Decay Ring Stacking Simulations

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$^6He^{2+}$ Case

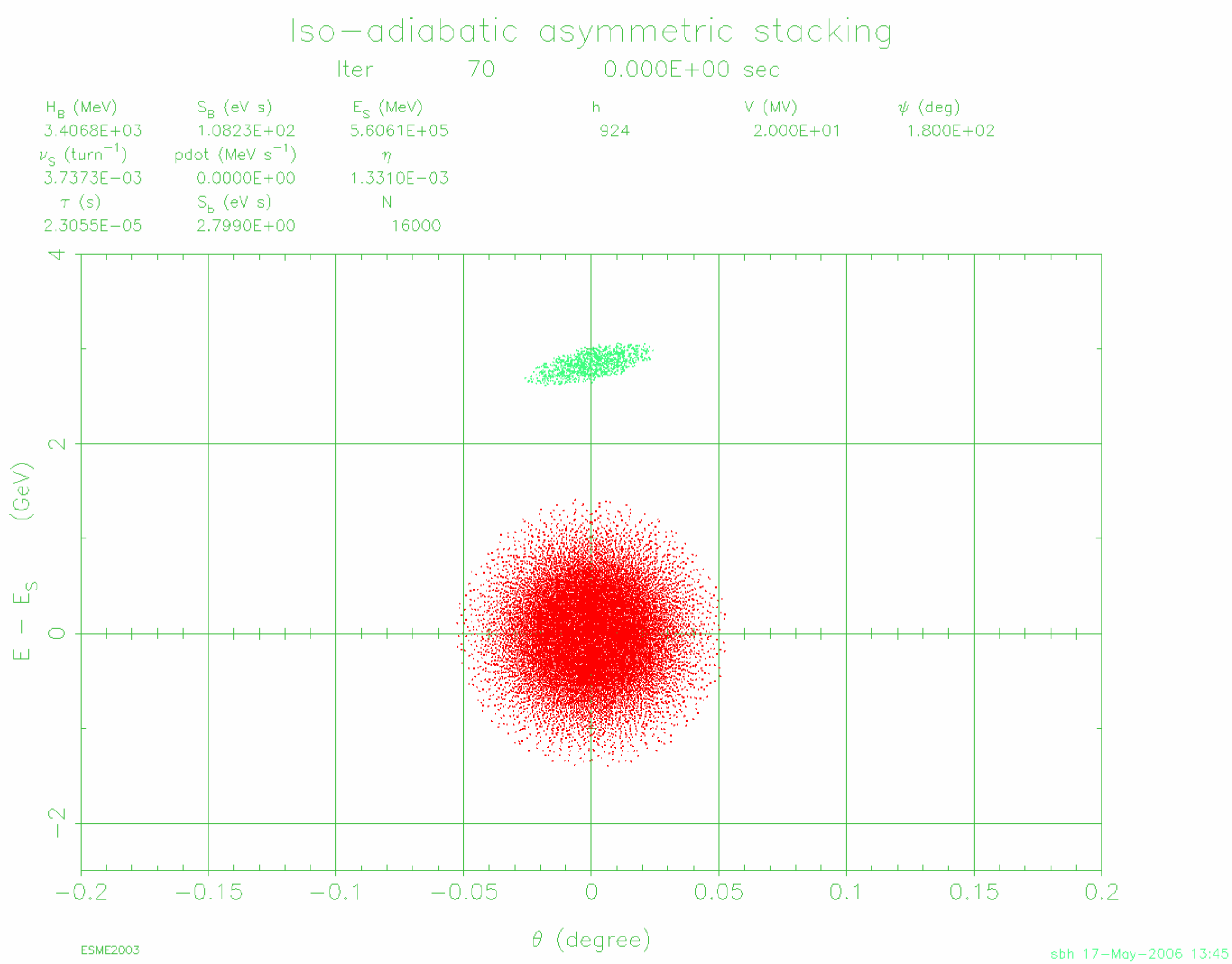
The complete stacking process (including the data-taking phase) loops over the following steps.

