Effect of DIFFERENT QUAD CONFIGURATIONS on EMITTANCE DILUTION of USColdLC LATTICE

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LET MEETING, JULY 5, 2005

USColdLC MAIN LINAC

- US Cold LC Main Linac Design
  - **Linac Cryogenic system is divided into Cryomodules(CM), with 12 structures / CM**
  - **Magnet Optics : FODO lattice, with β phase advance of 60^0 in each plane**
  - **Each quad has a *Cavity style BPM* and a *Vertical Corrector* magnet; horizontally focusing quads also have a nearby *Horizontal Corrector* magnet.**

- Main Linac Design
  - ~11 km length
  - 9 Cell structures at 1.3 GHz and 12 structures per cryostat
  - Total structures : 7920
  - Loaded Gradient : 30 MeV/m
  - Injection energy = 5.0 GeV
  - Initial Energy spread = 2.5 %
  - Extracted beam energy = 250.7 GeV

- Beam Conditions
  - Bunch Charge: 2.0 x 10^{10} particles/bunch
  - Bunch length = 300 μm
  - Normalized injection emittance: $\gamma\varepsilon_Y$ = 20 nm-rad

USColdLC MAIN LINAC

ab initio (Nominal) Installation Conditions

Tolerance	Vertical (y) plane
BPM Offset w.r.t. Cryostat	300 μm
Quad offset w.r.t. Cryostat	300 μm
Quad Rotation w.r.t. Cryostat	300 μrad
Structure Offset w.r.t. Cryostat	300 μm
Cryostat Offset w.r.t. Survey Line	200 μm
Structure Pitch w.r.t. Cryostat	300 μrad
Cryostat Pitch w.r.t. Survey Line	20 μrad
BPM Resolution	1.0 μm

- BPM transverse position is fixed, and the BPM offset is w.r.t. Cryostat
- Only Single bunch used
- No Jitter in position, angle etc.; No Ground Motion and Feedback
- Steering is performed using Dipole Correctors.

STEERING ALGORITHM : ONE-to-ONE vs. DFS

One-to-One

Divide linac into 7 segments

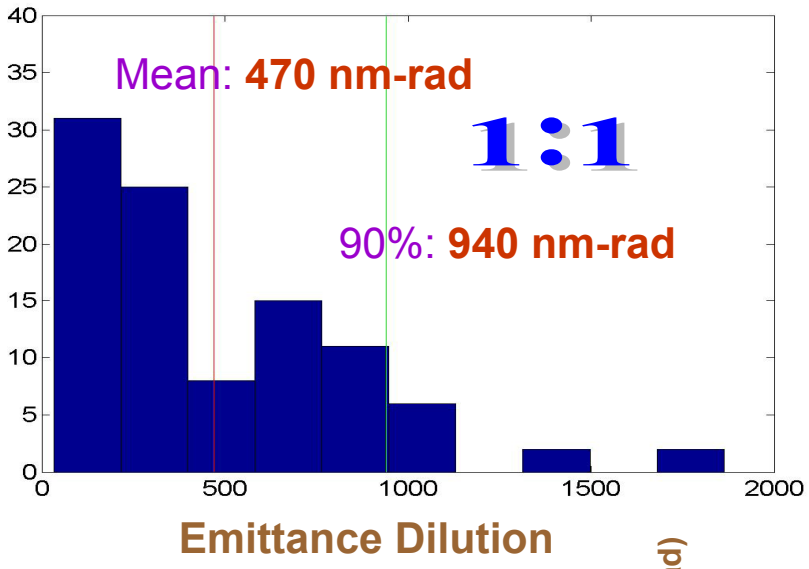
- Read all Q-BPMs in a single pulse
- Compute set of corrector readings and apply the correction
  - ⇨ Constraint – minimize (zero) RMS of the BPM readings
- Iterate few times before going to the next segment.
- Performed for 100 Seeds

