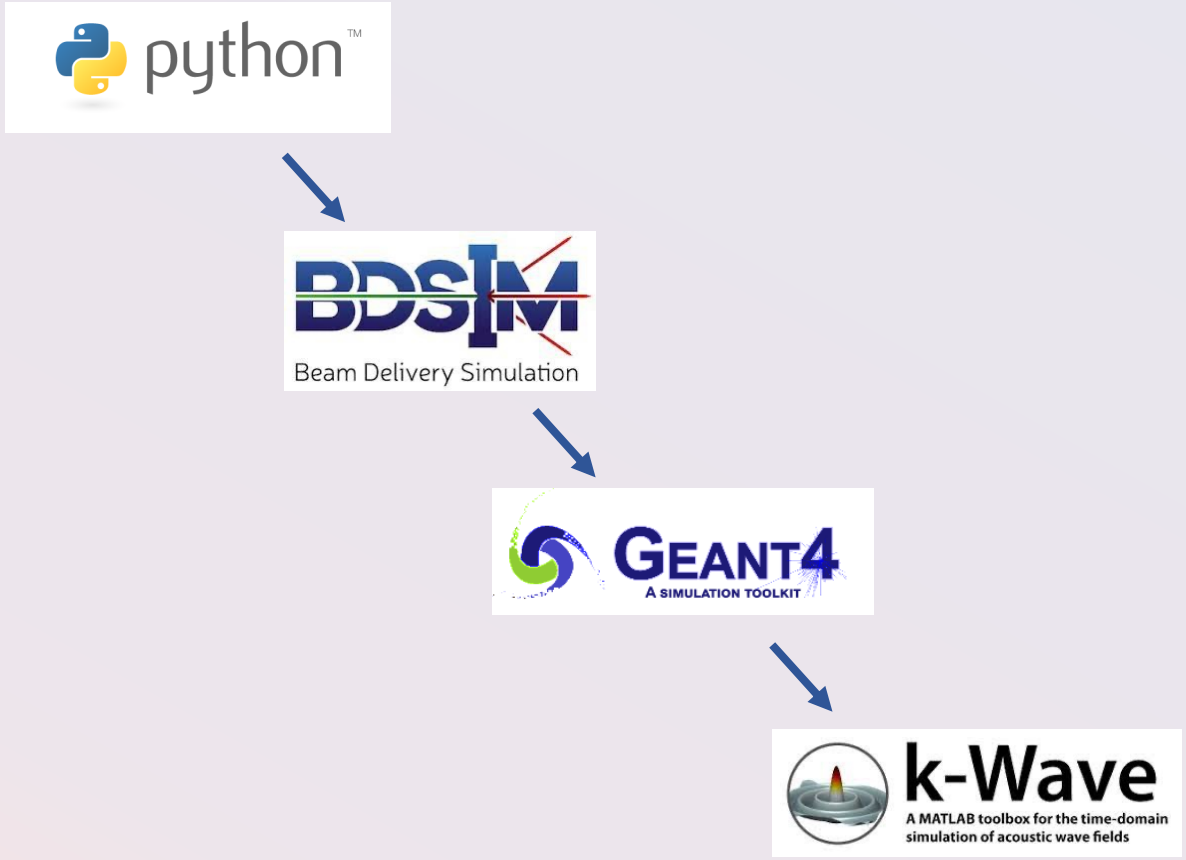
Ionacoustics Experiment at the LION beamline

5th Oct 2023

Simulation Pipeline



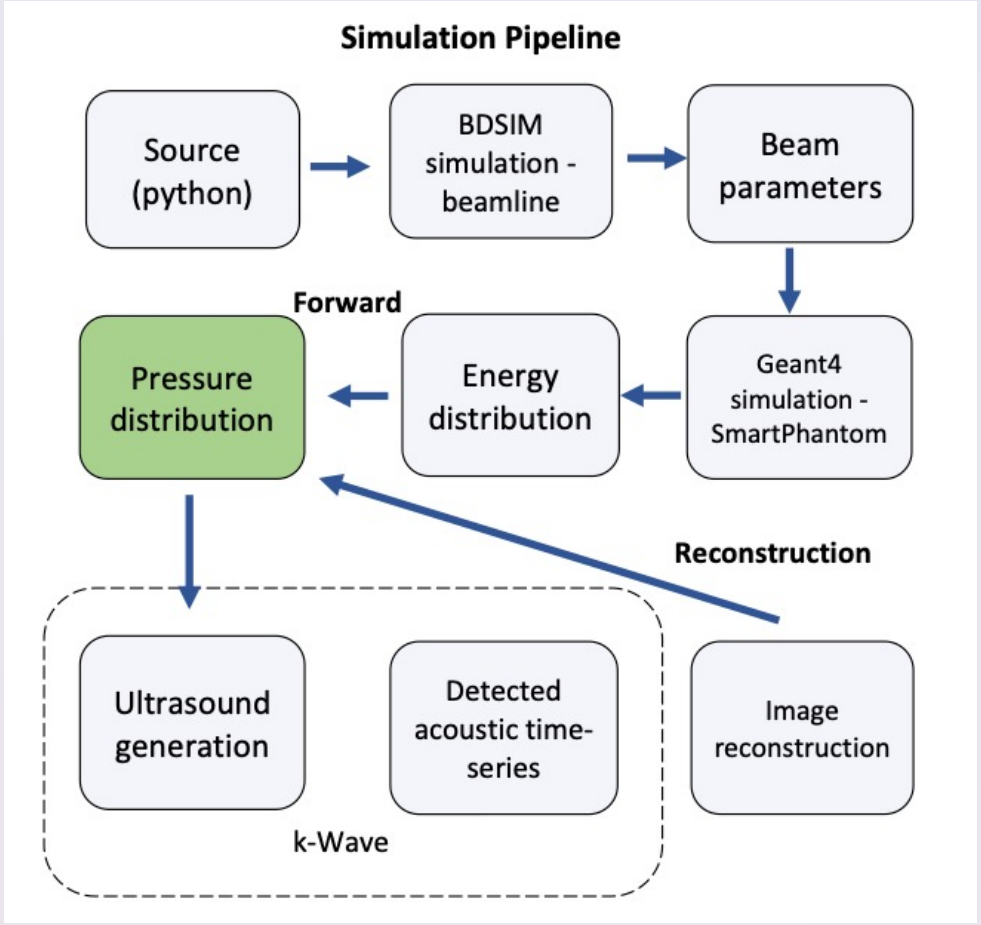


Figure 1: Simulation pipeline.

Python

Source

Energy Distribution

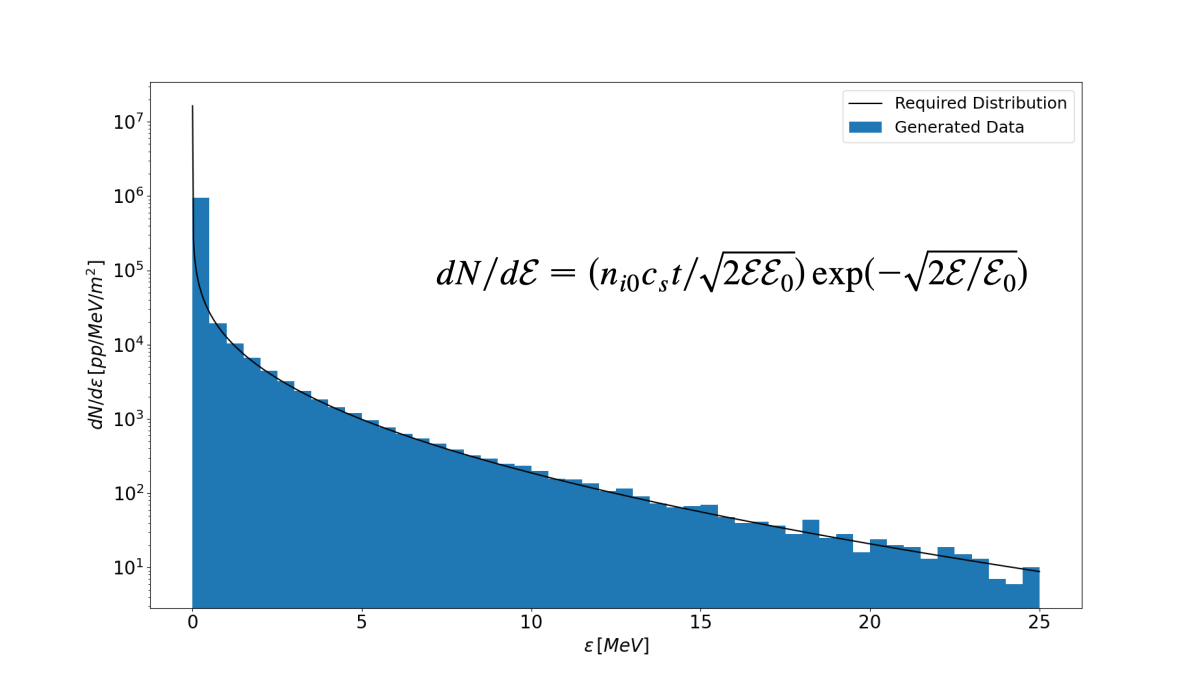


Figure 2: Simulated energy distribution.

Angular Distribution - flat

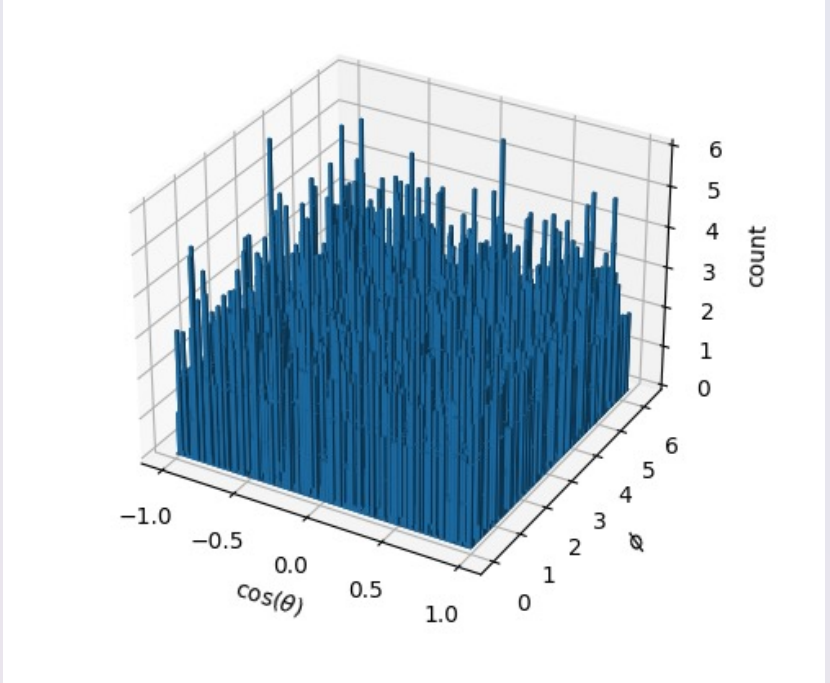


Figure 3: Simulated angular distribution.

BDSIM

LION beamline - BDSIM

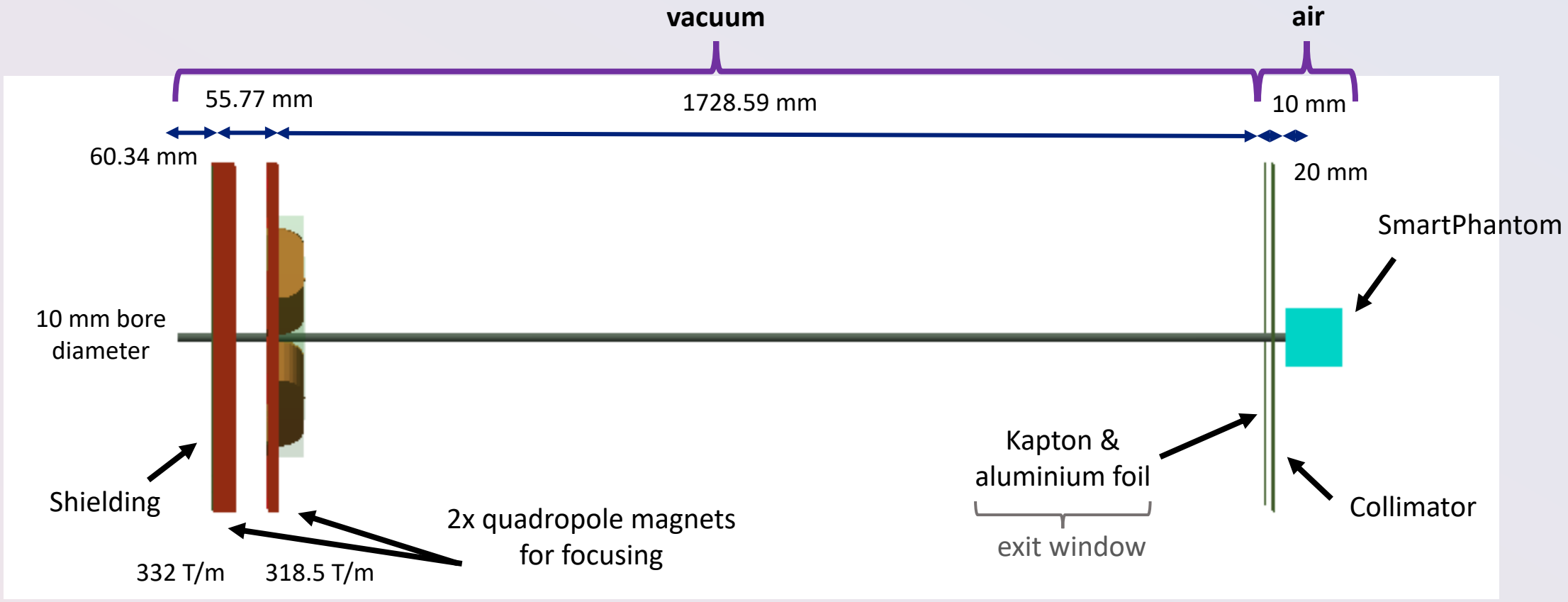


Figure 4: Side-on view of LION beamline in BDSIM.

Particle Depth

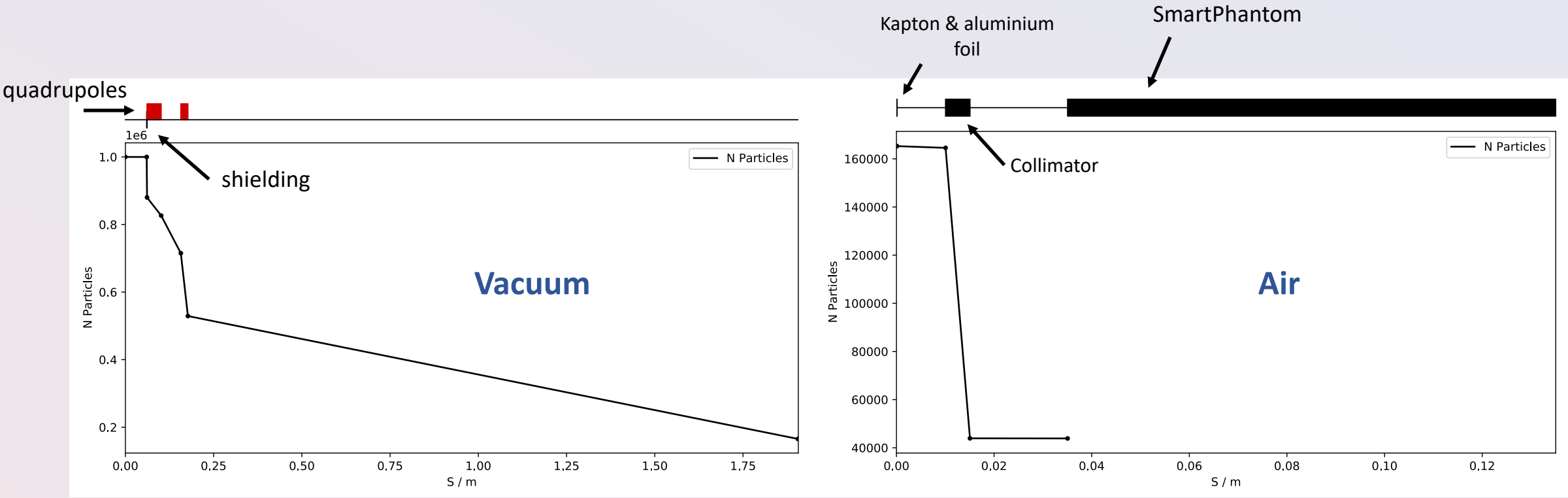


Figure 5: Particle depletion through the vacuum (left) and air (right) section of the simulated beamline.

Exit Window

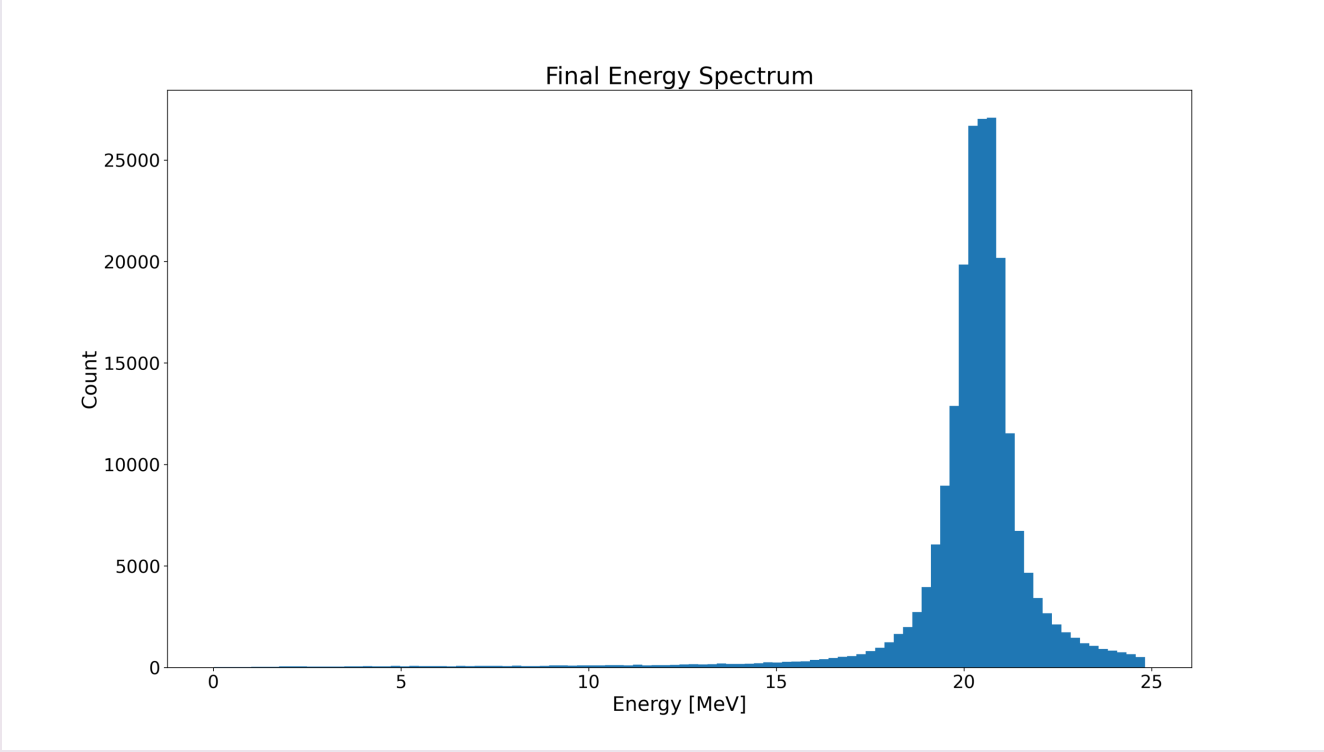


Figure 6: Particle energy spectrum at the exit window.

