Simulation of ILC ML Emittance in various Energy operation

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Conditions

- Initial Beam Energy, two cases
  - 15 GeV (ML after 2-stage BC: RDR)
  - 5 GeV (After 1-stage BC, same optics, longer by factor 245/235)
- Final Beam Energy (nominal 250 GeV)
  - From 90. 100, 120,150, 200 and 250 GeV
  - Change acc. gradient uniformly
- Set “effectively standard” errors (see next page)
  - 40 or 100 linacs with different random seeds for each condition
- Perform DFS (DMS) correction
  - Reduce initial energy 10% or 20% (ΔEinit)
  - Reduce acc. gradient 10%
- Computer code “SLEPT”

Some numbers are missed. They will be available when KEK computer system is recovered.

standard

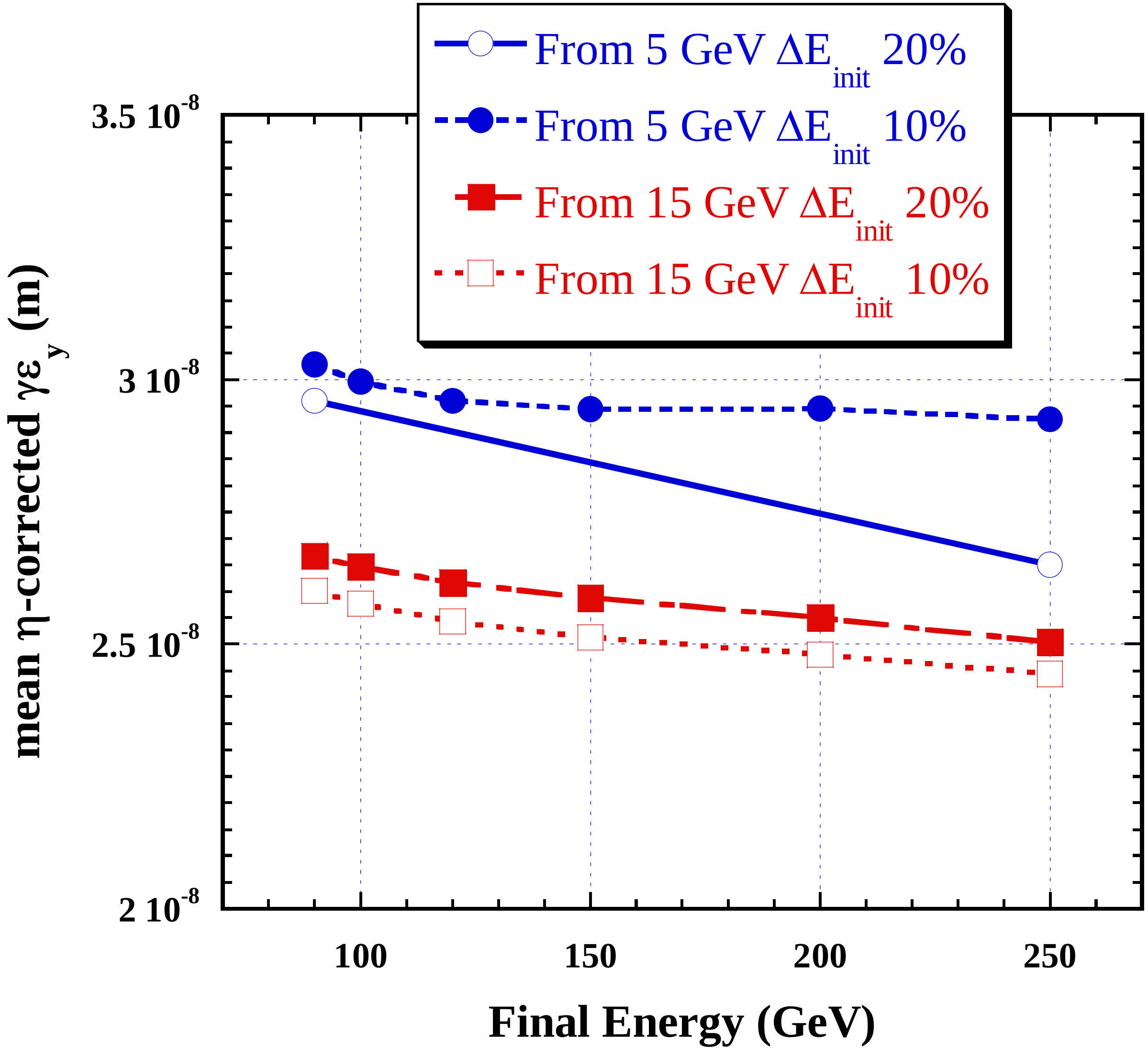
Error	RTML and ML Cold	with respect to
Quad Offset	300 μm	cryo-module
Quad roll	300 μrad	design
RF Cavity Offset	300 μm	cryo-module
RF Cavity tilt	300 μrad	cryo-module
BPM Offset (initial)	300 μm	cryo-module
Cryomoduloe Offset	200 μm	design
Cryomodule Pitch	20 μrad	design

