TK, Martini, arXiv:1611.07770

Neutrino Nucleus Cross Sections for Oscillation Experiments

outline

1. Timeline of the paper
2. Section structure
3. What we learned

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NuSTEC meeting, Jan. 17, 2017

Queen Mary
University of London

1. Paper timeline

2014 summer	JPhysG contacted Marco to write a review paper on "neutrino-nucleus cross-sections for neutrino oscillation experiments", Marco invited Teppei to join
2015 June	1st meeting (France+Belgium), make outline of the paper
2015 July	Start to write the paper
2015 July	The first draft of the paper (v2.1)
2015 August	2nd meeting (France), TRY to finalize the paper
2015 Autumn	Unexpected delay (Marco changed contract, new house, car accident), etc
2016 February	Getting pressure from JPhysG, resume to work
2016 April	3rd meeting (France), try to finish up the paper
2016 Summer	Lots of work done…, many changes to take into accounts new publications
2016 September	Marco had a baby, left few weeks
2016 October	Teppei had a baby, left few weeks
2016 October	Submit the paper to JPhysG/ArXiv
2017 now	Working on referee comment corrections

1. Basic ideas of the paper

Since there are several neutrino cross section review papers, we try to define this paper to be different. The main focus is the discussions around "data-theory comparison", and we skip discussions on physics where there is no data.

Marco

- Use and update/modify text from past proceedings
- Summarize various conference presentation (such as "famous" 2p2h model comparison) and make a reference

Teppei

- Use discussions from neutrino cross-section newsletter

Main tools

- drop box to share documents
- a lot of Skype (~3-4/month last 3 years)

2. Section 1

Introduction and abstract are mainly written by Marco

1.1 is based on lectures I gave on neutrino oscillations

1.2 is an updated copy of Luis/Hayato/Nieves paper experiment section (Sec. 2)

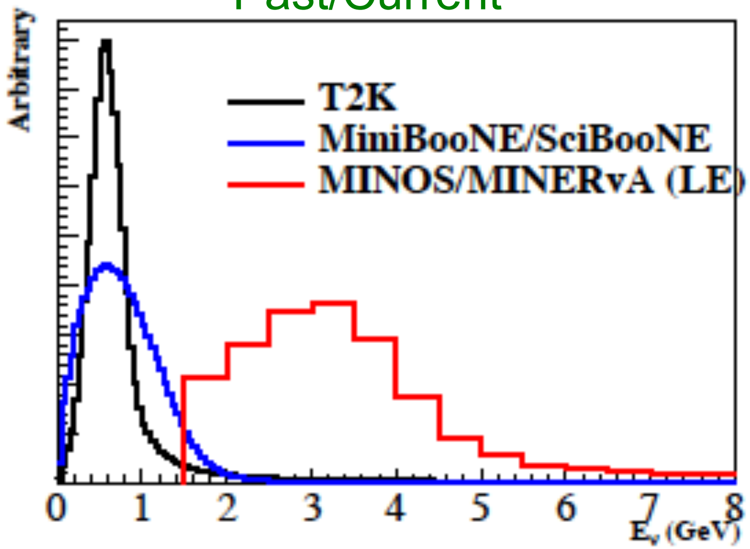
1.3 is new, I contacted all experiments to get preliminary flux
(DUNE, MINERvA medium energy beam ,etc)

