EVOLUTION OF
OPTICAL SATELLITE TRACKING.

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OPTICAL TRACKING HISTORY TIMELINE, Part 1

Serious planning toward optical observations of artificial Earth satellites started in the United States when Fred L. Whipple joined a small group of Space activists which included Wernher von Braun.

Nov 1951	Symposium on Manned Space Flight	Fred Whipple met Wernher von Braun
Mar 22, 1952	First Colliers Issue on Space Flight	Whipple and von Braun collaborated.

Some of the scientists and illustrators who took part in Collier's symposium (left to right): Rolf Klep, Willy Ley, Dr. Heinz Haber, Dr. Wernher von Braun, Dr. Fred L. Whipple, and Chesley Bonestell

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Jun 1954 First meeting of future Project Orbiter team of satellite enthusiasts

Whipple was an enthusiastic participant

von Braun described launch vehicle using existing rockets

All agreed time had come to begin development of an artificial satellite

May 23-24,1955 Project Orbiter meeting at Cape Canaveral

Watched launch of a Redstone Rocket, (To be booster for a satellite launch)

Whipple expounded concept for tracking a satellite optically

Project Orbiter team at Cape Canaveral, May 24, 1955

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Jul 1, 1955 Astrophysical Observatory of the Smithsonian Institution moved to Harvard Campus

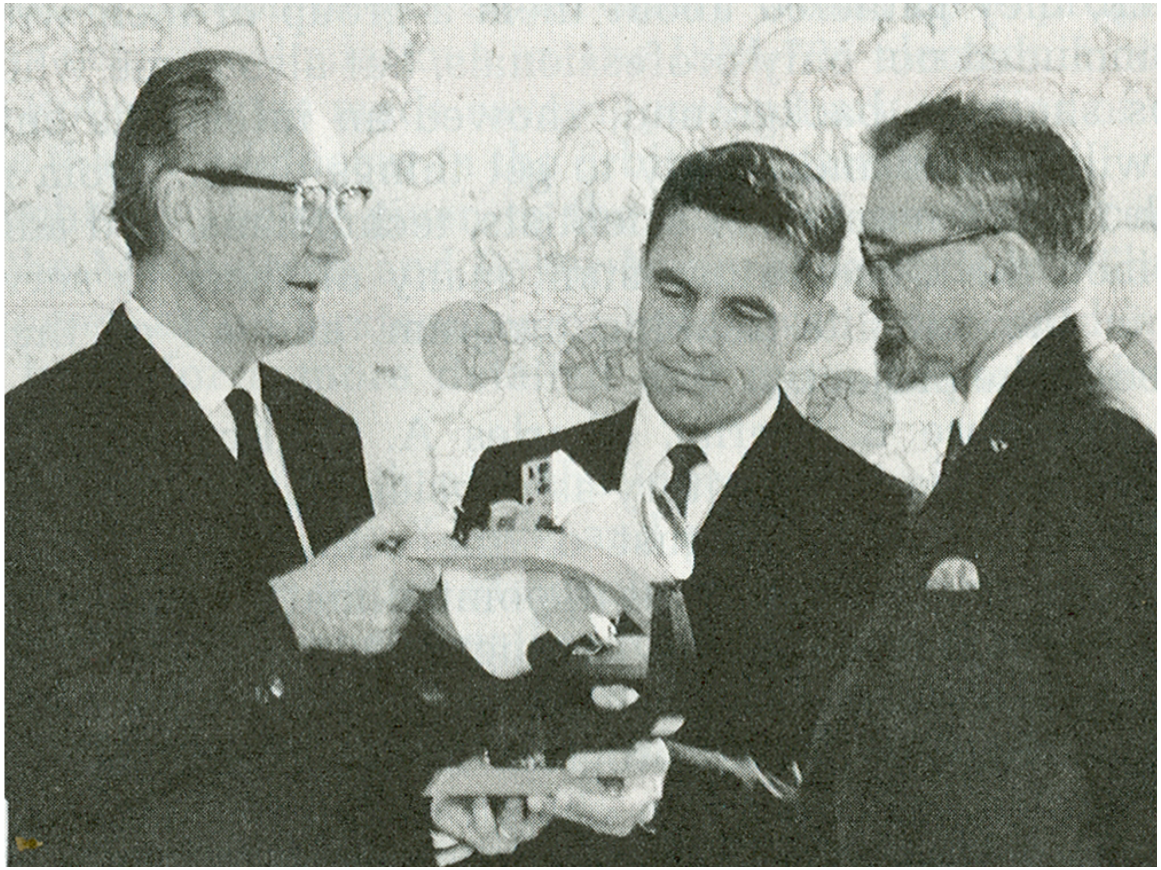
Fred Whipple was appointed the SAO Director.

Jul 29, 1955 White House announced U.S. intention to launch at least one satellite for the IGY, scheduled for Jul 1, 1957 to Dec 31, 1958.

