Tsukuba December 13-16 2001

Nuclear re-interaction effects in quasi-elastic neutrino nucleus scattering

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Paolo Bernardini

Giovanni Mancarella

Daniele Martello

Antonio Surdo

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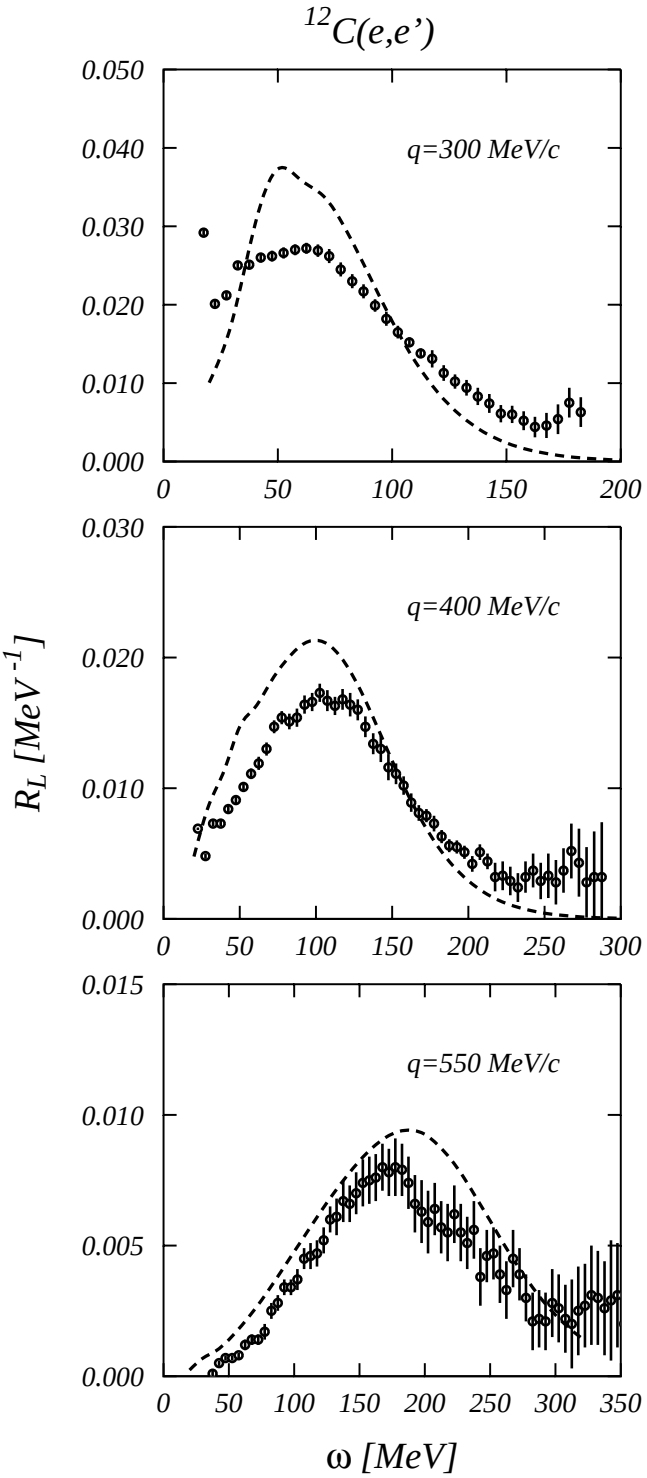
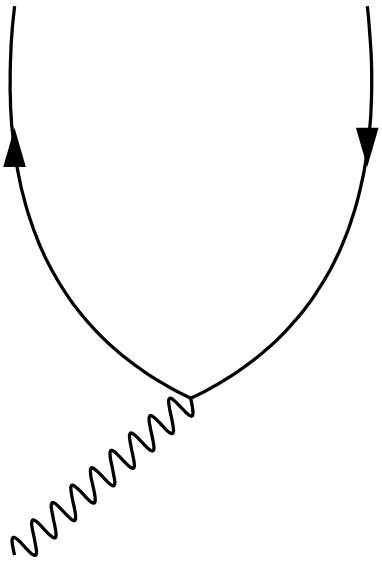
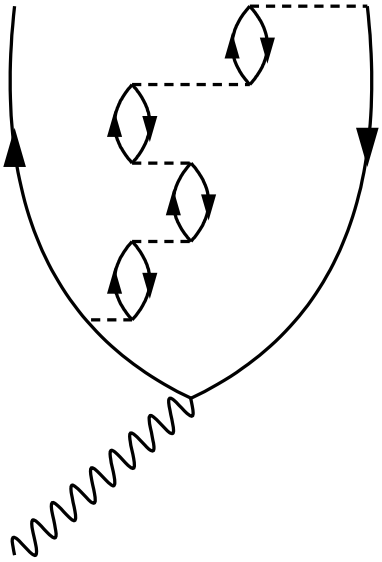
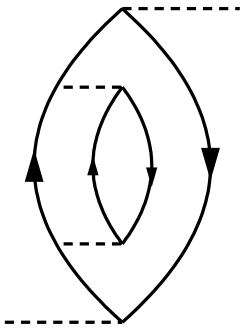

$^{12}C(e,e')$
q=300 MeV/c
q=400 MeV/c
q=550 MeV/c
R_L [MeV^{-1}]
ω [MeV]
0.050
0.040
0.030
0.020
0.010
0.000
0.015
0.005
0
50
100
150
200
250
300
350



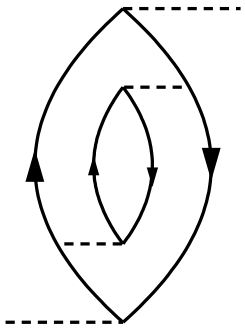
MF



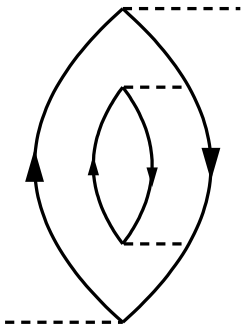
RPA



A



B



C

S. Drożdż, G. Co', J. Wambach and J. Speth,

Phys. Lett. B 185 (1987) 287.

