Slew, Track and Image taking with ComCam

This notebook is used for the level 3 integration tests from test plan LVV-P81 (https://jira.lsstcorp.org/secure/Tests.jspa#/testPlan/LVV-P81) as part of test cylce LVV-C176 (https://jira.lsstcorp.org/secure/Tests.jspa#/testCycle/LVV-C176). The following tests are currently run as part of this notebook:

- LVV-T2290 (https://jira.lsstcorp.org/secure/Tests.jspa#/testCase/LVV-T2290)

Execution steps are separated by horizontal lines. Upon completion, save the notebook and its output as a pdf file to be attached to the test execution in JIRA.

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 2022-04-29T18:35:27.853.
  At the summit? True
```

Run the setup.ipnyb notebook to bring all components up and in their enabled position. Check Chronograph.

Bring ComCom online and tranistion it to EnabledState. Check Chronograph.

In [2]:
```
%load_ext autoreload
%autoreload 2
```

In [3]:
```
import rubin_jupyter_utils.lab.notebook as nb
nb.utils.get_node()
```

```
/tmp/ipykernel_53072/1665379685.py:2: DeprecationWarning: Call to deprecated f
unction (or staticmethod) get_node. (Please use lsst.rsp.get_node())
  nb.utils.get_node()
```

Out[3]:
```
'yagan04'
```

In [4]:
```
import os
import sys
import asyncio
import logging

import pandas as pd
import numpy as np

from matplotlib import pyplot as plt

from lsst.ts import salobj
from lsst.ts.observatory.control.maintel import MTCS, ComCam
from lsst.ts.observatory.control import RotType
```

In [5]:
```
logging.basicConfig(format="%(name)s:%(message)s", level=logging.DEBUG)
```

In [6]:
```
log = logging.getLogger("setup")
log.level = logging.DEBUG
```

In [7]:
```
domain = salobj.Domain()
```

In [8]:
```
mtcs = MTCS(domain=domain, log=log)
mtcs.set_rem_loglevel(40)
```

```
setup.MTCS DEBUG: mtmount: Adding all resources.
setup.MTCS DEBUG: mtptg: Adding all resources.
setup.MTCS DEBUG: mtaos: Adding all resources.
setup.MTCS DEBUG: mtm1m3: Adding all resources.
setup.MTCS DEBUG: mtm2: Adding all resources.
setup.MTCS DEBUG: mthexapod_1: Adding all resources.
setup.MTCS DEBUG: mthexapod_2: Adding all resources.
setup.MTCS DEBUG: mtrotator: Adding all resources.
setup.MTCS DEBUG: mtdome: Adding all resources.
setup.MTCS DEBUG: mtdometrajectory: Adding all resources.
```

In [9]:
```
await mtcs.start_task
```

```
MTHexapod INFO: Read historical data in 0.01 sec
MTHexapod INFO: Read historical data in 0.03 sec
```

Out[9]:
```
[None, None, None, None, None, None, None, None, None, None]
```

```
MTHexapod.electrical WARNING: tel_electrical DDS read queue is filling: 13
 of 100 elements
MTHexapod.application WARNING: tel_application DDS read queue is filling: 2
0 of 100 elements
MTHexapod.actuators WARNING: tel_actuators DDS read queue is filling: 20 of
100 elements
```

In [ ]:
```
comcam = ComCam(domain=domain, log=log)
```

In [ ]:
```
comcam.set_rem_loglevel(40)
```

In [ ]:
```
await comcam.start_task
```

In [ ]:
```
await comcam.enable()
```

Find four targets separated by 5° in azimuth and elevation in a square pattern around az = 120° and el = 60° and rotator angle at PhysicalSky and 1.8°.

At this position, the rotator stays within a couple of degrees of its initial position. This is because the CCW is not running (MTmount in simulation mode).

target_1 -> az = 117.5^o, el = 57.5^o
target_2 -> az = 122.5^o, el =57.5^o
target_3 -> az = 122.5^o, el=62.5^o
target_4 -> az = 117.5^o, el = 62.5^o

In [10]:
```
target_1 = mtcs.radec_from_azel(az=117.5, el=57.5)
target_2 = mtcs.radec_from_azel(az=122.5, el=57.5)
target_3 = mtcs.radec_from_azel(az=122.5, el=62.5)
target_4 = mtcs.radec_from_azel(az=117.5, el=62.5)

print(f"Target 1: {target_1}\n"
      f"Target 2: {target_2}\n"
      f"Target 3: {target_3}\n"
      f"Target 4: {target_4}\n")
```

