

Satellite Orientation Effects on Centre of Mass Corrections

José C. Rodríguez¹, Toshimichi Otsubo²

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22nd IWLR, Guadalajara (Spain)

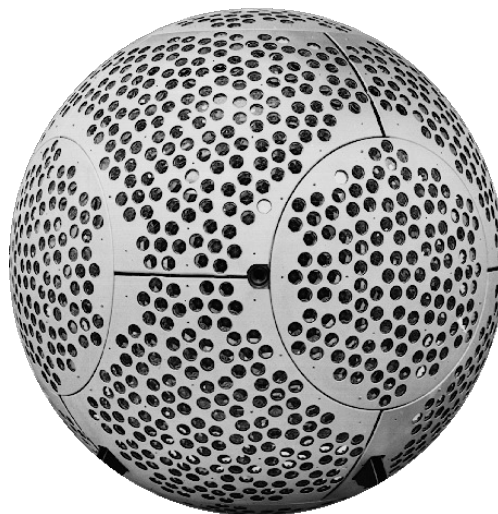
2022-11-08



Ajisai

Diameter m
Mass Kg
CCRs #

2.15
685
1436



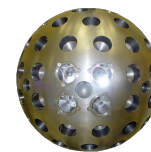
Etalon

1.29
1415
2146



LAGEOS

0.60
407
426



LARES

0.36
387
92



Starlette

0.24
48
60

How it all works

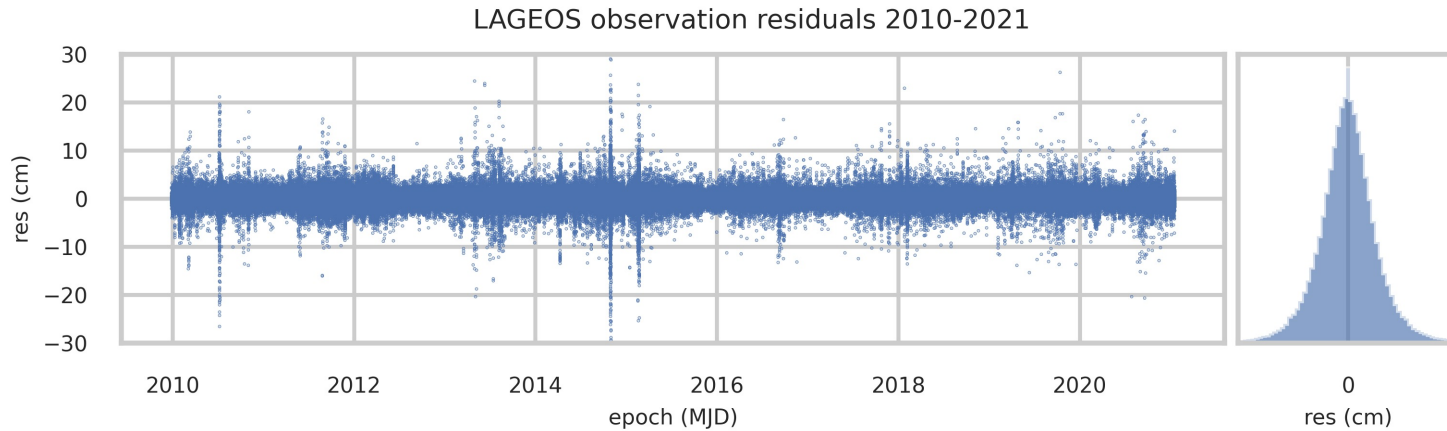
- Satellites in orbit + Lasers on the ground
- Time-of-flight measurements from ground network (+ corrections)
- Accumulation of observations

- Models for
 - Earth rotation
 - Station positions
 - Satellite dynamics
- Least-squares fit of model parameters

How good is our fit? → check residuals

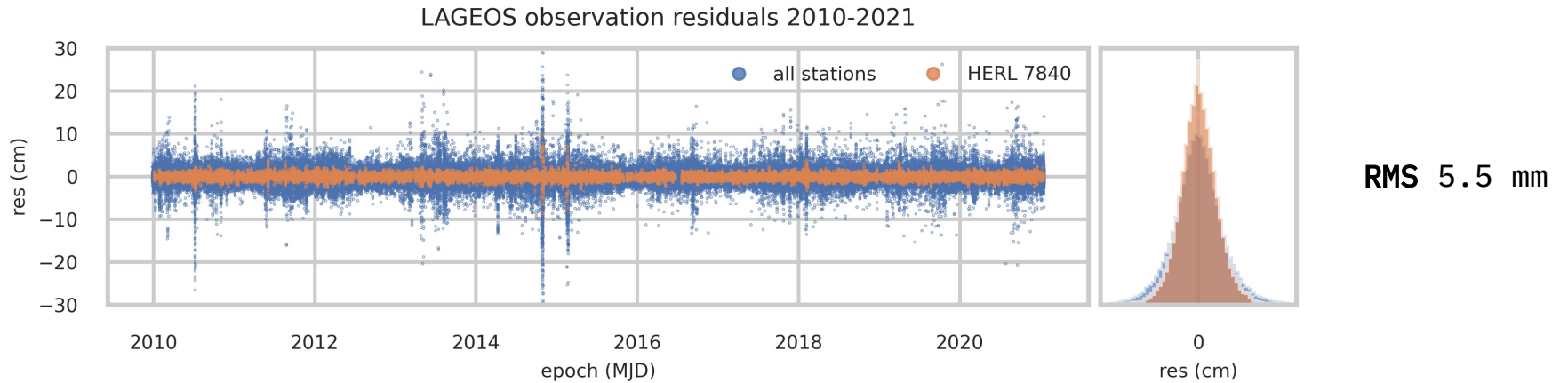
Compare the agreement between observations and fitted model

Checking residuals



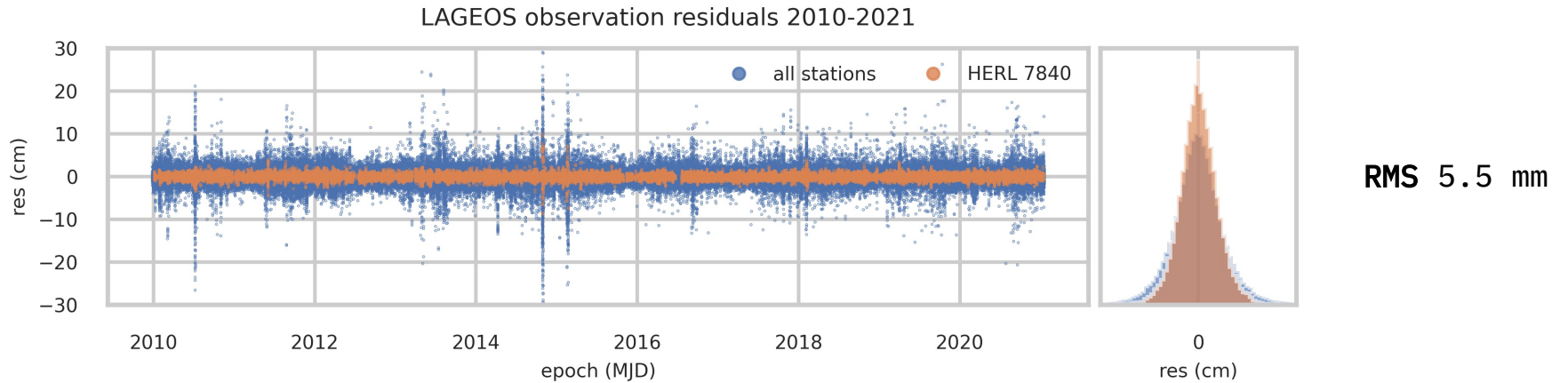
- For good reasons, we expect the residuals to be normally distributed
- Don't want strange features appearing here

Checking residuals



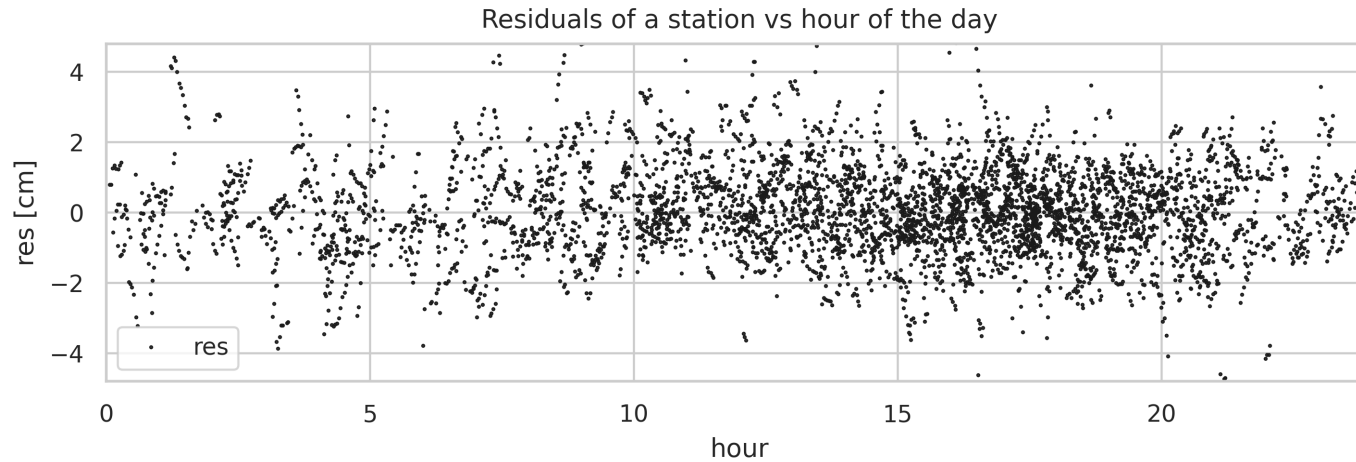
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- Can check time behaviour and compare stations

Checking residuals



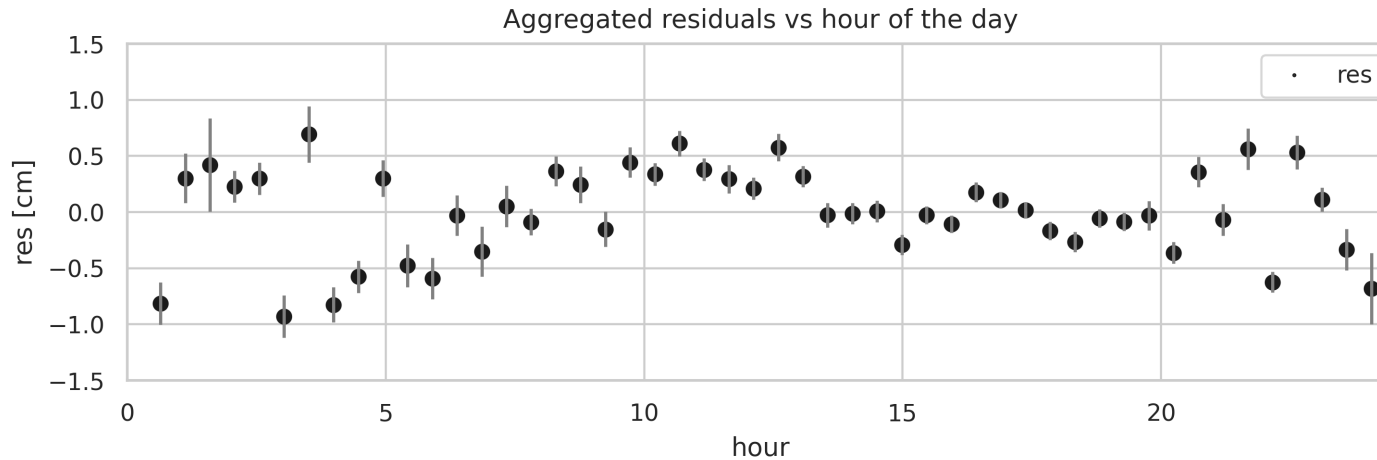
- For good reasons, we expect the residuals to be normally distributed
- Don't want strange features appearing here
- Can check time behaviour and compare stations
- We can dig in deeper, exploring correlations with other variables

