Polishing Collimation Optics

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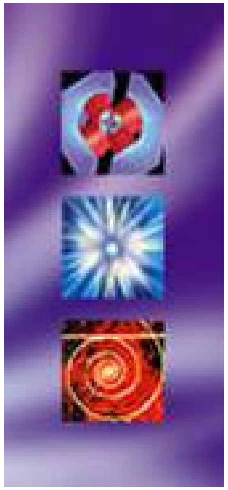

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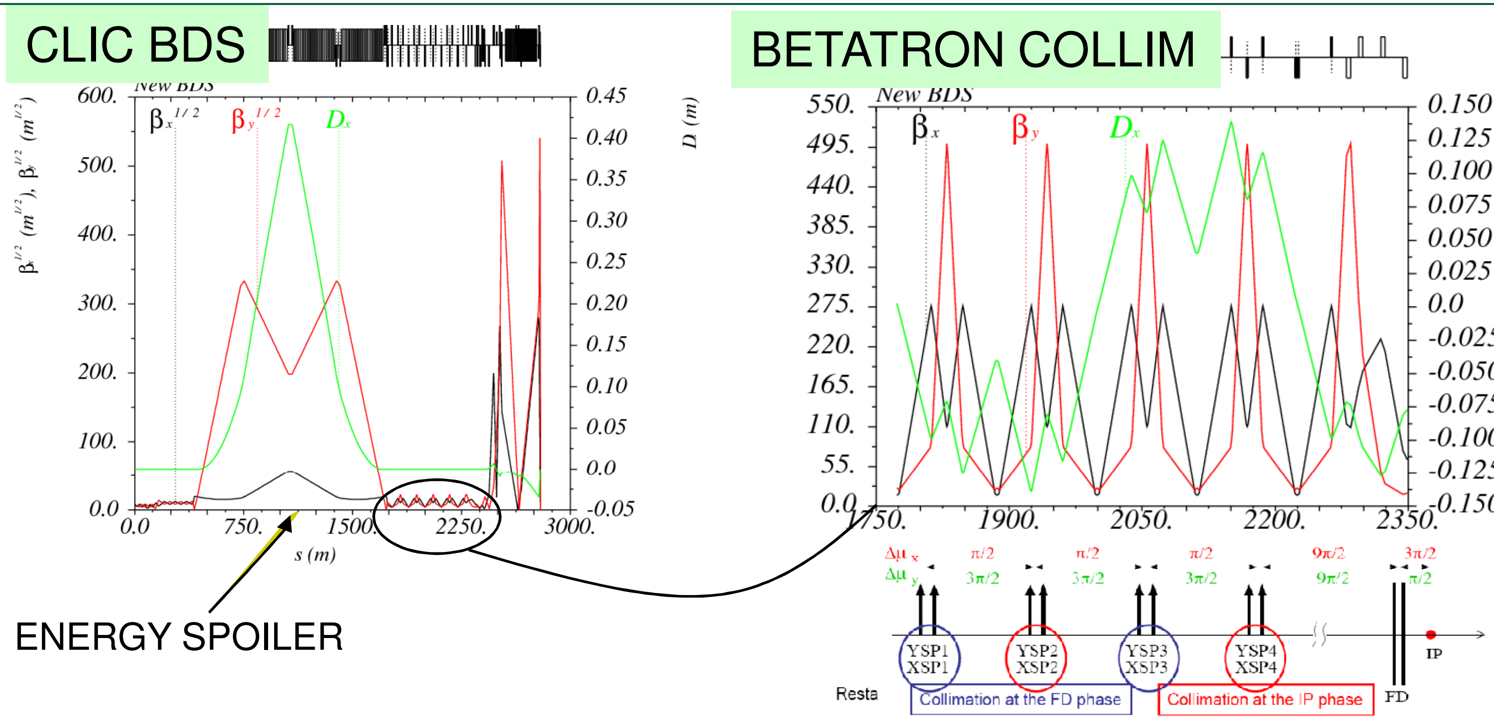
Introduction

- Already have adequate CLIC BDS collimation design
- Look at effectiveness of design and potential improvements
- Motivation comes from previous ILC collimation studies

CLIC Collimation Scheme



- Passively surviving energy collimation (huge β fn) followed by consumable betatron collimation
- Betatron collimation: 4 x,y spoilers □/2 apart (first two spoilers collimate position and angle, second two repeat this), matched to phase of FD/IP, full gaps ~ 200 μm
- Very strong matching quadrupoles in design.

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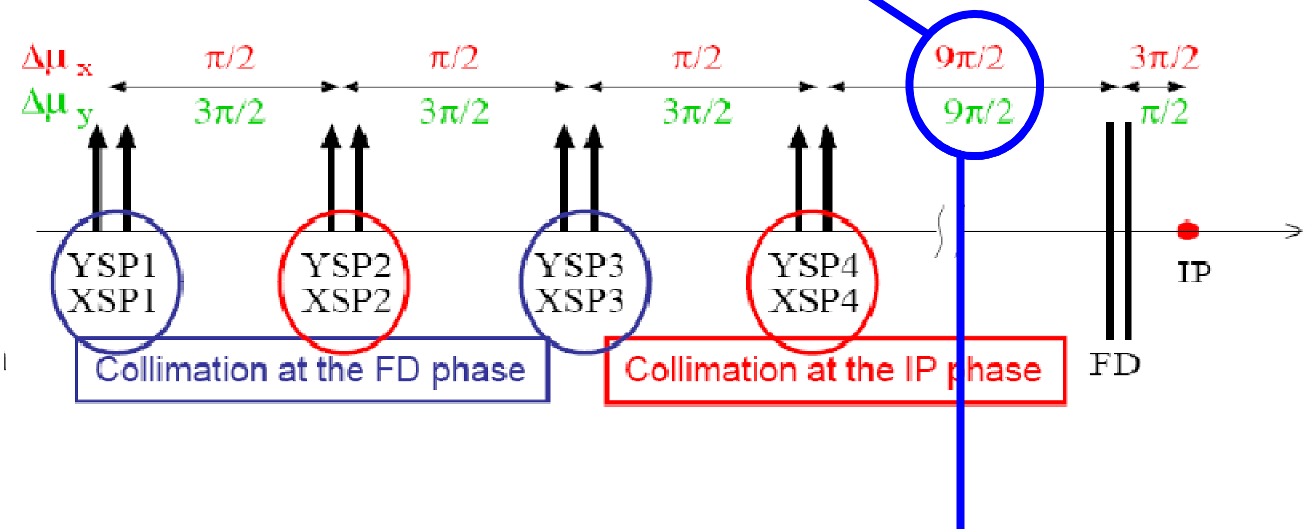
CLIC Collimation Performance

- Collimation depth revised in 2009 (B. Dalena, CERN)
  - Used full BDS halo tracking to account for all lattice 'imperfections' (non-linearities, phase mismatches, etc)
  - See PAC '09 paper **'Status of the CLIC Beam Delivery System'**
  - Spoilers set at $15\sigma_x$ and $55\sigma_y$ ensures no particle or photon hits final doublet
- This collimation depth calculation ensures 100% collimation performance <u>in the design</u>
- But can we do better? Improve transport, open spoilers further?

Collimation Phases

In principle, spoilers are matched to IP (exact multiples of $\pi/2$)



But actually, in current lattice
$\Delta\mu_x = 9.7\ \pi/2$
$\Delta\mu_y=10.6\ \pi/2$

