Recent results in the SuSA+MEC model

Maria Barbaro
Dipartimento di Fisica and INFN, Torino, Italy

NuSTEC Meeting, November 17, 2017

Collaboration

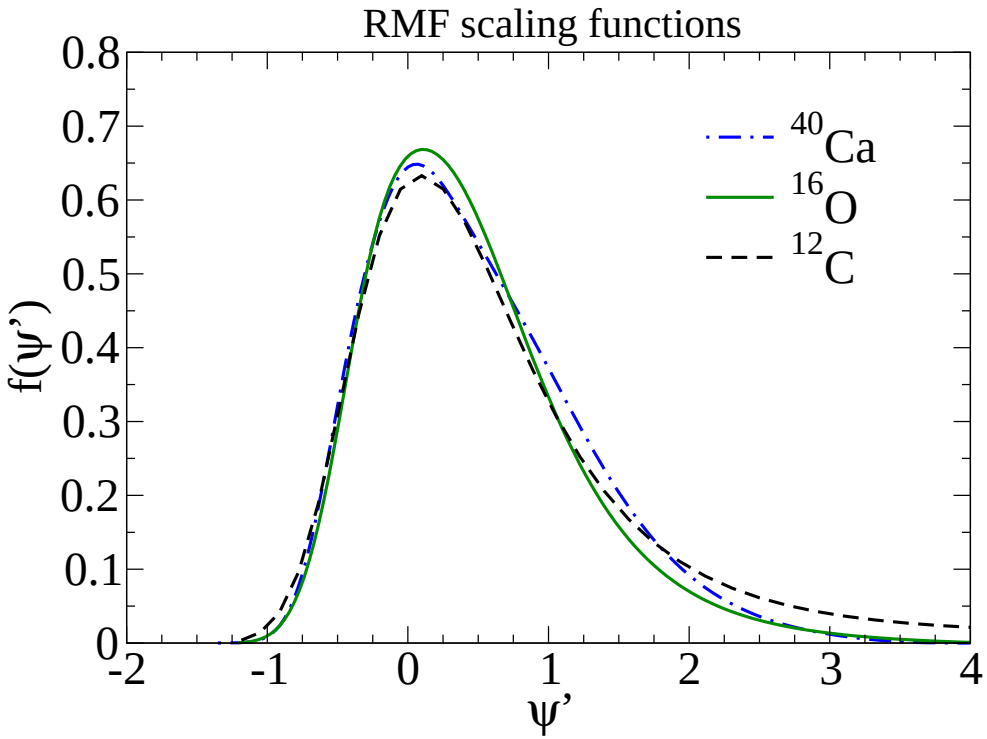
J.E. Amaro, MBB, J.A. Caballero, A. De Pace, T.W. Donnelly, G.D. Megias, I. Ruiz Simo, J.W. Van Orden

Recent work

1. **Extension of the SuSAv2-MEC model to different nuclei**
   - We have studied the density dependence of the 2p-2h MEC response in our model, based on RFG. We have found that the 2-body response scales differently from the 1-body response.
   - We have extended the SuSAv2-MEC calculation from carbon to oxygen target and validated it by comparing with all available (e,e') data on these two nuclei. Then we have compared with recent T2K CC0π data on oxygen.
     This project has greatly benefitted from frequent interactions with T2K experimentalists.
2. **Improving the efficiency of the 2p2h calculation**
   - We have explored approximate numerical methods to speed up the calculation of the 2p2h response functions, which at present is performed exacty and involves a 7-dim numerical integral for each value of ω and q.
     This project is mainly motivated by possible implementation of the model in MC generators.

