Some ISR History (US)

Why VHF to UHF frequencies?

- To determine Te/Ti, want to retain double humped spectral shape (related to Debye length) – sets minimum wavelength:

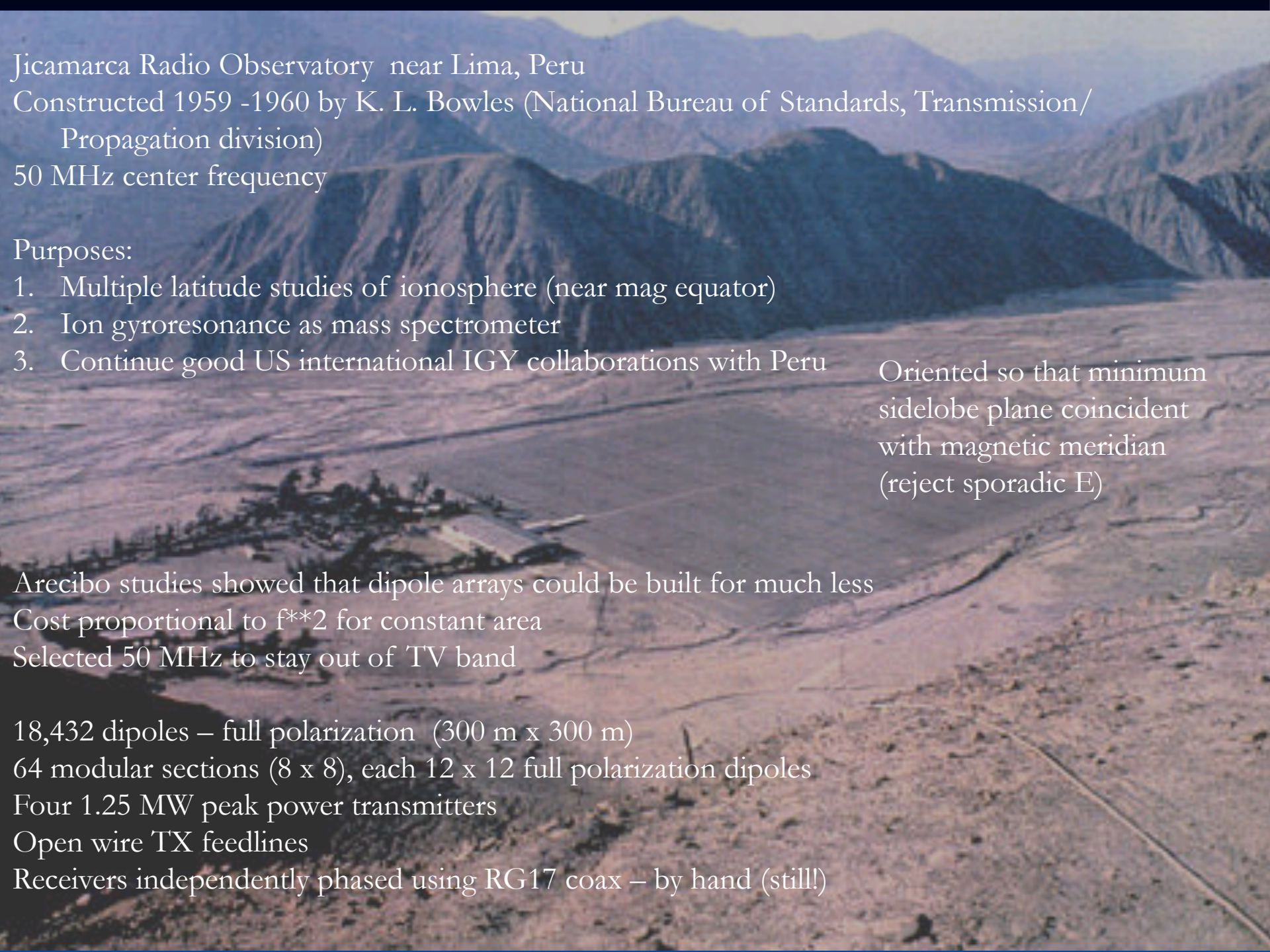
Region	Height, km	N, m-3	Te, K	Minimum wavelength, cm
E	120	1E10 1E11	300 300	25 10
F1	200	1E11 1E11	2000 3000	25 15
F2	300	1E11 1E12	2500 2500	25 7.5
Topside	1000	1E10	3000	95

- Cosmic background noise decreases but spectral width increases (larger bandwidth needed) as frequency goes up

Result: ~ meter scale wavelength ranges ideal for IS radar to probe to 1000 km

Incoherent Scatter Radars


Jicamarca Radio Observatory near Lima, Peru
Constructed 1959 -1960 by K. L. Bowles (National Bureau of Standards, Transmission/
Propagation division)
50 MHz center frequency



Jicamarca Radio Observatory near Lima, Peru
Constructed 1959 -1960 by K. L. Bowles (National Bureau of Standards, Transmission/ Propagation division)
50 MHz center frequency

Purposes:
1. Multiple latitude studies of ionosphere (near mag equator)
2. Ion gyroresonance as mass spectrometer
3. Continue good US international IGY collaborations with Peru

Oriented so that minimum sidelobe plane coincident with magnetic meridian (reject sporadic E)

Arecibo studies showed that dipole arrays could be built for much less
Cost proportional to f**2 for constant area
Selected 50 MHz to stay out of TV band

18,432 dipoles – full polarization (300 m x 300 m)
64 modular sections (8 x 8), each 12 x 12 full polarization dipoles
Four 1.25 MW peak power transmitters
Open wire TX feedlines
Receivers independently phased using RG17 coax – by hand (still!)

