Orthogonal Bumps in ILC Main Linac

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Previous works

- Proposed by P. Eliasson and D.Schulte at “CLIC Tuning Bump Strategies”, Daresbury LET face-to-face meeting, Jan. 2007
- Daniel Schulte and Andrea Latina are working on similar BUMPS for ILC linac (this meeting)
- Our first look for ILC Main Linac

Bumps

- For a given seed the final beam after BBA can be represented by a vector

$$s_i = \left(y_i^1, \ldots, y_i^n, \beta y_i'^1, \ldots, \beta y_i'^n\right), \quad i = 1 \ldots nseed$$

where *n* - number of particles (11x11x9 in our case)

- The effect of knobs (correctors) can be represented by matrix (*mx2n*)

$$K = \begin{pmatrix} k_1 \\ \vdots \\ k_m \end{pmatrix} \quad \textit{where:} \quad k_j = \left(\Delta y^1, \ldots, \Delta y^n, \beta \Delta y'^1, \ldots, \beta \Delta y'^n\right)_j, \quad j = 1 \ldots ncorr$$

s_i - contains the particle positions and angles at the end of the linac

k_j - contains *changes* in particle positions and angles for a unit change of knob *j*

- Matrix ***K*** is defined by lattice (independent of misalignment)

SVD

- To minimize final emittance for each seed s one should find a vector x of amplitudes of correctors, which minimize:

$$s - x \cdot K \Rightarrow \min$$

- Singular value decomposition (SVD) on K represents it as a product of orthogonal matrices U and V and diagonal matrix K_{svd}:

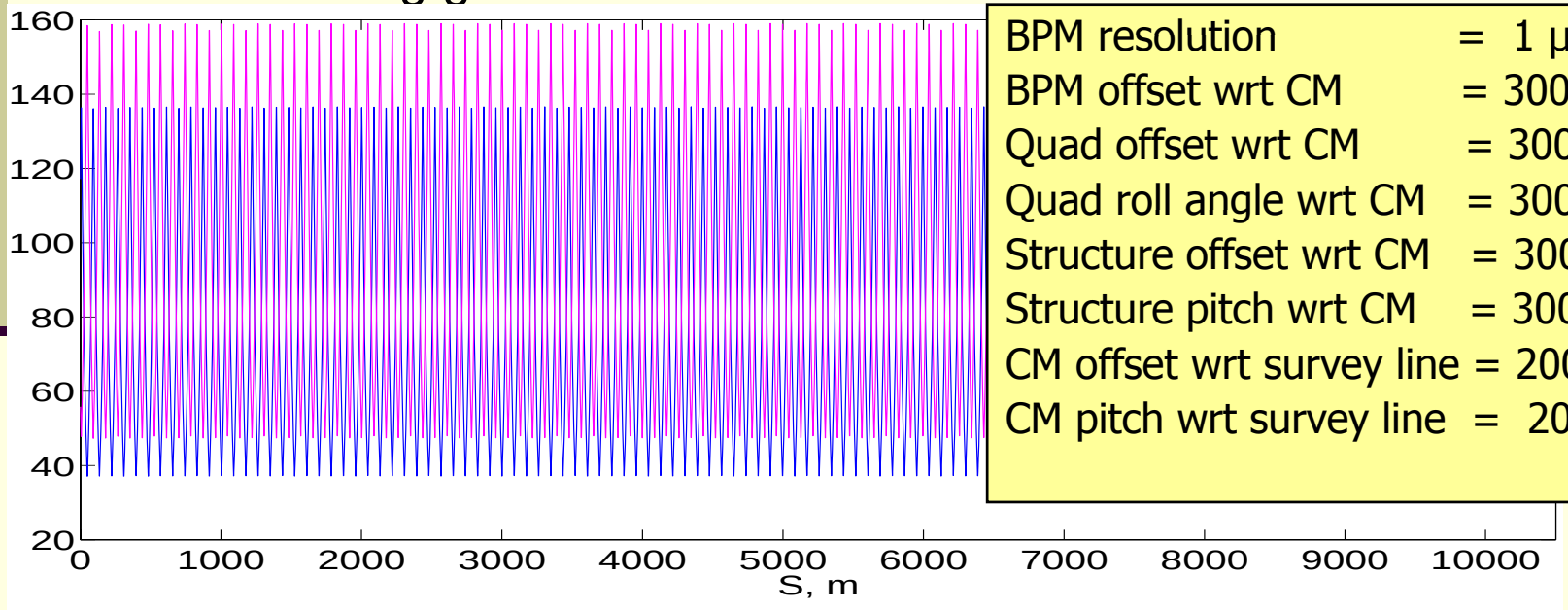
$$K = U \cdot K_{svd} \cdot V^T = \begin{pmatrix} U_1 & \cdots & U_n \end{pmatrix} \begin{pmatrix} \alpha_1 & & \\ & \ddots & \\ & & \alpha_n \end{pmatrix} \begin{pmatrix} V_1 \\ \vdots \\ V_n \end{pmatrix}$$

- Then $$s - \sum_{j=1}^{n} x_j \cdot \alpha_j \cdot \left(U_j \cdot V_j\right) \Rightarrow \min$$

- Column U_i is the weights of all correctors in j - th orthogonal bump.
  V_i - corresponding changes of particle coordinates and angle
  x_j – amplitude of j – th orthogonal bump

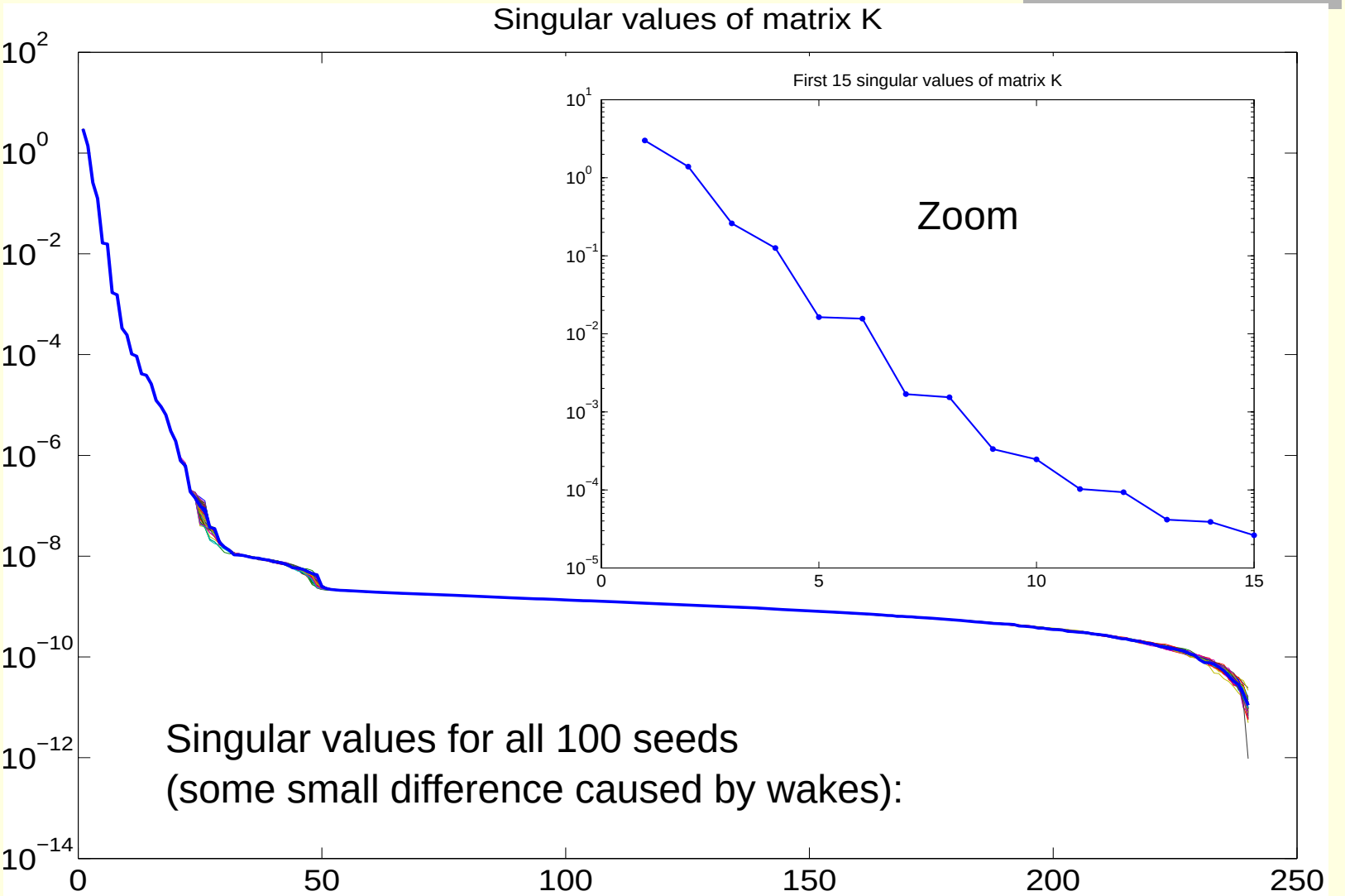
Example: Straight ML Lattice

- Regular straight FODO lattice, 114 cells
- X/Y phase advance per cell = 75/60
- 8 cavities per cryomodule (CM)
- 4 CM per quadrupole (TESLA-like)
- Quadrupole package = BPM, quadrupole, Xcorr, Ycorr.
- Accelerating gradient = 31.5 GeV/m

