VLA Capabilities and Operations

April 8, 2013 – Socorro, NM USA

Deb Shepherd

Atacama Large Millimeter/sub-millimeter Array
Karl G. Jansky Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array

NRAO

Outline

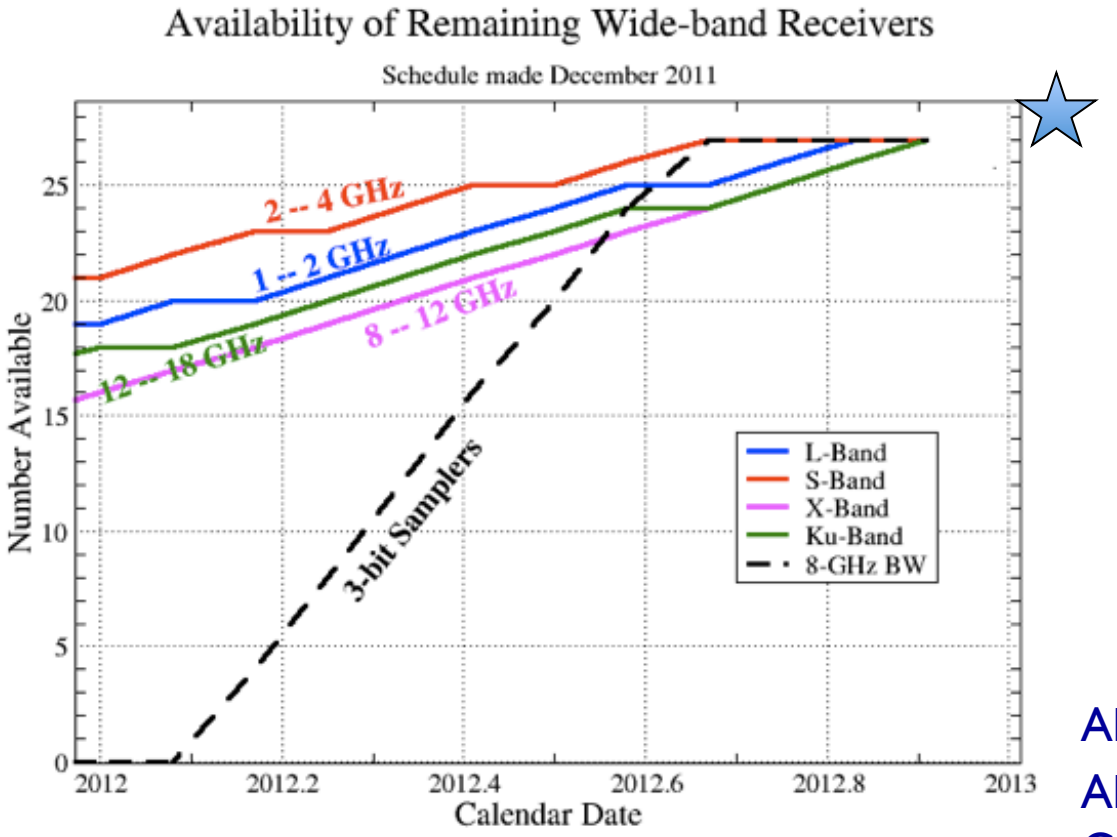
- EVLA → Jansky VLA
  - Receivers Status
  - Correlator Overview & Status
- Science Observing Capabilities
  - General Capabilities
  - Shared Risk (SR & RSRO)
  - Continuing Development
  - Restrictions
- Scheduling Considerations
- VLA Services

EVLA → Jansky VLA – Status

Parameter	Old VLA	EVLA (goal)	Factor	VLA (now)
Point Source Sensitivity (1σ, 12 hr)	10 μJy	1 μJy	10	1-2 μJy
Maximum BW in each polarization	0.1 GHz	8 GHz	80	1-8 GHz (band-dependent)
# of frequency channels at max BW	16	16,384	1024	16,384
Maximum number of frequency channels	512	4,194,304	8192	16,384
Frequency resolution (coarsest/finest)	50MHz / 381 Hz	2 MHz / 0.12 Hz	25	2 MHz / 122 Hz [1.9 Hz]
# of full-polarization spectral windows	2	64	32	64
Frequency Coverage (1 - 50 GHz)	22%	100%	5	100% + P-band

- All 28 antennas have been upgraded: new optics (feeds, towers, etc), new IF electronics, new samplers, new DTS, new receivers (1-50 GHz), 3-bit samplers in continuum mode.
- WIDAR (Wideband Interferometric Digital ARchitecture) correlator capabilities still expanding:
  - **Ongoing:** Still work being done in the areas of recirculation (increased spectral resolution to 1.9 Hz max.), 3-bit samplers in spectral line mode, complex mosaics (including OTF), phased array, sub-arrays, fast dumps (< 50 ms), P-band (230-470 MHz) & 4-band (58-84 MHz).

VLA Receiver Status



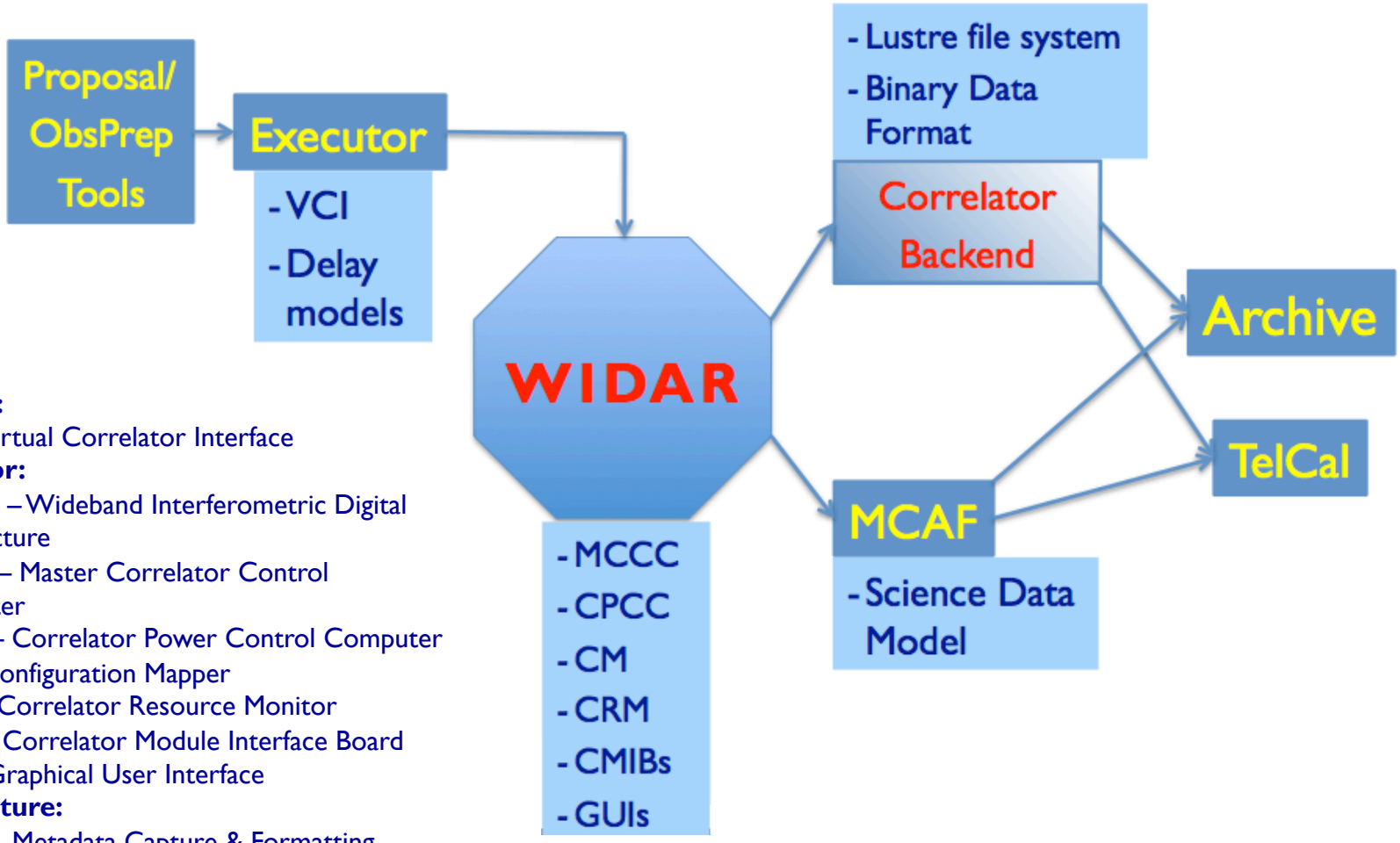
Band	Range (GHz)
90 cm (P)	0.23-0.47
20 cm (L)	1.0-2.0
13 cm (S)	2.0-4.0
6 cm (C)	4.0-8.0
3 cm (X)	8.0-12.0
2 cm (Ku)	12.0-18.0
1.3 cm (K)	18.0-26.5
1 cm (Ka)	26.5-40.0
7 mm (Q)	40.0-50.0

All receivers (still 2 hybrid L-bands)

All 3-bit samplers providing up to 8 GHz BW

Current focus: P-band (230-470 MHz) installation & commissioning.

System Overview

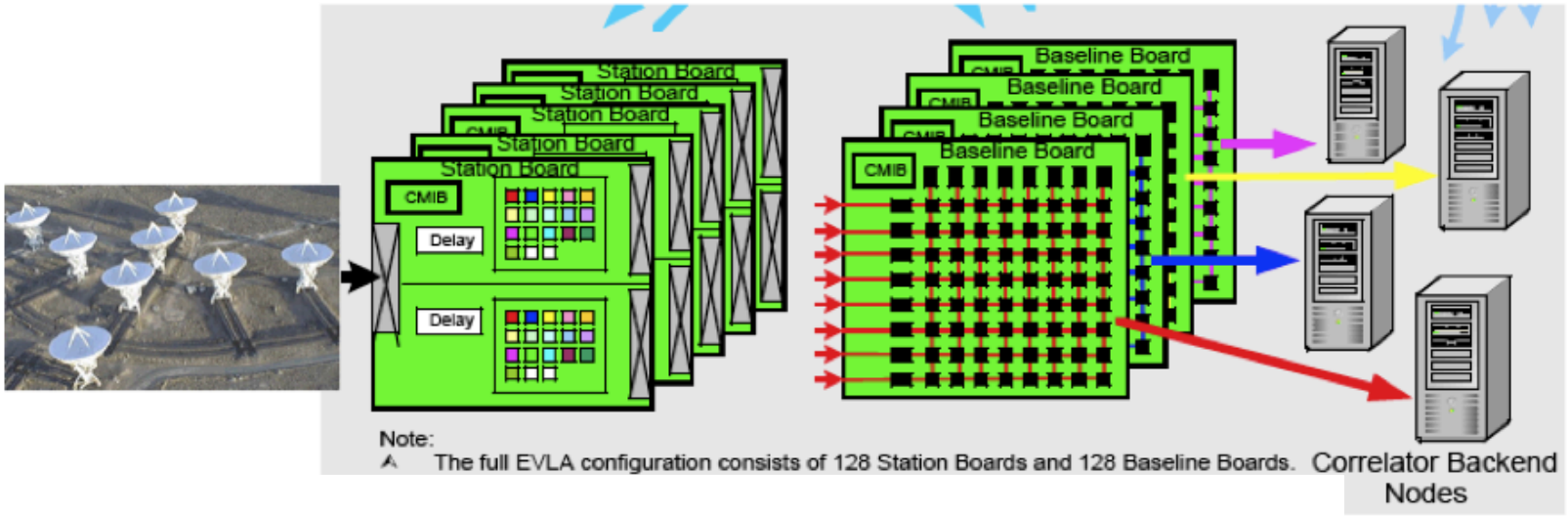


Executor:
- VCI – Virtual Correlator Interface

Correlator:
- WIDAR – Wideband Interferometric Digital Architecture
- MCCC – Master Correlator Control Computer
- CPCC – Correlator Power Control Computer
- CM – Configuration Mapper
- CRM – Correlator Resource Monitor
- CMIB – Correlator Module Interface Board
- GUI – Graphical User Interface

Data Capture:
- MCAF – Metadata Capture & Formatting

WIDAR Correlator Architecture



16 GHz/ant split into 4 x 2 GHz/pol'n (Baseband pairs)

Station Boards: split into 64x128 MHz/pol'n (Sub-band pairs)

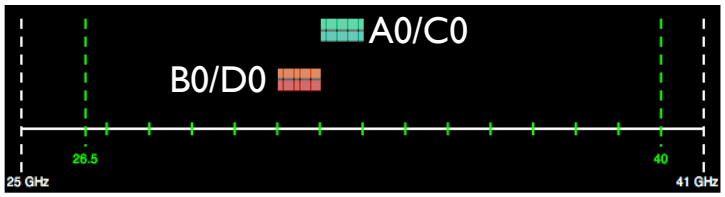
Baseline Boards: cross-multiply signals from antennas

CBE: Fourier transform, process, & write to disk

WIDAR

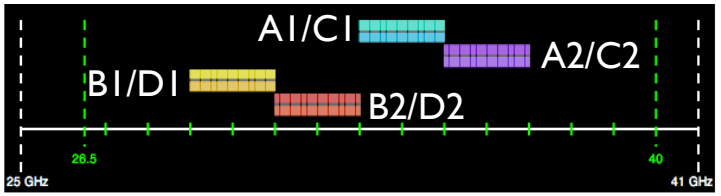
No. of stations	32
Polarization products	1, 2, 4 (RR, LL, RL, LR)
Quantization	8 or 3-bit initial quantization
Baseband BW/antenna	1 or 4 x 2 GHz/polarization
Sub-band BW	128 MHz, 64 MHz, …., 31.25 kHz (independently tunable)
Max spectral channels at max BW	16,384
Spectral dynamic range	~58/44 dB (8/3 bit)
Max dump rate (limits currently driven by archive capabilities)	60 MB/s (special justification if > 20 MB/s)
Sub-arrays	3 currently, up to 8 possible(4 antenna granularity)
Supports	Autocorrelations, Pulsar processing (binning/gating), phased array, VLBI

3-bit versus 8-bit sampling



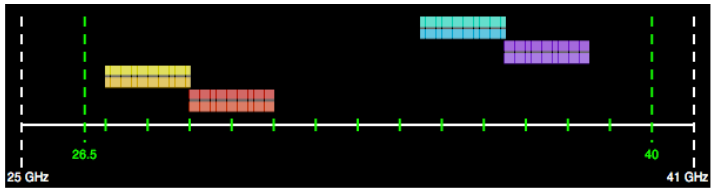
Ka band NRAO default
8-bit sampler/2 GHz BW

Total Bl. BPs Used:	16 of 64
Total Data Rate:	3.95 MB/s or 14.21 GB/h
Total Spectral Points:	1024
Total Bandwidth:	2.048GHz
Capability Mode:	General observing



Ka band NRAO default
3-bit sampler/8 GHz BW

Total Bl. BPs Used:	64 of 64
Total Data Rate:	15.64 MB/s or 56.31 GB/h
Total Spectral Points:	8192
Total Bandwidth:	8.192GHz
Capability Mode:	General observing



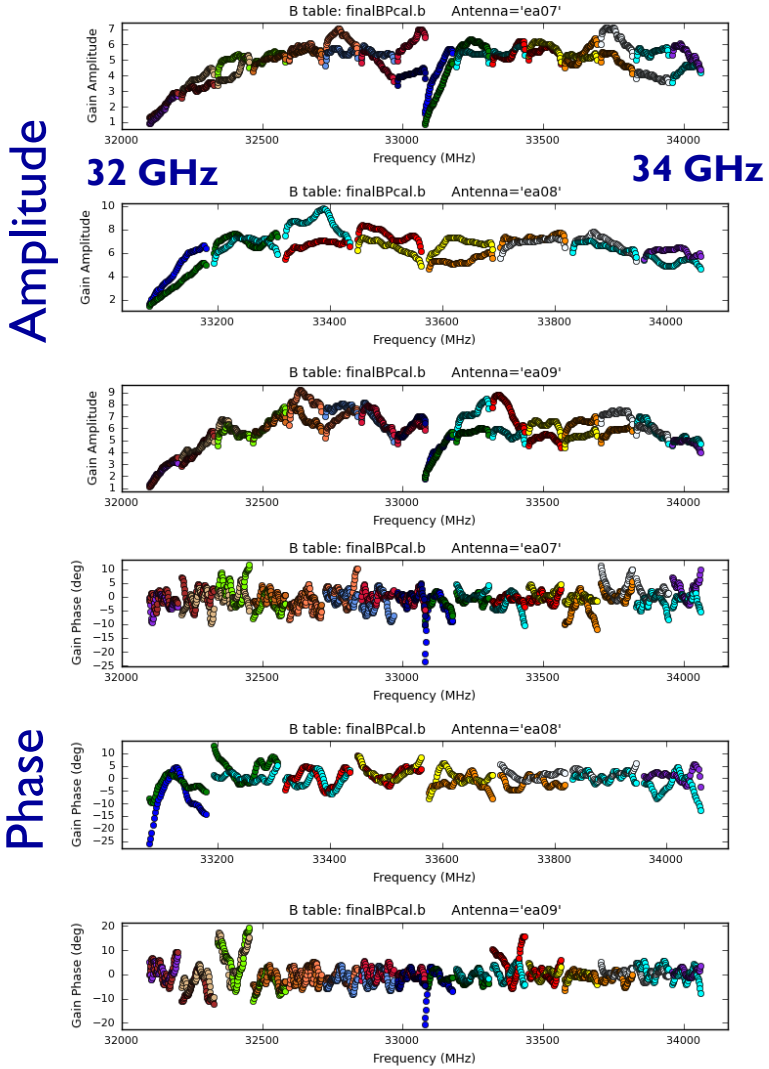
Ka band Custom
8-bit sampler/
8 GHz BW

Total Bl. BPs Used:	64 of 64
Total Data Rate:	15.64 MB/s or 56.31 GB/h
Total Spectral Points:	8192
Total Bandwidth:	8.192GHz
Capability Mode:	General observing

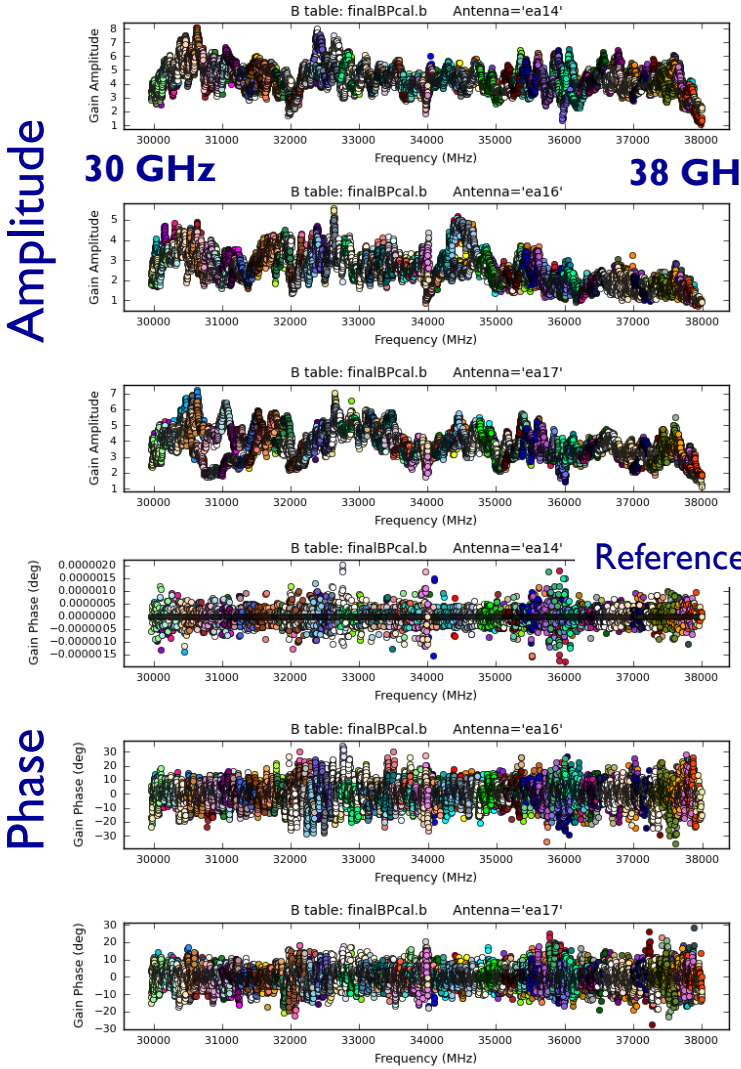
Band Name	Frequency (GHz)	BW (GHz)
6 cm (C)	4.0-8.0	4
3 cm (X)	8.0-12.0	4
2 cm (Ku)	12.0-18.0	6
1.3 cm (K)	18.0-26.5	8.5
1 cm (Ka)	26.5-40.0	13.5
7 mm (Q)	40.0-50.0	10

- 3-bit: 15% worse RMS than same BW 8-bit (should only be 4% worse w/ lower sampling: http://www.aoc.nrao.edu/evla/geninfo/memoseries/evlamemo166.pdf - EVLA memo 166
- Band set-up restrictions on separations between A and C, B and D basebands and between A/C and B/D pairs. Restrictions are built into the OPT!

2 GHz BW (8-bit)



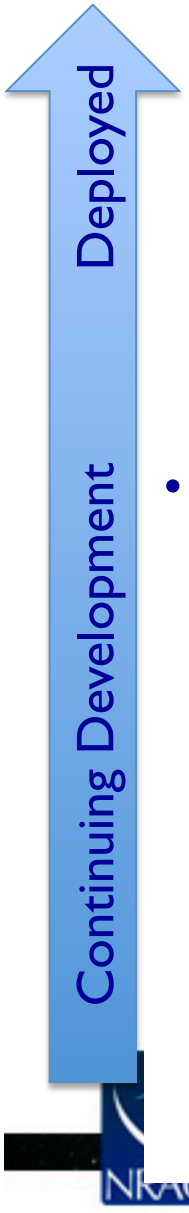
8 GHz BW (3-bit)



Reference antenna

(Pipeline bandpass solutions)

Science Observing Programs



- **General Observing (**Guaranteed for A-priority projects)
  - Use of fully commissioned & tested modes:
    - 8-bit samplers (cont. & spectral line); 3-bit samplers (K, Ka, Q band cont.), sub-arrays, pointed mosaics, up to 20 MB/s data rates.
  - *All projects processed by the pipeline: full reduction, QA report by staff noting issues, additional calibration or flagging needed before imaging. Optimized for Stokes I continuum.*
- **Shared Risk Observing**

  (https://science.nrao.edu/facilities/vla/proposing/sro2013b)
  - Non-resident (access to newest WIDAR capabilities, 1 hr test time)
    - 3-bit samplers (C, X, Ku wide-bandwidth), up to 60 MB/s data rates, P band (230-470 MHz) wide-band "continuum"
  - RSRO = 'Resident Shared Risk Observing' (help develop capabilities)
    - E.g., data rates up to 140 MB/s, recirculation, 3-bit mixed cont. & spectral line, recirculation, OTF mosaicing
    - Need to spend time in Socorro with skills to assist implementing advanced correlator modes or calibration methodologies.

Continuing Development & Science

Day-time activities for development & Maintenance:

- ~9:00am to ~5:00pm, ~3-4 days/week dedicated to:
  - Maintenance activities (Wednesdays), Observing support (software systems development)
  - System robustness issues, WIDAR (expanding existing capabilities, diagnosing existing issues)
  - Some system tests (e.g., baseline, pointing runs)

Science Observations:

- OST scheduling of science projects

  ~136 hours/week for science observing (up from 125)

Observing Restrictions

https://science.nrao.edu/facilities/vla/docs/manuals/obsguide/req

- Scheduling Block
  - Specify an LST start range & dynamic (API/wind) constraints
  - Be a multiple of 15 minutes
- Scans
  - Scheduled in LST durations
  - Set up scans for 8 & 3-bit samplers https://science.nrao.edu/facilities/vla/docs/manuals/obsguide/modes/set-up
  - Must have CalFlux, CalBP, CalGain targets (CalPolAng, CalPolLeak as needed), select *intents* correctly for pipeline to run!
  - Maximum scan length is 90 x integration time (1 to 5s, depending on band and configuration)
    - Upper limit is 10 minutes regardless of integration time

Observing Restrictions

https://science.nrao.edu/facilities/vla/docs/manuals/obsguide/req

- Scans
  - Must have at least 20 seconds on each source
    - Correlator configuration changes can take up to 30 seconds; add this amount to ensure adequate time on source when switching correlator configurations.
  - Must schedule adequate time for initial slew (~9 minutes)
    - Specify wrap (CW/CCW) for the first few scans based on your start LST range (to avoid unnecessary wraps during program).
- Reference Pointing
  - Both X and C band can be used
  - Must have 2.5 minutes ***on source*** for C and X (plus 30 sec for a correlator reconfiguration and move time).
  - Use 1 second integrations (standard NRAO pointing configuration)
  - Don't observe above 80 degrees elevation (pointing model difficulties).

Scheduling Considerations

http://www.aoc.nrao.edu/~schedsoc/tac2013a.shtml

2013A TAC report explains the dynamic queue's scheduling priorities:

- A = Observations almost certainly scheduled
- B = Observations scheduled on a best effort basis
- C = Observations scheduled as filler
- D = Observations not scheduled

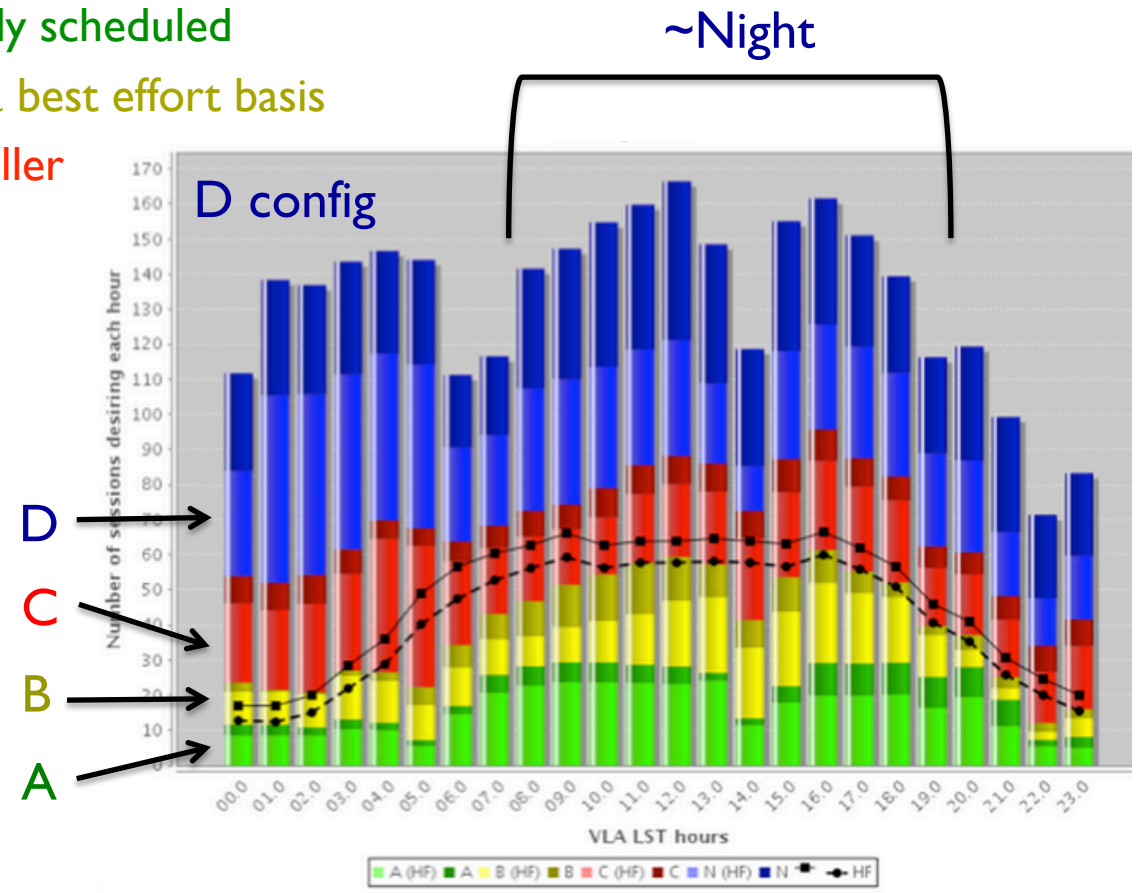
Pressure on dynamic time as a function of LST:

Dark shading (<10 GHz)

Light shading (>10 GHz)

Solid black line = All time available per LST hour

Dashed black line = high-frequency time available

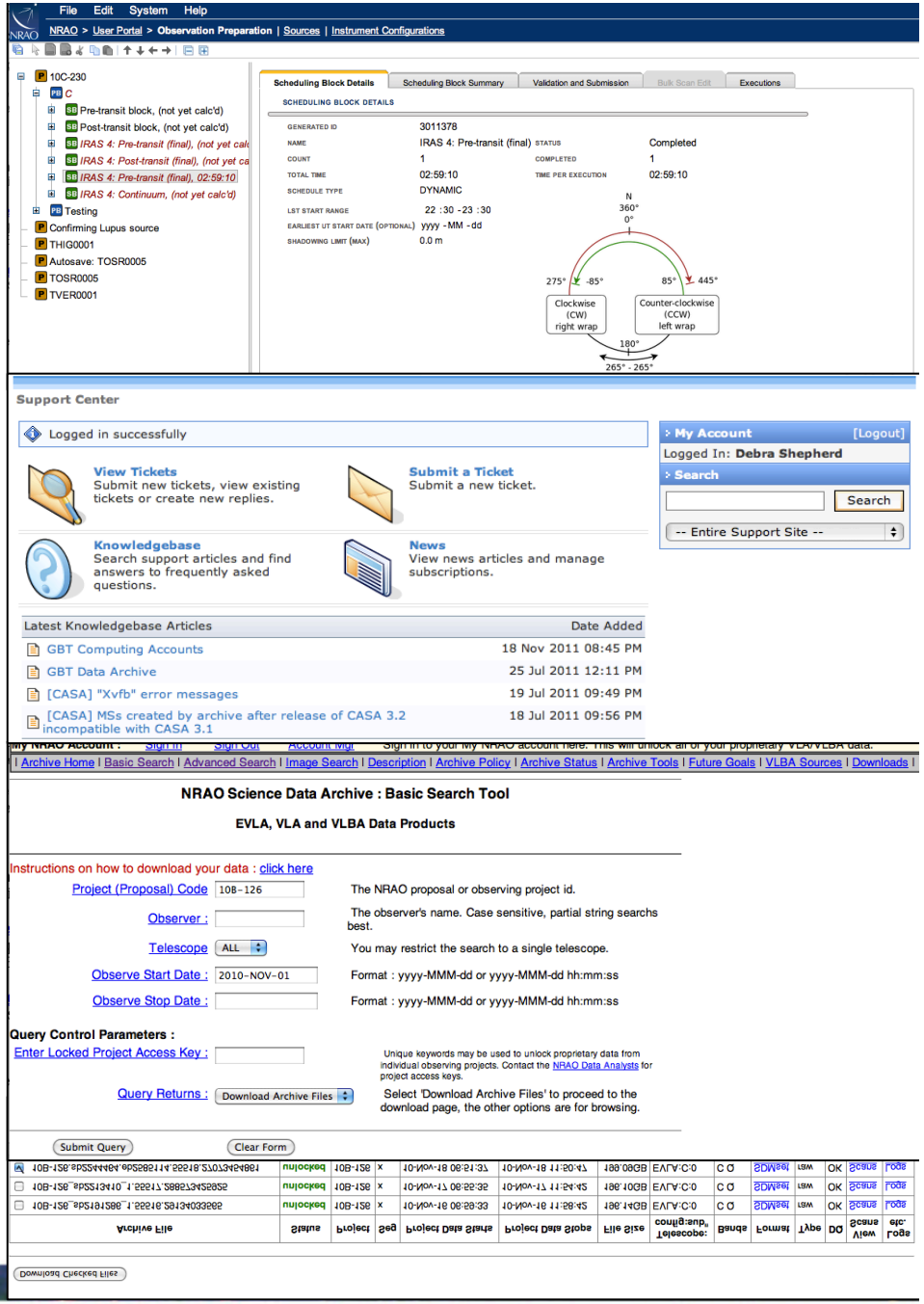


Shorter SBs can help B & C priority projects in high pressure LST ranges.
See: https://science.nrao.edu/facilities/vla/docs/manuals/obsguide

VLA Services

- http://my.nrao.edu integrates:
  - Proposal submission (PST)
  - Observing preparation (OPT)
  - Helpdesk
    - Interact with staff
    - Knowledgebase articles
- Archive
  - Data access and retrieval
- Other resources
  - Post-processing guides
  - Pipeline help & QA evaluations

  https://science.nrao.edu/facilities/vla/data-processing/pipeline
  - Splatalogue
  - Forum for discussions



Summary

- The VLA is operating with greatly expanded capabilities, still increasing with time.
- Key Links:
  - Main Page (with all required links): http://science.nrao.edu/facilities/vla
  - Proposing: https://science.nrao.edu/facilities/vla/proposing/vlapst2013b
  - Guide to VLA Observing: https://science.nrao.edu/facilities/vla/docs/manuals/obsguide
  - Observational Status Summary: https://science.nrao.edu/facilities/vla/docs/manuals/oss2013b
  - VLA Calibration Pipeline: https://science.nrao.edu/facilities/vla/data-processing/pipeline

Proposals:

- 1 February 2013 proposals for CnB, B, BnA configs currently being evaluated
- Next call for proposals: 1 August 2013 for A & D configs