EFLIGHT 2003
The Umbra on Ice from 35,000 ft.

Dr. Glenn Schneider, Ph. D.
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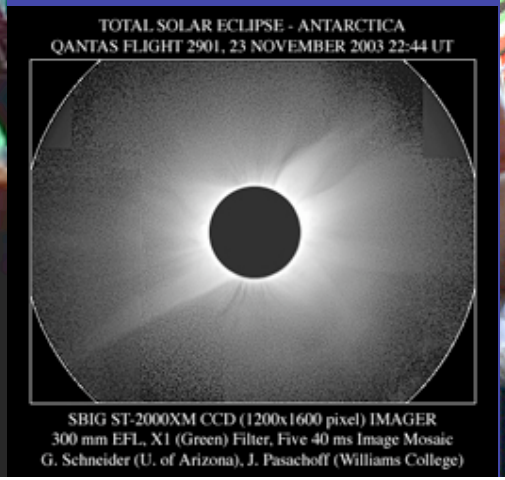
Steward Observatory, University of Arizona
Tucson, Arizona 85721 USA
http://nicmosis.as.arizona.edu:8000

QF 2901
23 Nov 2003 UT
Total Solar
Eclipse Flight
Antarctica

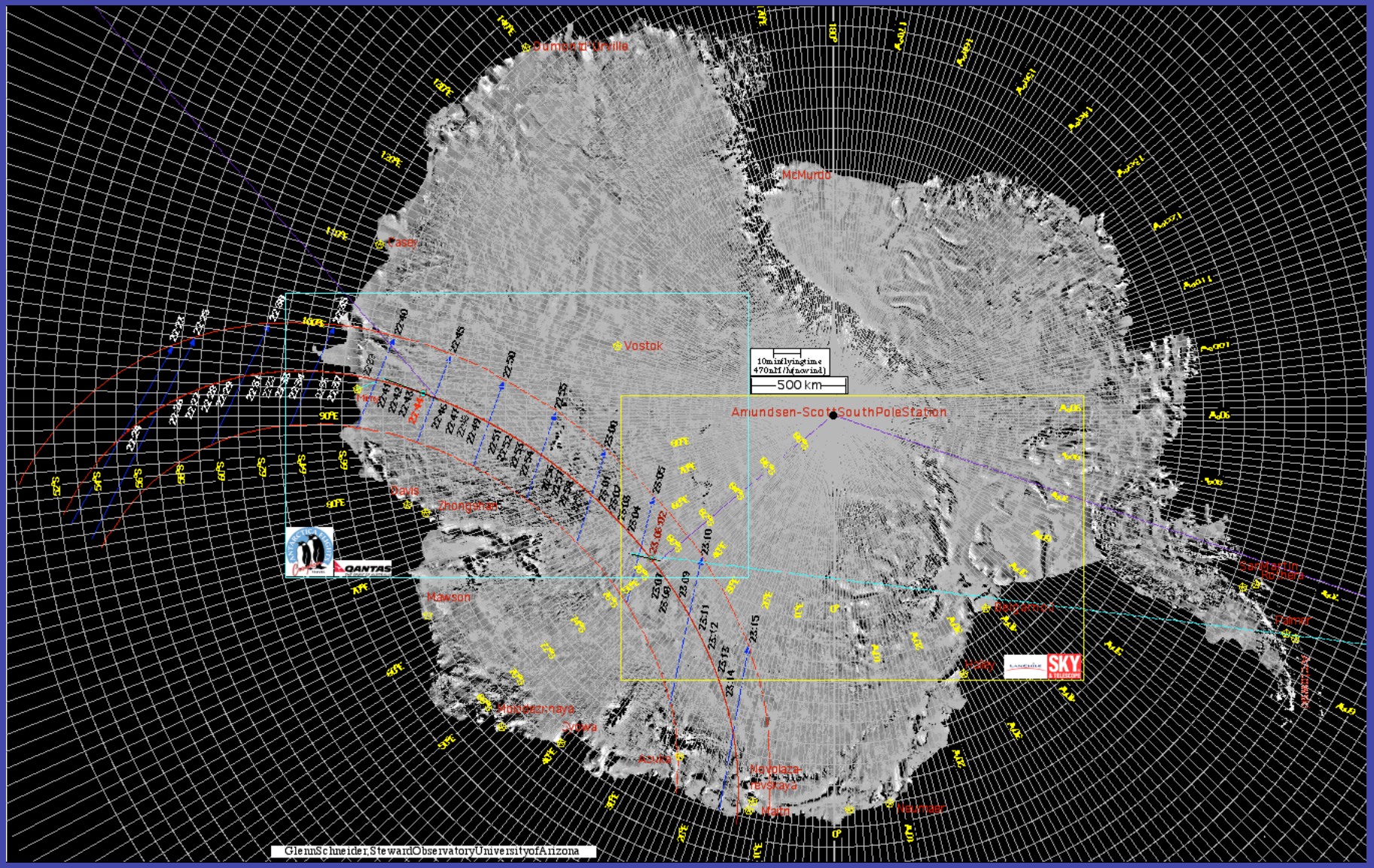


TSE2003 - PATH / VISIBILITY

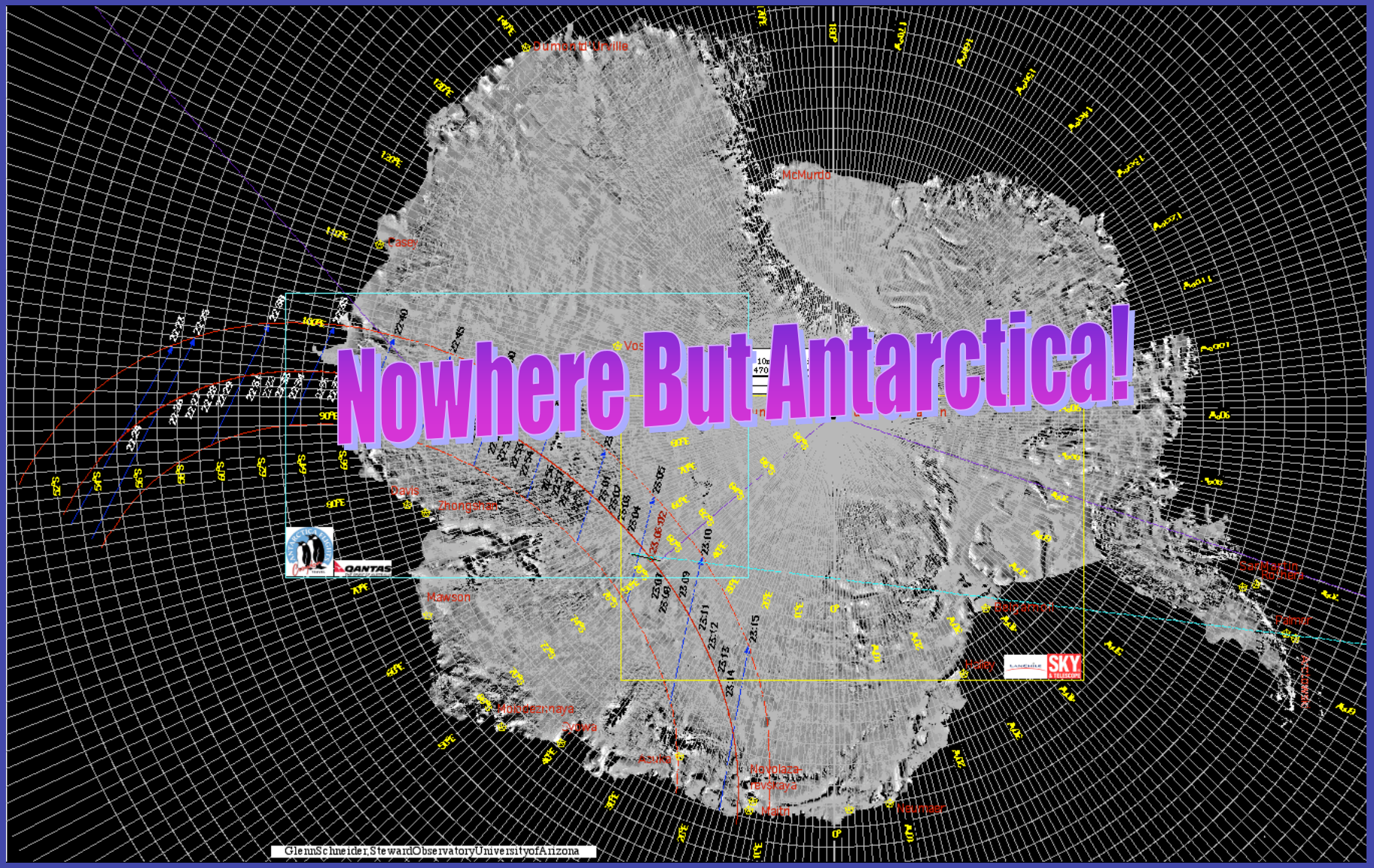
The Central Umbral Shadow

Touch down (near Kerguelen): 22:22.7 UT
Landfall Only South of Longitude 66 deg S
Lift off (near Matri): 23:15.6 UT
Minimum Speed: 3900 km/hr
Duration: 52.9 minutes
Path Length: 5000 km
Conic Width: 28-89 km
Area: 0.14% of the Earth's surface.

TSE2003 - PATH / VISIBILITY



TSE2003 - PATH / VISIBILITY



ACCESSIBLE?

ACCESSIBLE?

Glenn Schneider, Laura Kay & Opus
Amundsen-Scott South Pole Station
December, 1984

ACCESSIBLE?

“Shared Use” Plan Enabled by Croydon Travel

Phil Asker Gayle Brown

Captain John Dennis
Senior Check Captain
B747-400
QANTAS Airlines

You want to do WHAT with my airplane??

Captain John Dennis
Senior Check Captain
B747-400
QANTAS Airlines

You want to do WHAT with my airplane??

Captain John Dennis
Senior Check Captain
B747-400
QANTAS Airlines

The QANTAS/CROYDON Total Solar Eclipse Flight

23 November 2003 UT

Mission Planning & Definition Overview

REQUIREMENTS for Assisted Real-Time Computation and Navigation

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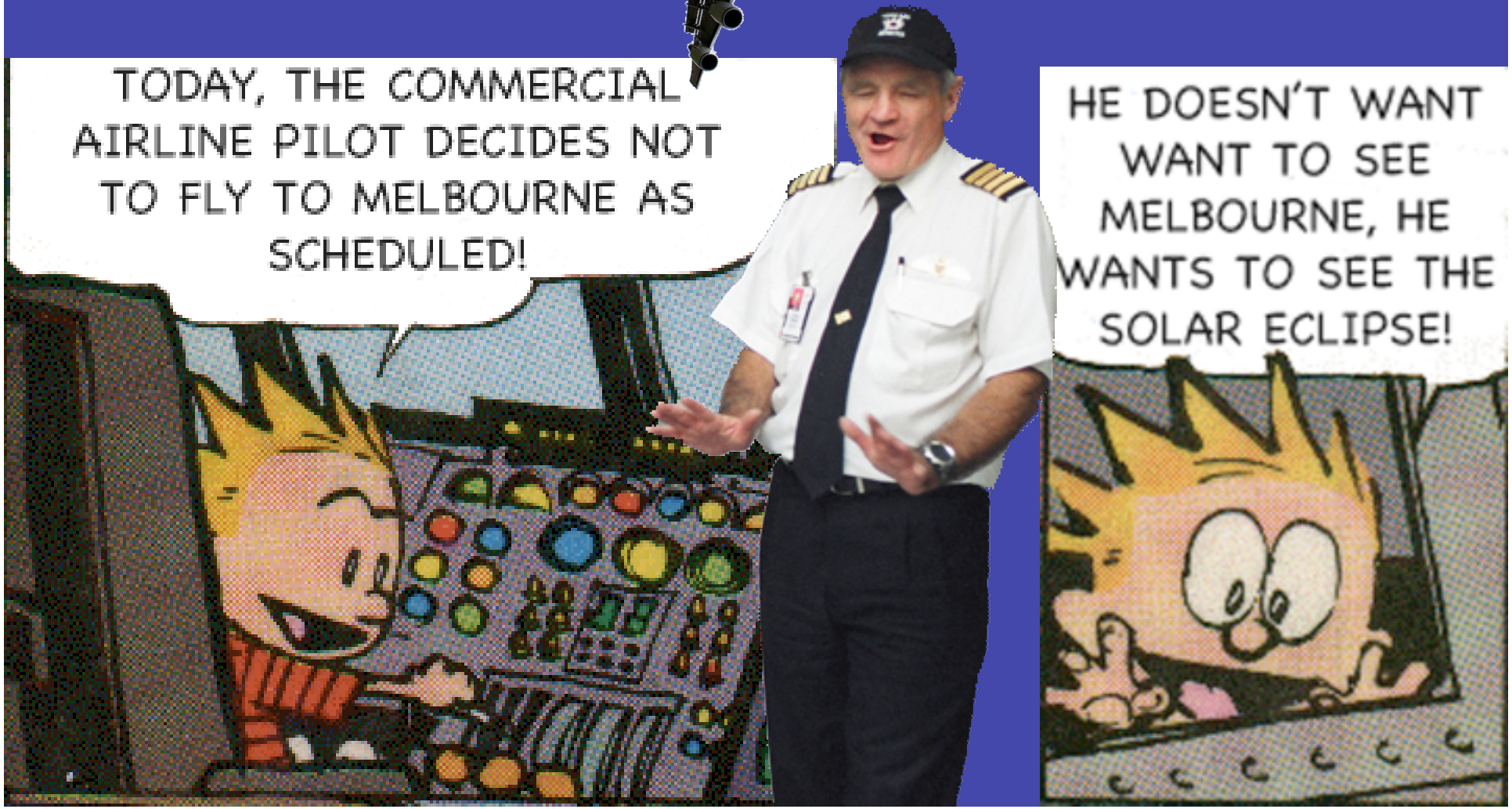
Abstract

No total solar eclipse has ever been observed from Antarctica both because of the infrequency of occurrence and the logistical complexities associated with Antarctic operations. This paradigm of elusivity regarding Antarctic eclipses in the historical record of science and exploration is about to be broken. The next total solar eclipse, which occurs on 23 November 2003 U.T., the first in the Antarctic since 12 November 1985, will be very largely unobserved due to the geographic remoteness of the path of totality. Yet, interest in securing phenomenological observations of, and associated with, the eclipse by members of the scientific research communities engaged in solar physics, astrodynamics, aeronomy and upper atmospheric physics, as well as educators and amateur astronomers has been extremely high. The development of a flight concept to enable airborne observations, with a dedicated aircraft chartered from QANTAS Airlines, will permit the previously unobtainable to be accomplished. To do so successfully requires detailed preparatory planning for the execution of such a flight. The technical groundwork to achieving this goal has been pursued with diligence over the past four years and is predicated on a legacy and computational infrastructure capability founded on more than three decades of eclipse planning for ground, sea, and airborne venues. Here, given the geometrical circumstances of the eclipse, the uncertainties associated with weather, and the constraints of operations of the Boeing 747-400 aircraft, the requirements for the successful execution an intercept flight with the base of the Moon's shadow over the Antarctic are reviewed. The *unequivocal need for real-time, in-situ re-computation of an executable flight plan in response to in-flight conditions* is discussed. The mechanism for fulfilling that need, through the expert operation of EFLIGHT, a well-tested highly specialized software package of unique pedigree designed specifically for this purpose by the author of this report, working in concert with the flight crew on the flight deck is elaborated upon in the specific context of the requirements of this flight.

Captain John Dennis
Pilot in Command
QF 2901
Antarctic Eclipse Flight



Real-Time Navigation/Targeting Requirements

1) **Absolute Position Error Tolerance:**
   a) Maximum Aircraft lateral (cross track) position error ±1 km at mid-eclipse, contact II, and contact III.
   b) Maximum Aircraft vertical position error ± 100 meters.

2) **Absolute Timing Error Tolerance:** ± 6s in time w.r.t. U.T. predictions* at CII and CIII.

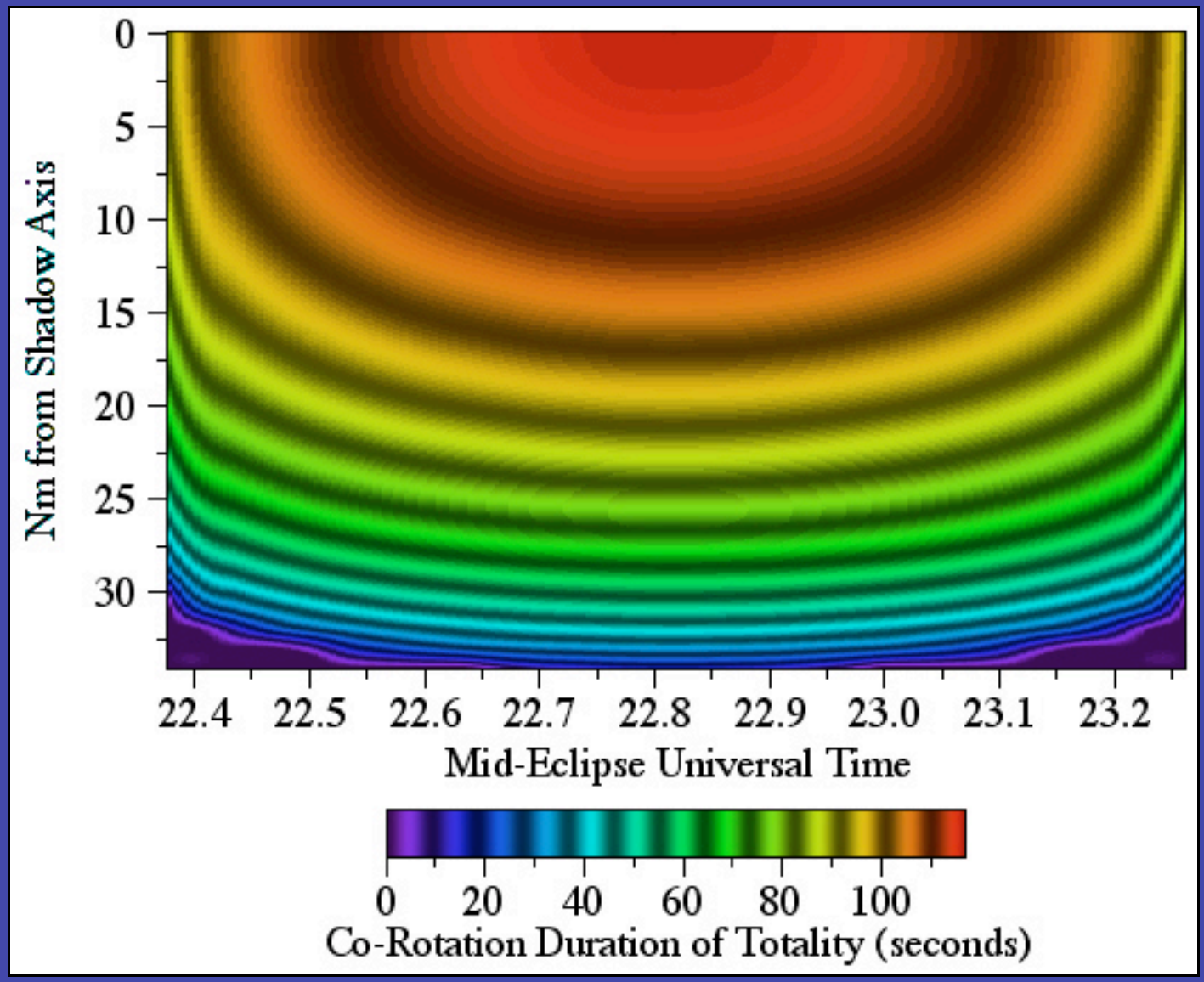
3) **Heading Constraint on Portside Orthogonality:**
   a) Absolute: ± 1.5° from mid-eclipse ± 5 minutes.
   b) Differential: ± 0.5° from mid-eclipse ± 5 minutes.

4) **CDU/FMS Way Point Input Updates During Totality Run:**
   a) Precluded ± 2 minutes of mid-eclipse, except mid-eclipse update.
   b) Avoided if possible within 5 minutes of mid-eclipse.
   c) Desired Granularity: 5 minute intervals at relative mid-eclipse times of -15, -10, -5, (0), +5 minutes.

5) **Aircraft Altitude:** Max possible altitude for min LOS air-mass to Sun.

* Exclusive of delta-T correction based upon pre-eclipse IERS updates.

Desire for Longest Duration

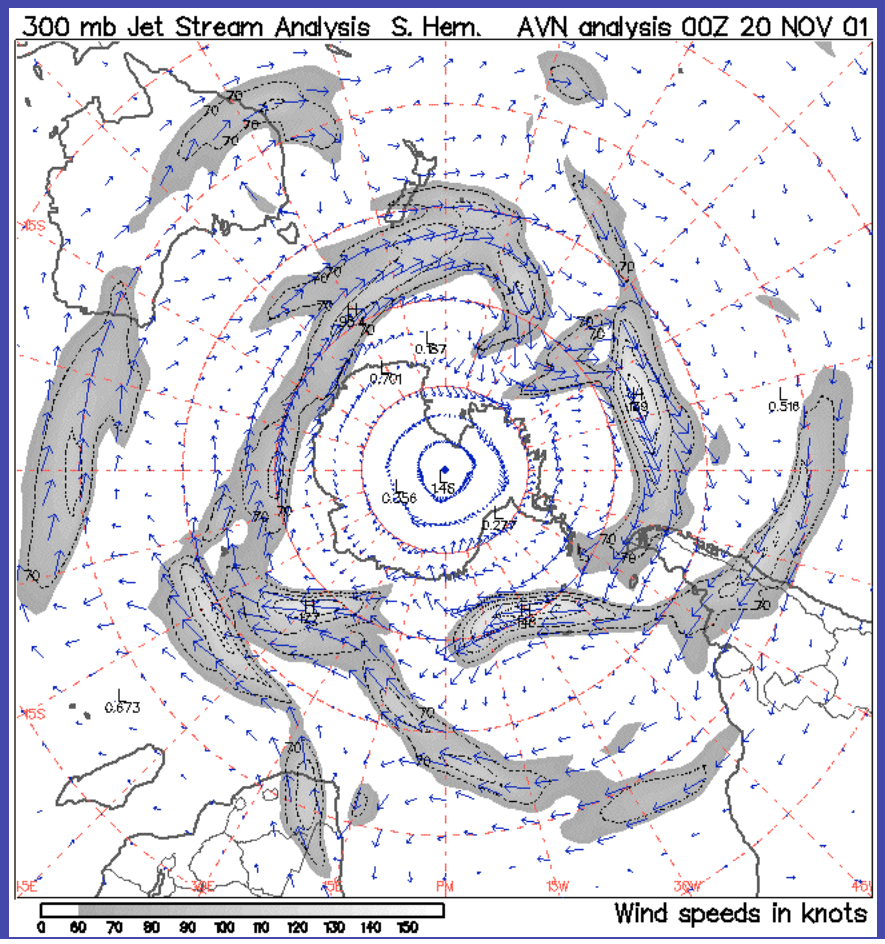


But Subject To…

PRIMARY FLIGHT DEFINITION VARIABLES, CONSTRAINTS & RESTRICTIONS

A) ATMOSPHERICS: METEROROGICAL CONDITIONS

- Local obscuration by cloud (ground station & remote sensing): monolithic and multi-layer along the line-of-sight to the Sun.
- Wind speed and direction: vector gradients.
- Atmospheric turbidity along line-of-sight to the Sun.
- Flight-level turbulence: (platform stability).

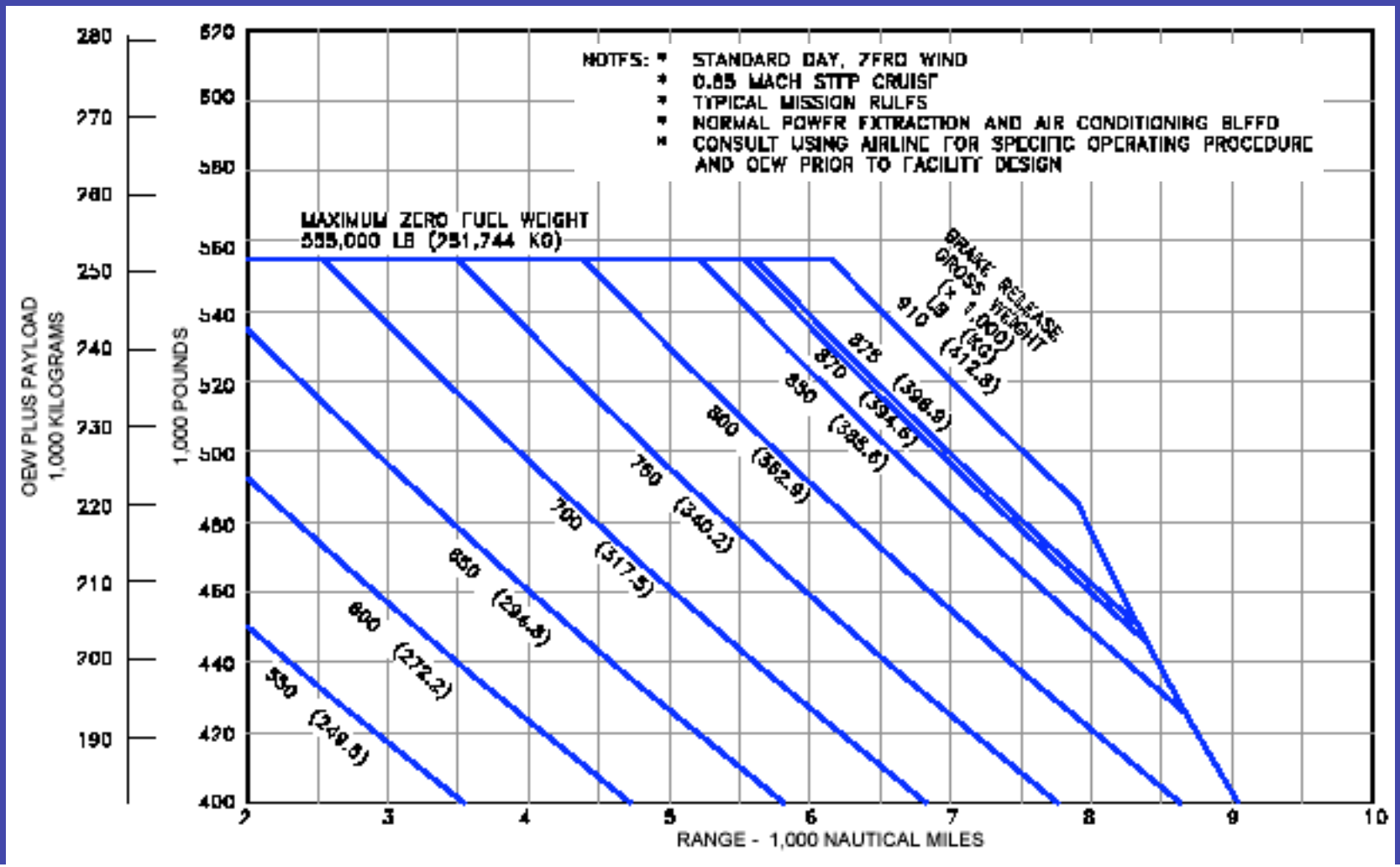


Play movie: wind_pattern.mov

PRIMARY FLIGHT DEFINITION VARIABLES, CONSTRAINTS & RESTRICTIONS

B) AIRCRAFT PERFORMCE & OPERATIONAL CONSIDERATIONS

- Maximum range for gross weight at eclipse intercept.



PRIMARY FLIGHT DEFINITION VARIABLES, CONSTRAINTS & RESTRICTIONS

B) AIRCRAFT PERFORMCE & OPERATIONAL CONSIDERATIONS

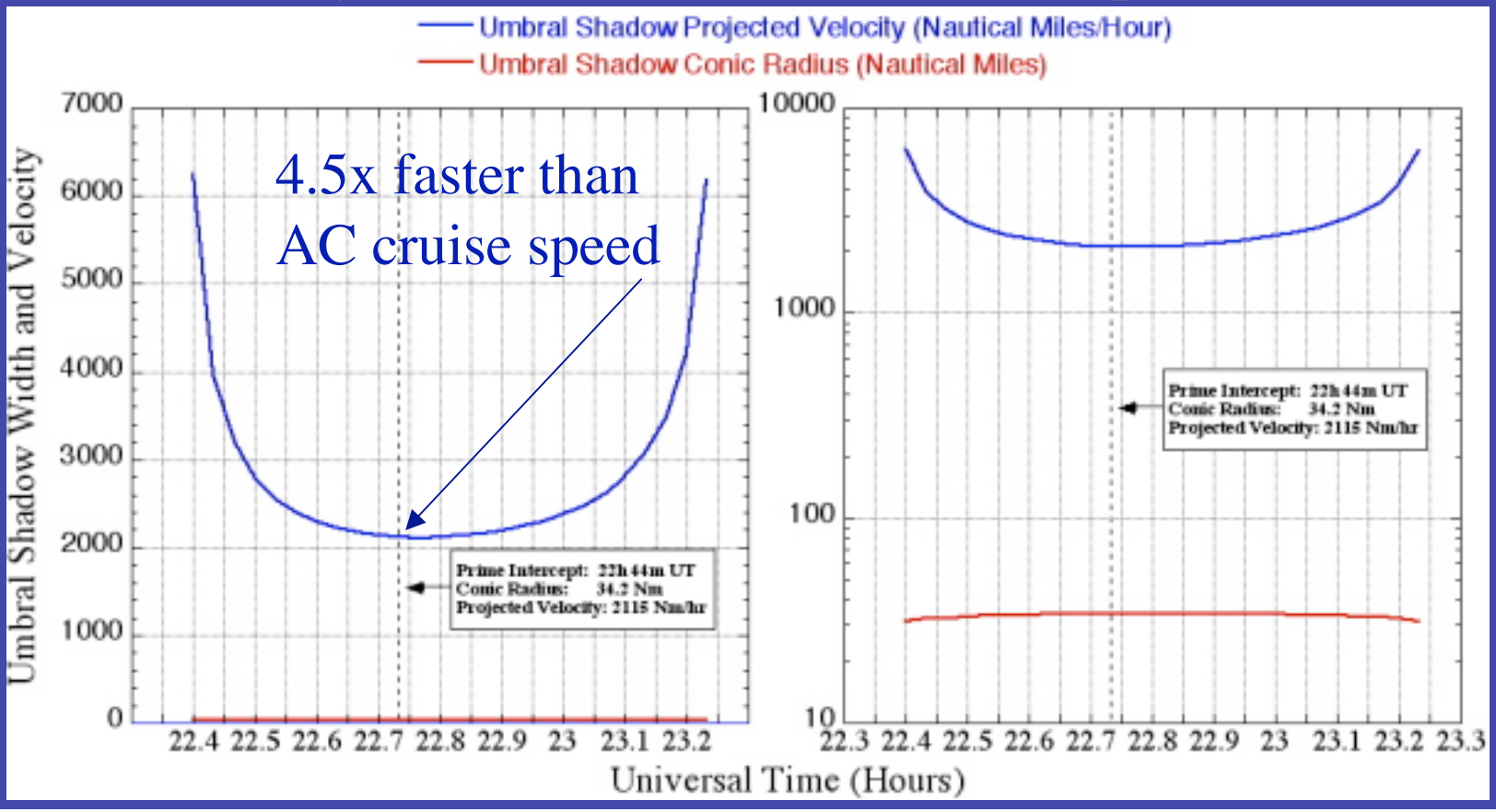
- Maximum range for gross weight at eclipse intercept.
- Maximum service ceiling for gross weight at eclipse intercept.
- Nominal/Maximum Cruise Speed.
- Take-off or In-flight delay.

PRIMARY FLIGHT DEFINITION VARIABLES, CONSTRAINTS & RESTRICTIONS

C) ASTRO-DYNAMICS:

TIME/POSITION DEPENDENT FUNDEMENTAL GEOMETRY

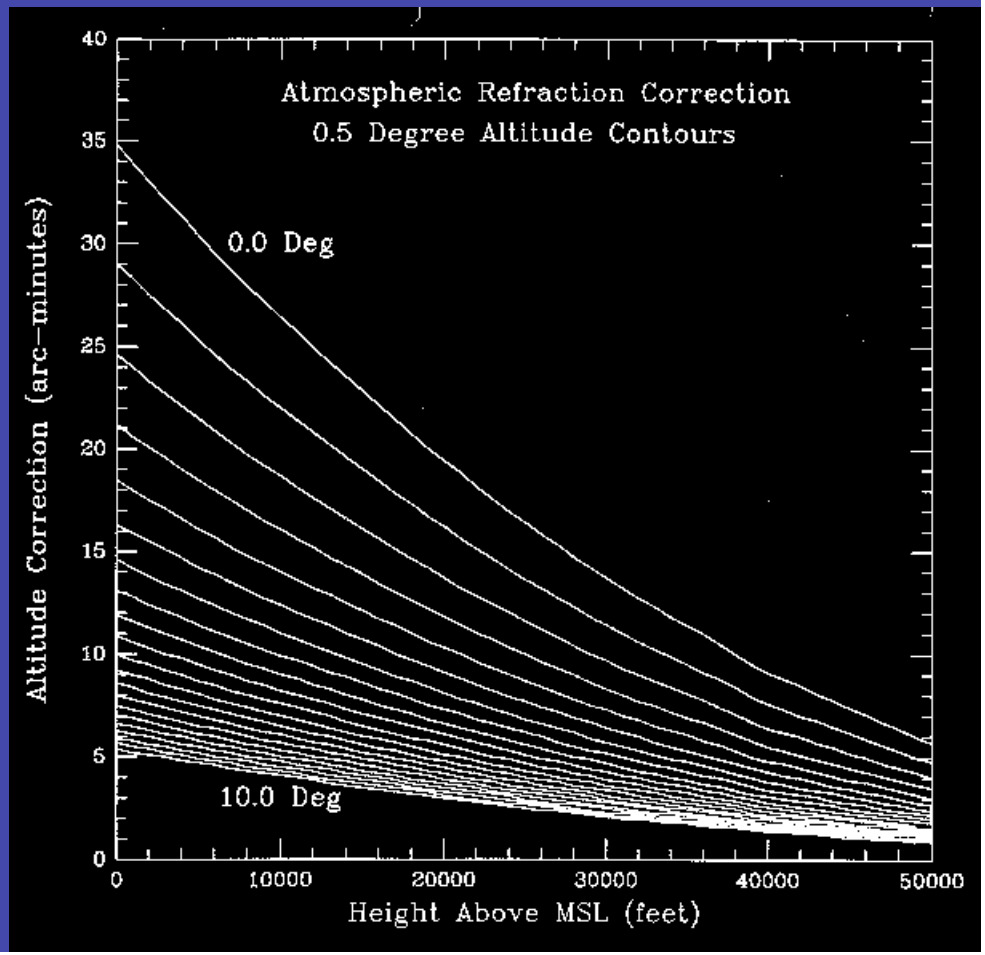
- Non-linear motions (absolute & relative) of Earth, Moon, and Sun.
- Shadow Velocity and instantaneous acceleration profile.



