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HVDC Dynamitron® for the Multi-Beam Single Pass RF Driver

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Each of the 16 front ends in the HIDIF design study used 50kV extraction and 150kV HVDC, on three separate ions sources, to launch a timed set of the isotopic pulses into three separate low energy beam transport lines, which converge into a 3-way, switching magnet, and emerge in series on a single beamline to the radiofrequency quadrupole. While the format of the Single Pass RF Driver is mainly four HIDIF linacs in parallel, the 16 sources in each front end are integrated into a compact array and mounted in the terminal of a ~1.5MeV Dynamitron®. Pierce-geometry extraction electrodes are integrated into the 1.5MV column, adding multiple isotopes to the high-brightness 1.5MeV front end demonstrated at the Argonne National Laboratory (ANL) 1976-80 (Watson, Nuc. Sci., 1979).

Where ANL put a magnetic triplet in the re-entrant geometry of the HVDC ground electrode, SPRFD puts the upstream end of the multi-channel RFQ. This close coupling avoids transporting low-energy, space-charge dominated beams, and simplifies the multi-isotope Front Ends for power producing fusion systems, which do not need the flexibility of research systems. RFQ's can circumvent the practical issues of MV preaccelerators, but high beam current is crucial for HIF drivers; the (βγ)5/3 scaling of the transport limit for space-charge-dominated beams provides an important factor for 1.5MeV vs. 200keV. HIF drivers need both MV preacceleration and the RFQ.

The nominally 1.5 MV Dynamitron® is programmed to output all isotopes at the same velocity, as needed by the RFQ. High vacuum is maintained by exploiting the pulsed nature of the beams to minimize gas load, and by providing large holes in the high voltage electrodes to maximize conductance to the pumps at electrical ground. For each ignition sequence, ten of the sources produce ~20 µsec of beam and the other 6 produce ~10µsec each. Including the ~100µsec gap between these groups of isotopes, with the driver producing 10 pps, the entire source array has a duty factor ~0.004, with only one source emitting beam at any one time. Means to provide gas puffs include fast valves, laser heating (with or without laser ionization), and field emission sources that use hollow needles containing liquid such as Hg. Capitalizing on the low duty factor of the sources also is an effective means to minimize the power that must be supplied to the 1.5 MV terminal to operate the sources.

The timed sequence of the individual isotopes means that the beam current accelerated by the Dynamitron® is that of a single isotope, i.e., ≥100mA. Allowing ~150kW for the power during each pulse of the SPRFD, the ~0.004 duty factor results in an average power of ≤1kW—far below the Dynamitron®'s capability.

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