SuSAv2 for different nuclei

- The basic ingredients of the SuSAv2 approach are scaling functions, which embody the nuclear dynamics, evaluated within the Relativistic Mean Field model with and without FSI (RPWIA)

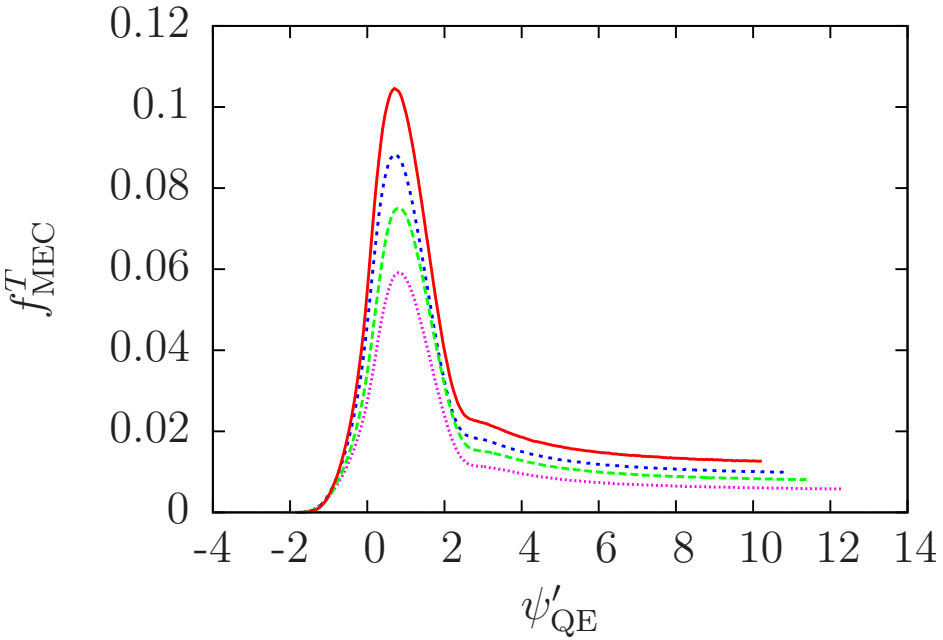


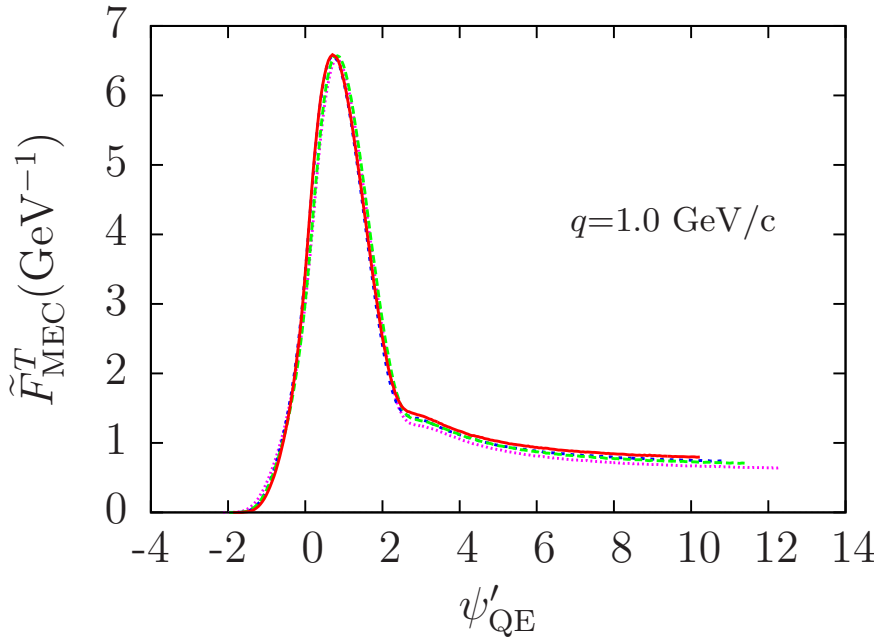
- Mild dependence of the 1-body scaling function upon A: the QE response scales as $1/k_F$ (second kind scaling)

