Pre-FFAG 5GeV 'Dogbone' Muon RLA

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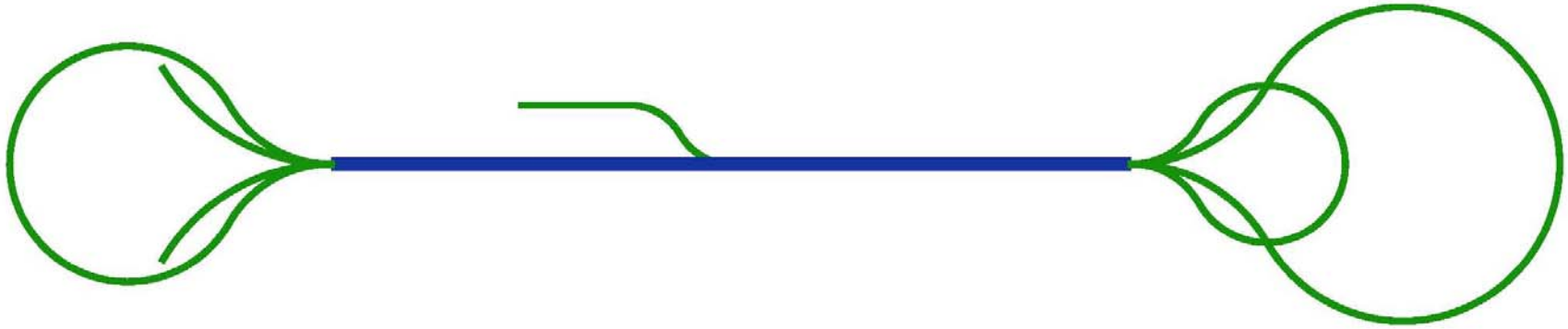
- FFAG acceleration below 5GeV not feasible (cost effective)
- 'Dogbone' RLA (3.5-pass) scheme based on 200MHz SRF
  - Pre-accelerator (250 MeV/c – 1.5 GeV) based on solenoid focusing
  - Main Linac (1 GeV/pass) based on triplet focusing
  - Three Arcs with horizontal multi-pass separation
- Initial beam parameters as in Study II – after cooling at 250 MeV/c
- Lattices – linear optics

'Dogbone' RLA (3.5-pass) scheme (Don Summers/Bob Palmer)