effective standard
all errors are w.r.t.
design

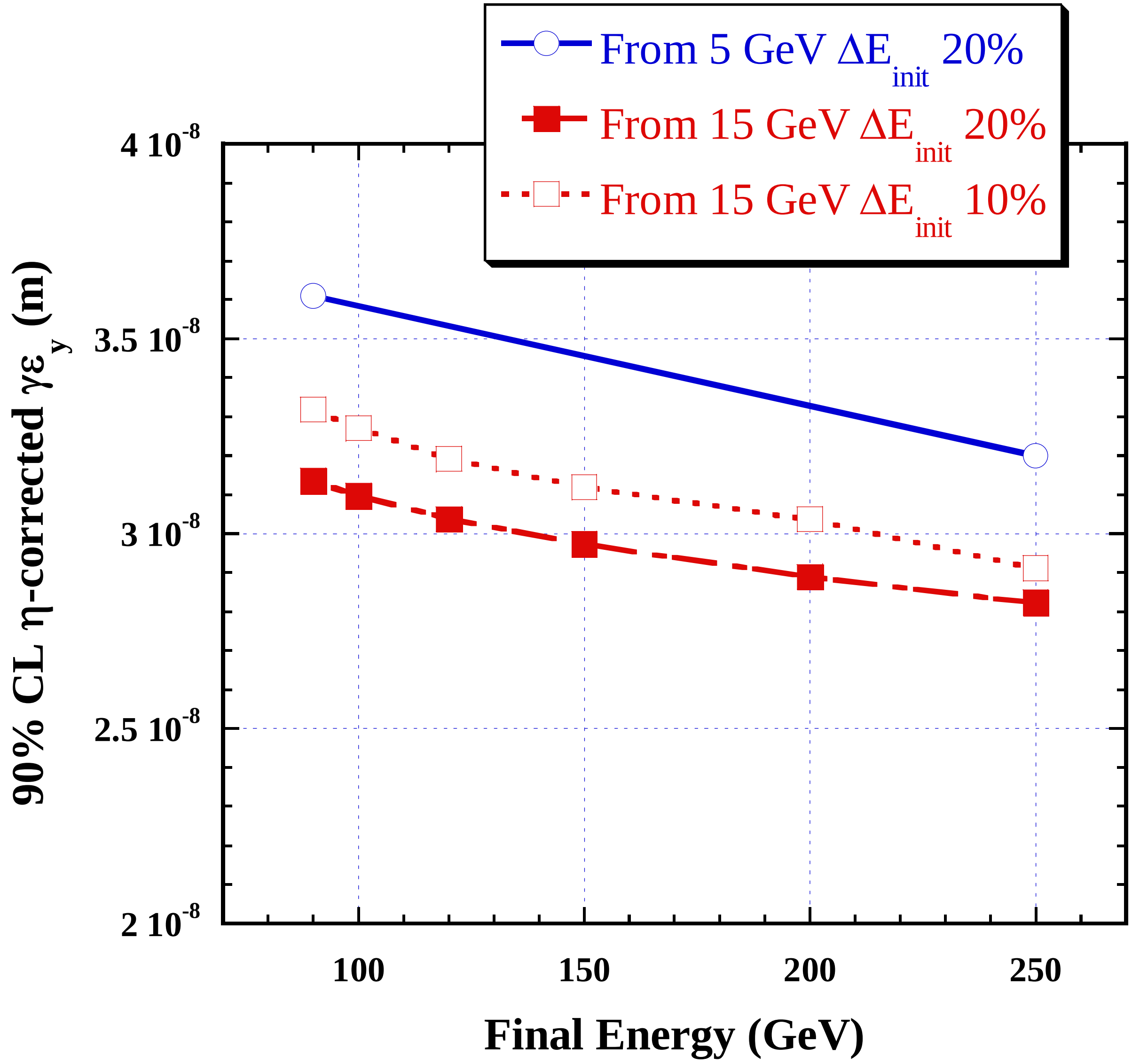
Quad Offset	360 μm
Quad roll	300 μrad
RF Cavity Offset	670 μm
RF Cavity tilt	300 μrad
BPM Offset (initial)	360 μm
BPM resolution	1 μm