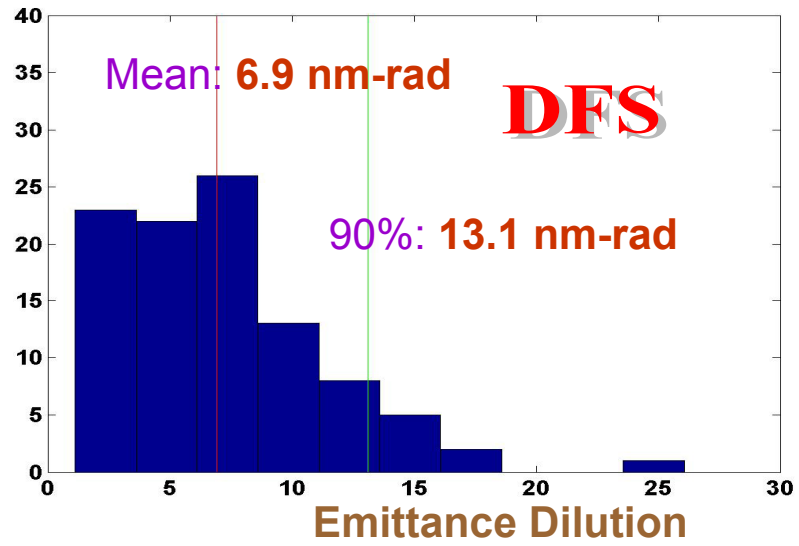
DFS

Divide linac into 18 segments

- Two orbits are measured
- Vary energy by switching off structures in front of a segment (no variation within segment)
- Measure change in orbit (fit out incoming orbit change from RF switch-off)
- Apply correction
  - ⇨ Constraint – simultaneously minimize dispersion and RMS of the BPM readings (weight ratio: $\sqrt{2} : 300$)
- Iterate twice before going to the next segment
- Performed for 100 Seeds

FOR USColdLC NOMINAL CONDITIONS



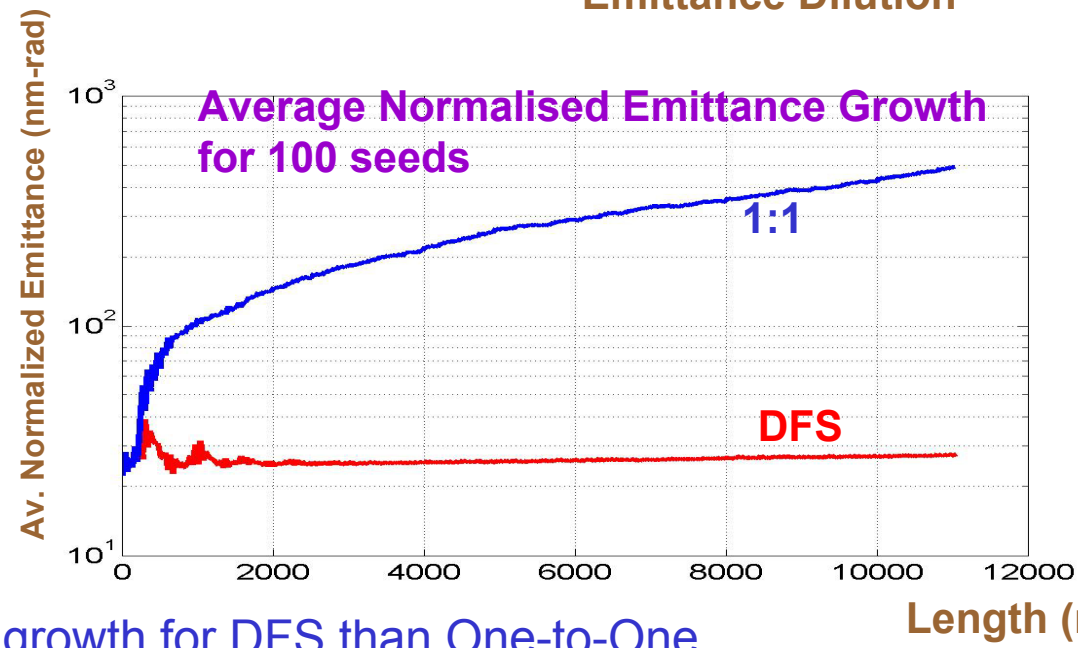


⇨ For 1 Quad / 2CM (330 Quads; 165 F and 165 D)

