

Arecibo's VLBI Sensitivity Upgrade

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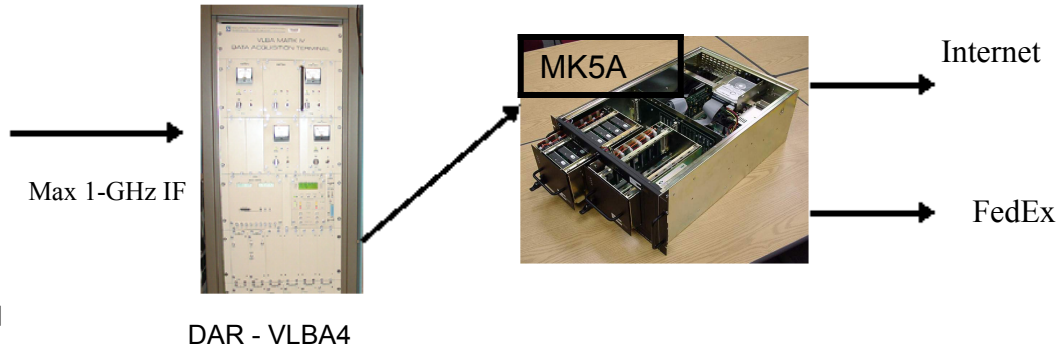


- **What Arecibo's 305-m contributes to VLBI observations with the present equipment**
- **Sensitivity upgrade:**
 - **Bandwidth => VLBI data Acquisition/recording**
 - **Integration time (limited) - phase referencing**
 - low slew rate of the 305-m dish
 - 12-m antenna

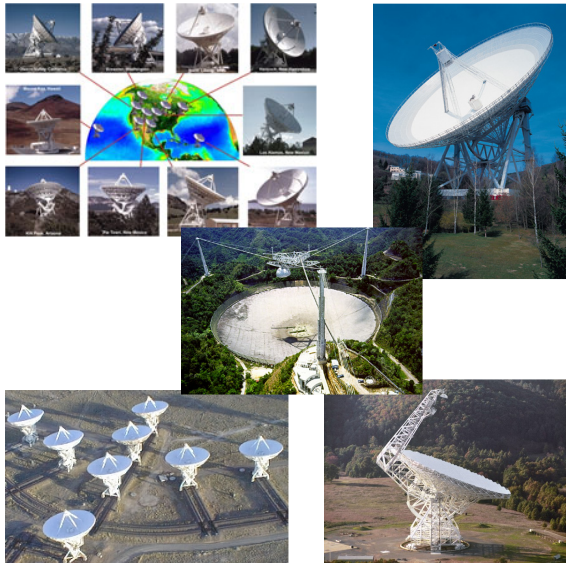
Existing Arecibo VLBI Capability



The Big Dish
(Gain~10k/Jy, SEFD~3-5 Jy)

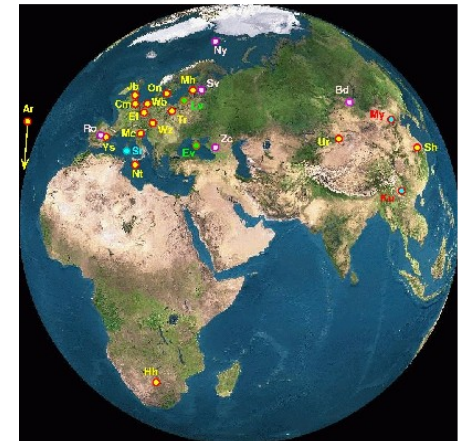


Receivers	Max. IF bandwidth/Rx	# of BBCs & Max $\Delta\nu$ /BBC	Total single-pol RF Bandwidth	Total data rate
327, 800, L, S-Lo, S-High, C, C-High, X	.05, .5 (#1,2 Rxs), 1 GHz	2 x 8, 16 MHz	256 MHz (max)	1024 Mbps



Co-Observing Networks:

