

## Calibration results

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### Normalized Residuals

Reprojection error (cam0): mean 0.385392703285618, median 0.3400166765294105, std: 0.2414295685084283  
Reprojection error (cam1): mean 0.46261206811737765, median 0.42189097515655716, std: 0.270943866211912  
Reprojection error (cam2): mean 0.4098809816867086, median 0.341505100337393, std: 0.299453405933923  
Gyroscope error (imu0): mean 1.297387187533648, median 1.053036773112588, std: 1.1789401144850835  
Accelerometer error (imu0): mean 2.4889914559527613, median 2.2896211047407675, std: 1.2927070788880815

### Residuals

Reprojection error (cam0) [px]: mean 0.385392703285618, median 0.3400166765294105, std: 0.2414295685084283  
Reprojection error (cam1) [px]: mean 0.46261206811737765, median 0.42189097515655716, std: 0.270943866211912  
Reprojection error (cam2) [px]: mean 0.4098809816867086, median 0.341505100337393, std: 0.299453405933923  
Gyroscope error (imu0) [rad/s]: mean 0.0015850594433998591, median 0.0012865287228883884, std: 0.0014403488639500902  
Accelerometer error (imu0) [m/s<sup>2</sup>]: mean 0.06829792555134377, median 0.06282720311408667, std: 0.03547188224468895

### Transformation (cam0):

#### T\_ci: (imu0 to cam0):

```
[[-0.99999962 0.0005534 0.00067927 0.09963088]
 [0.0005526 0.99999915 -0.00118271 0.02581204]
 [-0.00067993 -0.00118233 -0.99999907 0.00647339]
 [0. 0. 0. 1. ]]
```

#### T\_ic: (cam0 to imu0):

```
[[-0.99999962 0.0005526 -0.00067993 0.09962098]
 [0.0005534 0.99999915 -0.00118233 -0.0258595 ]
 [0.00067927 -0.00118271 -0.99999907 0.00643624]
 [0. 0. 0. 1. ]]
```

timeshift cam0 to imu0: [s] (t\_imu = t\_cam + shift)  
0.006761239617755742

Transformation (cam1):

-----  
T\_ci: (imu0 to cam1):

```
[[ -0.99999834  0.00134441 -0.00122727 -0.02023717]
 [  0.00134526  0.99999886 -0.00069226  0.02563391]
 [  0.00122634 -0.00069391 -0.99999901  0.00765302]
 [  0.          0.          0.          1.          ]]
```

T\_ic: (cam1 to imu0):

```
[[ -0.99999834  0.00134526  0.00122634 -0.02028101]
 [  0.00134441  0.99999886 -0.00069391 -0.02560137]
 [ -0.00122727 -0.00069226 -0.99999901  0.00764592]
 [  0.          0.          0.          1.          ]]
```

timeshift cam1 to imu0: [s] (t\_imu = t\_cam + shift)  
0.006784775077820741

Transformation (cam2):

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T\_ci: (imu0 to cam2):

```
[[ -0.99999189  0.00176128  0.00362215  0.06855274]
 [  0.00174654  0.9999902  -0.00406888  0.03190135]
 [ -0.00362928 -0.00406252 -0.99998516  0.0098371 ]
 [  0.          0.          0.          1.          ]]
```

T\_ic: (cam2 to imu0):

```
[[ -0.99999189  0.00174654 -0.00362928  0.06853217]
 [  0.00176128  0.9999902  -0.00406252 -0.03198181]
 [  0.00362215 -0.00406888 -0.99998516  0.00971845]
 [  0.          0.          0.          1.          ]]
```

timeshift cam2 to imu0: [s] (t\_imu = t\_cam + shift)  
0.00811377722300753

Baselines:

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Baseline (cam0 to cam1):

```
[[ 0.99999787 0.00079327 0.00190561 -0.11990065]
[-0.00079233 0.99999957 -0.00049098 -0.000096 ]
[-0.001906 0.00048947 0.99999806 0.0013569 ]
[ 0. 0. 0. 1. ]]
```

baseline norm: 0.11990836977878411 [m]

Baseline (cam1 to cam2):

```
[[ 0.99998815 0.00041352 -0.00484969 0.08881619]
[-0.00039714 0.99999422 0.00337711 0.0062337 ]
[ 0.00485106 -0.00337514 0.99998254 0.0023689 ]
[ 0. 0. 0. 1. ]]
```

baseline norm: 0.08906618799888644 [m]

