Low energy Helium beams at MC40. Considerations for ITRF

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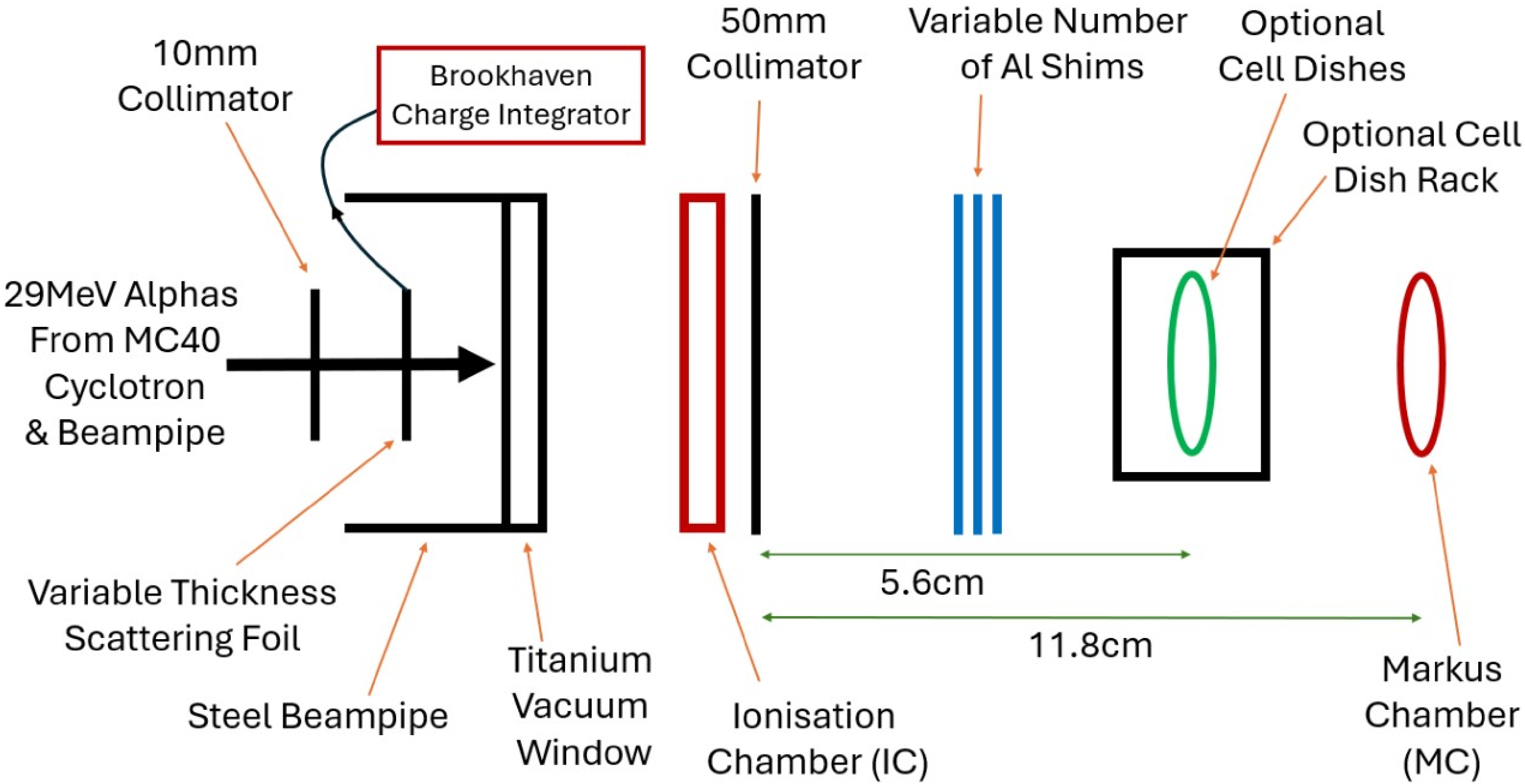
Overview

- MC40 cyclotron
- Scattering system
- Energy measurements
- Dosimetry


10mm Collimator
Brookhaven Charge Integrator
50mm Collimator
Variable Number of Al Shims
Optional Cell Dishes
Optional Cell Dish Rack
29MeV Alphas From MC40 Cyclotron & Beampipe
Variable Thickness Scattering Foil
Steel Beampipe
Titanium Vacuum Window
Ionisation Chamber (IC)
5.6cm
11.8cm
Markus Chamber (MC)

