The initial phases of the Telescopio Nazionale Galileo

- Initial Events (1988-1990)
- Construction Phases (1990-1998)

Cesare Barbieri
Emeritus of Astronomy
University of Padova

Documentation

- TNG-Newsletter Nr. 1 (Jan. 1992) to nr. 19 (May 1998)
- Technical Reports nr. 1 (1990) to nr. 77 (1998)

http://www.pd.astro.it/TNG/ (frozen in 1999)
(Award in Year 2000 by the Schoolzone Panel of 400 American Teachers)

Now moved to: http://dipastro.pd.astro.it/planets/tngproject

Some key initial events

- Jan. 1987 - GNA-CNR Working Group document: ***VLT+COLUMBUS (now LBT) + 4m class telescope optimized for imaging quality***

- Feb. 1988 - Approval of WG document by CRA and issue of Call for Proposal for a 4m class telescope

- Oct. 1988: approval by CRA of TNG Phase A study and first indication of sites (***La Palma, Mt. Graham***)

December 1988 – TNG Phase A study

- NTT-like
- 2 Nasmyth foci f/11

plus ***future possibility*** of:

- prime focus with corrector
- trapped f/6 focus with dedicated secondary after removal of tertiary

The proposers

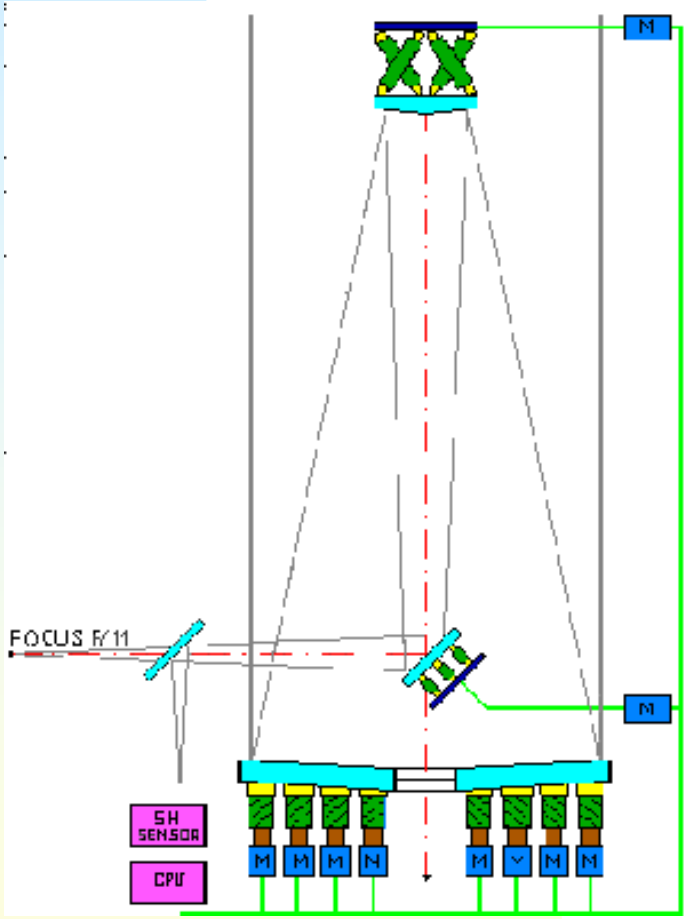
TABELLA A

Direzione del Progetto:	C. Barbieri	OA Padova
Ufficio del Progetto :	R.Falomo	OA Padova
	M. Zambon	
Sottosistema Telescopio ed Edificio:	P. Conconi	OA Milano
	F. Bonoli	OA Bologna
Sottosistema Ottica:	P.Rafanelli	DA Padova
	P. Conconi	OA Milano
	S. Furlani	OA Trieste
Sottosistema Movimentazione Controlli ed Acquisizione Dati:	D. Mancini	OA Napoli
	M. D'Alessandro	OA Padova
	D. Fantinel	OA Padova
	G. Natali	CNR Roma
	S. Sardone	OA Catania
Sottosistema Sito:	S. Ortolani	OA Padova
	S. Cristaldi	DA Catania
	A. Righini	DA Firenze
	V. Zitelli	OA Bologna
	M. Capaccioli	OA Padova

TABELLA B

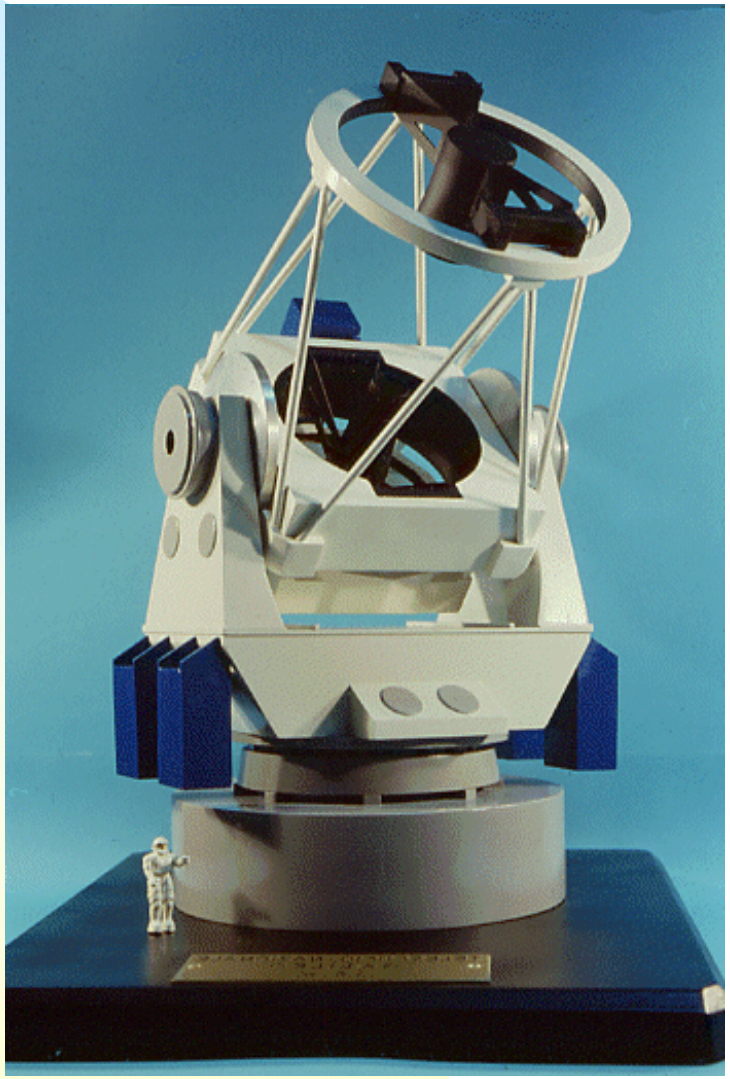
Coordinatore:	F.Fusi Pecci	OA Bologna
Imaging:	S. di Serego	ESA/ECF
	F. Bortoletto	DA Padova
	G. Bonanno	OA Catania
	R. Buonanno	OA Roma
Spettroscopia a bassa risoluzione e polarimetria	E. Tanzi	CNR Milano
	S. Cristiani	DA Padova
	E. Landi degli Innocenti	OA Firenze
	F. Scaltriti	OA Torino
	P. Vettolani	CNR Bologna
	A. Vittone	OA Napoli
Spettroscopia ad alta risoluzione:	P. Molaro	OA Trieste
	S. Catalano	DA Catania
	R. Gratton	OA Roma
Infrarosso:	D. Lorenzetti	CNR Frascati
	E. Oliva	OA Firenze
	F. Strafella	DA Lecce
Struttura dei dati e collegamento ASTRONET:	M. Pucillo	OA TRieste
	P. Battistini	DA Bologna
	L. Benacchio	OA Padova
	F. Bortoletto	DA Padova
	F. Delpino	OA Bologna

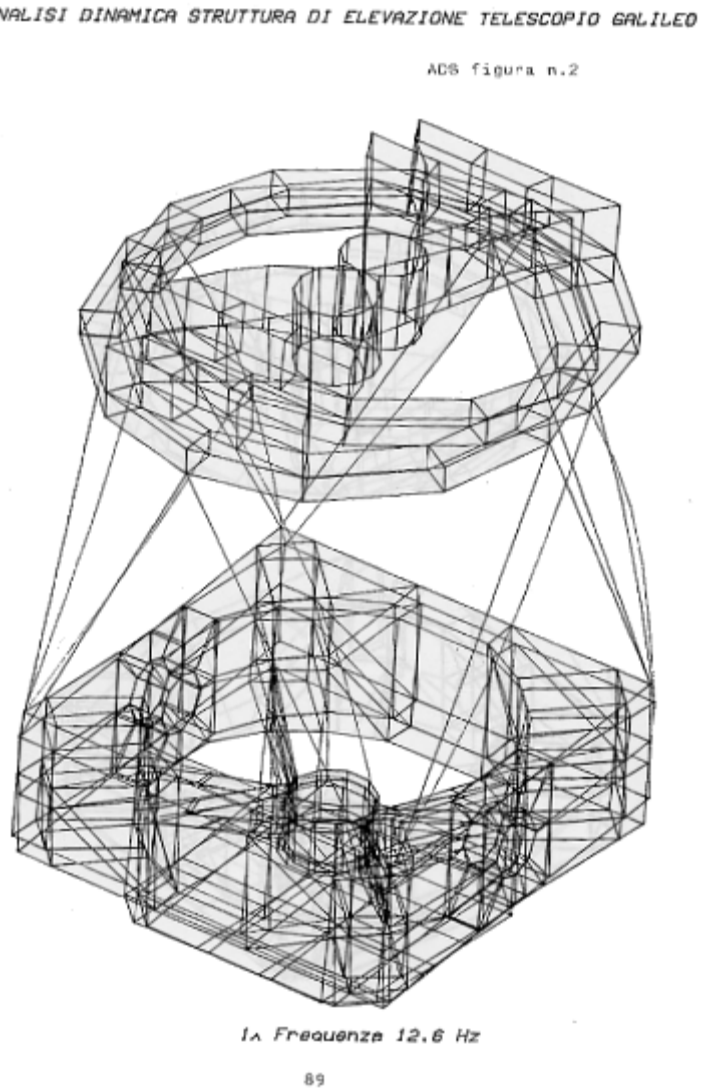
Modifications implemented to the NTT design



- *Possibility of prime focus (raise height of dome by 2 m; add crane;*
- *change control system of M1*
- *change support system of M2 (exapod) and the spider shape from 90° to 60° for easier removal and optimal imaging*
- *add tilting of M3 (up to 15 Hz)*
- *change electronics, control systems and operating system*