Gravity vector in target coords: [m/s<sup>2</sup>]

[-0.03308749 -9.77373691 -0.80087133]

Calibration configuration

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cam0

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Camera model: pinhole

Focal length: [1059.798441786791, 1058.7112853994076]

Principal point: [673.3870682823868, 331.65536460528125]

Distortion model: radtan

Distortion coefficients: [-0.4002742426392474, 0.17056618041313354, 0.00048741925230120315, 0.0007060954021436913]

Type: aprilgrid

Tags:

Rows: 5

Cols: 7  
Size: 0.04 [m]  
Spacing 0.01 [m]

cam1

-----  
Camera model: pinhole  
Focal length: [1055.3158626684692, 1054.641474987198]  
Principal point: [670.8052470781481, 324.5193403310099]  
Distortion model: radtan  
Distortion coefficients: [-0.40030215796888774, 0.16639937529942397, 0.00036765555387976463,  
0.0013303868471007867]  
Type: aprilgrid  
Tags:  
Rows: 5  
Cols: 7  
Size: 0.04 [m]  
Spacing 0.01 [m]

cam2

-----  
Camera model: pinhole  
Focal length: [1266.4626100231476, 1264.854376051191]  
Principal point: [649.0974421698934, 363.35085318485955]  
Distortion model: radtan  
Distortion coefficients: [-0.42058761598918115, 0.19684519573567003, 0.0008715049415326623,  
0.0002894328952163947]  
Type: aprilgrid  
Tags:  
Rows: 5  
Cols: 7  
Size: 0.04 [m]  
Spacing 0.01 [m]

IMU configuration

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IMU0:

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Model: calibrated

Update rate: 400.0

Accelerometer:

Noise density: 0.001372

Noise density (discrete): 0.02744

Random walk: 5e-05

Gyroscope:

Noise density: 6.10866e-05

Noise density (discrete): 0.0012217320000000001

Random walk: 4e-06

T\_ib (imu0 to imu0)

[[1. 0. 0. 0.]

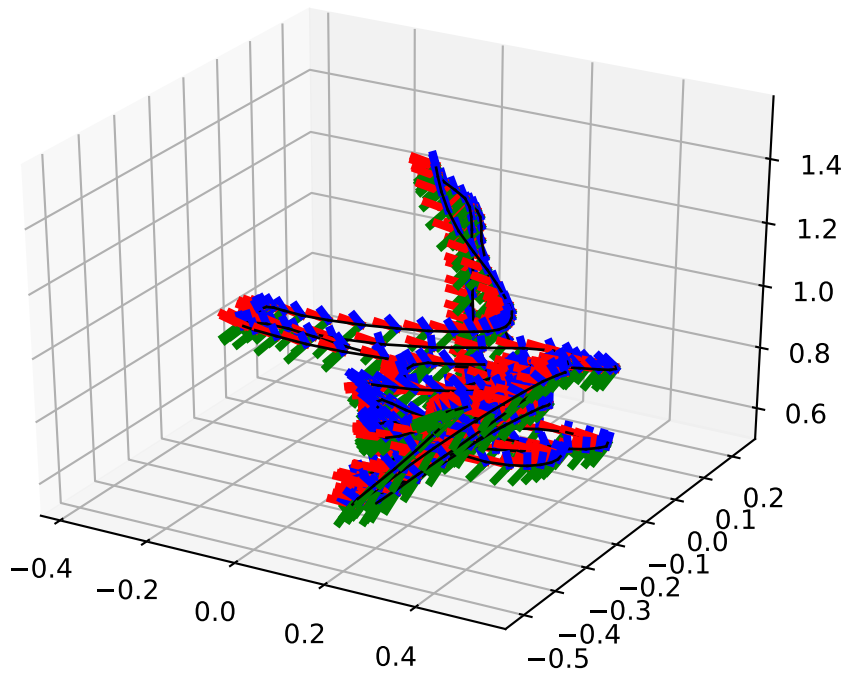
[0. 1. 0. 0.]

[0. 0. 1. 0.]

