G4Beamline lattice for baseline

Pavel Snopok
University of California Riverside

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Outline

TODO:

- Understand & resolve the issue with RF synchronization (quick question: is there a way to trace in ICOOL what RF phase has been set to?).
- Find a way to do it in a (semi-)automatic fashion for future simulations. G4Beamline built-in “tune” command can only tweak RF gradient.
- Achieve proper phase rotation.
- Compare outcome to ICOOL.
- Use happily ever after (hopefully).

Thanks Gersende

- Thanks for your detailed message on how to run RF diagnostics in ICOOL.
- Comparing the ICOOL and G4beamline logfiles revealed some 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
253	118.23	222.59	12.000	0.43285E-06	0.47800E-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
255	118.60	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
255	118.60	165.843

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? Depends on what we want from G4beamline:
  - If G4beamline is only used for cross-checking purposes this solution could be sufficient.
  - If we want to use G4beamline for full-blown simulations and dynamics optimization—need a self-consistent approach.

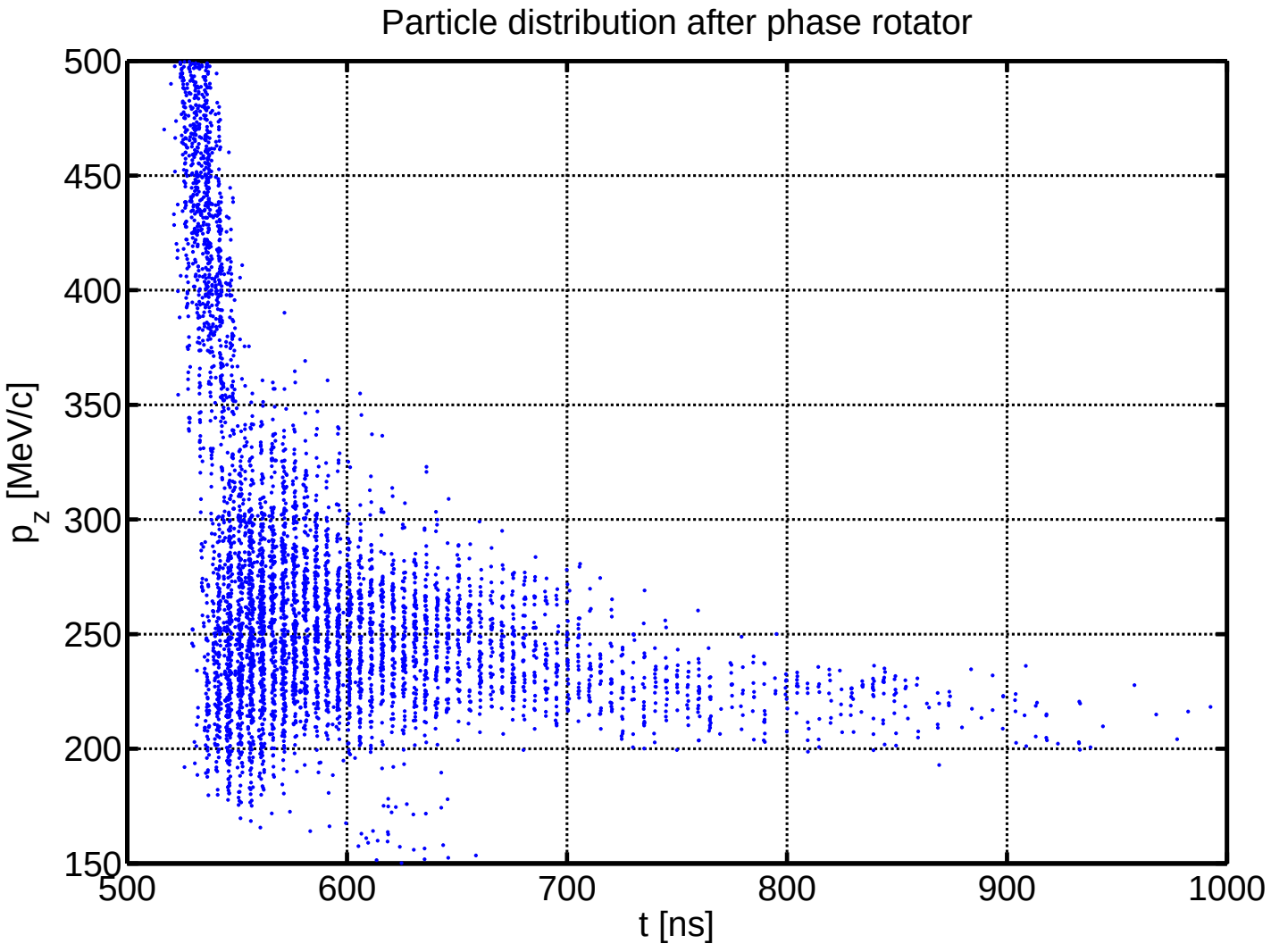
Simulation results

Numerical results

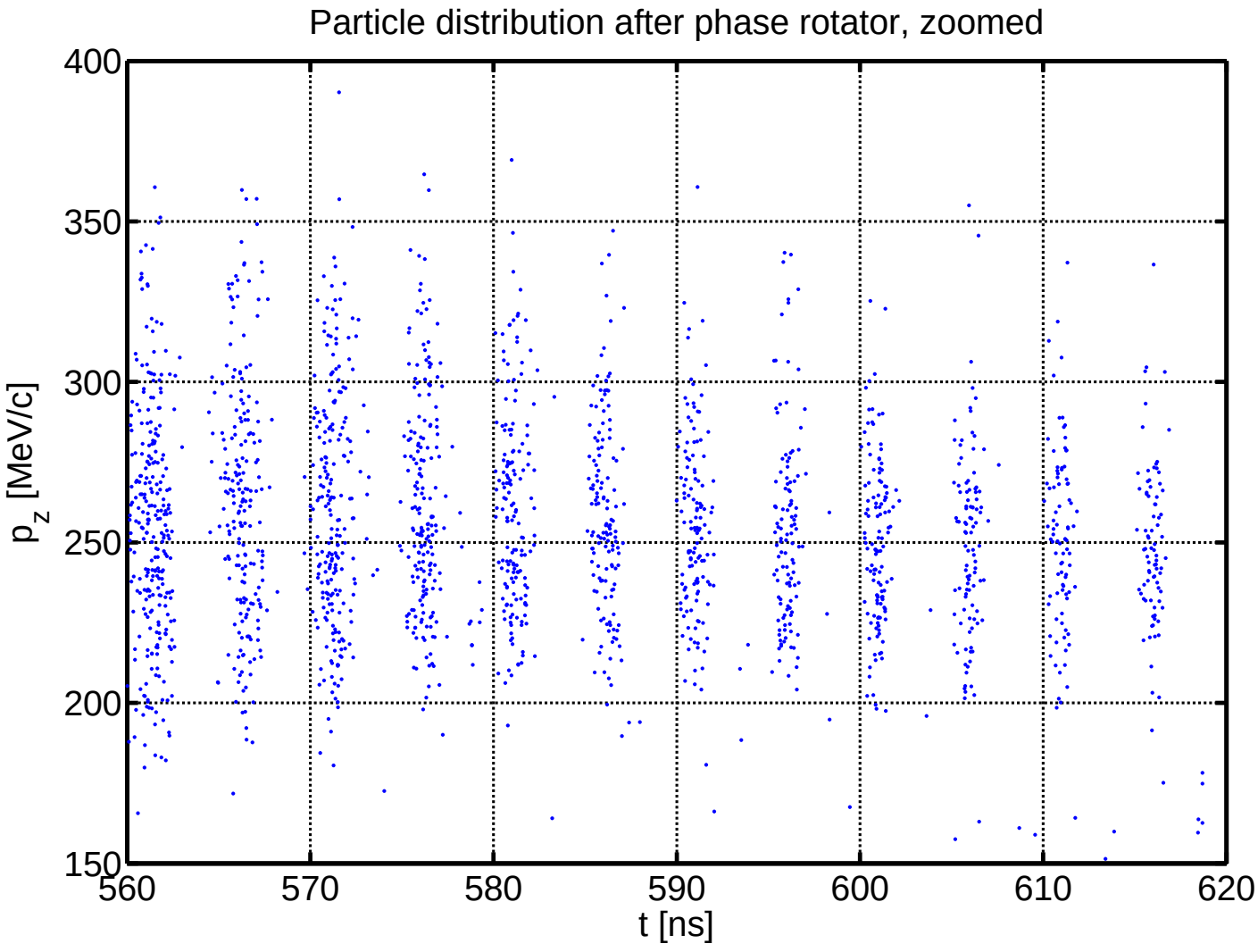
Region	Particle count
Initial distribution	9392 π (94%) 331 μ (3.3%)
after Rotator	236 π 7154 μ
after Cooler	0 π 3621 μ

- 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?