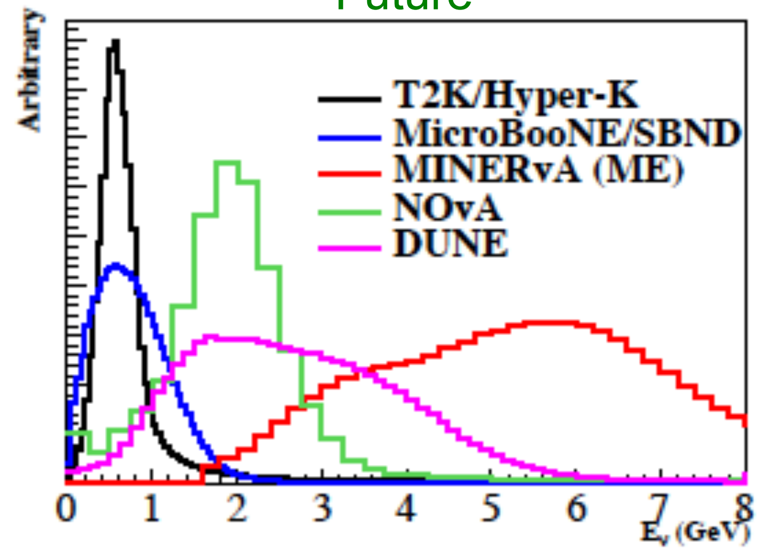
2. Section 1

It seems importance beyond QE interaction (>1 GeV physics) is evident

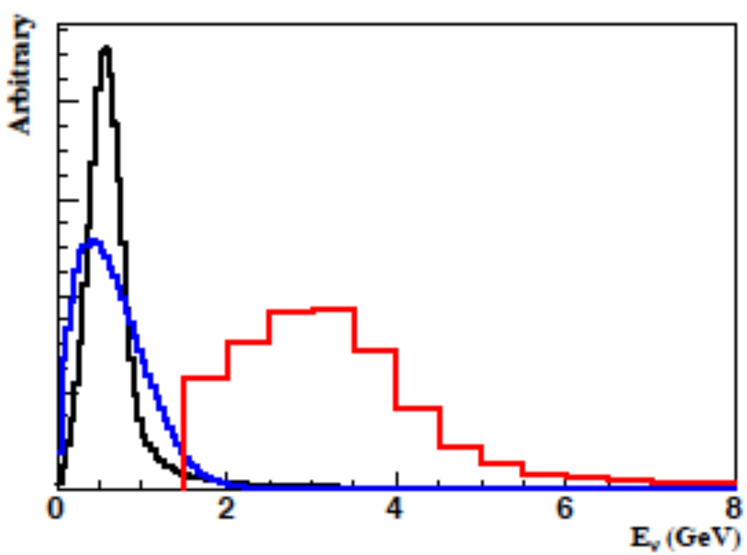
Past/Current | Future

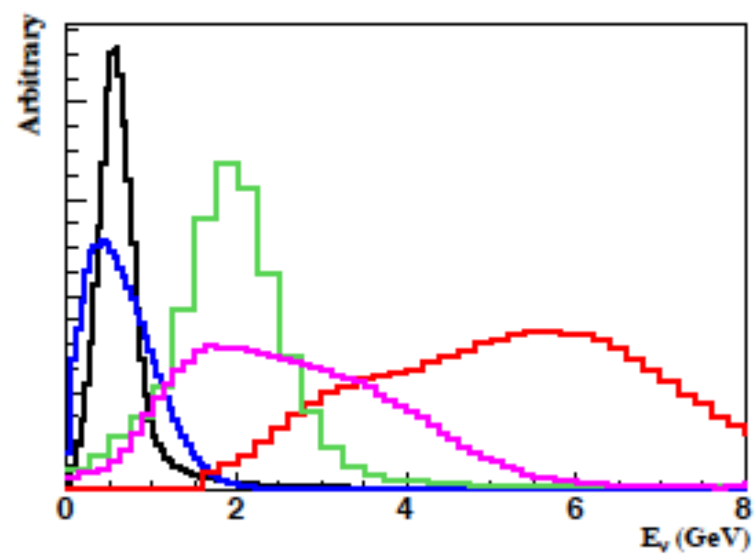
ν_μ-flux of ν-mode





$\overline{\nu}_\mu$-flux of $\overline{\nu}$-mode





2. Section 2

2.1 is by Marco

2.2 is loosely based on my proceedings and past papers

2.3 is based on our discussions from the first meeting. The section was revised by both and have inputs by both.

2. Section 2

$$\frac{d^2\sigma}{dT_l\, d\cos\theta} = \frac{1}{\int \Phi(E_\nu)\, dE_\nu} \int dE_\nu \left[\frac{d^2\sigma}{d\omega\, d\cos\theta}\right]_{\omega=E_\nu-E_l} \Phi(E_\nu)$$

Theorists

Experimentalists

$$\frac{d^2\sigma}{dT_l cos\theta} = \frac{\sum_j U_{ij}(d_j - b_j)}{\Phi \cdot T \cdot \varepsilon_i \cdot (\Delta T_l, \Delta cos\theta)_i}$$

Flux-integrated differential cross-section data are main tools for neutrino interaction physics community now. They allow theorists and experimentalists to talk

