

Trudging off to Chajnantor

The 20-year Random Walk to ALMA
(a somewhat personal account)

Paul Vanden Bout
NRAO

"Science with ALMA" - Madrid - 11/2006

Credits:

Peter Shaver

Angel Otarola

Masato Ishiguro

Al Wootten

Bob Brown

Roy Booth

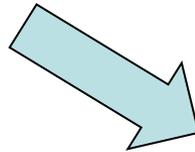
Theme -

The process of starting a new major international facility is long and subject to random events beyond our control.

This is not a bad thing.

The 1980s Roots of ALMA

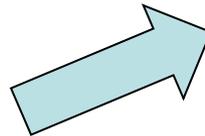
LSA
(1988)



MMA
(1982)



LMA
(1983)



First Events

- 1982 - NRAO's 25m telescope project was cancelled & national mm plans shifted to interferometry and a large mm array.
- 1983 - the LMA was discussed just following the dedication of the NRO.
- 1988 - discussions of LSA concepts began, with first formal presentation of a plan at ESO in 1991.

First U.S. Concept - 1982

MMA Memorandum #1 (F. Owen)

- (15) 10m antennas on the VLA site
- Cost: \$36M

This was a (bigger) version of the visions for the Hat Creek (to become BIMA) and the OVRO mm interferometers.

First Japanese Concept

The Large Millimeter Array (LMA):

- Expands NRO from 5 to 30 10m antennas;
- Works at frequencies up to 230 GHz;
- Baselines up to 1 km.

First European Concept

Idea came out of Onsala, following success of SEST:

- (10) 8m antennas near the VLT and Paranal;
- Cost: \$50M(US).

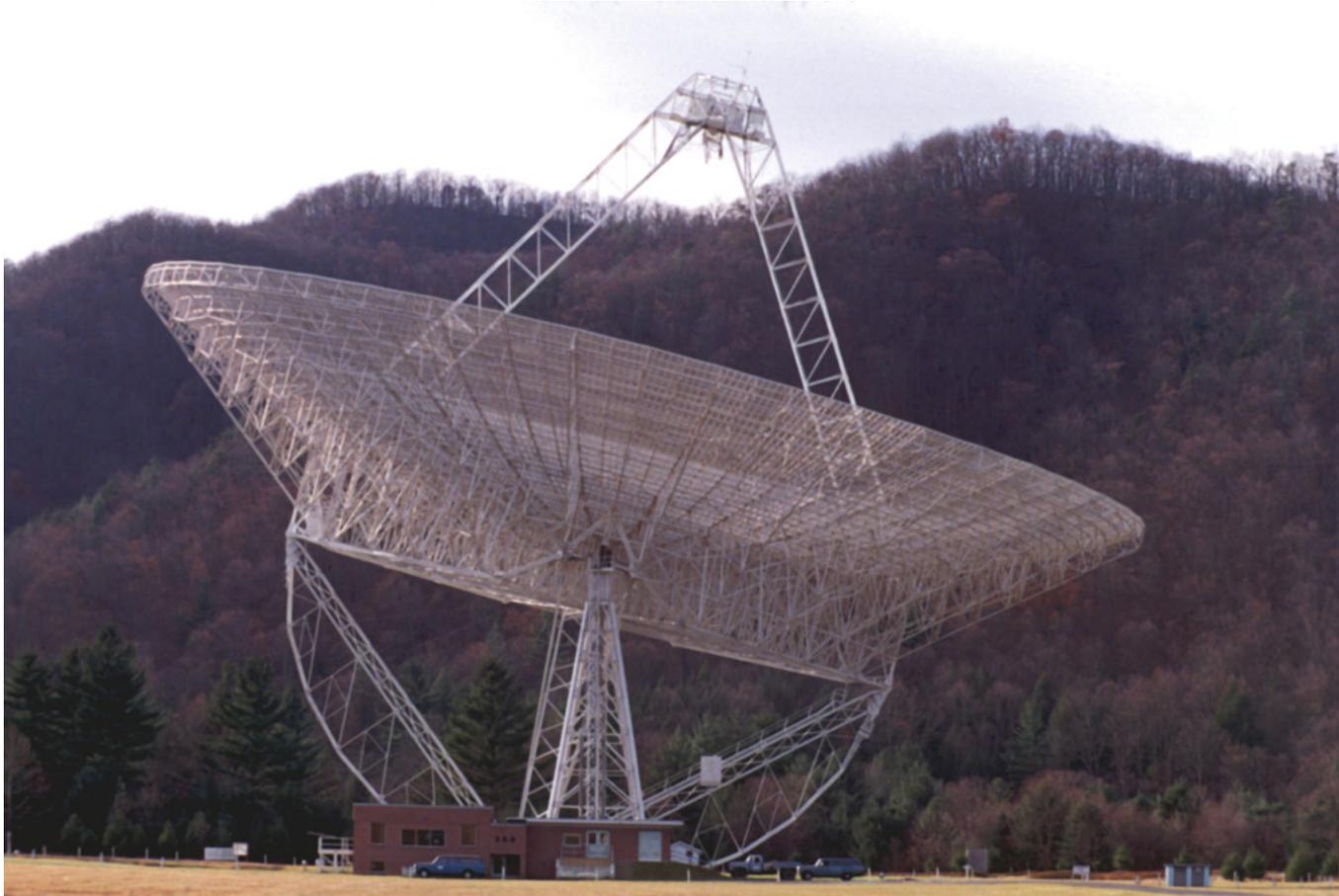
There were *serious* distractions in Europe, Japan, and the United States that impeded progress on these concepts.

