WP5: UoB Cyclotron Facility

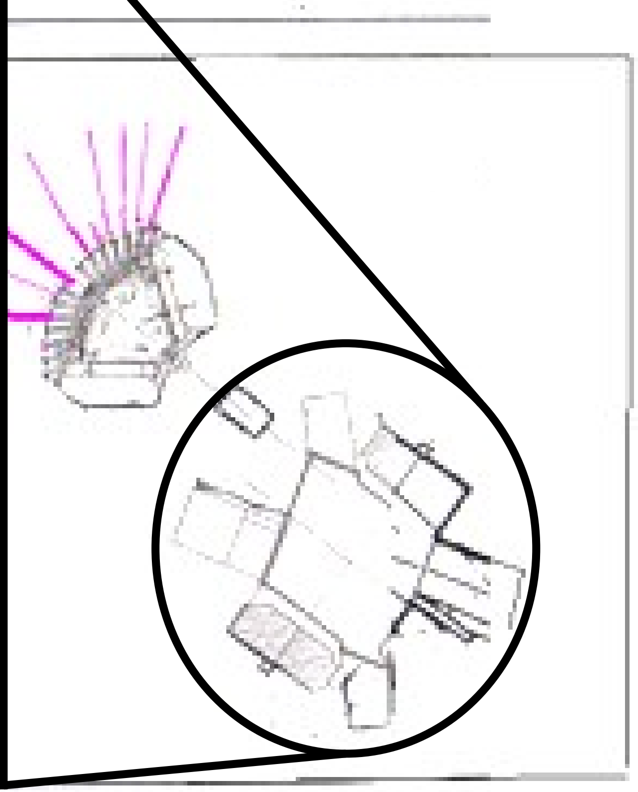
MC40 Accelerator

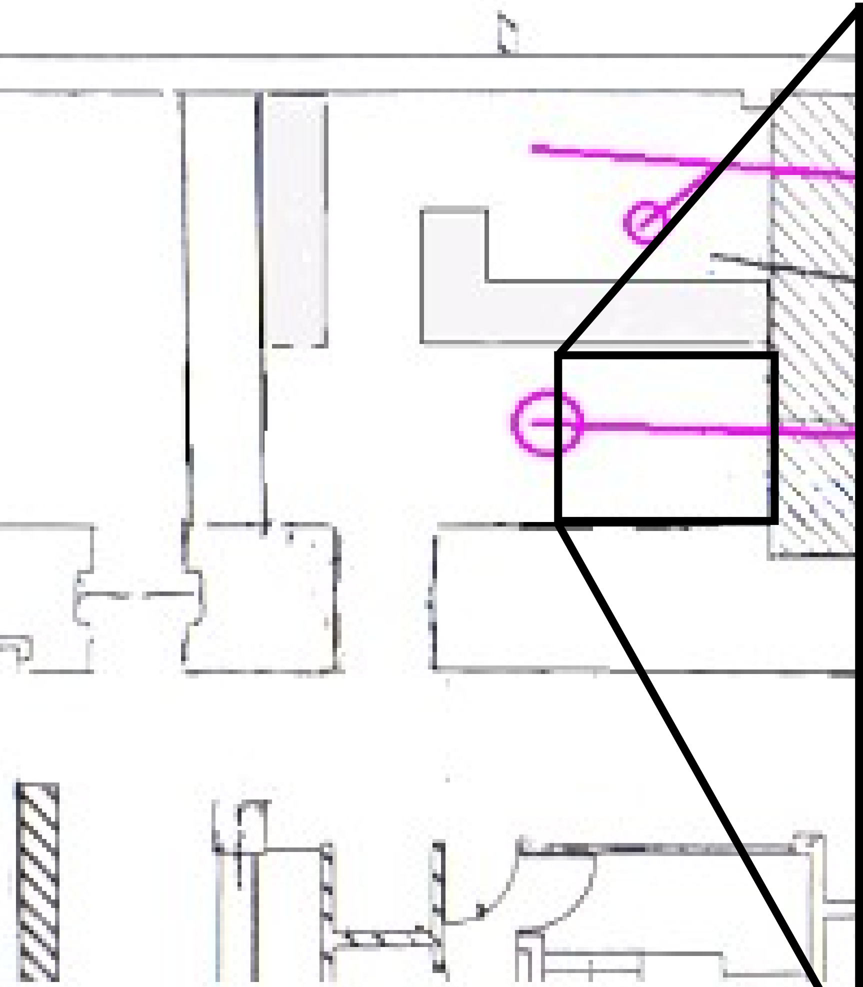
The Scanditronix MC40 was purchased at auction from the Veterans Affairs Medical Centre, Minneapolis in 2002 and following transfer and commissioning has been operational at UoB since 2004.

