Muon Bunching for a Muon Collider

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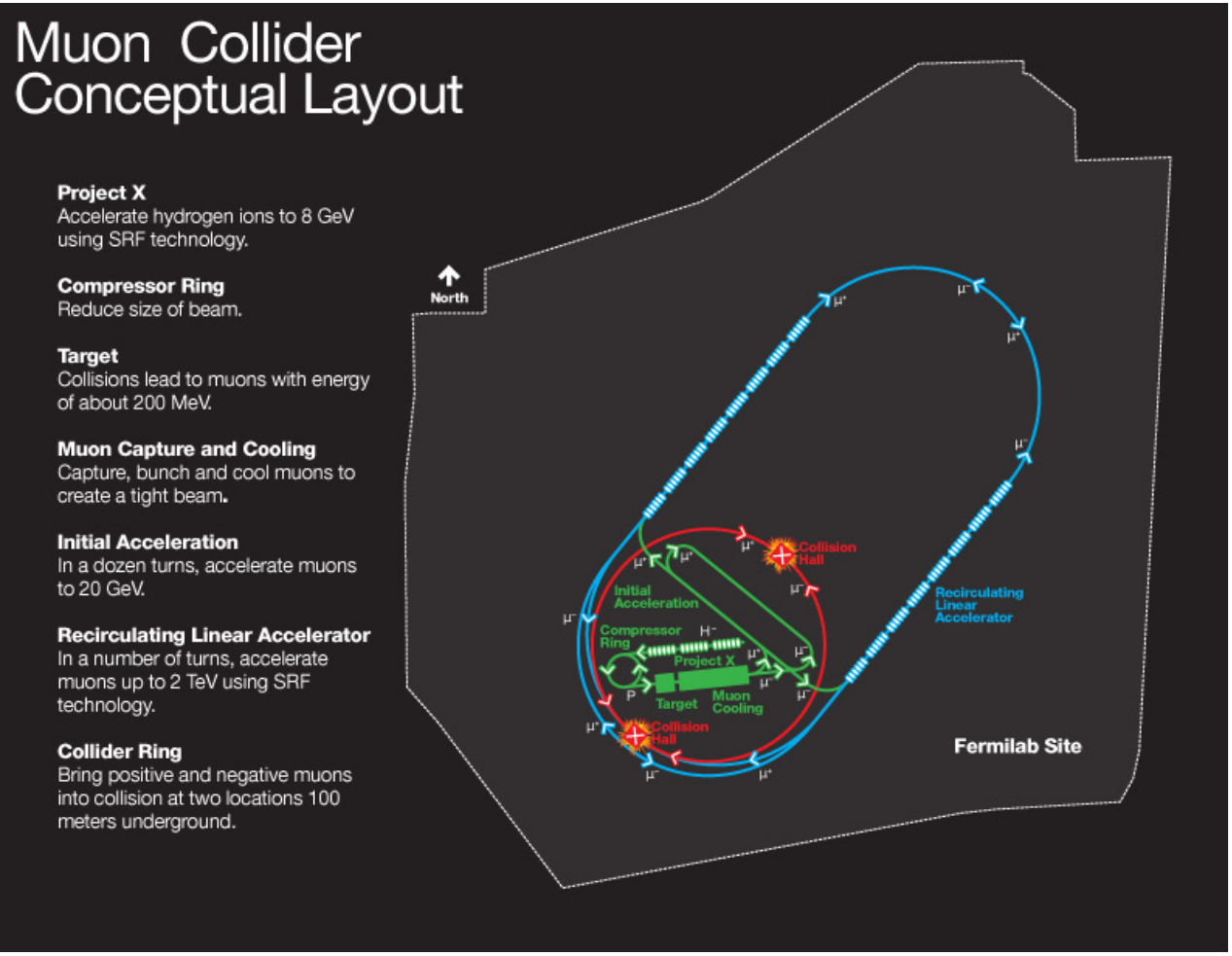
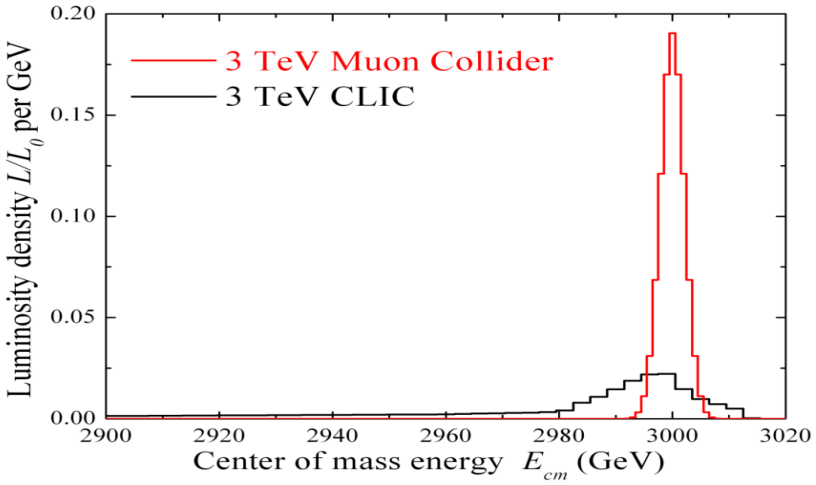
Outline