Checking residuals



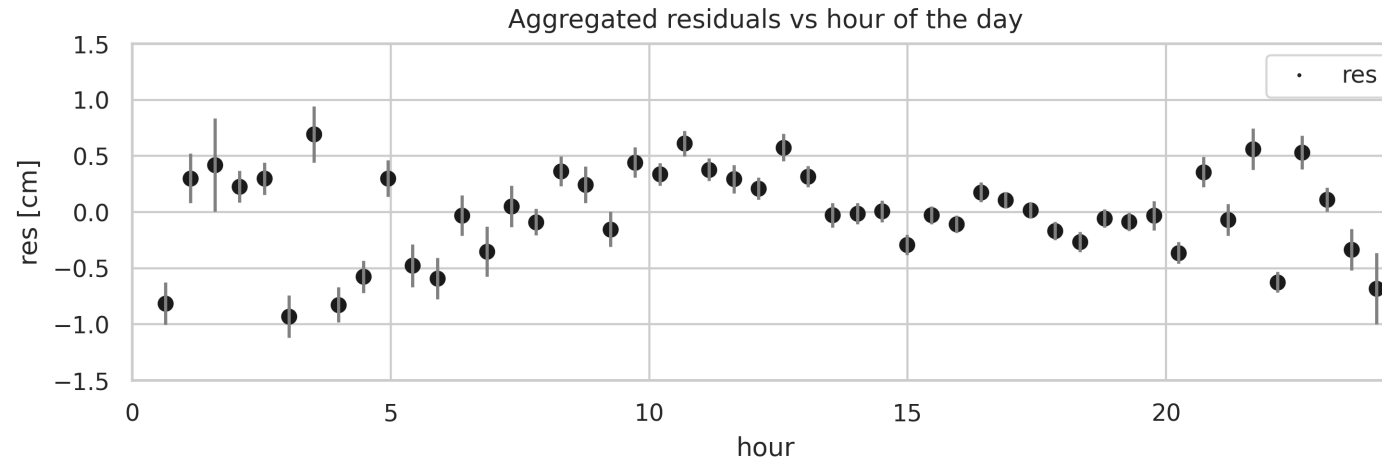
- For instance, we can have a look at **residuals vs time of the day**

Checking residuals



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- We can group residuals by even intervals and plot the averages
- Now we can detect trends and unexpected features

Checking residuals



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Checking 22IWLR posters in Slack!

22IWLR posters

Direct messages
Mentions & reactions
Slack Connect
More

Channels

- # 00-code-of-conduct
- # general
- # random
- # s01-p01-dariusz-strugarek
- # s02-p01-weijing-qu
- # s03-p01-flip-galdyn
- # s04-p01-tristan-meyer
- # s04-p02-bowen-guan
- # **s04-p03-toshimichi-otsubo**
- # s06-p01-manuel-catalan
- # s06-p02-igor-ignatenko
- # s06-p03-j-kaulins
- # s06-p04-randall-carman
- # s06-p05-arttu-raja-halli
- # s06-p06-christian-schwatke
- # s06-p07-andreja-susnik
- # s06-p08-justine-woo
- # s06-p09-justine-woo
- # s06-p10-justine-woo
- # s06-p11-erik-guenther
- # s06-p12-josé-c-rodriguez

s04-p03-toshimichi-otsubo

Alberto García 1:50 PM Friday, November 4th

<https://www.youtube.com/watch?v=...>

PDF

s04-p03-toshimichi-otsubo.pdf
PDF

YouTube 22nd International Workshop on Laser Ranging
Systematic range residuals 2021-2022

Message #s04-p03-toshimichi-otsubo

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- # s06-p12-josé-c-rodriguez

s04-p02-bowen-guan

1 Pinned + Add a bookmark

Thursday, November 3rd

Pinned by Alberto García

Alberto García 9:00 AM

PDF

s04-p02-bowen-guan.pdf
PDF

Abstract

2. the simulation of satellite signature effect

from the reference pointing. 3) Due to the distribution of the front and back edge of the 10 residual distribution, the center of mass value RMS presents the constant, and so

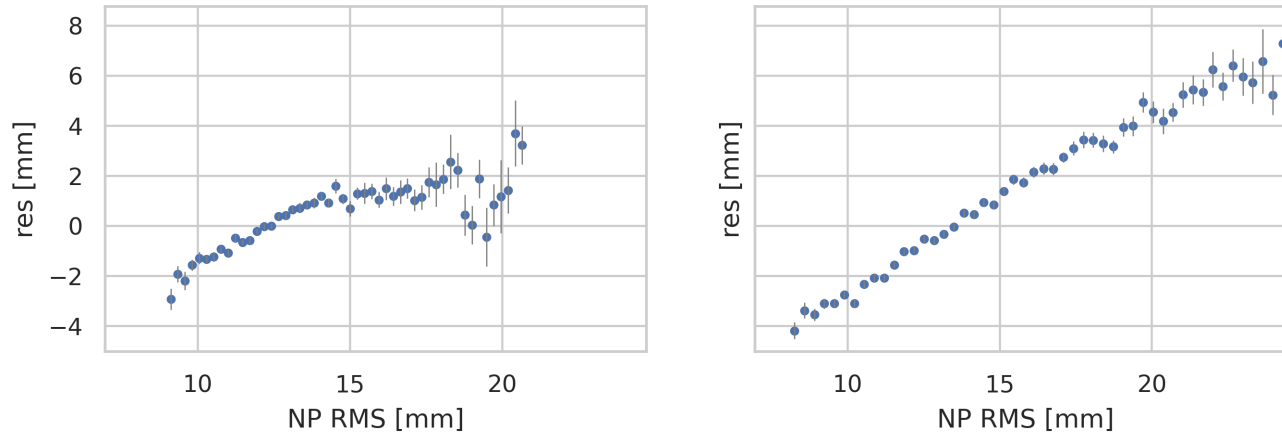
Yesterday

Ewan Schafer 10:05 AM
joined #s04-p02-bowen-guan along with 14 others.

Message #s04-p02-bowen-guan

Checking residuals

LG1 and LG2 post-fit residual vs NP RMS

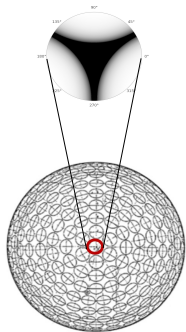


- Residual vs NP RMS, quite marked correlation for SPAD stations
- Systematic or random error?
- Peak to peak close to **10 mm**. Do they go into the coordinates???
- Where does it come from...?

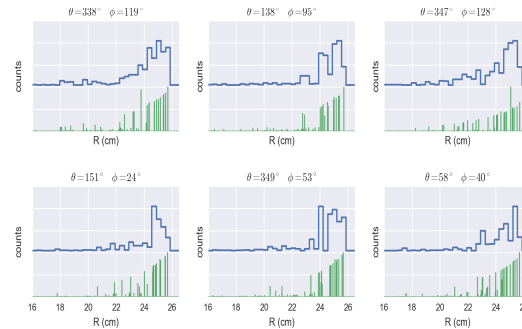
Computation of centre of mass values

- **Averaged** values *by design*
- We consider:
 - Physical characteristics of CCRs (material, size, coating)
 - CCR array geometry (position and clocking)
 - Laser wavelength
 - Satellite orientation ← **BUT** we *average* over all possible orientations

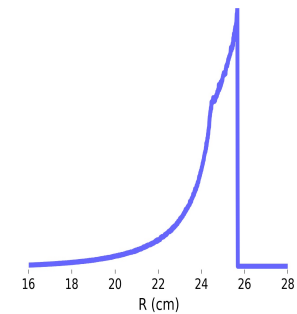
Reflectivity map



Response at arbitrary orientations

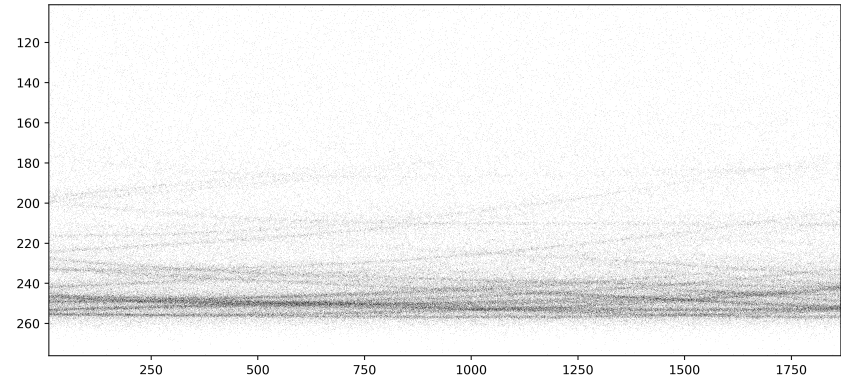
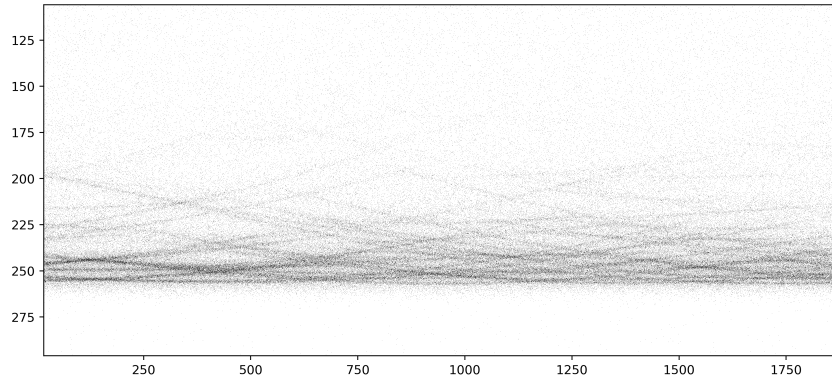


Average over 250K orientations



- What if we don't average orientations?

→ *Video of simulated LAGEOS passes...*



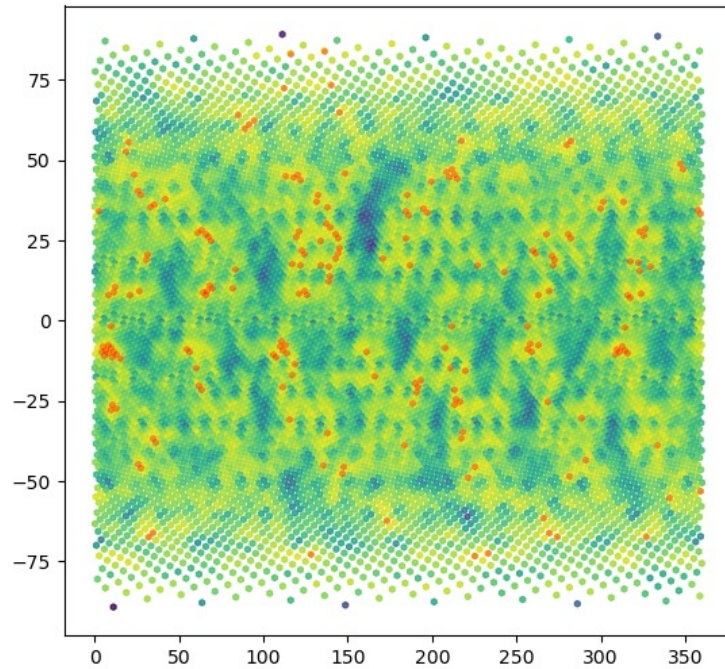
- We “see” different things for different orientations
- The obvious solution: apply the correction for the actual orientation...
- ...but this is not known (and if it were, there are some practical problems)

Instantaneous centre of mass values?