These spoilers are not collimating exactly at the FD or IP phase

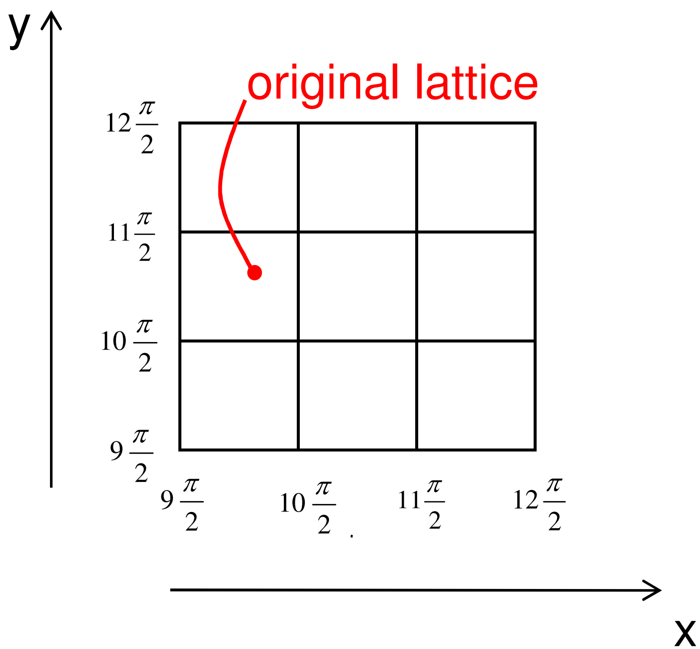
ILC Collimation Studies and Experience

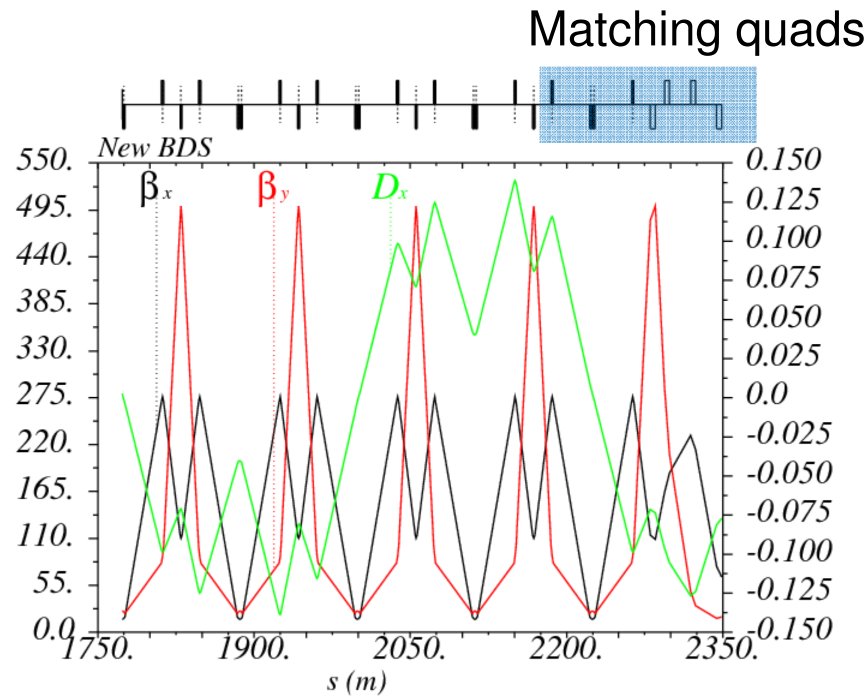
- For historical overview see ILC-Technical Review Committee comparisons of NLC, TESLA, CLIC collimation in 2003 (PAC '03)
- NLC had good collimation performance
  - ILC BDS collimation evolved from NLC
- Collimation phase relationships were lost during the evolution.
- Restoring phases in a random search of restored-phase-solutions
  - Recovered the original ILC (NLC) collimation performance*

*See for example “COLLIMATION OPTIMISATION IN THE BEAM DELIVERY SYSTEM OF THE INTERNATIONAL LINEAR COLLIDER”, F. Jackson, PAC’07.

Collimation Phase Matching

SP4→IP phase advances

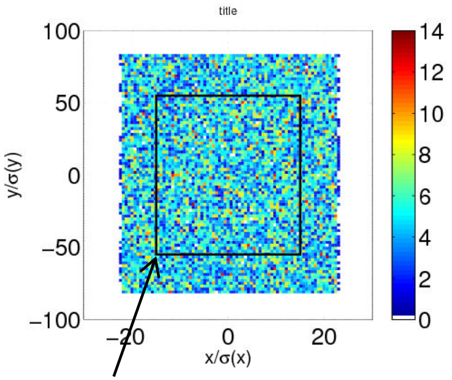




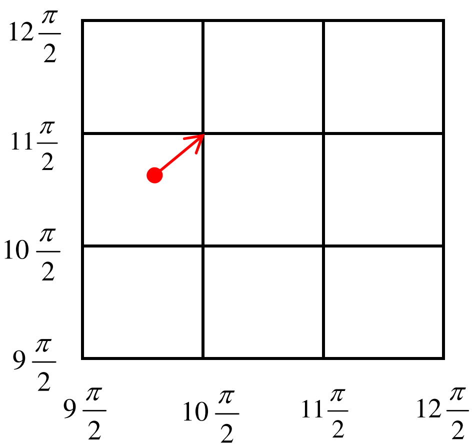
Perfect phase matching in both planes is possible in a number of discrete locations in phase space

Linear Collimation Performance (Original)