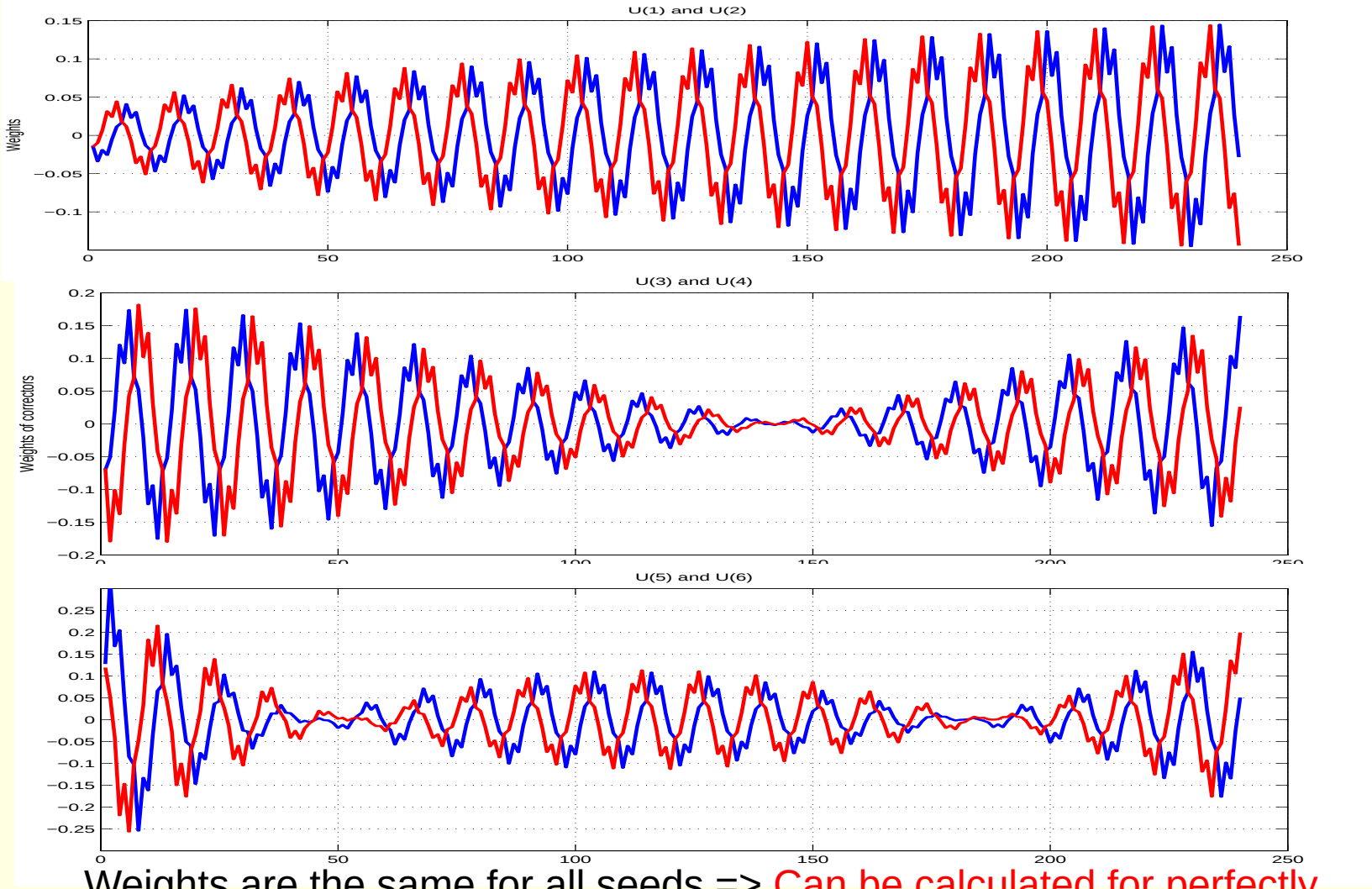


BPM resolution	= 1 μm
BPM offset wrt CM	= 300 μm
Quad offset wrt CM	= 300 μm
Quad roll angle wrt CM	= 300 μrad
Structure offset wrt CM	= 300 μm
Structure pitch wrt CM	= 300 μrad
CM offset wrt survey line	= 200 μm
CM pitch wrt survey line	= 20 μm

Singular value of matrix K

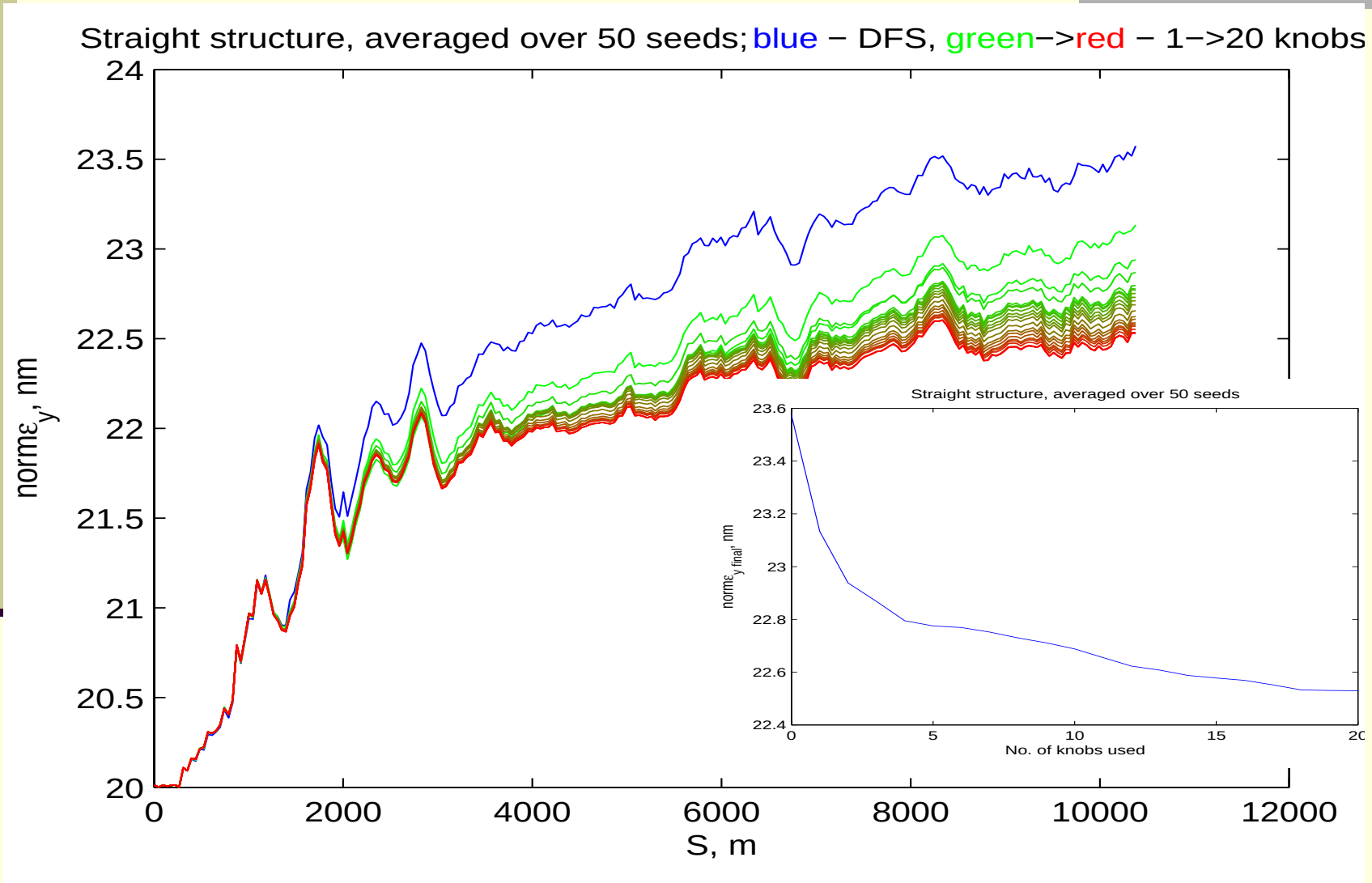


Weights of real correctors in orthogonal bumps.



Weights are the same for all seeds => Can be calculated for perfectly aligned lattice ones and later used for orthogonal correctors

Straight Linac, Regular Lattice Dispersion, Coupling, Wakefields



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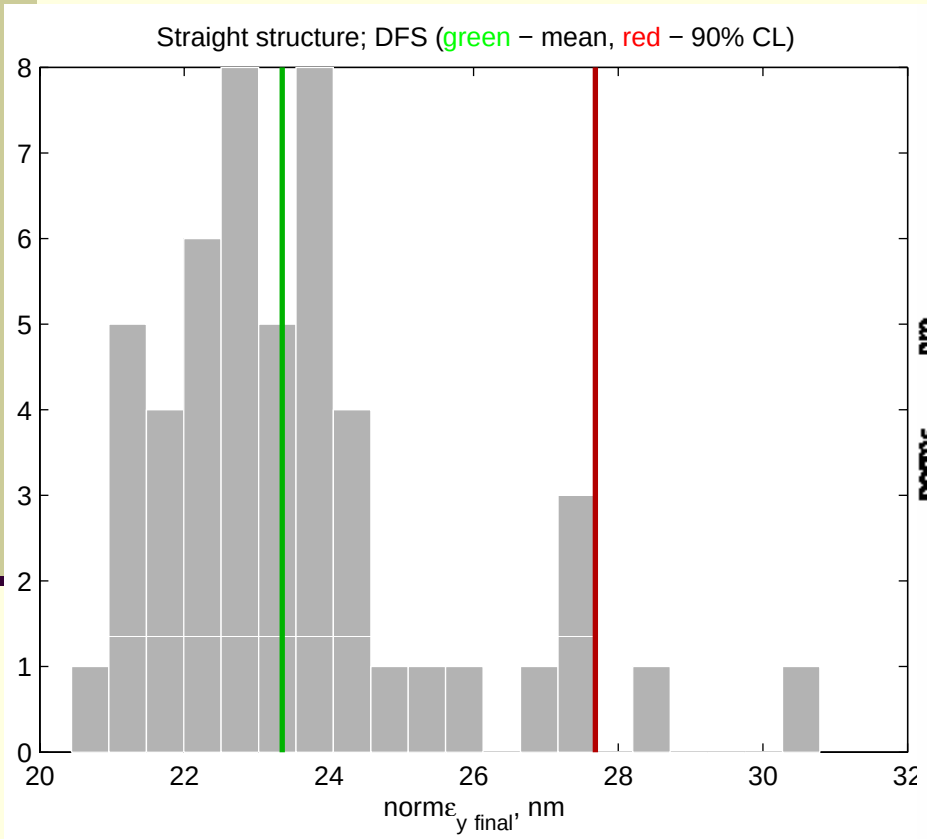

