# LhARA Collaboration Meeting

26/4/2024

# Source – Energy Distribution

| Parameters | |
|---|---|
| Laser Power [TW] | 200 |
| Laser Energy [J] | 5 |
| Laser Intensity [W/cm$^2$] | 4x10$^{20}$ |
| Laser Wavelength [nm] | 800 |
| Pulse Duration [fs] | 28 |
| Foil target thickness [nm] | 400-600 |

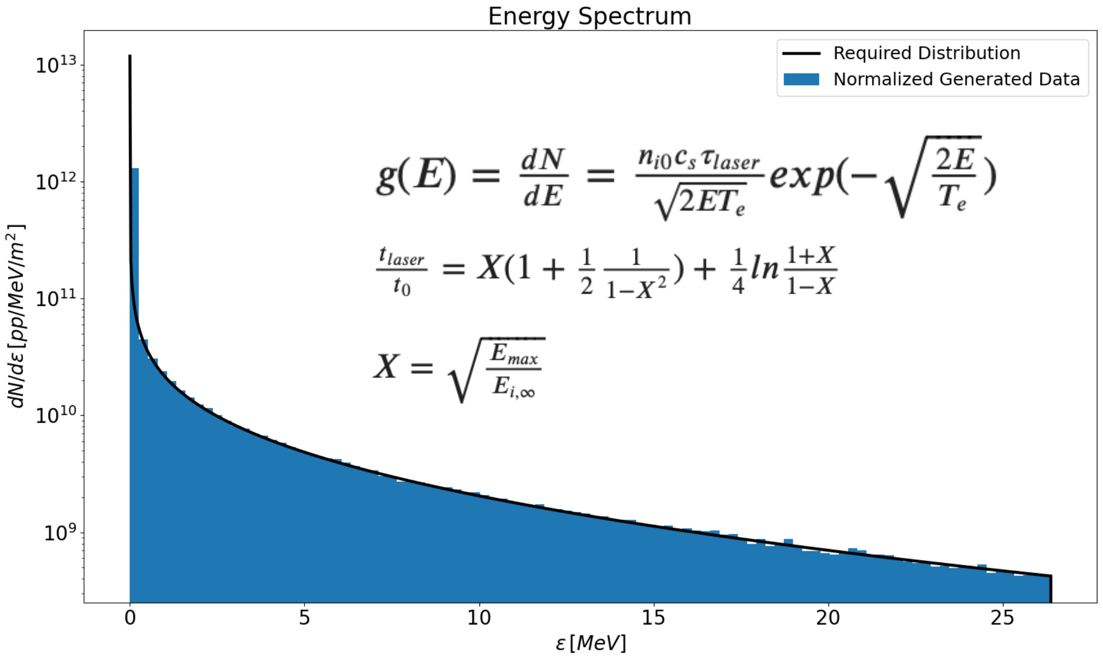



Figure 1: Normalized energy distribution of the laser-driven protons created at the LION beamline.

# Source – Angular Distribution

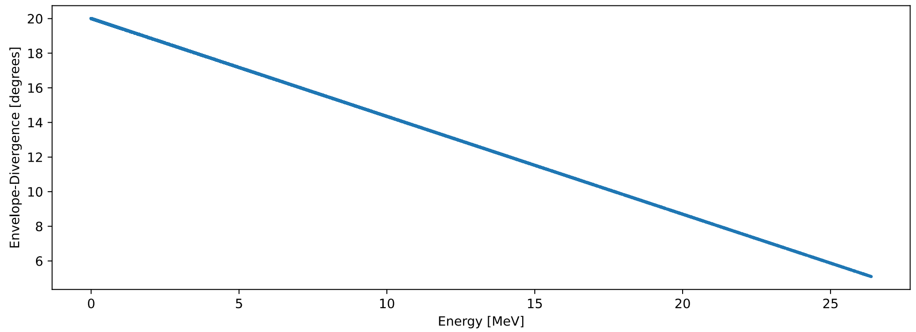



Figure 2: Energy dependent envelope divergence.

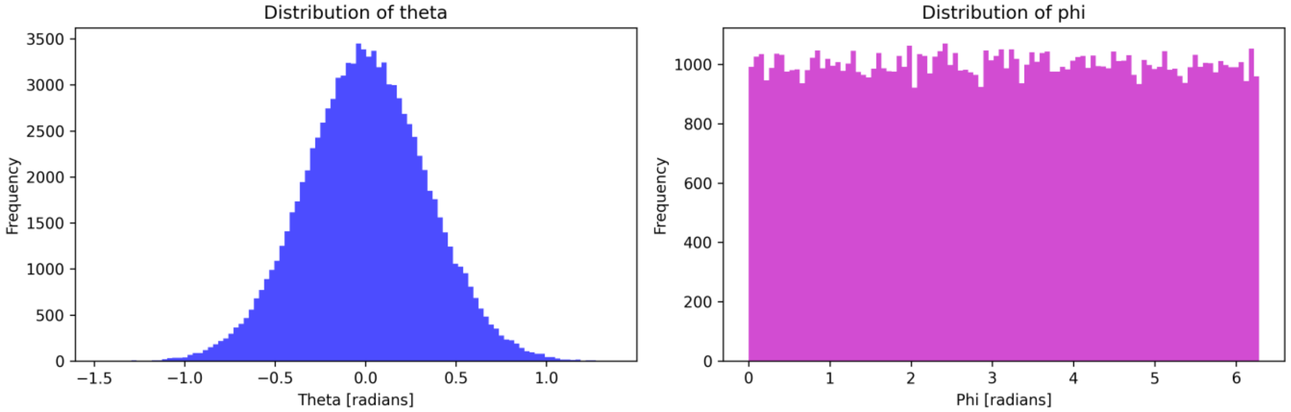



Figure 3: Angular distribution of the laser-driven protons at the LION beamline source.

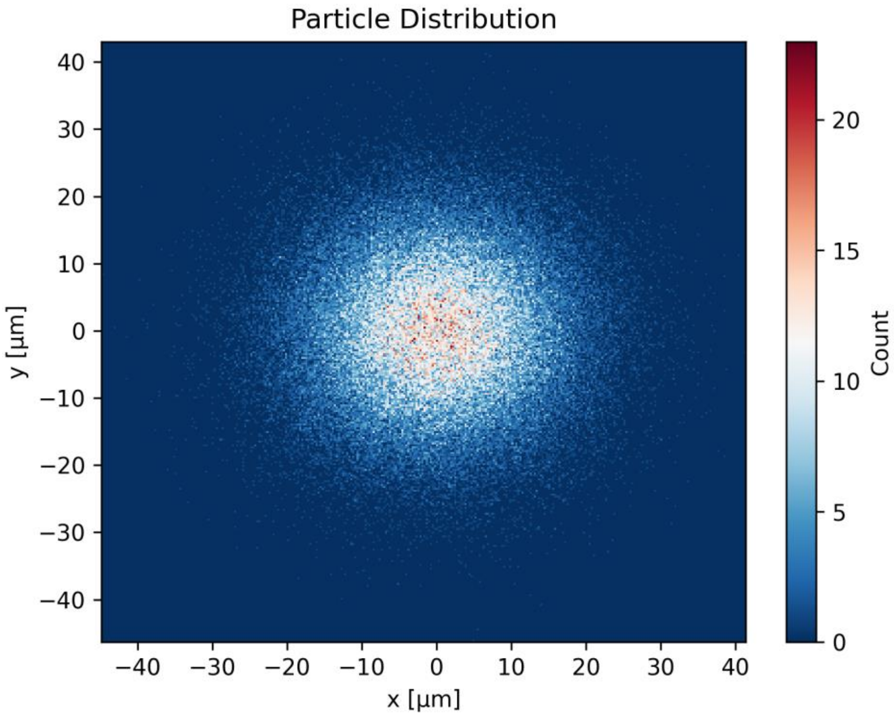



Figure 4: 2D angular distribution of 100000 protons at the source.