1. **VLBA + Ar & the HSA**
(HSA, includes the phased-VLA, GBT, EF)
2. **European VLBI Network + Ar**
3. **Global - Network**
4. **eVLBI (Real-time VLBI via internet: as yet with the EVN only)**



Arecibo's Contribution to the Arrays

- A continuum observation, $\lambda=18\text{-cm}$, data-rate=512 Mbps, i.e. 128 MHz of RF bandwidth, dual-polarization, $t = 120$ minutes on source:

<i>HSA (VLBA+Y27+EF+GB+Ar)</i> <i>-Ar</i>	1σ Image noise = <i>3.3</i> $\mu\text{Jy/beam}$ <i>7.1</i> $\mu\text{Jy/beam}$
<i>EVN+Ar</i> <i>-Ar</i>	1σ Image noise = <i>3.8</i> $\mu\text{Jy/beam}$ <i>9</i> $\mu\text{Jy/beam}$
<i>Global (EVN+VLBA+Y27+Gb)+Ar</i> <i>-Ar</i>	1σ Image noise = <i>2.5</i> $\mu\text{Jy/beam}$ <i>4.7</i> $\mu\text{Jy/beam}$

- A spectral-line observation, $\lambda=18\text{-cm}$, 64 channels over 1-MHz, 2 pol, 120 min.

<i>EVN</i>	<i>EVN+AR</i>	<i>VLBA</i>	<i>VLBA+Y27+GB</i>	<i>VLBA+Y27+Gb+AR</i>
<i>0.9 mJy/beam/ch</i>	<i>0.31</i>	<i>3.0</i>	<i>0.62</i>	<i>0.25 mJy/beam/ch</i>

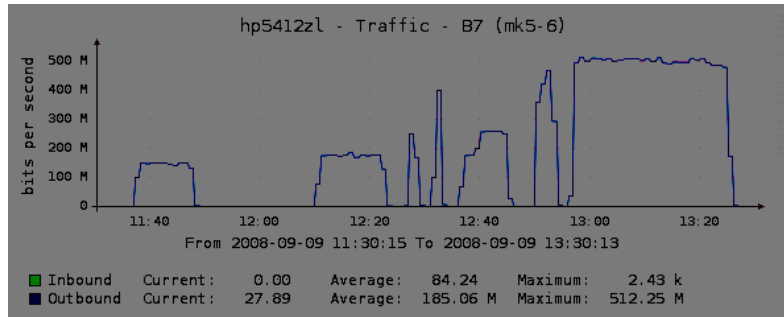


EVN Members MAG 03/2002

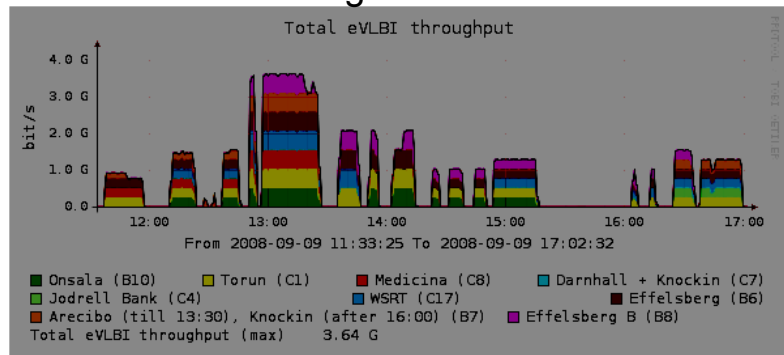
eVLBI : Test run at 512-Mbit/sec

First trans-Atlantic eVLBI fringes at a data rate of 512 Mbits/sec on 9 September 2008.