Spot Size at the focus

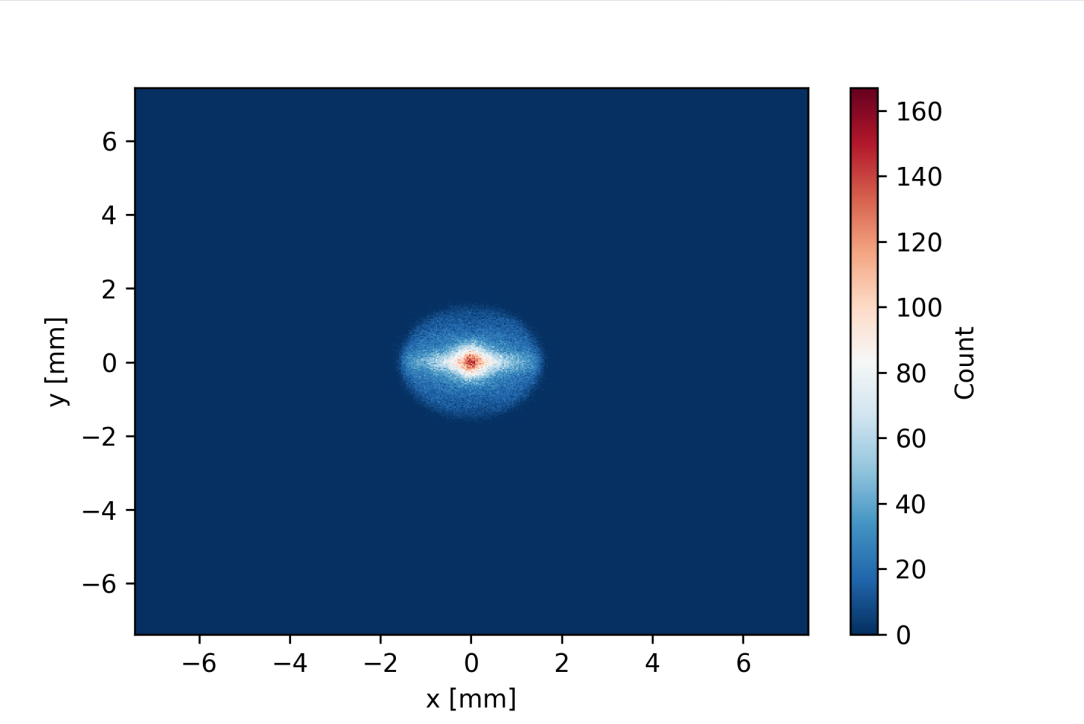


Figure 7: Spot size at the focus/end of the LION beamline.

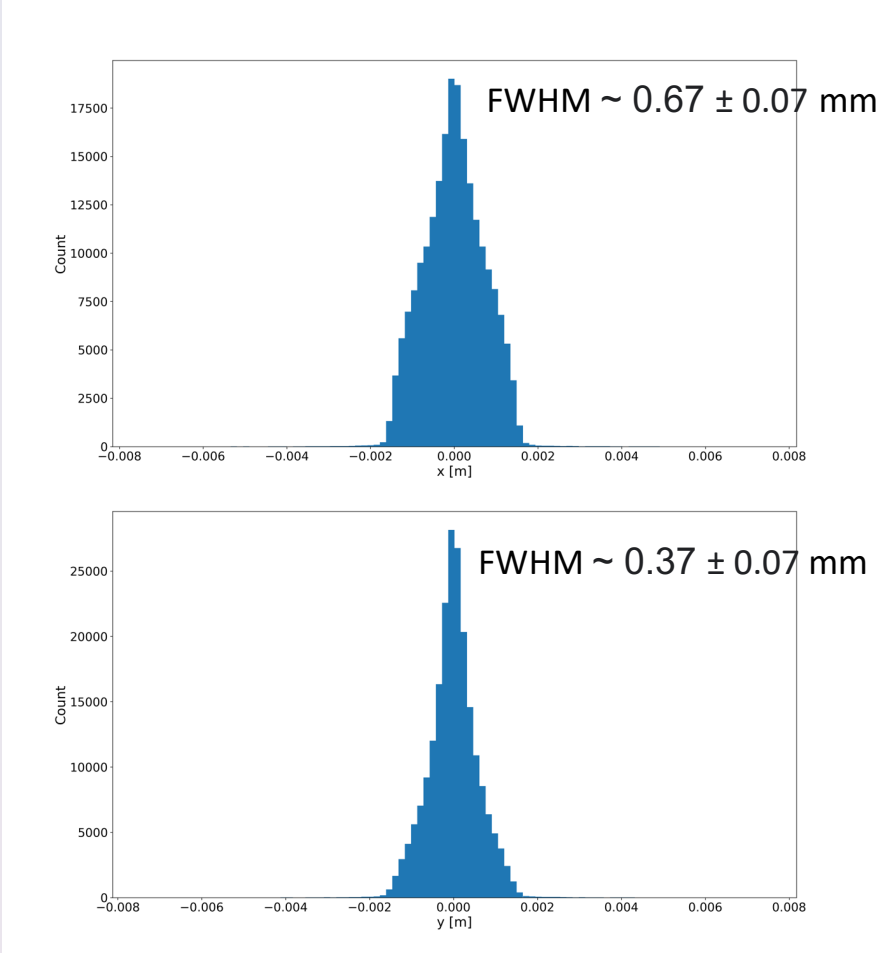


Figure 8: Spot size along the x (top) and y (bottom) directions.

Geant4

SmartPhantom

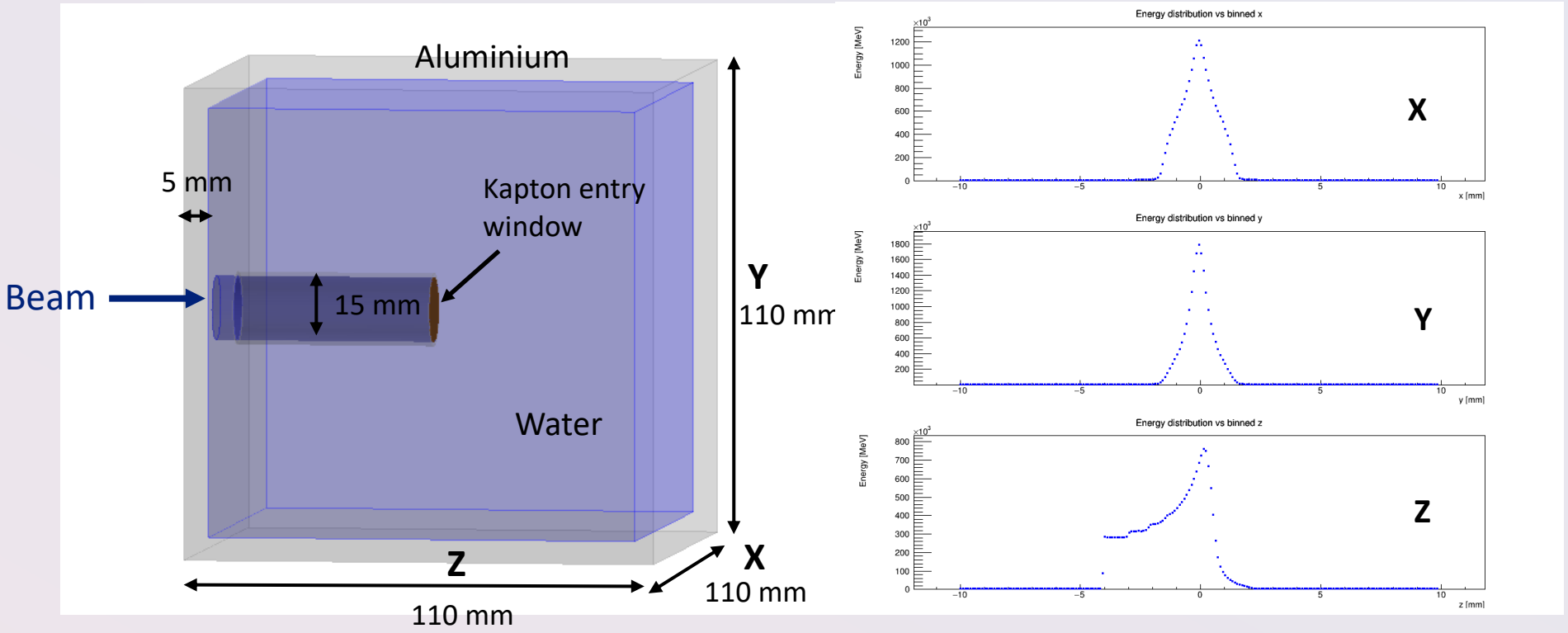


Figure 9: Geant4 simulation of the SmartPhantom (left) and binned energy depositions along the three axis (0.1 mm voxels).


