PION PRODUCTION IN A HYBRID-RPWIA MODEL

Natalie Jachowicz, R. González-Jímenez, K. Niewczas, J. Nys
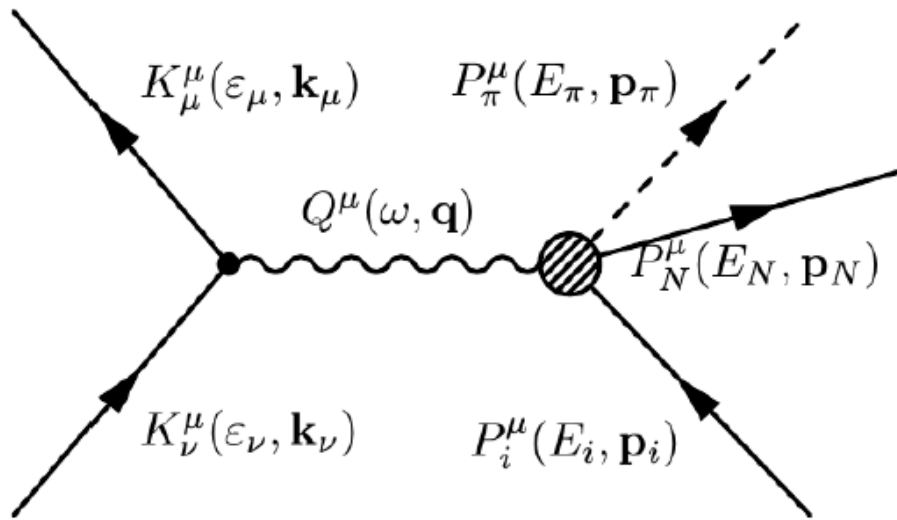
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AIM

- Detailed microscopic cross sections calculations for neutrino-induced pion production
- Formalism valid over a broad energy range
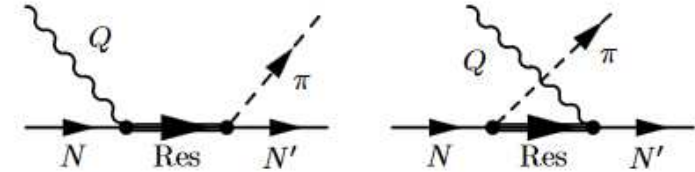- Taking into account as many nuclear physics aspects as feasible

References :
- Electroweak single-pion production ott the nucleon : from threshold to high invariant masses' R. Gonzalez-Jimenez, N. Jachowicz, K. Niewczas, J. Nys, V. Pandey, T. Van Cuyck, N. Van Dessel, Phys. Rev. D95, 113007 (2017) ; arXiv:1612.05511.
- 'Pion production within the hybrid-RPWIA model at MiniBooNe and MINERvA kinematics, R. Gonzalez-Jimenez, K. Niewczas, N. Jachowicz, arXiv:1710.08374

I. Single pion production on the nucleon – low energy model

$K^\mu_\mu(\varepsilon_\mu, \mathbf{k}_\mu)$ $P^\mu_\pi(E_\pi, \mathbf{p}_\pi)$

$Q^\mu(\omega, \mathbf{q})$ $P^\mu_N(E_N, \mathbf{p}_N)$

$K^\mu_\nu(\varepsilon_\nu, \mathbf{k}_\nu)$ $P^\mu_i(E_i, \mathbf{p}_i)$

Cfr. PRC 76, 033005 (2007), PRD87, 113009 (2013)

