Advancements and Applications of Cooling Simulation Tools: A Focus on Xsuite

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Objectives

- Implement and validate an electron cooling module using the **Parkhomchuk** model, benchmarked against **Betacool** with CERN e-coolers.
- Incorporate a laser cooling module in Xsuite.
- Apply the laser cooling module to simulate the **Gamma Factory PoP** experiment at CERN within the Super Proton Synchrotron (SPS).
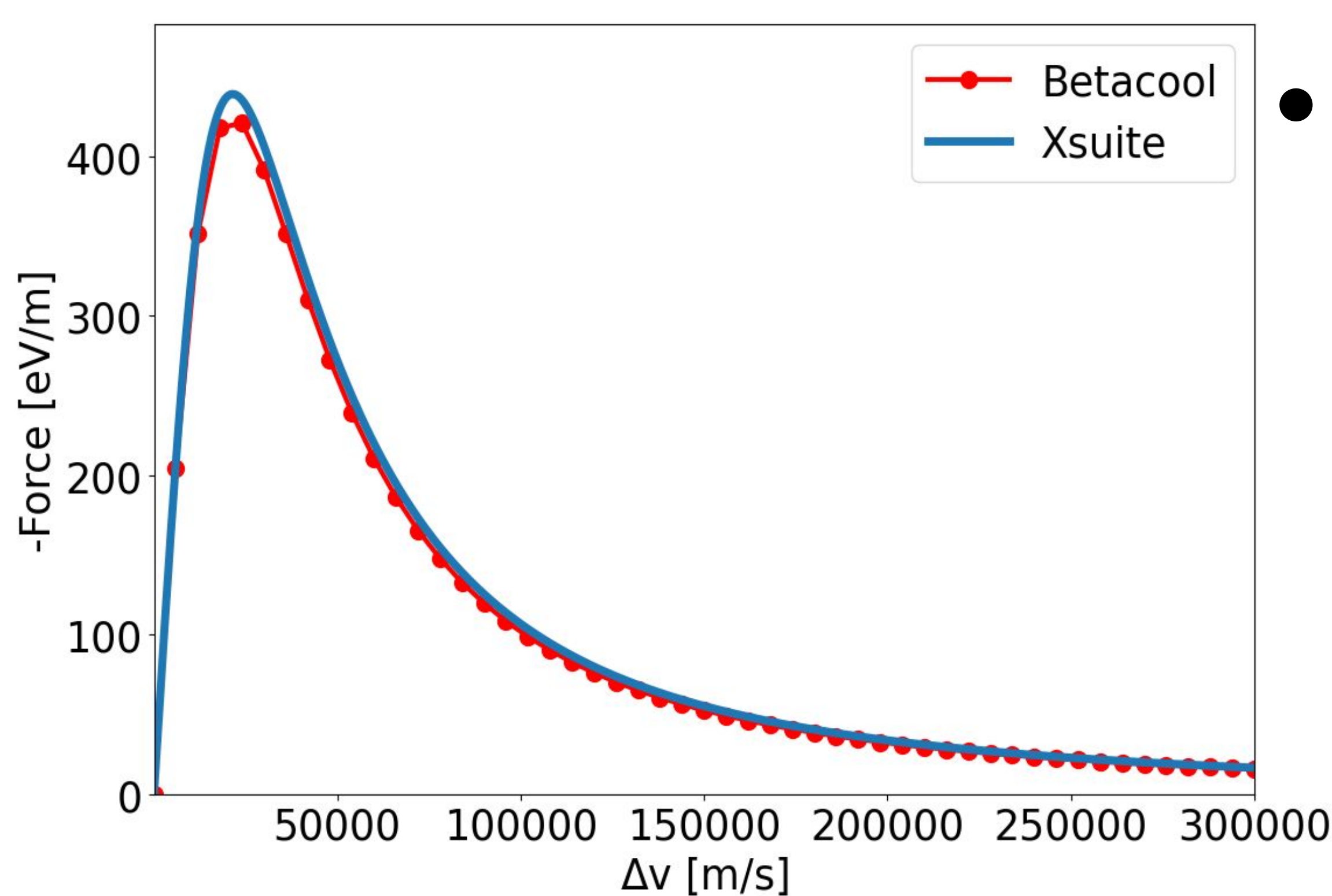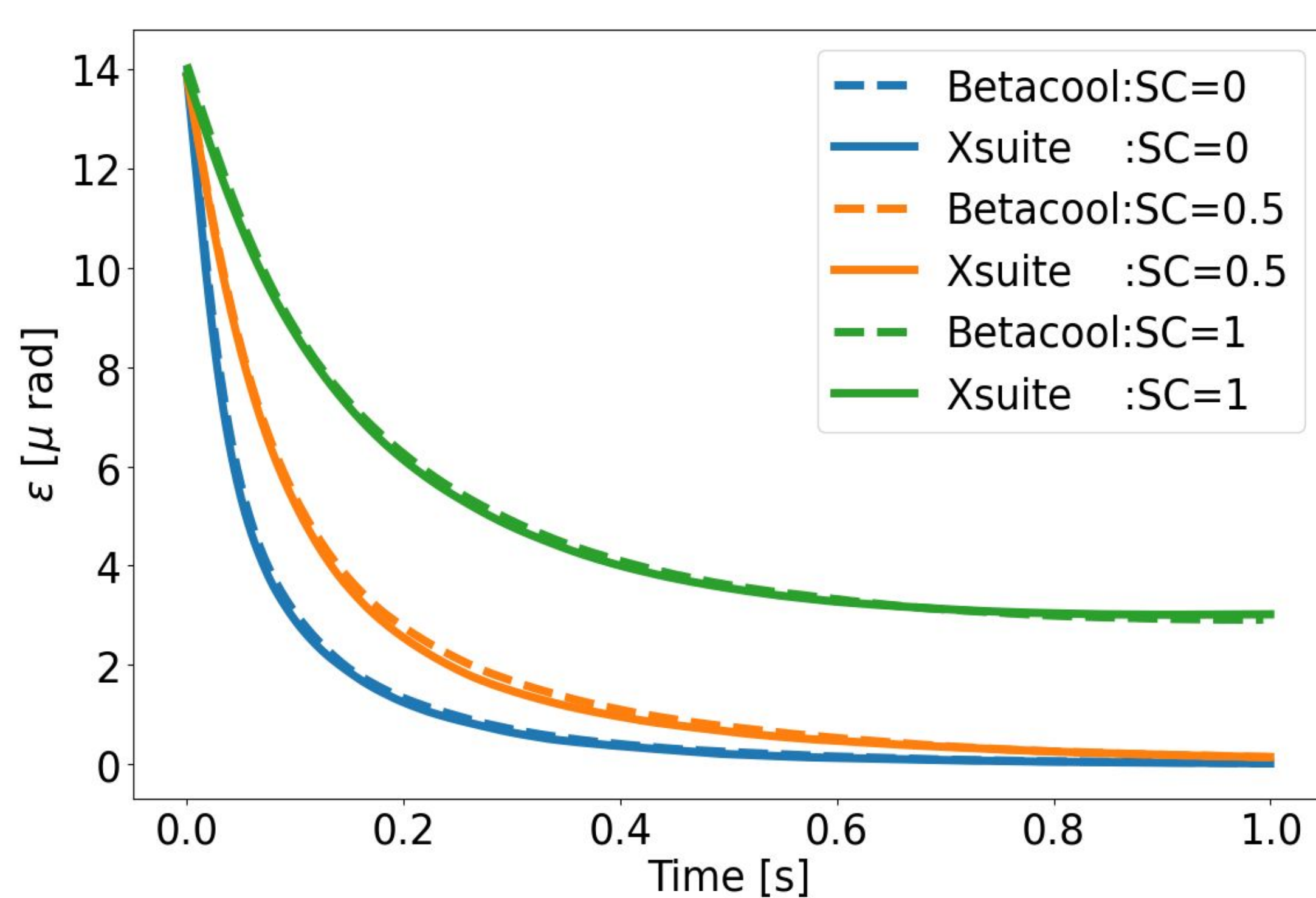
Map of steady state solutions
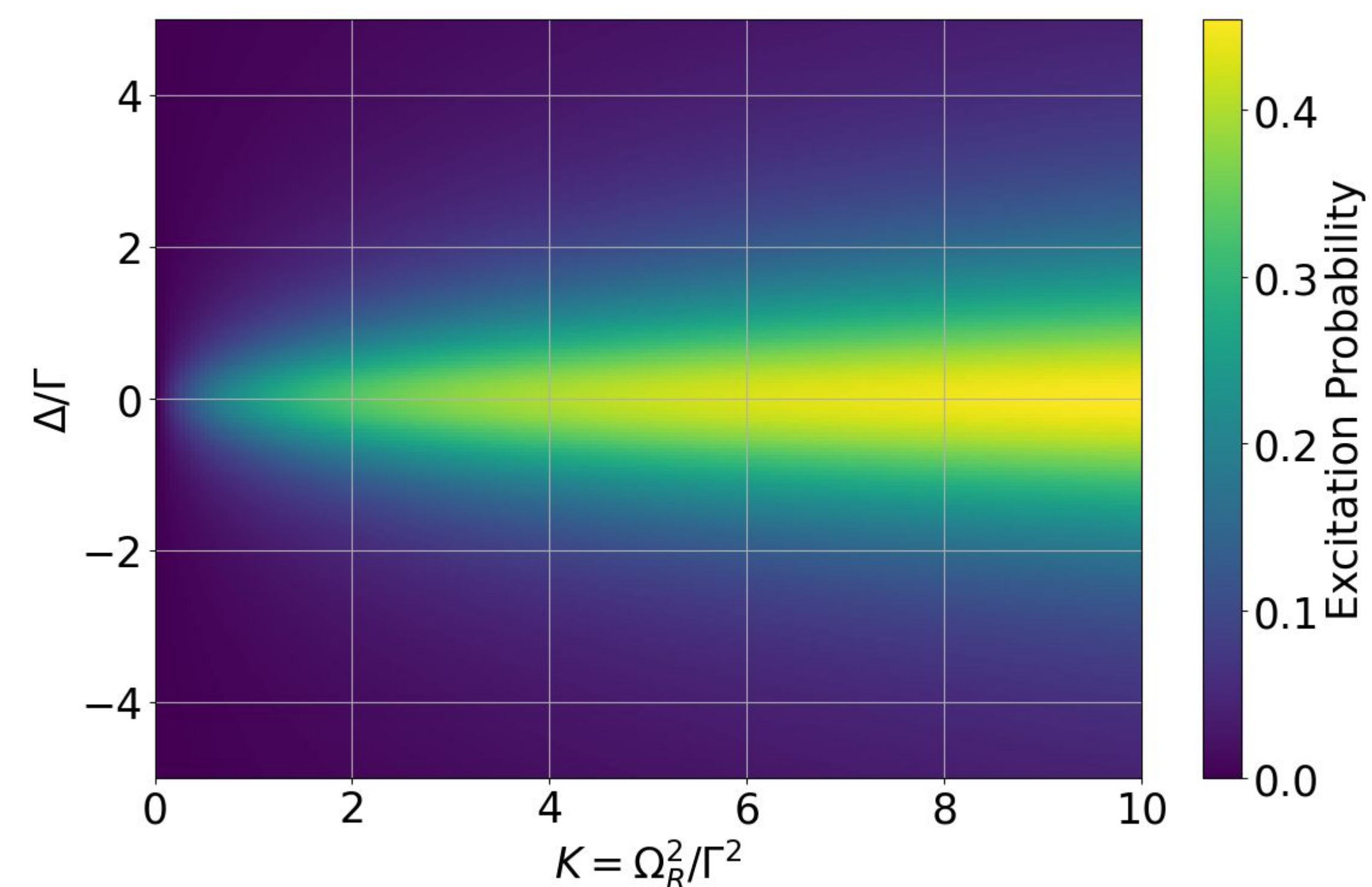
- Use map to give an excitation probability to each particle based on its parameters.

