# Planning VLA Observations: Tutorial

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# This tutorial

- Congratulations! You have been granted X amount of time...
- Instrument Configurations: Resource Configuration Tool
  - –Observing frequencies
  - –Channelization & dump rate
- Sources: Source Configuration Tool
  - –Scientific target
  - –Calibrators (complex gain, absolute flux scale, etc.)
- Scheduling Blocks: Observation Preparation Tool
  - –Putting together & submitting a Scheduling Block (SB)

# Congratulations!

# E-mail from schedsoc

- Time Allocation:

| Session Name | Config | Time (hours) | CenterLST (hours) | Scheduling Priority |
|---|---|---|---|---|
| Demo | C | 1 x 2.00 | 5.50 | B |

- Time Allocation Summary:
- 2.00 hours at priority B.

# Deciphering the message

- Priority A: the observations will almost certainly be scheduled
- Priority B: the observations will be scheduled on a best effort basis
- Priority C: the observations will be scheduled as filler
- Priority N*: will not be scheduled

# Getting on the telescope

- High priority (A+)
- Submit schedules ASAP
- Short Scheduling Blocks
- Wide range of LSTs (see pressure plots)
- Accept poor weather conditions (constraints - discussed later)

# Today's project

- 2 hrs in C configuration to observe Orion BN/KL
  - –Lowest (1,1) through (7,7) metastable ammonia ($NH_3$) transitions: < 1 km/s res'n, over > 120 km/s (gets the lower hyperfines as well)
  - –Plus as much continuum as you can get

# This tutorial

- Construct an appropriate Scheduling Block using the capabilities which will be available at the next call for proposals
- Use the current version of the tools
  - –By December: add a few capabilities (Doppler setting, flexible subband tuning), nicer displays, ability to load line lists, warnings & errors based on the advertised capabilities

# Instrument Configurations (Resource Configuration Tool)

# Planning: what do you want?

- Ammonia transitions: splatalogue or other sources
  - (1,1) 23694.50 MHz
  - (2,2) 23722.63 MHz
  - (3,3) 23870.13 MHz
  - (4,4) 24139.42 MHz
  - (5,5) 24532.99 MHz
  - (6,6) 25056.03 MHz
  - (7,7) 25715.18 MHz

# Planning: what can you do?

- This is JVLA **K band: 18.0-26.5 GHz**
- 2 x 1.024 GHz baseband pairs within that band
- Naïve approach:
  - –A0/C0: (1,1)-(5,5) → 23686.5-24710.5 MHz
    - Centered on **24198.5 MHz**
  - –B0/D0: (6,6) & (7,7) → 24873.5-25897.5 MHzMHz
    - Centered on **25385.5 MHz**
  - –Naïve because **no subband can cross a 128 MHz boundary**
  - –We'll return to this later…

# Offsets from baseband centers

- RCT currently wants offsets from baseband center frequencies rather than absolute frequencies – this will be easier by the fall
- Ammonia transitions then are as follows:
  - (1,1) 23694.50 MHz A0/C0 -504.00 MHz
  - (2,2) 23722.63 MHz A0/C0 -475.87 MHz
  - (3,3) 23870.13 MHz A0/C0 -328.37 MHz
  - (4,4) 24139.42 MHz A0/C0 -59.08 MHz
  - (5,5) 24532.99 MHz A0/C0 +334.49 MHz
  - (6,6) 25056.03 MHz B0/D0 -329.47 MHz
  - (7,7) 25715.18 MHz B0/D0 +329.68 MHz

# Planning: what can you do?

- WIDAR subband bandwidth & channelization possibilities
  - –Subband bandwidths: 128, 64, 32, …, 0.03125 MHz
  - –Channels: 256 channels/subband, spread over pol'n products
  - –Can trade subbands for channels ("Baseline Board stacking")
  - –64 Baseline Board pairs: if assign all to one subband, you get 64*256= 16384 channels (over all pol'n products)
- We want:
  - –Cover 120 km/s @ 22 GHz
    - → 120/3e5*22e9~10 MHz
  - –Want 1 km/s after Hanning smoothing
    - → (1/2)/3e5*22e9~ 0.04 MHz/channel

# Planning: what can you do?

- So we use a bit of over-kill:
  - **16 MHz** subbands
  - 0.04 MHz/channel → want 400 channels, dual polarization
  
  →use 512 channels in each of **2 pol'n products**
  
  →Total of 1024 channels= 256 x 4 → **factor 4 BIB stacking**

# What about the continuum?

- We want to cover the full 2 x 1024 MHz
- Use widest available subband bandwidth: **128 MHz**
- Need **8 subband pairs** to cover the full 1024 MHz **in a baseband**
- Spectral resolution is not very important. Default would be 256 channels & full pol'n products → 128/(256/4)= 2 MHz/channel.

# Summary

- K band
- A0/C0
  - –Center frequency: 24198.5 MHz
  - –5 "line" subbands: 16 MHz BW, dual pol'n products, x4 BIB stacking
  - –8 "continuum" subbands: 128 MHz BW, full pol'n products, no BIB stacking
- B0/D0
  - –Center frequency: 25385.5 MHz
  - –2 "line" subbands: 16 MHz BW, dual pol'n products, x4 BIB stacking
  - –8 "continuum" subbands: 128 MHz BW, full pol'n products, no BIB stacking

# Life will become easier…

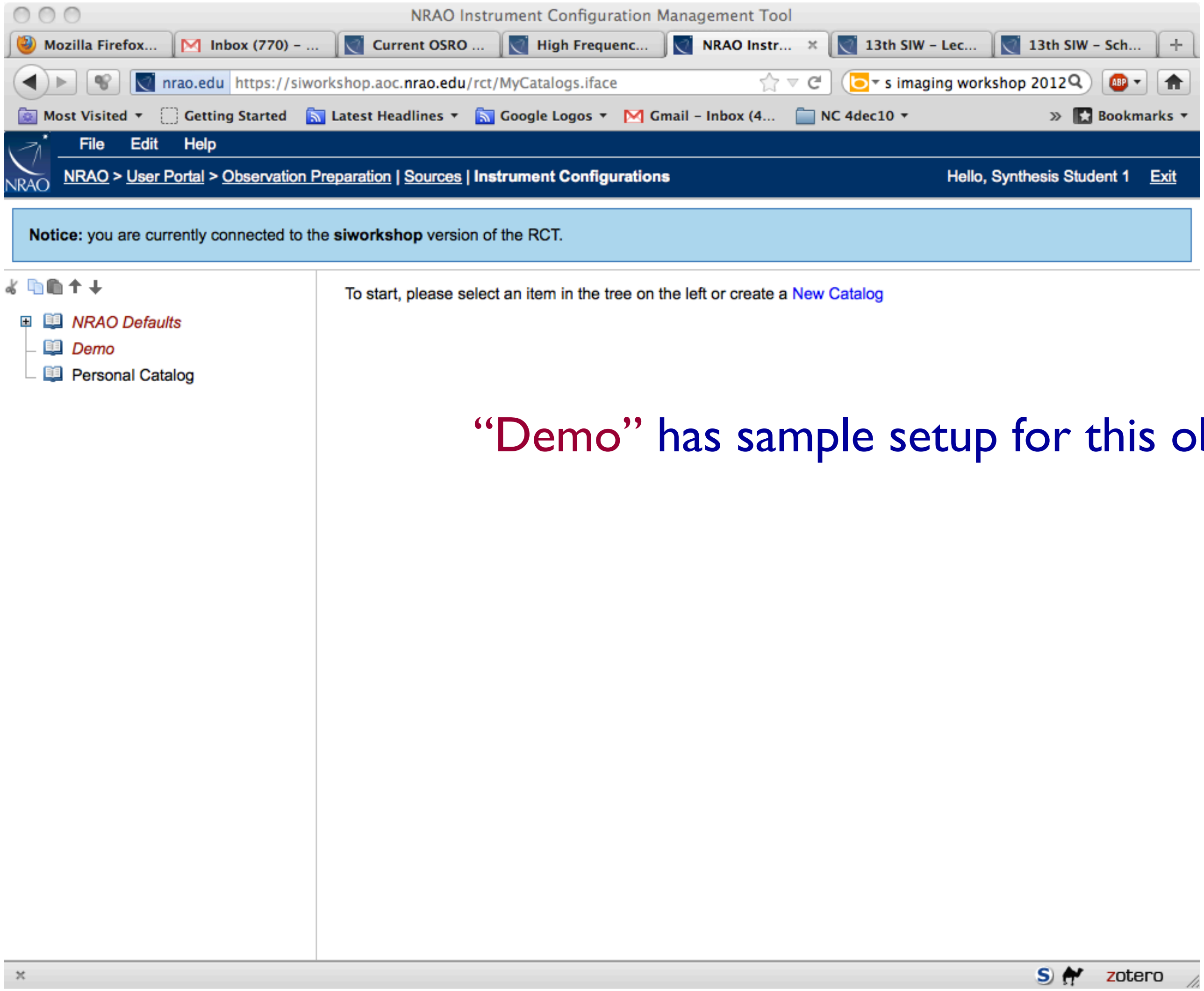
- We are working on tools to allow you to enter line frequencies directly & figure out how to set up the correlator
- Also displays to show what you're getting

- But for now, you're at the bleeding edge…

# Log in

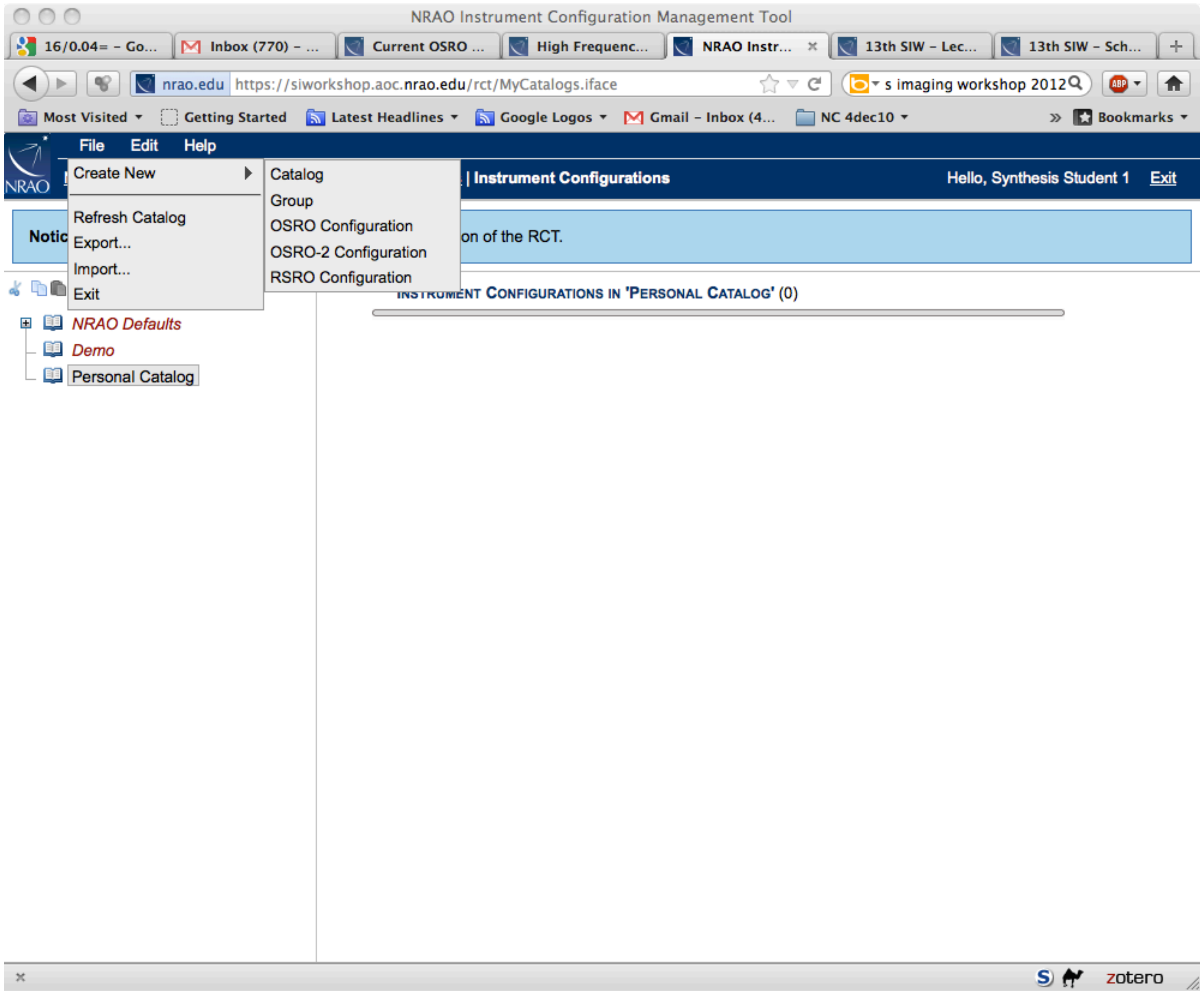
- https://siworkshop.aoc.nrao.edu/
  - –N.b.: normally just use http://my.nrao.edu
- Click on “Observation Preparation Tool (OPT)”
- Username: demo1…demo200
- Password: 300GHz
- Click on “Instrument Configurations”

