MXCuBE status at SOLEIL

Martin Savko
savko@synchrotron-soleil.fr

Proxima 1

Source: U20 in vacuum undulator

Focussing: KB, **CRL**

Tunable: 5.5 - 15.5 keV

Flux: 2.0e12 ph/s @ 500mA @ 12.65keV

Beam size: 20x40 μm

Detector: **Eiger X 16M**

Goniometer: SmarGon

Sample Changer: CATS

MXCuBE: **Qt4 v 2.3**

Proxima 2

Source: U24 in vacuum undulator

Focussing: KB + horizontal PFM

Tunable: 5.5 - 18.5 keV

Flux: 1.6e12 ph/s @ 500mA @ 12.65keV

Beam size: 5x10 μm

Detector: Eiger X 9M

Goniometer: MD2 with **MK3**

Sample Changer: CATS

MXCuBE: Qt3 v 2.1 (**Qt4 v2.3**)

Detectors

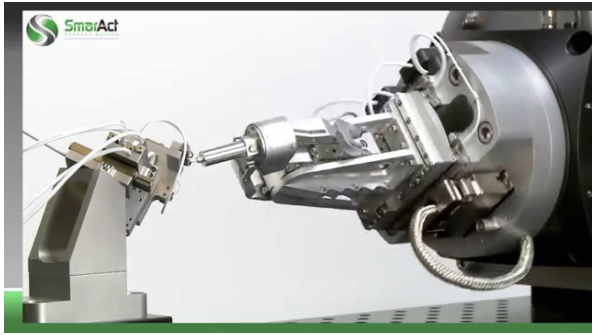
- Eiger X 9M on Proxima 2
    - In operation since 2015
- Eiger 16M and Pilatus 6M on Proxima 1
    - Pilatus In user operation since mid 2011
    - Passing to Eiger X 16M October 2018

MXCuBE development

- Following master branch
- Discipline to port back the local developments (bunch awaiting pull request)

Multiaxis goniometry

- Smargon goniometer on Proxima 1 (SmarAct)
  - SmarAxis Tango Device Server (C++) developed at SOLEIL



- Minikappa MK3 on Proxima 2 (Arinax)
  - JLIB software accessed through Tango Device server

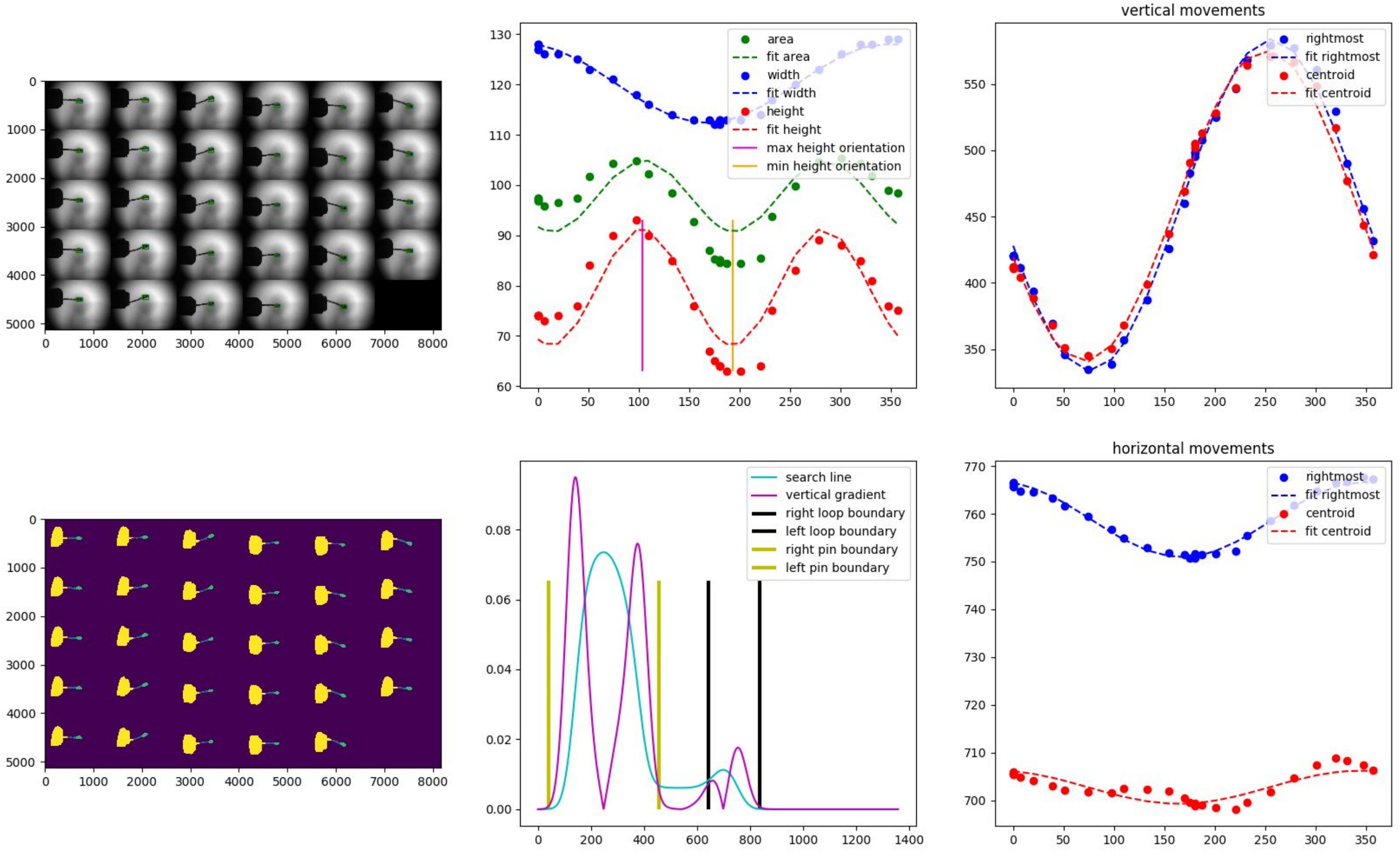
Sample changers

- CATS robots on both beamlines. Control via PyCats Tango Device Server
- Mature integration
  - Automated resolution of occasional problems
  - Failure rate below 1 per 1000

New software for optical sample segmentation

- Segmenting out pin, stem and loop
  - Based on analysis of series of images collected as function of omega axis
  - Speed: 4 seconds acquisition + 4 seconds analysis
- Loop bounding box in all orientation
- Chaining x-ray scan mesh with appropriate geometric parameters

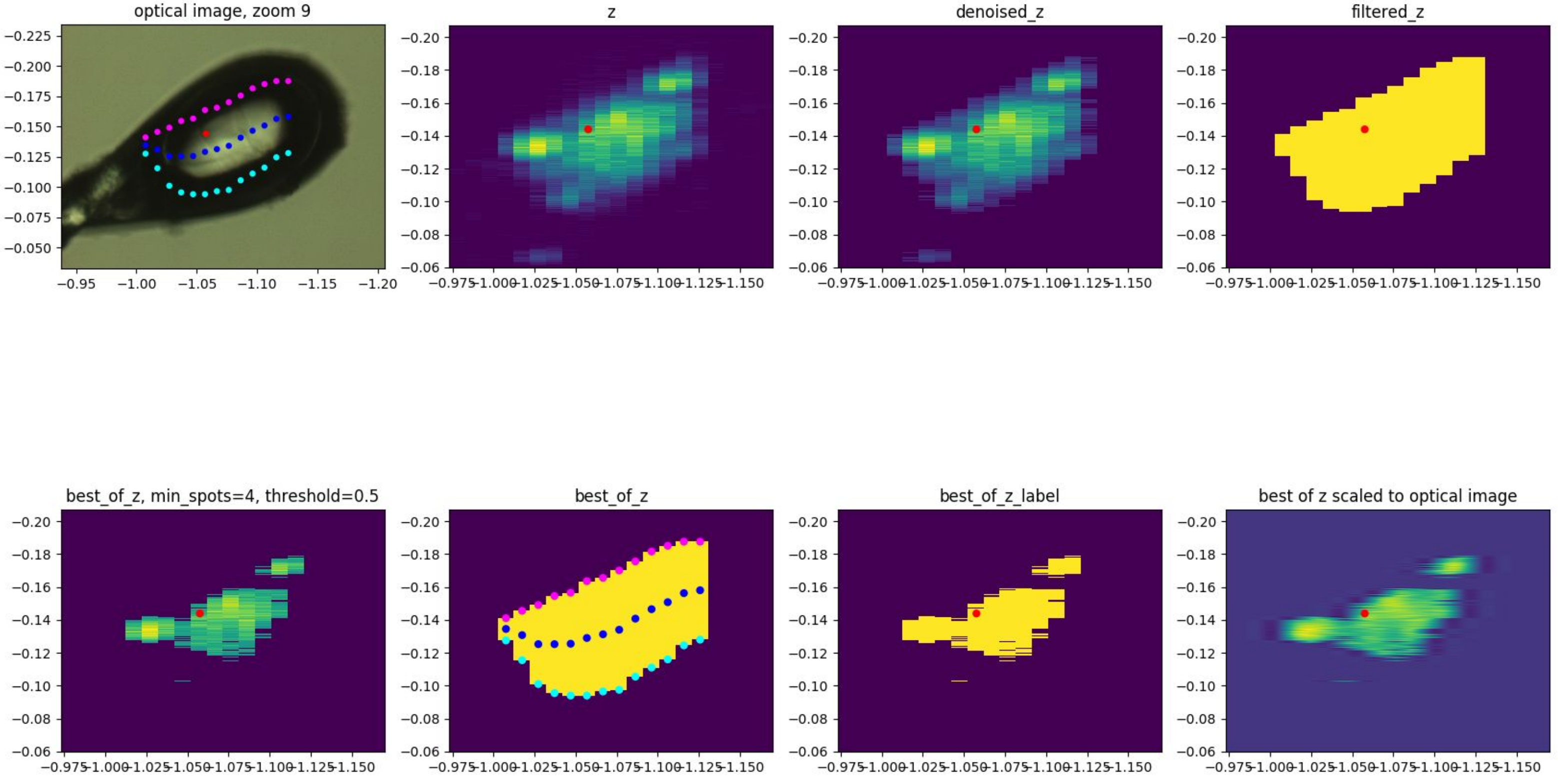
/nfs/data/Martin/Research/radiation_damage/2018-07-28/puck0027/7/7_z1a



