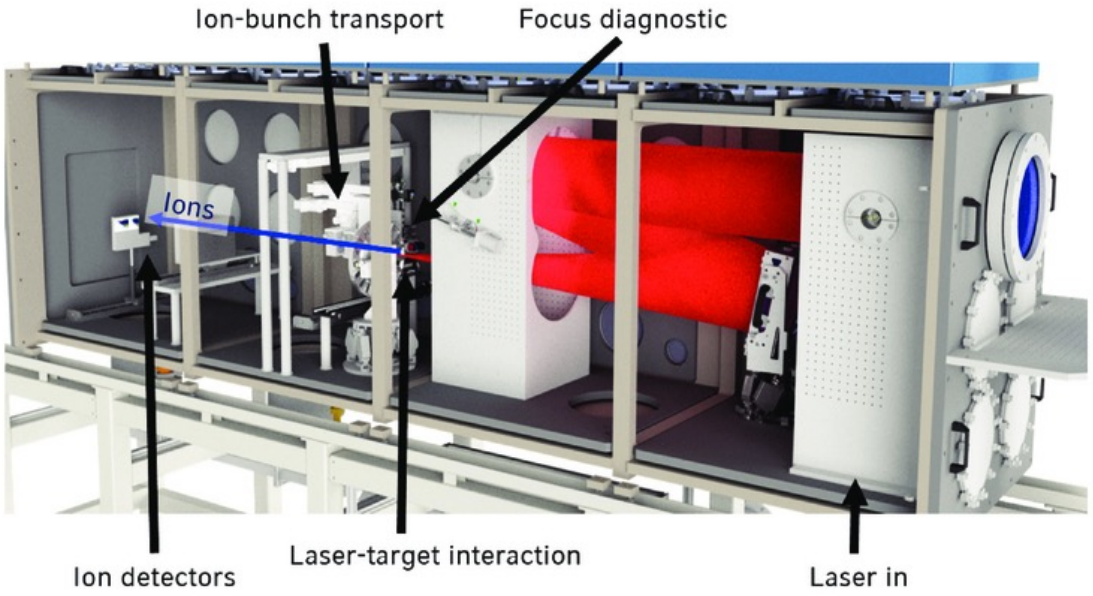
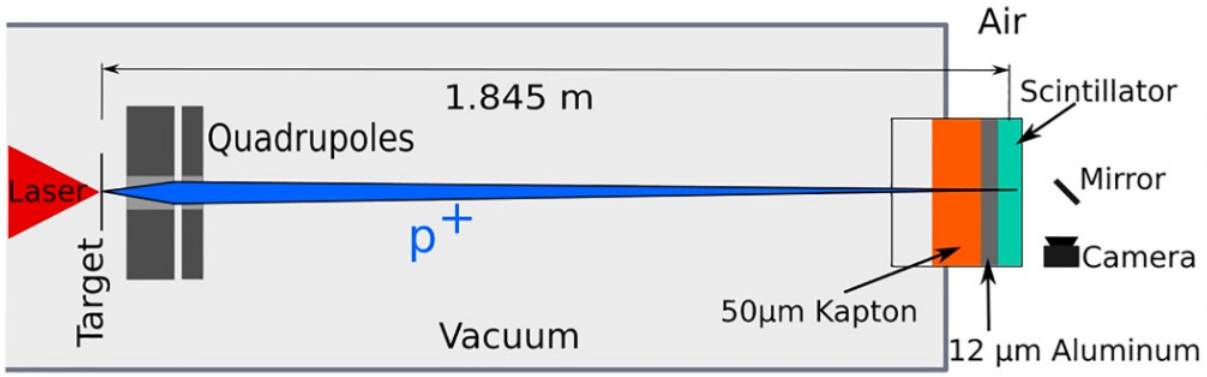
Ionacoustics Work Package

LhARA meeting

27/2/2024

Laser-Driven Ion (LION) Acceleration Beamline





Source – Energy Distribution

Parameters	
Laser Power [PW]	2.5
Laser Energy [J]	70
Laser Intensity [W/cm^2]	4x10^{20}
Laser Wavelength [nm]	800
Pulse Duration [fs]	28
Foil target thickness [nm]	400-600

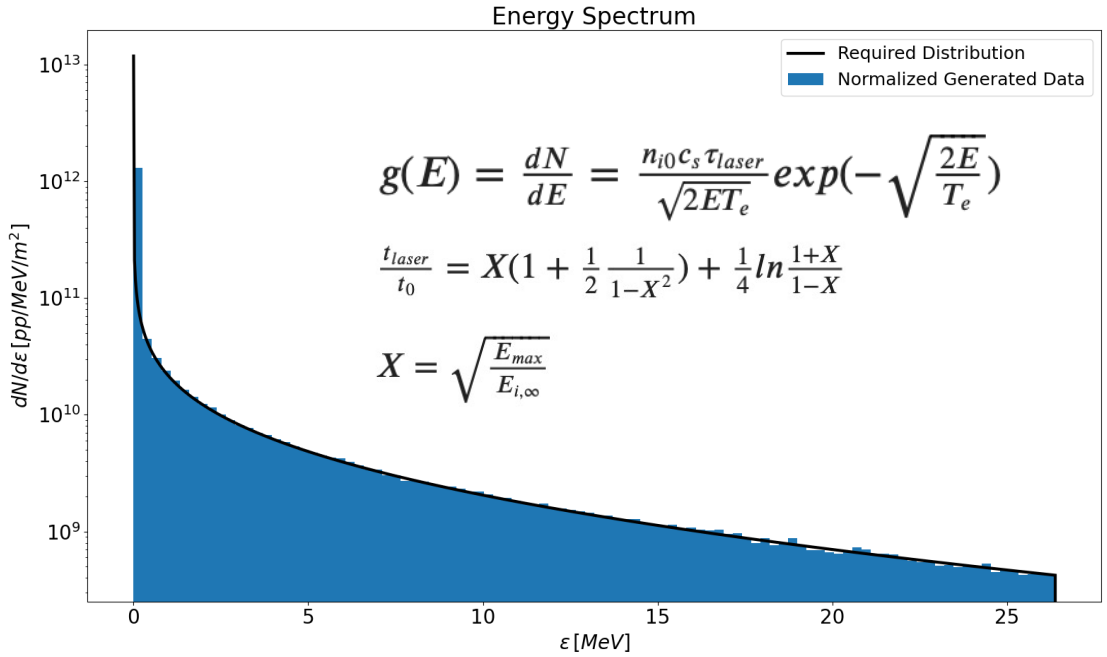


Figure 1: Normalized energy distribution of the laser-driven protons created at the LION beamline.

Source – Angular Distribution

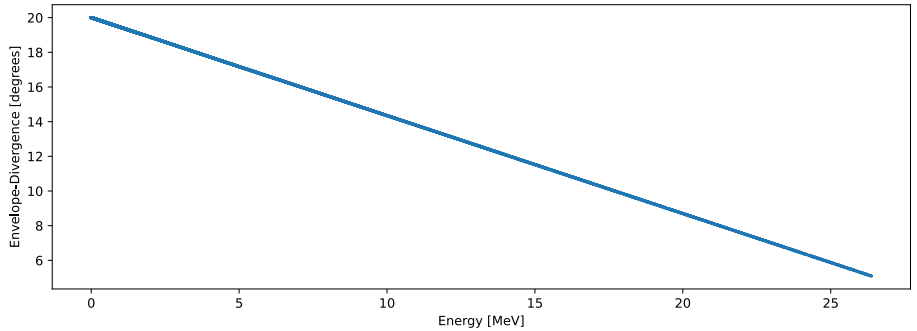


Figure 2: Energy dependent envelope divergence.