Resonances
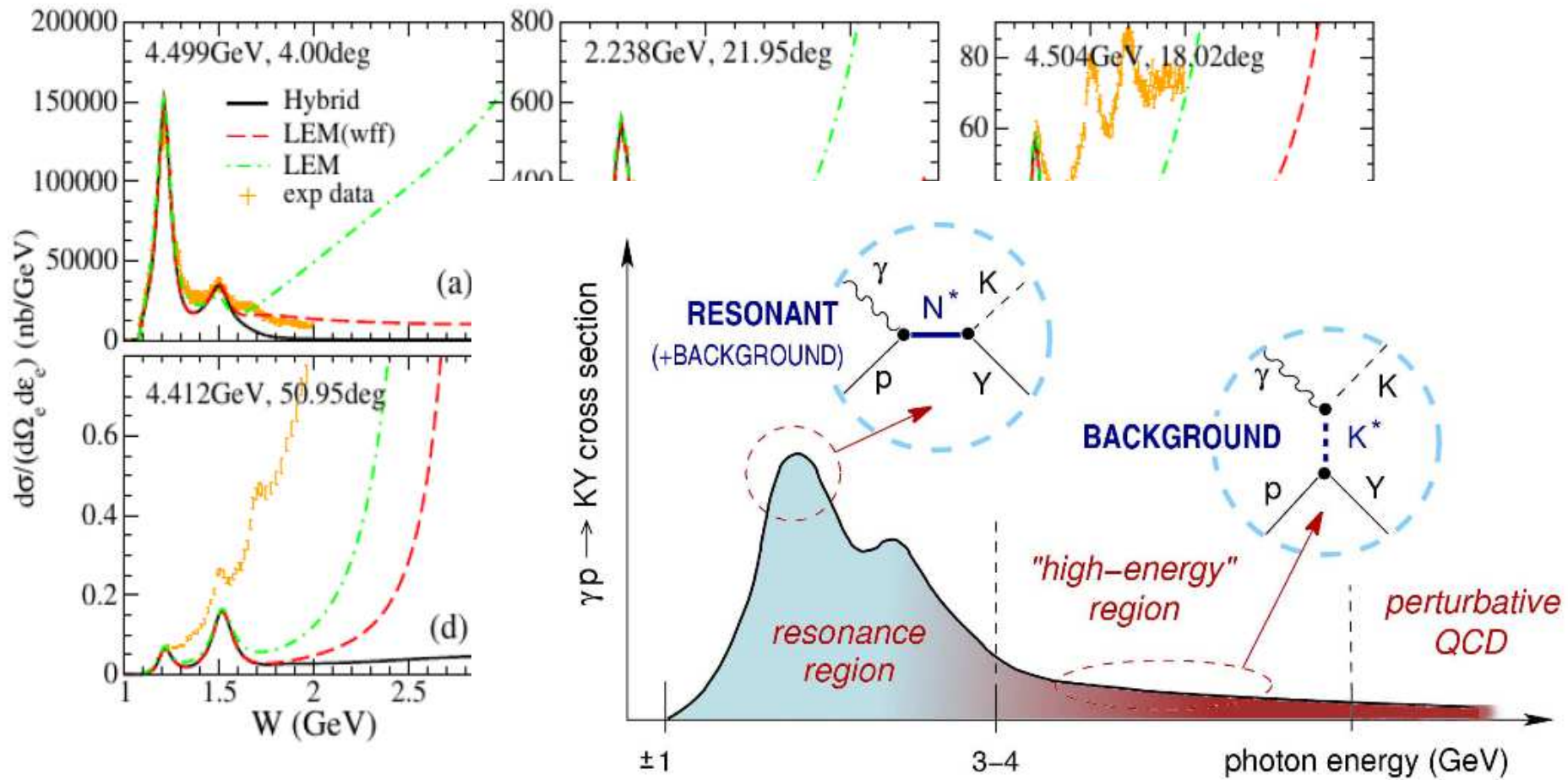

P33 (1232), P11(1411), D13 (1520), S11 (1535)

+

ChPT background

I. Single pion production on the nucleon – some issues of the LEM model …

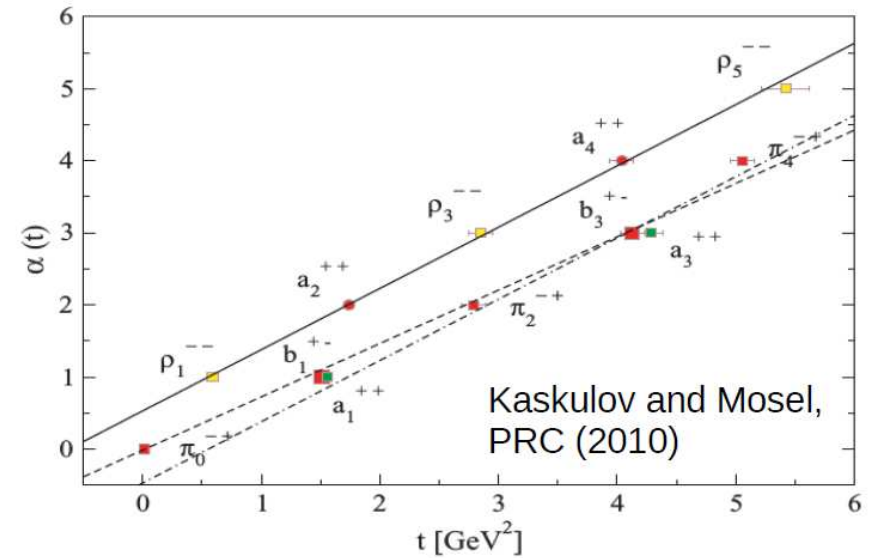# I. Single pion production on the nucleon – some issues of the LEM model …