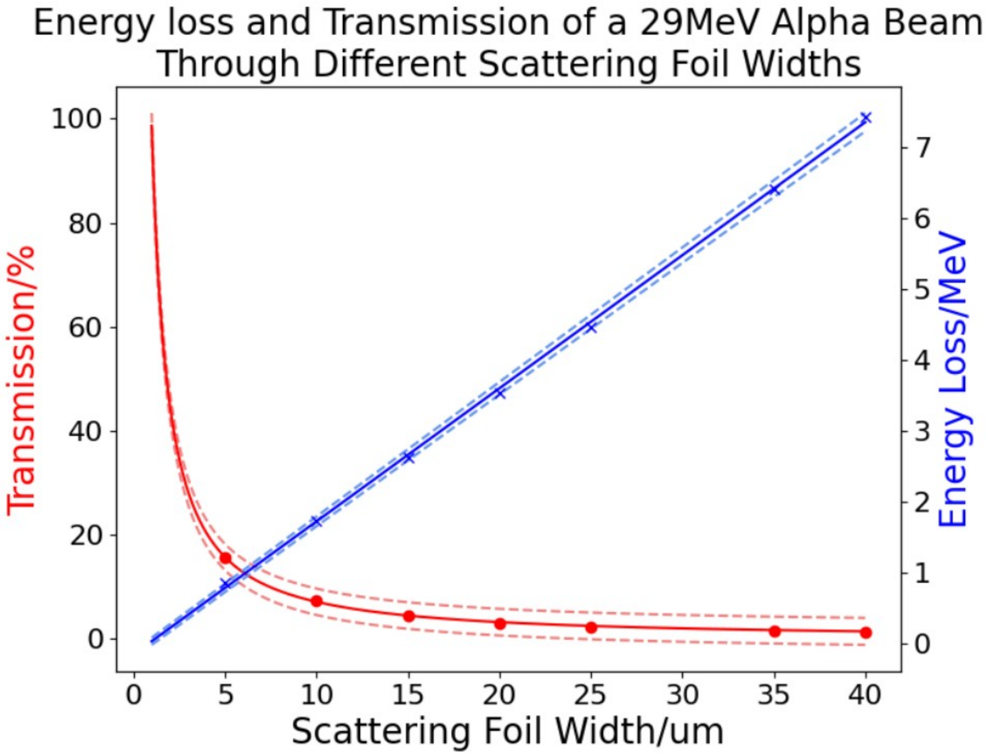
Scattering System Requirements

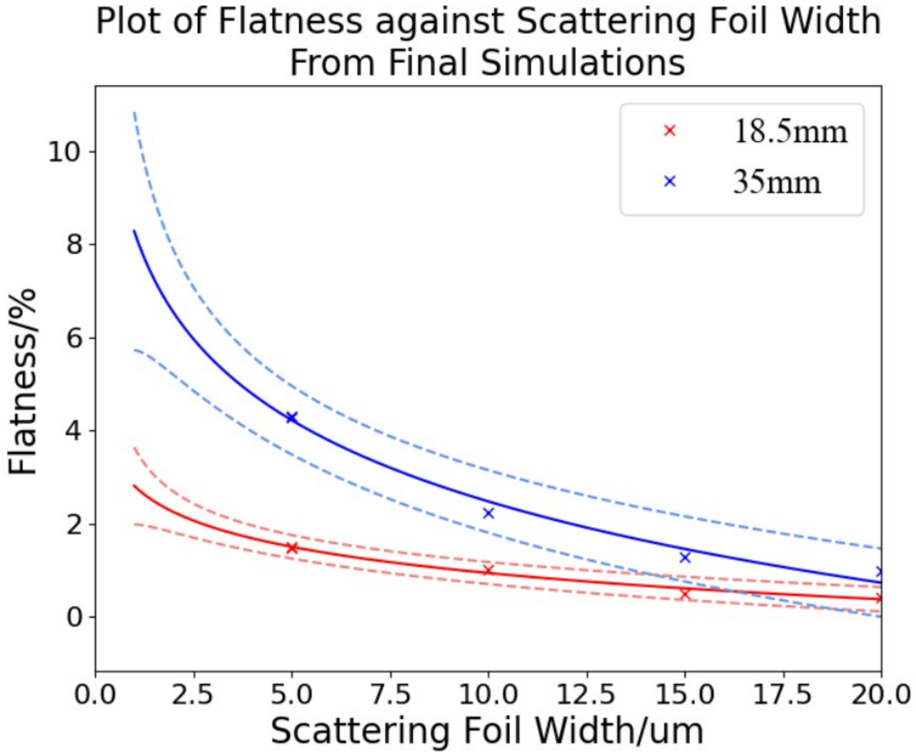
- Want a quick way to setup the beam and be reproducible
- Achieve at least 5% flatness over the cell dishes
- Minimal energy loss to preserve as much range as possible at the end station
- Maximum beam transmission from cyclotron to cells to enable potential He-FLASH and He-PMBT studies
- Existing 80um Ta for 36 MeV protons needs to be redesigned.
- Archie Griffiths completed a series of Geant4 simulations, RCF calibrations and measurements at the cyclotron

