LVV-T2190-plots

December 14, 2021

1 LVV-T2190 Plots

This notebook is designed to query the EFD and make diagnostics plots for the execution of Test Case LVV-T2190.

When executing the tests, duplicate the notebook and rename it using the test execution name.

1.1 Test executed in YYYY-MM-DD

[1]:

```
import os
import sys
import logging

import numpy as np
import pandas as pd

from astropy.time import Time
from astropy import units as u
from datetime import timedelta, datetime

import lsst_efd_client

import matplotlib.pyplot as plt
from matplotlib.colors import LogNorm

from pandas.plotting import register_matplotlib_converters
```

[2]:

```
%config Application.log_level="DEBUG"
```

[3]:

```
%matplotlib inline
```

1.2 Time window for the test execution.

Update the cells below to reflect the time when the test was executed.

This is the time window used to query the EFD.

[4]:

```
test_execution = ""
time_start_tai = 1636480426.529292-60.
```

```
time_end_tai = 1636480581.6822271
```

[22]:
```
test_execution = ""
time_start_tai = 1639495414.3939805-300
time_end_tai = 1639495414.3939805+300
```

[23]:
```
start = Time(time_start_tai, format="unix_tai", scale="tai")
end = Time(time_end_tai, format="unix_tai", scale="tai")
```

1.3 Initialization

We start by setting up a logger for the notebook and configuring the EFD Client.

[7]:
```
log = logging.getLogger("LVV-T2190")
log.setLevel(logging.DEBUG)
```

[8]:
```
lsst_efd_client.EfdClient.list_efd_names()
```

[8]:
```
['summit_efd',
 'ncsa_teststand_efd',
 'ldf_stable_efd',
 'ldf_int_efd',
 'base_efd',
 'tucson_teststand_efd',
 'test_efd']
```

[9]:
```
efd_name = "summit_efd"
```

[10]:
```
client = lsst_efd_client.EfdClient(efd_name)
```

[24]:
```
start.strftime("%m/%d/%Y, %H:%M:%S"), end.strftime("%m/%d/%Y, %H:%M:%S")
```

[24]:
```
('12/14/2021, 15:18:42', '12/14/2021, 15:28:42')
```

[25]:
```
log.debug(f"{start.utc}, {end}")
```

```
<IPython.core.display.HTML object>
```

1.4 Displaying results

1.4.1 Display degrees of freedom

The degrees of freedom are the first step performed by the OFC in converting the wavefront errors into corrections.

It is composed of two parts, the “aggregated” and the “visit” degrees of freedom. The “aggregated” is the combination of all corrections computed so far whereas the “visit” contains only the degrees of freedom from the last correction.

These values are published as vectors of 50 elements each in the “degreeOfFreedom” event. As with the `annularZernikeCoeff` case above we need to query them individually and then build the vectors afterwards.

[26]:

```
degrees_of_freedom = await client.select_time_series(
    'lsst.sal.MTAOS.logevent_degreeOfFreedom',
    [f"aggregatedDoF{i}" for i in range(50)] + [f"visitDoF{i}" for i in␣
 ↪range(50)],
    start.utc,
    end.utc
)
```

[27]:

```
degrees_of_freedom
```

[27]:

```
                                  aggregatedDoF0  aggregatedDoF1  \
2021-12-14 15:18:54.119000+00:00        0.169121        0.054919
2021-12-14 15:19:38.509000+00:00        0.000000        0.000000
2021-12-14 15:20:27.171000+00:00        0.338241        0.109839

                                  aggregatedDoF2  aggregatedDoF3  \
2021-12-14 15:18:54.119000+00:00      -71.852360      -11.856128
2021-12-14 15:19:38.509000+00:00        0.000000        0.000000
2021-12-14 15:20:27.171000+00:00     -143.704721      -23.712257

                                  aggregatedDoF4  aggregatedDoF5  \
2021-12-14 15:18:54.119000+00:00       -0.008164        0.008265
2021-12-14 15:19:38.509000+00:00        0.000000        0.000000
2021-12-14 15:20:27.171000+00:00       -0.016327        0.016529

                                  aggregatedDoF6  aggregatedDoF7  \
2021-12-14 15:18:54.119000+00:00        -0.02515       37.968733
2021-12-14 15:19:38.509000+00:00         0.00000        0.000000
2021-12-14 15:20:27.171000+00:00        -0.05030       75.937465

                                  aggregatedDoF8  aggregatedDoF9  …   \
2021-12-14 15:18:54.119000+00:00       -0.419880       -0.002405  …
2021-12-14 15:19:38.509000+00:00        0.000000        0.000000  …
2021-12-14 15:20:27.171000+00:00       -0.839761       -0.004809  …

                                  visitDoF40  visitDoF41  visitDoF42  \
2021-12-14 15:18:54.119000+00:00   -0.000021    0.000042    0.000041
2021-12-14 15:19:38.509000+00:00    0.000000    0.000000    0.000000
2021-12-14 15:20:27.171000+00:00   -0.000043    0.000085    0.000083

                                  visitDoF43  visitDoF44    visitDoF45  \
2021-12-14 15:18:54.119000+00:00    0.000018    0.000219  7.525153e-08
2021-12-14 15:19:38.509000+00:00    0.000000    0.000000  0.000000e+00
```

```
2021-12-14 15:20:27.171000+00:00    0.000036    0.000438  1.505031e-07

                                    visitDoF46  visitDoF47  visitDoF48  \
2021-12-14 15:18:54.119000+00:00  5.763935e-08   -0.000002    0.000464
2021-12-14 15:19:38.509000+00:00  0.000000e+00    0.000000    0.000000
2021-12-14 15:20:27.171000+00:00  1.152787e-07   -0.000004    0.000927

                                  visitDoF49
2021-12-14 15:18:54.119000+00:00    0.001309
2021-12-14 15:19:38.509000+00:00    0.000000
2021-12-14 15:20:27.171000+00:00    0.002618

[3 rows x 100 columns]
```

We need to unpack the data from the EFD query into vectors that are easier to plot.

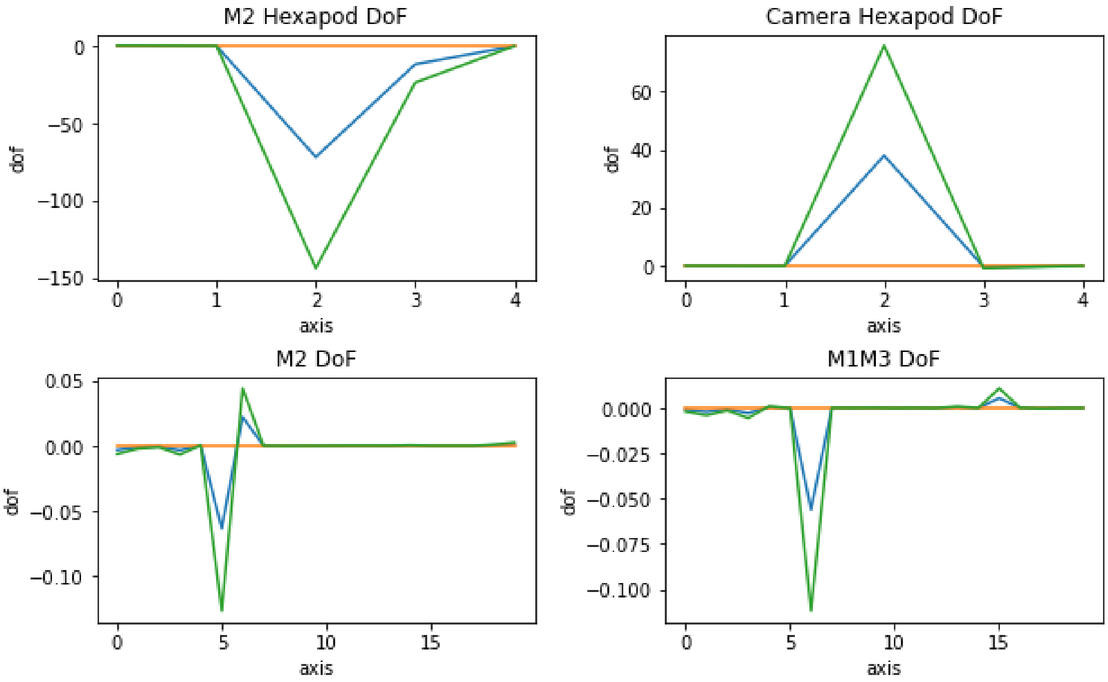
```
[28]: aggregated_dof = np.array([degrees_of_freedom[f"aggregatedDoF{i}"] for i in␣
       ↪range(50)]).T
      visit_dof = np.array([degrees_of_freedom[f"visitDoF{i}"] for i in range(50)]).T
```

```
[29]: comp_dof_idx = dict(
                  m2HexPos=dict(
                      startIdx=0,
                      idxLength=5,
                      state0name="M2Hexapod",
                  ),
                  camHexPos=dict(
                      startIdx=5,
                      idxLength=5,
                      state0name="cameraHexapod",
                  ),
                  M1M3Bend=dict(
                      startIdx=10, idxLength=20, state0name="M1M3Bending", rot_mat=1.0
                  ),
                  M2Bend=dict(startIdx=30, idxLength=20, state0name="M2Bending",␣
       ↪rot_mat=1.0),
              )
```