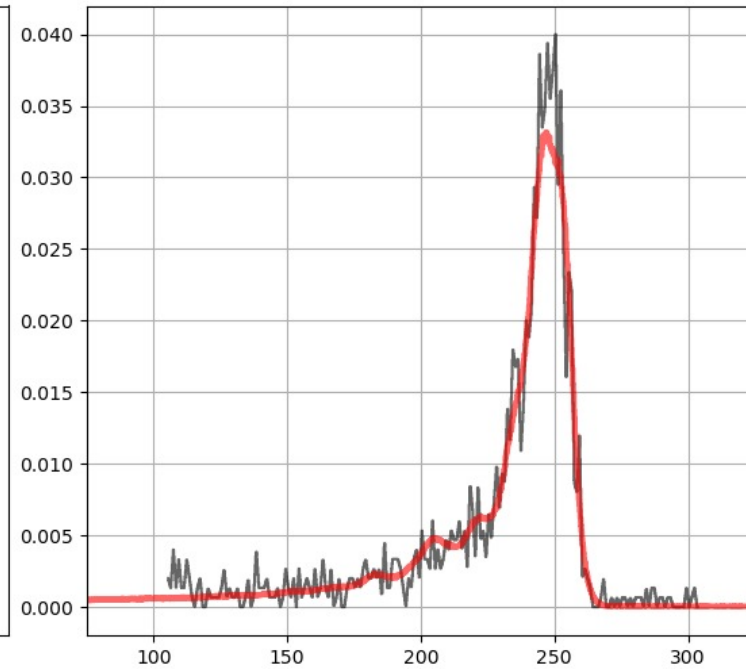
Brute force approach:

- 1) Precompute distributions of returns (and CoM values) for “all” orientations
- 2) Ask computer to find the best match to the real NP data
- 3) Apply the CoM for the matched distribution

Matched distributions



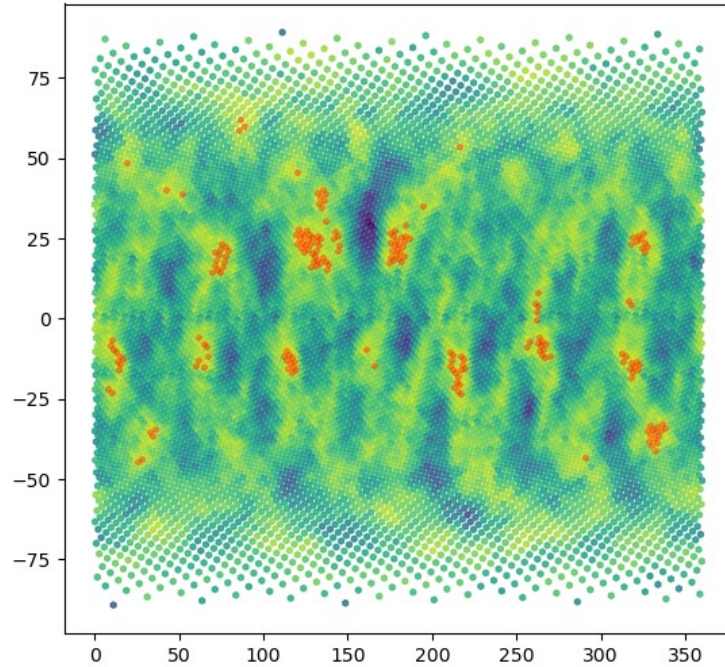
CCR array (**matched** positions)



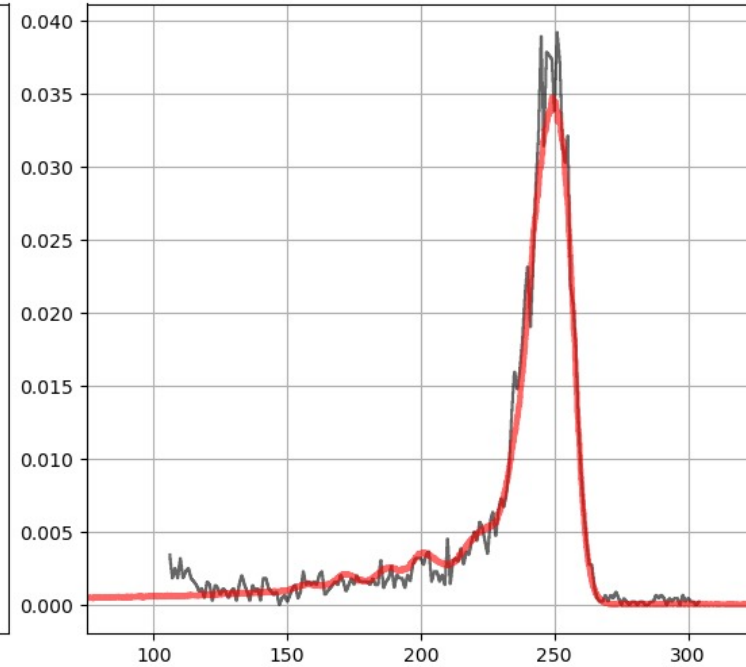
Empirical data

Model matched

Matched distributions



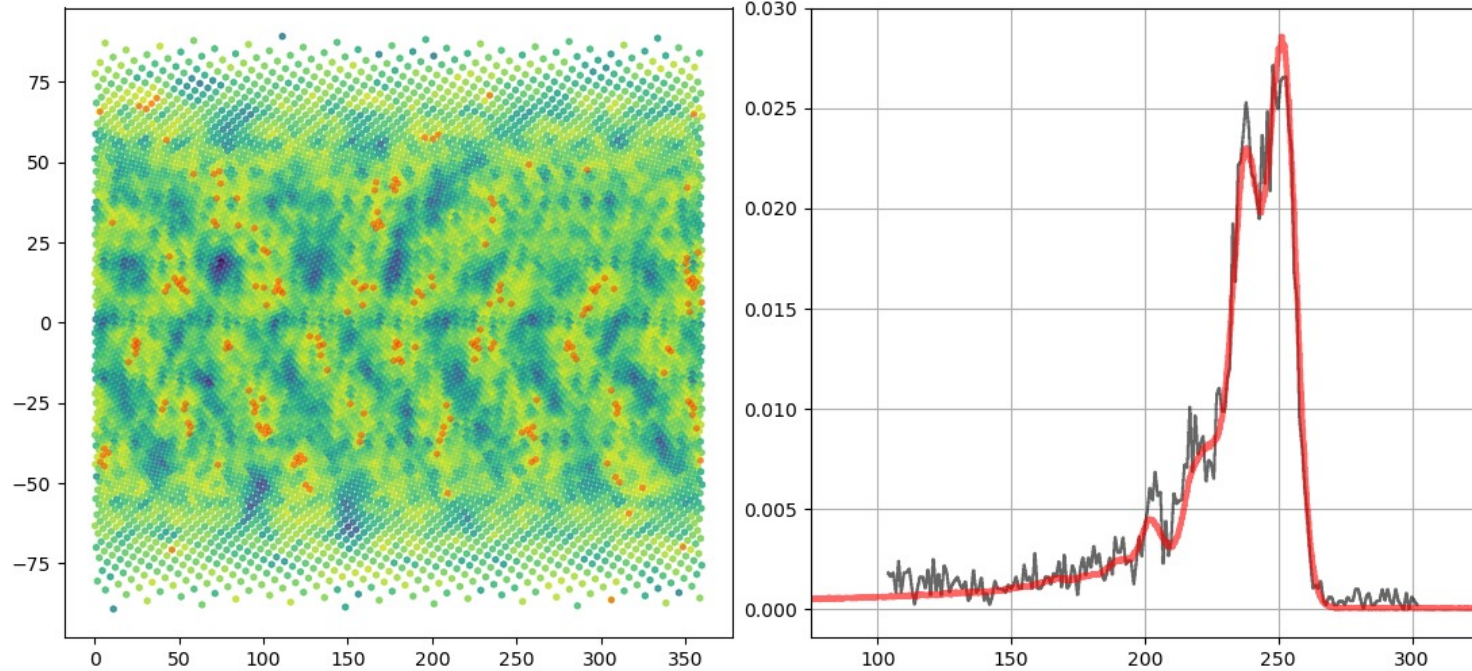
CCR array (**matched** positions)



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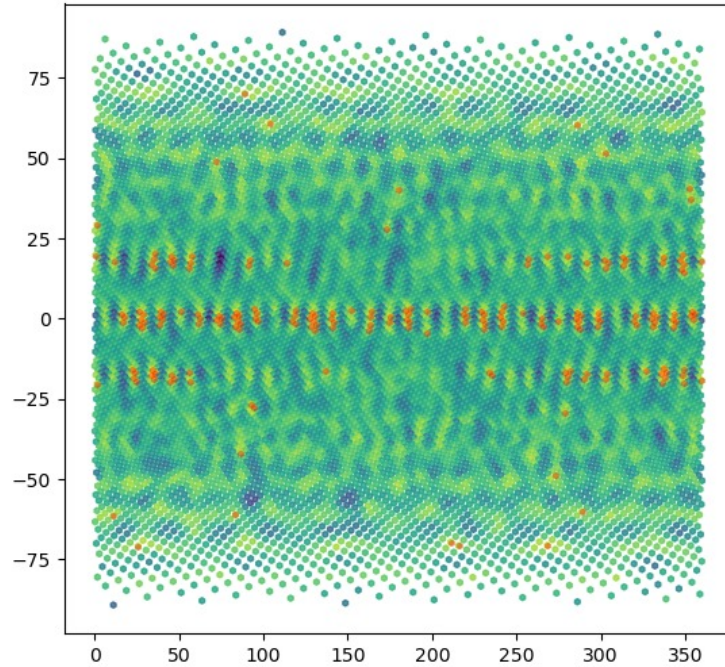


CCR array (**matched** positions)