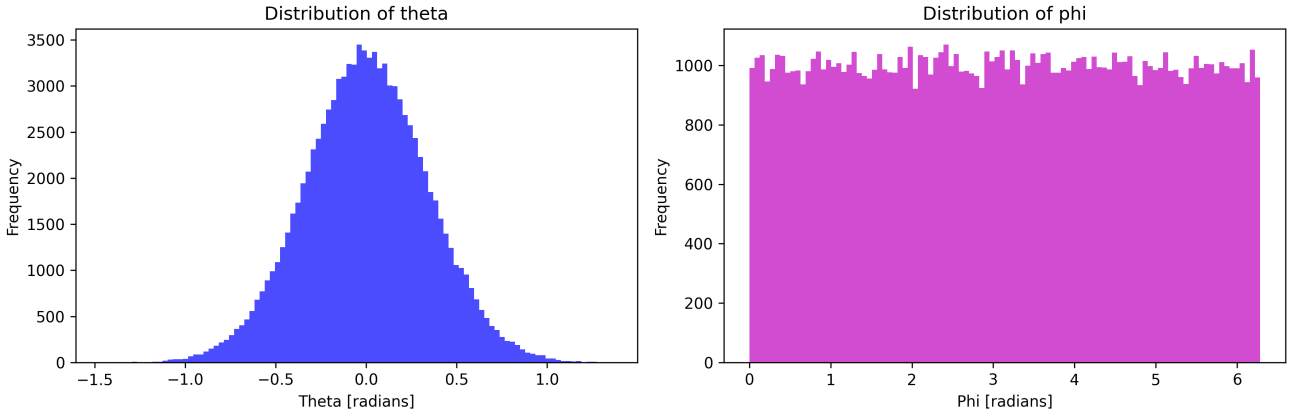


Figure 3: Angular distribution of the laser-driven protons at the LION beamline source.

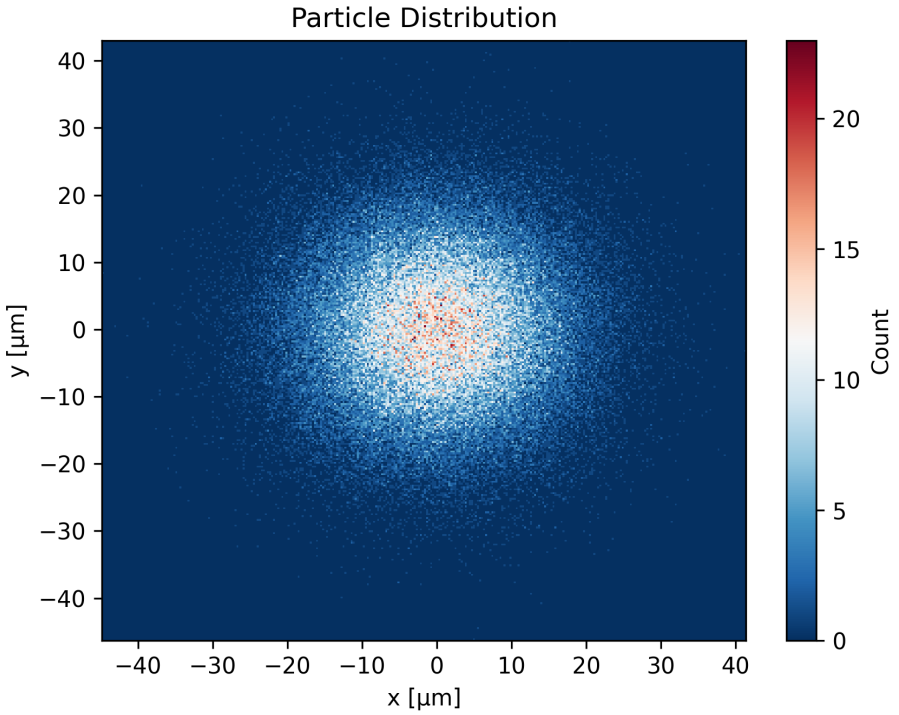


Figure 4: 2D angular distribution of 100000 protons at the source.

LION Beamline - BDSIM

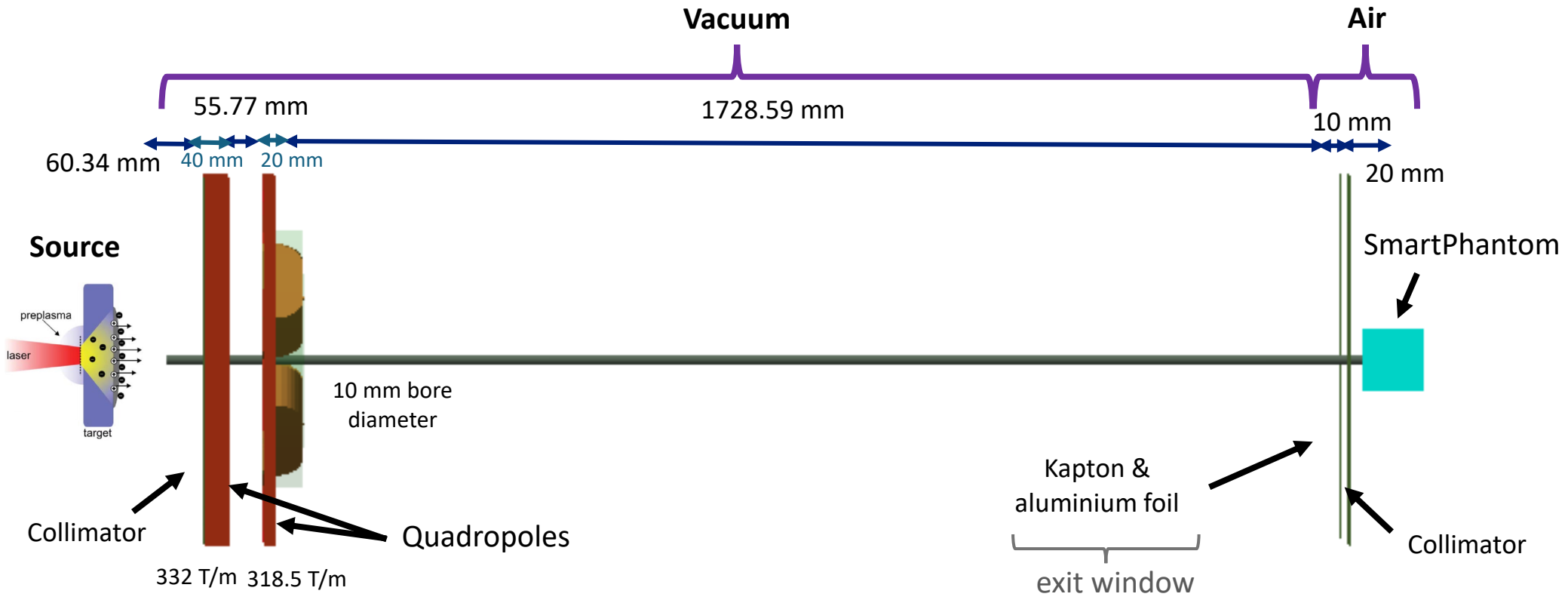


Figure 5: Side-on view of LION beamline in BDSIM.

