Historical Review of Airborne Astronomy : The Evolution of SOFIA

Edwin F. Erickson, NASA Ames Research Center (retired)

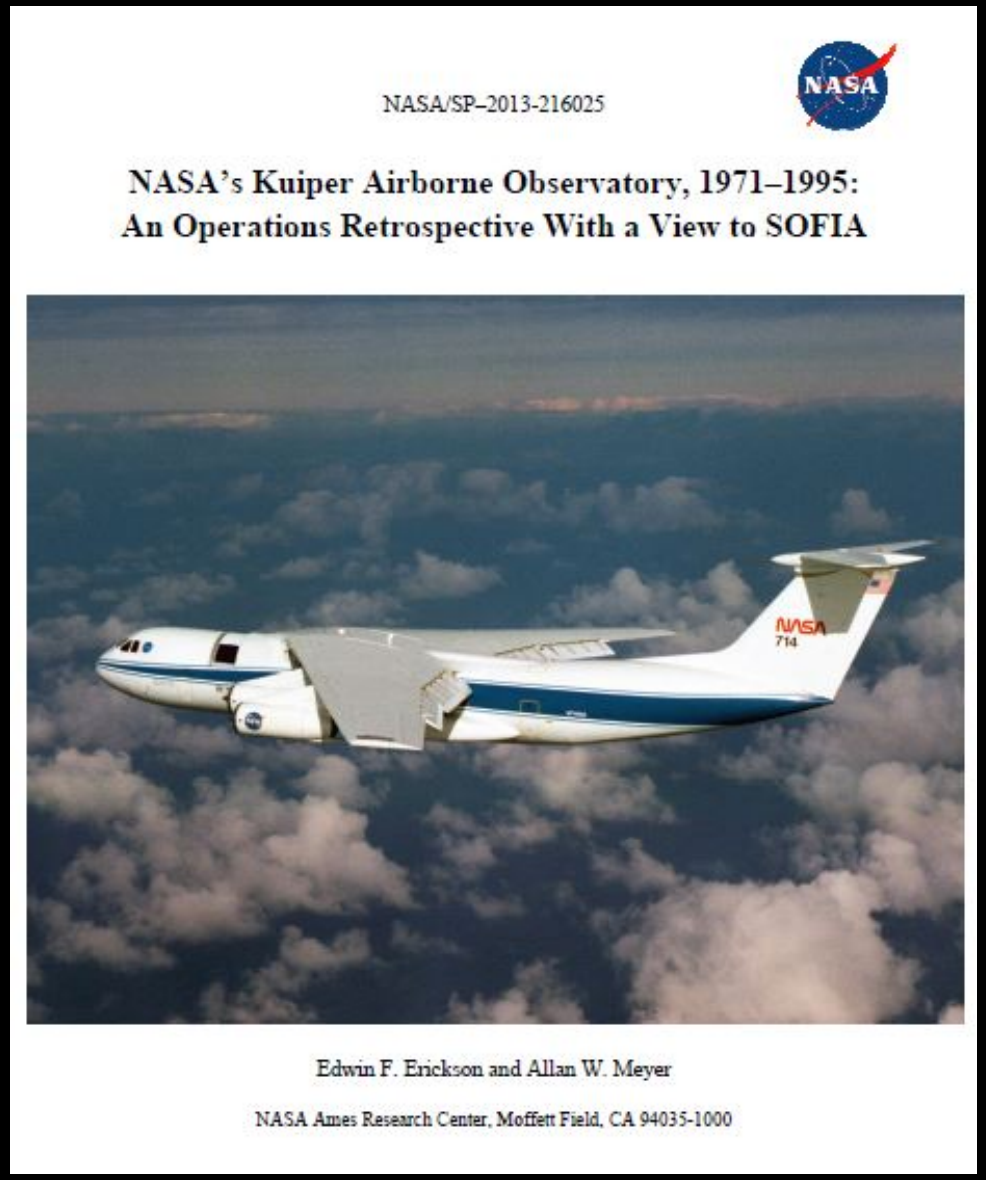
Dedication

Nans Kunz
1957 – 2016
NASA's Chief SOFIA Engineer
1985 – 2007

SOFIA Conference
Asilomar CA
18 October 2016

Wendy Whiting Dolci:
Milestones in Airborne Astronomy, from the 1920s to the Present.
AIAA 975609, 1997.

Historical Review of Airborne *Infrared* Astronomy : The Evolution of SOFIA



NASA/SP–2013-216025

NASA's Kuiper Airborne Observatory, 1971–1995: An Operations Retrospective With a View to SOFIA

Edwin F. Erickson and Allan W. Meyer

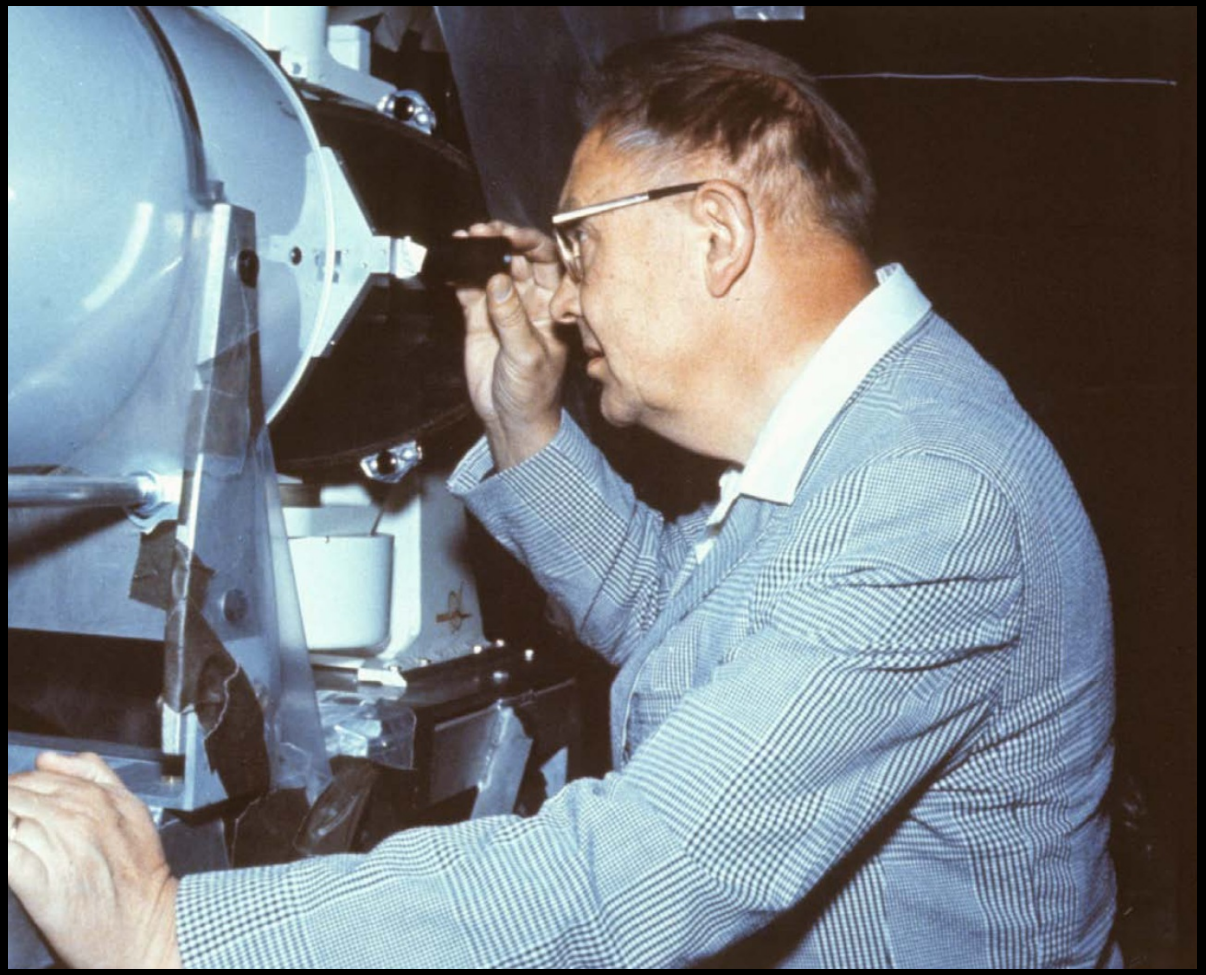
NASA Ames Research Center, Moffett Field, CA 94035-1000

1957: (Sir) John Houghton measured 1-6 µm solar flux from a Canberra jet

Martin B-57 Canberra Jet
Maximum Altitude 70,000 Feet

Mid 1960's: Program of IR astronomy began at NASA Ames, using a Convair 990 and a Learjet

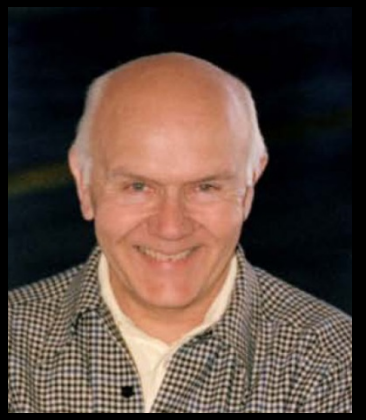
1966 Gerard Kuiper and Fred Forbes measured 1-2.5 µm spectrum of Venus, from the CV990.



KUIPER

1968: Frank Low and Carl Gillespie made Far-IR observations from the Lear Jet. Their telescope used a chopping secondary, and bolometer detectors.

LOW



GILLESPIE

1969 KAO Development began.

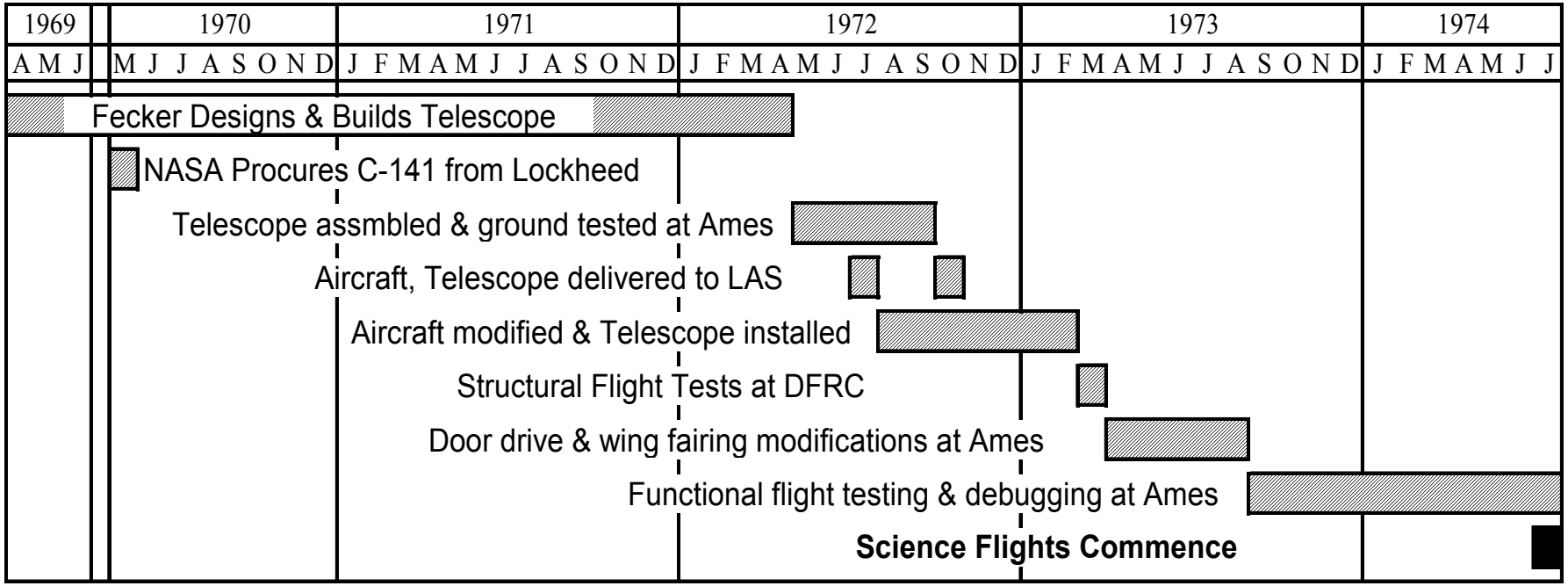


Figure 7. Development timeline of the Kuiper Airborne Observatory

1970: Decadal Survey "Greenstein" Report recommended study of 3-m class stratospheric infrared telescope.

