DMS steering with BPM scale error
- Test of New Optics -

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Problem of DMS (Dispersion Matching Steering) with BPM scale error

ILC Main Linac is curved, following earth's curvature (For L. He supply system.)

- Cryo-modules are aligned along the curvature
- In present (RDR) optics
  - Orbit goes through center of every quadrupole magnet (~ attached BPM)
  - Finite dispersion at all quadrupole magnets (and attached BPM)
  - DMS adjust the dispersion, finite orbit difference due to energy difference
  - BPM scale error affects DMS

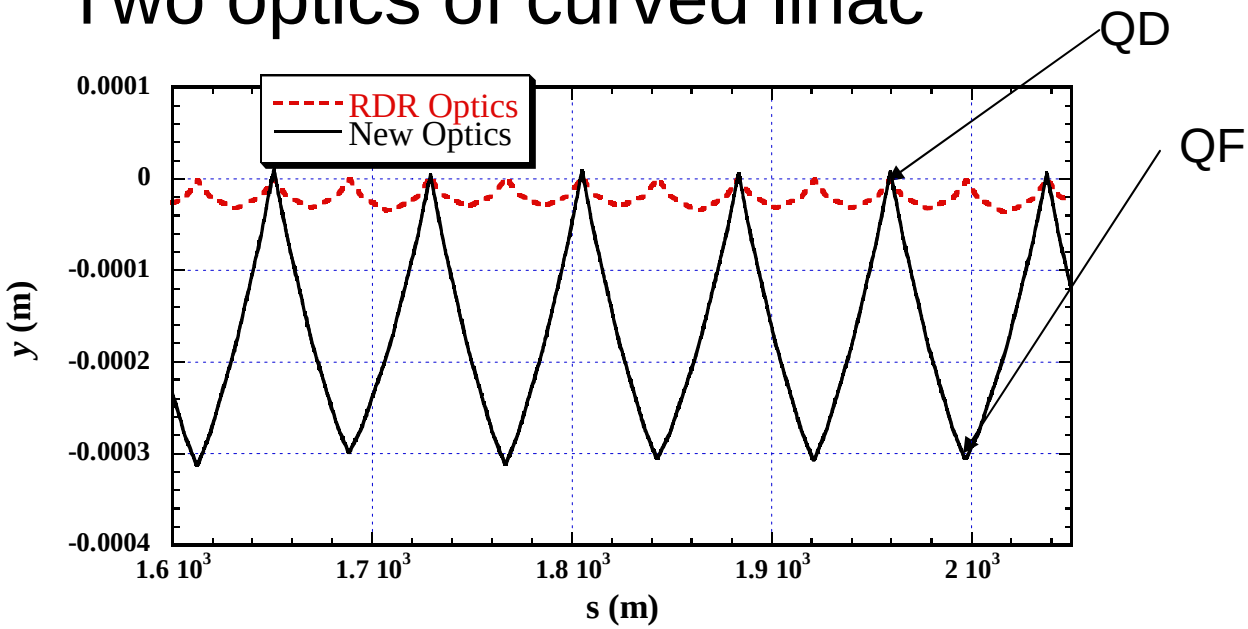
New Optics for DMS with BPM scale error

- Orbit goes through center of every vertically defocus quadrupole magnet (~ attached BPM)
- Zero dispersion at v-defocus quadrupole magnet (and attached BPM)
- Finite offset and finite dispersion at v-focus quadrupole magnets
- Scale error of BPM attached to v-defocus quads does not affect DMS