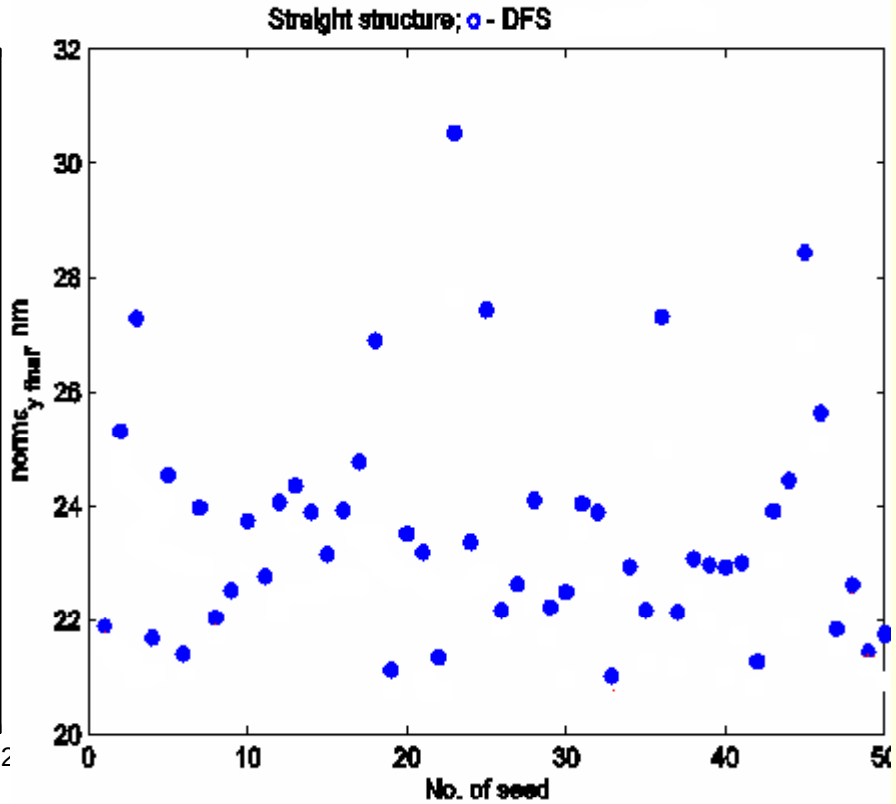

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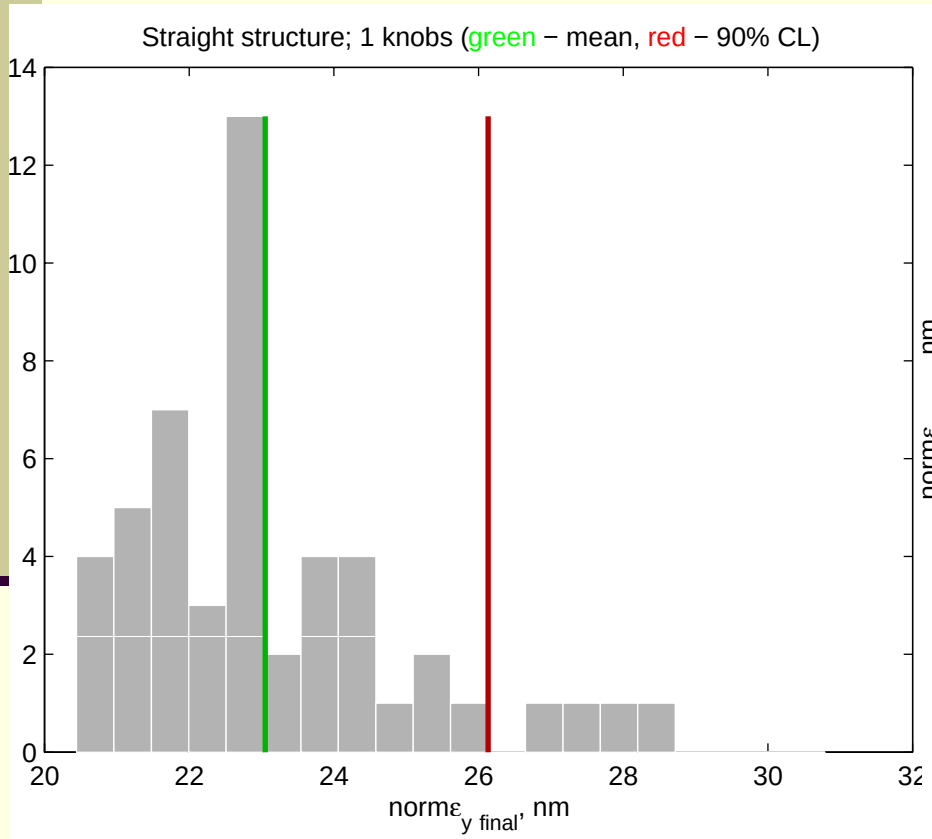

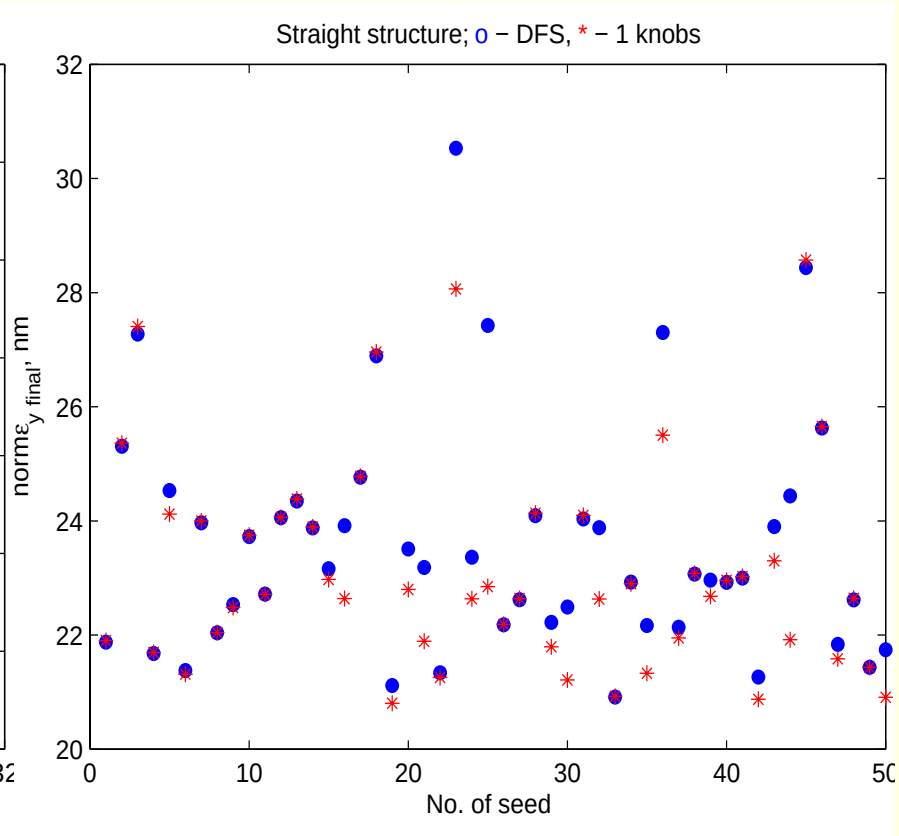

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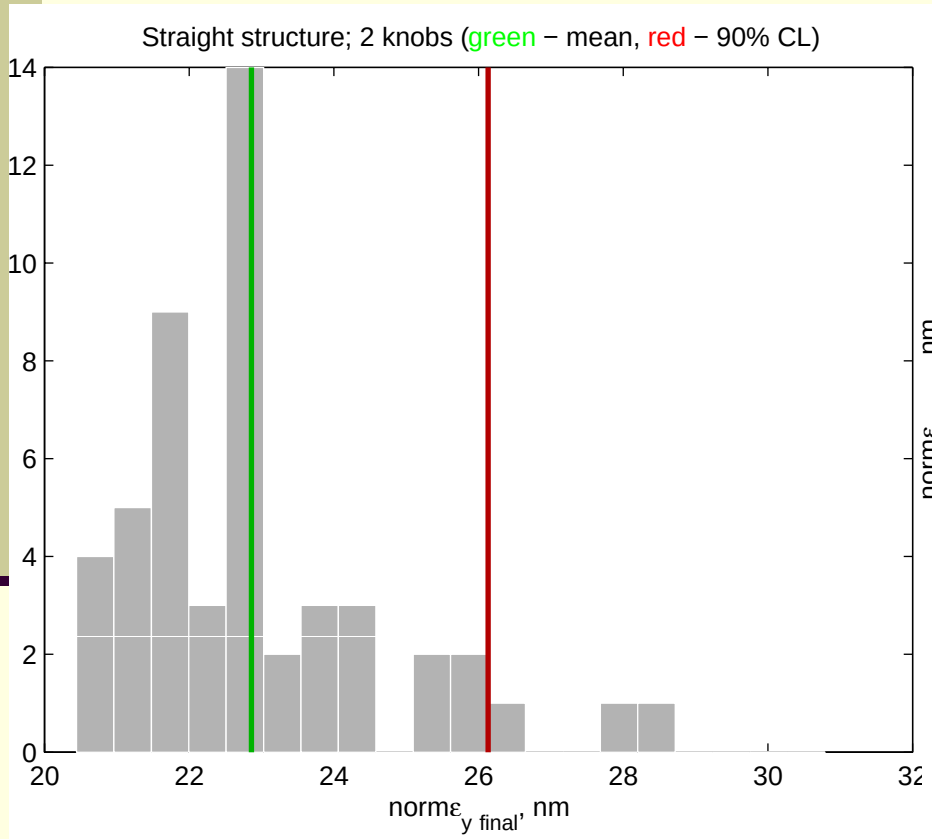

