EVLA Capabilities and Operations

February 22, 2012 – Socorro, NM USA

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

NRAO

Outline

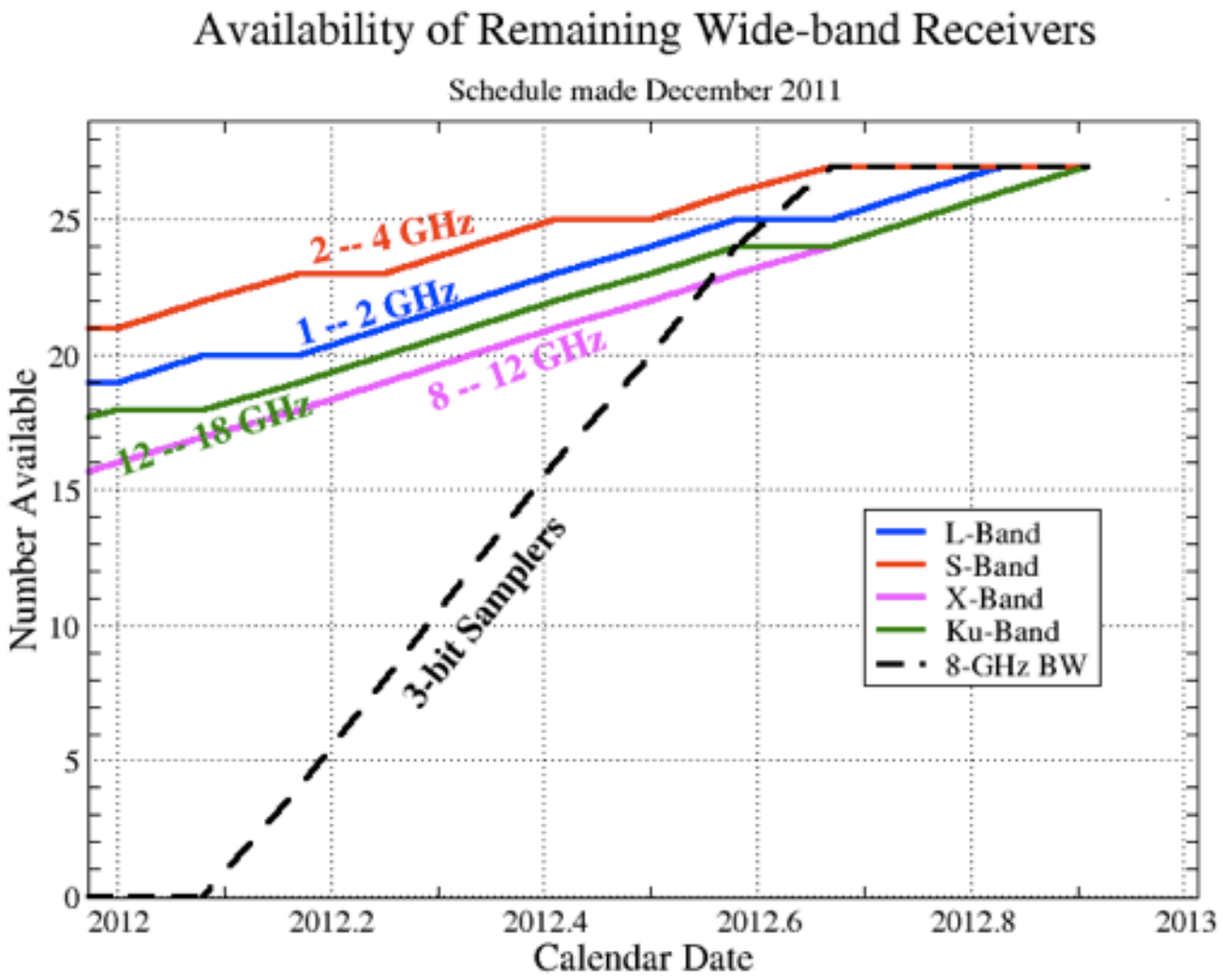
- EVLA Project
  - EVLA Goals & Status
  - Receivers Status
  - Correlator Overview & Status
- Data Acquisition Capabilities
  - OSRO
  - RSRO
  - Data rates
  - Restrictions
- Scheduling Considerations
- EVLA Services

VLA → EVLA status

Parameter	VLA	EVLA (goal)	Factor	EVLA (now)
Point Source Sensitivity (1σ, 12 hr)	10 μJy	1 μJy	10	2 μJy
Maximum BW in each polarization	0.1 GHz	8 GHz	80	2 GHz
# 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	16 [64]
Frequency Coverage (1 - 50 GHz)	22%	100%	5	100%

- All 28 antennas are converted to EVLA standards (new optics (feeds, towers, etc), new IF electronics, new samplers, new DTS).
- Ongoing receiver installation with expanding WIDAR (Wideband Interferometric Digital ARchitecture) correlator capabilities.
- **Ongoing construction, commissioning, science operations, maintenance.**
  - Ongoing: multi-band spectral line & continuum, recirculation (increased spectral resolution), 3-bit samplers (8 GHz BW), complex mosaics, phased array, sub-arrays, fast dumps (< 100 ms), low-band system.

EVLA Receiver Status



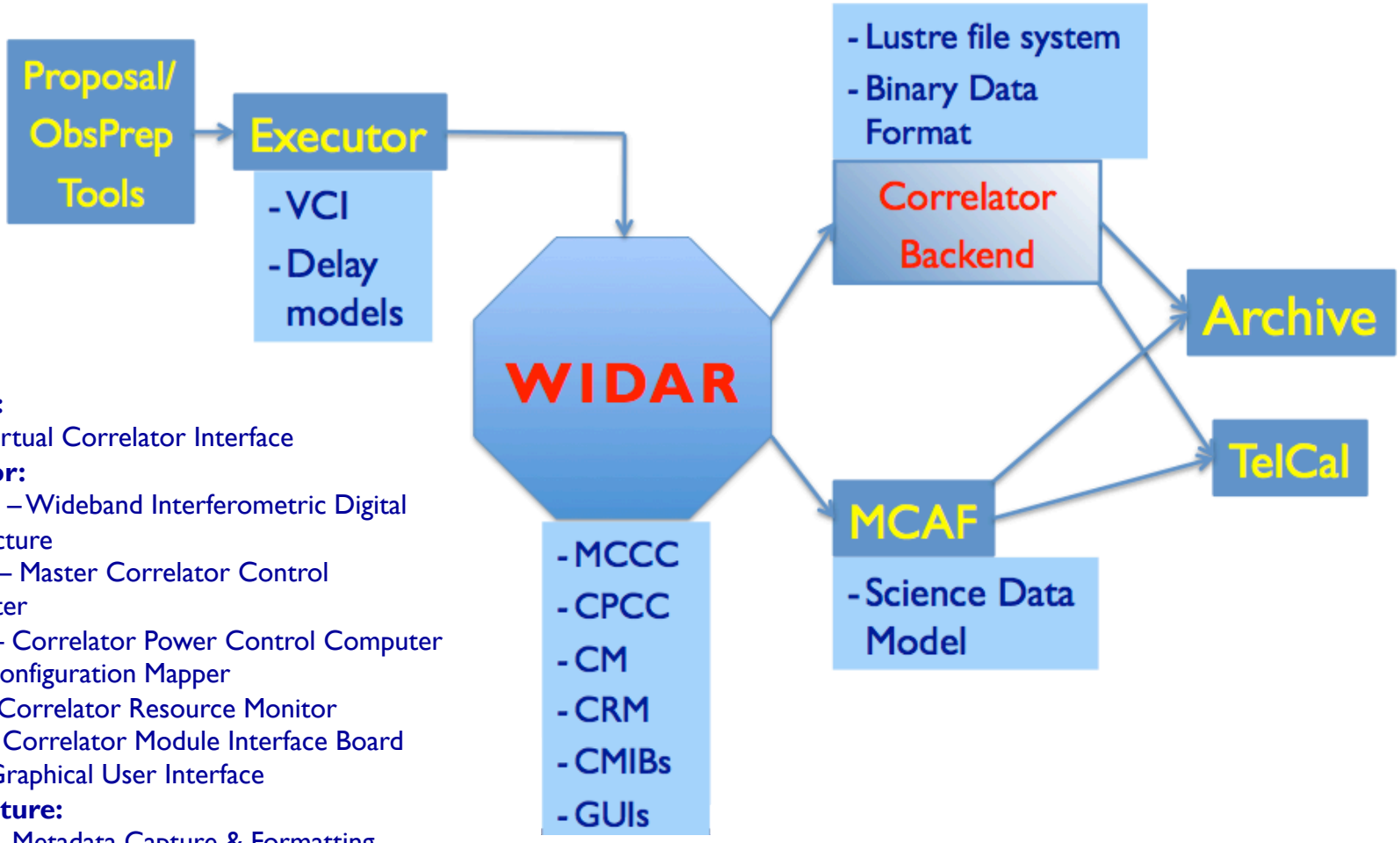
EVLA Receiver Status

Tuning Ranges & Receiver Availability February 2012

Band	Range (GHz)	Number of EVLA Systems	Total EVLA +VLA/Interim
Low-band *	-	-	-
20 cm (L)	1.0-2.0	19	27
13 cm (S)	2.0-4.0	22	22
6 cm (C)	4.0-8.0	27	27
3 cm (X)	8.0-12.0	16	27
2 cm (Ku)	12.0-18.0	19	19
1.3 cm (K)	18.0-26.5	27	27
1 cm (Ka)	26.5-40.0	27	27
7 mm (Q)	40.0-50.0	27	27

* New low-band system covering frequencies < 1 GHz under development

System Overview

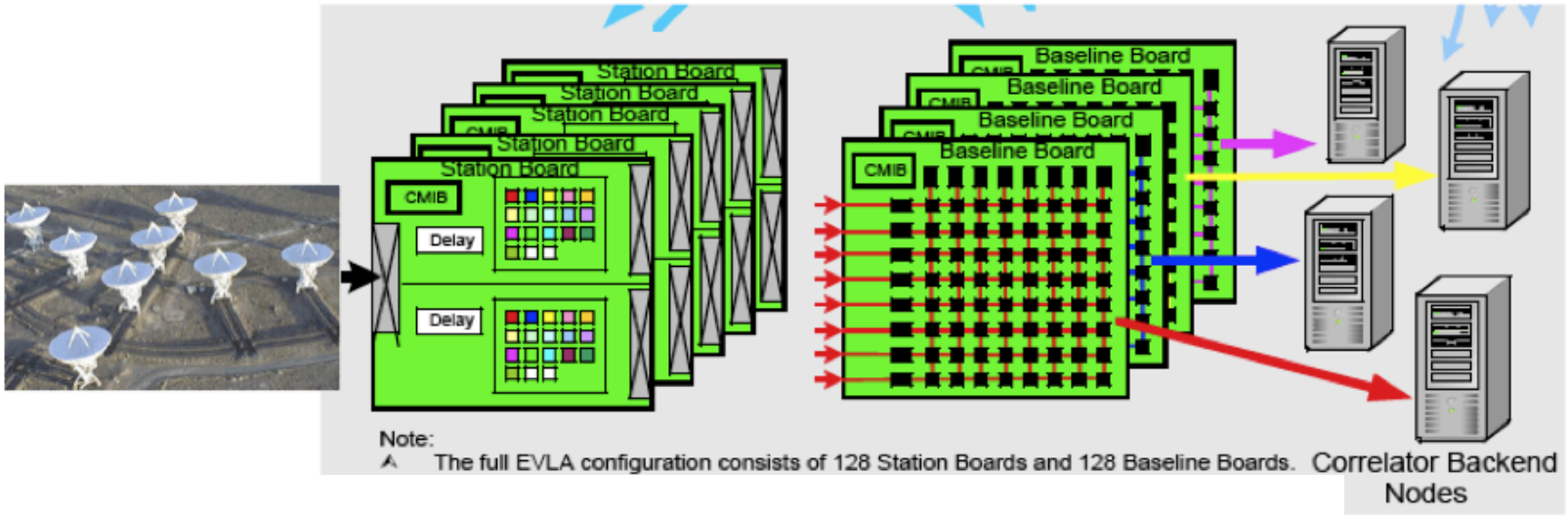


Executor:
- VCI – Virtual Correlator Interface

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; 4 or 7-bit requantization after sub-band filter
Baseband BW/antenna	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)
Min dump time	100 ms (all spectral channels)
Sub-arrays	Up to 8 (granularity of 4 antennas)
Supports	Autocorrelations, Pulsar processing (binning/gating), phased array, VLBI

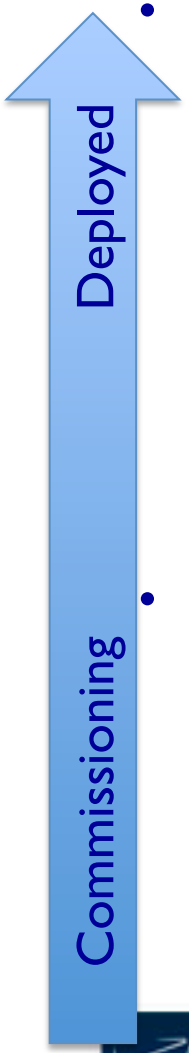
Commissioning WIDAR

- Complex instrument!
  - Hardware: boards, chips (25000), cabling (30 miles), connections, timing
  - Firmware: 11 major FPGA "personalities"
    - 6 Station Board (StB), 4 Baseline Board (BIB), 1 Crossbar board (XBB)
  - Internal software: Correlator Module Interface Boards (CMIBs), Configuration Mapper (CM), Correlator Resource Monitor (CRM), Master Correlator Control Computer (MCCC), Correlator Power Control Computer (CPCC) , Correlator Backend (CBE)
  - External Hardware: Fiber Optic Receiver Module, TIMECODE & clock, etc
  - External Software: ObsPrep Tools, Executor, Metadata Capture & Formatter (MCAF), TelCal, Science Data Archive, Monitor and Parameters Data Bases

WIDAR Status

- Hardware
  - 128 Station Boards (4/antenna x 32 antennas)+ 6 spares
    - 27x4 in constant use!
  - 128 Baseline Boards + 12 spares
  - 64 Crossbar Boards + 12 spares
- Software
  - Time averaging
  - Support for >25 MB/s
    - More features coming (e.g., higher data rates, frequency averaging, pulsar phase bins, fast dumps, 7-bit correlation, etc)

Early Science Observing Programs



- OSRO = 'Open Shared Risk Observing'
  - Standard observing protocol (proposal submission → grading → dynamic scheduling)
  - Access to incrementally expanding WIDAR capabilities
    - First set of configurations were based on VLA capabilities.
    - Capabilities increased in Sept 2011 to include those vetted and used by the RSRO program.
  - http://science.nrao.edu/evla/earlyscience/osro.shtml
- RSRO = 'Resident Shared Risk Observing'
  - For those willing to spend significant time in Socorro (3 or more months) and have skills and interest to assist in implementing advanced correlator modes or calibration methodologies.
  - Participants have more extensive observing capabilities made available to them.
  - http://science.nrao.edu/evla/earlyscience/rsro.shtml

Correlator Capabilities Timeline

Configuration Cycle	General Community (OSRO)	Resident Scientist (RSRO)
Mar 2010 (D) – Sept 2011 (A)	Up to 256 MHz BW	Up to 2 GHz BW
	Up to 2 spws (64-256 ch)	16 independently tunable spws (16x[64 to 256 ch])
	Std spectral line, continuum, polarization	Add ephemeris objects & phased array
Sept 2011 (D) – Jan 2013 (A)	Up to 2 GHz BW	Up to 8 GHz BW
	2 tunable bands each with 8 spws; 16x[64 to 256] spectral channels	Up to 64 independently tunable spws; recirculation (to increase resolution); flexible spw BWs
	Add S, Ku, wideband X & low frequencies	Add solar, pulsar, large mosaic modes
Jan 2013 (D)	Up to 8 GHz BW, up to 64 independently tunable spws; up to 16,384 ch (data rates up to 75 MB/s)	Possible extension of program to enable, e.g., new observing modes, advanced algorithm research

Commissioning Scheduling

Day-time activities (Tue-Fri):

- ~9:00am to ~5:00pm weekdays dedicated to:
  - Observing support (software systems development), System verification, WIDAR development (expanding existing capabilities, diagnosing existing issues), maintenance activities (upgrades, replacements, etc to problem hardware components), observing band commissioning activities (development to deploy new observing modes), etc

Science Mondays & Night-time activities:

- Generally dedicated to OST scheduling
  - *Includes critical commissioning tasks from above.*

~125 hours/week for science observing (up from 100); expected to continue to increase as construction/commissioning achieves EVLA goals.

Observing Restrictions

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

- Scheduling Block
  - Must specify an LST start range
  - Must be a multiple of 30 minutes
  - Must specify dynamic (API/wind) constraints
- Scans
  - Must be scheduled in LST durations
  - Must include a 'dummy' scan for each configuration
  - Must have CalFlux, CalBP, CalGain targets (CalPolAng, CalPolLeak as needed)
  - Maximum scan length is 90 x integration time
    - Low frequency default (5s): 450 seconds
    - High frequency default (3s): 270 seconds
    - Upper limit is 10 minutes regardless of integration time

Observing Restrictions

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

- 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 to 3.0 minutes on source for C and X (plus 30 sec for a correlator reconfiguration).
  - Use 1 second integrations (standard NRAO configuration)
  - Don't observe above 80 degrees elevation (pointing model difficulties).

Scheduling Considerations

http://www.aoc.nrao.edu/~schedsoc/tac2012a.shtml

2012A TAC report explains the dynamic queue's scheduling priorities:

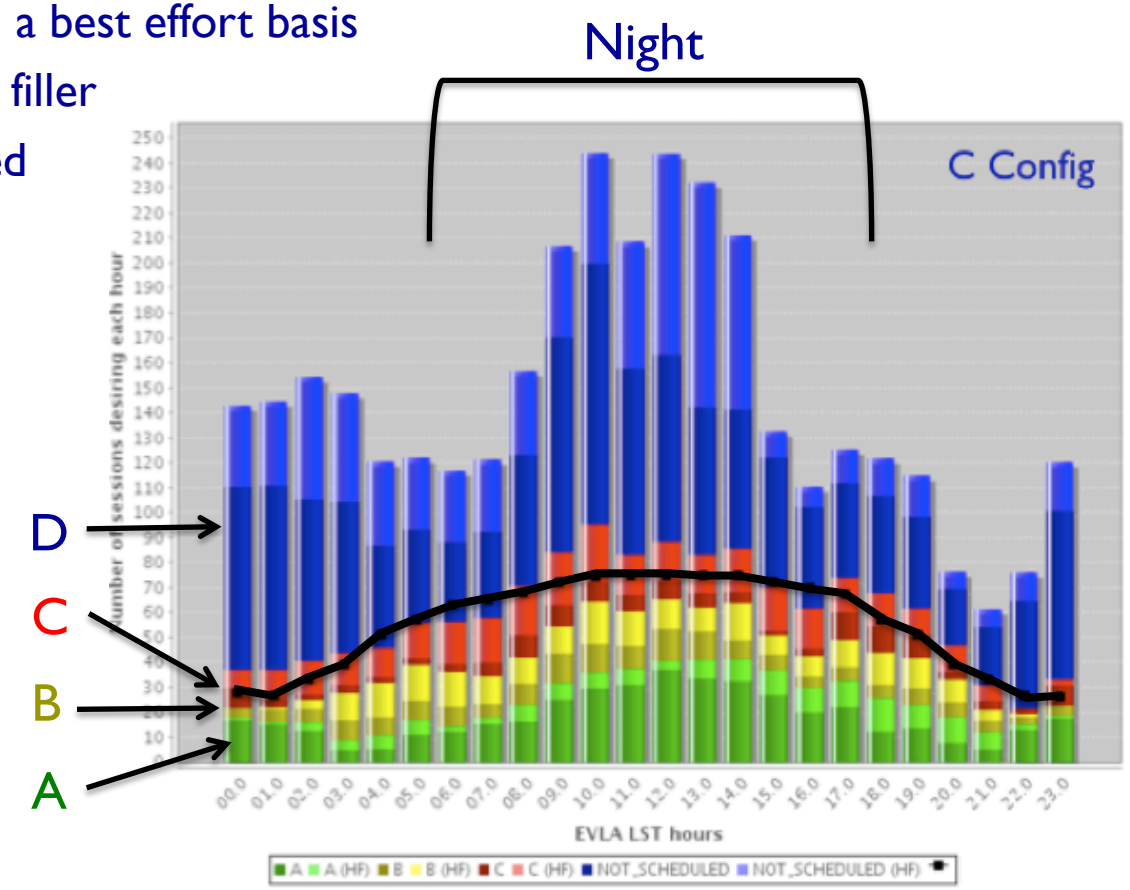
- A = Observations almost certainly scheduled
- B = Observations scheduled on a best effort basis
- C = Observations scheduled as filler
- D = Observations not scheduled

Pressure on dynamic time as a function of LST:

Dark shading (<10 GHz)

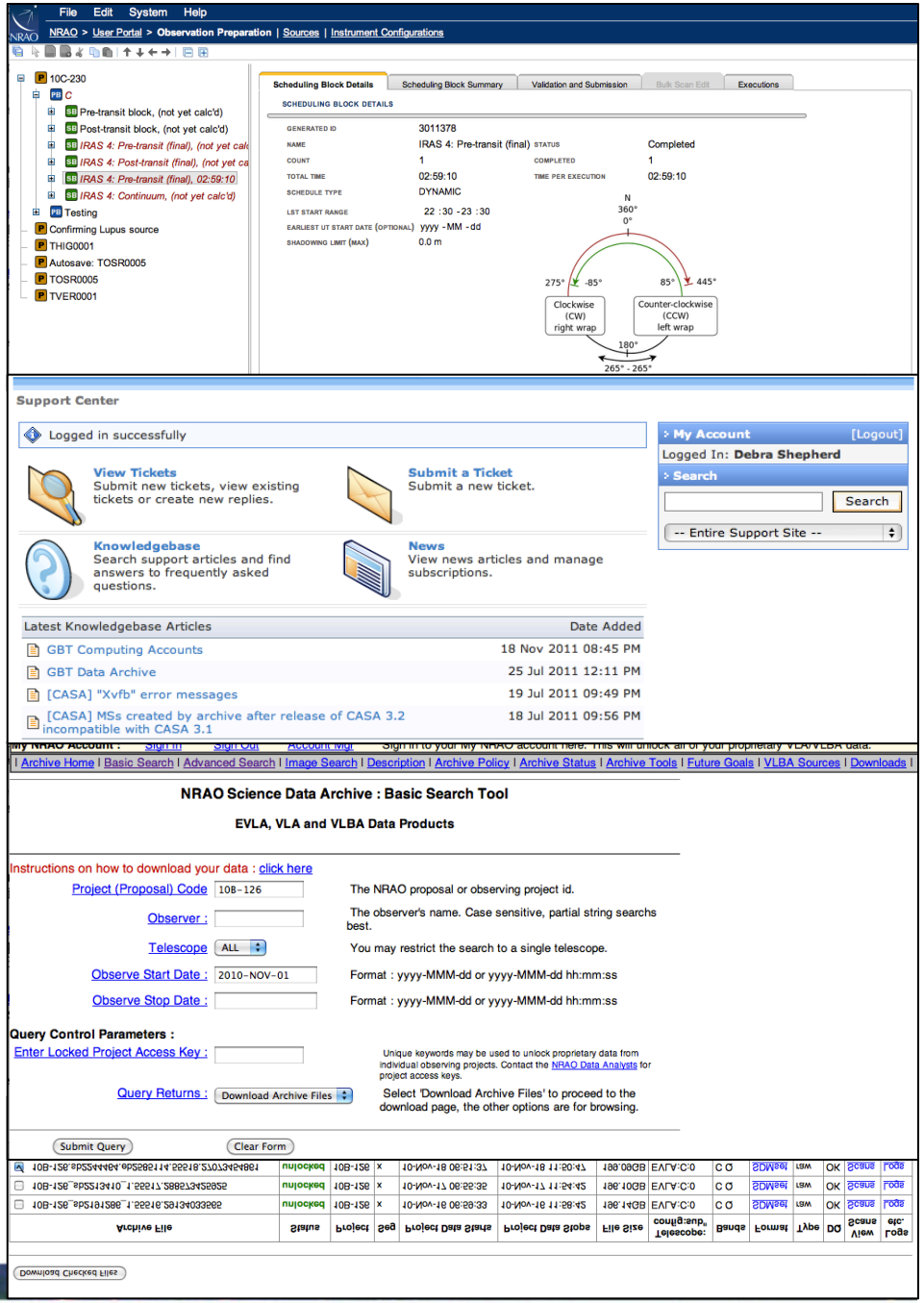
Light shading (>10 GHz)

Black line = time available per LST hour



EVLA Services

- http://my.nrao.edu integrates:
  - Proposal submission (PST)
  - Observing preparation (OPT)
  - Helpdesk
    - Interact with staff
    - Questions
    - Knowledgebase articles
- Archive
  - Data access and retrieval
- Other resources
  - Post-processing guides
  - Splatalogue
  - Forum for discussions



Summary

- EVLA is operating now with capabilities increasing with time.
  - Concurrent construction, commissioning and science operations has been challenging but it has enabled nearly uninterrupted access to the array throughout the conversion. Engagement by the community remains essential (via the RSRO+ programs) for completing the project on time.
- Key Links:
  - Main Page (with all required links): http://science.nrao.edu/evla
  - Observational Status Summary: http://evlaguides.nrao.edu/index.php?title=Observational_Status_Summary

Proposals:

- 1 February 2012 proposals for A & BnA configs currently being evaluated
- Next call for proposals: 1 August 2012 for D, DnC & C configs