CEA/Saclay experiment-theory collaborations

- Implementation of **Martini model in the MC**
- Study of **SuSa v2 model**
- Collaboration with in-house electron scattering experts to use **form factors from pion electro-production data** in neutrino scattering

Martini model in MC

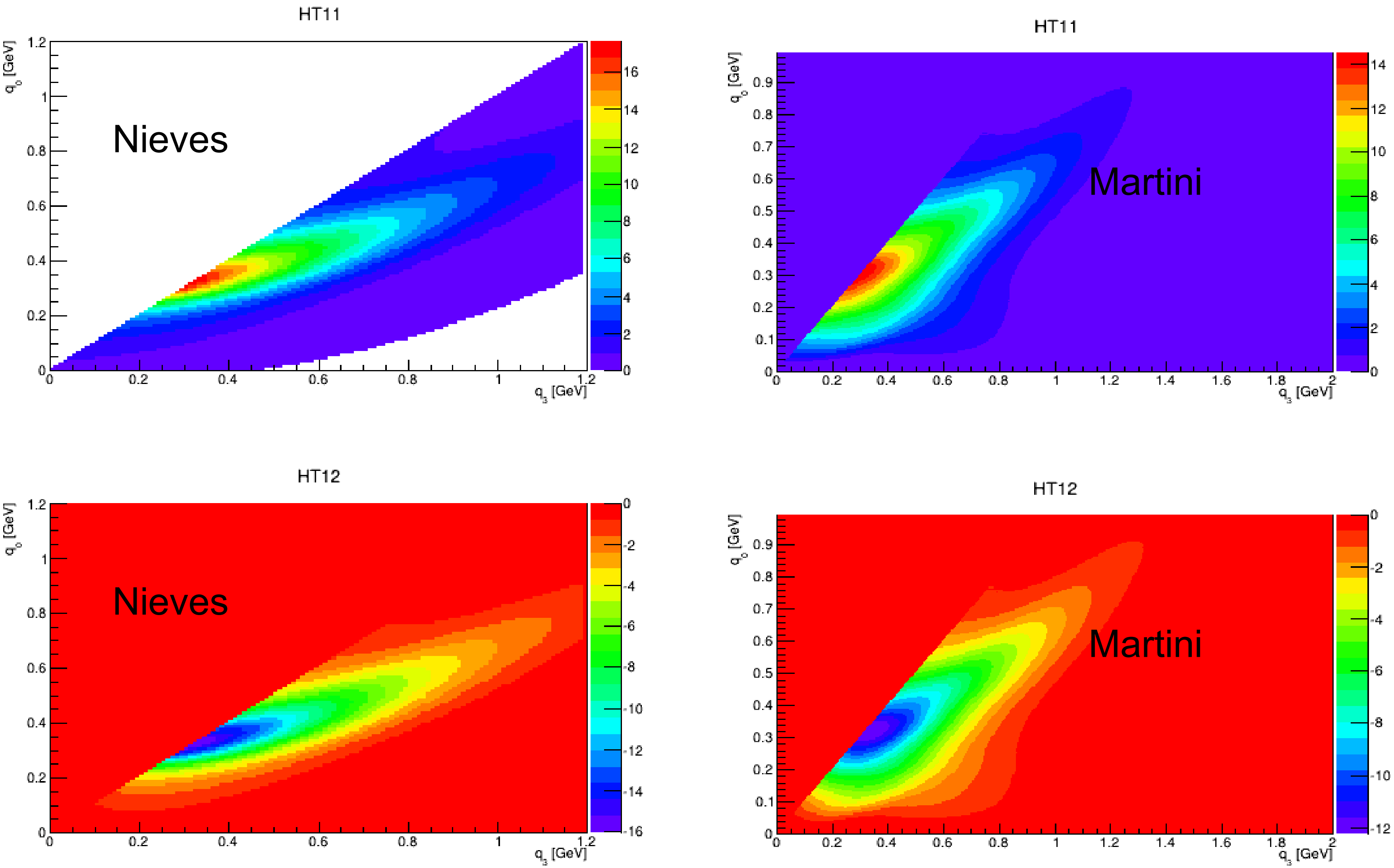
Implementation of Martini 2p2h model in GENIE (and then NEUT and possibly NuWro) using **Hadron Tensor machinery**

- HT code already implemented in GENIE for Nieves model
- HT from Martini code
- Need to adapt the numerical factors and the HT format

$$\frac{d^2\sigma}{dcos\,\theta\, d\,\omega} = F\,\frac{k'}{k_0}\,|L_{\mu\nu}^{Martini} H^{\mu\nu}|$$

$$\frac{d^2\sigma}{dcos\,\theta\, dT_\mu} = G\,k'\,k_0'\,|L_{\mu\nu}^{Nieves} H^{\mu\nu}|$$

