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BEAM DUMP EXPERIMENT: DIMUONS AND NEUTRINOS

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When the 10^{13} (tired) 200-BeV protons are finally brought to their last resting place in the beam dump, a judicious arrangement permits a sensitive search for neutral bosons in the mass range 5 to 20 BeV/c^2. This is patterned after the dimuon search scheduled in the AGS. The idea is that when 200-BeV protons are abosrbed in a uranium block, all the beams that will ever be made at NAL (except leptons) are simultaneously present with far higher intensity than even the most ingenious beam design can achieve. The uranium is immediately followed by ~ 40 ft of steel to absorb all the strongly interacting particles. What emerges are muons ($E_\mu > 20$ BeV) and neutrinos. A search for neutral boson states coupled, however weakly, to hadrons on one side and leptons on the other is made with great sensitivity by this arrangement. Speculation about the existence of bosons in the mass range 3-20 BeV/c^2 has reached hysterical proportions in recent theoretical papers explaining alternatively or collectively, g-2, Keuffel, weak interactions, CP, nucleon form factors and the weather in Aspen.

The multiple scattering completely dominates the mass resolution

$$M^2 = P_1 P_2 (\theta_1 + \theta_2)^2,$$

and this varies over the mass region from 4 to 10%. The sensitivity is limited by accidental coincidences between muons from π decay which appear with a rate of ~ 10 cm/110,000 = 10^{-4} of the pion flux above 20 BeV and at angles of M_B^o/P_B^o. For a mass range 6-20 BeV/c^2, the minimum transverse momentum of 3 BeV/c suppresses the singles rate by another factor of 10^4 leaving about 10^4 singles per pulse. A reasonable resolving time gives a rate of 0.1 trigger per pulse, and these can be subtracted to arbitrary precision, say signal/noise = 0.1. The sensitivity is then

$$10^{13} \text{ protons} \times \frac{\sigma B}{10^{-26}} \times E = 0.01.$$

where B is the branching ratio.

Experience at BNL with computations on various models of heavy particle production and decay indicates an overall efficiency which varies with mass from 1-5%. Let's take 1%:

$$\sigma B - \frac{10^{-2} \times 10^{-26}}{10^{-2} \times 10^{13}} = 10^{-39}.$$

Even at the depressing $\rho \rightarrow \ell^+ \ell^-$ branching ratio of 10^{-5}, we look at incredibly weak coupling constants. A 10-BeV boson would show up as a 5-σ bump in 100 hours if $\sigma B = 10^{-39}$ and with a width of ± 500 MeV. The relatively poor resolution means scintillator hodoscopes and thick range bins are satisfactory.

The beam dump arrangement permits one also to look at neutrinos from short lived parents; these are produced at the level of 10^{-30} cm^2. This requires a "simple" 50-ton spark chamber. Such neutrinos could be generated by intermediate bosons (made a la Keuffel, strongly) or by heavy leptons.

This all assumes a beam dump which is down stream of all the beam channels emerging from the last target, since some 50 meters of space is required after the dump for the detectors. The transverse space requirement is about ± 15 meters relative to the beam axis.