```
WARNING: AstropyDeprecationWarning: Transforming a frame instance to a frame c
lass (as opposed to another frame instance) will not be supported in the futur
e.  Either explicitly instantiate the target frame, or first convert the sourc
e frame instance to a `astropy.coordinates.SkyCoord` and use its `transform_to
()` method. [astropy.coordinates.baseframe]
astroquery WARNING: AstropyDeprecationWarning: Transforming a frame instanc
e to a frame class (as opposed to another frame instance) will not be suppo
rted in the future.  Either explicitly instantiate the target frame, or fir
st convert the source frame instance to a `astropy.coordinates.SkyCoord` an
d use its `transform_to()` method.
Target 1: <ICRS Coordinate: (ra, dec) in deg
    (106.07193646, -39.69045216)>
Target 2: <ICRS Coordinate: (ra, dec) in deg
    (105.64043108, -42.35619991)>
Target 3: <ICRS Coordinate: (ra, dec) in deg
    (99.05950669, -41.36217928)>
Target 4: <ICRS Coordinate: (ra, dec) in deg
    (99.64882447, -39.09836168)>

MTHexapod.electrical WARNING: tel_electrical DDS read queue is filling: 13
 of 100 elements
MTHexapod.application WARNING: tel_application DDS read queue is filling: 1
4 of 100 elements
MTHexapod.actuators WARNING: tel_actuators DDS read queue is filling: 13 of
100 elements
```

Slew to target 1:

In [11]:
```
await mtcs.slew_icrs(ra=target_1.ra, dec=target_1.dec, rot_type=RotType.Physica
```

```
setup.MTCS DEBUG: Setting rotator physical position to 1.9 deg. Rotator wil
l track sky.
setup.MTCS WARNING: Camera cable wrap following disabled in MTMount.
setup.MTCS DEBUG: Wait 5.0s for rotator to settle down.
setup.MTCS DEBUG: Workaround for rotator trajectory problem. Moving rotator
to its current position: 0.10
setup.MTCS DEBUG: Wait for MTRotator in position event.
setup.MTCS DEBUG: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator already in position. Handling potential race co
ndition.
setup.MTCS INFO: MTRotator in position: False.
setup.MTCS INFO: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator in position True. Waiting settle time 5.0s
setup.MTCS DEBUG: Sending slew command.
setup.MTCS DEBUG: Scheduling check coroutines
setup.MTCS DEBUG: process as completed...
setup.MTCS DEBUG: Monitor position started.
setup.MTCS DEBUG: Waiting for Target event from mtmount.
setup.MTCS DEBUG: mtmount: <State.ENABLED: 2>
setup.MTCS DEBUG: mtptg: <State.ENABLED: 2>
setup.MTCS DEBUG: mtaos: <State.ENABLED: 2>
setup.MTCS DEBUG: mtm1m3: <State.ENABLED: 2>
setup.MTCS DEBUG: mtm2: <State.ENABLED: 2>
setup.MTCS DEBUG: mthexapod_1: <State.ENABLED: 2>
setup.MTCS DEBUG: mthexapod_2: <State.ENABLED: 2>
setup.MTCS DEBUG: mtrotator: <State.ENABLED: 2>
setup.MTCS DEBUG: mtdome: <State.ENABLED: 2>
setup.MTCS DEBUG: mtdometrajectory: <State.ENABLED: 2>
setup.MTCS DEBUG: Wait for mtmount in position events.
setup.MTCS DEBUG: Wait for dome in position event.
setup.MTCS DEBUG: Wait for MTRotator in position event.
setup.MTCS DEBUG: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator already in position. Handling potential race co
ndition.
setup.MTCS DEBUG: Wait for MTMount elevation in position event.
setup.MTCS DEBUG: MTMount elevation in position: True.
setup.MTCS DEBUG: MTMount elevation already in position. Handling potential
race condition.
setup.MTCS DEBUG: Wait for MTMount azimuth in position event.
setup.MTCS DEBUG: MTMount azimuth in position: True.
setup.MTCS DEBUG: MTMount azimuth already in position. Handling potential r
ace condition.
setup.MTCS INFO: MTRotator in position: False.
setup.MTCS DEBUG: No new in position event in the last 3.0s. Assuming MTMou
nt elevation in position.
setup.MTCS DEBUG: MTMount elevation in position True. Waiting settle time
 3.0s
setup.MTCS DEBUG: No new in position event in the last 3.0s. Assuming MTMou
nt azimuth in position.
```

```
setup.MTCS DEBUG: MTMount azimuth in position True. Waiting settle time 3.0
s
setup.MTCS INFO: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator in position True. Waiting settle time 3.0s
```