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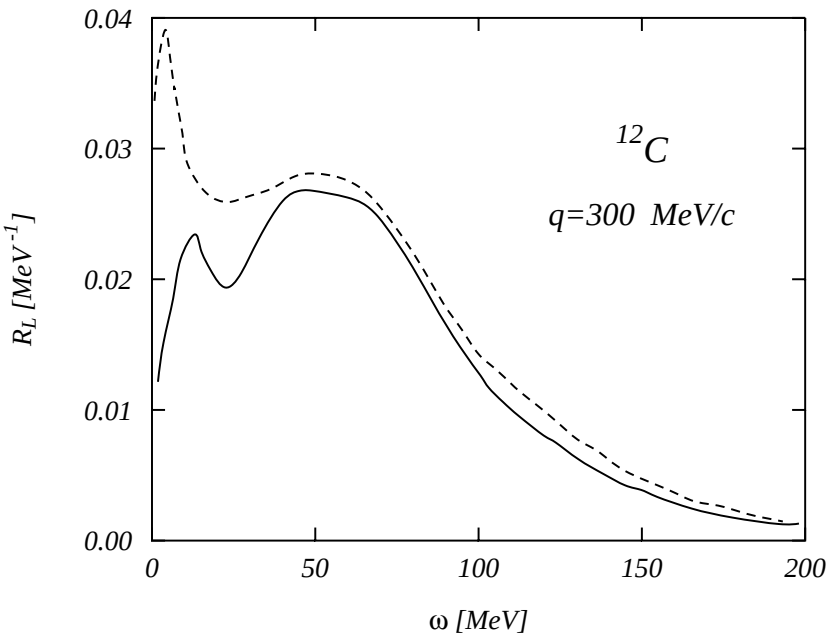

0.04
0.03
0.02
0.01
0.00
R_L [MeV^{-1}]
^{12}C
q=300 MeV/c
0
50
100
150
200
ω [MeV]

$$H = H_0 + H_1 \qquad H_0|\Phi_n >= E_n|\Phi_n >$$

$$S^0(|\mathbf{q}|,\omega) = \frac{1}{\pi} Im \sum_{n,n'} < \Phi_0|\mathcal{O}^+(\mathbf{q})|\Phi_n >$$
$$\left[\frac{1}{E_n\delta_{n,n'} - \omega - i\eta} + \frac{1}{E_n\delta_{n,n'} + \omega + i\eta}\right]$$
$$< \Phi_{n'}|\mathcal{O}(\mathbf{q})|\Phi_0 >$$

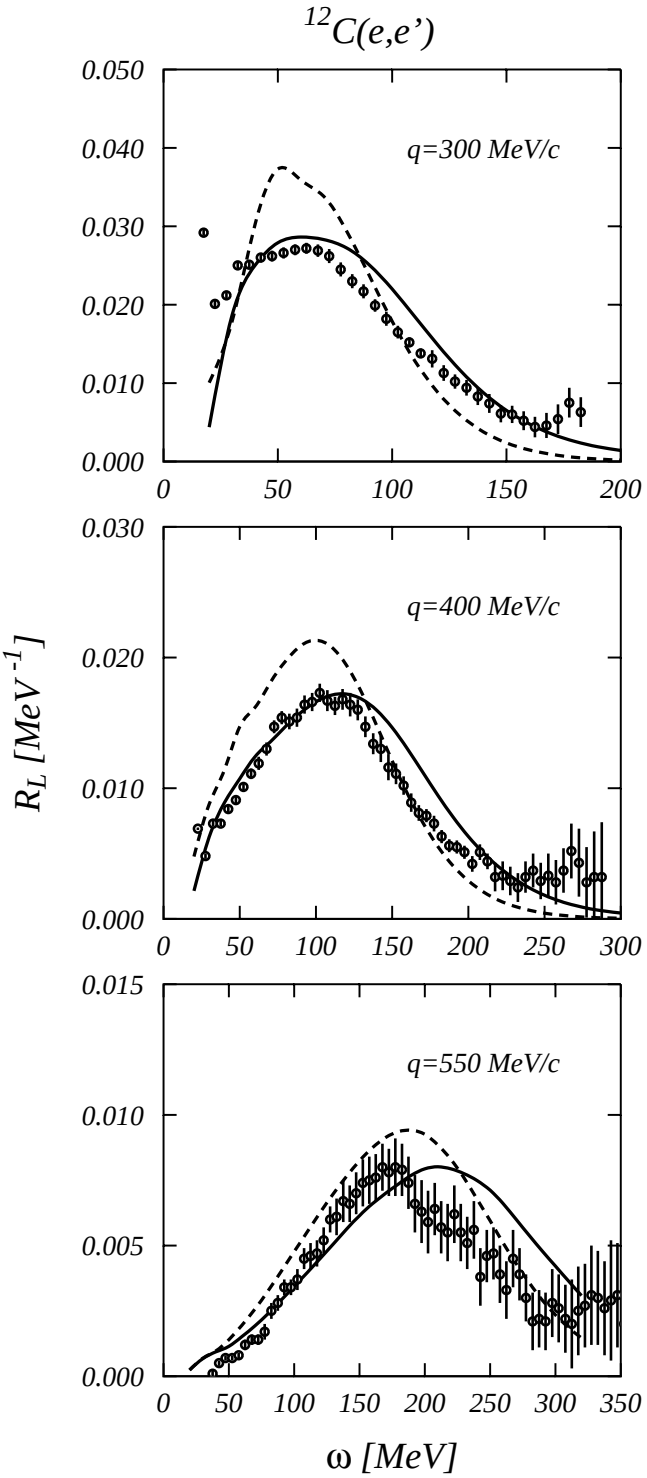
$$S(|\mathbf{q}|,\omega) = \frac{1}{\pi} Im \sum_{n,n'} < \Phi_0|\mathcal{O}^+(\mathbf{q})|\Phi_n >$$
$$\left[\frac{1}{E_n\delta_{n,n'} - \omega - \Sigma_{n,n'}(\omega) - i\eta}\right.$$
$$\left. + \frac{1}{E_n\delta_{n,n'} + \omega - \Sigma_{n,n'}(-\omega) + i\eta}\right]$$
$$< \Phi_{n'}|\mathcal{O}(\mathbf{q})|\Phi_0 >$$