Getting more information from mesh scans

- Optical segmentation of the loop
- Mesh scan at three orientations
- Determine sample size and shape
- Determine center curve
- -> spread the dose

7_max_0_a

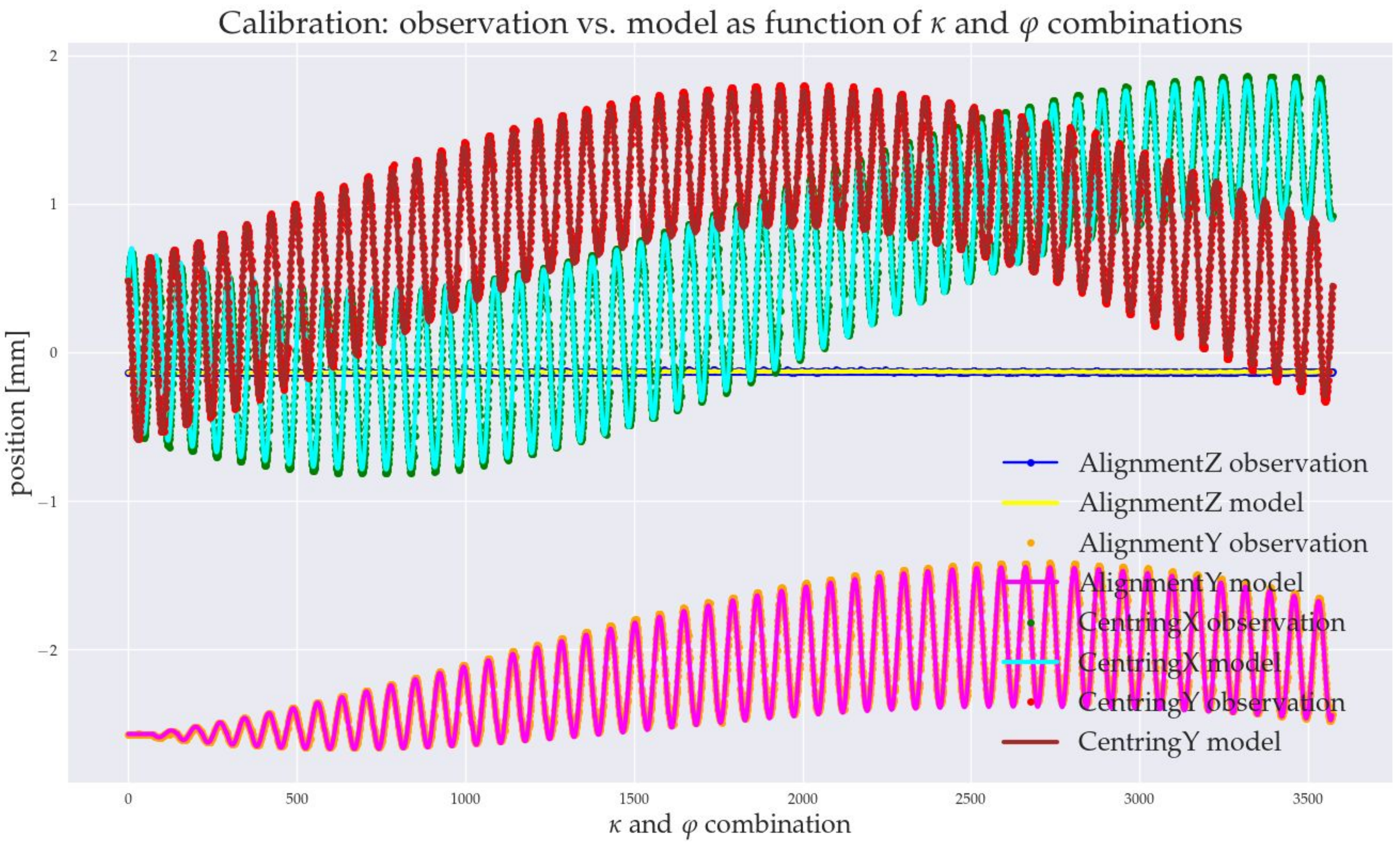

optical image, zoom 9
z
denoised_z
filtered_z
best_of_z, min_spots=4, threshold=0.5
best_of_z
best_of_z_label
best of z scaled to optical image

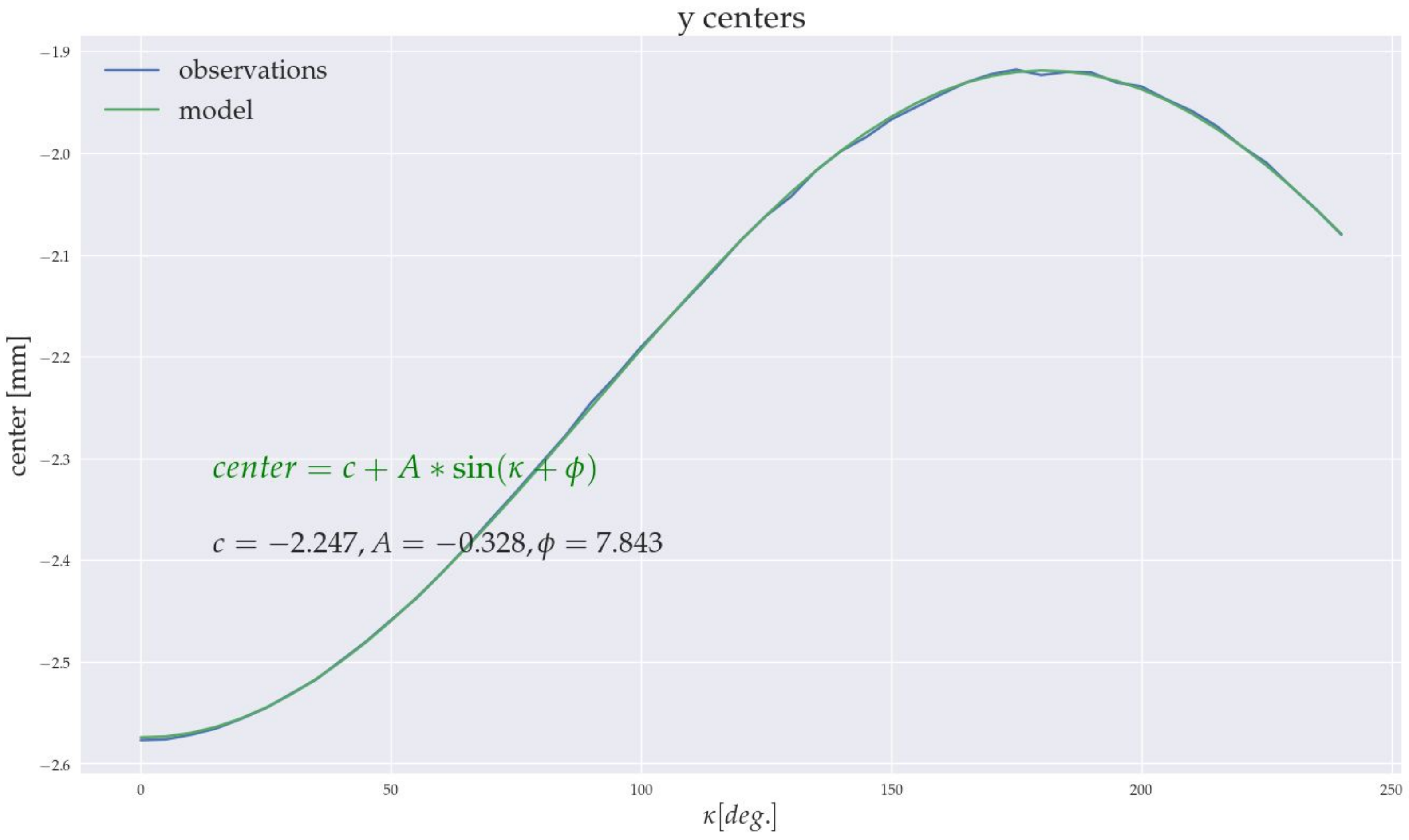
Minikappa calibration

- Using automated optical alignment and arbitrary sample (~3600 combinations of kappa and phi)
- Considering alignment axes separately