The first distraction at NRAO was finishing the Very Long Baseline Array

VLBA funding started in 1985 and construction involved every NRAO site.

The VLBA was not dedicated until 1992, and routine operation did not occur until later.

NRAO 300 Foot Telescope



Afternoon of November 15, 1988

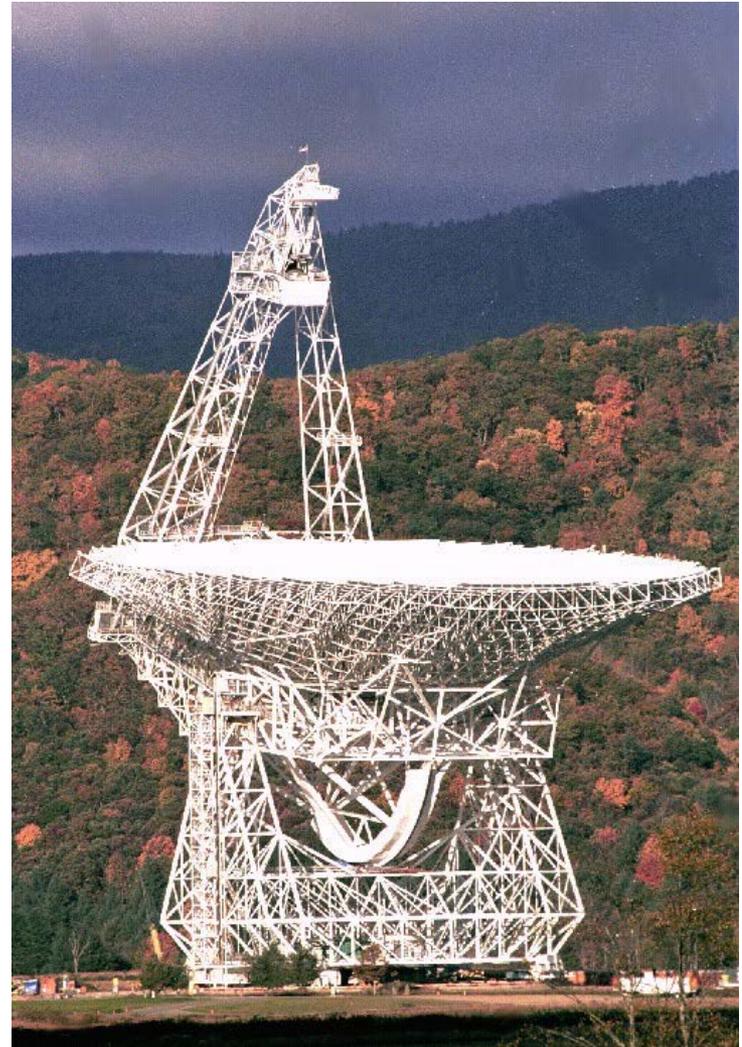


. . . and, the next morning

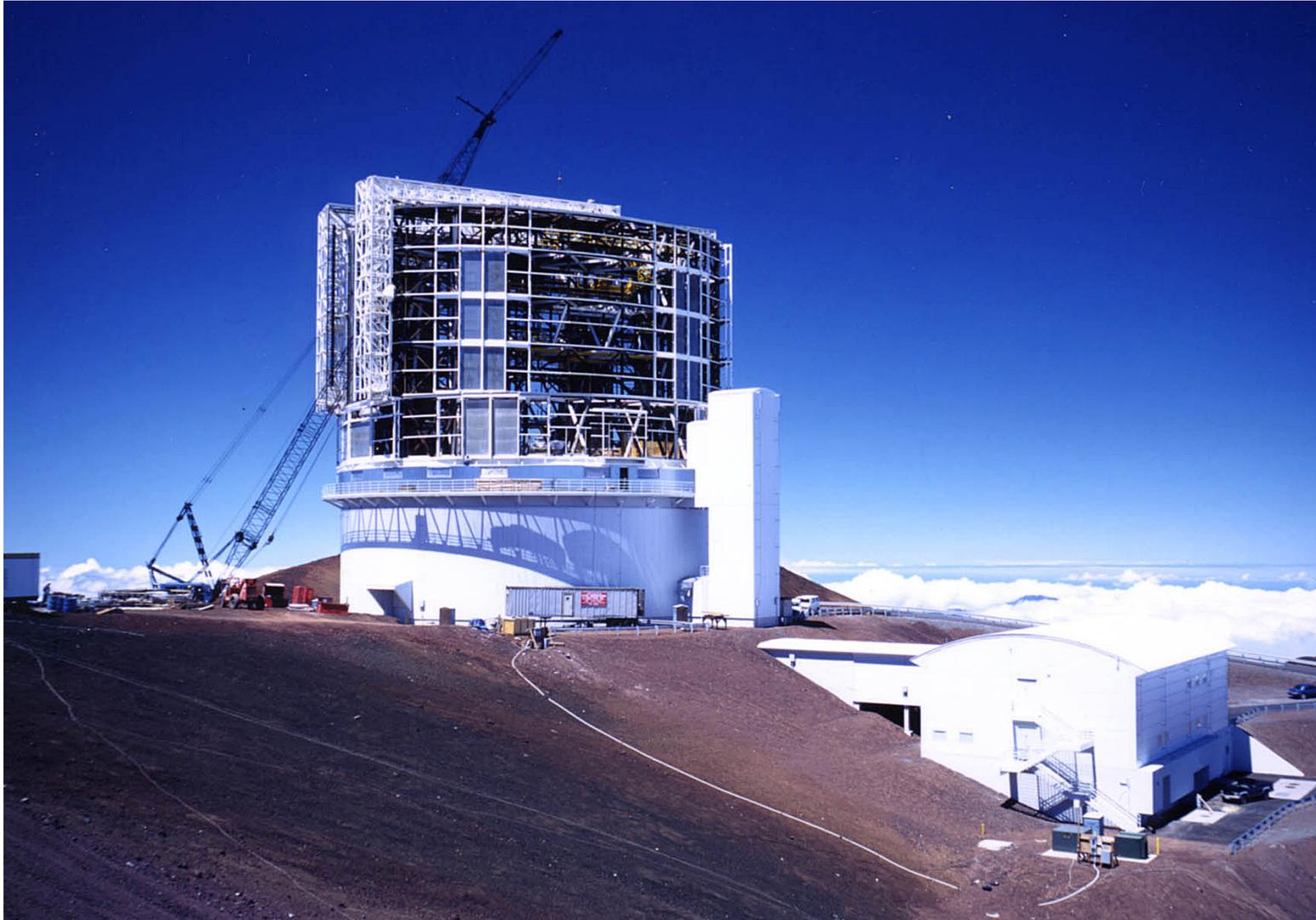
The Green Bank Telescope

Enjoyed enthusiastic support in Congress.

Took ten years (1990 - 2000) to complete.



Japan was building Subaru; first light in 2000



In Europe, the VLT occupied ESO's attention during the 1990s



But a Lot Happened Anyway

- There were (endless) workshops, meetings, reports, etc.
- From this, 2nd generation concepts emerged:

Large Southern Array (LSA)

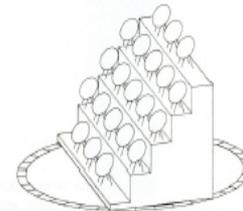
Large mm/submm Array (LMSA)

Millimeter Array (MMA)

I. Concept of the NRAO Millimeter Array



Full Tracking Array



2-D Rotating Azimuth Array



3-D Rotating Azimuth Array

The MMA Proposal was submitted in 1990

THE MILLIMETER ARRAY



NATIONAL RADIO ASTRONOMY OBSERVATORY
Operated by Associated Universities, Inc., under cooperative
agreement with the National Science Foundation.