# LION Beamline - BDSIM

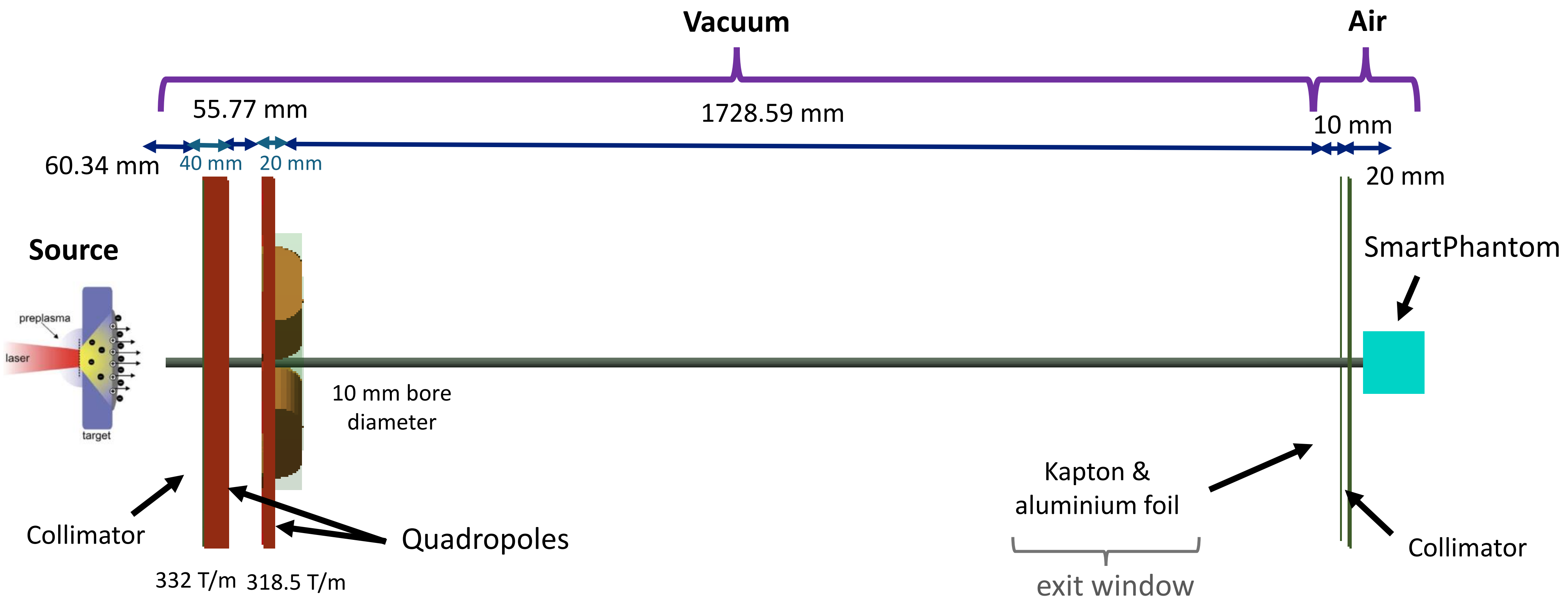



Figure 5: Side-on view of LION beamline in BDSIM.

# Proton Beam

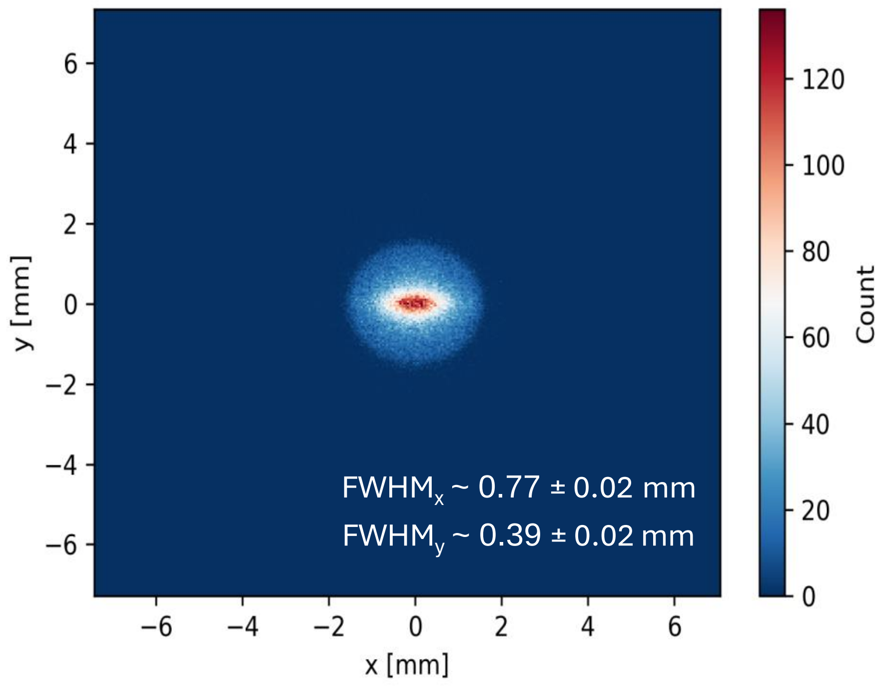



Figure 6: Spot size at the focus of the LION beamline.

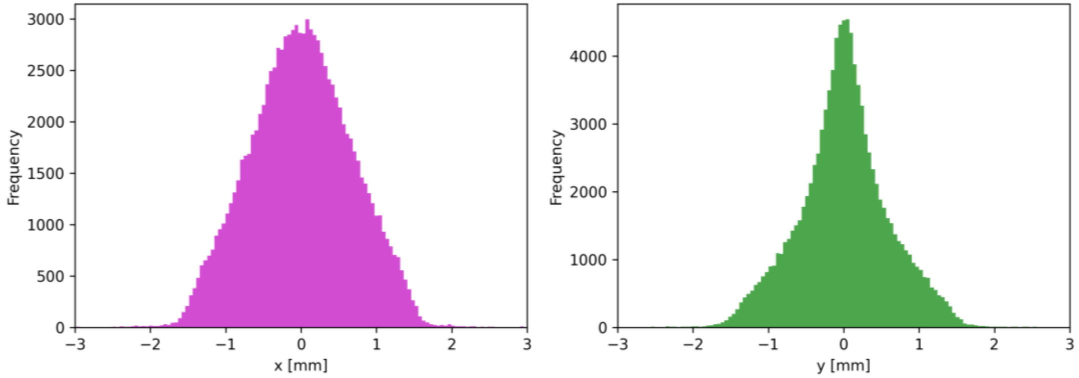



Figure 7: Distribution of particles at the focus.

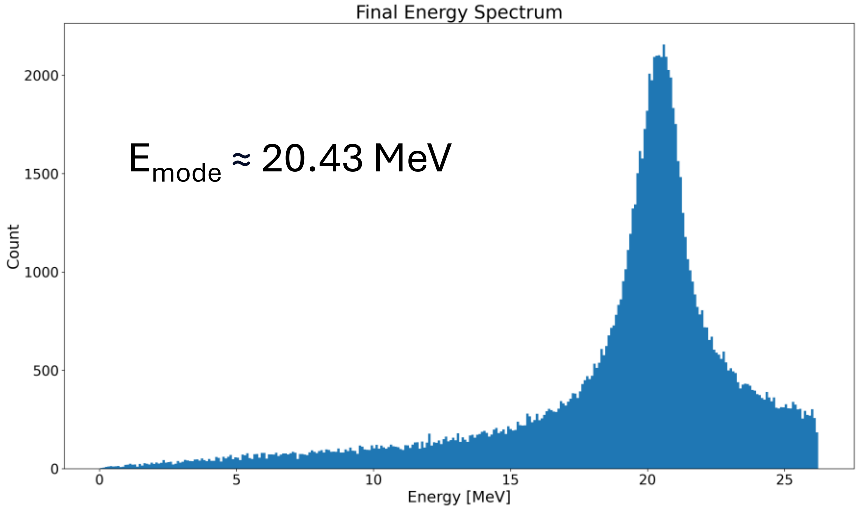



Figure 8: Energy spectrum of the particles at the focus.

# Electrons at the Source

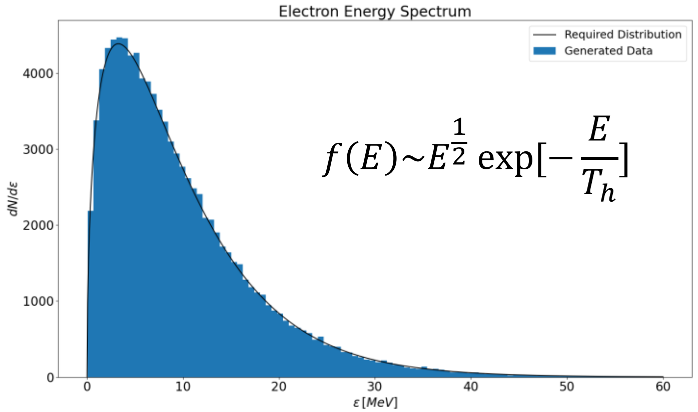



Figure 9: Energy distribution of the source-generated electrons.