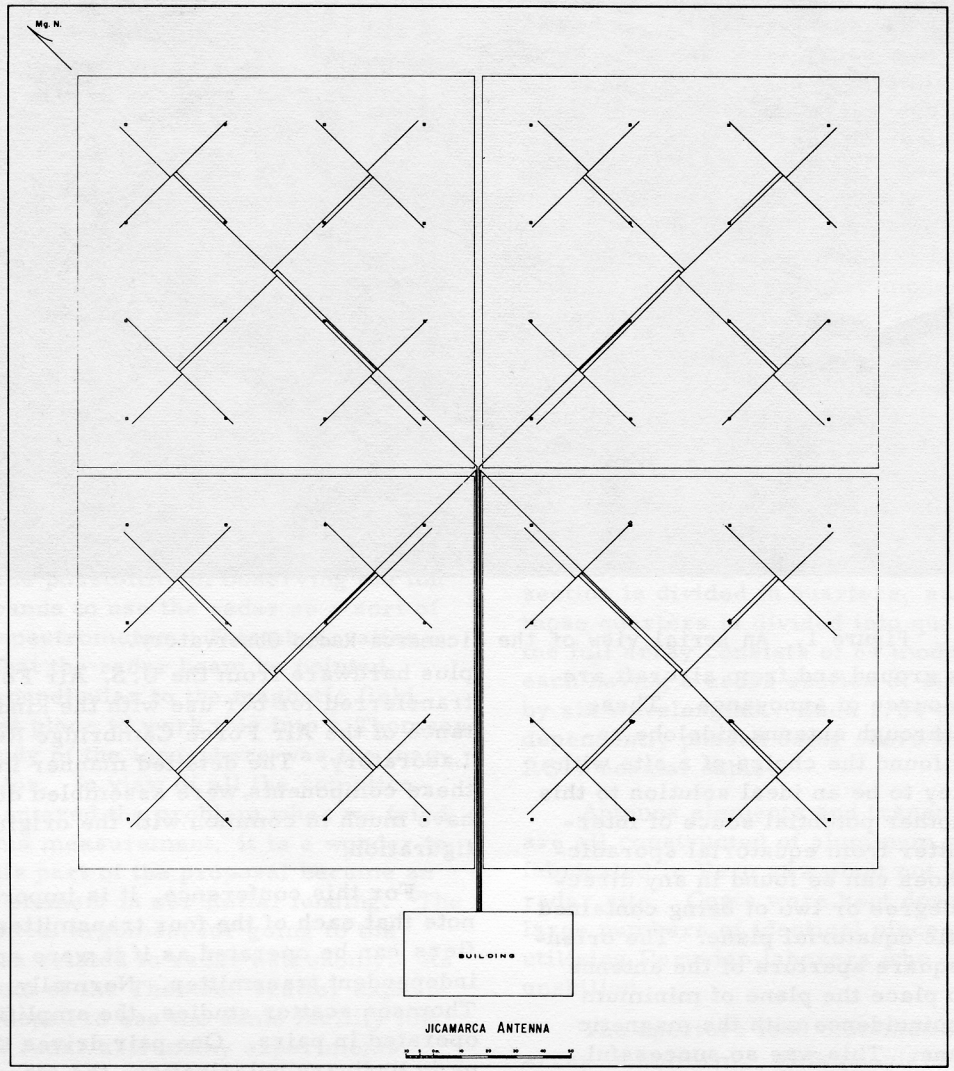
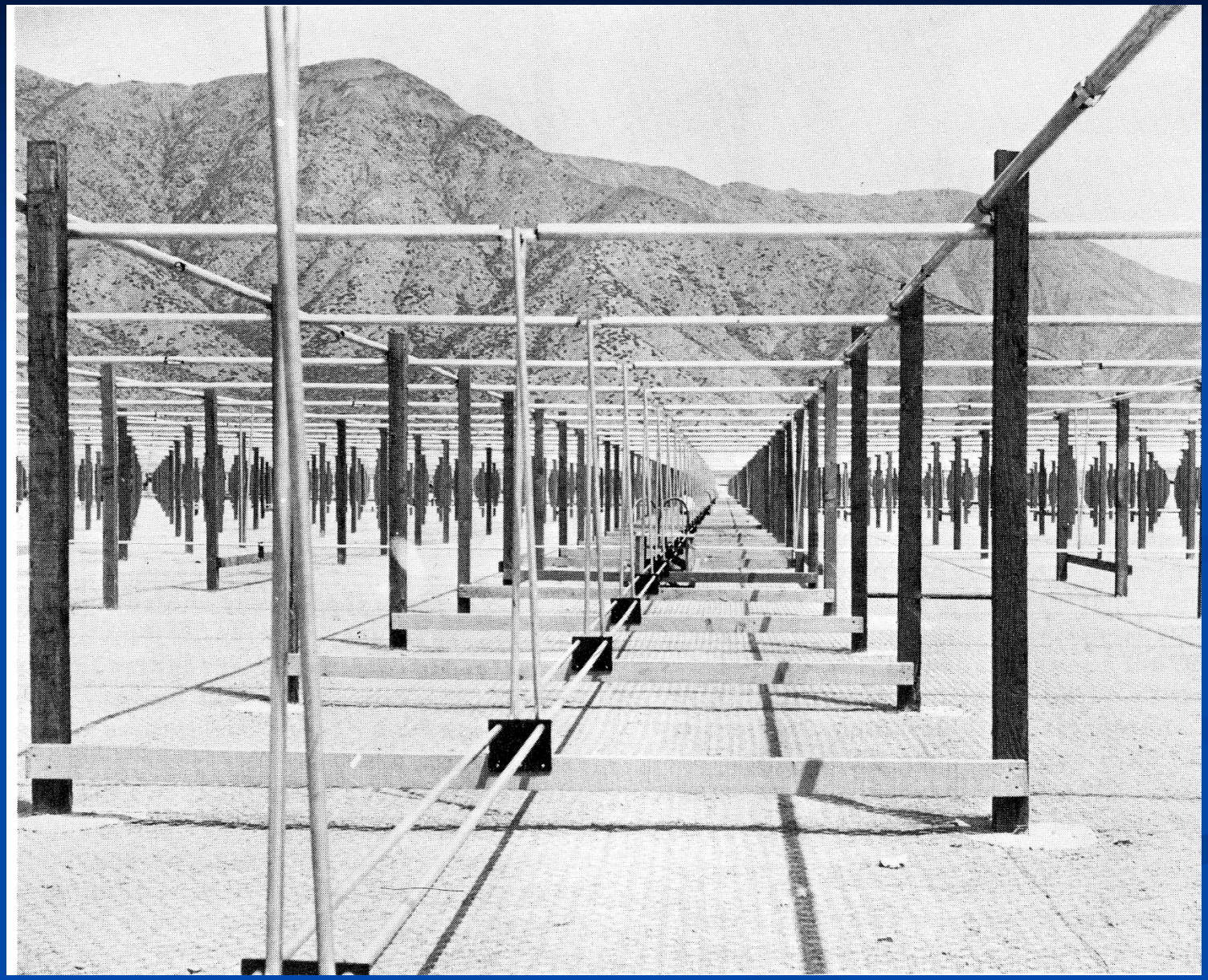