# Top level

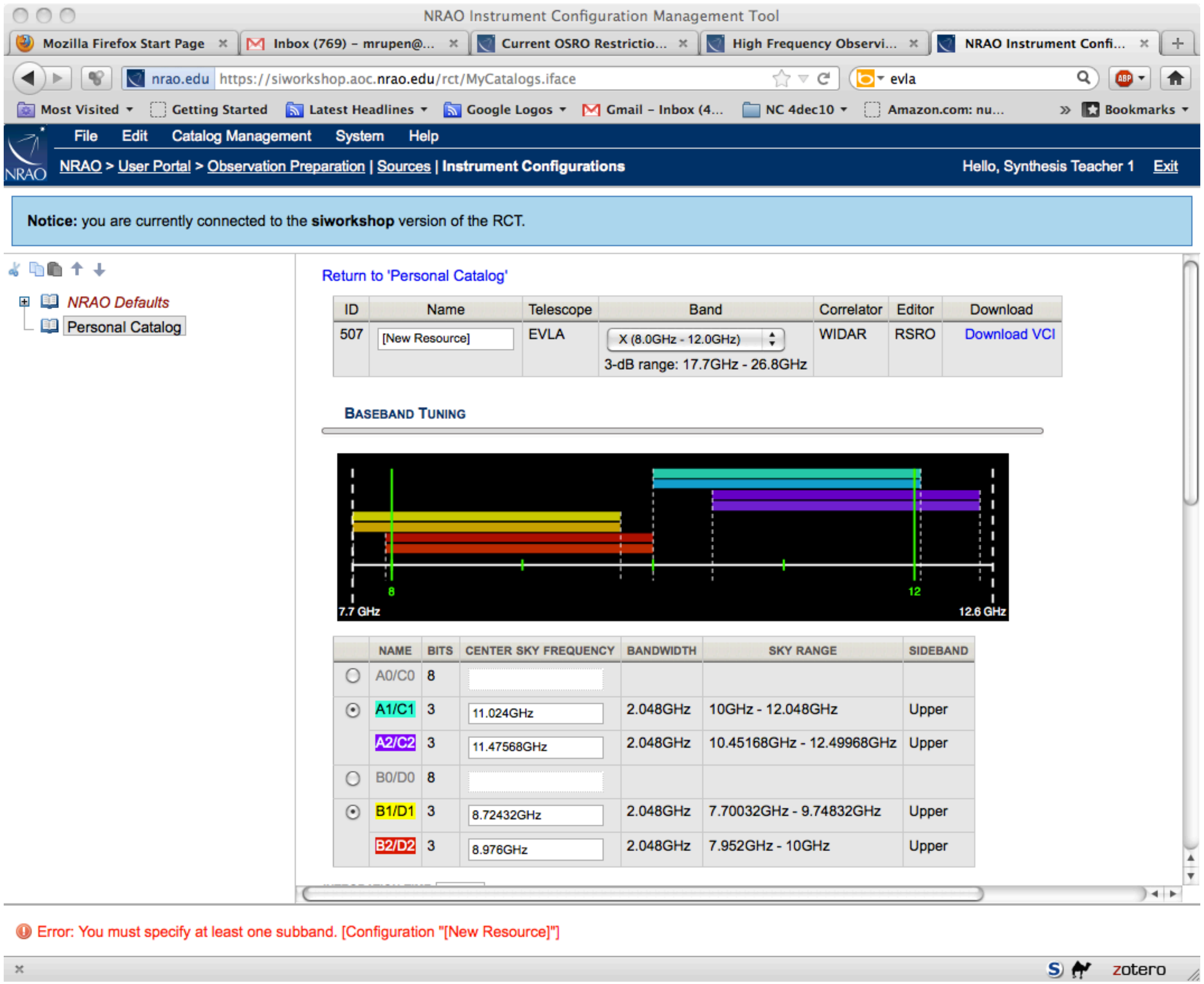



"Demo" has sample setup for this observation

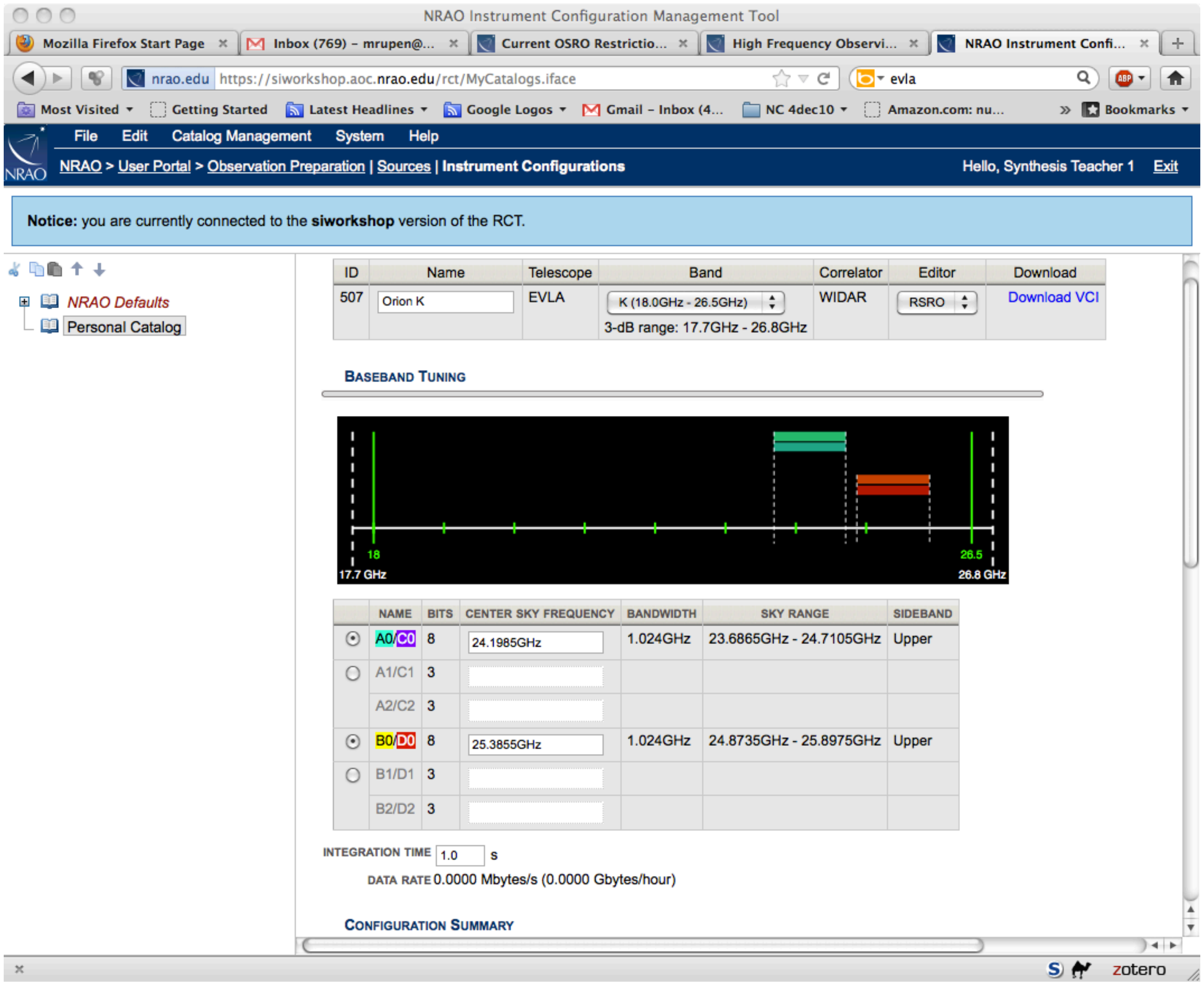
# Create new RSRO setup



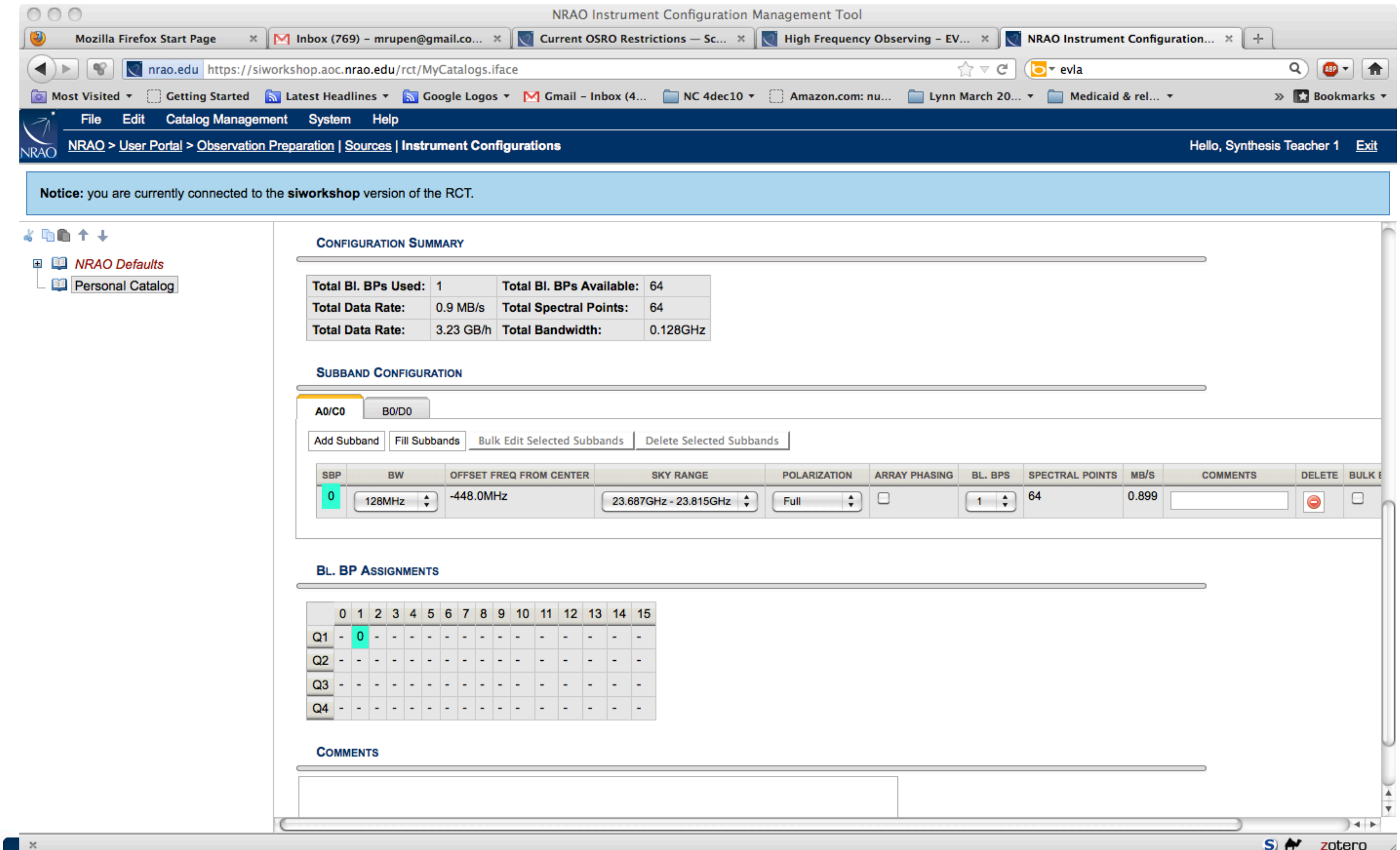
# Create new RSRO setup



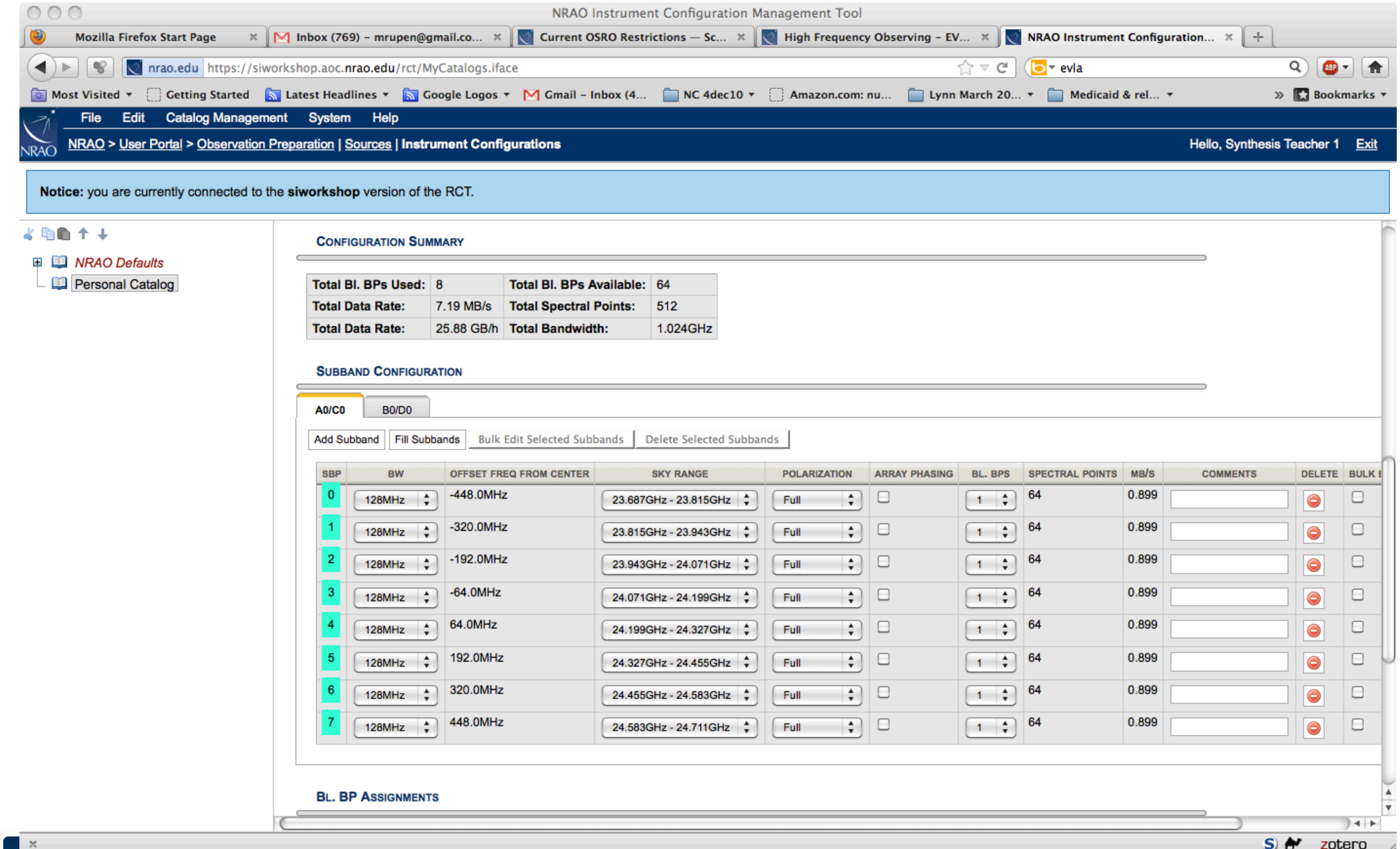
# Set to 8-bit, K band, center freqs.



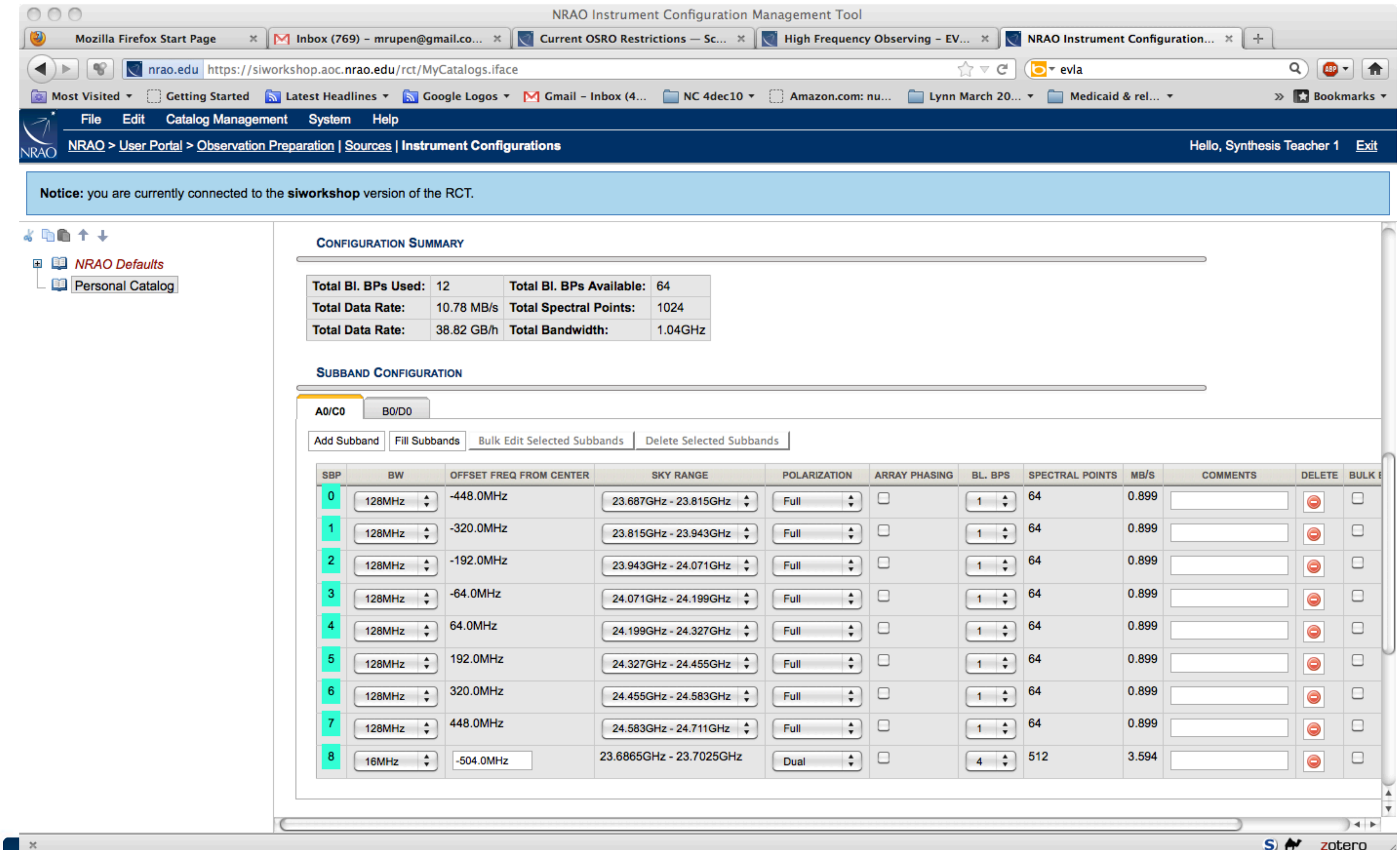
# Add a subband



# Continuum: 8 x 128 MHz, 4pp, 64 chan



# Add NH3(1,1): 16 MHz, 2pp, BIB x4


NRAO Instrument Configuration Management Tool

File | Edit | Catalog Management | System | Help

NRAO > User Portal > Observation Preparation | Sources | Instrument Configurations

