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A Novel Calorimeter Design for Synchrotron Produced X-ray Beams

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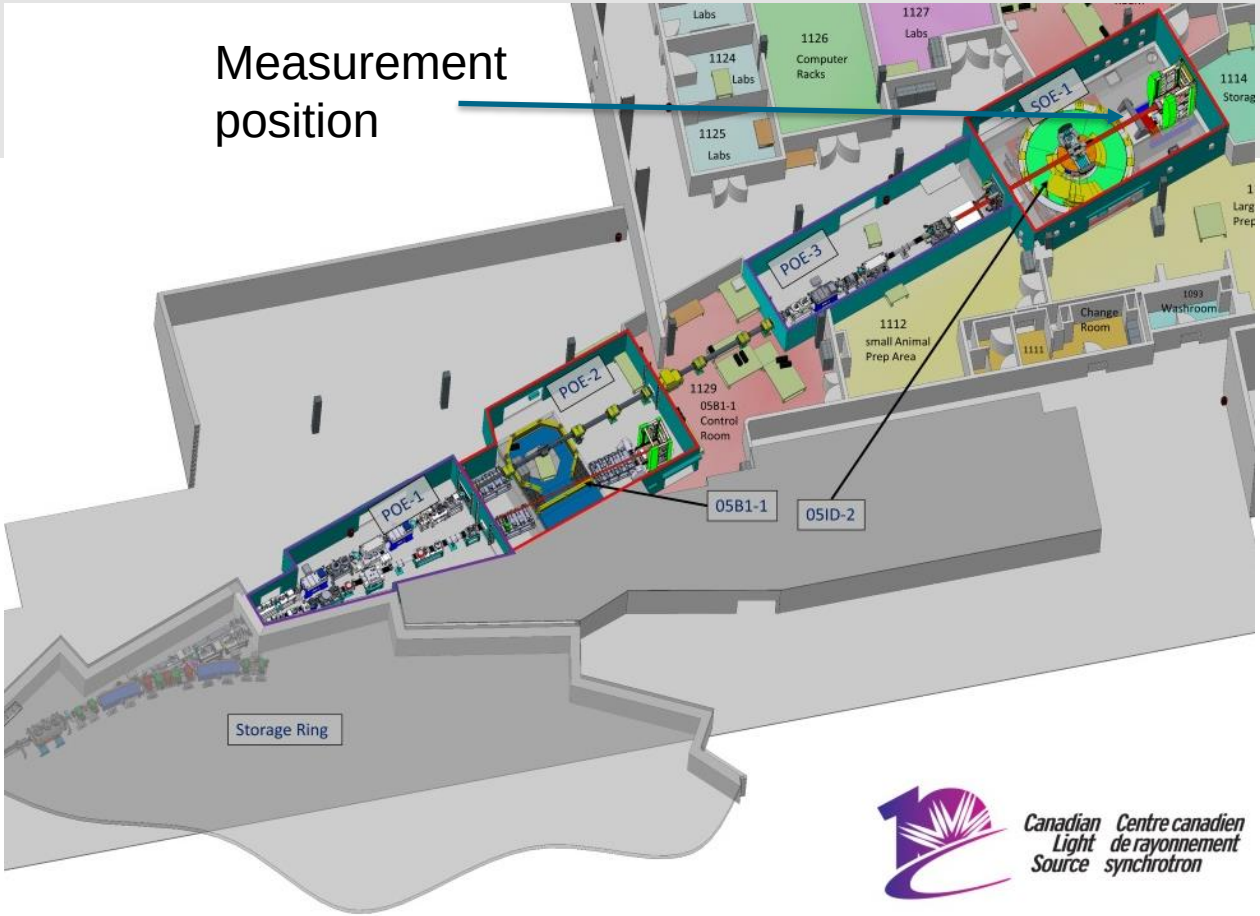
Introduction

- Synchrotron produced photons are:
    - Broad Spectrum 10 – 150 keV range
    - High dose rate – up to 10 Gy/s
    - Highly collimated
    - Polarized
    - Pulsed - on the order of ps
- Accurate absorbed dose measurements in synchrotron beams lag those in other modalities.
- A dedicated absorbed dose standard has the potential for significantly lower uncertainty.
- Will expand the use of synchrotron beams as a dosimetric research tool.

