
Towards a pion cross-section measurement with protoDUNE

Stefania Bordoni

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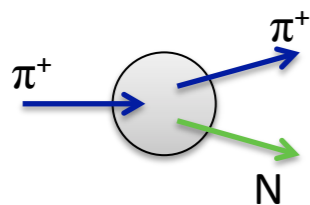
Motivations

- Pion cross-section measurements at protoDUNE is of interest for many aspects
 - LAr-based event reconstruction is challenging. A pion cross-section measurement can give one of the first data-driven estimation of the reconstruction performances
 - Pion cross-section measurements are also of importance to constrain systematics (FSI, SI) which will affect DUNE analyses. Measurements in LAr are just started with LArLat. New measurements are needed:
 - cross-check the measurement(s)
 - possibly extend the energy range.
 - Exclusive measurements can help to acquire a deep understanding of the detector and reconstruction performances. FSI are today one of the main systematics affecting oscillation analyses.

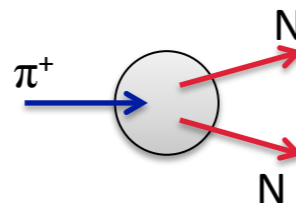
Analysis goal and strategy

- The final goal of the analysis is to extract exclusive pion cross-sections classifying the events by their topologies
- Topologies can be defined by looking to charged pions reconstructed in the detector. Simple example (from DUET experiment):
 - presence of 1 charged pion : QE from absorption and ch. exchange
 - presence of π^0 : ch. exchange from absorption
 - presence of > 1 pion (neutral or charged) : pion production
 - presence of michel-electron : pion decay at rest

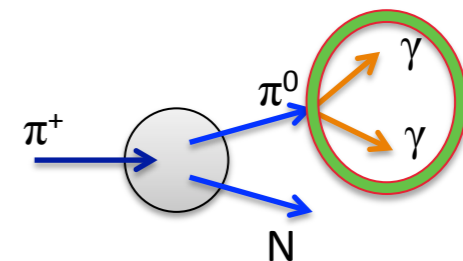
I. Quasi-elastic Scattering



2. Absorption (ABS)



3. Charge Exchange (CX)



Pion reaction modes

		signature
crossing		-
elastic scattering	$\pi^\pm + \text{Ar} \rightarrow \pi^\pm + \text{Ar}$	$\exists \pi^\pm$
inelastic scattering	$\pi^\pm + n (\rightarrow \Delta^\pm) \rightarrow \pi^\pm + n$	$\exists \pi^\pm$
	$\pi^\pm + p (\rightarrow \Delta^0) \rightarrow \pi^\pm + p$	\exists nucleons
absorption	$\pi^\pm + pn \rightarrow \pi^\pm + 2n$	$\nexists \pi^\pm$ \exists nucleons (≤ 1)
	$\pi^\pm + pnn \rightarrow \pi^\pm + 3n$	
	$\pi^\pm + ppn \rightarrow \pi^\pm + p + 2n$	
	$\pi^\pm + pprnn \rightarrow \pi^\pm + p + 3n$	
ch. exchange	$\pi^- + p (\rightarrow \Delta^0) \rightarrow \pi^0 + p$	$\exists \pi^0$
	$\pi^+ + n (\rightarrow \Delta^-) \rightarrow \pi^0 + n$	
pion production	$\pi^- + p/n \rightarrow \pi^0 + \pi^- + p/n$	$\exists > 1\pi$ (π^\pm or π^0)
	$\pi^- + p/n \rightarrow \pi^+ + \pi^- + \pi^- + p/n$	
decay at rest	$\pi^\pm \rightarrow \mu^\pm + e^\pm$	\exists michel el.
capture at rest	$\pi^\pm + pn \rightarrow 2n$	\exists nucleons

First steps

- Understand the reconstruction output and performances using MC :
 - Use of particle guns at different energies (0.5 - 3 GeV)
 - Look at basic distributions: tracks vs clusters, # vertices, dEdx, multiplicity for secondaries..
 - Once this is understood, look at specific particle type and see if and how they are reconstructed

In practice :

- Currently studying the output from the reconstruction (larexamples). Understand products coming from the reconstruction and see how to combine informations, if needed
- Working close to Dorota and Robert to set up the basic of the analysis module, follow the improvement on the reconstruction and give feedbacks

Synergy with LArIAT

- LArIAT is already addressing many issues that are of interest for the protoDUNE analysis
- Synergies with LArIAT would be of clear benefit for this analysis, avoiding to re-invent the wheel and allow to focus on the further developments.
- Possible solutions of how to set such synergies are under discussion

Conclusions

- Pion cross-section analyses are interesting for many aspects:
 - one of the first physics measurements at protoDUNE
 - measurements on LAr which is a entire new field (only LArIAT measurement so far)
 - Exclusive measurements can provide samples where to tests the reconstruction developments
- Many reconstruction developments are already available to be used at the analysis level.
- From the reconstruction output to the analysis level there is still a lot of work to be done
 - Need to understand the current reconstruction output
 - Use and define informations of interest at the analysis level
- Working close to Dorota and Robert will help to speed up the interactions between needs of the analysis and reconstruction performances.