

Discrete Vertical Bends in the ILC Main Linac

WG1 Layout Session

Motivation

- At 1 TeV CM and 30 MV/m, the LET will be ~53 km long
 - Straight LET: IR halls ~50 m deeper than bunch compressors
 - Continually curved LET: design dispersion at all BPMs, hard to tune emittance
- Consider piecewise-straight LET with up to 2 vertical arcs per side at 1 TeV CM

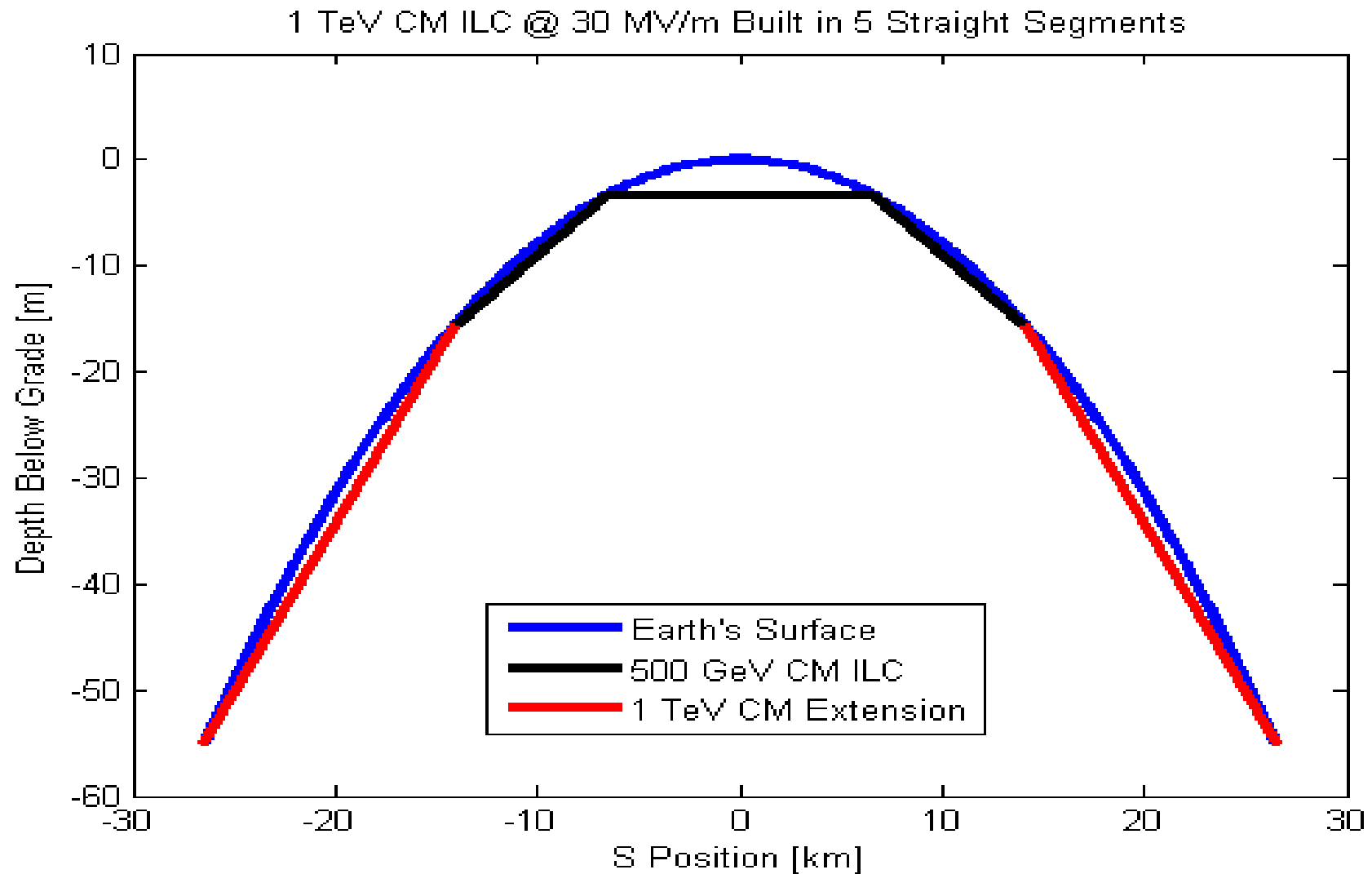
Parameters of VARC

- Divide LET into ~equal-length segments
 - Both BDS in the same straight
 - Straight next to BDS must be at least 7.5 km for dog-bone straights
- Arc angles should equal average curvature of “cue ball” earth
 - Real site will need somewhat different angles
- Limit SR effects
 - Emittance growth
 - Critical energy < 5 MeV limits component activation
- Use 90 degree FODO cells
 - Achieve dispersion match using Keil scheme
 - 6 cells: 4 at half-strength, 2 full
 - One PS for all bends, so half-strength == half as many windings
 - Tune η_y with quad strengths