And we finally plot them.

```
[30]: fig, axes = plt.subplots(2,2, figsize=(10,6))

      for i in range(len(aggregated_dof)):
          axes[0][0].plot(
              aggregated_dof[i][
                  comp_dof_idx["m2HexPos"]["startIdx"]:
                 ␣
       ↪comp_dof_idx["m2HexPos"]["startIdx"]+comp_dof_idx["m2HexPos"]["idxLength"]
```

```
        ]
    )
    axes[0][0].set_title("M2 Hexapod DoF")
    axes[0][0].set_xlabel("axis")
    axes[0][0].set_ylabel("dof")

    axes[0][1].plot(
        aggregated_dof[i][
            comp_dof_idx["camHexPos"]["startIdx"]:
           ␣
↪comp_dof_idx["camHexPos"]["startIdx"]+comp_dof_idx["camHexPos"]["idxLength"]
        ]
    )

    axes[0][1].set_title("Camera Hexapod DoF")
    axes[0][1].set_xlabel("axis")
    axes[0][1].set_ylabel("dof")

    axes[1][0].plot(
        aggregated_dof[i][
            comp_dof_idx["M2Bend"]["startIdx"]:
           ␣
↪comp_dof_idx["M2Bend"]["startIdx"]+comp_dof_idx["M2Bend"]["idxLength"]
        ]
    )
    axes[1][0].set_title("M2 DoF")
    axes[1][0].set_xlabel("axis")
    axes[1][0].set_ylabel("dof")


    axes[1][1].plot(
        aggregated_dof[i][
            comp_dof_idx["M1M3Bend"]["startIdx"]:
           ␣
↪comp_dof_idx["M1M3Bend"]["startIdx"]+comp_dof_idx["M1M3Bend"]["idxLength"]
        ]
    )
axes[1][1].set_title("M1M3 DoF")
axes[1][1].set_xlabel("axis")
axes[1][1].set_ylabel("dof")

fig.patch.set_facecolor('white')
plt.subplots_adjust(hspace=0.4, wspace=0.3)

fig.savefig("dof.png")
```



1.5 Step 8

1.5.1 Display Camera Hexapod Correction

[32]:

```
cam_hexapod_correction_computed_xyz = await client.select_time_series(
    'lsst.sal.MTAOS.logevent_cameraHexapodCorrection',
    ["x", "y", "z"],
    start.utc,
    end.utc
)

cam_hexapod_correction_computed_uv = await client.select_time_series(
    'lsst.sal.MTAOS.logevent_cameraHexapodCorrection',
    ["u", "v"],
    start.utc,
    end.utc
)
```

[34]:

```
cam_hexapod_correction_applied_xyz = await client.select_time_series(
    'lsst.sal.MTHexapod.logevent_uncompensatedPosition',
    ["x", "y", "z", "MTHexapodID"],
    start.utc,
    end.utc,
    index=1
)
```

```

cam_hexapod_correction_applied_uv = await client.select_time_series(
    'lsst.sal.MTHexapod.logevent_uncompensatedPosition',
    ["u", "v", "MTHexapodID"],
    start.utc,
    end.utc,
    index=1
)
```

[35]:

```
cam_hexapod_correction_command_xyz = await client.select_time_series(
    'lsst.sal.MTHexapod.command_move',
    ["x", "y", "z", "MTHexapodID"],
    start.utc,
    end.utc,
    index=1
)

cam_hexapod_correction_command_uv = await client.select_time_series(
    'lsst.sal.MTHexapod.command_move',
    ["u", "v", "MTHexapodID"],
    start.utc,
    end.utc,
    index=1
)
```

[36]:

```
cam_hexapod_correction_computed_xyz
```

[36]:

```
                                        x          y         z
2021-12-14 15:18:54.120000+00:00  0.02515  37.968733 -0.008265
2021-12-14 15:19:38.510000+00:00  0.00000   0.000000  0.000000
2021-12-14 15:20:27.186000+00:00  0.05030  75.937465 -0.016529
```

[37]:

```
cam_hexapod_correction_computed_uv
```

[37]:

```
                                         u             v
2021-12-14 15:18:54.120000+00:00  0.000117  6.679176e-07
2021-12-14 15:19:38.510000+00:00  0.000000  0.000000e+00
2021-12-14 15:20:27.186000+00:00  0.000233  1.335835e-06
```

[38]:

```
cam_hexapod_correction_applied_xyz
```

[38]:

```
                                        x          y         z  MTHexapodID
2021-12-14 15:18:56.905000+00:00  0.02515  37.968733 -0.008265            1
2021-12-14 15:20:02.351000+00:00  0.00000   0.000000  0.000000            1
2021-12-14 15:20:29.944000+00:00  0.05030  75.937465 -0.016529            1
```

[39]:

```
cam_hexapod_correction_applied_uv
```

[39]:

```
                                         u             v  MTHexapodID
2021-12-14 15:18:56.905000+00:00  0.000117  6.679176e-07            1
2021-12-14 15:20:02.351000+00:00  0.000000  0.000000e+00            1
2021-12-14 15:20:29.944000+00:00  0.000233  1.335835e-06            1
```

[40]:

```
cam_hexapod_correction_command_xyz
```

[40]:

```
                                        x          y         z  MTHexapodID
2021-12-14 15:18:56.903000+00:00  0.02515  37.968733 -0.008265            1
2021-12-14 15:20:02.349000+00:00  0.00000   0.000000  0.000000            1
2021-12-14 15:20:29.942000+00:00  0.05030  75.937465 -0.016529            1
```

[41]:

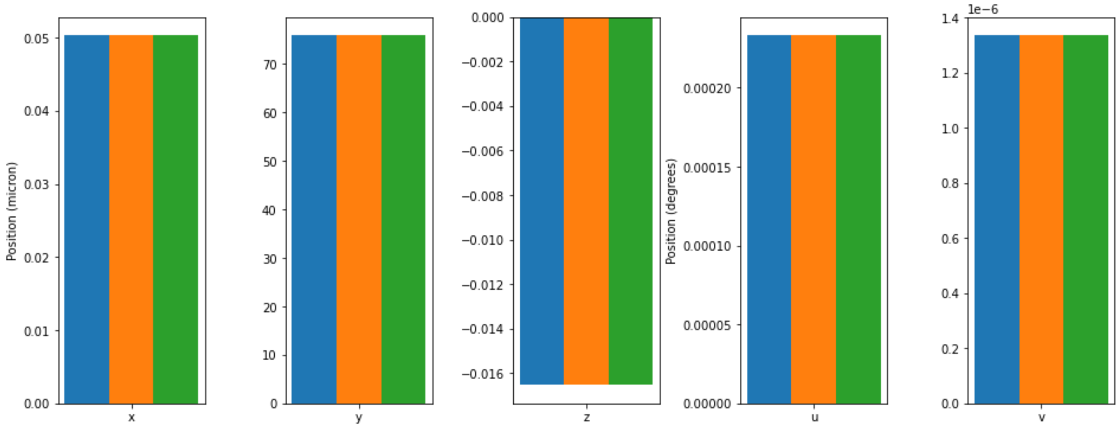
```
cam_hexapod_correction_command_uv
```