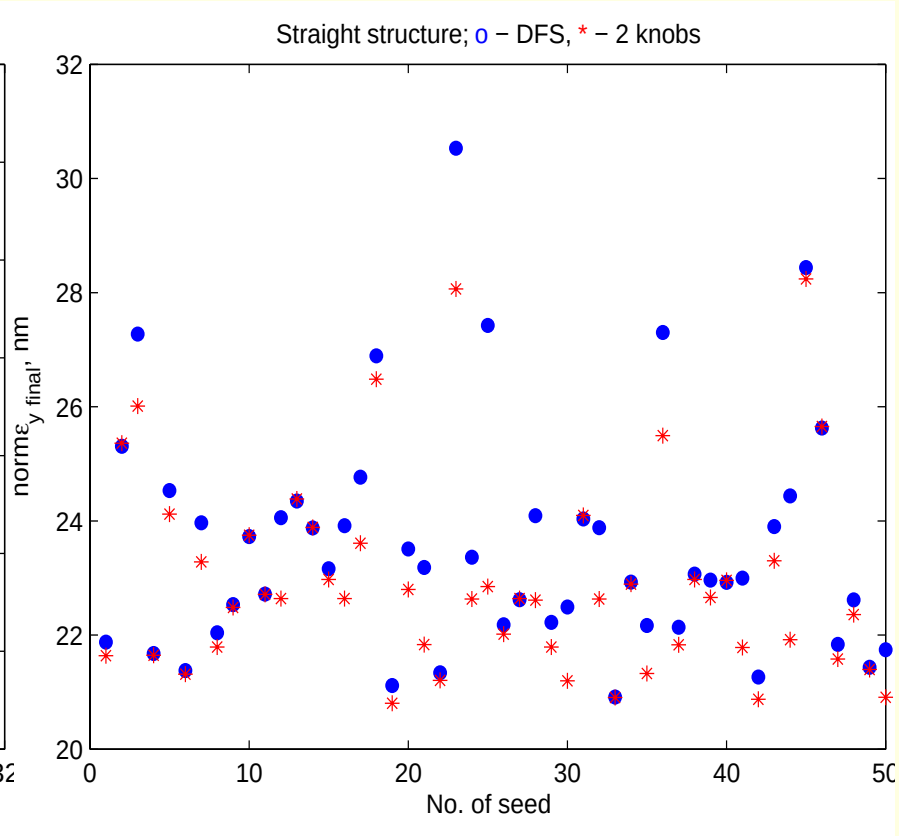

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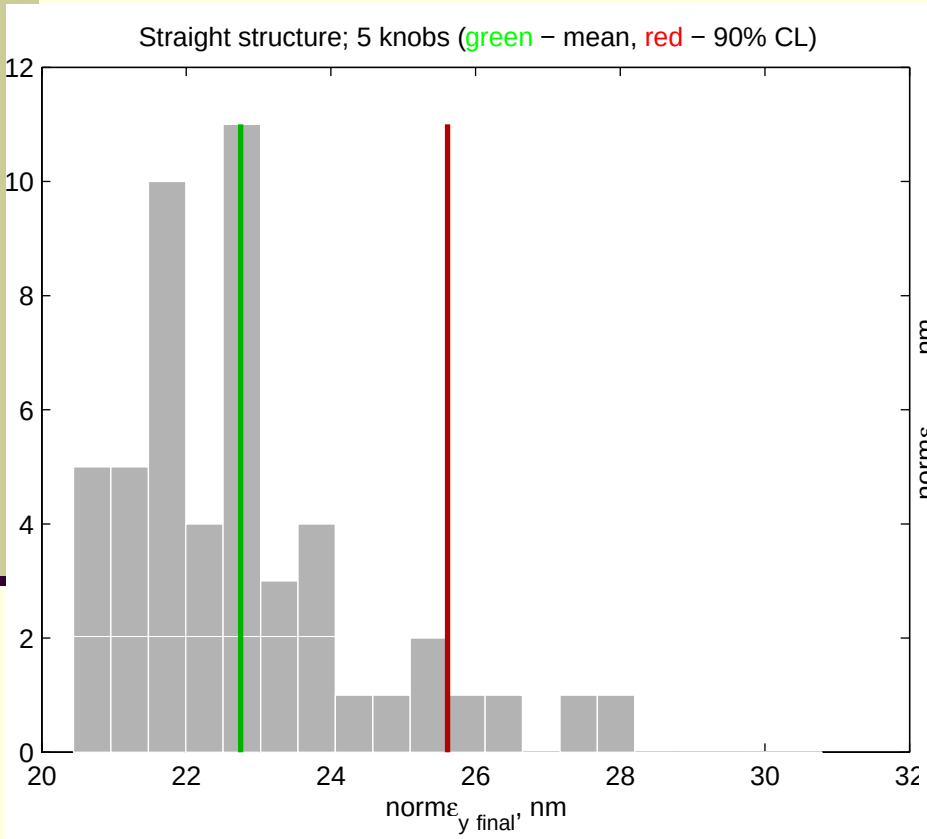

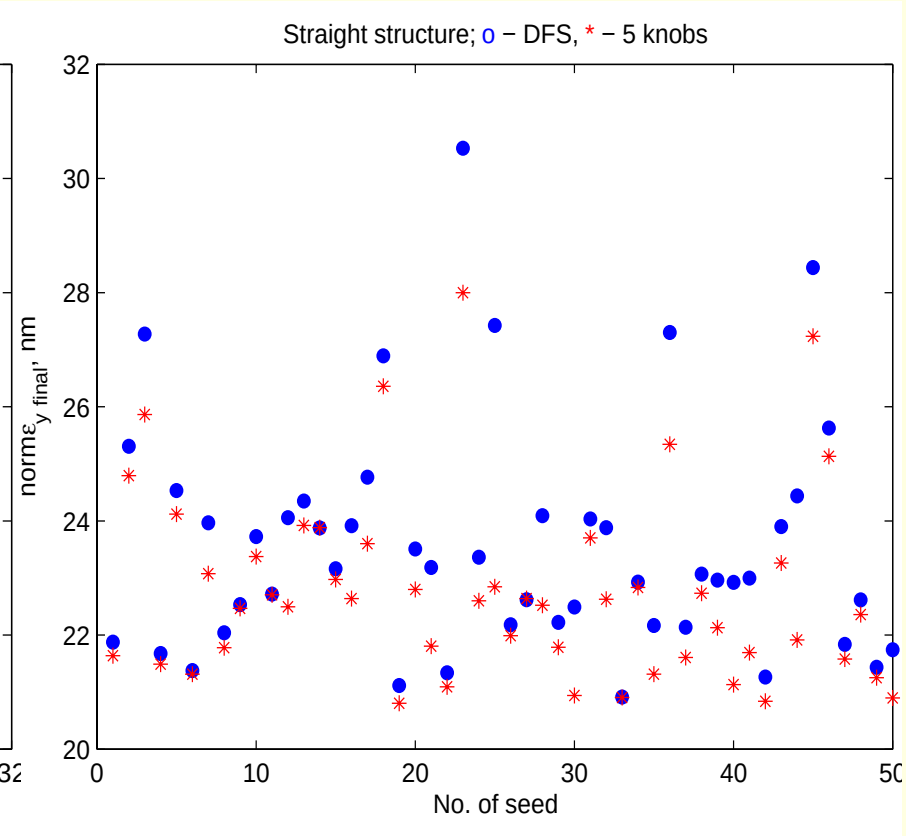

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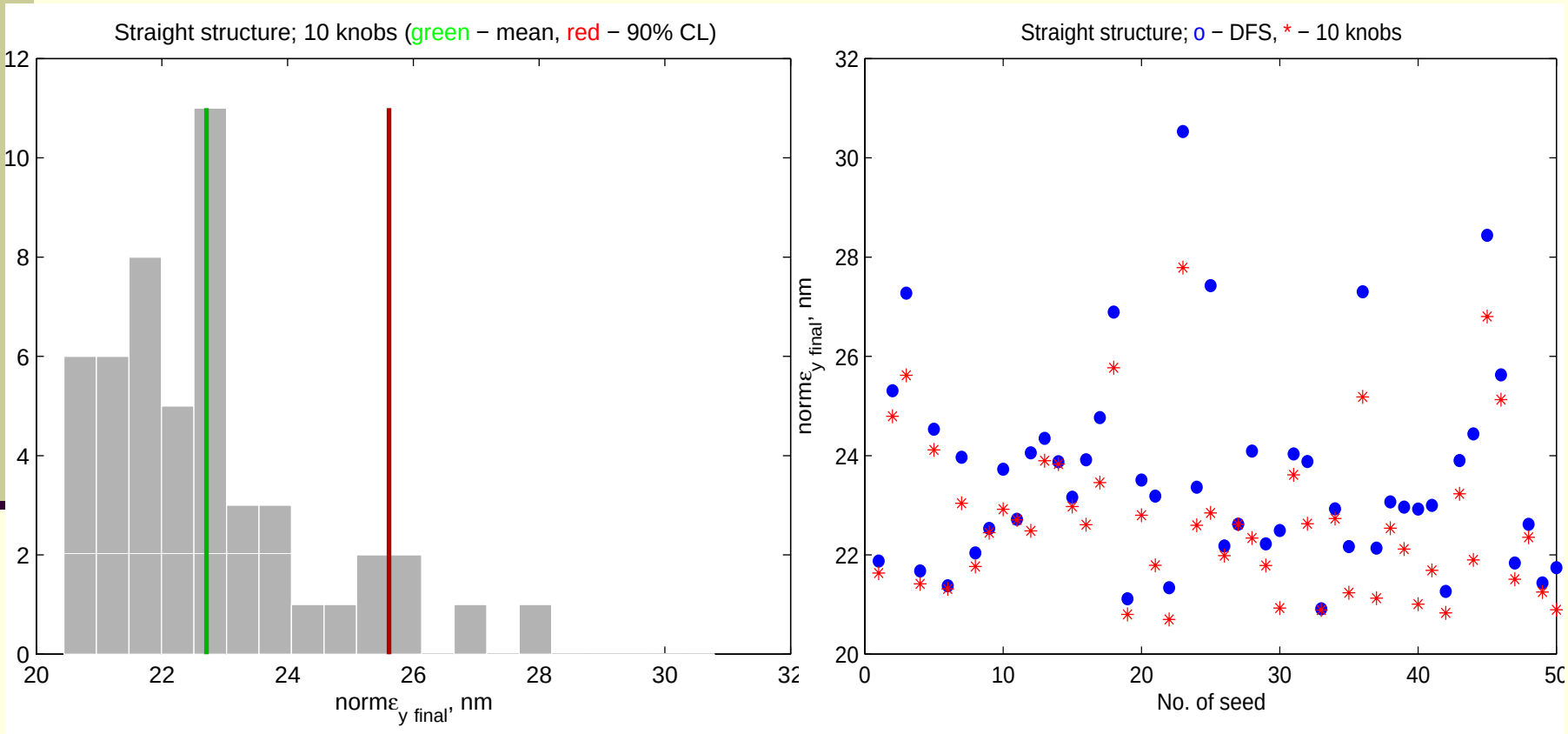

