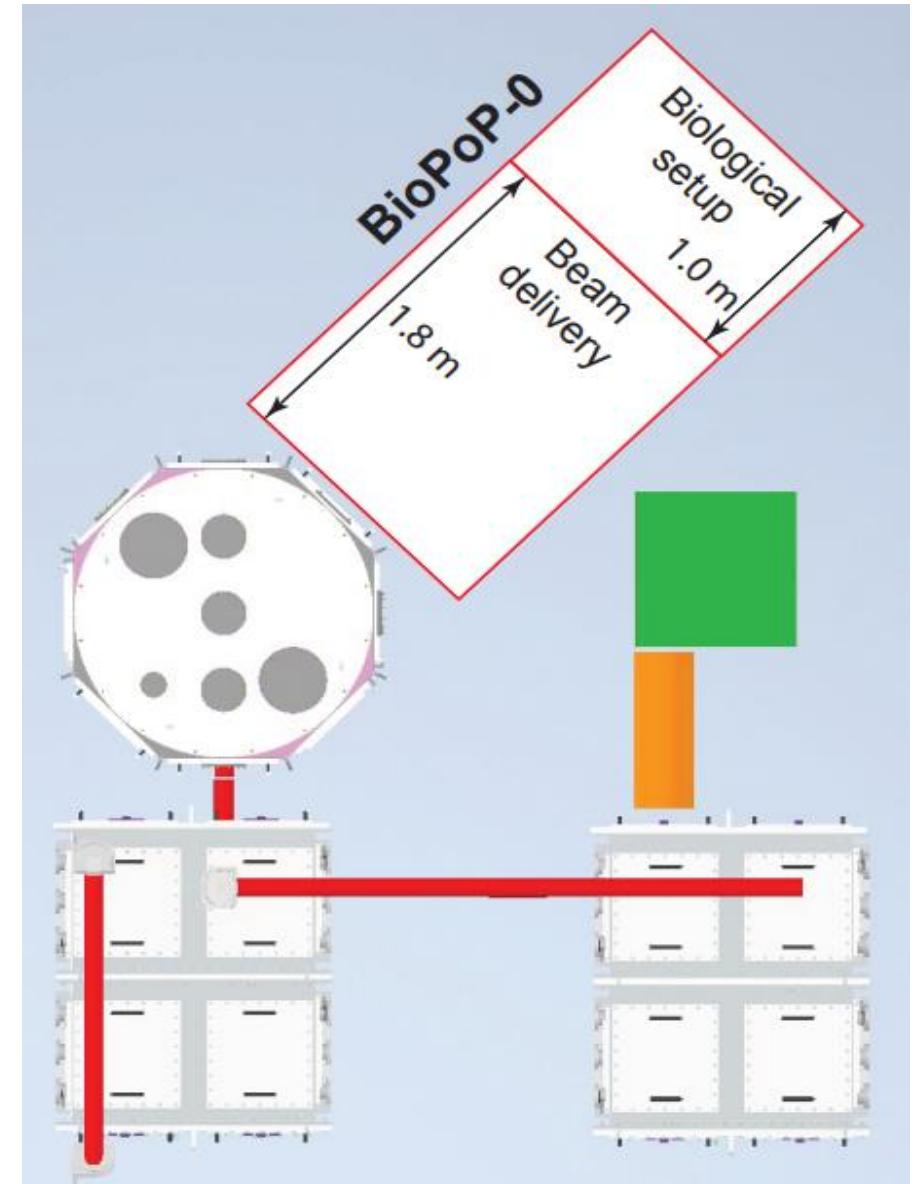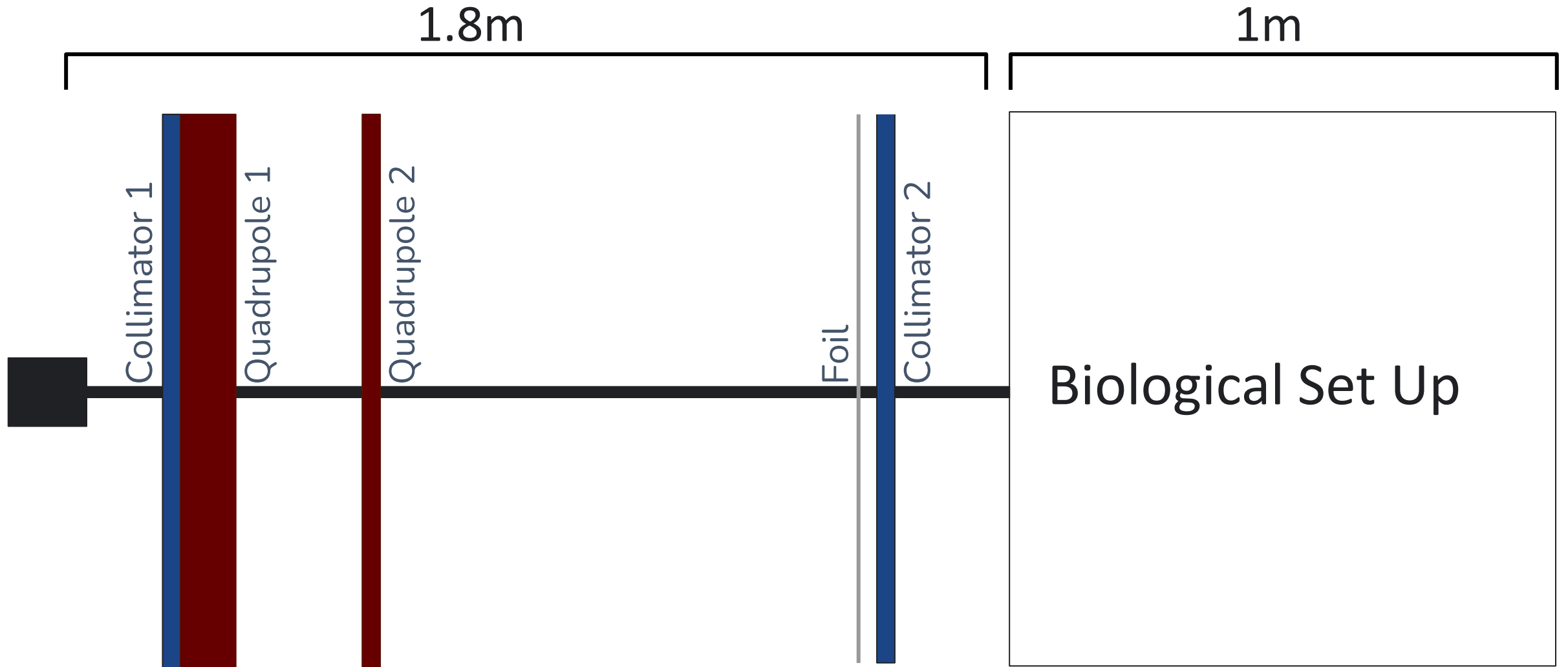# PoPLaR Beamline

