Orbit Correction, including transverse wake effects in the ILC Positron Source

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Beam and Undulator vessel Assumptions

- For the positron undulator vessel we are assuming (realistic):
  - 5.7mm diameter
  - A Copper Vessel
  - Surface Roughness Ra ~100nm
  - Temperature 4.2K
- The ILC bunch Parameters (Gaussian Bunch):

	rms Length (µm)	N electrons	Energy (GeV)
Maximum	500	$2\ 10^{10}$	150
Nominal	300	$2\ 10^{10}$	150
Minimum	150	$1\ 10^{10}$	150

Undulator Trans Wakefield Kicks & Comparison with BDS

- From the beam and vessel parameters the resistive wall transverse Wake kick can be calculated
- DC, AC and Anomalous Skin Effect Included (important at low temperatures, probably not in the BDS)
- NB this is for copper at 77K at 4.2K the kick is probably less

Bunch Length	(μm)	150	300	500
Und Trans Kick	(eV μm^{-1} m^{-1})	0.22	0.27	0.21
BDS Trans Kick	(eV μm^{-1} m^{-1})	??	0.11	??
BDS Length	m	1600		
Und Length	m	200		

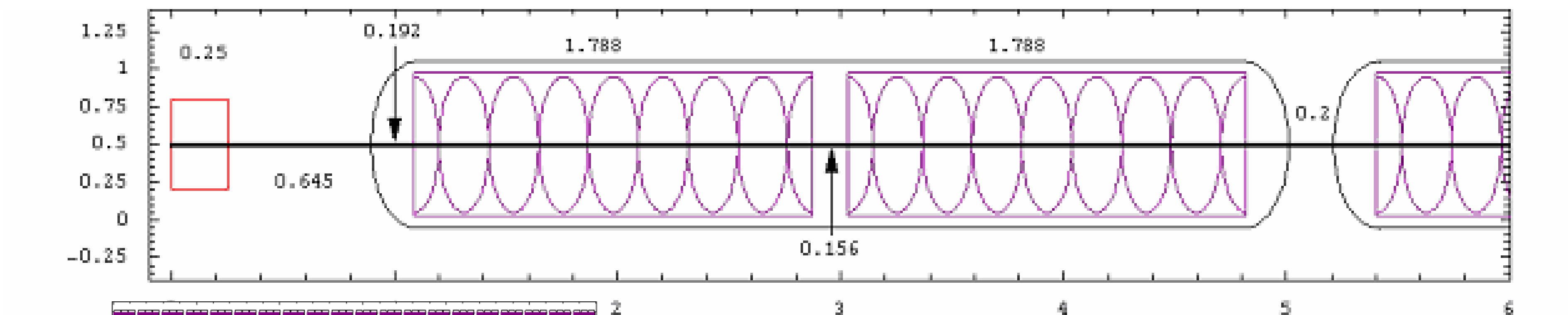
See Beam Delivery Meeting: May 16, 2006,
http://www-project.slac.stanford.edu/lc/bdir/Meetings/beamdelivery/2006-05-16/index.htm

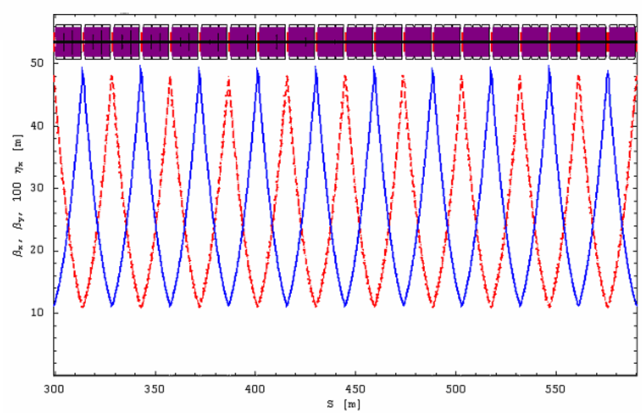
Assumptions for Tracking Study & Further Work