PRIMARY FLIGHT DEFINITION VARIABLES, CONSTRAINTS & RESTRICTIONS

C) ASTRO-DYNAMICS:
TIME/POSITION DEPENDENT FUNDEMENTAL GEOMETRY

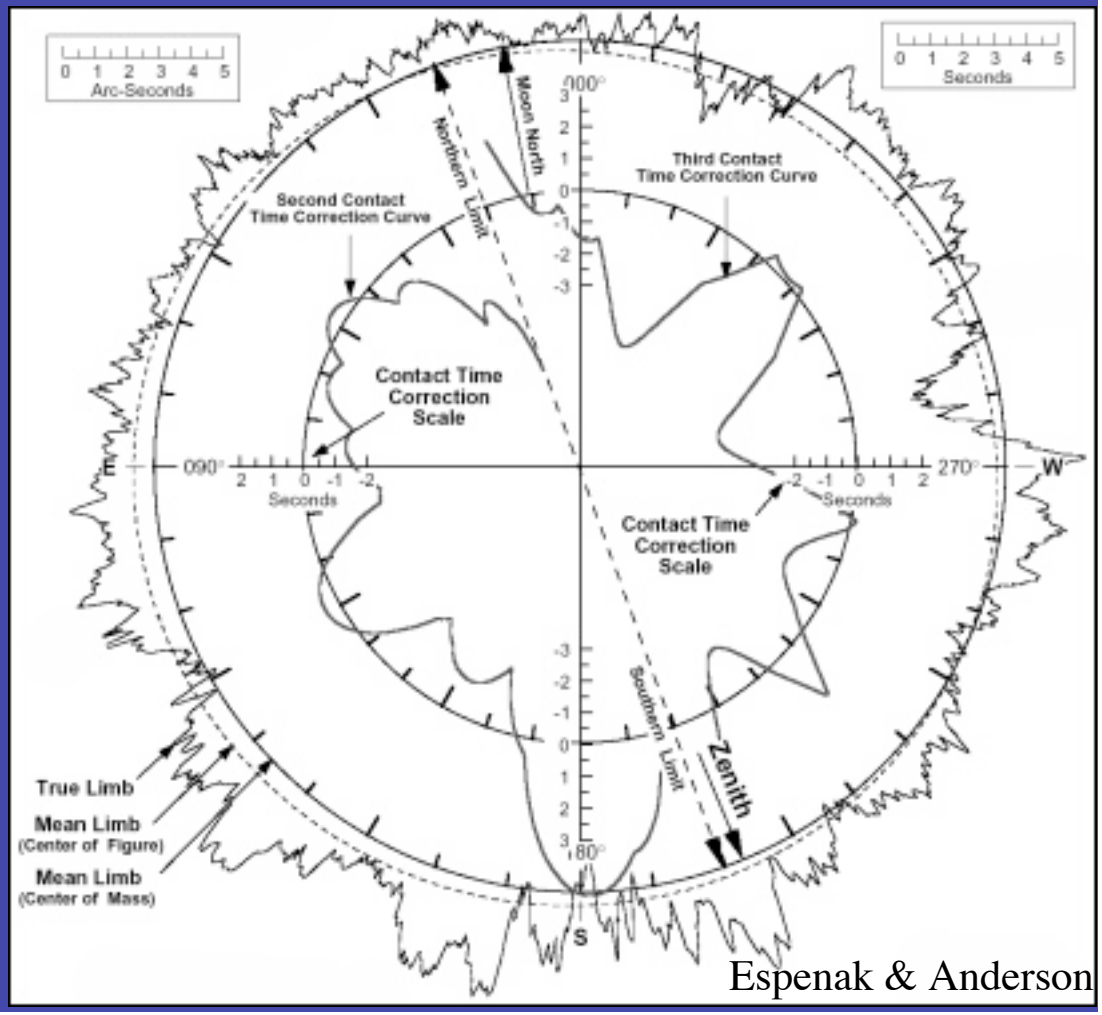
- Shadow axis (X,Y, Z) position loci as functions of altitude above geoidal surface, differentially corrected through atmospheric refraction models based upon Temperature/Pressure scale-height profiles.



PRIMARY FLIGHT DEFINITION VARIABLES, CONSTRAINTS & RESTRICTIONS

C) ASTRO-DYNAMICS: TIME/POSITION DEPENDENT FUNDEMENTAL GEOMETRY

- Shadow boundary loci as a functions topocentric lunar limb profile and atmospheric refraction corrections.
- Conic shadow projection on the elevated oblate geoidal surface.



Espenak & Anderson

Baseline Intercept Plan

U.T. Mid-Eclipse Intercept: 22:44:00
Flight Altitude: 35000ft
Heading: 198.80°
Air Speed*: 470.0nm/h
*Wind: 0.0 knots @ 0.0°

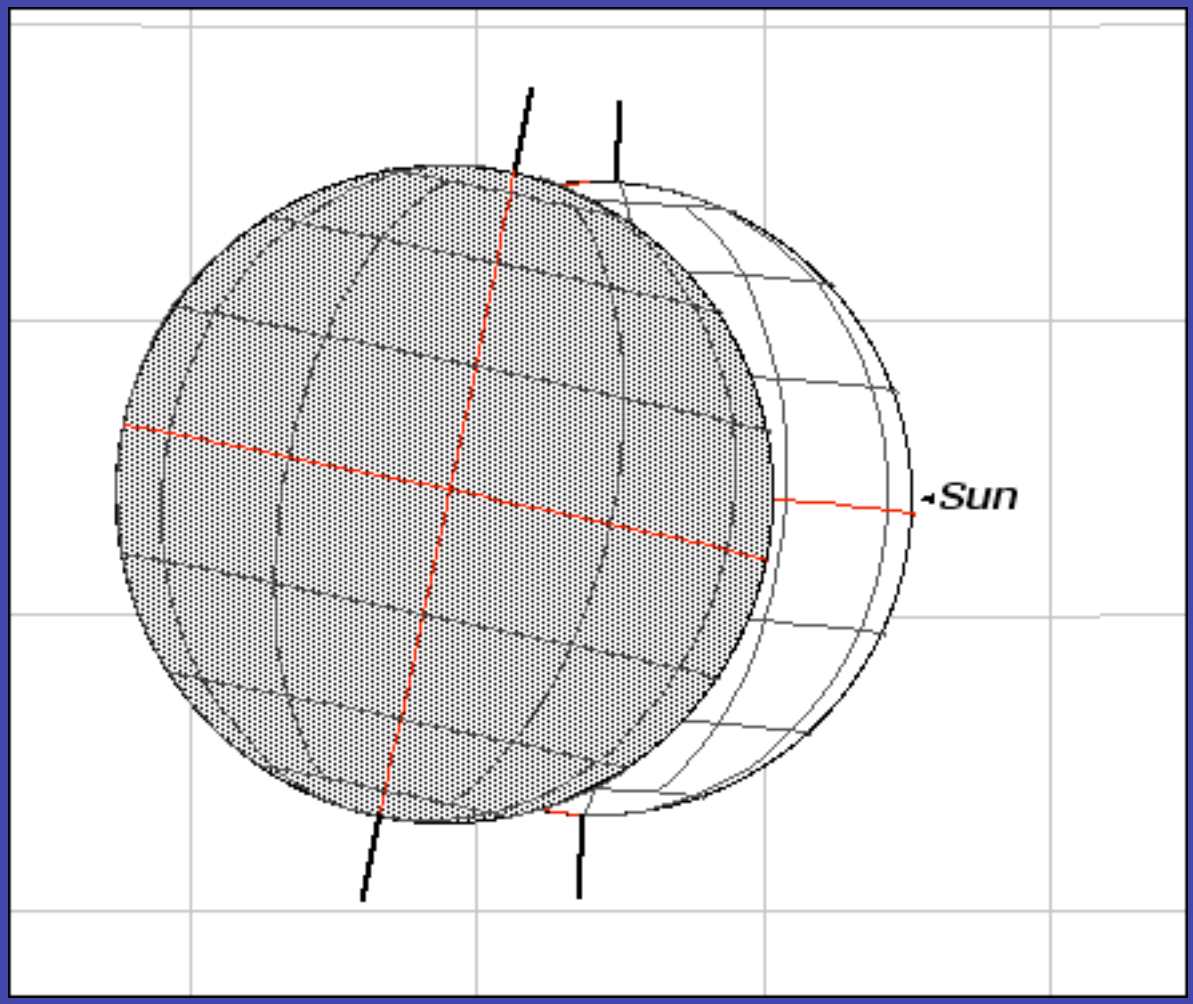
CENTERLINE RUN START: 22:29:00 UT
LATITUDE = -68° 07.1' S
LONGITUDE = +94° 42.0' E

MID-ECLIPSE INTERCEPT: 22:44:00 UT
LATITUDE = -69° 58.7' S
LONGITUDE = +93° 00.7' E

CENTERLINE RUN END: 22:49:00 UT
LATITUDE = -70° 35.7' S
LONGITUDE = +92° 24.9' E

Totality Run: ENTRY @ 22:29 UT

Lat = 68° 07.10'S, Lon = 94° 42.03'E

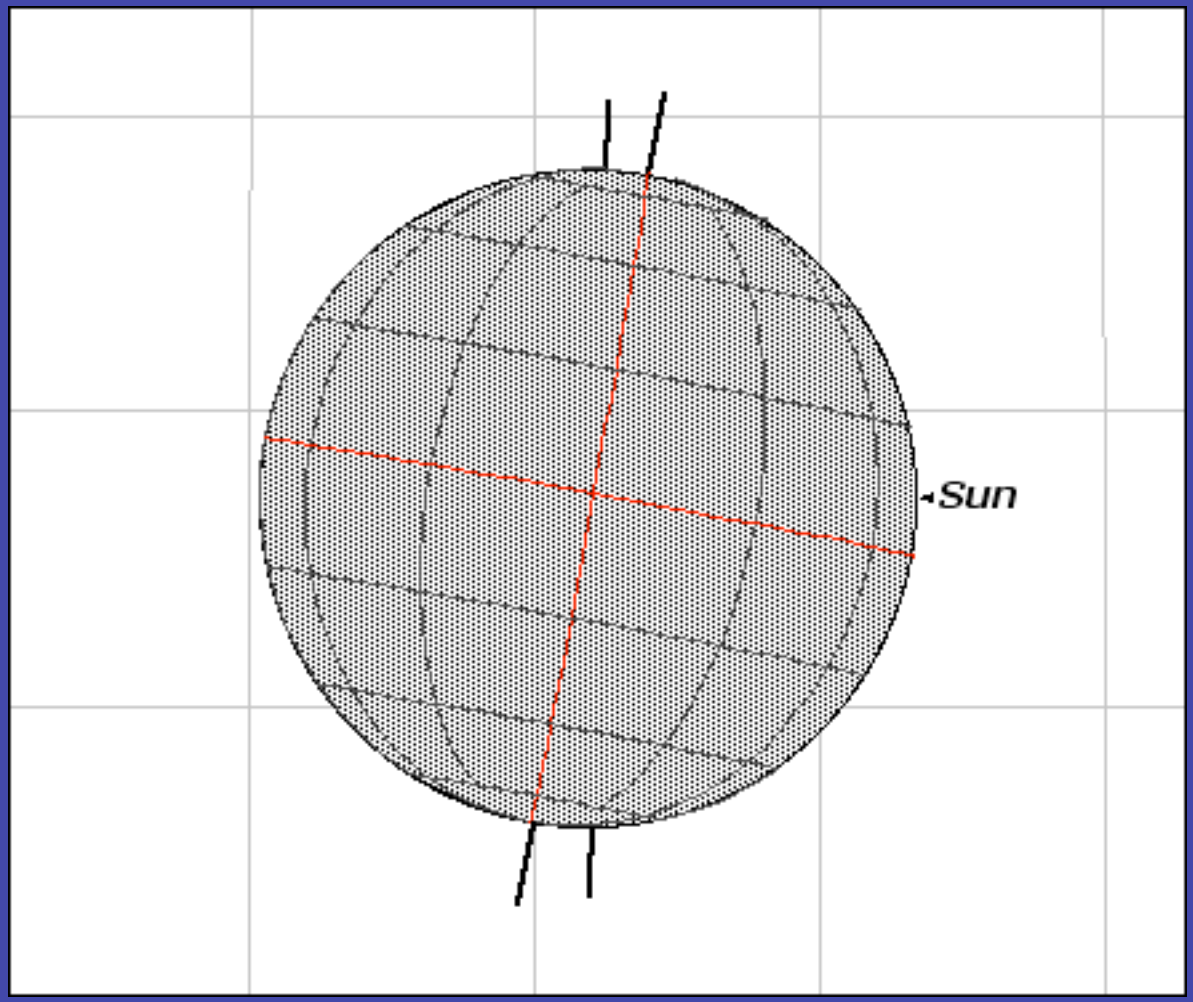


Altitude* = 14.6°, Azimuth = 108.5°

*astronomical horizon

Totality Run: MID-ECLIPSE @ 22:44 UT

Lat = 69° 58.66'S, Lon = 93° 00.61'E

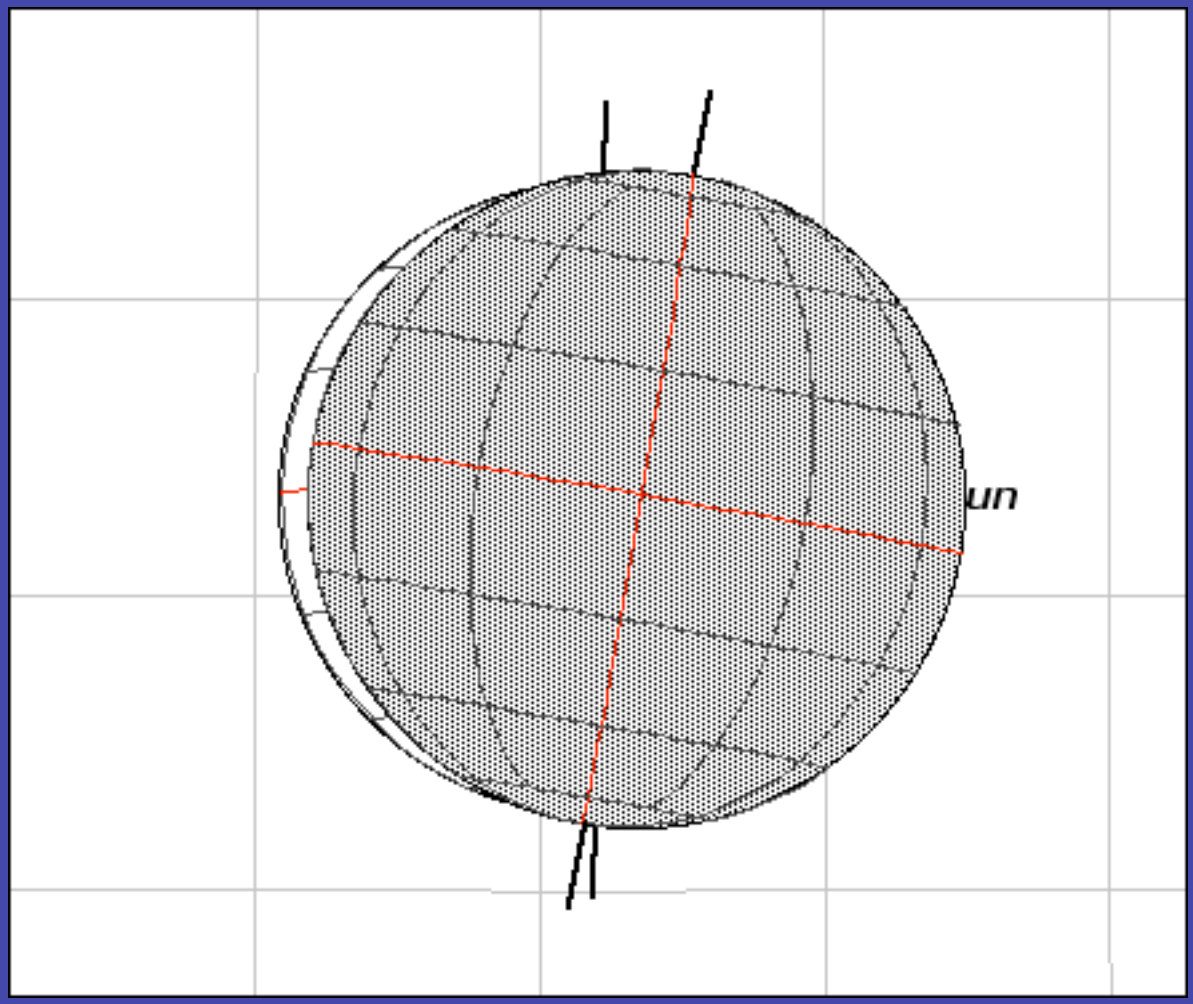


Altitude* = 14.9°, Azimuth = 108.8°

*astronomical horizon

Totality Run: EXIT @ 22:49 UT

Lat = 70° 35.73’S, Lon = 92° 24.86’E



Altitude* = 15.0°, Azimuth = 108.9°

*astronomical horizon

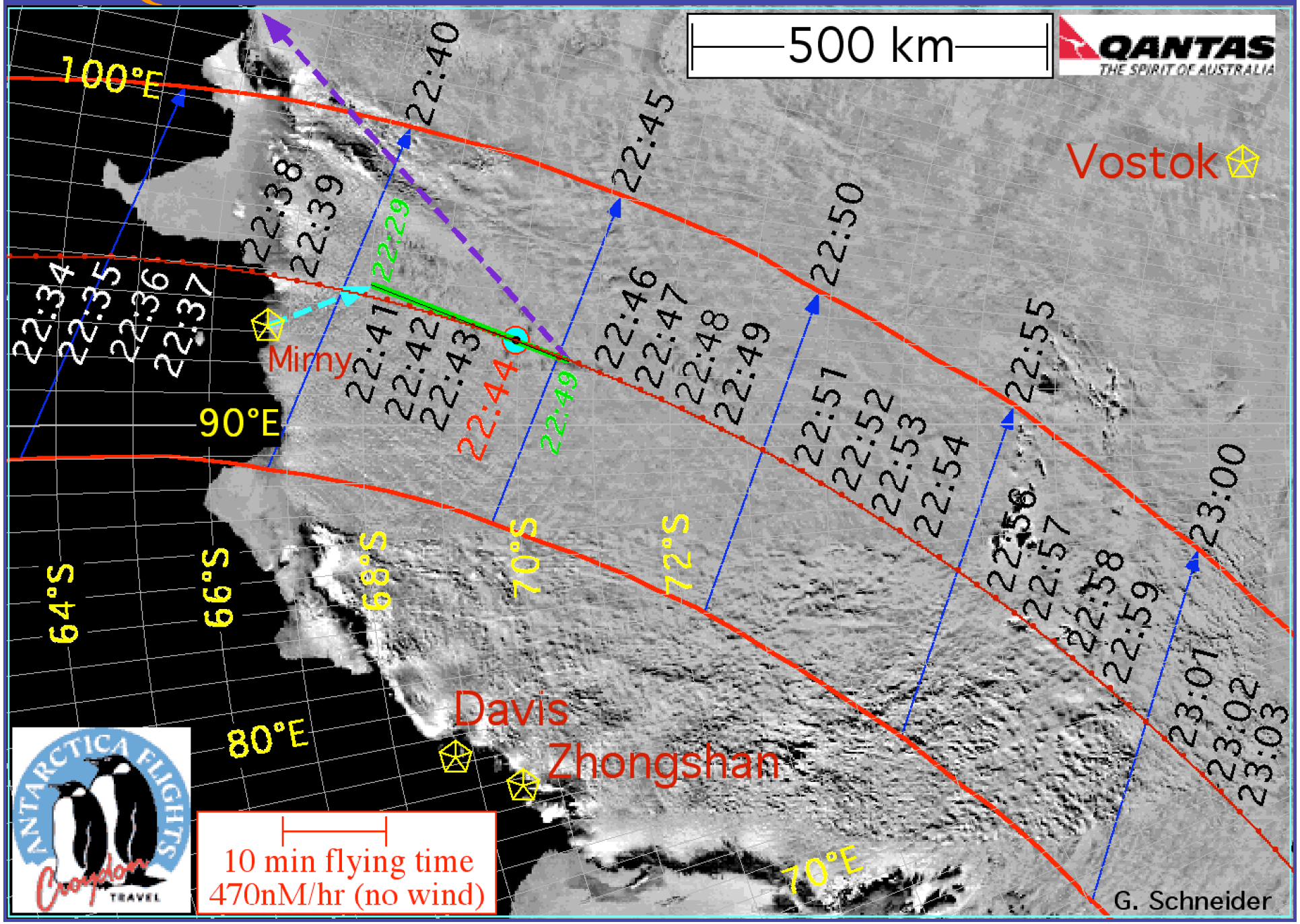
Baseline Intercept Plan

SECOND CONTACT = 22:42:42.7 UT (START OF TOTALITY)
AIRCRAFT LATITUDE = -069° 49' 09.4''
AIRCRAFT LONGITUDE = +093° 09' 59.0''
Solar Altitude = +14.8° Solar Azimuth = 109.0°
Position Angle of Contact = 109.3°

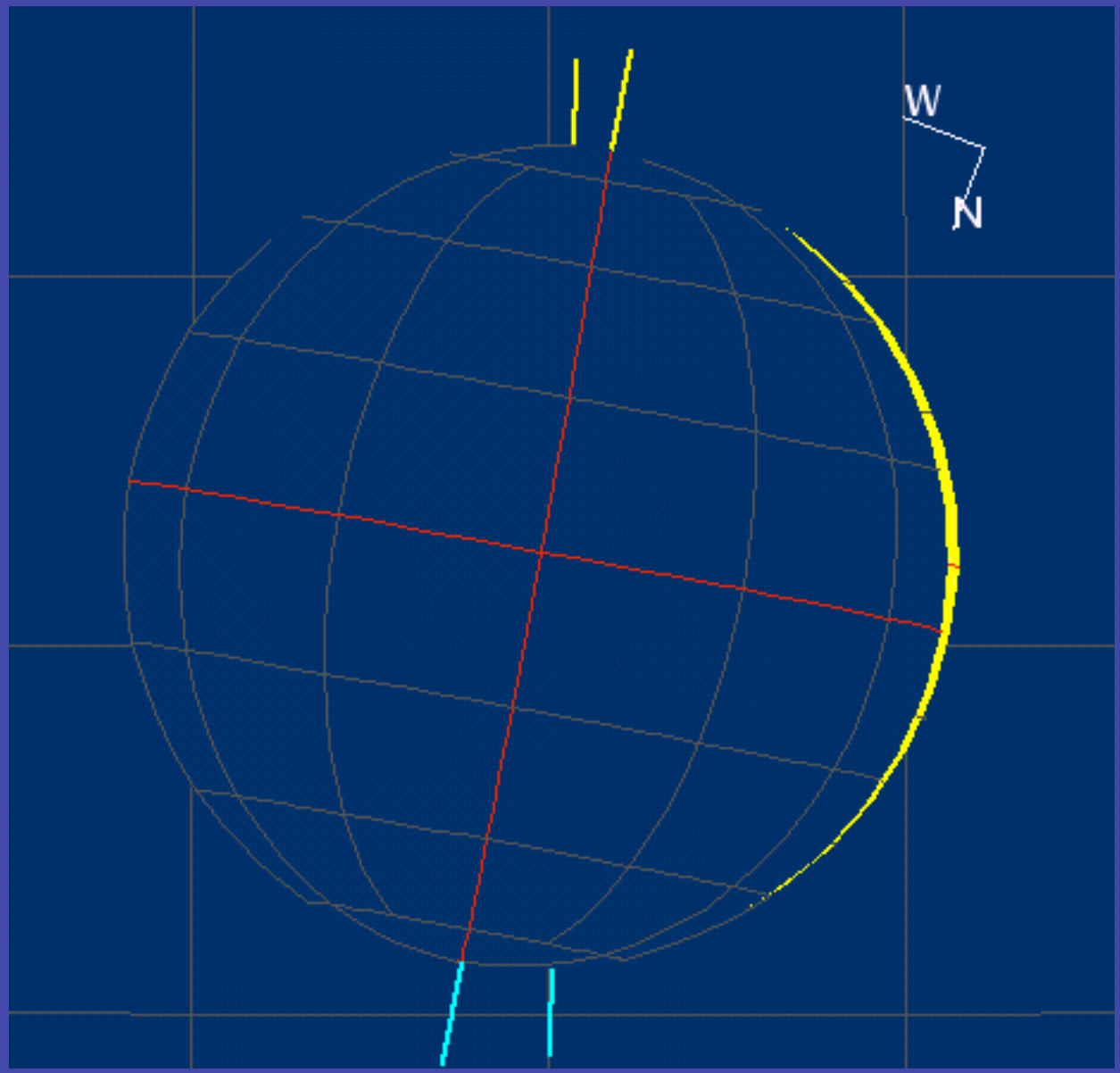
MID-ECLIPSE INTERCEPT = 22:44:00
AIRCRAFT LATITUDE = -69° 58' 39.8"S
AIRCRAFT LONGITUDE = +93° 00' 36.5"E
TOTALITY DURATION = 2m 34.7s
Solar Altitude = +14.9° Solar Azimuth = 108.8°

THIRD CONTACT = 22:45:17.4 UT (END OF TOTALITY)
AIRCRAFT LATITUDE = -070° 08' 17.2''
AIRCRAFT LONGITUDE = +092° 51' 06.8''
Solar Altitude = +15.0° Solar Azimuth = 108.6°
Position Angle of Contact = 289.7°

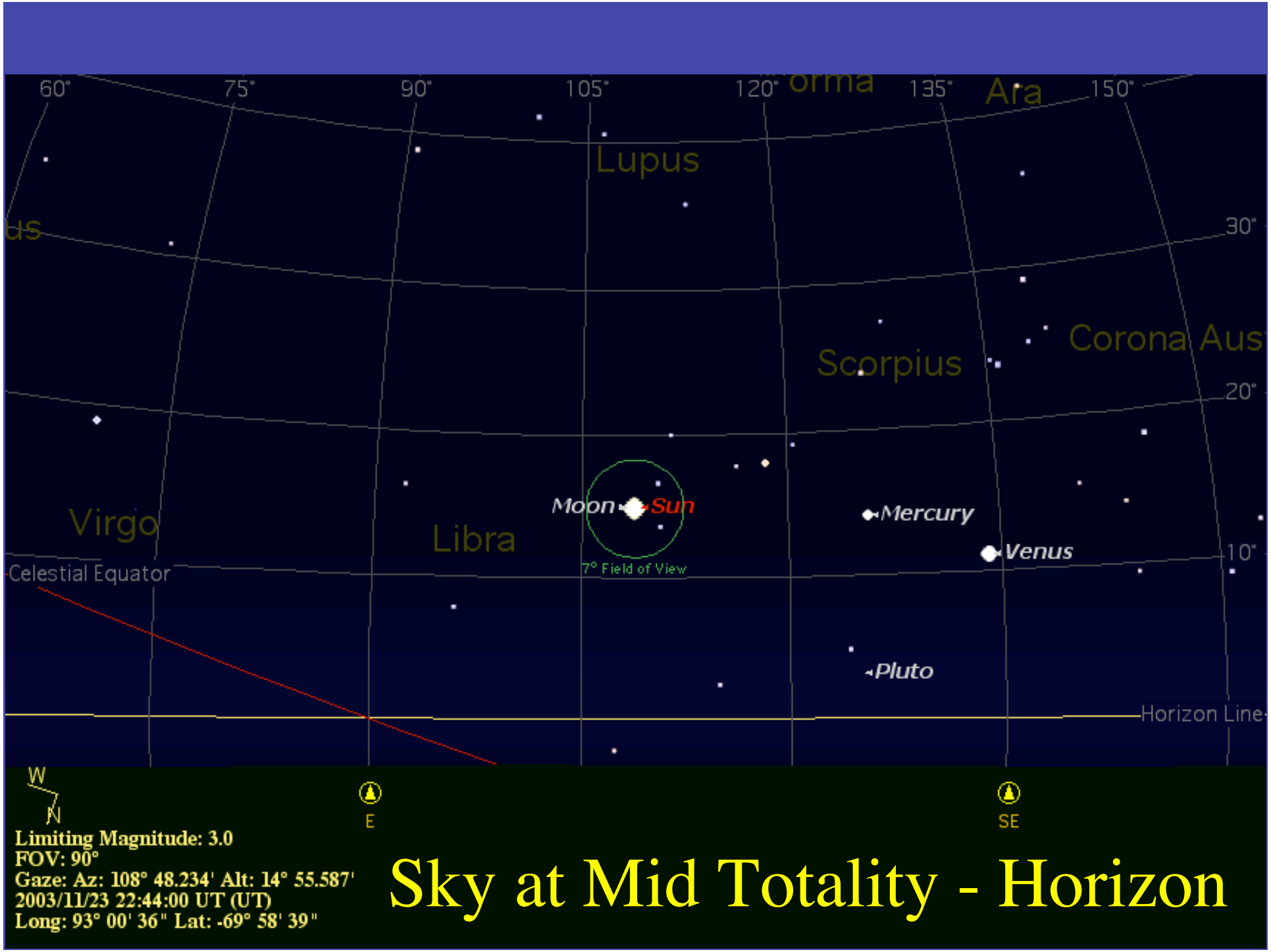
QF 2901 - 22:44 UT UMBRAL INTERCEPT



Contacts ± 1 Minute: Horizon Orientation



Play movie: CONTACTS.mov



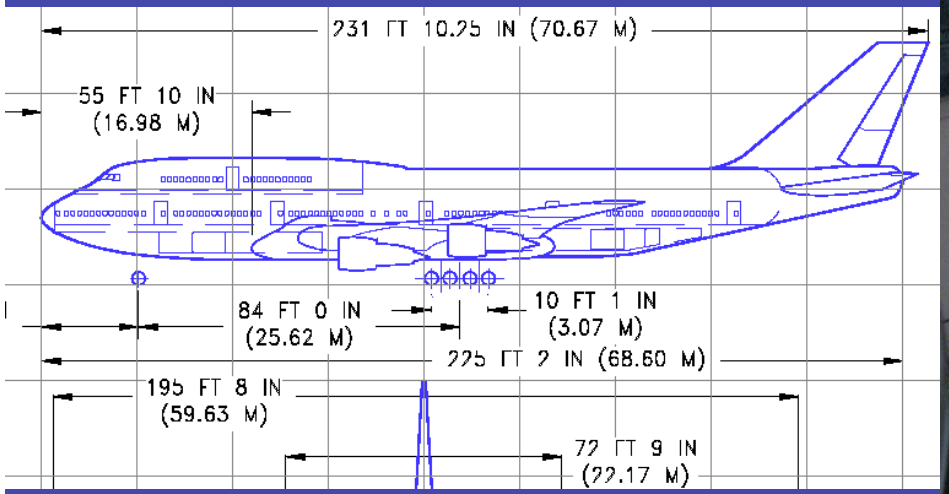
Sky at Mid Totality - Horizon

EFLIGHT 2003 X (MacOS X)

Eclipse Circumstance Calculator and Aircraft Navigation Aide

Specifically designed to address the problem optimally intercepting the moon's shadow from a moving aircraft.

