Karl G. Jansky Very Large Array (VLA)

Overview and Proposing

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NRAO

Atacama Large Millimeter/submillimeter Array

Karl G. Jansky Very Large Array

Robert C. Byrd Green Bank Telescope

Very Long Baseline Array

Jansky VLA

- 27x25m VLA antennas reconfigurable on baselines 35m to 36km
- located in Southern New Mexico at 2100m altitude
- Major upgrade concluded 2012 (in schedule, on budget)

Spatial Resolution

- Via a relocation of the antennas, the VLA can vary its spatial resolution by a factor of ~50 (depending on *largest* baseline/telescope separation)
- Reconfiguration every ~4 months; hybrids with extended northern arm for southern sources

Configuration	A	B	C	D
B_{max} (km[1])	36.4	11.1	3.4	1.03
B_{min} (km[1])	0.68	0.21	0.035[5]	0.035
	Synthesized Beamwidth θ_{HPBW}(arcsec)[1,2,3]			
74 MHz (4 band)	24	80	260	850
1.5 GHz (L)	1.3	4.3	14	46
3.0 GHz (S)[6]	0.65	2.1	7.0	23
6.0 GHz (C)	0.33	1.0	3.5	12
8.5 GHz (X)[7]	0.23	0.73	2.5	8.1
15 GHz (Ku)[6]	0.13	0.42	1.4	4.6
22 GHz (K)	0.089	0.28	0.95	3.1
33 GHz (Ka)	0.059	0.19	0.63	2.1
45 GHz (Q)	0.043	0.14	0.47	1.5

Major Elements of VLA Upgrade

- Continuous Frequency Coverage from 1 – 50 GHz
  - Requires 8 bands/receivers
    - 6 receivers increased bandwidth, 2 completely new
- Bandwidths up to 8GHz
  - Previously 100 MHz
  - Factor ~10 improvement in continuum sensitivity
- Powerful, flexible correlator
  - No serious trade-off required between total bandwidth and frequency resolution
  - Targeting many spectral lines at the same time
  - Combine spectral line and continuum
  - Enables blind searches for spectral lines

VLA – Jansky VLA Comparison

Parameter	VLA	Jansky VLA
Continuum sensitivity (1s, 9 hr)	10 μJy	1 μJy
Maximum bandwidth	0.1 GHz	8 GHz
Number of frequency channels at maximum bandwidth	16	16,384
Maximum number of frequency channels	512	4,194,304
Coarsest frequency resolution	50 MHz	2 MHz
Finest frequency resolution	381 Hz	0.12 Hz
Frequency coverage, 1 - 50 GHz	22%	100%
Number of baselines	351	351
Maximum spatial resolution (5GHz)	0.3”	0.3”

Elements of a VLA proposal

1. Actual proposal using NRAO Proposal Submission Tool (PST)
2. Exposure Calculator screenshot to justify time requested
3. For spectral line: General Observing Setup Tool (GOST) screenshot. Describes correlator use in detail