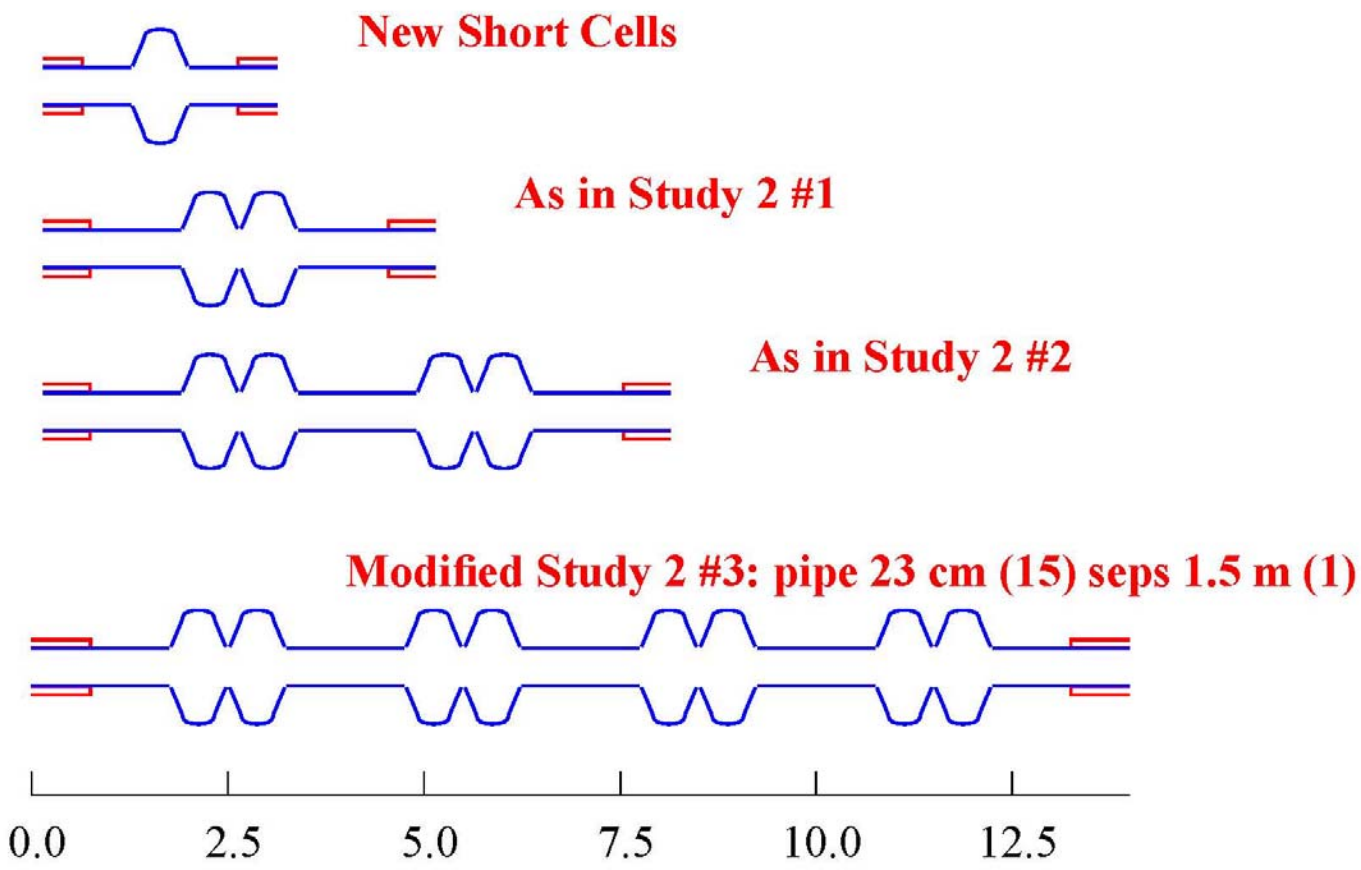


- Pre-accelerator (250 MeV/c – 1.5 GeV) – solenoid focusing
- Main Linac (1 GeV/pass) – triplet focusing
- Arcs with horizontal multi-pass separation

Initial beam emittance/acceptance after cooling at 250 MeV/c

Study II		ε	$A = (2.5)^2 \varepsilon$
normalized emittance: $\varepsilon_x/\varepsilon_y$	mm·rad	2x2.4	2x15
longitudinal emittance: ε_l ($\varepsilon_l = \sigma_{\Delta p}\, \sigma_z/m_\mu c$)	mm	27	170
momentum spread: $\sigma_{\Delta p/p}$		±0.08	±0.20
bunch length: σ_z	mm	163	408

Pre-accelerator – 4 styles of cryo-modules (Bob Palmer/Scott Berg)



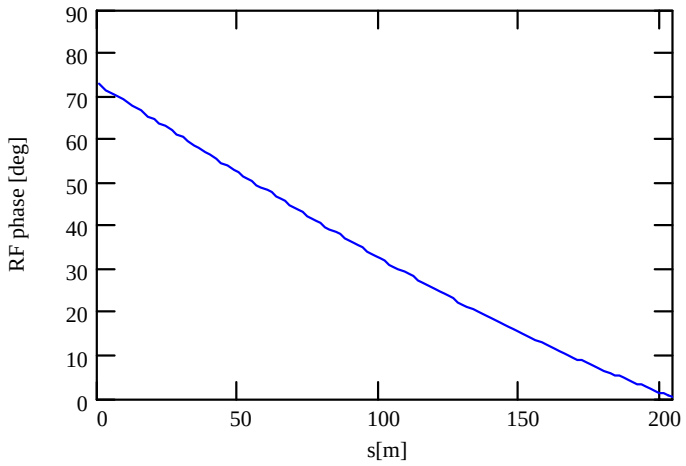
❖Pre-accelerator – parameters of different style cryo-modules

	Very short	Short	Medium	Long
Number of periods	6	8	12	12
Total length of one period	3 m	5 m	8 m	13 m
Number of cavities per period	1	1	2	4
Number of cells per cavity	1	2	2	2
Cavity accelerating gradient	15 MV/m	15 MV/m	15 MV/m	17 MV/m
Real-estate gradient	3.72 MV/m	4.47 MV/m	6.33 MV/m	7.79 MV/m
Aperture in cavities (2*a*)	460 mm	460 mm	460 mm	300 mm
Aperture in solenoids (2*a*)	460 mm	460 mm	460 mm	360 mm
Solenoid length	1 m	1 m	1 m	1.5 m
Solenoid maximum field	2.1 T	2.1 T	2.1 T	4.2 T