- Motivation
  - μ^+-μ^- Collider
    - Multi-TeV high-energy collider
- Produce, collect and cool as many muons as possible
  - Start with ν-Factory IDS design study
  - Reoptimize for Collider
    - Shorter bunch train
      - Higher energy capture, shorter front-end
    - Larger gradients
- ν-Factory→μ^+-μ^- Collider
- Discussion

Muon Collider at Fermilab





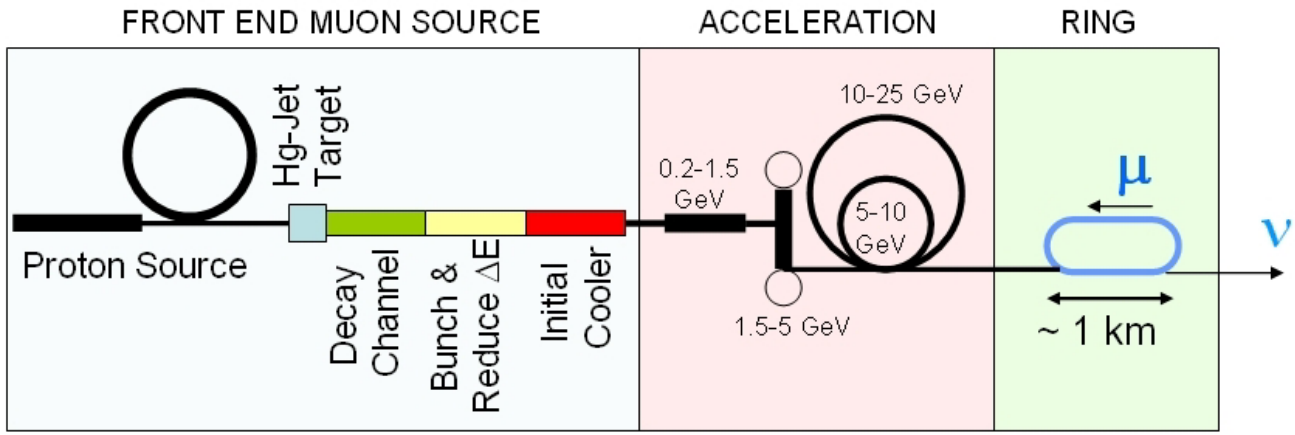
- *Beamstrahlung* in any e^+e^- collider
  - $\delta E/E \propto \gamma^2$

Need ~4MW pulsed proton source from Project X

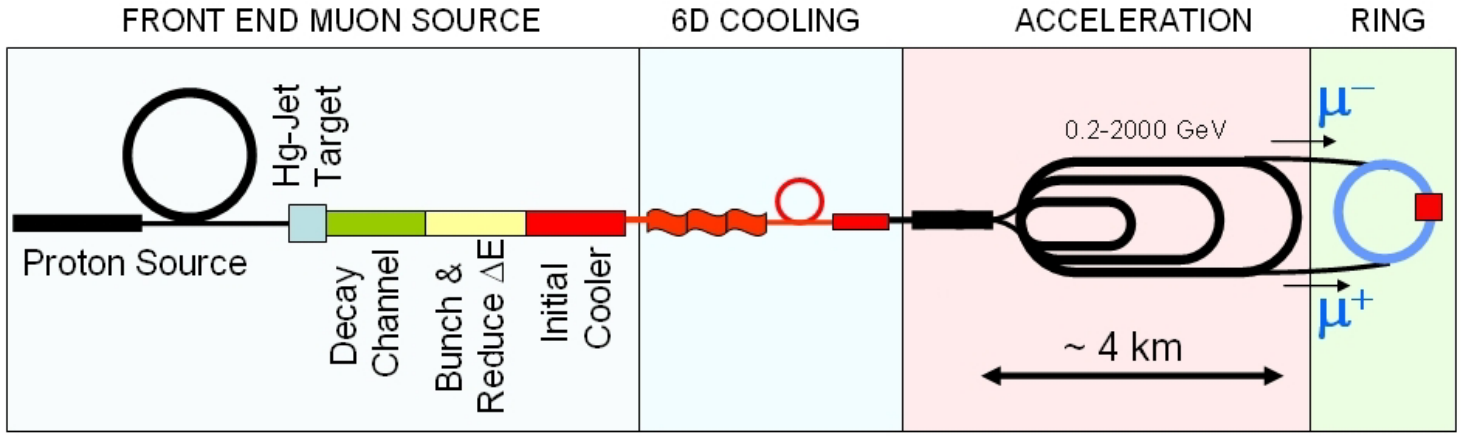
Initial Project X is (currently) cw 3GeV linac
<1G$
will need upgrade