- Injection + Rotation: $V_{40MHz} = 20MV$ $V_{80MHz} = 0MV$
- Fast Transition: $V_{40MHz} = 13.5MV$ $V_{80MHz} = 12.5MV$
- Asymmetric Merging: $V_{40MHz} = 13.5MV$ $V_{80MHz} = 12.5 \rightarrow 8.0MV$
- Symmetric Merging: $V_{40MHz} = 13.5MV$ $V_{80MHz} = 8.0 \rightarrow 6.8MV$
- Bunch Compression: $V_{40MHz} = 13.5 \rightarrow 20MV$ $V_{80MHz} = 6.8 \rightarrow 20MV$
- Bunch Decompression: $V_{40MHz} = 20MV$ $V_{80MHz} = 20 \rightarrow 0MV$

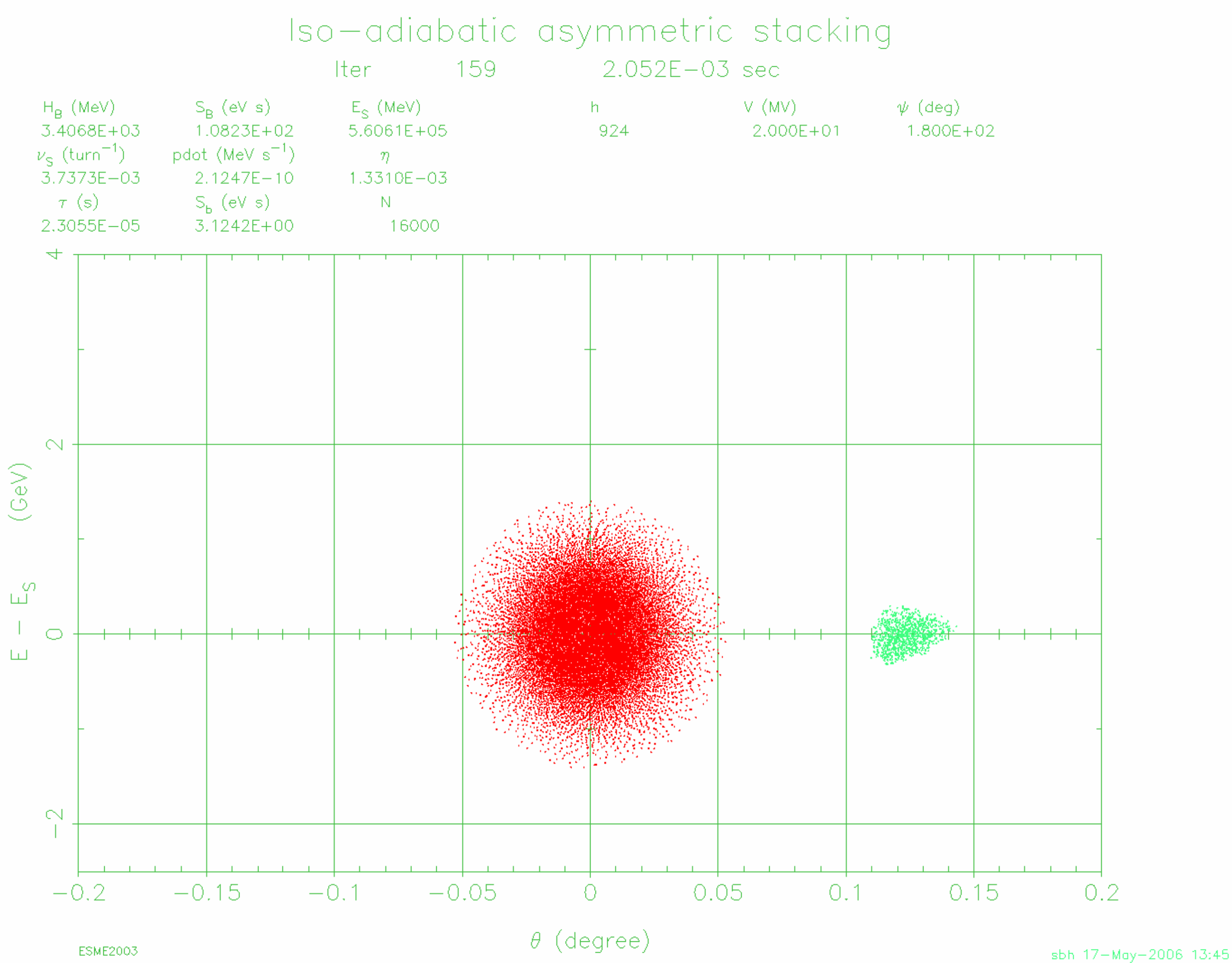
The two rf voltage components are carefully controlled functions during the slow ("→") transitions, as is the relative phase between them during asymmetric merging and bunch compression.