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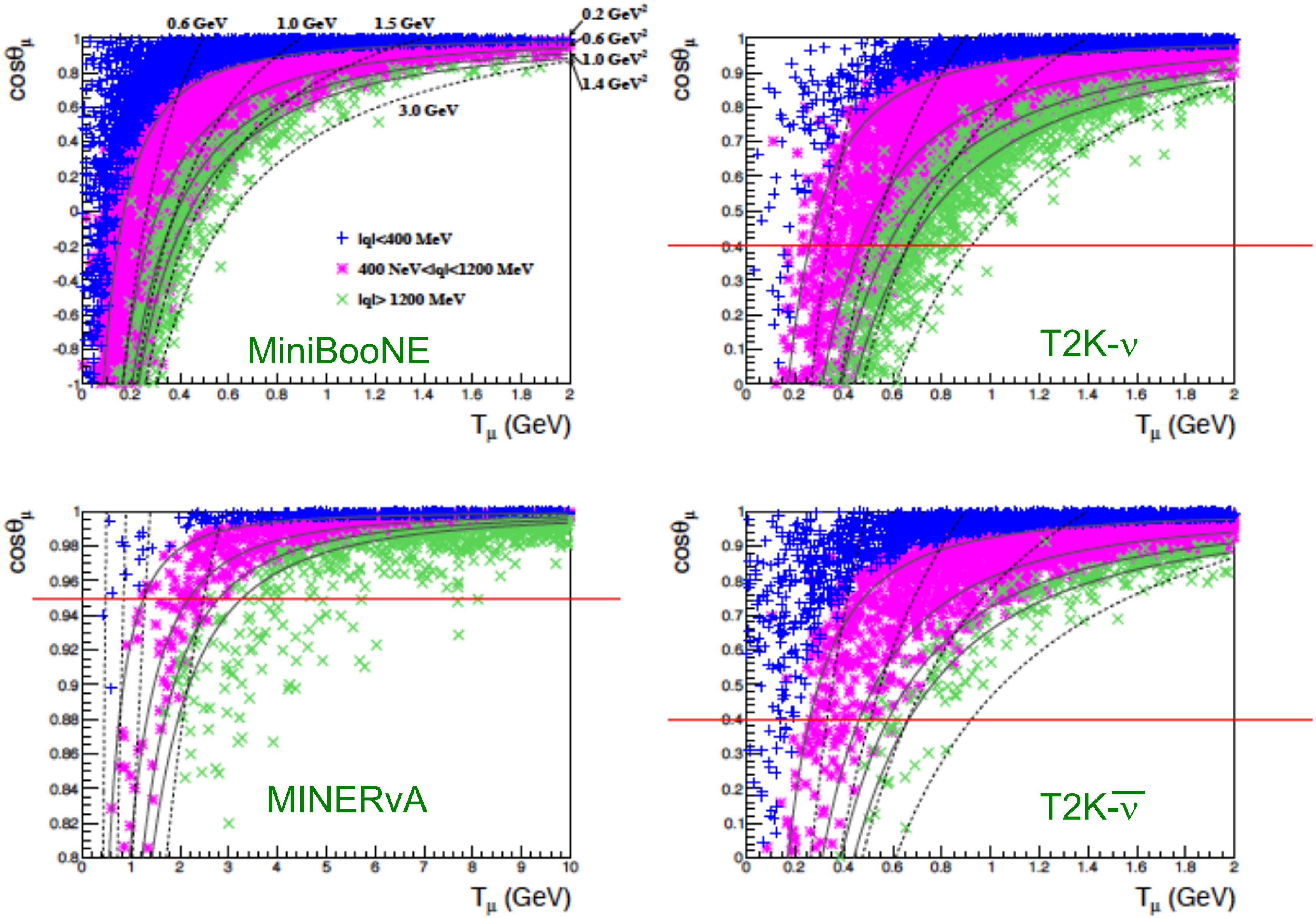
2. Section 2