Muon Collider/NF Beam Preparation

- **Baseline Muon Collider beam preparation system identical to that for Neutrino Factory**
  - downstream portions (6D cooling, acceleration, collider) are distinct
    - much more cooling and acceleration needed for collider



Neutrino Factory



Muon Collider

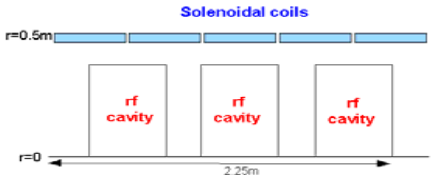
Front End variations

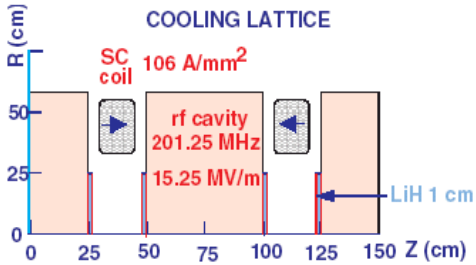
- **Muon Collider front end optimum is somewhat different**
  - Short bunch train preferred
    - Bunches are recombined later …
  - Maximum μ/bunch wanted
  - Longitudinal cooling included; may accept larger δp
  - Larger rf gradient can be used (?)
    - NF will debug gradient limits
    - Cost is less constrained

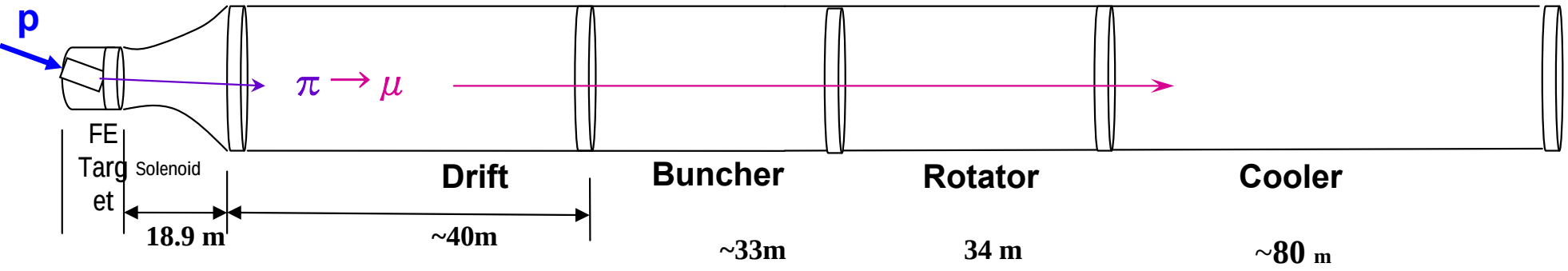
- **For variant, we will have shorter BR system, more gradient, and capture at higher momentum**
  - 230 → 270 MeV/c
  - 150m → 120m
  - 9/12/15 MV/m → 15/16/18 or 15/18/20 MV/m
  - 1.5T→2T

High-frequency Buncher and φ-E Rotator

- Drift (π→μ)
- "Adiabatically" bunch beam first (weak 350 to 232 MHz rf)
- Φ-E rotate bunches – align bunches to ~equal energies
  - 232 to 202 MHz, 12MV/m
- Cool beam 201.25MHz

