Optimized Beam Optics for Muon Acceleration

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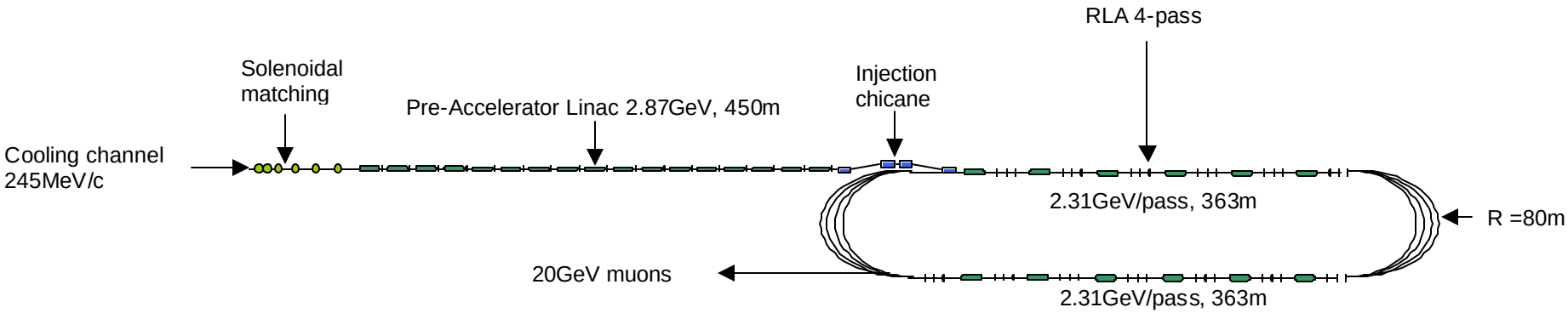
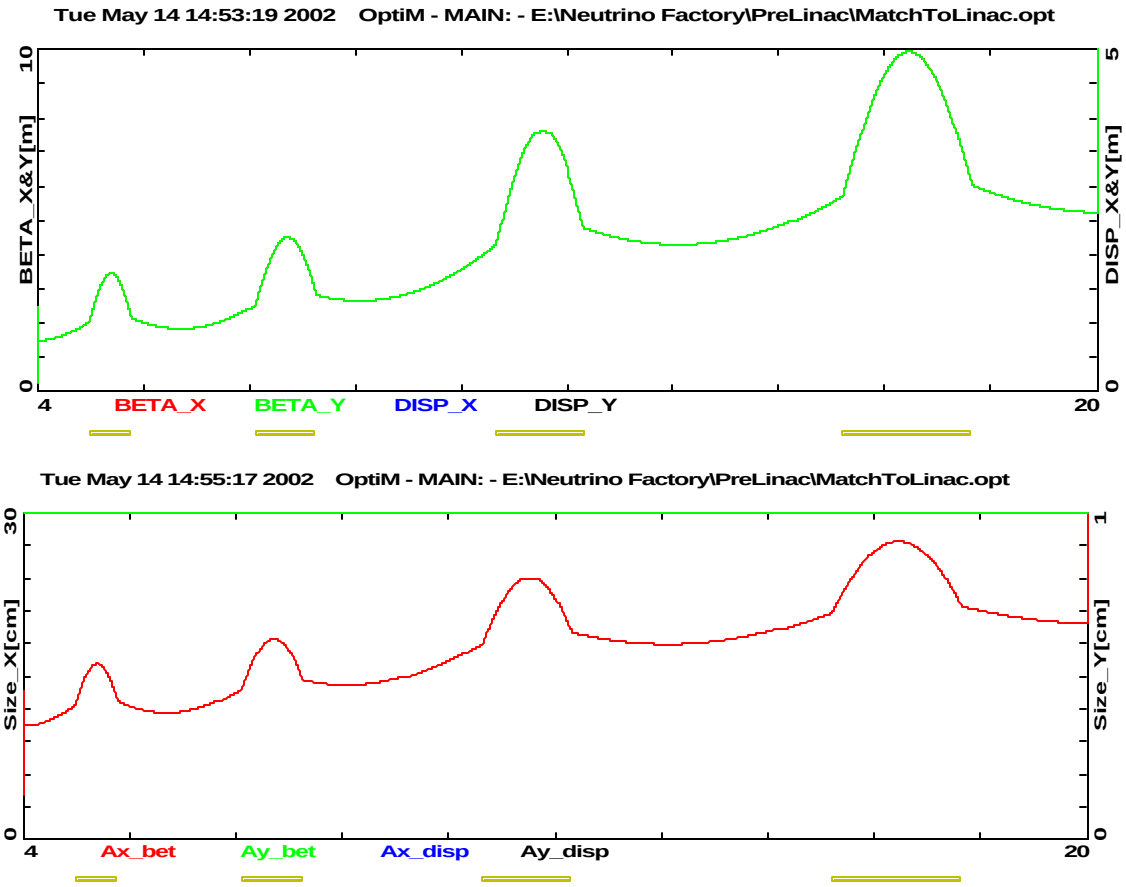
- Improvements to RLA scheme (200MHz SRF) – beyond Study II
  - Complete linear lattice (Pre-accelerator, Linacs & 7 Arcs)
    - Optimized beta matching from the cooling channel to the Pre-accelerator
    - Special optics for multi-pass linacs – equalized input/output Twiss functions
    - 'Smooth' transition of optics between linacs and Arcs – compact Spr/Rec
  - Transverse emittance preservation scheme
    - Chromatic corrections with sextupole families
    - Emittance dilution