Kinematics of these 3 experiments are not so different for CCQE



2. Section 3

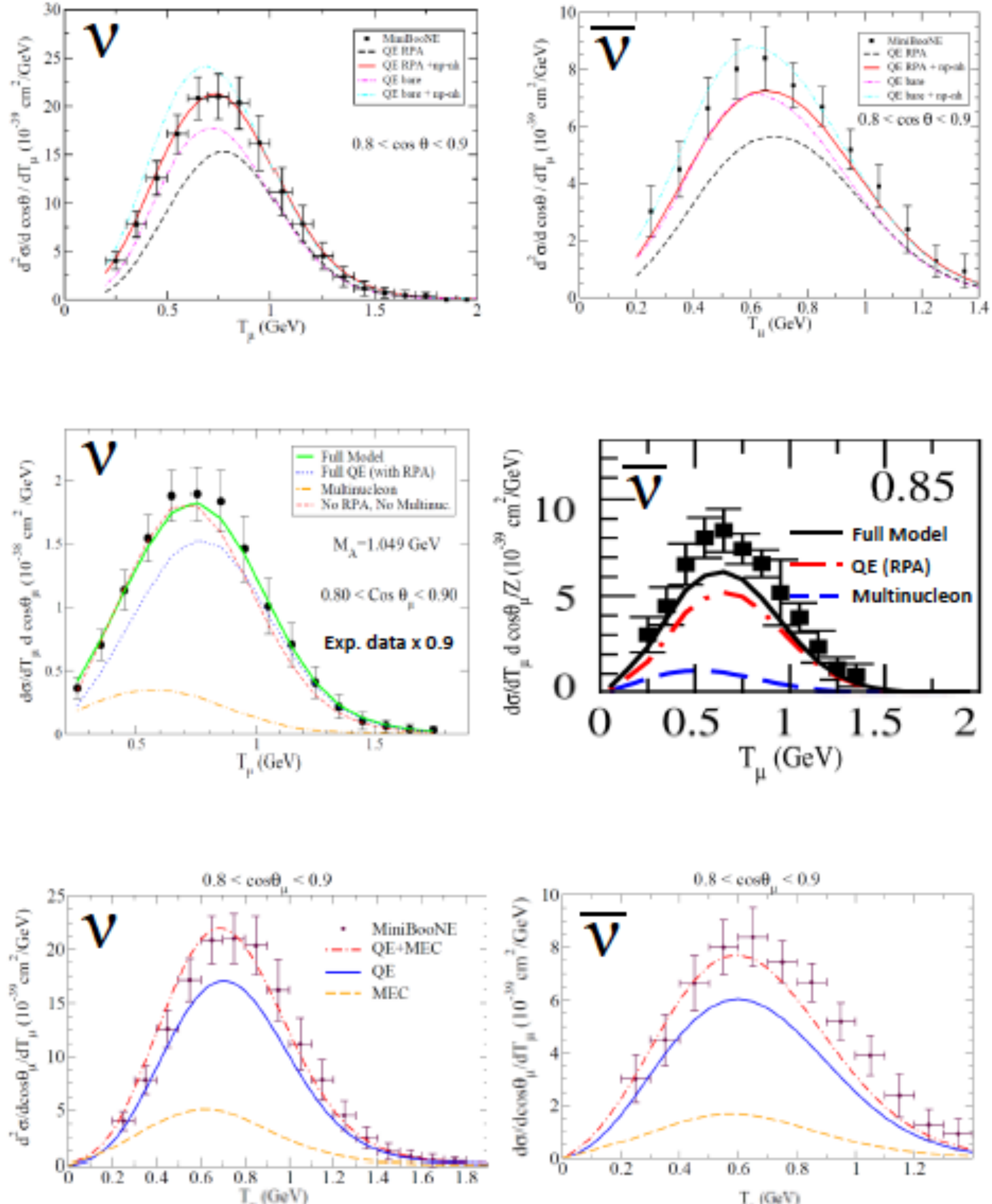
3.1 is based on Marco's past proceedings
3.2 is a summary of Marco's past talks at various conferences about 2p2h Model comparison

3.3 is summary of recent papers, also based discussion in neutrino cross-section newsletter

2. Section 3

After adding axial MEC contribution, SuSA collaboration (Megias et al.) shows similar enhancement with other groups (Martini et.al., Nieves et al., Meucci et al., Mosel et al., Bodek et al.).

All groups agree qualitatively with MiniBooNE CCQE-like double differential data.



