Drive Beam Linac Longitudinal Tolerances

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Requirements of outgoing beam

Energy	2.4	GeV
Energy Spread	<0.35	%
Bunch Length	1.0	mm
Phase error	0.2 (175)	deg (μm)
Bunch length variation	1	%
Variation at energy	?	%

Effects

- The variation of the phase of incoming bunch √
- The variation of the energy of incoming bunch √
- The variation of the charge of incoming bunch √
- The variation of the phase of cavities √
- Variation of the gradient of the cavities √

Beam loading

Layout

DBL1

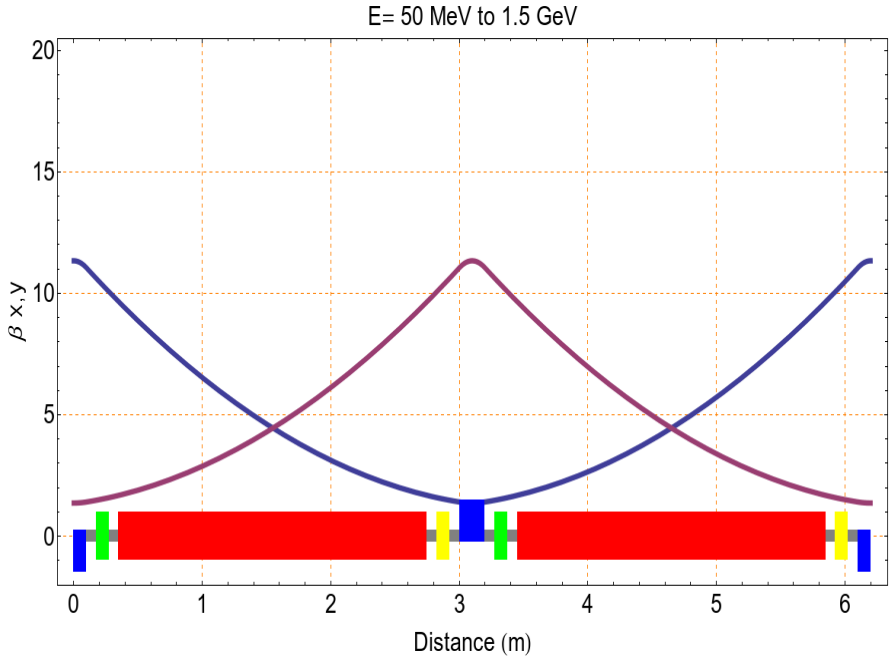
Bunc Compressor

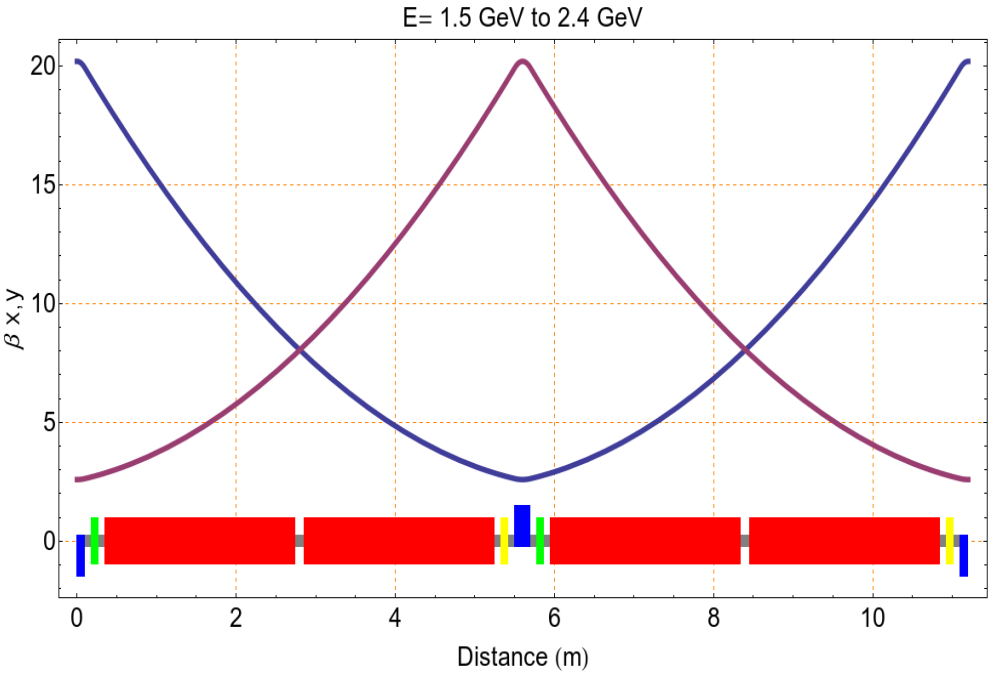
DBL2

Beam energy
50 → 300 MeV
Bunch lenght:
3 mm

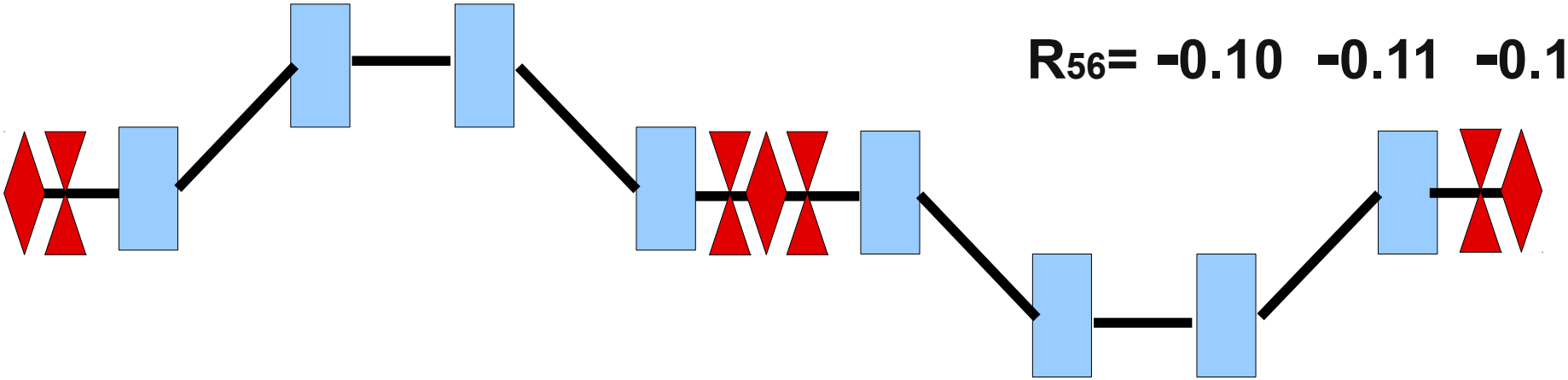
Compression
3mm →1mm

Beam energy
300 → 2400 MeV
Bunch lenght:
1 mm





CHICANE

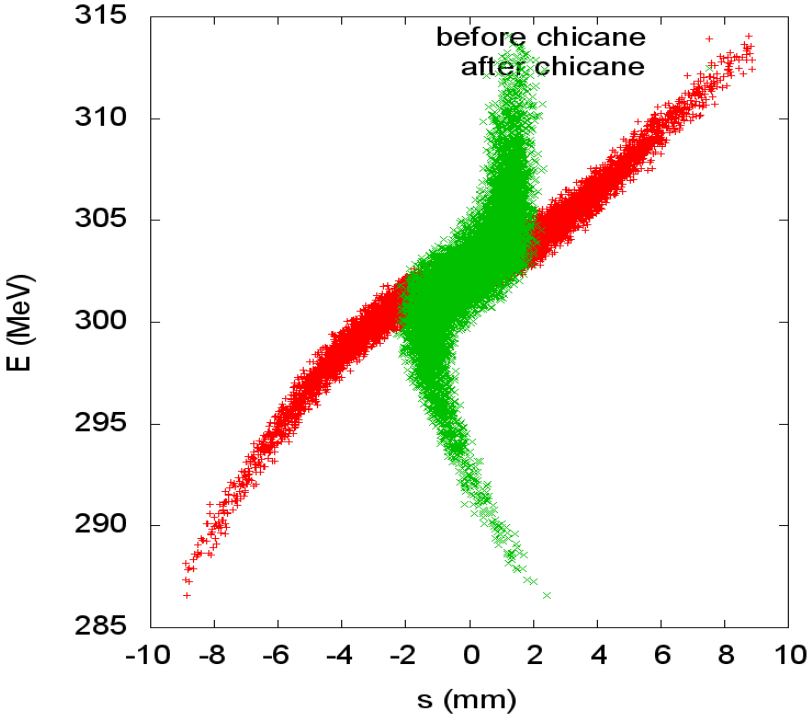


R_{56}= -0.10 -0.11 -0.13

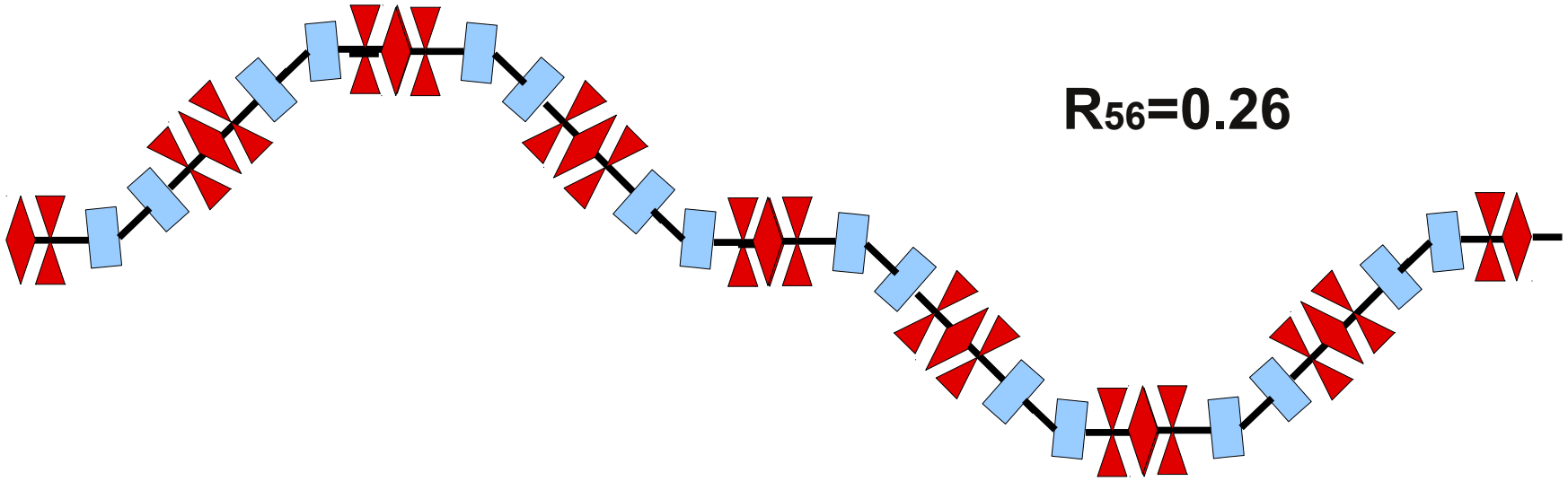