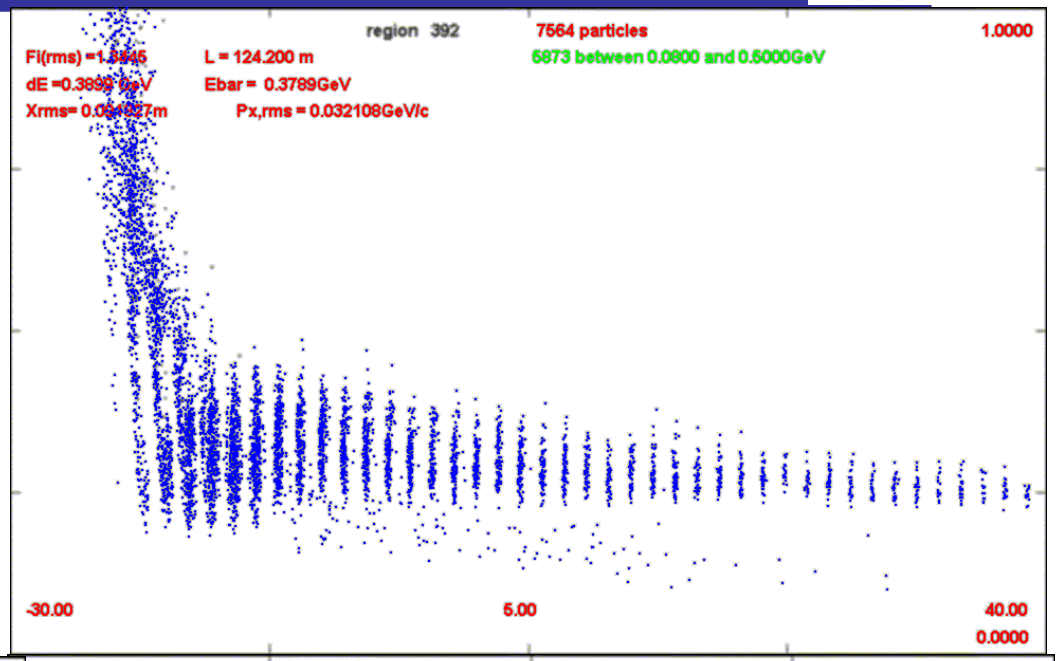


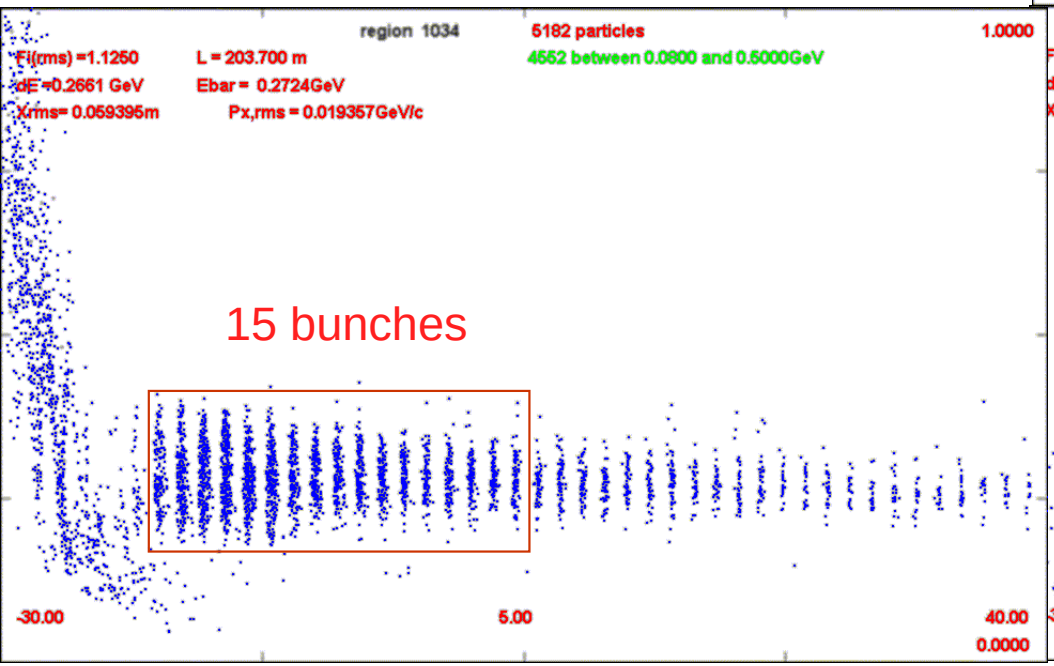


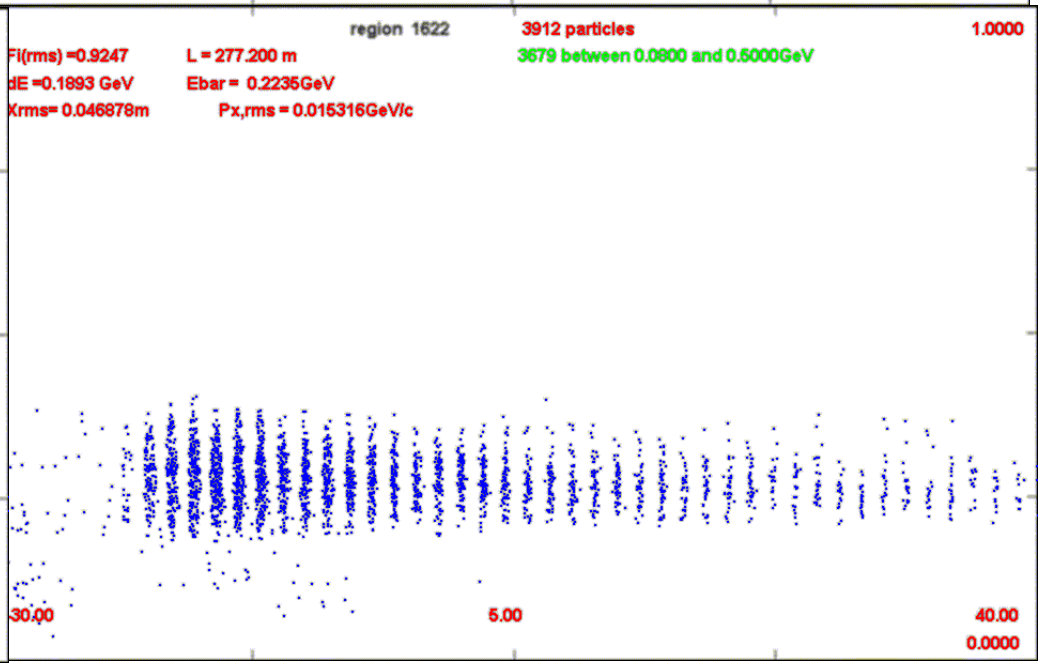


Rotated version

- End up with fewer, denser bunches
  - More μ/p
  - Larger δp

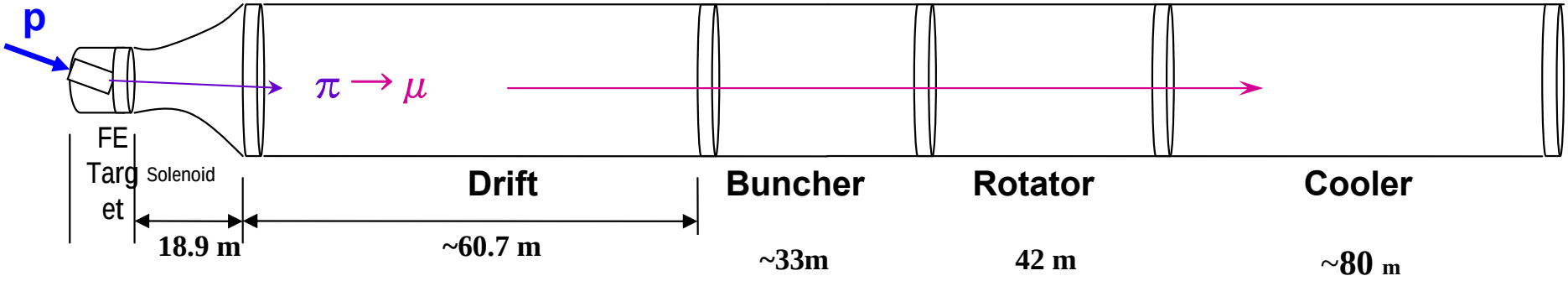


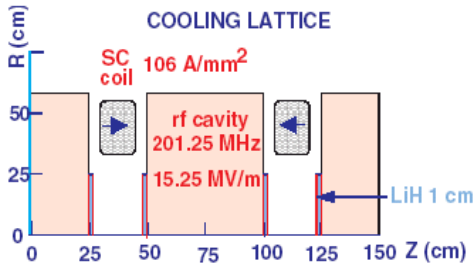


