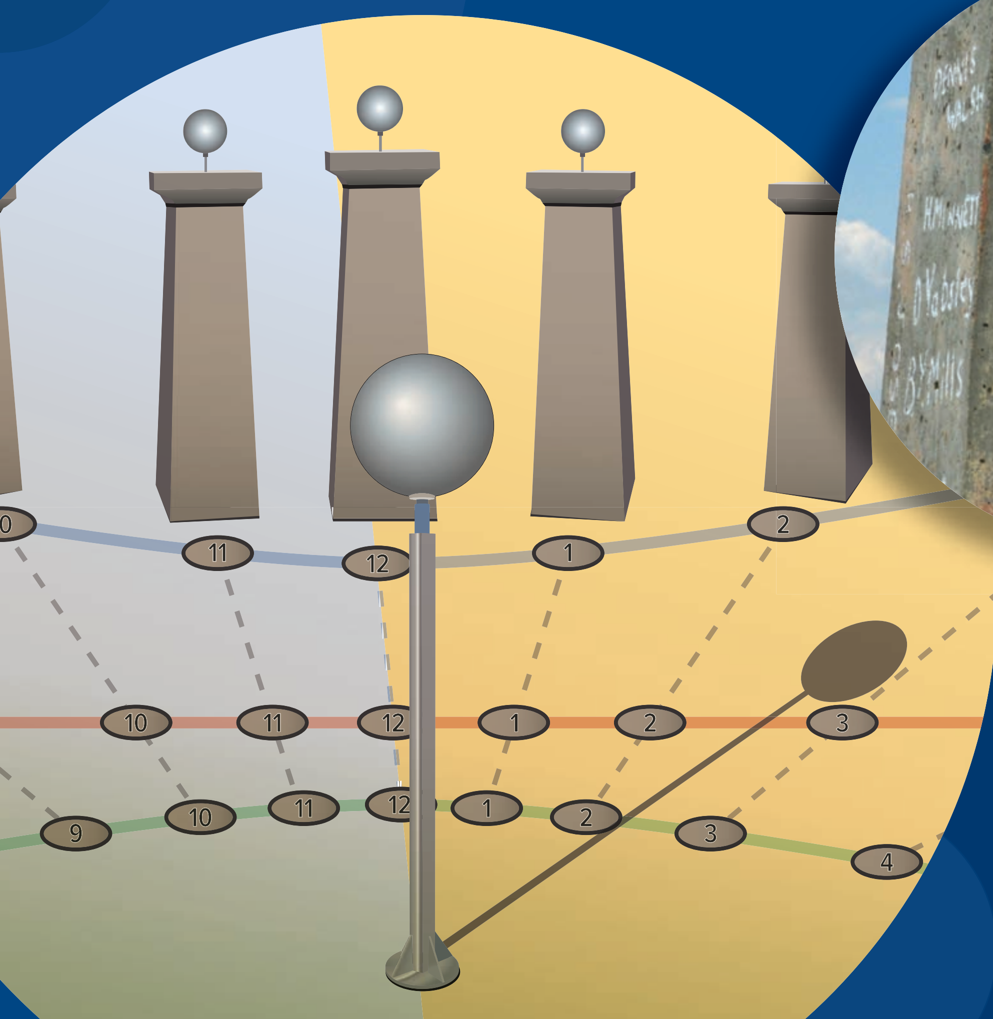
The Bracewell Radio Sundial

Sundials use the location of a shadow to indicate the time of day. As the Sun moves from east to west through the sky, an upright object's shadow will trace a moving path. Marks made along this path will indicate the time, as the shadow crosses the marks.

