DISPERSION MEASUREMENT AND CORRECTION IN THE VUV-FEL (FLASH)

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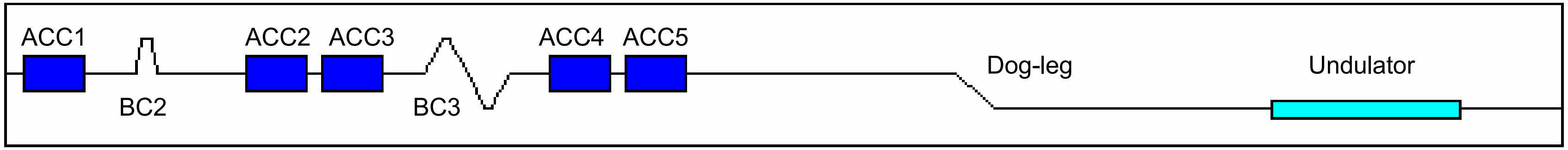
Introduction

$$\eta_x = \frac{\Delta x}{\Delta p / p}$$

$$\sigma = \sqrt{\varepsilon \cdot \beta(s) + \eta(s)^2 \cdot \left(\frac{\Delta p}{p}\right)^2}$$

Goal: dispersion in the undulator of **1 cm**

VUV-FEL (FLASH)



Generation mechanisms

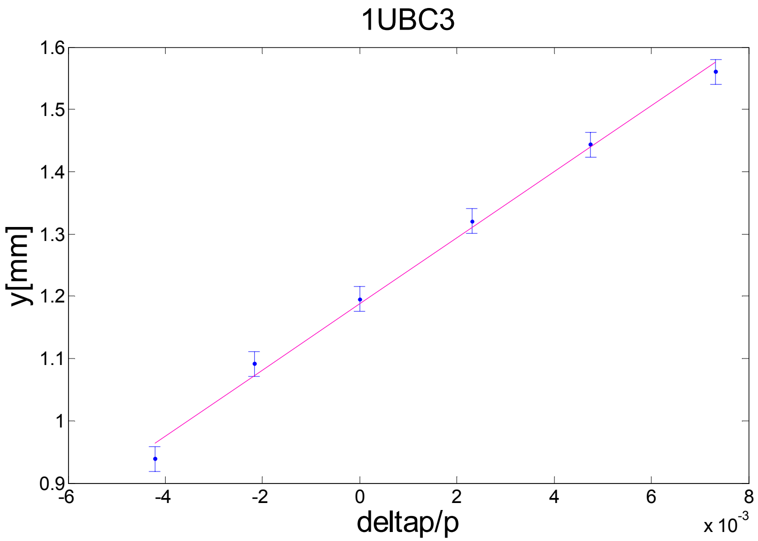
Source	Error (in all the lattice)	Error (only in the dog-leg)	Dispersion (after the dog-leg)
Quad malign	17 um	50 um	~ 1cm
Dipole field error	0.25 %	5 %	
Quad field error	0.75 %	0.75 %	

- Quad misalignment seems to be the most important dispersion source
- Dog-leg is a critical zone for dispersion generation

Dispersion Measurement Procedure

- Measure the orbit for different energies
  1. Change RF gradient of the module
  2. Apply orbit correction to restore launch conditions after the module
  3. Read BPM positions downstream last correction BPM

