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Transfer Line options optics

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Outline

- Option 1 (crossing through Main Ring Tunnel)
  - Design strategy
  - Site drawing
  - Optics
  - Magnet families
- Option 2 (crossing above Main Ring Tunnel)
  - Design strategy
  - Site drawing
  - Optics
  - Magnet families
- Conclusion

Option 1 transfer line design

- 4 slots for additional cryomodules (HB650) available for SC Linac upgrade (to 1.2 GeV)
- FODO cells with 90° phase advance per cell (H-V)
- 2 arcs of 32 horizontal dipole magnets (8+24)
- Straight section with dump and Mu2e line switch consisting of fast horizontal kicker, slow kicker + corrector and 3-way septum (horizontal)
- Vertical injection into the Booster realized with 3 vertical dipole magnets. The first 2 used for vertical dog-leg and a final C-magnet for injection into the Booster.

Option 1 Transfer Line

Correct:

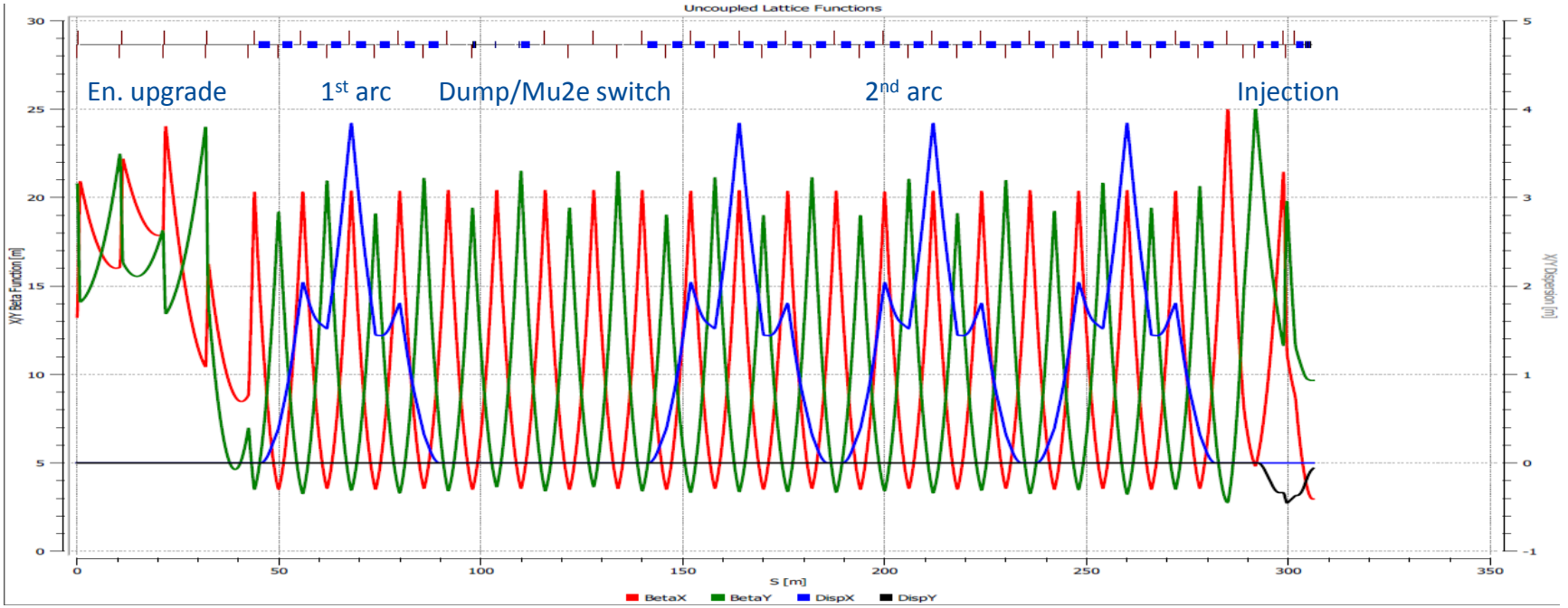
- CAD model of the front end, SC Linac and transfer line lattice and linac gallery.
- Beamline connecting to M4 line for Mu2e upgrade (lattice ready but not showed).