k-Wave
A MATLAB toolbox for the time-domain
simulation of acoustic wave fields

k-Wave

Pressure Distribution & Acoustic Sensor

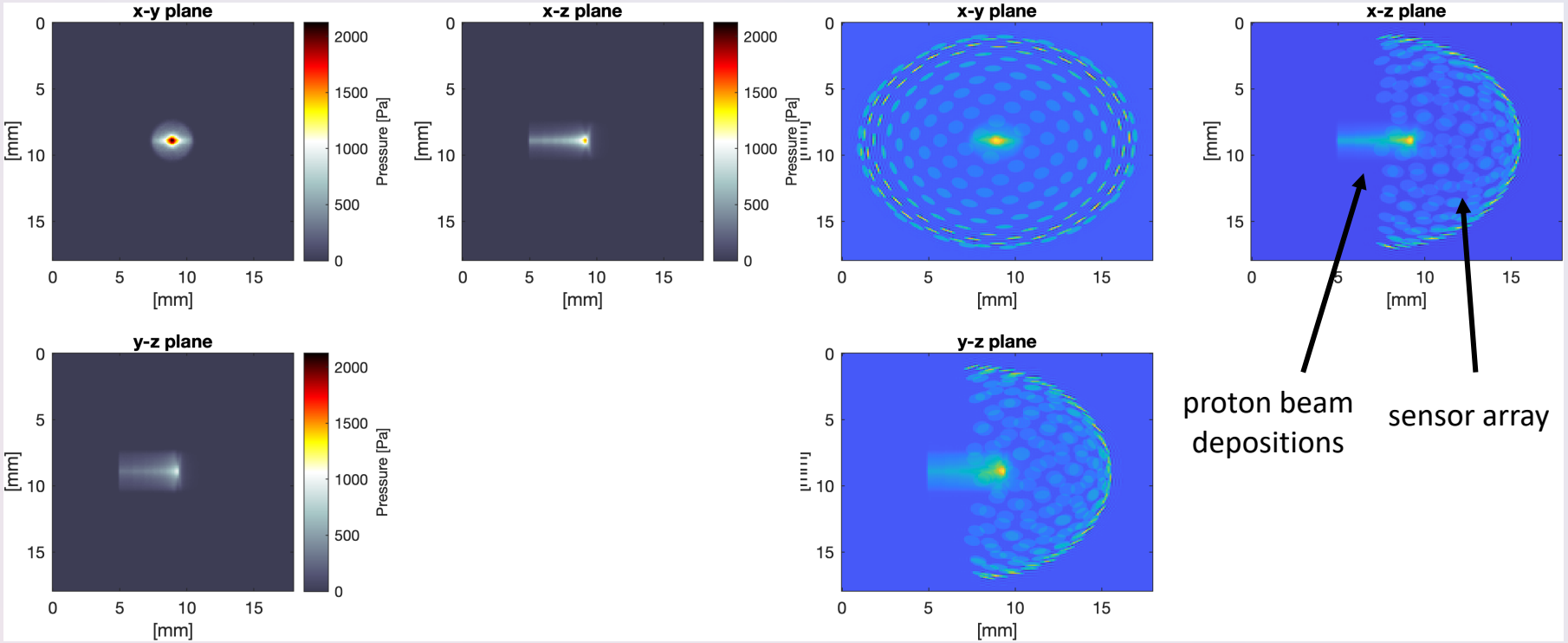


Figure 10: Source pressure distribution (left) and sensor location and geometry with respect to the beam depositions (right).

Acoustic Signals

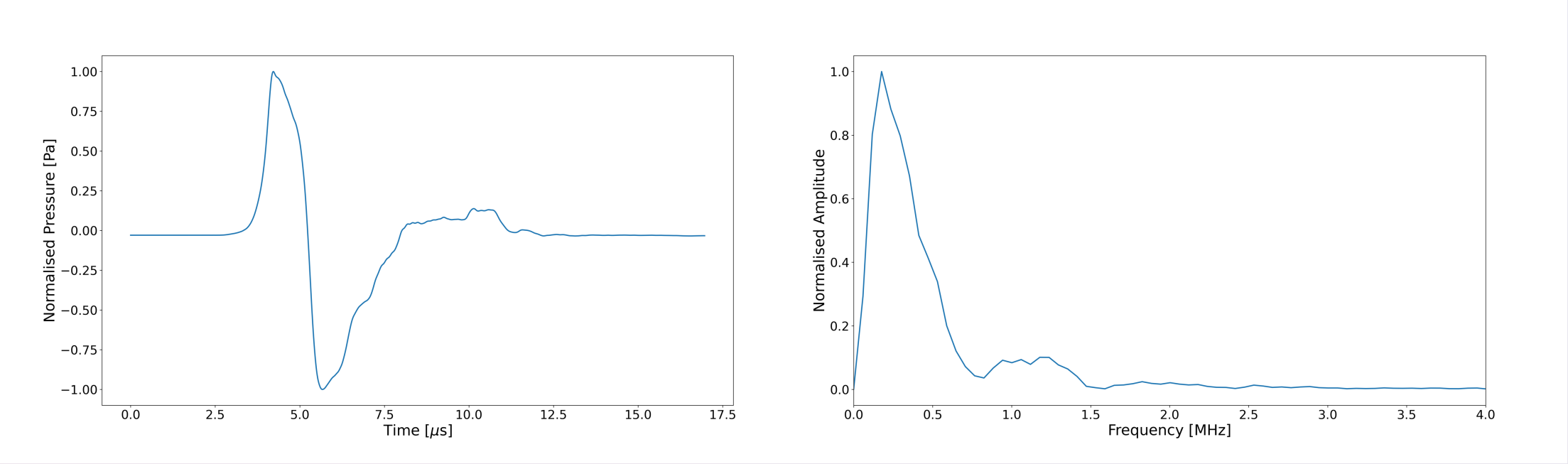


Figure 11: Normalised acoustic time-series (left) and frequency spectrum (right).

Image Reconstruction

Iterative Time-Reversal

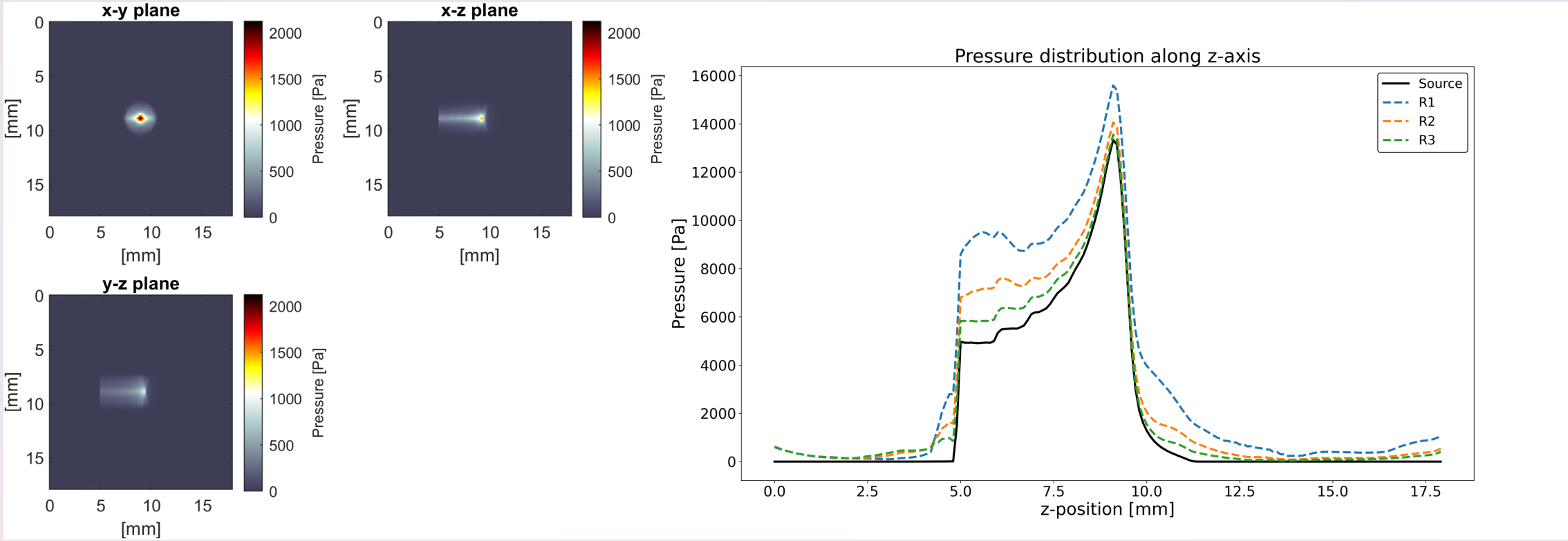


Figure 12: Reconstructed pressure distribution using an iterative time reversal algorithm.

Liquid Scintillator

Ultima Gold XR

Liquid scintillator : Water
50 : 50

Component	Name	Composition [weight %]
Solvents	di-isopropyl naphthalene (DIN)	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)	0-1.0
	1,4-bis (2-methylstyryl)-benzene (Bis-MSB)	0-1.0

Figure 13: Chemical composition of the liquid scintillator.

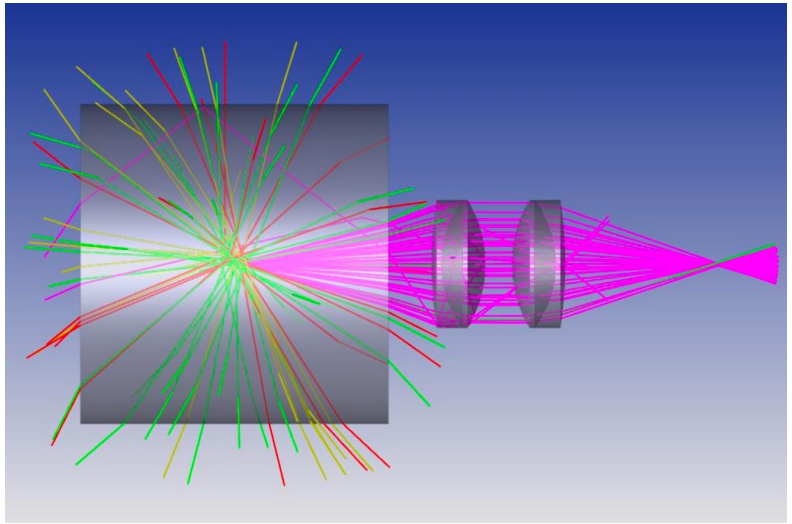


Figure 14: Liquid scintillator set up (taken from Peter Hobson's slides).

