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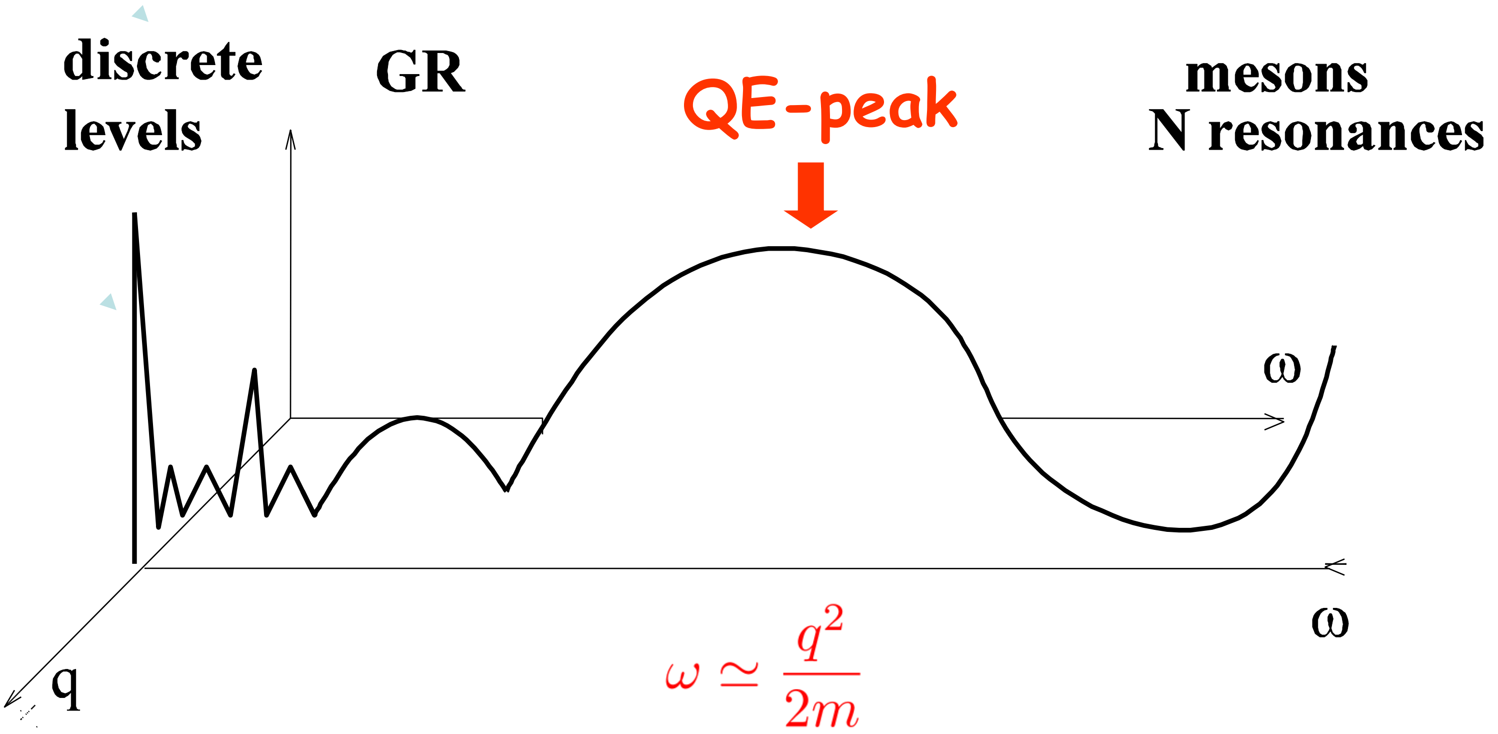
NN CORRELATIONS AND MEC IN ELECTRON SCATTERING

Carlotta Giusti

Università and INFN Pavia

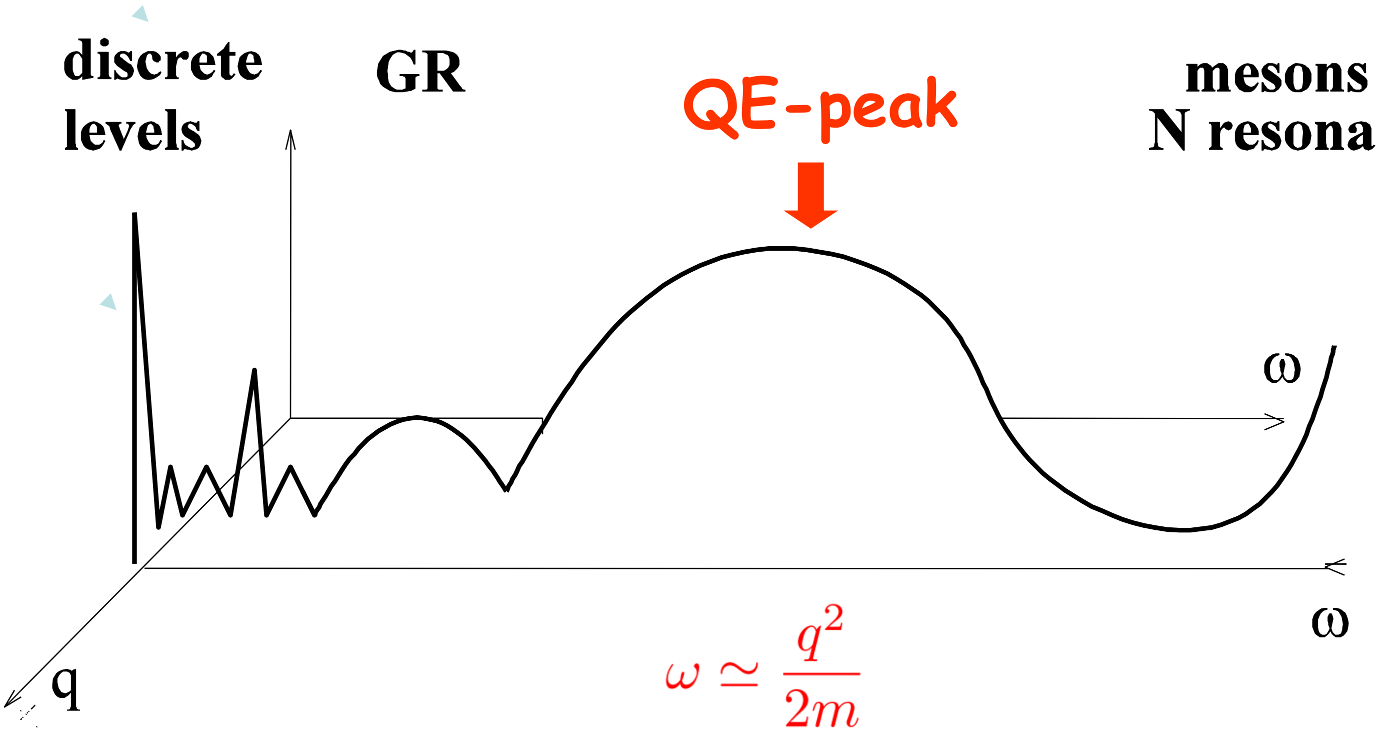
Two-body current contributions in neutrino-nucleus scattering. Saclay 18-22 April 2016

nuclear response to the electromagnetic probe



$$\omega \simeq \frac{q^2}{2m}$$

nuclear response to the electromagnetic probe

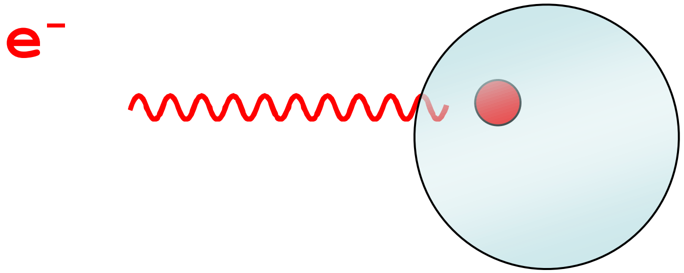


$$\omega \simeq \frac{q^2}{2m}$$

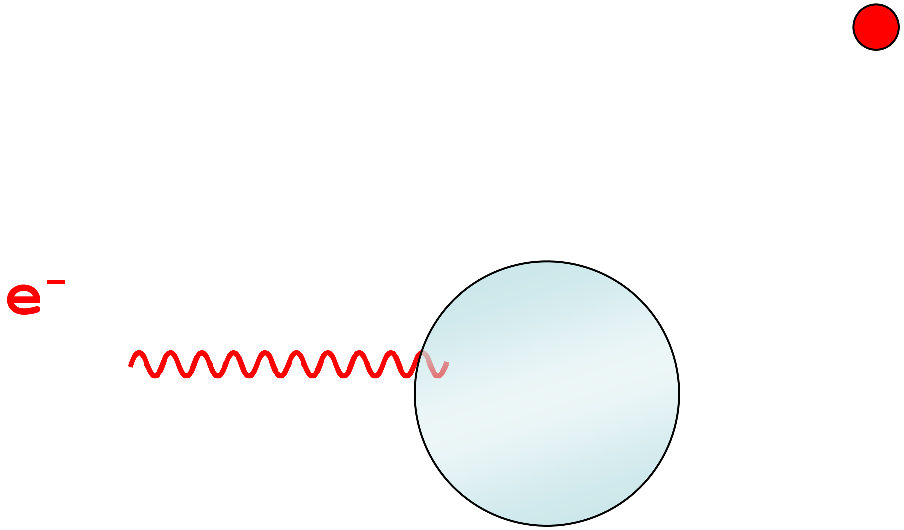
QE-peak dominated by one-nucleon knockout

(e,e′p) one-nucleon knockout

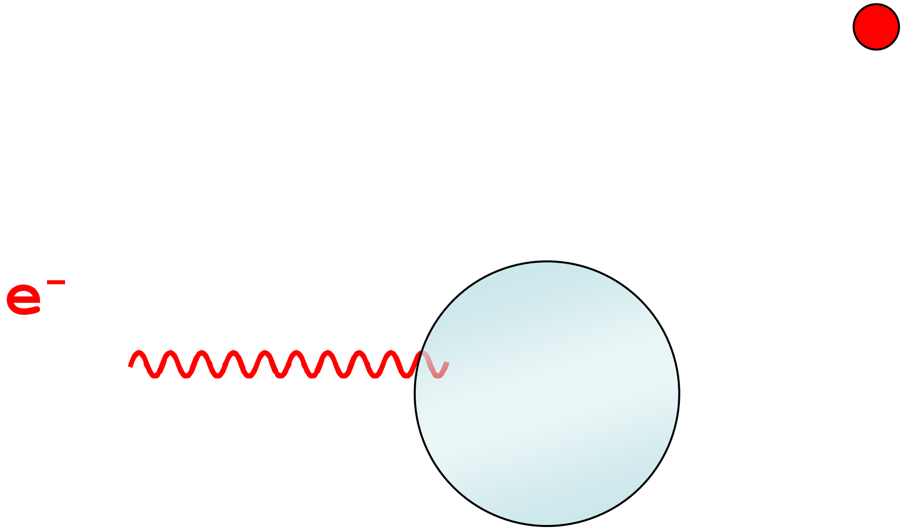
(e,e'p) one-nucleon knockout



(e,e'p) one-nucleon knockout



(e,e′p) one-nucleon knockout



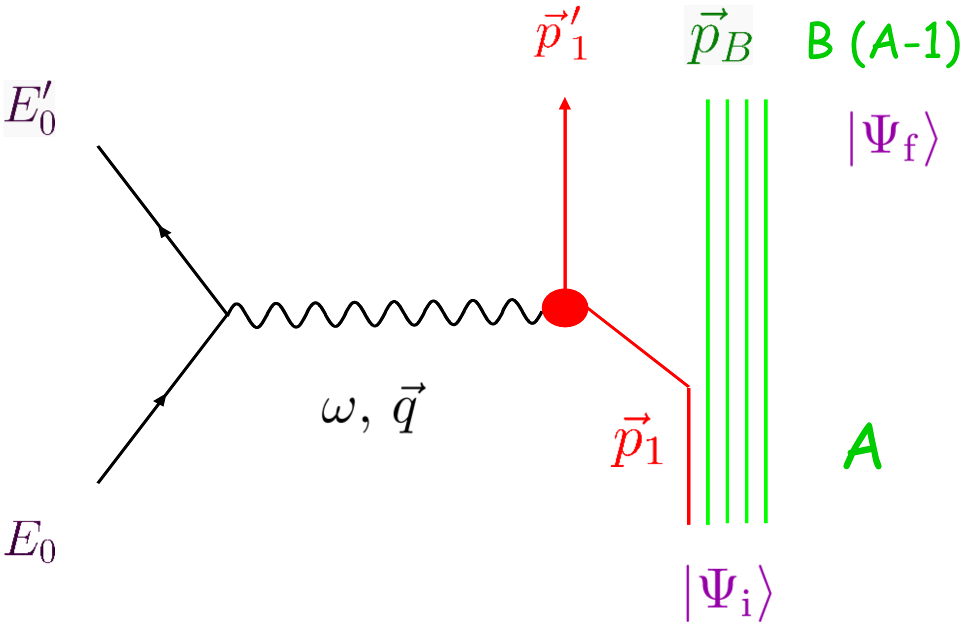
proton-hole states

properties of bound protons

validity and limit of a MF description

nuclear correlations

(e,e'p)



$$E_{\rm m} = \omega - \frac{{p'_1}^2}{2m} - \frac{{p_B}^2}{2m(A-1)} = W_B^* - W_A$$ missing energy

$$\vec{p}_{\rm m} = \vec{q} - \vec{p}\,'_1 = -\vec{p}_1 = \vec{p}_B$$ missing momentum

E_m

exclusive reaction

ONE-HOLE SPECTRAL FUNCTION

$$S(\vec{p_1}, \vec{\bar{p}}_1; E_m) = \langle \Psi_{\rm i} | a^{+}_{\vec{\bar{p}}_1} \delta(E_m - H) a_{\vec{p_1}} | \Psi_{\rm i} \rangle$$

$$\vec{p}_1 = \vec{\bar{p}}_1$$

joint probability of removing from the target a nucleon p_1
leaving the residual nucleus in a state with energy E_m

E_m

exclusive reaction

ONE-HOLE SPECTRAL FUNCTION

$$S(\vec{p_1},\vec{\bar{p}}_1;E_m) = \langle \Psi_{\mathrm{i}} | a^{+}_{\vec{\bar{p}}_1} \delta(E_m - H) a_{\vec{p_1}} | \Psi_{\mathrm{i}} \rangle$$

$\vec{p_1} = \vec{\bar{p}}_1$

joint probability of removing from the target a nucleon p_1 leaving the residual nucleus in a state with energy E_m

$$\int S(\vec{p_1},\vec{\bar{p}}_1;E_m)\mathrm{d}E_m = \boxed{\rho(\vec{p_1},\vec{\bar{p}}_1)}$$

inclusive reaction : one-body density

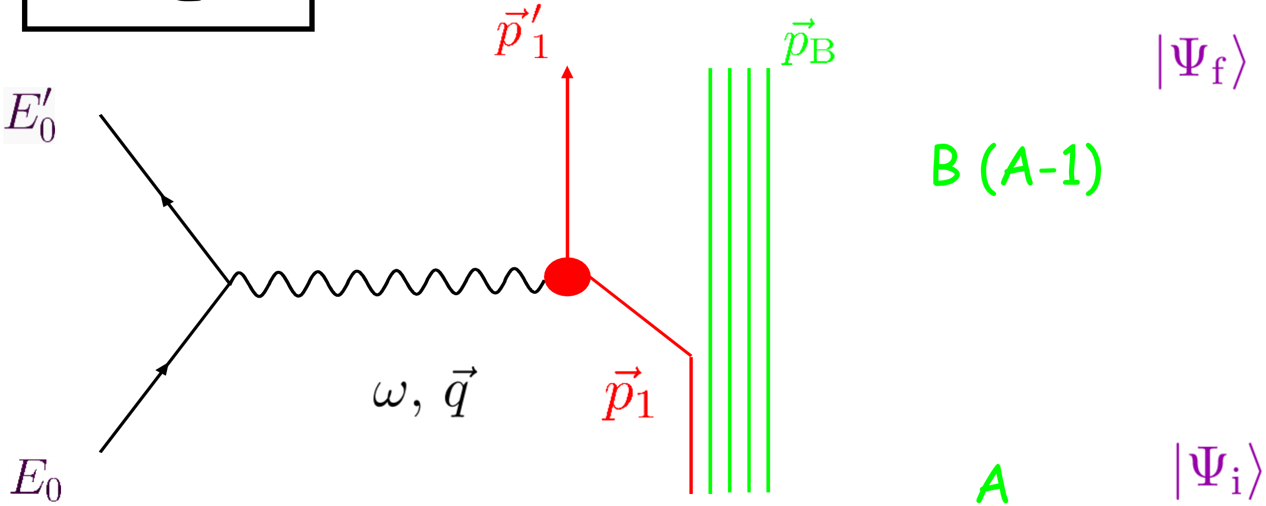
$\vec{p_1} = \vec{\bar{p}}_1$ ⇒ $\rho(\vec{p_1},\vec{\bar{p}}_1) = \boxed{F(\vec{p_1})}$

MOMENTUM DISTRIBUTION

$$F(\vec{p_1}) = \int |\Psi_{\mathrm{i}}(\vec{p_1},\vec{p_2},....,\vec{p_A}|^2 \mathrm{d}\vec{p_2}....\mathrm{d}\vec{p_A}$$

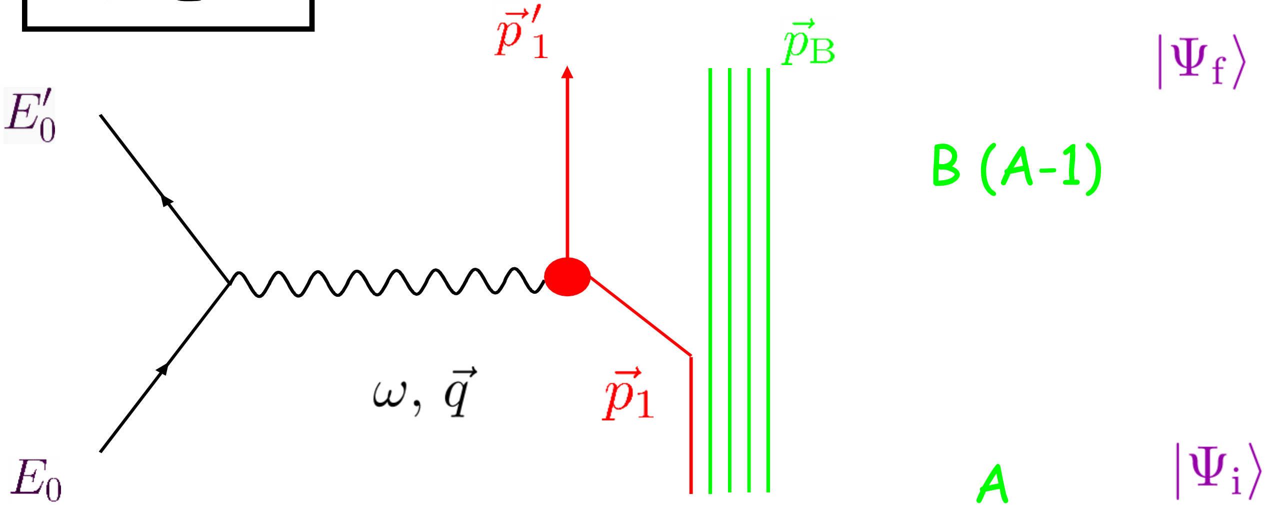
probability of finding in the target a nucleon with momentum p_1

OPEA



$$\sigma = K L^{\mu\nu} \ W_{\mu\nu}$$

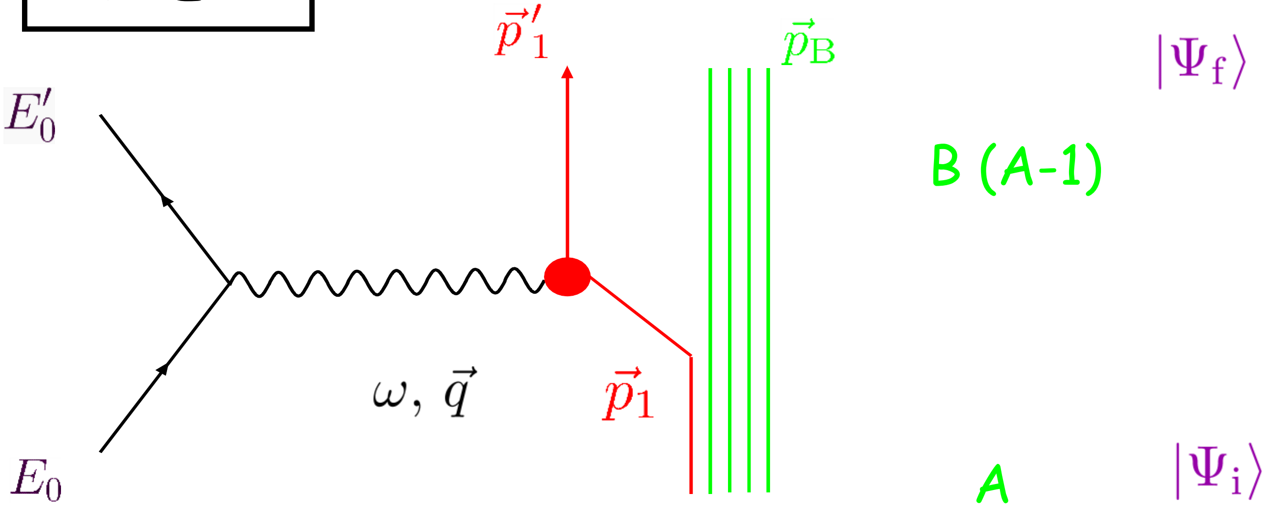
OPEA



$$\sigma = K L^{\mu\nu} \; W_{\mu\nu}$$

lepton tensor

OPEA

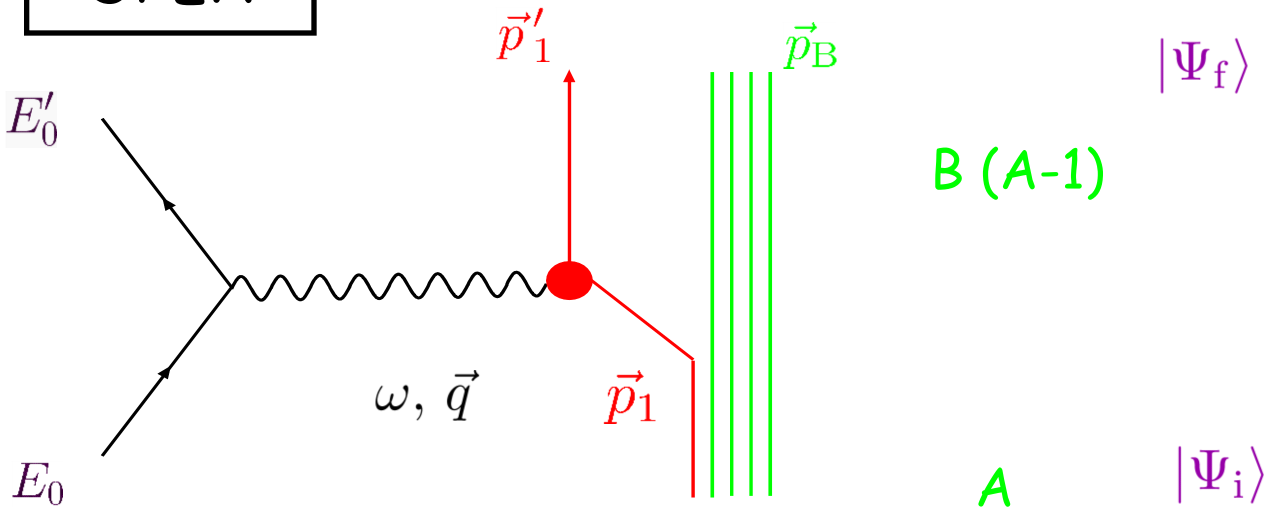


$$\sigma = K L^{\mu\nu} \; W_{\mu\nu}$$

↓

hadron tensor

OPEA



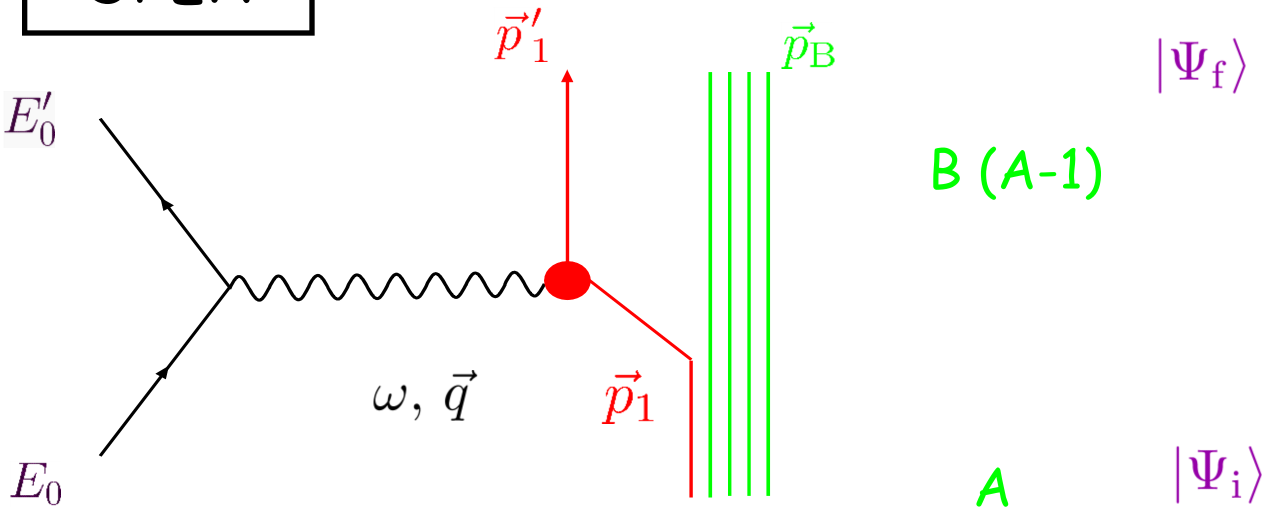
$$\sigma = K L^{\mu\nu} \ W_{\mu\nu}$$

hadron tensor

$$W^{\mu\nu} = \overline{\sum_{\rm i,f}} J^{\mu}(\vec{q}) J^{\nu *}(\vec{q}) \delta(E_{\rm i} - E_{\rm f})$$

$$J^{\mu}(\vec{q}) = \int {\rm e}^{{\rm i}\vec{q}\cdot\vec{r}} \langle \Psi_{\rm f} \mid \hat{J}^{\mu}(\vec{r}) \mid \Psi_{\rm i} \rangle {\rm d}\vec{r}$$

OPEA



$$\sigma = K L^{\mu\nu} \ W_{\mu\nu}$$

$$\big\downarrow$$

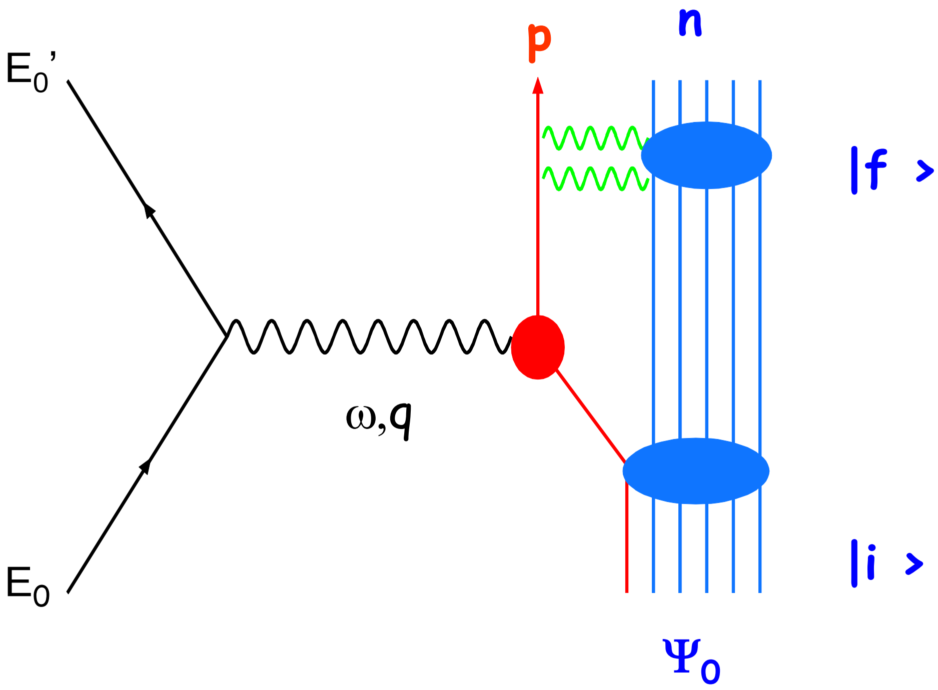
hadron tensor

$$W^{\mu\nu} = \overline{\sum_{\mathrm{i,f}}} J^{\mu}(\vec{q}) J^{\nu *}(\vec{q}) \delta(E_{\mathrm{i}} - E_{\mathrm{f}})$$

$$J^{\mu}(\vec{q}) = \int \mathrm{e}^{\mathrm{i}\vec{q}\cdot\vec{r}} \boxed{\langle \Psi_{\mathrm{f}} \mid \hat{J}^{\mu}(\vec{r}) \mid \Psi_{\mathrm{i}} \rangle} \mathrm{d}\vec{r}$$

(e,e'p)

- exclusive reaction n
- DKO mechanism: the probe interacts through a one-body current with one nucleon which is then emitted the remaining nucleons are spectators
- impulse approximation IA



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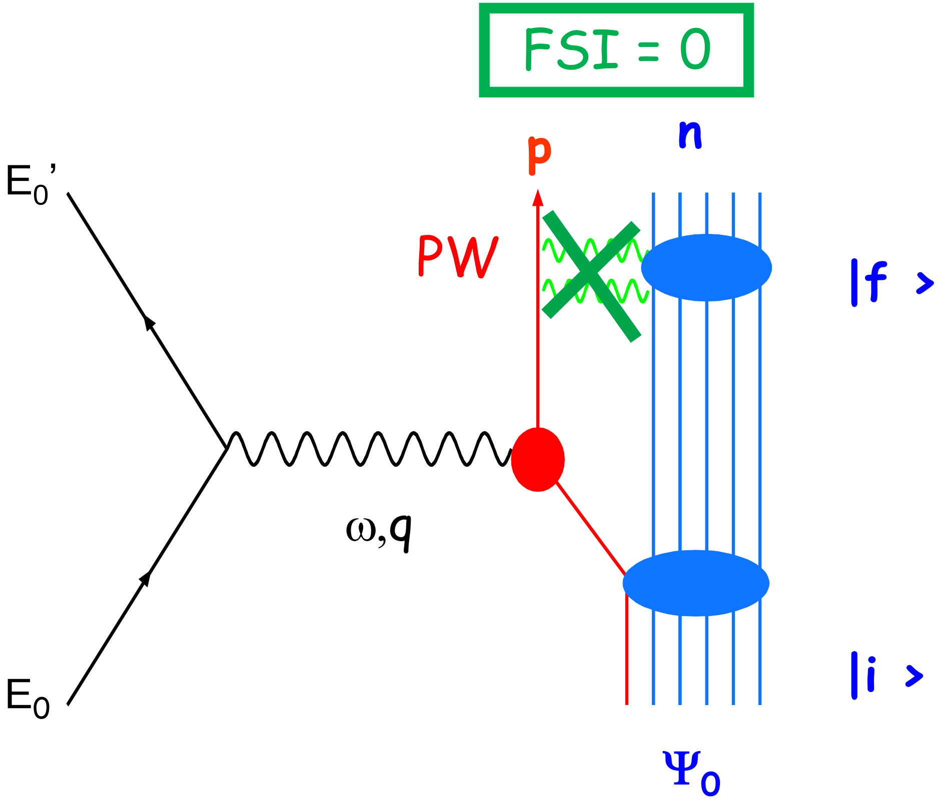

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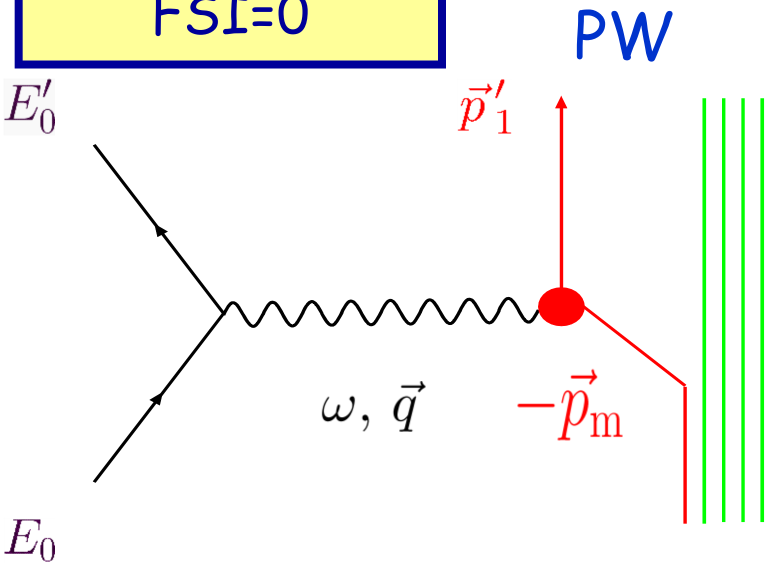


PLANE-WAVE IMPULSE APPROXIMATION

PWIA

factorized cross section

$$\sigma = K\ \sigma_{\rm ep}\ \ S(E_{\rm m}, -\vec{p}_{\rm m})$$

⇩

spectral function

$$S(E_{\rm m}, -\vec{p}_{\rm m}) = \sum_n\ \lambda_n(E_{\rm m})\ \ |\phi_n(-\vec{p}_{\rm m})|^2$$

⇩ ⇩

spectroscopic factor

overlap function

$$S(E_\mathrm{m}, -\vec{p}_\mathrm{m}) = \sum_n \lambda_n(E_\mathrm{m}) \; |\phi_n(-\vec{p}_\mathrm{m})|^2$$

spectroscopic factor — overlap function

For each E_m the mom. dependence of the SF is given by the mom. distr. of the quasi-hole states n produced in the target nucleus at that energy and described by the normalized OVF

The spectroscopic factor gives the probability that n is a pure hole state in the target.