```
---------------------------------------------------------------------------
TimeoutError                              Traceback (most recent call last)
File ~/auto-op-env-packages/ts_observatory_control/python/lsst/ts/observatory/control/maintel/mtcs.py:371, in MTCS.monitor_position(self, check)
    370 try:
--> 371     target = await self.rem.mtmount.evt_target.next(
    372         flush=True, timeout=self.long_timeout
    373     )
    374     self.log.debug(f"Mount target: {target}")

File /opt/lsst/software/stack/conda/miniconda3-py38_4.9.2/envs/lsst-scipipe-3.0.0/lib/python3.8/site-packages/lsst/ts/salobj/topics/read_topic.py:645, in ReadTopic.next(self, flush, timeout)
    644     self.flush()
--> 645 return await self._next(timeout=timeout)

File /opt/lsst/software/stack/conda/miniconda3-py38_4.9.2/envs/lsst-scipipe-3.0.0/lib/python3.8/site-packages/lsst/ts/salobj/topics/read_topic.py:659, in ReadTopic._next(self, timeout)
    658     self._next_task = asyncio.Future()
--> 659 return await asyncio.wait_for(self._next_task, timeout=timeout)

File /opt/lsst/software/stack/conda/miniconda3-py38_4.9.2/envs/lsst-scipipe-3.0.0/lib/python3.8/asyncio/tasks.py:501, in wait_for(fut, timeout, loop)
    500         await _cancel_and_wait(fut, loop=loop)
--> 501         raise exceptions.TimeoutError()
    502 finally:

TimeoutError:

During handling of the above exception, another exception occurred:

RuntimeError                              Traceback (most recent call last)
Input In [11], in <cell line: 1>()
----> 1 await mtcs.slew_icrs(ra=target_1.ra, dec=target_1.dec, rot_type=RotType.PhysicalSky, rot=1.9)

File ~/auto-op-env-packages/ts_observatory_control/python/lsst/ts/observatory/control/base_tcs.py:590, in BaseTCS.slew_icrs(self, ra, dec, rot, rot_type, target_name, dra, ddec, offset_x, offset_y, az_wrap_strategy, time_on_target, slew_timeout, stop_before_slew, wait_settle)
    585     valid_rottypes = ", ".join(repr(rt) for rt in RotType)
    586     raise RuntimeError(
    587         f"Unrecognized rottype {rot_type}. Should be one of {valid_rottypes}"
    588     )
--> 590 await self.slew(
    591     radec_icrs.ra.hour,
    592     radec_icrs.dec.deg,
    593     rotPA=rot_angle.deg,
    594     target_name=target_name,
    595     frame=self.CoordFrame.ICRS,
    596     epoch=2000,
    597     equinox=2000,
    598     parallax=0,
    599     pmRA=0,
    600     pmDec=0,
    601     rv=0,
    602     dRA=dra,
    603     dDec=ddec,
```

```
    604     rot_frame=rot_frame,
    605     rot_track_frame=rot_track_frame,
    606     az_wrap_strategy=az_wrap_strategy,
    607     time_on_target=time_on_target,
    608     rot_mode=self.RotMode.FIELD,
    609     slew_timeout=slew_timeout,
    610     stop_before_slew=stop_before_slew,
    611     wait_settle=wait_settle,
    612     offset_x=offset_x,
    613     offset_y=offset_y,
    614 )
    616 return radec_icrs, rot_angle

File ~/auto-op-env-packages/ts_observatory_control/python/lsst/ts/observatory/control/base_tcs.py:762, in BaseTCS.slew(self, ra, dec, rotPA, target_name, frame, epoch, equinox, parallax, pmRA, pmDec, rv, dRA, dDec, rot_frame, rot_track_frame, rot_mode, az_wrap_strategy, time_on_target, slew_timeout, stop_before_slew, wait_settle, offset_x, offset_y)
    755 getattr(self.rem, self.ptg_name).cmd_poriginOffset.set(
    756     dx=offset_x * self.plate_scale,
    757     dy=offset_y * self.plate_scale,
    758     num=0,
    759 )
    761 try:
--> 762     await self._slew_to(
    763         getattr(self.rem, self.ptg_name).cmd_raDecTarget,
    764         slew_timeout=slew_timeout,
    765         offset_cmd=getattr(self.rem, self.ptg_name).cmd_poriginOffset,
    766         stop_before_slew=stop_before_slew,
    767         wait_settle=wait_settle,
    768     )
    769 except salobj.AckError as ack_err:
    770     self.log.error(
    771         f"Command to track target {target_name} rejected: {ack_err.ackcmd.result}"
    772     )