Wrong:

- Dump line position changed to the other side.
- Elevation for main tunnel crossing not designed.
- Switch to dump/Mu2e line revised (but not visible).

Option 1 transfer line optics

Design meets the optical requirements.
Switch to dump/Mu2e line not correctly implemented in the lattice yet but with no impact on the optics.



Magnet families (option 1)

Quadrupole families: 20

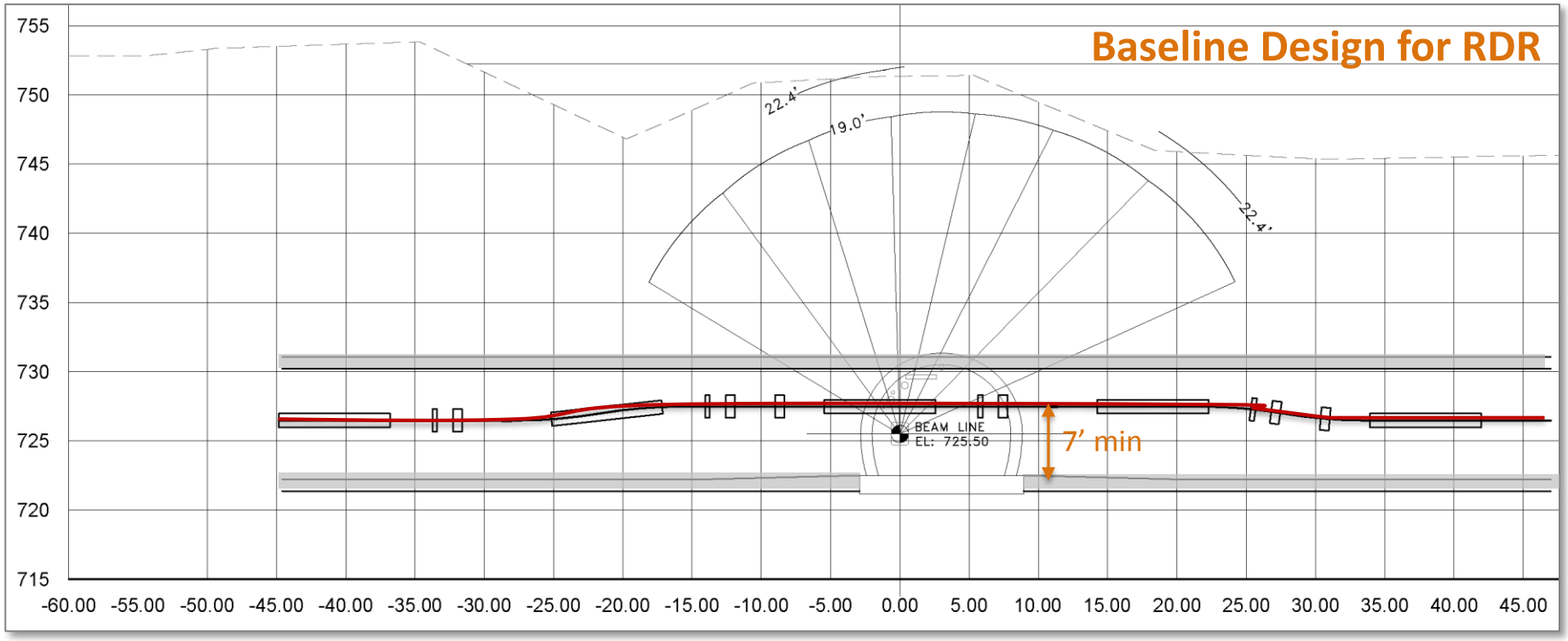
- All F and D quadrupoles in FODO cells and dump line are identical (39+5)
- Quadrupoles in SC Linac upgrade section (10) and quadrupoles at Booster injection (6) are currently in different families (but can be grouped if necessary)
- 2 large quadrupoles used in mu2e/dump line switch

Dipole magnets families: 7

- All bends in arcs and dump line are identical (32+4).
- The 2 vertical bends for Booster injection dog-leg are identical
- C-magnet for injection
- Dump/Mu2e line switch with fast pulsed magnet, slow pulsed magnet and corrector and 3-way septum.

