Considerations on Beam-Based Alignment

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- Reminder of alignment strategy
- dispersion free steering and possible implementation
- mixed acceleration of electrons and positrons
- a potential pre-linac design

TRC Findings

- The complete study of the correction of the machine in a wide variety of error sources is considered an R2
- dynamic effects during correction are important
- Peder is studying these effects
- but we should try to optimise the procedures anyway
- to make correction most efficient
  - minimise time needed for correction
  - correction conditions as close as possible to normal operation

Beam-Based Alignment

- Some imperfections cannot be measured directly
- but they harm the beam

$\Rightarrow$ measure the effect on the beam

- our strategy
  - prealign elements
  - align BPMs
  - align quadrupoles
  - align structures
  - globally correct wakefields
- will focus on alignment of quadrupoles and BPMs

Ballistic Alignment

- Different steps
  - switch of quadrupoles
  - steer beam into last BPM
  - re-align BPMs to beam
  - switch on quadrupoles
  - re-steer beam into BPMs
- conveniently seperates BPM alignment and quadrupole alignment
- switching on/off quadrupoles needs time required by machine protection
- stray fields can be a problem

Dispersion Free Steering

- Basic idea: use different beam energies/lattices
- NLC: switch on/off different accelerating structures
- CLIC (TESLA): accelerate beams with different gradient
- optimise trajectories for different energies together:

$$S = \sum_{i=1}^{n} \left(w_i (x_{i,1})^2 + \sum_{j=2}^{m} w_{i,j} (x_{i,1} - x_{i,j})^2 \right) + \sum_{k=1}^{l} w'_k (c_k)^2$$

- last term can be omitted
- need a good guess of the weights w
- align quadrupoles and BPMs at the same time
- sensitive to beam jitter/variation of incoming beam with energy