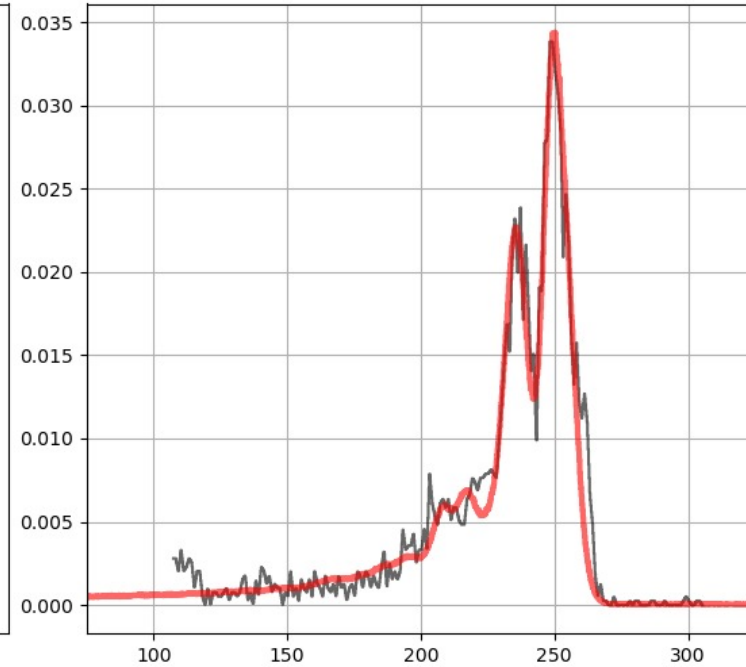
Empirical data

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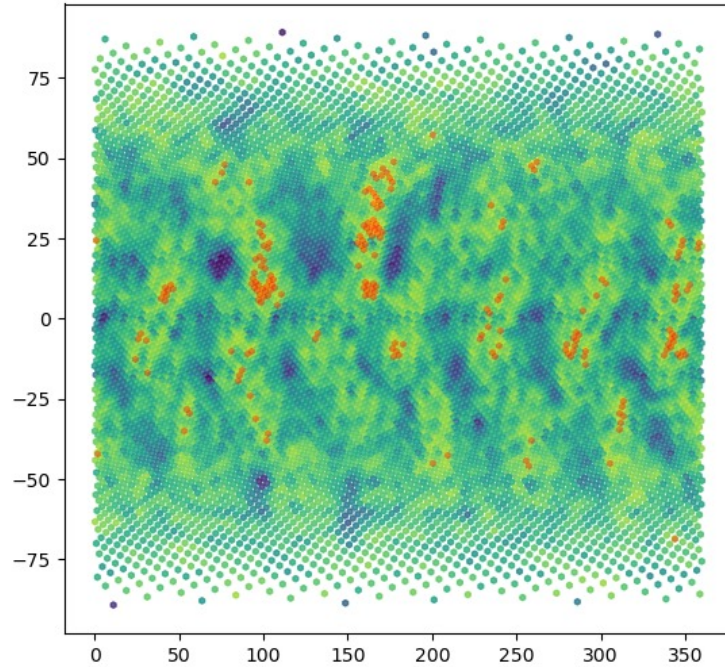
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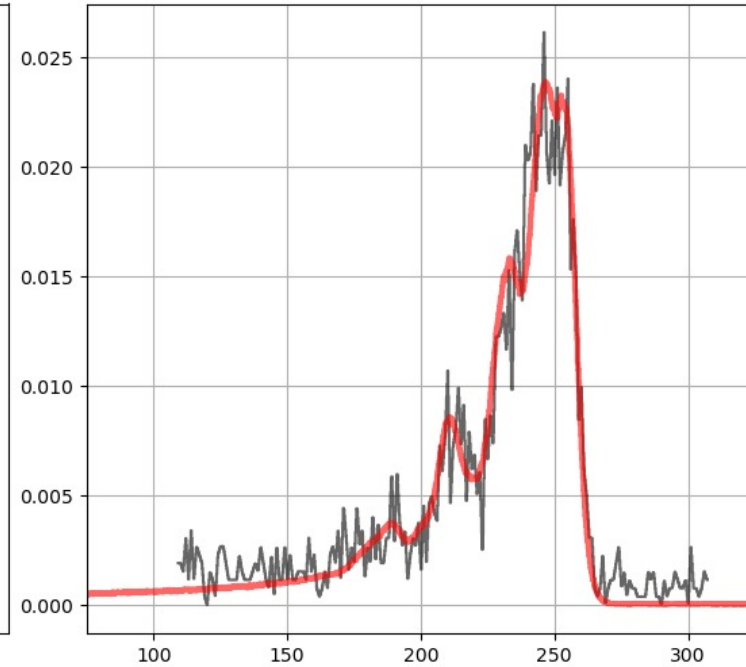
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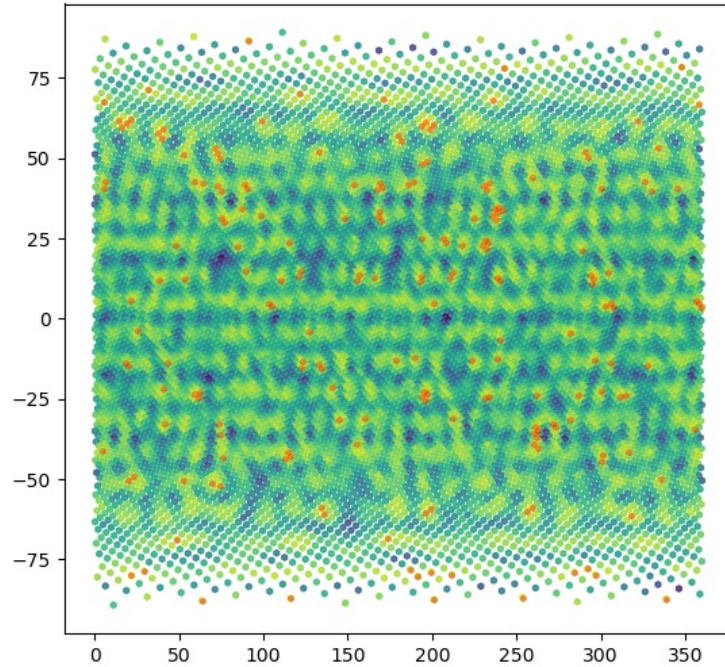
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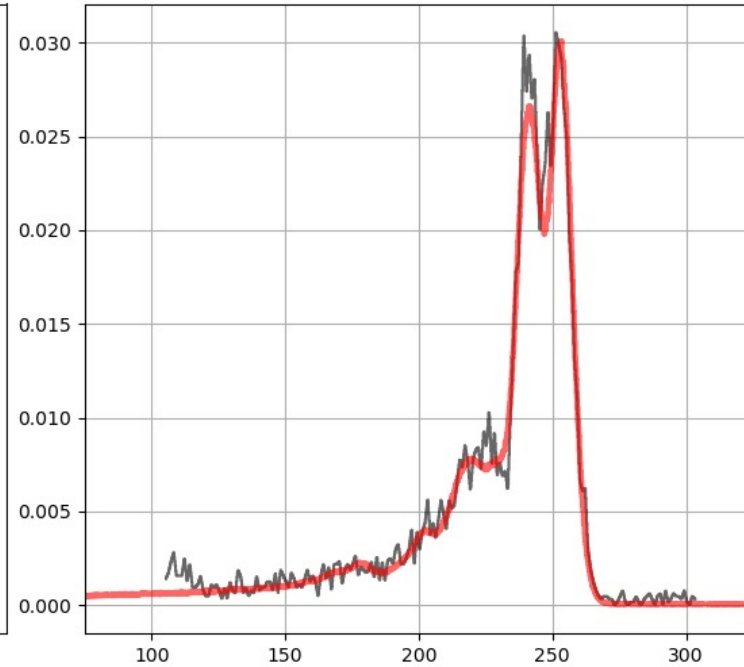
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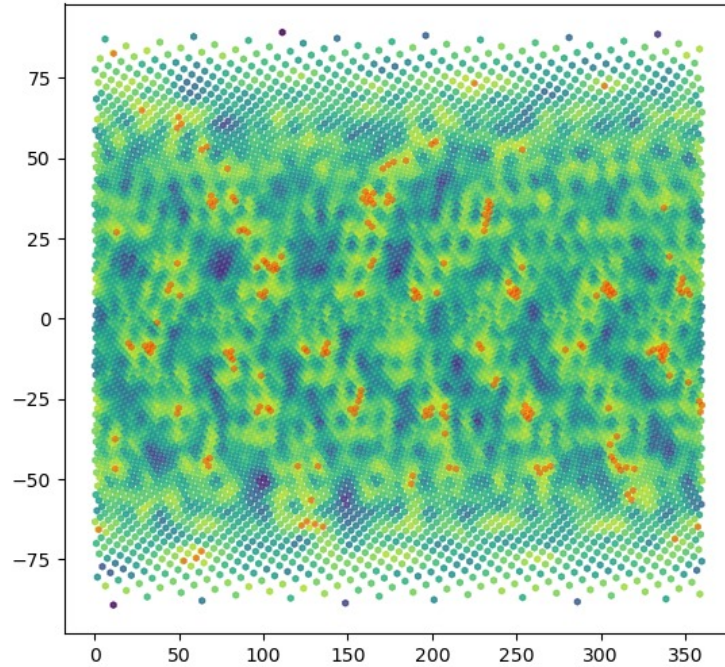
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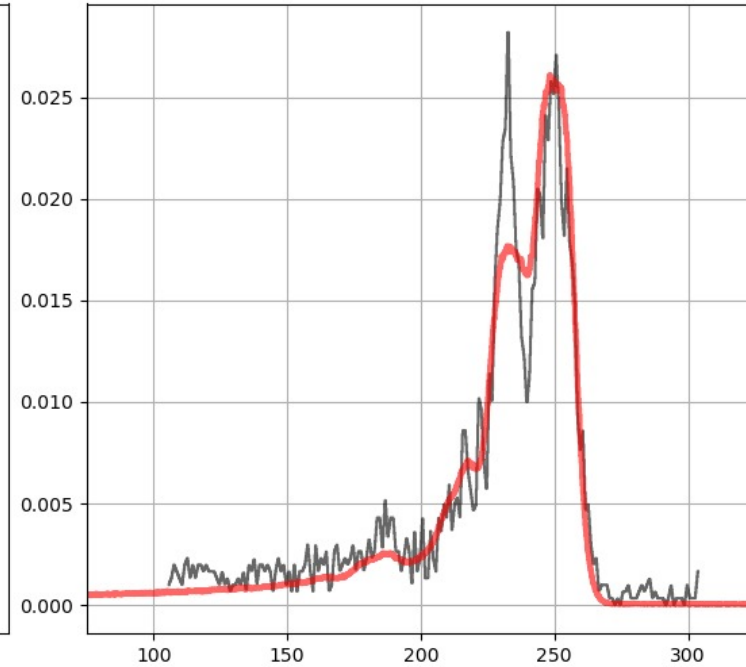
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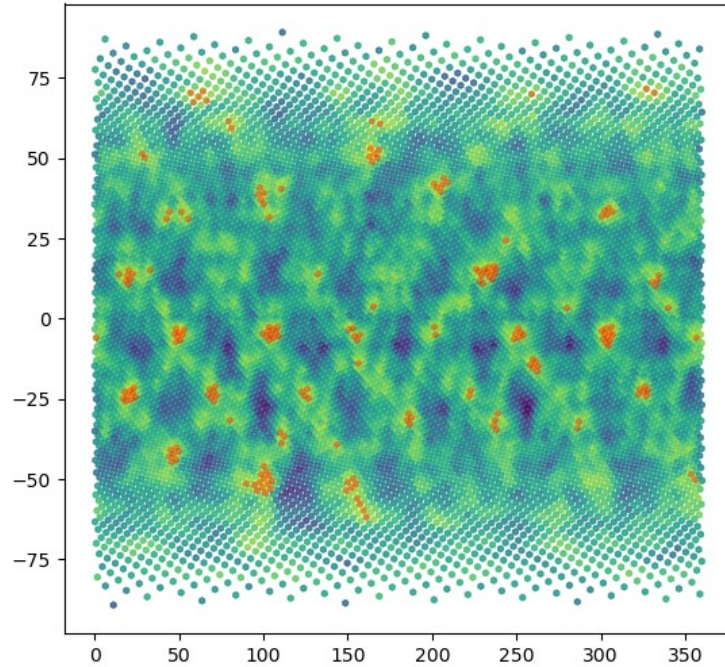
CCR array (**matched** positions)



