Effects of the ALBA slab movement on ALBA-II

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Overview

<u>Our goal is to foresee the requirements on orbit correctors and girders to mitigate the effect of ground motion</u>

Can we simulate the ground movement of ALBA ? : YES

- We use alignment data from ALBA to see the 6-months and 1-year displacement
- We compare with the orbit correction evolution

What is the effect of the movement on the 5BA ALBA II lattice ? :

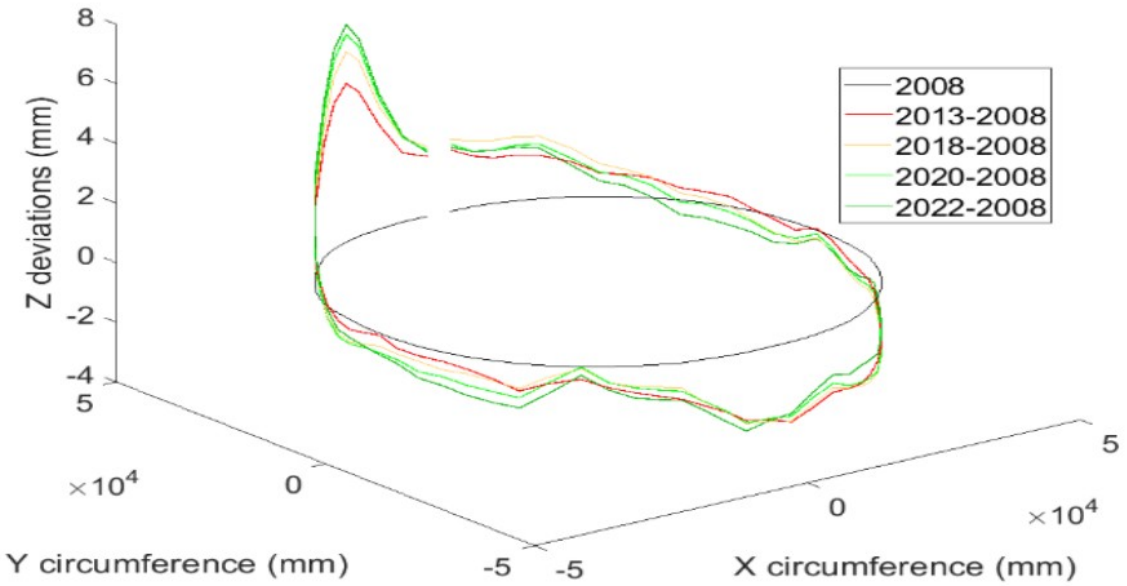
Low impact on the orbit corrector budget.

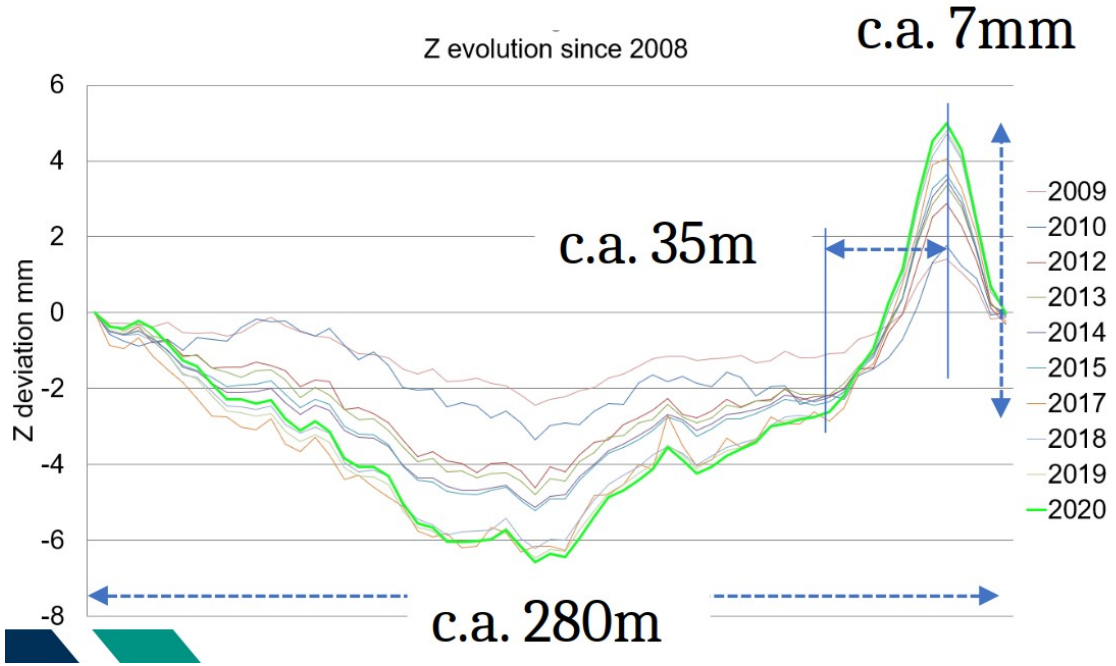
Individual girder motion could help to correct large local displacements.

Extra 1 mm DA needed to tolerate the foreseen effect of ground motion.

- We introduced a model of the ground movement and corrected its effects
- We checked different scenarios where the girder movement could be of use

ALBA ground movement





*Courtesy of the Alignment Group, and WP04 – Girders
Figures with respect to local gravity

The measured ground movement shows a large displacement of the ring since its installation in 2008.
The 2022 to 2023 evolution seems to be smaller.

Modelling the ground movement

We needed Tools to move data from alignment measurements R^3 (x,y,z) to the coordinates along the ring R^3 (R,V,L), and then to beam coordinates R^6 (x,px,y,py,δ,-ct).

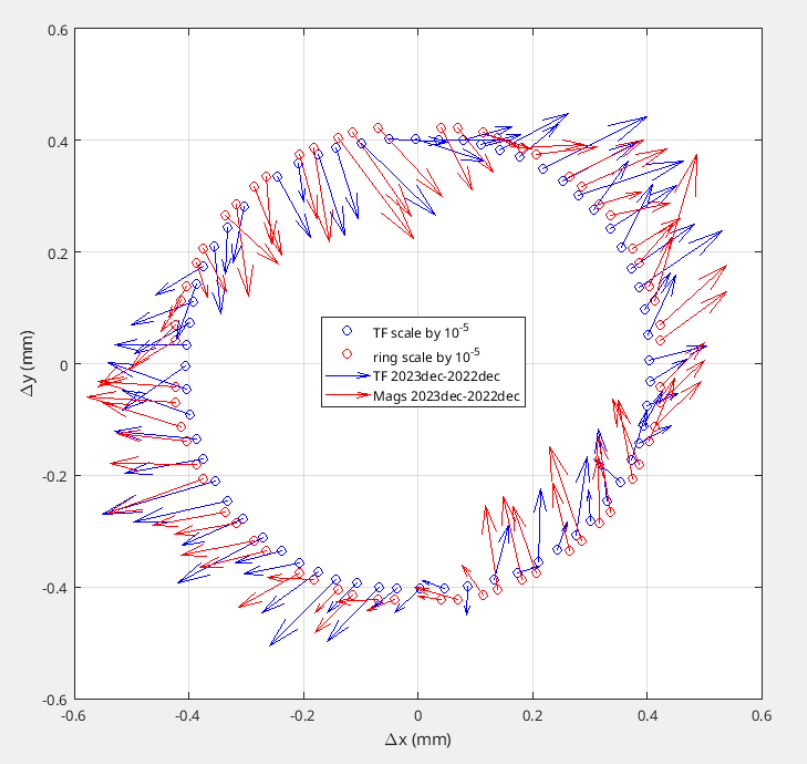
- From R3 to R3 : (x,y,z) → (R,V,L), we (Beam Dynamics and Alignment) agreed in some convention and format.
- From R3 to R6 : (R,V,L) → (x,px,y,py,δ,-ct). We used Simulated Commissioning from Thorsten Hellert.
  https://github.com/ThorstenHellert/SC/blob/master/SCgetTransformation.m

  SCgetTransformation gave very accurate calculations of translations and rotations taking also into account the curvature introduced by bendings, and not so small angles, for example, the 11.25° magnets of ALBA.