T. Corthals, PhD, UGent 2005

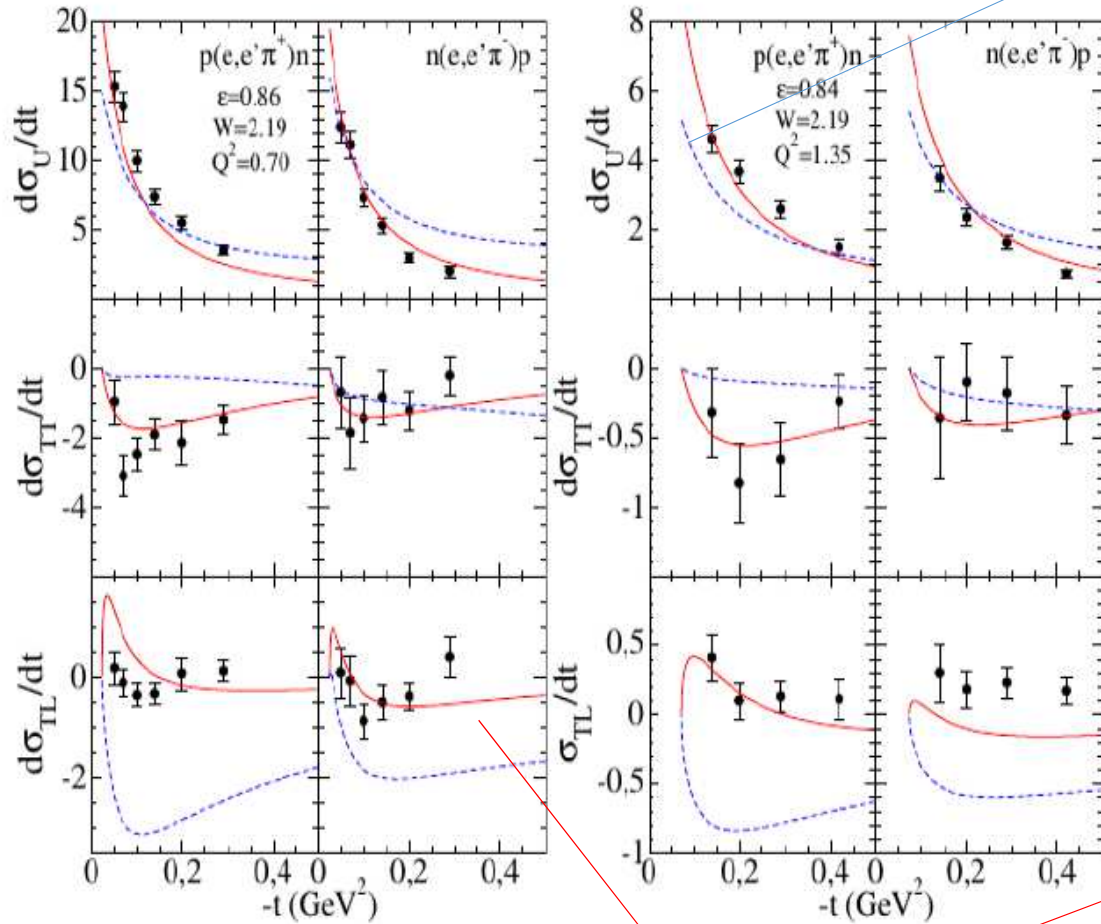GHENT UNIVERSITY

II.High energy model

Regge approach
Replace the pion propagator by the Regge trajectory of the family

$$\frac{1}{t - m_\pi^2}$$

$$\downarrow$$

$$\mathcal{P}_\pi(t,s) = -\alpha'_\pi \varphi_\pi(t) \Gamma[-\alpha_\pi(t)](\alpha'_\pi s)^{\alpha_\pi(t)}$$
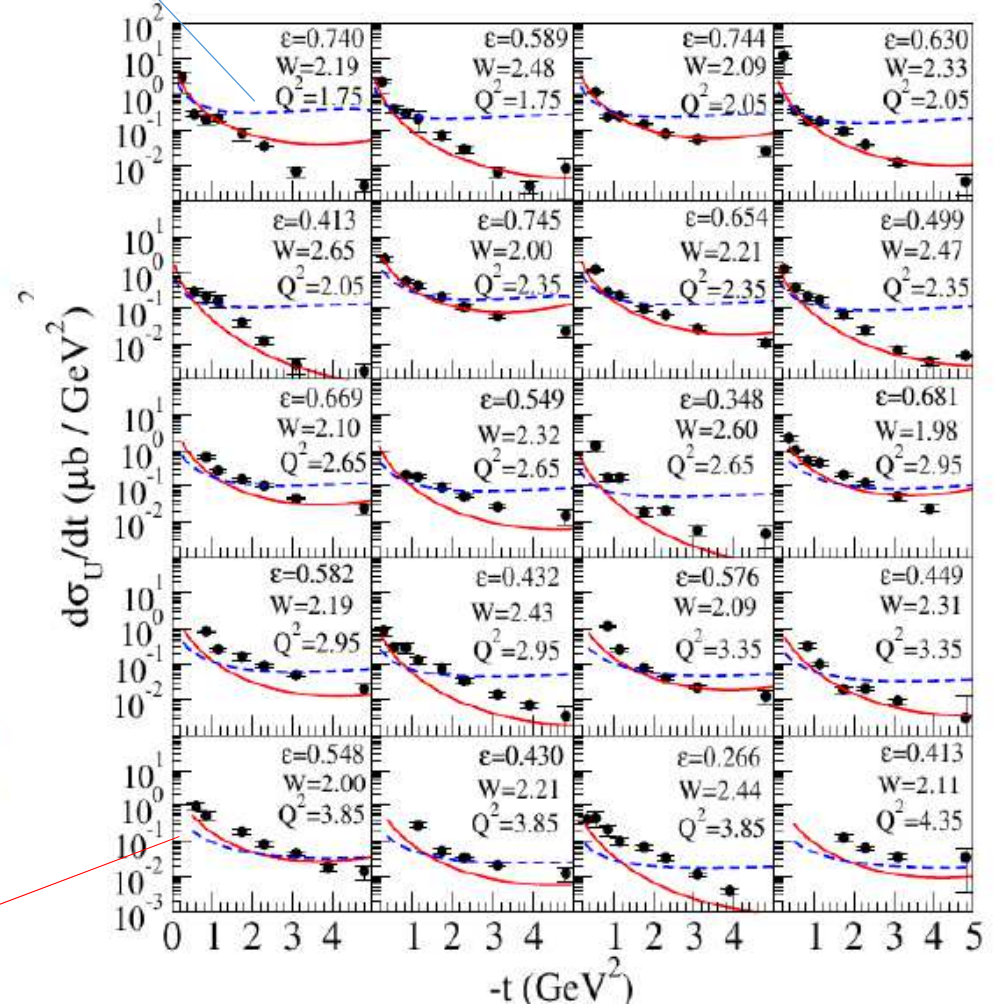