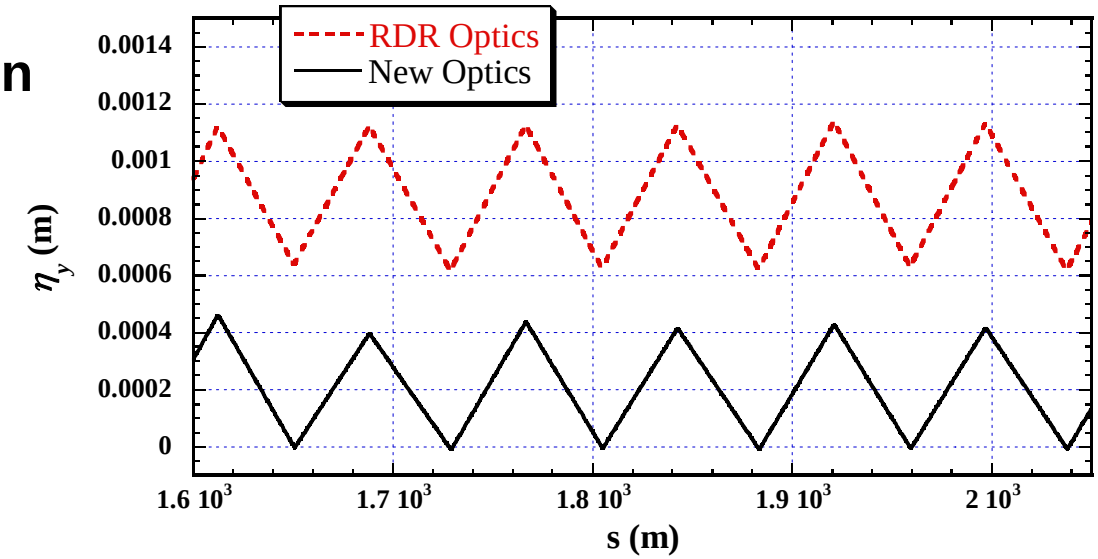
Vertical Orbit and Dispersion

Two optics of curved linac

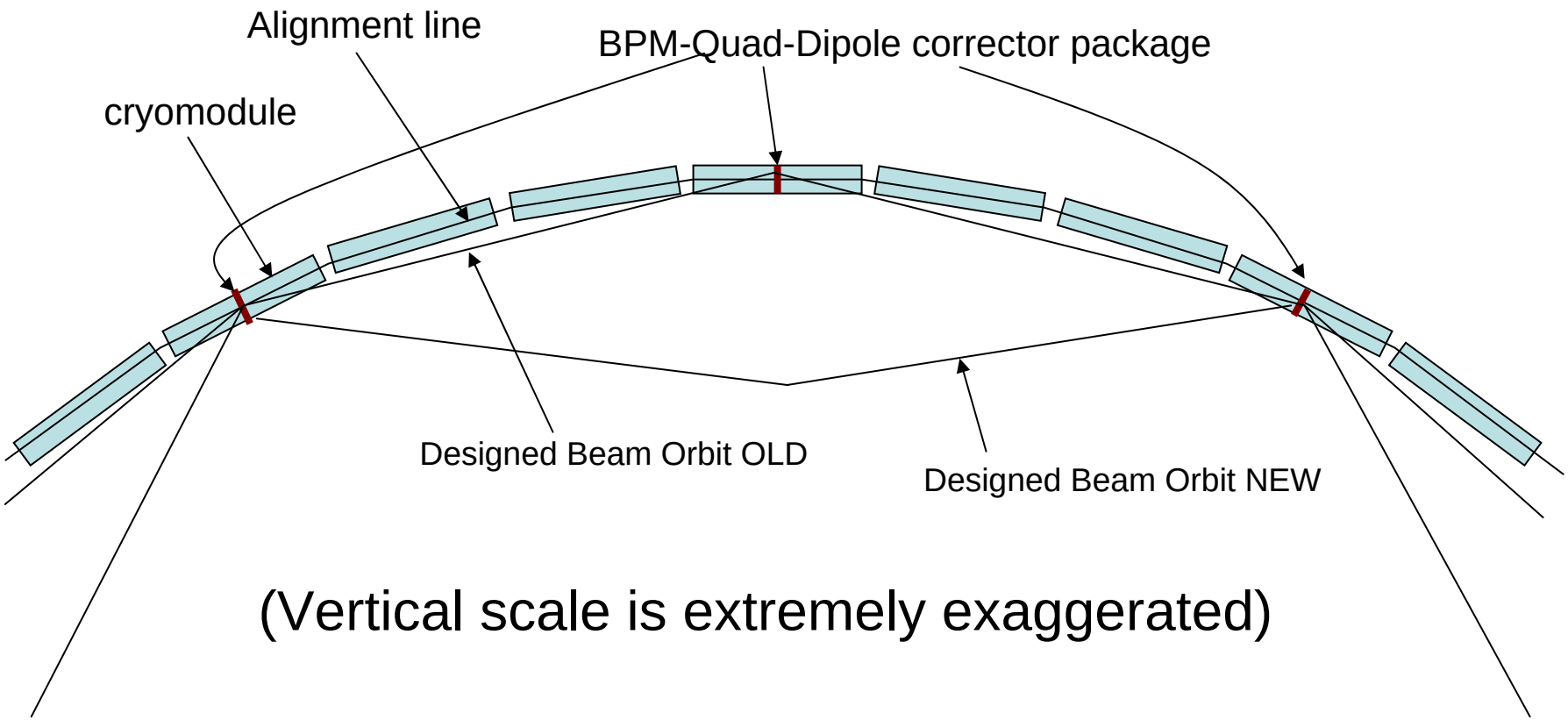
orbit



dispersion



Alignment and Beam Orbit in Curved Linac, Following earth curvature



(Vertical scale is extremely exaggerated)