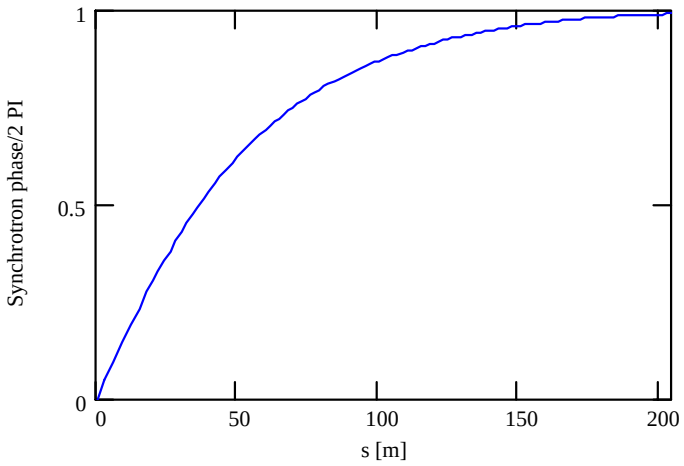
Total length: 206 m

Total gradient: 2.07 GV

- Introduction of synchrotron motion in the initial part of the linac
  - allows to perform adiabatic bunching/compression of the beam
  - prevents head-to-tail 'sag' in acceleration
  - reduction of effective accelerating gradient (1.4GV out of 2.1 GV)

