D&S: Acceleration

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MAP Collaboration Meeting
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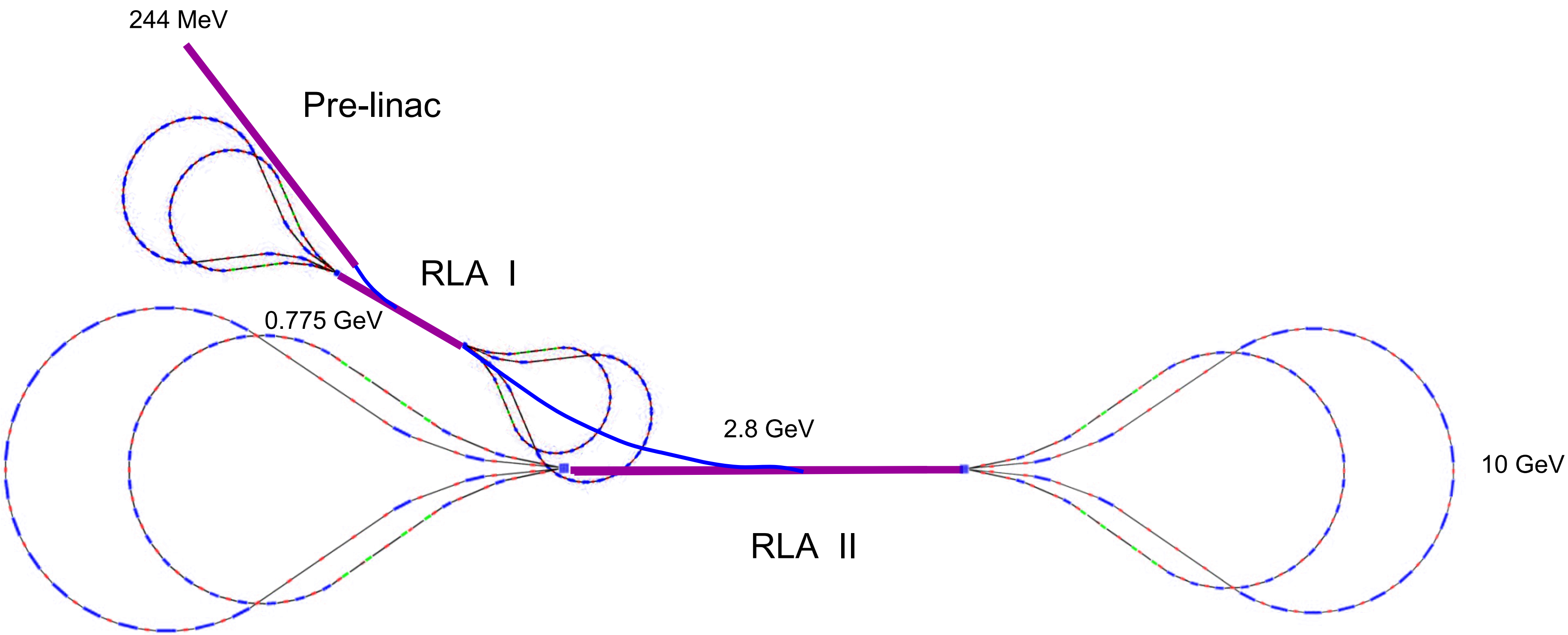
Three Machines

- IDS-NF 10 GeV Neutrino Factory
  - Bunch trains at 50 Hz
  - 30,000 μm normalized transverse acceptance
  - 150 mm normalized longitudinal acceptance
- 63 GeV Higgs factory
  - Single bunch at 15 Hz
  - 300 μm normalized transverse *emittance*
  - 1 mm normalized longitudinal *emittance*
- 750+ GeV muon collider
  - Single bunch at 15 Hz
  - 25 μm normalized transverse emittance
  - 72 mm normalized longitudinal emittance (**huge**)

The Big Picture

- Acceleration for the IDS-NF
  - Large transverse and longitudinal emittances
  - All using 201.25 MHz SCRF
  - Linac to 0.8 GeV
  - 4.5 pass RLA to 2.8 GeV
  - 4.5 pass RLA to 10 GeV
- Muon collider acceleration: working backward
  - Maximize number of passes through RF
    - Keeping average accelerating gradient high
  - Hybrid synchrotron to highest energies
  - FFAGs when hybrid synchrotron can't ramp fast enough
  - RLAs when comparably efficient to FFAG