File ~/auto-op-env-packages/ts_observatory_control/python/lsst/ts/observatory/control/maintel/mtcs.py:289, in MTCS._slew_to(self, slew_cmd, slew_timeout, offset_cmd, stop_before_slew, wait_settle, check)
    284         getattr(self.rem, comp).evt_summaryState.flush()
    285         self.scheduled_coro.append(
    286             asyncio.create_task(self.check_component_state(comp))
    287         )
--> 289 await self.process_as_completed(self.scheduled_coro)

File ~/auto-op-env-packages/ts_observatory_control/python/lsst/ts/observatory/control/remote_group.py:1075, in RemoteGroup.process_as_completed(self, tasks)
   1073 except Exception as e:
   1074     await self.cancel_not_done(tasks)
-> 1075     raise e
   1076 else:
   1077     await self.cancel_not_done(tasks)

File ~/auto-op-env-packages/ts_observatory_control/python/lsst/ts/observatory/control/remote_group.py:1072, in RemoteGroup.process_as_completed(self, tasks)
   1070 for res in asyncio.as_completed(tasks):
   1071     try:
-> 1072         ret_val = await res
   1073     except Exception as e:
```

```
   1074         await self.cancel_not_done(tasks)

File /opt/lsst/software/stack/conda/miniconda3-py38_4.9.2/envs/lsst-scipipe-3.0.0/lib/python3.8/asyncio/tasks.py:619, in as_completed.<locals>._wait_for_one()
    616 if f is None:
    617     # Dummy value from _on_timeout().
    618     raise exceptions.TimeoutError
--> 619 return f.result()

File ~/auto-op-env-packages/ts_observatory_control/python/lsst/ts/observatory/control/maintel/mtcs.py:376, in MTCS.monitor_position(self, check)
    374     self.log.debug(f"Mount target: {target}")
    375 except asyncio.TimeoutError:
--> 376     raise RuntimeError(
    377         "Not receiving target events from the NewMTMount. "
    378         "Check component for errors."
    379     )
    380 if not hasattr(
    381     self.rem.mtmount.tel_azimuth.DataType(), mtmount_actual_position_name
    382 ):
    383     self.log.debug("Running in xml 7.1 compatibility mode.")

RuntimeError: Not receiving target events from the NewMTMount. Check component for errors.
```

```
MTHexapod.electrical WARNING: tel_electrical DDS read queue is filling: 21 of 100 elements
MTHexapod.electrical WARNING: tel_electrical DDS read queue is filling: 10 of 100 elements
MTHexapod.application WARNING: tel_application DDS read queue is filling: 21 of 100 elements
MTHexapod.application WARNING: tel_application DDS read queue is filling: 10 of 100 elements
MTHexapod.actuators WARNING: tel_actuators DDS read queue is filling: 21 of 100 elements
MTHexapod.actuators WARNING: tel_actuators DDS read queue is filling: 10 of 100 elements
```

In [12]:
```
await mtcs.set_state(salobj.State.STANDBY, components=["mtptg"])
```

```
setup.MTCS DEBUG: [mtptg]::[<State.ENABLED: 2>, <State.DISABLED: 1>, <State.STANDBY: 5>]
setup.MTCS INFO: All components in <State.STANDBY: 5>.
```

In [13]:
```
await mtcs.set_state(salobj.State.ENABLED, components=["mtptg"])
```

```
setup.MTCS DEBUG: [mtptg]::[<State.STANDBY: 5>, <State.DISABLED: 1>, <State.ENABLED: 2>]
setup.MTCS INFO: All components in <State.ENABLED: 2>.
```

In [14]:
```
await mtcs.slew_icrs(ra=target_1.ra, dec=target_1.dec, rot_type=RotType.Physica
```

```
setup.MTCS DEBUG: Setting rotator physical position to 1.9 deg. Rotator will track sky.
setup.MTCS WARNING: Camera cable wrap following disabled in MTMount.
setup.MTCS DEBUG: Wait 5.0s for rotator to settle down.
```