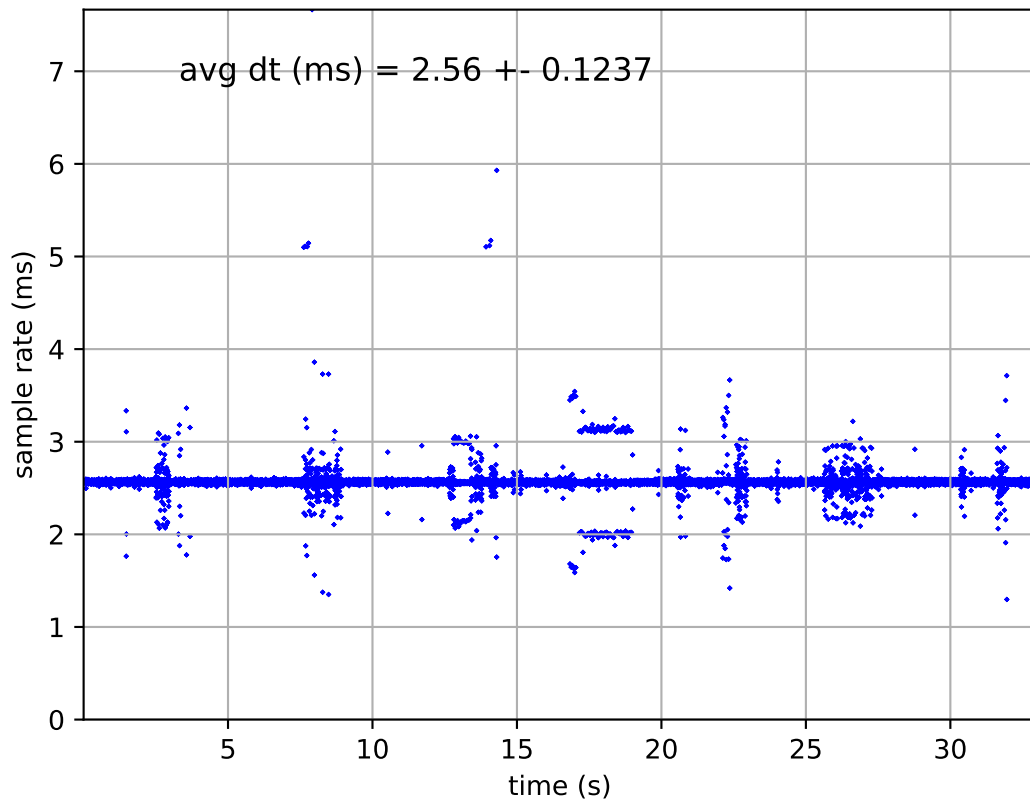
[0. 0. 0. 1.]]

time offset with respect to IMU0: 0.0 [s]