⇨ No Autophasing considered

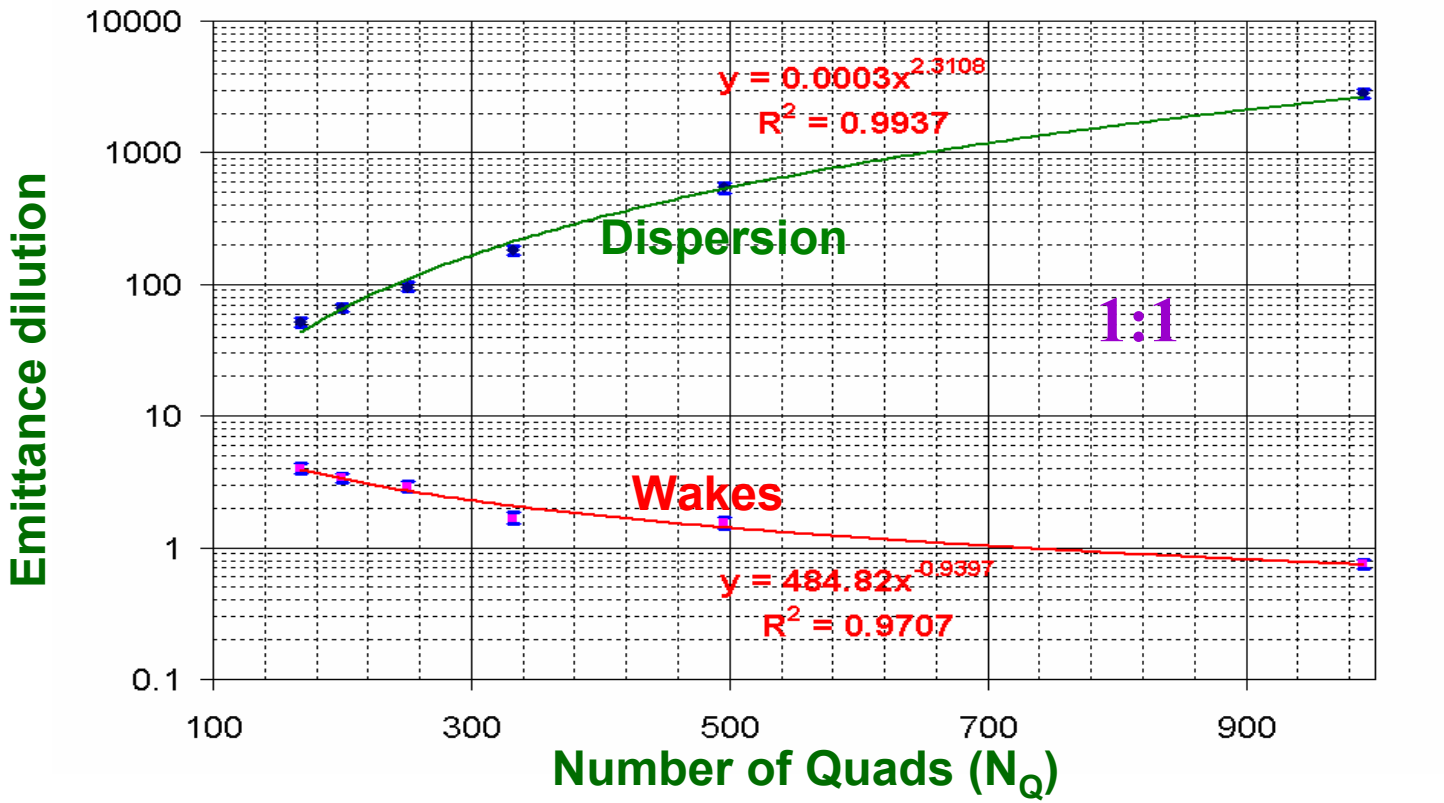
⇨ Wakefields Included (based on the calculations of Zagorodnov & Weiland 2003

⇨ 100 seeds



☞ Lower mean emittance growth for DFS than One-to-One

- Effect of varying quad spacing – 6 different configurations with diff. quad spacing (varies from 1 Quad / 1 CM to 1 Quad / 6 CM)
  - Dispersion Case – Quad, BPM Offsets and Structure, CM Pitch
  - Wake Case – Structure, CM offset, wakefields