Muon accelerator complex (245MeV/c – 20GeV)



- Complete lattice design for: matching section, linear pre-accelerator (sol.), injection chicane, linacs (tripl.), spreaders/recombiners (hor.) and 7 arcs
  - Solenoidal matching section after the cooling channel (beta~25cm to ~5m)
  - Off-crest bunch compression in linear pre-accelerator
  - Requirement of high periodicity and 'smooth' transition between different kinds of optics, linac-spreader-arc-recombiner-linac
- Principle of uniform focusing periodicity (90^0) – cancellation of chromatic effects

Solenoidal matching section – constant focal length

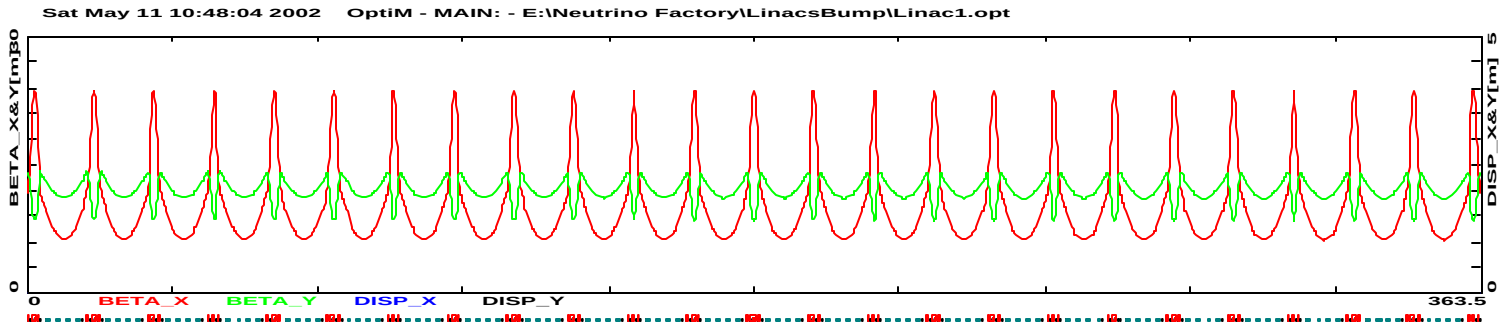


L/A[cm]	B[kG]
64.0973	35.8649
92.9411	24.7344
134.765	17.0582
195.409	11.7643

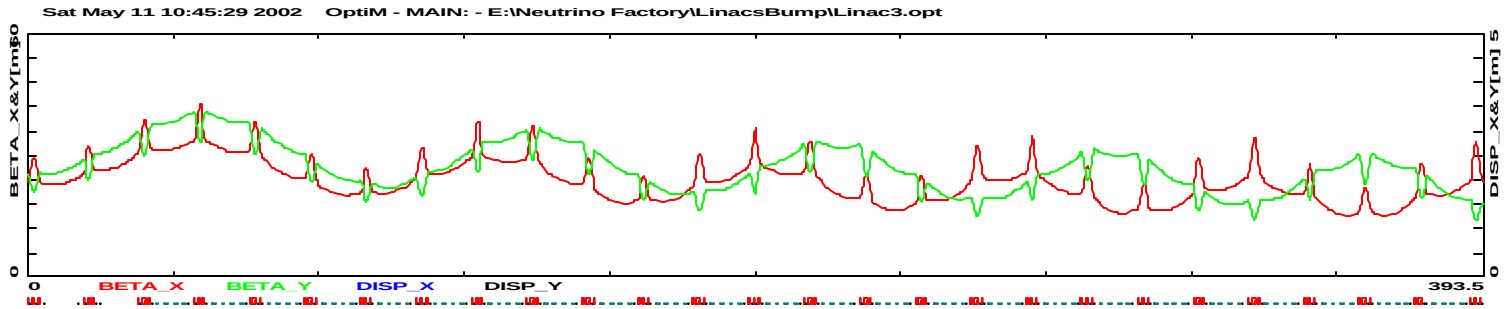
Beta-functions & beam envelopes $(2.5s)$ at 245MeV/c