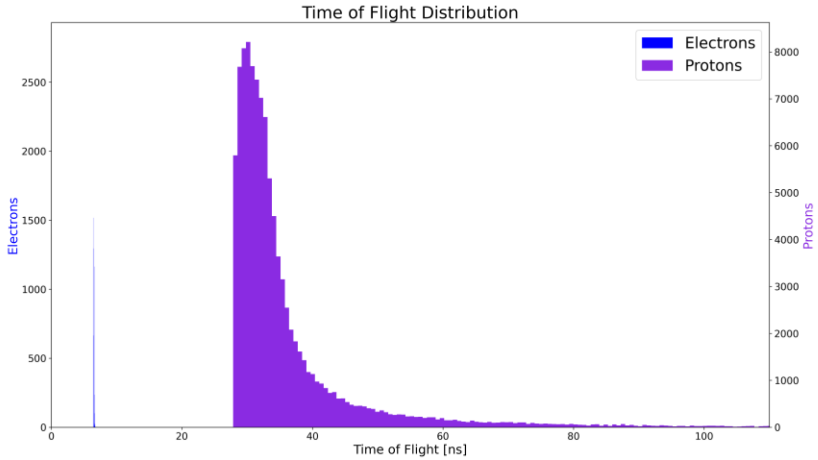



Figure 11: Time of flight of source generated electrons and protons.

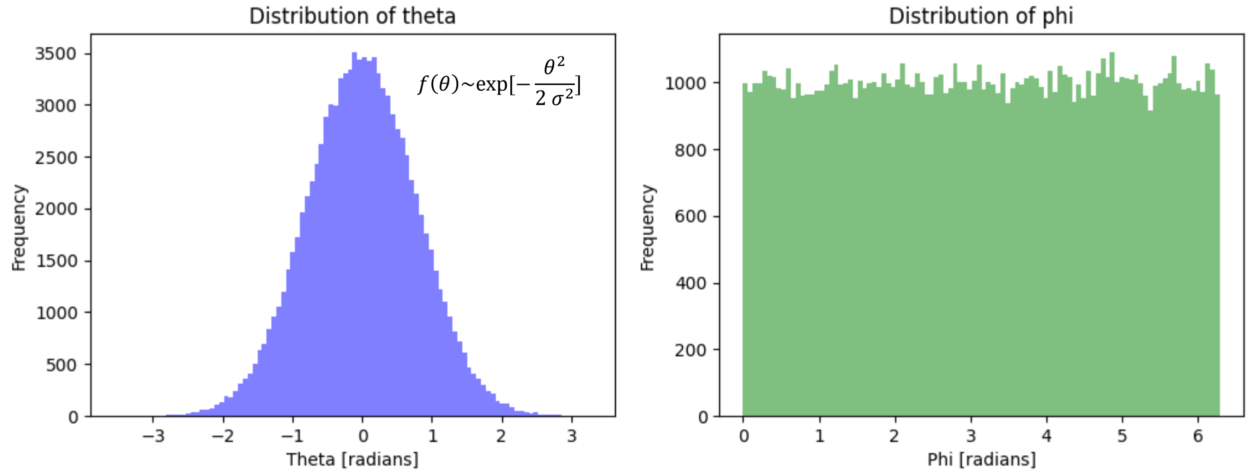



Figure 10: Angular distribution of the electrons.

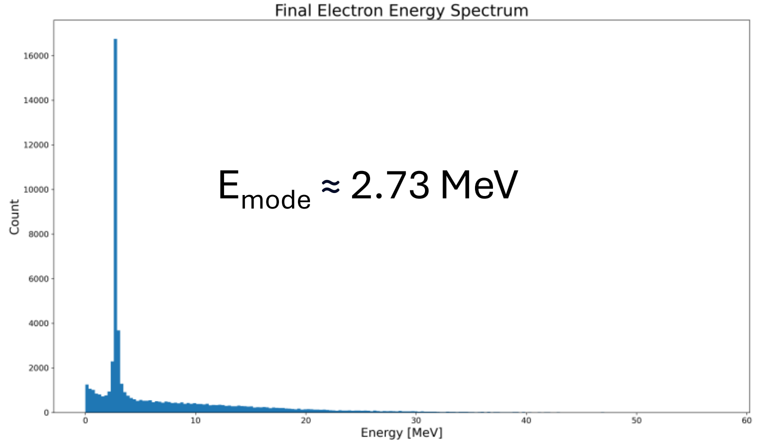



Figure 12: Energy spectrum of the electrons at the end of the LION beamline.

# SmartPhantom

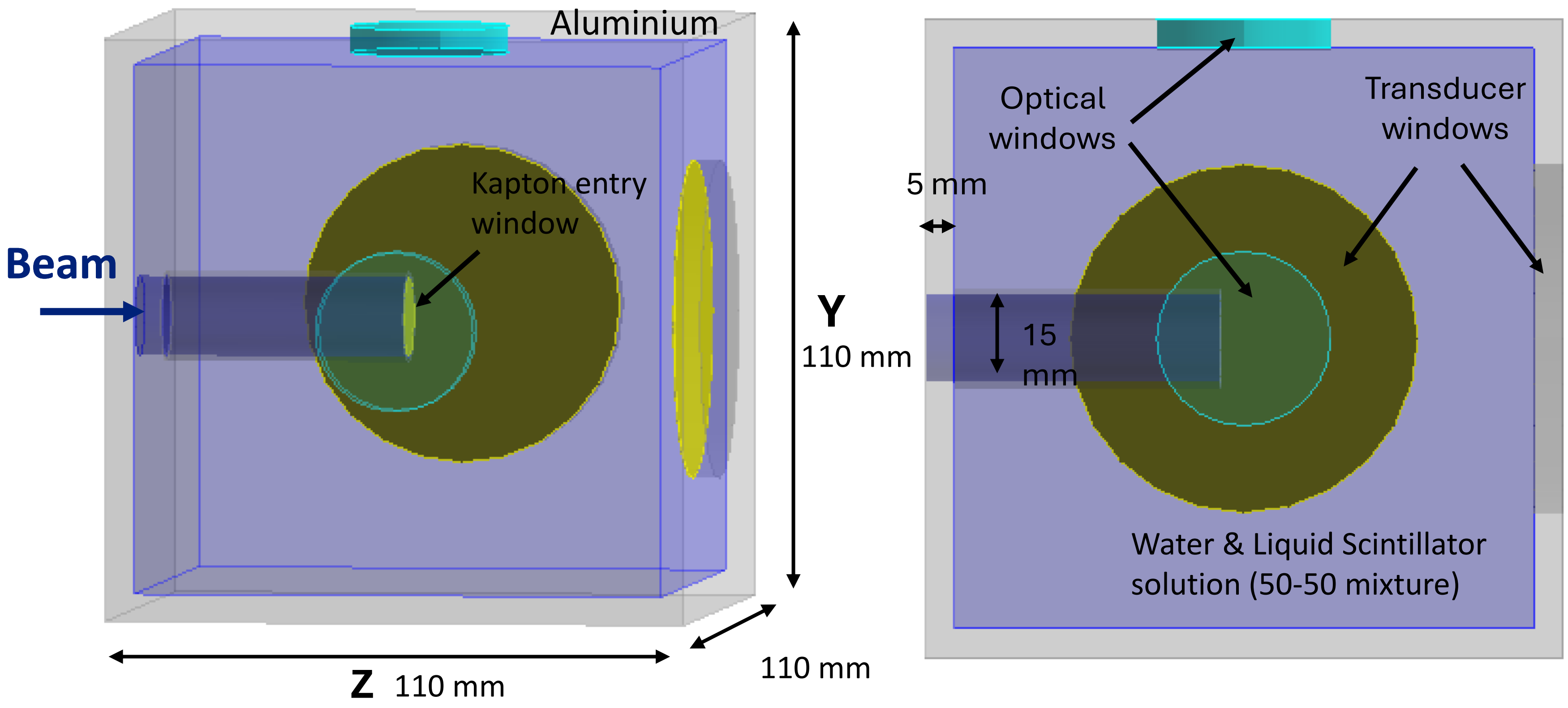



Figure 13: Geant4 simulation of the SmartPhantom. Angled view (left), cross-section view (right).