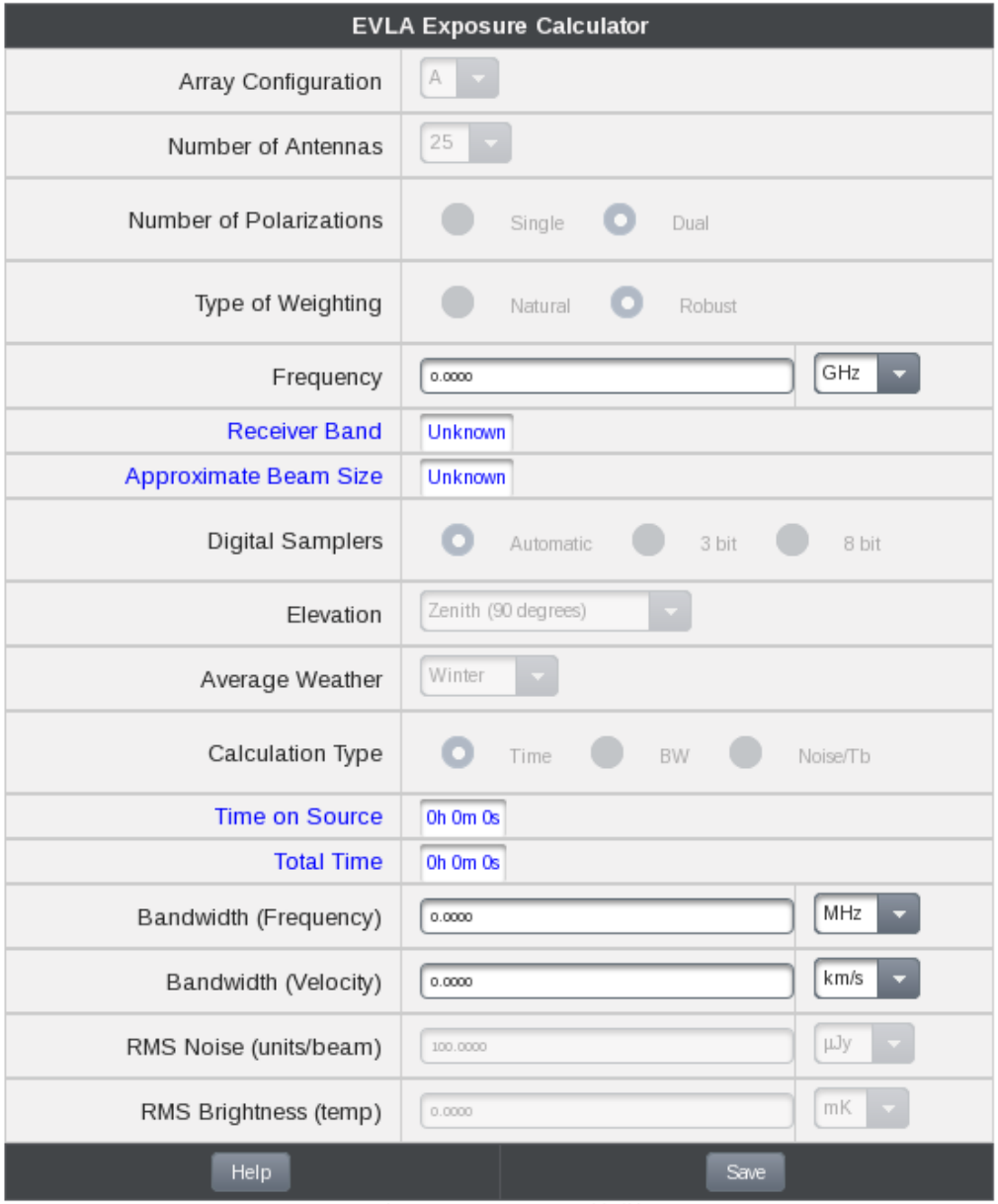
- This is an interim solution; eventually, the latter two will be integrated with the PST

Actual Proposal

- Use Proposal Submission Tool (PST)
  - Supports VLA, VLBA, GBT
  - Makes you choose between those three
- Three major parts:
  - Specify sources – objects or coordinates of interest
  - Specify resources – instrumental setup
  - Combine sources and resources into sessions; specify time (based on exposure calculator)
- Also needed:
  - Scientific justification (pdf to be added to proposal)
  - Technical Justification (checklist, part of the PST)

Intermezzo: 3-bit and 8-bit

- Describes samplers at the antennas
- Need to know which one to use – depends on science
- 8-bit
  - Offered for general observing right from the start (early 2010)
  - Provides up to 2GHz bandwidth (2 basebands of 1 GHz each)
  - Extensive tuning flexibility
  - Typical use: Spectral line; Continuum at low frequency (L, S)
- 3-bit
  - More recent: offered for general observing since 2012
  - Provides up to 8GHz bandwidth (4 basebands of 2 GHz each)
  - Now same tuning flexibility as 8-bit; somewhat higher rms noise
  - Typical use: Continuum at higher frequencies (C,X,Ku,K,Ka,Q)

