Canarias InfRAreD Camera Experiment

GTC Observing Guide

S. Nicholas Raines, Stephen S. Eikenberry, Craig D. Warner, Alan Garner, Richard Deno Stelter

On behalf of the CIRCE team
Colophon

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Executive Summary

This document will list and describe basic commands for observing with CIRCE.
Contact Information

The name, title, address, telephone number, fax number, and email address of the principal contact for CIRCE is:

Prof. Steve S. Eikenberry  
*MIRADAS Principal Investigator*  
University of Florida  
Department of Astronomy  
P.O. Box 112055  
211 Bryant Space Science Center  
Gainesville, FL 32611-2055 USA

00+1+352-294-1833 (direct)  
00+1+352-294-1870 (Department Main Office)

[eiken@astro.ufl.edu](mailto:eiken@astro.ufl.edu)  
[eiken@ufl.edu](mailto:eiken@ufl.edu)
Revisions

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Notes

The files for this document are tracked with Mercurial.
Acronyms, Abbreviations, and Terms

ADU Analog Data Units
API Application Programming Interfaces
ASIC Application Specific Integrated Circuit
CIRCE Canarias InfRAreD Camera Experiment
CIS CIRCE Interface Server
CJEC CIRCE Java Engineering Console
CoG Center of Gravity
DAS Data Acquisition Server
ETC Exposure Time Calculator (see ITC)
FC Folded Cassegrain
FITS Flexible Image Transport System
FOV Field of View
FPA Focal Plane Array
FWHM Full Width at Half Maximum
GCS GTC Control System
CORBA Common Object Request Broker Architecture
GTC Gran Telescopio Canarias
GUI Graphical User Interface, e.g. the Inspector
H2RG HAWAII-2RG
HgCdTe Mercury Cadmium Telluride, an alloy of CdTe and HgTe
IDL Interface Definition Language
I-SDEC IUCAA SIDECAR Drive Electronics Card
ITC Integration Time Calculator (see ETC)
IUCAA Inter-University Centre for Astronomy and Astrophysics
JDD Java Display Device
LCU Local Control Unit (a computer host)
LN$_2$ Liquid Nitrogen
MEF Multi-Extension FITS
MOC Module of Optical Control
N.A. Not Applicable
NGS Natural Guide Star
NIR Near Infrared
OMs Observing Modes
PSF Point Spread Function
ROIC Read-Out Integrated Circuit
ACRONYMS, ABBREVIATIONS, AND TERMS

SIDECAR  System for Image Digitization Enhancement Control and Retrieval
TCS    Telescope Control System
TIS    Telescope Information Server
UF     University of Florida
WCS    World Coordinates System
1 CIRCE Overview

CIRCE is the Canarias InfRAeD Camera Experiment. It is comprised of a single large Liquid Nitrogen-cooled Dewar, designed to be mounted to the GTC Folded Cassegrain Rotator. It is primarily a Near Infrared (NIR) imager, with polarimetry capabilities. The Dewar contains all of the powered optics, filters, stops, and the detector array; at some future date it will contain prisms for spectroscopy. A functional diagram will be included at a later date. A brief listing of important parameters is given.

**Array:** Teledyne HAWAII-2RG 2048×2048 pixel controlled by a cryogenic SIDECAR ASIC. Thirty (30) of the thirty-two (32) array amplifiers are active.

**Array Interface:** An Inter-University Centre for Astronomy and Astrophysics (IUCAA) I-SDEC ASIC to USB interface.

**Linearity:**
- 0.5% non-linear at XX,000 ADU
- 2.0% non-linear at YY,000 ADU
- > 3.5% non-linear at ZZ,000 ADU

**Plate Scale:** 0.1 arcsec/pixel

**Field of View:** ~200 arcsec × 190 arcsec

**Detector Characteristics**
- Full Well = XX,000 ADU
- Target Count Level = YY,000–ZZ,000 ADU
- CDS Read Noise = NN e⁻
- Gain = GG e⁻/ADU

**Filters** J, H, Ks

**Linear Polarimetry** A Half Wave Plate (HWP) insertable into the beam at the GTC focus and a Wollaston prism within the collimated beam.

