G4Beamline lattice for baseline

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TODO:

- Achieve proper phase rotation.
- Find a way to do it in a (semi-)automatic fashion for future simulations. G4Beamline built-in “tune” command can only tweak RF gradient.
- Compare outcome to ICOOL.
- Use happily ever after (hopefully).

Comparing the ICOOL and G4beamline logfiles revealed discrepancies causing problems in the rotator.

RF diagnostics in the phase rotator (excerpt)

REG	Z	FREQ	GRAD	TREFMN	T2REFMN
225	112.98	231.67	12.000	0.41363E-06	0.45701E-06
229	113.73	230.19	12.000	0.41637E-06	0.46003E-06
233	114.48	228.78	12.000	0.41912E-06	0.46305E-06
237	115.23	227.42	12.000	0.42187E-06	0.46606E-06
241	115.98	226.13	12.000	0.42461E-06	0.46906E-06
245	116.73	224.90	12.000	0.42736E-06	0.47205E-06
249	117.48	223.72	12.000	0.43010E-06	0.47503E-06

Mom. change, 233.5 MeV/c:

REG	Z	Pz
227	113.35	233.500
231	114.10	233.500
235	114.85	233.500
239	115.60	233.500
243	116.35	233.500
247	117.10	233.500
251	117.85	233.500

Mom. change, 154 MeV/c:

REG	Z	Pz
227	113.35	155.495
231	114.10	156.986
235	114.85	158.472
239	115.60	159.955
243	116.35	161.433
247	117.10	162.907
251	117.85	164.377

Rotator RF frequency calculation issue

- Using the time of flight formula $t_{ref\{1,2\}} = \frac{z}{v_{ref\{1,2\}}}$, $v_{ref\{1,2\}} = \frac{p_{ref\{1,2\}}}{\sqrt{p^2_{ref\{1,2\}} + m^2}}$ worked ok in the buncher, since the momenta of both reference particles were constant.
- In the phase rotator the first reference particle momentum stays constant, while the second one increases from 154 MeV/c to 233.5 MeV/c, so the formula has to take that change into account.
- In ICOOL this is done naturally, since the lattice is laid out cell by cell, the reference particles are tracked along, and the RF frequency is calculated based on the current values of p_{ref} and t_{ref} (RF model 10).
- To my knowledge there is no similar mechanism in G4beamline, in other words, I cannot track my reference particle for one cell to obtain the new value of p_{ref} for the next cell.

Possible solutions

- Derive and use an analytical expression taking into account the fact that p_{ref} is changing (estimate energy gain per RF).
- Import RF frequency data from ICOOL. I use it for the time being as a temporary solution.
    - Could we keep it as a permanent solution?
    - Apparently, not, since we want to use G4beamline for full-blown simulations and dynamics optimization—need a self-consistent approach.
    - Need to discuss the issue with Tom Roberts.