Fluorescent Dye Testing

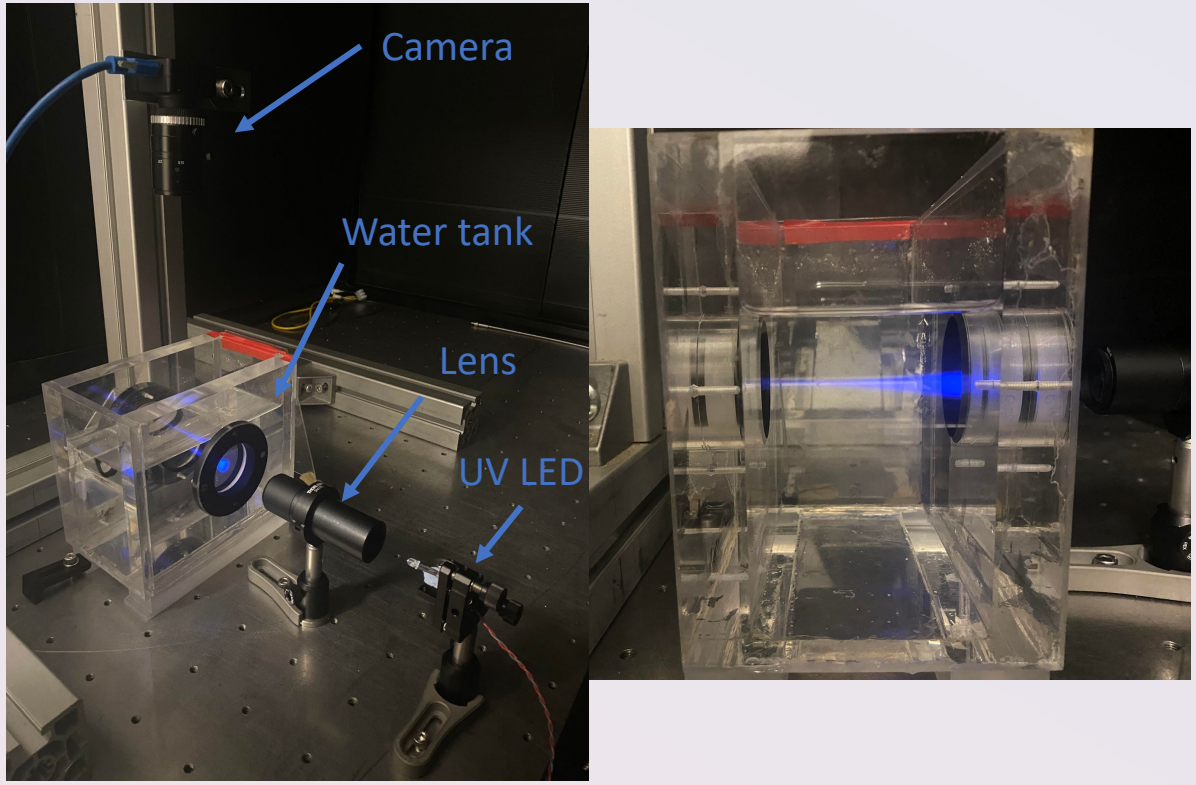


Figure 15: Fluorescent dye experimental set up: angled view (left), cross-section view (right).

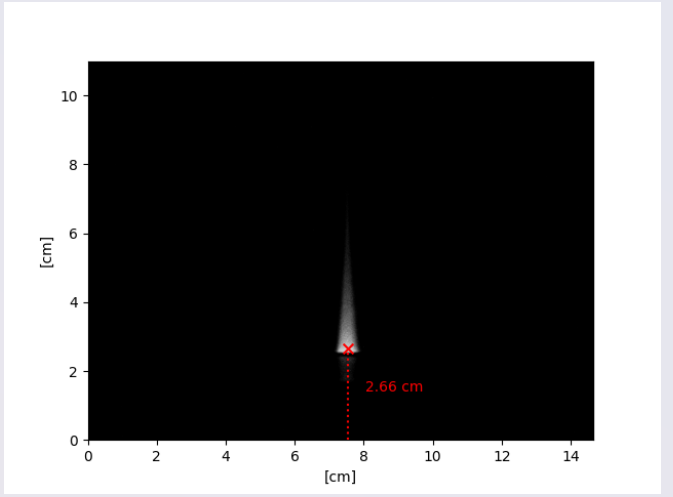
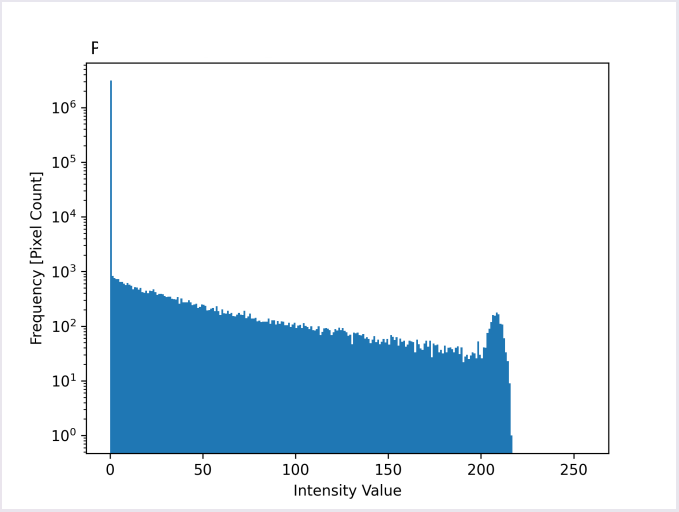


Figure 16: Captured image in grayscale.

Figure 17: Pixel intensity histogram.



SciFi Planes

Scintillating Fibre Planes: Beam Divergence

Average beam divergence = 1.114 radians

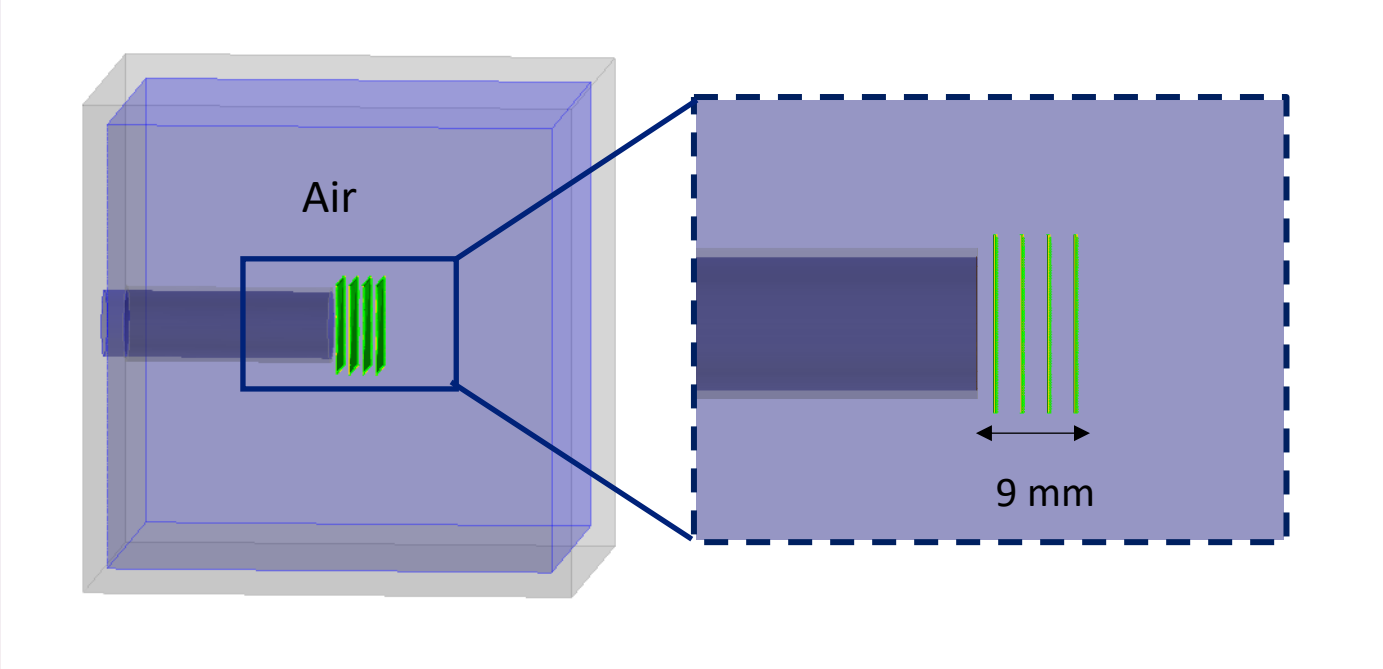


Figure 18: Scintillating fibre plane stations (green) in the Geant4 simulation geometry. Off-axis view (left), side-on view (right).

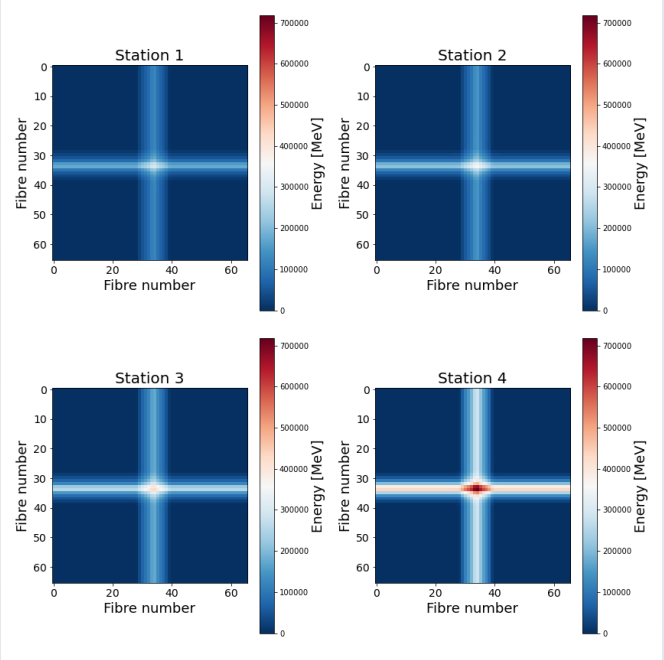


Figure 19: 2D energy distribution reconstruction at each SciFi station.

