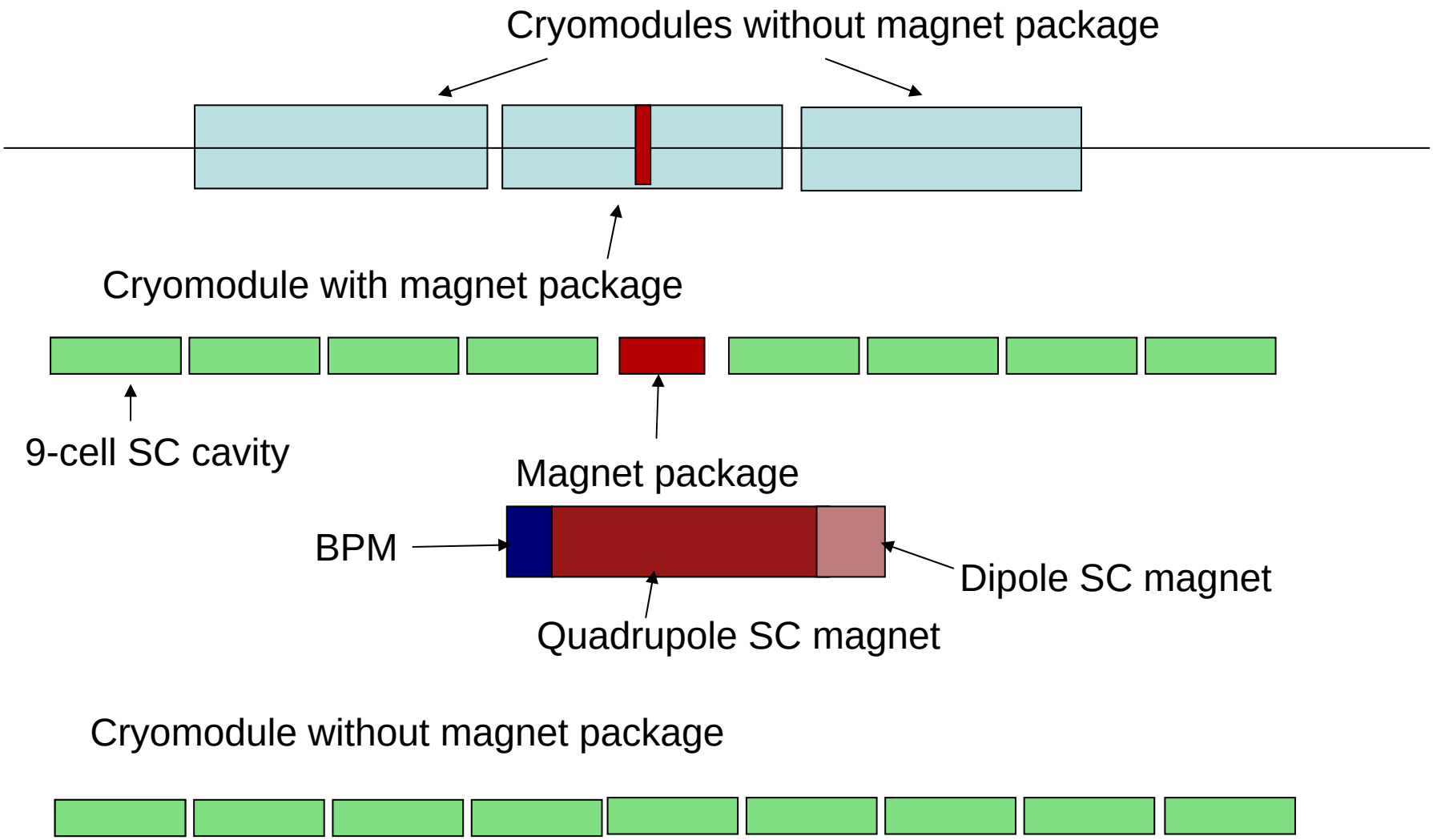