$$360 \approx \sqrt{300^2 + 200^2}, \quad 670 \approx \sqrt{300^2 + 9 \times 200^2}$$

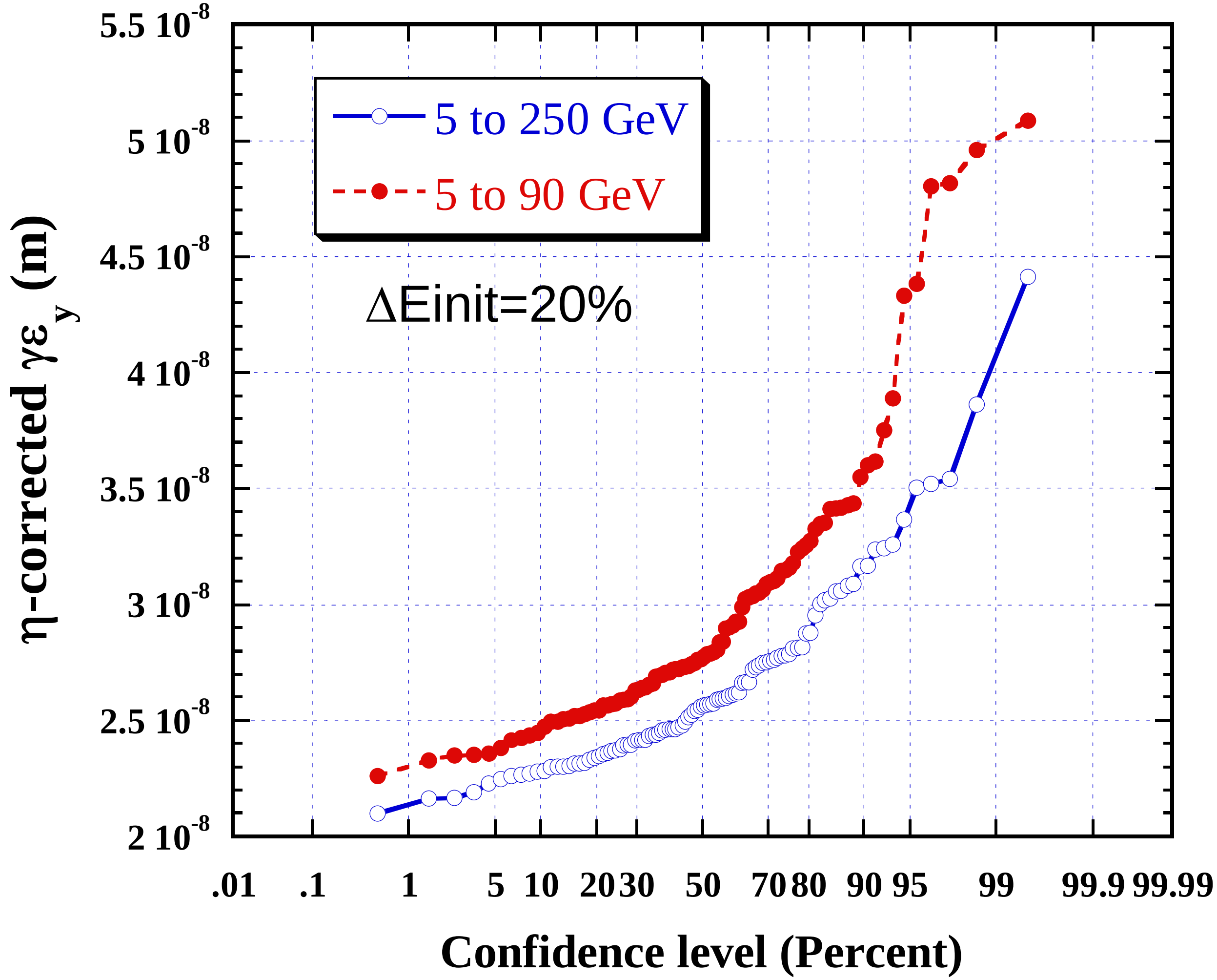
Dependence on Final energy 1



Dependence on Final energy 2



CL estimation from 100 seeds