Infrared Panel Members included:

Eric Becklin

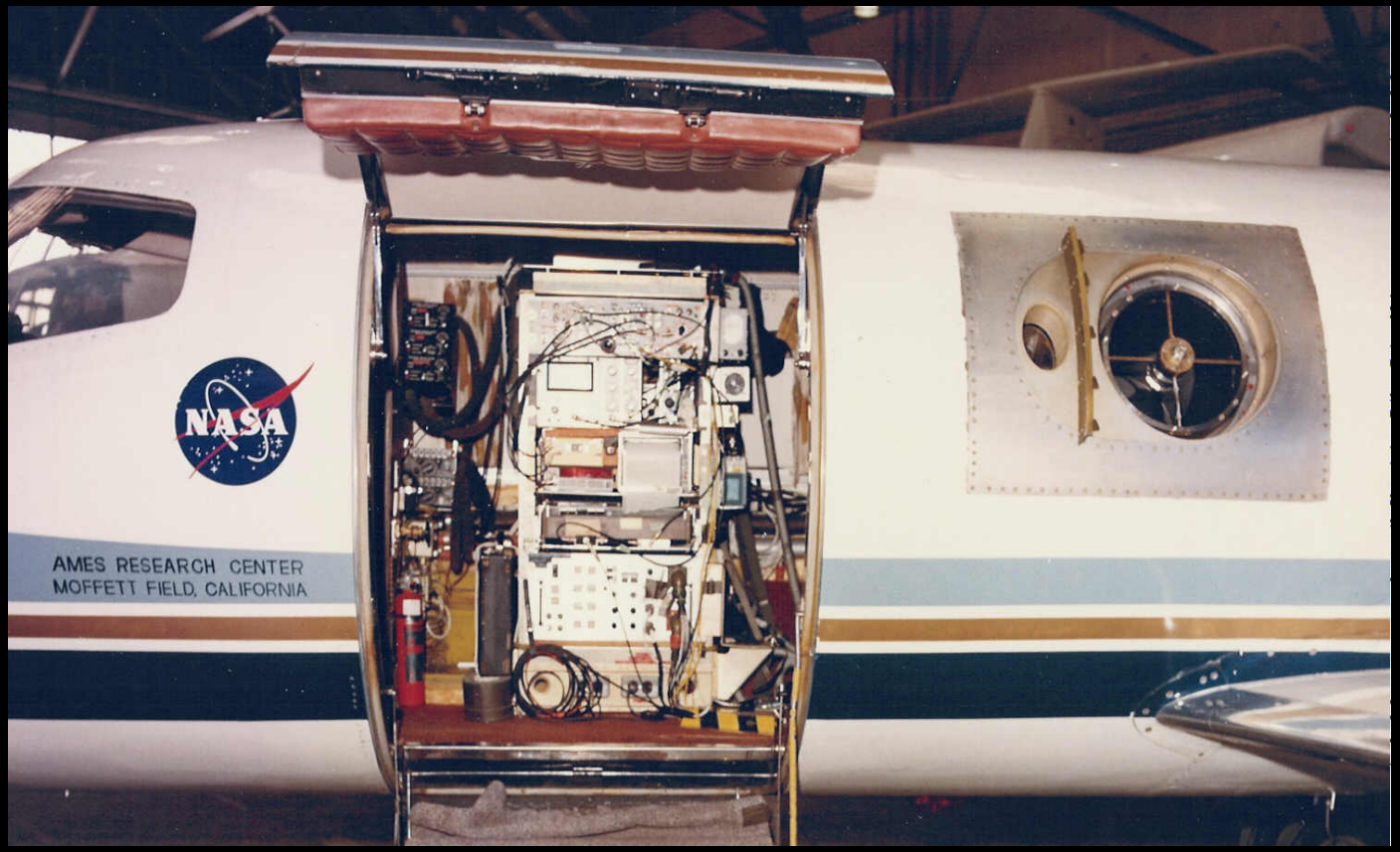
Jim Houck

Harold Larson

Frank Low

1970: NASA purchased the C-141 for the KAO from Lockheed for $1M

1971: Ames-built telescope for the Lear Jet became available for the IR community.



User group PIs:
Erickson/Ames, Harwit/Cornell, Houck/Cornell,
Pipher/Rochester, Townes/Berkeley, Witteborn/Ames

1972: KAO Telescope assembled and tested at Ames prior to installation at Lockheed Ontario.

1974: KAO became operational.

1974 –1995:

Three major activities:

1. KAO operations
    a. Observations / researcher training
    b. Instrument developments
    c. Teacher program
2. SOFIA promotions
3. SOFIA definition/design

1974 –1995: KAO operations

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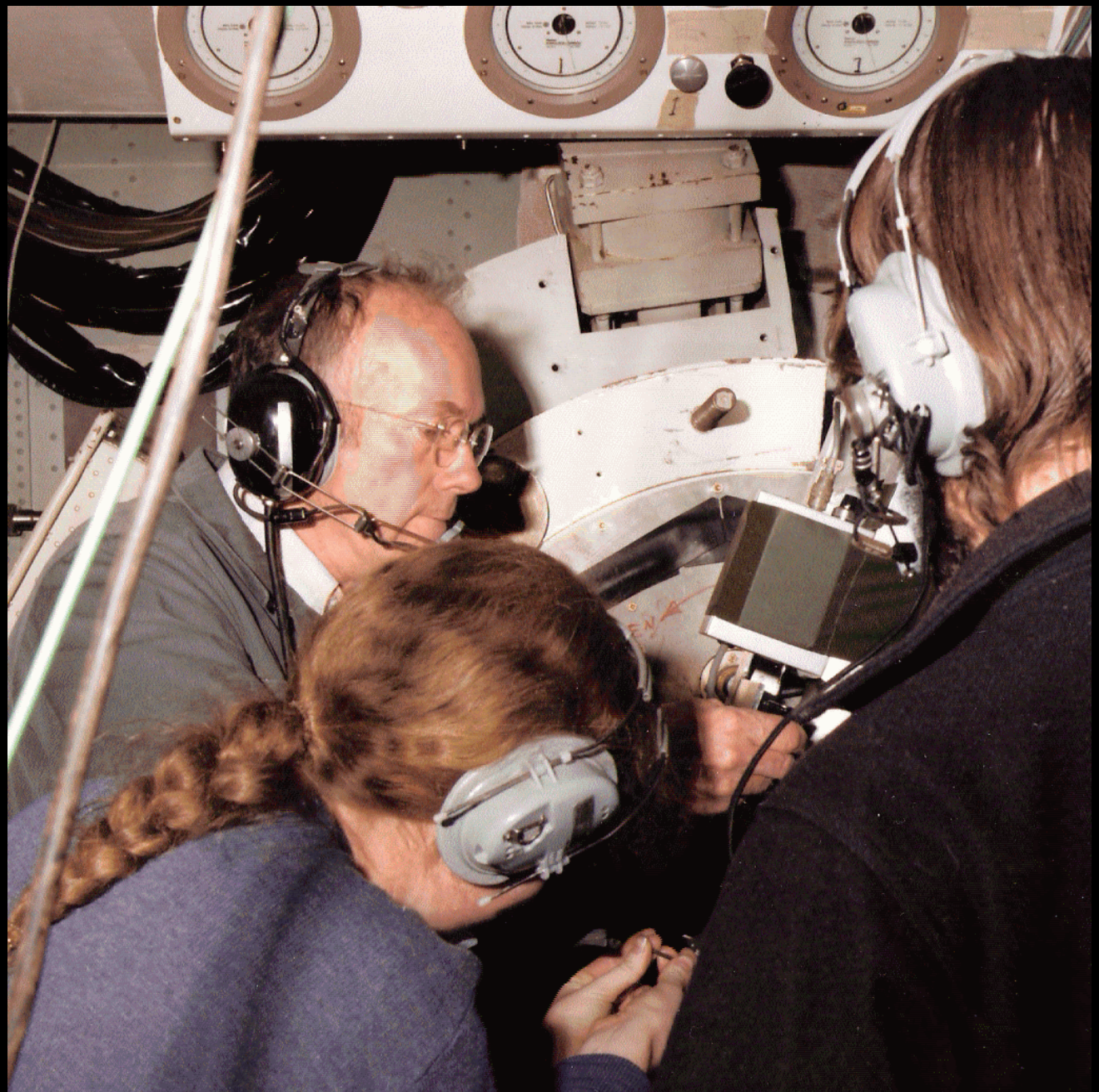

1974 –1995: KAO operations

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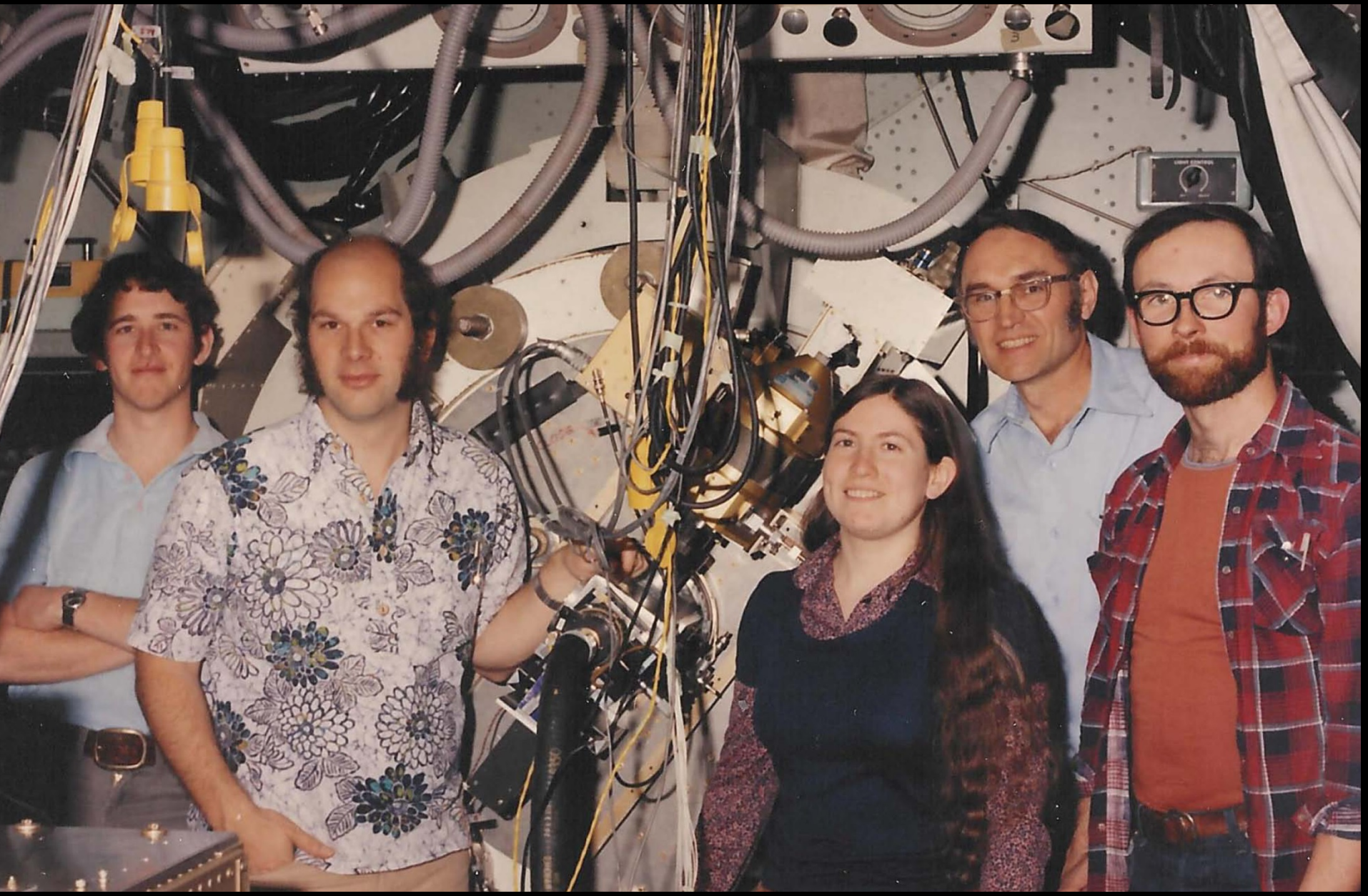
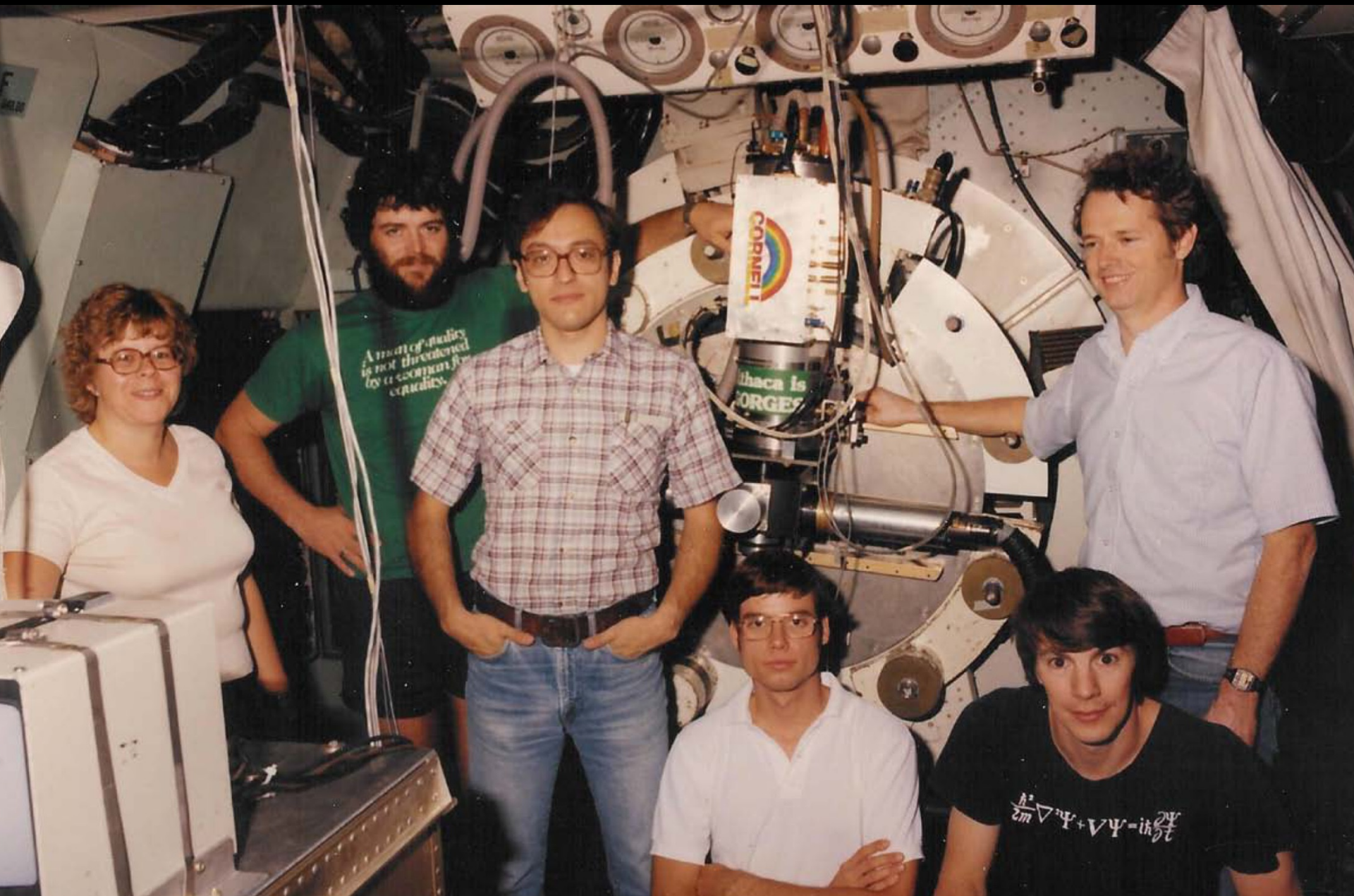


