

Title: Phasing ALMA

Date: Nov 13, 2014 03:45 PM

URL: <http://pirsa.org/14110107>

Abstract: We are now two years into development of hardware and software for phasing ALMA, with emphasis on Band 6 (1.2 mm) but applicability to bands 3 and 7. Central to the effort is software to continuously calculate and apply a phasing solution, and the hardware interface cards (PIC) and other upgrades to the correlator that apply the solution, format the data and extract the correlated data stream. Upstream from the correlator is a hydrogen maser, which is the new ALMA time standard. Downstream from the correlator are four high speed Mark 6 data recorders collectively capable of capturing 64 Gb/s, and an optical fiber link to bring the signal from the AOS, where the antennas and correlator are located, to the OFS where the recorders are located. All the hardware is currently installed and functional. A formal acceptance review for the maser was held this past week, and acceptance of the rest of the hardware will be reviewed in December. While some debugging of software is ongoing, the basic software elements are in place and (more or less) functional. Formal commissioning activities are planned to begin in January

Phasing ALMA

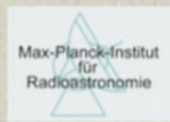


Overview and Status
November 13, 2015

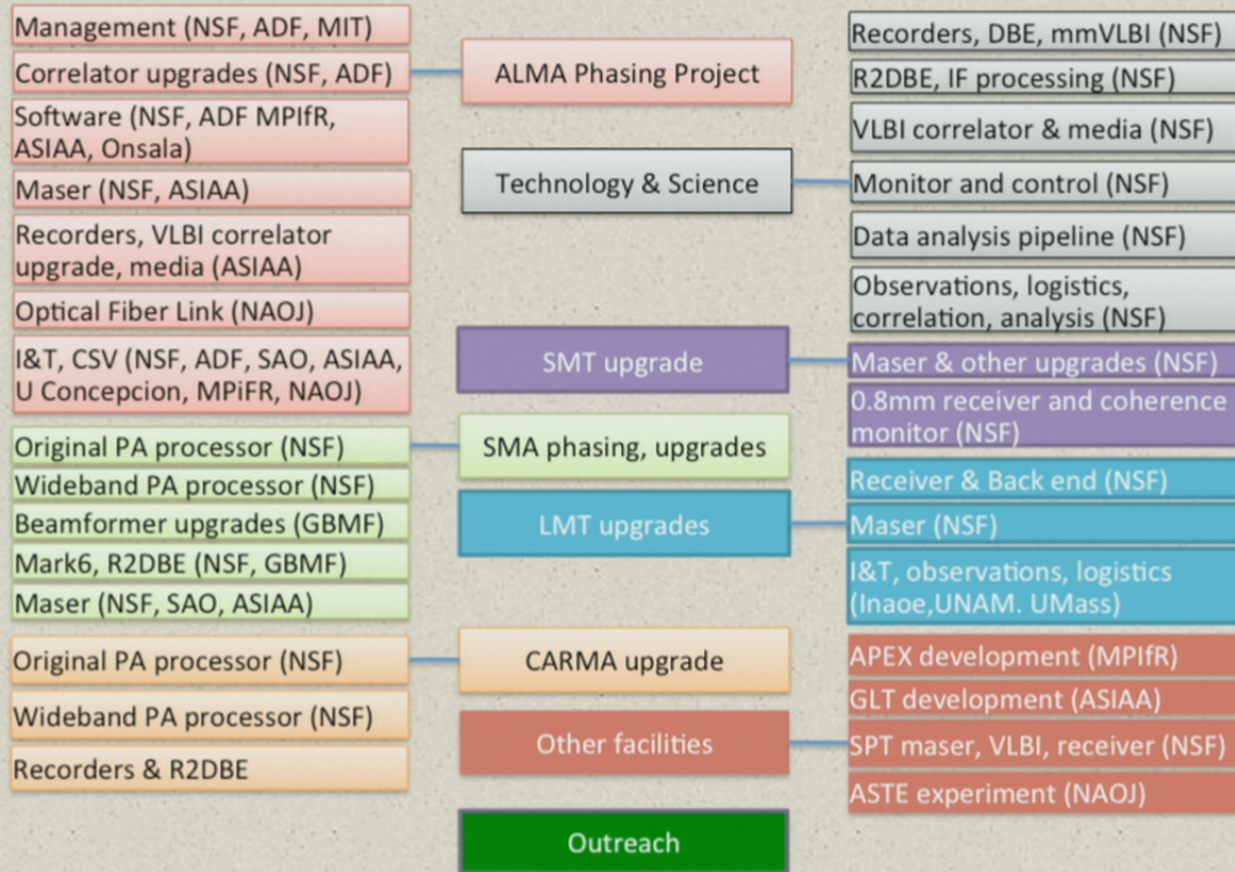
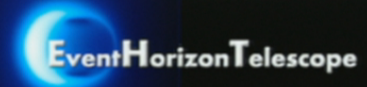
Thanks to...



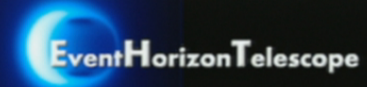
- ◆ Participating organizations below
- ◆ Sponsoring organizations
 - NSF Major Research Instrumentation program
 - ALMA NA Development Fund
 - Cost sharing partners
- ◆ ASTRON, Onsala, ESO, Univ. of Grenoble, IRAM, Board members, and especially JAO for making staff available to assist APP



EHT development (overview)



Essential design features



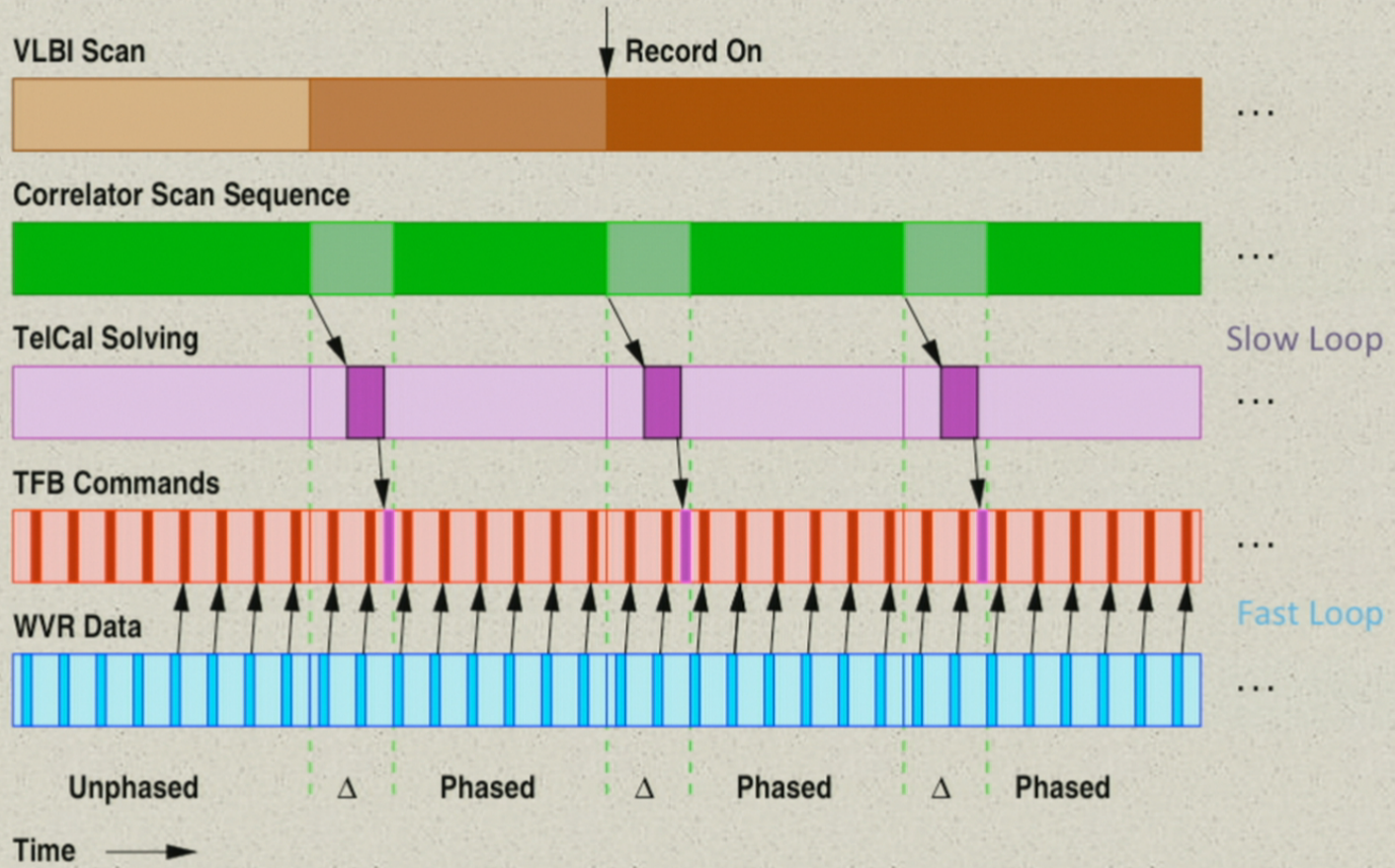
- ◆ Correlator upgrades are in parallel with the existing hardware/ firmware and **do not affect the normal data path**
- ◆ **Interferometric ALMA data products are available** while the VLBI data are being captured.
- ◆ Only relatively **“minor” software enhancements** to the ALMA code base are required.
- ◆ All of the phasing corrections are performed in the correlator and supporting computer system with **no front-end or Local Oscillator modifications** required.
- ◆ The phasing system includes a commercial **hydrogen maser** to provide a high stability, spectrally pure frequency standard to ALMA for routine operations as well as VLBI.

Essential design features

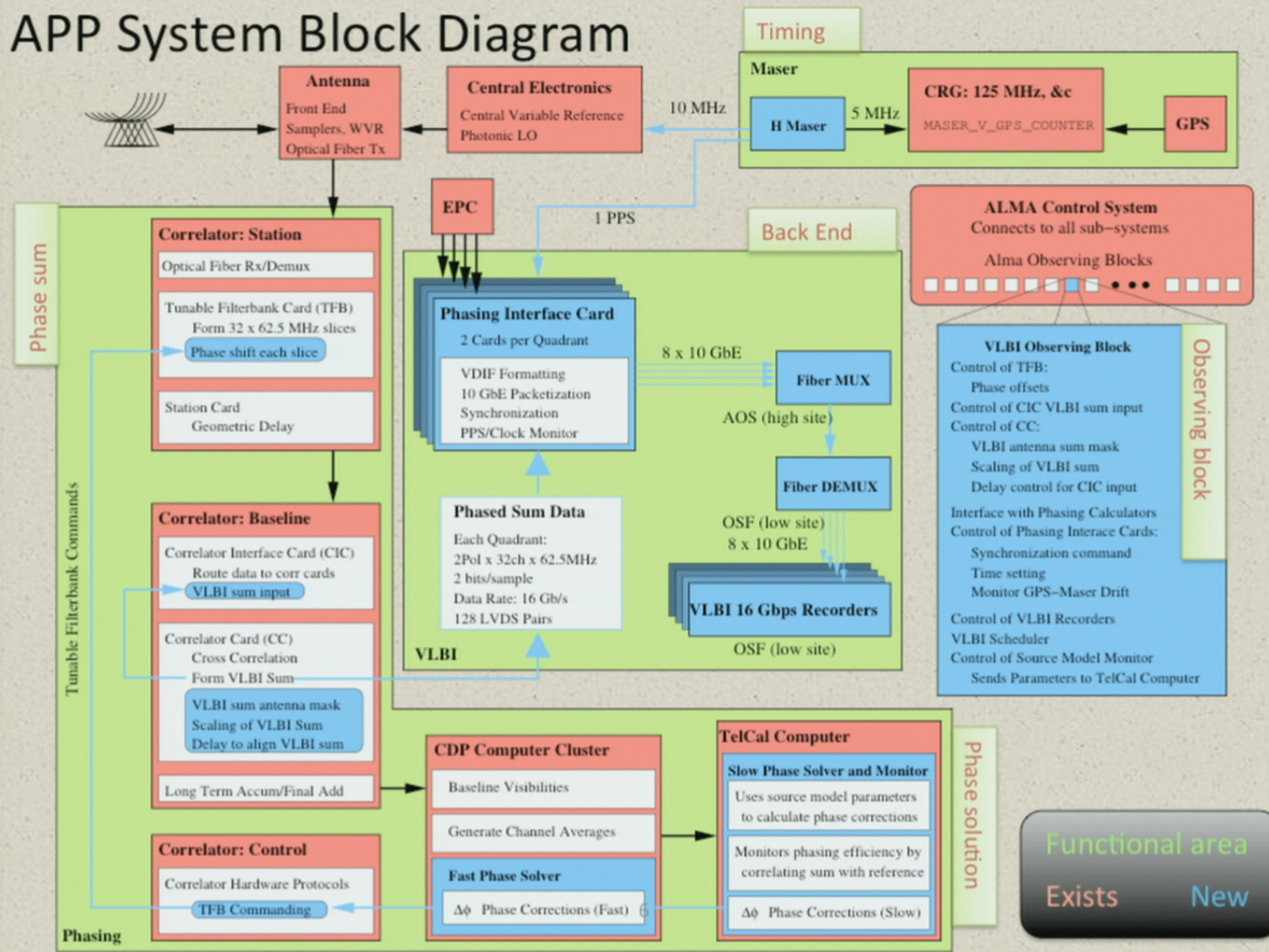


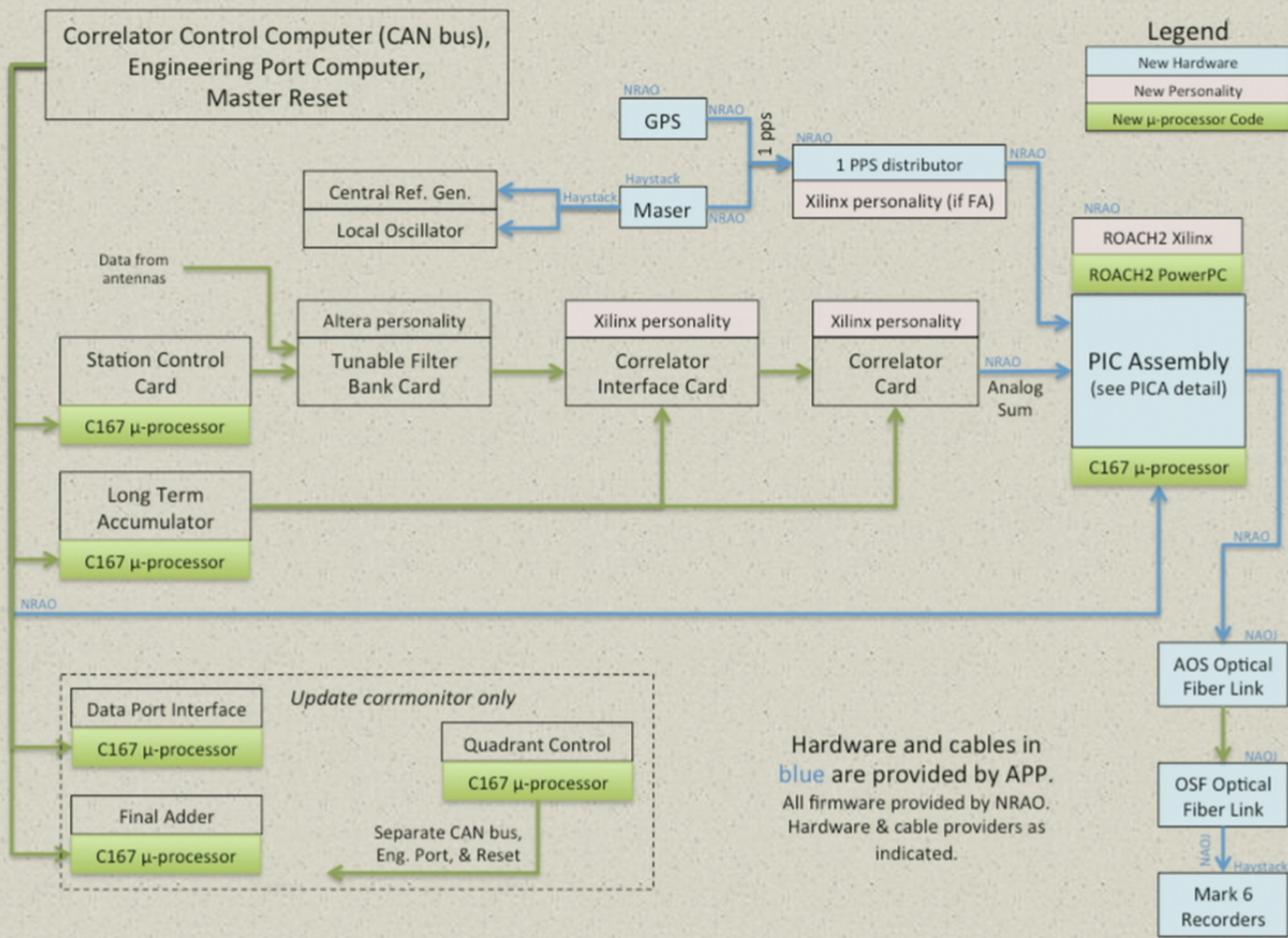
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Scan Strategy

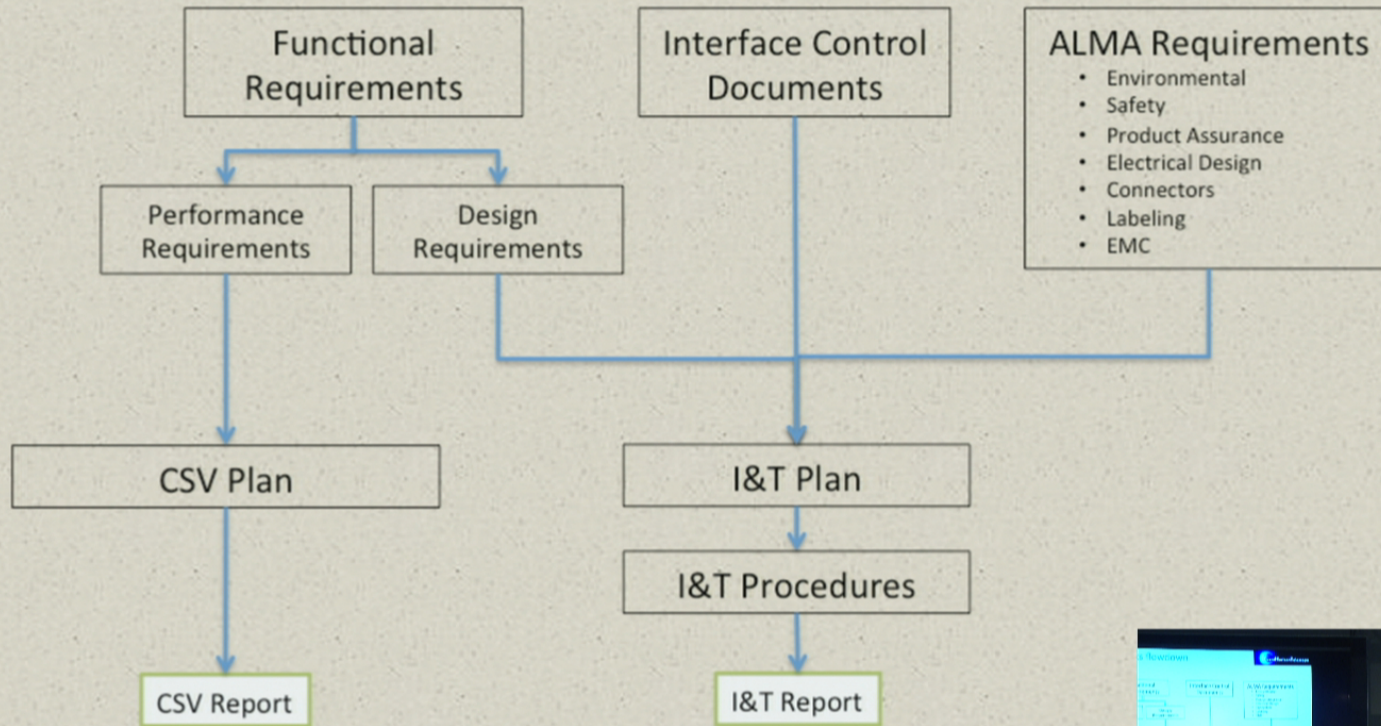


APP System Block Diagram

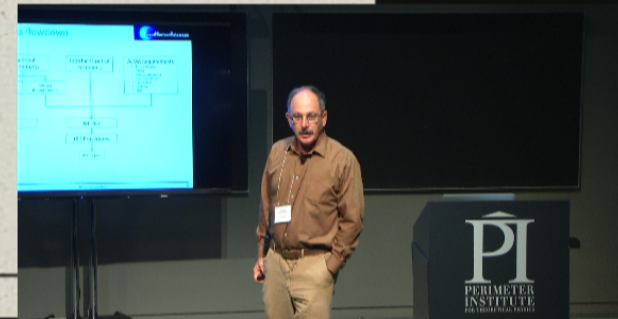




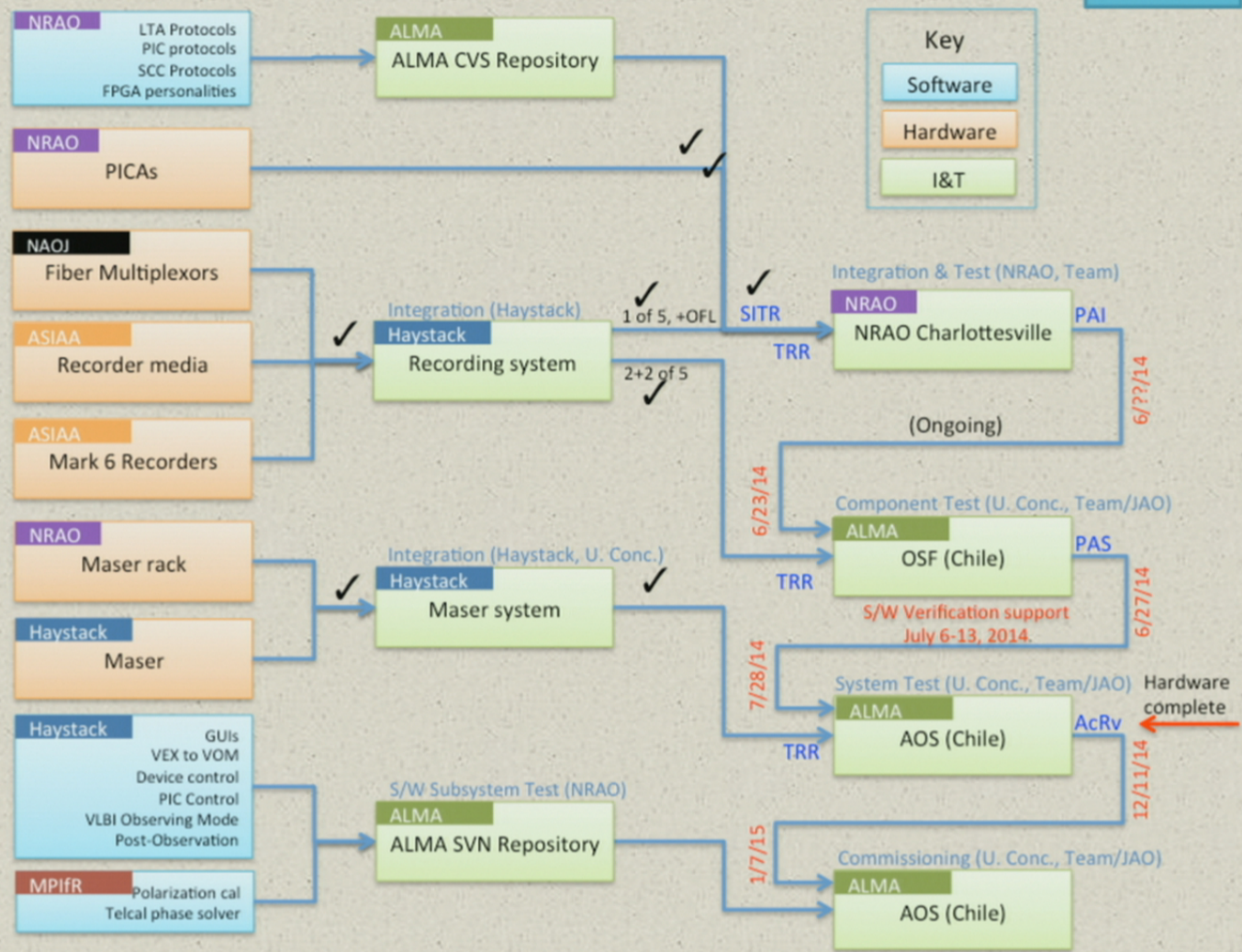
Requirements flowdown



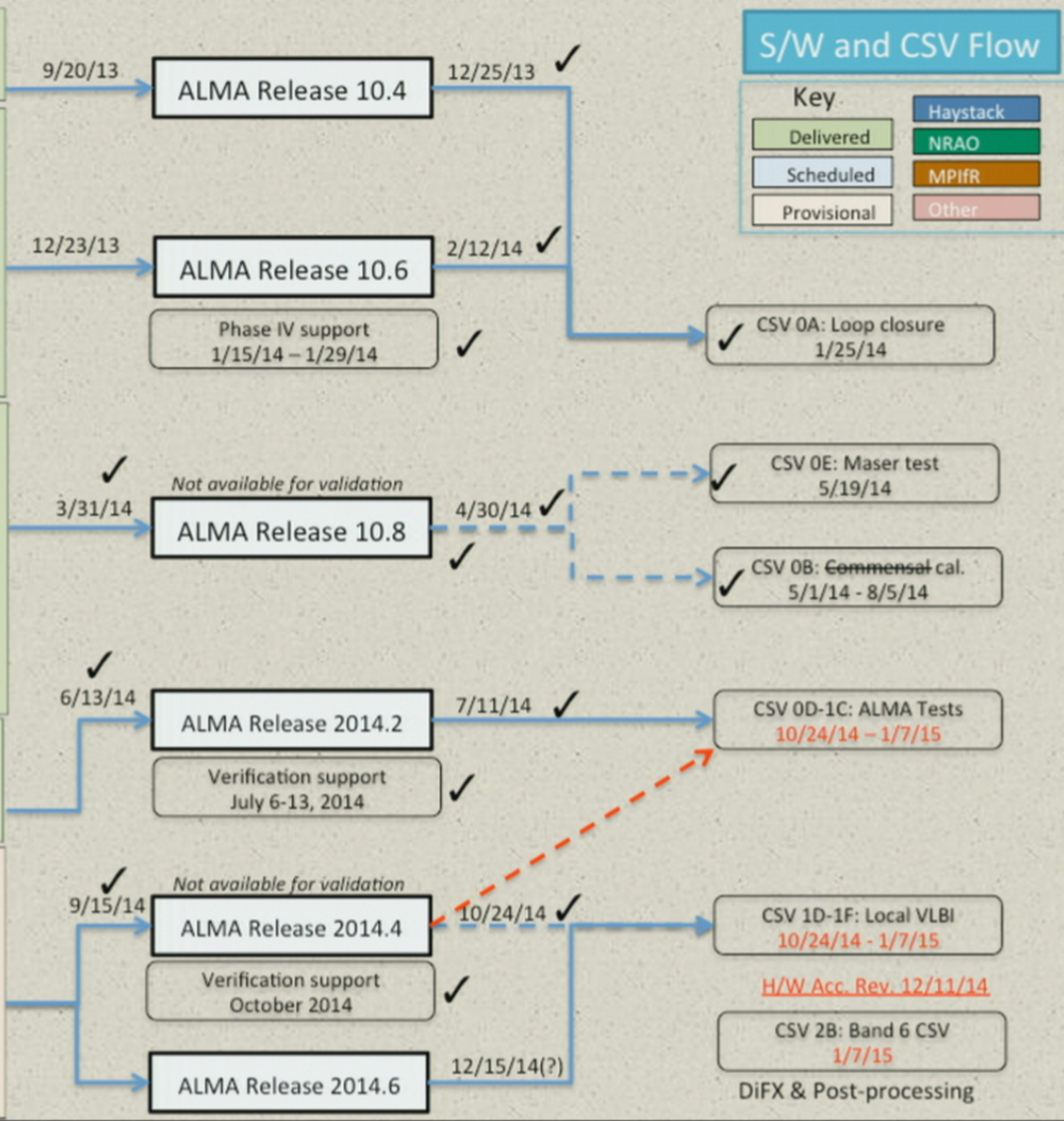
APP Overview and Status



I&T Flow



H/N	ICT-310	VOM InterferometryController
N	ICT-315	LTA protocols for antenna sum
N	ICT-317	TFB commands to support phasing
N	ICT-726	Retrieve and apply TelCal
H/N	ICT-966	VOM: VLBI interfaces
H	ICT-301	Device: Hydrogen Maser
H	ICT-302	Device: VLBI OFL
H/N	ICT-311	VOM: PhasingController
N	ICT-313	VOM: Control of Antenna CAI-63
N	ICT-314	VOM: DataCapturer support
M	ICT-321	TelCal: Simple Phase Solver
N	ICT-854	CDP support for slow phasing loop
N	ICT-967	ObservationControl interface
	ICT-1994	Adding CalAppPhase to ASDM
	ICT-2162	APP CAN commands
	ICT-2177	setAppPhaseParameters
	ICT-2293	NodeImpl::startSubscanSequence
	ICT-2310	TFB phase adjustments reset
	ICT-2311	APP phase corrections
H	ICT-303	Device: VLBI Recorder
H/N	ICT-312	VOM: VLBIController
N	ICT-316	PIC control
M	ICT-323	TelCal: Phase Solver (Advanced)
M	ICT-324	TelCal: Efficiency Monitor
H	ICT-326	VEX to XML
N	ICT-1003	PIC diagnostics interface
M	ICT-2305	TelCal Solver Antenna Index Error
M	ICT-2306	TelCal Solver zero phase
M	ICT-2317	TelCal adjust time
N	ICT-2329	Preserve array after using VOM
H	ICT-2446	Device: Hydrogen Maser
N	ICT-2449	cdp disable residual delay
N	ICT-2630	VLBI devices to CONTROL Master
M	ICT-2747	Refine quality calculation
N	ICT-2294	CDP support for sum scaling
N	ICT-2295	VOM: Advanced PhasingController
N	ICT-2803	PIC control implementation
H	ICT-2994	VLBI Recorder upgrade
H	ICT-3124	VLBI DeviceResource handling
N	ICT-2584	CDP support for sum delay/phase
H	ICT-304	GUI: VLBI Hardware Status Panel
H	ICT-305	GUI: TelCal Results Display
H	ICT-306	GUI: CCC phase updates
H	ICT-307	GUI: VLBI Observation Status
N	ICT-318	Phase update query interface
N	ICT-319	Phase updates for fast loop
H/N	ICT-325	VLBI Scripts (VEX2VOM v1.0)
N	ICT-965	QuickLook for CalAppPhase
N	ICT-2296	Access to Array Status GUI
N	ICT-2539	Parallelize APP CAN Commands
M	ICT-2833	Source modeler
M	ICT-2834	Per Spectral Window phase sol'n
M	ICT-2835	Phasing efficiency



Hardware is complete and installed!



+ CORRELATOR
MODIFICATIONS

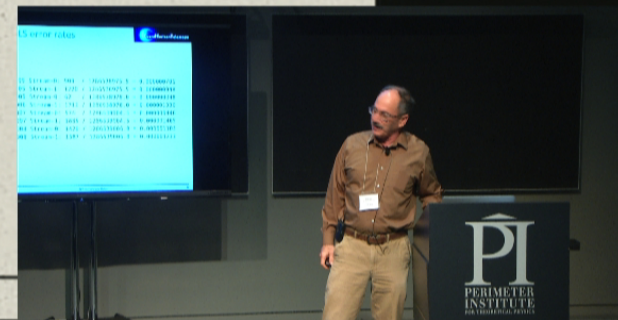
Recorder/OFLS error rates



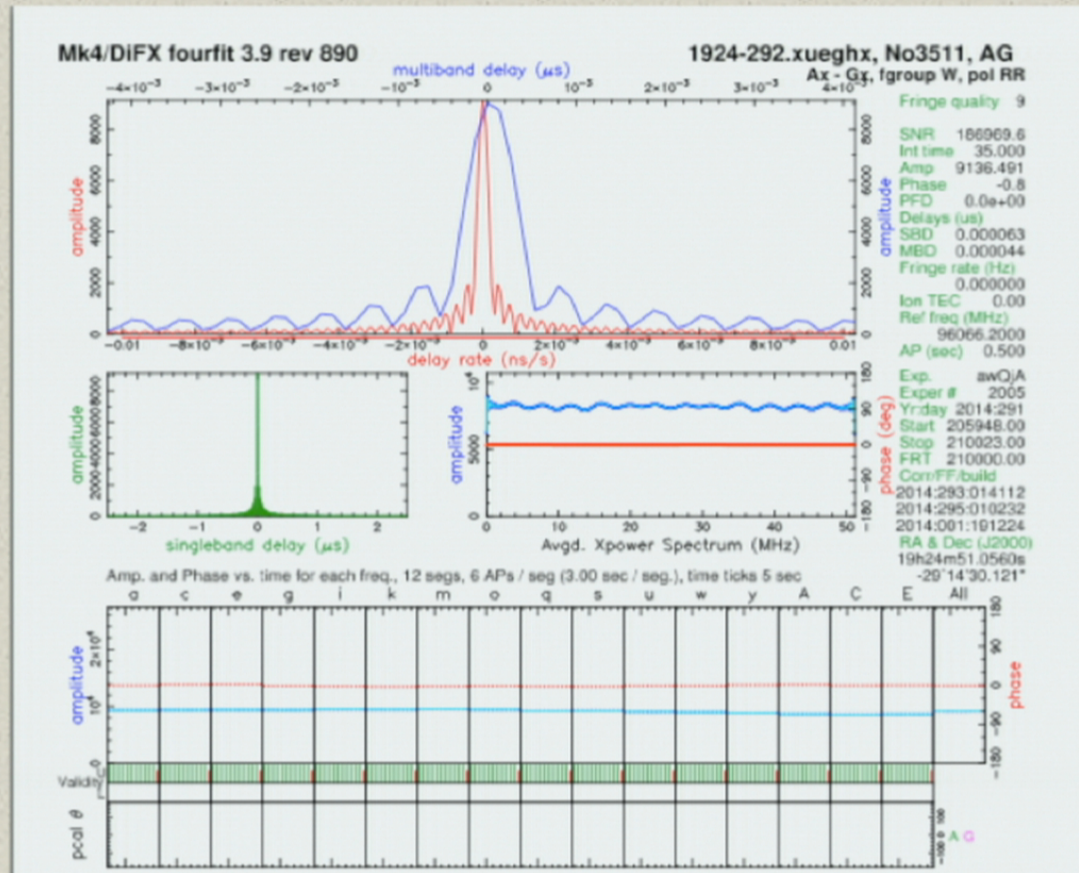
- Mark6-4005 Stream-0: 909 / 1286538975.5 = 0.000000706
- Mark6-4005 Stream-1: 1220 / 1286538975.5 = 0.000000948
- Mark6-4006 Stream-0: 62 / 1286538978.0 = 0.000000048
- Mark6-4006 Stream-1: 1712 / 1286538978.0 = 0.000001330
- Mark6-4007 Stream-0: 574 / 1286539004.5 = 0.000000446
- Mark6-4007 Stream-1: 1885 / 1286539004.5 = 0.000001465
- Mark6-4008 Stream-0: 1420 / 1286539006.0 = 0.000001103
- Mark6-4008 Stream-1: 1587 / 1286539006.0 = 0.000001233



APP Overview and Status



VLBI Recording: Q1X v Q3X

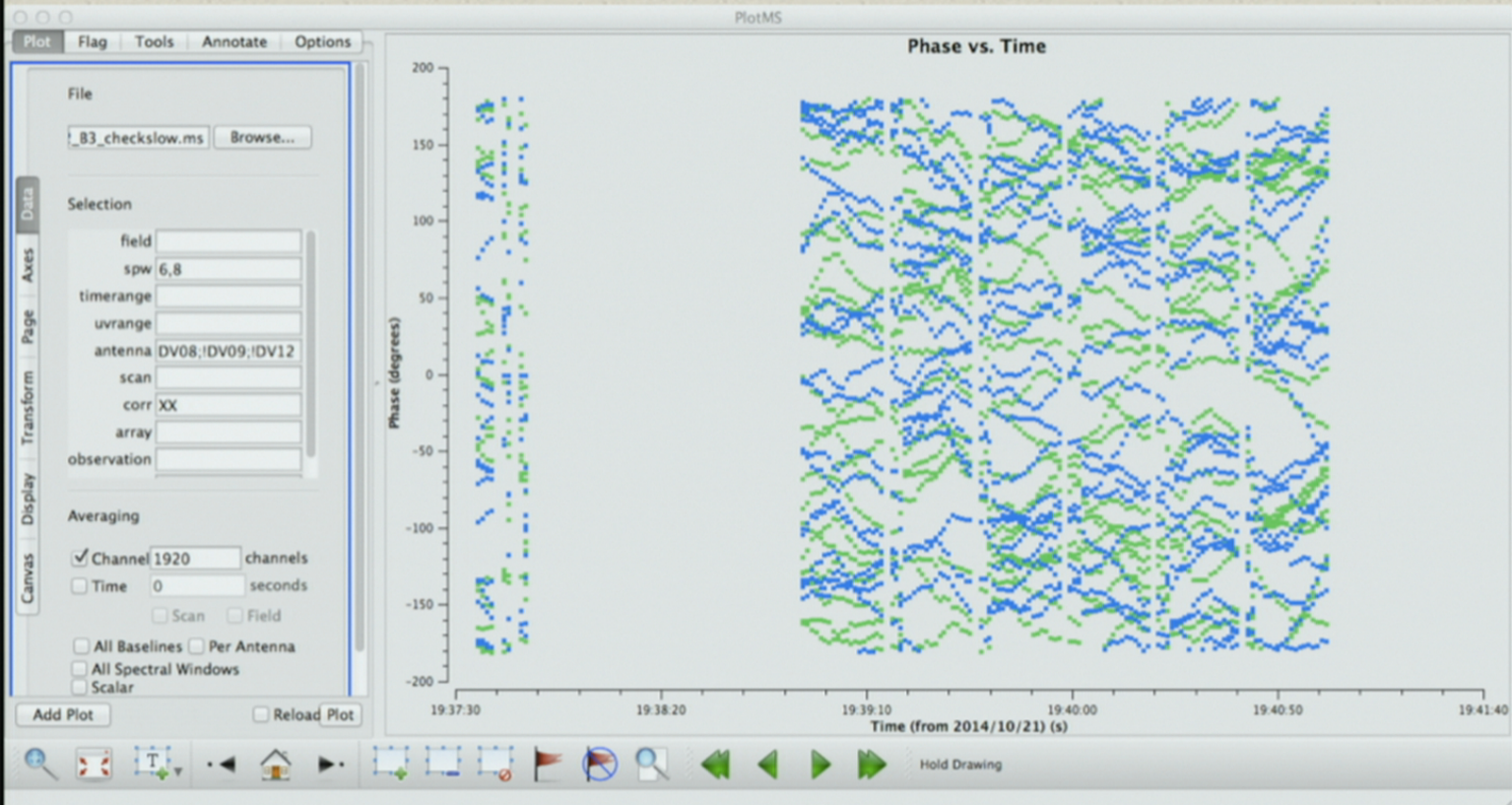


Fast Loop works (all quadrants)



- Absolute corrections
- Relative corrections
- Uncorrected

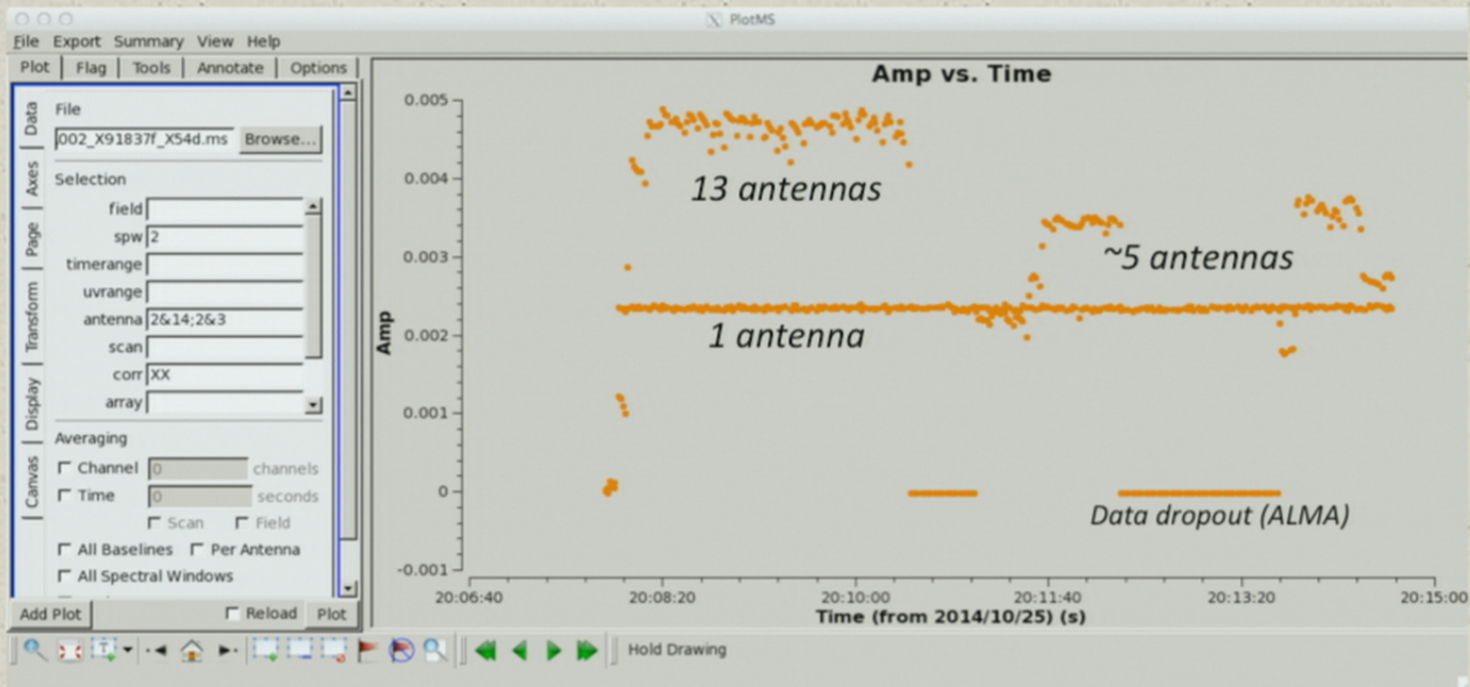
... sometimes



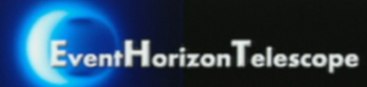
Quadrant 3 and 4



Sqrt(n) improvement – quad. 1, x pol



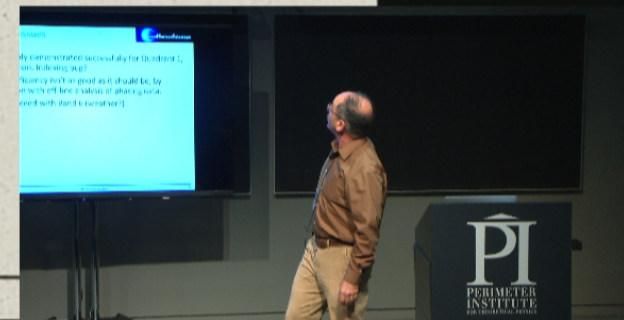
Outstanding issues



- ◆ Phasing only demonstrated successfully for Quadrant 1, x polarization. Indexing bug?
- ◆ Phasing efficiency isn't as good as it should be, by comparison with off-line analysis of phasing data.
- ◆ Didn't succeed with Band 6 (weather?)



APP Overview and Status



Phase 0 (Pre-Commissioning)



◆ Objectives:

- Test VOM block execution during real observations
- Insure that APP operation does not negatively impact standard ALMA operations
- Verify that data products meet specifications for phasing stability, efficiency (via commensal observing)
- Characterize polarization properties (via dedicated observations)

◆ Proposed Tests:

- **Test 0A:** Observations of calibrator sources (non-VLBI mode)
- **Test 0B:** Commensal calibrator source observations (non-VLBI mode)
- **Test 0C*:** Polarization characterization with the ALMA Beacon
- **Test 0D:** Polarization characterization using observations of astronomical sources

◆ Does not require PIC, maser, OFL, or recorders:

**Contingent upon availability/suitability of Beacon for testing*

Phase 1 (“Local VLBI”)



◆ Objectives:

- Exercise the APP in VLBI and pseudo-VLBI observing modes through “local VLBI”
- Demonstrate readiness of APP to participate in a global VLBI network

◆ Proposed Tests:

- **Test 1A**: Stepped scans with closure phase tests
- **Test 1B***: “Single-dish” spectroscopy of astronomical line source
- **Test 1C**: Inter-quadrant VLBI
- **Test 1D***: VLBI between APP and OSF antenna (fringe test)
- **Test 1E***: VLBI between APP and OSF antenna (stepped scans)
- **Test 1F**: VLBI between APP and APEX (fringe test)

**Desirable, not mandatory*

Phase 2 (Global VLBI)



◆ Objectives:

- Utilize APP in full-fledged global VLBI experiments
- Demonstrate the functionality of the fully-integrated APP for science

◆ Proposed Tests:

- **Test 2A:** Global VLBI (3 mm = Band 3)
- **Test 2B:** Global VLBI (1.3 mm = Band 6)

**As per agreement, observing targets will include neither Sgr A* nor M87*

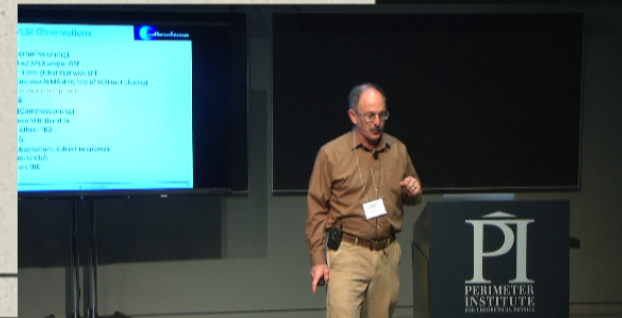
Anticipated VLBI Observations



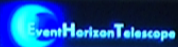
- ◆ Jan 2015 (Commissioning)
 - Local VLBI w/ APEX and/or OSF
 - Possible 1.3 mm global VLBI with SPT
 - Probably just one ALMA dish, test of VLBI (not phasing)
 - Pending hardware acceptance
- ◆ ~~March 2015~~
- ◆ May 2015 (Commissioning)
 - Global 3 mm VLBI (band 3)
 - w/ VLBA, others TBD
- ◆ March 2016
 - Science observations, subject to approval
 - Band 6, 16-32 Gb/s
 - Participants TBD



APP Overview and Status



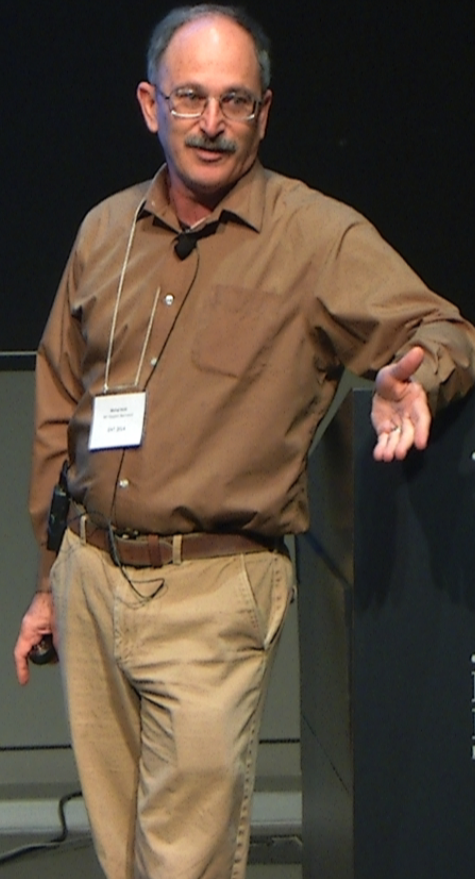
VLBI Observations



(Commissioning)
w/ APEX and/or OSF
3 mm global VLBI with SPT
just one ALMA dish, test of VLBI (not phasing)
hardware acceptance
5
(Commissioning)
mm VLBI (band 3)
others TBD
6
observations, subject to approval
16-32 Gb/s
nts TBD

APP Overview and Status

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