The BMIT-Beamline

Energy Range	25-150 keV
Source	Super conducting 4.3T wiggler
Nominal field size	22 x1.1 cm
Beamline length	55 m



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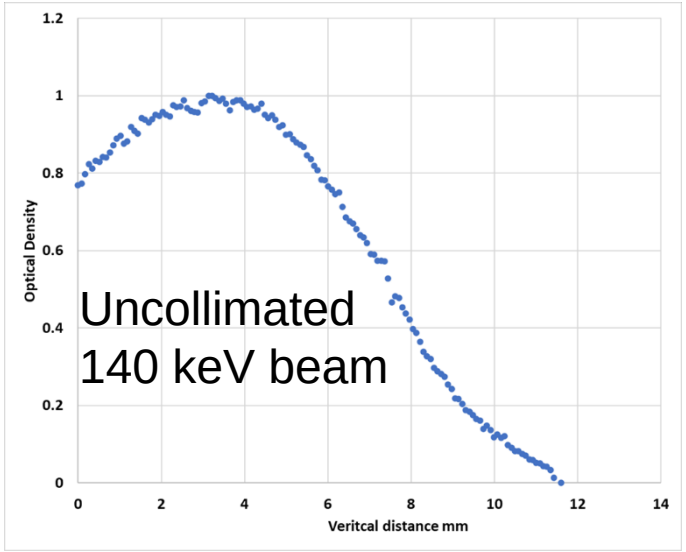
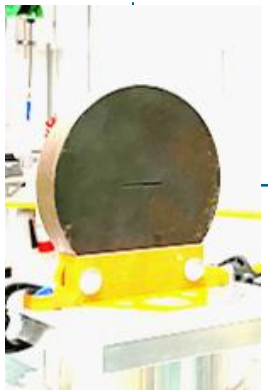
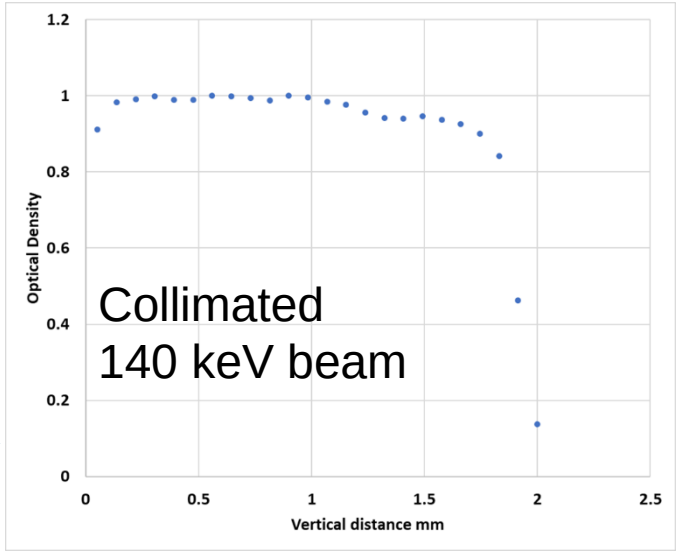
EBT3 Film Beam Profile Measurements

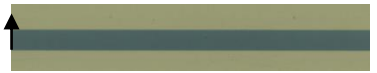


Beam is flat in horizontal direction, varies significantly in vertical direction





Arrows denote distance axis for profiles



Current Methods

- Current methods rely on ion chamber determined air-kerma rates
- Chambers are calibrated using sources with:
  - Lower dose rates ~ 2 mGy/s
  - Different energies
  - Larger field sizes

$$K_{air} = MN_K \prod P_{Corrections}$$

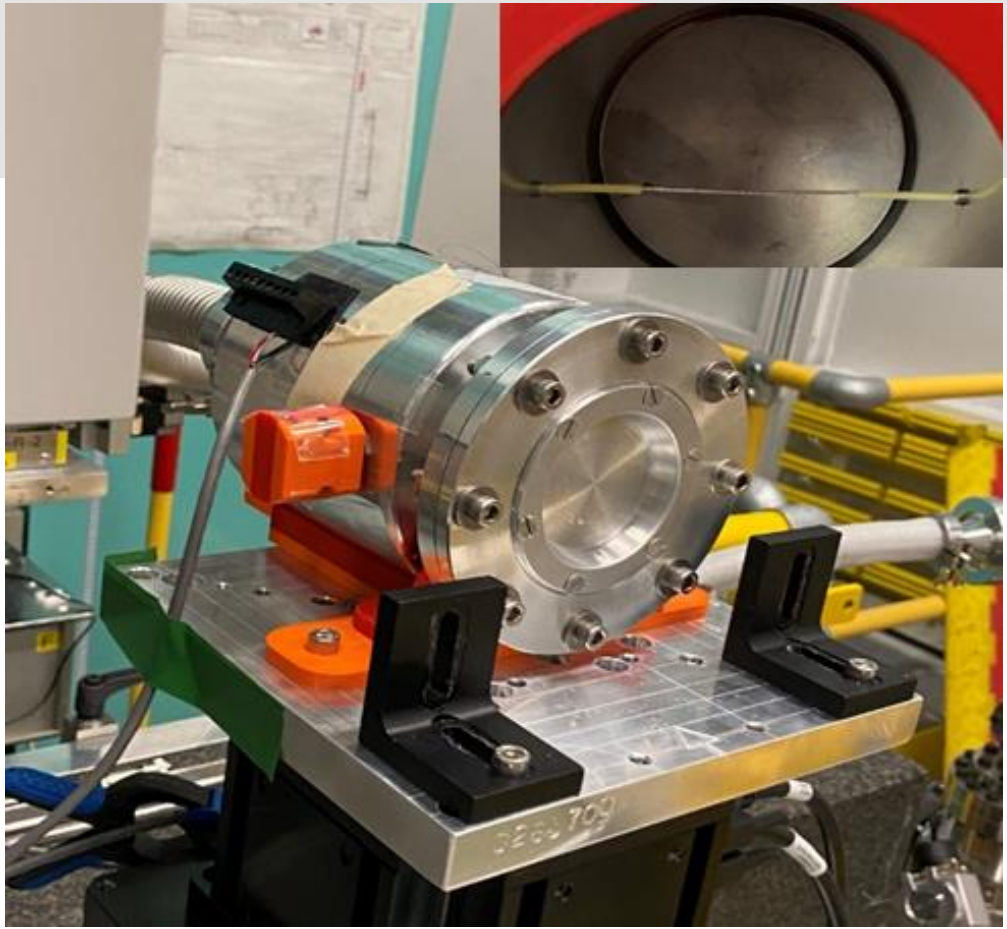
Calorimeter Prototype

- Measures the radiation induced temperature rise.
- Primary measurement, relies only on measurements performed in synchrotron.

$$D = c_{core}\,\Delta T \prod P_{corrections}$$

Goal: Determine absorbed dose to water at depth for 65 - 140 keV monochromatic beams.

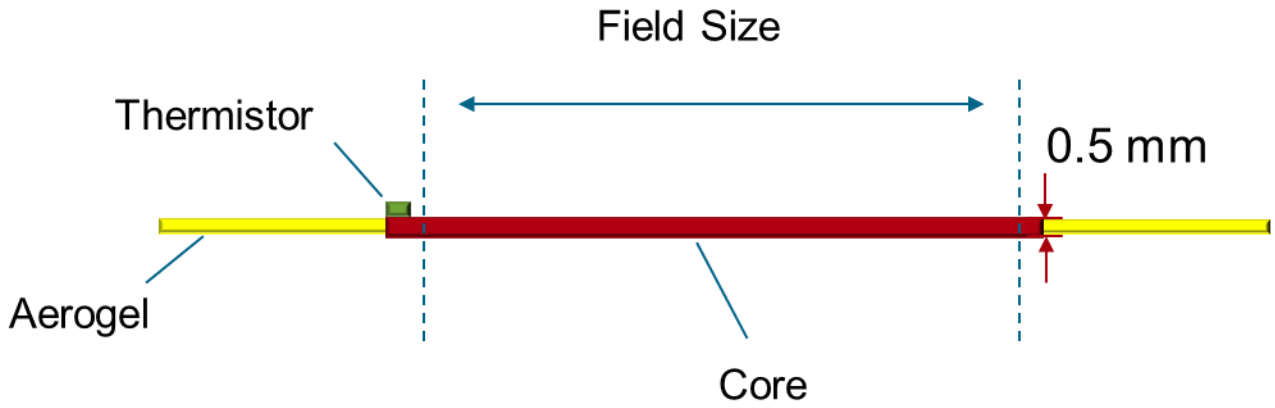
Design



- Vacuum required to reduce heat loss
- Conversion from aluminum to water will be required
- Portable design
- Set-up time < 1 hour