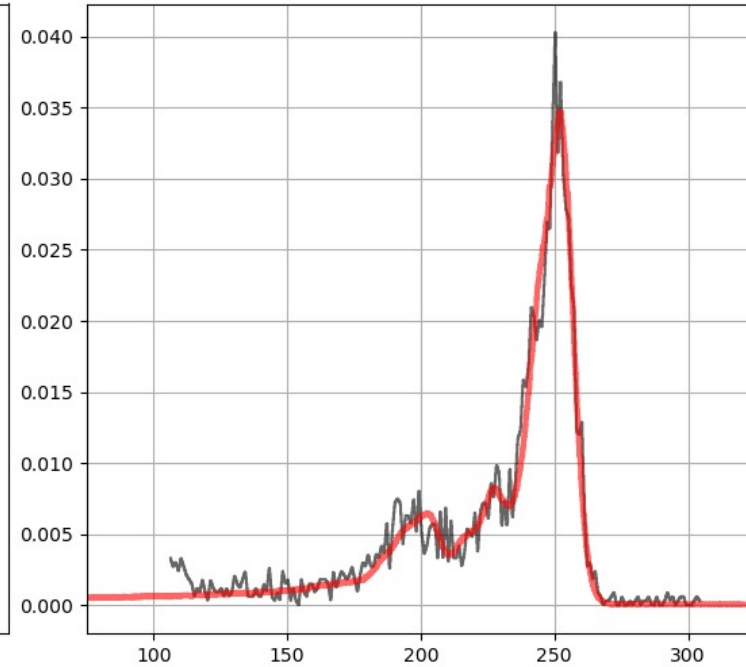
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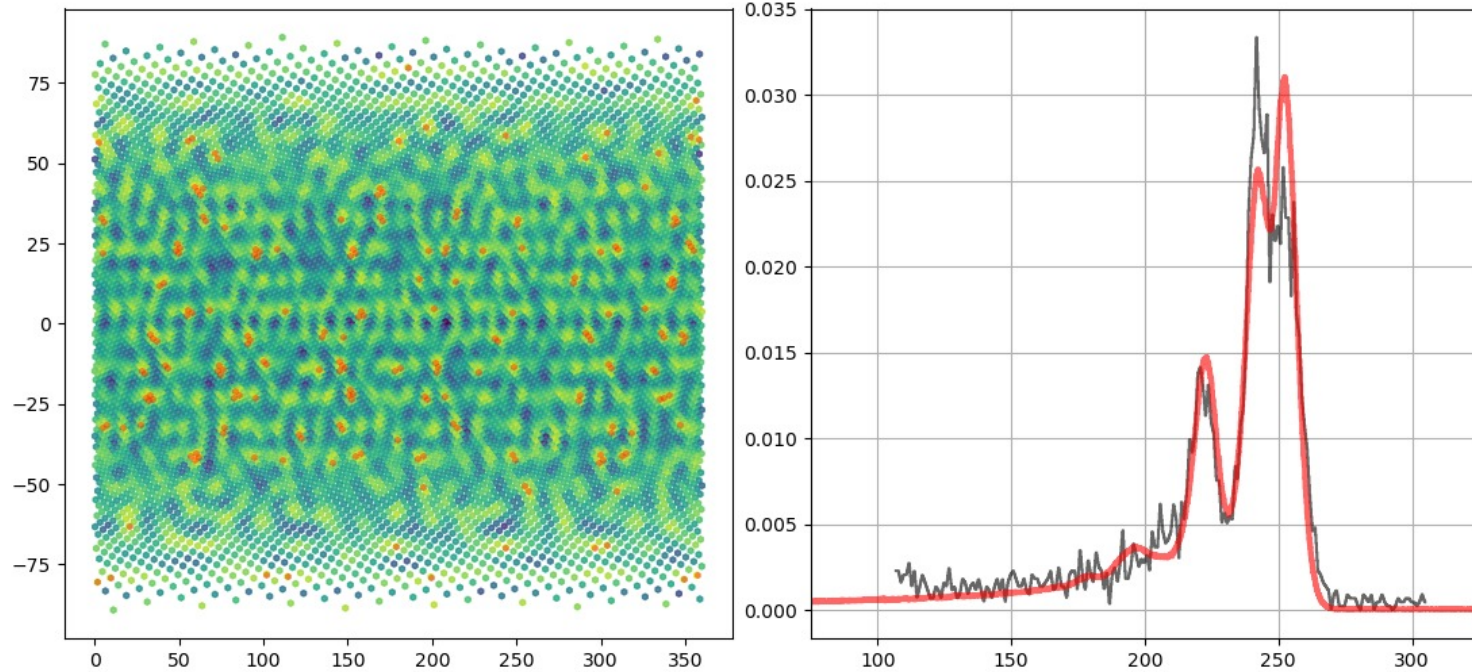
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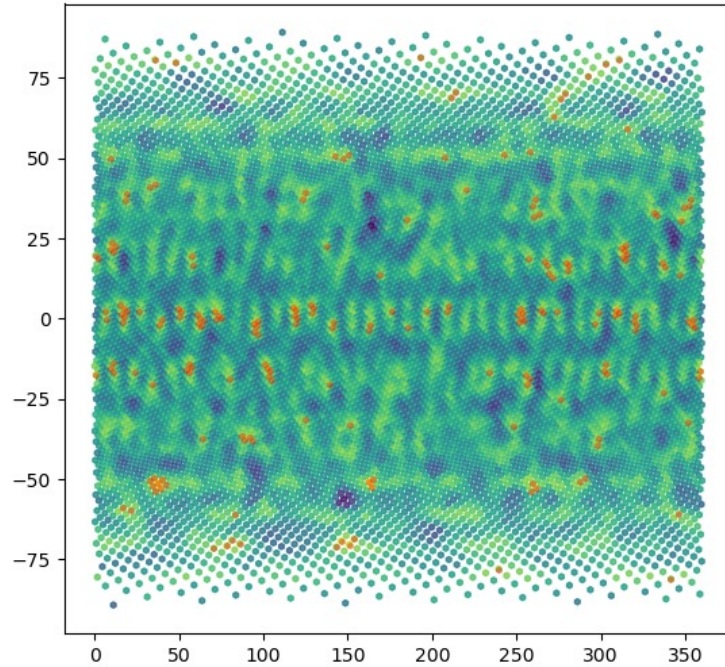


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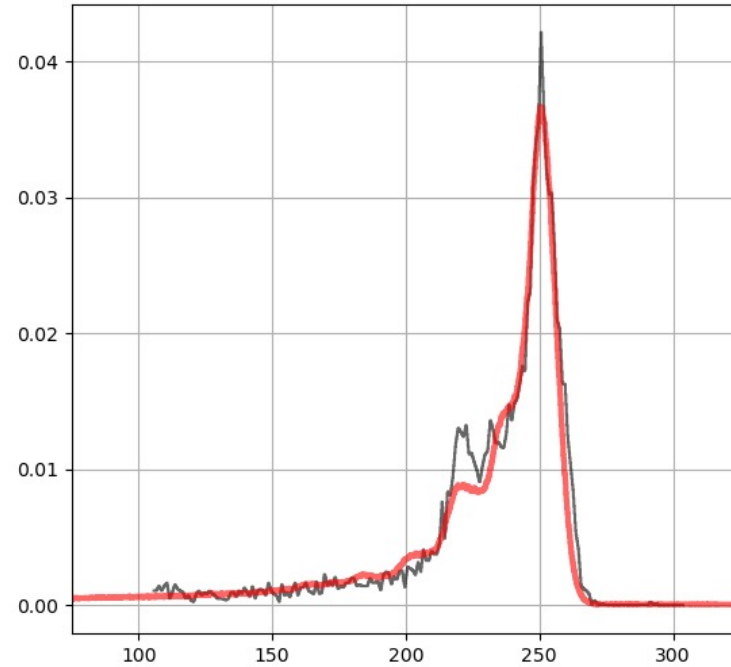
Empirical data

Model matched

Matched distributions



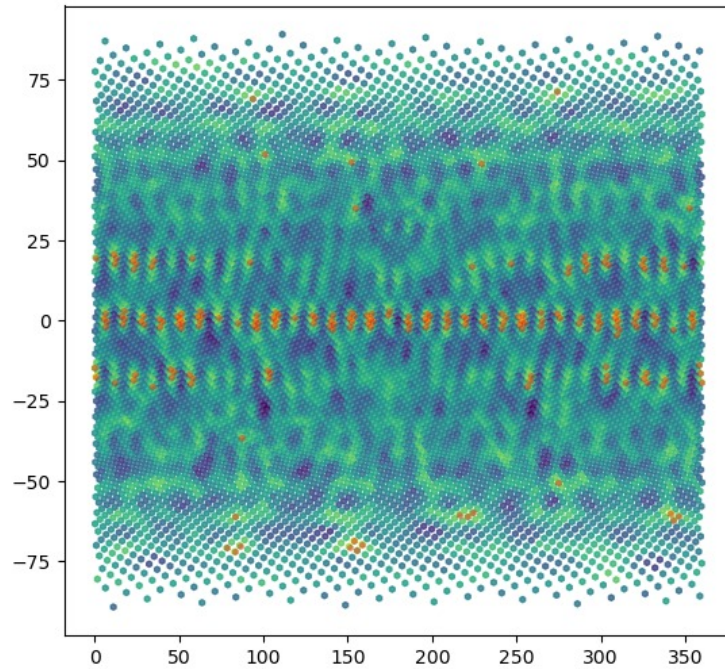
CCR array (**matched** positions)