1974 –1995: KAO operations



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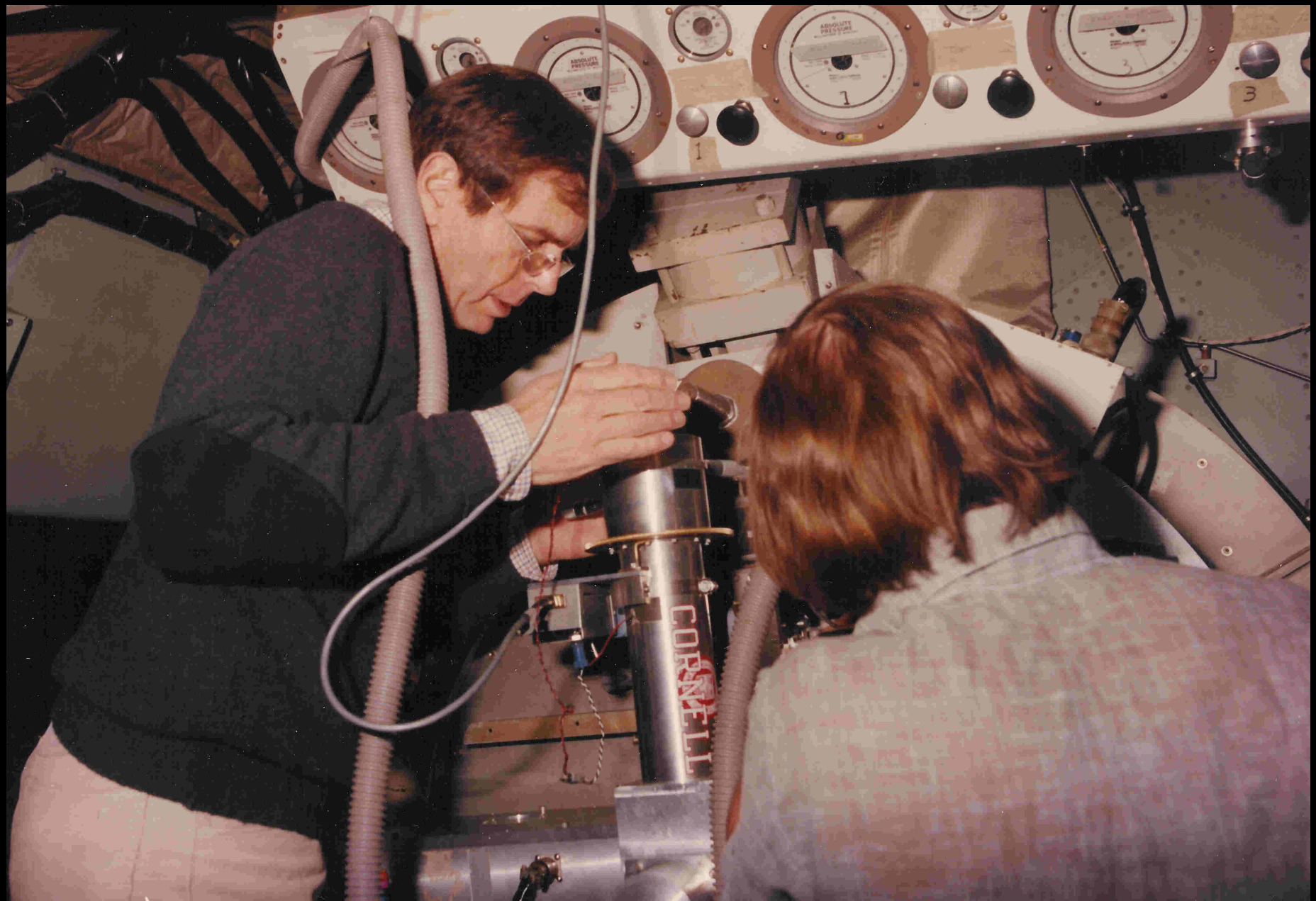

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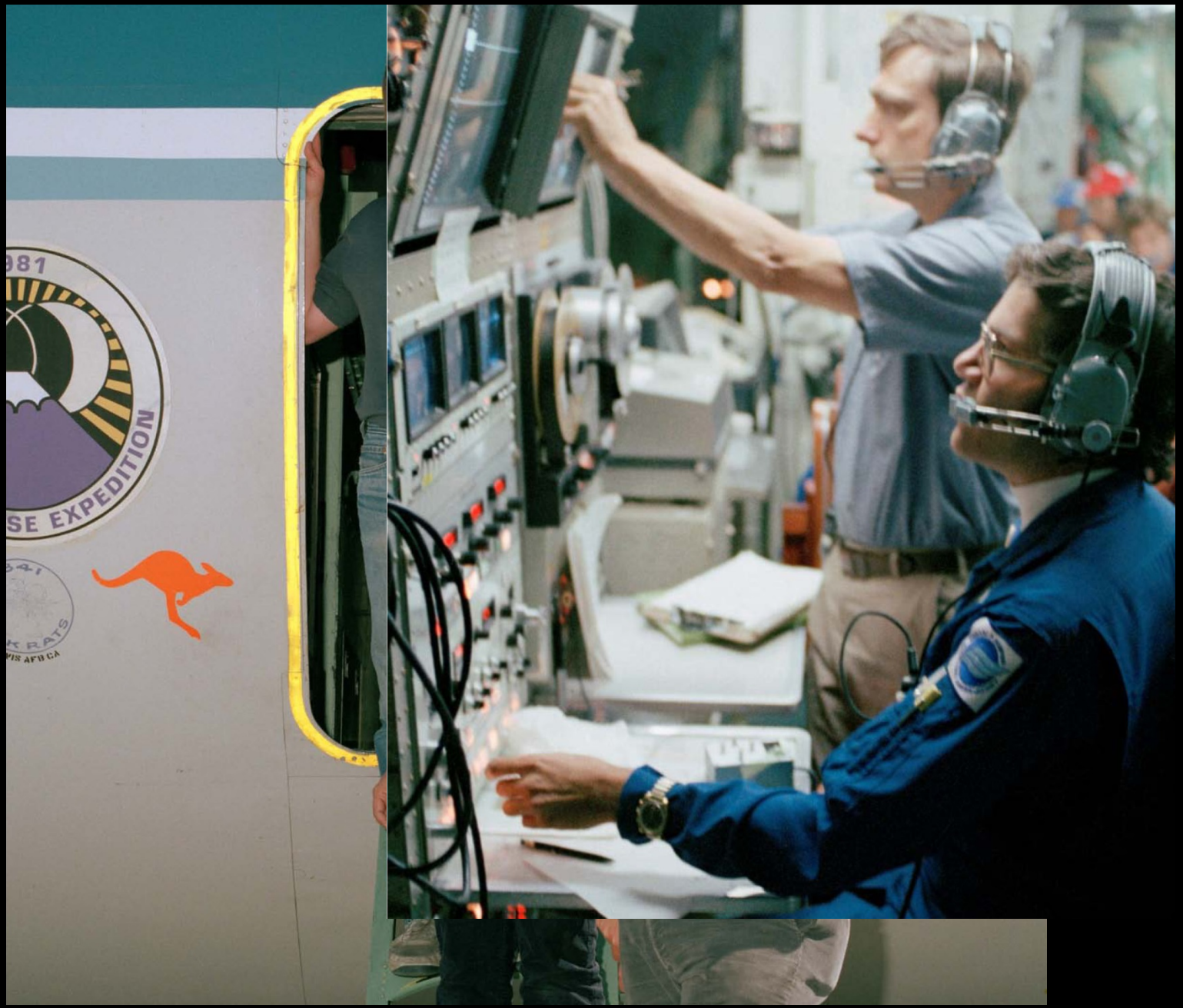

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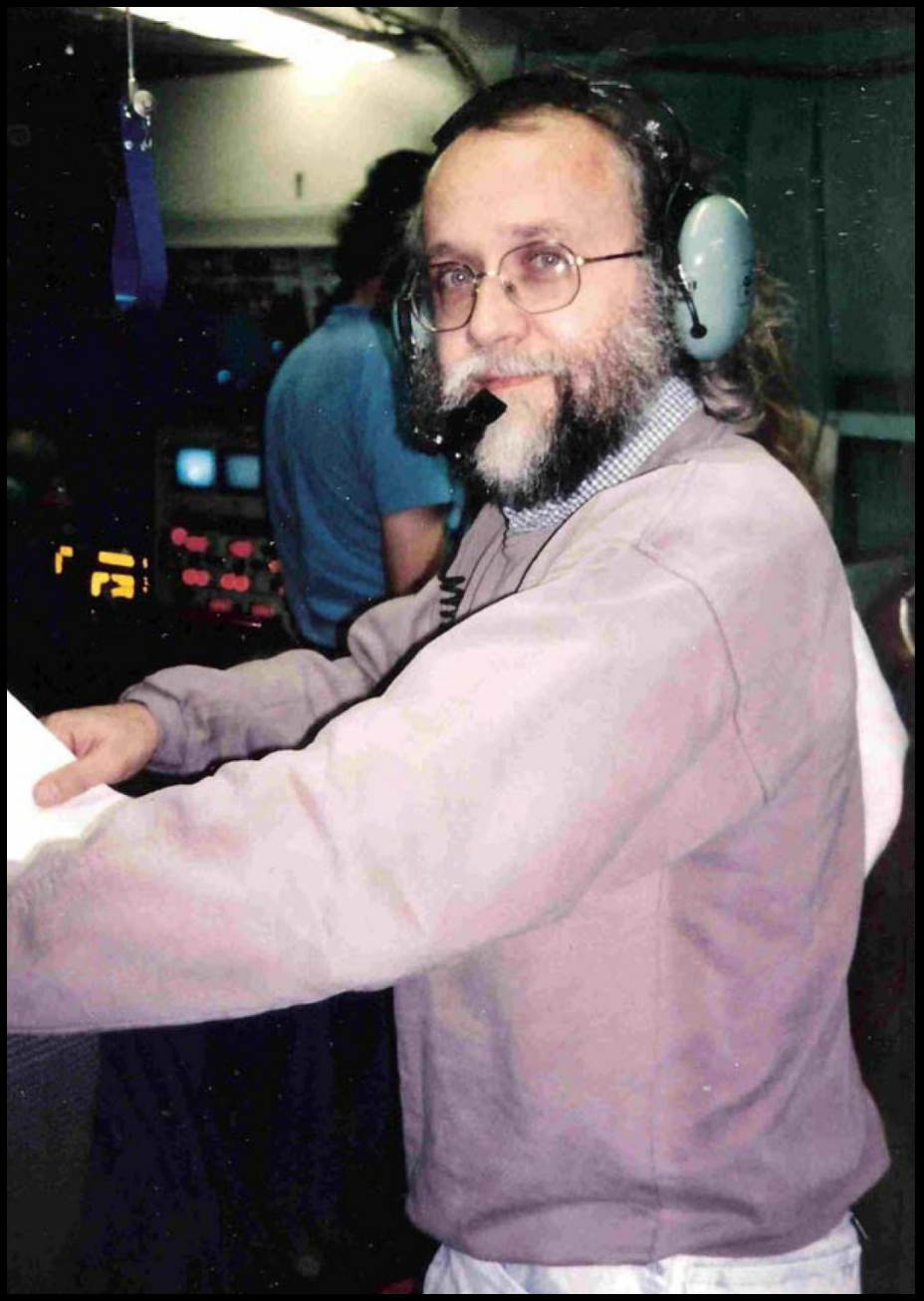