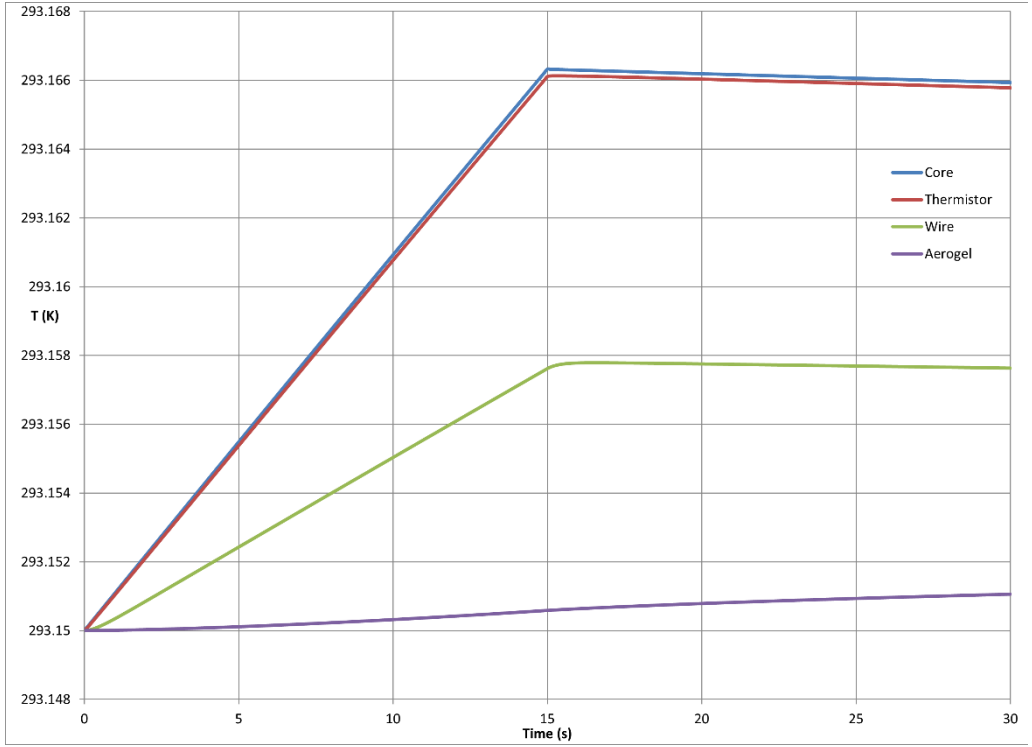
Design

- Measure temperature rise of Al core in vacuum, 40 x 0.5 x 3 mm.
- NTC thermistor chip in glass used, 1.4 x 0.3 mm.
- Aerogel supports used to position the core.



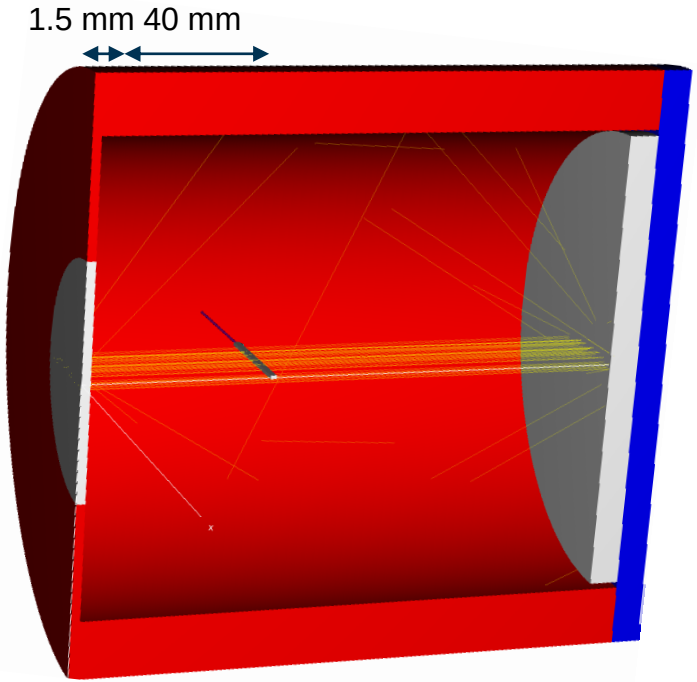
Thermal Simulation

- Thermal results show fast thermistor response to temperature rise.
- Thermistor connecting wires a significant thermal link – can't use copper
- A 2.5 % correction for conductive heat losses, less than water calorimeters in kV beams.