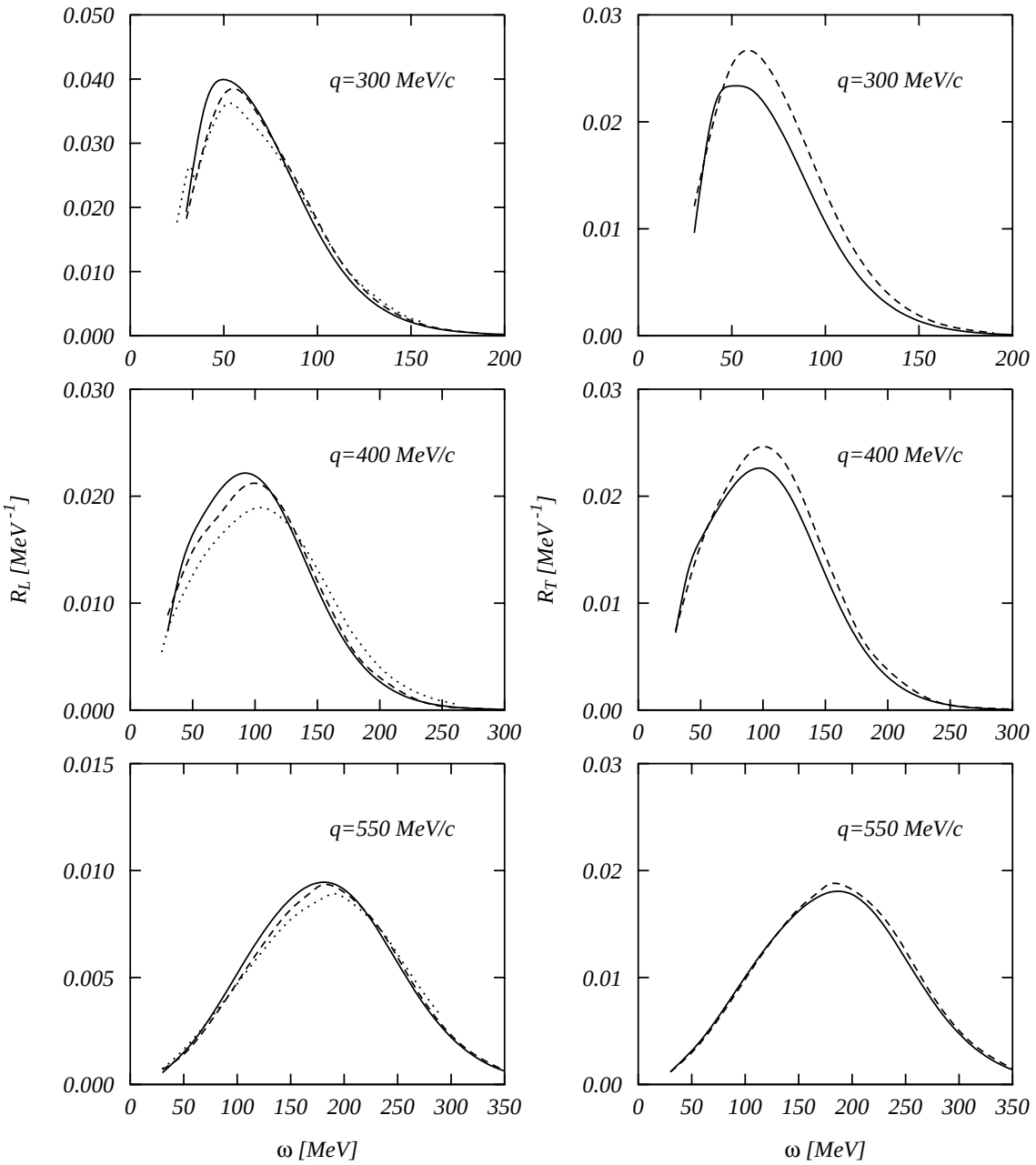
$$\Sigma_{n,n'}(\omega) \rightarrow \Sigma(\omega)\delta_{n,n'} \rightarrow \Delta(\omega) - \frac{i}{2}\Gamma(\omega)$$

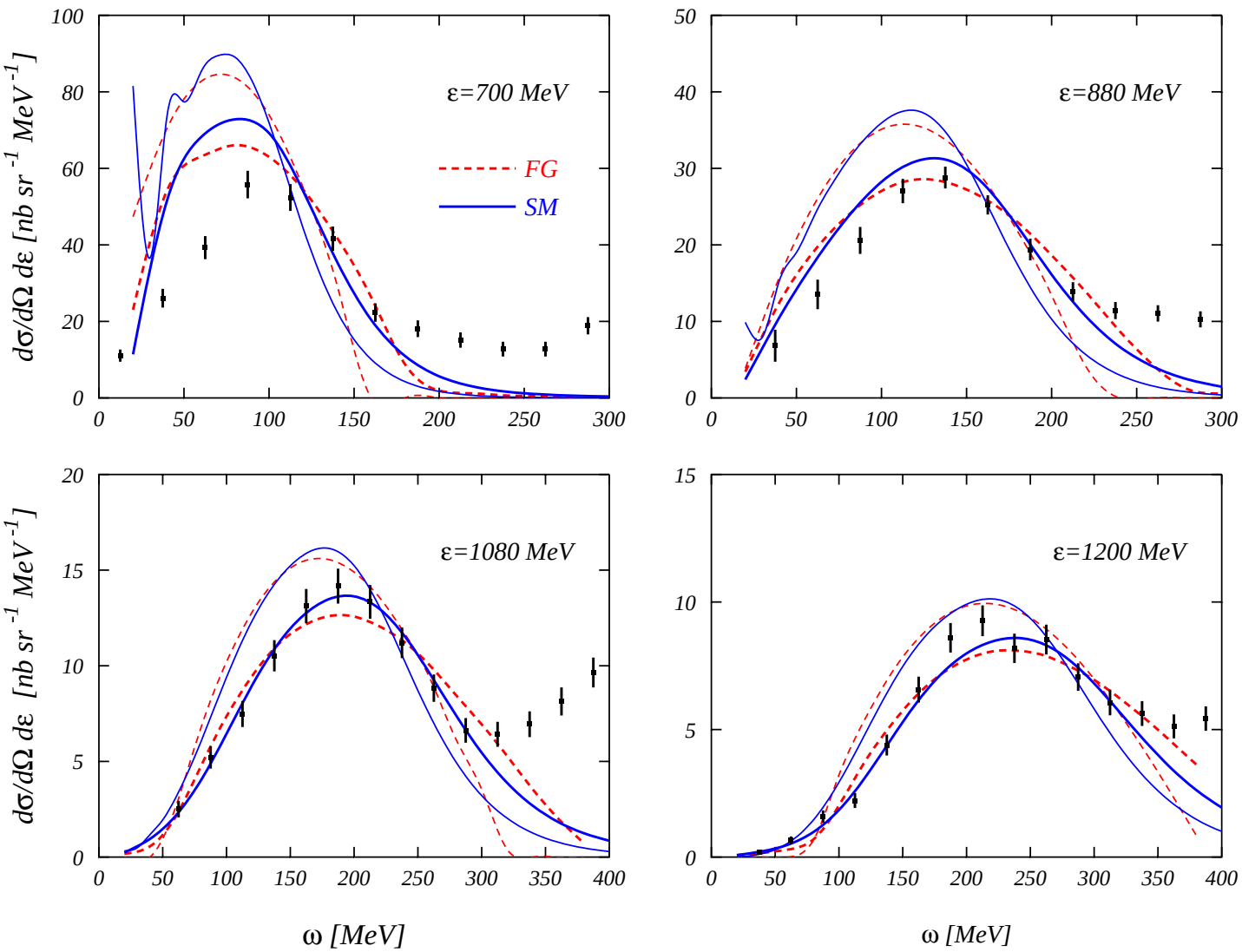
$$S(|\mathbf{q}|,\omega) = \int_0^\infty dE \;\; S^0(|\mathbf{q}|,E)\left[\rho(E,\omega) + \rho(E,-\omega)\right]$$