```
setup.MTCS DEBUG: Workaround for rotator trajectory problem. Moving rotator
to its current position: 1.35
setup.MTCS DEBUG: Wait for MTRotator in position event.
setup.MTCS DEBUG: MTRotator in position: False.
setup.MTCS INFO: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator in position True. Waiting settle time 5.0s
setup.MTCS DEBUG: Sending slew command.
setup.MTCS DEBUG: Scheduling check coroutines
setup.MTCS DEBUG: process as completed...
setup.MTCS DEBUG: Monitor position started.
setup.MTCS DEBUG: Waiting for Target event from mtmount.
setup.MTCS DEBUG: mtmount: <State.ENABLED: 2>
setup.MTCS DEBUG: mtptg: <State.ENABLED: 2>
setup.MTCS DEBUG: mtaos: <State.ENABLED: 2>
setup.MTCS DEBUG: mtm1m3: <State.ENABLED: 2>
setup.MTCS DEBUG: mtm2: <State.ENABLED: 2>
setup.MTCS DEBUG: mthexapod_1: <State.ENABLED: 2>
setup.MTCS DEBUG: mthexapod_2: <State.ENABLED: 2>
setup.MTCS DEBUG: mtrotator: <State.ENABLED: 2>
setup.MTCS DEBUG: mtdome: <State.ENABLED: 2>
setup.MTCS DEBUG: mtdometrajectory: <State.ENABLED: 2>
setup.MTCS DEBUG: Wait for mtmount in position events.
setup.MTCS DEBUG: Wait for dome in position event.
setup.MTCS DEBUG: Wait for MTRotator in position event.
setup.MTCS DEBUG: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator already in position. Handling potential race co
ndition.
setup.MTCS DEBUG: Wait for MTMount elevation in position event.
setup.MTCS DEBUG: MTMount elevation in position: True.
setup.MTCS DEBUG: MTMount elevation already in position. Handling potential
race condition.
setup.MTCS DEBUG: Wait for MTMount azimuth in position event.
setup.MTCS DEBUG: MTMount azimuth in position: True.
setup.MTCS DEBUG: MTMount azimuth already in position. Handling potential r
ace condition.
setup.MTCS DEBUG: Mount target: private_revCode: bdcb00ba, private_sndStam
p: 1651258241.3306124, private_rcvStamp: 1651258241.3308299, private_seqNu
m: 3, private_identity: MTMount, private_origin: 34591, elevation: 58.66690
766194088, elevationVelocity: 0.003194472973217041, azimuth: 117.7103703117
5068, azimuthVelocity: 0.0006515799730847417, taiTime: 1651258241.3896174,
 trackId: 2, tracksys: SIDEREAL, radesys: ICRS, priority: 0
setup.MTCS INFO: MTMount elevation in position: False.
setup.MTCS INFO: MTMount azimuth in position: False.
setup.MTCS INFO: MTRotator in position: False.
setup.MTCS DEBUG: [Tel]: Az = +000.018[+117.7]; El = +089.991[ -31.3] [Ro
t]: +001.349[  -0.0] [Dome] Az = +000.000; El = +000.000
setup.MTCS DEBUG: Dome azimuth in position.
setup.MTCS DEBUG: Dome elevation in position.
setup.MTCS INFO: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator in position True. Waiting settle time 3.0s
```

```
setup.MTCS DEBUG: [Tel]: Az = +046.697[ +71.0]; El = +066.698[  -8.0] [Ro
t]: +002.043[  +0.0] [Dome] Az = +000.000; El = +000.000
setup.MTCS INFO: MTMount elevation in position: True.
setup.MTCS DEBUG: MTMount elevation in position True. Waiting settle time
 3.0s
setup.MTCS DEBUG: [Tel]: Az = +091.888[ +25.8]; El = +058.708[  -0.0] [Ro
t]: +002.023[  -0.0] [Dome] Az = +000.000; El = +000.000
setup.MTCS INFO: MTMount azimuth in position: True.
setup.MTCS DEBUG: MTMount azimuth in position True. Waiting settle time 3.0
s
setup.MTCS DEBUG: [Tel]: Az = +117.723[  -0.0]; El = +058.727[  -0.0] [Ro
t]: +002.004[  +0.0] [Dome] Az = +000.000; El = +000.000
```

Out[14]:
```
(<ICRS Coordinate: (ra, dec) in deg
     (106.07193646, -39.69045216)>,
 <Angle 1.9 deg>)
```

Once on target_1 and tracking, take an image with ComCam

In [ ]:
```
exp1 = await comcam.take_object(15)
print(f"Target 1 exposure: {exp1}")
```

Slew to target_2:

In [15]:
```
await mtcs.slew_icrs(ra=target_2.ra, dec=target_2.dec, rot_type=RotType.Physica
```