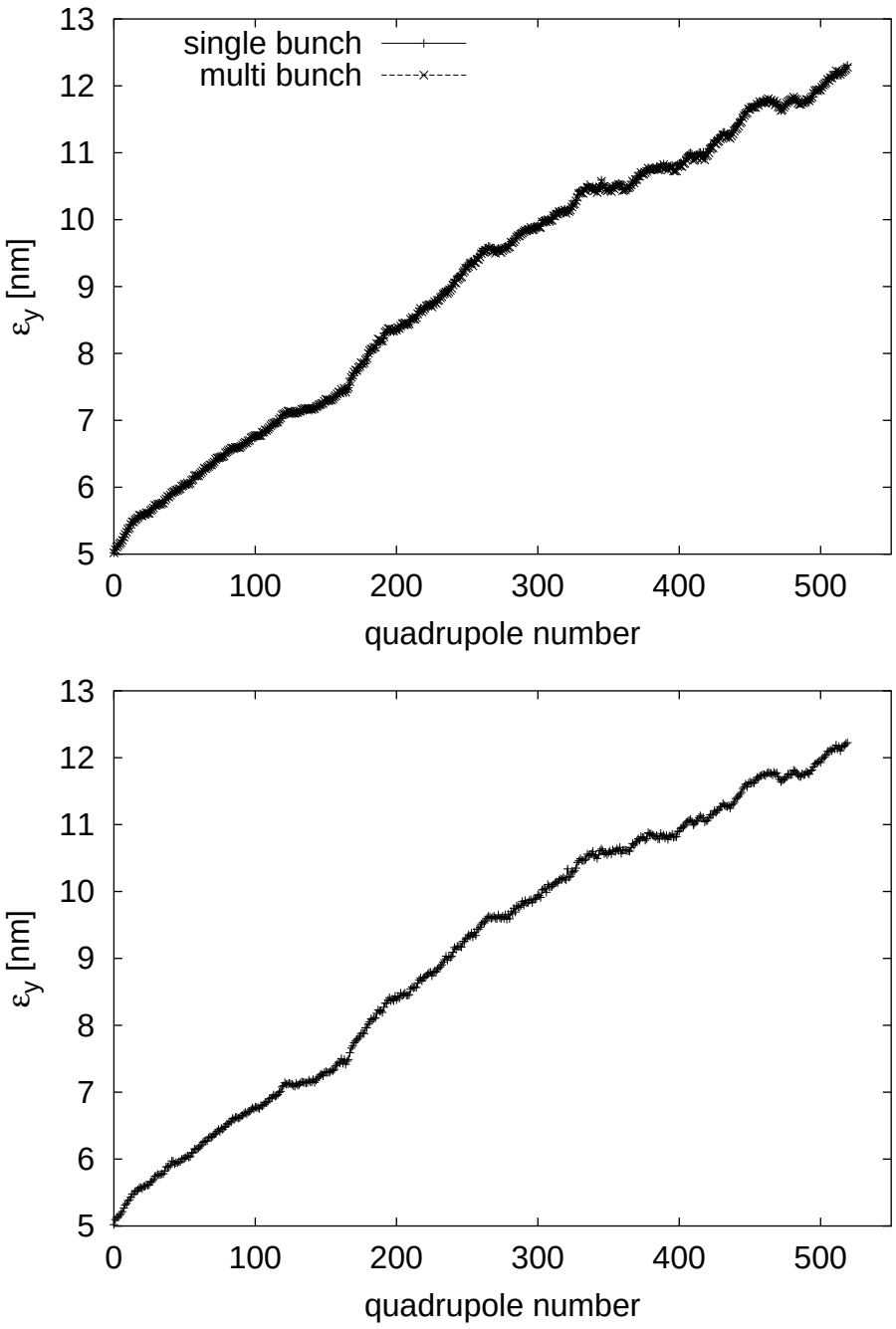
Some Considerations

- Steering with different quadrupole strengths
  - slow
  - machine changes from one measurement to next
  - shifts of quadrupoles centres cause problems

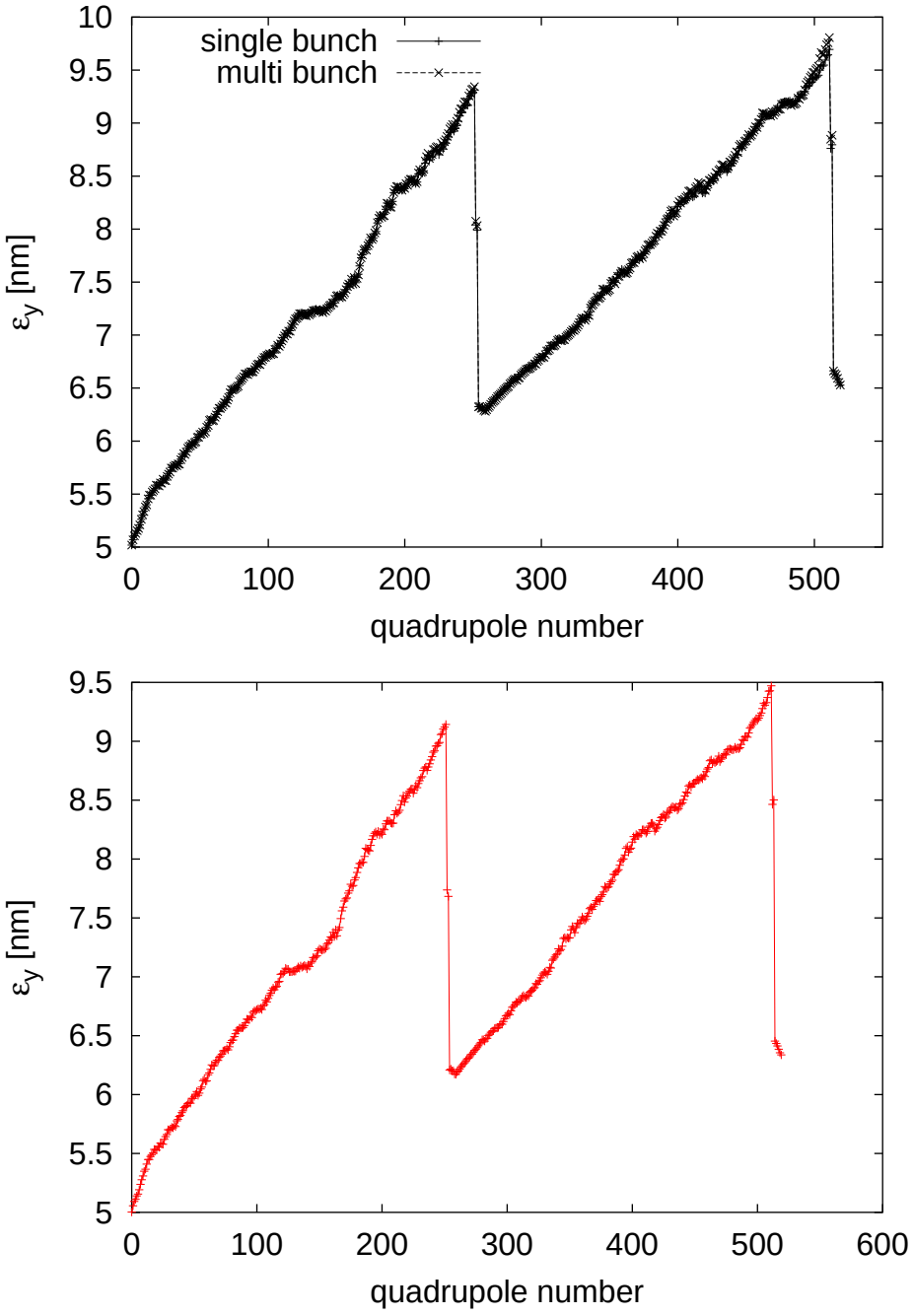
$$\frac{\partial y_c}{\partial K} \neq 0$$