Chicane located at 300 MeV

DBL1 off-crest 23 – 27.5 degree

DBL2 off-crest 18 degree



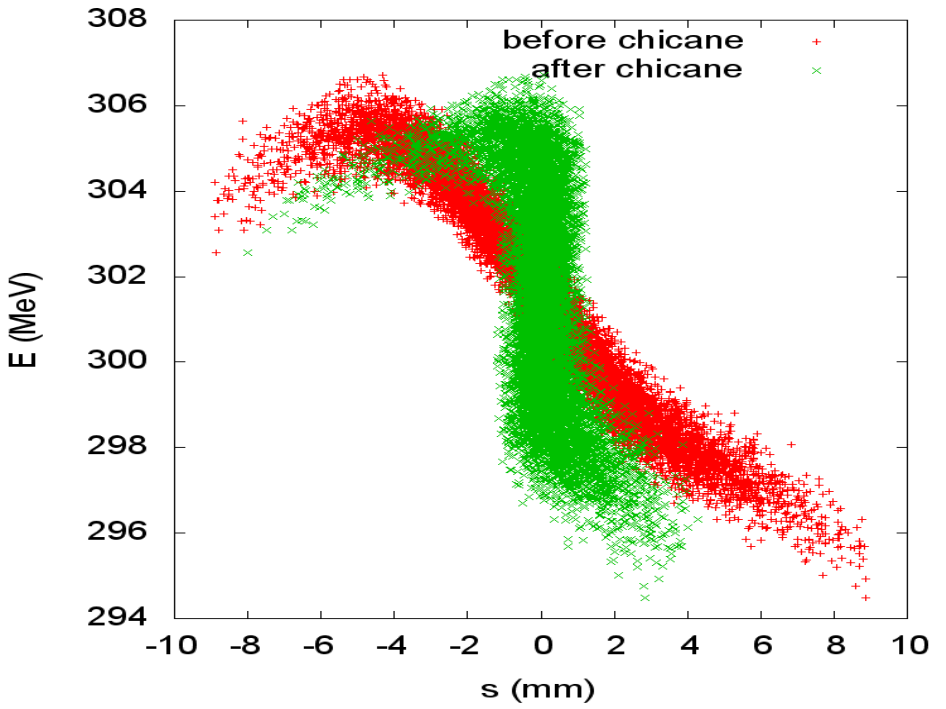
Positive R_{56}



Compressor located at 300 MeV

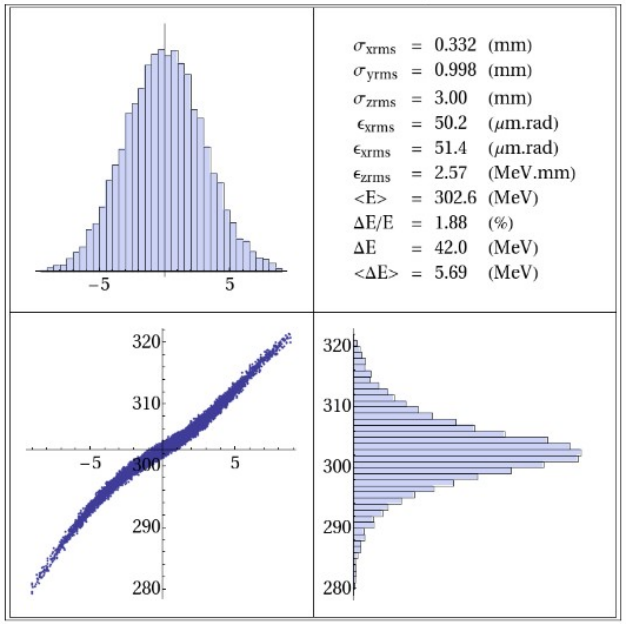
DBL1 linac off-crest -7.5 degree

DBL2 off-crest 18 degree

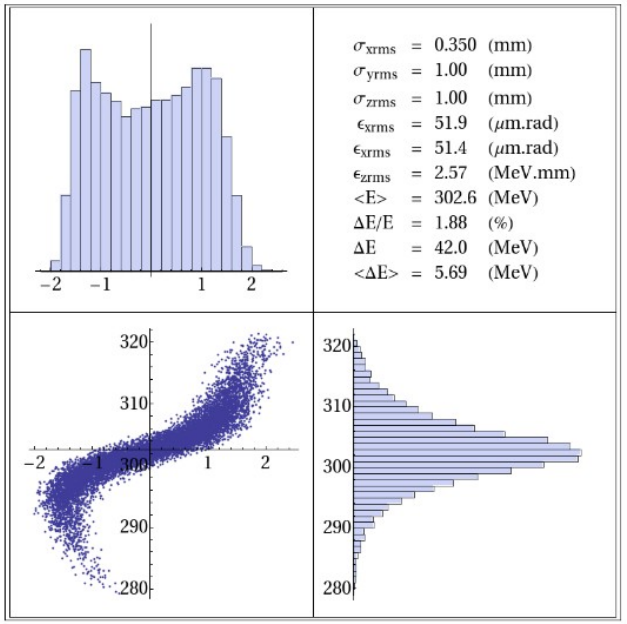


Phase spaces at different positions

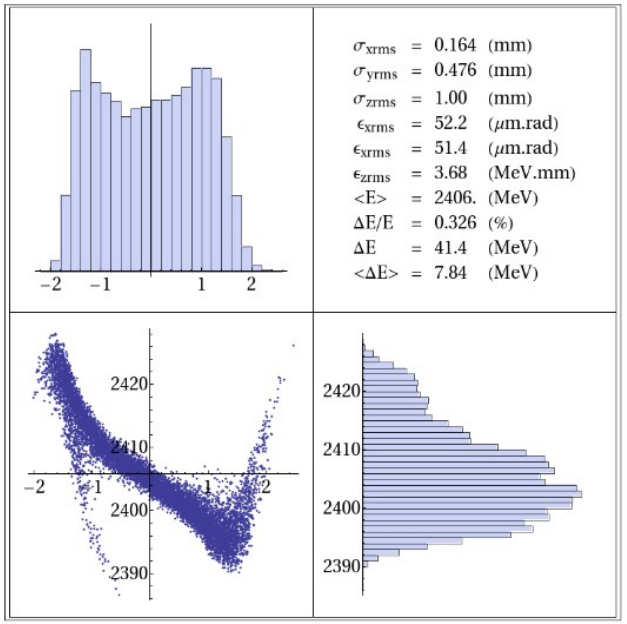
Phase at DBL1 end R_{56}=−0.11, f_{rf}=26