IDS-NF: Acceleration Layout

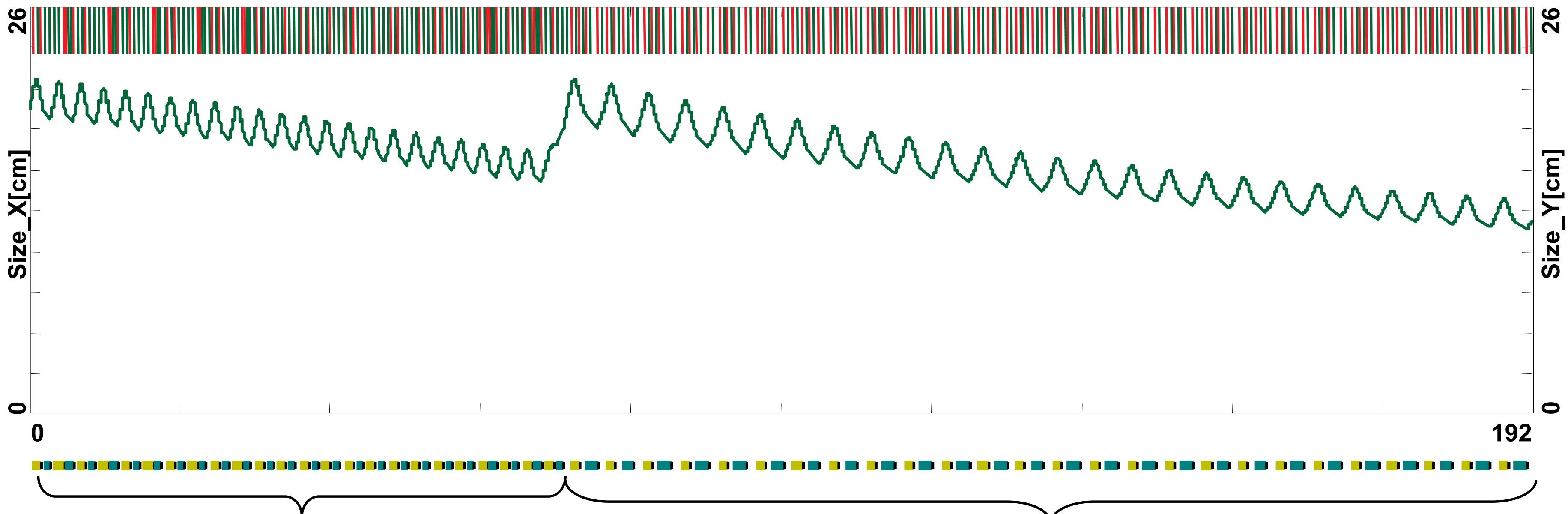


IDS-NF Acceleration

- Solenoid-focused linac from 0.244 to 0.775 GeV
- 25° double arc chicane transfer line
- 4.5-pass RLA from 0.775 to 2.8 GeV, FODO lattice
- 40° double arc chicane transfer line
- 4.5-pass RLA from from 2.8 GeV to 10 GeV, FODO lattice

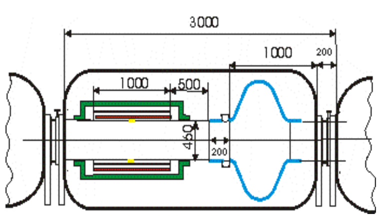
IDS-NF: Linac

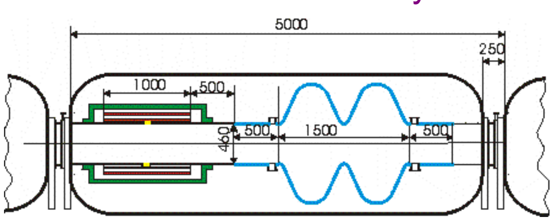
- Compact cells at start: keep beam small
- More efficient cells later