Table X-2. MMA Project Schedule

1991	Site Evaluation Site Selection Electronics Development	\$ 1.0 M
1992	Site Configuration Layout Antenna Design Electronics Development Algorithm Development	2.0 M
1993	Electronics Development Antenna Design Algorithm Development	5.0 M
1994	Site Configuration Construction Electronics Design Algorithm Development Construction	30.0 M
1995	Construction	30.0 M
1996	Construction Interim Operations	30.0 M
1997	Construction Interim Operations	22.0 M
1998	Full Operation	

Cost = 120 M\$

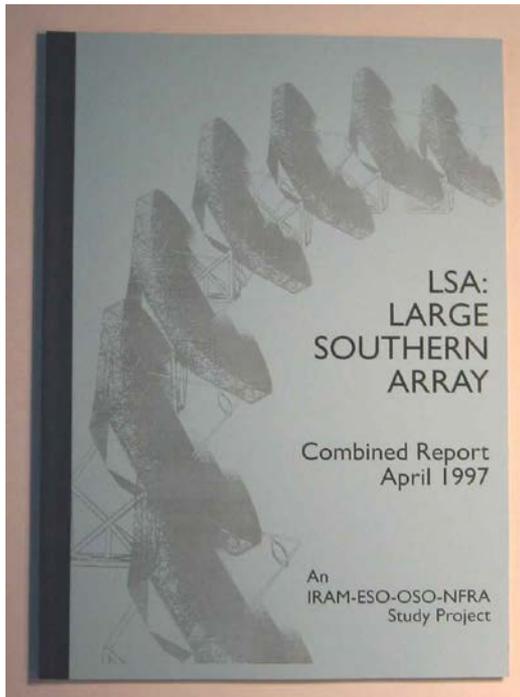
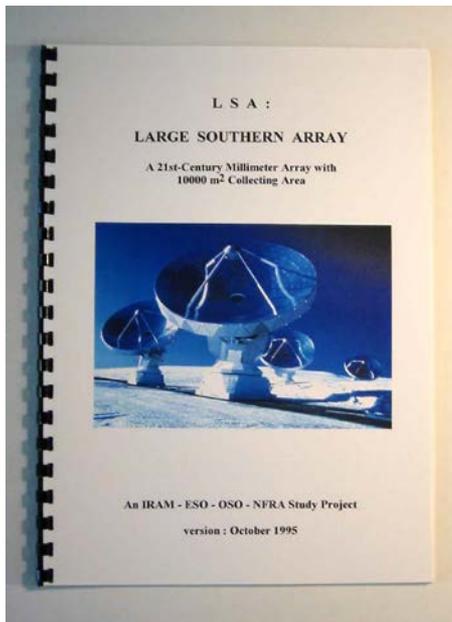
Large Southern Array (1997)

- 10000 m² collecting area (LARGE!) from (50) 16m or (100) 11m antennas;

- Operating at 70 - 350 GHz;

- 0.1" resolution or better (10 km baselines);

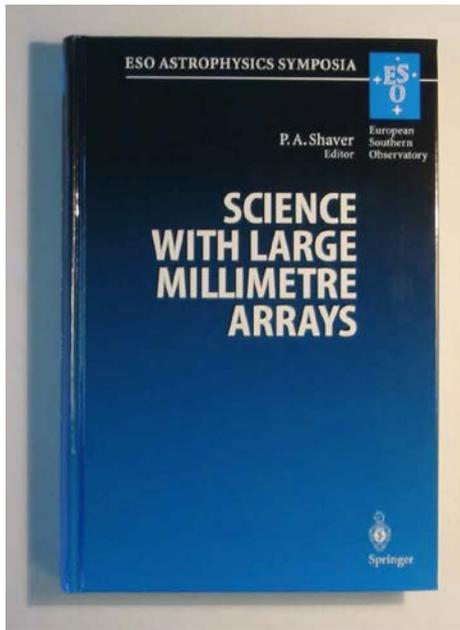
- Cost estimated at 250 M\$.