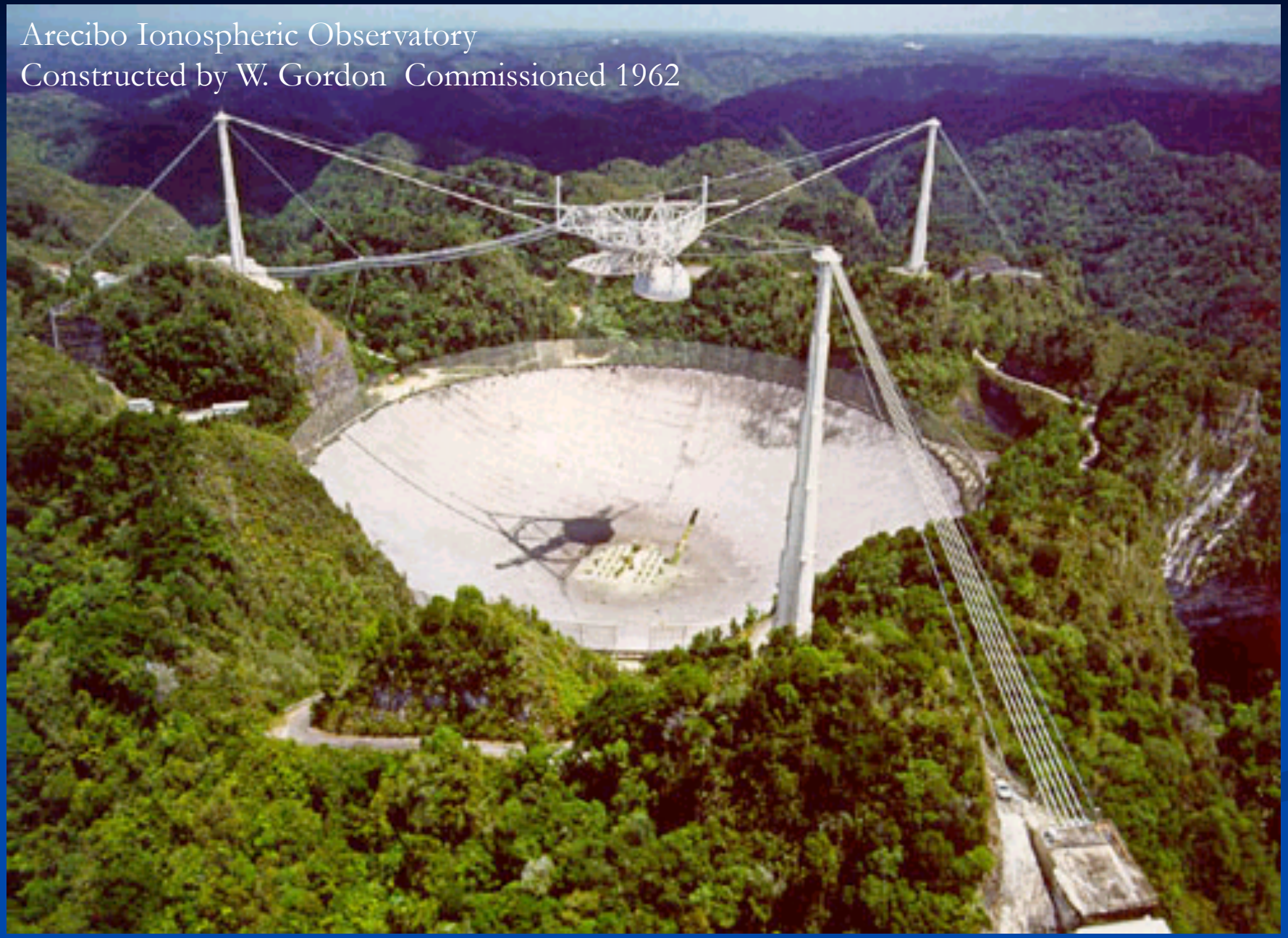
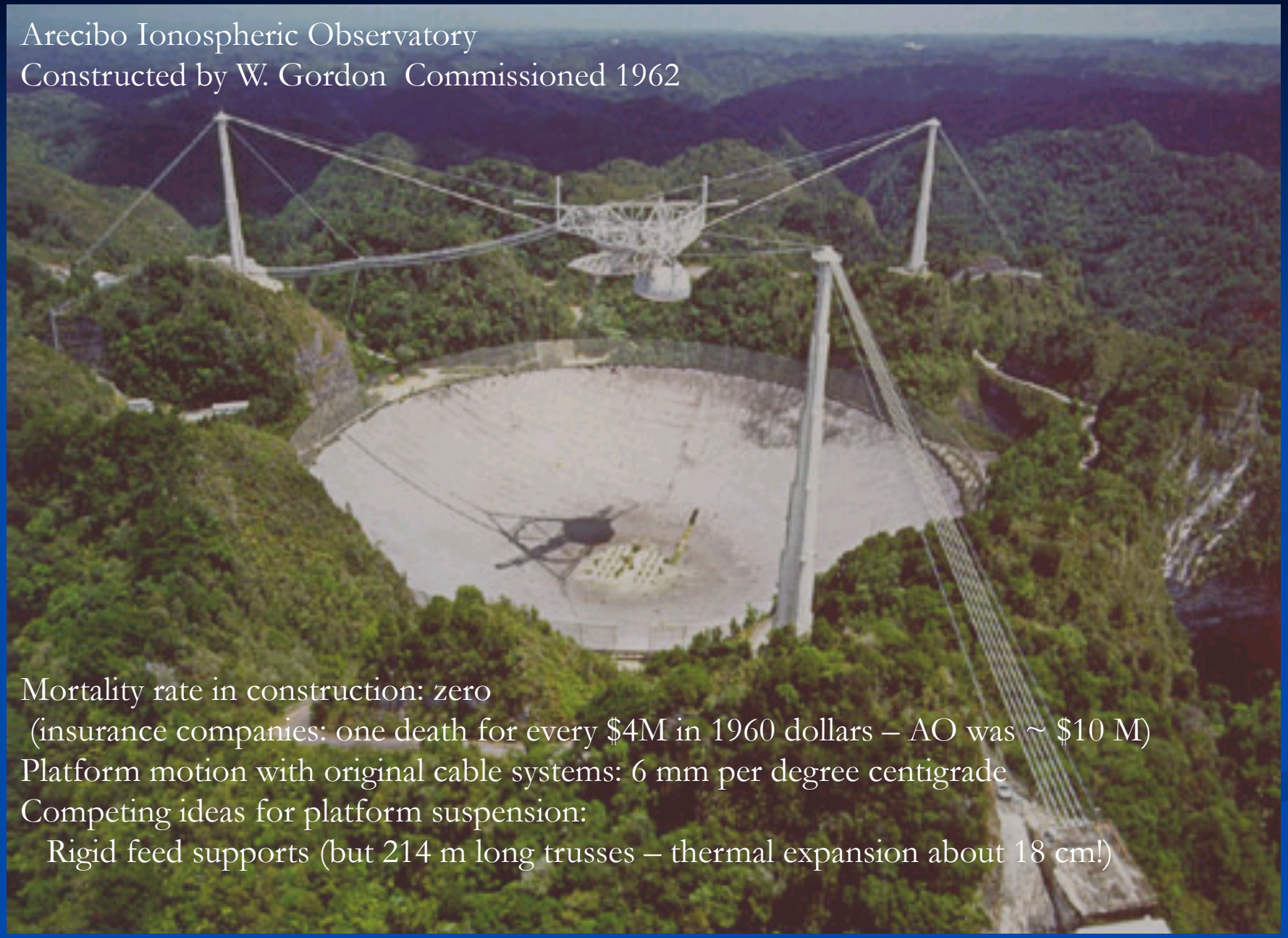


