The initial phases of the Telescopio Nazionale Galileo

- Initial Events (1988-1990)
- Construction Phases (1990-1998)
- My last paper with the TNG

Shadow on the Muchchos:
Cesare Barbieri

Professor Emeritus of Astronomy

University of Padova, and INAF

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

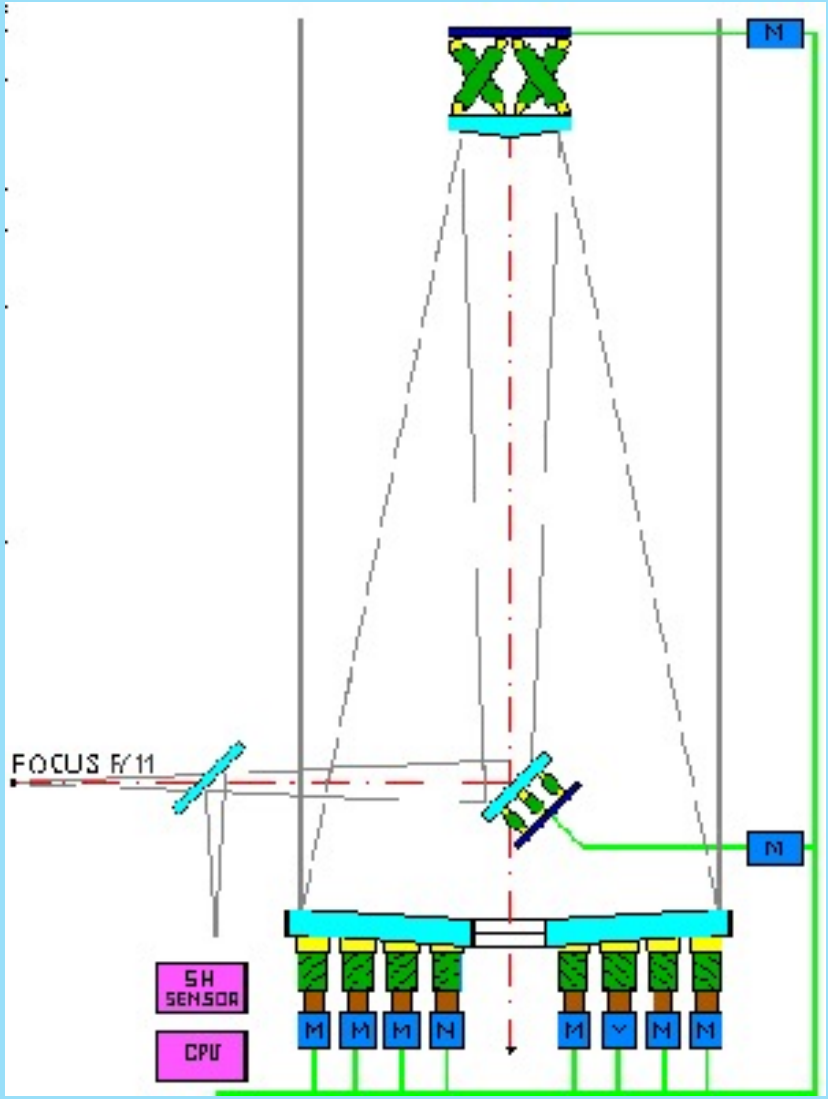
TABELLA A

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

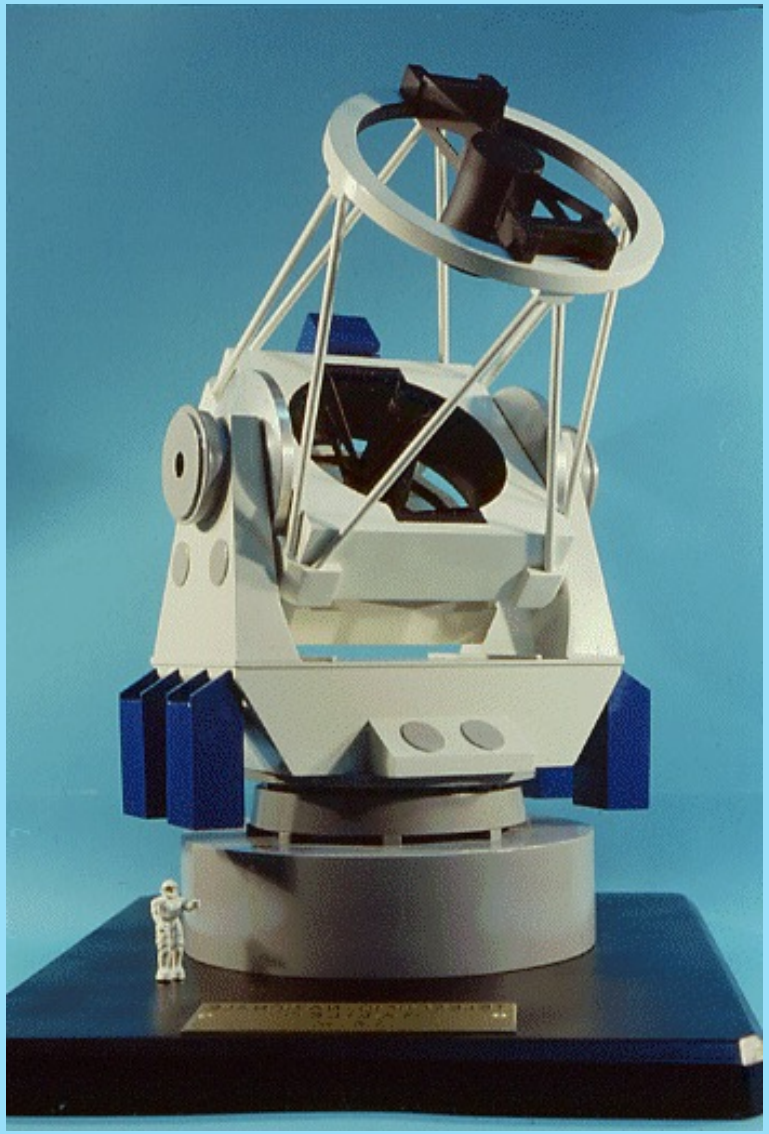
Coordinatore:	F.Fusi Pecci	OA Bologna
Imaging:	S. di Serego	ESA/ECF
	F. Bortoletto	DA Padova
	G. Bonanno	OA Catania
	R. Buonanno	OA Roma
Spettroscopia a bassa risoluzione e polarimetria	E. Tanzi	CNR Milano
	S. Cristiani	DA Padova
	E. Landi degli Innocenti	OA Firenze
	F. Scaltriti	OA Torino
	P. Vettolani	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

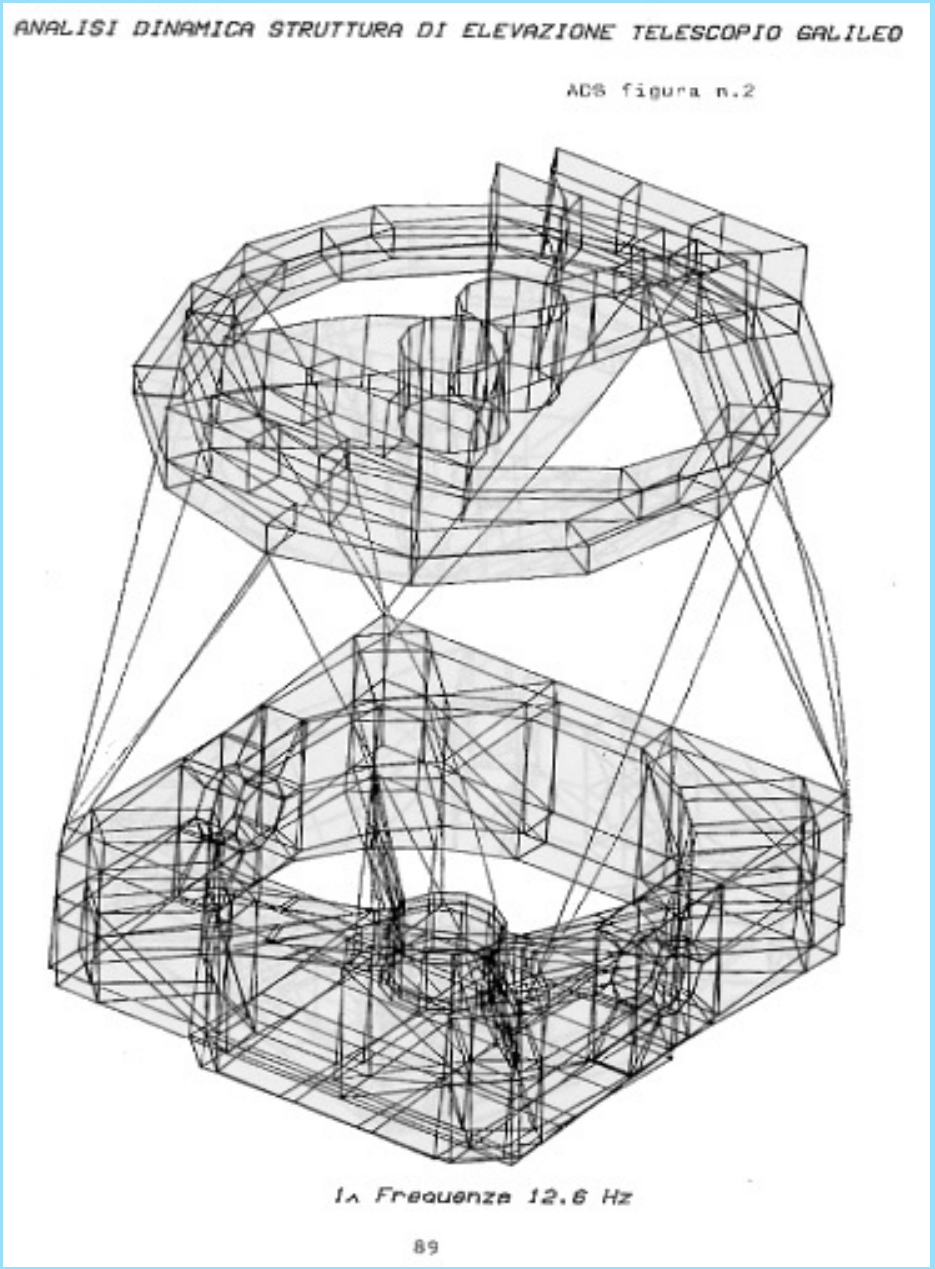
Modifications implemented to the NTT design