Capable of accelerating beams of:

- Protons (3-38 MeV)
- Deuterons (5.5-19 MeV)
- Helium-3 (9-53 MeV)
- Helium-4 (11-37 MeV)

Currents of fA to μA are possible dependant on beam line and experiment.





Medical Physics Research

BL4 serves the medical and nuclear beamline

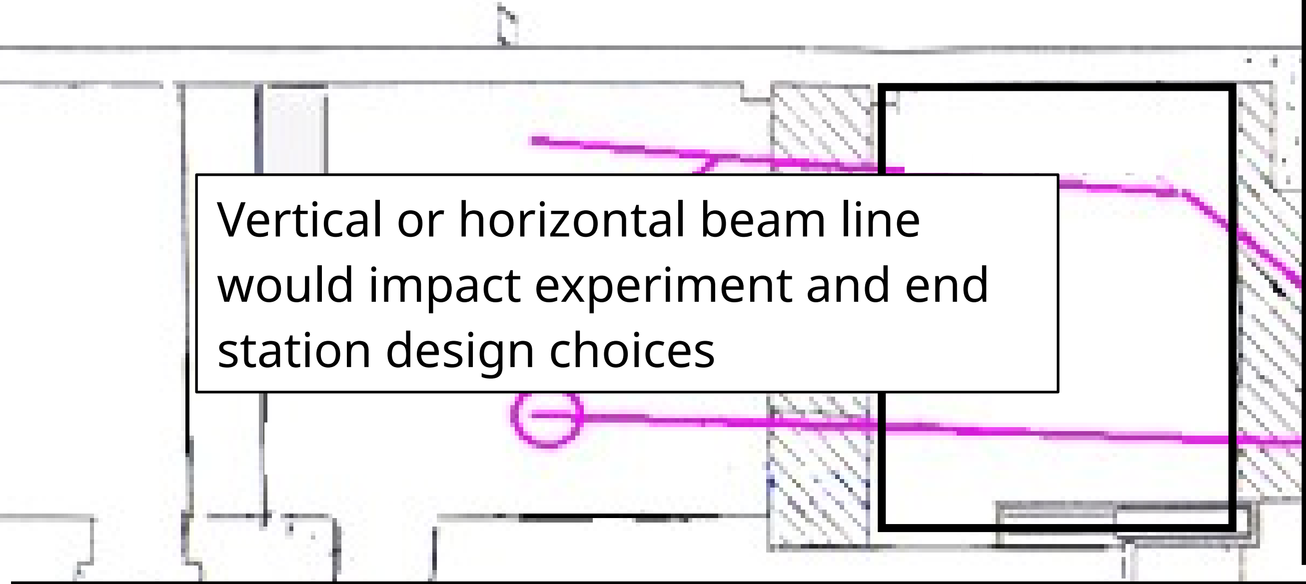
A beam of up to 50 mm diameter and 95 % dose uniformity is possible due to scattering system.

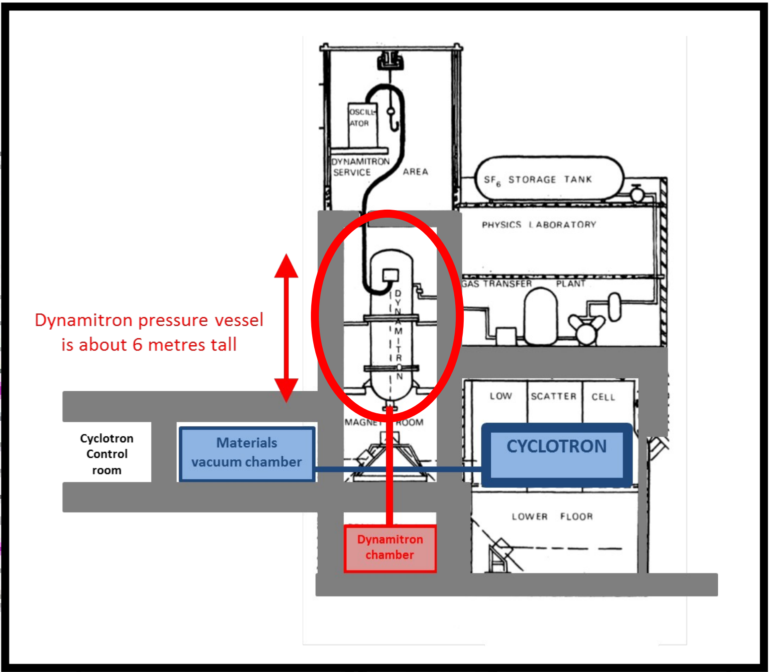
Rapid change collimators allow different beam shapes and sizes.

