Muon Recirculating Acceleration at CERN

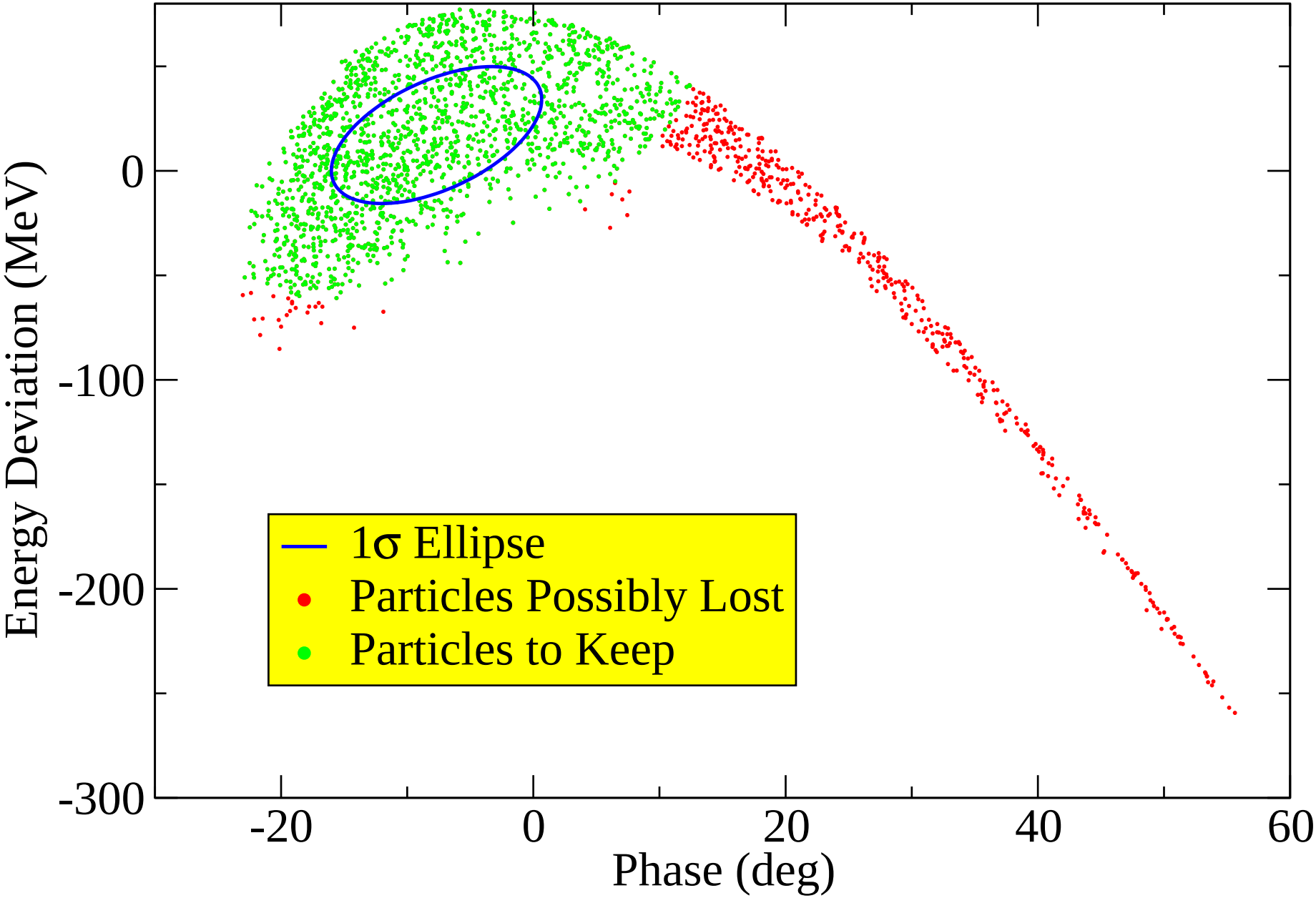
J. Scott Berg
Brookhaven National Laboratory
14 November 2001