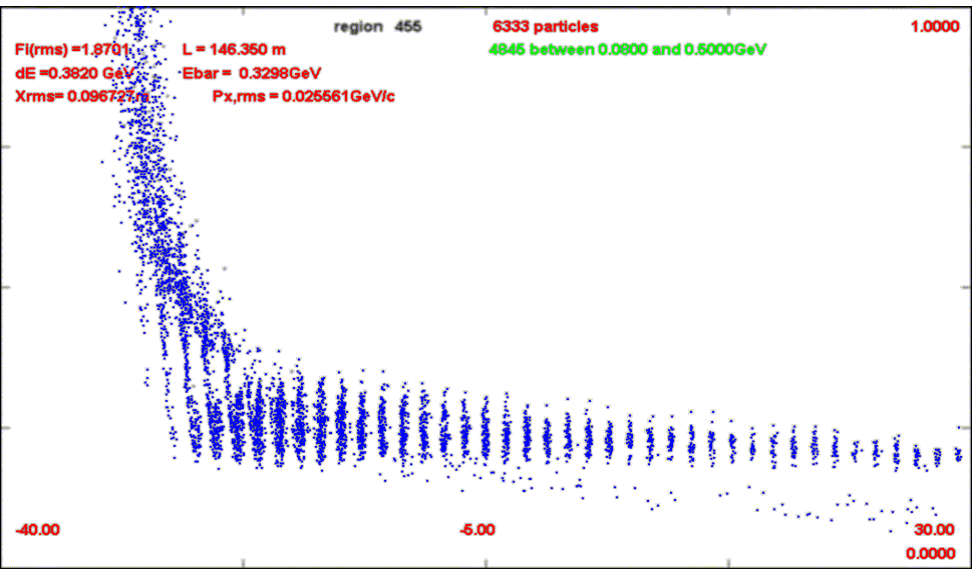


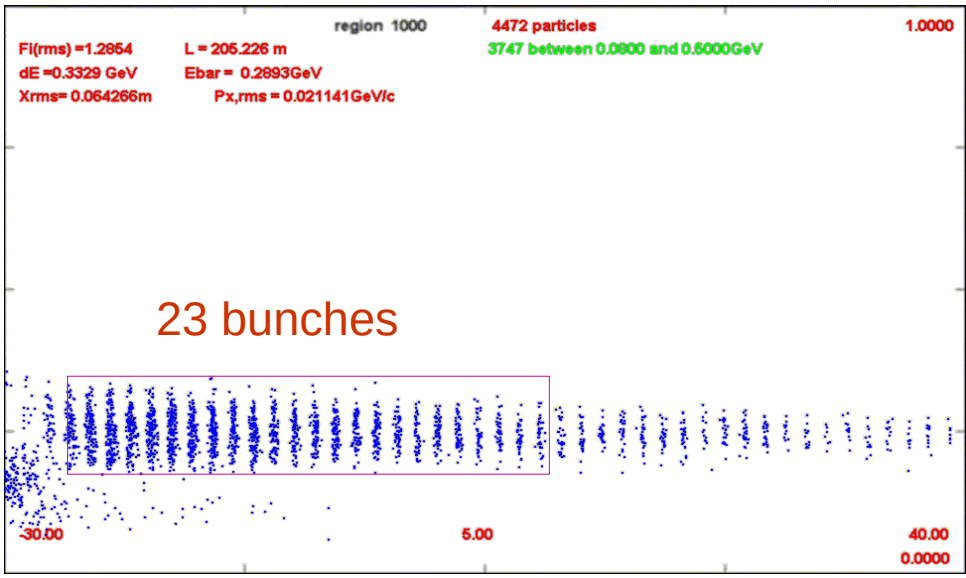
Neutrino Factory version

- NF baseline version



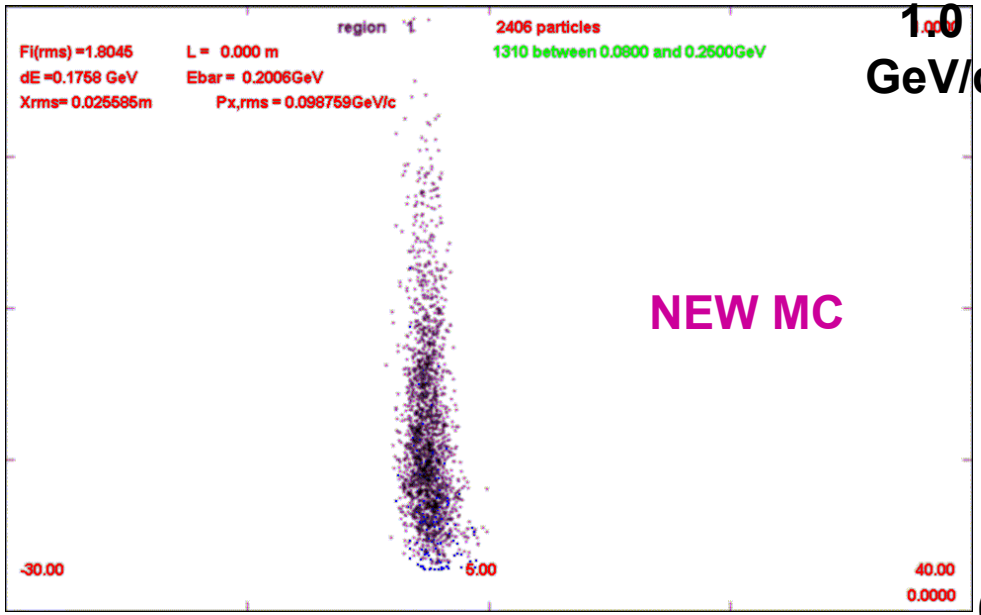


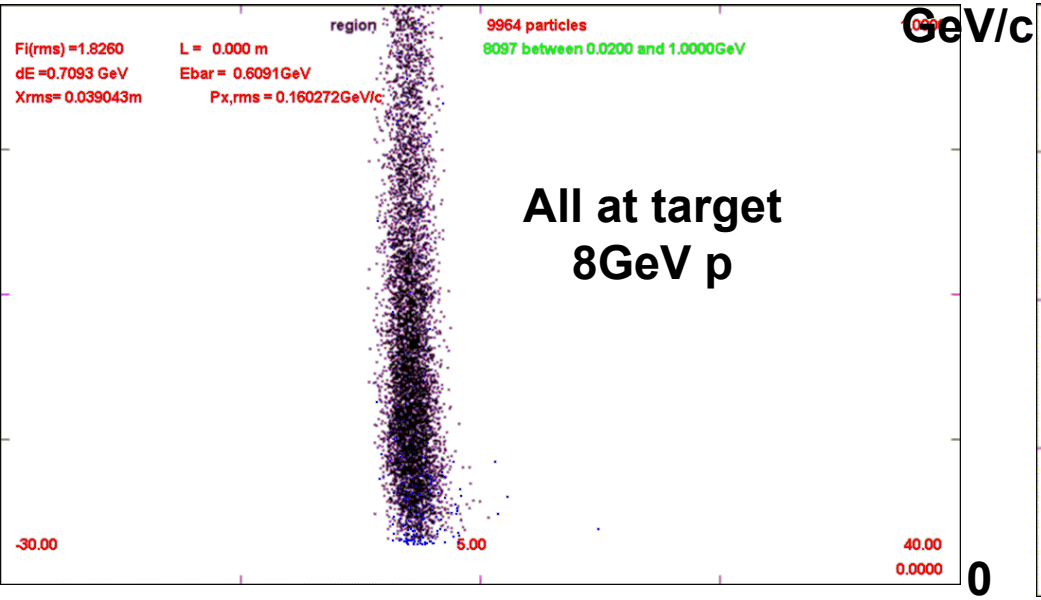


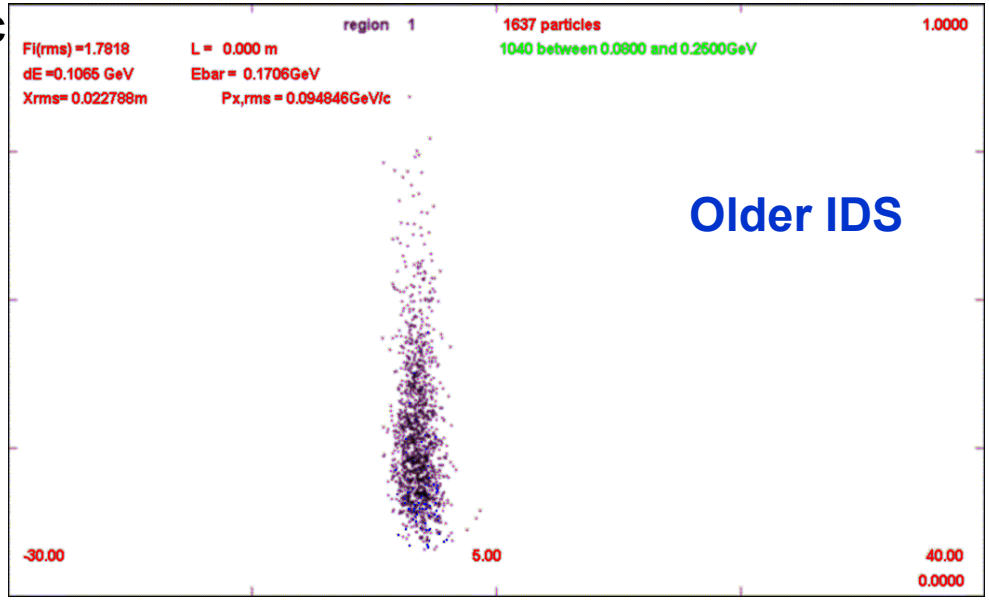