Proton Beam

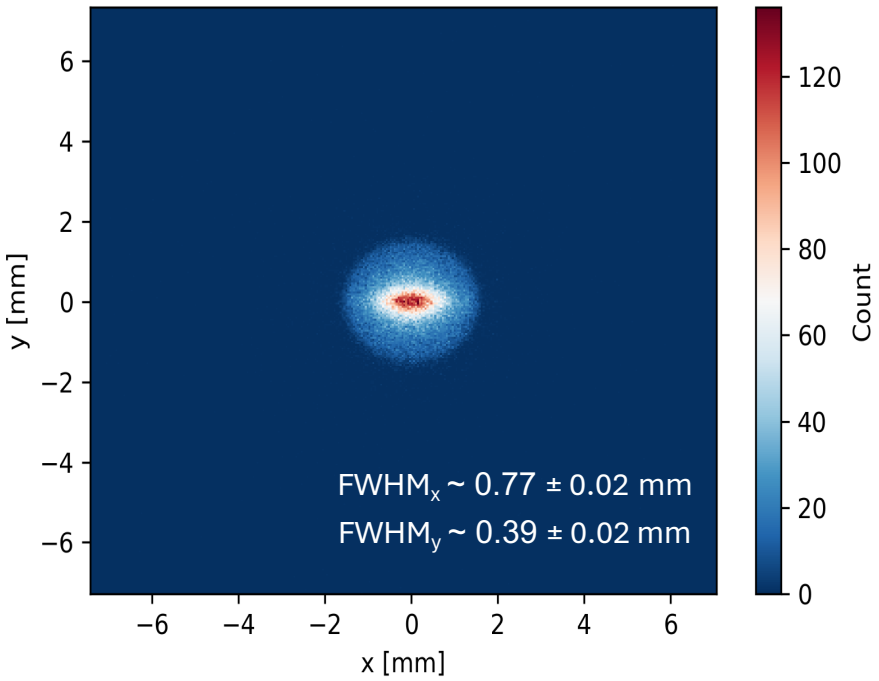


Figure 6: Spot size at the focus of the LION beamline.

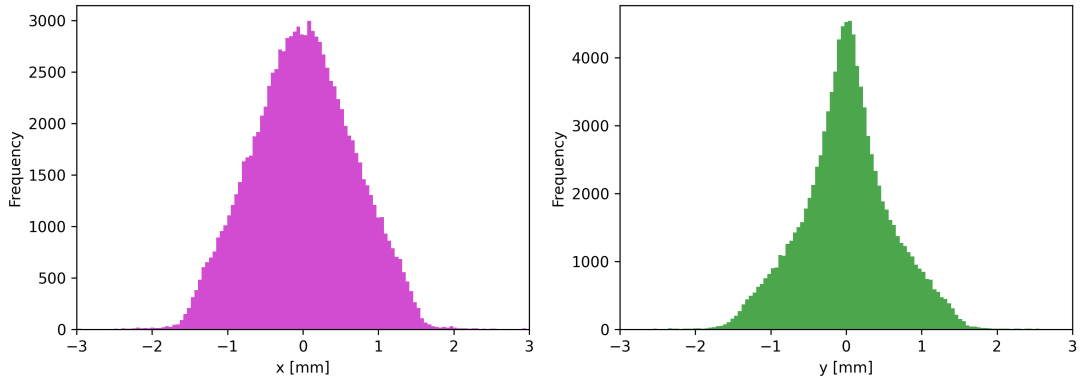


Figure 7: Distribution of particles at the focus.

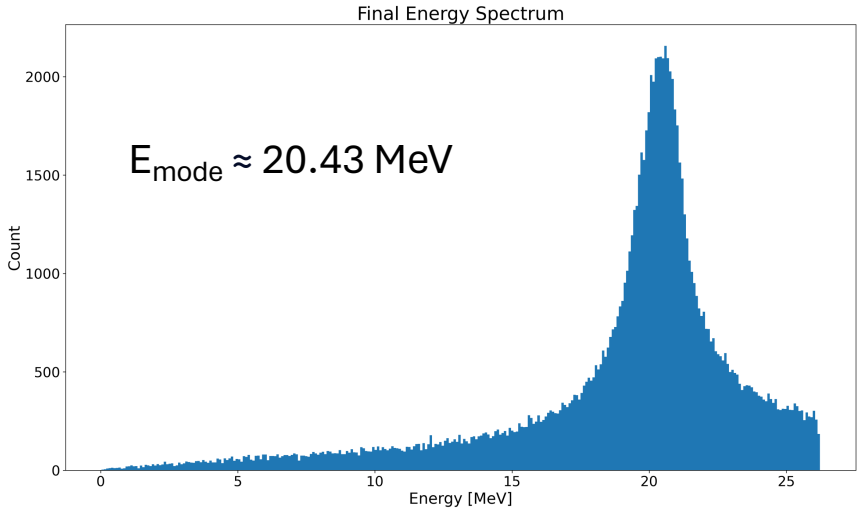


Figure 8: Energy spectrum of the particles at the focus.