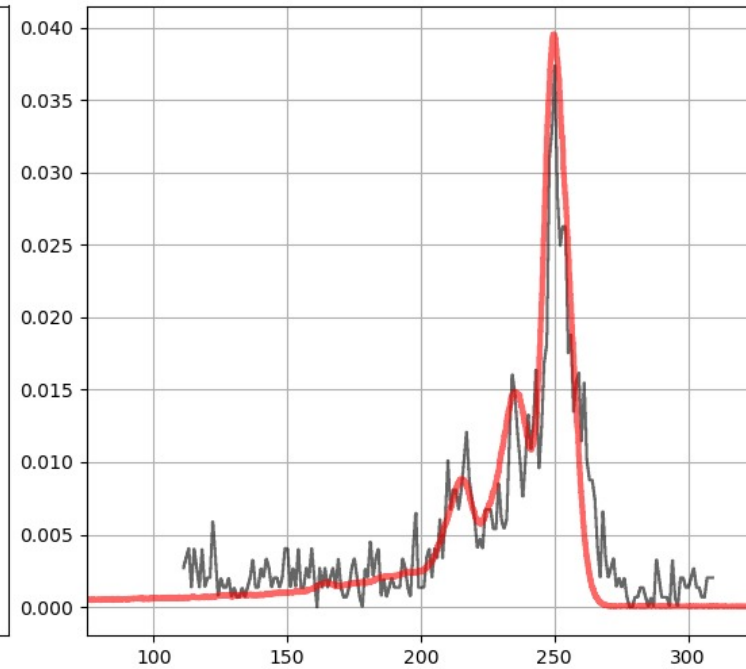
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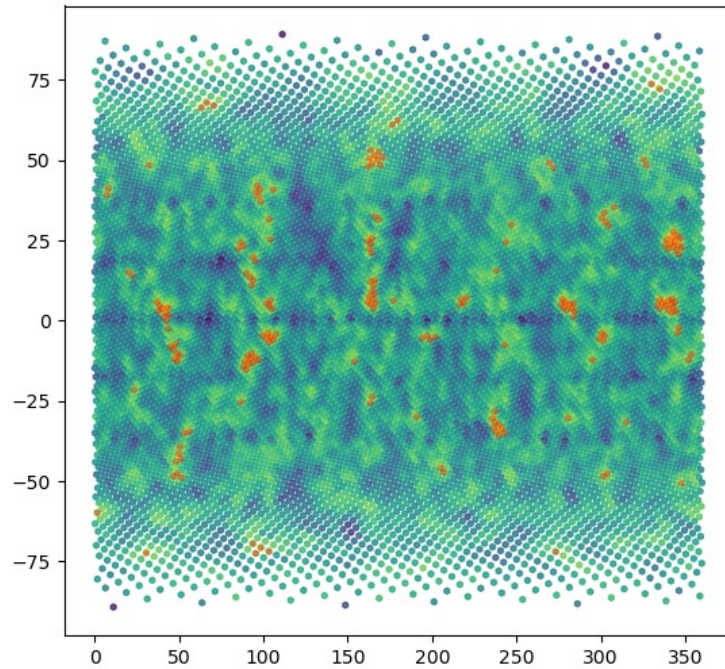
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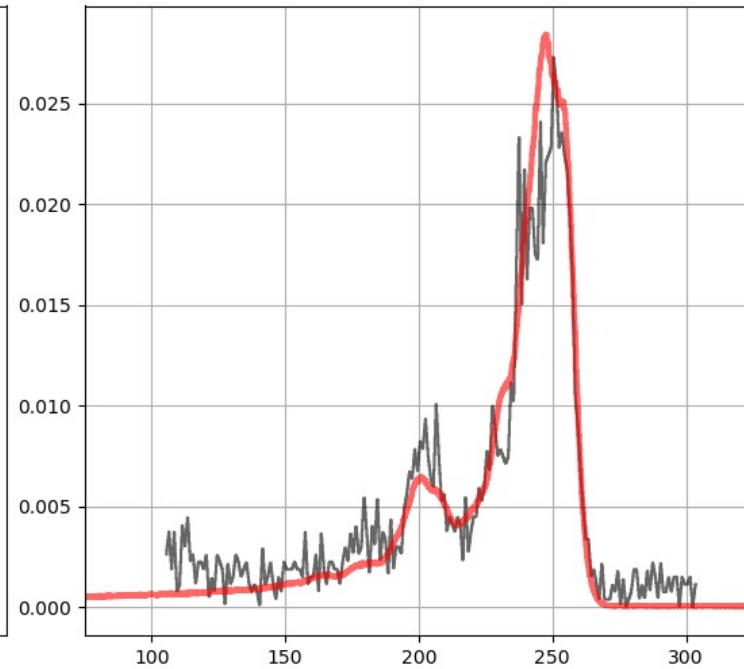
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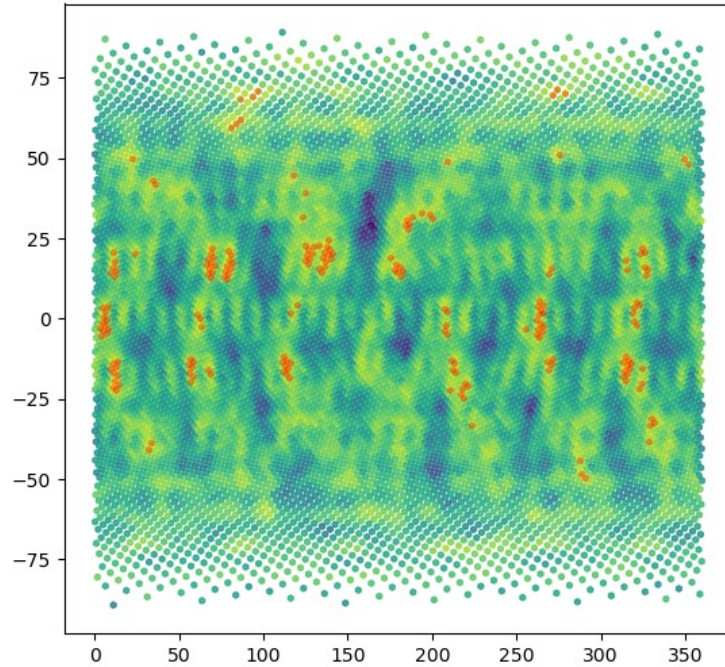
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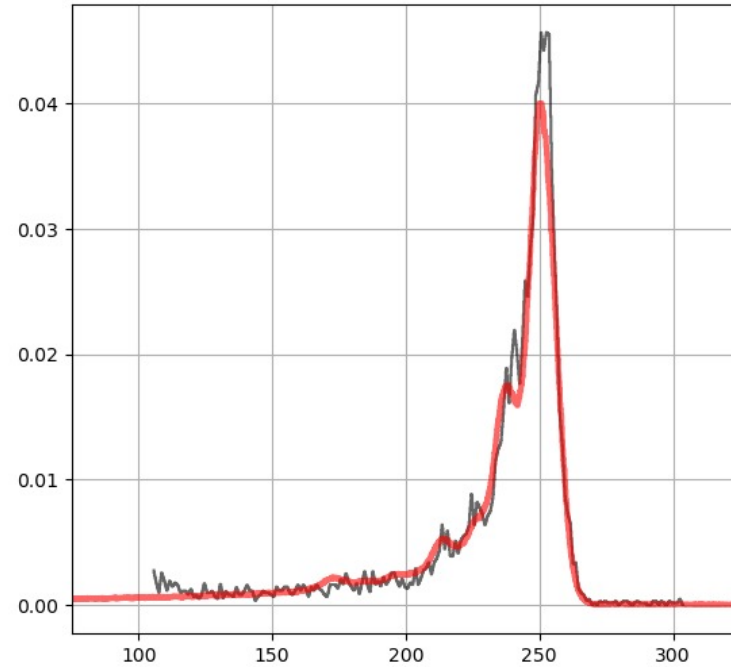
Empirical data

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Matched distributions



CCR array (**matched** positions)



Empirical data

Model matched

Instantaneous centre of mass values?

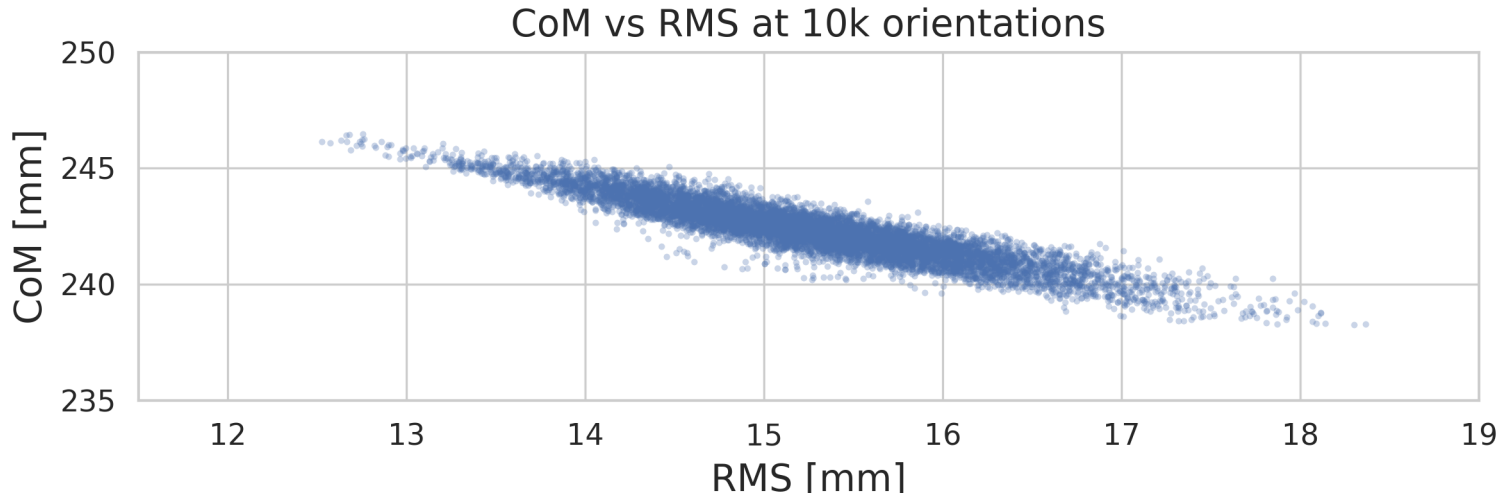
- It works!
- **Note:** we don't need the orientation to correct for an orientation-dependent effect

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- Meanwhile, maybe there is a *shortcut*?