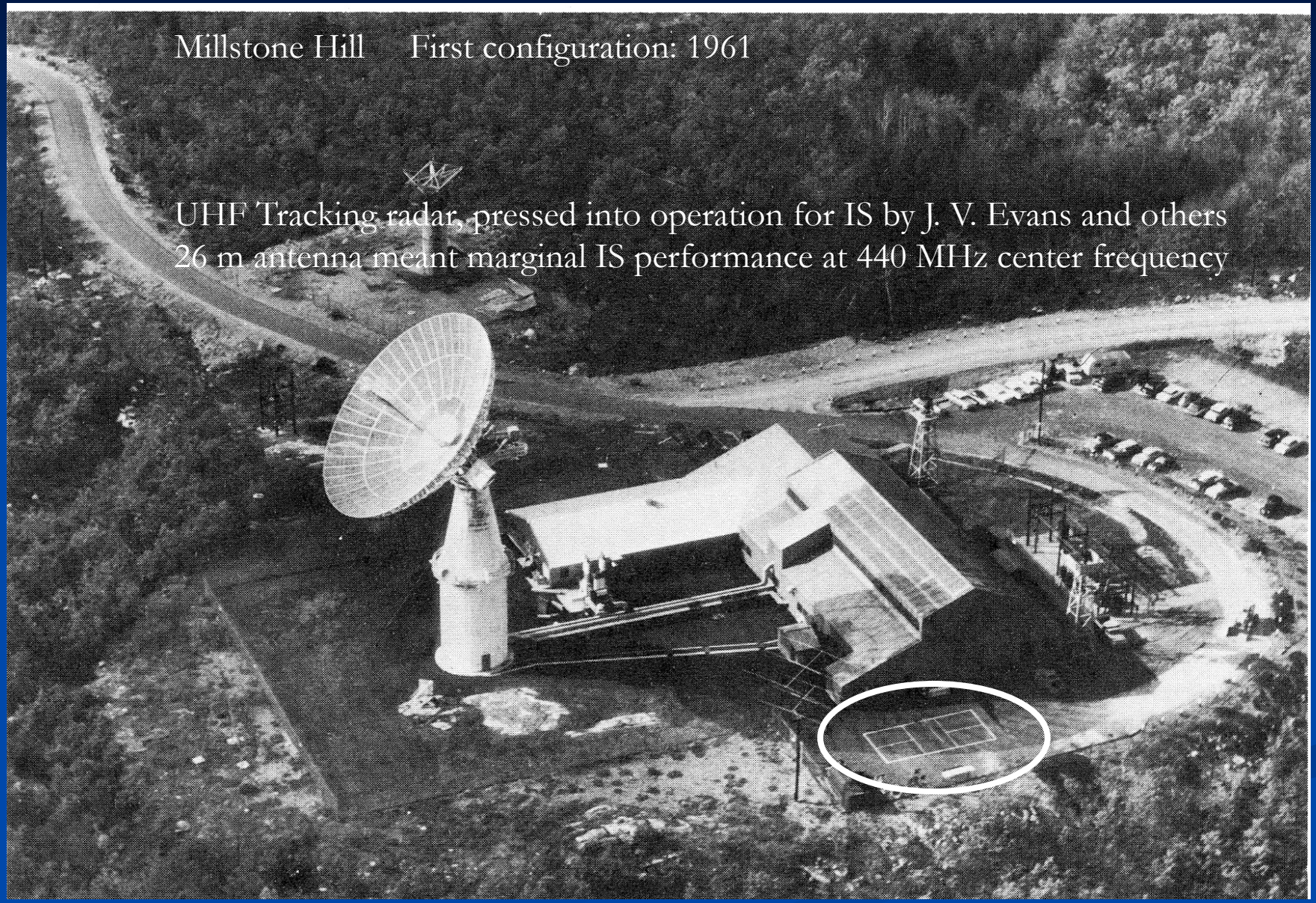
Figure 2. A schematical view of the antenna power distribution network.