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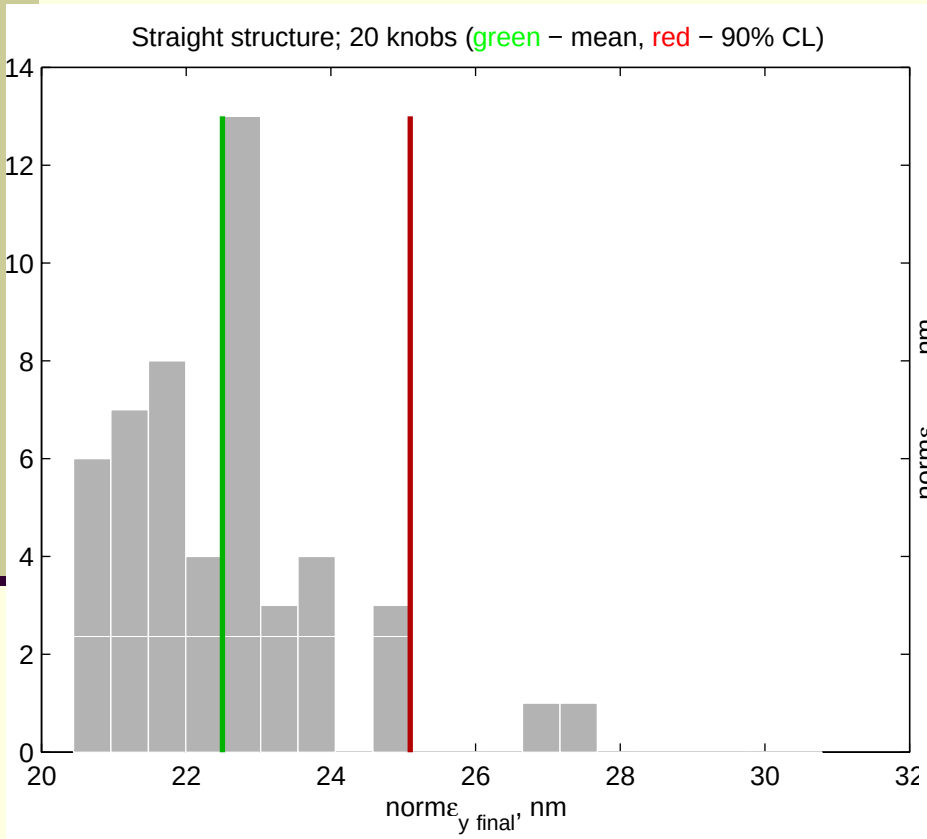
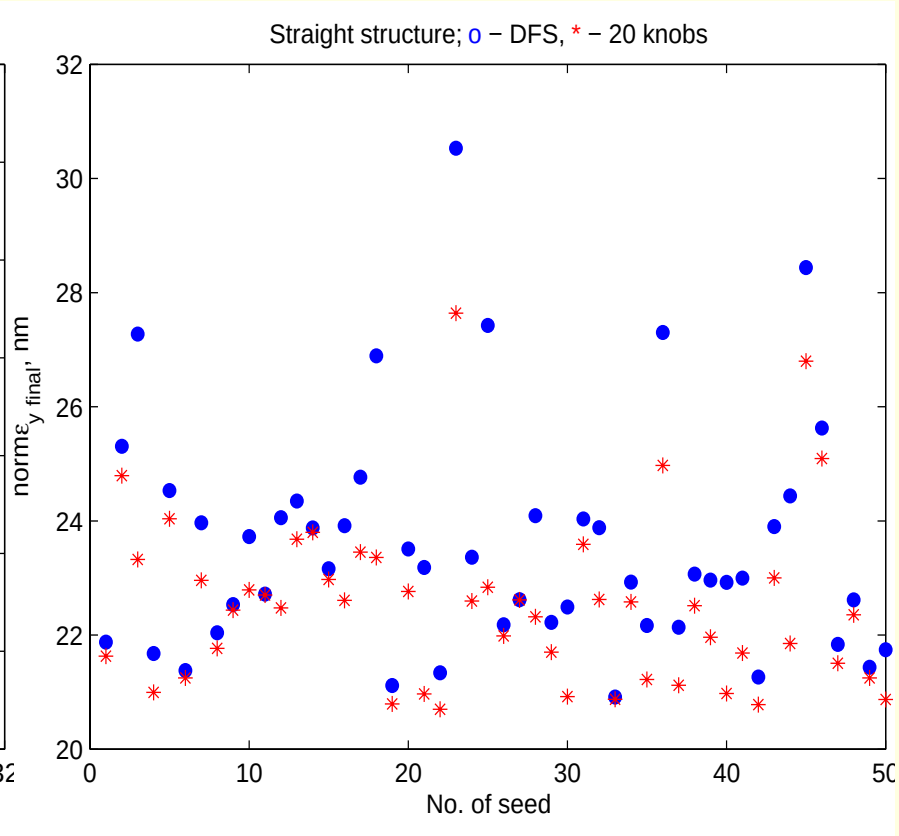
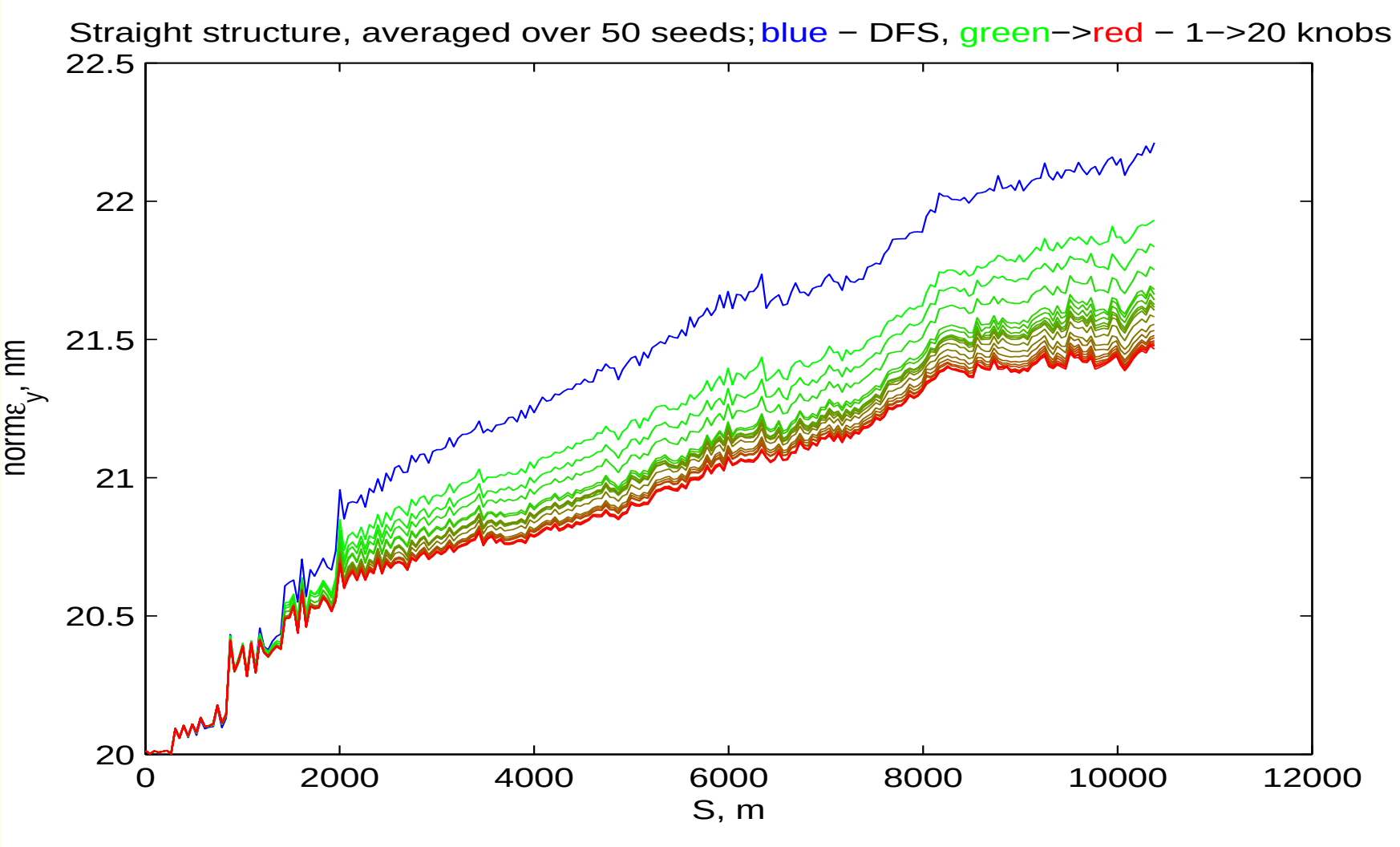
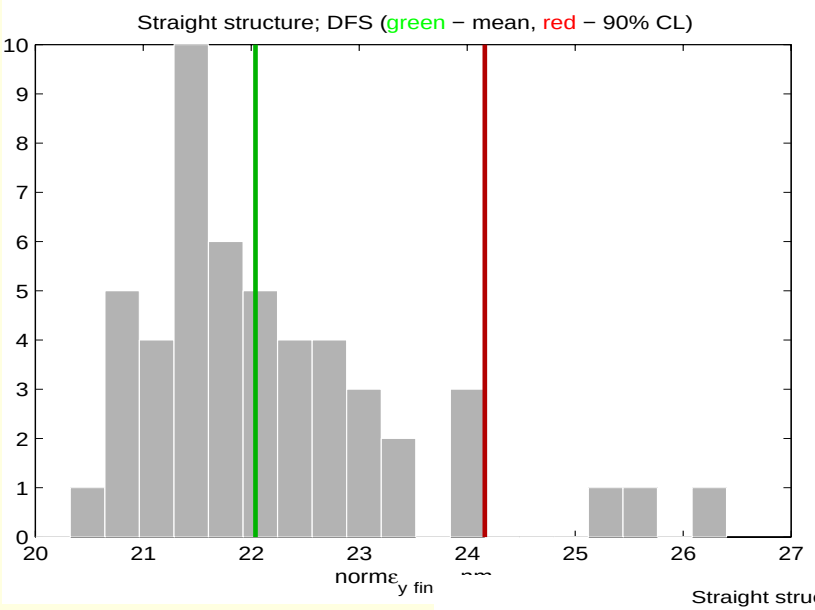


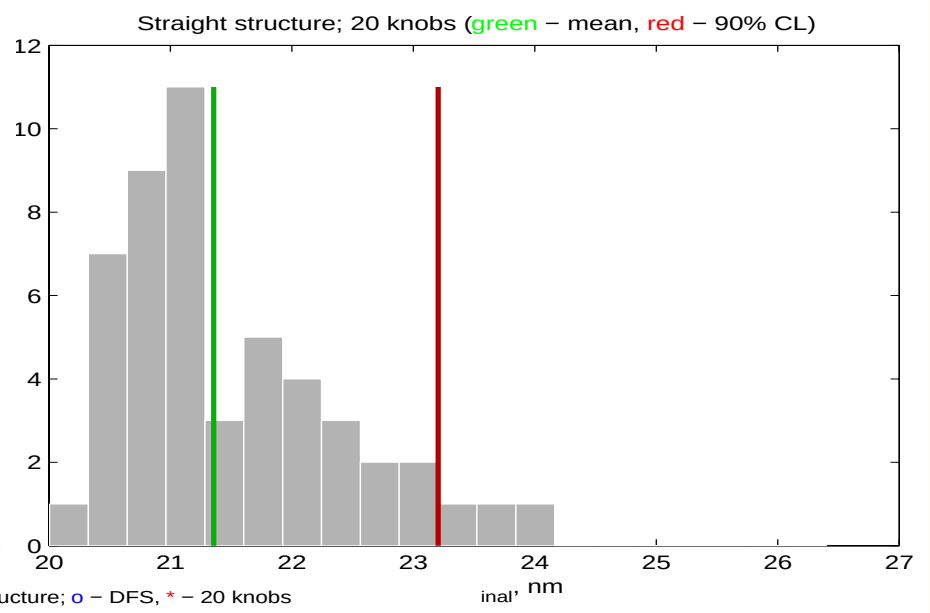


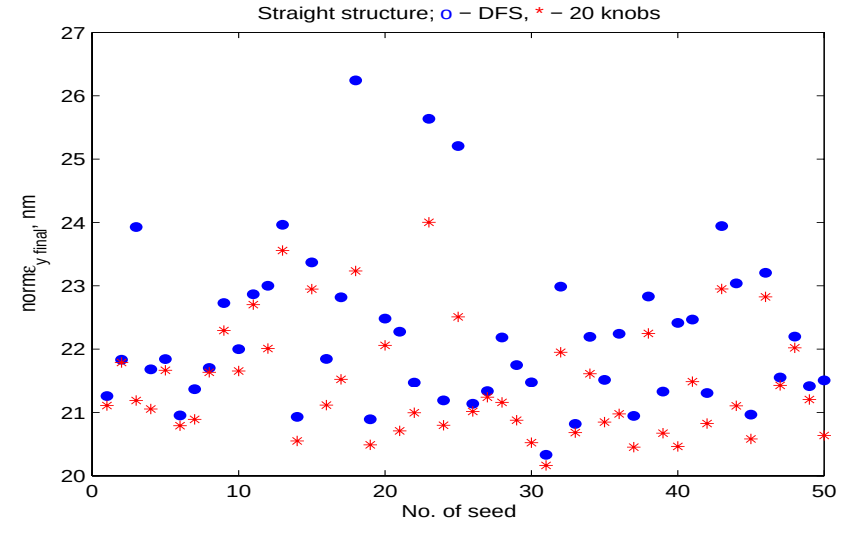
With wakefields turned off



With wakefields turned off (2)

