Study of NN Correlations by polarised photons *

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PiP/TOF Gruppe, A2 Kollaboration

17th March 1998

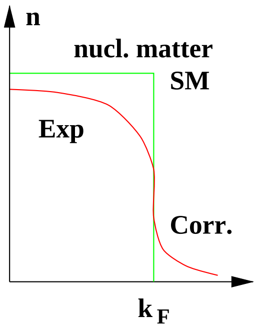
- Correlations and 2N knockout
  - Introduction
  - Approaches for measurements
- Survey on completed experiments
  - Experimental setup
  - ^{6}Li,^{12}C,^{4}He Results
- The ^{4}He($\vec{\gamma}$,2N) experiment
  - Aysmmetry and SRC
  - Production of polarised photons
  - Results

  Conclusion

*supported by DFG(Graduiertenkolleg),DAAD,NATO,EU,BMBF

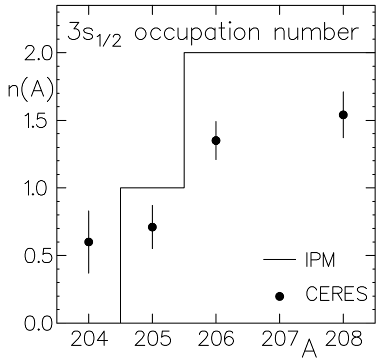
NN Correlations and Photo Absorption

Shell modell

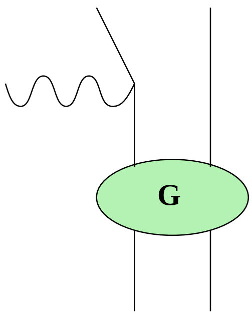


$$\sum V_{ij} = \sum V_i + V_{res}$$
IPM+Korr

CERES (P. Grabmayr)
Prog.Part.Nucl.Phys **29** (92) 251

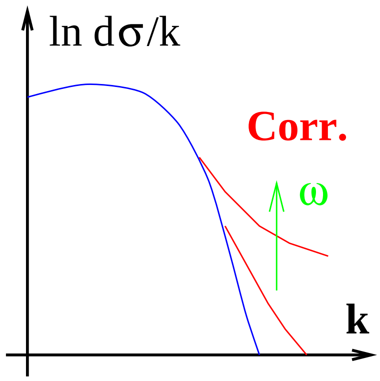


Approach via 1N knockout

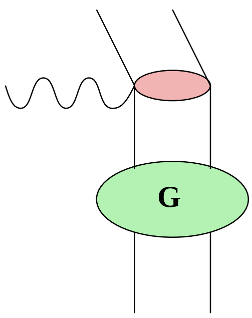


BHF calculations with
corr. Ψ_{NN} + real. V_{NN}
(Müther et al., PRC **51**(95)3040)

Idea: high $\omega \rightarrow$ SRC $\nearrow$
But: $E_x >$ 2N threshold



Approach via exclusive 2N emission



2B currents are sensitiv on SRC

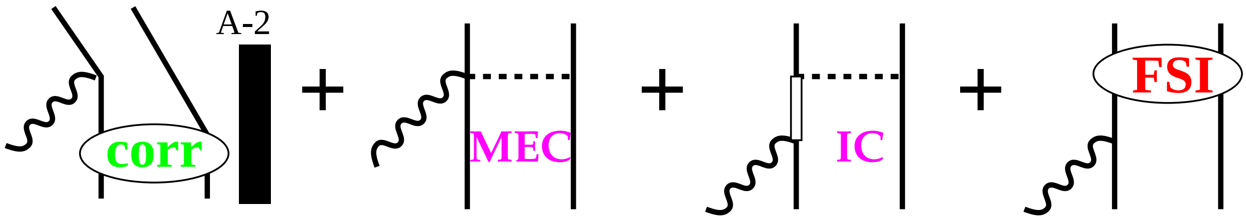
$$\sigma \quad \propto \quad |< f|j_{[1]} + j_{[2]}|i>|^2$$
$$\sim \quad F(P)S_{fi}(p_r)$$