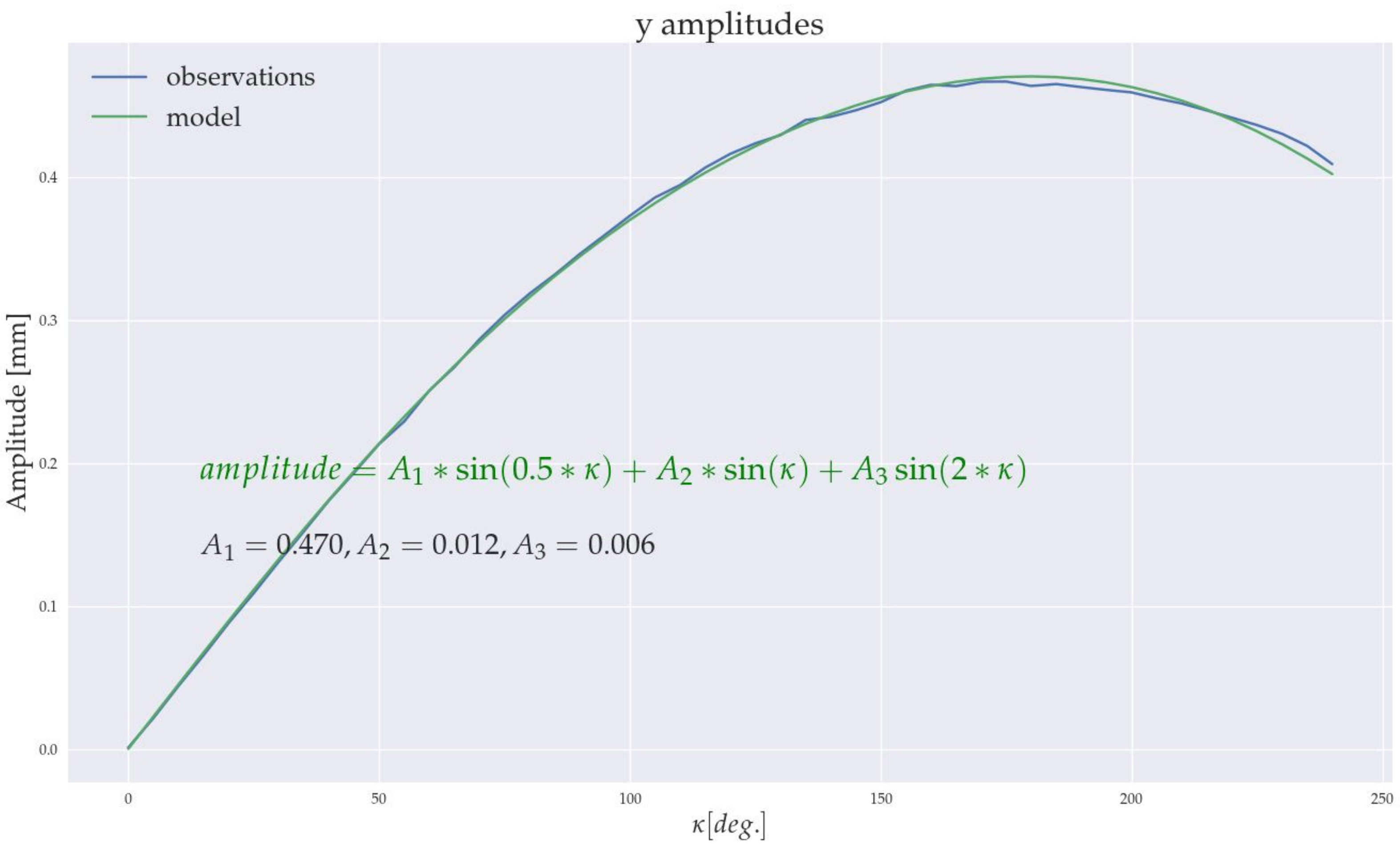
Model - circle moving on another circle

offset = center + amplitude*sin(k * phi - phase);
center, amplitude and phase are functions of kappa, k is 1 for centring motors (CentringX and CentringY) and 0.5 for horizontal alignment motor (AlignmentY)

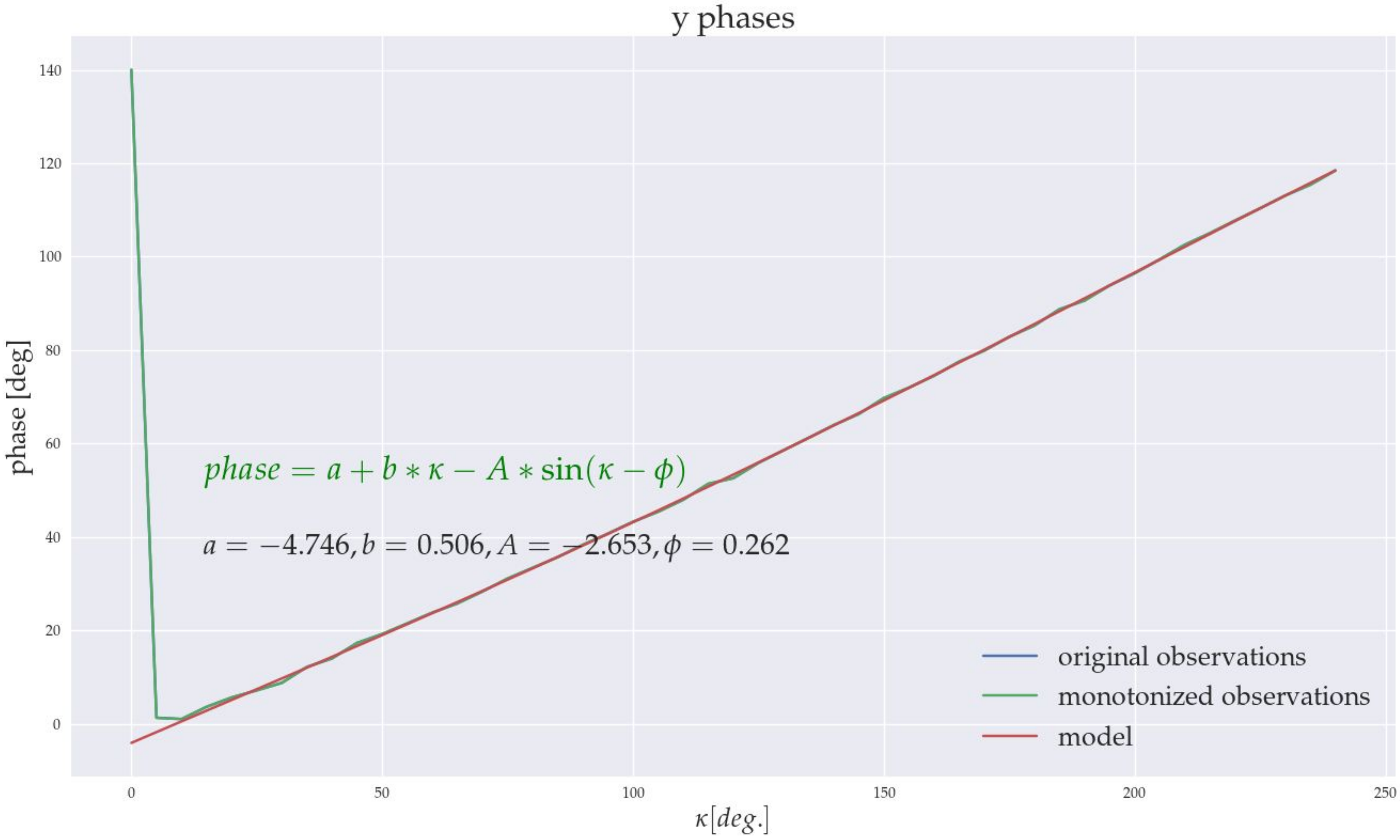

Calibration: observation vs. model as function of κ and φ combinations
position [mm]
2
1
0
−1
−2
0
500
1000
1500
2000
2500
3000
3500
κ and φ combination
AlignmentZ observation
AlignmentZ model
AlignmentY observation
AlignmentY model
CentringX observation
CentringX model
CentringY observation
CentringY model

