RF Capture in the RCS

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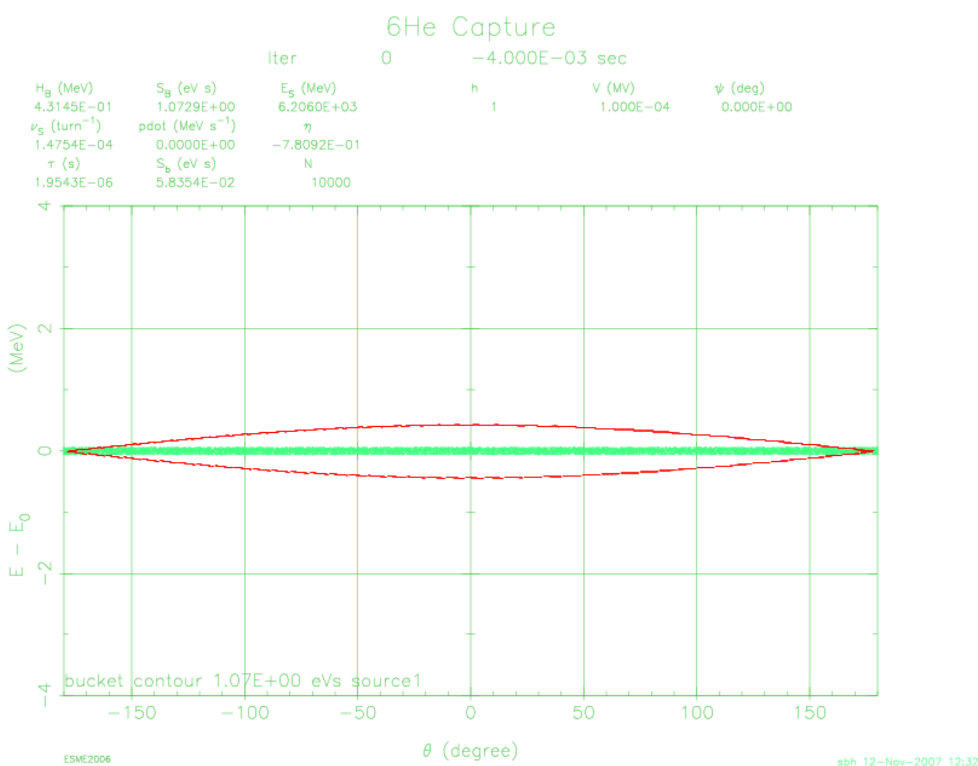
Overview

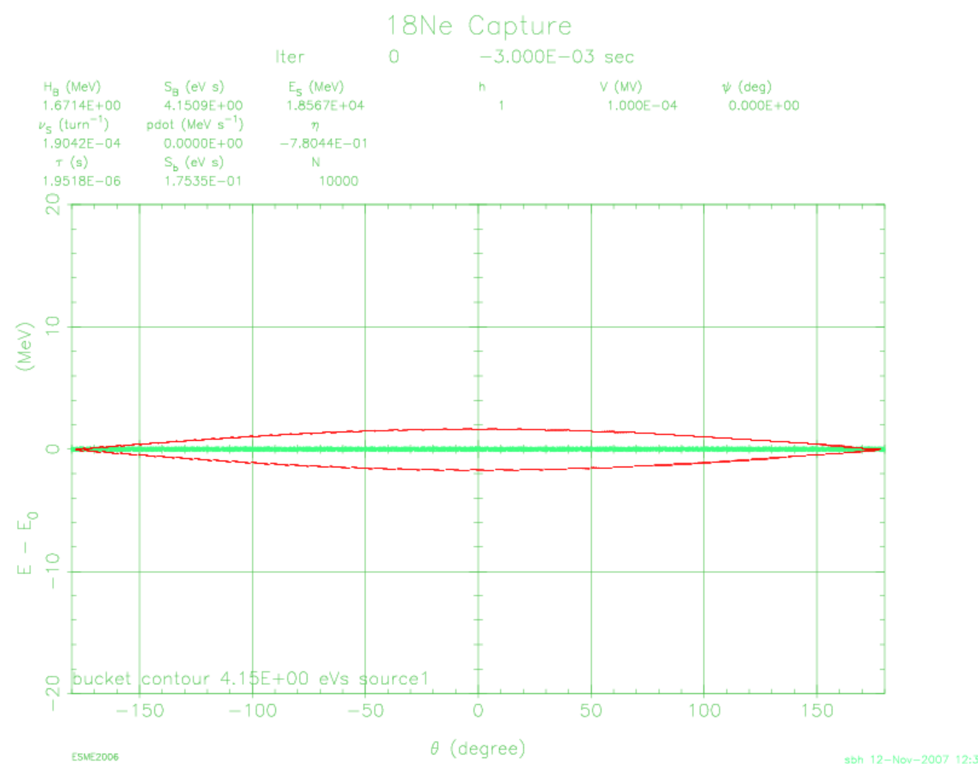
The constraints of high energy and fast cycling have pushed the size of the RCS to 40% of that of the PS machine. However, it is required to transfer a single bunch (h_{RCS}=1) into a relatively high harmonic bucket (h_{PS}=21). Consequently, the debunched beam at RCS injection must have a tiny energy spread in order to avoid the ejected bunch – which is squeezed into less than 10% of the RCS circumference – exceeding its emittance budget.

