Channel saturation rate estimates for beam events

F. Marinho

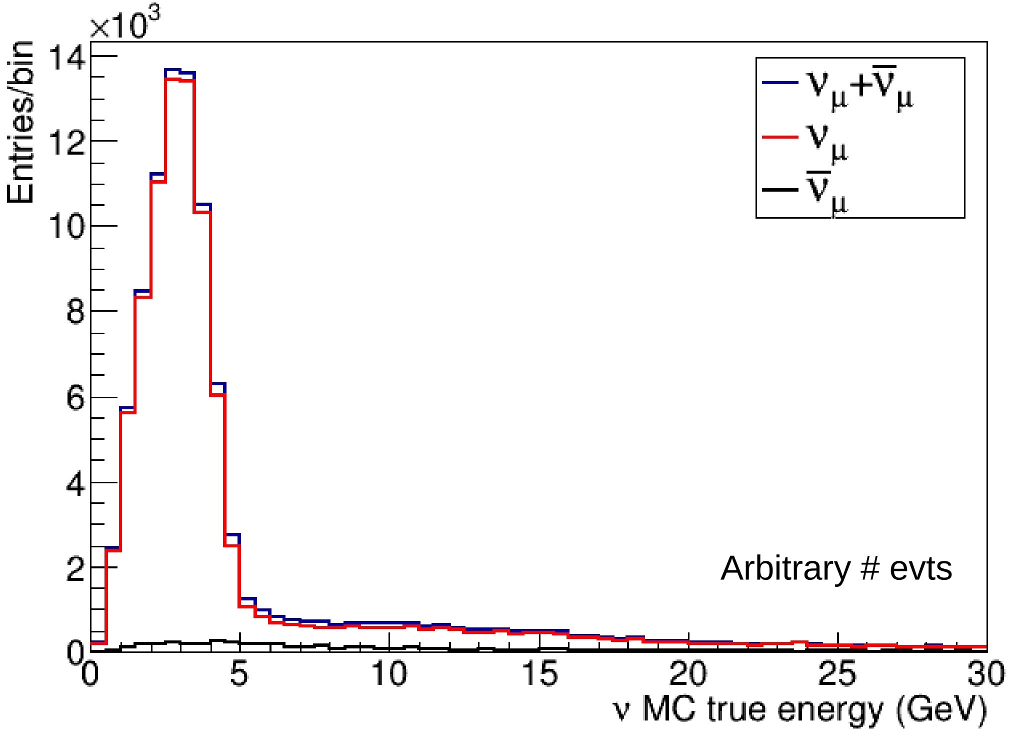
FD2-PDS Longevity qualification and Stability test Workshop

