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A 10 Electron Pairs Production at the ISR

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An experiment is in progress at the CERN Intersecting Storage Rings to identify and measure electron pairs, produced in proton–proton collisions up to $\sqrt{s}=63$ GeV. The pairs are detected using four modules, consisting of proportional chambers, plastic scintillator hodoscopes, lithium foil transition radiators followed by Xe-CO_2 linear proportional chambers—for the X-rays—and finally of a 17 rad. lengths liquid argon calorimeter, suitably segmented in the lateral and longitudinal direction.[1] Each module covers 50° to 130° in polar angle and 40° of azimuth.

As explained in[2,3] background arising from external or internal photon conversions, from hadrons producing showers in the calorimeter and from chance overlap of hadron tracks with photon showers can be effectively reduced by imposing requirements on the signals available from the detectors. We estimate the efficiency ε for electron pair events to pass each set of requirements by observing its effect on the J/ψ signal, which has a background that can be reliably subtracted even for the most loosely cut samples ($\varepsilon=0.43$). The results of these estimates agree well with direct determinations obtained from calibration exposures of a complete module to a test beam of known particles. The number of events observed in various mass intervals, after corrections for the efficiency ε, is shown in Fig. 1.

The horizontal scale has been chosen in such a way that the points for the mass interval 1.1–2 GeV, consisting essentially of background, fall on a straight line. For a pure electron pair sample one would expect values independent of ε, within statistics.

That is in fact what happens in the 2.8–3.4 GeV(J/ψ) region for $\varepsilon \leq .36$ and, for the full used range of ε, for events with mass above 8.7 GeV (*i.e.*, Υ and higher mass region).

For J/ψ at $\varepsilon=.19$ the background is calculated to be $\sim 6\%$ and for the ≥ 8.7 GeV mass region the background is $\sim 6\%$ for $\varepsilon=.36$.

The raw mass spectra in the J/ψ region and above 6 GeV are shown in Figs. 2 and 3a for $\varepsilon=.19$. In Fig. 3b the high mass region is

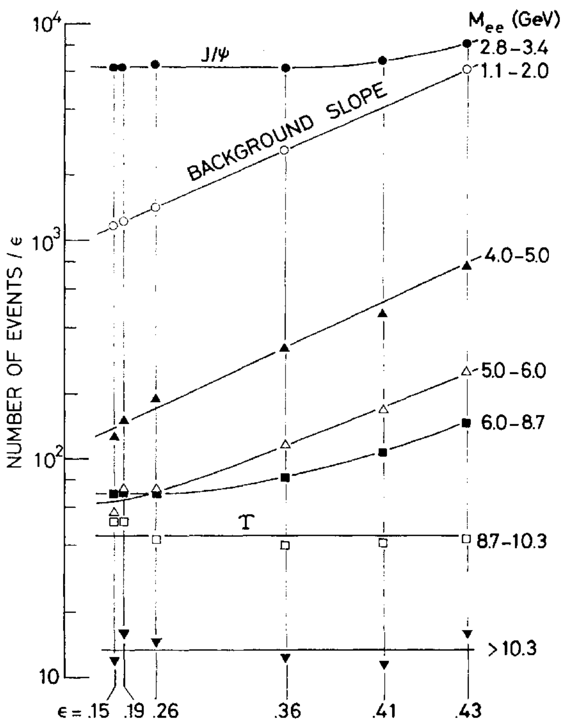

Fig. 1.

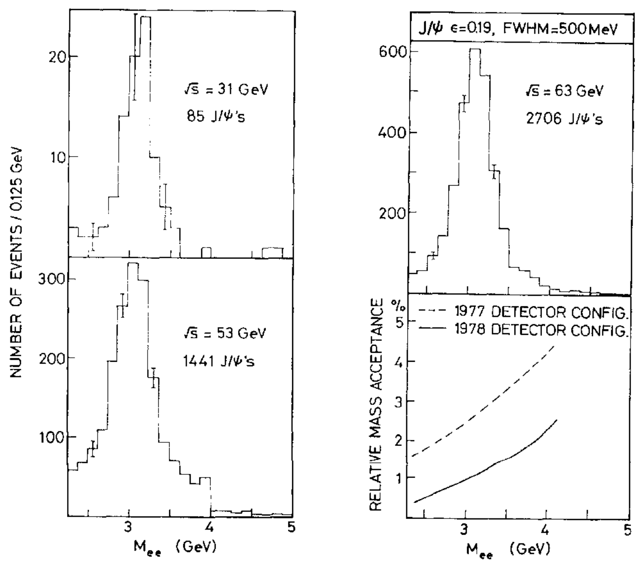

Fig. 2.

