# Overview of the Muon Accelerator Front-End

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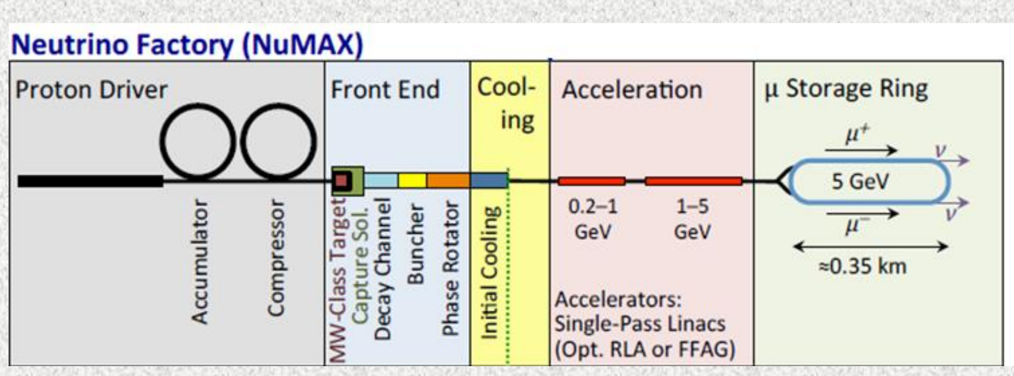
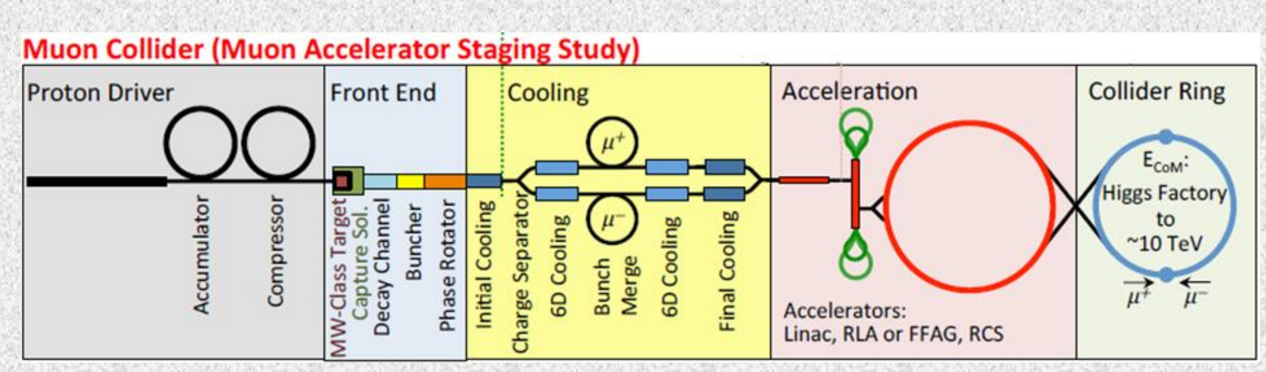
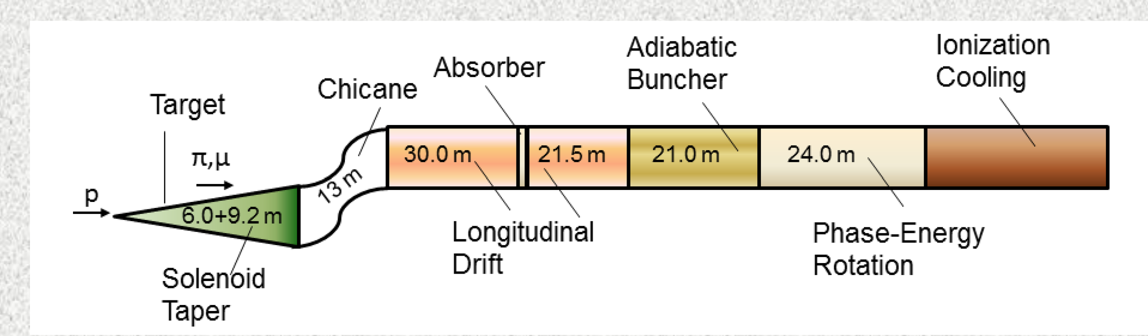
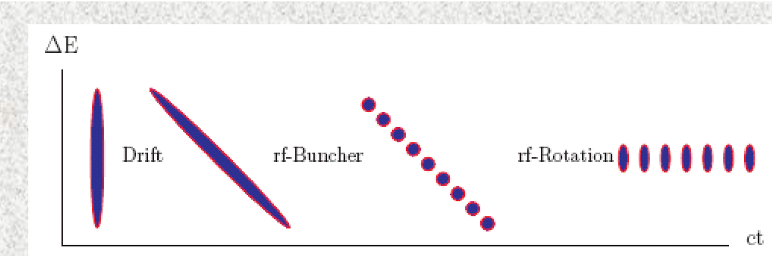
## INTRODUCTION

