Neutrino Interaction Physics

Expected nuSTORM Measurement Accuracy

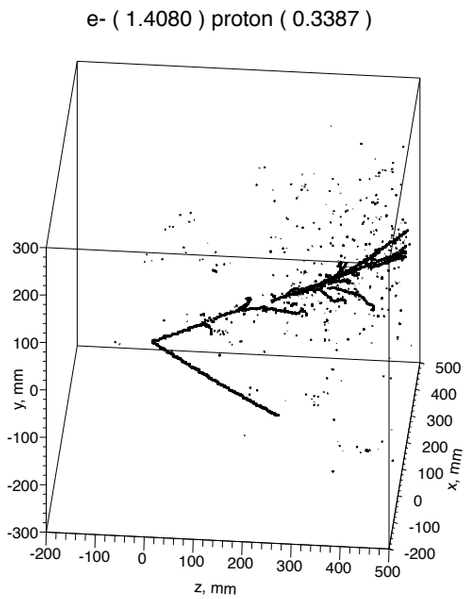
Edward Santos

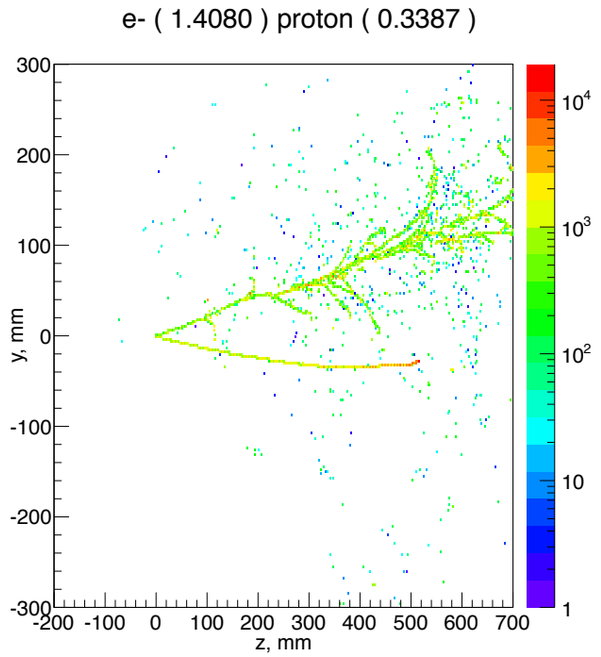
Overview

- Introduction
- Interaction Channels
- Cross-Section Measurements
- Impact on Oscillation
- Discussion

Introduction: the trip this far

- April, PAC proposal: LArSoft
  - micro
- Now: back to an independent setup (with
  - use detector smearing.
  - work ongoing





Introduction

- A point to discuss
  reconstruction in a LAr TPC.
  - Mission for LArIAT and MicroBooNE

The Interaction Physics section is about the
nuSTORM capabilities,
not about detector performance.
We want to understand the first by making
reasonable assumptions about the latter.

Extension to more Interaction Channels

- **CCQE + Single Pion Production (SPP)**
  - CCQE is the signal for oscillation experiments
  - main background is CC1pion -

- **In the nuSTORM's energy range**

Not much we can do about NC's.
Can't discriminate neutrino parent.

Interaction Channels

ID	Stored μ^+	Stored μ^-
1	$\bar{\nu}_\mu p \to \mu^+ n$	$\nu_\mu n \to \mu^- p$
2	$\nu_e n \to e^- p$	$\bar{\nu}_e p \to e^+ n$
3	$\bar{\nu}_\mu n \to \mu^+ \pi^- n$	$\nu_\mu n \to \mu^- \pi^+ n$
4	$\bar{\nu}_\mu p \to \mu^+ \pi^0 p$	$\nu_\mu n \to \mu^- \pi^0 p$
5	$\bar{\nu}_\mu p \to \mu^+ \pi^- p$	$\nu_\mu p \to \mu^- \pi^+ p$
6	$\nu_e n \to e^- \pi^+ n$	$\bar{\nu}_e n \to e^+ \pi^- n$
7	$\nu_e p \to e^- \pi^0 p$	$\bar{\nu}_e p \to e^+ \pi^0 n$
8	$\nu_e p \to e^- \pi^+ p$	$\bar{\nu}_e p \to e^+ \pi^- p$
9	$\bar{\nu}_\mu, \nu_e \to X$	$\nu_\mu, \bar{\nu}_e \to X$