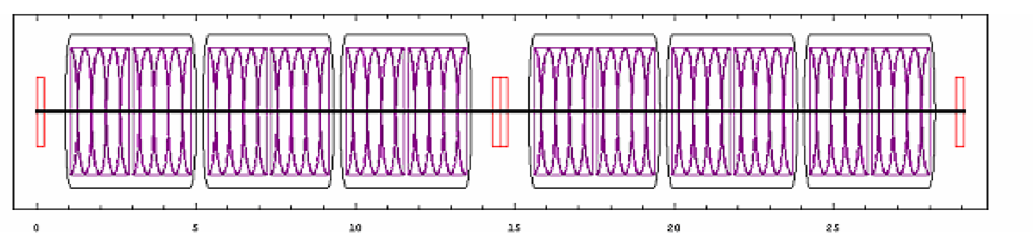
- We assumed a kick of 6 eV µm-1 m-1 a factor of 23 too big
- Further work will look at the geometric kicks from the undulator transitions and photon collimators
- A 200m long undulator is for **polarised positrons** with the undulator at 150GeV point.
- For un-polarised positrons the undulator length is:
  - ~70m @ 150GeV
  - (~25m @ 250GeV)
- Comparing the baseline ILC undulator to the BDS the Kick is ~2x as large but the length is ~23 times less
- (So the undulator is about a factor of ten easier than the BDS?)

Modified Undulator Lattice

- Packing density of NLC design is too low
  - Line has only 143m of undulator in 246m of line
- Assume 3 cryo-modules between quads, 2 undulators per cryo-module
  - Generate 214m of undulator for 293m line length







Set-up

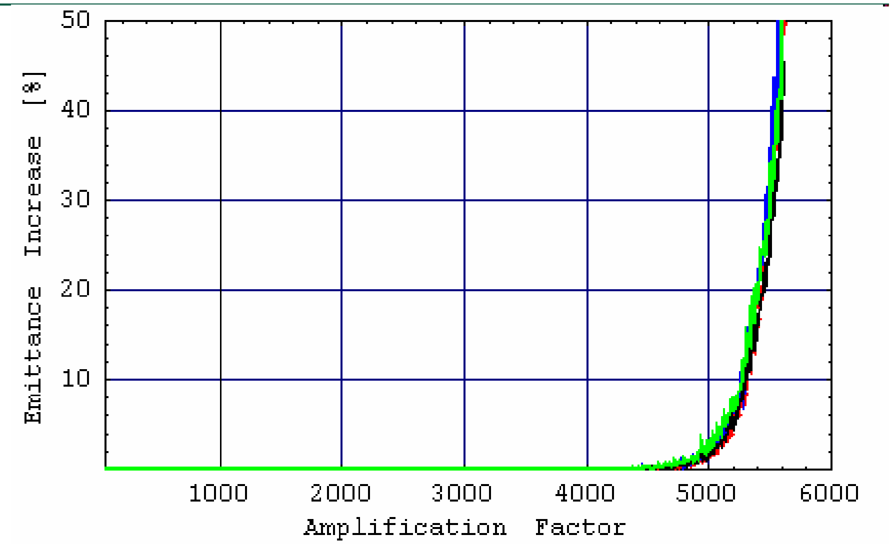
- Wake fields modelled as linear matrix elements

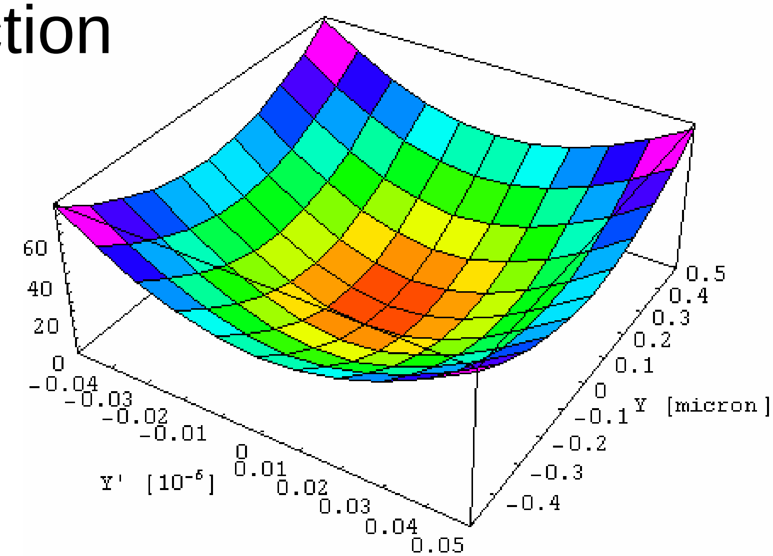
$$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ k_{Wake,x} & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & k_{Wake,y} & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