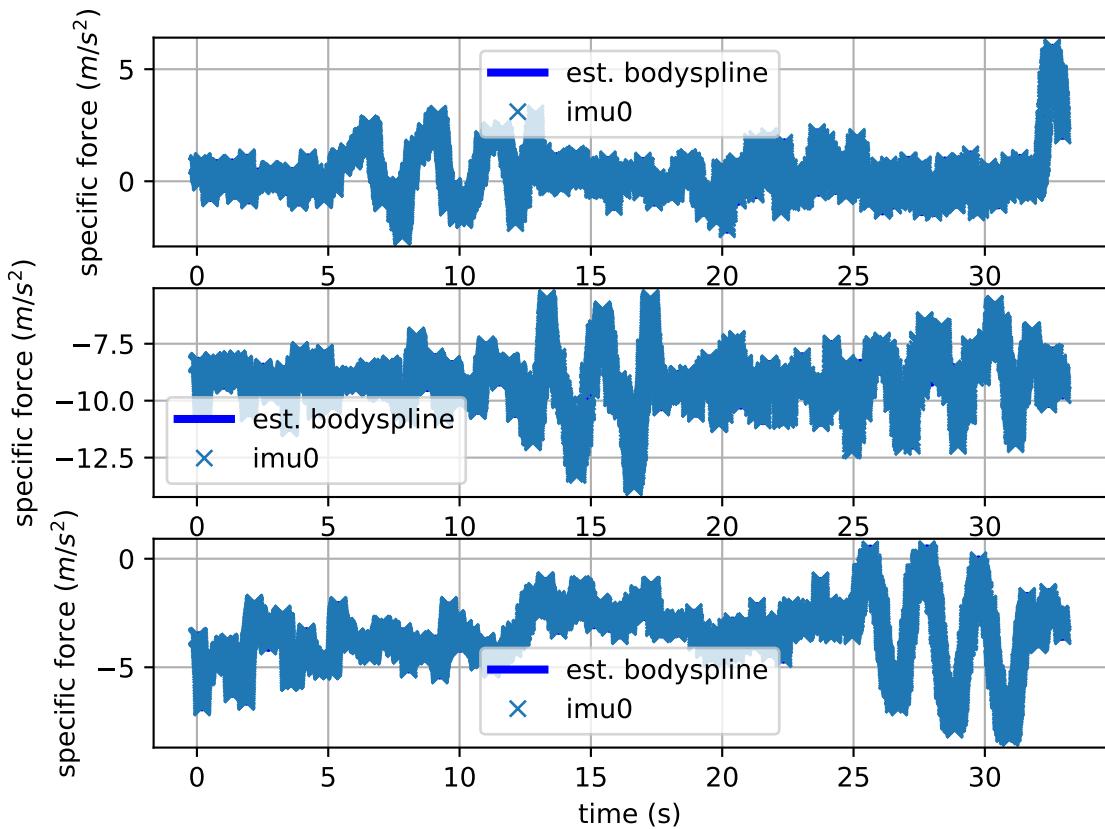
imu0: estimated poses



# imu0: sample inertial rate

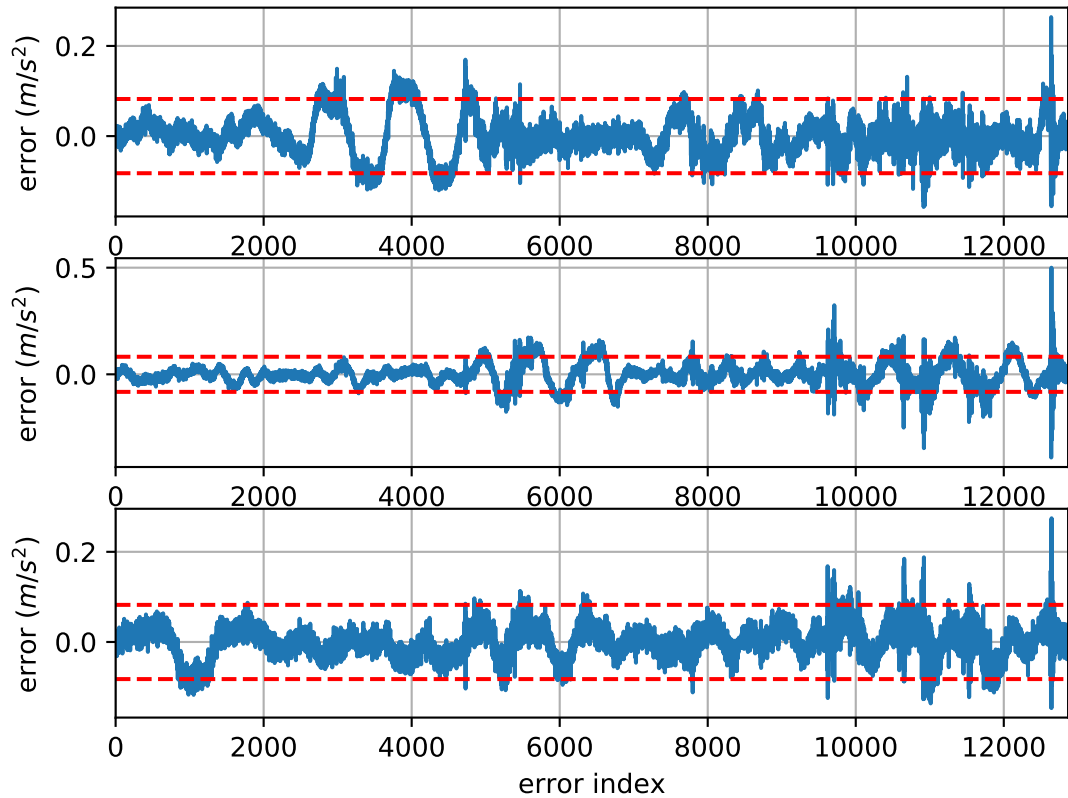