Sundial and pier photos by Robert Dickman

The time shown by a sundial will differ from what your watch indicates, for these reasons:

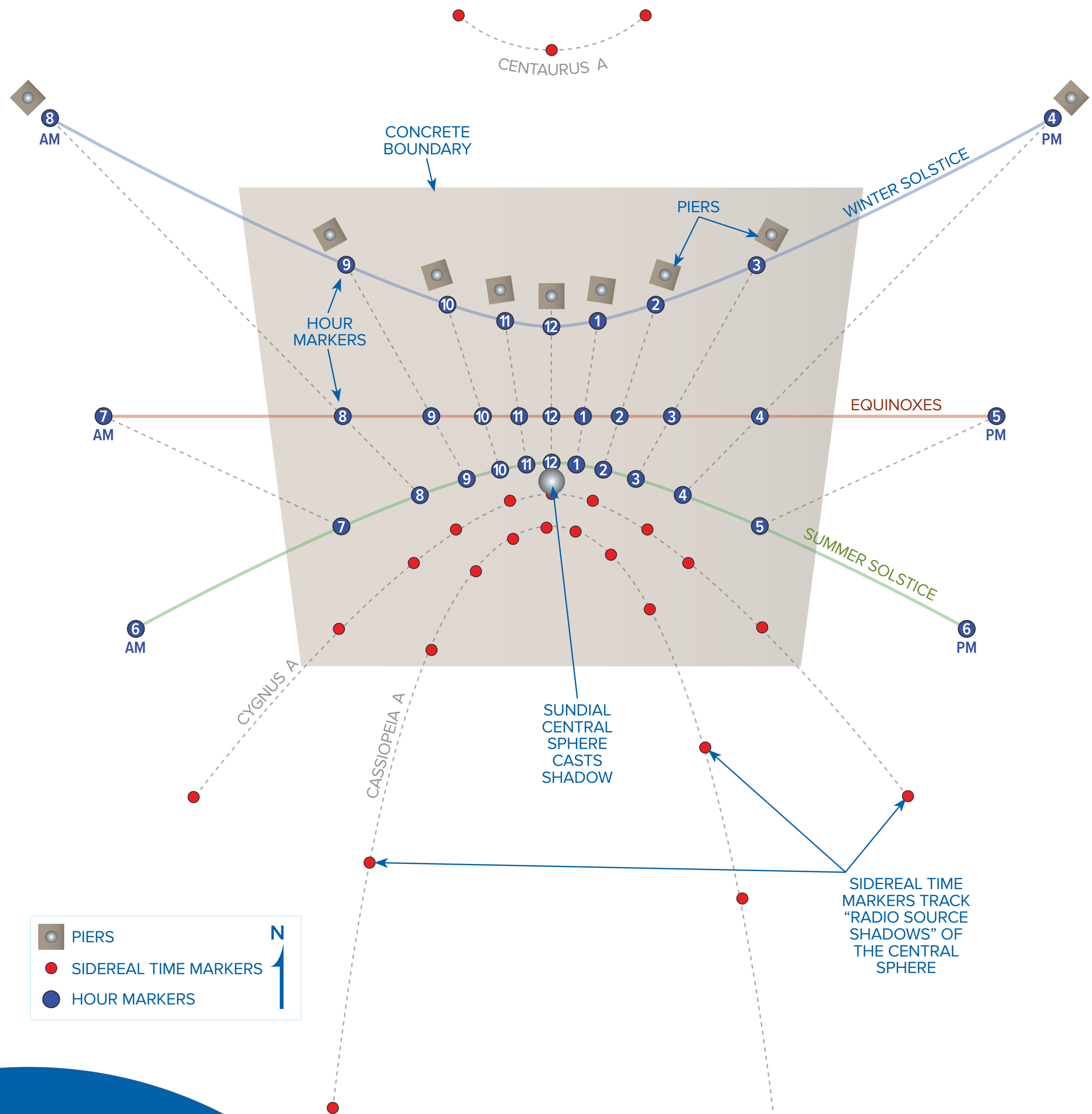
- The sundial shows the solar time for this specific location, not the standard time defined for a single location within each time zone.
- The Sun moves through the sky at a slightly different rate at different times of year.
- Daylight Saving Time will add one hour to the solar time. *See the graph at the bottom of page 2 for today's difference between sundial and clock time.*

