Program for JLab at 11 GeV

(1) Measure $\sigma(\mathrm{J}/\psi\mathrm{N})_{abs}$ using
A-dependence of $\sigma(\gamma\mathrm{A}\rightarrow\mathrm{J}/\psi\mathrm{X})$

Advantages (to SLAC):

- lower energy - smaller effects from ℓ_{coh},ℓ_F
- low background for $\mathrm{J}/\psi(1\mathrm{S})$
- reconstructed kinematics of $\mathrm{J}/\psi(1\mathrm{S})$
- separation of coherent and incoherent production
- several targets used

Disadvantages comparing to the SLAC experiment:

- ○ lower energy - stronger effect from Fermi motion

(2) Measure $\frac{d\sigma}{dt}(E)$ for $\gamma\mathrm{p}\rightarrow\mathrm{J}/\psi\mathrm{p}$

Goals:

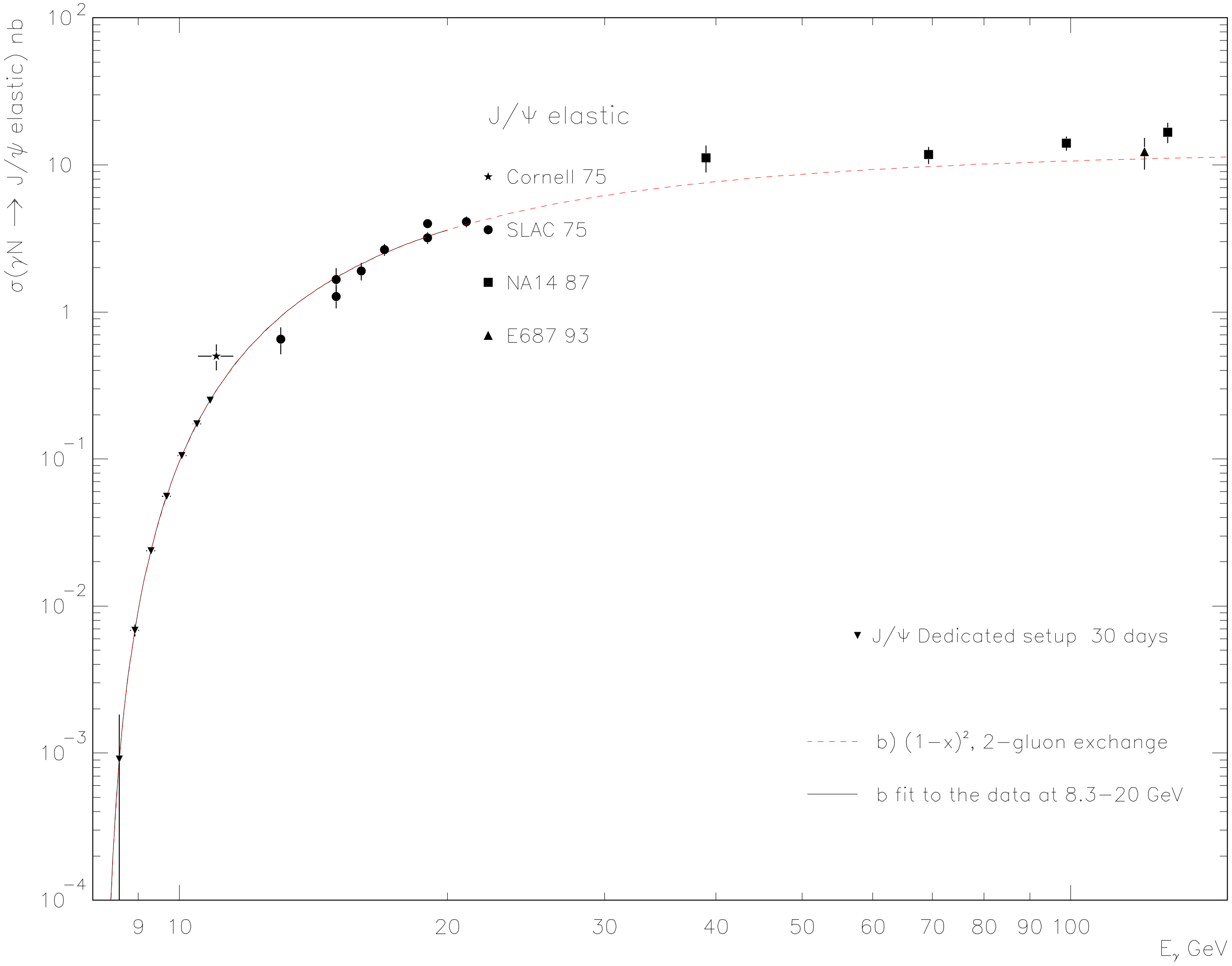
- Provide Fermi-motion correction for (1)
- Measurement in a new energy range (3-gluon exchange?)

(3) Look for more exotic effects:

- "Hidden color" $\gamma\mathrm{D}\rightarrow\mathrm{J}/\psi\mathrm{pn}$
- Bound state: peak in σ/V at x=1 (threshold)

Threshold J/ψ Production

Cross Section



SLAC results on γp$\rightarrow$ ψp at 13-21 GeV

Double spectrometer measurements.

5% RL, 30 cm ^{1}H, ^{2}H

20, 8 GeV spectrometers

J/ψ(1S)$\rightarrow$e$^+$e$^-$,$\mu^+\mu^-$

1200 J/ψ(1S) and 13 ψ(3770)

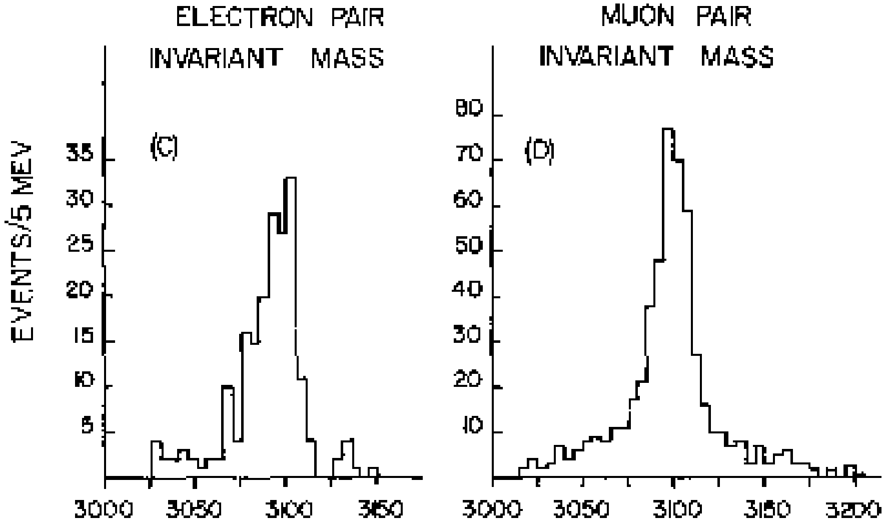
at 13 GeV:

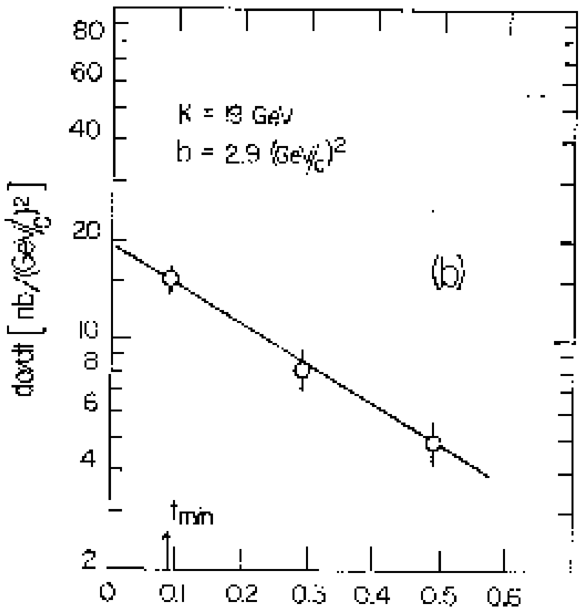
$\frac{d\sigma}{dt} \mid_{tmin} = 3.8 \pm 0.8$ nb/GeV^2

at 20 GeV:

σ: $\psi(3100)/\psi(3770) \sim 6.8 \pm 2.4$

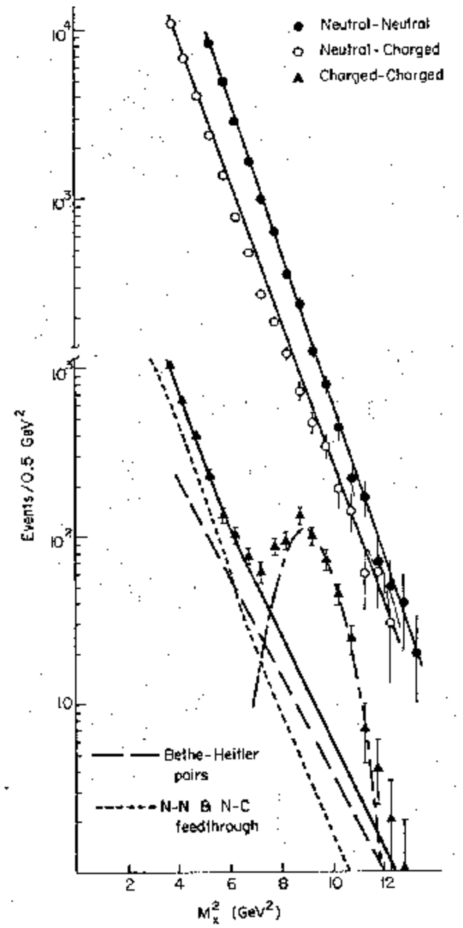
From VDM: $d\sigma(\psi N \rightarrow \psi N)/dt\ |_{t=0} \approx 25\mu$b



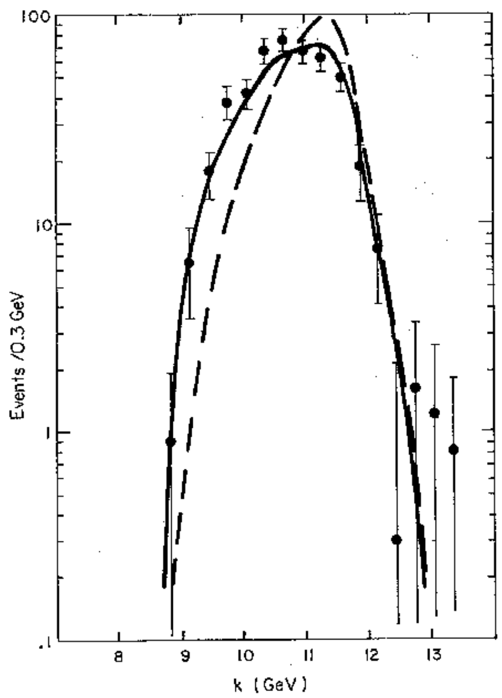


Cornell Results at 11.8 GeV

- J/ψ(1S)$\rightarrow e^+e^-$ detected with lead-glass calorimeters ($\sigma E/E = 0.16/\sqrt{E}$)
- $\langle$photon flux$\rangle$ $1\cdot 10^9$/s for 8.5<$E_\gamma < 11.8$ GeV, duty cycle=7%, Be 2.9g/cm^2



- Background: neutrals $\times 10$ charged, charged - BH
- Signal/background ~470/70
- Results: $\frac{d\sigma}{dt} = 0.9 \pm 0.1\ nb/GeV^2 \cdot e^{1.13 \pm 0.18\ GeV^2 \cdot t}$



No dependence of cross-section on E_γ observed!

JLab spectrometers

hall	beam μA	setup	$\Delta\Omega$ ster	θ_{min} deg	P_{max} GeV	$\pm\frac{\Delta P}{P}$ %	$\frac{\sigma P}{P}$ %	$\sigma\theta_{in}$ mrad	$\sigma\theta_{out}$ mrad
Hall A	100	HRS	0.006	12.5	4.0	-5./+5.	0.02	0.6	1.0
		HRS	0.006	12.5	3.2	-5./+5.	0.02	0.6	1.0
		MAD	0.030	35.0	8.0	-15./+30.	0.1	1.0	1.0
			0.006	12.0	8.0	-15./+30.	0.1	1.0	1.0
Hall C	100	HMS	0.008	10.5	7.3	-10./+10.	0.1	0.8	1.0
		SOS	0.009	-	1.8	40.0	0.1	1.0	1.0
		SHMS	0.004	10.0	11.0	-15./+25.	0.2	3.0	1.5
Hall B	0.03	CLAS	$\sim 2\pi$	-	-	0.5			
Hall D	γ		$\sim 4\pi$	-	-	<1.			

Specialized Setup

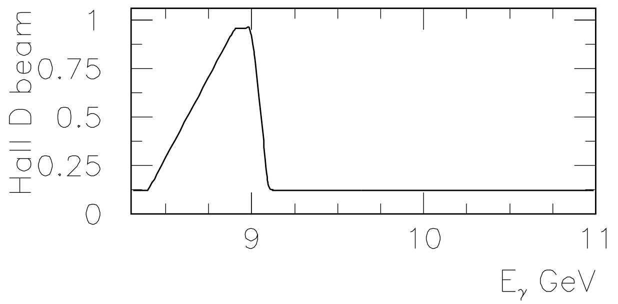
Specialized setup "ECAL":

- Solenoidal magnet R$\sim$0.6 m, L$\sim$1.5 m
- Calorimeter $\sim$2000 channels , $\sigma E/E \approx 0.05/\sqrt{E}$, $\sigma x \approx 1.5\ mm$
- Hodoscope
- GEM(?)
- Short target (4 cm) if no good tracking

Luminosity and Acceptance

Possible photon flux:

- Halls A,C: $50\mu A$ at 6% RL radiator: $6 \cdot 10^{12}\gamma$/s 8.5-11 GeV on 10 cm LH
- A,C ECAL: $2\mu A$ at 6% RL radiator: $3 \cdot 10^{11}\gamma$/s 8.5-11 GeV on 4 cm LH
- Halls B: no tagging forseen
- Halls B: $\mathcal{L} < 10^{35}$ cm^{-2}s^{-1}: $1.2 \cdot 10^{9}\gamma$/s 8.5-11 GeV on 10 cm LH
- Halls D, tagged:
  $\sim 2 \cdot 10^7/s$ in $8.4 < E_\gamma < 9.1$GeV coherent
  $\sim 2 \cdot 10^7/s$ in $8.4 < E_\gamma < 11.$GeV incoherent



- "Standard" 12 GeV equipment: acceptance A/B/C/D/ECAL
  $0.6 \cdot 10^{-3}$ / 0.2 / $0.4 \cdot 10^{-3}$ / 0.4 / 0.2

Measuring the photon energy

Measuring $\frac{d\sigma}{dt}(E_\gamma)$: ~ 6 bins of ~ 0.4GeV in E_γ.
E_γ should be measured to about 1%.

- Hall D tagger: $\sigma E_\gamma / E_\gamma < 0.1\%$
- Hall A,C - no tagging:
  - 2-body decay of $\mathrm{J}/\psi(1\mathrm{S})$ or $\overline{\mathrm{D}}^0$, (assuming the 2-body "elastic" reaction!) $\sigma E_\gamma / E_\gamma \approx 0.2\%$
  - Since the recoil particle is not detected, one can not be sure that the reaction is indeed defined, apart from a narrow energy band - just above the threshold.
  - Subtraction method: measuring several (~ 6) end-points.
    - Time/measurement selected to equalize the errors at different energies
    - Direct (no subtraction) measurement at low energy, example: $\gamma \mathrm{p} \rightarrow \overline{\mathrm{D}}^0$ X in a range 8.7-9.4 GeV, is limited to the $\Lambda_c^+ \overline{\mathrm{D}}^0$ final state.

Spectrometer Settings

θ, deg	P, GeV/c	θ, deg	P, GeV/c	E_γ	Acceptance	
HRS		MAD		GeV	full	E_γ range
20.0	4.25	15.0	5.5	10.5-11.0	0.29e-3	1.59e-3
22.5	4.10	15.0	5.5	10.0-10.5	0.67e-3	1.77e-3
24.5	3.70	15.0	5.5	9.5-10.0	0.60e-3	1.58e-3
29.0	3.00	15.0	5.5	9.5-10.0	0.40e-3	1.06e-3
33.0	2.60	15.0	5.5	8.5- 9.0	0.32e-3	0.95e-3
HMS		SHMS				
21.0	4.20	15.0	6.0	10.5-11.0	0.52e-3	2.30e-3
25.0	3.60	16.0	5.5	9.25-9.75	0.55e-3	1.90e-3

Statistical Accuracy

setup	$\sigma M_\psi/M_\psi$	σM_{rec}	$\sigma E_\Psi/E_\Psi$	$\sigma E_\gamma/E_\gamma$	$\sigma t (GeV/c)^2$
ECAL	0.020	45 MeV	0.007	0.020	0.11
HRS+MAD	0.002	-	0.001	0.002	0.014
Hall B,D no tag	0.010	26 MeV	0.004	0.006	0.03

E_γ	$\sigma_{J\psi}$	ECAL 30 days	CLAS: 300 days	Hall D: 300 days	MAD+HRS 90 days		SHMS+HMS 90 days	
GeV	nb	$\frac{\sigma(\sigma_{J\psi})}{\sigma_{J\psi}}$	$\frac{\sigma(\sigma_{J\psi})}{\sigma_{J\psi}}$	$\frac{\sigma(\sigma_{J\psi})}{\sigma_{J\psi}}$	$\frac{\sigma(\sigma_{J\psi})}{\sigma_{J\psi}}$	days	$\frac{\sigma(\sigma_{J\psi})}{\sigma_{J\psi}}$	days
8.57	0.0009	1.006	2.800	3.700	0.760	24	0.620	
8.92	0.0068	0.091	0.290	0.320	0.148	21	0.120	
9.29	0.0237	0.030	0.113	0.300	0.075	18	0.061	
9.68	0.0559	0.016	0.069	0.180	0.056	14	0.046	
10.07	0.1058	0.010	0.051	0.120	0.051	11	0.041	
10.47	0.1736	0.008	0.042	0.100	0.051	8	0.041	
10.84	0.2520	0.007	0.039	0.080	0.067	5	0.053	