The 2p2h scaling function for different nuclei: ^{4}He, ^{12}C, ^{16}O, ^{40}Ca

The 2-body response violates scaling of second kind

Amaro et al., PRC95 (2017), 065502



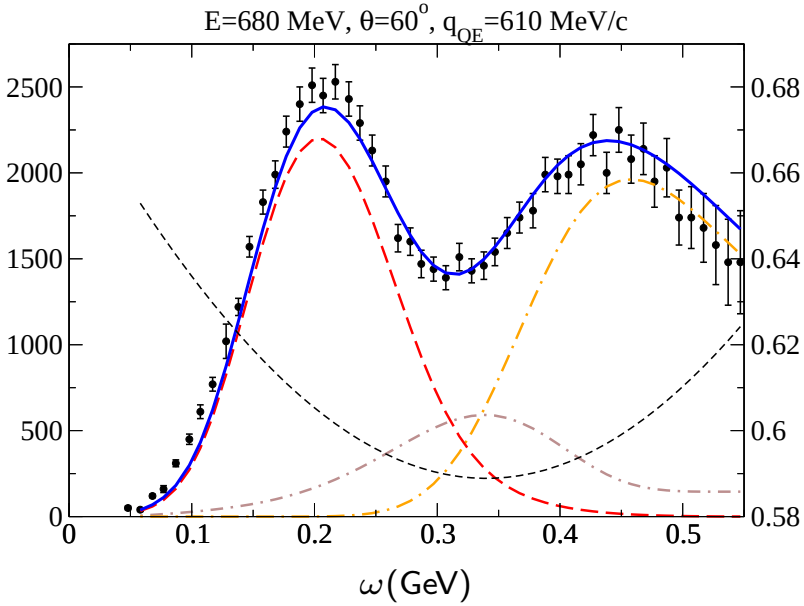


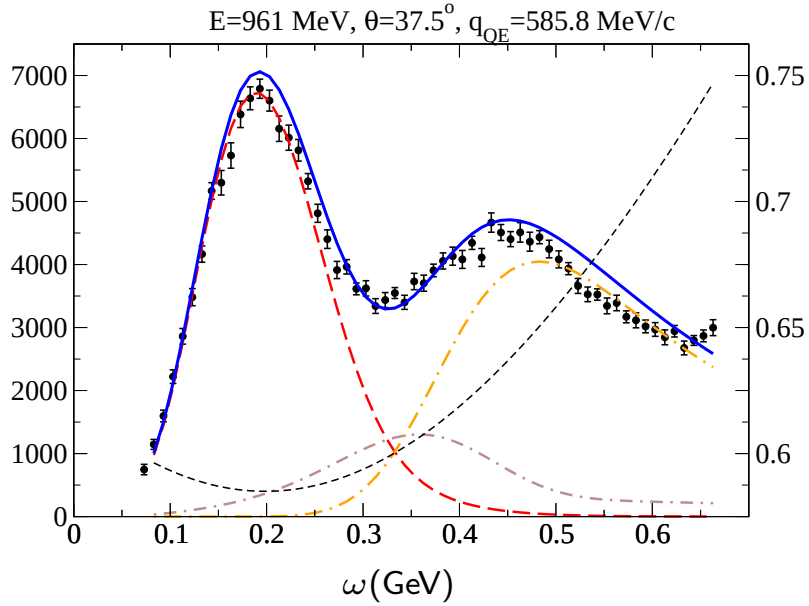
$$f^T_{\rm MEC} \sim k_F \times R^T_{\rm MEC}$$

$$\widetilde{F}^T_{\rm MEC} \sim R^T_{\rm MEC}/k_F^2$$

Validation: electron scattering data on Carbon

More comparisons in Megias *et al.*, PRD 94, 013012 (2016)