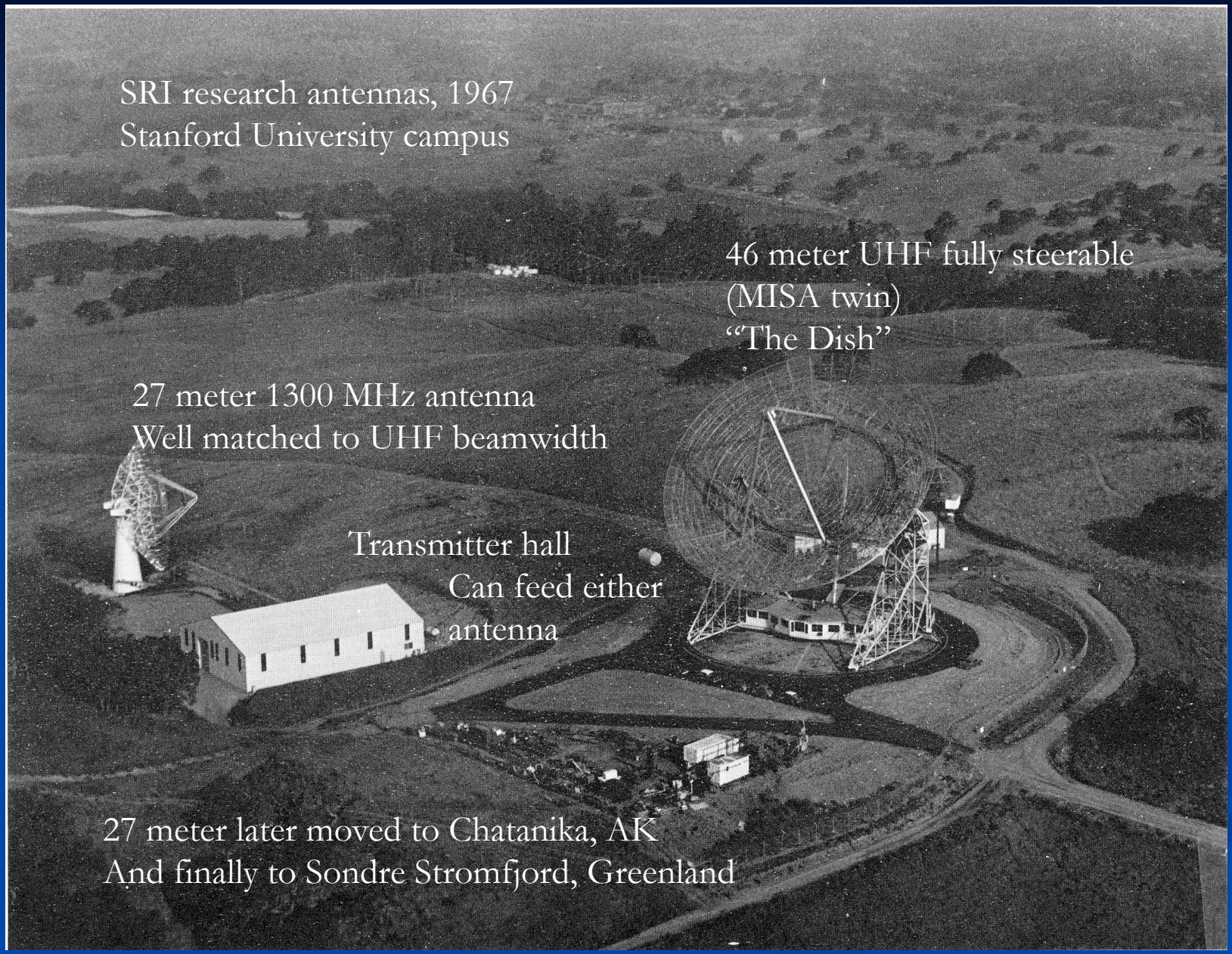

Arecibo Ionospheric Observatory
Constructed by W. Gordon Commissioned 1962

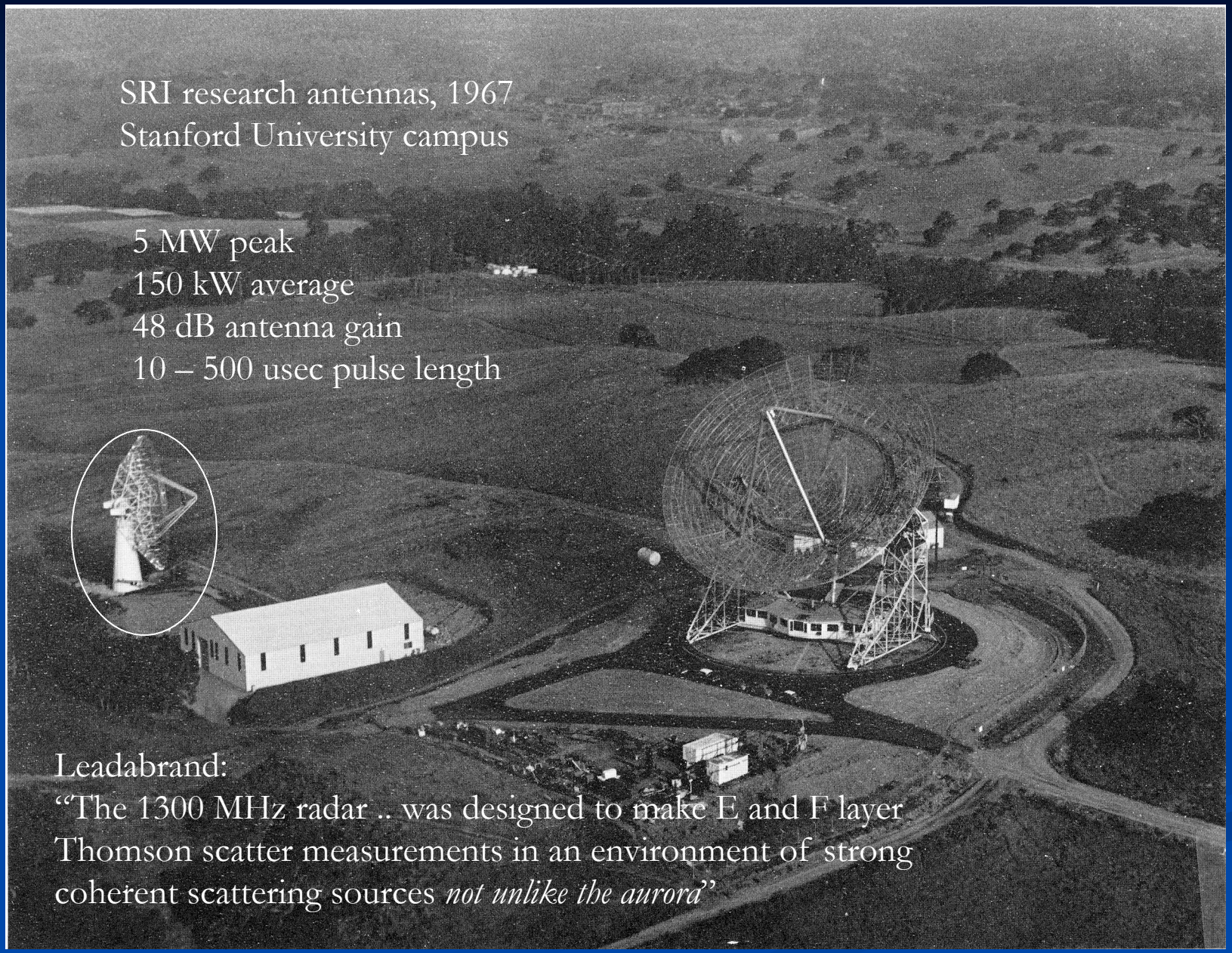

Arecibo Ionospheric Observatory
Constructed by W. Gordon Commissioned 1962
300 m spherical reflector (70 degree cap)
62 dB gain
430 MHz frequency
2.5 MW peak power (nominal)
Original platform weight 700 tons
Maximum steering angle 18 – 20 degrees


Arecibo Ionospheric Observatory
Constructed by W. Gordon Commissioned 1962
Mortality rate in construction: zero
(insurance companies: one death for every $4M in 1960 dollars – AO was ~ $10 M)
Platform motion with original cable systems: 6 mm per degree centigrade
Competing ideas for platform suspension:
Rigid feed supports (but 214 m long trusses – thermal expansion about 18 cm!)


Millstone Hill First configuration: 1961
UHF Tracking radar, pressed into operation for IS by J. V. Evans and others
26 m antenna meant marginal IS performance at 440 MHz center frequency


Millstone Hill current configuration
68 m Zenith antenna cost (1961):
$200K (Evans, 1967)
$400K (Lincoln property value)
46 m MISA acquired and installed 1978
SRI designed: AN FPS-50 system
at Sagamore Hill, MA
2.5 MW peak TX power
MISA beamwidth at UHF well
matched to L band beamwidth


SRI research antennas, 1967
Stanford University campus
46 meter UHF fully steerable
(MISA twin)
"The Dish"
27 meter 1300 MHz antenna
Well matched to UHF beamwidth
Transmitter hall
Can feed either
antenna
27 meter later moved to Chatanika, AK
And finally to Sondre Stromfjord, Greenland


SRI research antennas, 1967
Stanford University campus
5 MW peak
150 kW average
48 dB antenna gain
10 – 500 usec pulse length
Leadabrand:
"The 1300 MHz radar .. was designed to make E and F layer Thomson scatter measurements in an environment of strong coherent scattering sources *not unlike the aurora*"


Sondrestrom IS system today

And finally .. ISR Starts and Stops

- Mid 1950s: BMEWS network observes IS returns, discards them as ‘strange ubiquitous noise’
- France: St. Santin, (multi-static) 1963-1987
- UK: Malvern, (multi-static) 1968-1975
- MISCAT, Aberystwyth, UK, 1972 (multi-static--first ISR to measure three-dimensional drift velocities)

St. Santin bistatic ISR system (1963-1987)