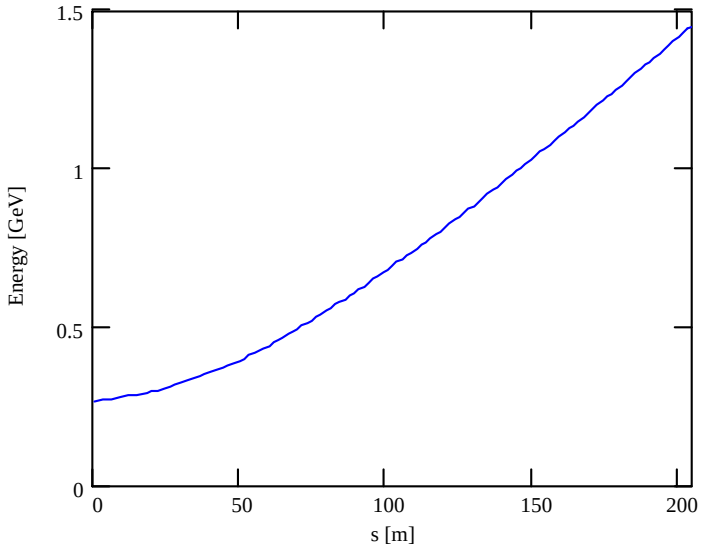


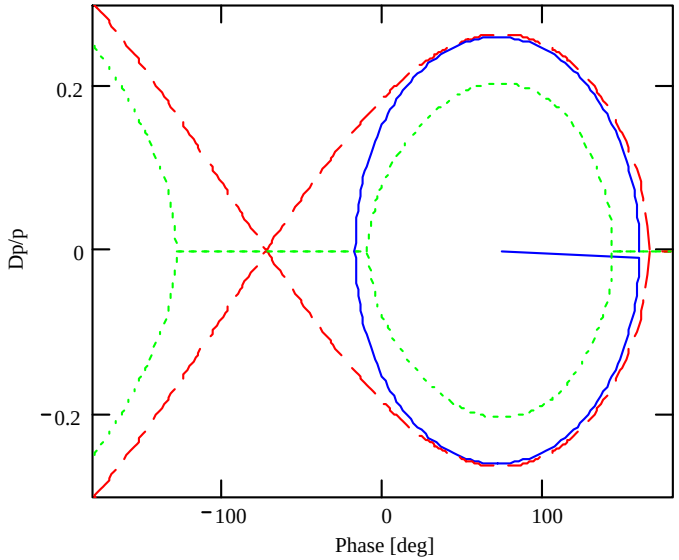
Cavity phase along the linac



Synchrotron phase along the linac

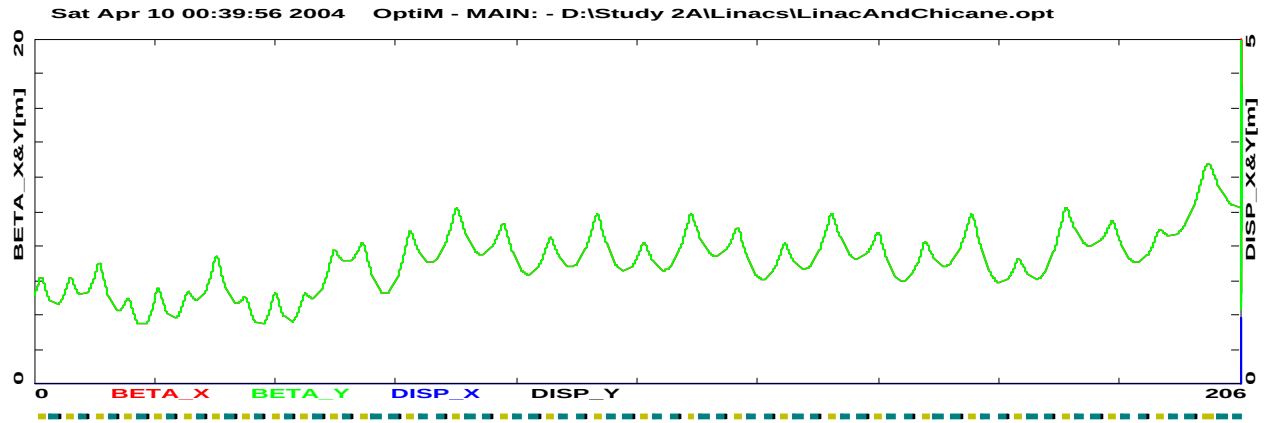
Pre-accelerator – Longitudinal dynamics

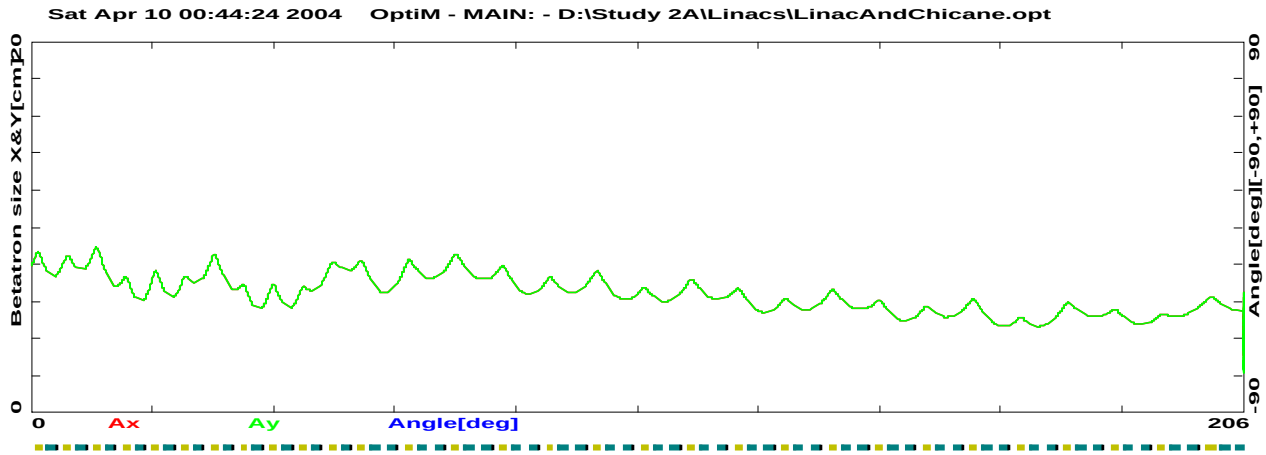




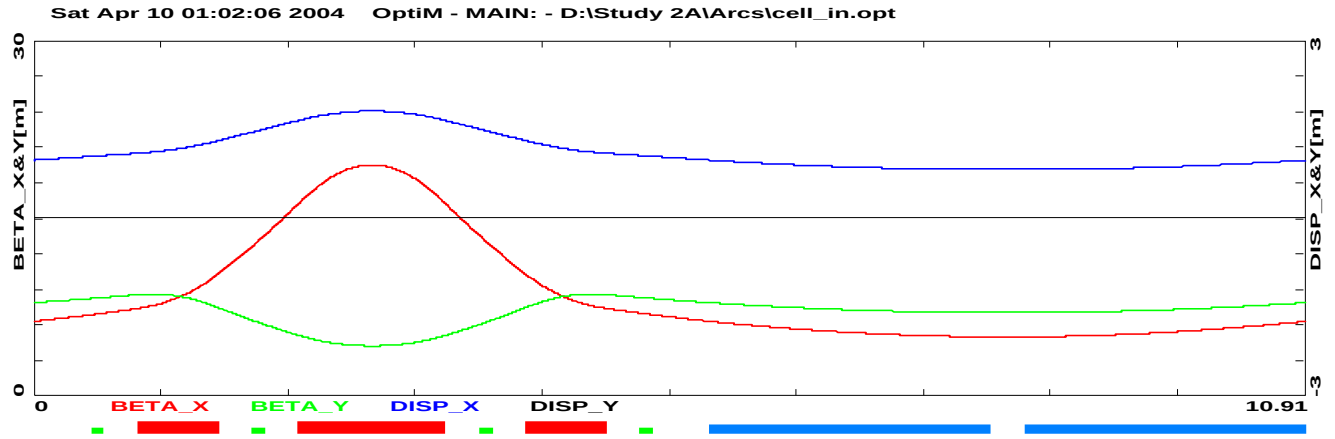
$\Delta p/p = \pm 0.21$ or $\Delta\phi = \pm 89$ (200MHz)