24 short cryos

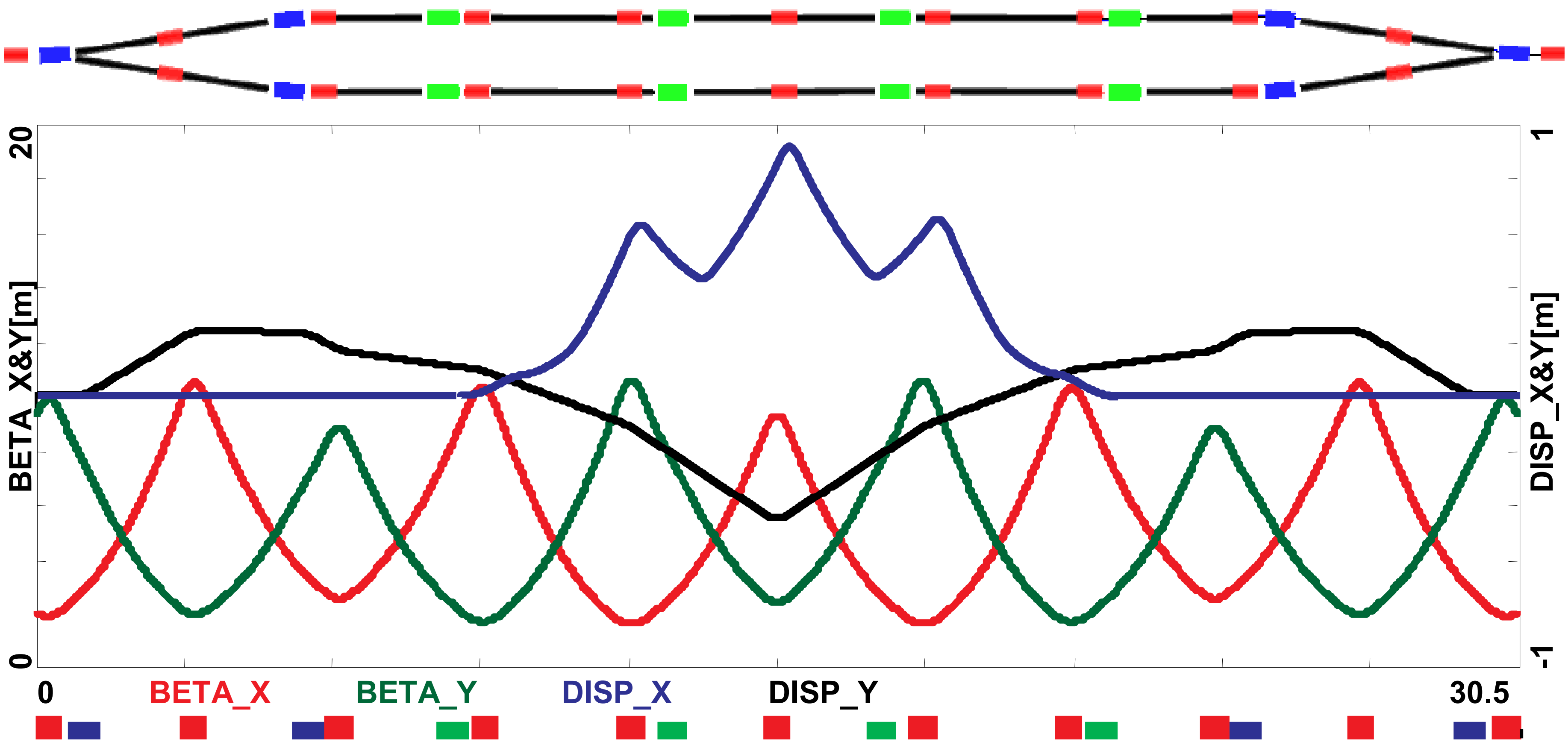
24 medium cryos



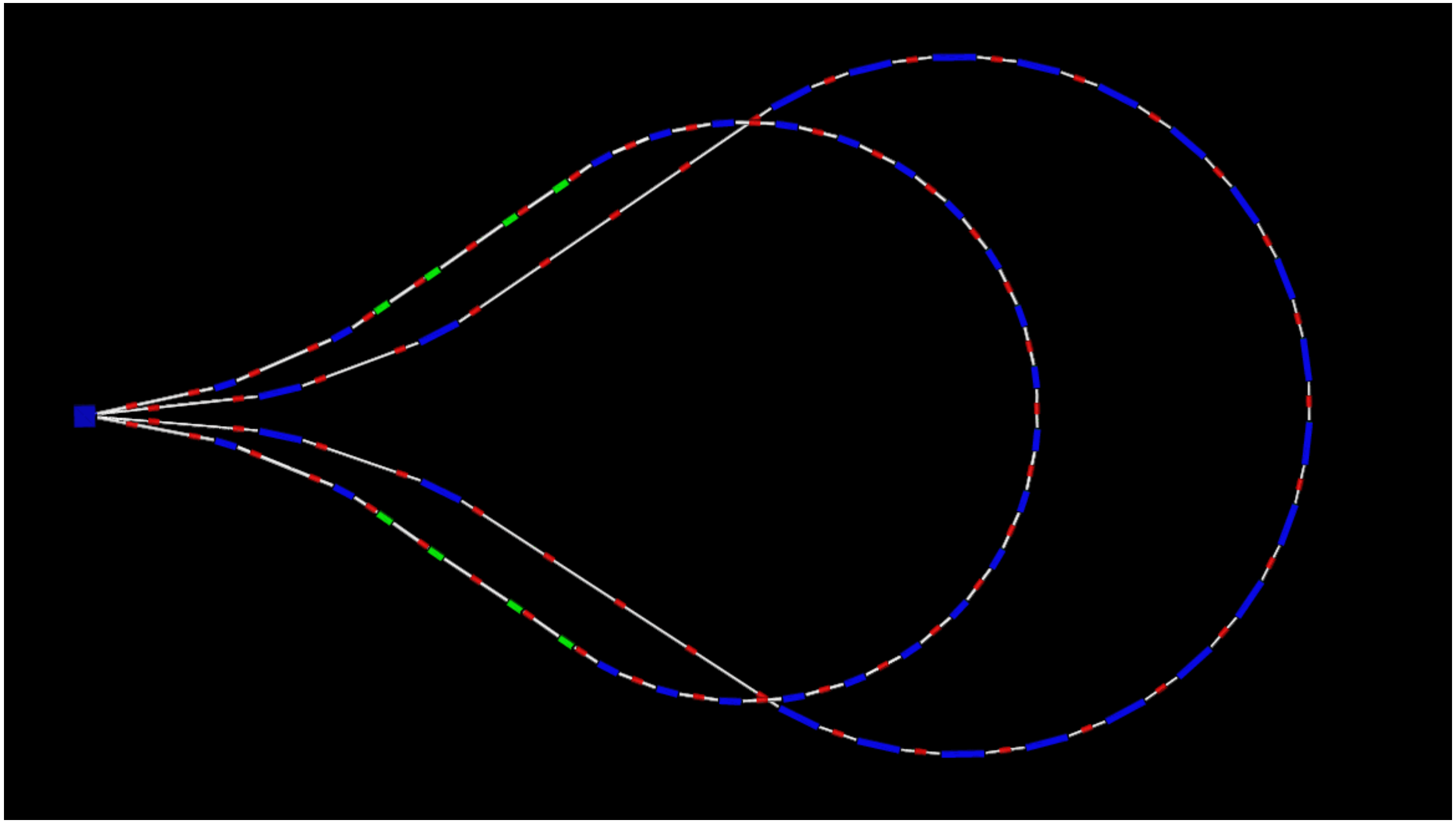


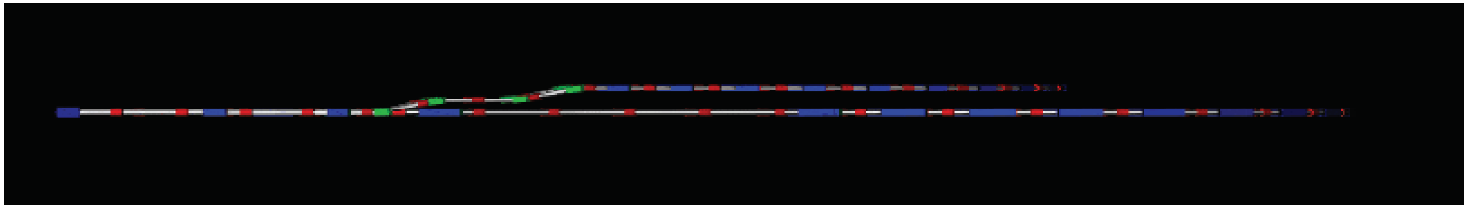
IDS-NF: Double Arc Chicane

- Different signs bend up or down
- Both bend horizontally in same direction



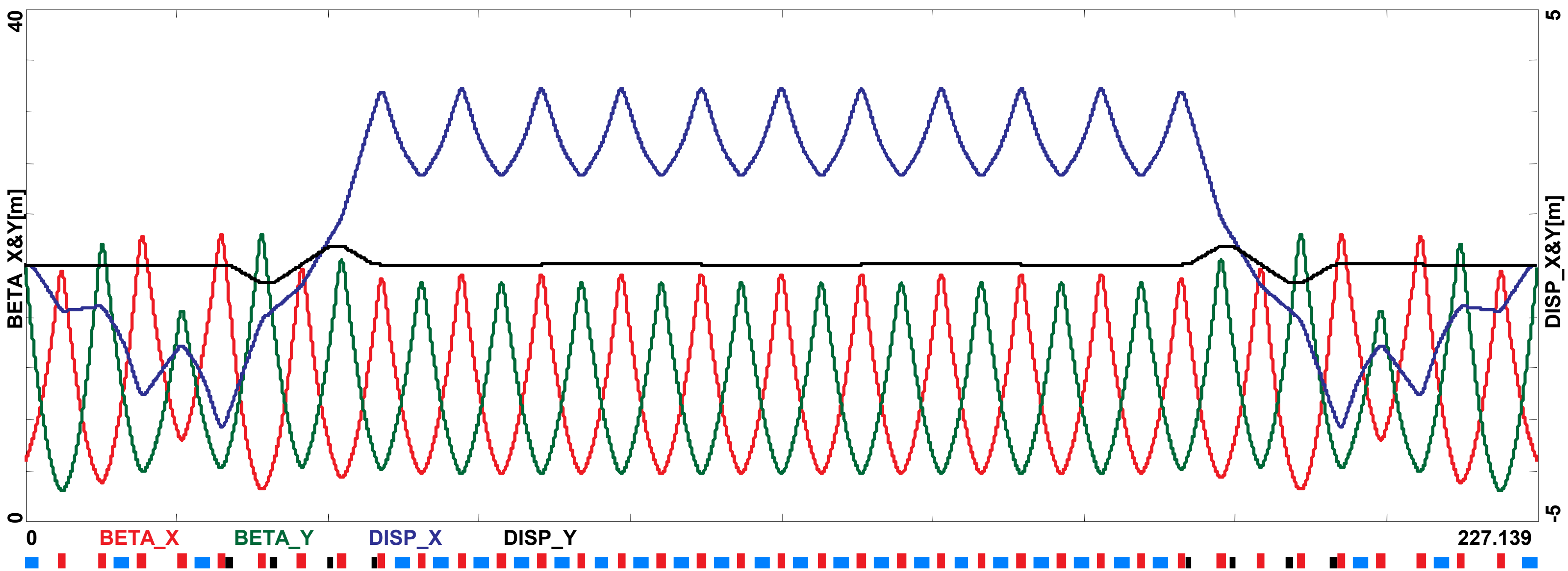
IDS-NF: RLA Arcs





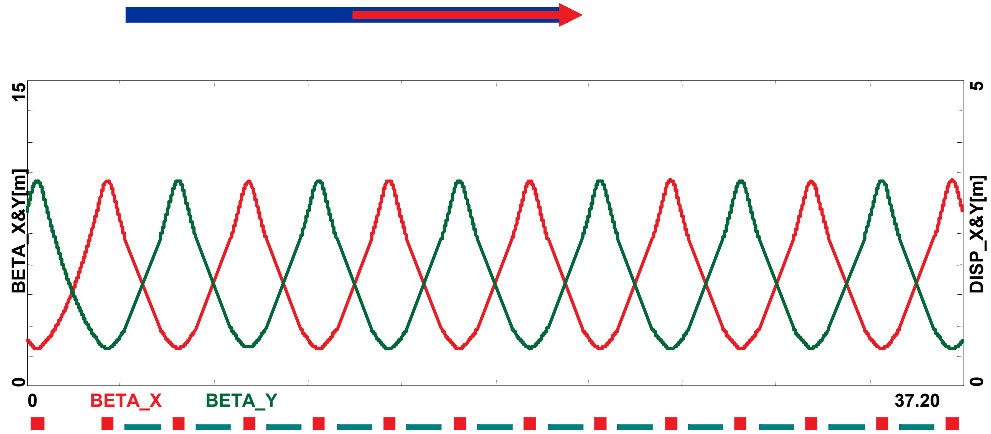
IDS-NF: RLA Arcs

- Arcs vertically separate at crossing
- Vertical dispersion corrected
- Horizontal dispersion flips when curvature direction changes

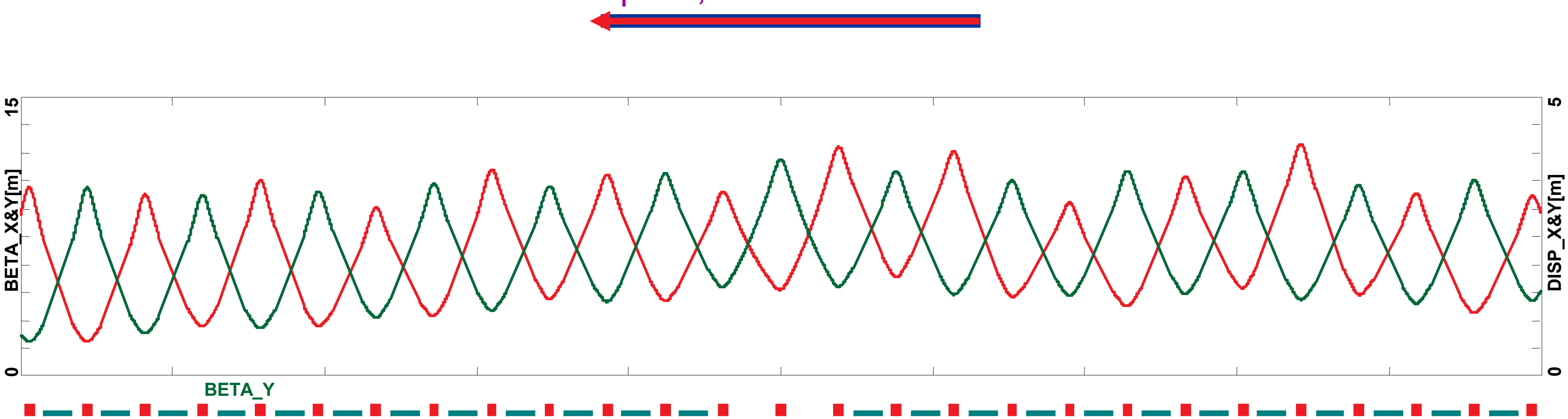


IDS-NF: RLA Linac

‘half pass’, 0.775-1.0 GeV



1-pass, 1.0-1.45 GeV



IDS-NF: RLA Linac

- Injection at linac center
- Quad gradients ramps to keep beta functions flat for first half pass
- Quad gradients reflection symmetric about linac center
- Linac modules in RLA I similar to last part of initial linac, but quad focused
- Linac modules in RLA II have two cavities, smaller aperture, to get better average gradient