Emittance growth (dispersion corrected, normalized, vertical)

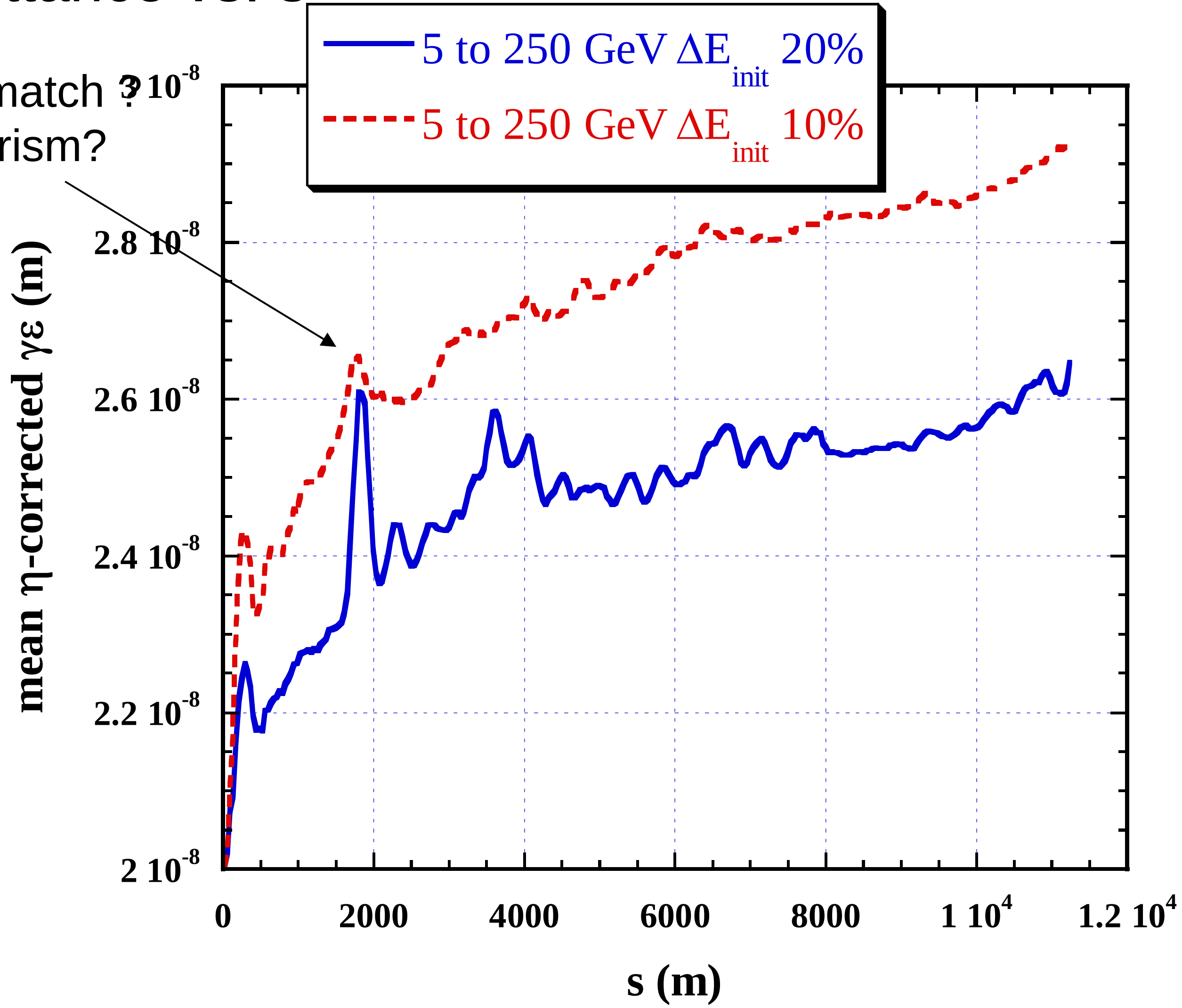
	ΔEinit 20%		ΔEinit 10%	
	Mean	90% CL	Mean	90% CL
5 to 250 GeV	6.5	12.0	9.2	
5 to 90 GeV	9.6	16.1	10.3	
15 to 250 GeV	5.0	8.2	4.4	9.1
15 to 90 GeV	6.7	11.4	6.0	13.2

ΔEinit is important only for the 1st case. (high gradient from low energy.)

Details on DFS parameters

Emittance vs. s

Optics mismatch ?
or bad algorism?

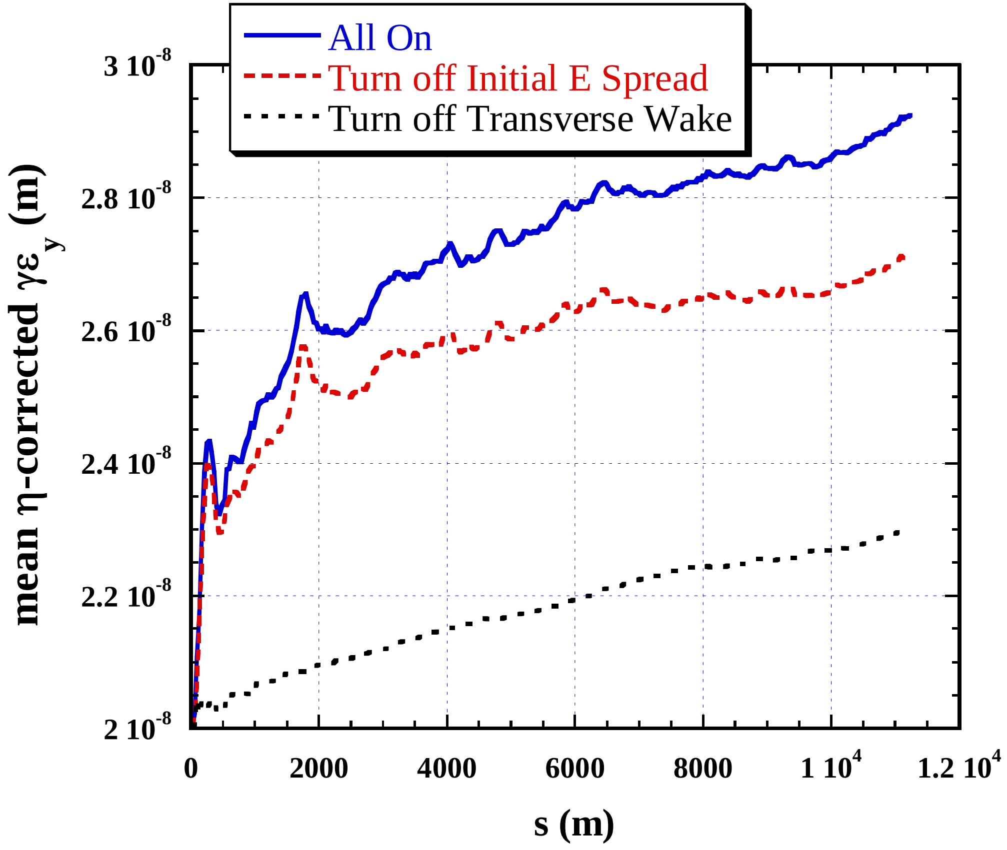


On Beam Energy Change for DFS

- For dispersion measurement, can we change initial energy and acc. gradient ? how much ?
- Simulation assumed
  - Initial energy 20% (is this realistic?)
  - Acc. gradient 10%
- Or (giving worse results)
  - Initial energy 10%
  - Acc. gradient 10%

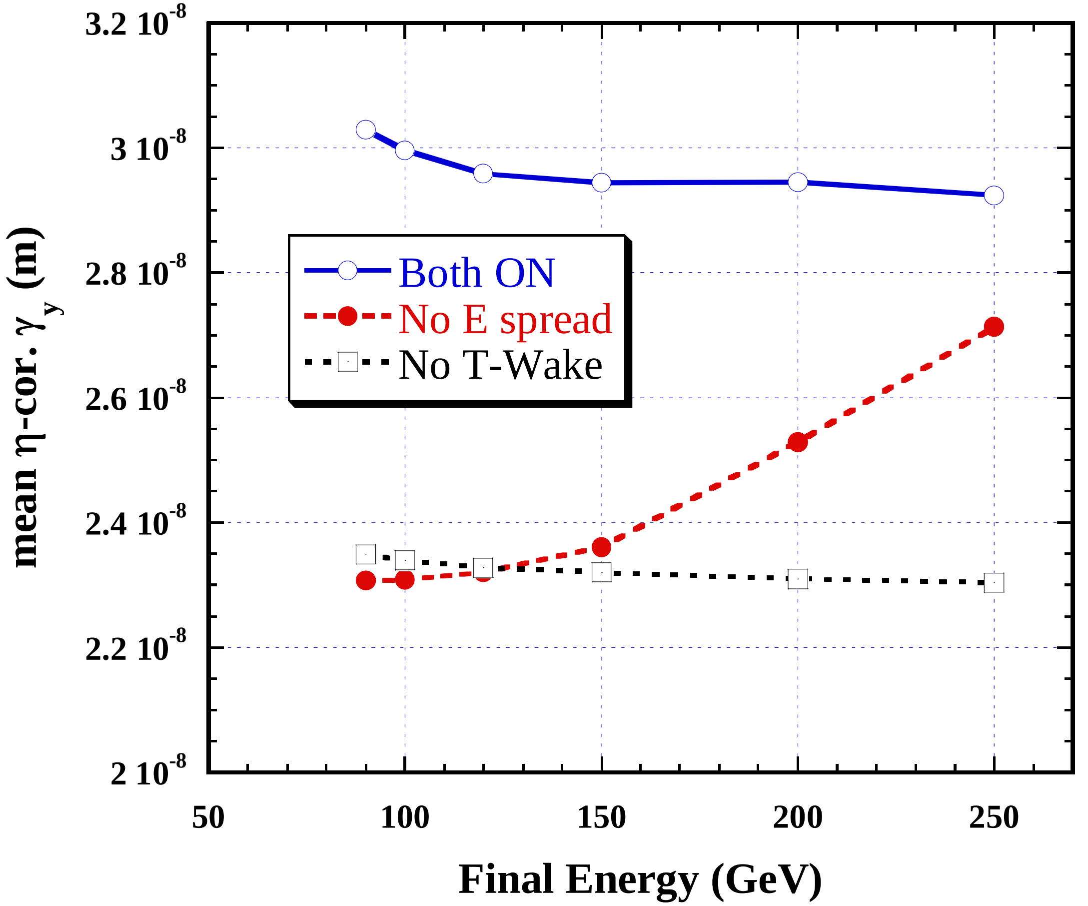
Turn off Energy spread or Transverse wake

Transverse wake is dominant source of emittance growth in low energy region.
Note that we are talking about “linear dispersion corrected” emittance.



5 to 250 GeV
ΔEinit 10%

Emittance vs Efinal, turn off Espread or Wake



ΔEinit 10%

Effect of wakefield is larger for higher acc. gradient.
It may look strange.