- Derive the dispersion

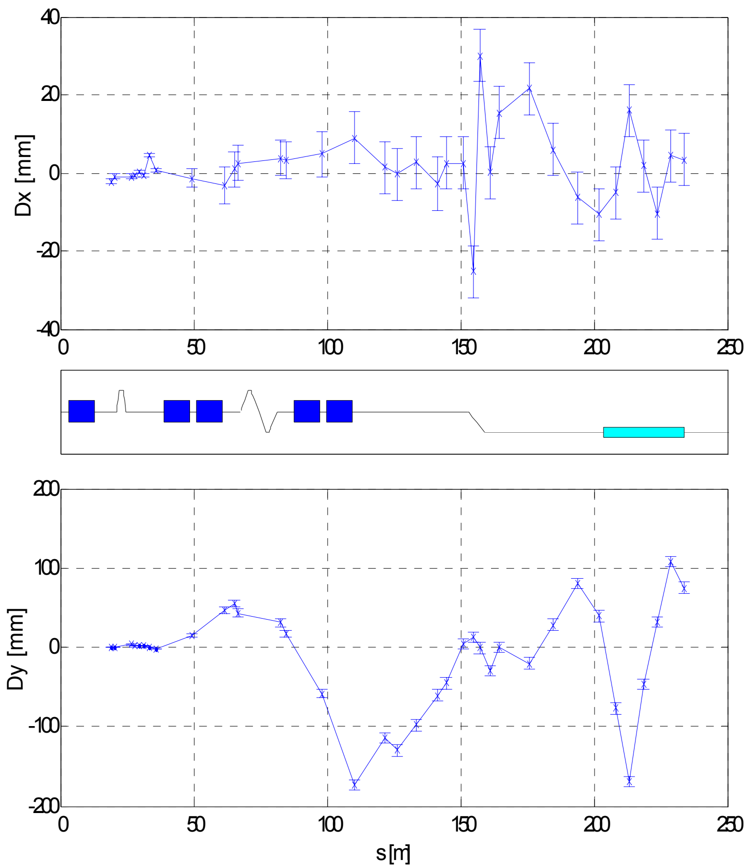


$$x = x_0 + D_0 \frac{\Delta p}{p} + D_1 \left(\frac{\Delta p}{p} \right)^2 + \ldots$$

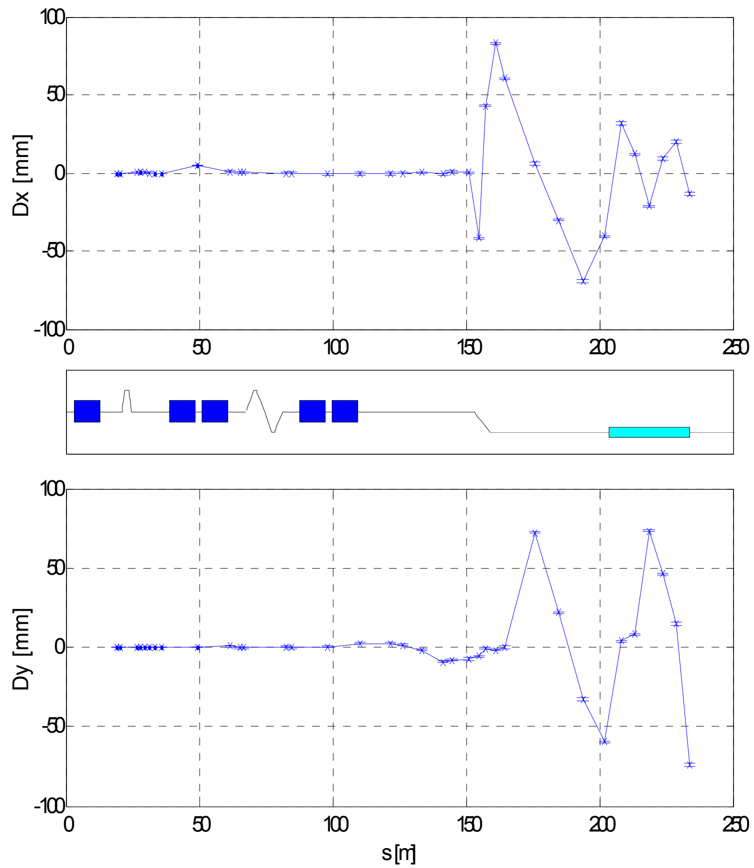
Dispersion

Dispersion Measurements (Nov. 05)

From DBC2



From ACC4-5



Dispersion Correction Algorithm

It corrects both orbit and dispersion, using the orbit and dispersion response matrices

