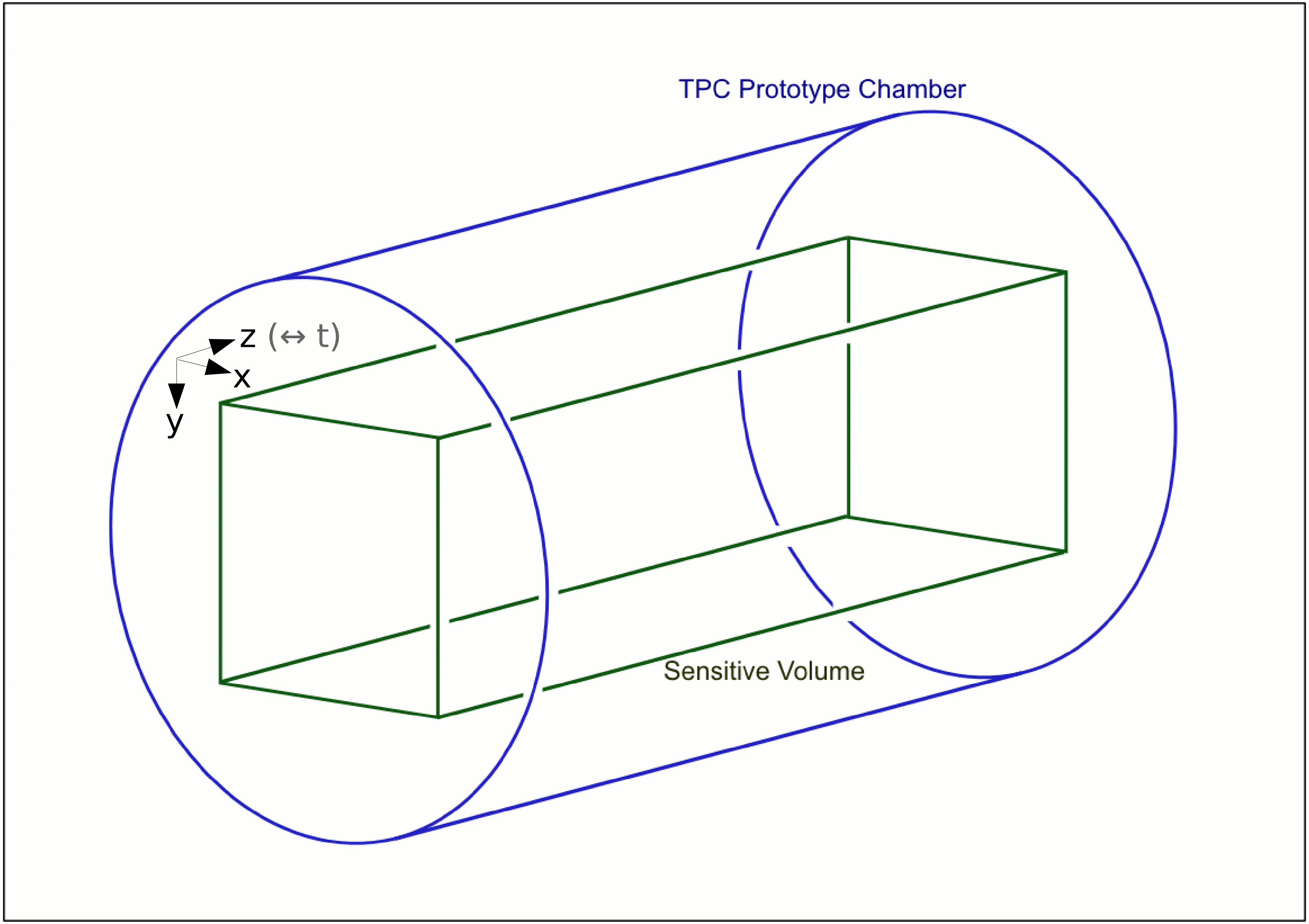
# Introduction

- What do we measure?
- What do we want to know?
- How to reconstruct the wanted parameters?

# Prototype Example

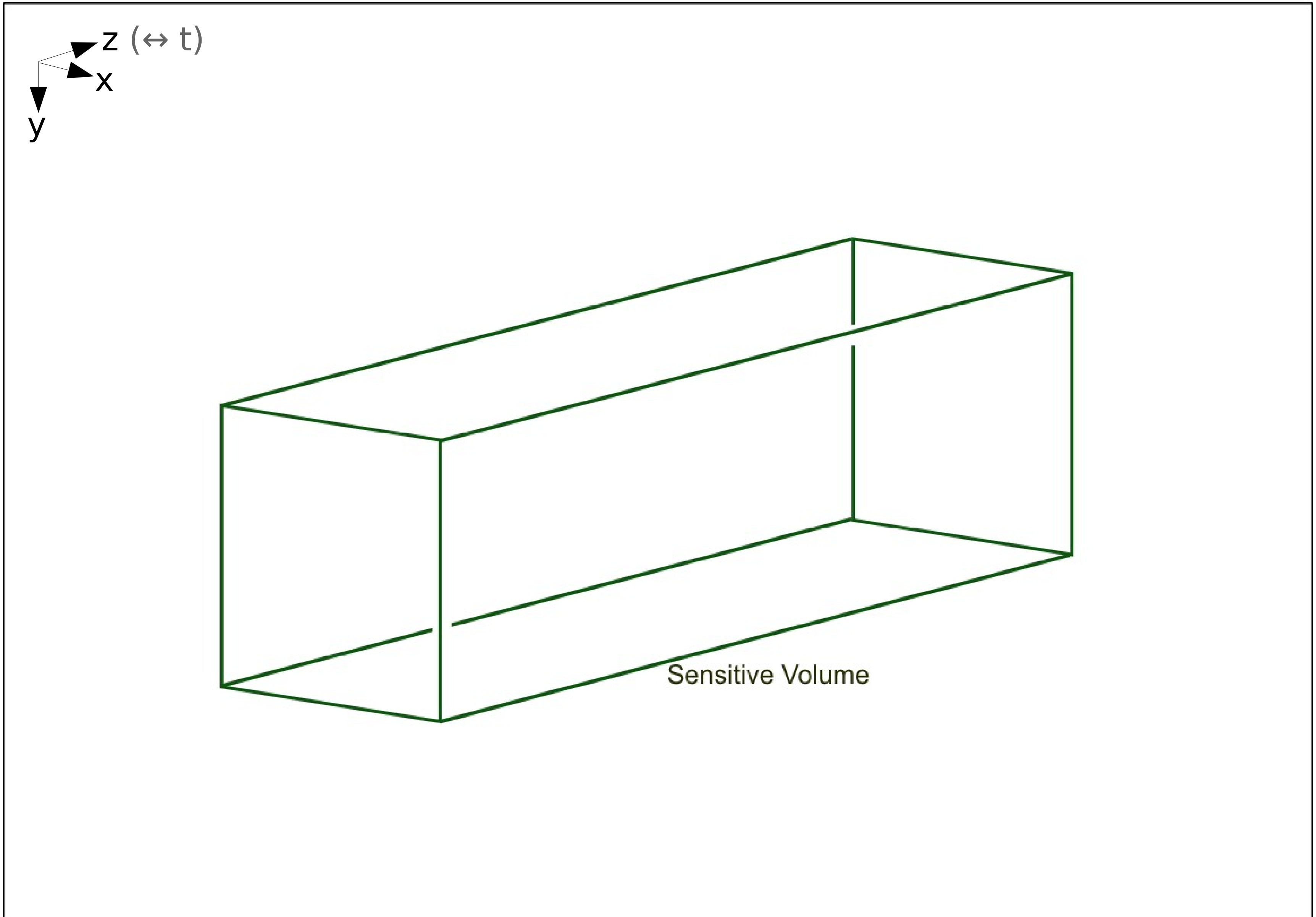
- First a simple example:
- A small prototype
- Readout by a quadratic amplification structure with a pad plane
- Measuring a cosmic muon

# Prototype Example



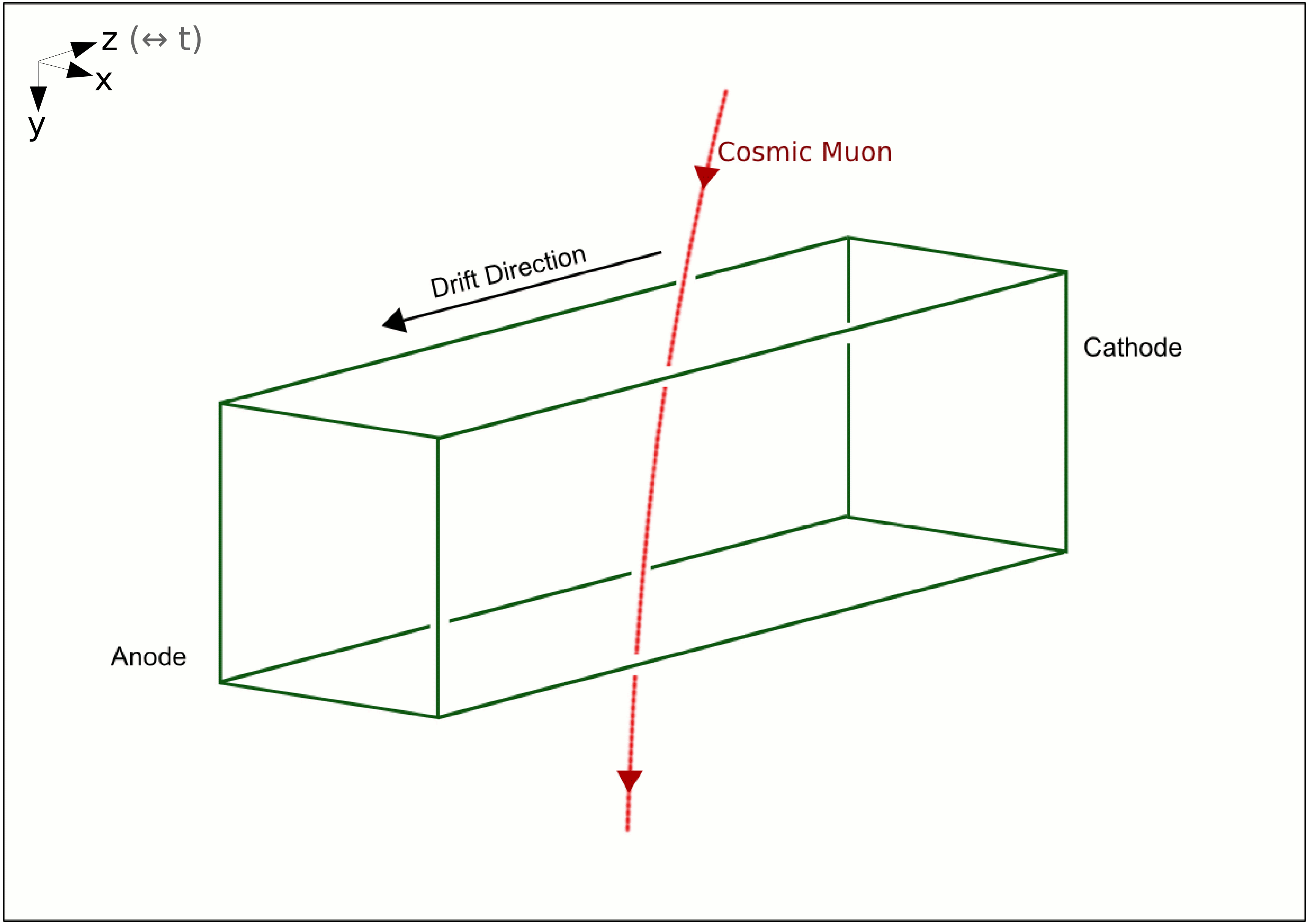
# Prototype Example

Only the sensitive volume is interesting (given by pad plane)