Optimized linac optics for multi pass beams – smooth transition Arc-linac

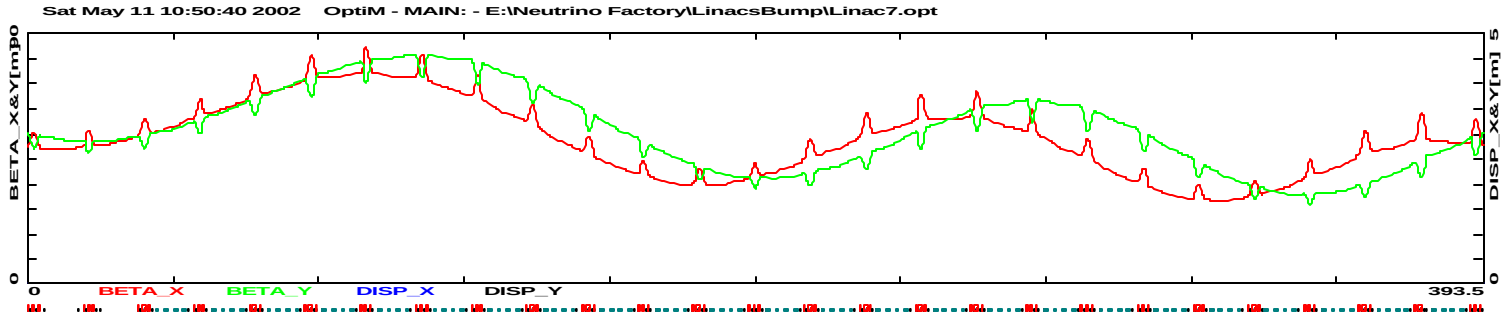
Pass 1



