7.5 *ep* cross section determination

The key step for ep cross section determination is the detector acceptance correction. This can in principle be done by extended maximum likelihood fitting if the distribution of signal and background can be parameterized and the acceptance $\epsilon(x)$ is accurately known at every point. With a new detector that is not very well understood and with the background not well understood, a more practical method is bin-average acceptance correction. The equation for this method is

$$\begin{aligned} N_{\text{signal}} &= \rho N_{\text{sel}} \\ &= \mathcal{L}_{ep} B \langle\epsilon\rangle \sigma_{ep}\,(y_1, y_2) \end{aligned} \tag{70}$$

where $\mathcal{L}_{ep}$ is the integrated ep luminosity, B is the branching ratio for $J/\psi \rightarrow e^+e^-$, ρ is the purity, $\sigma_{ep}(y_1, y_2)$ is the integrated ep cross section ((y_1, y_2) denotes W and Q^2 boundaries of the integration), and $\langle\epsilon\rangle$ is the bin-average acceptance defined by Eq. (69).

According to the Poisson distribution, $\sigma_{N'} = \sqrt{N'}$, where N' is the number of observed events and $\sigma_{N'}$ is the standard deviation. This statistical error propagates to $\sigma_N = \sqrt{N/\epsilon}$ where $N = N'/\epsilon$ is the inferred number of events. In order to reduce the error in N, poor acceptance regions(e.g., near the edge of the detector) are usually excluded. In addition, if ϵ is not uniform, deviations of ϵ from $\langle\epsilon\rangle$ also contribute to the error. This is due to the sampling error and possible systematic errors. The sampling error reflects the difference between the effective acceptance as felt by a small number of real events and $\langle\epsilon\rangle$ as felt by a very large number of MC events. The systematic errors in $\langle\epsilon\rangle$ are due to errors in the MC model and the detector simulation. Therefore, acceptance correction by $\langle\epsilon\rangle$(Eq. (70)) is more accurate if the bin is confined to a region in which ϵ is large and varies moderately, and the detector simulation is more reliable. Note that $d\epsilon/dx$ depends on choice of the variable x (e.g., a uniform distribution in x is non-uniform in $\ln(x)$). Rapidity y_{rap} is preferred since event distribution varies moderately in the rapidity space.

The cross section was calculated in the region $-1.35 < y_{\rm rap} < 1.15$ (corresponding to 140GeV $> W >$ 40GeV) and Q^2 up to 4GeV^2. The range of Q^2 was chosen so that the beam electron was inside the rear beampipe. The range of W was chosen for high acceptance, high purity, and small systematic effects. The $y_{\rm rap}$ bin size is chosen to contain most of the J/ψ candidates while ϵ does not vary too much. In effect, the CTD edge region is excluded(up to about 35°). Three bins of $y_{\rm rap}$ are used, which are (0, 1.15), (-1.35, 0) and (-1.35, 1.15), corresponding to W ranges (40GeV, 71.3GeV), (71.3GeV, 140GeV) and (40GeV, 140GeV).

The nominal acceptance was evaluated using EPJPSI13 MC sample which agrees with the real data in $y_{\rm rap}$ distribution fairly well, and with logical OR of BGF04 and BGF03 filters, which were stable during the 1993 runs, as part of the trigger requirements. The nominal purity was evaluated by ML fitting.

The results are summarized in Table 19, where raw σ_{ep} includes contributions from proton diffractive J/ψ production.

Table 19: Raw ep cross sections

$\mathcal{L} = 488$nb	$B_{J/\psi \to e^+e^-} = 0.060$		
W range(GeV)	40-140	40.0-71.3	71.3-140.0
$N_{\rm sel}$	89	32	57
$N_{J/\psi}$ by ML fit	61 ± 11	28 ± 7	35 ± 8
$\rho = \frac{N_{J/\psi}}{N_{\rm sel}}$	0.69 ± 0.13	0.88 ± 0.22	0.61 ± 0.15
nominal $\langle\epsilon\rangle$	0.35 ± 0.01	0.35 ± 0.01	0.35 ± 0.01
$\sigma_{ep} = \frac{N_{J/\psi}}{\mathcal{L}B\langle\epsilon\rangle}$ (nb)	6.0 ± 1.1	2.8 ± 0.7	3.4 ± 0.8