Scintillating Fibre Planes: Construction

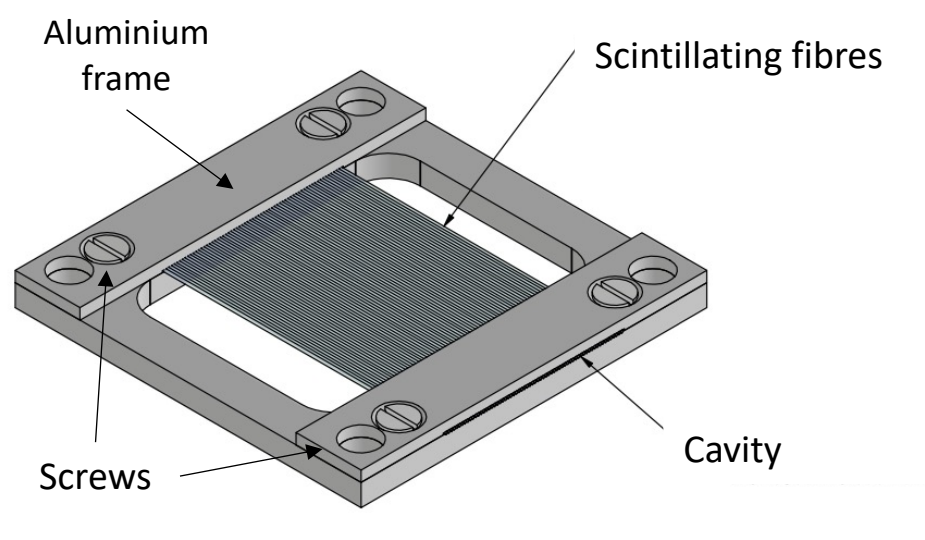


Figure 20: Fibre plane CAD design.

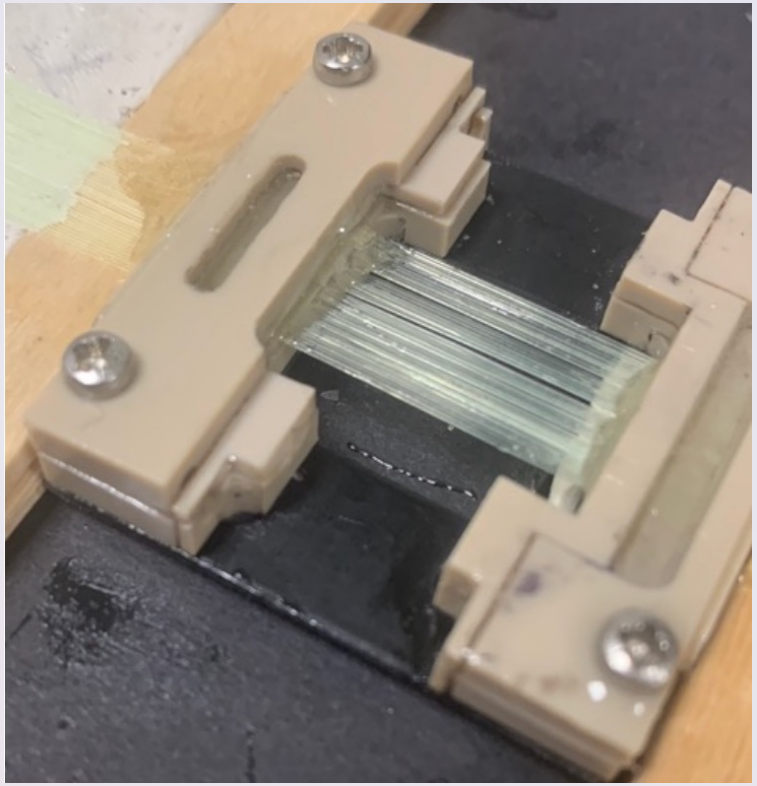


Figure 21: Fibre plane manufacturing.

Background Noise

1. Secondary Particles

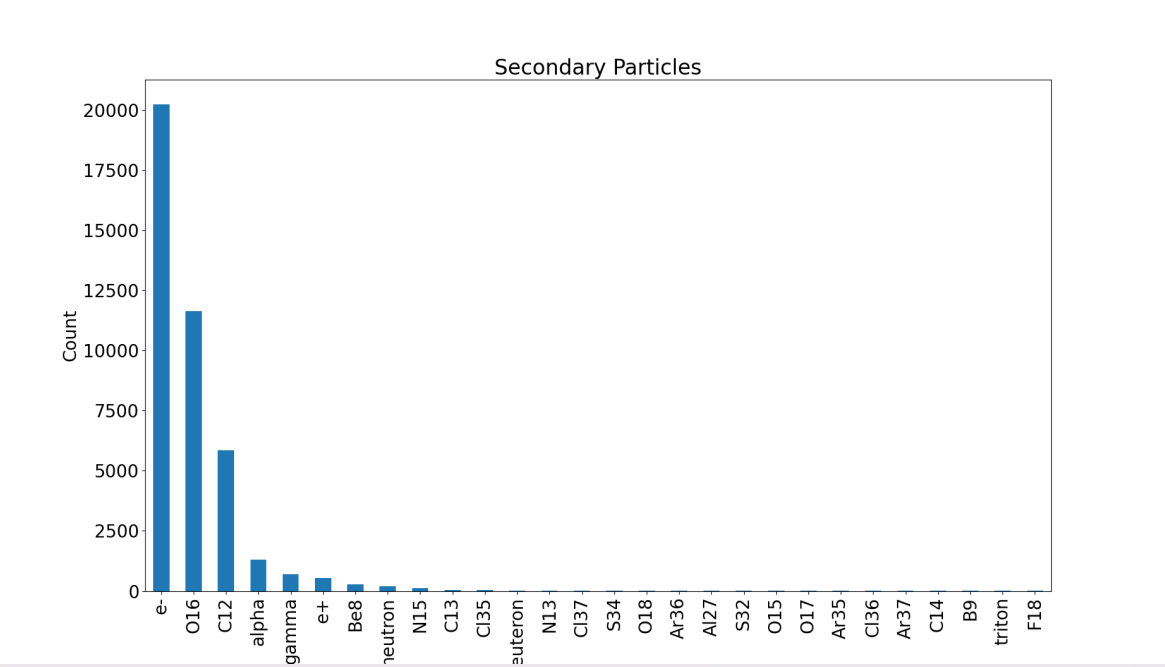


Figure 22: Secondary particles in the SmartPhantom.

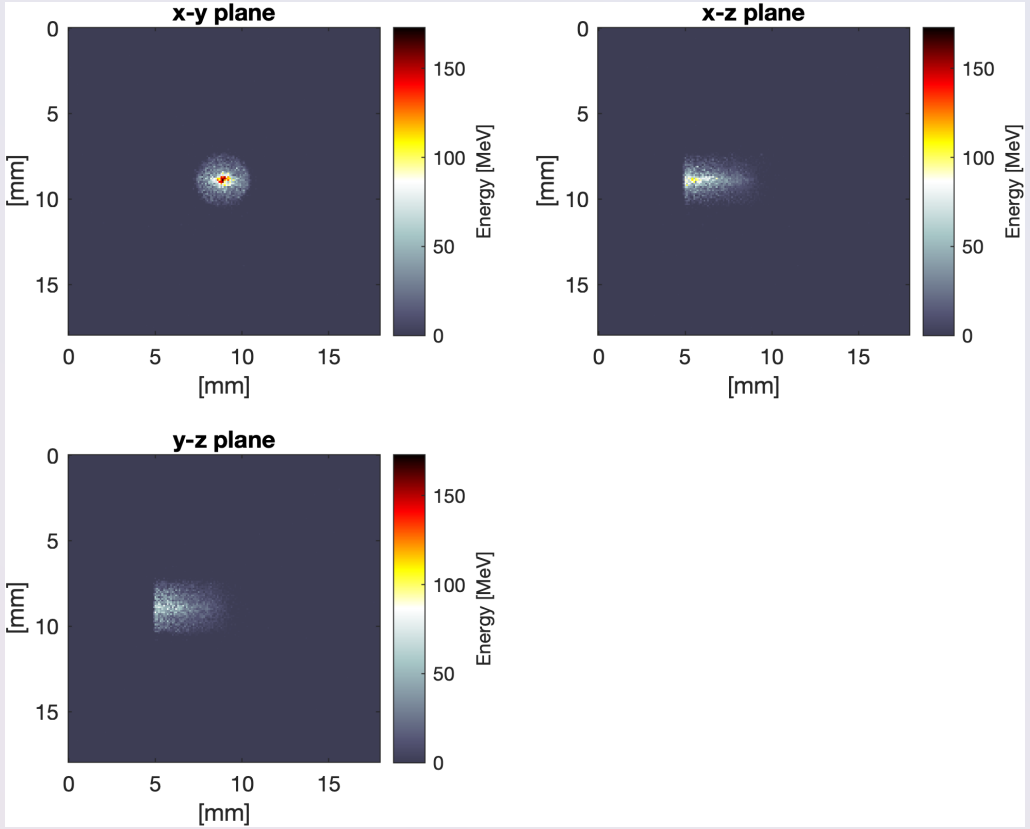


Figure 23: Secondary particles' energy depositions in the phantom.

2. Electrons at Source

Energy Distribution

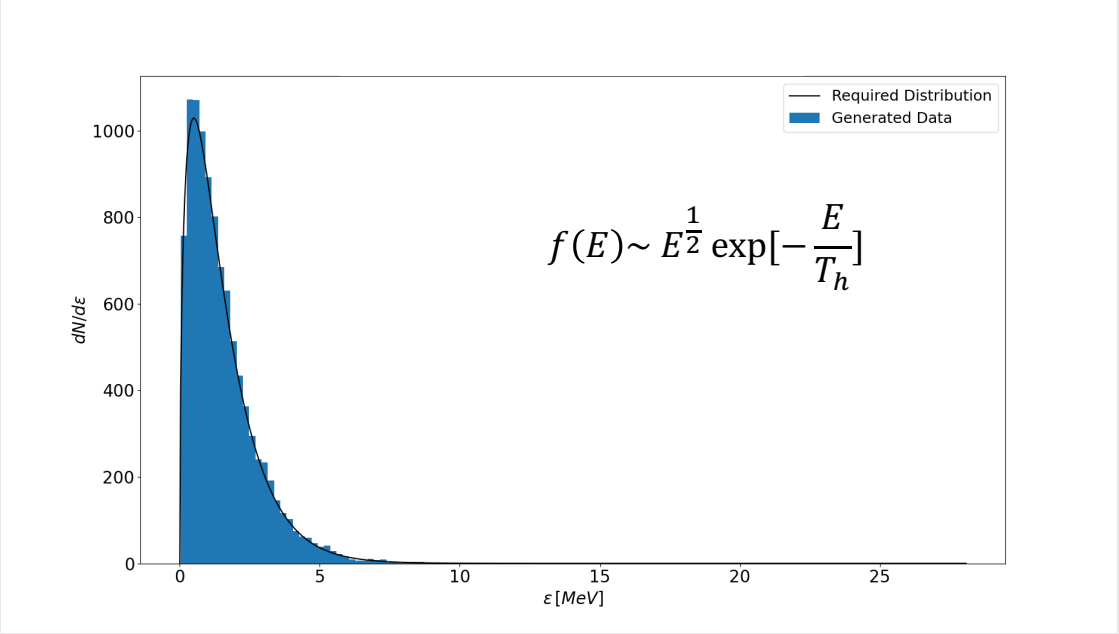


Figure 24: Electron energy distribution at the source.

Angular Distribution

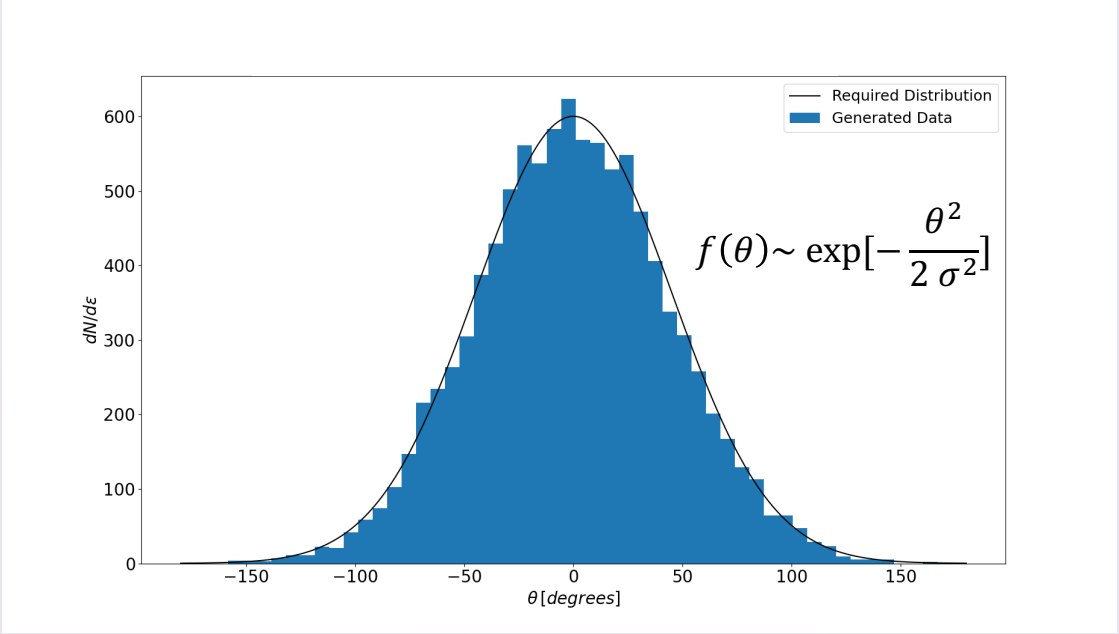


Figure 25: Electron energy distribution at the source.

2.Electron Energy Distribution & Depositions

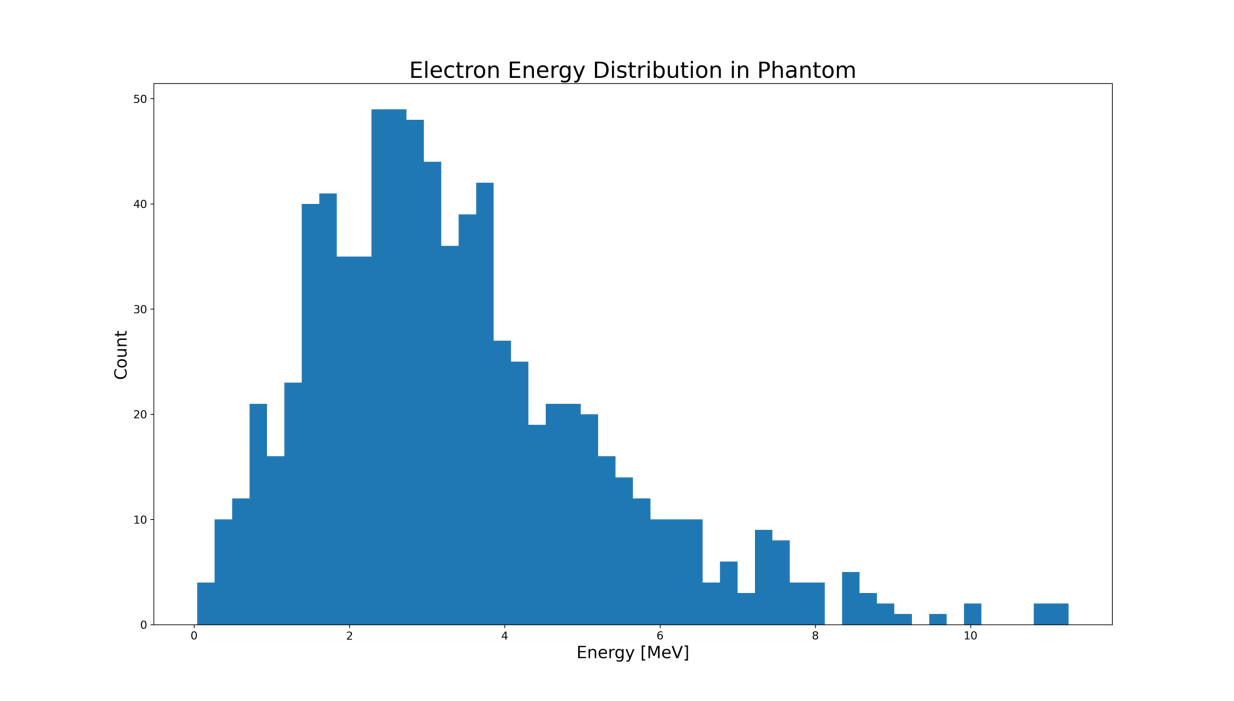


Figure 26: Energy spectrum of the electrons (3636 shown here) that arrive at the end of the LION beamline.

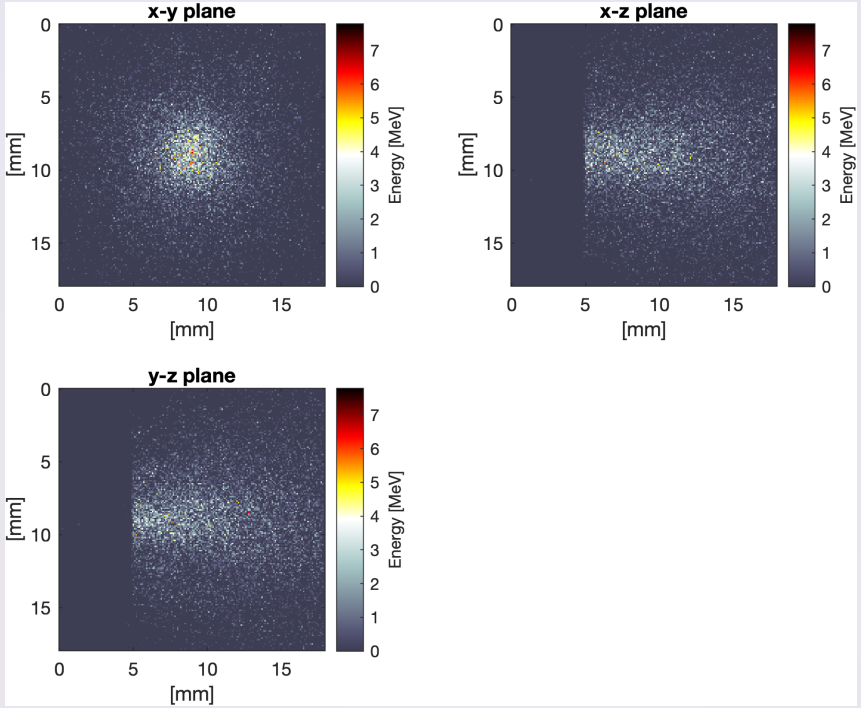


Figure 27: Source-generated electron energy distribution in the phantom.

Electron & Proton Time of Flight

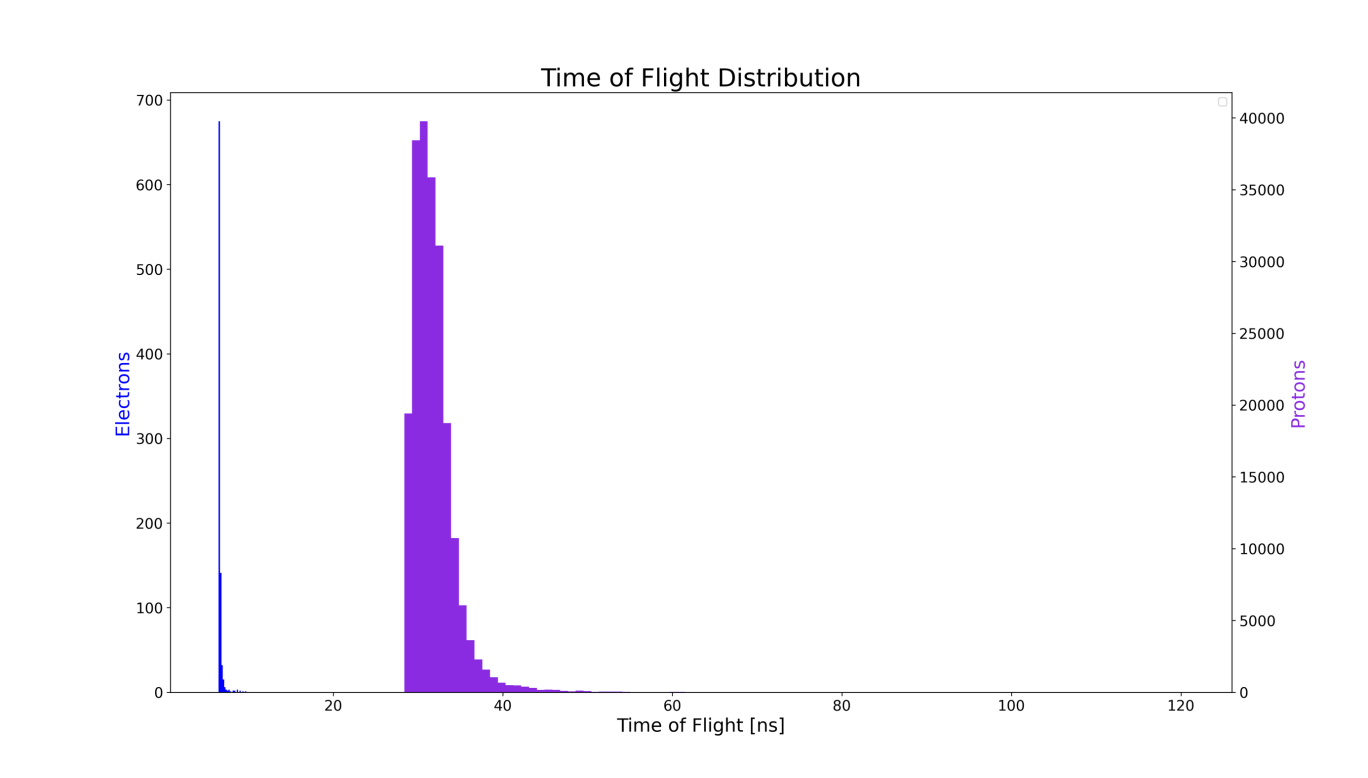


Figure 28: Time of flight distribution of electrons and protons in the LION beamline.

Acoustic Transducer

1. Matrix Array

Specifications for Vantage Volume Imaging Matrix Array Transducers

	3 MHz	8 MHz
Center Frequency	3.5 MHz	7.5 MHz
Bandwidth	60%	60%
Elements	1024 (32x32)	1024 (32x32)
Pitch	0.3 mm	0.3 mm
Elevation Aperture	12x14mm	12x14mm
Cable Length	Main cable = 1m; sub cables = 1m	Main cable = 1m; sub cables = 1m
Compatibility	Vantage 256	Vantage 256
Verasonics Part #	P01920	P01921

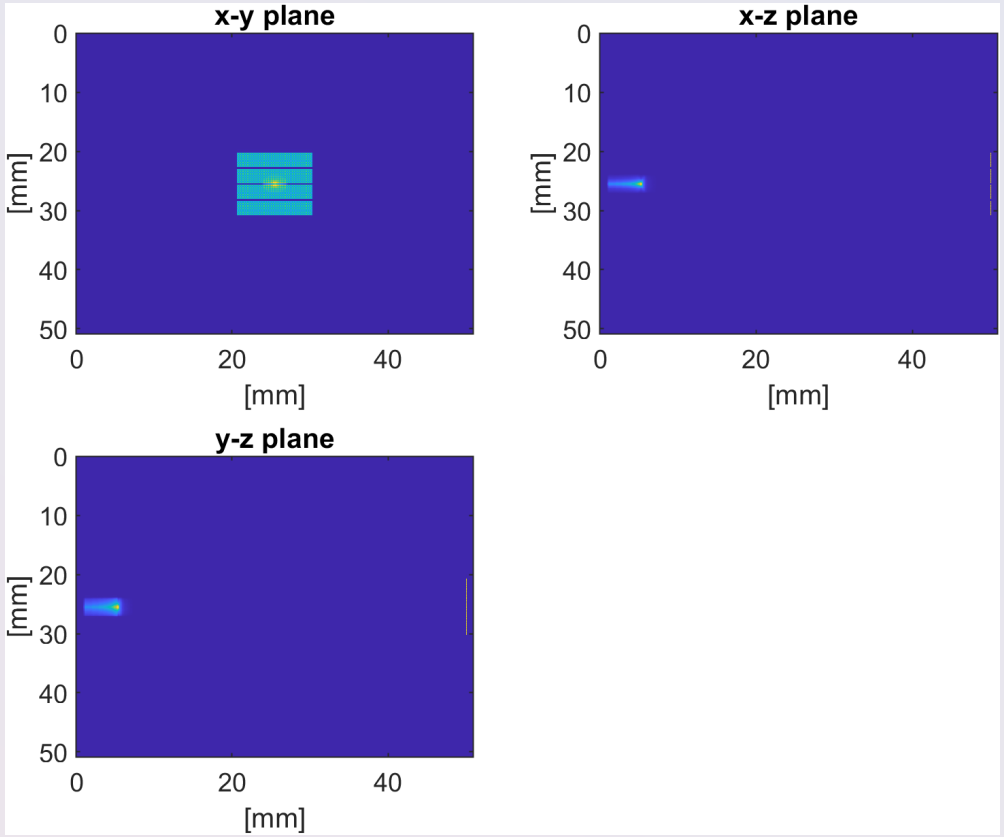


Figure 29: k-Wave simulation of the matrix array.

2. Linear Array

RC6gV Specifications and Values	
Center Frequency	6 MHz
Number of elements	256 (128 x 2)
Bandwidth (-6 dB)	100 %
Pitch	0.2 mm
Element Width	0.175 mm
Element Length	25.6 mm
Active aperture	25.6 x 25.6 mm^2
Cable length	2 m
UTA connector	UTA 408-GE

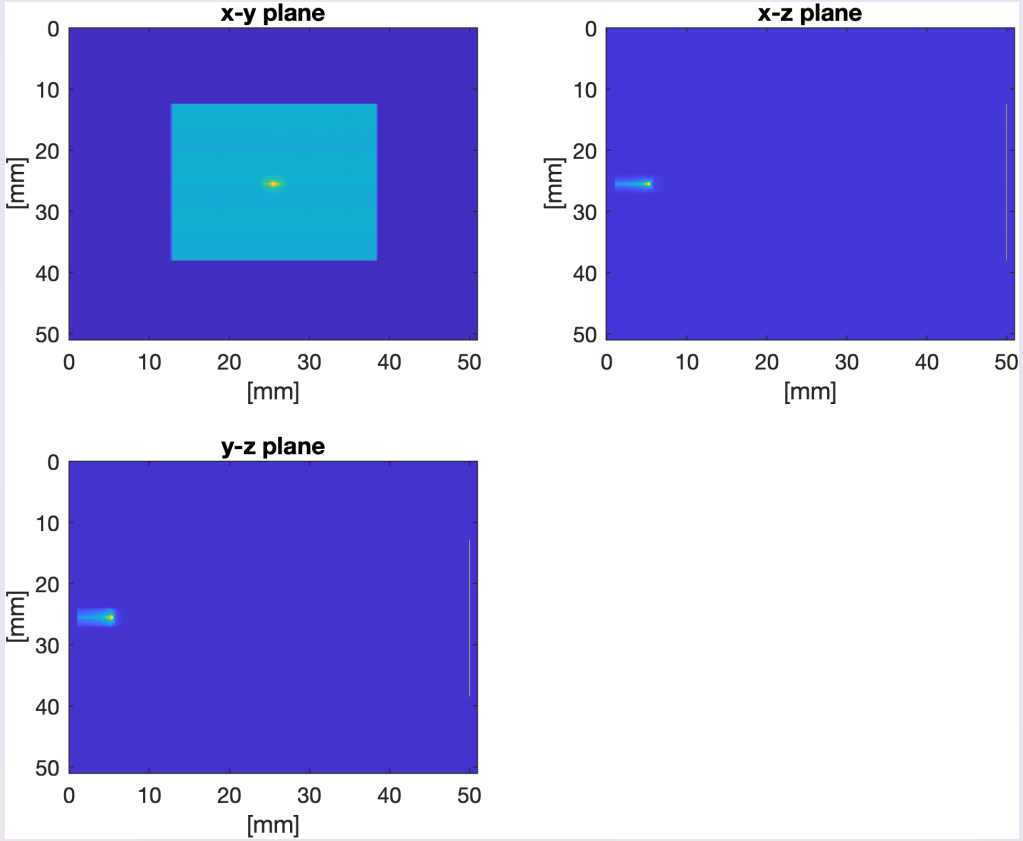


Figure 30: k-Wave simulation of the linear array.