# Liquid Scintillator

## Ultima Gold XR

| Component | Name | Composition [weight %] |
|---|---|---|
| Solvents | di-isopropyl naphthlene (DIP) | 40-60 |
| | ethoxylated alkylphenol | 20-40 |
| | bis(2-ethylhexyl) hydrogen phosphate | 2.5-10 |
| | triethyl phosphate | 2.5-10 |
| | Sodium di-octylsulphosuccinate | 2.5-10 |
| | 3,6-dimethyl-4octyne-3,6-diol | 1.0-2.5 |
| Scintillators | 2,5 diphenyloxazole (PPO) | 1-1.0 |
| | 1,4-bis (2-methylstyryl)-benzene (Bis-MSB) | 0-1.0 |

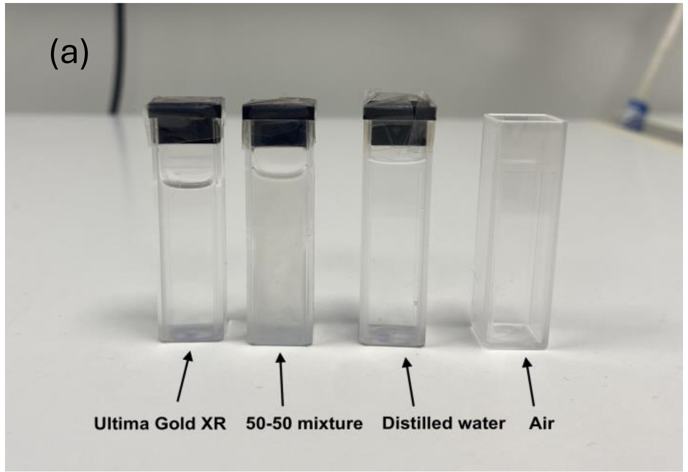
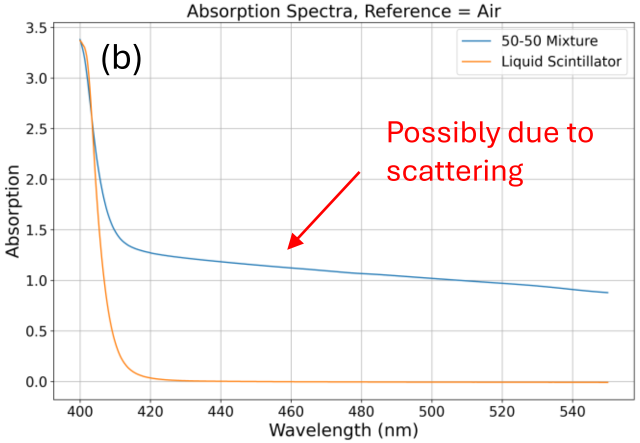
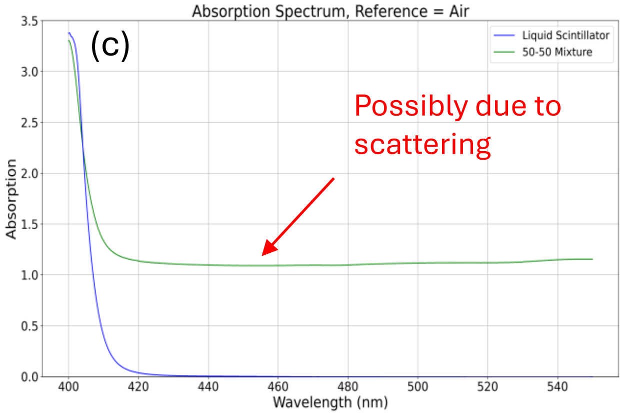
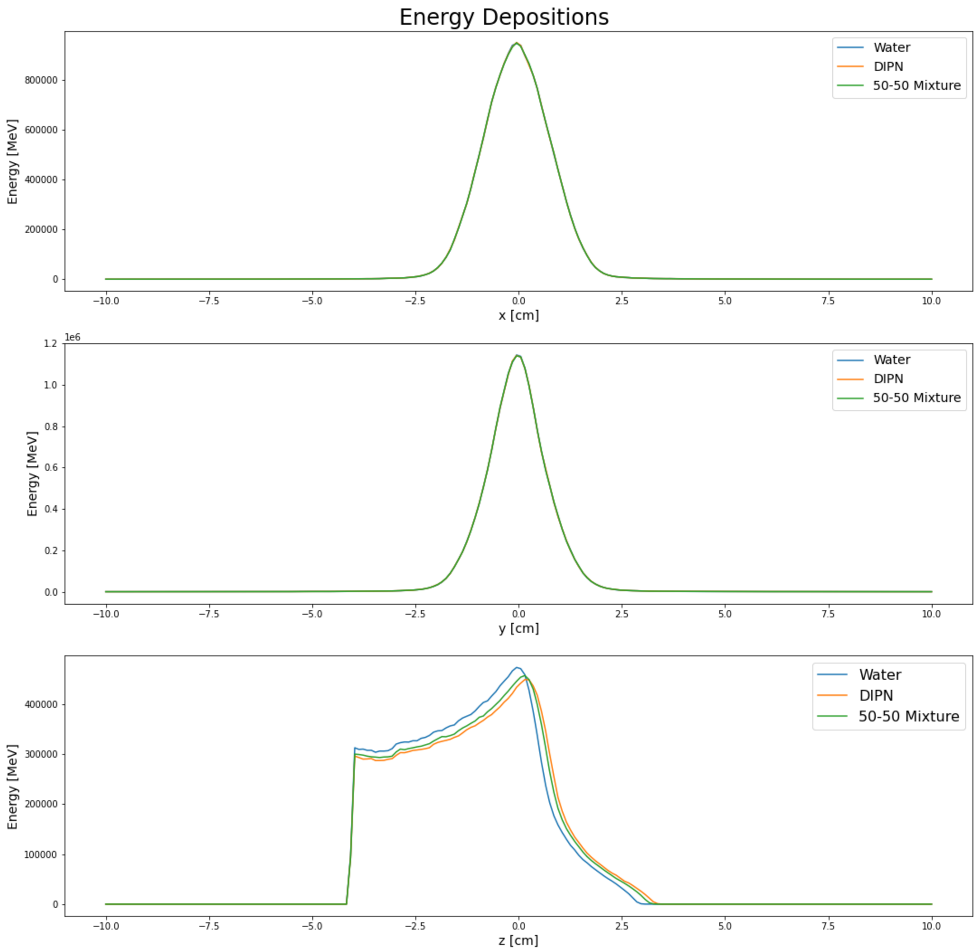



Figure14: Liquid scintillator absorbance measurement. (a) Solutions (b) & (c) Results.



