Modeling Neutrino-Nucleus Interactions
Do we need a new paradigm ?

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The *paradigm*[*] of electron-nucleus scattering

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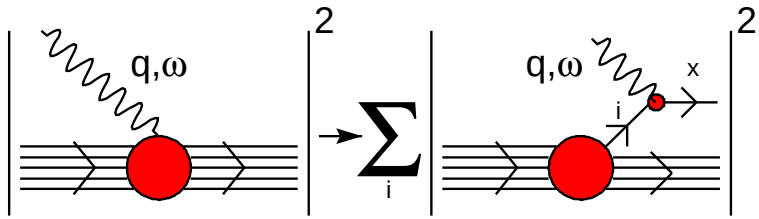
- The impulse approximation (IA) scheme:



$$d\sigma_A = \int d^3k dE \; d\sigma_N \; P(\mathbf{k}, E)$$

the spectral function $P(\mathbf{k}, E)$ (from nuclear many-body theory) describes the energy and momentum distribution of the struck nucleon

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Quasi elastic (QE) electron- & neutrino-nucleus x-sections

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- The data set of MiniBooNE CCQE events provides an unprecedented opportunity to perform a similar analysis and carry out a systematic study of the (flux averaged) double differential cross section

$$\frac{d\sigma_A}{dT_\mu d\cos\theta_\mu} = \frac{1}{N}\int dE_\nu \Phi(E_\nu) \frac{d\sigma_A}{dE_\nu dT_\mu d\cos\theta_\mu}$$

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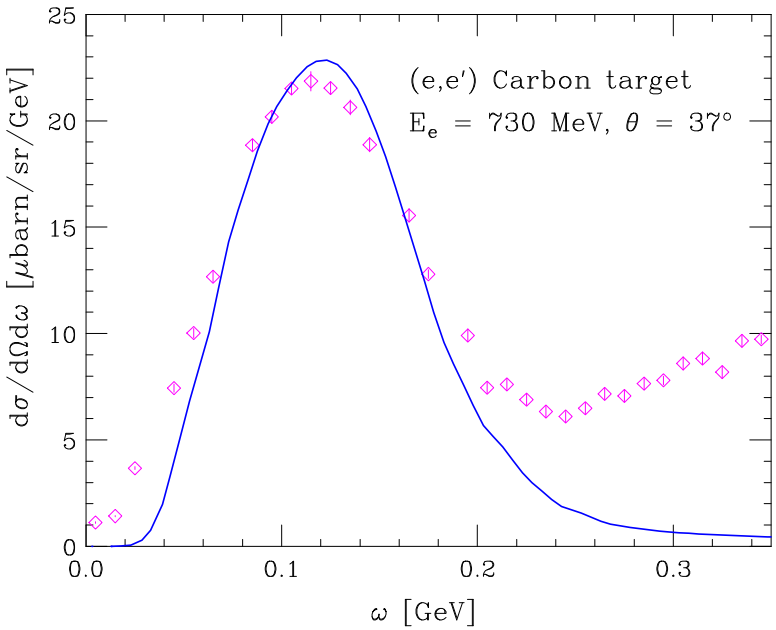
- Extending the paradigm of electron scattering to the analysis of the CCQE neutrino data amounts to using the nucleon axial mass $M_A = 1.03$ GeV, determined by deuteron data

Quasi elastic (QE) electron- & neutrino-nucleus x-sections

- Recall: Calculations involve *no adjustable parameters*

▷ Data: J.S. O'Connell *et al*, PRC **35**, 1063 (1987)



