Planning VLA Observations: Tutorial

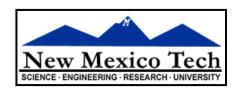
Michael P. Rupen



Thirteenth Synthesis Imaging Workshop 2012 May 29– June 5











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)



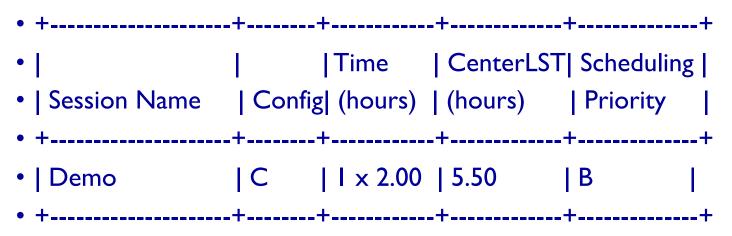
Congratulations!



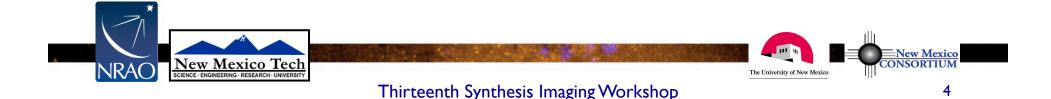
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E-mail from schedsoc

• Time Allocation:

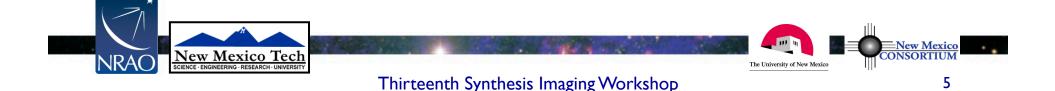


- Time Allocation Summary:
- 2.00 hours at priority B.



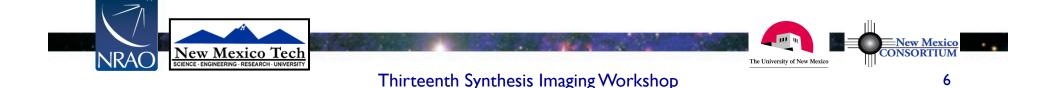
Deciphering the message

- 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



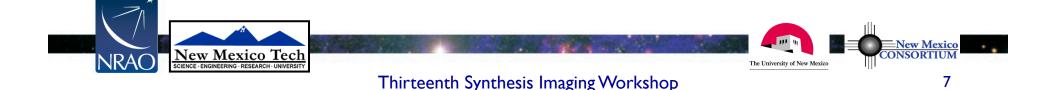
Getting on the telescope

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



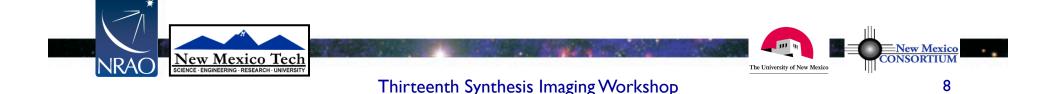
Today's project

- 2 hrs in C configuration to observe Orion BN/KL
 - –Lowest (I,I) through (7,7) metastable ammonia (NH₃) transitions: < I km/s res'n, over > I20 km/s (gets the lower hyperfines as well)
 - -Plus as much continuum as you can get

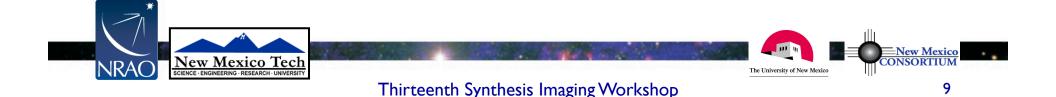


This tutorial

- 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

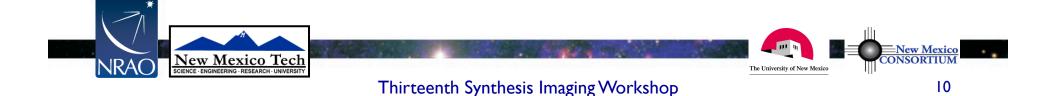


Instrument Configurations (Resource Configuration Tool)



Planning: what do you want?

- Ammonia transitions: splatalogue or other sources
 - (I,I) 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



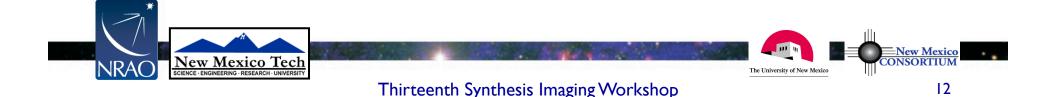
Planning: what can you do?

- This is JVLA K band: 18.0-26.5 GHz
- 2 x 1.024 GHz baseband pairs within that band
- Naïve approach:
 - $-A0/C0: (1,1)-(5,5) \rightarrow 23686.5-24710.5 \text{ MHz}$
 - 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
 - → I20/3e5*22e9~I0 MHz
 - -Want I km/s after Hanning smoothing
 - → (1/2)/3e5*22e9~ 0.04 MHz/channel



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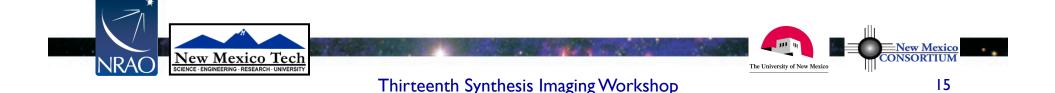
Planning: what can you do?

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



What about the continuum?

- We want to cover the full 2×1024 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.



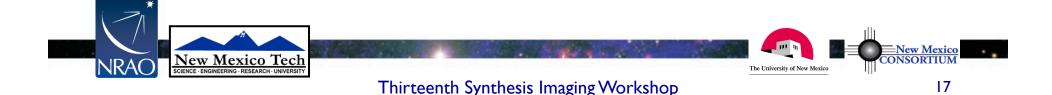
Summary

- K band
- A0/C0
 - -Center frequency: 24198.5 MHz
 - -5 "line" subbands: I6 MHz BW, dual pol'n products, x4 BIB stacking
 - -8 "continuum" subbands: I28 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

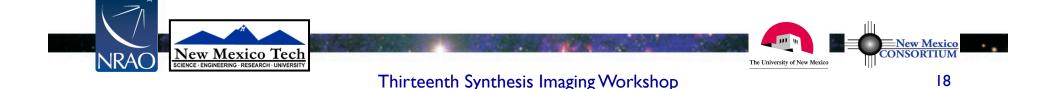
Life will become easier...

- 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

- <u>https://siworkshop.aoc.nrao.edu/</u>
 - -N.b.: normally just use http://my.nrao.edu
- Click on "Observation Preparation Tool (OPT)"
- Username: demo I ... demo 200
- Password: 300GHz
- Click on "Instrument Configurations"



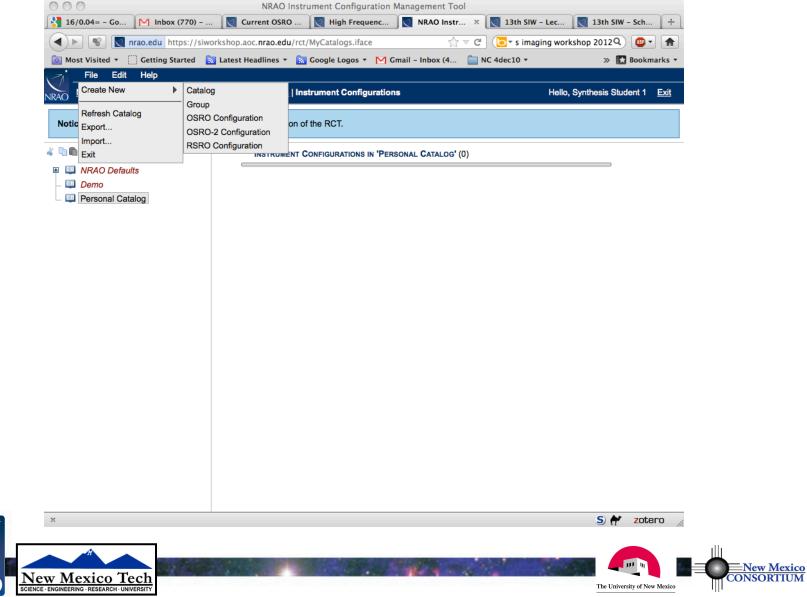
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Create new RSRO setup



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Create new RSRO setup

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

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

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4 new subbands: select...

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SUBBAND CONFIGURATION

A0/C0

B0/D0

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Thirteenth Synthesis Imaging Workshop

New Mexico

CONSORTIUM

111

The University of New Mexico

4 new subbands: ...and Bulk Edit

NRAO > User Portal > Observa	ation Preparation <u>Sources</u> Instrument Configurations	Hello, Synthesis Teacher 1 <u>Exit</u>
otice: you are currently connected	Ind to the siworkshop version of the RCT.	
n n ↑ ↓	Return to 'Personal Catalog'	
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Personal Catalog	507 Orion K EVLA K (18.0GHz - 26.5GHz) WIDAR RSRO Download VCI	
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) · · · · · · · · · · · · · · · · · · ·
		S 🕈 zotero

Offsets from baseband centers

- Ammonia transitions then are as follows:
 - (I,I) 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
- 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!

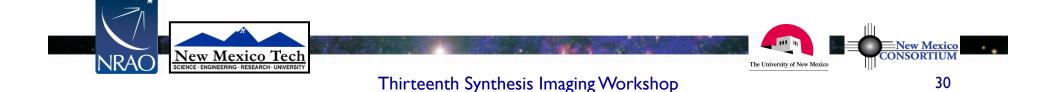


Data rates: 3sec averaging for sanity

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Thirteenth Synthesis Imaging Workshop

Sources (Source Configuration Tool)



Planning: where is your source?

• Orion BN/KL

-J2000: 05h 35m 14.50s, -05d 22' 30.00"

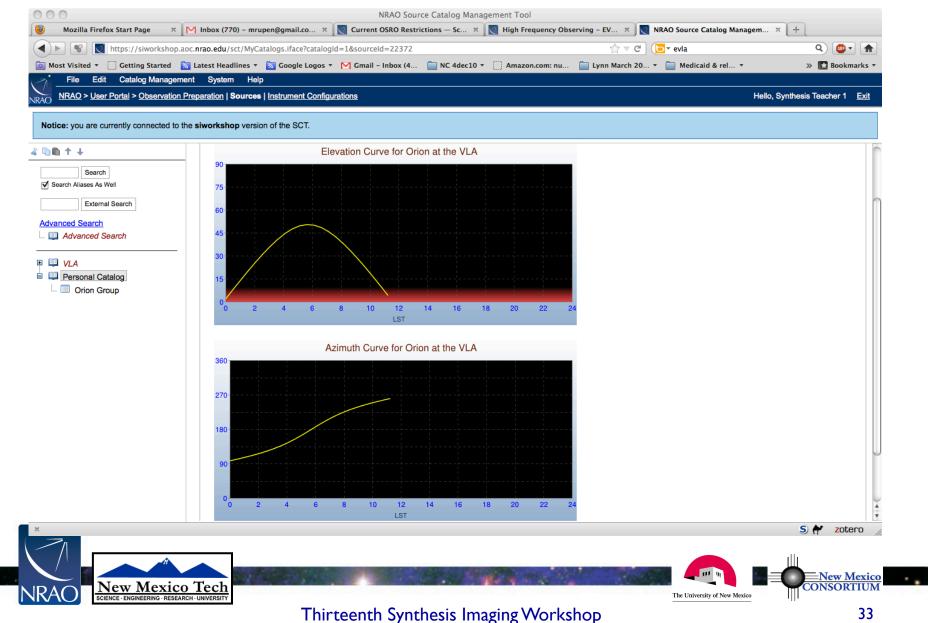


New source: Orion

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Thirteenth Synthesis Imaging Workshop

LST restrictions



Put it in a group

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Skymap: finding a nearby calibrator

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(Hover over source to see information here.)



Skymap: hover for info

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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} (k λ) UV_{max} (k λ) 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



Thirteenth Synthesis Imaging Workshop

Calibrators

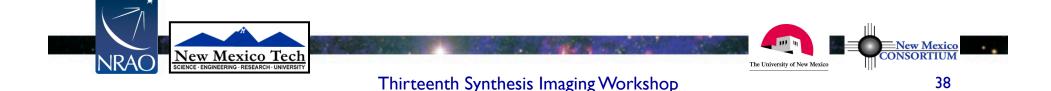
- Complex gain: nearby, fairly strong at observing band -J0541-0541
- Ref.ptg. calibrator: nearby, point-like, strong at X band –J0541-0541 (lucky!)
- Flux calibrator: check VLA Flux Cal catalog, LST range
 - -Ideally: similar elevation (30-45d) during the observing run
 - -0137+331=3C48 0500-0600 LST
 - -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



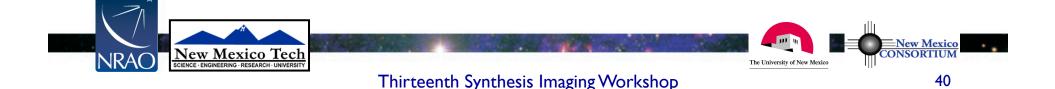
Scheduling Block (Observation PreparationTool)



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
 - -Imin "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 I sec 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!)



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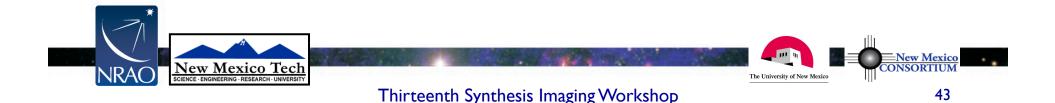
Scan lengths & sensitivities

- 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, Isec \rightarrow rms~ 150 mJy

 \rightarrow Want signal > 600 mJy for I sec, > 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 Imin~ 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

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Program Block

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Program Block, tweaked for Orion

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Scheduling Block: new...

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	Thi	rteenth Synthesis Imaging Workshop	48

Scheduling Block: ...set the LST range...

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Scheduling Block: ...and req'd weather

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Thirteenth Synthesis Imaging Workshop

At last, an actual scan!

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Dummy: K band, Orion

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TARGET SOURCE HARDWARE SETUP SCAN TIMING INTENTS Orion BN/KL RA: 5h 35m 14.50s DEC: -5d 22' 30.00" K band ammonia + continuum Receiver: K-band A0/C0: 24.1985GHz B0/D0: 25.3855GHz Change Duration (LST) CALIBRATE COMPLEX GAIN CALIBRATE FARGET CALIBRATE COMPLEX GAIN CALIBRATE COMPL



Dummy: X band, 3C48

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	TARGET SOURCE HARDWARE SETUP SCAN TIMING INTENTS
	0137+331=3C48 Primary X band pointing Duration (LST) ✓ OBSERVE TARGET RA: 1h 37m 41.299431s Receiver: X-band Outration (LST) ✓ OBSERVE TARGET DEC: 33d 9' 35.13299" A0/C0: 8.396GHz O0:01:00 CALIBRATE FLUX DENSITY SCALE B0/D0: 8.524GHz Keep Previous Conf. More >>> Change Change Change



3C48: X band RefPtg

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



3C48: K band, RefPtg applied

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Orion loop (bracketed)

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Orion loop (internals)

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Thirteenth Synthesis Imaging Workshop

Report/summary

New Mexico Tech

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Validation & submission!

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E P Demo Project	VALIDATE SCHEDULING BLOCK	
Drion ammonia		
■ SB Demo SB, 02:00:00	To submit your project, click Validate below. If there are no errors, you may then submit the project for scheduling. Validate Approve	
_ R STD: Dummy K _ R STD: Dummy Xptg	Success! Your project has no errors.	
- 🔊 IP: 3C48 Xptg		
- 🛣 STD: 3C48 K		
– 🔊 IP: J0541 Xptg	To request help, you must file a ticket with the help desk. Clicking the button below will send you to the help desk. Be sure to include the following text:	
The second seco	OPT Help for Project Code: 201_1	
– 🔊 IP: 3C84 Xptg – 🔊 STD: 3C84 K	SB ID: 1204 Request Help	
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	GENERATED OBSERVE SCRIPT	
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	# EVLA PROJECT 201 1, DB ID 1201	
	# Title: Demo Project	
	# PROGRAM BLOCK Orion ammonia, DB ID 1203	
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	# Array Configurations, C	
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A Warning: Schedule Summary: There is no time on source for scan 'Dummy Xptg'