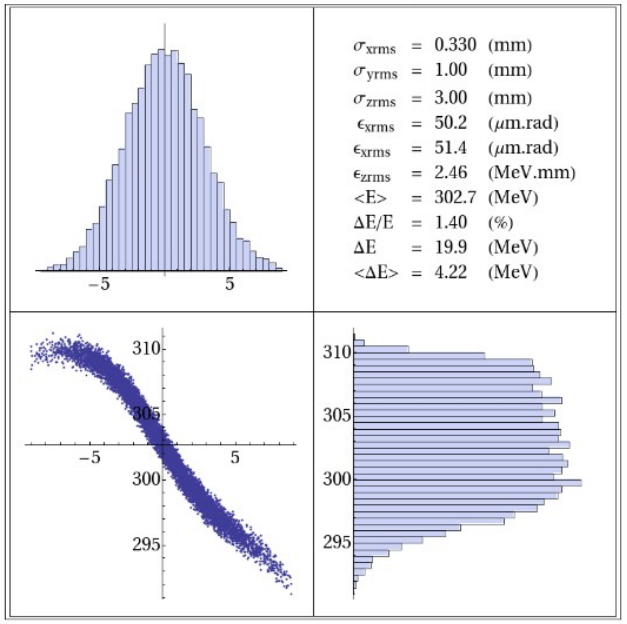
Phase at COMP end R_{56}=−0.11



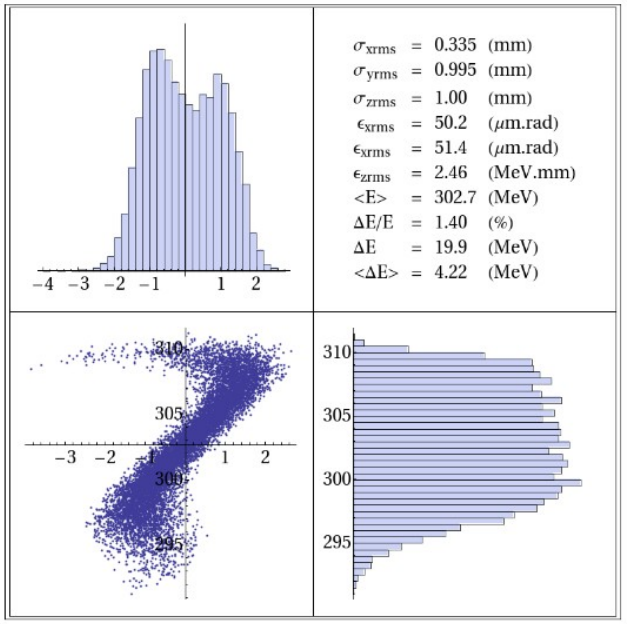
Phase at DBL2 end R_{56}=−0.11, f_{rf}=18



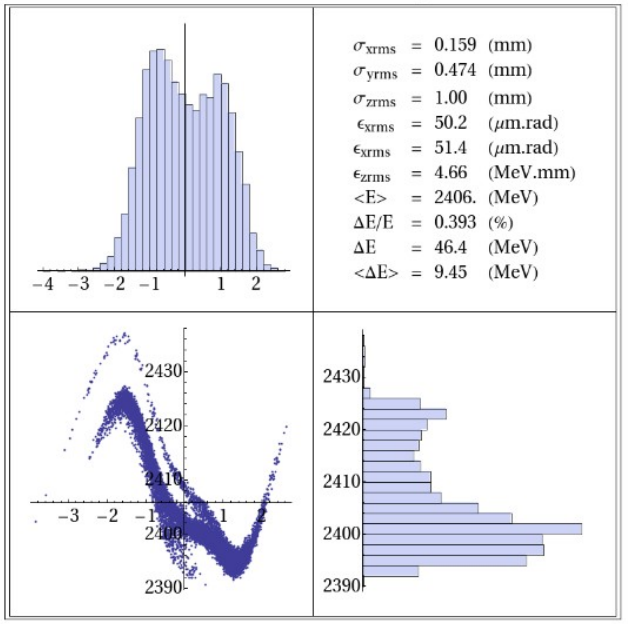
Phase at DBL1 end R_{56}=0.26, f_{rf}=−7.3



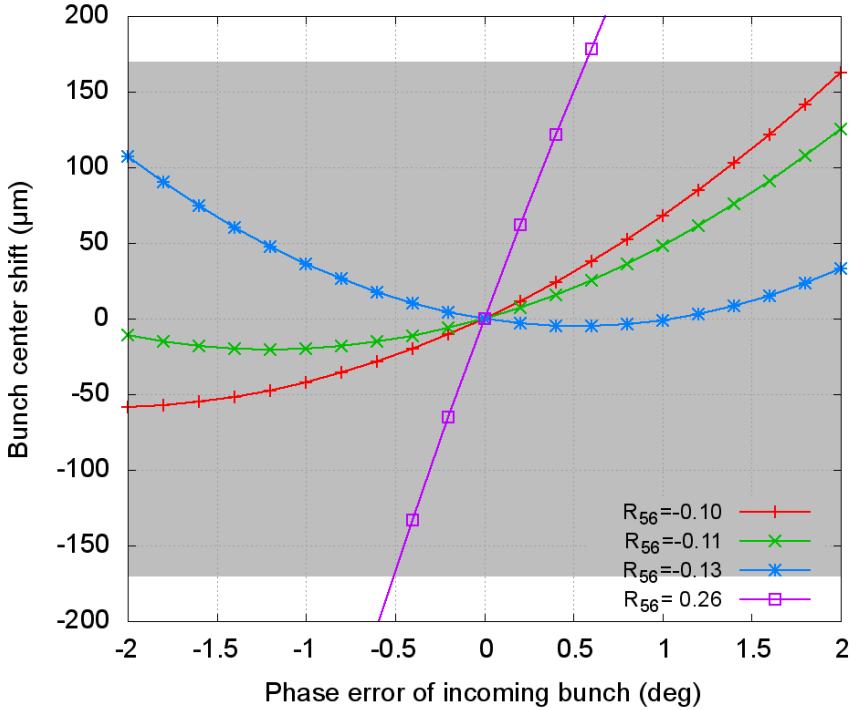
Phase at COMP end R_{56}=0.26

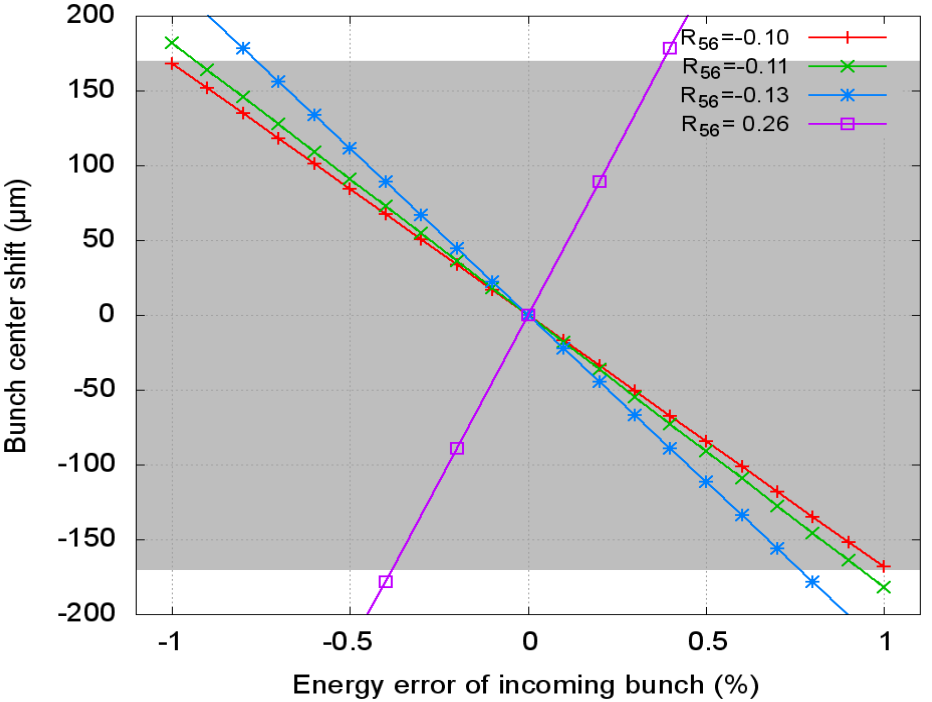


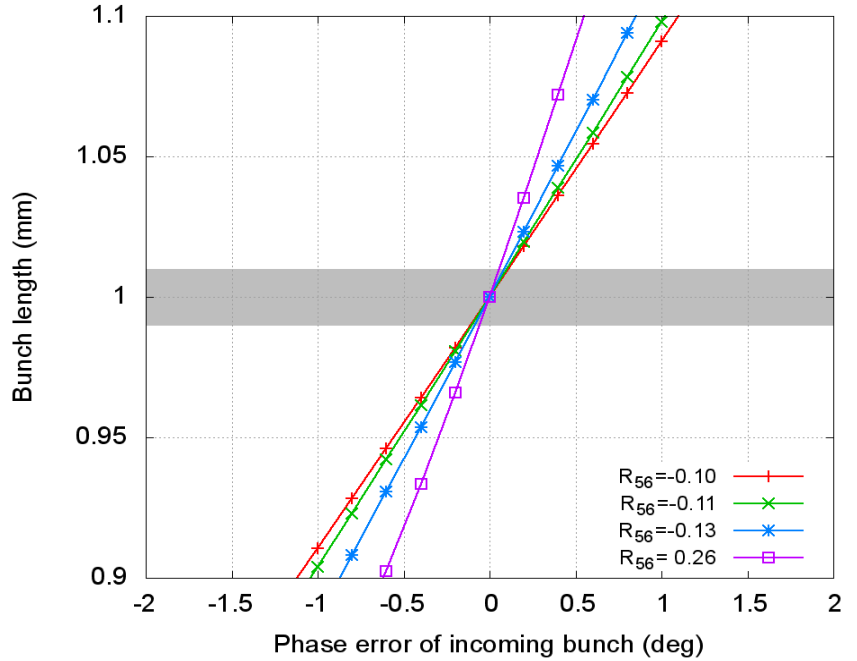
Phase at DBL1 end R_{56}=0.26, f_{rf}=18



Incoming Bunch Phase & Energy Error

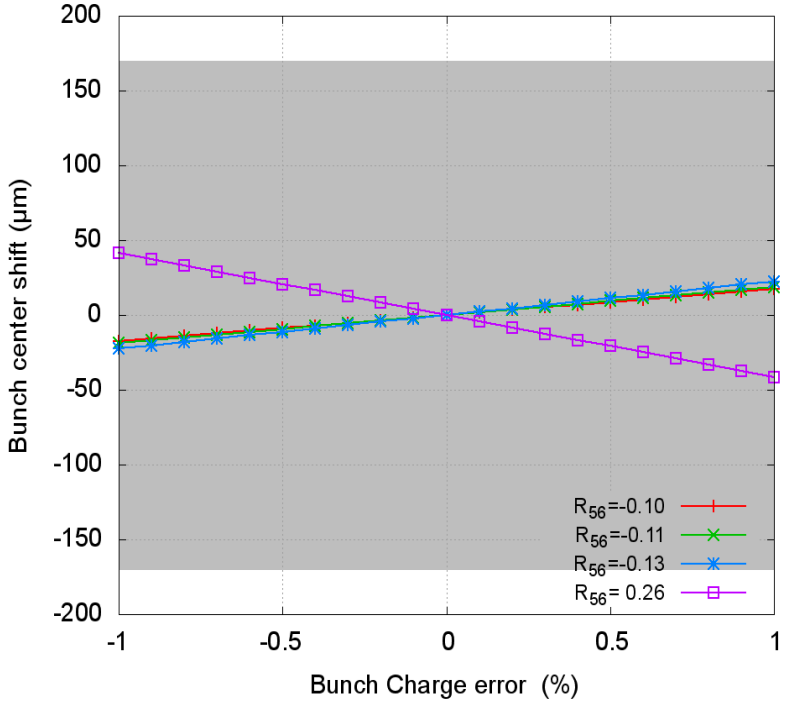


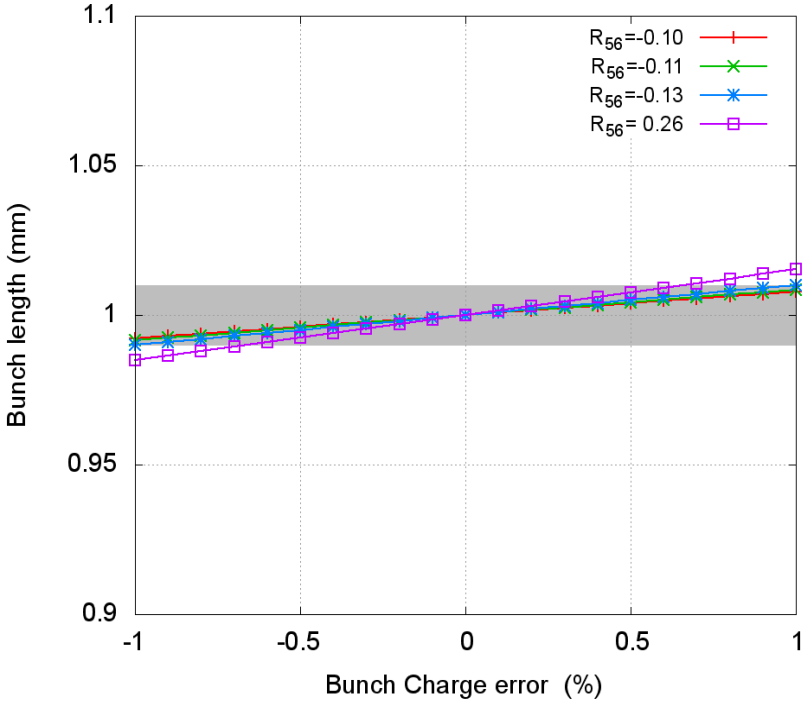


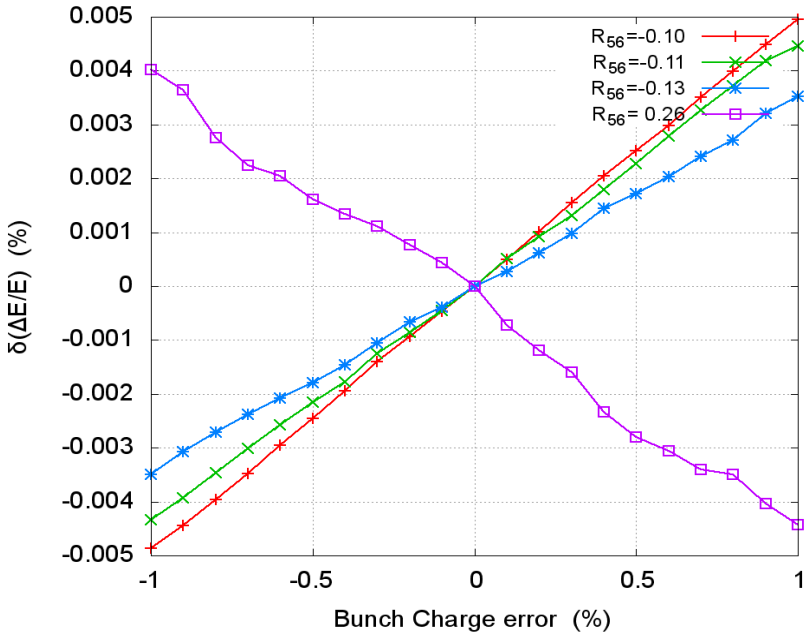


- Positive R56 is very sensitive to phase of incoming bunch about phase shifting and bunch length variation
- R56=-0.1 compensates maximum energy error of incoming bunch
- R56=-0.1 allows maximum phase error of incoming bunch

