

VLA Bracewell "Radio Sundial" Timeline

December 1955	Ron Bracewell joins Stanford University
1955 or '56	initial funding for 32 10-ft dish microwave spectroheliograph from Air Force Office of Scientific Research
1958	East-West arm finished; first data
April 1960	'Heliopolis' opens at Stanford; 3.1 arcmin resolution solar maps at 9.1 cm (3290 MHz). This is the first antenna system to make maps exceeding the resolution of the human eye!
1962-73	12 years of daily solar maps (on ~90% of all days)
1973	Bracewell adds an array of five 60-ft dishes to the observatory.
1980	32-dish array decommissioned at Stanford, with over 200 signatures recorded on the supporting piers.
March 1997	Bracewell and son Mark build Stanford sundial for wall of Terman Engineering Building at Stanford University (refurbished and relocated in 2013 to wall of Jen-Hsun Huang Engineering Center).
Summer 2004	Site clearing begins after Stanford fire marshal declares it a hazard; protests by many (led by Bob Lash and his Friends of the Bracewell Observatory) are able to delay planned demolition of 60-ft dishes and control bldg
10 March 2006	The five 60 foot dishes nevertheless demolished at Stanford (but not the 32 support piers of the original array); Bracewell video interview by Keri Kukral
1-2 February 2007	Libby and Miller Goss visit Helen and Ron Bracewell in Palo Alto. Ron and Miller discuss the history of Australian radio astronomy over several days and discuss the piers of the decommissioned spectroheliograph – in particular the signatures.
12 August 2007	Ron Bracewell dies (age 86) in Palo Alto of a heart attack.
6 November 2007	Memorial service at Stanford Memorial Church
24-25 July 2009	Libby and Miller Goss visit Palo Alto, organized by Bob Lash (President of the FBOA- Friends of the Bracewell Observatory Association) and Mark and Wendy Bracewell, children of Ron and Helen. Visit's primary purpose is to organize Bracewell's archives to send to the NRAO archive. Of great interest were Ron's letters to and from his mother during 1946-49 while Ron was at the Cavendish Lab, University of Cambridge. The idea of moving some of the piers to the VLA (for the historical signatures) stemmed from Miller's discussions with Bob and Mark after this visit.
24 March 2010	Judy Stanley, head of NRAO EPO, and Miller Goss discuss the possibility of using the piers for a sundial. At Miller's suggestion, Judy contacts Woody Sullivan,

astronomy professor at the University of Washington and sundial expert, to learn more. Woody, a colleague of Ron's through SETI, is enthusiastic. (In 1994 Woody had designed an elaborate radio-astronomy-themed sundial for the wall of the AOC building in Socorro, but could not raise the needed funds.)

- 28 March 2010 Miller and Woody have long telecon on first ideas for how to incorporate the piers into a sundial on the VLA site.
- 28 April 2010 Woody writes "Some Ideas for displaying the Bracewell Signature Piers as a 'Radio Sundial' " (Appendix A at end). This marks a turning point toward the configuration we see today, rather than a design using a radio receiver/antenna. The latter idea was dismissed due to cost, reliability and maintenance issues.
- April 2010 Peggy Perley, Assistant Director of VLA, and Bob Dickman, VLA/VLBA director, give tentative approval for the VLA to obtain the piers and build a Radio Sundial.
- January 2011 Woody's doc of 4/28/10 extended on 1/6/11. By the end of the month, specifications for the Sundial tentatively fixed.
- 16 February 2011 First conference call of all major parties, including Guy Stanzione, engineer in charge of the sundial project, Chris Langley, VLA site director, Judy, Miller and Woody
- 1 April 2011 Goss requests \$12.5K for sundial project from AUI head Schreier
- 4 May 2011 Stanford approves the removal of 10 piers plus the one surviving 10-ft dish. Extensive discussions on the choice of *which* piers are to be saved is guided by a partial list of signatures and piers made by Bracewell, as well as *in situ* inspection by Bob Lash.
- 13 July 2011 Exact site chosen at the VLA.
- 17 December 2011 Dick Thompson, an NRAO scientist and a member of the Friends of the Bracewell Observatory group, expresses concern about calling the sundial a 'radio sundial'. Woody explains the sundial to Dick, while noting that the project is a convergence of two of his and Ron's shared passions—radio astronomy and sundials!
- 23-26 July 2012 Piers and dish are "extracted" from original positions (after more than 50 years) under supervision of Bob Lash. Poison oak and more that had grown over the piers (photo at end as Appendix B) removed by one contractor, and the piers cut off at the base and removed by another contractor.
- 27-30 July 2012 Piers and dish are trucked from Stanford to VLA.
- 14-16 August 2012 Woody visits the VLA and the AOC for an initial mockup, using 7 of the piers. He lays out north-south & east-west lines using his transit, and gives talks at the AOC and the VLA: "The Astronomy and Art of Public Sundials, including the New 'Radio Sundial' Coming to the Plains of San Agustin." No final decision yet on treatment of tops of piers. All other major aspects of final design fixed.

