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# DEUTERON ACCELERATION IN THE AGS

The process of acceleration deuterons and heavier particles in the AGS was studied as early as 1962 by E.D. Courant.[1] The engineering details of the acceleration process has been altered by the hardware changes of the AGS Conversion program, but the basic principle is unchanged.

The rf program for deuteron acceleration has to accommodate a particle velocity range from 0.283 c to c. If a constant harmonic number was used throughout the accelerating process, the rf frequency would be required to sweep a frequency ratio of 3.53 to 1. This is beyond the capability of the new rf system presently being installed. This system was designed to cover the frequency region of 2.5 to 4.45 MHz. However, tests have shown that with reduced voltage the system can be operated over a wider frequency range (2.3 to 4.8 MHz). This extended frequency region will not accommodate operation with fixed harmonic numbers, it will accommodate the necessary particle velocity change with a single change in harmonic number. Acceleration can start on the 24th harmonic (f = 2.52 MHz) proceed until the frequency reaches 4.8 MHz at which time the harmonic number is reduced to 12 and the frequency to 2.4 MHz. The deuterons can then be accelerated to final energy. The frequency will approach 4.45 MHz.

1. E.D. Courant, "Acceleration of Deuterons or Alpha Particles in the AGS," BNL Accel. Dept. Int. Rep. EDC-49 (1962).

The rate of change of frequency during the early part of the acceleration process, (h = 24) can exceed the capabilities of the rf tuning system. But, if the rate of acceleration is slowed during this part of the cycle, this limitation can be overcome. This is compatible with the reduced rf required to extend the frequency region.

The change in harmonic number can be accomplished during a pause in the acceleration process. Magnet current during this time is held constant by the flat top system normally used for beam extraction. The beam is debunched by adiabatically reducing the rf amplitude. A one millisecond time constant for the reduction of this voltage appears ample, since the phase oscillation frequency at this time is 5.63 kHz ($1/\omega_s$ = 0.2 msec). With the rf off the tuning current in the rf accelerating cavities must be reduced to that required for the new frequency. With present equipment this will take approximately 100 milliseconds.

The beam can now be rebunched on the 12th harmonic. During the next 15 milliseconds the acceleration process is still limited by a frequency change rate. 30 GeV will be attained in 660 milliseconds and 33 GeV in 710 milliseconds.

During acceleration on the 24th harmonic a rf gap voltage of 5 kV per gap appears feasible with ten stations as planned and 4 gaps per station a 200 kV rf crest is available. After the change to the 12th harmonic, this voltage can be doubled.

The following figures; magnet voltage, kinetic energy, energy gain per turns and stable phase angle, accelerating frequency, and phase oscillation frequency all vs time, further describe this process.

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