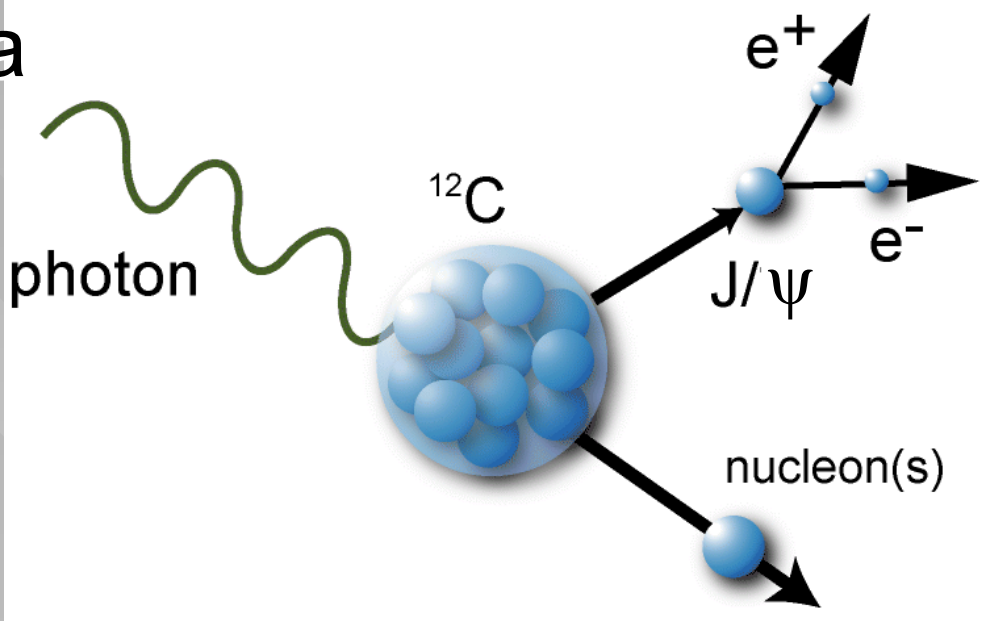
Sub-Threshold J/ψ Photoproduction

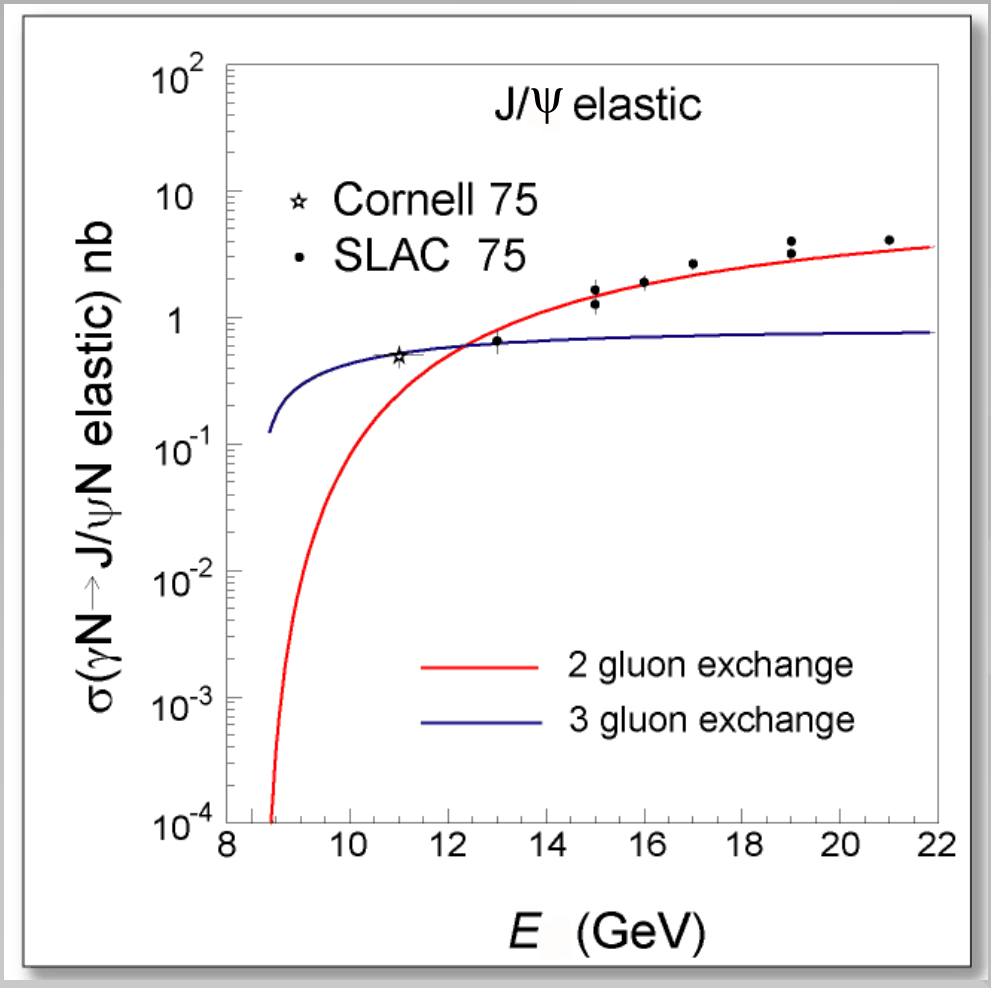
- Photoproduction Data
- Motivation
- Cross Section
- Summary



Jim Dunne

Mississippi State University

Near Threshold Photoproduction



Cornell:

- 11.8 GeV endpoint
- Be target
- e^+e^- detected in lead- glass calorimeter.

SLAC:

- 21-13.5 GeV endpoint
- D_2 and H_2 targets
- e^+e and $\mu^+\mu^-$ detected in pair of magnetic spectrometers

Cornell data indicate that the cross section flattens out near threshold.

SLAC Single Arm Muons

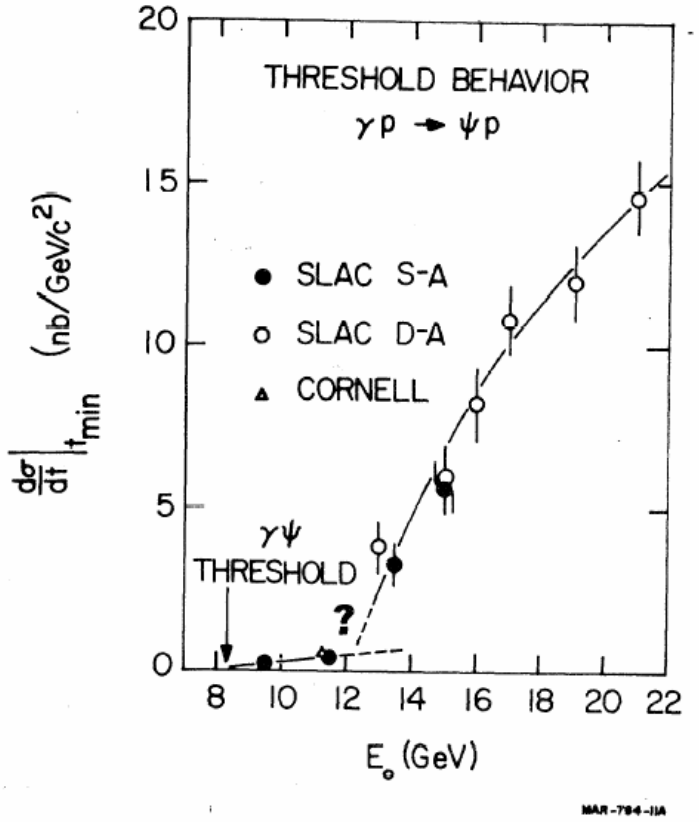


Fig. 10. Threshold behavior of dσ/dt at $t = t_{min}$ for ψ photoproduction. Black circles are the single arm measurements of this experiment.