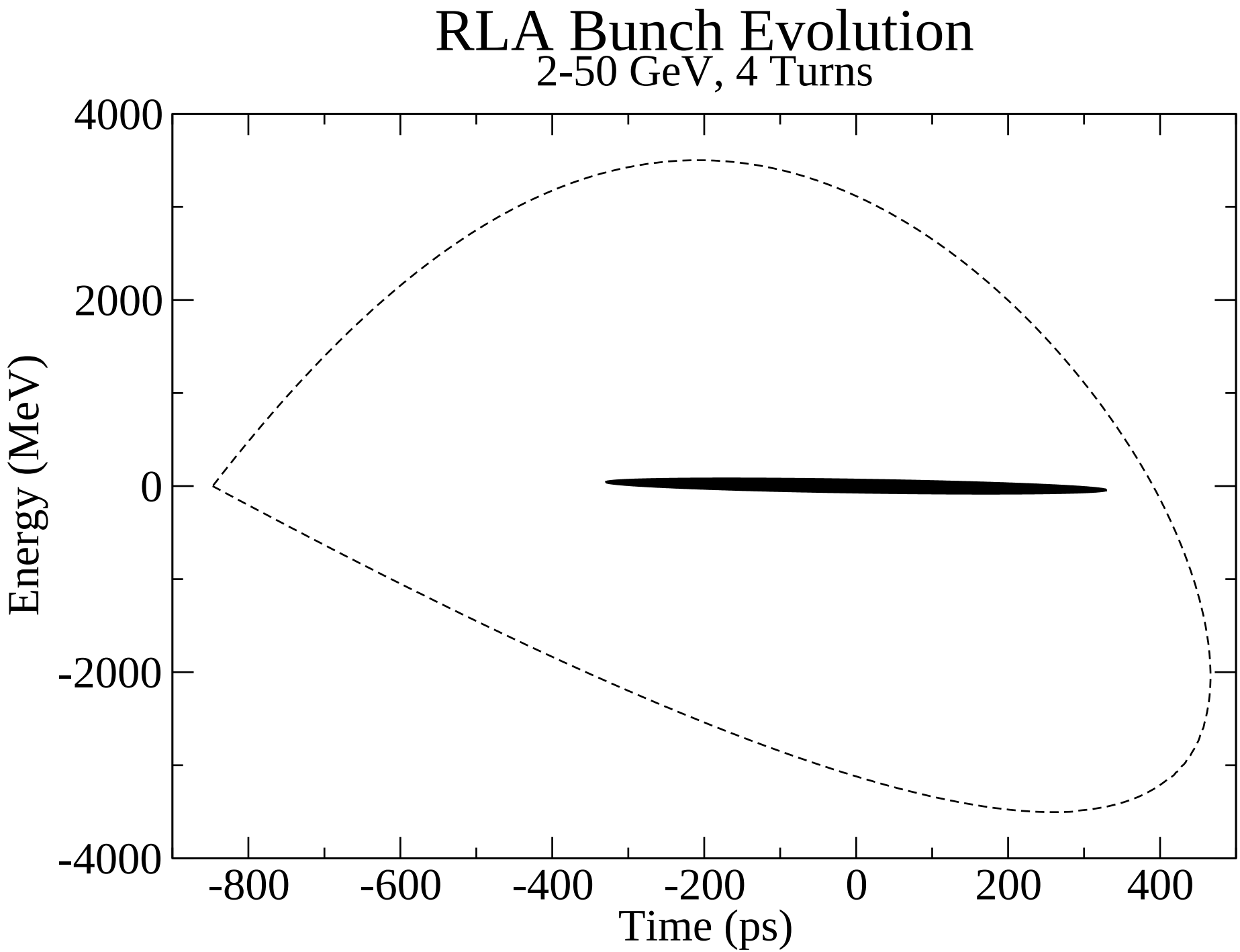
What We Need To Do

- Accelerate to required energy
- Minimize energy spread
  - Beam transport
  - Switchyard
  - Storage ring physics
- Synchrotron Oscillations
  - Can make bunch longer by running off-crest
  - Bucket area arbitrarily large
  - Matched bucket
- Rotate incoming beam into matched bucket: hard!