Modifications required (option 1)

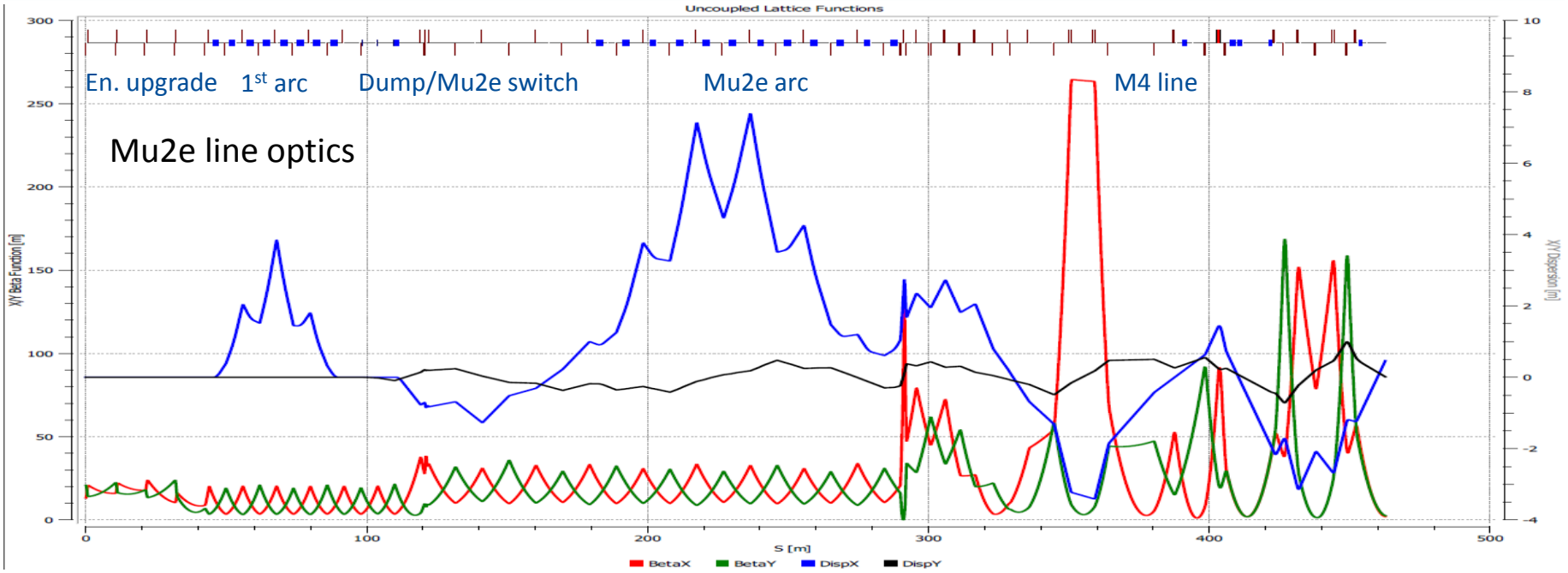
Even in case of option 1 (crossing Tevatron tunnel) the elevation of the transport line needs to be raised by about 3-4 feet when crossing the tunnel. This modification has not been implemented yet in the lattice but due to the small change needed we don't expect significant degradation of the current optics for this option.

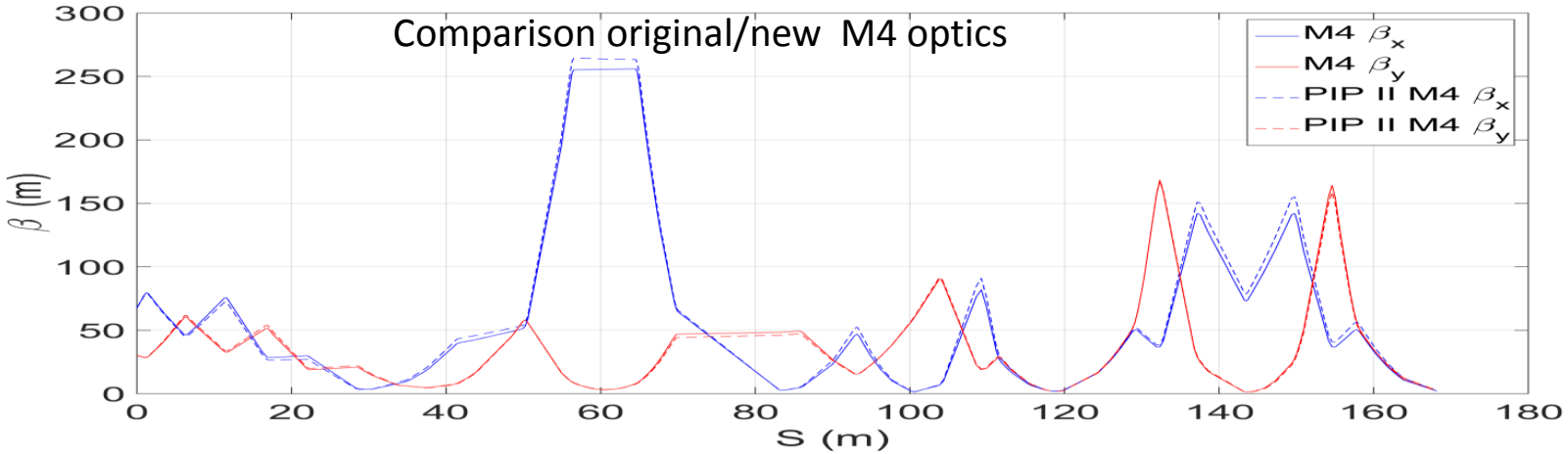


Mu2e line design (option 1)

- Connection from Mu2e switch in straight section to line M4 used by Mu2e experiment
- Preserve the optics of the original line (PIP II beam should be smaller than Mu2e beam) to avoid problems with apertures.
- Preserve elements and configurations of the original line to minimize changes necessary for upgrade.
- Employment of a 12-bend arc to connect to M4 line with first and last bends rolled to cover the different elevation (1.8 m).
- Use FODO cell lattice like for Booster transfer line.

Mu2e line optics (option 1)





Magnet families for Mu2e line (option 1)

Quadrupole families: 10

- All F and D quadrupoles in FODO cells for Mu2e line are identical (18)
- Quadrupoles used for matching (8) are currently in different families (but can be grouped if necessary)
- Quadrupoles used in M4 line (not counted)