**Abstract:** A key challenge for muon accelerators is that the initial muon beam occupies a region in phase space that vastly exceeds the acceptance of the downstream accelerators. Here we describe novel method for manipulating the longitudinal and transverse phase-space with the purpose to cool a muon beam. We show that a set of properly tuned rf cavities can reduce the emittance by a factor of three by first forming the muon beams into strings of bunches and then align them to nearly equal central energies. The sensitivity in performance of our proposed channel against key parameters such the number of cavities, accelerating gradient and magnetic field is analyzed.



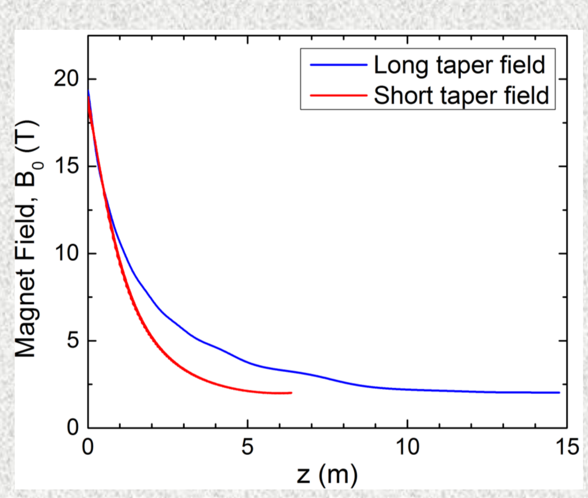



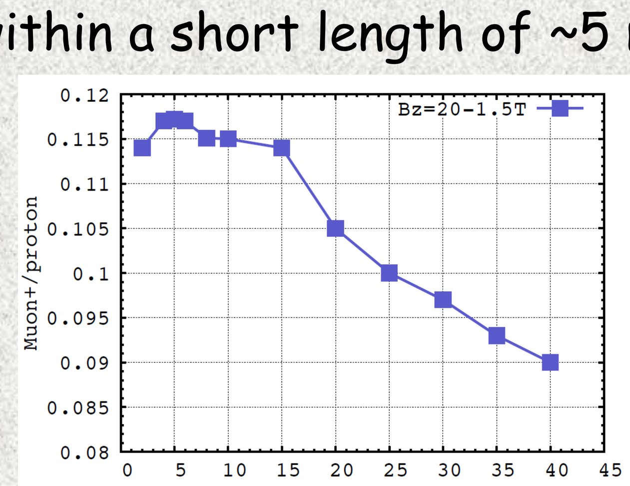

**Beam Manipulation**: FE manipulates the beam phase-space so that it ready downstream accelerators:

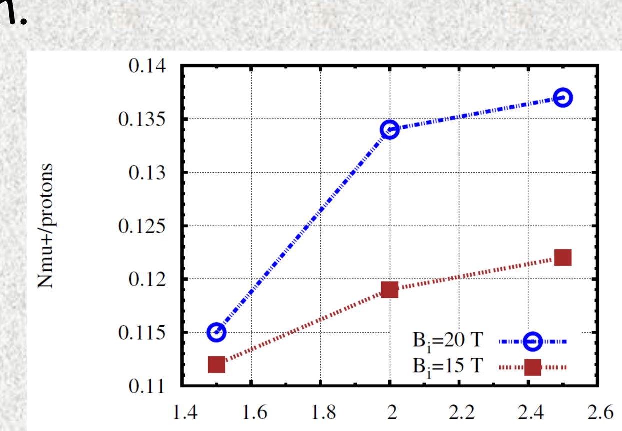
- •Pion capture in a 20 T solenoid
- •Drift and Pion -> Muons
- •Chicane to remove energetic protons
- •Increase progressively rf voltage and bunch the beam
- •Rotate bunches and align to equal energy