[41]:

```
                                         u             v  MTHexapodID
2021-12-14 15:18:56.903000+00:00  0.000117  6.679176e-07            1
2021-12-14 15:20:02.349000+00:00  0.000000  0.000000e+00            1
2021-12-14 15:20:29.942000+00:00  0.000233  1.335835e-06            1
```

[42]:

```
fig = plt.figure(figsize=(16,6))

axis = []
# label = "x"
for panel, label in enumerate("xyz"):

    ax = plt.subplot(1,5,panel+1)

    x = [0.]

    ax.bar(
        [-0.5],
        cam_hexapod_correction_computed_xyz[label],
        width=0.5
    )
    ax.bar(
        [0.],
        cam_hexapod_correction_applied_xyz[label],
        width=0.5
    )

    ax.bar(
        [0.5],
        cam_hexapod_correction_command_xyz[label],
        width=0.5
    )

    ax.set_xticks([0])
    ax.set_xticklabels([label])
    axis.append(ax)

axis[0].set_ylabel("Position (micron)")

for panel, label in enumerate("uv"):

    ax = plt.subplot(1,5,panel+4)

    x = [0.]

    ax.bar(
        [-0.5],
        cam_hexapod_correction_computed_uv[label],
        width=0.5
    )
    ax.bar(
        [0.],
        cam_hexapod_correction_applied_uv[label],
        width=0.5
    )

    ax.bar(
        [0.5],
        cam_hexapod_correction_command_uv[label],
        width=0.5
    )

    ax.set_xticks([0])
    ax.set_xticklabels([label])
    axis.append(ax)

axis[3].set_ylabel("Position (degrees)")


plt.subplots_adjust(hspace=0.3, wspace=0.55)
fig.patch.set_facecolor('white')

fig.savefig(f"camera_hexapod_{test_execution}.png")
```



1.5.2 Display M2 Hexapod Correction

[44]:
```
m2_hexapod_correction_computed_xyz = await client.select_time_series(
    'lsst.sal.MTAOS.logevent_m2HexapodCorrection',
    ["x", "y", "z"],
    start.utc,
    end.utc
)

m2_hexapod_correction_computed_uv = await client.select_time_series(
    'lsst.sal.MTAOS.logevent_m2HexapodCorrection',
    ["u", "v"],
    start.utc,
    end.utc
)
```

[45]:
```
m2_hexapod_correction_applied_xyz = await client.select_time_series(
    'lsst.sal.MTHexapod.logevent_uncompensatedPosition',
    ["x", "y", "z", "MTHexapodID"],
    start.utc,
    end.utc,
    index=2
)

m2_hexapod_correction_applied_uv = await client.select_time_series(
    'lsst.sal.MTHexapod.logevent_uncompensatedPosition',
    ["u", "v", "MTHexapodID"],
    start.utc,
    end.utc,
    index=2
)
```

[47]:
```
m2_hexapod_correction_command_xyz = await client.select_time_series(
    'lsst.sal.MTHexapod.command_move',
    ["x", "y", "z", "MTHexapodID"],
    start.utc,
    end.utc,
    index=2
)

m2_hexapod_correction_command_uv = await client.select_time_series(
    'lsst.sal.MTHexapod.command_move',
    ["u", "v", "MTHexapodID"],
    start.utc,
    end.utc,
    index=2
)
```

[48]:
```
m2_hexapod_correction_command_xyz
```

[48]:
```
                                         x           y         z  MTHexapodID
2021-12-14 15:18:56.902000+00:00 -0.054919  -71.852360 -0.169121            2
2021-12-14 15:20:02.348000+00:00  0.000000    0.000000  0.000000            2
2021-12-14 15:20:29.941000+00:00 -0.109839 -143.704721 -0.338241            2
```

[49]:
```
m2_hexapod_correction_computed_xyz
```

[49]:
```
                                         x           y         z
2021-12-14 15:18:54.120000+00:00 -0.054919  -71.852360 -0.169121
2021-12-14 15:19:38.510000+00:00  0.000000    0.000000  0.000000
2021-12-14 15:20:27.185000+00:00 -0.109839 -143.704721 -0.338241
```

[50]:
```
m2_hexapod_correction_applied_xyz
```

[50]:
```
                                         x           y         z  MTHexapodID
2021-12-14 15:18:56.904000+00:00 -0.054919  -71.852360 -0.169121            2
2021-12-14 15:20:02.350000+00:00  0.000000    0.000000  0.000000            2
2021-12-14 15:20:29.943000+00:00 -0.109839 -143.704721 -0.338241            2
```

[51]:
```
m2_hexapod_correction_command_uv
```

[51]:
```
                                         u         v  MTHexapodID
2021-12-14 15:18:56.902000+00:00  0.003293  0.000002            2
2021-12-14 15:20:02.348000+00:00  0.000000  0.000000            2
2021-12-14 15:20:29.941000+00:00  0.006587  0.000005            2
```

[52]:
```
m2_hexapod_correction_computed_uv
```

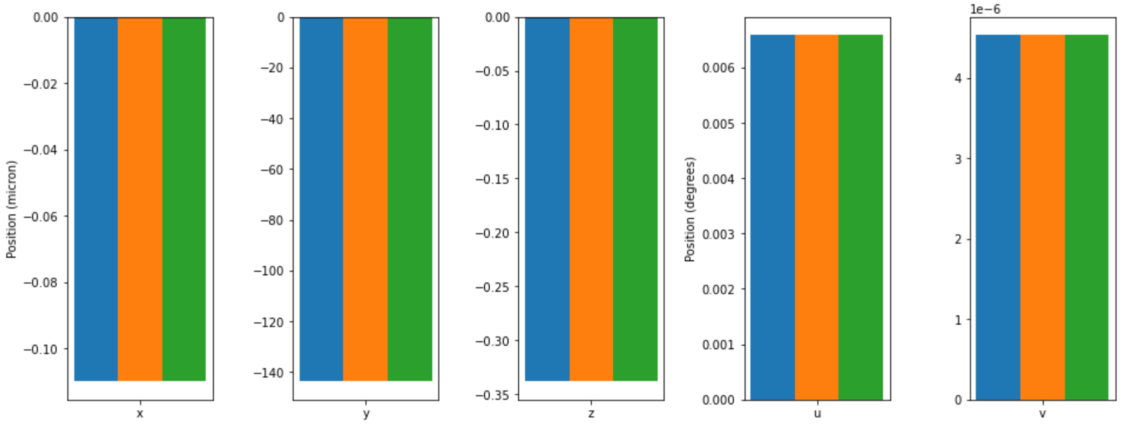
[52]:
```
                                         u         v
2021-12-14 15:18:54.120000+00:00  0.003293  0.000002
```

```
2021-12-14 15:19:38.510000+00:00  0.000000  0.000000
2021-12-14 15:20:27.185000+00:00  0.006587  0.000005
```

[53]:
```
m2_hexapod_correction_applied_uv
```

[53]:
```
                                         u         v  MTHexapodID
2021-12-14 15:18:56.904000+00:00  0.003293  0.000002            2
2021-12-14 15:20:02.350000+00:00  0.000000  0.000000            2
2021-12-14 15:20:29.943000+00:00  0.006587  0.000005            2
```