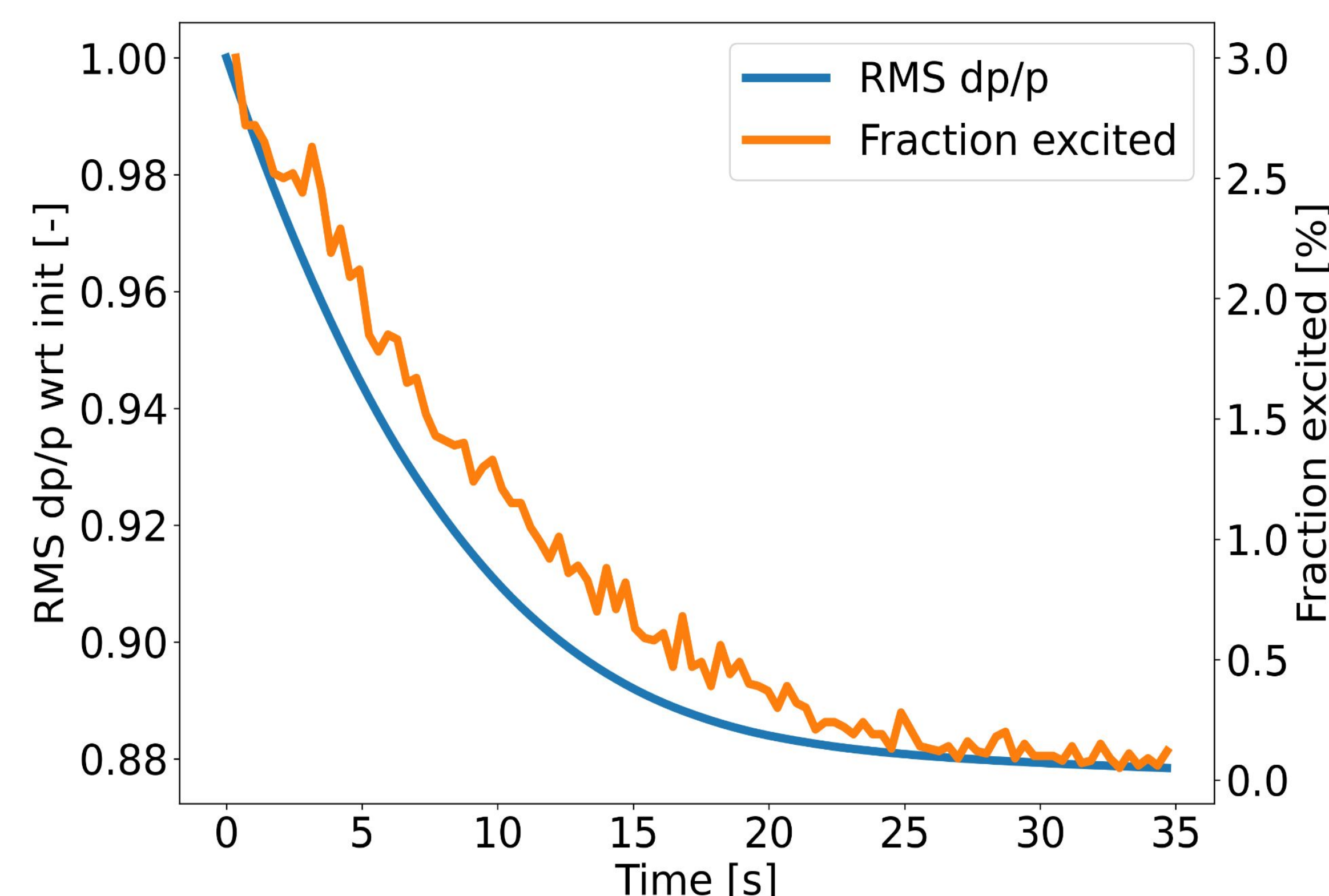## Electron Cooling

Comparison with Betacool

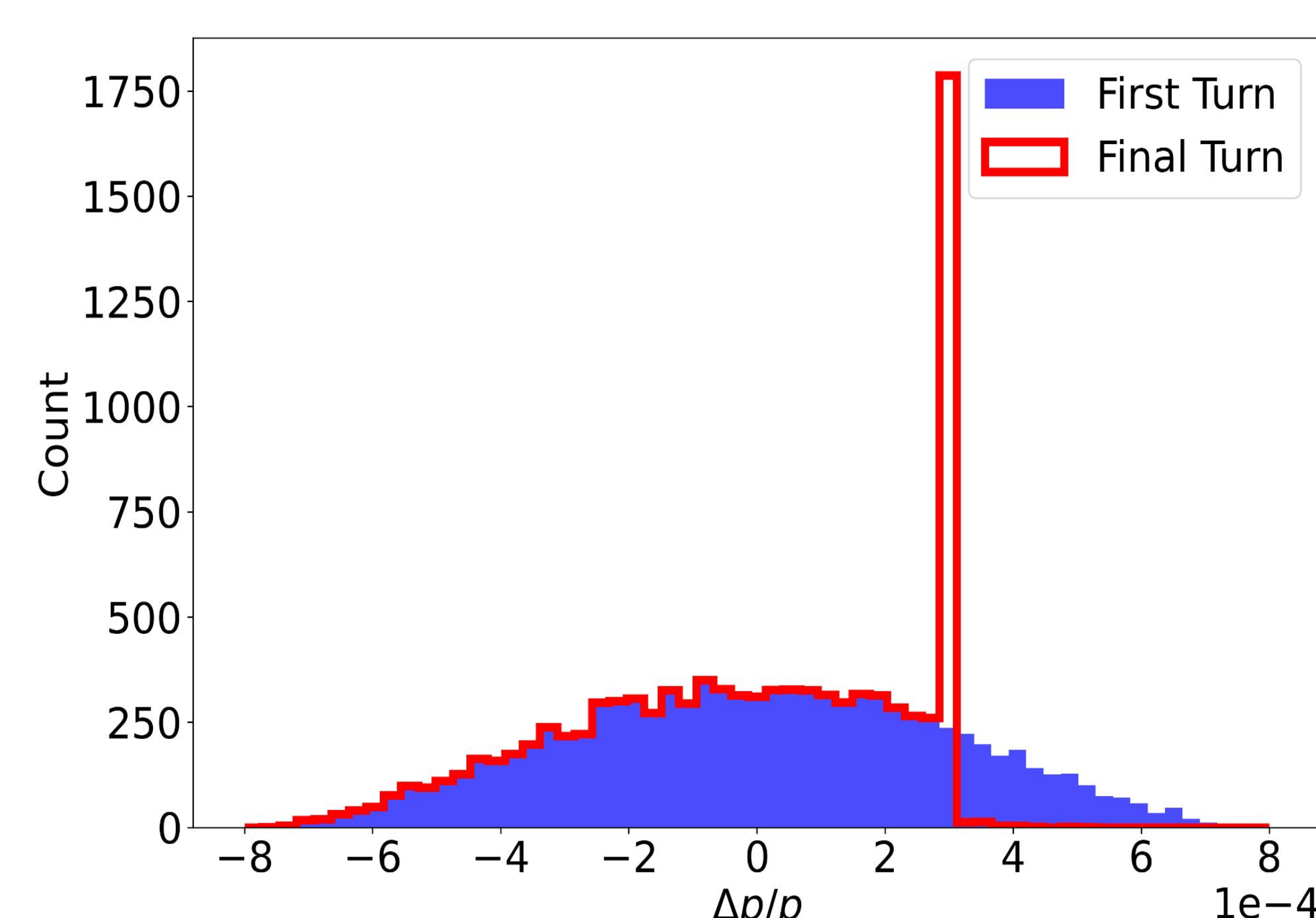- Cooling force between Xsuite and Betacool are in agreement.

- Emittance reductions are in agreement for different levels of electron beam space charge.

SPS simulations

- Reduction of momentum spread.
- Simultaneous reduction of number of excited particles.

- High energy particles have their energy reduced by interacting with the laser.

Laser Cooling

Excitation

Find steady state solutions of optical Bloch equations.

Emission

1. Particle loses energy because of the quasi head-on collision with the photon.
2. Excited particle emits photon in random direction, which can increase or decrease energy.

Conclusions

- **Successful benchmark** with Parkhomchuk model of Betacool.
- Introduced a laser cooling module in Xsuite.
- The first results of simulations of coasting beams in the SPS **capture the physics of laser cooling**.
- Next: Simulate the full Gamma Factory PoP experiment.