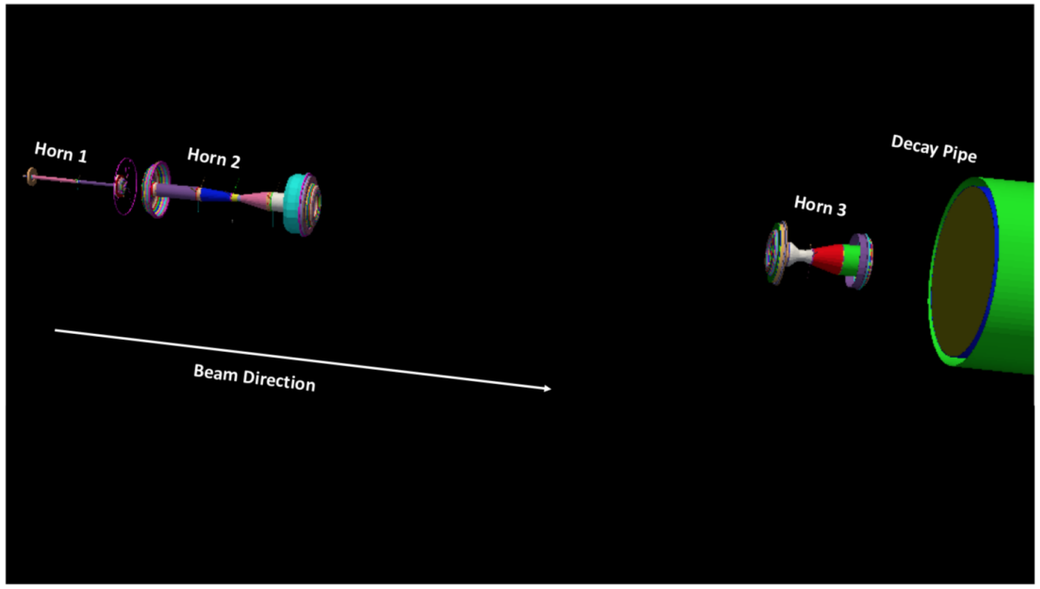
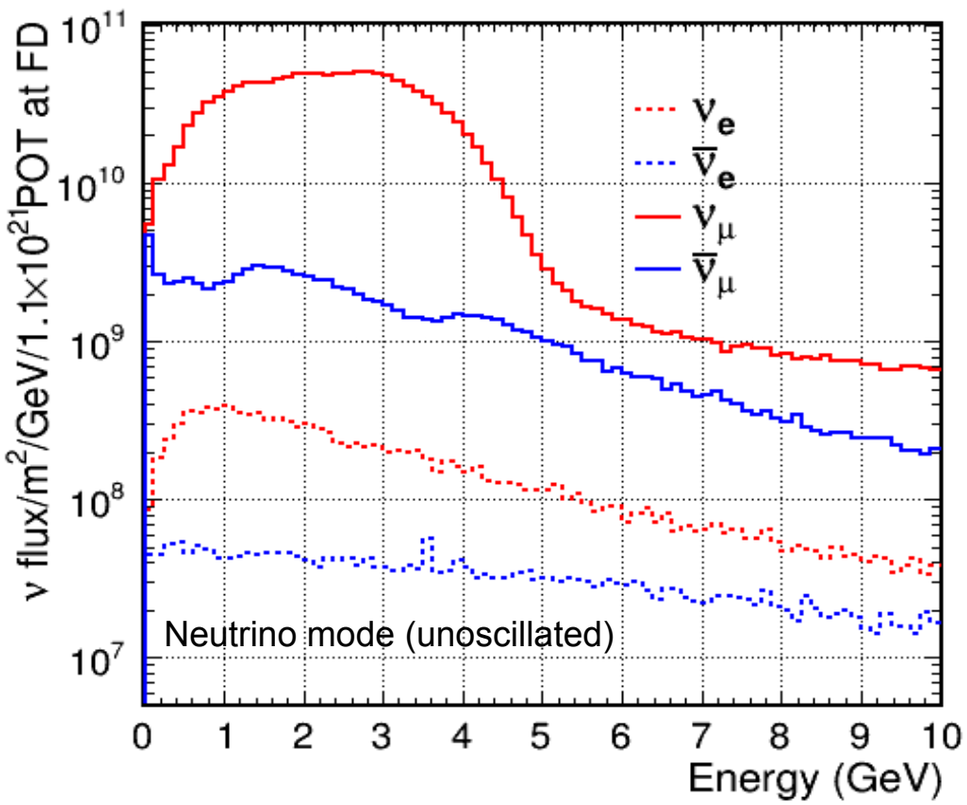
Flux prediction

