TWO TYPES OF PHYSICS EXPERIMENTS WITH THE ENERGY DOUBLER

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ABSTRACT

This note is concerned with two types of physics experiments that could be done with an energy doubler. The first uses an internal hydrogen jet target, the second uses high energy secondary beams. In each case, 5×10^{13} protons/100 sec accelerated to 1000 GeV appear adequate to investigate the physics.

Jet Target Experiments

The present NAL program using a jet target interacting with protons has been very successful and could be easily extended to higher energy. This program includes, among others, the following approved or proposed experiments:

1. A measurement of the slope parameter in p-p elastic scattering.
2. A measurement of ρ, the ratio of real to imaginary parts of the forward-scattering amplitude.
3. A measurement of the p-p total cross section.
4. Isobar production from the proton.
5. Measurements of elastic scattering, σ_T, and isobar production using a deuterium jet.
6. Measurements using a helium jet.

Slope parameter data from various sources is shown in Fig. 1. Extension to 1000 GeV corresponding to $s = 2000\ \text{GeV}^2$ would extend this precision data to ISR regions.

Figure 2 presents the available data on the ratio ρ. Preliminary data showing a positive value of real to imaginary amplitude at 400 GeV are indicated by the circles. Clearly this result is of extreme importance and its extension to 1000 GeV would greatly clarify the exact crossover point. This experiment seems extremely difficult if not impossible at the ISR.

Figure 3 shows the data for the third (proposed) experiment. The p-p cross section is known to rise from ISR data; this rise could be mapped out in detail between 500 and 1000 GeV if the doubler exists.

Experiments 5 and 6 are of interest primarily because they yield cross sections from the neutron. This physics is impossible at the ISR but would be rather simple using the doubler and a jet (or even an external) target. The cross section accuracy is limited by knowledge of the p-p subtraction and the Glauber correction.

Particle-Electron Scattering Experiments

The advent of very high energy accelerators has opened a new field of experiments, namely investigation of meson electromagnetic form factors by direct meson-electron scattering. The first such experiment was on π-e scattering and measured the pion radius. No matter what the form factor is assumed to be, it can be expanded as

$$f_\pi = 1 + aq^2 + bq^4 + \ldots$$

In the simple vector-dominance model the coefficient $a = \langle \frac{1}{6} r_\pi^2 \rangle$ is given from the ρ mass because $f_\pi = \frac{1}{1 + \frac{q^2}{m_\rho^2}}$. If this is compared to some other model, for example

$$f_\pi = \left(\frac{1}{1 + \frac{q^2}{m^2}} \right)^n$$

the first-order terms agree (with different mass) but the models differ in terms of order q^4, the point being that the q^2 term is a large effect at present NAL energies but that the q^4 term is so small that it is probably unattainable. Increasing the pion beam energy increases the effect of this term as p_π^2 so that the effect becomes measurable.

We can also consider measuring the charged kaon form factor. Vector dominance plus SU_3 predicts

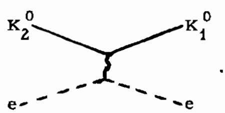
$$f_K = \frac{1}{2} \frac{1}{1+\frac{q^2}{m_\rho^2}} + \frac{3}{8} \frac{1}{1+\frac{q^2}{m_\phi^2}} + \frac{1}{8} \frac{1}{1+\frac{q^2}{m_\omega^2}} .$$

At NAL energies the charged K radius can be measured. The q^4 term is much more difficult primarily because the maximum q^2 available is smaller, i.e.,

$$q^2_{max} = \frac{4 m_e^2 E_K^2}{m_e^2 + m_K^2 + 2 m_e E_K}$$

and m_K^2 is comparable to $2 m_e E_K$ while it is much smaller in the π-e case. Thus the energy argument made for pions is even more important if the q^4 term is to be measured in K-e scattering.

The neutral K also has a radius. Here one probes the $K_2^0 - K_1^0$ vertex with a virtual photon via the diagram



The K radius form factor is, under the previous assumptions,

$$f_{K^0} = \frac{1}{2} \frac{1}{1 + \frac{q^2}{m_\rho^2}} - \frac{3}{8} \frac{1}{1 + \frac{q^2}{m_\phi^2}} - \frac{1}{8} \frac{1}{1 + \frac{q^2}{m_\omega^2}} .$$

The cross section varies as $\langle r_K^4 \rangle q^4$ and the higher energy supplied by a doubler would make such an experiment feasible. The cross section in the design of a particular experiment using 600 GeV K_2^0's is of order 5×10^{-33} cm^2 so that the experiment is still far from easy.

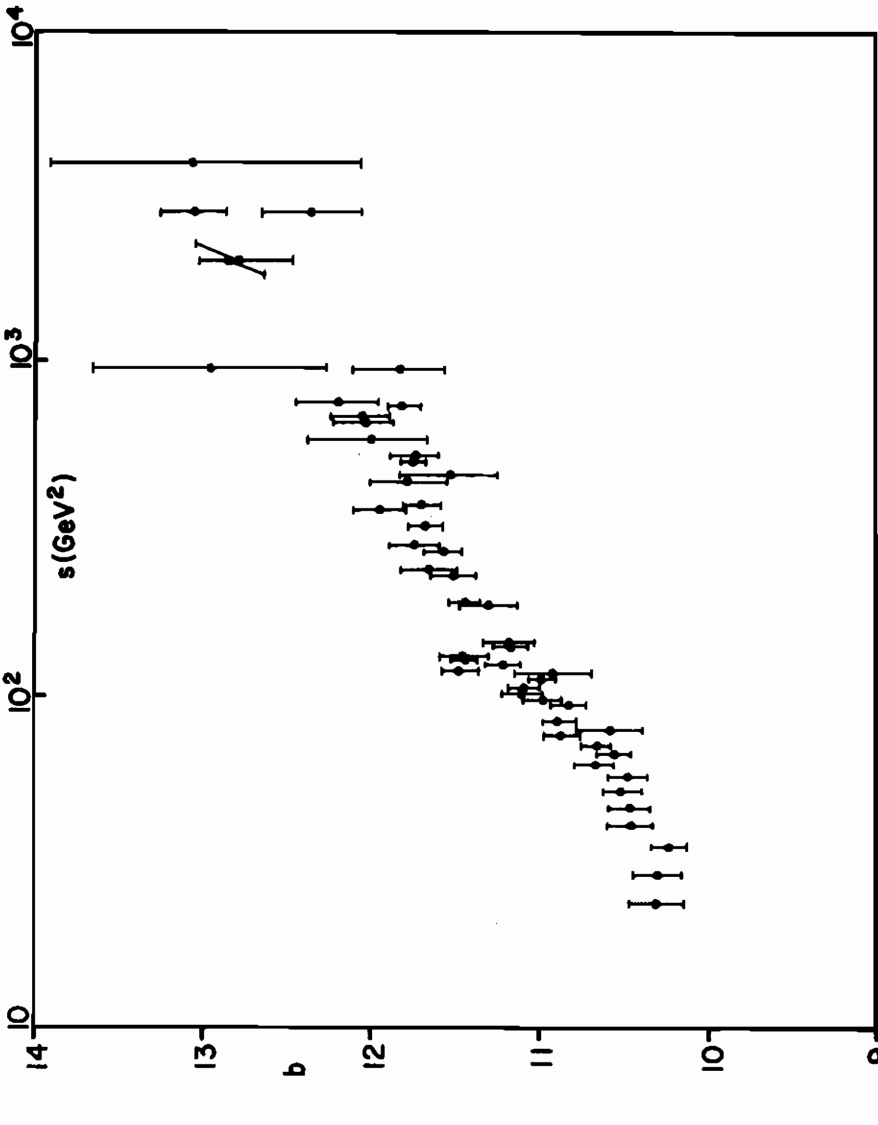


FIG. I

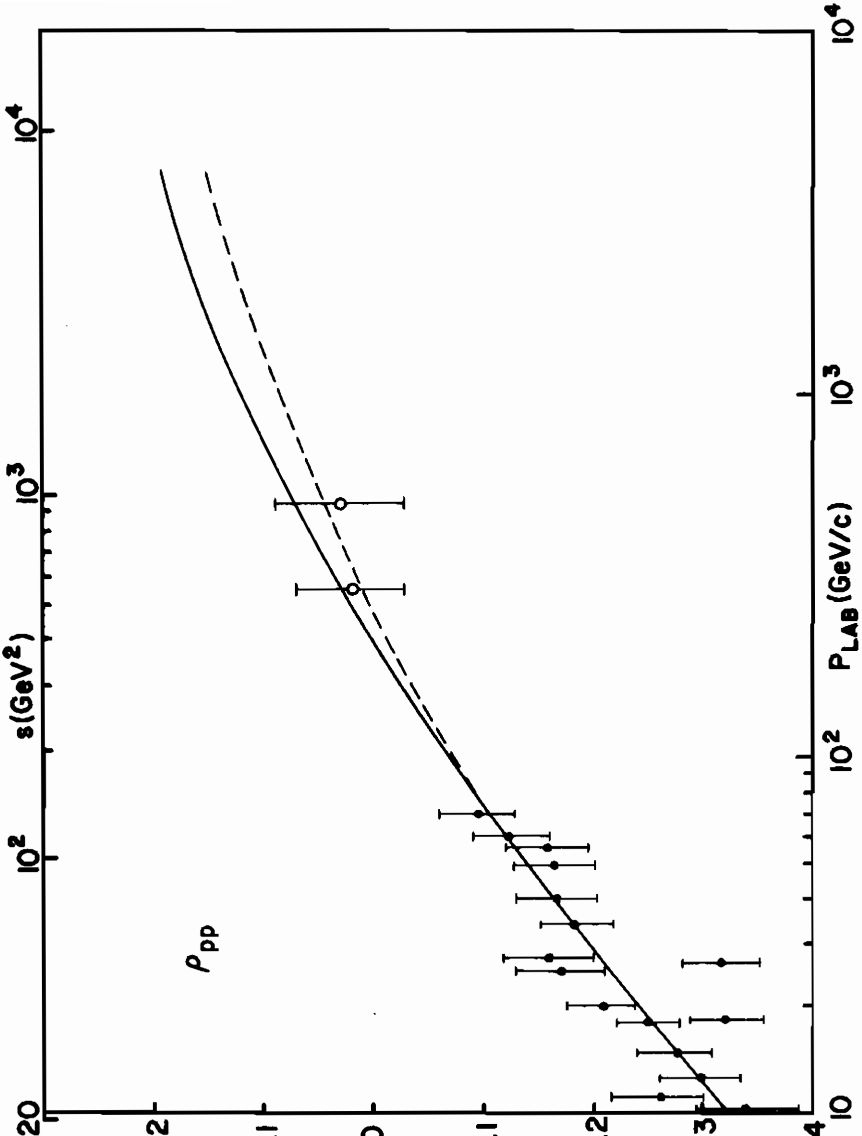
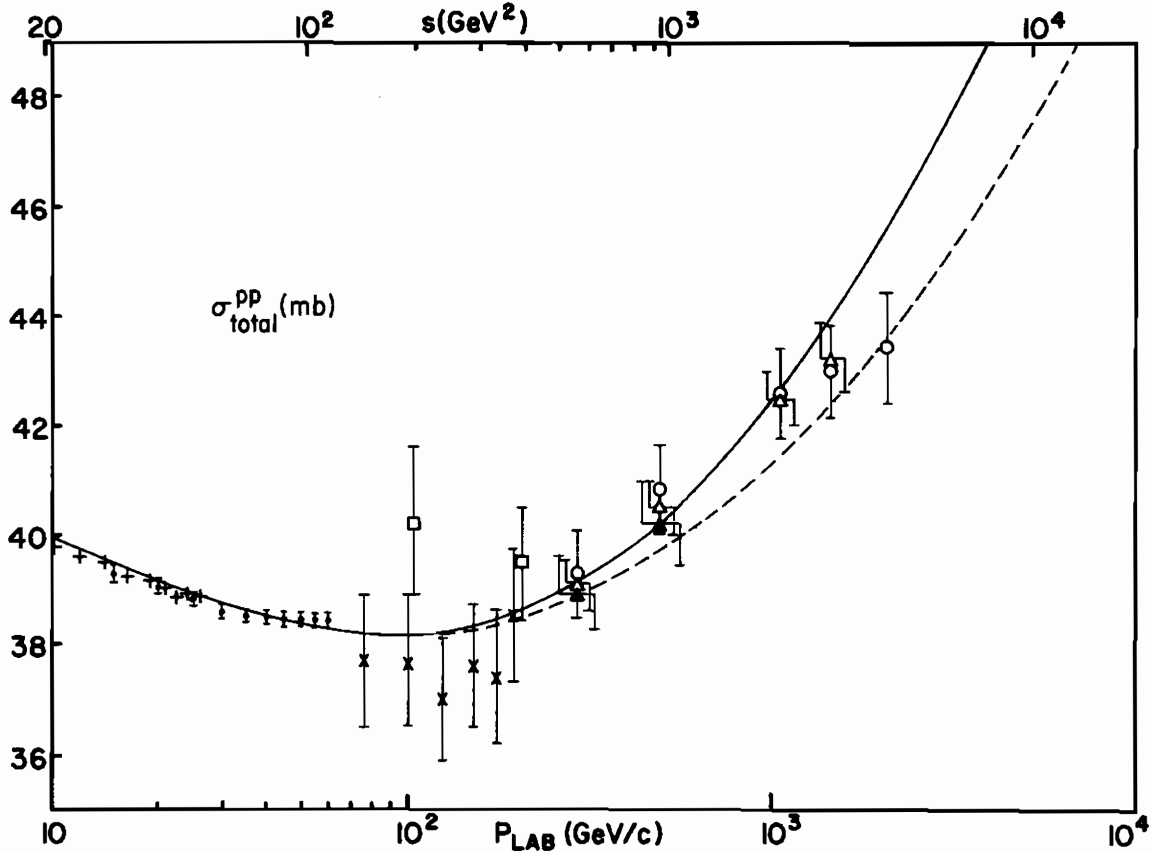

s(GeV^2)
20
10^2
10^3
10^4
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
ρ_{pp}
10
10^2
10^3
10^4
P$_{LAB}$ (GeV/c)

FIG. 2



s(GeV²)
20
10²
10³
10⁴
48
46
44
42
40
38
36
σ pp total (mb)
10
10²
P LAB (GeV/c)
10³
10⁴

FIG.3