**Mechanisms** To the observer there is one filter mechanism and one polarimetry mechanism. In reality the filter mechanism is comprised of three different filter wheels, a Lyot wheel, and a Grism wheel. Filter Wheel 1 (FW1) contains the NIR filters and a Dark, and the other filter wheels are empty. The Lyot wheel contains a stop for the GTC and two Hartmann masks for engineering. The Grism wheel presently (2014-12-11) contains the Wollaston prism for polarimetry.
1. CIRCE Overview

**Instrument Control**  The circe account on the GTC hosts runs the instrument GUIs, and communicate with the circelcu host within the CIRCE Electronics rack mounted on the Elevation Ring.

**Data Acquisition and Storage**  As noted above, data from the array are streamed from the ASIC through the I-SDEC controller to circelcu. Data are transferred to the GTC data archive. *Data will periodically (weekly or daily) need to be removed from the circelcu disk.*
2 Bringing up the CIRCE software at the GTC

CIRCE is presently controlled from two custom Java GUIs, ufjec (UF CIRCE Java Engineering Console), and ufjdd (the CIRCE Java Display Device). These tools can load Phase II-generated observing script XML files. The GUIs talk to the CIRCE instrument control computer, circelcu, which runs all of the software agents that actually control the instrument. This is schematically illustrated in a software deployment diagram in Figure 2.1 (below).

2.1 Log into ormcon4

CIRCE may be operated from any of the GTC computer hosts (e.g. devcon8, or ormcon4) under the circe account.

1. In the control room, log onto ormcon4 as circe. If logged in as another user, use
circe@ormcon4:> ssh circe@localhost

2. Ensure the shell is tcsh

![Diagram of software deployment]

**Figure 2.1.** The observer runs interface software on ormcon4 and software agents on circelcu; these agents interface with the Telescope Information server on ormserver5, and sends data to the GTC data archive.
2. Bringing up the CIRCE software at the GTC

```
circe@ormcon4:> tcsh
```

### 2.2 Starting the agents

A number of software agents act as interfaces between the high level user interface GUIs and the actual hardware; they include

**Executive**  This is a top level agent that keeps track of everything.

**Environmental**  These include

- **Pressure**  This agent talks to the Pfeiffer vacuum gauge, and monitors the current Dewar pressure.

- **Temperature**  This one agent that talks to two devices, the LakeShore 218 8-channel temperature monitor, and the LakeShore 331 2-channel temperature monitor and controller associated with the detector control and readout system.

**Motor**  This communicates with the mechanism motion control motors.

**CIS**  This is the CIRCE Interface Server; the DAS uses this to talk to the TCS (Telescope Control System).

**DAS**  This is the data acquisition server. Images taken with CIRCE are written to the `circelcu` host, and the DAS sends the data to the GTC data archive.

These are run on `circelcu`, and this sequence assumes the instrument is fully up and running for operation.

1. Log onto `circelcu`
   ```
   ssh circe@circelcu
   ```
   Do *not* use the -X or -Y options to ssh; we had weird X errors during engineering commissioning and X-forwarding is not required here.

2. Start the Executive and environmental (pressure, temperature) agents and begin logging
   ```
   circe@circelcu:> ufcircestart -preset default
   ```

3. Start the motor agents, DAS, and CIS
   ```
   circe@circelcu:> ufrestart mc
   circe@circelcu:> ufrestart das
   circe@circelcu:> ufrestart cis
   ```

*N.B.*  When the DAS starts it will automatically do an Init & Config Sidecar.

### 2.3 Starting the GUIs

An outline of the steps to startup the CIRCE GUIs from the GTC control room is given here. The `ormcon4` workstation contains four (4) monitors, `ormcon4:0.1` to `ormcon4:0.4`; from the terminal you can launch a new window on one of the other displays by first executing `setenv DISPLAY ormcon4:0.1`, for example.

Note: `ufcircestart -preset list` will list several preset options, *i.e.* `sim331` in cases where a mode other than the default is required.
2.3. Starting the GUIs

1. Log onto ormcon4 as circe. If logged in as another user, use
   
   ssh circe@localhost

2. Start tcsh
   
   circe@ormcon4:> tcsh

3. Start ufjec with
   
   circe@ormcon4:> ufjec -host circelcu -tcshost ormserver5
   
   This will launch a single window (Figure 2.2, page 5).

4. Start ufjdd with
   
   circe@ormcon4:> ufjdd -host circelcu
   
   This will launch two (2) windows (Figure 2.3, page 6).

