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Brookhaven National Laboratory Linear accelerator performance

The first time that protons were accelerated in the Linac to a 50 Mev energy level was on April 13, 1960. First acceleration in the AGS took place on July 29, of the same year. By now the Linac has accumulated a total running time of about 800 hours.

The output current of the Cockcroft-Walton type particle injector for the Linac is normally between 15 and 18 milliamperes. This is total current. This has been analyzed several times with a mass spectrometer (at the 750 Kev energy level). The proton content is approximately 55°/o. The ion source used until now has been the conventional P.I.G. type source,* pulse operated with a pulse length of 25 microseconds and repetition rate of 2.5 pulses per seconds. A dc extraction voltage of 25 Kv is used.

The total particle current is measured with beam transformers at several places along the Linac. The locations are as follows:

a) output C.W. preinjector

b) output Linear accelerator

c) immediately before entering the inflector of the AGS

The particle current measured may vary slightly from time to time but normally fall within the following values:

at a) 15-18 ma. (see above)

b) 2-2.5 ma.

c) 1.8 -2.3 ma

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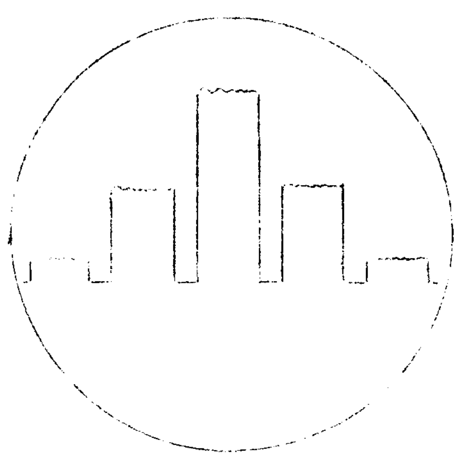
* This will be replaced in the near future with a Duoplasmatron source.

The output current of the Linac is as expected regarding:

18(location a) x 0.60 (proton percentage)x $\frac{75}{360}$(phase angle acceptance of Linac)$\longrightarrow$ 2.3 ma. A particle "buncher" is being fabricated and will be installed in the near future. In connection with these beam currents, it is interesting to note that the radiation level along the Linac tanks is essentially zero.

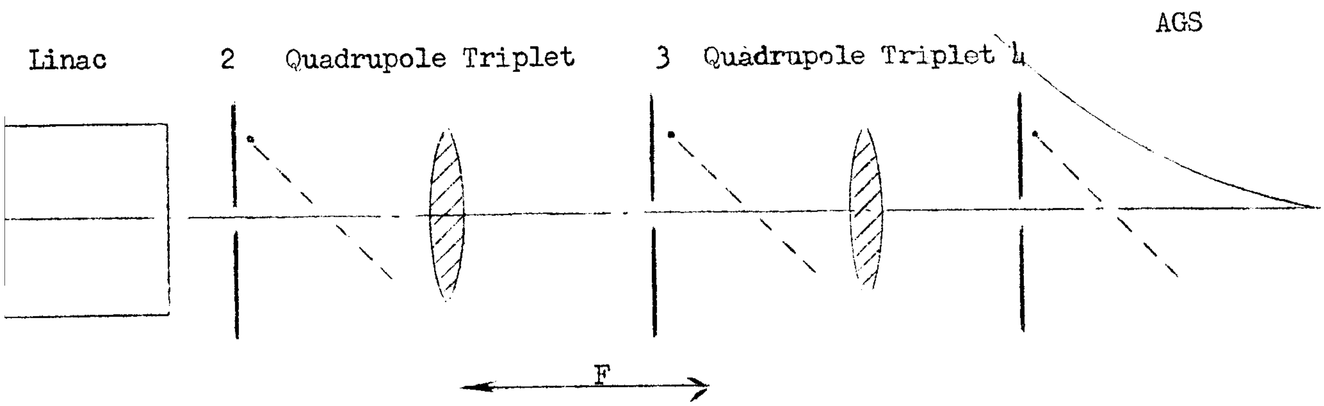
During normal operation, before injecting the beam into the AGS it is customary to analyse the output beam of the Linac with a deflecting magnet located about half-way between the high energy end of the Linac and the AGS inflector. The beam is then deflected into a multiple slit Faraday cup. An oscilloscope display is obtained from this by incorporating different time delays in the individual channels of the Faraday cup.

A typical display is shown below:



Because the channel separation of the Faraday cup is known to be 0.2 Mev/channel separation, the observed oscilloscope pattern yields immediately ΔE.