[54]:
```
fig = plt.figure(figsize=(16,6))

axis = []
# label = "x"
for panel, label in enumerate("xyz"):

    ax = plt.subplot(1,5,panel+1)

    x = [0.]

    ax.bar(
        [-0.5],
        m2_hexapod_correction_computed_xyz[label],
        width=0.5
    )
    ax.bar(
        [0.],
        m2_hexapod_correction_applied_xyz[label],
        width=0.5
    )

    ax.bar(
        [0.5],
        m2_hexapod_correction_command_xyz[label],
        width=0.5
    )

    ax.set_xticks([0])
    ax.set_xticklabels([label])
    axis.append(ax)

axis[0].set_ylabel("Position (micron)")

for panel, label in enumerate("uv"):

    ax = plt.subplot(1,5,panel+4)
    x = [0.]

    ax.bar(
        [-0.5],
        m2_hexapod_correction_computed_uv[label],
        width=0.5
    )
    ax.bar(
        [0.],
        m2_hexapod_correction_applied_uv[label],
        width=0.5
    )

    ax.bar(
        [0.5],
        m2_hexapod_correction_command_uv[label],
        width=0.5
    )

    ax.set_xticks([0])
    ax.set_xticklabels([label])
    axis.append(ax)

axis[3].set_ylabel("Position (degrees)")


plt.subplots_adjust(hspace=0.3, wspace=0.55)
fig.patch.set_facecolor('white')

fig.savefig(f"m2_hexapod_{test_execution}.png")
```



1.5.3 Display M2 Correction

[56]:
```
m2_correction = await client.select_time_series(
    'lsst.sal.MTAOS.logevent_m2Correction',
    [f"zForces{i}" for i in range(72)],
    start.utc,
    end.utc
)
```

[57]:
```
m2_correction
```

[57]:
```
                                  zForces0  zForces1  zForces2  zForces3  \
2021-12-14 15:18:54.122000+00:00 -0.759188 -0.741219 -0.704368 -0.630182
2021-12-14 15:19:38.511000+00:00  0.000000  0.000000  0.000000  0.000000
2021-12-14 15:20:27.187000+00:00 -1.518376 -1.482438 -1.408735 -1.260364

                                  zForces4  zForces5  zForces6  zForces7  \
2021-12-14 15:18:54.122000+00:00 -0.518267 -0.390221 -0.240212  -0.07902
2021-12-14 15:19:38.511000+00:00  0.000000  0.000000  0.000000   0.00000
2021-12-14 15:20:27.187000+00:00 -1.036534 -0.780443 -0.480423  -0.15804

                                  zForces8  zForces9  …  zForces62  \
2021-12-14 15:18:54.122000+00:00  0.083761  0.241742  …  -0.776518
2021-12-14 15:19:38.511000+00:00  0.000000  0.000000  …   0.000000
2021-12-14 15:20:27.187000+00:00  0.167522  0.483484  …  -1.553036

                                  zForces63  zForces64  zForces65  zForces66  \
2021-12-14 15:18:54.122000+00:00  -0.843476  -0.782143  -0.612518  -0.391572
2021-12-14 15:19:38.511000+00:00   0.000000   0.000000   0.000000   0.000000
2021-12-14 15:20:27.187000+00:00  -1.686953  -1.564286  -1.225036  -0.783143

                                  zForces67  zForces68  zForces69  zForces70  \
2021-12-14 15:18:54.122000+00:00  -0.138743   0.136610   0.387046   0.604225
2021-12-14 15:19:38.511000+00:00   0.000000   0.000000   0.000000   0.000000
2021-12-14 15:20:27.187000+00:00  -0.277485   0.273219   0.774092   1.208450

                                  zForces71
2021-12-14 15:18:54.122000+00:00   0.773663
2021-12-14 15:19:38.511000+00:00   0.000000
2021-12-14 15:20:27.187000+00:00   1.547327

[3 rows x 72 columns]
```

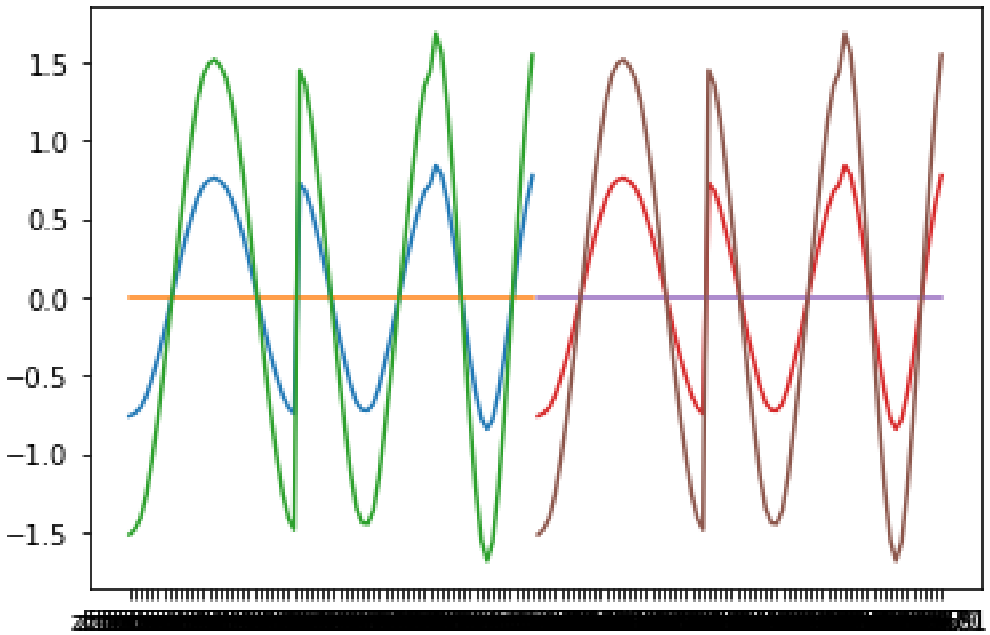
[58]:
```
m2_correction_applied = await client.select_time_series(
    'lsst.sal.MTM2.command_applyForces',
    [f"axial{i}" for i in range(72)],
    start.utc,
    end.utc
)
```

[59]:
```
m2_correction_applied
```

[59]:
```
                                    axial0    axial1    axial2    axial3  \
2021-12-14 15:18:56.903000+00:00 -0.759188 -0.741219 -0.704368 -0.630182
2021-12-14 15:20:02.349000+00:00  0.000000  0.000000  0.000000  0.000000
2021-12-14 15:20:29.942000+00:00 -1.518376 -1.482438 -1.408735 -1.260364

                                    axial4    axial5    axial6   axial7  \
2021-12-14 15:18:56.903000+00:00 -0.518267 -0.390221 -0.240212 -0.07902
2021-12-14 15:20:02.349000+00:00  0.000000  0.000000  0.000000  0.00000
2021-12-14 15:20:29.942000+00:00 -1.036534 -0.780443 -0.480423 -0.15804

                                    axial8    axial9  …   axial62   axial63  \
2021-12-14 15:18:56.903000+00:00  0.083761  0.241742  … -0.776518 -0.843476
2021-12-14 15:20:02.349000+00:00  0.000000  0.000000  …  0.000000  0.000000
2021-12-14 15:20:29.942000+00:00  0.167522  0.483484  … -1.553036 -1.686953

                                   axial64   axial65   axial66   axial67  \
2021-12-14 15:18:56.903000+00:00 -0.782143 -0.612518 -0.391572 -0.138743
2021-12-14 15:20:02.349000+00:00  0.000000  0.000000  0.000000  0.000000
2021-12-14 15:20:29.942000+00:00 -1.564286 -1.225036 -0.783143 -0.277485

                                   axial68   axial69   axial70   axial71
2021-12-14 15:18:56.903000+00:00  0.136610  0.387046  0.604225  0.773663
2021-12-14 15:20:02.349000+00:00  0.000000  0.000000  0.000000  0.000000
2021-12-14 15:20:29.942000+00:00  0.273219  0.774092  1.208450  1.547327

[3 rows x 72 columns]
```