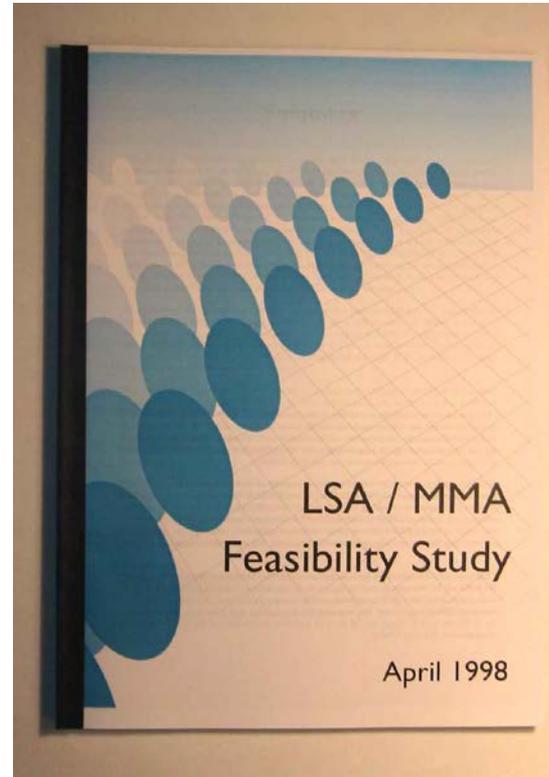
Large Millimeter Submillimeter Array

- (50) 10m antennas;
- Operating at 35 - 500 GHz + submm;
- 20 - 2000 m baselines;
- Cost unspecified.

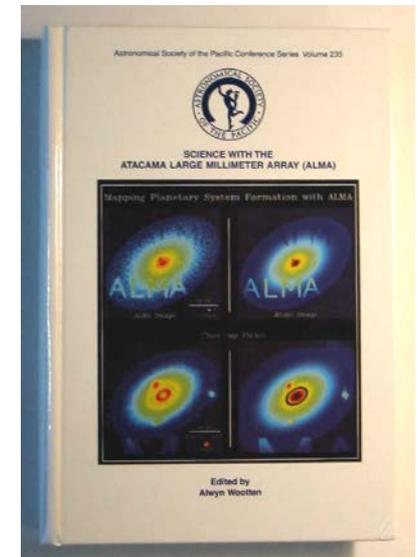
Workshops, Studies, and Reports - a few examples:



ESO Dec 1995



Joint Study April 1998

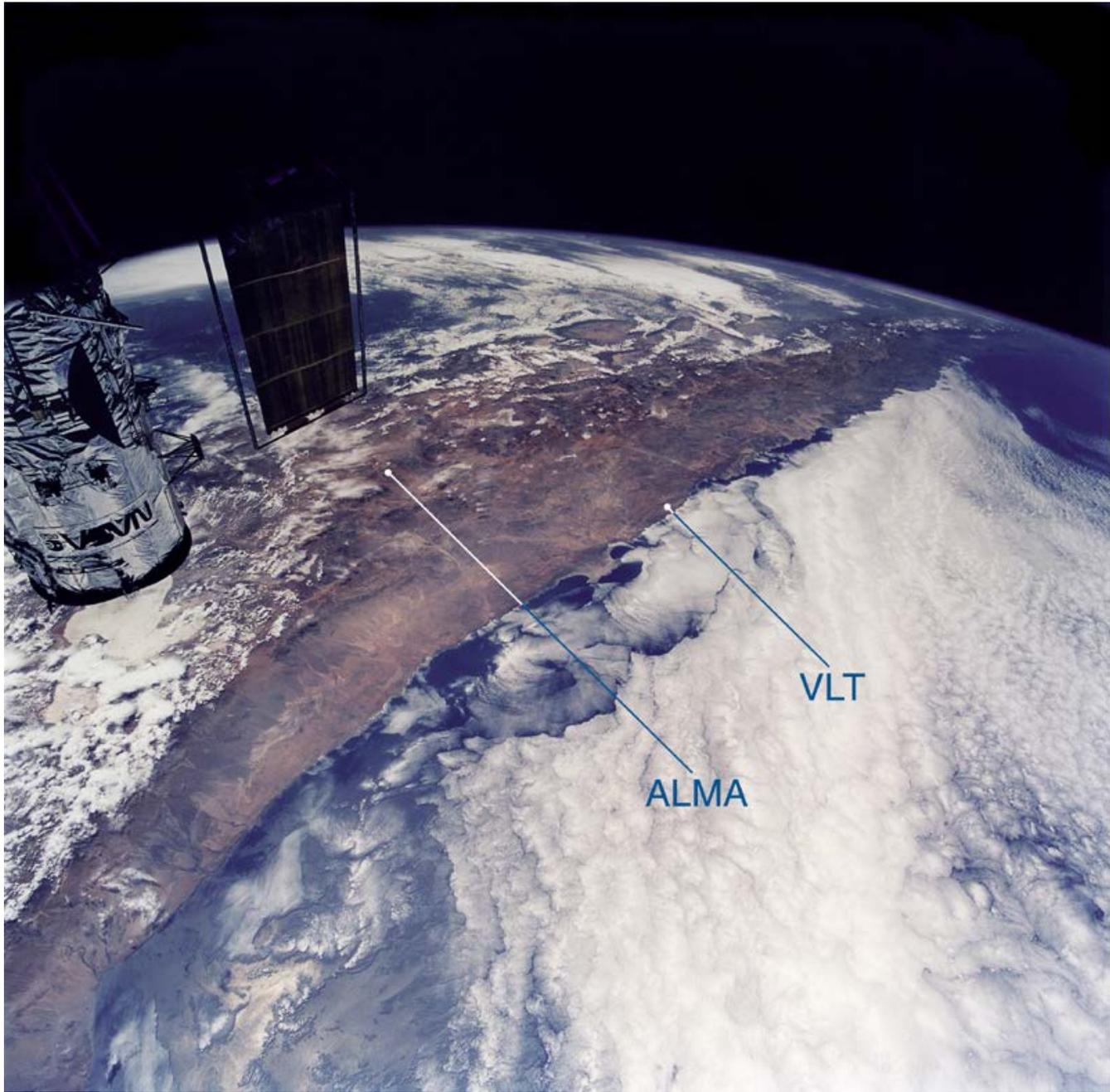


Wash DC Science
Conf. Oct 1999

And the site searches went on

- ESO looked at Chile;
- Japan looked at Mauna Kea, then Chile;
- The US looked at sites in the SW of the continental US, Mauna Kea, and then Chile.

How did we get to Chajnantor?





Angel Otarola

Angel, an ESO staff member and expert Atacama guide, was essential to the success of all the site searches and studies, by Japan, the US, Europe, and the first search of all by the SAO.

NAOJ studied Rio Frio and other sites, settling on a site to the east of Chajnantor called Pampa la Bola.



Above: the sign to Rio Frio.

Left: Masato Ishiguro at a site near Ollague.

In April 1994, an NRAO search party visited the highest sites surveyed by the CfA for the SMA.

Chajnantor was not on the list. The high ground *near* Chajnantor was visited at the end of this trip, partly by intent and partly as an excuse to see San Pedro de Atacama.

The most remote of the sites visited, and the only site close to comparable to Chajnantor, was near the border town of Ollague, where the train once stopped as it went from Calama, Chile, to La Pas, Bolivia.





Volcan Ollague - watch your step!



The road to Ollague is appallingly bad,



and it's a border town.



**Welcome
to Chez
Esmeraldo,
the best
(only?)
restaurant
in town!**



Possible MMA site above Ollague.



4500m up the Paseo de Jama

Major Event for MMA - The NSF Visits Chile



NSF brass
are taken to
a place near
Chajnantor.

NRAO was
ordered to
find a site.

Oct 24, 1994

The Chajnantor site was visited the next day by Bob Brown and Geraldo Valladares - October 26, 1994.



Study of the site began within weeks.



