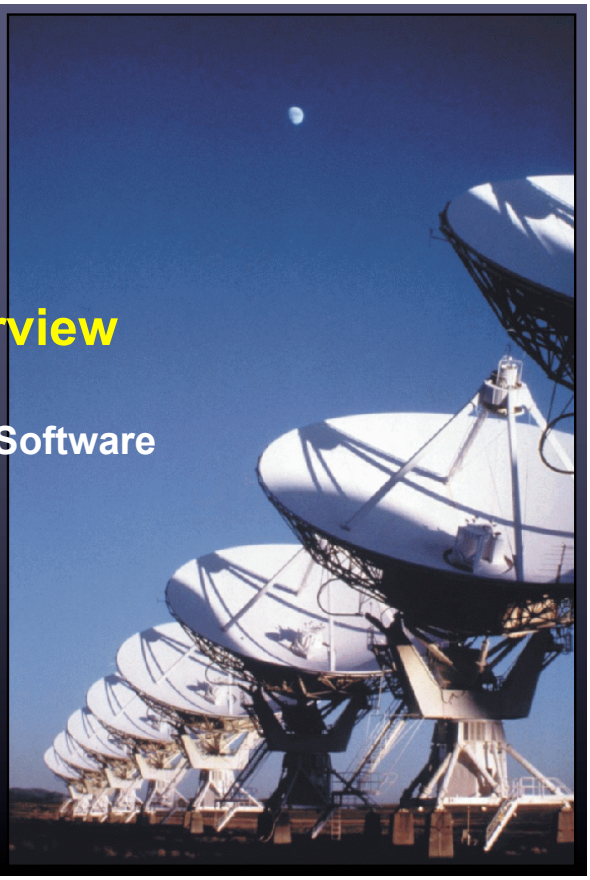

WIDAR Correlator Overview

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SAGE meeting

Socorro, May 22-23, 2007

Key EVLA Processing Capabilities

Deep Imaging Polarization	✓ 8 GHz Bandwidth (dual polarization). ✓ Full polarization processing. ✓ Wide-field imaging.
Narrow spectral lines Wideband searches	✓ 16,000 channels at max. bandwidth (BW). ✓ >10^5 channels at narrow BWs. ✓ Spectral resolution to match any linewidth. ✓ Spectral polarization (Zeeman Splitting).
Flexibility Many resources	✓ 8, 2 GHz wide bands. ✓ Each band - 16 tunable sub-bands. ✓ Sub-band – independent spectral resolution. ✓ Simultaneous line and continuum.
High time resolution	✓ 1000 pulsar “phase bins”. ✓ “Single-dish” data output to user instruments. ✓ Very fast time sampling (20 μs).

Correlator Basics

- 32 stations
- Four 2 GHz (per pol'n) baseband pairs
- Two digital sampling modes (before the correlator):
  - Four streams of 8 bits @ 2 GSamp/sec
    - Used for low frequency bands (~S and below) where RFI is a major issue
  - Eight streams of 3 bits @ 4 GSamp/sec
    - Used for high frequency bands (~C and above) where broader bandwidths are available

Sub-band Filtering and Special Modes

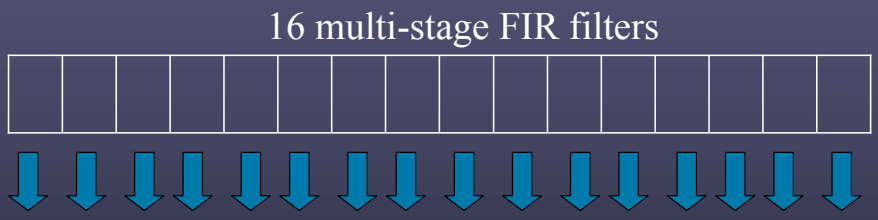
- Each baseband is digitally sub-divided into 16 sub-bands
  - independently tunable to (almost) any frequency within the baseband
  - sub-band bandwidths (independently selectable): 128, 64, …, 0.03125 MHz
  - sub-bands stitched together digitally, with at most a factor 2 loss in noise at boundaries
- Highly flexible in trading total BW, sub-band BW, polarization products for frequency resolution (number of channels)
- Nearly limitless sub-arraying
- Pulsar phase binning and gating
  - At least as capable as any existing single dish
- VLBI-ready; phased array possible
- Special sub-band and phase array outputs available for specialized (user-built?) backends
- RFI excision
  - Sub-band by sub-band at very high time resolution
  - Channel by channel at 10s of msec time resolution
- Flexible programming of Correlator Backend
- Initially (2012) throttled to 25 MB/sec

Correlator – FIR Filter

- Each of 8 inputs, each 2048 MHz wide, is digitally divided into 16 sub-bands.

Input data stream

4096 Gsamp/sec x 3 bits, or 2048 GSamp/sec x 8 bits.

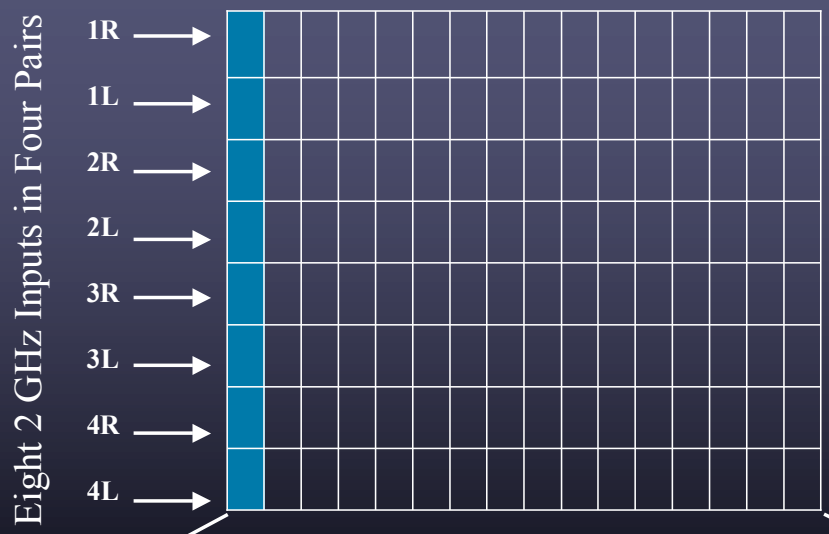


- Sub-bands independently tunable in frequency, BW, frequency & time resolution, number of bits correlated
- Simplest mode: 16,384 channels over full bandwidth

16 digitally defined subbands for each of 8 inputs

Max sub-band width = 128 MHz, min width = 31.25 KHz

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15



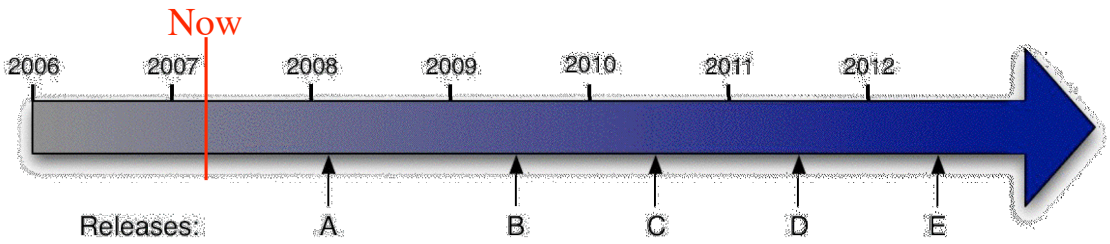
Each sub-band independently tunable in freq, BW, dt, Nchan, …

Each column processed by one sub-correlator, providing 1024 channels

Correlator Flexibility

- Flexibly trade resources between sub-bands and basebands
  - Increases resolution for one sub-band by up to a factor 256
- Recirculation is available on all four* baseband pairs --> up to 4 million total channels/baseline
  - Presuming the proposed rewiring plan is accepted.
- Can trade sensitivity for channels ("wideband recirculation")
- Simultaneous autocorrelations
  - Per baseband
  - Per sub-band

Timescale and Major Releases



Release	Date	Event	Comments
A	Q2 2008	Arrival Prototype Correlator	4 antennas; ~2 GHz
B	Q2 2009	Begin WIDAR Installation	12 antennas; ~2 GHz
C	Q2 2010	WIDAR Installation Complete	System integration testing
D	Q2 2011	Shared-risk Observing	Standard modes supported
E	Q2 2012	Full Operation	End of EVLA construction

Correlator Schedule

- Prototype correlator (4 stations, 2 GHz/pol'n)
  - Q2 2008: arrives at VLA
  - Q2 2008-Q1 2009: On-the-sky testing
    - Critical tests required before full production orders
  - PTC is a hardware/software testbed -- not intended for scientific use
- Limited-production hardware (12 antennas, ~2 GHz/pol'n)
  - Q2 2009: arrives at VLA
  - another (smaller!) WIDAR correlator to eMERLIN
- Correlator software (backend, ObsPrep, etc.)
  - Q1 2010: subset available for "regular" use
- Full correlator (32 antennas, 8 GHz/pol'n)
  - Q2 2009-Q2 2010: installation and testing at VLA
    - Gradual adding capabilities to limited-production hardware
  - Q2 2010-Q1 2011: commissioning (turning off the VLA correlator)

Correlator Schedule

- Risk factors
  - Still testing correlator chip & prototype boards
  - Complex system with hardware and software tightly coupled
  - Schedule here bounded by possibility of board re-spin
- Capabilities are set by both hardware and software

Prototype Correlator

- Hardware/software development testbed
- 4 stations, 2 GHz/polarization
- Correlator hardware checkout: on-the-sky tests
  - Does WIDAR work as planned?
    - Fringes; recirculation; 3- and 7-bits; sub-band filters; deep integrations; pulsar modes; phasing; …
    - Subset of these tests required before full production orders
- Software testing and integration in the field
  - Correlator setup & control
  - Correlator Backend
    - FT; averaging; smoothing; weights; SDM; …
  - Post-processing (CASA & AIPS)
    - Visibilities & meta-data (Reading, displaying, sub-band stitching, …)
- Development & checkout
  - Wideband feeds
  - Wideband calibration & stability
  - RFI environment & excision

Limited Production Hardware

- 12 antennas, roughly 2 GHz/polarization
- Hardware arrives Q2 2009
  - Very aggressive schedule
  - Capabilities partly set by correlator-related software ==> still used for integration, testing, and checkout
- Limited correlator software available Q1 2010
  - Currently discussing whether we can get something up by Q2 2009
- Potentially very interesting scientifically
  - 12 antennas (set by correlator hardware)
  - Roughly 2 GHz/pol'n bandwidth (set by correlator hardware)
  - 14 independently tunable sub-bands within the 2 GHz
  - Each sub-band can have different channelization, and possibly pulsar phase binning
  - Thousands to hundreds of thousands of channels
- Gradually builds as full production hardware arrives