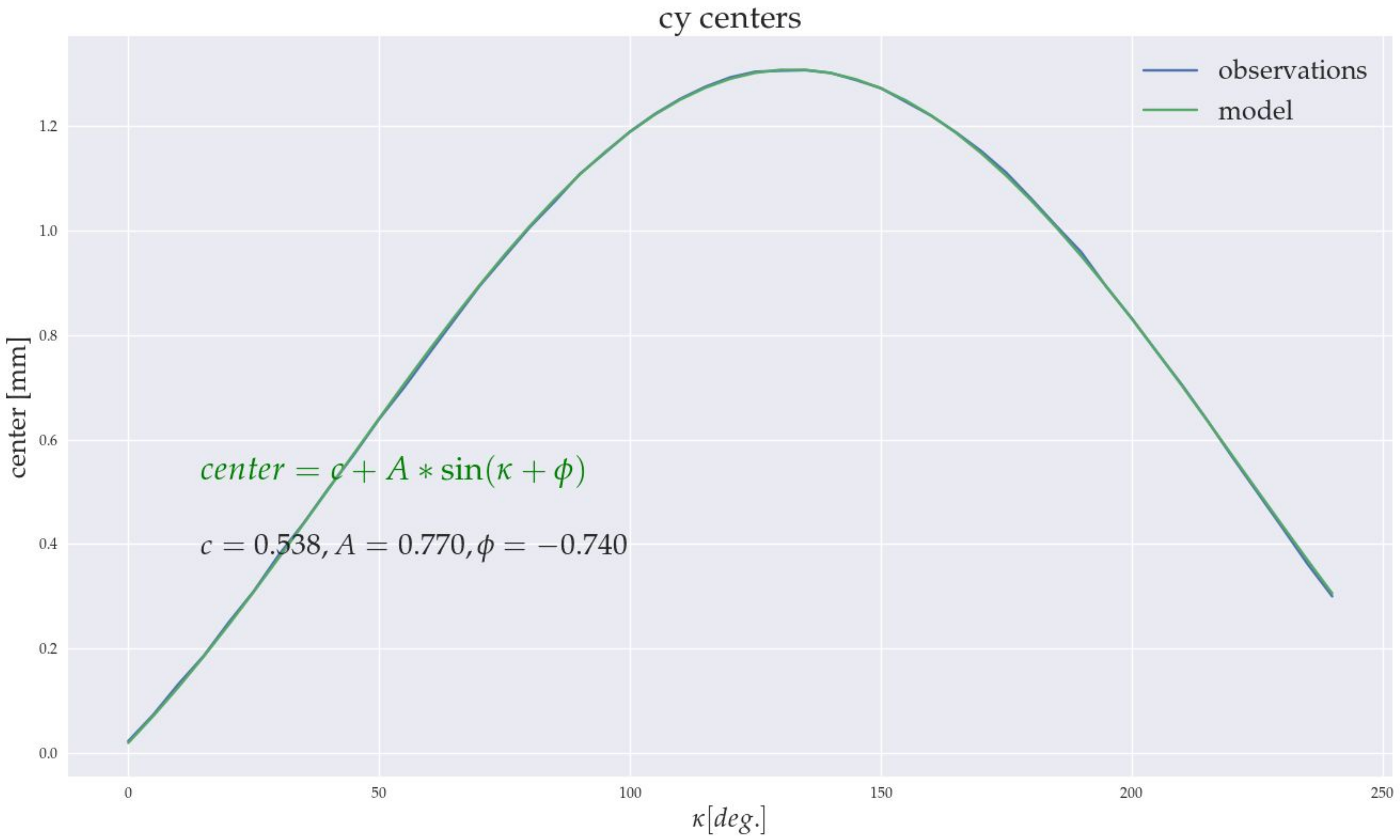


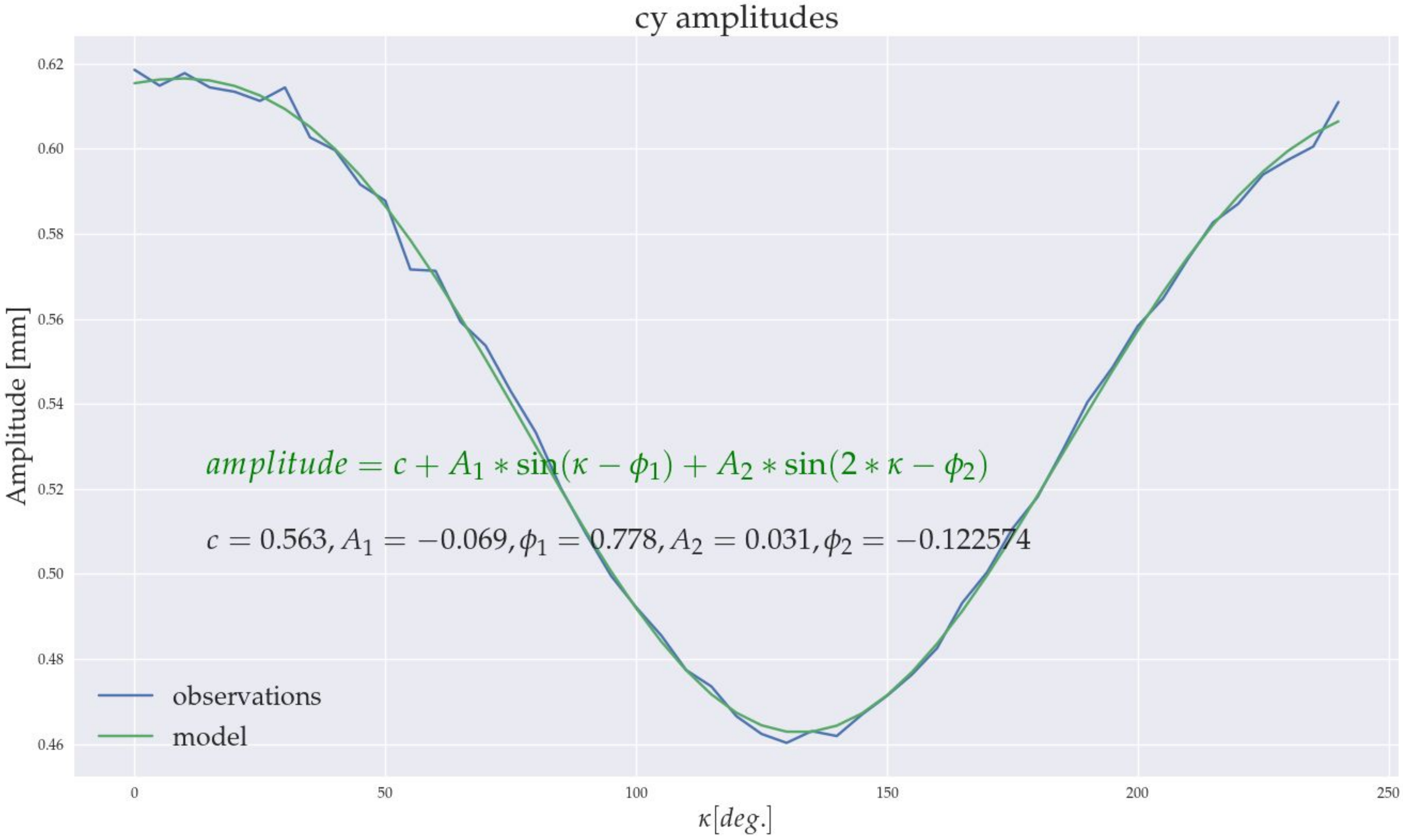
y centers
observations
model
center [mm]
−1.9
−2.0
−2.1
−2.2
−2.3
−2.4
−2.5
−2.6
0
50
100
150
200
250
κ[deg.]
center = c + A ∗ sin(κ + ϕ)
c = −2.247, A = −0.328, ϕ = 7.843

