Hall A Collaboration Meeting

Newport News, USA

December 11, 2003

Update to E97-111:

Study of SRC and (e,e'p) Reaction Mechanism via $^{4}He(e,e'p)^{3}H$

Bodo Reitz

for the E97111 Collaboration

Motivation: $^{4}He(e,e'p)^{3}H$

Why proton knockout?

- testing universal prediction of state-of-the-art 4N calculations
- sensitivity to short-range part of wavefunction and NN forces ??
- testing reaction dynamics for (e,e' p) at JLab energies

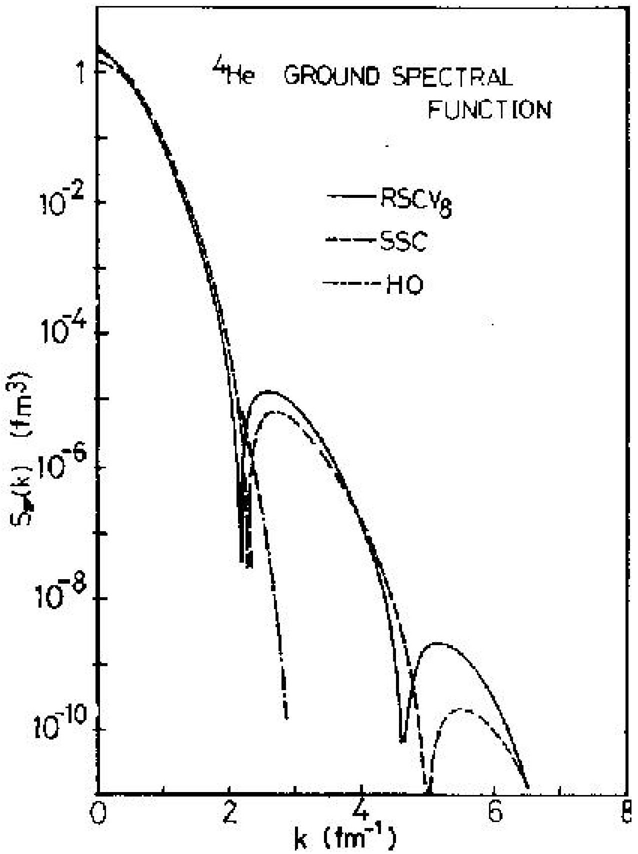
Why ^{4}He?

- most dense nucleus
- all features of a nucleus are present
- calculations are available

Outline

- Motivation
- Shortrange Correlations and Reaction Dynamics
- Status of the Analysis
- Some Results
- Next Steps