Hadron tensors (ΔΔ)



SuSa v2

G.Megias 6-12 months stay at CEA (from next week) and M.Barbaro ~3months stay in 2018

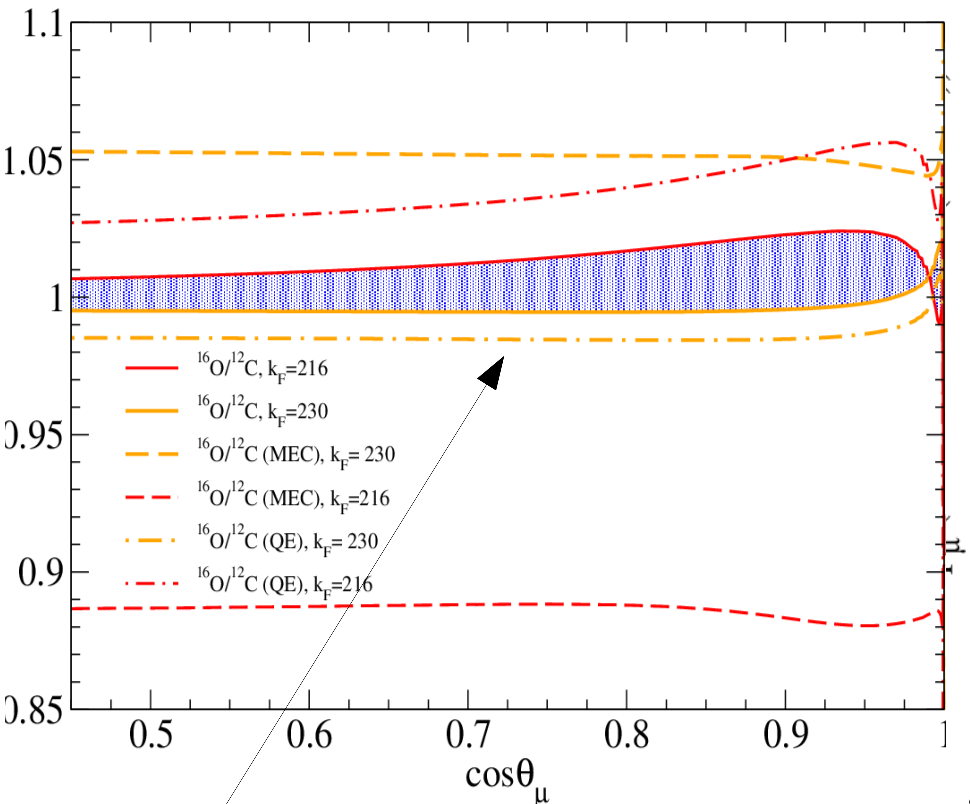
- Use Susav2 model to have a better estimate of C → O extrapolation uncertainty for QE and 2p2h (for T2K and T2HK)

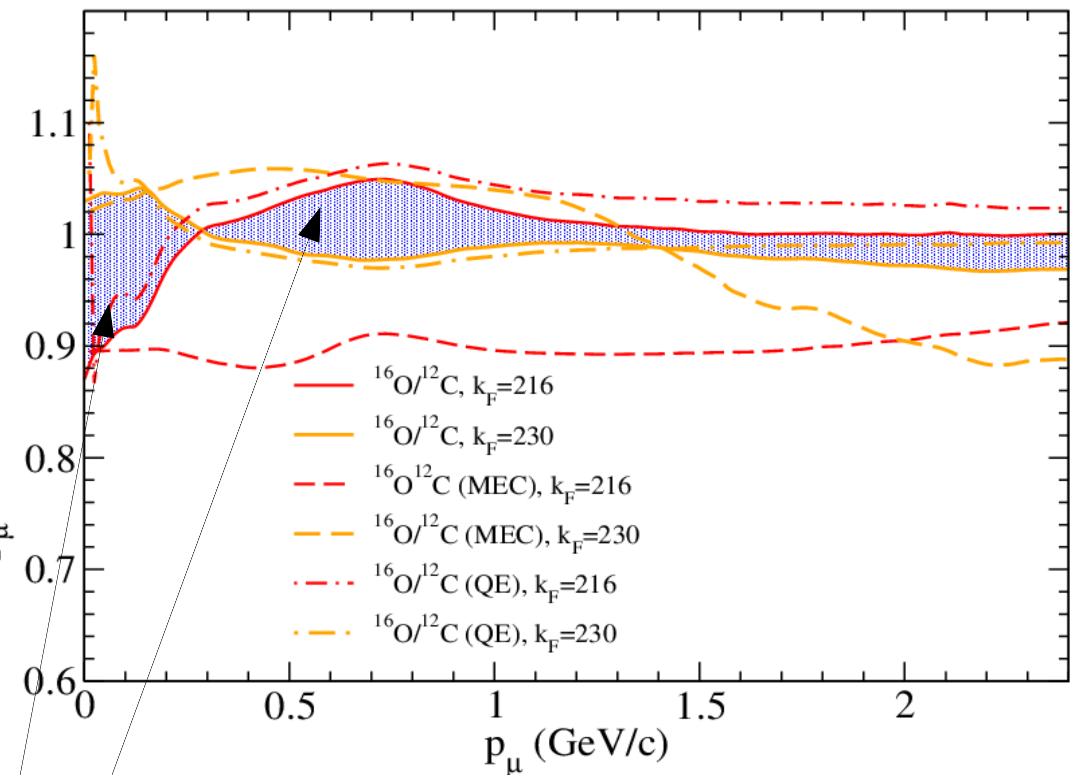
  → important **input for the design of the ND280 upgrade**

- Look into outgoing proton kinematics in QE with Relativistic Mean Field approach and in 2p2h

- And implement in MC (if not already done)

C/O





- 2p2h and CCQE have opposite C/O behavior! ← 2p2h ~ $A^*p_F^2$, CCQE ~ A/p_F
  Some cancellation: C/O difference 5% goes down to ~1-2%

- Most of the effect in the very low muon momentum region (very difficult to measure muons in water at ~100MeV)

- A large effect also at p_μ~600 GeV but this is due to change in 2p2h/CCQE ratio → quite model dependent effect...

Form factors

"2 components model" of the nucleus: intrinsic structure (qqq) + meson cloud (qqbar)

$$G_A(Q^2) = G_A(0)\, g(Q^2) \left[1 - \alpha + \alpha \frac{m_A^2}{m_A^2 + Q^2}\right]$$

→ motivated by meson cloud: m_A= 1.23 GeV mass of lowest axial meson a1(1260)

$$g(Q^2) = \left(1 + \gamma Q^2\right)^{-2} ,$$

→ coupling to 3 valence quarks: γ taken from previous studies of electromagnetic form factors

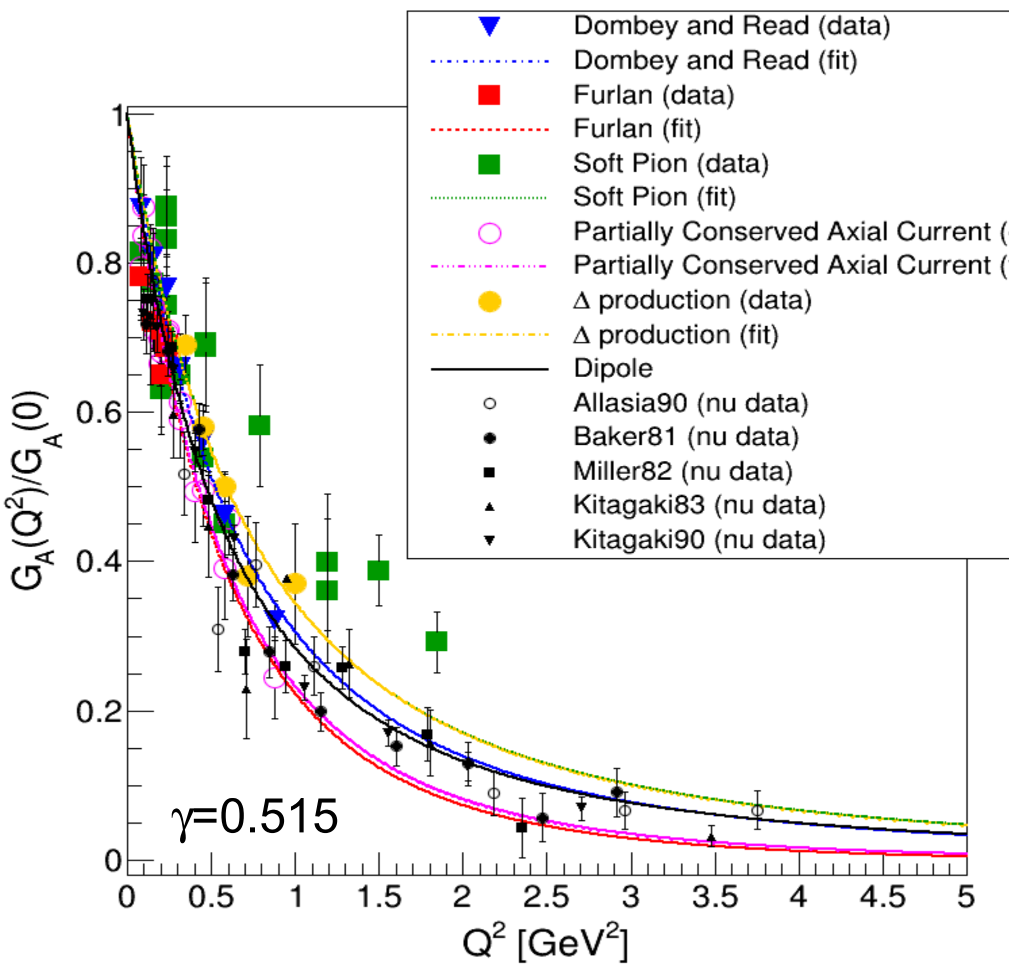
1 free parameter: α (+ γ to play with)