# Energy Depositions



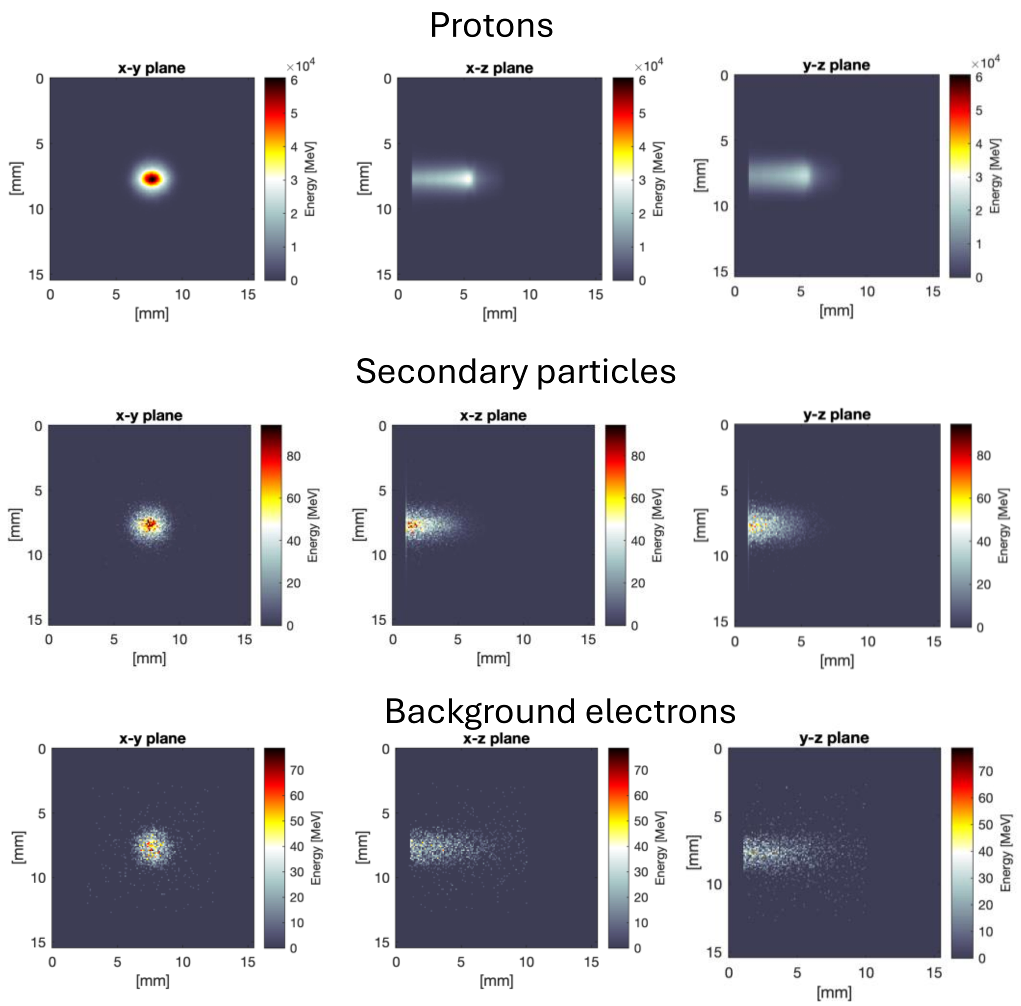




Figure 15: Binned energy depositions of the LION beam (1e6 protons).