Fall 1955 U.S. National Academy of Sciences assigned SAO to optically track U.S. satellites

Jan 1, 1956 SAO funded to implement optical tracking and orbit determination.

SAO team initiated crash program to field Baker-Nunn cameras by start of IGY.



SAO initial satellite optical tracking leadership

Fred L. Whipple, Karl G. Henize and J. Allen Hynek
with a model of a Baker-Nunn satellite tracking camera.

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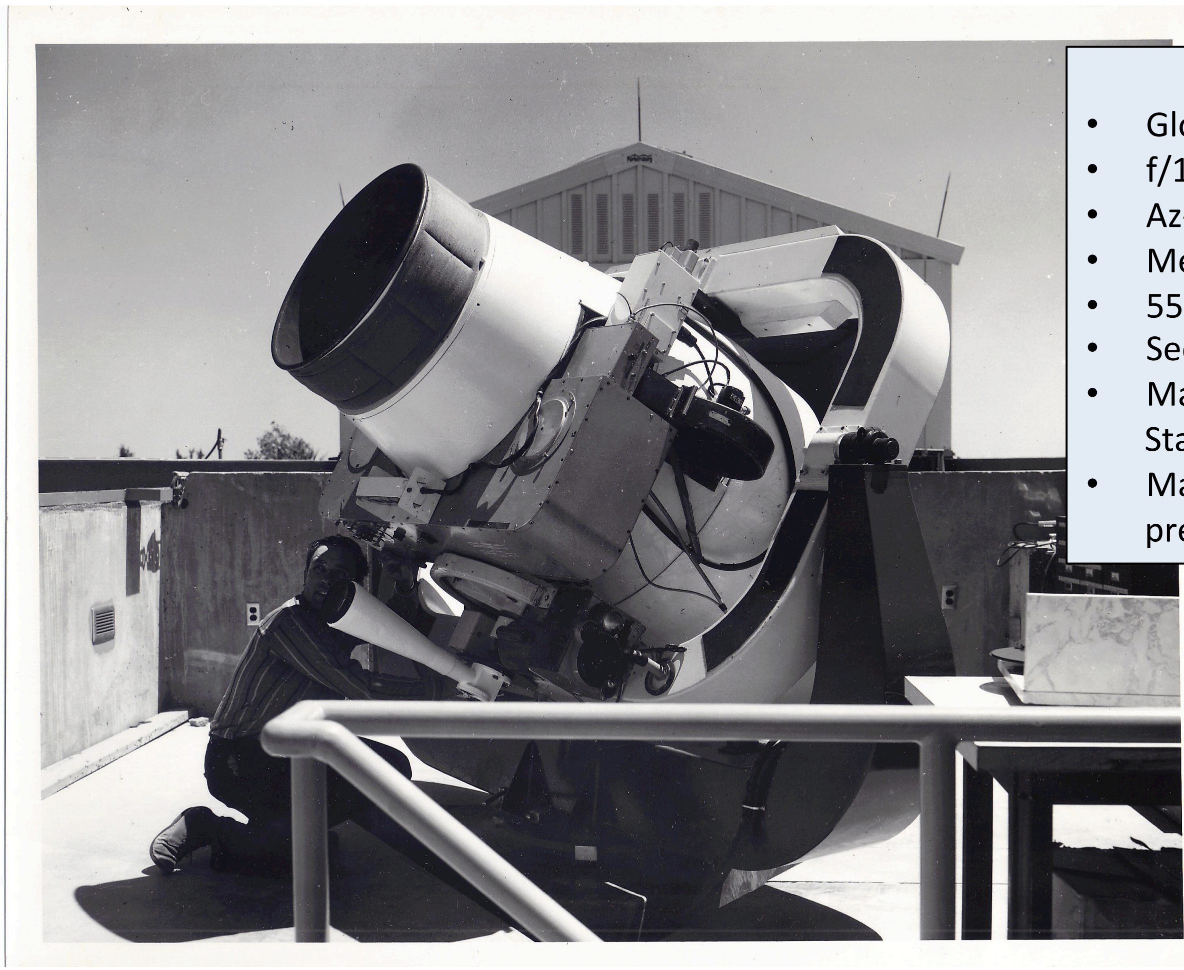
In following months and years, many more satellites were placed in orbit and tracked routinely with cameras by several nations.

Fred L. Whipple (left) and Harvard College Observatory Director Leo Goldberg (right) briefed E. K. Fedorov and Ala Massevitch at a 1962 visit to Cambridge. Ala Massevitch was the leader of satellite optical tracking in the USSR, using the AFU 75 cameras.

Baker Nunn Camera



- Global Network
- f/1 Schmidt Camera
- Az-Alt mount
- Mechanized film tracking transport
- 55 mm Film
- See down to 14 – 15 magnitude
- Main source of data for the early SAO Standard Earth Models
- Major source of data for SLR predictions

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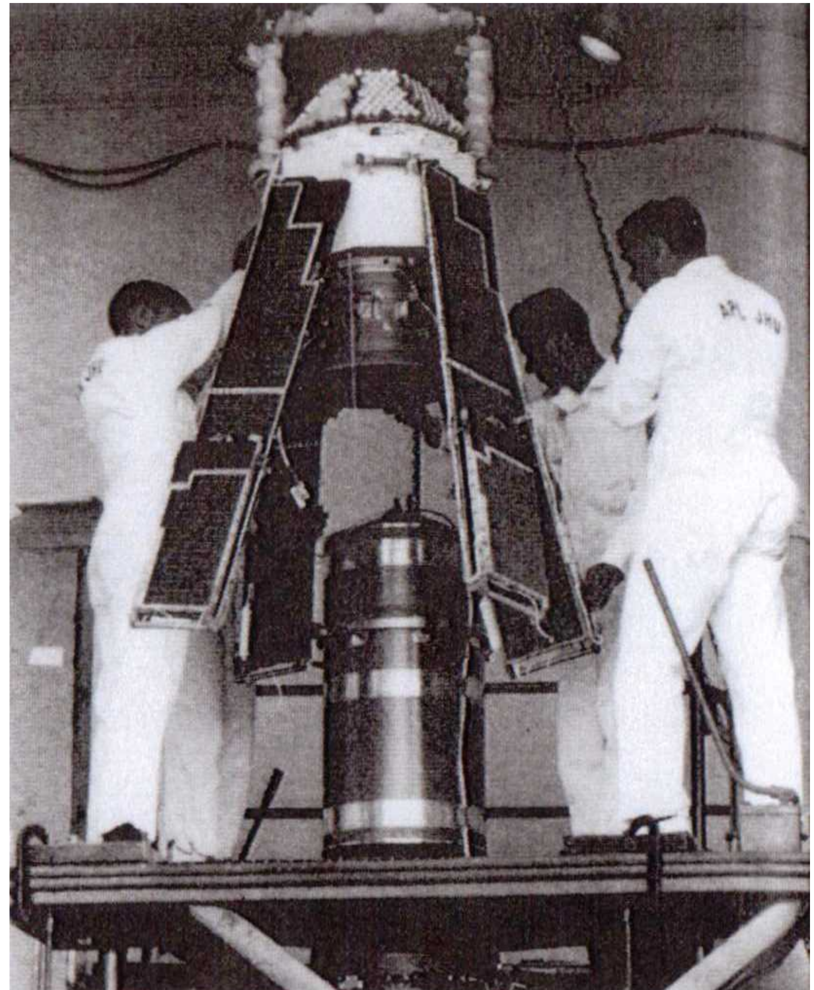
Beacon Explorer B (Explorer 22) during launch preparations.

The retroreflector array is on the top of the satellite.



NASA's dual purpose Explorer 22 for both ionospheric and geodetic research.

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First SAO Laser Ranging System

Organ Pass, New Mexico (1966 photo)

- Q switched ruby laser
- Visual tracking
- Partnership with GE
- Subsequently moved to the SAO site at Mt. Haleakala

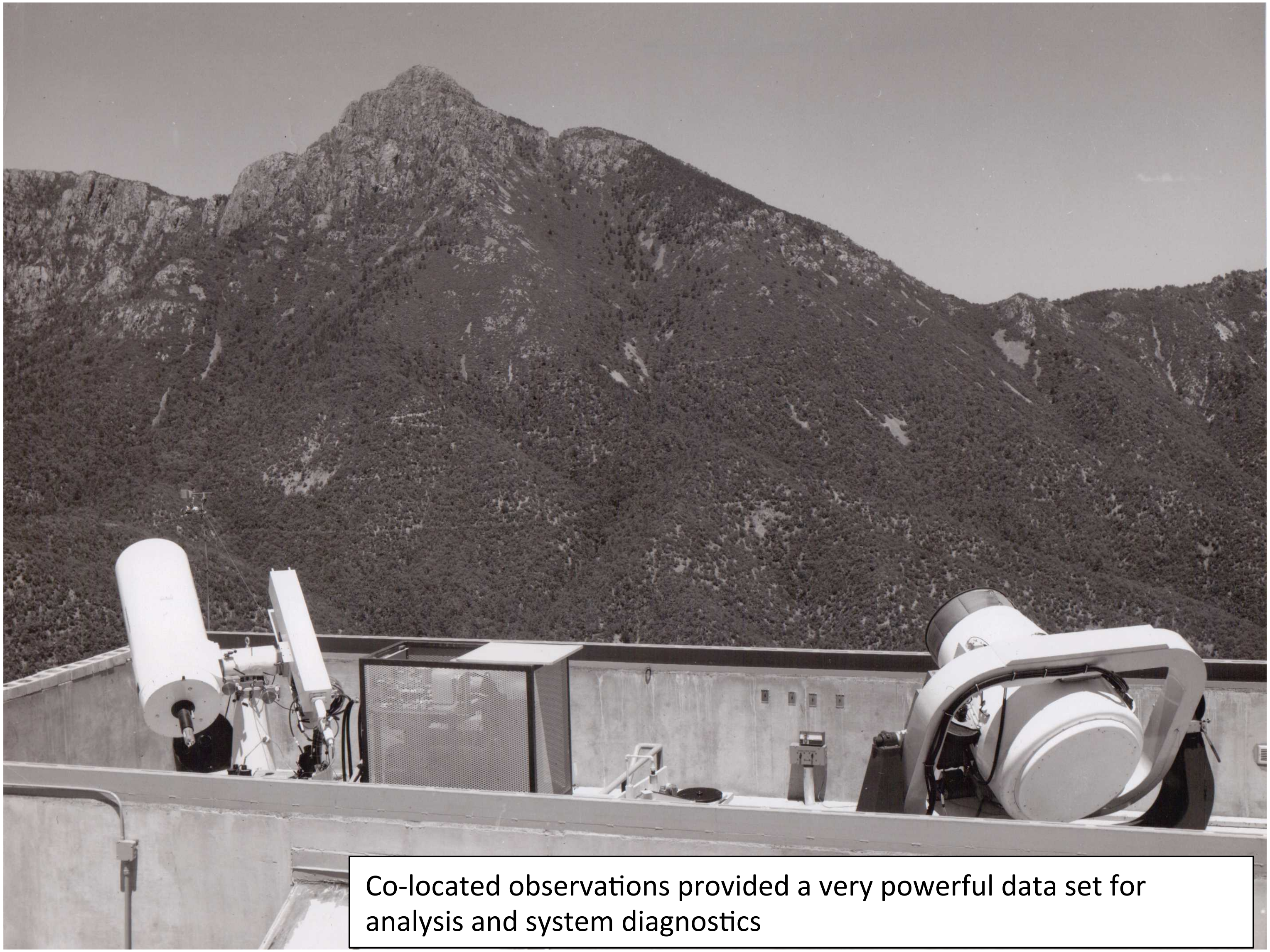
SAO Laser Ranging System

After prototype experiments at its Organ Pass NM site, a system of the configuration shown here was installed at the Baker Nunn sites at:

- Mount Hopkins, Arizona
- Arequipa, Peru
- Natal, Brazil (Moved to Matera, Italy in 1983); and
- Olifantsfontein, South Africa (moved to Orroral Valley, Australia in 1975

System Characteristics:

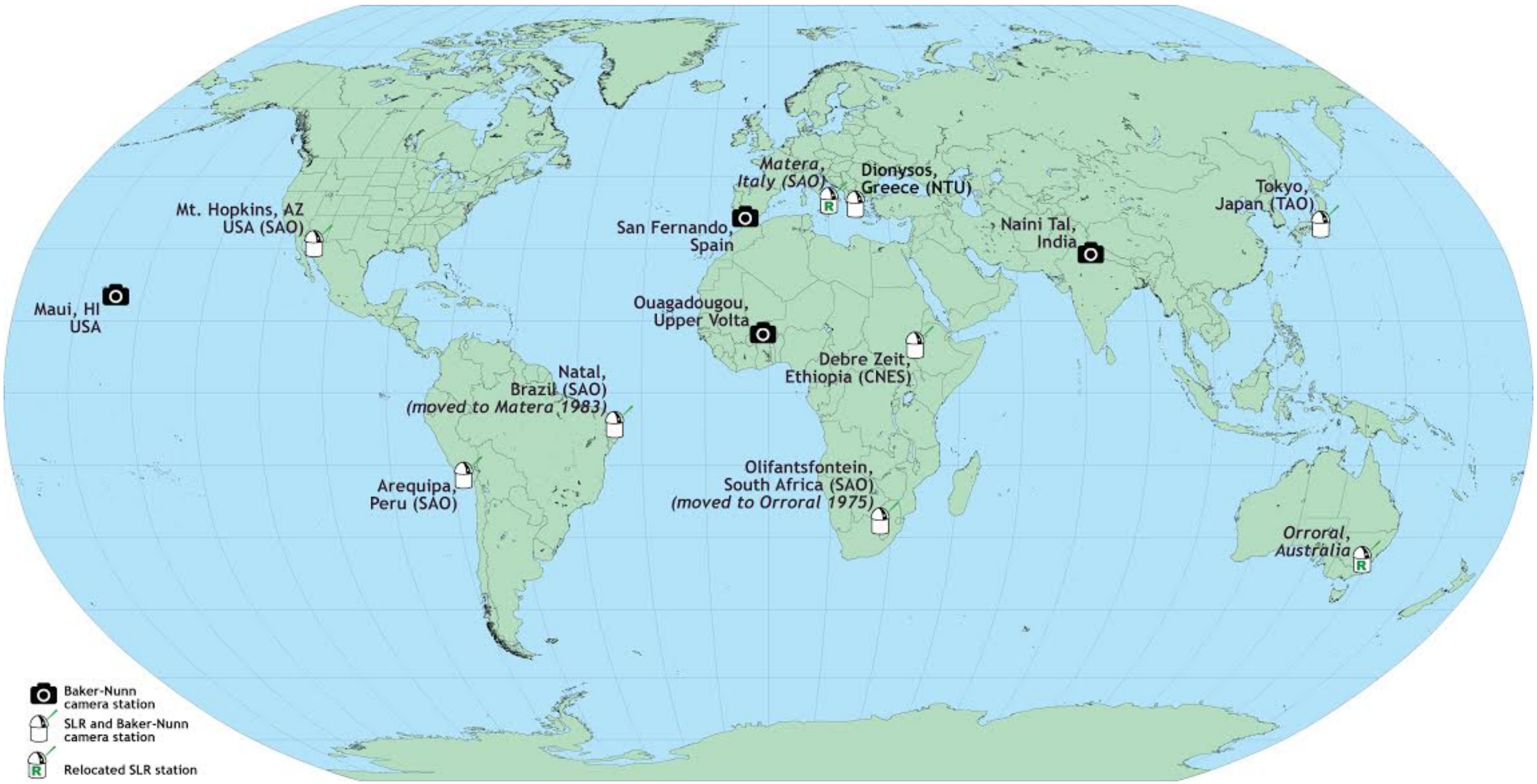
- Bi-Static, Az-Alt System
- Ruby oscillator/amplifier configuration
- Day and Night Time Tracking
- 4 – 30 ppm; 20 – 5 nsec pulse width