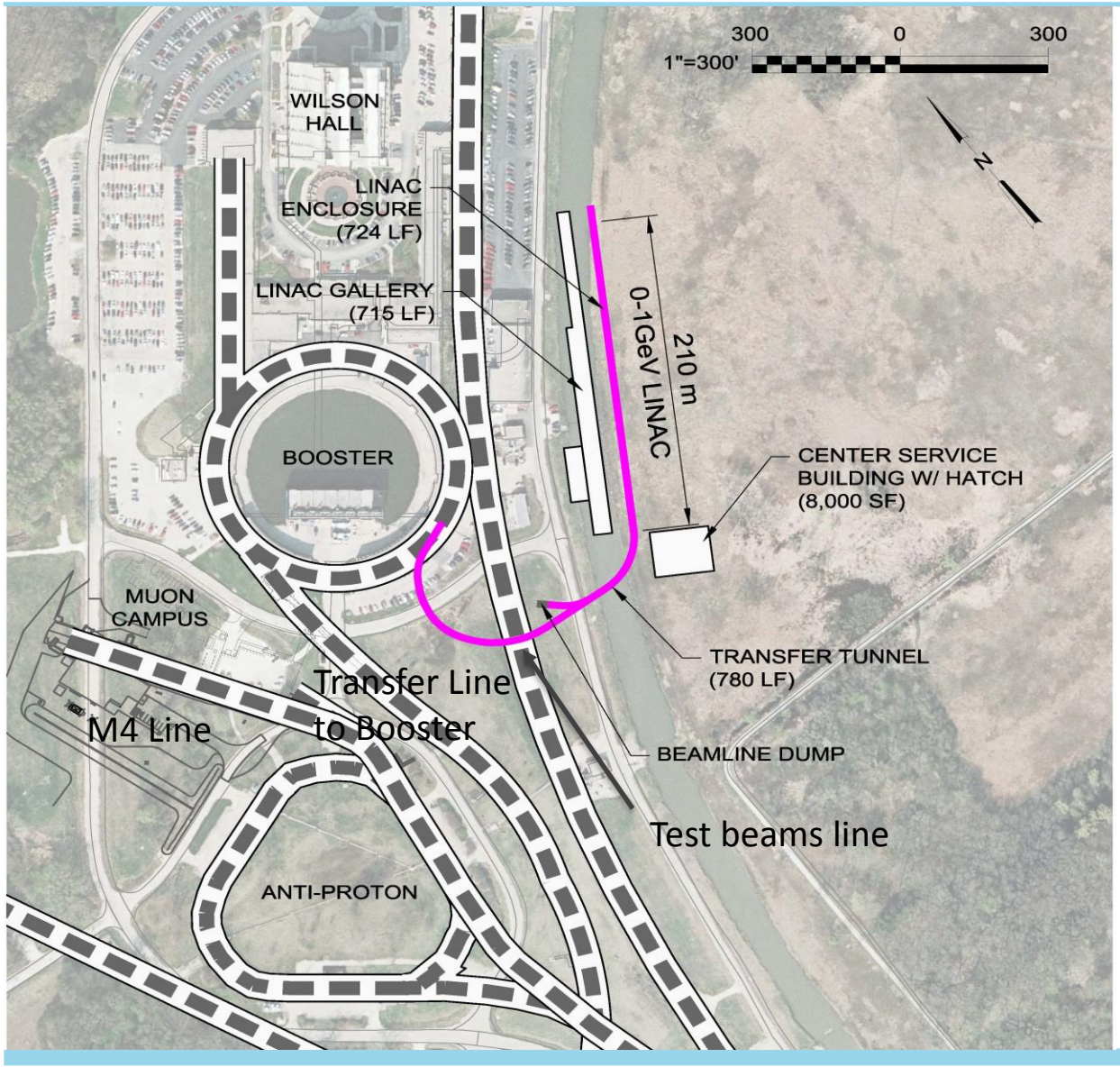
Bends families: 1

- All dipole magnets in the arc are identical (12).
- Dipole magnets used in M4 line (not counted)

Option 2 transfer line design

- Options are similar up to the start of the second arc (different field strength in the magnets)
- Design of option 2 using same element types/numbers of option 1
- Second Arc passes above Tevatron tunnel and so does the Mu2e line.
- Change in elevation of the line obtained by rolling the existing dipole magnets (no additional bends)
- Beamline bump is compact to reduce extra shielding on the surface.
- Reduction of the dispersion by rolling the other bends.