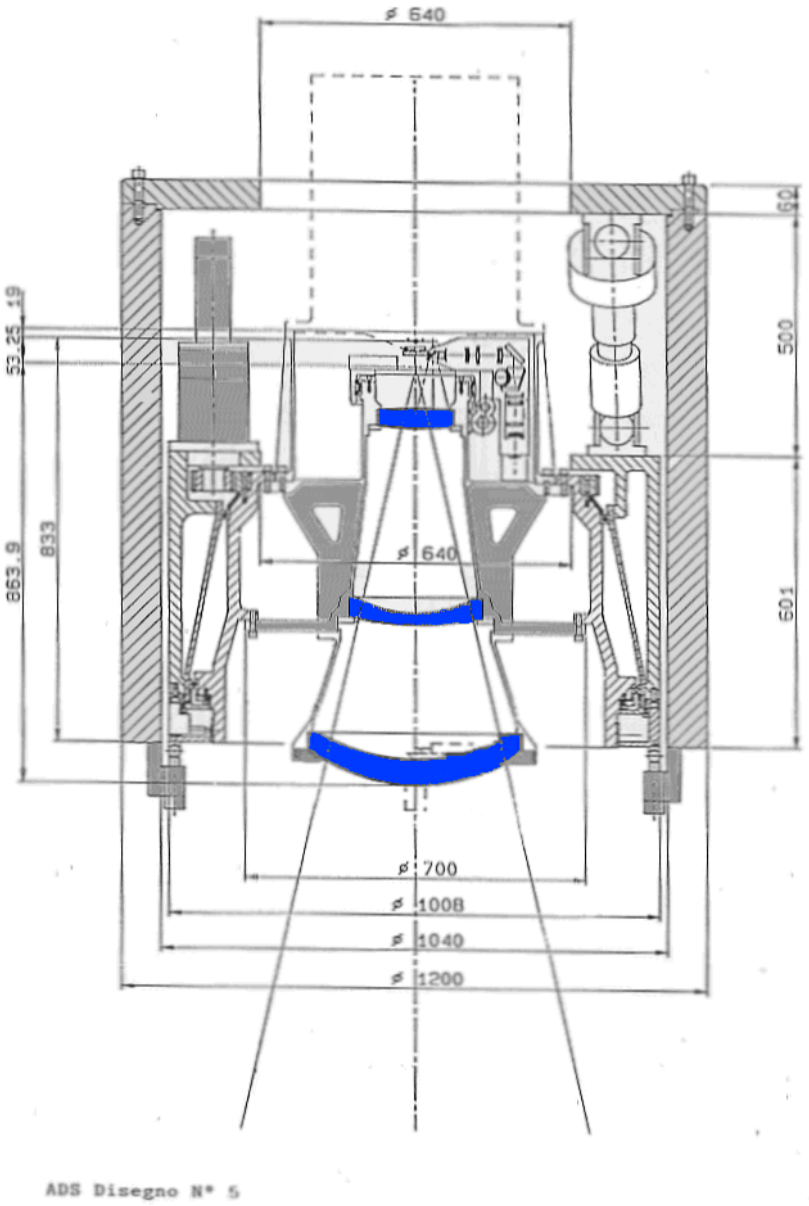
The original design



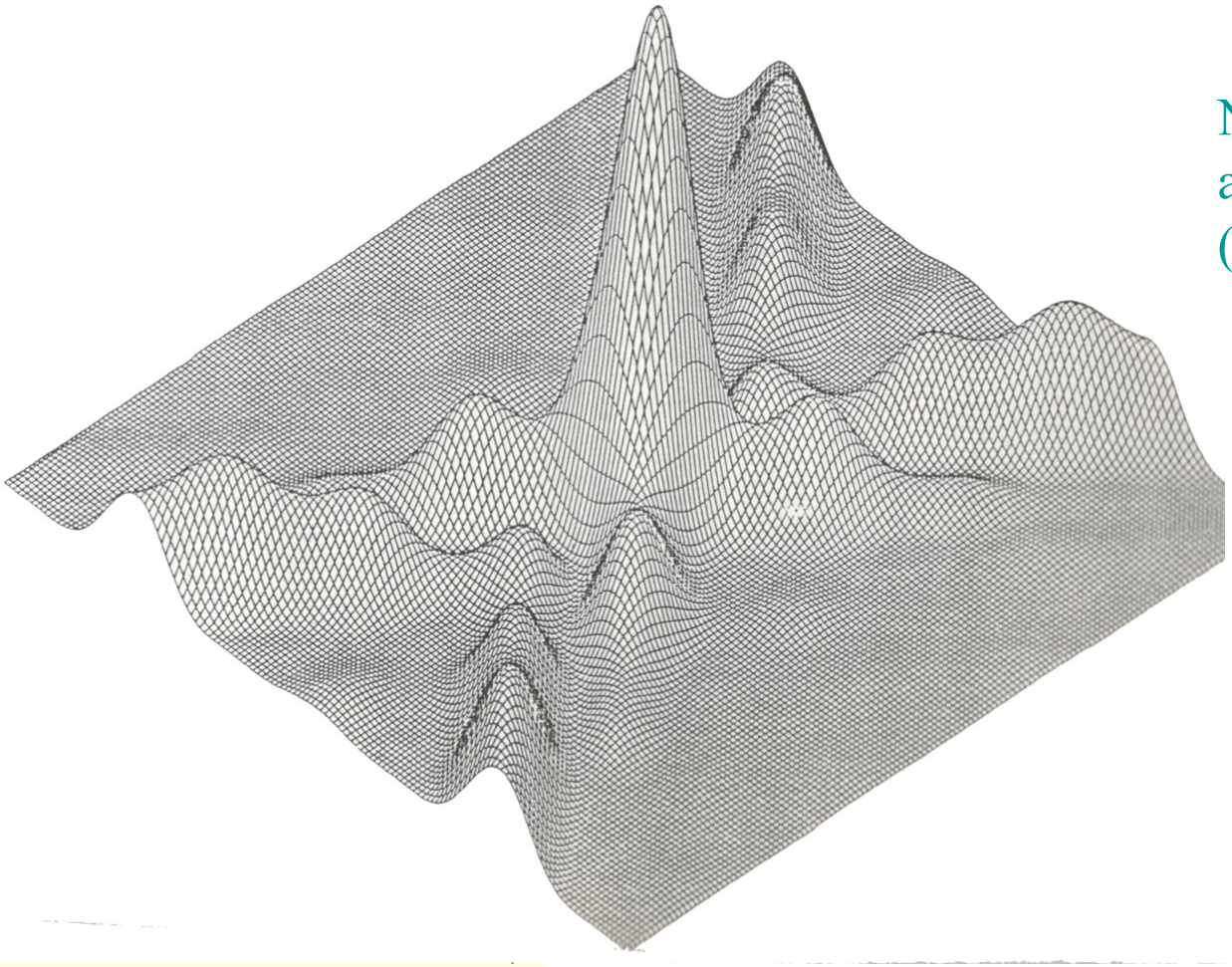


Structural analysis by ADS (W. Gallieni)

The 1988 f/2.4 prime focus design



The diffraction figure of the 60 deg TNG spiders



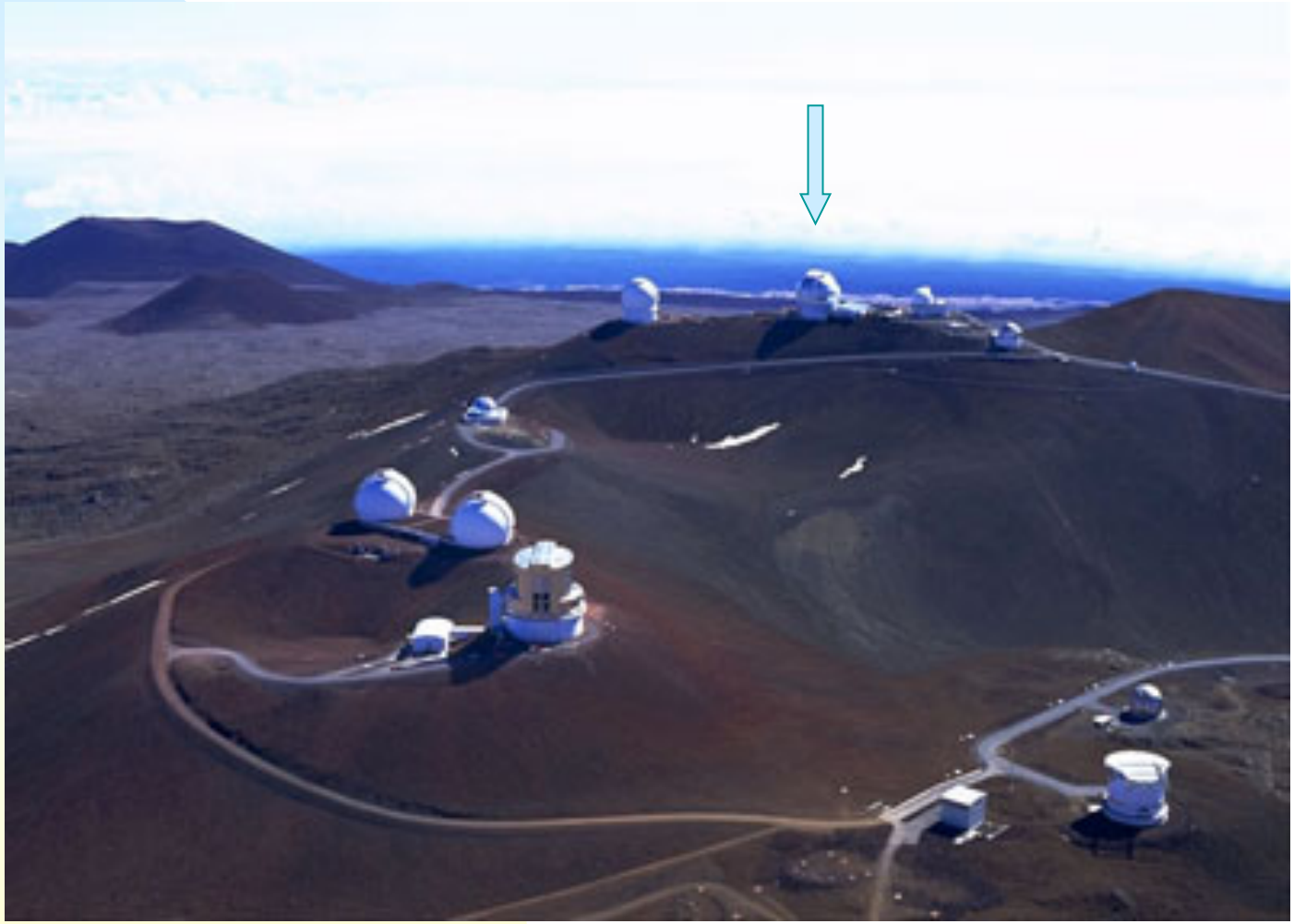
Notice the two large clean areas
(P. Conconi)

1990, another site was added by CRA: Mauna Kea (Hawaii, USA)

Motivated by the on-going project COLUMBUS in Arizona, the CRA decided to start negotiations with the University of Hawaii to site the TNG in Mauna Kea.

G. Setti and C. Barbieri inspect Mauna Kea

The possible TNG site in Mauna Kea



The TNG site was foreseen essentially where Gemini is now located

Period 1990 – 1991 – Mauna Kea (a)

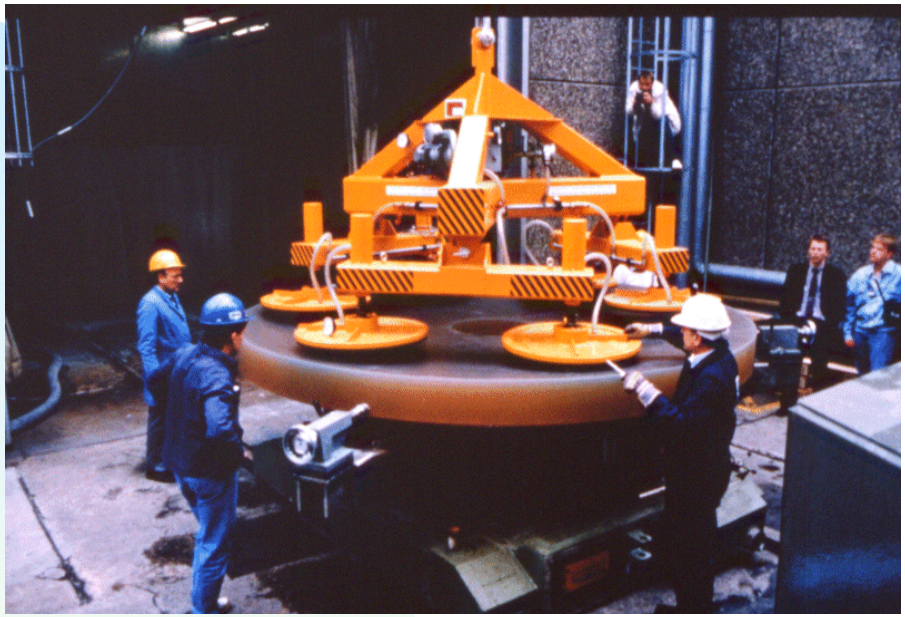
- Select Project Office team: sign agreements with Consorzio Padova Ricerche (A. Maurizio as Project Manager), and with Ministry of Public Education (M. Zambon as Deputy Project Manager and F. Rampazzi for documentation)
- perform soil exploration and define legal boundaries for Mauna Kea
- acquire NTT documentation (thanks ESO!)
- implement design modifications to the NTT telescope and building

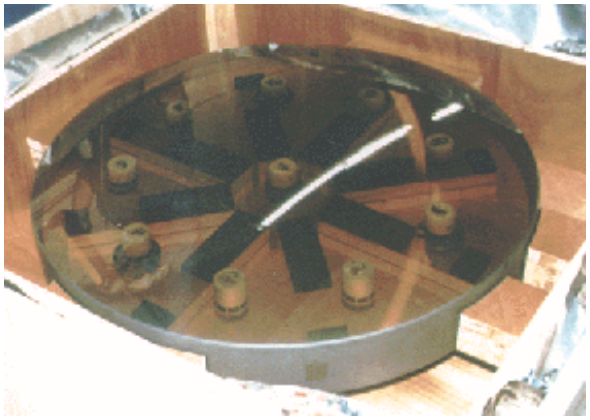
Period 1990- 1992 – Mauna Kea (b)

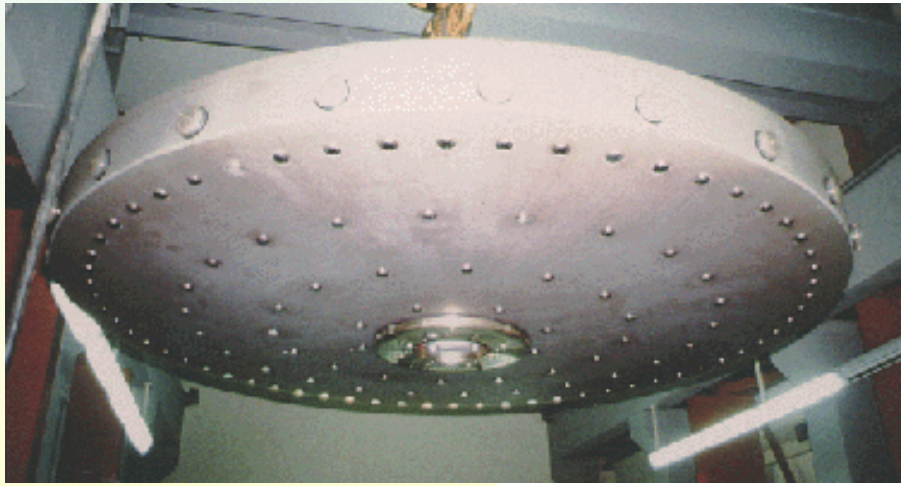
- Contract with ZEISS: procurement and figuring of blanks (P. Rafanelli)
- contract with Ansaldo - CRIV - EIE for telescope structure, including M1 cell (P. Conconi)
- contracts with Heidenhain for encoders and Sierracin-Magnedyne for motors (D. Mancini)
- define the active optics group (F. Bortoletto)
- define software control ambient (C. Bonoli) and remote control and user interface (M. Pucillo)
- Design and procure a Differential Image Motion Monitor (D. Mancini)

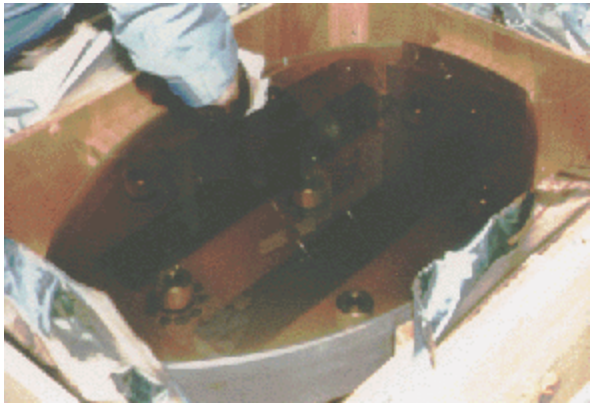
Period 1990-1992 (c)

Start and completion of contract with ZEISS

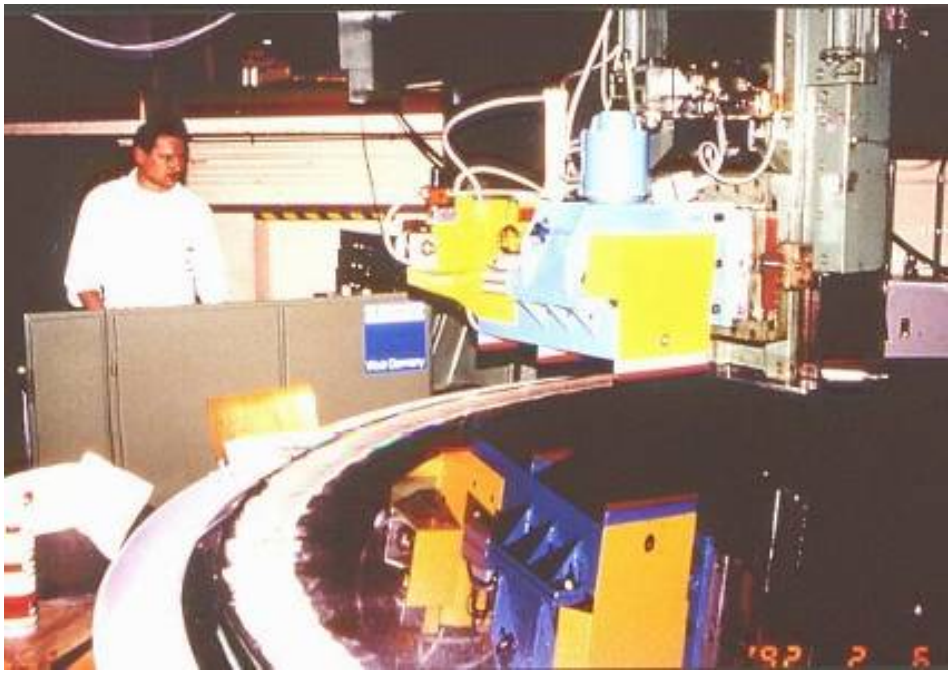








Lapping and figuring at ZEISS



M1 schedule at ZEISS

Primary Mirror GALILEO

Material:

ZERODUR from Schott with

- low thermal expansion
- low residual stresses
- high formstability
- high optical performance

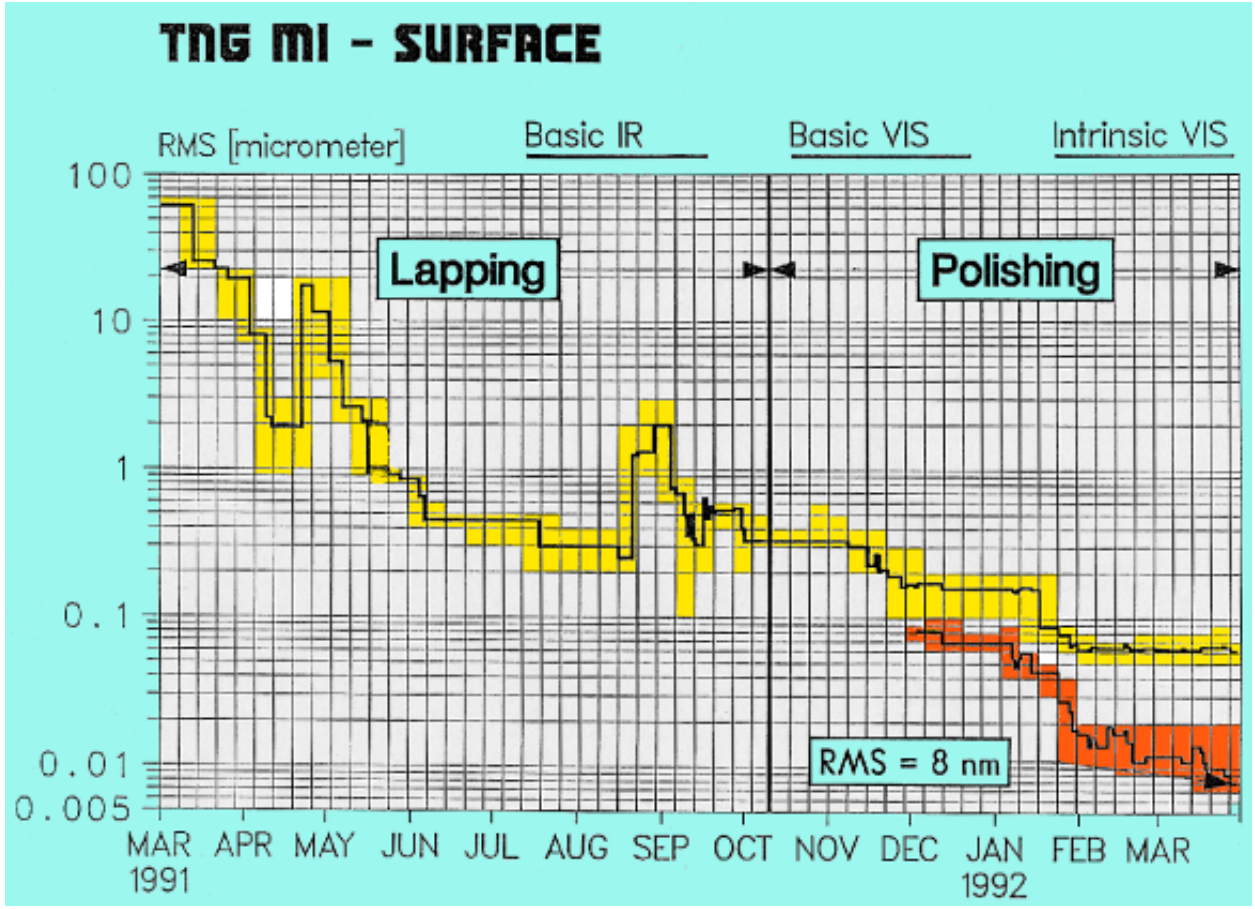
Geometry:

Outer diameter	3580	mm
Thickness	240	mm
Aspect ratio	D/h = 15	
Radius of curv.	15.4	m
Focal ratio	F/D = 2.2	
Deformation	200	µm
Weight	6.0	to

Support:

Active axial support on 4 rings
8 + 16 + 24 + 30 = 78 pads
3 fixpoints

passive lateral support at outer diameter with 24 pads



ZEISS quality

Basic Quality

after subtraction of

piston
tilt
focus
coma

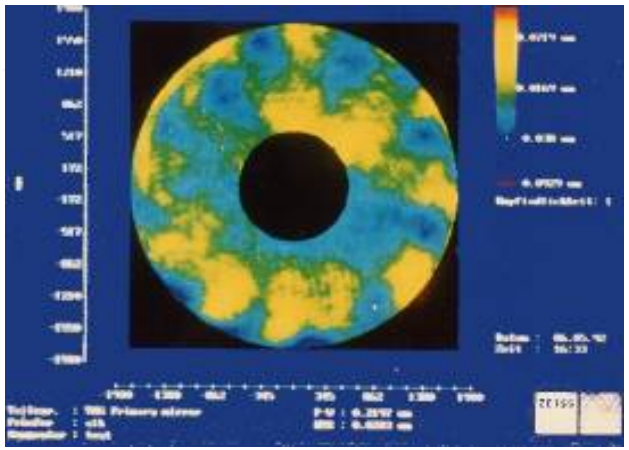
Scale: ± 1 λ
λ = 632.8 nm

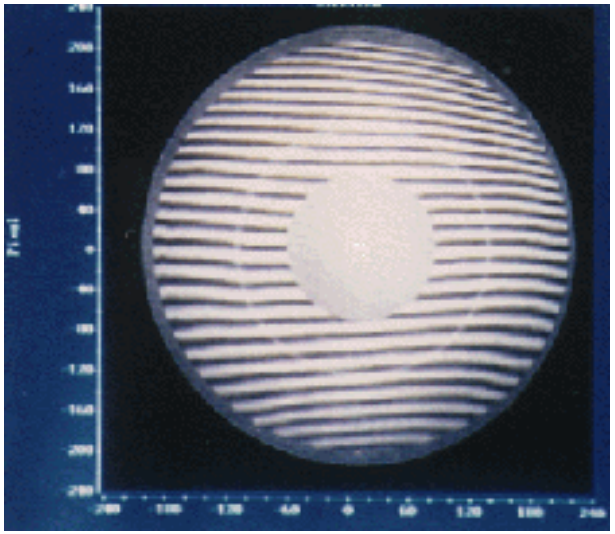
P-V 526 nm Surface

RMS 93 nm Surface

Encircled energy:

$E_{80\%}$ within 0.24 arcsec dia.
for 35x35 sampling points





Intrinsic Quality

after further subtraction of

astigmatism
spher. aberration
triangular coma
quadr. astigmatism

Scale: ± λ/2
λ = 632.8 nm

P-V 62 nm Surface

RMS 8 nm Surface

Encircled energy:

$E_{80\%}$ within 0.07 arcsec dia.
for 35x35 sampling points

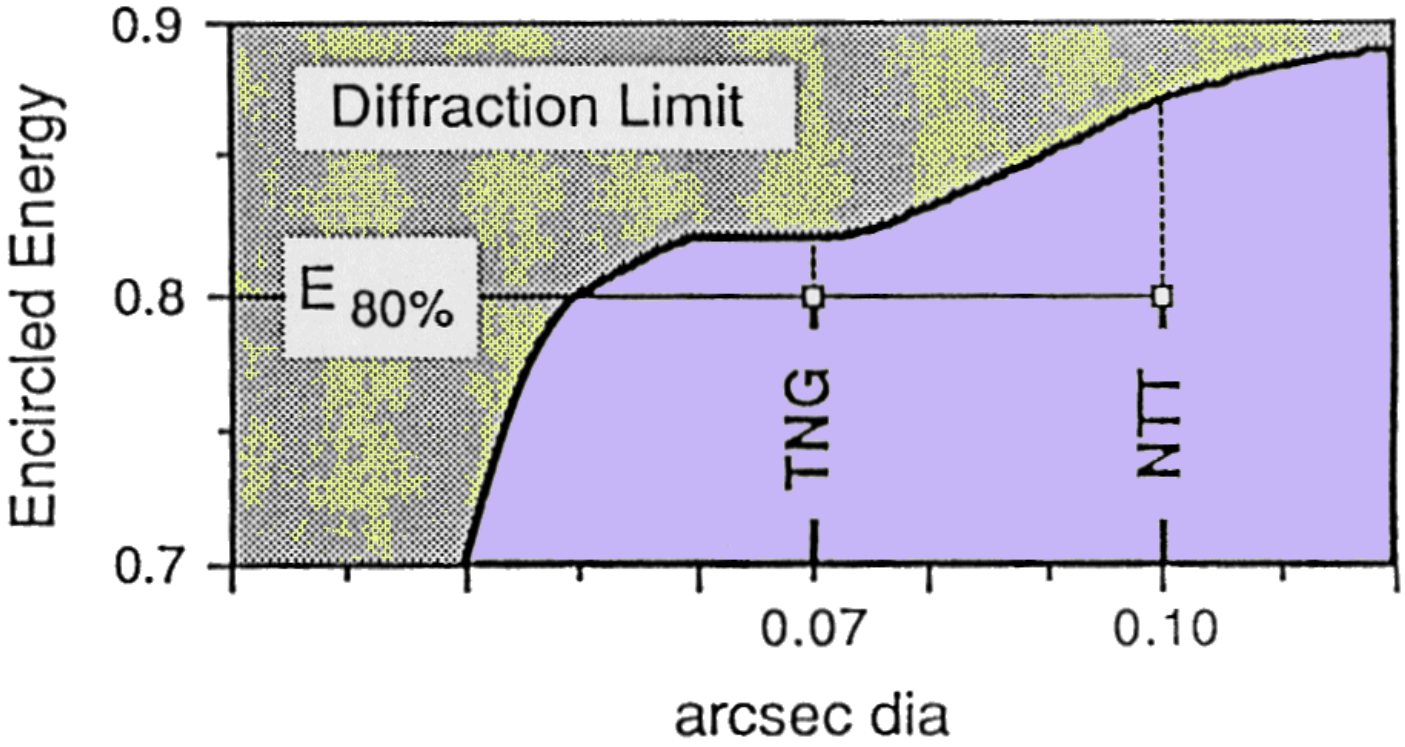
ZEISS Milestone

Another Milestone in modern Astronomy

The 3.6 m Primary Mirror of the Telescopio Nazionale Galileo (TNG)

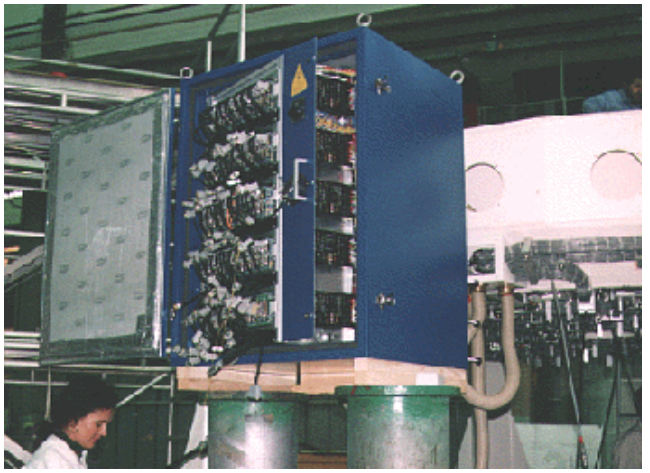
by Ernst-Dieter Knohl, Frank Schillke, Michael Schmidt

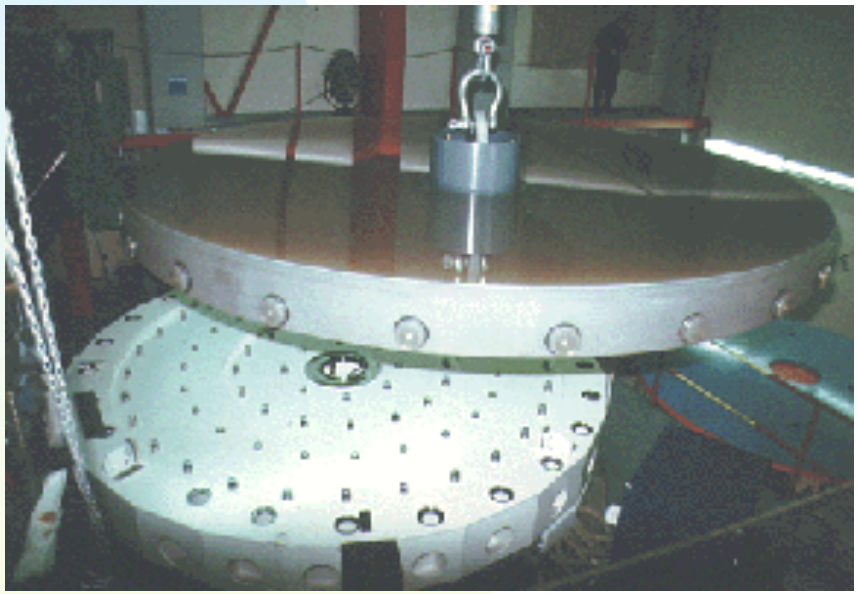
CARL ZEISS Oberkochen, West Germany



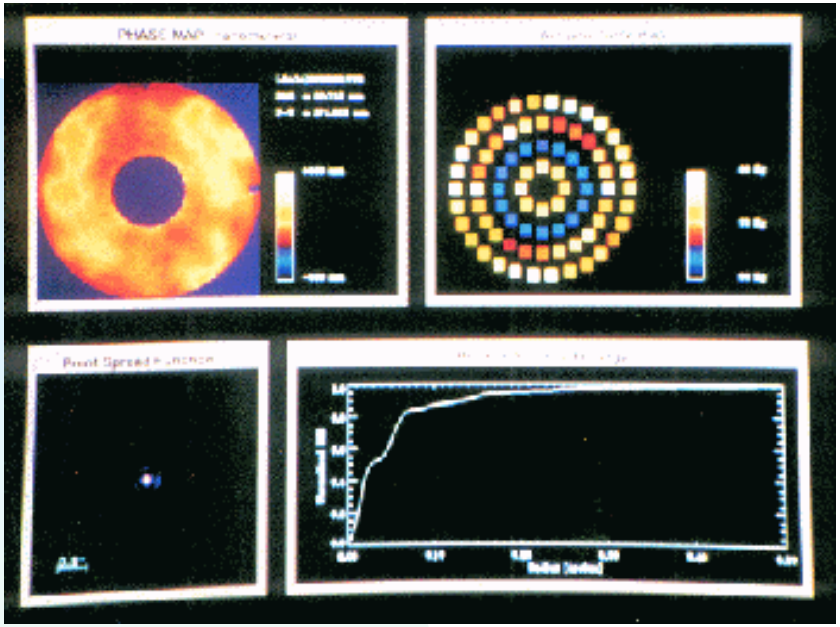
M1 tests at ZEISS on the TNG cell

The M1 cell and its electronics were completed in time for on site verification of Zeiss results.
A portable wavefront analyzer was developed and transported to Zeiss.

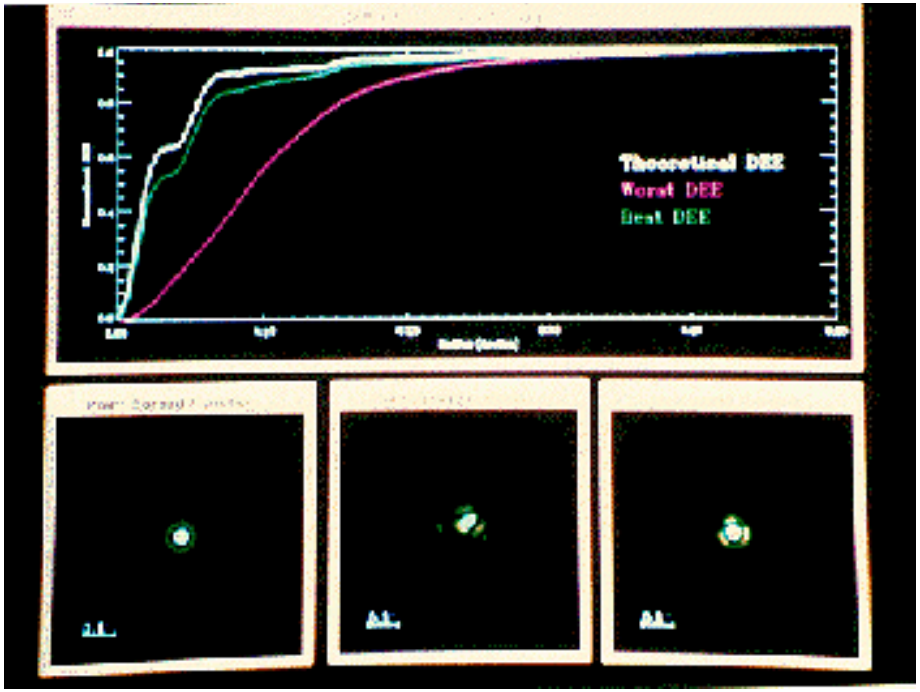




No spherical aberration!
See R. Ragazzoni, 1994
TNG - *Newsletter* nr. 8



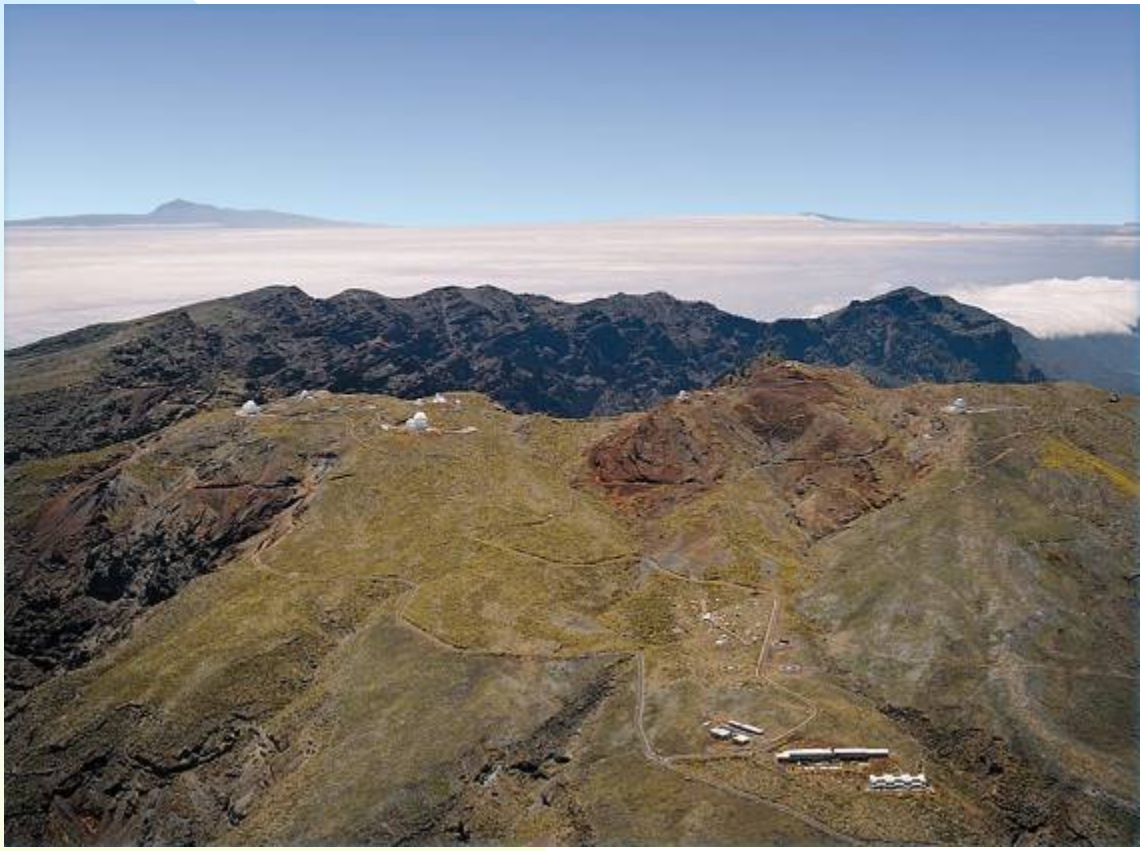
Active Optics at Zeiss (M1 on the TNG cell)



Formal acceptance of Mirrors: February 1993

(see TNG ***Newsletter*** nr. 4, April 1993)

End of 1991 : Change of site



- ***agreement with UH could not be reached!***
- *site changed from Mauna Kea to Roque de los Muchachos (unanimous decision of the Comite Cientifico International: November 1991, confirmed by the Spanish Parliament in 1992).Thanks to our Embassy in Madrid for the great work!*

Note: for other details see G. Setti, The C.R.A. and the Galileo Telescope, *TNG - Newsletter* nr. 1, Jan. 1992

The site of the Roque de los Muchachos

The Roque had been visited twice in 1981 by a OAN committee composed by R. Barbon, M. Tarenghi, B. Zanettin and myself, ***before the construction of the WHT and NOT***. We were impressed by the Western area, whose good quality was subsequently confirmed by seeing measurements performed by Arne Ardeberg.

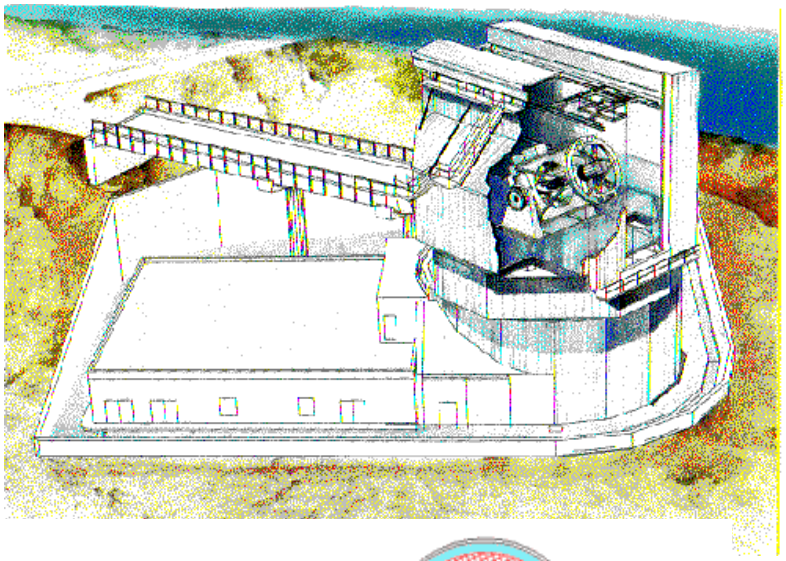
The committee pointed out also the ***severe winter conditions*** and the possibility of ***dust in the summer months***.