The linac is capable of delivering the 1E-4 relative momentum spread that is required, but a comparable bucket height would be generated by only a few volts of rf in the downstream RCS. Clean, iso-adiabatic rebunching is therefore excluded and a compromise must be made between particle loss and the final emittance of the distribution captured at a more meaningful minimum rf voltage.

Debunched Beam

I take the minimum rf voltage to be 100V (cf., ~100kV max).

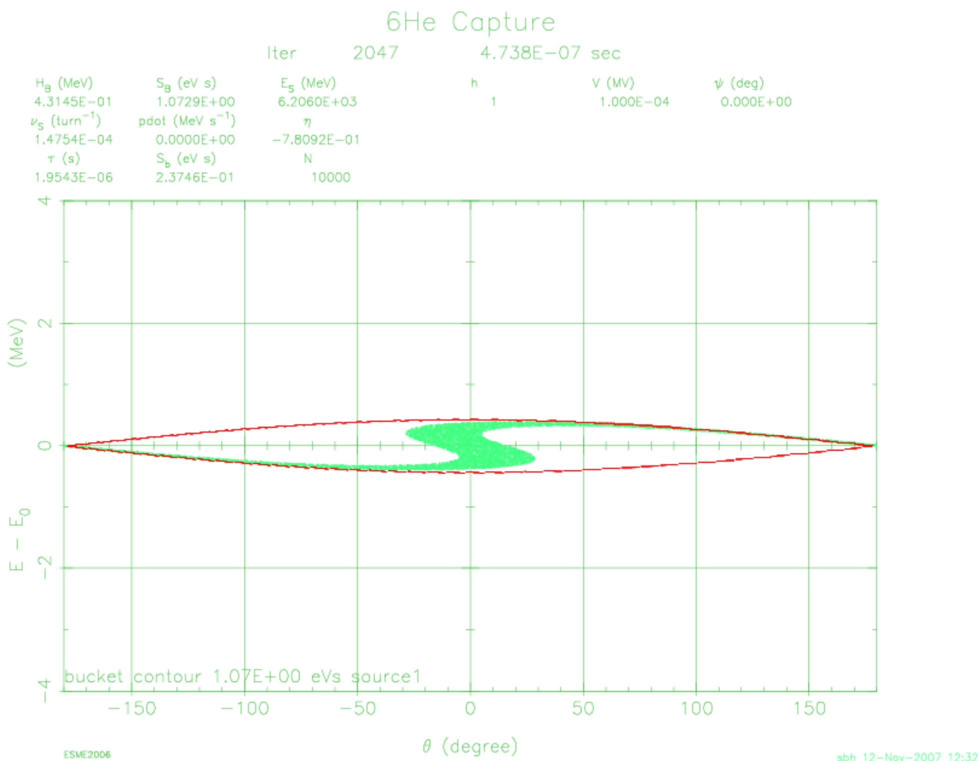


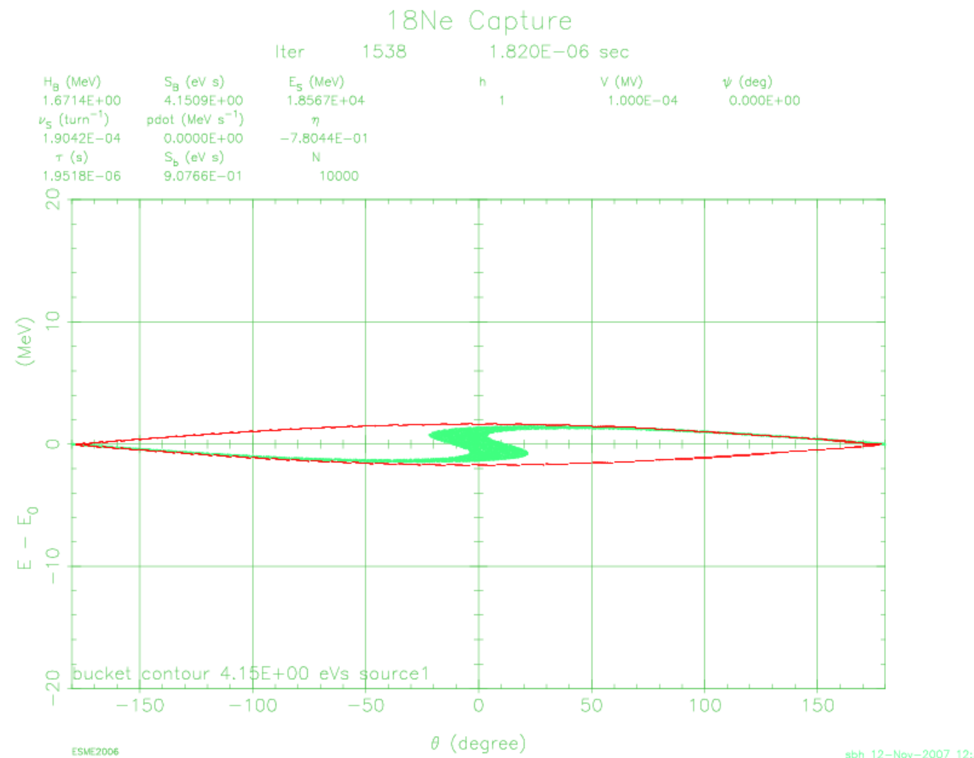


The acceptance/emittance ratio is 4.8 for ^{6}He and 6.2 for ^{18}Ne.

Filamentation at dB/dt=0

The RCS injection plateau provides up to 5ms.

