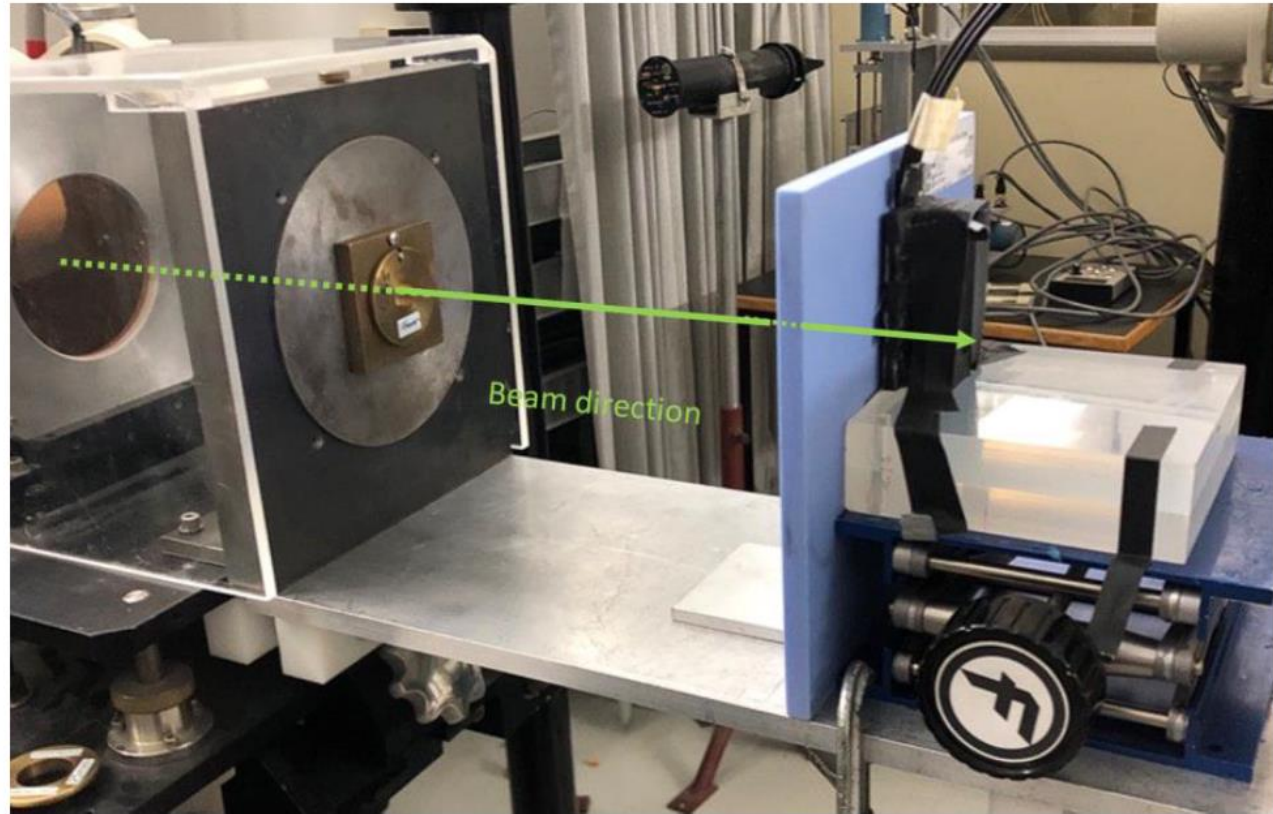


Optical fibre detectors for medical applications with accelerators

Cornelia Hoehr

Director | Life Sciences



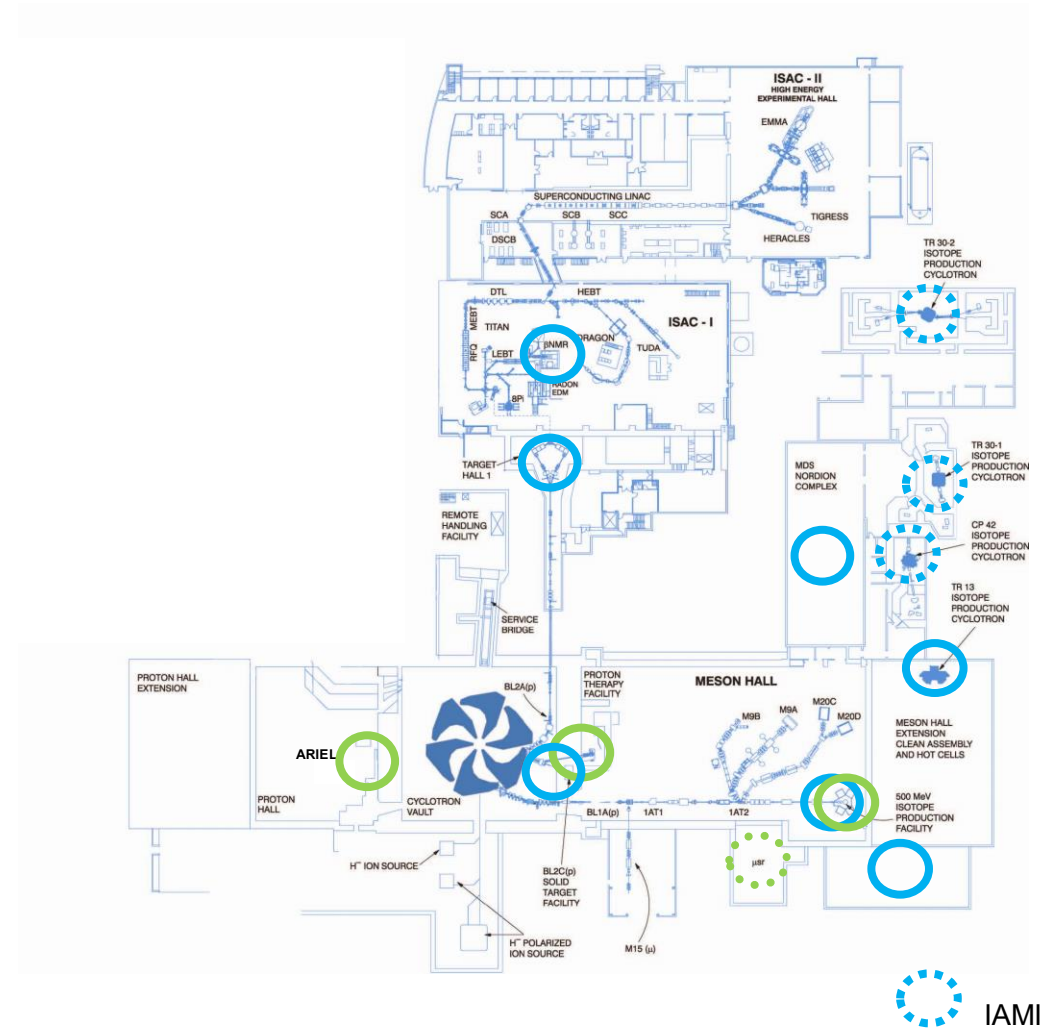
Introduction

TRIUMF - accelerator physics lab

Expertise in

- Accelerator technology
- Accelerator operation
- Detectors
- Targets for isotope production
- Interaction of particles

Applicable to medical isotopes (and radiotherapy)

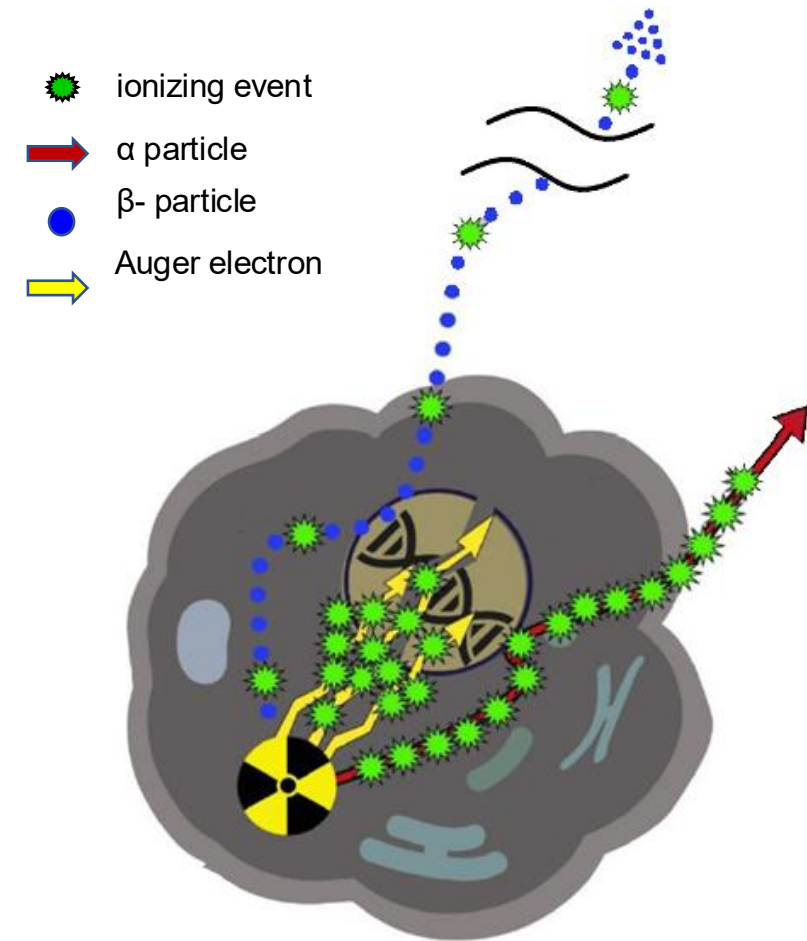
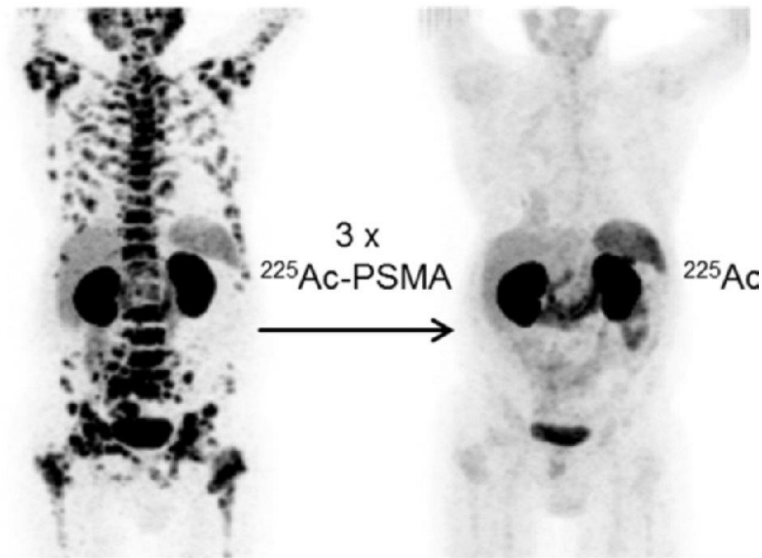