Input Phase Space Distribution

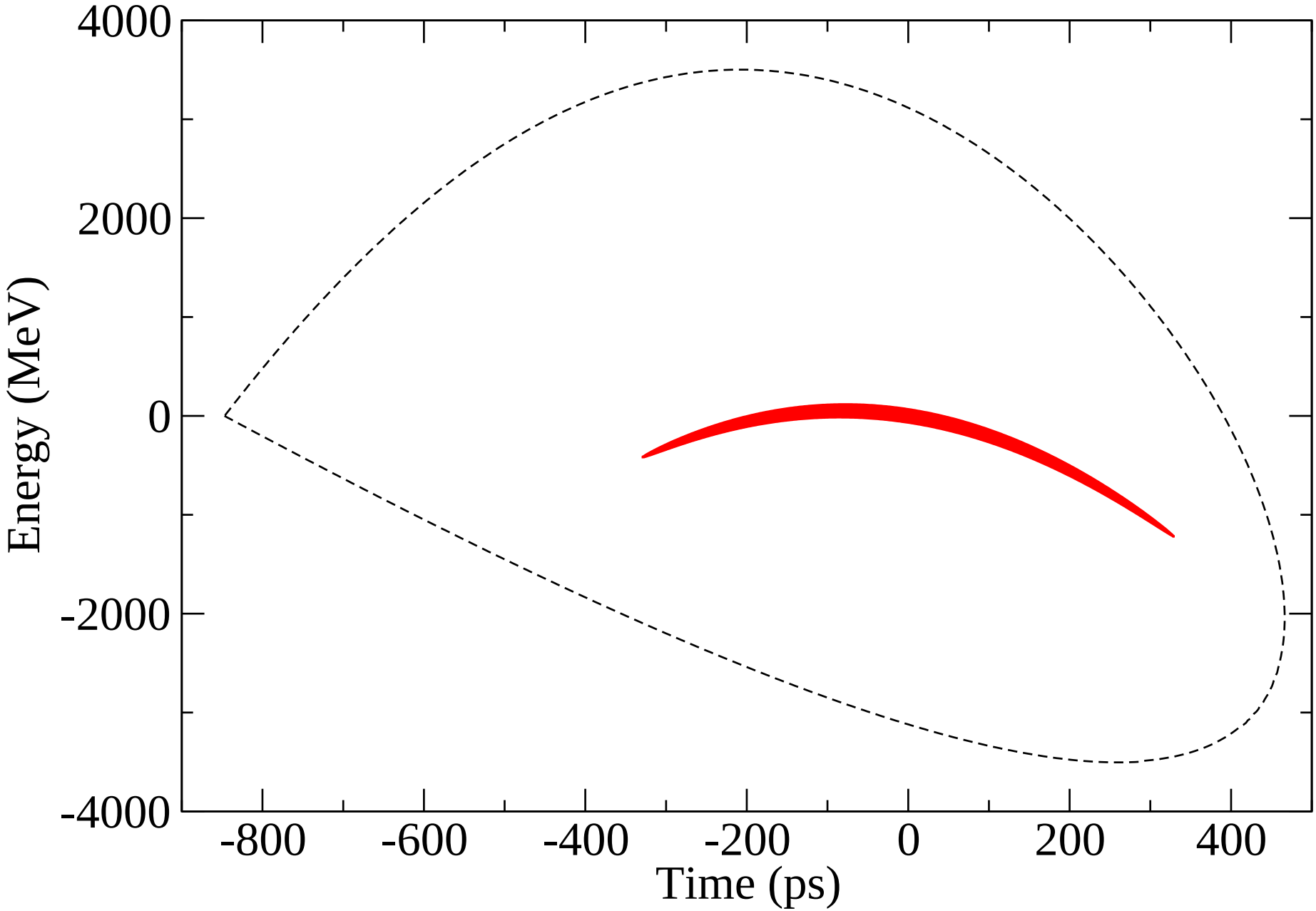
Recursively Cut to 2.5σ

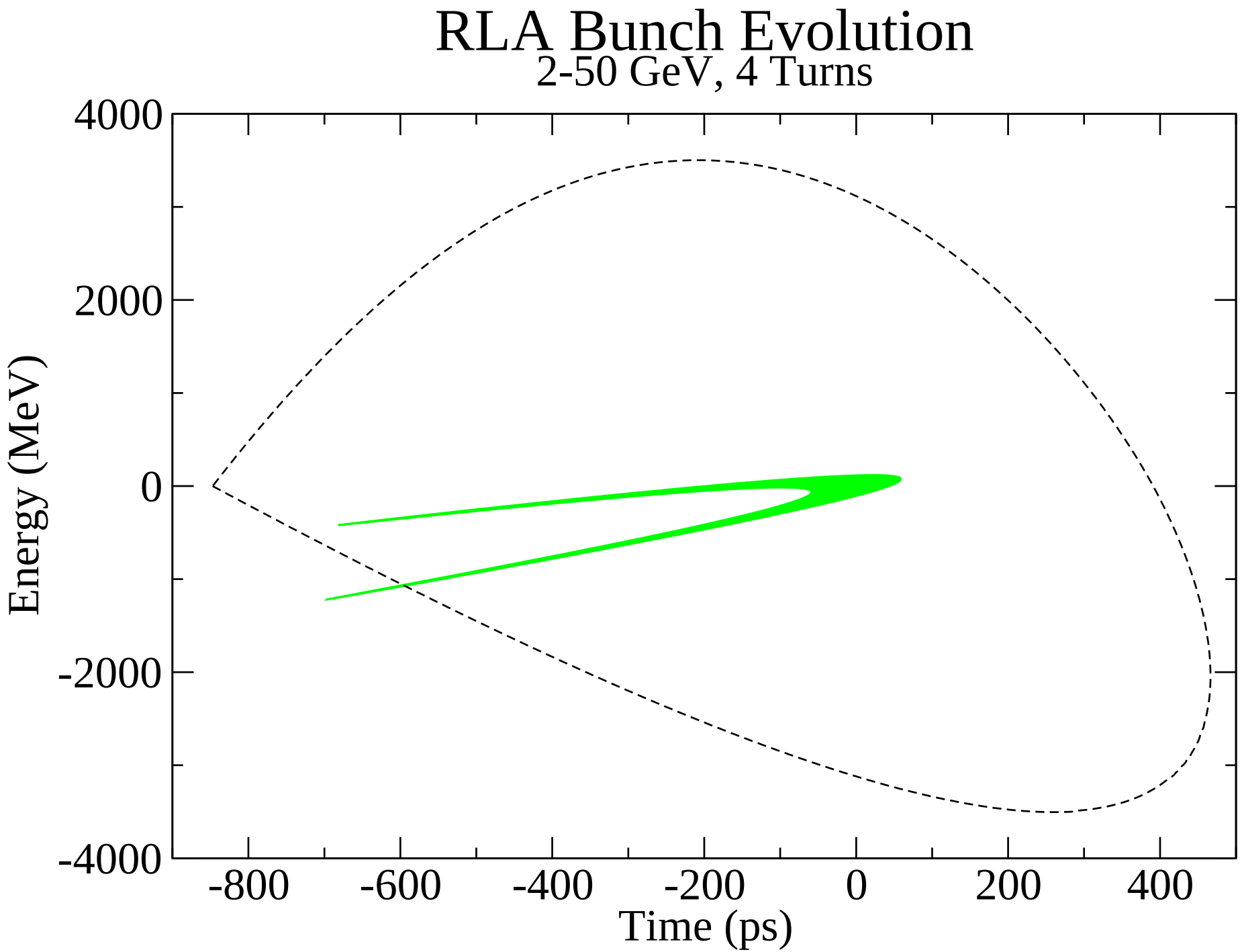


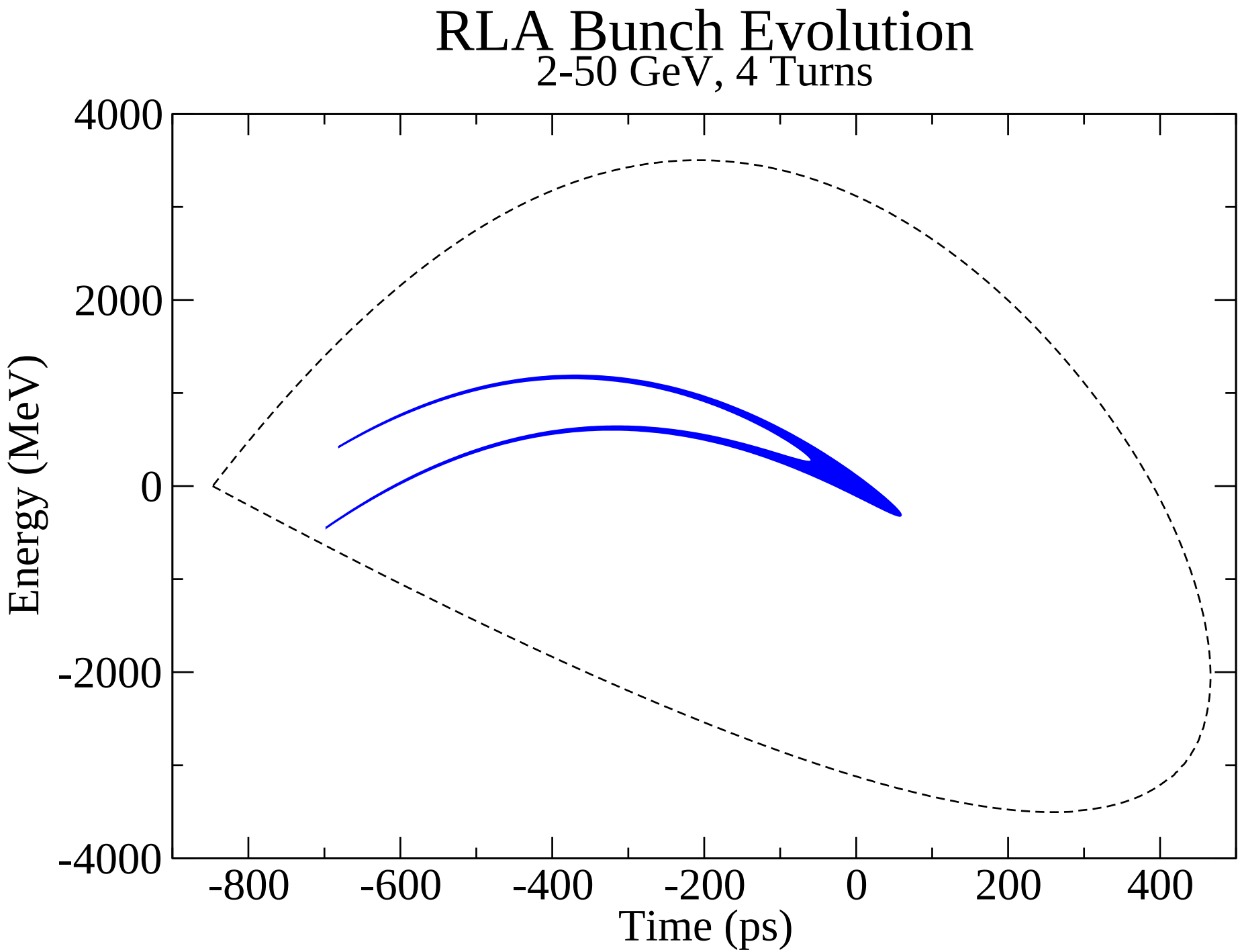

RLA Bunch Evolution
2-50 GeV, 4 Turns
4000
2000
0
-2000
-4000
Energy (MeV)
-800
-600
-400
-200
0
200
400
Time (ps)

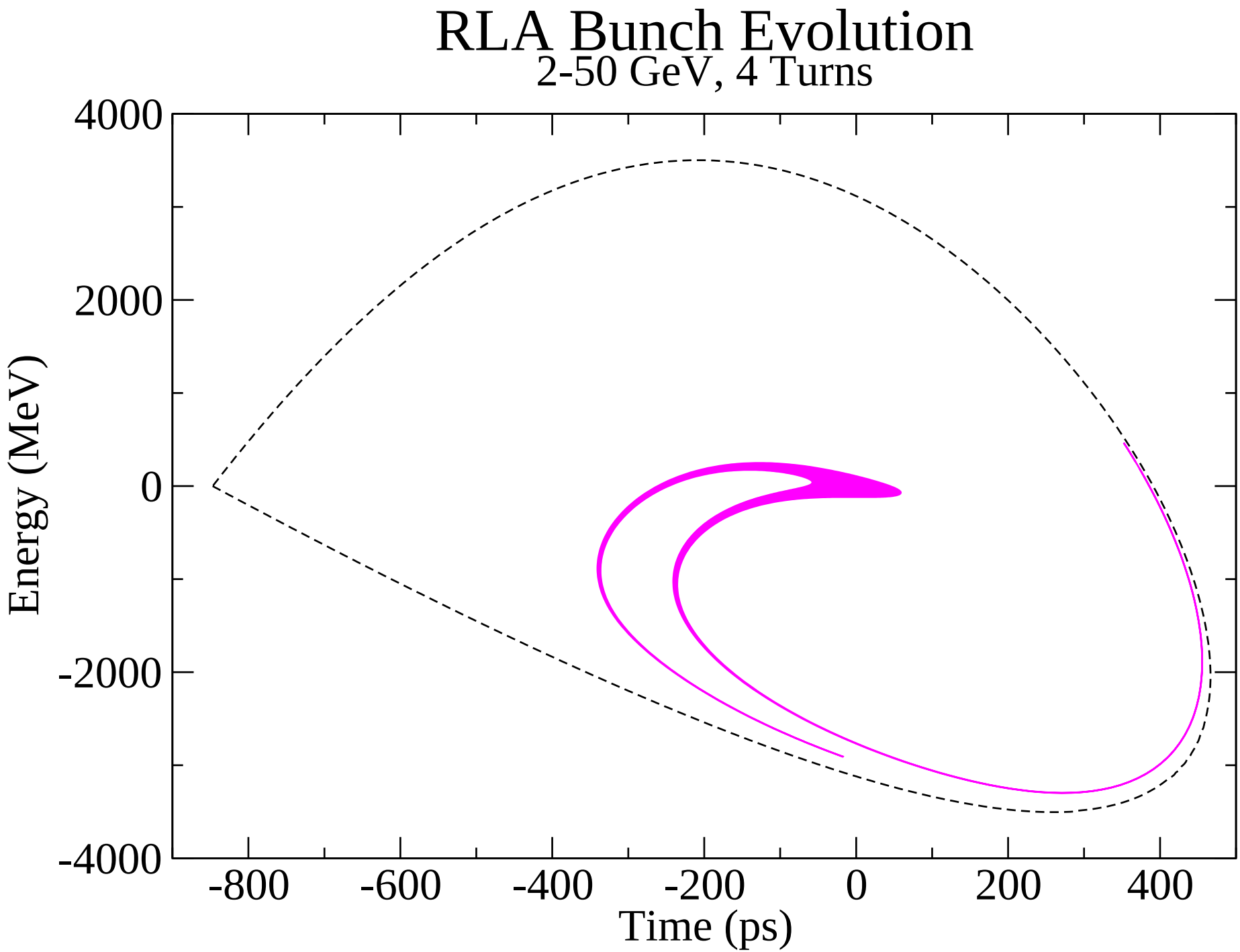
RLA Bunch Evolution

2-50 GeV, 4 Turns



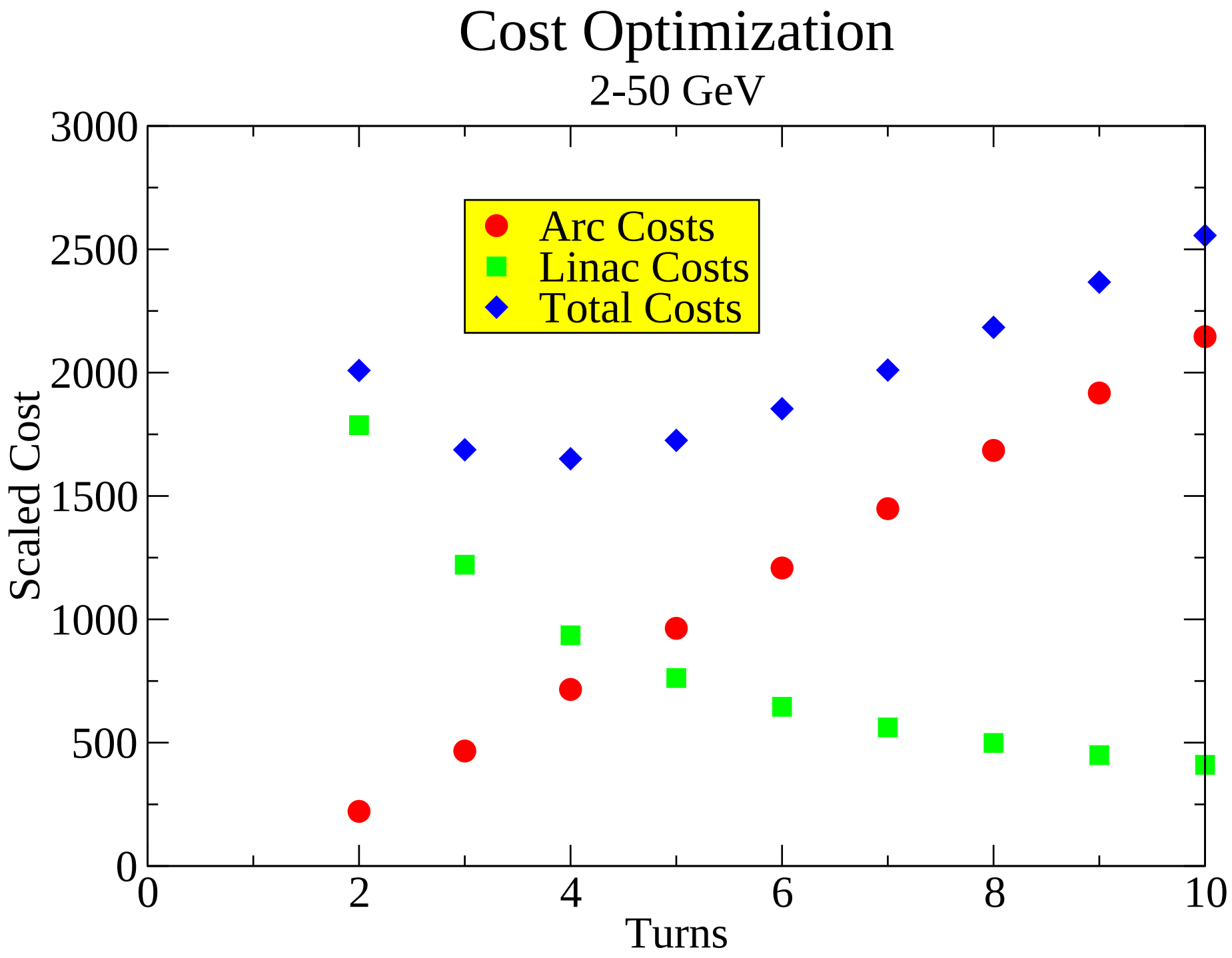

RLA Bunch Evolution
2-50 GeV, 4 Turns
4000
2000
0
-2000
-4000
Energy (MeV)
-800
-600
-400
-200
0
200
400
Time (ps)


RLA Bunch Evolution
2-50 GeV, 4 Turns
4000
2000
0
-2000
-4000
Energy (MeV)
-800
-600
-400
-200
0
200
400
Time (ps)


RLA Bunch Evolution
2-50 GeV, 4 Turns
4000
2000
0
-2000
-4000
Energy (MeV)
-800
-600
-400
-200
0
200
400
Time (ps)