Fully compliant with I/O and interface requirements of aircraft CU/FMS systems



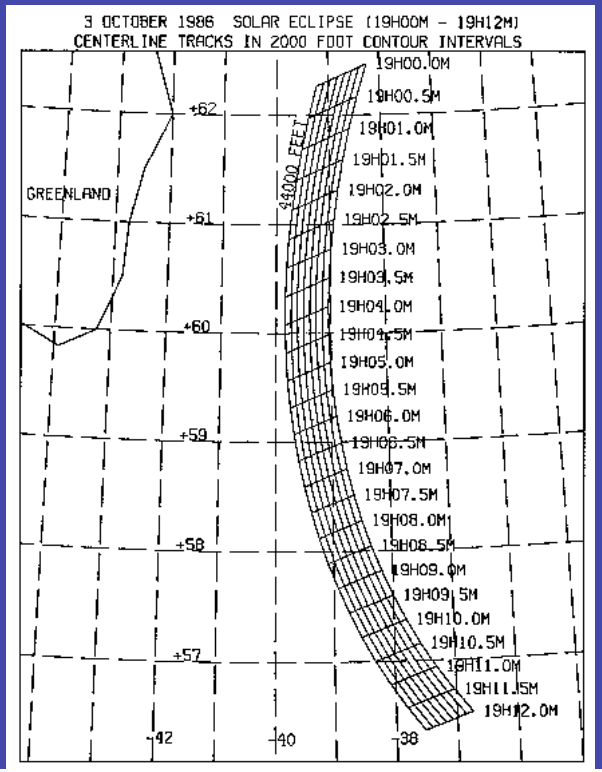
EFLIGHT 2003 X (MacOS X)

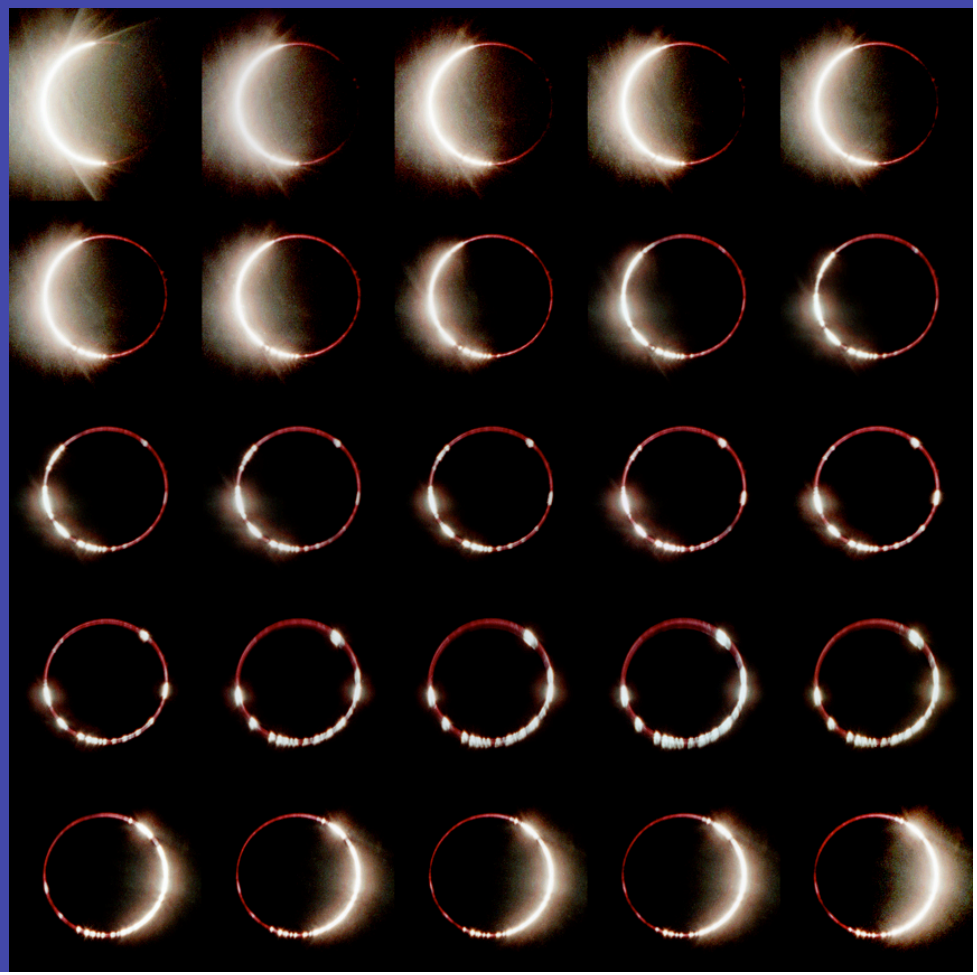
Eclipse Circumstance Calculator and Aircraft Navigation Aide

Specifically designed to address the problem optimally intercepting the moon's shadow from a moving aircraft.

PEDIGREE:

- 03 October 1986 Eclipse Flight





EFLIGHT 2003 X (MacOS X)

Eclipse Circumstance Calculator and Aircraft Navigation Aide

Specifically designed to address the problem optimally intercepting the moon's shadow from a moving aircraft.

PEDIGREE:

- 30 June 1992 DC-10 Eclipse Flight

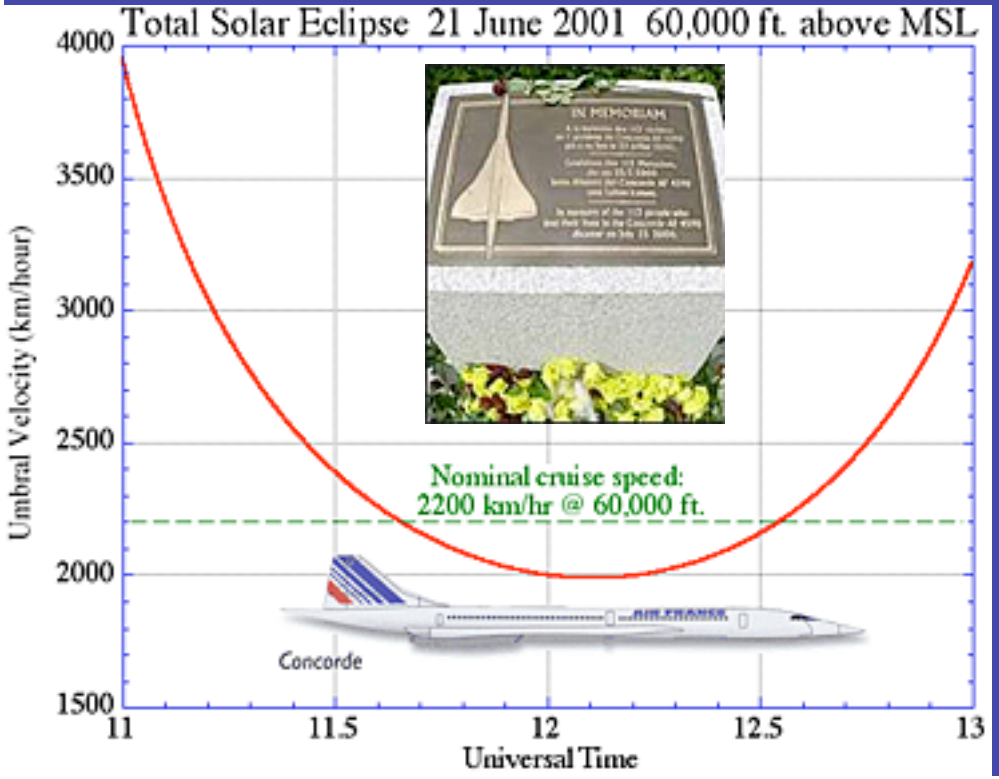
EFLIGHT 2003 X (MacOS X)

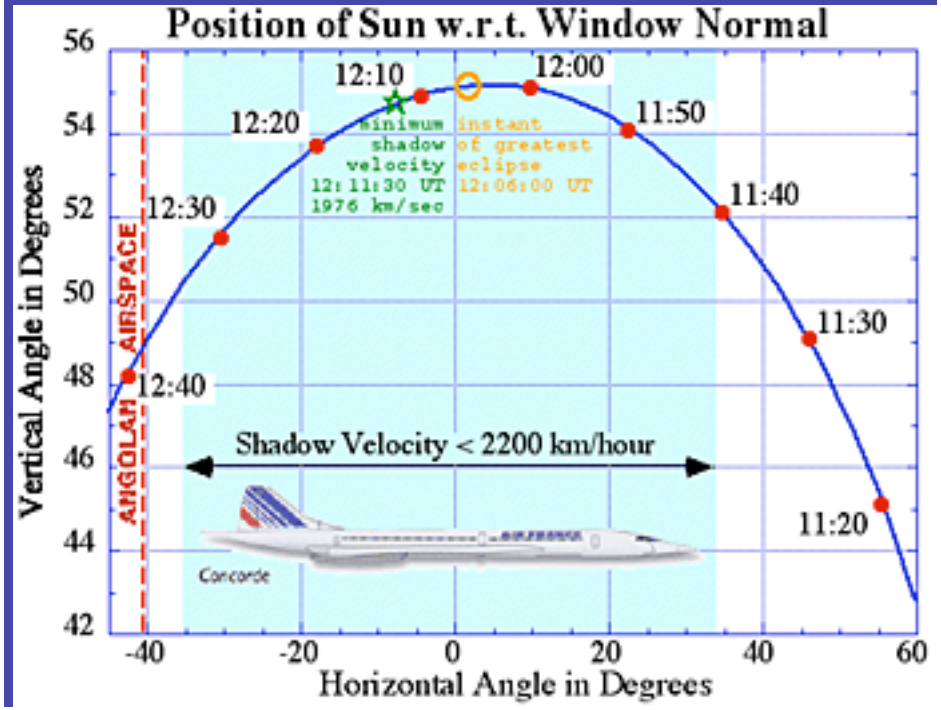
Eclipse Circumstance Calculator and Aircraft Navigation Aide

Specifically designed to address the problem optimally intercepting the moon's shadow from a moving aircraft.

PEDIGREE:

- 21 June 2001 Planned *1 Hour Totality* With Ill-Fated AF Concorde



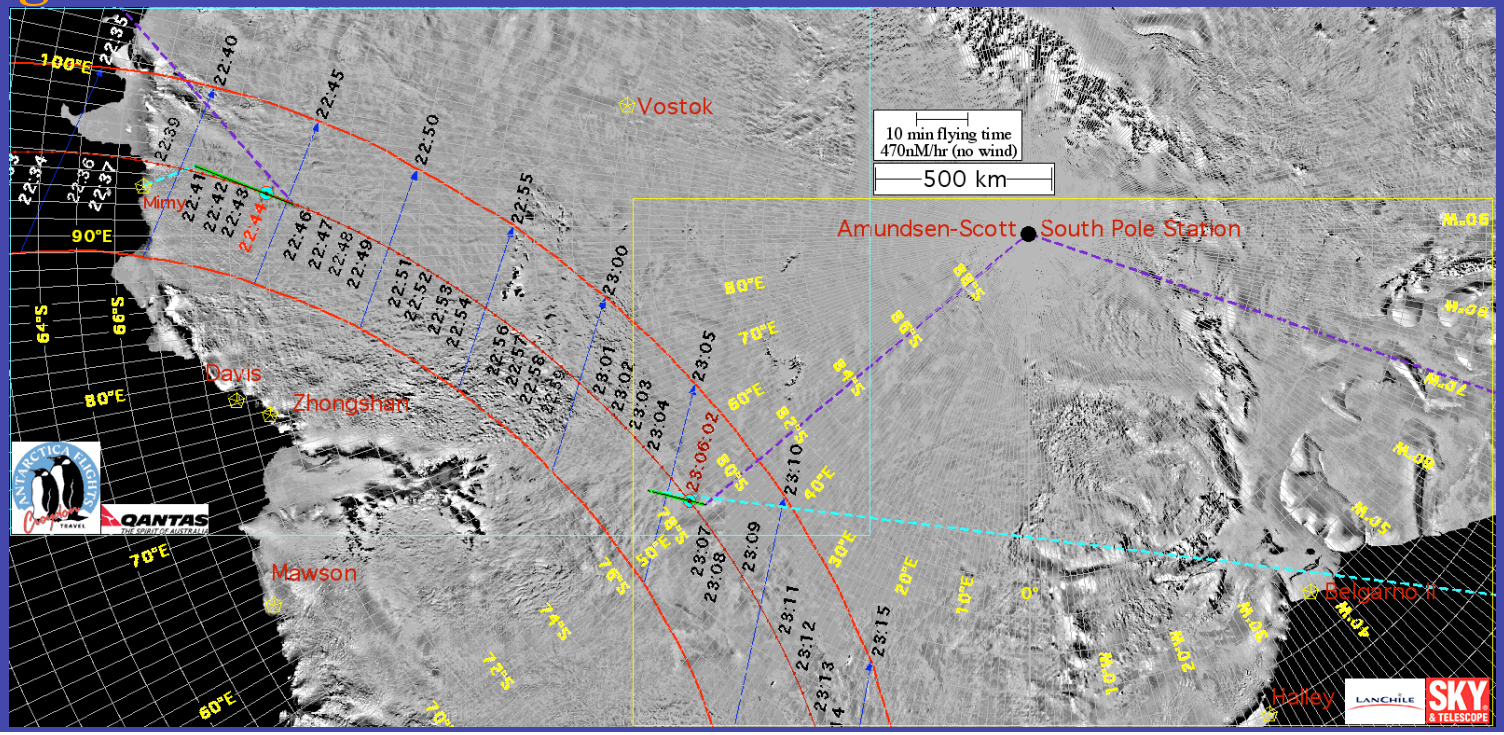


EFLIGHT 2003 X (MacOS X)

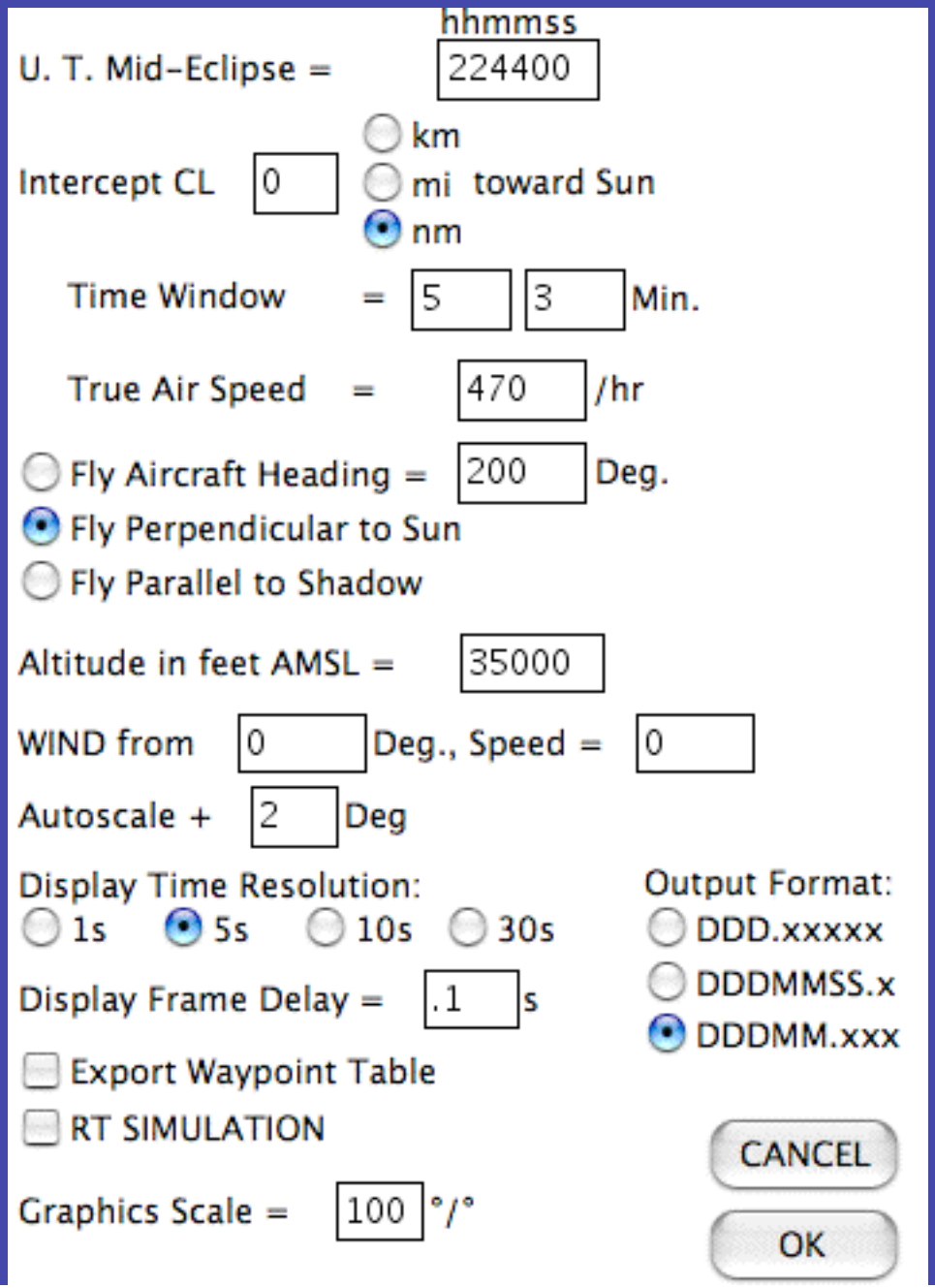
Eclipse Circumstance Calculator and Aircraft Navigation Aide

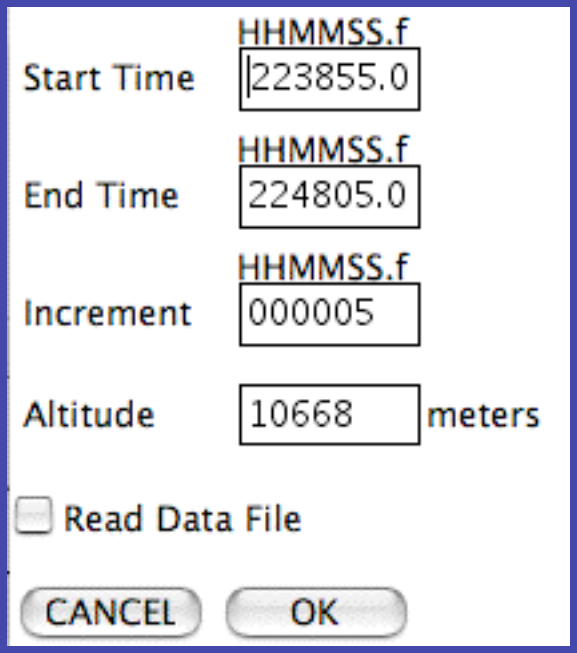
Specifically designed to address the problem optimally intercepting the moon's shadow from a moving aircraft.

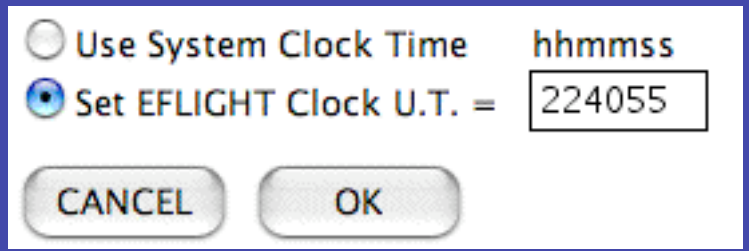
23 November 2003 - ANTARCTICA:
Planning and Real-Time Navigation Croydon/QANTAS QF 2901
Planning S&T/Lan Chile LC 8001



EFLIGHT Parametric Inputs







EFLIGHT Tabular Output

Co-Moving "Local Circumstances" from Moving Aircraft

EFLIGHT03:TABULATE TOTALITY RUN

```
U.T. Intercept:   22:44:00 | TOTALITY DURATION = 2m 34.7s
Flight Altitude:   35000ft |
Heading:            198.80° | Cnt  hh:mm:ss.f  Alt° Az°   P°      Cnt  hh:mm:ss.f  Alt° Az°   P°
Air Speed:       470.0nm/h | 2ND  22:42:43.1 +14.8 109.0 109.3  3RD  22:45:17.8 +15.0 108.6 289.7
Wind Speed:        0.0nm/h | LATITUDE:  -069° 49' 24.2''         LATITUDE:  -070° 08' 32.0''
Wind Direction:      0.0° | LONGITUDE: +093° 09' 44.5''         LONGITUDE: +092° 50' 52.3''
```

HHMMSS	UMbra Long	UMbra Lat	WidKM	Uaz°	Ual°	AirCr Long	AirCr Lat	MidΔT	MidΔD	LOS	Bearng	ACaz	ACal
223200	9422.514E	6239.618S	535.1	111.9	11.8	9423.086E	6829.493S	-720s	-94.0nm	+0.3	197.52	108.5	14.7
223205	9423.657E	6243.010S	534.8	111.8	11.8	9422.551E	6830.114S	-715s	-93.3nm	+0.3	197.52	108.5	14.7
223210	9424.773E	6246.395S	534.6	111.8	11.8	9422.015E	6830.736S	-710s	-92.7nm	+0.3	197.53	108.5	14.7
223215	9425.863E	6249.772S	534.4	111.7	11.9	9421.479E	6831.357S	-705s	-92.0nm	+0.3	197.54	108.5	14.7
223220	9426.927E	6253.143S	534.2	111.7	11.9	9420.942E	6831.978S	-700s	-91.4nm	+0.3	197.55	108.5	14.7
223225	9427.964E	6256.506S	533.9	111.7	12.0	9420.405E	6832.599S	-695s	-90.7nm	+0.3	197.56	108.5	14.7

KB: Non-APL

Time Correlated Aircraft Track, Centerline, and Umbra Intercept Data

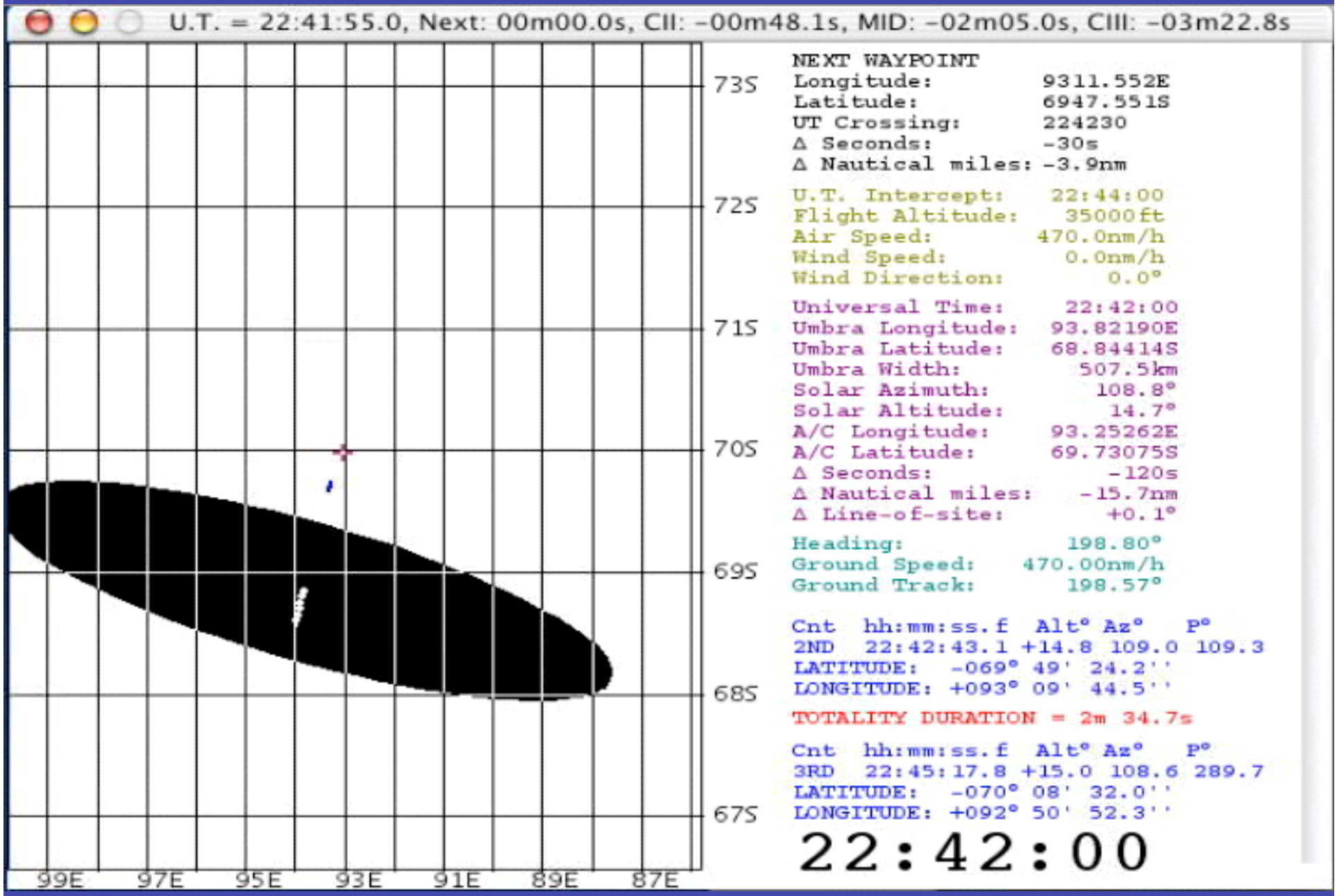
Selected WAYPOINTS

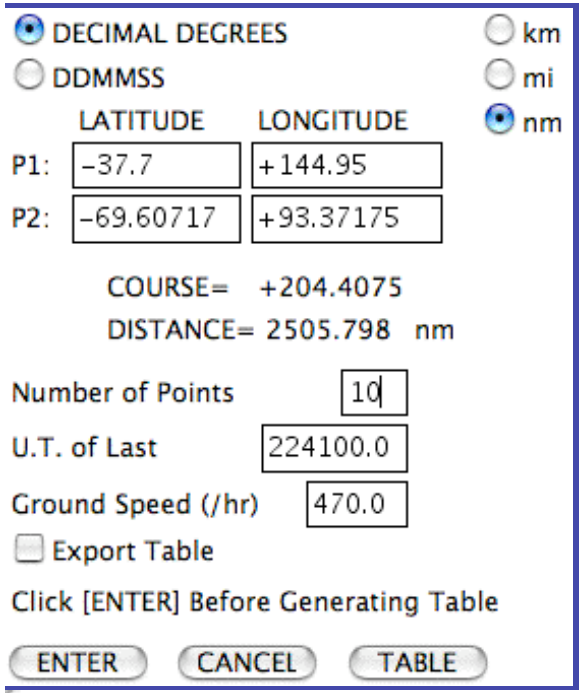
≠	HHMMSS	UMbra Long	UMbra Lat	WidKM	Uaz°	Ual°	AirCr Long	AirCr Lat	MidΔT	MidΔD	LOS	Bearng	ACaz	ACal
A	223200	9422.514E	6239.618S	535.1	111.9	11.8	9423.086E	6829.493S	-720s	-94.0nm	+0.3	197.52	108.5	14.7
B	223600	9449.442E	6515.523S	523.8	110.1	13.3	9356.833E	6859.287S	-480s	-62.7nm	+0.2	197.92	108.6	14.8
C	224000	9422.996E	6740.906S	512.7	109.0	14.3	9329.370E	6929.011S	-240s	-31.3nm	+0.1	198.35	108.7	14.9
D	224400	9300.609E	6958.660S	502.7	108.8	14.9	9300.609E	6958.663S	+0s	+0.0nm	-0.0	198.88	108.8	14.9
E	224800	9030.598E	7209.511S	494.5	109.6	15.2	9231.848E	7028.309S	+240s	+31.3nm	-0.1	197.54	108.9	15.0

FMS INPUT

"READ-BACK"

EFLIGHT Dynamic Display





EFLIGHT
Pre/Post "Totality Run" Approach/Recession Tracks and Penumbra Crossings

Great Circle Track and Penumbra Crossing: 22:41:00

Mid-Eclipse Intercept: 224400 U.T., Totality Run Start at -3 minutes

U.T. Start = 171938.5 Course = +204.1381° Ground Speed = 470.0nm/hr
U.T. End = 224100.0 Distance = 2517.302nm Number of Segments = 10

1ST Contact = 21:43:18 4TH Contact = xxxxxx.x

HHMMSS	Latitude	Longitude	Latitude	Longitude	Course	NEXTnm	TOTALnm	Elapsed	Remaining
171938.5	37 42.0S	144 57.0E	37.7000S	144.9500E	204.14	249.52		000000.0	052121.5
175129.8	41 32.4S	142 53.3E	41.5402S	142.8889E	205.67	249.15	249.52	003151.2	044930.2
182318.1	45 20.5S	140 35.7E	45.3422S	140.5944E	207.54	248.68	498.67	010339.6	041741.9
185502.9	49 05.7S	138 00.0W	49.0952S	138.0006E	209.86	248.07	747.35	013524.4	034557.1
192643.0	52 47.0S	135 01.1E	52.7837S	135.0184E	212.78	247.27	995.42	020704.5	031417.0
195817.0	56 23.2S	131 31.4E	56.3862S	131.5239E	216.52	246.25	1242.69	023838.5	024243.0
202943.2	59 52.2S	127 20.4E	59.8704S	127.3397E	221.44	245.04	1488.94	031004.7	021116.8
210100.1	63 11.1S	122 12.1E	63.1857S	122.2015E	228.17	243.93	1733.98	034121.6	013959.9
213208.5	66 14.7S	115 41.7E	66.2455S	115.6952E	238.05	244.23	1977.92	041230.0	010851.5
220319.2	68 52.8S	107 06.3E	68.8797S	107.1058E	255.11	227.77	2222.14	044340.7	003740.8
223223.8	70 37.0S	94 48.5E	70.6162S	094.8086E	255.11	67.39	2449.91	051245.3	000836.2
224100.0	69 36.4S	93 22.3E	69.6072S	093.3718E			2517.30	052121.5	000000.0

KB: Non-APL

B747-400 Flight Deck Work Space

Forward View from the Navigator (Second “Observer”) Seat

18 Dec 2002 Flight Deck Familiarization - Cpt J. Black

B747-400 Flight Deck Work Space

THE WINDOW

B747-400 Flight Deck Work Space

The Floor

Pilot Seat Forward

Flight Deck Eclipse Imaging Program

FOUR CAMERAS ON COMMON GYRO STABILIZED PLATFORM

KENYON KS-8 DUAL GYRO STABILIZER

AUTONOMOUS (Computer Controlled) IMAGE ACQUISITION

UMBRAPHILE (Film), MaximDL (CCD), iMovie (Video)

Flight Deck Eclipse Imaging Program

FOUR CAMERAS ON COMMON GYRO STABILIZED PLATFORM

1) SBIG ST-2001 XM (HIGH QE) 1600 x 1200 PIXEL CCD IMAGER
   High Spatial Resolution Spectrally Isolated Coronal Imaging

2) NIKON F5/400mm f/4.5 Vibration Reduction 35mm Film Camera
   High dynamic Range and Deep (High Sensitivity) Coronal Imaging

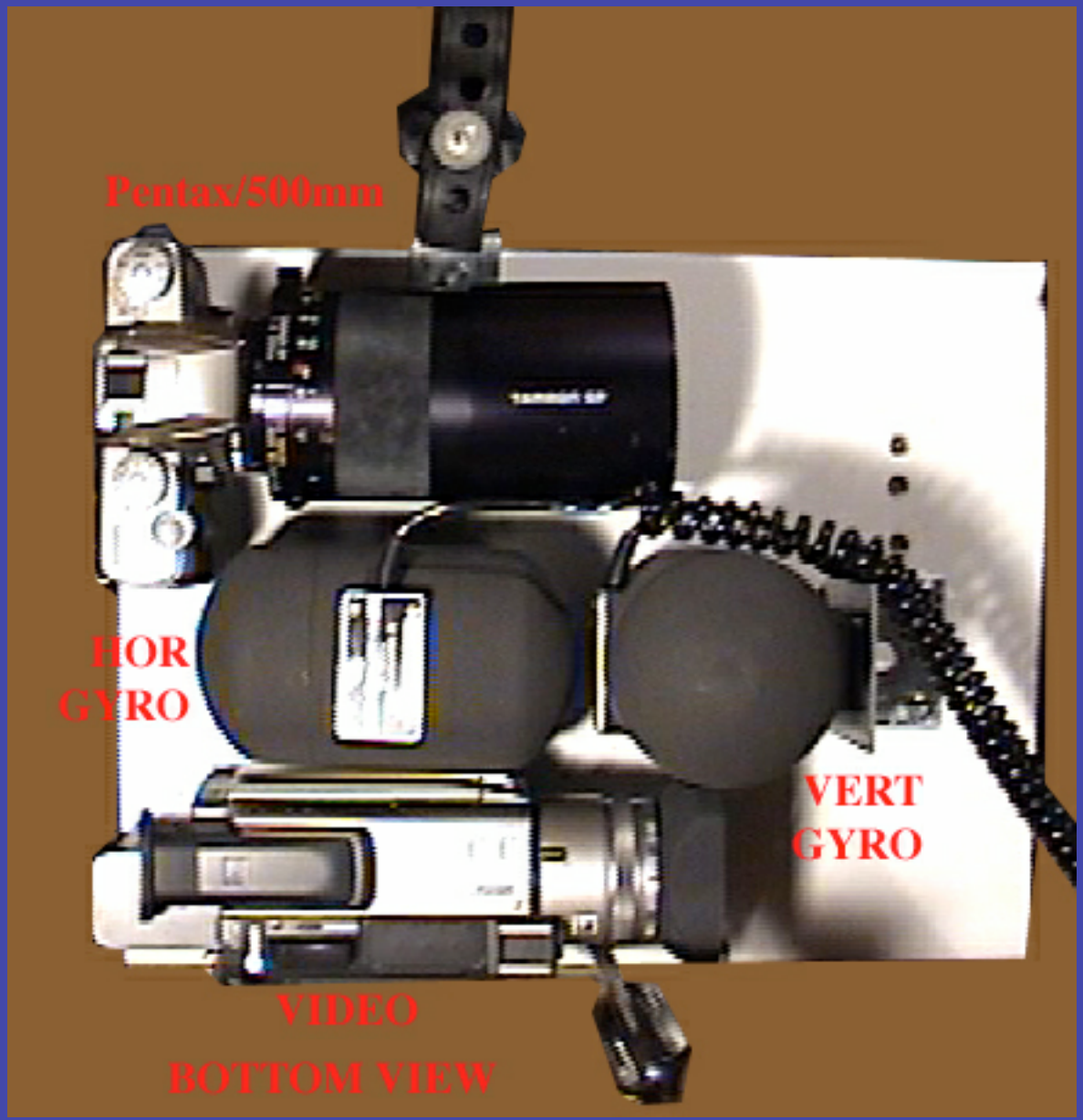
3) PENTAX/700mm f/11 35mm Film Camera
   Contact and Solar Limb Transition Phenomenon