[60]:
```
plt.plot(m2_correction.T)
plt.plot(m2_correction_applied.T)
```

[60]:
```
[<matplotlib.lines.Line2D at 0x7fdcae2db3a0>,
 <matplotlib.lines.Line2D at 0x7fdcae2db520>,
 <matplotlib.lines.Line2D at 0x7fdcae2db670>]
```



```
[61]: aa = np.loadtxt('%s/notebooks/M2_FEA/data/M2_1um_72_force.txt'%(os.
       ↪environ["HOME"]))
      # to have +x going to right, and +y going up, we need to transpose and reverse␣
       ↪x and y
      m2_xact = -aa[:,2]
      m2_yact = -aa[:,1]
```

```
[62]: aa = np.array(m2_correction.T)
```

```
[63]: aa.shape
```

```
[63]: (72, 3)
```

```
[64]: m2_correction.T
```

```
[64]:            2021-12-14 15:18:54.122000+00:00  2021-12-14 15:19:38.511000+00:00  \
      zForces0                           -0.759188                               0.0
      zForces1                           -0.741219                               0.0
      zForces2                           -0.704368                               0.0
      zForces3                           -0.630182                               0.0
      zForces4                           -0.518267                               0.0
      …                                        …                                …
      zForces67                          -0.138743                               0.0
      zForces68                           0.136610                               0.0
      zForces69                           0.387046                               0.0
      zForces70                           0.604225                               0.0
```

```
zForces71                          0.773663                               0.0

           2021-12-14 15:20:27.187000+00:00
zForces0                          -1.518376
zForces1                          -1.482438
zForces2                          -1.408735
zForces3                          -1.260364
zForces4                          -1.036534
…                                     …
zForces67                         -0.277485
zForces68                          0.273219
zForces69                          0.774092
zForces70                          1.208450
zForces71                          1.547327

[72 rows x 3 columns]
```

[65]:

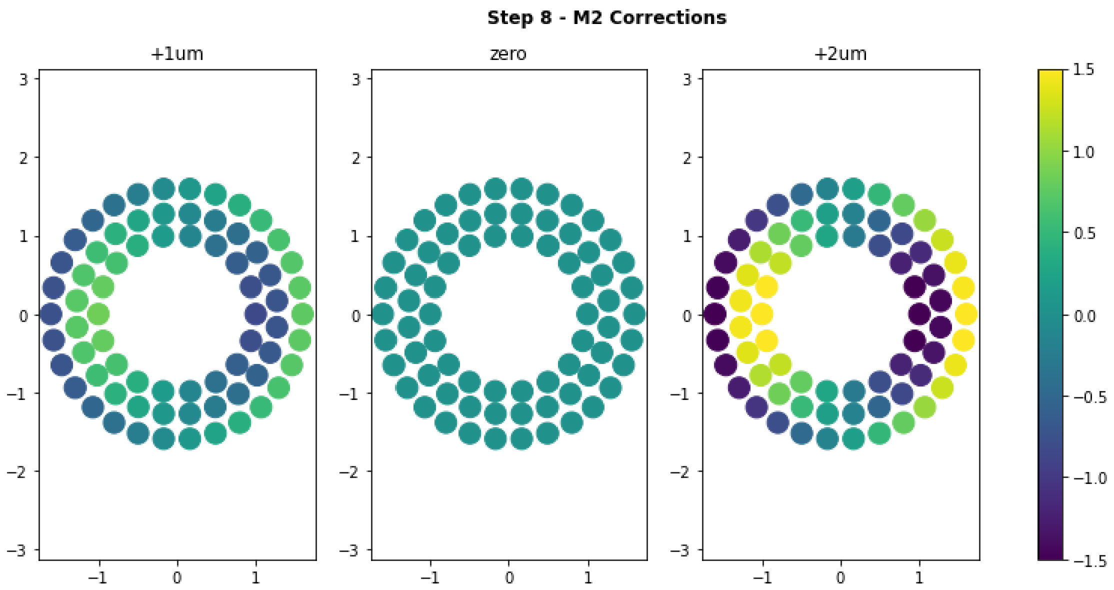
```
m2_correction_applied.T
```

[65]:

```
         2021-12-14 15:18:56.903000+00:00  2021-12-14 15:20:02.349000+00:00  \
axial0                          -0.759188                               0.0
axial1                          -0.741219                               0.0
axial2                          -0.704368                               0.0
axial3                          -0.630182                               0.0
axial4                          -0.518267                               0.0
…                                   …                               …
axial67                         -0.138743                               0.0
axial68                          0.136610                               0.0
axial69                          0.387046                               0.0
axial70                          0.604225                               0.0
axial71                          0.773663                               0.0

         2021-12-14 15:20:29.942000+00:00
axial0                          -1.518376
axial1                          -1.482438
axial2                          -1.408735
axial3                          -1.260364
axial4                          -1.036534
…                                   …
axial67                         -0.277485
axial68                          0.273219
axial69                          0.774092
axial70                          1.208450
axial71                          1.547327

[72 rows x 3 columns]
```

[68]:

```
fig, axes = plt.subplots(1,3, figsize=(14,6))

for panel, timestamp in enumerate(m2_correction_applied.index):

    img = axes[panel].scatter(
        m2_xact,
        m2_yact,
        c=m2_correction_applied.T[timestamp],
        s=200,
        vmin=-1.5,
        vmax=1.5
    )

    axes[panel].axis('equal')

# axis = fig.add_axes([0,1,0,1])

fig.colorbar(img, ax=axes)
axes[0].set_title("+1um")
axes[1].set_title("zero")
axes[2].set_title("+2um")
fig.patch.set_facecolor('white')
fig.text(
    0.5,
    0.95,
    "Step 8 - M2 Corrections",
    ha="center",
    weight="bold",
    size="large"
)

fig.savefig("m2.png")
```