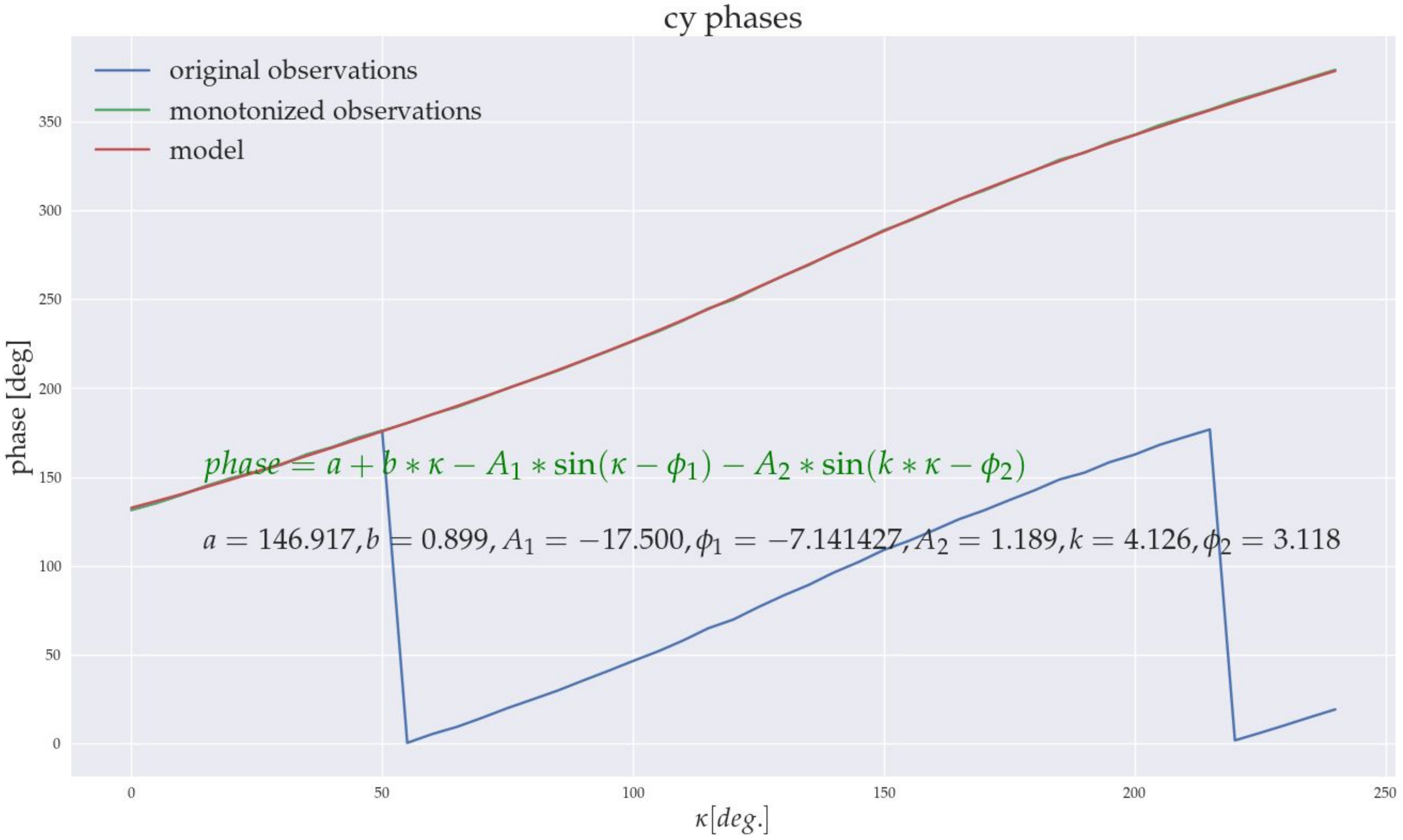


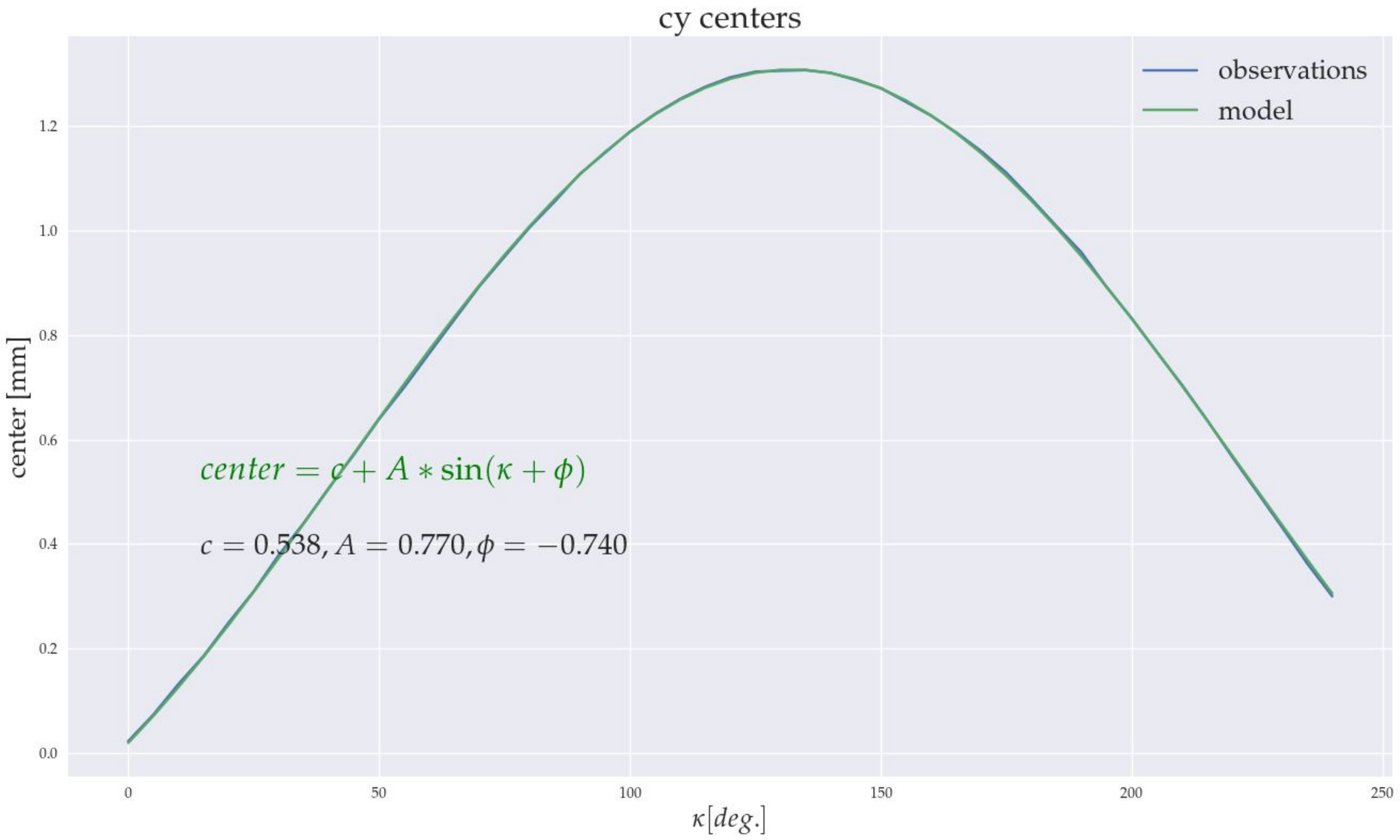
y amplitudes
observations
model
Amplitude [mm]
$\kappa[deg.]$
0.0
0.1
0.2
0.3
0.4
0
50
100
150
200
250
$amplitude = A_1 * \sin(0.5 * \kappa) + A_2 * \sin(\kappa) + A_3 \sin(2 * \kappa)$
$A_1 = 0.470, A_2 = 0.012, A_3 = 0.006$

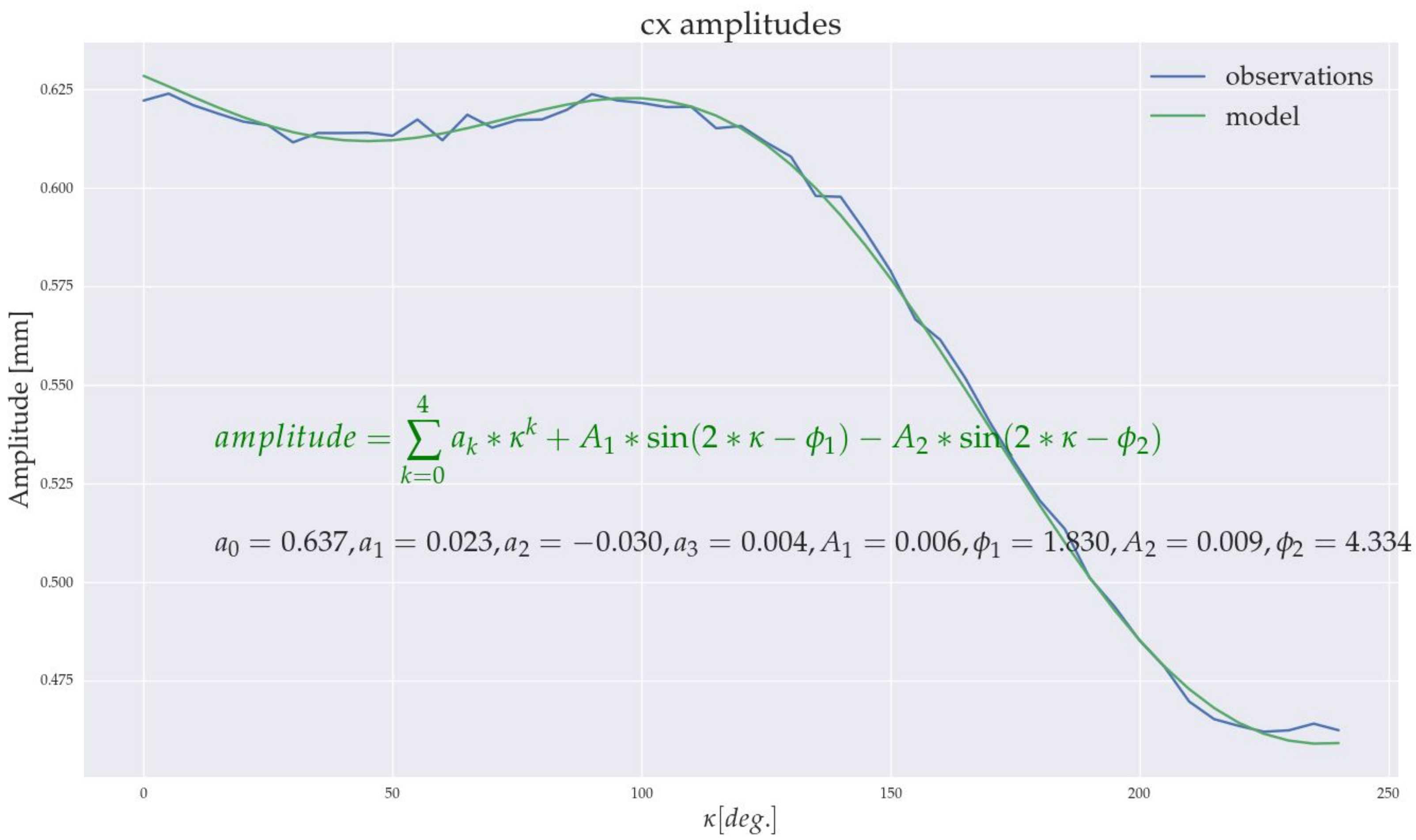

y phases
phase [deg]
140
120
100
80
60
40
20
0
0
50
100
150
200
250
$\kappa [deg.]$
$phase = a + b * \kappa - A * \sin(\kappa - \phi)$
$a = -4.746, b = 0.506, A = -2.653, \phi = 0.262$
original observations
monotonized observations
model