- Detailed GEANT4 simulation of the beam line
- Uncertainties constrained with external hadron production data
- Simulated neutrino and anti-neutrino mode configurations





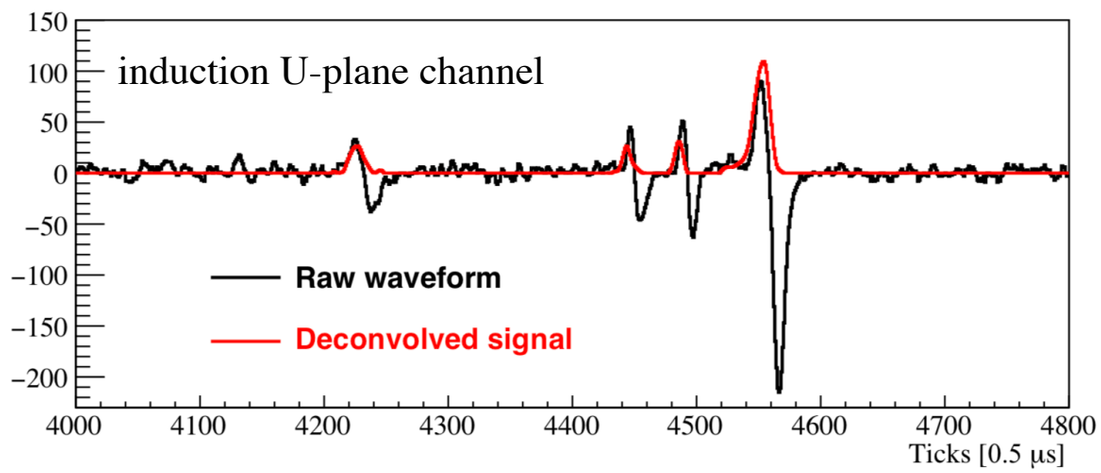
	Neutrino mode	Antineutrino mode
ν_μ	92%	90.4%
$\overline{\nu}_\mu$	7%	8.6%
ν_e	0.8%	0.2%
$\overline{\nu}_e$	0.2%	0.8%

Signal processing

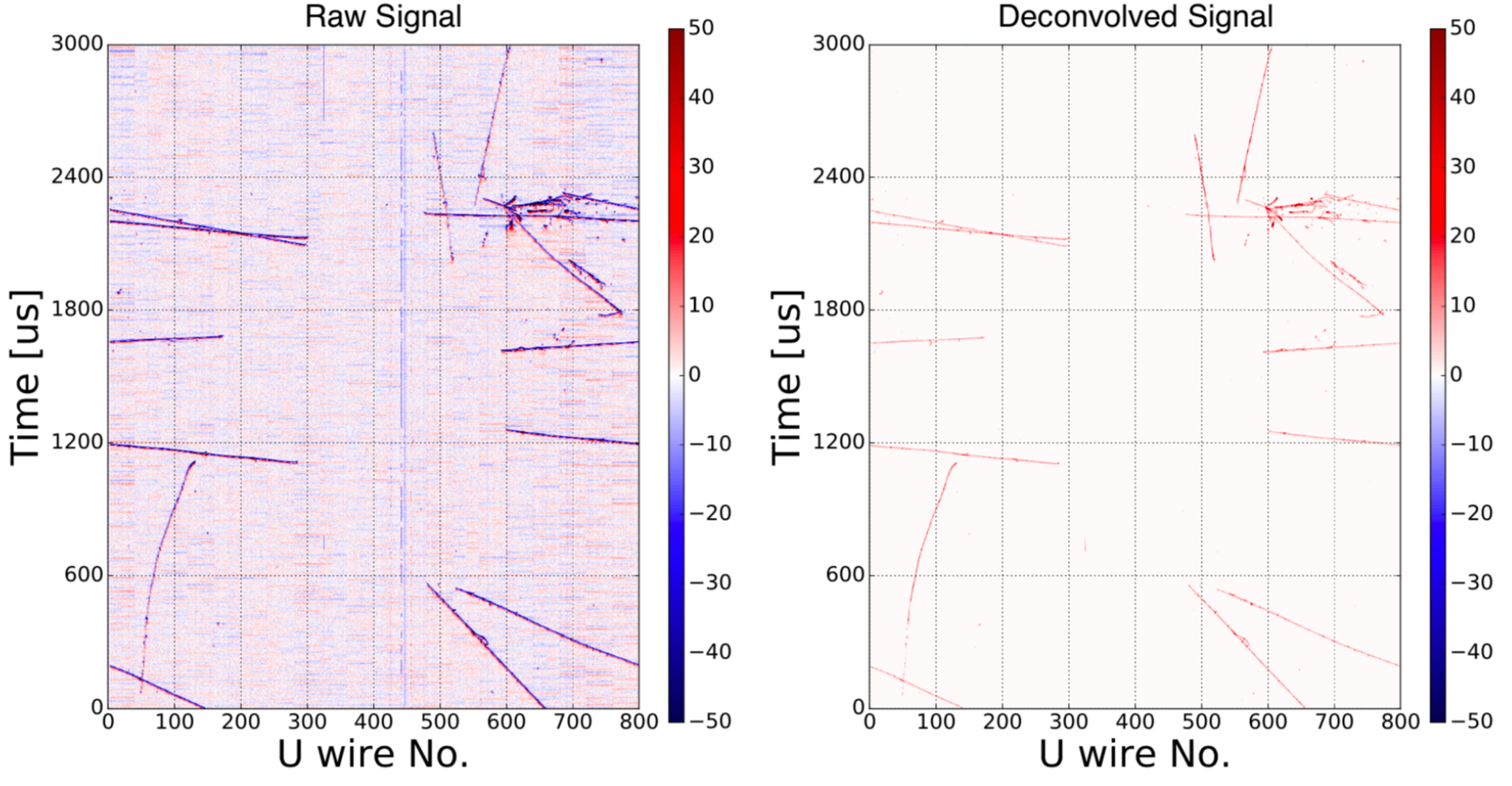
- Wire-Cell 2D deconvolution used in ProtoDUNE-SP: filters at frequency (time and wire) domain
- Fast and robust, able to “remove” impact of field and electronics response from measured signal

