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Time Dependence of the Beam in the 86-Inch Cyclotron

In the preliminary stages of setting up a time-of-flight system for measuring neutron spectra from proton reactions, a study of the time dependence of the beam in the 86-Inch Cyclotron was made. This study revealed the expected bunching of the protons to produce a short burst of beam on each cycle of the 13.4 Mc/s accelerating voltage. In addition to the 13.4 Mc/s structure, however, there was a 360 c/sec modulation of the beam pulses and a complicated pattern built upon that.

The accompanying photographs show oscilloscope pictures of the beam pattern taken by displaying on an oscilloscope the output of a fast plastic scintillation counter. The counter was exposed to beam scattered from an aluminum foil. The 60 c/sec line voltage and the envelope of the 13.4 Mc/s accelerating voltage are shown on the same time scale for reference.

Apparently the beam intensity is critically dependent on the accelerating voltage but is not a monotonic function of that voltage.

A plausible explanation of the data is that as the accelerating voltage is increased and the energy gain per turn increases, the turns structure moves radially outward. The beam is maximum when a turn reaches the septum in optimum position for extraction. If the turns structure moves out or in from this position, much of the beam will strike the septum and will not be extracted.

Since the turns structure moves in time, it is not possible to adjust the septum and deflection channel parameters optimally for all time.

The pictures suggest that if the r-f voltage could be held constant, the extracted beam could be increased perhaps tenfold. The ratio of average to peak beam would be greatly improved and this would be quite beneficial to counting experiments. The beam intercepted by the septum would be reduced so that the septum life would be increased. Also the increased brightness of the beam would permit better energy resolution in external beam experiments and probably a cleaner pulse separation in the time-of-flight system.

The pictures also indicate that a change of one percent of the accelerating voltage makes a significant change in the extracted beam. The 360 cycles-per-second ripple is about 15 percent of the peak accelerating voltage.

Top picture: The envelop of the r-f accelerating voltage.
2nd from top: 60 c.p.s. line voltage to show time scale.
3rd from top: Cyclotron beam intensity.
4th from top: Cyclotron beam intensity displayed on faster
oscilloscope sweep.

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