Interaction Channels

data exists

ID	Stored μ^+	Stored μ^-
1	$\bar{\nu}_\mu p \to \mu^+ n$	$\nu_\mu n \to \mu^- p$
2	$\nu_e n \to e^- p$	$\bar{\nu}_e p \to e^+ n$
3	$\bar{\nu}_\mu n \to \mu^+ \pi^- n$	$\nu_\mu n \to \mu^- \pi^+ n$
4	$\bar{\nu}_\mu p \to \mu^+ \pi^0 p$	$\nu_\mu n \to \mu^- \pi^0 p$
5	$\bar{\nu}_\mu p \to \mu^+ \pi^- p$	$\nu_\mu p \to \mu^- \pi^+ p$
6	$\nu_e n \to e^- \pi^+ n$	$\bar{\nu}_e n \to e^+ \pi^- n$
7	$\nu_e p \to e^- \pi^0 p$	$\bar{\nu}_e p \to e^+ \pi^0 n$
8	$\nu_e p \to e^- \pi^+ p$	$\bar{\nu}_e p \to e^+ \pi^- p$
9	$\bar{\nu}_\mu, \nu_e \to X$	$\nu_\mu, \bar{\nu}_e \to X$

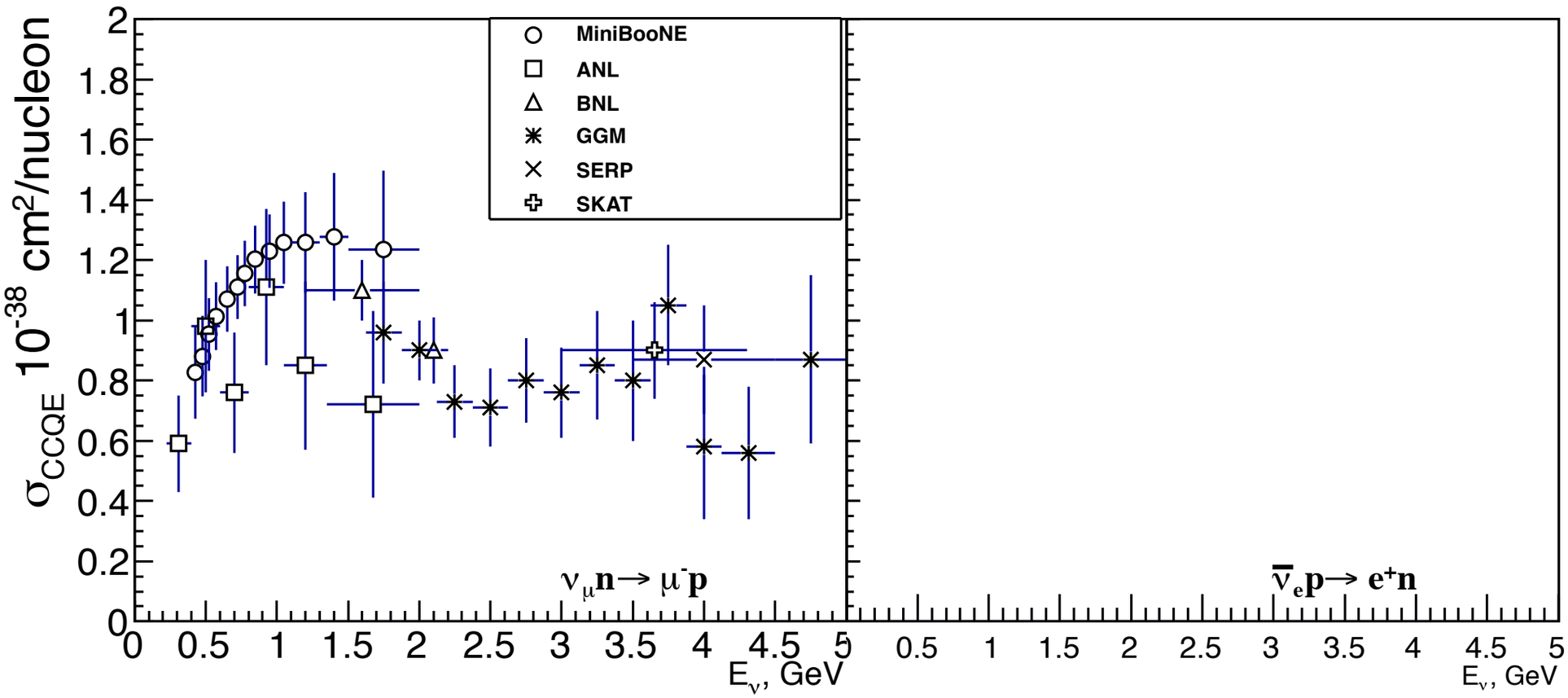
lack of measurements for anti-neutrino mode in the last ~35 years. In conventional accelerator beams:

ν_μ-beam: 5% $\bar{\nu}_\mu$ contamination

$\bar{\nu}_\mu$-beam: 50% ν_μ contamination

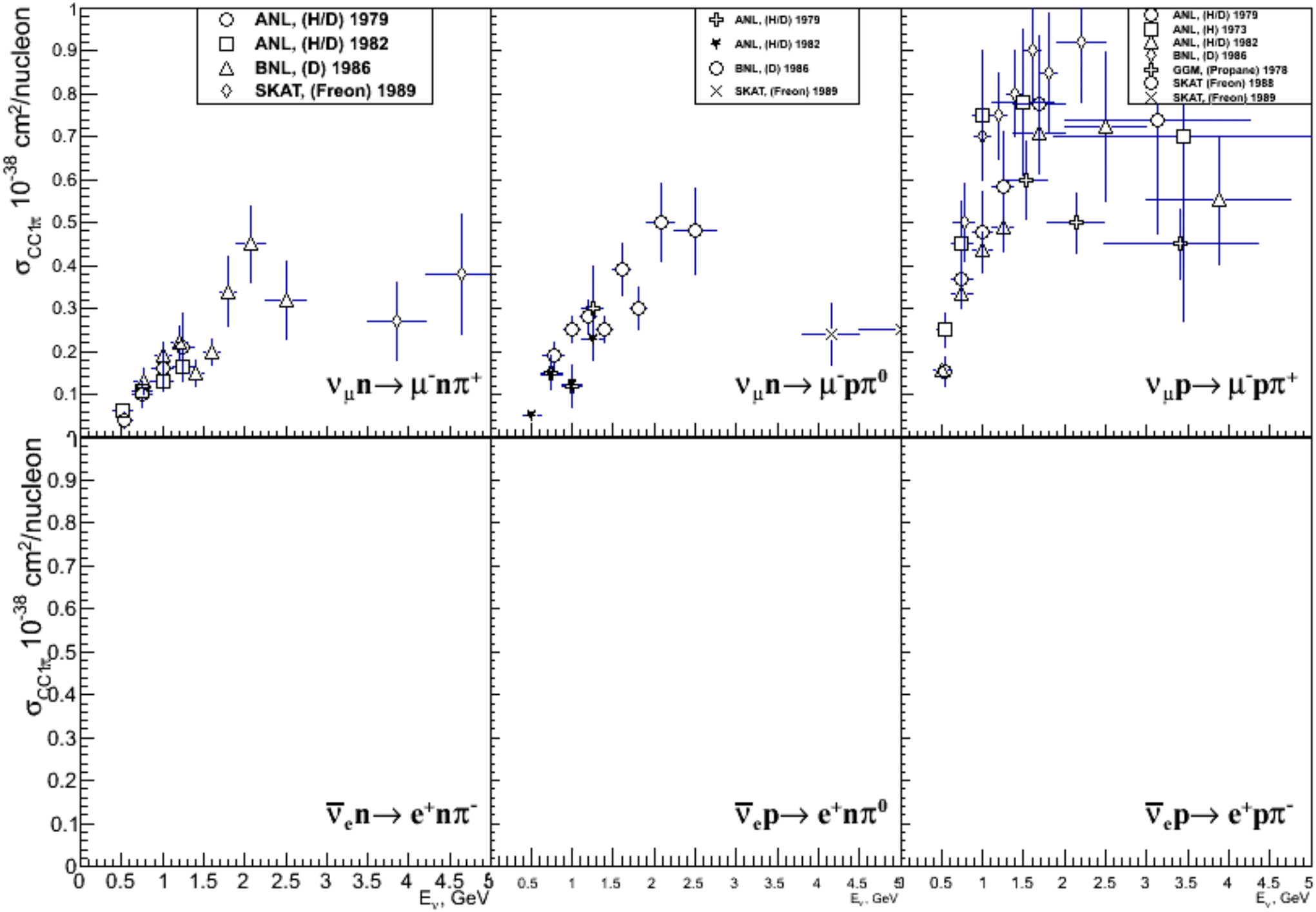
Interaction Channels

(relevant for stored mu-)



Interaction Channels

(relevant for stored mu-)



Analysis Considerations

Same exposure assumptions as before:

10e21 POT + LAr 100T ND (mu+ and mu- mode)

We don't care much where the cross-section line falls - determined by Genie;

We care about the size of the error band we add to it.