1.5.4 Display M1M3 Correction

[69]:
```
FATABLE_XPOSITION = 2
FATABLE_YPOSITION = 3

FATABLE = np.array([
    [0,101,0.776782776,0,-2.158743,'SAA',3,1,'NA',-1,-1,0,-1],
    [1,102,1.442567993,0,-2.158743,'DAA',1,17,'+Y',-1,0,1,0],
    [2,103,2.10837793,0,-2.158743,'DAA',4,17,'+Y',-1,1,2,1],
    [3,104,2.774187988,0,-2.158743,'DAA',2,17,'+Y',-1,2,3,2],
    [4,105,3.439998047,0,-2.158743,'DAA',3,17,'+Y',-1,3,4,3],
    [5,106,3.968012939,0,-2.158743,'SAA',2,1,'NA',-1,-1,5,-1],
    [6,107,0.44386499,-0.57660498,-2.158743,'SAA',1,1,'NA',-1,-1,6,-1],
    [7,108,1.109675049,-0.57660498,-2.158743,'DAA',4,18,'+Y',-1,4,7,4],
    [8,109,1.775484985,-0.57660498,-2.158743,'DAA',2,18,'+Y',-1,5,8,5],
    [9,110,2.441295898,-0.57660498,-2.158743,'DAA',3,18,'+Y',-1,6,9,6],
    [10,111,3.107080078,-0.57660498,-2.158743,'DAA',1,18,'+Y',-1,7,10,7],
    [11,112,3.772891113,-0.57660498,-2.158743,'DAA',4,19,'-X',0,-1,11,8],
    [12,113,0,-1.153209961,-2.158743,'DAA',2,19,'+Y',-1,8,12,9],
    [13,114,0.776782776,-1.153209961,-2.158743,'DAA',3,19,'+Y',-1,9,13,10],
    [14,115,1.442567993,-1.153209961,-2.158743,'DAA',1,19,'+Y',-1,10,14,11],
    [15,116,2.10837793,-1.153209961,-2.158743,'DAA',4,20,'+Y',-1,11,15,12],
    [16,117,2.774187988,-1.153209961,-2.158743,'DAA',2,20,'+Y',-1,12,16,13],
    [17,118,3.439998047,-1.153209961,-2.158743,'DAA',3,20,'+Y',-1,13,17,14],
    [18,119,3.9005,-0.997687012,-2.158743,'SAA',2,2,'NA',-1,-1,18,-1],
    [19,120,0.44386499,-1.729819946,-2.158743,'DAA',1,20,'+Y',-1,14,19,15],
    [20,121,1.109675049,-1.729819946,-2.158743,'DAA',4,21,'+Y',-1,15,20,16],
    [21,122,1.775484985,-1.729819946,-2.158743,'DAA',2,21,'+Y',-1,16,21,17],
    [22,123,2.44127002,-1.729819946,-2.158743,'DAA',3,21,'+Y',-1,17,22,18],
    [23,124,3.107080078,-1.729819946,-2.158743,'DAA',1,21,'+Y',-1,18,23,19],
    [24,125,3.724452881,-1.517949951,-2.158743,'SAA',4,1,'NA',-1,-1,24,-1],
    [25,126,0,-2.306419922,-2.158743,'DAA',2,22,'+Y',-1,19,25,20],
    [26,127,0.776782776,-2.306419922,-2.158743,'DAA',3,22,'+Y',-1,20,26,21],
    [27,128,1.442567993,-2.306419922,-2.158743,'DAA',1,22,'-X',1,-1,27,22],
    [28,129,2.10837793,-2.306419922,-2.158743,'DAA',4,22,'+Y',-1,21,28,23],
    [29,130,2.774187988,-2.306419922,-2.158743,'DAA',2,23,'+Y',-1,22,29,24],
    [30,131,3.387954102,-2.167409912,-2.158743,'SAA',3,2,'NA',-1,-1,30,-1],
    [31,132,0.44386499,-2.883030029,-2.158743,'DAA',1,23,'+Y',-1,23,31,25],
    [32,133,1.109675049,-2.883030029,-2.158743,'DAA',4,23,'+Y',-1,24,32,26],
    [33,134,1.775484985,-2.883030029,-2.158743,'DAA',2,24,'+Y',-1,25,33,27],
    [34,135,2.44127002,-2.883030029,-2.158743,'DAA',3,23,'-X',2,-1,34,28],
    [35,136,2.939364014,-2.745179932,-2.158743,'SAA',4,2,'NA',-1,-1,35,-1],
    [36,137,0.221945206,-3.459629883,-2.158743,'DAA',2,25,'+Y',-1,26,36,29],
    [37,138,0.88772998,-3.459629883,-2.158743,'DAA',3,24,'+Y',-1,27,37,30],
    [38,139,1.553540039,-3.267429932,-2.158743,'SAA',1,2,'NA',-1,-1,38,-1],
    [39,140,2.089733887,-3.436389893,-2.158743,'SAA',4,3,'NA',-1,-1,39,-1],
    [40,141,0.365734589,-4.00525,-2.158743,'SAA',1,3,'NA',-1,-1,40,-1],
    [41,142,1.085088013,-3.87276001,-2.158743,'SAA',2,3,'NA',-1,-1,41,-1],
    [42,143,1.60401001,-3.692780029,-2.158743,'SAA',3,3,'NA',-1,-1,42,-1],
    [43,207,-0.44386499,-0.57660498,-2.158743,'SAA',1,4,'NA',-1,-1,43,-1],
    [44,208,-1.109680054,-0.57660498,-2.158743,'DAA',4,24,'+Y',-1,28,44,31],
    [45,209,-1.77548999,-0.57660498,-2.158743,'DAA',2,26,'+Y',-1,29,45,32],
    [46,210,-2.441300049,-0.57660498,-2.158743,'DAA',3,25,'+Y',-1,30,46,33],
    [47,211,-3.107080078,-0.57660498,-2.158743,'DAA',1,24,'+Y',-1,31,47,34],
    [48,212,-3.772889893,-0.57660498,-2.158743,'DAA',4,25,'+X',3,-1,48,35],
    [49,214,-0.77678302,-1.153209961,-2.158743,'DAA',3,26,'+Y',-1,32,49,36],
    [50,215,-1.442569946,-1.153209961,-2.158743,'DAA',1,25,'+Y',-1,33,50,37],
    [51,216,-2.108379883,-1.153209961,-2.158743,'DAA',4,26,'+Y',-1,34,51,38],
    [52,217,-2.774189941,-1.153209961,-2.158743,'DAA',2,27,'+Y',-1,35,52,39],
    [53,218,-3.44,-1.153209961,-2.158743,'DAA',3,27,'+Y',-1,36,53,40],
    [54,219,-3.9005,-0.997687012,-2.158743,'SAA',2,4,'NA',-1,-1,54,-1],
    [55,220,-0.44386499,-1.729819946,-2.158743,'DAA',1,26,'+Y',-1,37,55,41],
    [56,221,-1.109680054,-1.729819946,-2.158743,'DAA',4,27,'+Y',-1,38,56,42],
    [57,222,-1.77548999,-1.729819946,-2.158743,'DAA',2,28,'+Y',-1,39,57,43],
    [58,223,-2.44127002,-1.729819946,-2.158743,'DAA',3,28,'+Y',-1,40,58,44],
    [59,224,-3.107080078,-1.729819946,-2.158743,'DAA',1,27,'+Y',-1,41,59,45],
    [60,225,-3.724449951,-1.517949951,-2.158743,'SAA',4,4,'NA',-1,-1,60,-1],
    [61,227,-0.77678302,-2.306419922,-2.158743,'DAA',3,29,'+Y',-1,42,61,46],
    [62,228,-1.442569946,-2.306419922,-2.158743,'DAA',1,28,'+X',4,-1,62,47],
    [63,229,-2.108379883,-2.306419922,-2.158743,'DAA',4,28,'+Y',-1,43,63,48],
    [64,230,-2.774189941,-2.306419922,-2.158743,'DAA',2,29,'+Y',-1,44,64,49],
    [65,231,-3.387949951,-2.167409912,-2.158743,'SAA',3,4,'NA',-1,-1,65,-1],
    [66,232,-0.44386499,-2.883030029,-2.158743,'DAA',1,29,'+Y',-1,45,66,50],
    [67,233,-1.109680054,-2.883030029,-2.158743,'DAA',4,29,'+Y',-1,46,67,51],
    [68,234,-1.77548999,-2.883030029,-2.158743,'DAA',2,30,'+Y',-1,47,68,52],
    [69,235,-2.44127002,-2.883030029,-2.158743,'DAA',3,30,'+X',5,-1,69,53],
    [70,236,-2.939360107,-2.745179932,-2.158743,'SAA',4,5,'NA',-1,-1,70,-1],
    [71,237,-0.221945007,-3.459629883,-2.158743,'DAA',2,31,'+Y',-1,48,71,54],
    [72,238,-0.88772998,-3.459629883,-2.158743,'DAA',3,31,'+Y',-1,49,72,55],
    [73,239,-1.553540039,-3.267429932,-2.158743,'SAA',1,5,'NA',-1,-1,73,-1],
    [74,240,-2.08972998,-3.436389893,-2.158743,'SAA',4,6,'NA',-1,-1,74,-1],
    [75,241,-0.365734985,-4.00525,-2.158743,'SAA',1,6,'NA',-1,-1,75,-1],
    [76,242,-1.085089966,-3.87276001,-2.158743,'SAA',2,5,'NA',-1,-1,76,-1],
    [77,243,-1.60401001,-3.692780029,-2.158743,'SAA',3,5,'NA',-1,-1,77,-1],