cy centers
observations
model
center [mm]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
50
100
150
200
250
κ[deg.]
center = c + A ∗ sin(κ + φ)
c = 0.538, A = 0.770, φ = −0.740

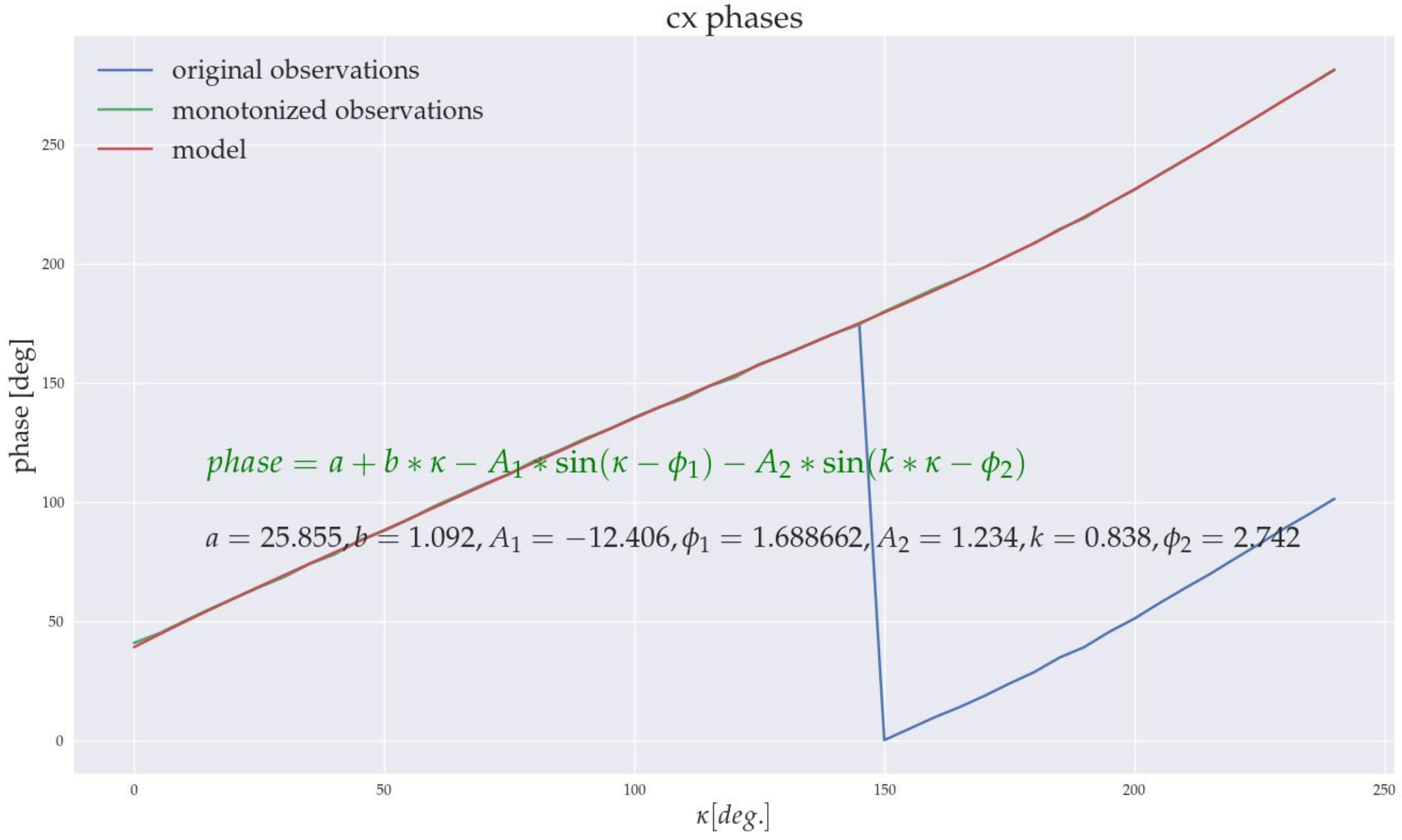

cy amplitudes
Amplitude [mm]
$\kappa[deg.]$
0.62
0.60
0.58
0.56
0.54
0.52
0.50
0.48
0.46
0
50
100
150
200
250
$amplitude = c + A_1 * \sin(\kappa - \phi_1) + A_2 * \sin(2 * \kappa - \phi_2)$
$c = 0.563, A_1 = -0.069, \phi_1 = 0.778, A_2 = 0.031, \phi_2 = -0.122574$
observations
model


cy phases
original observations
monotonized observations
model
$phase = a + b * \kappa - A_1 * \sin(\kappa - \phi_1) - A_2 * \sin(k * \kappa - \phi_2)$
$a = 146.917, b = 0.899, A_1 = -17.500, \phi_1 = -7.141427, A_2 = 1.189, k = 4.126, \phi_2 = 3.118$
phase [deg]
$\kappa[deg.]$
0
50
100
150
200
250
300
350


cy centers
observations
model
center [mm]
κ[deg.]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
250
$center = c + A * \sin(\kappa + \phi)$
$c = 0.538, A = 0.770, \phi = -0.740$



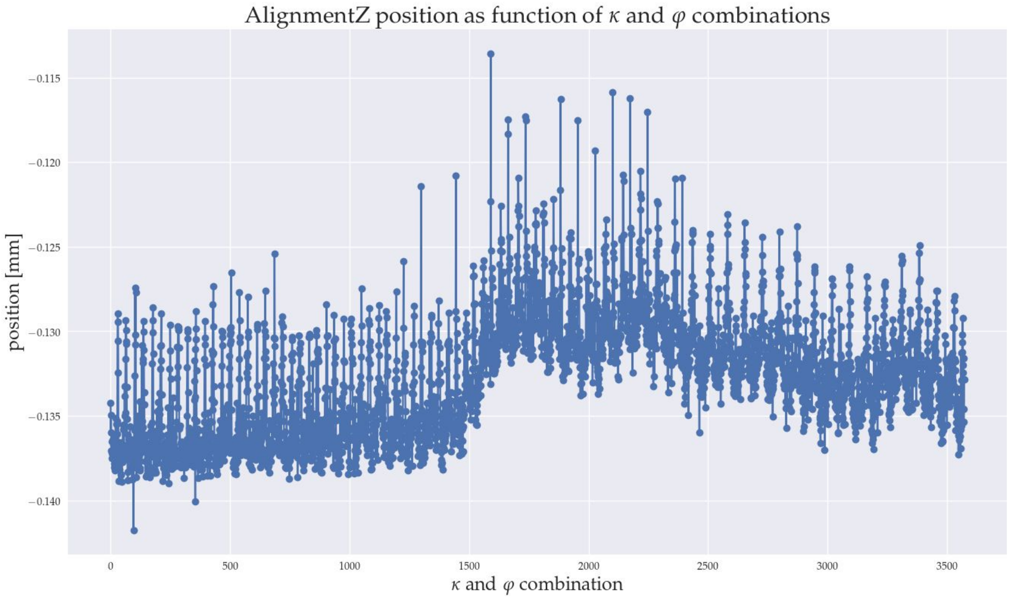
cx amplitudes
observations
model
0.625
0.600
0.575
0.550
0.525
0.500
0.475
Amplitude [mm]
0
50
100
150
200
250
κ[deg.]
amplitude = $\sum_{k=0}^{4} a_k * \kappa^k + A_1 * \sin(2 * \kappa - \phi_1) - A_2 * \sin(2 * \kappa - \phi_2)$
$a_0 = 0.637, a_1 = 0.023, a_2 = -0.030, a_3 = 0.004, A_1 = 0.006, \phi_1 = 1.830, A_2 = 0.009, \phi_2 = 4.334$



cx phases
original observations
monotonized observations
model
phase [deg]
κ[deg.]
0
50
100
150
200
250
$phase = a + b * \kappa - A_1 * \sin(\kappa - \phi_1) - A_2 * \sin(k * \kappa - \phi_2)$
$a = 25.855, b = 1.092, A_1 = -12.406, \phi_1 = 1.688662, A_2 = 1.234, k = 0.838, \phi_2 = 2.742$