4) SONY DCR-TRV 900 3-CCD DIGITAL VIDEO CAMERA
   Platform Guide Camera and Time-Tagged 30 Hz Imaging

Flight Deck Eclipse Imaging Platform

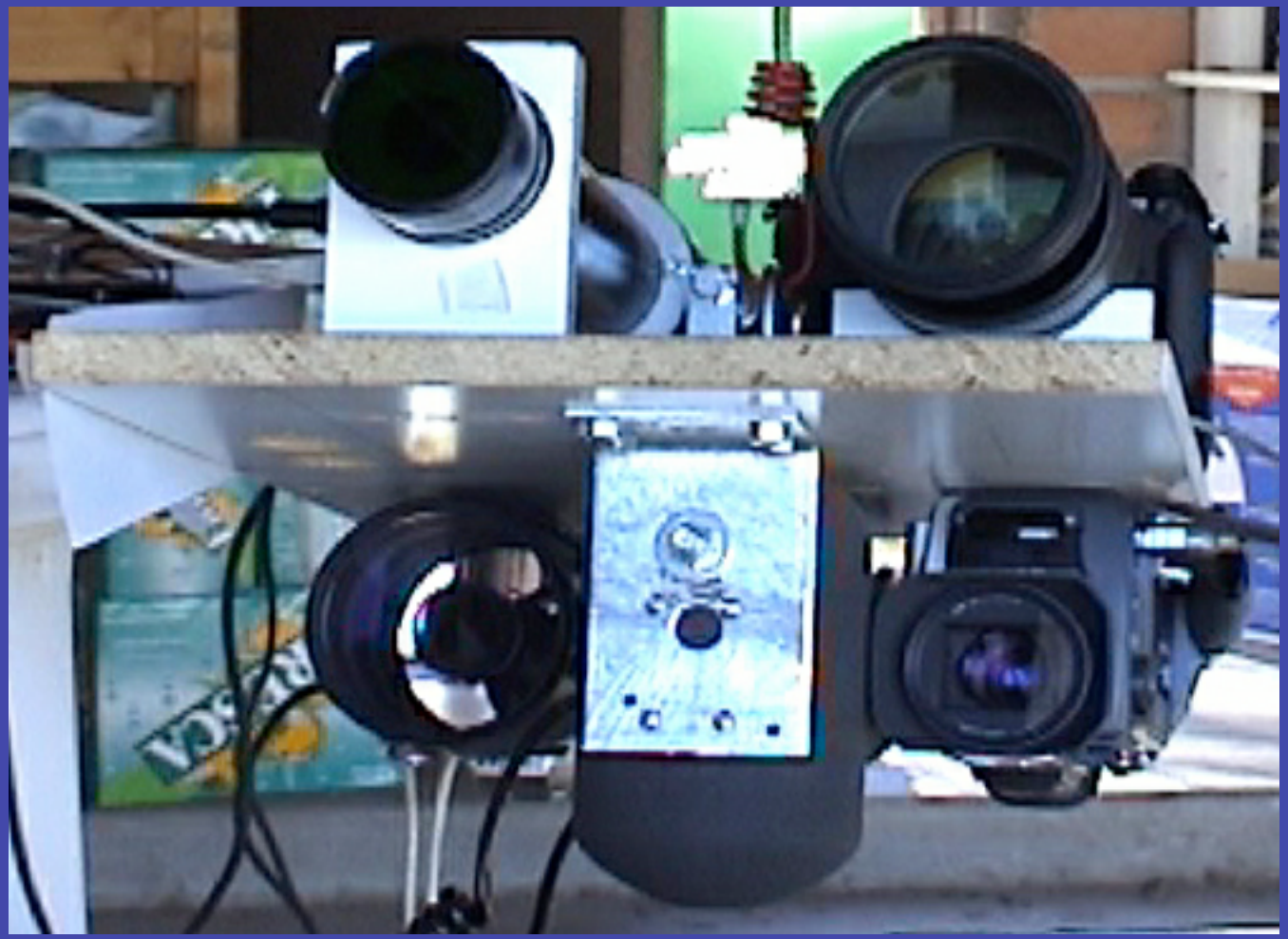
(without power/control/data cabling and counterweights)

Flight Deck Eclipse Imaging Platform



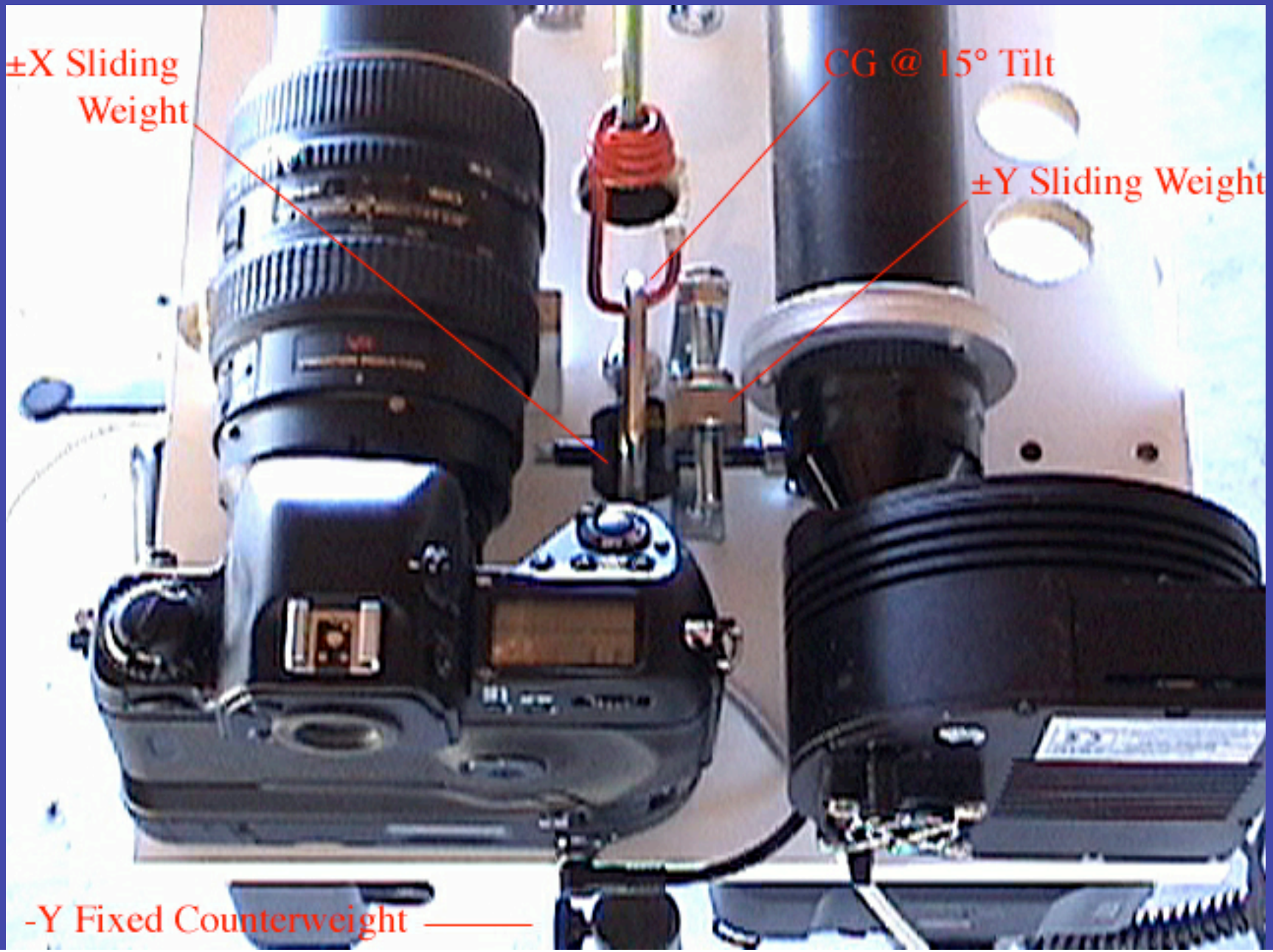
(without power/control/data cabling and counterweights)

Flight Deck Eclipse Imaging Platform



non-flight power/control/data cabling

Flight Deck Eclipse Imaging Platform

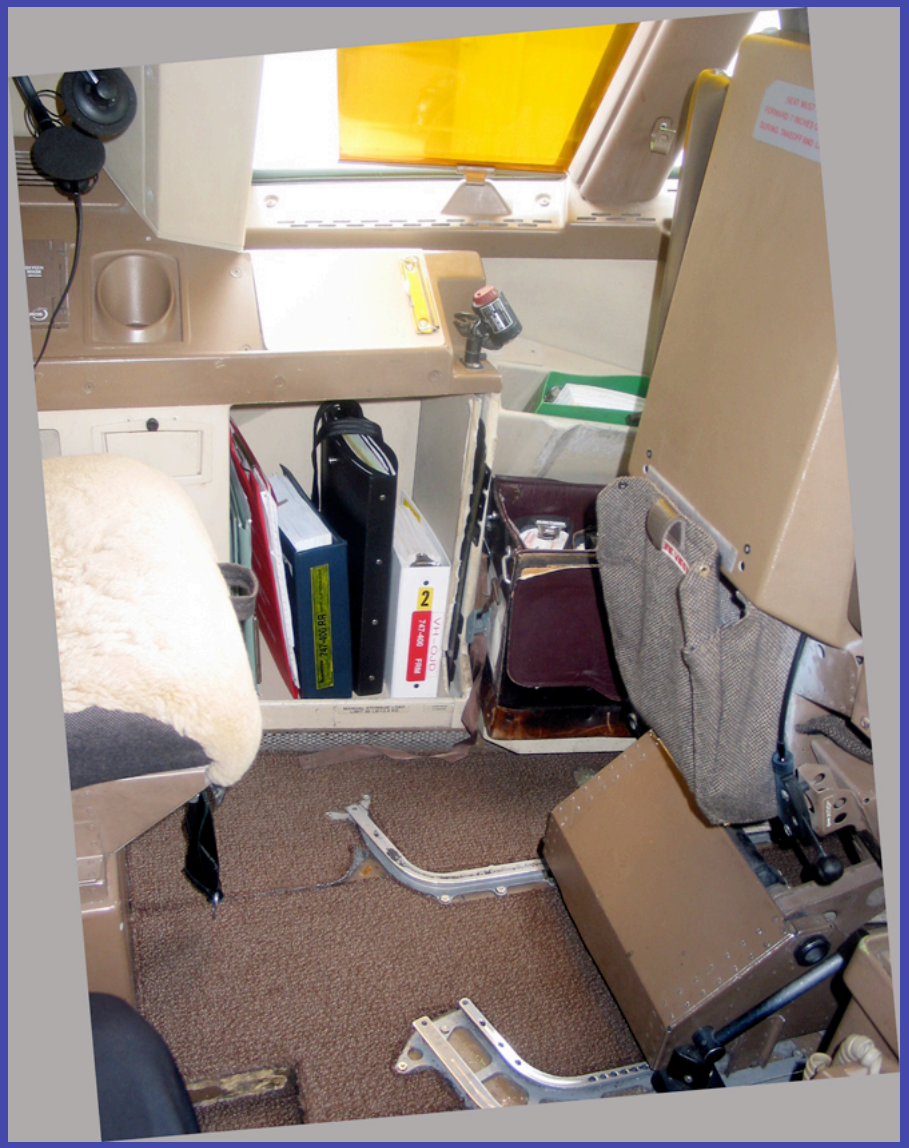


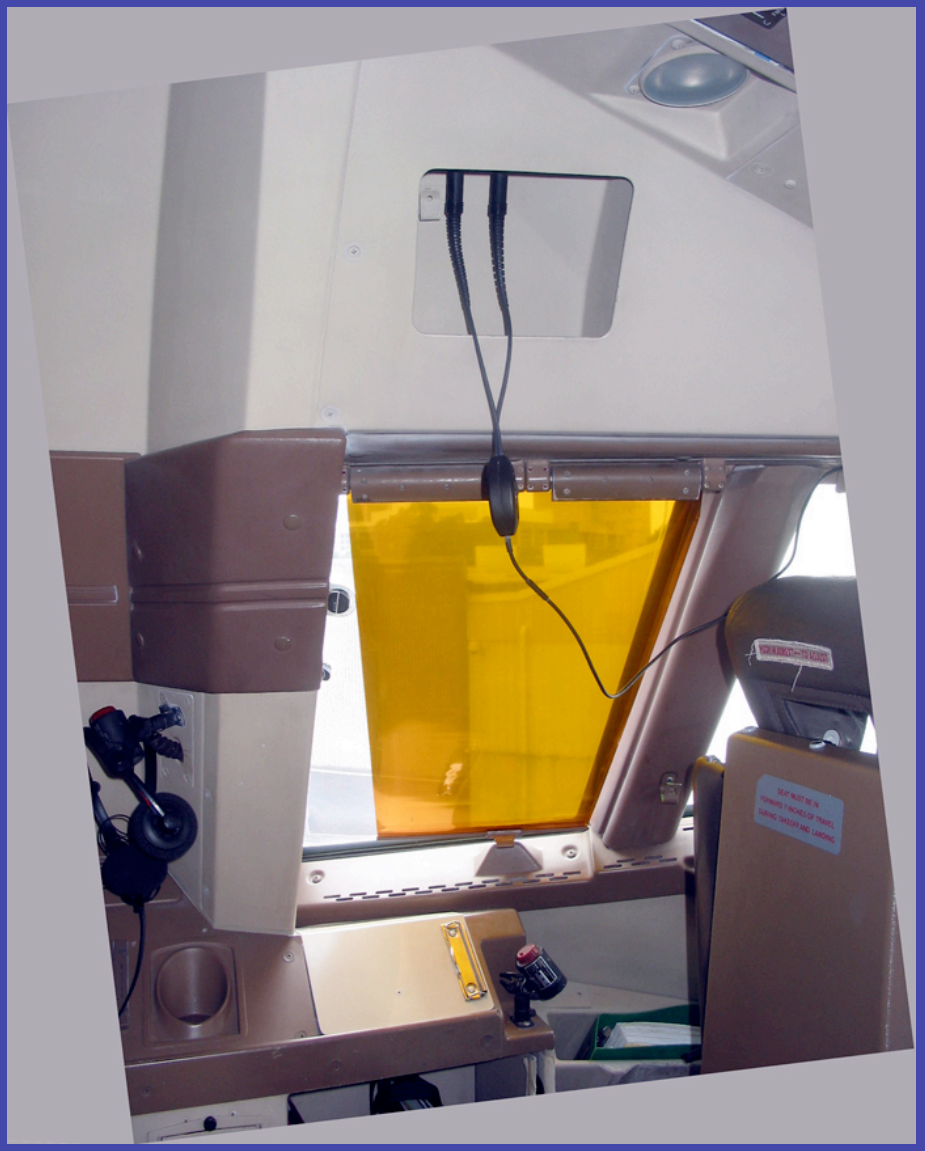
Flight Deck Eclipse Imaging Platform

First Integrated Systems Test

B747-400 *ER* Flight Deck Work Space

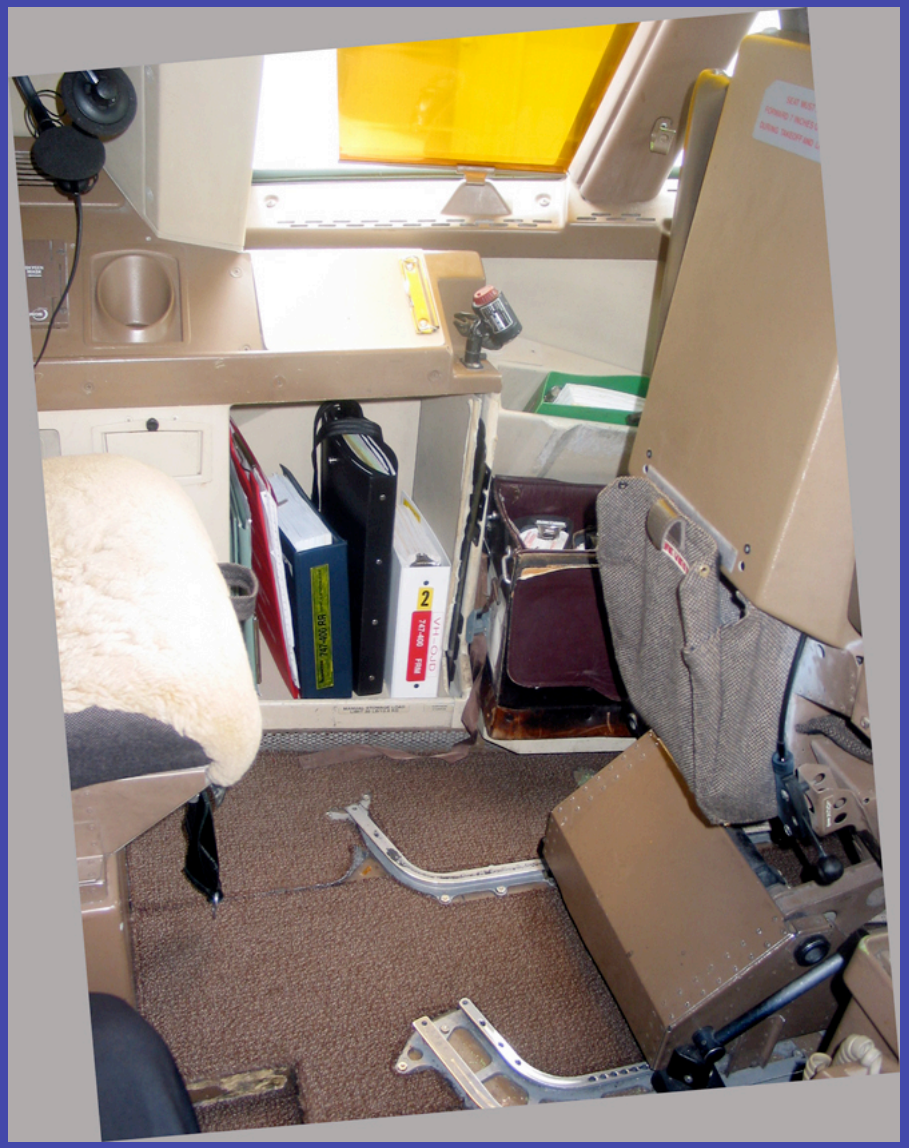
25 Mar 2003 Planning Meeting LAX/Catalina - Cpt J. Dennis

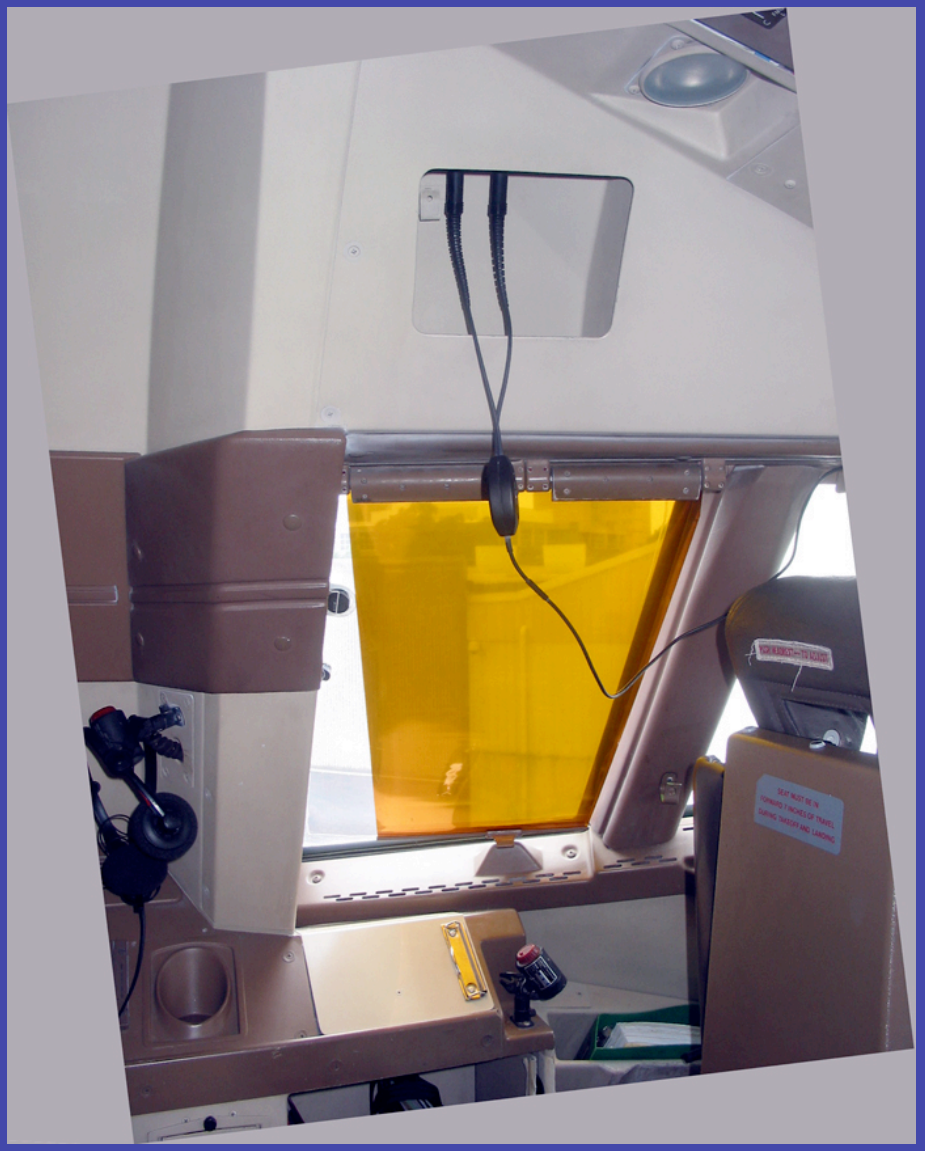




B747-400 *ER* Flight Deck Work Space

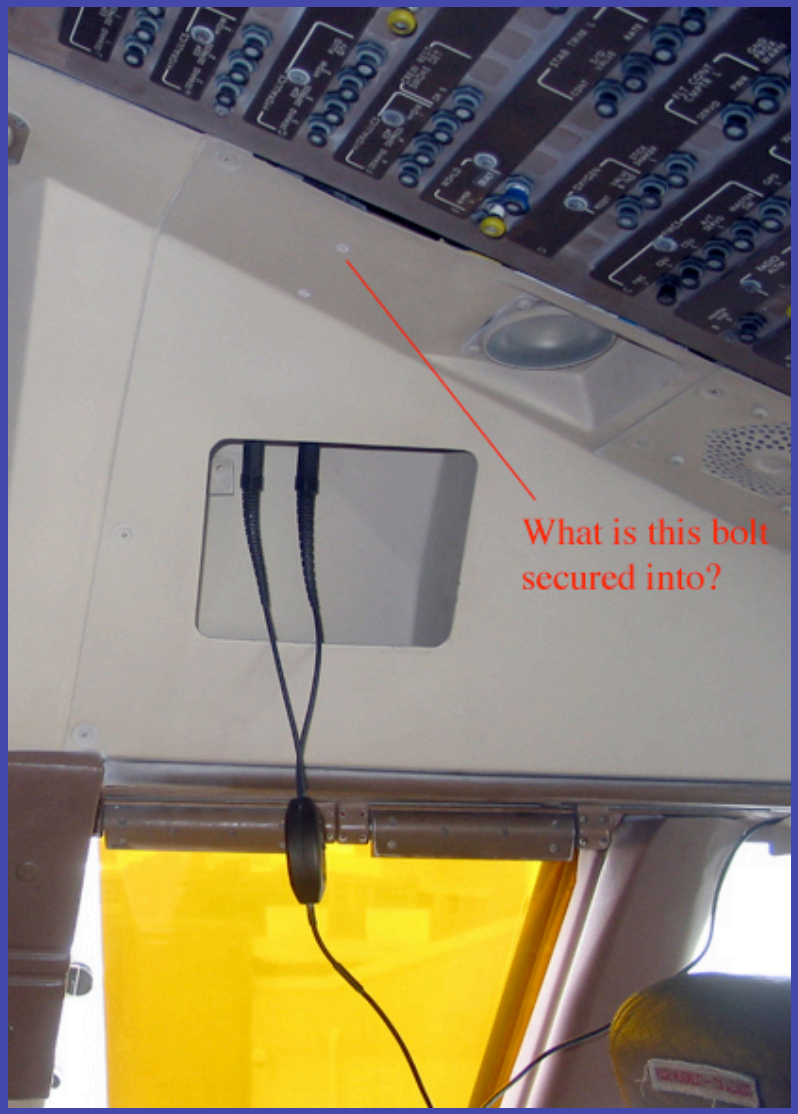
WHERE/HOW TO MOUNT THE GYRO PLATFORM???

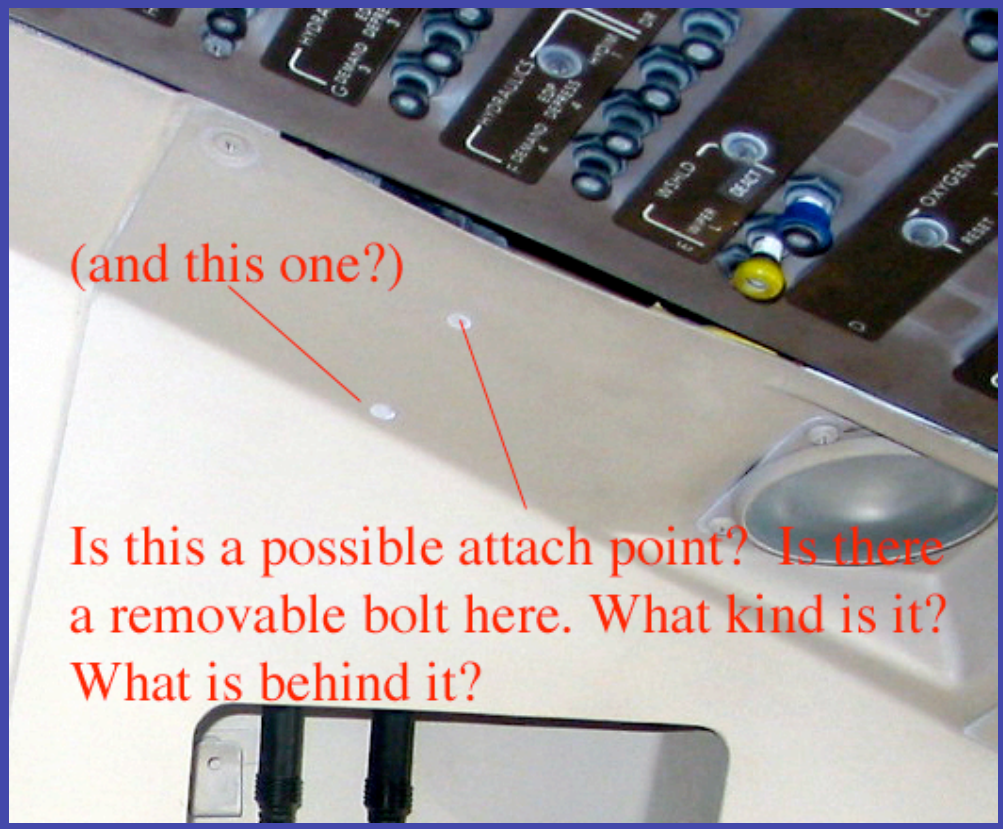




B747-400 *ER* Flight Deck Work Space

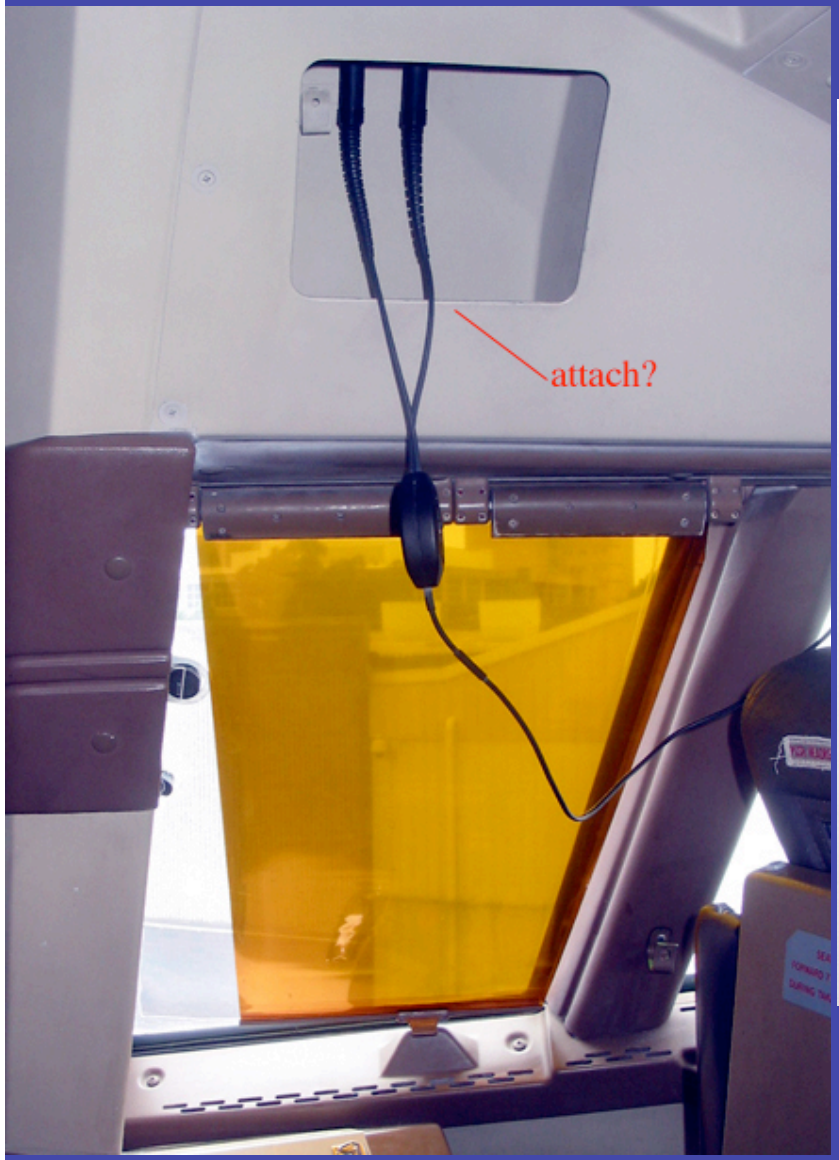
WHERE/HOW TO MOUNT THE GYRO PLATFORM???

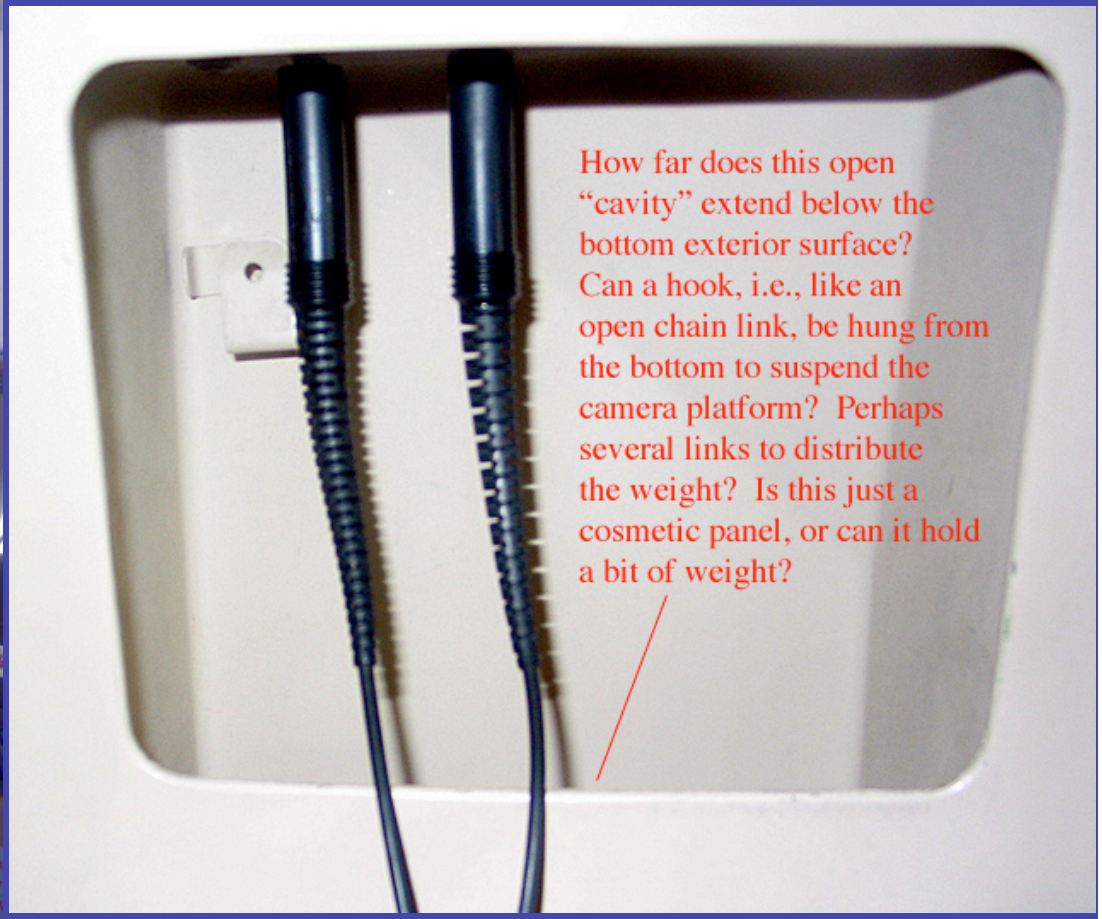




B747-400 *ER* Flight Deck Work Space

WHERE/HOW TO MOUNT THE GYRO PLATFORM???