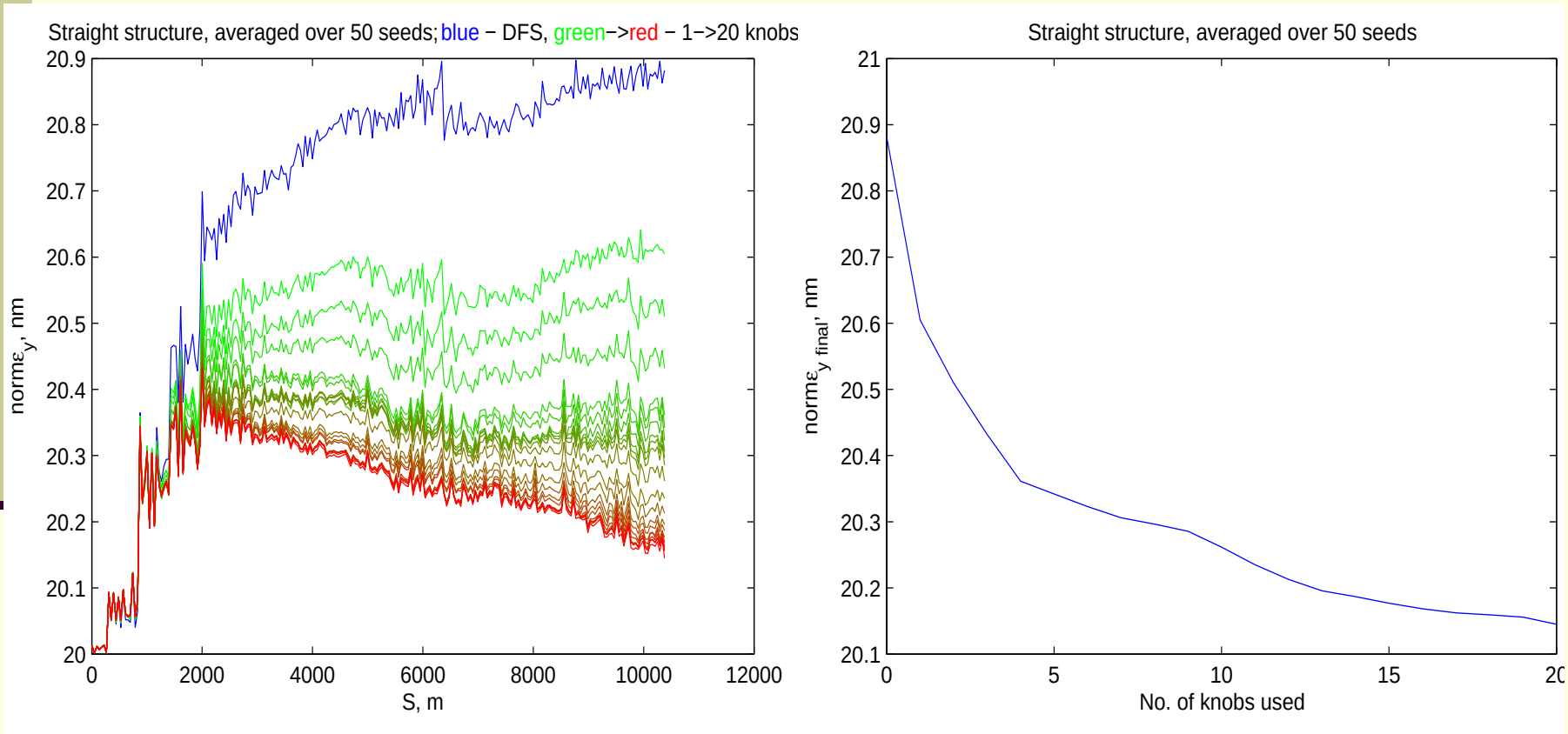






Straight Linac, Regular Lattice Dispersion Only

No Wakes, No coupling (Quad roll)



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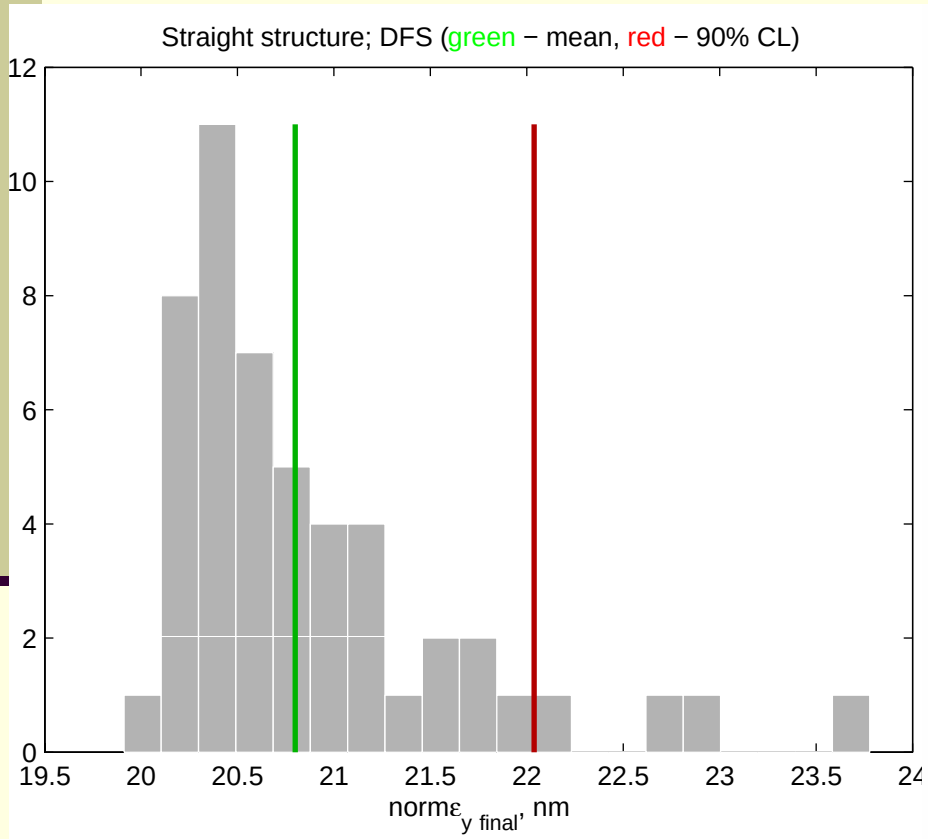

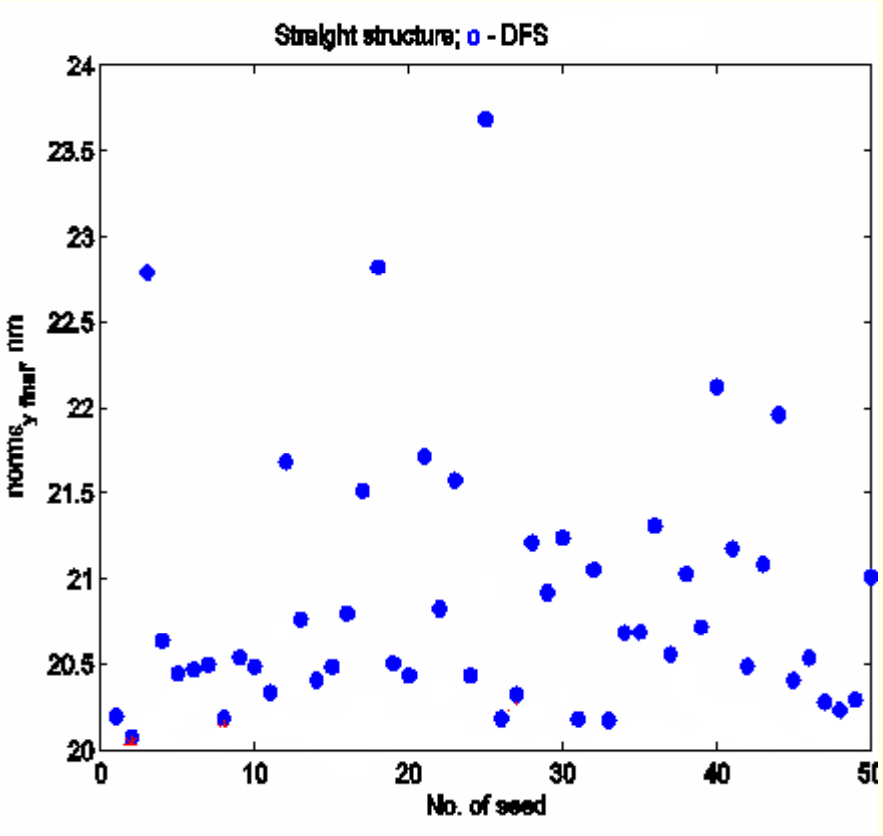

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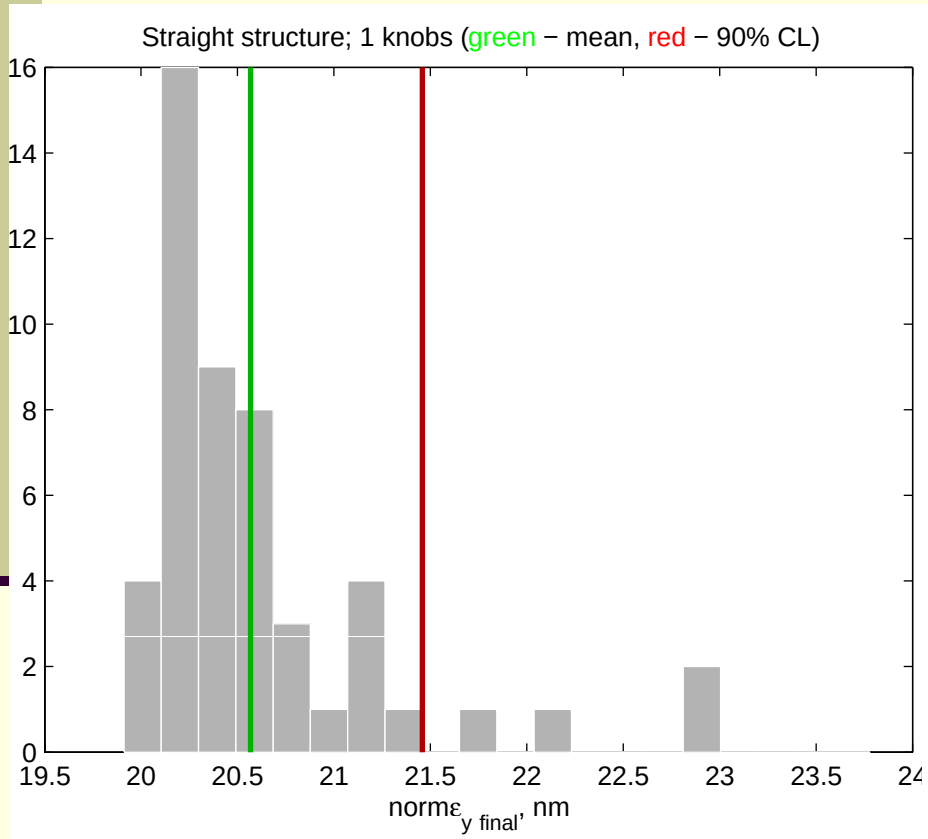