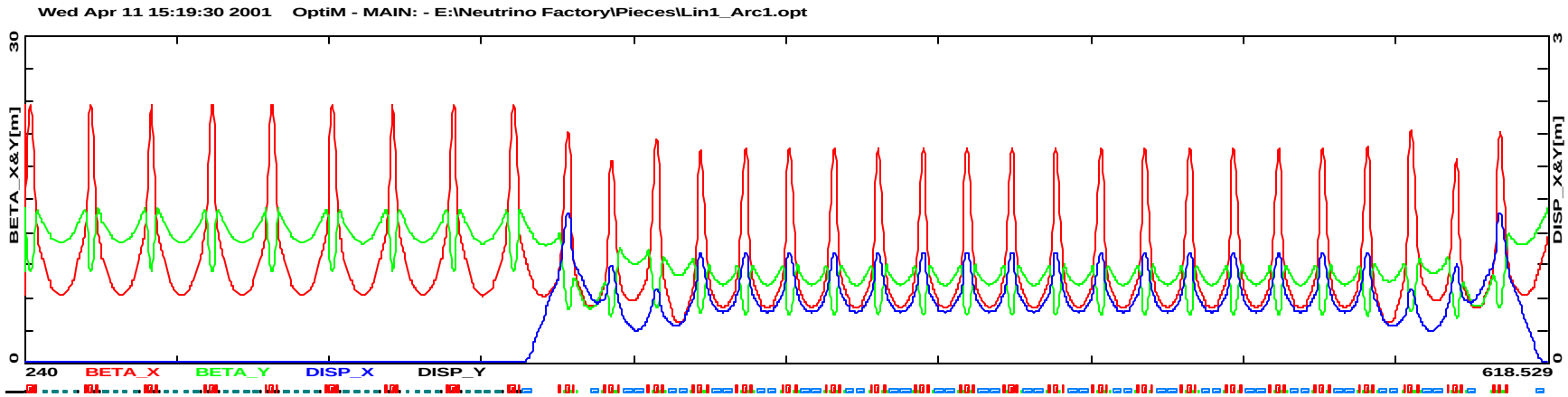
Pass 2

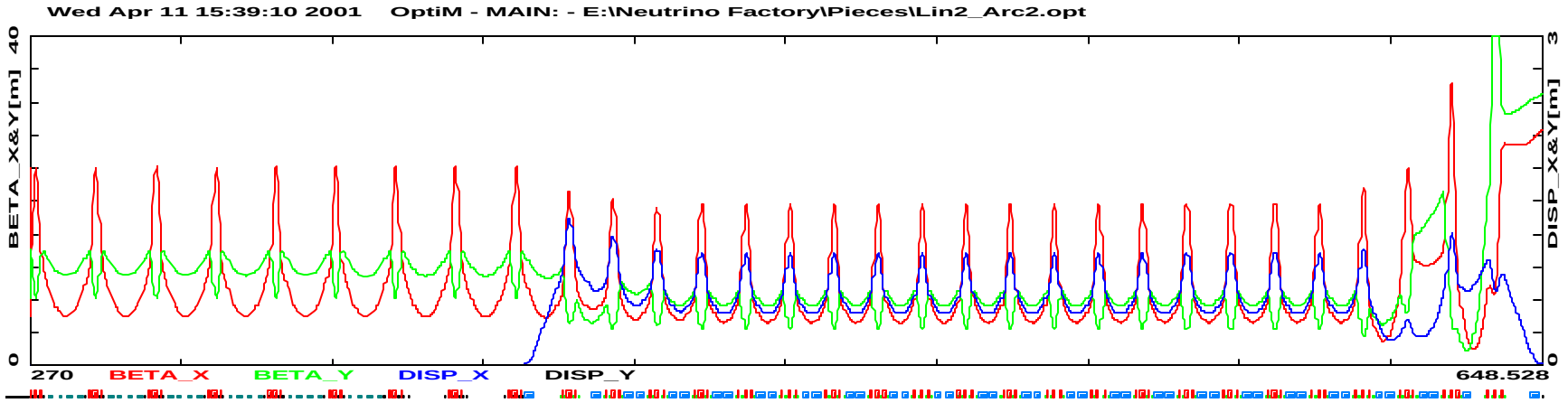


Pass 4

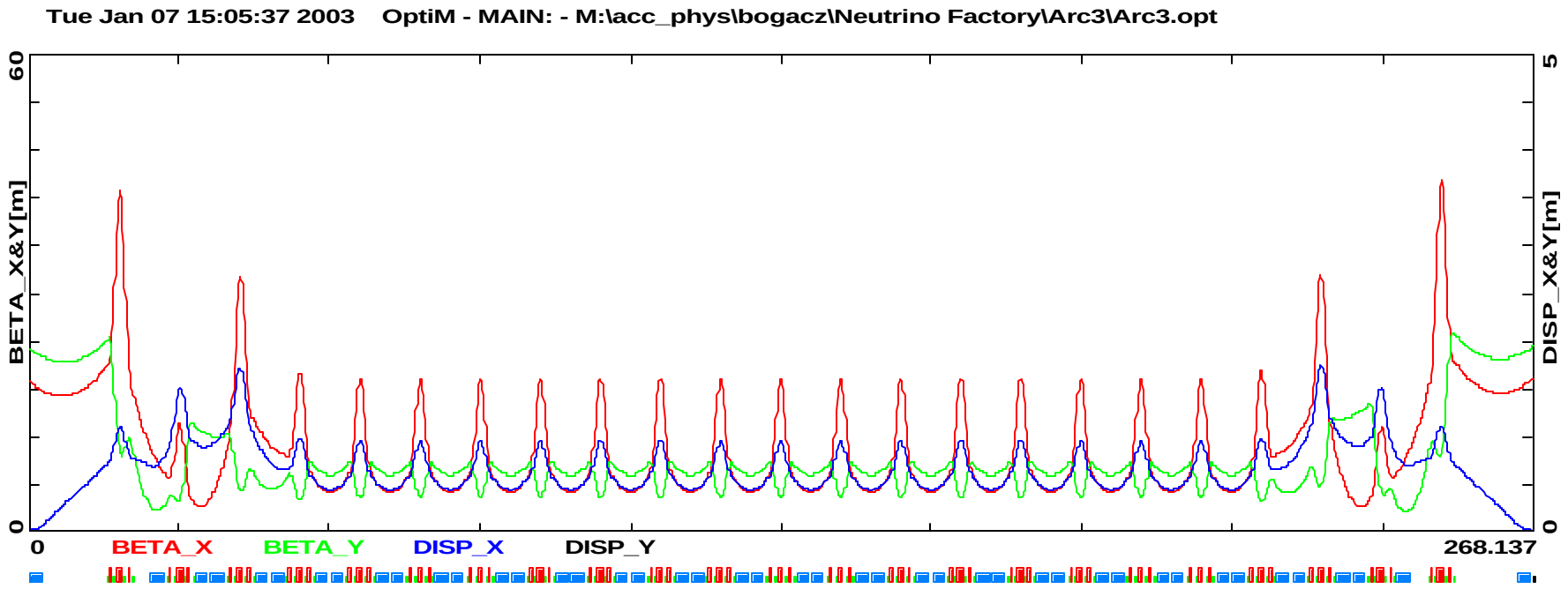