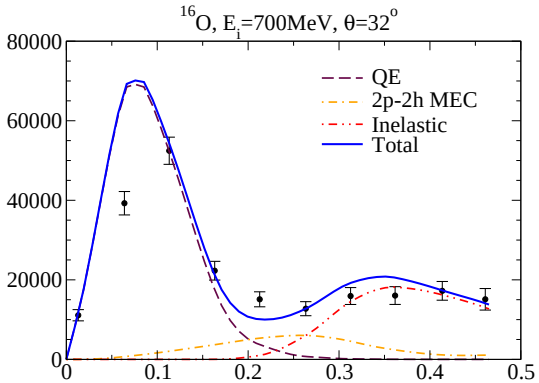


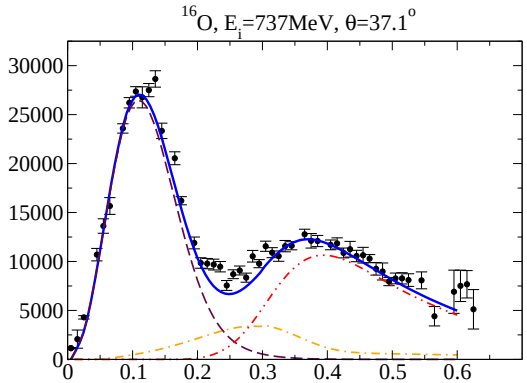
e-C data from Day *et al.*, http://faculty.virginia.edu/qes-archive/

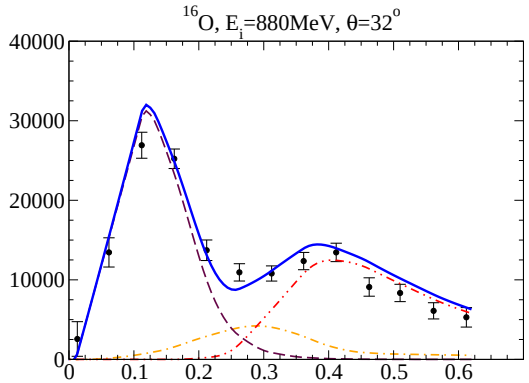
e-Oxygen

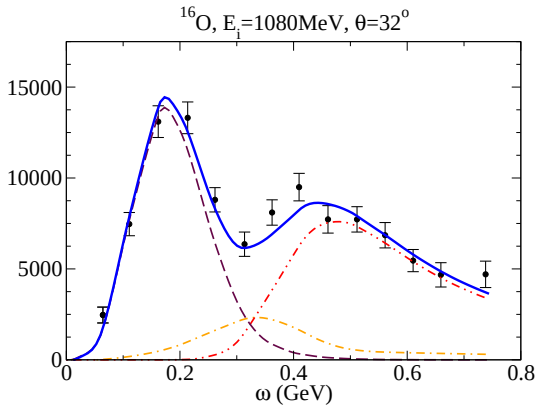
Validation: electron scattering data on Oxygen (few data)

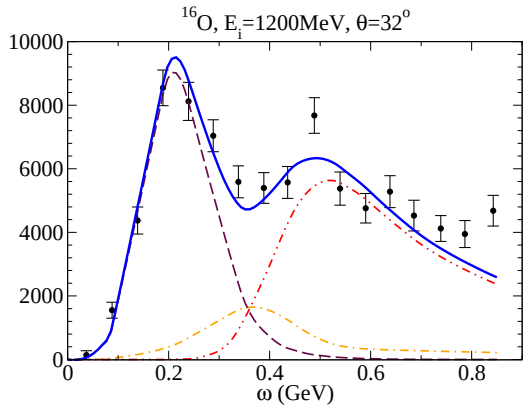
Megias *et al.*, e-Print: arXiv:1711.00771