Hello, Synthesis Teacher 1 Exit

**Notice:** you are currently connected to the **siworkshop** version of the RCT.

NRAO Defaults

Personal Catalog

**Configuration Summary**

| | | | |
|---|---|---|---|
| Total Bl. BPs Used: | 12 | Total Bl. BPs Available: | 64 |
| Total Data Rate: | 10.78 MB/s | Total Spectral Points: | 1024 |
| Total Data Rate: | 38.82 GB/h | Total Bandwidth: | 1.04GHz |

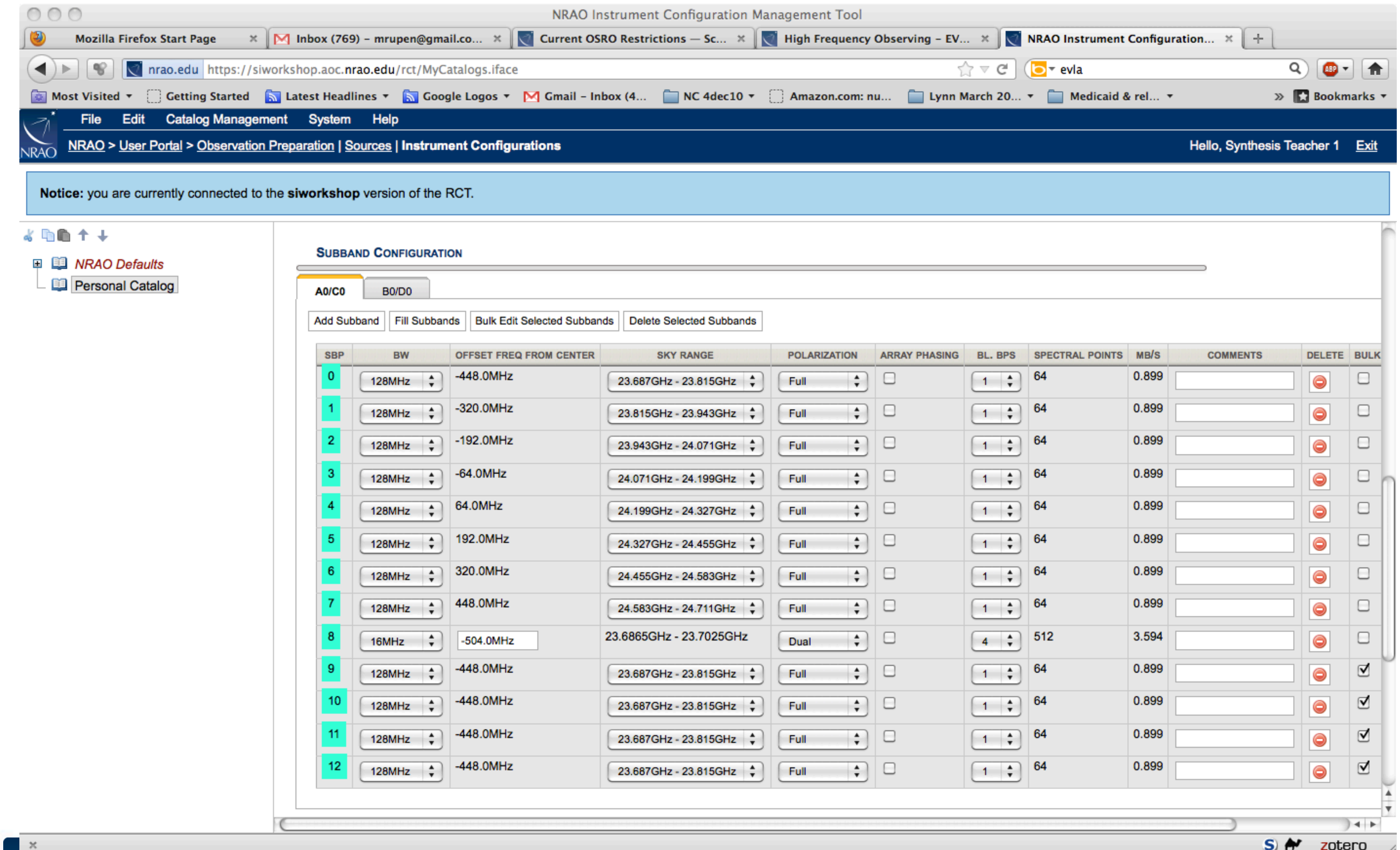
**Subband Configuration**

A0/C0 | B0/D0

Add Subband | Fill Subbands | Bulk Edit Selected Subbands | Delete Selected Subbands

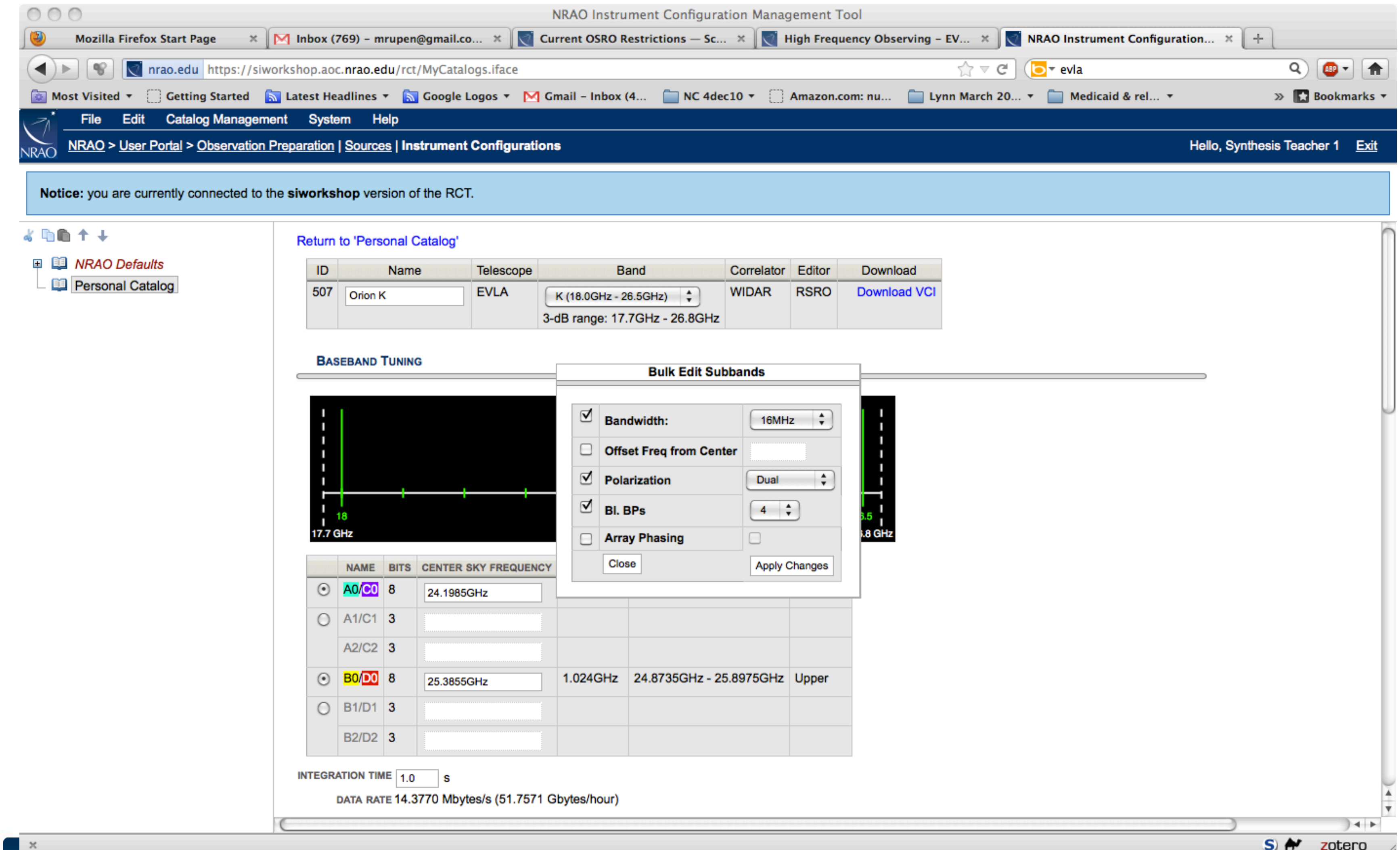
| SBP | BW | OFFSET FREQ FROM CENTER | SKY RANGE | POLARIZATION | ARRAY PHASING | BL. BPS | SPECTRAL POINTS | MB/S | COMMENTS | DELETE | BULK E |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 128MHz | -448.0MHz | 23.687GHz - 23.815GHz | Full | | 1 | 64 | 0.899 | | | |
| 1 | 128MHz | -320.0MHz | 23.815GHz - 23.943GHz | Full | | 1 | 64 | 0.899 | | | |
| 2 | 128MHz | -192.0MHz | 23.943GHz - 24.071GHz | Full | | 1 | 64 | 0.899 | | | |
| 3 | 128MHz | -64.0MHz | 24.071GHz - 24.199GHz | Full | | 1 | 64 | 0.899 | | | |
| 4 | 128MHz | 64.0MHz | 24.199GHz - 24.327GHz | Full | | 1 | 64 | 0.899 | | | |
| 5 | 128MHz | 192.0MHz | 24.327GHz - 24.455GHz | Full | | 1 | 64 | 0.899 | | | |
| 6 | 128MHz | 320.0MHz | 24.455GHz - 24.583GHz | Full | | 1 | 64 | 0.899 | | | |
| 7 | 128MHz | 448.0MHz | 24.583GHz - 24.711GHz | Full | | 1 | 64 | 0.899 | | | |
| 8 | 16MHz | -504.0MHz | 23.6865GHz - 23.7025GHz | Dual | | 4 | 512 | 3.594 | | | |

# 4 new subbands: select…




| SBP | BW | OFFSET FREQ FROM CENTER | SKY RANGE | POLARIZATION | ARRAY PHASING | BL. BPS | SPECTRAL POINTS | MB/S | COMMENTS | DELETE | BULK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 128MHz | -448.0MHz | 23.687GHz - 23.815GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☐ |
| 1 | 128MHz | -320.0MHz | 23.815GHz - 23.943GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☐ |
| 2 | 128MHz | -192.0MHz | 23.943GHz - 24.071GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☐ |
| 3 | 128MHz | -64.0MHz | 24.071GHz - 24.199GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☐ |
| 4 | 128MHz | 64.0MHz | 24.199GHz - 24.327GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☐ |
| 5 | 128MHz | 192.0MHz | 24.327GHz - 24.455GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☐ |
| 6 | 128MHz | 320.0MHz | 24.455GHz - 24.583GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☐ |
| 7 | 128MHz | 448.0MHz | 24.583GHz - 24.711GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☐ |
| 8 | 16MHz | -504.0MHz | 23.6865GHz - 23.7025GHz | Dual | ☐ | 4 | 512 | 3.594 | | | ☐ |
| 9 | 128MHz | -448.0MHz | 23.687GHz - 23.815GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☑ |
| 10 | 128MHz | -448.0MHz | 23.687GHz - 23.815GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☑ |
| 11 | 128MHz | -448.0MHz | 23.687GHz - 23.815GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☑ |
| 12 | 128MHz | -448.0MHz | 23.687GHz - 23.815GHz | Full | ☐ | 1 | 64 | 0.899 | | | ☑ |

# 4 new subbands: …and Bulk Edit



# Offsets from baseband centers

- Ammonia transitions then are as follows:
  - (1,1) 23694.50 MHz A0/C0 -504.00 MHz
  - (2,2) 23722.63 MHz A0/C0 -475.87 MHz
  - (3,3) 23870.13 MHz A0/C0 -328.37 MHz
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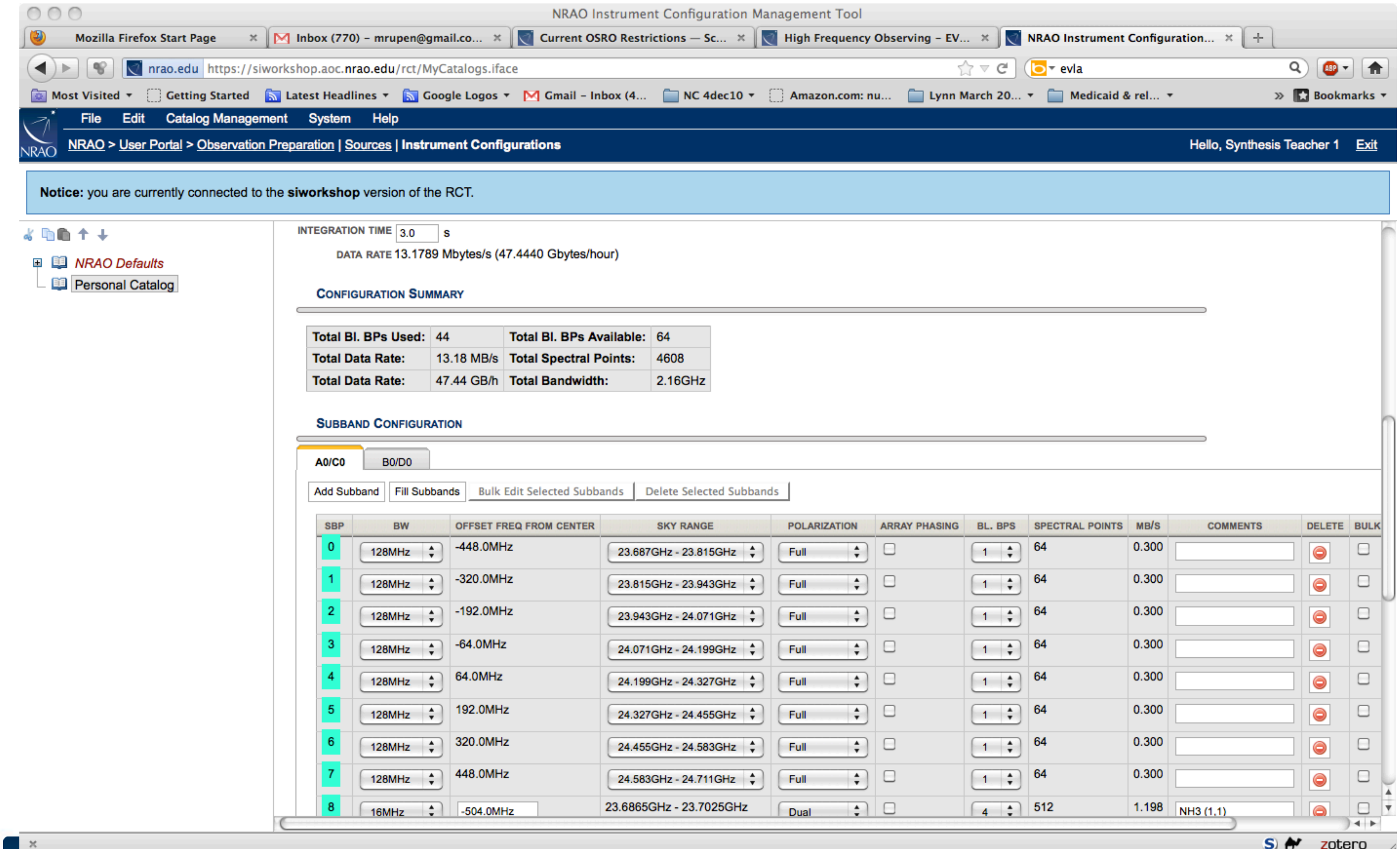
  - (5,5) 24532.99 MHz A0/C0 +334.49 MHz
  - (6,6) 25056.03 MHz B0/D0 -329.47 MHz
  - (7,7) 25715.18 MHz B0/D0 +329.68 MHz
- Next year you will be able to set these perfectly. For now, subbands "snap to a grid" set by the subband bandwidth.
- **No subband can EVER cross a 128 MHz boundary!**

# Data rates: 3sec averaging for sanity




| | | | |
|---|---|---|---|
| Total Bl. BPs Used: | 44 | Total Bl. BPs Available: | 64 |
| Total Data Rate: | 13.18 MB/s | Total Spectral Points: | 4608 |
| Total Data Rate: | 47.44 GB/h | Total Bandwidth: | 2.16GHz |

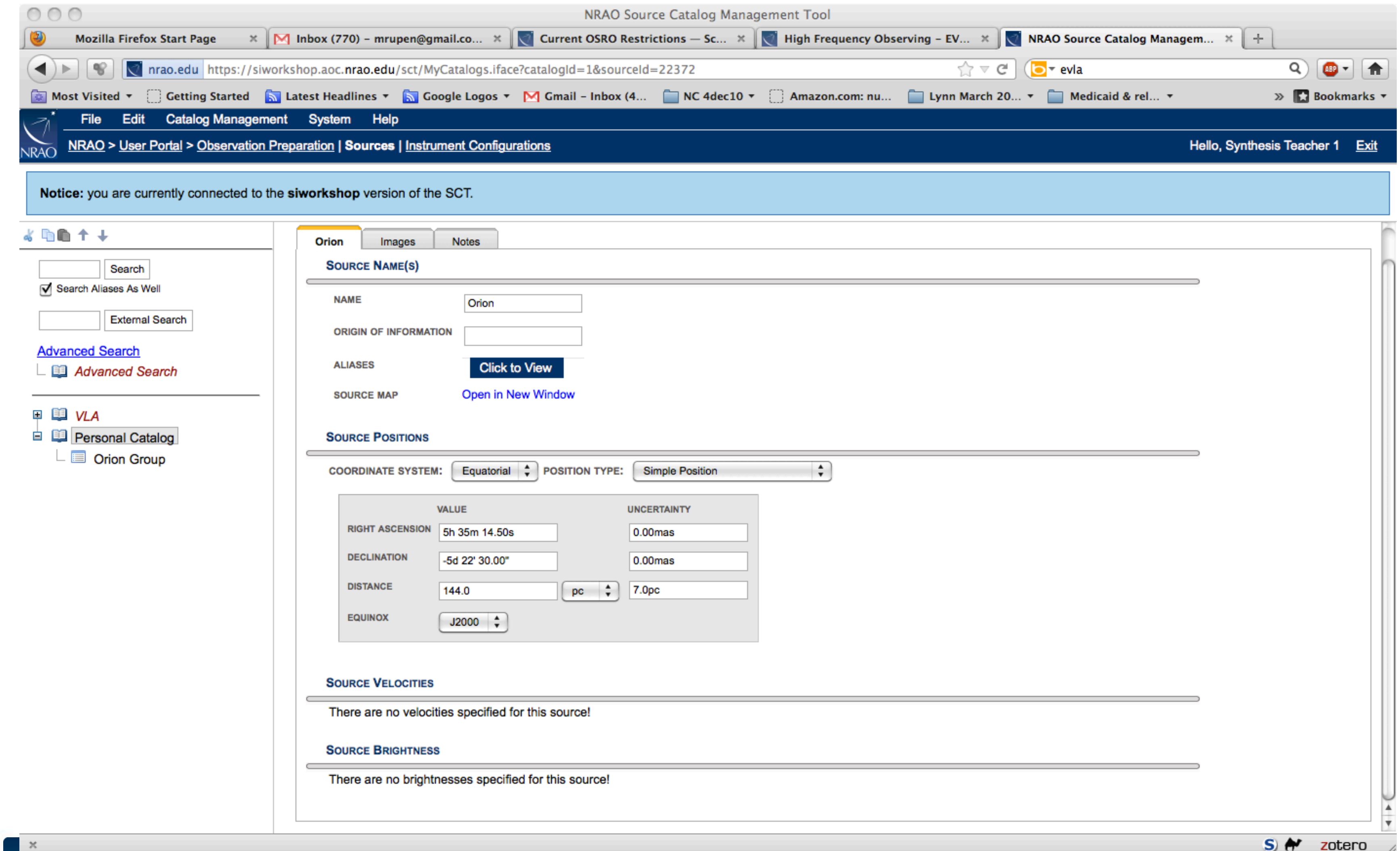
| SBP | BW | OFFSET FREQ FROM CENTER | SKY RANGE | POLARIZATION | ARRAY PHASING | BL. BPS | SPECTRAL POINTS | MB/S | COMMENTS | DELETE | BULK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 128MHz | -448.0MHz | 23.687GHz - 23.815GHz | Full | | 1 | 64 | 0.300 | | | |
| 1 | 128MHz | -320.0MHz | 23.815GHz - 23.943GHz | Full | | 1 | 64 | 0.300 | | | |
| 2 | 128MHz | -192.0MHz | 23.943GHz - 24.071GHz | Full | | 1 | 64 | 0.300 | | | |
| 3 | 128MHz | -64.0MHz | 24.071GHz - 24.199GHz | Full | | 1 | 64 | 0.300 | | | |
| 4 | 128MHz | 64.0MHz | 24.199GHz - 24.327GHz | Full | | 1 | 64 | 0.300 | | | |
| 5 | 128MHz | 192.0MHz | 24.327GHz - 24.455GHz | Full | | 1 | 64 | 0.300 | | | |
| 6 | 128MHz | 320.0MHz | 24.455GHz - 24.583GHz | Full | | 1 | 64 | 0.300 | | | |
| 7 | 128MHz | 448.0MHz | 24.583GHz - 24.711GHz | Full | | 1 | 64 | 0.300 | | | |
| 8 | 16MHz | -504.0MHz | 23.6865GHz - 23.7025GHz | Dual | | 4 | 512 | 1.198 | NH3 (1,1) | | |

# Sources
# (Source Configuration Tool)

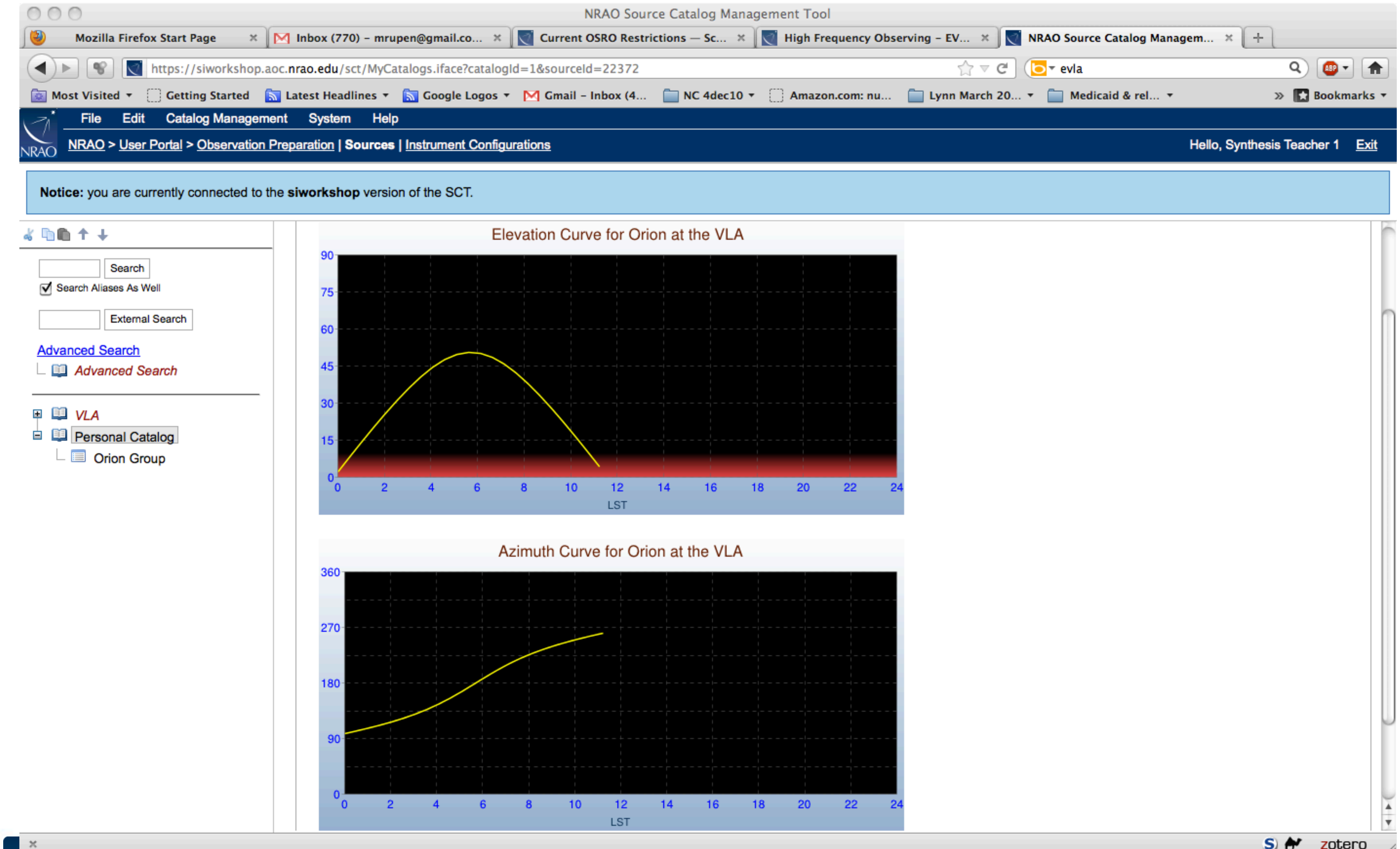
# Planning: where is your source?

- Orion BN/KL
  - J2000: **05h 35m 14.50s, -05d 22' 30.00”**

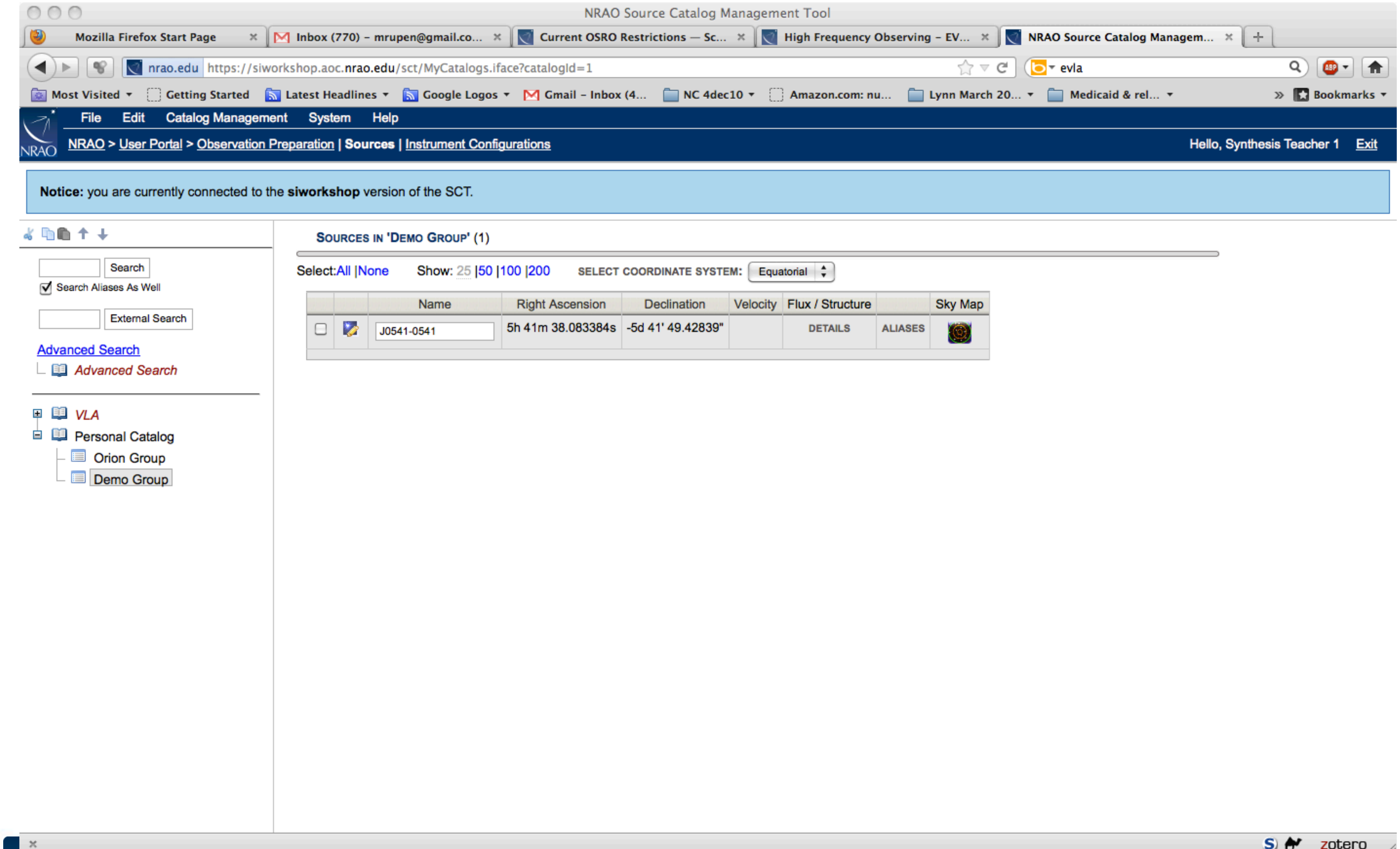
# New source: Orion



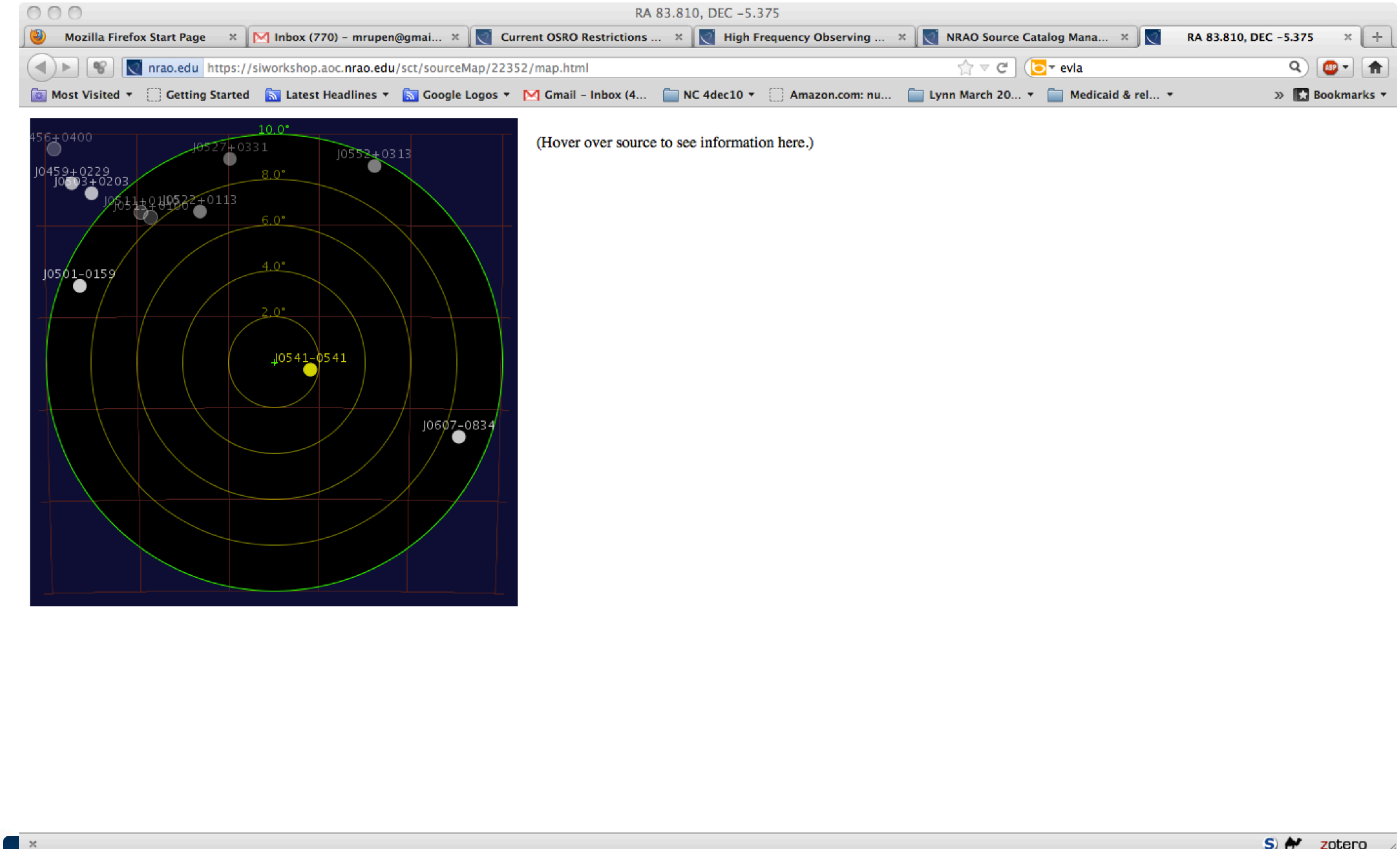
# LST restrictions



# Put it in a group



# Skymap: finding a nearby calibrator



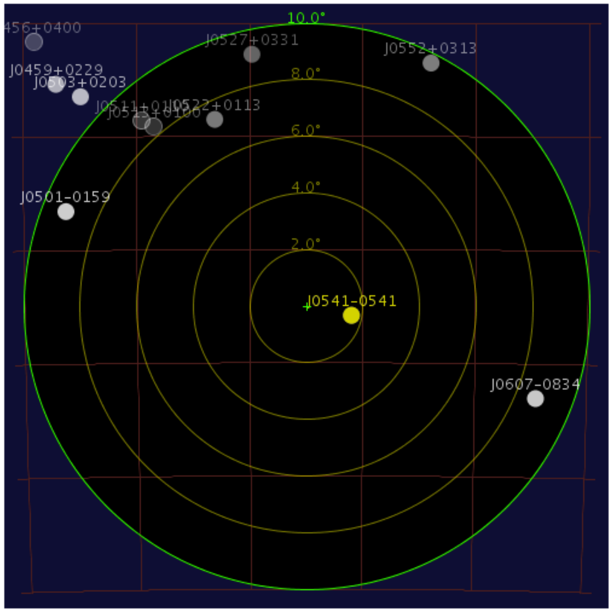
# Skymap: hover for info

RA 83.810, DEC –5.375

Mozilla Firefox Start Page | Inbox (770) – mrupen@gmai... | Current OSRO Restrictions ... | High Frequency Observing ... | NRAO Source Catalog Mana... | RA 83.810, DEC –5.375

nrao.edu https://siworkshop.aoc.nrao.edu/sct/sourceMap/22352/map.html

Most Visited | Getting Started | Latest Headlines | Google Logos | Gmail – Inbox (4... | NC 4dec10 | Amazon.com: nu... | Lynn March 20... | Medicaid & rel... | Bookmarks




## [J0541-0541]

*Aliases:* 0541-056 B0539-0543 0539-057

*Positions:*
*RA:* 5h 41m 38.083s
*Dec:* -5° 41' 49.428"

*Uncertainties (mas):*
*RA:* 2.0
*Dec:* 2.0

*Flux / Structure*

| Band | Flux | A | B | C | D | $UV_{min}$ (kλ) | $UV_{max}$ (kλ) |
|---|---|---|---|---|---|---|---|
| L (20.0cm) | 1.05Jy | S | S | S | S | | |
| C (5.0cm) | 1.25Jy | P | P | P | P | | |
| X (3.0cm) | 0.98Jy | P | P | P | P | | |
| Ku (2.0cm) | 1.3Jy | P | P | P | P | | |
| Q (0.7cm) | 0.7Jy | W | W | W | W | | |

*Velocities:*
No Information

*Images:*
None

zotero

# Calibrators

- Complex gain: nearby, fairly strong at observing band
  - J0541-0541
- Ref.ptg. calibrator: nearby, point-like, strong at X band
  - J0541-0541 (lucky!)
- Flux calibrator: check VLA Flux Cal catalog, LST range
  - Ideally: similar elevation (30-45d) during the observing run
  - 0137+331=3C48 0500-0600 LST
  - 0542+498=3C147 45-75d when Orion is up
- Bandpass calibrator: very strong for SNR in narrow channels
  - Search for > 5 Jy at K band: J0319+4130 (3C84)
  - Elevation 30-75d when Orion is up

# Calibrators

- Pol’n leakage: strong, known pol’n
  - J0319+4130
- Pol’n angle: known, non-0 pol’n
  - 3C48/3C138 will do…not great.
- See the EVLA polarization page for hints & details:
  https://science.nrao.edu/facilities/evla/early-science/polarimetry

# Scheduling Block
# (Observation Preparation Tool)

# Planning

- Basic "OSRO" guidelines will be updated, but currently look like this:

  https://science.nrao.edu/facilities/evla/observing/restrictions

- The High Frequency Observing Guide is preliminary but very useful:

  http://evlaguides.nrao.edu/index.php?title=High_Frequency_Observing

- NRAO helpdesk:

  https://help.nrao.edu/

# Planning

- Initial scans
  - 1min "dummy" for each instrument configuration
  - Long first scan since you don't know where the array is – can take ~12mins to get on-source
  - **Set CW/CCW explicitly!**
- Referenced pointing: errors can be up to an arcminute
  - Every hour and/or every source
  - At least 2.5minutes on-source
  - MUST use 1sec averaging – default primary X ptg

# Planning

- Flux calibrator (prefer same elevation as source)
- Bandpass calibrator (prefer to observe more than once)
- Basic loop: RefPtg, then cal-source-cal-source-….
  - –Maximize time on-source, but track the atmosphere!
  - –Ensure enough time on the calibrator (SNR; move time; flagging)
  - –K band, iffy weather: switch every 2mins in A/B cfg. Can usually get away with longer in C/D (7/10 minutes).
  - ➔Try 40sec/80sec (see next slides)
- Range of LST **start times** set by source AND calibrators (and length of SB!)
  - ➔For us, **0330-0630 LST** to avoid zenith & get 3C48

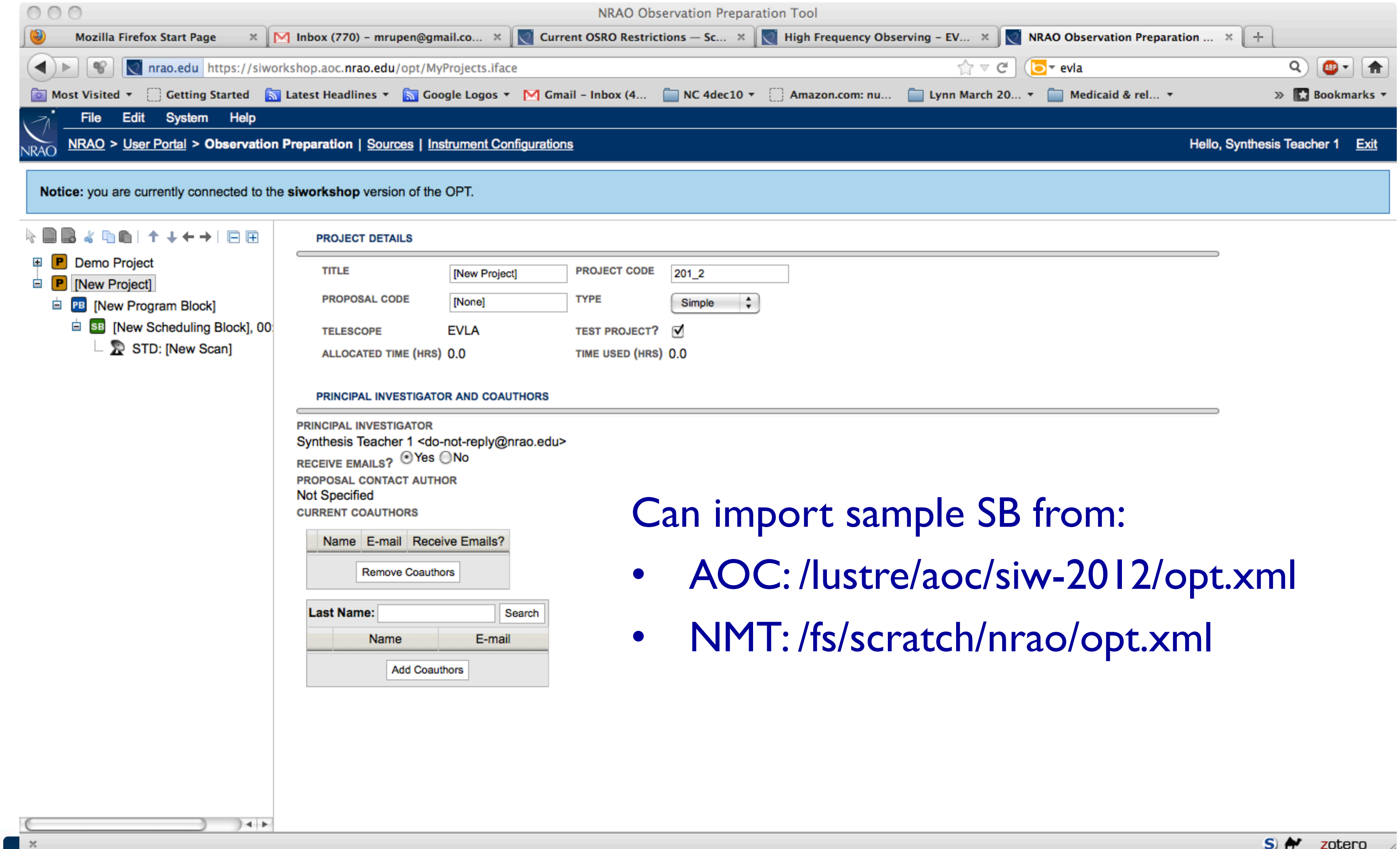
# Scan lengths & sensitivities

- EVLA exposure calculator:
  https://science.nrao.edu/facilities/evla/calibration-and-tools/exposure
- Flux/complex gain calibrators: want SNR>4 on single baseline, one pol'n product, one subband (16 MHz)
  - –Nant=2, Npol=1, 16 MHz, 1sec → rms~ 150 mJy
  - →Want signal > 600 mJy for 1sec, > 200 mJy for 9sec
- RefPtg: want SNR>4 on single baseline, 128 MHz, single pol'n product, in ~10sec at X band
  - Rms in 10sec= 7 mJy

# Scan lengths & sensitivities

- Bandpass calibration: want SNR better than your line, in each channel
  - 31.25 kHz channels, one baseline, one pol'n product: rms in 1min~ 400 mJy
  - Flux density matters!
- Paranoia is good!
  - Move time, esp. slow antennas
  - Flagging
  - It's cheap to spend a bit more time (move time often dominates anyhow), and horrible to have uncalibrated data

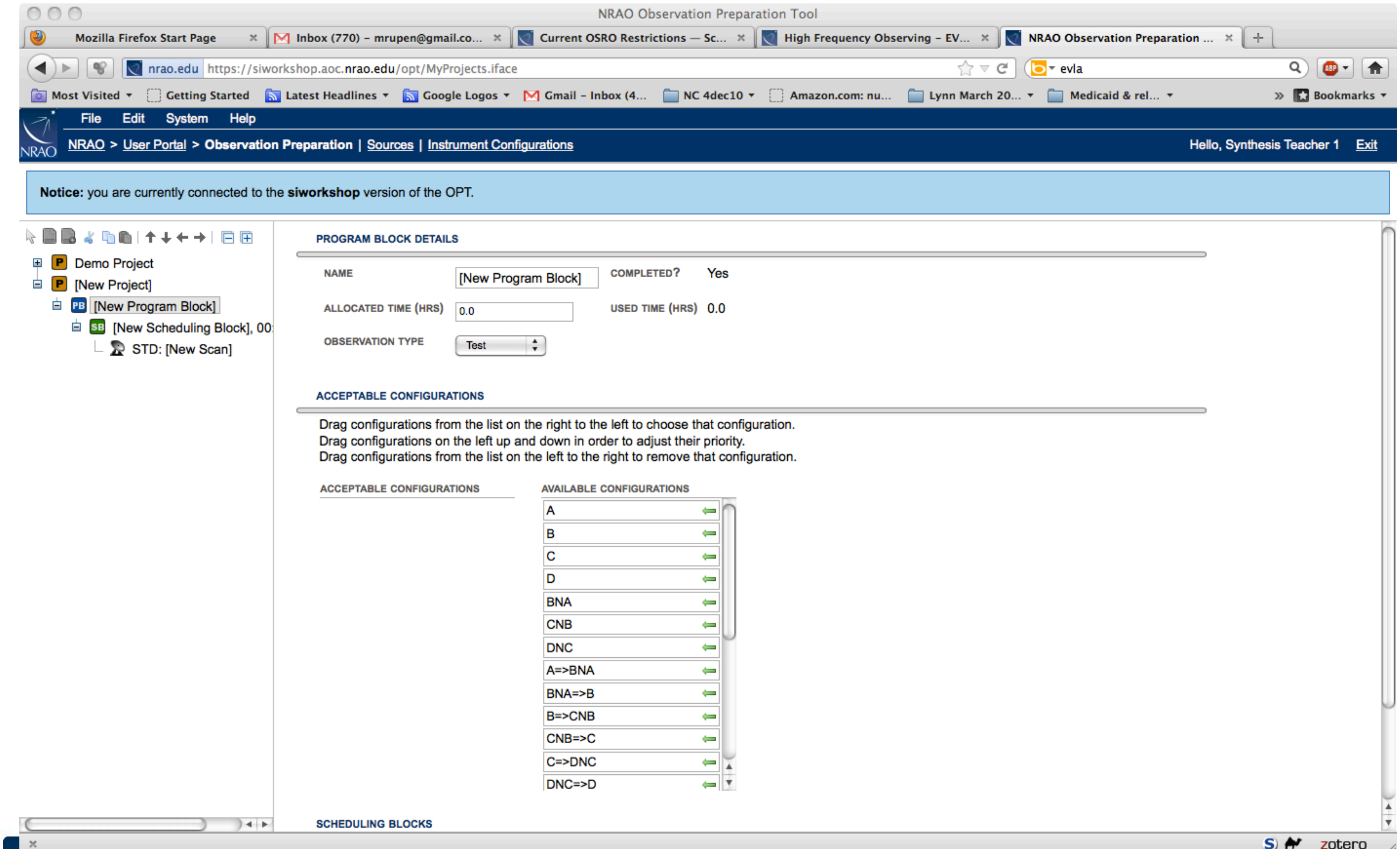
# The Project



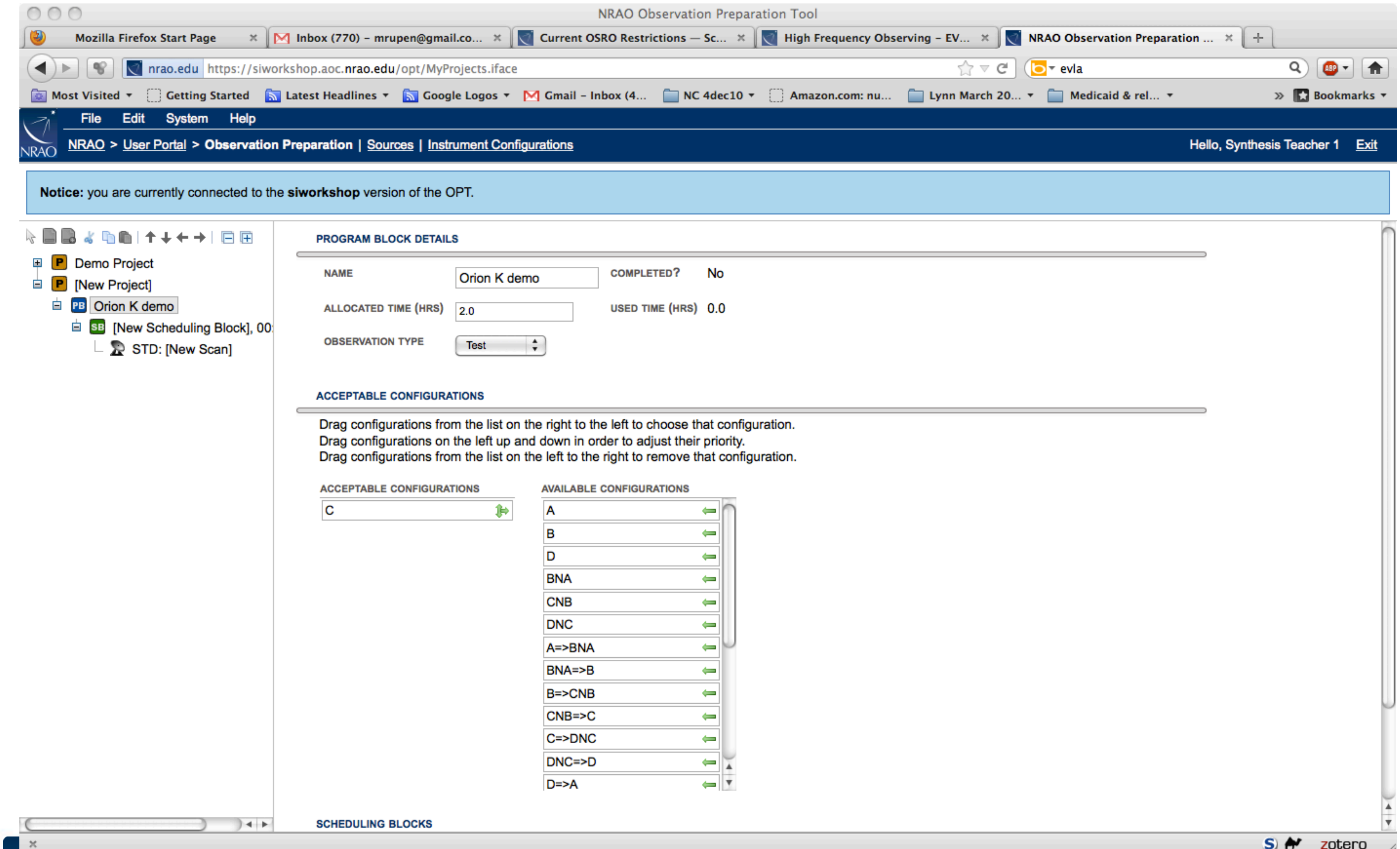

Can import sample SB from:

- AOC: /lustre/aoc/siw-2012/opt.xml
- NMT: /fs/scratch/nrao/opt.xml

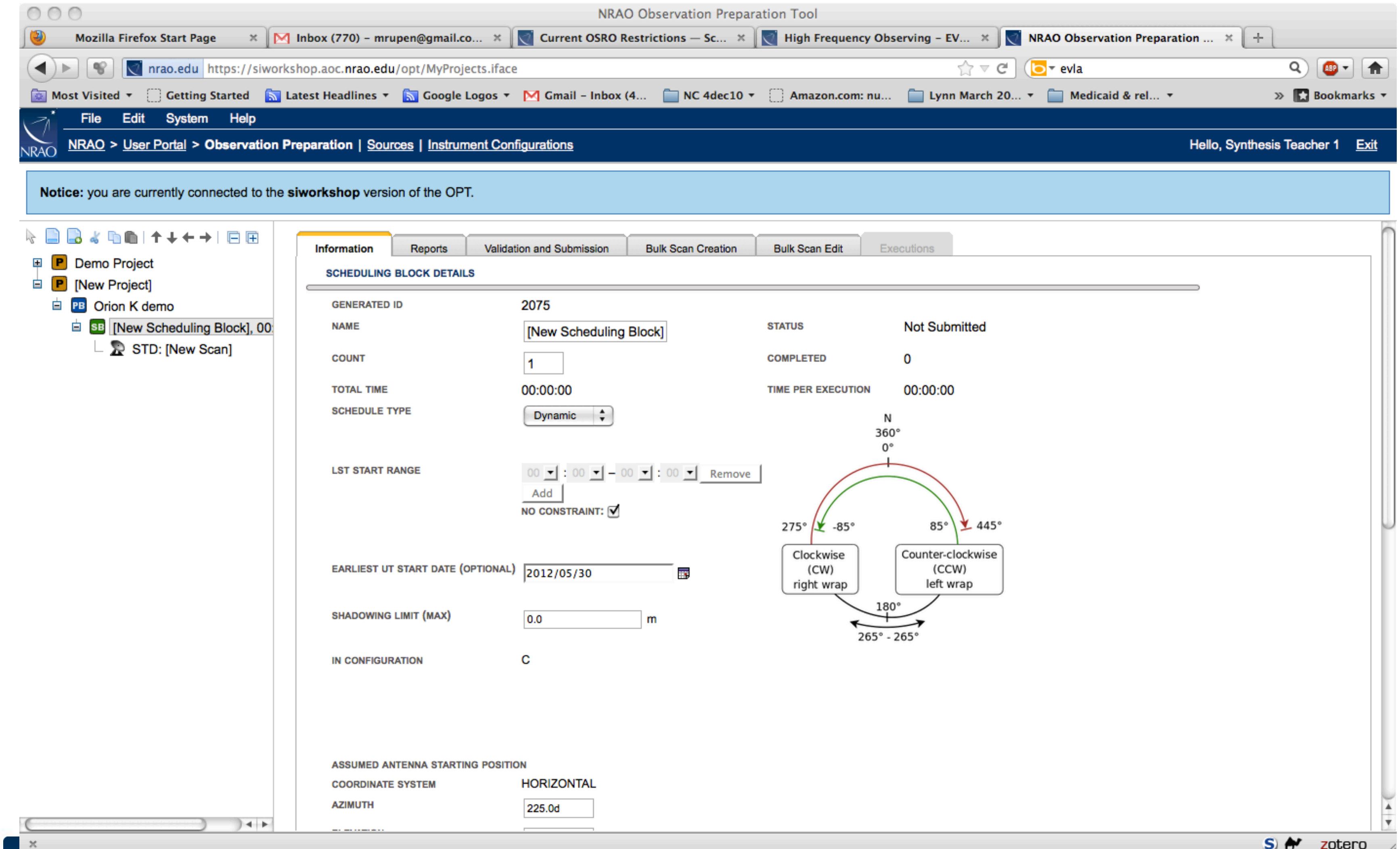
# Program Block



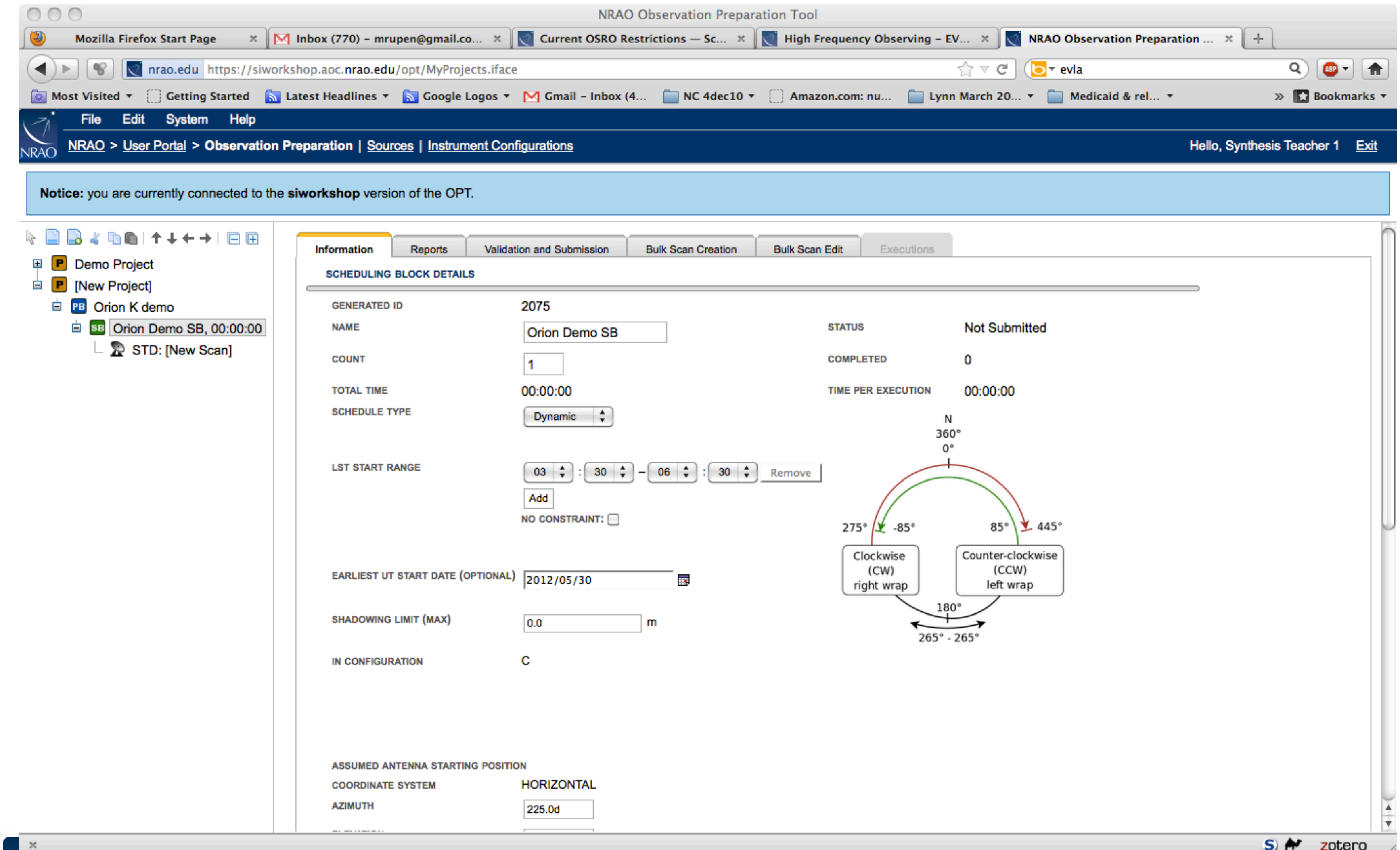
# Program Block, tweaked for Orion



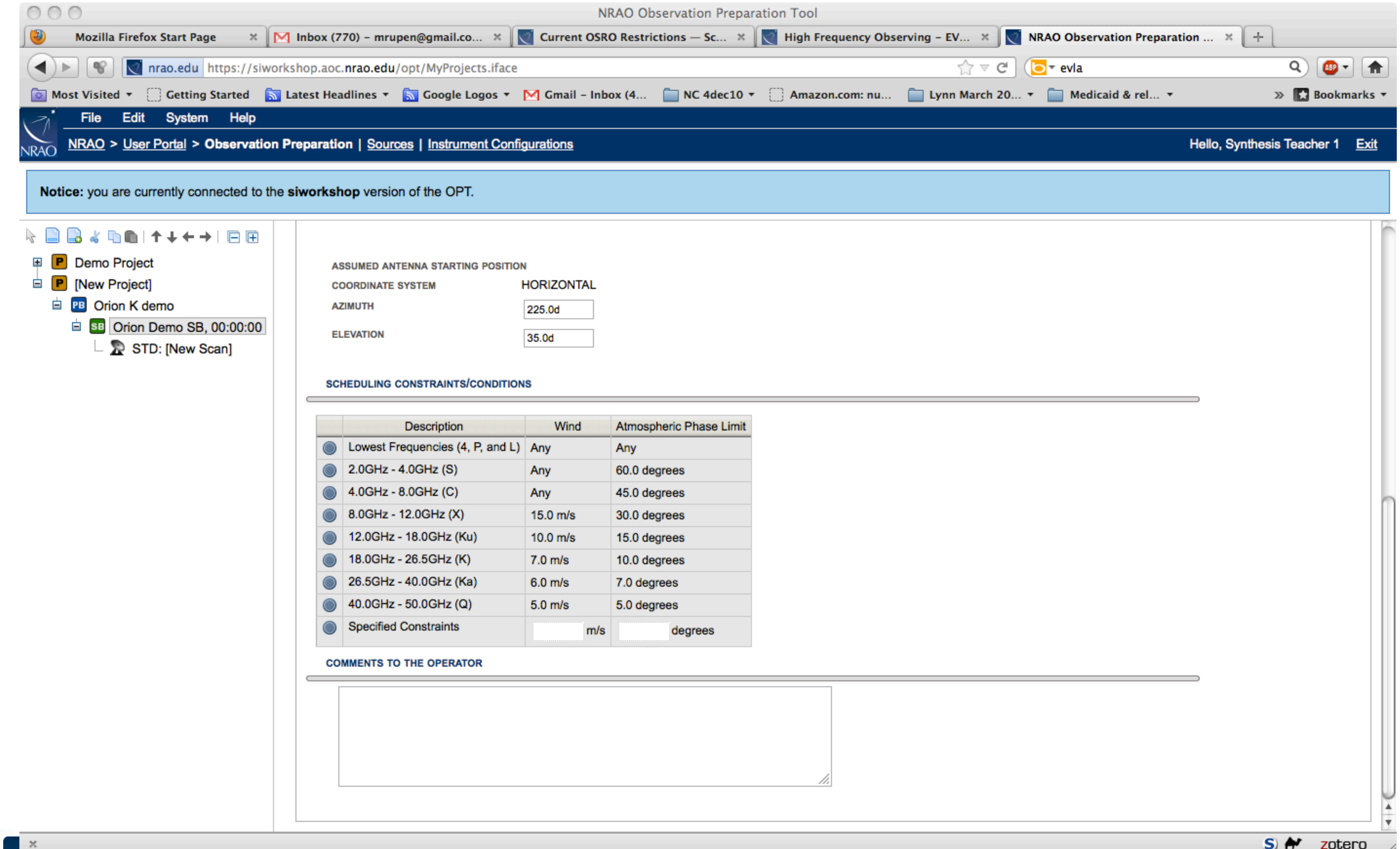
# Scheduling Block: new…



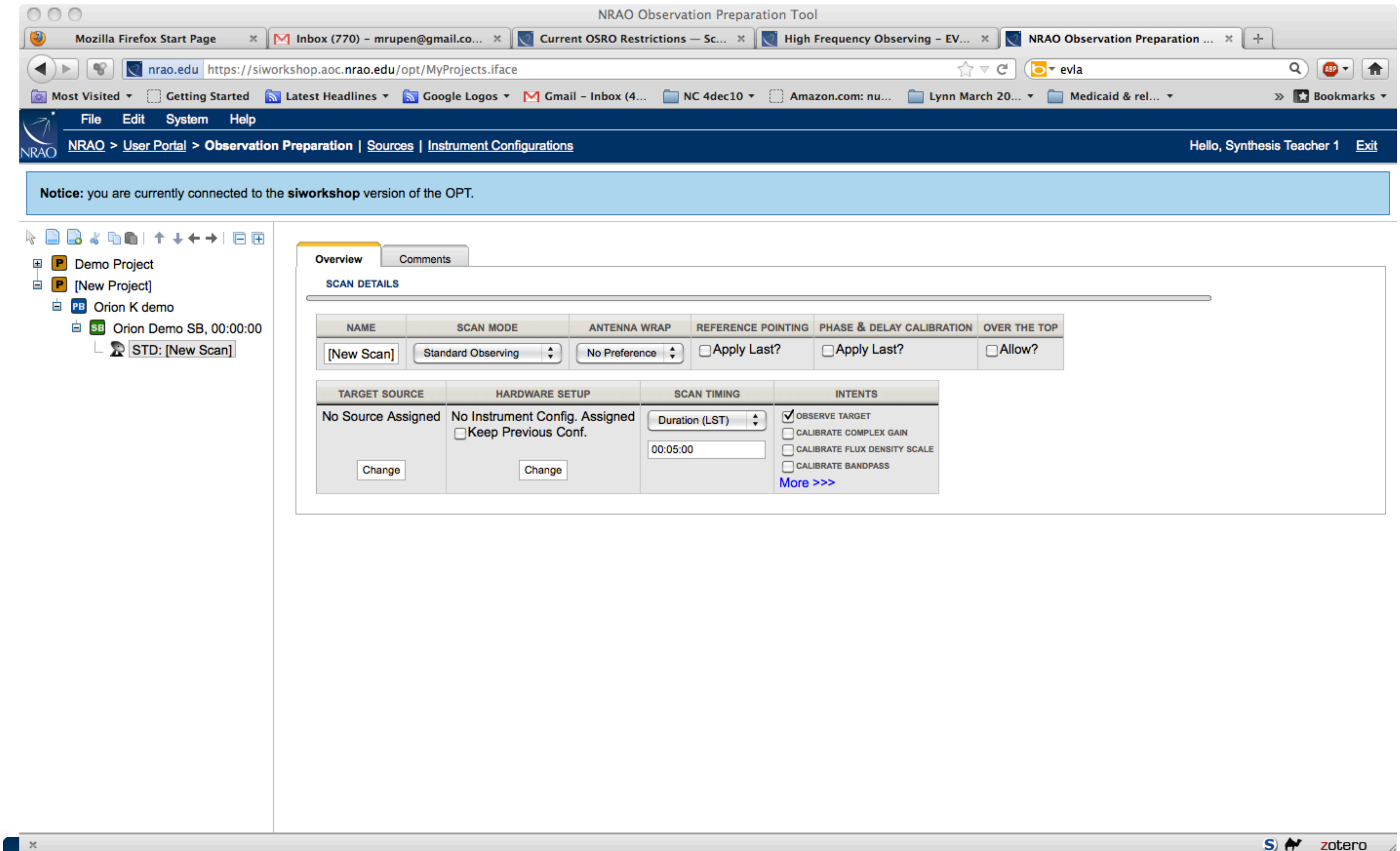
# Scheduling Block: …set the LST range…



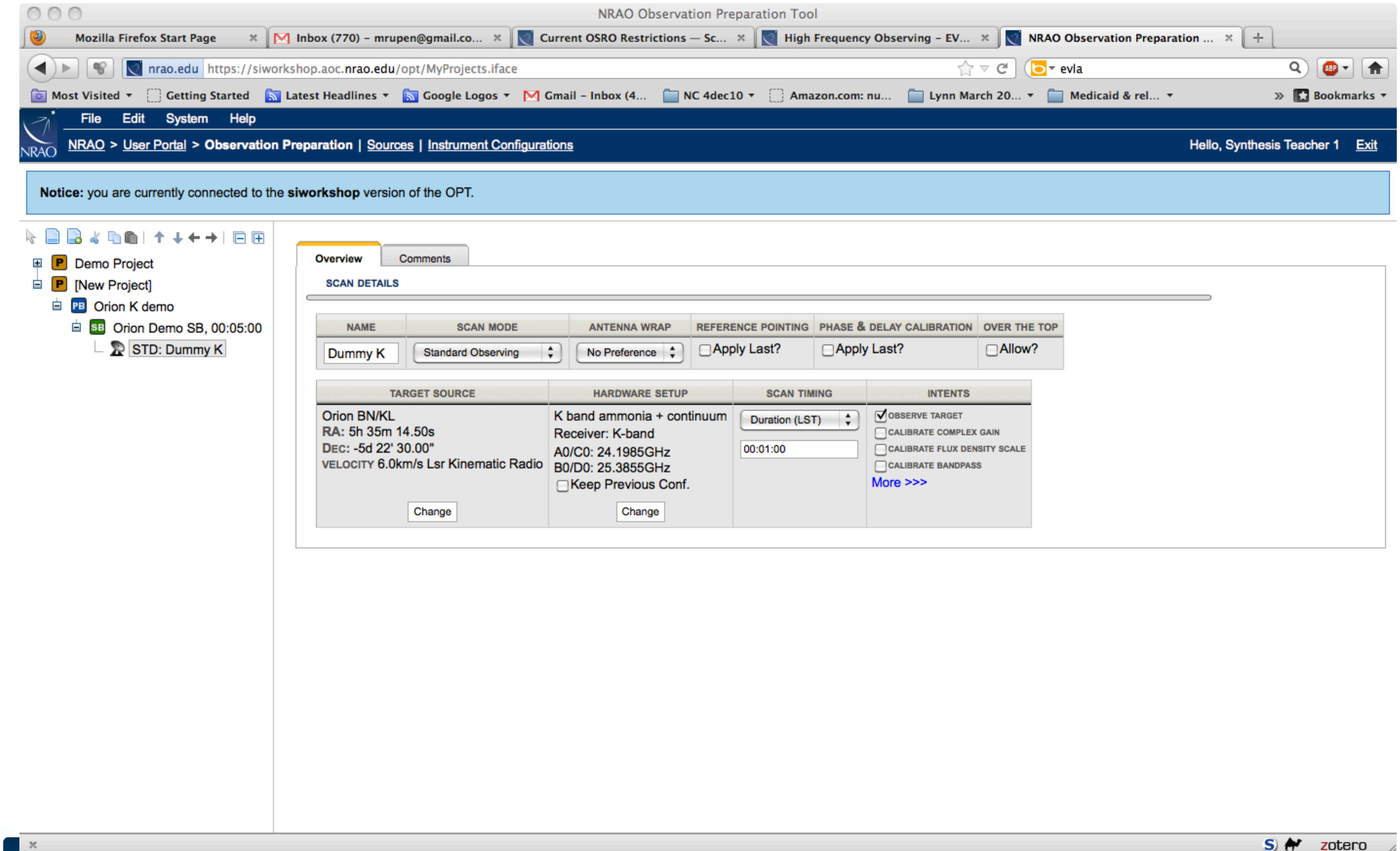
# Scheduling Block: …and req'd weather



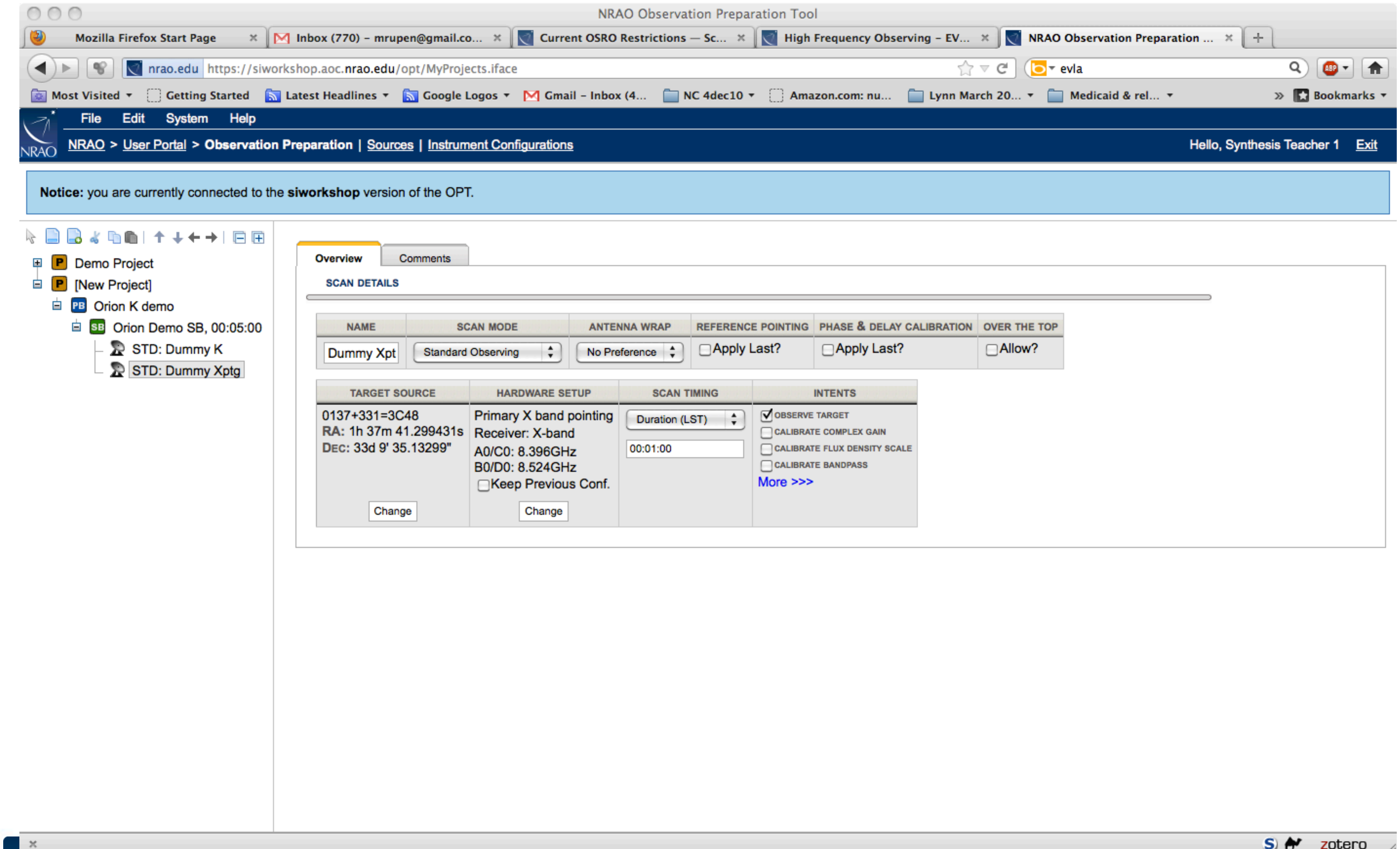
# At last, an actual scan!



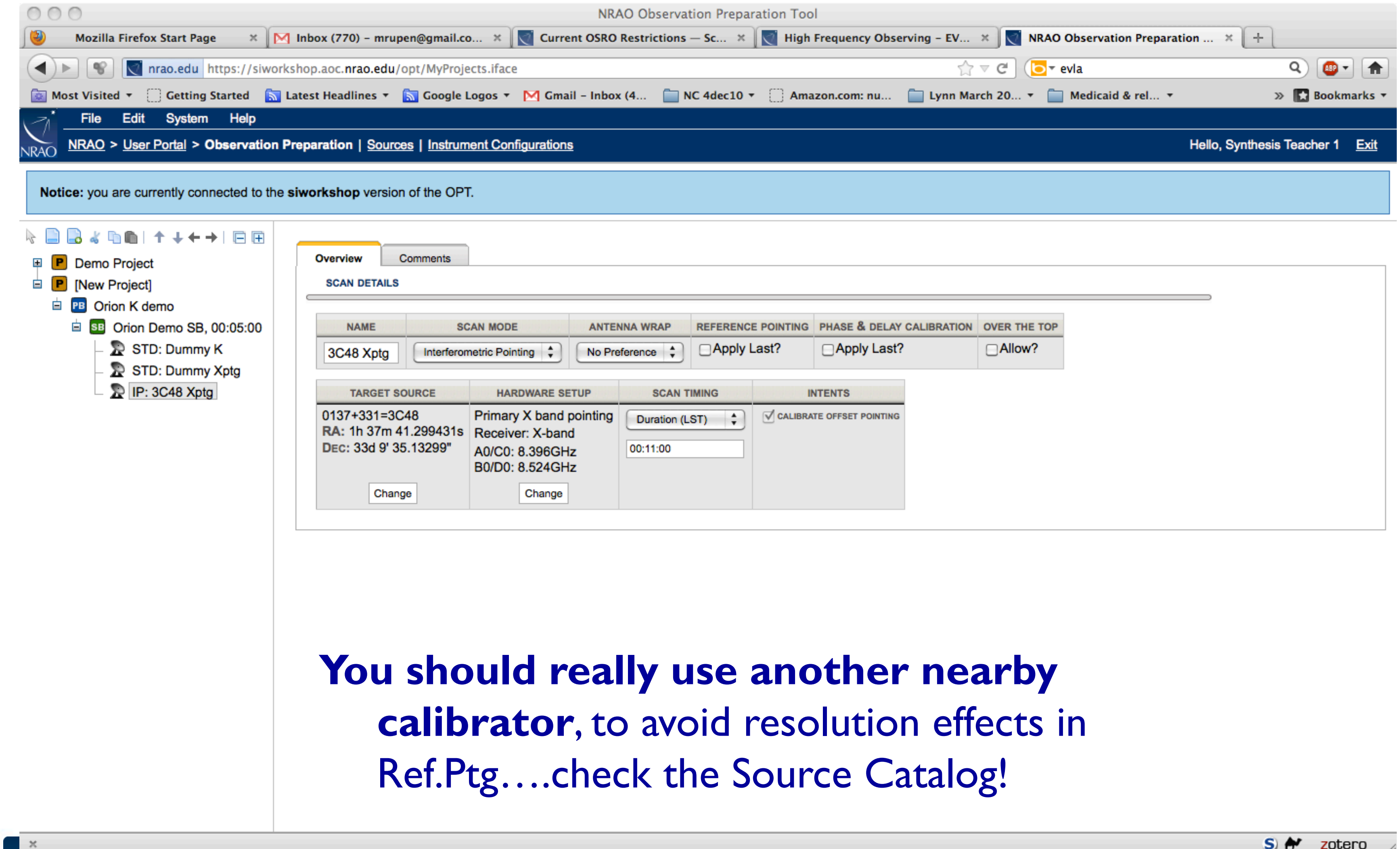
# Dummy: K band, Orion



# Dummy: X band, 3C48

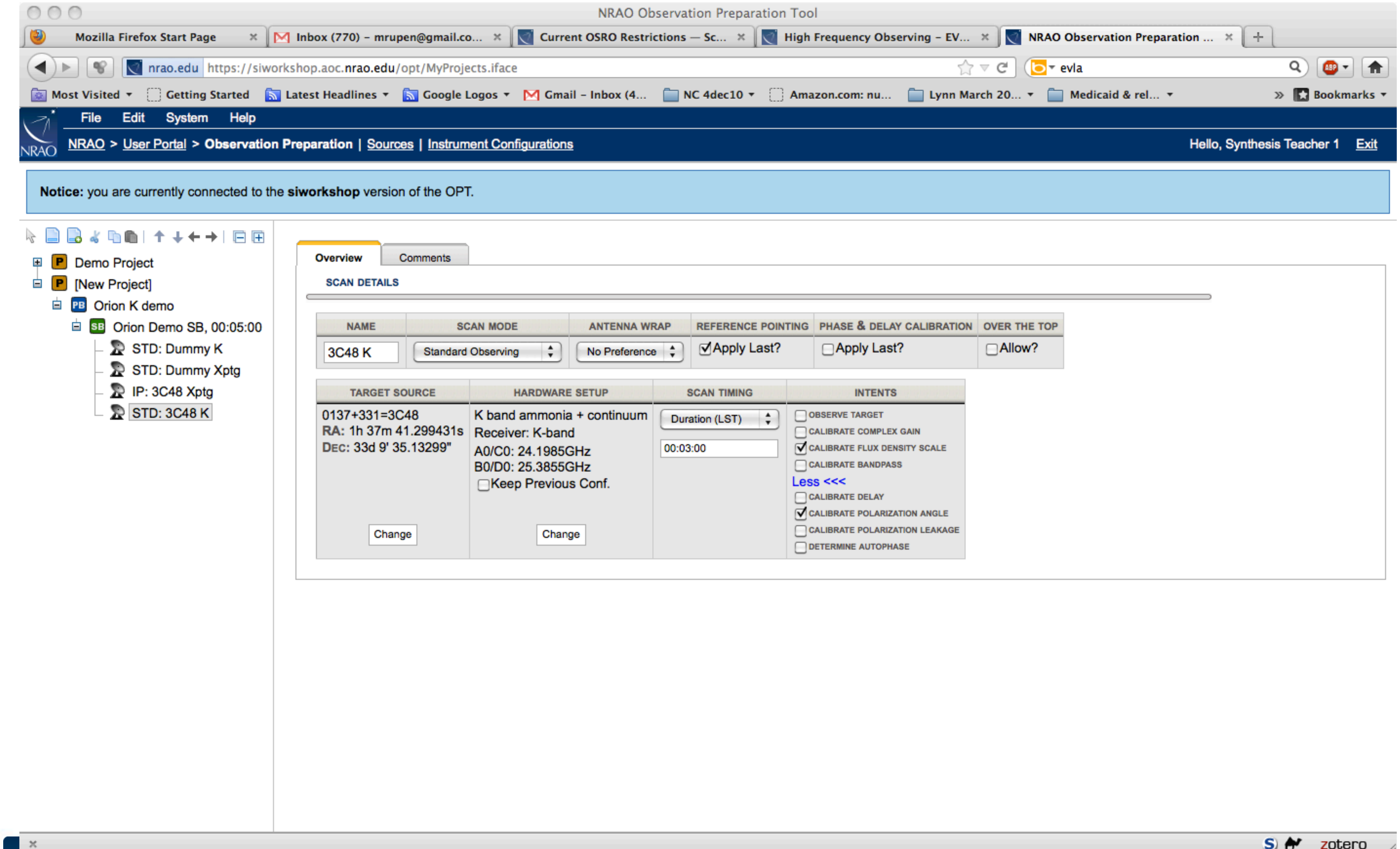


# 3C48: X band RefPtg

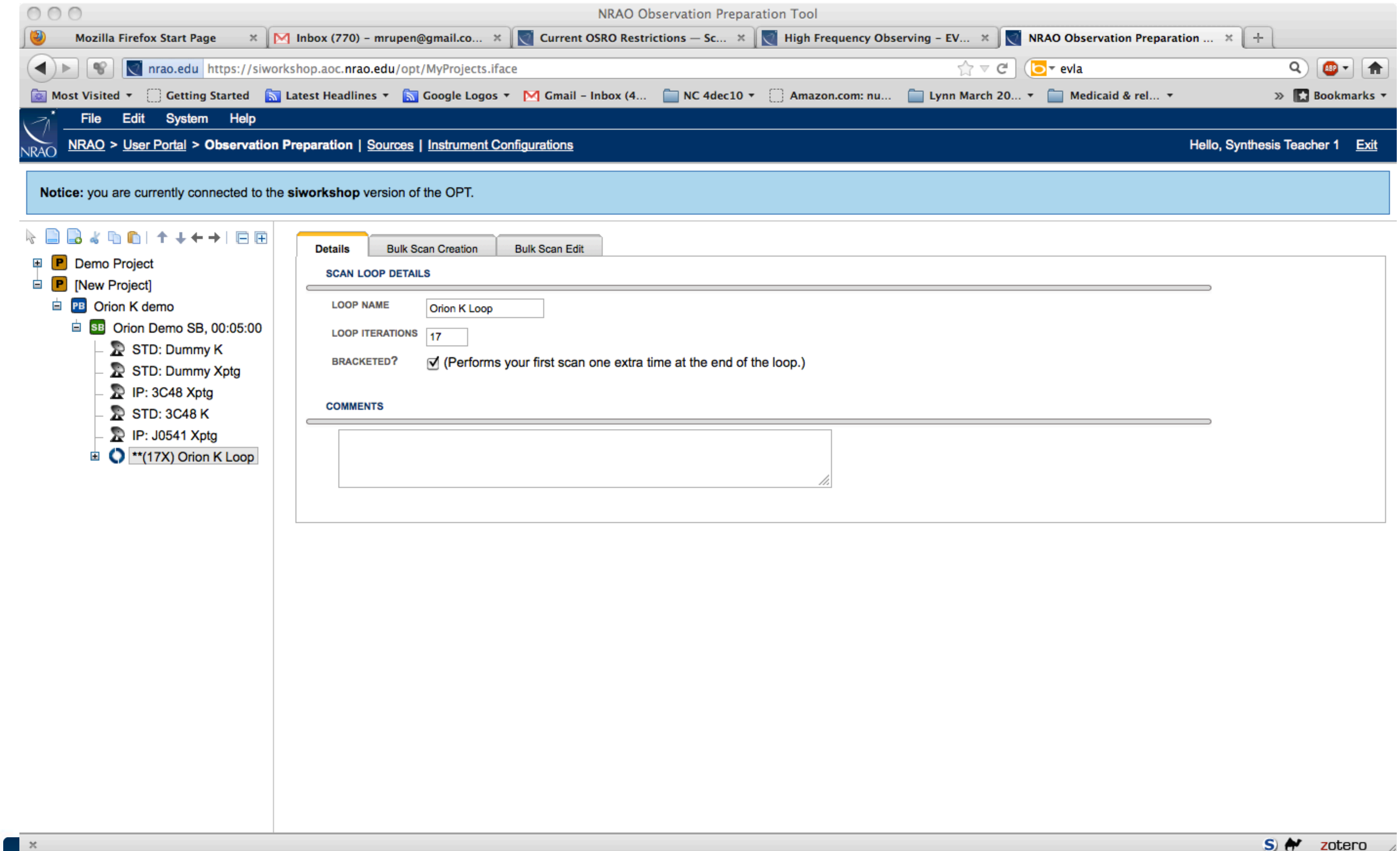



**You should really use another nearby calibrator**, to avoid resolution effects in Ref.Ptg….check the Source Catalog!

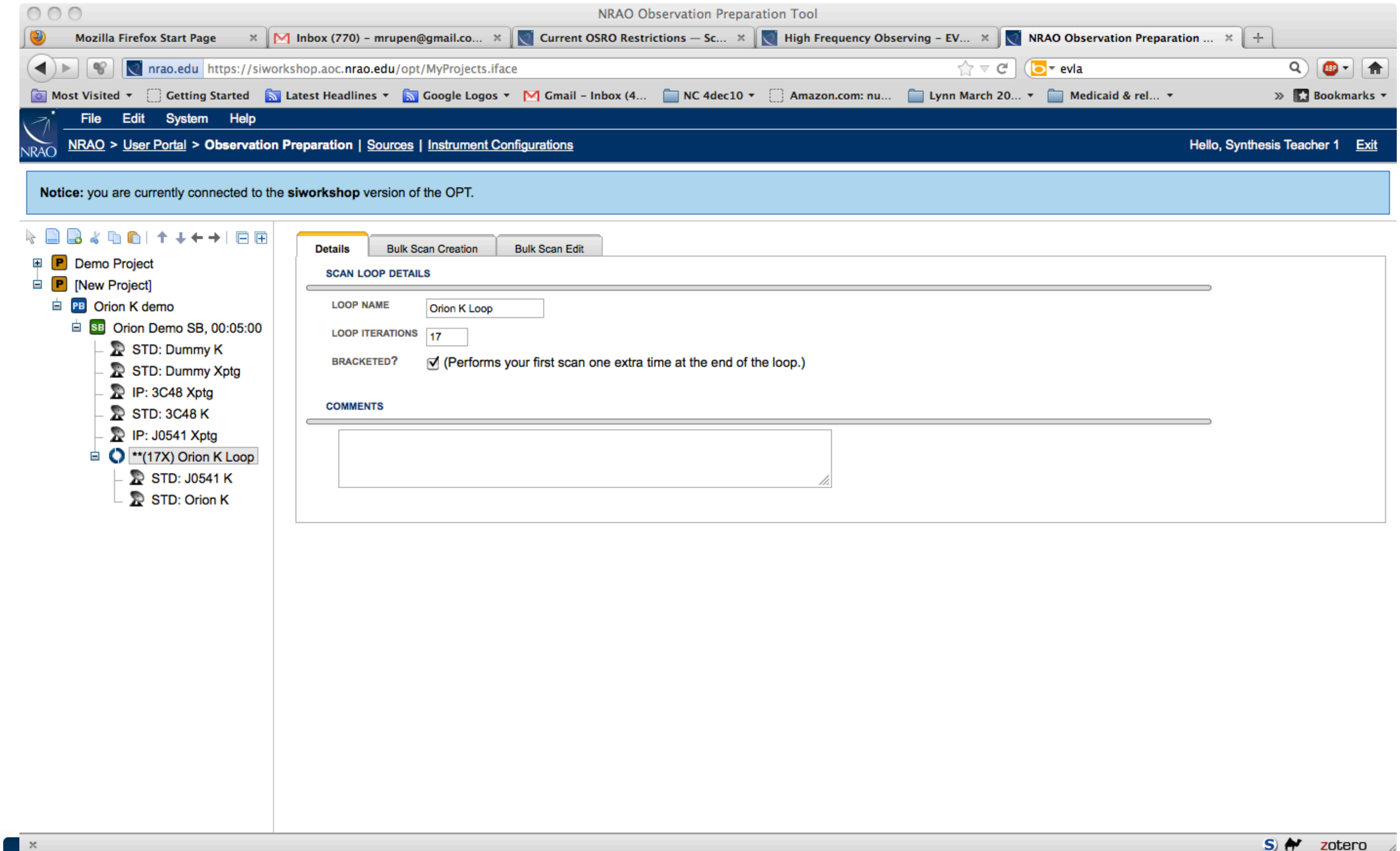
# 3C48: K band, RefPtg applied



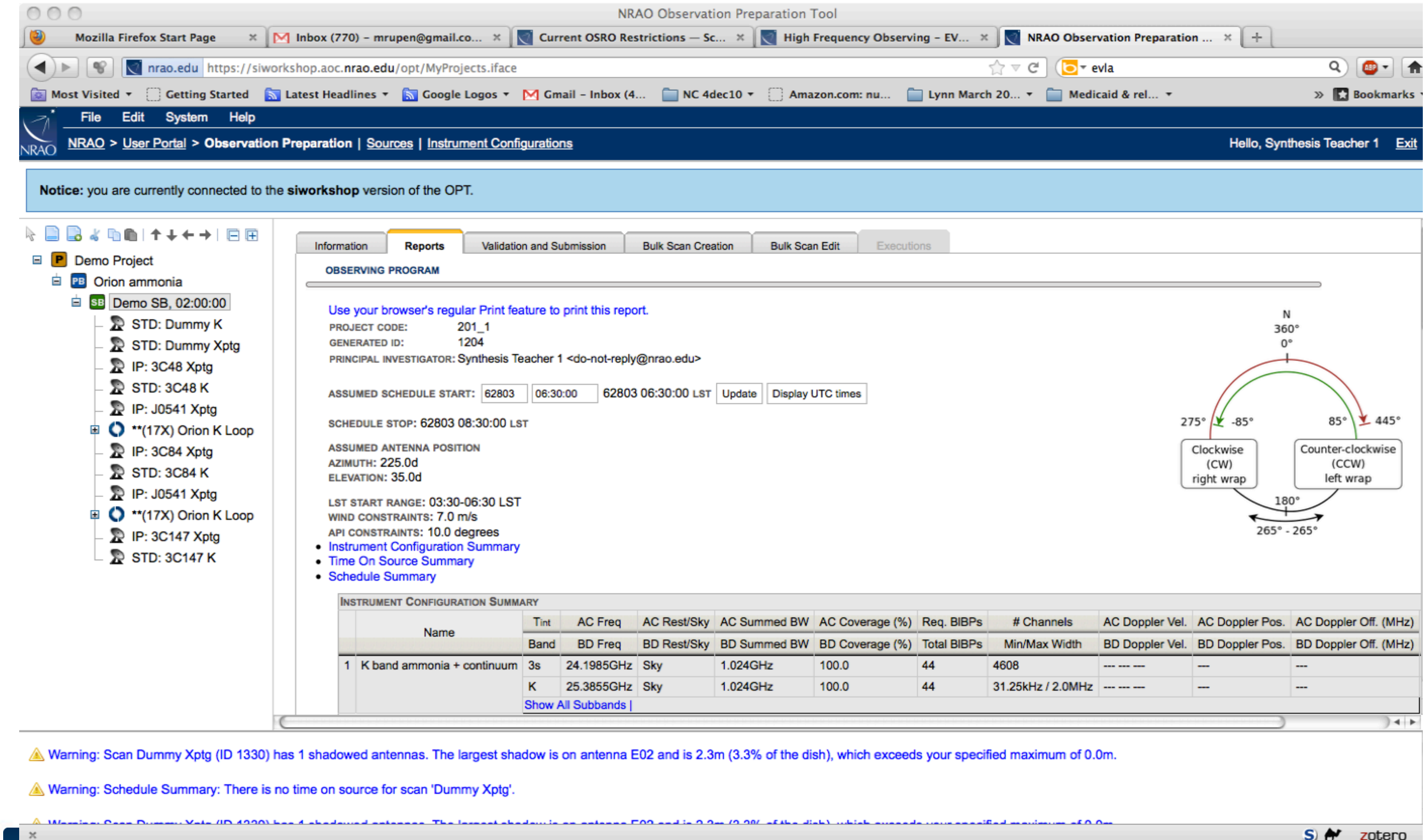
# Orion loop (bracketed)



# Orion loop (internals)



# Report/summary



# Validation & submission!