Kaskulov and Mosel, PRC (2010)

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II.High energy model - results

LEM

ReChi

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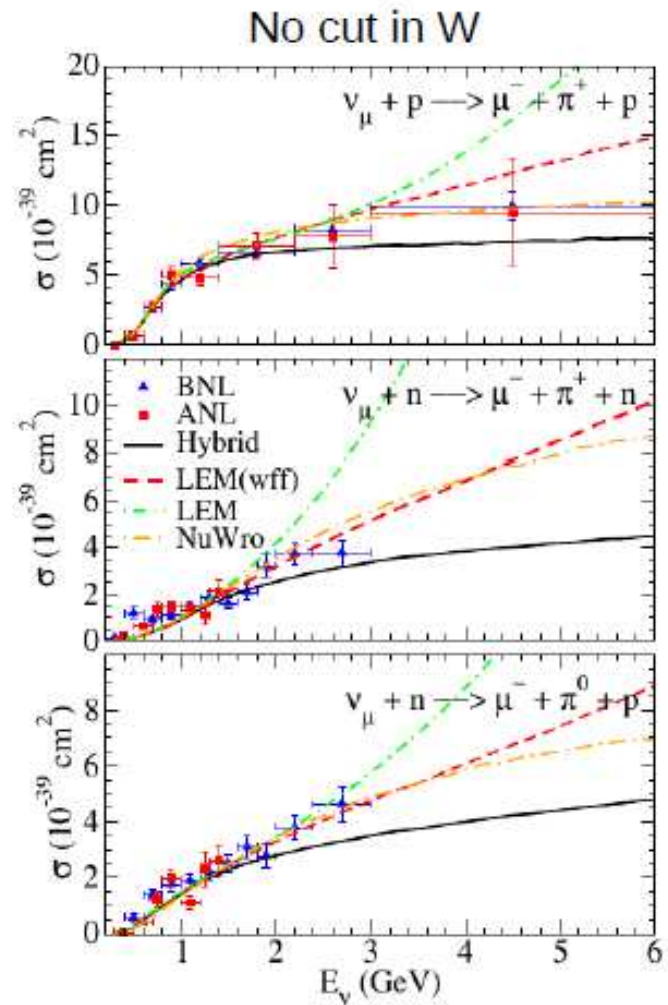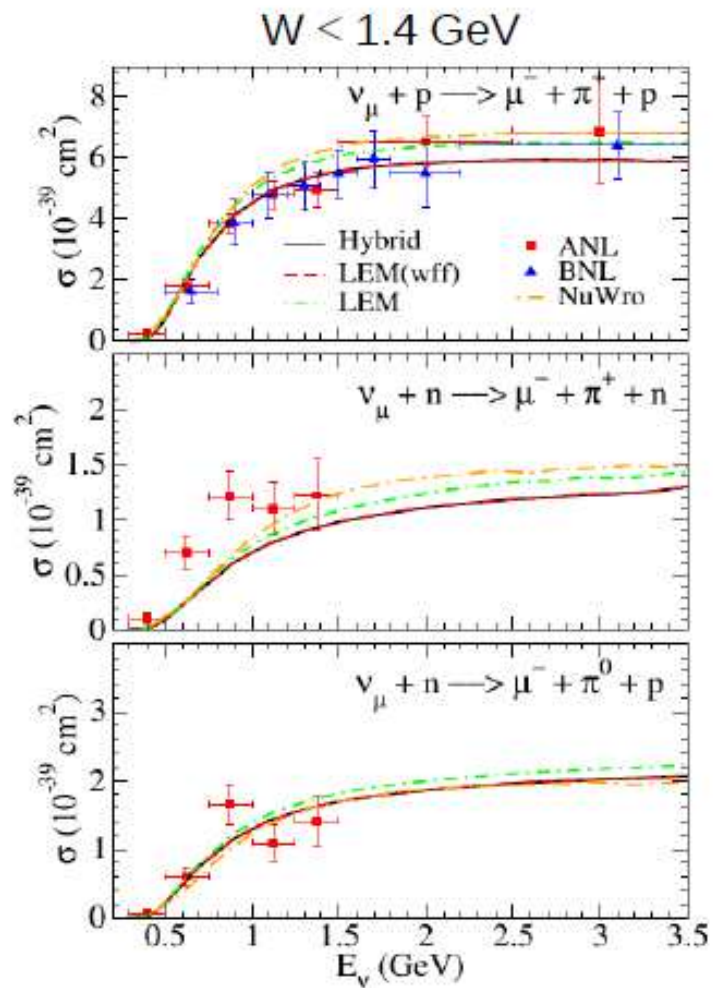# III.Hybrid model : merge both models in a phenomenological way

$$\widetilde{\mathcal{O}} = \cos^2 \phi(W) \mathcal{O}_{ChPT} + \sin^2 \phi(W) \mathcal{O}_{ReChi}$$

$$\phi(W) = \frac{\pi}{2} \left(1 - \frac{1}{1 + \exp\left[\frac{W - W_0}{L}\right]} \right)$$

