



Review of CTF3 optics

Ben Constance
30th January 2013



Outline

- Maximising CTF3 performance requires good control of optics
- Transverse matching for emittance preservation
- Dispersion control
 - Large energy spread of a few percent
 - Big beams in dispersive regions threaten losses
- Isochronicity to limit energy variation effects on power produced
 - Short bunches
 - Control of beam phase
- Performing campaign of transverse linear optics verification
 - Will describe technique for optics measurements
 - Discuss machine sections in turn



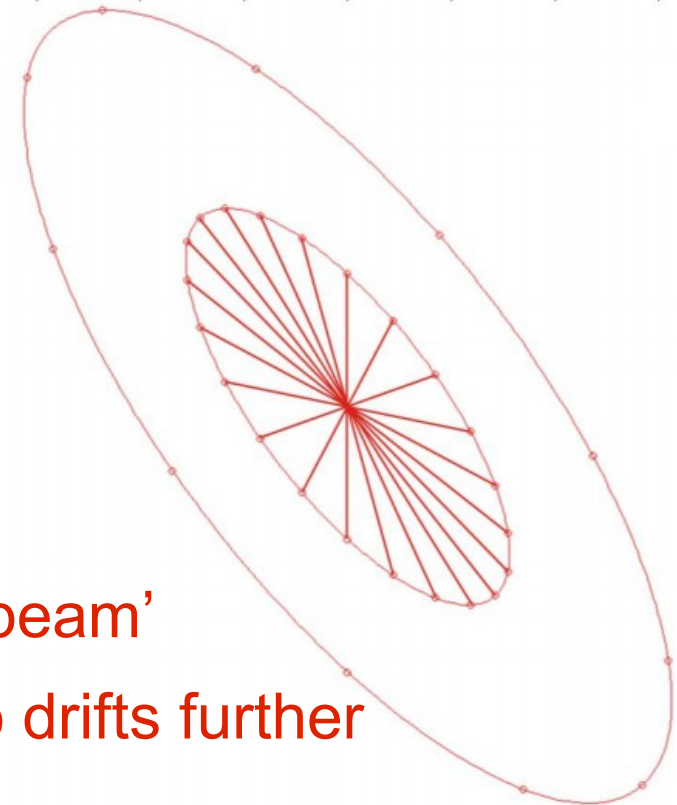
Transverse phase space painting

- CTF3 optics are designed in and referenced against MAD-X
- Pair of corrector magnets used to 'paint' a phase space ellipse
 - Ideally, correctors separated by a drift space
- Linear combination of kicks produces orbits with desired x, x'
 - Orbits behave as macroparticles, ensemble simulates beam
 - Orbits uniformly distributed in normalised phase space
- Ellipse is painted to match the design (MAD-X) phase space



Transverse phase space painting

- 'Star' pattern painted to maximise signal to noise
 - Difference of two orbits separated by 180 deg. phase adv.
 - Beam drifts thus cancelled
 - Use an average over typically 5 difference orbits