    [78,301,-0.77678302,0,-2.158743,'SAA',3,6,'NA',-1,-1,78,-1],
    [79,302,-1.442569946,0,-2.158743,'DAA',1,30,'+Y',-1,50,79,56],
    [80,303,-2.108379883,0,-2.158743,'DAA',4,30,'+Y',-1,51,80,57],
    [81,304,-2.774189941,0,-2.158743,'DAA',2,32,'+Y',-1,52,81,58],
    [82,305,-3.44,0,-2.158743,'DAA',3,32,'+Y',-1,53,82,59],
    [83,306,-3.96801001,0,-2.158743,'SAA',2,6,'NA',-1,-1,83,-1],
    [84,307,-0.44386499,0.576605408,-2.158743,'SAA',1,7,'NA',-1,-1,84,-1],
    [85,308,-1.109680054,0.576605408,-2.158743,'DAA',4,31,'+Y',-1,54,85,60],
    [86,309,-1.77548999,0.576605408,-2.158743,'DAA',2,33,'+Y',-1,55,86,61],
    [87,310,-2.441300049,0.576605408,-2.158743,'DAA',3,33,'+Y',-1,56,87,62],
    [88,311,-3.107080078,0.576605408,-2.158743,'DAA',1,31,'-Y',-1,57,88,63],
    [89,312,-3.772889893,0.576605408,-2.158743,'DAA',4,32,'+X',6,-1,89,64],
    [90,313,0,1.15321106,-2.158743,'DAA',2,34,'+Y',-1,58,90,65],
    [91,314,-0.77678302,1.15321106,-2.158743,'DAA',3,34,'+Y',-1,59,91,66],
    [92,315,-1.442569946,1.15321106,-2.158743,'DAA',1,32,'+Y',-1,60,92,67],
    [93,316,-2.108379883,1.15321106,-2.158743,'DAA',4,33,'+Y',-1,61,93,68],
    [94,317,-2.774189941,1.15321106,-2.158743,'DAA',2,35,'+Y',-1,62,94,69],
    [95,318,-3.44,1.15321106,-2.158743,'DAA',3,35,'+Y',-1,63,95,70],
    [96,319,-3.9005,0.997686584,-2.158743,'SAA',2,7,'NA',-1,-1,96,-1],
    [97,320,-0.44386499,1.72981604,-2.158743,'DAA',1,33,'+Y',-1,64,97,71],
    [98,321,-1.109680054,1.72981604,-2.158743,'DAA',4,34,'+Y',-1,65,98,72],
    [99,322,-1.77548999,1.72981604,-2.158743,'DAA',2,36,'+Y',-1,66,99,73],
    [100,323,-2.44127002,1.72981604,-2.158743,'DAA',3,36,'+Y',-1,67,100,74],
    [101,324,-3.107080078,1.72981604,-2.158743,'DAA',1,34,'+Y',-1,68,101,75],
    [102,325,-3.724449951,1.517954956,-2.158743,'SAA',4,7,'NA',-1,-1,102,-1],
    [103,326,0,2.306422119,-2.158743,'DAA',2,37,'+Y',-1,69,103,76],
    [104,327,-0.77678302,2.306422119,-2.158743,'DAA',3,37,'+Y',-1,70,104,77],
    [105,328,-1.442569946,2.306422119,-2.158743,'DAA',1,35,'+X',7,-1,105,78],
    [106,329,-2.108379883,2.306422119,-2.158743,'DAA',4,35,'+Y',-1,71,106,79],
    [107,330,-2.774189941,2.306422119,-2.158743,'DAA',2,38,'+Y',-1,72,107,80],
    [108,331,-3.387949951,2.167406982,-2.158743,'SAA',3,7,'NA',-1,-1,108,-1],
    [109,332,-0.44386499,2.8830271,-2.158743,'DAA',1,36,'+Y',-1,73,109,81],
    [110,333,-1.109680054,2.8830271,-2.158743,'DAA',4,36,'+Y',-1,74,110,82],
    [111,334,-1.77548999,2.8830271,-2.158743,'DAA',2,39,'-Y',-1,75,111,83],
    [112,335,-2.44127002,2.8830271,-2.158743,'DAA',3,38,'+X',8,-1,112,84],
    [113,336,-2.939360107,2.745180908,-2.158743,'SAA',4,8,'NA',-1,-1,113,-1],
    [114,337,-0.221945007,3.45963208,-2.158743,'DAA',2,40,'+Y',-1,76,114,85],
    [115,338,-0.88772998,3.45963208,-2.158743,'DAA',3,39,'+Y',-1,77,115,86],
    [116,339,-1.553540039,3.267430908,-2.158743,'SAA',1,8,'NA',-1,-1,116,-1],
    [117,340,-2.08972998,3.436391113,-2.158743,'SAA',4,9,'NA',-1,-1,117,-1],
    [118,341,-0.365734985,4.00525,-2.158743,'SAA',1,9,'NA',-1,-1,118,-1],
    [119,342,-1.085089966,3.872762939,-2.158743,'SAA',2,8,'NA',-1,-1,119,-1],
    [120,343,-1.60401001,3.692779053,-2.158743,'SAA',3,8,'NA',-1,-1,120,-1],
    [121,407,0.44386499,0.576605408,-2.158743,'SAA',1,10,'NA',-1,-1,121,-1],
    [122,408,1.109675049,0.576605408,-2.158743,'DAA',4,37,'+Y',-1,78,122,87],
    [123,409,1.775484985,0.576605408,-2.158743,'DAA',2,41,'+Y',-1,79,123,88],
    [124,410,2.441295898,0.576605408,-2.158743,'DAA',3,40,'+Y',-1,80,124,89],
    [125,411,3.107080078,0.576605408,-2.158743,'DAA',1,37,'-Y',-1,81,125,90],
    [126,412,3.772891113,0.576605408,-2.158743,'DAA',4,38,'-X',9,-1,126,91],
    [127,414,0.776782776,1.15321106,-2.158743,'DAA',3,41,'+Y',-1,82,127,92],
    [128,415,1.442567993,1.15321106,-2.158743,'DAA',1,38,'+Y',-1,83,128,93],
    [129,416,2.10837793,1.15321106,-2.158743,'DAA',4,39,'+Y',-1,84,129,94],
    [130,417,2.774187988,1.15321106,-2.158743,'DAA',2,42,'+Y',-1,85,130,95],
    [131,418,3.439998047,1.15321106,-2.158743,'DAA',3,42,'+Y',-1,86,131,96],
    [132,419,3.9005,0.997686584,-2.158743,'SAA',2,9,'NA',-1,-1,132,-1],
    [133,420,0.44386499,1.72981604,-2.158743,'DAA',1,39,'+Y',-1,87,133,97],
    [134,421,1.109675049,1.72981604,-2.158743,'DAA',4,40,'+Y',-1,88,134,98],
    [135,422,1.775484985,1.72981604,-2.158743,'DAA',2,43,'+Y',-1,89,135,99],
    [136,423,2.44127002,1.72981604,-2.158743,'DAA',3,43,'+Y',-1,90,136,100],
    [137,424,3.107080078,1.72981604,-2.158743,'DAA',1,40,'+Y',-1,91,137,101],
    [138,425,3.724452881,1.517954956,-2.158743,'SAA',4,10,'NA',-1,-1,138,-1],
    [139,427,0.776782776,2.306422119,-2.158743,'DAA',3,44,'+Y',-1,92,139,102],
    [140,428,1.442567993,2.306422119,-2.158743,'DAA',1,41,'-X',10,-1,140,103],
    [141,429,2.10837793,2.306422119,-2.158743,'DAA',4,41,'+Y',-1,93,141,104],
    [142,430,2.774187988,2.306422119,-2.158743,'DAA',2,44,'+Y',-1,94,142,105],
    [143,431,3.387954102,2.167406982,-2.158743,'SAA',3,9,'NA',-1,-1,143,-1],
    [144,432,0.44386499,2.8830271,-2.158743,'DAA',1,42,'+Y',-1,95,144,106],
    [145,433,1.109675049,2.8830271,-2.158743,'DAA',4,42,'+Y',-1,96,145,107],
    [146,434,1.775484985,2.8830271,-2.158743,'DAA',2,45,'-Y',-1,97,146,108],
    [147,435,2.44127002,2.8830271,-2.158743,'DAA',3,45,'-X',11,-1,147,109],
    [148,436,2.939364014,2.745180908,-2.158743,'SAA',4,11,'NA',-1,-1,148,-1],
    [149,437,0.221945206,3.45963208,-2.158743,'DAA',2,46,'+Y',-1,98,149,110],
    [150,438,0.88772998,3.45963208,-2.158743,'DAA',3,46,'+Y',-1,99,150,111],
    [151,439,1.553540039,3.267430908,-2.158743,'SAA',1,11,'NA',-1,-1,151,-1],
    [152,440,2.089733887,3.436391113,-2.158743,'SAA',4,12,'NA',-1,-1,152,-1],
    [153,441,0.365734589,4.00525,-2.158743,'SAA',1,12,'NA',-1,-1,153,-1],
    [154,442,1.085088013,3.872762939,-2.158743,'SAA',2,10,'NA',-1,-1,154,-1],
    [155,443,1.60401001,3.692779053,-2.158743,'SAA',3,10,'NA',-1,-1,155,-1],
])
```

[70]:
```
m1m3_xact = np.float64(FATABLE[:, FATABLE_XPOSITION])
m1m3_yact = np.float64(FATABLE[:, FATABLE_YPOSITION])
```

[72]:

```
m1m3_correction = await client.select_time_series(
    'lsst.sal.MTAOS.logevent_m1m3Correction',
    [f"zForces{i}" for i in range(156)],
    start.utc,
    end.utc
)
```

[73]:

```
m1m3_correction_applied = await client.select_time_series(
    'lsst.sal.MTM1M3.command_applyActiveOpticForces',
    [f"zForces{i}" for i in range(156)],
    start.utc,
    end.utc
)
```

[74]:

```
m1m3_correction
```

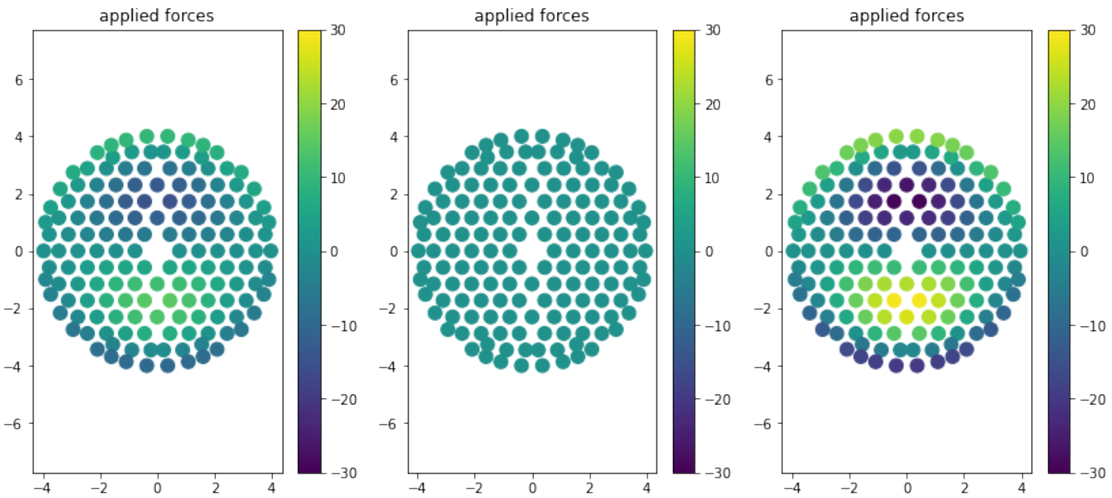
[74]:

```
                                  zForces0  zForces1  zForces2  zForces3  \
2021-12-14 15:18:54.121000+00:00  0.018060 -0.022865 -0.027896 -0.002299
2021-12-14 15:19:38.511000+00:00  0.000000  0.000000  0.000000  0.000000
2021-12-14 15:20:27.186000+00:00  0.036121 -0.045731 -0.055792 -0.004598

                                  zForces4  zForces5   zForces6   zForces7  \
2021-12-14 15:18:54.121000+00:00  0.027176  0.049886   5.305404   5.580944
2021-12-14 15:19:38.511000+00:00  0.000000  0.000000   0.000000   0.000000
2021-12-14 15:20:27.186000+00:00  0.054353  0.099772  10.610807  11.161887

                                  zForces8  zForces9  …  zForces146  \
2021-12-14 15:18:54.121000+00:00  4.462502  2.587142  …   -0.216042
2021-12-14 15:19:38.511000+00:00  0.000000  0.000000  …    0.000000
2021-12-14 15:20:27.186000+00:00  8.925003  5.174284  …   -0.432084

                                  zForces147  zForces148  zForces149  \
2021-12-14 15:18:54.121000+00:00    4.494667     6.57159     1.07034
2021-12-14 15:19:38.511000+00:00    0.000000     0.00000     0.00000
2021-12-14 15:20:27.186000+00:00    8.989333    13.14318     2.14068

                                  zForces150  zForces151  zForces152  \
2021-12-14 15:18:54.121000+00:00    2.656595    3.126895    8.191571
2021-12-14 15:19:38.511000+00:00    0.000000    0.000000    0.000000
2021-12-14 15:20:27.186000+00:00    5.313190    6.253790   16.383142

                                  zForces153  zForces154  zForces155
2021-12-14 15:18:54.121000+00:00    9.781115    9.392729     8.88616
2021-12-14 15:19:38.511000+00:00    0.000000    0.000000     0.00000
2021-12-14 15:20:27.186000+00:00   19.562229   18.785458    17.77232

[3 rows x 156 columns]
```

[75]:
```
m1m3_correction_applied
```

[75]:
```
                                 zForces0  zForces1  zForces2  zForces3  \
2021-12-14 15:18:56.902000+00:00  0.018060 -0.022865 -0.027896 -0.002299
2021-12-14 15:20:02.348000+00:00  0.000000  0.000000  0.000000  0.000000
2021-12-14 15:20:29.941000+00:00  0.036121 -0.045731 -0.055792 -0.004598

                                 zForces4  zForces5   zForces6   zForces7  \
2021-12-14 15:18:56.902000+00:00  0.027176  0.049886   5.305404   5.580944
2021-12-14 15:20:02.348000+00:00  0.000000  0.000000   0.000000   0.000000
2021-12-14 15:20:29.941000+00:00  0.054353  0.099772  10.610807  11.161887

                                 zForces8  zForces9  …  zForces146  \
2021-12-14 15:18:56.902000+00:00  4.462502  2.587142  …   -0.216042
2021-12-14 15:20:02.348000+00:00  0.000000  0.000000  …    0.000000
2021-12-14 15:20:29.941000+00:00  8.925003  5.174284  …   -0.432084

                                 zForces147  zForces148  zForces149  \
2021-12-14 15:18:56.902000+00:00    4.494667     6.57159     1.07034
2021-12-14 15:20:02.348000+00:00    0.000000     0.00000     0.00000
2021-12-14 15:20:29.941000+00:00    8.989333    13.14318     2.14068

                                 zForces150  zForces151  zForces152  \
2021-12-14 15:18:56.902000+00:00    2.656595    3.126895    8.191571
2021-12-14 15:20:02.348000+00:00    0.000000    0.000000    0.000000
2021-12-14 15:20:29.941000+00:00    5.313190    6.253790   16.383142

                                 zForces153  zForces154  zForces155
2021-12-14 15:18:56.902000+00:00    9.781115    9.392729     8.88616
2021-12-14 15:20:02.348000+00:00    0.000000    0.000000     0.00000
2021-12-14 15:20:29.941000+00:00   19.562229   18.785458    17.77232

[3 rows x 156 columns]
```

[76]:
```
fig, axes = plt.subplots(1,3, figsize=(14,6))

for ax, time in zip(axes.flatten(), m1m3_correction.T):
    img = ax.scatter(m1m3_xact, m1m3_yact, c=m1m3_correction.T[time], s=100,␣
 ↪vmin=-30, vmax=30)
    #plt.jet()
    ax.axis('equal')
    ax.set_title('applied forces')
    fig.colorbar(img, ax=ax)
```



applied forces

applied forces

applied forces

[ ]: