Building a Simple Instrument Utility using ginga and astropy

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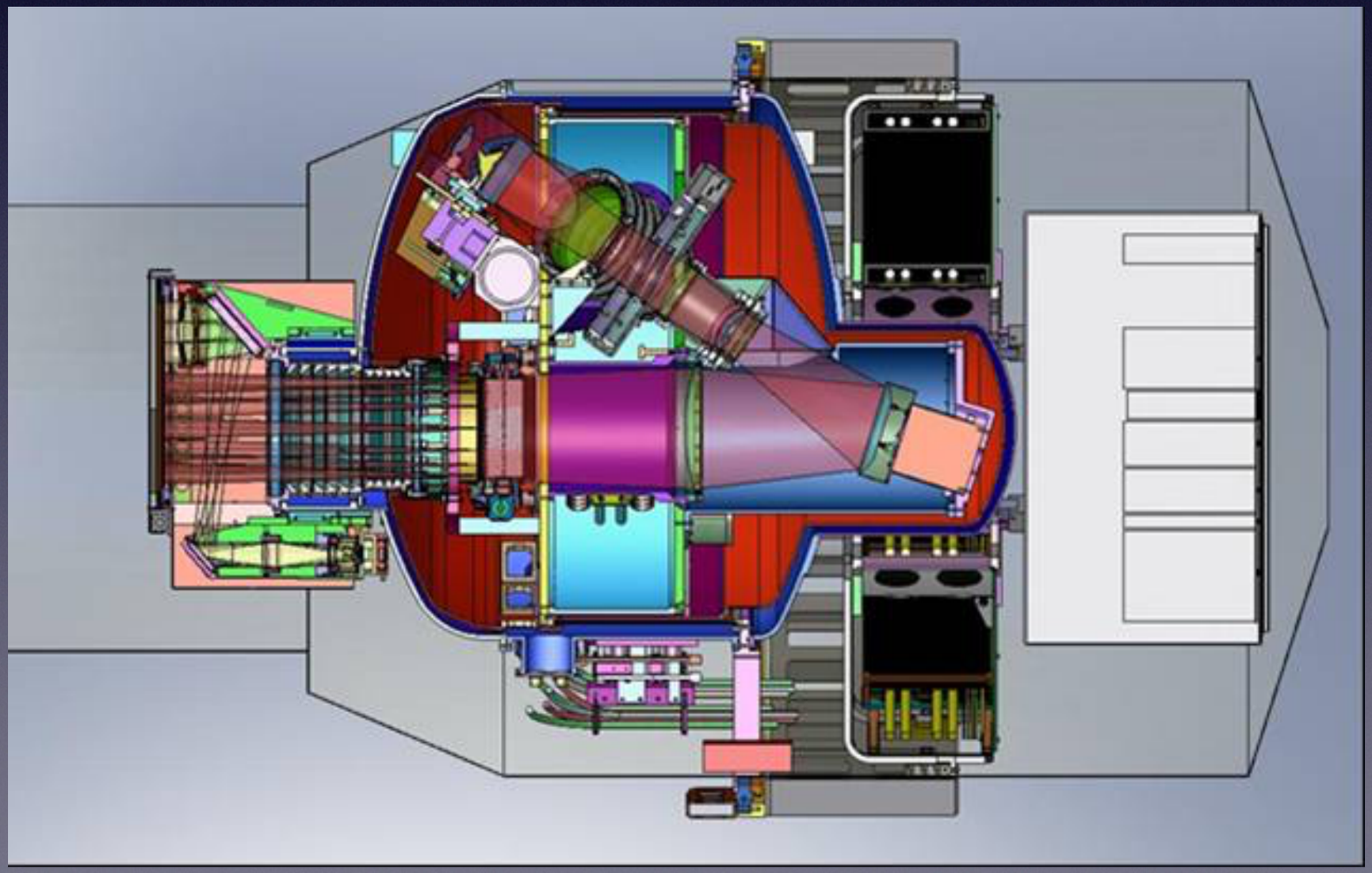
(W. M. Keck Observatory)

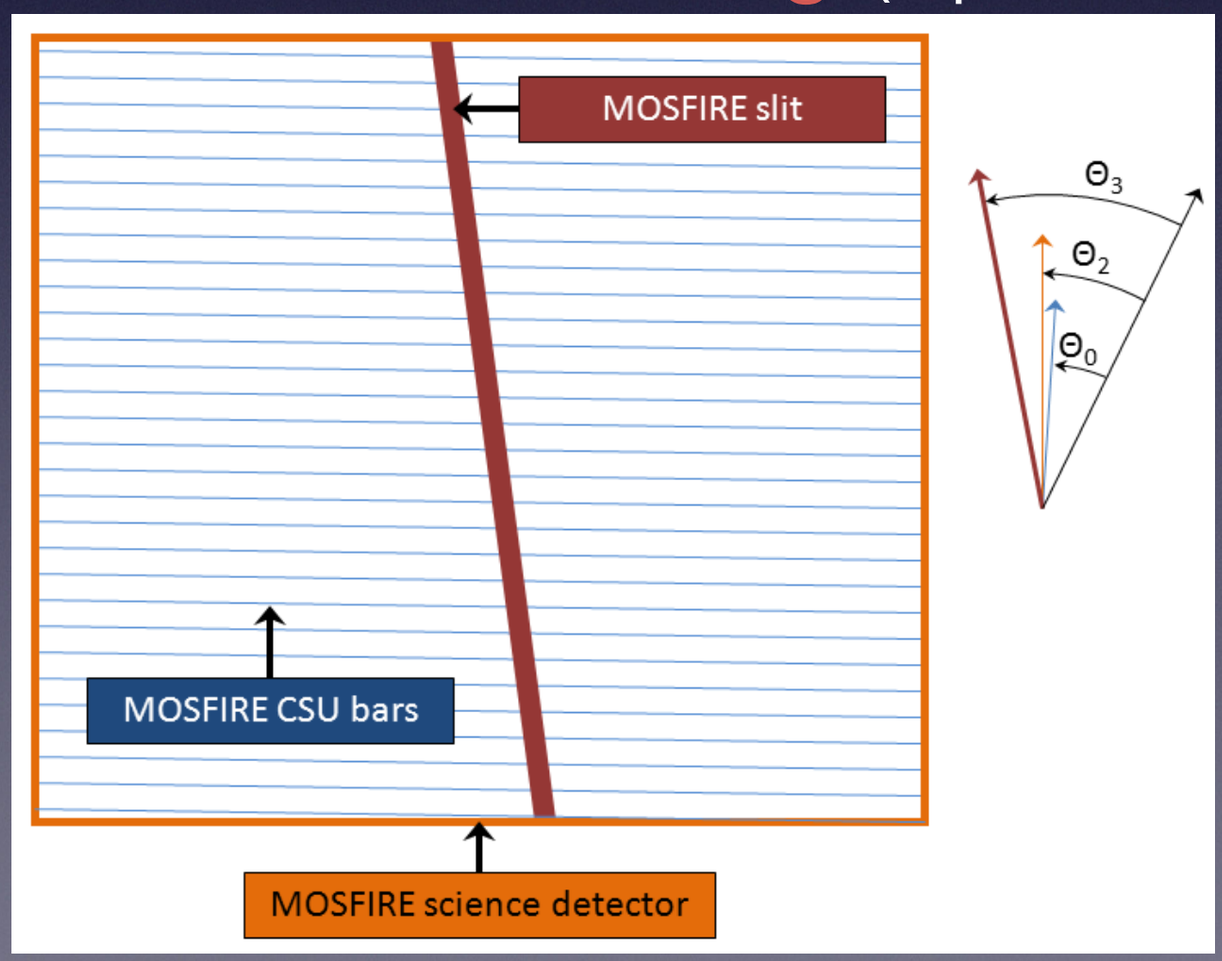
MOSFIRE

- One of Keck's most used instruments
- Uses a novel "configurable slit mask unit" (CSU)



CSU Fatal Error

- A rare but costly failure is the CSU Fatal Error
- Recovery requires reinitializing individual bars, often all 92 of them which is time consuming (up to 1.5 hours).
- Bar initialization is serial.
- Bar moves are parallel.



CSU Fatal Error

- Recovery can be much faster if the SA can optimize the procedure. Move each bar to near its home switch using a fast move, then perform a slow init for that bar.

- This requires going through a decision tree for each of the 92 bars, but that is time consuming and prone to error.

- **Python to the rescue!**

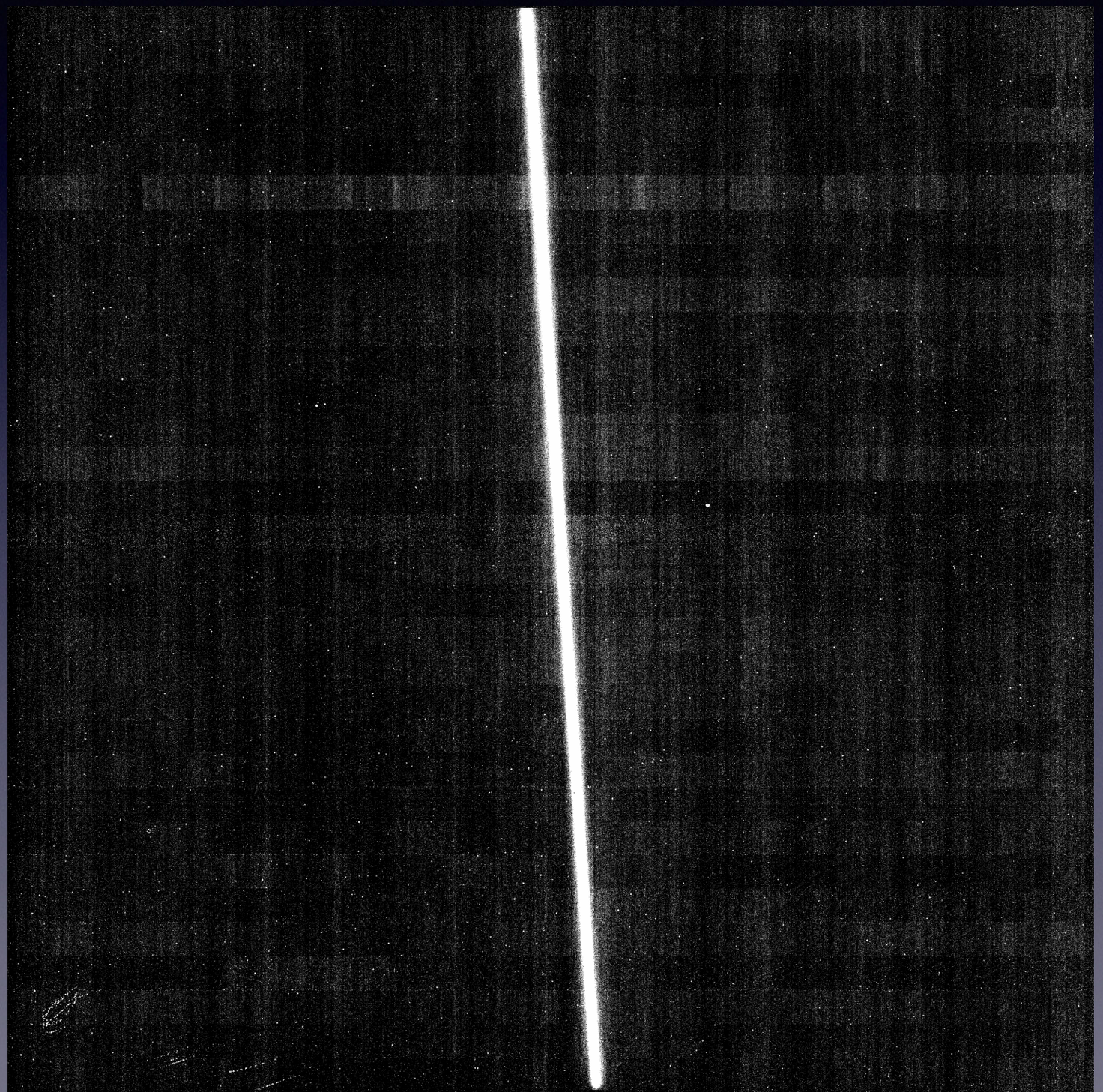
Solution

- Need image analysis software —> python
- Need user to confirm moves are safe —> GUI
    - Inspired by “Kassis Init” software (IDL + shell scripts), but need higher reliability on image analysis and better UI for user.

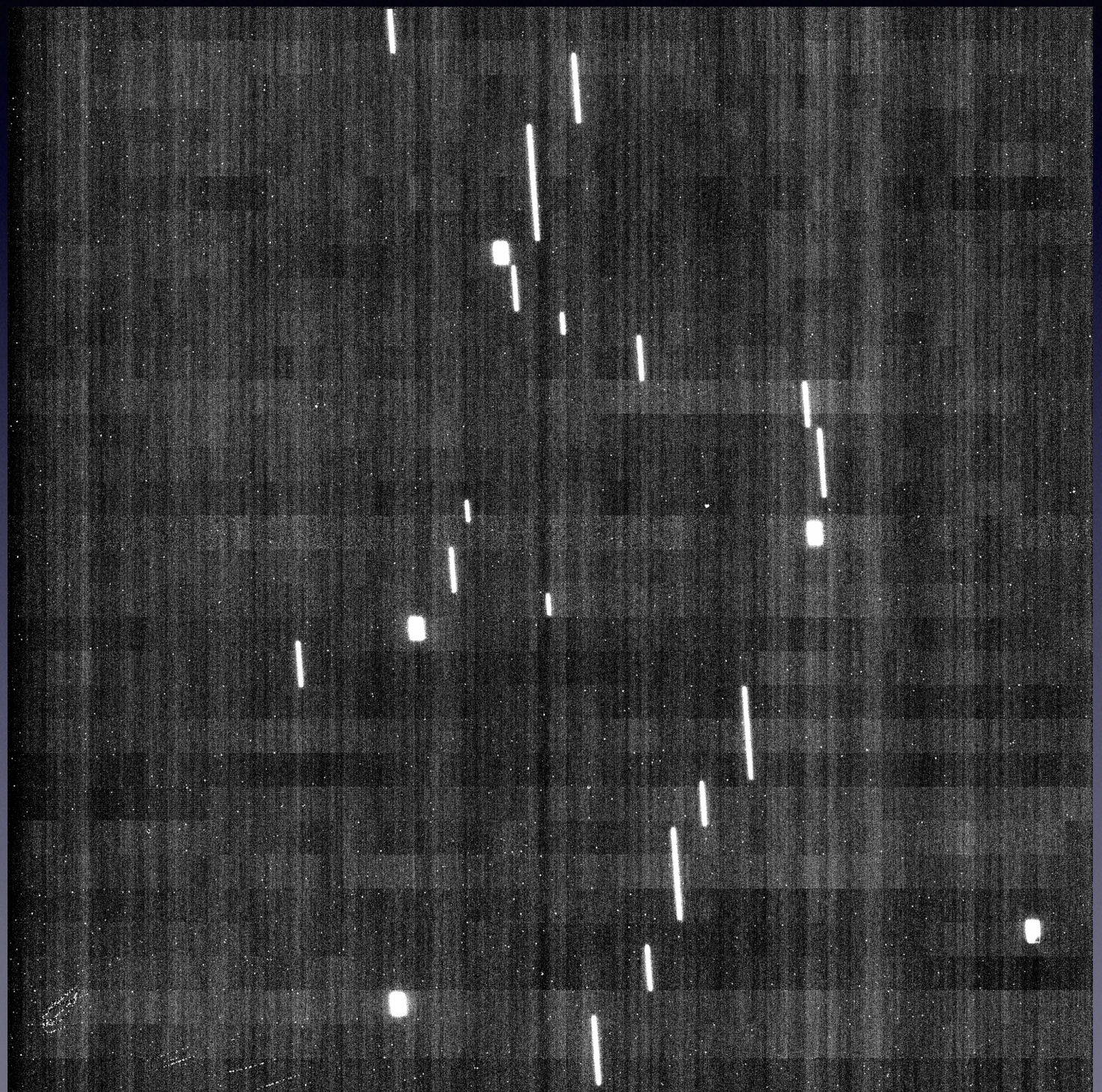
Image Analysis

- Image the mask and measure the bar locations.
  - Know the relationship between pixels and bar coordinates (also a python solution)
  - Divide image up by bar. Median filter vertically.
  - Take horizontal gradient of pixel values.
  - Fit gradient to a model to determine slit edges

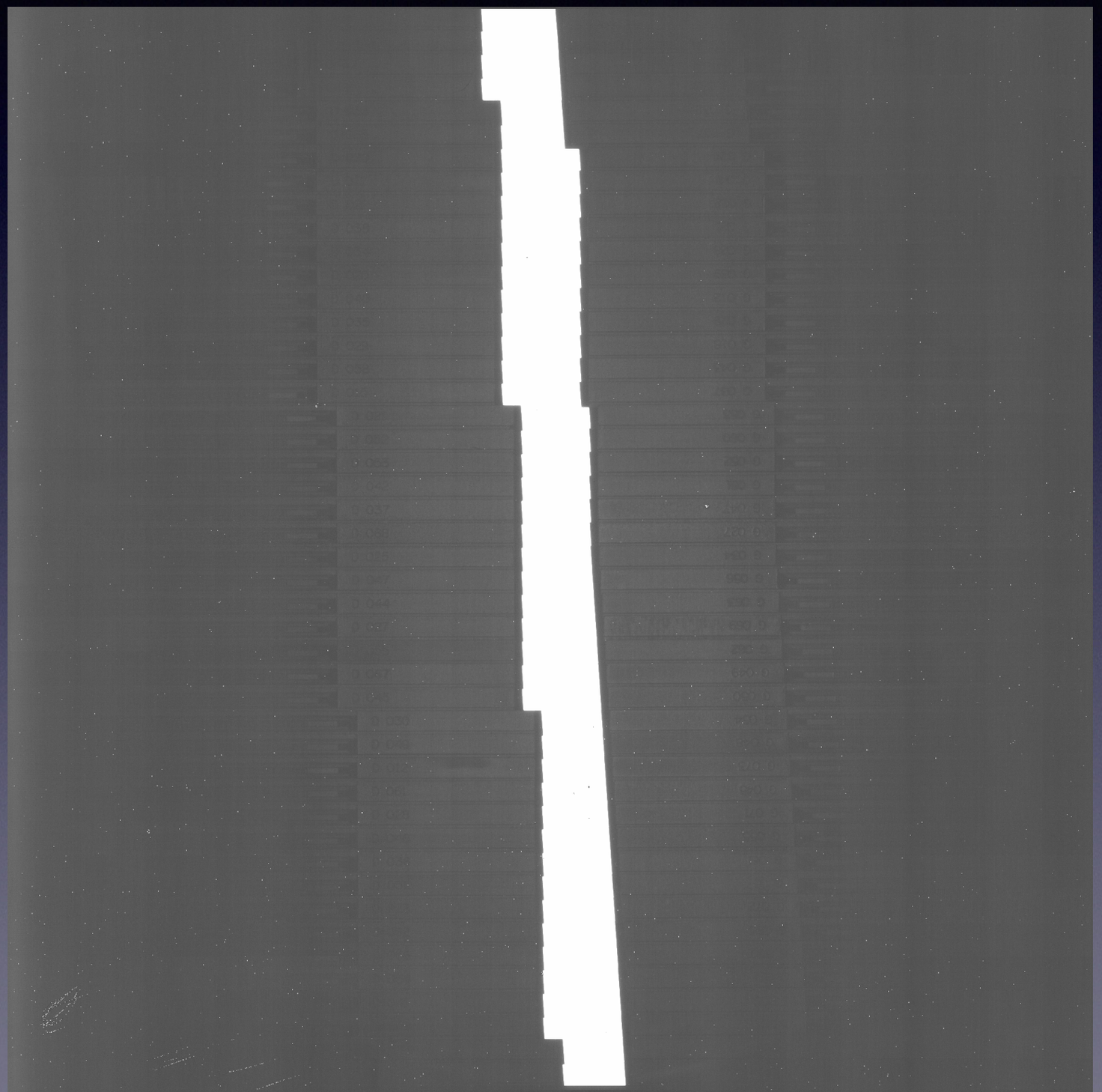
CSU Long Slit



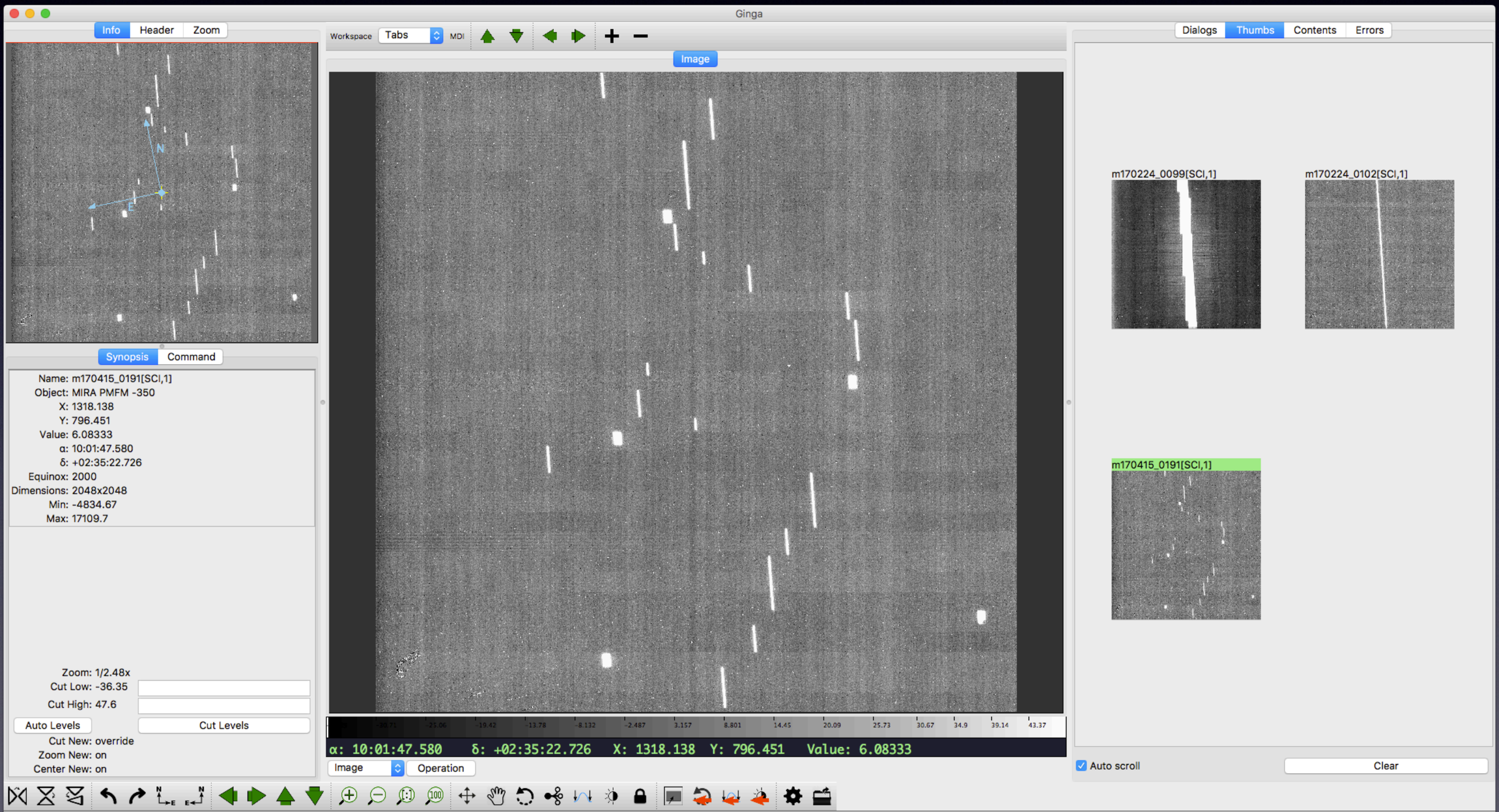
CSU MOS Mask



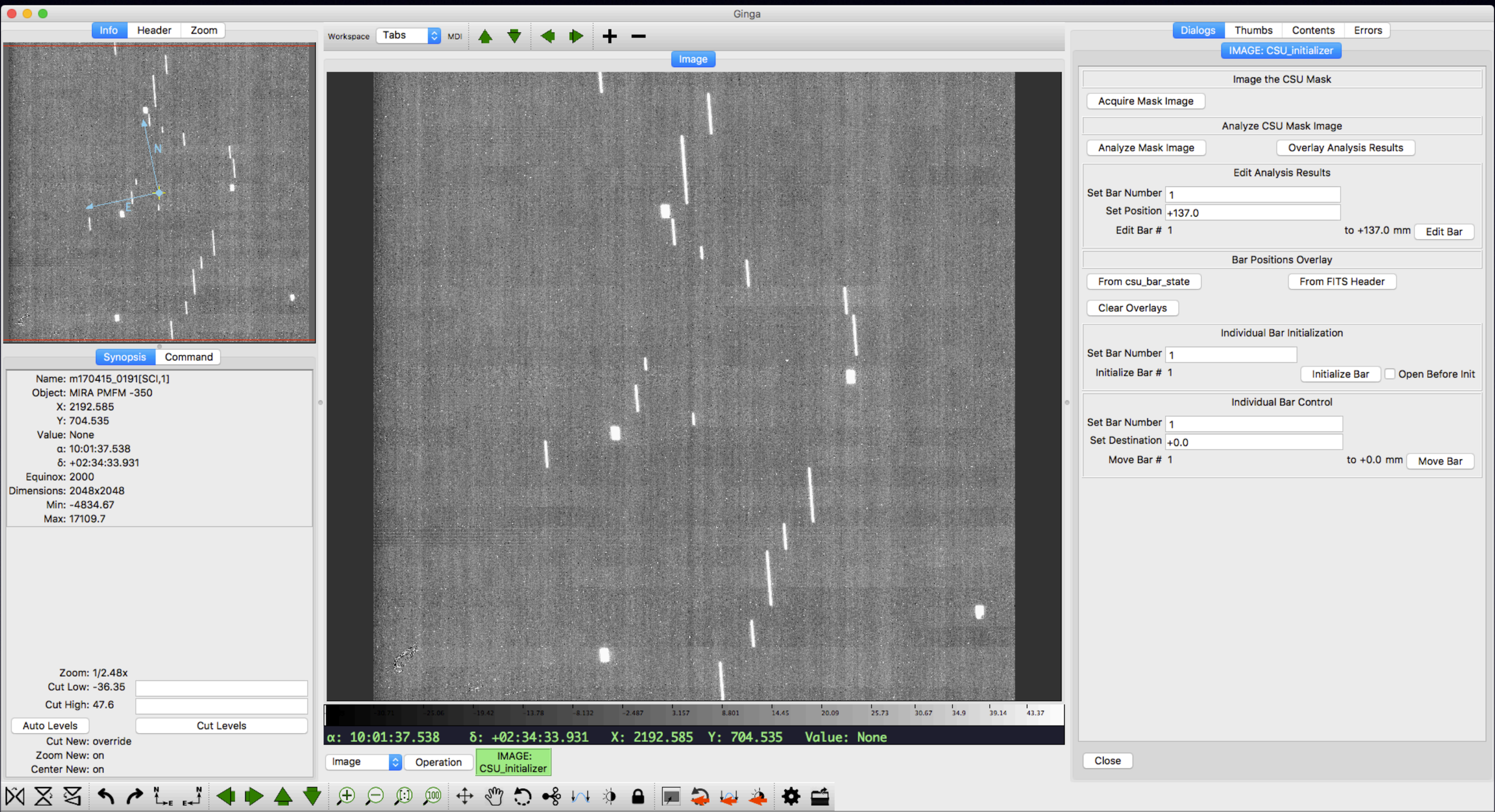
CSU Fatal Error



Ginga


Ginga
Info
Header
Zoom
Workspace
Tabs
MDI
Image
Dialogs
Thumbs
Contents
Errors
N
E
m170224_0099[SCI,1]
m170224_0102[SCI,1]
m170415_0191[SCI,1]
Synopsis
Command
Name: m170415_0191[SCI,1]
Object: MIRA PMFM -350
X: 1318.138
Y: 796.451
Value: 6.08333
α: 10:01:47.580
δ: +02:35:22.726
Equinox: 2000
Dimensions: 2048x2048
Min: -4834.67
Max: 17109.7
Zoom: 1/2.48x
Cut Low: -36.35
Cut High: 47.6
Auto Levels
Cut Levels
Cut New: override
Zoom New: on
Center New: on
-30.71 -25.06 -19.42 -13.78 -8.132 -2.487 3.157 8.801 14.45 20.09 25.73 30.67 34.9 39.14 43.37
α: 10:01:47.580 δ: +02:35:22.726 X: 1318.138 Y: 796.451 Value: 6.08333
Image
Operation
Auto scroll
Clear

Ginga Plugin



Dialogs | Thumbs | Contents | Errors

IMAGE: CSU_initializer

Image the CSU Mask

Acquire Mask Image

Analyze CSU Mask Image

Analyze Mask Image | Overlay Analysis Results

Edit Analysis Results

Set Bar Number 1

Set Position +137.0

Edit Bar # 1 to +137.0 mm Edit Bar

Bar Positions Overlay

From csu_bar_state | From FITS Header

Clear Overlays

Individual Bar Initialization

Set Bar Number 1

Initialize Bar # 1 Initialize Bar ☐ Open Before Init

Individual Bar Control

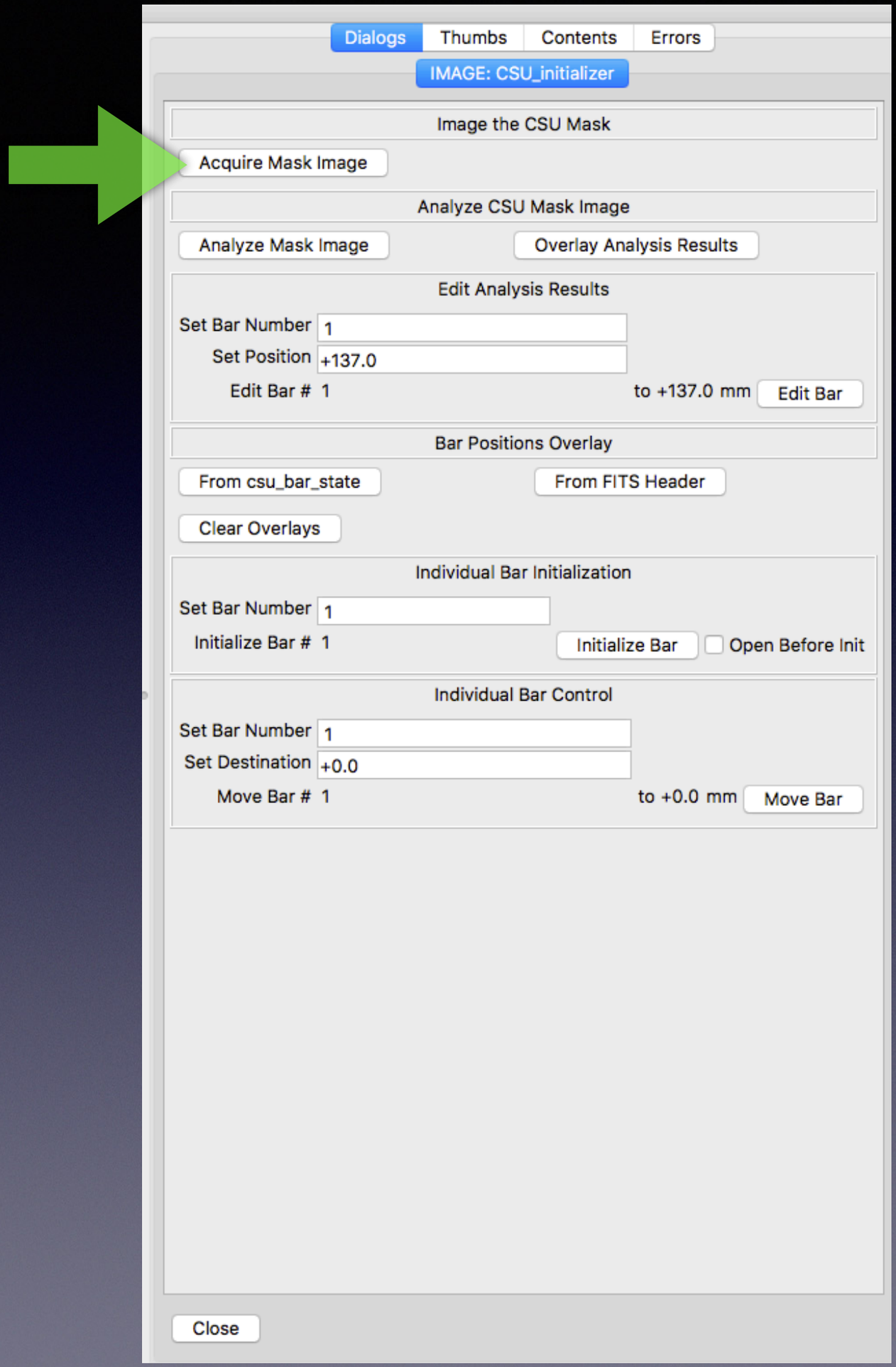
Set Bar Number 1

Set Destination +0.0

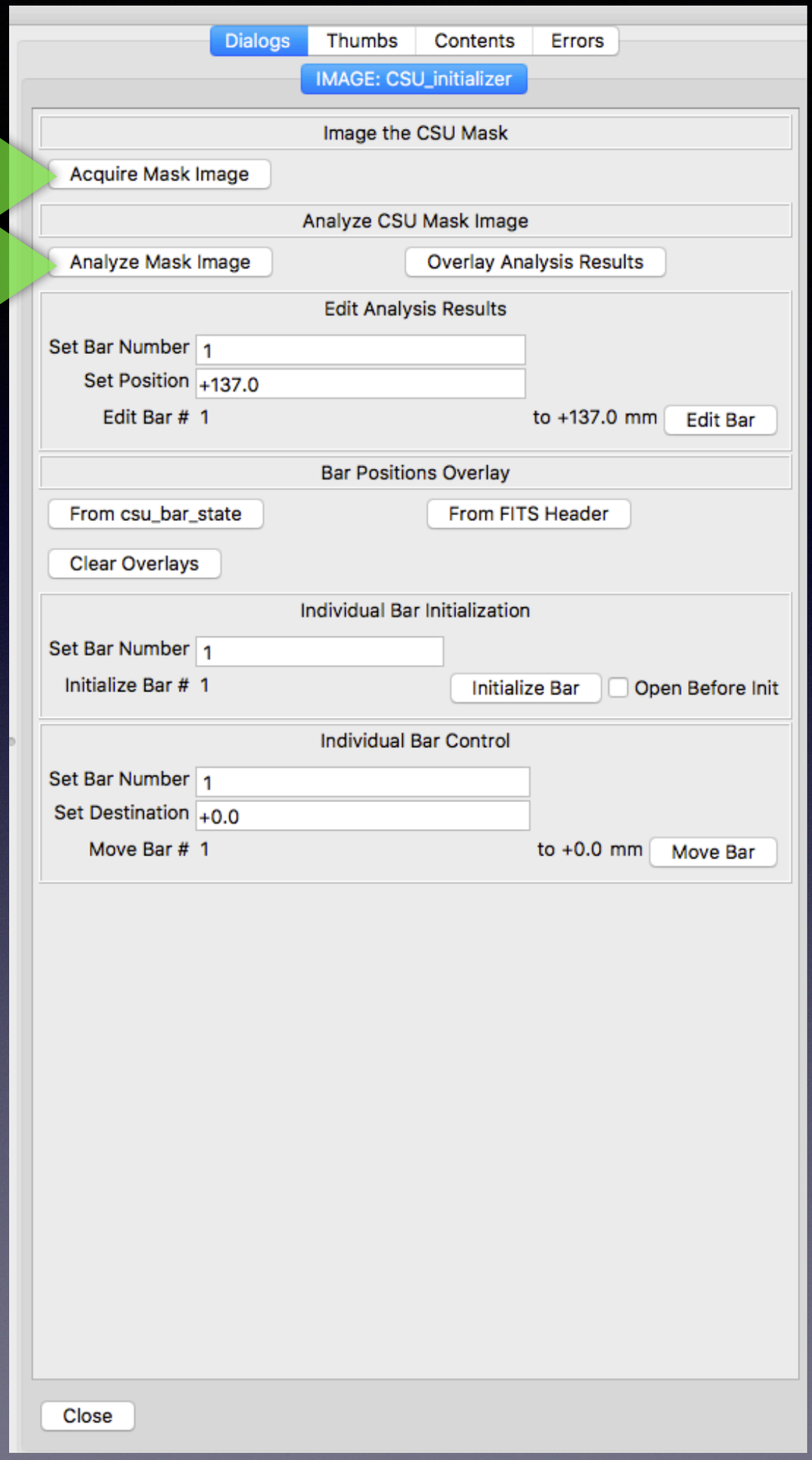
Move Bar # 1 to +0.0 mm Move Bar

Close

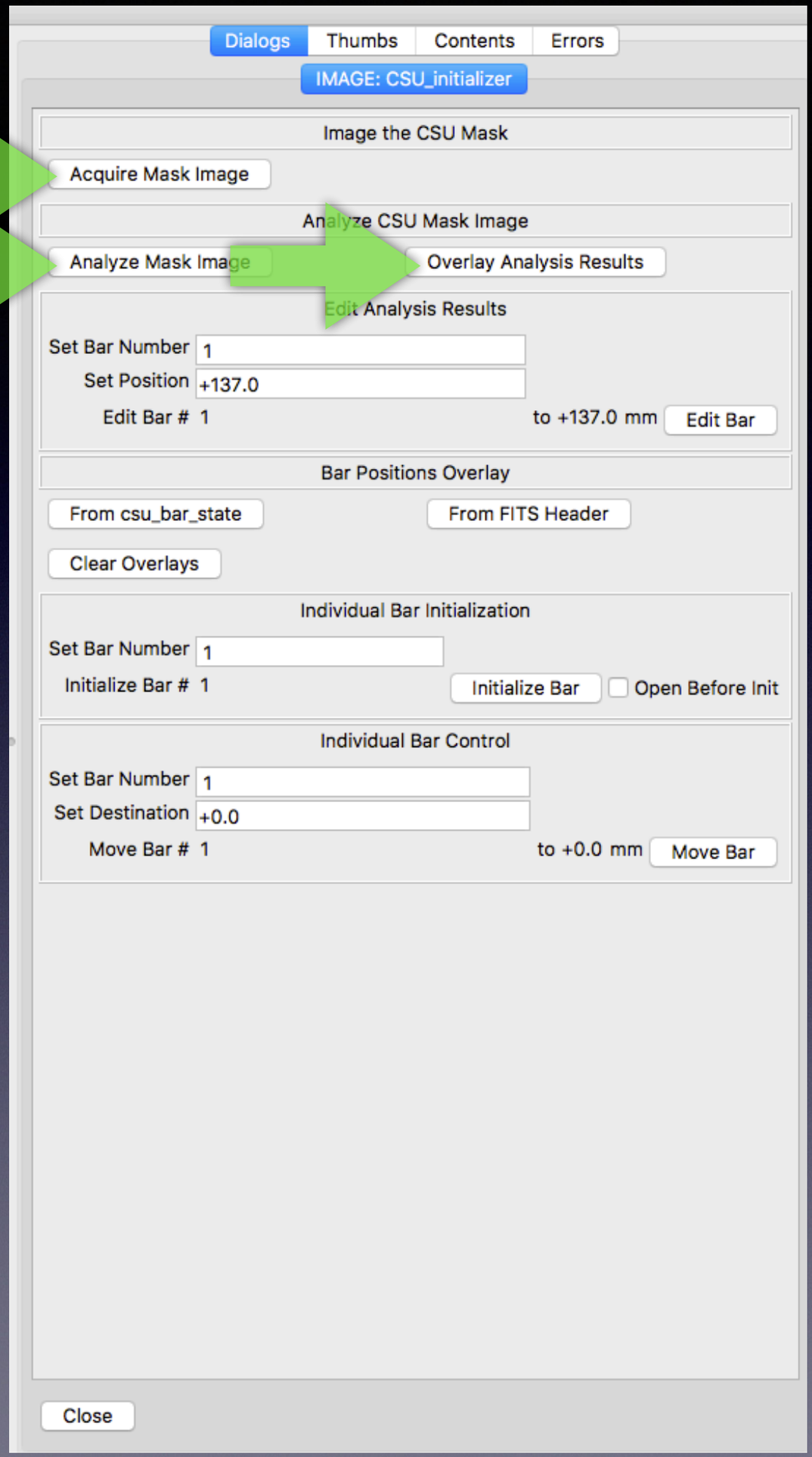
- Acquire Mask Image



- Acquire Mask Image
- Analyze Mask Image



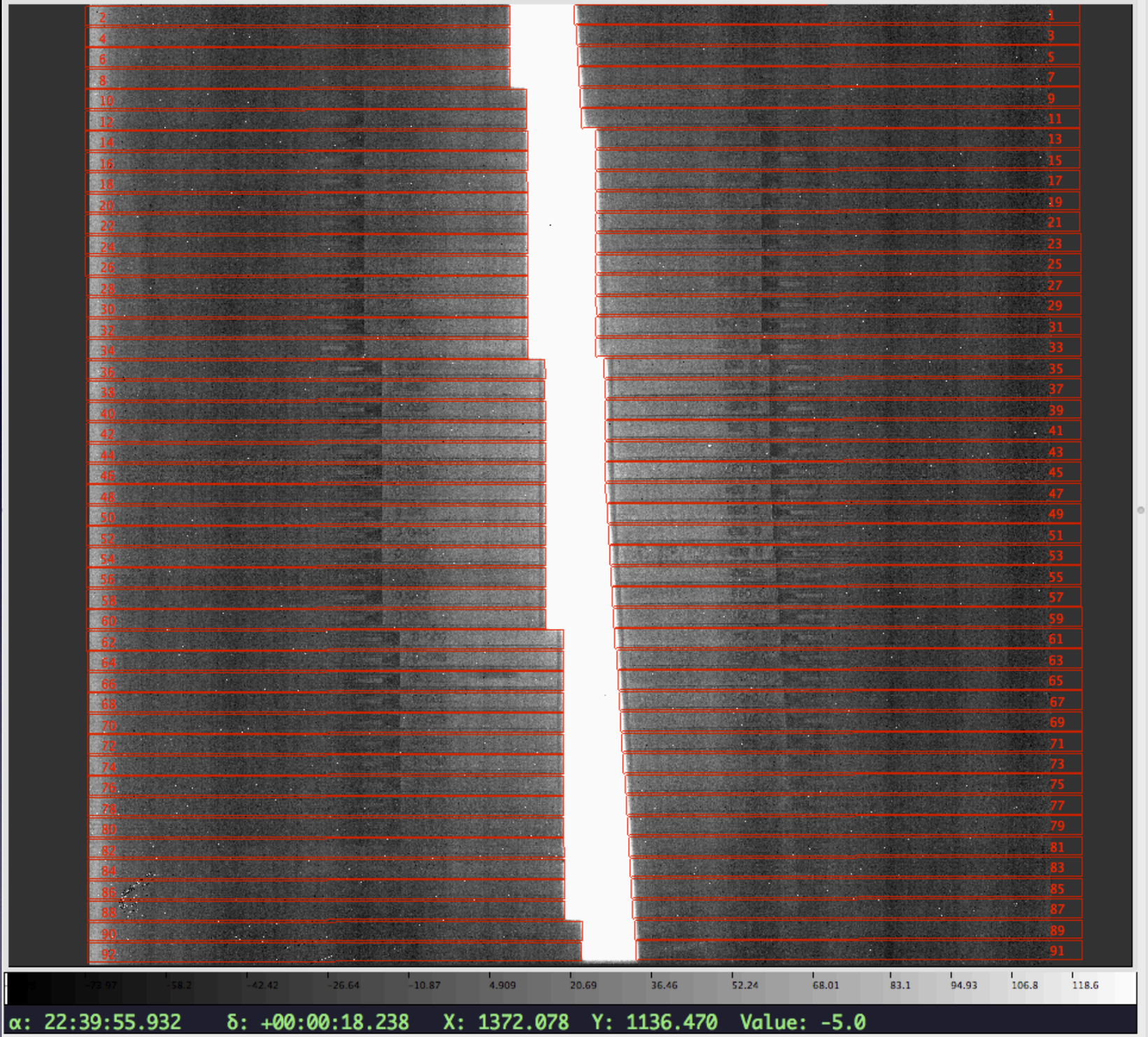
- Acquire Mask Image
- Analyze Mask Image
- Overlay Results



Ginga

Workspace Tabs MDI

Image



α: 22:39:55.932 δ: +00:00:18.238 X: 1372.078 Y: 1136.470 Value: -5.0

Image | Operation | IMAGE: CSU_initializer

Dialogs | Thumbs | Contents | Errors

IMAGE: CSU_initializer

Image the CSU Mask

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Initialize Bar # 1 Initialize Bar ☐ Open Before Init

Individual Bar Control

Set Bar Number 1

Set Destination +0.0

Move Bar # 1 to +0.0 mm Move Bar

Close

Ginga

Workspace Tabs MDI

Image

α: 10:02:01.394 δ: +02:39:17.557 X: -77.995 Y: 1834.857 Value: None

Image Operation IMAGE: CSU_initializer

Dialogs | Thumbs | Contents | Errors

IMAGE: CSU_initializer

Image the CSU Mask

Acquire Mask Image

Analyze CSU Mask Image

Analyze Mask Image | Overlay Analysis Results

Edit Analysis Results

Set Bar Number 1

Set Position +137.0

Edit Bar # 1 to +137.0 mm Edit Bar

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Set Bar Number 1

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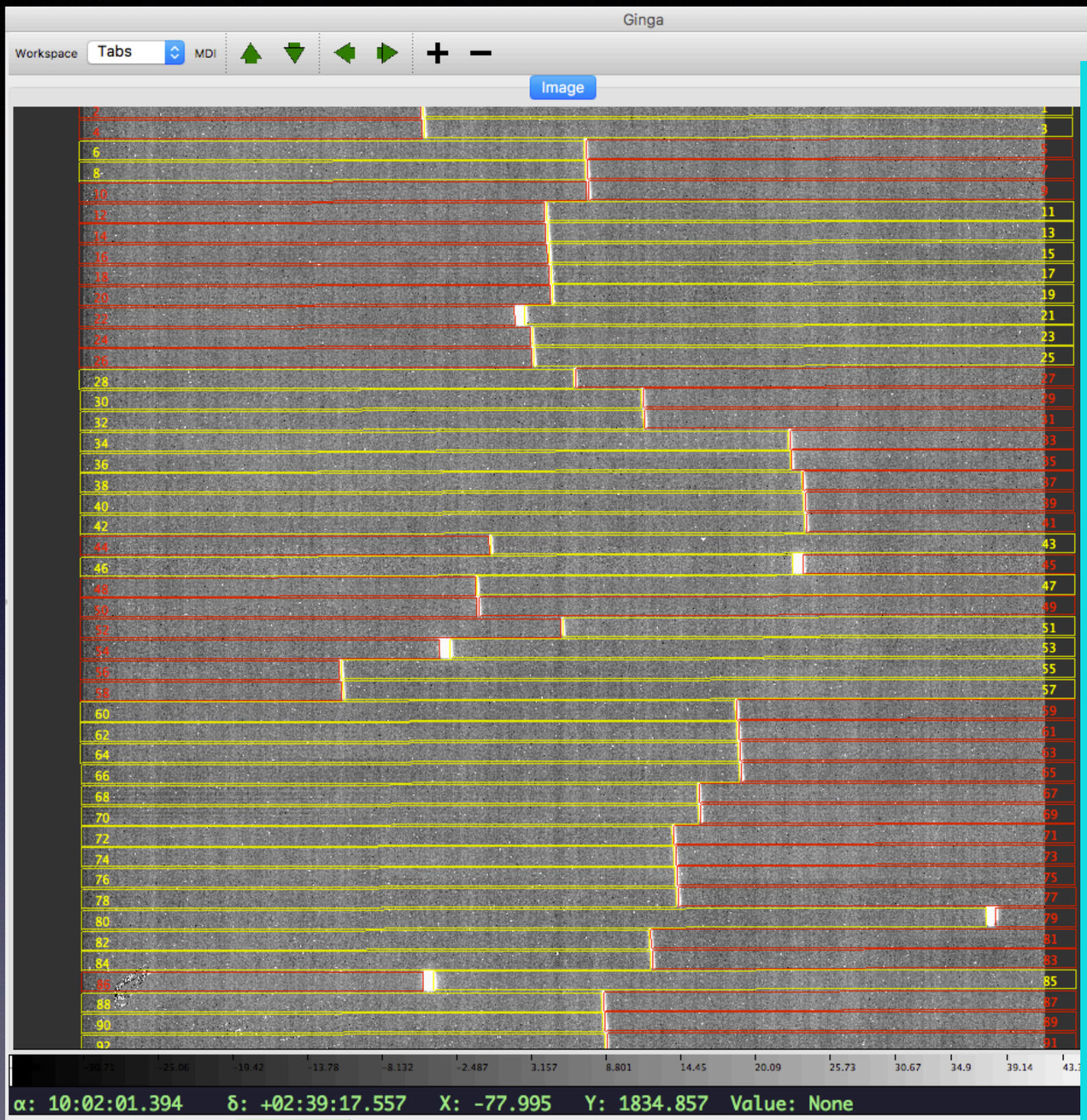
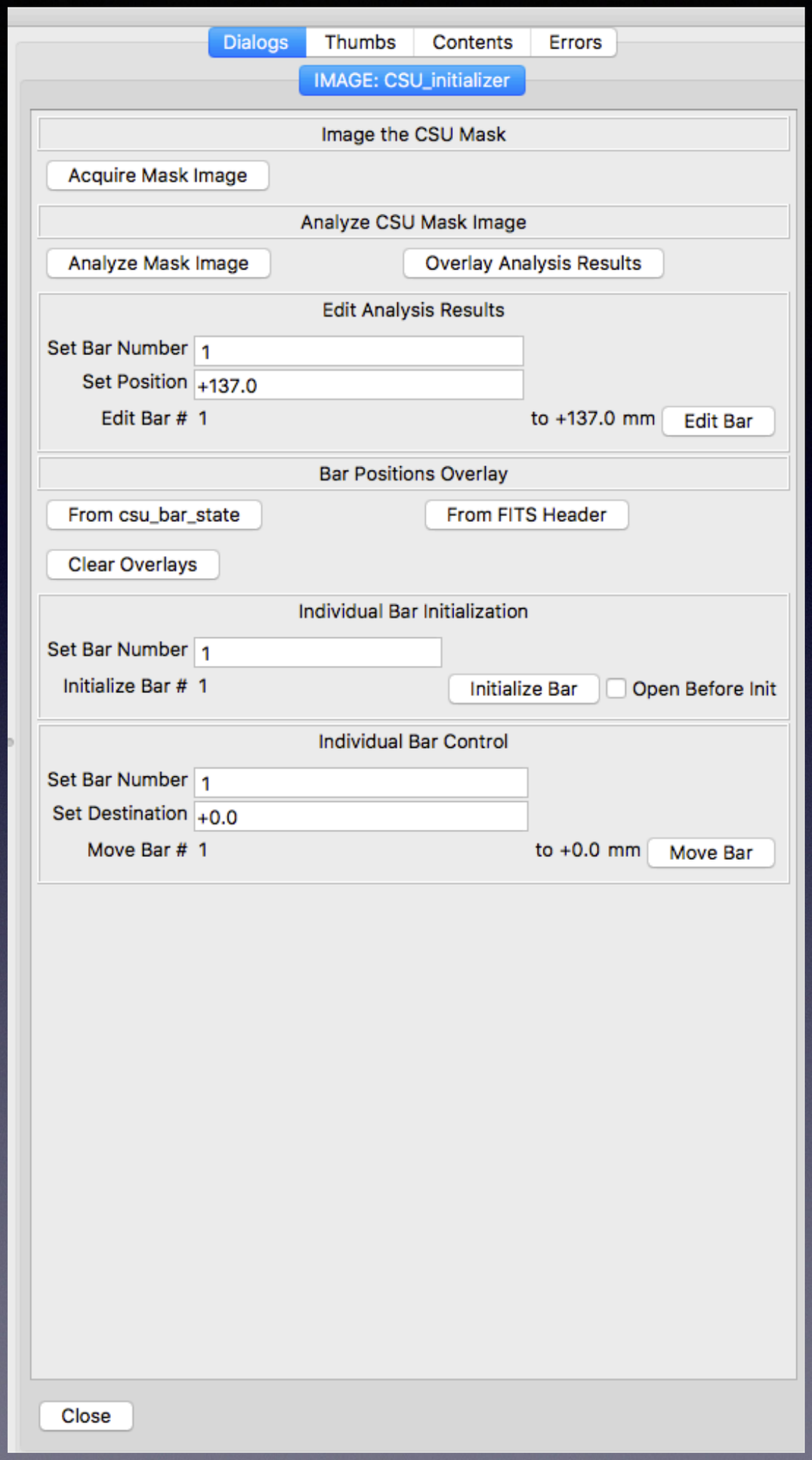


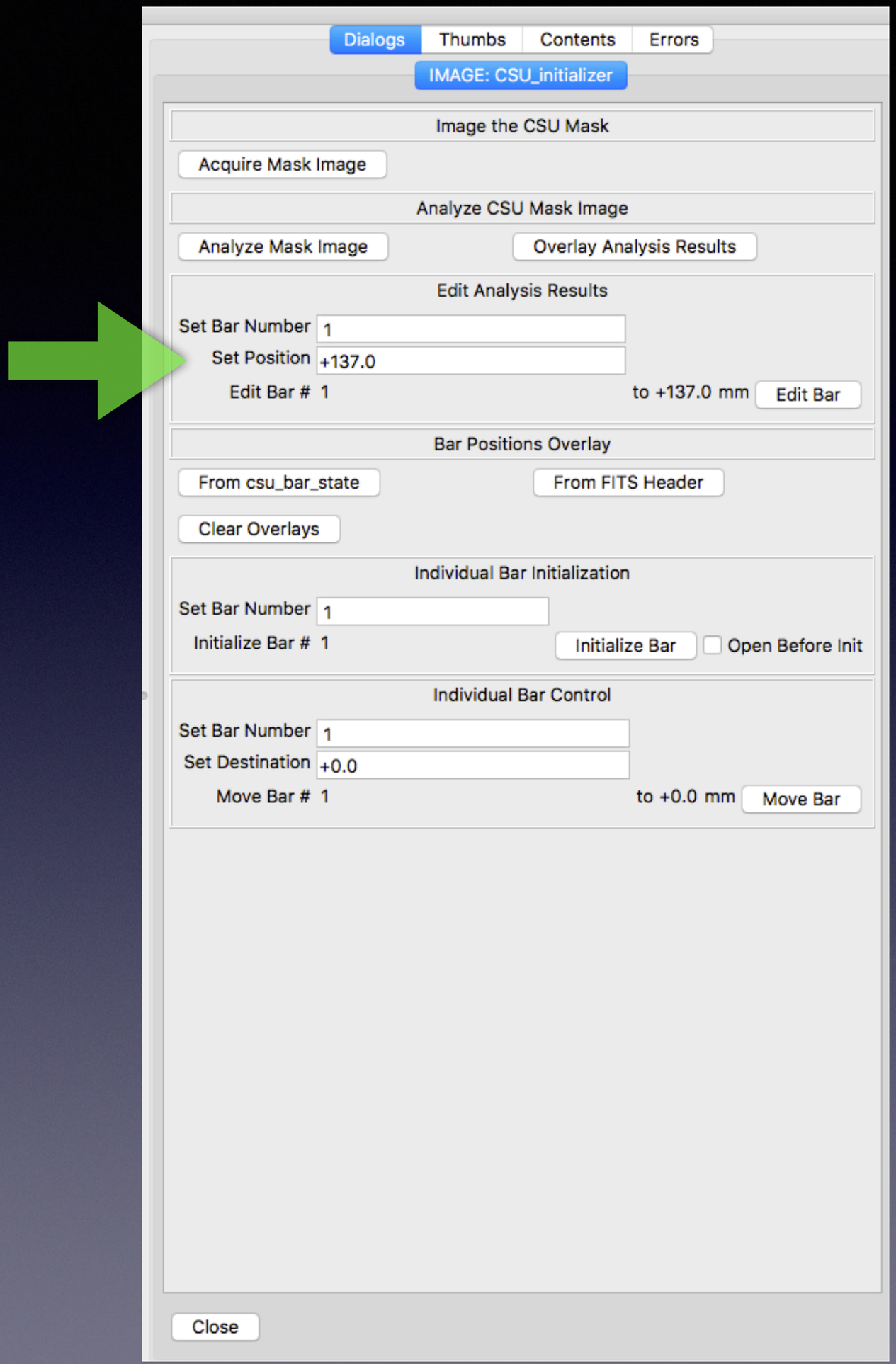
- Determine pixel position of slit edges
- Transform those in to physical coordinates of the CSU
- Compare to controller positions
- Color code based on “safety”

- Acquire Mask Image
- Analyze Mask Image
- Overlay Results



- Acquire Mask Image
- Analyze Mask Image
- Overlay Results

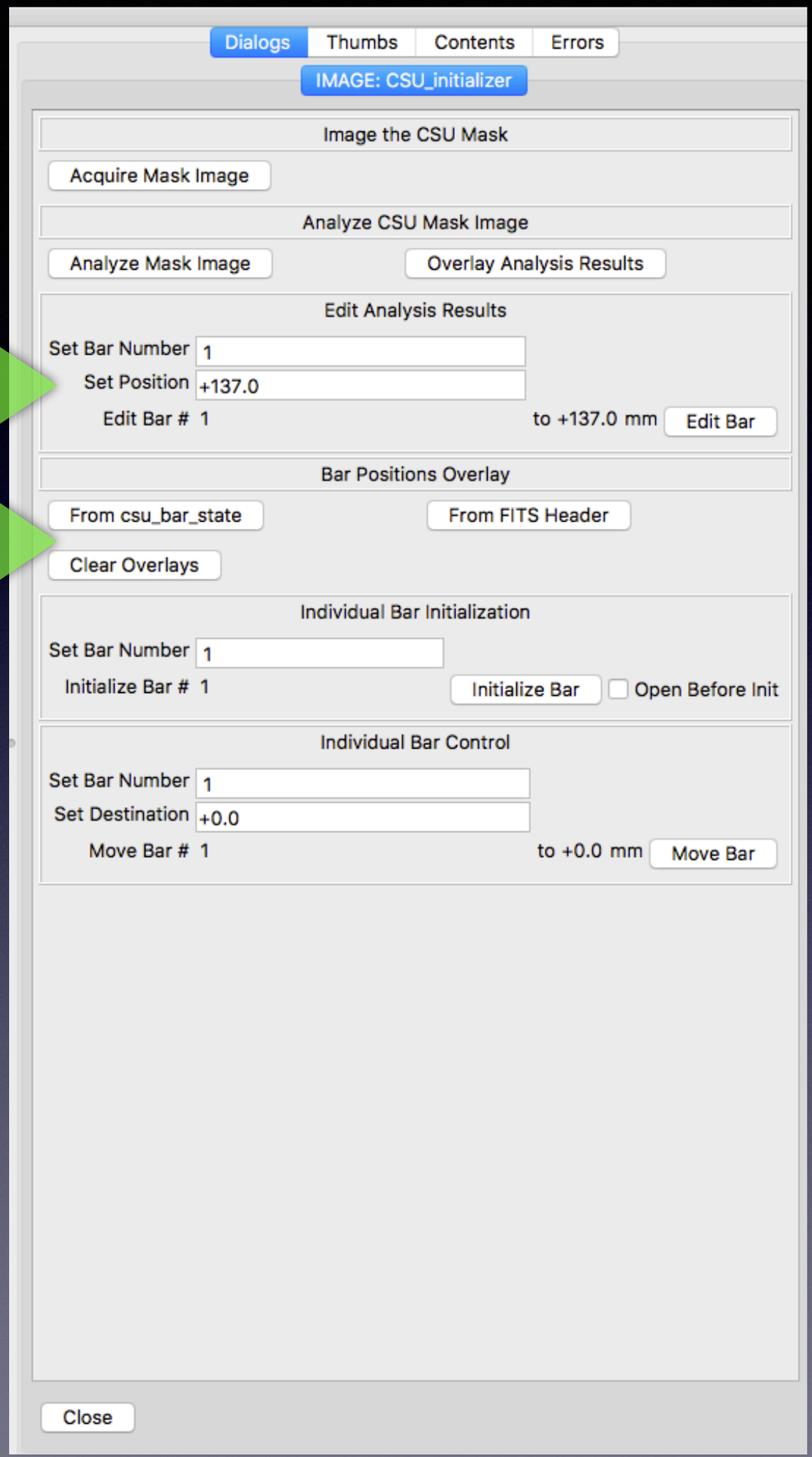
- User can edit results



- Acquire Mask Image
- Analyze Mask Image
- Overlay Results

- User can edit results

- Or compare to others

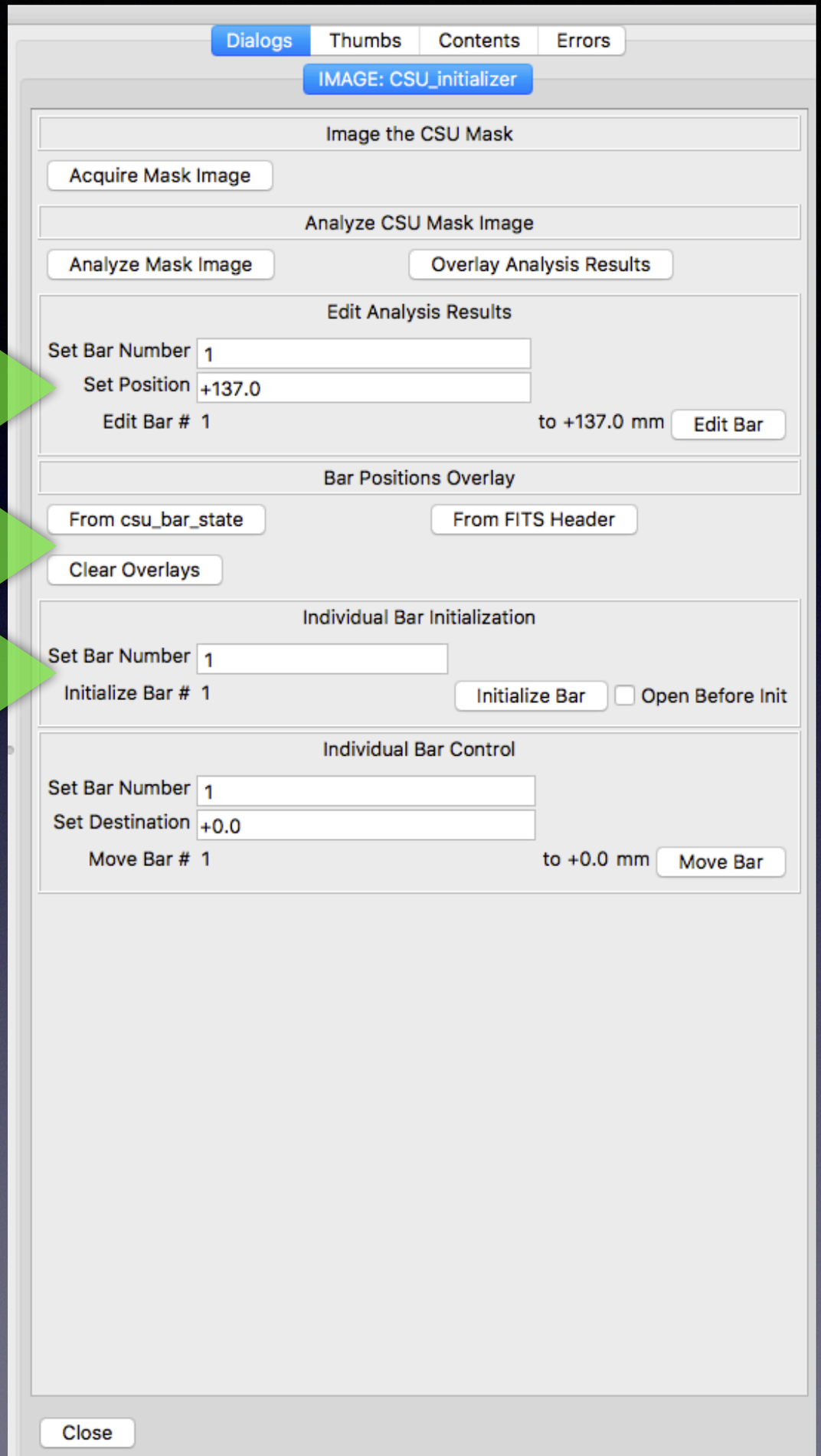


- Acquire Mask Image
- Analyze Mask Image
- Overlay Results

- User can edit results

- Or compare to others

- Init an individual bar



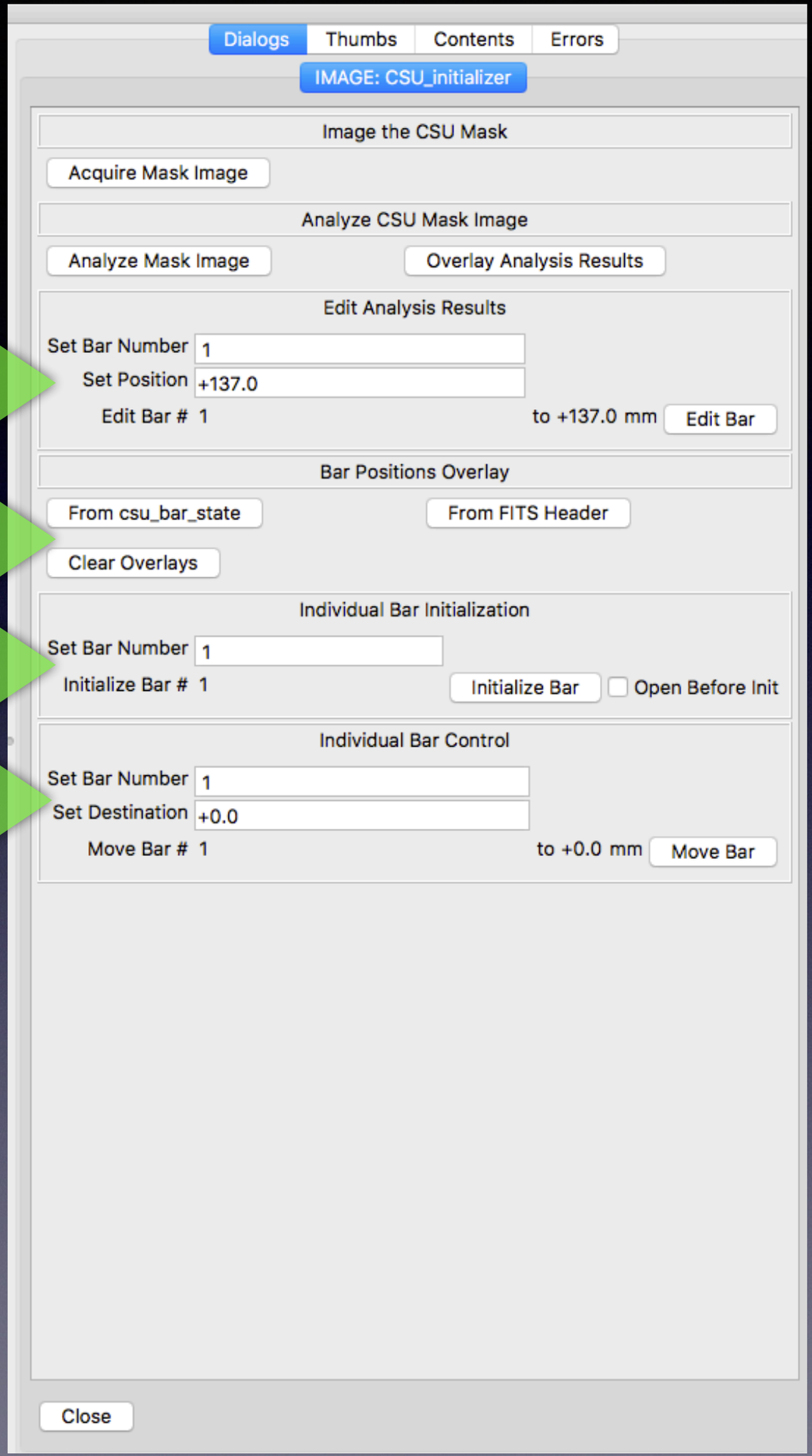
- Acquire Mask Image
- Analyze Mask Image
- Overlay Results

- User can edit results

- Or compare to others

- Init an individual bar

- Move an individual bar



- Acquire Mask Image
- Analyze Mask Image
- Overlay Results

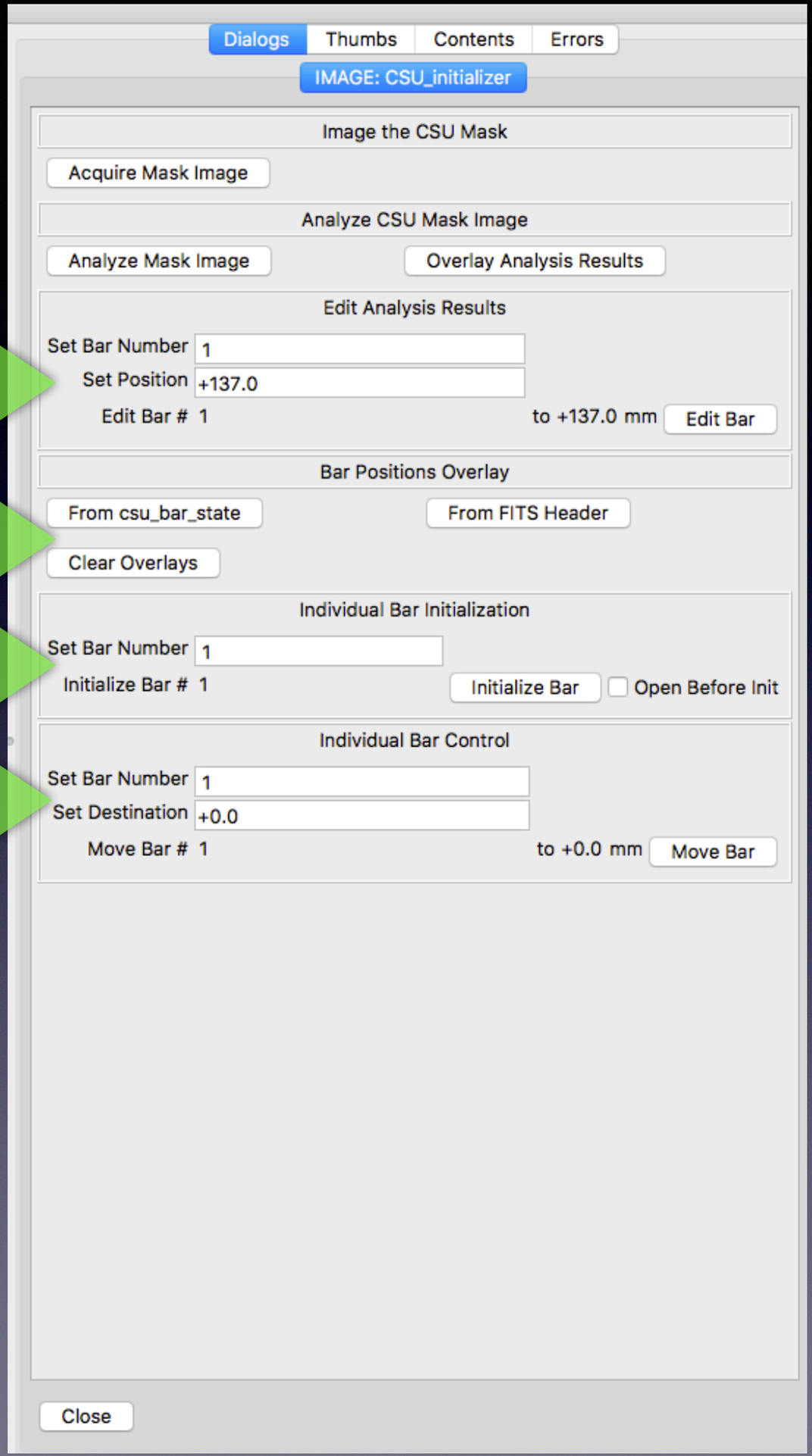
- User can edit results

- Or compare to others

- Init an individual bar

- Move an individual bar

As final step, software will generate and run a sequence of parallel move and serial init commands for each bar which are both safe and optimized to recover in the minimum time.



```
        ## ------------------------------------------------------------¬
        ## Analyze Image¬
        ## ------------------------------------------------------------¬
        fr = Widgets.Frame("Analyze CSU Mask Image")¬
        vbox.add_widget(fr, stretch=0)¬
    ¬
        btns2 = Widgets.HBox()¬
        btns2.set_spacing(3)¬
    ¬
        btn_analyze = Widgets.Button("Analyze Mask Image")¬
        btn_analyze.add_callback('activated',¬
                                 lambda w: self.analyze_mask_image())¬
        btns2.add_widget(btn_analyze, stretch=0)¬
        btns2.add_widget(Widgets.Label(''), stretch=1)¬
    ¬
        btn_overlay = Widgets.Button("Overlay Analysis Results")¬
        btn_overlay.add_callback('activated',¬
                                 lambda w: self.overlay_analysis_results())¬
        btns2.add_widget(btn_overlay, stretch=0)¬
        btns2.add_widget(Widgets.Label(''), stretch=1)¬
    ¬
        vbox.add_widget(btns2, stretch=0)¬
```

The Power of Python

- We will control the instrument using a python interface to Keck KTL keywords (see Kyle Lanclos' talk tomorrow) or by calling existing instrument scripts via subprocess module.
- While also getting powerful analysis tools:
    - numpy (dot, linalg.lstsq, gradient)
    - astropy.modeling

The Power of Python

- Two non-programmers (SA and OA) made GUI with no previous GUI programming experience.
  - Eric's ginga-plugins template was very useful. Lots of copy and pasting of code!
- As a plugin, we get all ginga features for free: image display, stretch, cut, zoom, WCS, etc.
- This is a work in progress.