15 × 1eVs injections fill the stack acceptance defined by the collimator.

Injection

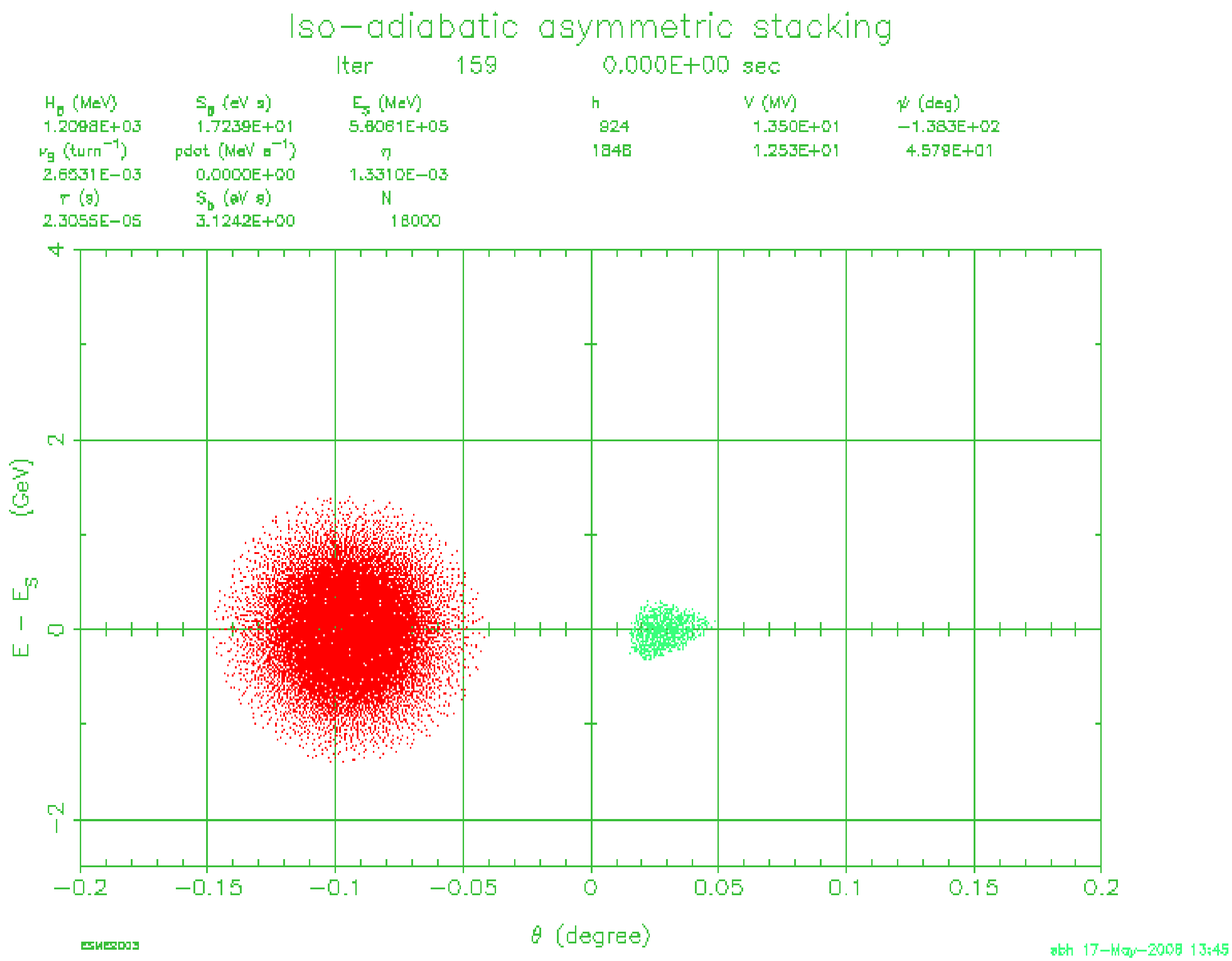

Iso-adiabatic asymmetric stacking
Iter 70 0.000E+00 sec
H_B (MeV) 3.4068E+03
S_B (eV s) 1.0823E+02
E_S (MeV) 5.6061E+05
h 924
V (MV) 2.000E+01
ψ (deg) 1.800E+02
ν_S (turn^-1) 3.7373E-03
pdot (MeV s^-1) 0.0000E+00
η 1.3310E-03
τ (s) 2.3055E-05
S_b (eV s) 2.7990E+00
N 16000
E - E_S (GeV)
θ (degree)
ESME2003
sbh 17-May-2006 13:45

Rotation



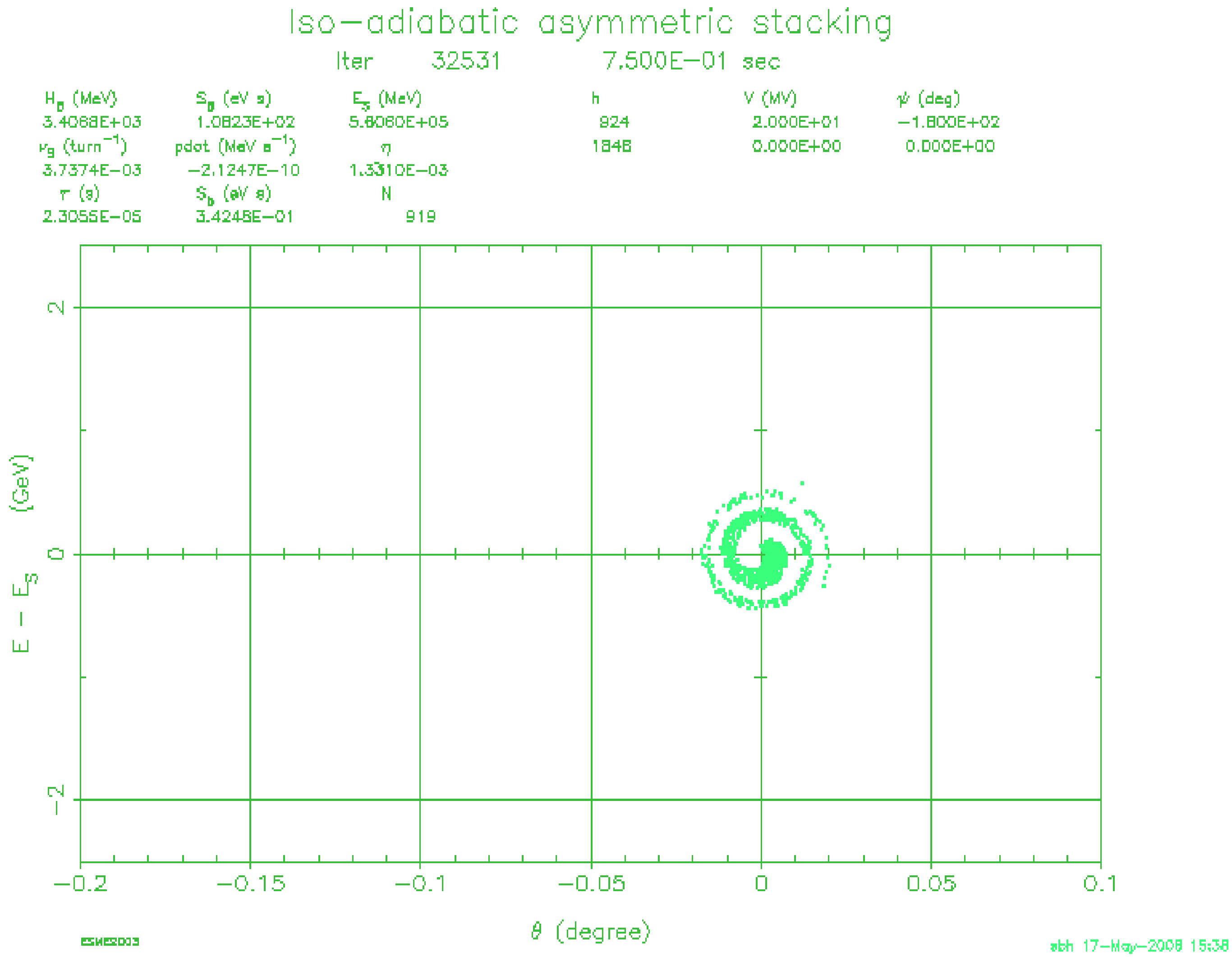
Iso-adiabatic asymmetric stacking
Iter 159 2.052E-03 sec
H_B (MeV) 3.4068E+03
S_B (eV s) 1.0823E+02
E_S (MeV) 5.6061E+05
h 924
V (MV) 2.000E+01
ψ (deg) 1.800E+02
ν_S (turn^{-1}) 3.7373E-03
pdot (MeV s^{-1}) 2.1247E-10
η 1.3310E-03
τ (s) 2.3055E-05
S_b (eV s) 3.1242E+00
N 16000
$E - E_S$ (GeV)
4
2
0
-2
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
θ (degree)
ESME2003