W<1.4 GeV : LEM model : resonances + ChPT background

W>2GeV : Regge background contributions

III.Hybrid model – results

IV. Hybrid model – put the nucleon in a nucleus

Plane waves (for the moment...)

$$J_{had}^{\mu} = \sum_i^A \int d\mathbf{r}\, \overline{\Psi}_F(\mathbf{r})\, \phi^*(\mathbf{r})\, \hat{\mathcal{O}}_{one\text{-}body}^{\mu}(\mathbf{r})\, \Psi_B(\mathbf{r})\, e^{i\mathbf{q}\cdot\mathbf{r}}$$
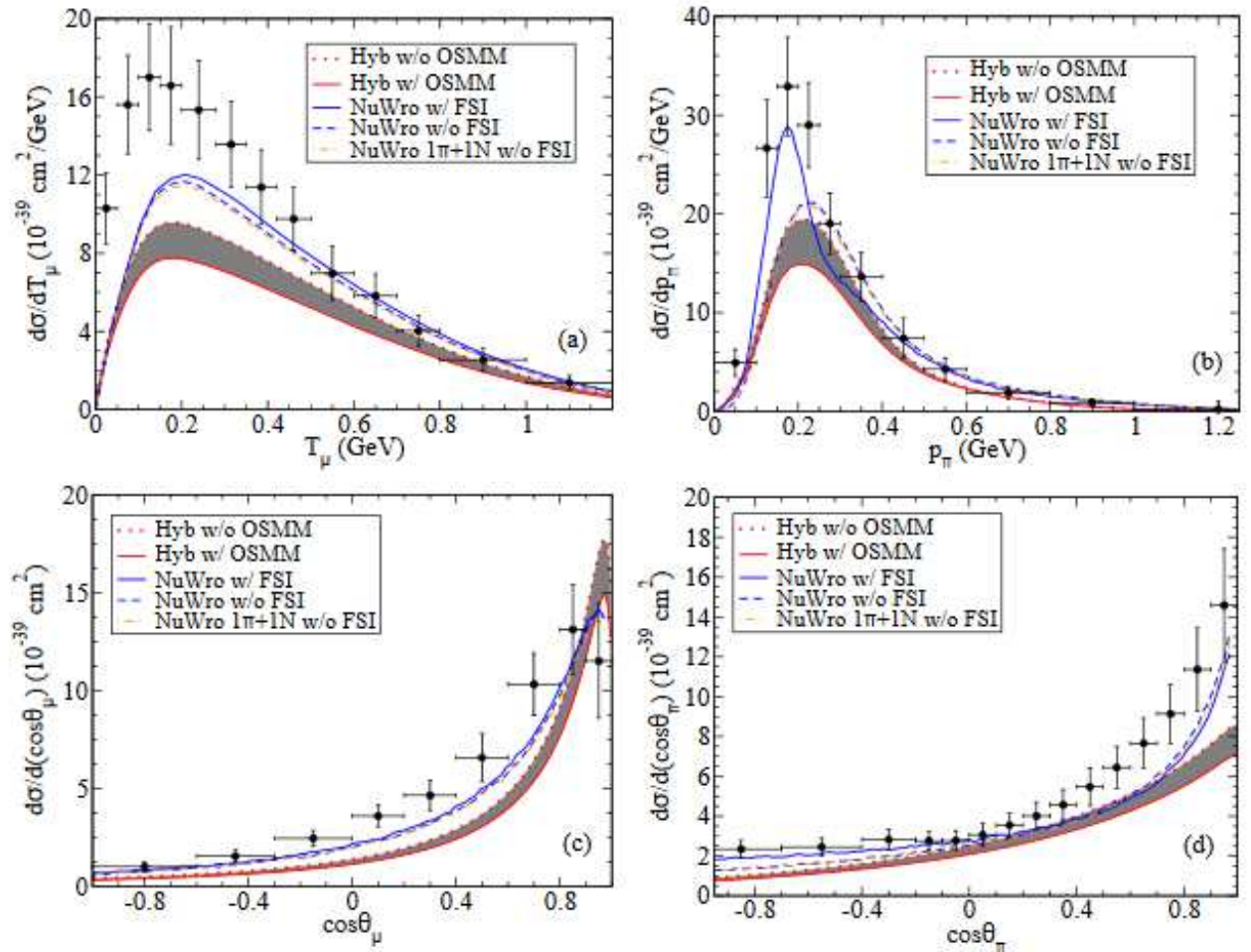
not yet

?

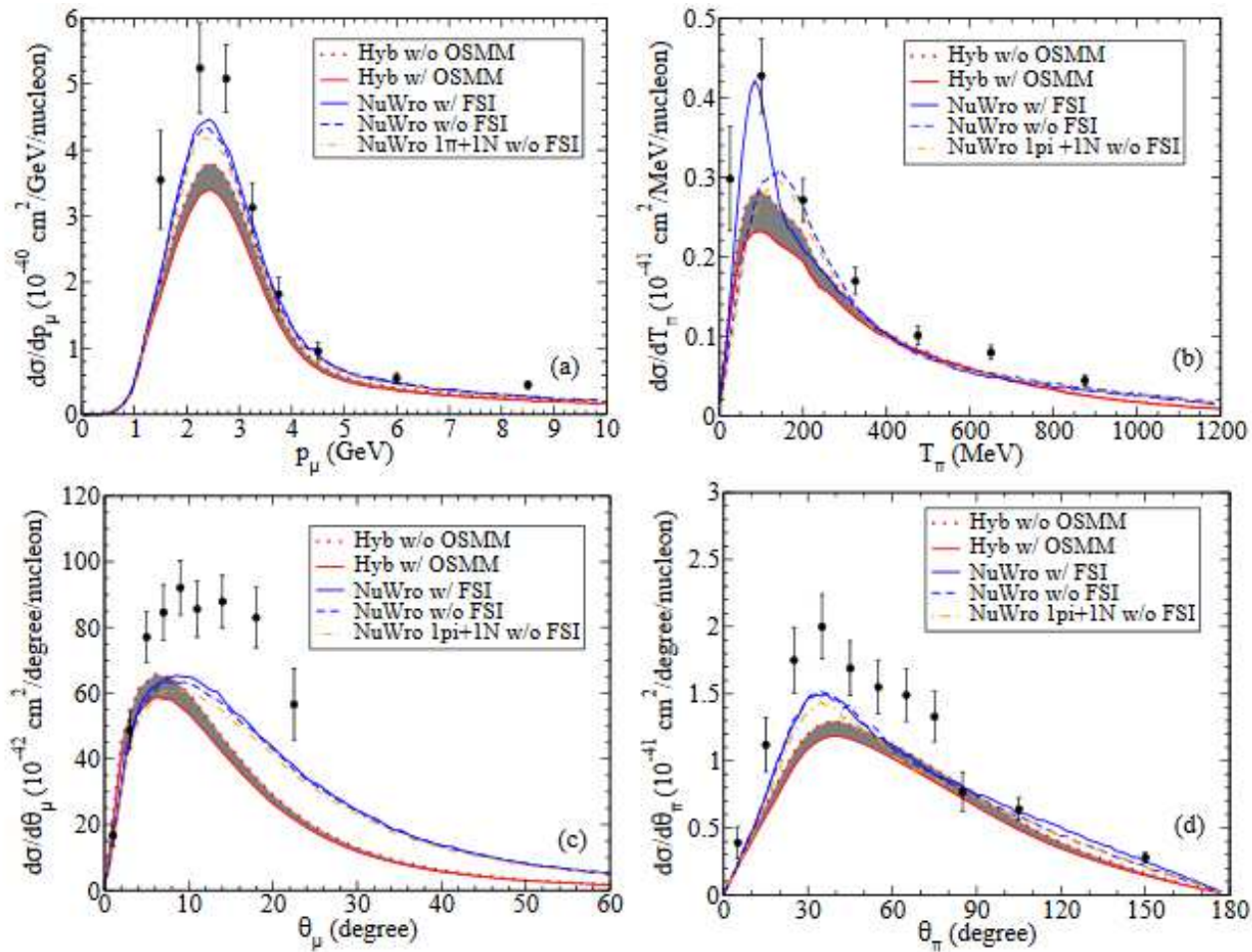Relativistic mean-field wave functions

+ comparison with NuWro final state

+ investigate effect of medium modifications

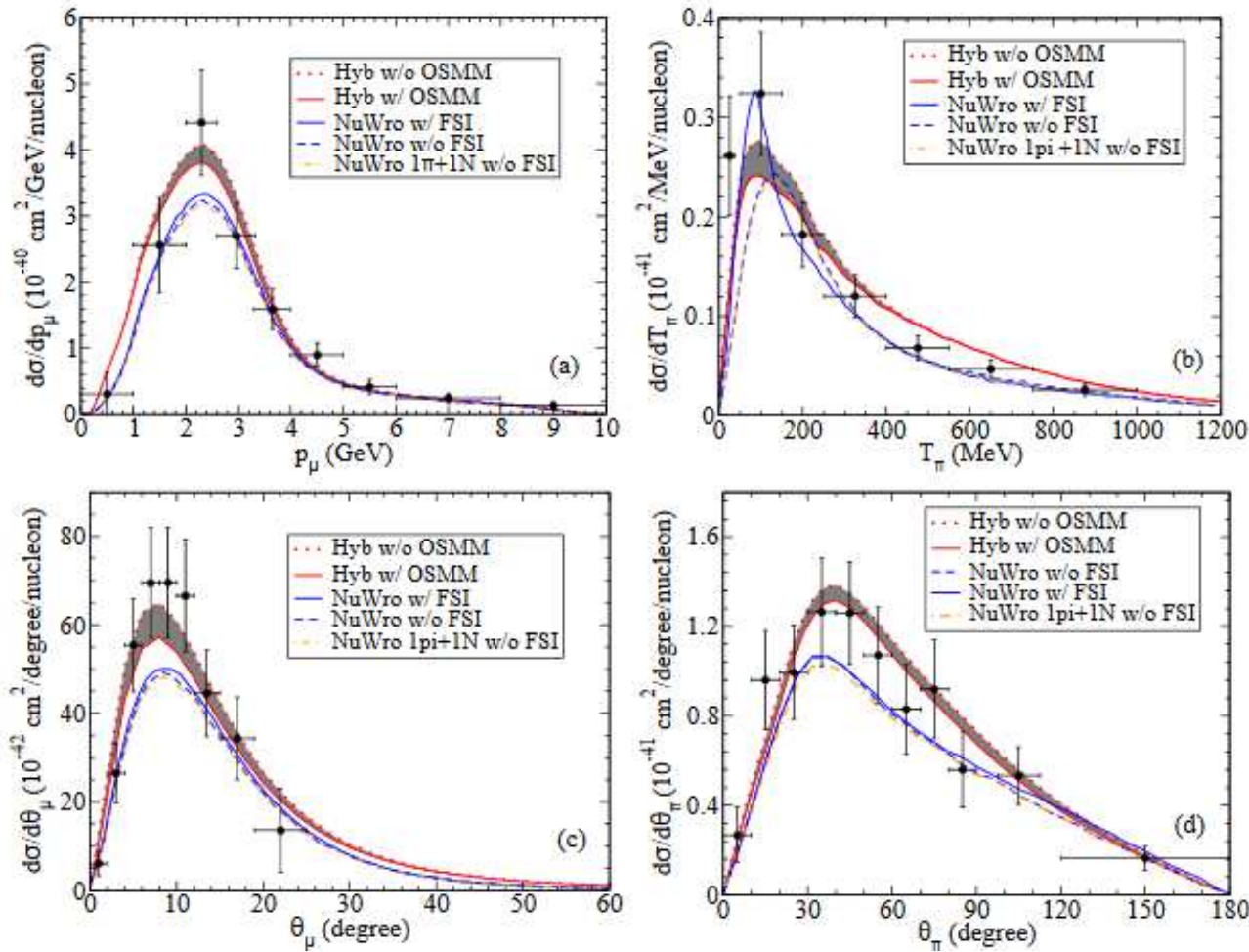# IV. Hybrid RPWIA model – results

MiniBooNE νCC $1\pi^0$

IV. Hybrid RPWIA model – results

MINERvA νCC $1\pi^0$

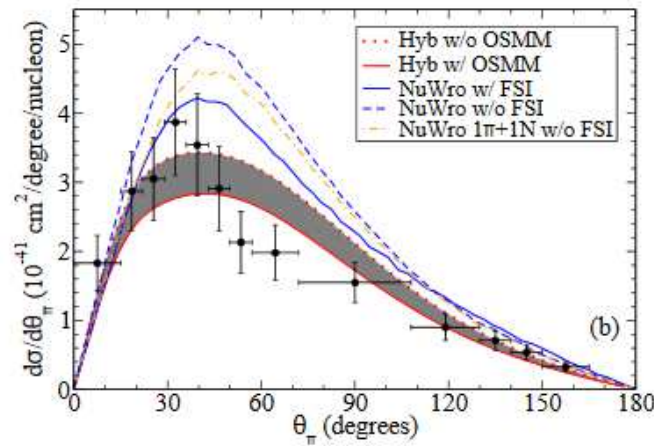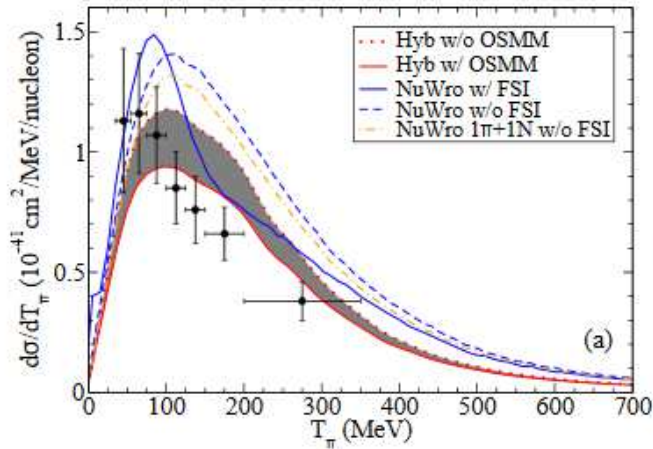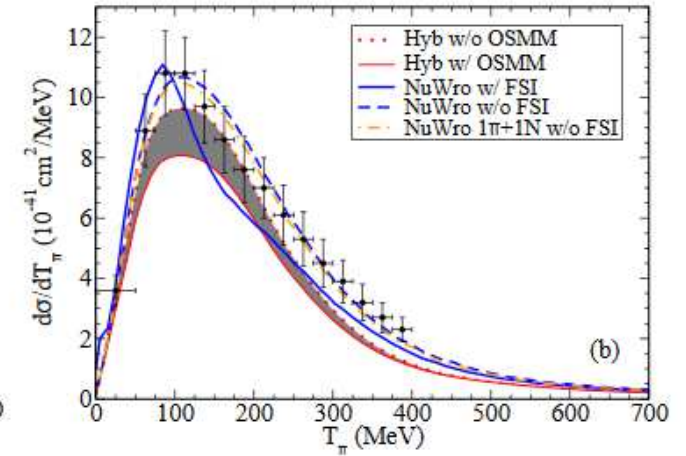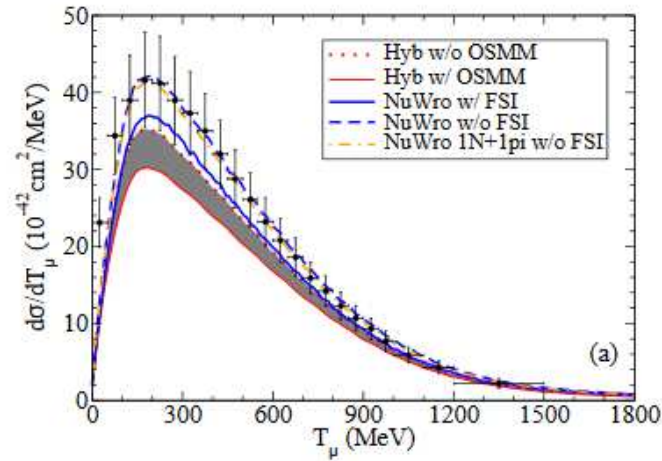# IV. Hybrid RPWIA model – results