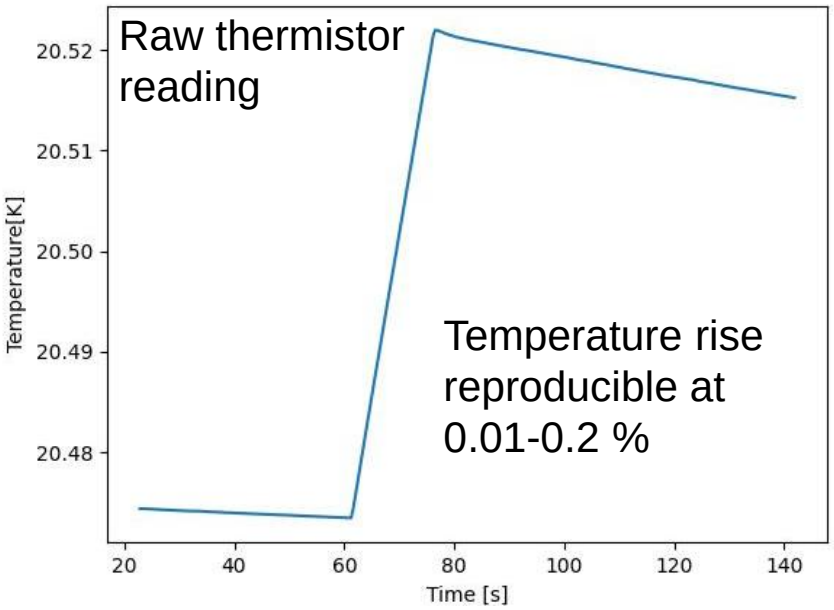


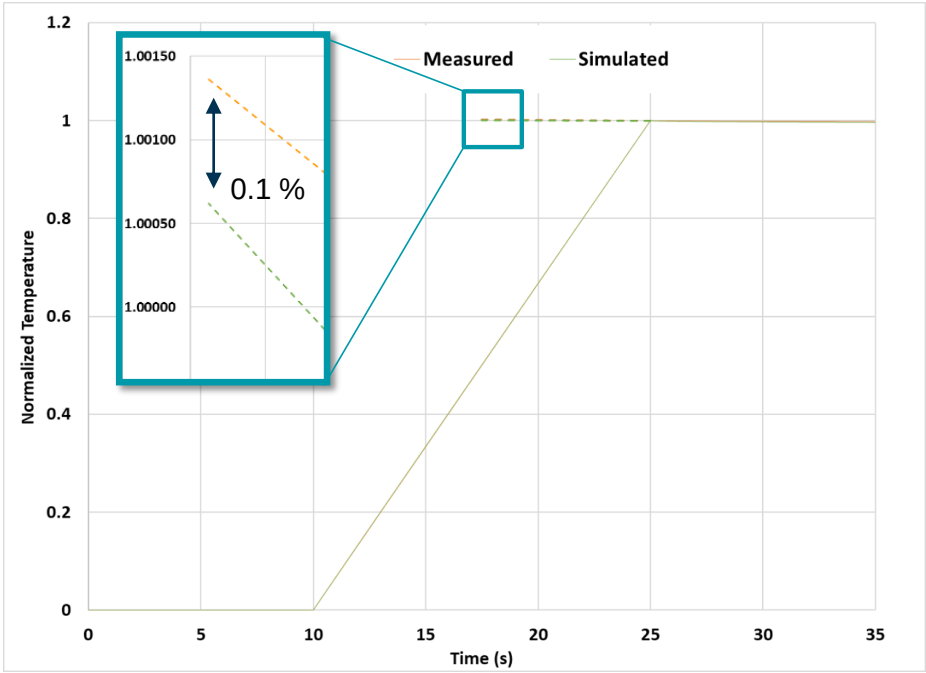
Vacuum Vessel

- Overall Monte Carlo calculated scatter and attenuation correction ranges from **5-15 %** depending on energy.
- No non-Aluminum material in beam path.
- If dose at depth is desired overall correction for all energies is **< 2 %** .



Preliminary Measurements





Future Work

- Overall uncertainty < 2 % for the absorbed dose to water is possible.
- Extensive synchrotron beam measurements to investigate influence quantities.
- Validate theoretical conversion to absorbed dose to water.
- Investigate other applications for this design.

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THANK YOU

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