Same set of pion electro-production data interpreted in different models → 5 different fits

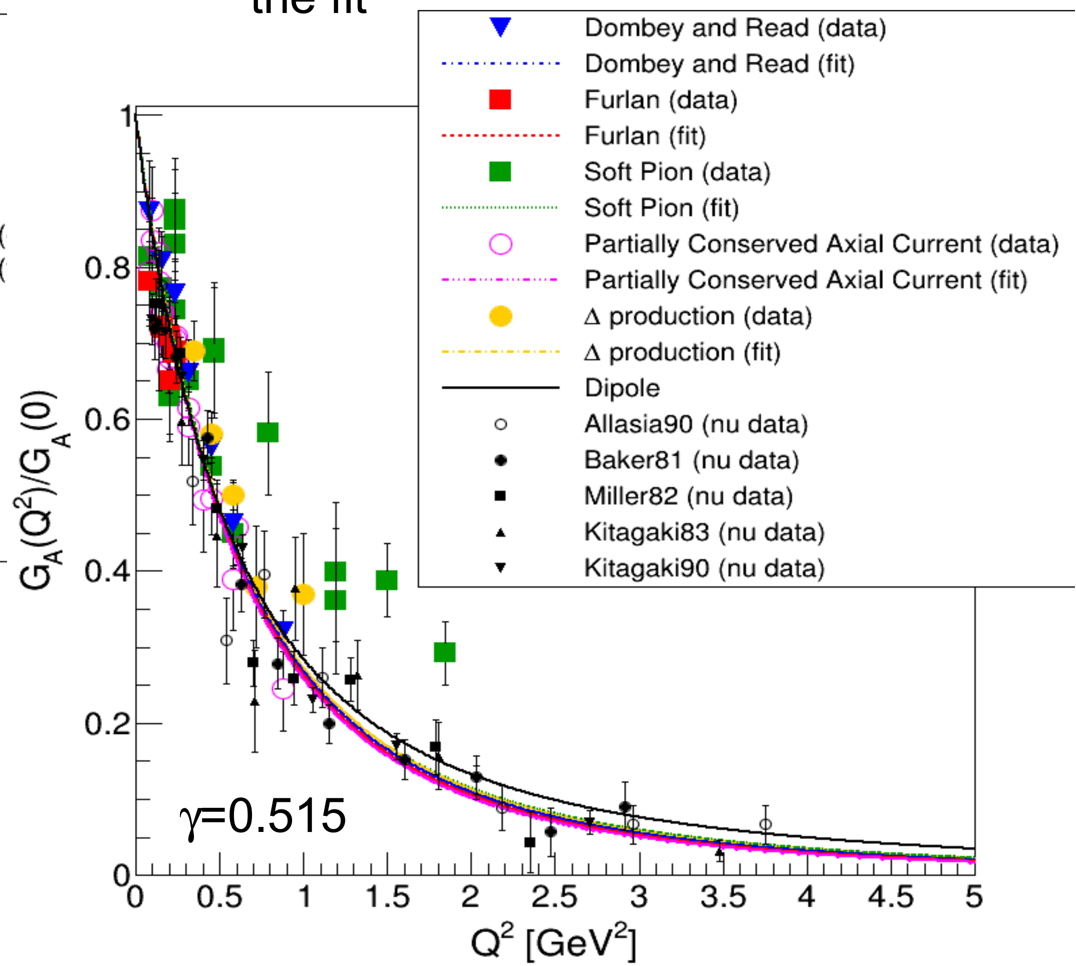
- Soft Pion approximation
- Partially Conserved Axial Current approximation
- Furlan approximation
- Dombey and Read approximation
- data corresponding to Δ excitation analysed separately

