LVV-T2190 Plots

This notebook is designed to query the EFD and make diagnostics plots for the execution of Test Case LVV-T2190.
This test case consists of applying `1 um` to the 7th component of the Annular Zernike Coefficient.
Then it resets the corrections and applies `2 um` to the same component.

This means that we can expect to have three values for each metric (at +1um, at 0um, and at +2um).
We can expect that that each telemetry on the third row will be twice the values of the first row.
If they are not, it can mean that the corrections are not properly calculated or that their relationship with the Zernike Coefficients are not linear.

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

In [1]:
```
from lsst.ts import utils

# Extract your name from the Jupyter Hub
__executed_by__ = os.environ["JUPYTERHUB_USER"]

# Extract execution date
__executed_on__ = utils.astropy_time_from_tai_unix(utils.current_tai())
__executed_on__.format = "isot"

# This is used later to define where Butler stores the images
summit = os.environ["LSST_DDS_PARTITION_PREFIX"] == "summit"

print(f"\nExecuted by {__executed_by__} on {__executed_on__}."
      f"\n  At the summit? {summit}")
```

```
lsst.ts.utils.tai INFO: Update leap second table
lsst.ts.utils.tai INFO: current_tai uses the system TAI clock
Executed by b1quint on 2022-05-10T18:52:36.951.
  At the summit? True
```

Set Up

In [2]:
```
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
```

In [3]:
```
%config Application.log_level="DEBUG"
```

In [4]:
```
%matplotlib inline
```

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.

In [28]:
```
test_execution = "LVV-E1860"
time_start_utc = "2022-05-10T18:58:00"
time_end_utc = "2022-05-10T19:01:00"

# test_execution = "LVV-E1788"
# time_start_utc = "2022-04-08T14:20:42"
# time_end_utc = "2022-04-08T15:21:31"
```

In [29]:
```
start = Time(time_start_utc, format="isot", scale="utc")
end = Time(time_end_utc, format="isot", scale="utc")
```

Initialization

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

In [30]:
```
log = logging.getLogger("LVV-T2190")
log.setLevel(logging.DEBUG)
```

In [31]:
```
lsst_efd_client.EfdClient.list_efd_names()
```

Out[31]:
```
['test_efd',
 'summit_efd',
 'ncsa_teststand_efd',
 'ldf_stable_efd',
 'ldf_int_efd',
 'base_efd',
 'tucson_teststand_efd']
```

In [32]:
```
efd_name = "summit_efd"
```

In [33]:
```
client = lsst_efd_client.EfdClient(efd_name)
```

In [34]:
```
start.strftime("%m/%d/%Y, %H:%M:%S"), end.strftime("%m/%d/%Y, %H:%M:%S")
```

Out[34]: ('05/10/2022, 18:58:00', '05/10/2022, 19:01:00')

In [35]:
```
log.debug(f"{start.utc}, {end}")
```

```
LVV-T2190 DEBUG: 2022-05-10T18:58:00.000, 2022-05-10T19:01:00.000
```

In [36]:
```
os.makedirs("plots", exist_ok=True)
```

Displaying results

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.

In [37]:
```
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(5
    start.utc,
    end.utc
)
```

In [38]:
```
degrees_of_freedom
```

Out[38]:

	aggregatedDoF0	aggregatedDoF1	aggregatedDoF2	aggregatedDoF3
2022-05-10 18:58:02.068000+00:00	0.263911	0.094081	-184.532732	-28.676308
2022-05-10 18:59:02.745000+00:00	0.000000	0.000000	0.000000	0.000000
2022-05-10 19:00:03.563000+00:00	0.338241	0.109839	-143.704721	-23.712257

3 rows × 100 columns

During the [LVV-T2190] test, we first issue an `1 um` aberration, reset the the corrections, and then issue a `2 um` aberration.
Common sense says that row 2 and row 0 must have a factor of 2 of difference.

In [39]:
```
degrees_of_freedom.iloc[2] / degrees_of_freedom.iloc[0]
```

Out[39]:
```
aggregatedDoF0      1.281651
aggregatedDoF1      1.167495
aggregatedDoF2      0.778749
aggregatedDoF3      0.826894
aggregatedDoF4      1.001580
                      ...
visitDoF45         -8.462181
visitDoF46        -30.273142
visitDoF47         -2.080730
visitDoF48        -16.624659
visitDoF49        -16.965747
Length: 100, dtype: float64
```