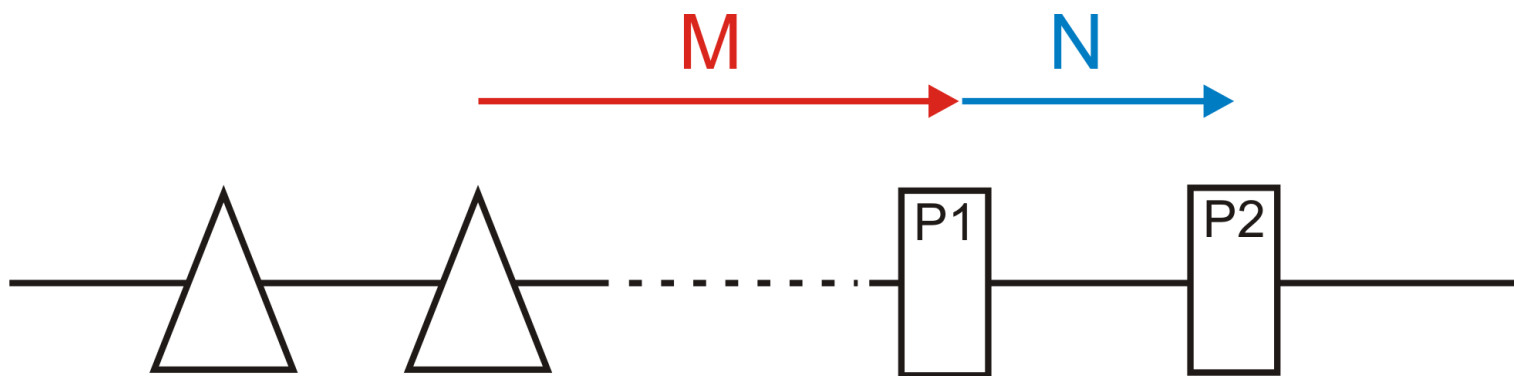


- Repeat measurement with multiple ellipses
 - Increase the 'emittance' of the painted 'beam'
 - Combine ellipses, reducing sensitivity to drifts further



Evolution of painted ellipse

- Aim to measure matrix M
 - Know phase space painted at downstream corrector
 - Want to observe how the ellipse evolves at the BPM P1
 - This requires knowledge of position and angle at P1
 - Assume matrix N from MAD-X, reconstruct using P1 & P2





Reconstruct transfer matrix with symplectic fit

- **MATLAB non-linear fitting code (fmincon). Solve for M :**

$$\mathbf{x}_{BPM} - M\mathbf{x}_K = 0$$

- **Where for the N difference orbits:**

$$\mathbf{x} = (\vec{x}_1, \vec{x}_2, \dots, \vec{x}_N)$$

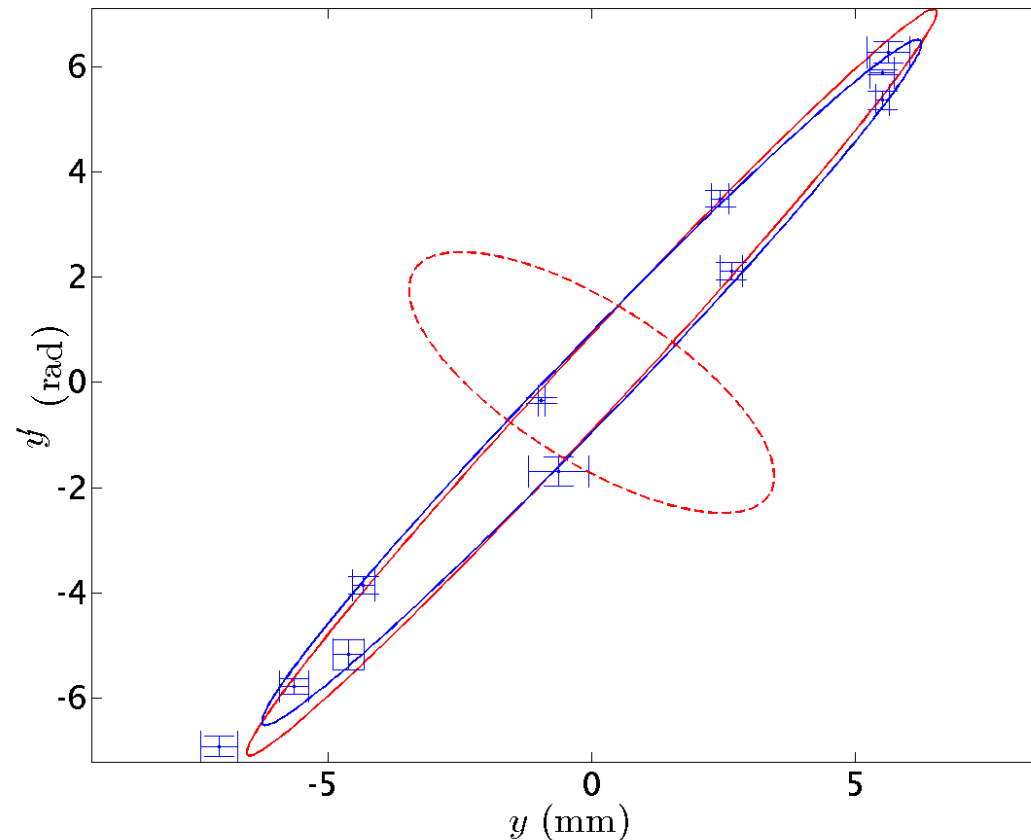
- **And the symplectic constraint is applied:**

$$M'\Omega M - \Omega = 0$$



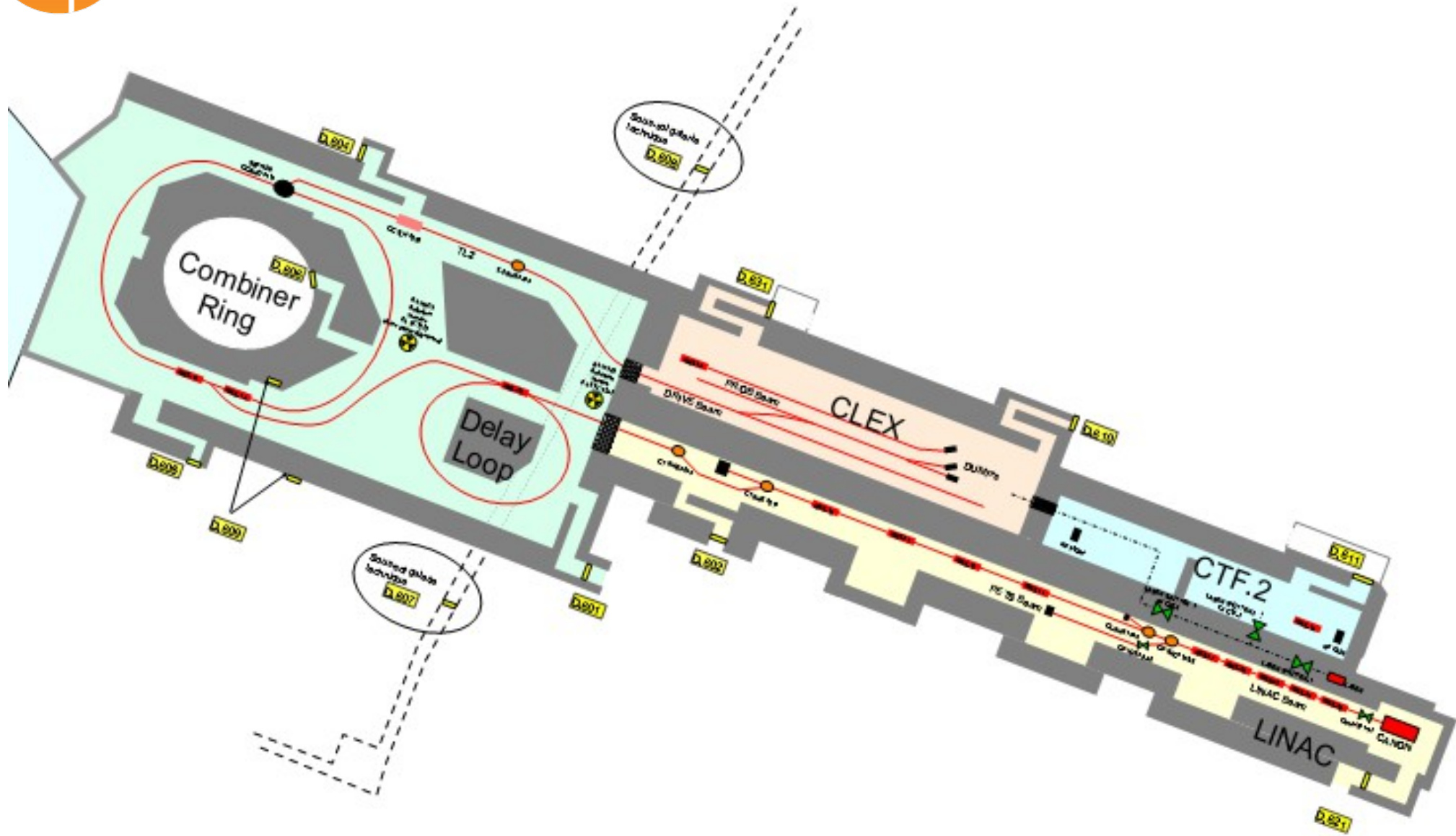
Example data

- Example of reconstructed ellipse in TL2 BPM
 - Blue – data and symplectic fit
 - Dashed and solid red – original and modified MAD-X





