

# Emittance growth in the LHeC recirculating Linac

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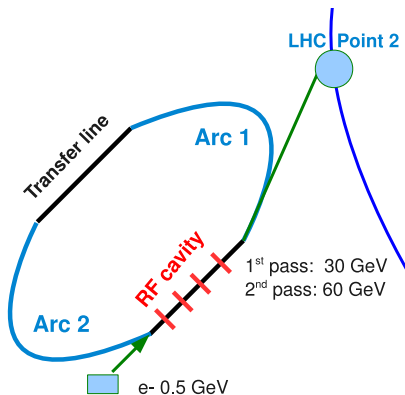
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# Content

- Preliminary study
- LHeC (RL option) linac lattice & beta-beat
- Simulation set-up
- Beam energy and rms energy spread
- Emittance growth with acceleration
- Emittance growth with acceleration, radiation and quantum effects

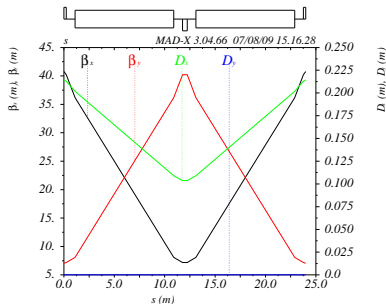
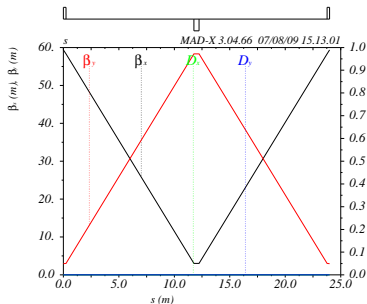
## Layout (RL option)



## Note

Total length 20.3 km

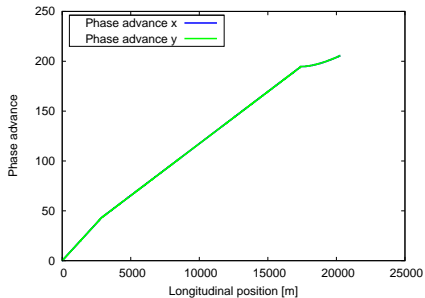
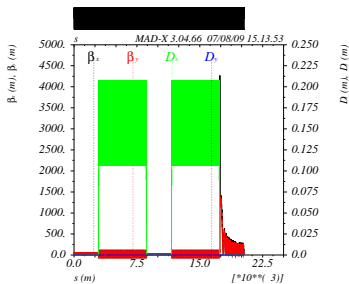
## Linac cell &amp; Arc cell



## Note

Left: linac cell 130 degree 1st pass (78 T/m max); Right: arc cell with 90 degree phase advance

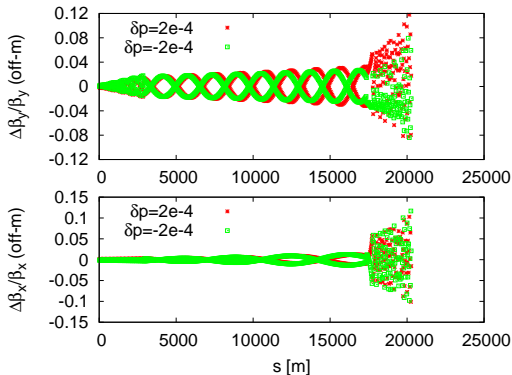
## Lattice



## Note

1st pass linac (2.9 km) + Arc (5.8 km) + Transfer line (2.9 km) + Arc (5.8 km) + 2nd pass linac (2.9 km)

## Beta-beating



## Note

Less than 12%, for energy offset  $\pm 2 \times 10^{-4}$

# Simulation set up

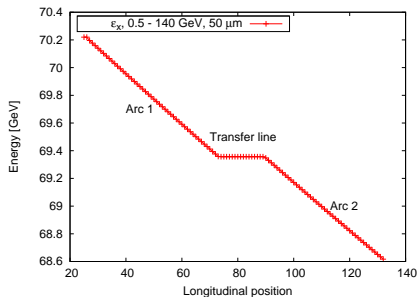
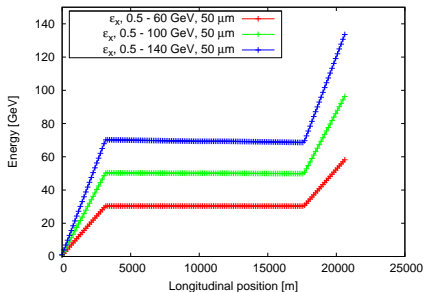
## Code & beam

- 10,000 macro-particles
- Modified MADX thin-lens tracking
- 0.5 GeV accelerated to 60 GeV (100 GeV or 140 GeV)
- Bunch length  $300 \mu\text{m}$ , initial energy spread  $1 \times 10^{-4}$ ,  
 $\gamma\epsilon_{x,y} = 50, 100, 200 \mu\text{m}$

## RF cavity

- 700 MHz
- Accel. gradient 13-32 MV/m

# Beam energy

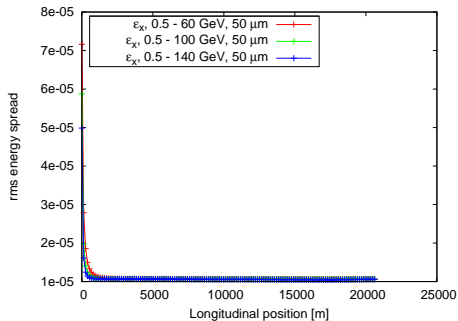


## Note

- 70 GeV, 2% energy loss in arc
- Up to 30 GeV, neglectable

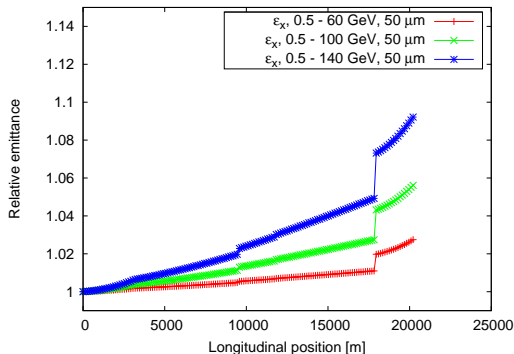


## rms energy spread



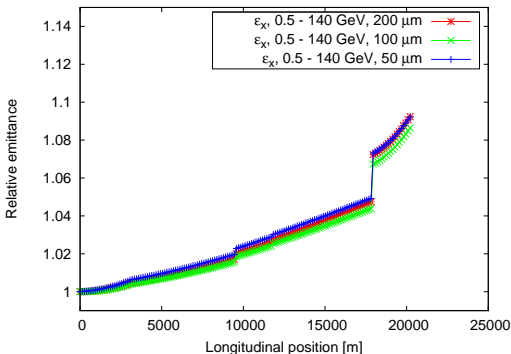
## Note

- initial energy spread  $1 \times 10^{-4}$ , decreased to  $1.2 \times 10^{-5}$  during acceleration

Emittance growth with acceleration,  $\gamma\epsilon = 50 \mu\text{m}$ 

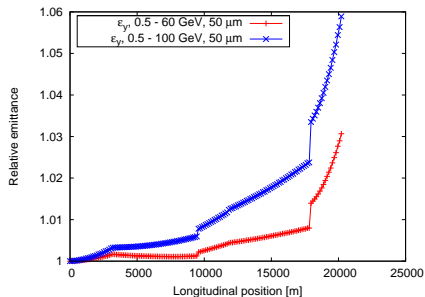
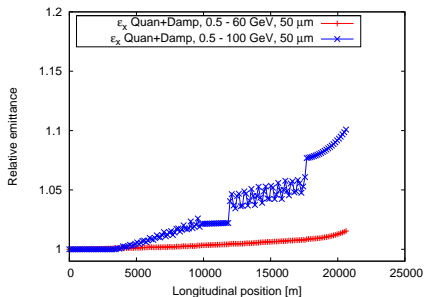
## Note

- Energy accelerated from 0.5 GeV to 60 (100 or 140) GeV
- Energy spread and chromatic effects

Emit. growth with accel. (three  $\epsilon$ ), 140 GeV

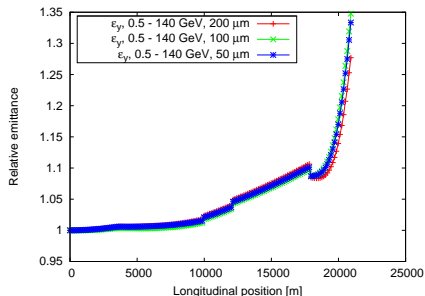
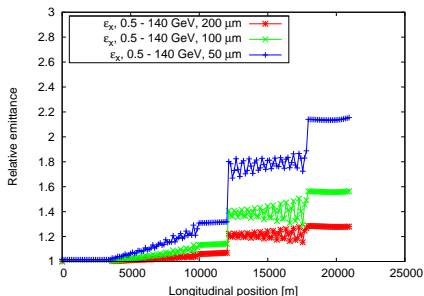
## Note

- Emittance  $\gamma\epsilon = 50 \mu\text{m}, 100 \mu\text{m}, 200 \mu\text{m}$
- Energy 0.5 GeV to 140 GeV

Emit. growth with accel. and SR,  $\gamma\epsilon = 50 \mu\text{m}$ 

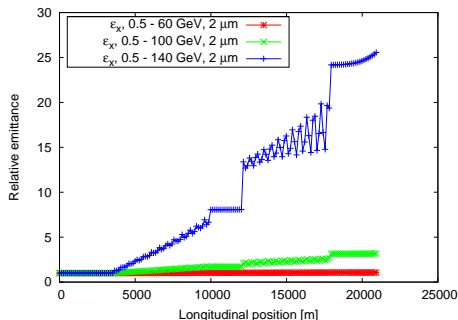
## Note

- Synchrotron Radiation damping and quantum excitation
- Energy 0.5 to 60 (100) GeV

Emit. growth with accel. and SR (three  $\epsilon$ ), 140 GeV

## Note

- Emittance  $\gamma\epsilon = 50 \mu\text{m}, 100 \mu\text{m}, 200 \mu\text{m}$
- Energy 0.5 GeV to 140 GeV

Emit. growth with accel. and SR,  $\gamma\epsilon = 2 \mu\text{m}$ 

## Note

- DESY XFEL beam
- Energy 0.5 to 60 (140) GeV

## Conclusion

- Energy spread + chromaticity, small effect (10% growth for 140 GeV)
- +Radiation fluctuations at 140 GeV,  $\Delta\gamma\epsilon = 50 \mu\text{m}$  emittance growth;
- Up to  $E = 100 \text{ GeV}$ ,  $\gamma\epsilon = 50 \mu\text{m}$  is preserved in the RLA
- For  $E = 140 \text{ GeV}$ ,  $\gamma\epsilon > 100 - 200 \mu\text{m}$  at IP

## What To do next

- Improvement of lattice (transition)
- Beam break up due to wake field (Placet & formulae)
- Higher Order Mode heat loss