- Orbit response term $O_{i,j} = \frac{\Delta x_i}{\Delta \theta_j}$
- Dispersion response term $D_{i,j} = \frac{\Delta D_i}{\Delta \theta_j}$

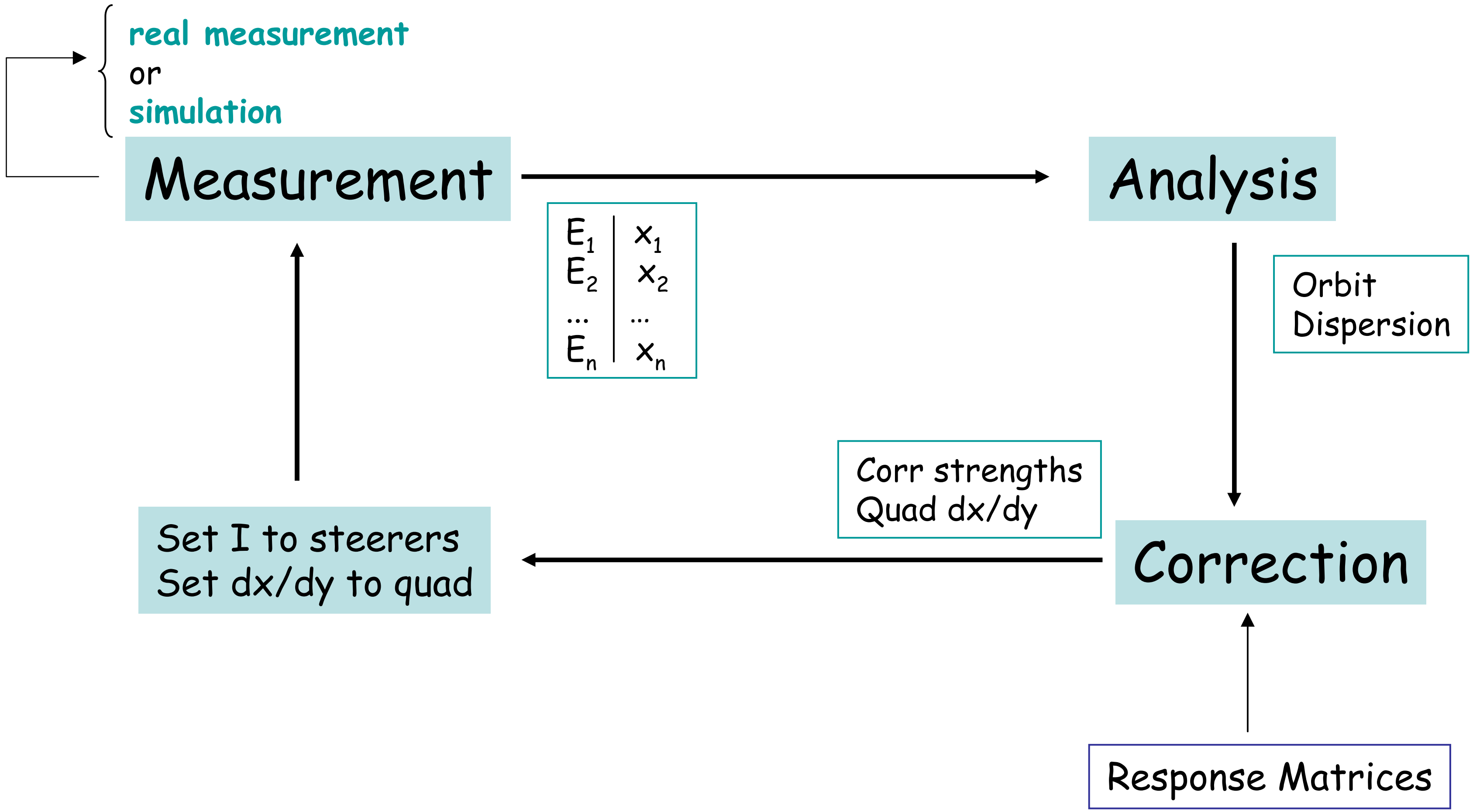
Δx_i / ΔD_i ----------> change of the orbit / dispersion at the BPM *i*
$\Delta\theta_j$ -----------> change of the kick angle of the steerer *j*

$$\begin{pmatrix} \underline{\underline{O}} \cdot (1-w) \\ \underline{\underline{D}} \cdot w \end{pmatrix} \cdot \underline{\Delta\theta} = \begin{pmatrix} \underline{x} \cdot (1-w) \\ \underline{d} \cdot w \end{pmatrix}$$