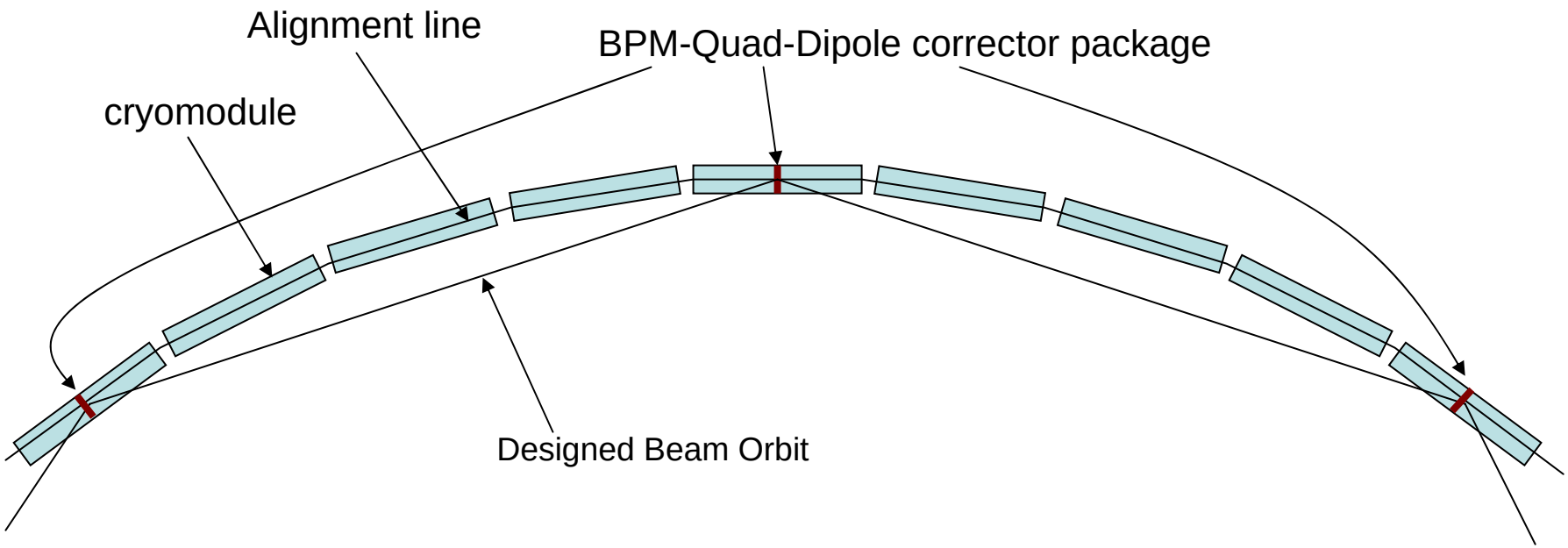
Main Linac Beam Dynamics

K.Kubo

Unit of main linac, about 280 units/linac

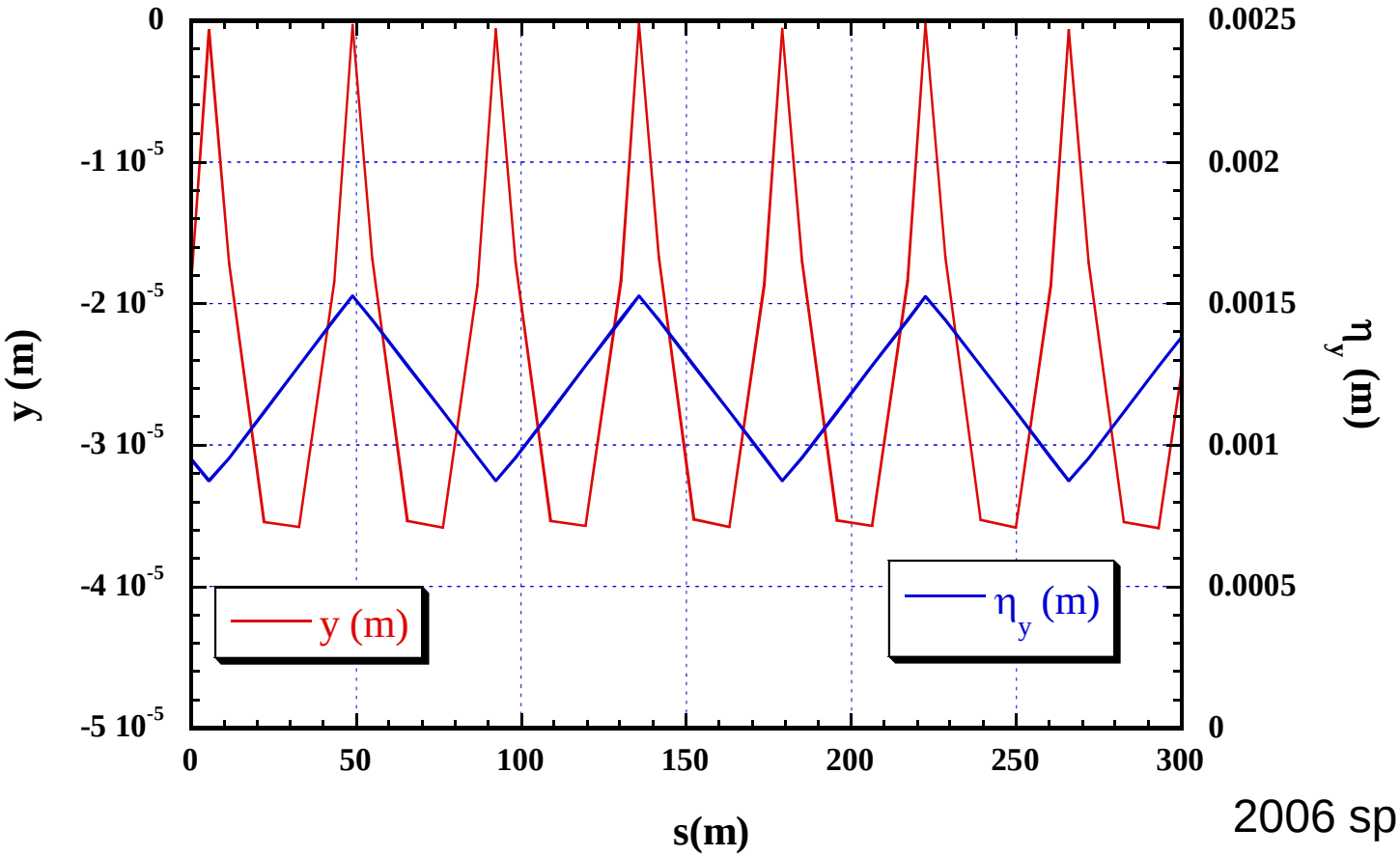


Alignment and Beam Orbit in Curved Linac, Following earth curvature



(Vertical scale is extremely exaggerated)

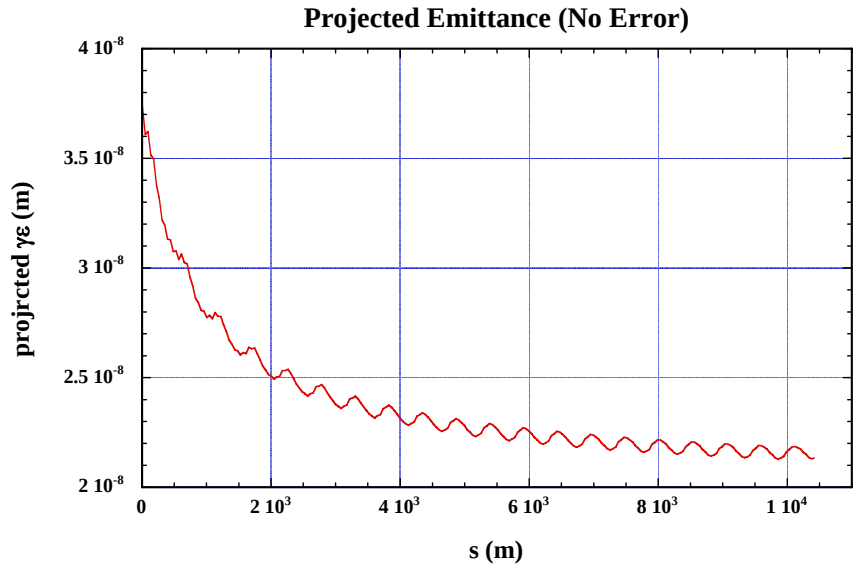
Design orbit w.r.t. the reference line and dispersion