Arc 1 and 2 optics – smooth transition in Spreaders/Recombiners

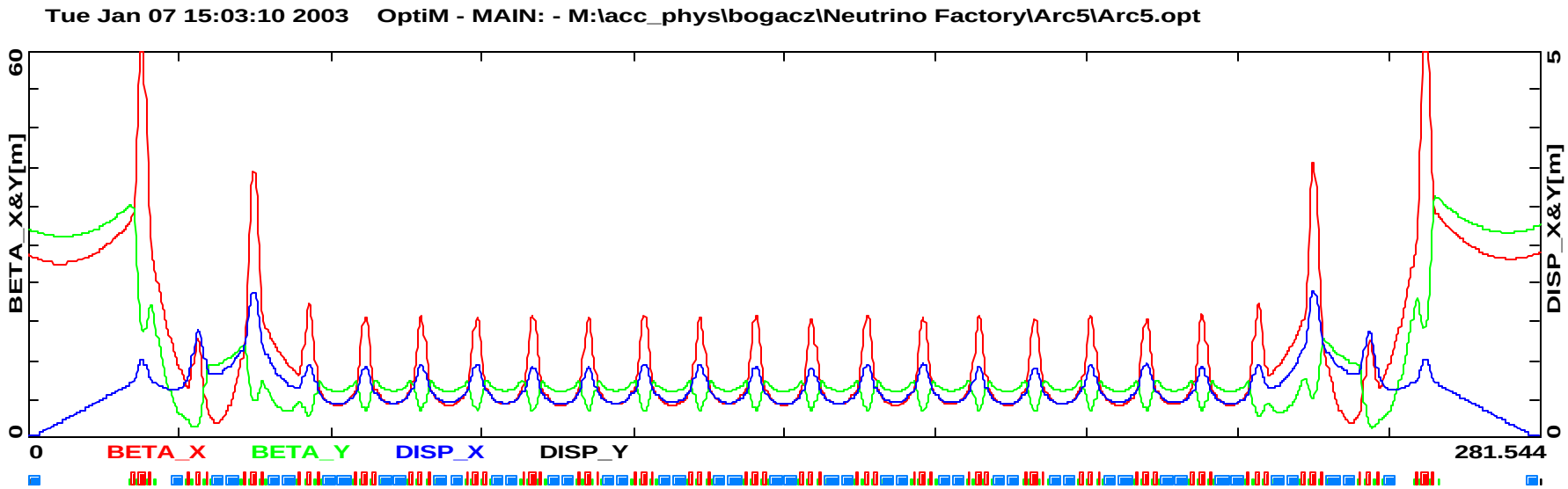




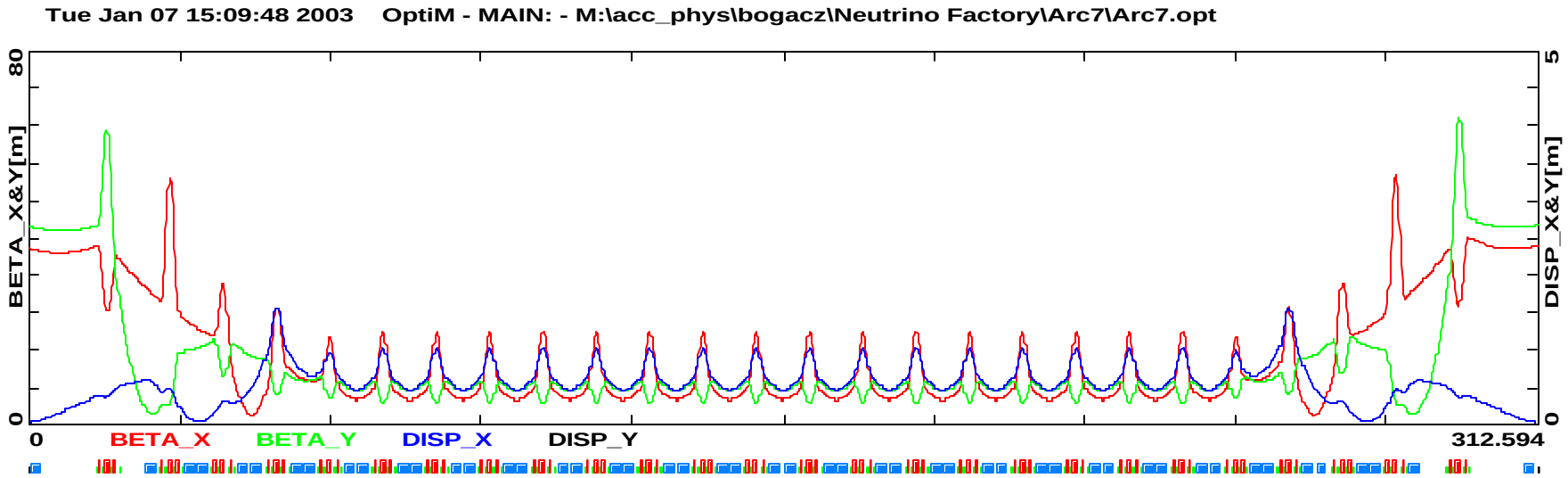
- Arc 3 Optics - beta-functions and the horizontal dispersion matched to both adjacent linacs.



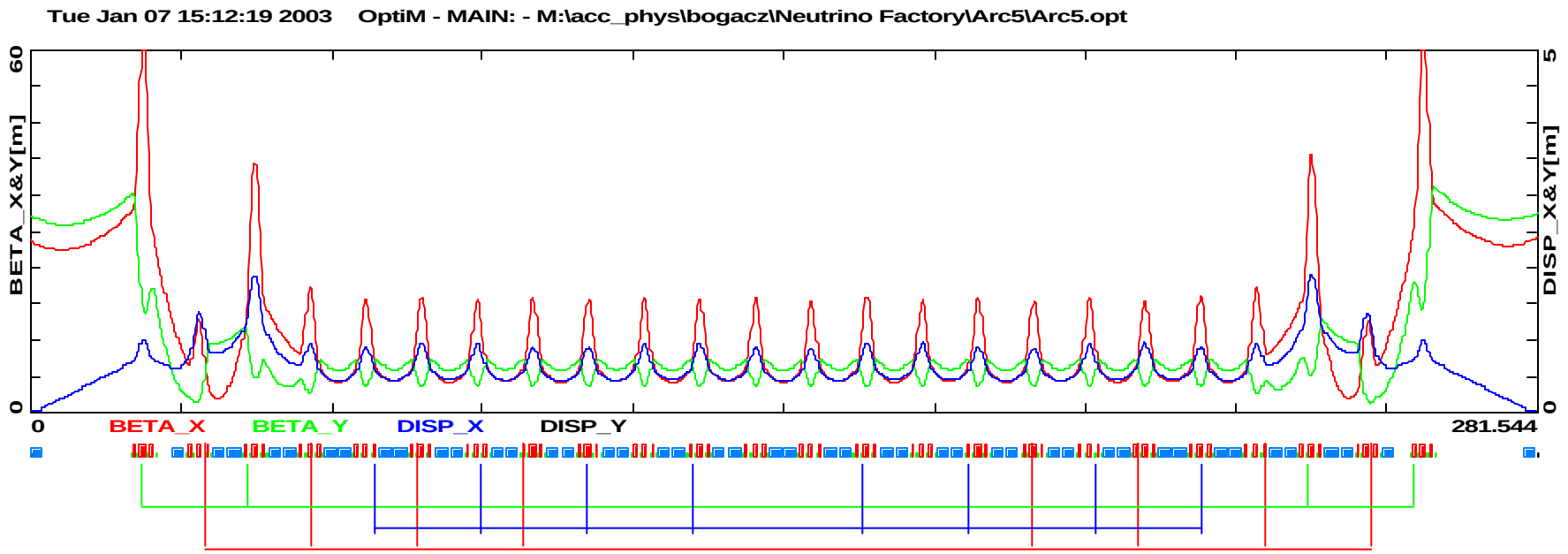
- Arc 5 Optics - beta-functions and the horizontal dispersion matched to both adjacent linacs, larger difference of Twiss functions.



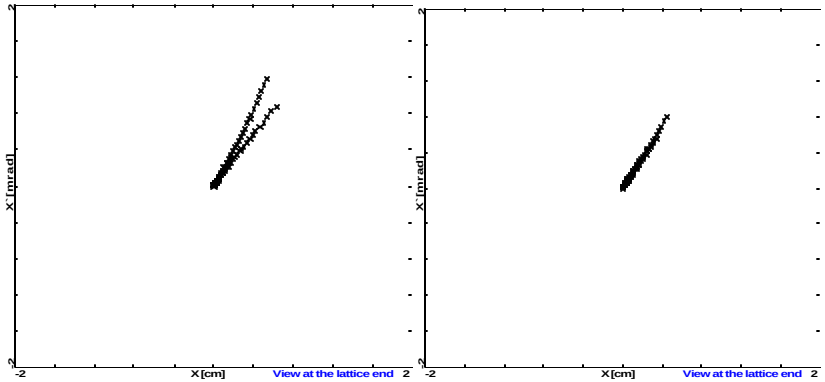
- Arc 7 Optics - beta-functions and the horizontal dispersion matched to both adjacent linacs, much larger Twiss functions difference (compared to Arc 1, 3 and 5)



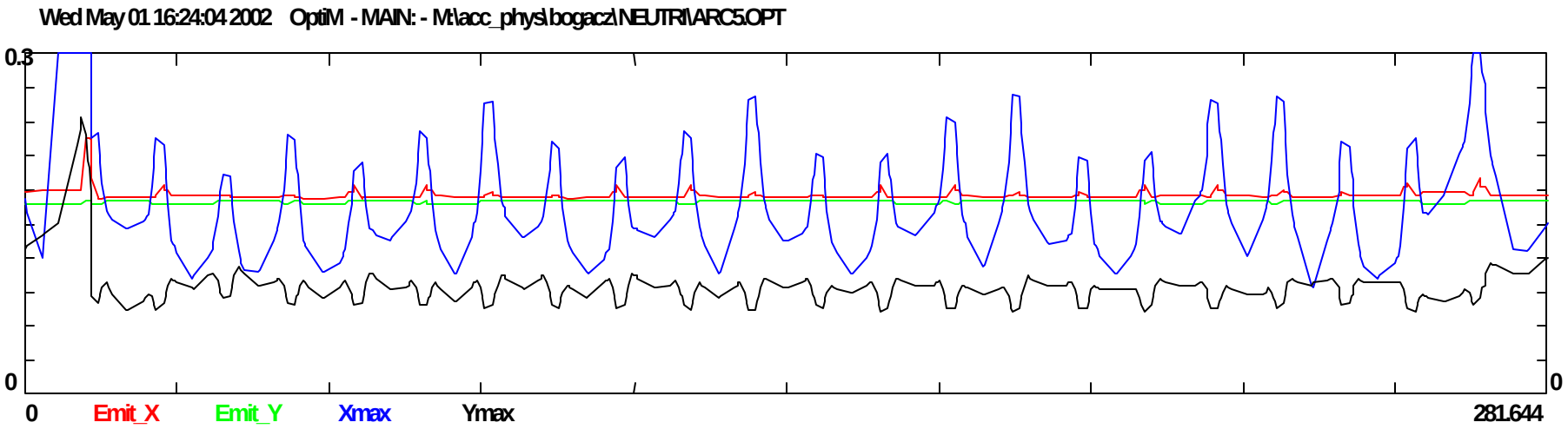
❖Chromatic Corrections Scheme in the Arcs – Arc 5 example



- Three families of sextupoles (**R**, **B** and **G**); each family configured as follows:
  - 4 focusing quads have build-in sextupole component, SdL=0.15 kG/cm
    - it corresponds to S=1 G/cm^2 or ≈5% correction for G at r = 20 cm
  - Quads are shifted by π/2 in betatron phase and their effects are canceled in linear approximation
    - 4 quads are better than 2 shifted by π (case of complete cancellation for small energy spread)
  - The sextupole gradient is chosen to minimize the total emittance growth
  - Particle displacement for uncompensated and compensated chromaticity



- Arc 5 emittance preservation via chromatic corrections – particle tracking s\shows no emittance dilution with 0.8% particles loss ('clipping' of large amplitude tails)



Summary

- Lattice improvements to RLA scheme – better optimized linear optics
  - Optimized beta matching from the cooling channel to the Pre-accelerator
  - Special optics for multi-pass linacs – equalized input/output Twiss functions
  - 'Smooth' transition of optics between linacs and Arcs – compact Spr/Rec
  - Complete lattice designed for the entire complex
- Emittance preservation scheme – nonlinear corrections in the Arcs
  - Chromatic corrections in the Arcs to effectively restore longitudinal space linearity (via three families of sextupoles)
  - Multi-particle tracking studies (Arc-by-Arc) show no emittance dilution for all Arcs, with small level (~ 1%) of particle loss.