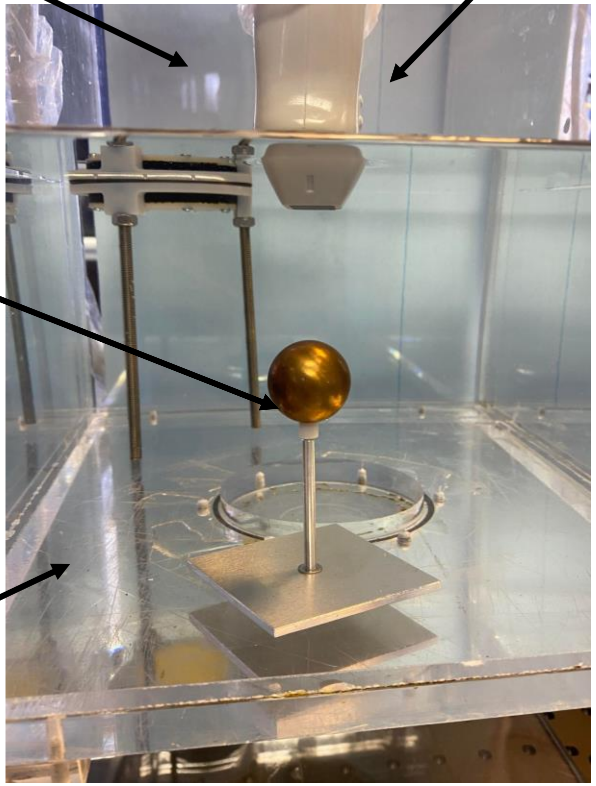
# 50µm Kapton Acoustic Transmission

Air

Matrix array transducer

2.5 cm bronze ball bearing

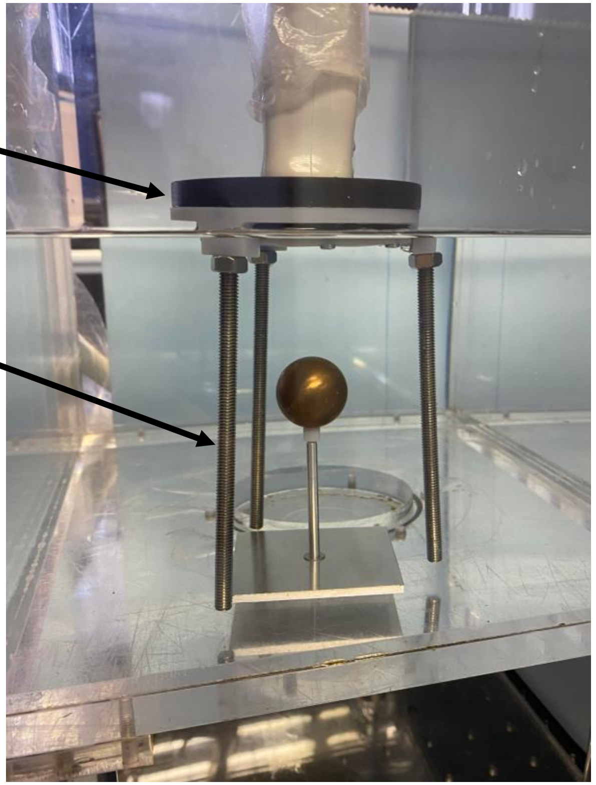
Water



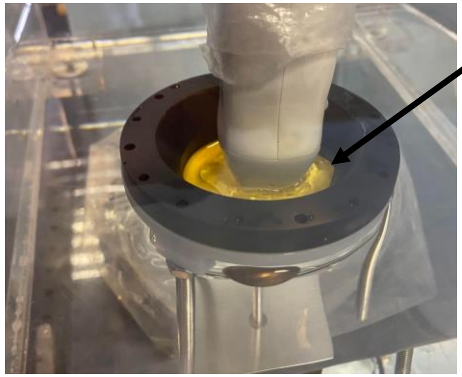
**Experiment 1**

Kapton window

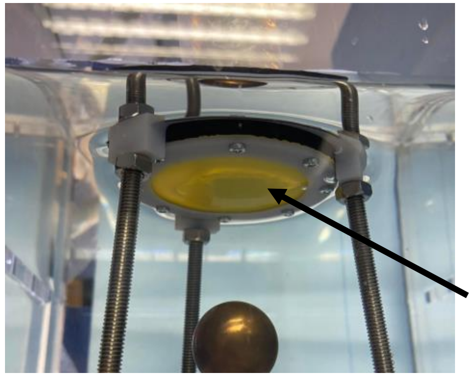
Tripod



Acoustic gel

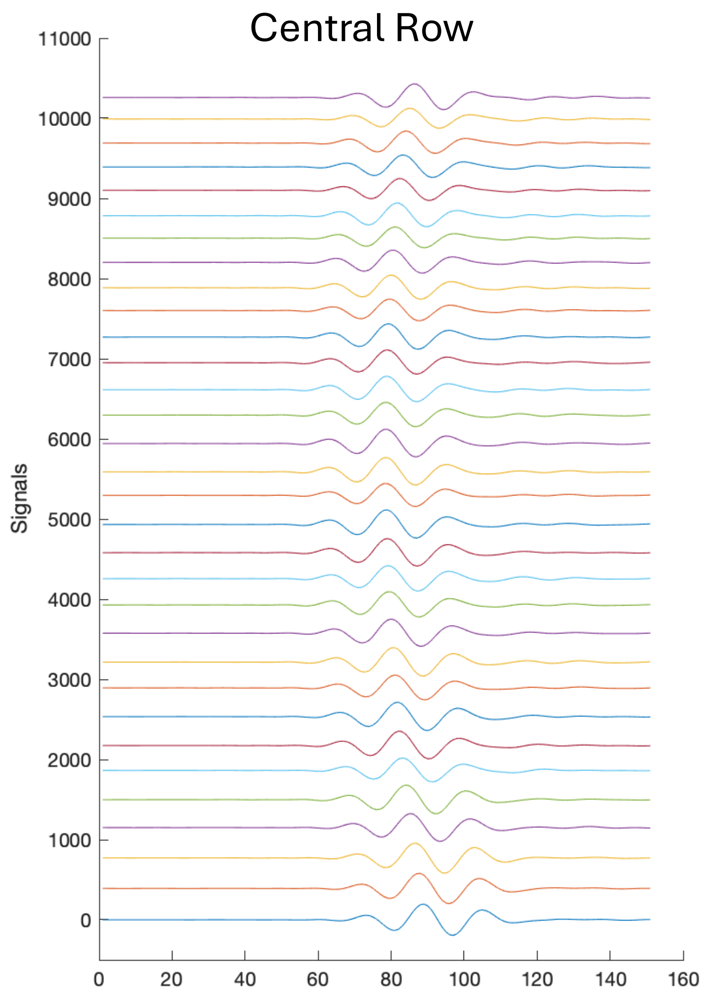


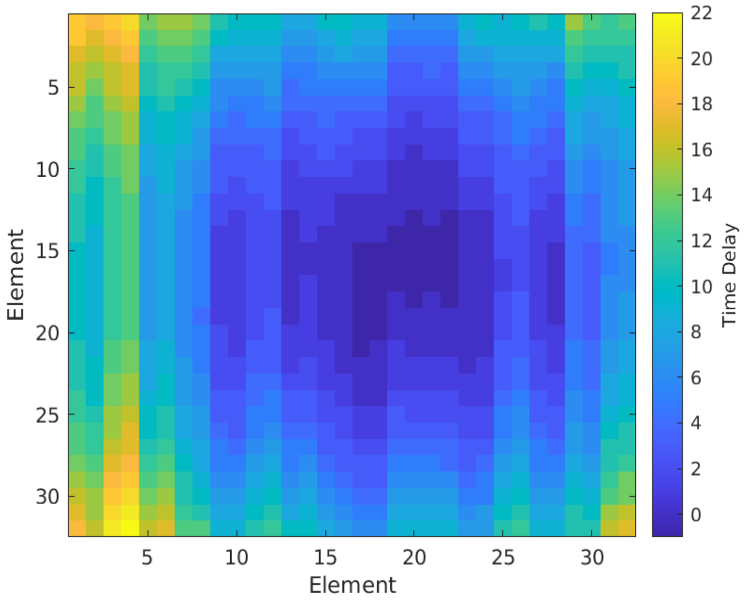
Kapton foil

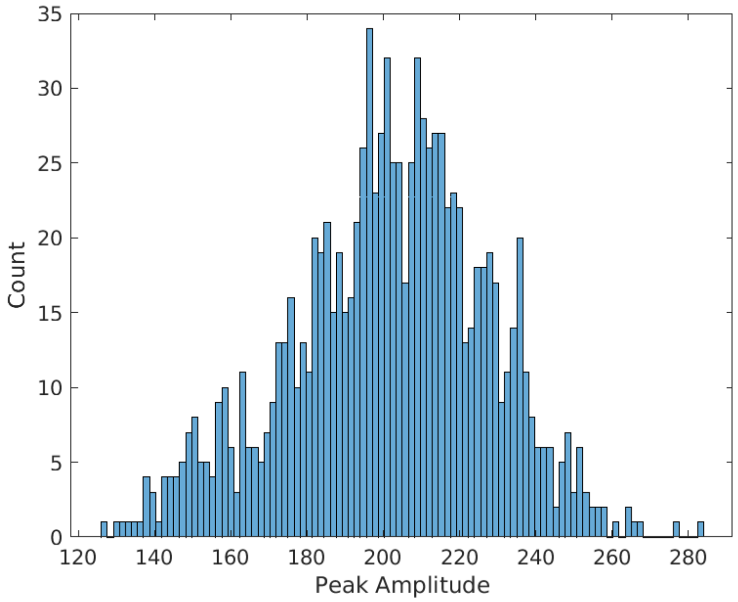


**Experiment 2**

# 50μm Kapton Acoustic Transmission

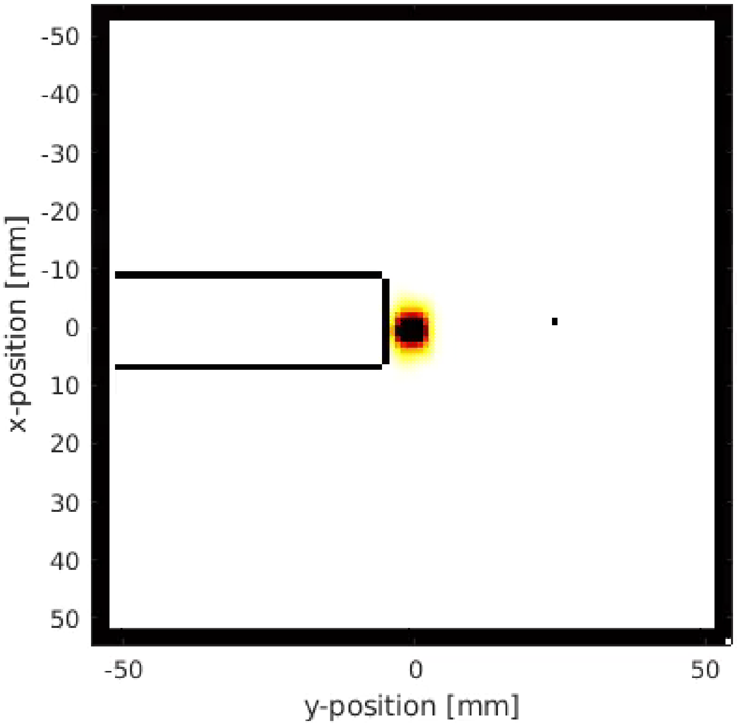


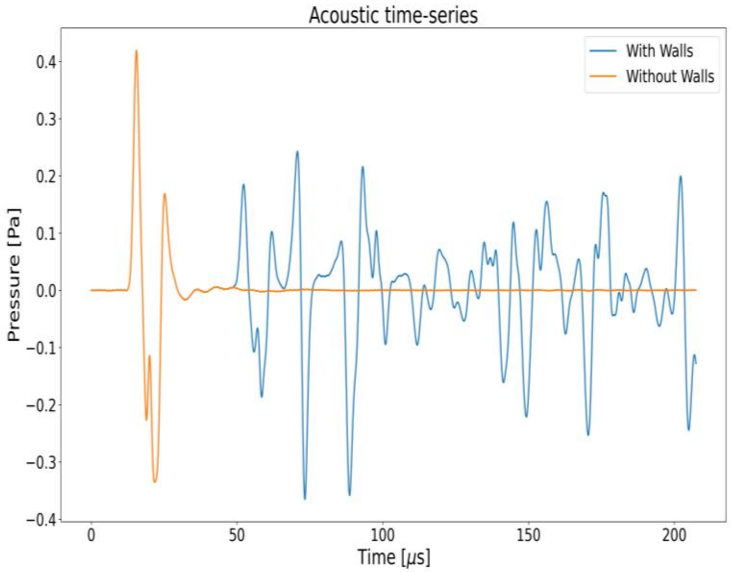



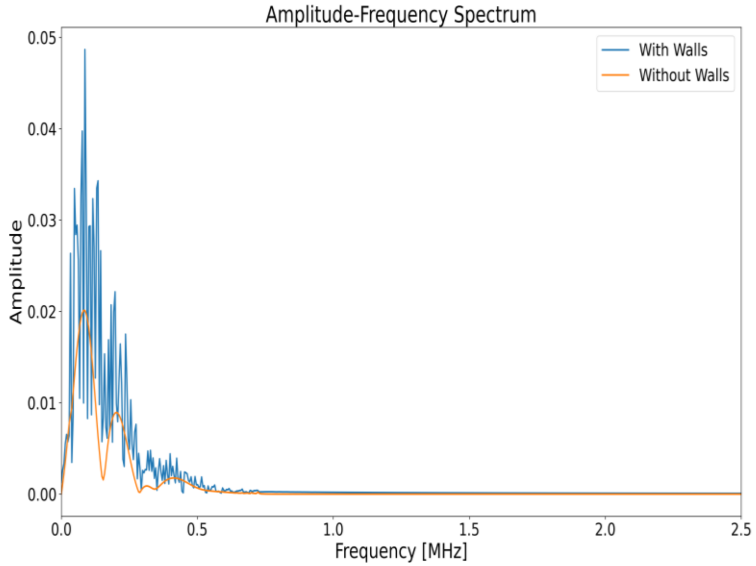




$$\text{loss\_dB} = 20 \times \log_{10}\left(\frac{\text{average\_kapton\_amplitude}}{\text{average\_water\_amplitude}}\right)$$

# SmartPhantom: Aluminium Walls



# Ultrasound Transducers

## Matrix Array

| | |
|---|---|
| Center Frequency | 3.5 MHz |
| Bandwidth | 60% |
| Elements | 1024 (32x32) |
| Pitch | 0.3 mm |

## Linear Array

| | |
|---|---|
| Center Frequency | 5.3 MHz |
| Bandwidth | 75% |
| Elements | 192 (192x1) |
| Pitch | 0.23 mm |