IDS-NF Acceleration

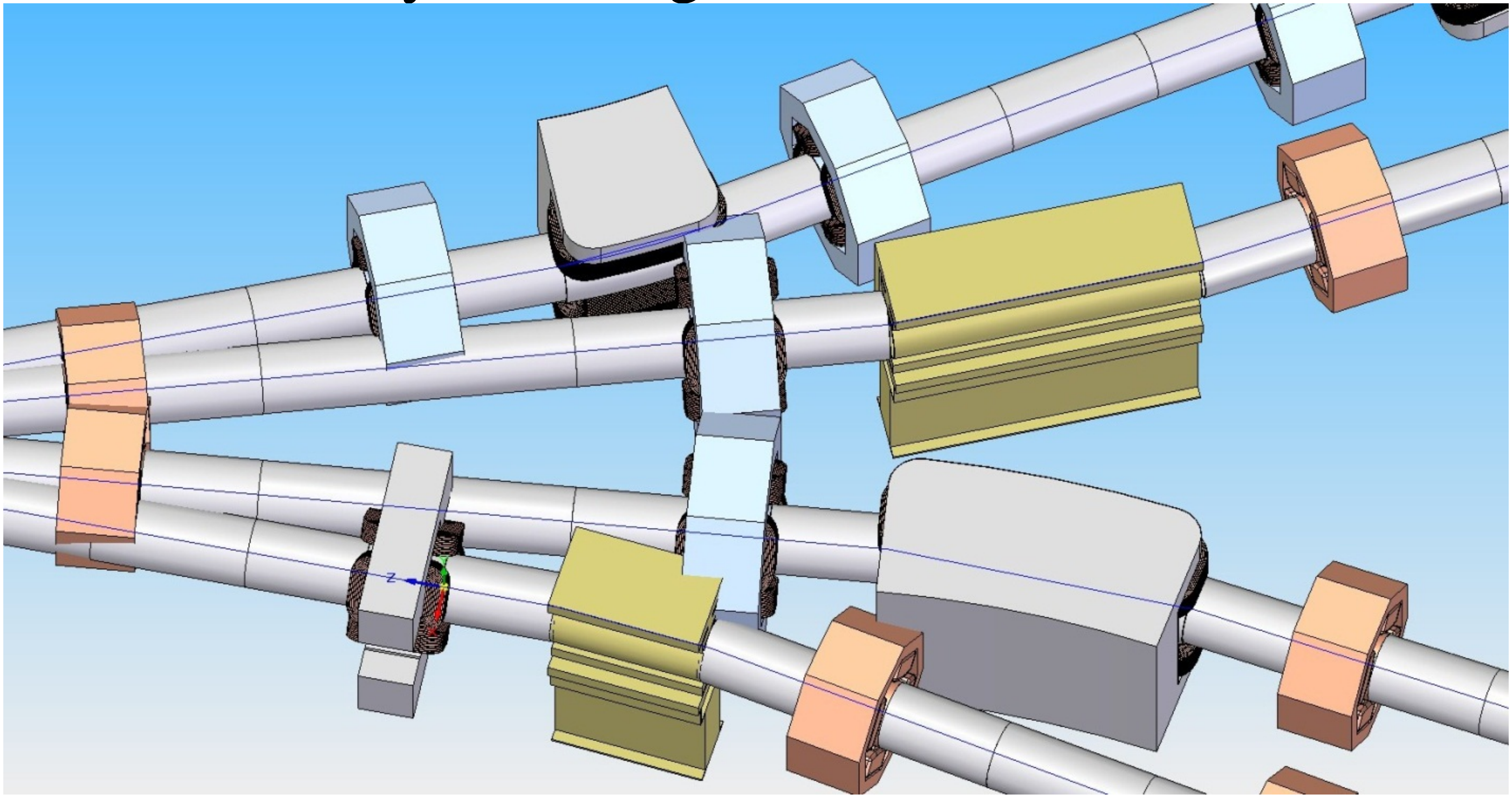
- FFAG dropped from the scenario when energy dropped from 25 GeV to 10 GeV
- Lattices recently completed, but have been mostly stable for a few months
- Engineering effort on full design from UK
  - Lots of thinking about layout and civil
  - Work on cryotstat designs
- Major questions to be addressed in engineering
  - Is it possible to lay out the linac as compactly as designed?
  - Will everything fit into the switchyard?

IDS-NF RLA Switchyard Layout

- Large beam emittance requires magnets near spreader dipole
  - Possibly easier for collider beam parameters
- Current design has magnet/beamline conflicts
  - Can hopefully be addressed with design modifications, but
  - Will not have time to close loop for IDS-NF
- Importance of doing a good engineering layout with RLA designs

IDS-NF RLA Switchyard Layout

Preliminiary, showing some ideas [N. Collomb]



Linacs and RLAs for Muons

- Linac: compact cells at start
  - Needed for large longitudinal emittance
  - Could always switch to expensive acceleration (cooling channel, etc.)
- RLAs: turn limitations
  - What limits the number of RLA passes
  - Switchyard engineering drawings provide important input
  - Can we push to more turns?
  - Important to understand for collider designs