Co-located observations provided a very powerful data set for analysis and system diagnostics

Mount Hopkins Station

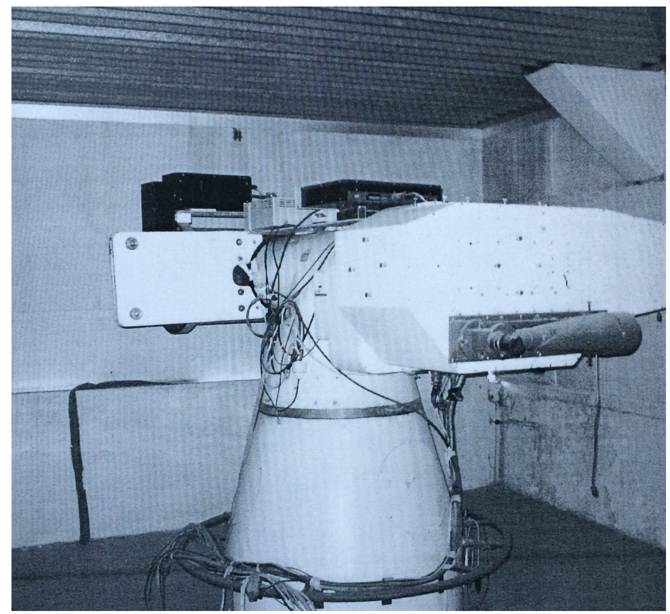
SAO Network with Associated Stations



Associated Network Stations

Tokyo Astronomical Observatory
SLR System

National Technical University
Athens, Greece SLR System



