# Ionacoustic Simulation

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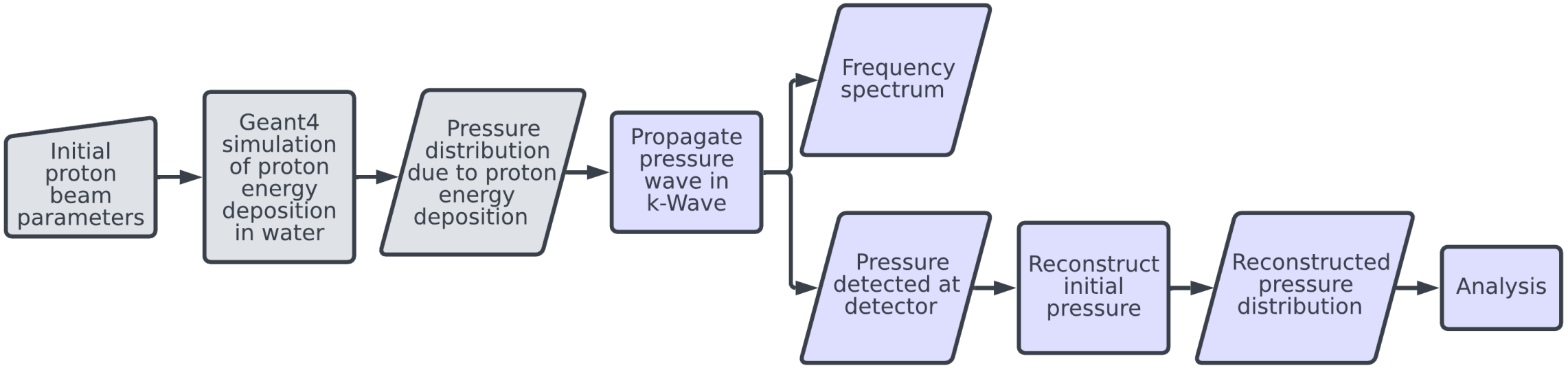
27th April 2022

# Simulation pipeline



# k-Wave

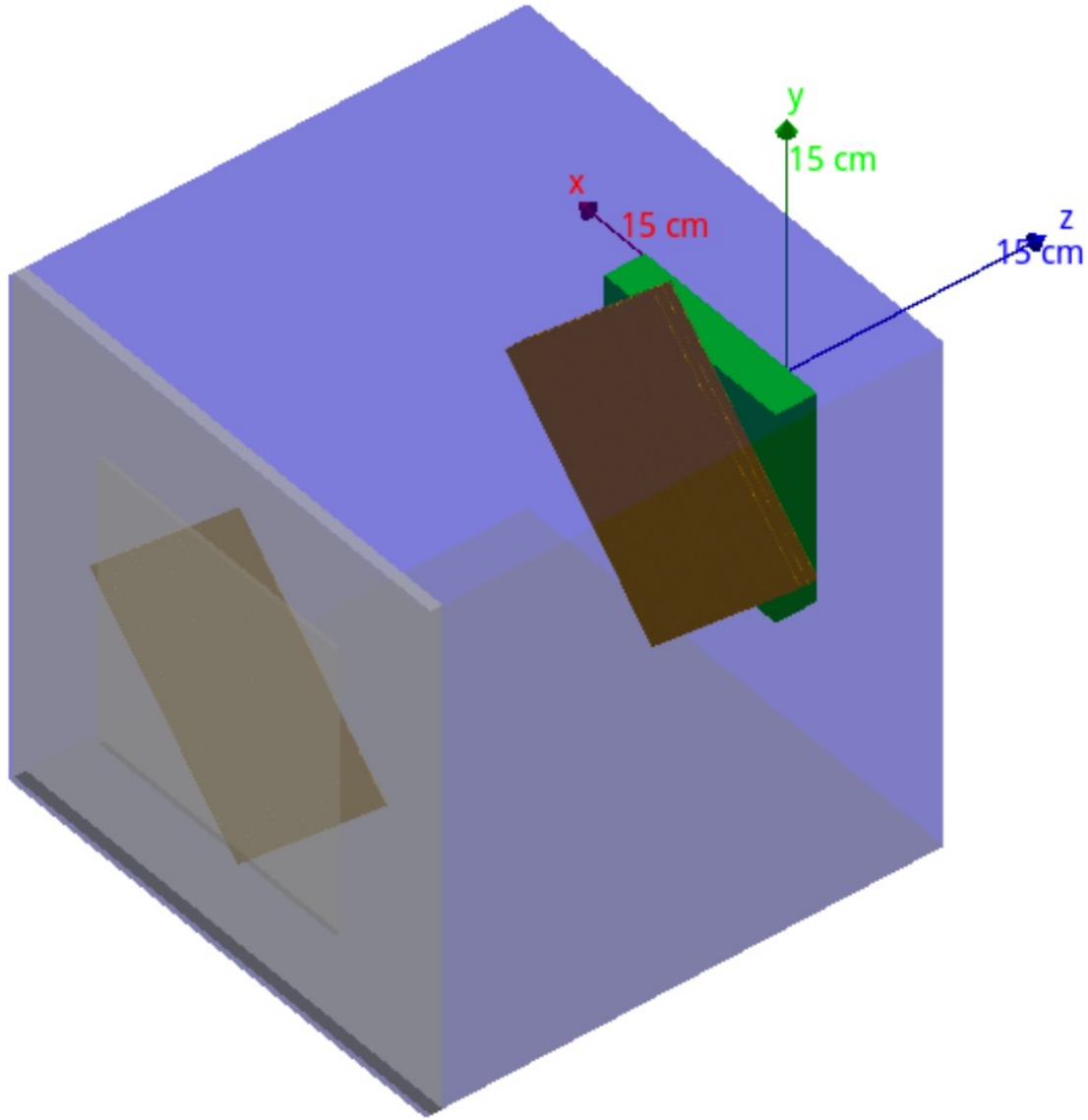
- Open-source acoustic modelling toolbox for MATLAB
- Given an initial distribution – how does this propagate?
- Simulate detectors
- Image reconstruction


B. E. Treeby and B. T. Cox, ‘k-Wave: MATLAB toolbox for the simulation and reconstruction of photoacoustic wave fields’, J. Biomed. Opt., vol. 15, no. 2, p. 021314, 2010, doi: 10.1117/1.3360308.

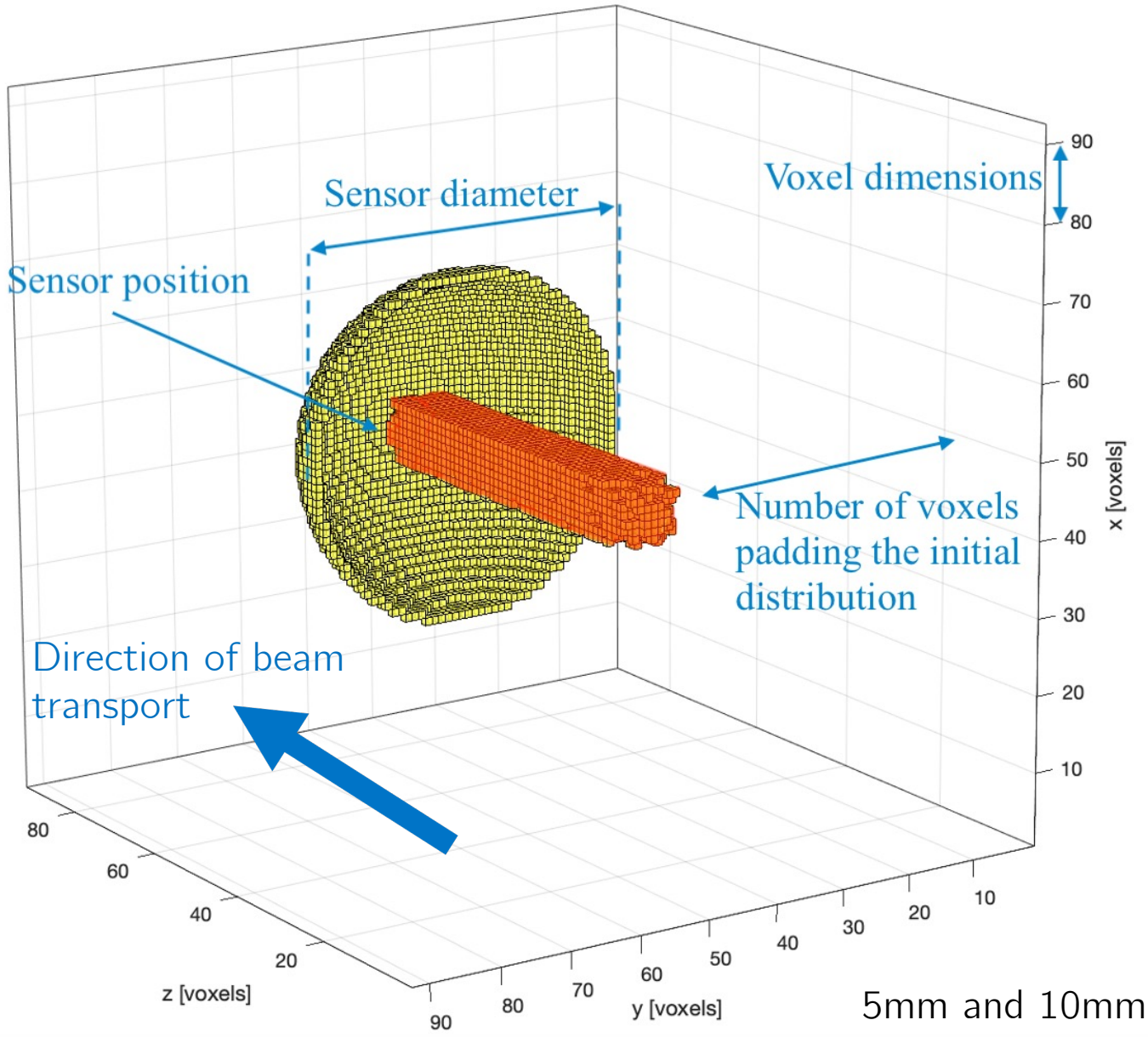
# Test beam parameters

| Particle property | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|
| Energy [MeV] | 200 | 2 | 192 | 208 |
| X position [mm] | 0 | 0.74 | -1.66 | 1.64 |
| Y position [mm] | 0 | 2.34 | -5.24 | 5.21 |
| Normalised X momentum [no unit, $\times 10^{-3}$] | 0 | 0.4 | -1.0 | 1.0 |
| Normalised Y momentum [no unit, $\times 10^{-3}$] | 0 | 1.6 | -3.5 | 3.5 |

# Geant4 Simulation

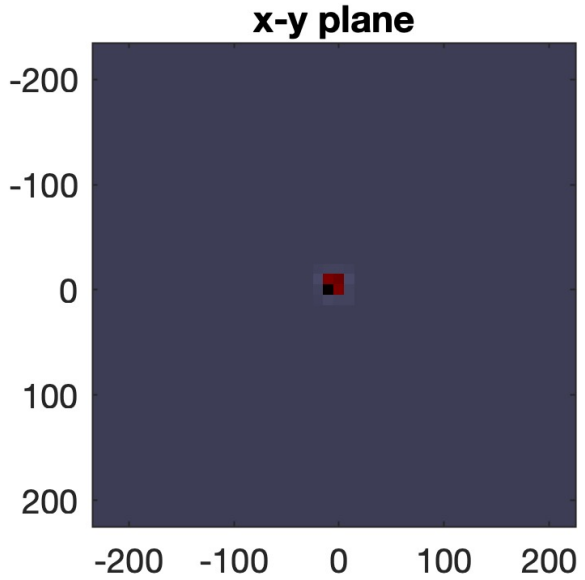


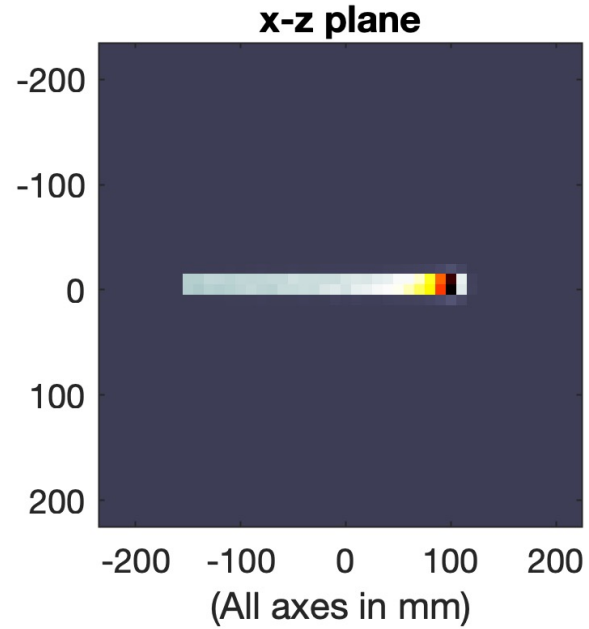
# k-Wave simulation

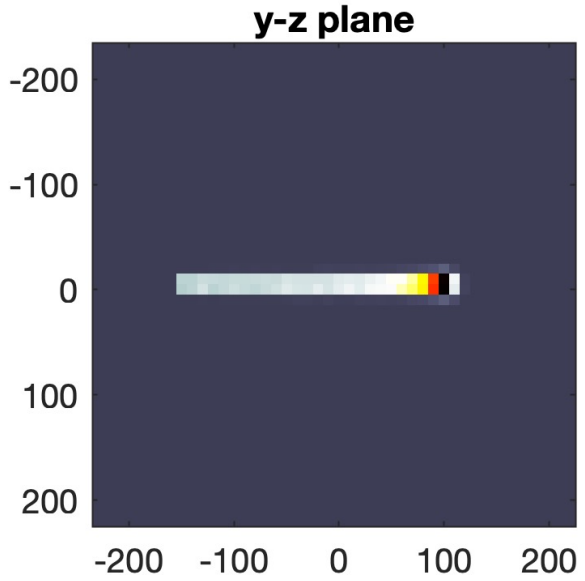



5mm and 10mm voxels
1– 30 iterations tested
Varied detector diameter and longitudinal position

# Initial pressure distribution

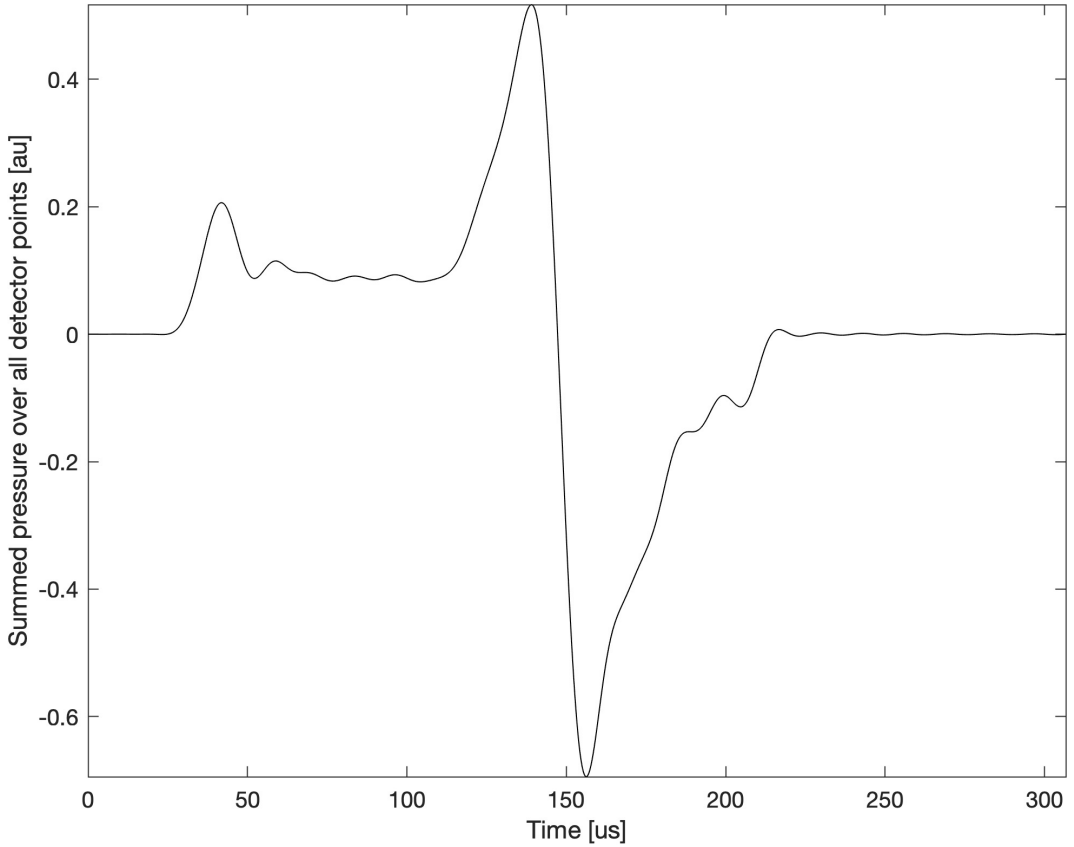


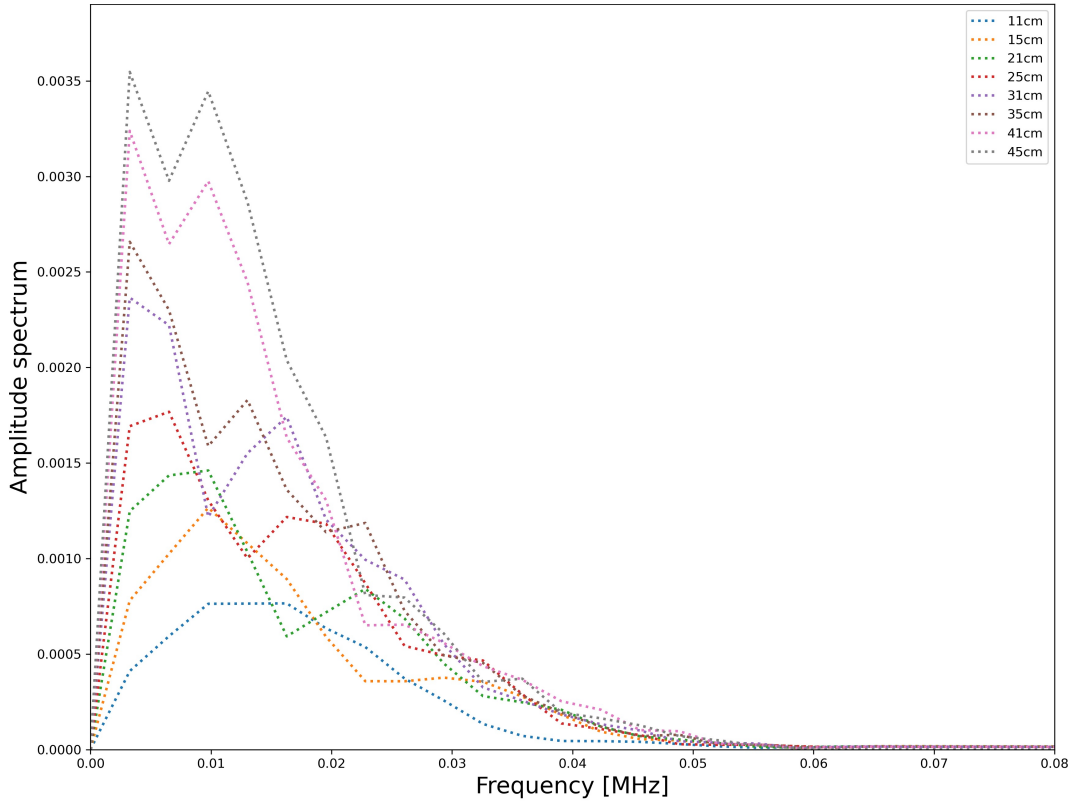
# Out of simulation...

Time series




Example time series for 29 cm detector

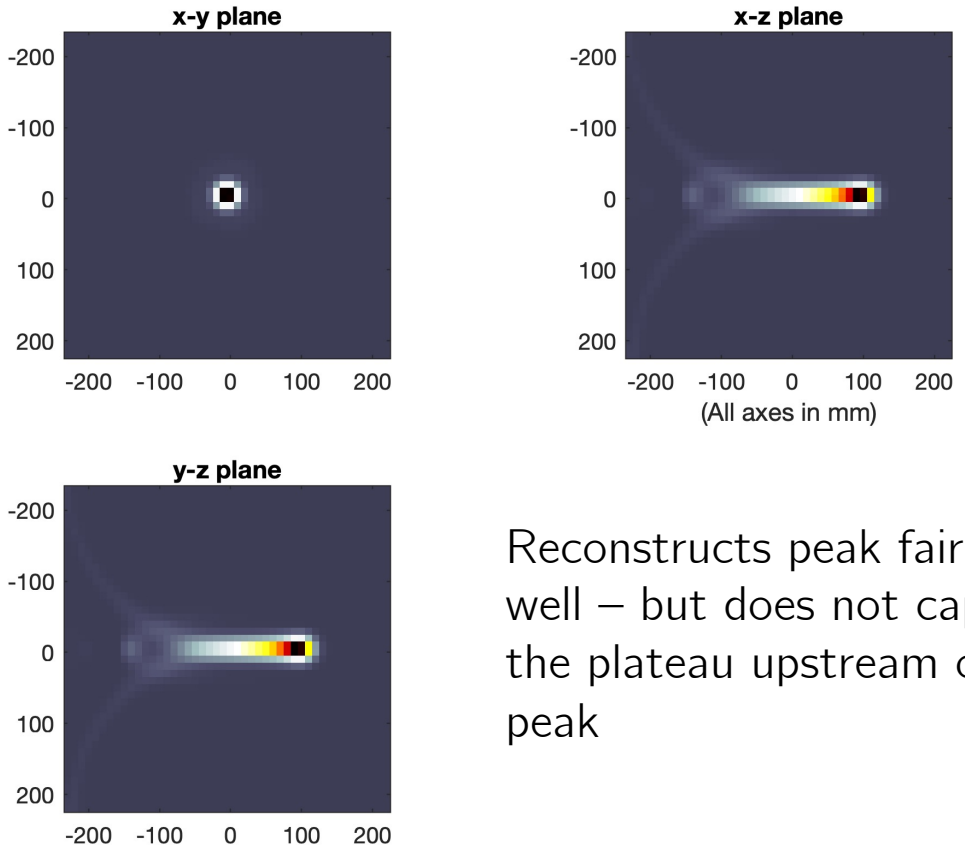
Amplitude frequency spectra



# Reconstruct initial pressure distribution

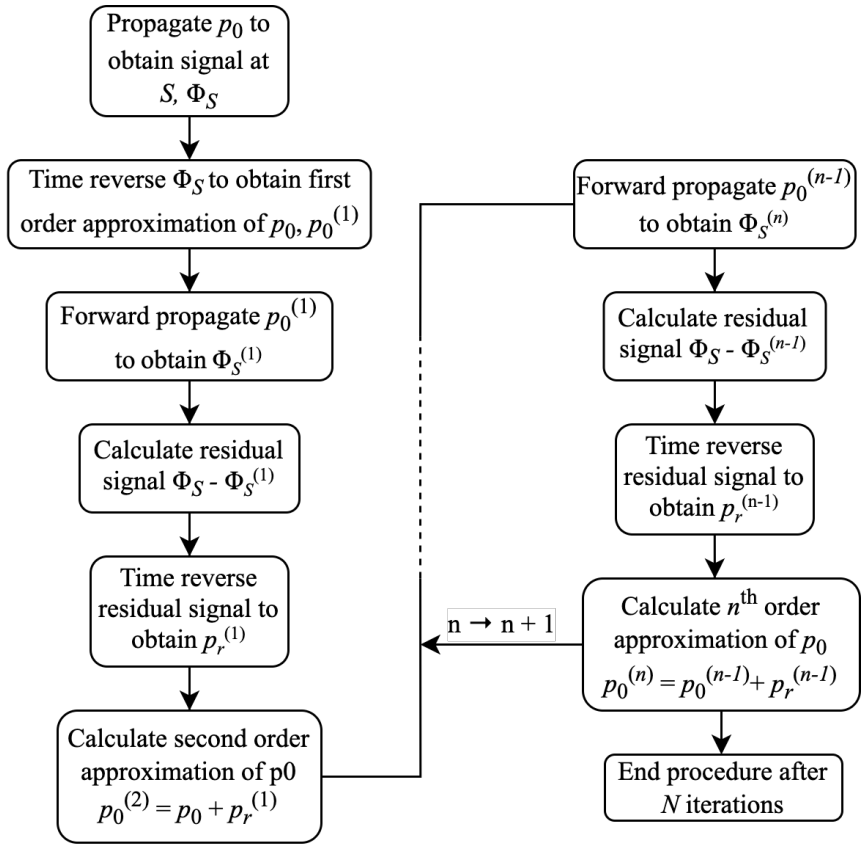
## Reconstruction example

(Detector position = 42cm, Detector diameter = 45cm)




Reconstructs peak fairly well – but does not capture the plateau upstream of the peak

## Iterative time reversal reconstruction algorithm



# Next steps?

- Convergence testing for grid size
- Convergence testing for time step
- Simulation run-time on personal computer is an issue (up to 40mins per iteration) → move onto cluster
- Limited view of reconstructed distributions – need to decide whether we want to image the pre-peak plateau as well
- Different detector configurations
- Divide detector into separated detector elements – more representative of real-life prototype
- Alternative reconstruction algorithms for increased efficiency and performance