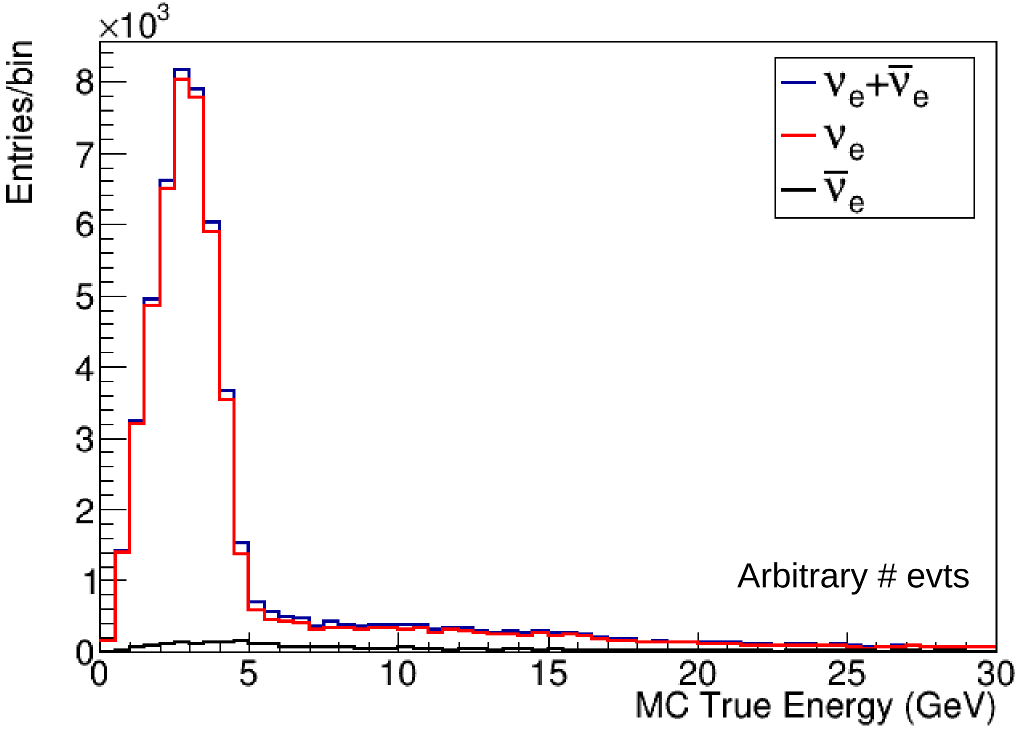
LArSoft simulation dataset

- TDR simulation of beam events

Geometry: (top vol: full width and drift, z: 21m)

Generator: Genie (ν_μ & ν_e)





