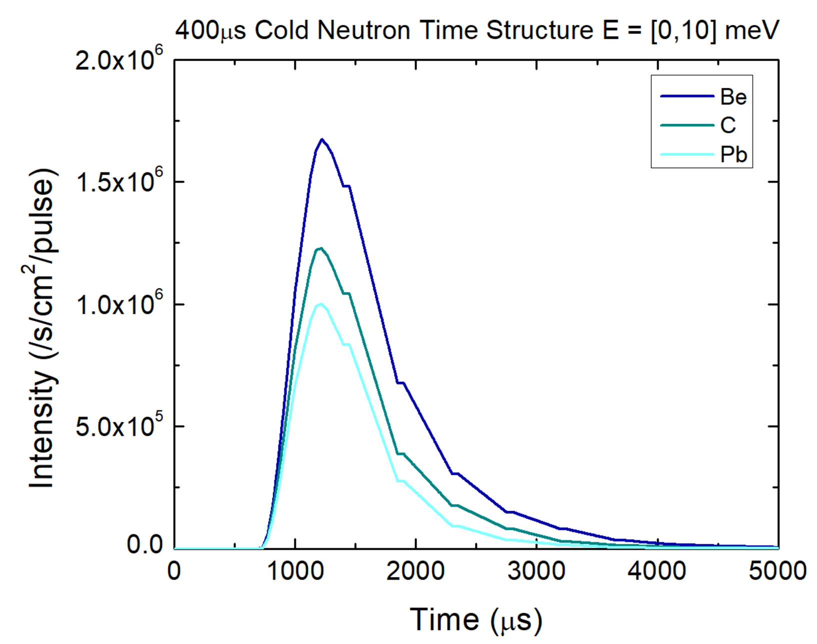


Fig. 7: Cold neutron time structure obtained from 400μs proton pulse of 1mA assumed.

## SUMMARY

The PC CANS project is multi-disciplinary, and highlights a successful cross-Canada collaboration. The R&D efforts towards the PC CANS facility have been published in a conceptual design report that supports a CFI grant application which was submitted in July 2022. This projects ultimately helps to secure the future of neutron sciences in Canada and benefits from TRIUMF's experience as a global leader in accelerator sciences and large-scale projects.

**Discovery, accelerated**