Pampa El Chino 3300m



Pampa San Eulogio 3750m

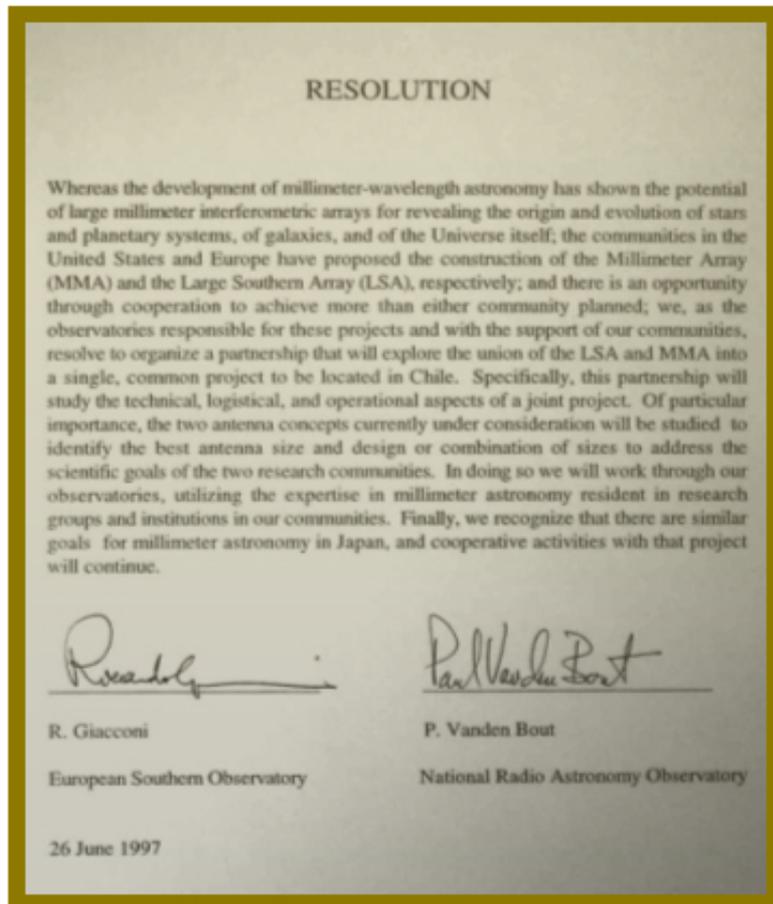
ESO studied sites
at 3000 - 4000 m
elevation.



Lars-Åke Nyman in front
of the Casa de Don
Tomas - the center of
much site study activity.

Major Event for ALMA- Merger of the LSA & MMA

26 June 1997



Elements of the Agreement:

- a big array - 64x12m antennas;
- a high (submm) Chilean site;
- 50:50 deal between the U.S. and Europe (and a pledge to begin negotiations with Japan);
- ESO and NRAO to do the job (no new observatory).

The ALMA partners picked Chajnantor as the ALMA site (June 1997)

- Secure, 50-year access was achieved in 2004.
- AUI had filed mining claims early, to protect the site until the process was finished. It was the largest mining claim in Chilean history - 28,000 hectares. These claims are now maintained by the ALMA Executives.
- Site negotiations involved ESO, AUI, and ~15+ Chilean government agencies. Heroes: E. Hardy (AUI), D. Hofstadt (ESO), the Chilean astronomers, and many others.

ALMA is presented to the Atacamenan Community



President Frei declares Chajnantor to be a Science Reserve - 17 June 1998



E. Hardy

President Frei M. Haynes

The Site Agreement

- ALMA gets a site for 50 years, in a combination of concessions and leases;
- Chile gets 10% of the observing time;
- ALMA makes annual payments to support cultural activities in Region 2 and the development of astronomy in Chile.