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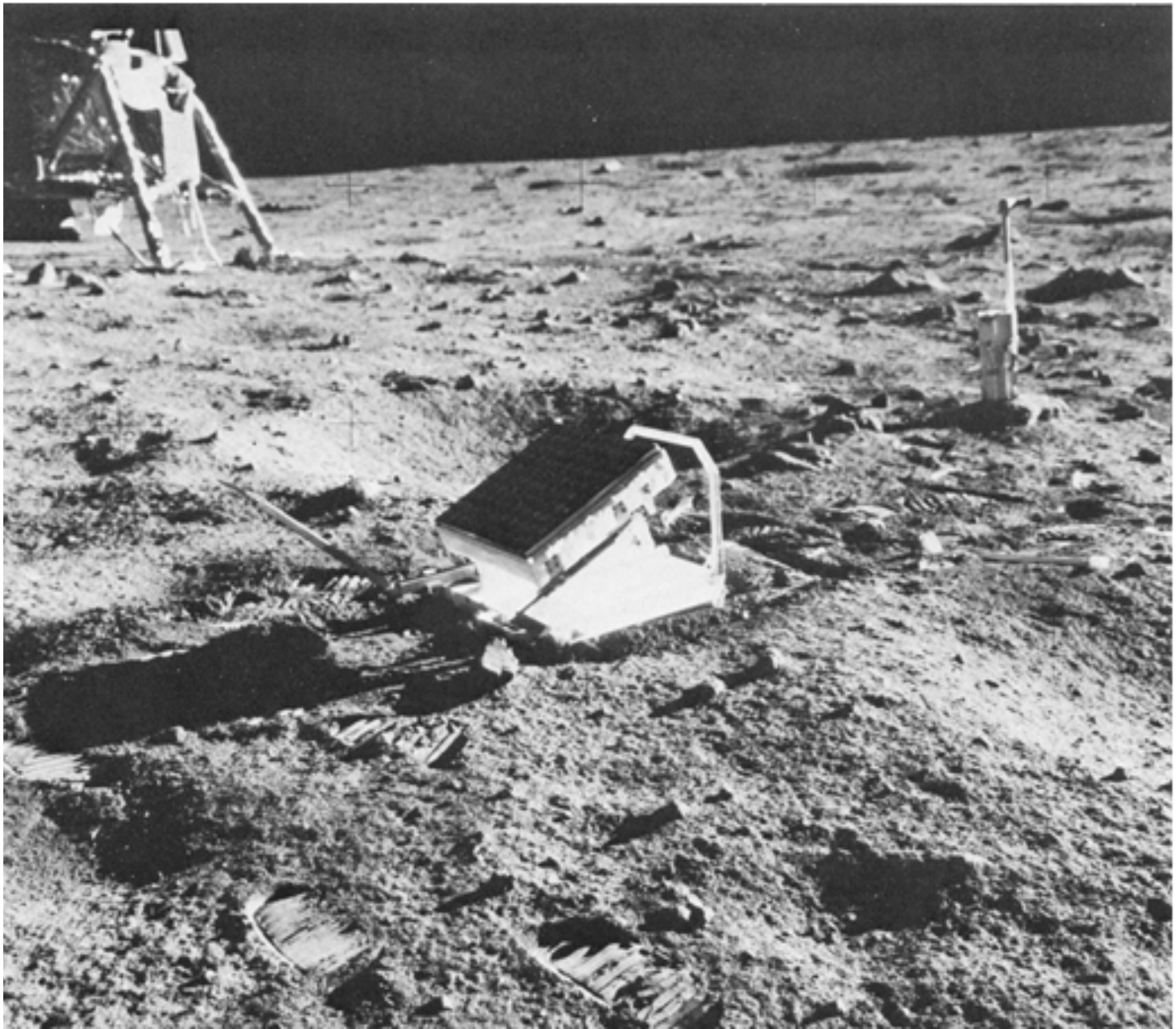
Apollo 11 Retroreflector Array



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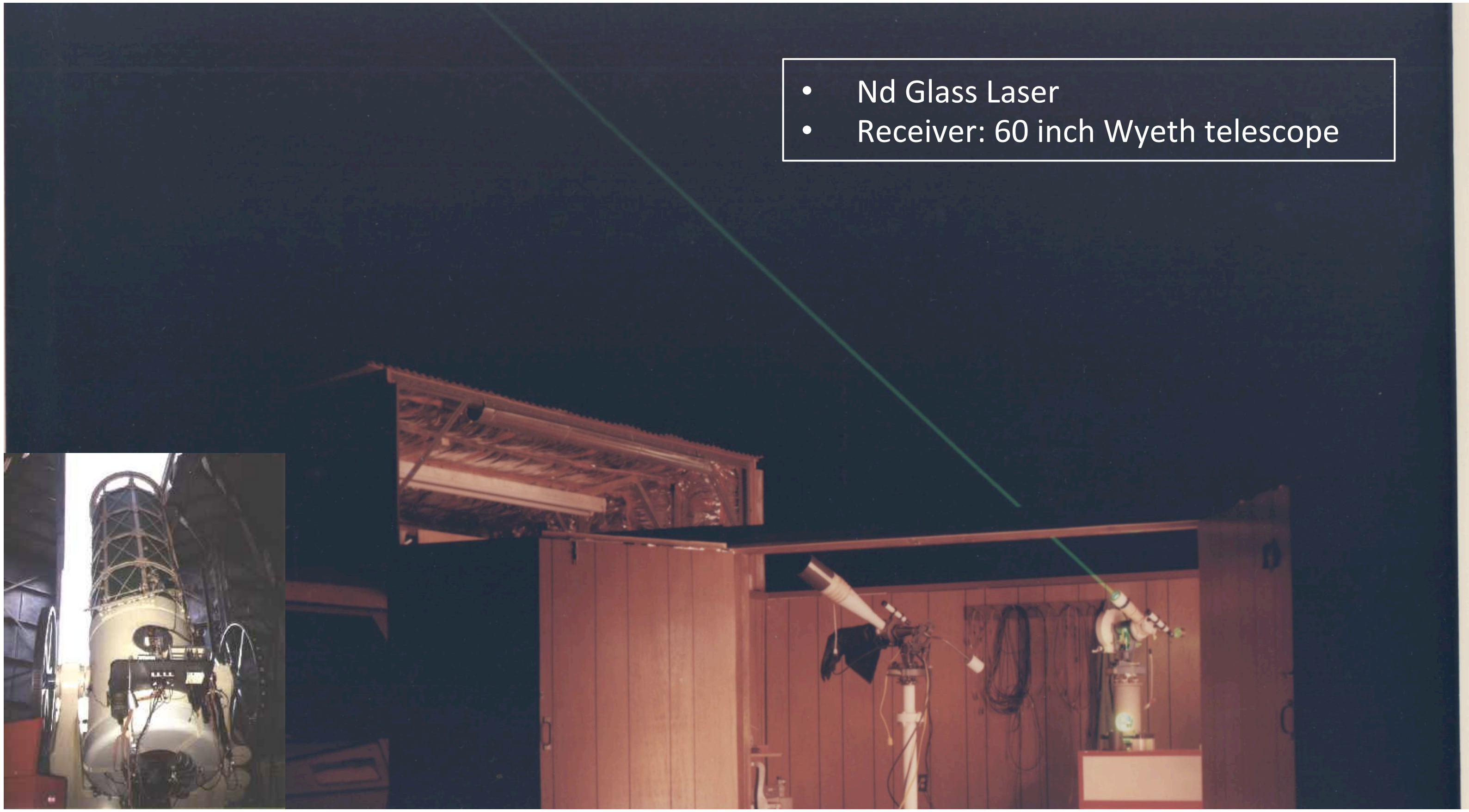
		Observations shortly thereafter from Lick Observatory.
		Pic du Midi Observatory, Tokyo Astronomical Observatory
		and McDonald Observatory.