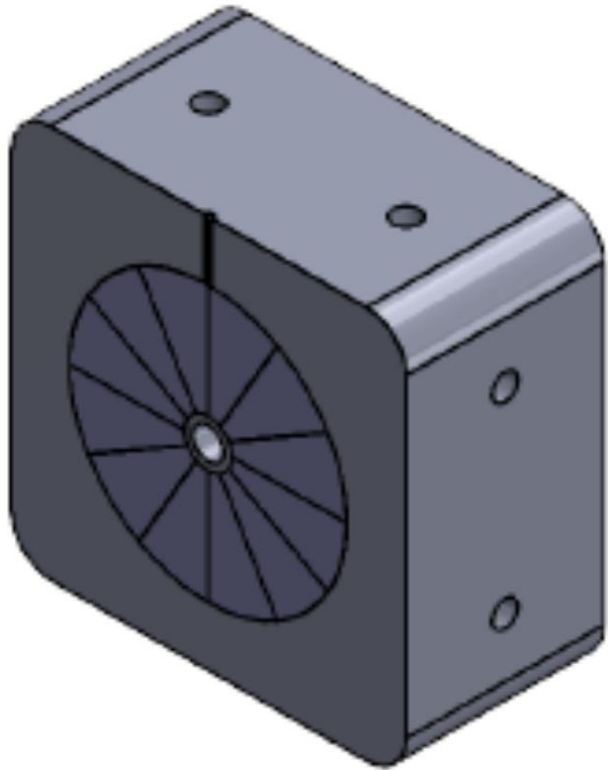Equipment, set up & simulations

# Limitations

- Must be focused within 1.8m

- Must not be too close to laser

- Must be able to focus energies from 5-15MeV

# Beamline set up

# Quadrupole Design



- Halbach quads from Magnet Sales Ltd

- Ni coated blocks for vacuum protection

- 2/3 months design 7 manufacture time

# Linear Optics Simulation

$$\phi = \begin{pmatrix} x \\ x' \\ y \\ y' \\ z \\ \delta \end{pmatrix} \qquad T_{drift} = \begin{pmatrix} 1 & l & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & l & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & \dfrac{1}{\beta_0{}^2 \gamma_0{}^2} \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Trace Space Matrix                                           Drift Matrix

# Linear Optics Simulation

$$T_{Fquad} = \begin{pmatrix} \cos(\sqrt{k_q \cdot l_q}) & \dfrac{\sin(\sqrt{k_q \cdot l_q})}{\sqrt{k_q}} & 0 & 0 & 0 & 0 \\ -\sqrt{k_q}\sin(\sqrt{k_q \cdot l_q}) & \cos(\sqrt{k_q \cdot l_q}) & 0 & 0 & 0 & 0 \\ 0 & 0 & \cosh(\sqrt{k_q \cdot l_q}) & \dfrac{\sinh(\sqrt{k_q \cdot l_q})}{\sqrt{k_q}} & 0 & 0 \\ 0 & 0 & \sqrt{k_q}\sinh(\sqrt{k_q \cdot l_q}) & \cosh(\sqrt{k_q \cdot l_q}) & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & \dfrac{1}{\beta_0{}^2\gamma_0{}^2} \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Focusing Quadrupole Matrix

# Linear Optics Simulation

$$T_{Dquad} = \begin{pmatrix} \cosh(\sqrt{k_q \cdot l_q}) & \dfrac{\sinh(\sqrt{k_q \cdot l_q})}{\sqrt{k_q}} & 0 & 0 & 0 & 0 \\ \sqrt{k_q}\sinh(\sqrt{k_q \cdot l_q}) & \cosh(\sqrt{k_q \cdot l_q}) & 0 & 0 & 0 & 0 \\ 0 & 0 & \cos(\sqrt{k_q \cdot l_q}) & \dfrac{\sin(\sqrt{k_q \cdot l_q})}{\sqrt{k_q}} & 0 & 0 \\ 0 & 0 & -\sqrt{k_q}\sin(\sqrt{k_q \cdot l_q}) & \cos(\sqrt{k_q \cdot l_q}) & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & \dfrac{1}{\beta_0{}^2 \gamma_0{}^2} \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

## Defocusing Quadrupole Matrix

# Quadrupoles Tested

| Quadrupole | Strength | Length | Aperture |
|:---:|:---:|:---:|:---:|
| Quad 1 | 130 T/m | 25mm | 20mm |
| Quad 2 | 130 T/m | 18mm | 20mm |
| Quad 3 | 130 T/m | 13mm | 20mm |

# Optimal Quad Set

25mm then 13mm Quad at 130 T/m

1.8m

1m

Collimator 1

Quad 1

Quad 3

Foil

Collimator 2

Biological Set Up

# Optimal Quad Set

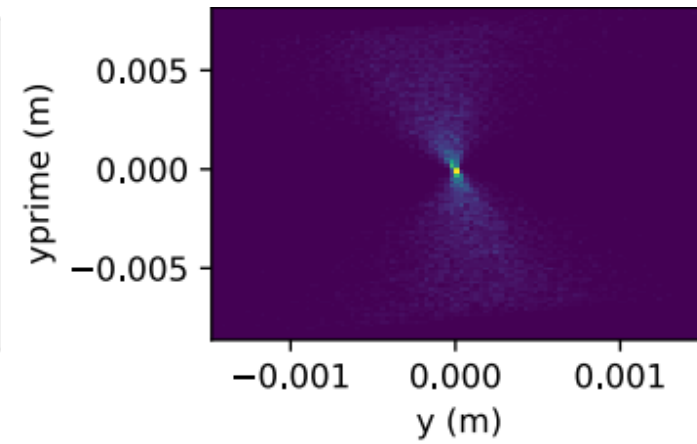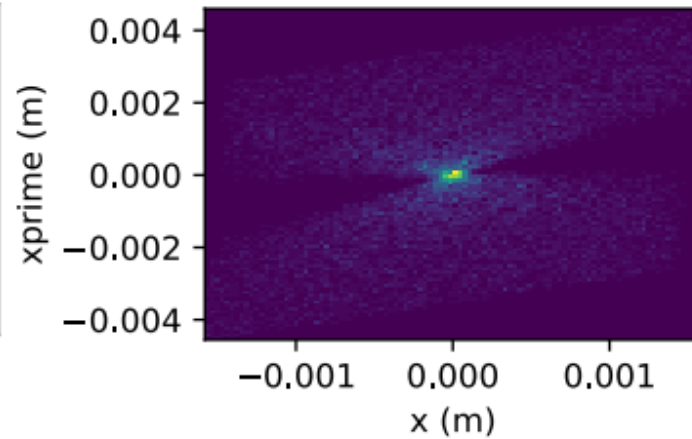| Energy (MeV) | Focusing quad position (m) | Drift between quads (m) |
|:---:|:---:|:---:|
| 5 | 0.138 | 0.145 |
| 7.5 | 0.170 | 0.193 |
| 10 | 0.194 | 0.243 |
| 12.5 | 0.218 | 0.279 |
| 15 | 0.239 | 0.325 |

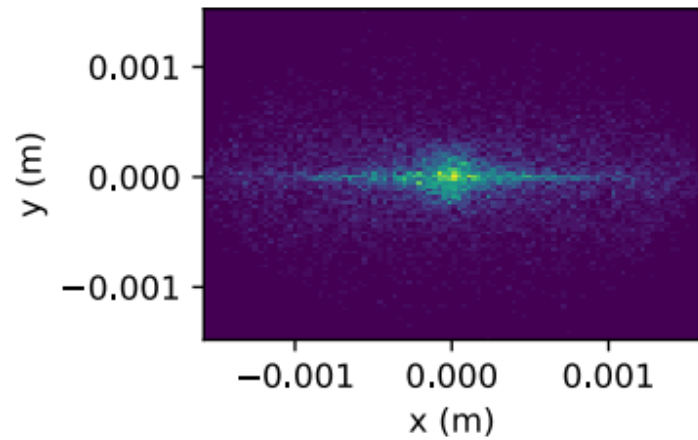# Optimal Quad Set-Example: 10MeV Visualiser



Key:

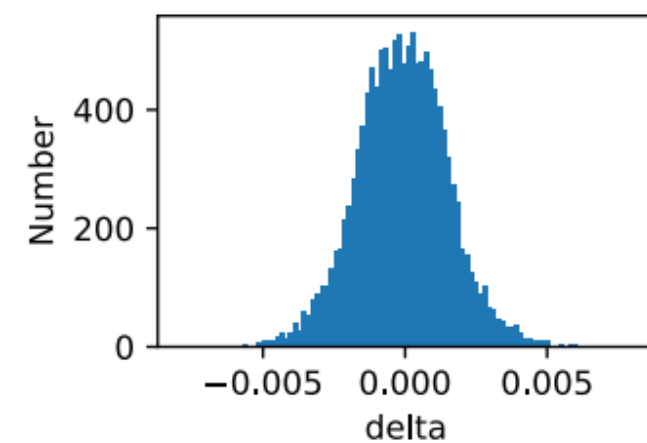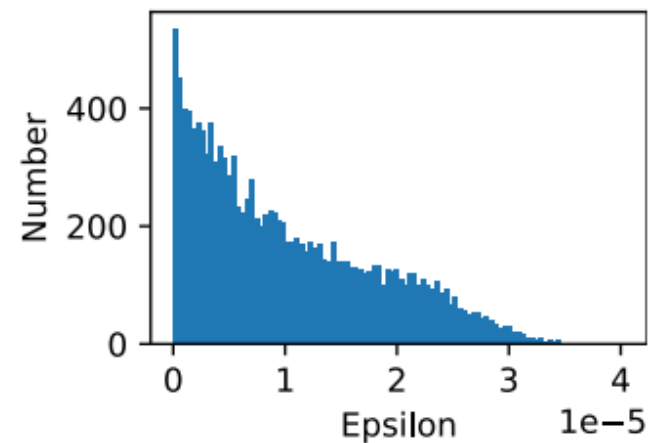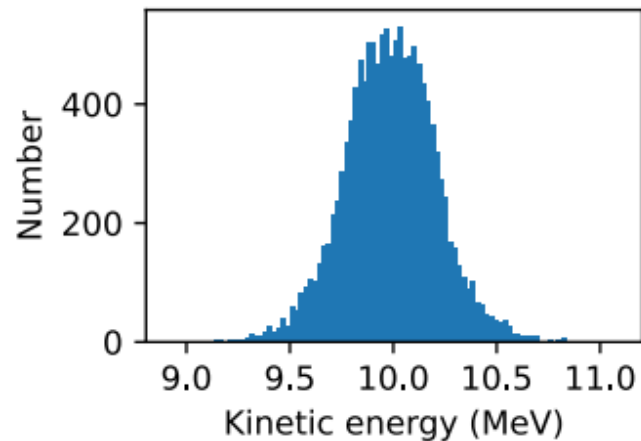Blue- Particles that make it to the target

Red- Particles that don't make it to the target

# Optimal Quad Set- Example: 10MeV Beam shape at target

Beam geometrics

Beam distribution

# PROPOSED TIMELINE

Deliverables for PoPLaR to keep the project on track for completion by October 2024.

**Spring 24** — Order quadrupoles

**Summer 24** — Test Quadrupoles

**Autumn 24** — Experiment Design

**By October 24** — Experiment