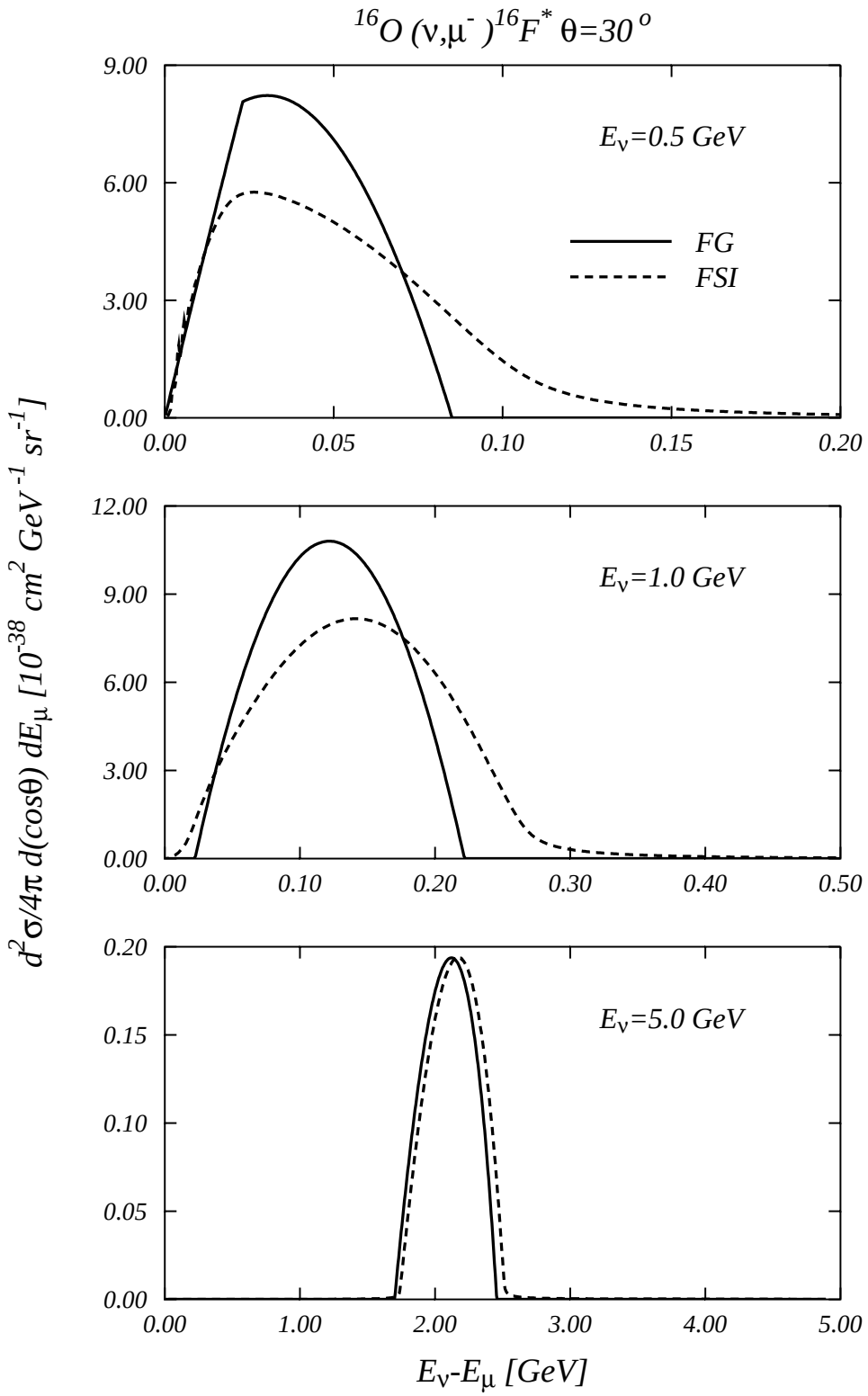
$$\rho(E,\omega) = \frac{1}{2\pi}\frac{\Gamma(\omega)}{[E-\omega-\Delta(\omega)]^2 + [\Gamma(\omega)/2]^2}$$

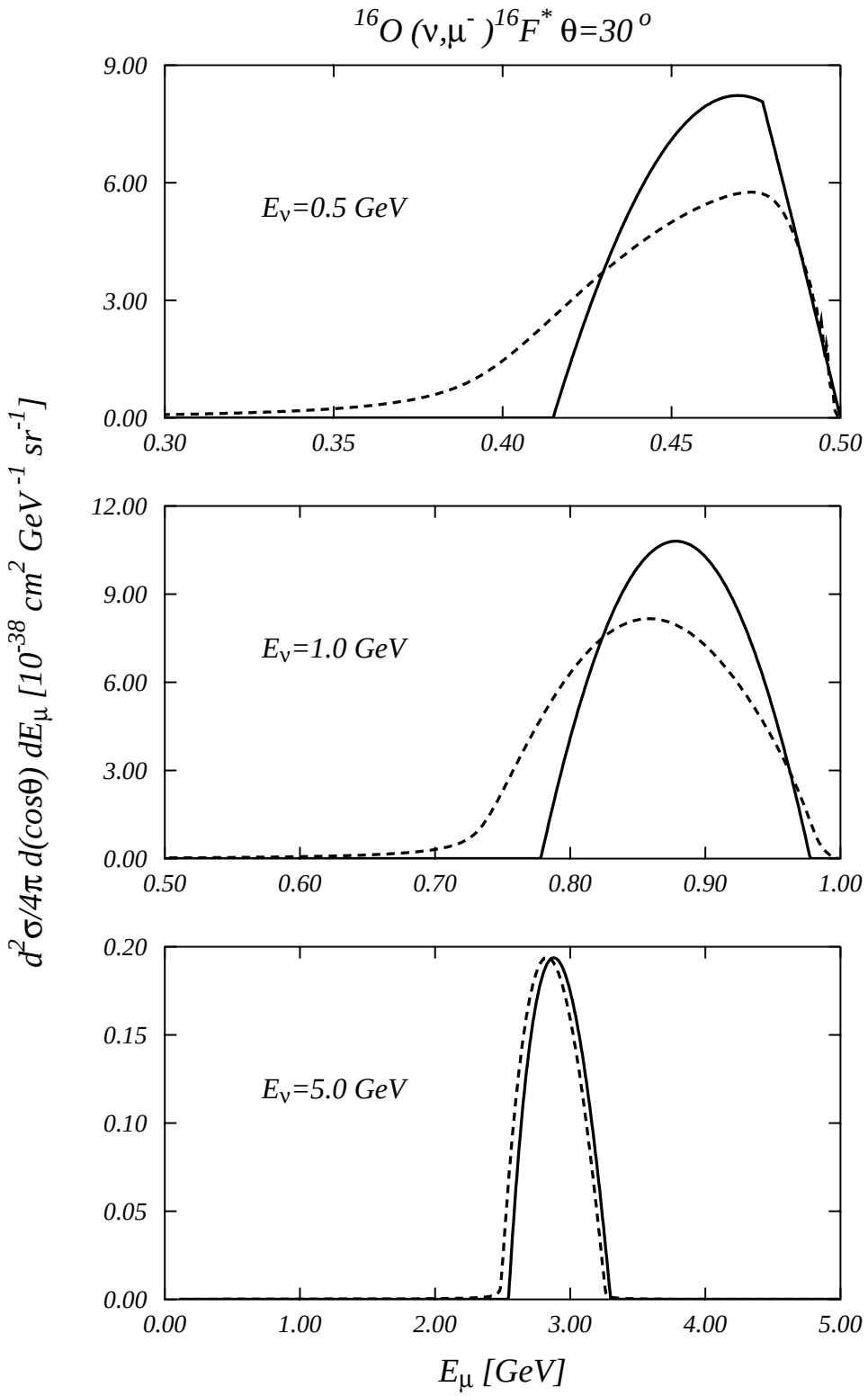
$$\Delta(\omega) = \frac{1}{2\pi}P\int_0^\infty d\omega' \;\; \frac{\Gamma(\omega')}{\omega'-\omega}$$