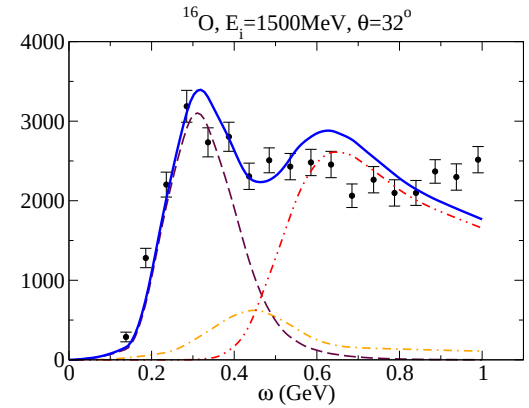






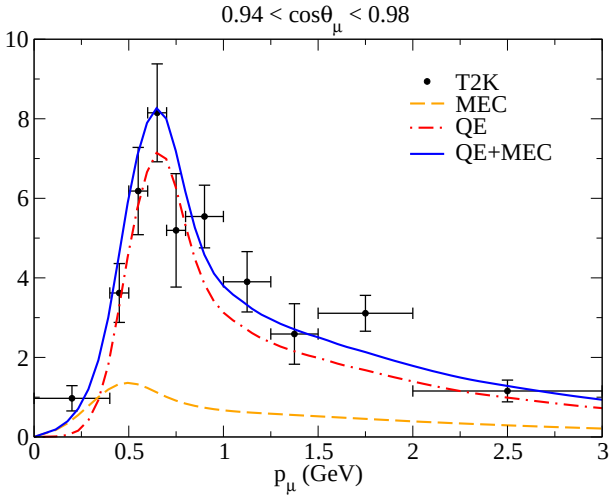




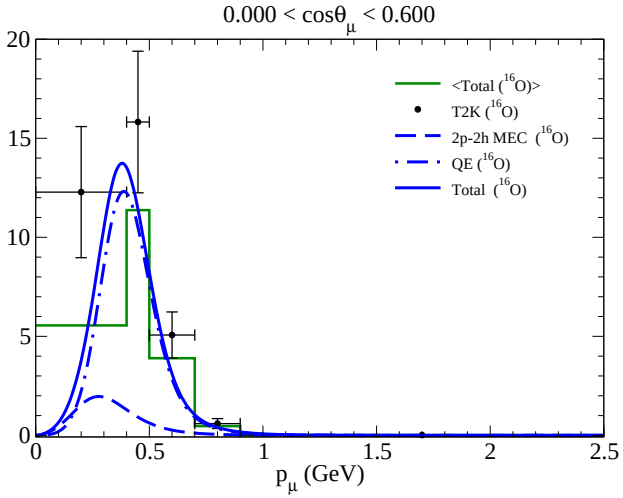


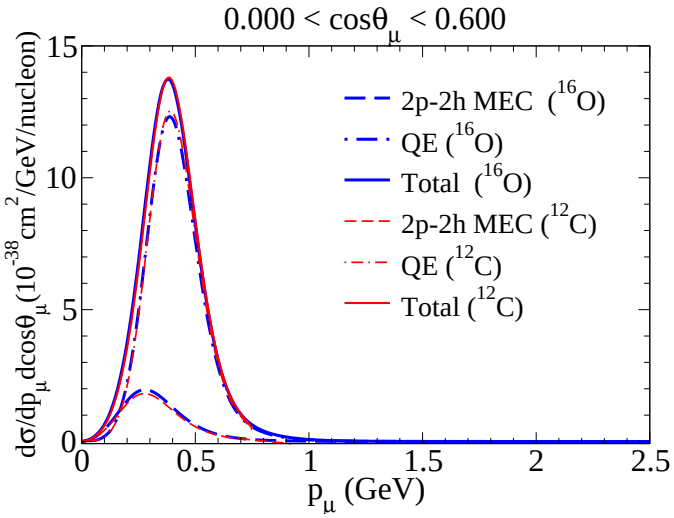
Comparison with T2K CC0π data on carbon and water