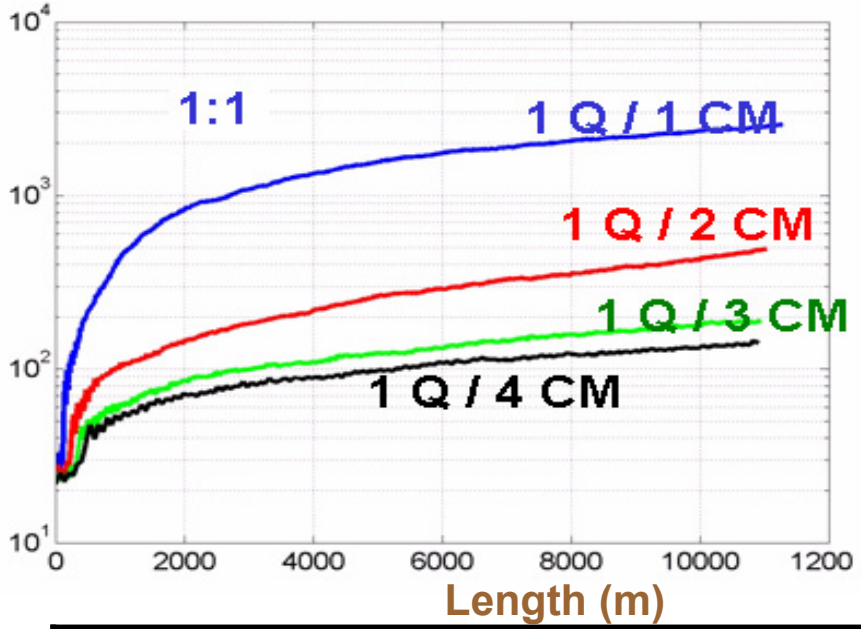


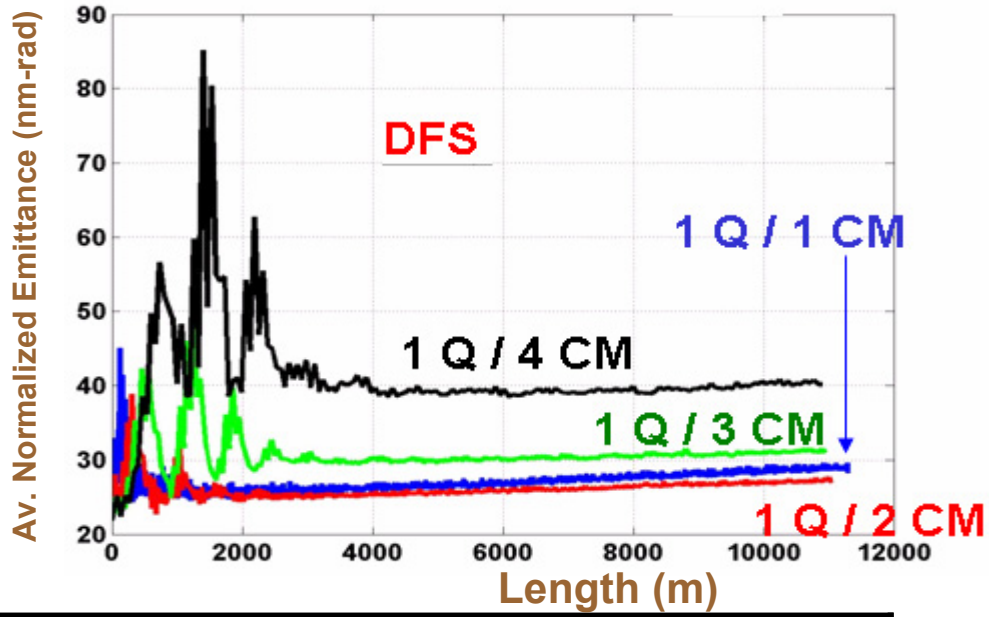
☞ Projected emittance growth is dominated by dispersive sources

☞ Large quad spacing seems to be an attractive choice

QUAD CONFIGURATIONS

⇨ Constant phase advance of 60^0; No Autophasing considered; Nominal Misalignment conditions; 100 seeds; 18 DFS segments; Launch region has 7 BPMs

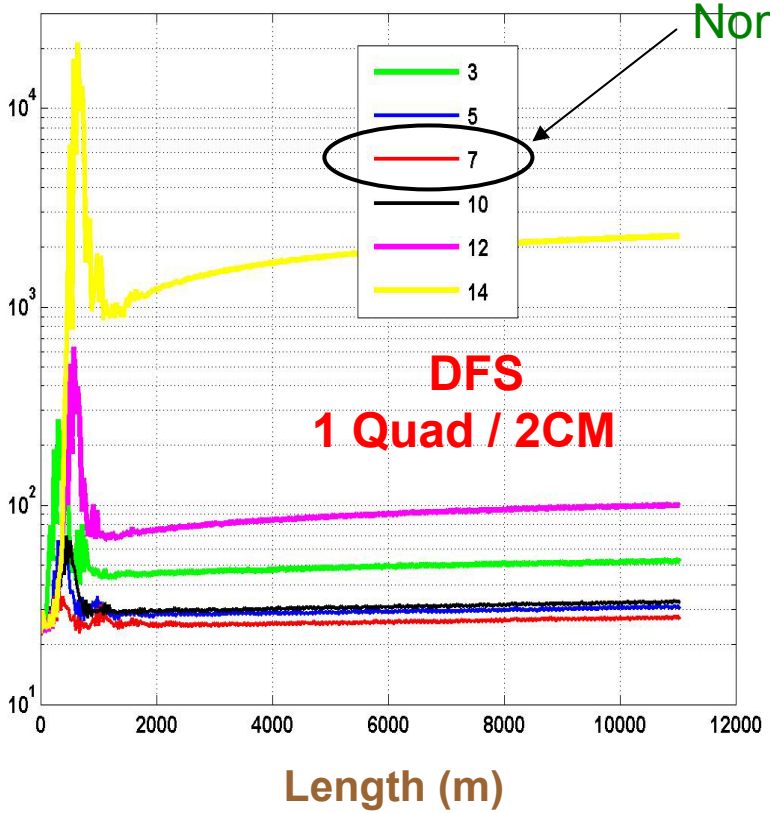




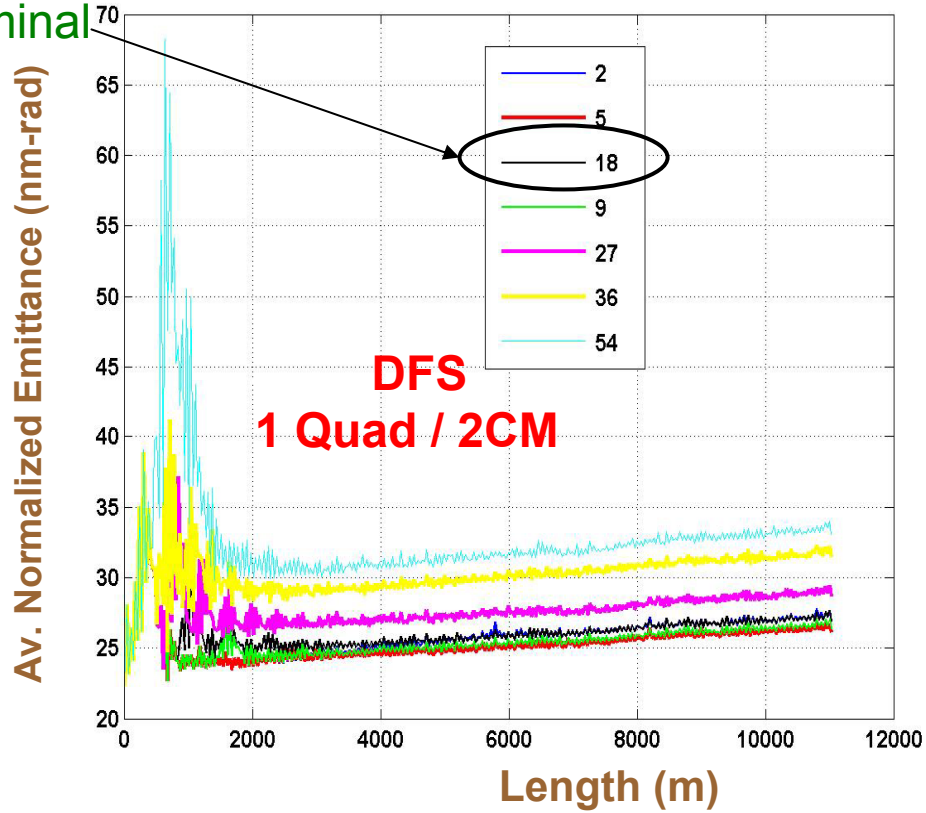
	Mean dilution (nm)		90% dilution (nm)	
	1:1	DFS	1:1	DFS
1 Q / 1CM	2537	8.3	5252	15.3
1 Q / 2CM	470.9	6.9	940.1	13.1
1 Q / 3CM	170.7	11.0	367.3	21.2
1 Q / 4CM	120.8	20.2	232.5	39.4

QUAD CONFIGURATIONS

Effect of No. of BPMs in Launch region (DFS Segments = 18)



Effect of No. of quads per DFS segment (BPMs in Launch region = 7)

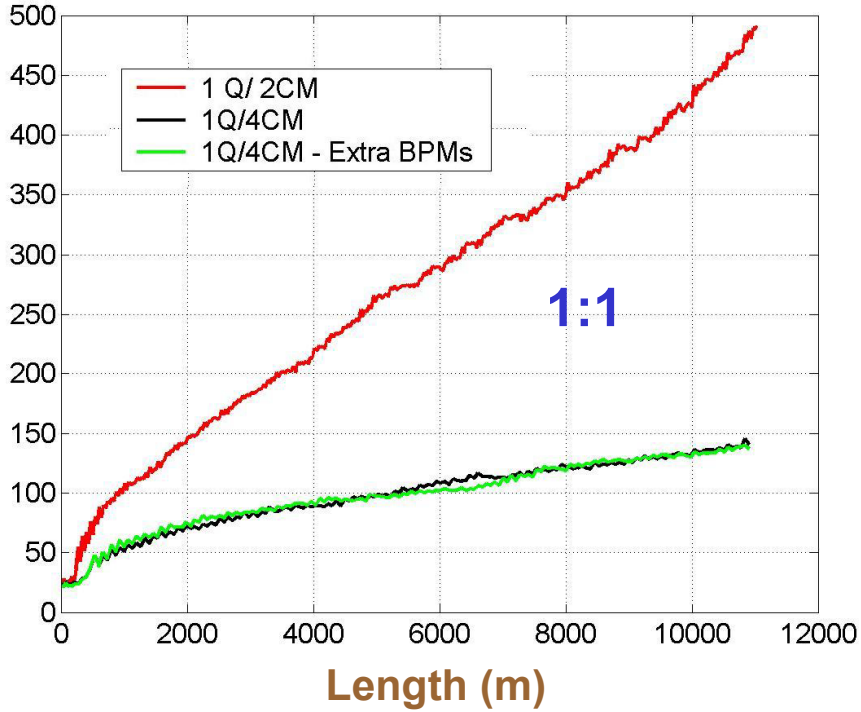


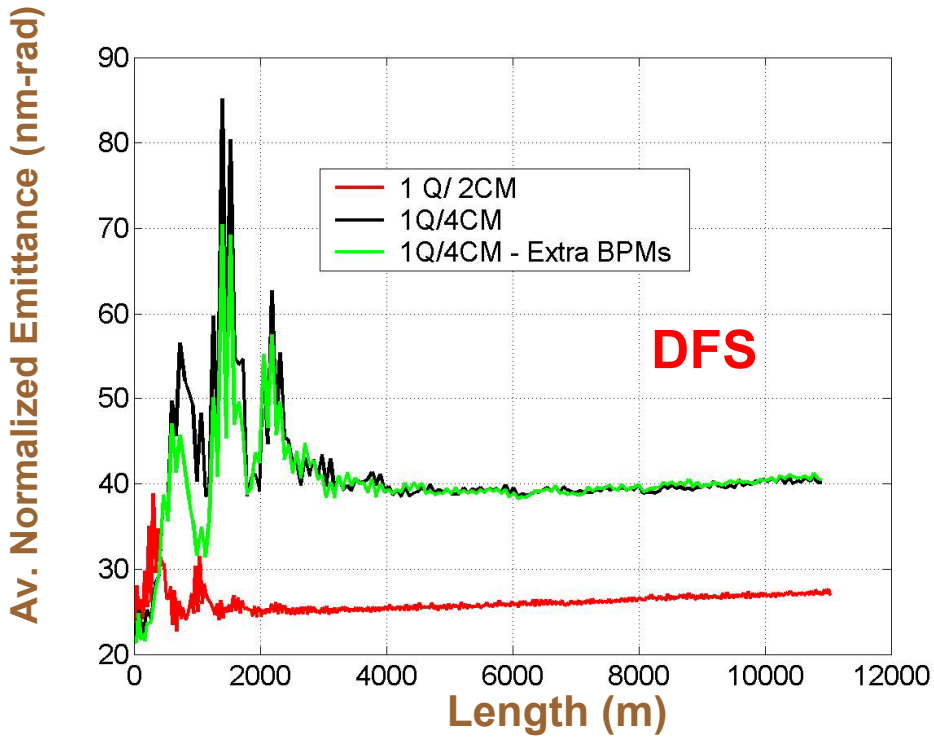
- Tuned for 7 BPMs in Launch Region for 1Q/2CM (5,7,10 give almost similar results

- Better for larger number of quads per DFS segment (2,5,9,18 give almost comparable results)