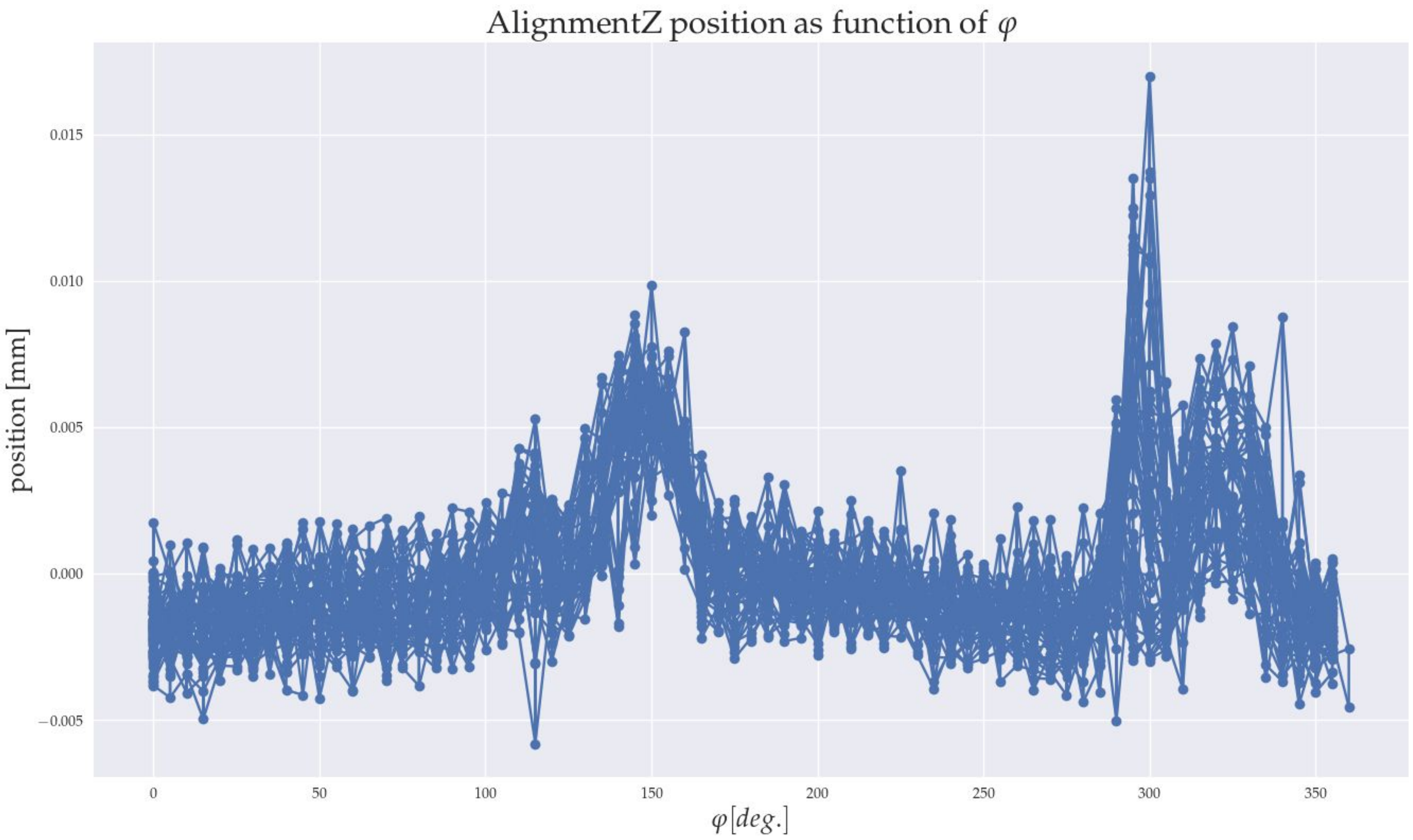
Omega axis position variations

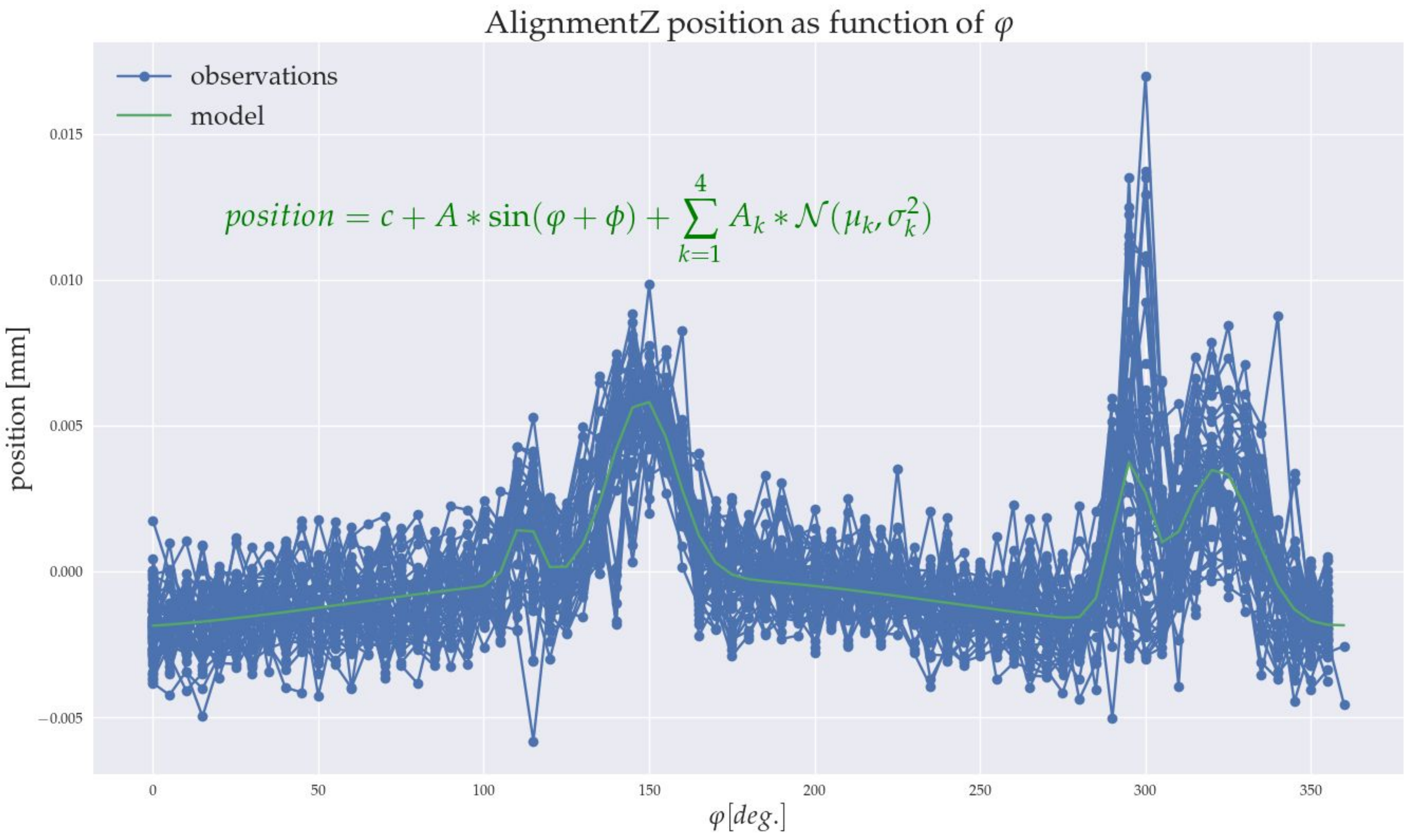
High number and accuracy of acquired data points allows for close inspection of omega axis position variations as a function of κ and φ.