```
setup.MTCS DEBUG: Setting rotator physical position to 1.9 deg. Rotator wil
l track sky.
setup.MTCS WARNING: Camera cable wrap following disabled in MTMount.
setup.MTCS DEBUG: Wait 5.0s for rotator to settle down.
setup.MTCS DEBUG: Workaround for rotator trajectory problem. Moving rotator
to its current position: 1.84
setup.MTCS DEBUG: Wait for MTRotator in position event.
setup.MTCS DEBUG: MTRotator in position: False.
setup.MTCS INFO: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator in position True. Waiting settle time 5.0s
setup.MTCS DEBUG: Sending slew command.
setup.MTCS DEBUG: Scheduling check coroutines
setup.MTCS DEBUG: process as completed...
setup.MTCS DEBUG: Monitor position started.
setup.MTCS DEBUG: Waiting for Target event from mtmount.
setup.MTCS DEBUG: mtmount: <State.ENABLED: 2>
setup.MTCS DEBUG: mtptg: <State.ENABLED: 2>
setup.MTCS DEBUG: mtaos: <State.ENABLED: 2>
setup.MTCS DEBUG: mtm1m3: <State.ENABLED: 2>
setup.MTCS DEBUG: mtm2: <State.ENABLED: 2>
setup.MTCS DEBUG: mthexapod_1: <State.ENABLED: 2>
setup.MTCS DEBUG: mthexapod_2: <State.ENABLED: 2>
setup.MTCS DEBUG: mtrotator: <State.ENABLED: 2>
```

```
setup.MTCS DEBUG: mtdome: <State.ENABLED: 2>
setup.MTCS DEBUG: mtdometrajectory: <State.ENABLED: 2>
setup.MTCS DEBUG: Wait for mtmount in position events.
setup.MTCS DEBUG: Wait for dome in position event.
setup.MTCS DEBUG: Wait for MTRotator in position event.
setup.MTCS DEBUG: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator already in position. Handling potential race co
ndition.
setup.MTCS DEBUG: Wait for MTMount elevation in position event.
setup.MTCS DEBUG: MTMount elevation in position: True.
setup.MTCS DEBUG: MTMount elevation already in position. Handling potential
race condition.
setup.MTCS DEBUG: Wait for MTMount azimuth in position event.
setup.MTCS DEBUG: MTMount azimuth in position: True.
setup.MTCS DEBUG: MTMount azimuth already in position. Handling potential r
ace condition.
setup.MTCS DEBUG: Mount target: private_revCode: bdcb00ba, private_sndStam
p: 1651258289.3908708, private_rcvStamp: 1651258289.391098, private_seqNum:
963, private_identity: MTMount, private_origin: 34591, elevation: 58.752501
440392905, elevationVelocity: 0.0030288220540594856, azimuth: 122.923064842
27504, azimuthVelocity: 0.0011277678572926928, taiTime: 1651258289.4497886,
trackId: 3, tracksys: SIDEREAL, radesys: ICRS, priority: 0
setup.MTCS INFO: MTMount azimuth in position: False.
setup.MTCS INFO: MTMount elevation in position: False.
setup.MTCS INFO: MTMount elevation in position: True.
setup.MTCS DEBUG: MTMount elevation in position True. Waiting settle time
 3.0s
setup.MTCS INFO: MTMount azimuth in position: True.
setup.MTCS DEBUG: MTMount azimuth in position True. Waiting settle time 3.0
s
setup.MTCS DEBUG: [Tel]: Az = +117.764[  +5.2]; El = +058.810[  -0.1] [Ro
t]: +001.843[  -0.0] [Dome] Az = +000.000; El = +000.000
setup.MTCS DEBUG: Dome azimuth in position.
setup.MTCS DEBUG: Dome elevation in position.
setup.MTCS DEBUG: No new in position event in the last 3.0s. Assuming MTRot
ator in position.
setup.MTCS DEBUG: MTRotator in position True. Waiting settle time 3.0s
```

Out[15]:
```
(<ICRS Coordinate: (ra, dec) in deg
    (105.64043108, -42.35619991)>,
 <Angle 1.9 deg>)
```

Once on target_2 and tracking, take an image with ComCam

In [ ]:
```
exp2 = await comcam.take_object(15)
print(f"Target 1 exposure: {exp2}")
```

Slew to target_3

In [16]:
```
await mtcs.slew_icrs(ra=target_3.ra, dec=target_3.dec, rot_type=RotType.Physica
```

