Near Detector Studies

Some first steps

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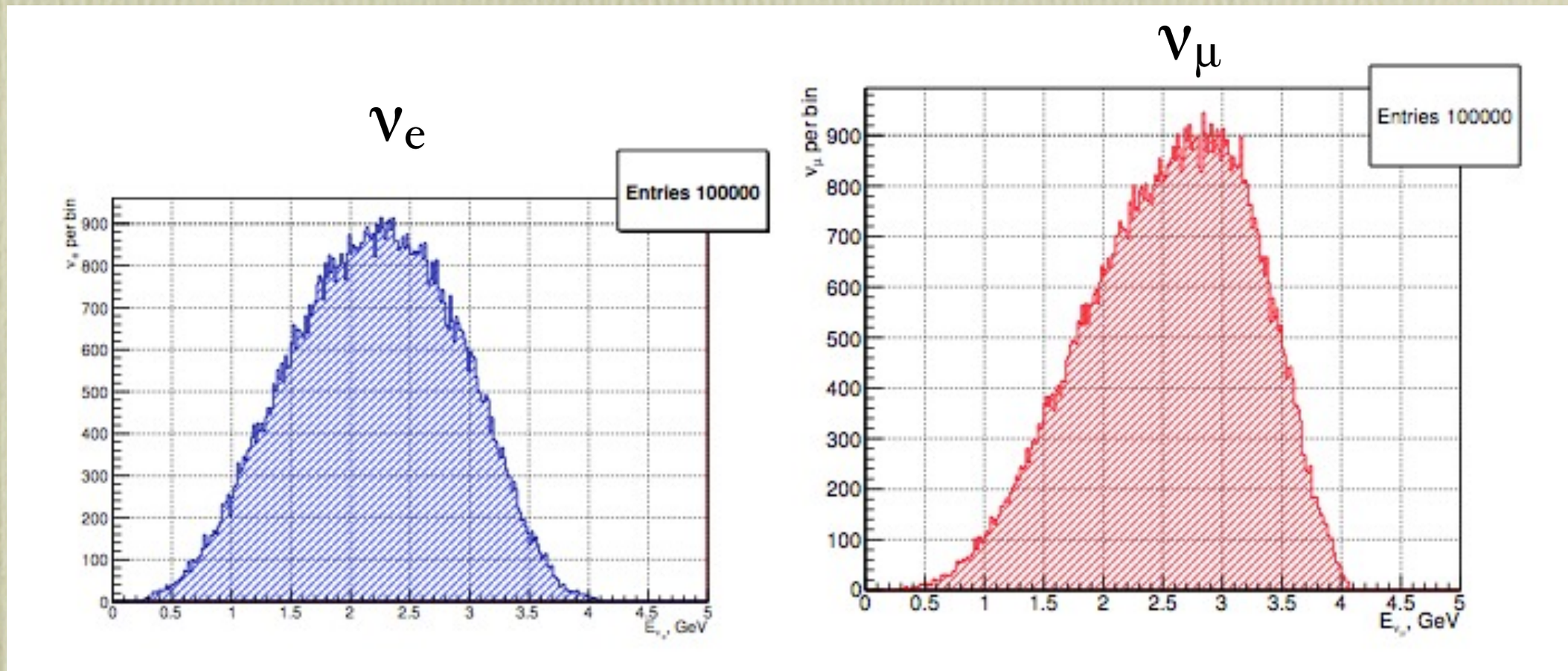
Introduction

- The goal of the work done so far is determine what kinds of cross-section measurements can be made in the NuSTORM beam with different detectors:
  - magnetized **Fe** (MIND style);
  - liquid **Ar** TPC;
  - straw-tube tracker - target is **C**.

- We assume the neutrino flux showed in the LOI still holds.



These plots above are precisely the energy spectra of the neutrinos we simulated with GENIE.

Event Generation & Analysis

- GENIE was used to compute all cross-section splines for ν_e and anti-ν_μ interactions with two hypothetical detector targets: **Fe**, **Ar**, **C**.

- Two types of analyses:
  - event mode - *the type of interaction*
  - final state - *particles produced: their energy, direction...*
- No realistic MC simulation of detector for now; only smearing of truth values.

Event mode

- Same as in page 8 of http://arxiv.org/abs/1208.2735
- At the LOI energy range the single lepton/single pion events are as frequent as the DIS.

FIGURE 4. ν_e event mode for νSTORM LOI flux.

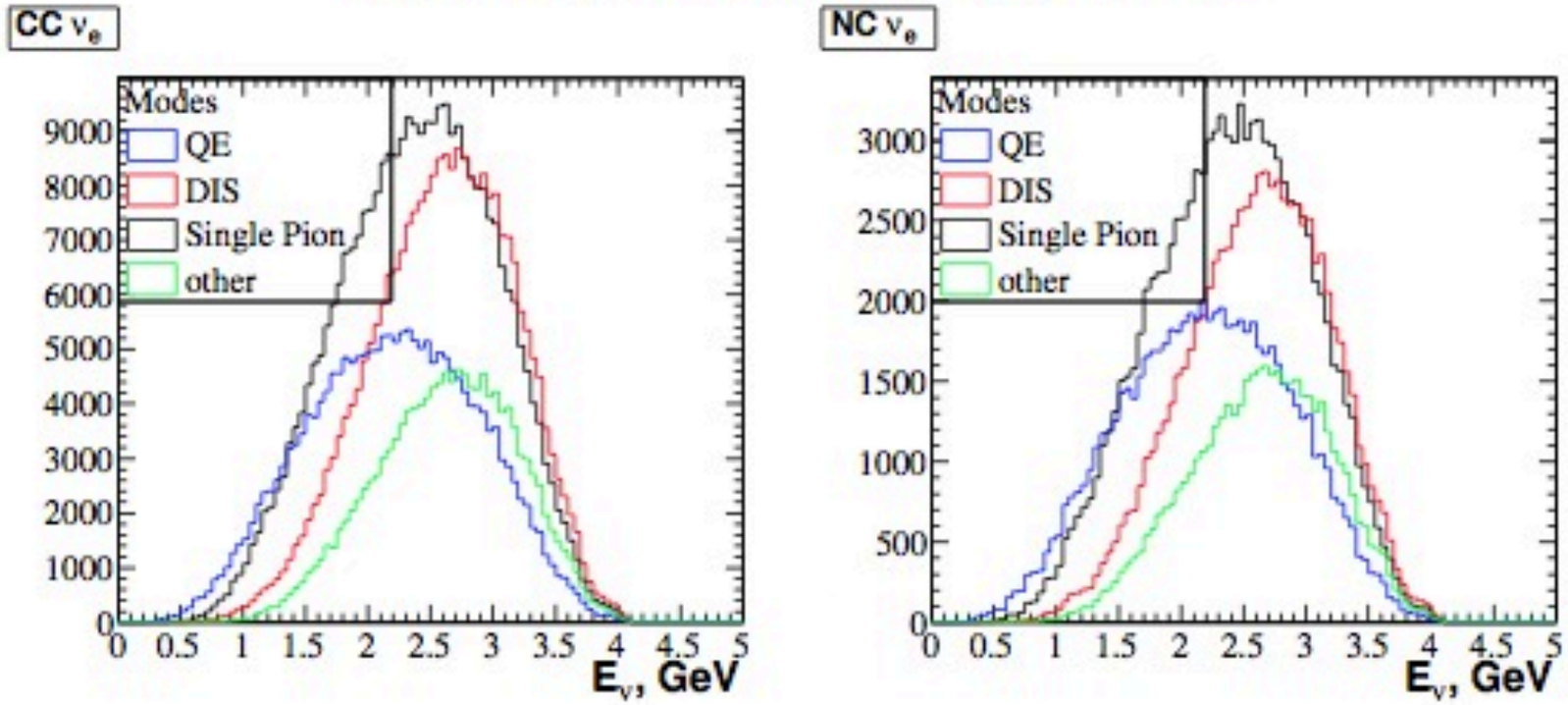
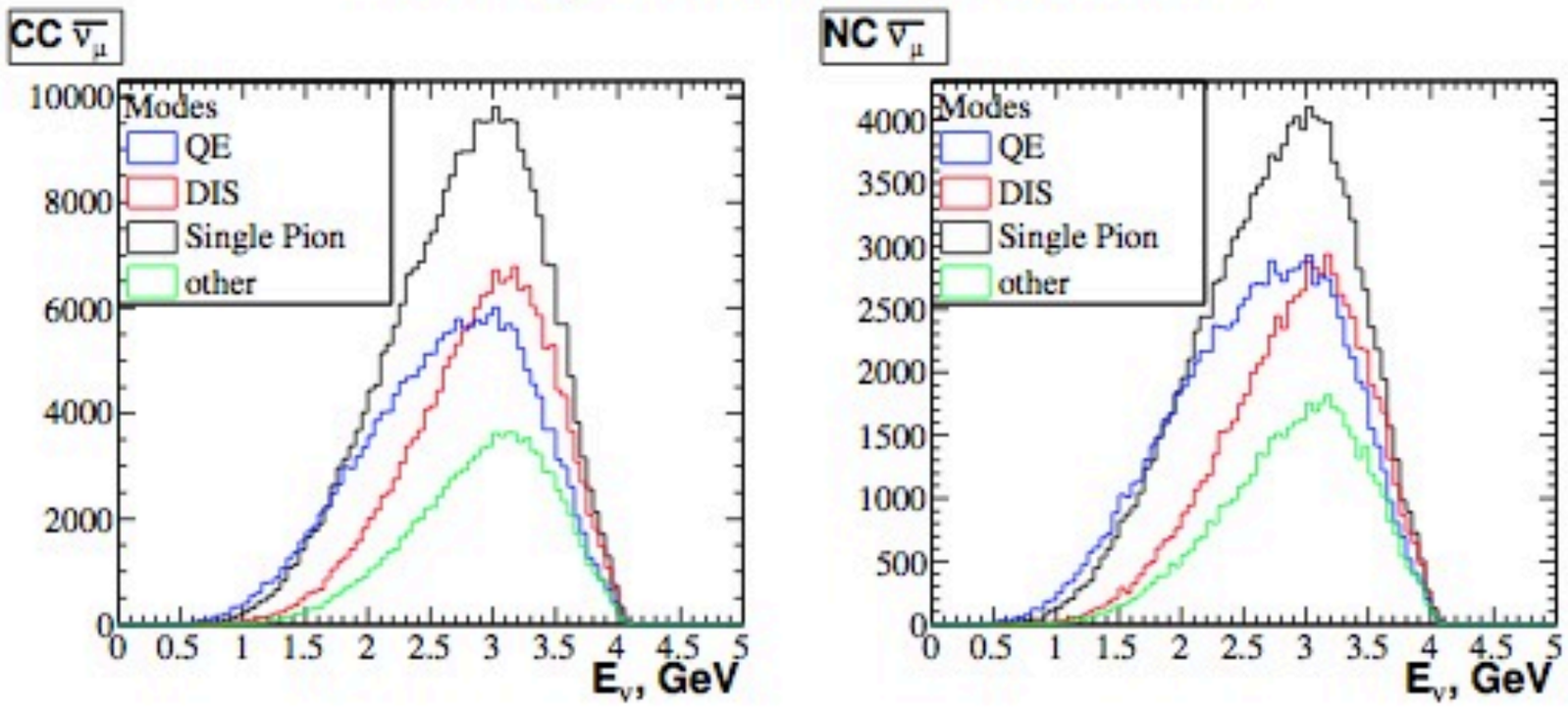


FIGURE 5. $\bar{\nu}_\mu$ event mode for νSTORM LOI flux.

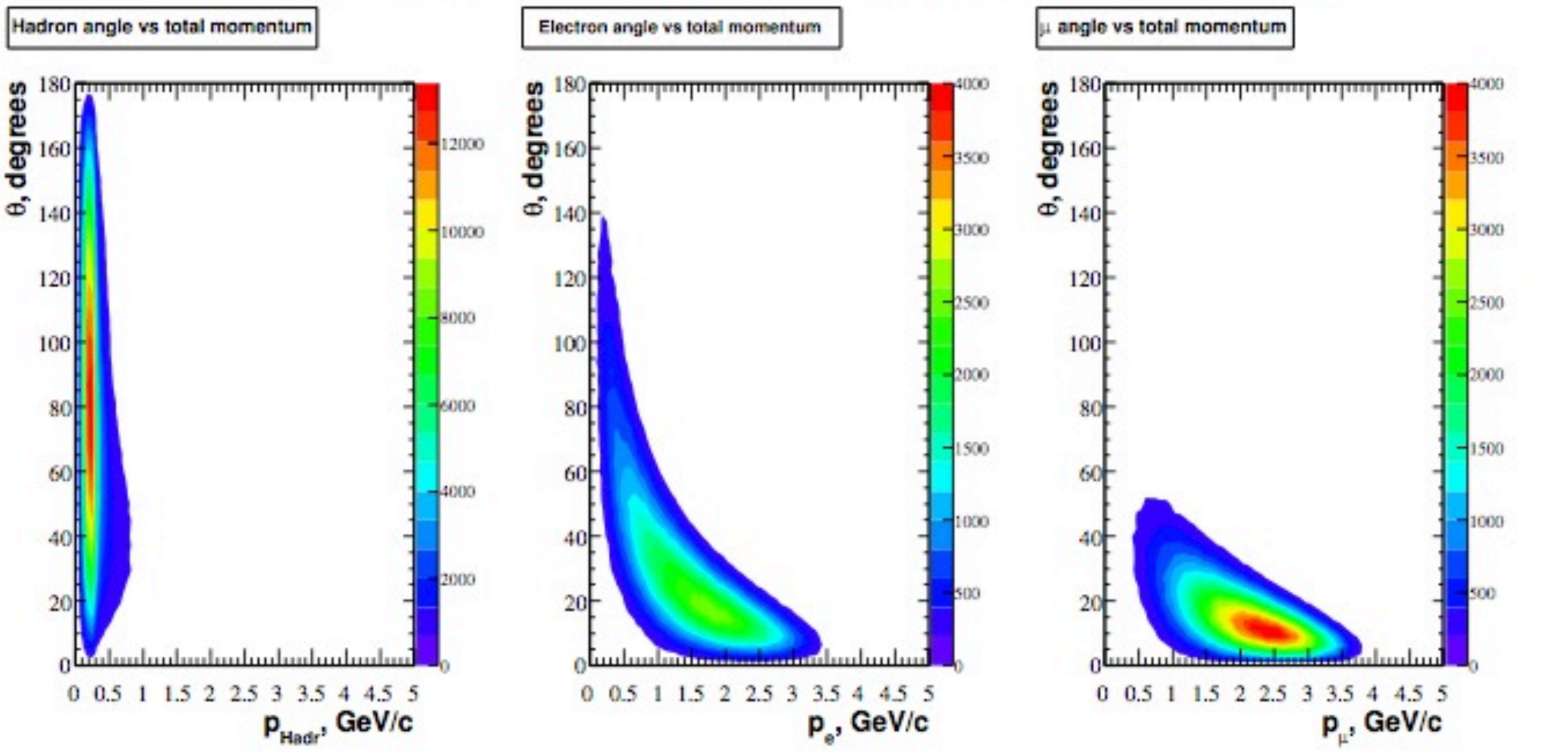


Final State Analysis

- cut: momentum > 50 MeV/c

  in the plots below, θ is the angle the outgoing particle makes with the neutrino's direction.

FIGURE 7. Hadron and primary lepton distributions for a LOI ν flux.



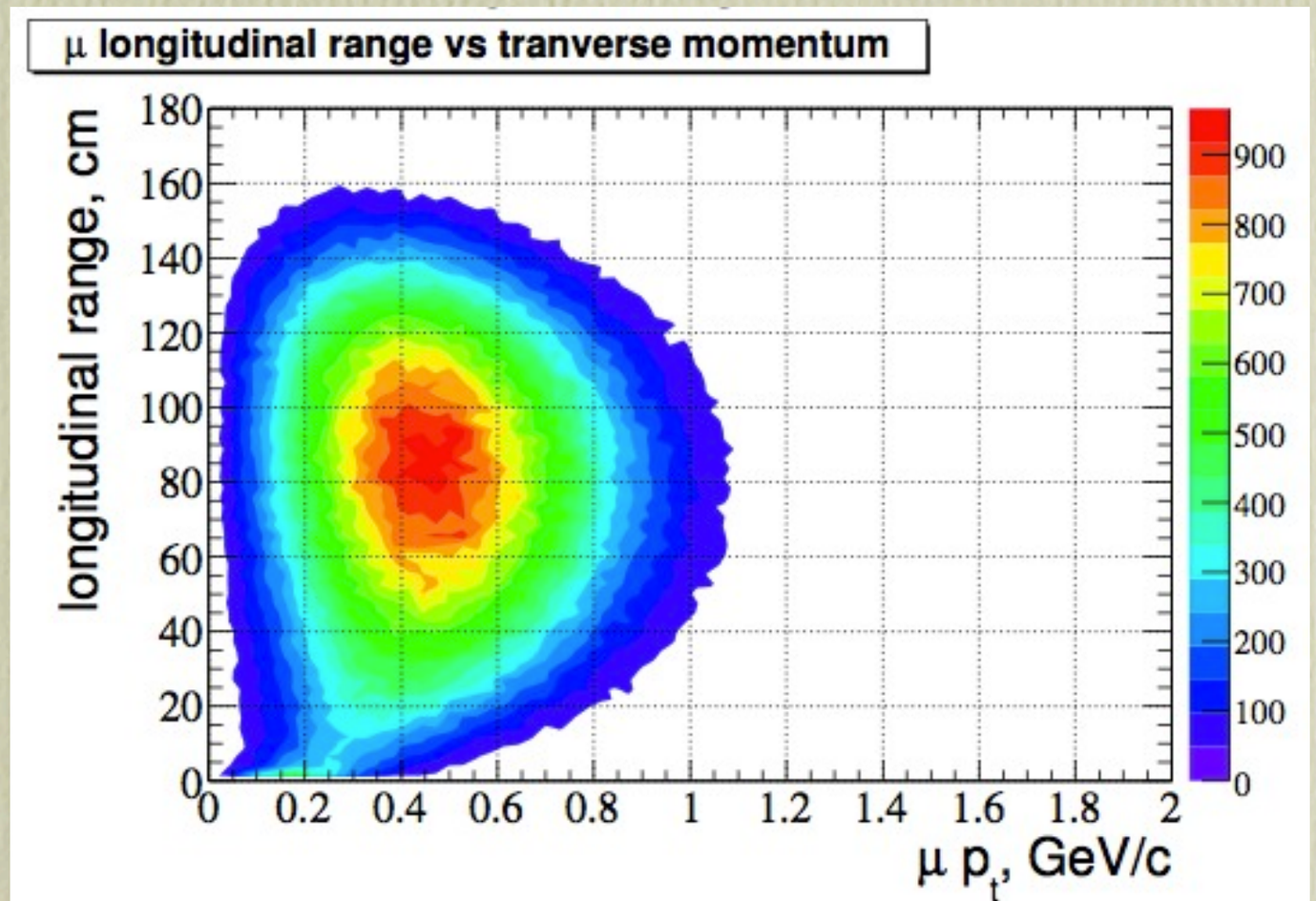
Interaction channels

- table below shows interaction channels for anti-ν_μ. It is incomplete: only looks for QE and single π channels. Channels found are ~40% of the events.

channel id	particles	count (% of $\bar{\nu}_\mu$)
1	$\mu^+ + \mathrm{n}$	11.6
2	$\mu^+ + \mathrm{p}$	0.515
3	$\mu^+ + \mathrm{n} + \pi^-$	7.58
4	$\mu^+ + \mathrm{p} + \pi^-$	4.52
5	$\mu^+ + \mathrm{n} + \pi^0$	3.53
6	$\bar{\nu}_\mu + \mathrm{n}$	3.65
7	$\bar{\nu}_\mu + \mathrm{p}$	2.48
8	$\bar{\nu}_\mu + \mathrm{p} + \pi^0$	1.75
9	$\bar{\nu}_\mu + \mathrm{n} + \pi^+$	1.61
10	$\bar{\nu}_\mu + \mathrm{n} + \pi^0$	1.78
11	$\bar{\nu}_\mu + \mathrm{p} + \pi^-$	1.41
	total	40.5

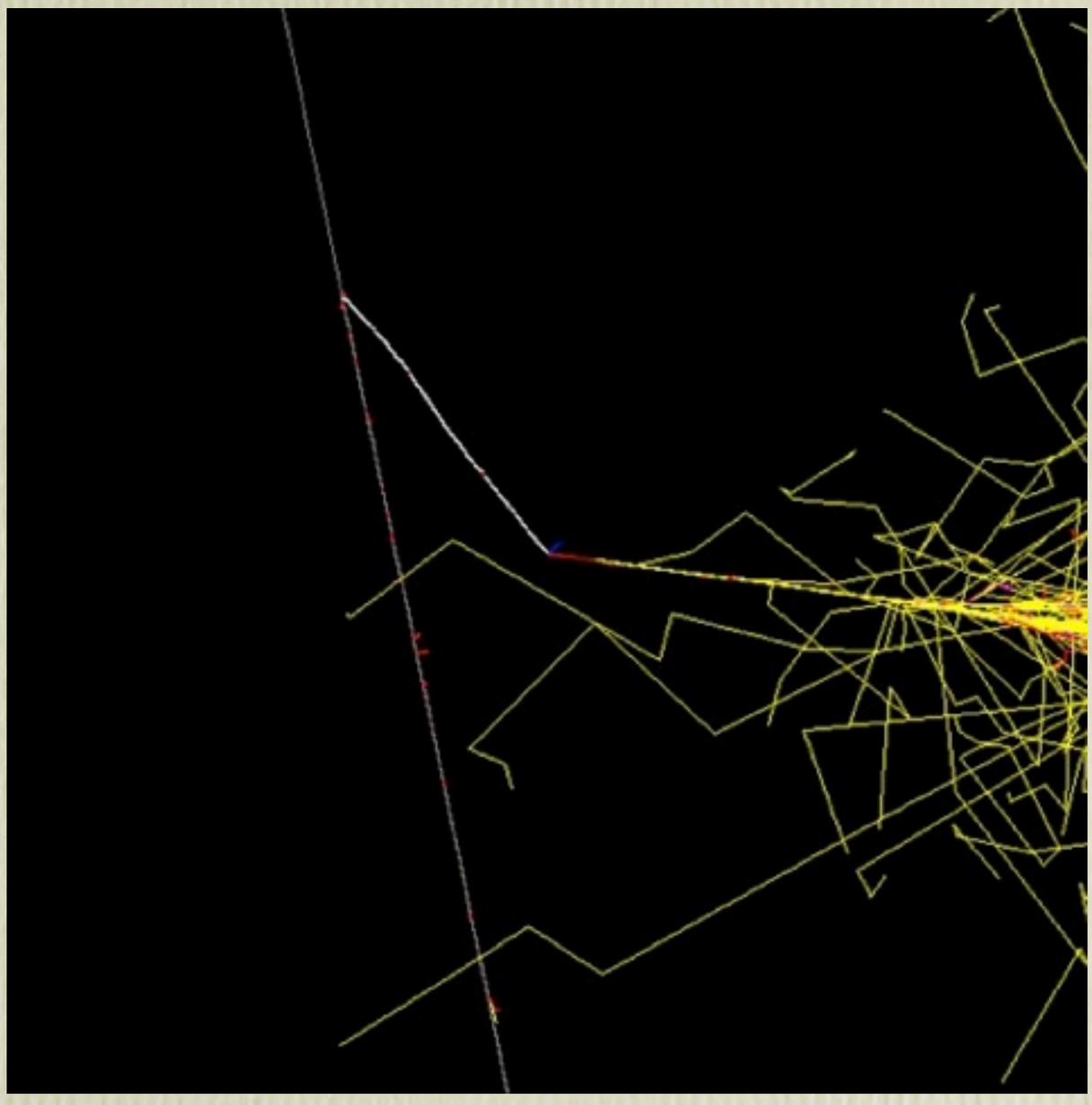
μ range

- because we don't have a full MC simulation, we started looking at the range of the products so that we could add further cuts.
- Range is calculated by integrating Bethe-Bloch.
- the longitudinal range is the range along the incoming neutrino direction.



Firts steps towards MC Simulation of Detector

- went as far as linking GENIE to GEANT4 via ROOT so that the products of the neutrino interactions are propagated in a (general) LAr volume.
- on the right, GEANT's propagation of a final state e^- + p + π^+ in LAr. Yellow are gammas.



Conclusion:

- Smeared truth analysis is underway;
- Full MC to follow?

Suggestions for the future?