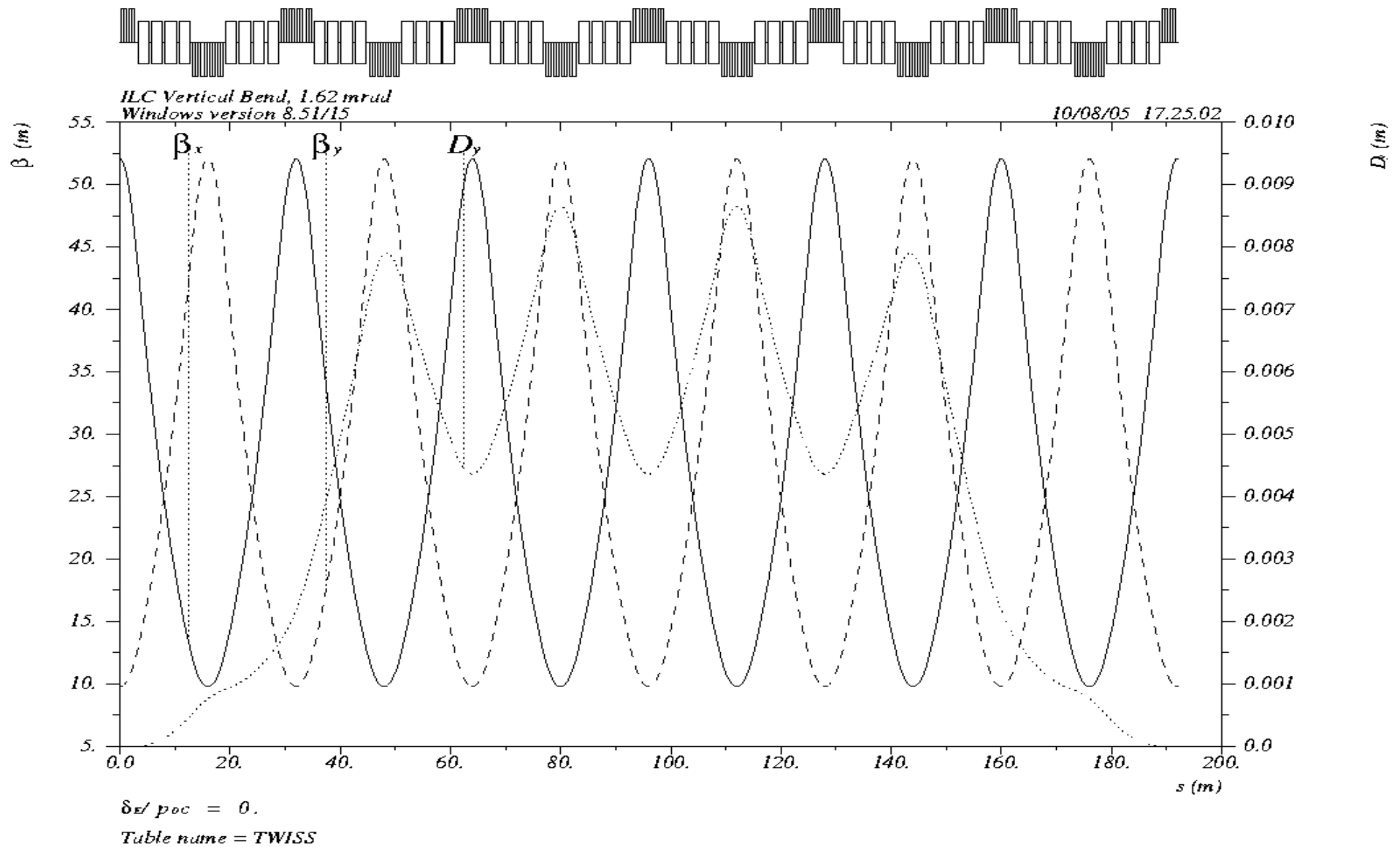
VARC Parameters (2)