2. The default TCS port value is -tcsport 12008.
2. Bringing up the CIRCE software at the GTC

Figure 2.3. The two windows of JDD are shown. Top: This window displays the full image from CIRCE. The image may be displayed with different scale factors. It has two buffers, called $S_{rc}$ and $B_{gd}$, and can display either one or their difference. Bottom: This window shows subregions of the Full Display window. Single exposures may be initiated here, and an exposure’s status and progress may be followed (bottom left).
Table 2.1. CIRCE Normal Ranges. Note that Ch 1 is attached to the vacuum jacket and should be within 4 Kelvin of the dome ambient.

<table>
<thead>
<tr>
<th>Pressures (Torr)</th>
<th>Temperatures (K)</th>
</tr>
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<tbody>
<tr>
<td>Pfeiffer</td>
<td>LakeShore 218</td>
</tr>
<tr>
<td>Normal 5 × 10⁻⁷ to 2 × 10⁻⁷</td>
<td>Ch 1 274 ± 10</td>
</tr>
<tr>
<td>OK &lt; 5 × 10⁶</td>
<td>Ch 2 100 ± 10</td>
</tr>
<tr>
<td></td>
<td>Ch 3 105 ± 10</td>
</tr>
<tr>
<td></td>
<td>Ch 4, 5, 6, and 7</td>
</tr>
<tr>
<td></td>
<td>Ch 8 95 ± 10</td>
</tr>
</tbody>
</table>

If out of range contact

Steve Eikenberry
Teléfono: +1 352 514 7632
24 horas, 7 días

LakeShore 331
Ch A Muerto
(no conexión)
Ch B 82 ± 4

2.4 Initialize ufcjec

The GUI will start up on the CJEC Main tab (Figure 2.3, page 5), which will show the status of the ExecutiveAgent, LakeshoreAgent, VacAgent, and circeDAS³. The system will be ready once all of their fields say

Health: Good
Status: Idle

Note, the ExecutiveAgent will take 30-40 s before reaching this state, upon initial startup, as it takes that long to communicate with the Baytech remote AC power control. In the event that the buttons on CJEC are in a disabled state due to an error, they may all be enabled or disabled under Options pulldown menu at the top left. The log may also be viewed.

Once the agents are ready, it is also a good idea to see if the temperature and pressure readings are at good values; these are tabulated in Table 2.1 (page 7). Ten (10) temperature readings are shown in the green sub-region on the left of the main tab, and all of the values excluding LS218CH1 should be < 110 K. A strip chart of the LakeShore 218 temperature values may be examined in Figure 2.4 (page 8). The pressure reading is shown on the Vac tab⁴ (cf. Figure 2.5, page 8), which also has a strip chart; the normal range should be 5 × 10⁻⁷–2 × 10⁻⁷ Torr (cf. Table 2.1).

The Detector Control parameters are set in the top right light-blue region on the CJEC Main tab. It is a good idea to press the yellow Check Sidecar Status button after bringing up CJEC.

2.5 Verify the GTC software is running

The CIRCE telescope information server (TIS; or CIRCETelescopeServer) must be running on some GTC host, in order to obtain correct FITS header information, and for the data

³. A present the status of the CIS is not shown
⁴. The pressure shown in the figure is 3.2 × 10⁻³ Torr.
2. Bringing up the CIRCE software at the GTC

![CIRCE Software Interface]

**Figure 2.4.** The CJEC Temperatures tab shows a strip chart of recent temperature values. Different channels may be displayed, and regions may be examined by holding down the left mouse button and selecting a rectangular region within the strip chart.

To be moved into the data archive. Note, the data will always be written to `\data` on `circelcu`, which also has an NFS mount point to `orm-scibb`. To verify,

1. Select the CJEC TIS tab and press the Update button. The RA and Dec text values on the tab should update to match the present telescope position.

2. Also, examine the file `circe@circelcu:` `\log.CIS` for connection error messages (e.g. `grep ERROR`).

2.6 Restarting or shutting down the software

*If the Dewar is under vacuum and at any temperature below ambient, the agents shall be kept running.* This is so that the instrument’s health can be monitored at any time. However, while the instrument is in use it is sometimes necessary to stop and restart the agents.

2.6.1 Closing the GUIs

It is always possible to quit the GUI interfaces, simply by closing their windows.
2.6. Restarting or shutting down the software

Figure 2.5. The CJEC Vac tab shows a strip chart of recent pressure values, and the Pressure 1 entry on the left shows the numerical pressure reading in Torr.