IPSM

ϕ_n s.p. SM state

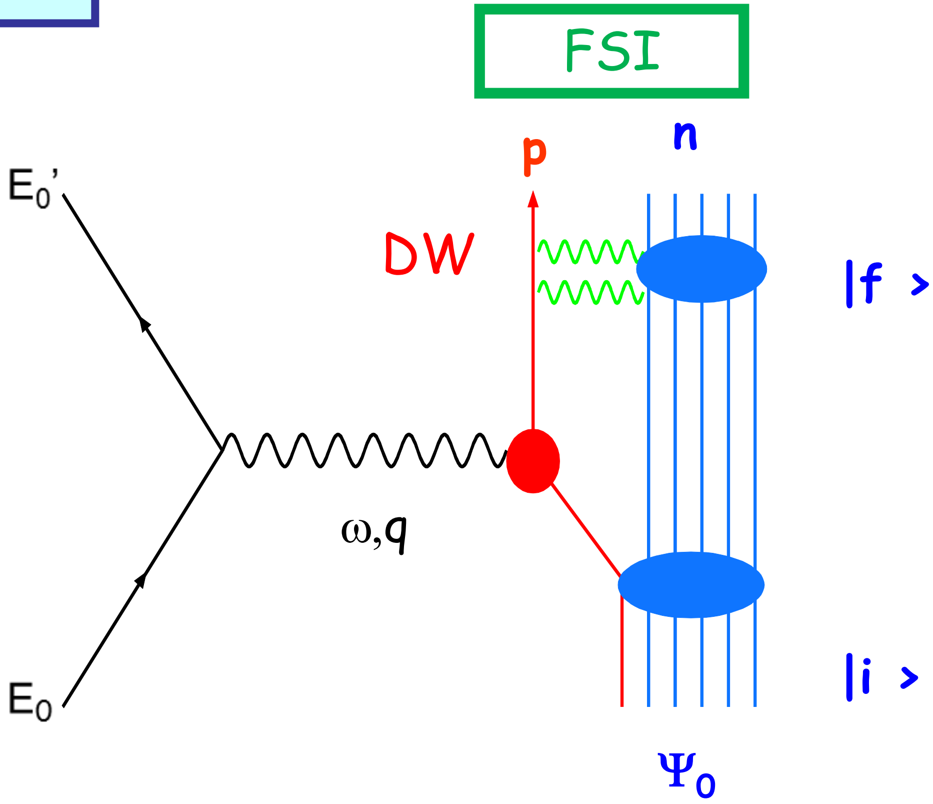
λ_n 1 occupied SM states

0 empty SM states

There are correlations and the strength of the quasi-hole state is fragmented over a set of s.p. states $0 \leq \lambda_n \leq 1$

DWIA (e,e′p)

- exclusive reaction n
- DKO IA
- FSI DWIA
- unfactorized c.s.
- non diagonal SF



$$\langle f \mid J^{\mu}(\boldsymbol{q}) \mid i \rangle \Rightarrow \lambda_n^{1/2} \; \langle \chi_{\boldsymbol{p}}^{(-)} \mid j^{\mu}(\boldsymbol{q}) \mid \phi_n \rangle$$

Direct knockout DWIA (e,e′p)

$$\lambda_n^{1/2}\ \langle \chi^{(-)} \mid j^\mu \mid \phi_n \rangle$$

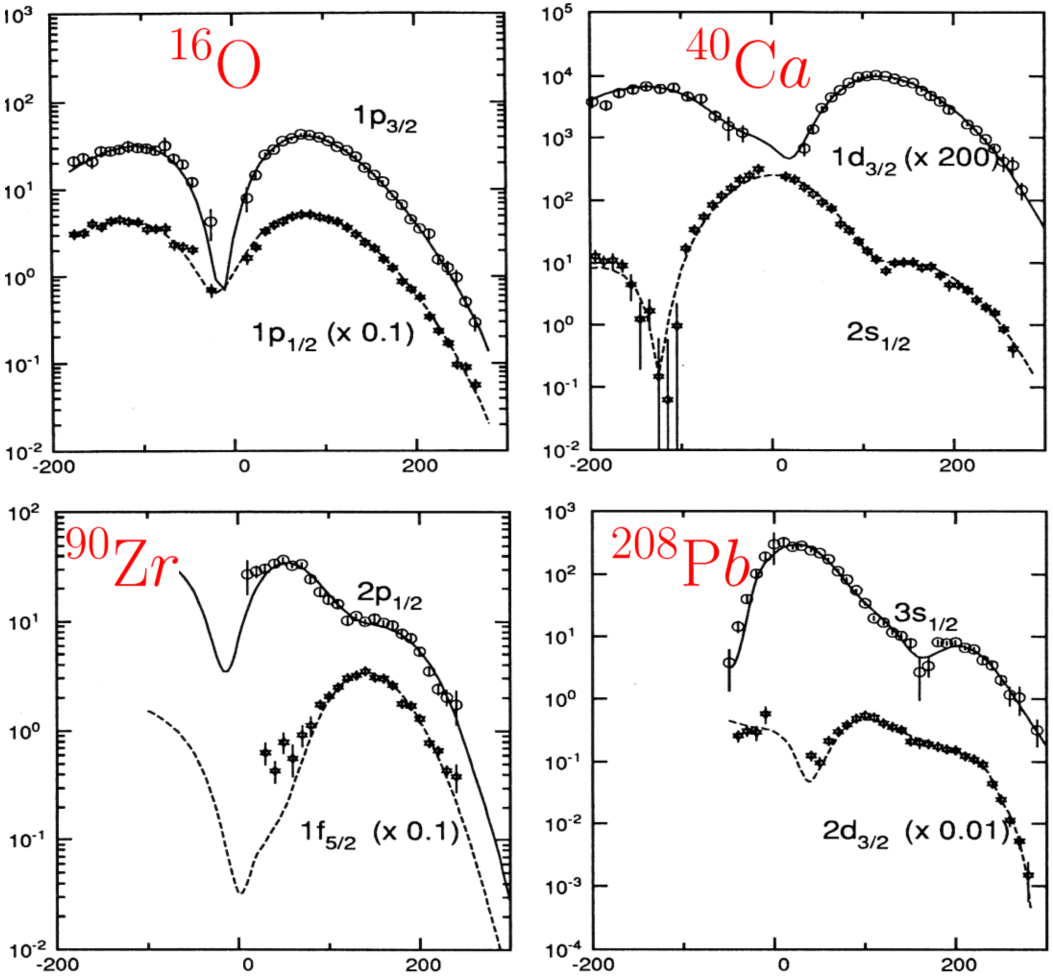
- j^μ one-body nuclear current
- $\chi^{(-)}$ s.p. scattering w.f. $H^+(\omega+E_m)$
- ϕ_n s.p. bound state overlap function $H(-E_m)$
- λ_n spectroscopic factor
- $\chi^{(-)}$ and ϕ consistently derived as eigenfunctions of a Feshbach optical model Hamiltonian

DWIA calculations

- phenomenological ingredients usually adopted
- $\chi^{(-)}$ phenomenological optical potential
- ϕ_n phenomenological s.p. wave functions WS, HF (some calculations including correlations are available)
- λ_n extracted in comparison with data: reduction factor applied to the calculated c.s. to reproduce the magnitude of the experimental c.s.
- DWIA calculations excellent description of (e,e′p) data

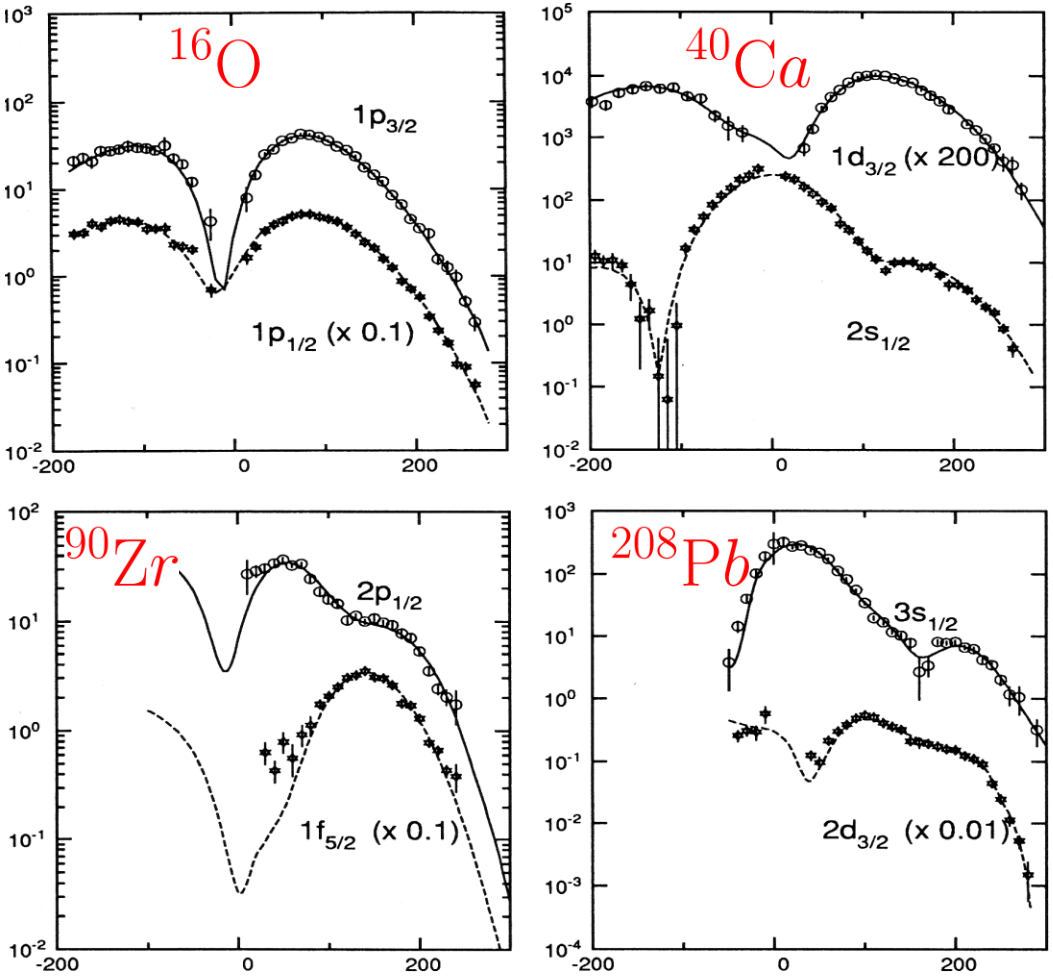
Experimental data: E_m and p_m distributions

Experimental data: p_m distribution



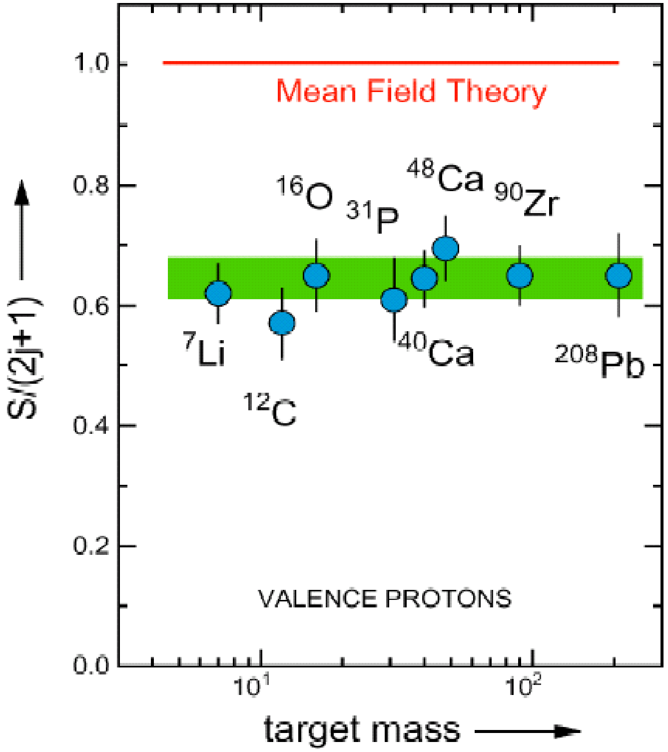
NIKHEF data & CDWIA calculations
1993

Experimental data: p_m distribution



reduction factors applied:
spectroscopic factors

0.6 - 0.7



NIKHEF data & CDWIA calculations
1993

SPECTROSCOPIC FACTORS and NN CORRELATIONS

- depletion due to NN correlations
- SRC Short-Range Correlations:

  short-range repulsion of NN interaction pp pairs
- TC Tensor Correlations:

  tensor component of NN interaction pn pairs
- LRC Long-Range Correlations:

  long-range part of NN interaction

  collective excitations of nucleons at the nuclear surface

SPECTROSCOPIC FACTORS and NN CORRELATIONS

- from different independent investigations our calculations with correlated w.f. + C. Barbieri PRL 103 202502 (2009)
- SRC account for only a few % of the depletion, up to 10-15 % with TC
- LRC give the main contribution to the depletion

SRC

- account for only a small part of the depletion
- depletion compensated by the admixture of high-momentum components of the s.p. w.f.
- SRC effects on (e,e′p) cross sections at high p_m are small for low-lying states
- calculations of the 1BDM and of the momentum distribution indicate that the missing strength due to SRC is found at large p_m and E_m, beyond the continuum threshold, where many processes are present and a clear-cut identification of SRC appears very difficult
- in exclusive (e,e′p) one does not measure the mom. distrib. but only the SF at specific (low) values of E_m

SRC

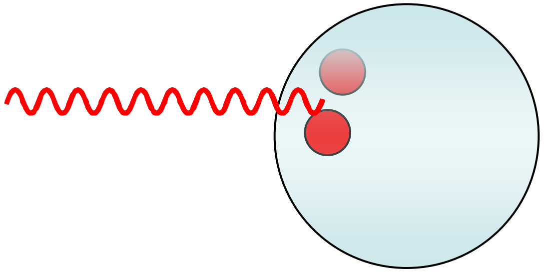
- (e,e′p) at high E_m
- TWO-NUCLEON KNOCKOUT

SRC

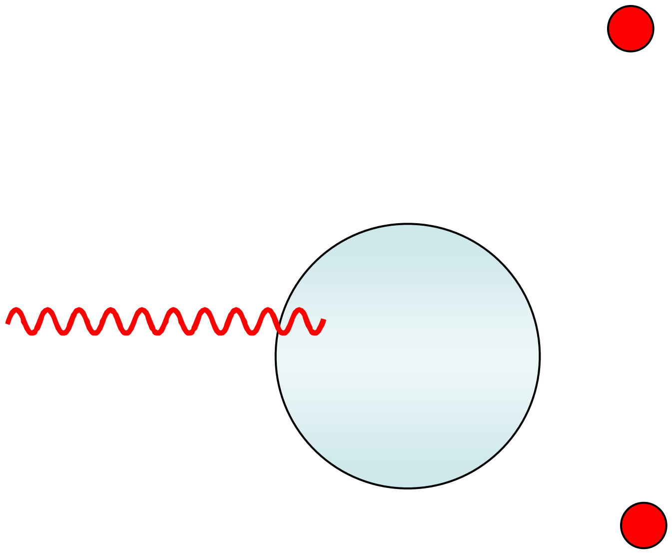
- (e,e′p) at high E_m
- TWO-NUCLEON KNOCKOUT ⇦

TWO-NUCLEON KNOCKOUT

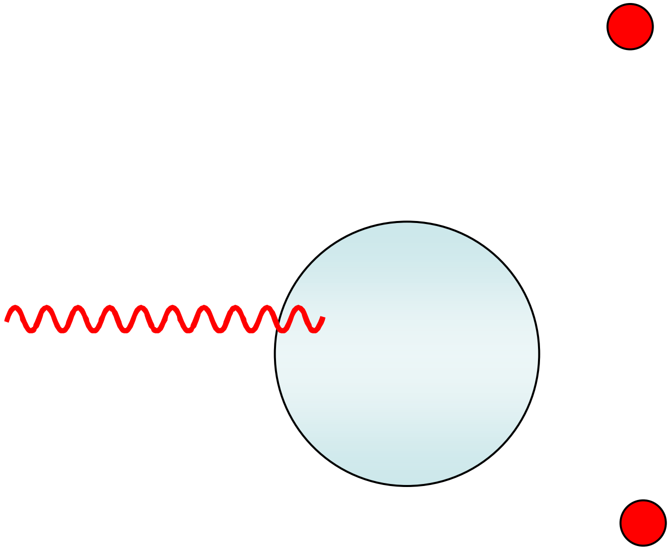
TWO-NUCLEON KNOCKOUT



TWO-NUCLEON KNOCKOUT



TWO-NUCLEON KNOCKOUT



DKO:

restricted kinematic conditions

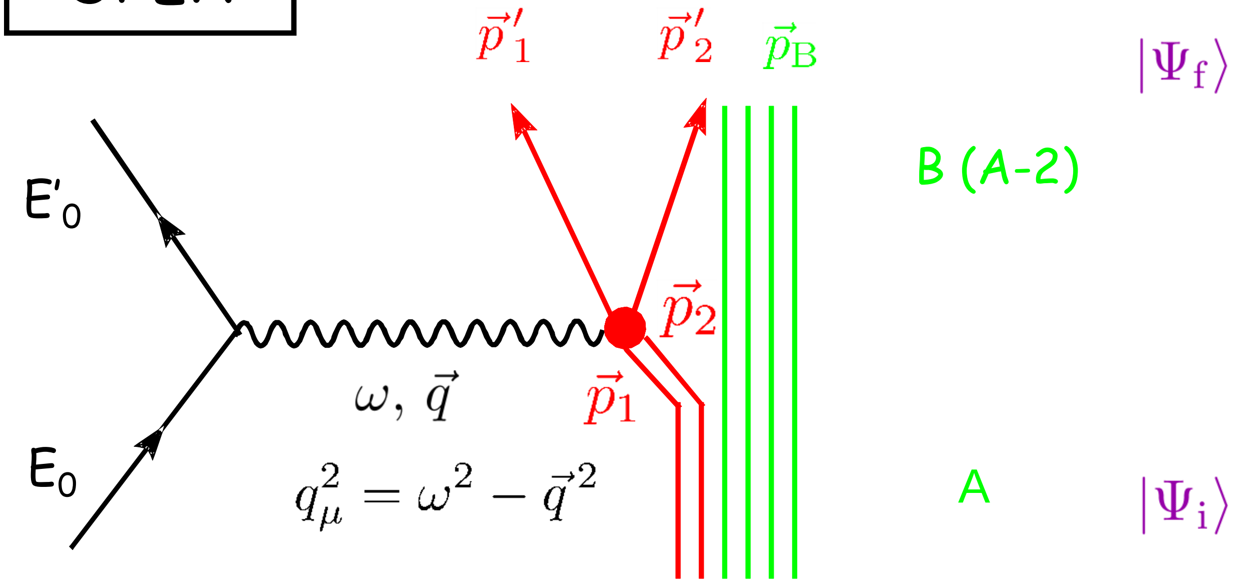
between the QE and Δ peak

back to back kinematics

exclusive reactions low values of E_x

OPEA

(e,e'NN)



$$q_\mu^2 = \omega^2 - \vec{q}^{\,2}$$

$$E_\mathrm{m} = \omega - \frac{{p'_1}^2}{2m} - \frac{{p'_2}^2}{2m} - \frac{{p_\mathrm{B}}^2}{2m(A-1)} = W_B^* - W_A$$ missing energy

$$\vec{p}_\mathrm{m} = \vec{q} - \vec{p}'_1 - \vec{p}'_2 = -\vec{P} = -(\vec{p}_1 + \vec{p}_2) = \vec{p}_B$$ missing momentum