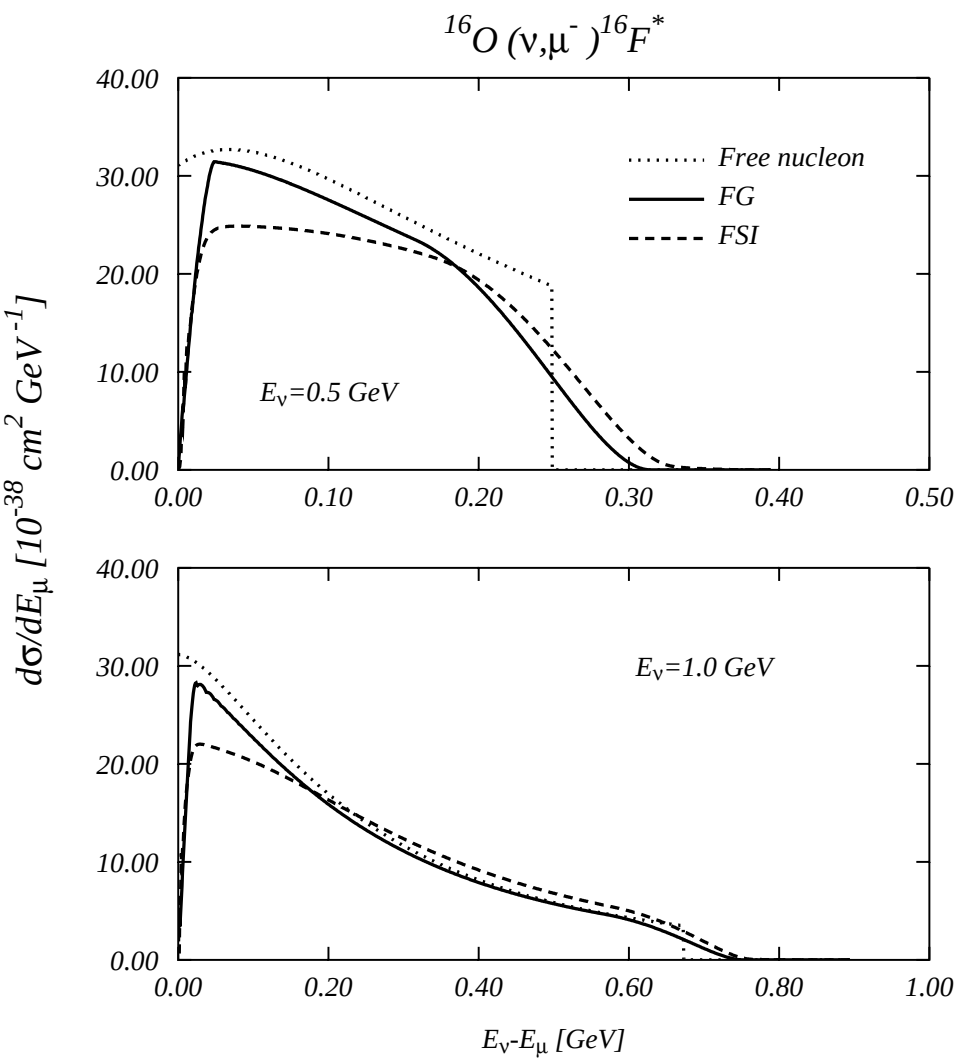

$^{12}C(e,e')$
q=300 MeV/c
q=400 MeV/c
q=550 MeV/c
R_L [MeV^{-1}]
ω [MeV]
0.050
0.040
0.030
0.020
0.010
0.000
0.015
0.005
0
50
100
150
200
250
300
350

