Arc Optics Design and Tracking

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Outline

- Beam Transport Issues
- Design Choices
- 'Odd Arcs' – proof-of-principle lattice design
- Chromatic corrections– Tracking
- Beam transport

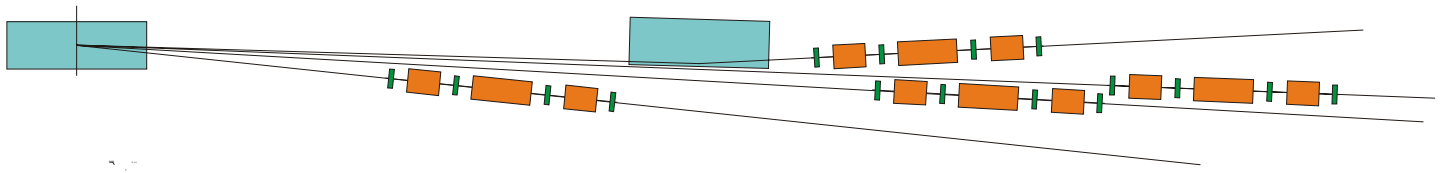
Beam Transport Issues

- Single dipole separation of multi-pass beams
  - small energy difference between injection and extraction energy (< 5 times)
  - high injection energy, 2480 MeV
- Maintaining short matching regions in Spreaders/Recombiners, compact arcs
- Maintaining manageable beam sizes
  - need for short cells or periods
  - vertical size small (due to uniform focusing and small betas)
  - limits on dispersion and beta functions (beam envelopes)

- Longitudinal Acceptance
  - need for momentum compaction management, M_{56} = 1.4 m
  - accounting for nonlinear effects
- Transverse Acceptance
  - need to limit momentum-driven mismatch in the horizontal plane
- Requirement of high periodicity and 'smooth' transition between different kinds of optics, Linac-Spreader-Arc-Recombiner-Linac
  - aberrations (second order dispersion) suppression, possible chromatic corrections

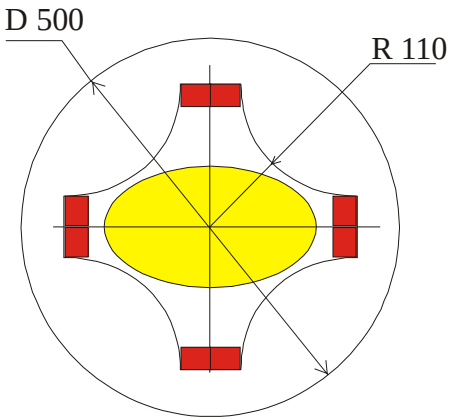
Design Choices

- Spreader-Recombiner configuration
  - single dipole, horizontal separation without dispersion suppression (vertical separation not feasible)
  - compact structures for Spreaders/Recombiners
  - need for sextupole corrections in S/R