Targeted Radiation Therapy (TRT)

Theranostics – therapeutic and imaging

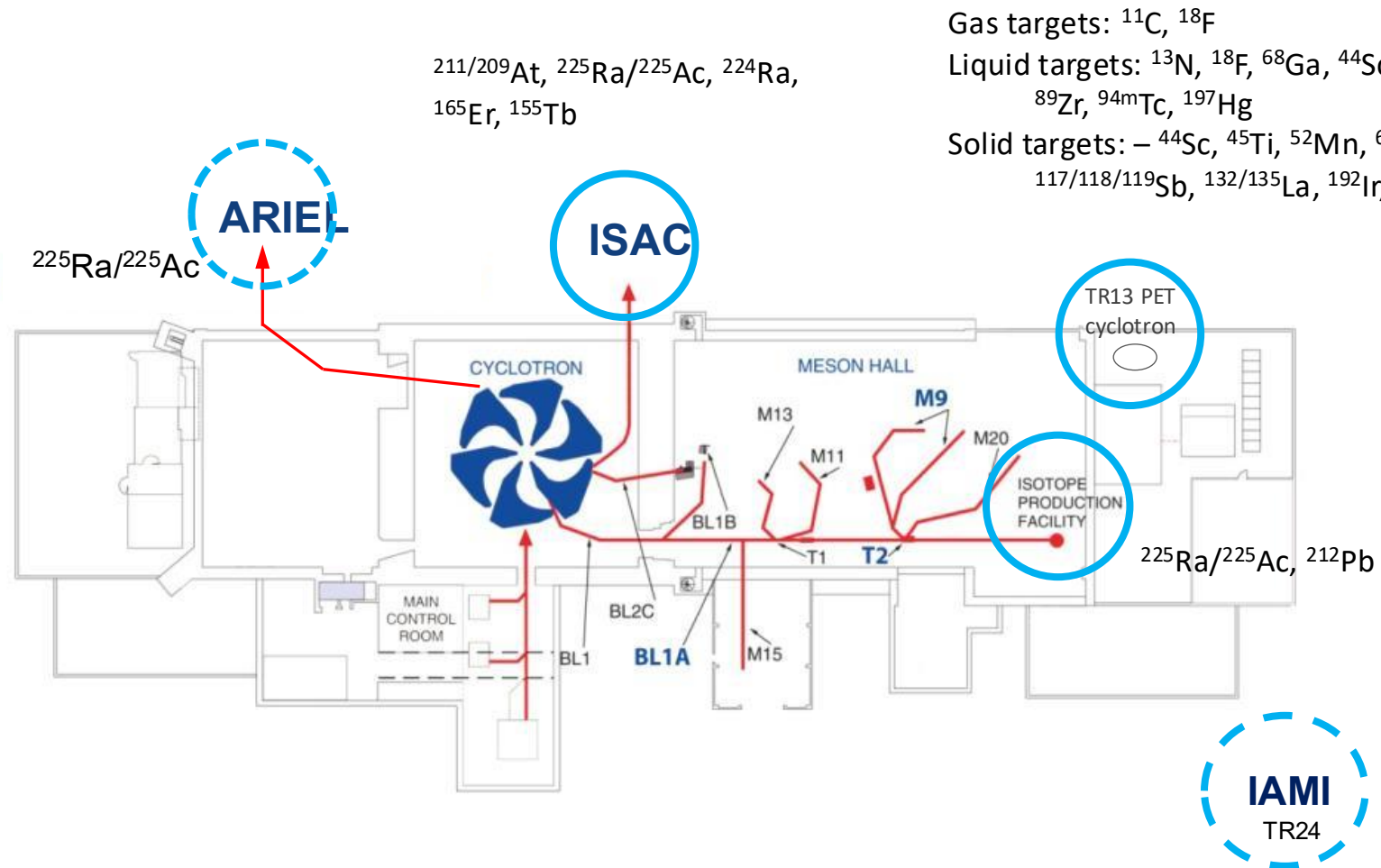
- Beta emitters
- Alpha emitters
- Auger emitters

- SPECT
- PET



V. Radchenko

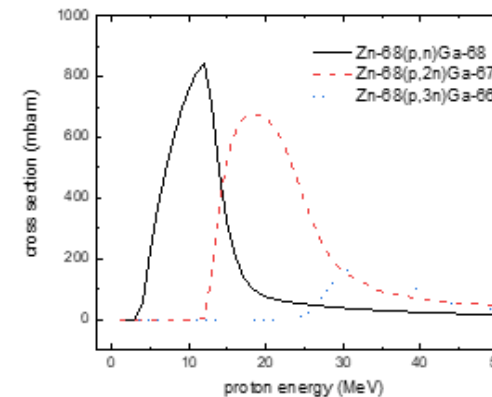
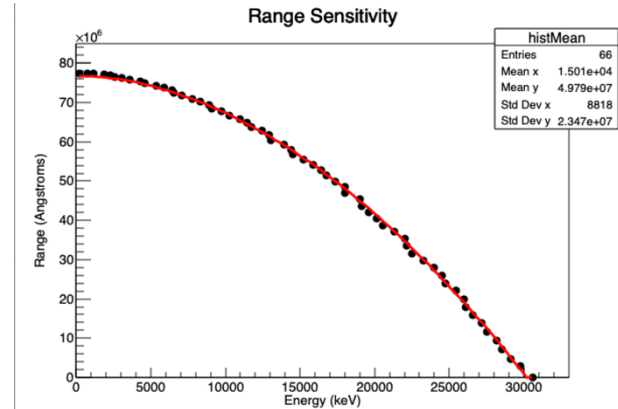
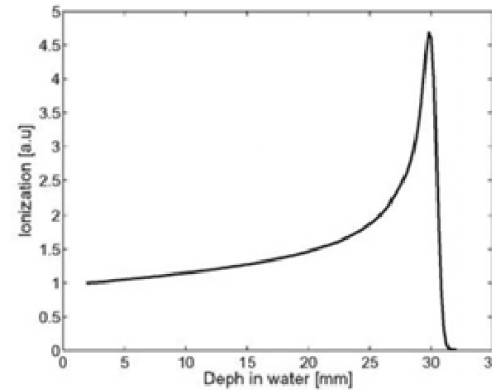
Medical isotopes @ TRIUMF