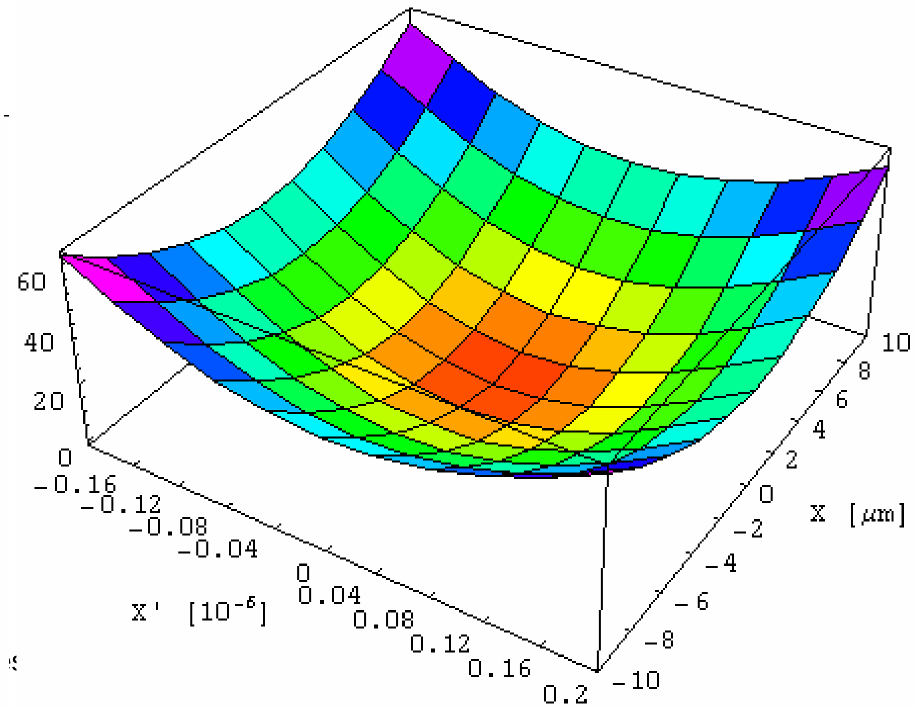
- Assume BPMs and Correctors at Quads (zero-length)
- Correct orbit using SVD-based correction system
  - 21 correctors & 21 BPMs
  - Use half the number of singular values (this has not been optimised!)
- Track 500 particle beam to determine emittance growth

Wakefield Strength & Incoming Beam Jitter

- Assumed 0.27eV/micron/m.
- How strong does it have to be disrupt the beam?
  - Over 5000 times larger!
- Also looked at incoming trajectory errors in both planes
- Tolerances are tight with no correction