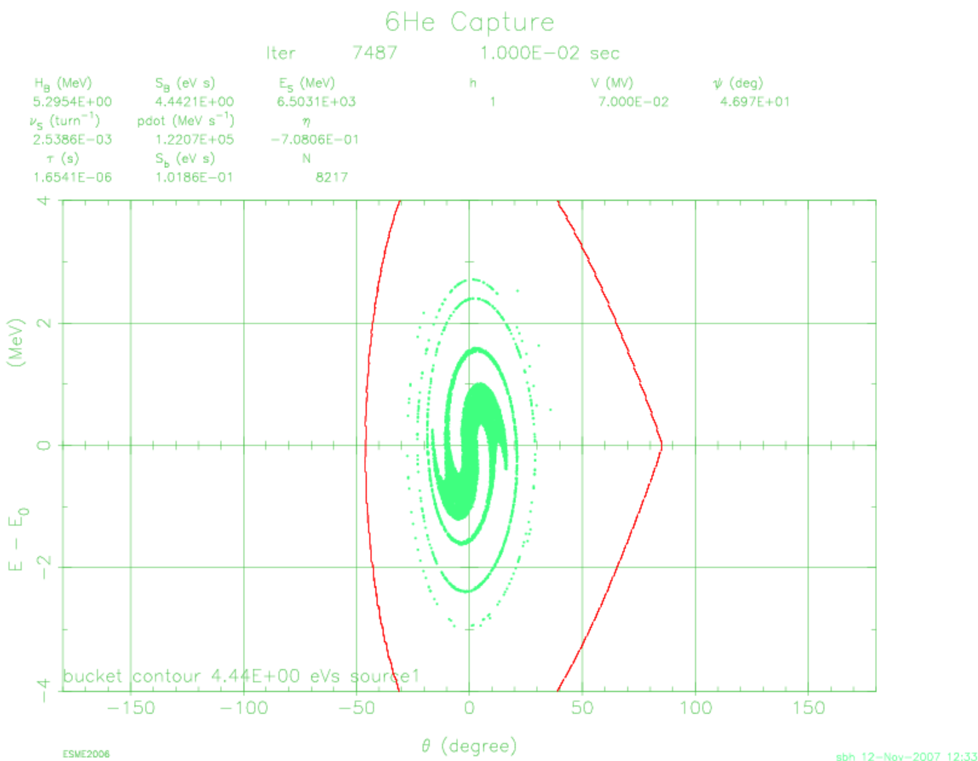


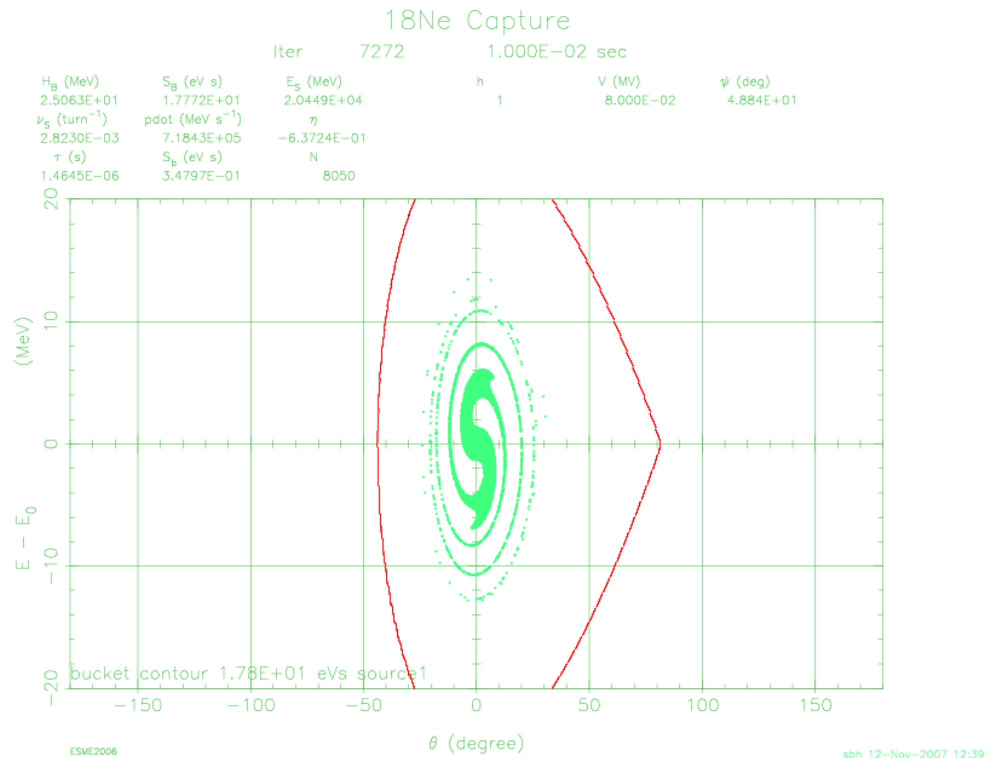


I take 4ms for ^{6}He and 3ms for ^{18}Ne.

10ms up the Ramp

A linear voltage increase provides quasi-constant acceptance early in the cycle.

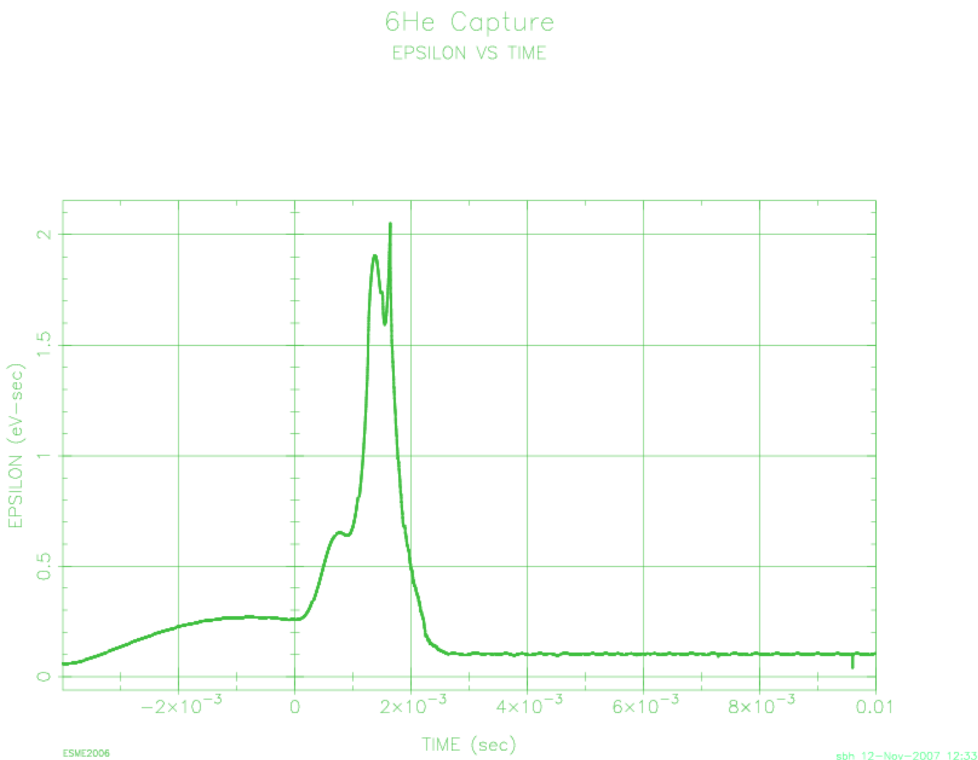


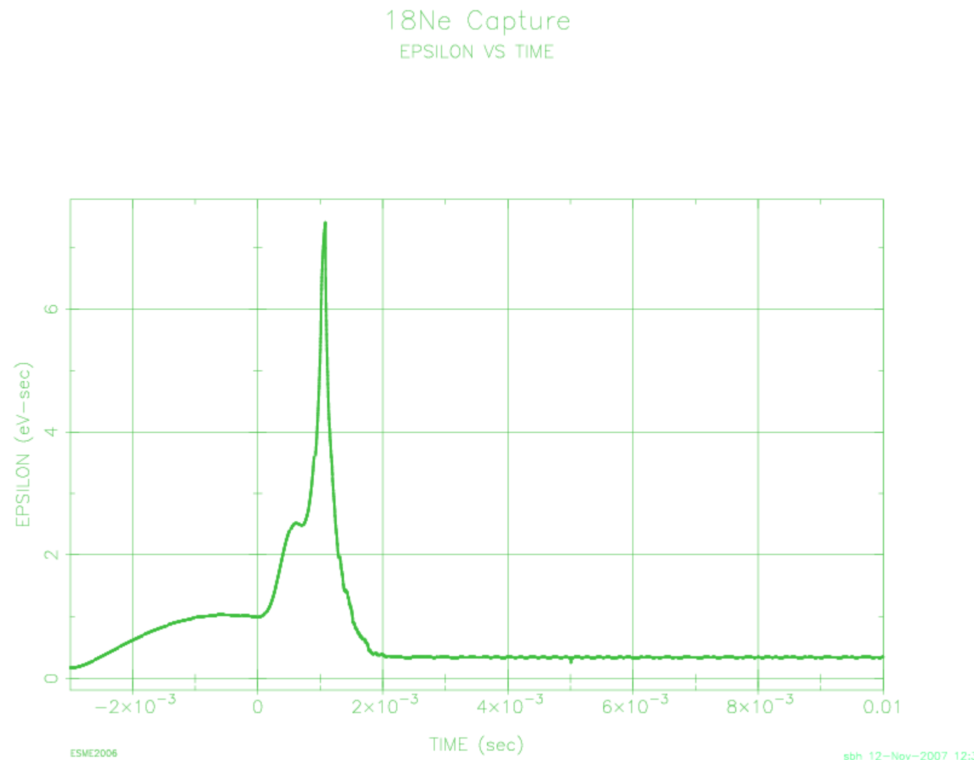


Survival rates are >80% for both ion species.

RMS Emittance Blow-up

The calculation is unreliable until all uncaptured particles are lost (cf., ACCSIM).





Blow-up factors are 1.7 (cf., 2.9 margin) for ^{6}He and 2.0 for ^{18}Ne (cf., 2.1).

Concluding Remarks

"Rough-and-ready" ESME simulations have been made to confirm that the tiny momentum spread from the linac can be digested within the emittance budget of the RCS. The capture efficiency is already better than 80% for both ion species, but the degree of filamentation is hideous.

Nothing more sophisticated was investigated than the standard magnetic cycle (as per the parameter list: 5ms injection plateau, 47.5ms ramp up, 47.5ms ramp down) and a linear rf voltage increase at the start (10ms) of acceleration. Space charge was ignored.

ACCSIM is the code of choice for more in-depth optimizations.