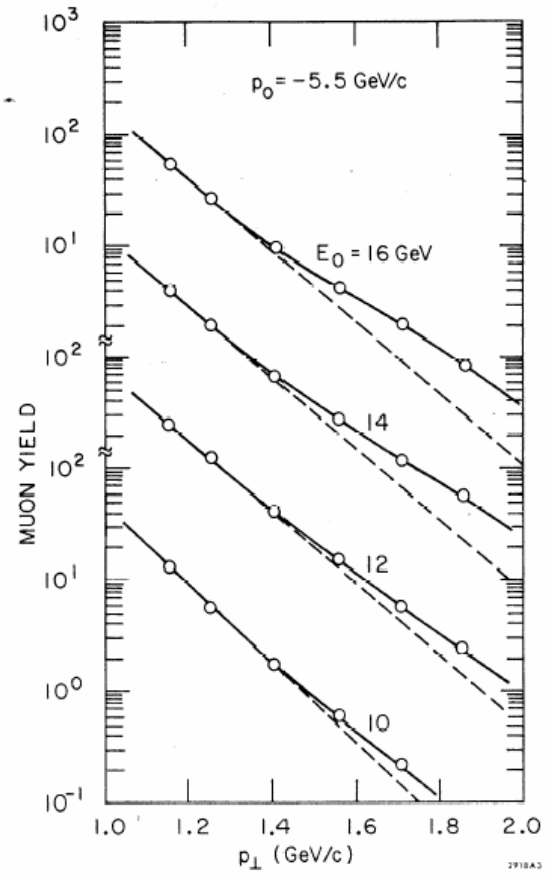


Fig. 9. Muon yield curves at incident photon energies of 10, 12, 14, and 16 GeV/c for a muon momentum at the target of -5.5 GeV. Photon beam was used.

Slope Parameter

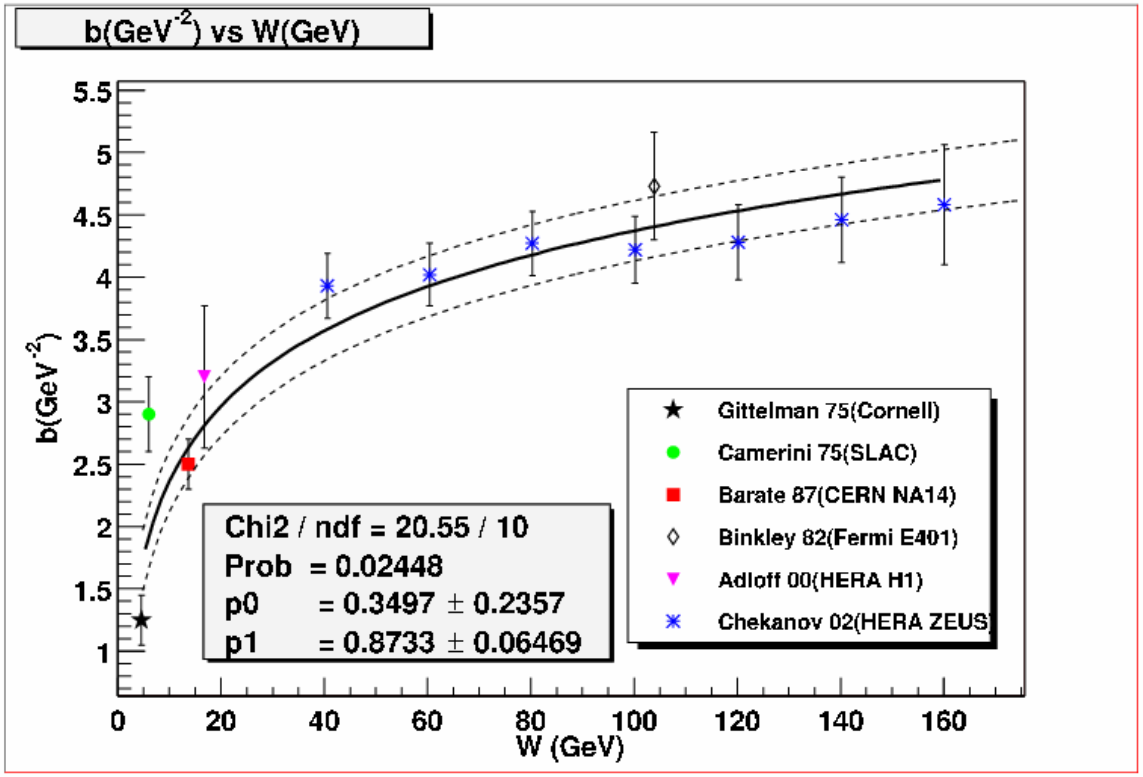
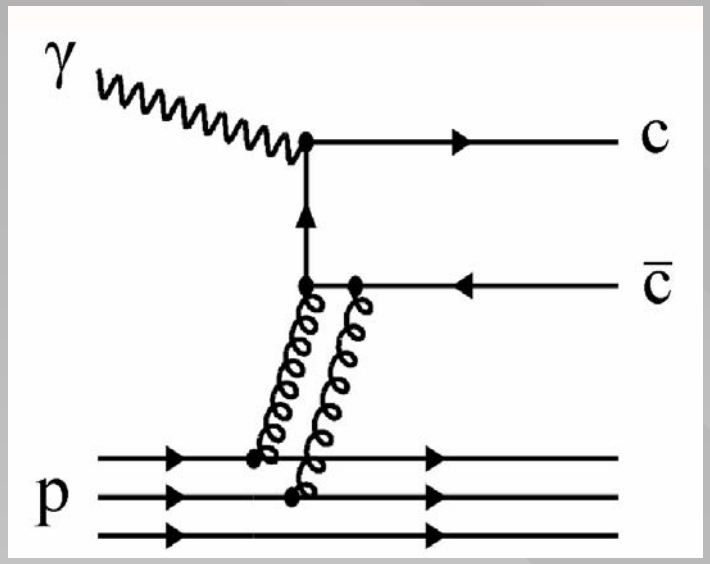
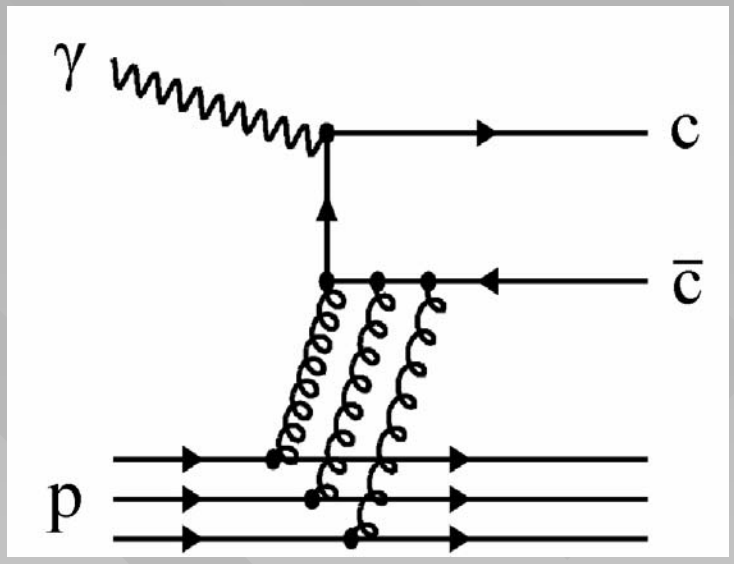