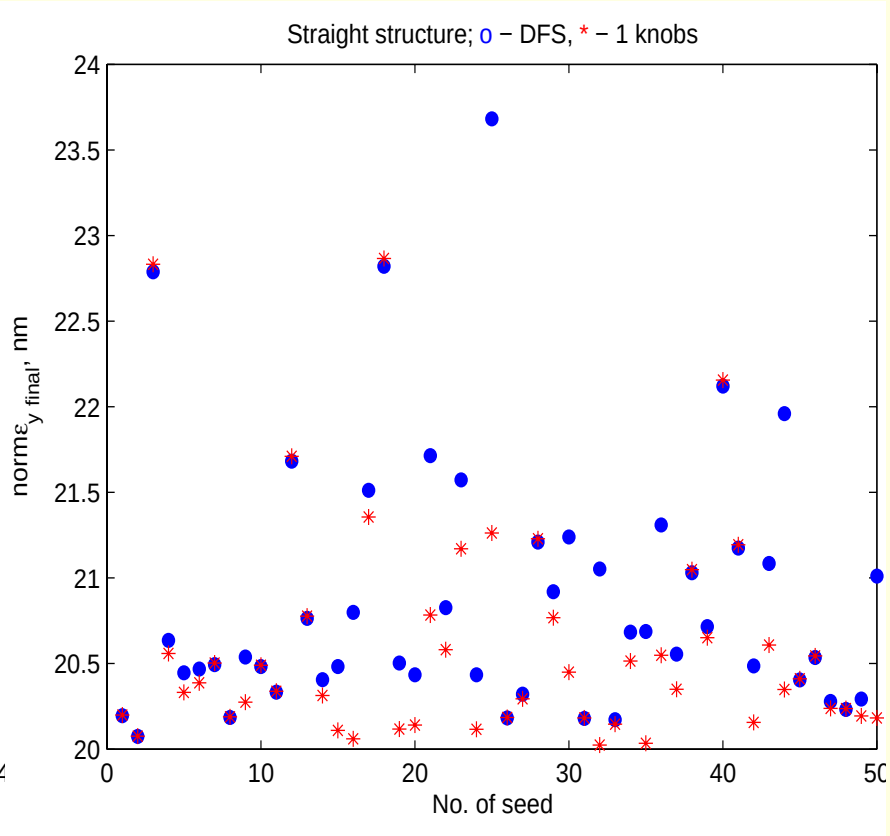

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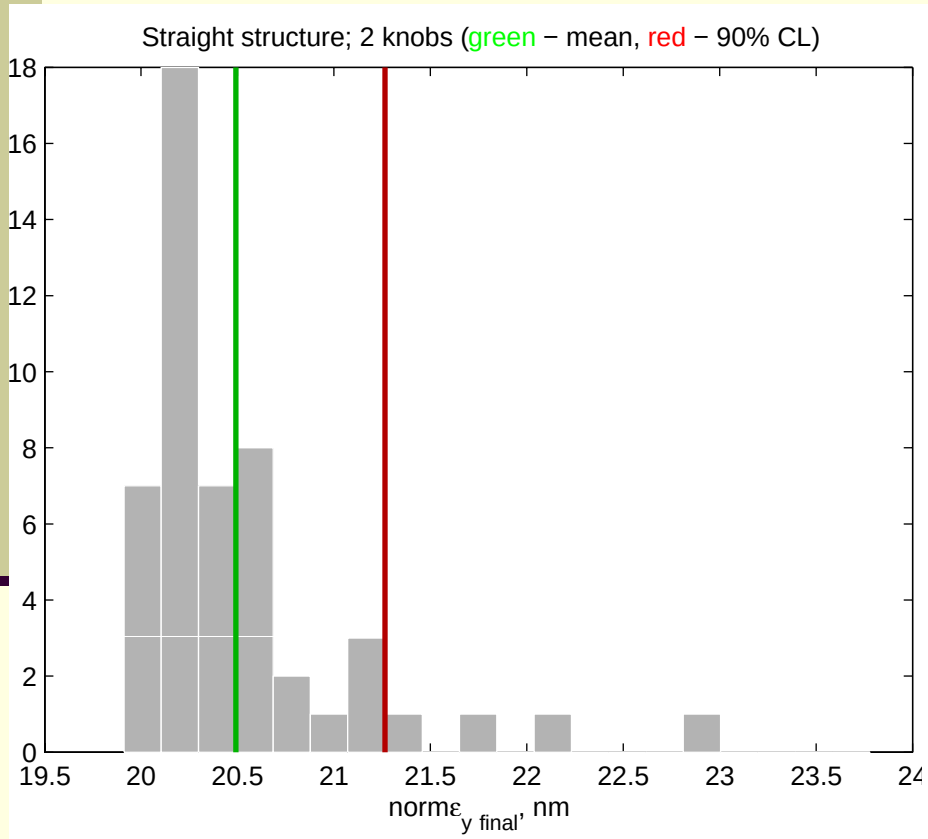

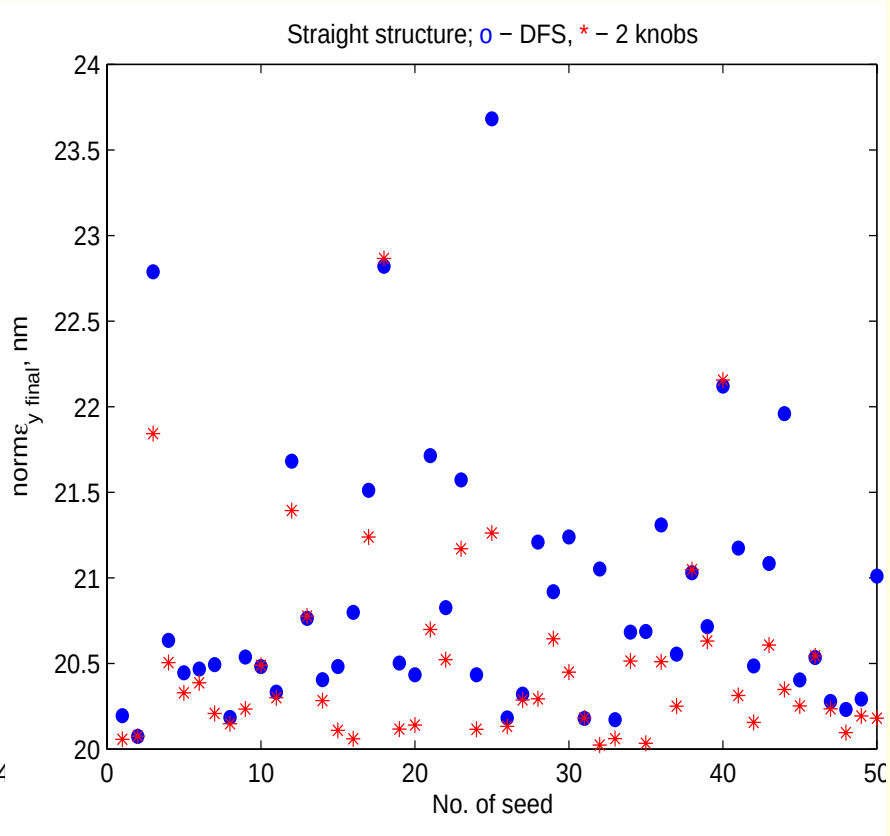

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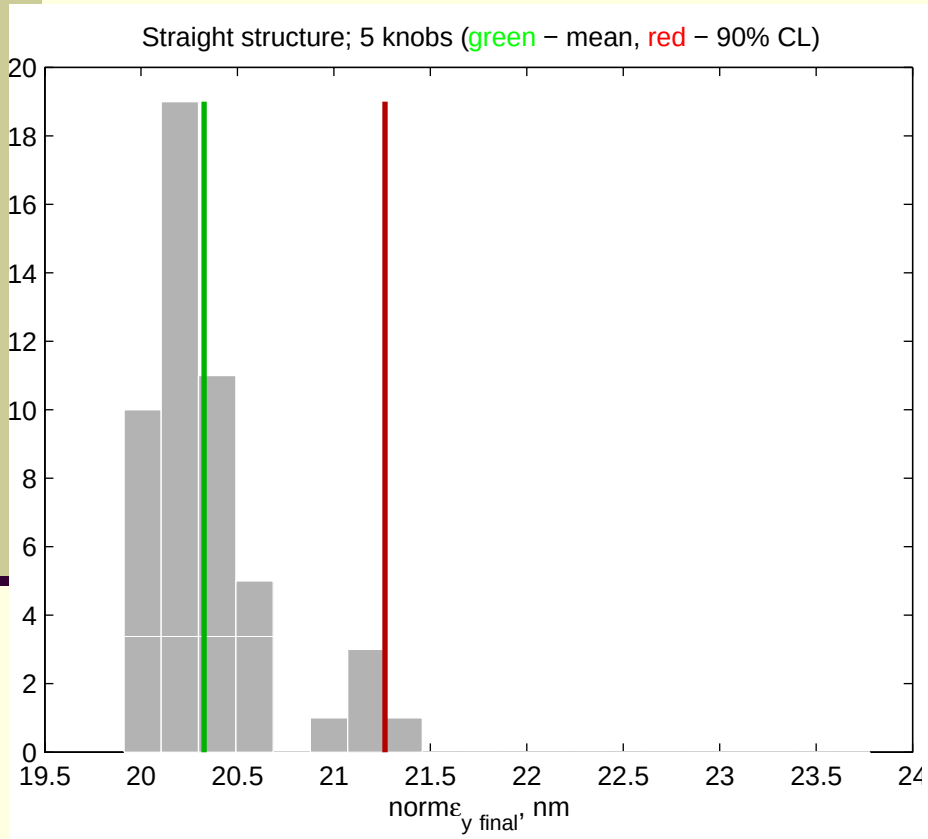