- *Possibility of a 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

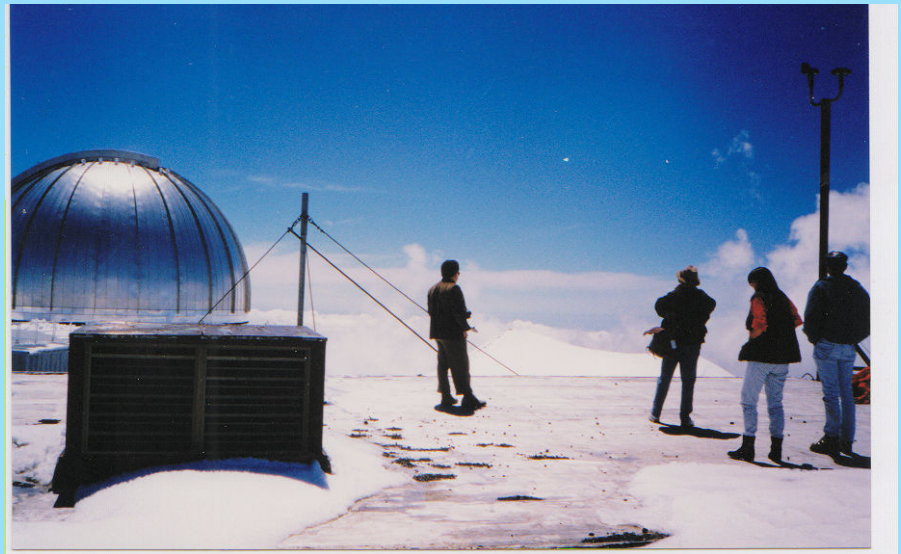




Structural analysis by ADS (W. Gallieni)

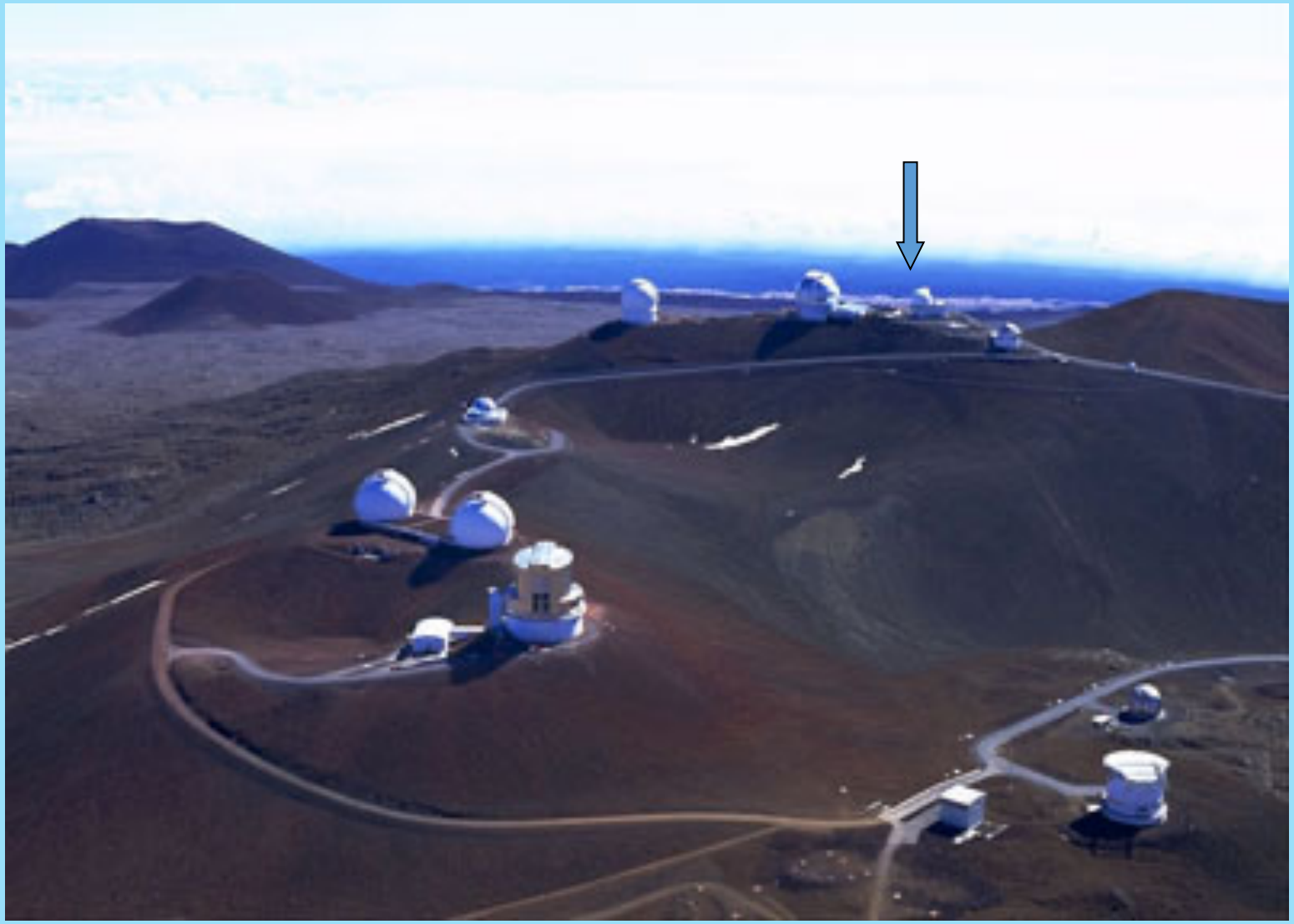
1990, another site was added by CRA: Mauna Kea (Hawaii, USA)

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 where Gemini North is now located

Period 1990 – 1991 – Mauna Kea (a)

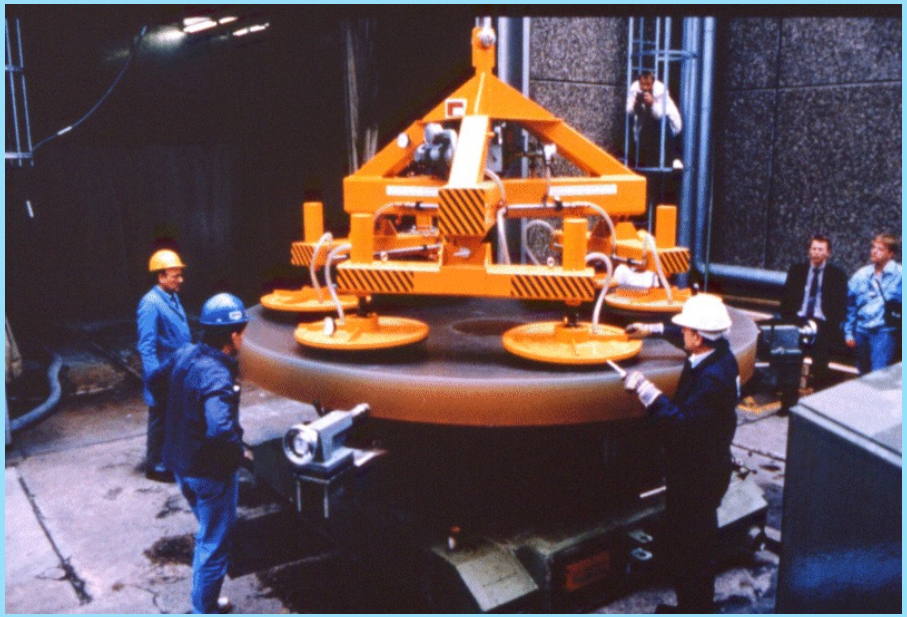
- Select Project Office team: sign agreements with Consorzio Padova Ricerche of the University of Padova (A. Maurizio as Project Manager), and with Ministry of Public Education (M. Zambon as Deputy Project Manager and F. Rampazzi for documentation)
- perform soil exploration and define legal boundaries for Mauna Kea
- acquire NTT documentation. ***Many thanks, ESO!***
- I cannot forget how important ***Ray Wilson*** was at the time, and how ***Massimo Tarenghi*** smoothed all ***relationships.*** Two great ESO directors accompanied constantly our work***, Lodewijk Woltjer*** and ***Riccardo Giacconi).***
- implement design modifications to the NTT telescope and building.

Period 1990- 1992 – Mauna Kea (b)

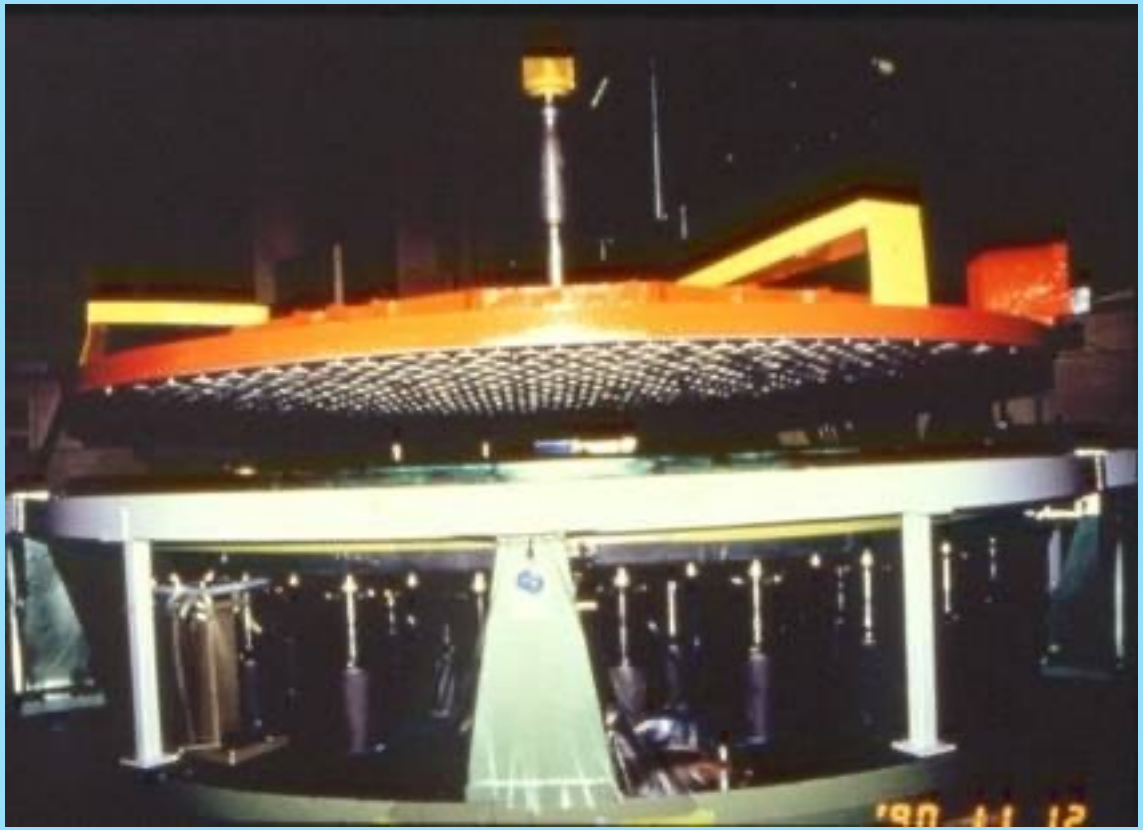
- Contract with ZEISS: procurement and figuring of blanks (P. Rafanelli)
- contract with Ansaldo - CRIV - EIE for telescope structure, including M1 cell (P. Conconi)
- contracts with Heidenhain for encoders and Sierracin-Magnedyne for motors (D. Mancini)
- define the active optics group (F. Bortoletto)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