E_m

exclusive reaction

TWO-HOLE SPECTRAL FUNCTION

$$S(p_1, p_2, \bar{p}_1, \bar{p}_2; E_m) = \langle \Psi_\mathrm{i} | a^+_{\bar{p}_2} a^+_{\bar{p}_1} \delta(E_m - H) a_{\bar{p}_1} a_{\bar{p}_2} | \Psi_\mathrm{i} \rangle$$

$\bar{p}_1 = p_1, \bar{p}_2 = p_2$

joint probability of removing from the target a pair of nucleons p_1 p_2 leaving the residual nucleus in a state with energy E_m

inclusive reaction :

TWO-BODY DENSITY

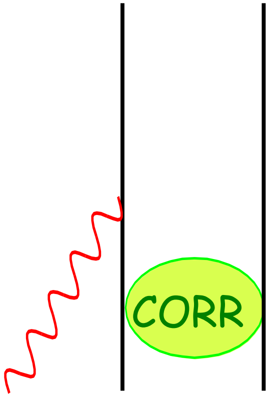
$$\int S(p_1, p_2, \bar{p}_1, \bar{p}_1; E_m) \mathrm{d}E_m = \rho_2(p_1, p_2; \bar{p}_1, \bar{p}_2)$$

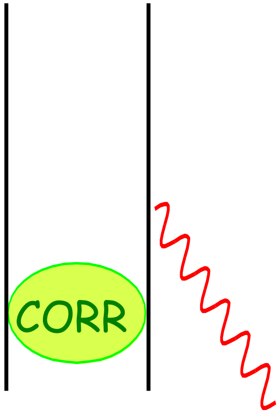
$$\rho_2(r_1, r_2, r_1, r_2) = \int |\Psi_\mathrm{i}(r_1, r_2, r_3, ...r_\mathrm{A})|^2 \mathrm{d}r_3 ....\mathrm{d}r_\mathrm{A} = C(r_1, r_2)$$

PAIR CORRELATION FUNCTION

probability of finding in the target a nucleon at r_1 if another nucleon is known to be at r_2

TWO-NUCLEON KNOCKOUT

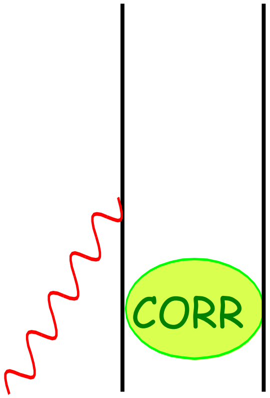


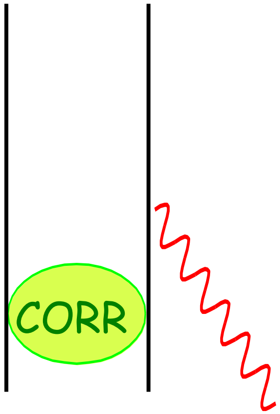


1-body current OB

NN correlations

TWO-NUCLEON KNOCKOUT





1-body current OB

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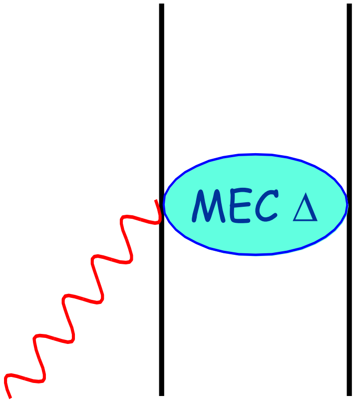
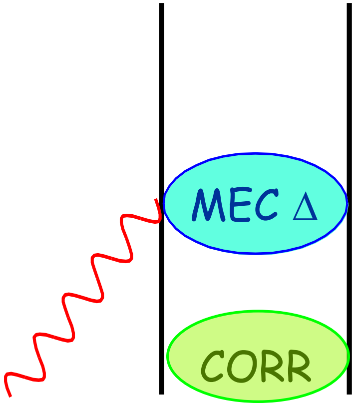


2-body currents TB

TWO-NUCLEON KNOCKOUT

1-body current OB

NN correlations

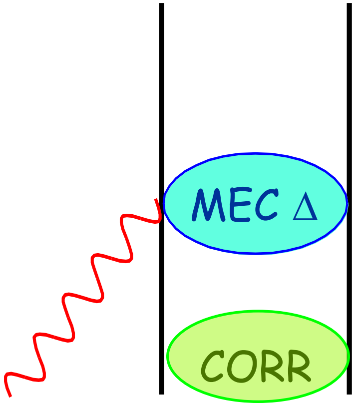


correlations affect also the reaction process due to TB currents

TWO-NUCLEON KNOCKOUT

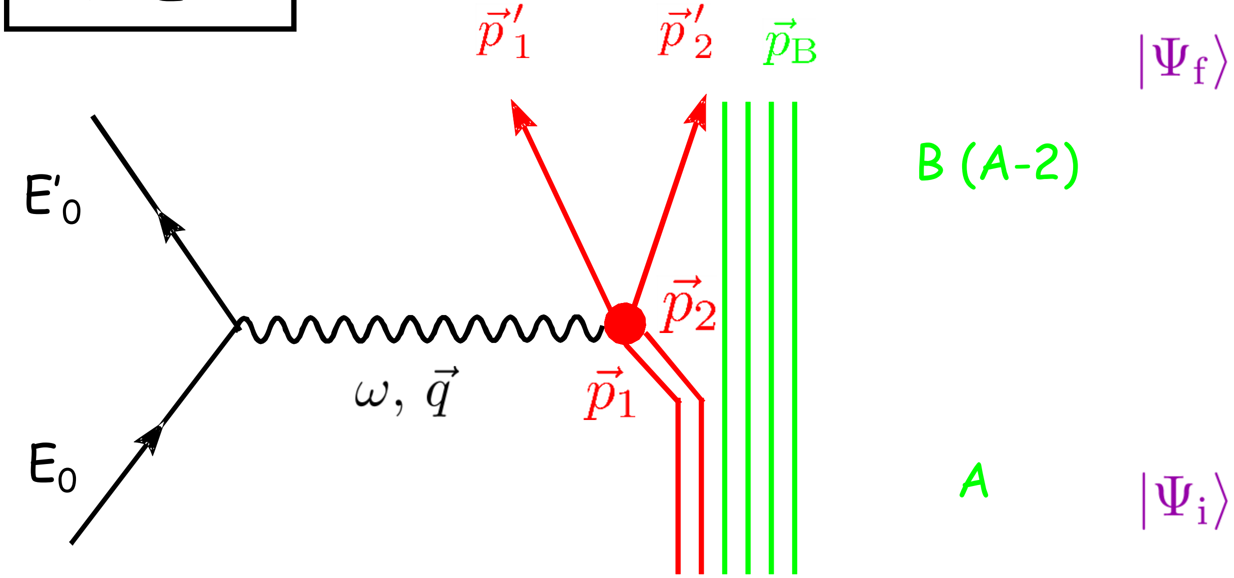
1-body current OB

NN correlations



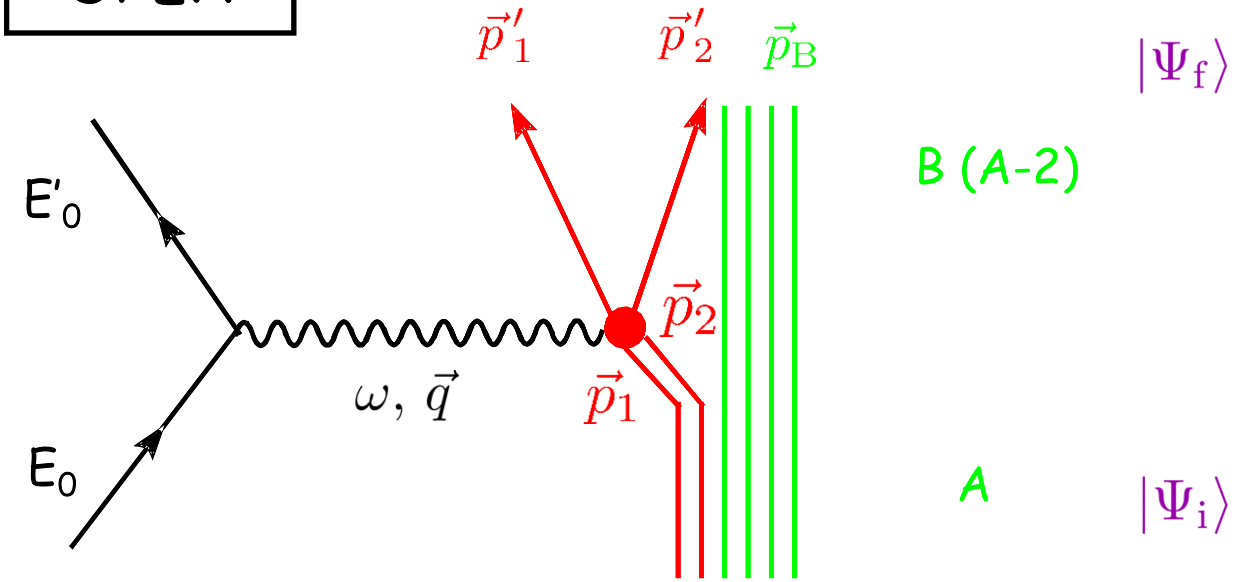
correlations affect also the reaction process due to TB currents

OPEA



$$\sigma = K L^{\mu\nu}\ W_{\mu\nu}$$

OPEA



$$\sigma = K L^{\mu\nu}\ W_{\mu\nu}$$

hadron tensor

$$W^{\mu\nu} = \overline{\sum_{\mathrm{i,f}}} J^{\mu}(\vec{q}) J^{\nu *}(\vec{q}) \delta(E_{\mathrm{i}} - E_{\mathrm{f}})$$

$$J^{\mu}(\vec{q}) = \int \mathrm{e}^{\mathrm{i}\vec{q}\cdot\vec{r}} \langle \Psi_{\mathrm{f}} \mid \hat{J}^{\mu}(\vec{r}) \mid \Psi_{\mathrm{i}} \rangle \mathrm{d}\vec{r}$$

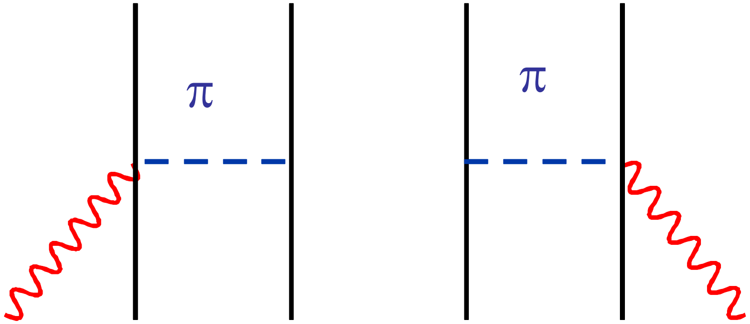
$$J^{\mu}(\vec{q}) = \int \mathrm{e}^{\mathrm{i}\vec{q}\cdot\vec{r}} \langle \Psi_{\mathrm{f}} \mid \hat{J}^{\mu}(\vec{r}) \mid \Psi_{\mathrm{i}} \rangle \mathrm{d}\vec{r}$$

- **exclusive reaction**
- **DKO mechanism**

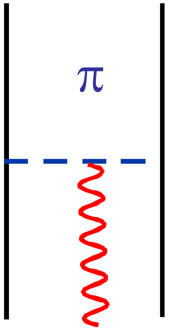
$$\boxed{J^{\mu}(\vec{q}) = \int \mathrm{e}^{\mathrm{i}\vec{q}\cdot\vec{r}} \chi^{(-)*}(\vec{r}_1, \vec{r}_2) J^{\mu}(\vec{r}_1, \vec{r}_2, \vec{r}) \phi(\vec{r}_1, \vec{r}_2) \mathrm{d}\vec{r} \mathrm{d}\vec{r}_1 \mathrm{d}\vec{r}_2}$$

- $J^{\mu}=J^{(1)\mu}+J^{(2)\mu}$ nuclear current
- $\chi^{(-)}(r_1,r_2)=<\Phi_B\, r_1\, r_2|\Psi_f>$ two nucleon scattering w.f. $H^+(\omega+Em)$
- $\phi\,(r_1,r_2) = <\Phi_B\, r_1\, r_2|\,\Psi_i>$ two-nucleon overlap function $H(-Em)$
- $\chi^{(-)}$ and ϕ consistently derived as eigenfunctions of a Feshbach-type optical model Hamiltonian

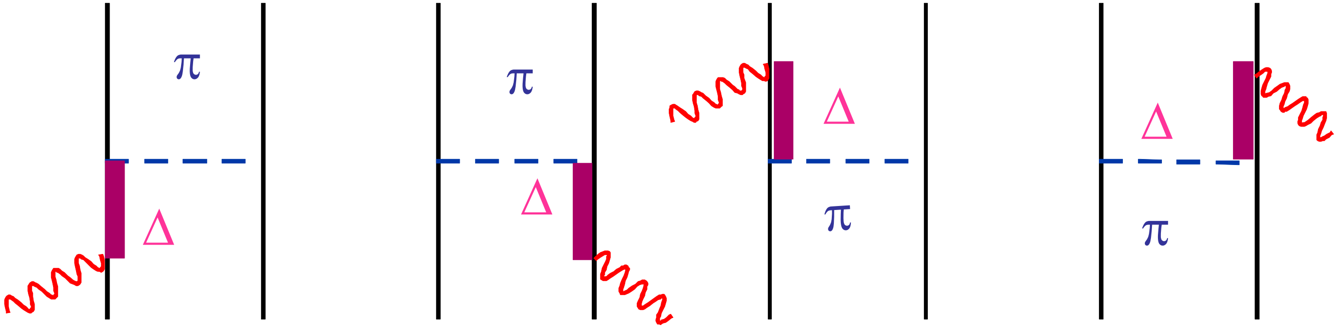
TWO-BODY CURRENTS



seagull

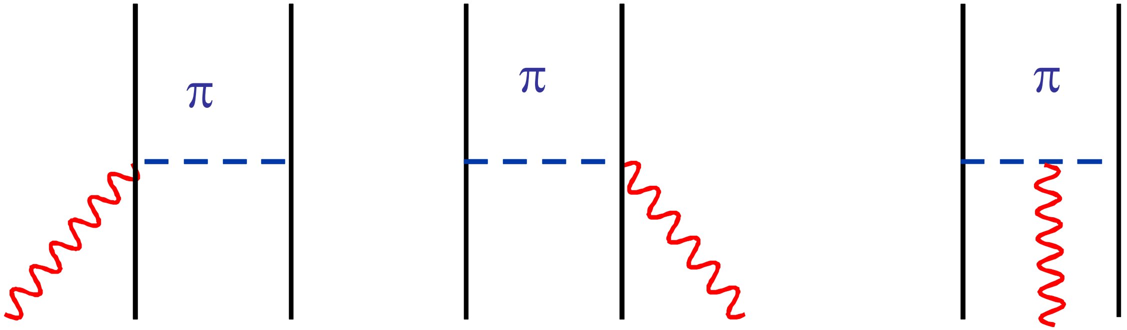


pion-in-flight



Δ isobar current

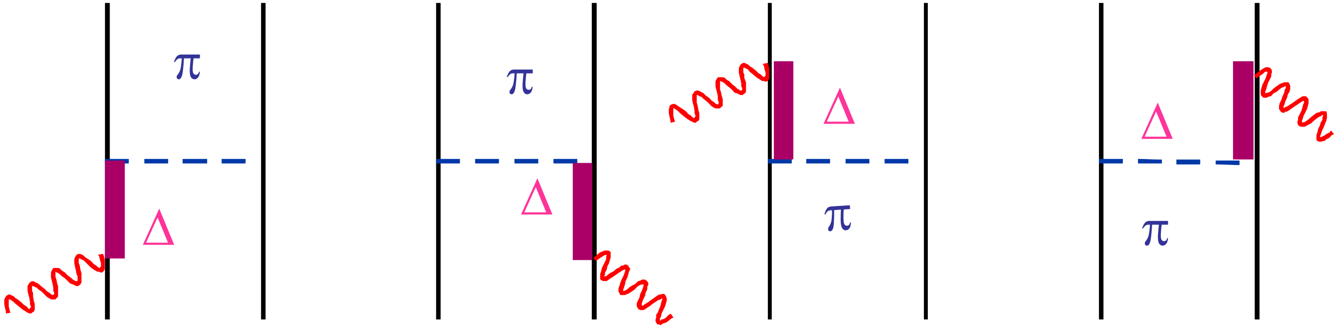
TWO-BODY CURRENTS



seagull

pion-in-flight

pn knockout



Δ isobar current

pn and pp knockout

FINAL-STATE INTERACTION

$$J^{\mu}(\vec{q}) = \int \mathrm{e}^{\mathrm{i}\vec{q}\cdot\vec{r}} \boxed{\chi^{(-)*}(\vec{r}_1, \vec{r}_2)} J^{\mu}(\vec{r}_1, \vec{r}_2, \vec{r}) \phi(\vec{r}_1, \vec{r}_2) \mathrm{d}\vec{r} \mathrm{d}\vec{r}_1 \mathrm{d}\vec{r}_2$$