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

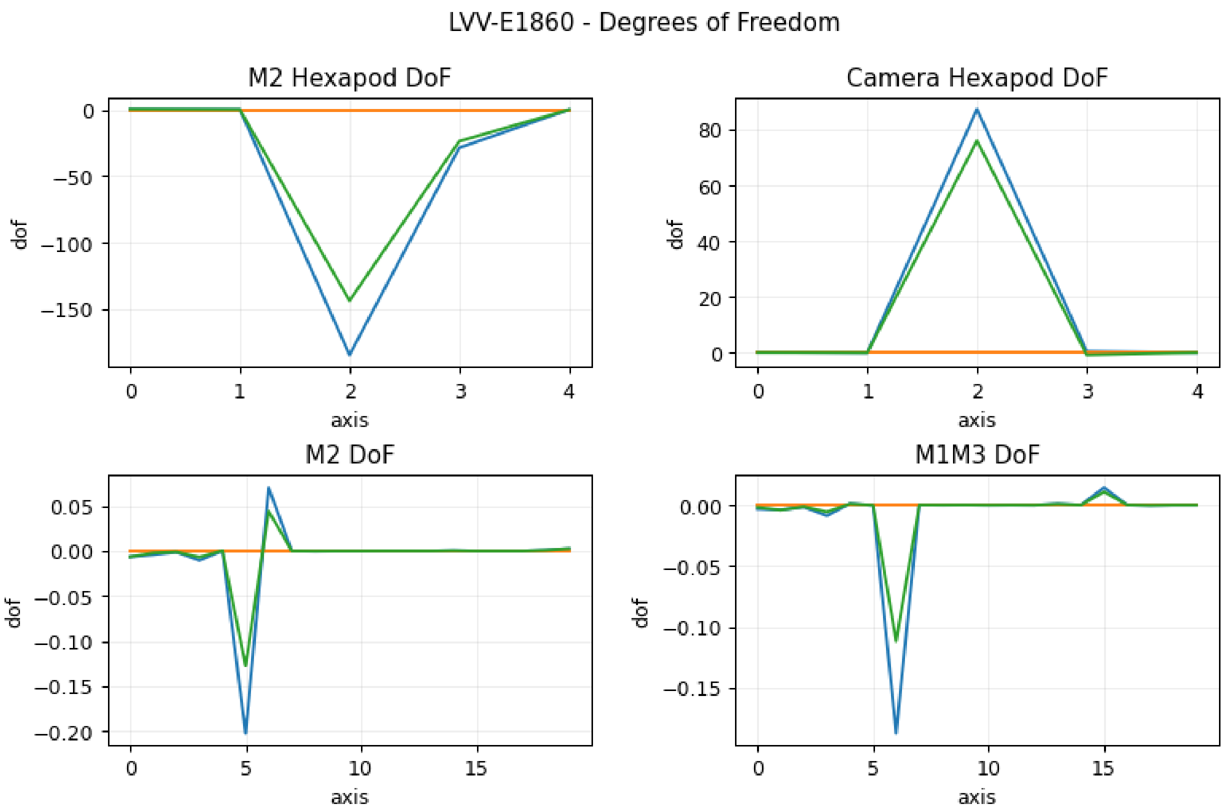
In [40]:
```
aggregated_dof = np.array([degrees_of_freedom[f"aggregatedDoF{i}"] for i in ran
visit_dof = np.array([degrees_of_freedom[f"visitDoF{i}"] for i in range(50)]).T
```

In [41]:
```
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.
            ),
            M2Bend=dict(startIdx=30, idxLength=20, state0name="M2Bending", rot_
        )
```

And we finally plot them.

In [42]:
```
fig, axes = plt.subplots(2,2, figsize=(10,6), dpi=90)

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"]["idxL
        ]
    )

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

    axes[1][0].plot(
        aggregated_dof[i][
            comp_dof_idx["M2Bend"]["startIdx"]:
```

```
            comp_dof_idx["M2Bend"]["startIdx"]+comp_dof_idx["M2Bend"]["idxLengt
        ]
    )

    axes[1][1].plot(
        aggregated_dof[i][
            comp_dof_idx["M1M3Bend"]["startIdx"]:
            comp_dof_idx["M1M3Bend"]["startIdx"]+comp_dof_idx["M1M3Bend"]["idxI
        ]
    )

ax_titles = ["M2 Hexapod DoF",  "Camera Hexapod DoF", "M2 DoF", "M1M3 DoF"]
for i in range(4):

    r = i // 2
    c = i % 2

    axes[r][c].set_title(ax_titles[i])
    axes[r][c].set_xlabel("axis")
    axes[r][c].set_ylabel("dof")
    axes[r][c].grid("-", alpha=0.2)

fig.suptitle(f"{test_execution} - Degrees of Freedom")
fig.patch.set_facecolor('white')
plt.subplots_adjust(hspace=0.4, wspace=0.3)

fig.savefig(f"plots/{test_execution}_dof.png")
```