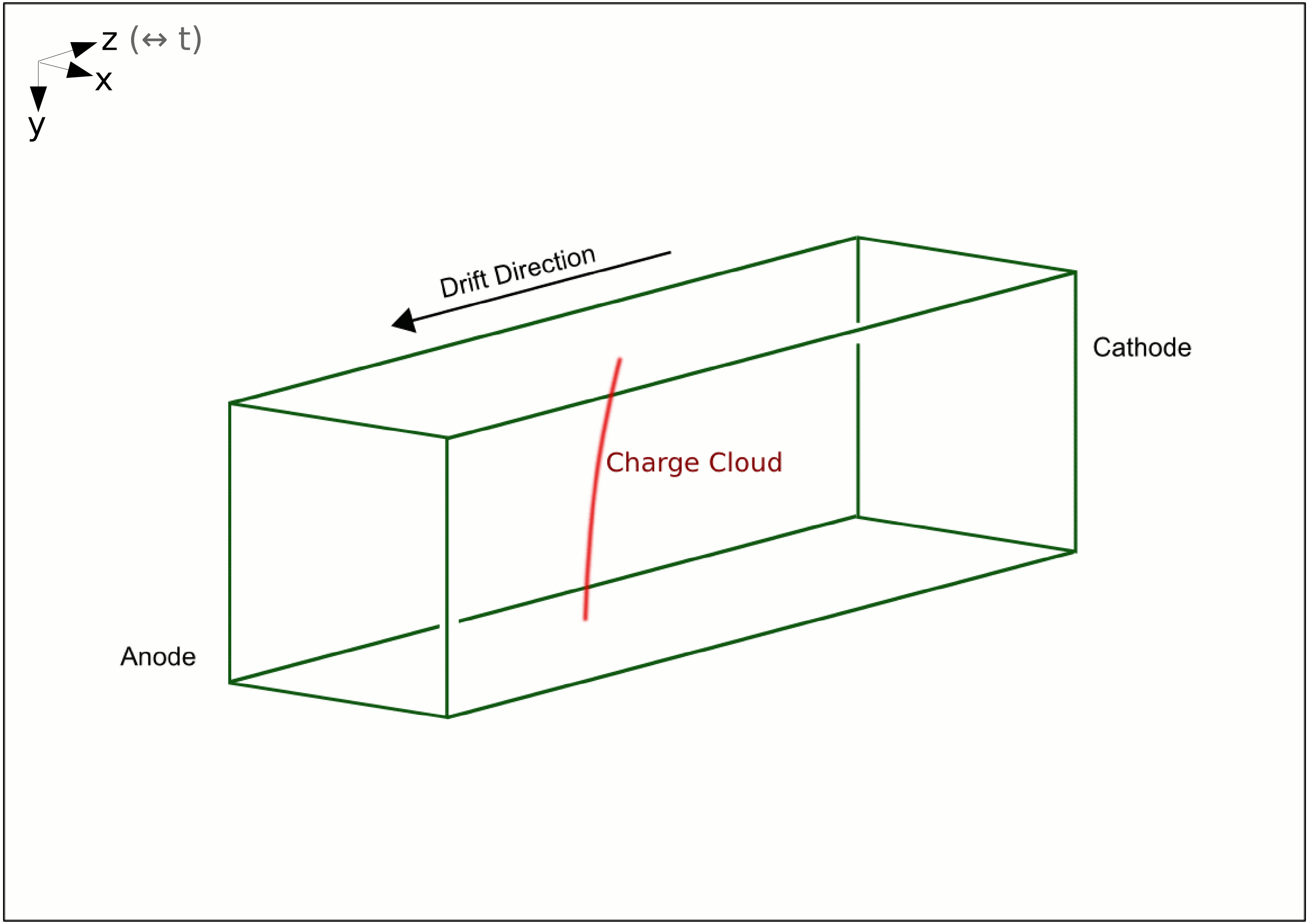
# Prototype Example

Cosmic muon passes the sensitive volume and ionizes the gas



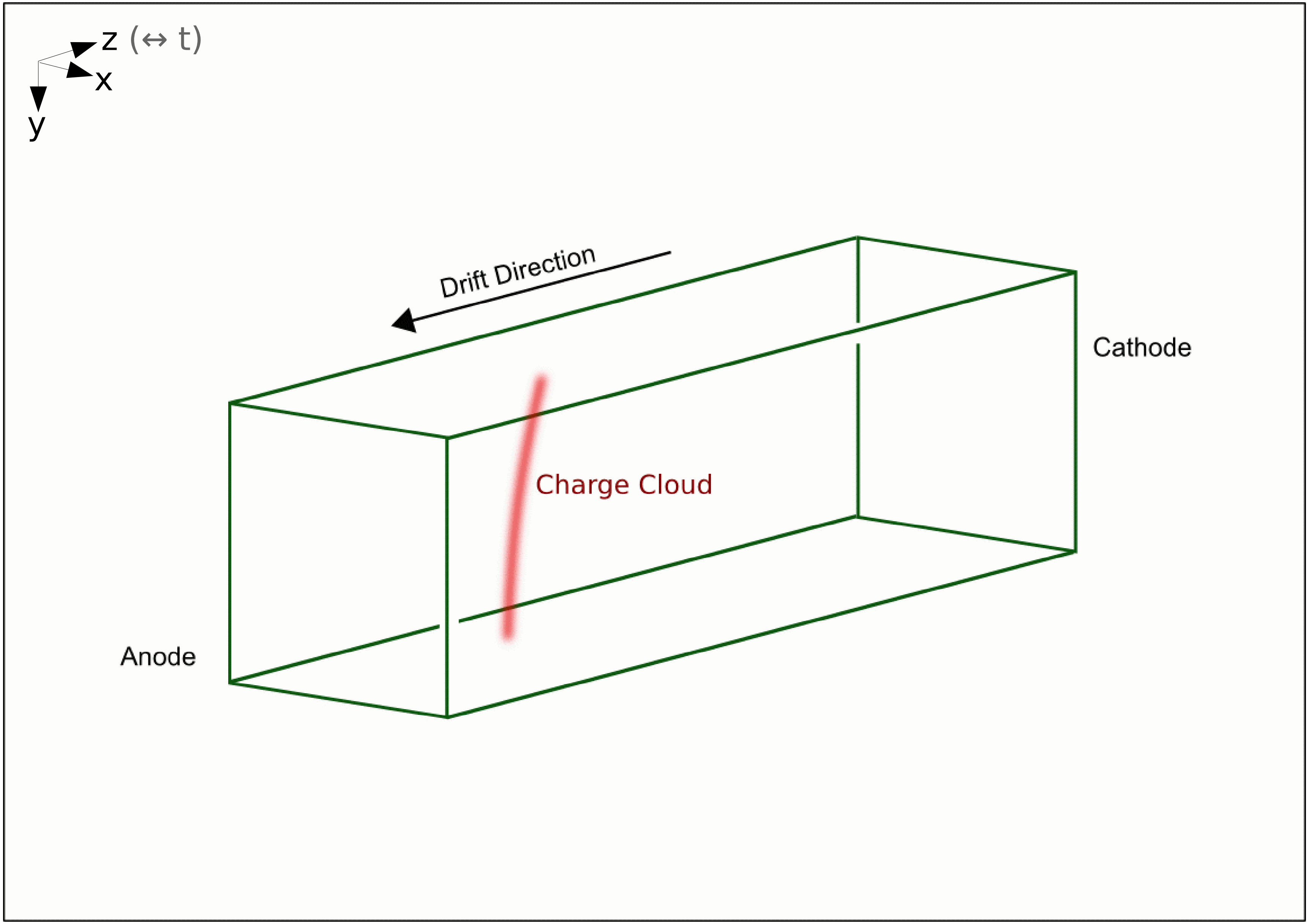
# Prototype Example

The charge cloud drifts towards the anode



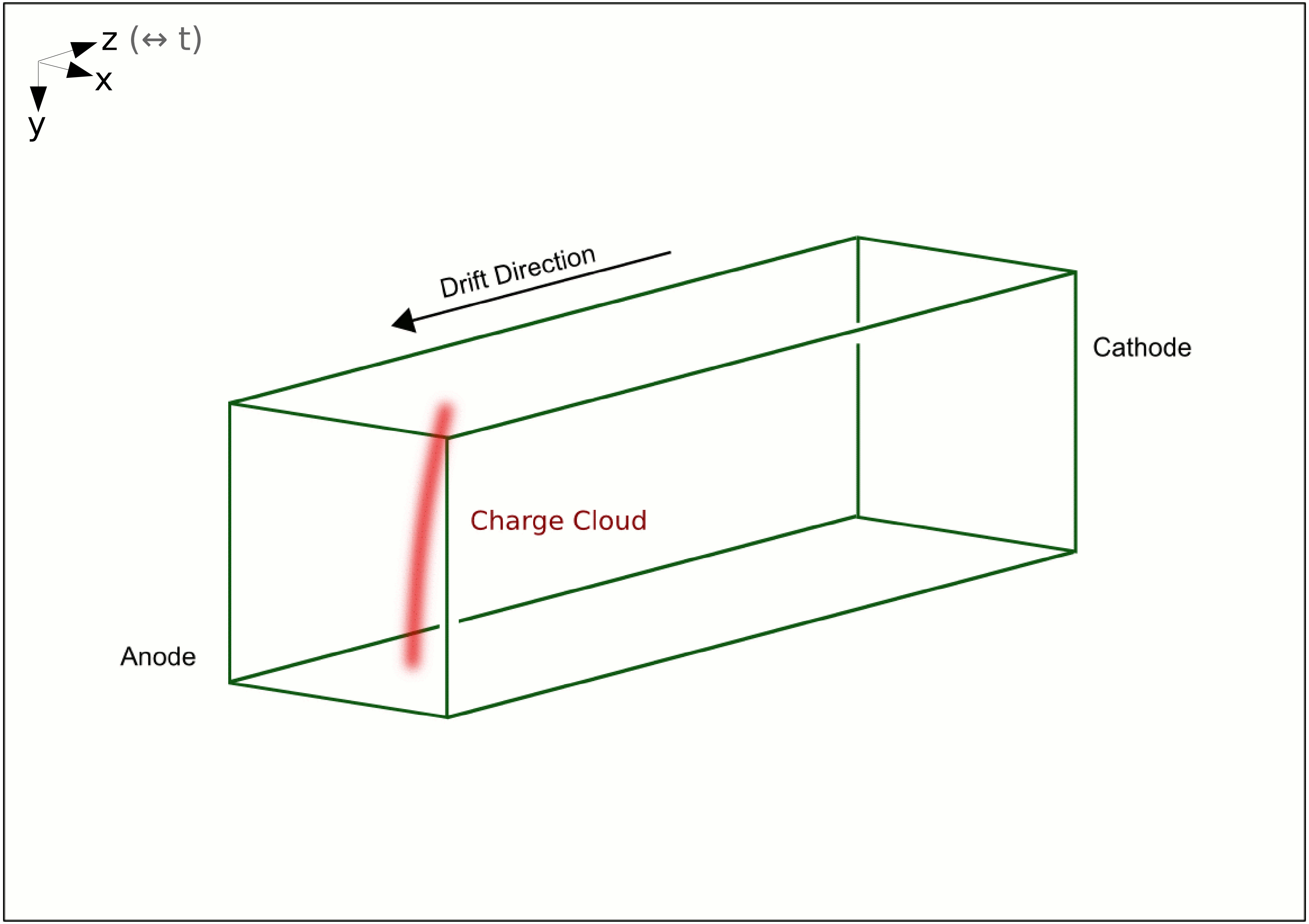