sbh 17-May-2006 13:45

Merging



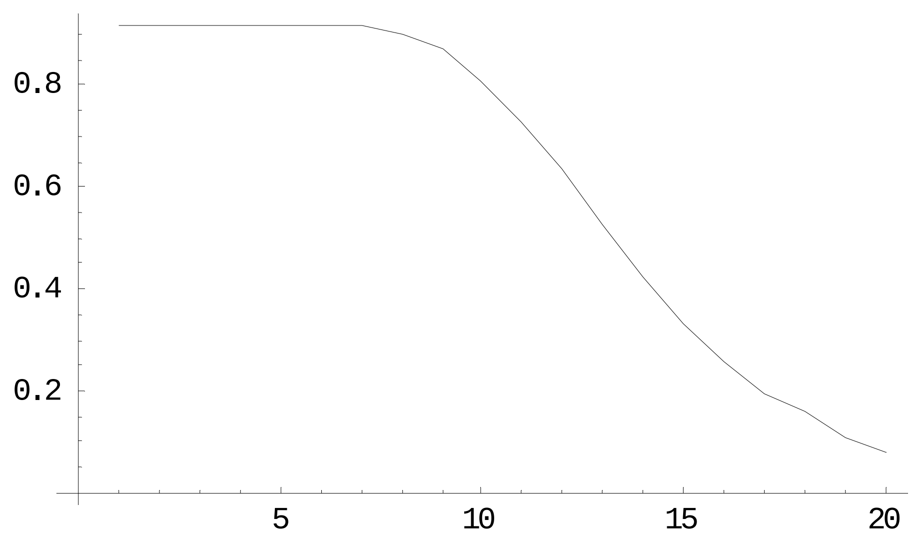
Iso–adiabatic asymmetric stacking
Iter 159 0.000E+00 sec
H_B (MeV) 1.2098E+03
S_B (eV s) 1.7239E+01
E_s (MeV) 5.6061E+05
h 924 1848
V (MV) 1.350E+01 1.253E+01
ψ (deg) −1.383E+02 4.579E+01
ν_s (turn⁻¹) 2.6531E−03
pdot (MeV s⁻¹) 0.0000E+00
η 1.3310E−03
τ (s) 2.3055E−05
S_b (eV s) 3.1242E+00
N 18000
E − E_s (GeV)
θ (degree)
4
2
0
−2
−0.2
−0.15
−0.1
−0.05
0
0.05
0.1
0.15
0.2