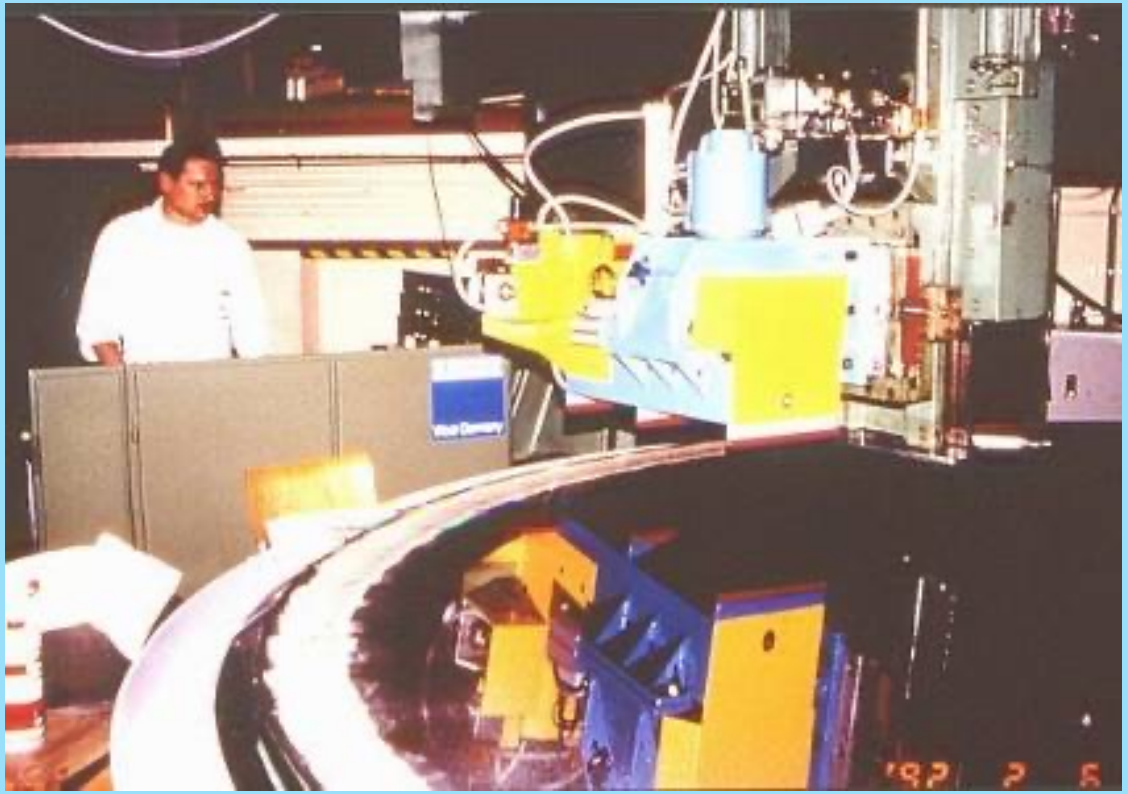
Period 1990-1992 (c)

Start and completion
of contract with ZEISS (+ Schott)



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

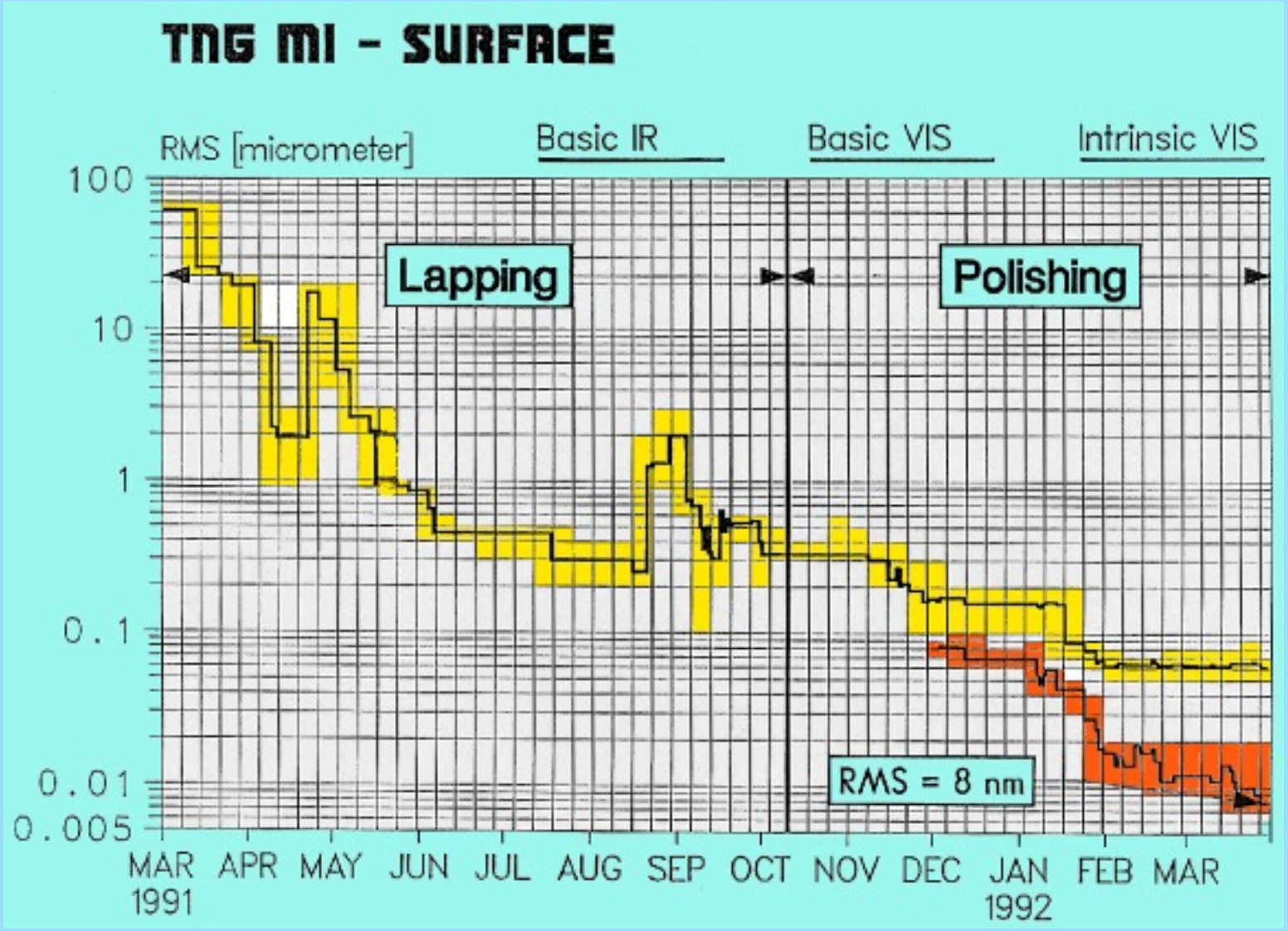
Geometry:

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



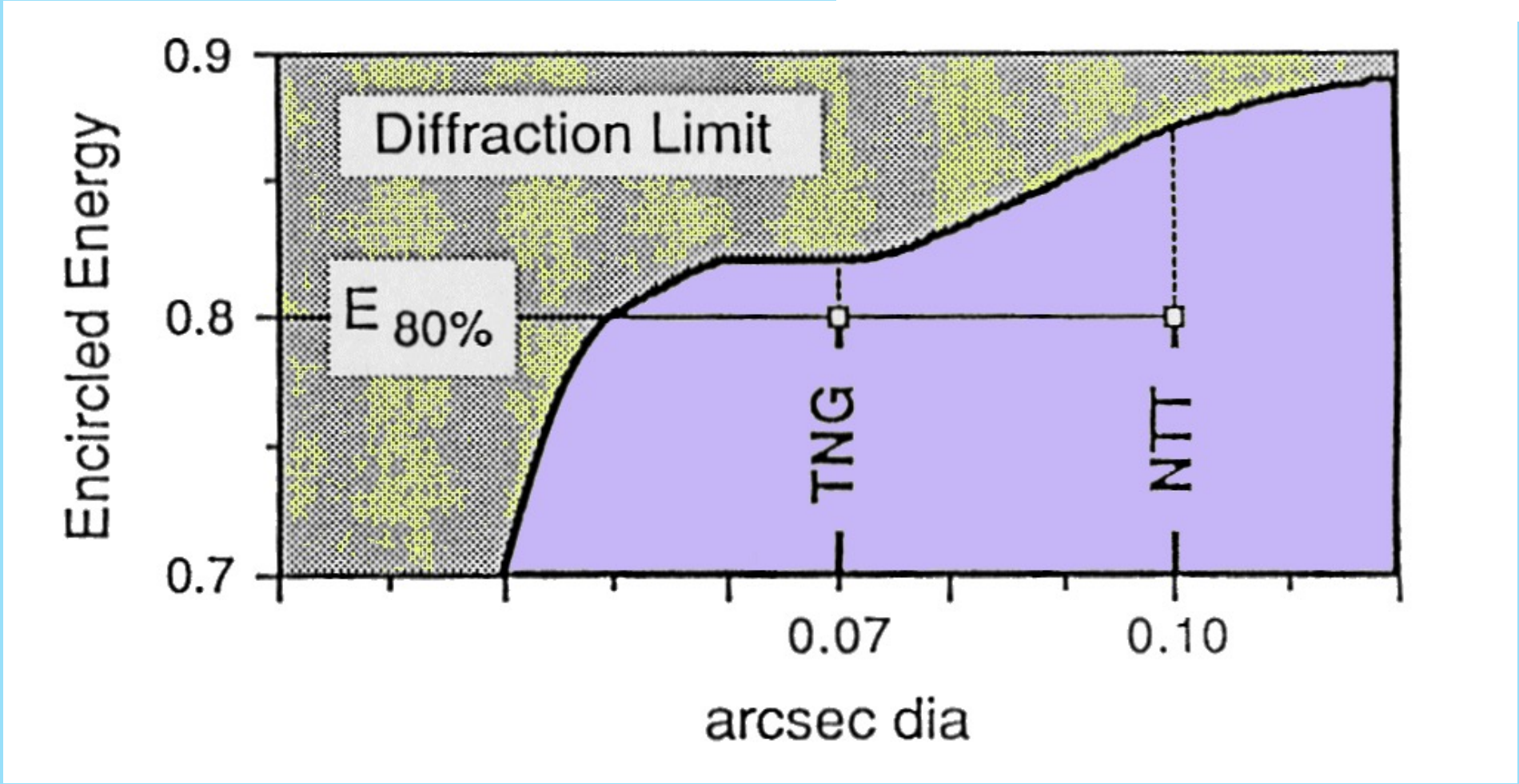
A ZEISS Milestone

Another Milestone in modern Astronomy

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

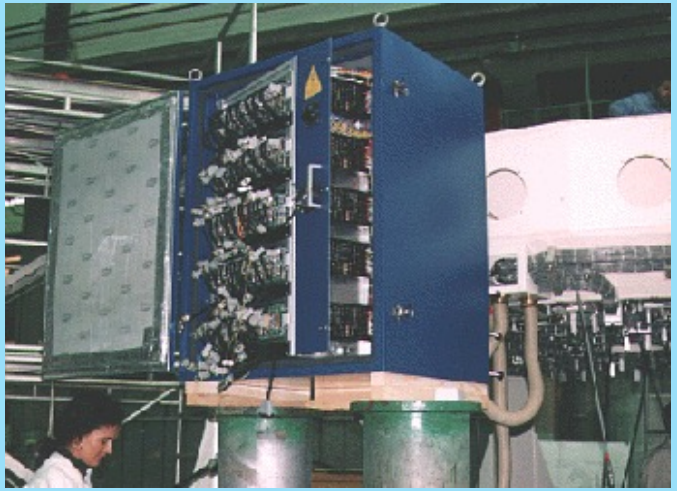
by Ernst-Dieter Knohl, Frank Schillke, Michael Schmidt

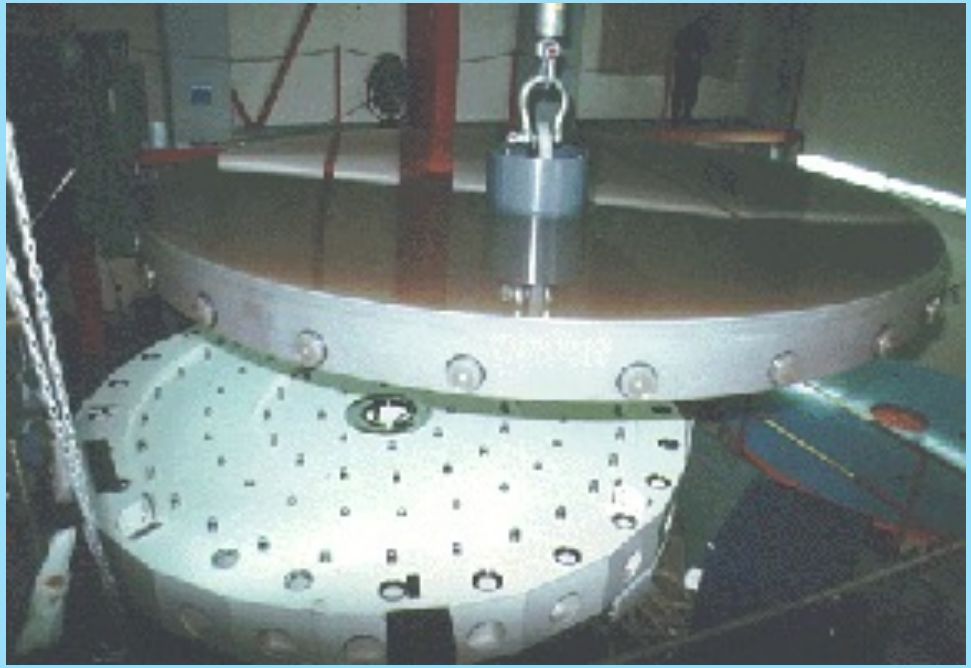
CARL ZEISS Oberkochen, West Germany



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.

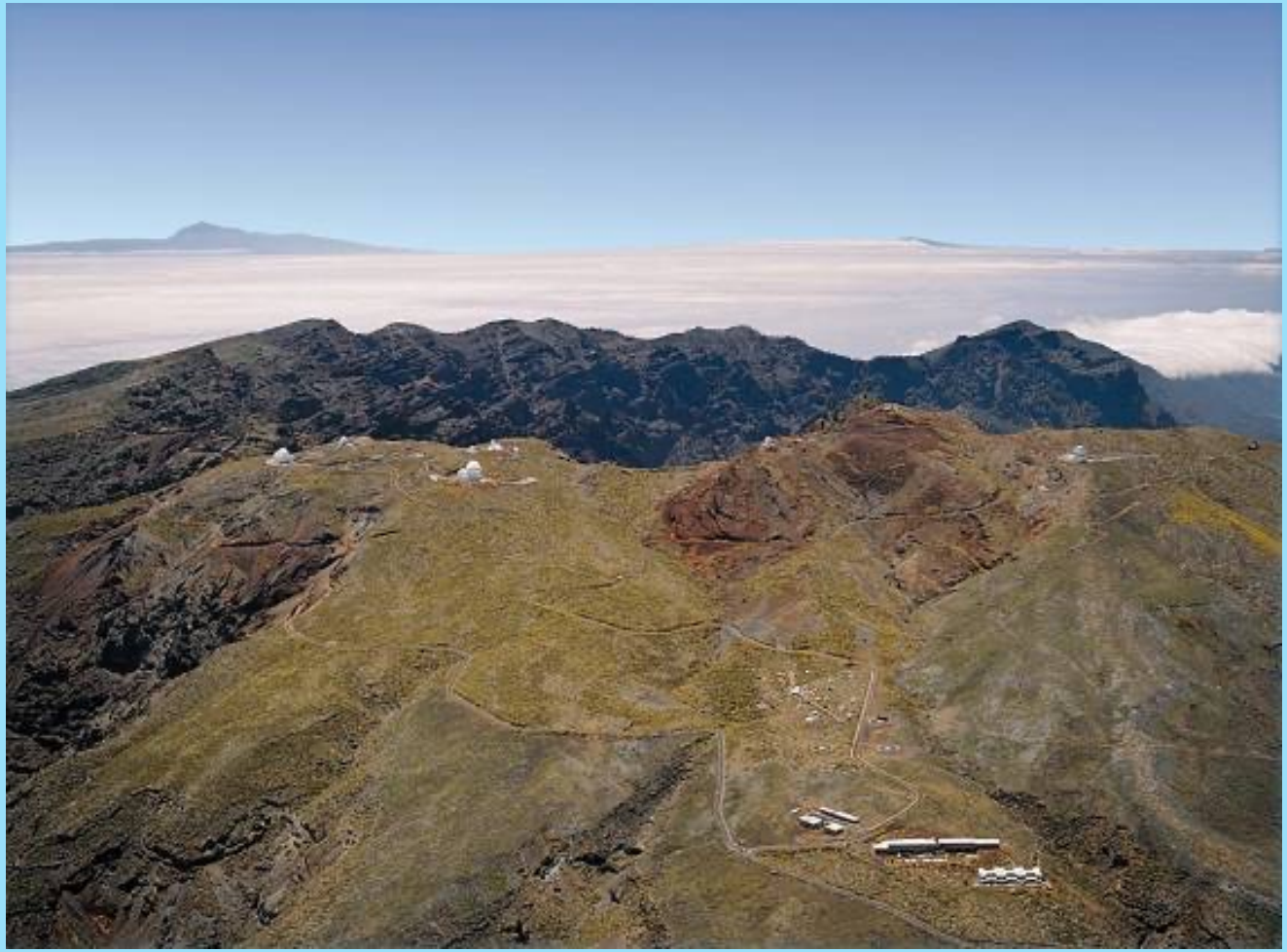




No spherical aberration!

See R. Ragazzoni, 1994, ***TNG*** - *Newsletter* nr. 8

End of 1991 : Change of site



- ***agreement with UH could not be reached!***
- site changed from Mauna Kea to Roque de los Muchachos
- The TNG was accepted by unanimous decision of the Comite Cientifico Internacional in in Nov. 1991 and confirmed by the Spanish Parliament in 1992.
- Thanks to our Embassy in Madrid for the great work!

For 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***.

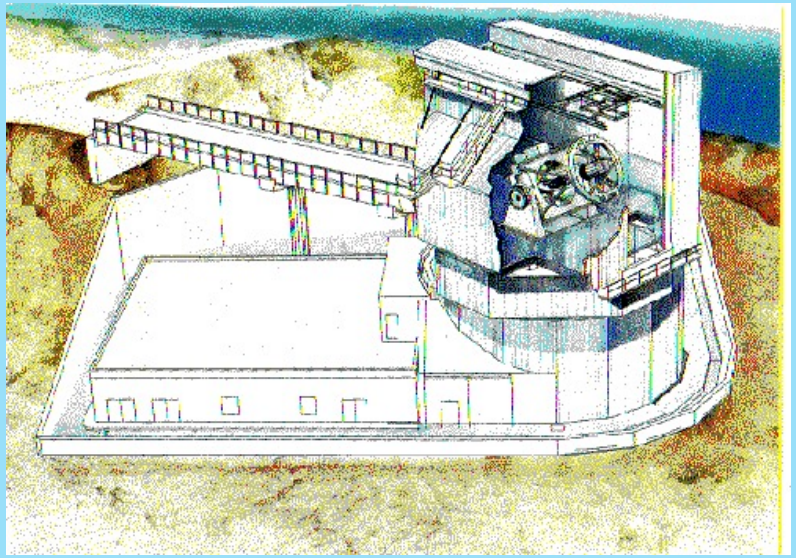
Consequences of site change

- 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)

