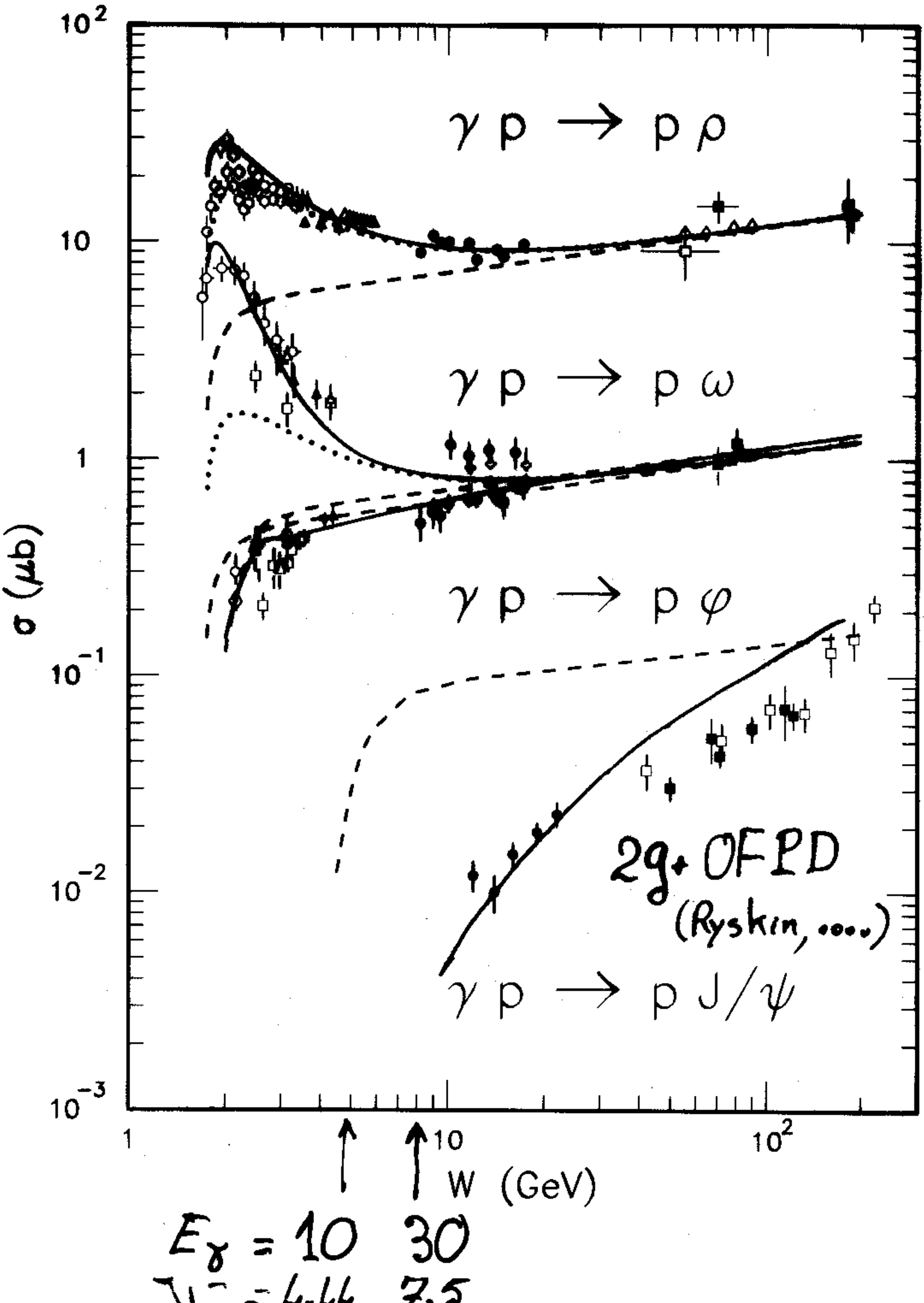
Parallel Session I	Friday, January 14, 08.30 am	L102/104
08.30 - 09.10	The Novel Phenomenology of Charm at Threshold	Stan Brodsky
09.10 - 09.50	Photoproduction of Char monium near Threshold -Open Issues	Mark Strikman
09.50 - 10.05	Open Charm Production in a Lagrangian Approach	Egle Tomasi
10.05	Coffee	
10.20 - 11.00	Possible Experiments on Charm Production at JLab	Eugene Chudakov
11.0 - 12.00	Discussion	

~ 25 Participants

J .M. Laget

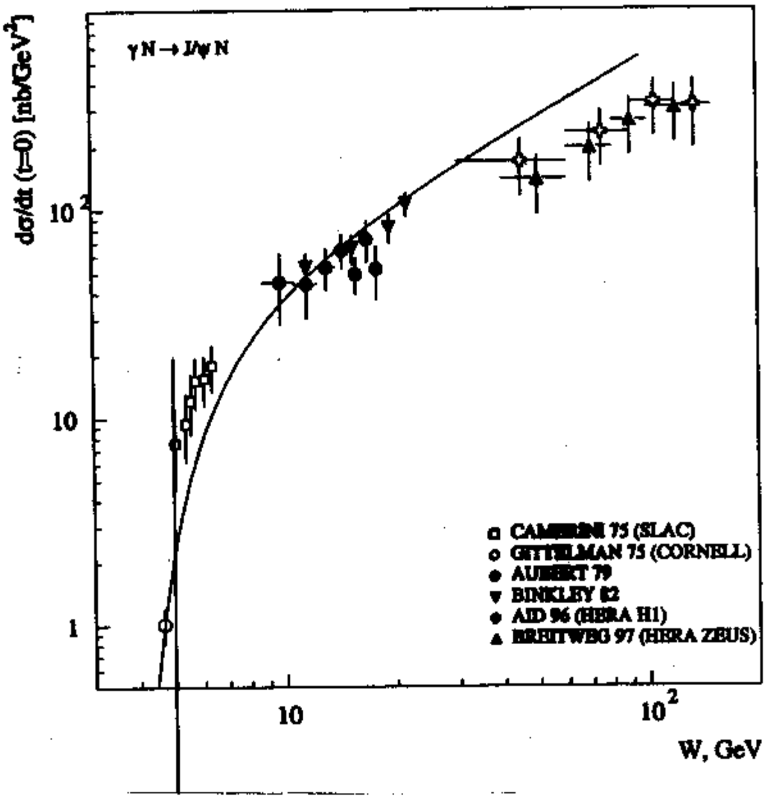
[redacted]

- m_c sets the hard scale
- Elementary mechanism?
  - 2 gluon exchange
  - 3 gluon exchange
- Subthreshold production
  - Compact subnuclear objects
- Bound Charmonium
- Connection with QGP

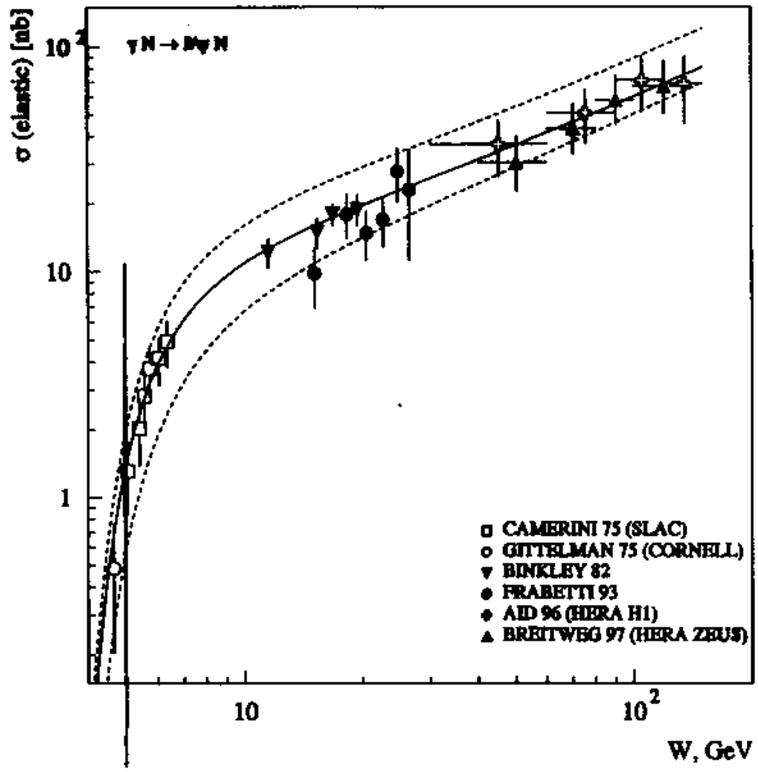


10^2
10
1
10^{-1}
10^{-2}
10^{-3}
σ (μb)
γ p → p ρ
γ p → p ω
γ p → p φ
γ p → p J/ψ
2g+OFPD
(Ryskin, ...)
1
10
10^2
W (GeV)
E_γ = 10 30
W = 4.44 7.5

t = 0



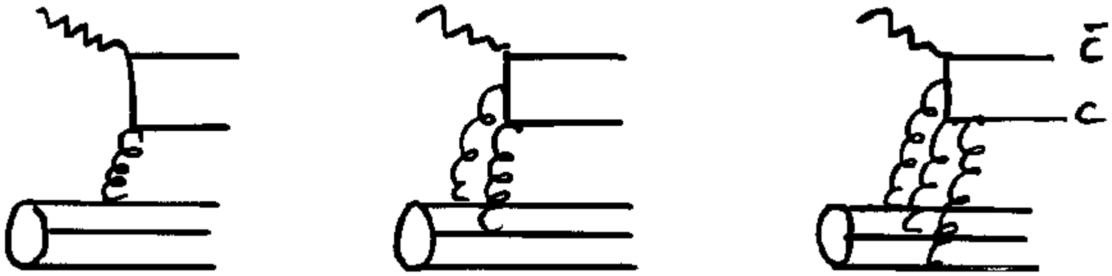
σ_{TOT}



$E_\gamma = 12$ GeV

Elementary Mechanisms

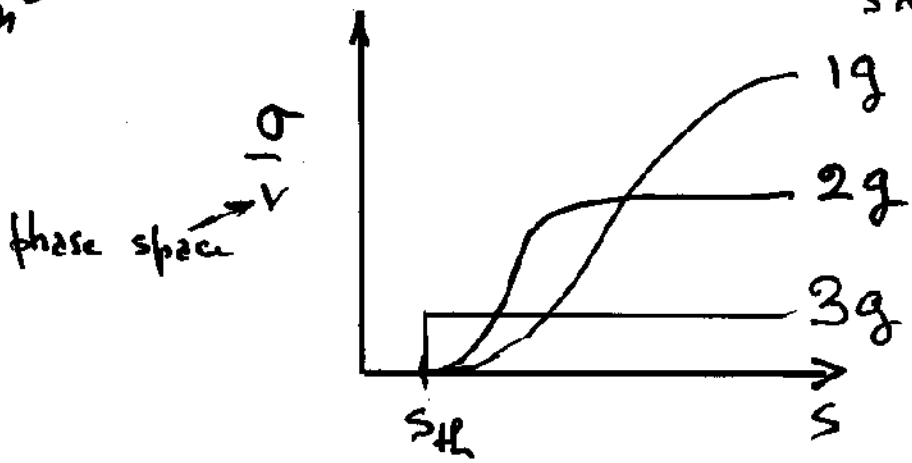
Near threshold all the quarks are close



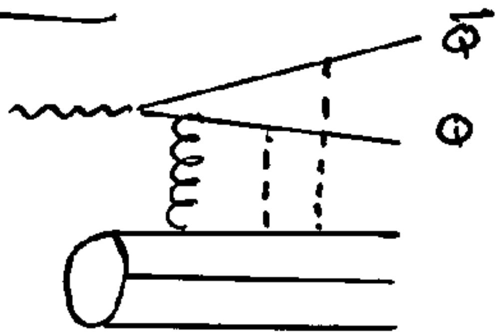
$\alpha_s^2 (1-x)^4$ $\alpha_s^4 (1-x)^2$ $\alpha_s^6 (1-x)^0$

Small x
$s \gg m^2$

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

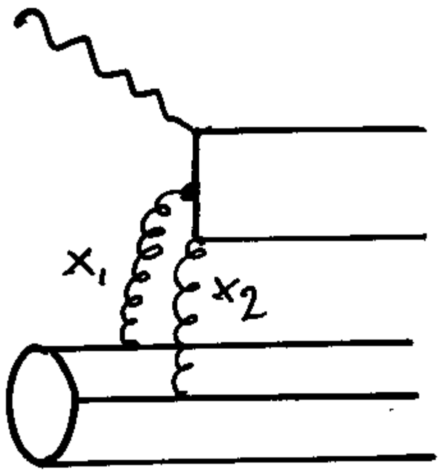


FSI corrections?



Strong Interactions at Low Relative Velocity

Quark Correlation



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

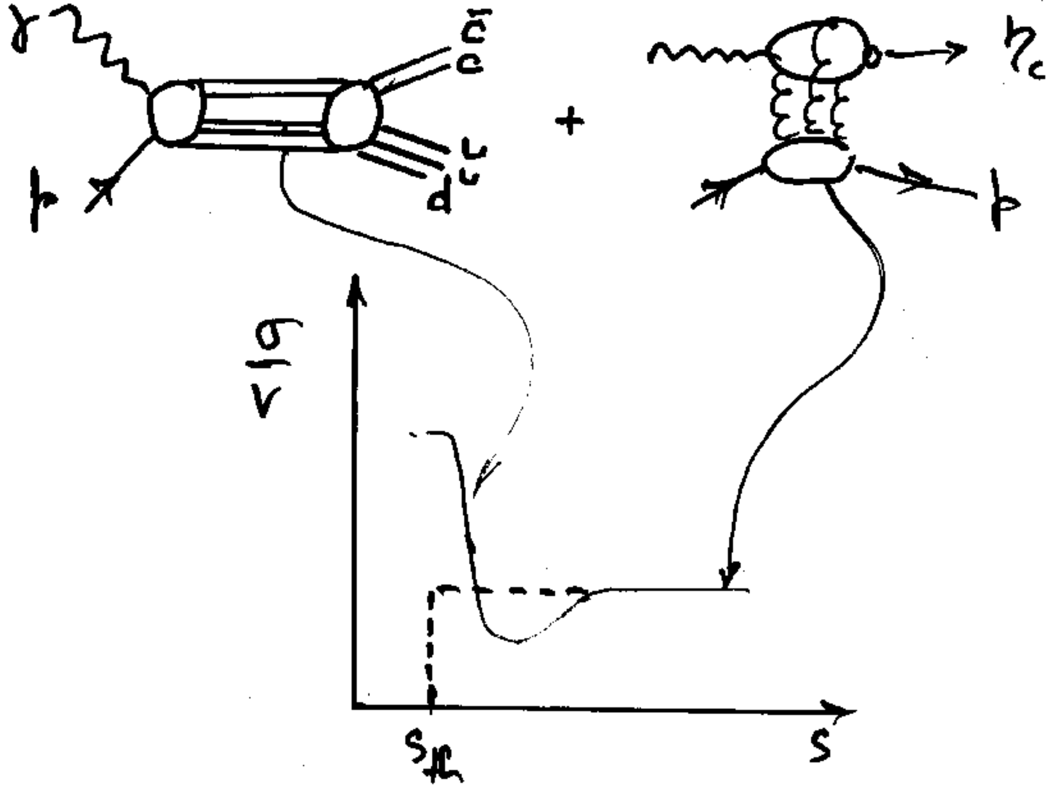
Resonances and Spin Effects

(I) A_{NN} and σ in $pp \to pp$

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

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

- Expect strong Enhancement
- " " Spin Effects

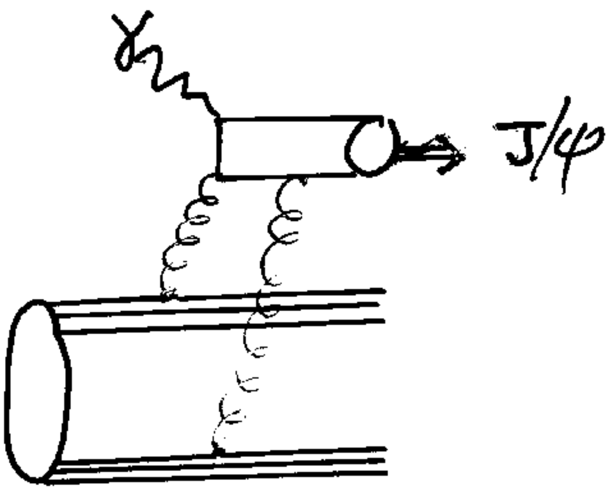


Nuclear Effects

(I) Subthreshold production

- Sensitive to small size configurations "hot spots"
- High momentum components
- Nucleon correlations

(II) Hidden Color in Deuterium



(III) Issues

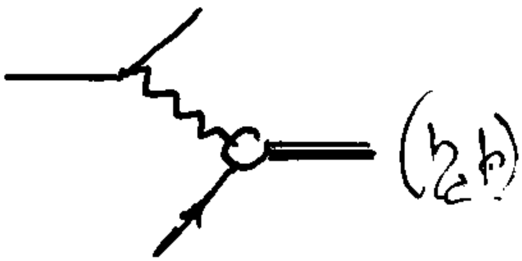
- X-Sections ?

Bound Quarkonium

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

- possible bound state for large A

- Electroproduction



missing mass $M \sim 4$ Ge

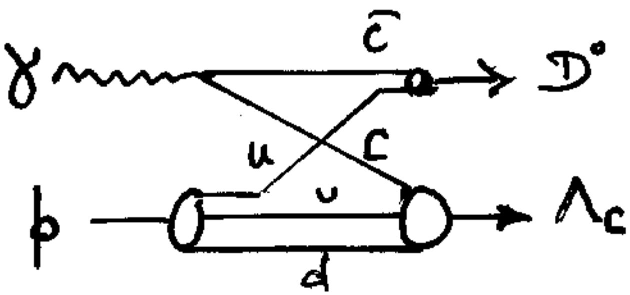
- X_section , counting rate ?
- Feasibility at JLab ?

Open Charm

(I) Lagrangian approach

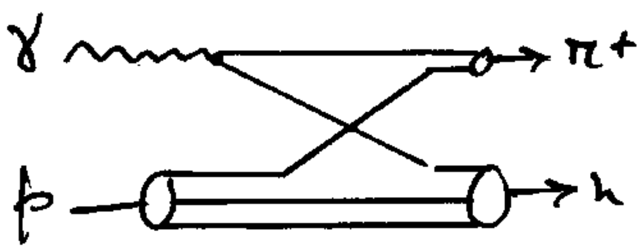
• "Expert" $\gamma p \to \pi^+ n$ methods ?

(II) Hard description



m_c Large

similar to



Large (s, t)

Charm Photoproduction at threshold

1. Opens New Window to QCD
2. Exotic Resonances?
3. Expect Strong Polarization Effects
4. 2gluon, 3 gluon Exchanges Dominate
5. ⇒ Access to Quark correlations
   - Nucleon
   - Nuclei
6. $\sigma(J/\psi\, N)$
   - VDM
   - A dependence

Possible Experiments on Charm at JLab

E.Chudakov, JLAB

reaction	E_γ threshold
$\gamma p \rightarrow J/\psi(1S) p$	8.2 GeV
$\gamma p \rightarrow \psi(3770) p$	11.0 GeV
$\gamma p \rightarrow \Lambda_c^+ \overline{D}^0$	8.7 GeV
$\gamma p \rightarrow D^0 \overline{D}^0 p$	11.1 GeV

These reactions are within the reach at 12 GeV. **At 7-8 GeV** one may consider subthreshold **production on nuclei, using** Fermi motion.

Detecting charm is difficult:

- Low cross-section: $\approx$1nb.
- Low branching ratios, for ex. $J/\psi(1S) \rightarrow e^+e^-$ 6%.

Illustration:

the yield $J/\psi(1S) \rightarrow e^+e^-$ to $\phi(1020) \rightarrow K^+K^- \sim 10^{-4}$.

Nevertheless: charm detection at low energies is *possible*.

What can be done at JLab?

reaction	measured	impact
$\gamma p \to J/\psi(1S)p$ $\psi \to e^+e^-, \mu^+\mu^-$	$\frac{d\sigma}{dt}$ (E_γ)	Production mechanisms Models: gluon PDF Models: $\sigma_{\psi N}$
$\gamma A \to J/\psi(1S)X$ $\psi \to e^+e^-, \mu^+\mu^-$	$\frac{d\sigma}{dt}$ (A)	Models: $\sigma_{\psi N}$
$\gamma A \to \psi(3770)X$ $\psi \to e^+e^-, \mu^+\mu^-$	$\frac{d\sigma}{dt}$ (A)	Models: $\sigma_{\psi N}/\sigma_{\psi' N}$
$\gamma p \to \Lambda_c^+ \overline{D}^0$ $\overline{D}^0 \to K^+\pi^-$	$\frac{d\sigma}{dt}$ (E_γ)	Production mechanisms
$\gamma A \to \chi_{c1}(1P)X$ $\chi_{c1}(1P) \to J/\psi(1S)\gamma$ $\psi \to e^+e^-, \mu^+\mu^-$	$\frac{d\sigma}{dt}$	Production mechanisms
....		

Improvements with respect to the old experiments:

- Higher statistics $\times 100$
- Better systematics

Summary of the options

$J/\psi(1S)p$ study:

- Hall A HRS: too high momenta.
- Hall C HMS+SOS - very limiting, HMS+SHMS - OK
- Hall B/D very low statistics
- Hall A/C calorimeter: good.

process	setup	$\sigma M/M$	BG/sig	events/day
$\gamma p \rightarrow J/\psi(1S)p$				
$\rightarrow e^+e^-$	(A), ECAL	3.5%	0.15	6000
$\rightarrow e^+e^-, \mu^+\mu^-$	A, HRS+LAS	0.2%	<0.02	1360
$\rightarrow e^+e^-, \mu^+\mu^-$	C, S/HMS	0.2%	<0.02	360
$\rightarrow e^+e^-, \mu^+\mu^-$	B/D no tag	1.0%	0.05	4
$\gamma p \rightarrow \Lambda_c^+ \overline{D}^0$				
$\rightarrow K^+\pi^-$	A, 2HRS	0.2%	0.10	40
$\rightarrow K^+\pi^-$	A, HRS+LAS	0.2%	0.10	350
$\rightarrow K^+\pi^-$	C, S/HMS	0.2%	0.10	80
$\rightarrow K^+\pi^-$	B/D no tag	1.0%	0.10	2

LAS – spectrometer proposed for structure functions measurements

Electromagnetic calorimeter

Electromagnetic calorimeter may be a good option for $\psi \rightarrow e^+e^-$:

- large acceptance
- relatively high background:
  - sucessfully used at Cornell (duty cycle 0.07, BG/sig$\sim$ 0.15)
  - Hall A real Compton scattering: OK

Assumed parameters:

- 2 arms of lead glass, 1×1 m^2
- 3 m from the target, $\pm 19^o$ ($< E_e >= 4.1$ GeV)
- $\sigma(E)/E = 0.02 + 0.06/\sqrt{E}$, $\sigma x \sim 0.5$ cm
- 5μA, 6% radiator, 10 cm LH target (RCS experience)

process	accept	$\sigma M/M$	events/day
γp $\rightarrow$J/ψ(1S)p	0.033	3.5%	6000

$\sigma M/M$ is dominated by the energy resolution.
Luminocity $\sim \times 5.8$ of Cornell during the spill

Planning

(I) Core working group

E. Chudakov
J. Dunne
J. Templon
- - - - - - -

(II) Mini Workshop : March

(III) Proto_proposal in June

- "Improved" X_sections
- Concentrate on $\gamma p \to J/\psi\, p$

  $\gamma p \to D^0 \Lambda_c$
- Study of the Calorimeter option