Including neutrino data

Comparing to neutrino data



Including neutrino data in the fit

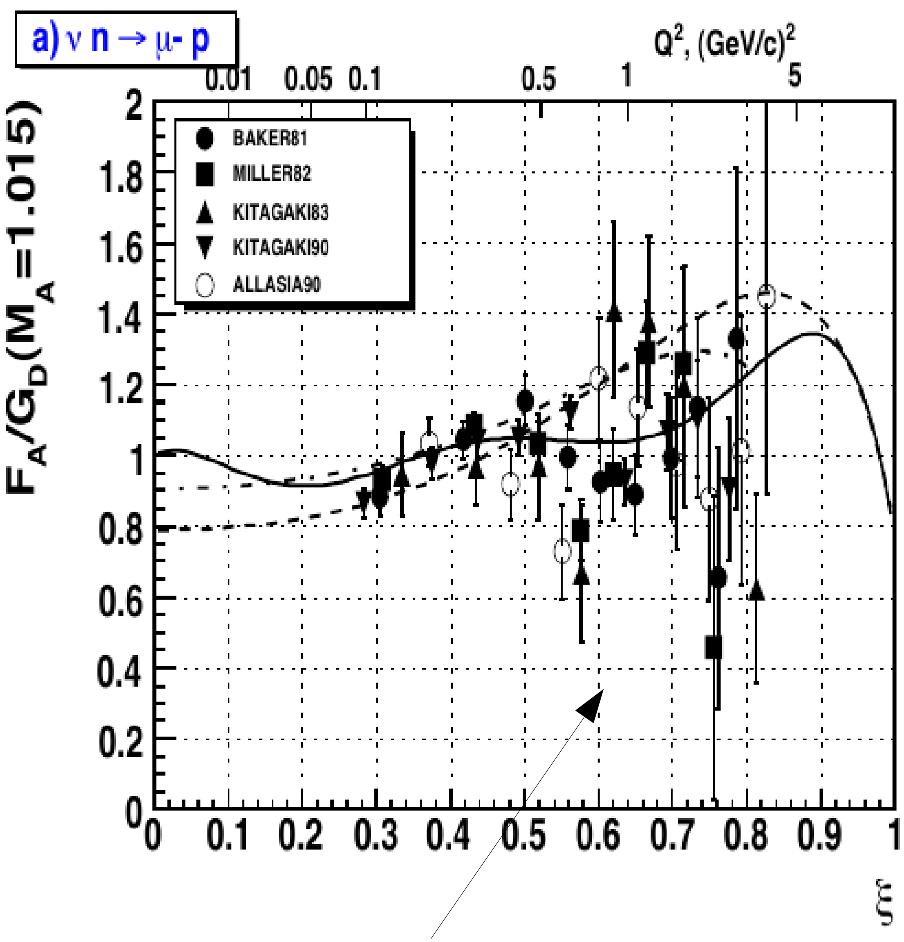


Uncertainty from comparison between these different fits

BACKUP

Neutrino data

Neutrino data from Bodek publication (arXiv:0708.1946): tabulated data from following Figure



NB: I multiplied these data by dipole with M_A=1.014 GeV (as for Bodek text)

He use: g_A=-1.267, how this compare with gA for pion electro-production data?

Baker81

N.J. Bakeret al., Phys. Rev. D23 (1981)

BNL: 1138 QE events $\nu_\mu n \rightarrow \mu^- p$ wideband <En>=1.6GeV

Miller82

K.L. Miller et al., Phys.Rev. D26 (1982) 537

ANL: 1737 QE events $\nu_\mu d \rightarrow \mu^- p p_s$

Kitagaki83

T. Kitagaki et al., Phys. Rev. D28 (1983) 436

FNAL: $\nu_\mu n \rightarrow \mu^- \Lambda\ \pi^+/K^+$

(is F_A the same when strangeness production?)

Kitagaki90

T. Kitagaki et al., Phys. Rev. D42 (1990) 1331

BNL: 2538 QE events μ^- p + 1384 Δ^{++} events (does superimpose with Baker81 sample?)

Allasia90

D. Allasia et al., Nucl. Phys. B343 (1990) 285

WA25: QE events μ^- p + single and double p production (ν and $\bar{\nu}$)