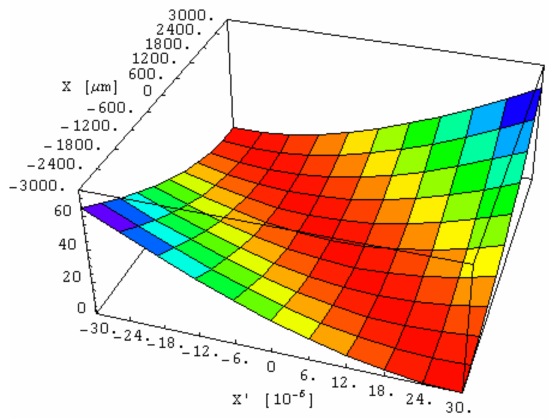


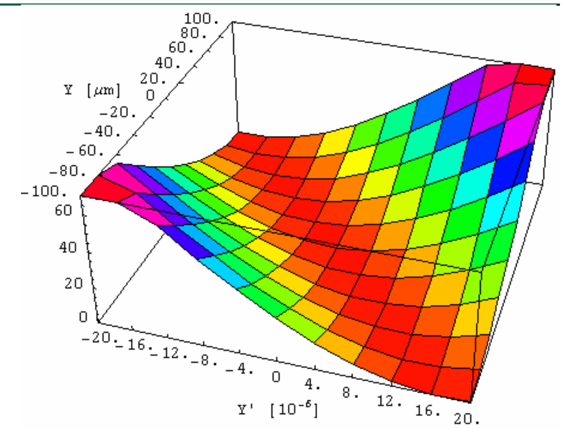




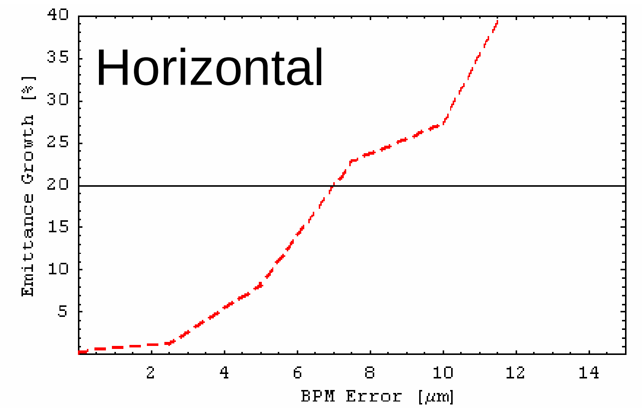
With correction

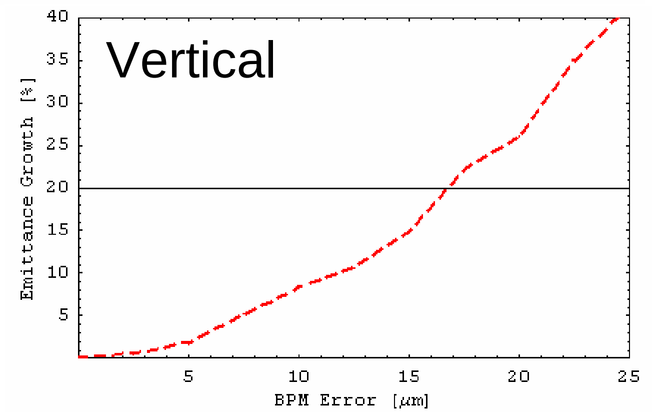
- With “perfect” trajectory correction the tolerances are greatly relaxed.
- *No dispersion Correction*





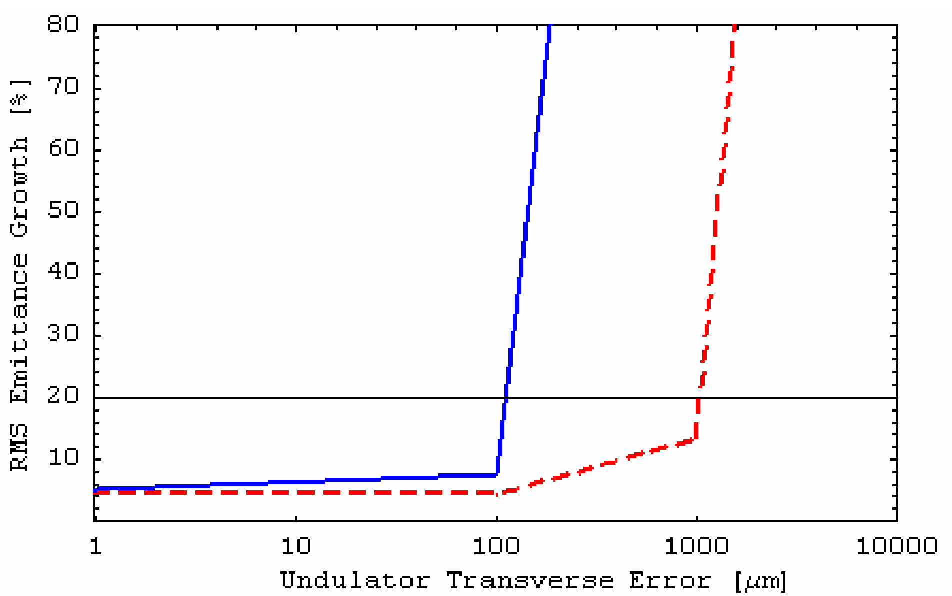
- If we look at the BPM error tolerance,
  - Error on BPM readout – can be quad-bpm misalignment or BPM read error
- Dominated by dispersion – corrected ***only*** in Vertical Plane





Undulator Alignment – ***with 6eV/micron/m***!

- The tolerance on the vertical and horizontal alignment of the undulator is also tight, considering they are in cryo-modules – 100microns or less
- Assume only orbit correction, no movers on cryo-modules etc.



- Simulations currently time limited – can't do this in MAD
  - Custom built matrix tracking code – ***very*** slow.

Conclusions

- The Undulator Wakes don't seem to be a **big** problem, though they do have an effect. Tolerances dominated by correction systems.
- Still…
  - Need to analyse the tolerances on the in-cryo-module alignment
  - Ensure correction algorithms for undulator are integrated with rest of linac
  - Make sure the wakefields are as small as we think they are!