Isotope production

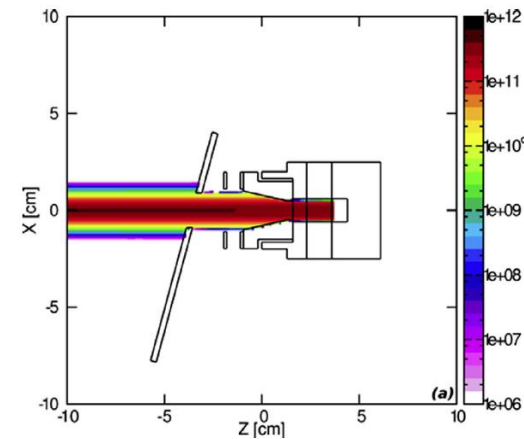
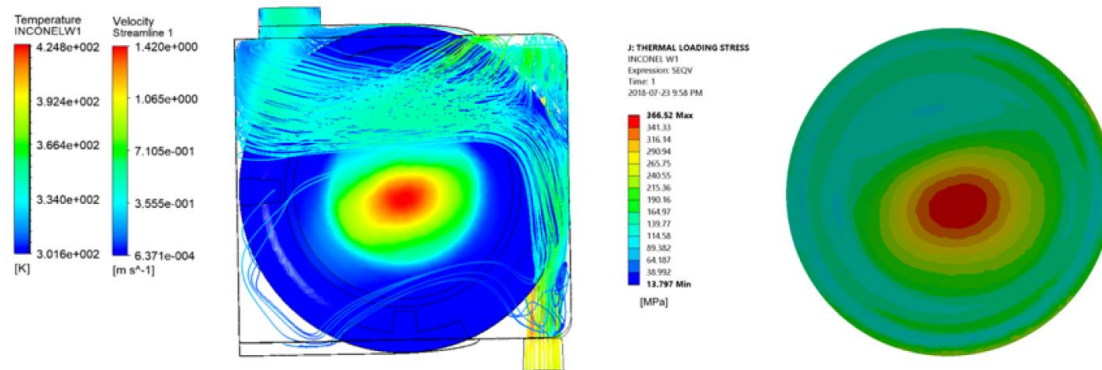
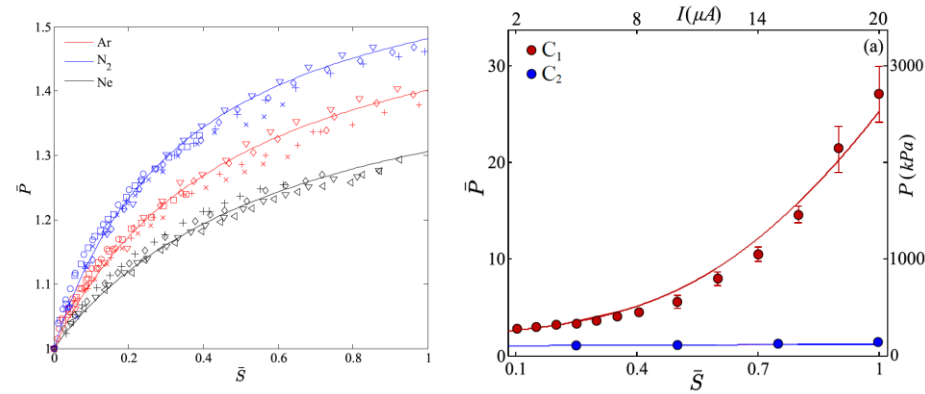
Exercise in compromise:

- Beam range (volume of irradiation)
- Cross section(s) (contaminants)
- Target material (gas, liquid, solid, enriched, recycling....)
- Target holder (corrosiveness, cooling, radiation hardness, activation....)



Irradiation modelling

- Temperature, mechanical stress
- Thermodynamics (convection currents, phase changes)
- Yields



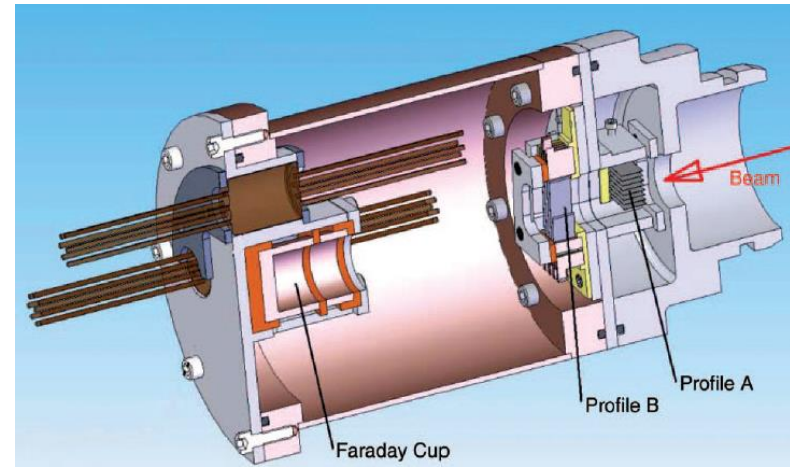
One model:
temperature,
mechanical stress,
thermodynamics
(convection currents,
phase changes),
yields

**Local observables
needed for
validation**

A. Robertson et al., Instruments 3 18 (2019)
P. Jahangiri, et al., Applied Radiation and Isotopes 107 252 (2016)
P. Jahangiri, et al., Applied Radiation and Isotopes, 120 22 (2017)
A. Infantino et al., NIM B 366 117 (2016)

Monitors

- Small (spatial resolution, limited space)
- Radiation hard
- Temperature
- Pressure
- Real time
- Dose (photons, protons, neutrons)
- Ionizing radiation (beam alignment)
- Independent of environment
(electromagnetic field, temperature, light)

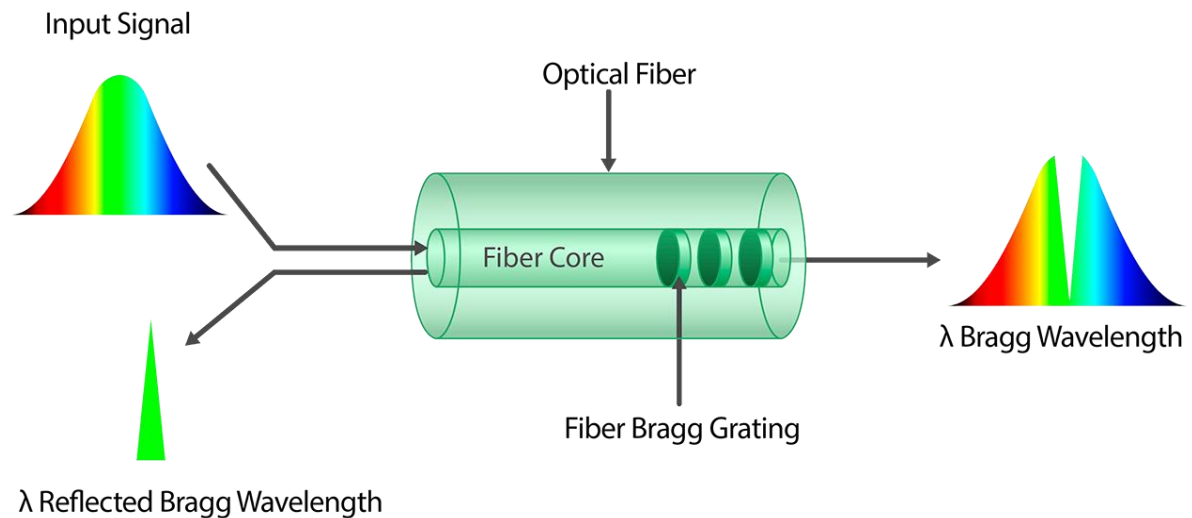


- Pressure transducers (global)
- Thermocouple (global)
- Beam monitors
- Radiochromic films

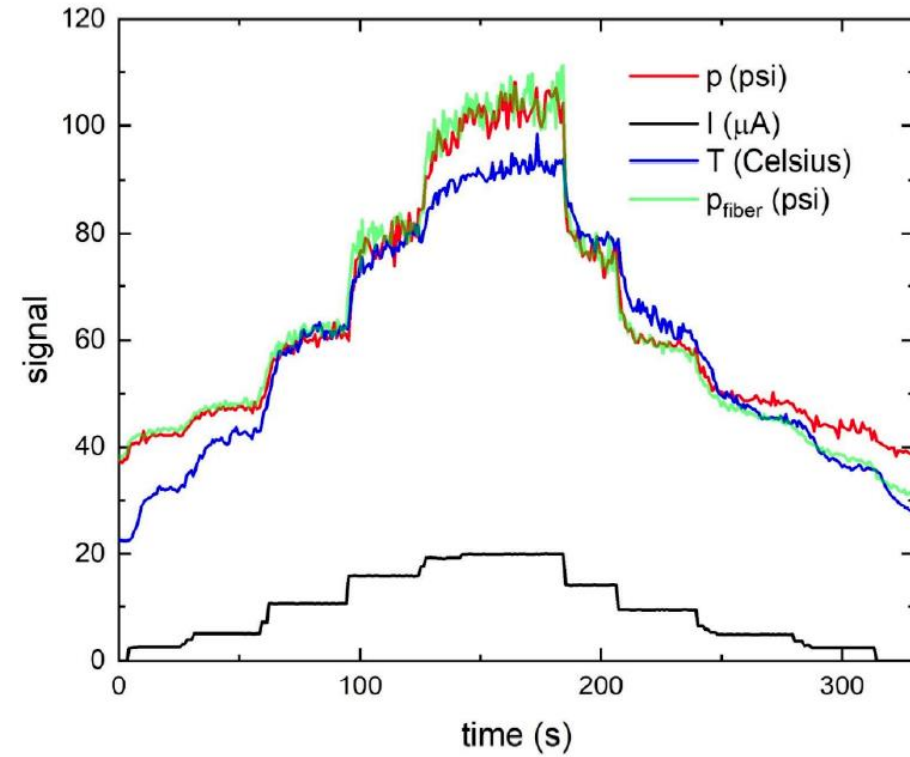
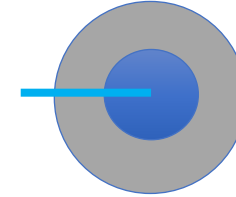
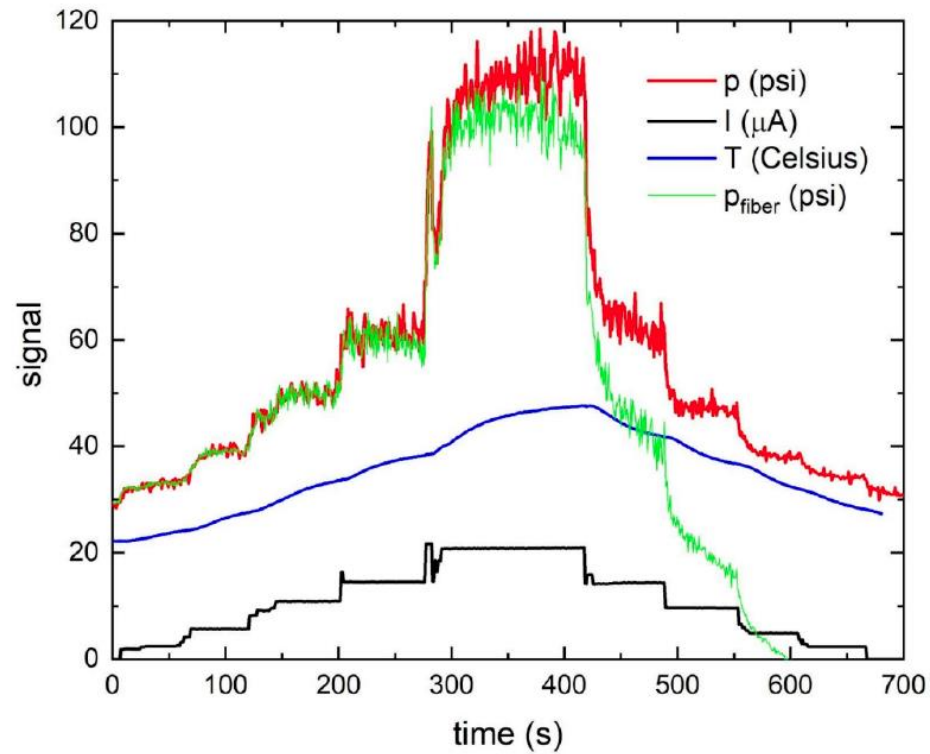
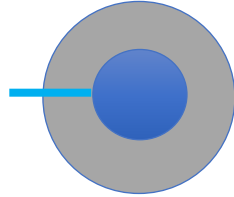
Optical fibers?