```
setup.MTCS DEBUG: Setting rotator physical position to 1.9 deg. Rotator wil
l track sky.
setup.MTCS WARNING: Camera cable wrap following disabled in MTMount.
setup.MTCS DEBUG: Wait 5.0s for rotator to settle down.
setup.MTCS DEBUG: Workaround for rotator trajectory problem. Moving rotator
to its current position: 1.74
setup.MTCS DEBUG: Wait for MTRotator in position event.
setup.MTCS DEBUG: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator already in position. Handling potential race co
ndition.
setup.MTCS INFO: MTRotator in position: False.
setup.MTCS INFO: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator in position True. Waiting settle time 5.0s
setup.MTCS DEBUG: Sending slew command.
setup.MTCS DEBUG: Scheduling check coroutines
setup.MTCS DEBUG: process as completed...
setup.MTCS DEBUG: Monitor position started.
setup.MTCS DEBUG: Waiting for Target event from mtmount.
setup.MTCS DEBUG: mtmount: <State.ENABLED: 2>
setup.MTCS DEBUG: mtptg: <State.ENABLED: 2>
setup.MTCS DEBUG: mtaos: <State.ENABLED: 2>
setup.MTCS DEBUG: mtm1m3: <State.ENABLED: 2>
setup.MTCS DEBUG: mtm2: <State.ENABLED: 2>
setup.MTCS DEBUG: mthexapod_1: <State.ENABLED: 2>
setup.MTCS DEBUG: mthexapod_2: <State.ENABLED: 2>
setup.MTCS DEBUG: mtrotator: <State.ENABLED: 2>
setup.MTCS DEBUG: mtdome: <State.ENABLED: 2>
setup.MTCS DEBUG: mtdometrajectory: <State.ENABLED: 2>
setup.MTCS DEBUG: Wait for mtmount in position events.
setup.MTCS DEBUG: Wait for dome in position event.
setup.MTCS DEBUG: Wait for MTRotator in position event.
setup.MTCS DEBUG: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator already in position. Handling potential race co
ndition.
setup.MTCS DEBUG: Wait for MTMount elevation in position event.
setup.MTCS DEBUG: MTMount elevation in position: True.
setup.MTCS DEBUG: MTMount elevation already in position. Handling potential
race condition.
setup.MTCS DEBUG: Wait for MTMount azimuth in position event.
setup.MTCS DEBUG: MTMount azimuth in position: True.
setup.MTCS DEBUG: MTMount azimuth already in position. Handling potential r
ace condition.
setup.MTCS DEBUG: Mount target: private_revCode: bdcb00ba, private_sndStam
p: 1651258316.6253684, private_rcvStamp: 1651258316.6256, private_seqNum: 1
507, private_identity: MTMount, private_origin: 34591, elevation: 63.831249
11061434, elevationVelocity: 0.003016852714062511, azimuth: 123.27344523053
218, azimuthVelocity: 0.0019243913549106075, taiTime: 1651258316.6842453, t
rackId: 4, tracksys: SIDEREAL, radesys: ICRS, priority: 0
setup.MTCS INFO: MTMount azimuth in position: False.
setup.MTCS INFO: MTMount elevation in position: False.
```

```
setup.MTCS INFO: MTMount azimuth in position: True.
setup.MTCS DEBUG: MTMount azimuth in position True. Waiting settle time 3.0
s
setup.MTCS DEBUG: [Tel]: Az = +123.008[  +0.3]; El = +058.862[  +5.0] [Ro
t]: +001.742[  -0.0] [Dome] Az = +000.000; El = +000.000
setup.MTCS DEBUG: Dome azimuth in position.
setup.MTCS DEBUG: Dome elevation in position.
setup.MTCS INFO: MTMount elevation in position: True.
setup.MTCS DEBUG: MTMount elevation in position True. Waiting settle time
 3.0s
setup.MTCS DEBUG: No new in position event in the last 3.0s. Assuming MTRot
ator in position.
setup.MTCS DEBUG: MTRotator in position True. Waiting settle time 3.0s
```

Out[16]:
```
(<ICRS Coordinate: (ra, dec) in deg
    (99.05950669, -41.36217928)>,
 <Angle 1.9 deg>)
```

Once on target_3 and tracking, take an image with ComCam

In [ ]:
```
exp3 = await comcam.take_object(15)
print(f"Target 1 exposure: {exp3}")
```

Slew to target 4

In [17]:
```
await mtcs.slew_icrs(ra=target_4.ra, dec=target_4.dec, rot_type=RotType.Physica
```

```
setup.MTCS DEBUG: Setting rotator physical position to 1.9 deg. Rotator wil
l track sky.
setup.MTCS WARNING: Camera cable wrap following disabled in MTMount.
setup.MTCS DEBUG: Wait 5.0s for rotator to settle down.
setup.MTCS DEBUG: Workaround for rotator trajectory problem. Moving rotator
to its current position: 1.64
setup.MTCS DEBUG: Wait for MTRotator in position event.
setup.MTCS DEBUG: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator already in position. Handling potential race co
ndition.
setup.MTCS INFO: MTRotator in position: False.
setup.MTCS INFO: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator in position True. Waiting settle time 5.0s
setup.MTCS DEBUG: Sending slew command.
setup.MTCS DEBUG: Scheduling check coroutines
setup.MTCS DEBUG: process as completed...
setup.MTCS DEBUG: Monitor position started.
setup.MTCS DEBUG: Waiting for Target event from mtmount.
setup.MTCS DEBUG: mtmount: <State.ENABLED: 2>
setup.MTCS DEBUG: mtptg: <State.ENABLED: 2>
setup.MTCS DEBUG: mtaos: <State.ENABLED: 2>
setup.MTCS DEBUG: mtm1m3: <State.ENABLED: 2>
```