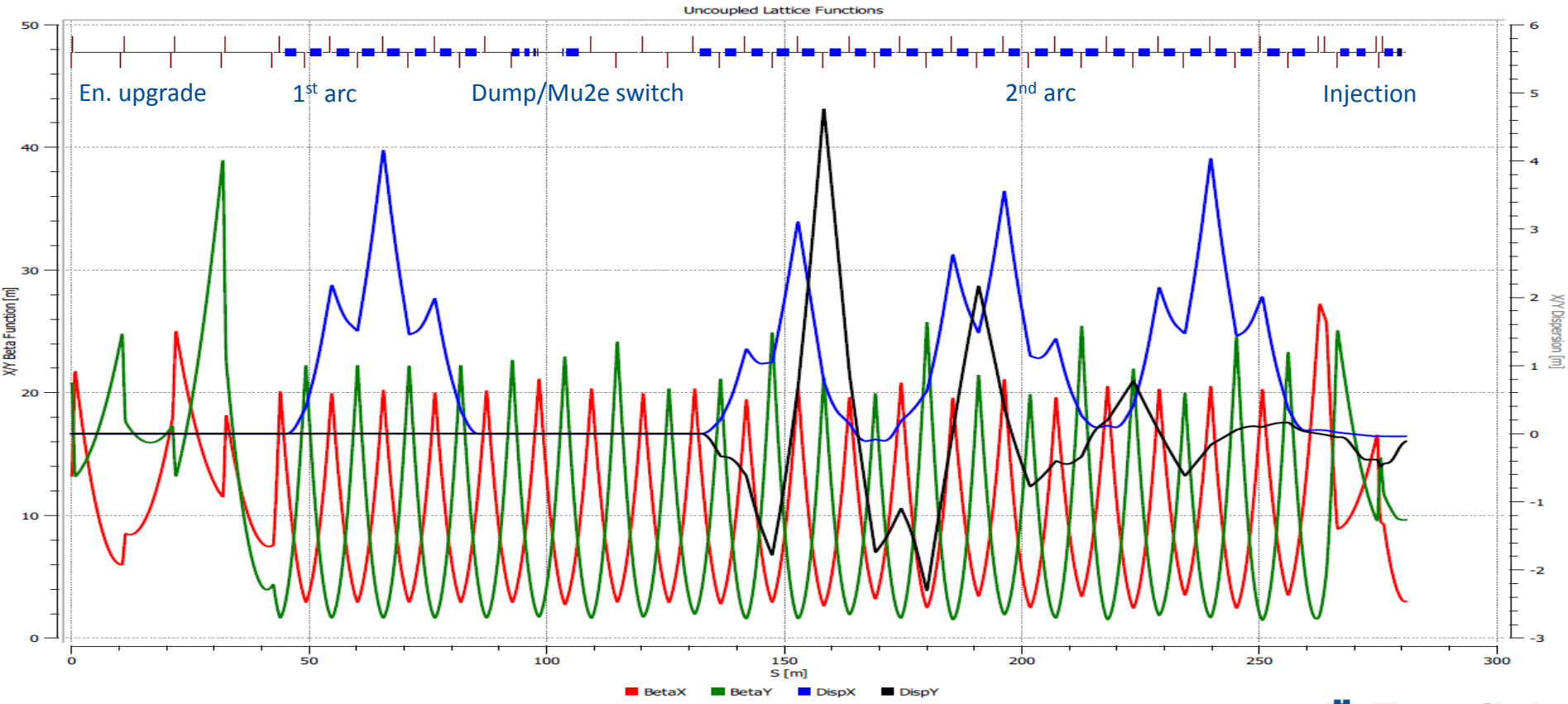
Transfer Line (option 2)



- CAD model for the transfer line not ready yet.
- Linac front end, SC Linac and linac gallery unchanged.
- Switch to dump/Mu2e line almost ready.
- Beamline connecting to M4 line for Mu2e upgrade not yet designed.
- Dump line correct

Option 2 transfer line optics

Design meets the optical requirements.
Switch to dump/Mu2e line not correctly implemented in the lattice yet but no impact on optics.



Option 2 Magnet families

Quadrupole families: 20

- All F and D quadrupoles in FODO cells and dump line are identical (39+5)
- Quadrupoles in SC Linac upgrade section (10) and quadrupole at Booster injection (6) are currently in different families (but can be grouped if necessary)
- 2 large quadrupoles used in mu2e/dump line switch

Bends families: 7

- All bends in arcs and dump line are identical (32+4).
- The 2 vertical bends for Booster injection dog-leg are identical
- C-magnet for injection
- Dump/Mu2e line switch with fast pulsed magnet, slow pulsed magnet and corrector and Lambertson septum.