IDS-NF Beam: Tracking Studies

- Large longitudinal and transverse emittance
- Needs 6-D tracking through full system, avoiding approximations
- First attempt done earlier in IDS-NF
  - Not particularly successful
  - Importance of re-turning lattice in tracking code to match tuning parameters of design
- Primary concerns
  - Nonlinear longitudinal-transverse coupling due to lack of chromaticity correction
  - Losses due to longitudinal tail clipping (or effective longitudinal emittance growth)
    - Can propagate to transverse

Other NF Acceleration

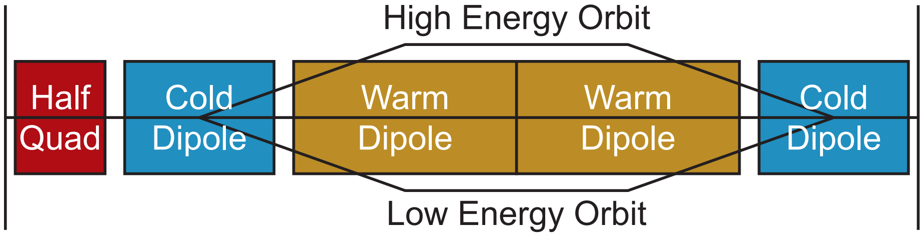
- Neutrino factory acceleration to 5 GeV designed
  - Linac plus one RLA, 325 MHz
- Idea for combining two RLA arcs into a single arc
- FFAG for 25 GeV neutrino factory
  - Design had significant engineering work and feedback
  - Problems with transmission, but cause and solution known
  - Dropped due to reduction in final energy to 10 GeV

Muon Collider Plans

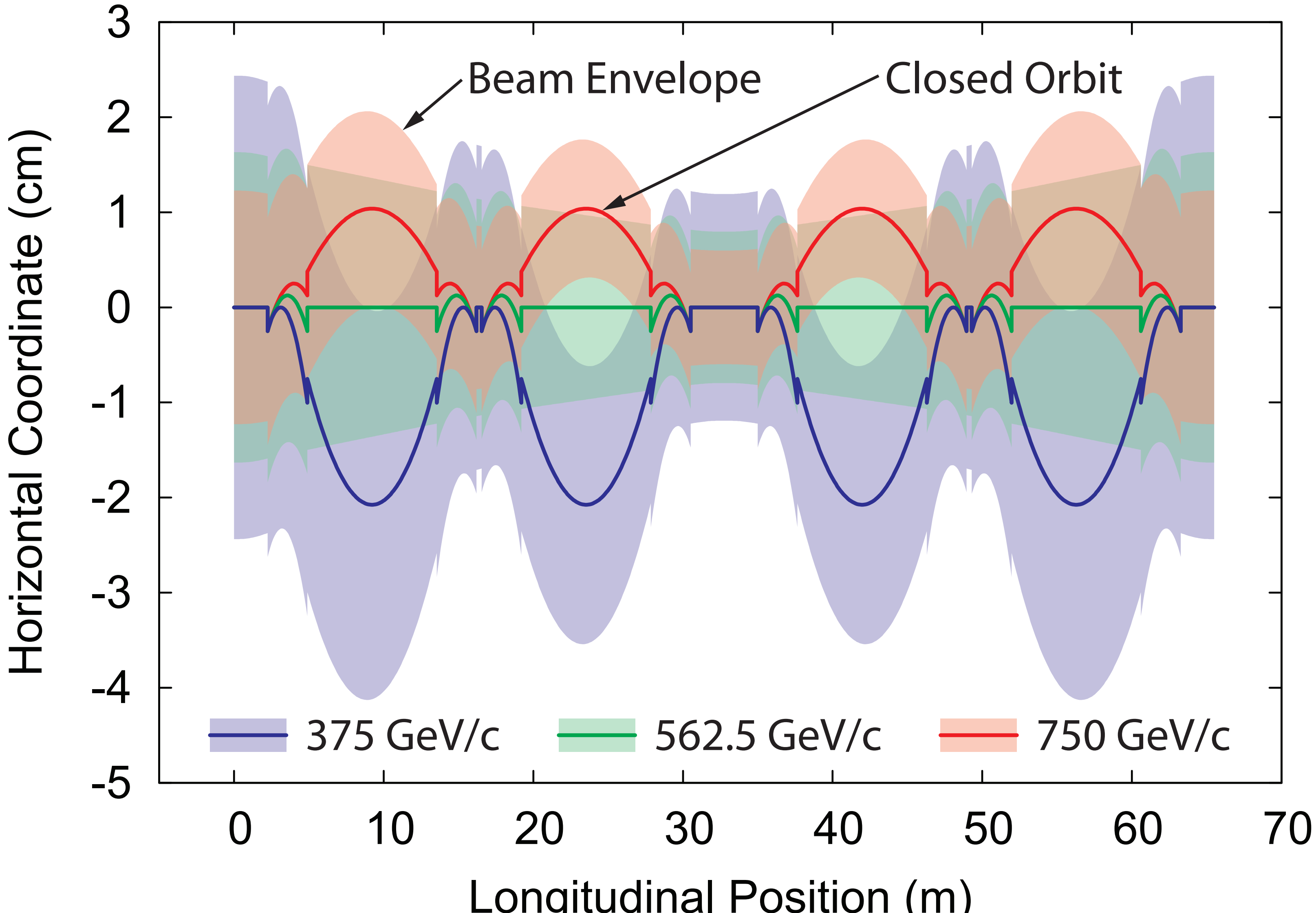
- Goal: baseline designs at end FY 2014
- Challenged by limited manpower
- Keep costs down and efficiencies high by maximizing passes through RF
  - Hybrid synchrotrons at highest energies
    - Limited at low energy due to magent ramp rate
    - Not in Higgs factory
  - FFAGs at intermediate energies
  - RLAs when efficiency no longer favors FFAGs
  - Linac from lowest energy

Muon Collider Plans

- Hybrid synchrotron design
  - Garren design gives proof of principle and first cut at scale and parameters
  - Still needs
    - Chromaticity correction
    - Time of flight correction
      - Will require significant horizontal aperture increase
      - Interaction with chromatic correction
  - Challenges to efficiency
    - Large longitudinal emittance
    - Very high energies: fitting onto site
      - Importance of high fields in ramped magnets

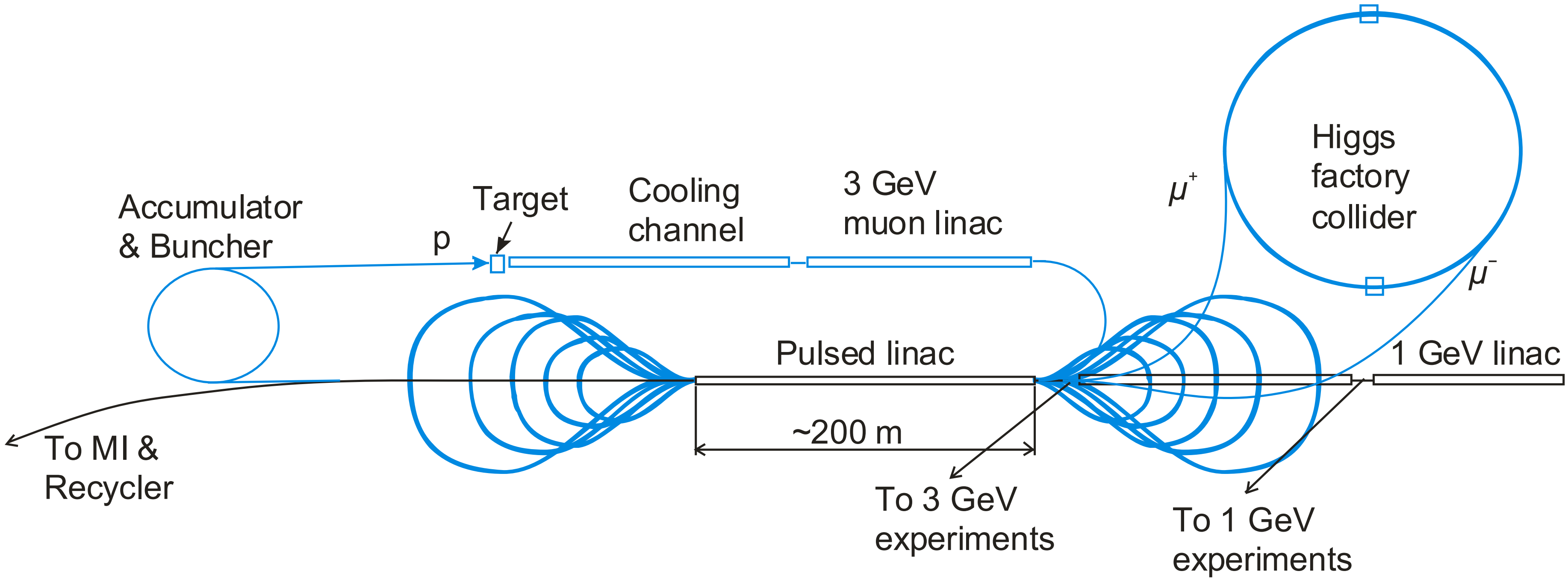


Muon Collider Plans



Muon Collider Plans

- Shared proton-muon linac with muon RLA falling outside this scenario [Lebedev]
  - First pass at design/tracking exists



Muon Collider Plans

- FY13 plans
  - FFAG design work for FFAG to choose breakpoint between RLA and FFAG for Higgs
  - IDS-NF linac and RLA designs
- FY14 plans
  - Linac, RLA, and FFAG parameters for Higgs factory
  - Linac, RLA, FFAG, and hybrid synchrotron parameters for muon collider
- FY15: back to physics
  - Tracking studies in Linac-RLA chain
  - Switchyard and turn limitation studies for RLAs
  - Tracking studies and design optimizations for FFAGs
  - Hybrid synchrotron lattice design