Incoming Bunch Charge Error

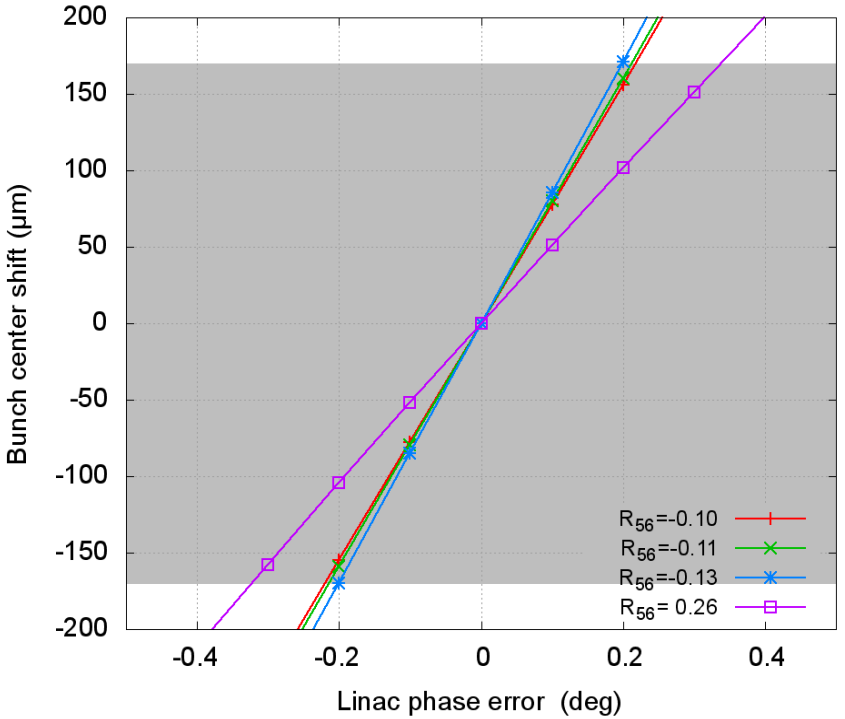


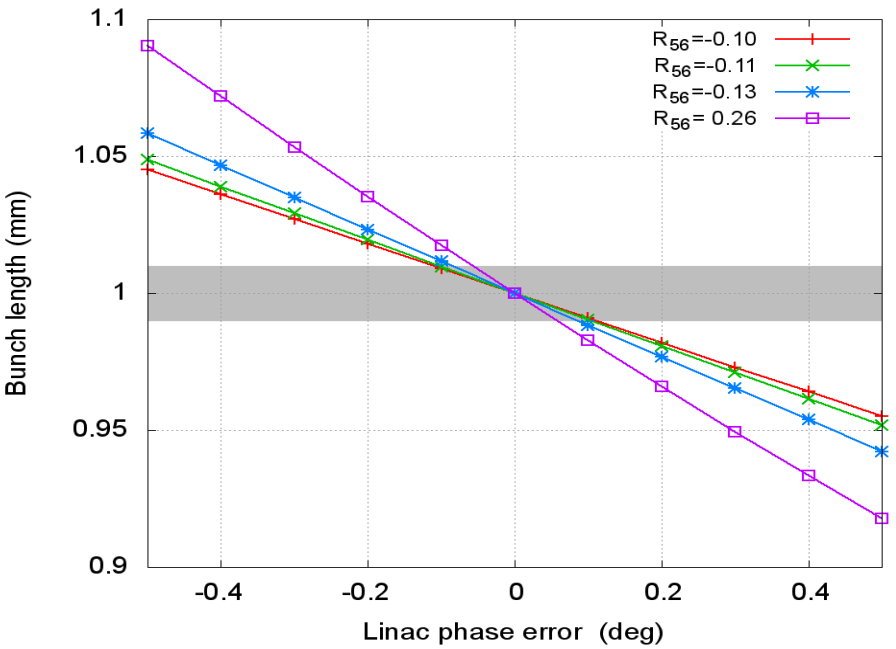


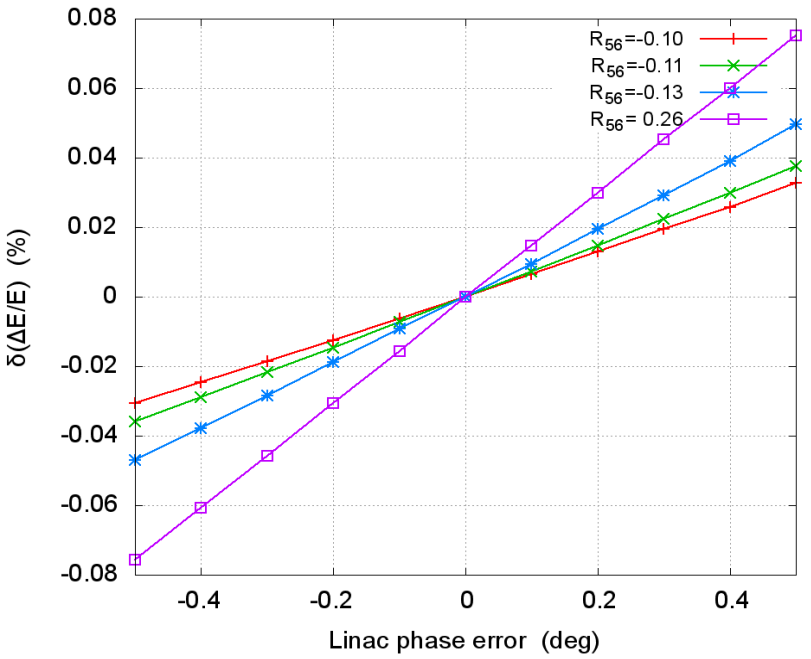


- All compressors are agreeable for ±1% charge errors regarding phase shift of outgoing bunch
- R56=-0.1 compensates charge error regarding bunch length variation
- Variation of energy spread for ±1% charge error is negligible

