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From electron scattering to neutrino interactions

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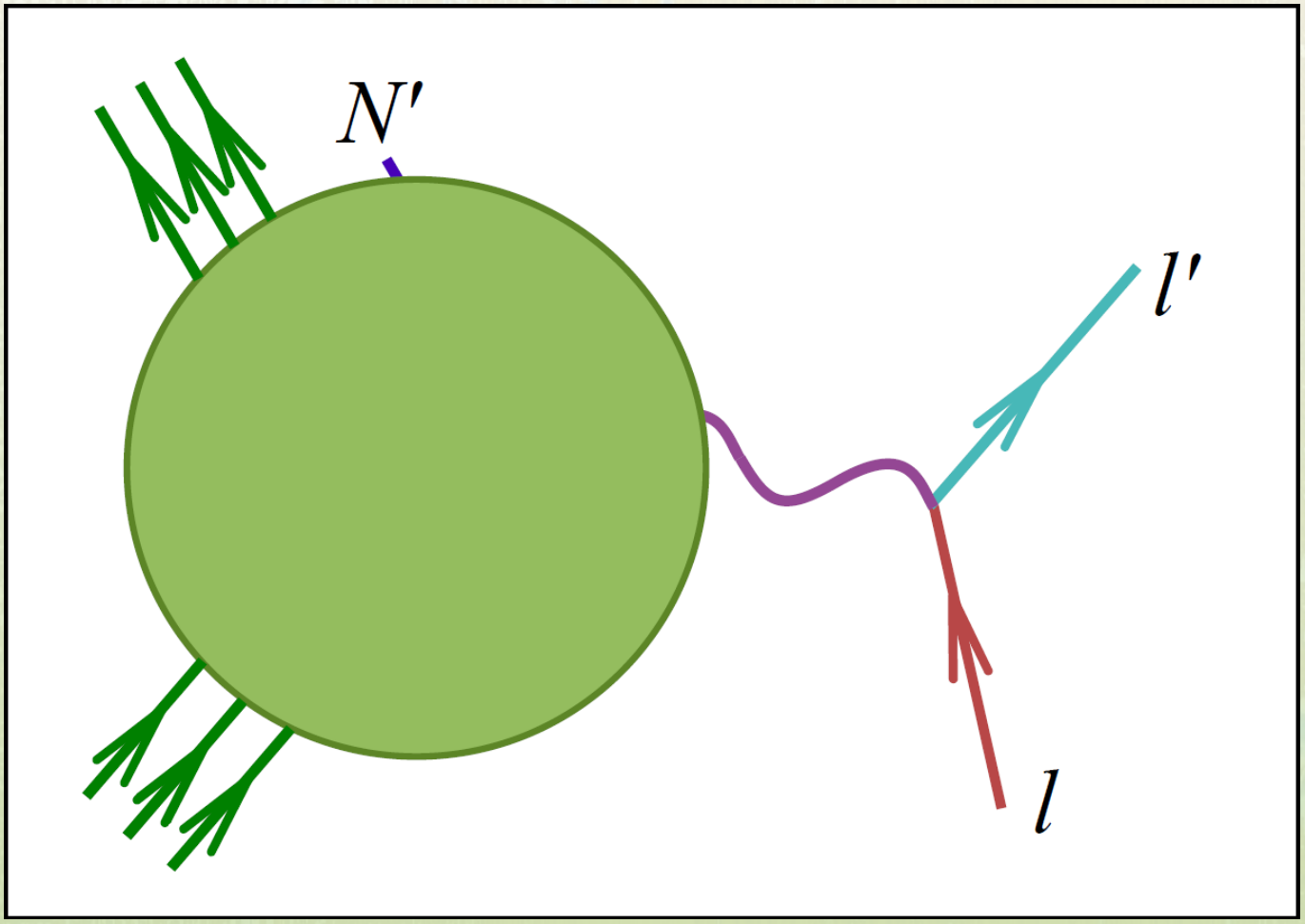
Outline

- Introduction
  - What is the impulse approximation (IA) and spectral function?
- Which e^- scattering data correspond to ν interactions?
- When the IA breaks down?
- What are consequences for ν physics?
- Summary

Introduction



Initial lepton

$$k = (E_{\mathbf{k}}, \mathbf{k})$$

Final lepton

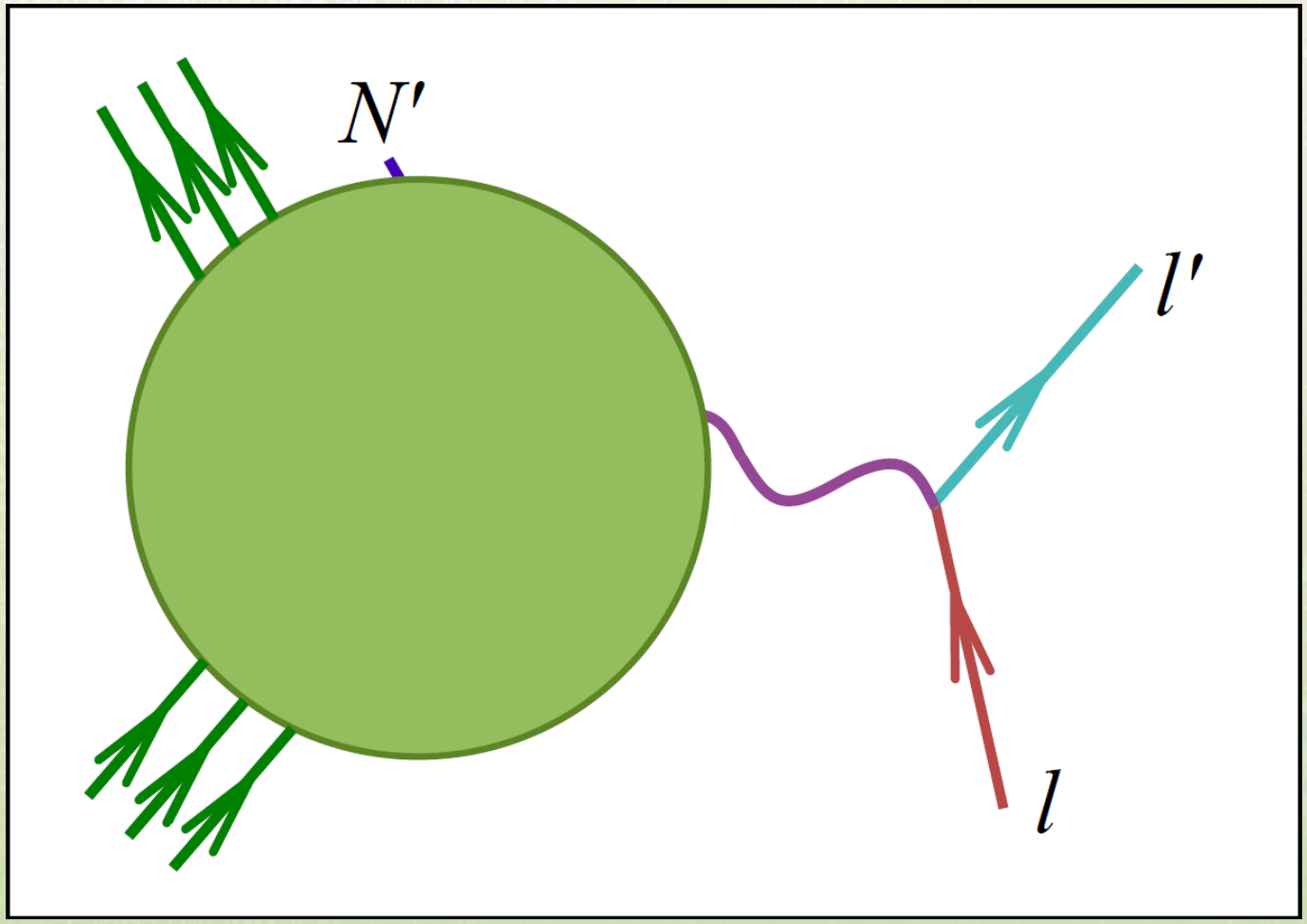
$$k' = (E_{\mathbf{k}'}, \mathbf{k}')$$

Energy transfer and momentum tr.