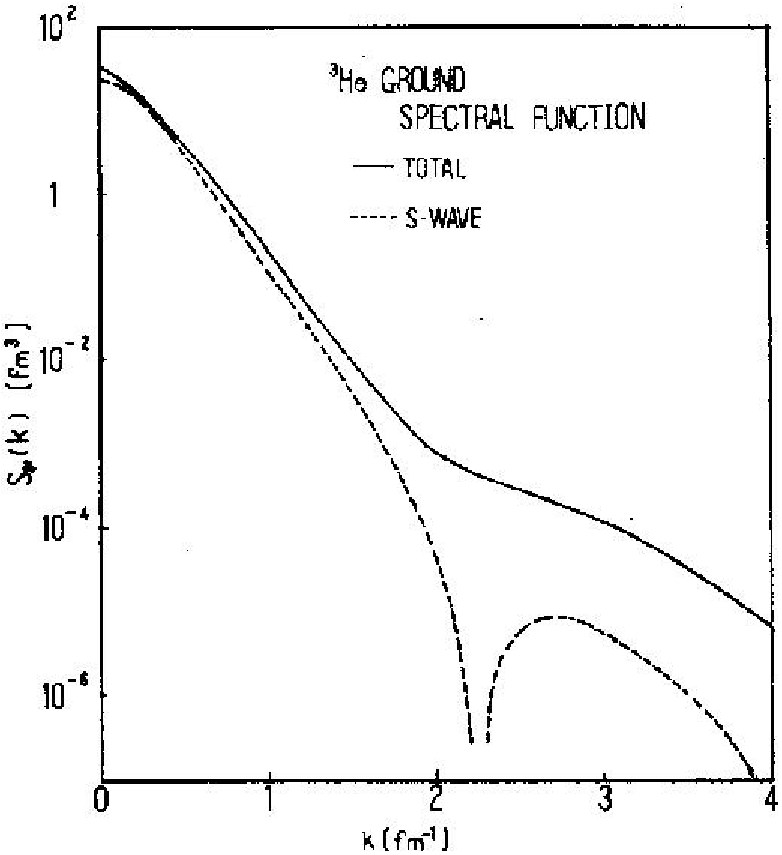
Spectral Functions and SRC



S. Tadokoro *et al.*, Prog. Theor. Phys 79, 732 (1987)

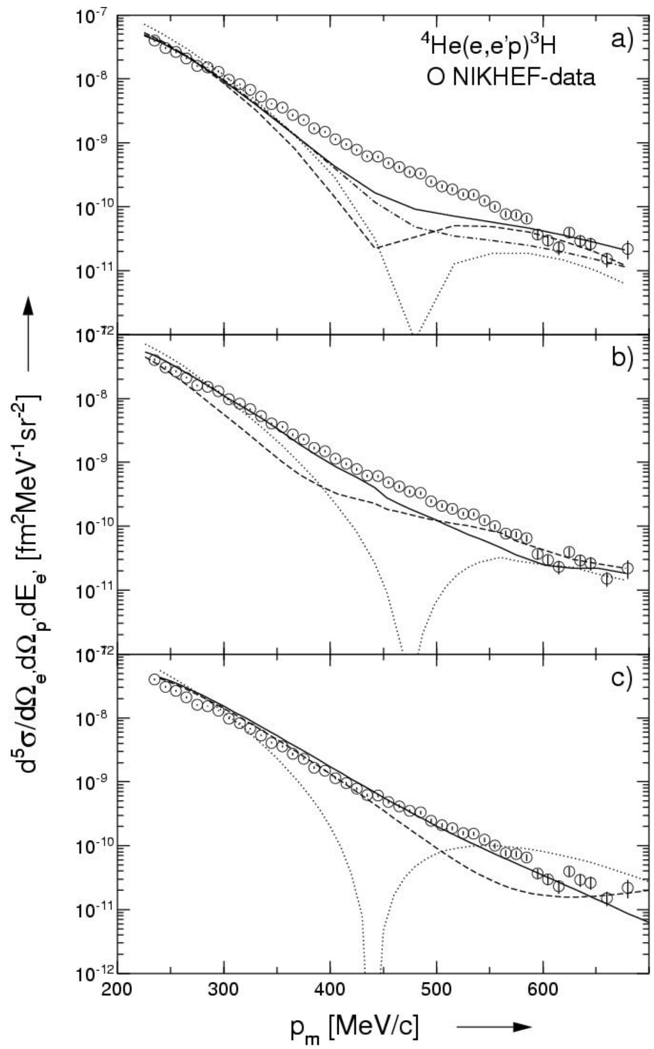
- harmonic oscillator:
  spectral function (spf) drops monotonical
- realistic interactions and correlations produce high-k structure
- position of minima, height of second maximum are sensitive to details

Comparison ^{3}He and ^{4}He



S. Tadokoro *et al.*, Prog. Theor. Phys 79, 732 (1987)

- no minimum in ^{3}He, because of d-wave contributions
- s-wave spectral functions alone are similar in ^{3}He and ^{4}He
- minimum in ^{4}He is caused by s-wave SRC