Analysis Considerations

Error listing:

- statistics (determined by scaling simulation to nuSTORM's POT)

- flux (1%)

- detector (3-10%)

- Nuclear effects. Determined by simulation: difference between events created and events reconstructed in each bin.

First hints:

- statistical errors small except for first and last bin (where they dominate)

- detector errors dominate systematics.

$$\sqrt{\sigma^2_{flux} + \sigma^2_{detector}}$$
$$\sqrt{10^2 + 10^2} = 14.1$$
$$\sqrt{1 + 10^2} = 10$$

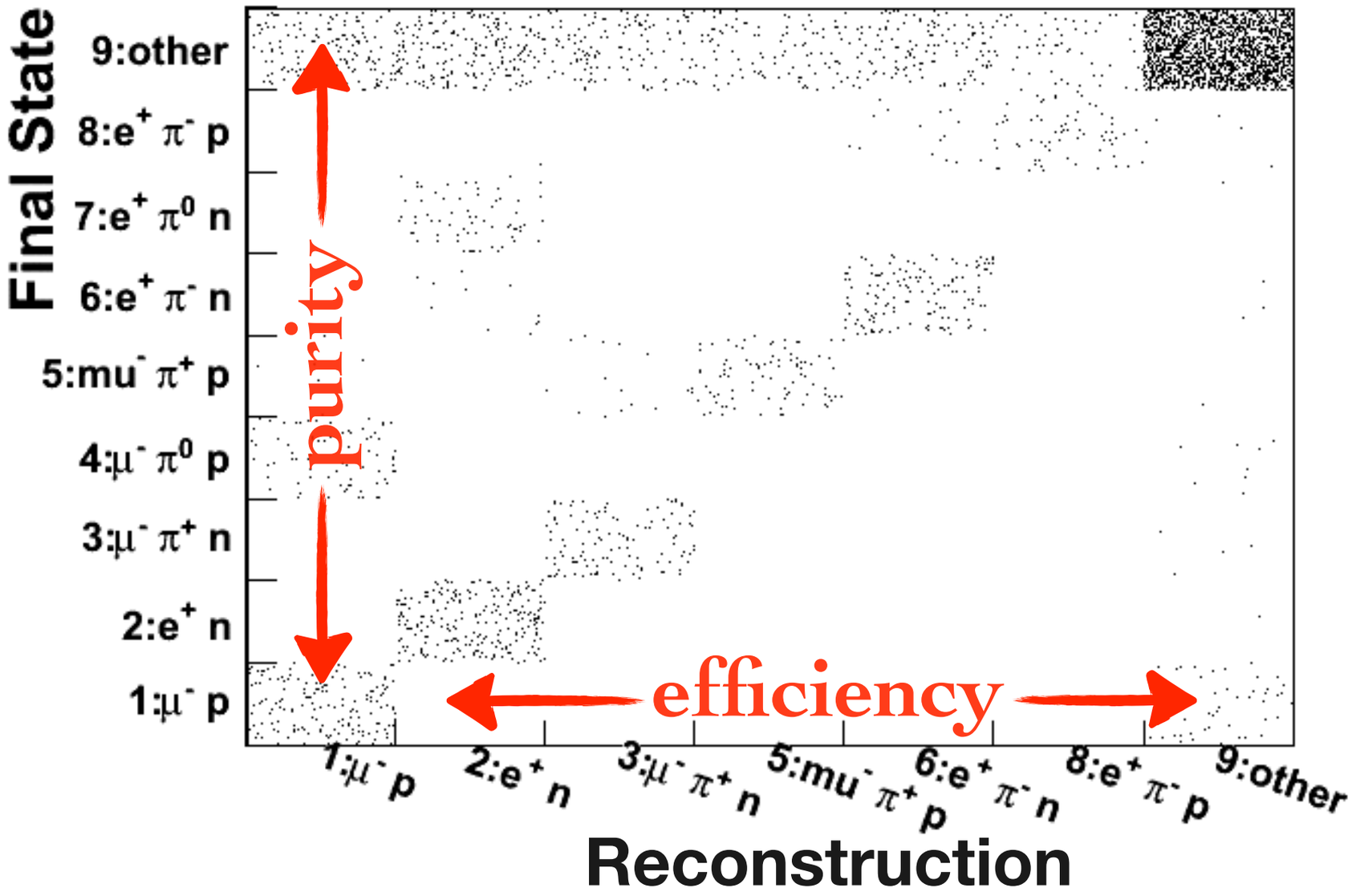
Work on progress:

- disentangling of channels, more realistic reconstruction efficiency for electrons and Pi0's, NC backgrounds…

Interaction Channels

Without any reconstruction smearing, nuclear effects are already changing the spectra measured.

Shown here, only detector density effect (impact on FS).

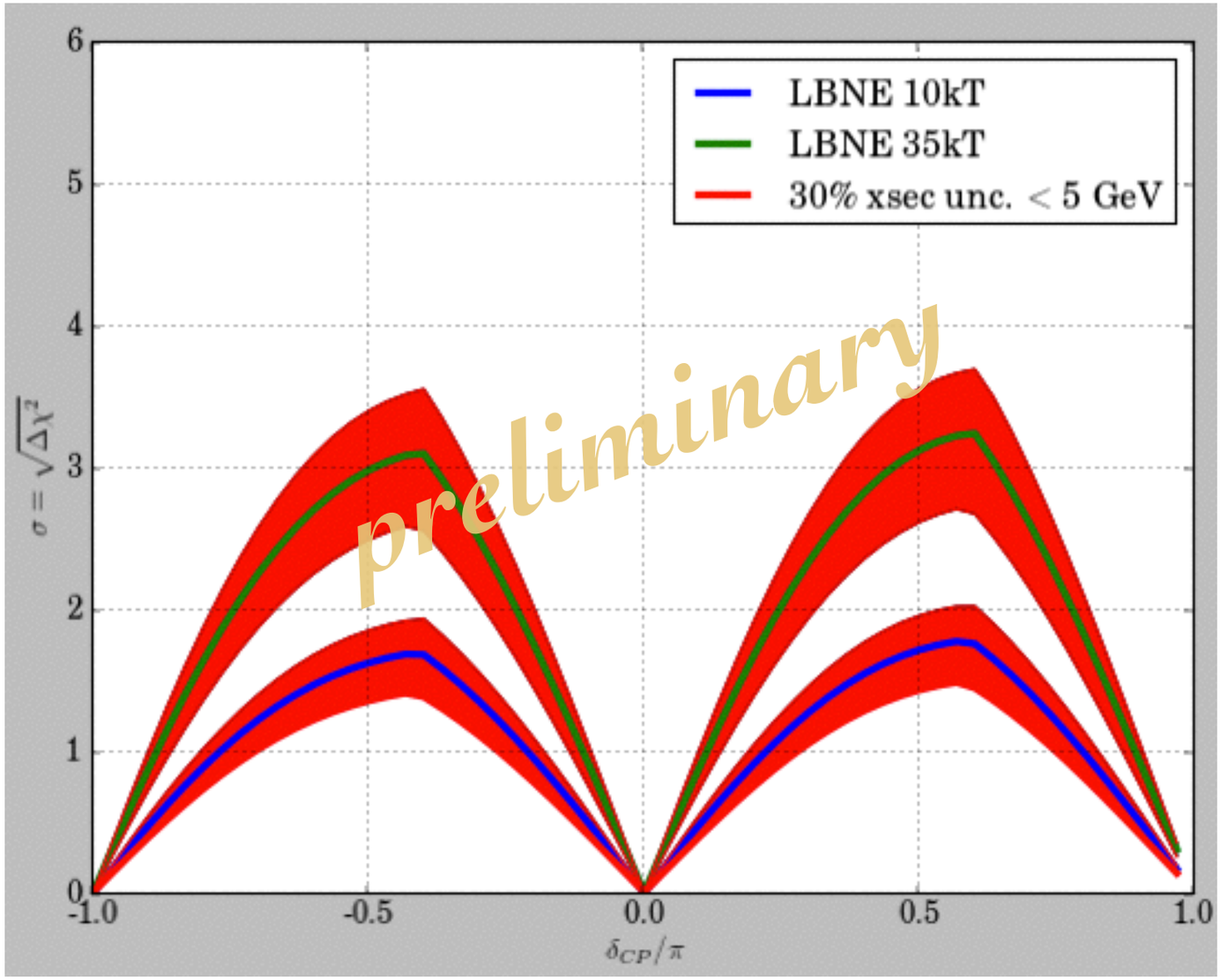


Impact on Oscillation Searches

special thanks to Sam Z./LBNE colleagues

Cross section unc. aren't explicitly introduced into Globes. They are "encapsulated" in the signal and background error estimations.

The approach followed here: vary the input cross sections by their uncertainty and see the effect on the sensitivity.



Discussion