Response matrices ($\underline{\underline{O}}$, $\underline{\underline{D}}$); Corrector strengths ($\underline{\Delta\theta}$); Orbit ($\underline{x}$); Dispersion ($\underline{d}$); Weighting factor ($w$)

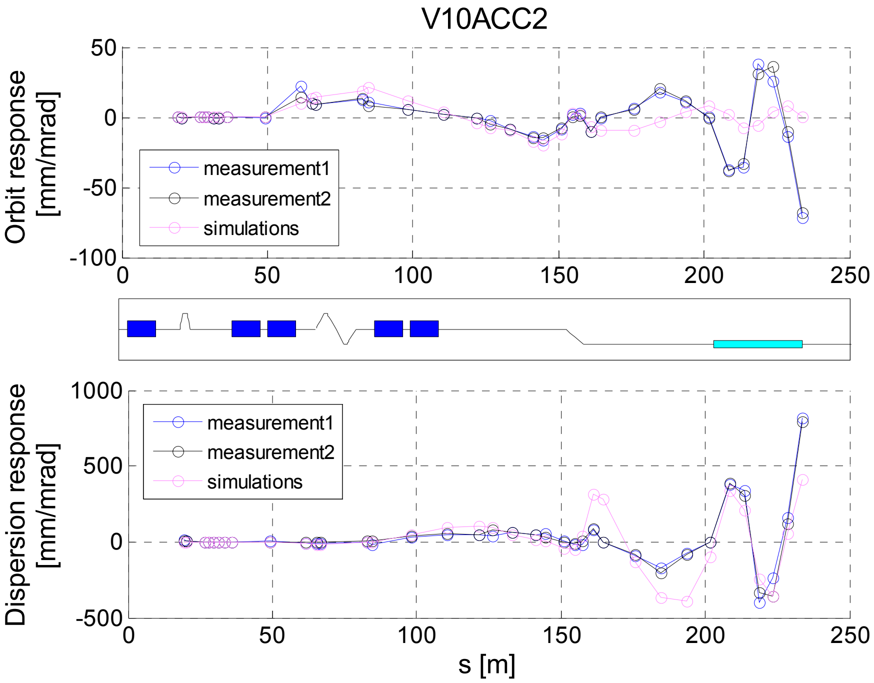
$$\sum \left[\begin{pmatrix} \underline{x}_{meas} \\ \underline{d}_{meas} \end{pmatrix} - \begin{pmatrix} \underline{x} \\ \underline{d} \end{pmatrix} \right]^2 = \min \Rightarrow \underline{\Delta\theta}$$