2.6.2 Restarting the temperature or pressure agents

It is the Executive agent which restarts the temperature and pressure agents; *n.b.* it cannot restart the motors or DAS. This should be done from *ufcjec*, on the tab labeled Executive (Figure 2.6, page 10). Use the pulldown menu in the top right of the tab to select the agent(s) to reboot, then press the Reboot Agent(s) button.

Note, `circe@circelcu:` `ufcircestop -h` will list the syntax for stopping either agent from the command line.

1. First stop the agent
   
   ```
   circe@circelcu:` `ufcircestop ufVac` or
   circe@circelcu:` `ufcircestop ufcirceLakeshore`
   ```

2. Then restart the agent
   
   ```
   circe@circelcu:` `ufcircestart ufVac` or
   circe@circelcu:` `ufcircestart ufcirceLakeshore`
   ```

Alternatively, stop and restart the agent all in one command:

1. `circe@circelcu:` `ufrestart ufVac` or
2. `circe@circelcu:` `ufrestart ufcirceLakeshore.`

`circe_110_001_gtc_obs_guide; hg tag: 1.A`
2. Bringing up the CIRCE software at the GTC

Figure 2.6. The CJEC Executive tab shows reboottable agents in the top section of the panel. The left side is an interface to the Baytech power outlet controller.

2.6.3 Restarting all of the agents

1. Log onto circelcu
   
   ssh circe@circelcu

2. circe@circelcu:>
   
   ufrestart -preset

2.6.4 Restarting the motor agent or the DAS

1. Log onto circelcu
   
   ssh circe@circelcu

2. circe@circelcu:>
   
   ufrestart mc

3. circe@circelcu:>
   
   ufrestart das

2.6.5 Stopping the agents

To stop all of the agents from circelcu

1. circe@circelcu:>
   
   ufcircestop -a
3 Running CIRCE at the GTC

The CJEC Main tab will probably be the most used interface for loading observing scripts, along with the CIRCE Java Data Display’s (JDD) two windows. However, after starting the software the instrument’s current configuration should be verified on the CJEC Motors tab (Figure 3.1 page 12).

3.1 Read the mechanism positions

In general use, CIRCE mechanism positions will be controlled via Phase II-generated Observing Scripts; in this case the CJEC Motors tab should be used display the current positions. The CJEC Motors tab may be used to Datum or Move the mechanisms, but this should only be used by experienced CIRCE users. The mechanism’s names, and associated indexers are listed in the column second from right labeled Mech Name. Each name has an associated check box, which enables the associated Abort, Datum, or Move buttons, and the corresponding Named Position pull-down menu. The mechanisms are

- A> Window,
- B> HWPRot (the Half Wave Plate Rotator),
- C> LinSlide (the linear slide, which carries the HWP),
- D> FW1
- E> FW3 ⇒ This mechanism should not be moved, as of 2014-12-11.
- F> FW2
- G> LW (the Lyot wheel)
- H> GW (the Grism wheel, which also carries the Wollaston prism for polarimetry).

As can be seen from the list, CIRCE has three separate wheels for filters, but the Phase II observing scripts treat them as one unified Filter Wheel.

After starting all of the agents it is good to query their positions.

1. Select the CJEC Motors tab.
2. Press the button Check Locations.
3. Wait for the motor indexers to read out. The values in the right most column, under the heading Indexer Sta... will update from top (A) to bottom (H).
3. Running CIRCE at the GTC

![CIRCE Interface](image)

**Figure 3.1.** The CJEC Motors tab is used to query and position the mechanisms.

3.2 Datum the mechanisms

Datuming a mechanism tells the indexer to move the mechanism until a knocker on it triggers an associated snap action switch. The mechanism immediately stops, and undergoes a small ‘dance’ where it backs off of the switch and then re-datums at a lower speed, after which the indexer drives the mechanism back off the switch by a small amount. The step count is then set to origin.

To datum,

1. Select the check box of mechanism,

2. Press the associated Datum button.

We generally datum only one or two mechanisms at a time.

**Precautions**

- Do not Datum the Window mechanism (as it moves to Open) if the differential temperature between the current temperature and the dew point temperature is $> 4^\circ$C.
3.3. Taking images

Notes

- The Window mechanism’s Datum position is at Open. The Window mechanism was replaced 03 March 2015. The new window cover is a rugged shutter (compared to the iris mechanism it replaced). It has a travel range of $\sim 270,000$ steps and takes $\sim 45$ seconds to close or open.

