2.7 Alternate Structures

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Two alternate structures were presented to the workshop and subsequently not followed up as they were clearly inferior to the scenario developed using high-field superconducting solenoids and multigap accelerating structures. The two rejected scenarios are outlined here and further presented in Appendix A.

Structure 1: Conventional Alvarez Linac

This structure was developed as the tools for constructing a conventional Alvarez linac are well known and documented.

A 100 MHz frequency was selected for a Ne^{+1} structure (q/A = 1/20) with an electrical beam current of 200 mA to be accelerated. Focusing is provided through magnetic quadrupoles located in the drift tubes.

The linac generation parameters were:

Frequency	100	MHz
E_0	2.0	MV/m
aperture radius	2	cm
Quad length	0.5	drift tube length

In order to keep the quadrupole strengths down, a FFFDDD focusing sequence was assumed, and a 2 MeV injection energy (100 keV/n) was chosen, but even then, the quadrupole strengths at the beginning of the linac are 20 kG/cm, about a factor of 2 higher than obtainable with the best permanent-magnet quadrupoles.

The calculated length is 13 meters, containing 143 cells to accelerate the Ne^{+1} to 20 MeV total energy, for an average energy gain of 1.4 MeV/meter. The fraction of 200 mA input beam current surviving to the exit is 83%.

This rather conventional design is seen as inefficient, producing less than 200 mA at the end of a large (100 MHz), 13 meter long structure, requiring a high injection energy and very high gradient quadrupoles.

Structure 2: Single-bunch pulsed drift tube linac

This is essentially a very low-frequency structure where a single bunch is accelerated through a series of drift tubes, each pulsed by a trapezoidal-shaped voltage waveform, timed to provide a field in the gap between adjacent drift tubes as the single bunch traverses the gap.

As this was entirely a study of longitudinal beam dynamics, no transverse beam dynamics, space charge or focusing systems were considered.

A high-voltage injector, 1 MV in this case, injects a Ne^{+1} pulse 100 nsec long into the first drift tube. As the bunch travels through the drift tube, its potential is raised by 500 kV, so the voltage across the following gap is 500 kV, which accelerates the bunch. After the bunch enters the second drift tube, its potential is raised by 500 kV and the acceleration process continues in the same way, through all the gaps in the structure until the final energy of 20 MeV is reached. Five centimeter gaps are assumed between each drift tube, for a gap gradient of 10 MV/m.

As the bunch is accelerated, longer drift tubes are required to contain the entire bunch. In addition, a 100 nsec risetime of the potential is assumed (5MV/microsecond pulser slew rate), which is added to the time the bunch must be contained in each drift tube. This risetime is a major contributor to the overall length of the accelerator.

It is possible to compress the bunch in the accelerator by applying a few percent tilt to the voltage pulse of each drift tube, which introduces a correlation between the bunch energy and position along the bunch. A reasonable scenario can achieve a compression of a factor of 5, producing a 20 nsec, 20 MeV beam at the end of the structure.

In Appendix A a spreadsheet design of such an accelerator is presented which comprises 30 drift tubes, each with its own 500 kV pulser that occupies a length of 57.7 meters. This length is dominated by the 100 nsec risetime of the pulsers, where the bunch must be contained within each drift tube, with the 5cm gaps and the total length of the bunch itself a lesser contributor.

Since this was only an exercise in longitudinal beam dynamics, the space charge limit of this scheme is unknown. The sheer length of the structure renders this approach undesirable, although it may be employed just after the gun, or prior to injecting into an IH-structure accelerator module.