SmartPhantom

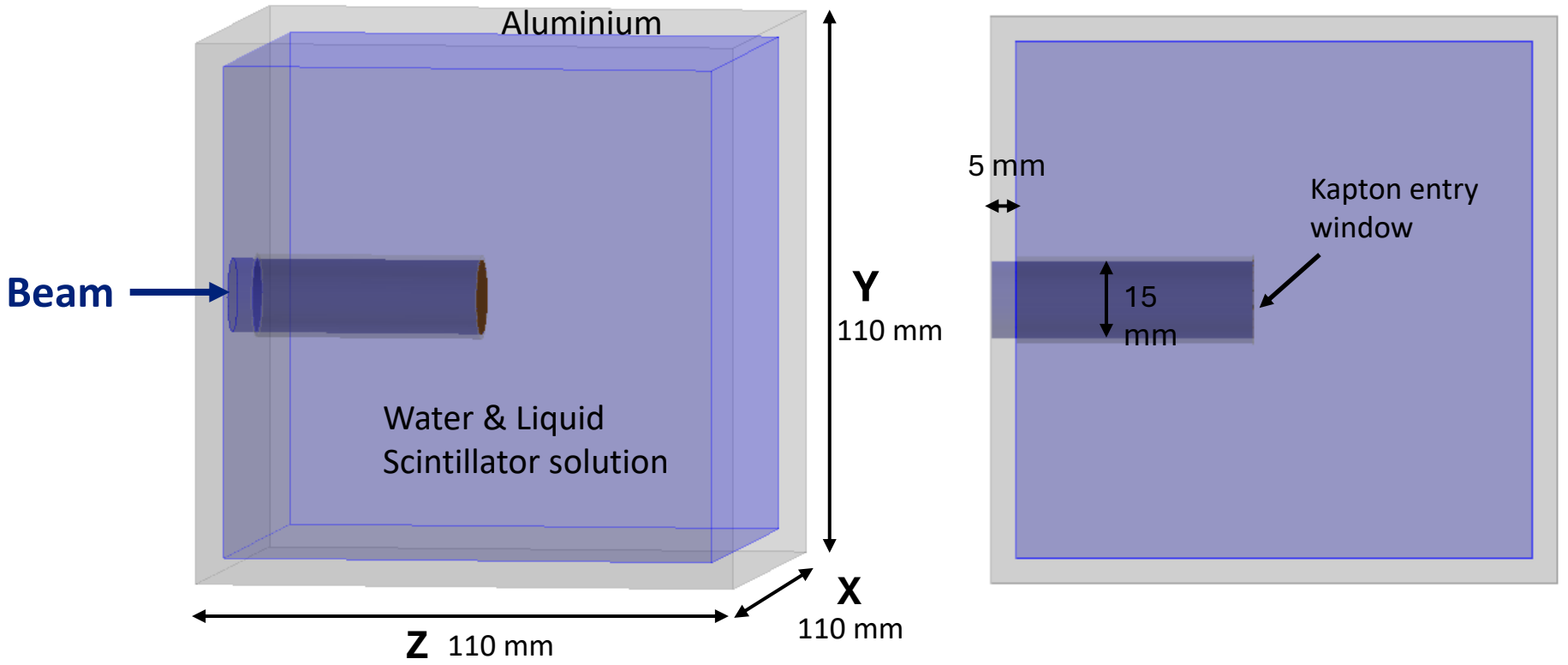
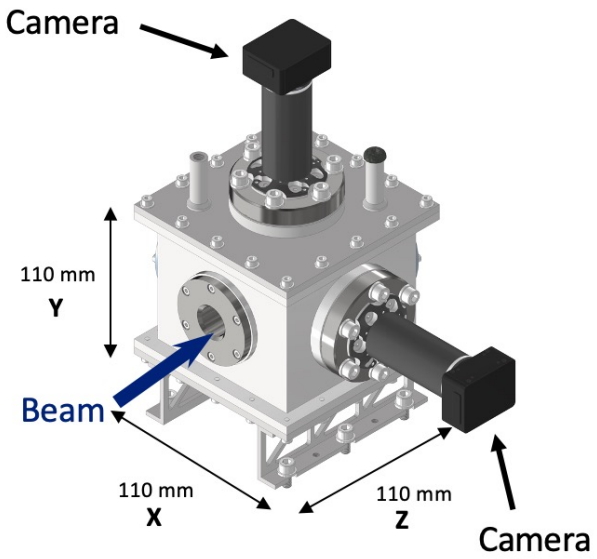
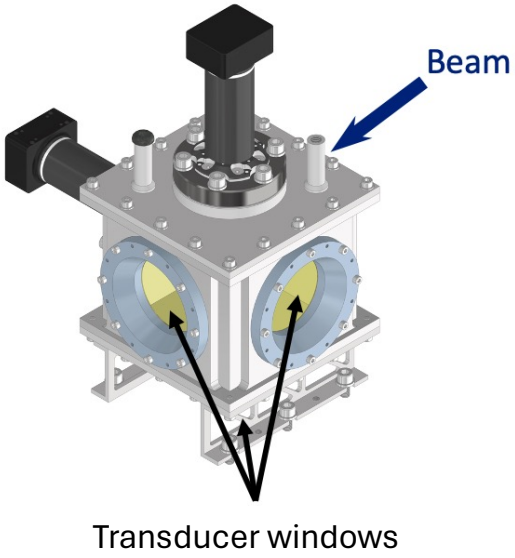
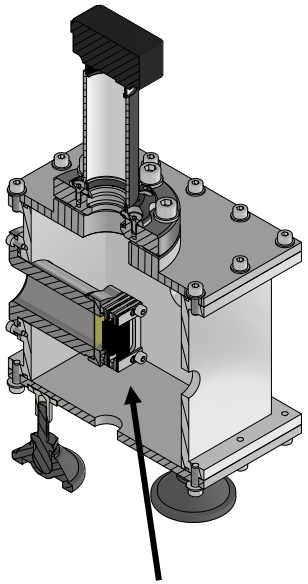


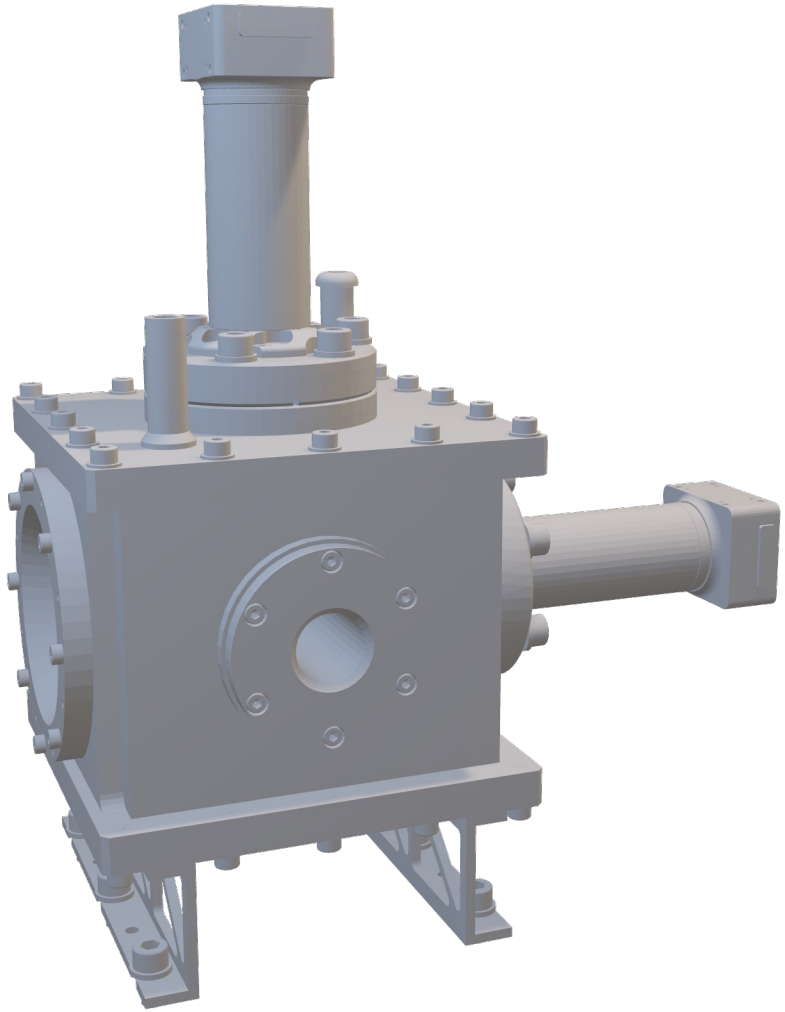
Figure 9: Geant4 simulation of the SmartPhantom. Angled view (left), cross-section view (right).