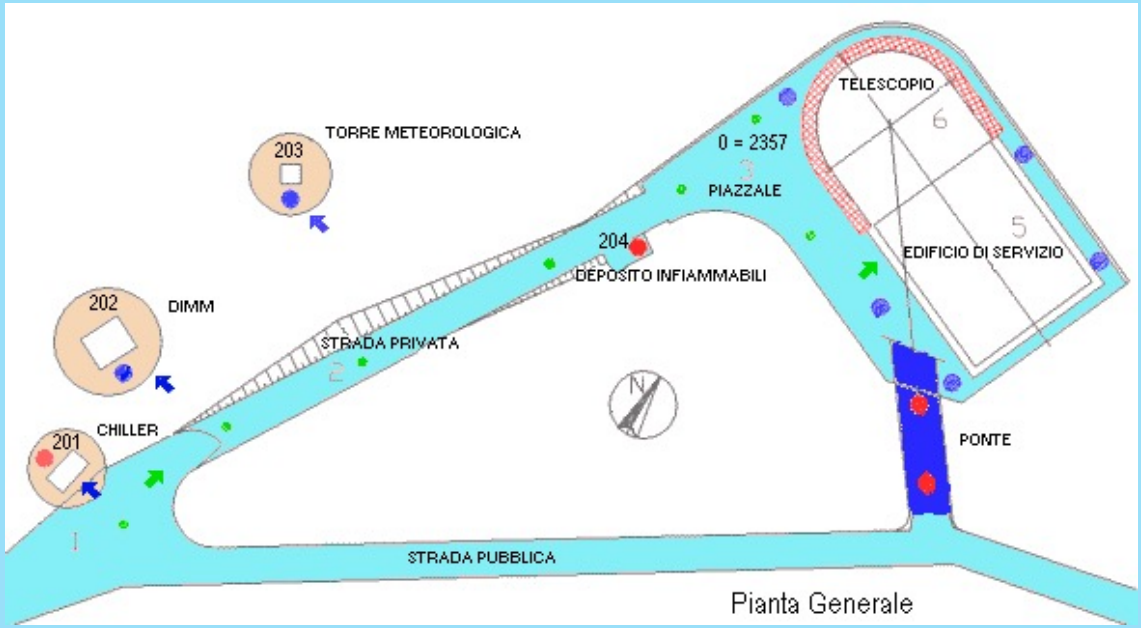
The general scheme of the TNG on the RdM

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*** with respect to all European currencies, 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

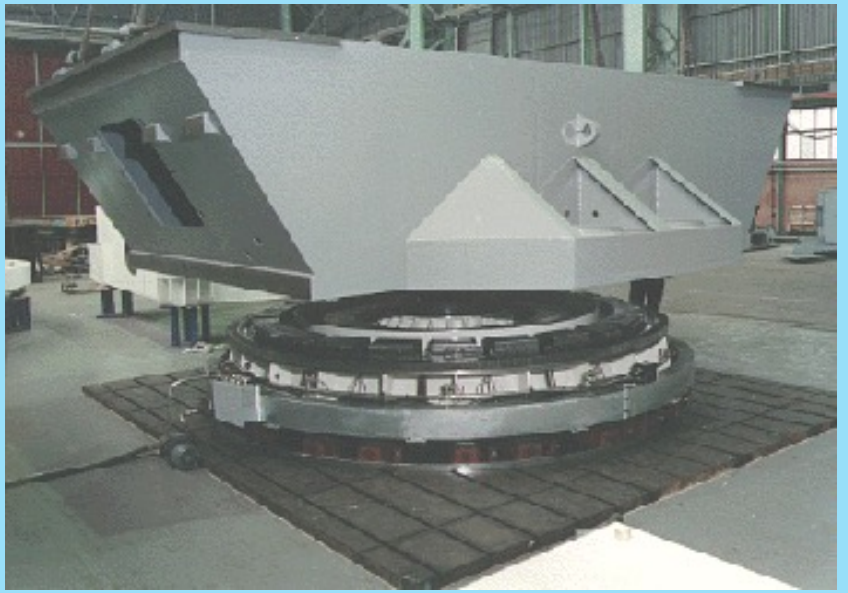
Fortunately the soil strength was found much better than at the WHT site

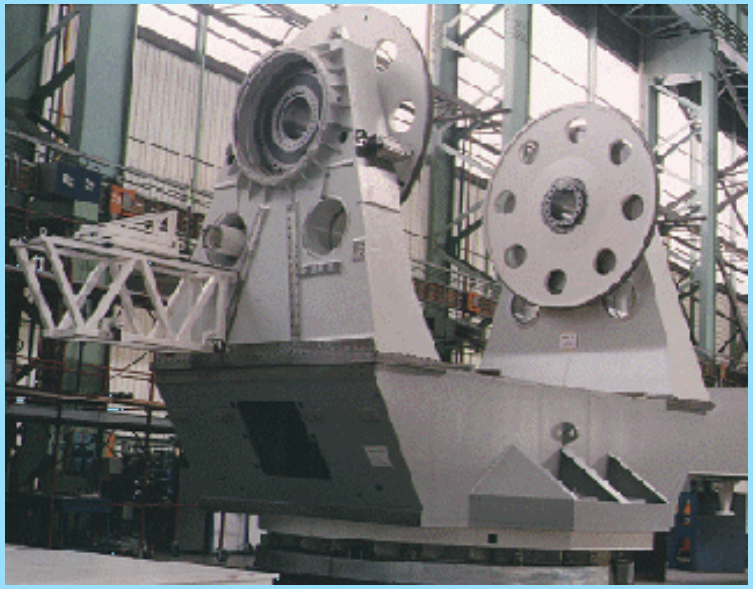
Construction Phases, 1994 - 1995

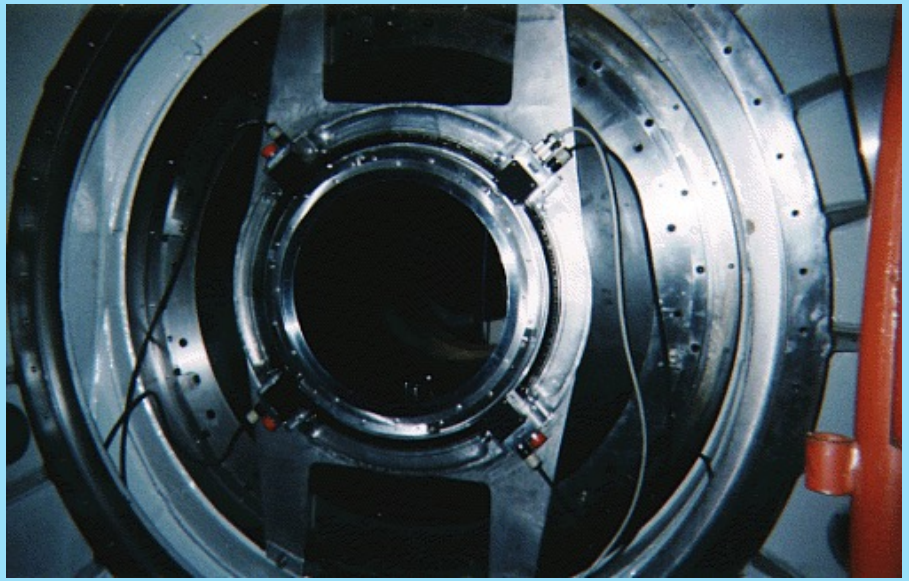
Excavation and Civil works were committed to two Spanish firms, namely Fomento and Huarte, with the direction on site performed by Salamanca Eng. Some ***800 tons of concrete*** were poured on the Roque for the TNG.

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)

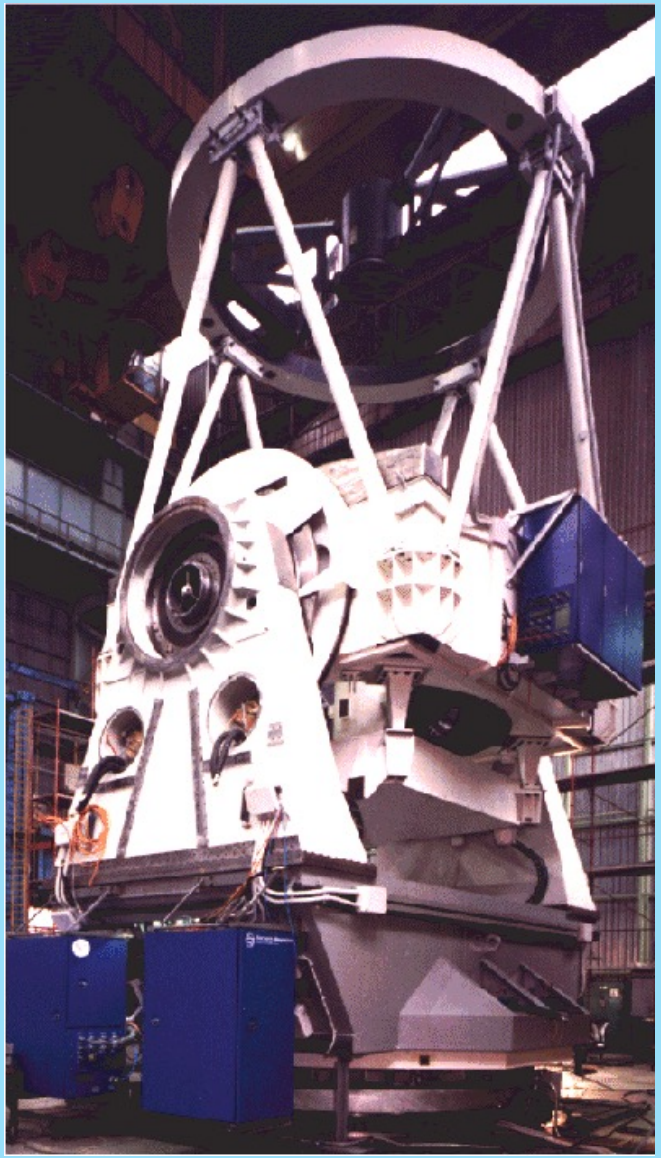
The telescope in Ansaldo, 1993-1994







In Ansaldo, December 1994



The first VLT telescope was just being erected on an adjacent area

1995, Contracts for the Rotating Building, the Rotator-Adapter and 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