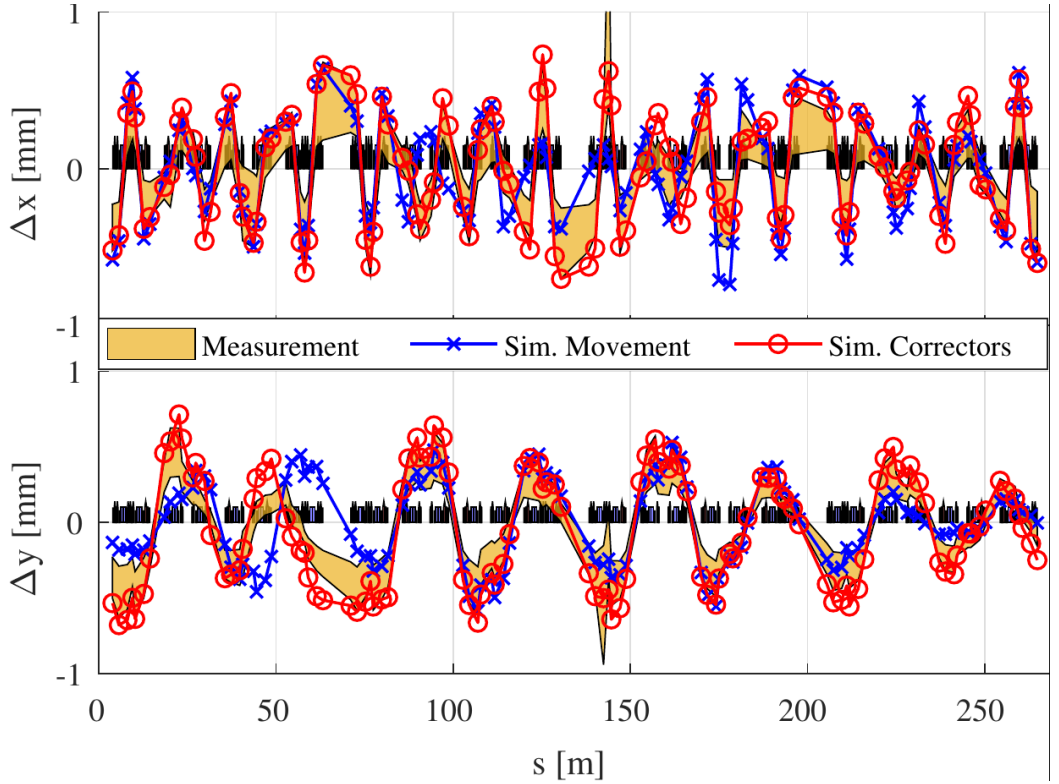
With the offset in R6, we can input the data to simulate the effect in Accelerator Toolbox.

Effect of ground movement on ALBA's orbit correction

Movement of 64 points on the tunnel floor, and on 64 magnets (2 by 32 girders)

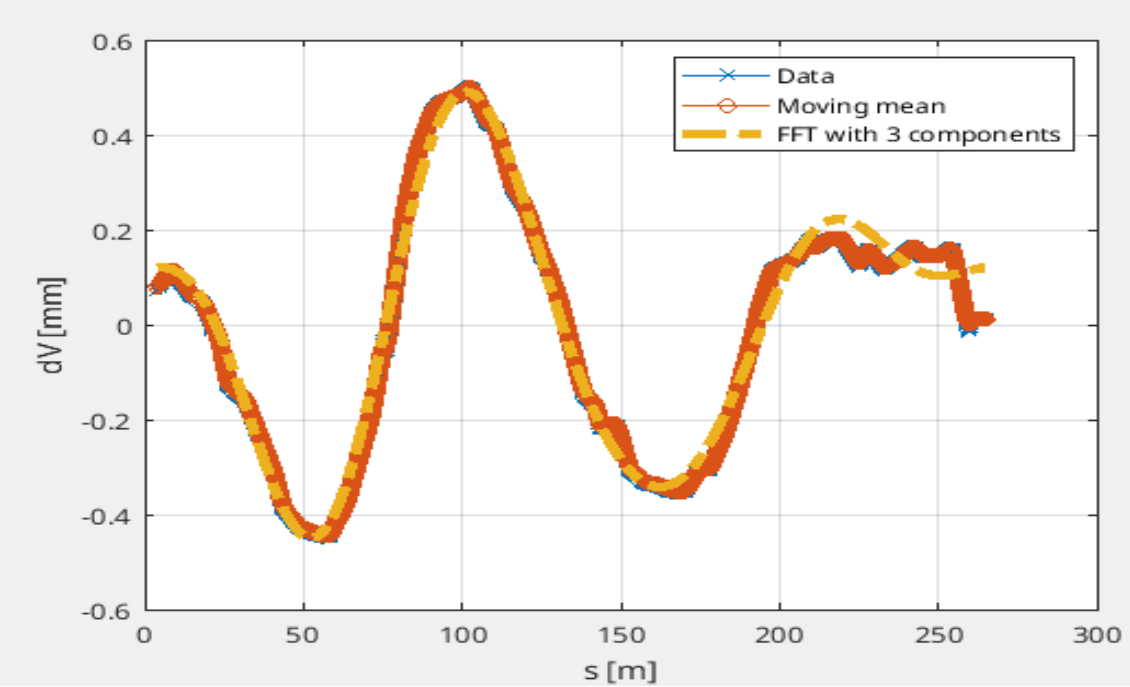


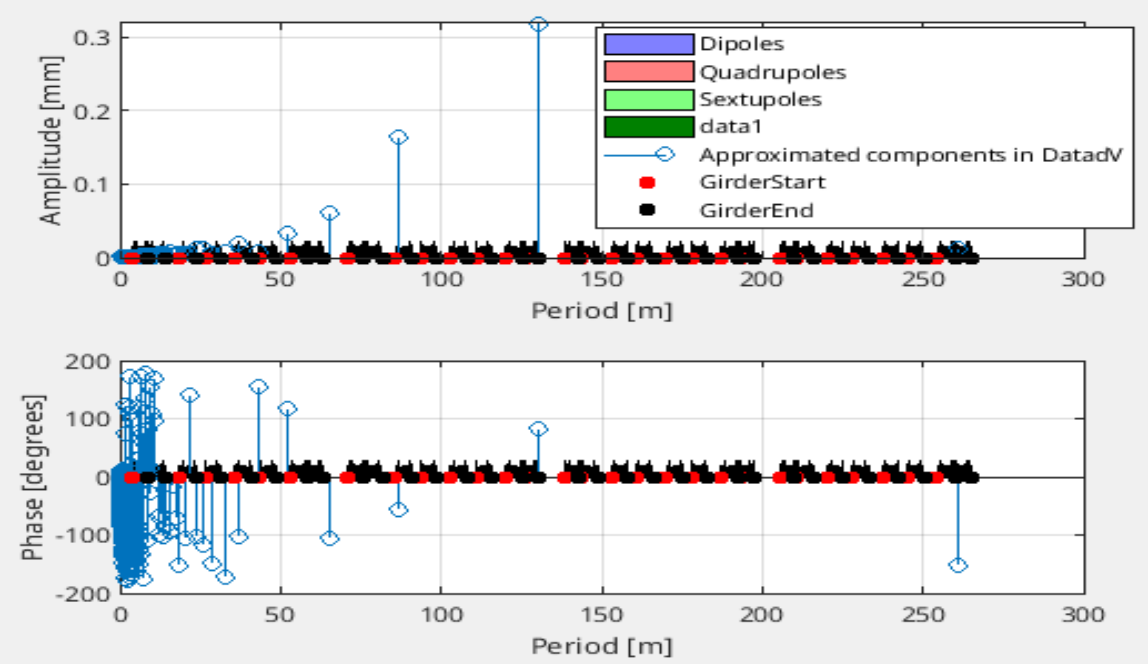
Measured and simulated closed orbit from 2022 to 2023 ground movement



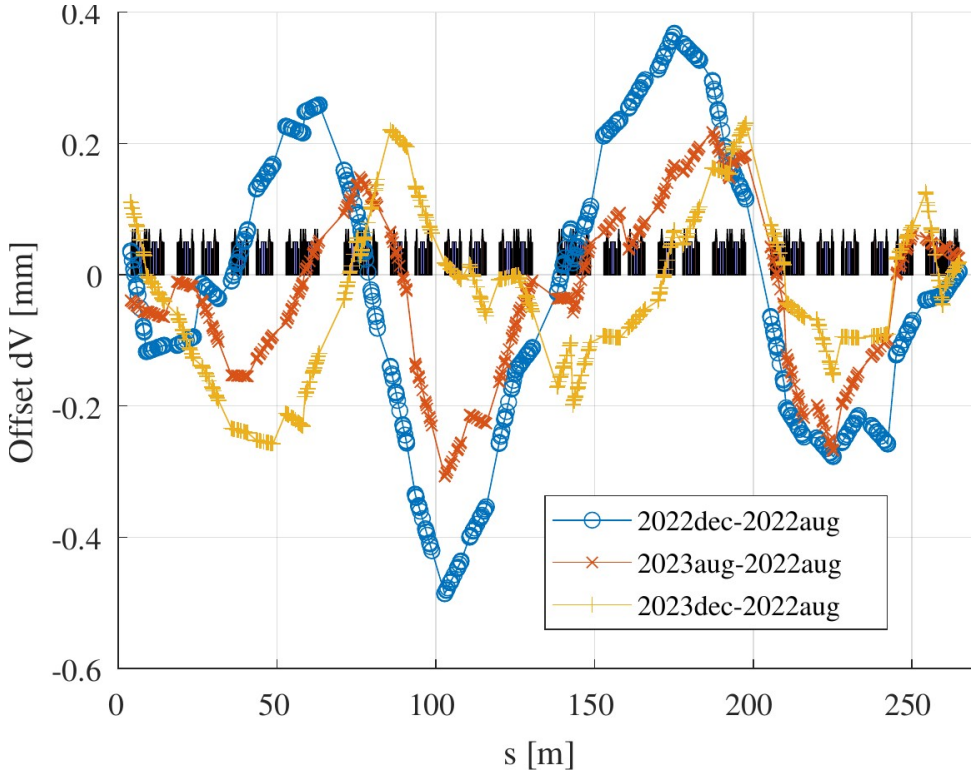
The measured movement between 2022 and 2023 matches the changes on the measured closed orbit, and the orbit corrections applied to the model.

Example of 1-year evolution Frequency decomposition





Model of the ALBA slab movement, 6-months and 1-year



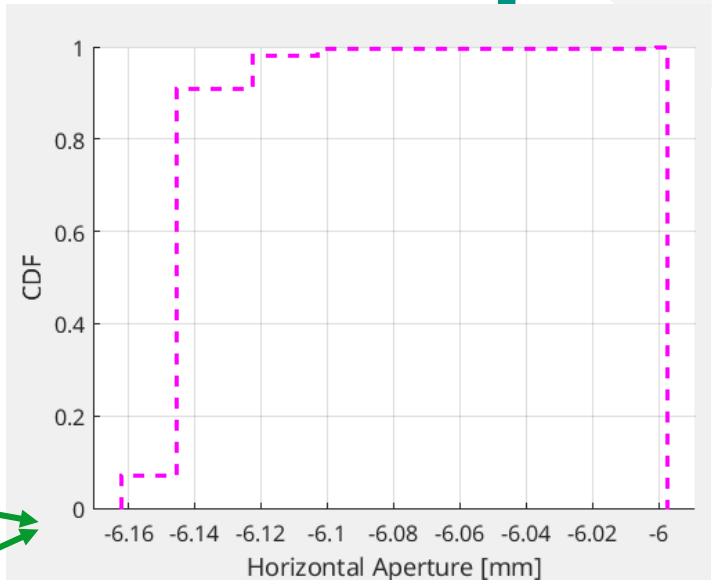
Period	6-months			one-year		
	dL μm	dR μm	dV μm	dL μm	dR μm	dV μm
Mean	-	280	-	-	-*	-
T	-	-	-	-	-	-
$T/2$	-	70	260	70	110	320
$T/3$	-	-	110	-	-	160
$T/4$	-	-	90	-	-	80

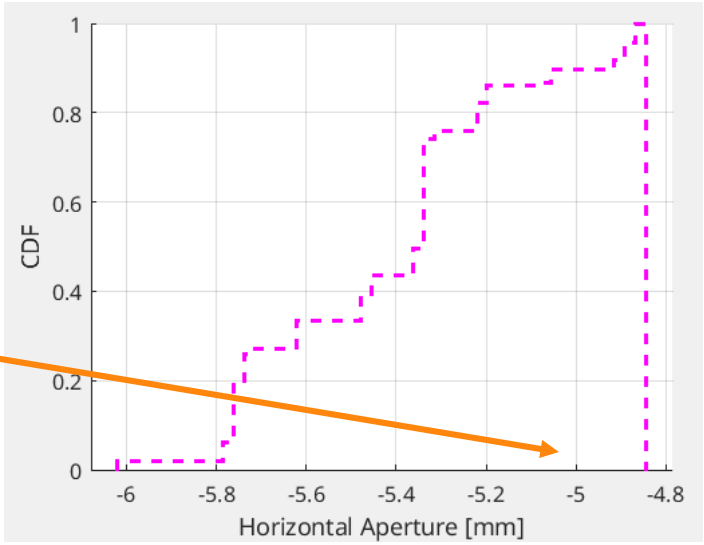
Data measured between 2022 an 2023 on the ALBA tunnel floor has been used to obtain the 6-months and one-year movement. **The movement seems non-cumulative, low-frequency and large amplitude.** Precision is estimated to be 50 μm. Values below 50 μm are ignored.

Effect on ALBA II Dynamic Apert.

- Statistical simulation of 300 rings with different ground movement:
  - **Scenario1 : motion over 6-months, or 1-year of operation**
    - Low spatial frequency, high amplitude
    - **Continuous correction : DA always recovered**
    - **Low corrector budget < 50 µrad**
  - **Scenario 2 : motion of weeks to few months**
    - High spatial frequency, low amplitude,
    - i.e. girder-to-girder movement of 10 µm rms
    - (40 µm peak-to-peak)
    - **Continuous correction : DA always recovered**
    - **Low-Medium Corrector Budget : 50~100 µrad**
    - **Long stop, no correction : DA 1 mm loss**
    - NOTE : -5 mm are needed for off-axis injection
    - Risk to have problems with off-axis injection

Plots : Cumulative Density Function (CDF) of the negative side of the horizontal dynamic aperture (DA)



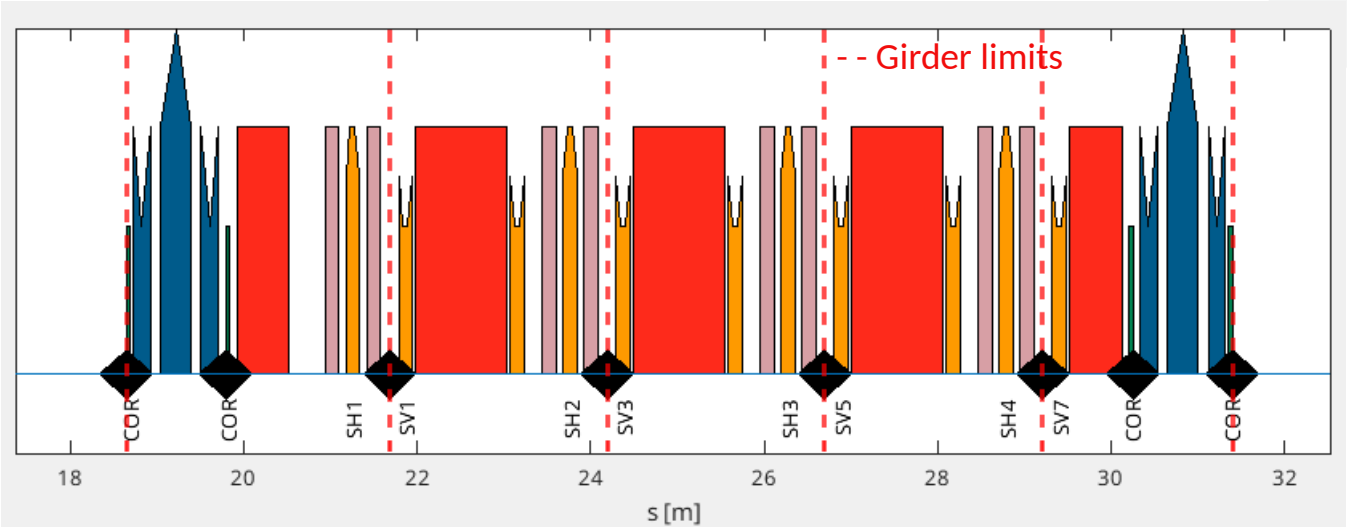


ALBA II correctors and girders

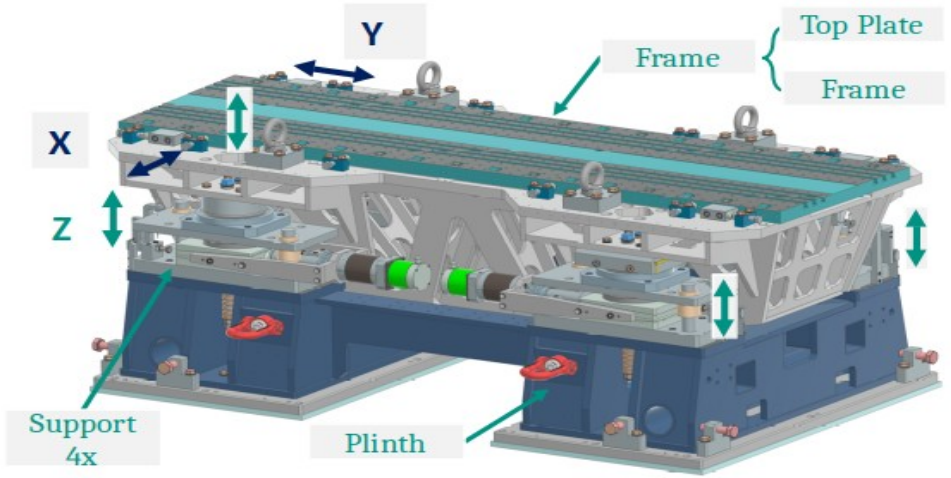
- **BPMs : 128** (8 by 16 arcs)

- Orbit Correctors
  - **128 correctors per plane** (8 by 16 arcs)
  - **500 µrad max**
  - 2 different combinations
    - On horizontal sextupoles,
    - or on vertical sextupoles,
    - plus stand-alone correctors
    - on each side of every triplet

- Girders
  - **80 girders** (5 by 16 arcs)
  - Not exactly as the prototype

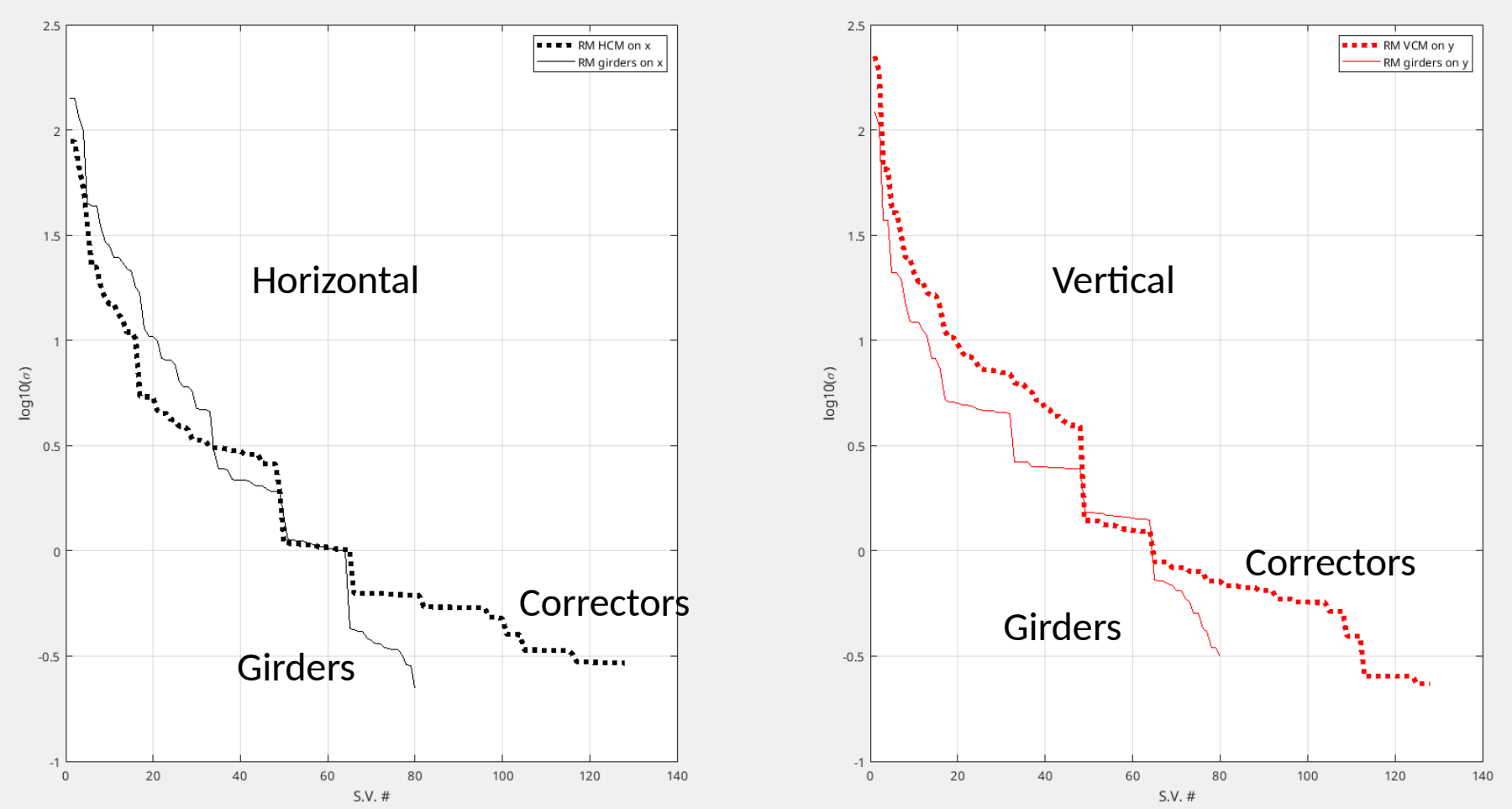


* Girder prototype model and specifications, courtesy of J. Boyer

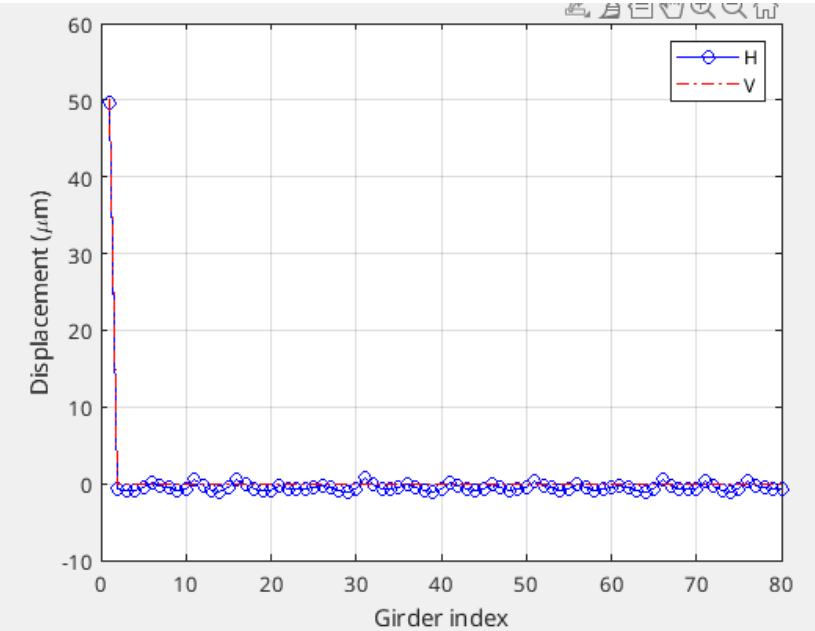


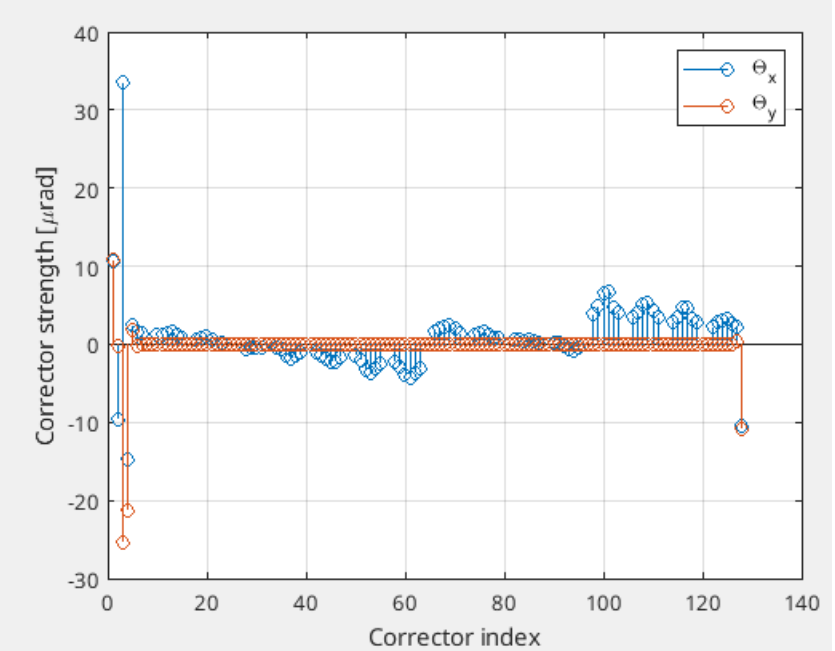
2 DOF	Drive	Resolution	Range
Z	Motorized	2 µm	±1 mm
X_R (Pitch)	Motorized	15 µrad	700 µrad
X	Manual	20 µm	± 5 mm
Y	Manual	20 µm	± 5 mm

SVD of girder-to-BPM and corrector-to-BPM response matrix



Orbit corrections with girders vs orbit correction with correctors (1 of 2)





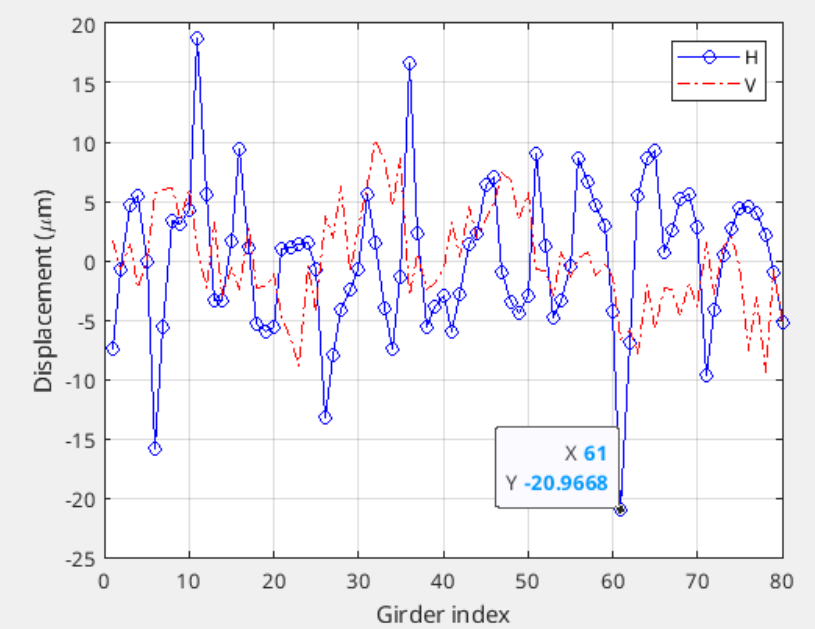
We would like to model a sudden local change in position due to installation, or weight distribution

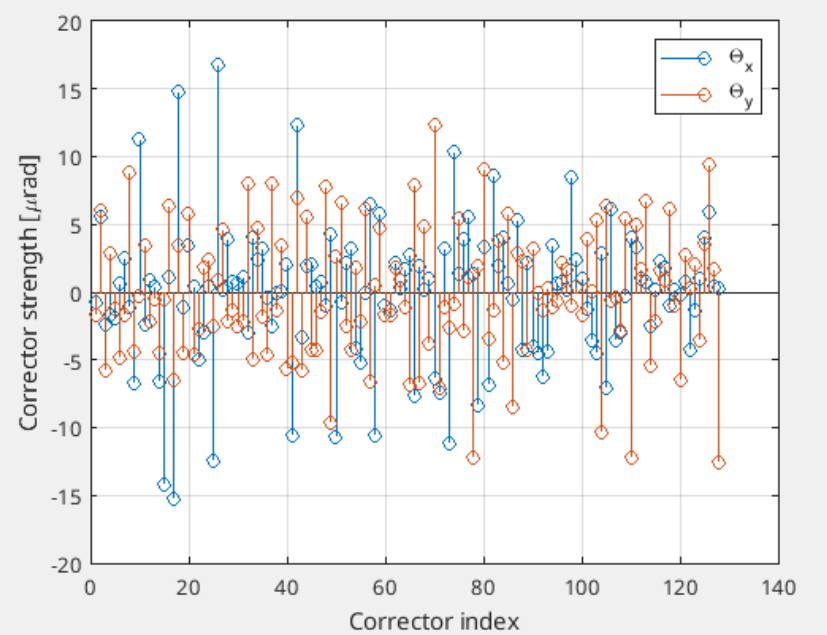
We introduce a local displacement of 50 μm on a girder

The suggested girder correction is effective.

Correctors could also be used taking into account some additional budget

Orbit corrections with girders vs orbit correction with correctors (2 of 2)





We introduce 10 μm rms displacement on girders, and correct using the SVD decomposition of the girder-to-BPM response matrix (RM), and separatedly the inverse of the corrector-to-BPM RM.

The suggested girder correction does correct the orbit but does not match the initial displacements.

Correctors can compensate easily the displacement with low budget

Conclusions

- The current ALBA storage ring has been used to validate the ALBA model behavior subject to ground motion.

- ALBA II ground movement studies have been based on 6-months and 1-year cycles from 2022 and 2023 alignment data.

- The ground movement seems non-cumulative in the most recent years, large amplitude and low spatial frequency.

- The lattice could be corrected in case of :
  - 6-months or 1-year of continuous motion modelled as low spatial frequency and high amplitude
    - Corrector budget < 50 µrad would be continuously used.
  - Weeks or months of continuous motion modelled as :
    - Girder to girder variations of 10 µrad rms, or girder-to-girder jumps of 50 um
    - Each case contributes to < 50 µrad of corrector budget

- The girder movers could help to reduce the corrector budget by removing the girder-to-girder jumps

- In case of non-continuous correction we expect at most 1 mm loss in horizontal D.A.
- This is the case of a long stop, and could reduce efficiency or stop off-axis injection

- Ways to mitigate this issue could be:
  - Increase the D.A. from design so that we can tolerate 1 mm hor. DA. loss
  - Study the DDK in dipolar mode to be used as a kicker during injection

Thanks!

ALBA II

BL02-CoDI

BL04-CORUS

JEMCA

Joint Electron Microscope Center

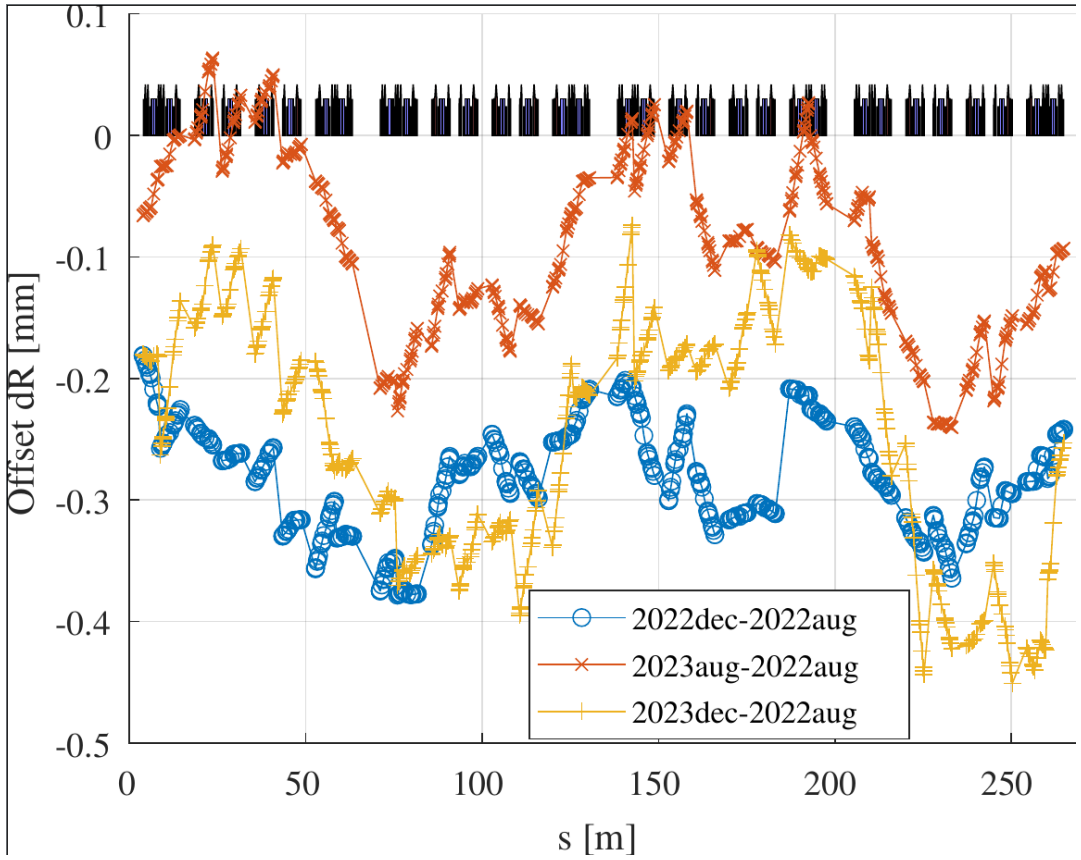
3 x TEMs

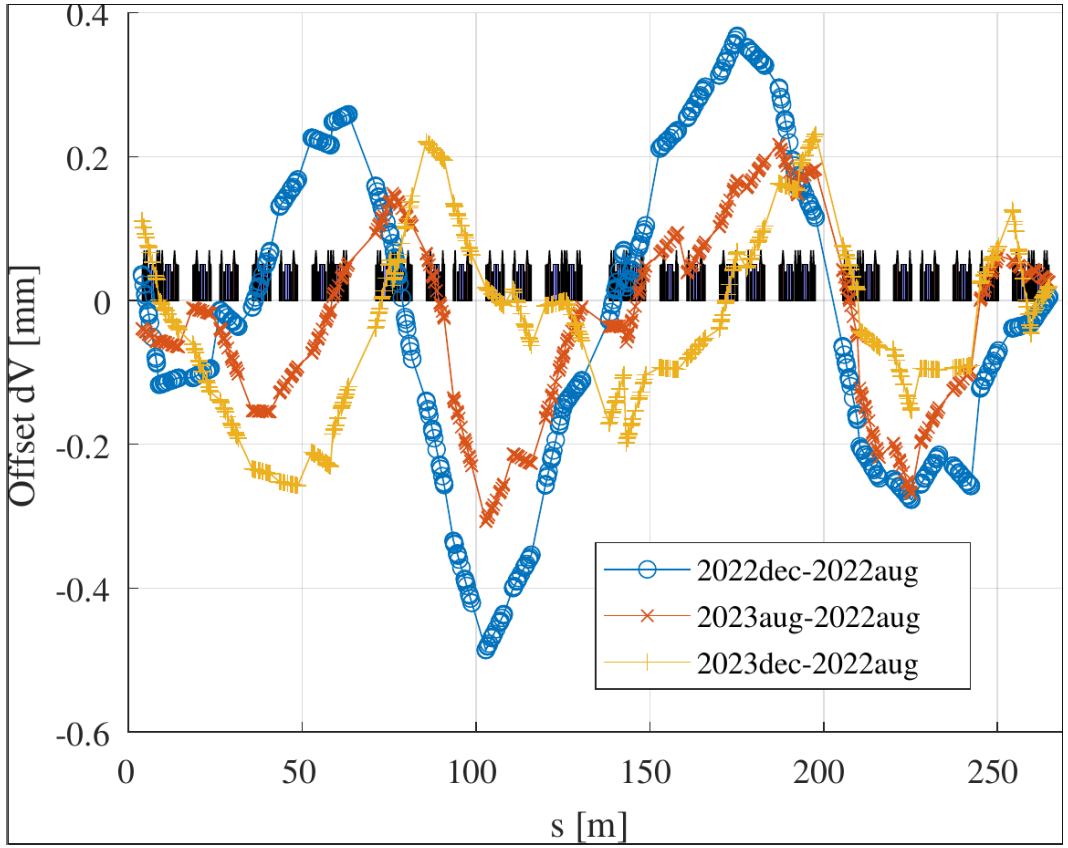
(1x Glacios, 2x Spectra)

ALBA II BLs portfolio in 2032

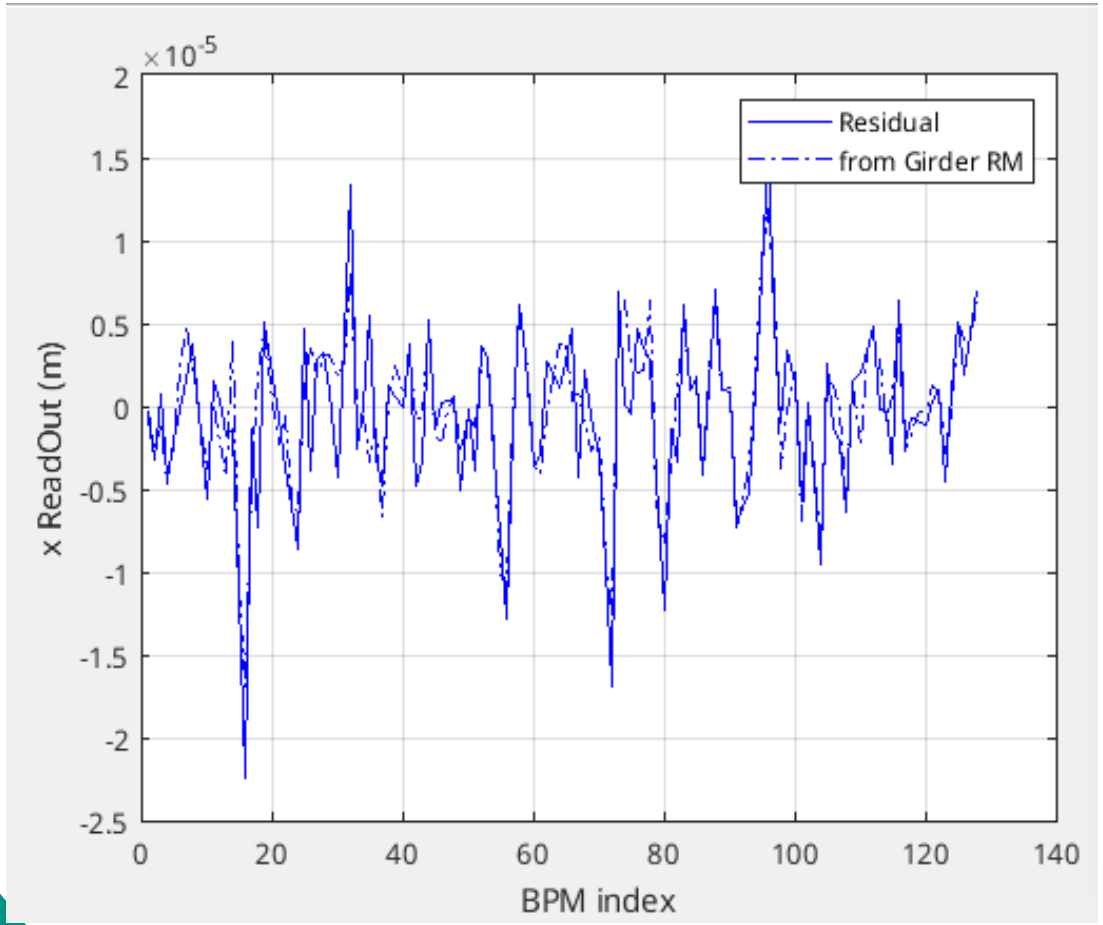
- *13 ID beamlines (full)*
- *4 BM beamlines*
- *1 IR beamline*
- *1 Visible diagnostics*
- *2 XR pinhole diagnostics*

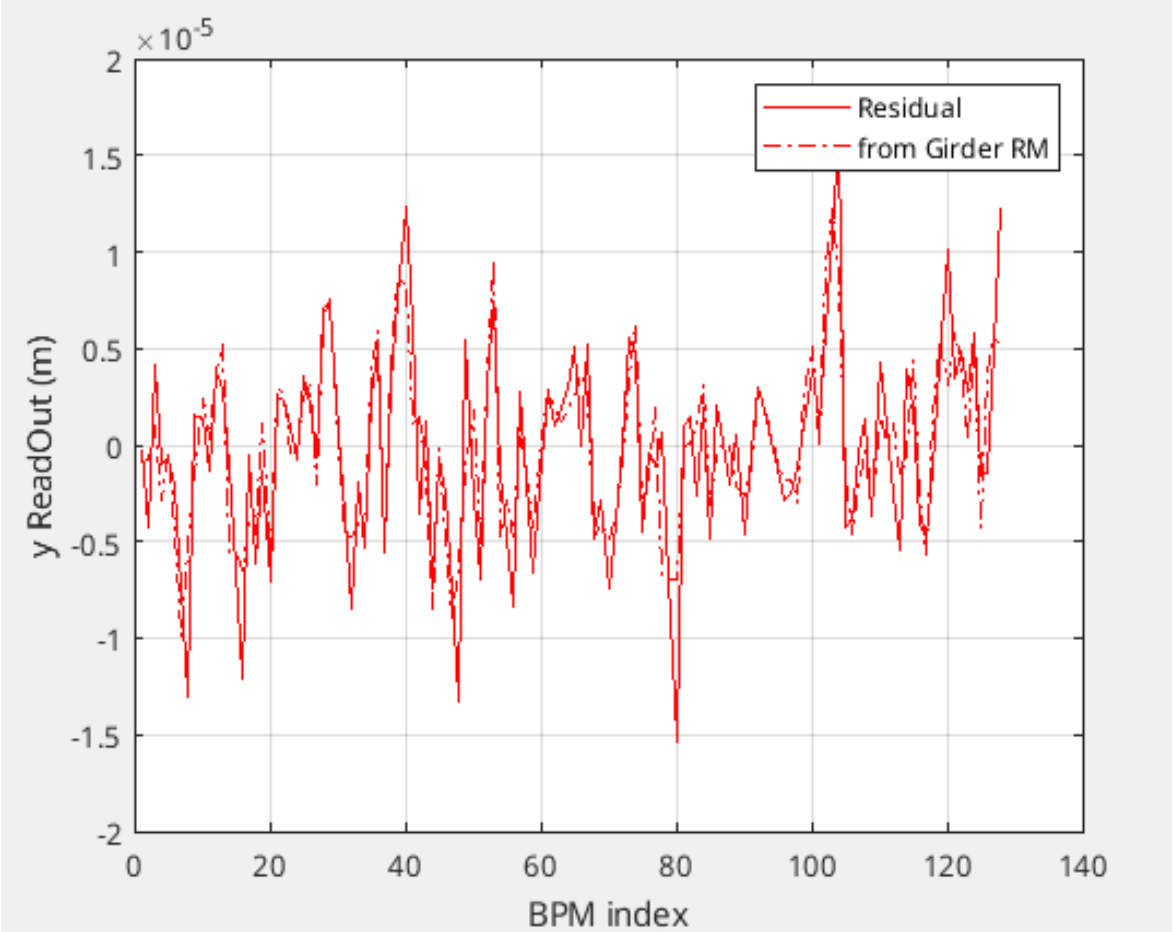
Summer and winter measured Ground movement, 2022-2023



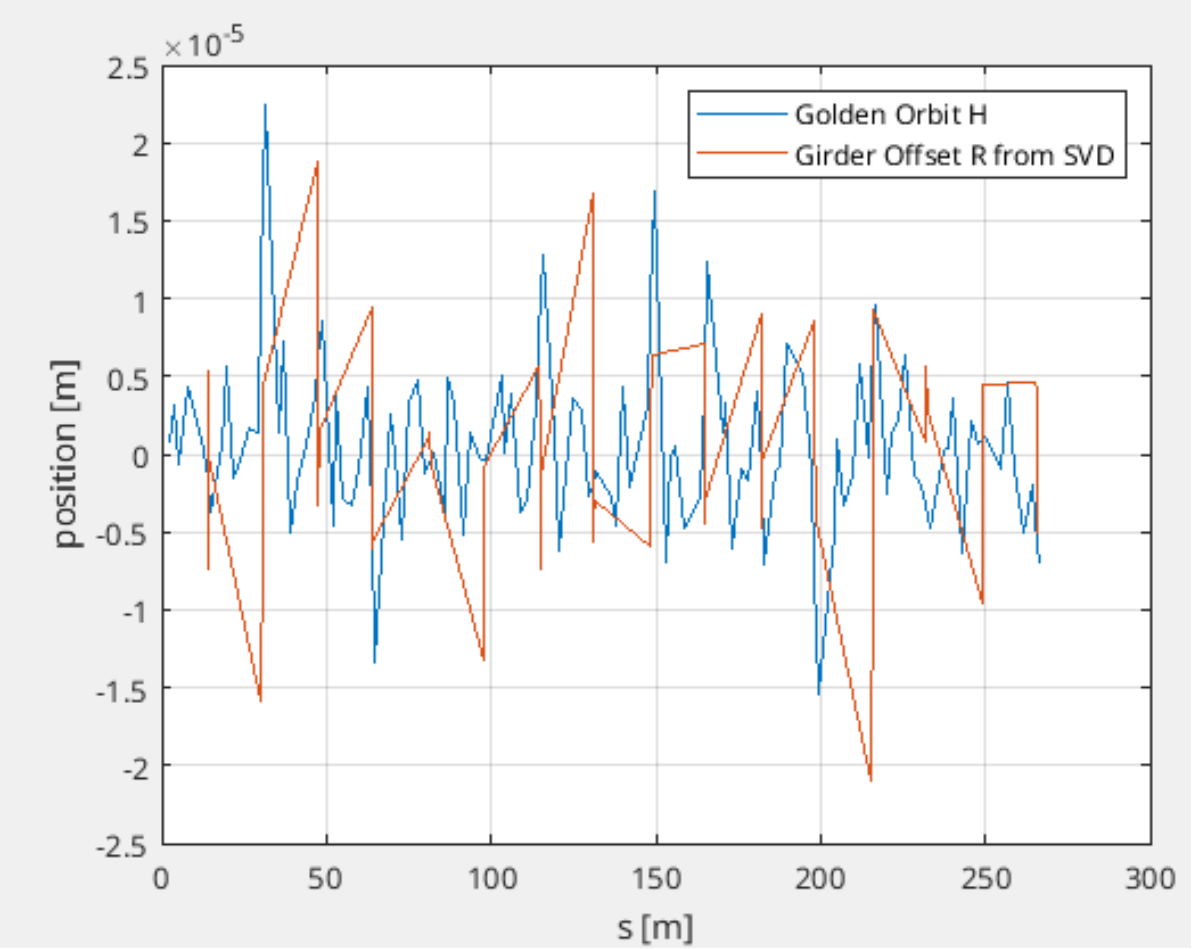


Example of Orbit from girder-to-BPM SVD



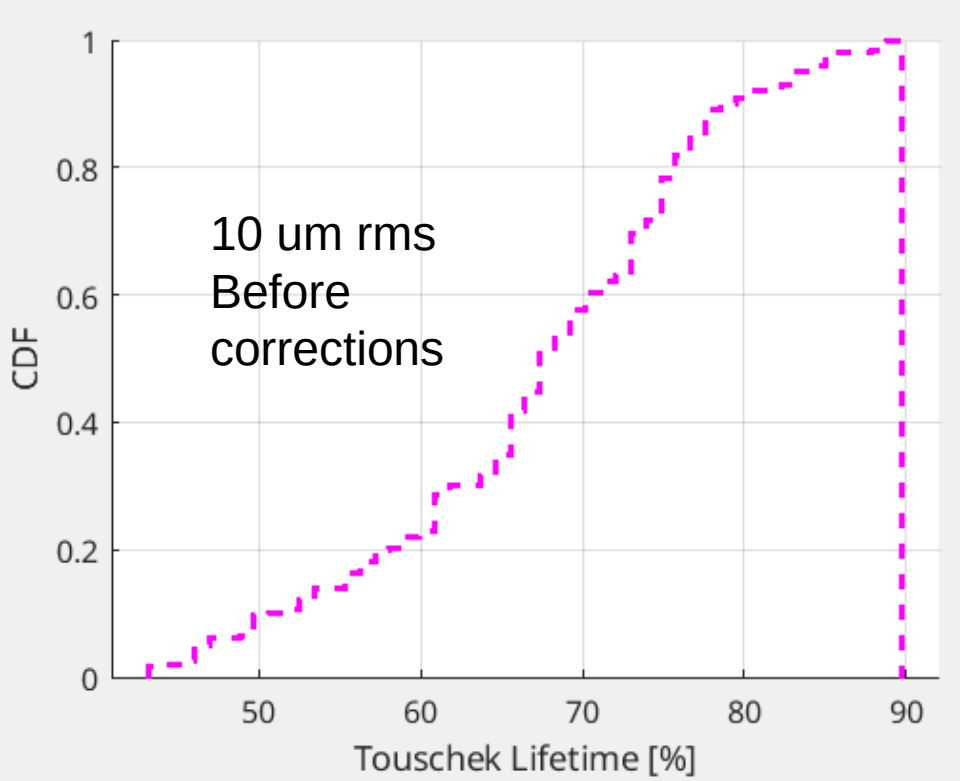


Girder movement and Estimation result from SVD



Touschek Lifetime

results_Jun_07_2024-07-23-12.mat
ALBA II 20240326 A
10 um rms, no correction



results_Jun_08_2024-10-04-12.mat
ALBA II 20240326 A
10 um rms, plus correction