CTF3



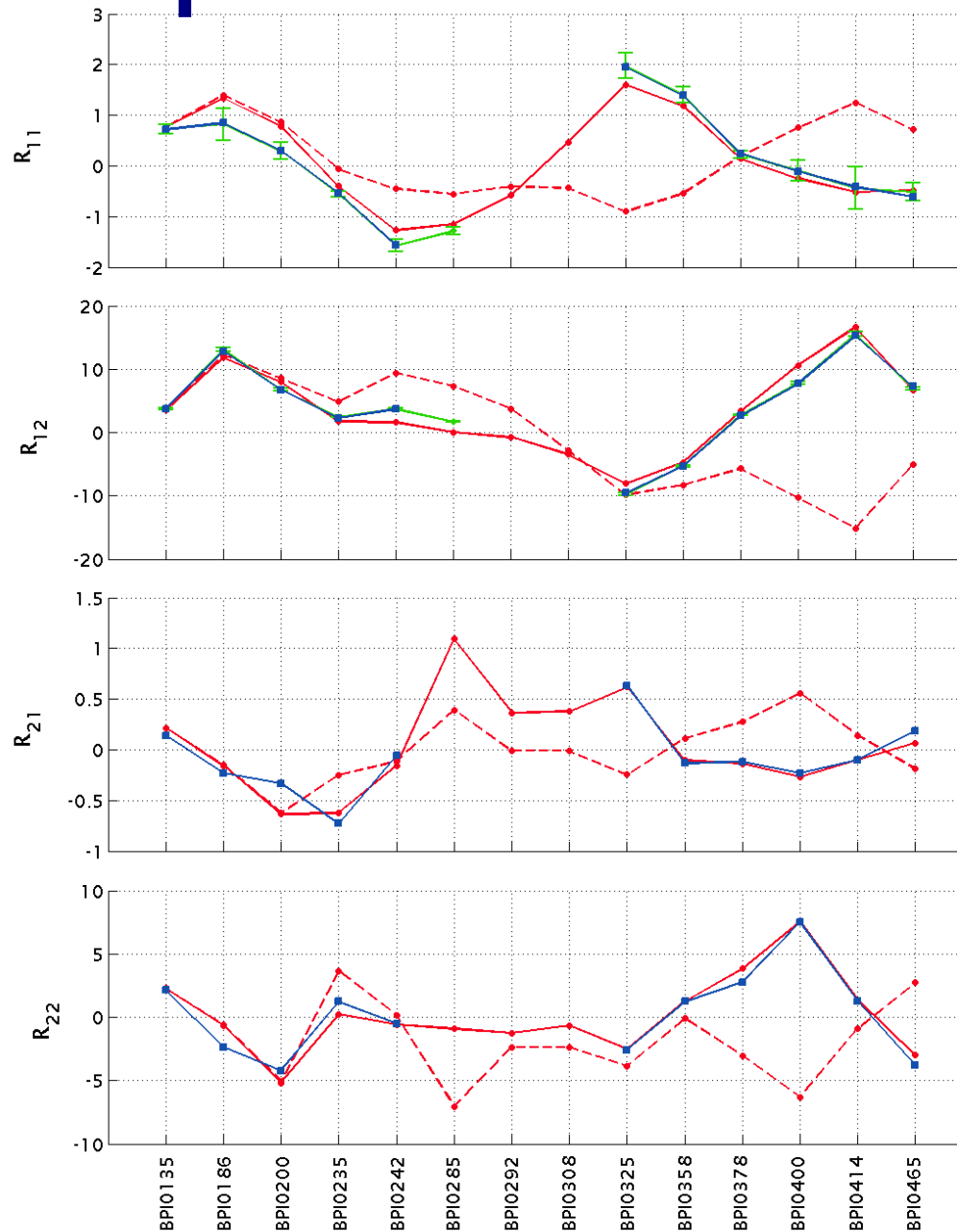


Delay loop optics measurements

- Good agreement with MAD-X for horizontal optics
- However, large discrepancy in the vertical plane
 - Lead to suspect modelling of dipole edge focussing
 - Developed an iterative optimisation routine in MATLAB
 - Reconciled with measurements by optimising dipole FINT



Delay loop vertical measurements



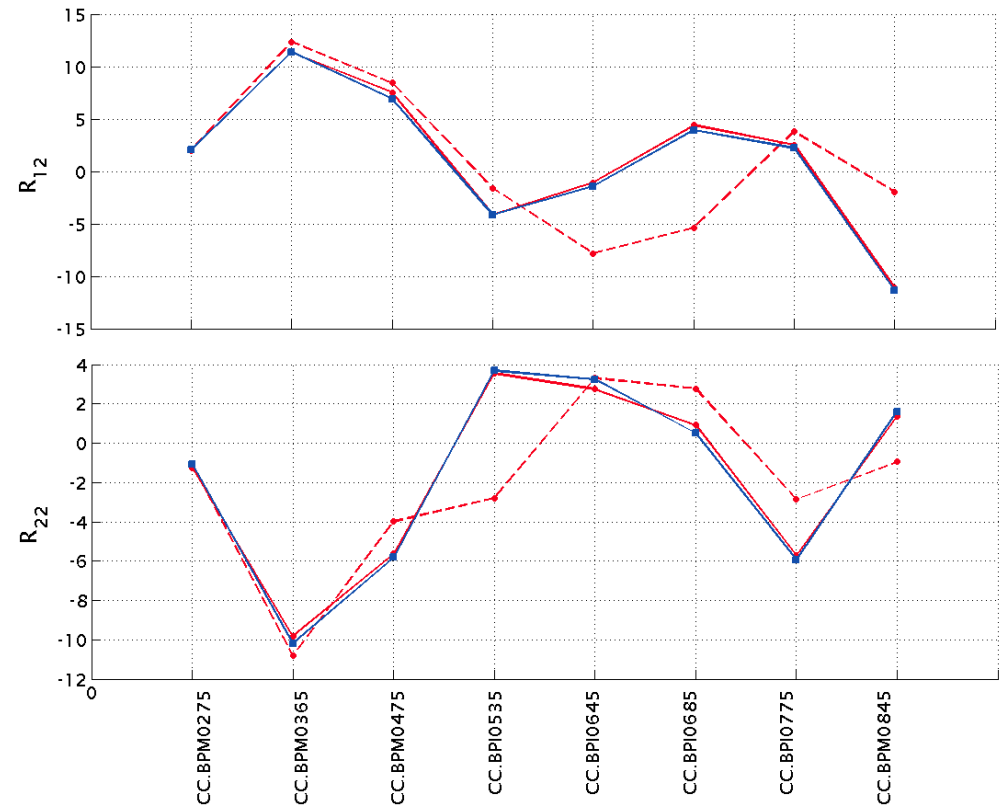
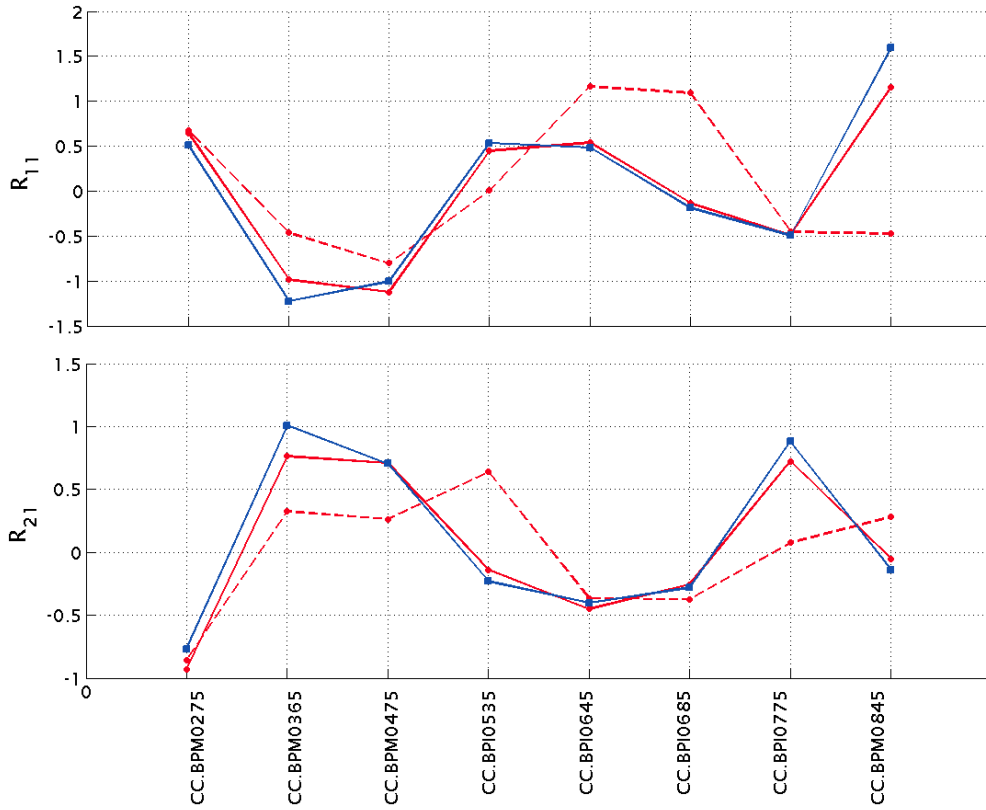