Major Event for Europe - ESO Council Visits Chajnantor - March 2000

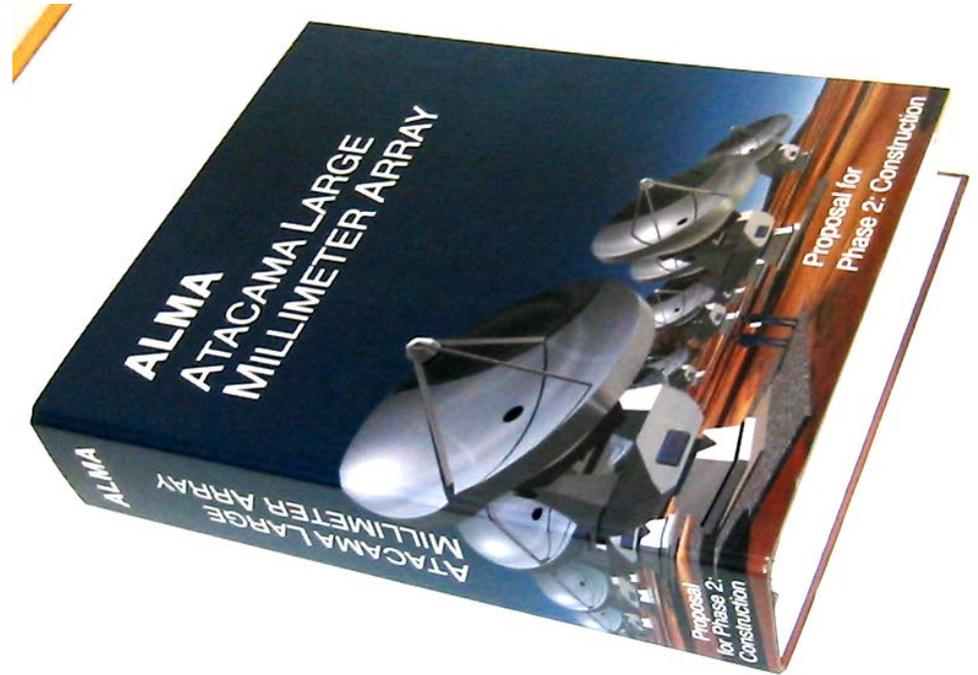


Some Milestones:

2000 December:
Submission of the proposal for the construction of ALMA to ESO Council

2001 April:
Resolution for a trilateral project (Europe, US, Japan)

2001 November: US approved FY 2002 funds for start of construction



2002 July: Approval of ALMA project by ESO Council

2002 August: Approval of the project by the NSF Board

2002 October: ESO-Chile agreement on use of Chajnantor

2003 January: ESO-Spain Agreement signed

2003 February:

ESO and NSF signed the Bilateral Agreement on ALMA (ESO on behalf of its ten member countries and Spain, and NSF on behalf of the U.S. and Canada).



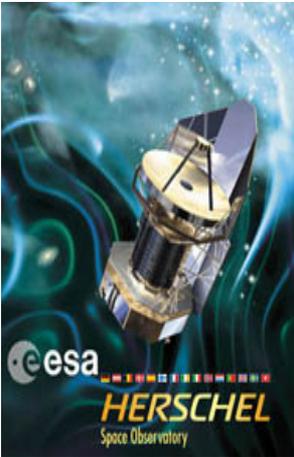
2003 June: Agreement signed by NSF(US) and NRC(Canada) bringing Canada into ALMA.

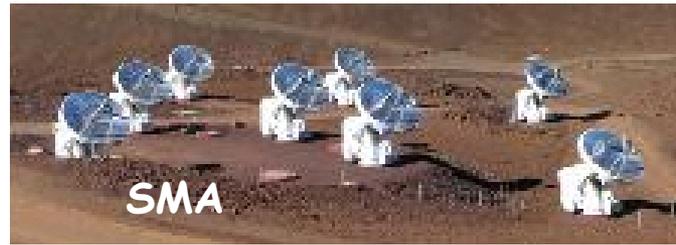
2006 July: Agreement signed between NSF, ESO, and NINS to begin the tri-lateral ALMA Project.

Delay Can Be a Good Thing, Providing the Time Needed to Realize a Bigger Project

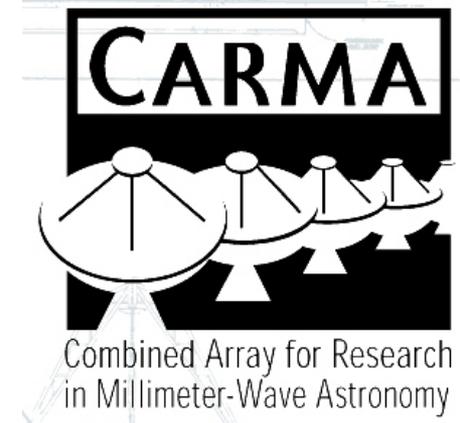
Date	Document	Array	Cost
Sept 82	MMA Memo #1	15x10m	36 M\$
Aug 89	MMA Design Estimate	40x8m	66 M\$
July 90	MMA Proposal	40x8m	120 M\$
1999	US Reference Array	36x10m	343 M\$
May 91	SEST++	10x8m	50 M\$
1994	LSA Concept	40x16m	284 M\$
June 97	ALMA=MMA+LSA	64x12m	552 M\$
Today	Re-baselined ALMA, with Japan as partner	68x12m + 12x8m	~ 1 B\$

The ALMA / Spitzer / Herschel / Planck / - / - Era is just ahead





ALMA will be uniquely powerful, but not alone.



Only A Few Details Remain ...

- Completion of Construction
- Start of Operations

