

μCATALYST 07/13/2026 Update

Rosalyn Beckwith – Northeastern University

Brookhaven National Lab

Advisors: Dr Stephen Brooks | Professor Toyoko Orimoto

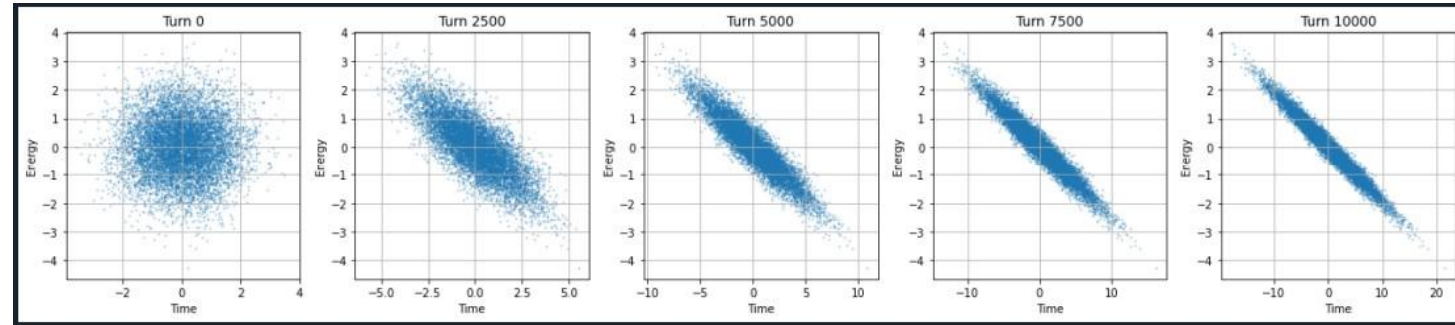
Background: Longitudinal Beam Dynamics Simulation for the AGS Proton Bunch Compression

- Future muon colliders require extremely short, intense proton bunches to efficiently produce muons
- One proposed test facility would use AGS to investigate proton driven muon production
- Project focuses on modeling longitudinal beam dynamics to study how RF systems compress a proton bunch to a target of 2ns RMS before extraction

Week 1 Progress

Started developing a Python simulation that models particle motion in a longitudinal phase space and investigates how RF voltage programs affect bunch compression. Git: <https://github.com/rbeckwith1/bnl-beam-simulation>

Initial Phase Space
Distribution – no RF



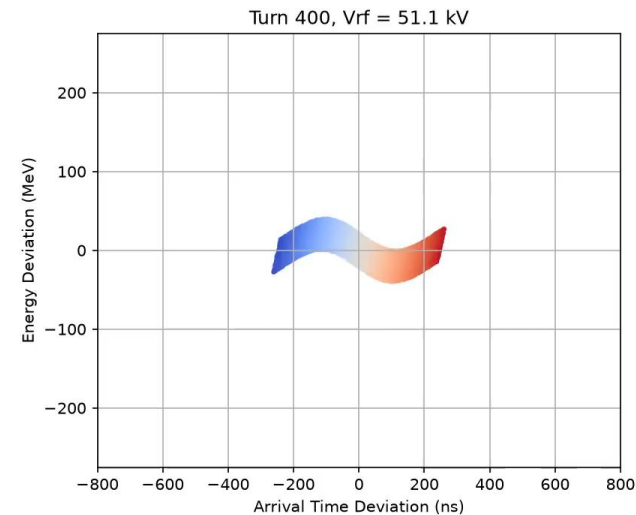
AGS parameters:

Momentum Compaction ~ 0.014

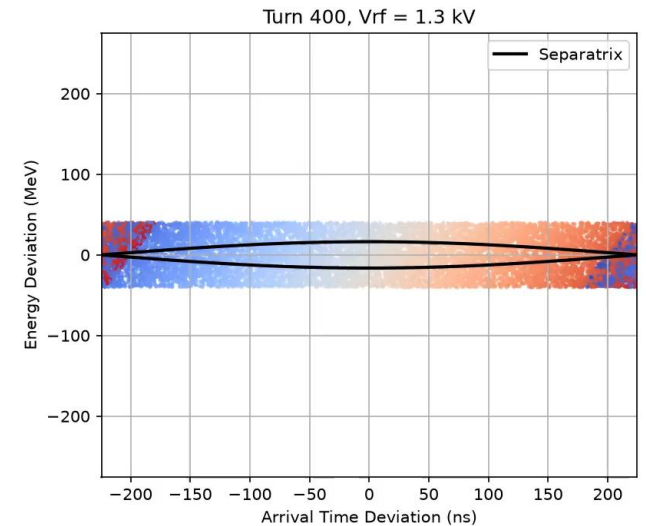
Harmonic number $h = 6$

*AGS operates above transition
energy

Added RF contributions for
multiple particles over number
of turns with increasing voltage
->