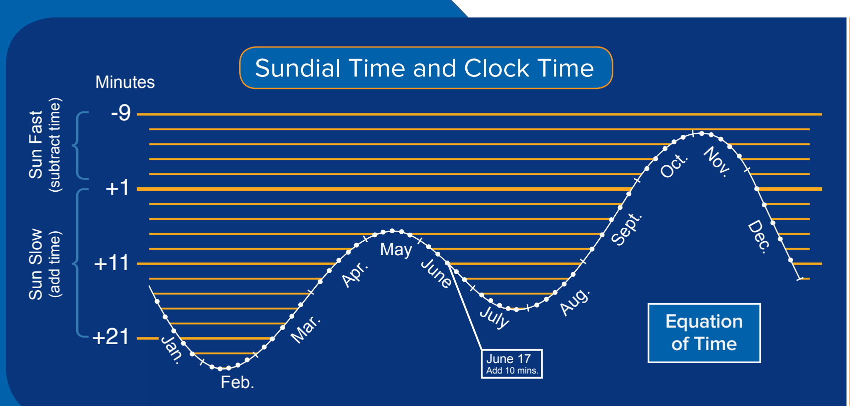


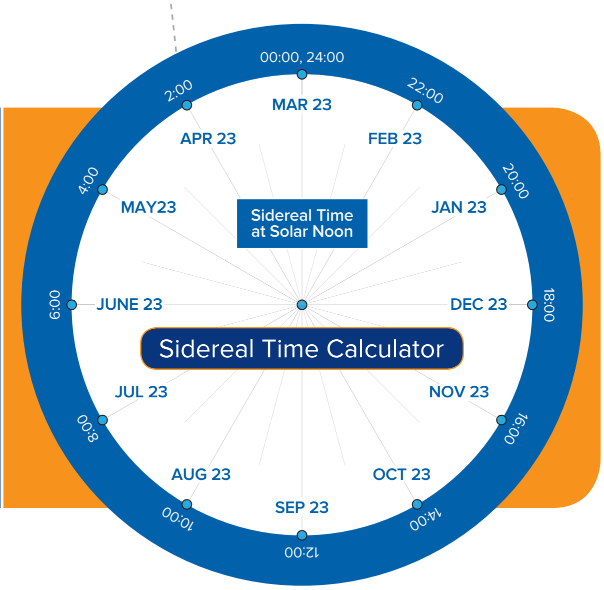
National Radio Astronomy Observatory

NRAO

www.nrao.edu


CENTAURUS A
CONCRETE BOUNDARY
PIERS
WINTER SOLSTICE
HOUR MARKERS
EQUINOXES
SUMMER SOLSTICE
8 AM
4 PM
7 AM
5 PM
6 AM
6 PM
CYGNUS A
CASSIOPEIA A
SUNDIAL CENTRAL SPHERE CASTS SHADOW
SIDEREAL TIME MARKERS TRACK “RADIO SOURCE SHADOWS” OF THE CENTRAL SPHERE
PIERS
SIDEREAL TIME MARKERS
HOUR MARKERS
N


Sundial Time and Clock Time
Minutes
Sun Fast (subtract time)
Sun Slow (add time)
-9
+1
+11
+21
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
June 17
Add 10 mins.
Equation of Time


00:00, 24:00
22:00
20:00
18:00
16:00
14:00
12:00
10:00
8:00
6:00
4:00
2:00
MAR 23
FEB 23
JAN 23
DEC 23
NOV 23
OCT 23
SEP 23
AUG 23
JUL 23
JUNE 23
MAY23
APR 23
Sidereal Time at Solar Noon
Sidereal Time Calculator

A complex array transforms radio skies;
A creeping shadow shows us time flies.