Simulation

- "Standard" error set + BPM scale error
- DMS steering.
  - Change energy by 10% for dispersion measurement
  - Minimize

~0 in new optics

$$w_1 \sum_{\text{BPM at QD}} \left(y_0 - y_{\Delta E} - (\Delta E / E)\eta_{y,\text{design}} \right)^2$$

$$+ w_2 \sum_{\text{BPM at QF}} \left(y_0 - y_{\Delta E} - (\Delta E / E)\eta_{y,\text{design}} \right)^2$$

$$+ \sum_{\text{all BPM}} \left(y_0 - y_{\text{design}} \right)^2$$

(QD: defocus in vertical plane)

$y_{\Delta E}$: BPM read with energy change ΔE

y_{design} : Design beam position at BPM

$\eta_{y,\text{design}}$: Design dispersion at BPM

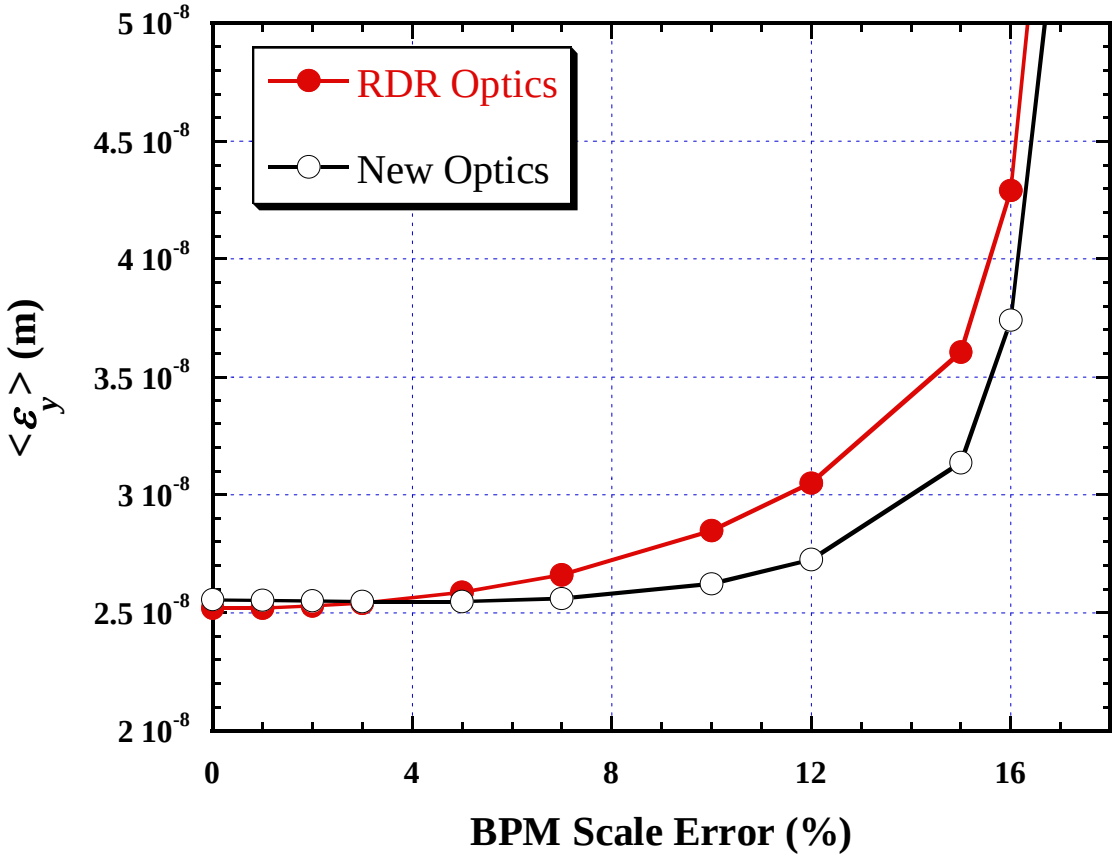
w_1 and w_2 : Weight factors

“standard” set of errors (RMS)

	“standard”	Used in this study (approximation)
Quad Offset (μm)	300	360
Cavity Offset (μm)	300	640
Cavity Pitch (μrad)	300	300
BPM Offset (μm)	300	360
Cryomodule ofset (μm)	200	0
Cryomodule pitch (μm)	20	0
Quad and BPM roll (μrad)	300	0
Horizontal	Vertical x 3	0
BPM resolution (μm)	1	1

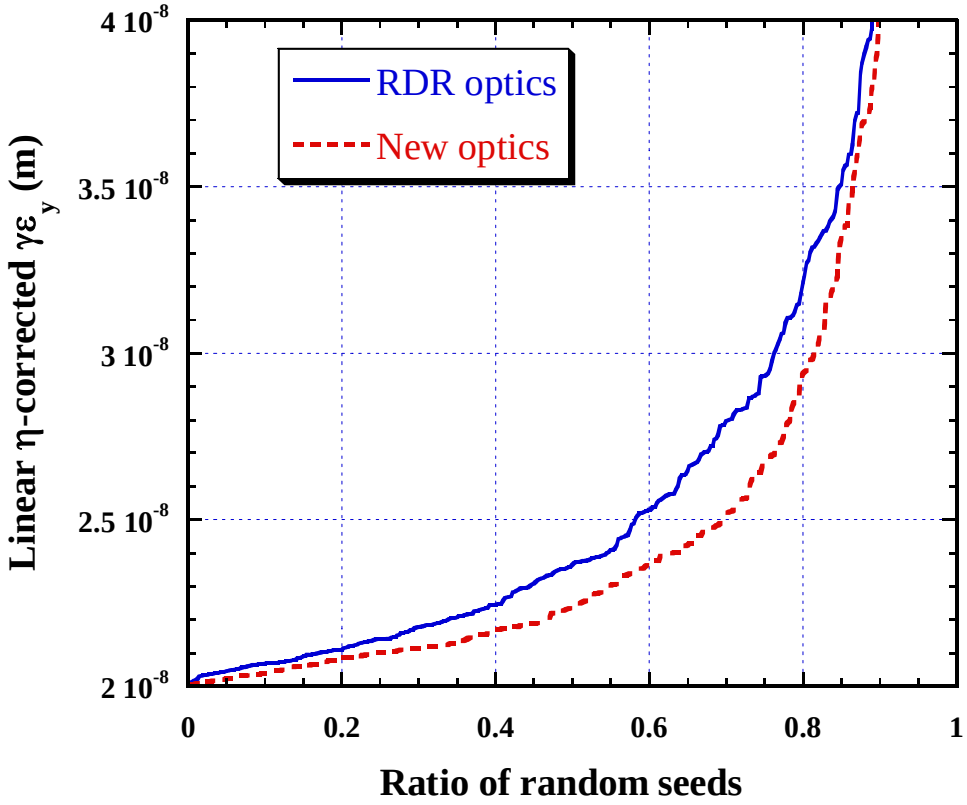
All errors are random and independent.
No roll errors, no horizontal errors.

Vertical emittance (average of 40 random seeds) vs. BPM scale error



New optics is less sensitive to BPM scale error.
But scale error > 10% will still cause a problem.

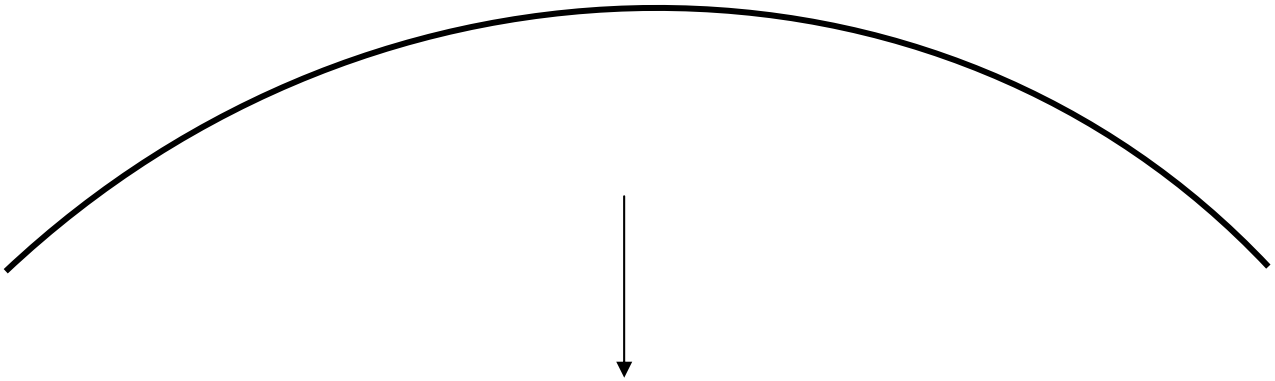
Distribution of emittance
Scale error 20%