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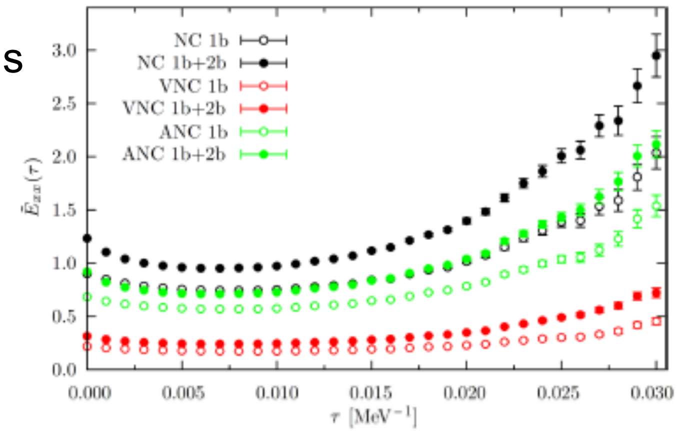
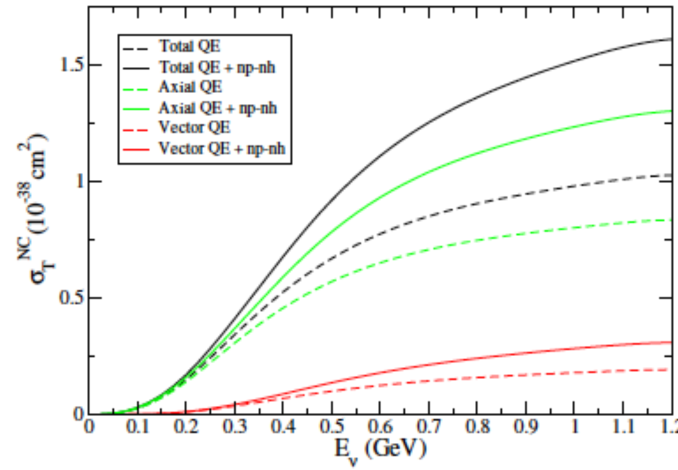
2. Section 3