SAO Lunar Ranging Transmitter

at the Oak Ridge Observatory in Harvard, MA
1972-3.



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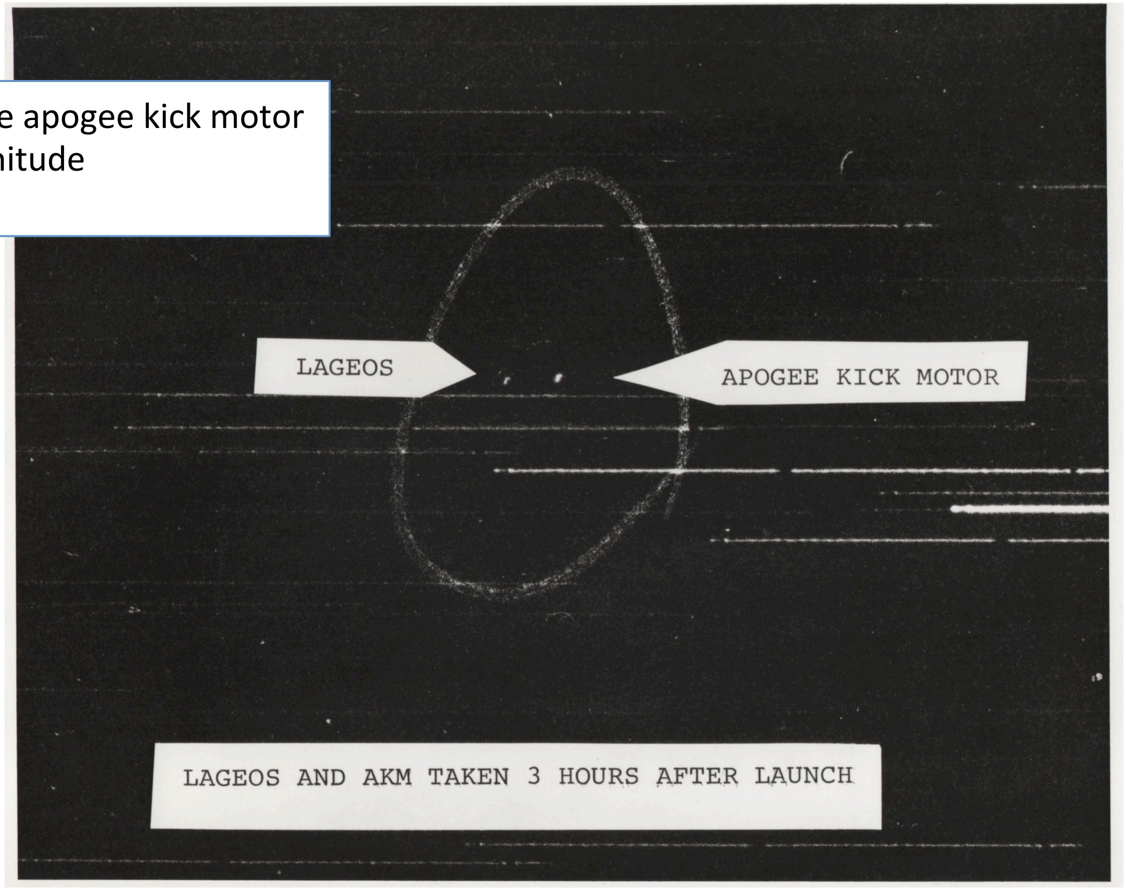
May 4, 1978	Lageos 1	Launched by NASA,