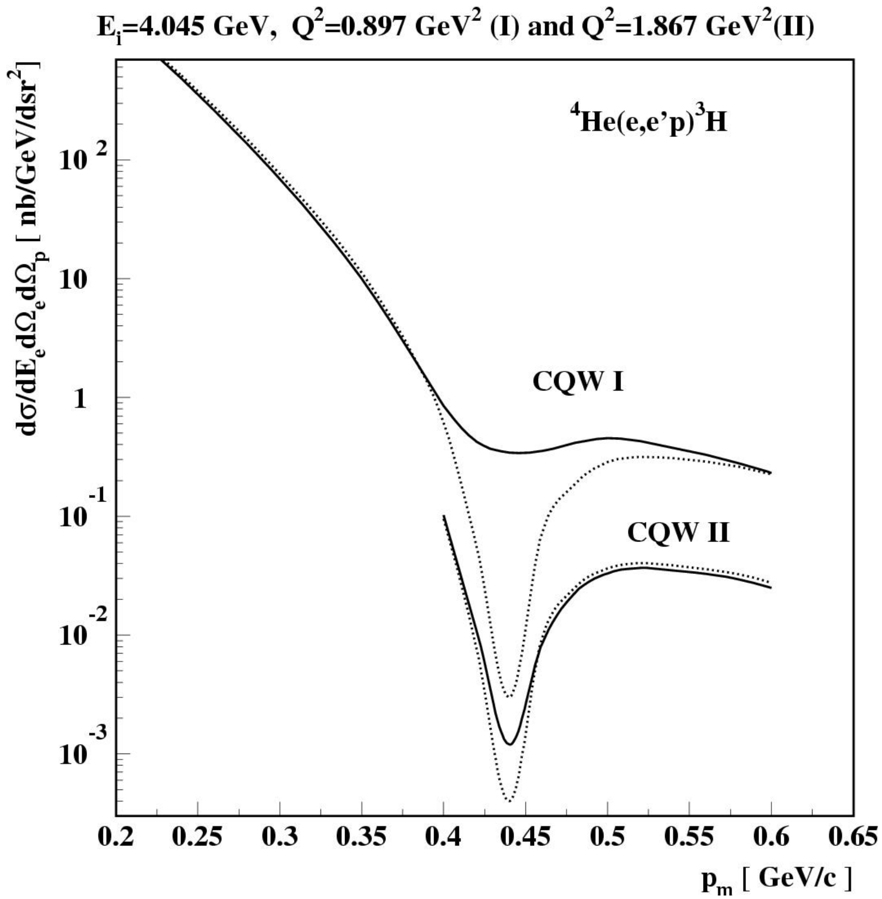


J.J. van Leeuwe *et al.*, PRL 80, 2543 (1998)

Theory and Experiment

- calculations from:
  a) Laget, b) Schiavilla, and c) Nagorny
- PWIA (dotted):
  location of minimum differs
  (different NN interactions)
- FSI (dashed), FSI+MEC (solid):
  obscure the minimum
- NIKHEF data:
  fixed electron kinematics
  (ω = 215 MeV and q = 400 MeV/c)
  ⇒ perpendicular kinematics
  ⇒ relativly low momentumtransfer

How to Suppress FSI in (e,e'p)



- higher momentum transfer
  - momentum of outgoing proton increases
  - FSI (elastic rescattering) decreases
- parallel kinematics
  - always selects minimum p_{miss}
  - in perpendicular kinematics: rescattered low p_{miss} nucleons can contribute at larger p_{miss}
  - GEA predicts minimal sensitivity to FSI for parallel kinematics

How to Suppress FSI: Large *y* Values

- *y* is minimum struck-nucleon momentum consistent with electron kinematics at parallel kinematics $|p_{miss}| = y$
- positive *y*:
  - nucleon moves parallel with virtual photon
  - high energy side of quasielastic peak
  - all momenta (p_s, p_f, and q) are aligned
  - multistep and contaminating processes are suppressed, "nothing but PWIA can happen"
- negative *y*:
  - nucleon motion opposite to mometum of virtual photon
  - preferable for inclusive electrons scattering
  - GEA shows: FSI also suppressed, but not as efficiently

How to Suppress MEC and N*

- large Q^2:
  - kill $NN\pi$ form factor
  - kill π propagator
- large negative y values
  - smaller ω smaller MEC and N* amplitudes

Jlab Experiment E97-111

	E_0 (GeV)	Q^2 ((GeV/c)^2)	ω (MeV)	p_m (MeV/c)	p_e (MeV/c)	p_p (MeV/c)
cq2a	3.952	1.78	525	395	3427	1041
cq2b	3.952	1.78	525	446	3427	1041
cq2c	3.952	1.78	525	495	3427	1041
cq3	3.952	1.82	487	468	3465	960
py1a	2.389	0.44	284	26	2105	744
py1b	2.389	0.42	369	126	2020	870
py1c	2.389	0.40	478	226	1911	1015
py1d	2.389	0.37	624	325	1765	1193
py1e	2.389	0.33	830	425	1559	1431
py1f	2.389	0.28	1035	495	1354	1657
py2a	3.170	0.89	537	24	2633	1105
py2b	3.170	0.85	653	124	2517	1250
py2c	3.170	0.80	798	223	2372	1419
py2d	3.170	0.73	985	323	2185	1627
py2e	3.170	0.65	1239	423	1931	1900
py2f	3.170	0.57	1481	493	1689	2154