Beam current monitored via Ionisation chambers.
Doses calibrated using Markus Chambers.

Allows currents down to fA to test detectors for pCT and up to 100s of nA for FLASH dose rates.

Radiobiological experimental facilities currently under development.





Future Development: Dedicated Beamline

High Intensity Neutron Source funded by EPSRC (NNUF) scheduled to open in 2022

Current dynamitron to be removed by January ready for pressurised water test rig

Asbestos removed in the next few weeks

Potential of other groups applying for money for vertical beamline.

LhARA beam energy

A test bed at UoB for LhARA testing would require the correct energy and a controllable intensity for as high an instantaneous dose rate as possible.

Validated Geant4 model exists of the horizontal beam line model including all beam components. 15 MeV beam is susptable to all materials in the beam line

Dose rate and integrated dose needs to be controllable

MC40 BL4 Medical Line - Scattering System

Currently we have a 50mm diameter beam, 95% uniform in fluence obtained by small angle scattering of 36 MeV protons in 80um of Ta 4m upstream of experiment

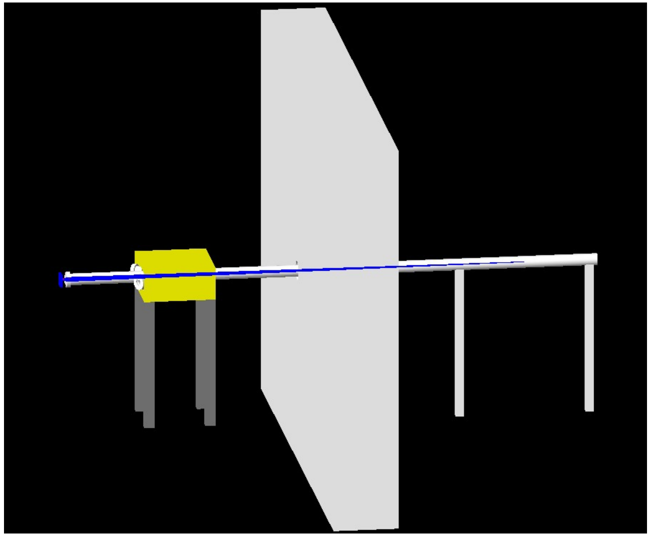
- This reduced the beam energy of 36 MeV by ~ 1 MeV
- Reduced beam current to 1/100th at 36 MeV

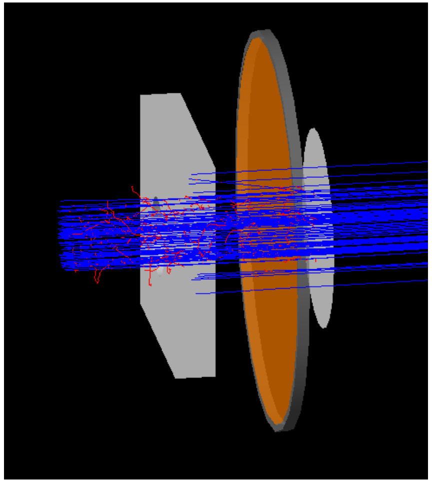
Would be too invasive at 15 MeV

Without the scattering foil, the beam profile varies on a day by day basis and getting a beam much larger than 1cm diameter by defocusing is time consuming

Question: How large a beam spot do we need for LhARA studies?