## MUON CAPTURE OPTIMIZATION

- •Liquid mercury target, optimized for 8 GeV, 4MW proton driver
- •Inside a 20 T magnet that captures muons of both signs.
- •Optimization studies showed that it is favorable to increase target peak field (20 T), end field (2.0 T) and field taper length ( ~5 m)
- •Current baseline assumes that the 20 T target field drops to 2.0 T within a short length of ~5 m.

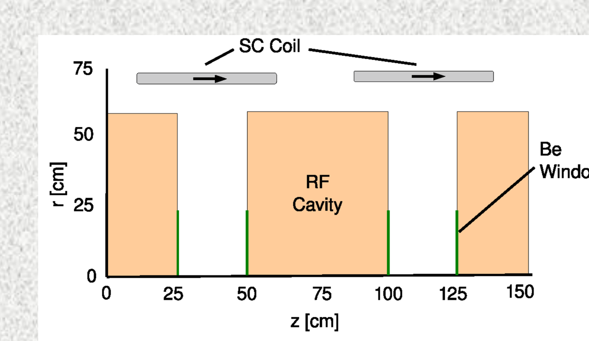



## BUNCHER & PHASE-ROTATOR

- •Buncher & Phase-Rotator match to a 325 MHz cooler
- •RF Frequencies were discretized
- •Buncher has 14 rf frequencies
- •Rotator has 16 rf frequencies
- •Results are sensitive to the rotator rf gradient

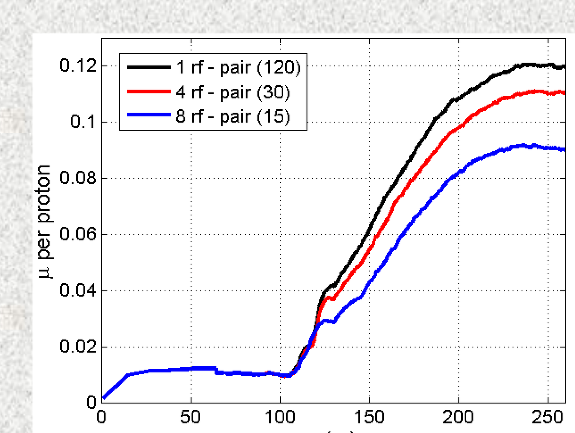


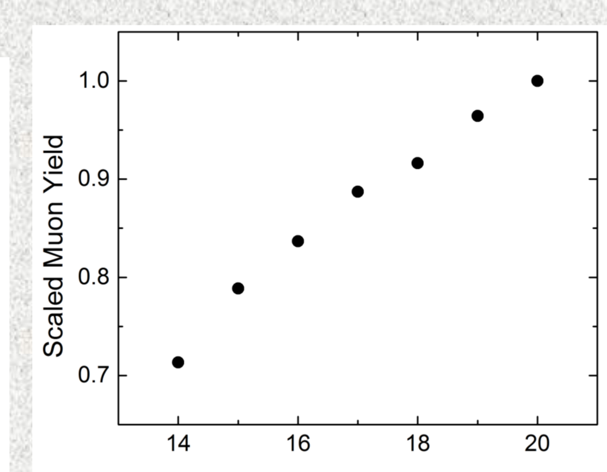

Buncher rf parameters

| Frequency (MHz) | Gradient (MV/m) |
|---|---|
| 493.71 | 0.30 |
| 482.21 | 1.24 |
| 470.27 | 1.95 |
| 458.40 | 3.38 |
| 448.07 | 4.45 |
| 437.73 | 5.52 |
| 427.86 | 6.60 |
| 418.43 | 7.67 |
| 409.41 | 8.74 |
| 400.76 | 9.81 |
| 392.48 | 10.88 |
| 384.53 | 11.95 |
| 376.89 | 13.02 |
| 369.55 | 14.30 |

Rotator rf parameters

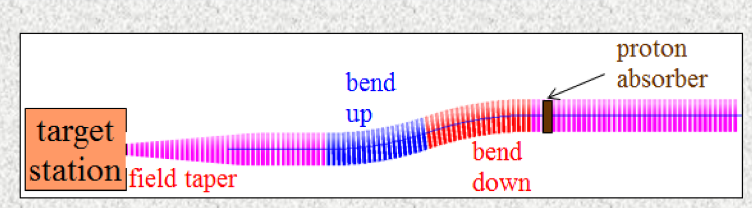
| Frequency (MHz) | Gradient (MV/m) |
|---|---|
| 363.86 | 20.0 |
| 357.57 | 20.0 |
| 352.20 | 20.0 |
| 347.59 | 20.0 |
| 343.65 | 20.0 |
| 340.27 | 20.0 |
| 337.39 | 20.0 |
| 334.95 | 20.0 |
| 332.88 | 20.0 |
| 331.16 | 20.0 |
| 329.75 | 20.0 |
| 328.62 | 20.0 |
| 327.73 | 20.0 |
| 327.08 | 20.0 |
| 326.65 | 20.0 |
| 326.41 | 20.0 |

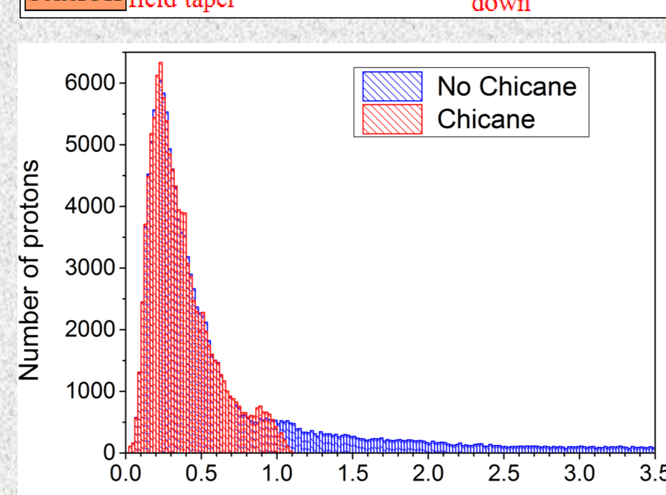


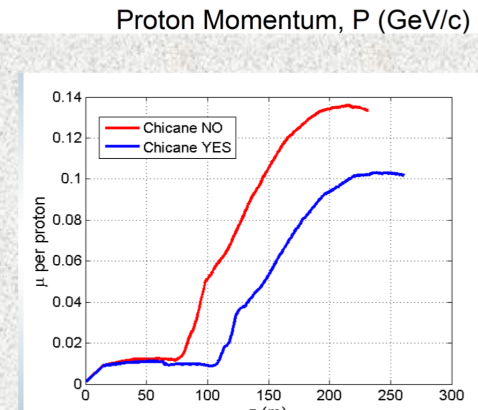




## CHICANE AND ABSORBER SYSTEM

- •Bent solenoid chicane induces vertical dispersion to the beam
  - – High monentum particles scrape
  - – Single chicane for both muons
- •Chicane removes > 700 MeV/c protons
- •Proton absorber removes low momentum protons
- •Absorber was found to stop pions before they decay to muons and was therefore moved downstream by about 30 m from the chicane.
- •Chicane system reduces the muon yield by ~ 15%.
- •Chicane optimization: See TUPME022




## PHASE-SPACE MANIPULATION