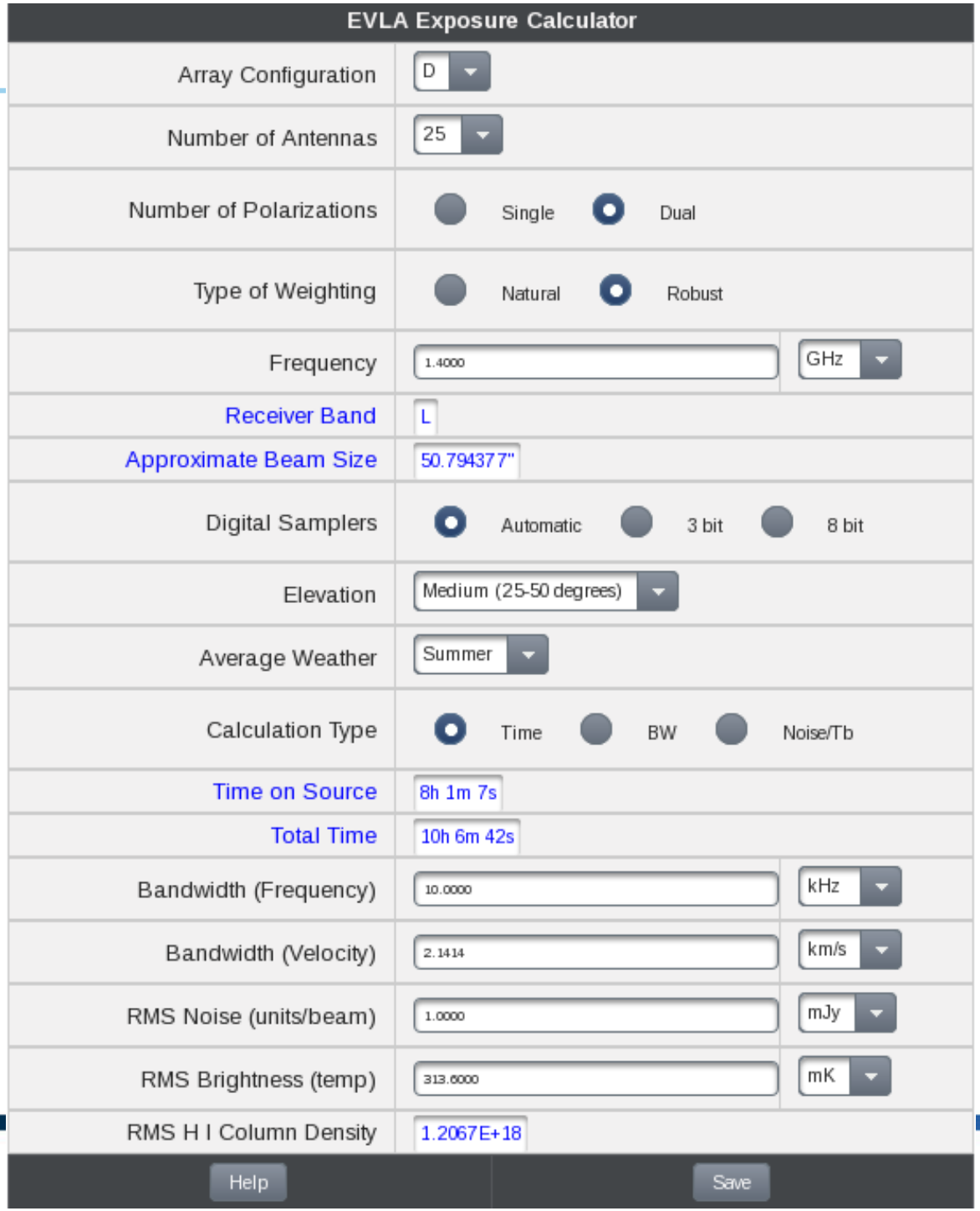


Input center frequency

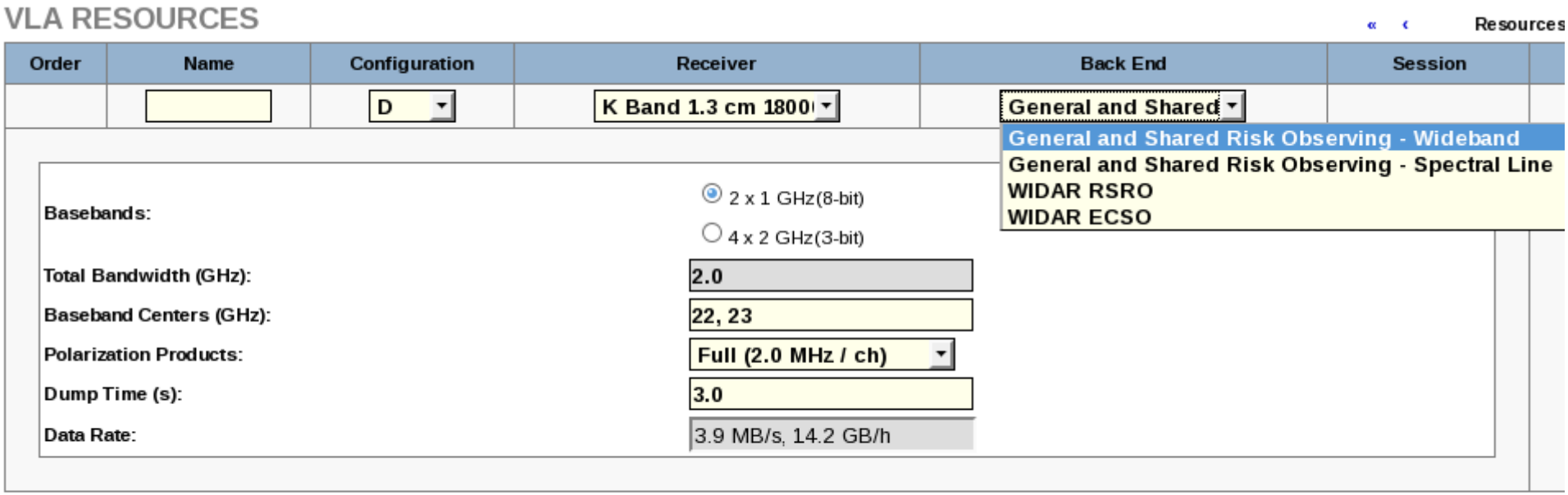
You must provide a value for Frequency. Press the <Tab> key afterwards to move to the Bandwidth field.