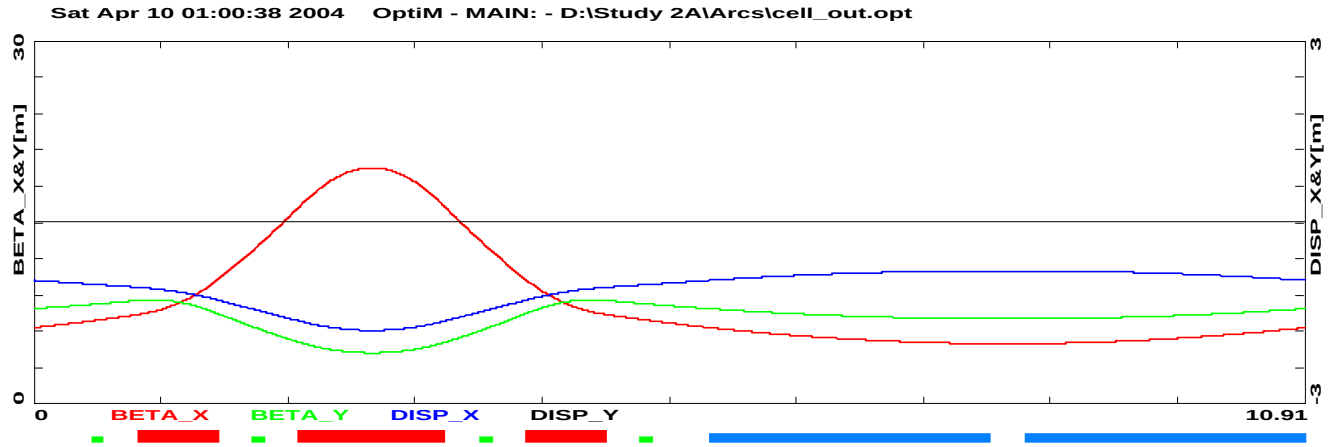
Linear Pre-accelerator – Twiss functions and beam envelope