TL2 optics measurements

- Disagreement with MAD-X for both vertical and horizontal optics
- Suggests problem with quadrupole position and/or calibration
 - Confirmed positions are accurate during shutdown
 - Able to reconcile model by fitting selected quadrupole strengths and focussing due to vertical dogleg dipoles
 - Fits agreed to within a few percent for majority of magnets
 - One doublet with 25% error
- Optics to be rematched and exercise repeated after restart

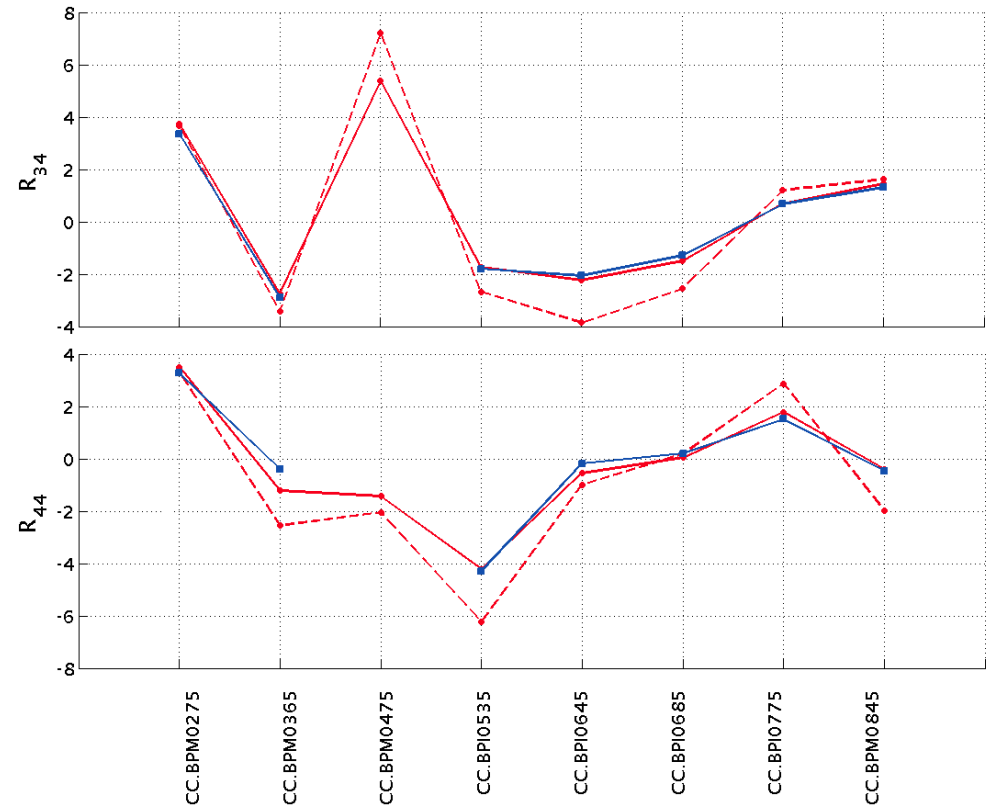
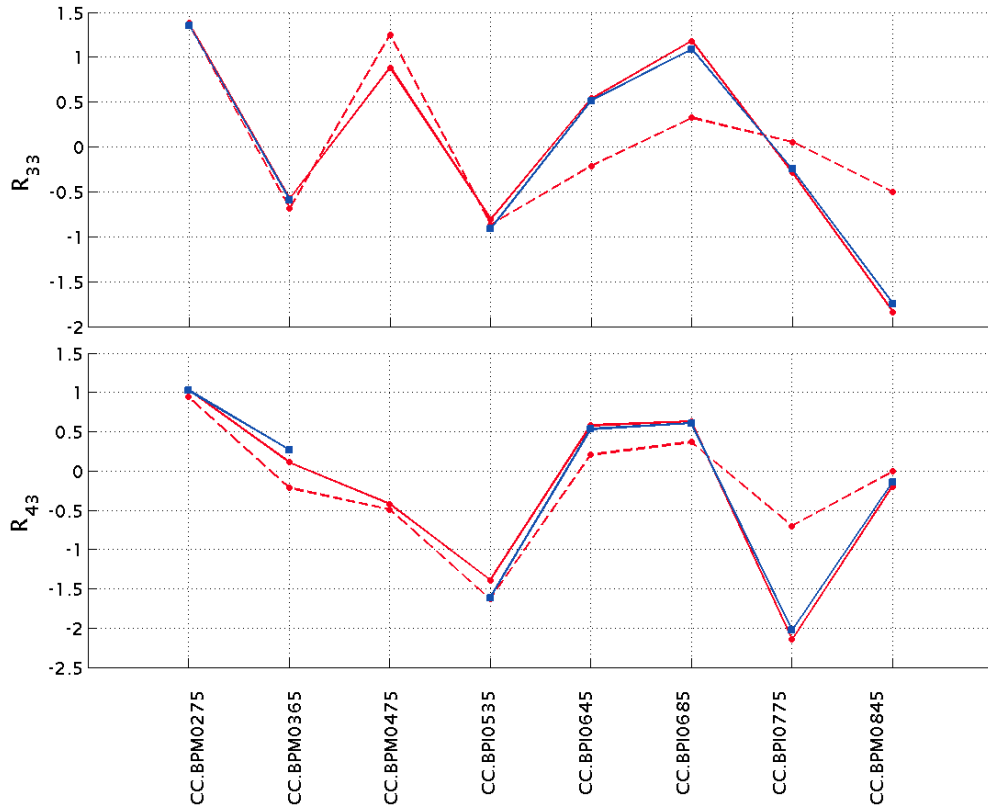


TL2 horizontal measurements





TL2 vertical measurements





Summary

- Optics verification part of consolidation of CTF3 operation
- Confidence of linac, TL1 and combiner ring MAD-X models
- Error in model of delay loop dipole edge focussing corrected
- Error in TL2 optics found
 - Model parameters fitted to measurements
 - New model to be confirmed with further data