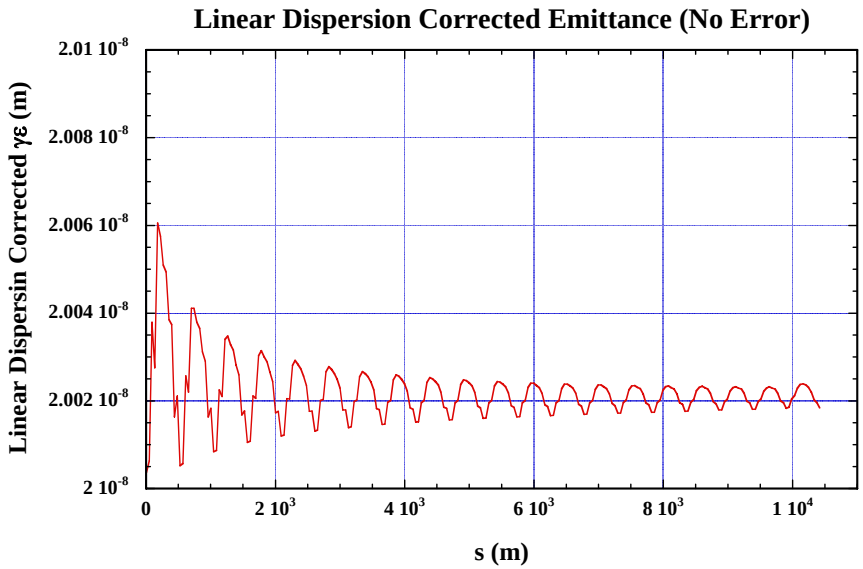
2006 spring lattice

Injection orbit and dispersion are non-zero, and should be matched to the optics.

Emittances in curved linac without errors



This is getting small as the relative energy spread becomes small.



The emittace increases by 0.1% of nominal. Initial dispersion should be matched

2006 spring lattice

Beam Dynamics issues in Main Linac (and RTML) -1

Longitudinal

- Energy stability
- Energy spread
- Timing (relative time between e+ and e- at IP)

Depend on RF phase and amplitude stability.

Tightest in RTML (see RTML presentation)

- Long range longitudinal wakefield will not be important, if there is some ‘detuning’ (cavity to cavity frequency spread).

Beam Dynamics issues in Main Linac (and RTML) -2

Transverse:

Vertical emittance < 1/200 of Horizontal emittance

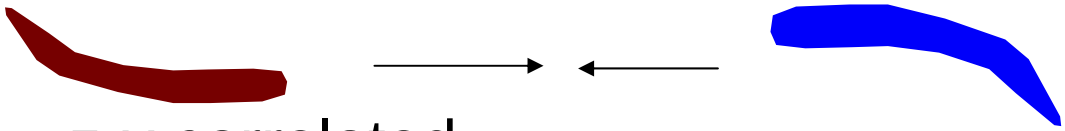
→ Vertical tolerance is much tighter than horizontal

- Single bunch
  - Dispersive effect
    - Quad misalignment and cavity tilt: Most important
      - Beam based steering, e.g. Dispersion Free Steering is expected to cure this problem.
  - Wakefield of cavities
    - Wake due to large iris of SC cavities: Emittance will not increase much and probably OK. But still may cause "banana" effect at IP (?) (Depend on cavity design. ICHIRO cavity has smaller iris than TESLA cavity.)

Beam Dynamics issues in Main Linac (and RTML) -3

- Multibunch
  - Dispersive effect (transverse position difference due to bunch by bunch energy difference)
    - should not be very important.
  - Long range transverse wakefield of cavities
    - Cavity offset: Probably OK, with some detuning.
    - x-y coupling due to rotation of wakefield modes
      - Probably can be cured by natural detuning (cavity by cavity frequency spread), mode rotation angle spread and x-y betatron phase advance difference.
    - If not OK, cavity should have intentional detuning.

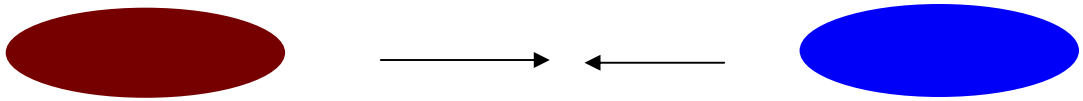
So called “banana effect”



z-y correlated

Beam -beam force cause large intra-bunch oscillation.

