ESTIMATES OF JETS AND DIRECT PHOTON PRODUCTION IN VERY HIGH ENERGY HADRON-HADRON COLLISIONS

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This note contains rough estimates of the yields of events produced in very high energy hadron-hadron collisions which contain jets at large transverse momenta, P_T. These estimates are expected to be useful in designing experiments which detect final states with two jets or a jet and a large P_T direct γ. The physics motivation behind these measurements is to measure constituent-constituent scattering, hadron structure functions, quark and gluon fragmentation, and to search for heavy objects which decay into two jets and/or a jet and a photon.

We consider reactions of the type:

$$h1 + h2 \rightarrow jet' + jet'' + residue1 + residue2 \quad (1)$$
$$h1 + h2 \rightarrow jet' + \gamma + residue1 + residue2, \quad (2)$$

where the index 1 stands for the beam hadron and index 2 for the target hadron. Our calculations are for large P_T (> 5 GeV) collisions where it is expected that the events will indeed contain forward and backward low P_T "jets" (residue1 and residue2) and the large P_T jets (jet' and jet'' or jet' and a γ). It is expected that $P_T' = P_T''$ and $P_T' = P_T^{\gamma}$.

In order to estimate the cross sections for reactions 1 and 2 we rely heavily on the work of Jacob and Landshoff.[1] They emphasize that the cross section for π^0 production in pp collisions at 90° in the center-of-mass system can be parameterized by the equation

$$E\frac{d\sigma}{d^3P} = 0.5\times10^{-27} \; P_T^{-8}(1 - X_T)^9 \; cm^2/GeV^2, \quad (3)$$

where $X_T = 2P_T/s^{1/2}$ and P_T is measured in GeV. They further suggest that the jet production cross section is roughly 10^2 times the π^0 cross section. We assume that the direct photon cross section is approximately 0.5 times the π^0 cross section. It should be noted that Eq. (3) appears to under-estimate the π^0 cross section at high $P_T > 6$ GeV.[1]

As an estimate for jet cross sections, we plot Eq. (3) times 10^2 for $s^{1/2}$ = 40, 200, 800, 2000, and 40,000 GeV in Fig. 1. These $s^{1/2}$'s correspond approximately to 800 GeV and 20 TeV fixed-target experiments and to 400 GeV, 1 TeV, and 20 TeV colliding-beam experiments, respectively. (Note that these jet cross sections should be divided by a factor of 200 to get the jet-photon cross sections at the same P_T.)

In an experiment which measures direct photons and/or jets we assume that the detectors can only tolerate 10^6 interactions per second. If we assume a total cross section of σ = 50 mb this gives a luminosity of $\mathcal{L}_0\sigma = 10^6$ sec^{-1} or $\mathcal{L}_0 = 2\times10^{31}$ cm^{-2} sec^{-1}. Under these assumptions, fixed-target machines will be limited in the useable luminosity to the range of those expected from future pp and $\bar{p}p$ colliders. However, the availability of $\pi^{\pm}$ and $K^{\pm}$ beams in fixed-target experiments has significant physics merit. Also, fixed-target experiments which do not observe the residue jets can run at substantially higher luminosities, perhaps three orders of magnitude higher.

We note that

$$E\frac{d\sigma}{d^3P} = \frac{1}{\pi}\frac{d\sigma}{dydP_T^2},$$

where y is the rapidity. For $\Delta y = 1$ this gives an effective cross section $d\sigma_e/dP_T^2$ of:

$$\frac{d\sigma_e}{dP_T^2} = \pi E\frac{d\sigma}{d^3P}.$$

If we consider the effective mass of two jets, we get, roughly, $M \sim (P_T' + P_T'') \sim 2\,P_T$. Thus,

$$\frac{d\sigma_e}{dP_T} \sim 2\frac{d\sigma_e}{dM}.$$

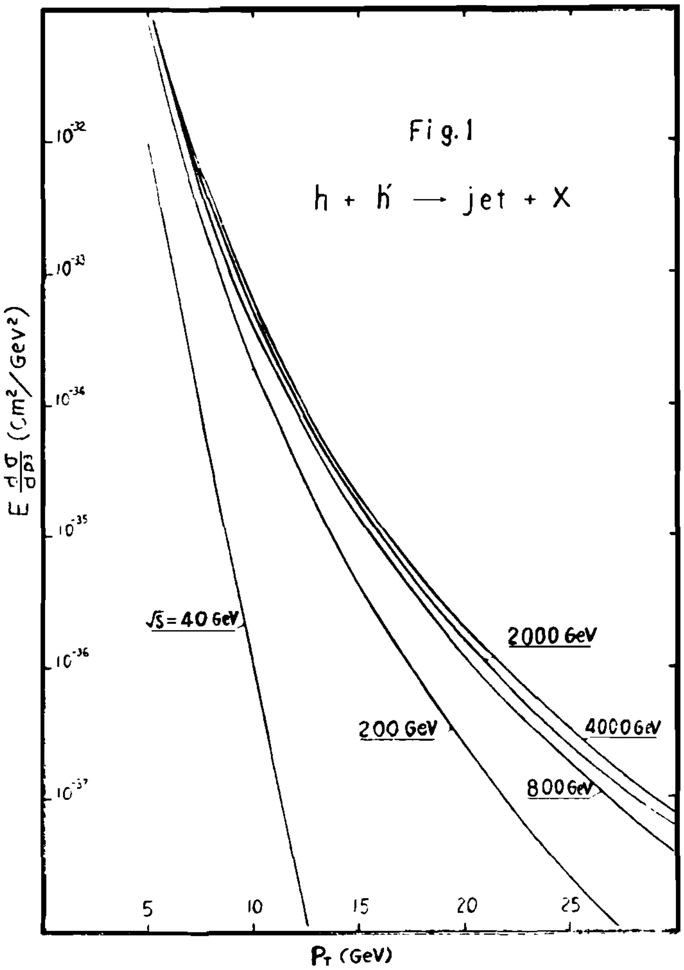
In Fig. 2 we plot $d\sigma_e/dP_T$ and the expected yields versus P_T for jets assuming $\mathcal{L} = 10^{31}$cm^{-2} sec^{-1}, and $\Delta T = 10^7$ sec for several values of $s^{1/2}$.

J. Leveille[2] has calculated the production cross sections for an excited quark, q^*, at various energies and masses. For $s^{1/2}$ = 2000 GeV and M_{q^*} = 60 GeV, he gets $\sigma_{total} \sim 3\times10^{-33}$cm^2. Assuming this total cross section is spread over Δy = 10 gives $\sigma_e \sim 3\times10^{-34}$cm^{-2}. The jet-jet background at P_T = 30 GeV from Fig. 2 is for a ΔP_T = 1 GeV, Δy = 1, $\sigma_e \sim 4\times10^{-35}$cm^2. Thus, such a q^* may be observable above the estimated jet-jet background.

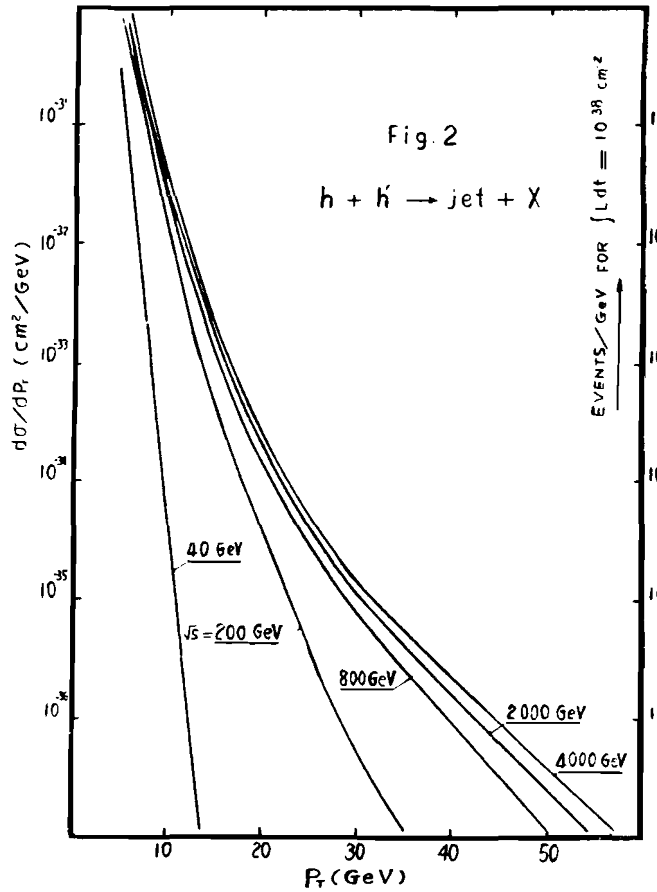
We warn the reader that the estimates in this note give jet cross sections many orders of magnitude below the calculations of F. Paige[3] and those contained in the ICFA report.[4] Hopefully, within the next few years the $\bar{p}p$ colliders will provide data which will allow more reliable estimates to be made. If the lower estimates contained in this note turn out to be correct it will make jet-jet mass spectroscopy much easier because of the greatly reduced continuum cross section.

References

1. M. Jacob and P. V. Landshoff, Physics Reports **48** (No. 4), 286 (1978).
2. J. Leveille, private communication and these proceedings.
3. F. Paige, private communication and these proceedings.
4. Proceedings of the Second ICFA Workshop (1979), European Organization for Nuclear Research.



Estimated jet cross sections vs. P_T.



Effective jet cross sections and expected jet yields vs. P_T (for details see text).