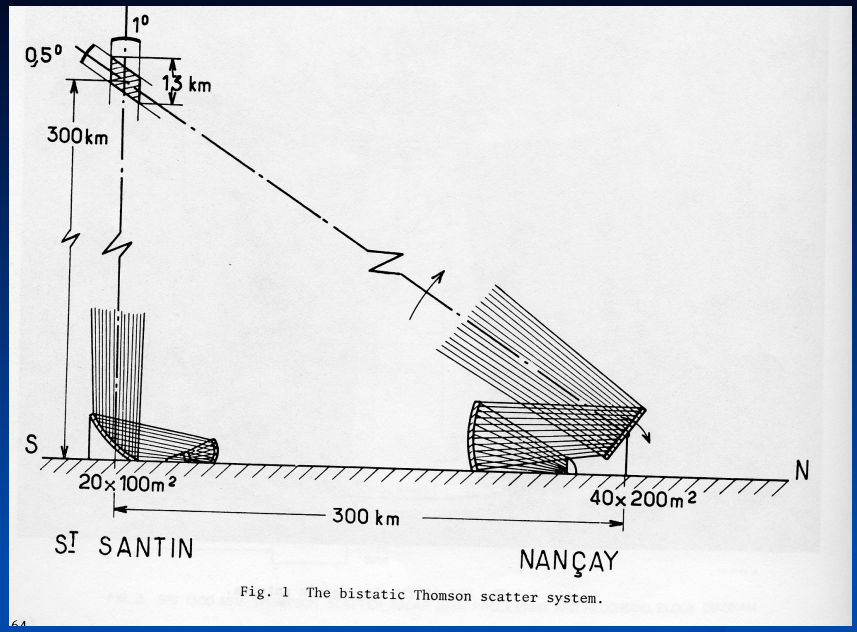
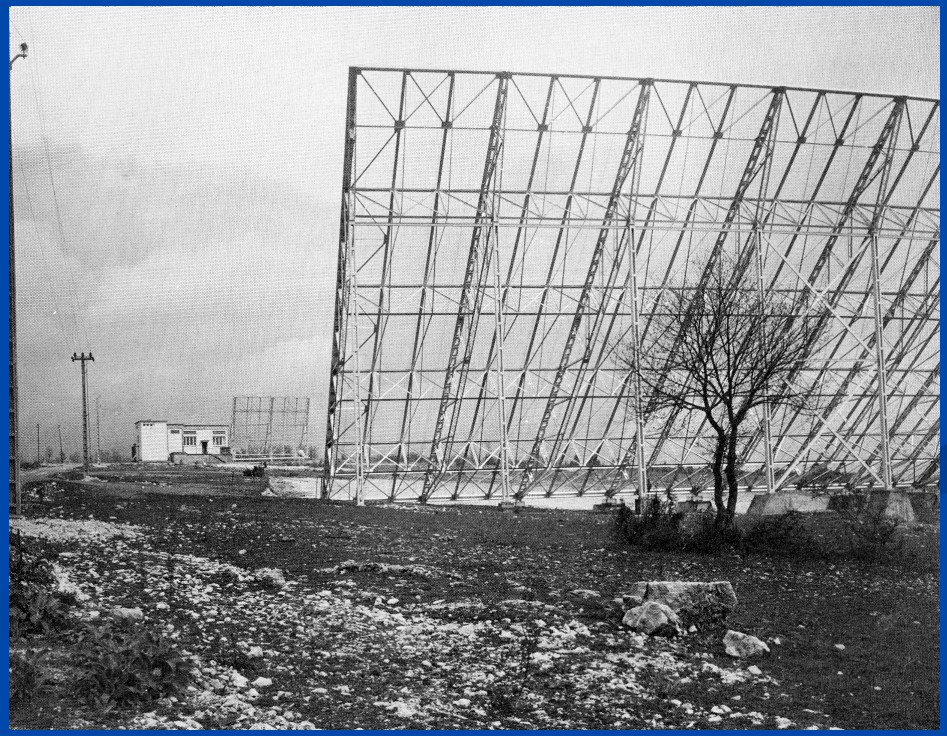


Fig. 1 The bistatic Thomson scatter system.

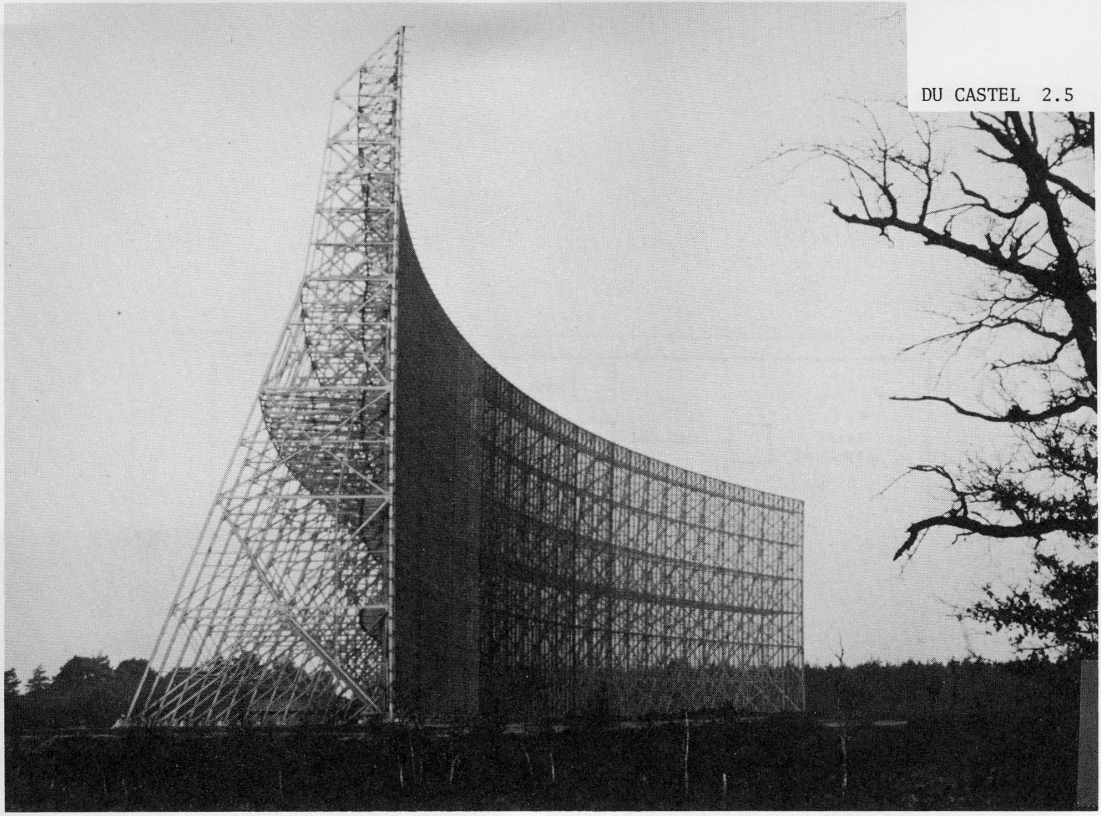
935 MHz frequency
75 kW power – CW
52 m antenna
49 dB antenna gain