Input bandwidth

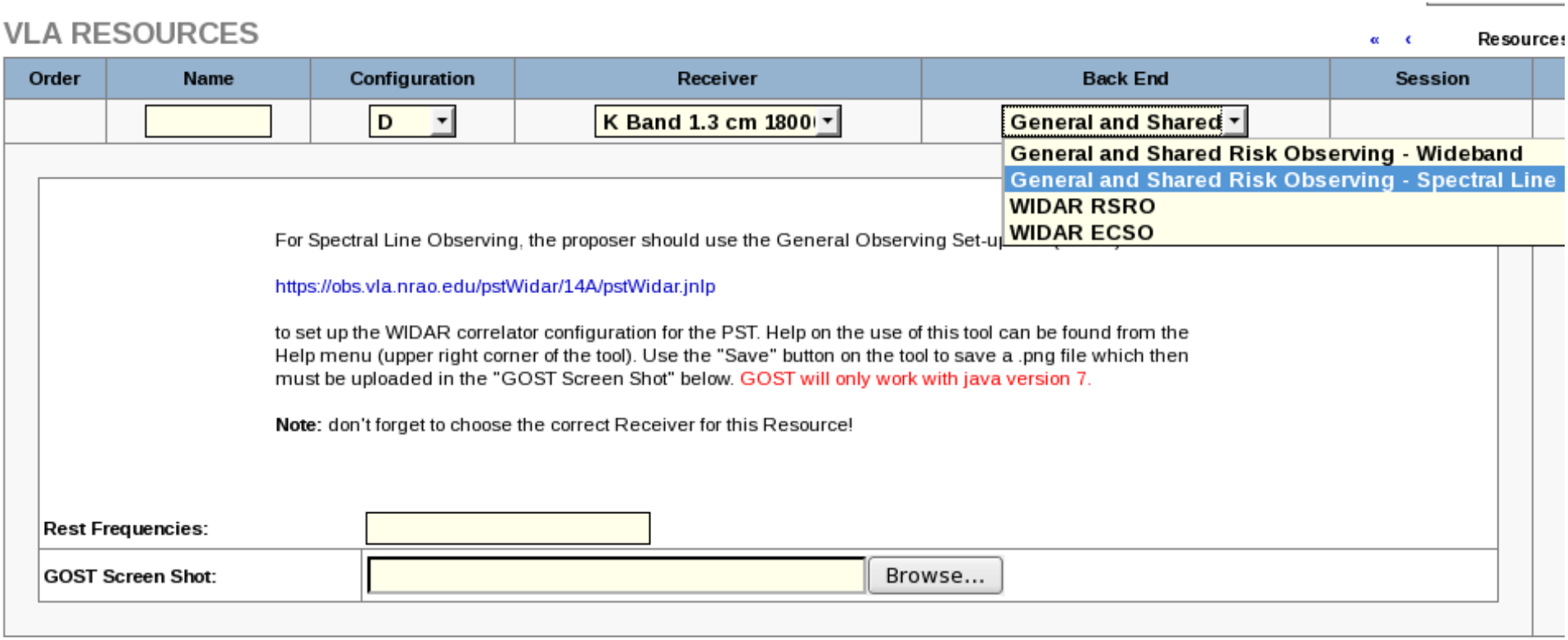
You must provide a value for Bandwidth. Press the <Tab> key to leave the field and perform the calculation.

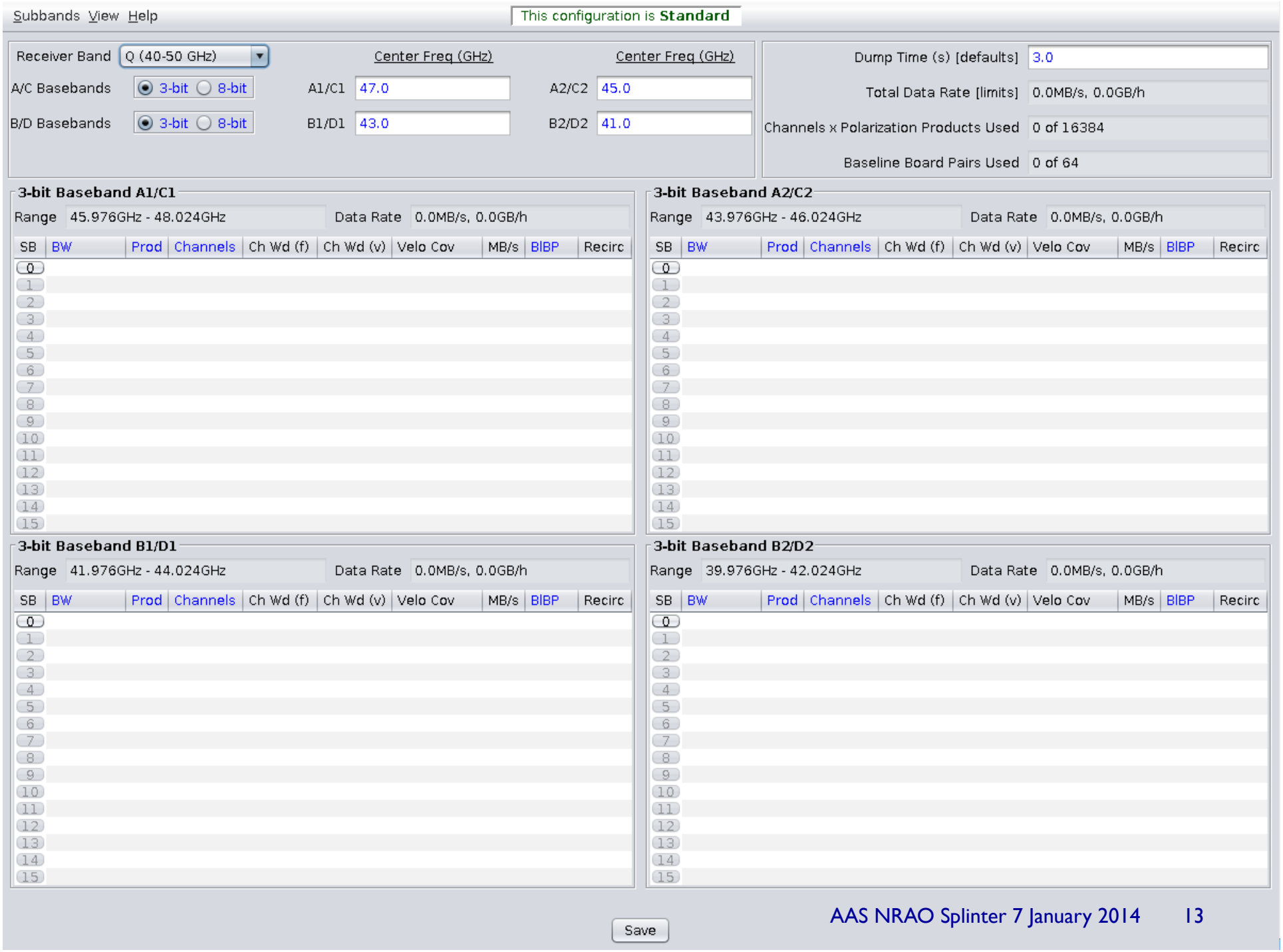

EVLA Exposure Calculator
Array Configuration
D
Number of Antennas
25
Number of Polarizations
Single
Dual
Type of Weighting
Natural
Robust
Frequency
1.4000
GHz
Receiver Band
L
Approximate Beam Size
50.794377"
Digital Samplers
Automatic
3 bit
8 bit
Elevation
Medium (25-50 degrees)
Average Weather
Summer
Calculation Type
Time
BW
Noise/Tb
Time on Source
8h 1m 7s
Total Time
10h 6m 42s
Bandwidth (Frequency)
10.0000
kHz
Bandwidth (Velocity)
2.1414
km/s
RMS Noise (units/beam)
1.0000
mJy
RMS Brightness (temp)
313.6000
mK
RMS H I Column Density
1.2067E+18
Help
Save

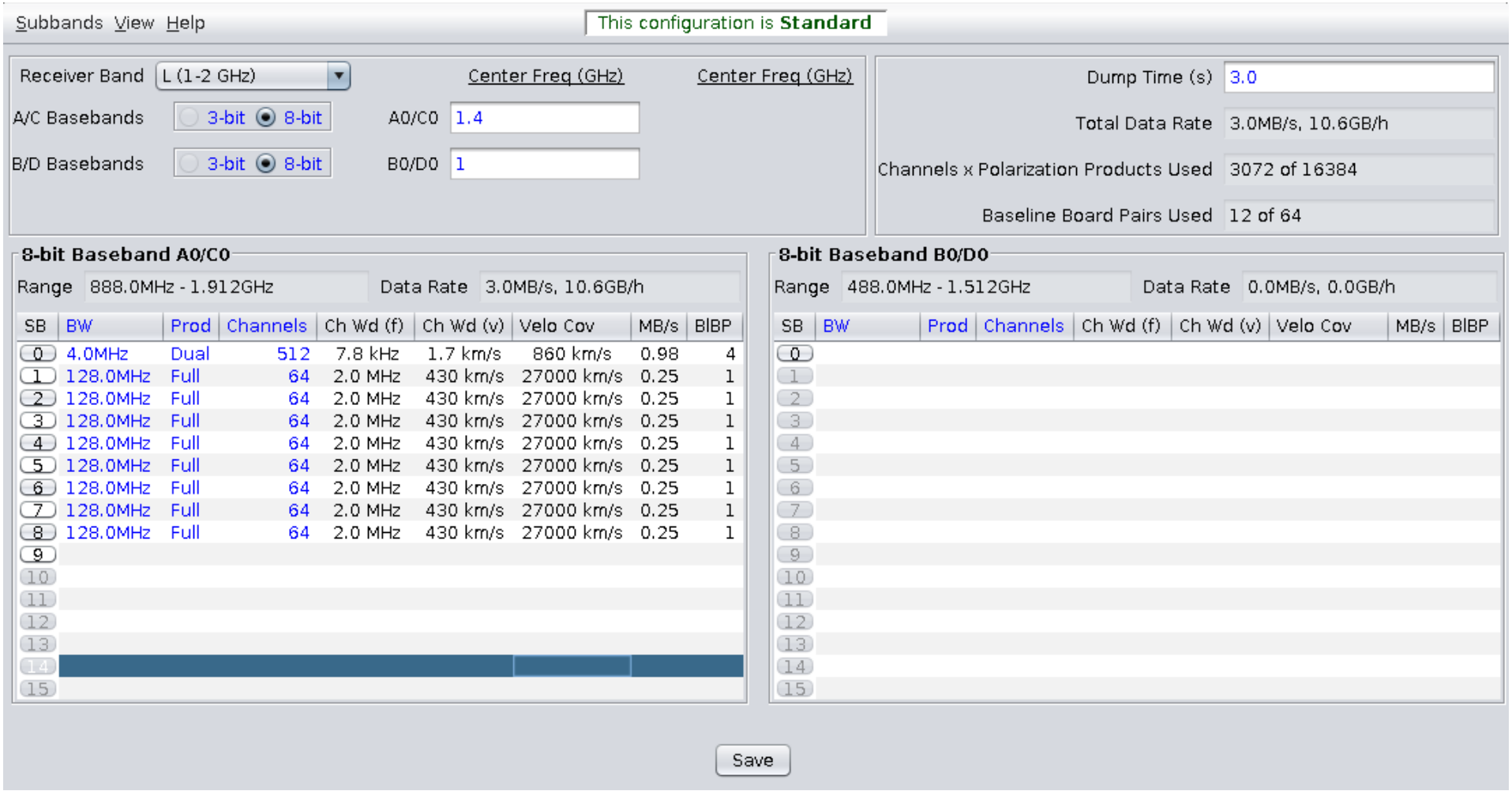
PST resource page - continuum



PST resource page – spectral line




Subbands View Help
This configuration is Standard
Receiver Band
Q (40-50 GHz)
Center Freq (GHz)
Center Freq (GHz)
A/C Basebands
3-bit
8-bit
A1/C1
47.0
A2/C2
45.0
B/D Basebands
3-bit
8-bit
B1/D1
43.0
B2/D2
41.0
Dump Time (s) [defaults]
3.0
Total Data Rate [limits]
0.0MB/s, 0.0GB/h
Channels x Polarization Products Used
0 of 16384
Baseline Board Pairs Used
0 of 64
3-bit Baseband A1/C1
Range
45.976GHz - 48.024GHz
Data Rate
0.0MB/s, 0.0GB/h
SB
BW
Prod
Channels
Ch Wd (f)
Ch Wd (v)
Velo Cov
MB/s
BlBP
Recirc
3-bit Baseband A2/C2
Range
43.976GHz - 46.024GHz
Data Rate
0.0MB/s, 0.0GB/h
3-bit Baseband B1/D1
Range
41.976GHz - 44.024GHz
Data Rate
0.0MB/s, 0.0GB/h
3-bit Baseband B2/D2
Range
39.976GHz - 42.024GHz
Data Rate
0.0MB/s, 0.0GB/h
Save



Subbands View Help

This configuration is **Standard**

Receiver Band: L (1-2 GHz) | Center Freq (GHz) | Center Freq (GHz)

A/C Basebands: 3-bit 8-bit | A0/C0: 1.4

B/D Basebands: 3-bit 8-bit | B0/D0: 1

Dump Time (s): 3.0

Total Data Rate: 3.0MB/s, 10.6GB/h

Channels x Polarization Products Used: 3072 of 16384

Baseline Board Pairs Used: 12 of 64

8-bit Baseband A0/C0

Range: 888.0MHz - 1.912GHz | Data Rate: 3.0MB/s, 10.6GB/h

SB	BW	Prod	Channels	Ch Wd (f)	Ch Wd (v)	Velo Cov	MB/s	BlBP
0	4.0MHz	Dual	512	7.8 kHz	1.7 km/s	860 km/s	0.98	4
1	128.0MHz	Full	64	2.0 MHz	430 km/s	27000 km/s	0.25	1
2	128.0MHz	Full	64	2.0 MHz	430 km/s	27000 km/s	0.25	1
3	128.0MHz	Full	64	2.0 MHz	430 km/s	27000 km/s	0.25	1
4	128.0MHz	Full	64	2.0 MHz	430 km/s	27000 km/s	0.25	1
5	128.0MHz	Full	64	2.0 MHz	430 km/s	27000 km/s	0.25	1
6	128.0MHz	Full	64	2.0 MHz	430 km/s	27000 km/s	0.25	1
7	128.0MHz	Full	64	2.0 MHz	430 km/s	27000 km/s	0.25	1
8	128.0MHz	Full	64	2.0 MHz	430 km/s	27000 km/s	0.25	1
9								
10								
11								
12								
13								
14								
15								

8-bit Baseband B0/D0

Range: 488.0MHz - 1.512GHz | Data Rate: 0.0MB/s, 0.0GB/h

SB	BW	Prod	Channels	Ch Wd (f)	Ch Wd (v)	Velo Cov	MB/s	BlBP
0								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Save

Save | H

TECHNICAL JUSTIFICATION

EXAMPLE

« ‹ Technical Justification ›

VLA Technical Justification

Use this page to specify how the technical set-up requested for your proposal enables the scientific goals to be met. Input is required for all fields. If a field is not relevant for your propo then enter "NA" into the textbox. The links within each box provide information concerning these technical questions.

Explain the reason for the array configuration(s) requested: https://science.nrao.edu/facilities/vla/docs/manuals/oss2014a/performance/resolution	In order to maximize surface brightness sensitivity we request D-configuration observations
Note whether the targets will be nighttime or daytime sources for the configurations proposed and whether there will be any potential scheduling issues (e.g., solar or other interference during the daytime, or number of available passes at a particular LST for large projects): https://science.nrao.edu/facilities/vla/proposing/configpropdeadlines	To reduce solar interference night-time observations are preferred, but if this poses too many scheduling constraints we will accept day-time observations as well
Explain choice of receiver(s) requested: https://science.nrao.edu/facilities/vla/docs/manuals/oss2014a/performance/bands	Since we are observing in the HI line, we require L-band receivers
Describe correlator set-up(s) requested: https://science.nrao.edu/facilities/vla/docs/manuals/oss2014a/performance/correlator	The HI spectral line will be placed in a 8 MHz wide sub-band centered at the average radial velocity of the group. We employ a factor 4 baseline board stacking in order to produce 512
Sensitivity required to achieve the science goal: include frequency or velocity width assumed:	Our science requires a 1 sigma HI column density of 2 e^18 atoms/cm2 in one 3 km/s wide channel, which means 1 mJy/beam.
Required on-source integration time to achieve the required sensitivity, and total time including overhead; include considerations such as source confusion in compact configurations, RFI in the geostationary satellite belt, self-noise for strong sources; if the overhead assumed is different from that given by the exposure calculator, please explain: Please upload exposure calculator graphic(s). Multiple files should be uploaded if there are multiple resources. Use the "Save" button on the tool to save a png file which can then be uploaded using the browse/upload buttons to the right. https://science.nrao.edu/facilities/vla/docs/manuals/oss2014a/performance/sensitivity	As the attached exposure calculator screenshot shows, we require 5 hours on source, or 6 hours and 20 minutes including overhead Browse... Upload

Capabilities offered for 2014B General Observing (deadline 3 Feb 2014) - I

- Configurations DnC, C, CnB
- 8-bit samplers (2 basebands, 1GHz each = 2 GHz BW total)
  - Standard default setups for
    - 2 GHz BW continuum at S ➠ Q band
    - 1 GHz BW continuum at L band
  - Flexible set-ups for spectroscopy, using two independently tunable 1 GHz basebands, each of which can be split into up to 16 flexibly tunable sub-bands
- 3-bit samplers (4 basebands, 2GHz each = 8GHz BW total)
  - Standard default setups for:
    - 8 GHz BW continuum at K ➠ Q band
    - 6 GHz BW continuum at Ku band
    - 4 GHz BW continuum at C ➠ X band
  - Flexible set-ups for spectroscopy, using four independently tunable 2 GHz basebands, each of which can be split into up to 16 flexibly tunable sub-bands

Capabilities offered for 2014B General Observing (deadline 3 Feb 2014) - II

- Common to 8- and 3-bit:
  - Single, dual, and full polarization products
  - Up to 16,384 channels (summed over all polarizations products)
- Other:
  - Ability to mix 3-bit and 8-bit samplers, to allow for simultaneous continuum and high-resolution spectral line observing
  - Up to 3 independent sub-arrays using standard 8-bit continuum set-ups
  - Phased array for VLBI