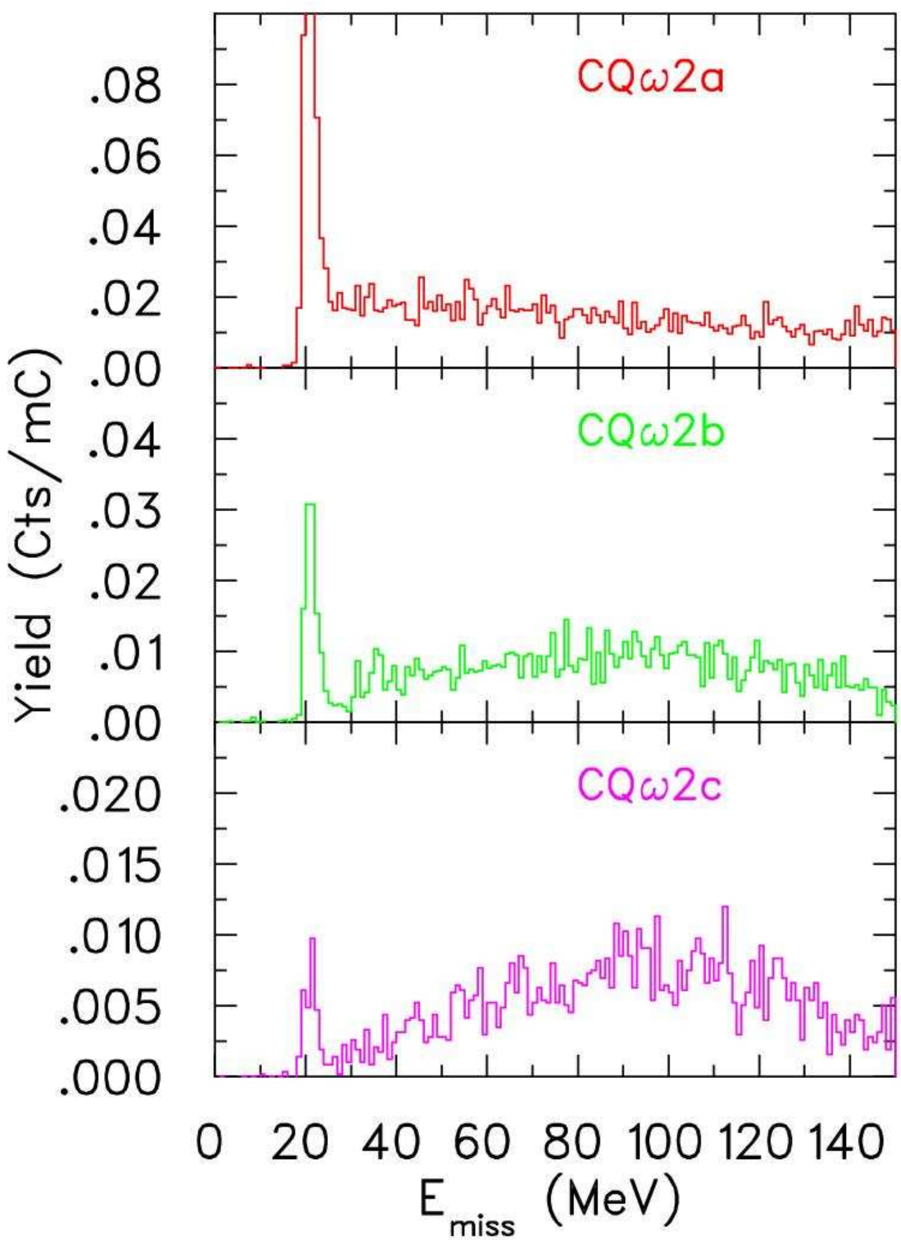
- Hall A experiment to measure the two-body-breakup of ^{4}He: $^4\text{He} \rightarrow t + p$
- emphasizes parallel kinematics
- measures at various values of (large, positive) *y*
- measures at various Q^2
- kept CQω approach for comparison
- testing reaction dynamics
- testing spectral function

Status of the Analysis I

- completed so far:
  - database (optics, pointing, gains & pedestals, angular offsets, target model, ...)
  - electronic and computer deadtime
  - scintillator efficiencies
- further done, but not necessary final:
  - monte carlo (MCEEP)
  - acceptance cuts (at present R-function)
  - PID cuts