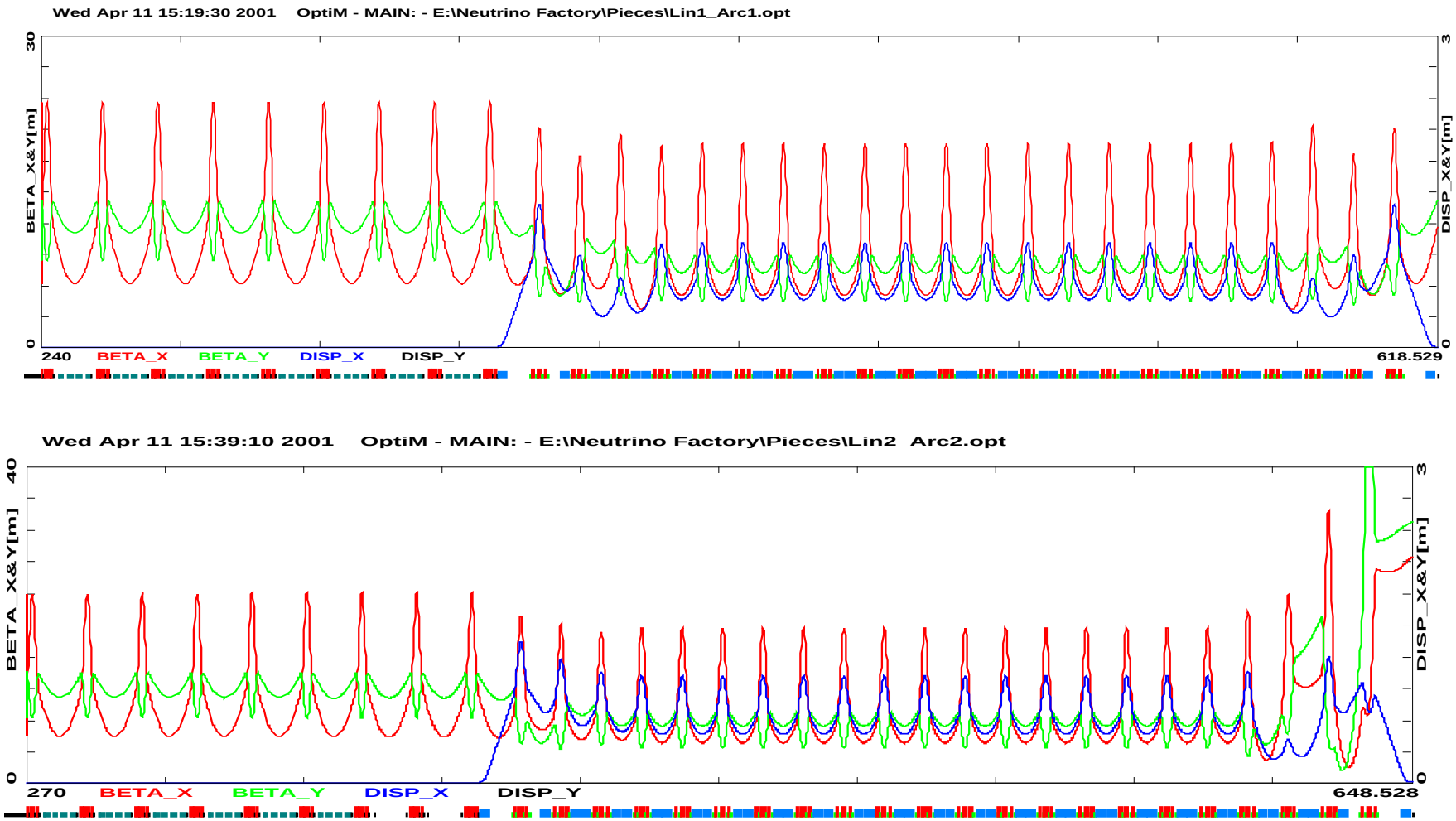


Beam separation scheme for 'Odd Arc' Spreaders

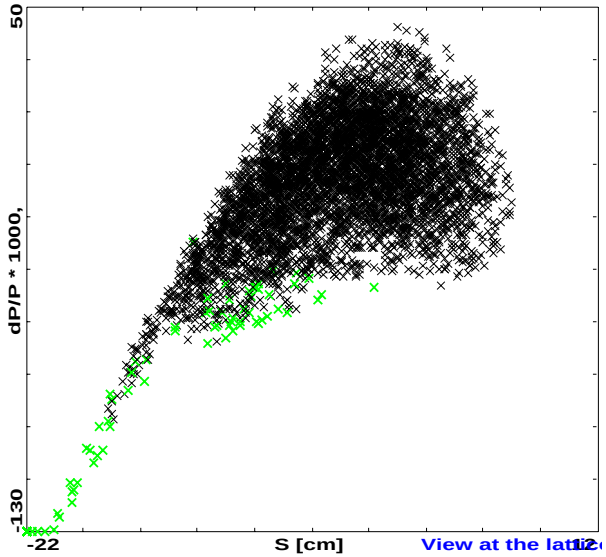
- Arc Optics architecture
  - rotationally phased 90$_0$ (horizontal and vertical) high periodicity triplet cells
  - need for sextupole corrections in Arcs
  - 2 Tesla dipoles for the highest energy arc
  - 1 Tesla quadrupole field at the aperture