2N and residual nucleus : 3-body problem

FINAL-STATE INTERACTION

$$J^\mu(\vec{q}) = \int \mathrm{e}^{\mathrm{i}\vec{q}\cdot\vec{r}} \boxed{\chi^{(-)*}(\vec{r}_1,\vec{r}_2)} J^\mu(\vec{r}_1,\vec{r}_2,\vec{r})\phi(\vec{r}_1,\vec{r}_2)\mathrm{d}\vec{r}\mathrm{d}\vec{r}_1\mathrm{d}\vec{r}_2$$

2N and residual nucleus : 3-body problem

$V= V_{1B} + V_{2B} +V_{12}$

FINAL-STATE INTERACTION

$$J^\mu(\vec{q}) = \int \mathrm{e}^{\mathrm{i}\vec{q}\vec{r}}\chi^{(-)*}(\vec{r}_1,\vec{r}_2)J^\mu(\vec{r}_1,\vec{r}_2,\vec{r})\phi(\vec{r}_1,\vec{r}_2)\mathrm{d}\vec{r}\mathrm{d}\vec{r}_1\mathrm{d}\vec{r}_2$$

2N and residual nucleus : 3-body problem

$V = V_{1B} + V_{2B} + V_{12}$

DW

phenomenological optical potential $\chi^{(-)}(r_1,r_2)=\chi^{(-)}(r_1)\,\chi^{(-)}(r_2)$ DW

FINAL-STATE INTERACTION

$$J^{\mu}(\vec{q}) = \int \mathrm{e}^{\mathrm{i}\vec{q}\cdot\vec{r}} \boxed{\chi^{(-)*}(\vec{r}_1,\vec{r}_2)} J^{\mu}(\vec{r}_1,\vec{r}_2,\vec{r})\phi(\vec{r}_1,\vec{r}_2)\mathrm{d}\vec{r}\mathrm{d}\vec{r}_1\mathrm{d}\vec{r}_2$$

2N and residual nucleus : 3-body problem

$V = V_{1B} + V_{2B} + V_{12}$

NN-FSI

DW

phenomenological optical potential $\chi^{(-)}(r_1,r_2)=\chi^{(-)}(r_1)\,\chi^{(-)}(r_2)$

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NN-FSI perturbative approach based on 3-body scattering theory

M. Schwamb, S. Boffi, C. Giusti, F.D. Pacati Eur. Phys. J. A17 (2003) 7; A20 (2004) 233

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NN-FSI perturbative approach based on 3-body scattering theory

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⇒ $\chi^{(-)}(r_1,r_2)=\chi^{(-)}(r_1)\ \chi^{(-)}(r_2)\ F(r_1,r_2)$ **DW-NN**

TWO-NUCLEON OVERLAP

$$J^{\mu}(\vec{q}) = \int \mathrm{e}^{\mathrm{i}\vec{q}\cdot\vec{r}} \chi^{(-)*}(\vec{r}_1, \vec{r}_2) J^{\mu}(\vec{r}_1, \vec{r}_2, \vec{r}) \boxed{\phi(\vec{r}_1, \vec{r}_2)} \mathrm{d}\vec{r}\mathrm{d}\vec{r}_1\mathrm{d}\vec{r}_2$$

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IPSM correlations neglected:

Φ_B 2h state in the SM J^{π} $(n_1\ l_1\ j_1, n_2, l_2, j_2)^{-1}$

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$\phi_{JMT}{}^{SM}(r_1\ \sigma_1\ \tau_1,\ r_2\ \sigma_2\ \tau_2)$ SM pair function ⇦

TWO-NUCLEON OVERLAP

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$\phi_{JMT}{}^{SM}(r_1\ \sigma_1\ \tau_1,\ r_2\ \sigma_2\ \tau_2)\ F^{SRC}(|r_1-r_2|)$ SM-SRC

$F^{SRC}(|r_1-r_2|)$ Jastrow corr. function central state-independent SRC

TWO-NUCLEON OVERLAP

$$J^{\mu}(\vec{q}) = \int \mathrm{e}^{\mathrm{i}\vec{q}\cdot\vec{r}} \chi^{(-)*}(\vec{r}_1, \vec{r}_2) J^{\mu}(\vec{r}_1, \vec{r}_2, \vec{r}) \phi(\vec{r}_1, \vec{r}_2) \mathrm{d}\vec{r} \mathrm{d}\vec{r}_1 \mathrm{d}\vec{r}_2$$

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more complete and sophisticated approach:

ϕ obtained from microscopic calculations of the NN spectral function of ^{16}O include consistently different types of correlations SRC, TC, LRC

C. Giusti, F.D. Pacati, K. Allaart, W. Geurts, H . Muether, W.H. Dickhoff, PRC 54 (1996) 1144

C. Barbieri, C. Giusti, F.D. Pacati, W.H. Dickhoff PRC 70 (2004) 014606

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^{16}O suitable target due to the presence of discrete final states in the E_x spectrum of ^{14}C and ^{14}N well separated in energy

experimental data available for pp and pn knockout off ^{16}O

TWO-NUCLEON OVERLAP

$$J^{\mu}(\vec{q}) = \int \mathrm{e}^{\mathrm{i}\vec{q}\cdot\vec{r}} \chi^{(-)*}(\vec{r}_1,\vec{r}_2) J^{\mu}(\vec{r}_1,\vec{r}_2,\vec{r}) \phi(\vec{r}_1,\vec{r}_2) \mathrm{d}\vec{r} \mathrm{d}\vec{r}_1 \mathrm{d}\vec{r}_2$$

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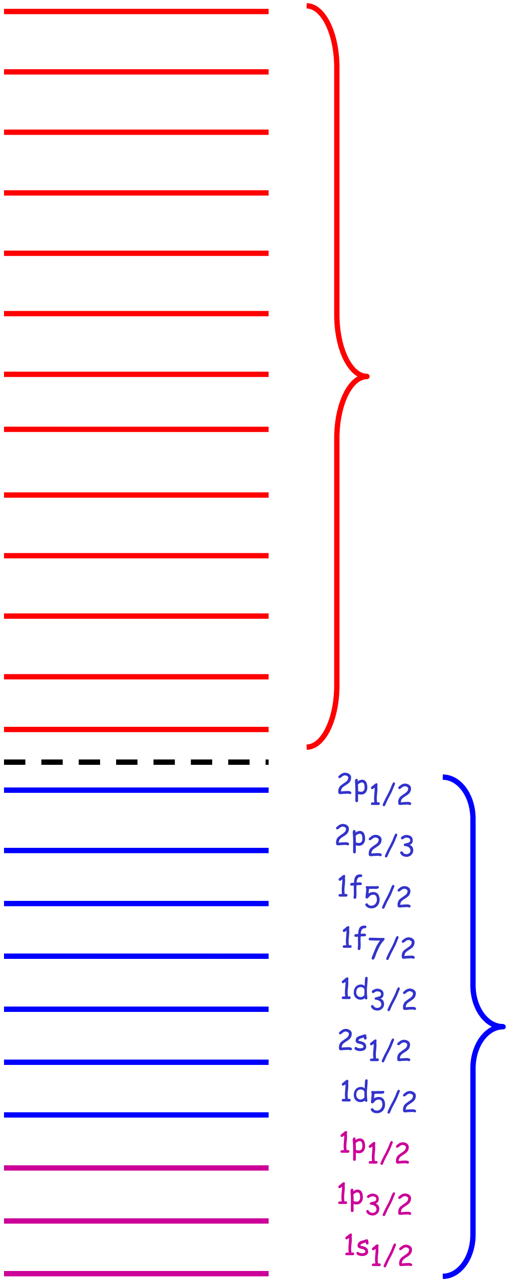
C. Barbieri, C. Giusti, F.D. Pacati, W.H. Dickhoff PRC 70 (2004) 014606 ⬅

The two-nucleon overlap is obtained from a self-consistent calculation of the 2hGF, where the coupling of nucleons and collective excitations of the system is calculated with realistic NN forces employing the Faddeev RPA method

SETUP TO INCLUDE SRC AND LRC

SM space



$2p_{1/2}$

$2p_{2/3}$

$1f_{5/2}$

$1f_{7/2}$

$1d_{3/2}$

$2s_{1/2}$

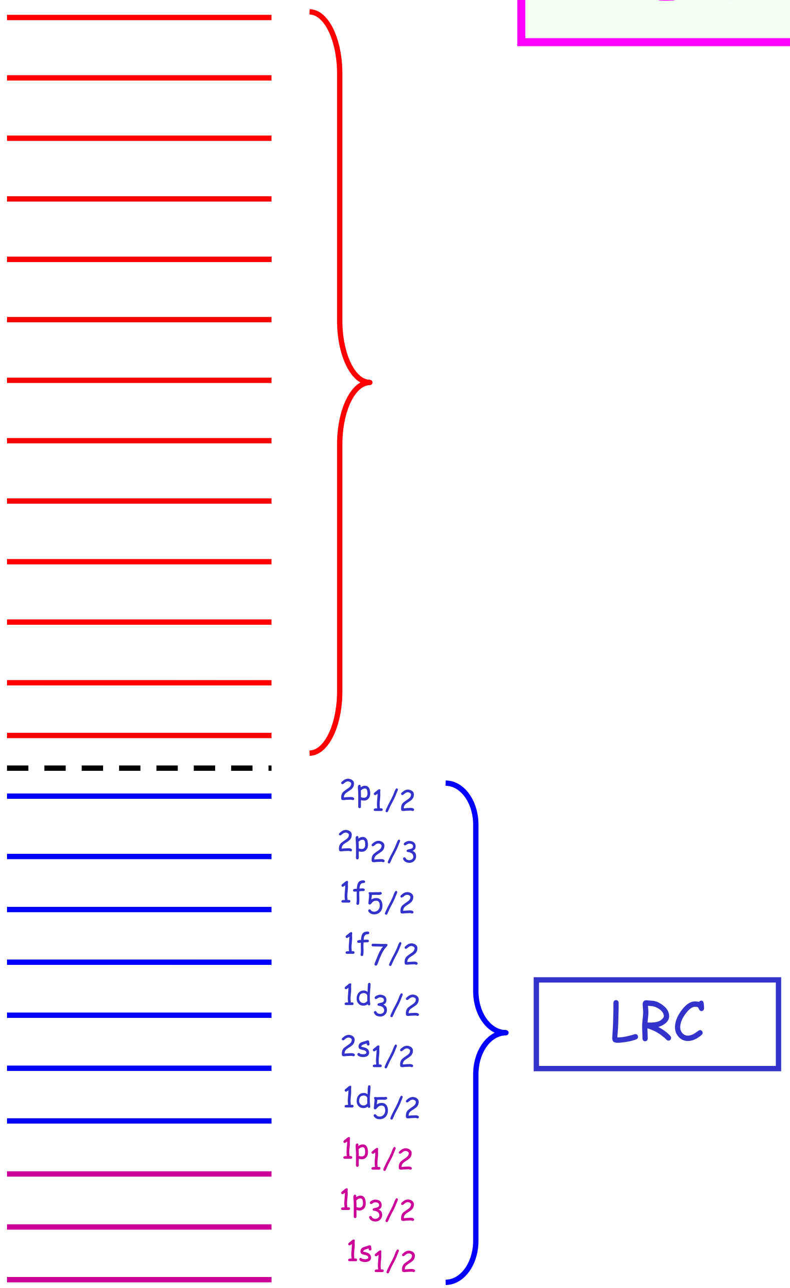
$1d_{5/2}$

$1p_{1/2}$

$1p_{3/2}$

$1s_{1/2}$

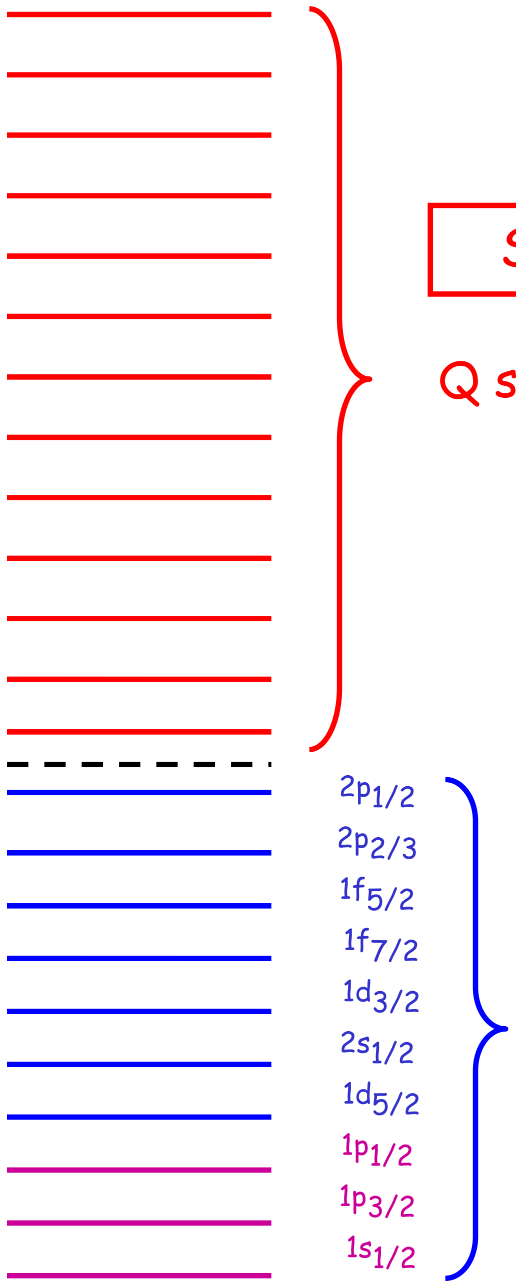
SETUP TO INCLUDE SRC AND LRC



LRC and the LR part of TC computed using the self-consistent Green's function formalism in a 10 shell h.o. basis large enough to account for the main collective features that influence the pair removal amplitudes

SETUP TO INCLUDE SRC AND LRC

SM space



SRC

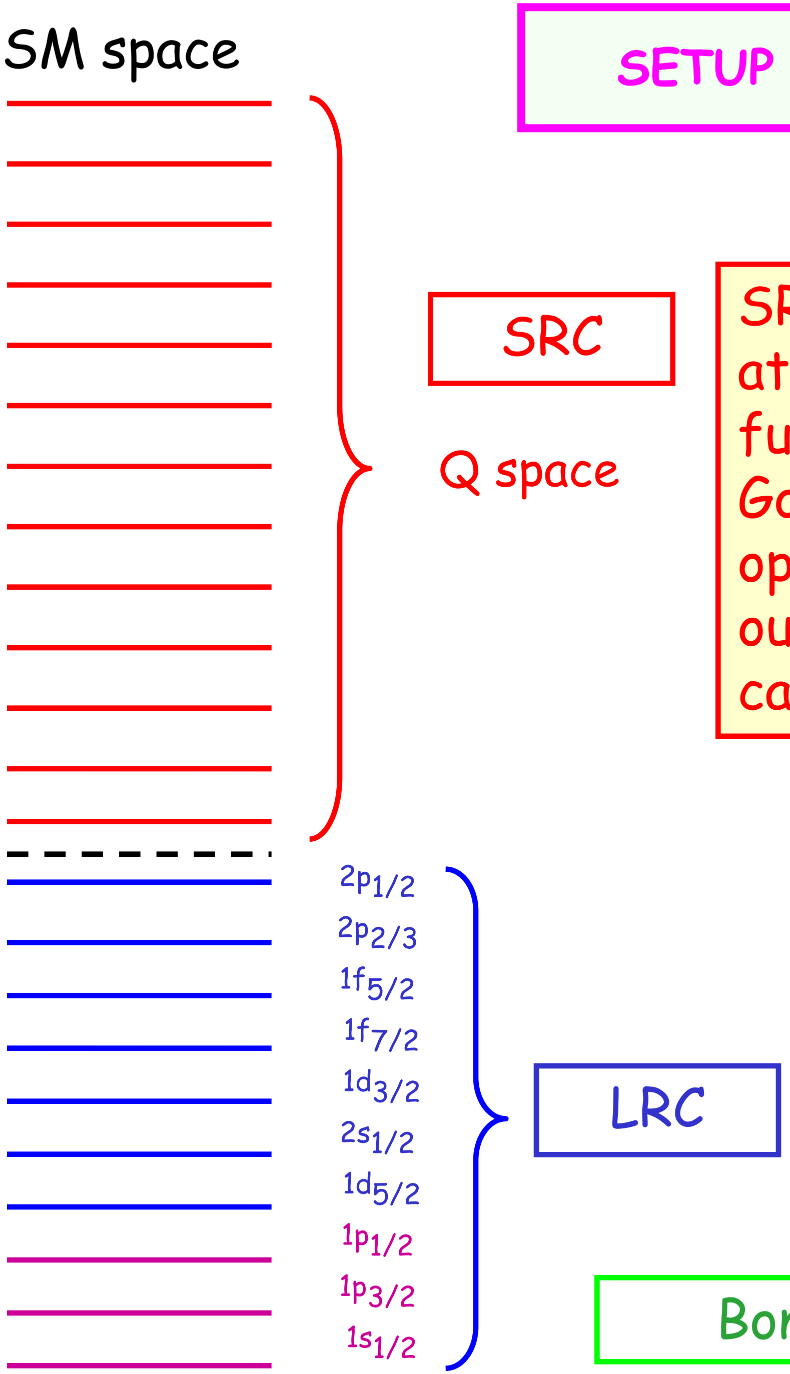
Q space

SRC due to the central and tensor part at high momenta added by defect functions obtained from the Bethe-Goldstone equation where the Pauli operator considers only configurations outside the model space where LRC are calculated

LRC

LRC and the LR part of TC computed using the self-consistent Green's function formalism in a 10 shell h.o. basis large enough to account for the main collective features that influence the pair removal amplitudes