Collider version

- Has ~30% shorter train
- More μ/p
  - ~0.12 μ/p (from ~0.09)
- Captures more of the "core" of the initial π/μ
  - Rather than lower half of the core …

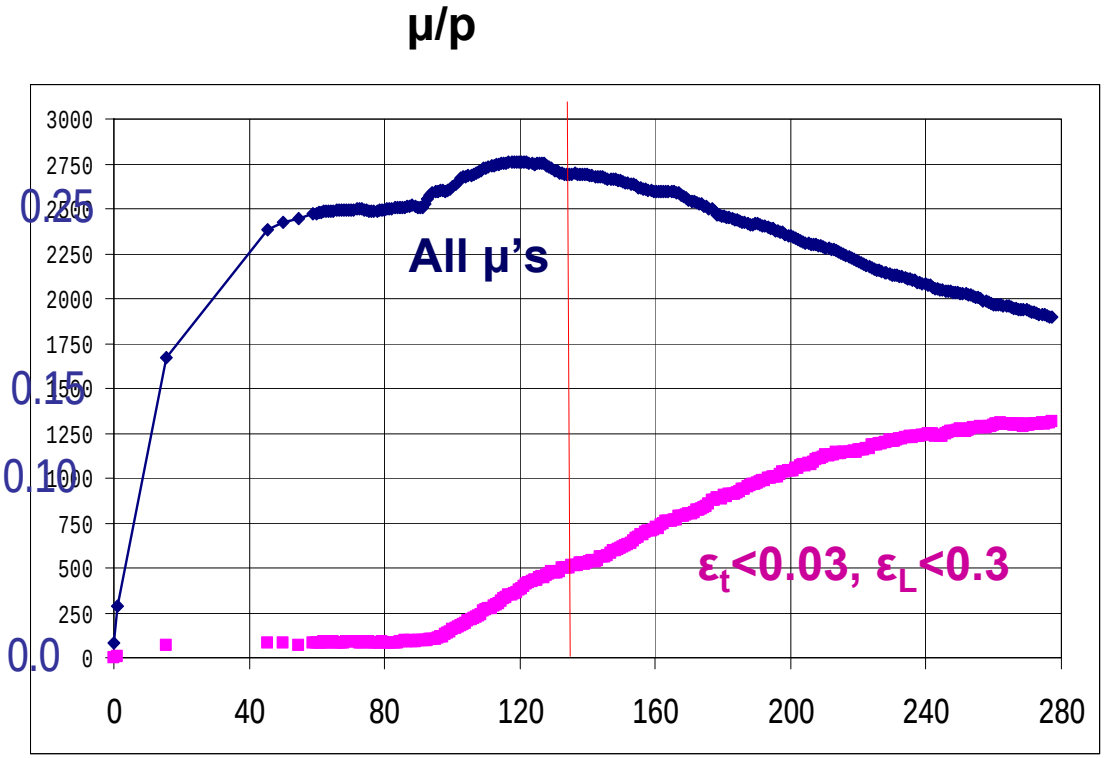






Comments

- **Muon Collider version is an incremental change from IDS**
  - ~25% shorter
  - Higher gradients
    - 9/12/15 → 15/16/18
    - →16/18/20 ?
  - Capture at ~275MeV/c rather than 230MeV/c
- **Collider optimum might be a further increment along … ?**
- **Optimization should include initial cooling with 6-D**
  - Used only transverse in present study, LiH absorbers (~1.2cm)



Thoughts for IDS/NF

- **Shoud central capture momentum be increased**
  - 210 →230→ 270?
- **Would start cooling at higher momentum**
  - Longer channel for cooling
- **Might want to increase acceptance**