Dispersion Correction Procedure



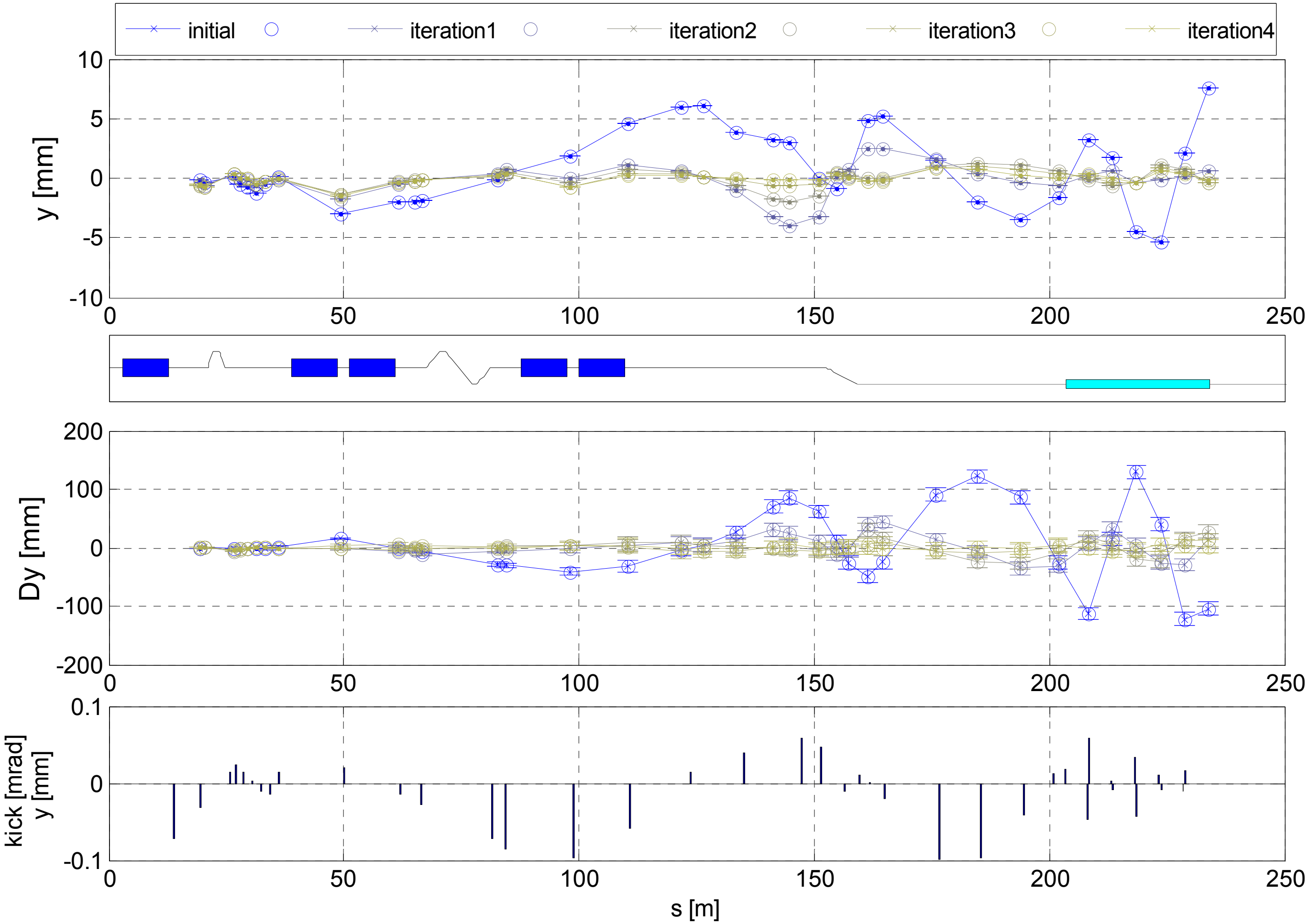
Response matrix measurements (April 06)

- For dispersion correction, optics of the machine have to be close to the design optics or one has to use the measured response matrices
- Comparing the measured and simulated orbit and dispersion response will let to fix possible optic errors
- We have measured the complete response for the machine and the data is presently being analyzed

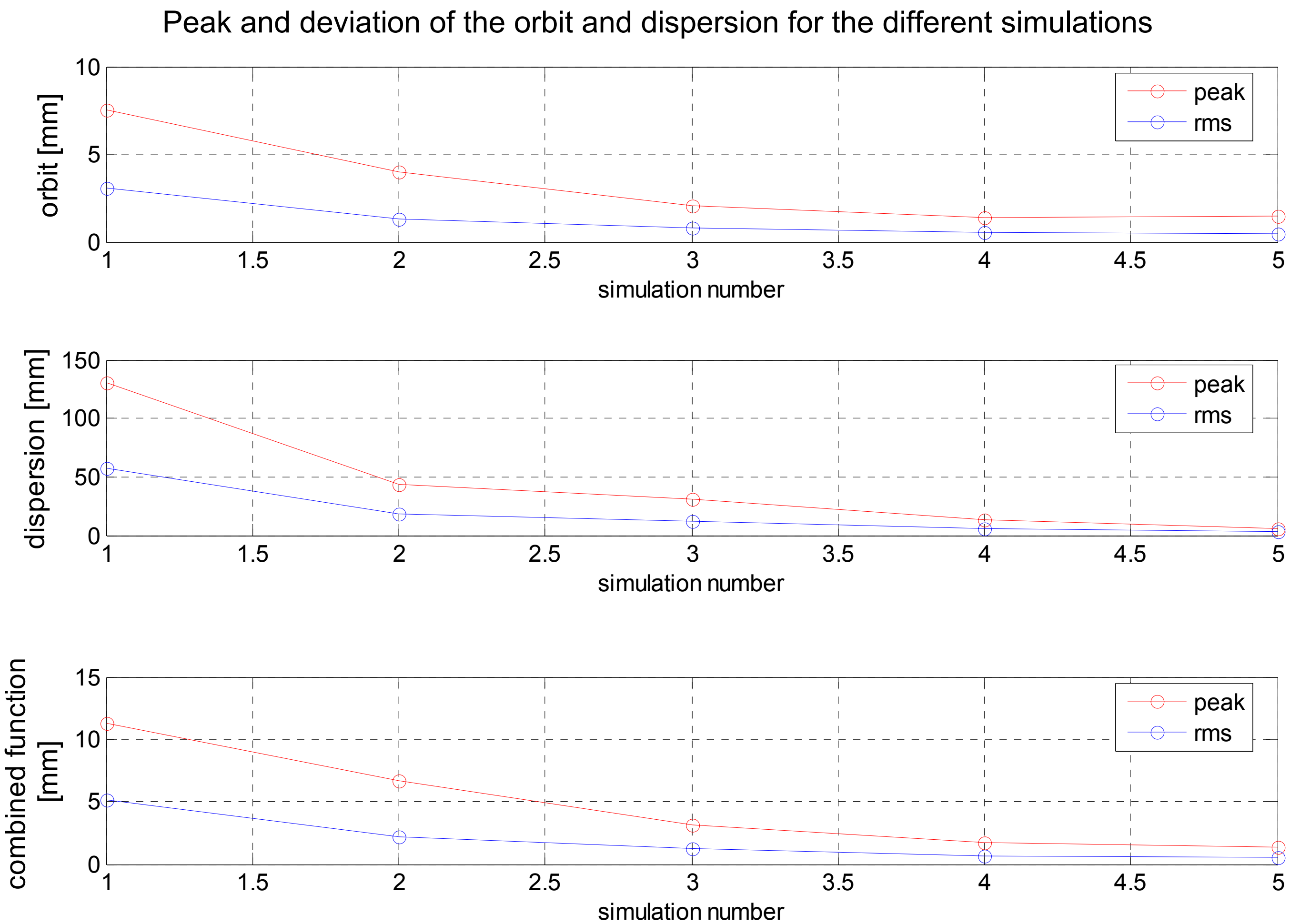


Dispersion correction simulations

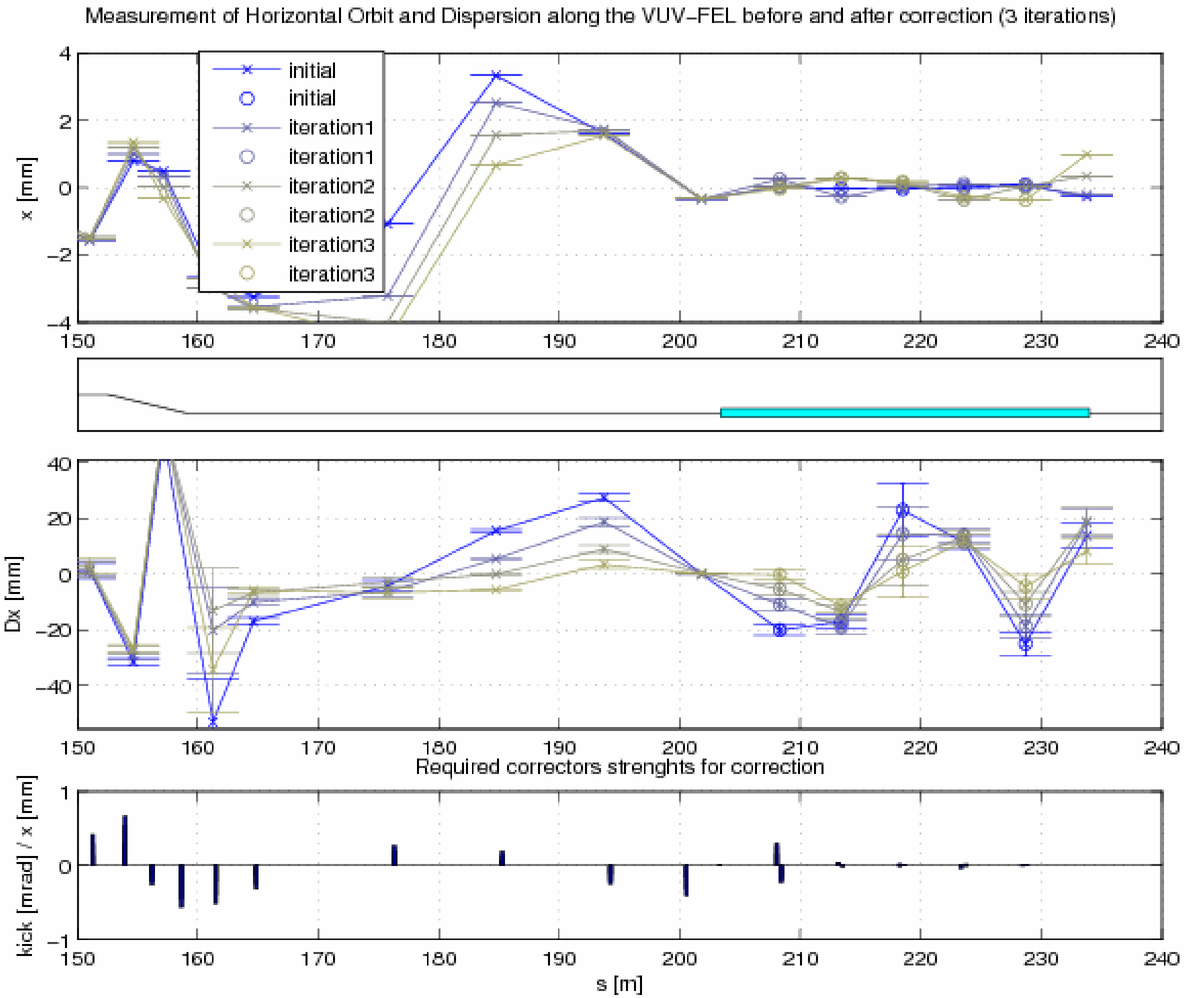
vertical plane, w = 0.1; quad malign = 200um, dipole field error = 1%;
quad field error = 1%; bpm noise = 20um; bpm off-set = 100um; all bpm's ; all steerers



Dispersion correction simulations



1st Dispersion correction measurements (April 06)