Parameter	30 MV/m value	35 MV/m value	40 MV/m value
Geographic Gradient [GeV/km]	19.8	23.1	26.4
Segment 1 length [km]	12.4	10.6	9.3
Segment 2 length [km]	7.5	7.5	7.5
BDS segment length [km]	13.2	9.8	7.4
LCD extra depth [m]	3.42	1.88	1.07
VARC1 energy [GeV]	250	250	250
VARC2 energy [GeV]	399	424	448
VARC1 angle [mrad]	1.56	1.42	1.32
VARC2 angle [mrad]	1.62	1.36	1.17

Schematic View



VARC Optics



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PT and Mark Woodley

6

Non-Issues

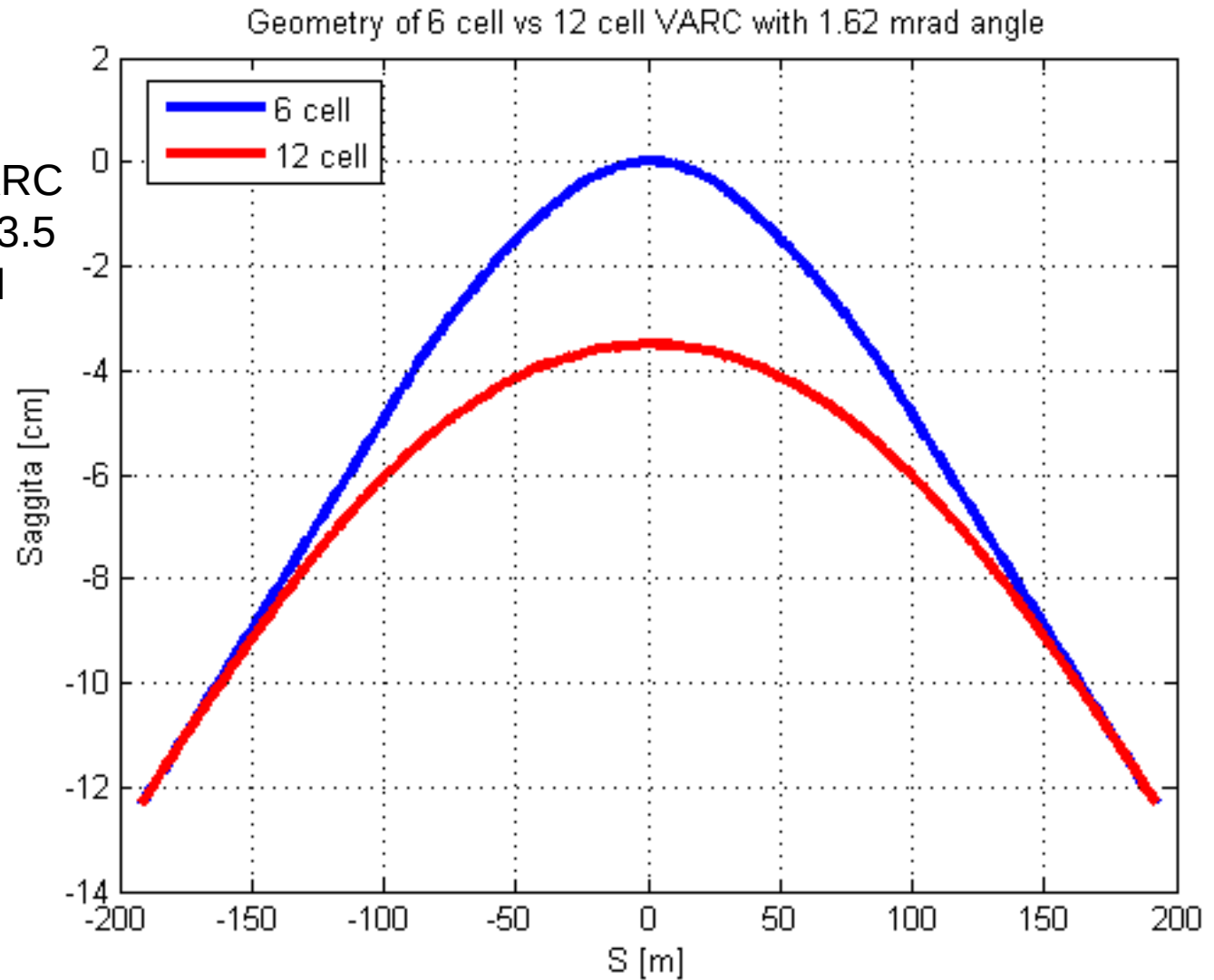
- Power supply strength tolerances
 - 1e-3 is good enough
- Horizontal dispersion from rotated bends or quads
 - very small effect; η_x tuning not needed
- SR effects for E_{CM} up to 1 TeV
 - critical energy below 5 MeV
 - emittance growth $\sim 2\%$ for all cases studied