Consequences of site change

- Raise of elevation axis for horizon clearance: larger and taller central pillar, larger dome, larger dome rotation device
- important excavation works, a 100 m road, a massive long bridge
- change in electrical plant and motors
- change in legal framework (Canaries at the time were not fully integrated in the EC)

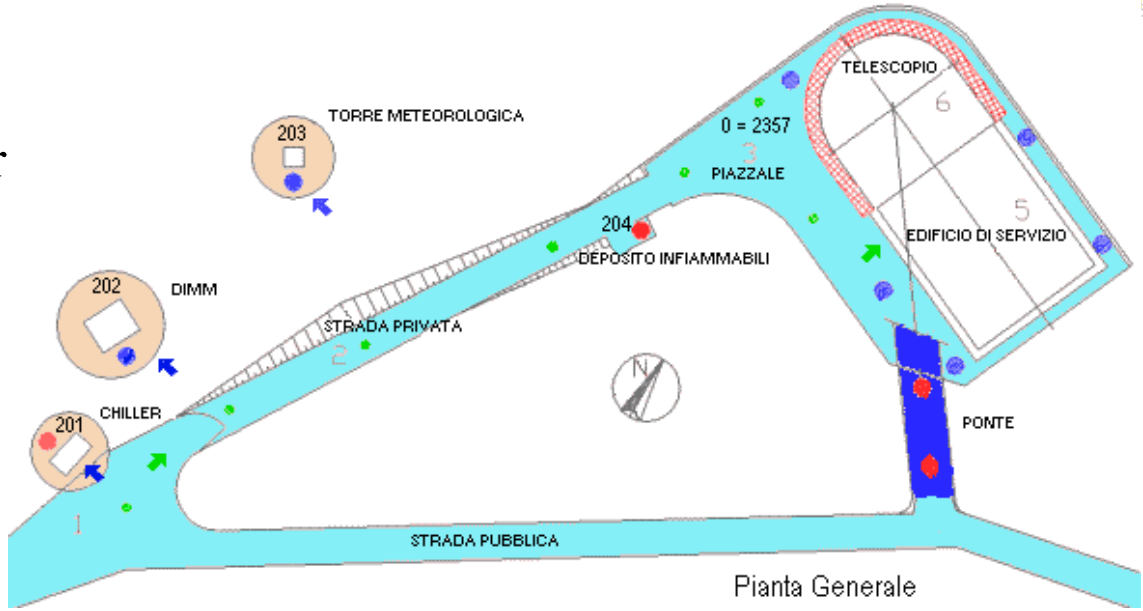
The general scheme of the TNG on the RdM

A sturdy bridge was designed to reach the telescope floor by the public road leading to the Roque summit.



The rotation of the building was constrained to ± 270°; a main control room was identified in the annex building, keeping an engineering control room below the telescope floor.

Heath venting devices (chillers) were located as far as possible from the dome. The location of the DIMM and of a meteo tower were defined below the private access road



Problems at the end of 1992

- ***Strong devaluation of the Italian lira*** in respect to all European currency, including the Spanish peseta (that was before the Euro!)
- ***ceiling imposed*** to the expenditures of all public bodies (Astronomical Observatories too…)
- ***signature of new contracts (excavation, building, etc.) put on hold***: first excavation could start only in October 1993! Till then, the only tangible sign of the Italian presence on the Roque was the DIMM tower.

Excavating from Oct. 25 1993 to June 1994

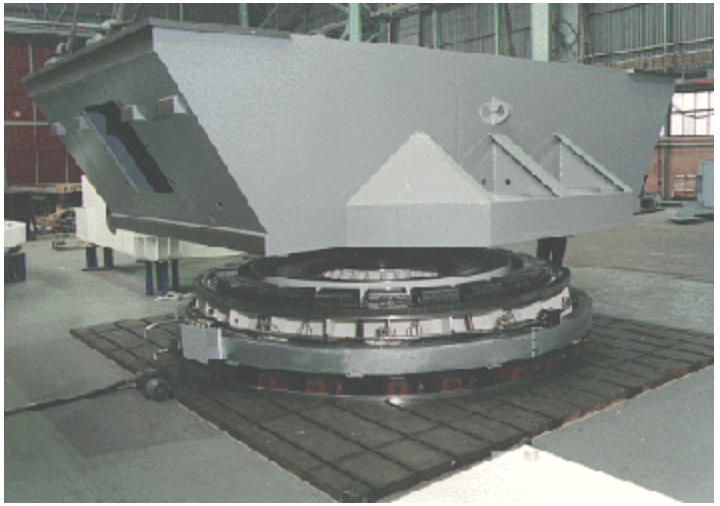
Fortunately the soil strength was found much better than at the WHT site

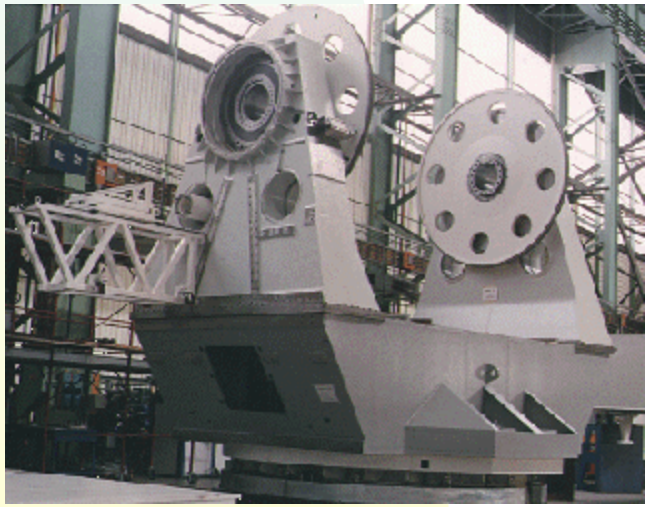
Construction Phases in 1994 - 1995

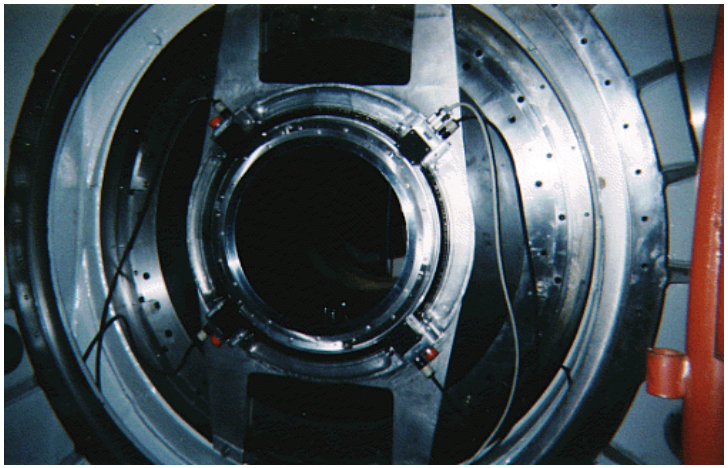
Excavation and Civil works were committed to two Spanish firms, namely Fomento and Huarte, with the direction on site performed by Salamanca Eng. Some 800 tons of concrete were poured on the Roque for the TNG.

The availability of the center of the pillar permitted the precise determination of the astronomical and geodetical coordinates of the TNG (see ***TNG*** - *Newsletter* nr. 11, 1995)

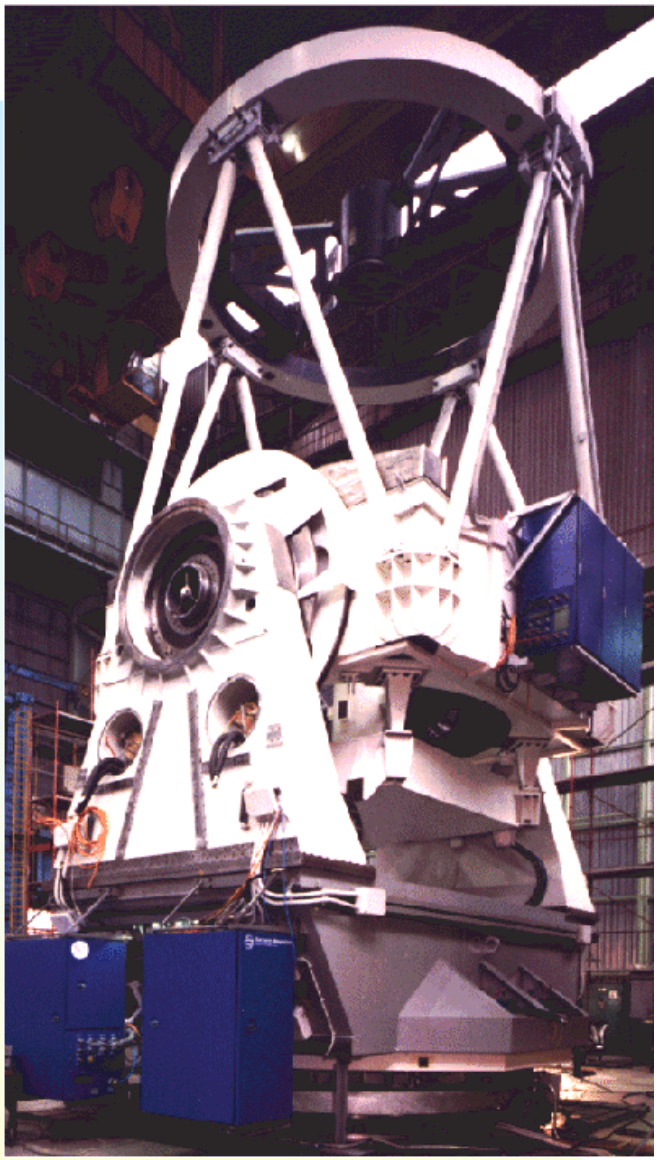
The Telescope in Ansaldo, 1993-1994







In Ansaldo, December 1994



One VLT telescope was just being erected in a nearby area

1995, Contracts for the Rotating Building, the R-A, the Electrical Plant

- It was only in 1995 that finances permitted the signature of the contract for the rotating building, with the Italian firm Bertolotti of Incisa Valdarno;

- in 1995 we could also sign the contracts with CINEL and Officine Galileo for the Rotator - Adapters (M. D'Alessandro), and in December with Guerrato for the electrical plant.

Transport Saga

More than 200 large containers were transported from Italy to La Palma

The Az Box was the largest piece ever transported to the Roque. It was fun...

1995 - Mounting the Az Box on the pillar

1995 - The dome rotation crisis

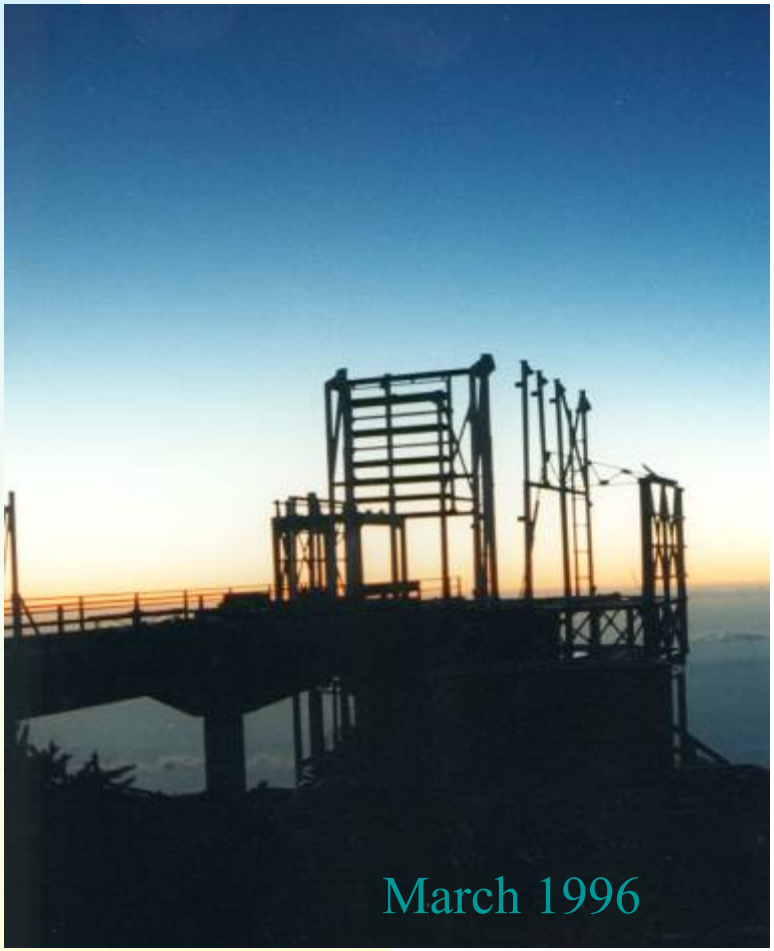
Following the bankruptcy of the firm who had delivered the device to NTT, a novel support for the dome rotation was invented by our consultants F. Bevini and P. Favaron, namely the rotating mini-sphere THK device

Erection of the metal structure

The terrible winter of 1995-96 severely affected the schedule.

Hyakutake's comet and then Hale-Bopp went by, unobservable by the still not operational TNG.

Proceeding toward the end of the erection works, early 1996



End of May 1996 - An imposing structure indeed

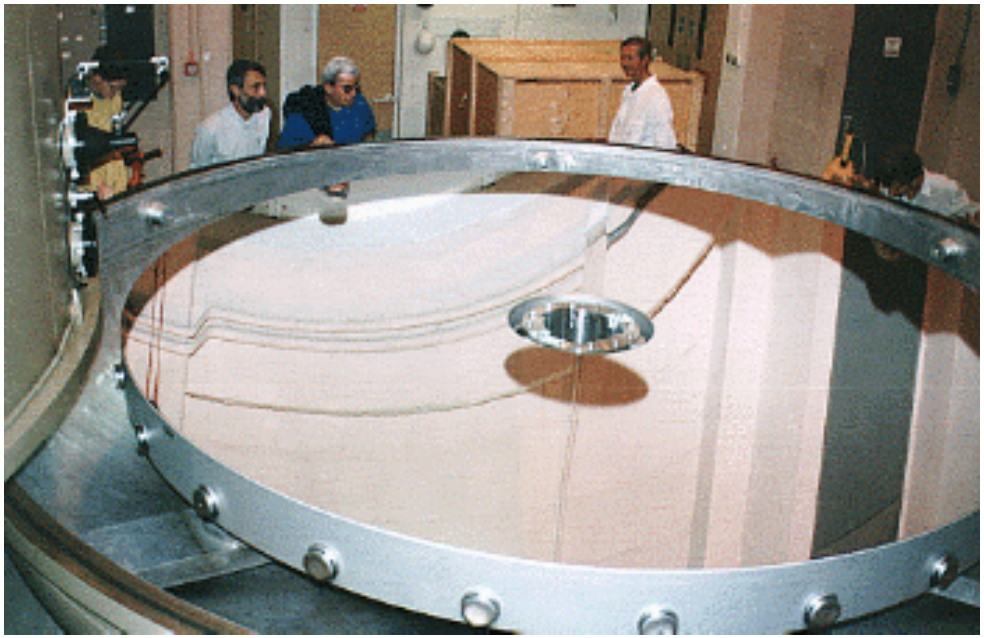
Early June 1996 - Transporting M1 to the WHT

On the same truck from Germany to the Roque

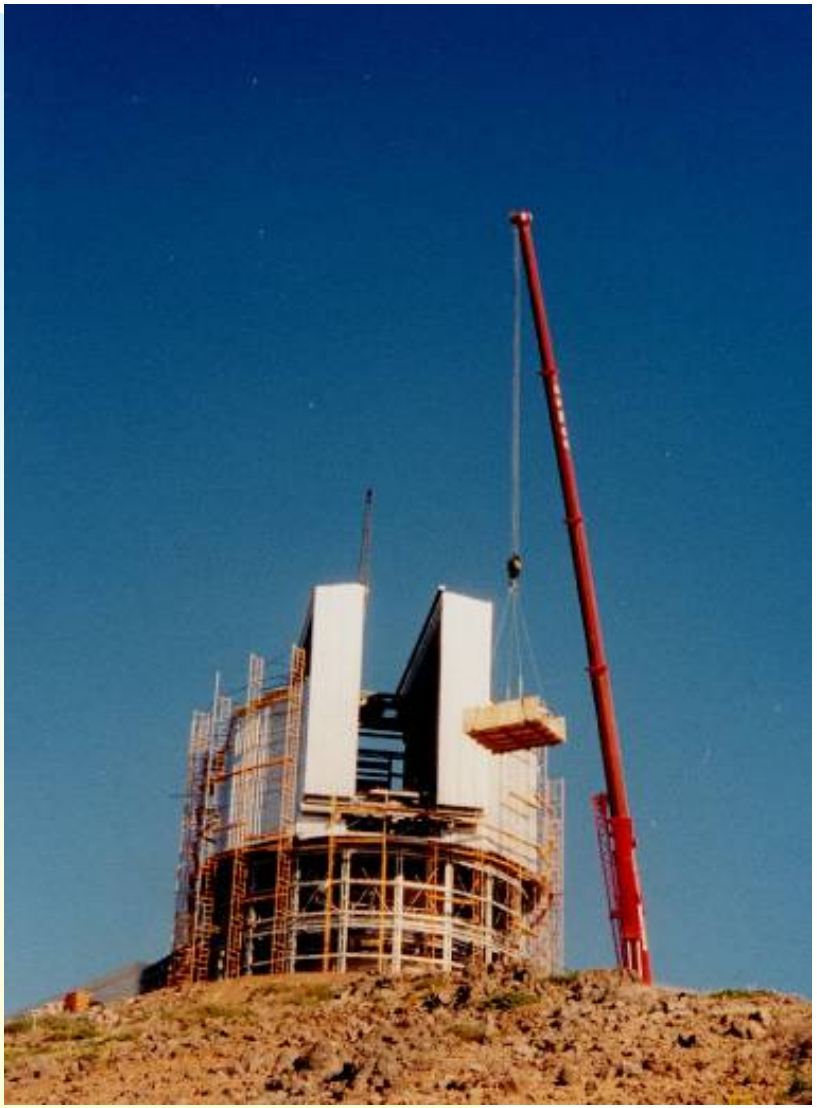
F. Bevini and H.D. Knohl inspect the mirror inside the WHT building

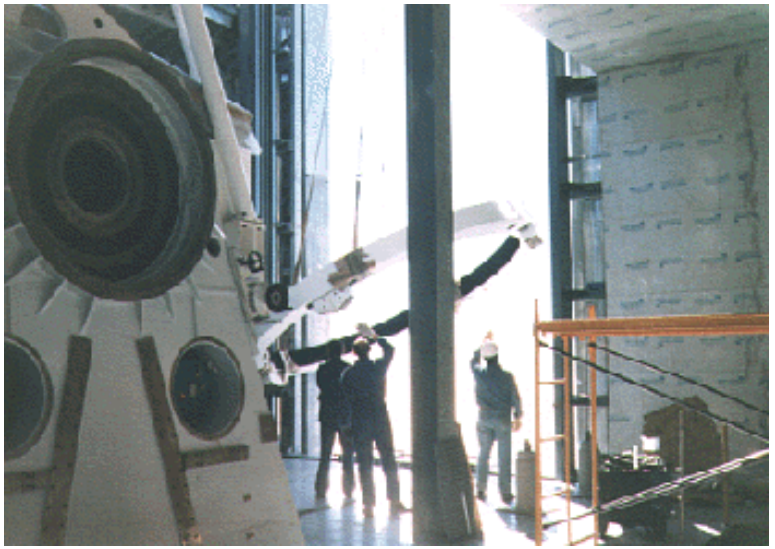
EarlyJune 1996 - Aluminizing M1 at the WHT

F. Bevini, P. Conconi, H.D. Knohl, P. Rafanelli watch all aluminizing phases



Early June 1996 - Mounting the telescope





June 1996 - The telescope inside the dome

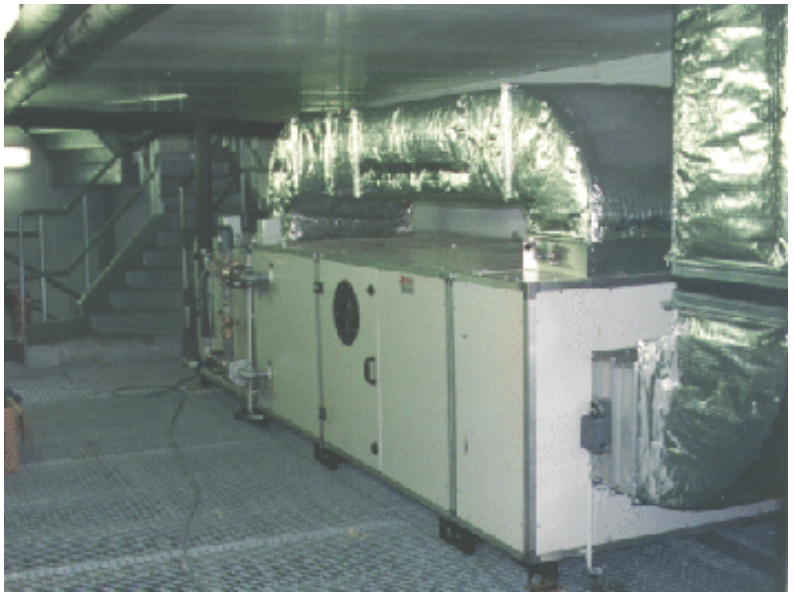
At this date, the M1 dummy is attached to the telescope

June 1996: Dedication of the new installations on the RdM and on Izaña

Aug. 1996 - Testing the rotation of the dome

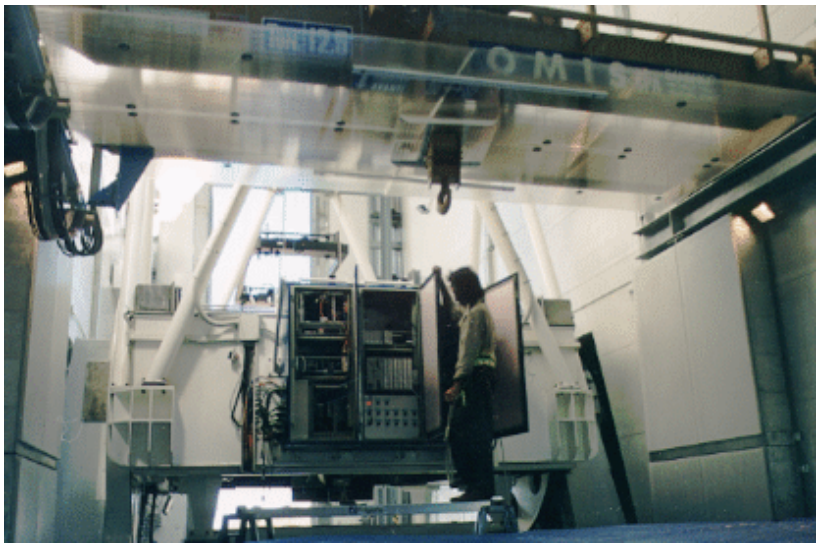
January 1997 - Snow again…, and heavy damage to the East Roof

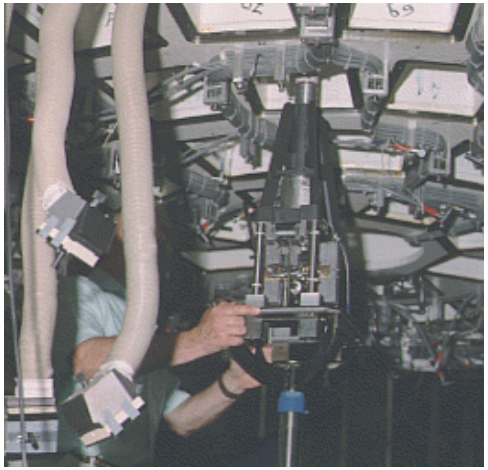
1997 - Installing the air conditioning system



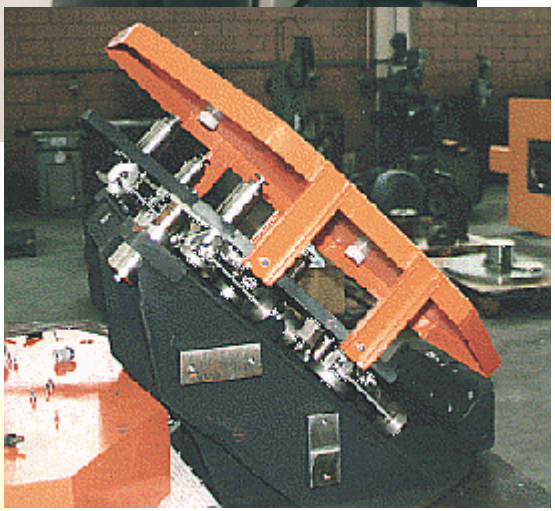
1997 - Installing the dome controls

1997 - Early 1998 Completing the installation of the telescope

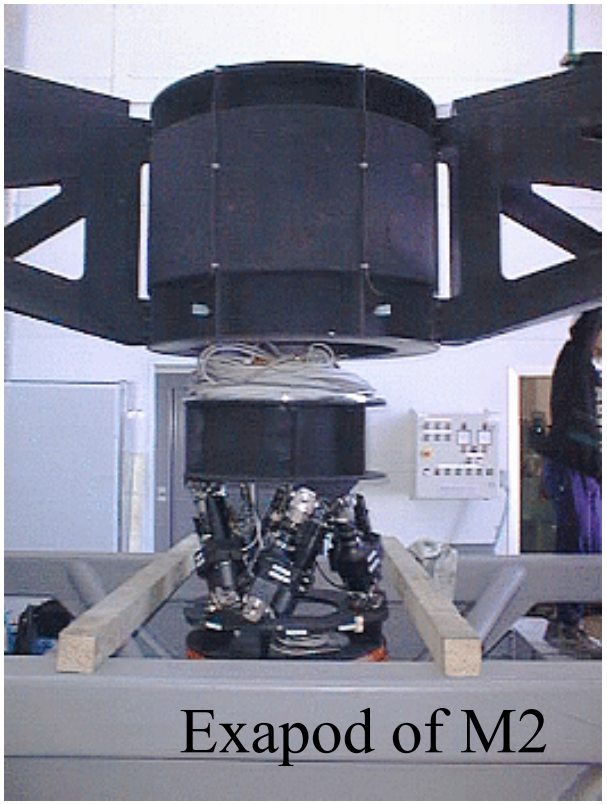




Early 1998 - Mounting the mirrors



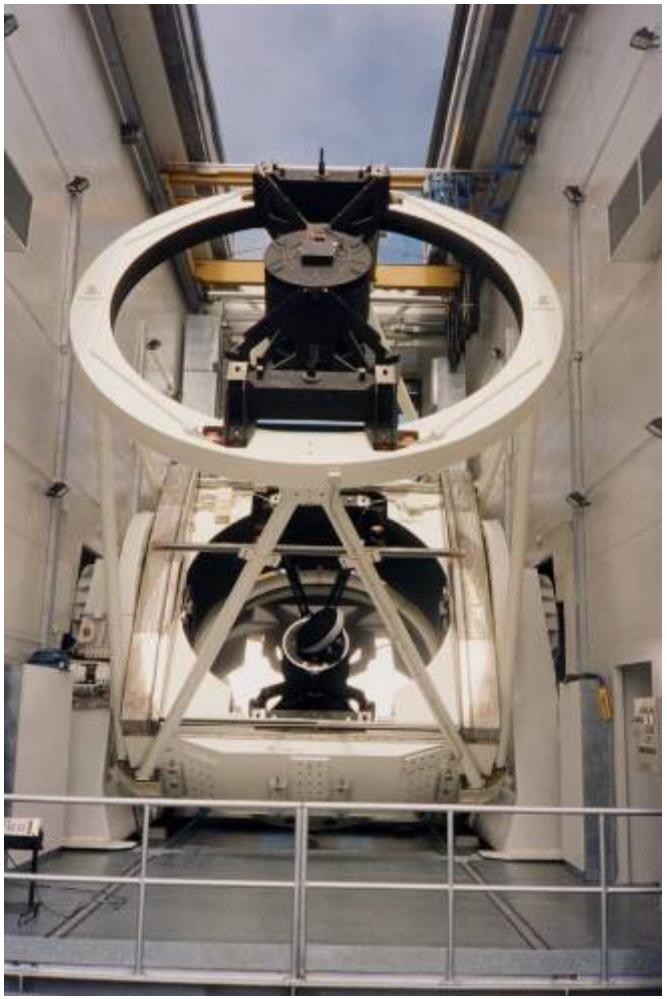
All supports of M1, M2 and M3 of the TNG are very different from those of the NTT.



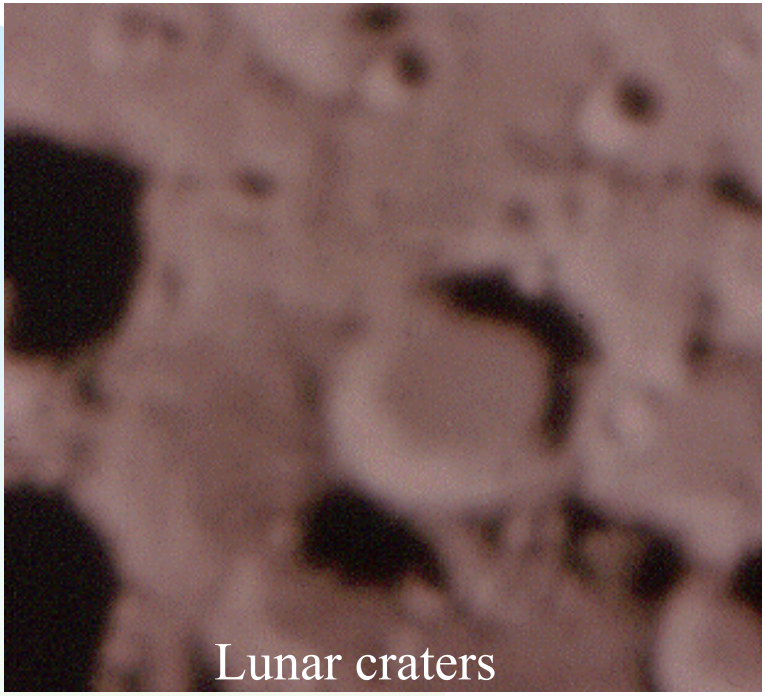
Exapod of M2

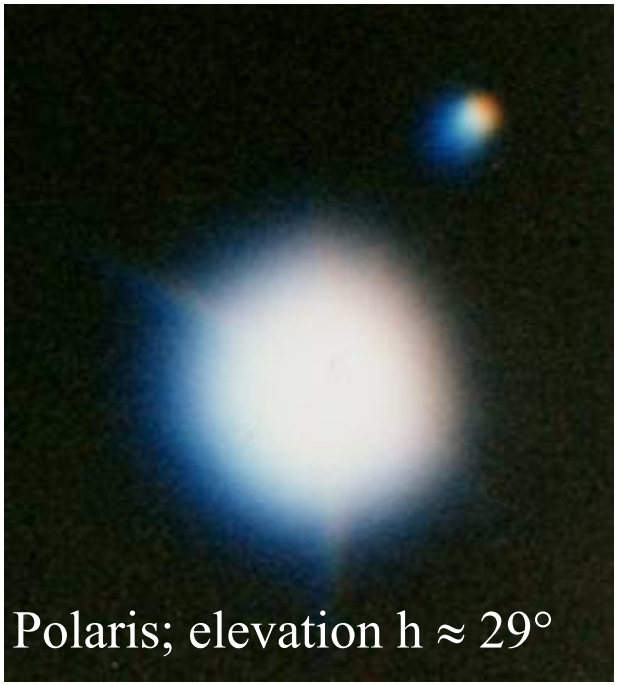
The tilting support of M3

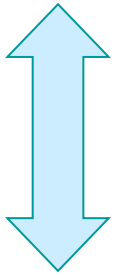
Early 1998 - mirrors installed, telescope completed and moving



March 1998: my first pictures with the TNG







That night, I went all alone to the telescope, mounted my photographic camera (with film…) and took several unguided images.
Exactly 25 years after my first plates with the Copernicus telescope at Cima Ekar, I could see that the TNG was on right track.
After several years spent up there, ***I could leave the telescope*** to the commissioning group and to the first scientific director, S. di Serego A.

The TNG construction team

warmest thanks to all of them!