# Prototype Example

During the drift, the electron cloud undergoes diffusion



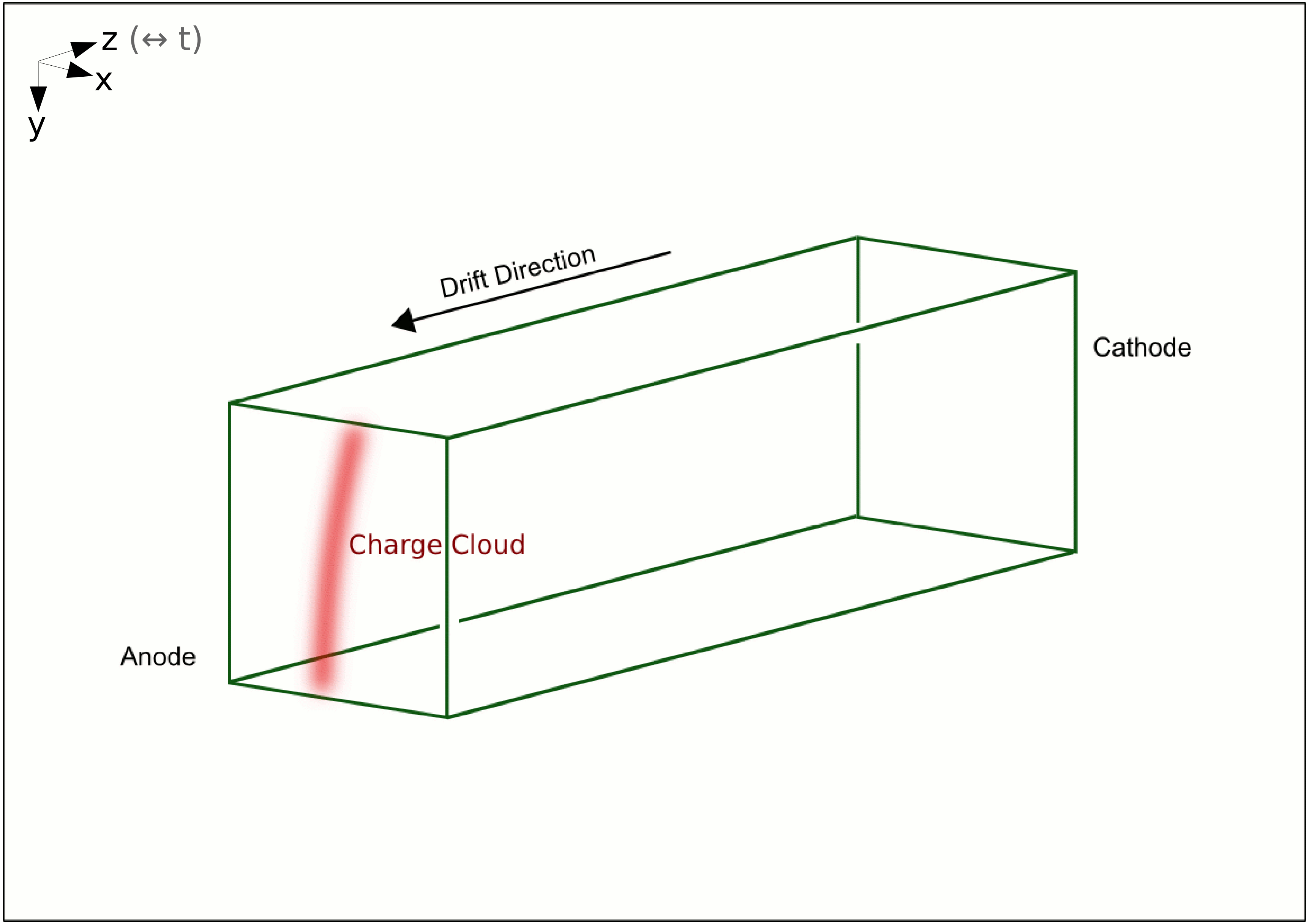
# Prototype Example

So the charge deposition gets broader



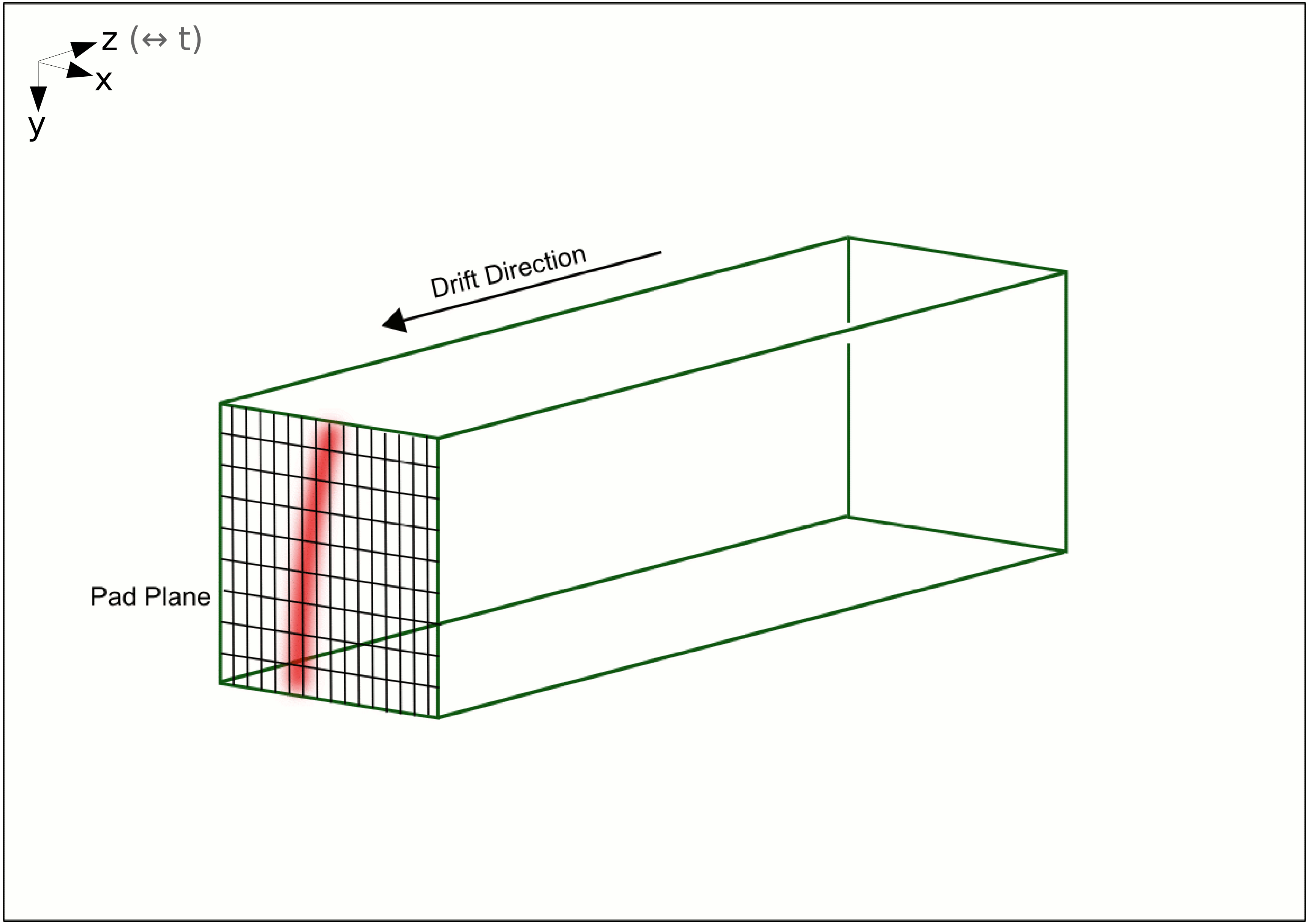
# Prototype Example

... and broader ...