Optical fibres – temperature and pressure

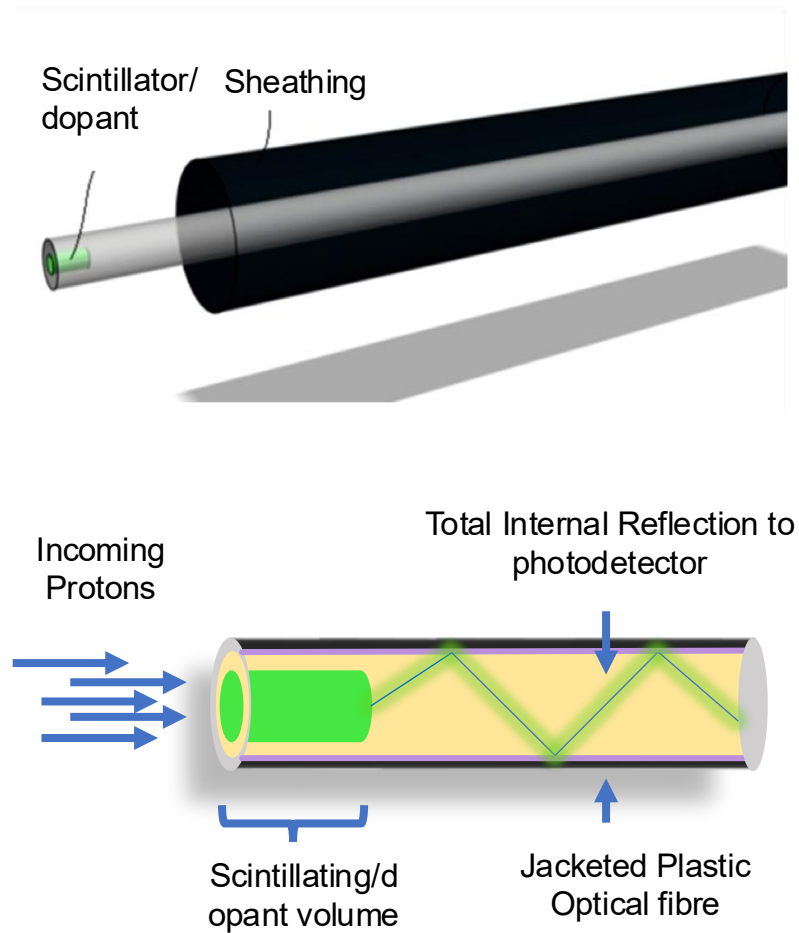
- Localized temperature/pressure unknown in gas/liquid targets – often only global measured
- Silica fibers with grating are radiation ‘hard’
- Can measure temperature to 0.1 °C, up to 1000 °C



Optical fibres – temperature and pressure



Optical fibres – ionizing radiation



Organic fibers (PMMA)

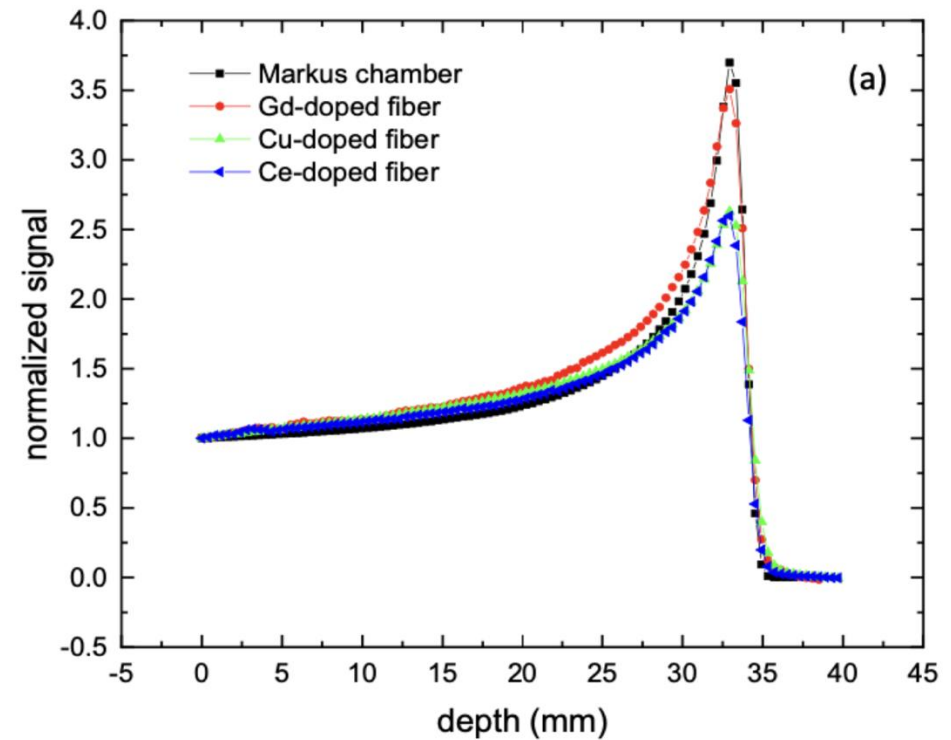
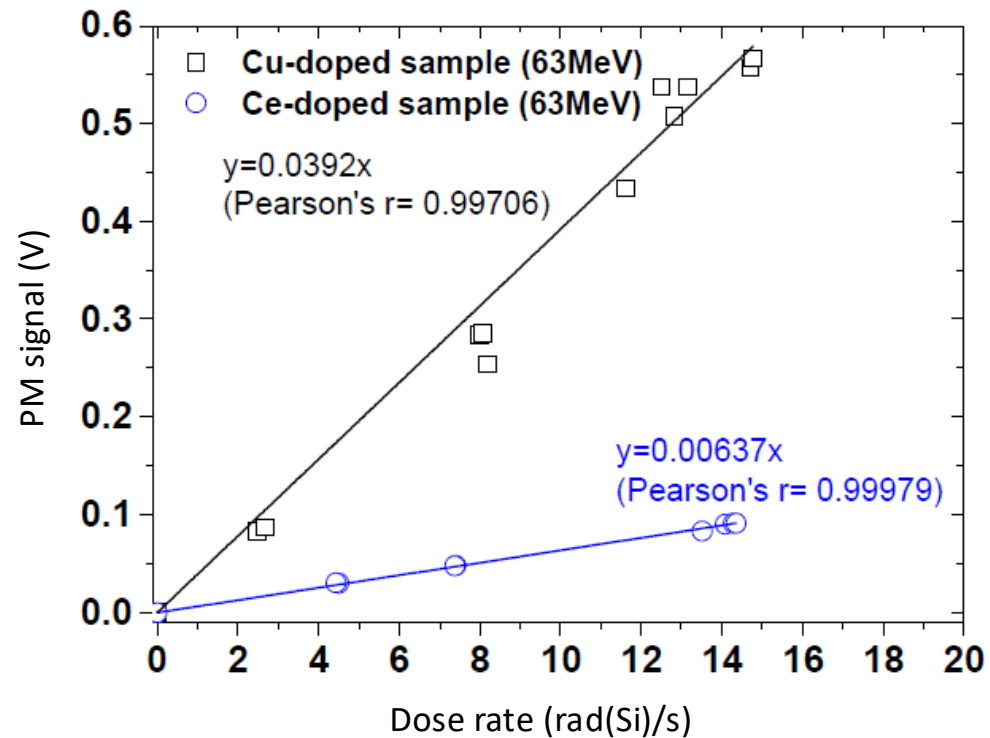
- $\text{Gd}_2\text{O}_2\text{S:Tb}$
- $\text{Gd}_2\text{O}_2\text{S:Eu}$
- YVO_4
- $\text{Y}_2\text{O}_2\text{S:Eu}$
- $\text{Y}_2\text{O}_3\text{:Eu}$
- EJ_{260}
- Kuraray