Figure 2: Slope parameter b from fits of the form Ae^{bt} to various J/ψ photoproduction experiments, as a function of $W = \sqrt{s}$.

Near Threshold Production Mechanism

Qualitative picture from S. Brodsky, E. Chudakov, P. Hoyer, J.M. Laget Phys. Lett. B498, 23 (2001).





$$\frac{d\sigma}{dt} = \mathcal{N}_{2g} v \frac{(1-x)^2}{R^2 \mathcal{M}^2} F_{2g}^2(t)(s - m_p^2)^2$$

$$\frac{d\sigma}{dt} = \mathcal{N}_{3g} v \frac{(1-x)^0}{R^4 \mathcal{M}^4} F_{3g}^2(t)(s - m_p^2)^2$$

$$\text{where} \quad x = \frac{s_{thres} - m_p^2}{s - m_p^2}, \quad \mathcal{M} = 2m_c, \quad R \approx 1/m_c$$

Hidden-Color

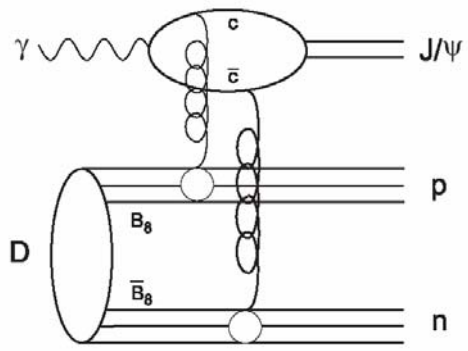


FIG. 4. The simplest diagram which reveals a hidden-color state in deuterium [18].

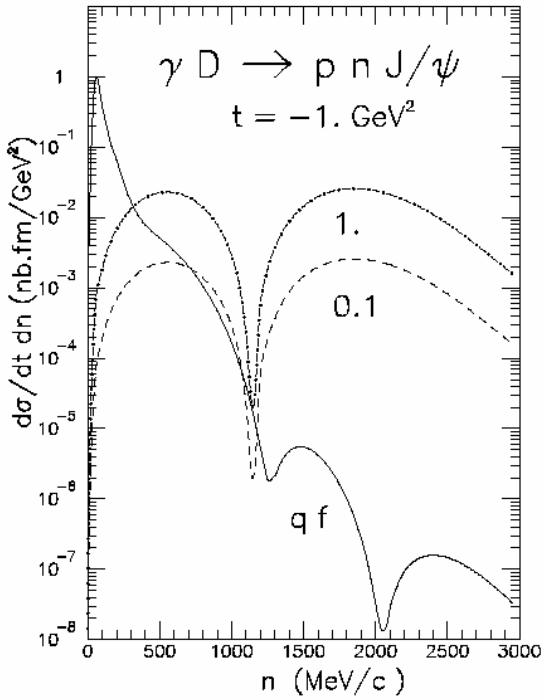
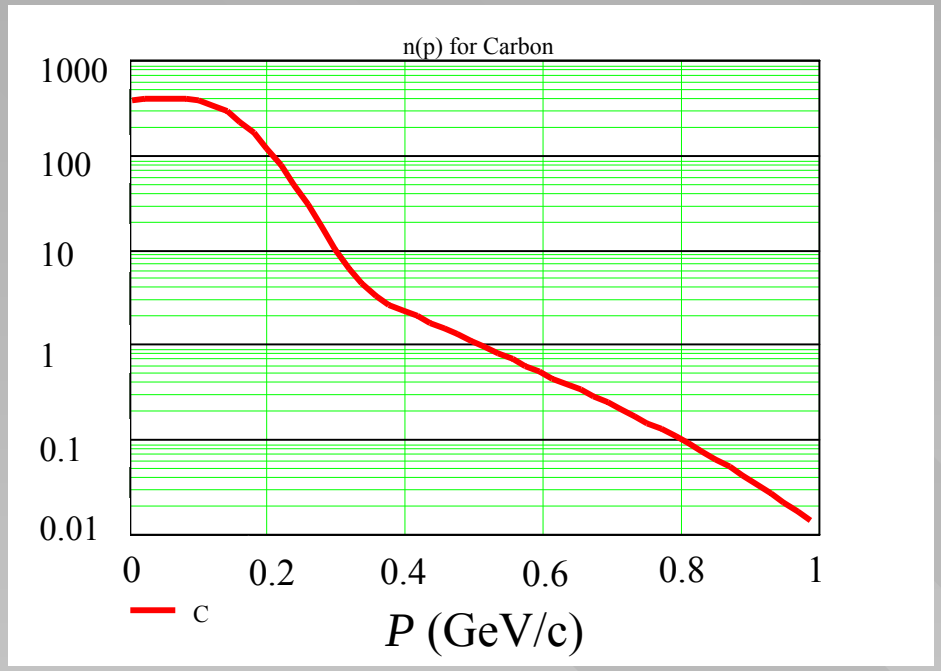
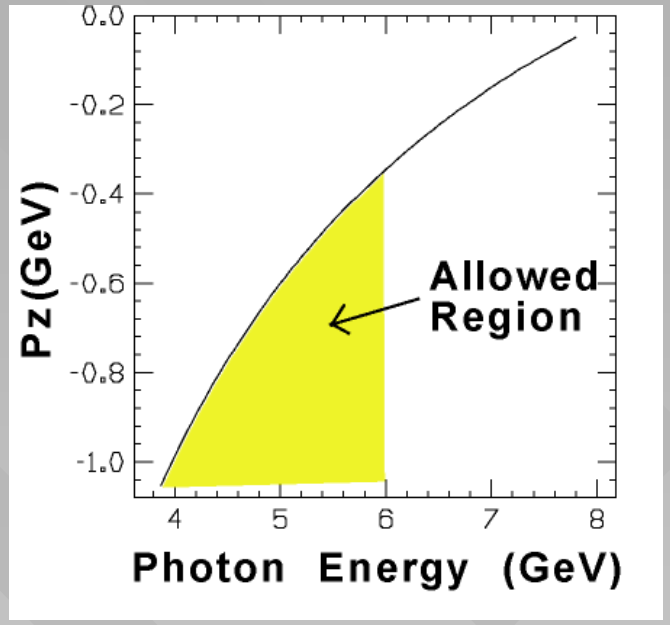


FIG. 5. The variation of the cross-section of the reaction $\gamma D \to pnJ/\psi$ against the neutron momentum $|\vec{n}|$, at fixed t. Solid line: quasi-free contribution. Dashed line: contribution of a hidden-color component when its probability is 0.1%. Dash-dotted curve: the same for a probability of 1%.

Each exchanged gluon may couple to a colored quark cluster to reveal hidden-color.

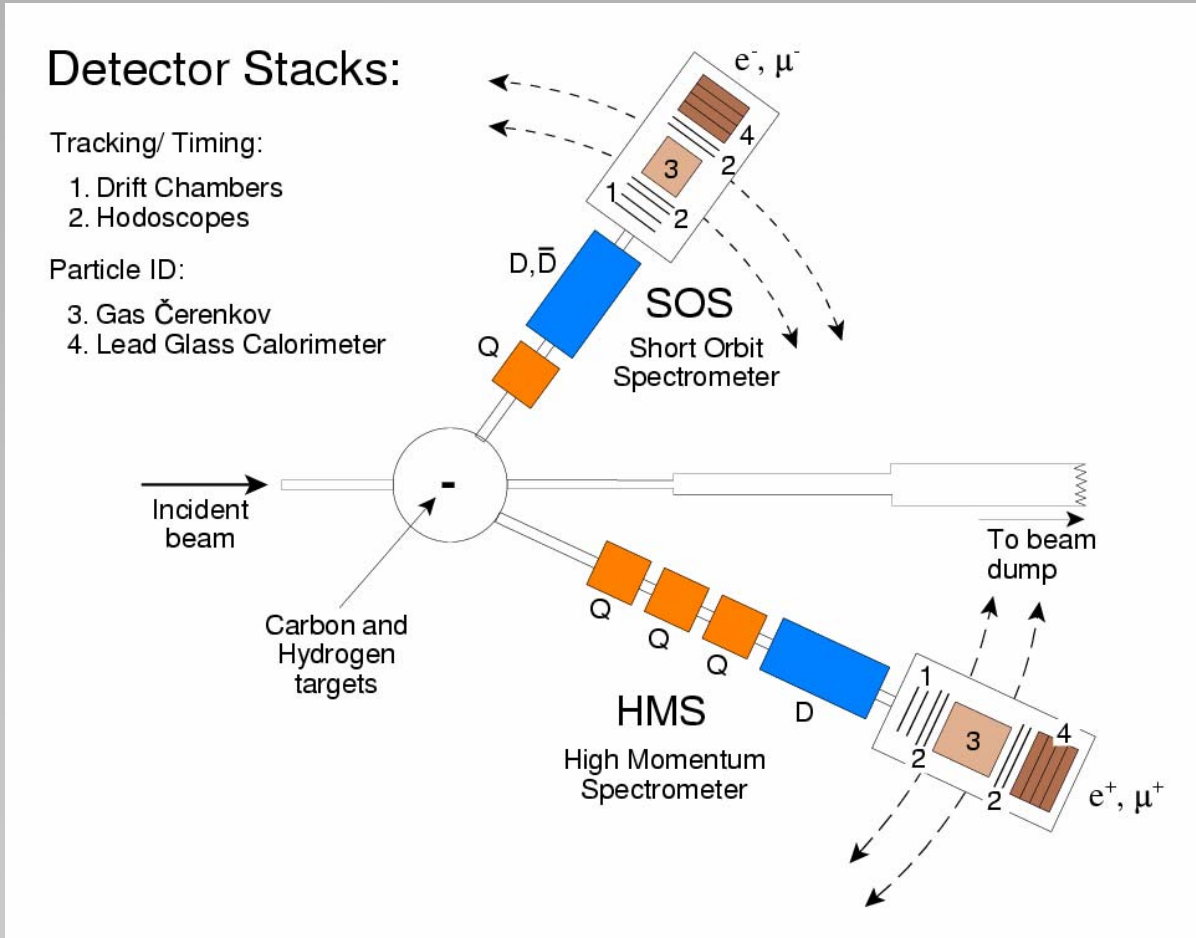
Nucleon Momentum Distribution





- Threshold for free nucleon is k = 8.2 GeV.
- Minimum nucleon momentum required for quasi-free production decreased with increasing energy.
- To emphasize region where short-range effects important, want p_f > 0.35 GeV or k < 6 GeV.

Experiment: E03-008



6% RL
Carbon target

<u>Kinematics:</u>

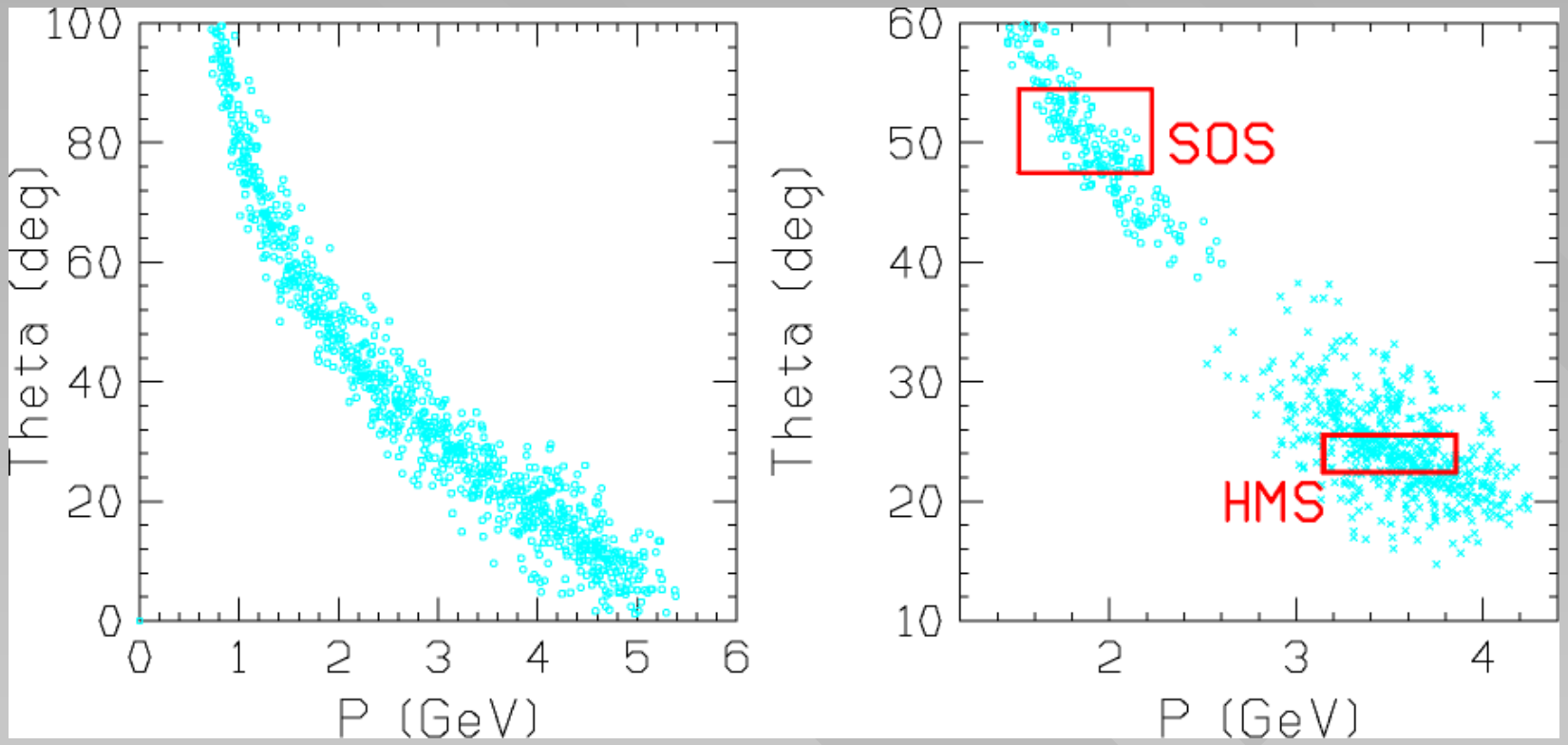
$\theta_{SOS} = 53^o$

$P_{SOS} = 1.7$

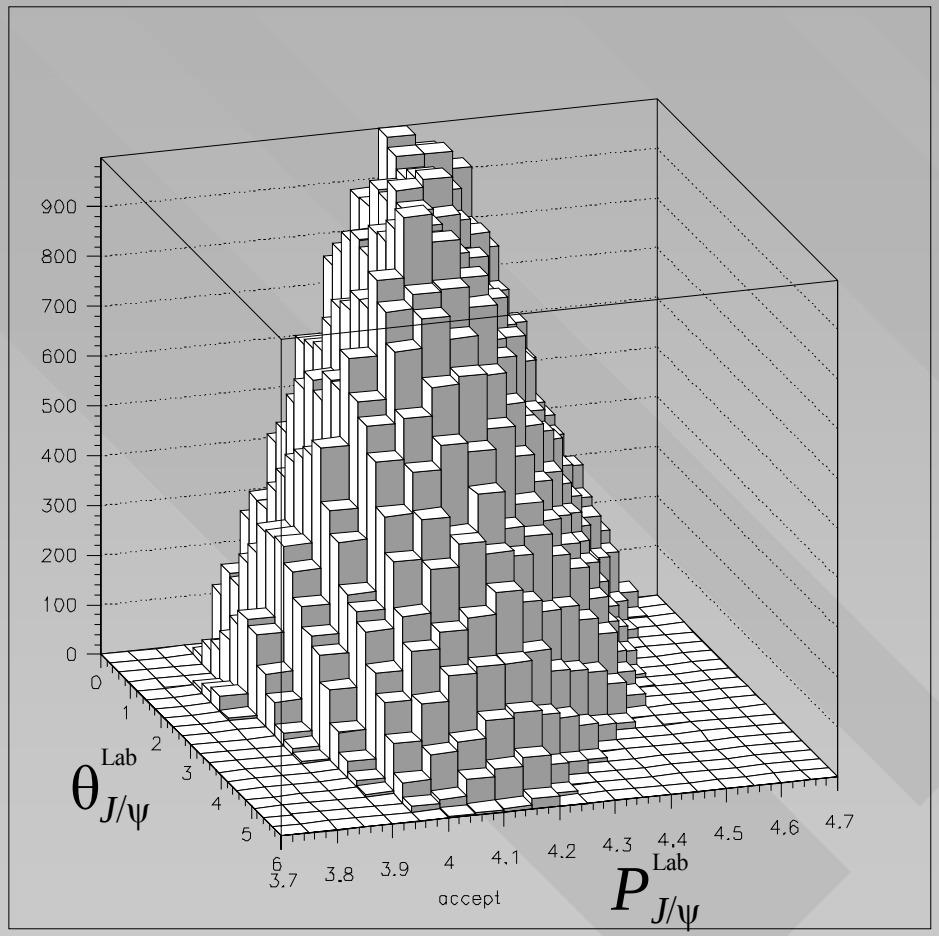
$\theta_{HMS} = 24^o$

$P_{HMS} = 3.5$

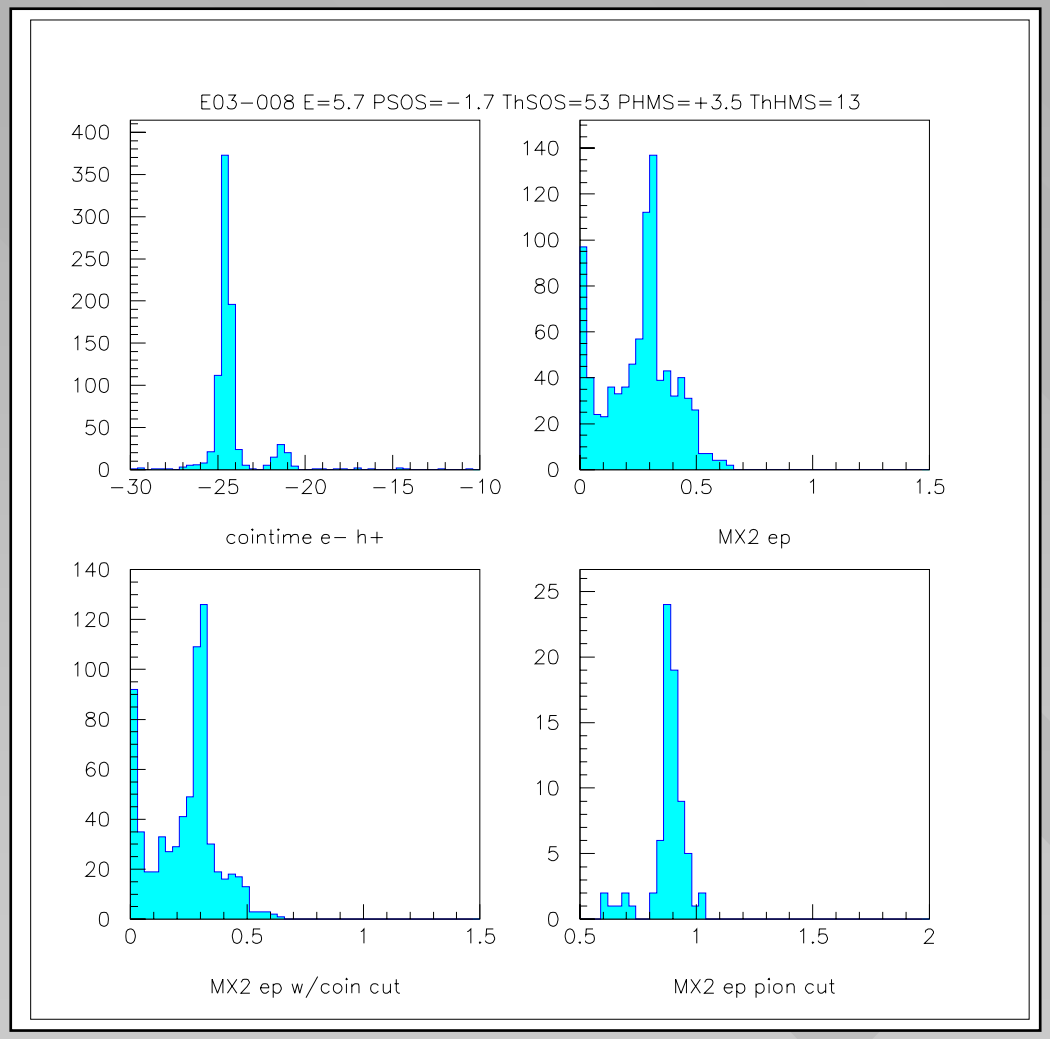
Monte Carlo Lepton Spectrum



J/ψ Acceptance



Calibration Runs



Hydrogen Target

<u>Kinematics:</u>

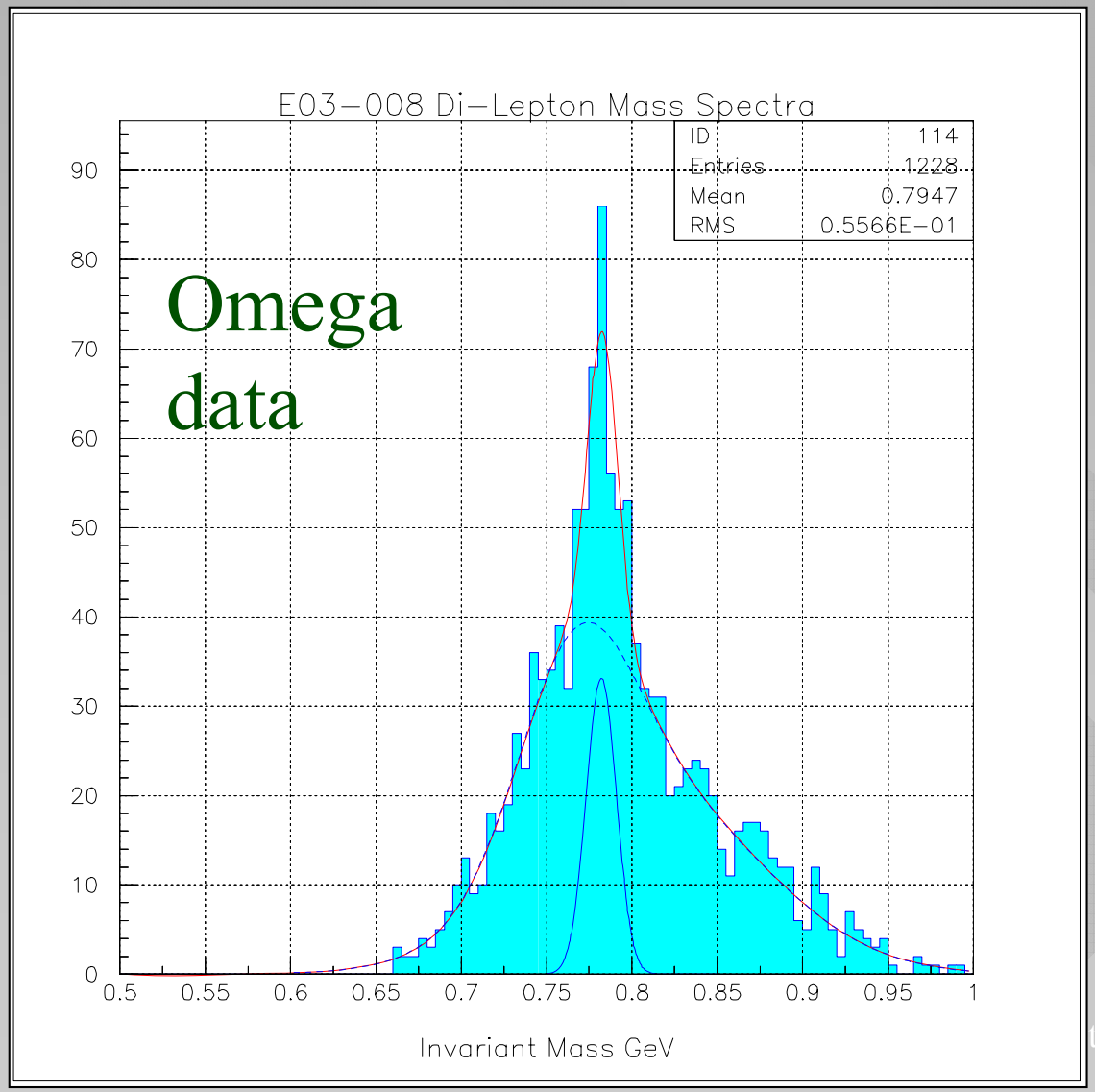
$\theta_{SOS} = 53^o$

$P_{SOS} = 1.7$

$\theta_{HMS} = 13^o$

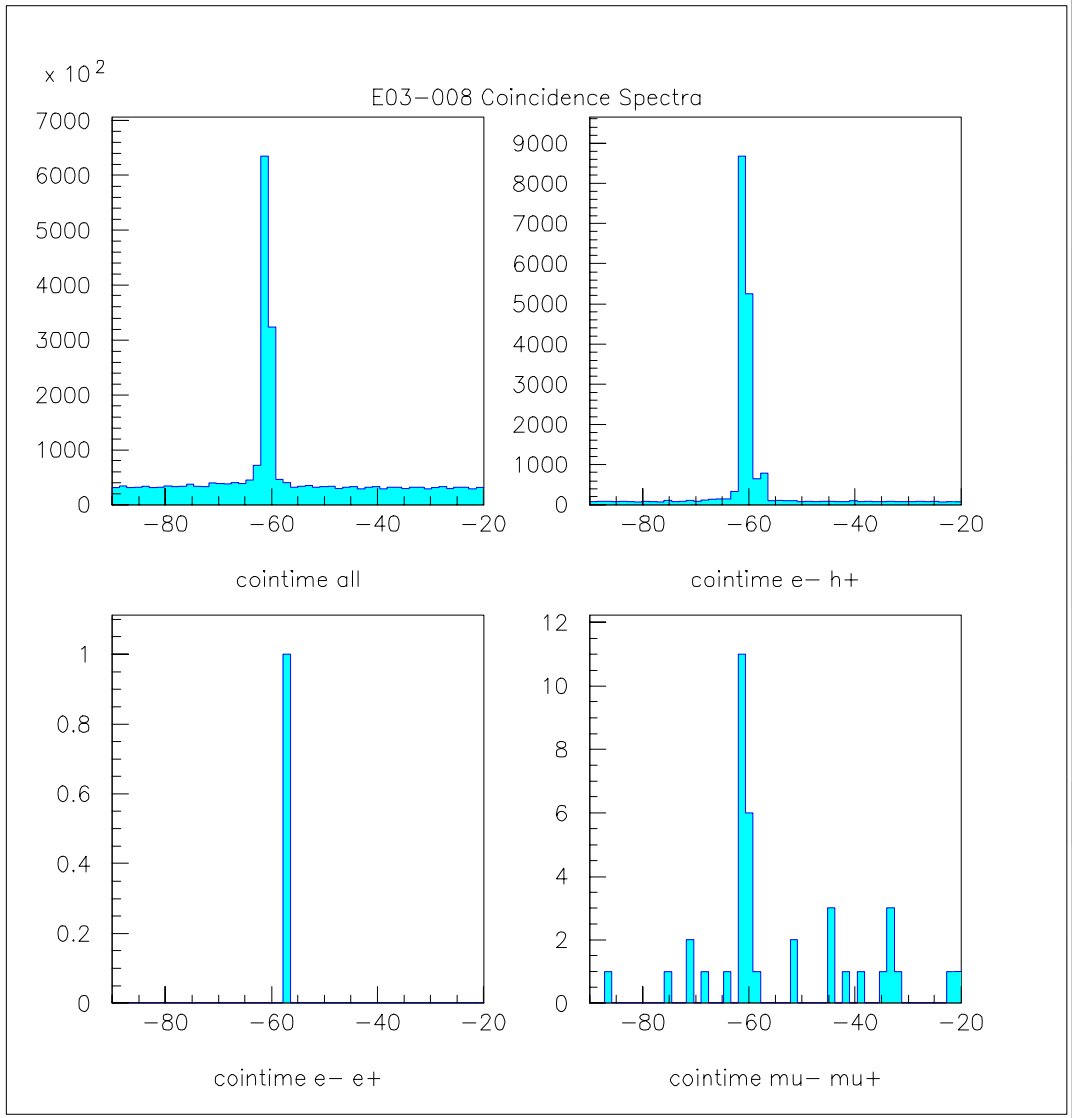
$P_{HMS} = 3.5$

Calibration Runs

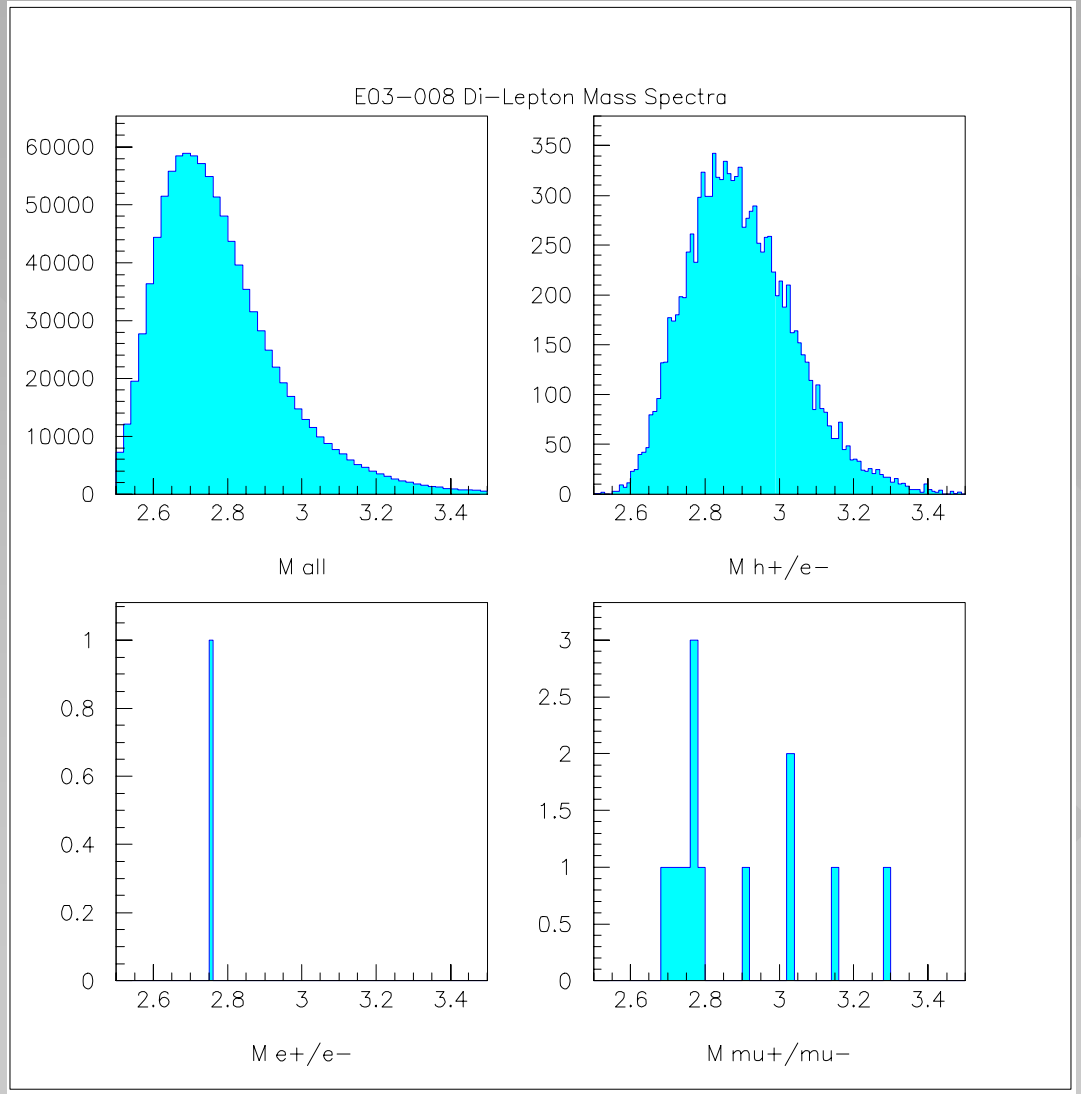


- Eta from (e,e',p)
- Vector meson photoproduction
  - Phi (m = 1.02)
  - Omega (m =0.782)

Production Runs: Coincidence Time



Invariant Mass



Cross Section Upper Limit

Each Model has the form:

$$\frac{d\sigma}{dt} = a\, f(bt)$$

Model I: $f(bt) = e^{bt}$

Model II: $f(bt) = \dfrac{1}{(1 - bt)^4}$

Model III: $f(bt) = \dfrac{(1 - x)^2}{(1 - bt)^4}$

- For each model, used two different energies of the struck nucleon of momentum p_f
  - E_1: energy M (where M is nucleon mass)
  - E_2: energy $M - p_f^2/(2(12M))$

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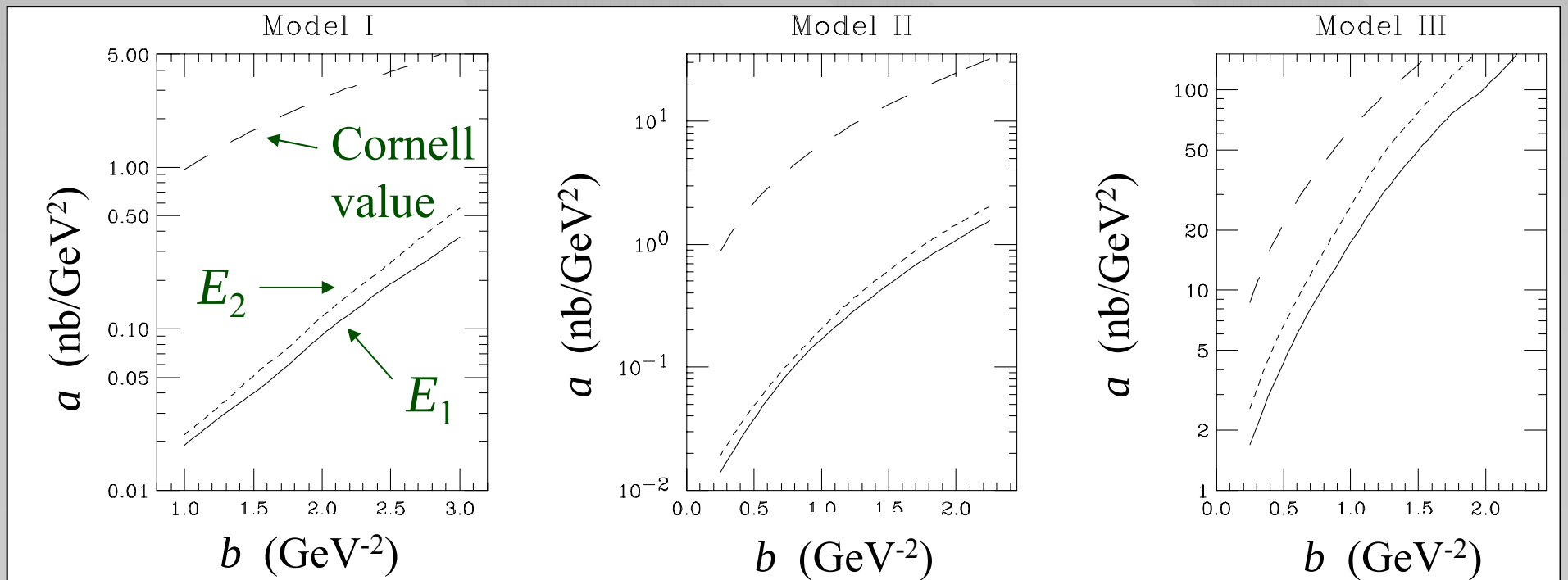
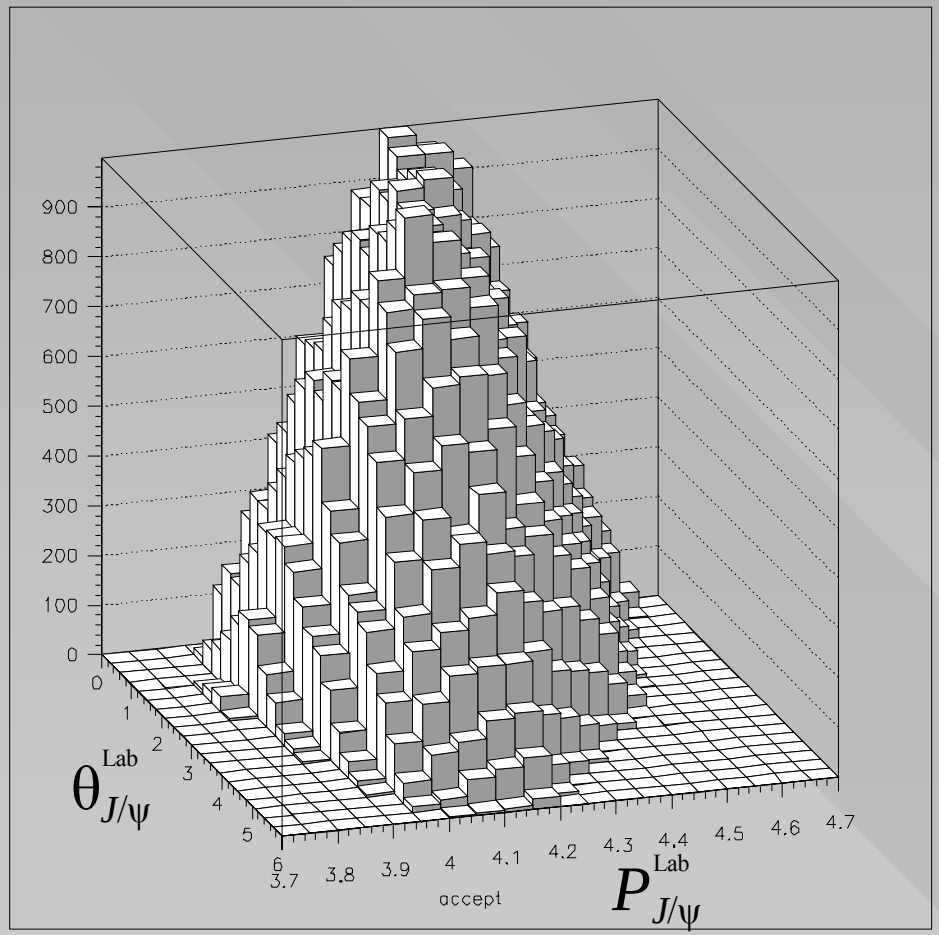


Summary

- Exploratory measurement, sensitive to short range effects in nuclei.
- Upper limit of cross section is more compatible with model III or 2-gluon hypotheses.
- Currently writing the long paper.

J/ψ Acceptance