$\rightarrow$ measurement of p_r, includes correlations

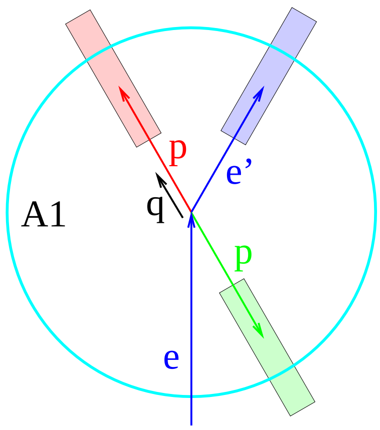
PiP
TOF

2N Knockout Measurements

Ground state correlations and competing processes



$(e, e'pp)$

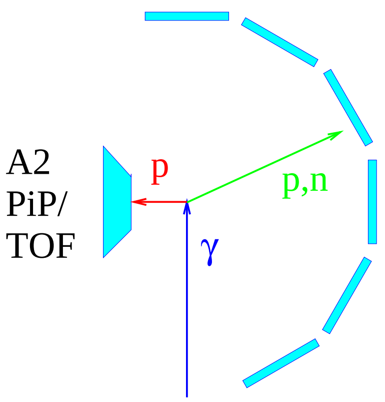


- superparallel kinematics:
  MEC=0, IC=0 for σ_L

→ direct approach to central SRC

But: Fermi motion of pair: $\vec{q} \neq \vec{p}_N$
Xsec very small

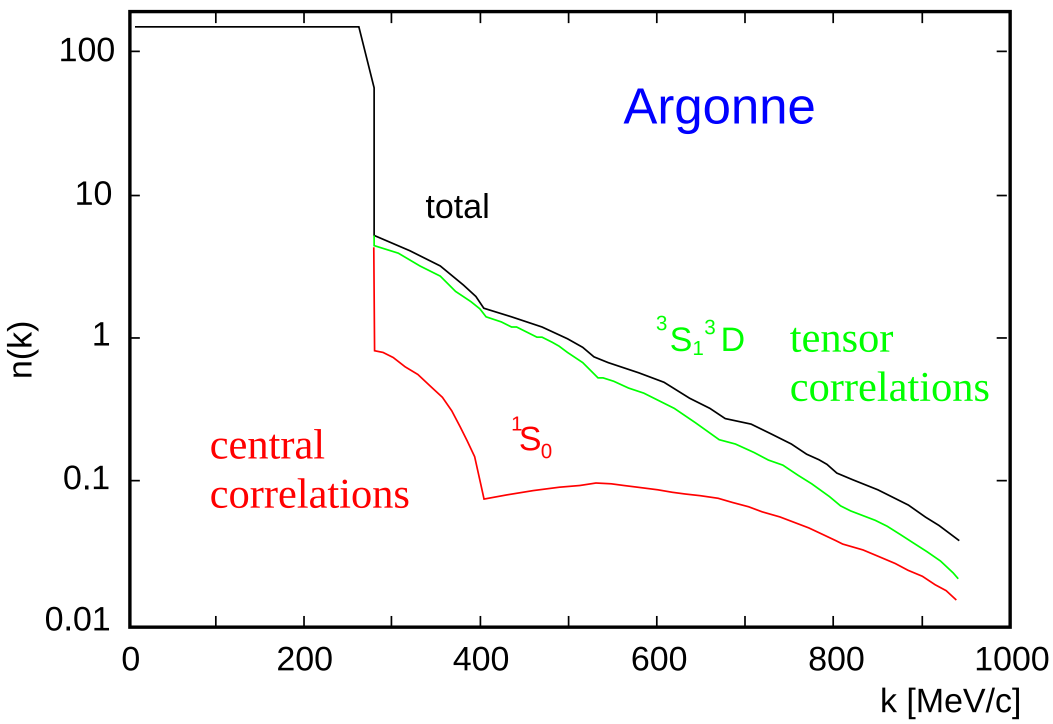
(γ, np)

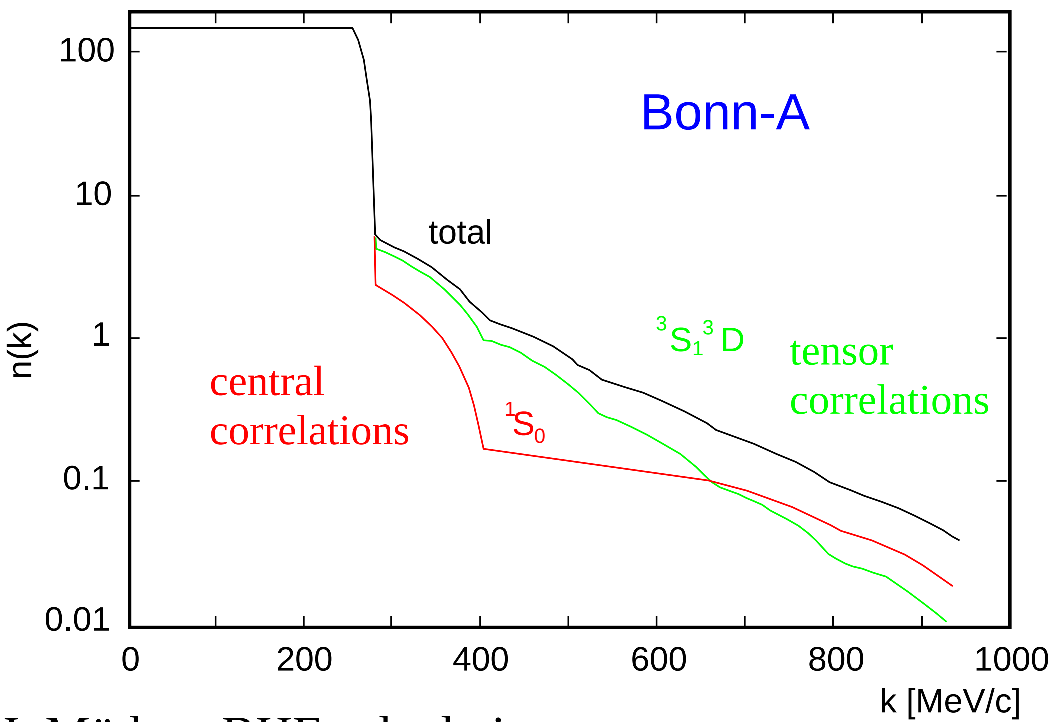


- Coincident measurement
  over wide angle and E_γ range
- Real (transversal) photons
  sensitive on larger tensor SRC
- MEC/IC might be separated
  via kinematics and isospin
  (Daniel Knödler, Tübingen, talk 16.3 2N Corr.)

PiP TOF

Tensor Correlations (nuclear matter)





H. Müther: BHF calculations

Survey of ^{6}Li, $^{1}2$C, ^{4}He, D

^{6}Li

- Absorption process understood in QD- and αd cluster model

  ^{6}Li(γ,np/pp)^{4}He exc. $\rightarrow$ 2N from α cluster
  ^{6}Li(γ,np)^{4}He g.s. $\rightarrow$ 2N from d cluster

- Data are well reproduced by calculations with Moskau potential (Kukulin et al. NPA 513(90)332)
  $\rightarrow$ Correlated WF dominated by tensor forces
- d-cluster in Li $\equiv$ deuteron (besides Fermi motion)

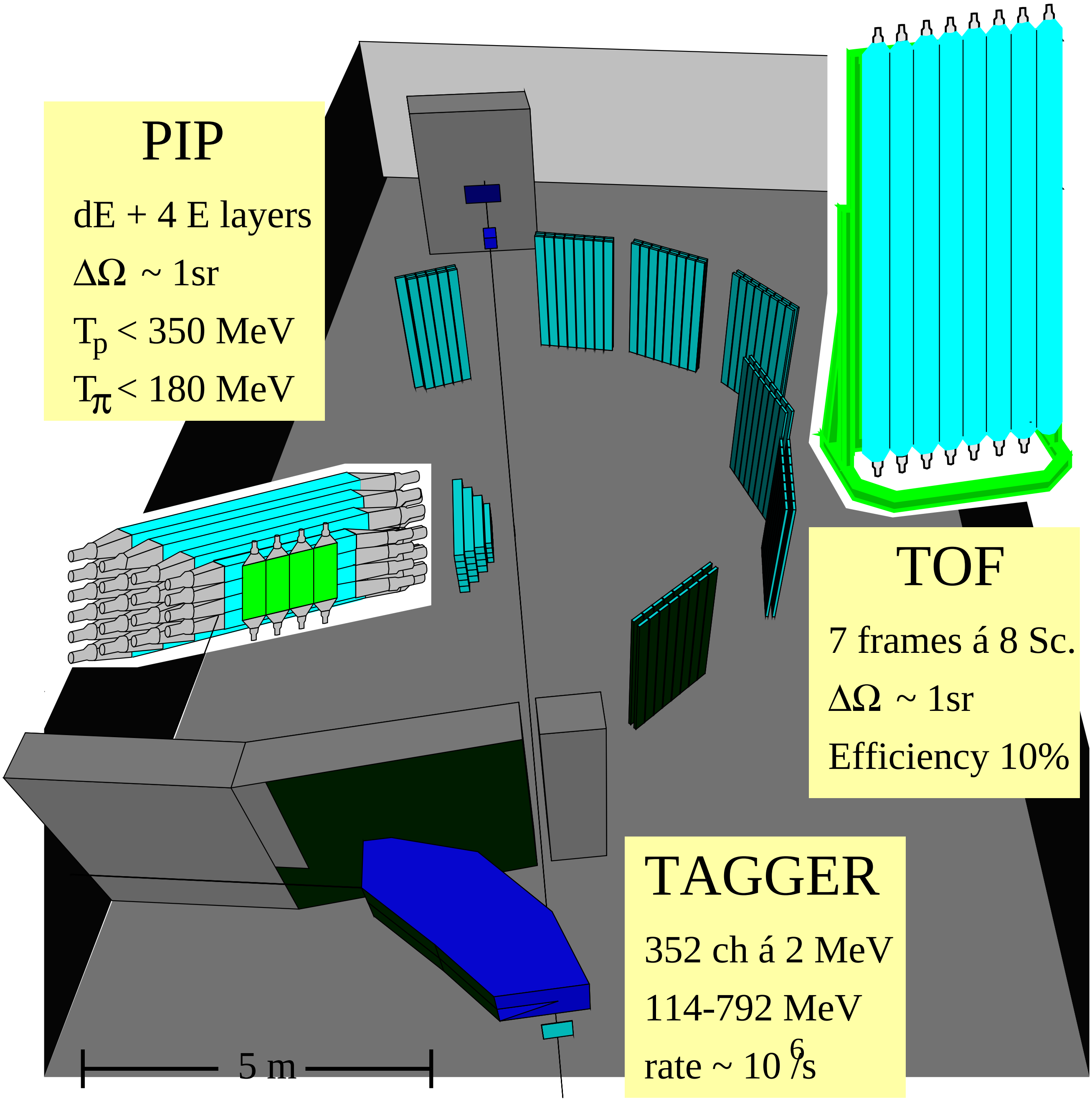
^{12}C

- Yielded understanding of reaction mechanisms via comparison with Oset's code
- separation of direct 2N absorption possible
- pp channel weak (possible fed by dominating (γ,np) and FSI induced charge exchange current)

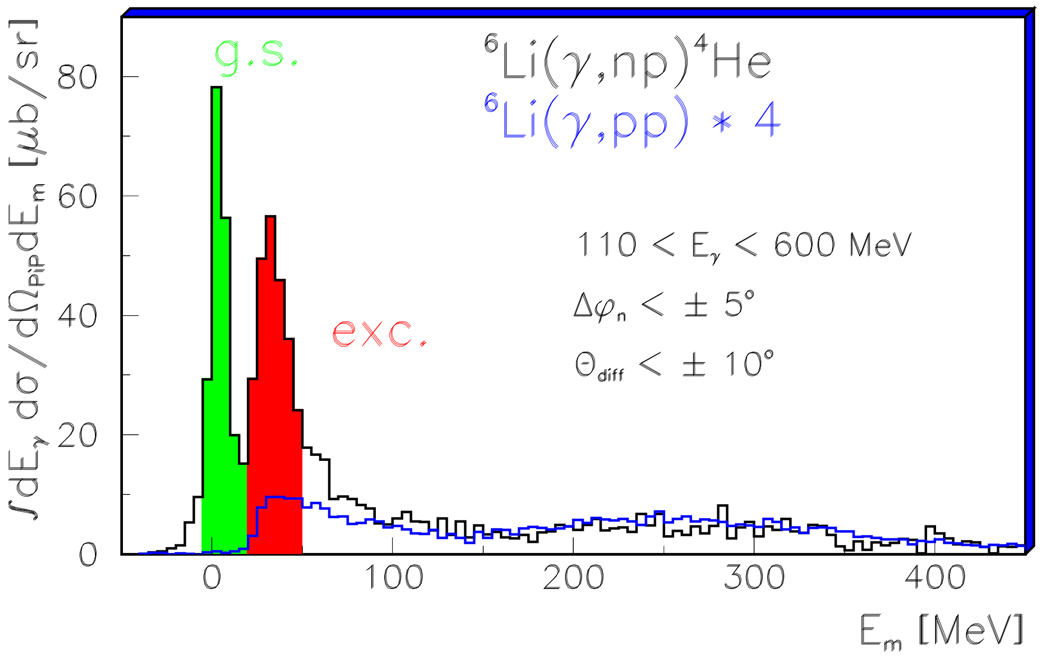
^{4}He

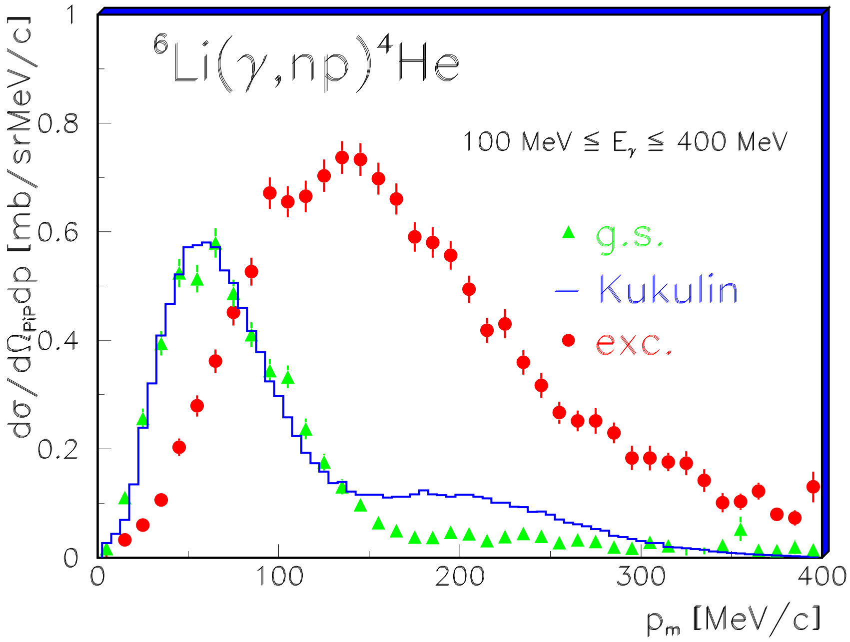
- basically 1S states $\rightarrow$ barely shell mixing
- high density, few nucleons $\rightarrow$ SRC $\nearrow$ FSI $\searrow$
- microscopic calculations $\leftrightarrow$ phenomenologic models
- photon asymmetry (lin. $\vec{\gamma}$) $\rightarrow$ SRC $\nearrow$ FSI $\searrow$

Experimental Setup



^{6}Li: α-d Cluster Strucuture

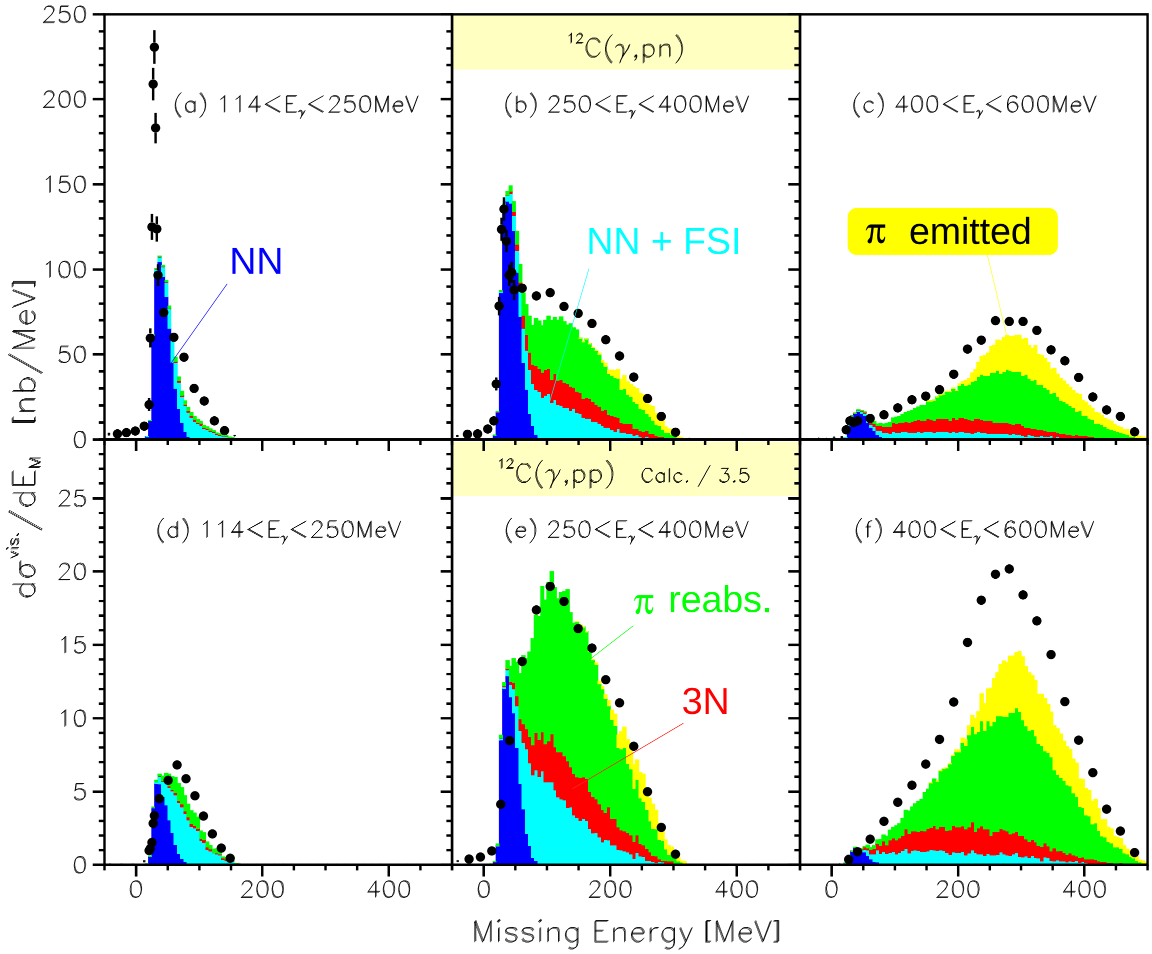




$$\vec{p}_m = \vec{p}_{A-2} = \vec{p}_\gamma - \vec{p}_n - \vec{p}_p \overset{PWIA}{=} - \vec{p}_d$$

P. Grabmayr et al., Phys. Lett. B 370 (96) 17

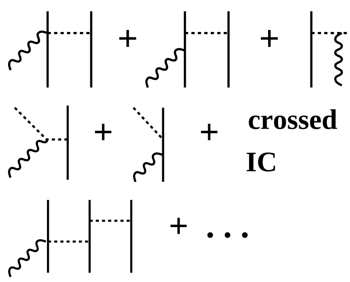
^{12}C: Reaction Mechanisms



2N absorption (+ FSI)

QFπ produktion (emit/reabs)

3N absorption



E_m serves for enhancing direct 2N absorption

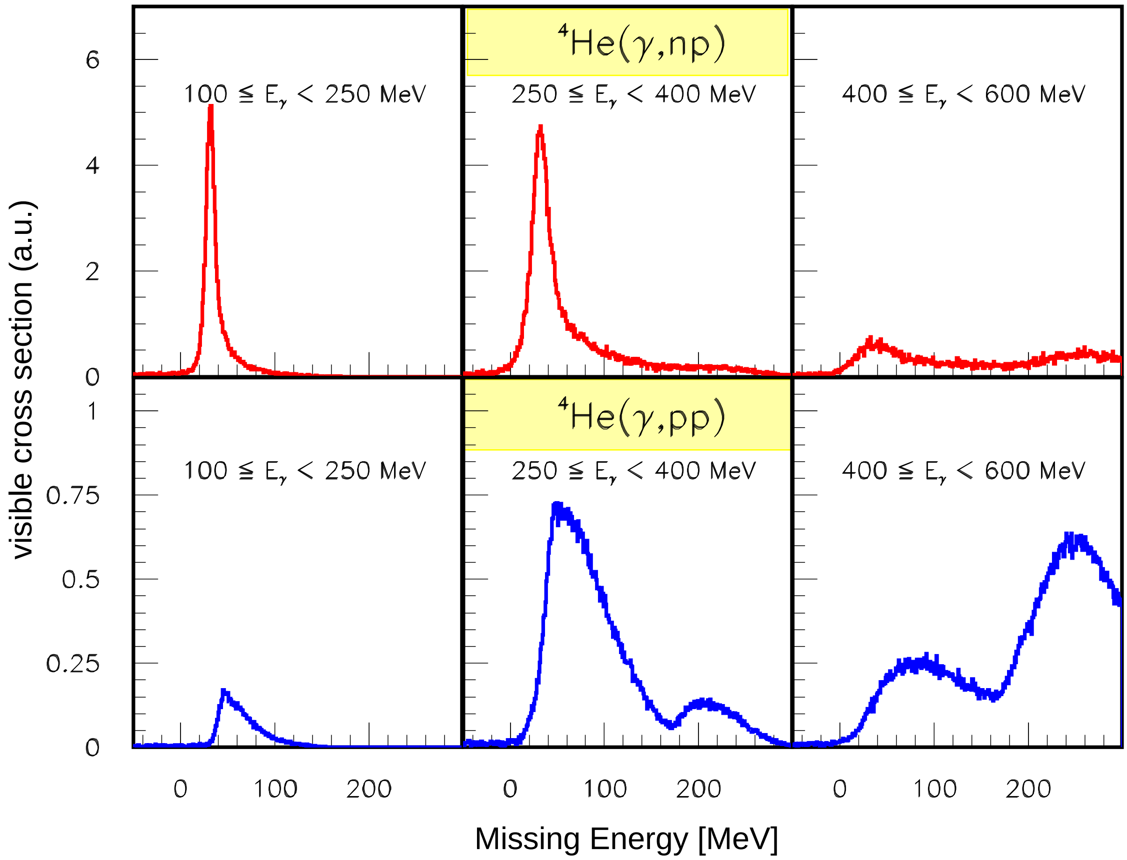
$$\sigma_{\text{tot}} = -\int d^3r \, \frac{\rho(r)}{k} \, \text{Im}\Pi(k,\rho)$$

Carrasco,Oset NPA **536** (92) 445

T. Lamparter et. al. ,Z. Phys. A **355** (96) 1; T. Hehl, Prog. Part. Nucl. Phys. **34** (95) 385

PiP TOF

^{4}He Missing Energy Distribution



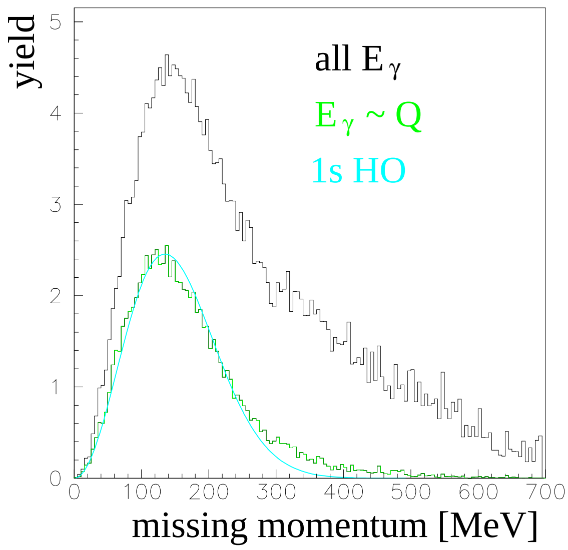
Missing momentum

$$\vec{p}_m = \vec{k}_\gamma - \vec{p}_p - \vec{p}_n$$

Cut on $E_m = Q$

$\rightarrow$ 1s Mom. distr.