$$M(t',x') = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} R(t,t',x,x')\cdot[S(t,x)+N(t,x)]dtdx$$

$$S(\omega_t,\omega_x) \sim \frac{F(\omega_t,\omega_x)\cdot M(\omega_t,\omega_x)}{R(\omega_t,\omega_x)} \xrightarrow{IFT} S(t,x)$$



Comparison of raw and deconvolved induction U-plane signals for a ProtoDUNE-SP event

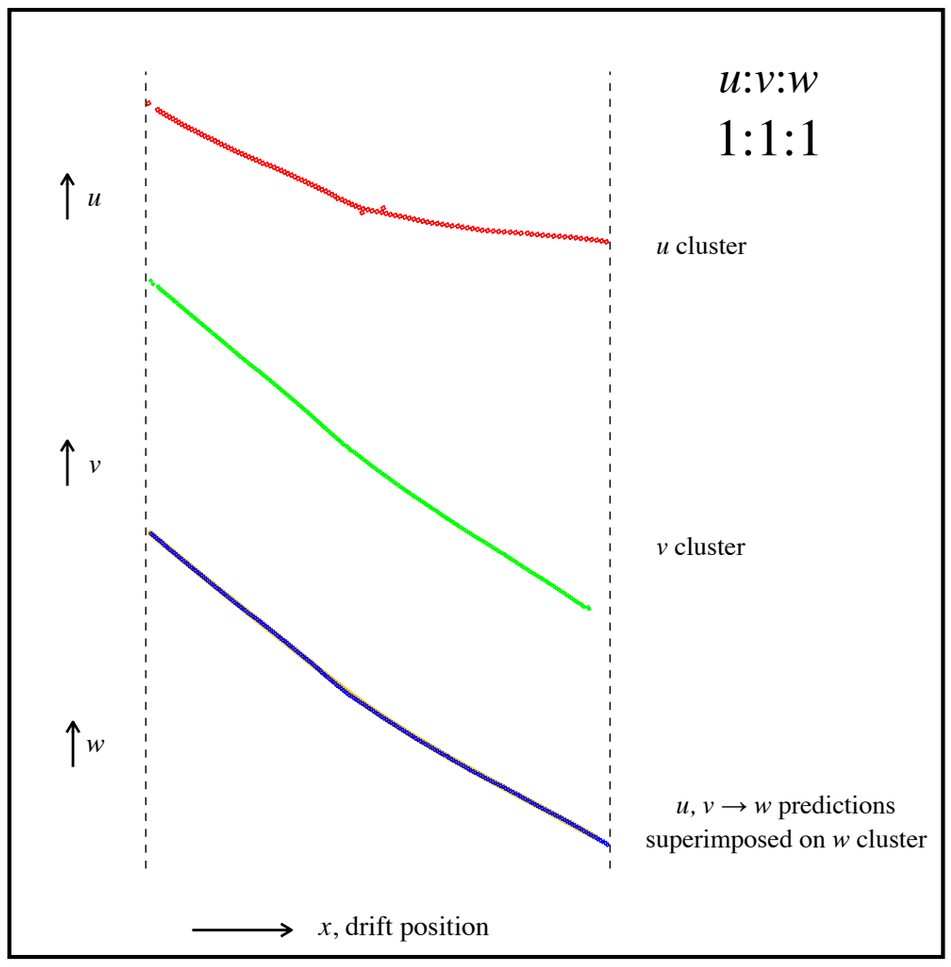


Fully-automated reconstruction