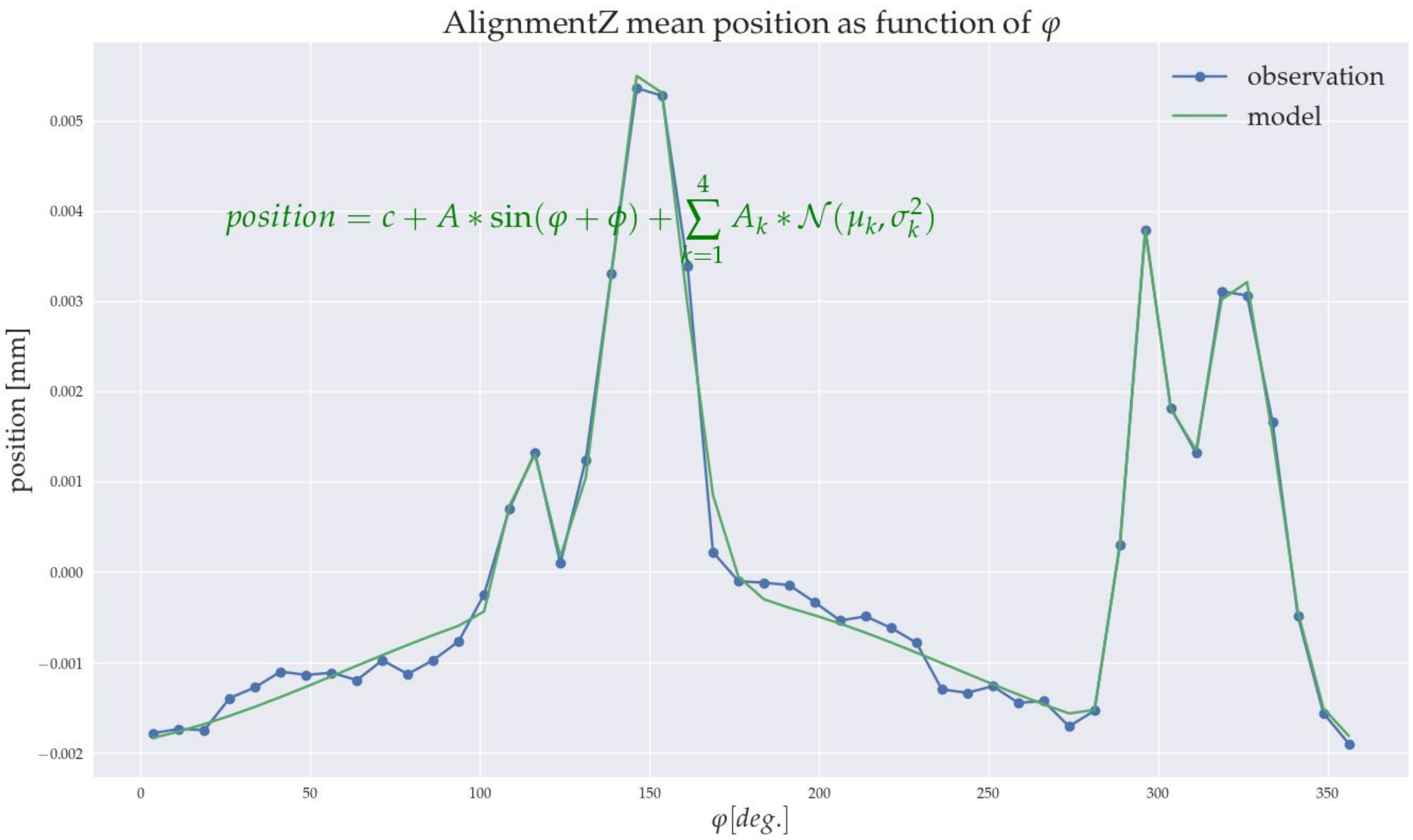



AlignmentZ mean position as function of κ
position [mm]
−0.128
−0.129
−0.130
−0.131
−0.132
−0.133
−0.134
−0.135
−0.136
0
50
100
150
200
250
κ[deg.]

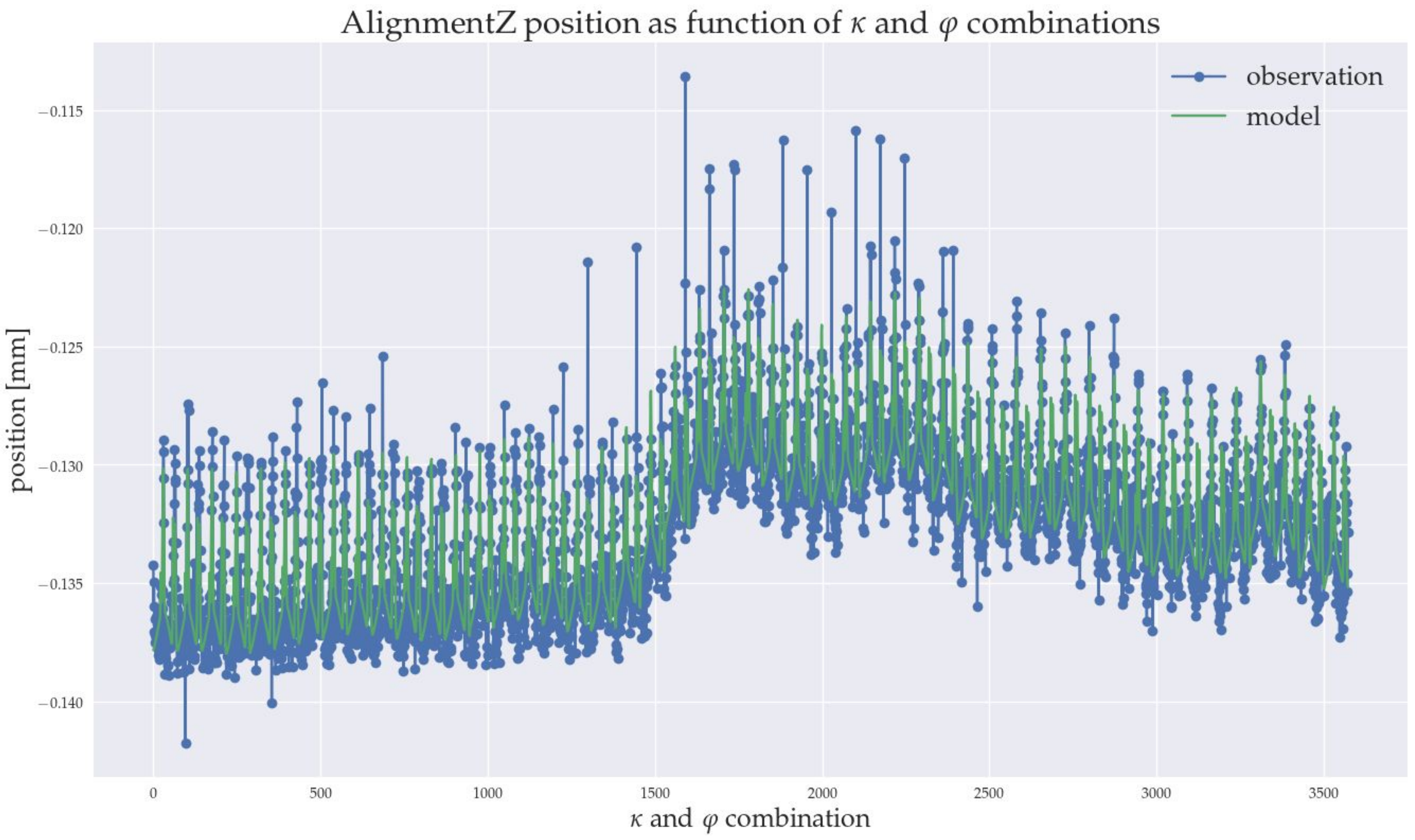
AlignmentZ mean position as function of κ
position [mm]
κ[deg.]
observation
model
$position = \sum_{k=0}^{24} a_k * \kappa^k$
−0.128
−0.129
−0.130
−0.131
−0.132
−0.133
−0.134
−0.135
−0.136
0
50
100
150
200
250


AlignmentZ position as function of φ
position [mm]
0.015
0.010
0.005
0.000
−0.005
0
50
100
150
200
250
300
350
$\varphi[deg.]$


AlignmentZ position as function of φ
observations
model
position = c + A * sin(φ + ϕ) + Σ_{k=1}^{4} A_k * N(μ_k, σ_k^2)
position [mm]
0.015
0.010
0.005
0.000
−0.005
0
50
100
150
200
250
300
350
φ[deg.]



AlignmentZ mean position as function of φ
observation
model
$position = c + A * \sin(\varphi + \phi) + \sum_{k=1}^{4} A_k * \mathcal{N}(\mu_k, \sigma_k^2)$
position [mm]
0.005
0.004
0.003
0.002
0.001
0.000
−0.001
−0.002
0
50
100
150
200
250
300
350
$\varphi[deg.]$



AlignmentZ position as function of κ and φ combinations
observation
model
position [mm]
−0.115
−0.120
−0.125
−0.130
−0.135
−0.140
0
500
1000
1500
2000
2500
3000
3500
κ and φ combination

Omega axis position variations

- Optical alignment sufficiently accurate to reveal fine structure in Omega axis positioning due to mechanical imperfections of kappa and phi axes.
- step function of ~7 um at kappa 103°
- gravitational sag of ~5 um at specific phi positions: 115°, 145°, 295° (115° + 180°) and 325° (145° + 180°)

Model accuracy

axis name	Mean absolute error [µm]	Median absolute error [µm]	Standard deviation [µm]
AlignmentZ	1.1	0.8	1.5
AlignmentY	14.1	11.5	19.3
CentringX	24.0	22.9	29.8
CentringY	20.5	18.7	26.3

Acknowledgements

- Lidia Ciccone
- Pierre Legrand
- Bill Shepard
- Leo Chavas
- Gavin Fox
- Damien Jeangerard
- Serena Sirigu
- Tatiana Isabet
- Patrick Gourhant
- Bixente Rey
- Olof Svensson