MC40 BL4 Medical Line - Energy





Vacuum Window 25um Ti

Ionisation chamber ~200um mylar

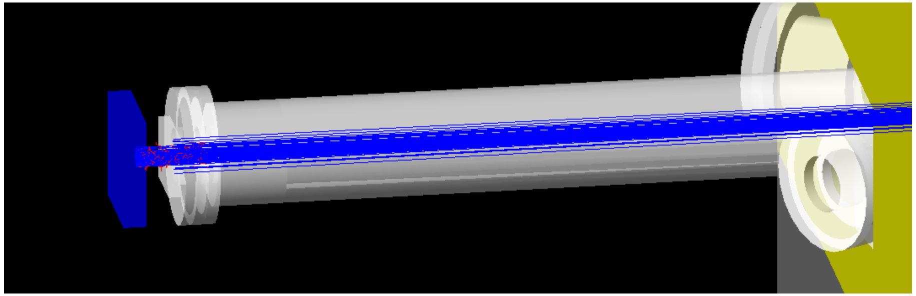
Vacuum window to downstream collimator face ~ 5cm air

End station would have a window

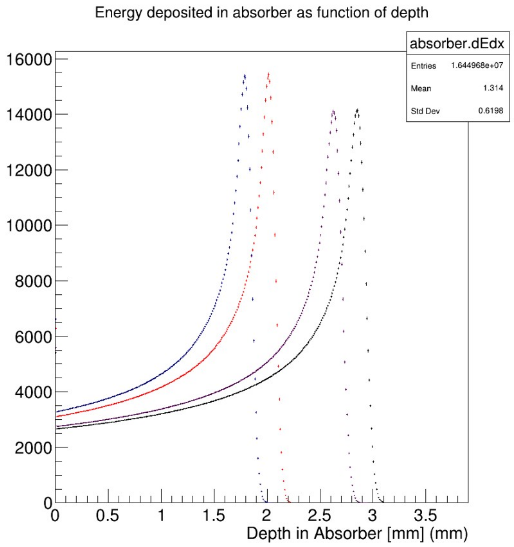
Samples then inside the end station

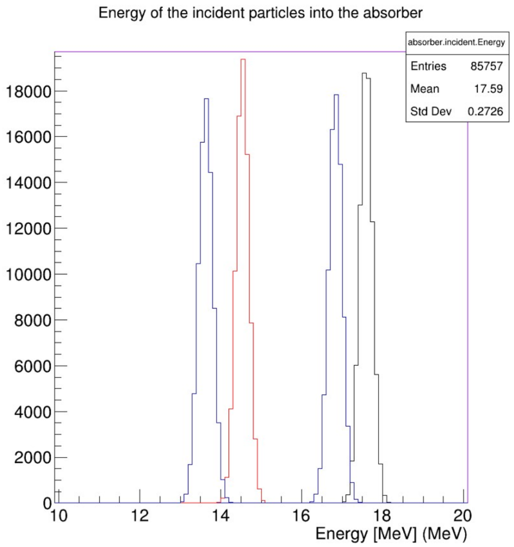
Significant amount of air for a 15 MeV proton beam so beam will diverge, scatter, lose energy

Scoring BP in PMMA and incident KE at a vacuum window to PMMA distance of 6cm



MC40 BL4 Medical Line - Energy





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15 MeV source with IC and w/o IC
18 MeV source with IC and w/o IC

MC40 BL4 Medical Line – FLASH delivery

Cyclotron able to deliver UHDR

Experiment with 36 MeV beams, no scattering system

NPL Secondary Standard Calorimeter which is a graphite core matching ROOS chamber volumes

Senses temperature changes with a wheatstone bridge

Energy = mC(deltaT)

1s pulse were delivered using FC timing

Doses of up to 2.5kGy measured but need to be verified in this project

Publication from NPL on SSCal submitted

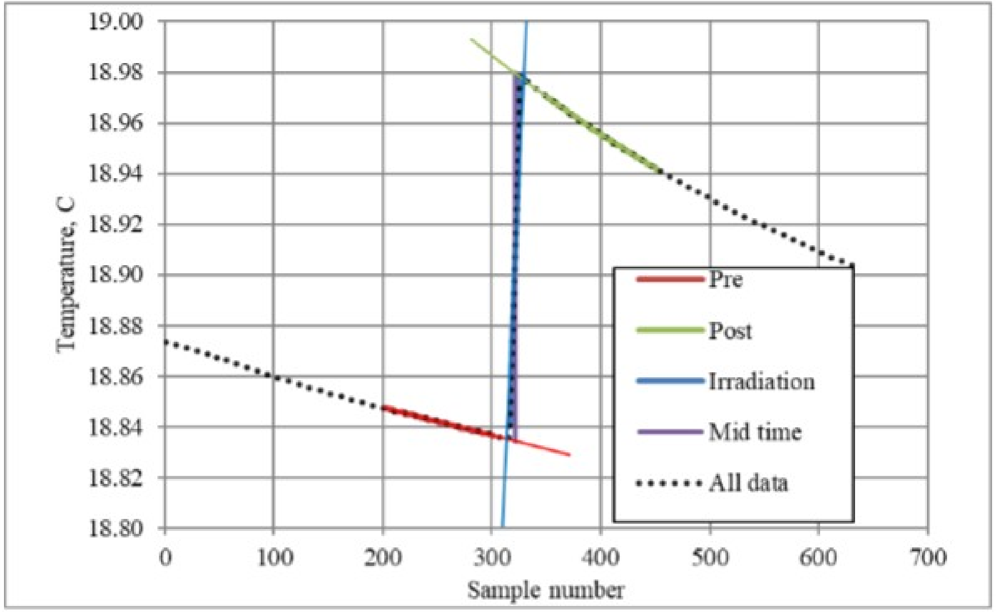
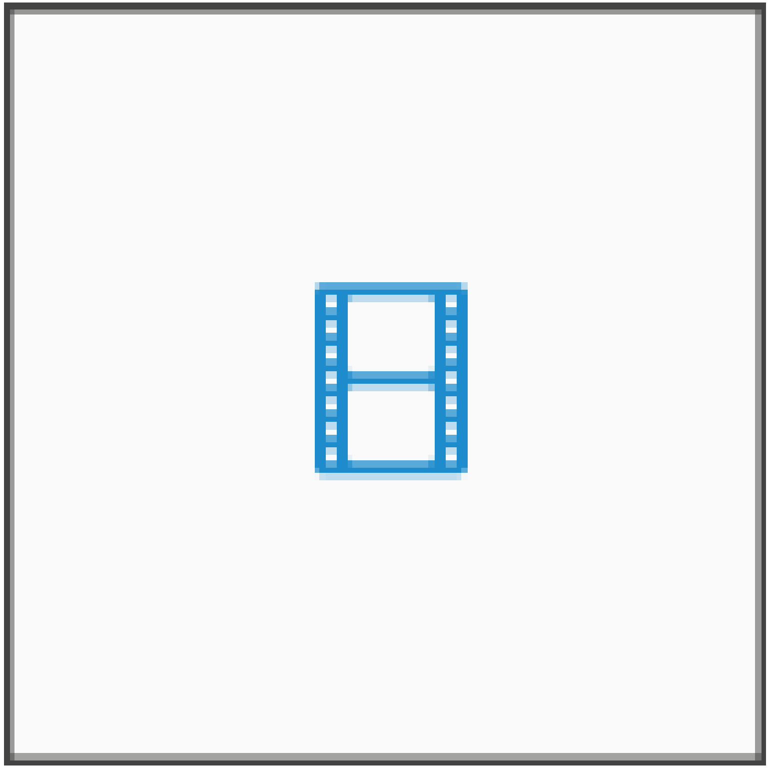


Figure 8 Typical graphite-core SSC measurement and analysis, 28 MeV proton beam, approximately 100 Gy delivered in 1 second. The sample interval is 0.1s.

MC40 BL4 Medical Line – FLASH Shutter

- Based off designs from Oxford FLASH X-rays
- Modified and tuned by Rob Wheeler @ UoB
- Testing underway by Max Conway (Summer & MSc Student)
- Controlled by arduino, monitored via lasers
- Dosimetry to be completed as his project



MC40 BL4 Medical Line – Microbeam delivery

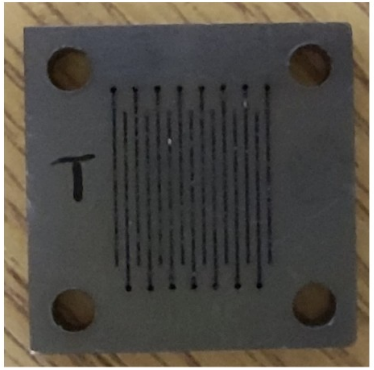


Figure 6: Photograph of one of the Ta collimators.

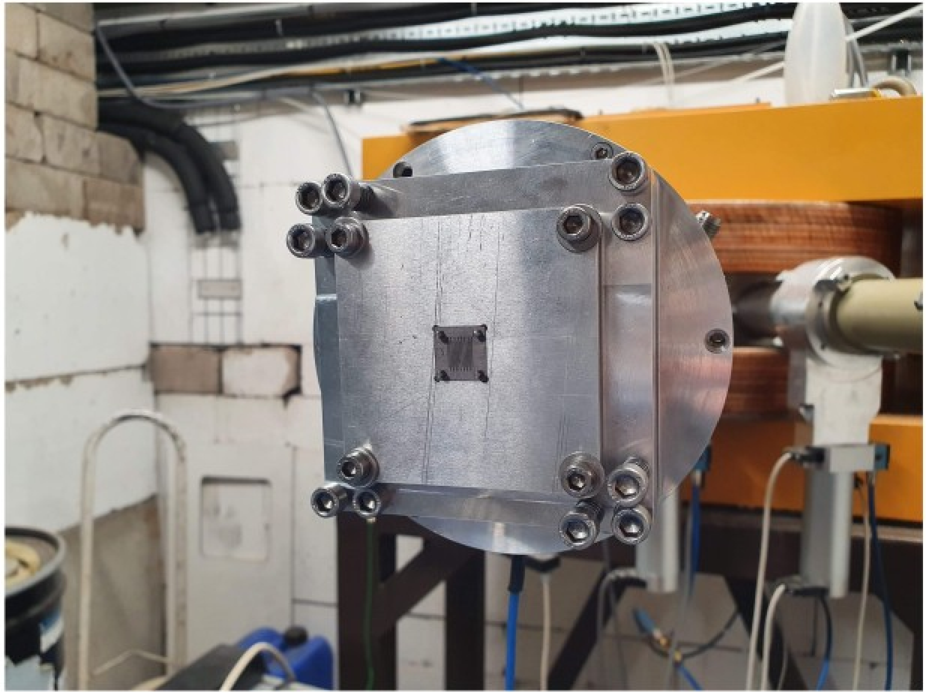
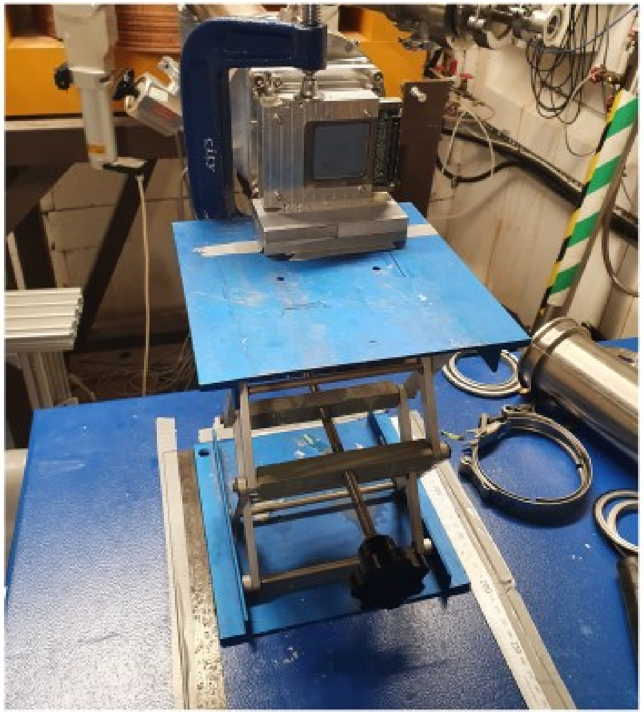
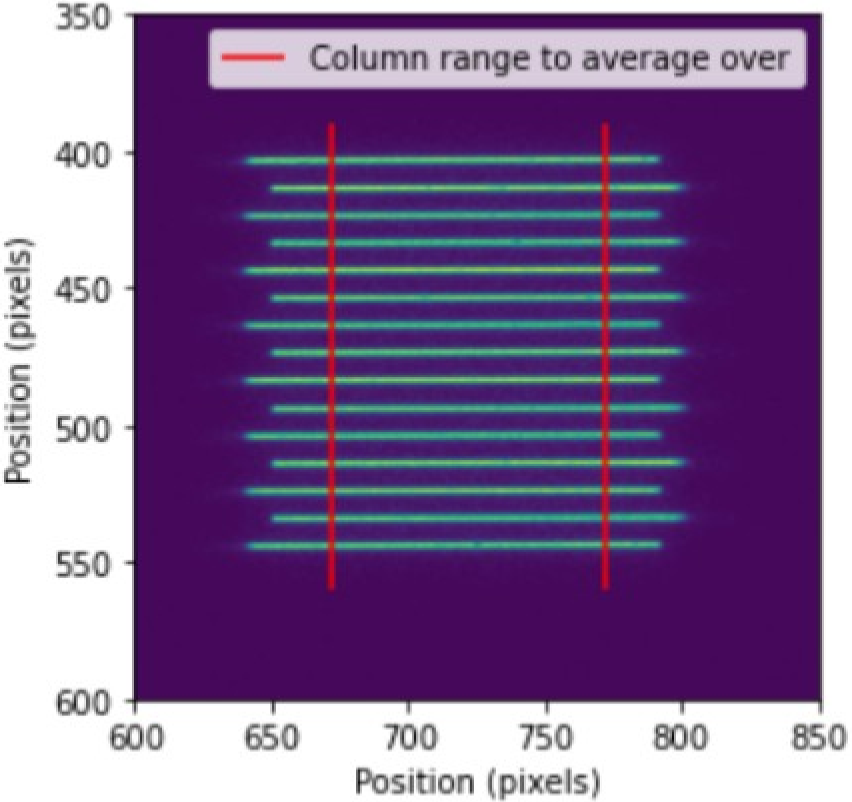


Figure 9: A single collimator mounted on the end of beamline 4, with pins sticking out visible.

MC40 BL4 Medical Line – Microbeam delivery



(b) Sensor setup showing the measurement/sliding mechanism and sensor.



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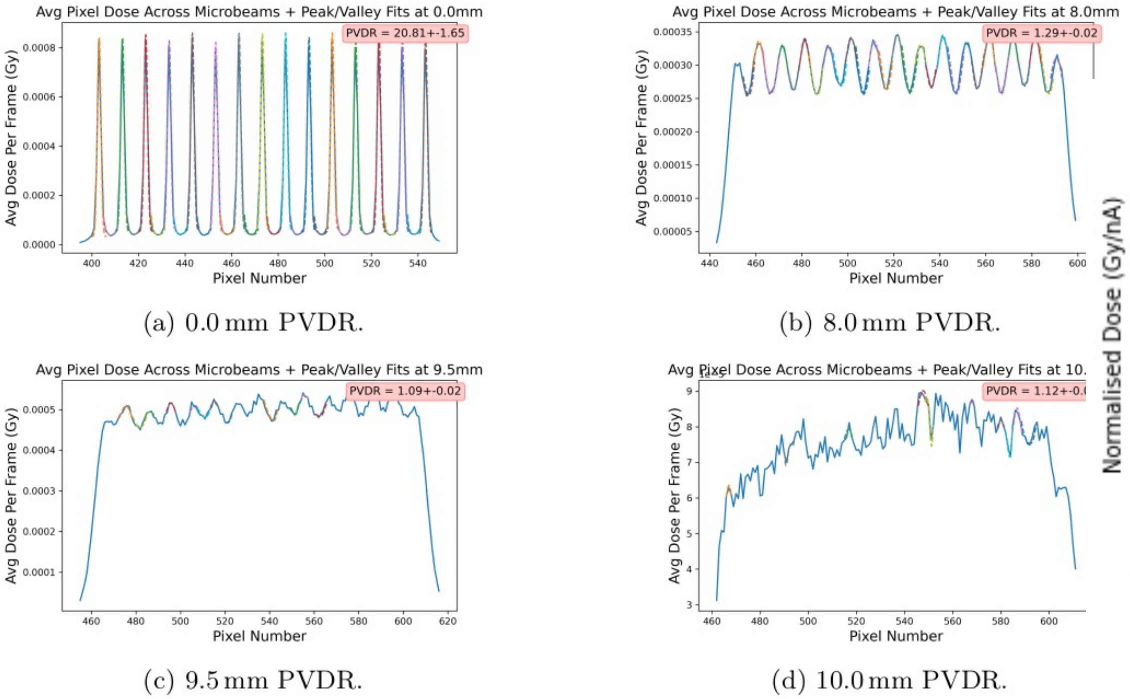

Figure 19: Plots of PMMA experiment average dose per frame distributions across microbeams with peak and valley fits overlayed at four distances.