- Indexer A is ‘flakey’. While opening and closing the Window, we noticed (March 2015) that sometimes the indexer claims the mechanism is moving; the step count changes as expected. However, it moves well over 270,000 steps without hitting a limit switch. As the operator, you can check to see if the Window is moving by taking 3 second exposures with the Ks filter:
  1. If the Window is at Closed, start by moving FW1 to ‘Ks’. Take a 3s exposure (Single-Frame Mode) and send this frame to background in JDD; this will act as the Dark frame. Move the Window to open using the CJEC Motors tab. Take a set of 3s exposures (one at a time) to verify that the window is actually moving; the IR light from the telescope turret is more than adequate to indicate if the Window is actually moving.
  2. Similarly, if the Window is at Open, take a series of 3s Ks exposures in Single-Frame Mode to verify that the Window is closing. The Window shutter will block enough IR light to be easily noticeable if the Window is actually moving to closed.

- If the Window seems to be ‘stuck’, try increasing the run current to 75% via the Display & Adjust Motor Parameters in the lower center of the CJEC Motors tab. If that fails to work, try increasing the run current to 90%. Make sure to lower the run current to its nominal 50% after successfully moving the Window to Open or Closed.

3.3 Taking images

Images may be taken singly through either the CJEC Main tab (Figure 2.2, page 5) or through the JDD main window (see Figure 2.3, page 6). Sequences of images with CIRCE in different configurations, and with or without moving the telescope (i.e. Observing Sequences) may be executed from the CJEC Main tab.

3.3.1 Acquiring single images

Acquiring single frames is easy to do using the CJEC Main tab. Verify that the OBSERVE SEQUENCE Input is set to ‘Single-Frame Mode’; if not, select ‘Single Frame Mode’ from the pull-down menu and hit the green Apply’ button in the lower left (see Figure 2.2). Configure the DETECTOR CONTROL (blue box) to the settings you want (exposure time is in milli-seconds, so a 3 second exposure requires 3000 in the Exp Time field), making sure to press ‘Enter’ after changing any of the settings. Press the green ‘Apply’ button again to send the new settings to the ISDEC.

Pressing the green ‘Observe’ button on the lower right will start the exposure. JDD, if already running, will automatically grab the frame as it becomes available (typically 2
3. **Running CIRCE at the GTC**

- 3 seconds after the frame is written to disk). If JDD fails to load the latest frame, you can use the light blue ‘Load Newest Image’ button on JDD to force it to grab the newest frame available.

### 3.3.2 Acquiring images using Observing Sequence files

Observing Sequence Pattern (XML) files\(^1\) may be selected and run from the CJEC Main window; see the bottom left region in Figure 2.2 (page 5). These files may also be written to just configure the instrument for exposures, such as for darks, flat fields, or gain-linearity curves.

### 3.4 Focusing CIRCE

Focusing CIRCE should be done as soon as stars appear (after twilight flats). The Window should be at ‘Open,’ Filter Wheel 1 at the filter you’ll be using for science observations, and the Lyot wheel should be at ‘Lyot.’

1. Using JDD, select a bright-ish star in the field (the first science field of the night works).
2. Offset the telescope using the Telescope Offset Control panel in JDD (see §3.5 for a guide) by 10 or 20 arcseconds in your favorite direction (remember which direction you chose so that you can undo the motion later!).
3. Ensure that you are using the filter you want to use for your science observations.
4. Take a short exposure (3 – 5 seconds).
5. Click on the Telescope Offset Control tab in JDD to open the Telescope Offset Control panel.
6. Note the current focus number (relative or absolute) for comparison.
7. We have noticed that the focus should be driven to the LEFT (using positive values in the Focus increment field) when the star image appears to be stretched along a ‘y = -x’ line, and to the RIGHT (again, using positive values) when the star image appears to be stretched along a ‘y = +x’ line.
8. Adjust the focus until the star image appears round.
9. Record the focus (one day we might have a good idea of what the focus should be relative to the focus for OSIRIS and CANARICAM, and thus be more efficient at switching between instruments).

### 3.5 Using the Telescope Offset Control panel in JDD

JDD has a very nice tool for offsetting and centering the telescope called the Telescope Offset Control panel. To access it, click on the Telescope Offset Control tab in JDD. A new window will pop up with three main parts.