SETUP TO INCLUDE SRC AND LRC



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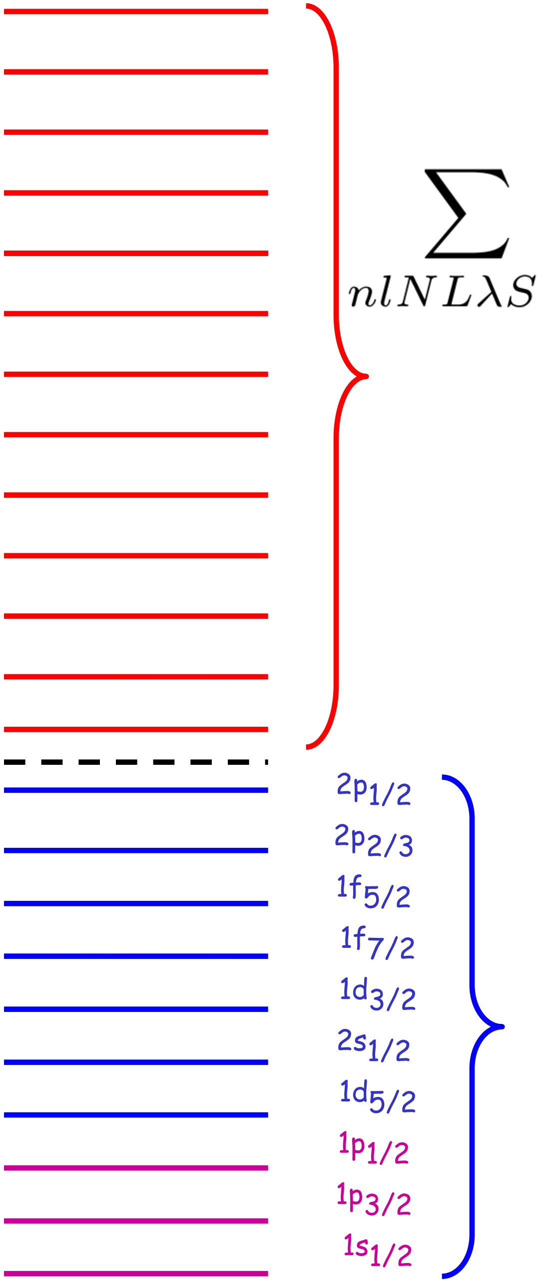
LRC and the LR part of TC computed using the self-consistent Green's function formalism in a 10 shell h.o. basis large enough to account for the main collective features that influence the pair removal amplitudes

Bonn-C NN interaction

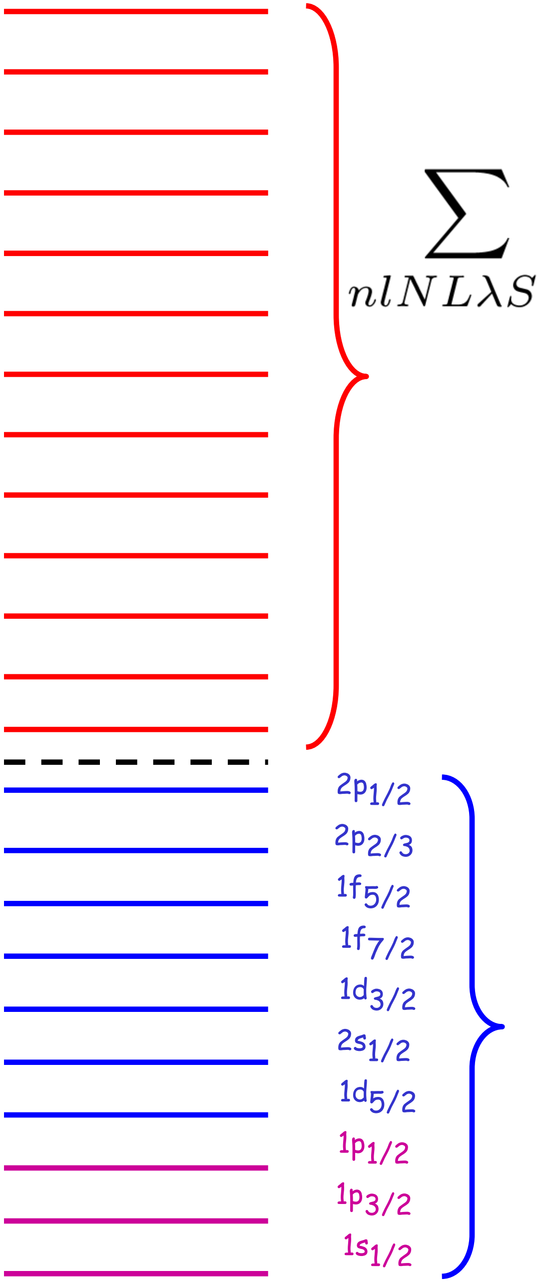
SM space

$$\langle {}^{14}\mathrm{C}(J^{\pi})\vec{r}\vec{R}\,|{}^{16}\,O_{\mathrm{g.s.}}\rangle \quad \langle {}^{14}\mathrm{N}(J^{\pi})\vec{r}\vec{R}\,|{}^{16}\,O_{\mathrm{g.s.}}\rangle$$

$$\sum_{nlNL\lambda SJ'} c^{\alpha_1\alpha_2 J}_{nlNl\lambda SJ'}\ \Phi_{NL}(\vec{R})\ \left(\phi_{nlSJ'}(\vec{r}) + \ D_{lsJ'}(\vec{r})\right)$$



SM space



$$\langle {}^{14}\mathrm{C}(J^{\pi})\vec{r}\vec{R}\,|^{16}\,O_{\mathrm{g.s.}}\rangle \quad \langle {}^{14}\mathrm{N}(J^{\pi})\vec{r}\vec{R}\,|^{16}\,O_{\mathrm{g.s.}}\rangle$$

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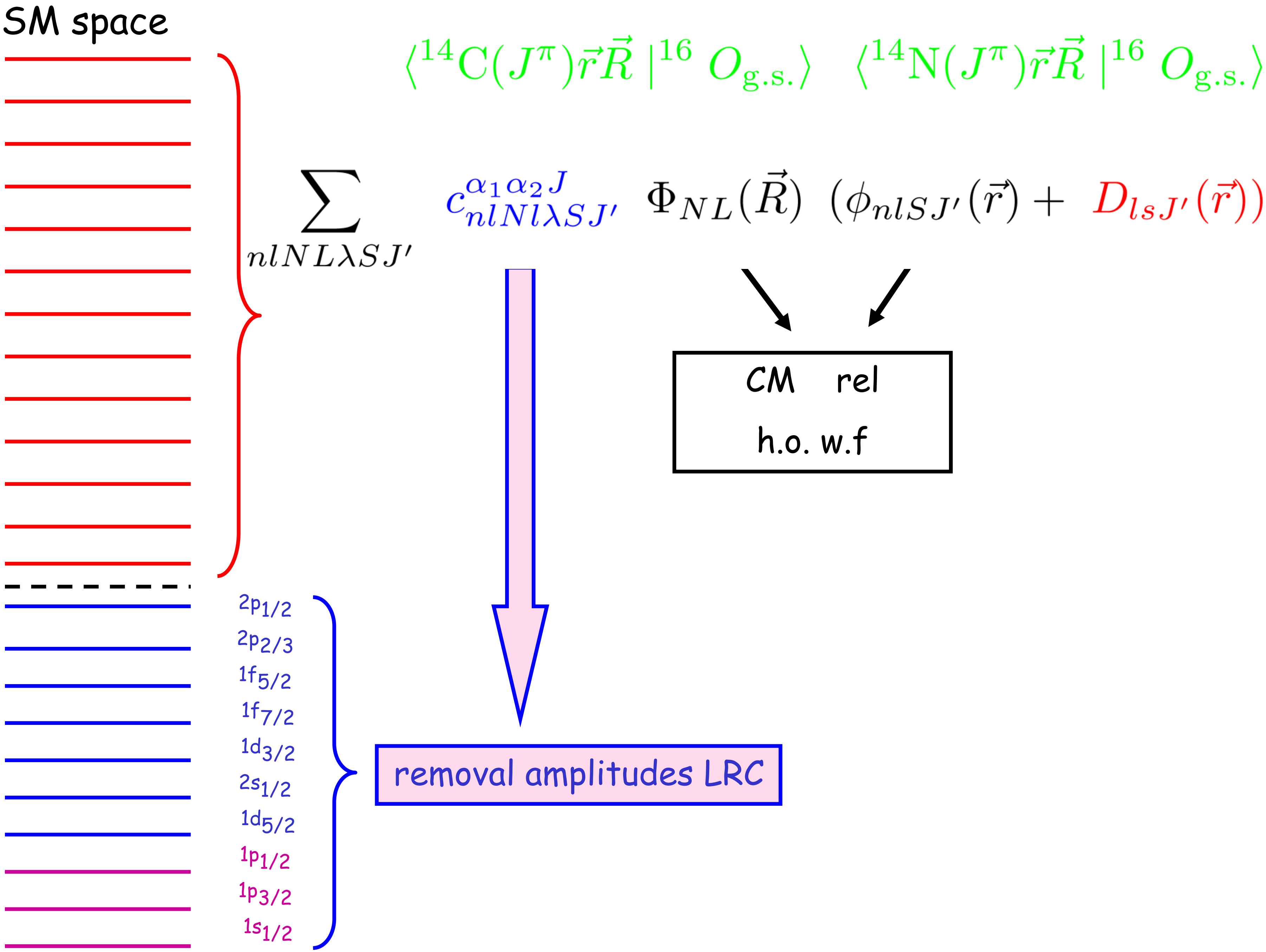
CM rel

h.o. w.f



SM space

$$\langle {}^{14}\mathrm{C}(J^\pi)\vec{r}\vec{R}\,|^{16}\,O_{\mathrm{g.s.}}\rangle \quad \langle {}^{14}\mathrm{N}(J^\pi)\vec{r}\vec{R}\,|^{16}\,O_{\mathrm{g.s.}}\rangle$$

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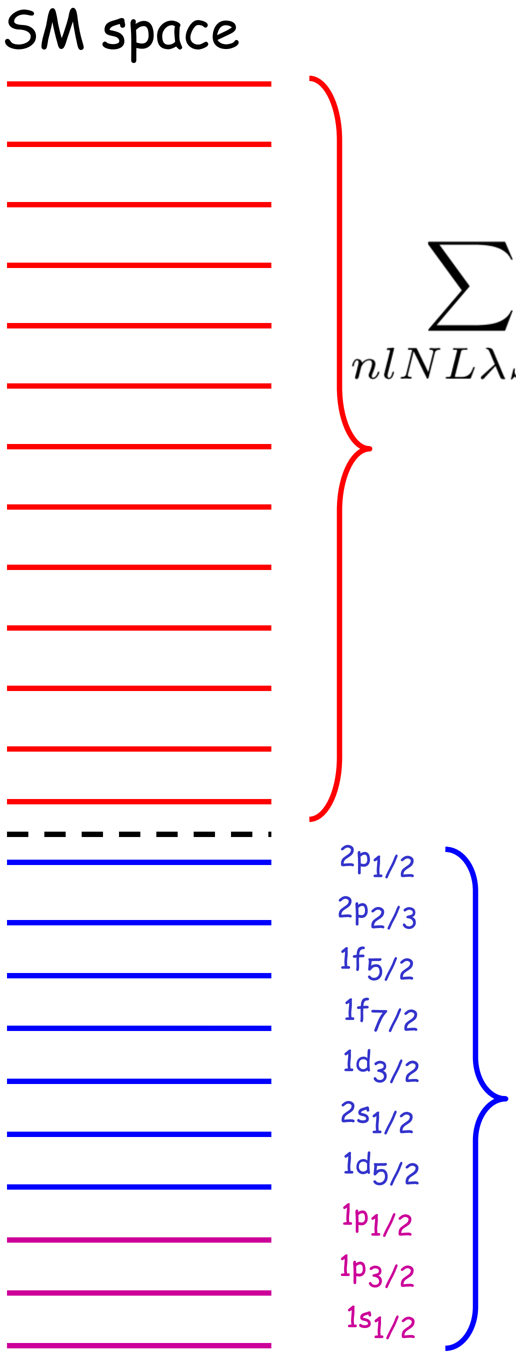
CM rel

h.o. w.f

removal amplitudes LRC



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CM rel

h.o. w.f

defect functions
SRC

removal amplitudes LRC

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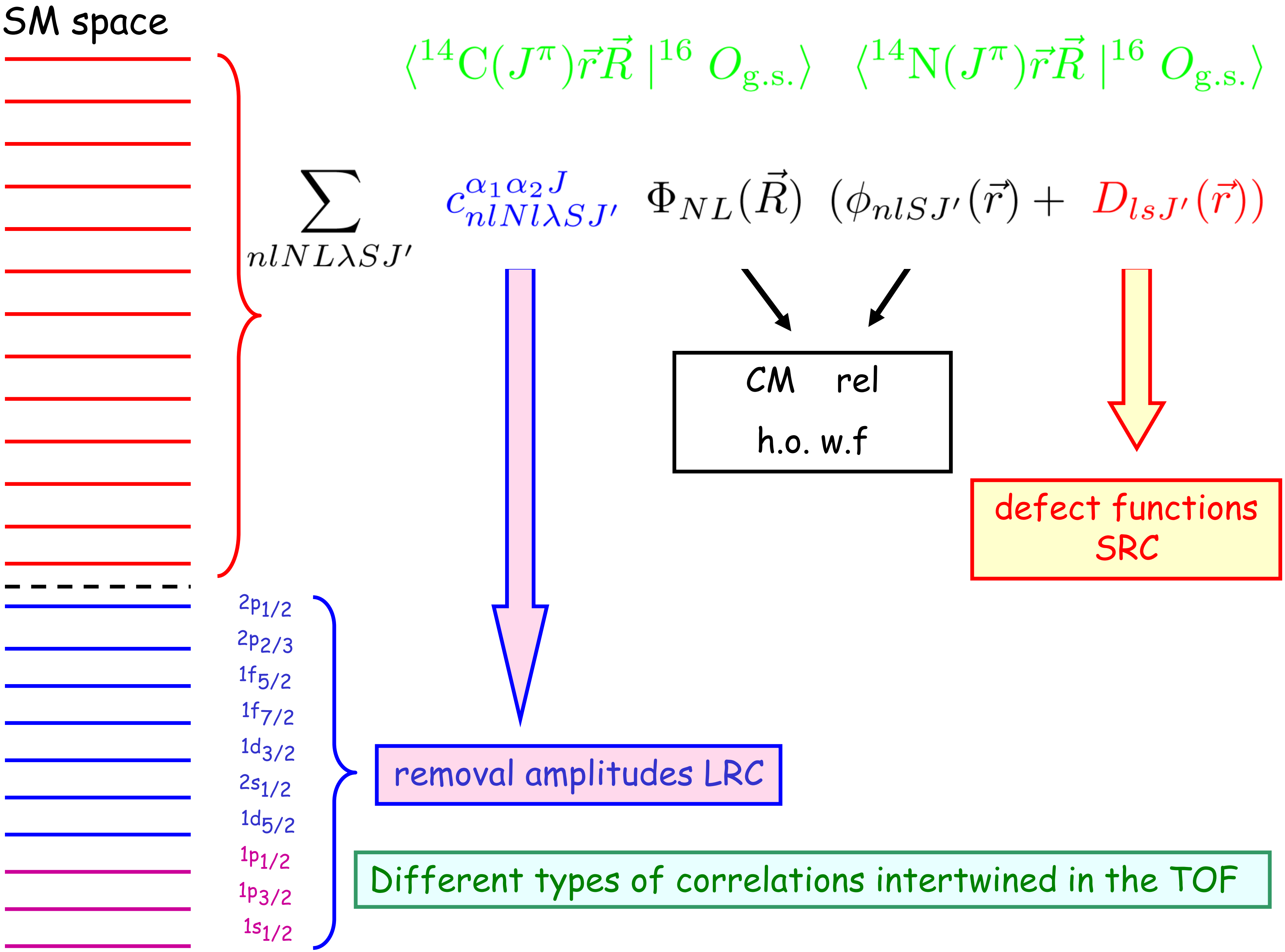