Inorganic fibers (silica)

- Ce-doped
- Cu-doped
- Gd-doped
- N-doped
- Ge-doped
- B-doped

Optical fibres – ionizing radiation

Light output or light attenuation
proportional to absorbed dose

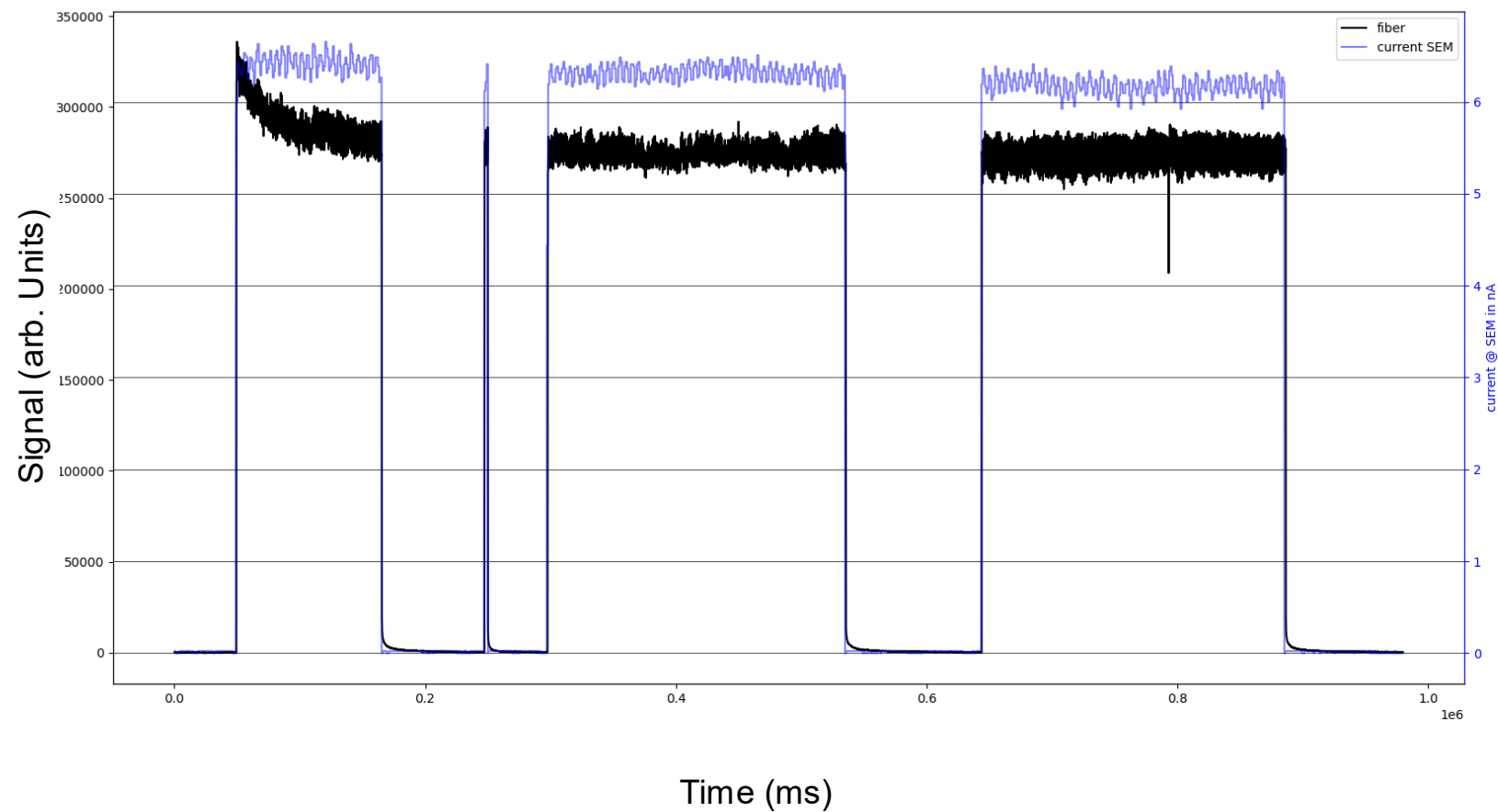


C. Penner, PhD thesis, UBC, 2024

F. Sogus, MSc thesis, 2025