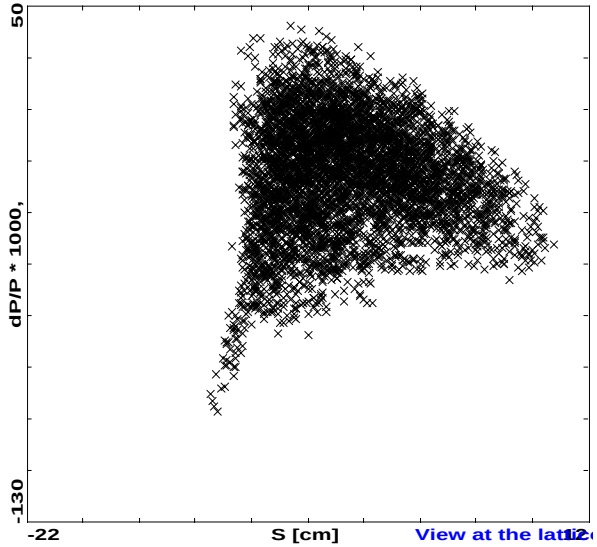


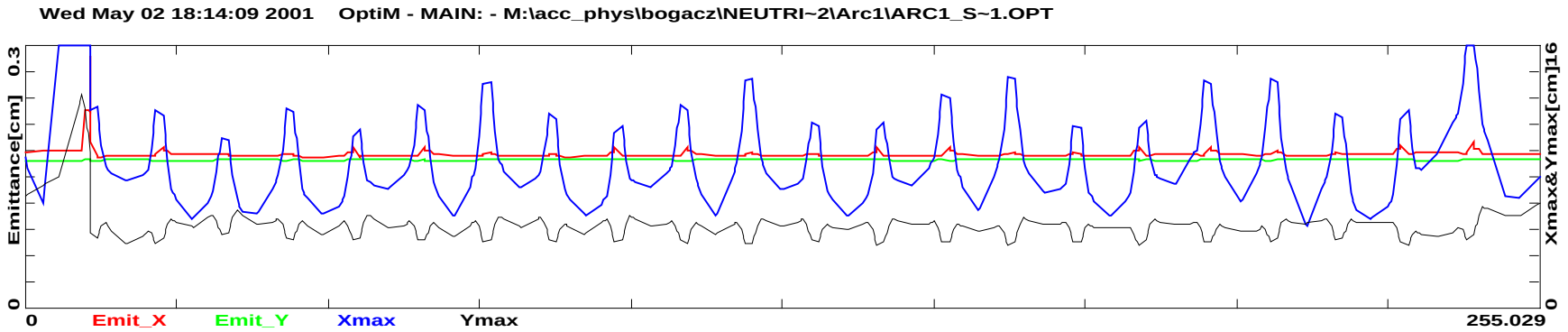
Typical large aperture Arc quadrupole



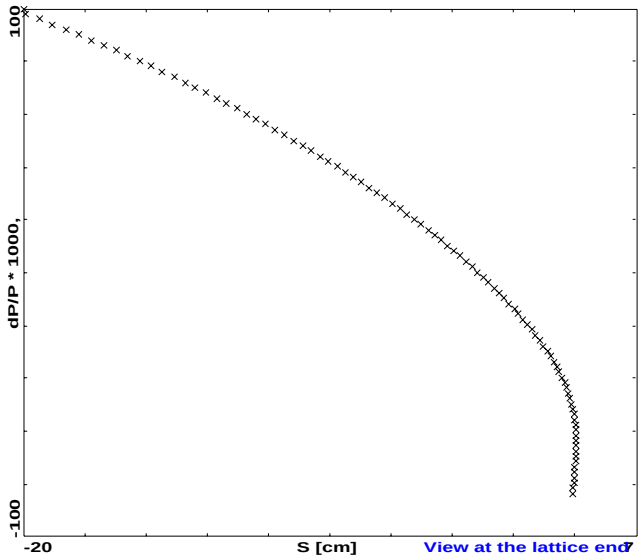
Arc 1 and Arc 2 Optics - beta-functions and the horizontal dispersion matched to both adjacent linacs

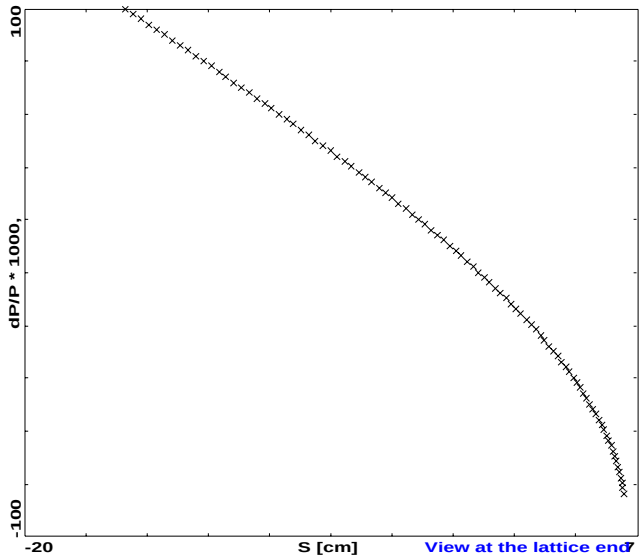


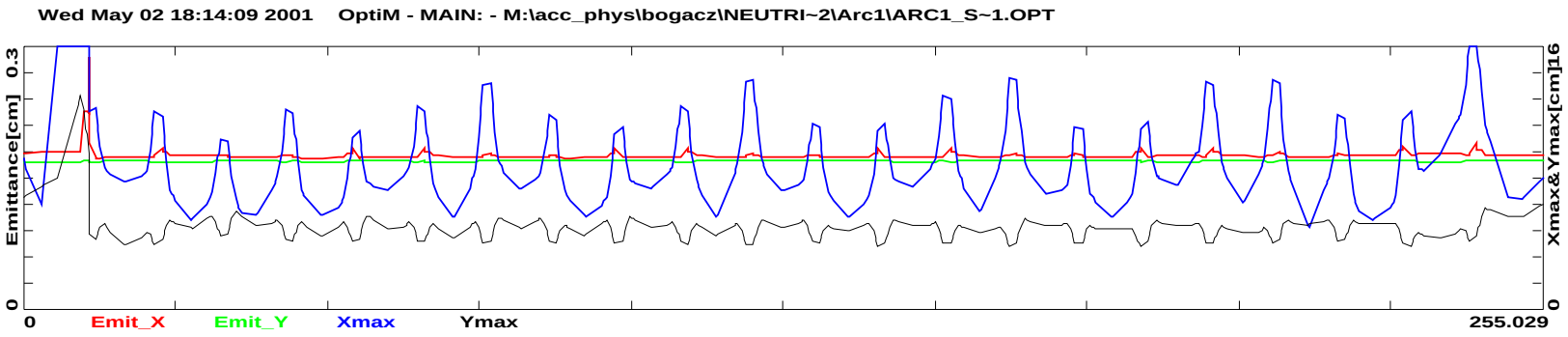




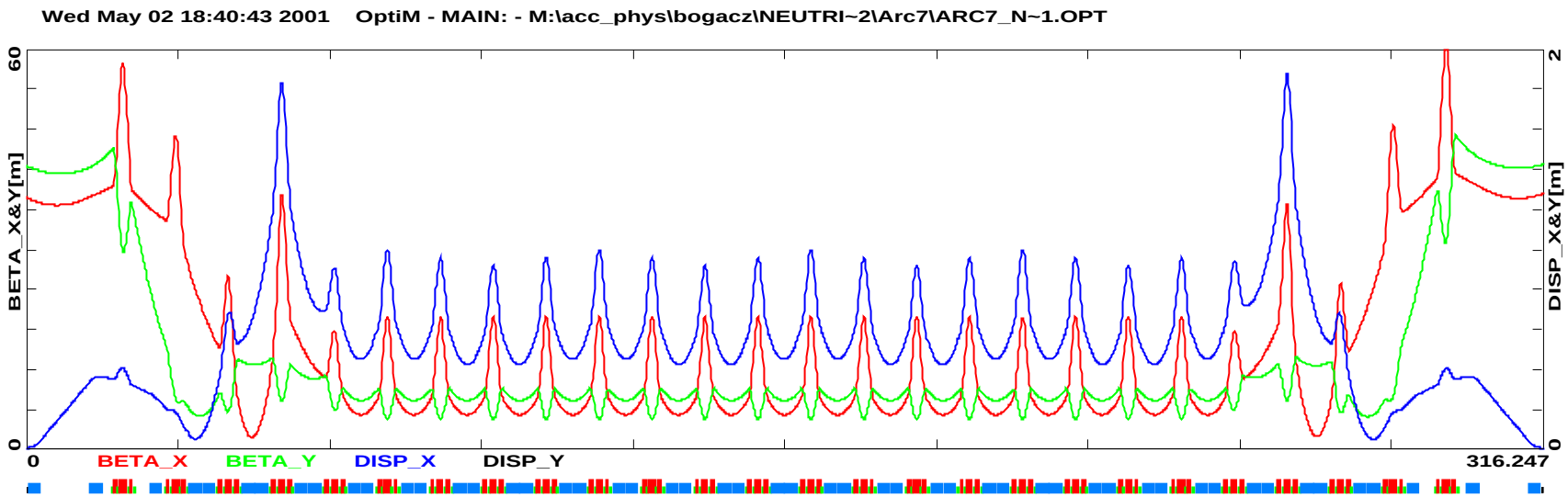
Arc 1, multi-particle tracking without any sextupole correction, < 1% of particles lost on 15 cm aperture



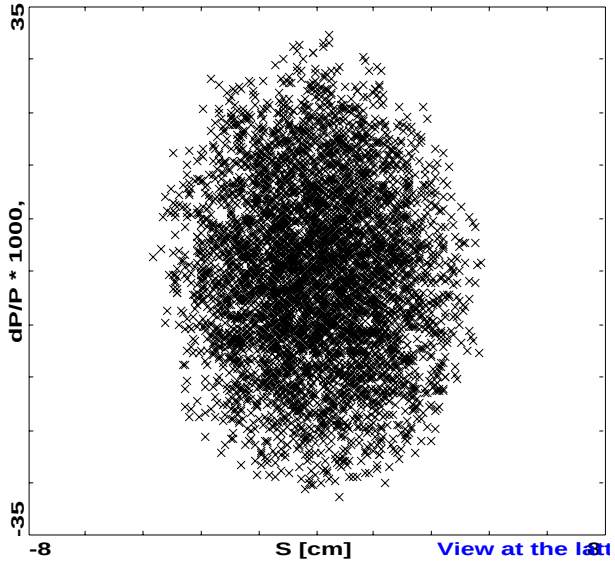


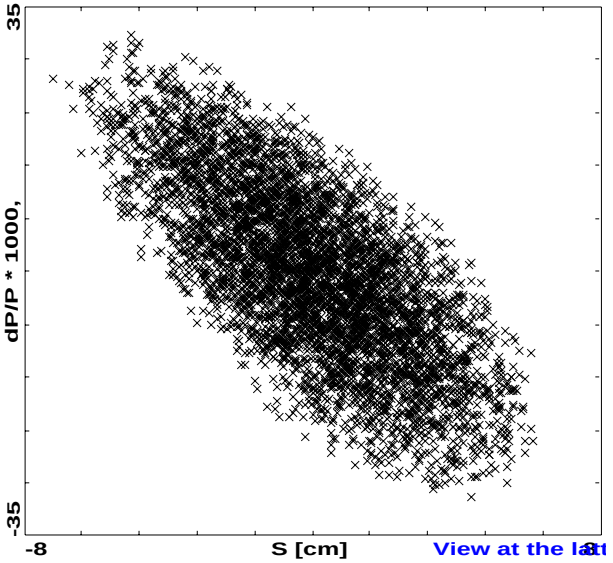


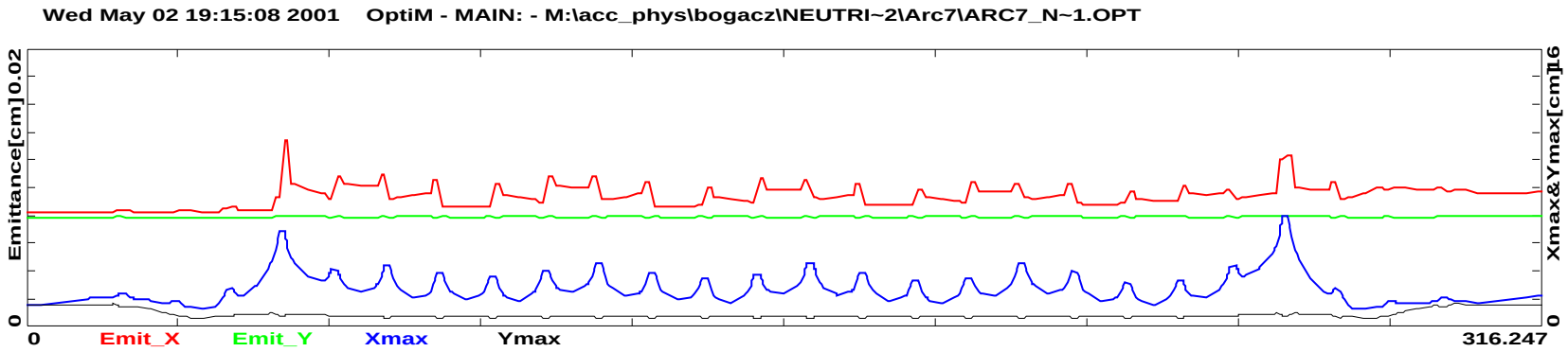
Arc 1 - longitudinal phase-space nonlinearity without and with sextupole correction, 280 kG/cm per triplet, no emittance dilution, no horizontal beam envelope increase



Arc 7 Optics - beta-functions and the horizontal dispersion matched to both adjacent linacs, much larger difference (compared to Arc 1) between the values of beta functions in the adjacent linacs and Arc 7; A quest to maintain 'smooth' transition of beta functions across Spreaders/Recombiners.







Arc 7 - multi-particle tracking without any sextupole correction, no particles lost on 15 cm aperture

Conclusions

- Design Choices driven by Beam Transport Issues
- 'Odd Arcs' proof-of-principle lattice design
- Chromatic corrections in arcs - effective mean of longitudinal space linearity correction
- Possible emittance control in the higher arcs via families of sextupoles
- Presented 'Odd Arcs' architecture can be extended other arcs
- Further lattice optimizations could be facilitated via presented beam dynamic schemes