SmartPhantom

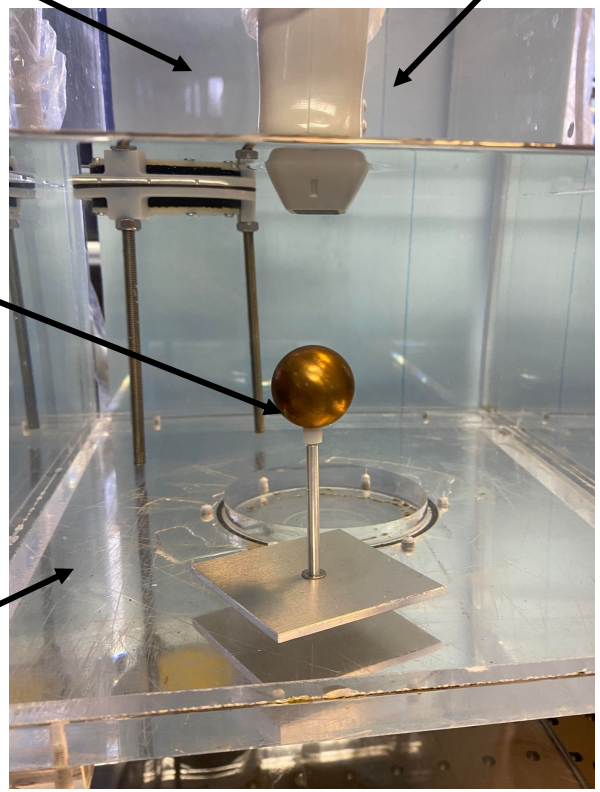




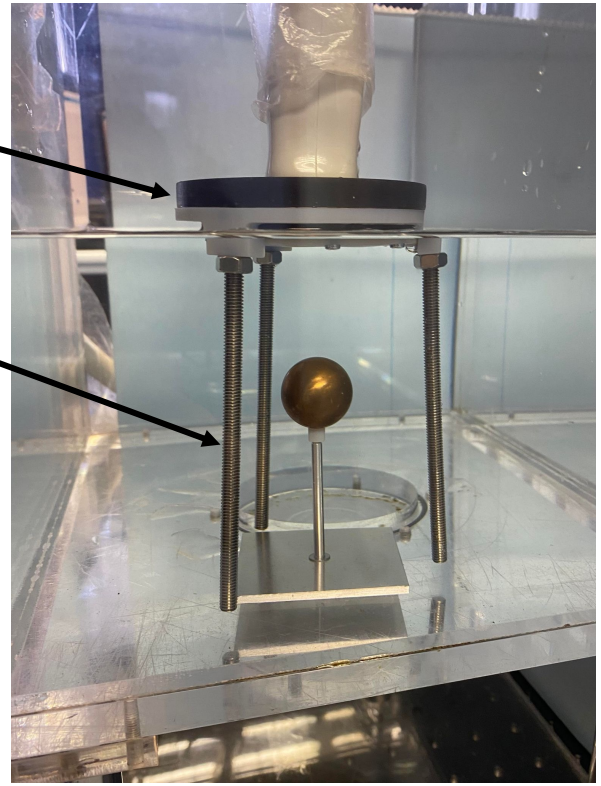


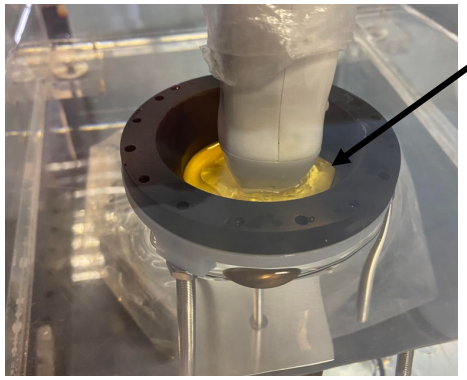


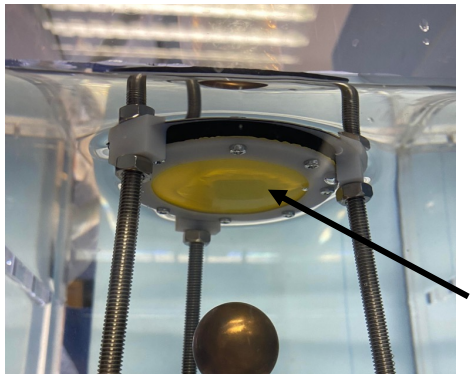
50µm Kapton Acoustic Transmission



Setup 1





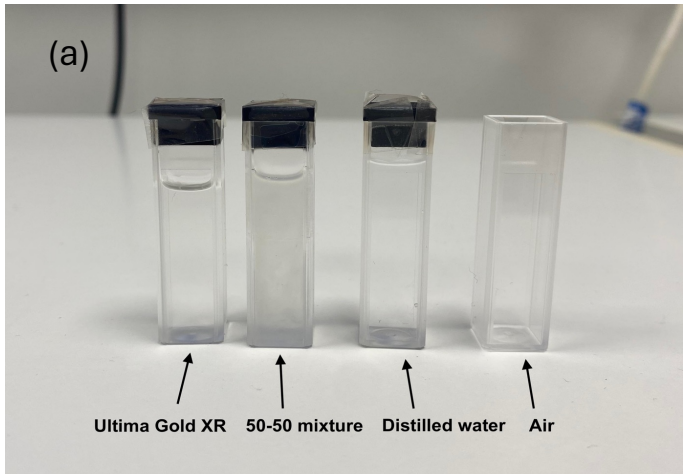


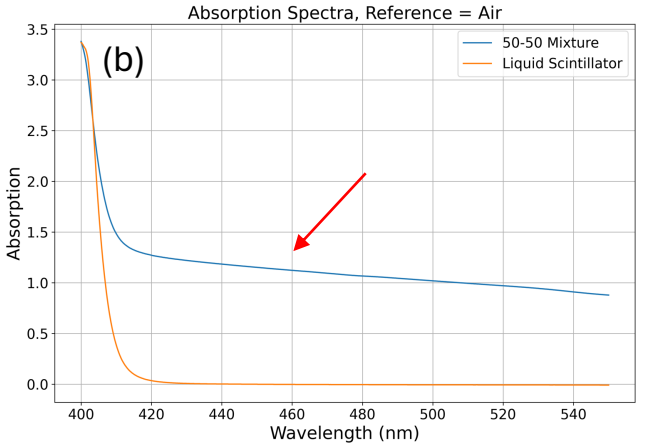
Setup 2

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





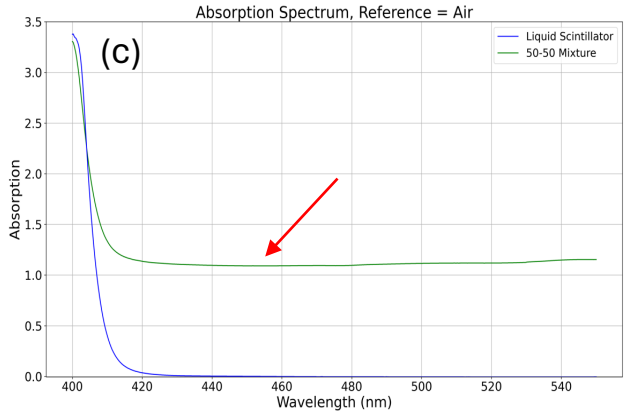


Figure10: Liquid scintillator absorbance measurement. (a) Solutions (b) & (c) Results.

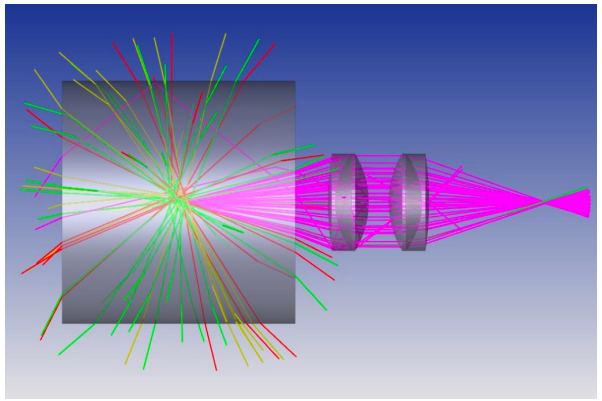


Figure 11: Liquid scintillator ZEMAX simulation.

?

saturation point

Energy Depositions

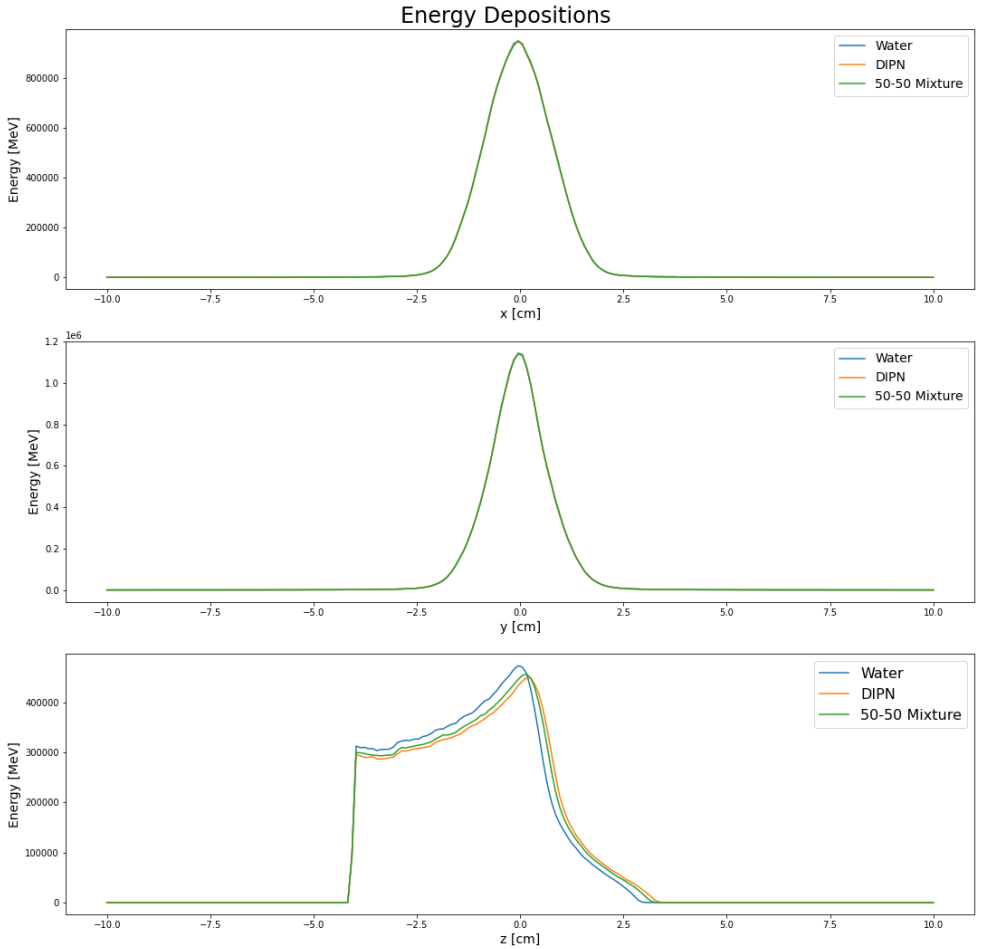
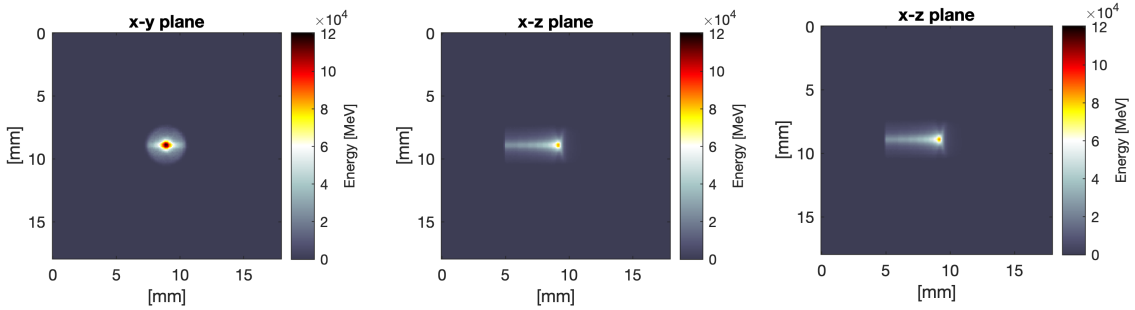


Figure 12: Binned energy depositions of the LION beam (1e6 protons).

Energy (MeV)	Range (Water)	Range (DIPN)	Ratio
10	1.202	1.303	1.083
12	1.703	1.804	1.059
15	2.605	2.705	1.038
20	4.408	4.609	1.045
30	9.217	9.918	1.076

Figure 13: Beam range comparison for different proton energies.

Pressure Distribution & Acoustic Detection



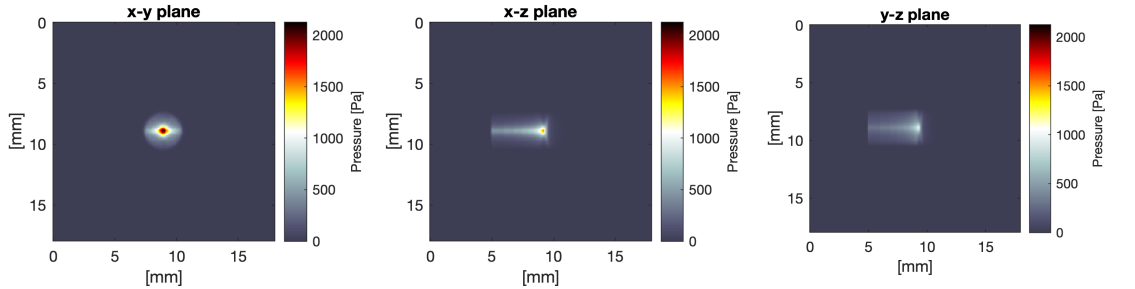
Initial energy

$$p_0(r) = \Gamma(r)E(r)\rho(r)$$

Initial pressure

Gruneisen parameter

Medium density



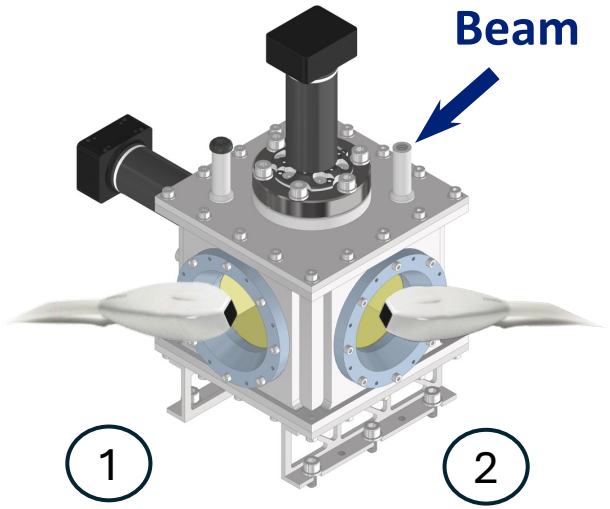
Matrix Array

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

Linear Array

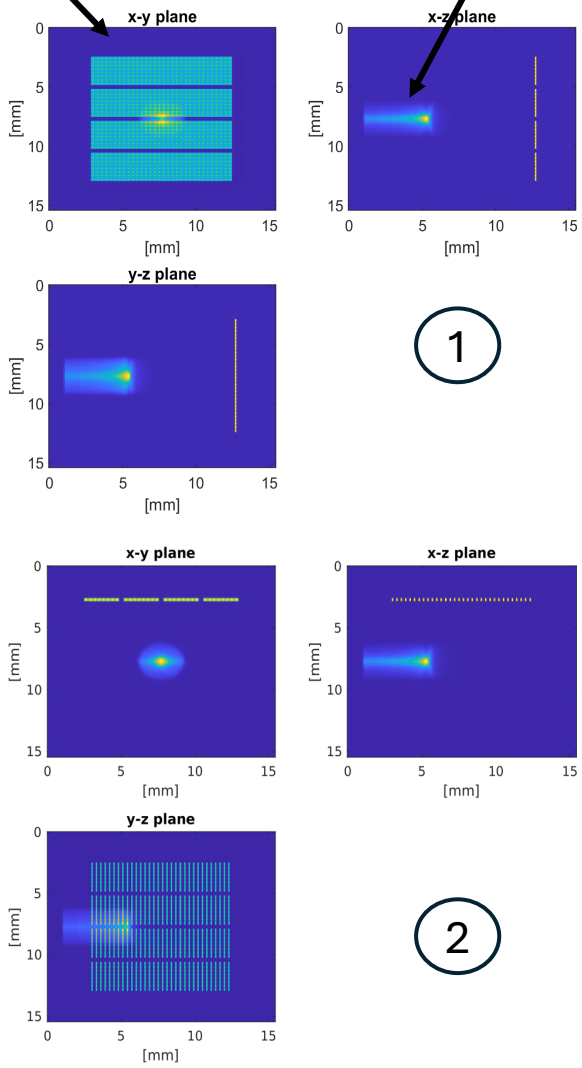
Center Frequency	5.3 MHz
Bandwidth	75%
Elements	192 (192x1)
Pitch	0.23 mm