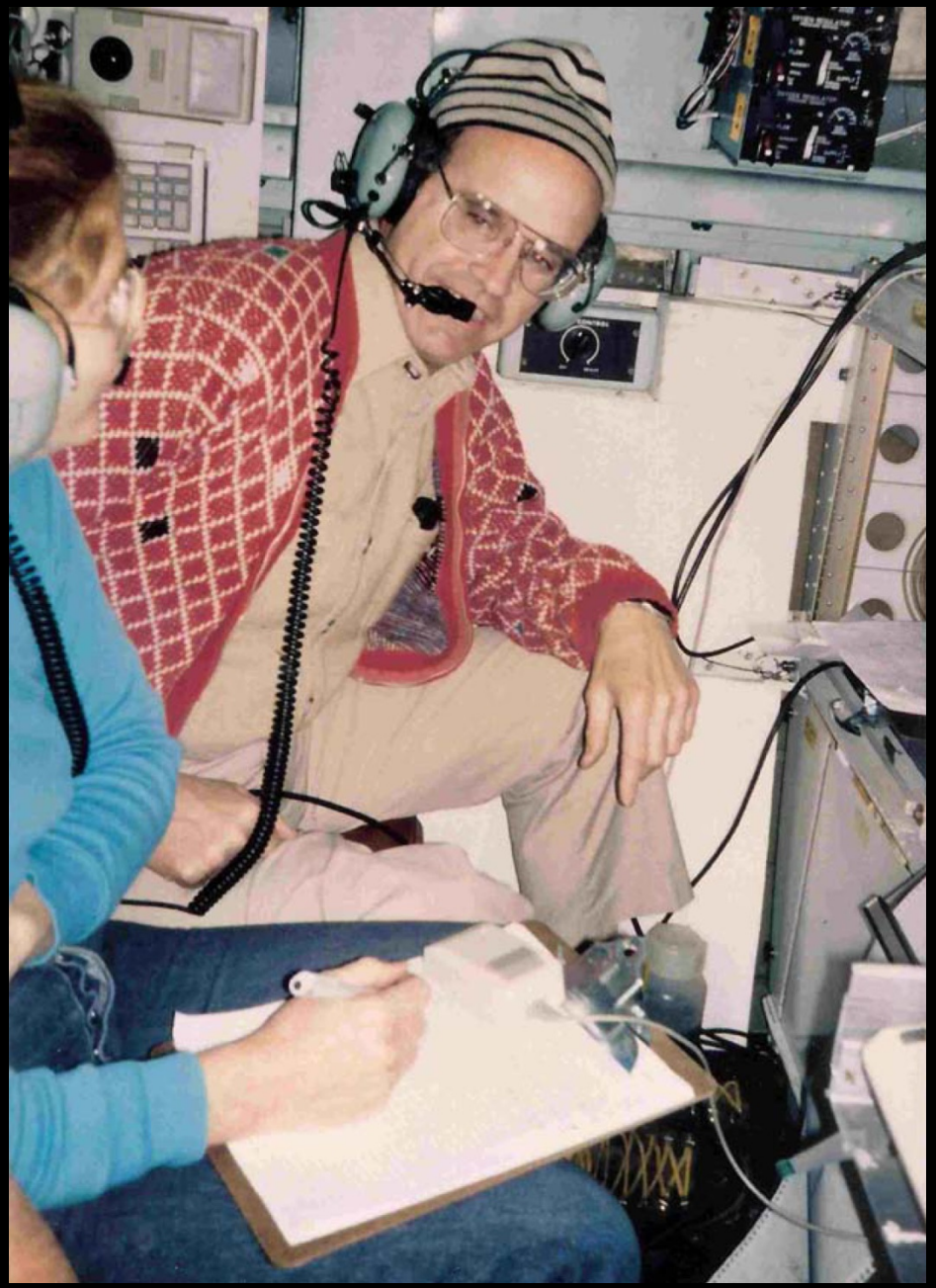

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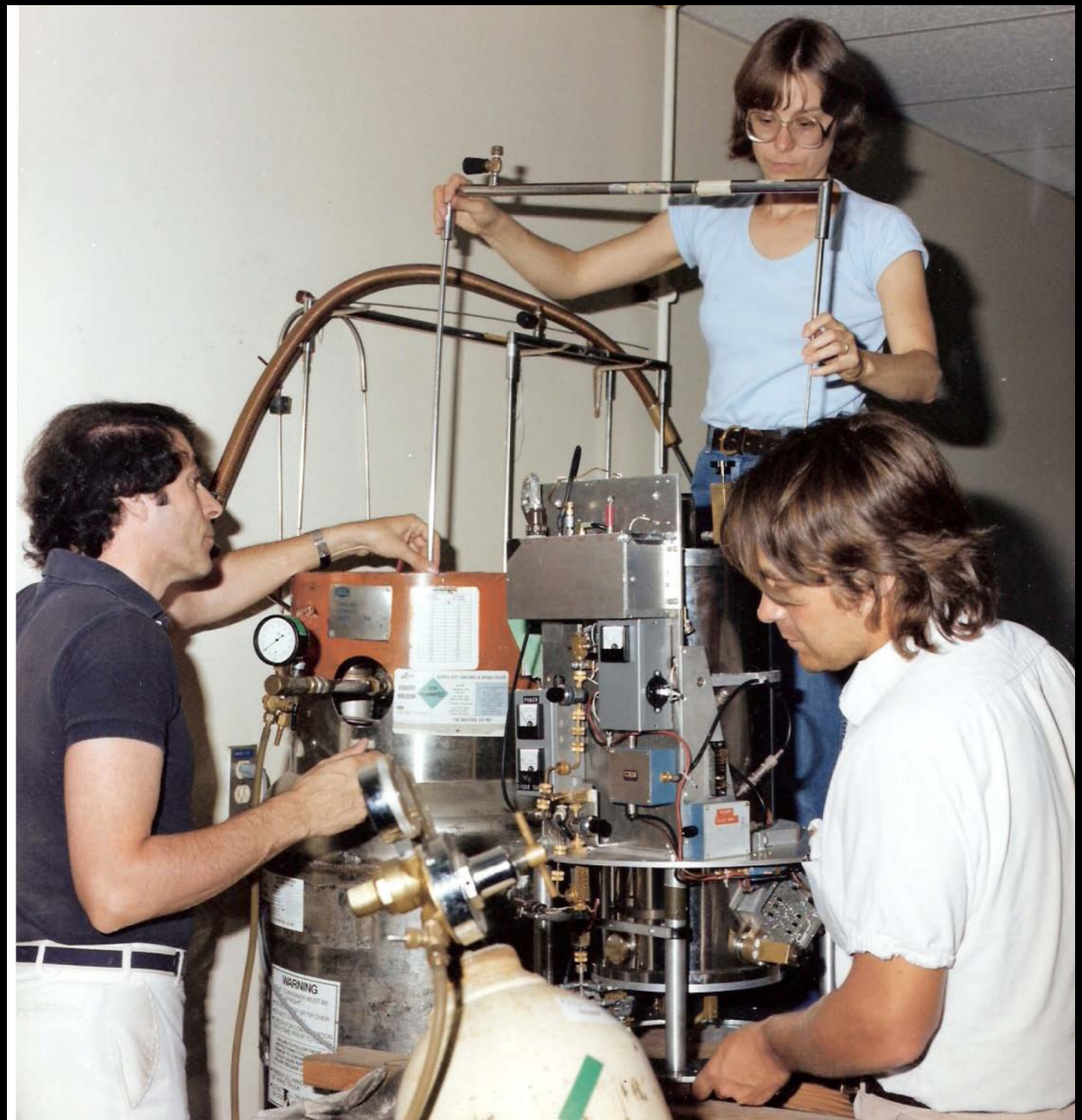

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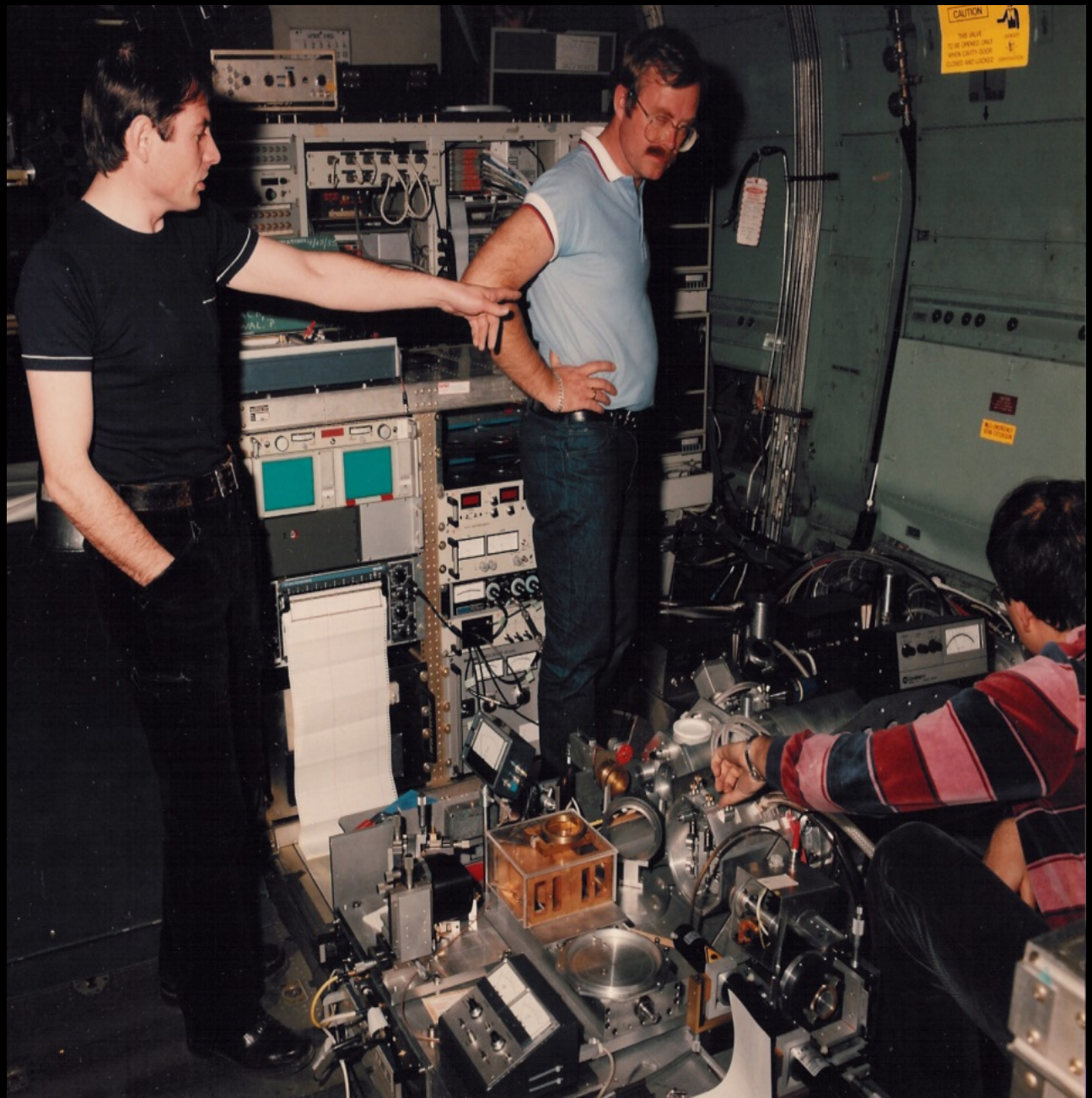

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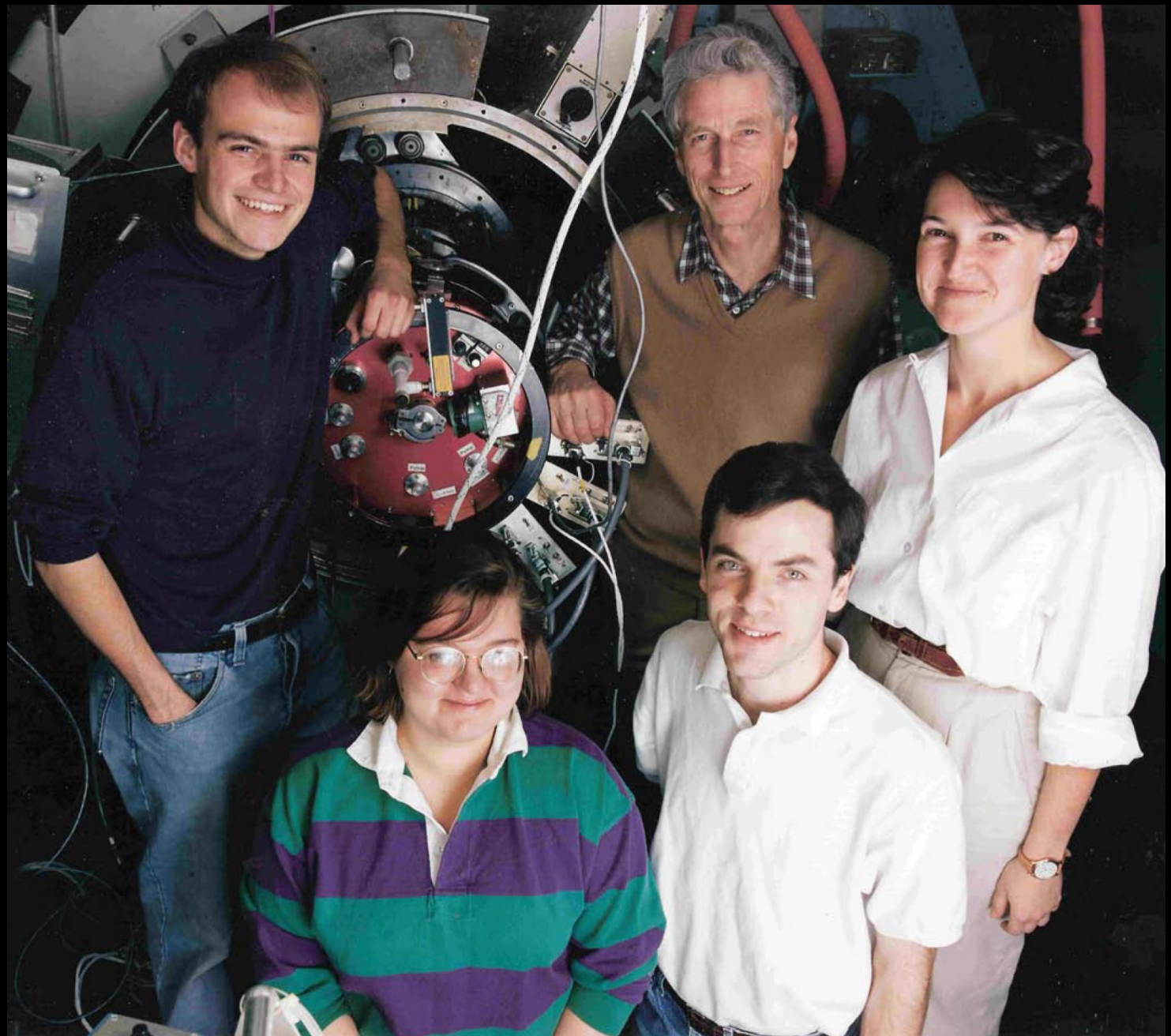