QUAD CONFIGURATIONS

⇨ Effect of ADDING 3 extra BPMs and COR in 1Q/4CM b/w Quads 1-2; 2-3; 3-4



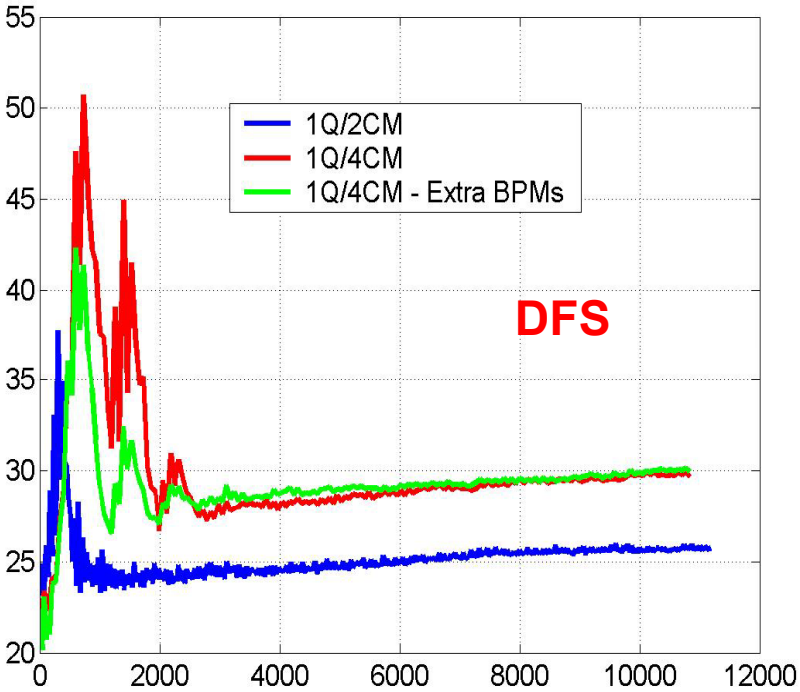


☞Almost no effect of adding extra BPMs / YCOR

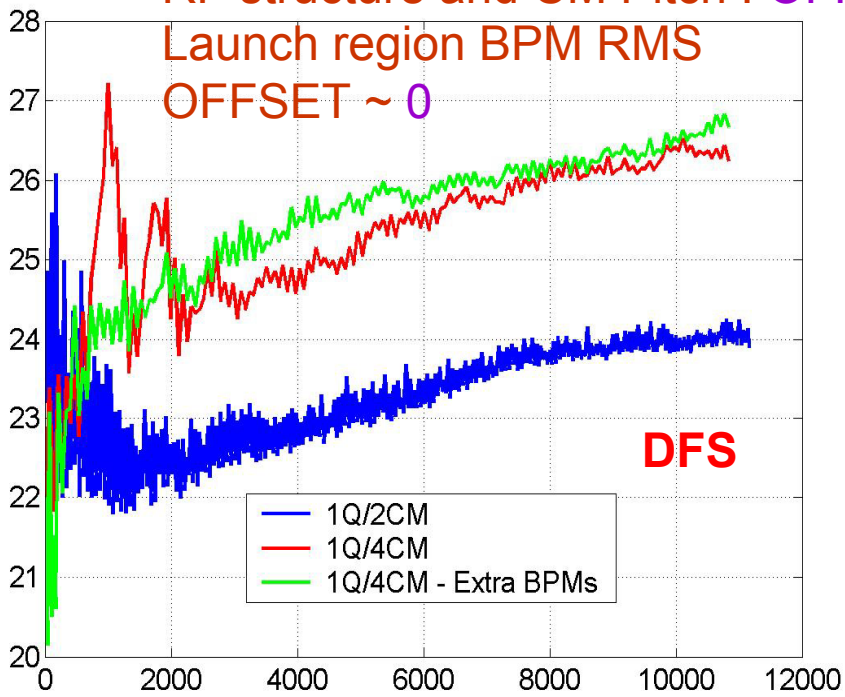
QUAD CONFIGURATIONS

⇨ To avoid the possible systematic effects

RF structure and CM Pitch : OFF



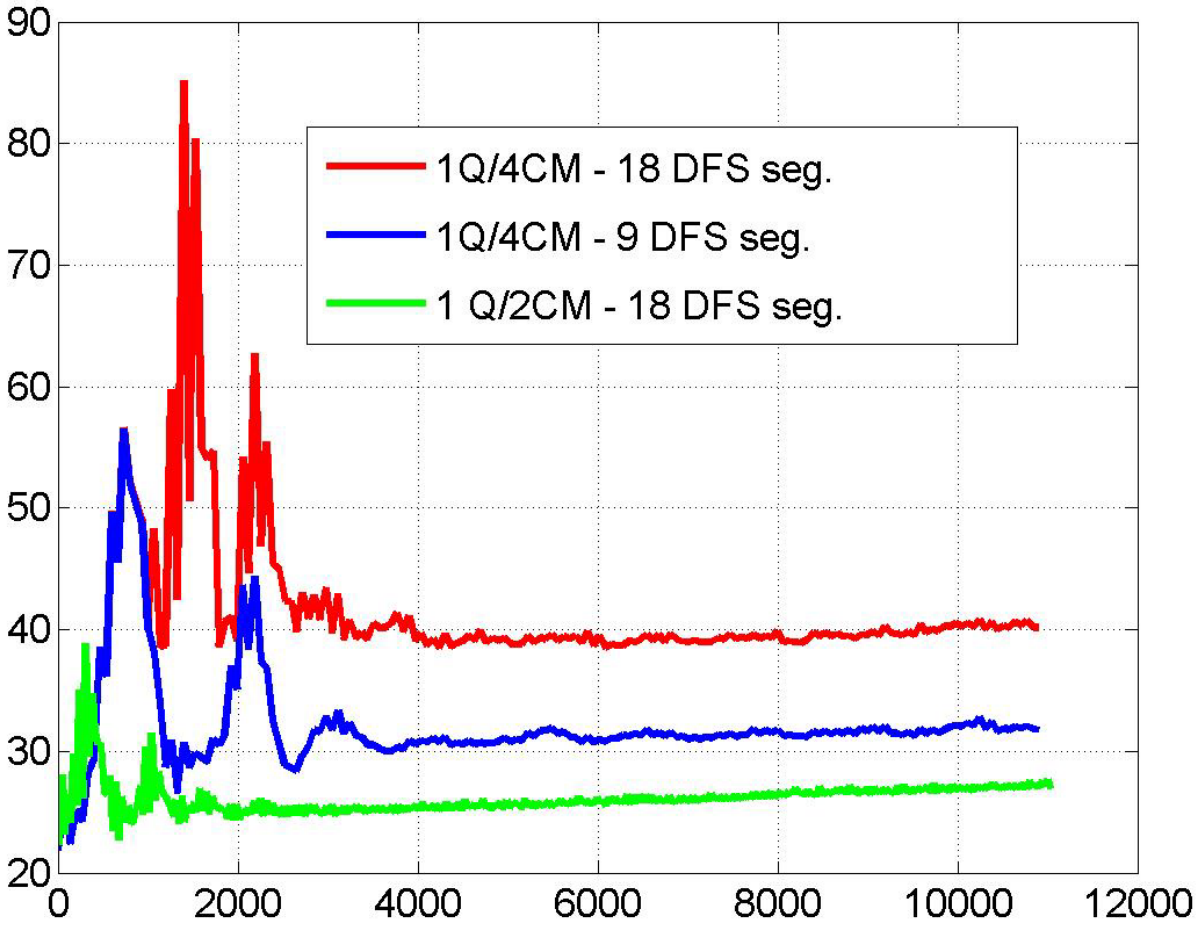
RF structure and CM Pitch : OFF
Launch region BPM RMS OFFSET ~ 0