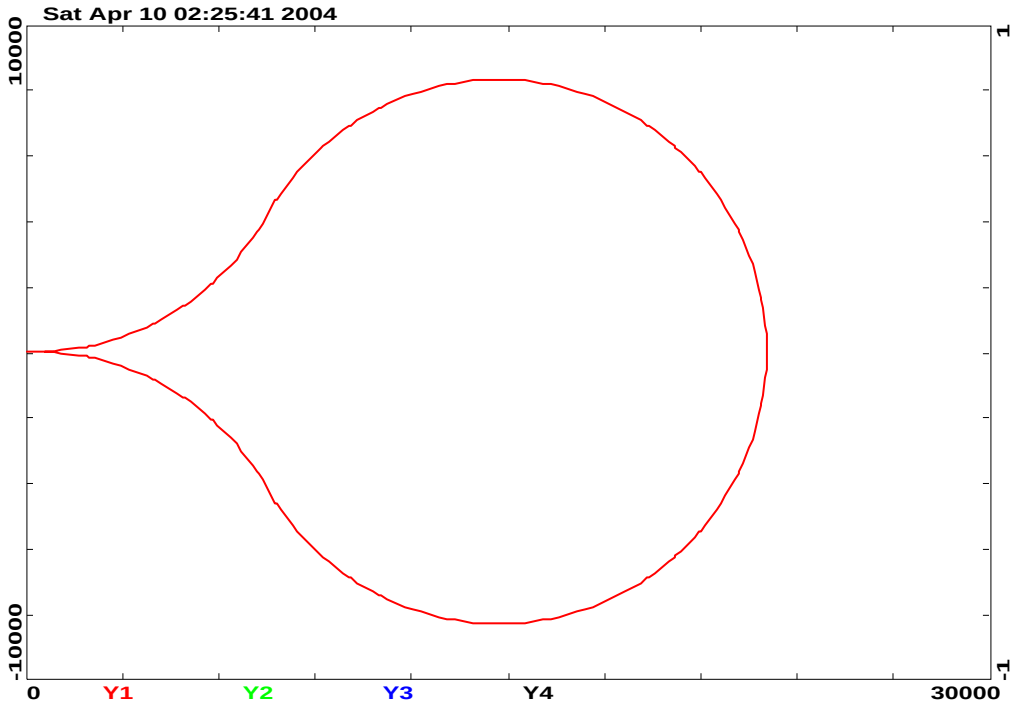


- 'Droplet' return arc (inward and outward cells)





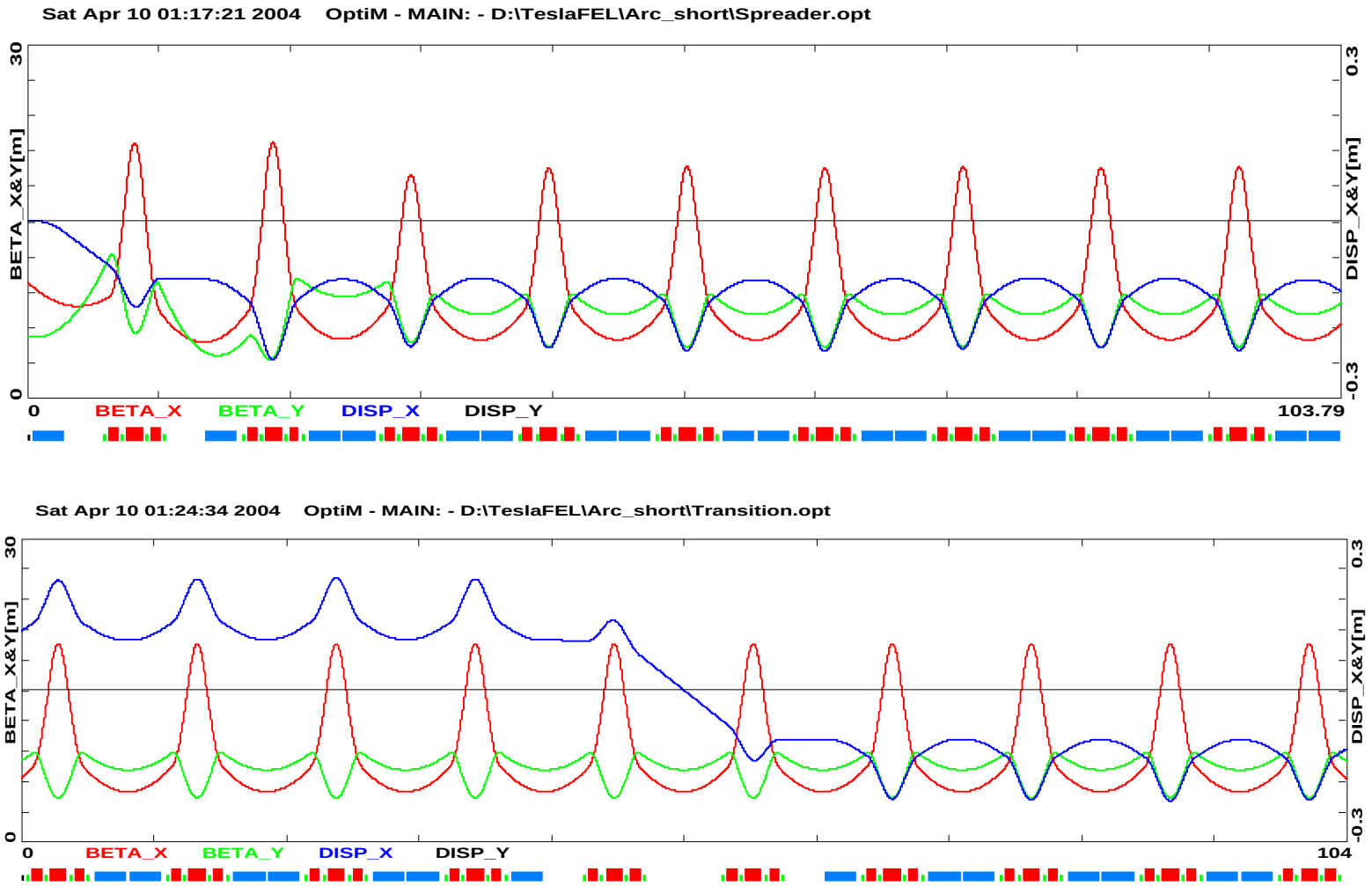
- Droplet' return arc footprint (60^0 out – 300^0 in – 60^0 out)