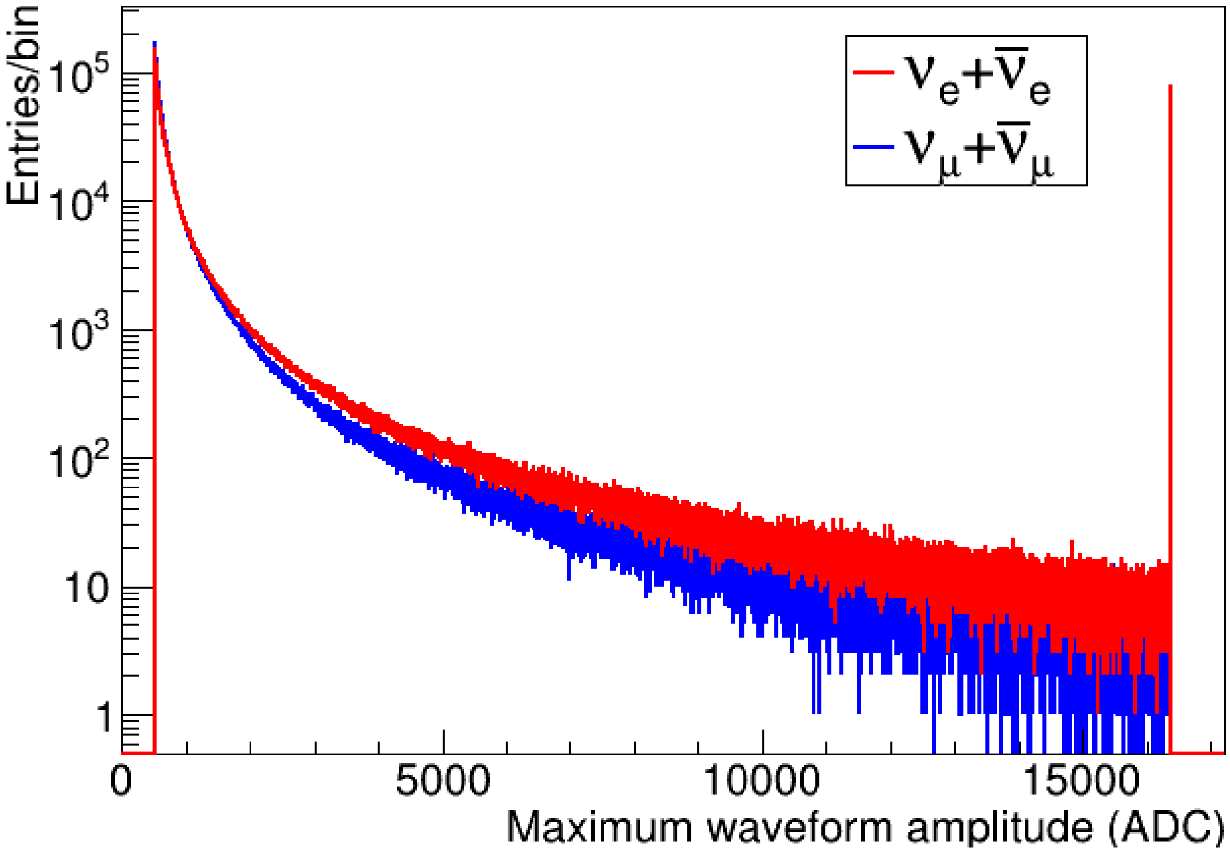
Waveform amplitudes

Channel saturation:
Amplitude = 2^{14}

Baseline: 500 ADC

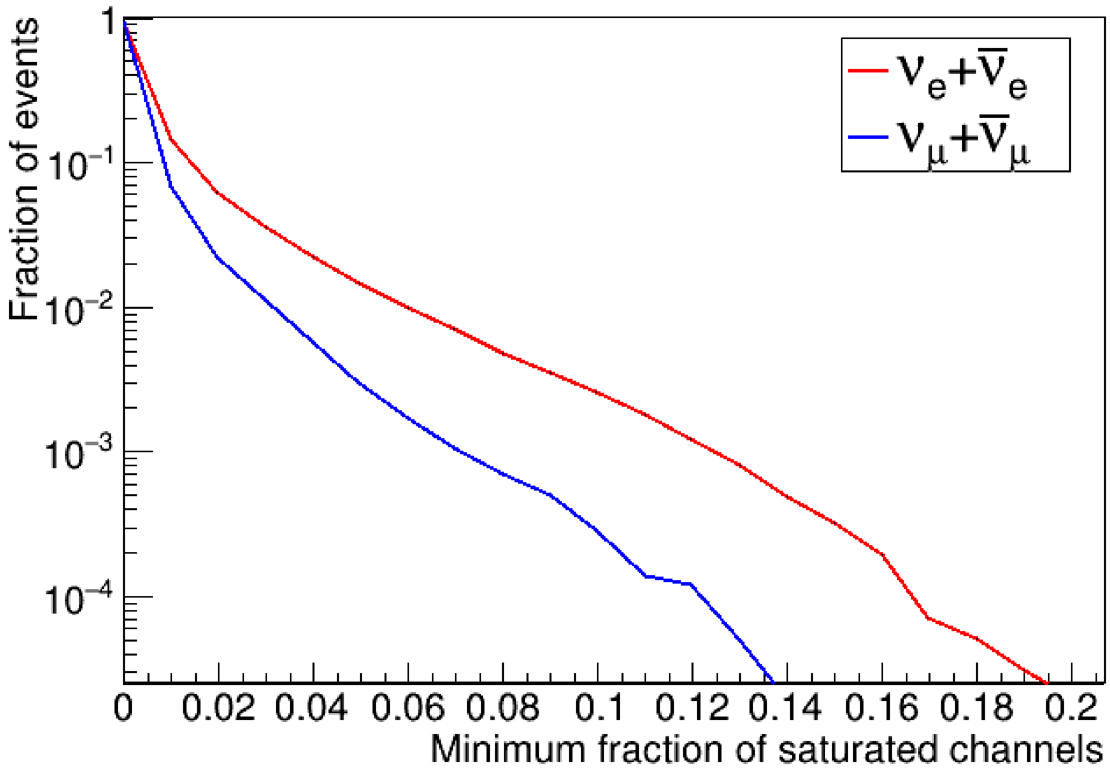
Low impact also for ProtoDUNE-SP values:

average and fluctuation



Fraction of saturated channels

- TDR simulation of beam events

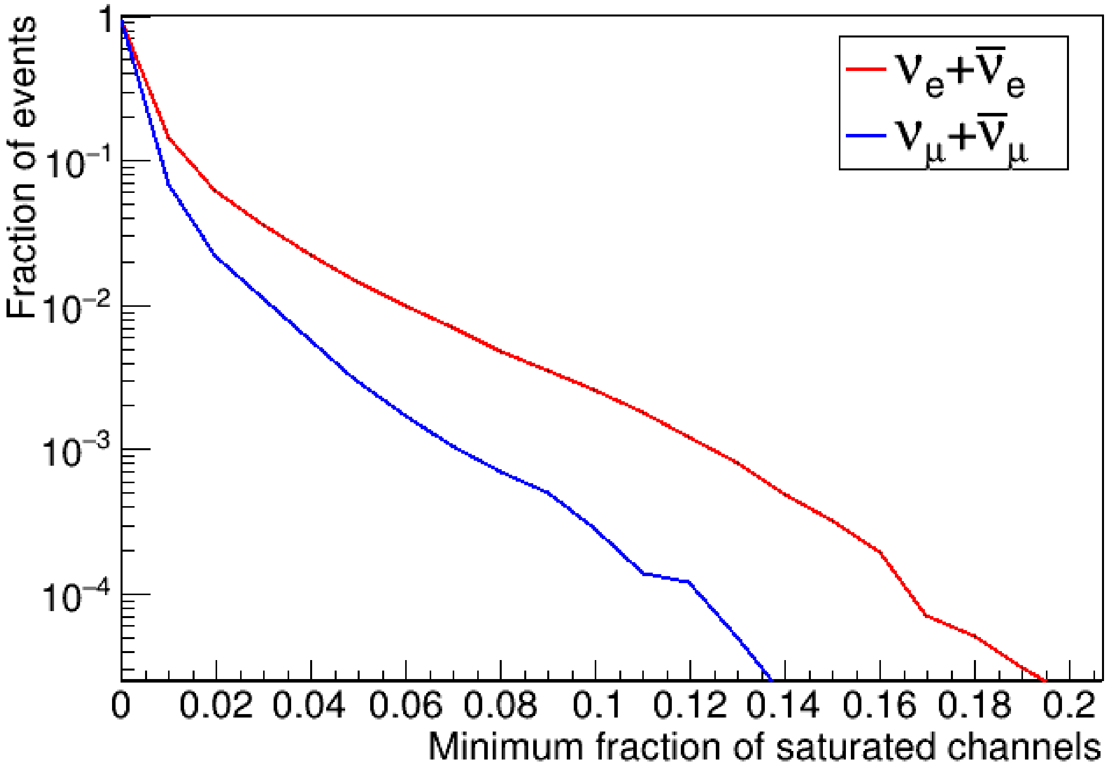


Channel saturation studies

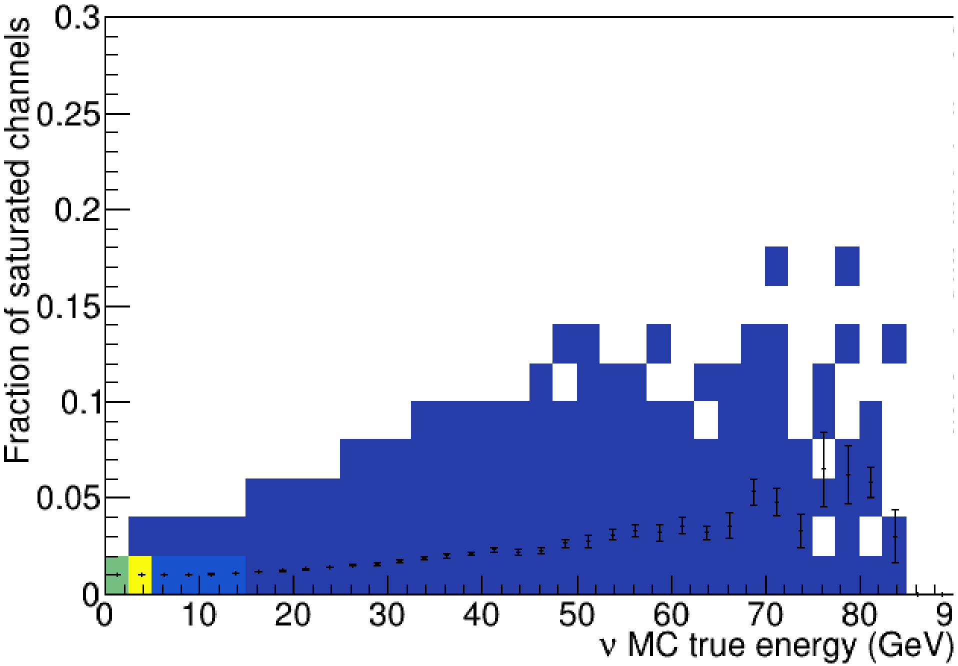
- TDR simulation of beam events

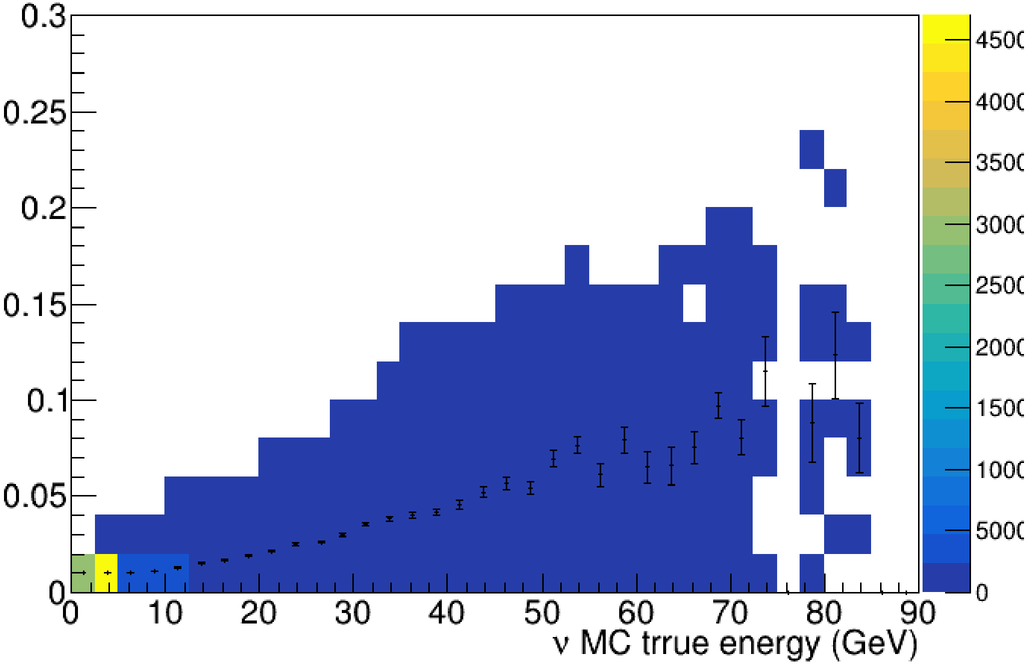
<Signal integ. reduction>
15(**16**)**%** per channel

<Summed signal reduction>
2(**3**)**%** per event



Saturated channels vs energy

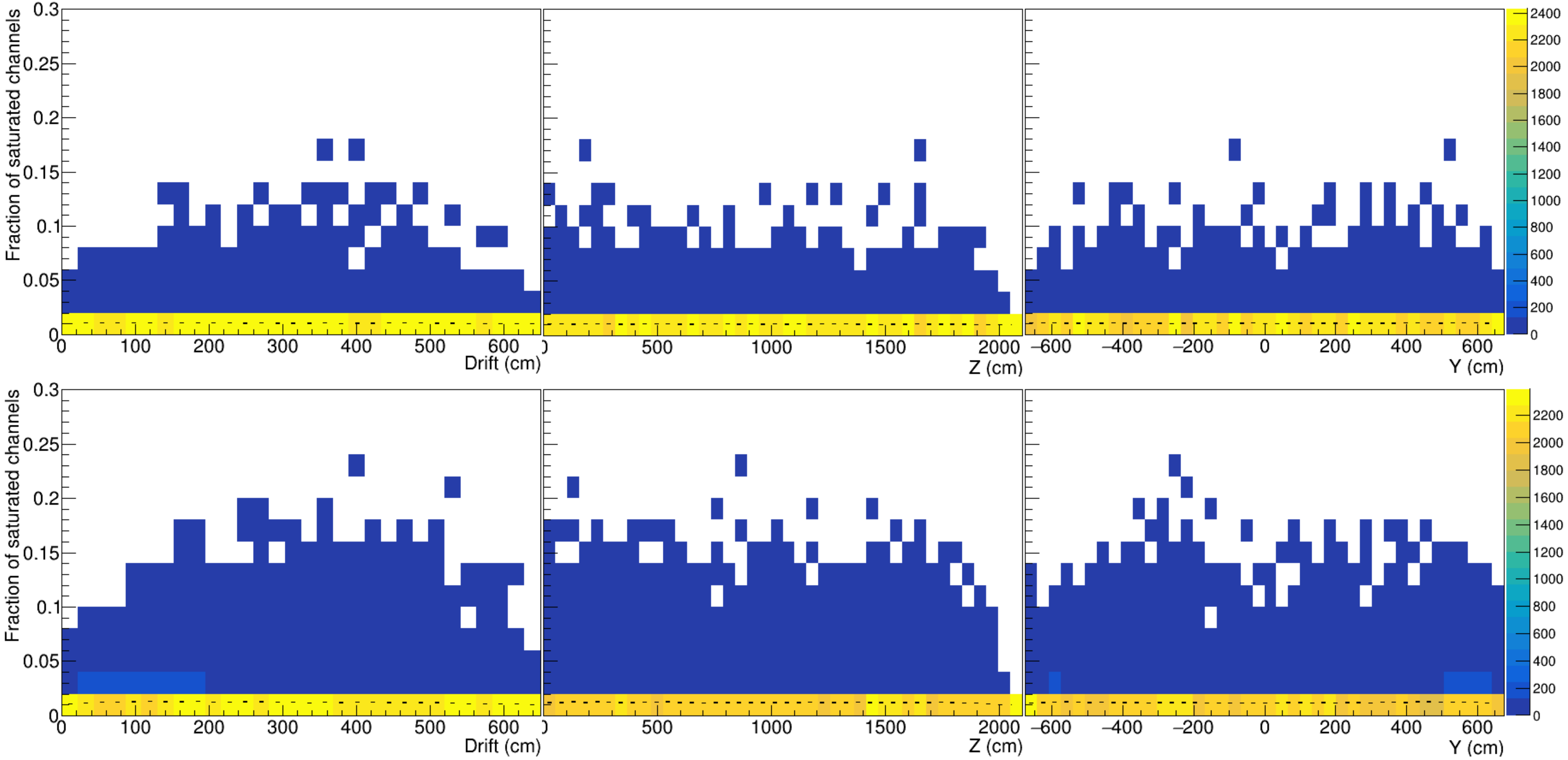




<saturated channels> < 0.1% for E < 10 GeV

<saturated channels> < 0.2% for E < 10 GeV

Channel saturation studies



Expected beam event yields

3.5 (staged) years
- 1.1 x 10^{21} POT per year

Sample	Expected Events	
	NO	IO
ν mode		
ν_μ Signal	7235	7368
$\bar{\nu}$ mode		
$\bar{\nu}_\mu$ Signal	2656	2633

Sample	Expected Events			
	$\delta_{CP} = 0$		$\delta_{CP} = -\frac{\pi}{2}$	
	NO	IO	NO	IO
ν mode				
Oscillated ν_e	1155	526	1395	707
Oscillated $\bar{\nu}_e$	19	33	14	28
Total oscillated	1174	559	1409	735
$\bar{\nu}$ mode				
Oscillated ν_e	81	39	95	53
Oscillated $\bar{\nu}_e$	236	492	164	396
Total oscillated	317	531	259	449

Long-baseline neutrino oscillation physics potential of the DUNE experiment
The European Physical Journal C volume 80, Article number: 978 (2020)

Saturated waveforms

3.5 (staged) years
- 1.1 x 10^{21} POT per year

$$N^{3.5\ years}_{sat.\,waves} = \sum_{\nu_{\mu,e},\,\bar{\nu}_{\mu,e}} N_\nu \cdot f^{MC}_\nu \approx 2.3 - 3.0\,k\,,$$ where

N_ν: Expected ν type events

$$f^{MC}_\nu = \frac{N^{MC}_{sat.\,waves}}{N^{MC}_\nu} \cdot r_{VD}$$

Caveats: N_ν values as no selection correction is considered
Energy range: 0.5-10 GeV
No volume difference between modules

In this work, FD event rates are calculated assuming the following nominal deployment plan, which is based on a technically limited schedule:

- Start of beam run: two FD module volumes for total fiducial mass of 20 kt, 1.2 MW beam
- After one year: add one FD module volume for total fiducial mass of 30 kt
- After three years: add one FD module volume for total fiducial mass of 40 kt
- After six years: upgrade to 2.4 MW beam

Saturated waveforms

Table 2.2: Atmospheric neutrino event rates per year in 40 kt fiducial mass of the DUNE FD.

Sample	Yearly Event Rate
Fully contained atmospheric e-like	1.6×10^3
Fully contained atmospheric μ-like	2.4×10^3
Partly contained atmospheric μ-like	7.9×10^2

The DUNE Far Detector
Interim Design Report

$$N^{atm.\ 1\,yr}_{sat.\,waves} = \sum_{\nu_{\mu,e},\,\bar{\nu}_{\mu,e}} N_{\nu} \cdot f^{MC}_{\nu} \approx 1\,k$$

, where

N_{ν}: Expected ν type events

$$f^{MC}_{\nu} = \frac{N^{MC}_{sat.\,waves}}{N^{MC}_{\nu}} \cdot r_{VD}$$

Caveats: No atmospheric simulation for VD – fractions from VD beam evts simulation

Summary

- Channels saturation on VD similar/lower than HD (charge & light)
- Expected dependence on event energy
- Also homogeneous in the bulk volume
- Signal integral decrease
  - Low values $\longrightarrow$ small impact on deposited energy determination
- Number of saturated channels estimates for design of stress test
- Beam (or atmospheric): $\sim 10^3$ saturated waveforms per year
- Simple estimates: consider conservative exposure factor
- Cosmic ray muons not evaluated