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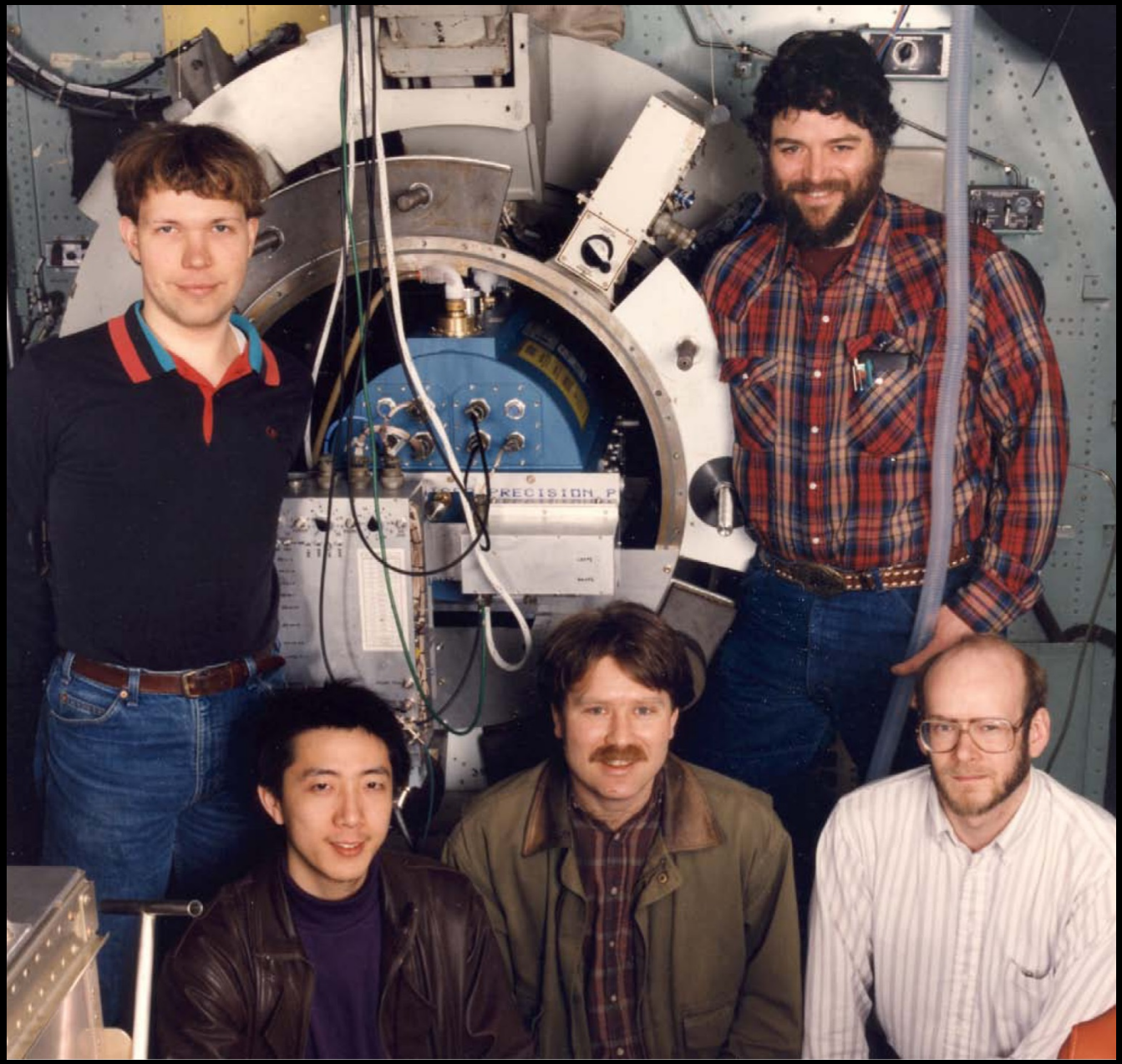

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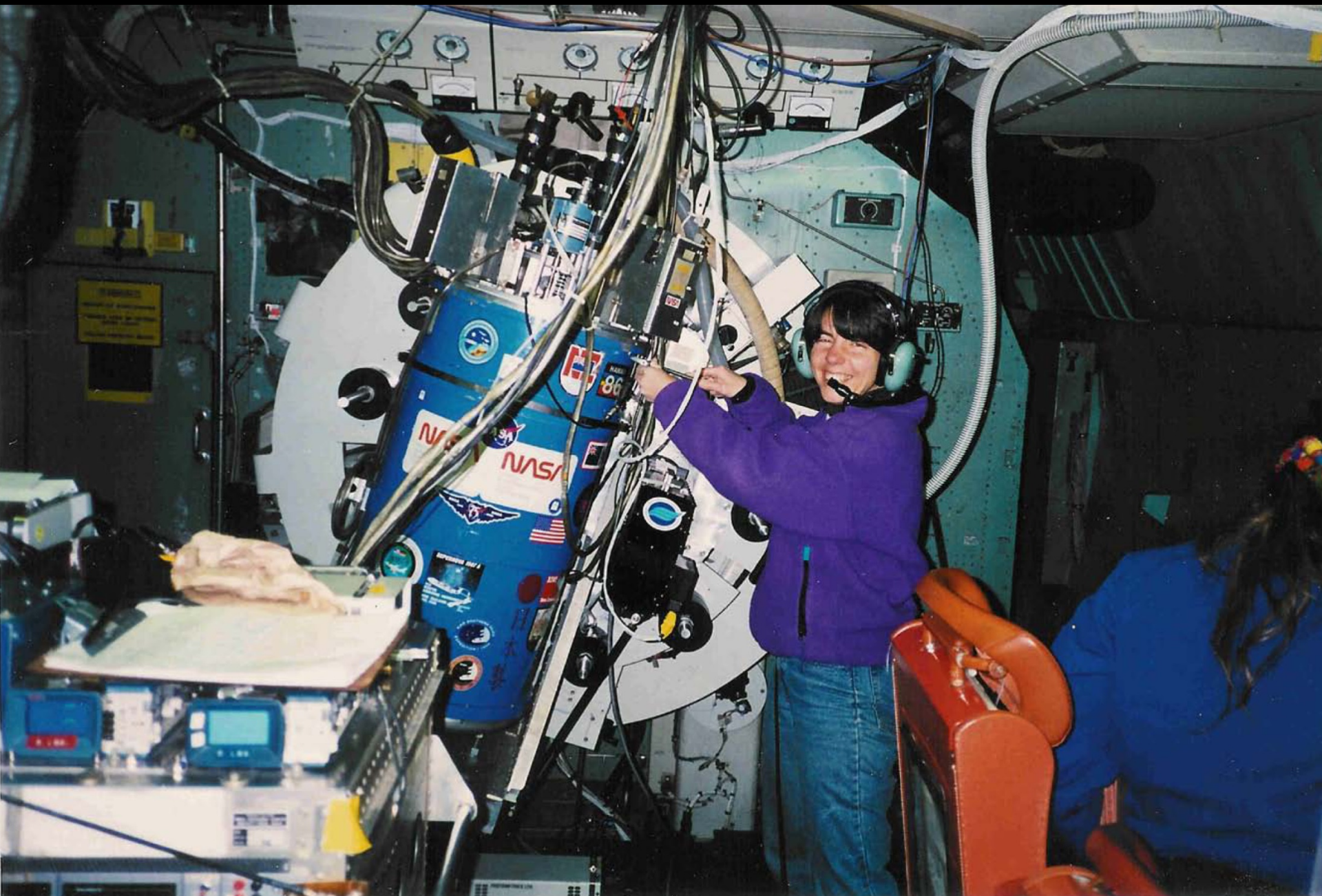

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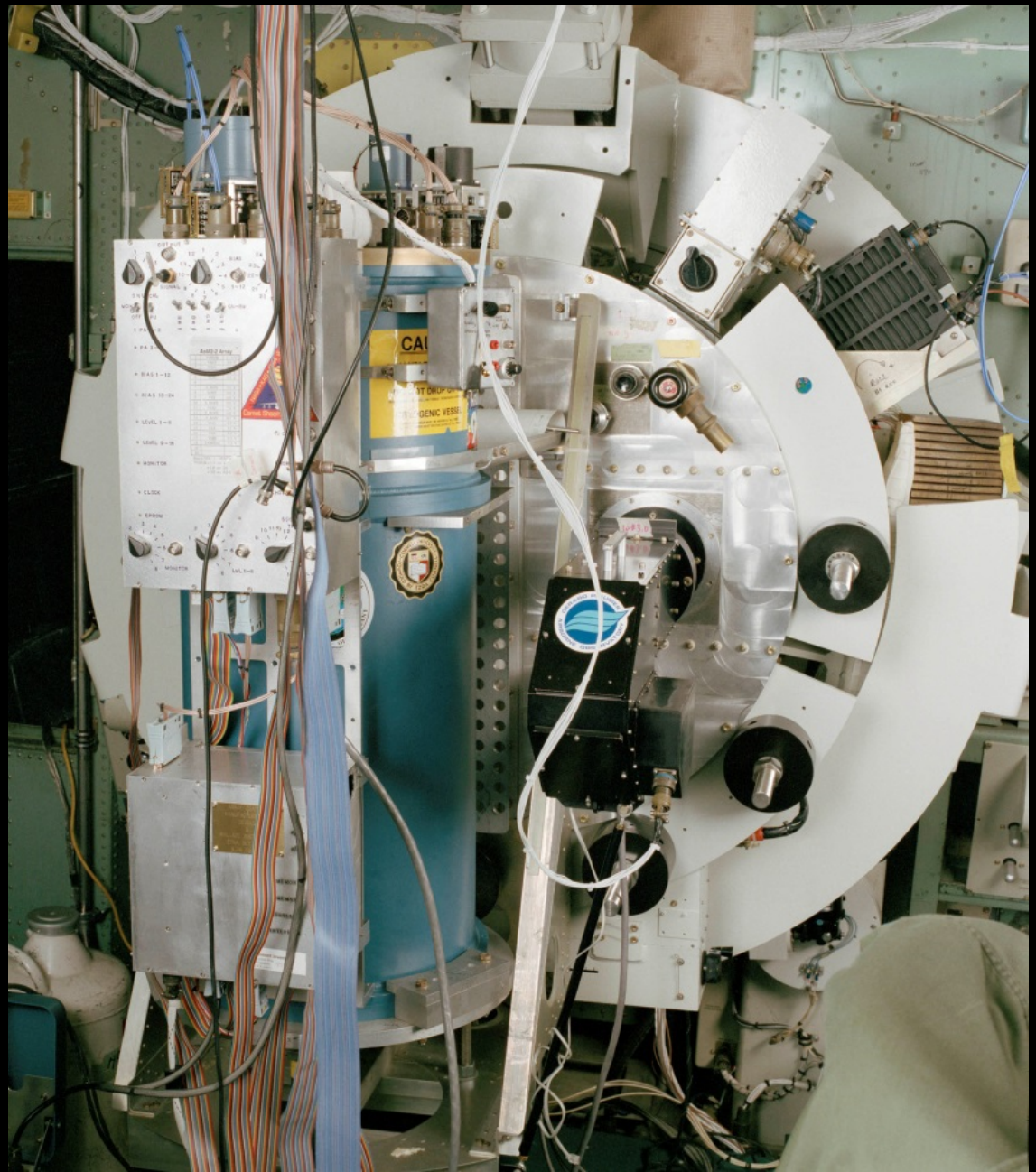

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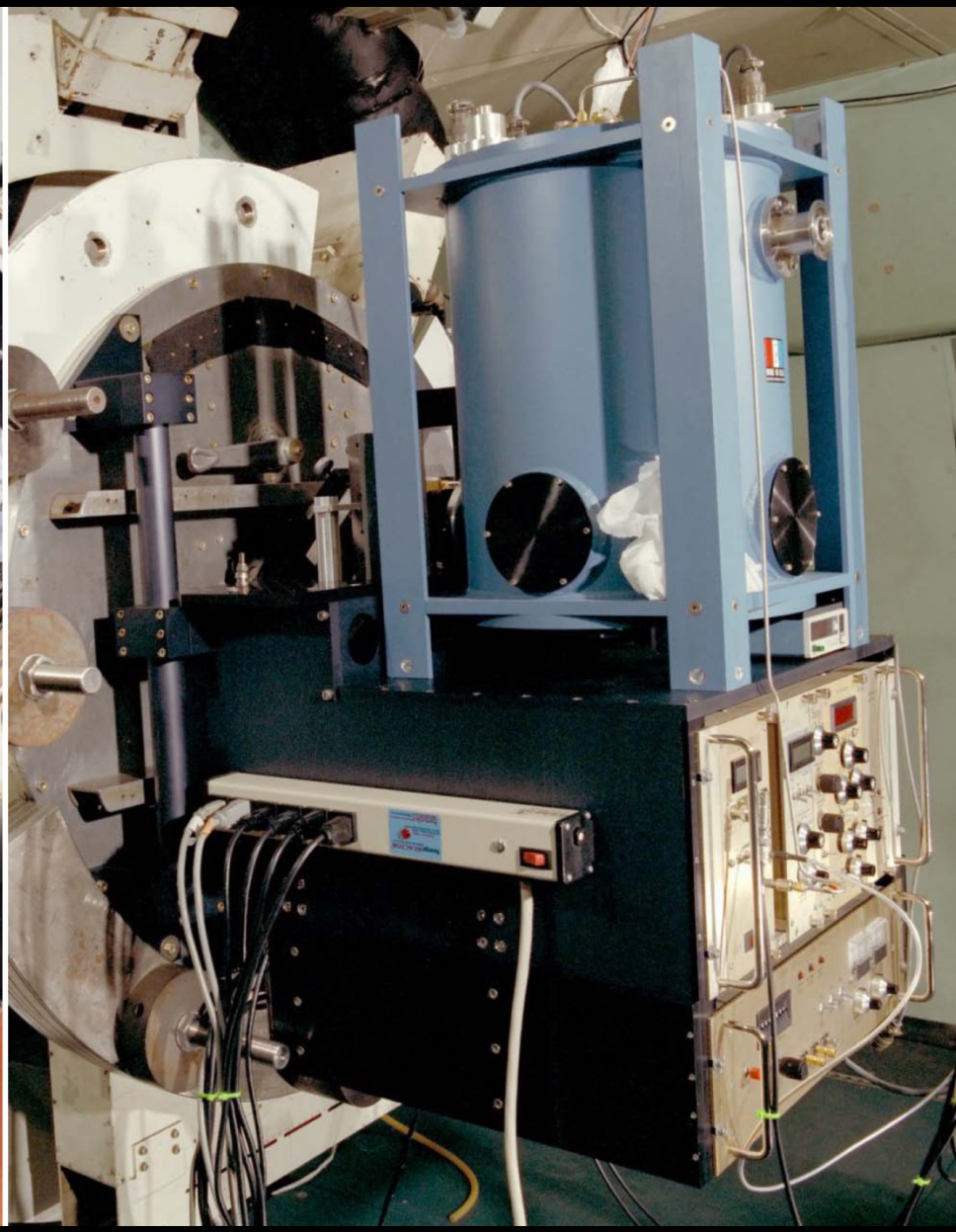

1974 –1995: KAO operations

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1974 –1995: SOFIA Promotion Highlights

1974 – 1980: Impressive KAO results and advancing science-instrument technology generated enthusiasm for a Large Airborne Telescope (LAT). Ames managers and scientists began promoting the LAT concept at NASA HQ.

1980: Decadal Survey "Field" Report endorsed LDR – a wasted IR silver bullet.

1980: First IAU Symposium on IR Astronomy: LAT concept received positive reaction from the community.

1982: Peter Mezger toured KAO, expressed interest for Germany to participate in the airborne program.

1984: Airborne Astronomy Symposium celebrated 10 years of KAO operation. Much enthusiasm for a LAT.

1984: Martin Harwit produced first glitzy brochure promoting airborne astronomy.

1985: Carl Gillespie coined the acronym SOFIA. SOFIA Study Office & Science Working Group formed. NASA-BMFT (DLR) begin collaboration discussions.

1986: SOFIA Technology Workshop hosted U.S. and German contractors interested in building SOFIA. Collaboration with Germany firmly established.

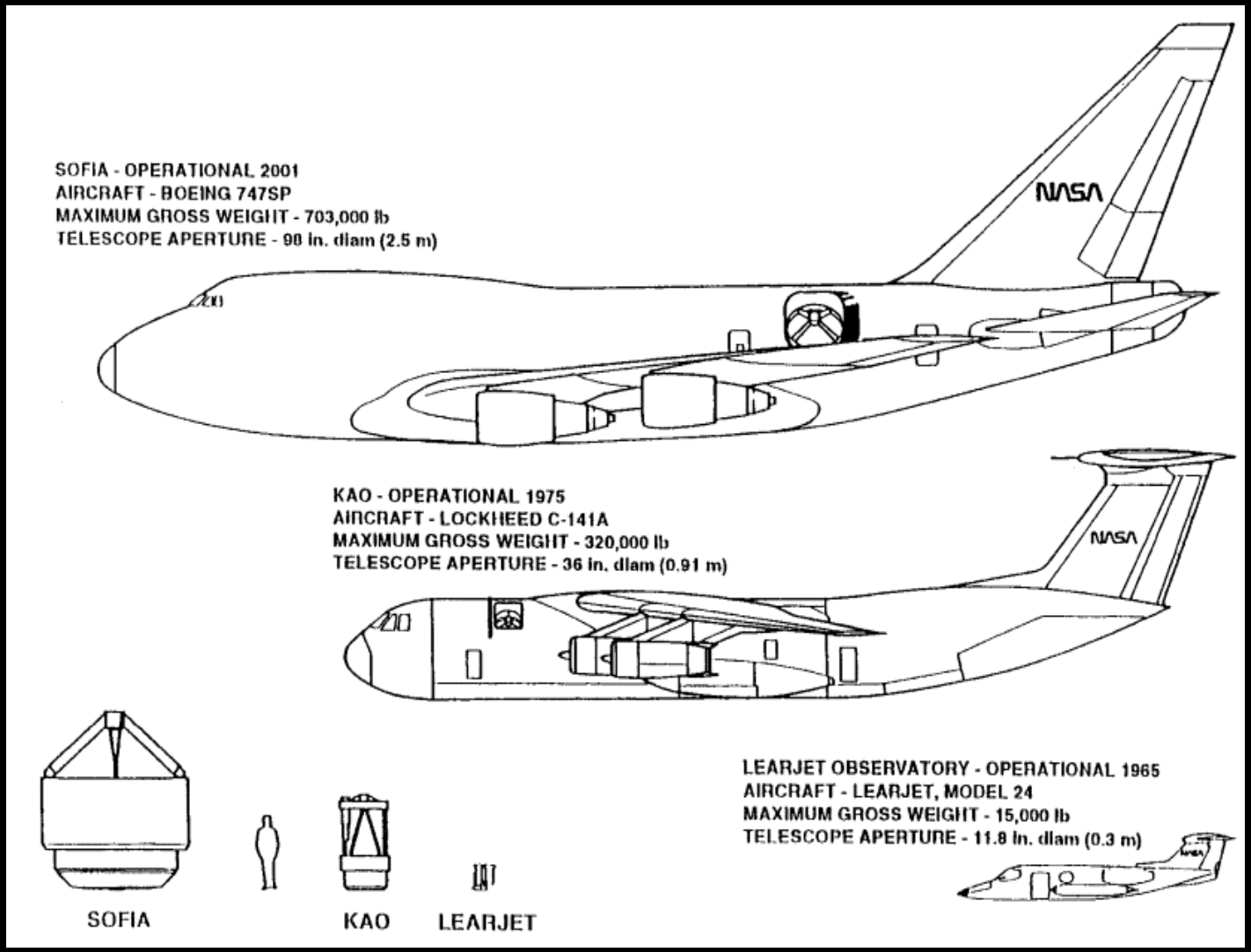
1987 : Detailed studies funded.
KAO users began serious advocacy efforts.

1990: Decadal Survey "Bahcall" Report recommended development of SOFIA and SIRTF.

1994: Following 2nd Airborne Astronomy Symposium, NASA requested funding to develop SOFIA.

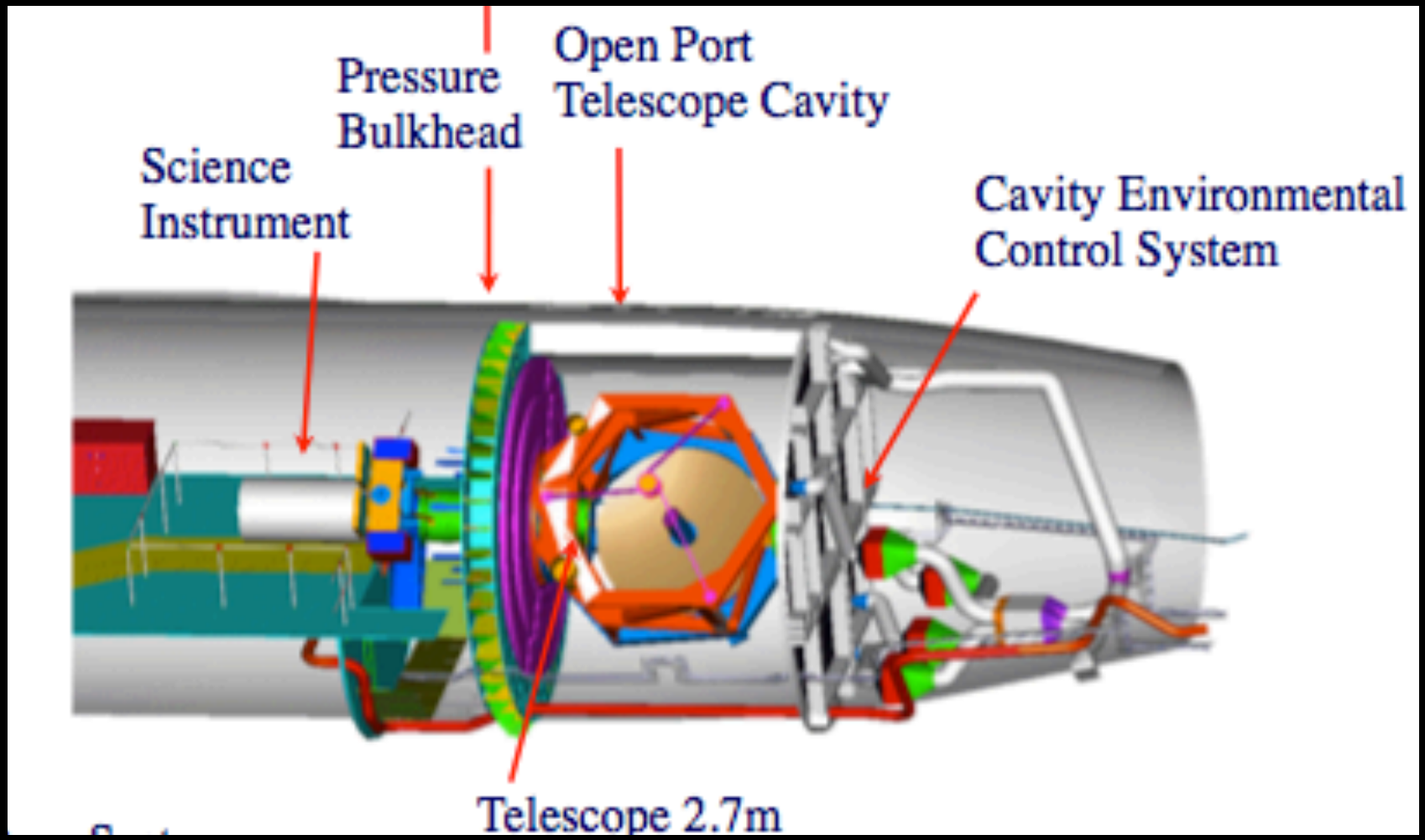
1974 –1995: SOFIA Definition & Design

Engineering problem: B747SP is not 3x C141



1974 –1995: SOFIA Definition & Design

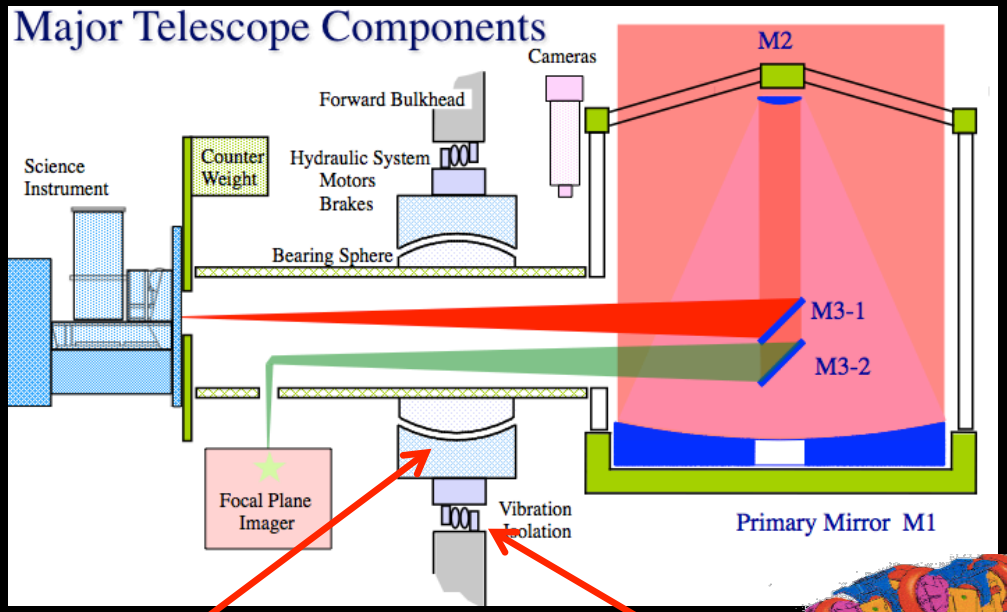
General configuration of telescope installation



1974 –1995: SOFIA Definition & Design

Studies addressed *critical* issues before development :

TELESCOPE: support, isolation



Hydraulic spherical bearing isolation

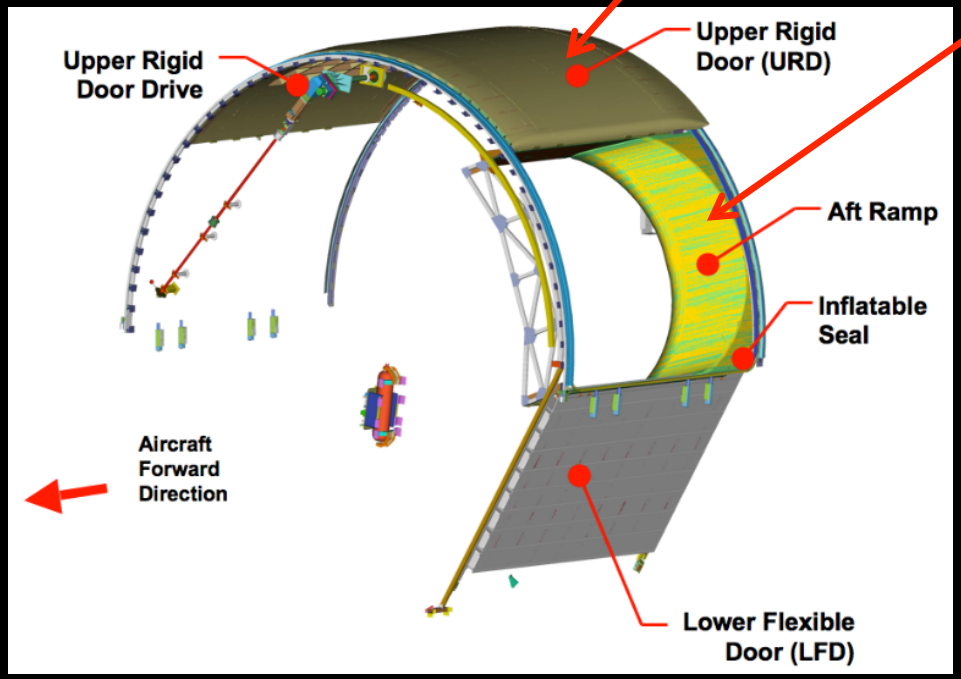
Rubber bladder supports

1974 –1995: SOFIA Definition, Design

Studies addressed *critical* issues before development :

AIRCRAFT: cavity door and shear layer control.

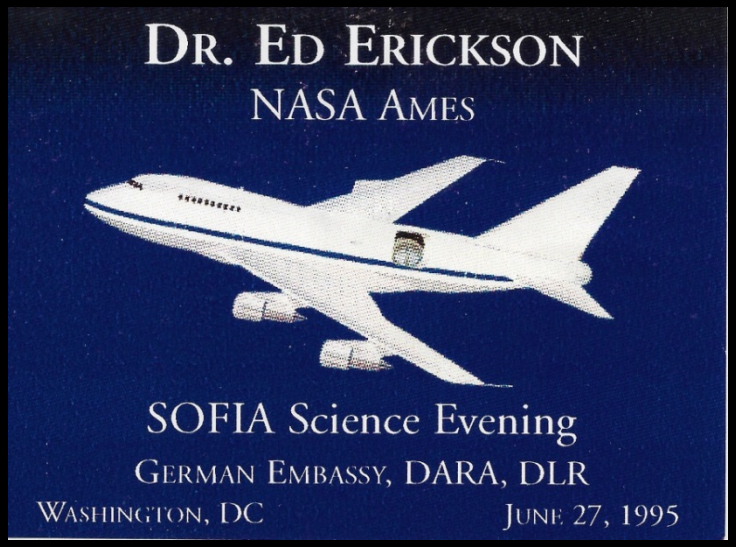
Aft Ramp



Ames Wind Tunnel tests

1995: Congress was deliberating the budget.

A SOFIA Science Evening at German Embassy in D.C. was organized by Hans Peter Röser



Talks given by
David Hollenbach, NASA Ames
Reinhard Genzel, MPI Garching
France Cordova, Chief Scientist NASA HQ

Attended by:
NASA HQ Officials
SOFIA Science Working Group
> 100 Congressional Staffers

Congress approved SOFIA funding one month later.

1995: KAO operation ended to help fund SOFIA.

KAO Focal Plane Instrument PIs in 1995*

A. Betz, Colorado
E. Dunham, NASA Ames
D. Harper, Yerkes
T. Herter, Cornell
H. Moseley, NASA GSFC
H. Röser, DLR Berlin
G. Stacey, Cornell
F. Witteborn, NASA Ames
J. Bregman, NASA Ames
E. Erickson, NASA Ames
P. Harvey, UT Austin
R. Hildebrand, Chicago
H. Larson, Arizona
R. Russell, Aerospace Corp.
C. Townes, UC Berkeley
J. Zmuidzinas, Caltech

These and other KAO users – in particular Dan Lester and Harley Thronson – advocated SOFA at NASA HQ, in the science community, and in congress.

*Not all 16 flew in 1995, but all instruments were highly advanced, had flown.

Kuiper Airborne Observatory (KAO)

1974 - 1995

A Lockheed C-141 Star Lifter with a three-foot diameter telescope.

Based at NASA Ames Research Center in California

>300 investigators, ~50 Ph.D.s, ~40 instruments,

1463 research flights, ~9200 observing hours

1995, 29 September: Farewell to the KAO

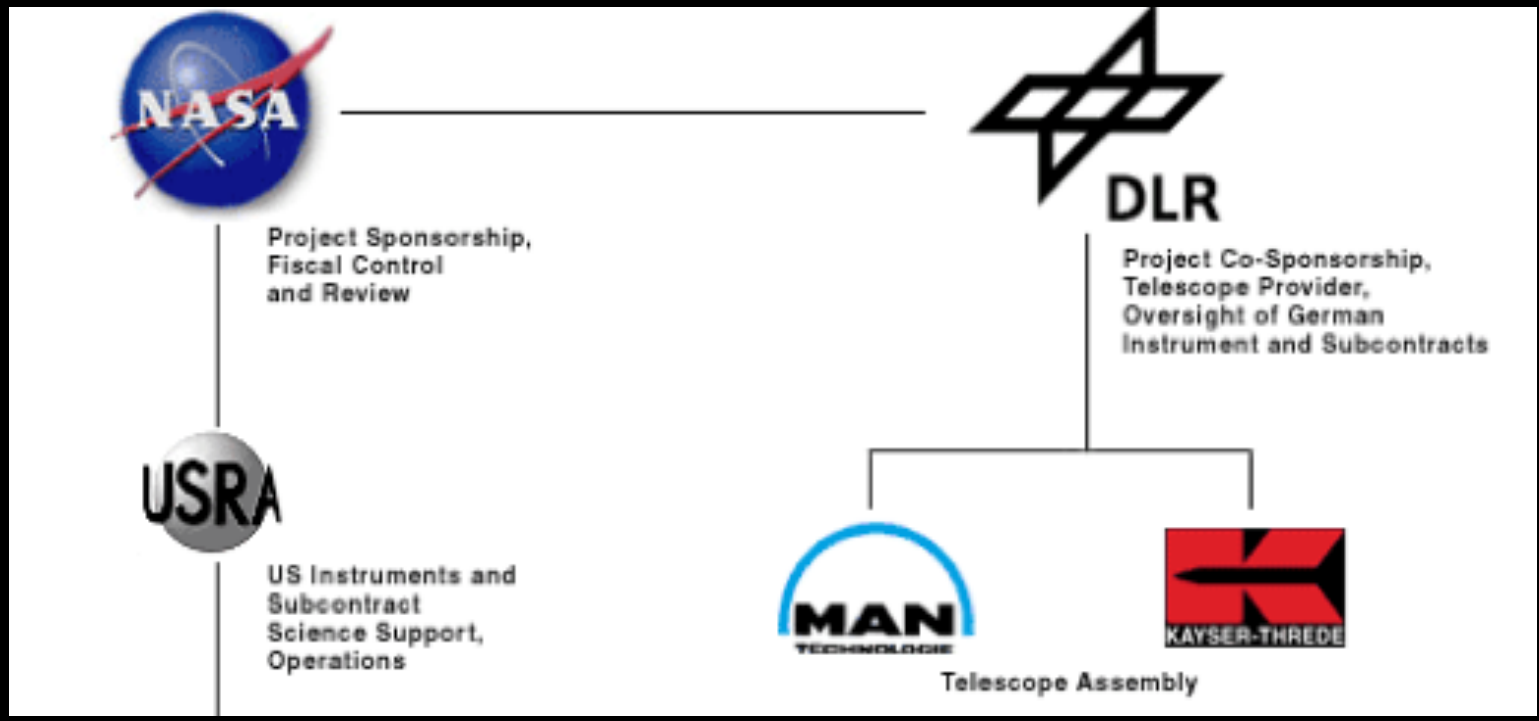
Many users came to pay their respects.

SOFIA was supposed to fly in five years.

1997 January: SOFIA Development began.

The decade+ of prior study paid off: the technical features of SOFIA were developed with no surprises.

Organization of the project:



1997: Principal People at Start of SOFIA


Caroff


Wiltsee


Kunz


Erickson


Dunham

NASA

DLR


Himmes

USRA


Bonner


Becklin


Davidson

MAN


Kärcher

K-T

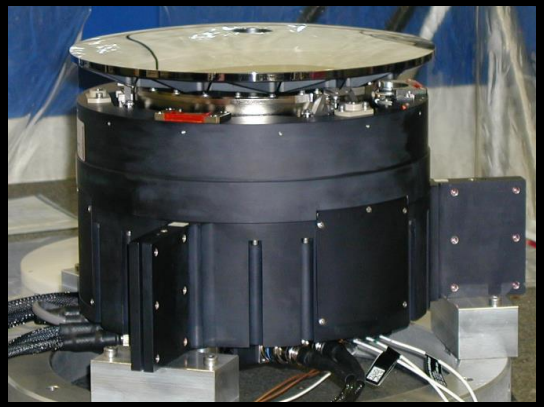

Bittner

1997 – 2007: Development

1997: *Clipper Lindbergh* B747SP acquired

1997 – 2007: Development

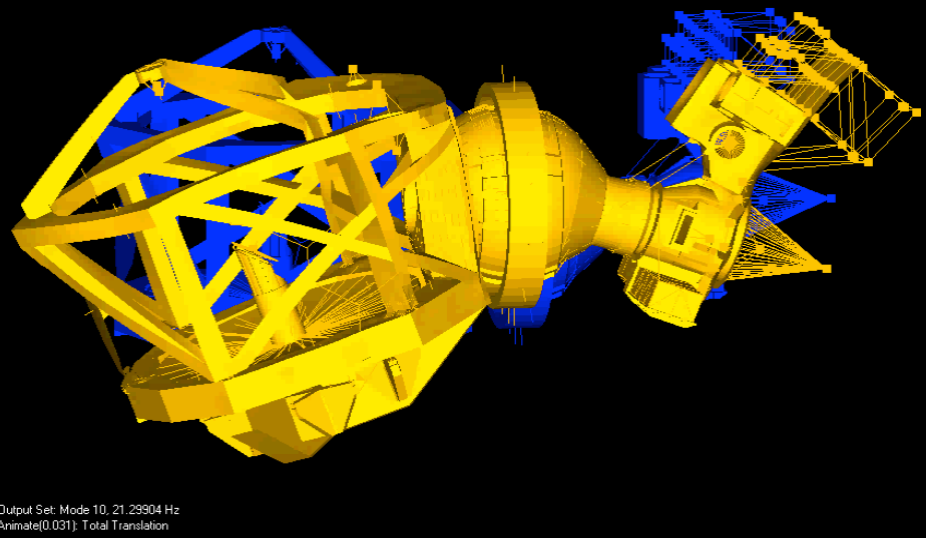
Optics



1997 – 2007: Development
2001: Telescope structure

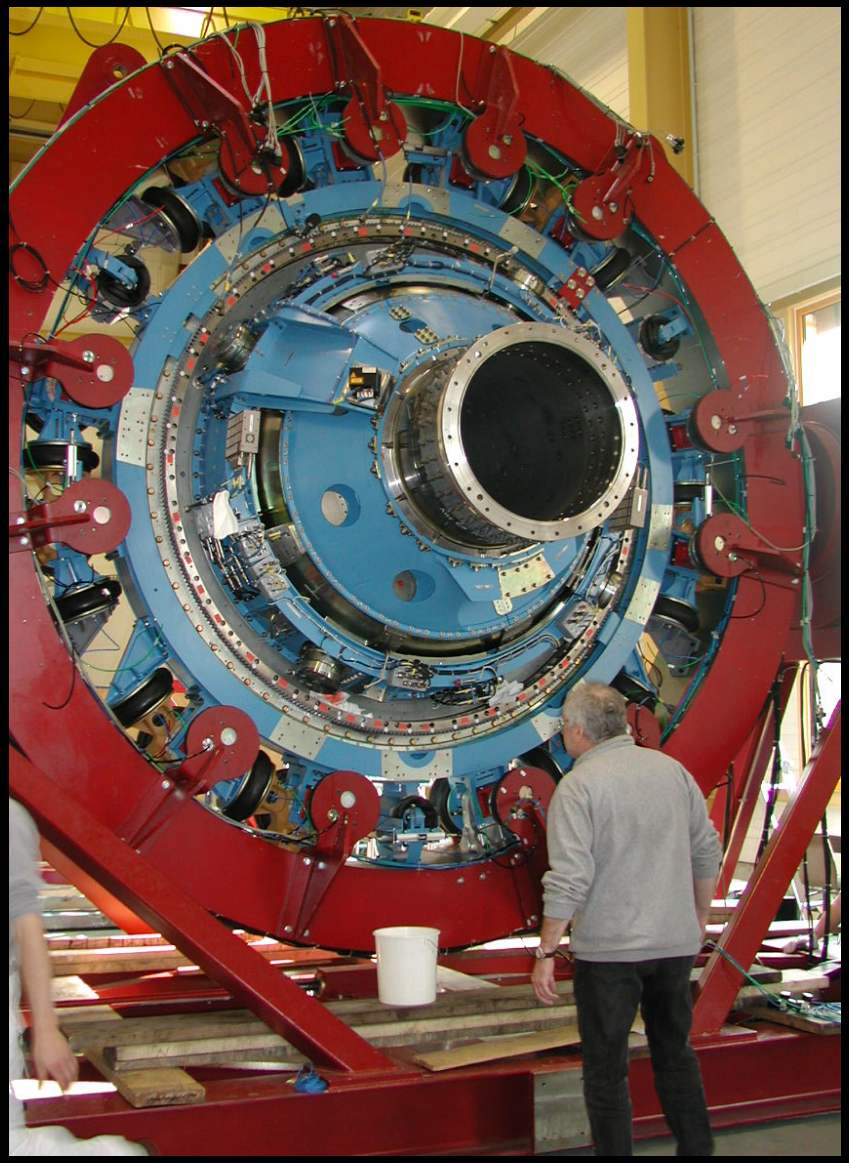
Primary mirror cell - CFRP

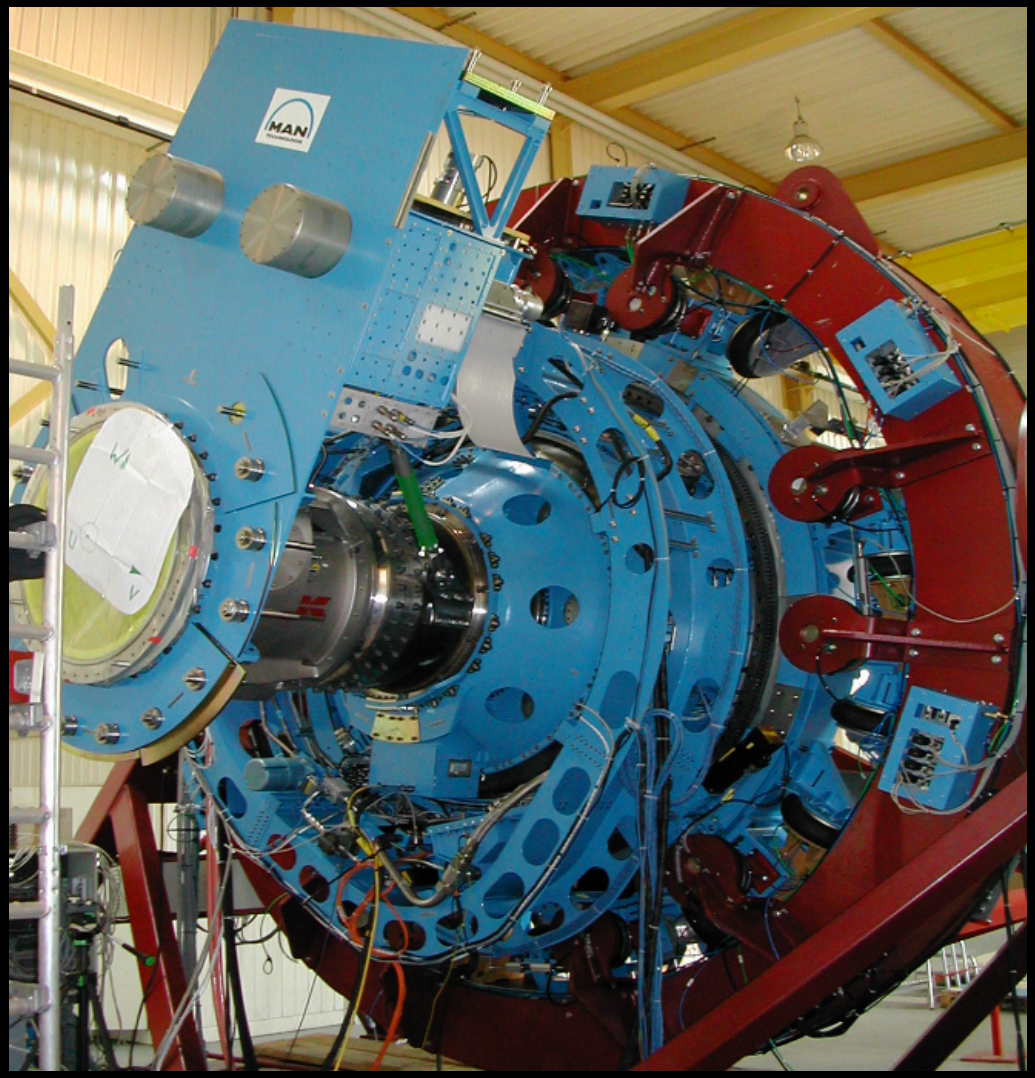
Deformation analysis



1997 – 2007: Development

2001: Telescope assembly in Augsburg





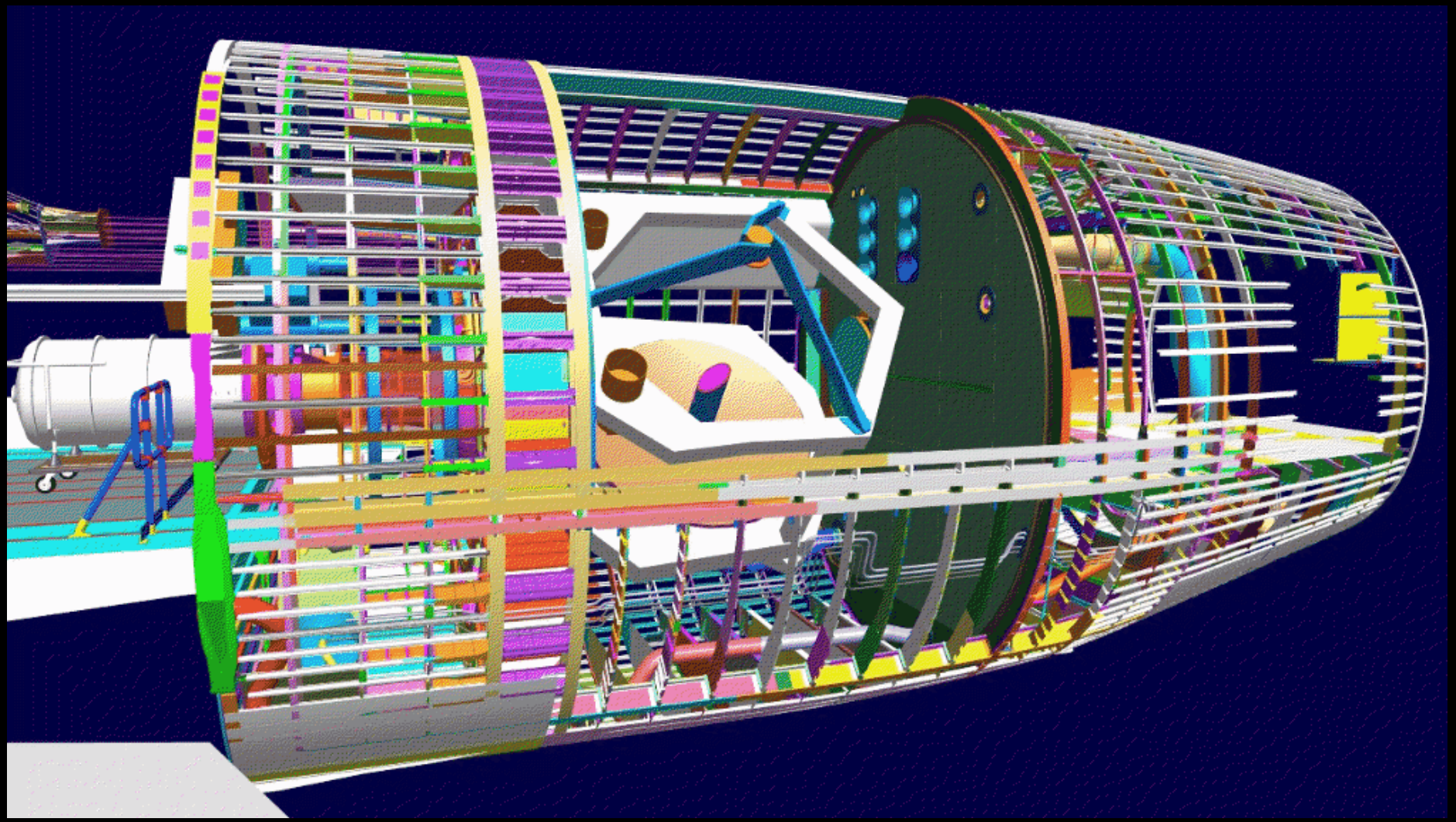
1997 – 2007: Development

2002: Aircraft modification in Waco

1997 – 2007: Development

Aircraft modification

Prior engineering design

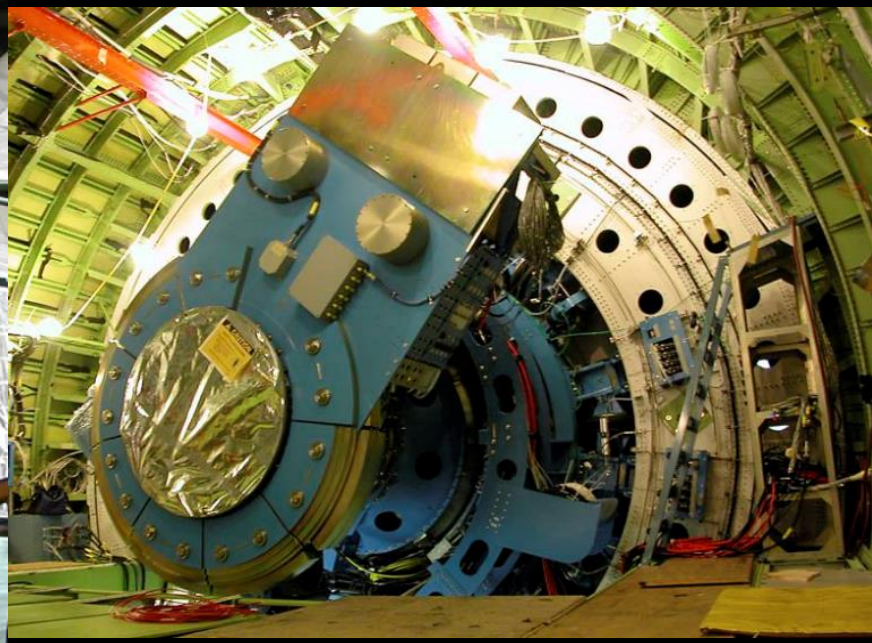


1997 – 2007: Development

2002: Telescope delivered to Waco.

1997 – 2007: Development

2003: Telescope installed.

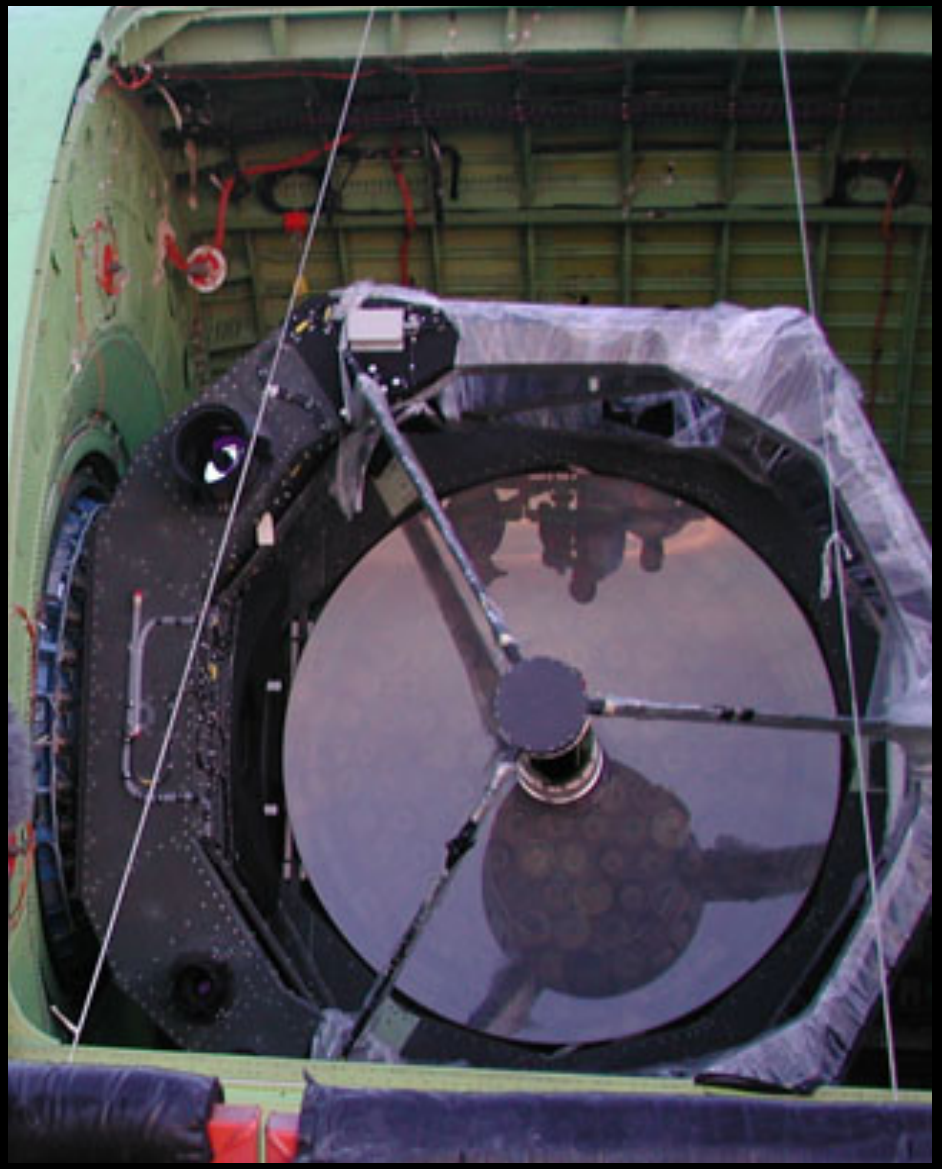


1997 – 2007: Development

2004: Proof pressure test.

1997 – 2007: Development

2004: First light.



1997 – 2007: Development

2004: First light.

1997 – 2007: Development

2005: Ames team installs their door

Aft Ramp

1997 – 2007: Development

April 2007: First flight!

1997 – 2007: Development

June 2007: Celebration at AFRC.