Same projected emittance.
Different luminosity



no correlation

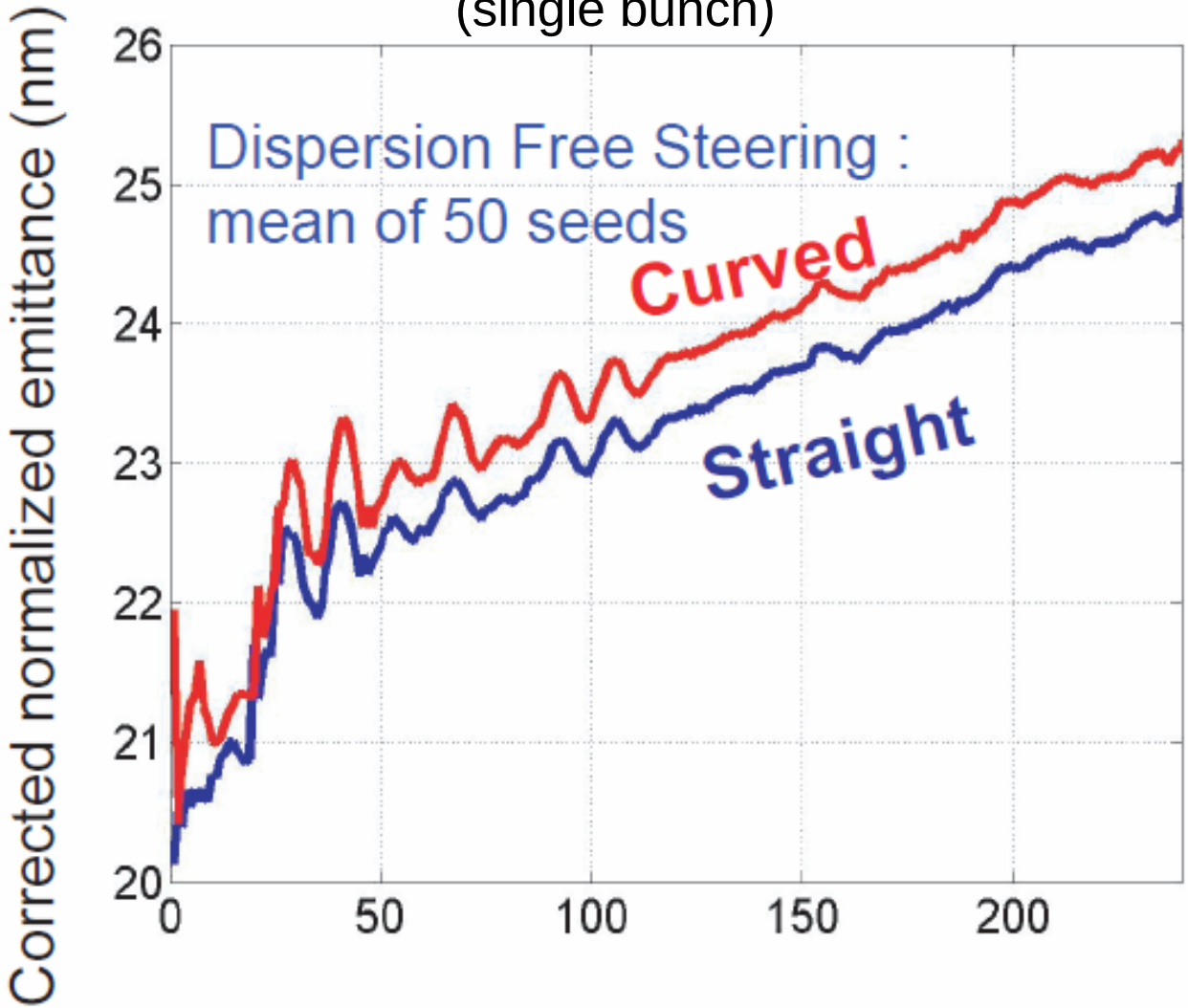
Assumed ‘standard’ errors

Error	with respect to	value (RMS)
Cavity offset	cryomodule	0.3 mm
Cavity tilt	cryomodule	0.3 mrad
Quadrupole offset	cryomodule	0.3 mm
Quadrupole roll	perfect angle	0.3 mrad
BPM offset	cryomodule	0.3 mm
BPM roll	perfect angle	0.3 mrad
Cryomodule offset	perfect line	0.2 mm
Cryomodule tilt	perfect line	0.02 mrad
BPM resolution		1 micron

Need input from engineering point of view for more realistic model.

Example of Simulation

(single bunch)



Kirti Ranjan (Fermilab), ILC GDE meeting Vancouver, 2006

SUMMARY

- A lot of simulation works have been done for single bunch emittance preservation.
  - Beam based steering, etc.
- Multibunch study is less matured.
  - Need more communication with cavity designers.
- Integration of all low emittance transport (DR exit to IP) just started.
  - Still a lot of works, especially including time changing errors (‘Dynamic effect’).