Status of the Analysis II

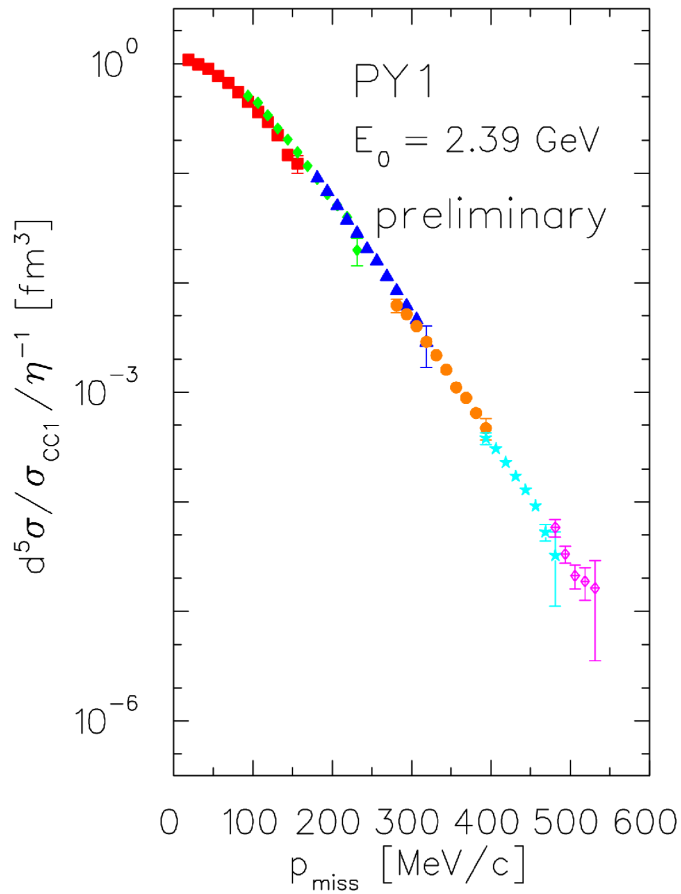
- work in progress:
  - VDC efficiencies
  - boiling studies
  - analysis of elastic runs (normalisation)
- all data has been replayed, preliminary results are available