```
setup.MTCS DEBUG: mtm2: <State.ENABLED: 2>
setup.MTCS DEBUG: mthexapod_1: <State.ENABLED: 2>
setup.MTCS DEBUG: mthexapod_2: <State.ENABLED: 2>
setup.MTCS DEBUG: mtrotator: <State.ENABLED: 2>
setup.MTCS DEBUG: mtdome: <State.ENABLED: 2>
setup.MTCS DEBUG: mtdometrajectory: <State.ENABLED: 2>
setup.MTCS DEBUG: Wait for mtmount in position events.
setup.MTCS DEBUG: Wait for dome in position event.
setup.MTCS DEBUG: Wait for MTRotator in position event.
setup.MTCS DEBUG: MTRotator in position: True.
setup.MTCS DEBUG: MTRotator already in position. Handling potential race co
ndition.
setup.MTCS DEBUG: Wait for MTMount elevation in position event.
setup.MTCS DEBUG: MTMount elevation in position: True.
setup.MTCS DEBUG: MTMount elevation already in position. Handling potential
race condition.
setup.MTCS DEBUG: Wait for MTMount azimuth in position event.
setup.MTCS DEBUG: MTMount azimuth in position: True.
setup.MTCS DEBUG: MTMount azimuth already in position. Handling potential r
ace condition.
setup.MTCS INFO: MTMount azimuth in position: False.
setup.MTCS INFO: MTMount elevation in position: False.
setup.MTCS DEBUG: Mount target: private_revCode: bdcb00ba, private_sndStam
p: 1651258333.4969594, private_rcvStamp: 1651258333.4972153, private_seqNu
m: 1844, private_identity: MTMount, private_origin: 34591, elevation: 63.95
606856119757, elevationVelocity: 0.0031843164831425724, azimuth: 118.058203
84599805, azimuthVelocity: 0.0013687420519315546, taiTime: 1651258333.55555
18, trackId: 5, tracksys: SIDEREAL, radesys: ICRS, priority: 0
setup.MTCS INFO: MTMount elevation in position: True.
setup.MTCS DEBUG: MTMount elevation in position True. Waiting settle time
 3.0s
setup.MTCS INFO: MTMount azimuth in position: True.
setup.MTCS DEBUG: MTMount azimuth in position True. Waiting settle time 3.0
s
setup.MTCS DEBUG: [Tel]: Az = +123.181[  -5.1]; El = +063.938[  +0.0] [Ro
t]: +001.642[  -0.0] [Dome] Az = +000.000; El = +000.000
setup.MTCS DEBUG: Dome azimuth in position.
setup.MTCS DEBUG: Dome elevation in position.
setup.MTCS DEBUG: No new in position event in the last 3.0s. Assuming MTRot
ator in position.
setup.MTCS DEBUG: MTRotator in position True. Waiting settle time 3.0s
```

Out[17]:
```
(<ICRS Coordinate: (ra, dec) in deg
    (99.64882447, -39.09836168)>,
 <Angle 1.9 deg>)
```

Once on target_4 and tracking, take an image with ComCam

In [ ]:
```
exp4 = await comcam.take_object(15)
print(f"Target 1 exposure: {exp4}")
```

Stop tracking to prevent hitting the Rotator soft limit.

In [18]:
```
await mtcs.stop_tracking()
```

```
setup.MTCS DEBUG: Stop tracking.
```

Use ComCam recent images CCS to ensure that the images were taken (http://ccs.lsst.org/RecentImages/comcam.html).

Query the butler to verify that the images are there and check the metadata. This step must be verified using a separate noteboook.

Wrap Up and Shut Down

This cell is not currently included as part of the test execution, but included here as needed to shutdown the systems

In [ ]:
```
await mtcs.set_state(salobj.State.STANDBY, components=["mtaos"])
```

In [ ]:
```
await mtcs.lower_m1m3()
```

In [ ]:
```
await mtcs.set_state(salobj.State.STANDBY, components=["mtm1m3"])
```

In [ ]:
```
await mtcs.set_state(salobj.State.STANDBY, components=["mtm2"])
```

In [ ]:
```
await mtcs.set_state(salobj.State.STANDBY, components=["mthexapod_1"])
```

In [ ]:
```
await mtcs.set_state(salobj.State.STANDBY, components=["mthexapod_2"])
```

In [ ]:
```
await mtcs.standby()
```

In [ ]:
```
await comcam.standby()
```