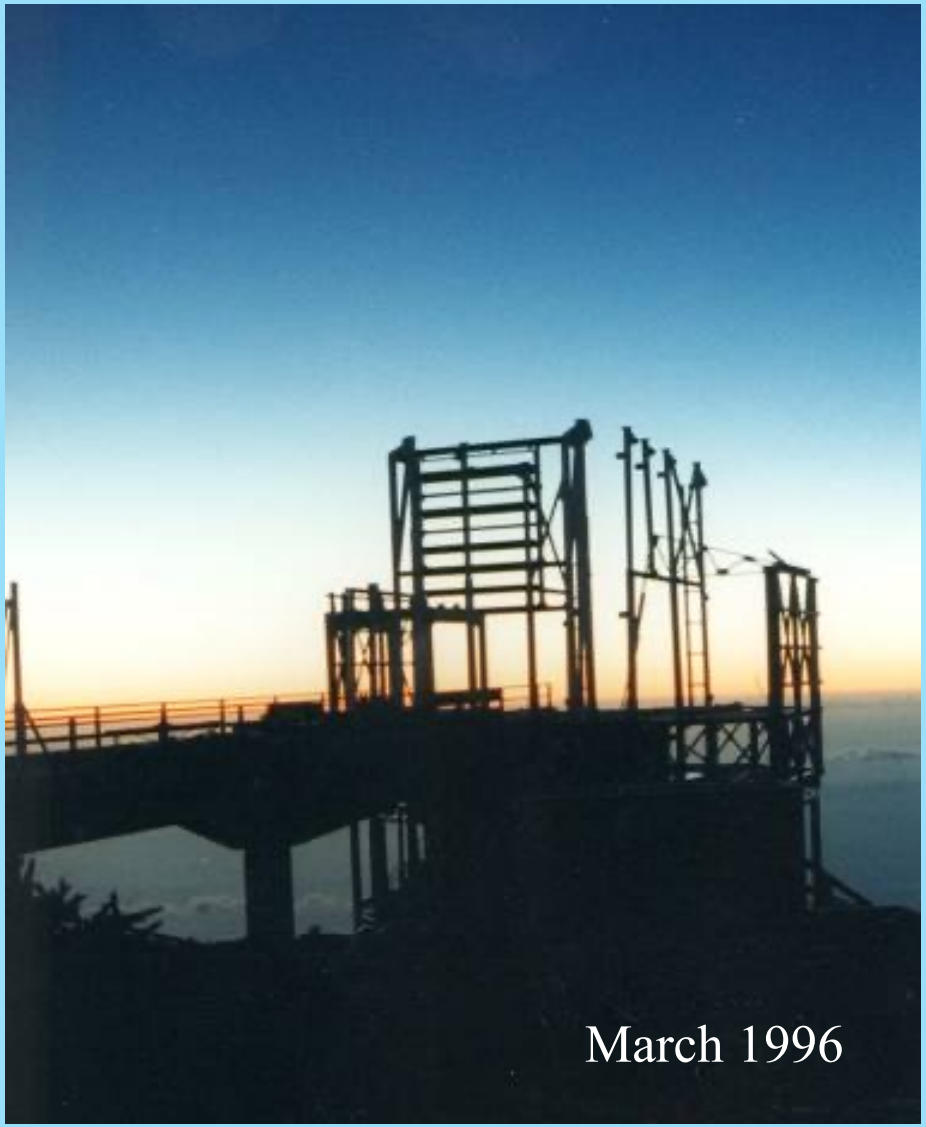
Following the bankruptcy of the firm who had delivered the device to NTT, a novel support for the dome rotation was invented by our consultants F. Bevini and P. Favaron, namely the rotating mini-sphere THK device

Erection of the metal structure

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

Hyakutake's comet and 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

Early June 1996 - Aluminizing M1 at the WHT

F. Bevini, P. Conconi, H.D. Knohl, P. Rafanelli watch all aluminizing phases. Technicians from Asiago Observatory were also present

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 (TNG and THEMIS) on the RdM and Izaña

INSTITUTO DE ASTROFISICA DE CANARIAS

IAC noticias

N. 2-1996

Nuevas nebulosas alrededor de estrellas simbióticas

Espejismos gravitatorios

Los chorros del cometa Hale-Bopp

ESA aprueba la misión COBRAS/SAMBA

Laboratorio de Calibración Eléctrica del IAC

El proyecto GTC

A TRAVÉS DEL PRISMA: HUBERT REEVES "Los primeros momentos del Universo"

ENTREVISTA con: *Robert Williams,* director del STScI

ESPECIAL: 3ª Euroconferencia DENIS

INAUGURACIONES 1996

Acto oficial de las inauguraciones en la explanada del telescopio nacional "Galileo Galilei", instalado en el Observatorio del Roque de los Muchachos (La Palma)

Foto oficial de las inauguraciones en la explanada del telescopio franco-italiano "THEMIS", instalado en el Observatorio del Teide (Tenerife)

SS.MM. LOS REYES DE ESPAÑA

inauguraron los nuevos telescopios de los Observatorios del IAC

Los pasados días 29 y 30 de junio, SS.MM. los Reyes de España Don Juan Carlos y Doña Sofía inauguraron los nuevos telescopios instalados en el Observatorio del Roque de los Muchachos, en la isla de La Palma, y en el Observatorio del Teide, en la isla de Tenerife, ambos pertenecientes al Instituto de Astrofísica de Canarias (IAC). A los actos asistieron el Presidente del Gobierno de Canarias, Manuel Hermoso, los Ministros de Educación y Ciencia de Francia e Italia, François Bayrou y Luigi Berlinguer, respectivamente, junto con la Ministra de Educación y Cultura española, Esperanza Aguirre, entre otras personalidades políticas y científicas.

NUEVAS INSTALACIONES

OBSERVATORIO DEL ROQUE DE LOS MUCHACHOS

En el Observatorio del Roque de los Muchachos, al borde del Parque Nacional de la Caldera de Taburiente, a 2.400 m de altitud, se encuentra una de las baterías de telescopios más completa del mundo.

Más ha instalado en este Observatorio su gran **Telescopio Nacional GALILEO (TNG)**, de 3,58 m de diámetro. Es un telescopio de los llamados de «nueva tecnología», que permite obtener imágenes de una calidad superior a la de los telescopios convencionales. Diseñado para la observación del cielo nocturno, está dotado de los mejores soluciones ópticas, informáticas y de ingeniería. Tiene montura altazimutal y configuración óptica de tipo Ritchey-Chrétien con dos focos basculantes tipo Nasmyth. Su óptica tiene unos sistemas de control activo que optimizan la calidad óptica y que hacen del Telescopio Nacional Galileo un telescopio de vanguardia. Este telescopio pertenece al Consejo de Investigaciones Astronómicas italiano (CNAI) y ha sido construido bajo la responsabilidad del Observatorio de Padua.

En este solar es el nuevo telescopio de los Países Bajos, el **DOT (Dutch Open Telescope, Telescopio Abierto Holandés)**. Es un instrumento de diseño innovador, con una gran resolución angular y que puede destinarse también a observaciones nocturnas. Consiste en una torre de celosías abierta de 15 m de altura sobre la que se sitúa un telescopio de 45 cm de apertura. Su estructura abierta (sin una cúpula cerrada que albergue el telescopio) permite que el aire fluya libremente, manteniendo la misma de uso en torno al instrumento térmicamente homogénea y garantizando así la mejor calidad de imagen posible. Este telescopio pertenece a la Universidad de Utrecht (Países Bajos) y ha sido financiado por la Fundación de Tecnología Holandesa.

El Observatorio del Roque de los Muchachos aman también a la Astrofísica de Altas Energías, habiéndose instalado en el una amplia **red de detectores de rayos cósmicos (Experimento HEGRA, High Energy Gamma Ray Astronomy)** en este experimento hispano-alemán participan las universidades alemanas de Hamburgo, Kiel y Wuppertal, el Instituto Max-Planck de Física y Astrofísica de Munich, el Instituto Max-Planck de Física Nuclear de Heidelberg, el Instituto de Física de Yerevan (Armenia) y la Universidad Complutense de Madrid. Recientemente HEGRA se ha ampliado con la colaboración de Italia.

OBSERVATORIO DEL TEIDE

La Astrofísica en Canarias empezó en este Observatorio, en la zona de Izaña (Tenerife), a 2.400 m. de altitud, y hace ahora más de veinticinco años, el primer telescopio para realizar estudios de luz zodiacal, la luz dispersada por la materia interplanetaria, empezó a funcionar en 1964. Su situación geográfica (entre los observatorios solares del este y del oeste), unido a la transparencia y excelente calidad astronómica de su cielo, han contribuido a que el Observatorio del Teide se reserve preferentemente al estudio del Sol, concentrándose en él los mayores telescopios solares europeos.

El telescopio franco-italiano **THEMIS (Telescopio Heliográfico para el Estudio del Magnetismo Solar)**, concebido para observar el magnetismo solar especialmente, comenzó a construirse en el Observatorio del Teide tras la firma de los correspondientes Acuerdos por parte de Francia, cansados previamente para instalar telescopios en los Observatorios del IAC. Con sus 90 cm de diámetro, es el telescopio solar más avanzado de momento. Consta de un telescopio al vacío (para evitar la turbulencia que provoca la atmósfera), de un espejo primario de 90 cm de diámetro, de un sistema de óptica activa que corrige los desplazamientos de la imagen debidos a la agitación de la atmósfera terrestre, de un conjunto de detectores CCD y de un sistema de espectrógrafos como instrumentación auxiliar. Este telescopio ha sido construido por el Instituto Nacional de Ciencias del Espacio (INSU), del Centro Nacional de Investigaciones Científicas francés (CNRS), en colaboración con el Consejo Nacional de Investigación italiano (CNR).

El **Laboratorio solar** del IAC, en forma de pirámide y orientado en la línea norte-sur, alberga un conjunto de instrumentos para la observación continua de las oscilaciones o «pulsaciones» del Sol. Tal es el caso del **instrumento** que forma parte de la red internacional de Sismología Solar **GONG** (Global Oscillation Network Group), un programa internacional para el estudio detallado del interior del Sol) liderado por el Observatorio Solar Nacional de Estados Unidos. Completan la red GONG instrumentos ubicados en los observatorios de Big Bear (California), Learmonth (Australia), Udaipur (India), Cerro Tololo (Chile) y Mauna Loa (Hawai).

Pero en este Observatorio también se encuentran los peculiares **radiotelescopios** que forman parte de un experimento conjunto conocido como «**Experimento de Tenerife**» (entre el IAC y los Laboratorios de Radioastronomía de Nuffield (NRAL), de la Universidad de Manchester en Jodrell Bank (Reino Unido). El objetivo de estos radiotelescopios, que operan a 10, 15 y 33 GHz, es el estudio de anisotropías en la radiación de fondo cosmológica, la débil radiación «fósil» procedente de la Gran Explosión («Big Bang») que dio origen al Universo, hace unos 15.000 millones de años. Se trata de partes de manifiesto la existencia de inhomogeneidades cosmológicas, las primeras «construcciones», origen de las macroestructuras observables en el Universo actual. Fruto de la colaboración entre el IAC y el Instituto Bartol de la Universidad de Delaware (Estados Unidos), es un experimento pionero, en su primera campaña, a cortísimas en el rango milimétrico la detección de las variaciones espaciales en la temperatura del Fondo de Microondas (descubierta por el Experimento de Tenerife. Actualmente, una pequeña antena con un espejo primario de 45 cm de diámetro equipado con un bolómetro detecta a cuatro canales en la correspondiente a las subcompras de la Radiación de Fondo Cósmico.

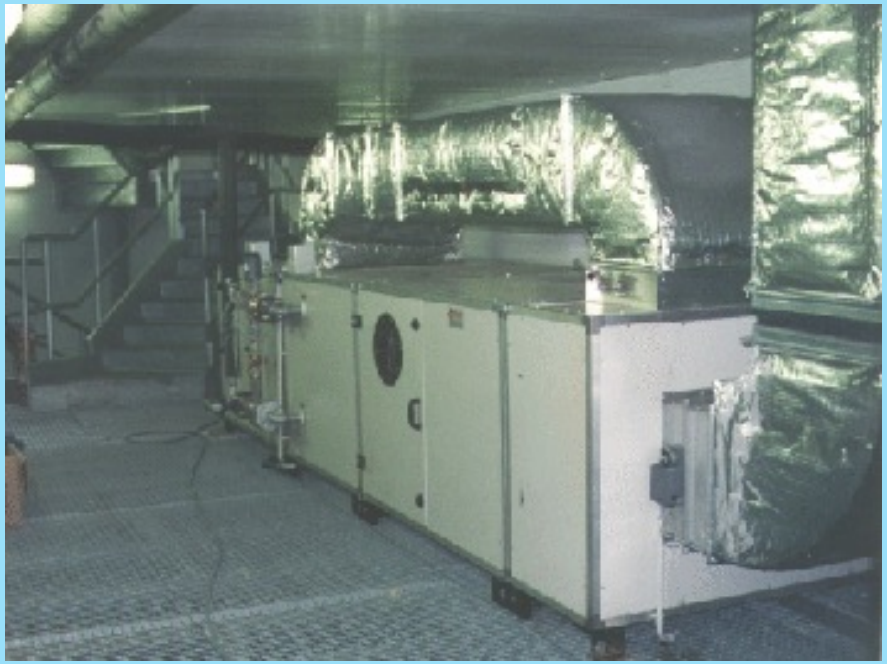
En virtud del acuerdo de colaboración firmado entre la Agencia Europea del Espacio (ESA) y el IAC, se instaló en el Observatorio del Teide la **Estación Óptica Terrestre** (Optical Ground Station, OGS) del satélite de telecomunicaciones ARTEMIS (Advanced Research and Technology Mission) que ESA lanzará en 1997. La creación de esta Estación Óptica Terrestre en el Observatorio del Teide del IAC, para la recepción de señales ópticas de láser procedentes de la telecomunicación procedentes del satélite ARTEMIS de la ESA, forma parte del esfuerzo de la ESA en el desarrollo de comunicaciones ópticas espaciales empleando el láser, cuyo primero comunicación se realizará en 1997. Para ello se ha construido un telescopio de 1 metro de diámetro, a instalar en esta estación terrestre en 1996, que además de recibir las señales emitidas por el satélite ARTEMIS, y en virtud del acuerdo, es utilizado por el IAC a tiempo parcial para investigaciones astrofísicas y para la observación de asteroides espaciales.

Aug. 1996 - Testing the rotation of the dome

The corners of the bridge had to be trimmed, too much cement…,
but only few centimeters

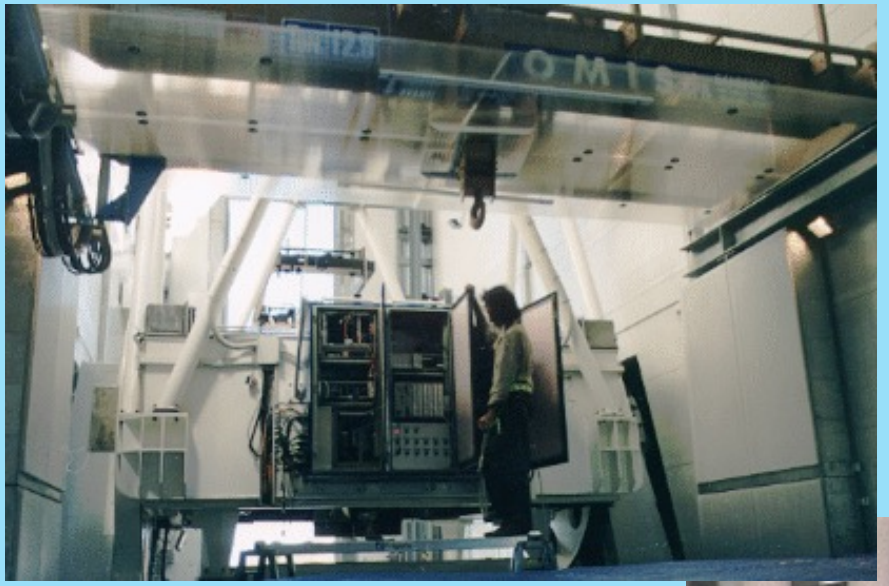
January 1997 - Snow again…, and heavy damage to the East Roof

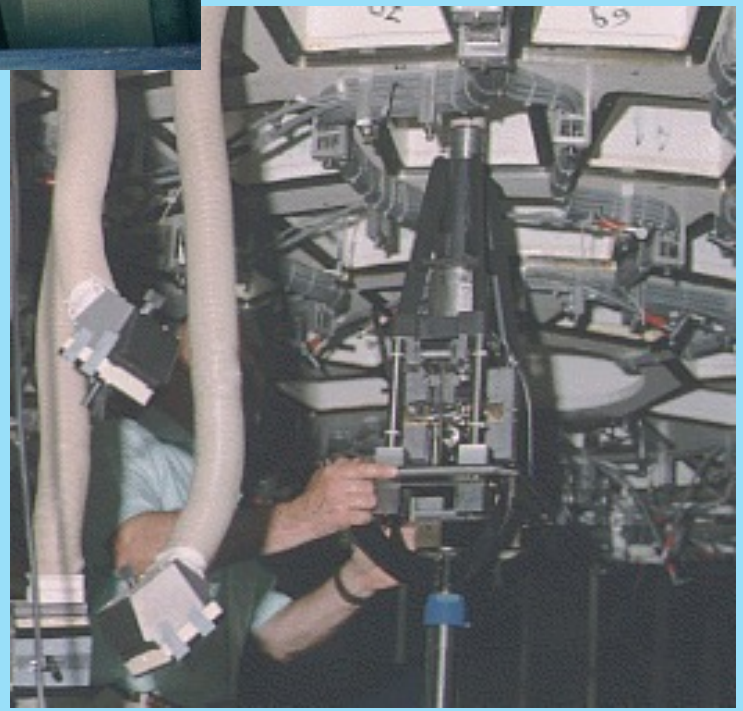
1997 - Installing the air conditioning system



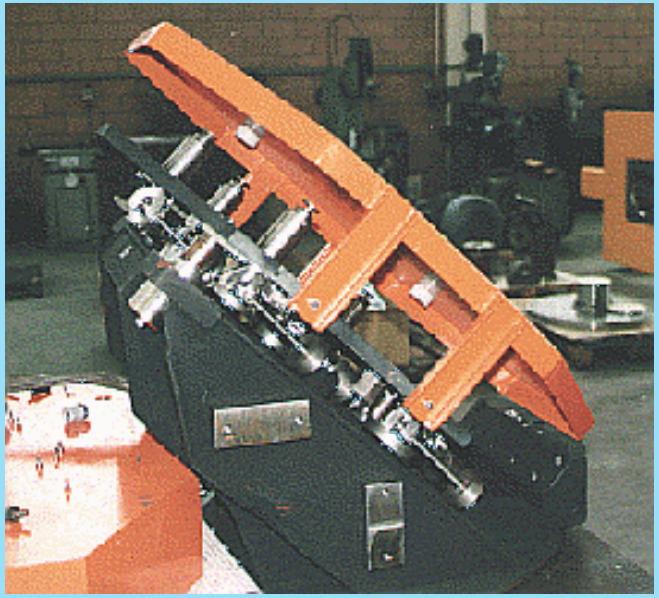
1997 - Installing the dome controls

1997 - Early 1998 Completing the installation of the telescope

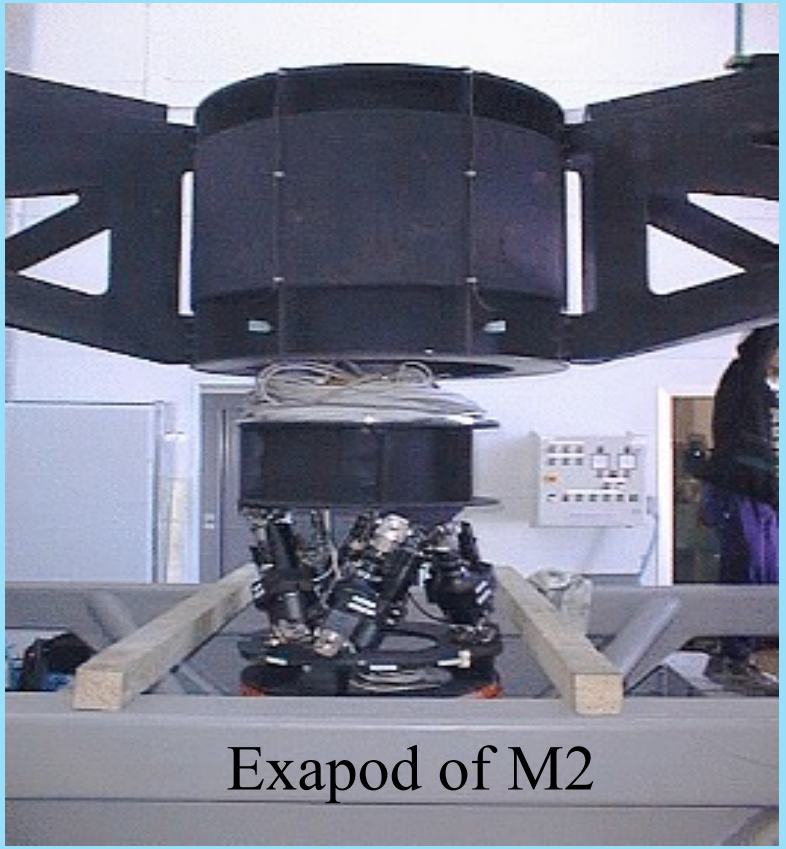




Early 1998 - Mounting the mirrors



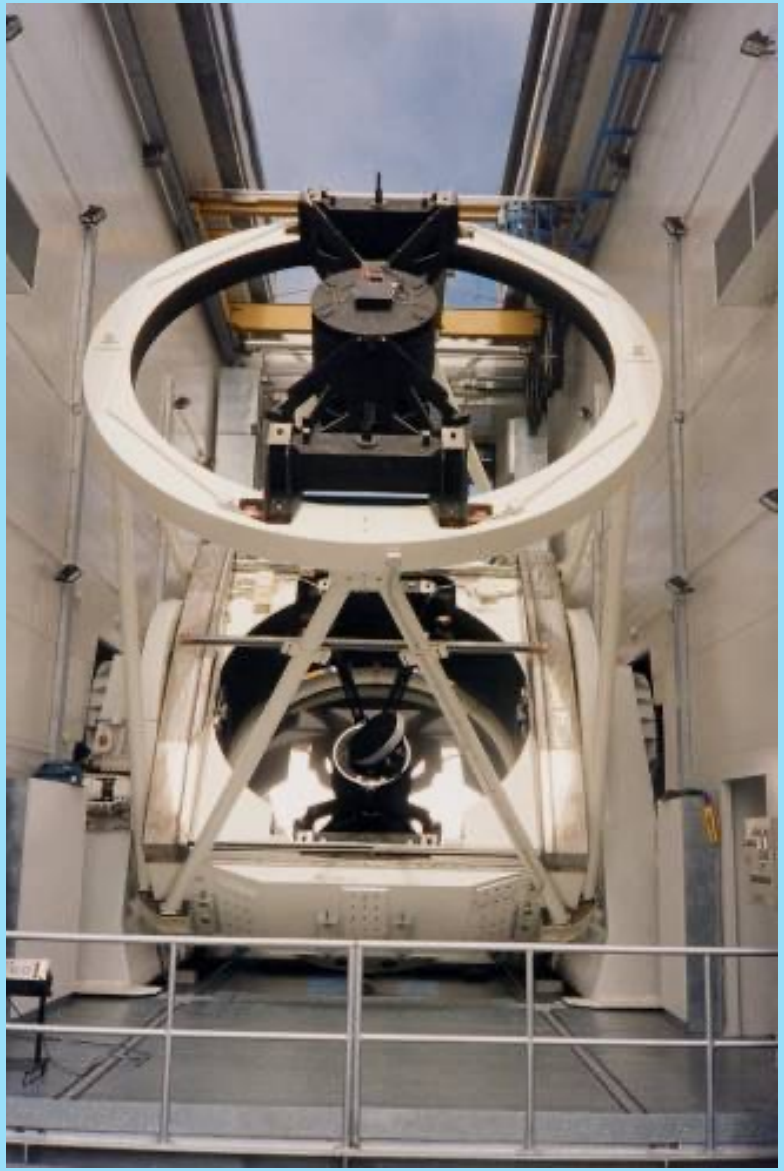
The tilting support of M3



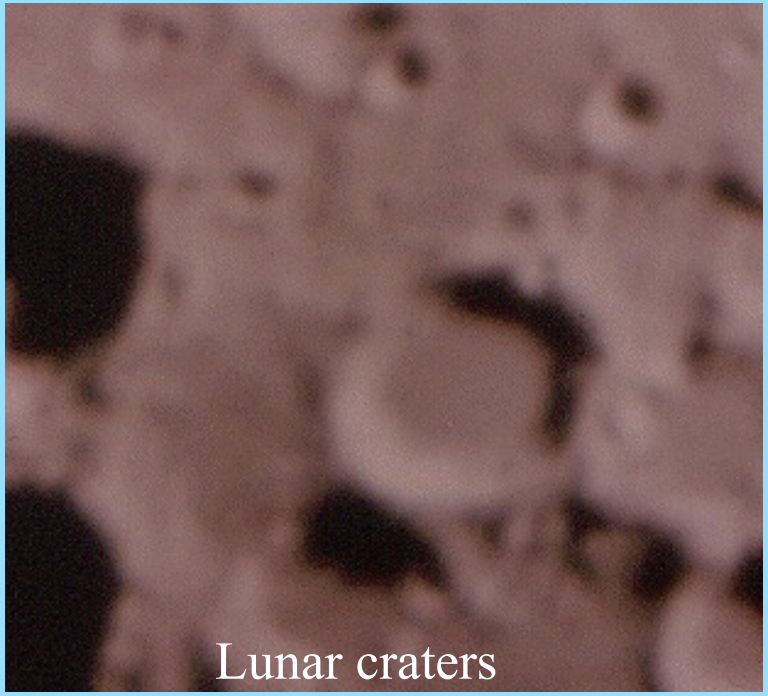
Exapod of M2

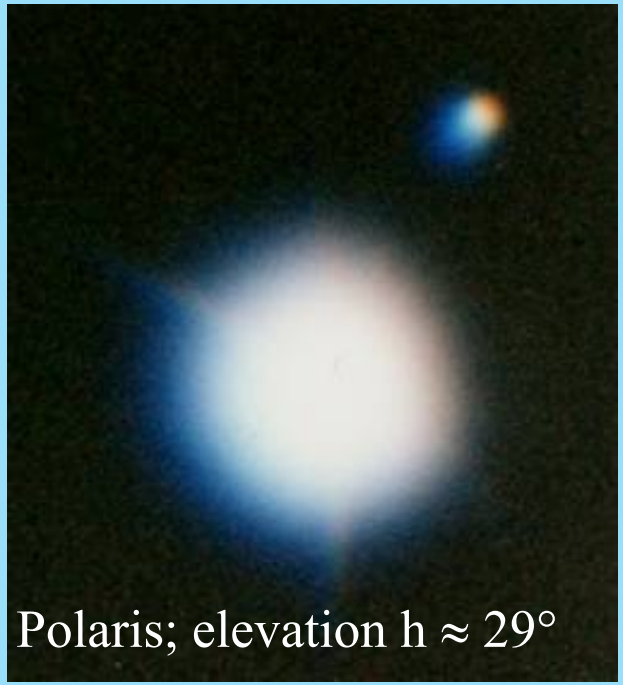
All supports of M1, M2 and M3 of the TNG are very different from those of the NTT.

Early 1998 - mirrors installed, telescope completed and moving



March 1998: my first pictures with the TNG


Lunar craters


Polaris; elevation h ≈ 29°

18 ”

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.

End of 2021: my last paper with the TNG

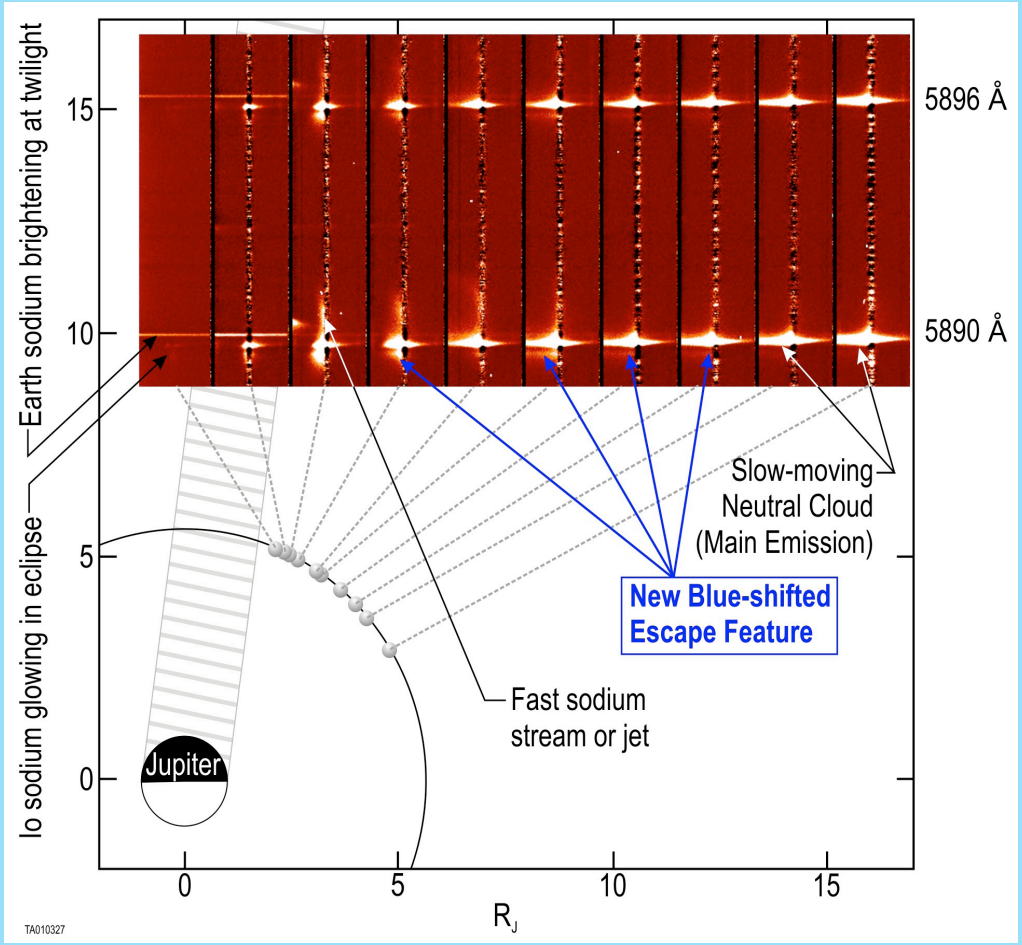
I'm afraid it will be my last (*not my latest* unfortunately…) scientific paper.

A possible dust origin for an unusual feature in Io's sodium neutral clouds

C. Grava et al., Astron. Journal, Vol. 162 nr. 5

Abstract: *We report the results of model simulations performed to explain the nature of a sodium emission feature in Io Neutral Clouds. The feature was detected* ***via high-resolution spectroscopic observations from the 3.6-meter Italian telescope TNG….***

Data were taken way back, in 207 and 2009, with SARG. It took may years, other studies and space missions, to understand how significant were the SARG high-res spectra.



The TNG construction team

Some of the great players of
those years passed away.
I cannot forget

Nicola Boaretto
Favio Bortoletto
Walter Gallieni
Adriano Maurizio

Our warmest thanks to all of them!

I wish to the TNG

many more years of

prosperous scientific production

THNKS!