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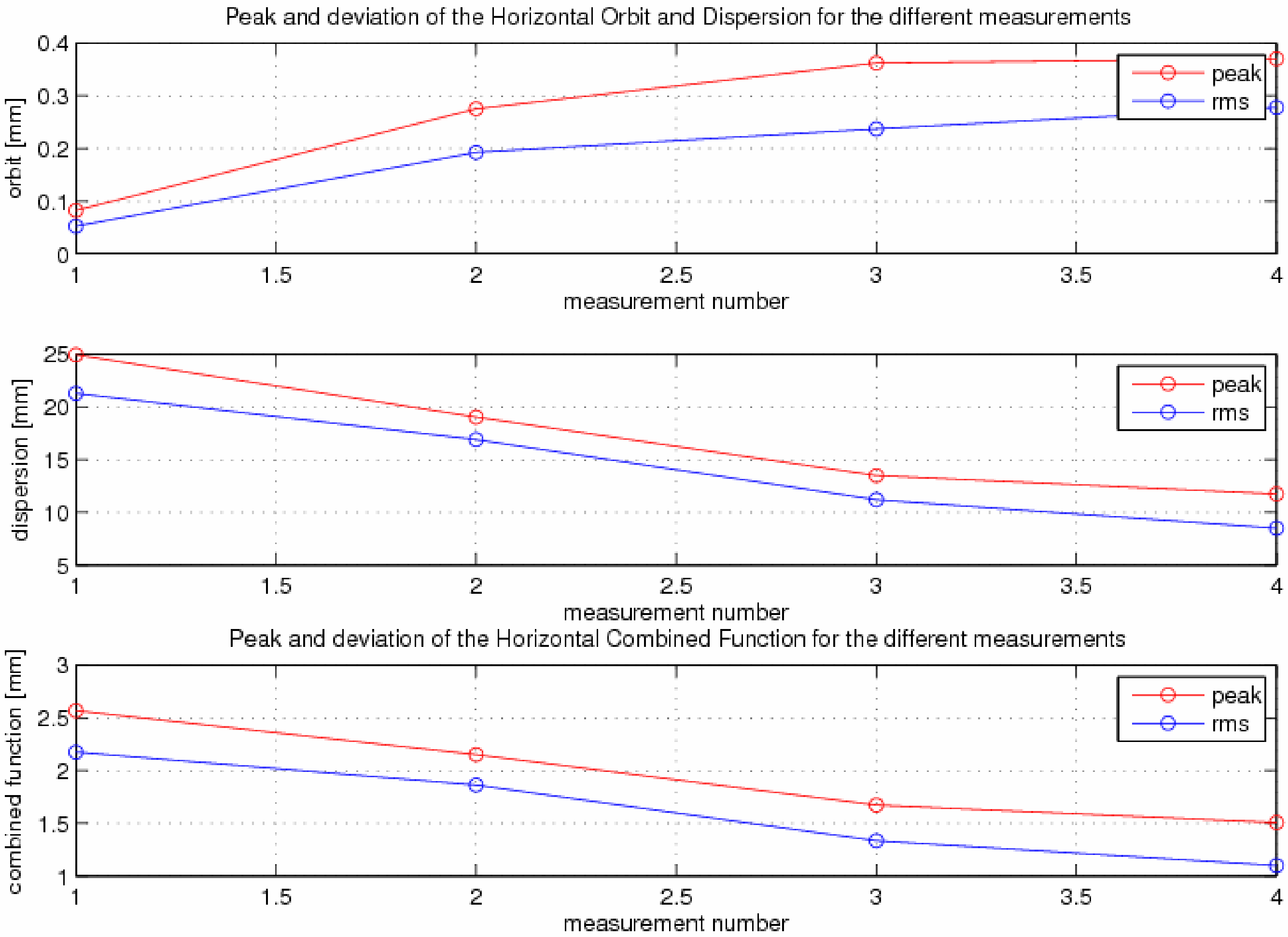
1st Dispersion correction measurements (April 06)



Summary and next steps

Summary:

- A tool for measuring and correcting orbit and dispersion has been developed
- Several dispersion measurements done on November 05
- Complete response matrix measurement has been done
- Simulations of dispersion correction have been performed
- Dispersion correction in the undulator in the horizontal plane done

Next steps:

- Analyze data from orbit and dispersion response measurements
- Make dispersion correction program more user friendly
- Correct dispersion in vertical plane