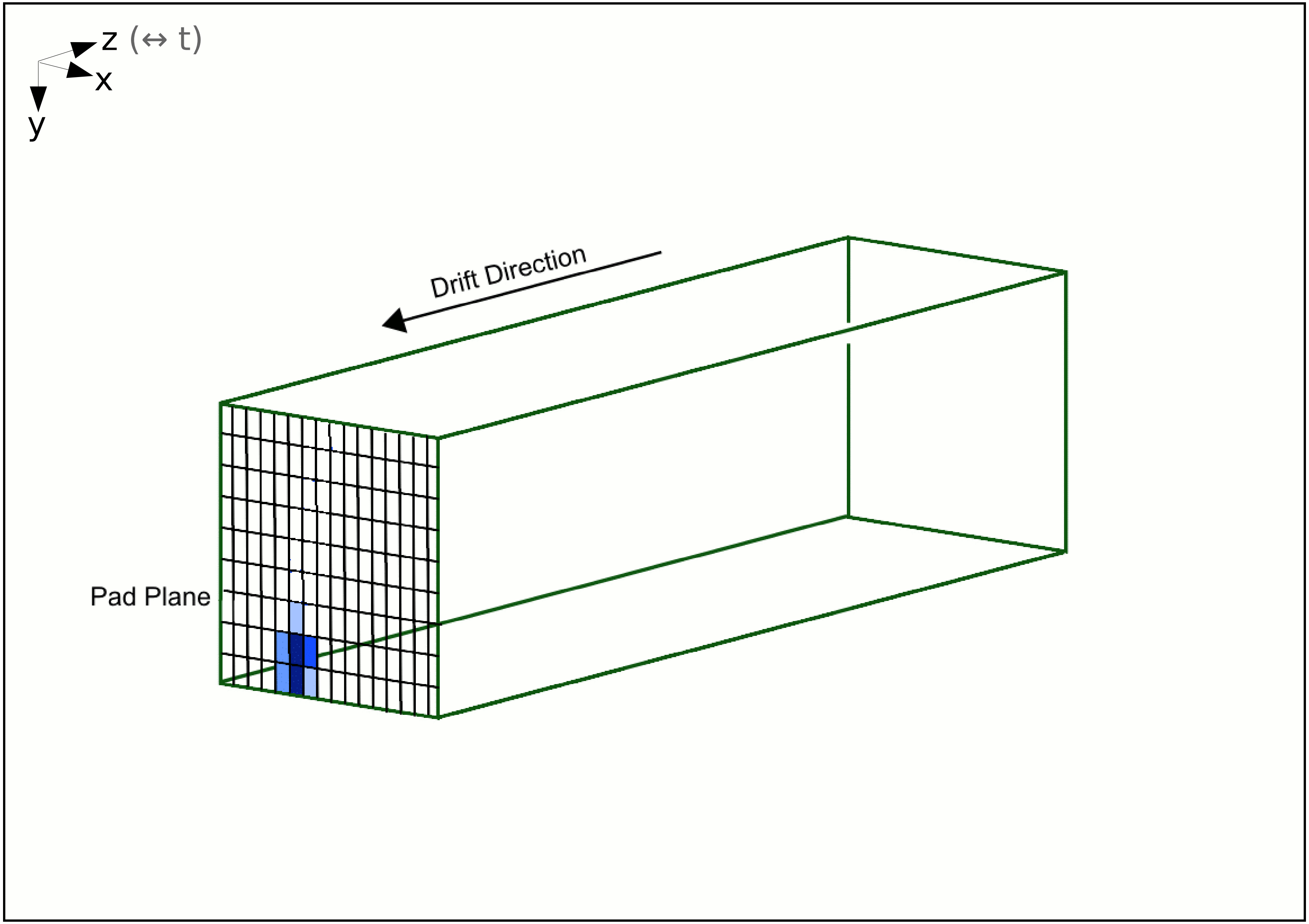
# Prototype Example

Until it arrives at the pad plane, where it is amplified



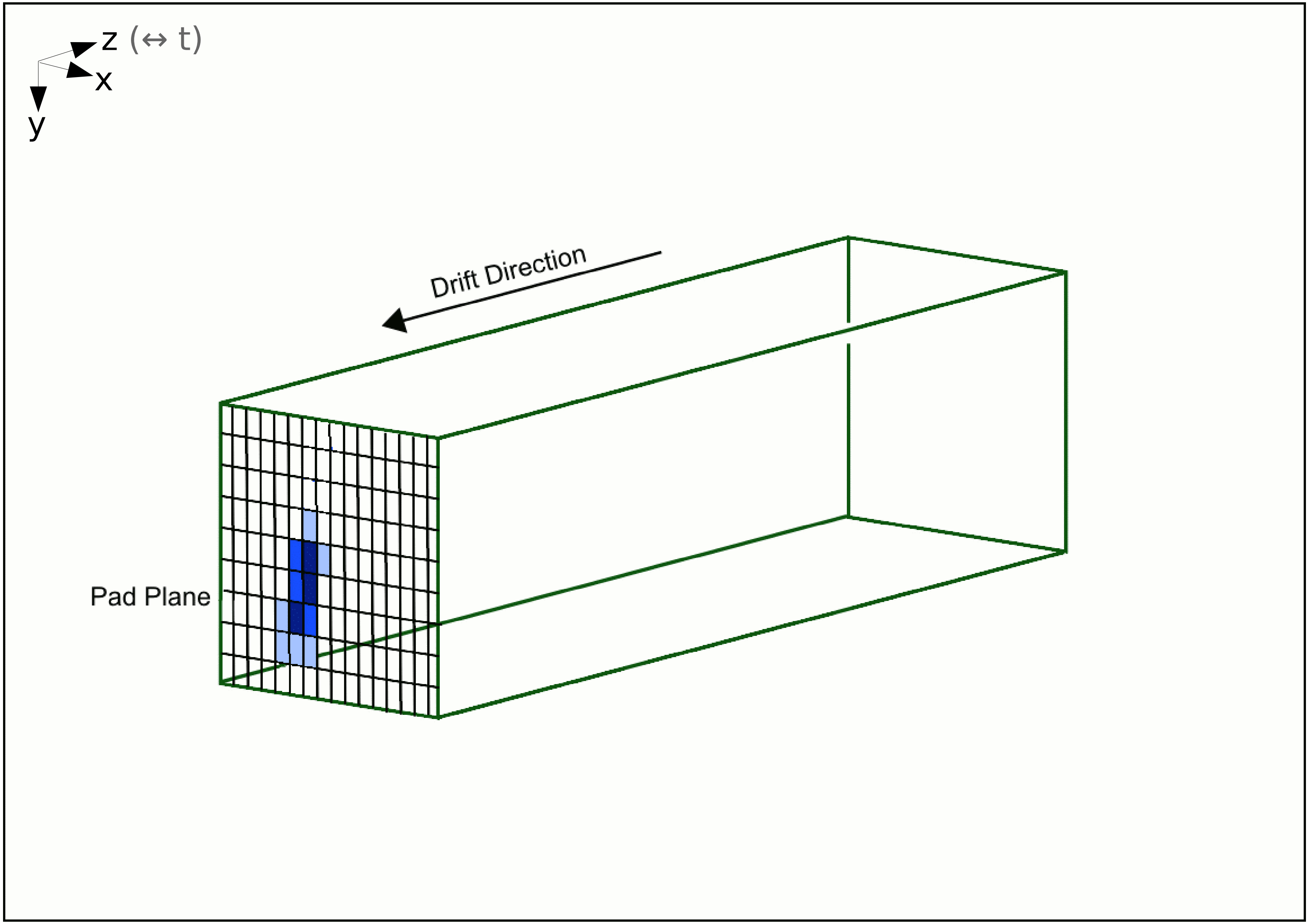
# Prototype Example

Now the signal on the single pads: since track is inclined, some parts arrive earlier