BDS entrance

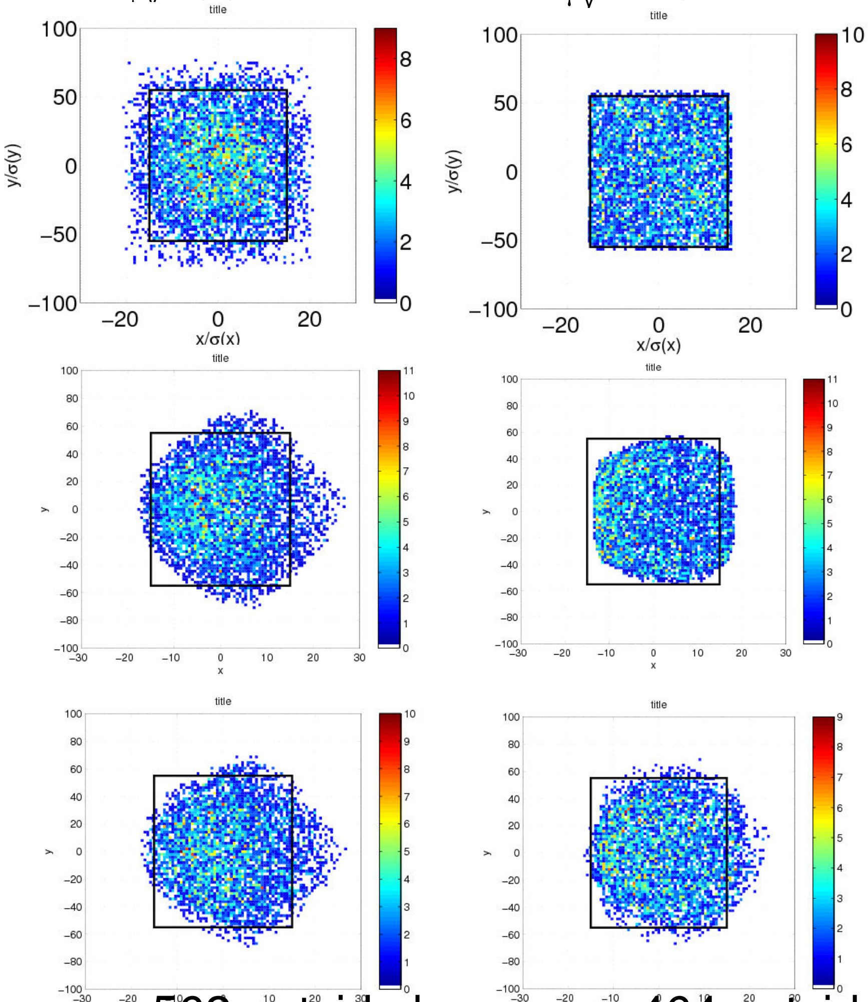


15σx, 55σy box



Original lattice
$\Delta\mu_x = 9.7\ \pi/2$
$\Delta\mu_y = 10.6\ \pi/2$

Matched Lattice
$\Delta\mu_x = 10.0\ \pi/2$
$\Delta\mu_y = 11.0\ \pi/2$



FD entrance. Linear tracking dp = 0%

FD entrance. Multipoles on, dp = 0%

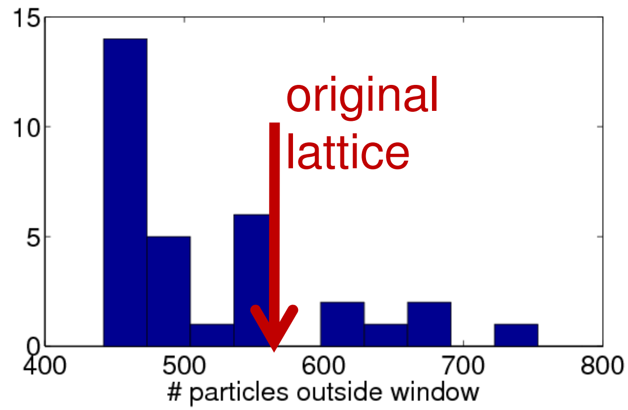
FD entrance. Multipoles on, dp = 1%

562 outside box

464 outside box

Collimation Optimisation = Random Search

- Search phase-matched solutions for best collimation performance (non-linear tracking, dp = 1%)



- Can reduce 'escaped particles' by ~ 20%.
- NB: some phase-matched solutions have <u>poorer</u> performance than the original.

Conclusion

- Present design with 15, 55 gives good collimation performance (even though ~2% of halo particles escape)
- Phase-matching collimation→FD gives somewhat better performance
  - Not clear yet if this will permit wider collimation apertures
- More extensive search and optimisation (multipoles) might be useful
- Needs to be integrated with luminosity optimisation.

Background 1

- CLIC Lattice v_09_04_01
- Tracking in MADX-PTC
  - Can only track up to sextupole in MERLIN. Can't track all the multipoles since MERLIN can't cope with zero length multipoles in the CLIC lattice.
  - No point in doing MERLIN tracking with sextupoles on but other multipoles off – presents an unrealistic picture.
  - MERLIN tracking was done in 2009 phone meetings, but these results are unreliable.

Background 2

- Matching Quad Strengths
  - 150 T/m to 440 T/m (c.f. QD0 permanent magnet 575 T/m, aperture radius ~ 4 mm)
- Collimation parameters

For old collimation depth
10 sx, 44 sy
CLIC Spoiler tables:
xgaps = 80 um,
ygaps = 80 um,
for 10 sigx and 44 sigy
In MERLIN this is X0.16Y10 for xspoiler
X10Y0.16 for yspoiler
0.16 = 0.16 mm = 2 × half gap of 80 um

For new collimation depth
15 sx, 55 sy
xgaps = 117 um,
ygaps = 100 um
In MERLIN
X0.23Y10 for xspoiler
X10Y0.20 for yspoiler