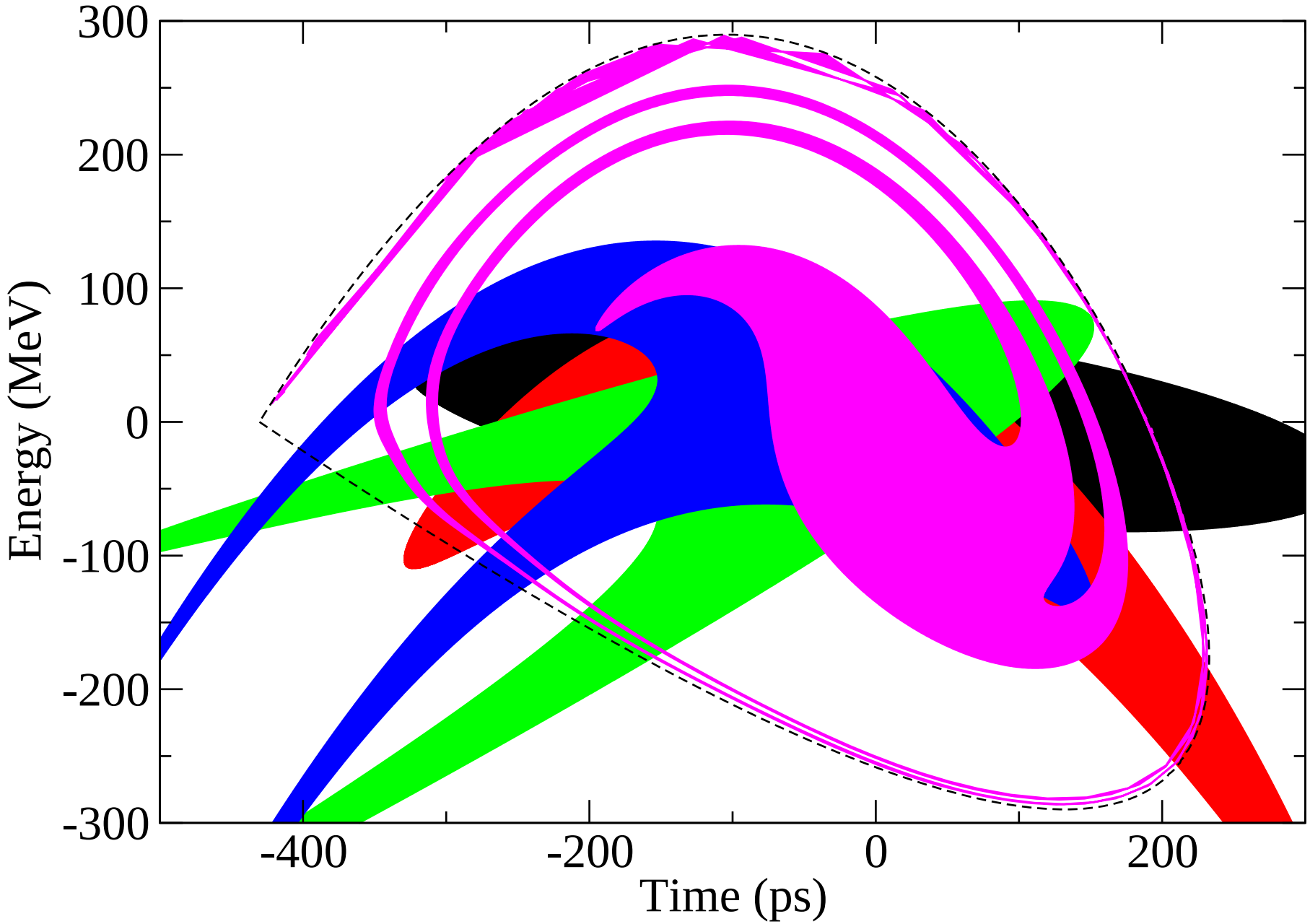
Scenarios and Costs

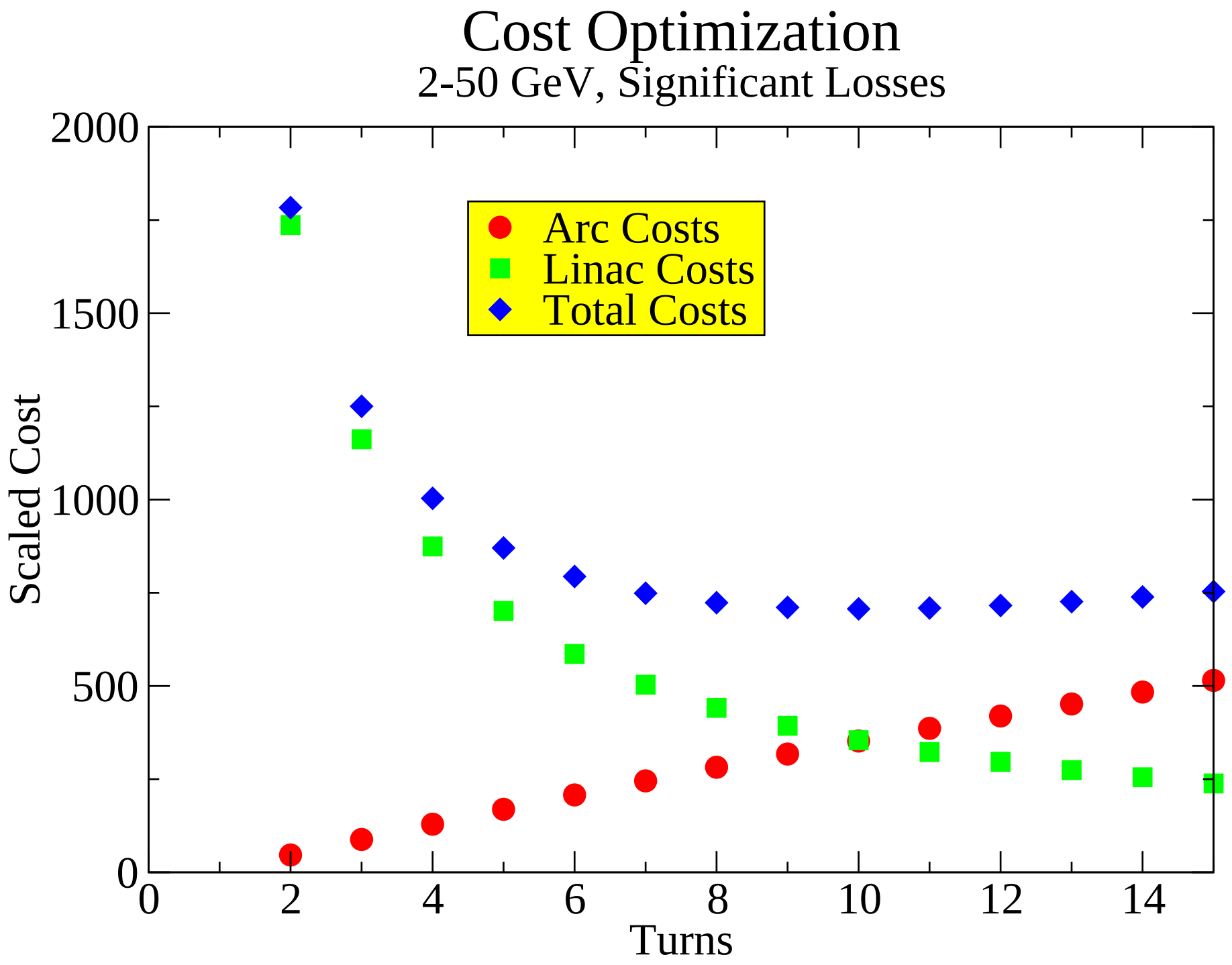
- Cost assumptions:
  - Proportional to length
  - Proportional to energy spread
  - Can show optimum near where linacs and arcs cost same
- 4 turns, 2-50 GeV, keeping everything: cost 1651
  - Forced near crest (too much voltage): gives distortion
  - Bucket size excessive
- 2-50 GeV, Throw away particles: cost 706
- Two-stage system, throw out small tail: cost 690