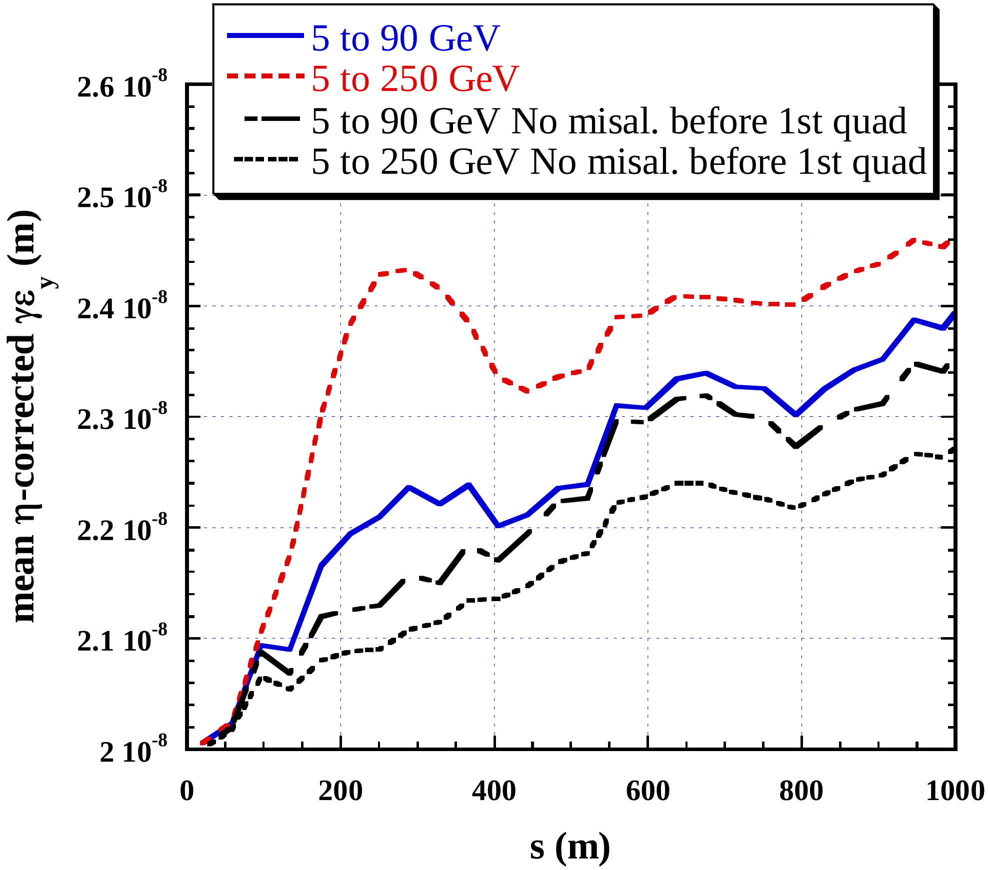
What happened?
Why high gradient is bad at the beginning?

- Cavities' tilts change orbit angle, proportional to gradient/E_beam
  – At the beginning of linac, it is larger for higher acc. gradient.
- Transverse wake with the orbit increase emittance.