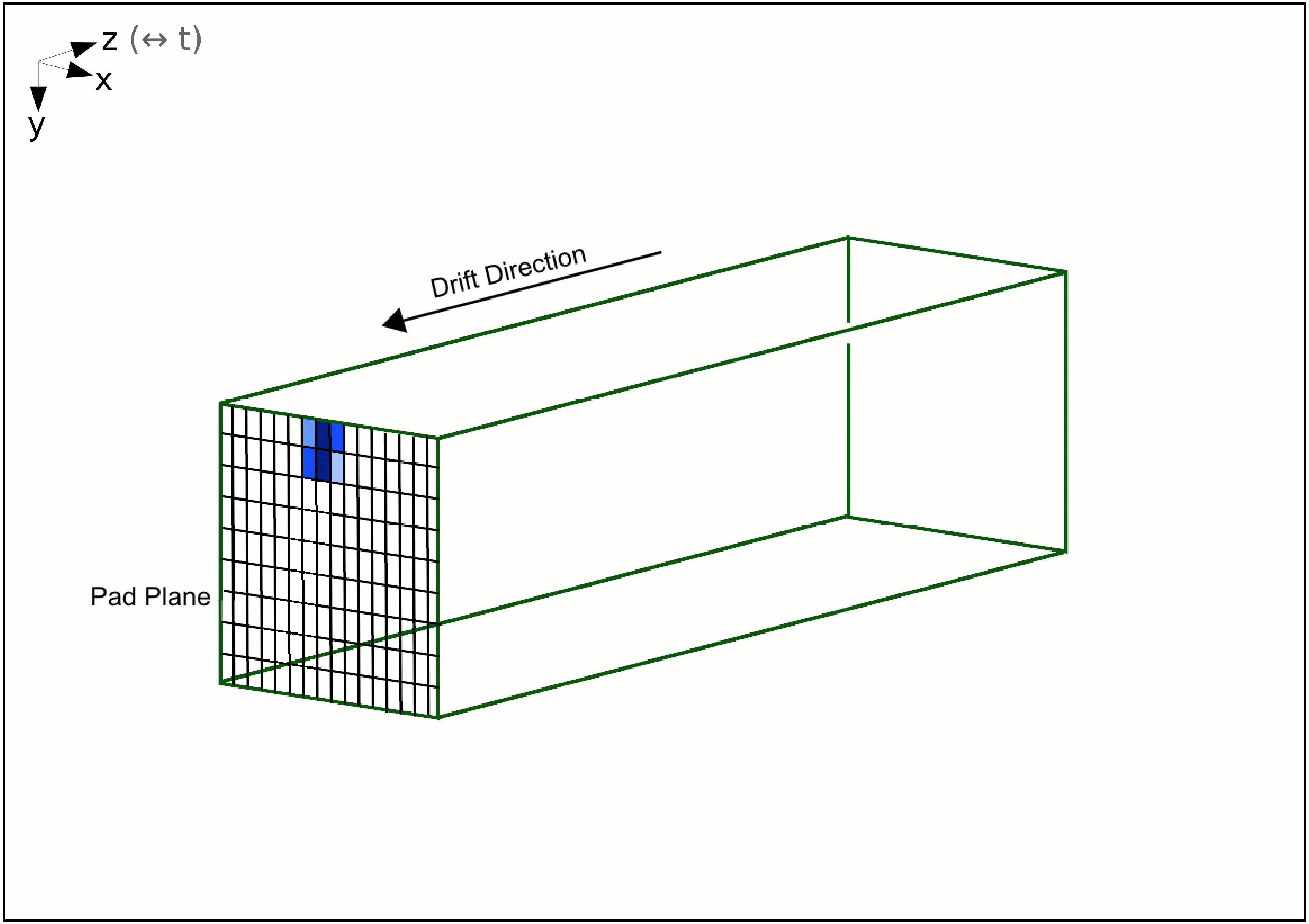
# Prototype Example

Timesteps here are somewhat coarse



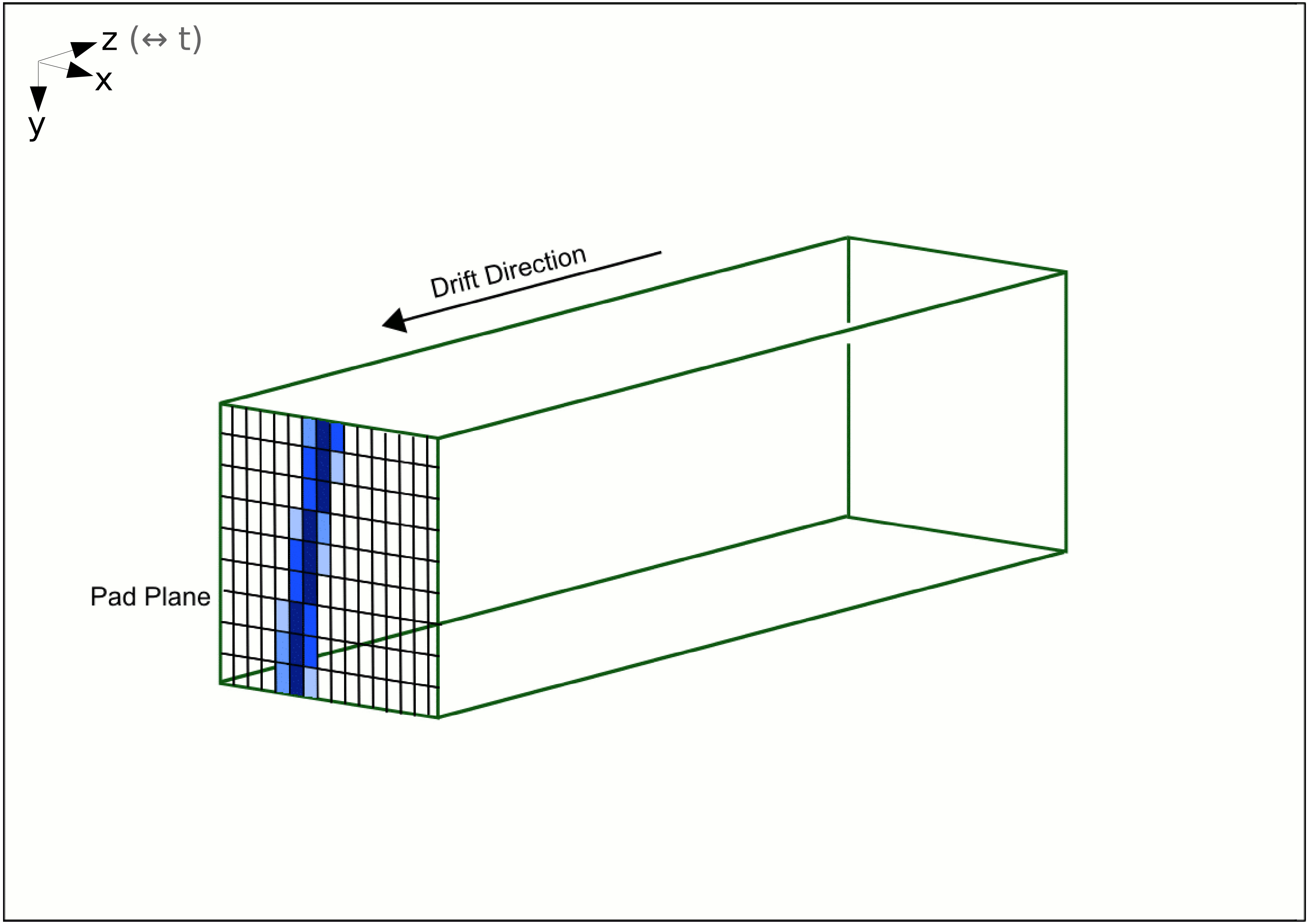
# Prototype Example

The last part of the signals

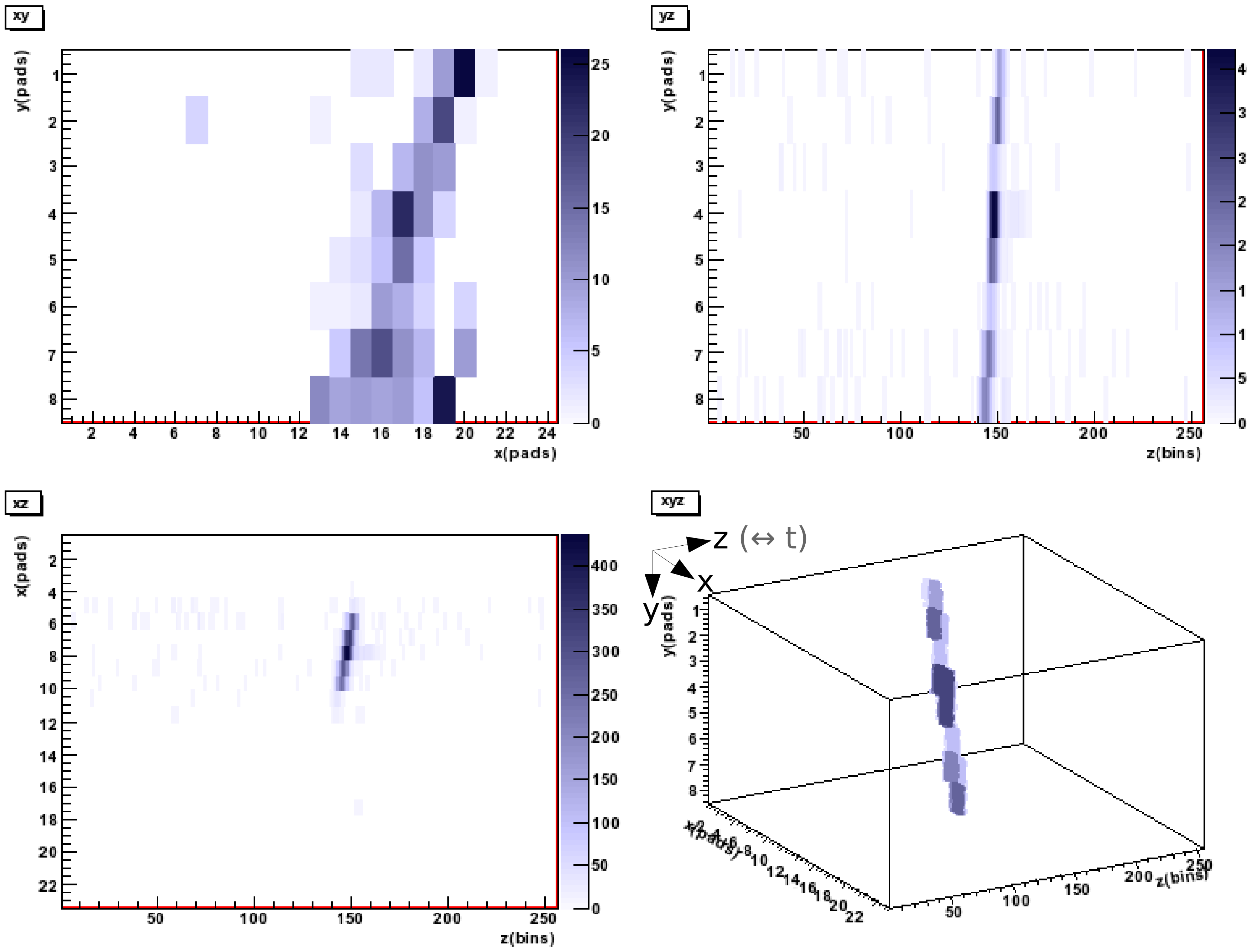


# Prototype Example

Integration over time of the signal on the pad plane

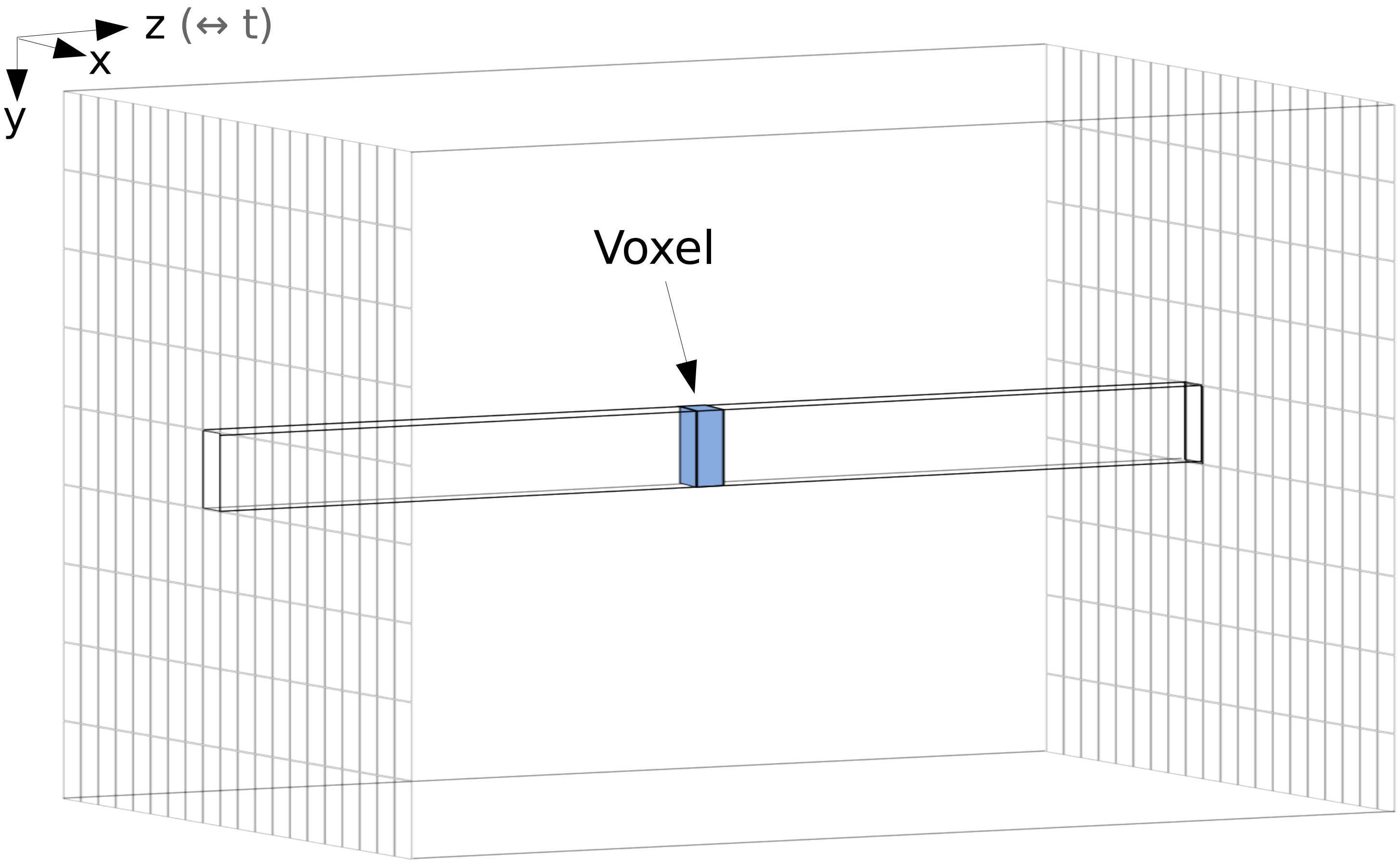


# Real Prototype Example



# Voxel

- A ***Voxel*** is here a cuboid in 3D space:
  XY division given by the pad size / layout
  Z   division given by the sample frequency of the electronics
- this corresponds to a charge measurement at a space point
- it is the smallest “unit” in the reconstruction process



# Reconstruction Goals

- What do we want to know?

- The momentum of the particle!
- To get the momentum, we need to reconstruct its trajectory
- If we know the curvature of the trajectory in a given B field, we get the momentum by:

$$\frac{transverse\, momentum\, p_T}{GeV} \approx 0.3 * \frac{Radius\, R}{m} * \frac{B\, field}{T}$$

- Other parameters we want to know:

- Where does the particle enter and leave the TPC (connection to other detector parts: vertex detector, calorimeter)
- Specific energy loss (dE/dx) → Particle Identification

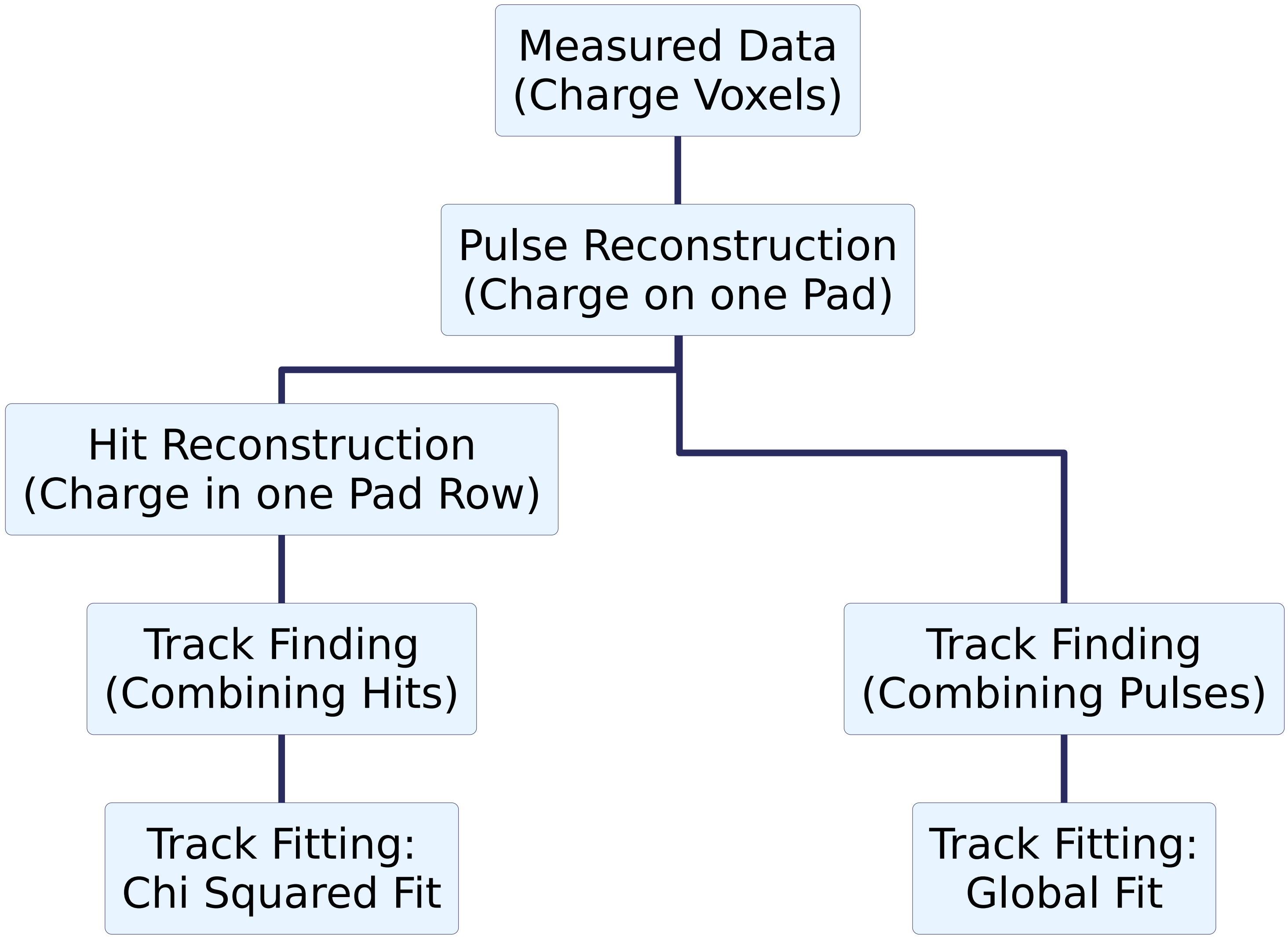
# Reconstruction Flow

- How do we get there from the measured charge voxels?
- 2 basic principles:
  - Global Fit Method (likelihood fit)
  - Chi Squared Method (least squares fit)

- Both fit a function to the measurement which contains the curvature as a fit parameter
- Both fit functions contain information where the track is

- Difference:
  - the Global Fit function describes the charge deposition on the pad plane and is fitted to the measured charge depositions
  - the Chi Squared fit function is fitted to reconstructed space points (so here an intermediate step is taken to reconstruct these space points)

# Reconstruction Flow



# Next

- The reconstruction flow will be followed and the methods explained

- Here, mainly methods that are *simple* are explained:
  - They are robust
  - Effects are “easy” understood
  - They need little input from outside

- Most methods have been used by R&D groups to reconstruct prototype measurement data:
  http://www-flc.desy.de/tpc/projects/multifit/index.php
  http://www.linearcollider.ca:8080/lc/Members/karlen/jtpc/index_html
  ( https://particle.phys.uvic.ca/~karlen/jtpc/ )
  http://ilcsoft.desy.de/portal/software_packages/marlintpc

- For every step, the properties a corresponding data object should have will be listed
  (object of an object oriented programming language: C++, Java)