$$\omega = (E_{\mathbf{k}} - E_{\mathbf{k}'})$$

$$\mathbf{q} = (\mathbf{k} - \mathbf{k}')$$

Introduction



Transferred momentum

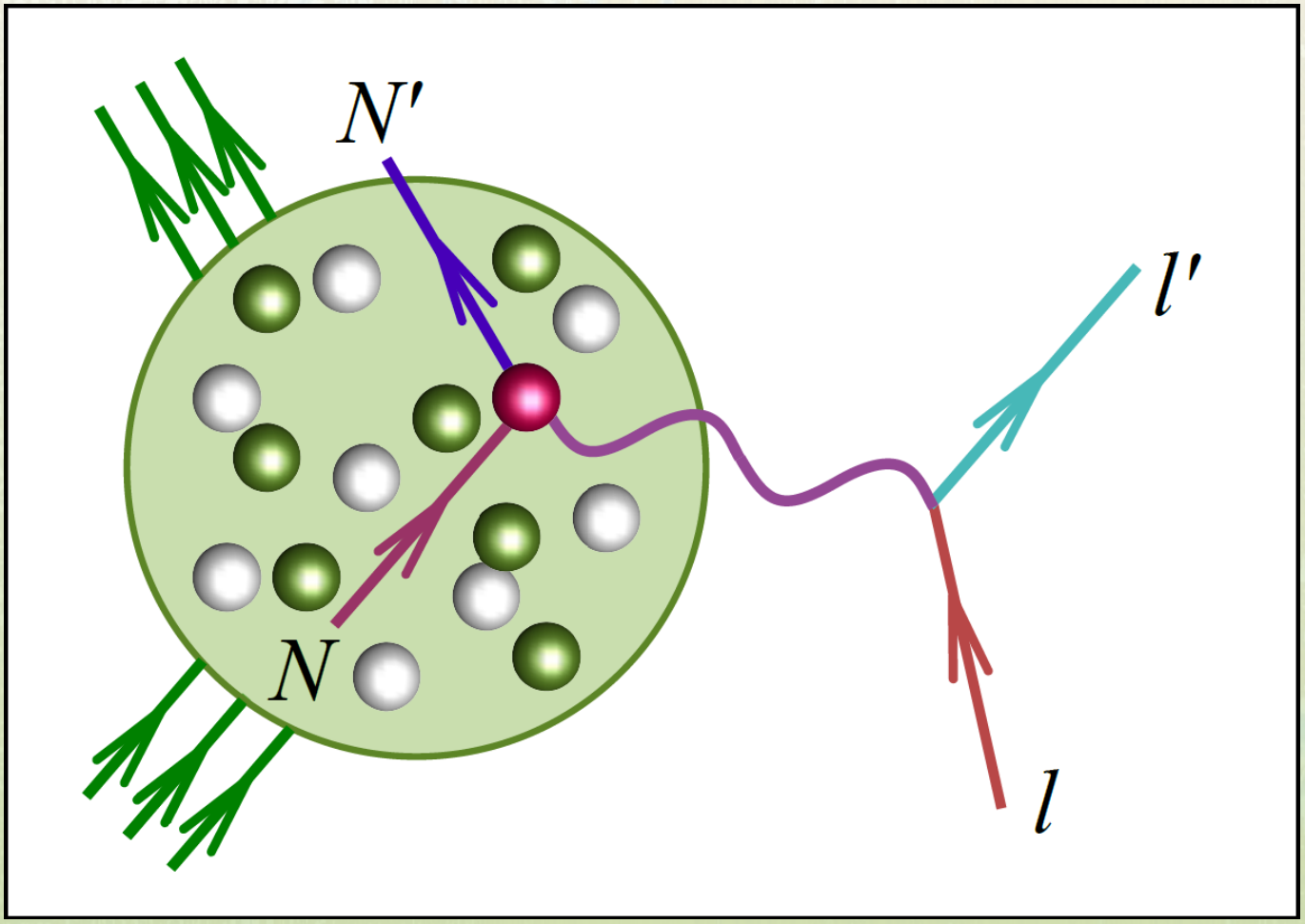
q

means that

spatial resolution

~ 1/|**q**|

Introduction



Transferred momentum

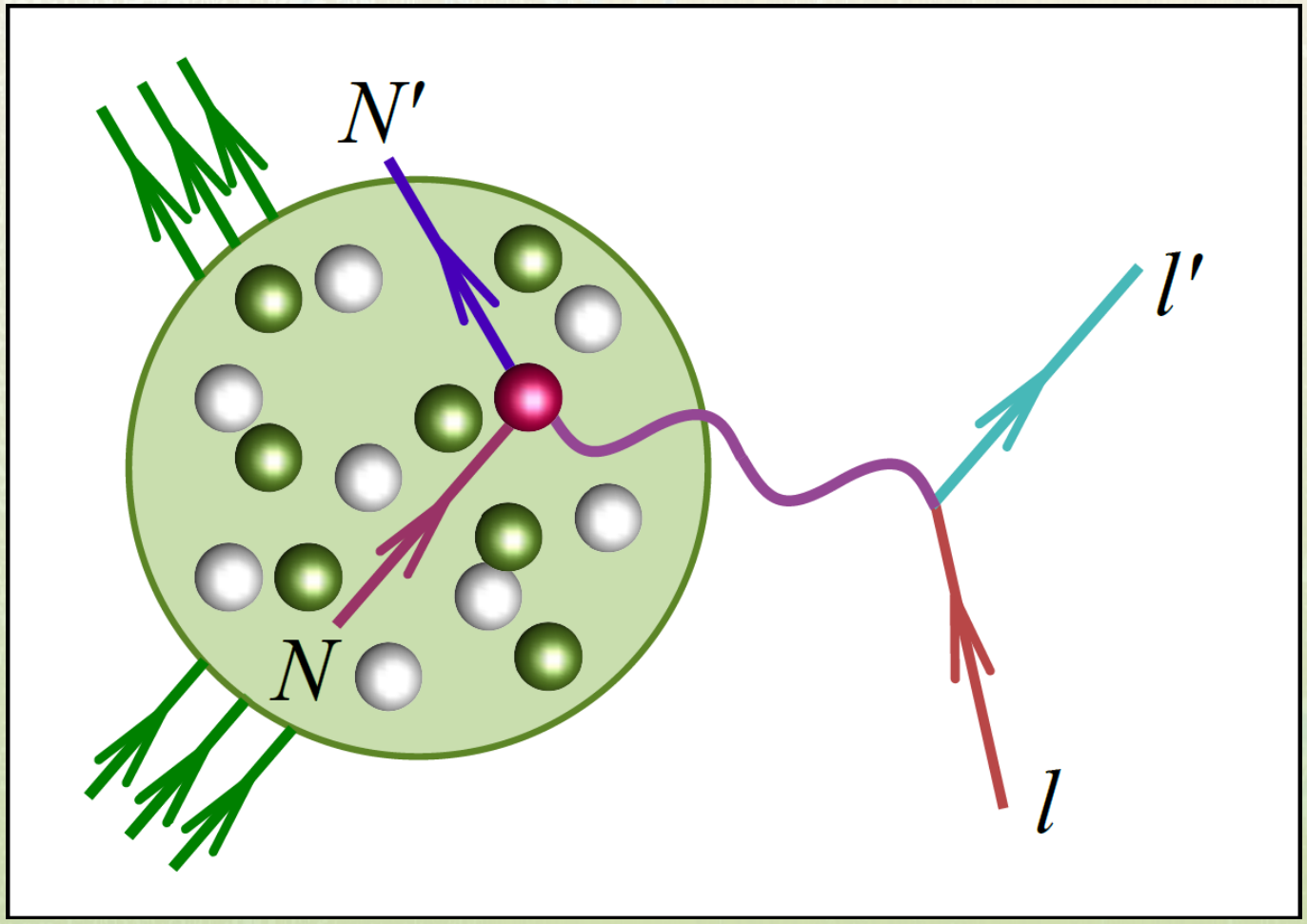
~ few 100 MeV

means that

nucleons

are degrees of freedom

Impulse approximation (IA) formalism



Nucleus
may be treated
as
a collection
of independent
nucleons

Neutrinos vs. electrons in the IA

$$\sigma \propto \int dE\, d^3p\, P(\mathbf{p}, E)\, \sigma_N\, \delta(\omega + M - E - E_{\mathbf{p}'})$$

Spectral function describing nucleons in nucleus

Elementary x-section differing between ν and e^-

Energy conservation

Spectral function

The spectral function (SF) of a given nucleus describes distribution of momenta and energies of nucleons inside it.

Neutrinos vs. electrons in the IA

$$\sigma \propto \int dE\, d^3p\, P(\mathbf{p}, E)\ \sigma_N\ \delta(\omega + M - E - E_{\mathbf{p}'})$$

Averaging over initial state of nucleon

Neutrinos vs. electrons in the IA

Adjusting **beam energy** and **scattering angle** one can sample with **electrons** the same area of the spectral function as in the **neutrino** case.

Neutrinos vs. electrons in the IA

For example:

800-MeV ν's produce μ's mostly at **~33º**

It corresponds to

880-MeV e^- scattering at **~33º**
1080-MeV e^- scattering at **~25º**
1200-MeV e^- scattering at **~23º**

Neutrinos vs. electrons in the IA

More details:

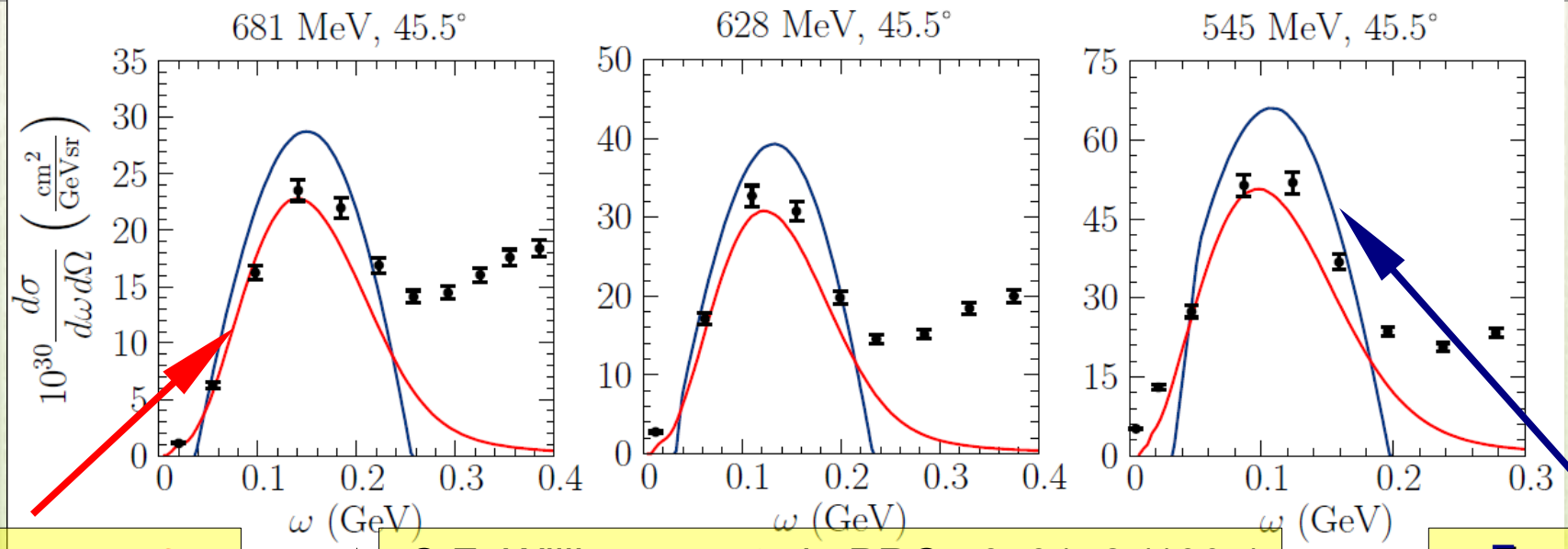
800-MeV ν's produce μ's mostly in **[20º; 56º]**

It corresponds to

880-MeV e^- scattering at **[19º; 50º]**
1080-MeV e^- scattering at **[17º; 39º]**
1200-MeV e^- scattering at **[15º; 36º]**

A.A and J.Sobczyk., PRC 77, 044311 (2008)

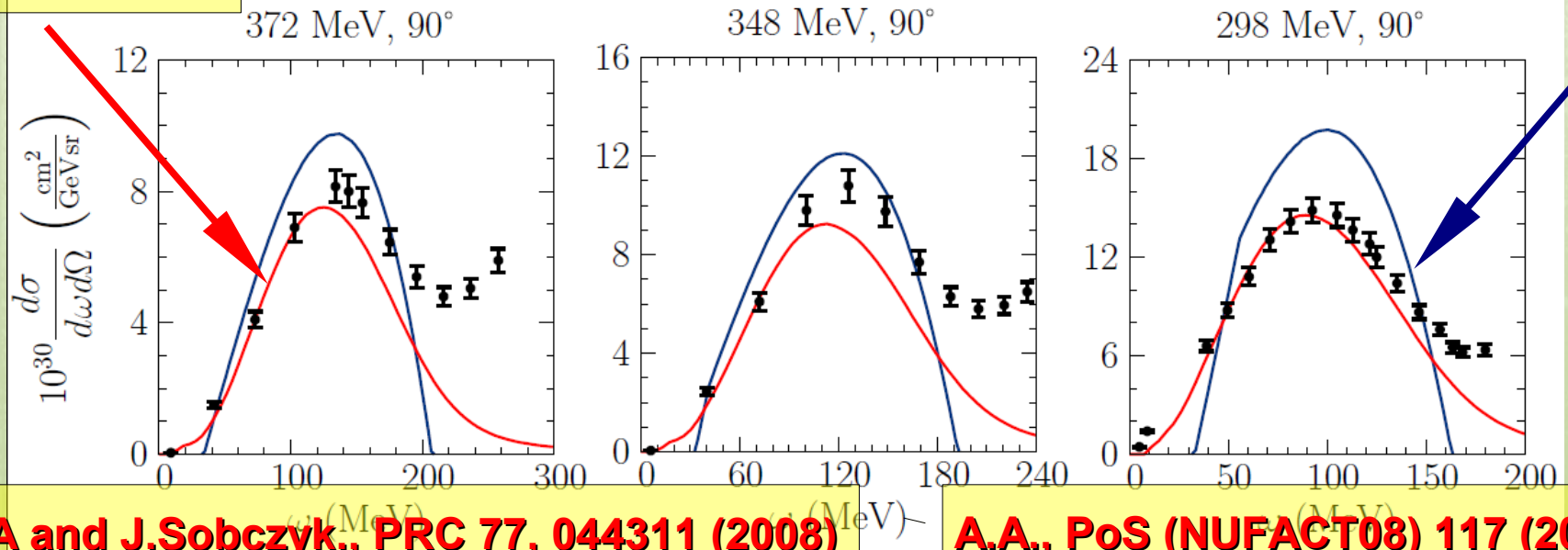
Electron scattering off calcium



Spectral f.

C.F. Williamson et al., PRC 56, 3152 (1997)

Fermi gas



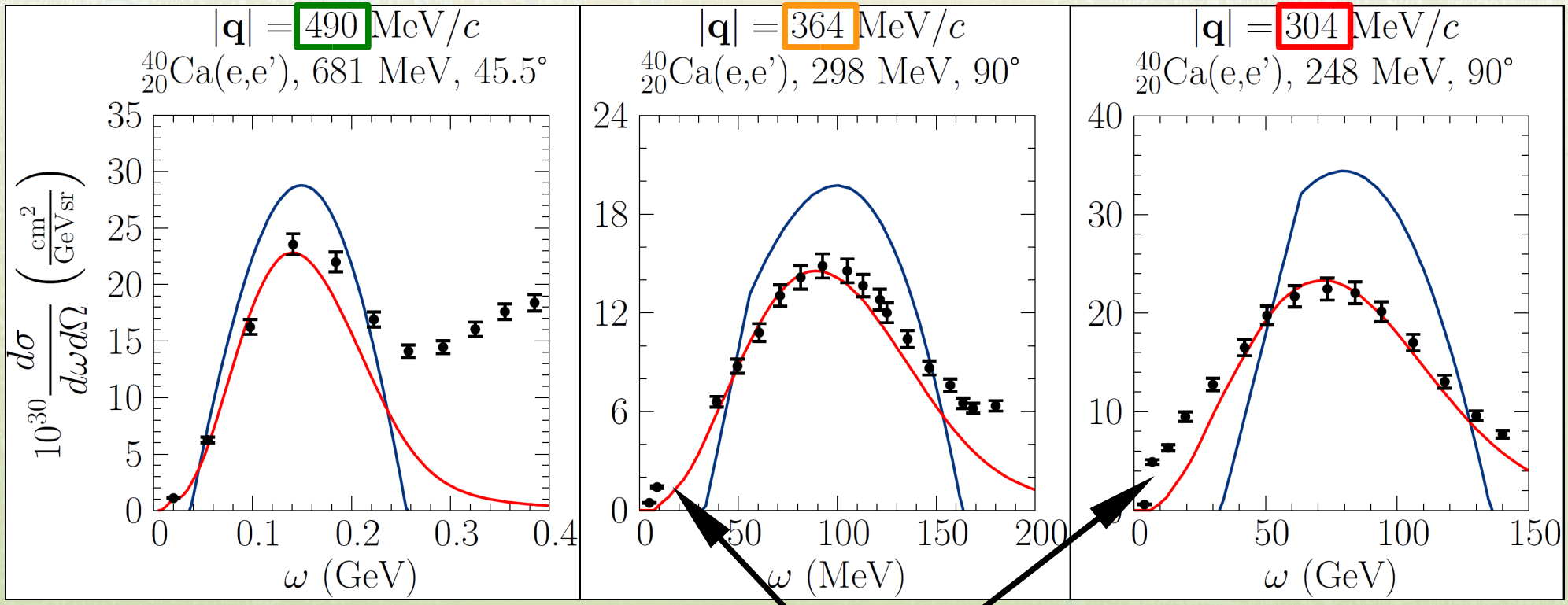
A.A and J.Sobczyk., PRC 77, 044311 (2008)

A.A., PoS (NUFACT08) 117 (2008)

Breakdown of the impulse approximation

A.A and J.Sobczyk., PRC 77, 044311 (2008)

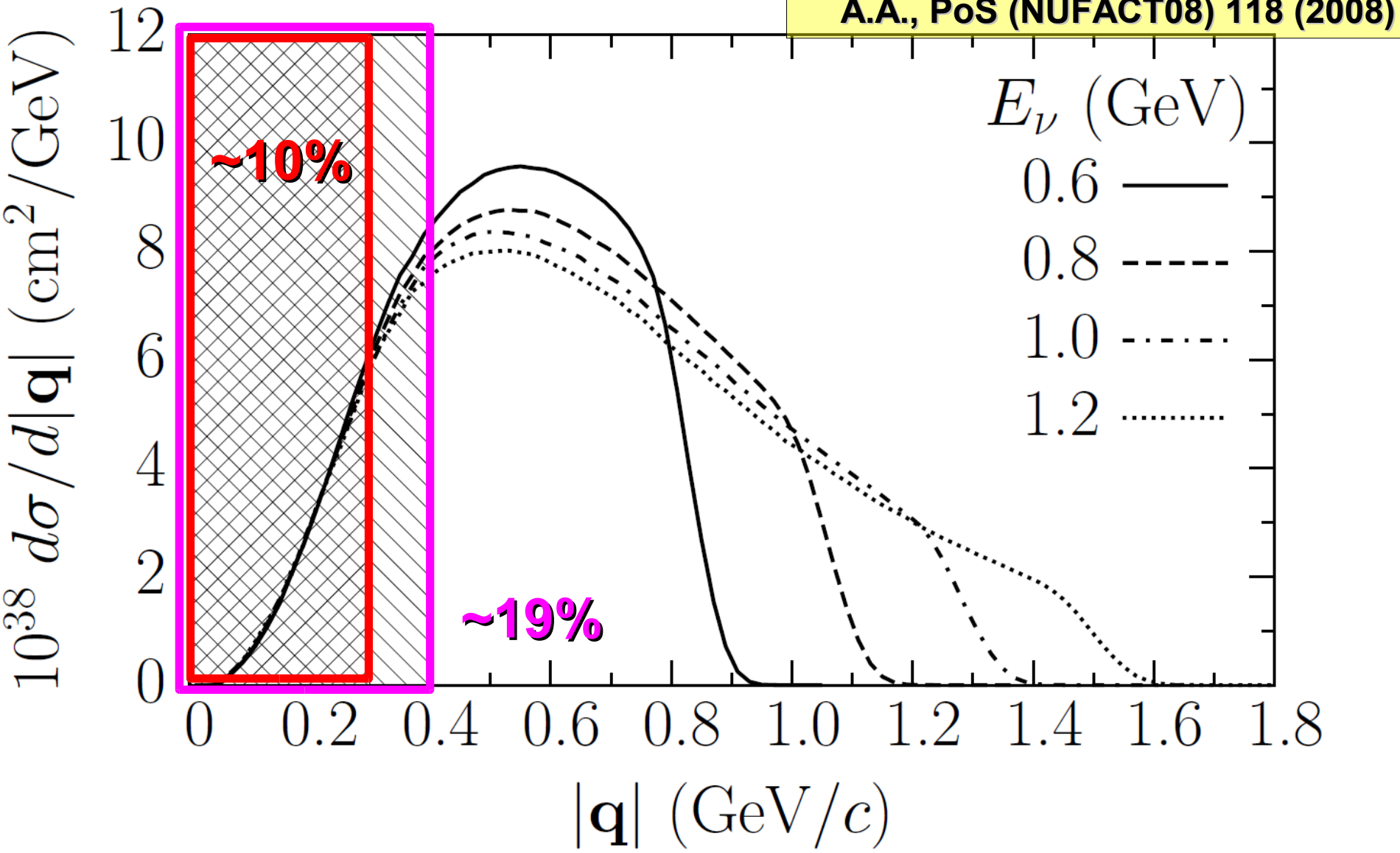
A.A., PoS (NUFACT08) 118 (2008)



When $|\mathbf{q}| \lesssim 400$ MeV two- and few-nucleon contributions appear

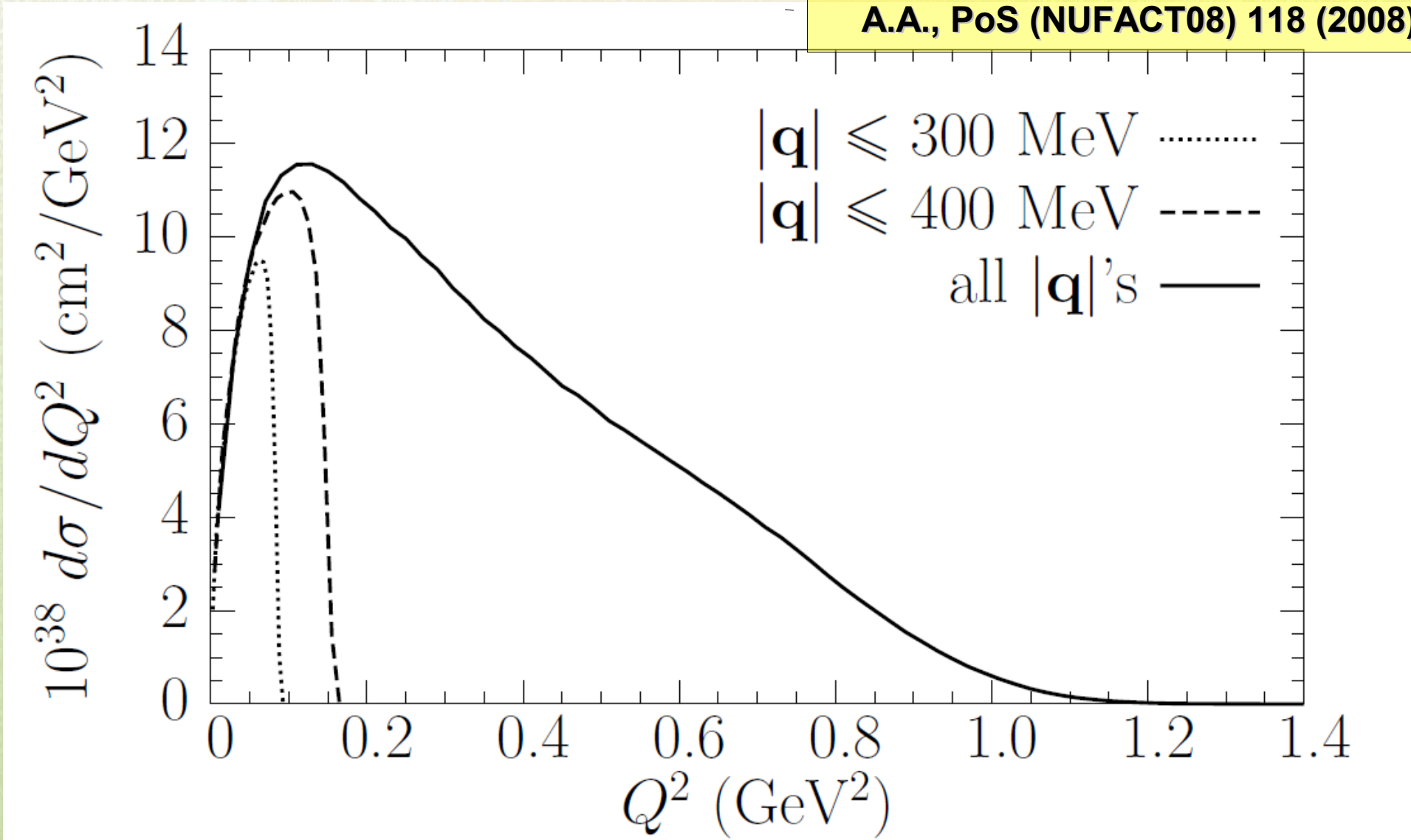
Consequences for neutrino physics

A.A., PoS (NUFACT08) 118 (2008)

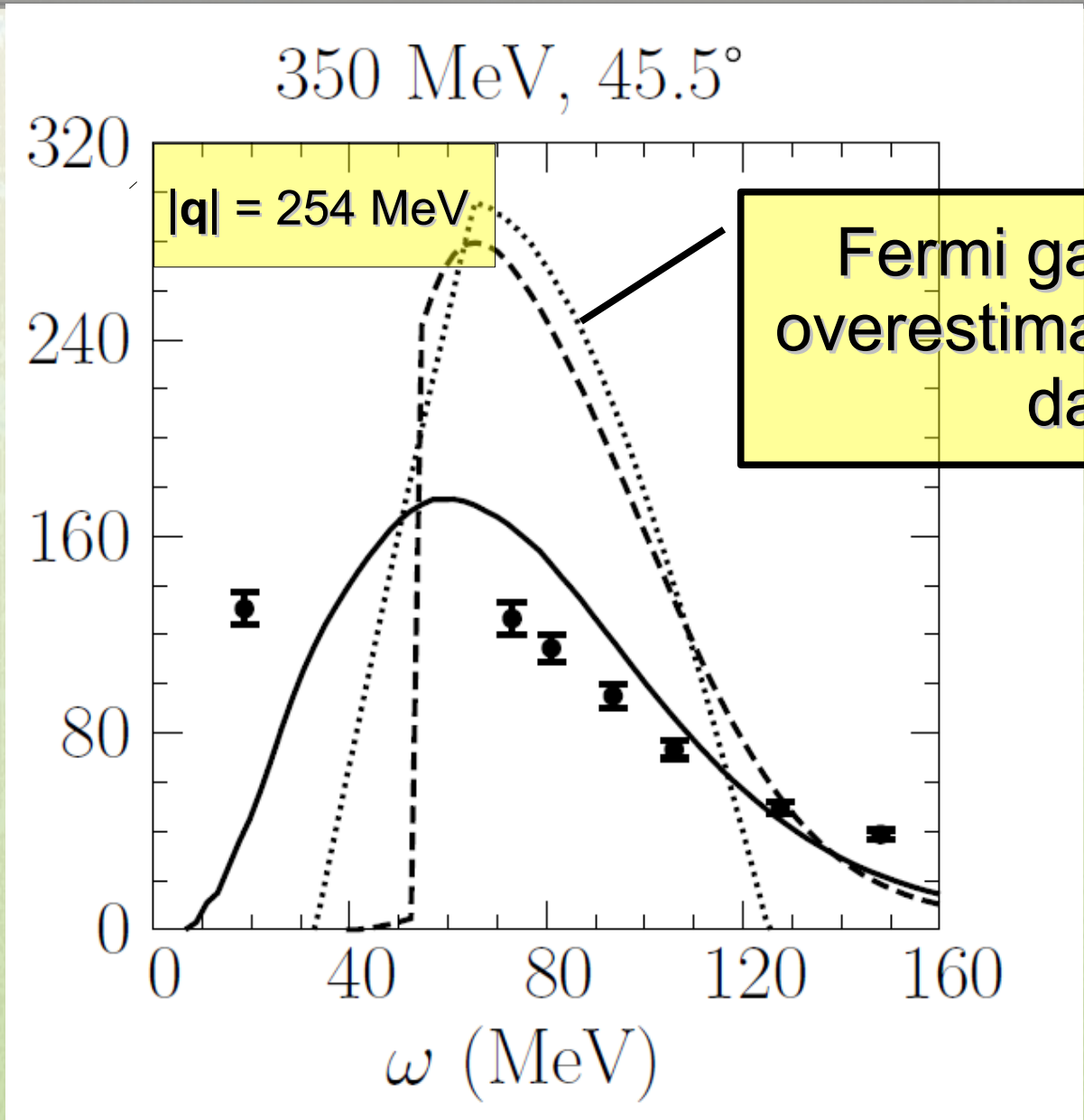


Consequences for neutrino physics

A.A., PoS (NUFACT08) 118 (2008)



Consequences for neutrino physics



Fermi gas clearly overestimates low-|q| data

Summary

- Some electron scattering data correspond kinematically to neutrino interactions
- One may use them to verify models
- Within the IA formalism we cannot calculate significant part of the neutrino QE cross section

Back-up slides

Comment on the de Forest approximation