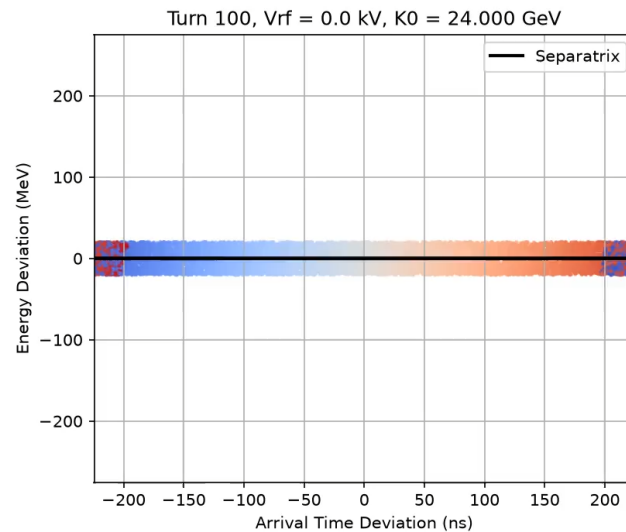
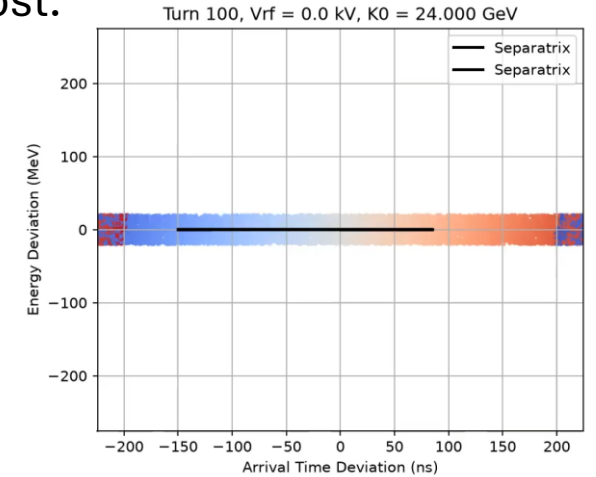
Wrapped particles
to one bucket and
derived
Hamiltonian to
calculate the
separatrix ->



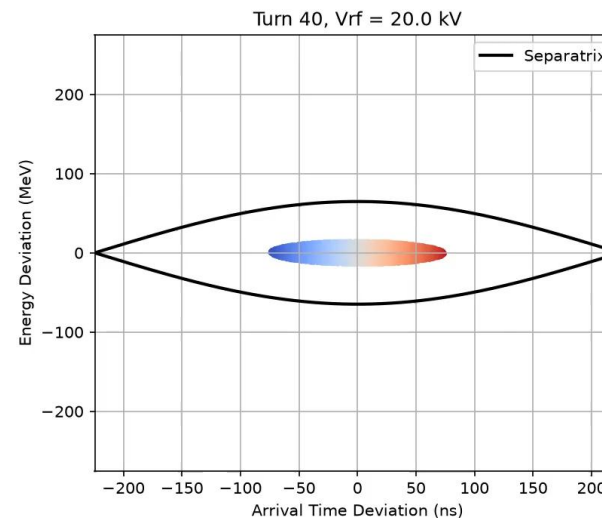
Week 2 Progress

- Added additional features such as acceleration, a controlled voltage ramp, and wrapped the particles to 1 bucket to focus on particle capture
- Modeled different types of bunching: adiabatic, non-adiabatic, and resonant methods in simulation
- Different bunching methods trade off capture speed, emittance preservation, and achievable compression

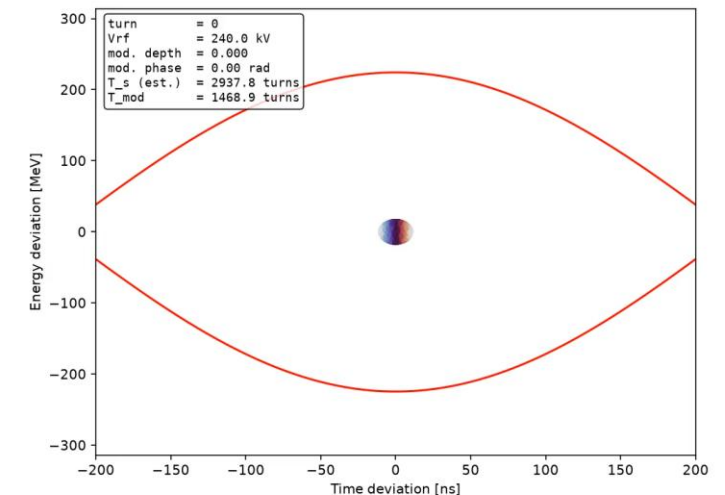
With no applied method,
particles can be easily lost:



Adiabatic



Non-Adiabatic



Resonant

Conclusion and Next Steps

Current model includes:

RF acceleration and momentum-dependent drift, time-varying RF voltage ramp and acceleration ramp, multiple bunching/compression schemes

Currently Working on:

Validating model against newly received AGS run data and studying how bunching method choice maps onto actual longitudinal dynamics and control

Next Steps:

- Benchmark simulation against AGS run data
- Quantify bunch length compression
- Evaluate Compression toward the 2ns RMS target
- Google drive link to simulation videos: <https://drive.google.com/drive/folders/11ixKoxDSA6jx8vHndLBQtLzrfnX7Z02e?usp=sharing>