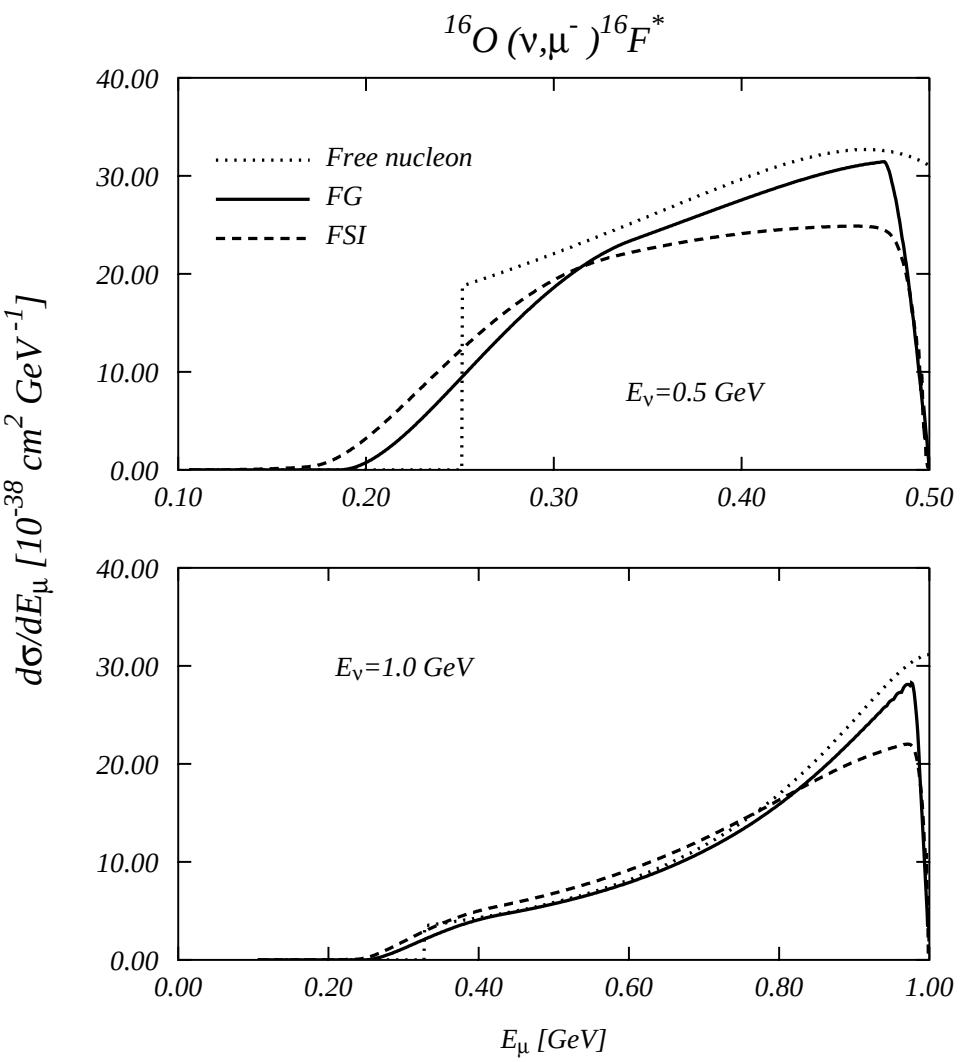

q=300 MeV/c
q=400 MeV/c
q=550 MeV/c
R_L [MeV^{-1}]
R_T [MeV^{-1}]
ω [MeV]
ω [MeV]

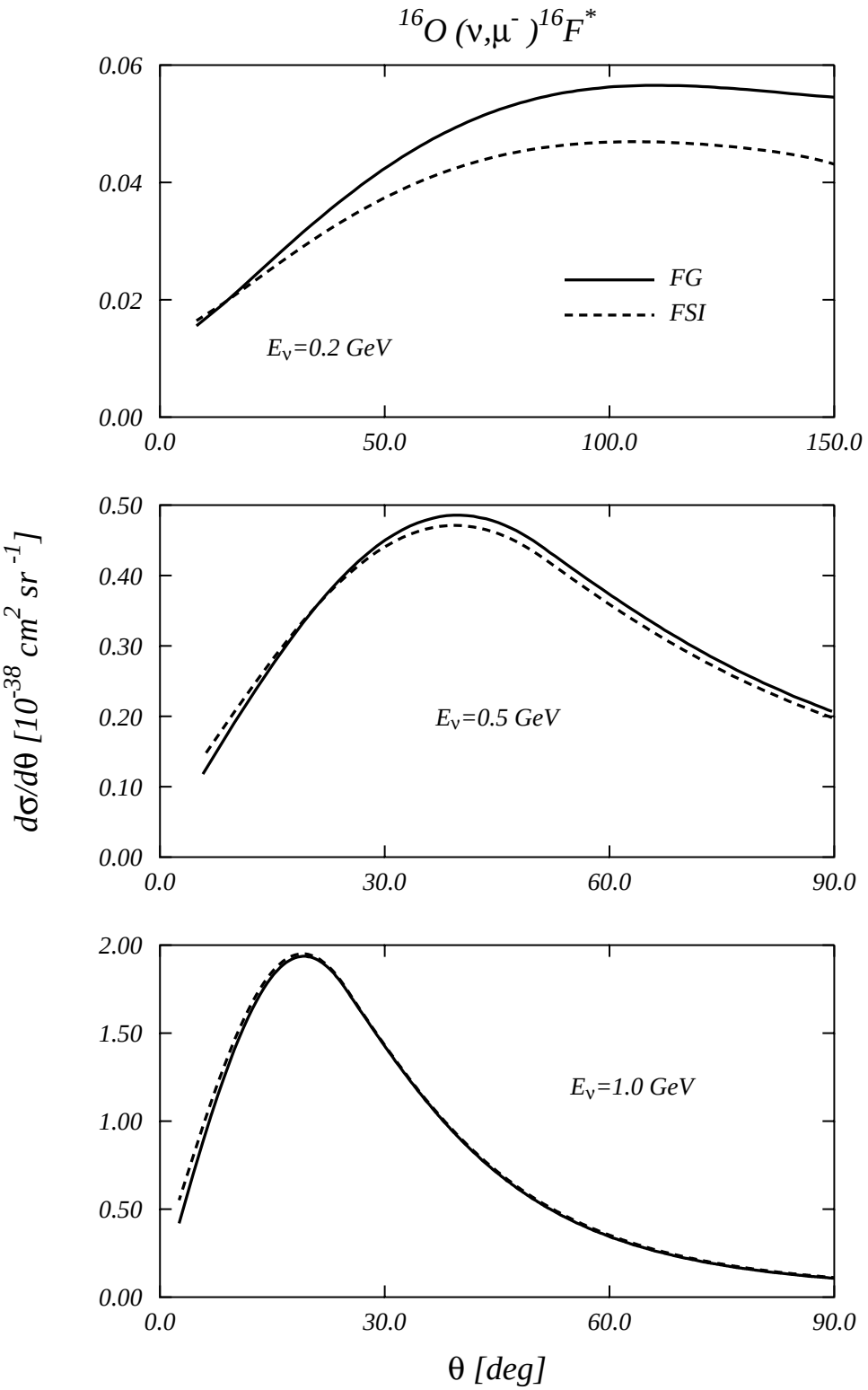

$^{16}O(e,e')$ θ=32°
ε=700 MeV
ε=880 MeV
ε=1080 MeV
ε=1200 MeV
FG
SM
dσ/dΩ dε [nb sr⁻¹ MeV⁻¹]
ω [MeV]

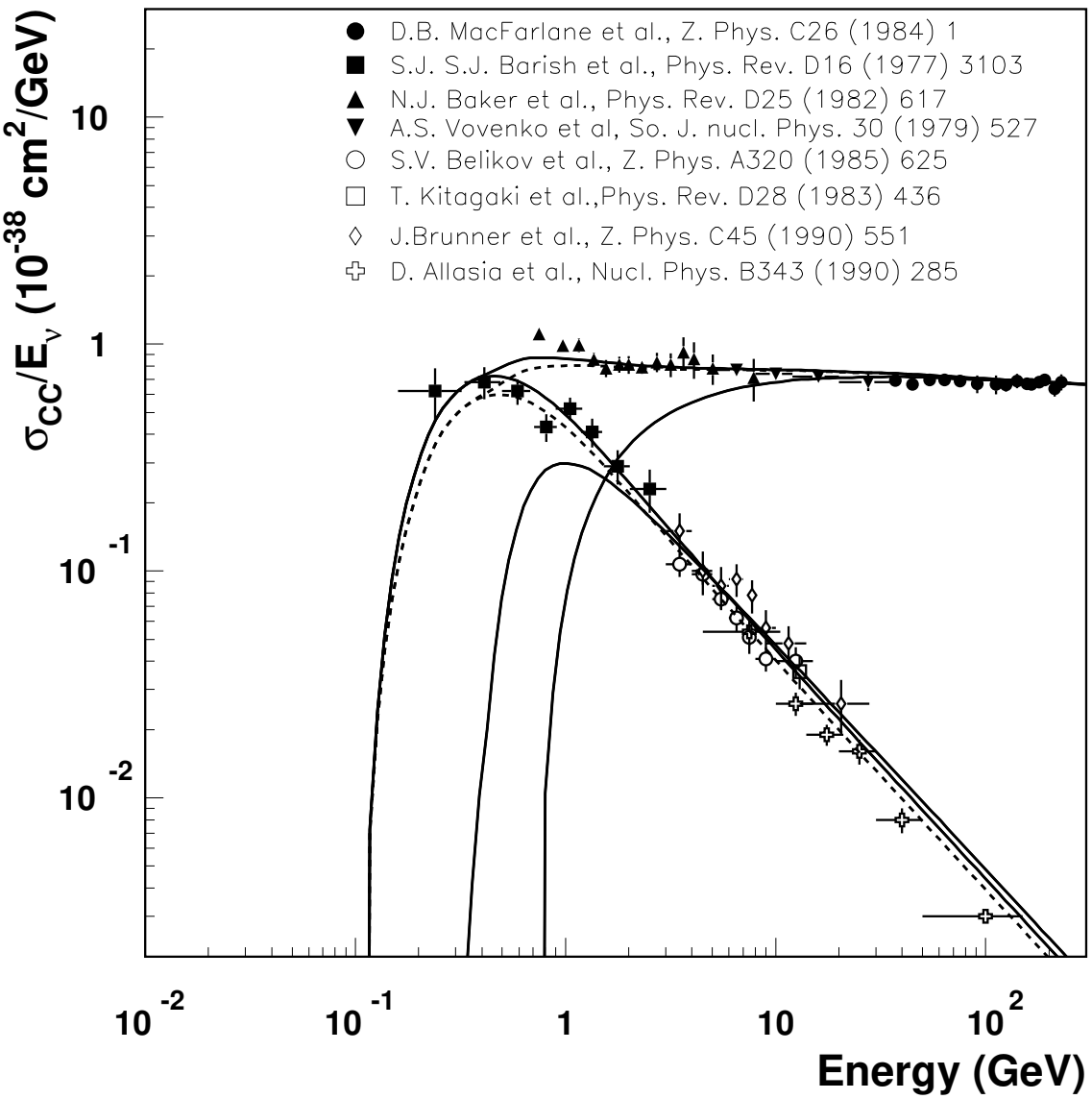

$^{16}O\ (\nu,\mu^-)^{16}F^*\ \theta=30^o$
E_ν=0.5 GeV
FG
FSI
E_ν=1.0 GeV
E_ν=5.0 GeV
$d^2\sigma/4\pi\ d(cos\theta)\ dE_\mu\ [10^{-38}\ cm^2\ GeV^{-1}\ sr^{-1}]$
E_ν-E_μ [GeV]


$^{16}O\ (\nu,\mu^-)^{16}F^*\ \theta=30^o$
E_ν=0.5 GeV
E_ν=1.0 GeV
E_ν=5.0 GeV
$d^2\sigma/4\pi\ d(cos\theta)\ dE_\mu\ [10^{-38}\ cm^2\ GeV^{-1}\ sr^{-1}]$
E_μ [GeV]


$^{16}O\ (\nu,\mu^-)\ ^{16}F^*$
Free nucleon
FG
FSI
E_ν=0.5 GeV
E_ν=1.0 GeV
$d\sigma/dE_\mu$ [10^{-38} cm^2 GeV^{-1}]
E_ν-E_μ [GeV]
40.00
30.00
20.00
10.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.80
1.00


$^{16}O\ (\nu,\mu^-)^{16}F^*$
Free nucleon
FG
FSI
E_ν=0.5 GeV
E_ν=1.0 GeV
$d\sigma/dE_\mu$ [10^{-38} cm^2 GeV^{-1}]
E_μ [GeV]
40.00
30.00
20.00
10.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.80
1.00


$^{16}O\ (\nu,\mu^-)^{16}F^*$
0.06
0.04
0.02
0.00
0.0
50.0
100.0
150.0
FG
FSI
E_ν=0.2 GeV
0.50
0.40
0.30
0.20
0.10
0.00
0.0
30.0
60.0
90.0
E_ν=0.5 GeV
2.00
1.50
1.00
0.50
0.00
0.0
30.0
60.0
90.0
E_ν=1.0 GeV
$d\sigma/d\theta\ [10^{-38}\ cm^2\ sr^{-1}]$
θ [deg]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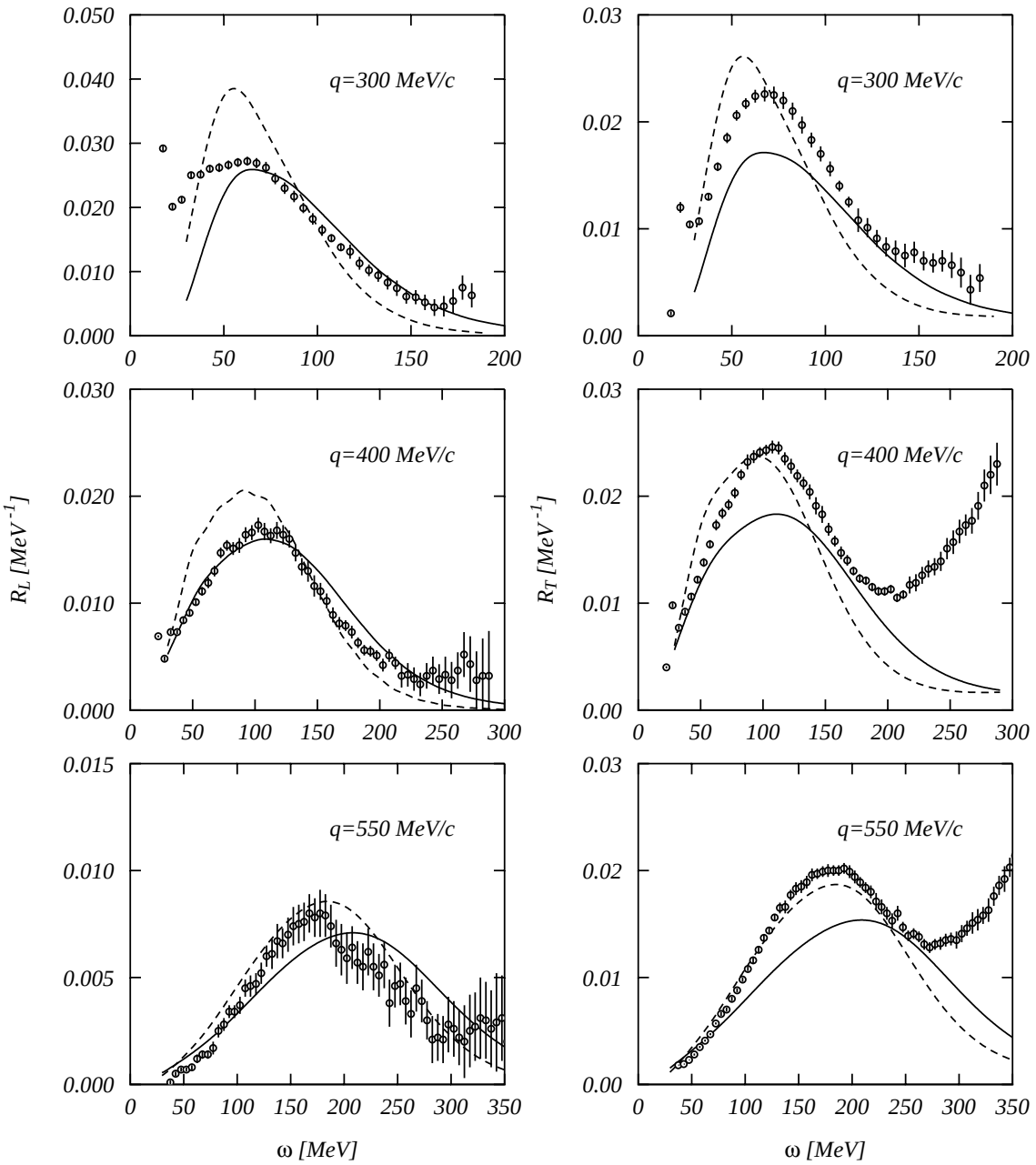
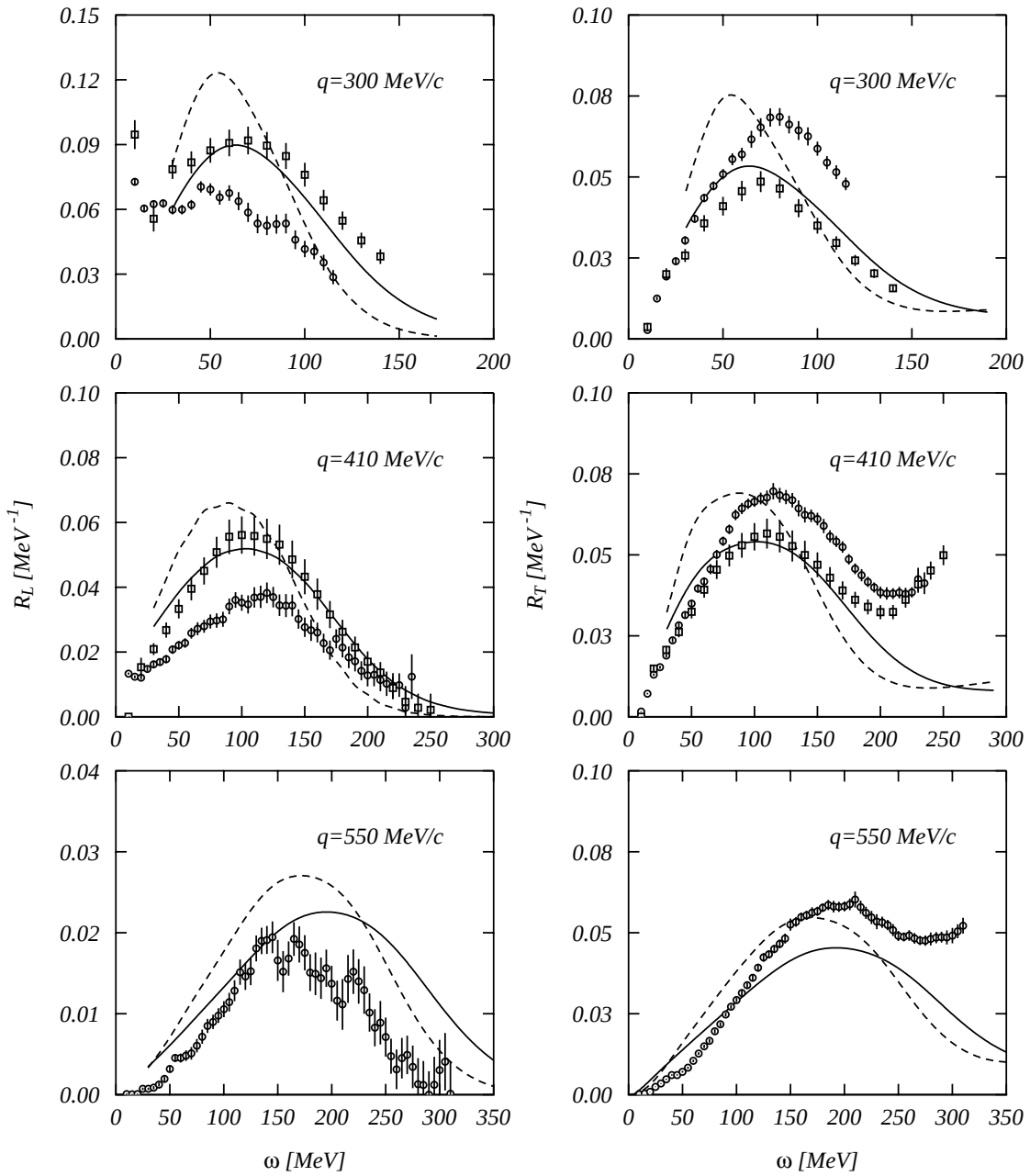
N.J. Baker et al., Phys. Rev. D25 (1982) 617
A.S. Vovenko et al, So. J. nucl. Phys. 30 (1979) 527
S.V. Belikov et al., Z. Phys. A320 (1985) 625
T. Kitagaki et al.,Phys. Rev. D28 (1983) 436
J.Brunner et al., Z. Phys. C45 (1990) 551
D. Allasia et al., Nucl. Phys. B343 (1990) 285
σ_{CC}/E_ν (10^{-38} cm^2/GeV)
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
Energy (GeV)


q=300 MeV/c
q=400 MeV/c
q=550 MeV/c
R_L [MeV^{-1}]
R_T [MeV^{-1}]
ω [MeV]
ω [MeV]


q=300 MeV/c
q=300 MeV/c
q=410 MeV/c
q=410 MeV/c
q=550 MeV/c
q=550 MeV/c
R_L [MeV^{-1}]
R_T [MeV^{-1}]
ω [MeV]
ω [MeV]