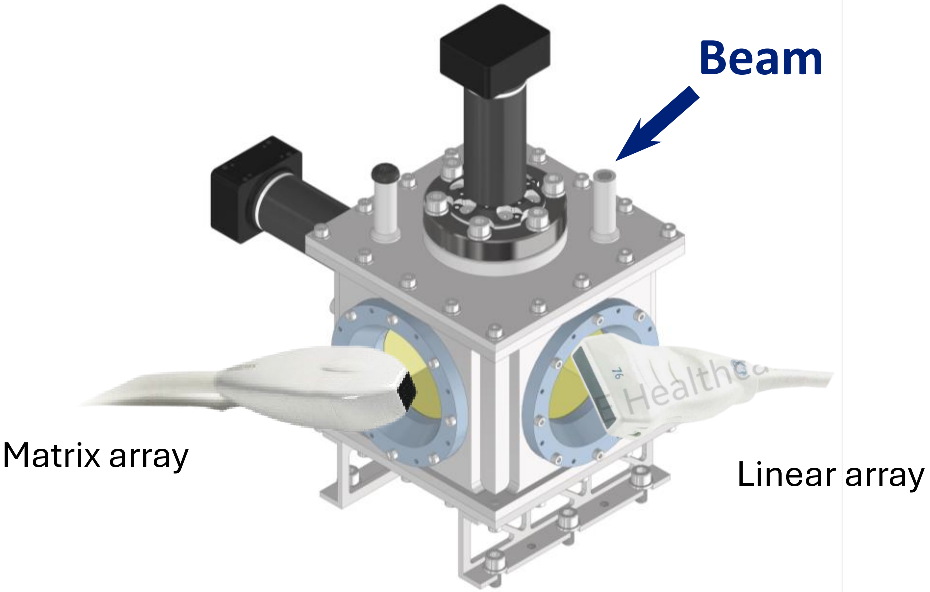
## Olympus V303 Transducer

| | |
|---|---|
| Center Frequency | 1 MHz |
| Bandwidth | 80% |
| Elements | 1 |
| Pitch | - |

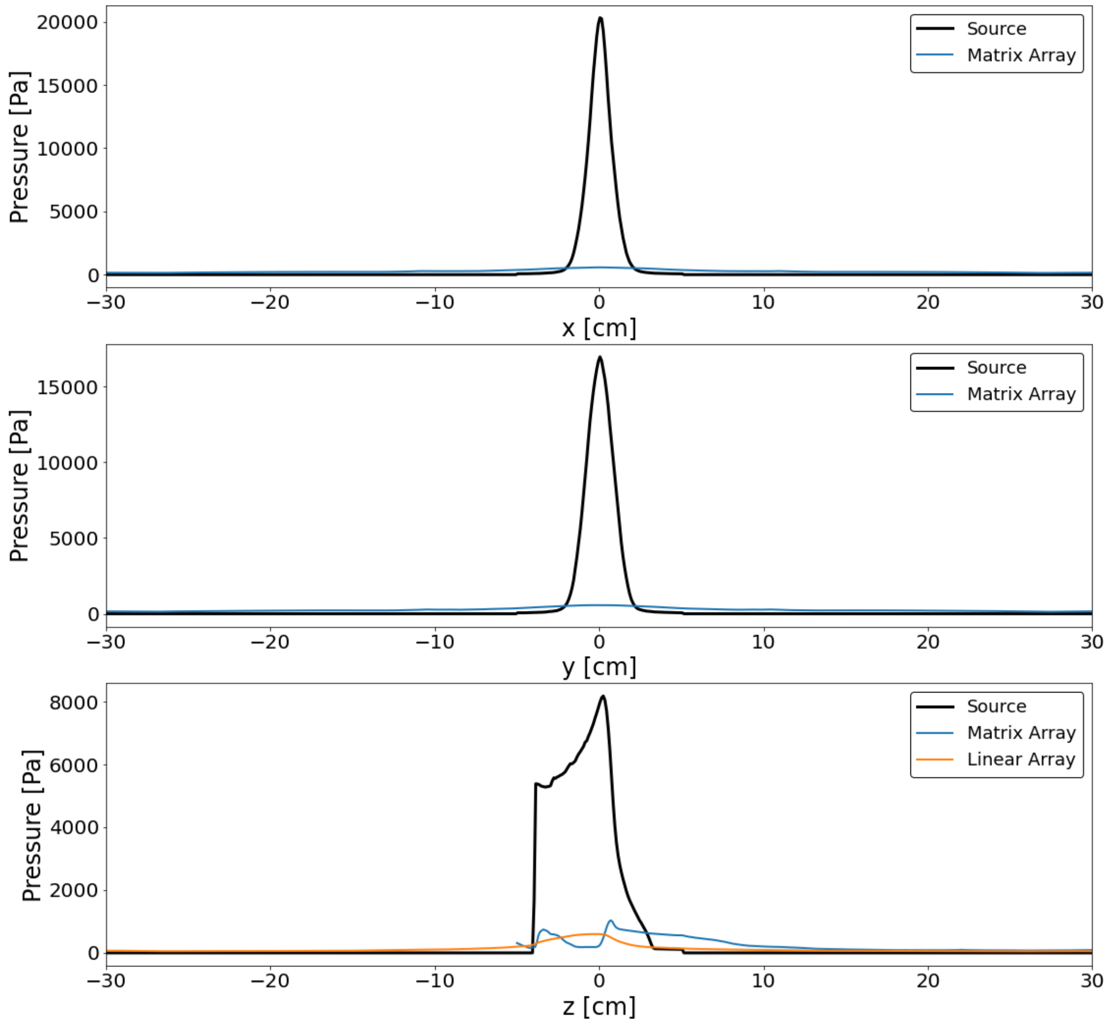
## PA Piston Hydrophone

| | |
|---|---|
| Center Frequency | 0.1 - 1 MHz |
| Bandwidth | ? |
| Elements | 1 |
| Pitch | - |

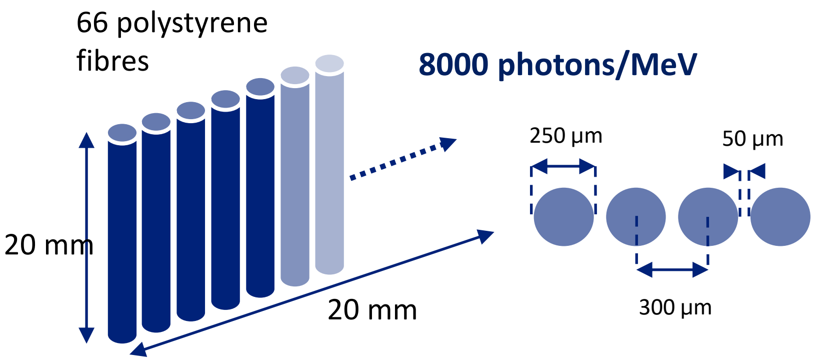
# Image Reconstruction

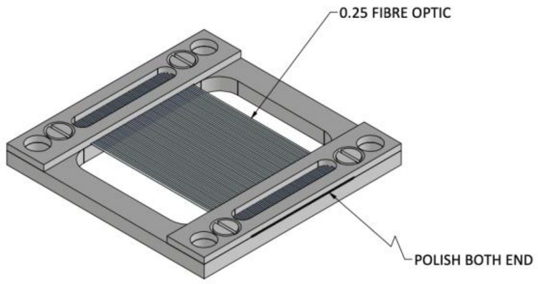



Time-Reversal Algorithm



# Scintillating Fibre Planes



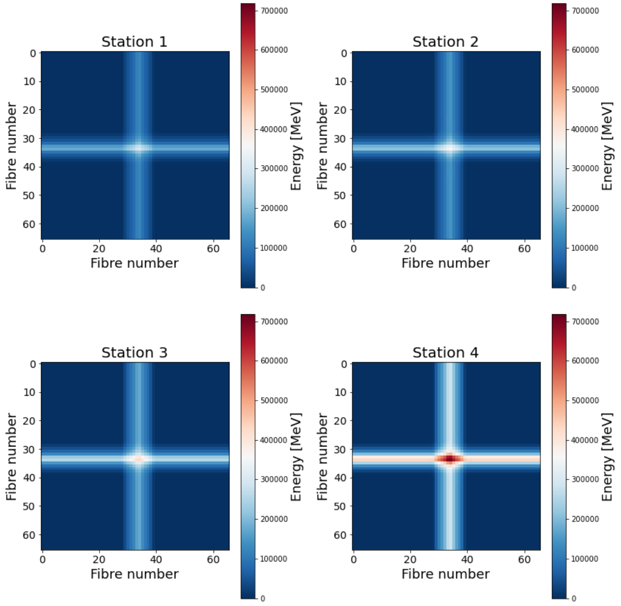




Figure 17: 2D reconstruction with the scintillating fibres at each station location.

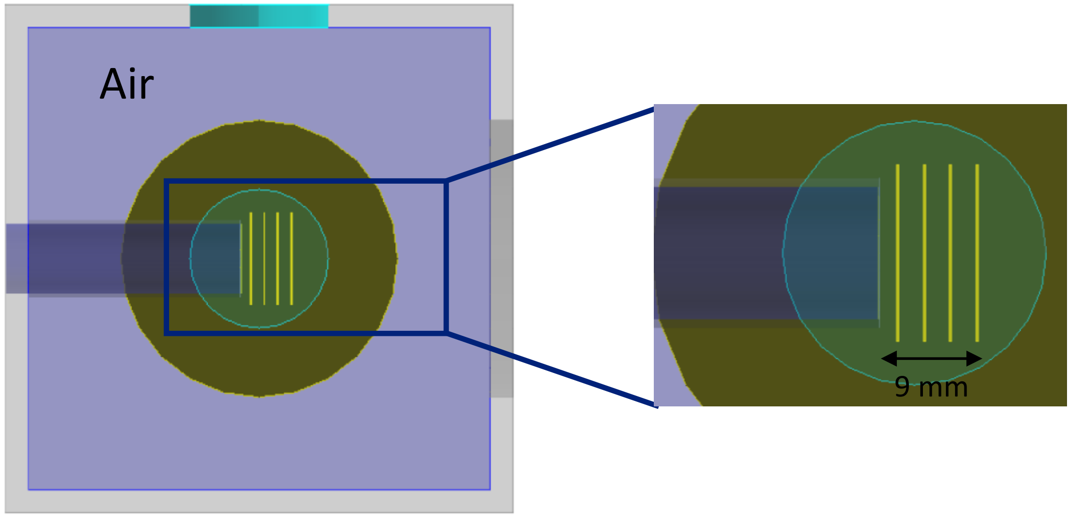
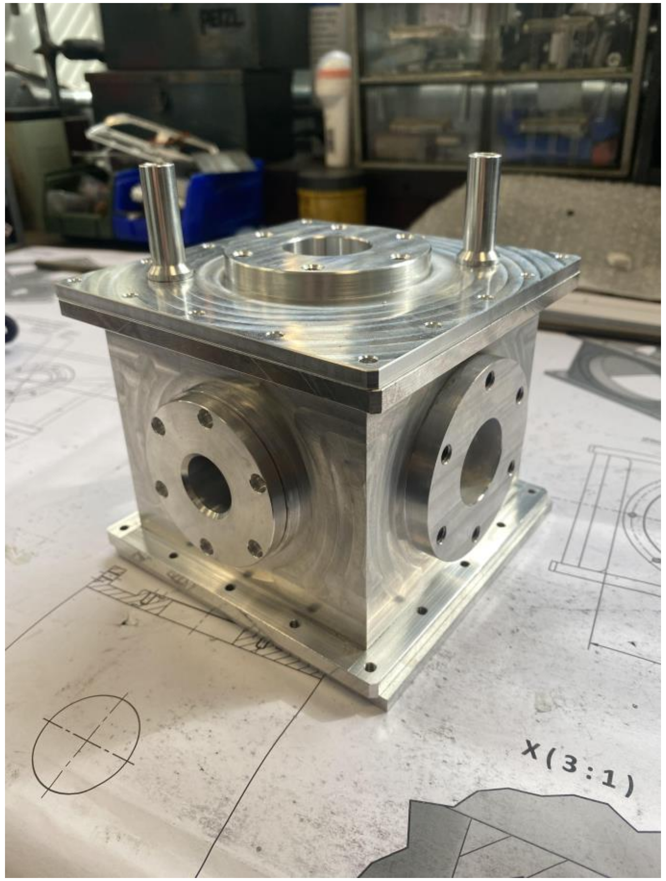
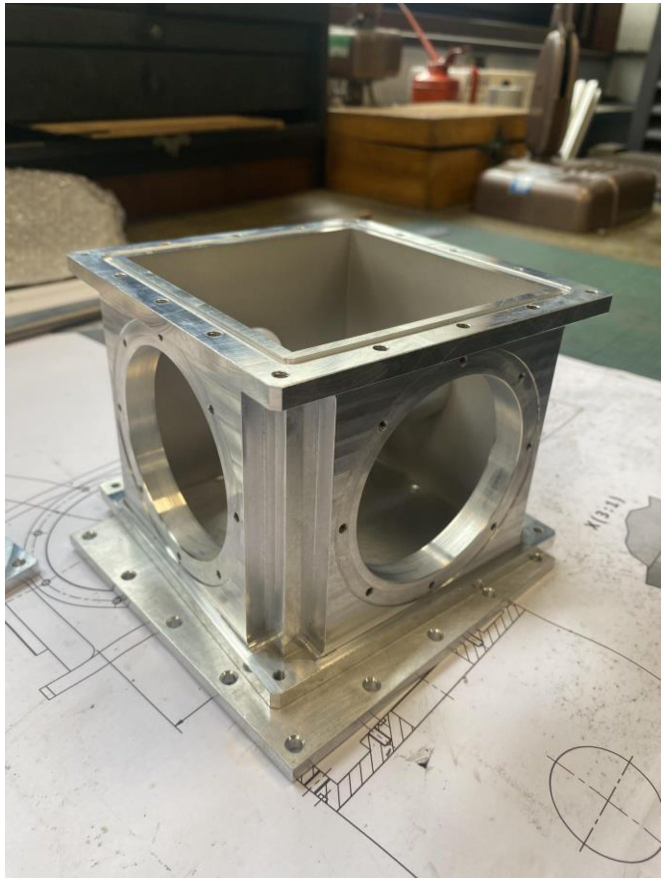


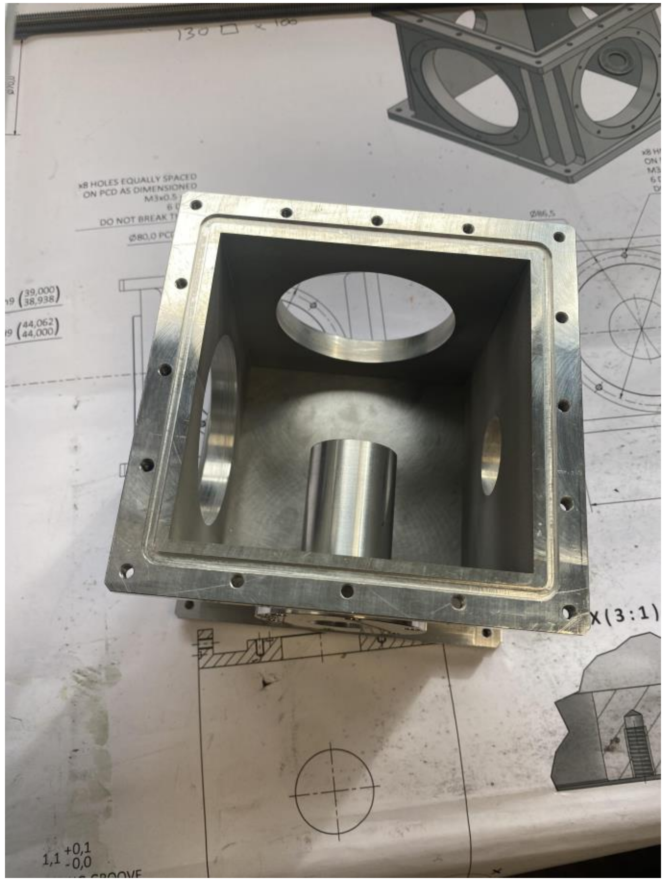

Figure 16: Scintillating fibre plane stations (green) in the Geant4.

Figure 18: Scintillating fibre plane detectors built in the lab.

# SmartPhantom: Current Status





# Future Work

- K-Wave simulations
- Scintillating fibre detector characterization
- Liquid scintillator & scintillating fibre detectors saturation measurement
  **25-26 June Birmingham**
- Optimize the optical system
- Rehearsal experiments