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Internal

THE POSSIBILITY OF HIGH INTENSITIES FROM FFAG ACCELERATORS PROVIDING A MEANS OF INCREASING THE ENERGY

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Several times the loss of energy due to the recoil of the target nucleus has been emphasized in MURA discussions of the problem of achieving high energies (LWJ-LJL/MAC-5 and R. G. Sach's discussions of June 19, 1954). The great advantage to having the center of mass of the target plus projectile system stationary in the laboratory ought to be brought up again because of interesting possibilities with fixed field accelerators.

The energy available in the center of mass is

$$T_{cm} = 2\sqrt{1 + \frac{T_{lab}}{2}} - 2 \qquad \text{where}$$

T's are kinetic energies in terms of the proton rest mass. Protons are projectiles and targets in this case. Another way to say this is

$$T_{lab} = 2\left(\frac{T_{cm}}{2} + 1\right)^2 - 2$$

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If we had two fixed field accelerators with a portion of their high energy orbit paths in common but with particles circulating in opposite directions through this common portion, and if we had the radio frequencies just right so that the bunches of particles would strike in a synchro-clash manner, then nuclear reactions could occur in this common beam against beam target section of the accelerators. If these accelerators gave 8 Bev. to the particles they accelerate, then in the center of mass of opposing particles 16 Bev. would be available. To achieve this large an energy available for particle reactions with one accelerator would require an accelerator of 184. Bev!

Two two Bev. constant frequency cyclotrons, say of the FFAG Mark V type with a common portion somehow built into them, would provide an energy equivalent to one 17.8 Bev. accelerator.

In the past when we have thought about this, we realized that the counting rates with existing beams would be several counts per year. However, suppose we can lift particles to high energy and leave them there to circulate while we go back in radio frequency to get some more particles. This is the idea Symon and Sessler have been considering. We can then build up an intense circulating beam at the high energy orbit. The life time of this beam would depend on gas scattering and possibly on some long time stability questions of dynamics. The gas may be pumped out by the intense beam during the process.

The number of interactions per second is

$$n = 2 N_1 N_2 v \ell \sigma A$$

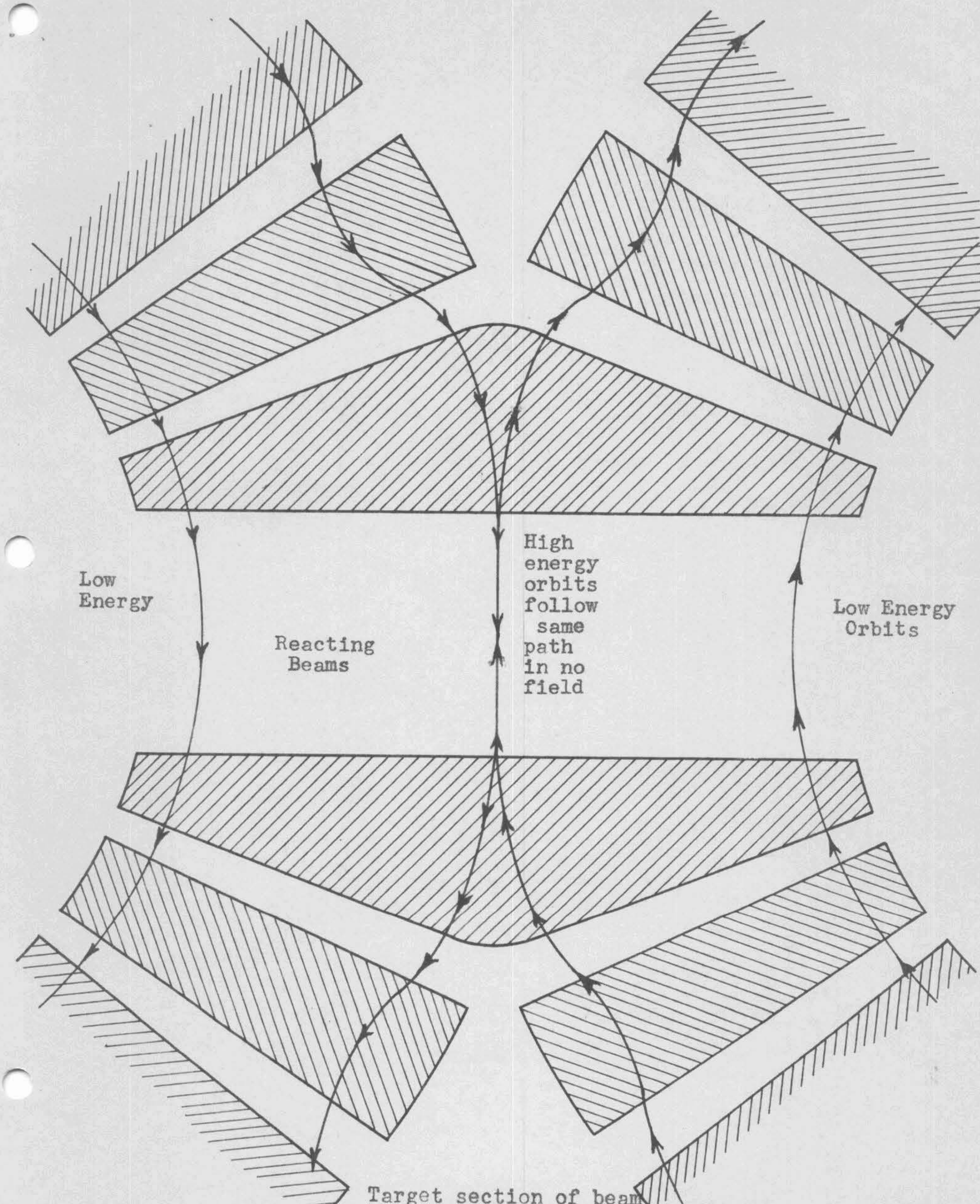
where N_1 is the number of particles per square centimeter circulating in accelerator number one percentimeter of circumference and N_2 are in accelerator number two. v is the velocity of the particles (about the velocity of light). ℓ is the length of the beam on beam target section. A is the cross sectional area of the beam. If we take the geometrical cross section for $\sigma \sim 5 \times 10^{-26}$ cm^2, and $A = 1$ cm^2, R_o the radius of the orbit $\sim 10^4$cm. N is the total number of particles circulating in each accelerator (try 10^{10} as in proposed accelerators), then:

$$n = 2 A \ell \sigma \left(\frac{N}{A \, 2\pi R_o} \right)^2 c \cong 6 \ell \times 10^{-5} \text{ interactions per second.}$$

If the target section is 100. cm long, we have only $\sim 6. \times 10^{-3}$ interactions per second, but if we now accumulate a large number of batches of circulating particles the reaction rate will go up as the square of the number of batches we can hold in the circulating beam. If we want ~ 100 disintegration particles/cm^2/sec. at 100 cm distance from the target section, then we need $100 \times 4\pi (100)^2 = 1.2 \times 10^7$ interactions per second.

This would require N $\sim$ 5 x 10^{14} particles in each machine. Thus for this high a yield we would need thousands of accumulated batches of particles. This might be approached.

The interaction or target section presents problems which have not been thought through, but one can imagine a positive and a negative momentum compaction FFAG overlapping or more simply a straight field-free section as shown in the drawing.



Target section of beam on beam double accelerator