- using different energies
  - fast
  - machine changes less from pulse to pulse
  - no dependence on quadrupole centre shift
  - need to start with different energies/find other solution for start of linac
  - beam loading effects may enter
- using different energies in the same pulse
  - machine does not change
  - fast instrumentation required
  - beam loading effects may enter

Comparison of Ballistic Alignment and Dispersion Free Steering



Adding Bumps



Correction Performance

- Comparison done for $E_{cm} = 500\,\mathrm{GeV}$
- 100%, 90% and 80% gradient and intial energy for dispersion free steering

$\Rightarrow$ the results are very similar

- some remarks on dispersion free steering
  - scaling the gradient and not switching on/off structures gives best performance
  - sensitive to beam jitter
  - switching structures changes path
    $\Rightarrow$ fit of incoming beam introduces error
  - gradient changes does not necessarily require fit
    $\Rightarrow$ better performance, but dangerous
  - single pulse measurement should have less systematic errors
  - one could use an alignment pulse once in a while

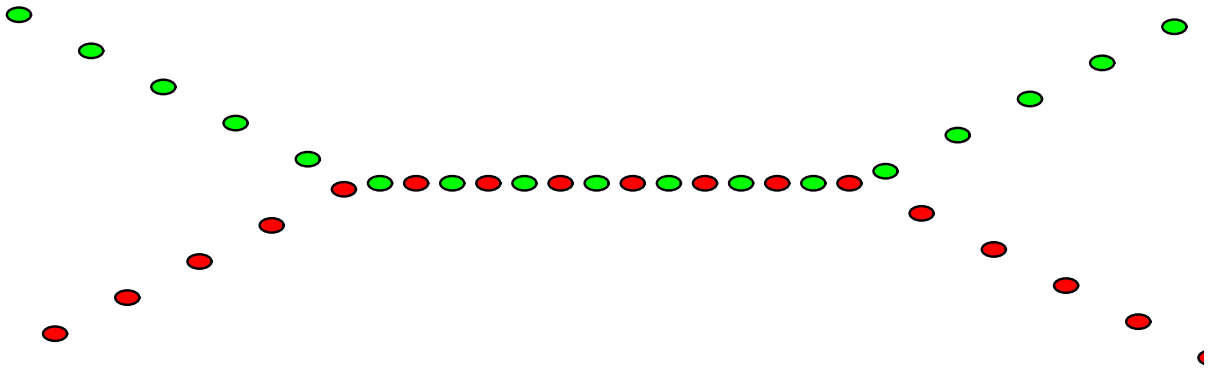
$\Rightarrow$ dispersion free steering seems to be a viable option

Different Charges

- Very different energies (200%)
- could be useable in luminosity operation

  $\Rightarrow$ exactly the right machine is corrected

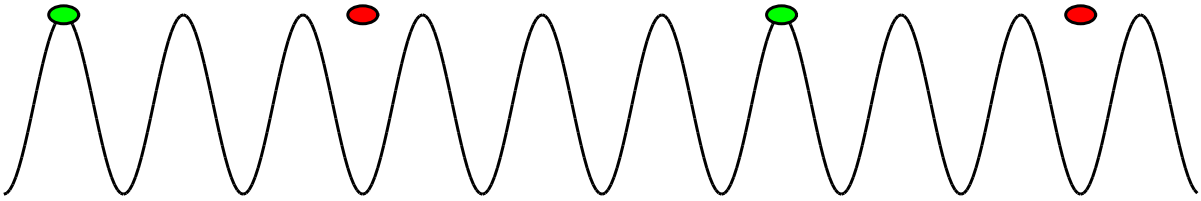
  $\Rightarrow$ can correct any time
- combine and separate beams with dipoles



- run two detectors at the same time
  - both BDSs can be tuned in parallel
  - half the background per unit time
  - less multi-bunch kink
  - less power in collimation system

Some Considerations

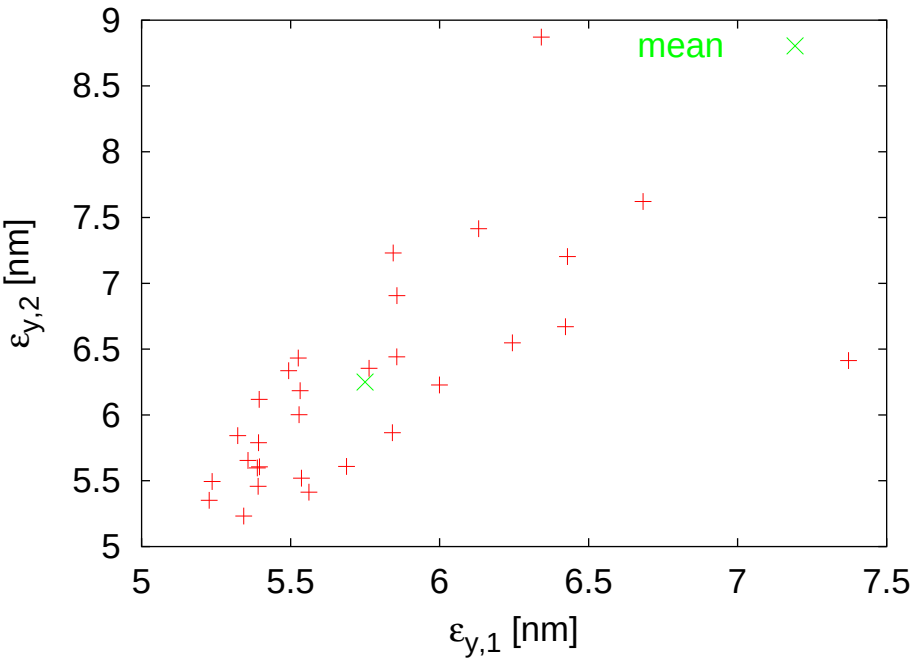
- Acceleration is trivial



- lattice remains FODO
- fast beam ion instability very much reduced
- some fundamental changes in PLACET necessary
- if no combined acceleration is wished, can use opposite charge pusles for alignment once in a while

Correction Strategy

- Simplified model for now
  - prealign elements
  - use dispersion free steering
  - use emittance tuning bumps
    (full 20-dimensional optimisation)



$\Rightarrow$ seems acceptable

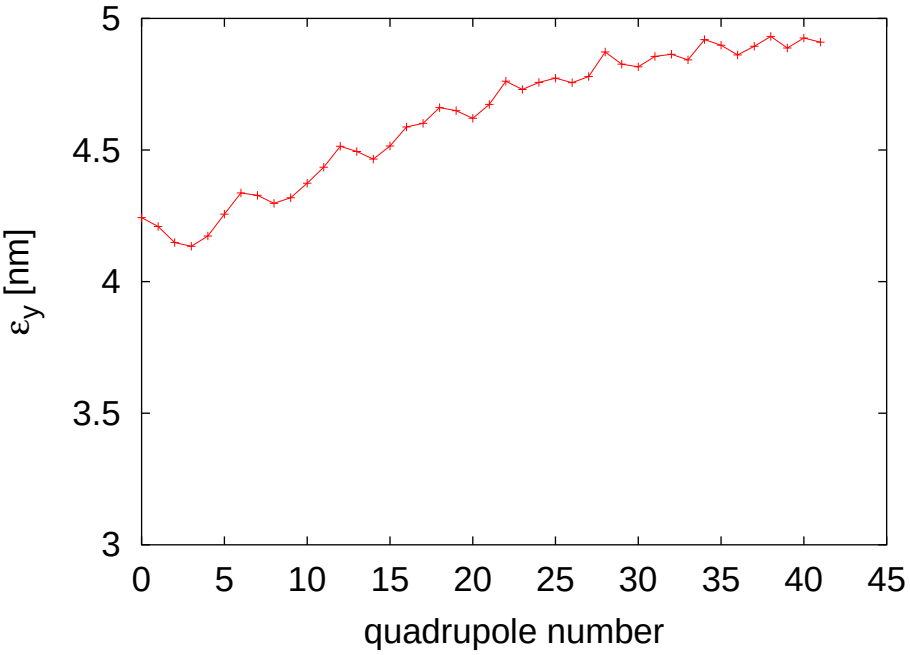
- more detailed work necessary
- more deterministic bump optimisation