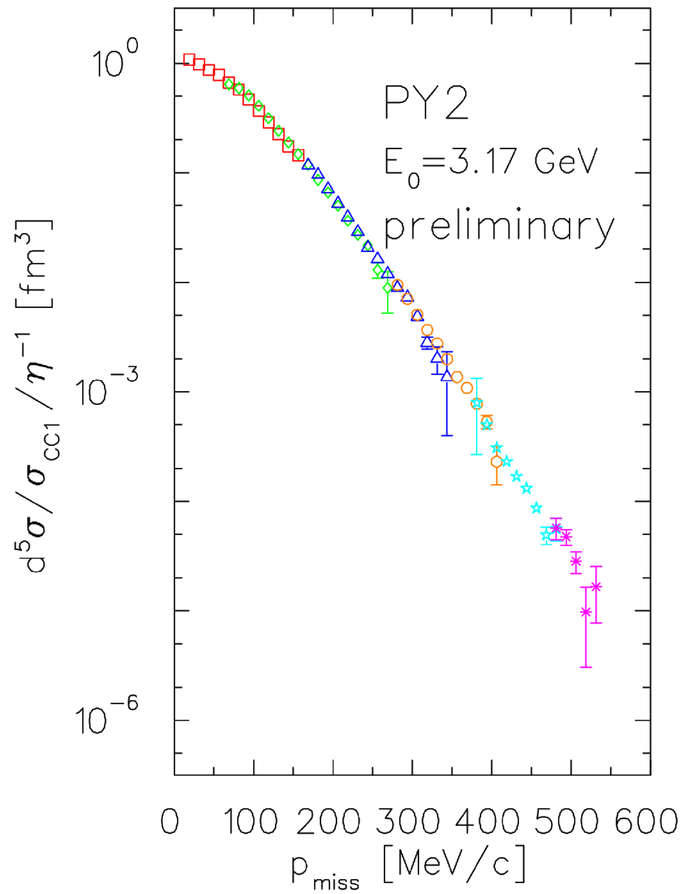


Missing Energy Spectra

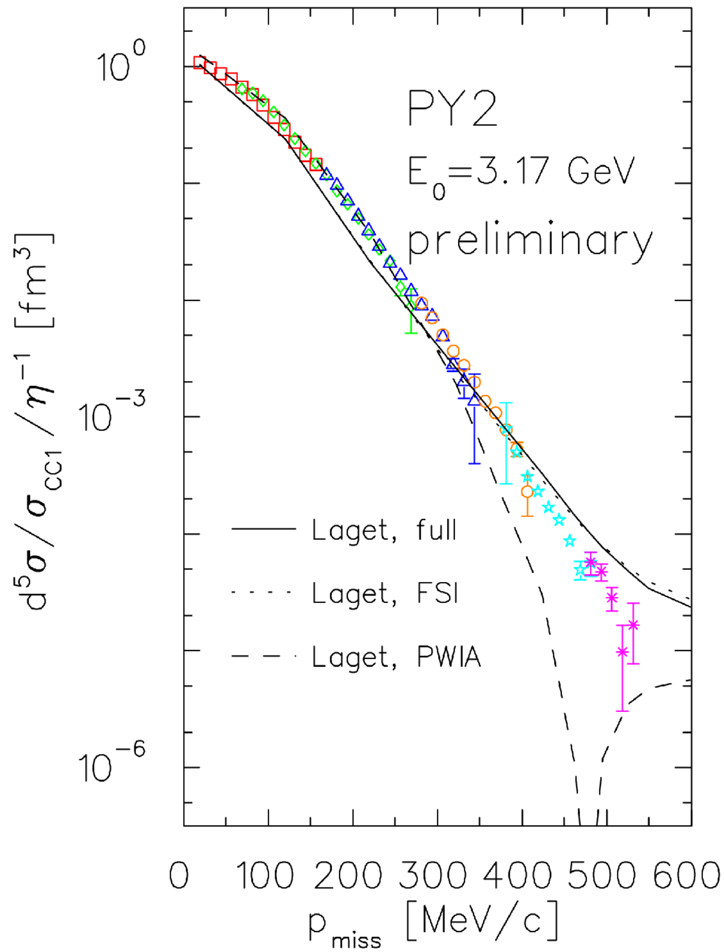
- beam energy 3.95 GeV
- electron scattering angle 20.9°
- Q^2 = 1.78 $(GeV/c)^2$
- CQw2a: p_{miss} = 410 MeV/c
- CQw2b: p_{miss} = 470 MeV/c
- CQw2c: p_{miss} = 525 MeV/c