MINERvA $\bar{\nu}$CC $1\pi^0$

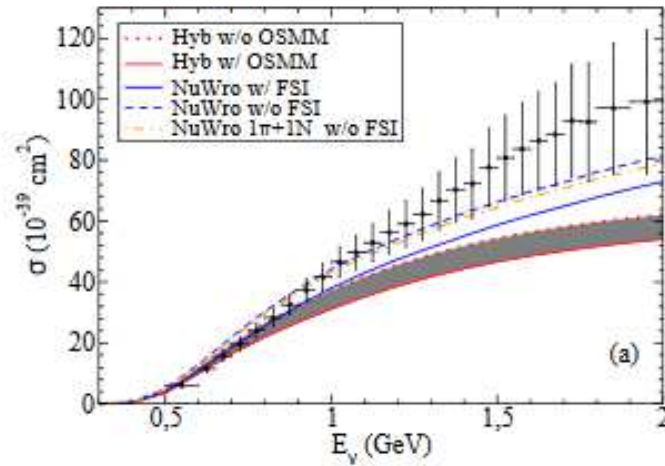# IV. Hybrid RPWIA model – results

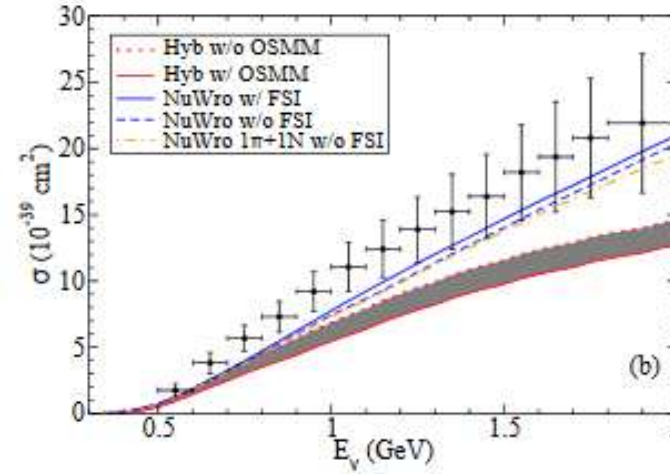

MiniBooNE νCC $1\pi^+$

MINERvA νCC $1\pi^+$
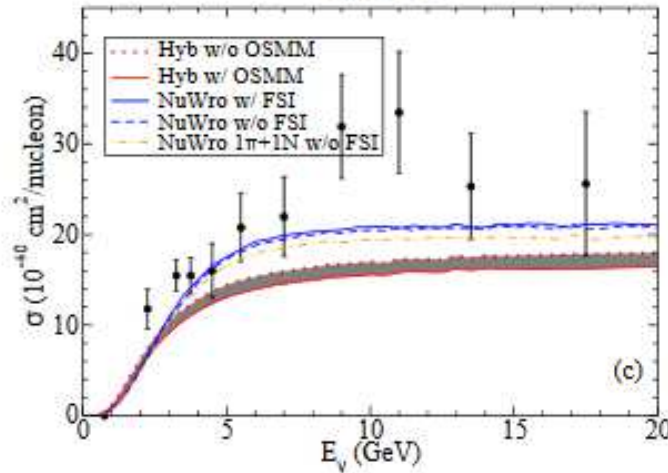
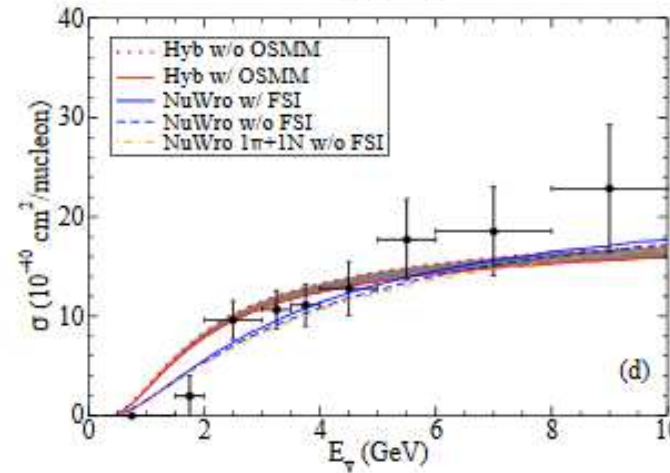# IV. Hybrid RPWIA model – results

MiniBooNE νCC $1\pi^+$

MiniBooNE νCC $1\pi^0$

MINERvA νCC $1\pi^0$

MINERvA $\bar{\nu}$CC $1\pi^0$

Summary

- Detailed microscopic cross sections calculations for neutrino-induced pion production
- Formalism valid over a broad energy range
- Taking into account as many nuclear physics aspects as feasible
- Estimate effect of FSI in comparing with NuWro