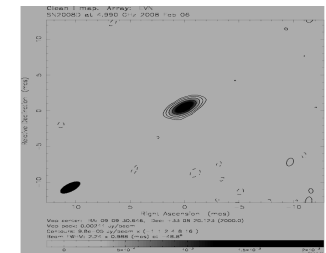
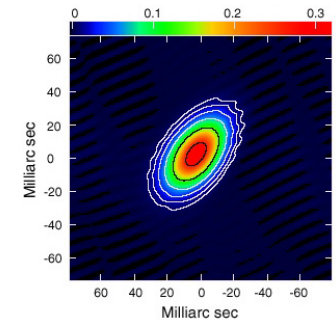
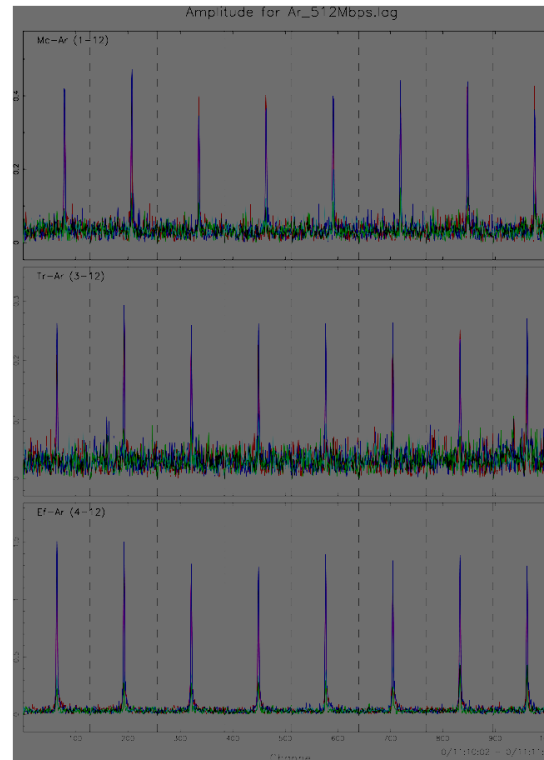
Data leaving Arecibo



Data arriving at JIVE



Arecibo Fringes with EVN Telescopes



øPRISANET (PR) of the Arecibo Obs./UPR.

øAMPATH (US) of Florida Intl. Univ.

øAbilene (US) of Internet 2.

øSURFnet (NL) of SURFnet BV.

Arecibo has a dedicated 200 Mbit/sec, Internet-2 connection. In addition, for eVLBI run it borrows ~300 Mbps from the University of PR's commodity internet, allowing data to be transferred at a rate of 512 Mbps.

Arecibo VLBI Sensitivity Upgrade

Increasing the US VLBI data recording rate to at least 4 Gbps by 2010 was a goal set by the Taylor Committee (2004).

Arecibo is in the process of:

1. Increasing the Recorded Bandwidth:

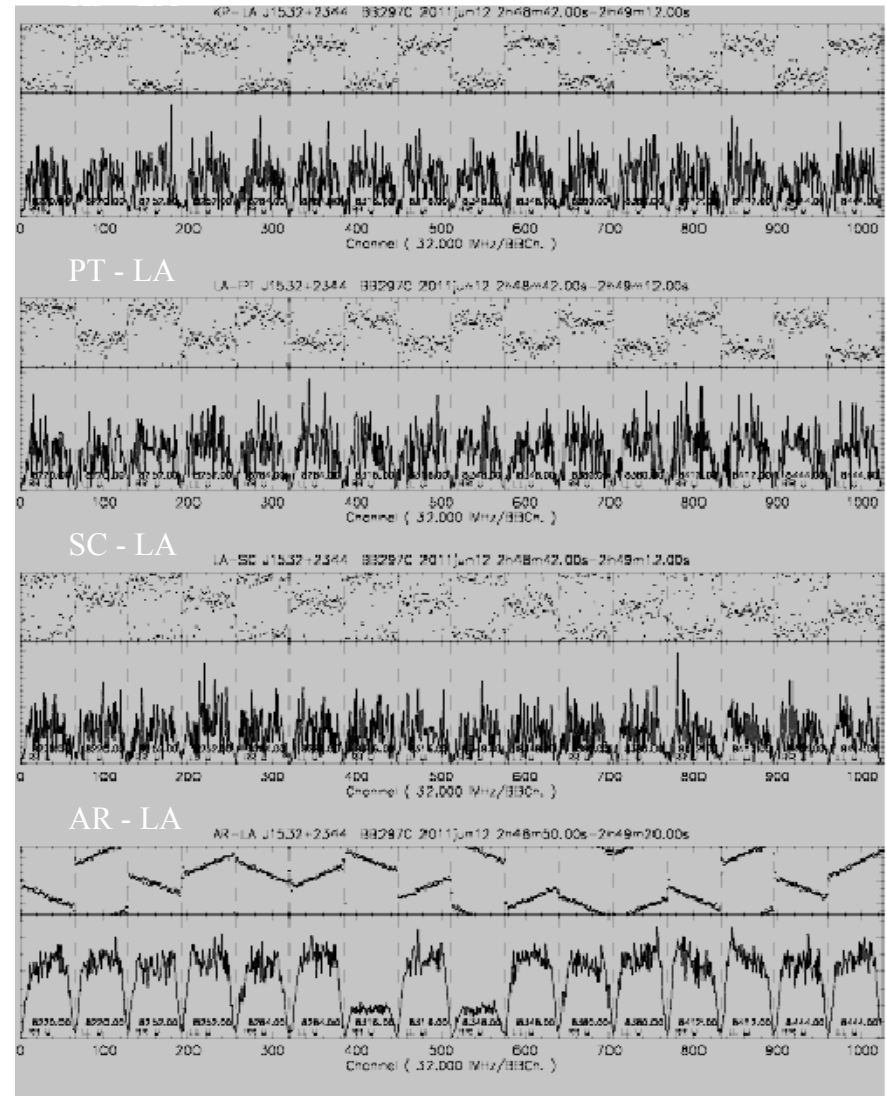
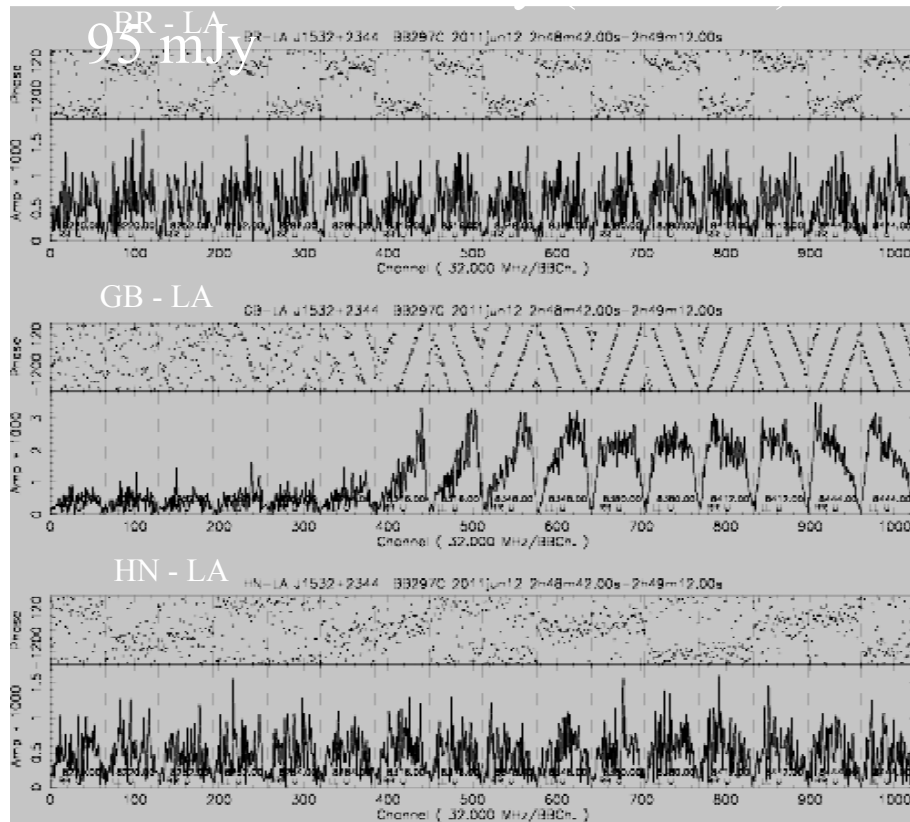
- (a) Replacing our analog DAR with a Digital Back End (RDBE). Arecibo has purchased two RDBEunits from NRAO.
- (b) Upgrading to Mark5C recording. Arecibo bought two Mark5C units from Conduant Corp.

One set of RDBE+Mk5C was successfully tested out (fringe plots coming up soon).

2. Increasing Integration Time:

The low slew rate of the 305-m dish can lead to $> 50\%$ loss of integration time in phase-referenced VLBI. The new Arecibo 12-m dish will track the phase-calibrator continually, while the 305-m tracks the target, just occasionally visiting the calibrator. Phases derived from the 12-m data will be applied to the 305-m data under the assumption that the same ionospheric corrections apply to both data sets.

MK5C Fringes to LA-VLBA (11 June, 2011)



The Arecibo 12-m Antenna

Why 12-m?: A 12-m antenna provides a baseline sensitivity within a factor of 2 of a VLBA dish. Sources brighter than ~ 110 mJy can be used for phase referencing.

Frequency Coverage: L, S, C & X bands are required for use with the 305-m dish; S/X bands are being installed initially. Thereafter, a 1 – 12 GHz broad-band front-end is anticipated.

Other Potential Uses: (a) Possible participation in regular VLBA operations, (b) Geodesy within the umbrella of VLBI2010; (c) The L-band, voltage beamwidth of the 12-m antenna contains all 7 ALFA beams, opening up the possibility of multi-beam interferometric applications, (d) Education and research applications with Puerto-Rican universities and other educational establishments.

The Arecibo 12-m Antenna



The Arecibo 12-m Patriot Antenna



Access Road (then nearing completion)



12-m Antenna Site

Observations will begin with a coaxial S/X feed, A wideband receiver (ideally 1 – 12 GHz) will be installed later. Will be able to cover $+90^\circ < \delta < -66^\circ$.

The 12-m Site

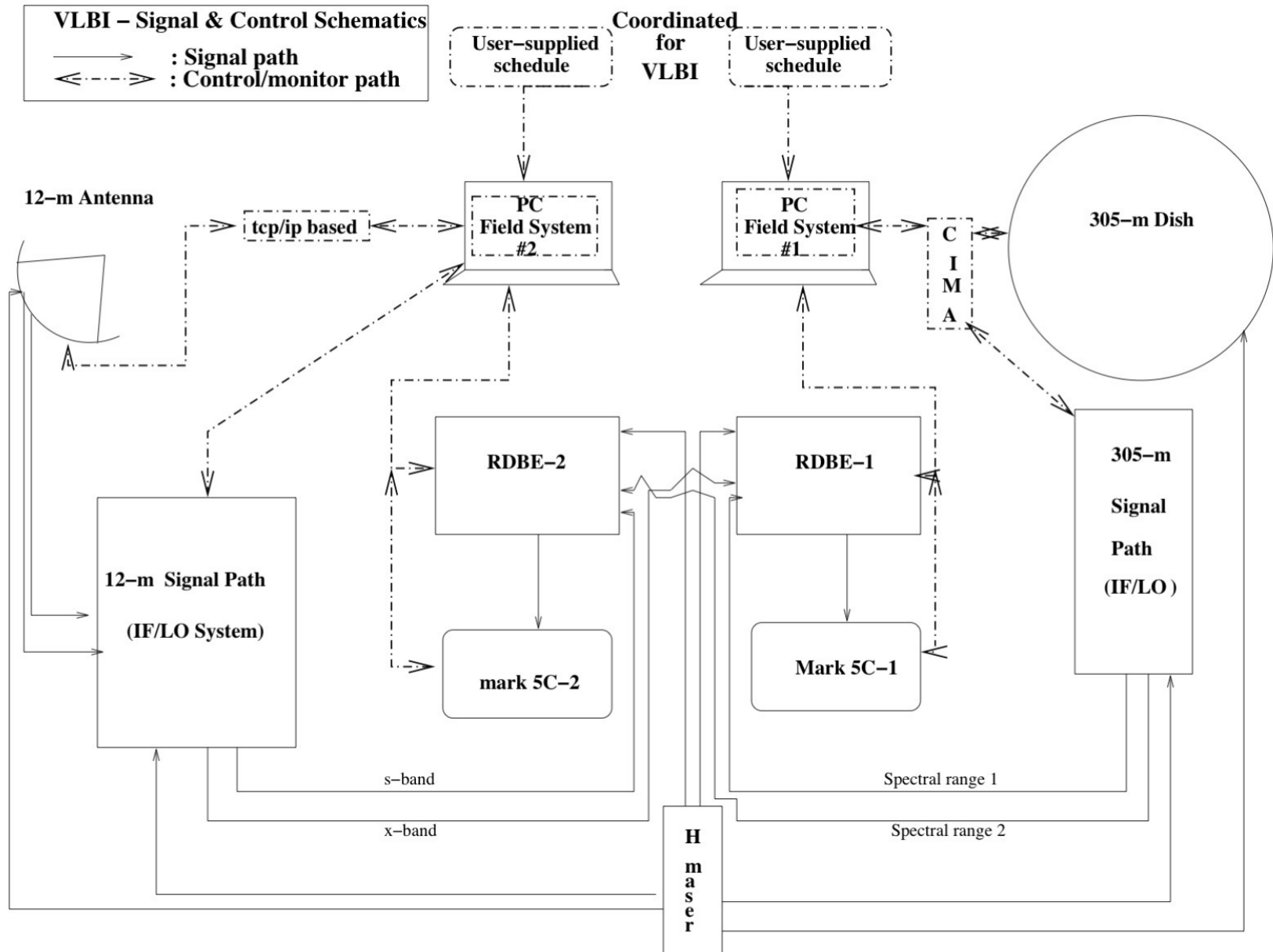
The AUT Patriot
12-m Antenna



*Science Areas: Astronomical VLBI with 305-m,
Stand-alone VLBI for astronomy, astrometry &
Geodesy, Single dish uses, and UG-teaching aid*



Operational block diagram (evolving)



The Small Antenna (12-m?)

Problem for the Big Dish: Slow slew rate of 305-m antenna can lead to >50% loss of time in phase referencing VLBI.

Solution? The nearby small antenna will track the calibrator continually, while the 305-m, tracks just the target, with occasional visits to the calibrator. Phase derived from the small antenna will be applied to the 305-m data under the assumption that the same ionospheric correction applies to both data sets.

How Big? - In order to provide a baseline sensitivity within a factor of 2 of an intra-VLBA baseline, the small antenna should be at least about 12-m. With this, sources brighter than 110 mJy can be used as a phase referencing calibrator.

Freq. Coverage - L, S, C & X bands are needed for astronomy; S/X for now. Eventually, 1 -12 GHz will be covered.

Slew Rate - For geodetic use, az slew rates of 5 deg/sec are required.

The Arecibo 12-m Antenna

- ***Current Status*** – The antenna has arrived at the Observatory, site preparation is basically finished, assembly work is about to begin. When commissioned, it will primarily be used for VLBI phase referencing, enhancing astrometric work.
(<http://www.aoc.nrao.edu/events/astrometry>)
 - ***Freq. Coverage*** – An S/X receiver has been ordered from Patriot Antenna Systems Inc. This will be supplemented later by C- (and L-band) systems. It is intended that a broadband system will eventually be installed.
 - ***Single Dish Uses*** – Education and research applications with Puerto-Rican universities and other educational establishments.
 - ***Other Uses*** – (a) Participation in VLBI2010; (b) At L-band, the voltage beam-width of a 12-m antenna contains all seven beams of the ALFA receiver, opening up a possibility of multi-beam interferometric applications.
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