Optical fibres – ionizing radiation

Radiation hardness

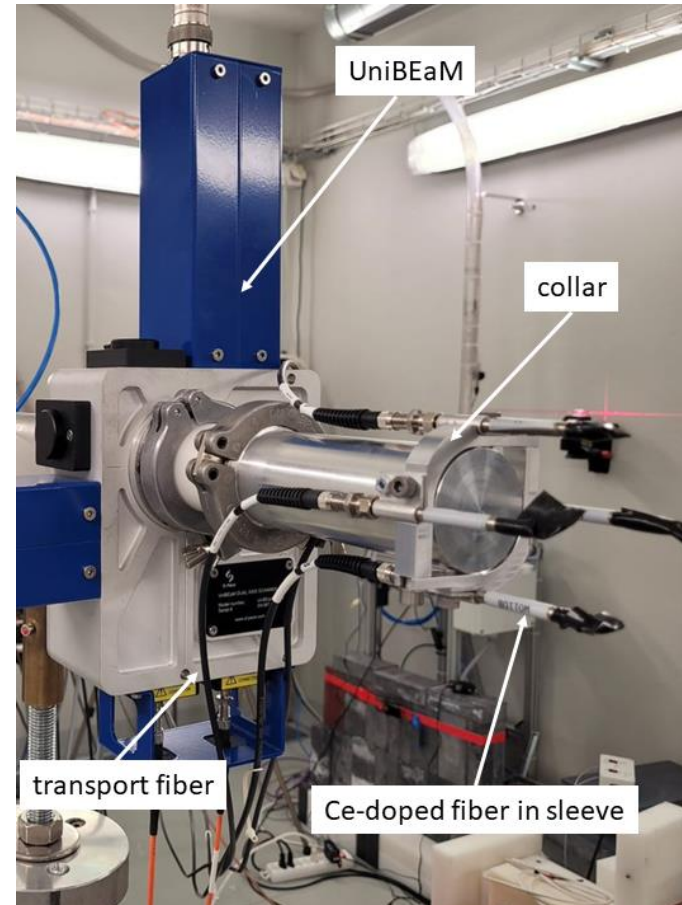


Beam monitoring

TR13 cyclotron, TRIUMF

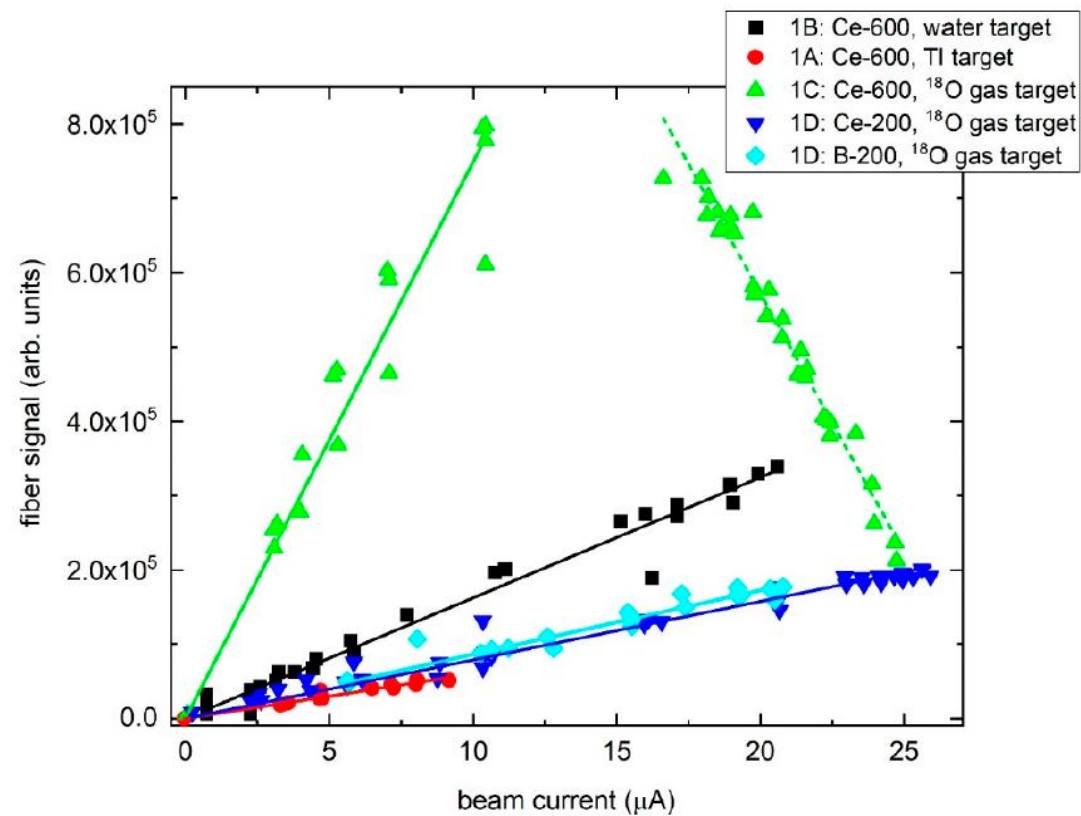


18 MeV IBA cyclotron, U Bern

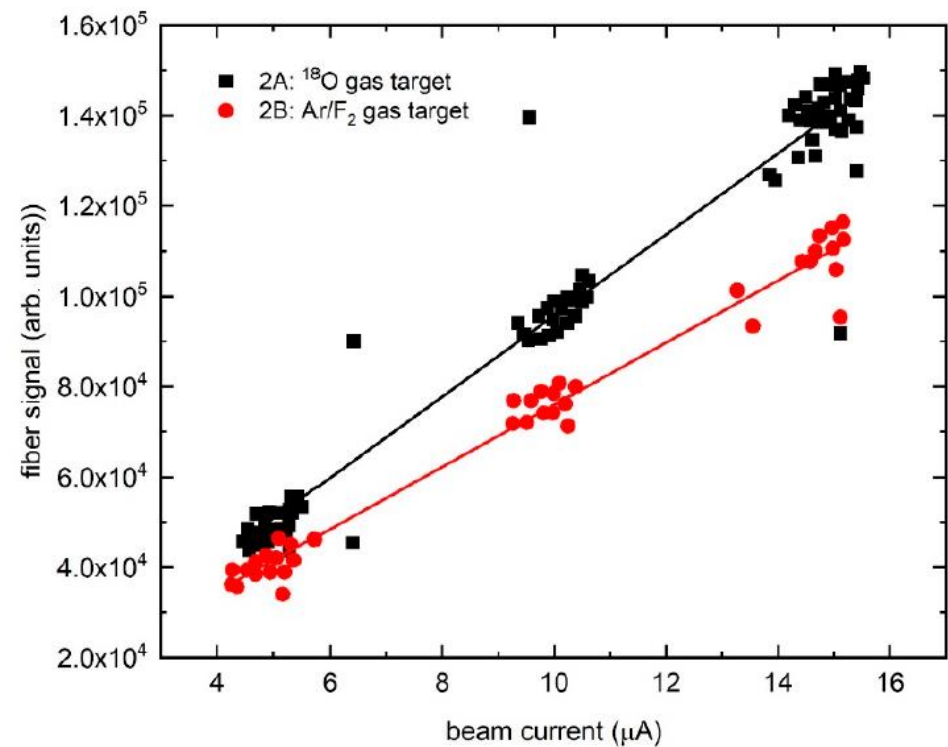


Beam monitoring

Beam current

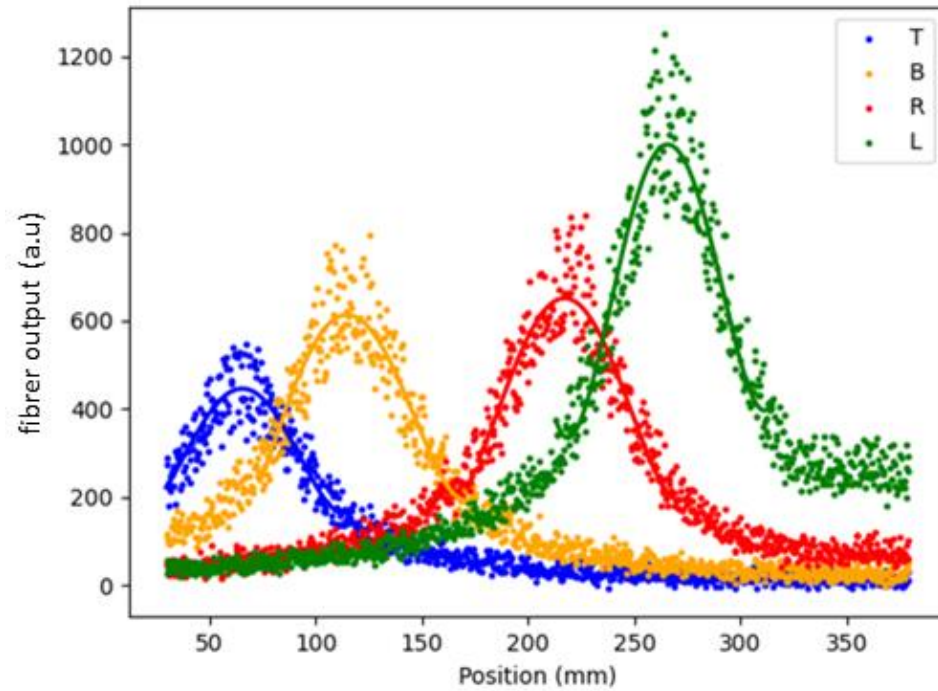