Scattering system - Geant4

- The scattering system is located ~3.2m in vacuum before the Ti vacuum window.
- Assumed a small uniform beam incident upon it, same as my validated proton work
- Energy loss and transmission calculated.
- Parameters evaulated at the vacuum window of beam flatness and symmetry using ICRU recommendations for scattered beam systems

$$S = 100\frac{D_1 - D_2}{D_1 + D_2} \qquad F = \frac{max - min}{max + min} \times 100$$


Energy loss and Transmission of a 29MeV Alpha Beam
Through Different Scattering Foil Widths
Transmission/%
Energy Loss/MeV
Scattering Foil Width/um
0
20
40
60
80
100
0
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35
40


Plot of Flatness against Scattering Foil Width
From Final Simulations
Flatness/%
Scattering Foil Width/um
18.5mm
35mm
0
2
4
6
8
10
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0

Scattering Foil Measurements

- Used HD-V2 film
- Essential due to range restrictions meaning He stops in the substrate layer
- Dose estimated via Marcus Chamber measurements
- Beam monitored with PTW Ionisation Chamber
- Absolute dose to be compared with NPL in the near future

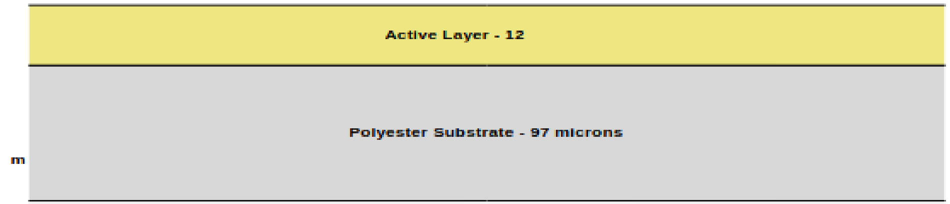


Figure 1: Configuration of GAFChromic® HD-V2 Dosimetry Film

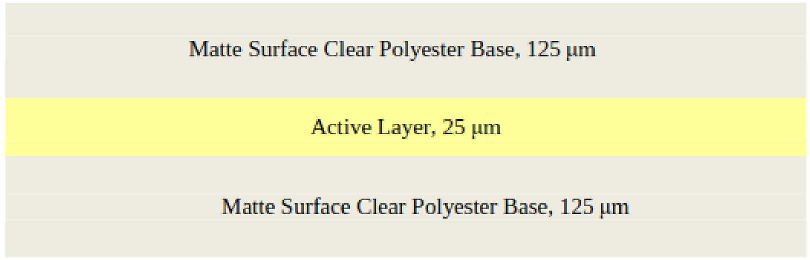


Figure 1: Structure of GAFChromic EBT-XD Dosimetry Film

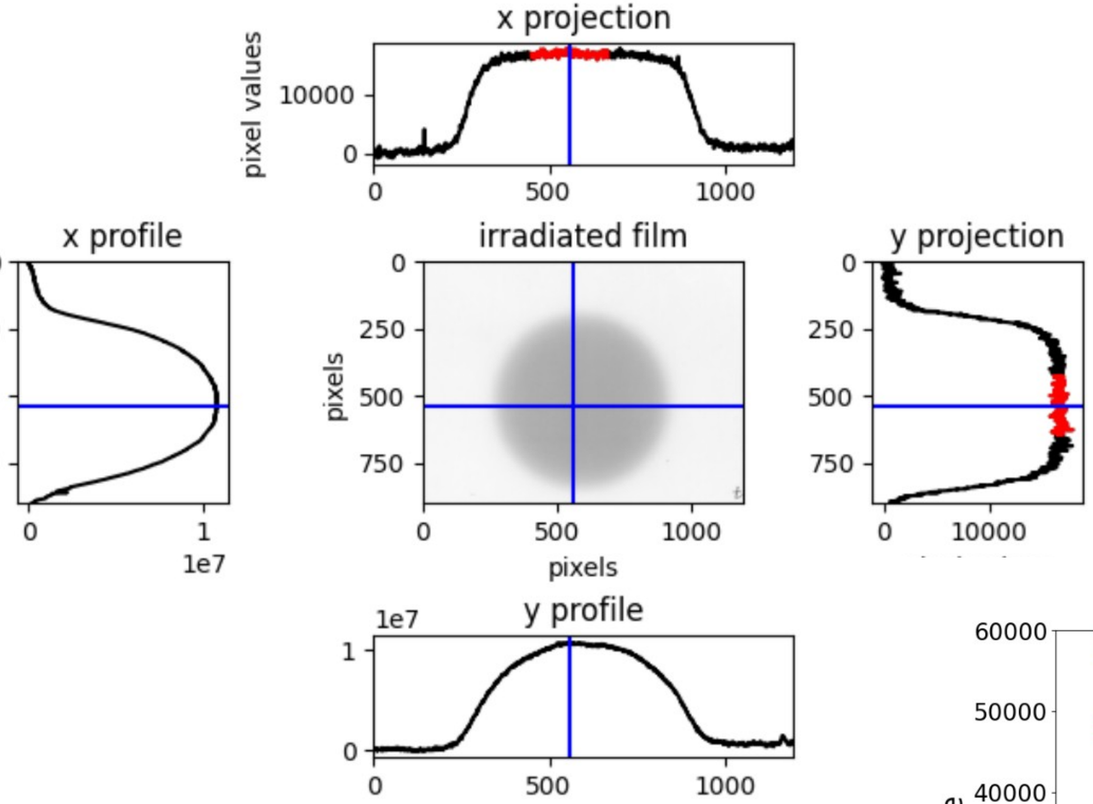
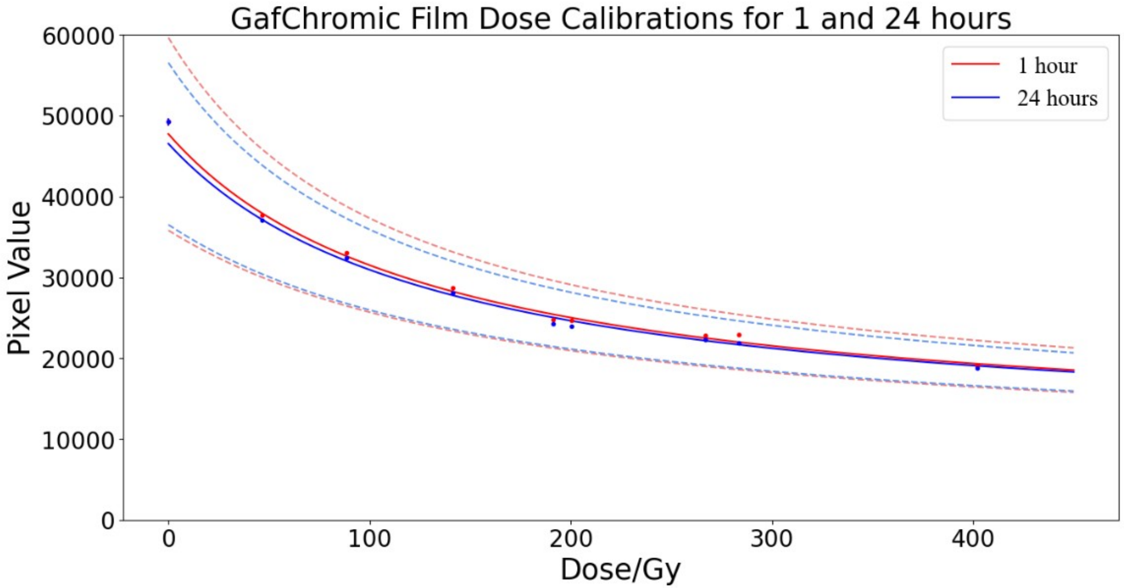
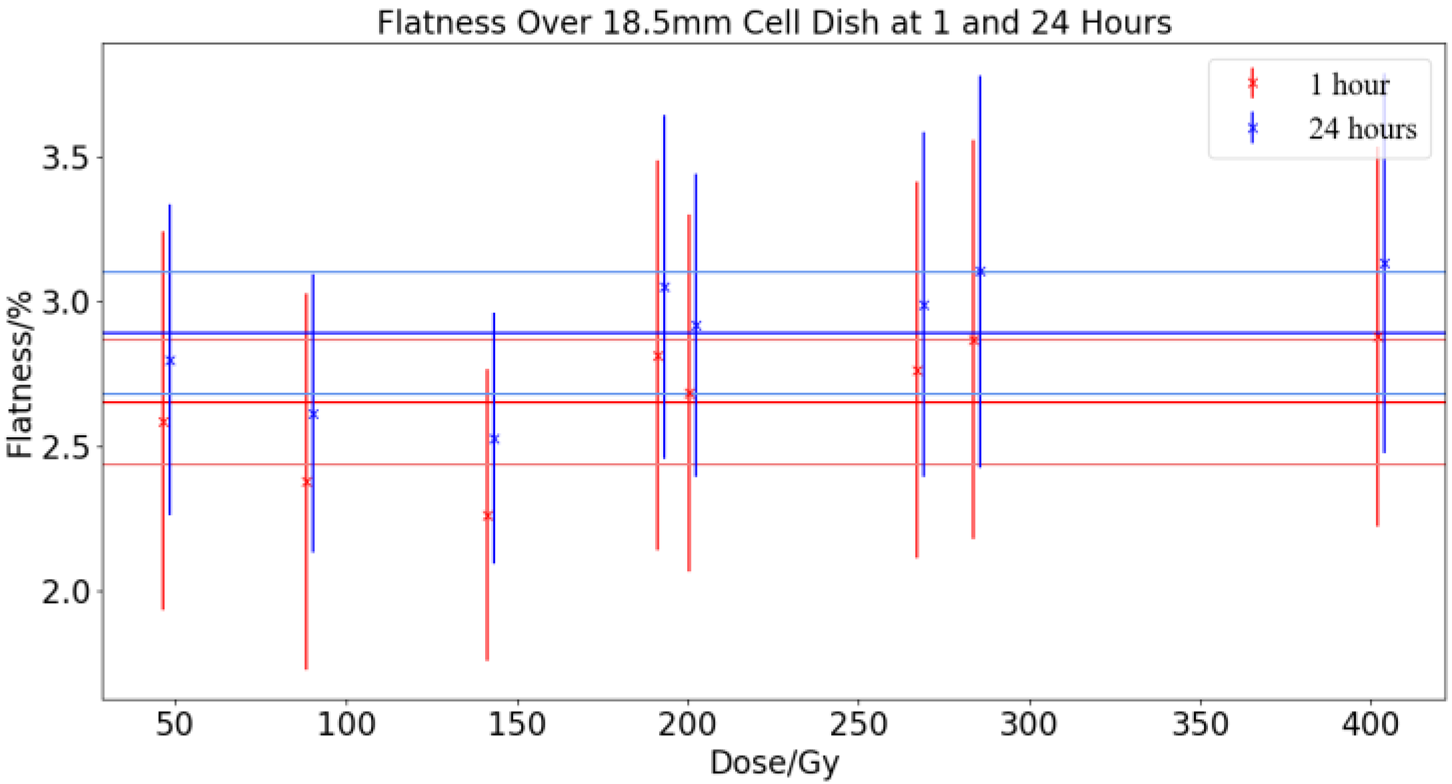