Repeated Merging



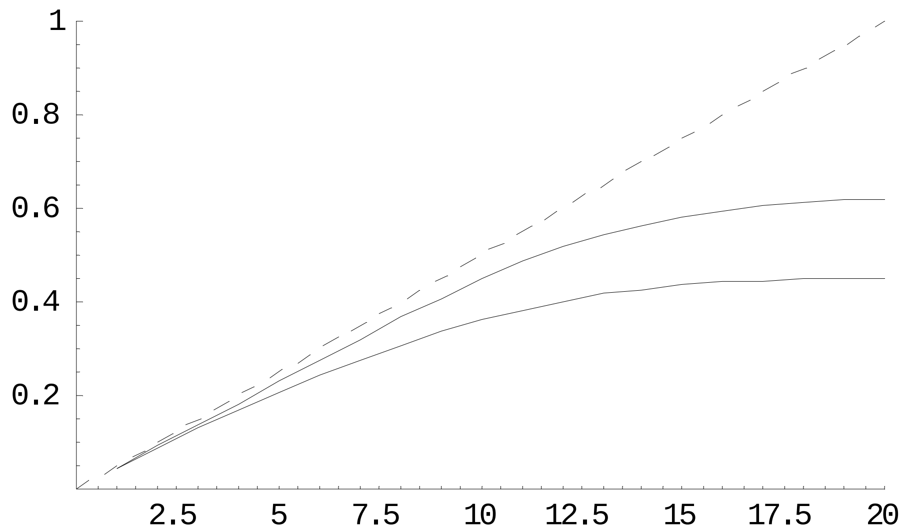
Survival Profile

The relative increment due to each of the mergings reveals that some of the captured particles are collimated well before the 15th injection which fills the stack emittance and that some of the original particles even remain after it. The latter effect is due to the symmetric part of the merging, which mixes particles at the core of the stack.



A Posteriori β-decay

Particles can be removed according to how long they have been in the decay ring. Thus, the decays at the 15th step can be (under-)estimated from the number of ions that are uncollimated after 14 repetition times of the injector chain. This keeps the decays specific to each ESME partition, but neglects particles that might have decayed before being collimated. This is pessimistic from the point of view of counting potential physics events, but the total losses (collimation plus β-decay) should be correct.



The Bottom Line ($^6He^{2+}$)

The effective number of shots accumulated is 9.

Cf., $(k^{mergesratio} - 1) / (k-1) = 10.7$
for the ideal stacking of Version 2, where $k = 2^{-spsrepetitiontime/(topgamma\ thalf)}$.

Given the less idealized value of the ultimate stack size, then 9 (1-k) = 45% of an injected bunch will decay in the time between two consecutive shots.

The rest must be collimated.