Pre-Linac: Principle Considerations

- $15\,\mathrm{GHz}$ structures
- scaled from $30\,\mathrm{GHz}$
- gradient $\approx 70\,\mathrm{MV/m}$
- natural pulse length twice main linac pulse length
  - e.g. second delay loop
- power taken from drive beam long pulse
- several potential configurations:
  - one linac, electrons and positrons interleaved for both sides, separated by RF deflector
  - two linacs, electrons and positrons interleaved
  - two linacs, electrons in one, positrons in other
  - two linacs, electrons after positrons
  - four linacs
- lower frequencies are possible for reduyced drive beam intensity

Lattice Design

- Simple FODO lattice



- running at $\Phi_{RF} = -30^\circ$

  $\Rightarrow$ creates $\approx$ 2% energy deviation per $\sigma_z = 133\,\mu\mathrm{m}$

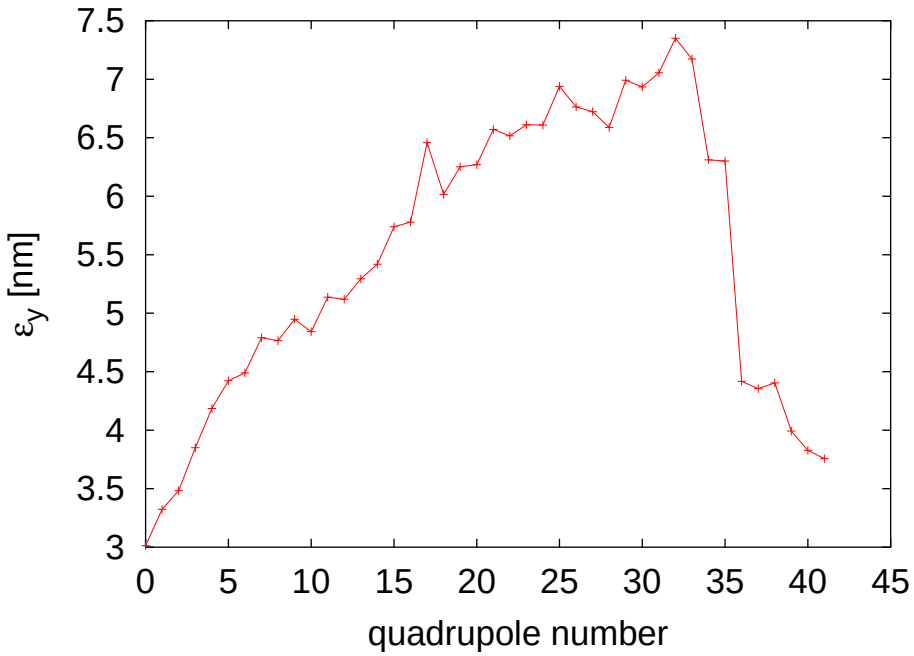
- emittance for 1σ vertical offset

$\Rightarrow$ acceptable

- multi-bunch wakefields for same distance as in main linac have small safety margin

  $\Rightarrow$ keep same number of buckets between bunches

Emittance Growth



- emittance growth due to wakefields
- assuming dispersion free steering or ballistic alignment

  $\Rightarrow$ details to be decided depending on configuration
- one emittance tuning bump

$\Rightarrow$ acceptable

Conclusion

- Using dispersion free steering seems a viable option preferable with
  - with different gradients
  - in the same pulse
- using electrons and positrons in each linac seems feasible and improves
  - collimation requirement
  - background
  - time lost for tuning
  - dispersion correction
- more study of operational aspects is needed
- a $15\,\mathrm{GHz}$ pre-accelerator seems an option
- more studies to be done