Beam transport choices

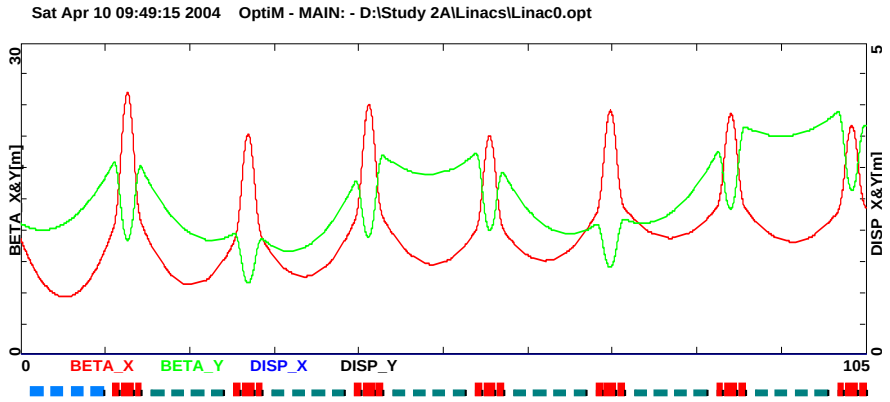
- Principle of uniform focusing periodicity (90°) – cancellation of chromatic effects
- Single dipole (horizontal) separation of multi-pass beams in RLA
  - No need to maintain achromatic Spreaders/Recombiners
  - Compact Spreaders/Recombiners – minimized emittance dilution
- SC dipoles and quads (triplets) in RLA (2 Tesla dipoles/1 Tesla quads)
- Requirement of high periodicity and 'smooth' transition between different kinds of optics, linac-spreader-arc-recombiner-linac

'Droplet' return arc (Spr/Rec and Transition)

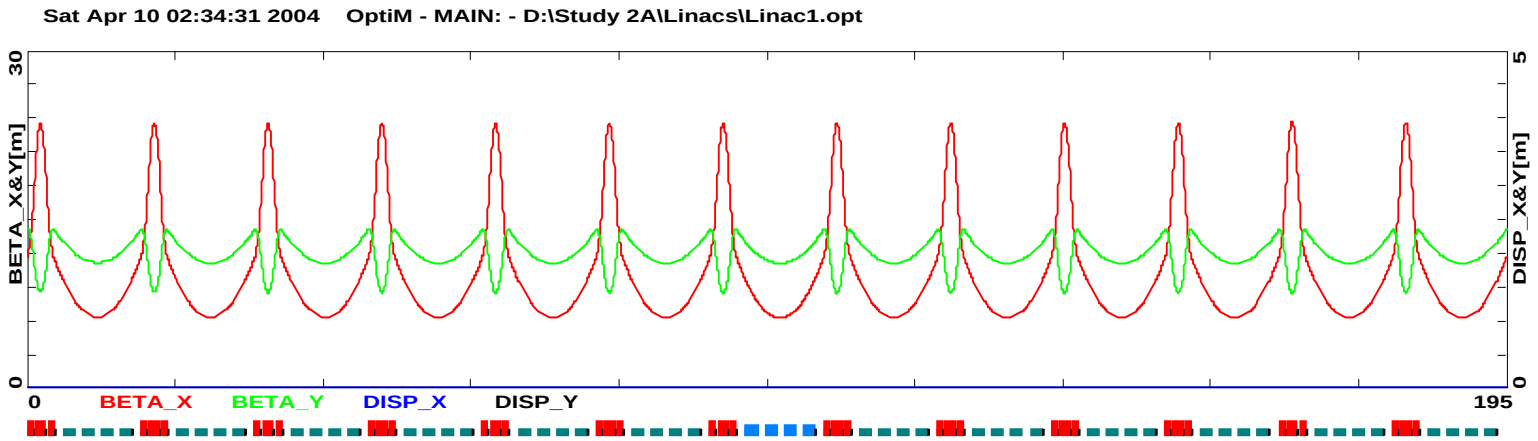


❖Main Linac – multi-pass Optics (lower passes)