# Comparison of predicted and measured specific force (imu0 frame)

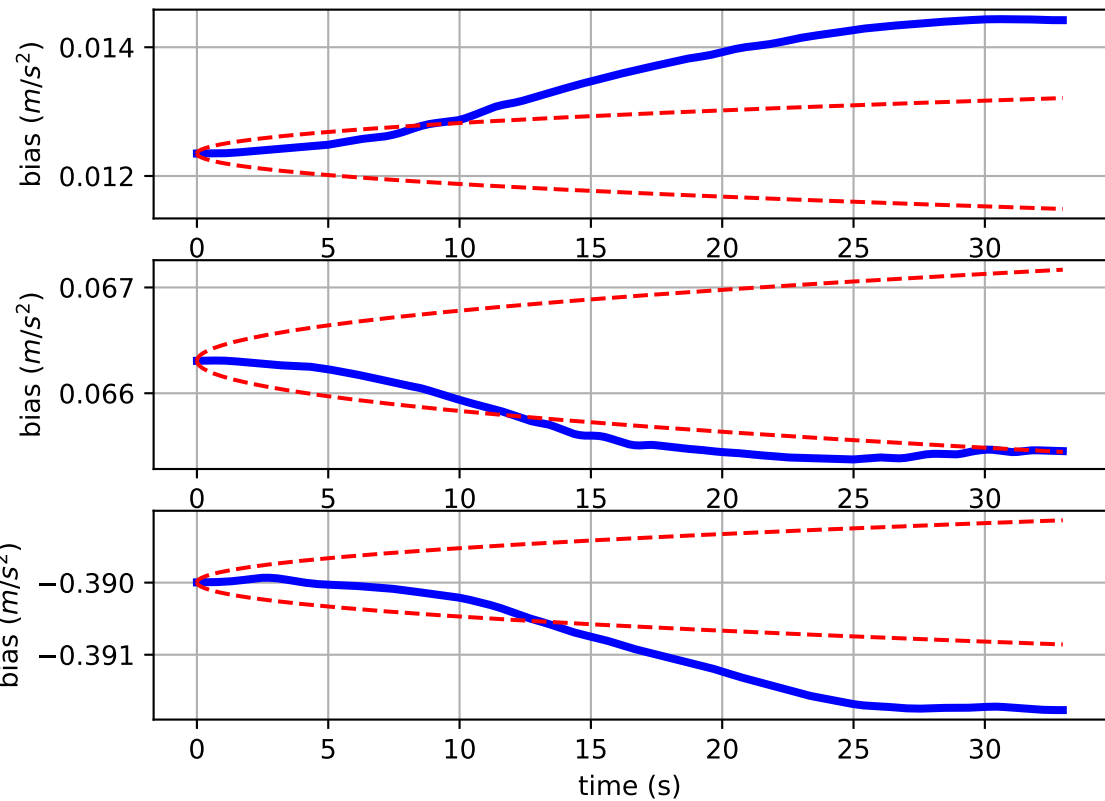




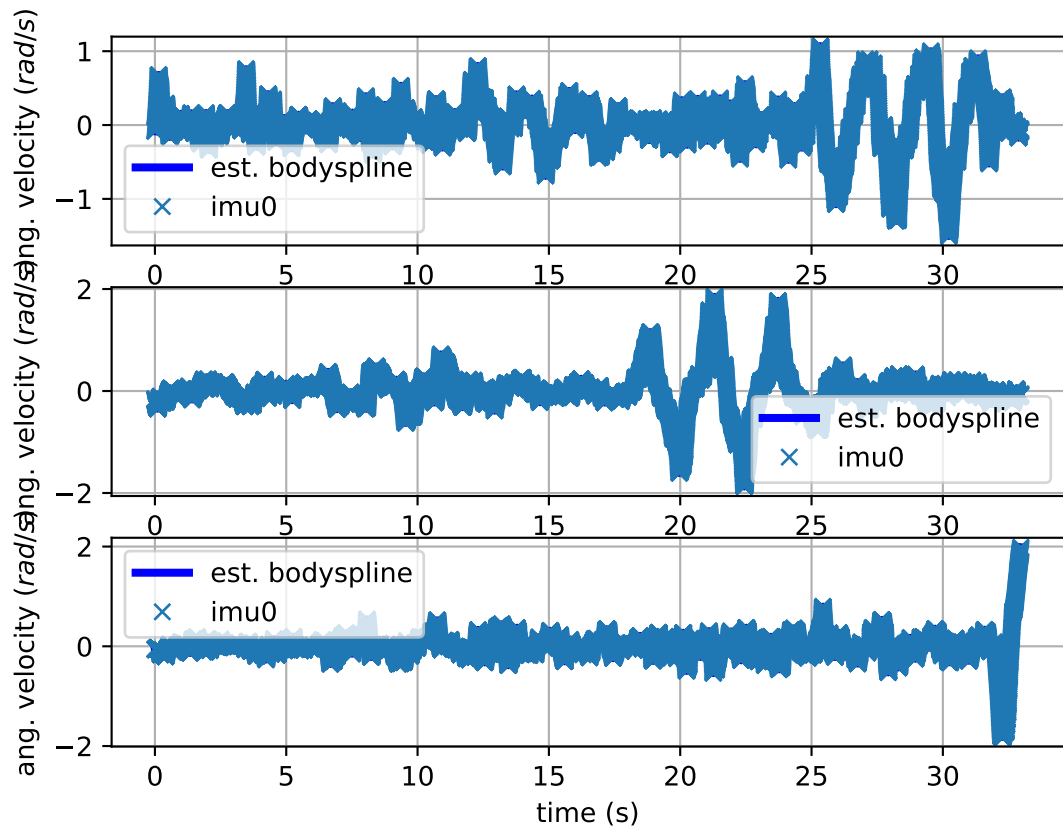
# imu0: acceleration error



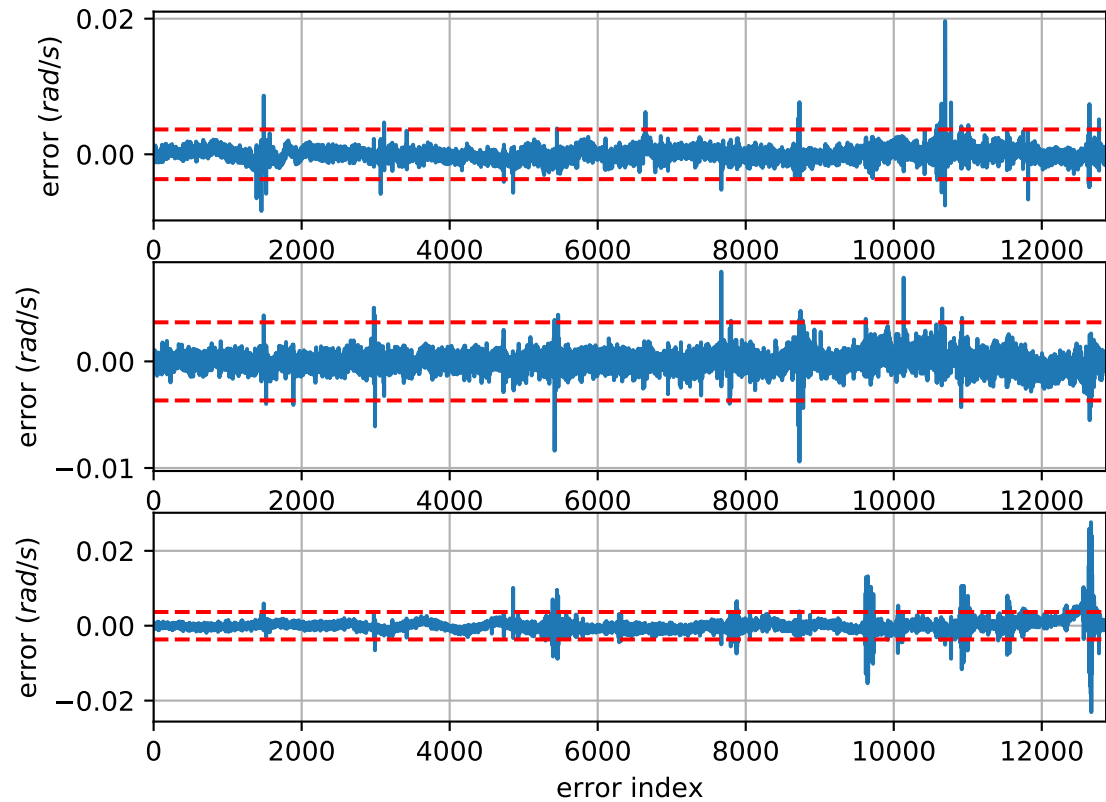
imu0: estimated accelerometer bias (imu frame)



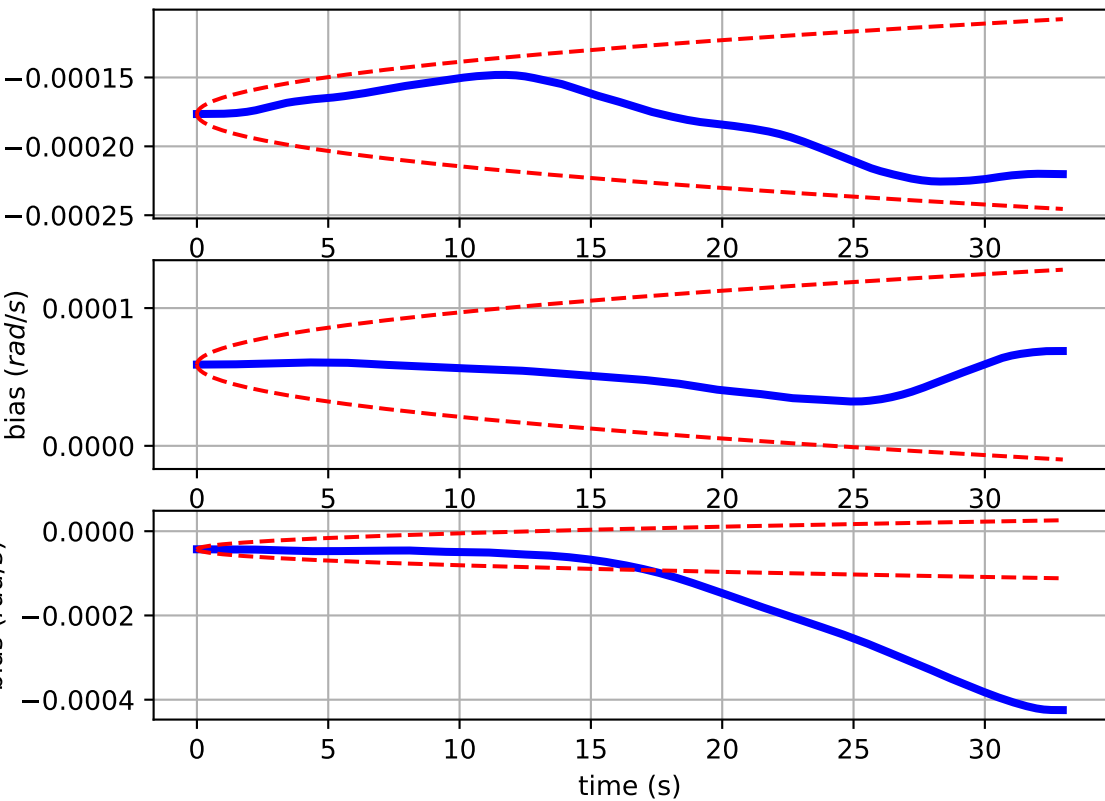
# Comparison of predicted and measured angular velocities (body frame)



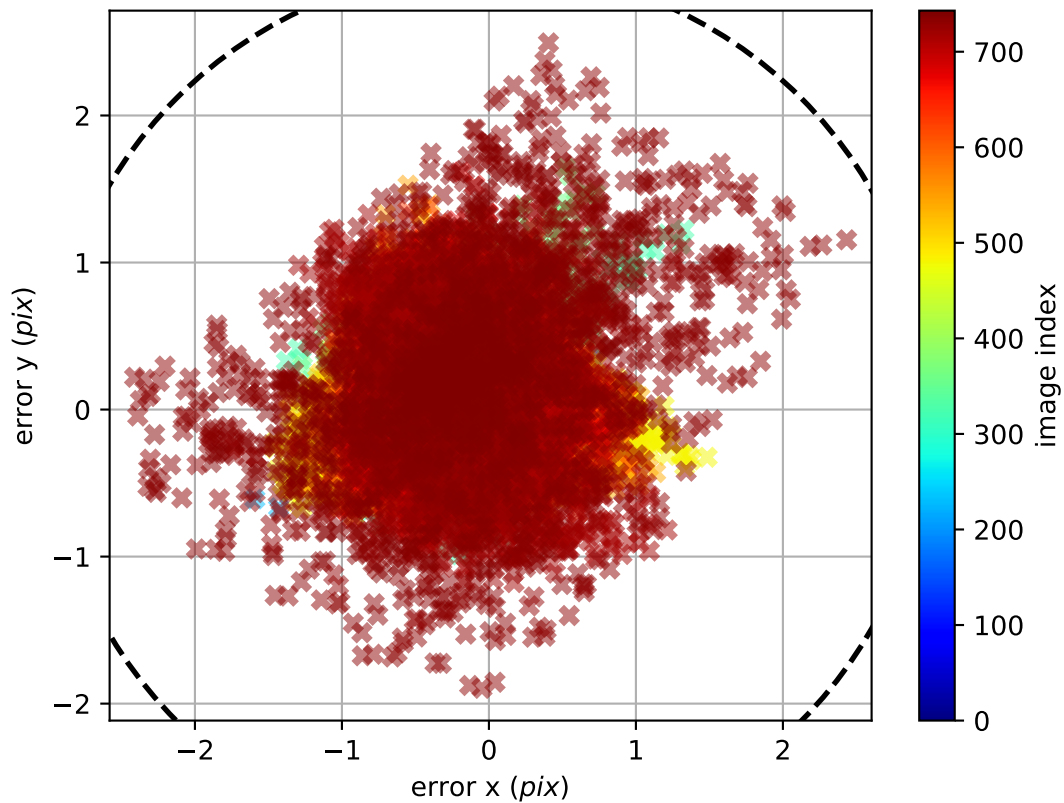
imu0: angular velocities error



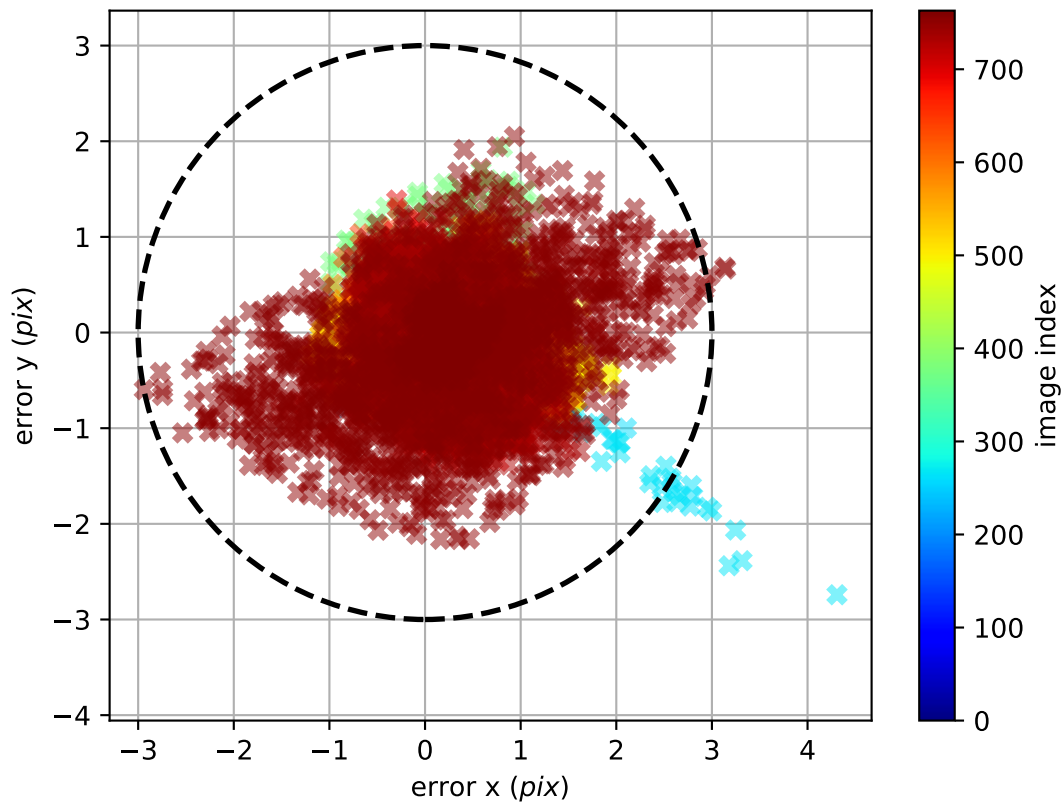
imu0: estimated gyro bias (imu frame)



cam0: reprojection errors



cam1: reprojection errors



cam2: reprojection errors