CM rel

h.o. w.f

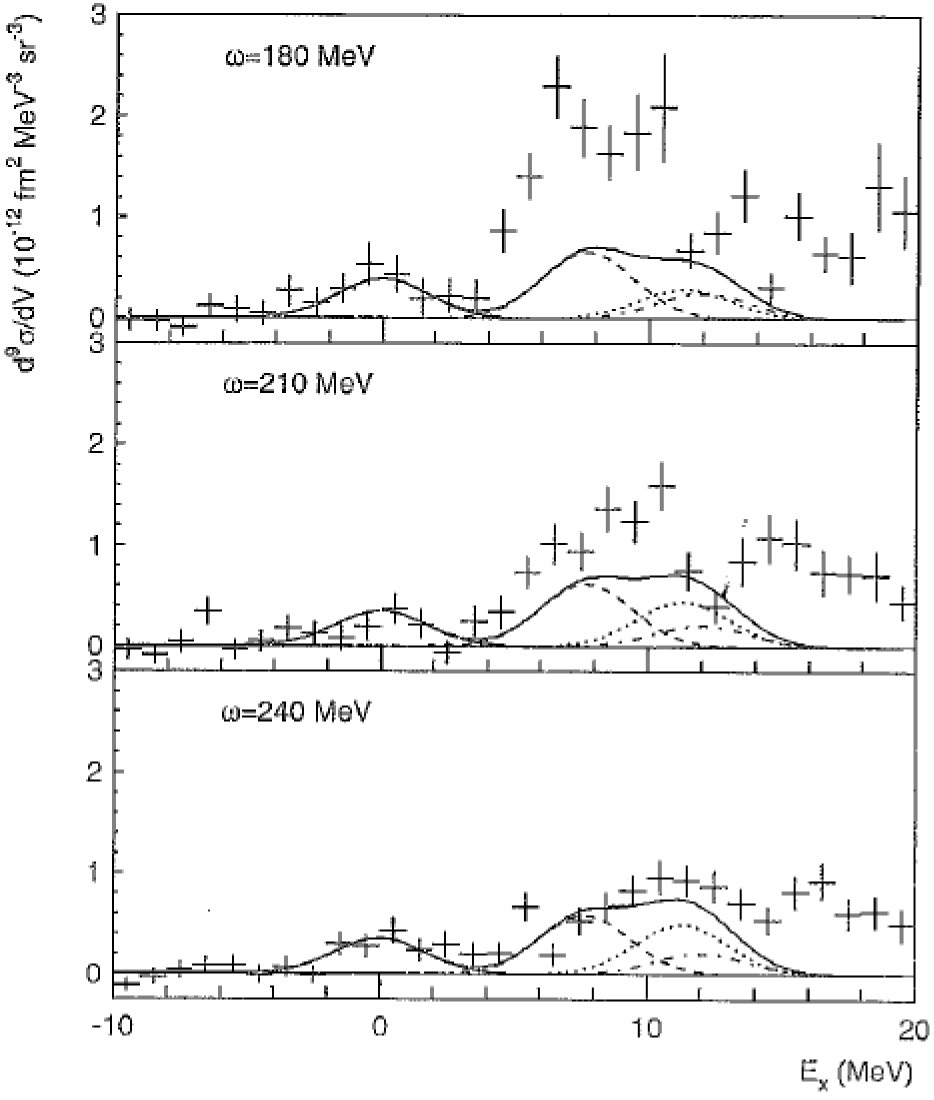
defect functions

SRC

removal amplitudes LRC

Different types of correlations intertwined in the TOF

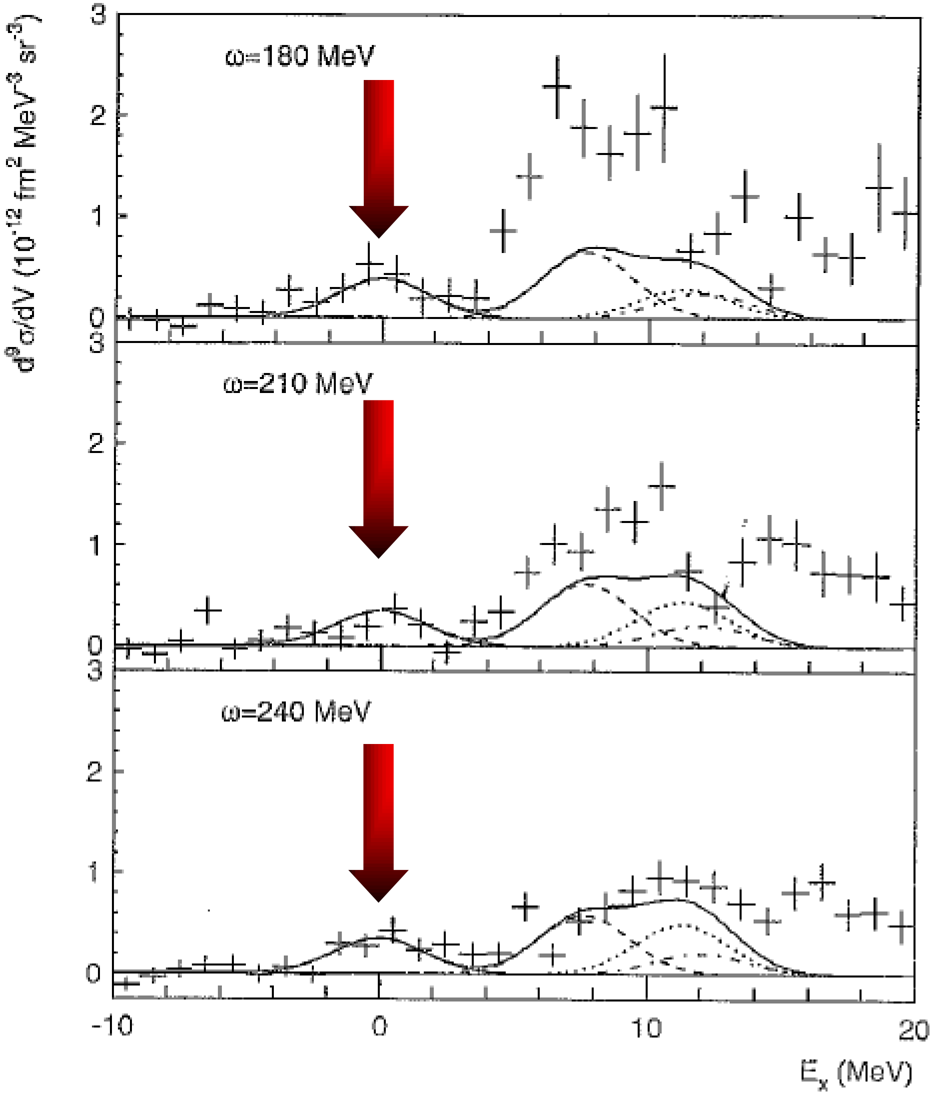
$^{16}O(e,e'pp)^{14}C$: NIKHEF data



R. Starink, Ph.D thesis 1999

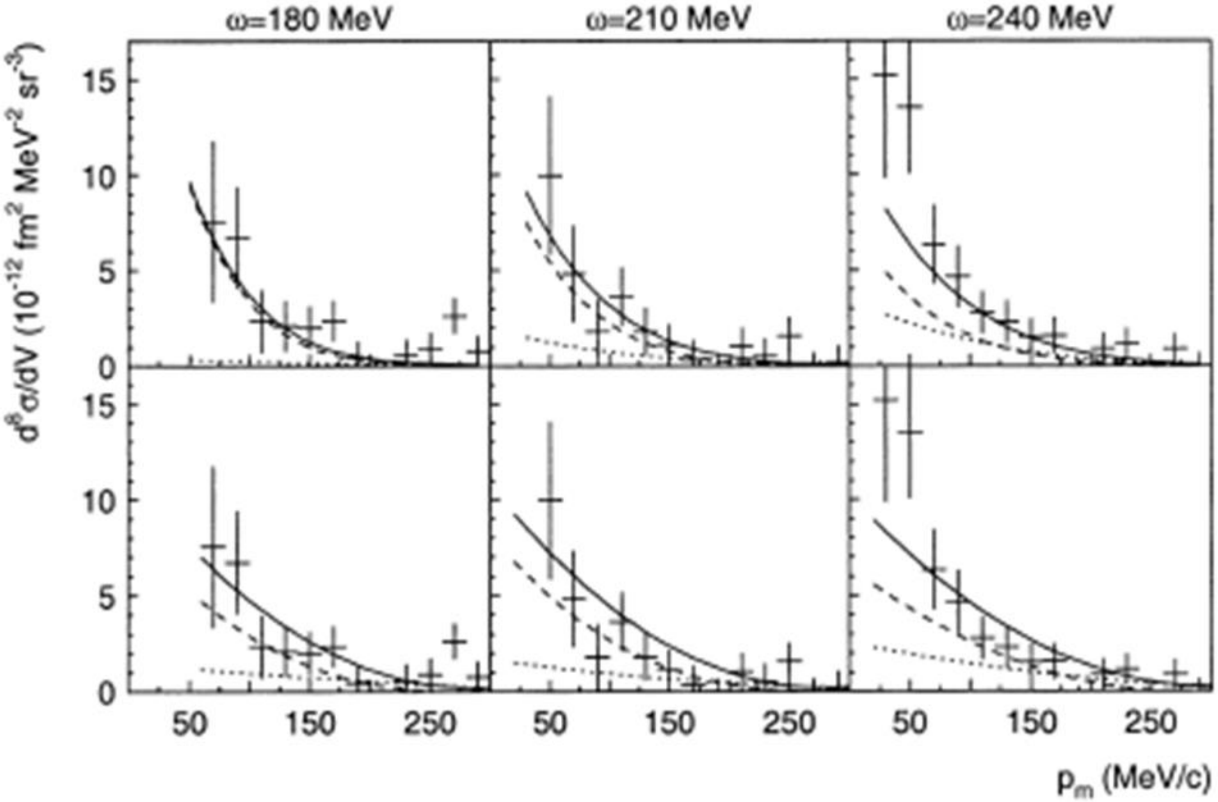
$^{16}O(e,e'pp)^{14}C$: NIKHEF data

g.s. 0^+



R. Starink, Ph.D thesis 1999

$^{16}O(e,e'pp)^{14}C_{g.s.}$ NIKHEF data



Pavia

Gent

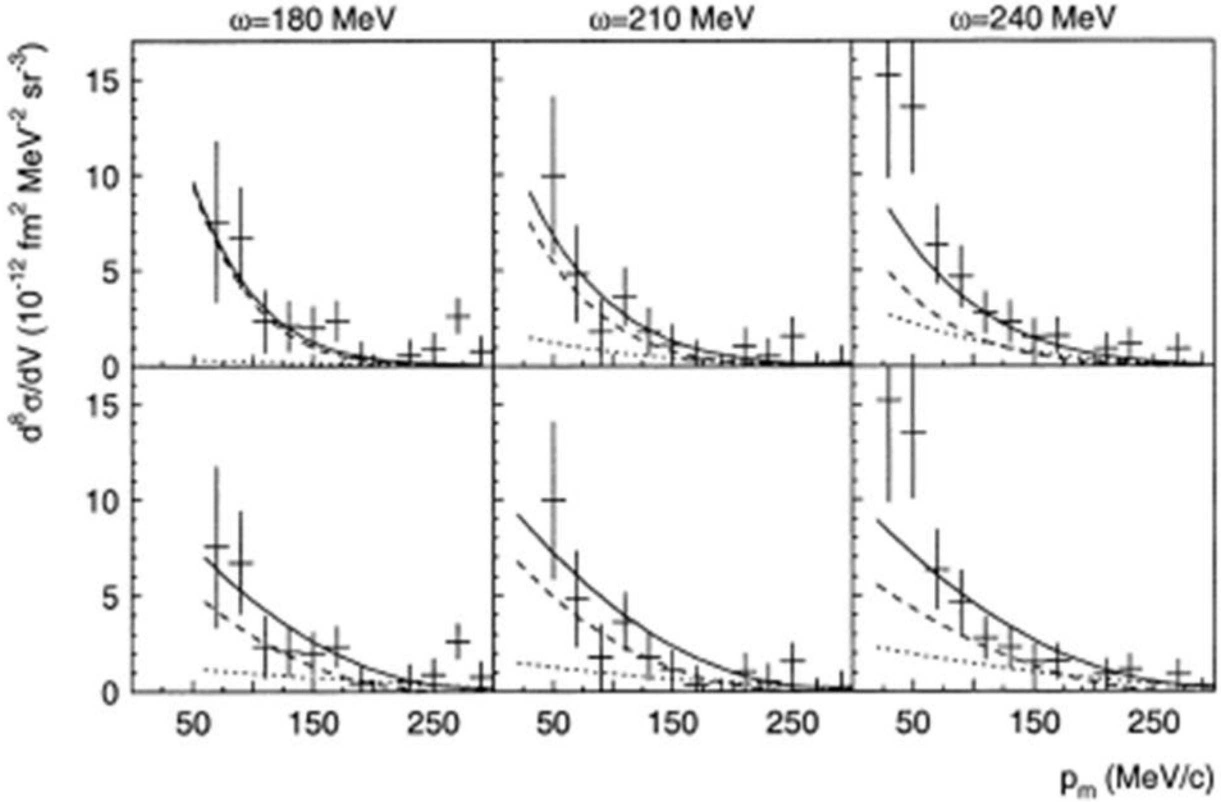
——— 1-b +Δ

------ 1-b

·········· Δ

R. Starink et al. PLB 474 33 (2000)

$^{16}O(e,e'pp)^{14}C_{g.s.}$ NIKHEF data



Pavia

Gent

—— 1-b +Δ

- - - - - - 1-b

·········· Δ

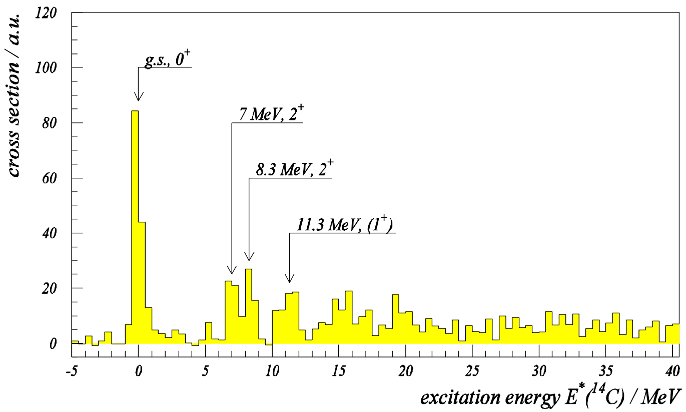
EVIDENCE FOR SRC !