\(^1\)For reference, these files are in the circe home space on the GTC machines (e.g. ormcon4), in \$ucircleinstall/etc/obsSequences/.
3.5. Using the Telescope Offset Control panel in JDD

Precautions when taking images

- During Engineering commissioning (2014-12-11) we saw several garbled images, due to USB transfer errors from the I-SDEC controller and circelcu. It is a good idea to keep the CJEC Main tab in view, to watch the DAS status for ERROR, in addition to watching the images as they are displayed in JDD.
4 Daily actions with CIRCE

4.1 Dome closed

If the weather is bad enough during the night that the dome is periodically opened and closed, move Window to Closed to prevent condensation.

4.2 End of night tasks

After deciding to stop observing for the night, please

1. Move Window to Closed. Verify that the Window has indeed closed by taking a few Ks exposures before and after closing

2. Park the Filter at Dark; from the CJEC Motors tab this moving [D]> FW1 to Dark.

4.3 Useful reference information

- The array center of rotation during Science Commissioning (2015-03-04) was at \((x, y) = (968.8, 982.2)\) in pixel coordinates.
- The CIRCE optical axis is at \((x, y) = (943, 1003)\); for reference the detector center is at \((1023.5, 1023.5)\).
- The array center of rotation during First Light (2014-12-10) was at \((x, y) = (965.5, 975.3)\) in pixel coordinates.

This corresponds to a shift of \((x, y) = (25, 21)\) pixel ⇔ \(dx = 0.45\) mm, \(dy = 0.38\) mm.
5  CIRCE Trouble Shooting

5.1 General Items

**Window fails to reach Closed**

1. Abort
2. Datum
3. Re-move to Closed

   Iterate. See also the notes on page 13. This procedure worked during Engineering commissioning within three iterations.

**Mechanism positions are wrong or do not make sense**

   It is possible the mc agent has lost connection to the indexers via the Perle.

1. On the CJEC Motors tab press the green button at bottom right labeled Re-Connect MC agent to indexers.
2. Next, press the yellow button at the bottom middle labeled Connecting Sockets.... This will reopen the sockets between the panel and the agent.

**If nothing response to clicks on the CJEC Motors tab**

1. Press the yellow button at the bottom middle labeled Connecting Sockets.... This will reopen the sockets between the panel and the agent.
6 Mechanism Operational Parameters
Details

This chapter will contain some low level details regarding the operation of various mechanisms, including nominal parameters.

6.1 Window Mechanism

Notes from 12 June 2015 servicing
These notes are from S.S. Eikenberry.

6.1.1 Nominal mechanism indexer parameters

Initial Speed = 24
Term speed = 5036
Acceleration = 32
Deceleration = 32
Drive current = 25
Back Lash = 0
Datum speed = 5036
Final Speed = 100
Datum Direction = 0

Step resolution (D) = 1 = Full stepping\(^1\)

Other key features of this mechanism to remember:

- Datum position = Open
- Moving from Open ⇒ Closed: Move Positive Steps
- Moving from Closed ⇒ Open: Move Negative Steps
- The nominal distance from Open to Closed = 222 024 steps.

\(^1\)Not 1/2 or 1/8 stepping.
As noted above, the nominal distance from Open to Closed is 222,024 steps. However, this is VERY nominal. In practice, once datumed, the Closed position seems to range from 199 to 850 steps greater than this (as of June 2015). This means that the true Closed position is probably more like 222,550 steps from the datum location, and there is a spread of at least ±350 steps around that value. The scatter seems to be smaller (<100 steps) in a given gravity vector, but changing FC Rotator orientation shifts the overall position by a few hundred steps. Note that this is <1 mm overall shift, and is compatible with expectations.

Note also that moving to Open is also systematically shifted from the datum location (even though datuming the window cover sets these to equal!). This is probably because the move to Open is a controlled move (including a rampdown), while datuming includes a fast move and a slow move into a limit switch — the nominal datum backlash is probably insufficient, creating the observed offset. This does NOT harm operations in any way — just a note of explanation.

As a result of this, sending the Window Cover to Open or Closed seldom ends with the step count equalling the actual Open and Closed nominal step counts. As a result, the Named Position pulldown in CJEC will be colored yellow. This is normal for the window cover, and no need to worry.

As long the window cover datums properly, and moving to the Closed position terminates in something like 222,500 steps (give or take 1,000 steps), the window cover is OK.