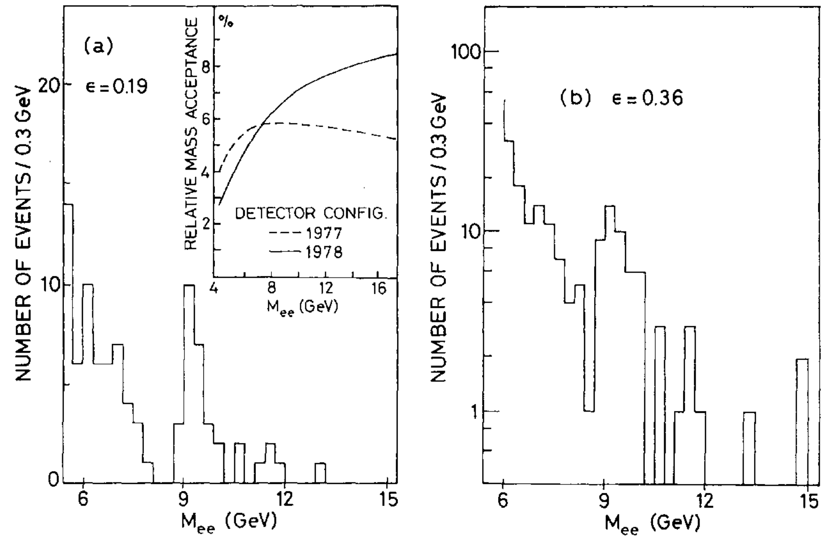

Fig. 3.

shown again on log scale for the less str identification requirements with $\varepsilon = .36$.

The 8.7–10.3 region in Fig. 3b contains 41 events. We estimate a background of 2.5 events and, by extrapolating the continuum from the region 6 to 8.7 GeV following the $m/\sqrt{s}$ dependence form ref. 4, we evaluate an electron pair continuum of about 8 events.

The mass resolution is calculated to be $\sigma_M = 380$ MeV at the Υ mass, from the experimental width of the J/ψ.

Relative values of the P_T acceptance of the apparatus have been calculated, using a Monte Carlo program which takes into account the known geometry and incorporates the threshold behaviour of each calorimeter, measured directly using events recorded without demanding *a priori* a trigger from that calorimeter. It assumes flat rapidity and isotropic decay.

Figure 4 present the acceptance corrected

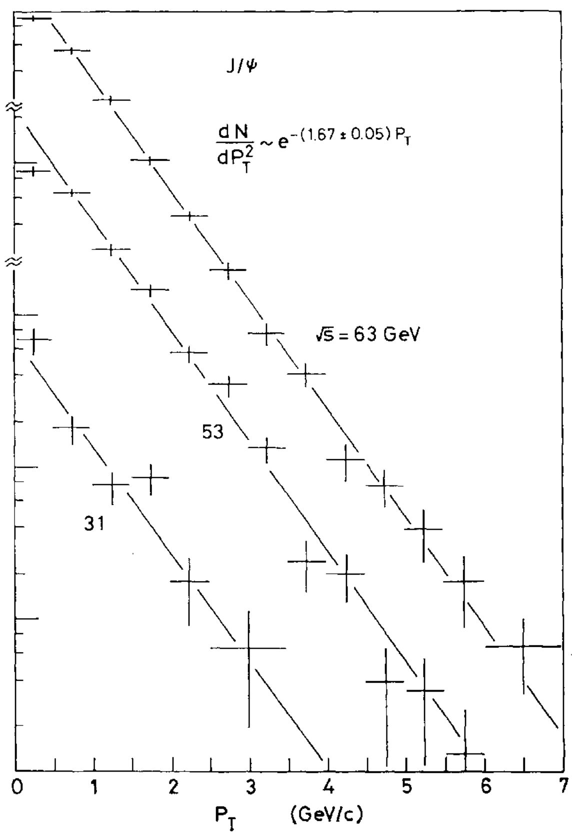

Fig. 4.

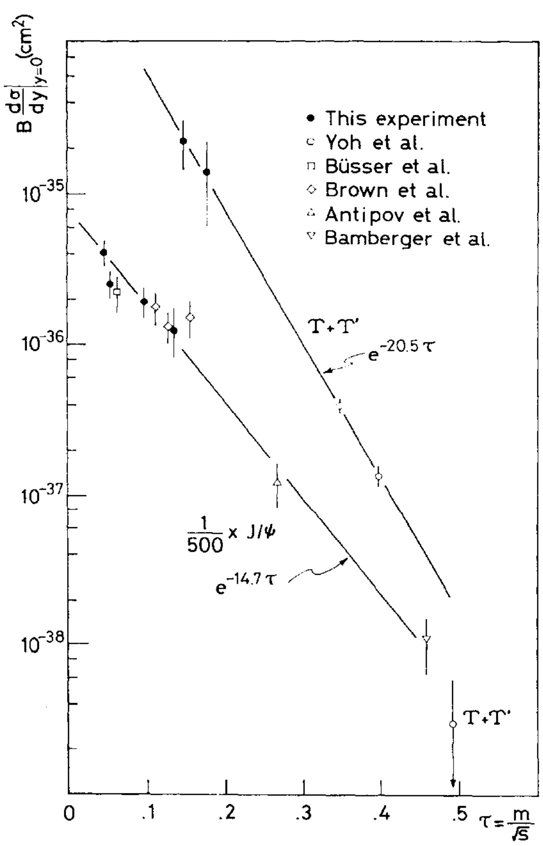

Fig. 5.

Table I.

$\sqrt{s}$ [GeV]	$\mathcal{L}$ [10^{36} cm^{-2}]	# Events $J/\psi \to ee$	b parameter [GeV^{-1}] $d\sigma/dP_\perp^2 \propto e^{-bP_\perp}$	$\langle P_\perp \rangle_{FIT} = 2/b$ [GeV/c]	$B(d\sigma/dy)\|_{y=0}$ [10^{-33} cm^2]
31	0.91	77±10	1.64±0.23	1.22±.17	9.64 ±2.30
53	8.20	754±35	1.68±0.04	1.19±.03	12.58±2.58
63	23.89	2286±70	1.67±0.03	1.20±.02	20.53±4.15

Table II. Υ region (8.7–10.3 GeV).

$\sqrt{s}$ [GeV]	Number of events	Background estimate #ev.	Continum estimate #ev.	Signal –continuum #ev.	$B(d\sigma/dy)\|_{y=0}$ [10^{-36} cm^2]	Luminosity [10^{36} cm^{-2}]
53	9	0.5	1.7	6.8±3.7	14±8	14
63	32	2	6.2	23.8±7	22±8	26.5

dN/dP_T^2 distribution for the J/ψ. All points for $P_T > .5$ GeV/c, in the P_T range which extends up to 7 GeV/c at $\sqrt{s} = 63$ GeV, follow well an exponential law vs P_T with slope $b = 1.67 \pm .05$ (GeV/c)$^{-1}$ independent of $\sqrt{s}$.* The corresponding $\langle P_T \rangle$ calculated from the fit is $2/b = 1.20 \pm .04$ GeV/c. Also in the Υ region, within the relatively large statistical error, the exponential fit continues to be adequate and produces the slope $b = 1.2 \pm .13$ (GeV/c)$^{-1}$ and $\langle P_T \rangle = 1.67 \pm .18$ GeV/c.

The cross section values for the J/ψ and Υ are listed in Tables I and II.

The errors quoted for $B \cdot d\sigma/dy|_{y=0}$ include, in addition to the statistical errors, the estimated 20% systematic uncertainty from run to run at different $\sqrt{s}$.

Figure 5 shows the data plotted vs $m/\sqrt{s}$ The line shown on the J/ψ data is from ref. 4. It should be remarked that the relative lack of experimental points, with sufficiently small errors at large values of $m/\sqrt{s}$, leaves some freedom to its slope. The line drawn through the Υ points is an eye-ball fit and appears to be somewhat steeper than the J/ψ line. In fact at the weighted average $\sqrt{s} = 60$ GeV, $B \cdot d\sigma/dy|_{y=0}$ (integrated from 8.7 to 10.3 GeV, after continuum subtraction) is about 50 times higher than the corresponding sum for the Υ and Υ' measured[7] at $\sqrt{s} = 27$. It is also interesting to remark that the ratio of resonance to continuum contribution, in the mass interval 8.7–10.3 GeV, is estimated to be 4 to 1 at $\sqrt{s} = 60$ compared with about 1 to 1 at $\sqrt{s} = 27$,[7,9] over the same mass interval.

* The value of the slope $b = 1.67 \pm .05$ (GeV/c)$^{-1}$ we find for $dN/dP_T^2 \simeq e^{-bP_T}$ for J/ψ can be compared with the result $b = 1.51 \pm .12$ (GeV/c)$^{-1}$ of ref. 8, over the P_T range 0–2 GeV/c.

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