1.5-2 GeV

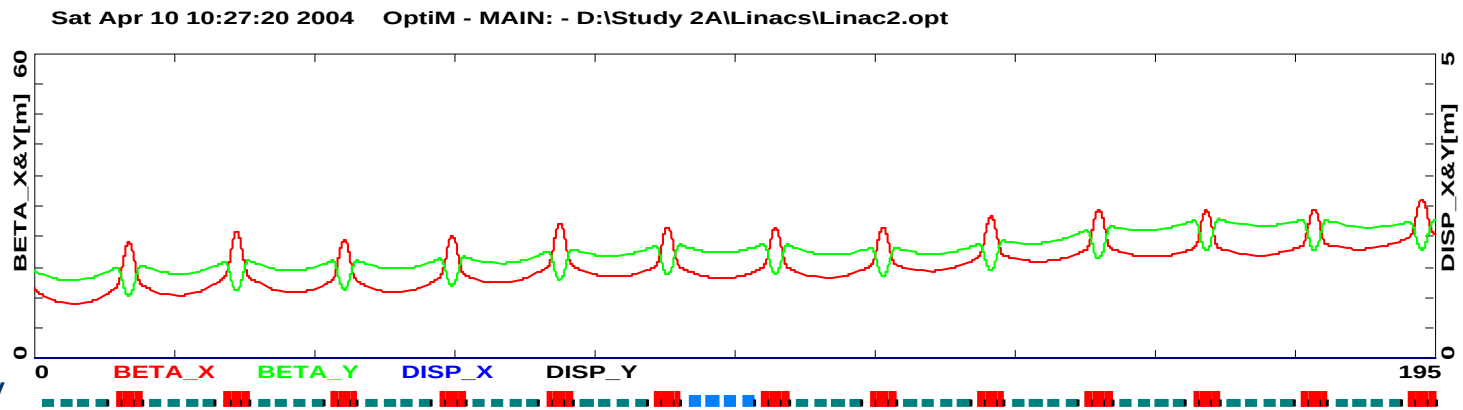


2-3 GeV

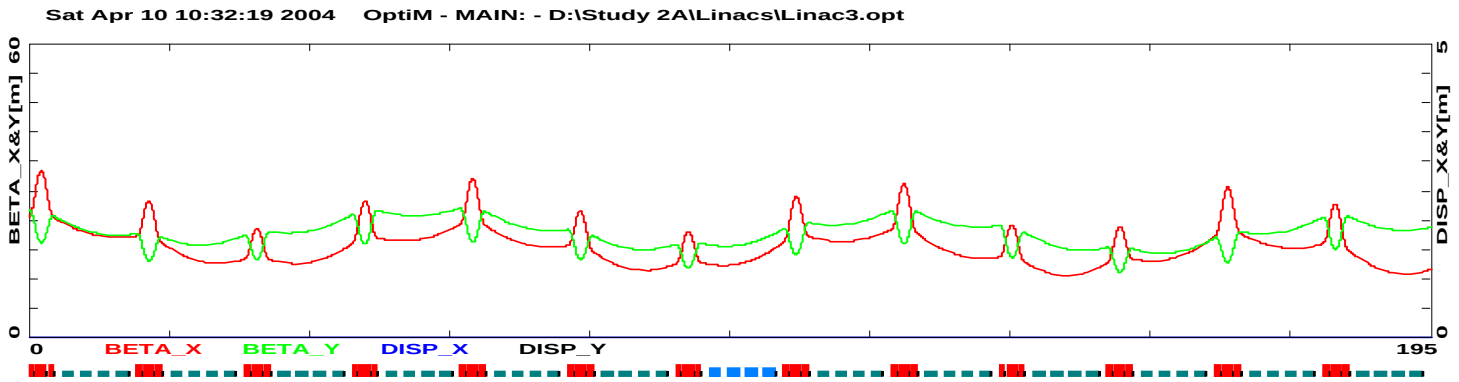


❖Main Linac – multi-pass Optics (higher passes)

3-4 GeV



4-5 GeV



Summary

- Lattice for 3.5-pass, 5 GeV, RLA based on 200MHz SRF – linear optics
  - Pre-accelerator, four styles of cryo-modules
  - Proof-of-principle Arc optics lattice – further longitudinal compression in the Arcs, with M_{56}
  - multi-pass linac optics
  - compact Spr/Rec - 'smooth' transition of optics between linacs and Arcs
- Still to be demonstrated… Emittance preservation scheme – nonlinear corrections in the Arcs
  - Chromatic corrections in the Arcs to effectively restore longitudinal space linearity (via three families of sextupoles)