  - Low energy gain in stage 1, less RF, less distortion
  - More “adiabatic”
  - Many turns:


Cost Optimization
2-50 GeV
Arc Costs
Linac Costs
Total Costs
Scaled Cost
Turns
0
500
1000
1500
2000
2500
3000
0
2
4
6
8
10

RLA Bunch Evolution

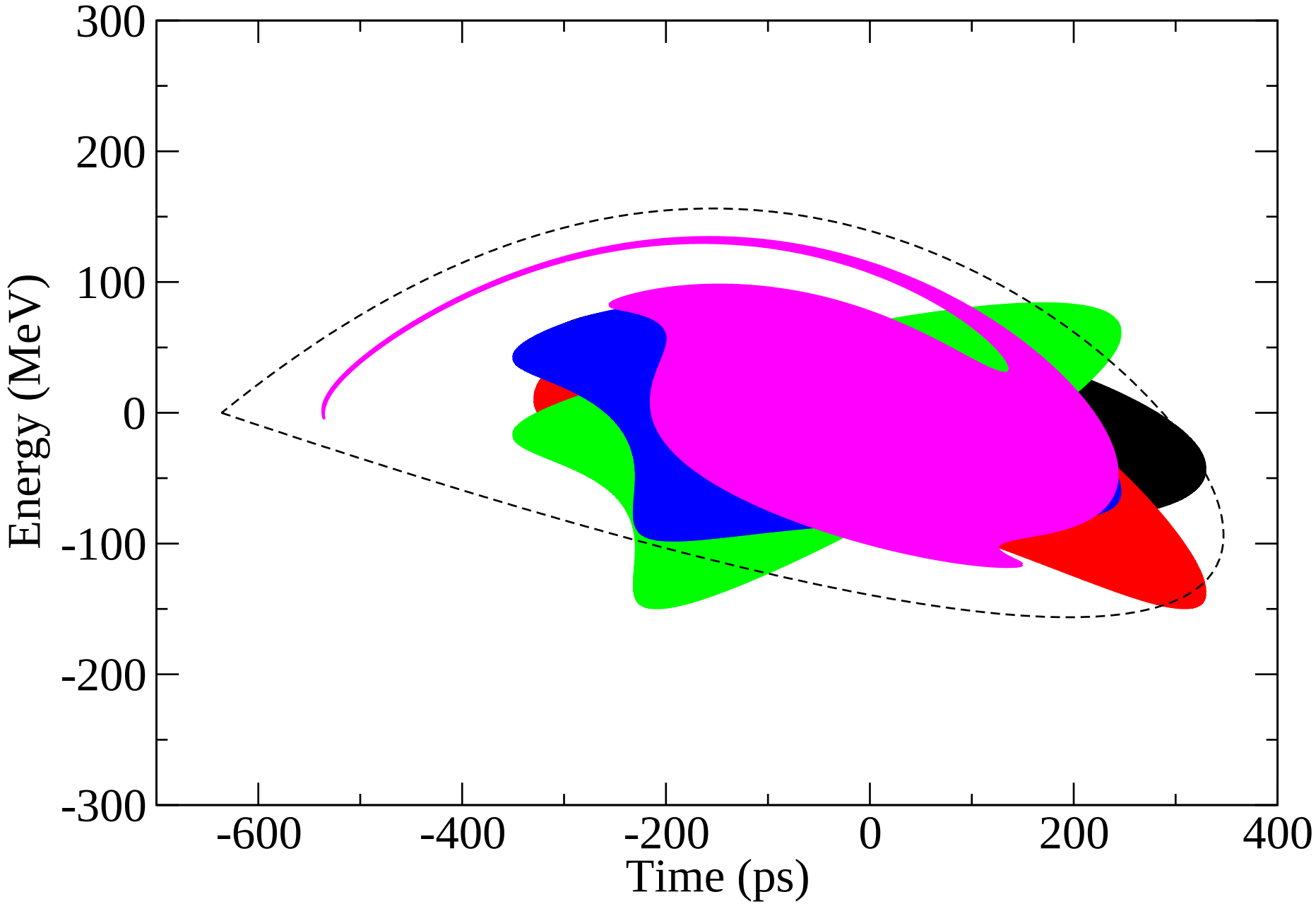
2-50 GeV, 10 Turns, Significant Losses




Cost Optimization
2-50 GeV, Significant Losses
Arc Costs
Linac Costs
Total Costs
Scaled Cost
Turns
0
500
1000
1500
2000
0
2
4
6
8
10
12
14