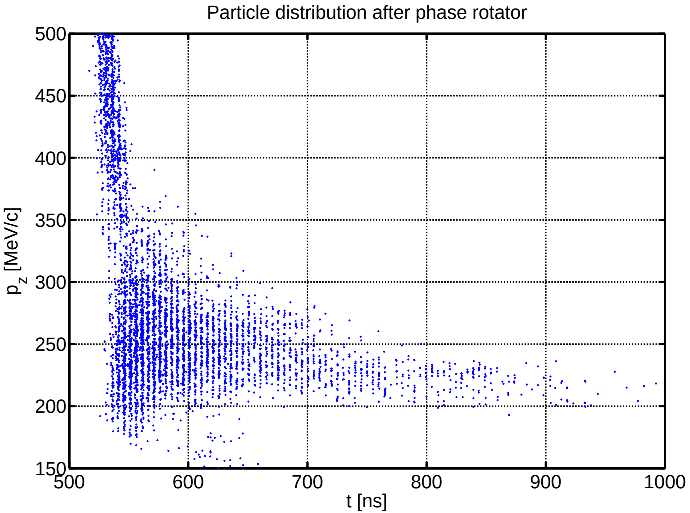
Simulation results

Numerical results

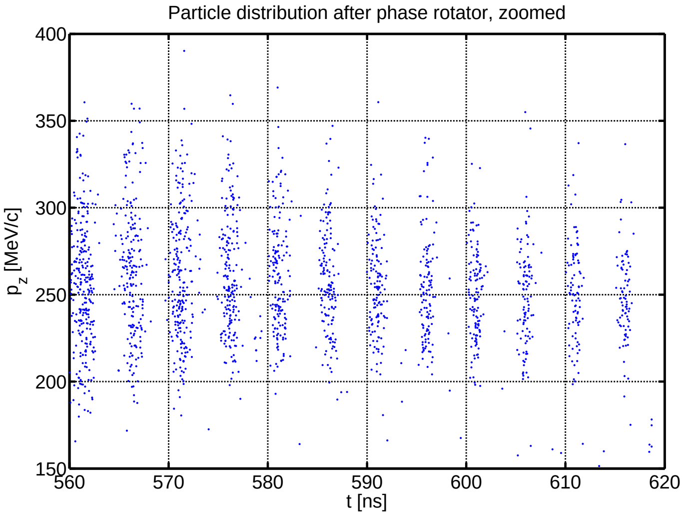
Region	Particle count
Initial distribution	9392 π (94%) 331 μ (3.3%)
after Rotator	236 π 7154 μ
after Cooler	0 π 3621 μ

- Initial distribution of 10000 particles is used for tracking.
- Only 50% of muons survive the cooling channel (starting from the end of rotator).
- Is that a common particle loss for the cooling channel?

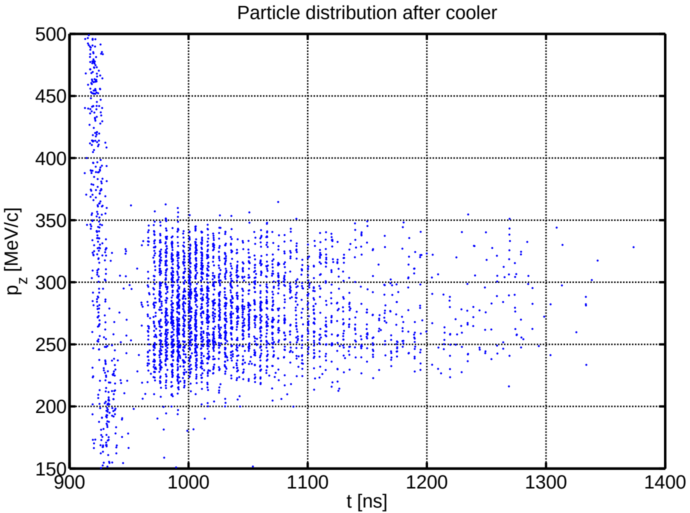
After rotator



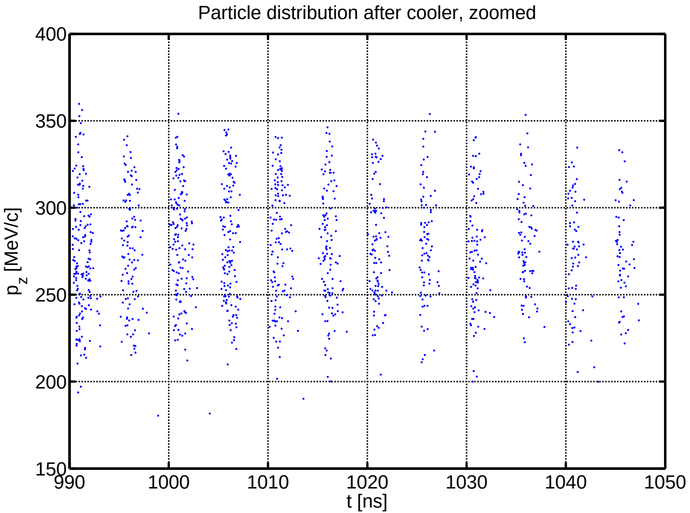
After rotator, zoom



After cooler



After cooler, zoom



Summary

- The G4beamline decks for both the baseline and the discrete lattice are working!
- The issue with phase rotation has been “fixed”.
- TODO: get feedback on implementing a more permanent solution for bunch rotation (“model 10 issue”).
- TODO: compare ICOOL + G4beamline in terms of μ/p yield and emittance behavior.
- TODO: run simulations with more particles.