Charm Photoproduction at threshold

① Opens New Window to QCD

② Exotic Resonances ?

③ Edge effect Polarization Effect

④ 2gluon, 3gluon Exchanges Dominate

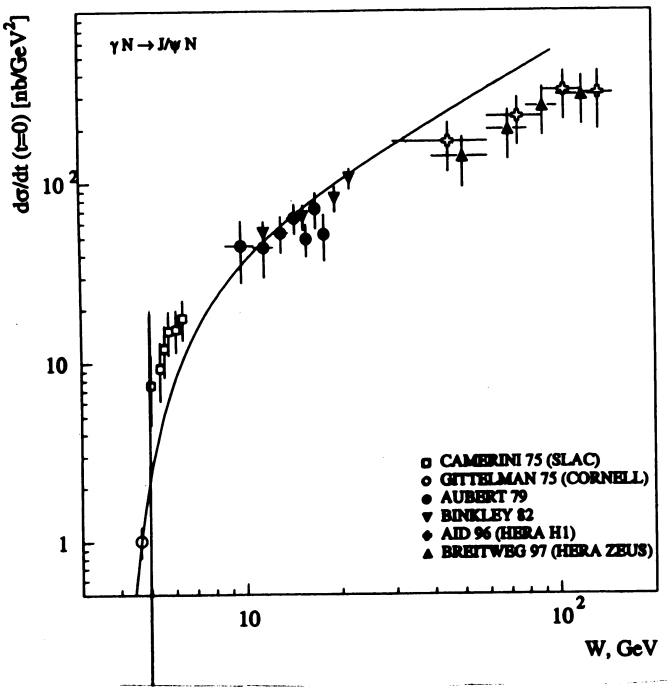
⑤ ⇒ Access to Quark correlations

- Nucleon
- Nuclei

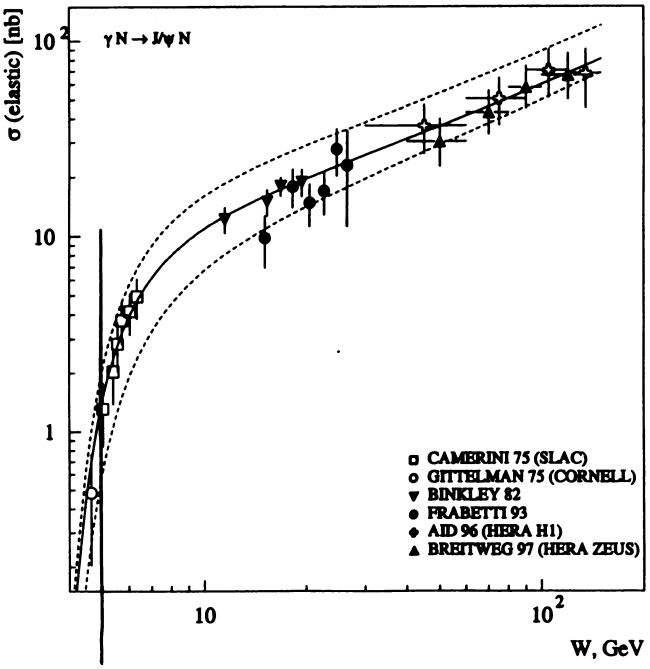
⑥ $\sigma(J/\psi N)$

- VDM
- A dependence

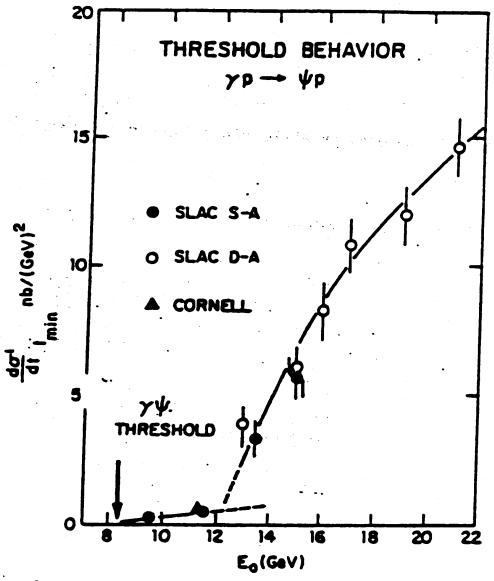
$t = 0$



σ_{TOT}

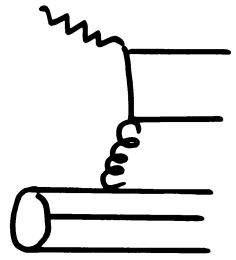


$E_\gamma = 12$ GeV

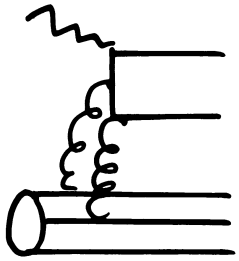

THRESHOLD BEHAVIOR
γp → ψp
SLAC S-A
SLAC D-A
CORNELL
γψ THRESHOLD
dσ/dt|min nb/(GeV)²
E₀(GeV)
0
5
10
15
20
8
10
12
14
16
18
20
22

Elementary Mechanisms

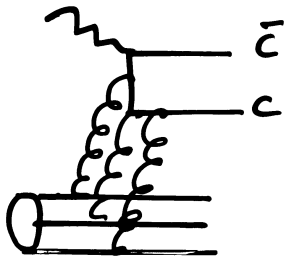
Near threshold all the quarks are close



$\alpha_s^2 (1-x)^4$



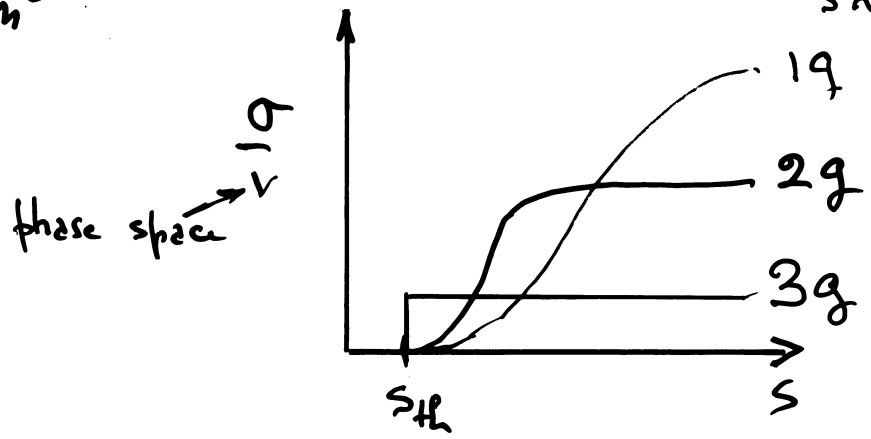
$\alpha_s^4 (1-x)^2 \frac{1}{R^2 M^2}$



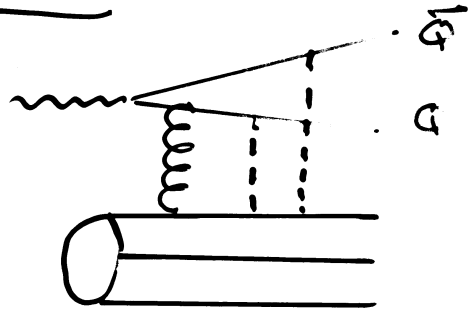
$\alpha_s^6 (1-x)^0 * \frac{1}{R^4 M^4}$

Small x
$s \gg m^2$

$x \sim 1$
$s \sim s_{th}$

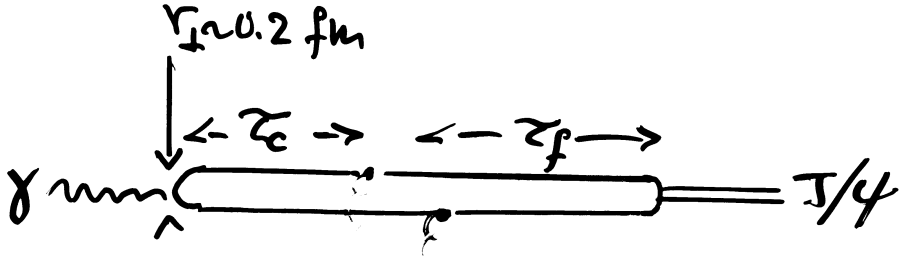


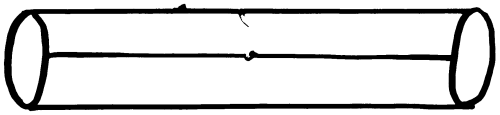
FSI corrections?



Strong Interactions at Low Relativ Velocity

Characteristic Lengths/Times





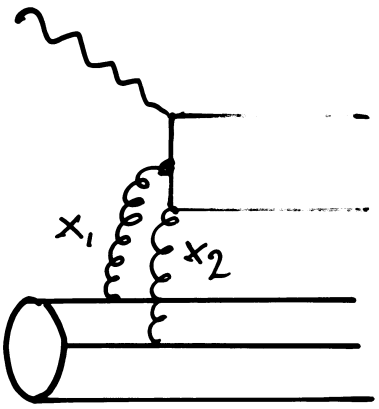
$$\tau_c = \frac{2\hbar c\,\nu}{4m_c^2 + Q^2} \rightarrow 0.044\,\nu \text{ fm}$$

$$\tau_f = \frac{2\hbar c}{m_{\psi'} - m_{J/\psi}} \frac{E_{J/\psi}}{2m_c} \simeq 0.2\,\nu \text{ fm}$$

- <u>Near Threshold</u> : $\rightarrow \tau_c \simeq 0.4$ fm
  $\rightarrow \tau_f \simeq 2$ fm
  $\rightarrow -t_{min} \simeq 1$ GeV^2
  → All [illegible]

- cf. Physics of ϕ production at high t

Quark Correlation



$$G(x_1, x_2) \sim G(x)$$

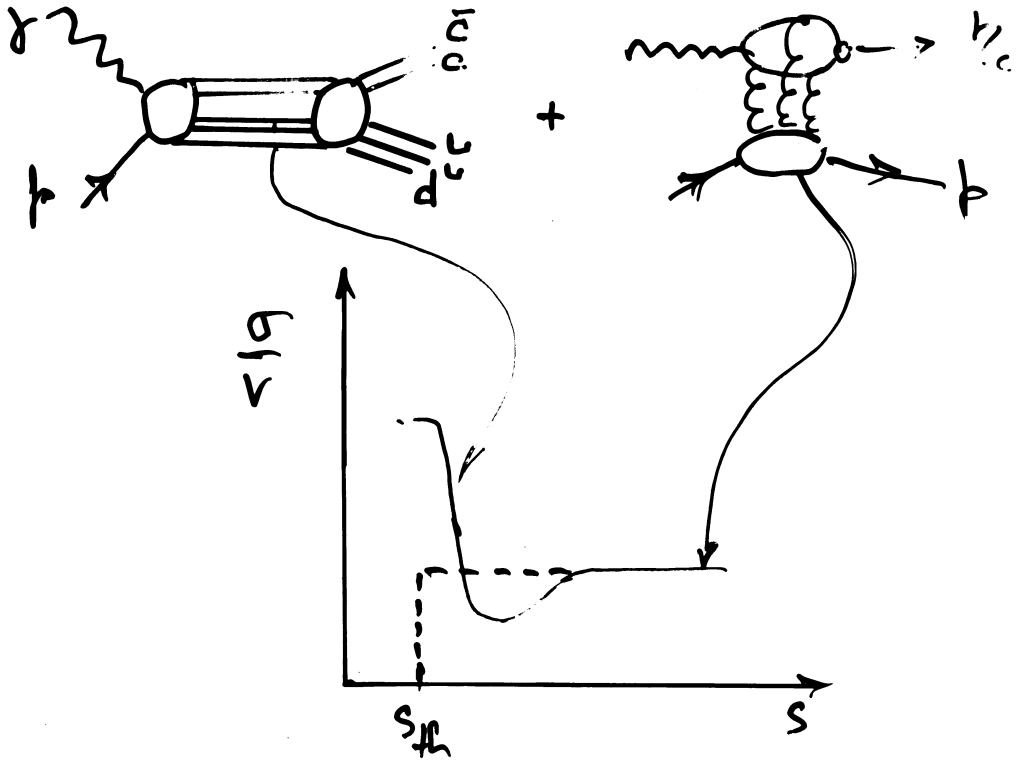
Resonances and Spin Effects

(I) A_{NN} and CT in $pp \to pp$

- Strong Effects near Threshold
- Possibly linked to $c\bar{c}uuduud$ state

(II) $\gamma_\uparrow p_\uparrow \to c\bar{c}X$

- Expect strong Enhancement
- " " Spin Effects

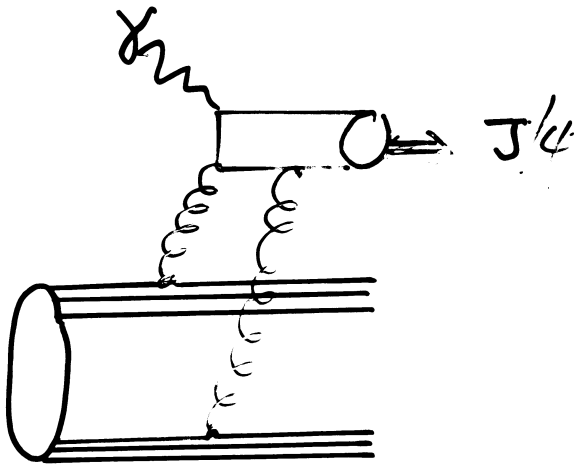


Nuclear Effects

① Subthreshold production

- Sensitivity to small size Configurations "hot spots"
- High momentum nucleons
- Nucleon correlations

② Hidden Color in Deuterium



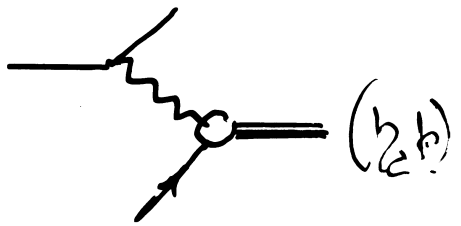
③ Issues

- X_ Sections ?

Bound Quarkonium

$(J/\psi\text{-}A)$, $(\chi_c A)$

- possible bound state for large A
- Electroproduction



missing mass M_X GeV

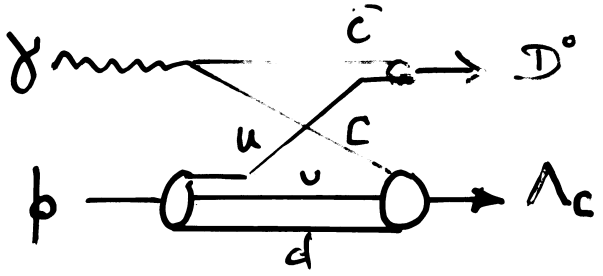
- X-section , counting rate ?
- Feasibility at JLab ?

Open Charm

(I) Lagrangian approach

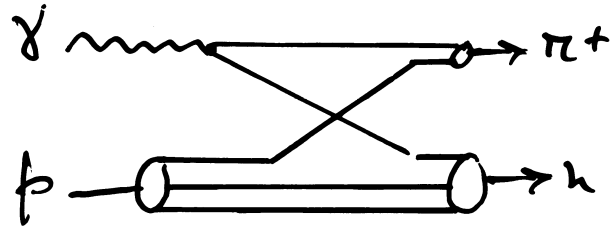
"Exp^t" $\gamma p \to \pi^+ n$ methods ?

(II) Hard description



m_c Large

Similar to



Large (s,t)

Draft

Ⅰ General Motivation

- New window to QCD
- New threshold : cf. Strange threshold ?
- New flavor (impurity ?)

- Charateristic Lengths / Time
- short distance

Ⅱ Nucleon (Draft Brodsky + talk Khandzeel)

- 1, 2, 3 gluons
- Threshold Effects / Resonance

Ⅲ Nucler

A subpoint

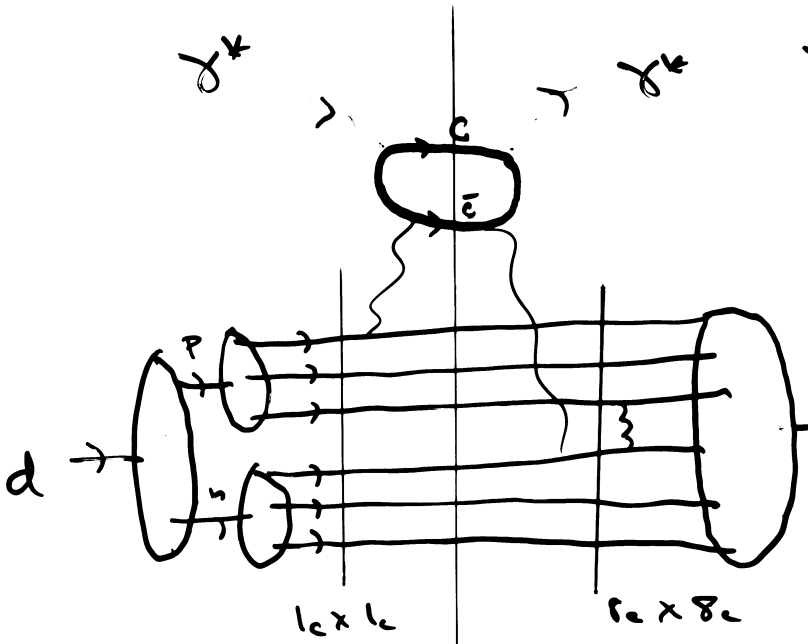
- Hidden color, multiquark state, quark correlations
- Bound state ?
- $c\bar{c}$ formation and propagation (→ QGP ?)

Ⅳ Reactions accessible at CEBAF 12

Enhancement of Charm Production in Nuclei

$\gamma^* d \to c\bar{c} X$

$\gamma d \to c\bar{c} X$



Linear in $\psi_{8_c \times 8_c}$

d

(Hidden color component)

Enhances $\langle p | G^2 | p \rangle$ at $x \gtrsim 1$

Many connectors also enhance role in A

(Similar to $\langle \bar{q} q \rangle$) Higher

Also enhance $\gamma d \to J/\psi d$, $\gamma d \to J/\psi p n$

with higher threshold