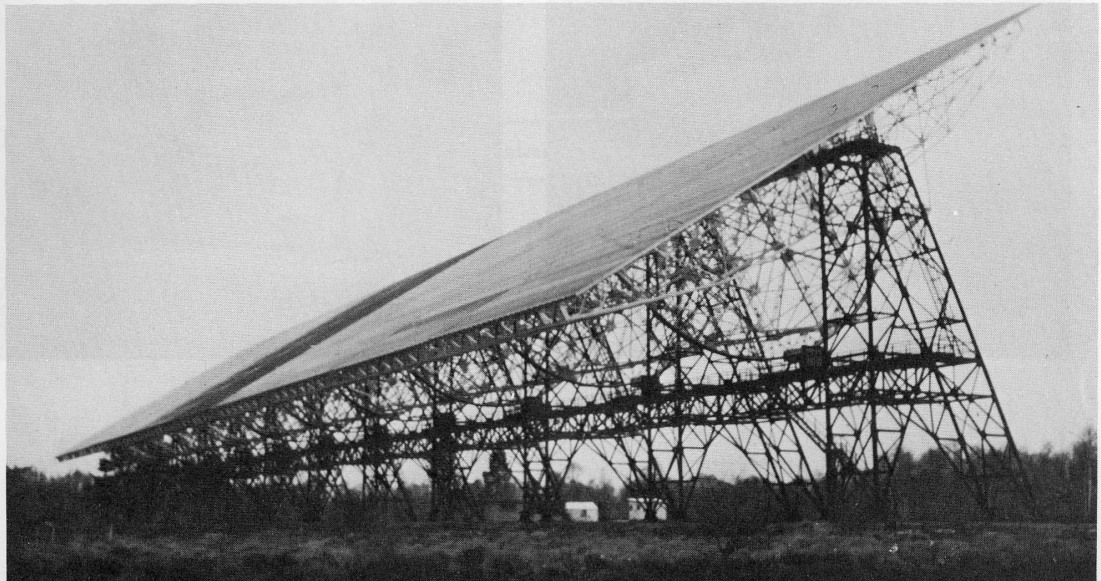


St. Santin transmitter facility

1967: used for IS measurements
"36 hours every fortnight"

Shunrong Zhang, John Holt have the entire St. Santin IS dataset available in Madrigal
(with an empirical model!)





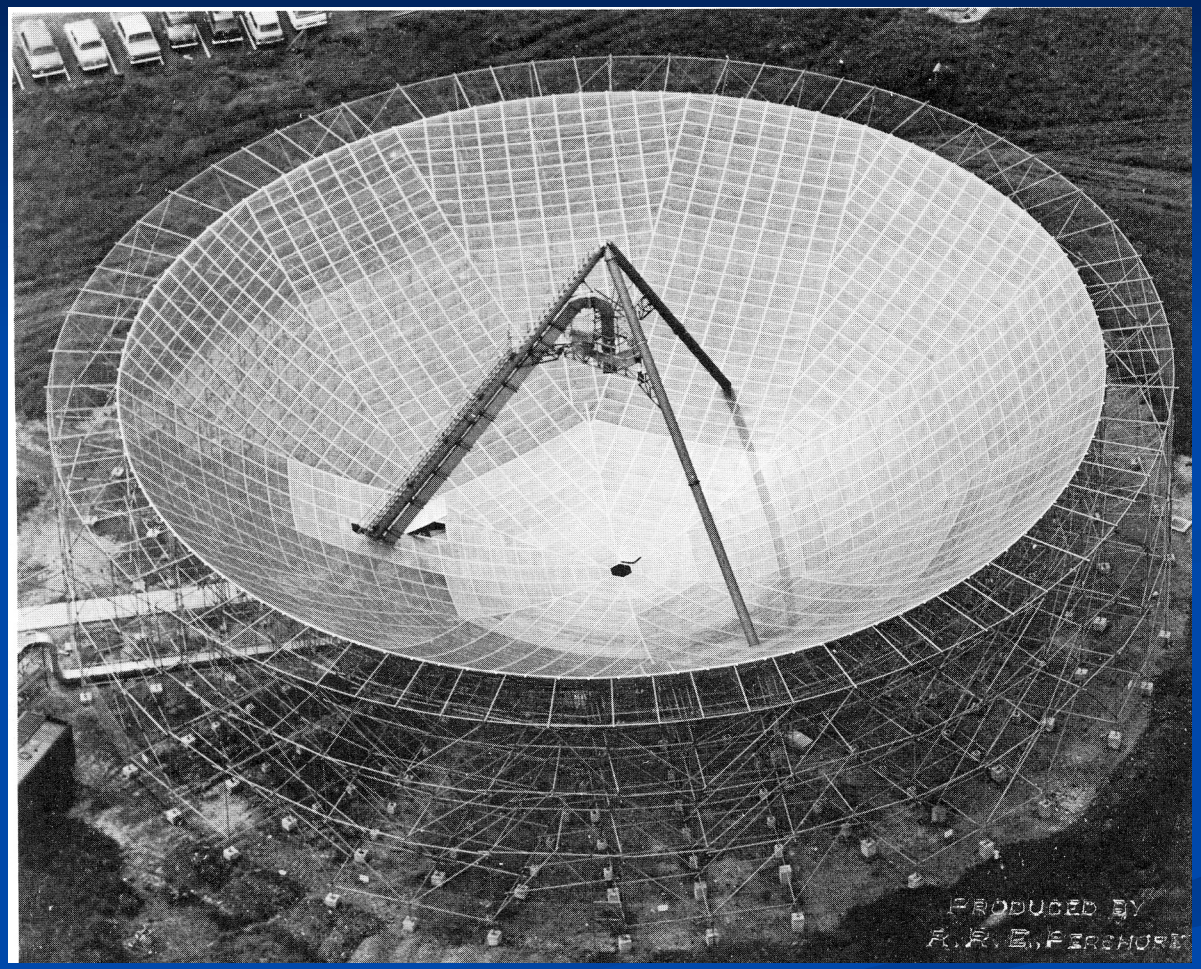
Nancay receiver

43 m vertical antenna
33 dB gain
400.5 MHz center frequency

15 MW peak power
theoretical max!
(150 kW average power)

30 to 200 usec pulse length

Tony van Eyken may have the data…



Malvern ISR (UK, 1968-1975)