Issues

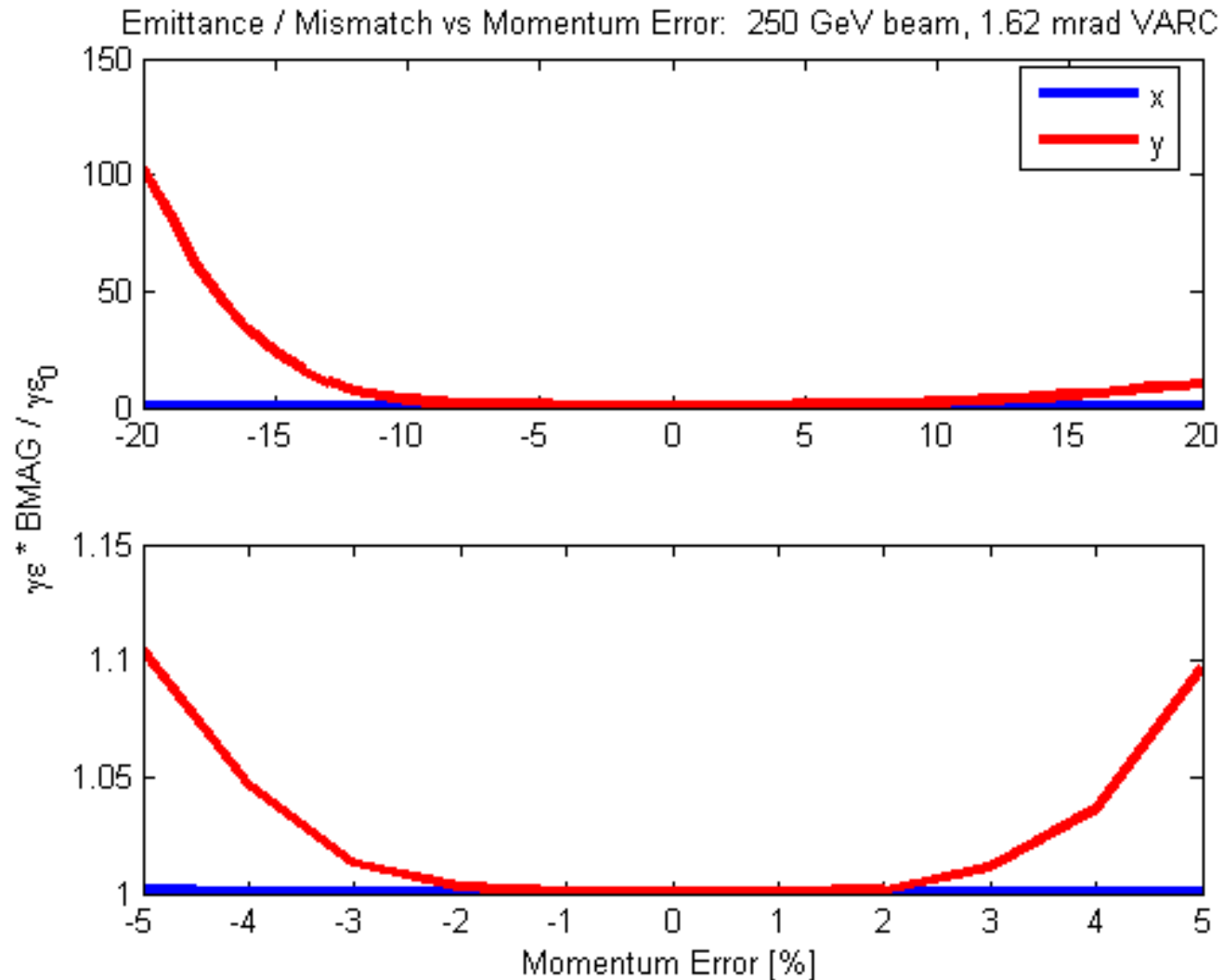
- SR at energies higher than 1 TeV CM
 - emittance growth excessive
 - may need to lengthen arc, switch to gradient bends
- Bandwidth
 - High-order dispersions not corrected
 - steering and mismatches for off-energy bunches

Lengthening VARC

Can “rip out” linac around VARC and extend – center of VARC has to be lowered by 3.5 cm for 1.62 mrad total bend angle