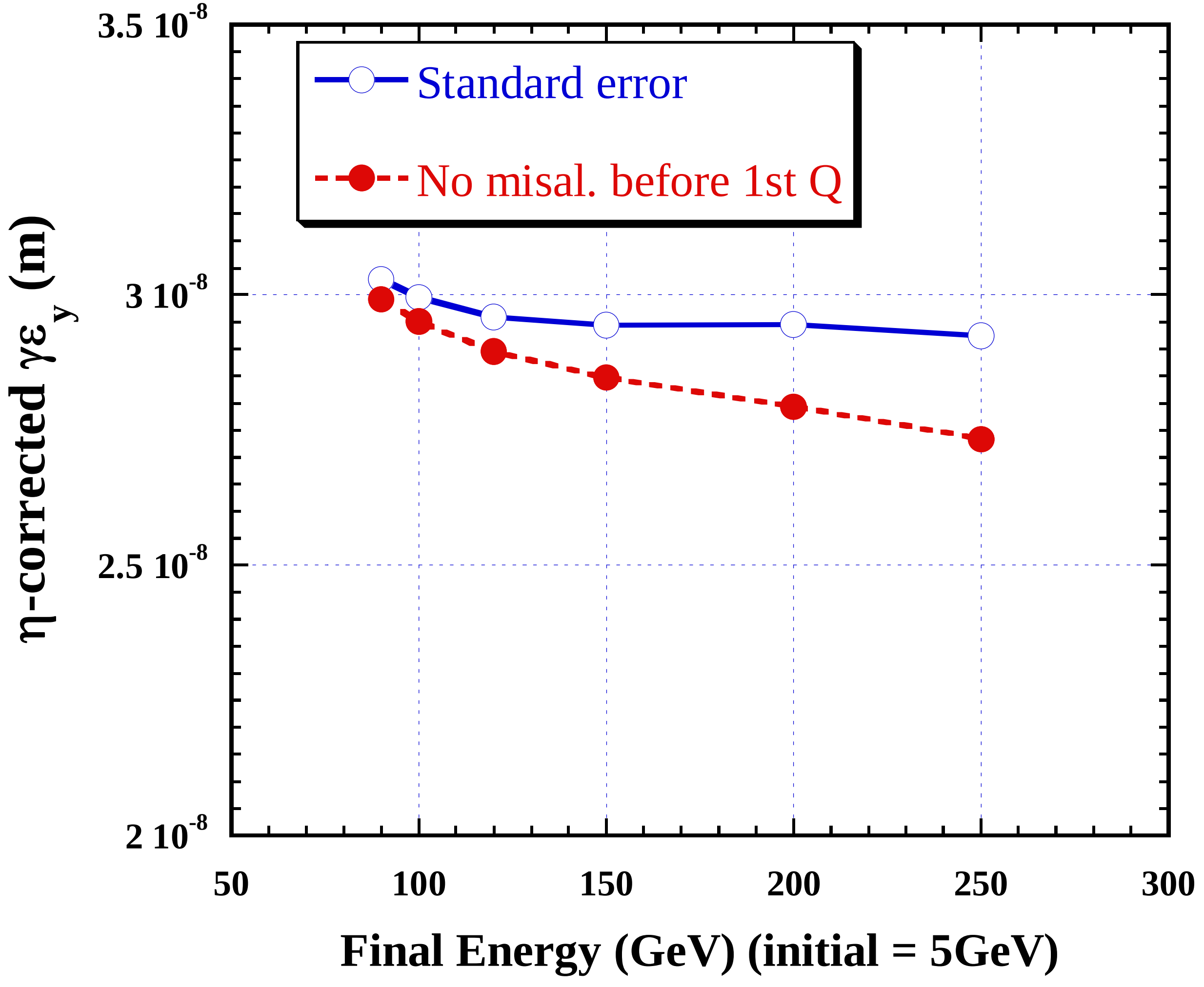
- DFS, changing E_init and Eacc the same ratio, is not effective for cavity tilt at the very beginning.

Effect of misalignment before the 1st Quad

For high gradient, effect of misalignment at the entrance of linac is very large.
But not so much for low gradient



Dependence on Final energy (acc. gradient) with and without misalignment before 1st Quad



Summary

- Emittance growth in Main Linac with “standard” errors is estimated for different final energies. Initial energy 5 and 15 GeV.
  - Emittance growth weakly depend on final energy (acc. gradient)
  - Emittance growth from 5 to 15 GeV depend on DFS parameter (how beam energy is changed in measurement).
- At the beginning of the linac, emittance increases rapidly.
  - Especially low initial beam energy and high acc. gradient.
  - Cavity tilt induce orbit → wake field increase emittance
- Need to understand what is realistic beam energy change.
- Low energy part needs special care?
  - Stronger focusing optics?
    - Less effects of cavity tilt and wake.
  - Other method of correcting cavity tilt?
- Cleverer Algorism at the very beginning of linac?