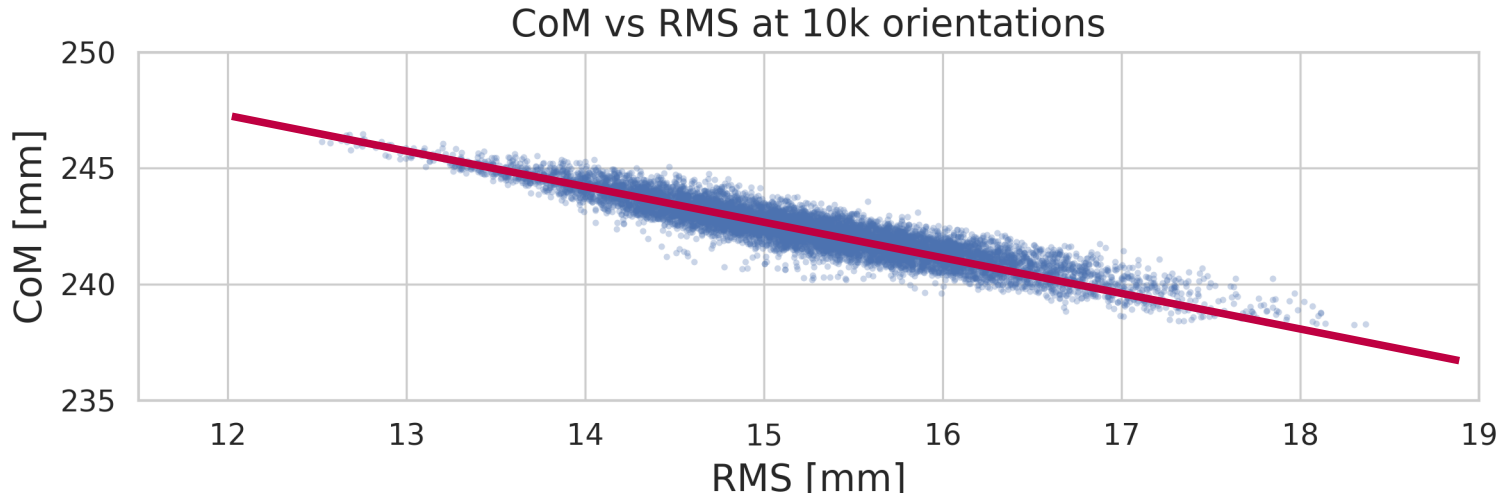
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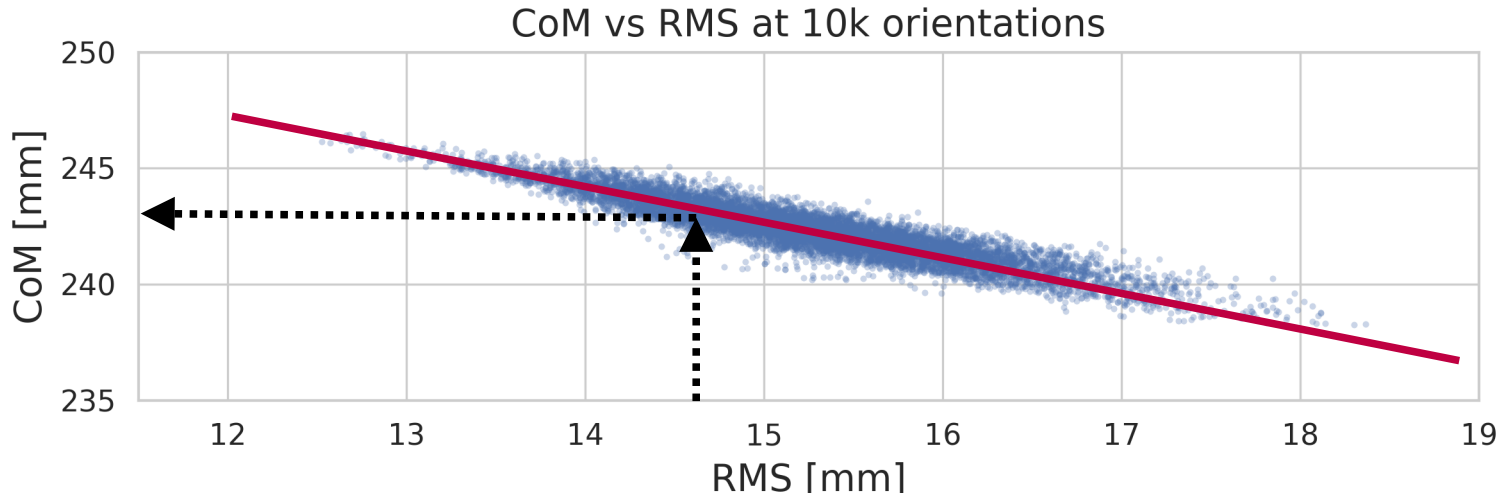
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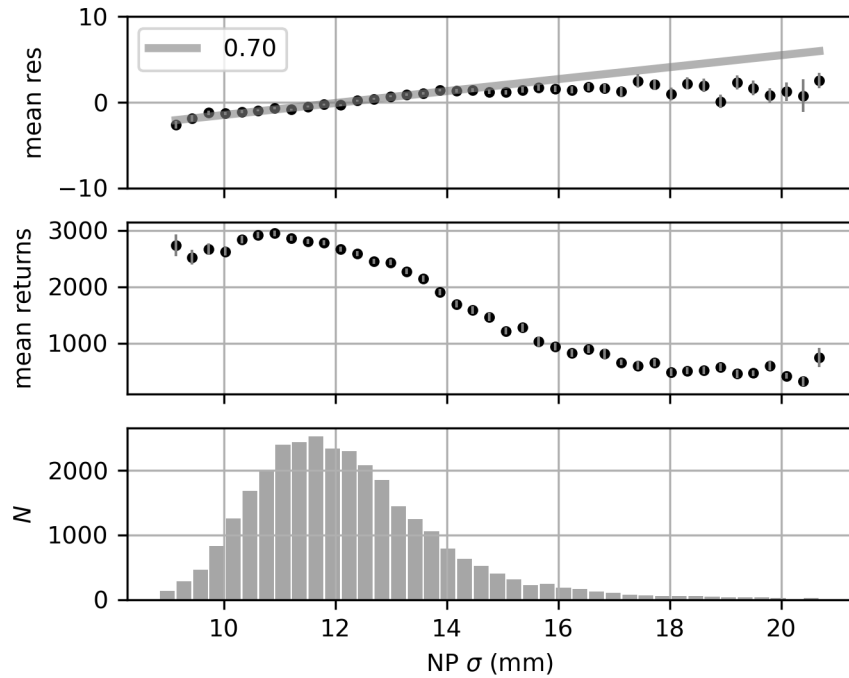


Test

- Regular 7-day arc solutions:
 - LG1/LG2 orbits
 - Stations, EOPs, RBs
 - 2015–2021
- Standard CoM corrections
- RMS-dependent CoM for Herstmonceux

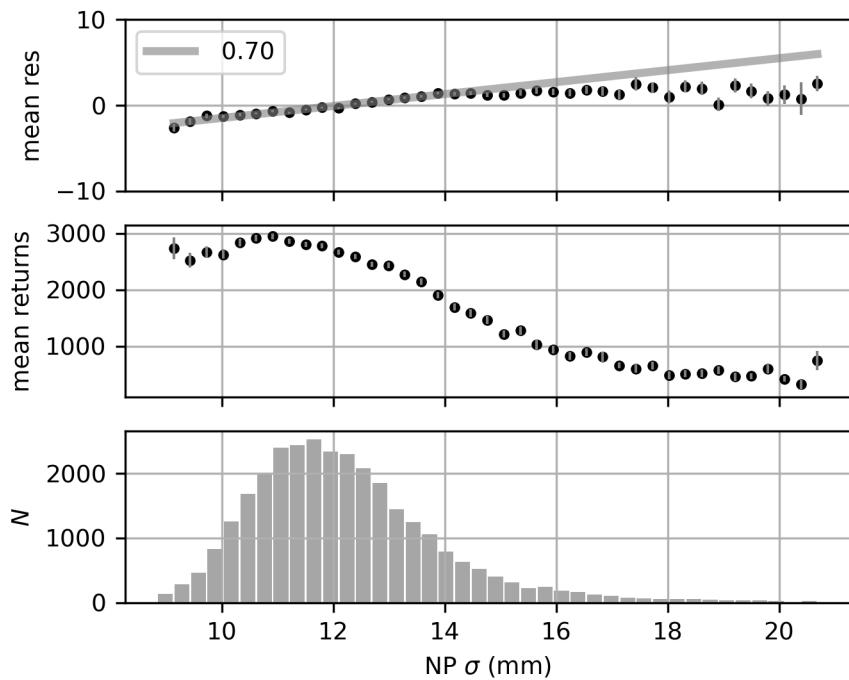
LAGEOS-1: Resids vs NP RMS

Standard CoM

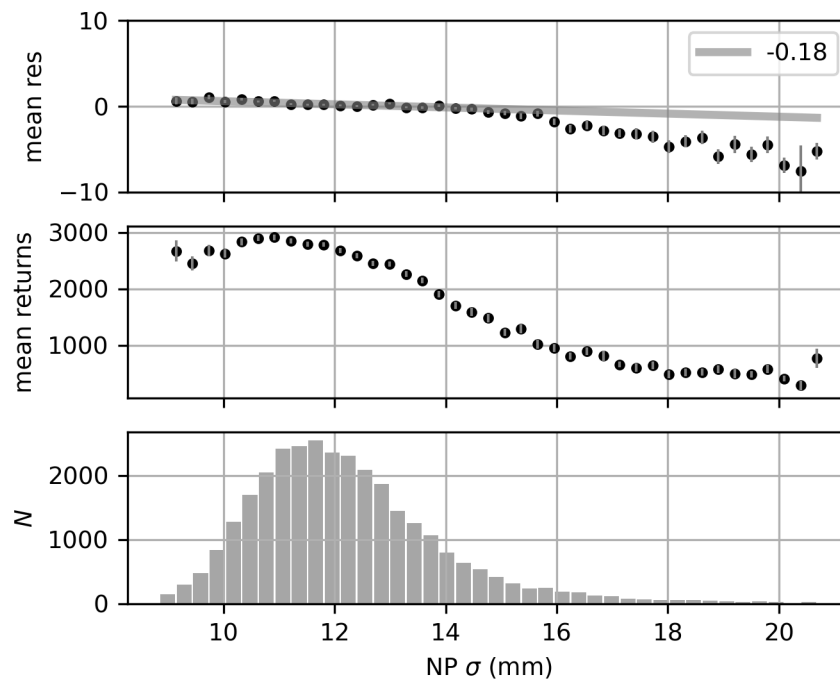


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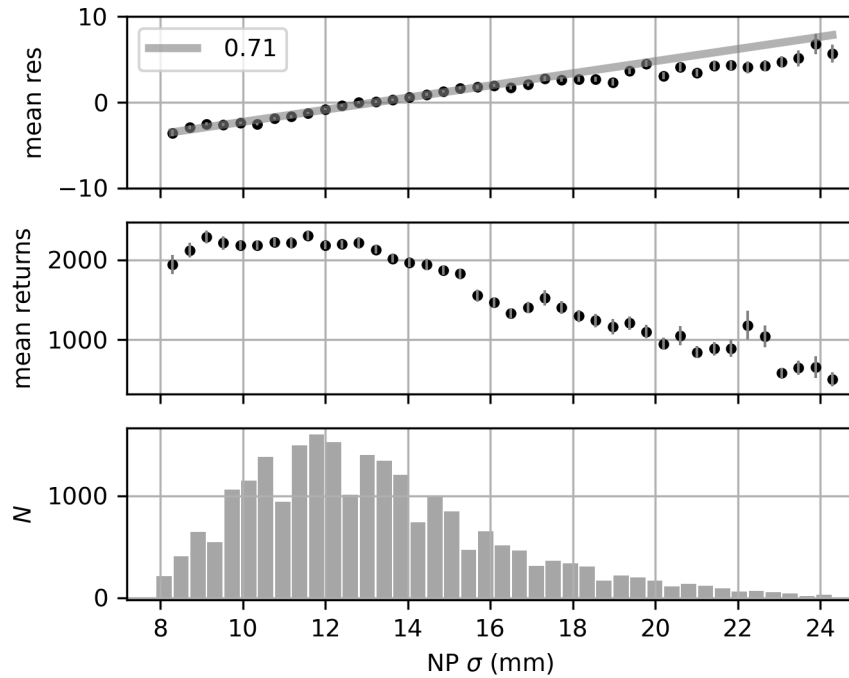


RMS-dependent CoM



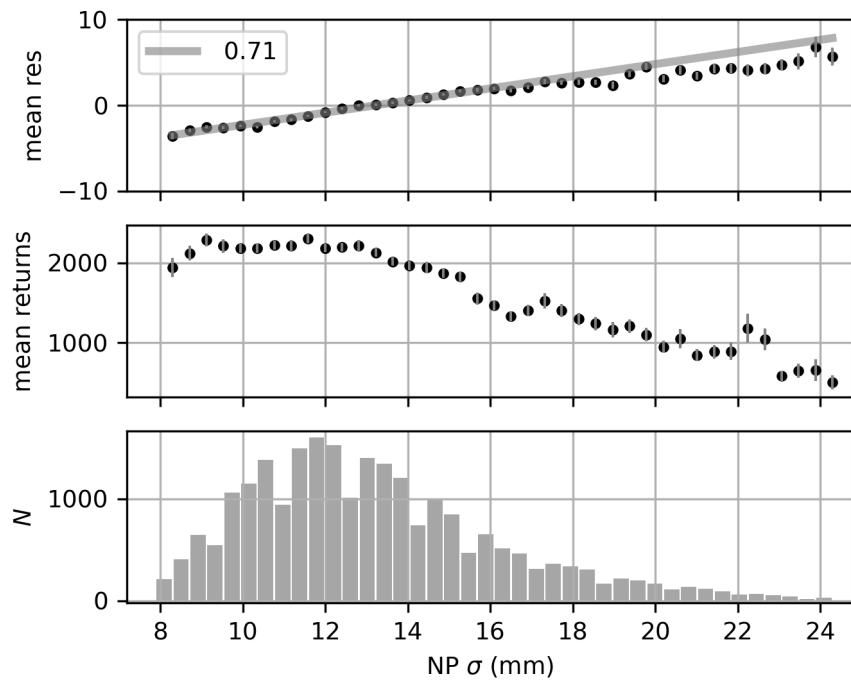
LAGEOS-2: Resids vs NP RMS

Standard CoM

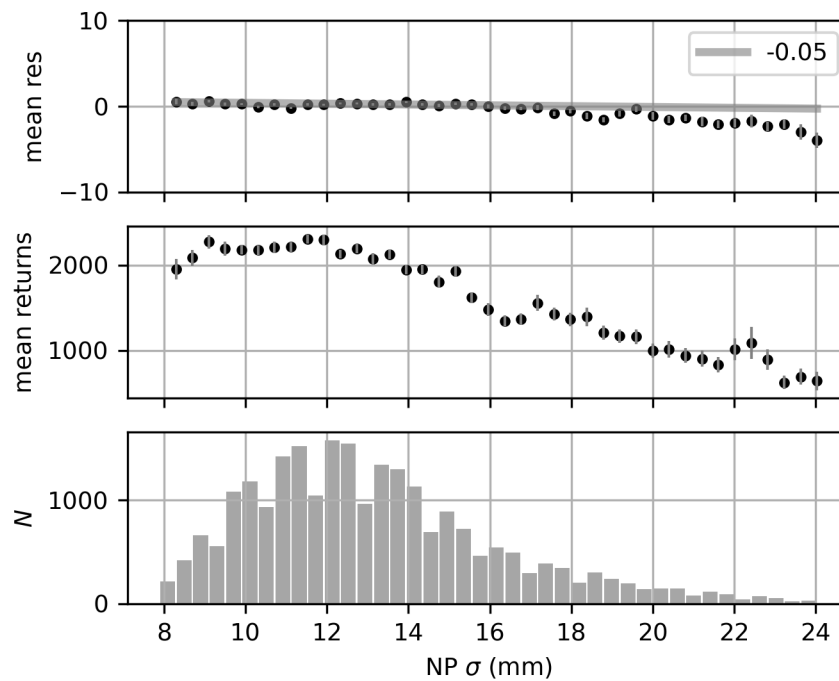


LAGEOS-2: Resids vs NP RMS

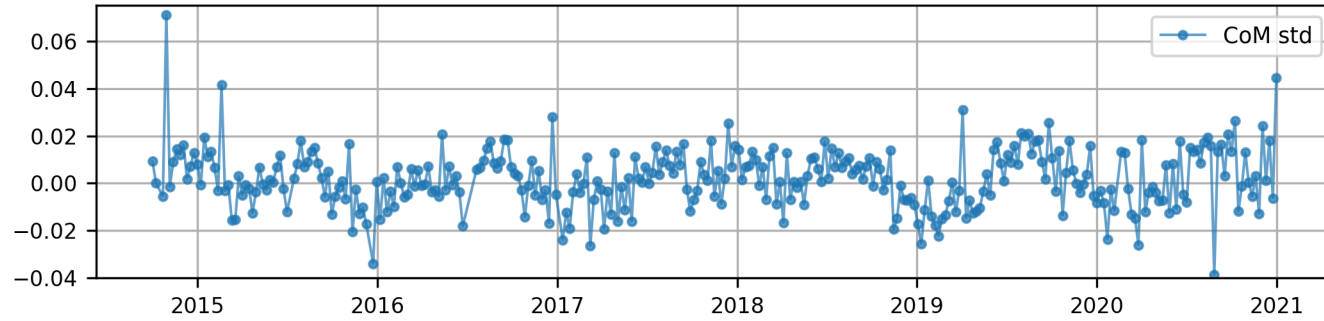
Standard CoM



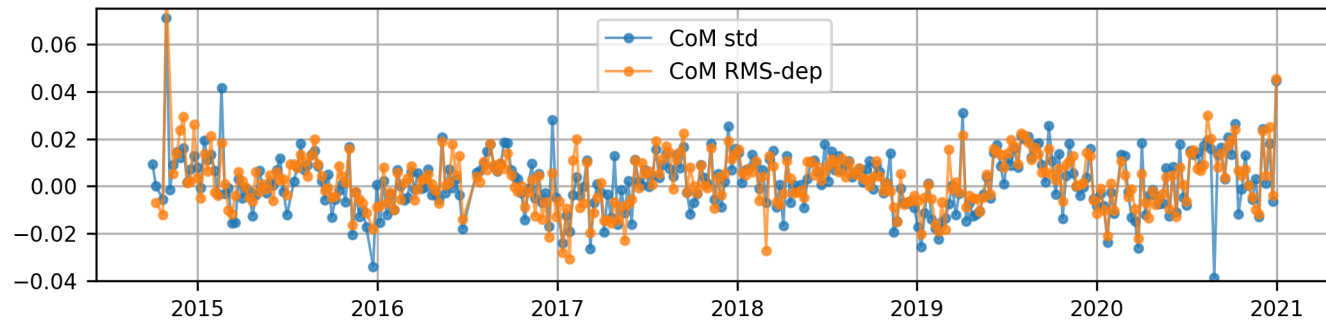
RMS-dependent CoM



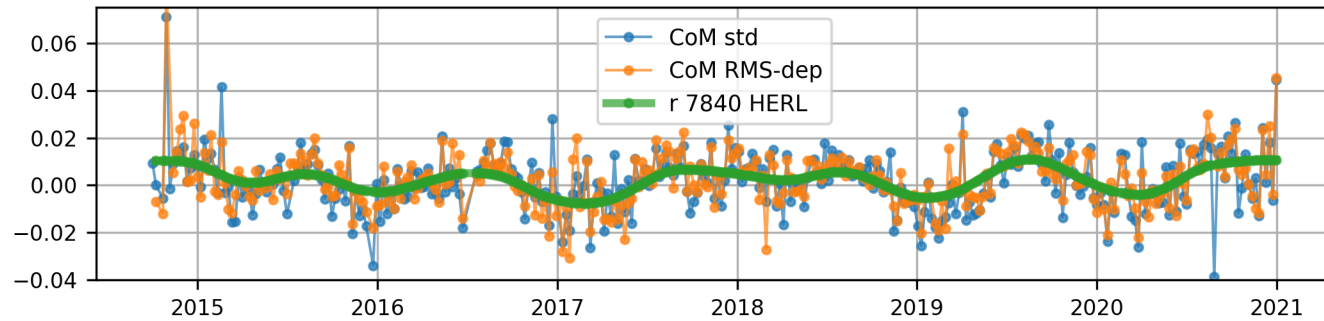
7840 HERL height



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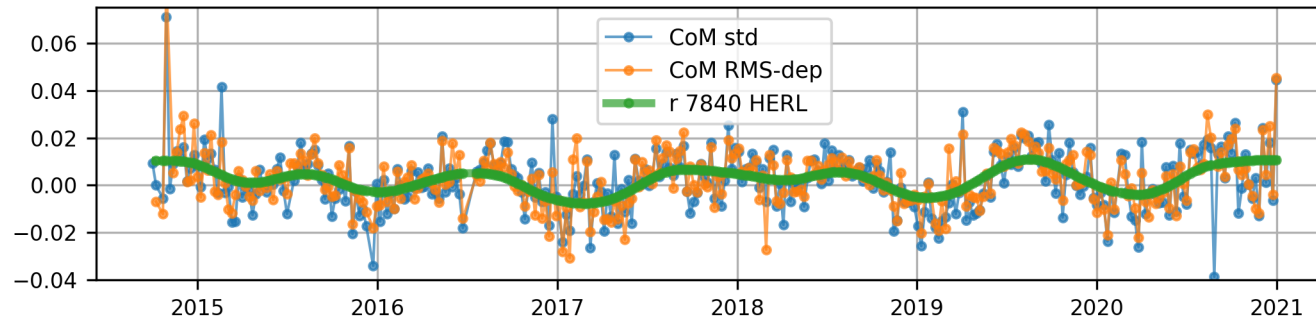


7840 HERL height



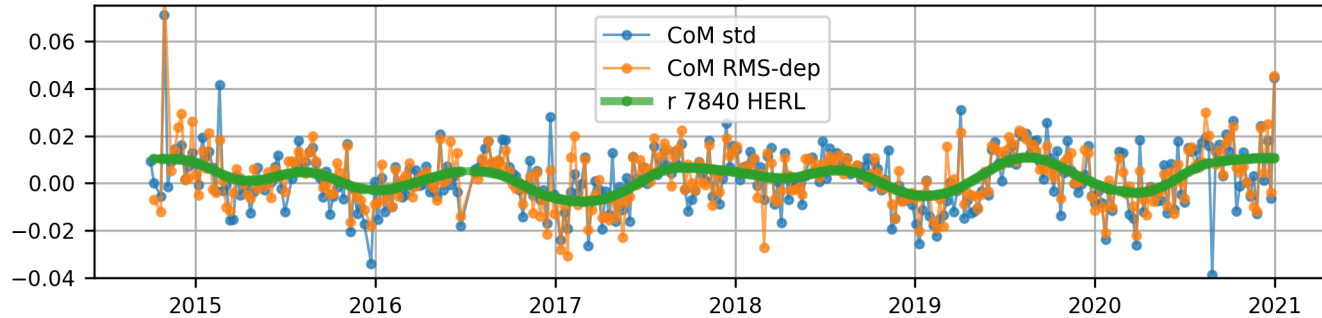
- RMS detrended height (CoM standard): **9.5 mm**
- RMS detrended height (CoM rms-dep): **8.3 mm**

7840 HERL height



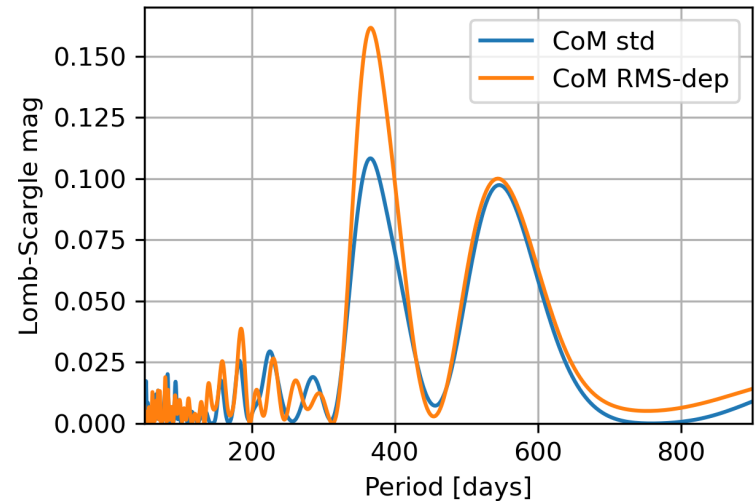
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7840 HERL height



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Periodogram height



WIP. Some remarks:

- Relative orientation determines the instantaneous distribution of returns
- This results in a distribution of centre of mass values around the mean
- Resids vs NP RMS trend not that scary
- We can take this effect into account to a good extent → RMS is a feature, not a bug
- Impact on geodetic products: limited but positive
- Instantaneous CoM correction possible for high-rate (KHz and beyond)
- More analysis required

Thank you