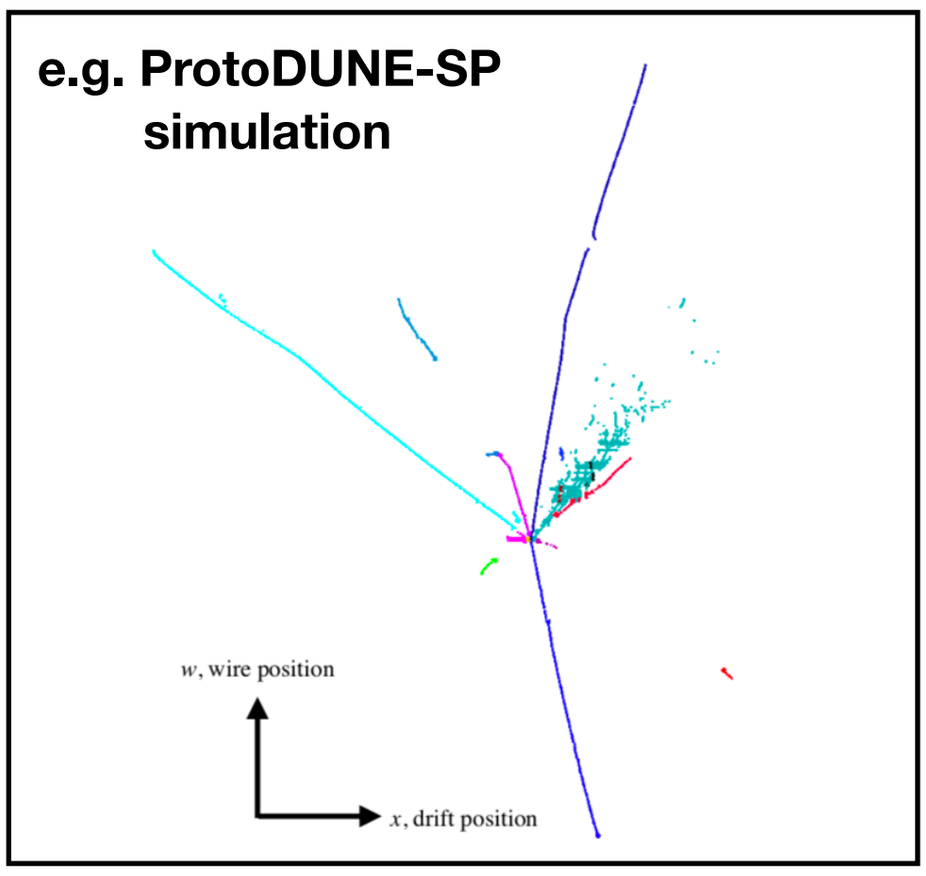
- Different reconstruction efforts exist within the DUNE collaboration
- Official reconstruction performance using **Pandora multi-algorithm pattern recognition** (Eur. Phys. J. C 2015, 75: 439, Eur. Phys. J. C 78, p82 2018)

Pandora uses hundreds of algorithms to build up events gradually

Using 2D -> 3D matching information



And building full particle hierarchies (parent-daughter links)