Target material

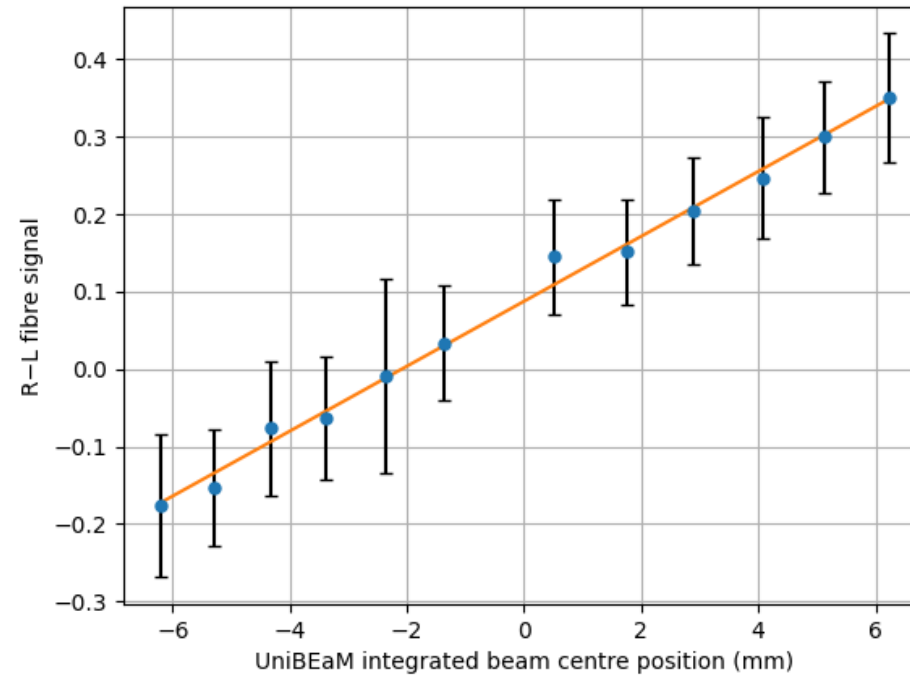


Beam monitoring

Channel calibration

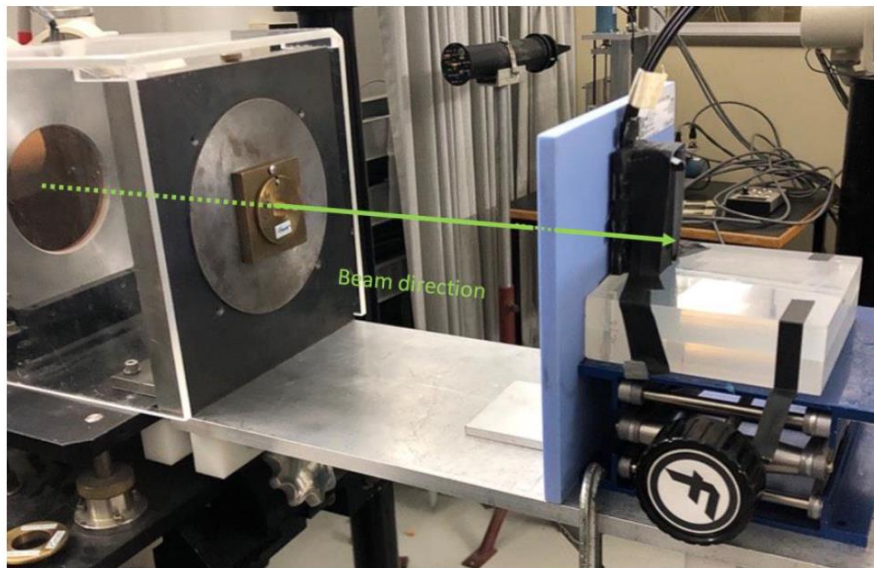


Beam alignment



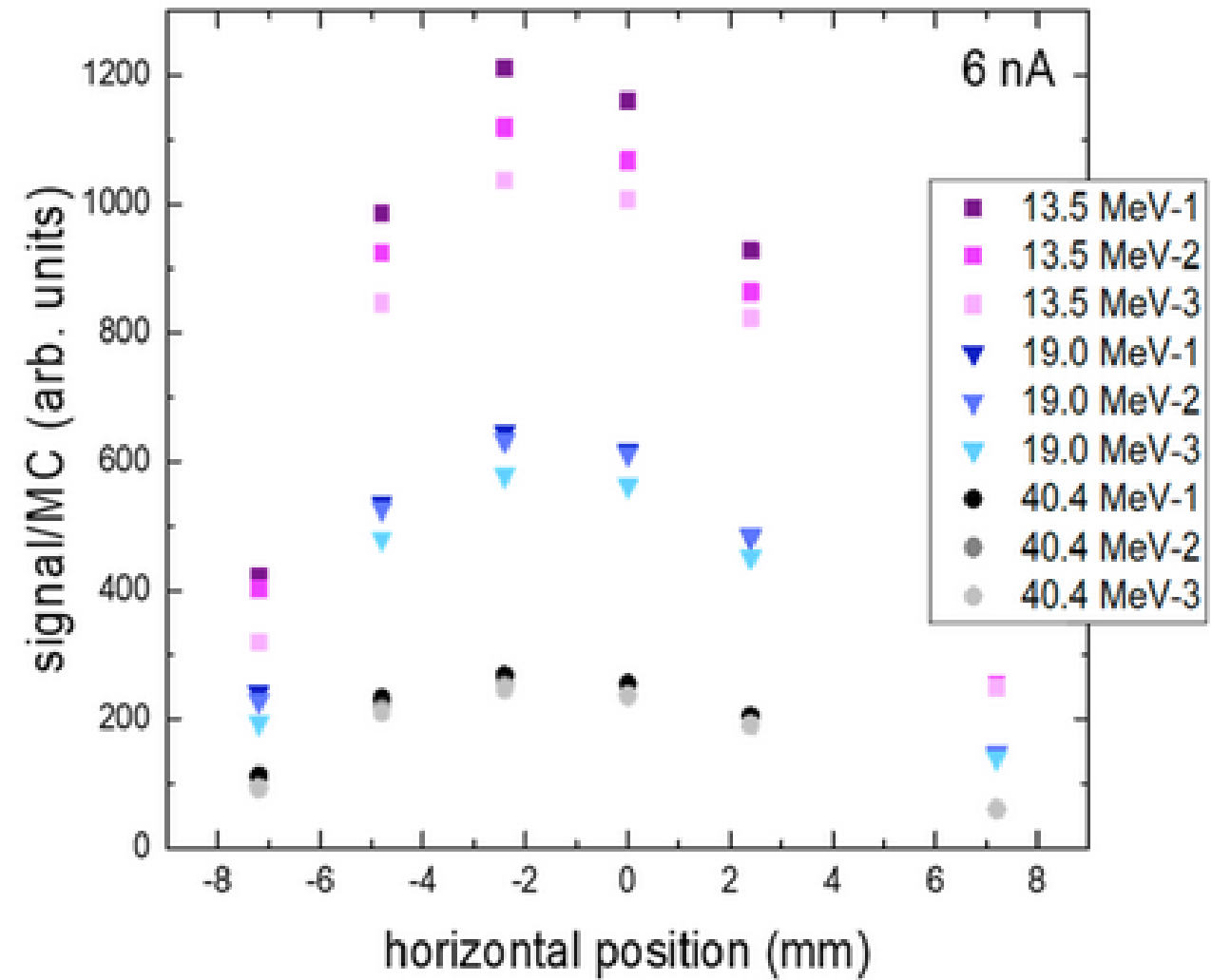
Proton FLASH

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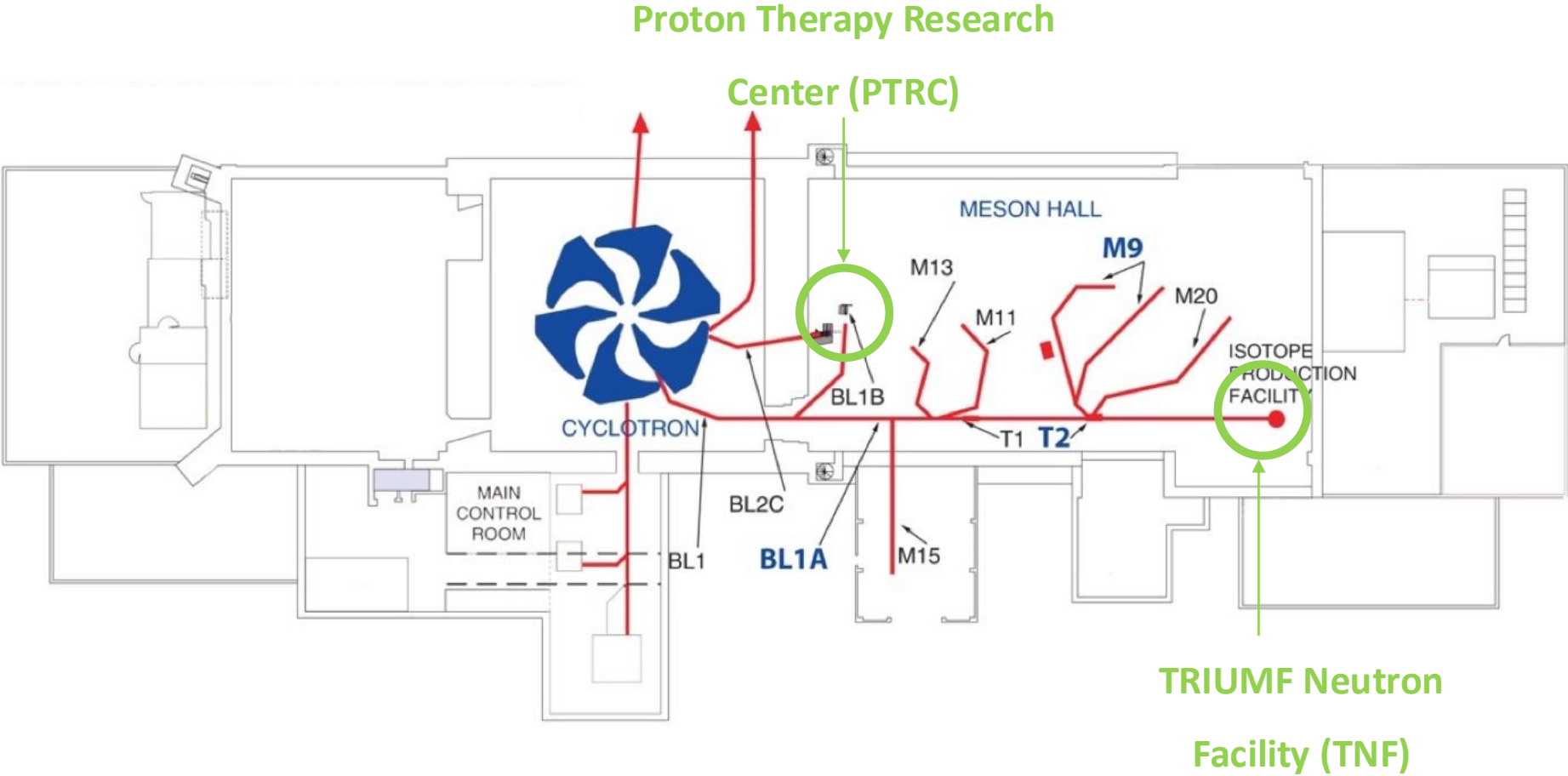