Same as for option1 transfer line but field strength increased of 10-15%

Conclusions

- Design of the transport line have been realized for the 2 options of main ring intersection considered. Both designs fulfill optics requirements.
- Designs are very similar up to the 2nd arc (same dump line and dump/Mu2e line switch).
- Mu2e line for option 2 not yet designed but should be possible to use same element types/numbers of option 1.

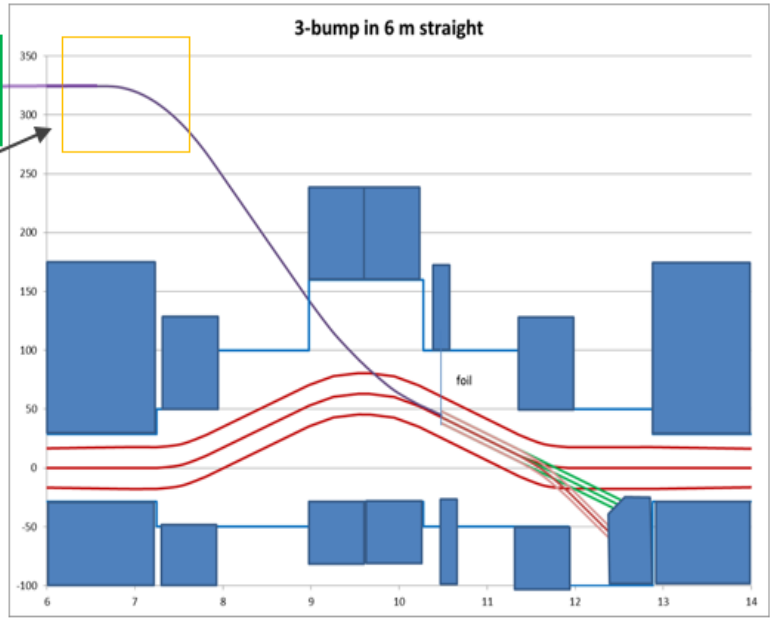
Backup

Booster injection scheme

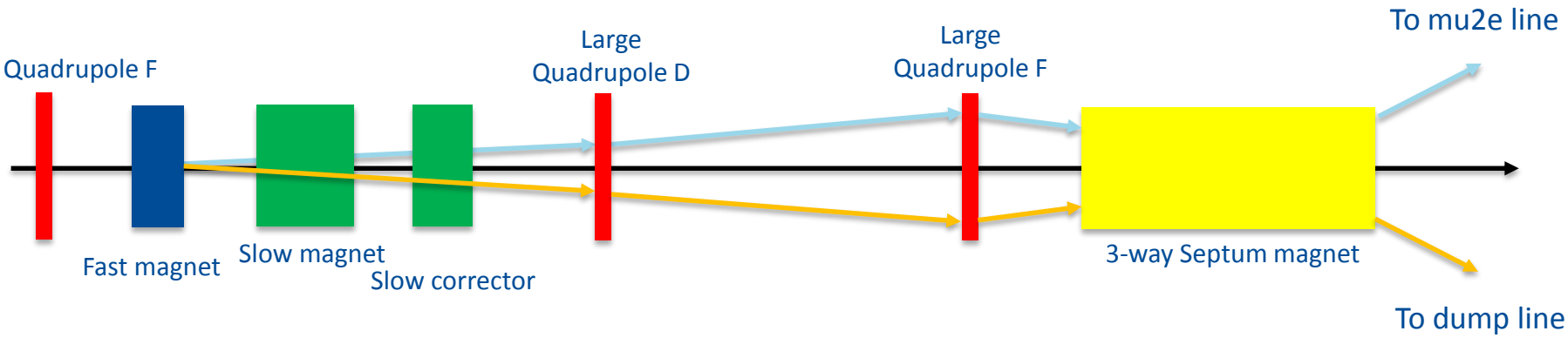
N. Bends = 3
N. Quadrupoles = 6

Dog-leg bends
Length = 1.8 m
Magnetic Field ~ 2.5 kG

C-magnet
Length = 1.8 m
Magnetic field ~ 3.3 kG
Vertical half-size < 160 mm



Dump and Mu2e line switch



Dump line optics