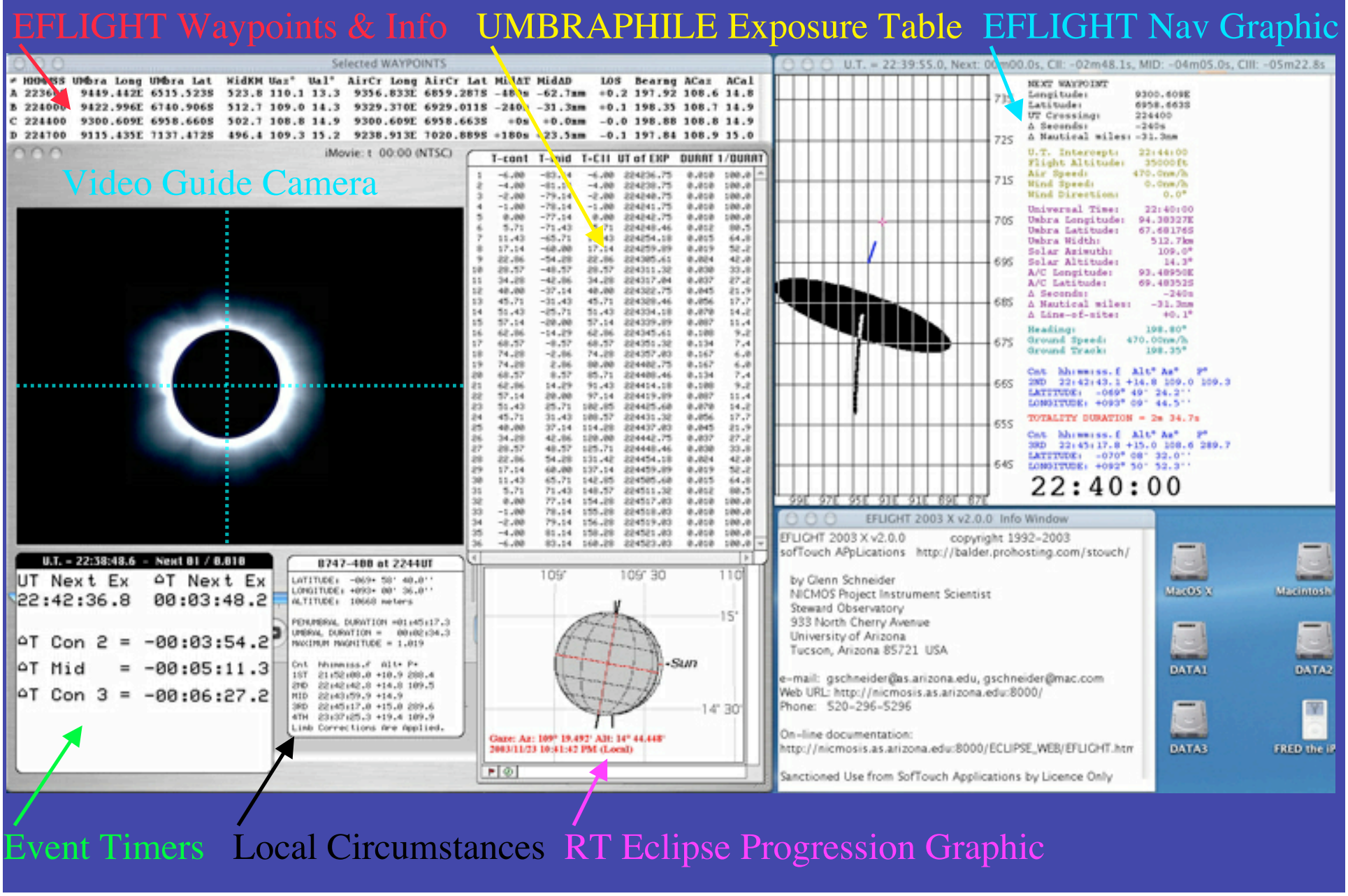
EFLIGHT TEST & VALIDATION

21 Jul 2003 QANTAS Jet Base B747-400 Simulator - Sydney

EFLIGHT TEST & VALIDATION

21 Jul 2003 QANTAS Jet Base B747-400 Simulator - Sydney

Flight Deck Navigation & Image Acquisition S/W

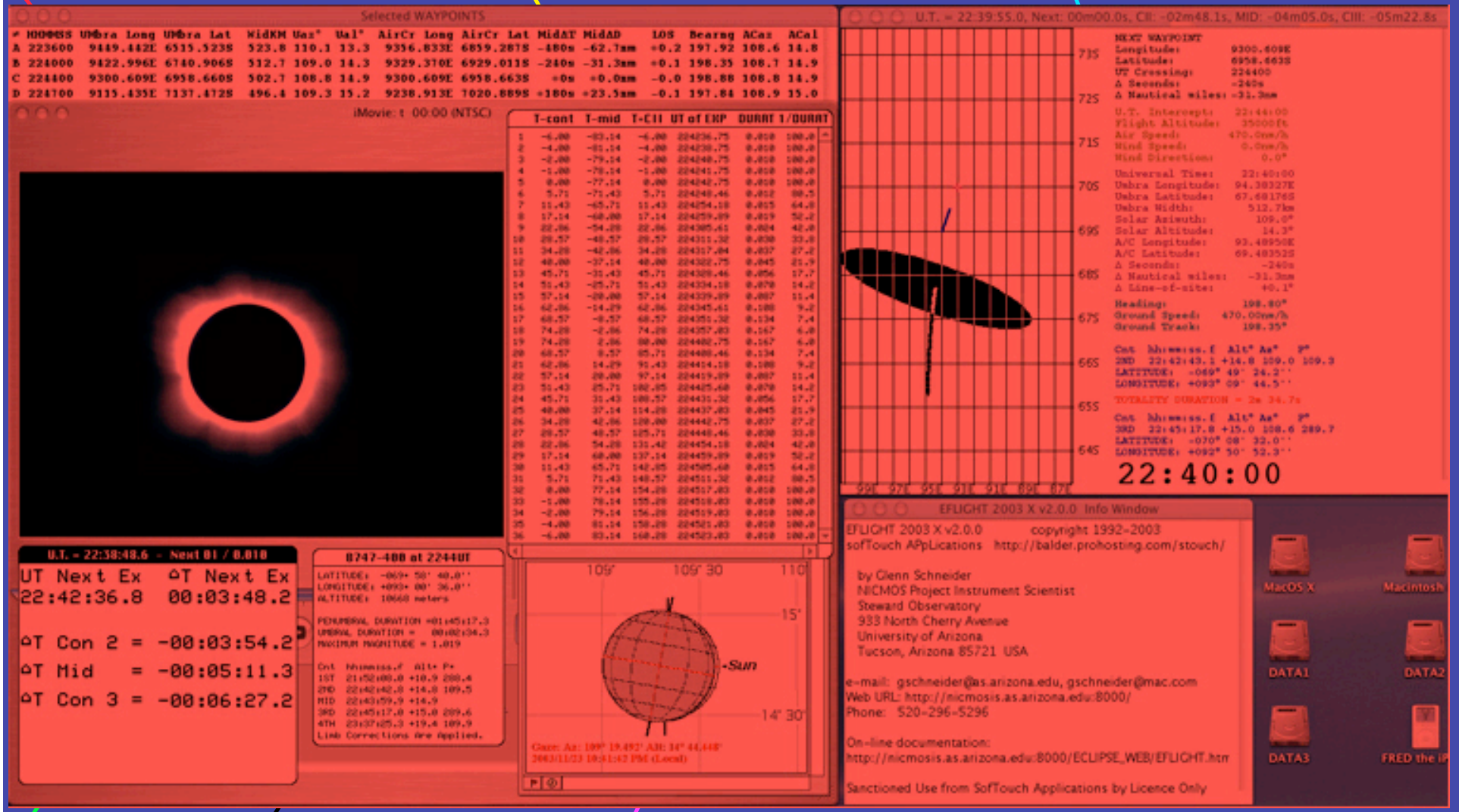


Flight Deck Navigation & Image Acquisition S/W

EFLIGHT Waypoints & Info

UMBRAPHILE Exposure Table

EFLIGHT Nav Graphic



Event Timers

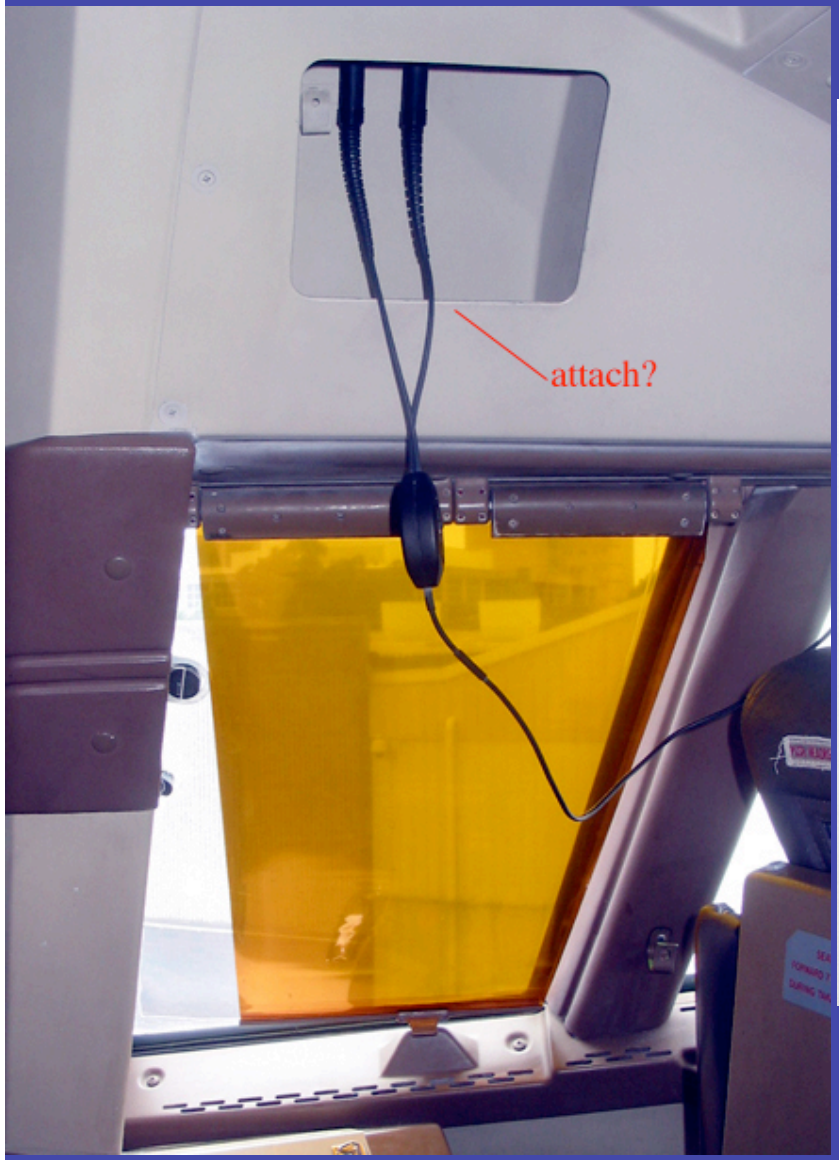
Local Circumstances

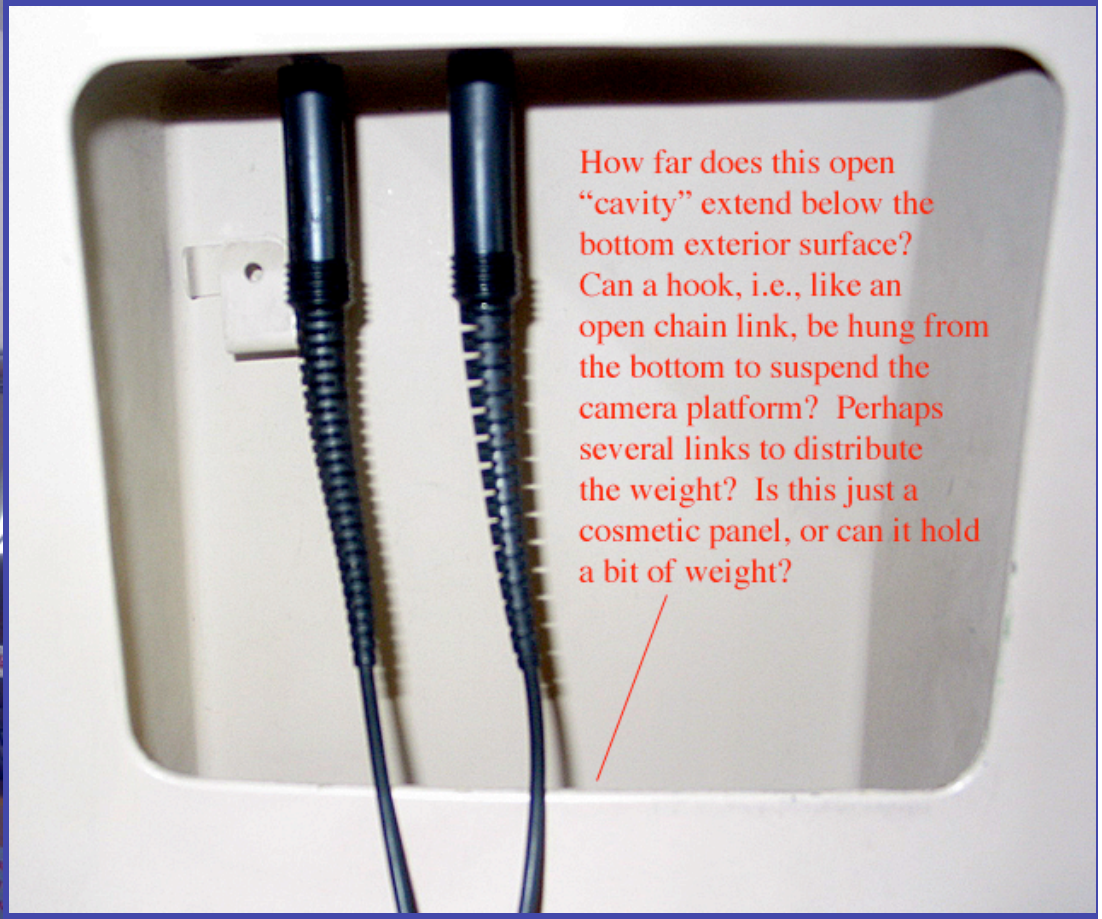
RT Eclipse Progression Graphic

DARK ADAPTION

B747-400 *ER* Flight Deck Work Space

WHERE/HOW TO MOUNT THE GYRO PLATFORM???





B747-400 *ER* Flight Deck Work Space

WHERE/HOW TO MOUNT THE GYRO PLATFORM???

Jay Friedland's "Out of the Box" Suggestion…

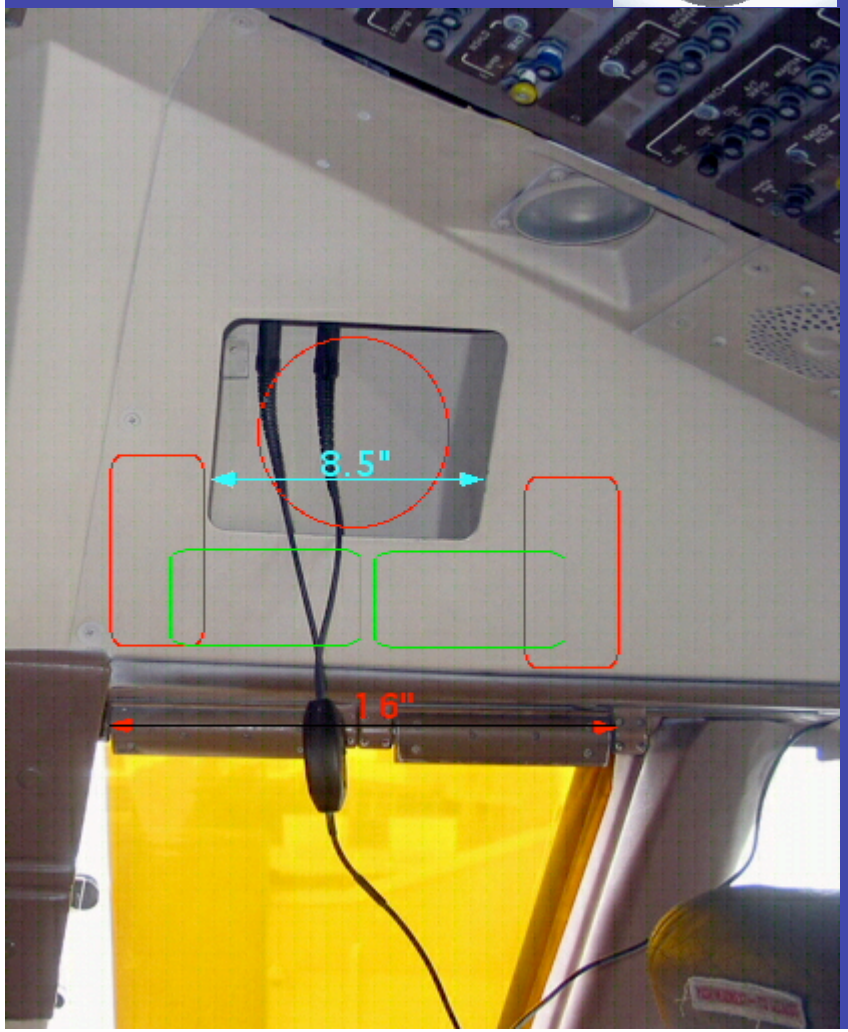
Vacuum Pumped Suction Cups

8.5" diameter 70 lb. static load

B747-400 *ER* Flight Deck Work Space

WHERE/HOW TO MOUNT THE GYRO PLATFORM???

Could this work?



QANTAS B747-400 Captain Ian Getley*:
"Try it on Cpt. Ian Barnet's QF 94 flight"

*Ph.D. Student in Space Weather and Cosmic & Solar Radiation Events

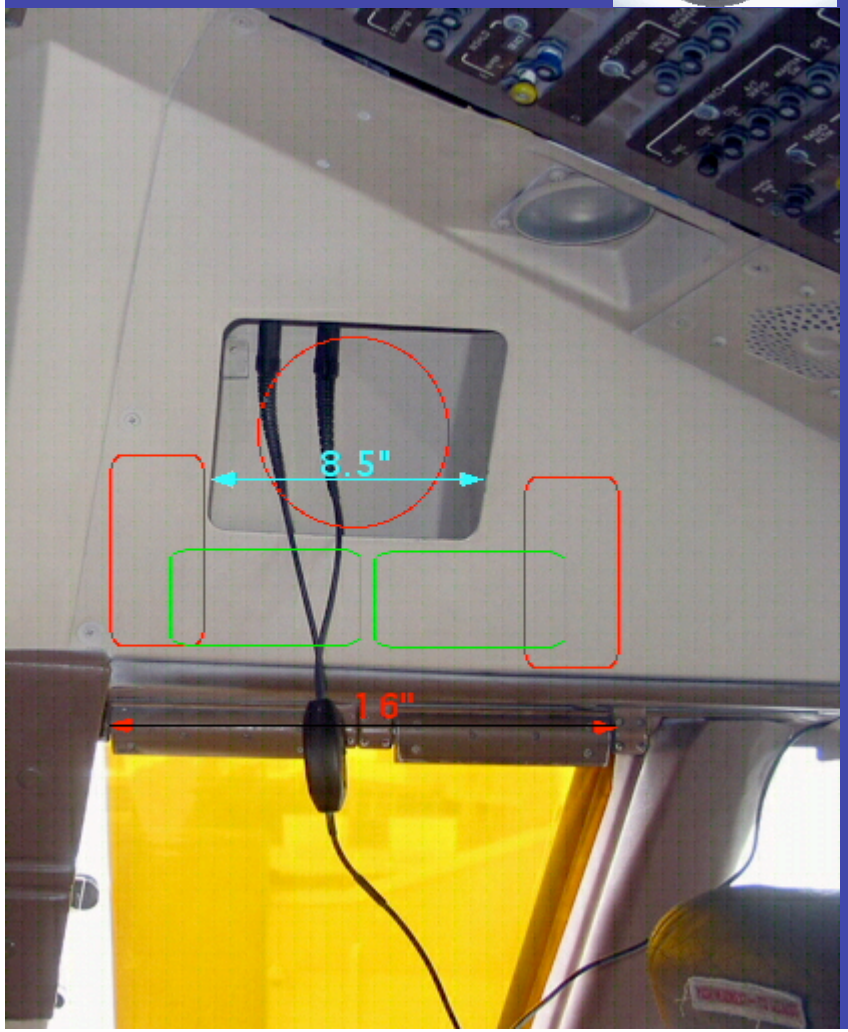
Solar storms could place crew and frequent flyers at risk *(Image: U.S. Senator Reed's Office)*

B747-400 *ER* Flight Deck Work Space

WHERE/HOW TO MOUNT THE GYRO PLATFORM???

Could this work?

QANTAS B747-400 Captain Ian Getley*:
"Try it on Cpt. Ian Barnet's QF 94 flight"



23 November 2003 -- QF 2901
QANTAS
Longreach
Integration: Umbraphillia+Optics+Avionics+Electronics

QANTAS

SECURITY - IN - CONFIDENCE

SECURITY DIRECTION

Security & Investigation Services

SD QF2901/03

SOLAR ECLIPSE FLIGHT – QF2901 – 24 NOVEMBER 2003

BACKGROUND

Qantas Airways Limited has received approval from the Australian Department of Transport and Regional Services (DOTARS) to load within the aircraft cabin specialised astronomical equipment, screwdrivers, pliers

QANTAS

Security & Investigation Services

SPECIAL HANDLING REQUEST

Screening Authority

The holder of this letter has requested and been given approval by Qantas Airways with the concurrence the Australian Department of Transport and Regional Services, for the screening authority to undertake a hand search of any specialised high speed film and any specialised astronomical equipment in the possession of the passenger.

QANTAS

SECURITY - IN - CONFIDENCE

SECURITY DIRECTION

Security & Investigation Services

SD QF2901/03

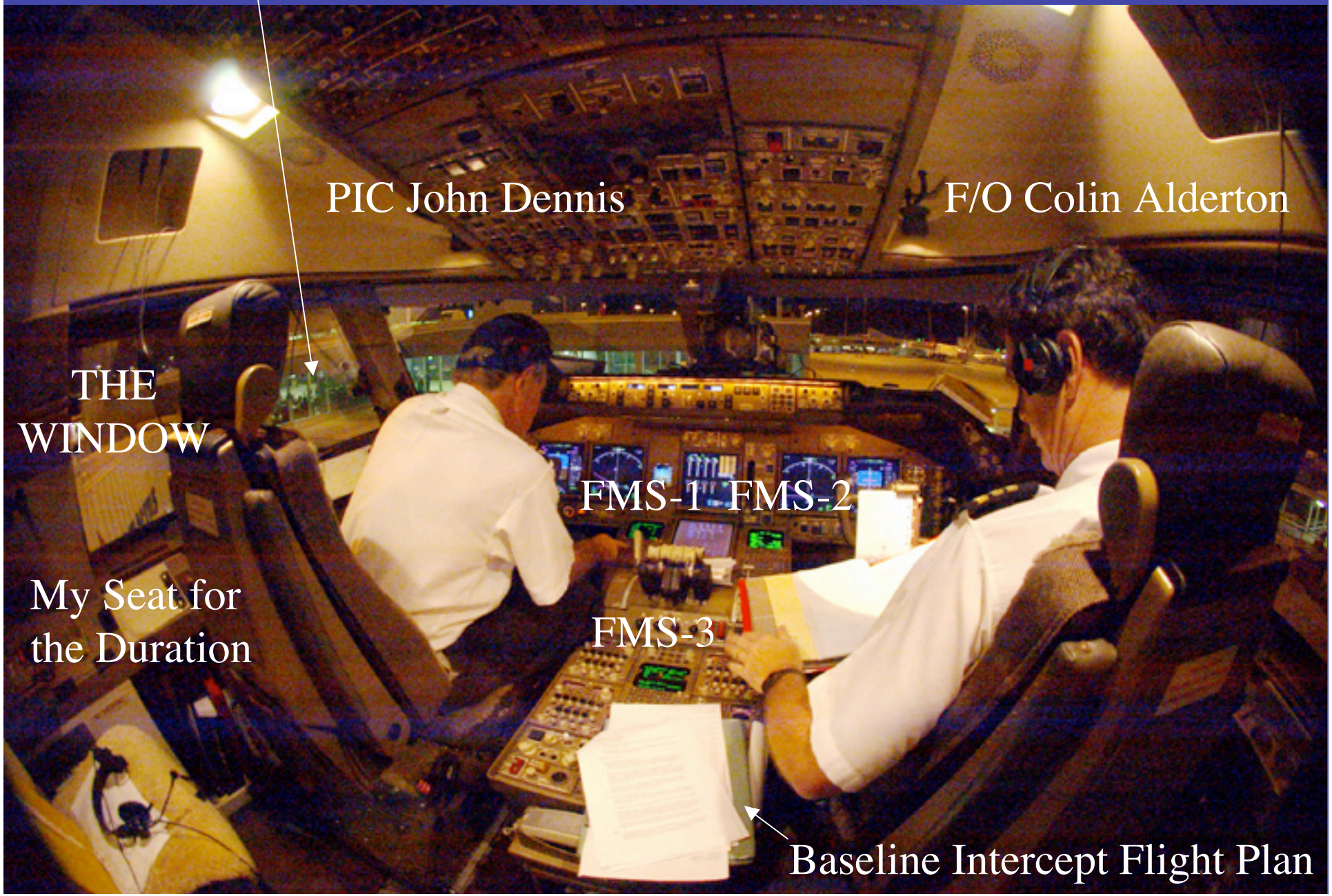
SOLAR ECLIPSE FLIGHT – QF2901 – 24 NOVEMBER 2003

BACKGROUND

Qantas Airways Limited has received approval from the Australian Department of Transport and Regional Services (DOTARS) to load within the aircraft cabin specialised astronomical equipment, screwdrivers, pliers

Pre-Flight Equipment Prep in the QANTAS Lounge

QF 2901 Pre-Flight



On The Flight Deck - 15h of Isolation

On The Flight Deck

Bungie Cords & Velcro

The camera platform was suspended from a bungie cord attached to a 70-lb static load capacity vacuum suction cup secured to the flight deck wall in a panel pass-through.

During the set-up of the equipment, a second suction cup was rigged as a safety against a possible loss of vacuum (and load bearing) of the primary suction cup.

On The Flight Deck

Dighaye

A sign hung right above the second observer's seat was a constant reminder to "check and re-pump" the suction cup vacuum pressure frequently.

The support point for the camera/gyro platform was immediately above the window behind the pilot's seat. Operations procedures document attached to seat back.

On The Flight Deck

110 VAC 400 Hz gyro power inverters and Ni-Cad battery packs attached with velcro to bottom of pilot's seat and flight deck floor next to seat rail system.

12 V DC-to-DC regulated power supply and Ni-Cad battery source for SBIG CCD camera velcroed to flight deck wall and floor next to observer's seat.

Dighaye

On The Flight Deck

Camera operations laptops on seat; film and video guide camera with PowerBook, CCD camera with ThinkPad. UMBRAPHILE and NIKON VR interfaces velcroed on shelf.

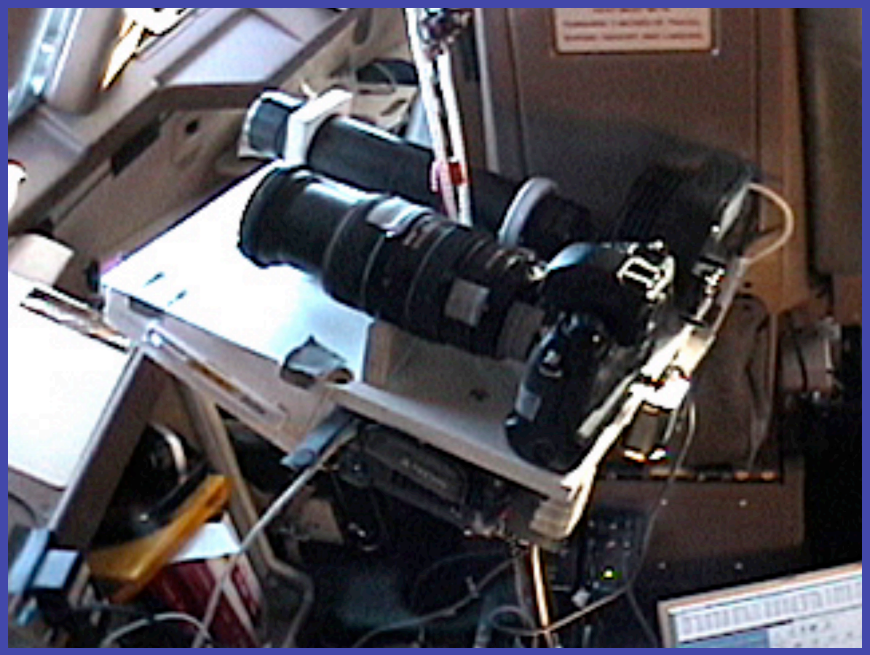
Rotating swivel clip held bungie cord to suction cup permitting alignment. Loosely coupled safety ropes straddle platform support but do not hinder floating support.

Dighaye

On The Flight Deck

Dighaye

Camera/gyro platform fully rigged and suspended from flight deck wall, in position at observer's window behind pilot's seat ready for final balance and alignment check.



Electrical (power and control) connections established to/from cameras/computers and gyros. Note green light on gyro power inverter #2.

On The Flight Deck

Camera Platform Power, Data & Control Cables

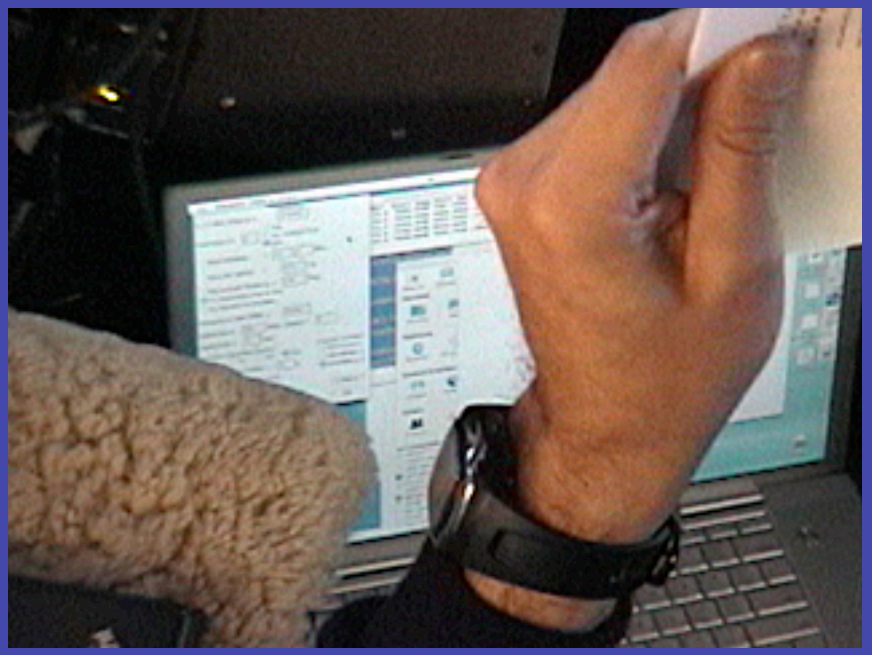
Cabling was rigged vertically downward and supported from below from platform center of gravity to minimize unbalanced torques on the platform.

The camera platform was pre-balanced to tilt upward at an angle of 14.9°, the solar altitude at mid-totality, when suspended from it's support point at the COG.

Dighaye

On The Flight Deck

A third laptop (floor) was used for real-time eclipse navigation, computing flight position updates based upon winds aloft. Note solar filter now on observer's window bottom.



First of several in situ flight plan updates are computed via EFLIGHT and relayed to flight crew for input into Boeing 747-400 Flight Management System computer.

Dighaye

On The Flight Deck

Solar Filters

Dighaye

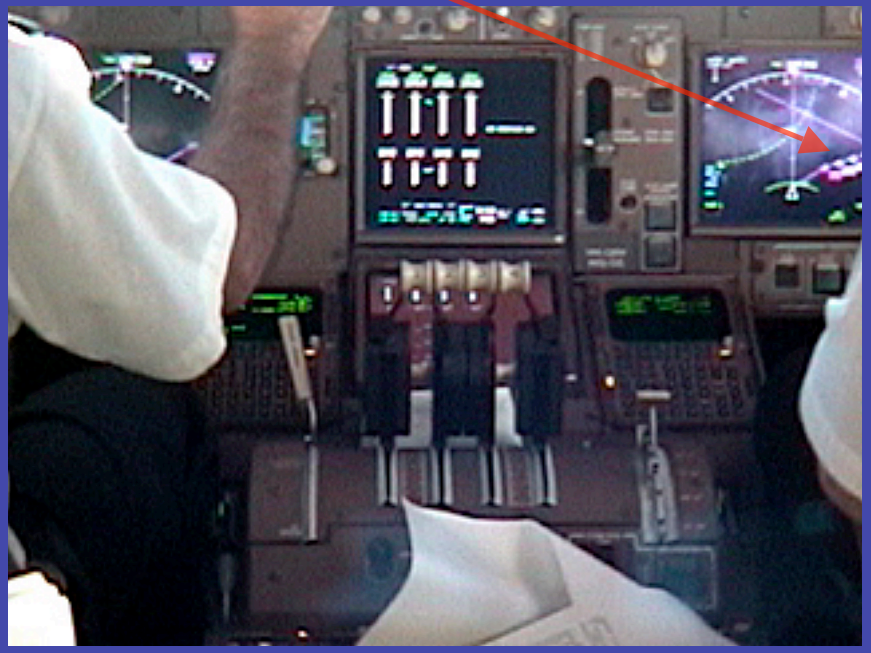
With ingress phase of eclipse well in progress Di Patterson (with eclipse viewing glasses in hand) assists Glenn Schneider in with final procedures review.

Cpt. John Dennis (with eclipse viewing glasses) and Cpt Brian Meade take a peek at the dwindling solar crescent as we align the aircraft for the Totality run.

Totality Run Loaded
& Ready to Execute

On The Flight Deck

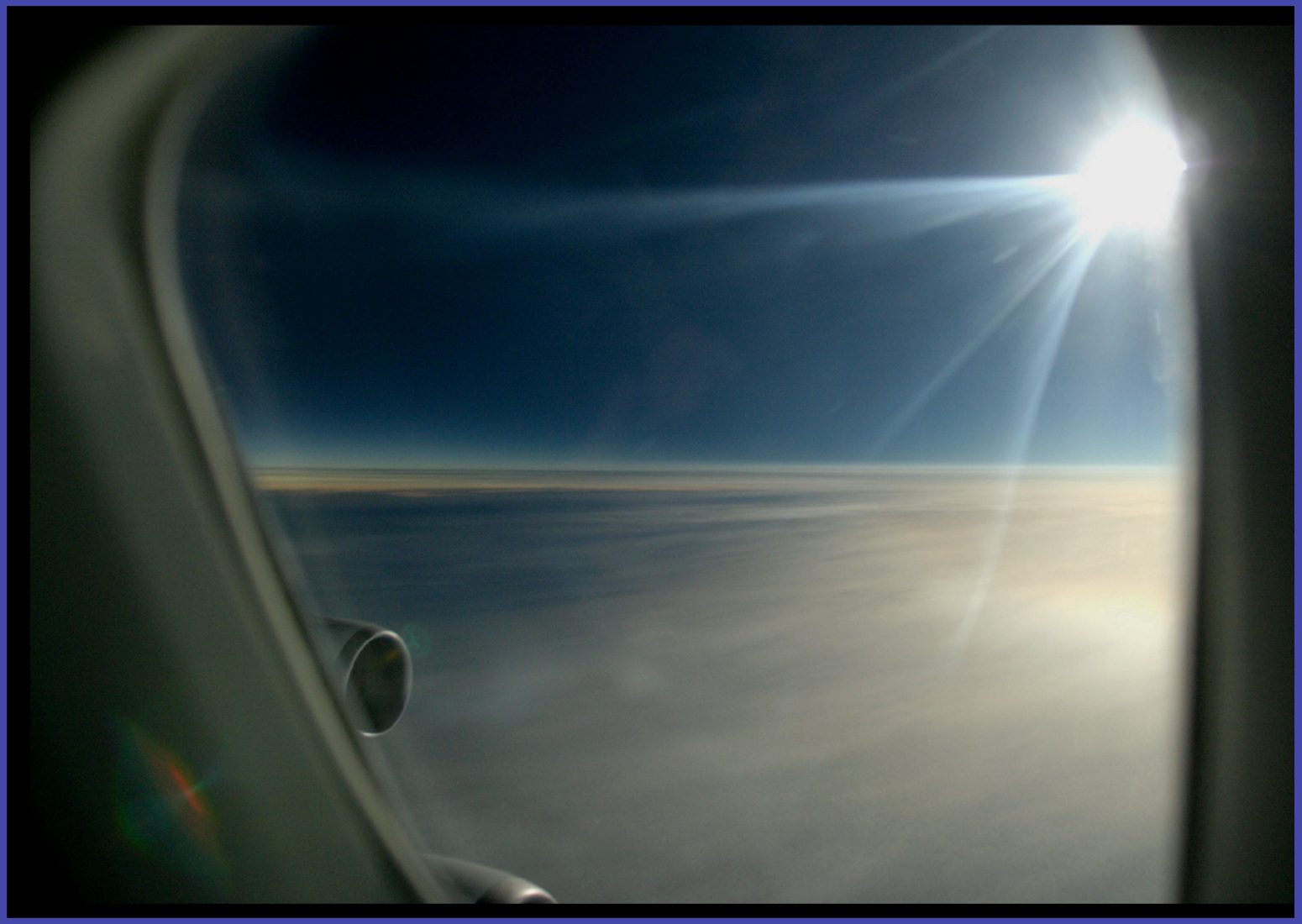
Dighaye



Penultimate set of target way points are ingested into and read back from the FMS. "Glass cockpit" display on right shows first three of five totality run waypoints.

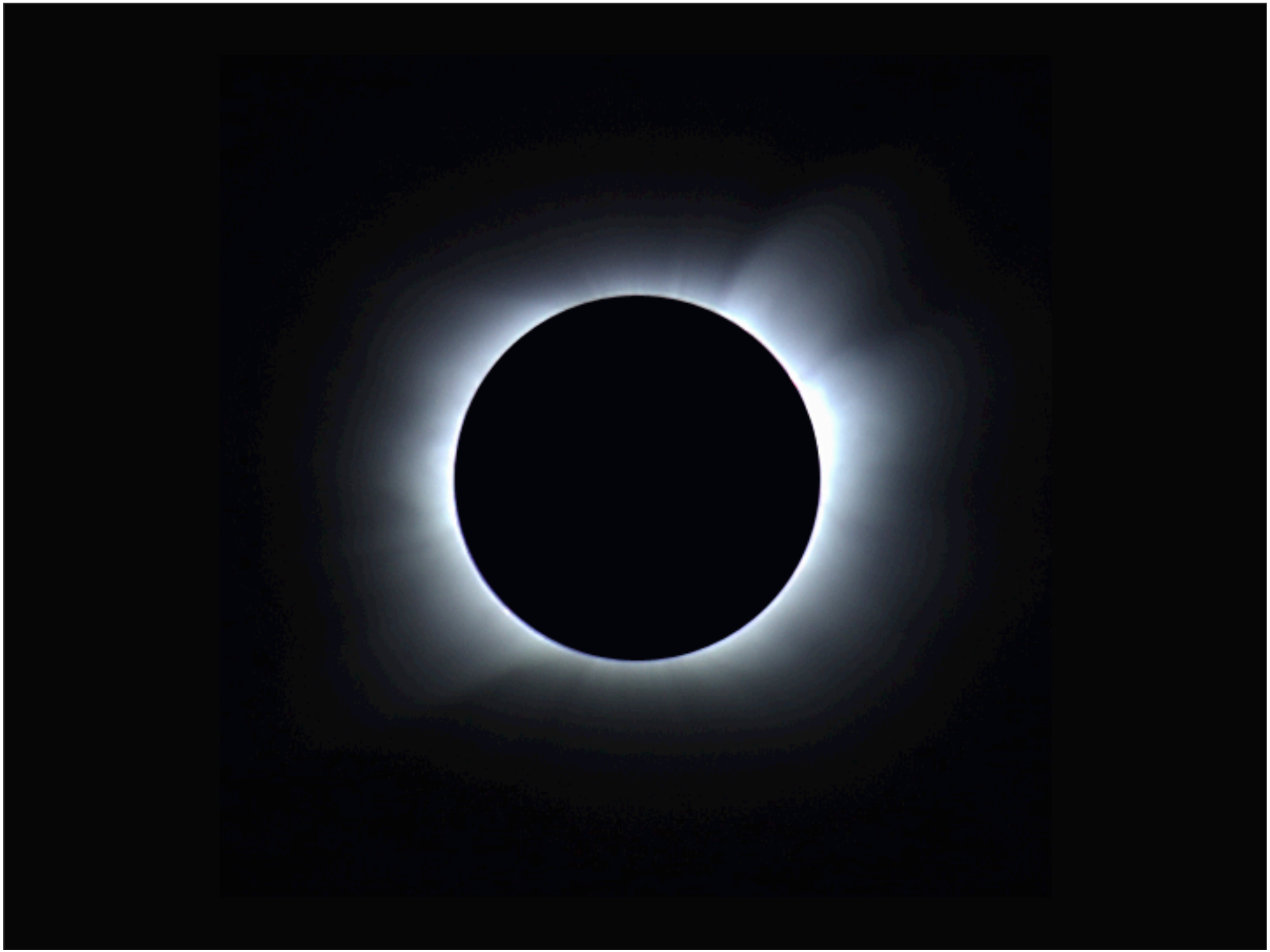
For the final time before totality, Glenn Schneider checks and re-pumps the vacuum pressure on the platform support suction cup in preparation for Totality.

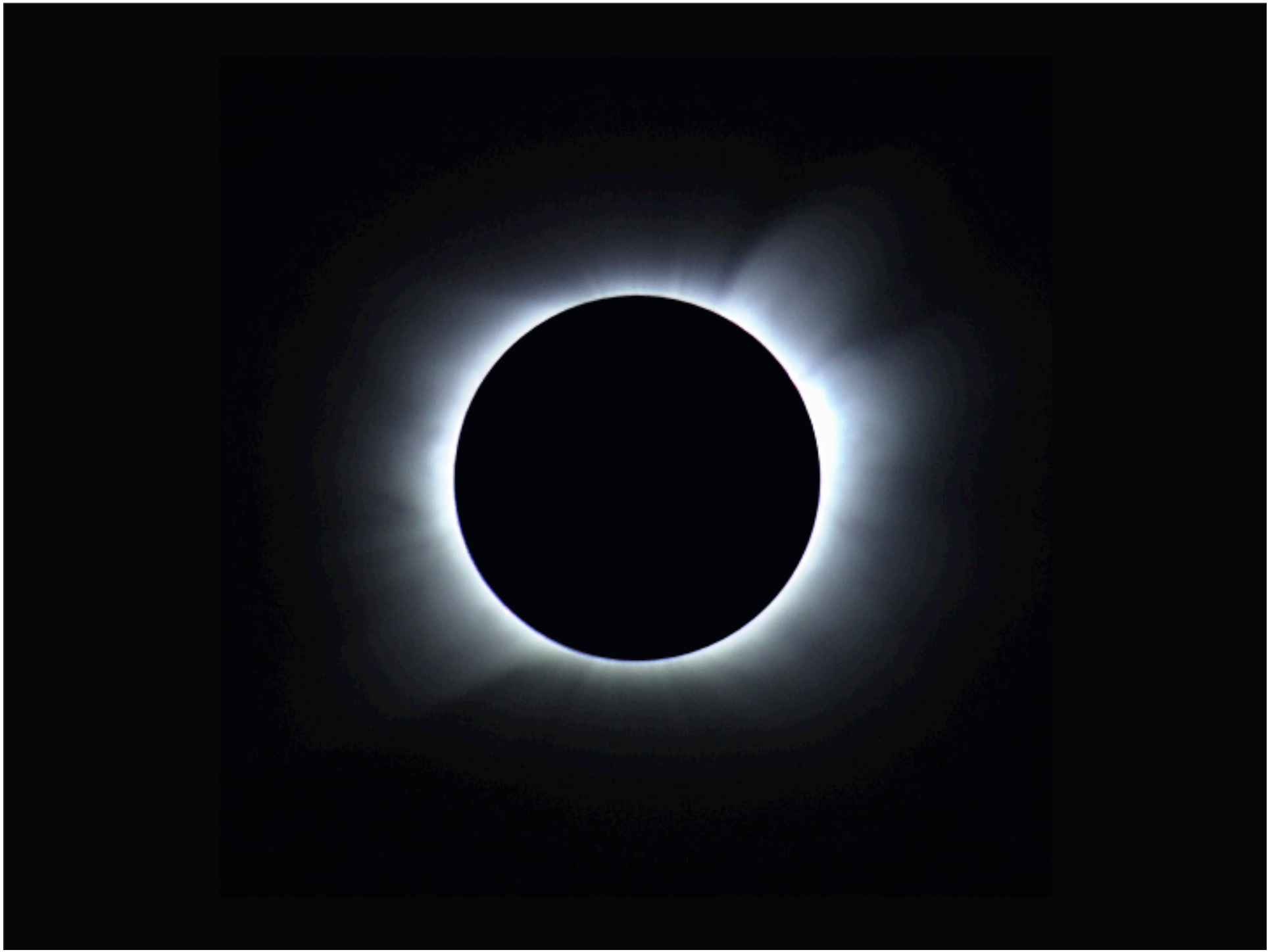
The Umbra Approaches

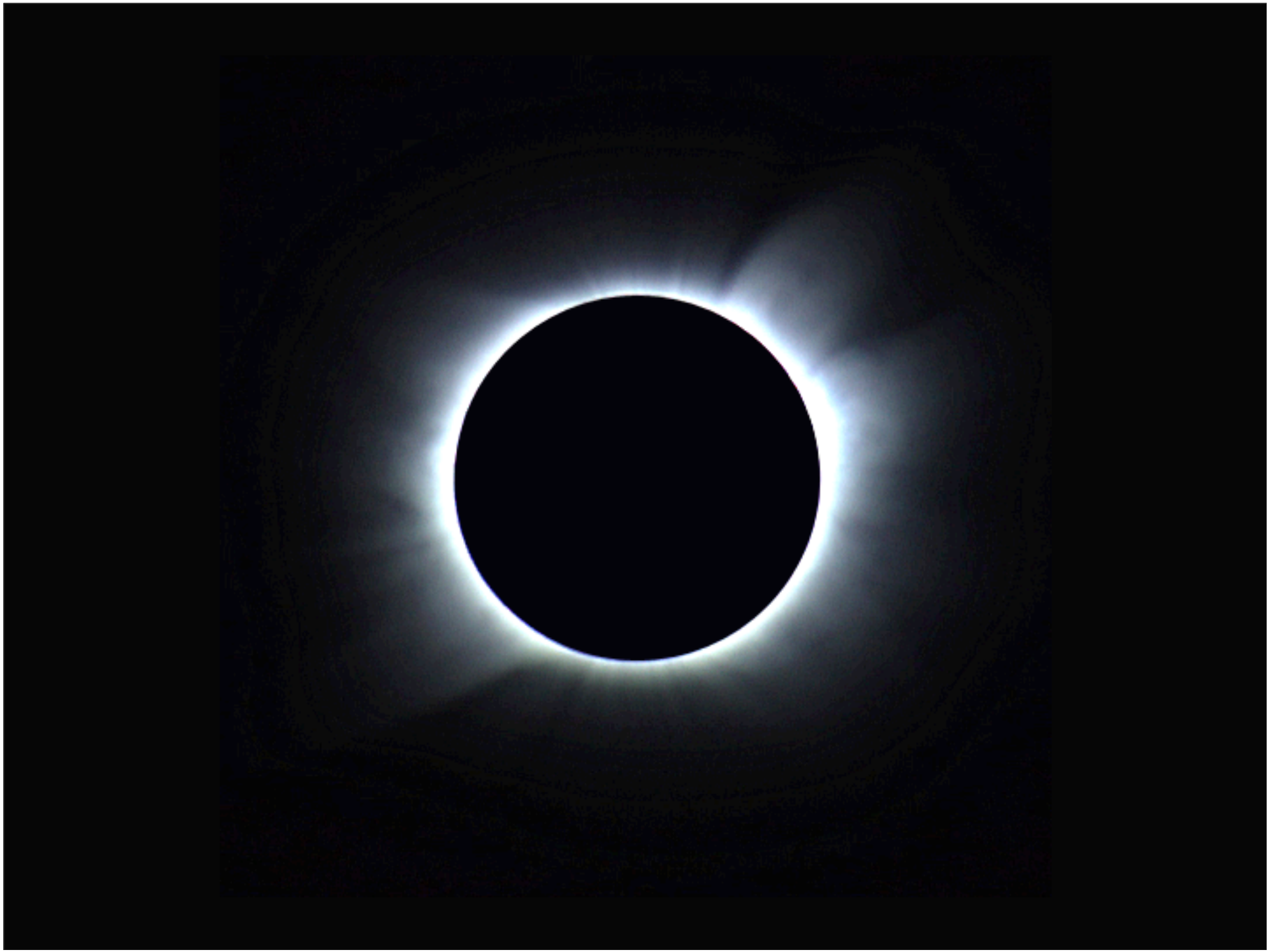


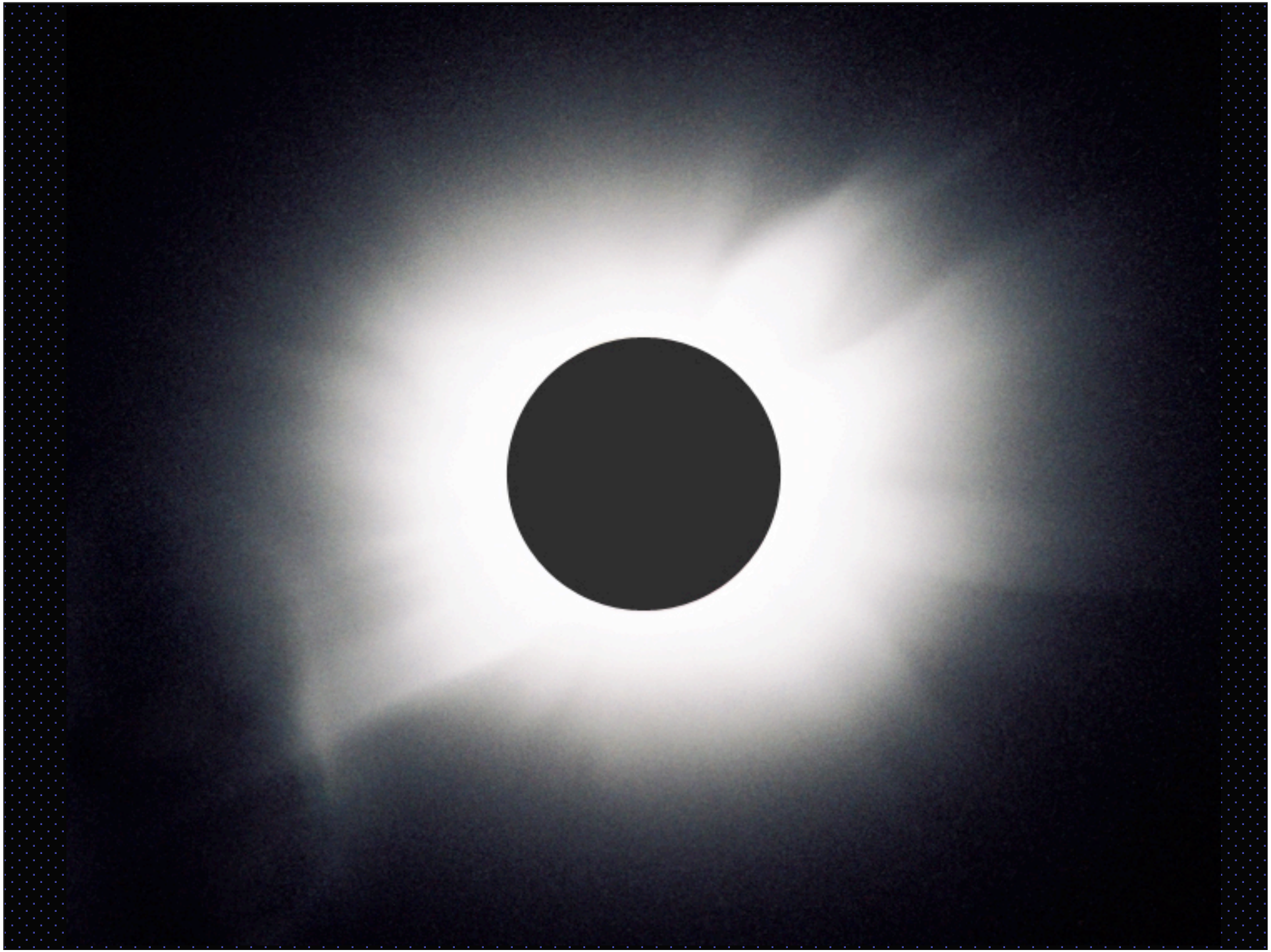
C. Roberts

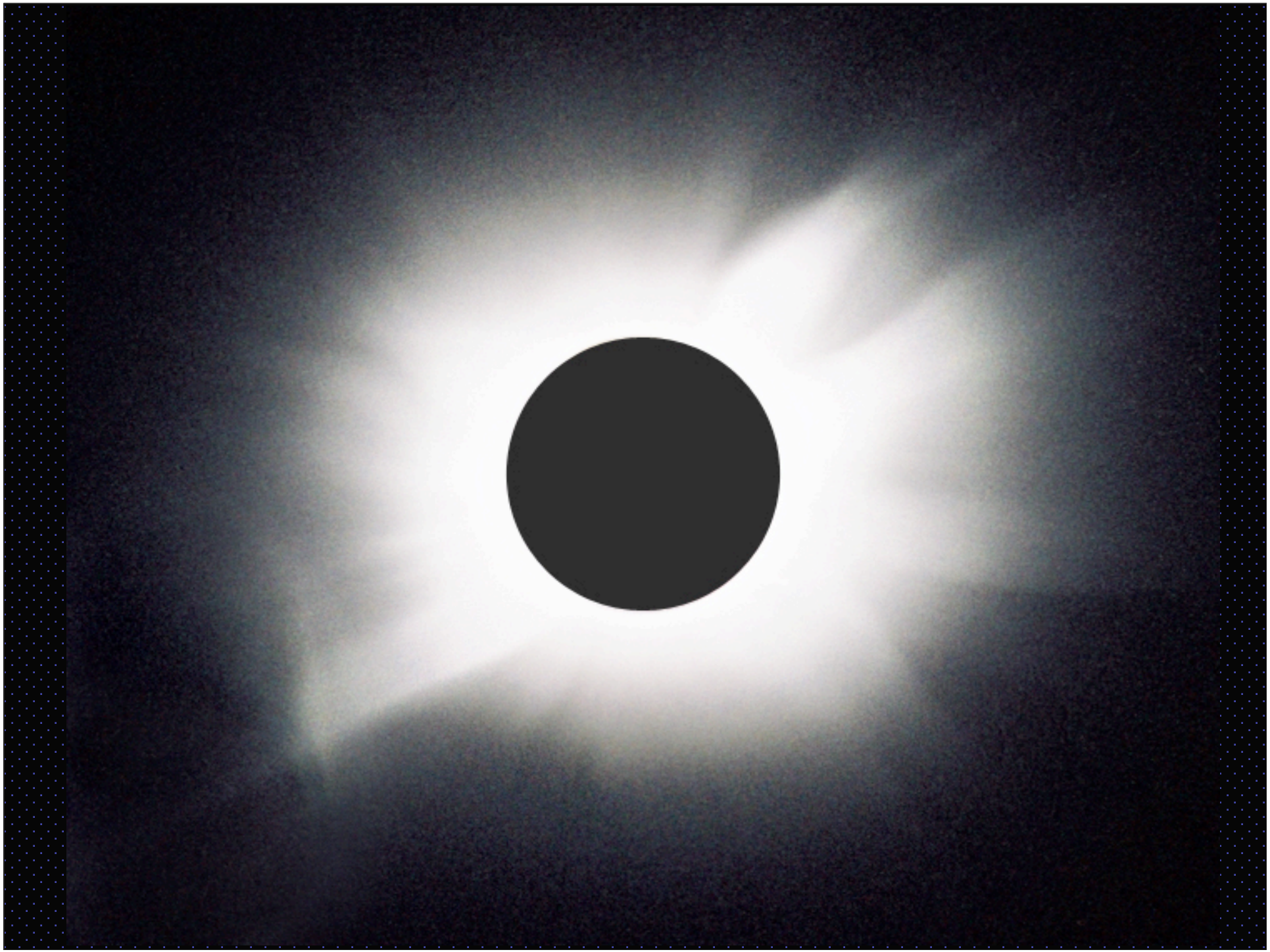
Play movie: INGRESS_VIDEO.mov

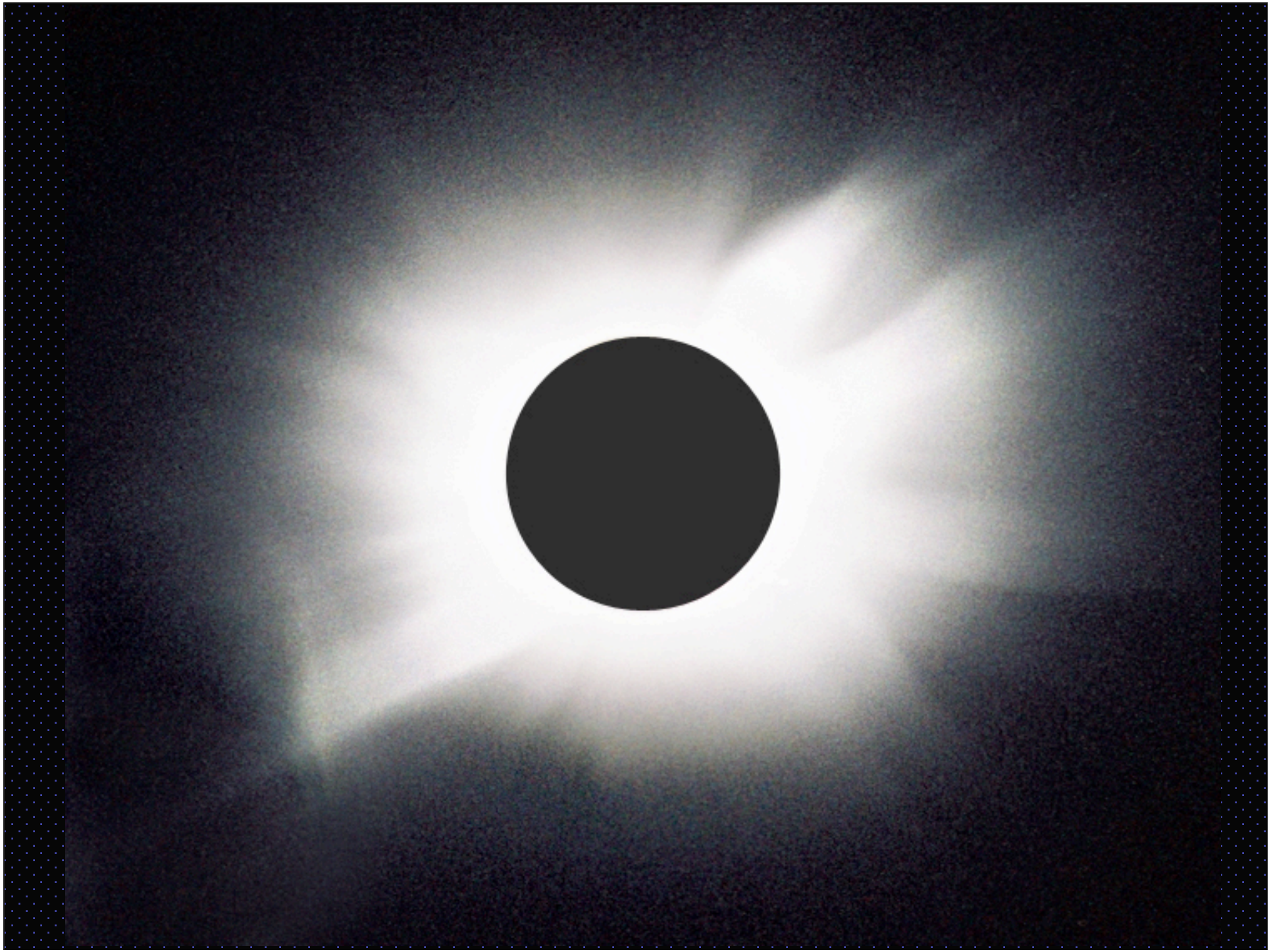


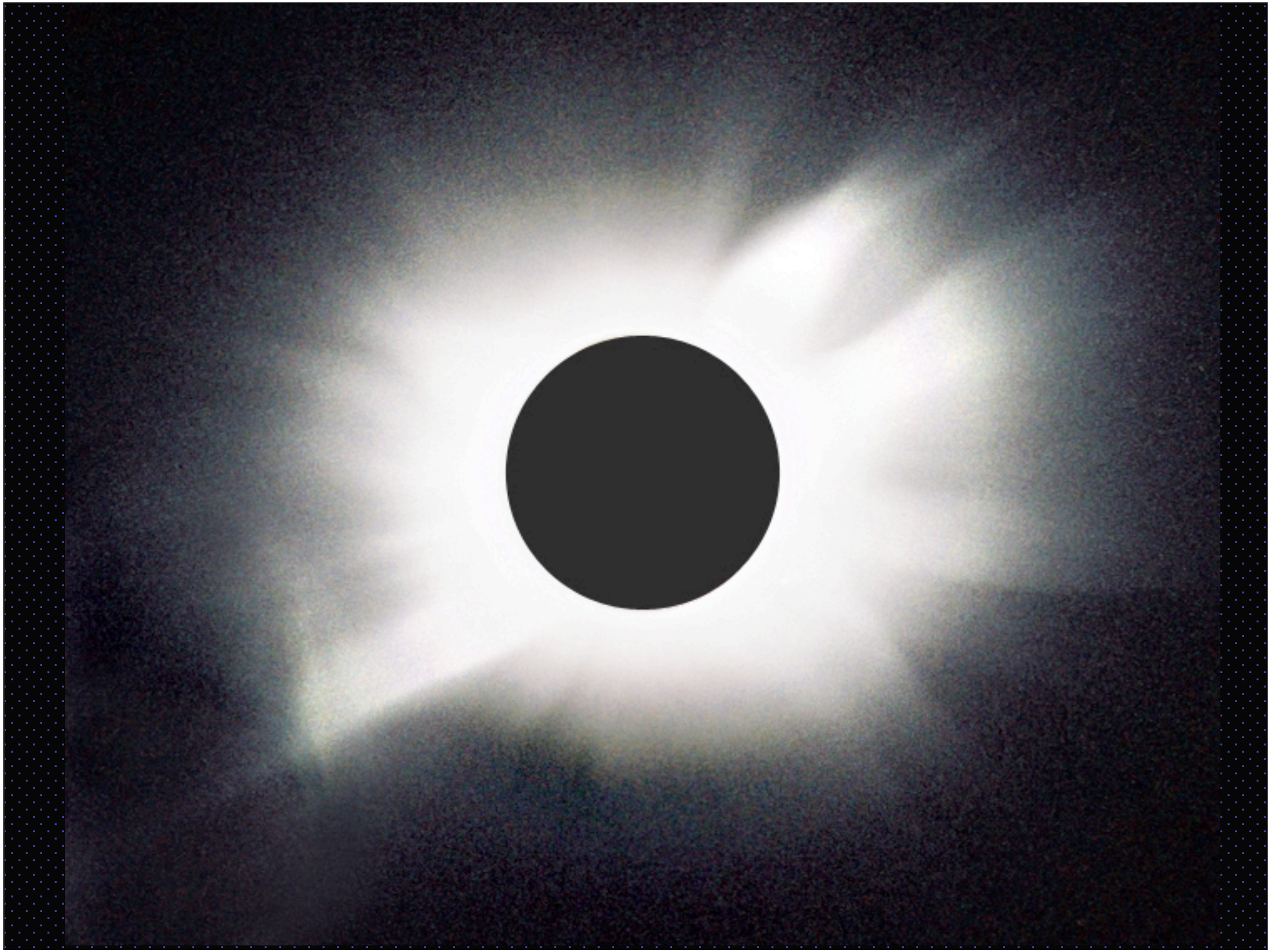


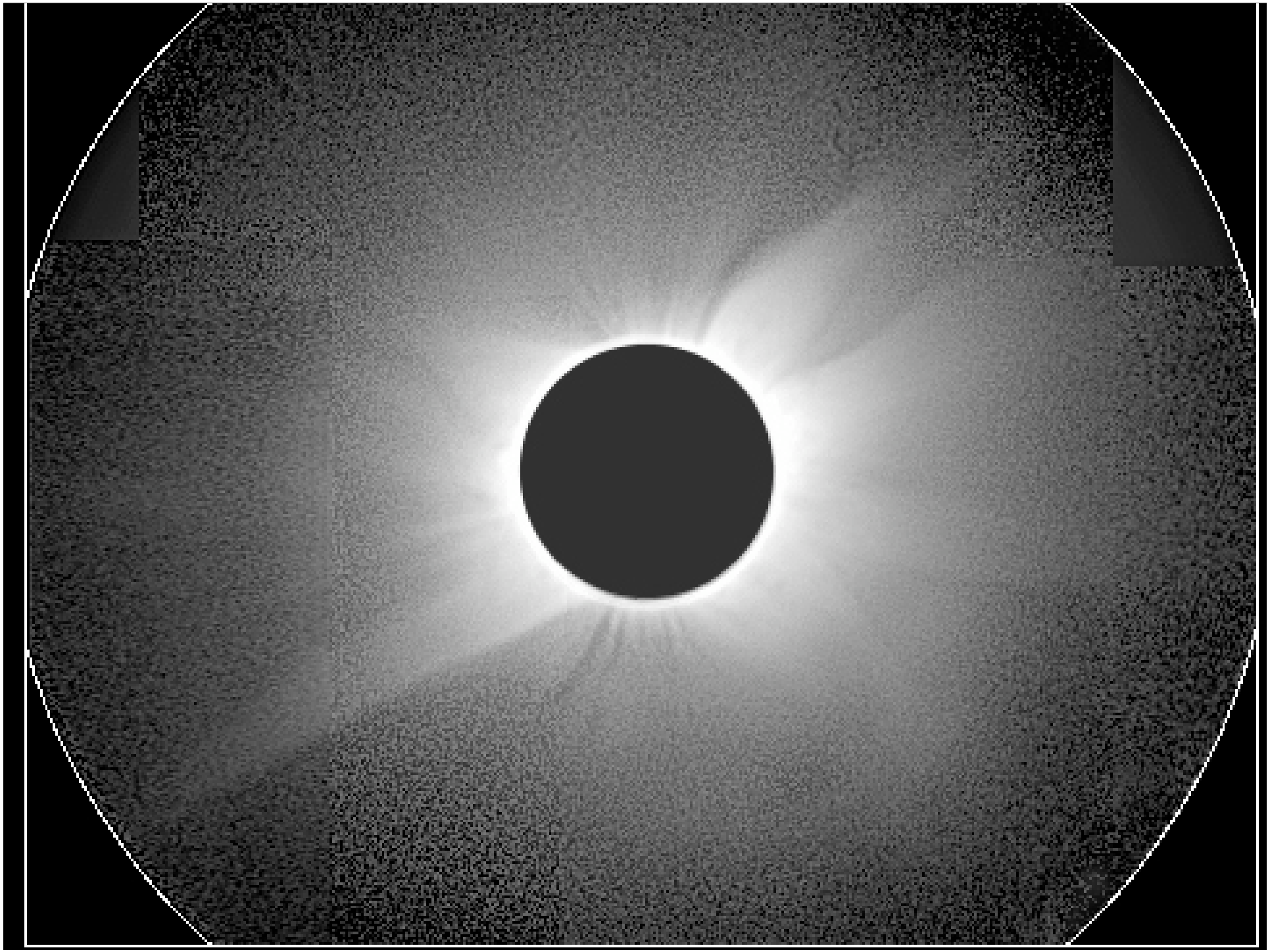


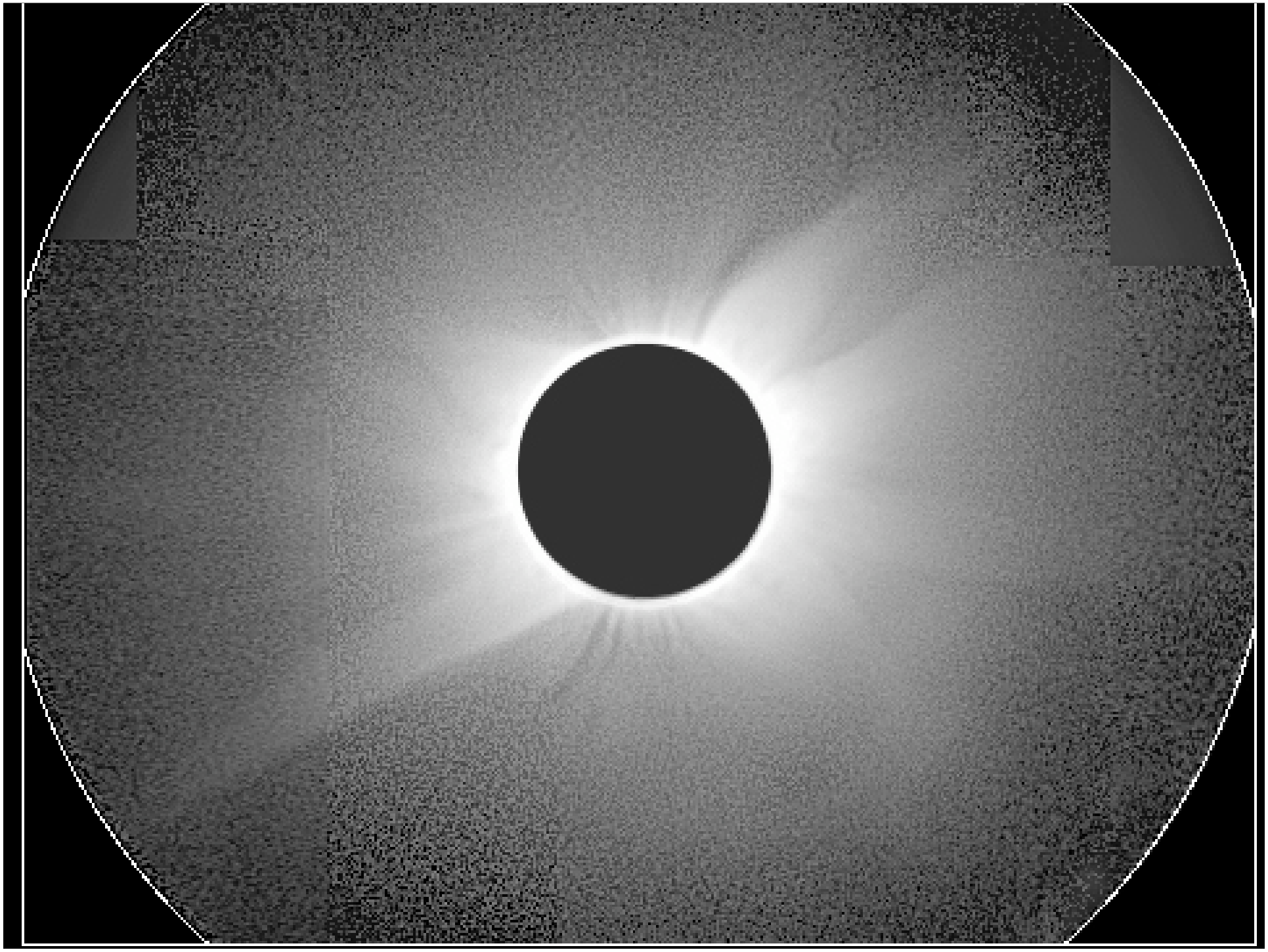


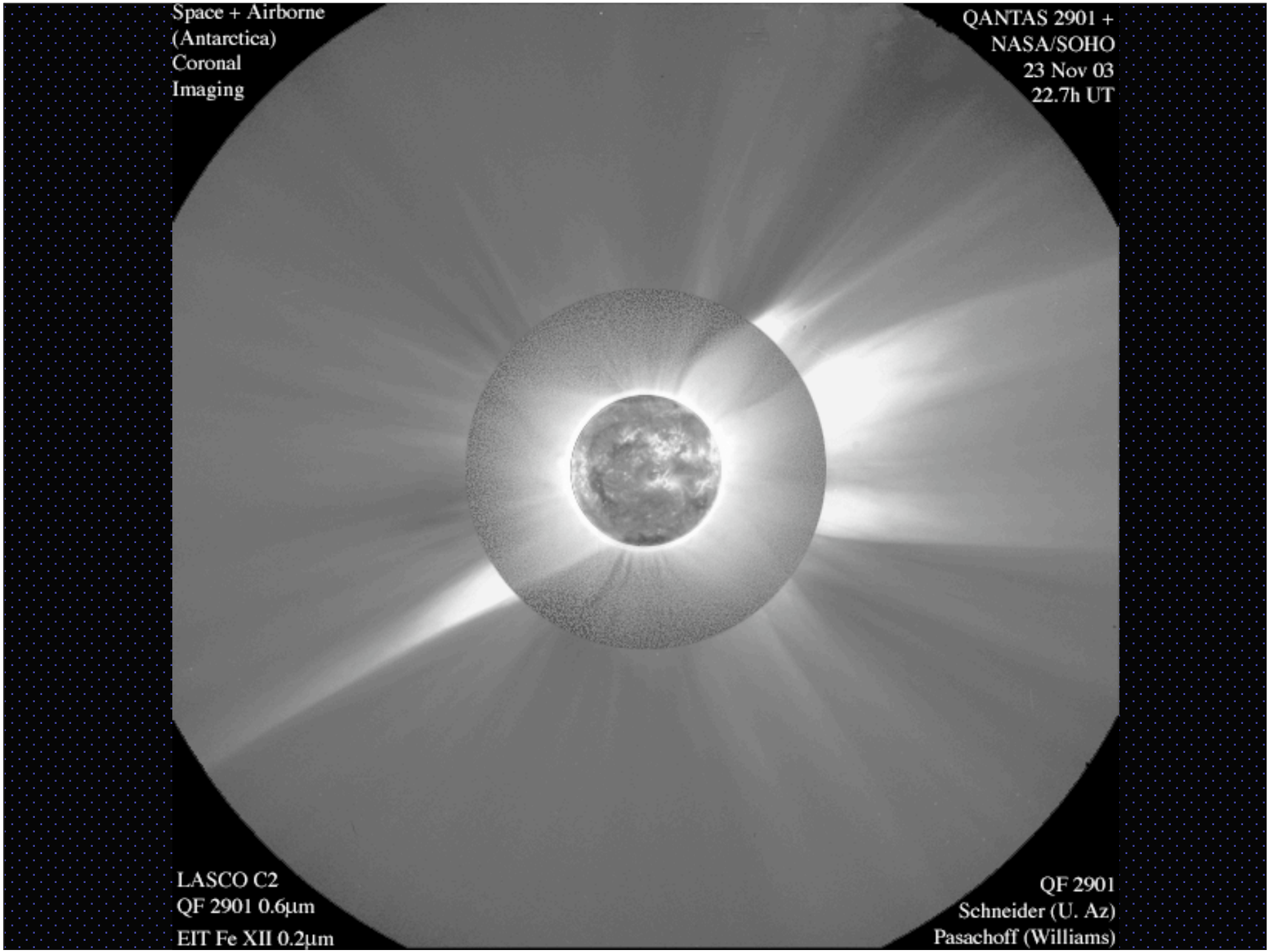











Space + Airborne
(Antarctica)
Coronal
Imaging
QANTAS 2901 +
NASA/SOHO
23 Nov 03
22.7h UT
LASCO C2
QF 2901 0.6μm
EIT Fe XII 0.2μm
QF 2901
Schneider (U. Az)
Pasachoff (Williams)

Play movie: EGRESS_VIDEO.mov

The Umbral Shadow Apex

J. Pasachoff

The Umbra Moves On

C. Roberts

The Shadow Passes

Anti-Sun Side Imaging

Play movie: Friedland_1sEQ1m.mov

1 frame per 10 seconds - J. Friedland

In the Main Cabin

Play movie: GILL_IMSIDE.mov

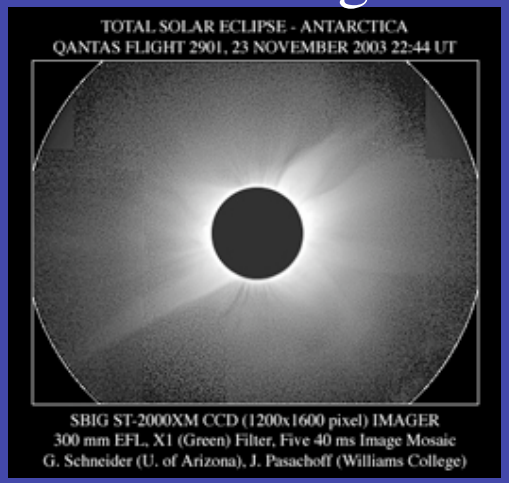
1 frame per 30 seconds - M. Gill

Flight Deck Eclipse Imaging Program

IT WORKED, TOO!

Video Guide Camera

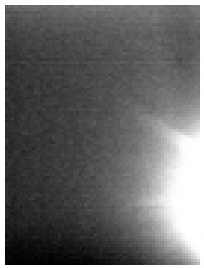
CCD Imager



400mm Film Camera

CCD Imaging Program

SBIG ST-2000XM 1600x1200 CCD CAMERA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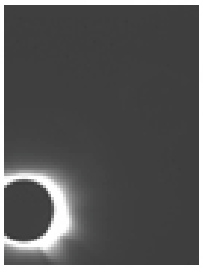
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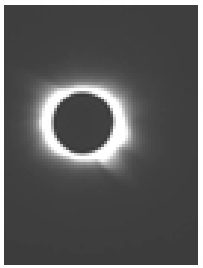
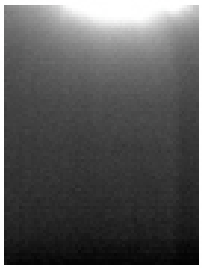

15_04.jpg

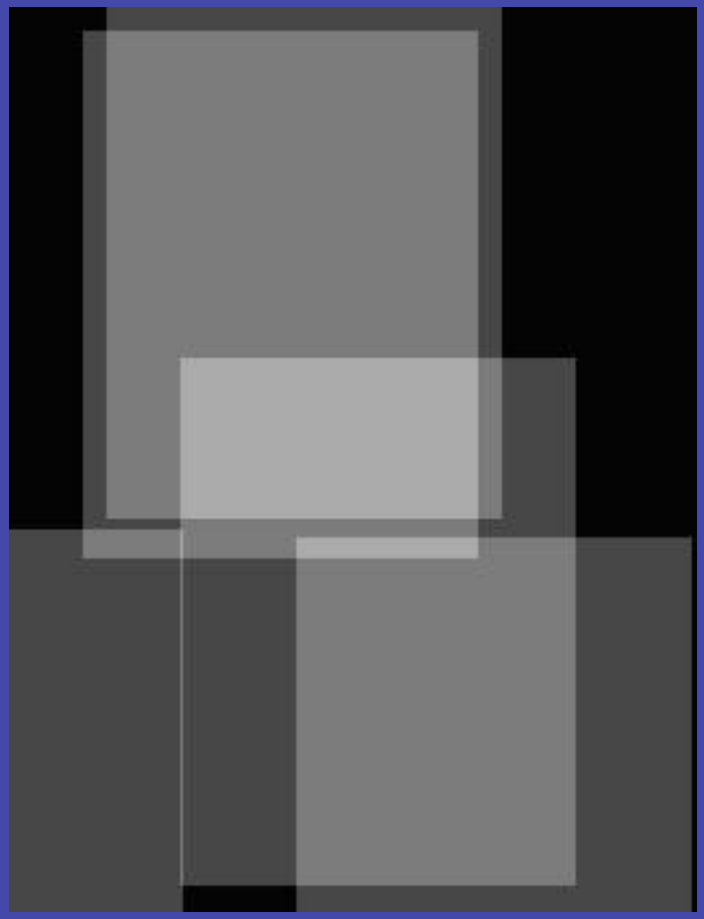
16_04.jpg

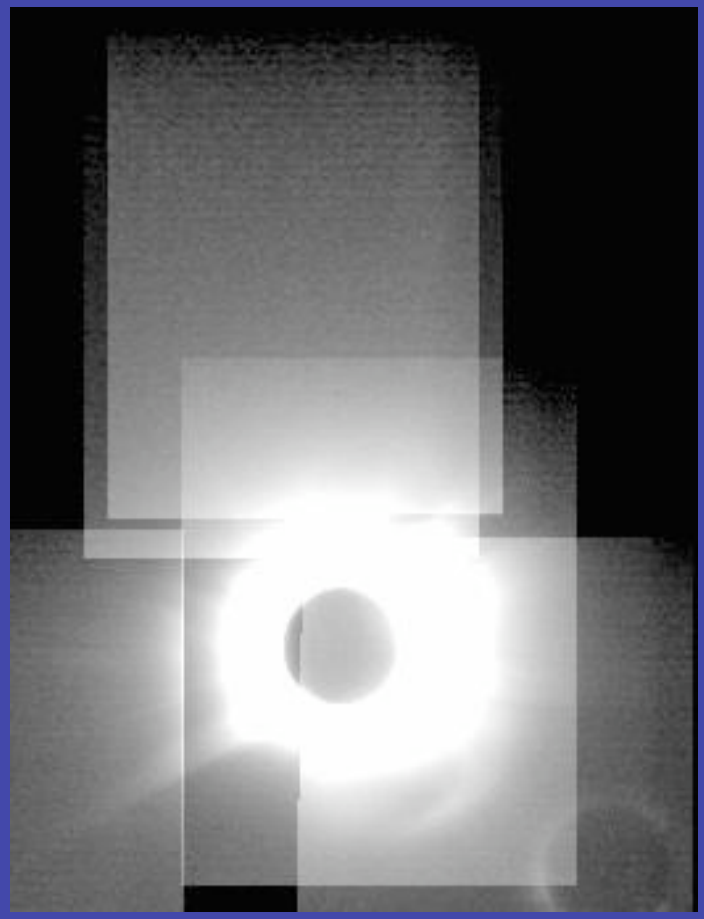

17_04.jpg

Individual 40ms “dithered” frames before combination

CCD Imaging Program

Image Registration and (pre-calibration) combination

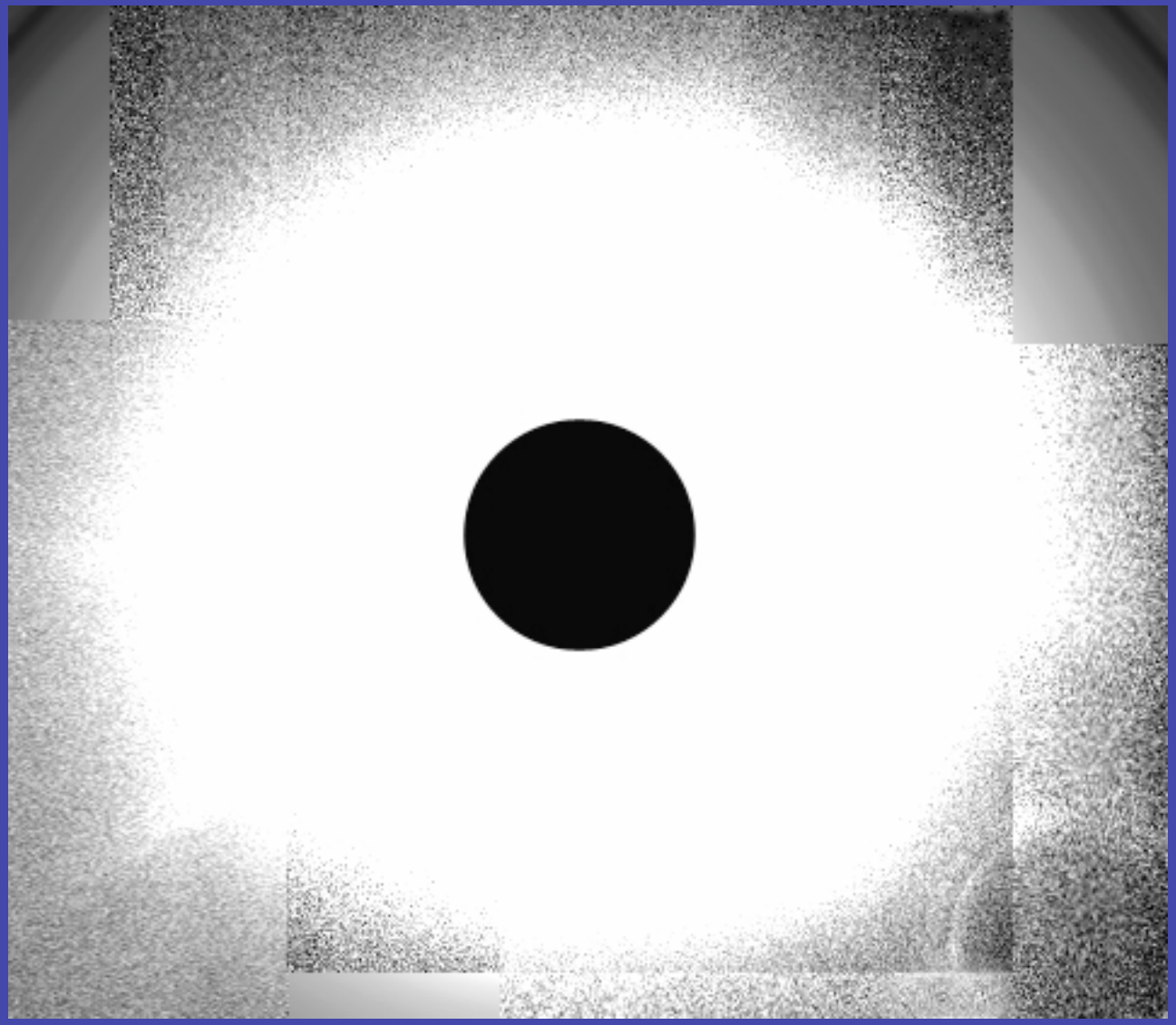




CCD Imaging Program

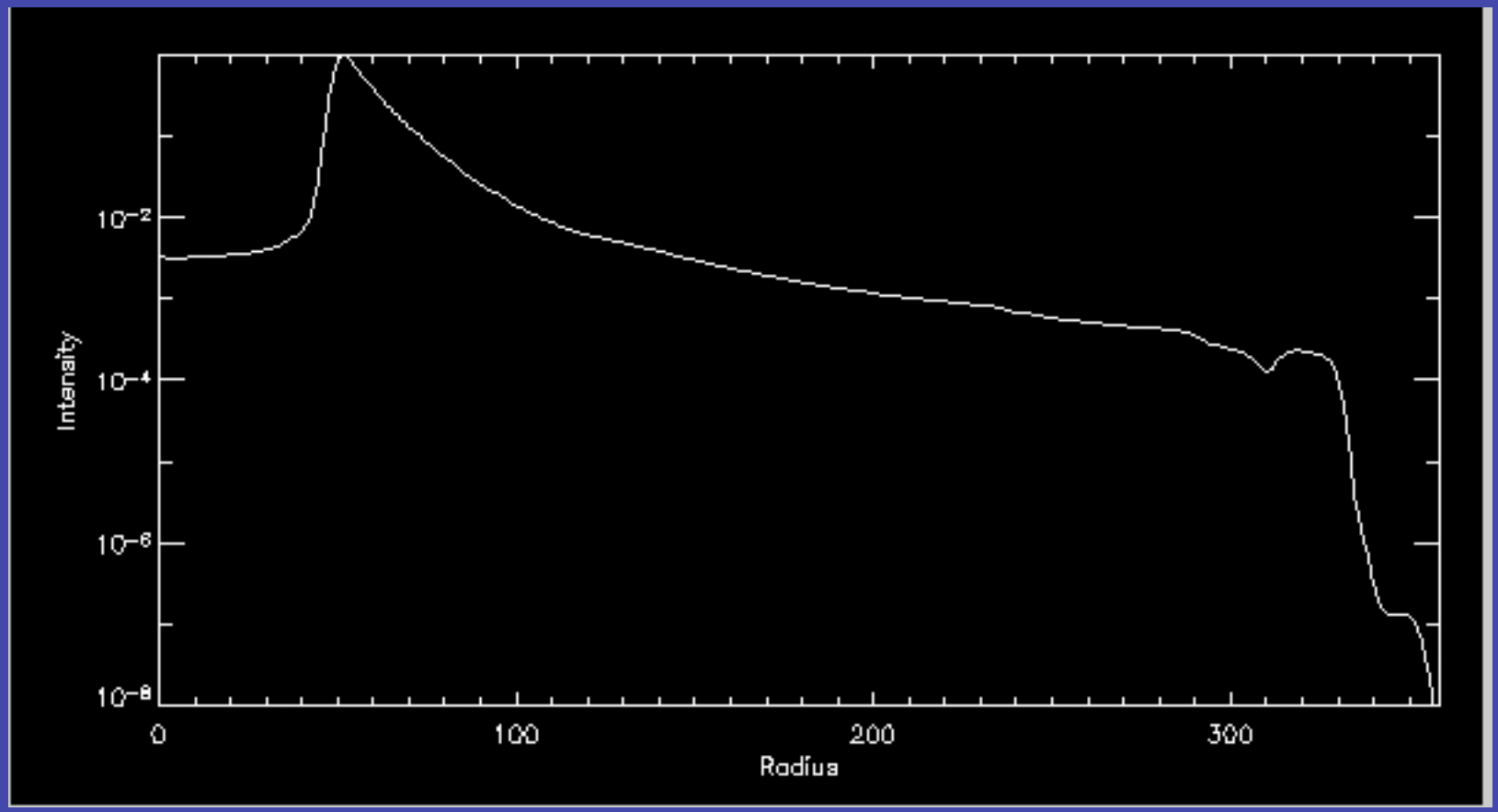
Imaging Dynamic Range

CCD Imaging Program



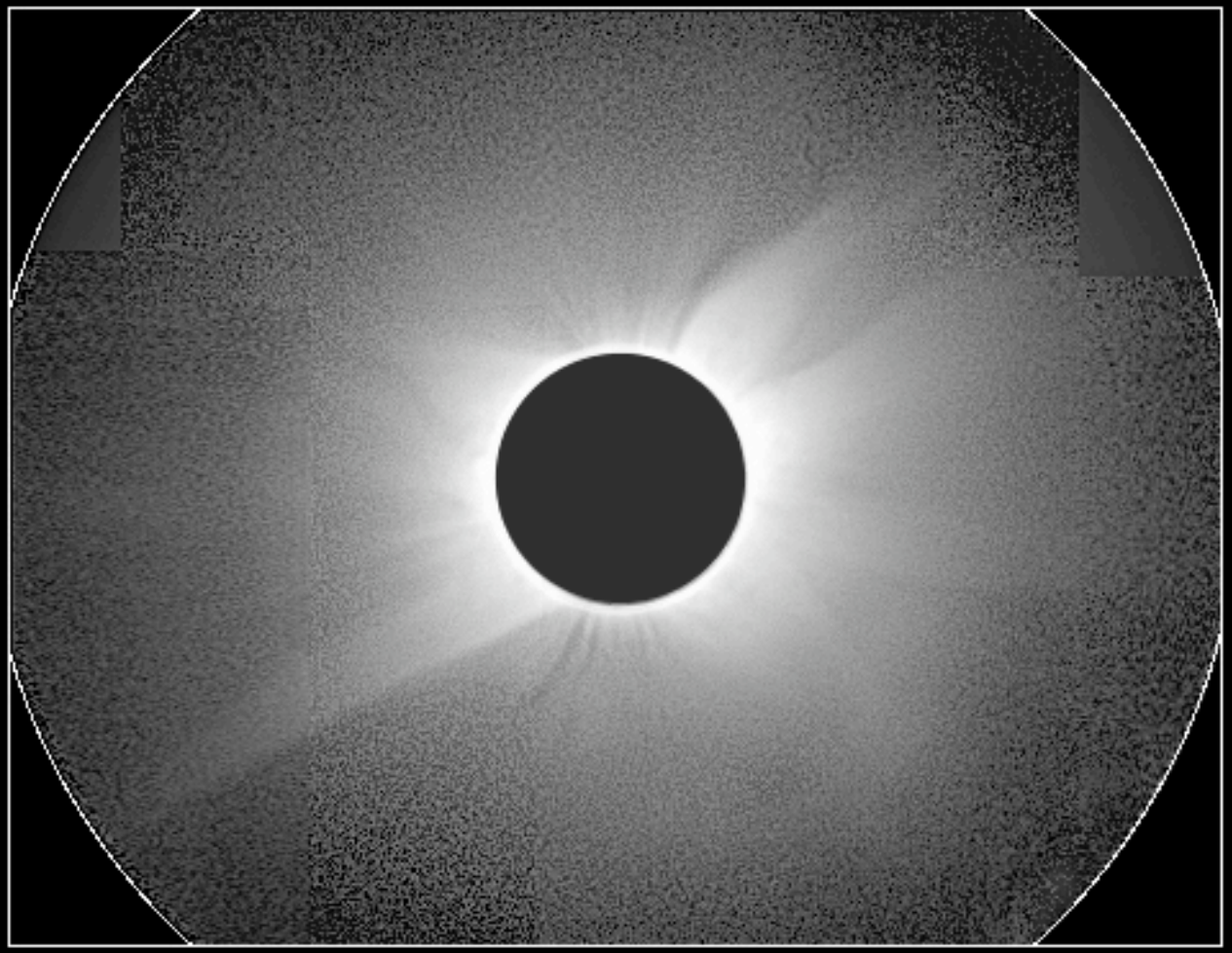
Coronal Extent: S/N=3 pixel^{-1} @ 6 Solar Radii

CCD Imaging Program



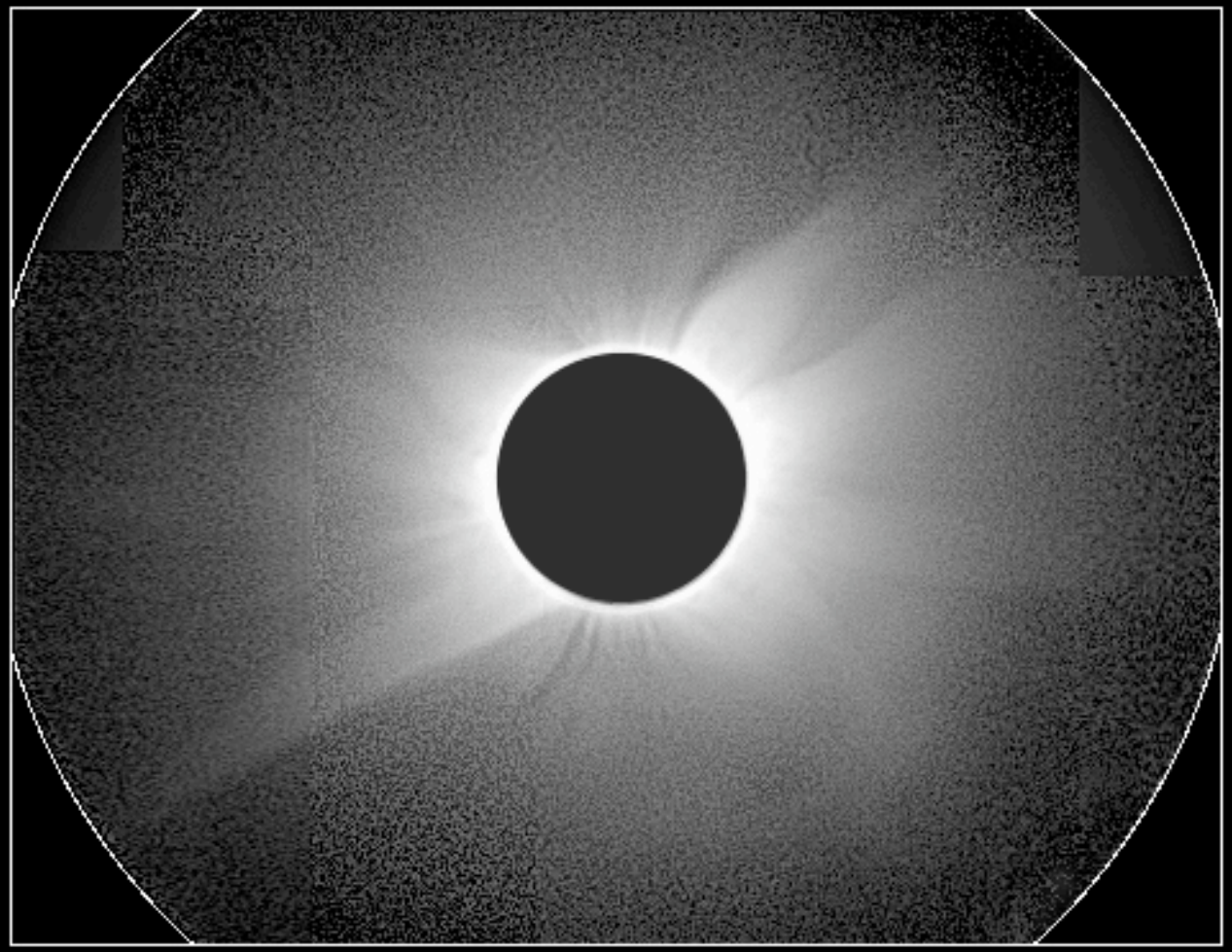
Radial Coronal Surface Brightness - Azimuthal Median
(1/4x resampled pixels)

TOTAL SOLAR ECLIPSE - ANTARCTICA
QANTAS FLIGHT 2901, 23 NOVEMBER 2003 22:44 UT



SBIG ST-2000XM CCD (1200x1600 pixel) IMAGER
300 mm EFL, X1 (Green) Filter, Five 40 ms Image Mosaic
G. Schneider (U. of Arizona), J. Pasachoff (Williams College)

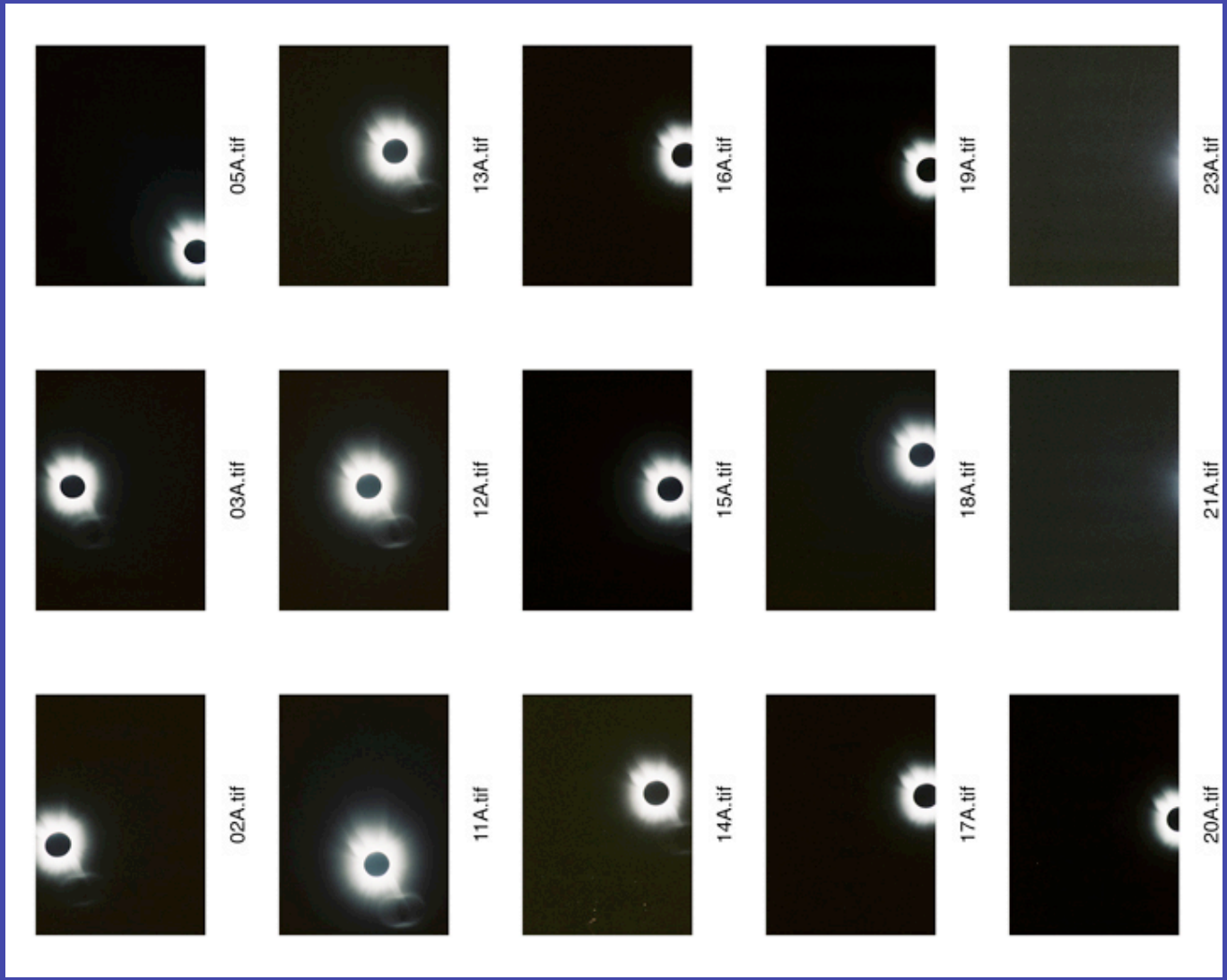
TOTAL SOLAR ECLIPSE - ANTARCTICA
QANTAS FLIGHT 2901, 23 NOVEMBER 2003 22:44 UT



SBIG ST-2000XM CCD (1200x1600 pixel) IMAGER
300 mm EFL, X1 (Green) Filter, Five 40 ms Image Mosaic
G. Schneider (U. of Arizona), J. Pasachoff (Williams College)

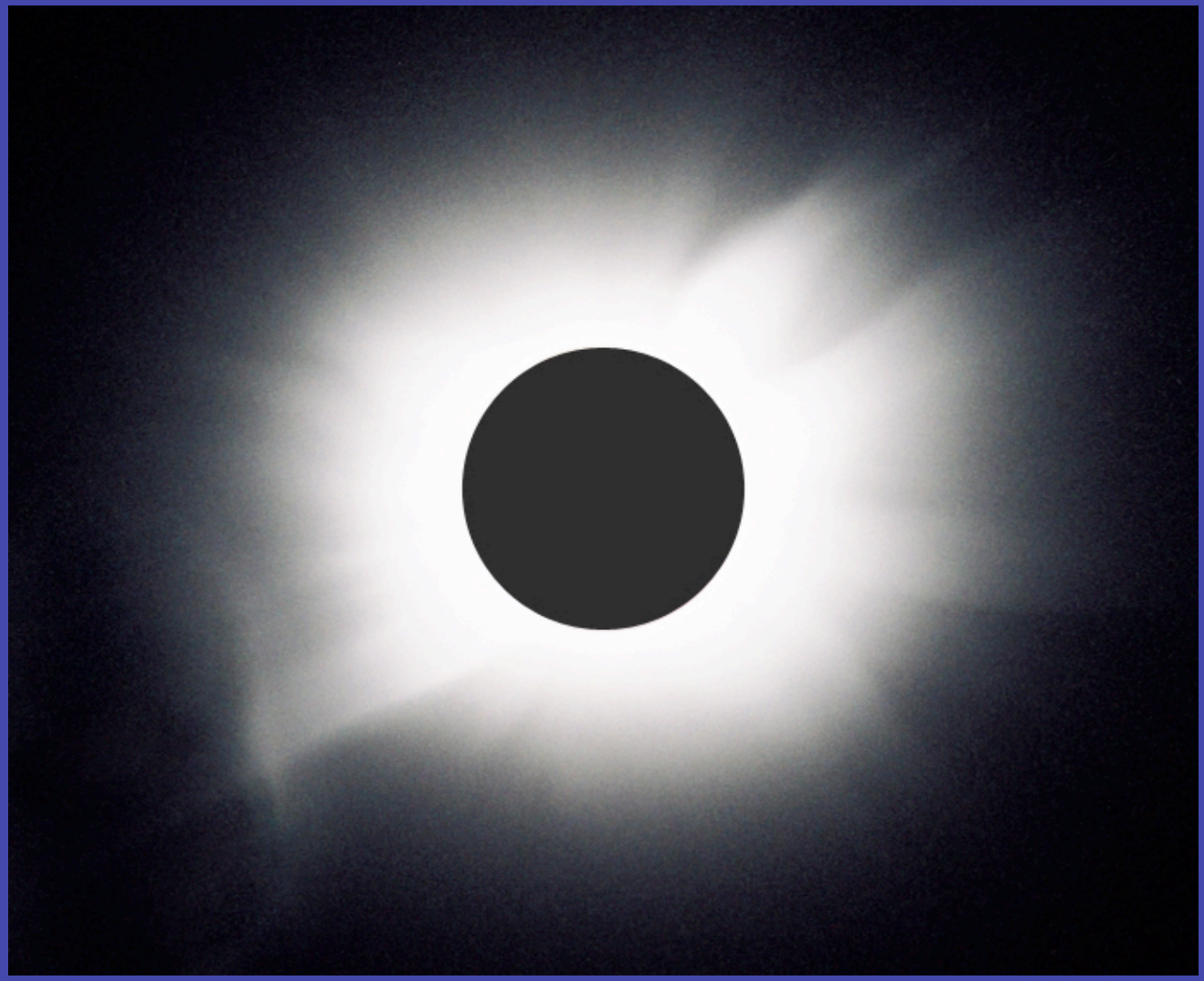
Photographic Imaging Program

NIKON F5 - 400mm f/5.6 Vibration Reduction Lens
FUJI NPZ-800 Color Negative Film Pushed to ISO 3200



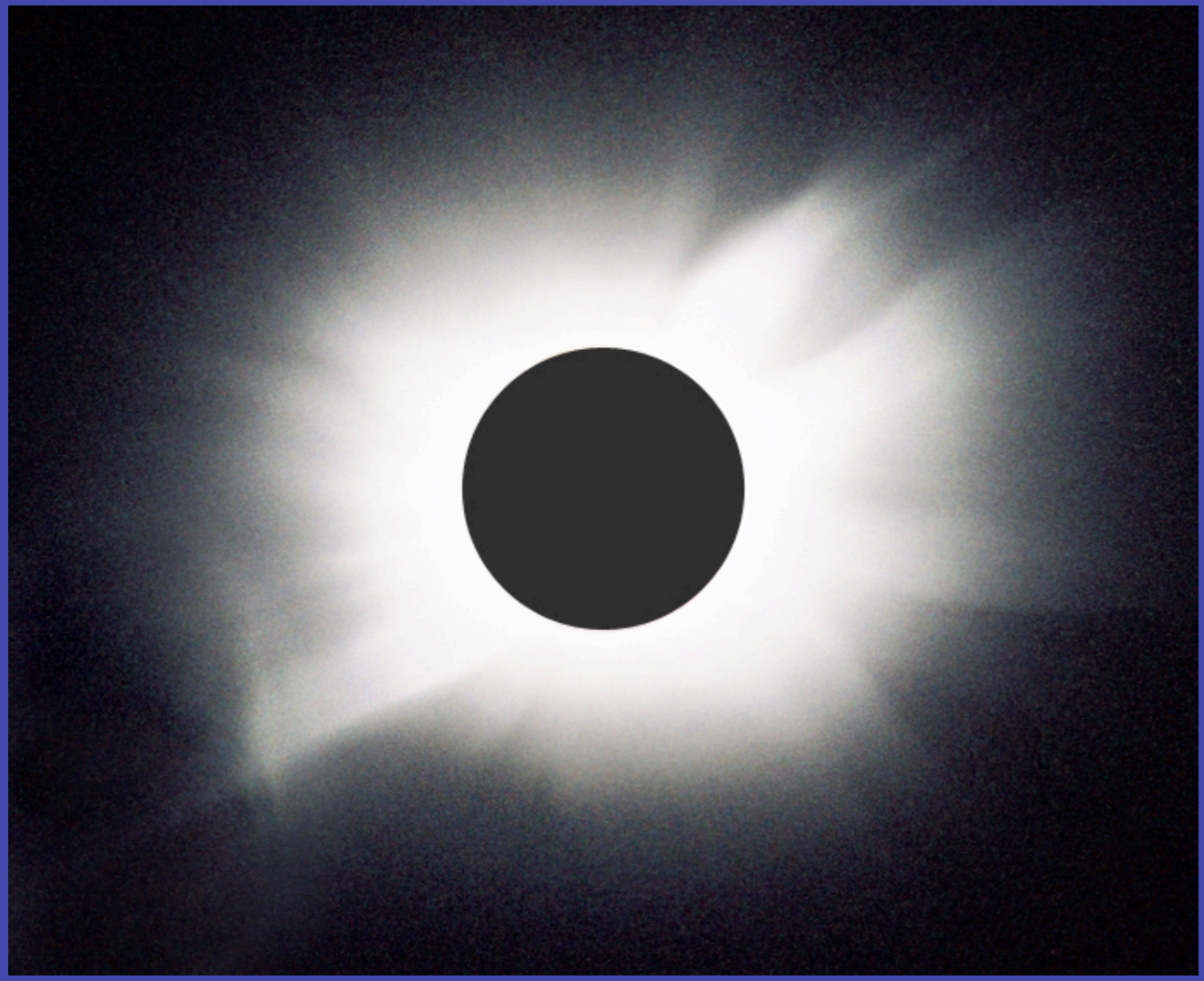
Individual “dithered” frames via UMBRAPHILE

Photographic Imaging Program



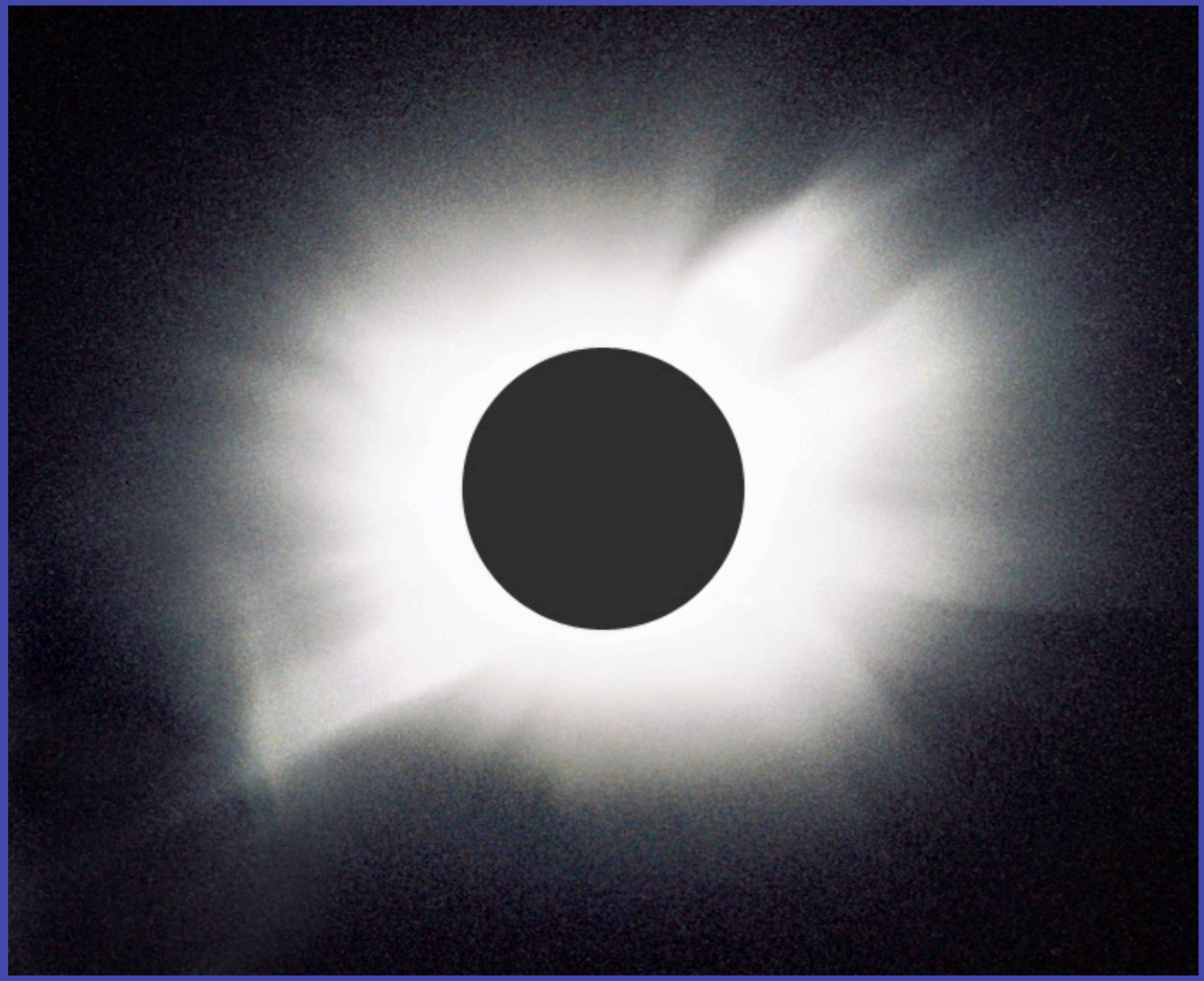
Linear display. Composite of ten (intensity scaled median) and mosaiced digitized image frames.

Photographic Imaging Program



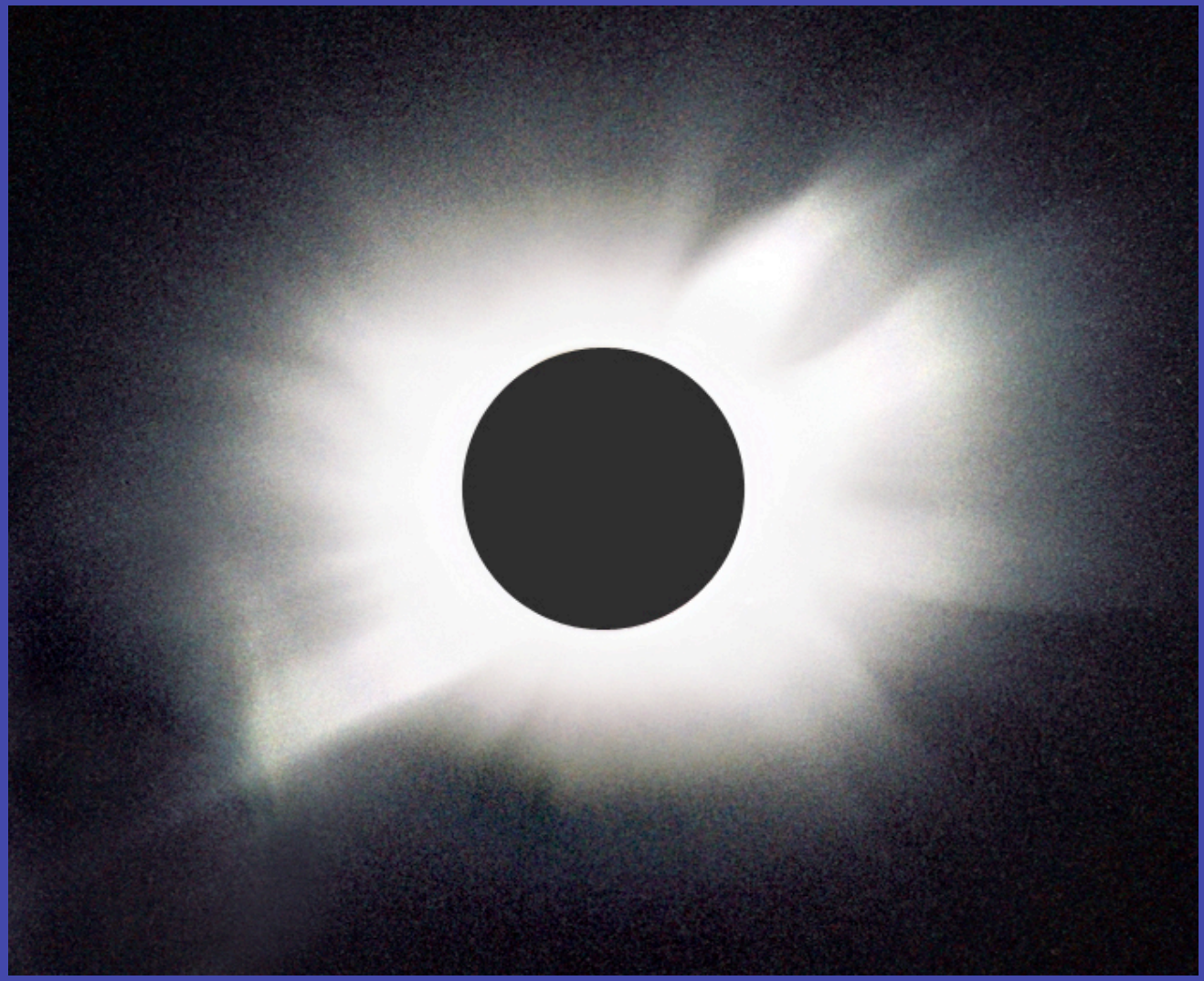
Renormalized 50% intensity of measured median radial brightness profile subtracted from 50% of original image.

Photographic Imaging Program



33% opaque "unsharp mask" of original image (2 pixel FWHM Gaussian kernel, 75% peak pixel normalization) layered on original

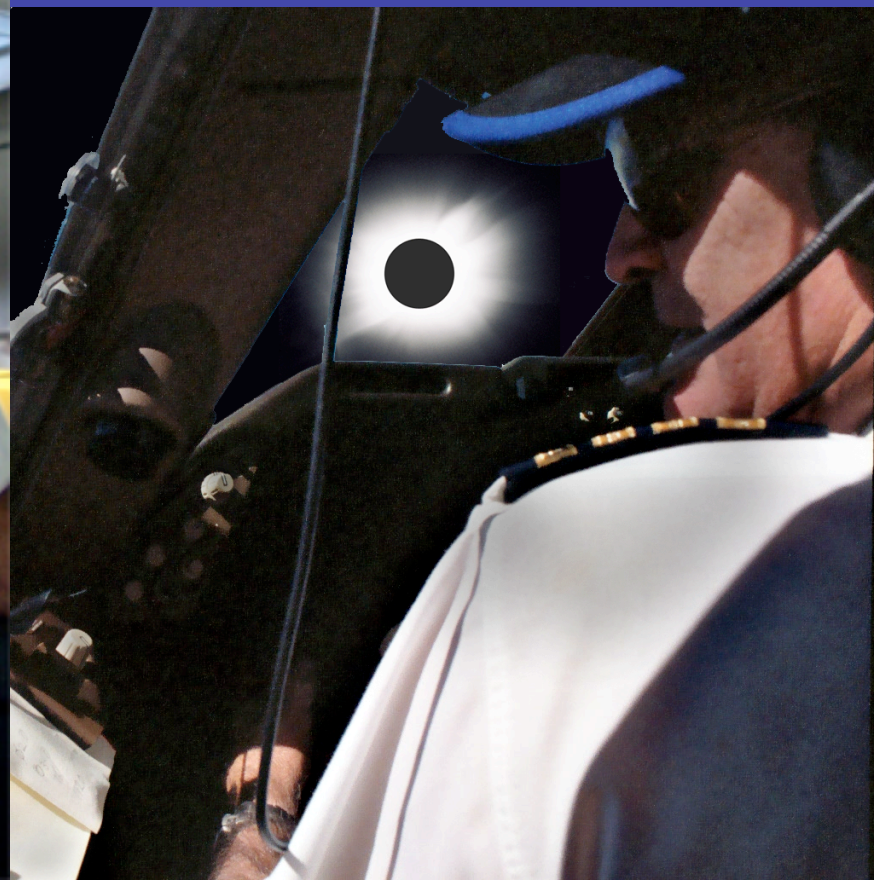
Photographic Imaging Program



50% intensity of measured median radial brightness profile subtracted from previous image

POST-ECLIPSE:

"There was something wrong"
- Cpt. J. Dennis



Play movie: DENNIS_POST_VIDEO.mov

QF 2901 UP-FRONT UMBRAPHILES

QF 2901 UMBRAPHILES ALL!

QF 2901 UMBRAPHILES ALL!

And Now, A Word from Our Sponsor…

Joel Moskowitz

http://www.mac.com/switch

Play movie: Umbraphile_small.mov

From the Makers of EFLIGHT & UMBRAPHILE…

The shaky hand of Jay Friedland

15s (900 frame) Video Segment

Play movie: Friedland_1s_half.mov

"Digital Magic" for Hand-Held Coronal Videography

From the Makers of EFLIGHT & UMBRAPHILE…

The shaky hand of Jay Friedland

"Digital Magic" for Hand-Held Coronal Videography

Most look like this…

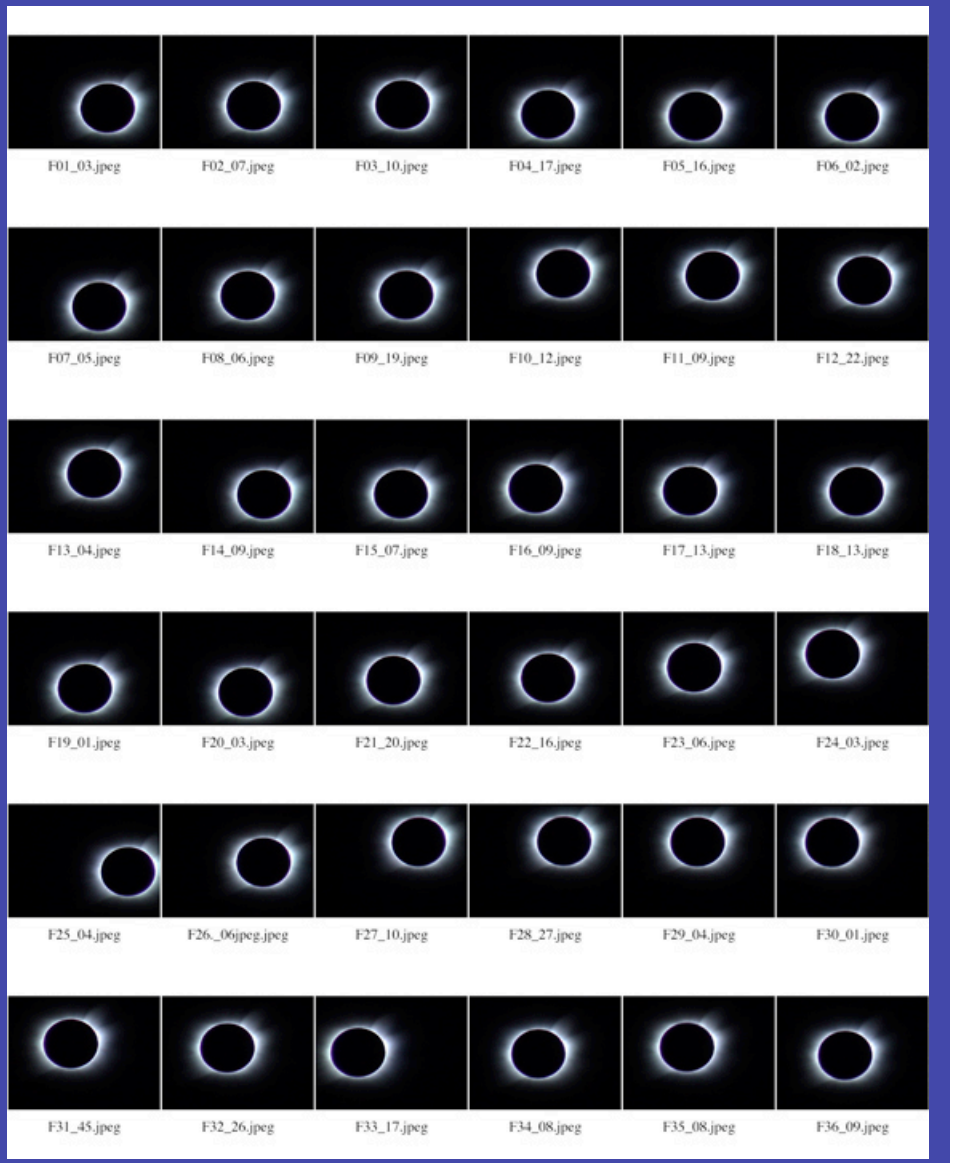
But a few look like this…

From the Makers of EFLIGHT & UMBRAPHILE…

Most look like this…

But a few look like this…

Automated "Good Frames" Identification & Extraction

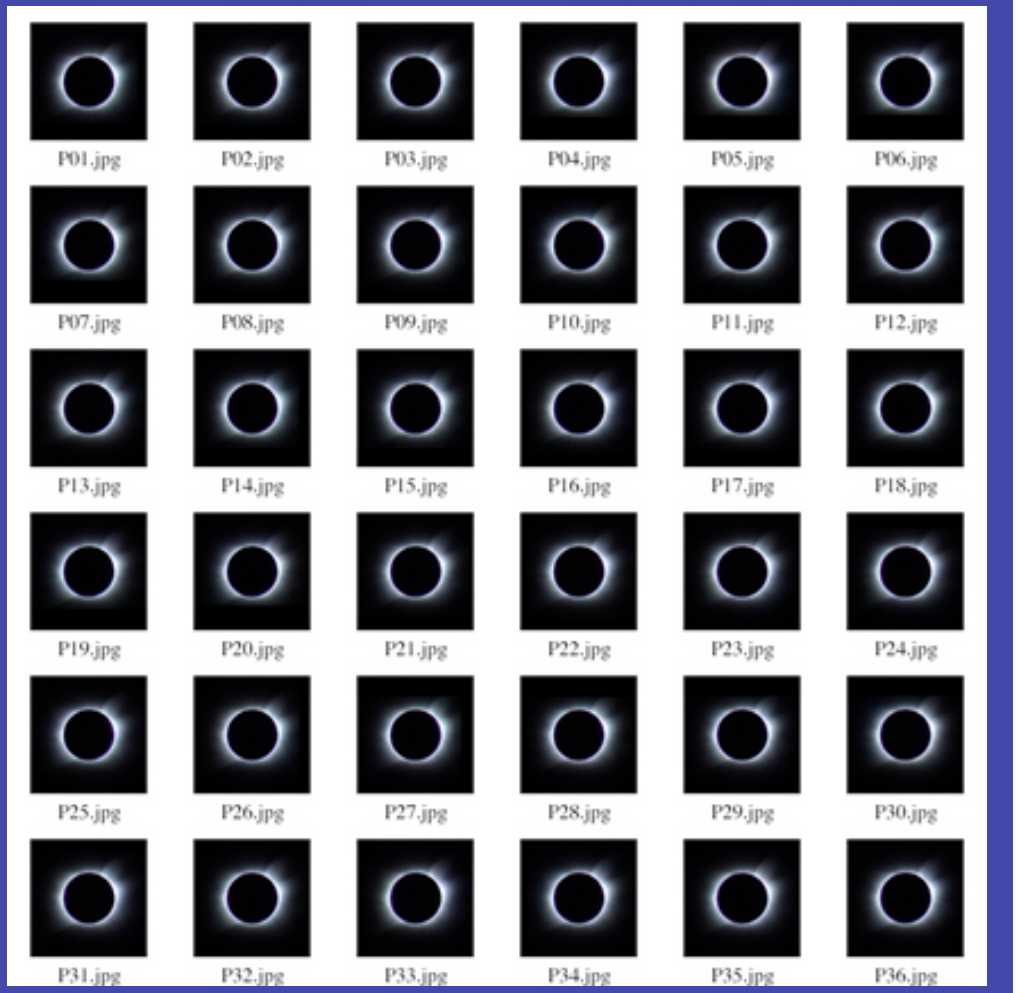


From the Makers of EFLIGHT & UMBRAPHILE…

Most look like this…

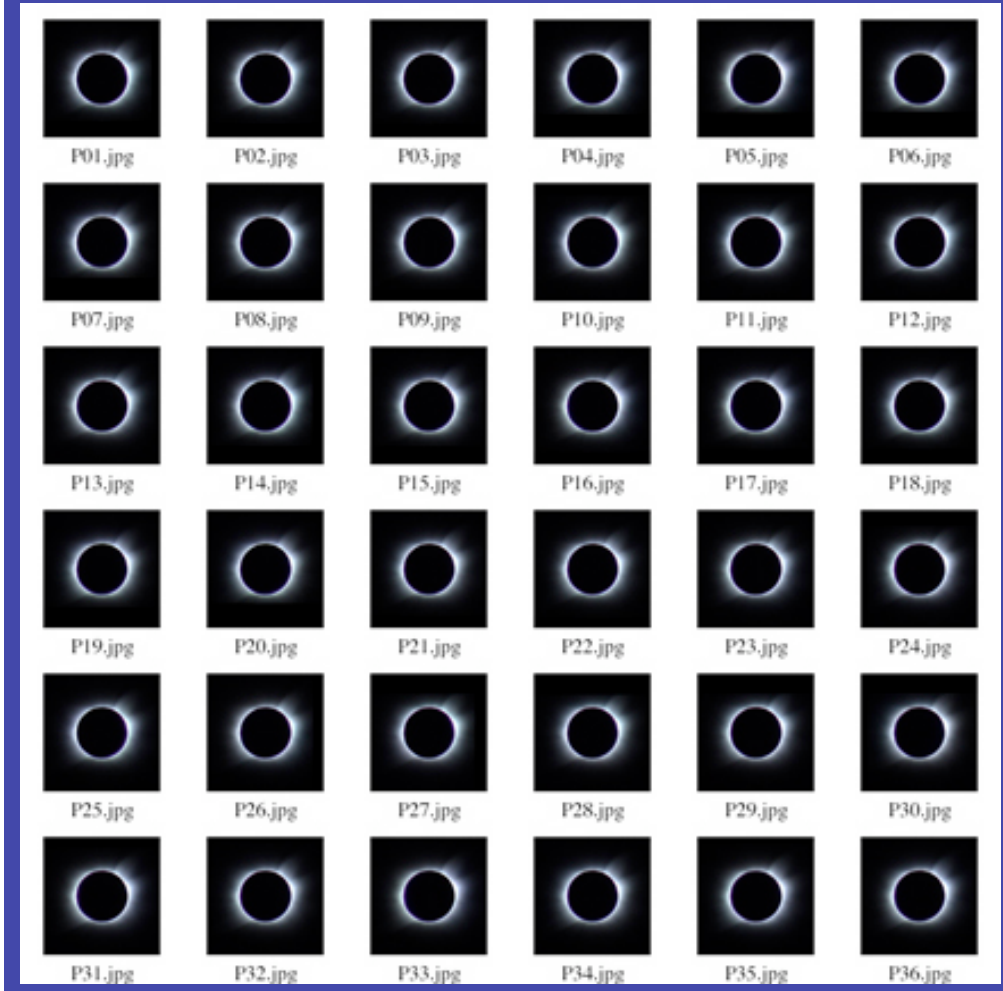
But a few look like this…

Automated "Good Frames" Identification & Extraction



From the Makers of EFLIGHT & UMBRAPHILE…

Automated "Good Frames" Registration

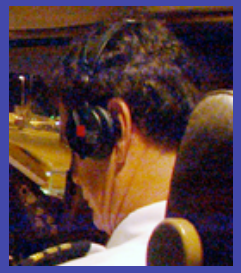


Critical Filtered Selection & Median Combination

http://nicmosis.as.arizona.edu:8000/ECLIPSE_WEB/ECLIPSE_03/DIGITAL_MAGIC/DIGITAL_MAGIC.html

My Personal THANKS to…

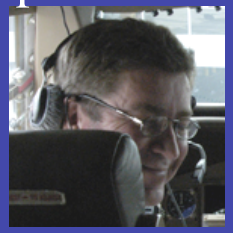
F/O. C. Alderton



F/O. P. Ward

Cpt. P. Elston

Cpt. J. Black



Cpt. I. Getley

T. Jones - Mgr. Security Policy, Planning & Compliance
R. Sheely - Security & Investigation Services Division
Cpt. C. Manning - Group GM Flight Ops & Chief Pilot
Cpt. W. Kearns - GM Flight Ops & Deputy Chief Plot
Cpt. R. McDonald - GM B747 Fleet
S. Stone - QANTAS LAX Duty Manager
Cpt I. Barnet - B747-400 Pilot QF 94
Cpt P. Hunter - B747-400 Pilot QF 64
G. Dixon - CEO QANTAS Airways Ltd.

All the Folks at CROYDON TRAVEL

Friends & Colaborators

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J. Moskowitz
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