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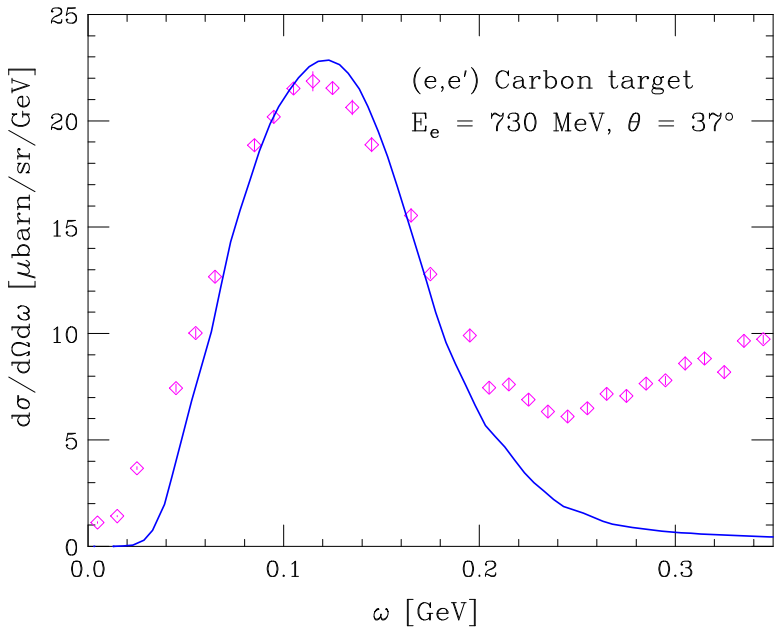

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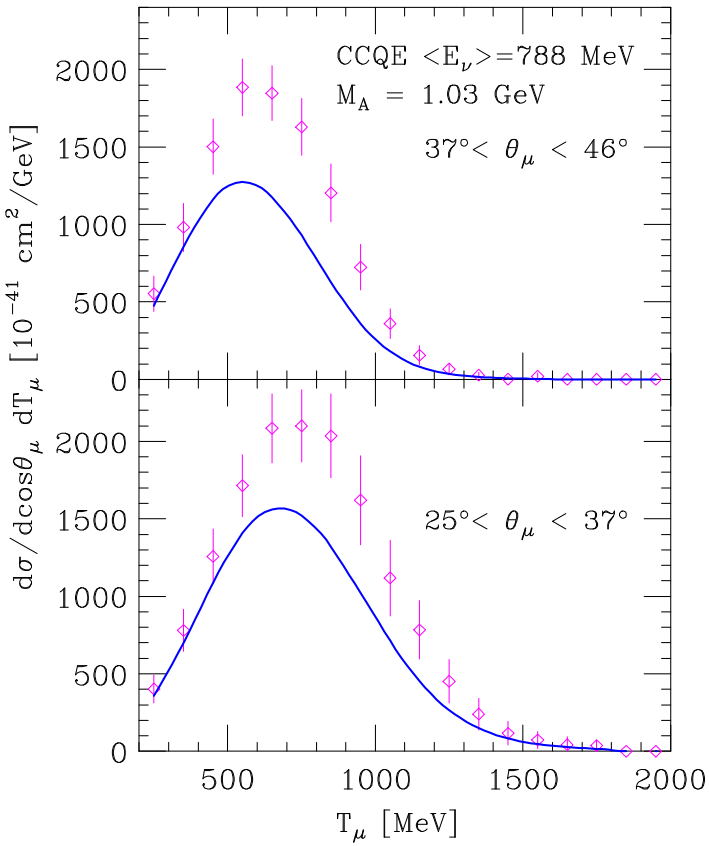

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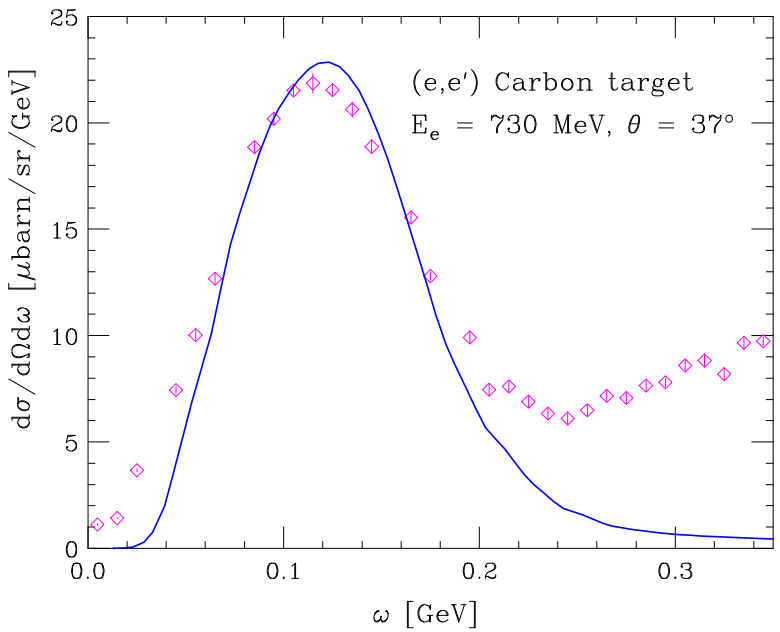

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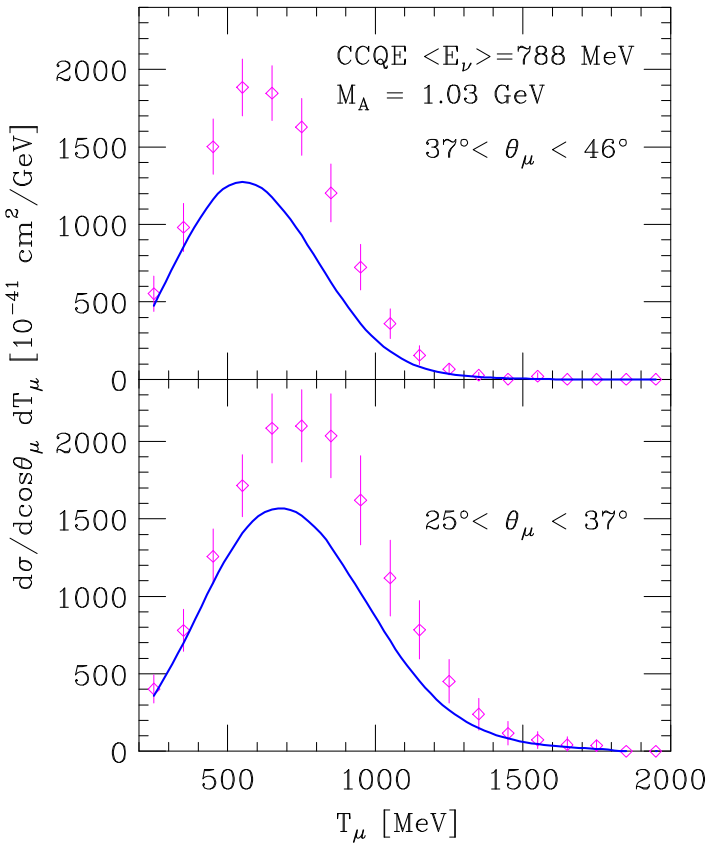

- The paradigm of electron scattering appears to badly fail !

The axial mass issue

- The analyses of the CCQE data collected by K2K and MiniBooNE using a carbon target yield a value of the axial mass significantly larger than the world average. The MiniBooNE collaboration recently reported the value $M_A = 1.35$ GeV

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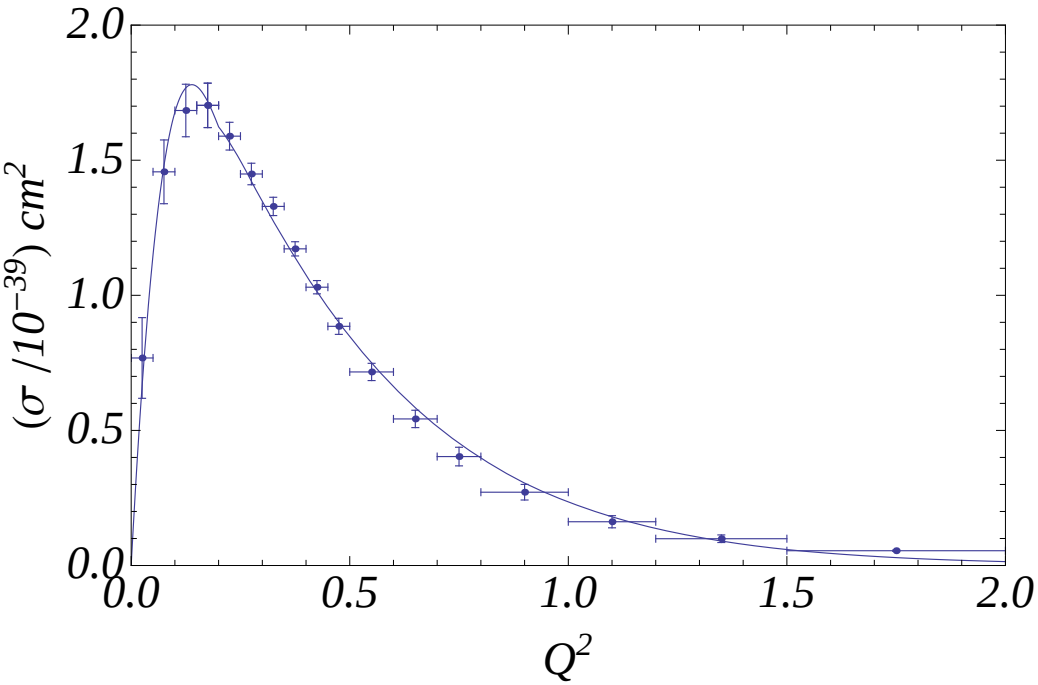
- Using more advanced nuclear models may in fact lead to predict a value of M_A even larger than the one resulting from the MiniBooNE analysys

Determining M_A from a χ^2-fit of the Q^2-distribution

- The resulting axial mass is $M_A = 1.6$

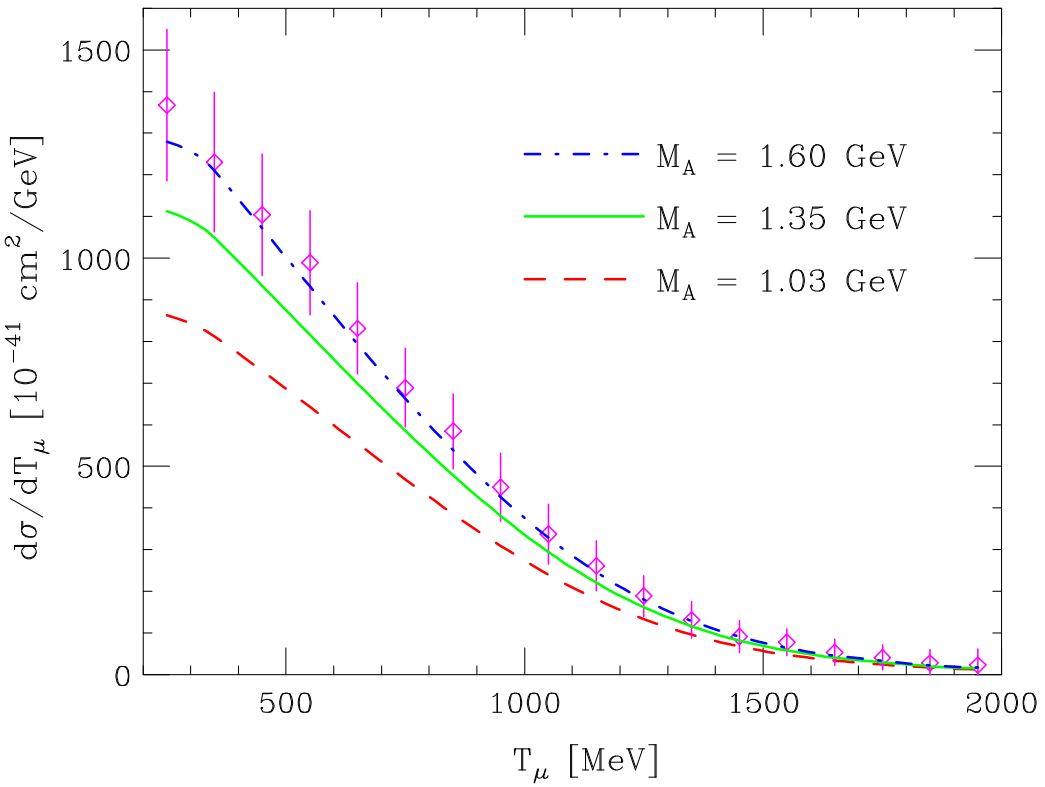


- Warning: the Q^2-distribution is biased by the approximations needed to reconstruct the neutrino energy

$$Q^2 = 2E_\nu E_\mu \left(1 - \frac{p_\mu}{E_\mu}\cos\theta_\mu\right) - m_\mu^2$$

M_A- dependence of the flux-integrated T_μ spectrum

$$\frac{d\sigma_A}{dT_\mu} = \int d\cos\theta_\mu \frac{d\sigma_A}{dT_\mu d\cos\theta_\mu}$$



M_A-dependence of the flux-integrated $\cos\theta_\mu$ distribution

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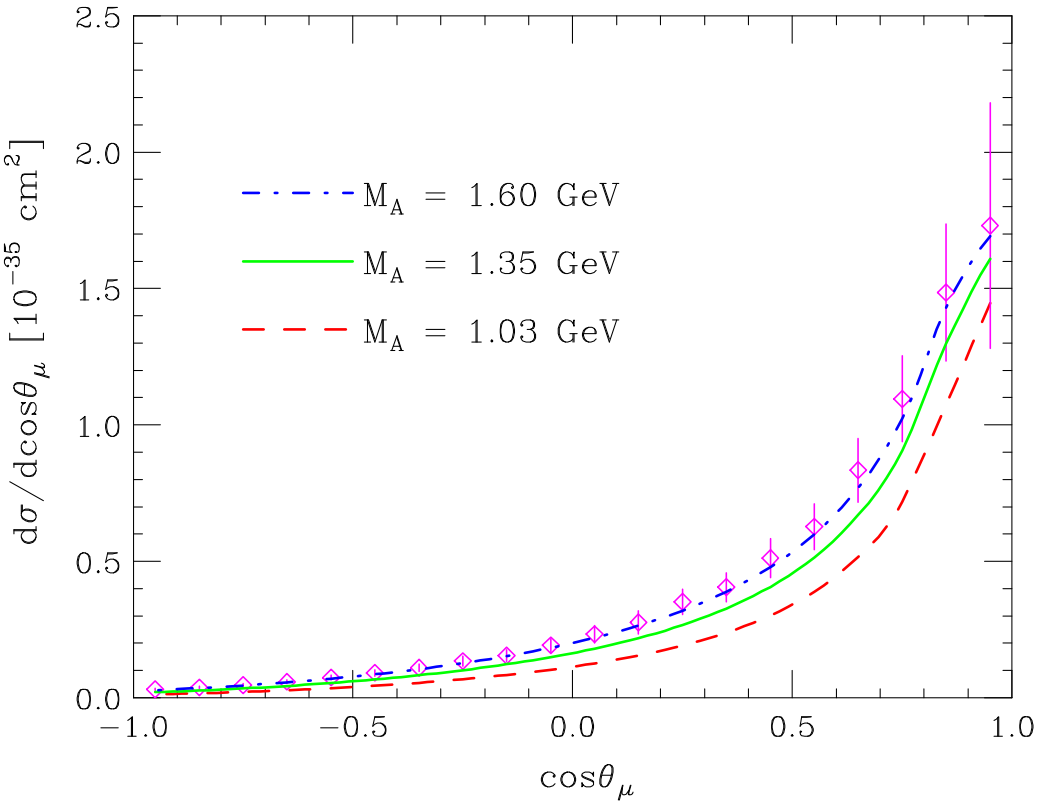
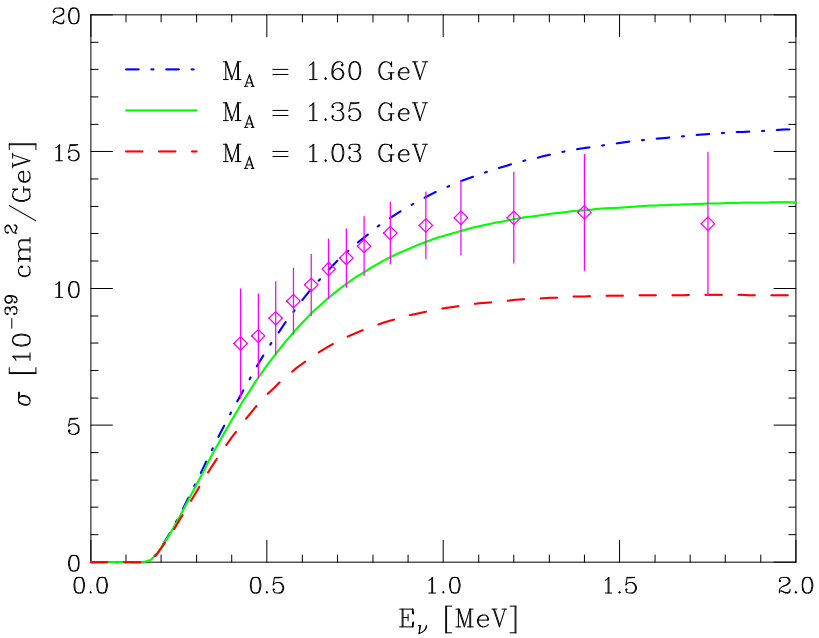


Flux-unfolded total x-section



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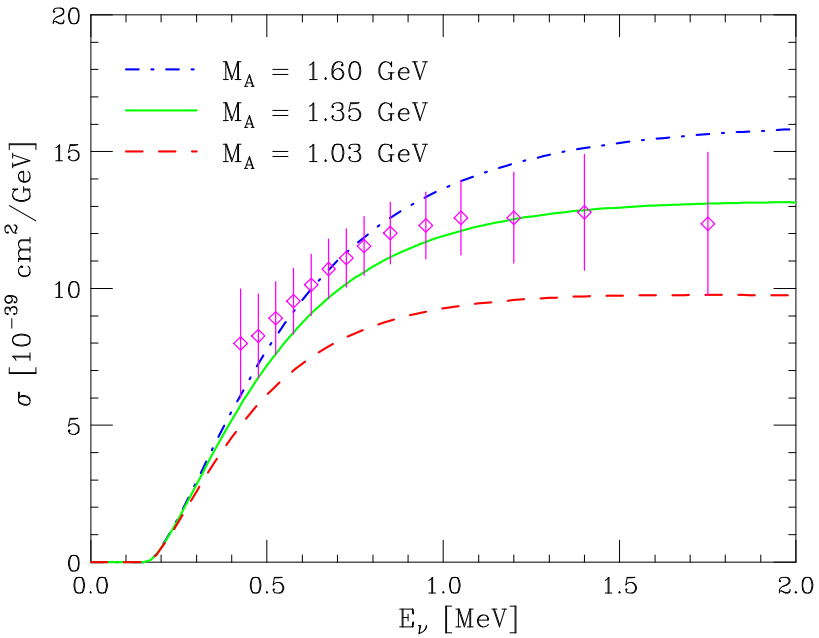

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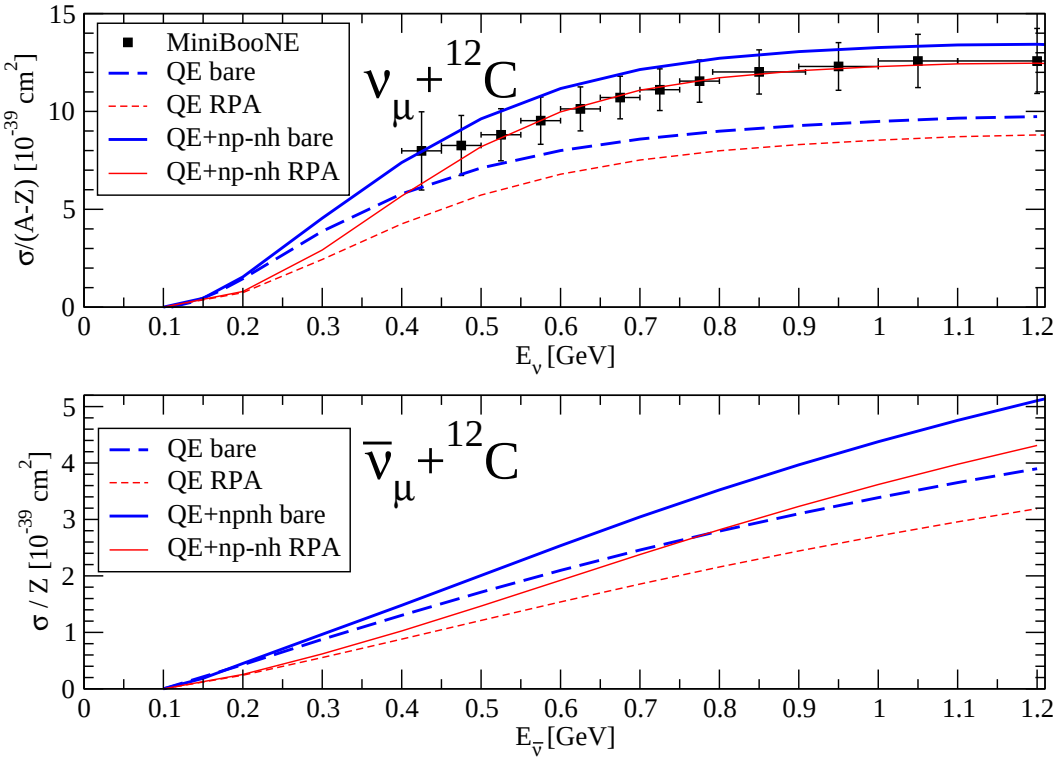

- Martini *et al* (2010), $M_A = 1.03$ GeV

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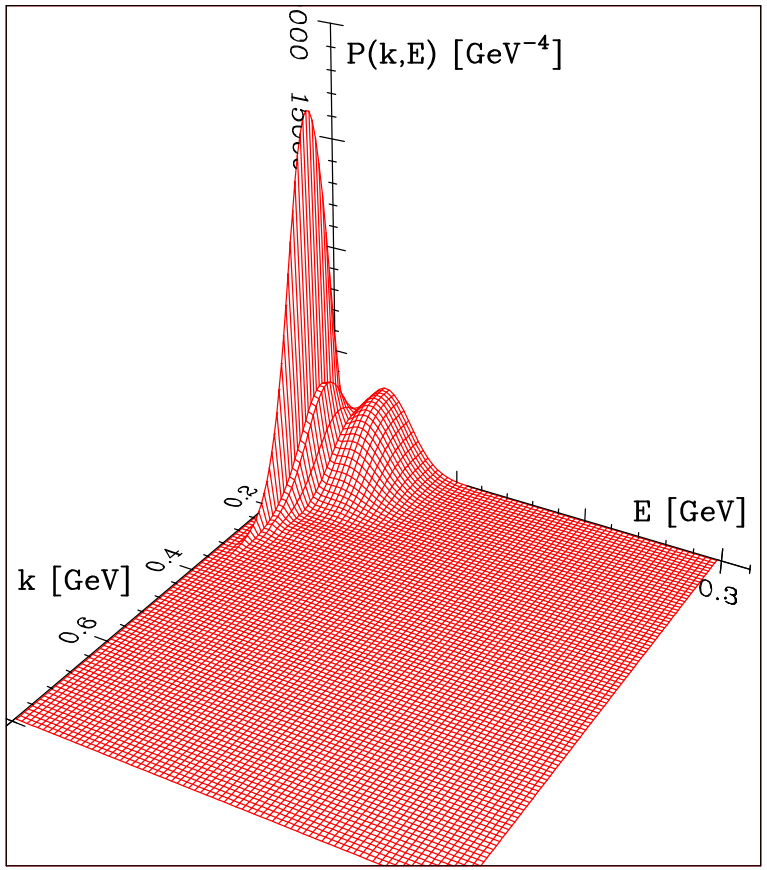
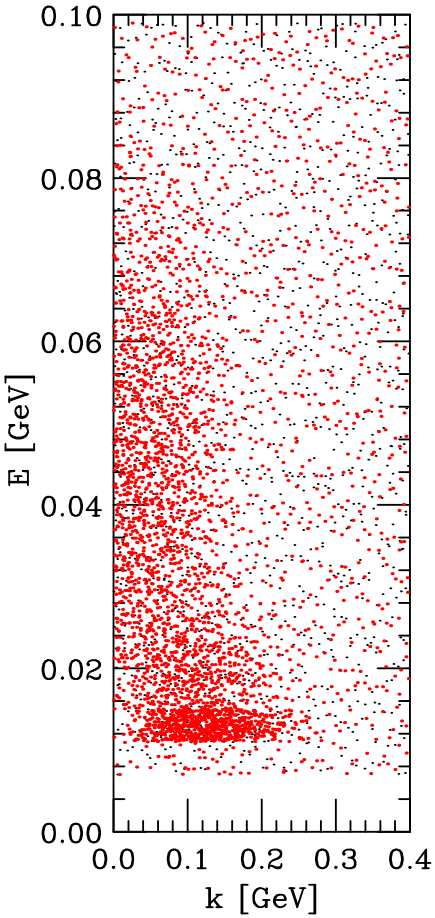
- In order to clarify the role of nuclear dynamics beyond the 1p-1h sector, the results of the model of Martini et al should be thoroughly tested comparing its predictions to electron scattering data

Oxygen spectral function





- shell model states account for ~ 80% of the strenght
- the remaining ~ 20%, lies in the region of high momentum *and* large removal energy

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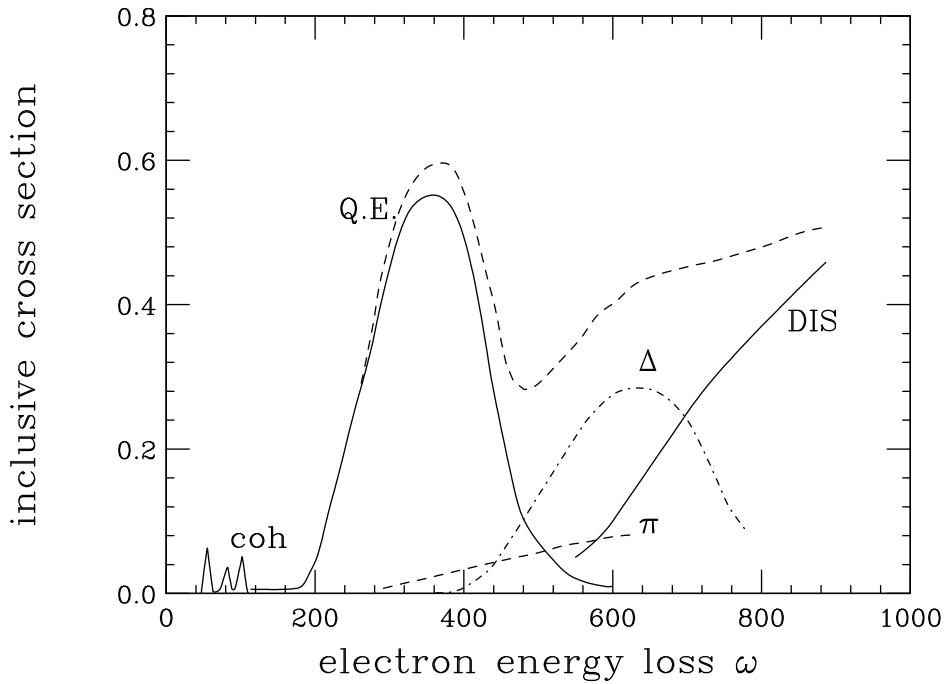
- Schematic view of the electron-nucleus cross section at beam energy in the few GeV region



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