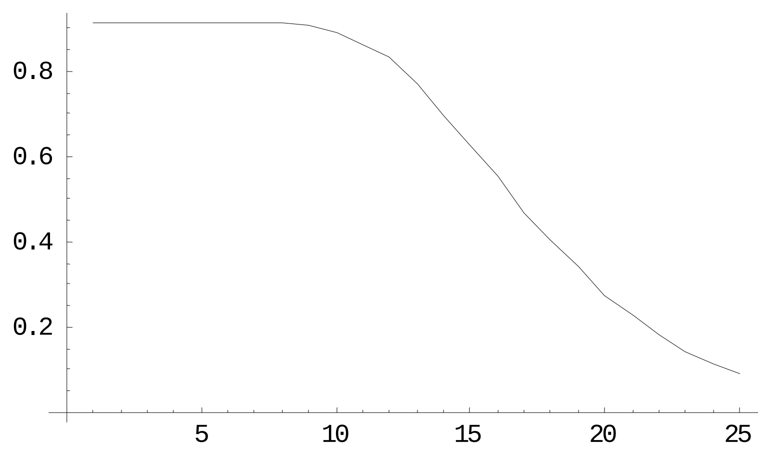
$^{18}Ne^{10+}$ Case

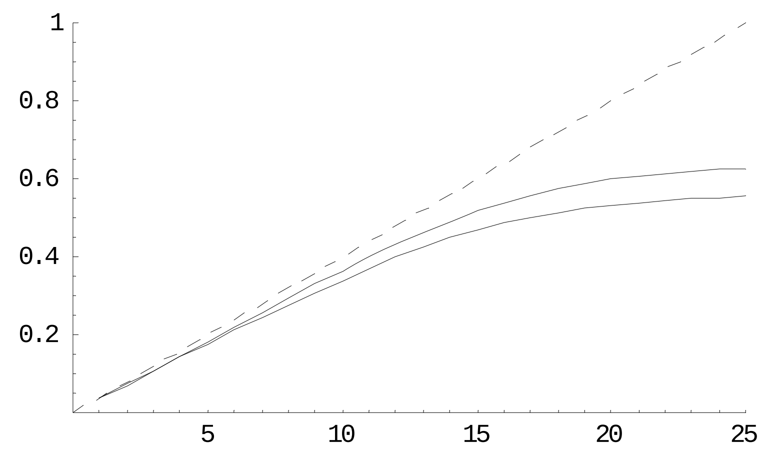
The relative momentum spread of the stack at injection and the relative momentum deviation of the incoming bunch are both established by the helium case. Consequently, 20 × 2.2eVs injections fill the stack acceptance defined by the collimator.

- Injection + Rotation: V_{40MHz} = 12MV V_{80MHz} = 0MV
- Fast Transition: V_{40MHz} = 7.9MV V_{80MHz} = 7.4MV
- Asymmetric Merging: V_{40MHz} = 7.9MV V_{80MHz} = 7.4→4.5MV
- Symmetric Merging: V_{40MHz} = 7.9MV V_{80MHz} = 4.5→4.0MV
- Bunch Compression: V_{40MHz} = 7.9→12MV V_{80MHz} = 4.0→12.6MV
- Bunch Decompression: V_{40MHz} = 12MV V_{80MHz} = 12.6→0MV

Collimation and β-decay losses

Again, some of the captured particles are collimated well before the 20th injection which fills the stack emittance and some of the original particles remain after it. The number of decays introduced after the simulation is an under-estimate, but there are obviously fewer than in the helium case.





The Bottom Line ($^{18}Ne^{10+}$)

The effective number of shots accumulated is 14.

Cf., $(k^{mergesratio} - 1) / (k-1) = 17.4$

for the ideal stacking of Version 2, where $k = 2^{-spsrepetitiontime/(topgamma\ thalf)}$. Aside: increasing the repetition time from 3.6 to 6 seconds to make it the same as for helium would cost less than 10% in annual rate (17.4→15.9 effective shots).

Given the less idealized value of the ultimate stack size, then 14 (1-k) = 21% of an injected bunch will decay in the time between two consecutive shots.

The rest must be collimated.