$\rightarrow$ direct 2N absorption



Polarised Measurements

Photon asymmetry Σ (new SRC sensitive observable):

$$\Sigma = \frac{1}{P_\gamma}\frac{\sigma_{||}-\sigma_\perp}{\sigma_{||}+\sigma_\perp} \qquad \text{with } \sigma_{||,\perp} = \sigma_0(1 \pm P_\gamma \Sigma)$$

Jastrow Correlation:

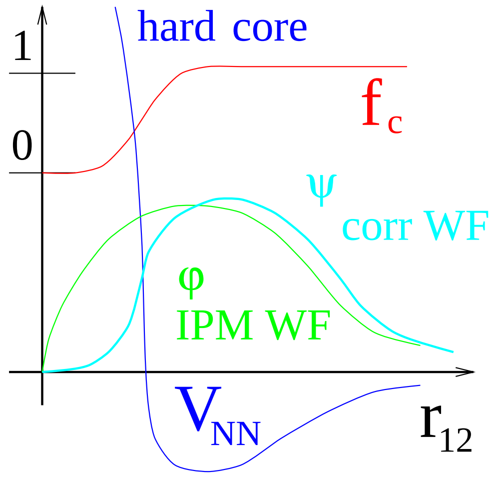
$$\psi_{12} = \phi_1 \phi_2 f_c(r_{12})$$

$$g(k) = \mathcal{F}(1 - f_c)$$

trivial correlations:

$\rho_{\mathrm{NN}}(1,2) =$

$[\rho(1)\rho(2) - \rho(1,2)\rho(2,1)]/2$



Direct photo absorption:

factorized Xsec in QD and zero range approximation:

(Jan Ryckebusch, Phys. Lett. B383 (96); Boato/Giannini J. Phys. G15 (89))

$$\sigma_0 \sim W_{1B}^{M,C}(g) + W_{2B}^{\pi}(g) + W_{\Delta}^{\text{(non)res}}$$

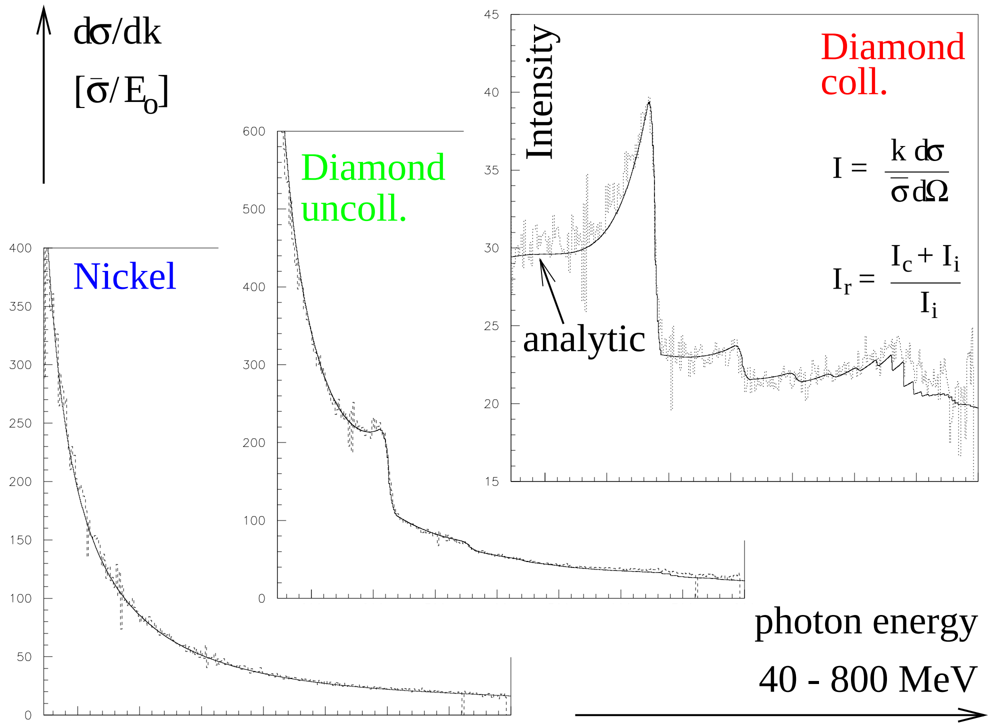
$$\sigma_0 \Sigma \sim \quad \text{dito}(\pm g) \quad + W_{\Delta}^{\text{(non)res}}$$

Additional evidence:

Boffi et. al., Nucl. Phys. A **564** (1993) 473 : $^{16}\mathrm{O}(\gamma, \mathrm{pn})^{14}\mathrm{N}$

A. Buchmann, Leidemann Nucl. Phys. A 443 (85) 726 : $\sigma, \Sigma\{\mathrm{d}(\gamma,\mathrm{p})\mathrm{n}\}$

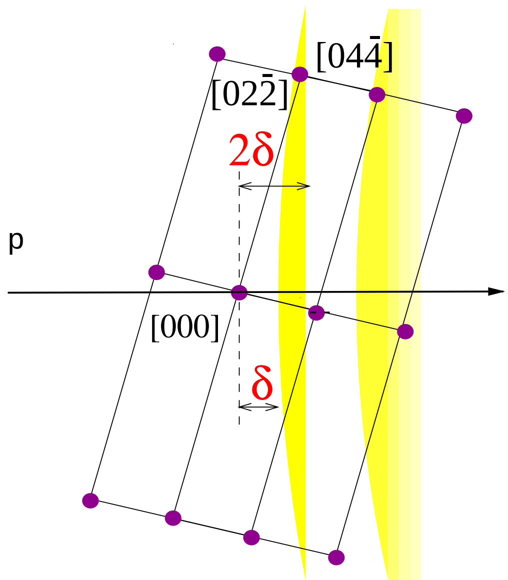
Bremsstrahlung (experimental)



Kinematic:

$$q_l^{\min}(E_\gamma) = \delta < q_l < 2\delta$$

MAMI: $q_t / q_l \approx 10^3$



Cross section:

$$\sigma \sim \frac{1}{k} \cos^2 \phi$$

Main contrib:

$\vec{E} \parallel \vec{\epsilon} \in (\vec{p}, \vec{q})$ plane

Incoherent Bremsstrahlung

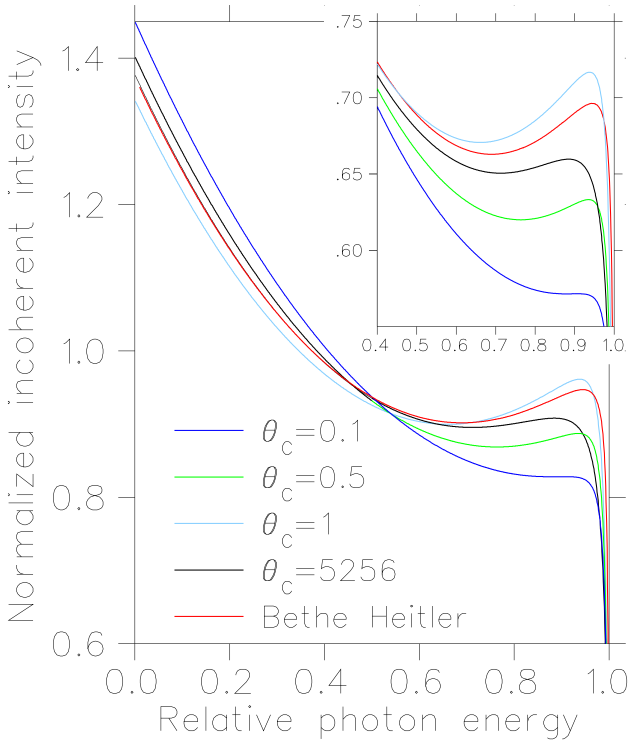
Hubbell Xsec

($\int^{\theta_c} d\theta_c$ Schiff)

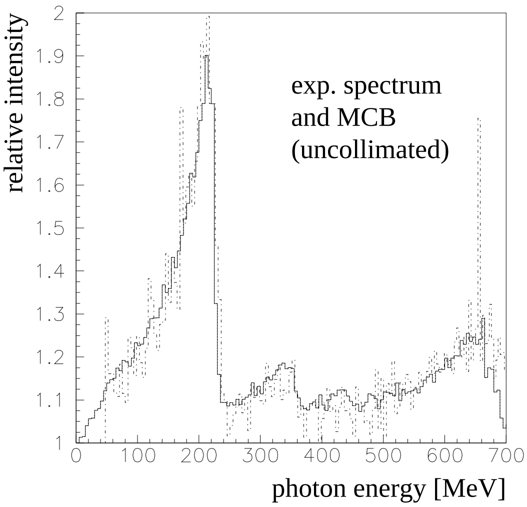
- more accurate E_γ, θ_c, Z dependence than BH
- e^- brems contribution (E_γ, Z), E_B corrected
- møller scattering ($\sim 5\%$)

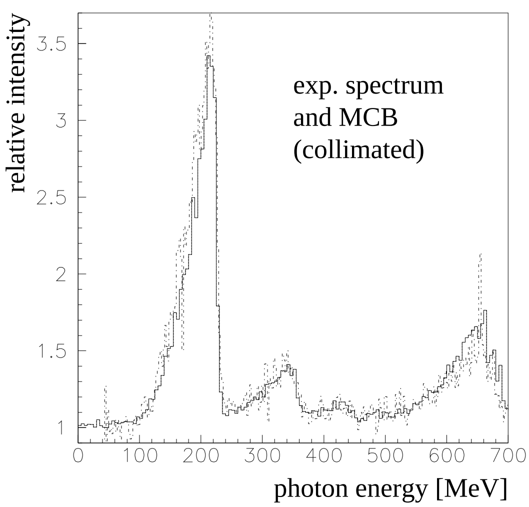
Hubbell, JAP 30/7 (59) 981

Mathews,Owens, NIM 111 (73) 157



MCB: S. Wunderlich, Dipl. thesis, Tuebingen 97





▶BH: $\bar{P}_{1/2} = 51\%$ $\Longleftrightarrow$ Hubbell: $\bar{P}_{1/2} = 48\%$

^{4}He/^{12}C Photon Asymmetry in Comparison

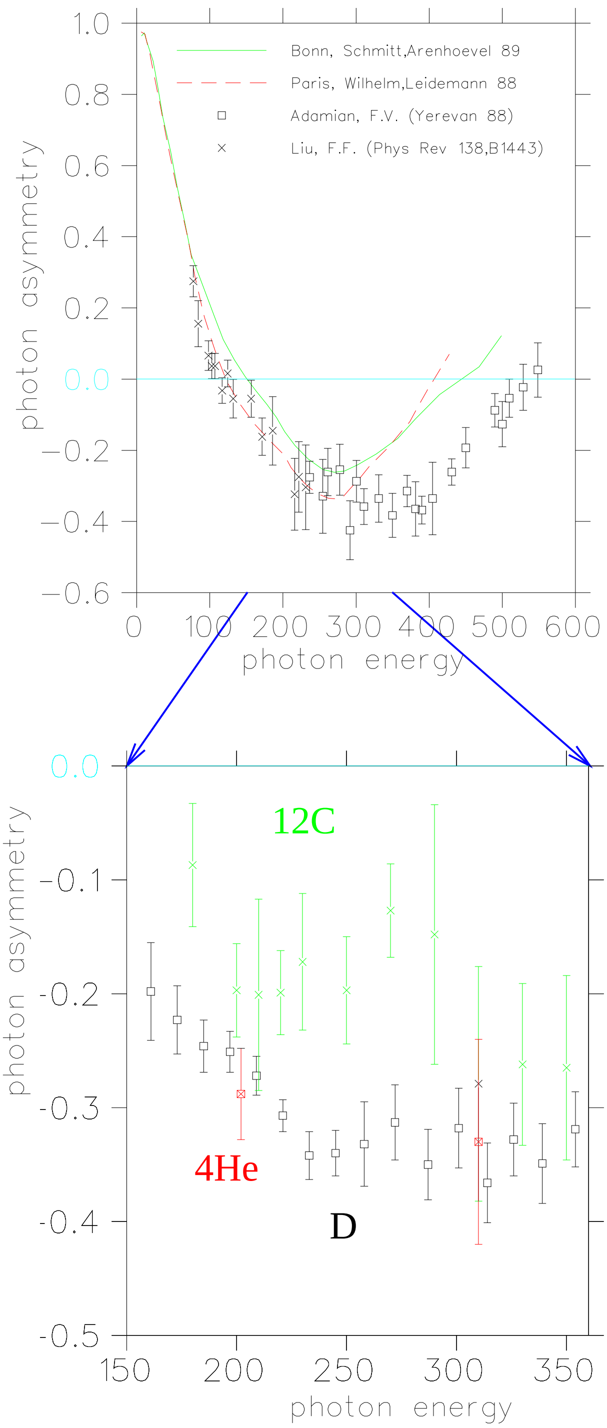
Low E_γ :

E1 dominant $\rightarrow \Sigma$ pos

$E_\gamma > \pi$ threshold :

M1 dominant $\rightarrow \Sigma$ neg
(N-Δ transition $\sim$ M1)

$(\theta_p = 90^\circ)$



^{4}He $\sim$ D ?
(only subset of data !,
calibration not yet finished)

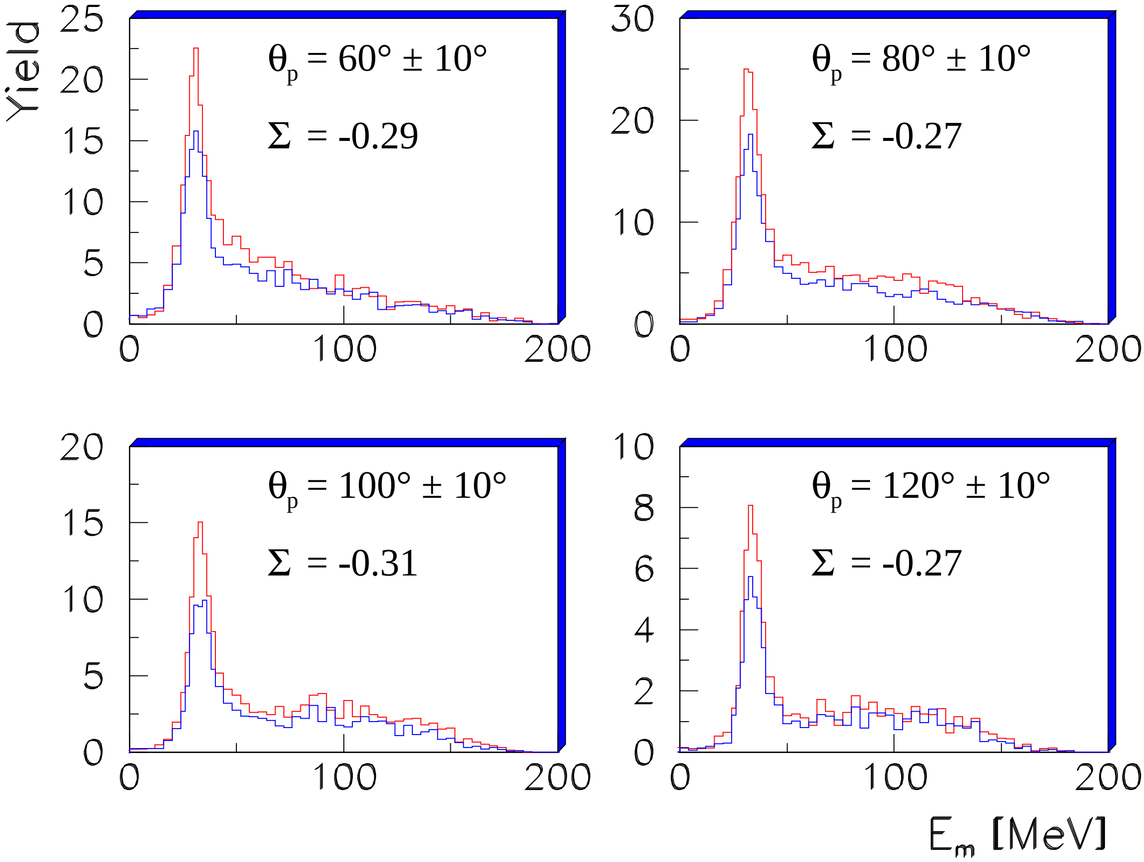
^{12}C : FSI or
medium SRC effects

$(50^\circ < \theta_p < 130^\circ)$

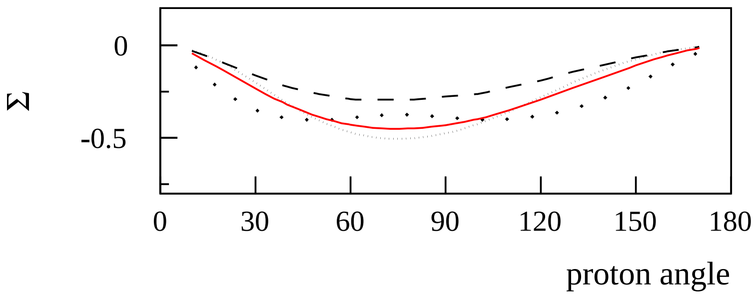
preliminary !!

Angular Dependence of the Asymmetry

$^4\mathrm{He}(\vec{\gamma},\mathrm{np})$ photon asymmetry at $E_\gamma = 220\mathrm{MeV}$,
perpendicular und parallel polarisation:



Jan Ryckebusch
$^{12}\mathrm{C}(\gamma,\mathrm{pn})^{10}B$
$E_\gamma = 200$ MeV
(to be published)



preliminary !!

Summary

- Previous experiments:
  - reaction mechanisms understood
  - direct 2N absorption separable
- Improved description of polarised Bremsstrahlung
  $\rightarrow$ reliable determination of degree of polarisations
- Photon asymmetry measurements on ^{4}He und ^{12}C successfully finished
  - reliable data and high statistics
  - encouraging preliminary results

Prospects

- Continue analysis on all E_γ for both (np,pp) channels
  $\rightarrow$ (Σ) in dependence of E_γ and ϑ_N
- Better theoretical calculations necessary, in particular ^{4}He
  $\rightarrow$ enhanced cooperation with theorists
  from Gent, Trento, Pavia, Valencia, Tübingen
- High resolution ^{16}O Experiment (accepted)
  separat resolved final states allow studying of indivial reaction mechanisms (aimed at E_m resolution of 1.5 MeV)