ν_μ-C



ν_μ-O



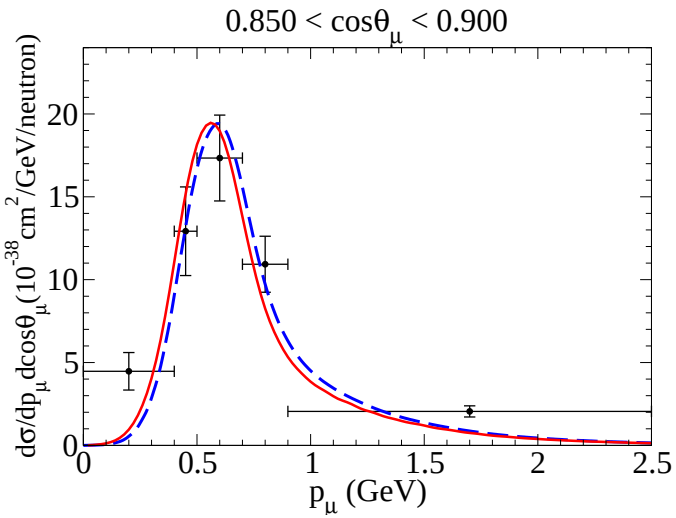


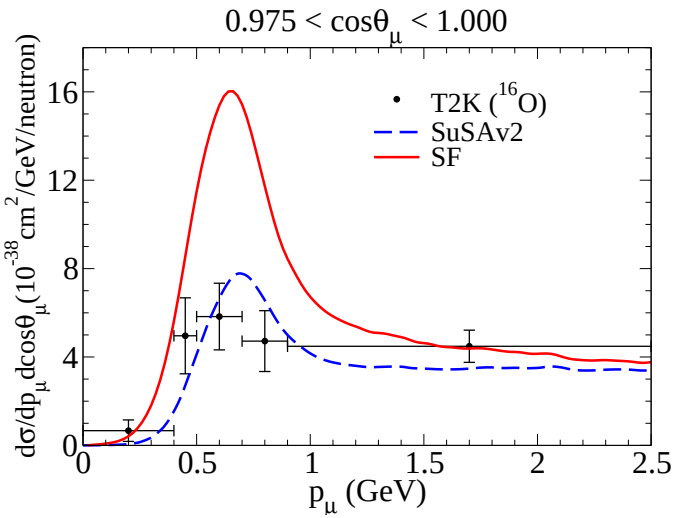
Good agreement with data

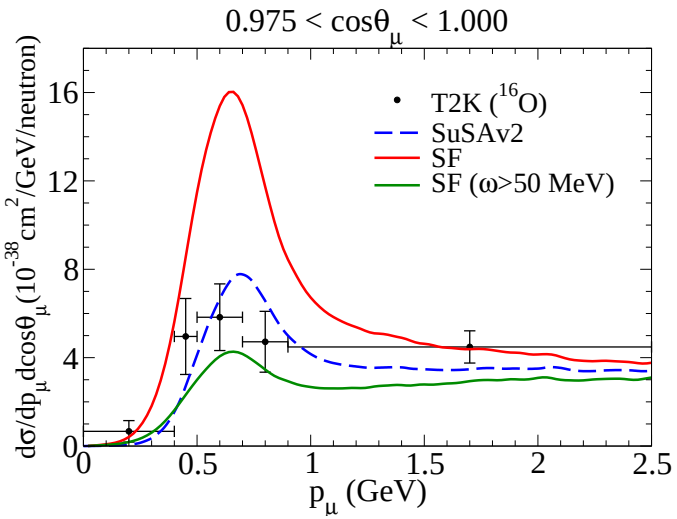
Very similar results for the two nuclei

Megias *et al.*, e-Print: arXiv:1711.00771

Comparison of QE SuSAv2 with the Spectral Function PWIA approximation







Oxygen SF from O. Benhar

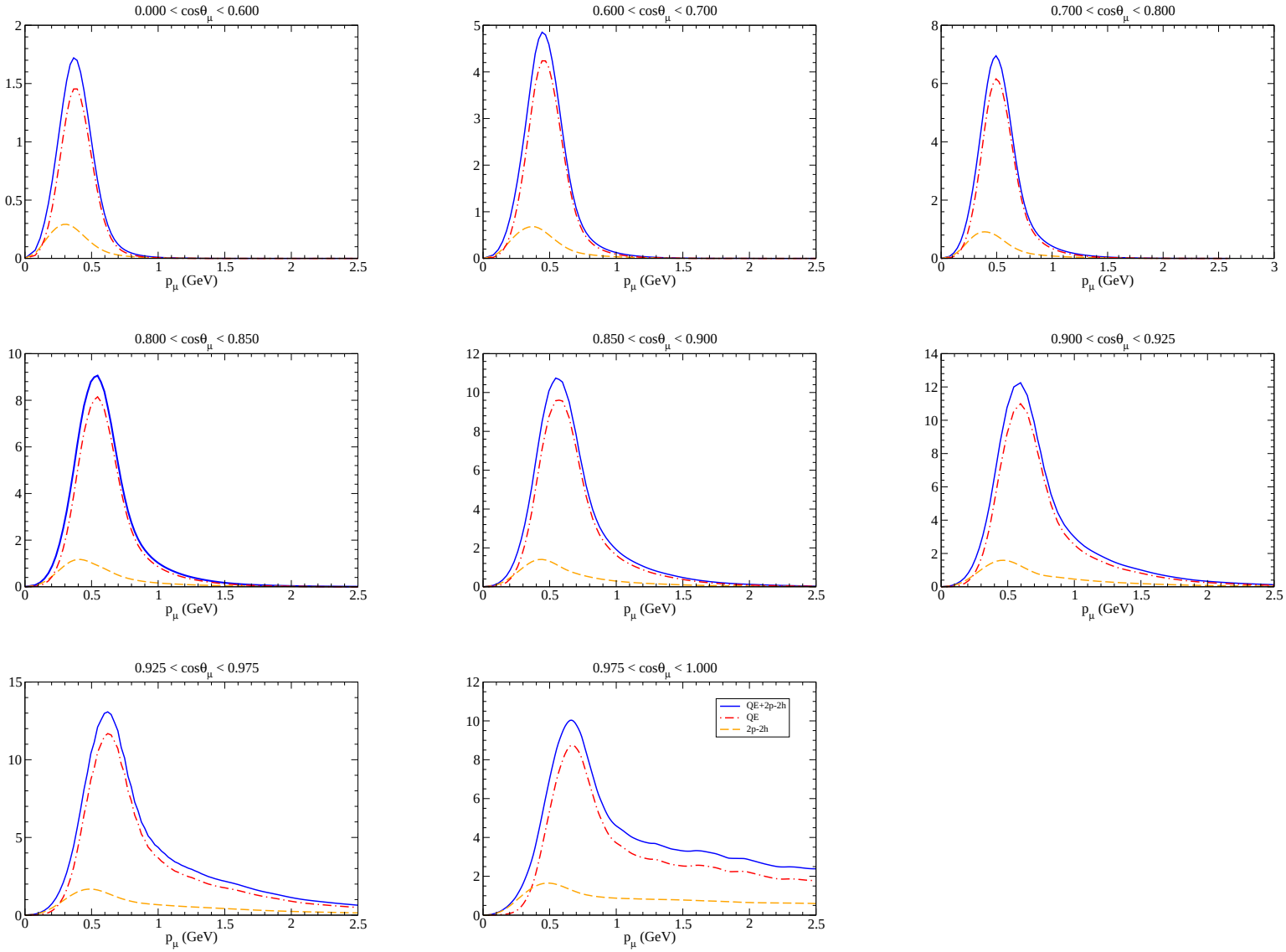
SuSAv2 and SF + PWIA give similar results at $\cos\theta < 0.9$

Large differences at forward angles, where SF+PWIA overestimates the data

Low energy transfers dominate at small angles

[Megias *et al.*, e-Print: arXiv:1711.00771]

T2K CC0π $\bar{\nu}_\mu$-O predictions in the SuSAv2-MEC model



[Megias *et al.*, e-Print: arXiv:1711.00771]

Summary and future work

- The SuSA-MEC model has been validated against electron scattering inclusive (e,e') data and successfully compared with neutrino CCQE-like data on C and O.
- MEC 2p2h excitations give sizeable contributions to ν-A cross sections in the GeV region. They violate scaling of both kinds: numerical studies show that the ratio 2body/1body roughly scales as k_F^3.
- Work in progress: extension to asymmetric nuclei (N$\neq$Z), inclusive neutrino scattering including all inelasticities.
- Inclusive data are reproduced equally well by very different models: need to test models in more exclusive channels?

References

- **Neutrino-Oxygen CC0π scattering in the SuSAv2-MEC model,**
  G.D. Megias *et al.*, e-Print: arXiv:1711.00771

- **Density dependence of 2p-2h meson-exchange currents,**
  J.E. Amaro *et al.*, Phys.Rev. C95 (2017) no.6, 065502

- **The frozen nucleon approximation in two-particle two-hole response functions,**
  I. Ruiz Simo *et al.*, Phys.Lett. B770 (2017) 193-199

- **Two-nucleon emission in neutrino and electron scattering from nuclei: the modified convolution approximation,**
  I. Ruiz Simo *et al.*, e-Print: arXiv:1706.06377