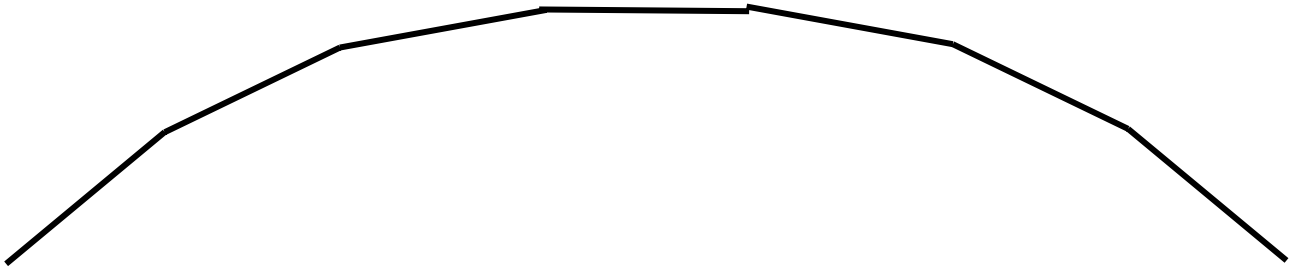
Average is affected by small number of bad random seeds.

Polygon linac was tried

RDR: Following the earth. Every cryo-module is aligned horizontally.
Finite dispersion at every BPM.

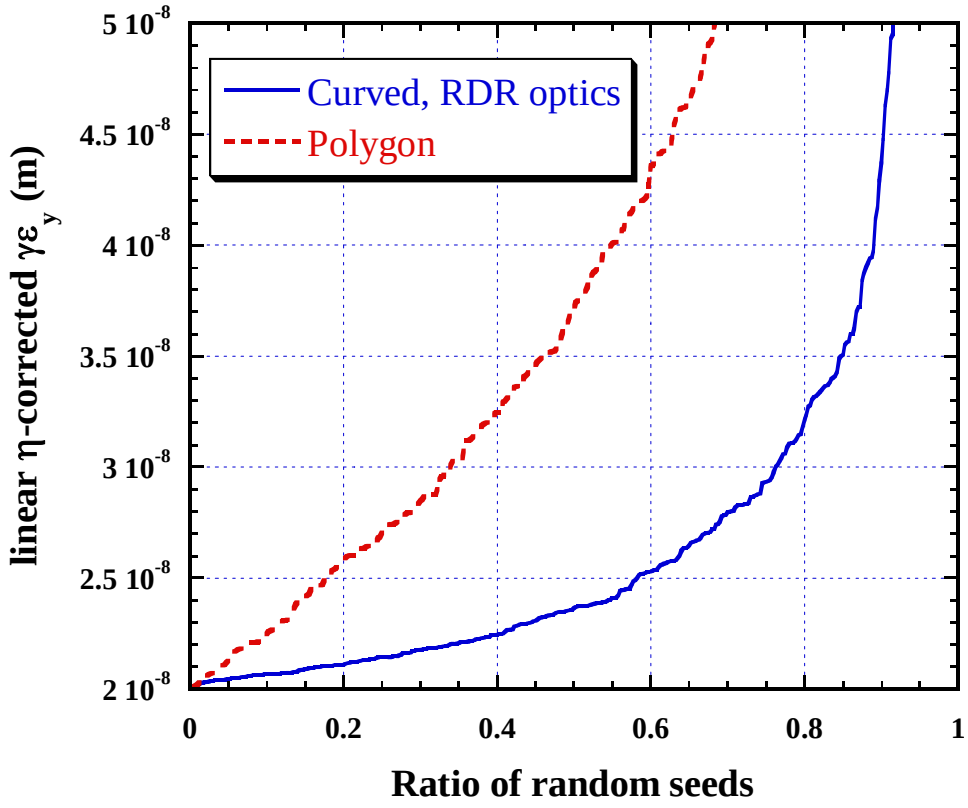


Polygon: Matching section around every kink.
Zero dispersion at most of BPMs. But large dispersion around kinks.



DFS for a polygon linac with 9 lines (8 kinks) was simulated.

Distribution of emittance
Scale error 20%



Polygon linac is worse than curved linac.

SUMMARY

- DMS was simulated in curved linac with BPM scale error for a new optics, compared with old (RDR) optics.
  - New: Zero dispersion at V-defocus quad magnets
  - Old: Finite dispersion at all quad magnets
- New optics is less sensitive to BPM scale error.
  - Tolerance may be increase from “a few%” to “about 10%”. But not 20 % (which was suggested by some BPM experts.).
- Polygon linac (instead of smoothly curved linac) was tried.
  - Large dispersion around kinks but zero dispersion in most of the linac.
  - DMS result was not good.