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Comments on Machines for the Energy Range 2 Bev to 10 Bev

Several possibilities for accelerators in the 2- to 10-Bev range have been examined by members of the summer conference following the suggestion of the National Science Foundation's committee that high current accelerators are needed in this energy range.

The question of choice of particle, utilization and desirable energy were examined by R. G. Sachs (RGS(MURA)-1), "On the Application of Very High Energy Machines." Among other things this valuable discussion gives the cross sections to be expected and shows that electron accelerators will give about 1000 times fewer interesting particles than proton accelerators of the same current. Even if the secondary pion beam from a proton accelerator is used to produce the interesting particles, the proton accelerator's pion beam will make 10 to 100 times more of these particles than the photon beam of the electron accelerator can. In addition, a photon beam striking a target will give about 500 to 1000 times more electromagnetic background than will the proton or pion beam. This background is inevitable, since it comes from the experiment performed and not from the accelerator.

Although the value of an electron accelerator for study of strange particles seems less than that of a proton accelerator, some questions of the effects of electromagnetic orbital radiation during acceleration are being looked at by Vogt-Nilsen, who is visiting us.

The attractiveness of a linear proton accelerator of about 2 Bev as a high current source of K-mesons from an external and easily accessible target led us to see what such an accelerator was like. For short-lived strange particles an external source close to the experimental equipment is desirable. The British are planning to construct such an accelerator for 600 Mev with currents of 1 microamp to 10 microamps (ONRL-42-53) and (AERE G/M 151). L. W. Jones took the British parameters and information from Johnston on R.F. systems to estimate the sizes and costs of such an accelerator. The cost came out between 20 million dollars and 38 million dollars, while scaling the Harwell cost gave 16.3 million dollars. In addition to this great cost, the maintenance on large R.F. tubes alone would cause continuous operation interruption and would cost about 3 million dollars per year. Perhaps one should consider using a cosmotron of Brookhaven's size for this energy range, although the present average current from the cosmotron is about 1000 times less than that which might come from a linear accelerator. The possibility of increasing the output of the cosmotron by an order of magnitude by improved injection is being studied at Brookhaven and the possibility of increasing yield by raising the repetition rate an order of magnitude in a redesigned machine always exists. The present cosmotron is about an order of magnitude from the space charge limit of the magnet.

The next question considered was whether or not a strong focussing 6-Bev proton accelerator should be made. In discussing this question the intent to use the accelerator as a basis for a regional midwestern high energy laboratory must be considered.

One might take the position that the yield from a 6-Bev accelerator must be at least as great as that from the 6-Bev Berkeley conventional bevatron if the experimental work is to be done in the midwest. Although the bevatron output is now orders of magnitude below the space charge limit of the magnet, the Brookhaven cosmotron is within a factor of 50 of its magnet's space charge limit. This may mean that in time, as injection currents are raised, these limits may be nearly attained. The estimates of F. T. Cole on this problem show that the limit of circulating current at injection into the cosmotron is about .75 amperes for a change of 0.2 in n. Since the cosmotron injects about 6 turns around the machine, an injection current of at least .125 amps is needed from the Van de Graaff. This is about 50 times more than now comes out of the Van de Graaff, so the need for improvement is evident. The bevatron could hold about 2.3 amps at the injection velocity, so it is evident that a current of the order of a half an ampere is needed for injection to the limit. Cole finds that a 6-Bev strong focussing constant gradient machine with the same space charge limit as the bevatron and with the same injection energy has a magnet gap about 83% of the bevatron gap length. Thus the magnet is not going to be much smaller for an alternating gradient synchrotron if an attempt is made to match the space charge limit per pulse. The A.G. magnet would have an n of 35 and 18 sectors.

The point of this comparison is to show that there is doubt that a strong focussing machine would be better to build than a revised bevatron at 6 Bev. This situation is changed if we say that there is little likelihood that such high injection currents will ever be achieved. Then one could use a much smaller conventional magnet or strong focussing magnet to equal the bevatron's eventual yield. One could also raise the repetition rate to gain yield but he would lose because of only one turn injection into these smaller magnets. High repetition rate with a small magnet has the advantage that the injector current need not be improved much to approach the space charge limit. The A. C. machine may also be more favorable if we can succeed in learning how to use non-linear restoring forces since then much greater space charge distortion of n can occur without causing resonant blow-up. The situation is such that there is a good likelihood that a 6-Bev strong focussing machine can be made to compete in yield and cost with the bevatron.

It would be unfortunate to be at 6 Bev if nucleon anti-nucleon pairs can be created because the threshold is 5.7 Bev. It may be that 10 Bev is still too close to threshold to give much yield. However, if nucleon pairs are possible, the case for 10 Bev should be strong in the minds of the physicists, while the case for 6 Bev would be weak to the physicists but strong to the budget authorities. The accompanying report shows the characteristics of a 15 pulse/sec 10-Bev proton accelerator quite similar to the electron accelerator designed last summer by Jones and Laslett (LWJ-LJL-MAC-5). An accelerator of this type might well be worth striving for in the Midwest. The main features are similar to the Cornell type of machine.