NC Euclidean transverse response

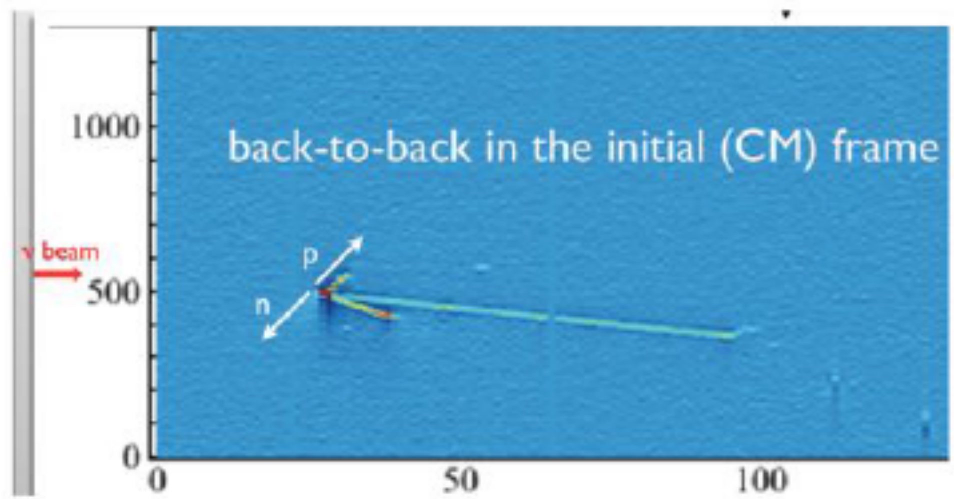


NCQE-like xs transverse contribution



Phenomenological models have strong support from ab initio calculations

The tests of models including nucleon kinematics are just started



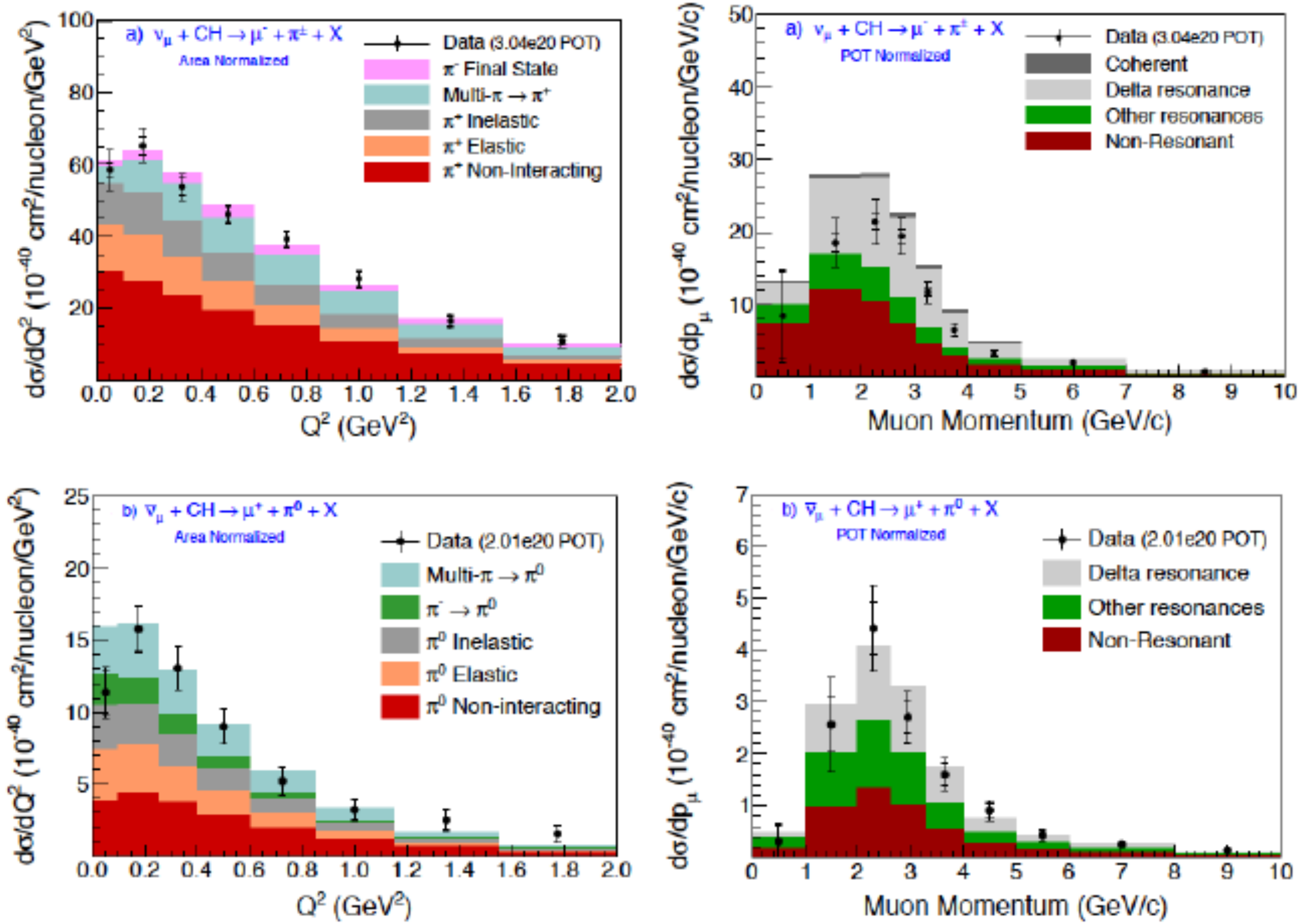
2. Section 4

Teppei

The main focus is "how to read hadron data" (Sec. 4.1) and "pion puzzle" (4.3, 4.5). There are so many new papers during writing this section (NuMI new flux, new MINERvA pion paper) and I needed to change text constantly…

2. Section 4

Do we understand MINERvA $\nu_\mu CC1\pi^+$ and $\overline{\nu}_\mu CC1\pi^o$ data differences?



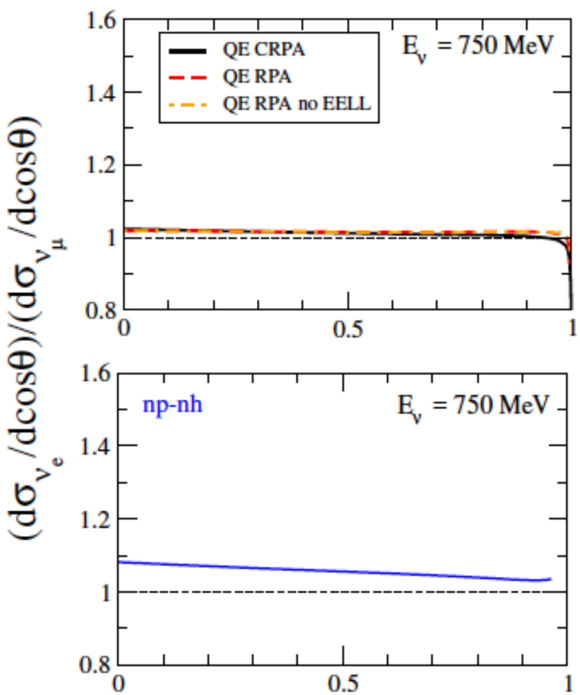
2. Section 5, 6

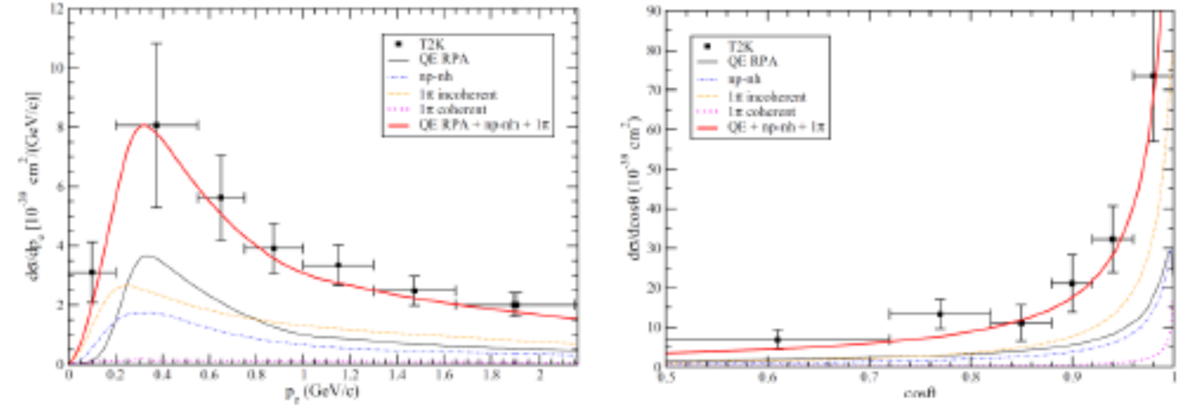
Marco did everything for chapter 6 and 7. There are new arguments/original plots here, too.

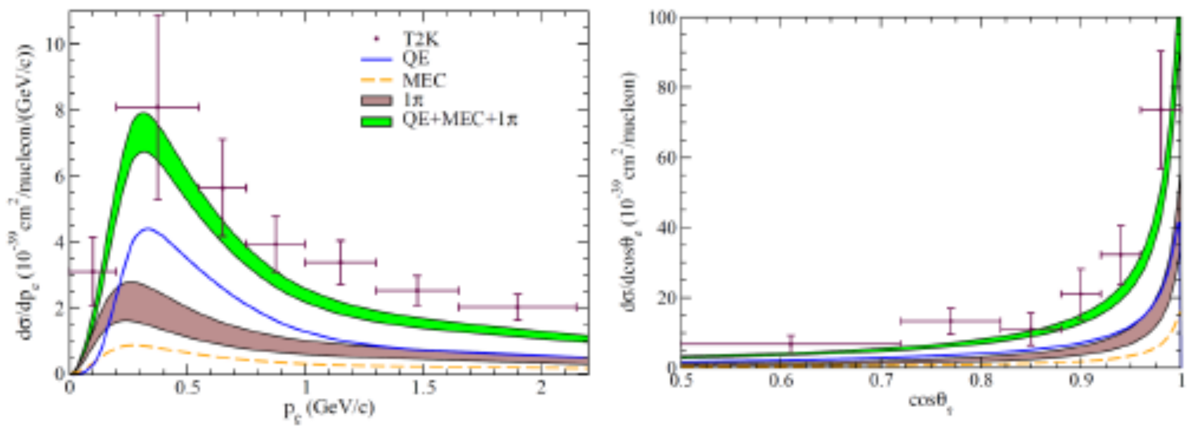
2. Section 5, 6

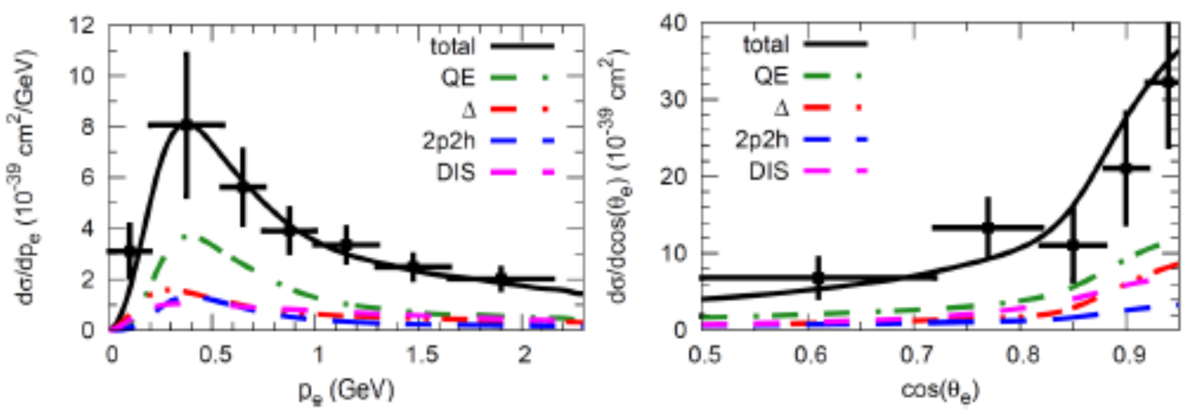
The first ν_eCC differential cross section was published on 2014 by T2K, and already models agree very well!