➢ 1 Q / 4CM is more sensitive to RF / CM pitches

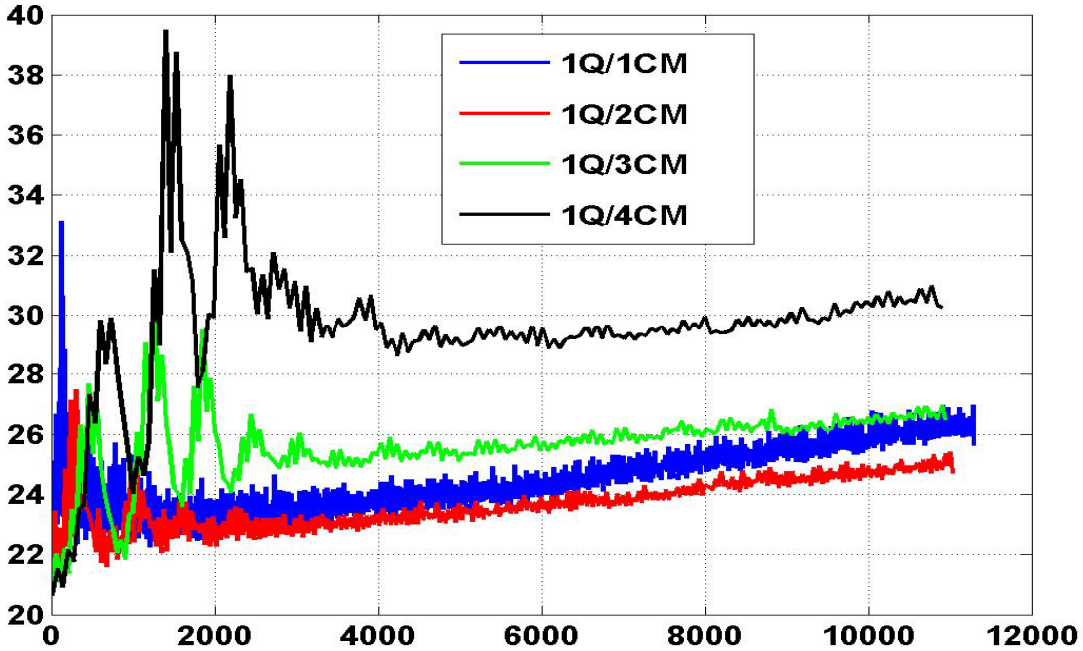
QUAD CONFIGURATIONS

⇨ Effect of varying No. of DFS segments for 1 Q / 4 CM ; Nominal misalignment; 100 seeds



QUAD CONFIGURATIONS

⇨ Initial Energy = 15 GeV (energy spread 130 MeV); Nominal misalignment; 100 seeds



Injection energy →	Mean dilution (nm) DFS		90% dilution (nm) DFS	
	5 GeV	15 GeV	5 GeV	15 GeV
1 Q / 1CM	8.3	5.6	15.3	9.1
1 Q / 2CM	6.9	4.7	13.1	9.3
1 Q / 3CM	11.0	6.5	21.2	13.6
1 Q / 4CM	20.2	10.2	39.4	19.3