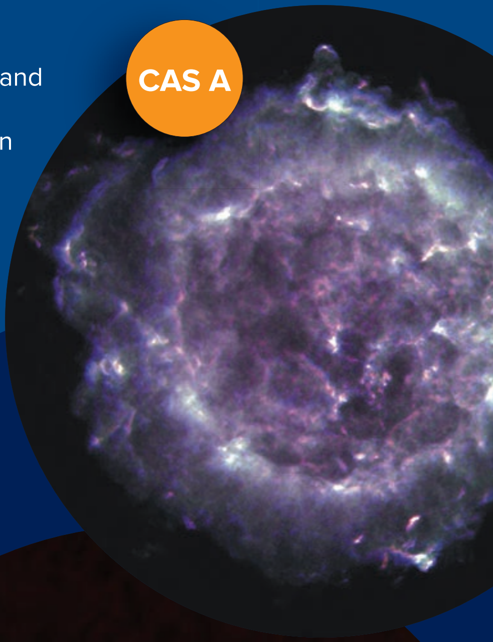
Using the Bracewell Sundial

The Bracewell Sundial has a large sphere mounted atop a slim metal post. Locate this sphere and note where its shadow falls. There are three major sets of markers -- metal disks -- set into the concrete that mark the hours from 8 a.m. to 4 p.m. at four dates of the year. The disks labeled “Summer Solstice” show the time on June 21; the disks labeled “Winter Solstice” are for December 21; and the disks labeled “Equinoxes” are for March 20 and September 23. Small, diamond-shaped markers indicate the hours at intermediate dates, such as July 21, August 21, etc. The sphere’s shadow thus indicates not only the time of day but also, roughly, the time of year. All the markers for a particular hour, the round disks and the diamonds, trace a line toward one of the concrete piers.

The markers for the Summer Solstice are closest to the central sphere and its post, with the markers for the Winter Solstice the farthest, and the ones for the Equinoxes in between.

Small square markers indicate important dates in the history of radio astronomy. The center of the sphere’s shadow crosses these markers on the exact date commemorated on that marker. Other small markers are in the shape of dish antennas. When the sphere’s shadow crosses these markers, it is solar noon at the observatory noted on that marker.

The Sundial and the Radio Sky



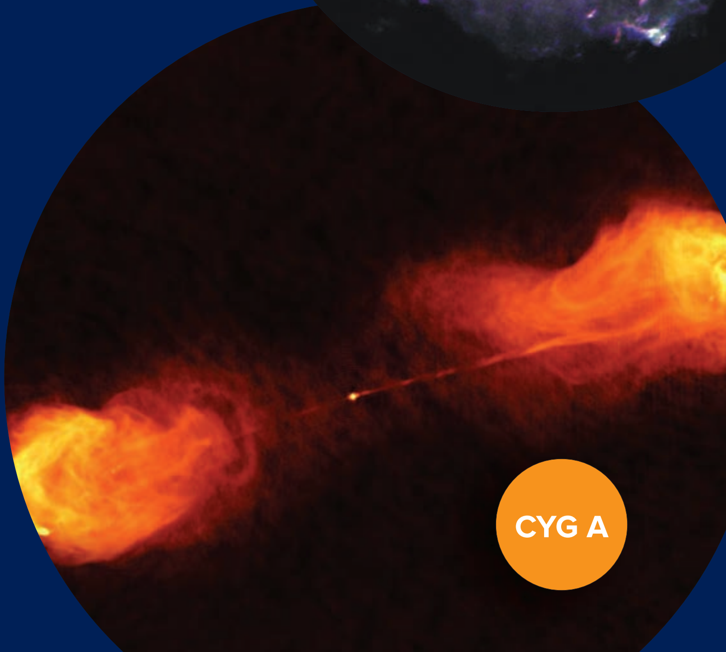
Other markers allow you to find the current location in the sky of three prominent and important objects for radio astronomers. These are Centaurus A (Cen A), a galaxy about 9 million light-years from Earth; Cygnus A (Cyg A), a galaxy some 600 million light-years away; and Cassiopeia A (Cas A), the remains of a stellar explosion in our own Milky Way Galaxy, about 11,000 light-years from Earth. The markers for Centaurus A are north of the main portion of the sundial, while those for Cygnus A and Cassiopeia A are south of the sundial’s main area.

To find the location of these objects in the sky, you first must determine the local sidereal time, or star time, which differs from the solar time we normally use. See the chart (left) to determine the sidereal time at noon for this time of year, then add or subtract hours as necessary for the current time of day. Sidereal time is measured in the 24-hour system.

Next, check to see if any of the radio objects are currently above the horizon. Those sidereal times are:

Centaurus A: 12:30 to 14:30
Cygnus A: 13:00 to 24:00 and 00:00 to 03:00
Cassiopeia A: 13:00 to 24:00 and 00:00 to 09:00

If any of those objects currently are above the horizon, you may locate their position by finding the marker for that object that corresponds most closely to the current sidereal time. If you place your eye next to that marker and look up toward the large sphere on the metal post, the radio object will be behind the sphere in the sky. If you could see radio waves instead of light waves, you would be putting your eye in the “radio shadow” of the object.



The Sundial's Namesake: Ronald N. Bracewell (1921-2007)

An Australian native, Ron Bracewell received his Ph.D. from Cambridge University in England. During World War II, he worked in Sydney designing radar equipment. After the war, he turned his expertise in physics and electronic engineering toward establishing Australia as an early world leader in the emerging field of radio astronomy.

In the 1950s and 1960s, Bracewell made major contributions to developing the mathematical techniques for combining the radio signals received by multiple antennas to produce detailed images of astronomical objects. These techniques remain at the heart of how the VLA and many other radio telescopes operate today. In addition, Bracewell applied these mathematical techniques to developing Computer-Assisted Tomography (CAT) scans for making images of the interior of the human body. He was honored for his pioneering work in producing that valuable medical tool.

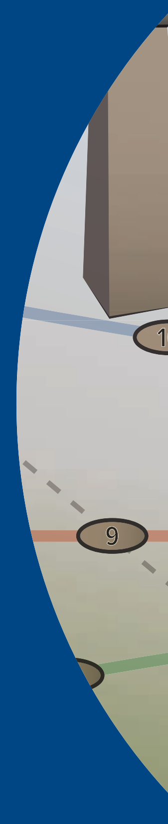
Bracewell became a professor at Stanford University in 1955. At Stanford, he built a radio telescope using 32, 10-foot-diameter dish antennas, one of which is mounted south of the sundial. He used this system to study the Sun and to refine his mathematical techniques. For a decade, beginning in 1961, Bracewell monitored variations in the Sun's radio emission on a daily basis. In addition to helping understand the Sun's workings, his system provided warnings of solar bursts that could affect satellites and endanger the Apollo astronauts during their voyages to the Moon.

A man of many interests, he wrote about such disparate subjects as trees and the search for extraterrestrial intelligence. He designed several sundials, including one that remains on a building at Stanford.

The Concrete Piers and the Signatures

Each of the dish antennas of Bracewell's Stanford radio telescope sat atop a concrete pier. He invited his visitors to use a chisel and "sign" their names to one of the piers. Over a 20-year period, he accumulated more than 220 of these signatures. Those who "signed" his piers included two Nobel Prize recipients, directors of observatories, both radio and optical, from around the world, and many of the early pioneers of radio astronomy who established that field in the years following World War II.

Bracewell's antenna array was abandoned in 1980. In 2012, with help from generous donors, ten of the piers were sawed off and shipped here to the VLA, to become part of this sundial. The piers here at the VLA contain approximately 220 signatures, including some in Chinese, Russian, and Greek. In the Visitor Center, you may borrow a list of the names on these piers, along with short descriptions of their careers.



The Ronald N. Bracewell Radio Sundial was designed by Dr. Woody Sullivan of the University of Washington and was opened on the Autumn Equinox of 2013. Historic piers and antenna dish were donated to the National Radio Astronomy Observatory (NRAO) for this purpose by Stanford University. Funding was provided by Friends of the Bracewell Observatory Association (Bob Lash, M.D., President), Associated Universities, Inc. (AUI), and the National Science Foundation (NSF). NRAO Project Lead: Dr. Miller Goss | Project Engineer: Guy Stanzione | Project Coordinator, Judy Stanley. The NRAO is a facility of the NSF operated under cooperative agreement by AUI.