ν_e/ν_μ ratio is understood well?
→ first time modern interaction models contribute to reduce xs systematic errors







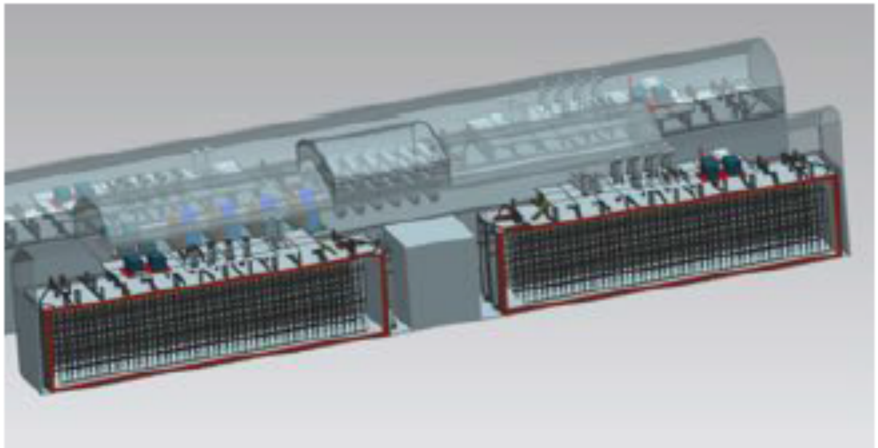


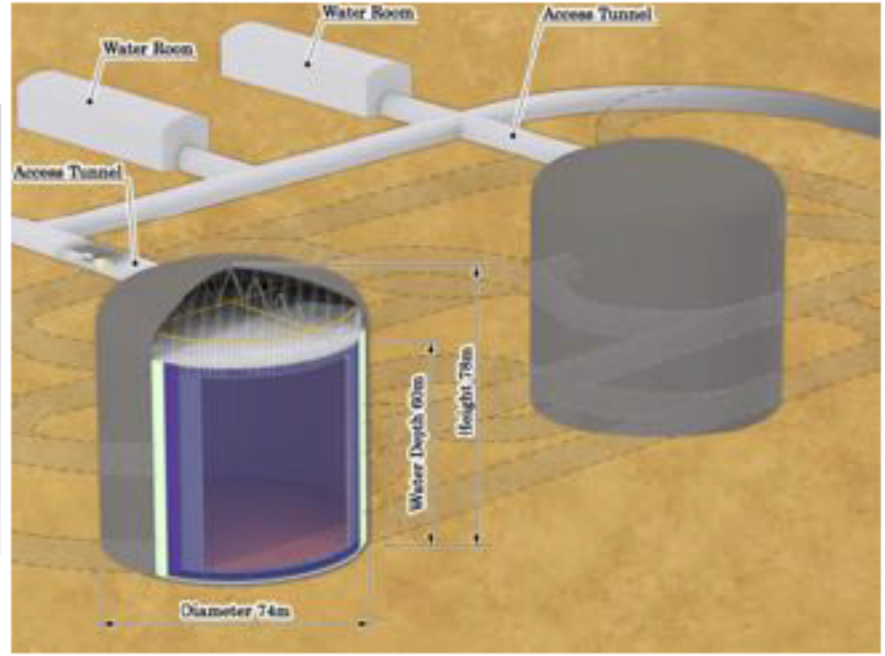
2. Section 7, 8

I summarize all beam neutrino projects (analysis method, detector, beam) on the table. I try to be nice to both LArTPC and Water Cherenkov.

I also wrote most of conclusions.

2. Section 7, 8





DUNE (2025?)
LArTPC detector
argon target
wideband 1-4 GeV
(on-axis beam)

Hyper-Kamiokande (2026?)
Water Cherenkov detector
water target
narrowband 0.6 GeV
(off-axis beam)

3. What we learned

We use our skills for different fields

- Marco: all theory sections
- Teppei: experiment/beam descriptions, event generation by GENIE/ROOT

What we learned

- Culture and working habits of theorists and experimentalists
- Skill transfer on paper writings (reference, figure format, etc)
- It's manageable for 2 people, but not easy to expand more

New ideas

- Section 2.3, Matching theory and experiment
- Section 3.3, Hadron information