29 Sept 2012	Judy and Miller give talk to The Albuquerque Astronomical Society (TAAS) in Albuquerque.
March 2013	Cleaning and identification of the signatures begins; stainless steel disks engraved in Seattle and shipped to VLA
April 2013	Design specs finalized by Woody and Guy.
17 April 2013	Since only 9 piers needed for the sundial itself, decision made on the location of the nearby 10 th pier (the Lovell pier) and the 10-ft dish. Three concrete pours for sundial pad. Small footings constructed for outlying markers and two of the piers.
6-8 May 2013	Intensive visit by Woody to place (with crane) the 9 piers of the sundial. Locations and orientations of piers chosen by Miller and Woody to optimize signature locations. Gnomon pole & sphere erected. Exact positions determined for all markers on the concrete pad by measuring (x, y, r) from reference lines and gnomon.
7 June 2013	The NM Tech astronomy club paints the signatures with Judy, Kathy Jones, and her sister. Dan Klingsmith, NMT astronomy professor and adviser to the astronomy club, also assists.
19-21 June 2013	Third visit by Woody. Check of all disk positions, etc. Small spheres on tops of piers need "help"; decided to make rust pyramids as apparent supports; these completed by early August.
late June 2013	All disks installed.
July 2013	Large ornate central disk, designed by Judy, engraved in Albuquerque and installed. Sundial is finished!
23 Sept 2013	Sundial's inauguration on the day after the autumn equinox (to avoid having it on a Sunday) — sunny and breezy. Tony Beasley, director of NRAO, and Woody speak at event, along with Ron Bracewell's children Mark and Wendy. Moreau Jansky Parsons (daughter of Karl Jansky), Stuart Pawsey (son of Joe Pawsey), and two signatories (Barry Clark and Barney Ricketts) also attend.

Appendix A

“Some Ideas for displaying the Bracewell Signature Piers as a ‘Radio Sundial’ ”

— Woody Sullivan (U. Washington), 28 April 2010

It is marvelous that the VLA may well become the final home for the piers from the Stanford spectroheliograph built by Ron Bracewell in the late 1950s. Ten of these piers (which each are ~6 ft high and slope from 18 to 12 inch square in cross-section) are particularly valuable for the history of radio astronomy because about 200 names of radio astronomers (and others) were chiseled into the sides of the concrete piers by visitors to Stanford, including many of the pioneers of early radio astronomy (Lovell, Ryle, Pawsey, Bolton, Mills, etc.).

I propose to display these at the VLA site so that they are part of a unique working sundial, one that will refer to the strongest radio sources that were vital for the development of early radio astronomy and are still important today. The basic scheme centers on having a sphere (12-inch diameter) mounted on top of one of the piers. The shadow of this sphere falling on markings on the ground allows both the time and date to be read. The size of this pattern at the VLA's latitude would be ~10 ft square (which might best be a concrete pad). The remaining piers (now expected to be ten in total) could best be used as an attractive arc of "label holders" for the sundial's hour-lines, i.e., they would hold (perhaps as a 3-dimensional object on top) the 8, 9, 12, 1 values of the hours. The markers on the ground that define the hourlines and lines for the solstices and equinoxes might be bronze or stainless steel disks embedded in the soil.

The radio aspect of this dial is that it would refer not only to the sun, but also to the 3-6 strongest radio sources. It would do so by markings on the ground that refer to the location of the (invisible!) radio shadow (cast by the central sphere) of each radio source as it travels across the VLA's sky. The usual datelines on a sundial are defined of course by the annual change of declination of the sun, so to calculate the radio source lines, one simply uses the declination of the sources. One then has values well outside the sun's declination range, since Sgr A is at -29° and Cen A at $+43^\circ$, while Cas A is at $+58^\circ$. Cas A is particularly nice because it is so far north that it is circumpolar and therefore its trace on the ground is not an hyperbola, but an ellipse, and also totally to the south of the usual pattern (on the north side of the sphere). Explanatory plaques would comment on the key persons with signatures, on how to read the sun/radio dial, and on the radio sources, perhaps comparing the first crude maps with the latest VLA maps.

Appendix B

A sample pier at Stanford