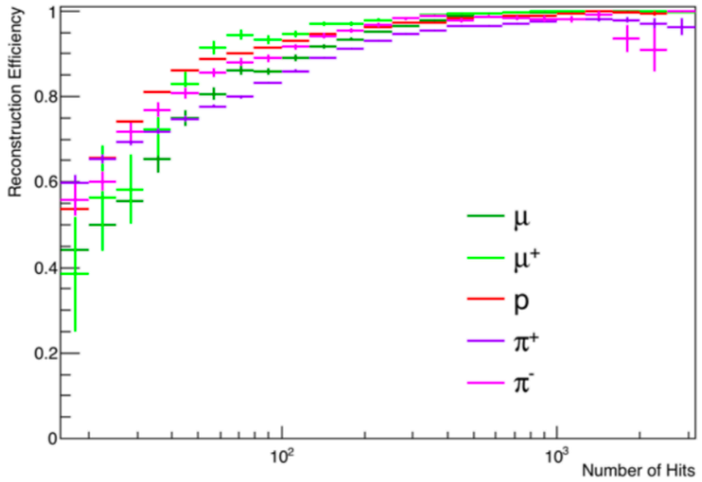


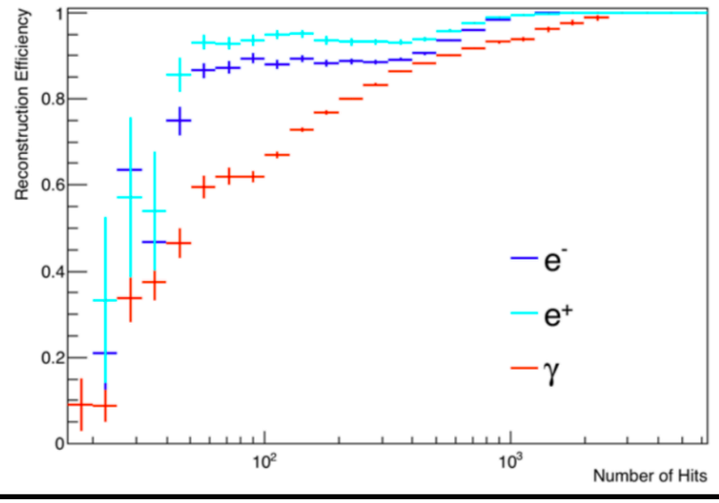
Fully-automated reconstruction

- Pandora reconstruction is achieving a good performance on reconstructing neutrino interactions (DUNE FD) as well as cosmic-ray muons and test beam particle interactions (ProtoDUNE-SP)

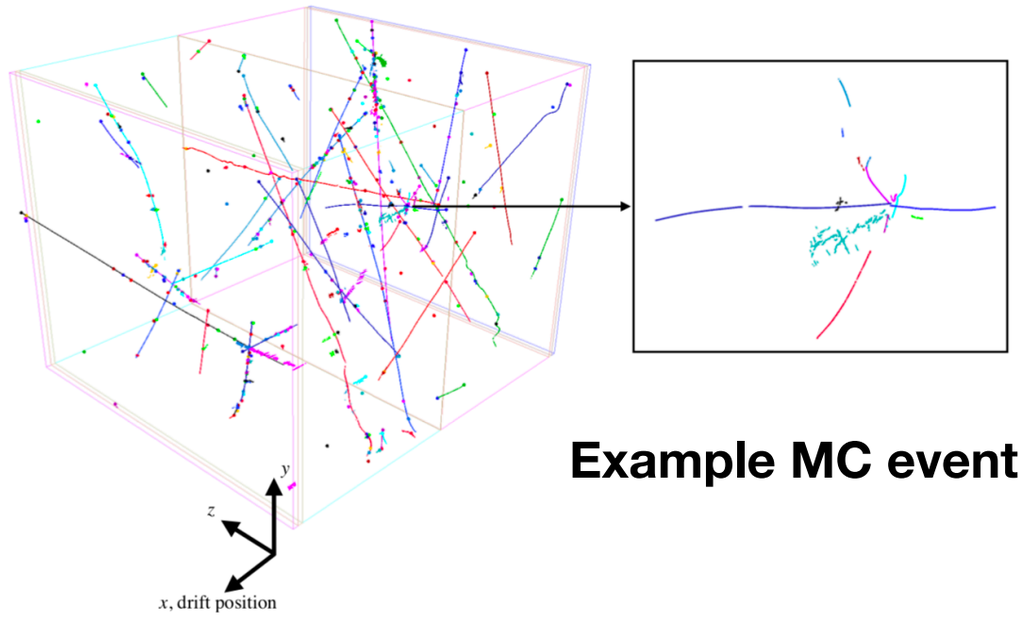
DUNE FD

Reconstruction efficiency for different particle types as a function of total number of hits





ProtoDUNE-SP



Example MC event

Efficiency for reconstructing and identifying the test beam particle. At low momentum interactions might happen before active volume