Multi-point dosimeter for
conventional and FLASH dose rates

C. Penner, PhD thesis, UBC, 2024

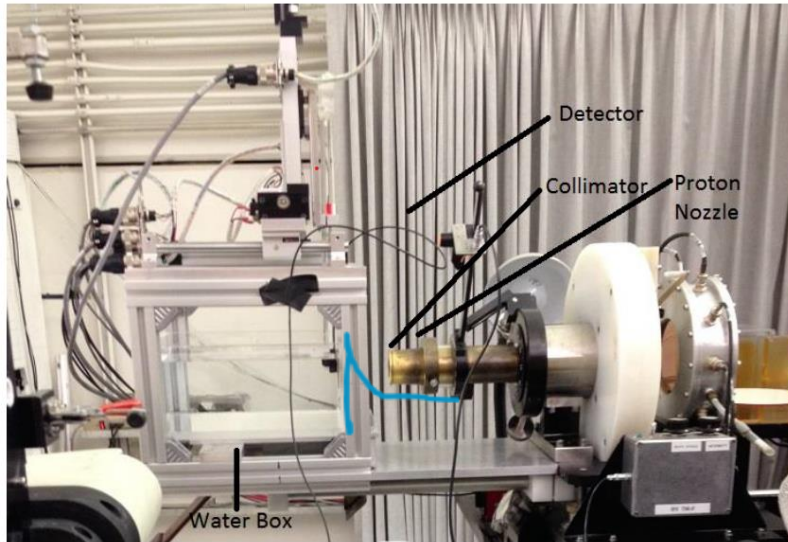


Particle discrimination

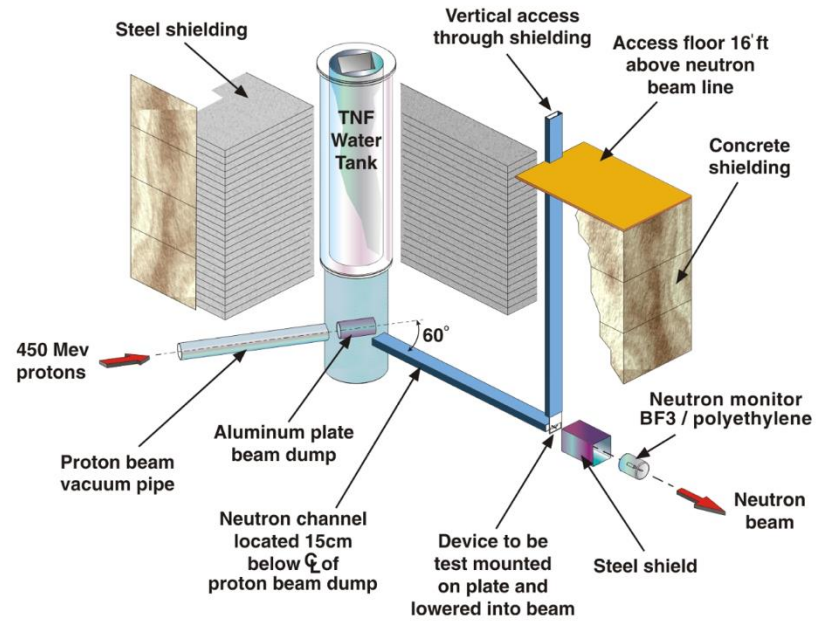


Particle discrimination

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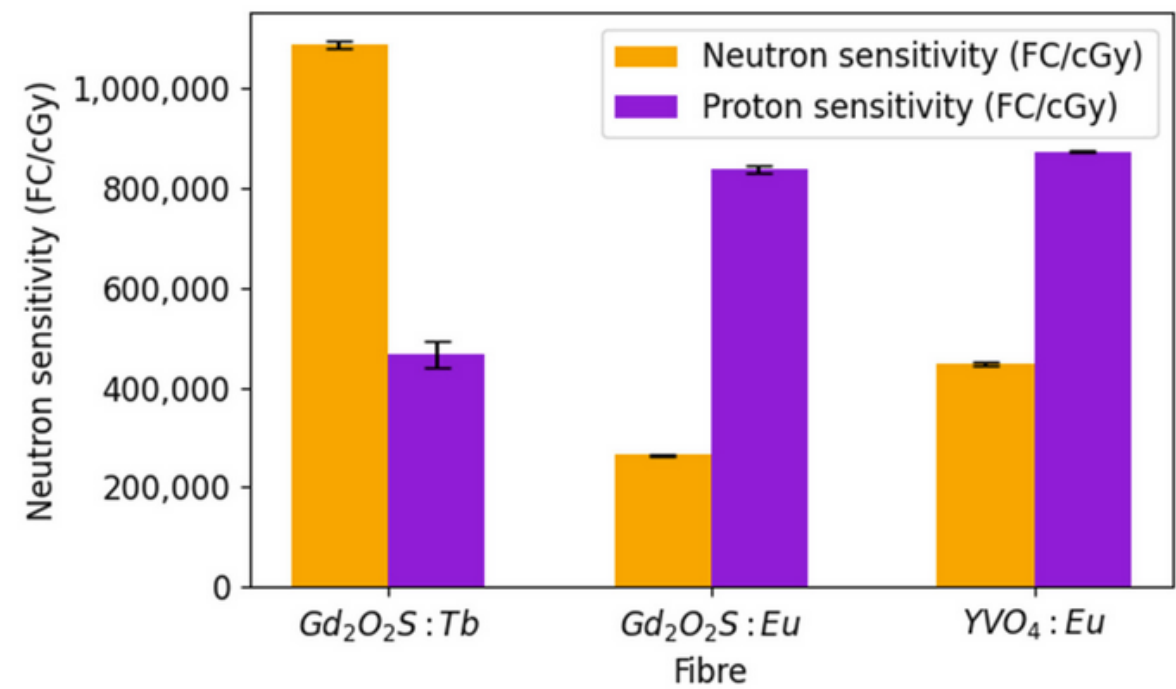
PTRC - protons (with photons & neutrons)



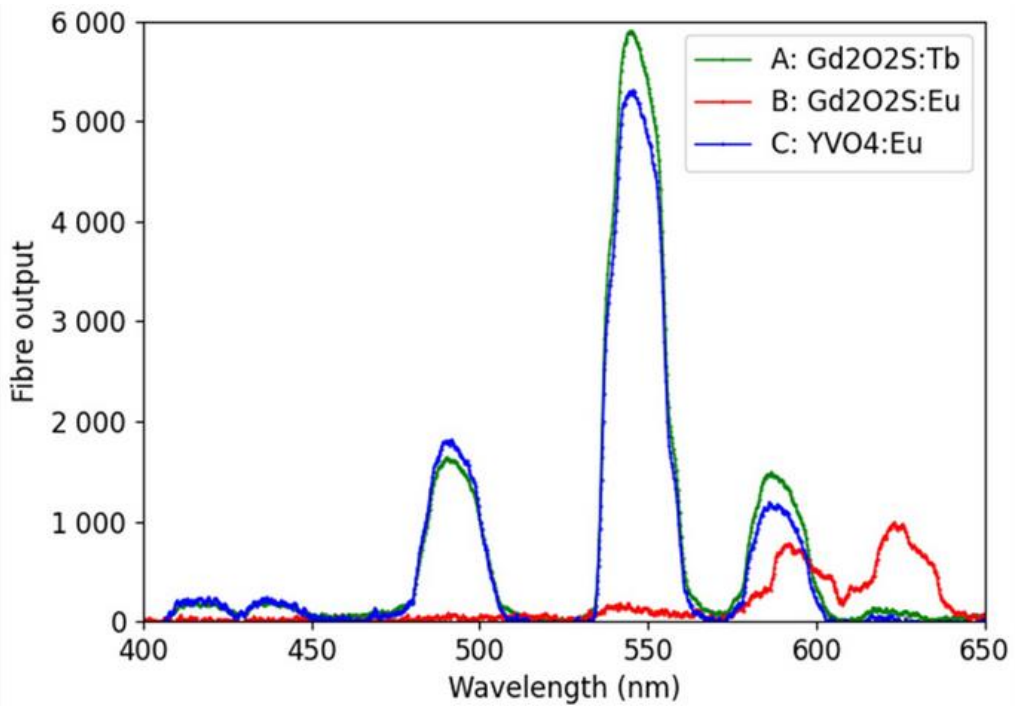
TNF - neutrons (with photons)

Particle discrimination

Total signal discrimination



Spectrometric discrimination

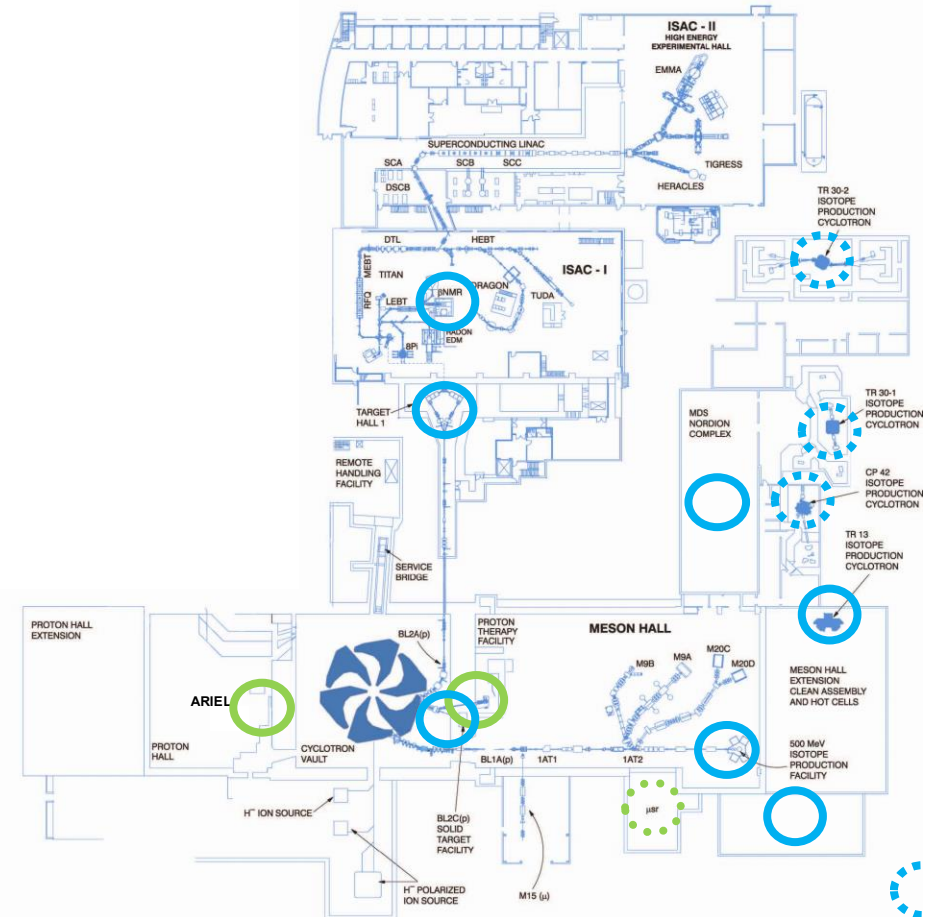


Summary

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Fibers potentially monitor to measure:

- ✓ Local temperature
- ✓ Local pressure
- ✓ Beam current
- ✓ Target material
- ✓ Beam alignment
- ✓ Particle discrimination
- ✓ Very large range of particle flux



Acknowledgment

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- Prof. Girard and collaborators, Uni St. Etienne, France
- Prof. Duzenli and group, BCCA, Vancouver, Canada
- Prof. O’Keeffe and collaborators, Uni Limerick, Ireland
- Prof. Braccini and group, Uni Bern, Switzerland
- Dr. Dehnel, UBC-O and D-Pace, AccelLink, Nelson, Canada



Thank you
Merci

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