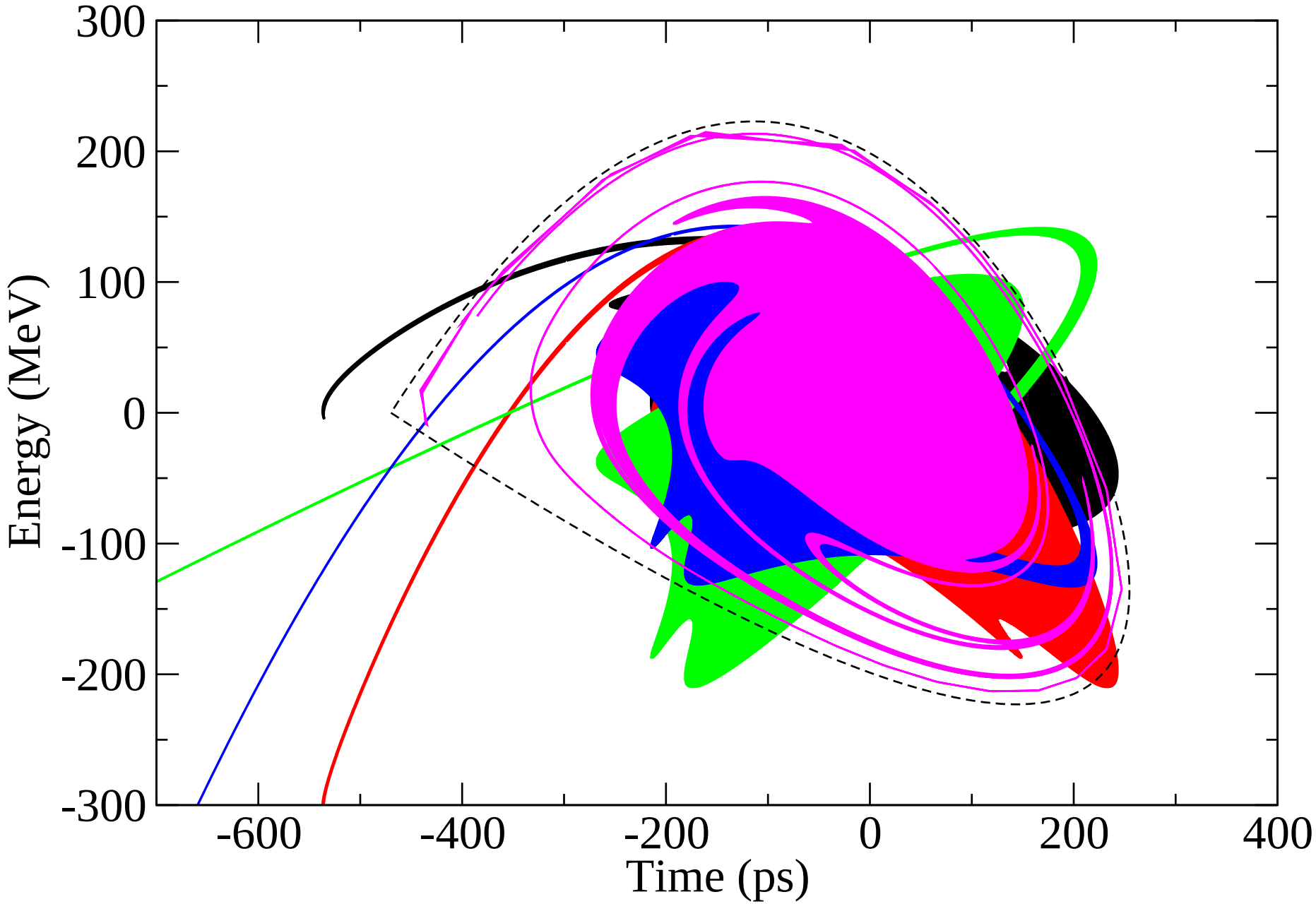
RLA Bunch Evolution

2-10 GeV, 7 Turns, Small Losses



RLA Bunch Evolution

2-10 GeV, 7 Turns, Small Losses



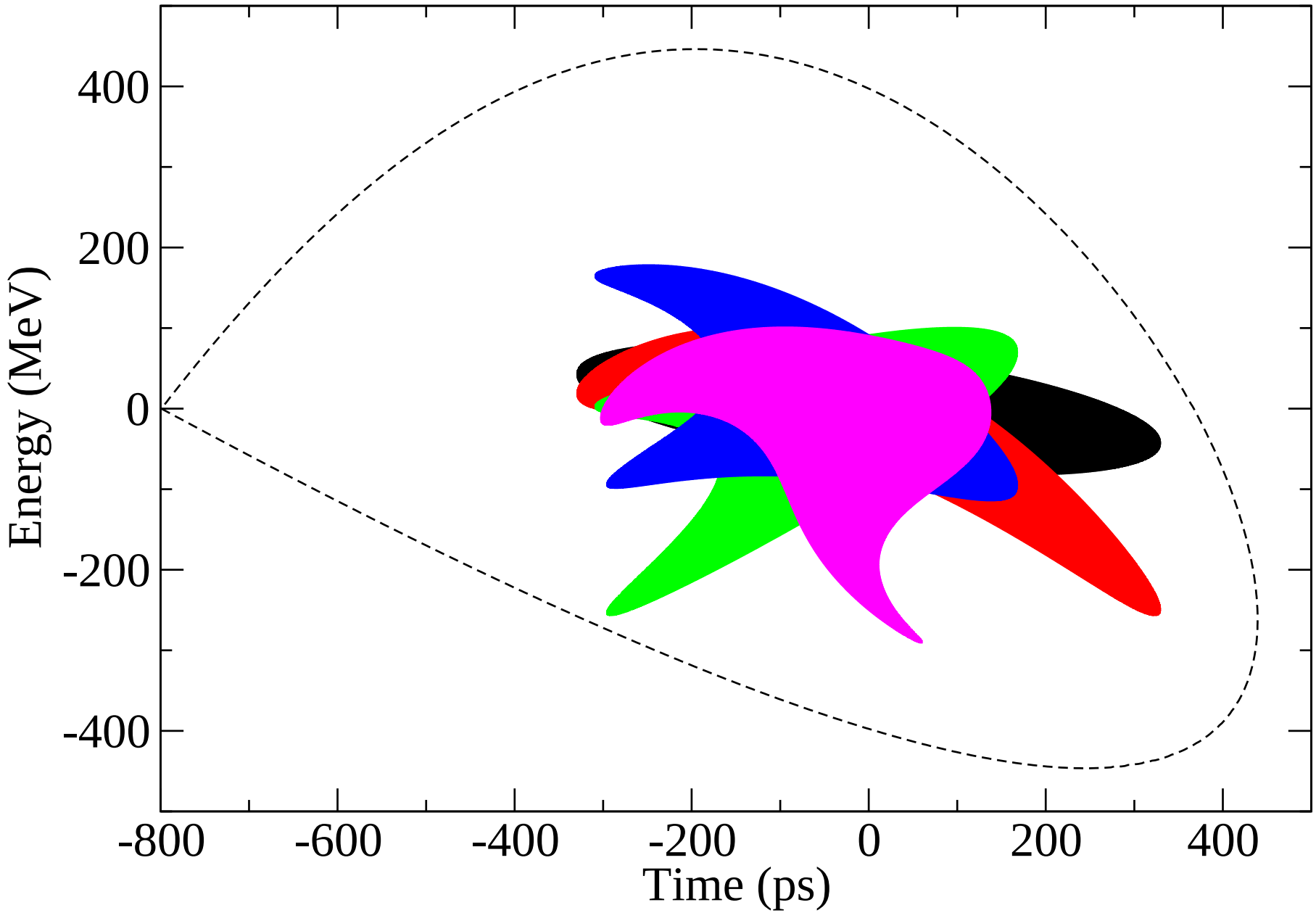
- ⋆ Smaller energy spread, better matched
- ⋆ Cost optimum

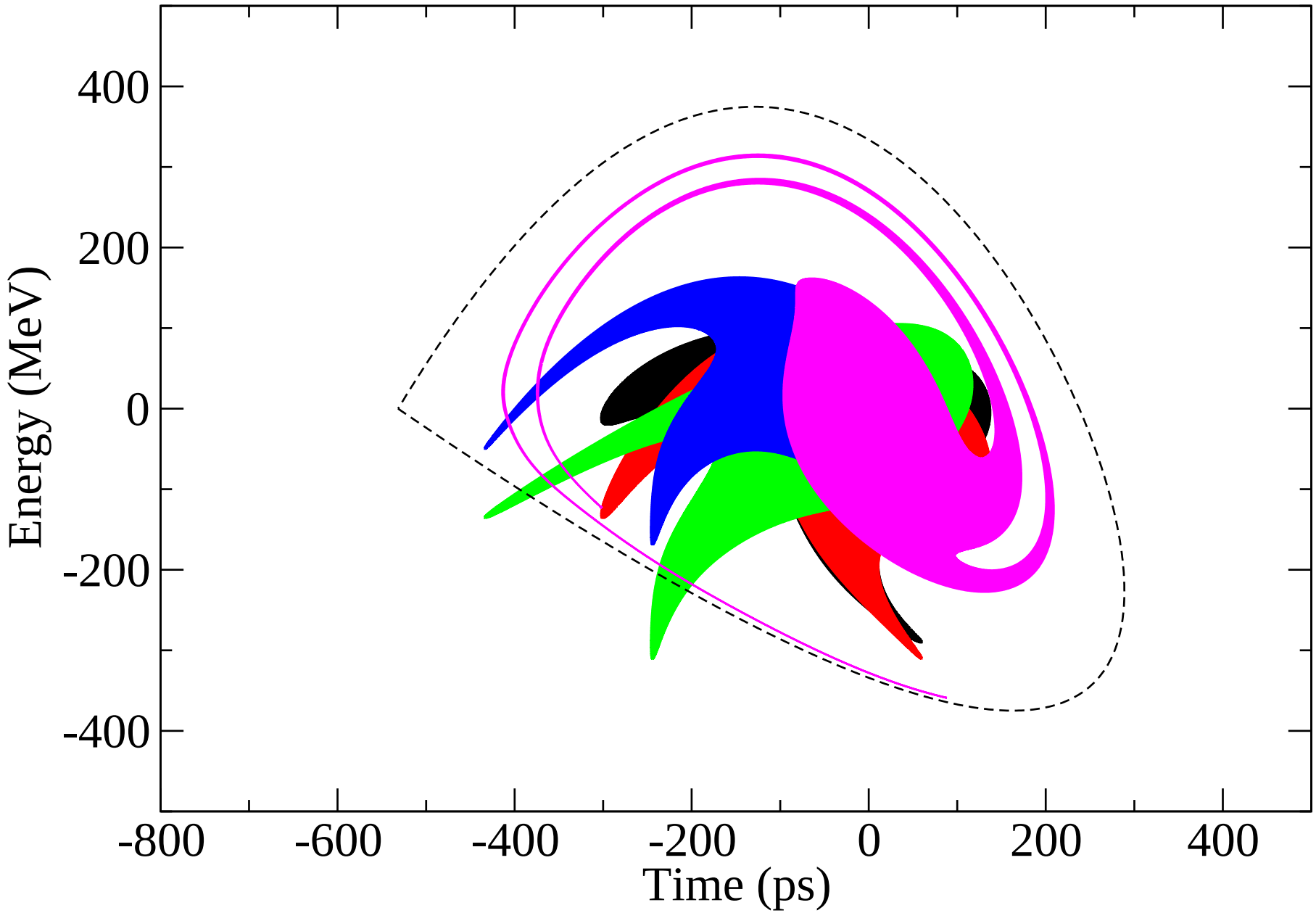
- ◆ Losses in stage 2

- Two-stage, larger stage 1 bucket
  - ◆ First RLA costs less, not a big deal to open bucket
  - ◆ Less nonlinear distortion since further from separatrix
  - ◆ Partially eliminates troublesome tail

RLA Bunch Evolution

2-10 GeV, 10 Turns, No Loss, Stage 1



RLA Bunch Evolution

2-10 GeV, 10 Turns, No Loss, Stage 2