Correlator Growth Path

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

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Overview

- *24jun08-15dec08 Prototype Correlator*
  - Correlator hardware tests, leading to WIDAR critical design review
  - See previous talk (Prototype correlator testing)
- *4mar09-Q1 2010: WIDAR-0 (10 antennas)*
  - Systems integration testing of wideband (3-bit) sampler
  - Systems integration, software development, and testing leading to Open Shared Risk Observing (OSRO)for early EVLA science
- *Q1 2010 and beyond*
  - Open Shared Risk Observations (OSRO)
  - Resident Shared Risk Observations (RSRO)

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WIDAR-0: March 2009-Q1 2010

- *WIDAR-0 is the first part of the final correlator*
  - Located in new correlator room, with final wiring
  - Populated with production boards
  - Can accept inputs from up to 10 antennas
  - General capabilities
    - Full polarization, on timescale of June 2009 (based on station board delivery)
    - Bandwidths of 256 MHz to 640 MHz per polarization in 2 to 5 x 128 MHz sub-band pairs
    - 1 MHz frequency resolution for wide bandwidth in dual polarization (RR+LL)

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Priorities for WIDAR-0

- Test systems integration of wide-band (3-bit, 2 GHz) samplers
- Prepare two WIDAR configurations for OSRO starting in Q1 2010 [Chandler]
  - Continuum: Two independently tunable sub-bands, full polarization, each with 128 MHz bandwidth and 64 channels
  - Spectral line: One tunable sub-band, dual polarization, with 128 MHz bandwidth and 256 channels
- **NOT** for science
- **NOT** for open use

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WIDAR-0: Preparing for OSRO

- Correlator configuration
  - ObsPrep Tool
  - Real-time control
  - Configuration Mapper
- Important subset of metadata
  - Tsys application
  - On-line flags
- Correlator Backend (CBE) processing
  - time/frequency averaging
- Demonstrate WIDAR polarization capability

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Current Status of WIDAR-0

- Racks installed and fully cabled up

- Boards installed on March 2, 2009
  - 8 station boards, 3 crossbar boards, 2 baseline boards
  - Supports 8 antennas, 512 MHz BW, single polarization

Includes graphical user interfaces (GUIs) for correlator, racks, boards, and chips

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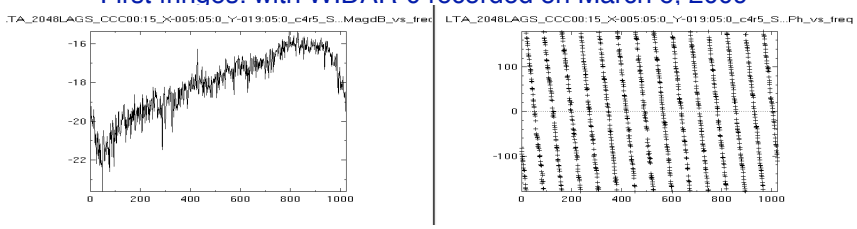
Current Status of WIDAR-0 (cont'd)

- First fringes: with WIDAR-0 recorded on March 6, 2009



- First fringes with 5 antennas, 4 sub-bands (4x128= 512 MHz) recorded at L, C, and X bands on March 11
  - First use of science data model (SDM) and binary data format (BDF) with this correlator configuration
- Already providing important feedback on hardware and software
- Excellent working relationship with DRAO
- An incredible pleasure to use

Final WIDAR

- Final WIDAR consists of 128 Baseline Boards and 128 Station Boards
  - Station Boards perform digital filtering and delay tracking of antenna signals (4 StB per antenna)
    - More Station Boards allows more antennas
  - Baseline Boards contain correlator chips where correlations are computed
    - More Baseline Boards allows more bandwidth and more channels

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Circuit Board Delivery

- Correlator configurations for OSRO in Q1 2010 require growth of stations initially and bandwidth later
- Places priority on Station Board delivery. Schedule:
  - 20 Station Boards by June 1, 2009
  - 40 by August 1, 2009
  - 96 by December 1, 2009 (for 24 antennas)
- Only 4 Baseline Boards are needed to support initial configurations
  - These are scheduled to be in place in May 2009
- All boards are scheduled for delivery to the VLA site by December 2009

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Bandwidth Growth

- After OSRO is initiated, WIDAR capability grows in bandwidth
- WIDAR-relevant recommendations by 2008 SAGE
  - Implement wide bandwidth capability
  - Improve spectral resolution (through WIDAR recirculation)
  - Special modes (e.g. phased array, pulsar) are of lower priority
- Growth during OSRO [Chandler]
  - T1 2010-T1 2011: 256 MHz total bandwidth
  - T2 2011-T2 2012: 2 GHz total bandwidth
  - T3 2012+ : 8 GHz total bandwidth

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RSRO: T1 2010-T2 2011

Date	Array Config	Total bandwidth per pol'n	Number of subband pairs	Channels per sb pair (4 pp)	Comments
T1 2010	D	1 GHz	16	64	All sb identical 8-bit samplers
T2 2010	C	8 GHz	64	64	All sb identical 3-bit samplers
T3 2010	B	8 GHz	64	<= 16,384	All sb identical Add recirculation
T1 2011	A	8 GHz	64	<=16,384	Independent subbands
T2 2011	D	8 GHz	64	<= 16,384	Can trade subbands for channels

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Backup slides

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Special Correlator Capabilities

- Not guaranteed in 2010-2012
  - (Even) more flexibility in the allocation of correlator resources
  - Multiple subarrays
  - Phased array and single-dish VLBI
  - Burst mode
  - Radar mode
  - Pulsar binning
  - Pulsar gating
  - 7-bit correlation
  - Fast switching between correlator set-ups
  - Very fast dumps

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Special Correlator Capabilities (cont'd)

- Mixing of 3-bit and 8-bit samplers
- More processing by the correlator back-end
- Enable more channels for single-polarization observations
- Online RFI flagging
- Multiple phase/delay tracking centers

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OSRO WIDAR modes (1)

- Continuum applications and spectro-polarimetry
  - Two independently-tunable sub-band pairs (IFs), full pol., each with bandwidth $128/2^n$ MHz (n=0,..,12), 64 channels

Sub-band BW (MHz)	Number of poln. products	Number of channels/poln product	Channel width (kHz)	Channel width (kms^{-1} at 1 GHz)	Total velocity coverage (kms^{-1} at 1 GHz)
128	4	64	2000	600/ν(GHz)	38,400/ν(GHz)
64	4	64	1000	300	19,200
32	4	64	500	150	9,600
16	4	64	250	75	4,800
8	4	64	125	37.5	2,400
4	4	64	62.5	19	1,200
2	4	64	31.25	9.4	600
1	4	64	15.625	4.7	300
0.5	4	64	7.813	2.3	150
0.25	4	64	3.906	1.2	75
0.125	4	64	1.953	0.59	37.5
0.0625	4	64	0.977	0.29	18.75
0.03125	4	64	0.488	0.15	9.375

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OSRO WIDAR modes (2)

- Spectral line applications
  - One tunable sub-band pair (IF), dual polarization, with bandwidth $128/2^n$ MHz (n=0,..,12), 256 channels

Sub-band BW (MHz)	Number of poln. products	Number of channels/poln product	Channel width (kHz)	Channel width (kms^{-1} at 1 GHz)	Total velocity coverage (kms^{-1} at 1 GHz)
128	2	256	500	150/ν(GHz)	38,400/ν(GHz)
64	2	256	250	75	19,200
32	2	256	125	37.5	9,600
16	2	256	62.5	19	4,800
8	2	256	31.25	9.4	2,400
4	2	256	15.625	4.7	1,200
2	2	256	7.813	2.3	600
1	2	256	3.906	1.2	300
0.5	2	256	1.953	0.59	150
0.25	2	256	0.977	0.29	75
0.125	2	256	0.488	0.15	37.5
0.0625	2	256	0.244	0.073	18.75
0.03125	2	256	0.122	0.037	9.375

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RSRO capabilities: per subband, no recirculation

- In the end WIDAR will provide 64 completely independent subband pairs (independent tuning, bandwidth, pol'n products, etc.)

Sub-band BW (MHz)	Number of poln. products	Number of channels/poln product	Channel width (kHz)	Channel width (kms^{-1} at 1 GHz)	Total velocity coverage (kms^{-1} at 1 GHz)
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RSRO capabilities: per subband, with recirculation

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64	4	128	500	150	19,200
32	4	256	125	37.5	9,600
16	4	512	31.25	9.4	4,800
8	4	1024	7.813	2.3	2,400
4	4	2048	1.953	0.59	1,200
2	4	4096	0.488	0.15	600
1	4	8192	0.122	0.037	300
0.5	4	16384	0.031	0.0092	150
0.25	4	16384	0.015	0.0046	75
0.125	4	16384	0.0076	0.0023	37.5
0.0625	4	16384	0.0038	0.0011	18.75
0.03125	4	16384	0.0019	0.00057	9.375