R. Starink et al. PLB 474 33 (2000)

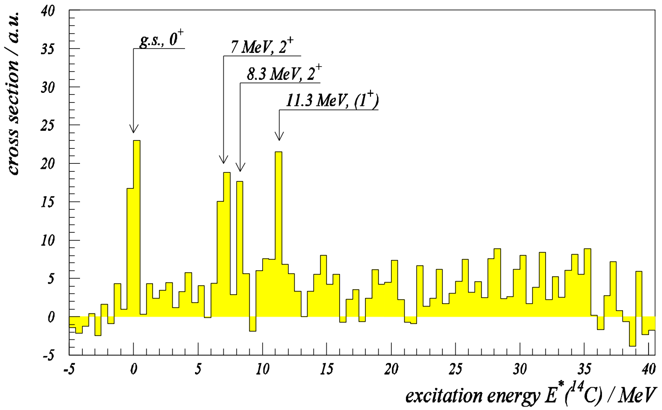
$^{16}O(e,e'pp)^{14}C$: MAMI data

super-parallel kinematics

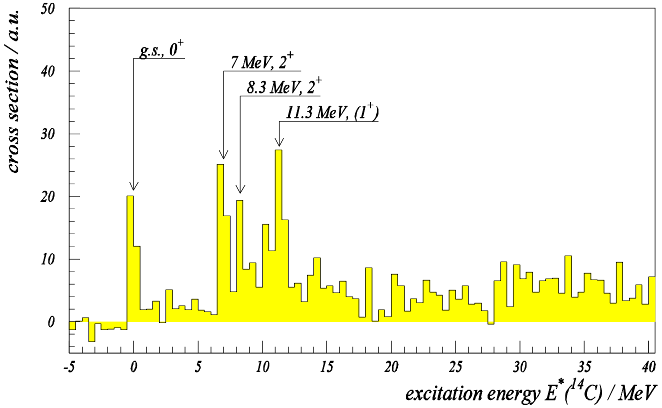
$\langle p_m \rangle$ =0 Mev/c



$\langle p_m \rangle$ =70 Mev/c

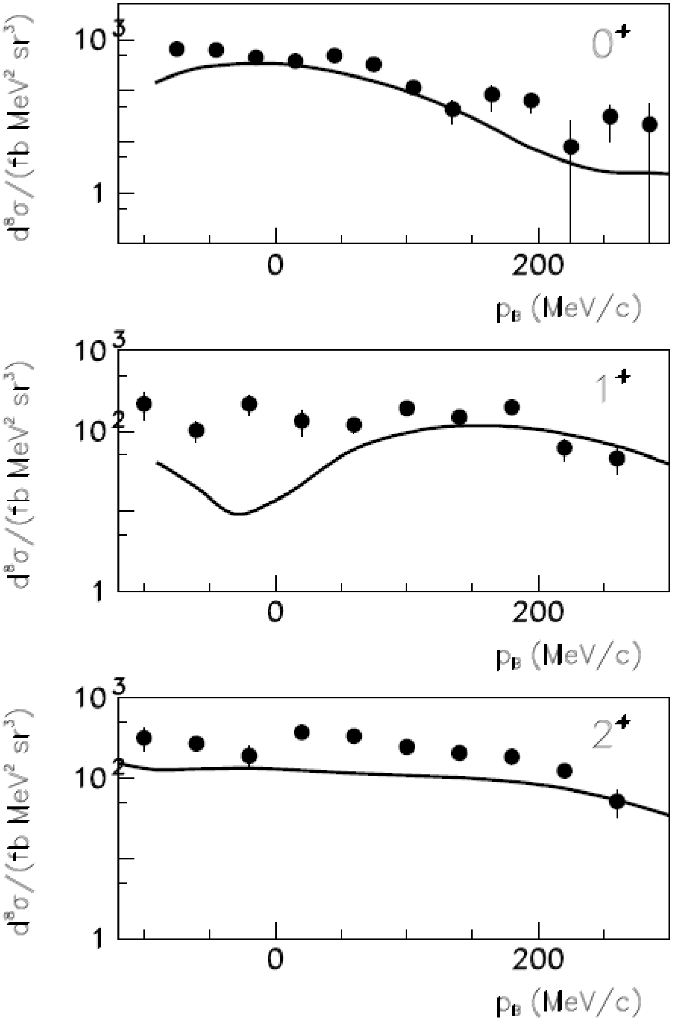


$\langle p_m \rangle$ =125 Mev/c



G. Rosner, Prog. Part. Nucl. Phys. 44 (2000) 99

$^{16}O(e,e'pp)^{14}C$: comparison to MAMI data



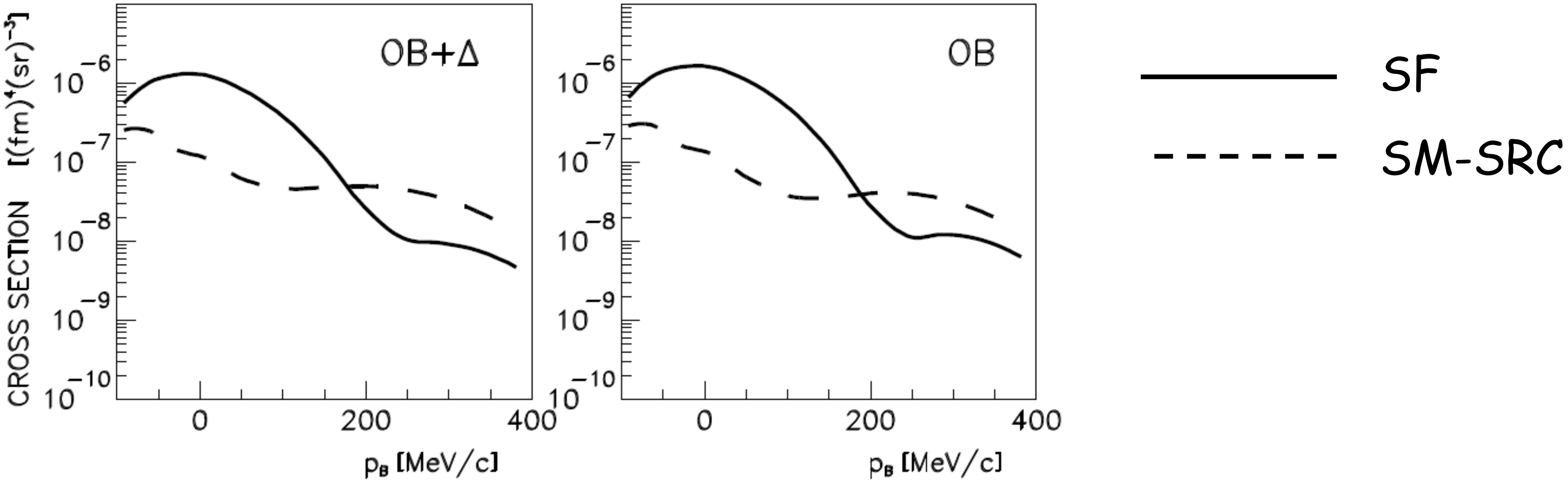
0^+

1^+

2^+

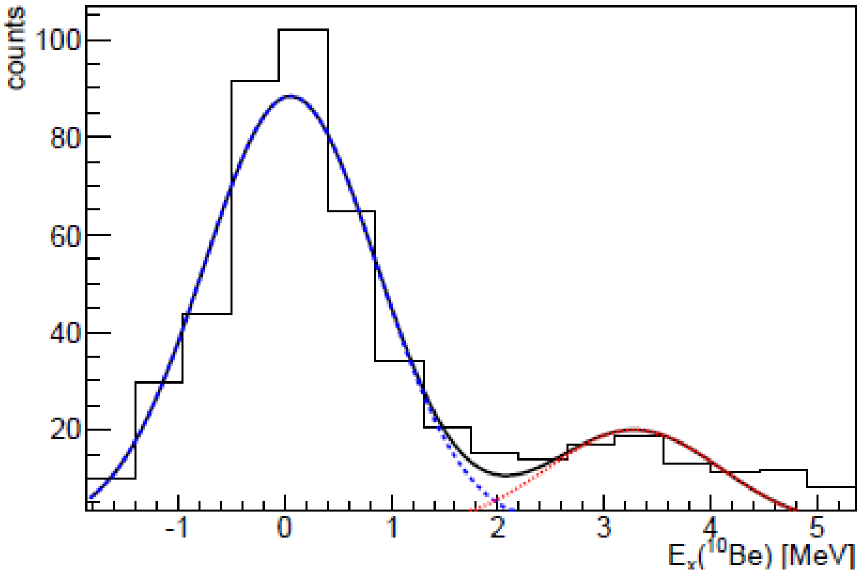
exp. data : G. Rosner, Prog. Part. Nucl. Phys. 44 (2000) 99

super-parallel kinematics $^{16}O(e,e'pp)^{14}C_{g.s.}$ 0^+



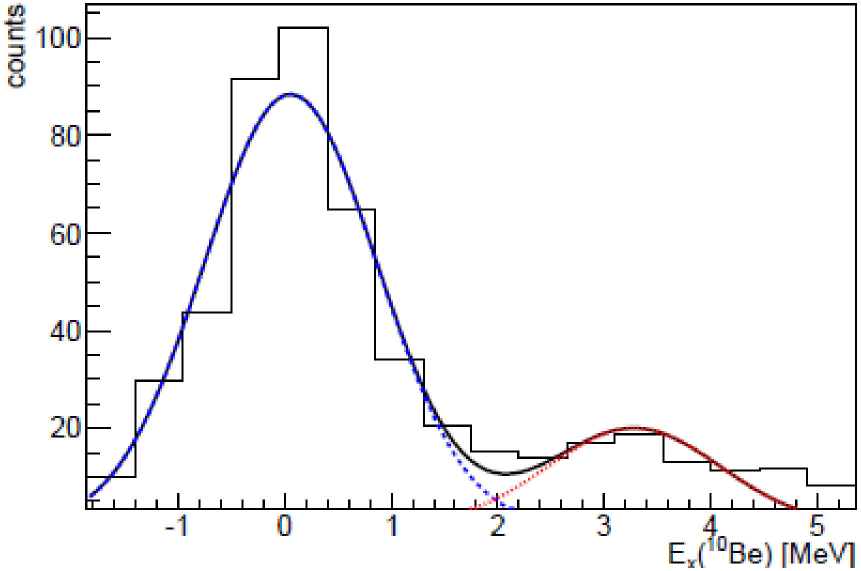
results very sensitive to correlations and to their treatment

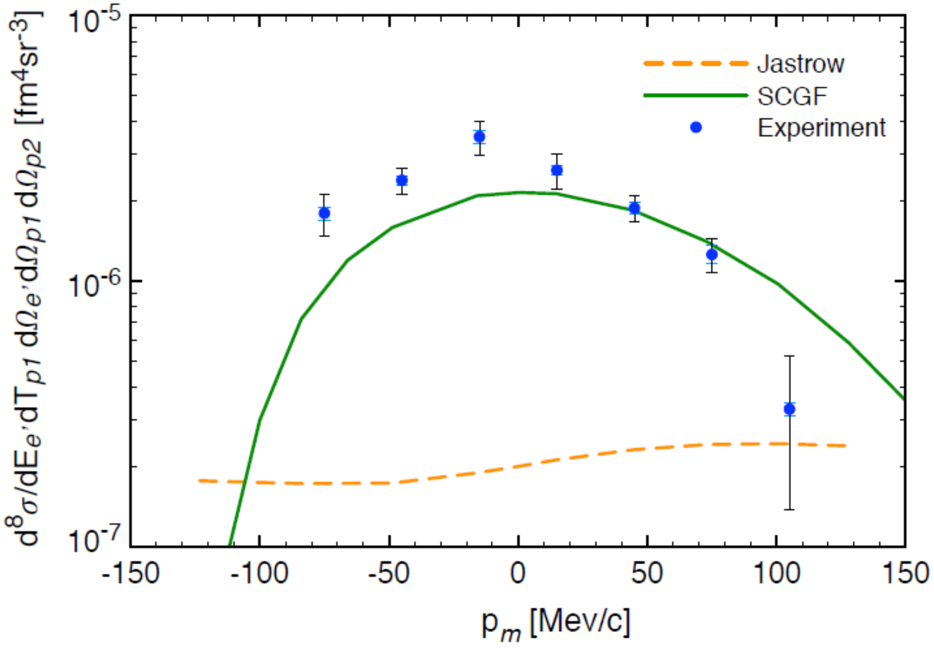
super-parallel kinematics $^{12}C(e,e'pp)^{10}Be_{g.s.}$ 0^+



M Makek et al. 2016 (MAMI)

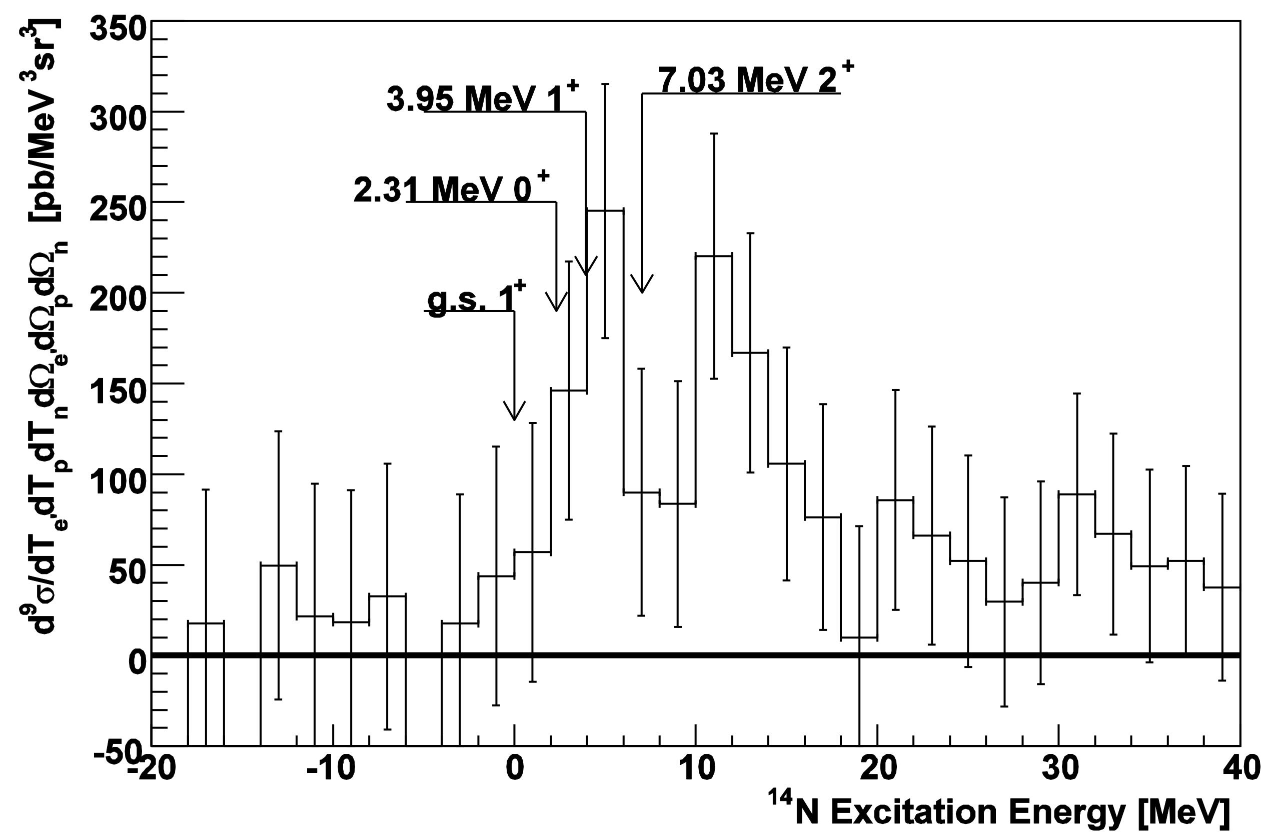
super-parallel kinematics $^{12}C(e,e'pp)^{10}Be_{g.s.}$ 0^+





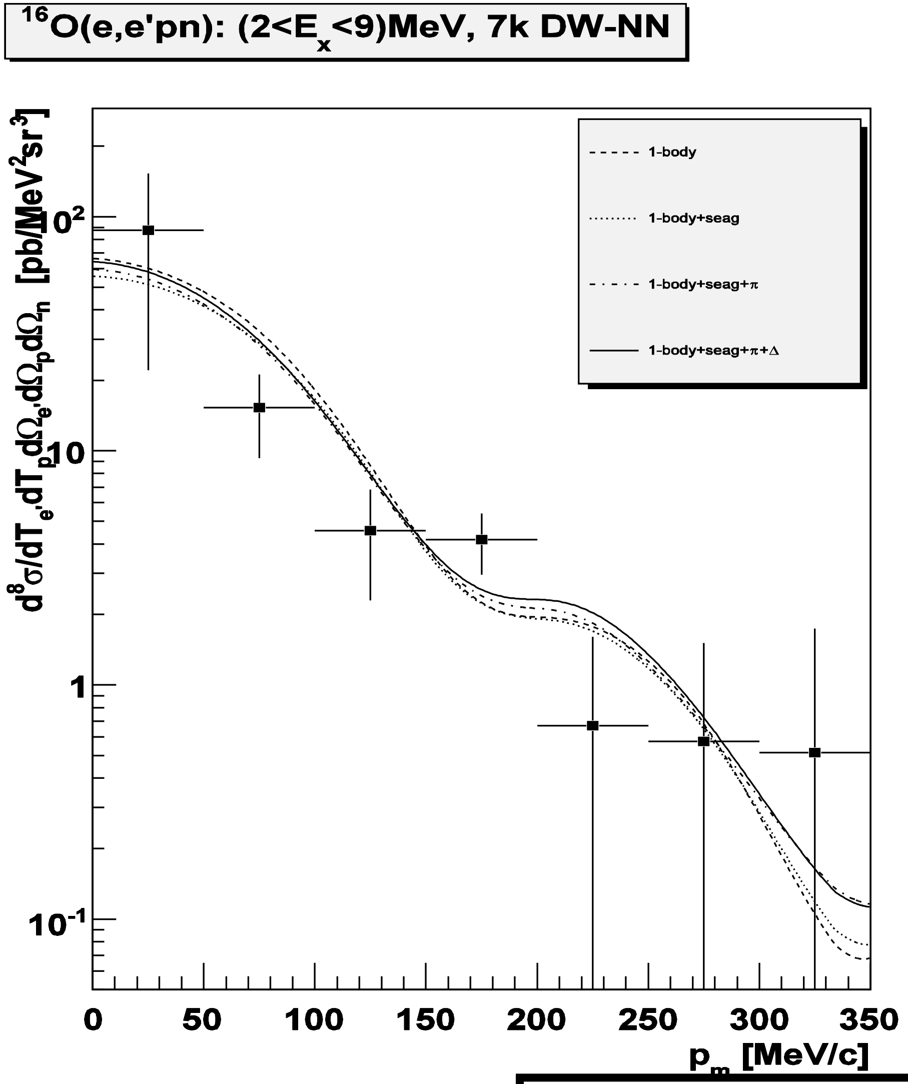
M Makek et al. 2016 (MAMI)

$^{16}O(e,e'pn)^{14}N$: MAMI data



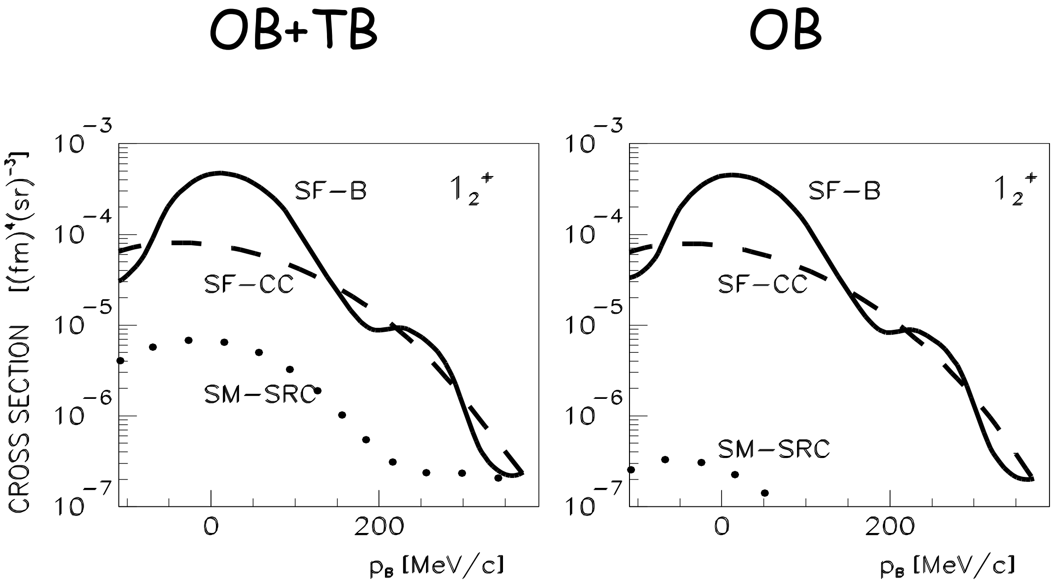
D. Middleton et al., EPJA 29 (2006) 261

^{16}O(e,e′pn)^{14}N: comparison to MAMI data



D. Middleton et al., EPJA 43 (2010) 137

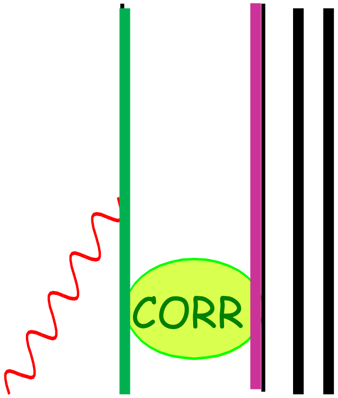
super-parallel kinematics $^{16}O(e,e'pn)^{14}N$



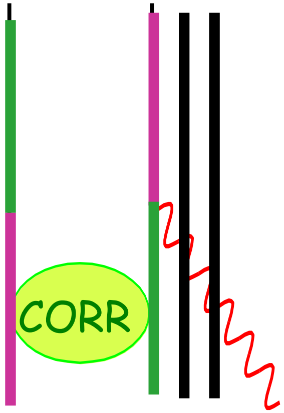
———	SF-B
- - - - - - -	SF-CC
• • • • • • • • • •	SM-SRC

results very sensitive to correlations and to their treatment

MEC in one-nucleon emission

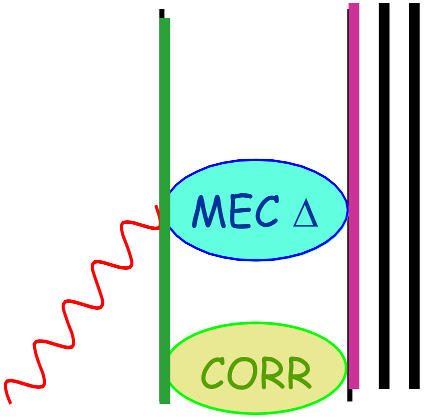


direct



exchange

1-body current



2-body current MEC

C. Giusti and F.D. Pacati, PRC 67 (2003) 044601

CAN THIS WORK BE USEFUL FOR NEUTRINO-NUCLEUS SCATTERING?