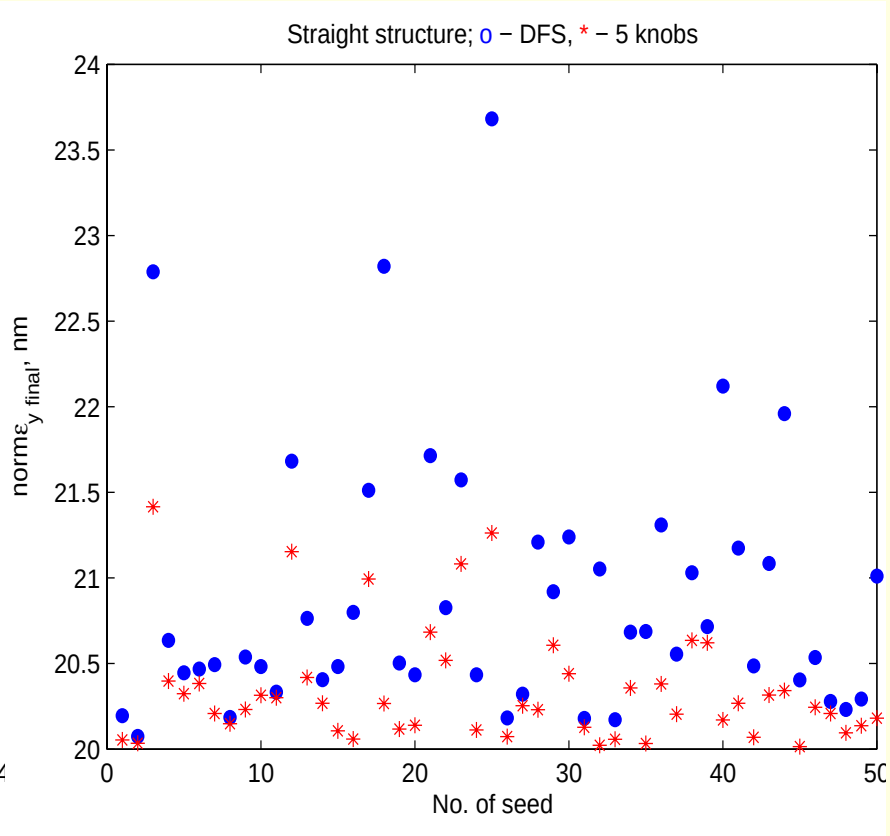

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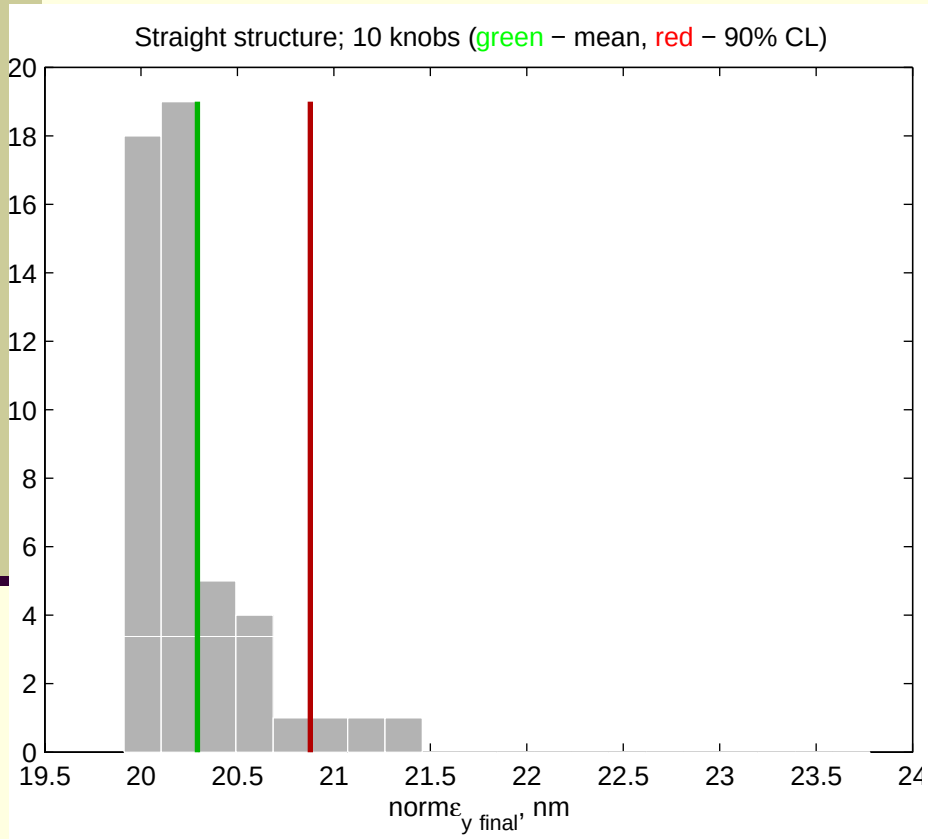

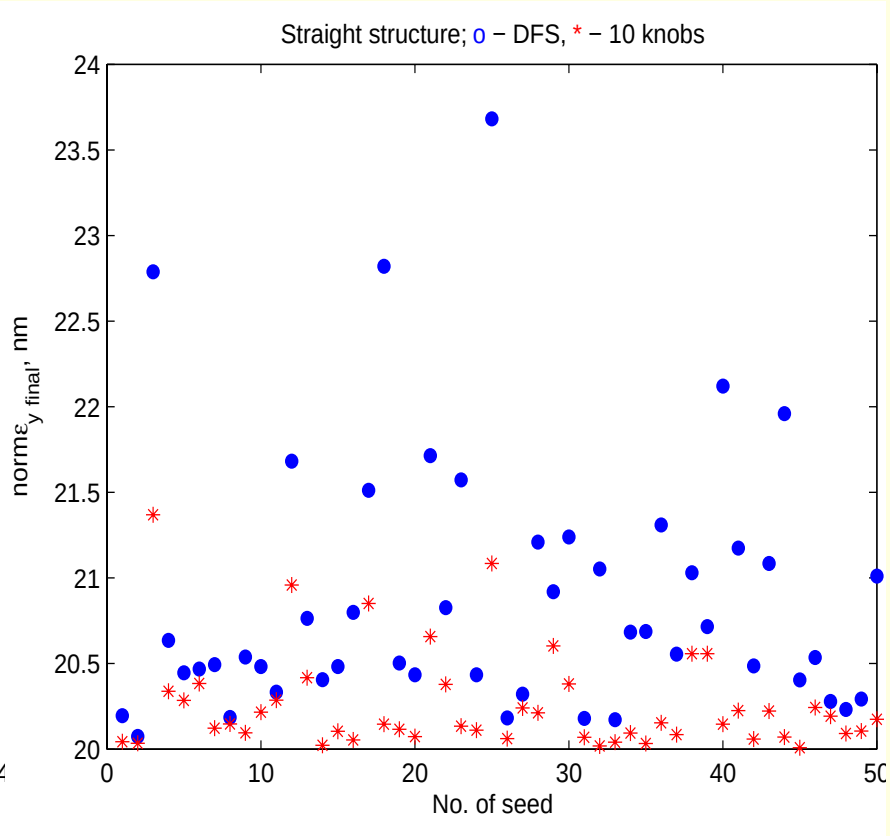

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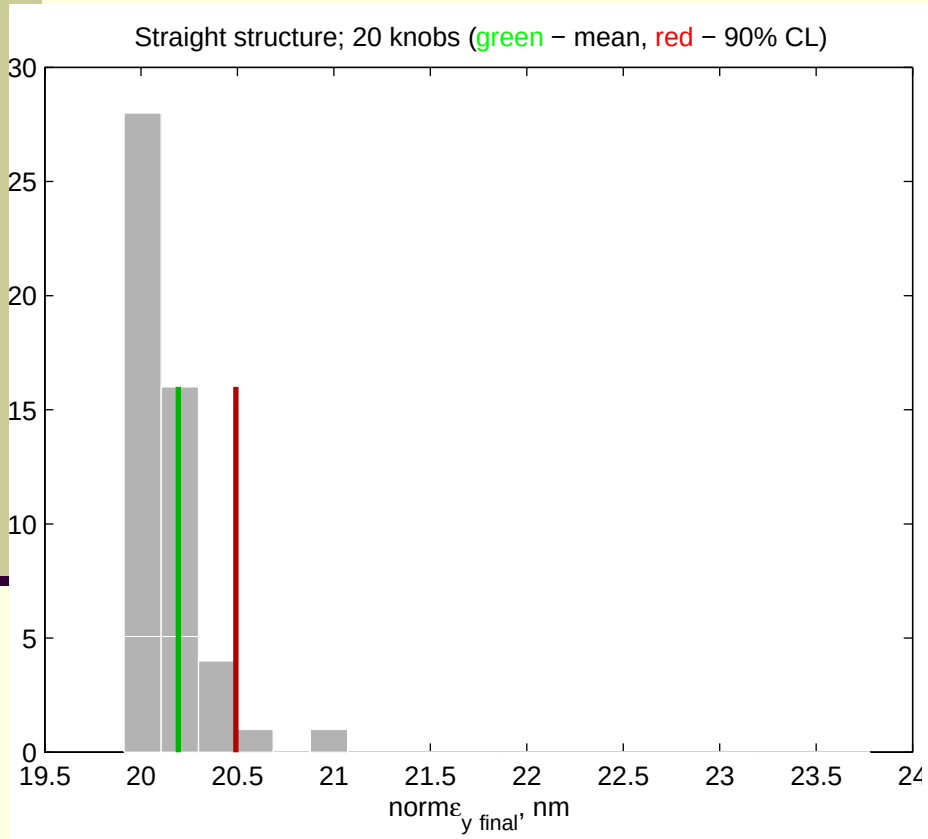

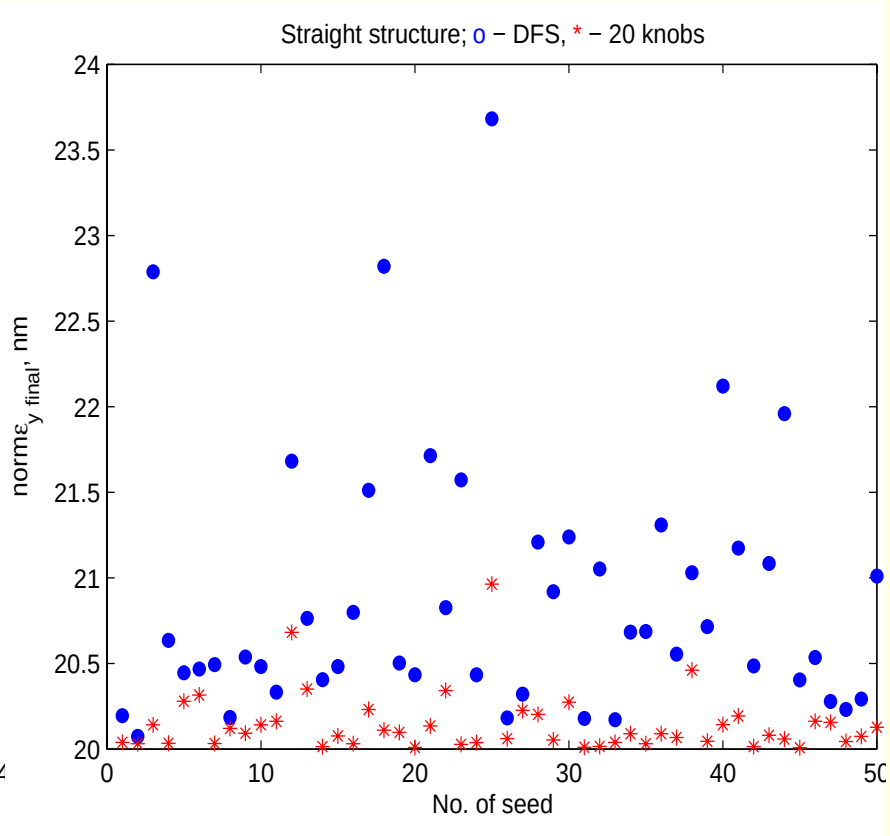

Summary and Plans

- Orthogonal bumps was implemented in Lucretia
- It works good in straight linac. Coupling and wakes cann't be corrected.
- Future work: Perform the same study for irregular curved ILC ML lattice as for straight linac
- The same study in presence of ground motion