Step 8

Display Camera Hexapod Correction

In [ ]:
```
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
)
```

In [ ]:
```
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
)
```

In [ ]:
```
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
)
```

In [ ]:
```
cam_hexapod_correction_computed_xyz
```

In [ ]:
```
cam_hexapod_correction_computed_uv
```

In [ ]:
```
cam_hexapod_correction_applied_xyz
```

In [ ]:
```
cam_hexapod_correction_applied_uv
```

In [ ]:
```
cam_hexapod_correction_command_xyz
```

In [ ]:
```
cam_hexapod_correction_command_uv
```

In [ ]:
```
fig, axs = plt.subplots(figsize=(14, 6), ncols=5)

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

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

    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])
    ax.set_ylabel("Position (micron)")

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

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

    x = [0.]

    b0 = ax.bar(
        [-0.5],
        cam_hexapod_correction_computed_uv[label],
        width=0.5,
    )

    b1 = ax.bar(
        [0.],
        cam_hexapod_correction_applied_uv[label],
        width=0.5,
    )

    b2 = ax.bar(
        [0.5],
        cam_hexapod_correction_command_uv[label],
        width=0.5,
    )

    ax.set_xticks([0])
    ax.set_xticklabels([label])
    ax.set_ylabel("Position (degrees)")

fig.suptitle(f"{test_execution} - Camera Hexapod\nComputed/Applied/Commanded Co
fig.tight_layout(h_pad=0.3)
```

```
fig.patch.set_facecolor('white')

fig.savefig(f"plots/{test_execution}_camera_hexapod.png")
```

Display M2 Hexapod Correction

In [ ]:
```
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
)
```

In [ ]:
```
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
)
```

In [ ]:
```
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
)
```

In [ ]:
```
m2_hexapod_correction_command_xyz
```

In [ ]:
```
m2_hexapod_correction_computed_xyz
```

In [ ]:
```
m2_hexapod_correction_applied_xyz
```

In [ ]:
```
m2_hexapod_correction_command_uv
```

In [ ]:
```
m2_hexapod_correction_computed_uv
```

In [ ]:
```
m2_hexapod_correction_applied_uv
```

In [ ]:
```
fig, axs = plt.subplots(figsize=(16, 6), ncols=5)

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

    ax = axs[panel]

    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])
    ax.set_ylabel("Position (micron)")


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

    ax = axs[panel + 3]

    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])
    ax.set_ylabel("Position (degrees)")


fig.suptitle(f"{test_execution} - M2 Hexapod\nComputed/Applied/Commanded Correc
fig.tight_layout(h_pad=0.3)
fig.patch.set_facecolor('white')

fig.savefig(f"plots/{test_execution}_m2_hexapod.png")
```

Display M2 Correction

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

In [ ]:
```
m2_correction
```

In [ ]:
```
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
)
```

In [ ]:
```
m2_correction_applied
```

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

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

In [ ]:
```
m2_yact
```

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

In [ ]:
```
aa.shape
```

In [ ]:
```
m2_correction.T
```

In [ ]:
```
m2_correction_applied.T
```

In [ ]:
```
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')

axes[0].set_title("+1um")
axes[1].set_title("zero")
axes[2].set_title("+2um")

fig.patch.set_facecolor('white')
fig.suptitle(f"{test_execution} - Step 8\nM2 Corrections", x=0.435)
fig.tight_layout()
fig.colorbar(img, ax=axes, label="Correction [um]", pad=0.01)

fig.savefig(f"plots/{test_execution}_m2.png")
```

Display M1M3 Correction

In [ ]:

```
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],
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[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],
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    [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],
])
```

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

In [ ]:
```
m1m3_yact
```

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

In [ ]:
```
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
)
```

In [ ]:
```
m1m3_correction
```

In [ ]:
```
m1m3_correction_applied
```

In [ ]:
```
fig, axes = plt.subplots(1, 3, figsize=(17, 7))

for ax, time in zip(axes.flatten(), m1m3_correction.T):
    img = ax.scatter(m1m3_xact, m1m3_yact, c=m1m3_correction.T[time], s=150, vm
    ax.axis('equal')
    ax.set_title(f"applied forces\n{time}")

fig.patch.set_facecolor('white')
fig.suptitle(f"{test_execution} - Step 9\nM1 Corrections", x=0.43)
fig.tight_layout()
fig.colorbar(img, ax=axes, label="Correction [um]", pad=0.01)
fig.savefig(f"plots/{test_execution}_m1.png")
```

In [ ]:

In [ ]: