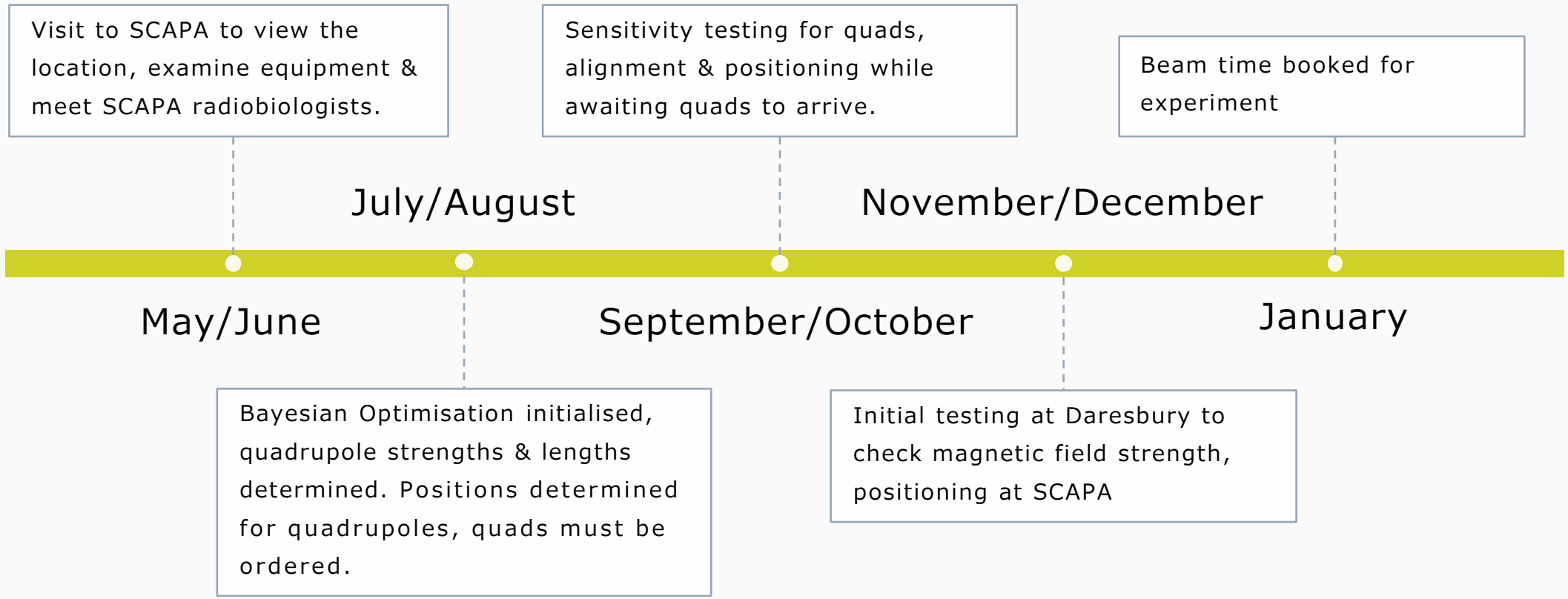
# POPLAR

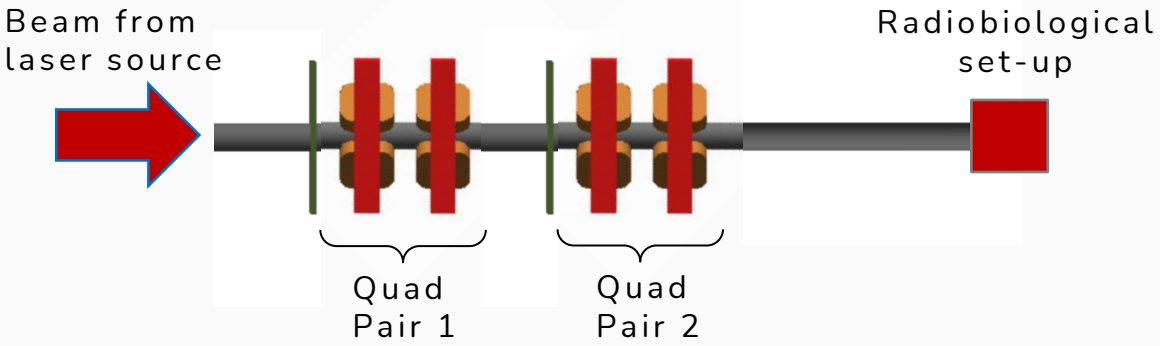
03/09/2024


Visit to SCAPA to view the location, examine equipment & meet SCAPA radiobiologists.
Sensitivity testing for quads, alignment & positioning while awaiting quads to arrive.
Beam time booked for experiment
July/August
November/December
May/June
September/October
January
Bayesian Optimisation initialised, quadrupole strengths & lengths determined. Positions determined for quadrupoles, quads must be ordered.
Initial testing at Daresbury to check magnetic field strength, positioning at SCAPA

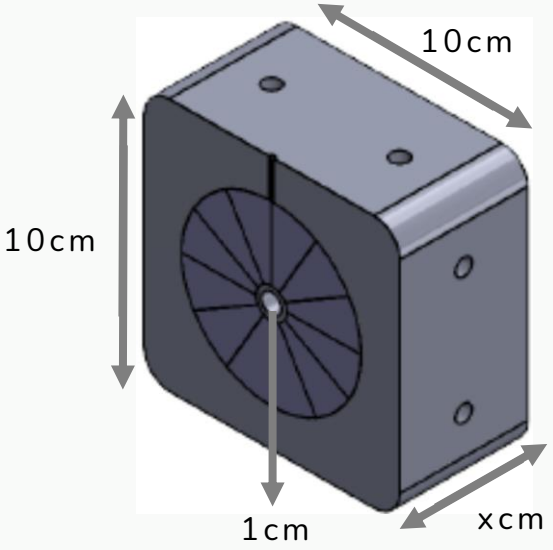
# Timeline

Collimator

Quadrupoles




## Halbach Quadrupoles




| Quad | Length (x) | Strength |
|---|---|---|
| Fquad 1 | 2 cm | 150 T/m |
| Dquad 1 | 4 cm | 150 T/m |
| Fquad 2 | 2 cm | 150 T/m |
| Dquad 2 | 2 cm | 150 T/m |

# PoPLaR Components

# Linear Optics Simulations

$$\phi = \begin{pmatrix} x \\ x' \\ y \\ y' \\ z \\ \delta \end{pmatrix}$$

Trace Space Matrix

$$T_{drift} = \begin{pmatrix} 1 & l & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & l & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & \frac{1}{\beta_0{}^2 \gamma_0{}^2} \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Drift Matrix

# Linear Optics Simulations

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

Focusing Quadrupole Matrix

# Linear Optics Simulations

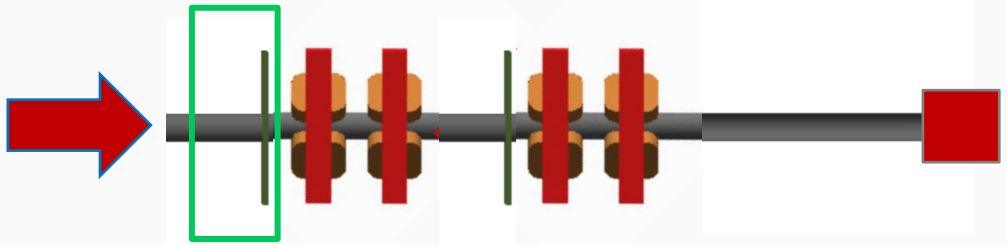
$$T_{Dquad} = \begin{pmatrix} \cosh(\sqrt{k_q \cdot l_q}) & \frac{\sinh(\sqrt{k_q \cdot l_q})}{\sqrt{k_q}} & 0 & 0 & 0 & 0 \\ \sqrt{k_q}\sinh(\sqrt{k_q \cdot l_q}) & \cosh(\sqrt{k_q \cdot l_q}) & 0 & 0 & 0 & 0 \\ 0 & 0 & \cos(\sqrt{k_q \cdot l_q}) & \frac{\sin(\sqrt{k_q \cdot l_q})}{\sqrt{k_q}} & 0 &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

Defocusing Quadrupole Matrix

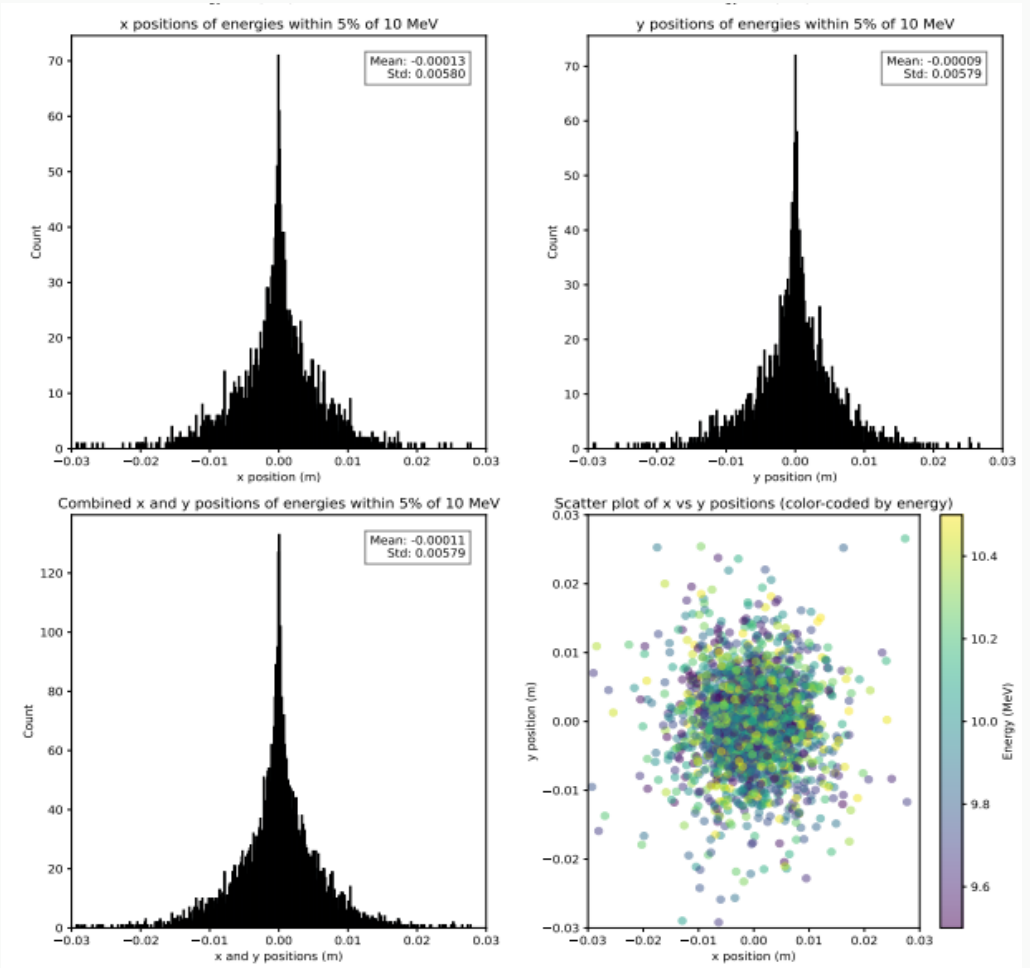
# Optimisation Step 1- Collimator 1

Mapping the positions of the particles with 10MeV (+/- 5%) at 3cm:

- Mean & std similar in x and y- use circular collimator
- 1cm radius circular aperture decided on



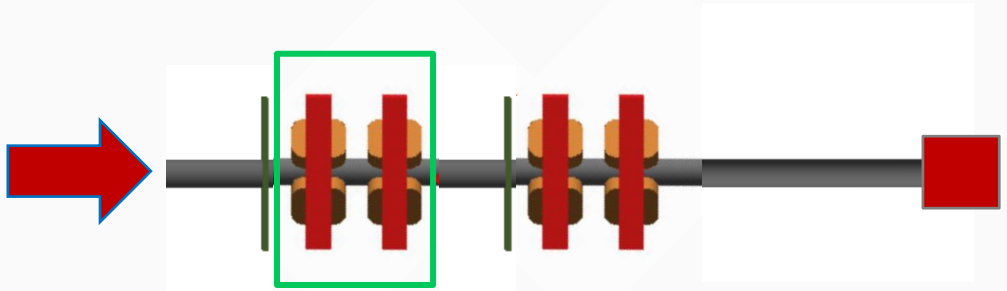
PoPLaR: Source



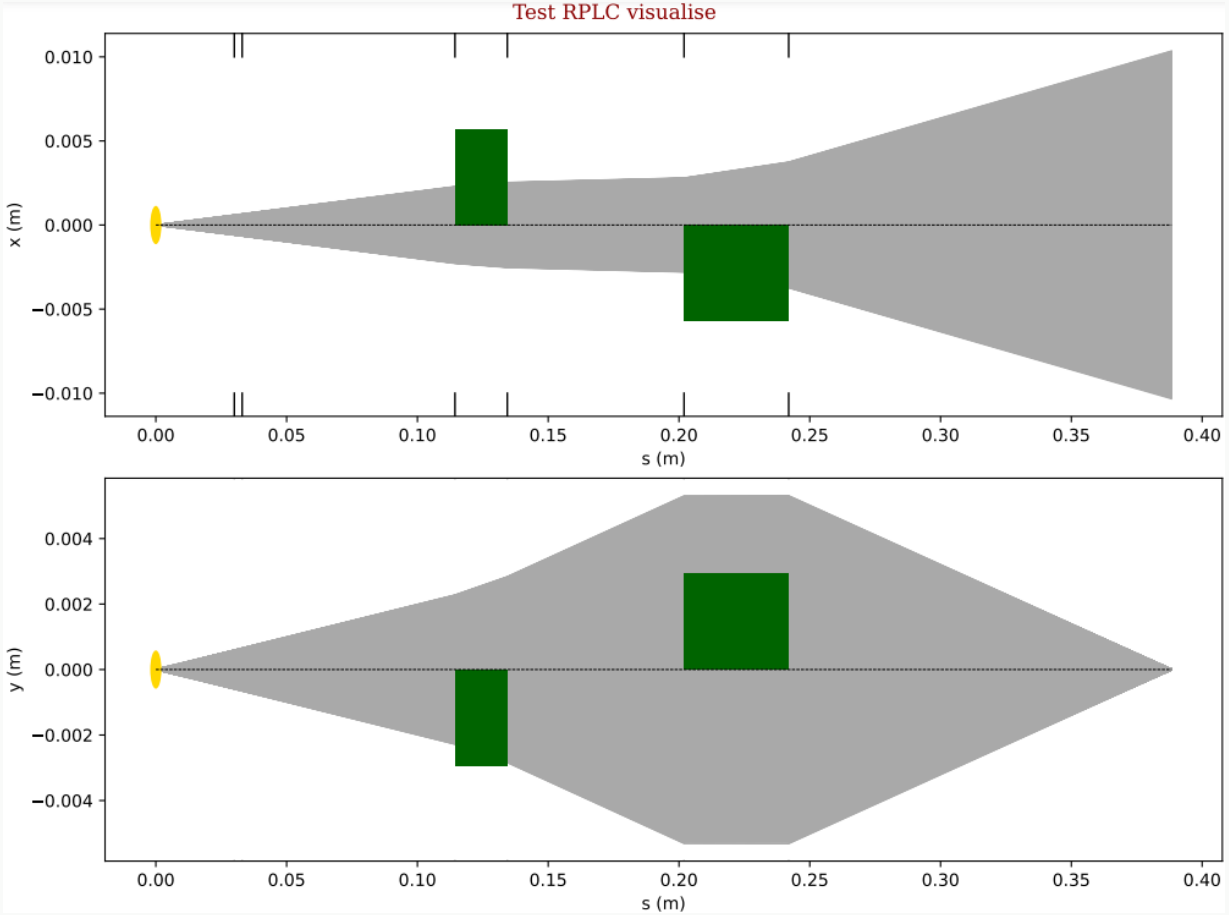
# Optimisation Step 2- Quad doublet 1

Bayesian Optimisation showed optimal positions of:

- Focus quad: 8.1cm from collimator
- Defocus quad: 6.8cm from Fquad
- Collimator 2: 14.6cm from Dquad



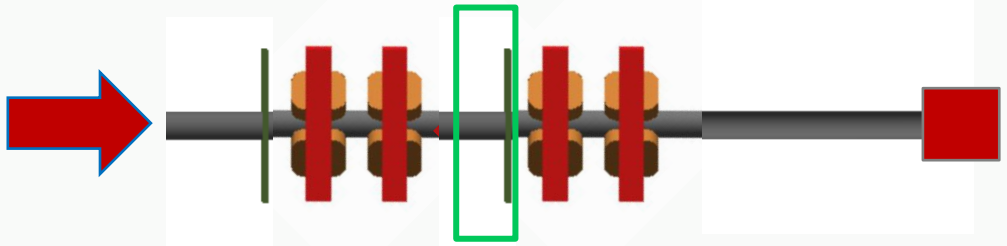
PoPLaR: Quad 2



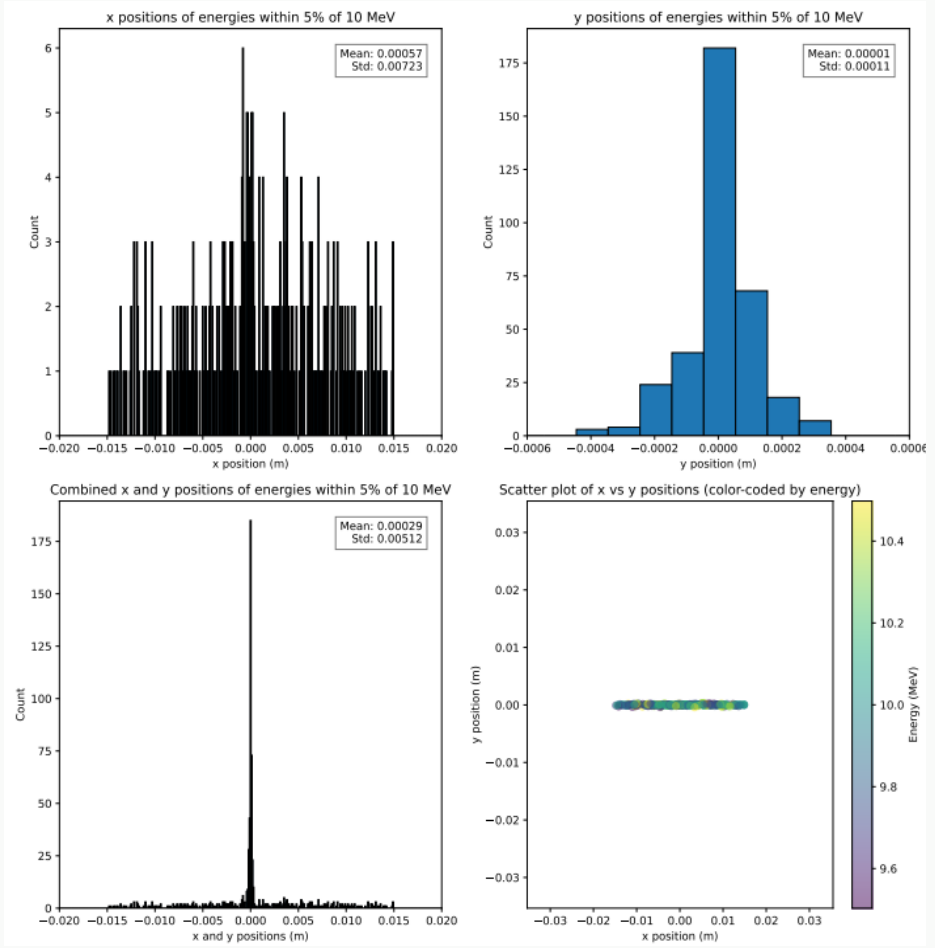
# Optimisation Step 3- Collimator 2

Mapping the positions of the particles with 10MeV (+/- 5%) collimator 2:

- 15mm x rad and 0.1mm y rad elliptical aperture decided on to begin



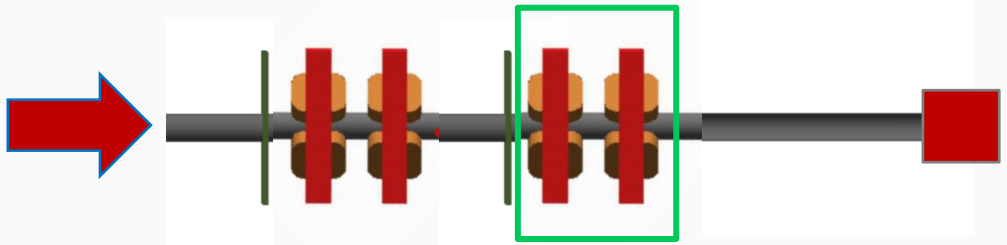
PoPLaR: Quad 2

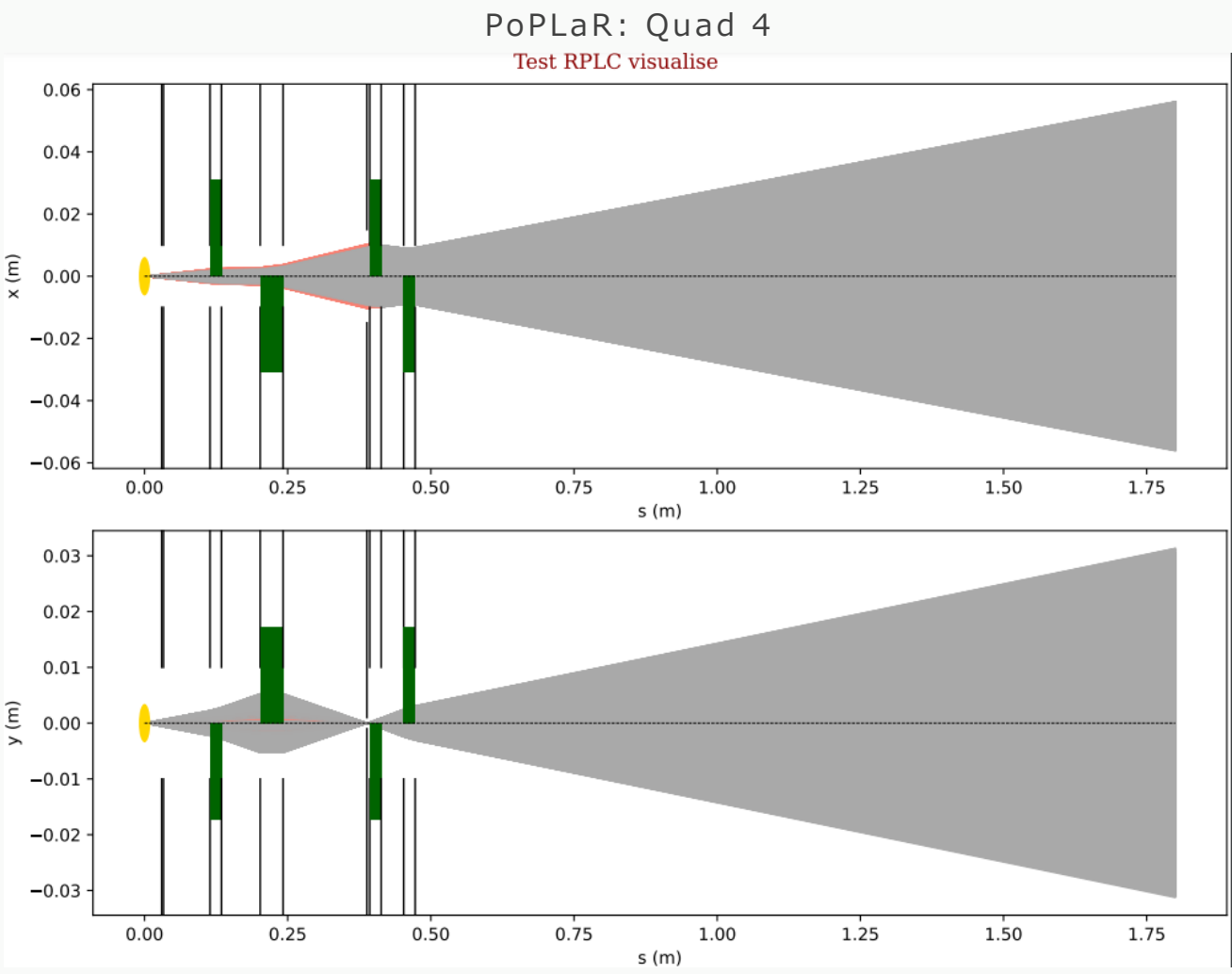


# Optimisation Step 2- Quad doublet 2

Bayesian Optimisation showed optimal positions of:

- Focus quad: 8.1cm from collimator
- Defocus quad: 6.8cm from Fquad
- Collimator 2: 14.6cm from Dquad
- Focus quad 2: 5mm from collimator
- Defocus quad 2: 3.9cm from focus quad 2
- Final drift 1.33m

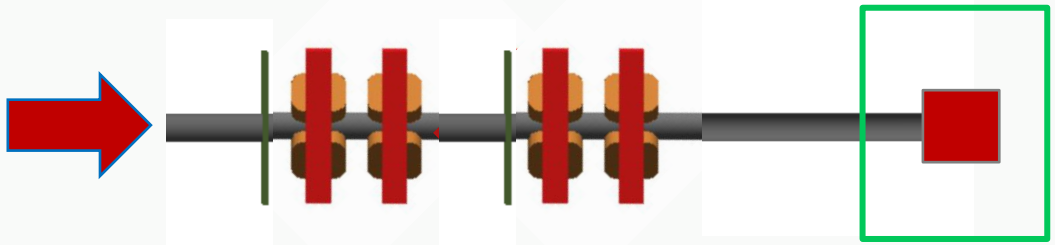


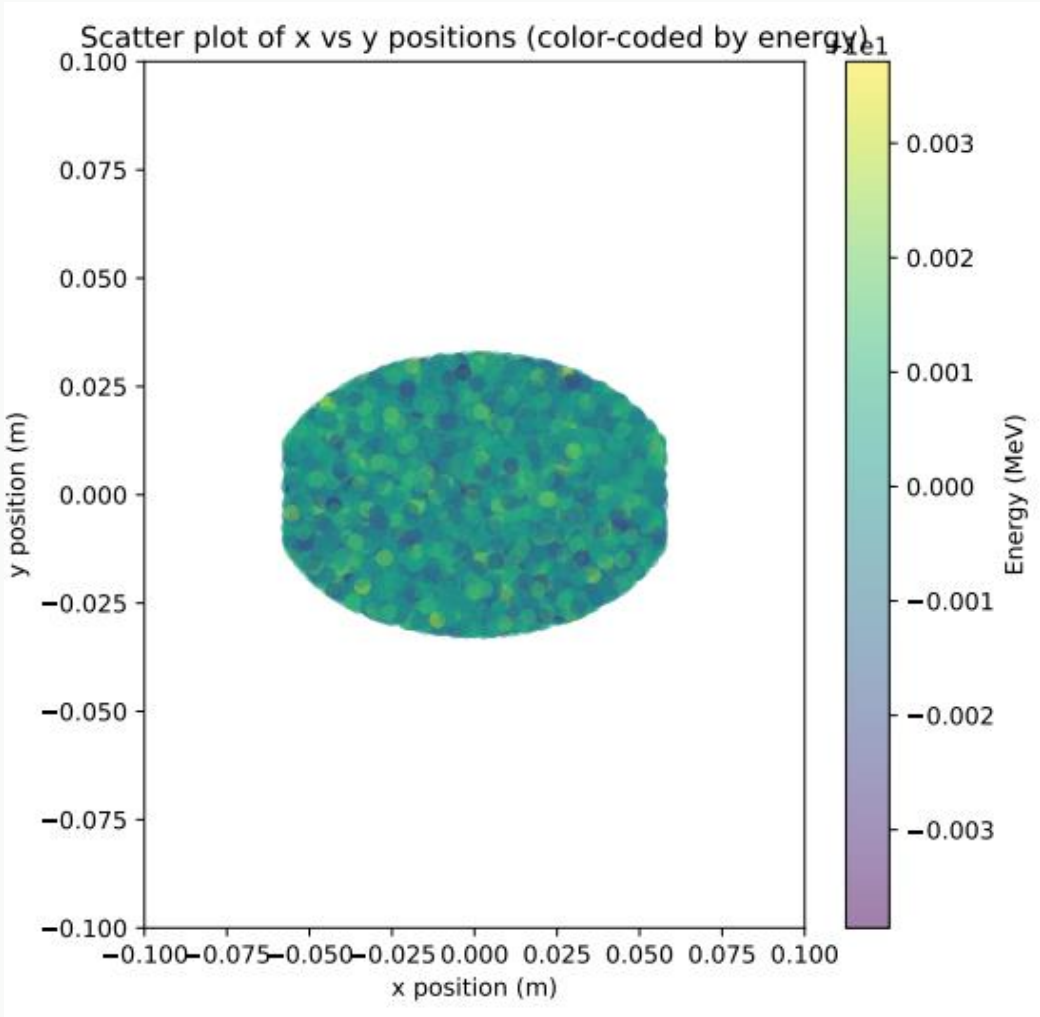


# End distribution visualisation

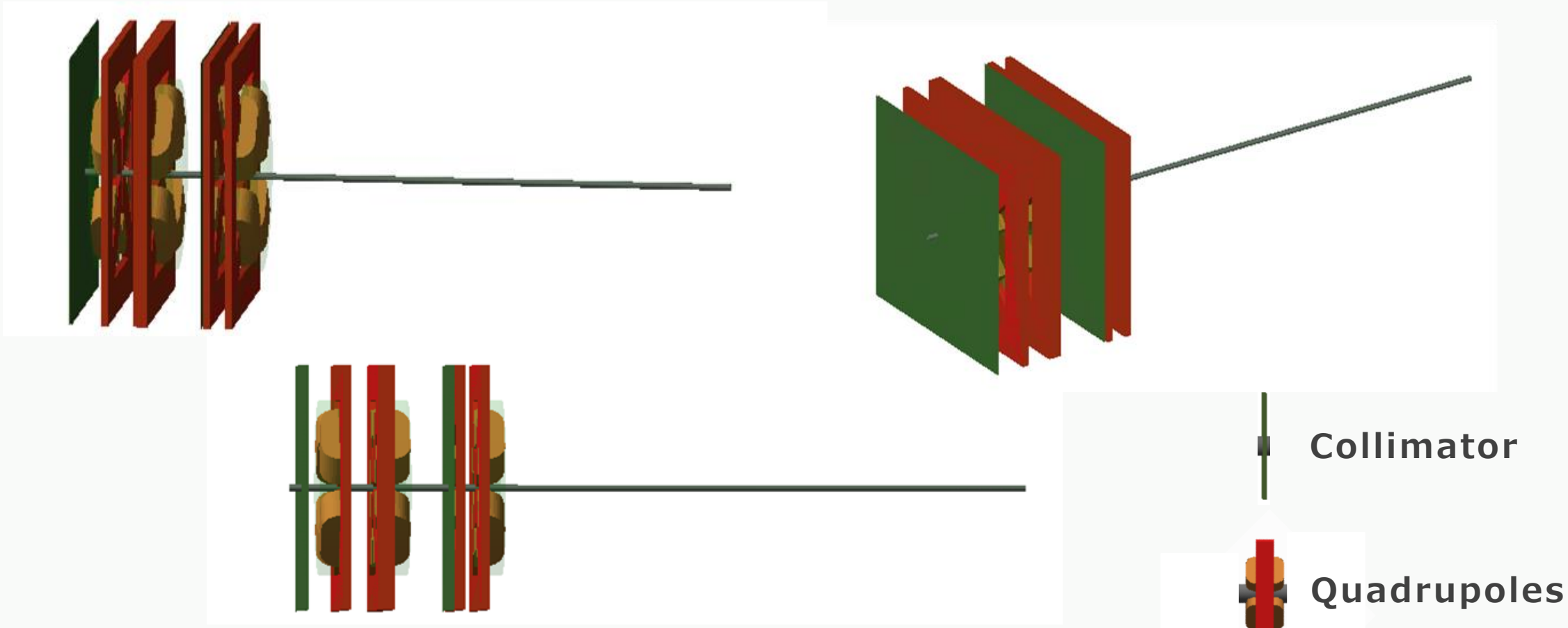
Total number of particles at the end of the line: 97670

% of particles at the end of the line: 97.67%





# BDSIM visualisation



# Next steps

- Validate with BDSIM
- Run with SCAPA laser source parameters
- Repeat for 7.5MeV, 12.5MeV and 15MeV
- Sensitivity testing
- Order quads, design/make/order collimators
- Check MF of quads
- Alignment tests at SCAPA
- Experiment!