Parallel Kinematics





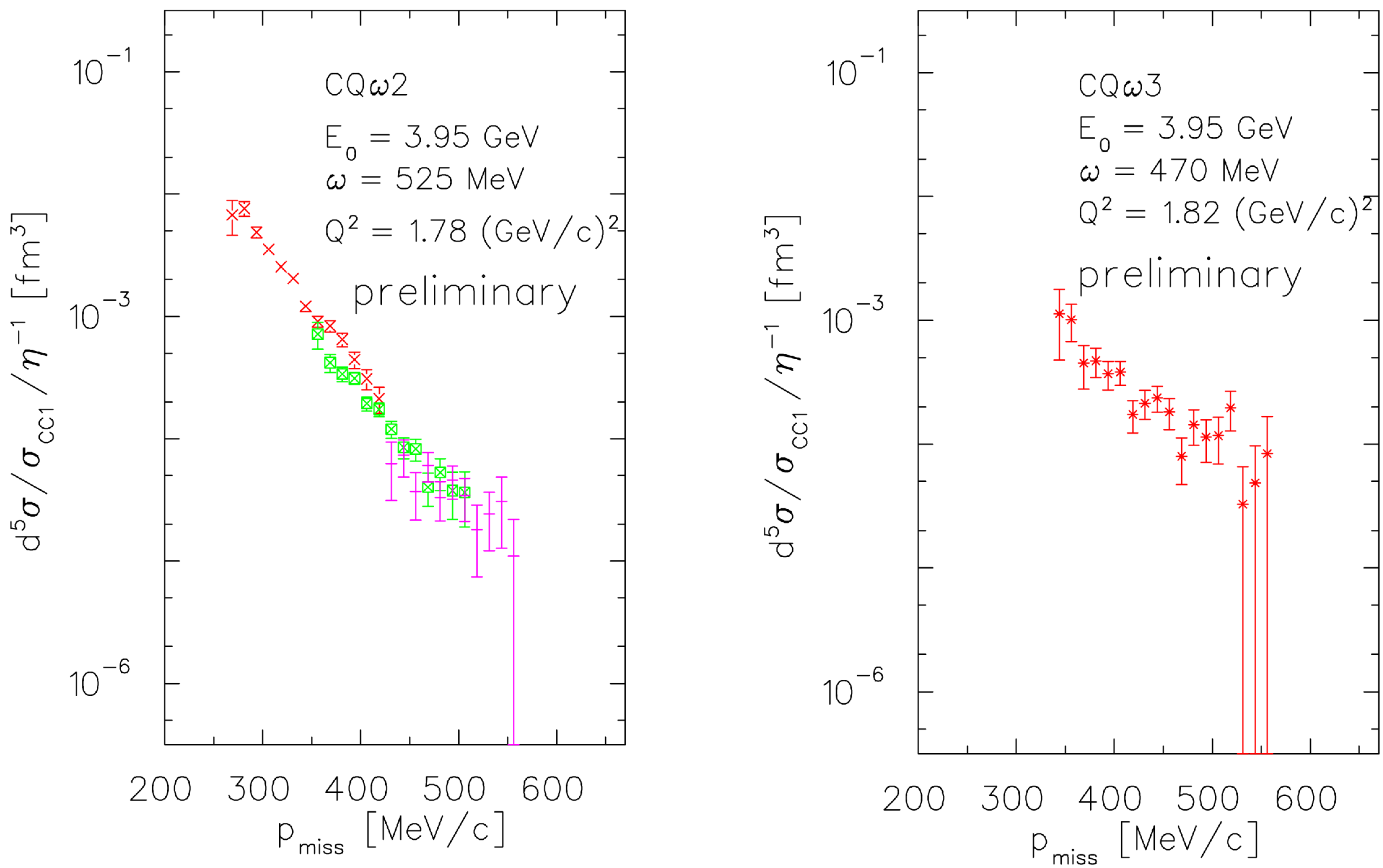
Parallel Kinematics II



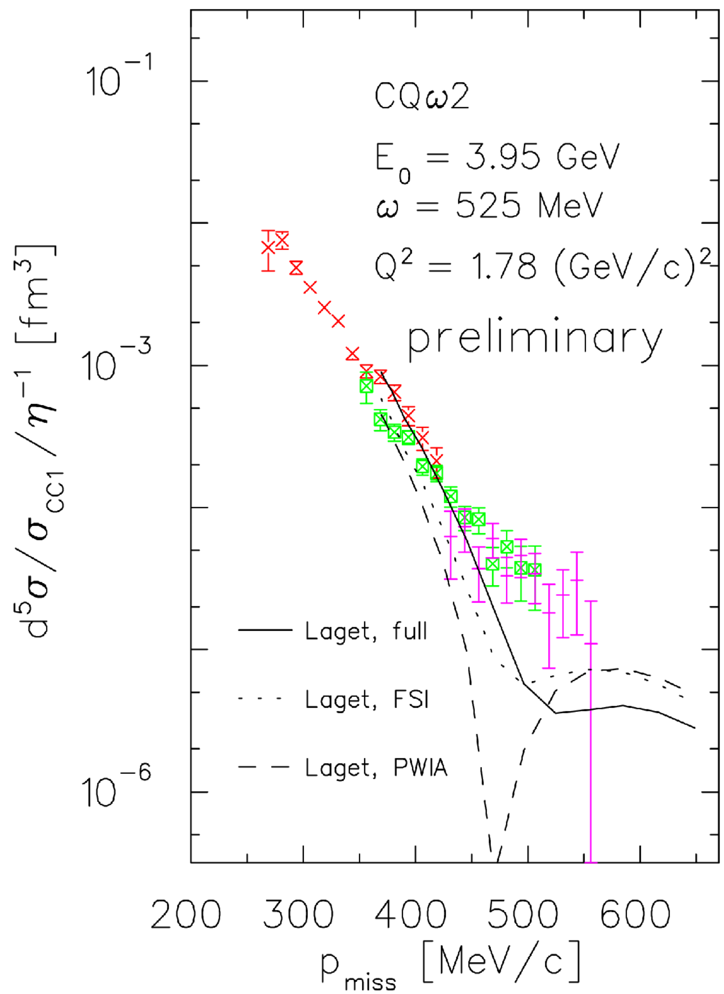
- theory works at low missing momentum
- PWIA predicts minimum
- including FSI the minimum vanishes
- MEC and Δ give only minor contributions
- no minimum in experimental data

