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363
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MIDWESTERN UNIVERSITIES RESEARCH ASSOCIATION*
2203 University Avenue - Madison, Wisconsin

STUDIES ON ELECTRON SYNCHROCLASH

D. S. Ling**

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Machine characteristics

$K = 15$ $\quad \frac{1}{\omega} = 65$ $\quad \nu_x \cong 4$

$N = 15$ $\quad f = 1$ $\quad \nu_y \cong 2$

$\bar{B} = 7000$ gauss

Injection energy = 50 Kev. $\quad r_i = 62$ cm.

Field energy = 200 Mev. $\quad r_f = 95$ cm.

Usable injection aperature = 1 cm^2 (Involves guessing at the stability limits.)

Final beam area = 10^{-2} cm^2

Adiabatic damping would reduce the beam size below 10^{-2} cm^2 but we will permit gas scattering and beam stacking to spread the beam to the given dimension.

Gas Scattering: The beam can circulate 10 sec. without spreading more than 10^{-2} cm^2.

This is computed for nitrogen at 10^{-6} mm. pressure.

Pulse Stacking: It is possible to stack 555 pulses without spreading the beam more than 0.1 cm.

Computed from Kerst's formula

$$n_p = \frac{2(K+1)p_2\,\delta R}{\frac{\Delta E_1}{T_1}\,p_1 R} \quad \text{with} \quad \frac{p_2}{p_1} = 870, \quad \delta R = 0.1 \text{ cm}, \quad \frac{\Delta E_1}{T_1} = 0.05$$

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** Summer 1956 participant from University of Kansas

Stacking 500 pulses, each containing 2×10^{10} electrons, gives a beam of 10^{13} electrons with a cross sectional area of 10^{-2} cm^2.

At 200 Mev. and 100 cm. radius a beam of 10^{13} electrons is a current of 75 amps.

Electron-Electron scattering

$$\text{Yield} = 2\left(\frac{N}{2\pi RA}\right)^2 c\,\ell\,A\,\sigma$$

A - beam area

ℓ - interaction length

N - no. of particles per machine

The Møller cross section at 90° is $\frac{9}{4} r_0^2 \left(\frac{mc^2}{E}\right)^2 \frac{cm^2}{sterad}$ in the C. of M. system which for colliding beams is also the lab system. For 200 Mev electrons we get $\sigma = 10^{-30}$ cm^2/sterod.

Putting $A = 10^{-2}$ cm^2, $\ell = 1$ cm., $R = 10^2$cm.

$N = 10^{13}$, $\sigma = 10^{-30}$ cm^2/sterod.

Yield = 1,520 scatterings /sterad/sec.

Background in e-e scattering

Coulomb scattering off gas nuclei is given by $\frac{Z^2}{2} r_0^2 \left(\frac{mc^2}{E}\right)^2$ at 90° in lab system. For nitrogen at 10^{-6} mm. and A, ℓ, R and N as given above the yield is twice the background.

Would like to do e-e scattering to at least 1% accuracy in order to see radiative corrections to Møller scattering. Coincidence measurements can help to supress background.

Muon production

$\sigma = 10^{-34}$ cm^2. This is estimated from the cross section for the production of electron pairs by colliding charged particles.

For an $N = 10^{13}$ we find a total yield of 0.3 muons/sec. If we could reach $N = 10^{14}$ the yield would be 30 muons/sec.

Background in muon production

It takes 103 Mev electrons to produce muons in colliding beam. It would take about 200 Mev electrons to produce muons off gas nuclei since they must be produced in pairs. However above about 140 Mev it is possible to produce pions off gas nucleons and the decay muons from these would cause severe background problems. At around 120 Mev it should be possible to do experiments without too much background difficulty.

Pion production

If we again take 10^{-34} cm^2 as a reasonable guess for the electromagnetic pion pair production cross section, the yields are the same as for muons.

0.3 pions/sec for $N = 10^{13}$

30 pions/sec for $N = 10^{14}$

Background in pion production

The background is more troublesome than in the muon case since the cross section for the production of pions in electron-nucleon collisions is about 10^{-30} cm^2. Thus when $N = 10^{14}$ there will be 1350 background pions/sec when there are 30 per sec. produced by the intersecting beams.

If we look only at pions near the maximum energy (200 Mev for machine considered) and near 90° to the beam, we will discriminate against the background pions and it may be possible to do an experiment.