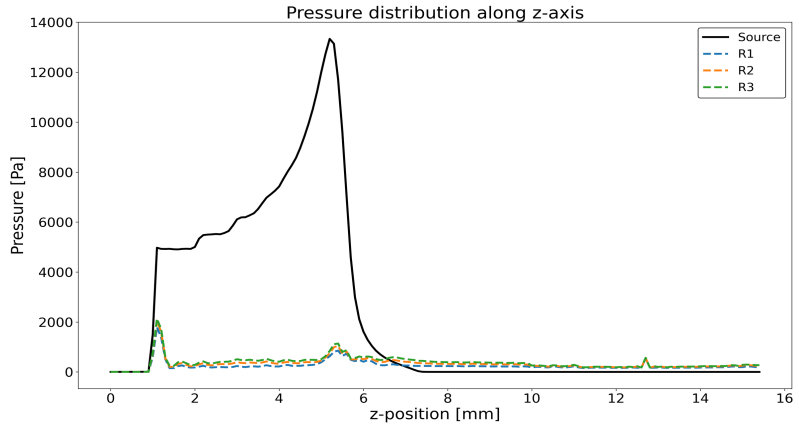
Matrix Array

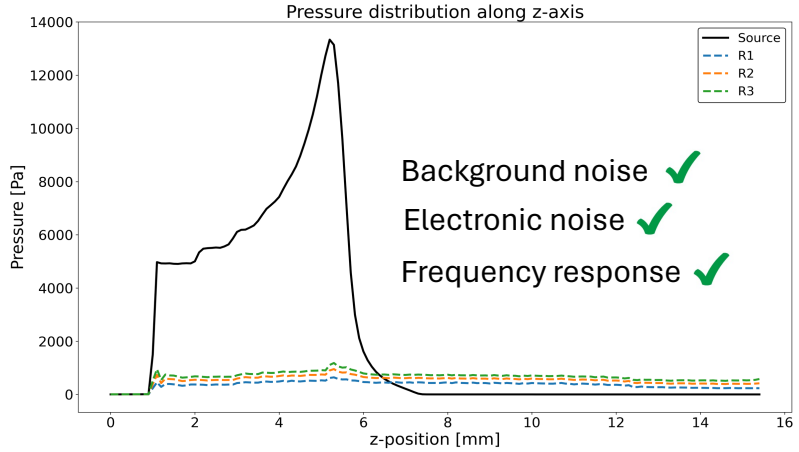


Matrix array

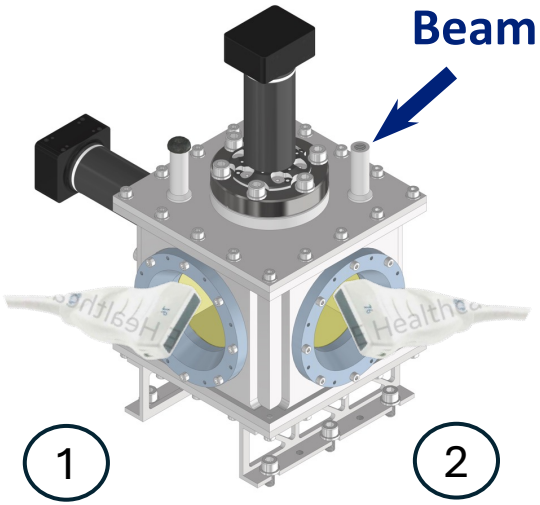
Beam depositions





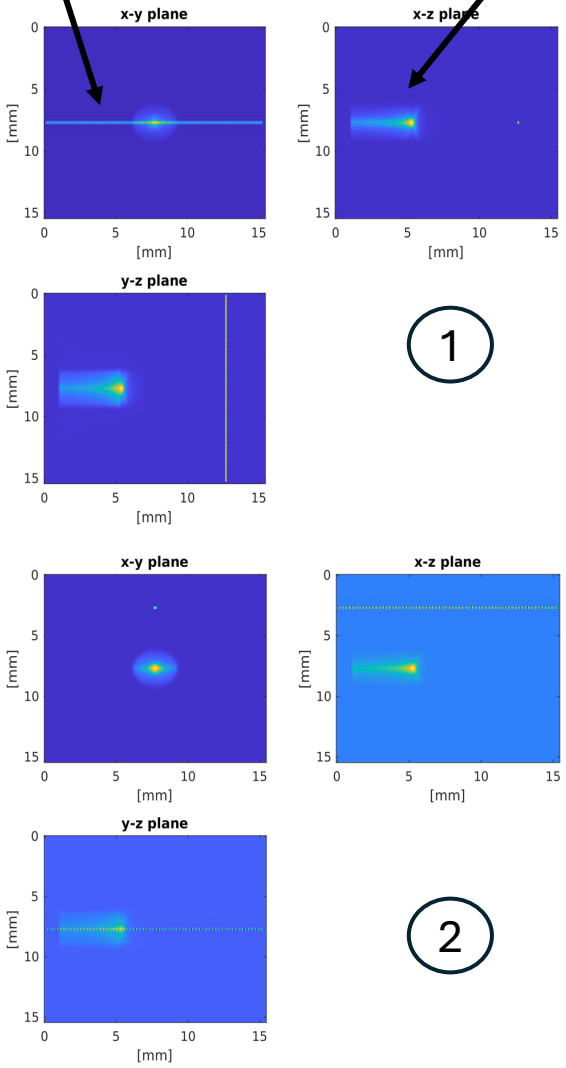


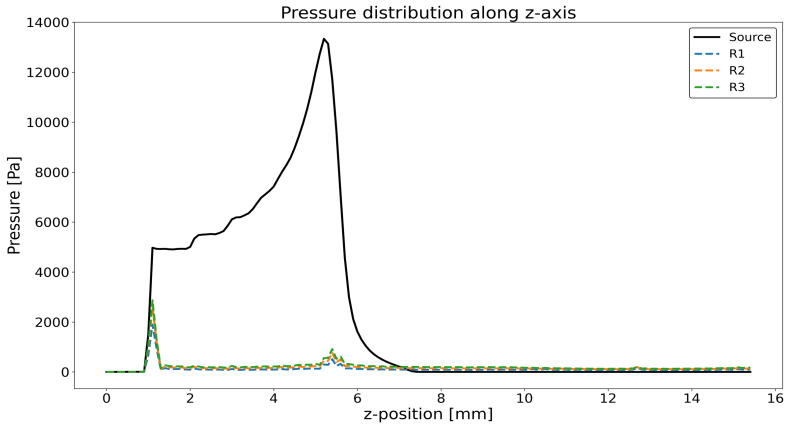
Linear Array

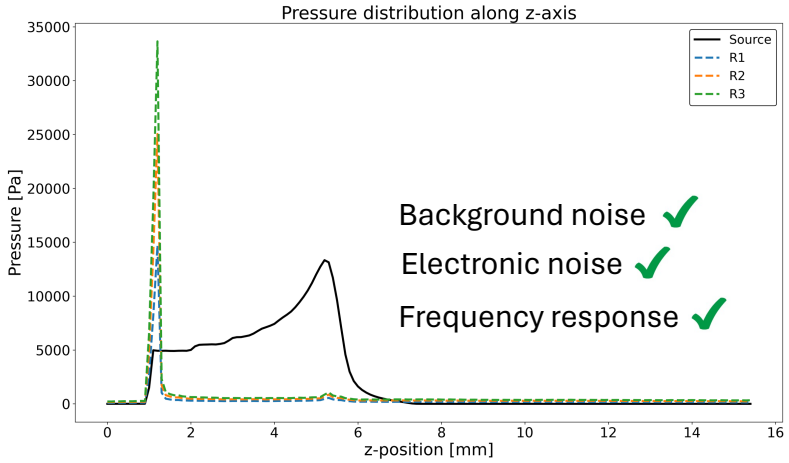


Linear array

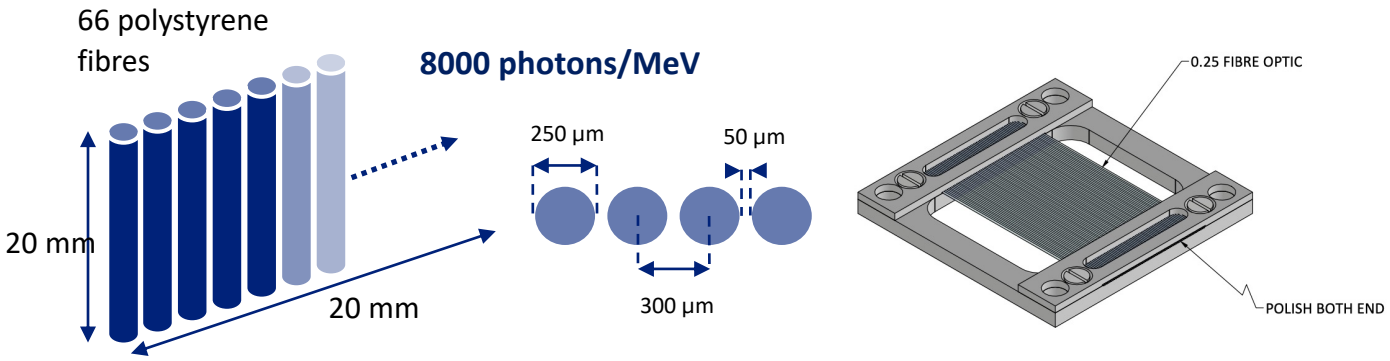
Beam depositions







Scintillating Fibre Planes



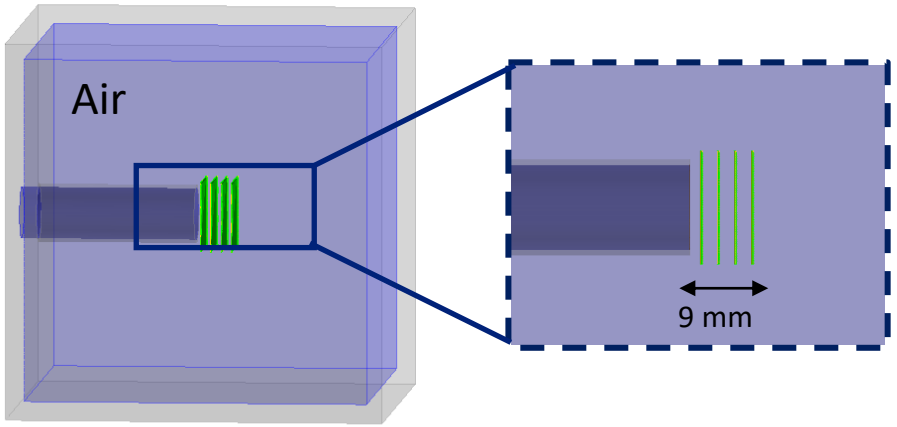


Figure 14: Scintillating fibre plane stations (green) in the Geant4.

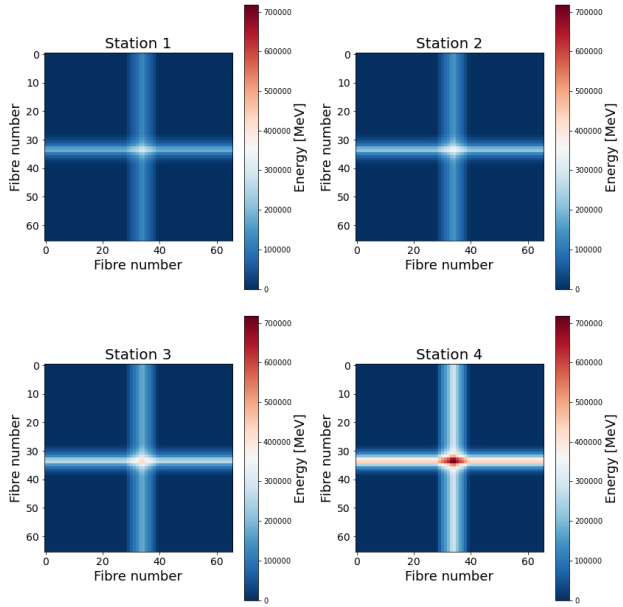


Figure 15: 2D reconstruction with the scintillating fibres at each station location.

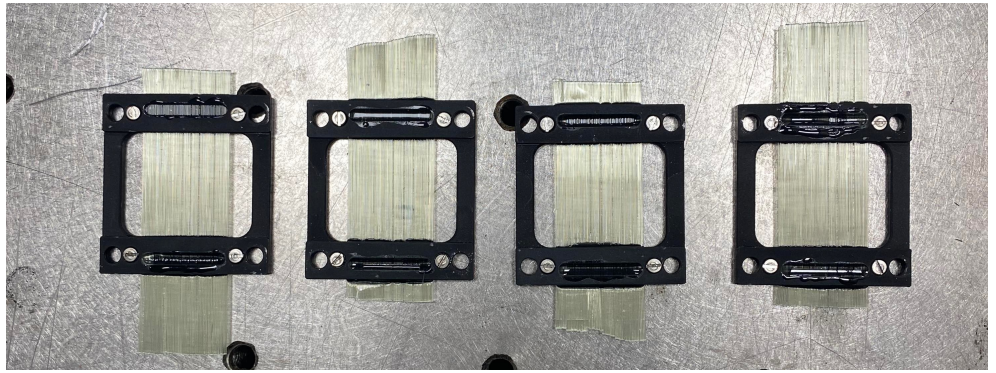


Figure 16: Scintillating fibre plane detectors built in the lab.