calculations by J.- M. Laget

Perpendicular Kinematics



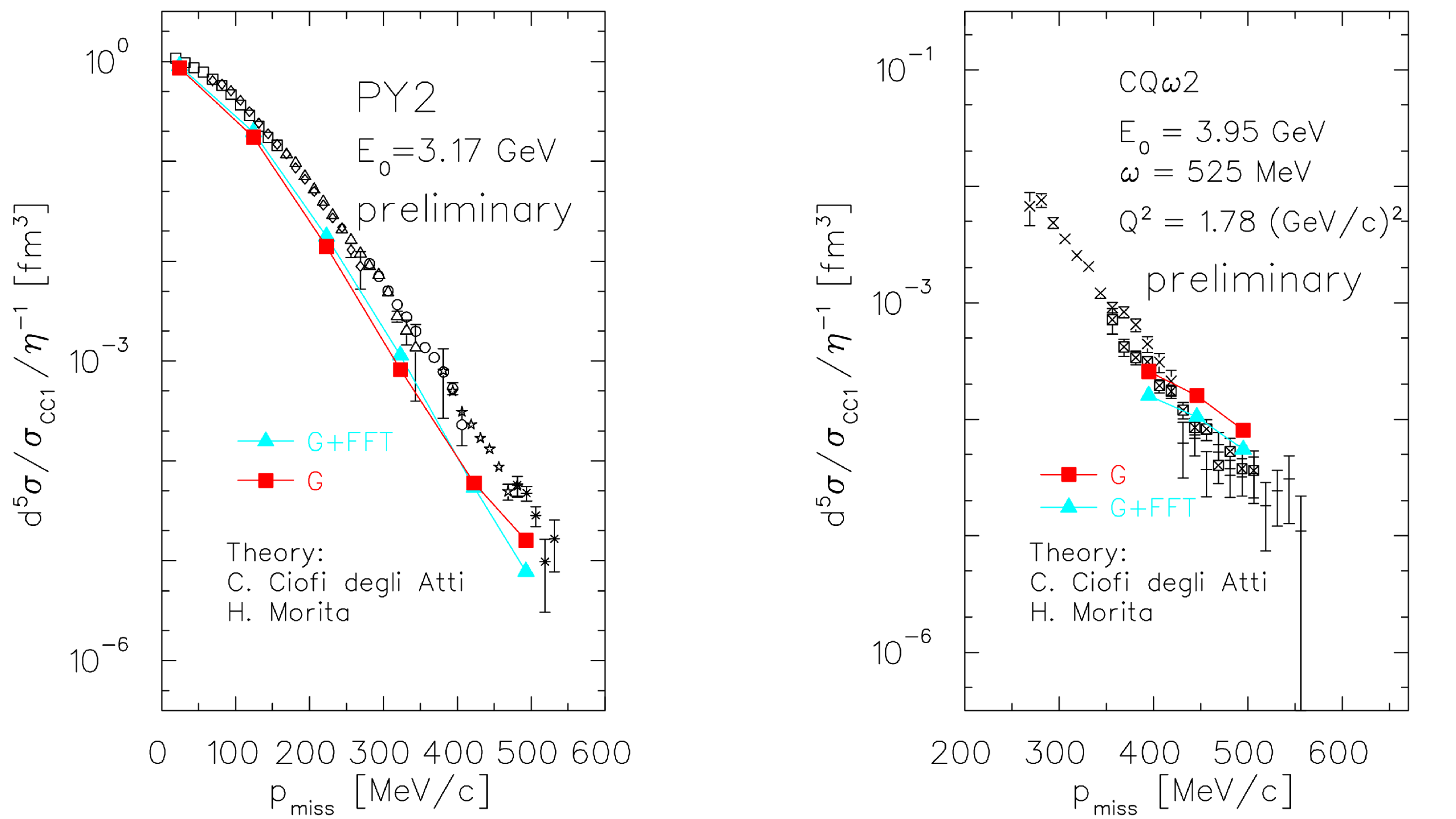
Perpendicular Kinematics II



- PWIA (dashed):
  minimum at 470 MeV/c
- including FSI (dotted):
  minimum mostly filled in
- full calculation (solid):
  includes FSI + MEC + Δ
  minimum mostly filled
- experiment:
  no sign of minimum at all

calculations by J.- M. Laget

Finite Formation Time Effects



Next Tasks

- finishing VDC analysis
- gas and aerogel Cherenkov efficiencies
- acceptance studies (finalize, induced uncertainties)
- radiative corrections (finalize, induced uncertainties)
- dummy target substraction vs. reactz cuts
- ...
- PHYSICS
- analysis of continuum data ???