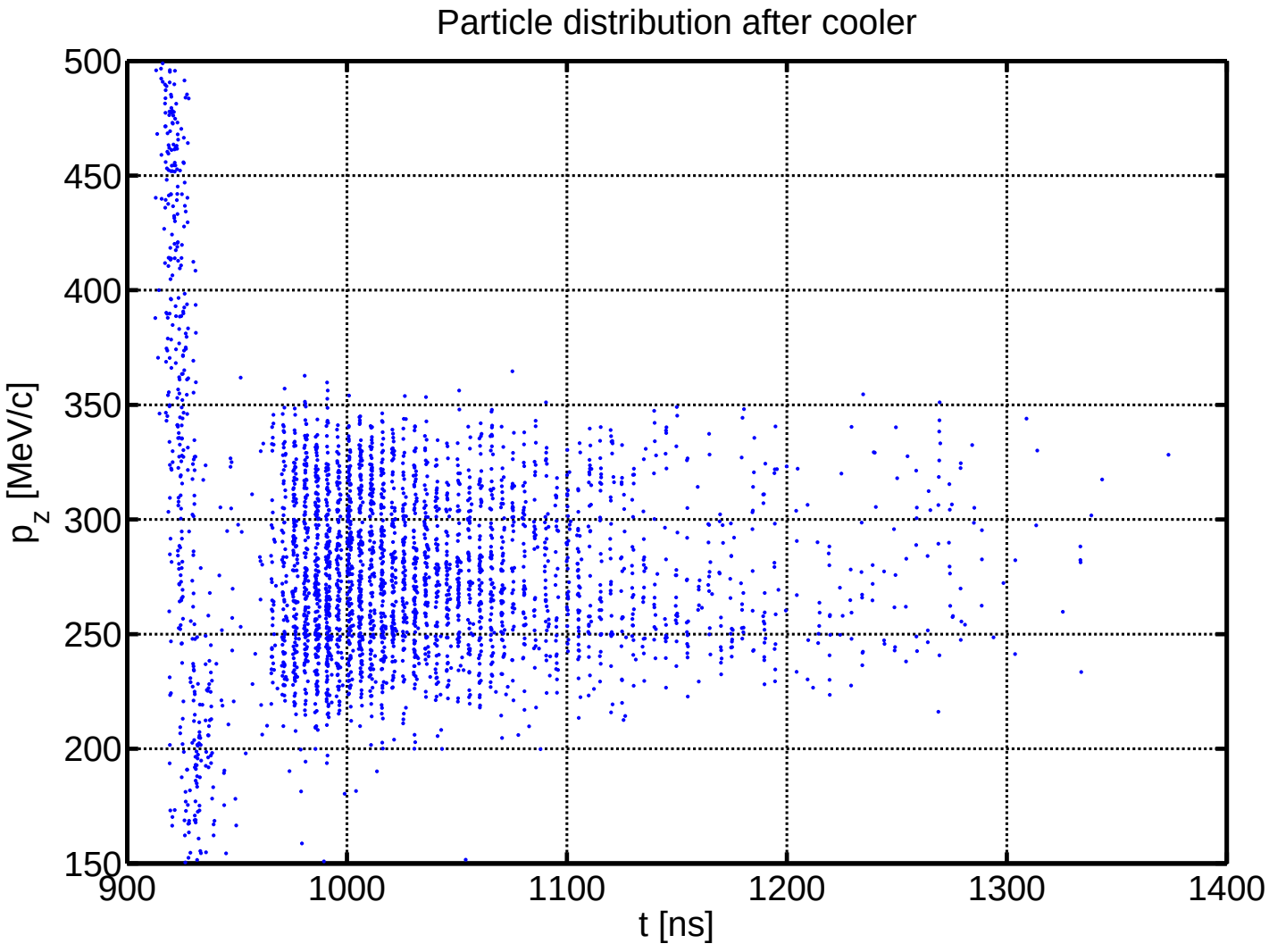
After rotator



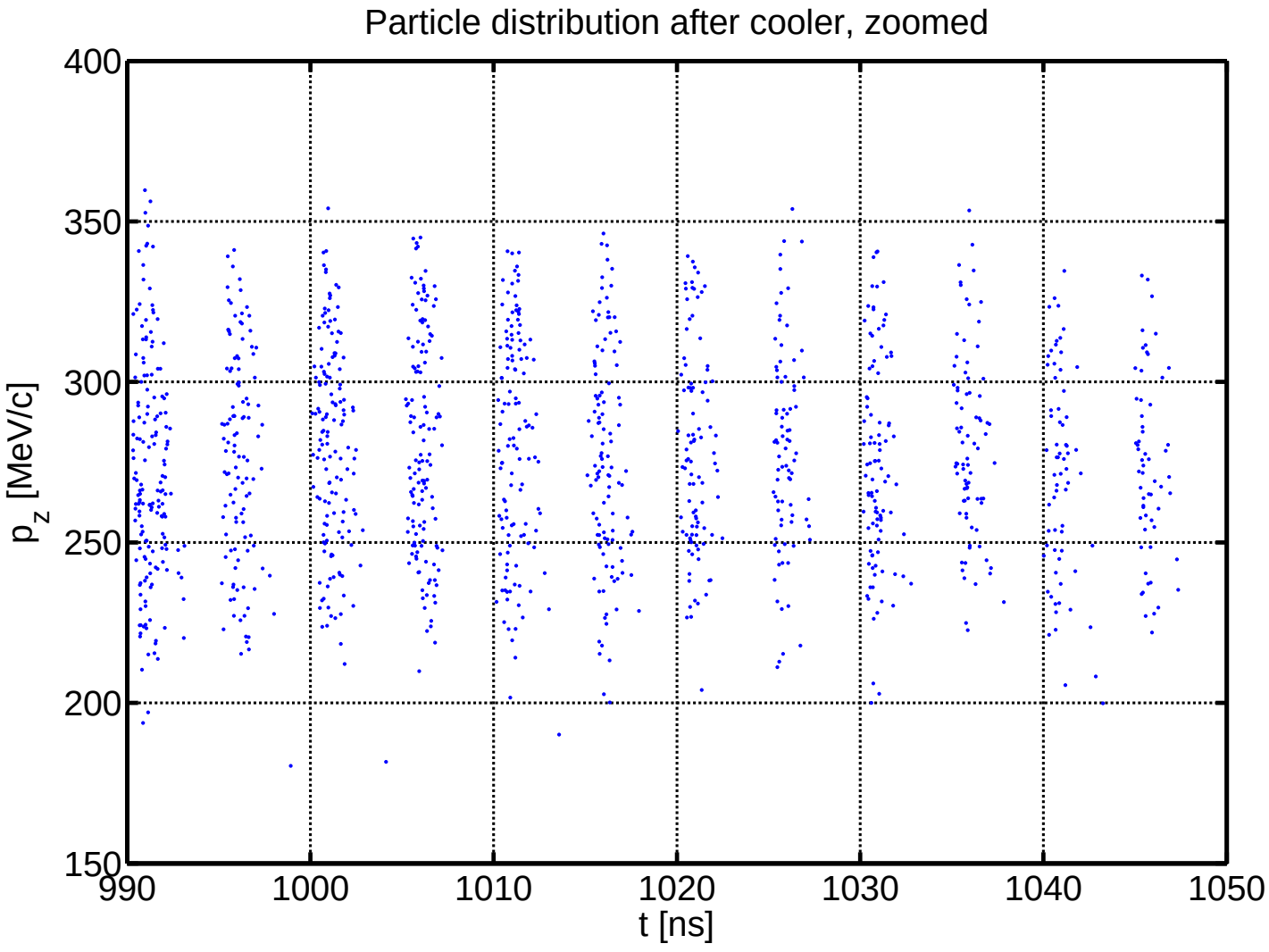
After rotator, zoom



After cooler



After cooler, zoom



Summary

- The G4beamline deck for the baseline lattice is working!
- The issue with phase rotation has been “fixed”.
- One source of concern: after cooling the muons tend to have momenta around 280 MeV/c.
- TODO: get feedback on implementing a more permanent solution for bunch rotation (“model 10 issue”).
- TODO: discuss G4beamline simulation plans.