During initial operation of the Linac ΔE had values as high as 0.8 Mev (total width at half amplitude), now this value is normally between 0.2 and 0.3 Mev. Because of the slit separation in the Faraday cup present resolution does not allow measuring any smaller values for ΔE than those mentioned, however, it is a simple matter to increase the resolving power by decreasing the slit width and increasing the number of slits in the Faraday cup. Recently a higher frequency response (up to $\cong$ 10 mc/s) beam transformer has been installed at the high energy end of the Linac and a high frequency hash of about 5°/o in amplitude is normally observed on the beam current pulse; this can be traced back to the ion source. The emittance of the Linac is measured regularly as follows:



The lens between viewing box 2 and 3 is set so that its focal length equals the distance from the lens to viewing box 3. The observations on screen 3 give the maximum beam divergence. Using now a slit in viewing box 2 and observing again beam spot size on screen 3 will give the divergence of the central rays. The following results were obtained:

in the horizontal plane 0.3×10^{-3} inch radian

in the vertical plane 0.2×10^{-3} inch radian

During the initial operation of the Linac, these figures were higher by about a factor of 2. From calculations involving phase acceptance and drift tube bore diameters the maximum emittances to be expected are approximately 3×10^{-3} inch radian. Actual values are therefore smaller by a factor of 10 than those expected.

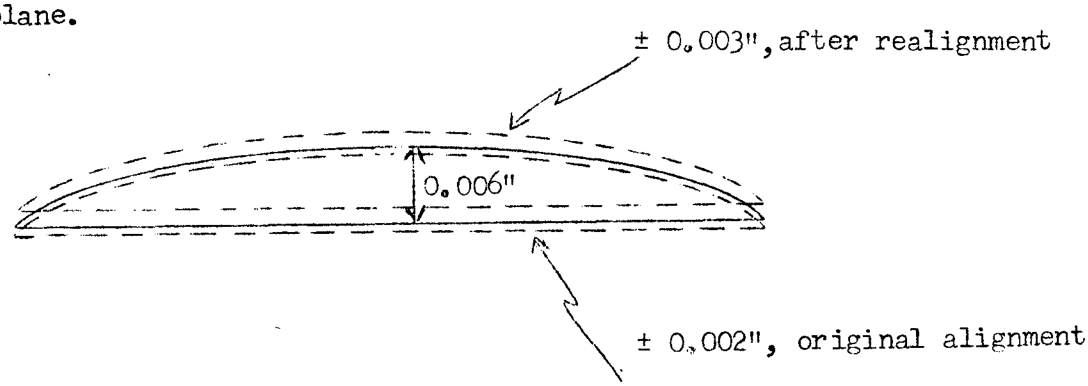
The geometry between Cockcroft-Walton injector and Linac does not allow any accurate measurement of the preinjector emittance. However, crude measurements indicate an approximate value of 0.5×10^{-3} inch radian.

Regarding the dependence of the Linac output parameters (current, beam size, phase space area orientation etc.) on injection energy it was found that a variation of about 10 kv in Cockcroft-Walton voltage (765 kv normal) did not cause any observable changes in Linac output. The same holds for changes of several percent in Linac focussing quadrupole fields.

Interruptions in operations have occurred. The longest shut-downs involved opening the Linac tank. Each time the tank is brought to atmospheric pressure it is done by using dry nitrogen. If the tanks are at normal pressure for not longer than a few hours normal operation will be obtained within 24 hours, if rf power is applied for conditioning. If extensive repairs necessitate that a person works inside the Linac tank then usually a period of 4 to 5 days is required for reconditioning.

One recurrent reason of Linac shutdown has been drift tube vacuum leaks located at either the tin-indium solder joints between drift tube cover and drift tube body or between the stainless steel bore tube and drift tube body. After repairs the joint on the cover plate has been copper plated and up till now no leakage has recurred in these copper plated joints.

During a recent shut down it was found that the drift tubes had shifted from their original aligned positions. This necessitated a check on all drift tube positions and as a result about 20 were realigned, so that presently all drift tubes line up to within ± 0.003" of a smooth curve as indicated below for the horizontal plane.



Misalignments in the vertical plane were of the same order of magnitude as those in the horizontal plane, except that the maximum displacements were located near both ends of the Linac. These might have been caused by changes in Linac supports due to the addition of a shielding wall at the high energy end and building excavations in the vicinity of the low energy end.