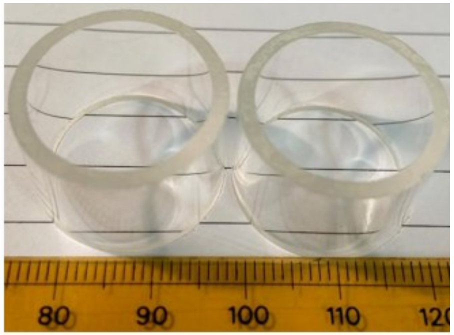
Figure 4.2: Plot of film scan, profiles and projections for centri

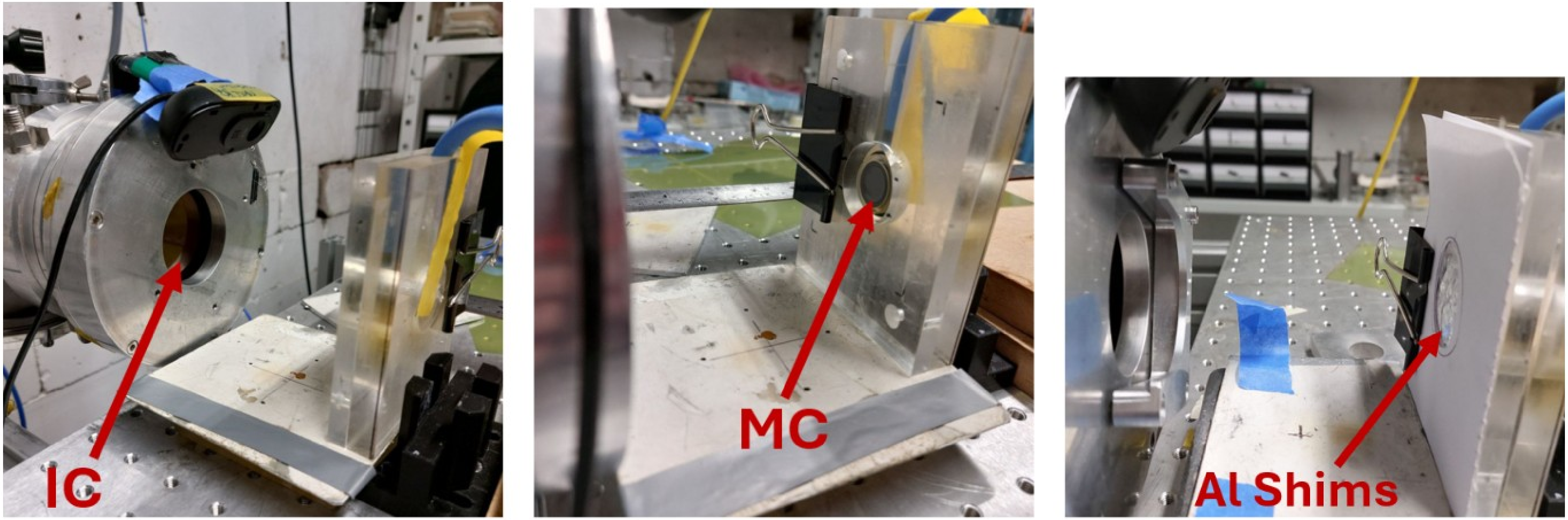


Beam Flatness at Cells



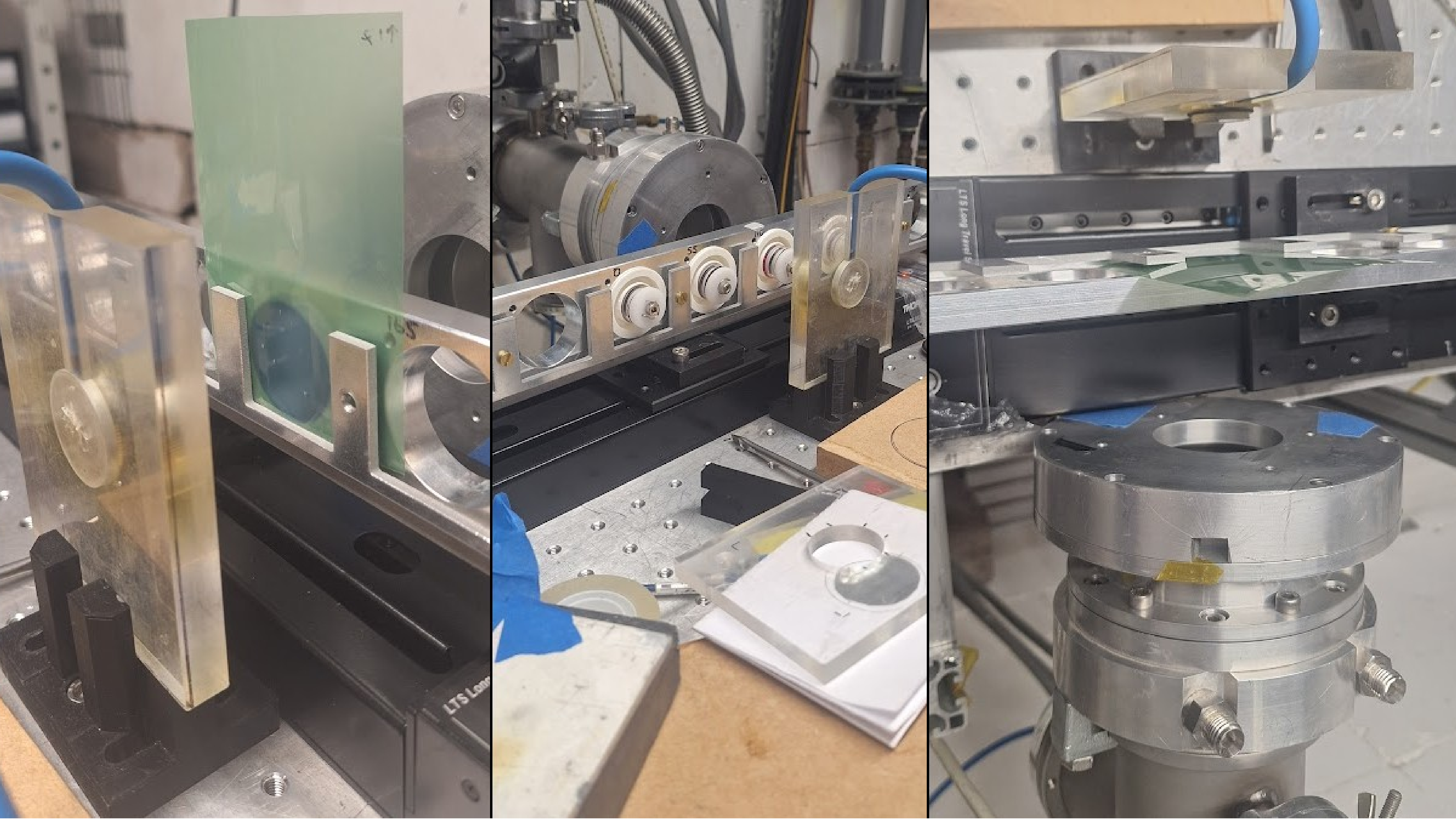
$$F = \frac{max - min}{max + min} \times 100$$





(a) (b) (c)

Figure 6: Photos of the end of beamline 4 at the MC40 cyclotron facility, showing the Ionisation Chamber (a), Markus Chamber (b) and aluminium shims (c).



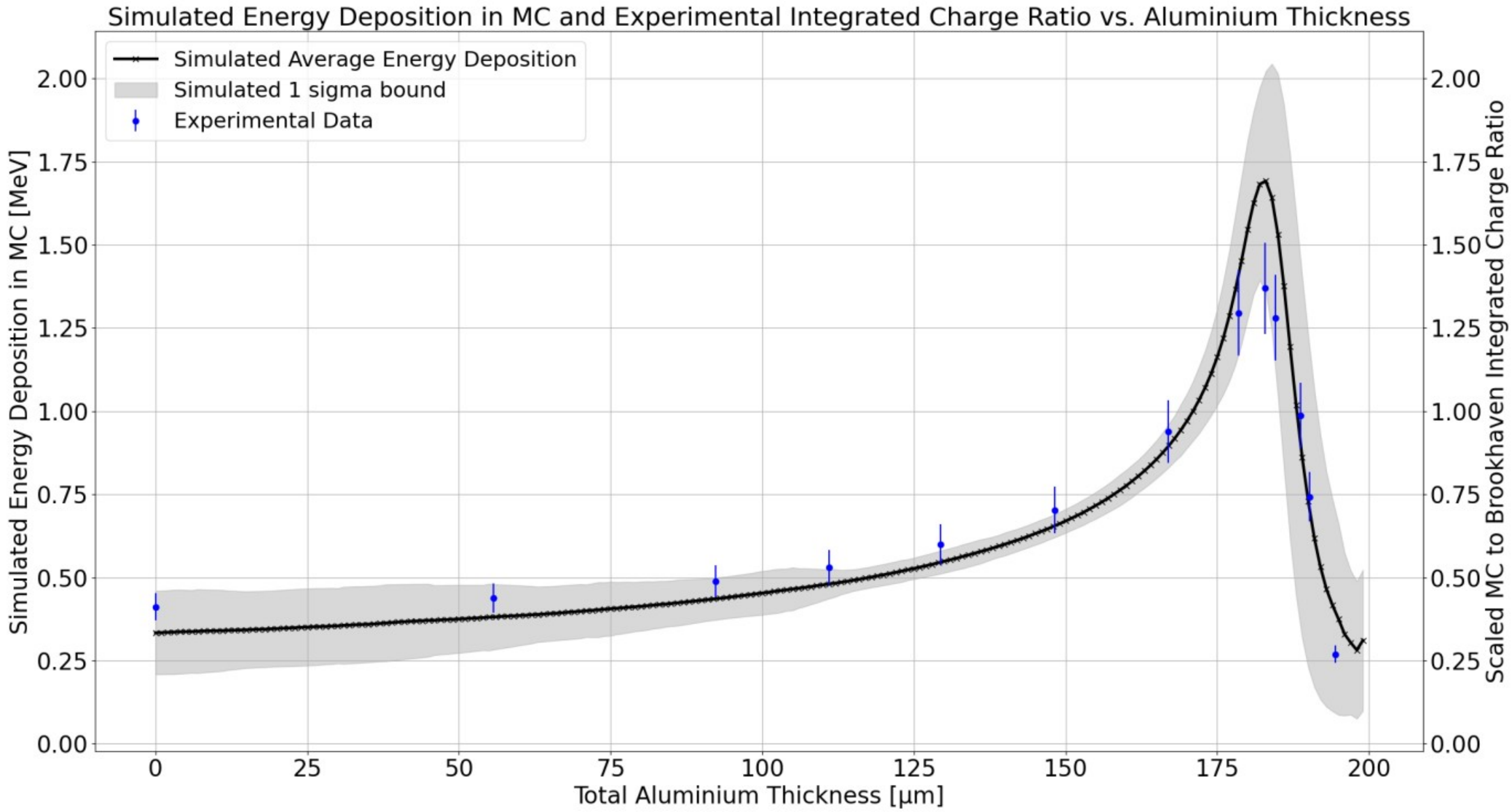


Figure 8: Overlaid plots for simulated Markus Chamber energy deposition per particle (left axis) and experimental Markus Chamber to Brookhaven integrated charge ratio (right axis) as functions of total aluminium thickness. A simulated energy of 24.10 ± 0.05MeV was used for alpha particle generation.

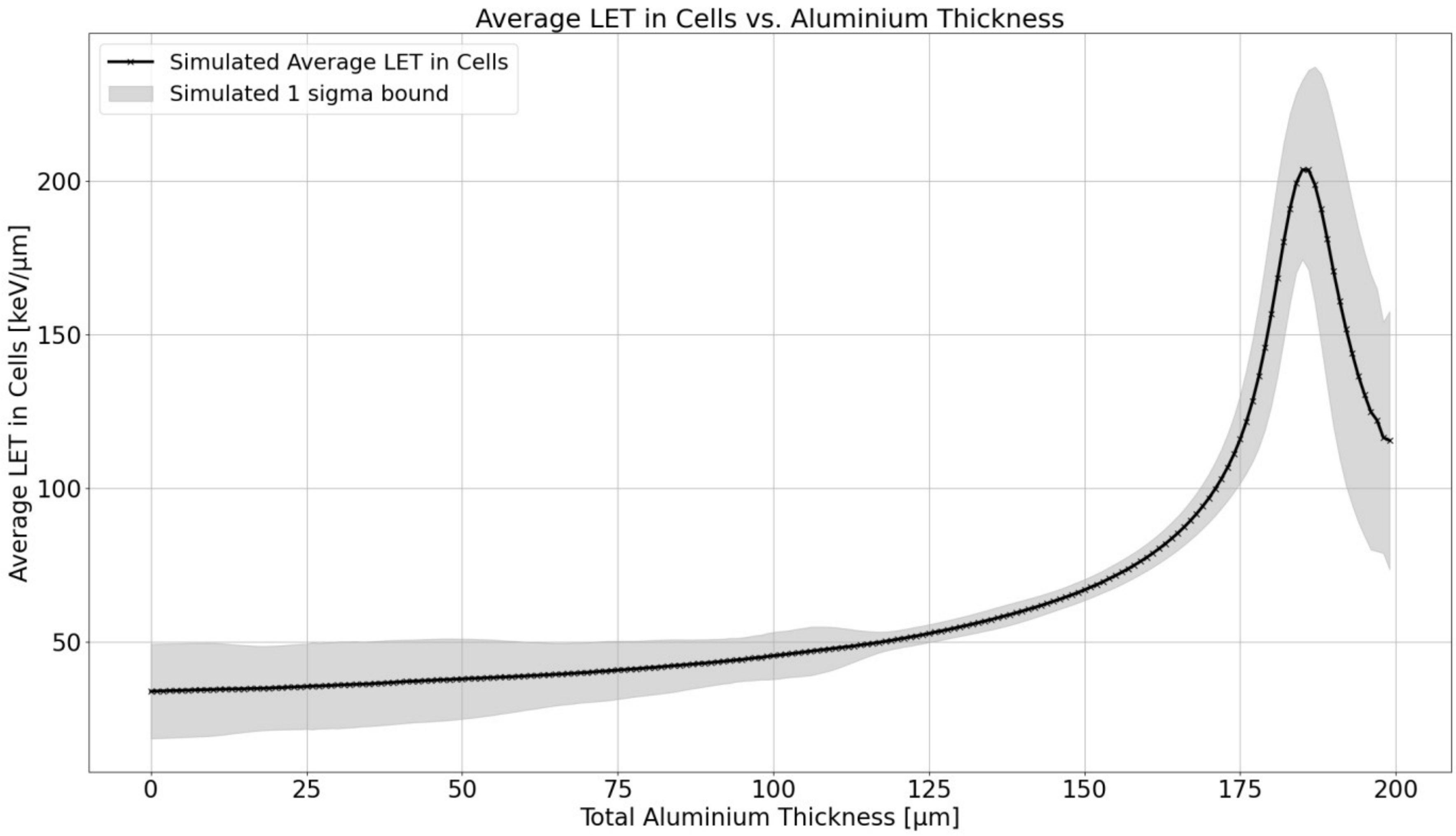


Figure 12: Plot of simulated alpha particle LET in cells as a function of total aluminium thickness. A simulated energy of 24.10 ± 0.05MeV was used for alpha particle generation.

Low energy implications

- Our standard way to monitor beam current is using a PTW X-ray tranmission chamber
  - ~200 um of Mylar
  - Reduced beam energy too much and prevented entrance dose measurements so needed to be removed
- Beam current currently monitored using induced charge on scattering foil. Seems stable but as of yet uncalibrated
- Monte Carlo suggests a 24 MeV beam not 29 MeV.
  - Equivalent to 90um Al or 18 cm air
  - Range of 5 MeV alpha in air is 1 cm
  - Stripped beamline completely to find discrepancy – no obvious signs
  - Air volume in Geant4 was actually vacuum… so we lost 18 cm of air energy loss
- Simulations now agree nicely
- All materials are important and in the correct locations. Geometries are not permutable!
- Implications for the 10 MeV proton run I need the double check.