Lageos I Baker Nunn Photo after Launch taken from Maui

- With 4th stage apogee kick motor
- 12 – 13 magnitude
- May 4, 1976



OPTICAL TRACKING FUTURE TIMELINE

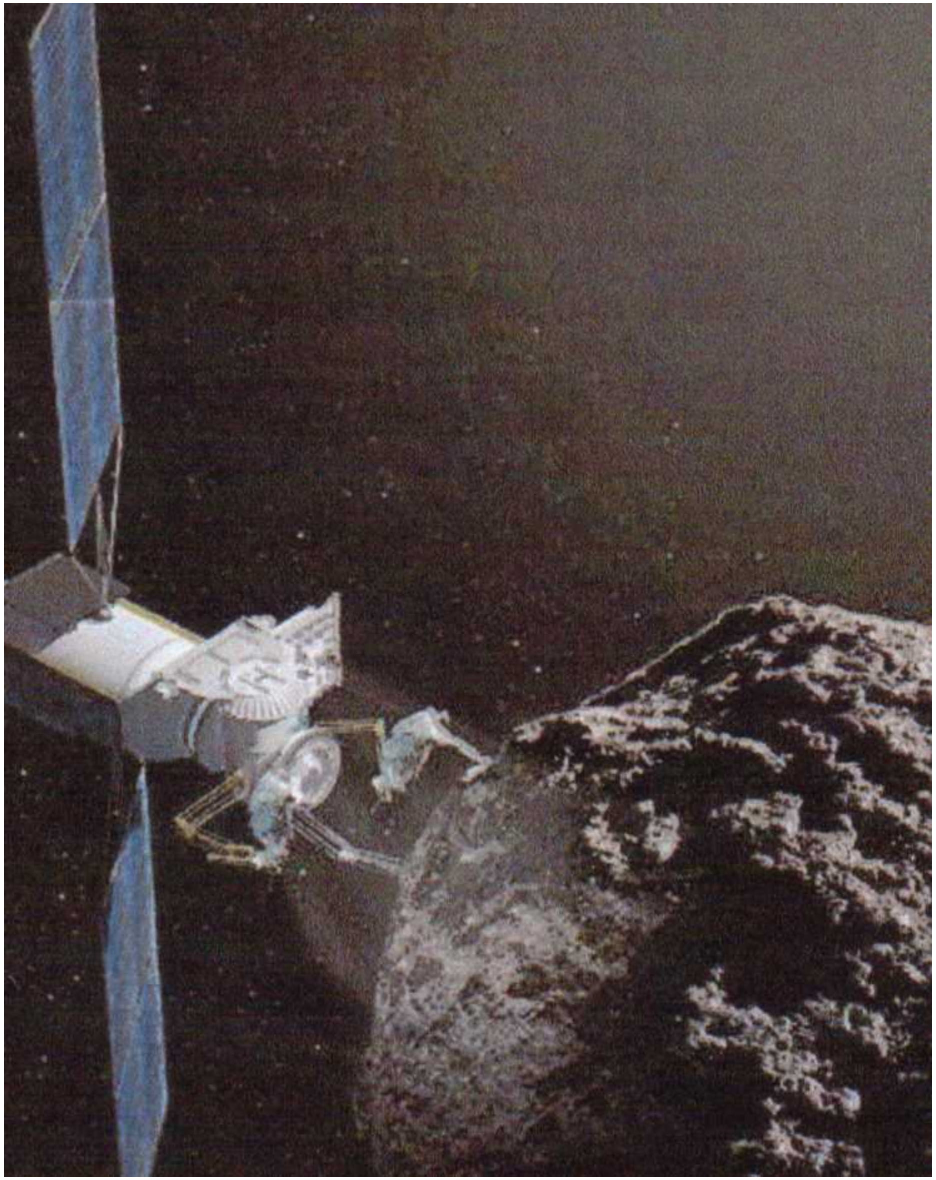
Since the lunar retroreflectors were not a primary objective of the Apollo Program, the celestial mechanics community benefited fortuitously from the Apollo Program with what is probably its longest continuing feature.

Looking ahead, the celestial mechanics community can contemplate another Apollo-like opportunity.

The laser ranging organizations can promote the inclusion of retroreflectors on the asteroid that the US plans to capture and move to an orbit around the Moon.

Artists concept of an astronaut placing instrumentation, perhaps a retroreflector array,

on an asteroid in orbit about the Moon.



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Accurate ranging to a satellite of the Moon could be a future major milestone in the evolution of the discipline.