# Systematic Probe for SRC in the $^4$He "dip"

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- Experimental Background (E91-10 at NIKHEF-K)
- Theoretical and Speculational Background
- Proposed Measurements
- Relation to Other Approved Proposals

# NIKHEF-K E91-10

## $^{4}\mathrm{He}(e, e'p)$ at High $E_m$ and $p_m$

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# Kinematical Setup

$E_e = 525$ MeV $\quad Q^2 = 0.11$ $(\text{GeV}/c)^2$

$|\vec{q}| = 401$ MeV/$c$ $\quad \omega = 215$ MeV

$p_m$ range: 20–690 MeV/$c$

$E_m$ range: 0–140 MeV

Expt. done in constant $(\vec{q}, \omega)$ kinematics; large $(E_m, p_m)$ range from

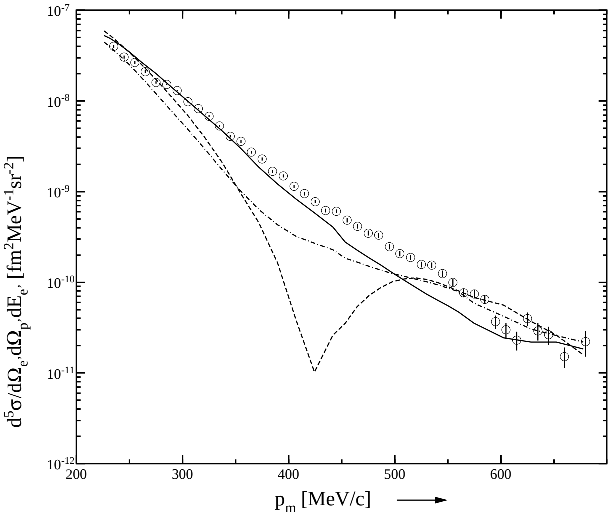
- large proton-energy bite (65–185 MeV)
- large proton-angle coverage (45–136 deg)
- used HADRON-4 detector (Vrije Universiteit/NIKHEF)

Invariant mass (1B mechanism): 1081 MeV

$= m_p +$ 143 MeV

$= m_\Delta -$ 151 MeV

## $\sigma(p_m)$ for Two-Body Breakup Channel
## $(\omega, \mathrm{q})$=(215 MeV, 401 MeV/$c$)

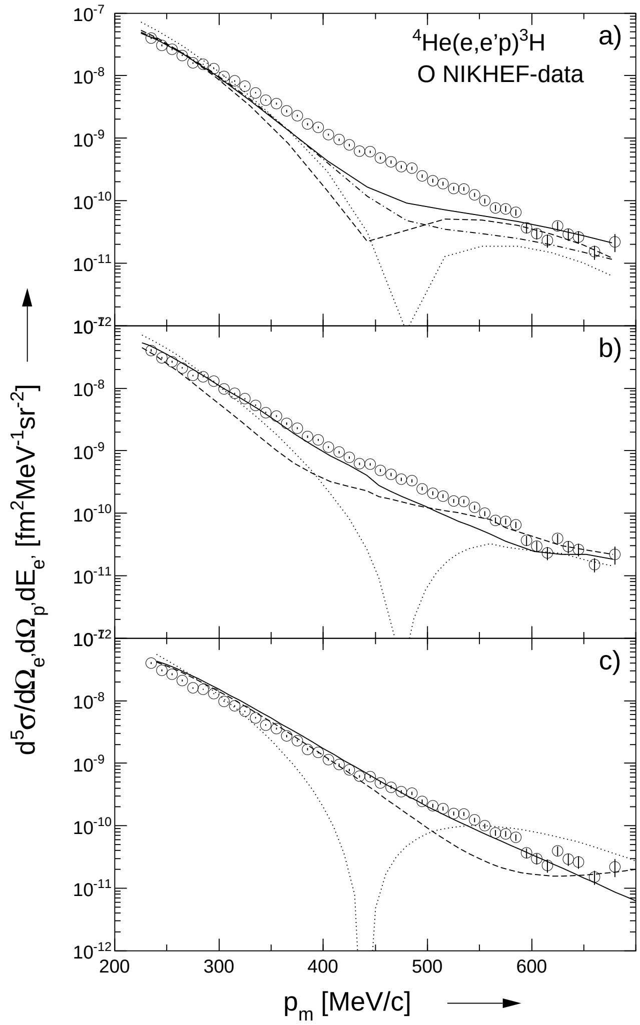



Koos van Leeuwe, Ph.D. Thesis (NIKHEF-K), 1996

Calculations: R. Schiavilla, variational MC

- Dip in PWIA driven by short-range part of NN interaction
- *not observed* in cross section
- dashed curve: PWIA
- dot-dashed: DWIA
- solid: DWIA + two-body currents

# Latest Calculations




Koos van Leeuwe *et al*, submitted to PRL, 1997

- Top Plot: Laget
- Middle Plot: Schiavilla
- Bottom Plot: Nagorny

# Kinematics for E91-10

Limited by

- AmPS (beam energy)
- nonmagnetic proton detector $(\theta_p, T_p)$

Electron kinematics fixed, make $p_m$ distribution by changing proton emission angle $\theta_p$.

Disadvantage: expect reaction effects (FSI, MEC) to be large when $\theta_{pq} \gtrsim 20\,\mathrm{deg}$[a]

For $p_m \sim 450$ MeV/$c$, $\theta_{pq} \sim 50\,\mathrm{deg}$ in NIKHEF kinematics. Obscurance of "dip" in this respect not surprising.

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[a] A. Bianconi and M. Radici, Phys. Lett. **B363**, 24 (1995).

## Ideas About How To Suppress Reaction Effects

- increase $|\vec{q}|$
- parallel kinematics
- go to $-y$
- go to $+y$

Rationales:

- increase $|\vec{q}|$:
  increase in outgoing proton momentum decreases FSI
- parallel kinematics:
  - calculations show this minimizes FSI effects

## Ideas About How To Suppress Reaction Effects (II)

- go to $-y$
  - put less energy into system $\rightarrow$ decrease effects from $\Delta$ and MEC
  - has been observed to "work" in inclusive $(e, e')$ experiments
- go to $+y$ (parallel kinematics)
  - put *all* of $\vec{q} + \vec{p}_i$ into final proton
  - contaminant processes must all conspire in order to reach same $\vec{p}_p$

# Ideas About How To Suppress Reaction Effects (III)

more $+y$ arguments

- supported by calculation[a]; $p_m^z > k_F \rightarrow$ "FSI" amplitude sensitive to SRC
- also predict SRC sensitivity in $-y$ kinematics whenever $|p_m^z| - E_x^B > k_F$
- note that both these constraints demand parallel kinematics!
- at low $E_x^B$, predict little advantage of $+y$ over $-y$, but $-y$ becomes less advantageous with $E_m$

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[a] Frankurt, Sargsian, and Strikman; Los Alamos Archive nucl-th/9603018 and Phys. Rev. C **56**, 1124 (1997).

## Proposed Experiment

Measure $^4\text{He}(e,e'p)^3\text{H}$ at JLab

Kinematics

- (I) "NIKHEF" kinematics — fix electron, vary $\theta_{pq}$ to vary $p_m$. Use higher $|\vec{q}|$ (1000 MeV/$c$) than at NIKHEF (400 MeV/$c$).
- (II) "$+y$" kinematics — parallel, vary $\omega$, $p_p$ and $\theta_p$ simultaneously to vary $p_m$.

Perform both types of kinematics at two $Q^2$ values — vary reaction effects but not structure (theorists like this).

## Kinematics Summary: "NIKHEF I"

```
Beam energy  4045.0 MeV, scatang.  14.17  deg
omega =  400.00 MeV,     3-mom xfer = 1028.21 MeV/c
 Q^2  =     0.897 (GeV/c)^2, y = -104.72 MeV/c

thetap =  61.30 deg, pp =  923.40, pm = 106.44 MeV/c
thetap =  80.01 deg, pp =  894.00, pm = 355.99 MeV/c
thetap =  85.00 deg, pp =  878.00, pm = 434.81 MeV/c
thetap =  90.03 deg, pp =  859.00, pm = 512.44 MeV/c
```

# Kinematics Summary: “NIKHEF II”

```
NIKHEF kinematics II
Beam energy  4045.0 MeV,  scatang.    20.88  deg
omega =  530.00 MeV,   3-mom xfer = 1465.72 MeV/c
Q^2   =    1.867 (GeV/c)^2,     y = -399.64 MeV/c

thetap =  59.51 deg, pp = 1066.00, pm = 400.08 MeV/c
thetap =  64.82 deg, pp = 1061.00, pm = 425.86 MeV/c
thetap =  68.90 deg, pp = 1052.00, pm = 468.66 MeV/c
thetap =  75.31 deg, pp = 1029.30, pm = 562.09 MeV/c
```

# Kinematics Summary "$+y$"

+y kinematics I

Beam Energy 2445.00 MeV, scat. ang. 16.83 deg

| w (MeV) | 3-q (MeV/c) | p_m (MeV/c) | thetap (o) | p_p (MeV/c) |
|---|---|---|---|---|
| 650.00 | 893.57 | 337.93 | 35.56 | 1231.5 |
| 850.00 | 1027.90 | 432.02 | 26.70 | 1459.9 |
| 1050.00 | 1180.97 | 499.24 | 20.00 | 1680.2 |

+y kinematics II

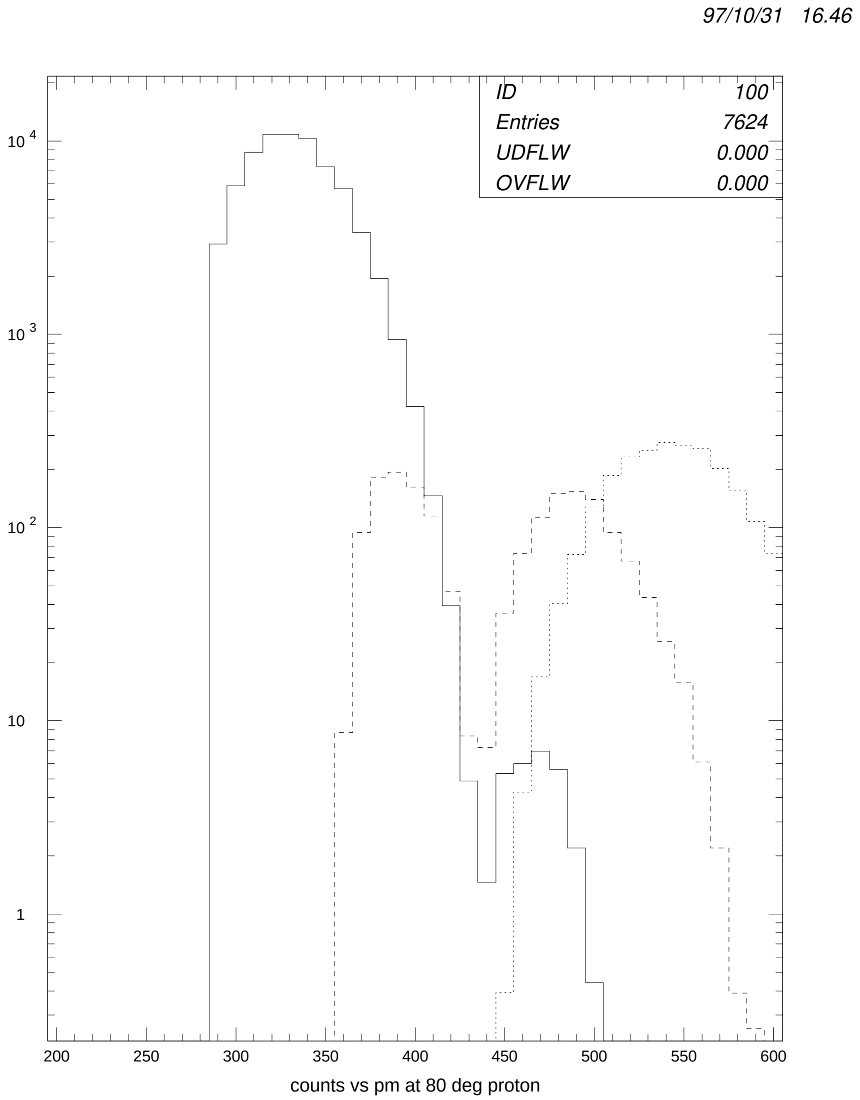
Beam Energy 3245.00 MeV, scat. ang. 18.78 deg

| w (MeV) | 3-q (MeV/c) | p_m (MeV/c) | thetap (o) | p_p (MeV/c) |
|---|---|---|---|---|
| 1000.00 | 1332.55 | 319.96 | 32.85 | 1652.5 |
| 1300.00 | 1536.89 | 436.17 | 24.04 | 1973.1 |
| 1500.00 | 1689.06 | 493.26 | 19.43 | 2182.3 |

## Count Rate Estimates

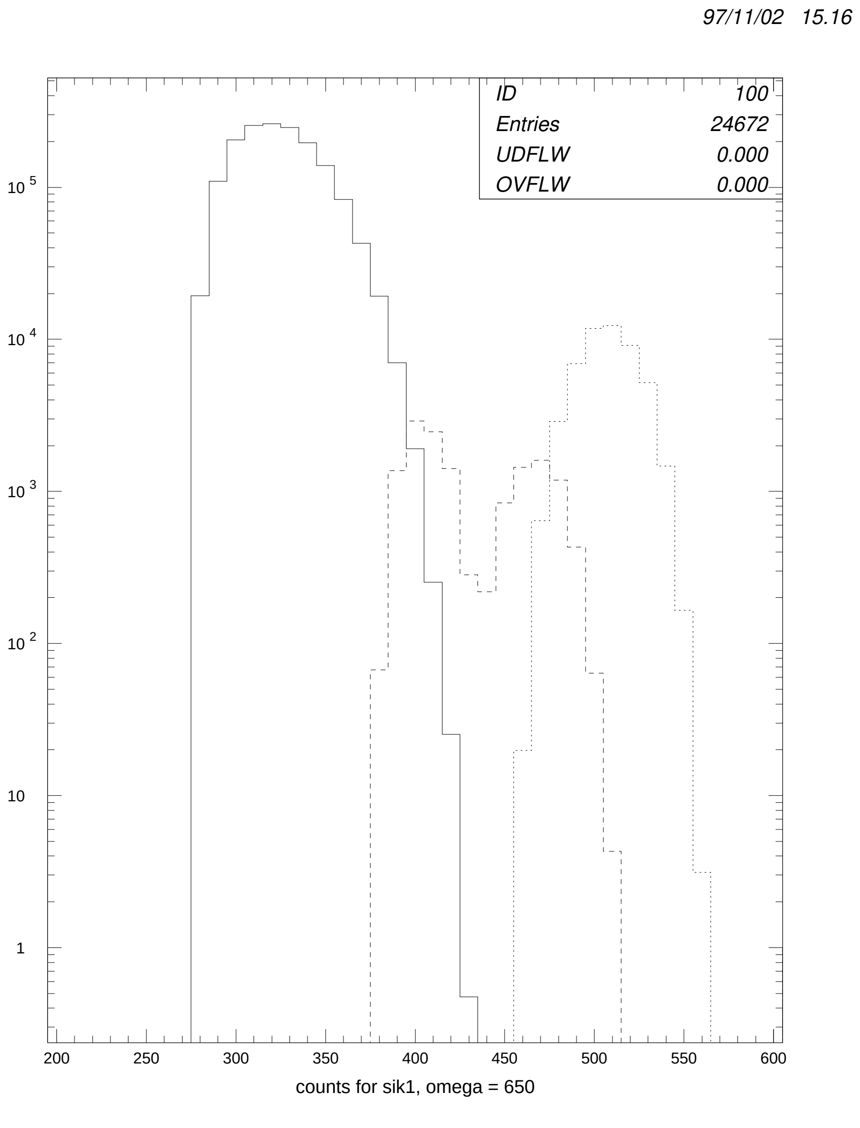
- Use proton-triton channel momentum distribution from R. Wiringa
- "cc1" version of $ep$ cross section
- PWIA (AEEXB code)
- cryotarget parameters from J.P. Chen
  - density 0.1525 g/cm$^3$
  - length 10 cm along beam
  - max current 100 $\mu$A
- compute rates in counts/(100 $\mu$A-hr)

# Count Rates
# "NIKHEF" Kinematics I




Vertical Axis: counts per 100 $\mu$A per hour
Horizontal Axis: $p_m$ (MeV/$c$)
proton angles 80, 85, 90 deg

# Count Rates
# "$+y$" Kinematics I




Vertical Axis: counts per 100 $\mu$A per hour

Horizontal Axis: $p_m$ (MeV/$c$)

$\omega$ settings of 650, 850, and 1050 MeV

## Relation to Other Experiments

- **Mainz** (A1/1-93 and A1/3-96)
  - L/T separation
  - high ($\sim 150$ MeV) $E_m$
  - $685 \leq |\vec{q}| \leq 900$ MeV/*c*
  - $p_m$ limited to about 300 MeV/*c* for $tp$ breakup
- **JLab 97-011**
  - strong overlap between point at $Q^2 = 2$ $(\text{GeV}/c)^2, y = -450$ MeV/*c* and our NIKHEF II kinematics
  - no data past $p_m$ = 450 MeV/*c*
  - no $+y$ measurements at all
  - push to higher $Q^2$, and emphasis on continuum breakup (high $E_m$)

## Summary

- measure $^4$He$(e, e'p)^3$H
- measure cross sections in “SRC dip” of $tp$ breakup channel
- use a variety of “best methods”
- short experiment (few days)
- who wants to help?