Linac Phase Error

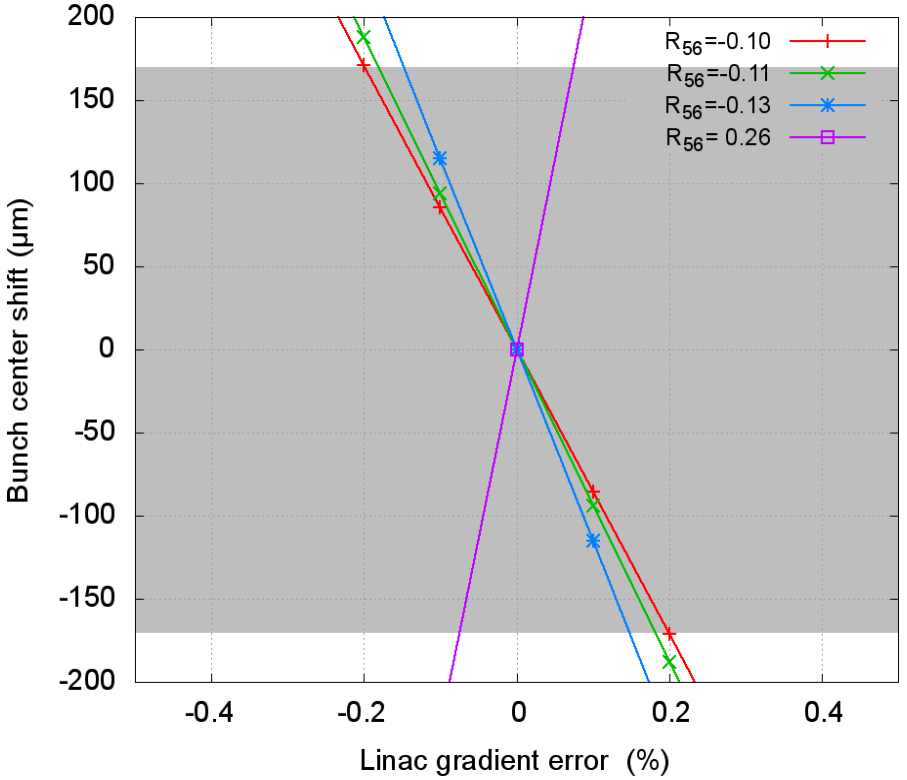


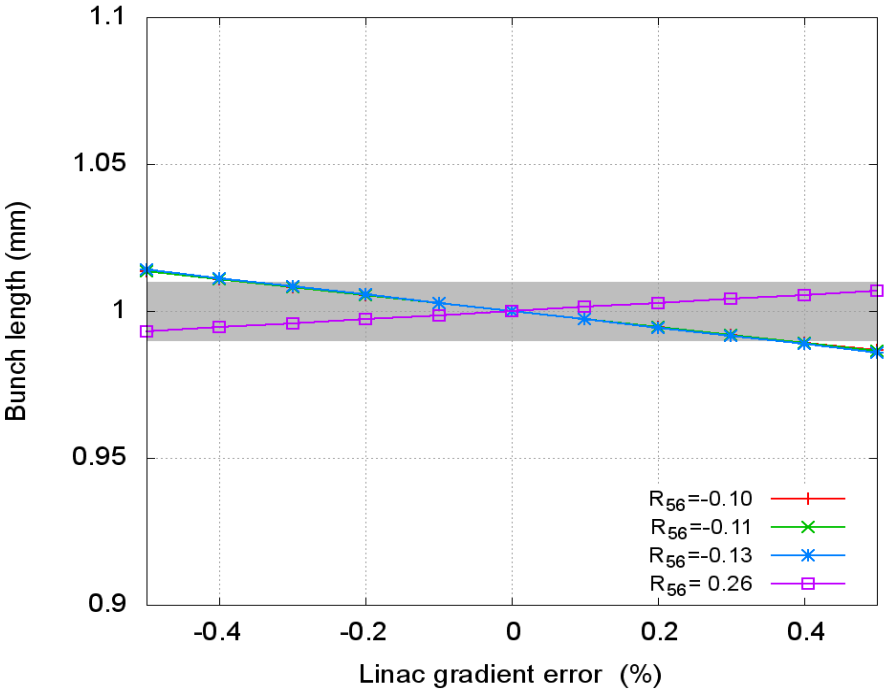


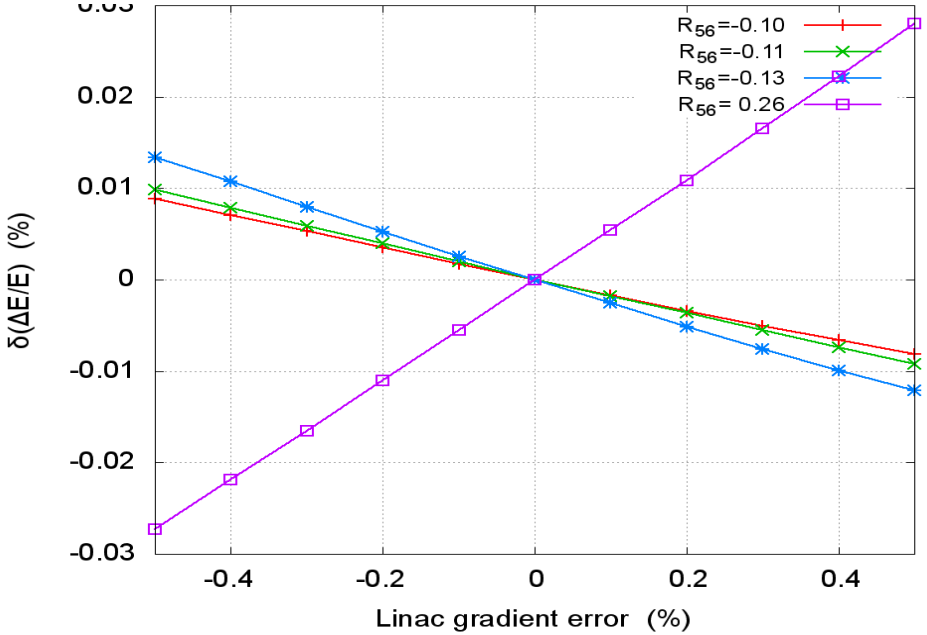


- R56=0.26 allows larger linac phase error regarding phase shift of outgoing bunch (±0.25 deg)
- R56=-0.1 allows larger linac phase error regarding bunch length variation outgoing bunch (±0.1 deg)

Linac Gradient Error







- R56=0.26 is very sensitive to linac gradient errors
- R56=-0.1 allows larger linac gradient error regarding phase shift variation outgoing bunch (±0.1 deg)
- All compressors are acceptable for gradient errors

Conclusion

- Computations on compressor sections were performed under linear approximation
- It was found out that the limitation of variation of bunch length makes tolerances very tight
- Although it seems positive R56 compressor is good for saving RF power, it is not acceptable for longitudinal errors.
- Traditional chicane with biggest R56 seems better (R56=-0.1)

- The tolerances using R56=-0.1 can be summarized as
  - Incoming bunch phase error 0.2 deg (due to bunch length var)
  - Incoming bunch energy error 1 % (due to bunch phase shift)
  - Incoming bunch charge error 1 % (due to bunch length var)
  - Linac gradient error 0.2 % (due to bunch phase shift)
  - Linac phase error 0.1 deg (due to bunch length var)