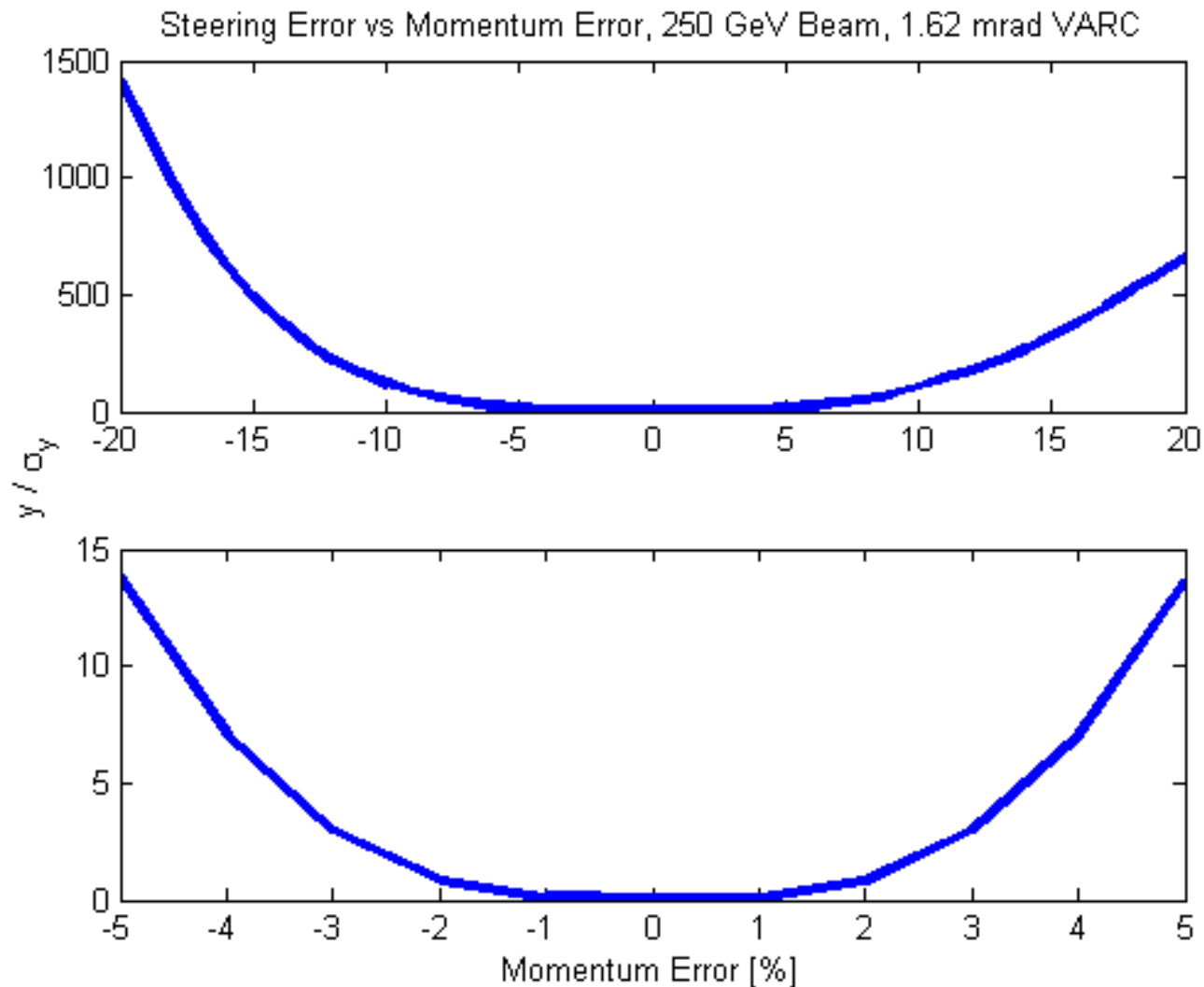
Emittance Growth and Mismatch



Even 20% off-momentum beam will have tolerable matched emittance (about 2 $\mu\text{m}\cdot\text{rad}$)

Mismatch over BDS luminosity bandwidth is quite small

Steering



-20% off-momentum beam gets steering error of 1500σ , or about 3.8 mm (10% of the cavity apertures), so it doesn't hit anything in the linac

For more modest momentum errors the offset is well within the capture range of the intra-train feedbacks

Conclusions

- In my opinion the vertical arcs look usable
- Need to consider operational implications of arcs
 - in particular whether tuning procedures can tolerate large oscillations and mismatches for off-momentum bunches
 - Intra-train feedback issues
 - Does large high-order dispersion drive halo formation?
- Don't know yet what beta match from linac looks like
 - might be highly chromatic...
- Note that if 6-cell arcs prove marginal, can expand to 10-cell arcs
 - Dramatic reduction in high-order dispersion and mismatches for off-momentum bunches