The Exploration of comet P/Wild 2 by STARDUST

T. Duxbury (Jet Propulsion Laboratory)

The NASA Discovery STARDUST Mission will fly by comet P/Wild 2 in January 2004 and return cometary dust particles to earth in January 2006. This is the first planetary sample return mission launched since the Apollo days. The STARDUST spacecraft is over half way on its voyage to P/Wild 2 and is carrying JPL Aerogel Dust Collector, the Max Planck Institute Cometary and Interstellar Dust Analyzer (CIDA), the University of Chicago Dust Flux Monitor Instrument (DFMI) and the JPL camera. Additionally, radio science and high rate attitude data will be taken within the comet coma. The aerogel collector has been deployed already to collect interstellar dust particles and will open again this summer for its second collection of interstellar dust particles. The camera had been contaminated with an unknown coating after launch that has since been successfully removed by heating the optics and CCD. The DFMI has a power problem that only allows the instrument to operate less than 1 hour before needing to be reset. However both CIDA and DFMI have made observations of interstellar dust during cruise and the camera has imaged the moon during an earth gravity assist flyby. Details of the remaining mission will be given.

Solar System Planetary Missions JPL

Exploration of Comet P/Wild 2 by STARDUST

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29 July 2002

STARDUST

JPL

- *4th NASA Discovery Project*
  - *Mars Pathfinder, NEAR, Lunar Explorer prior Missions*
- *1st NASA Unmanned Planetary Sample Return Mission*
- *NASA, Univ of WA, JPL and LMA Partnership*
- *Prof. Donald Brownlee, University of Washington, PI*
  - *Co-I's*
    - *Drs. Martha Hanner, JPL, Fred Horz, JSC,*
    - *Tony McDonald, UK, Scott Sandford, ARC,*
    - *Zdenek Sekanina, JPL, and Mike Zolensky, JSC*
  - *Co-I's with Payload Instruments*
    - *Aerogel Collector - Dr. Peter Tsou, Deputy PI, JPL*
    - *CIDA - Dr. Jochen Kissel, MPI fur Kernphysik,*
    - *DFMI - Dr. Anthony J. Tuzzolino, U of Chicago*
    - *NavCam - Dr. Ray Newburn, JPL*
    - *Radio Science - Dr. John Anderson, JPL*
    - *High Rate Attitude - Dr. Benton Clark, LMA*

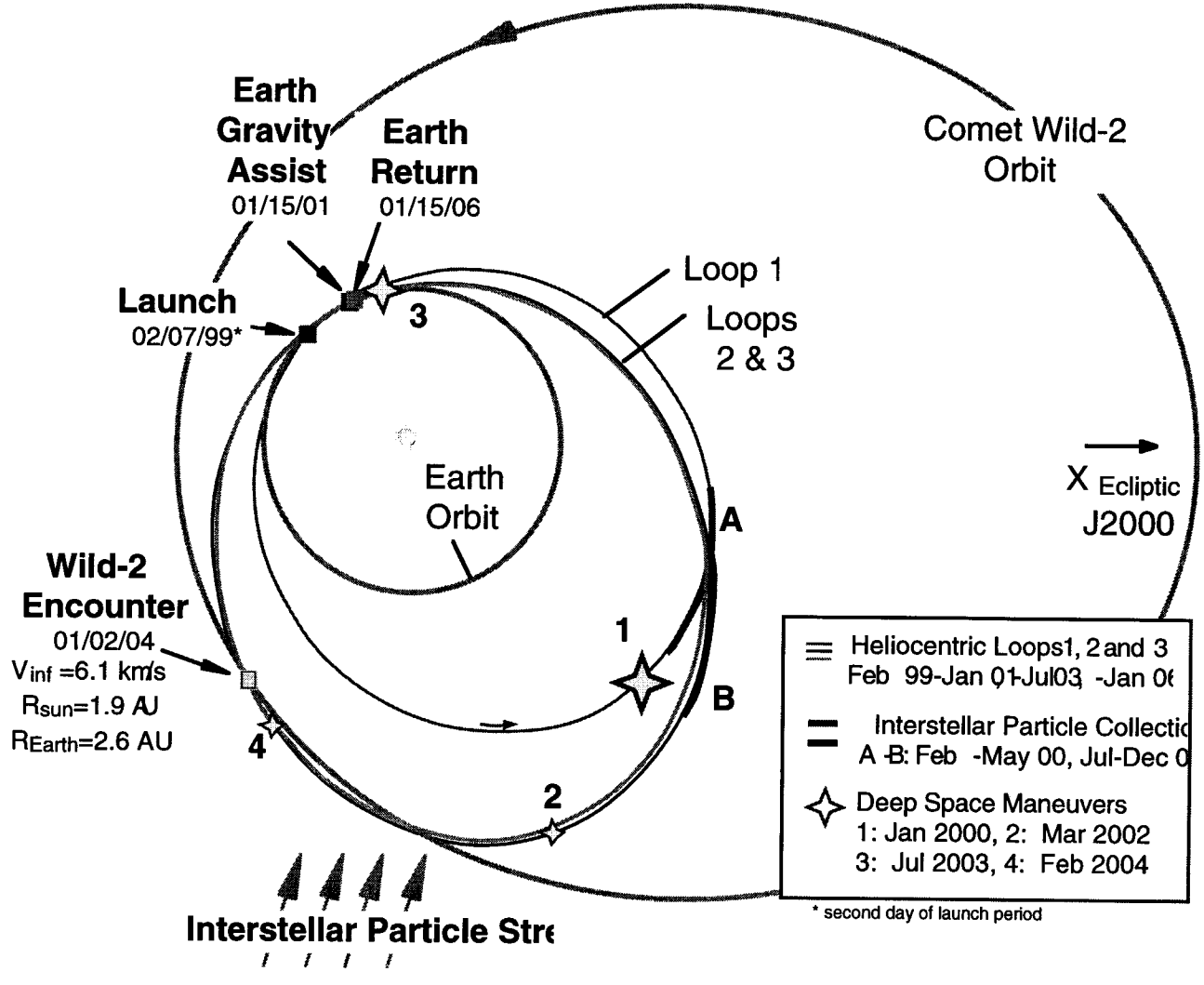
STARDUST SCIENCE OBJECTIVES

JPL

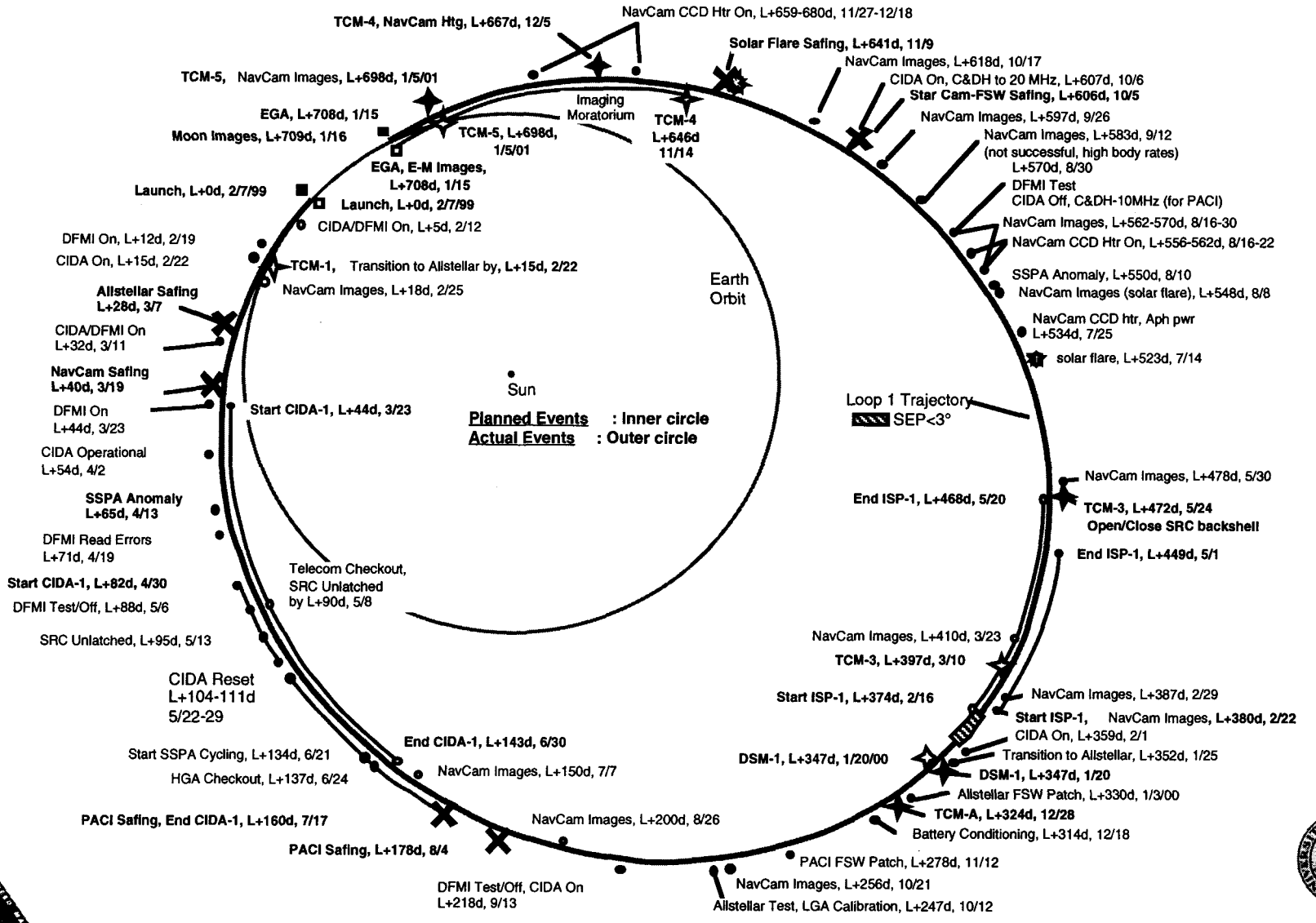
Primary Requirement:	Collect 1000 Comet particles >15 μm at encounter velocity < 6.5 km/sec and return to Earth
Secondary Requirements:	Collect 100 Interstellar particles >0.1 μm and return to Earth. Provide ≥ 65 images of P/Wild 2, having a resolution of at least 67 μrad per pixel, taken within 2000 km of the comet nucleus through selected filters; Provide in situ particle analysis for comet coma flythrough capable of resolving abundant elements in cometary solids
Tertiary Requirements:	Provide in situ particle analysis for interstellar and interplanetary dust; Measure dust mass fluence, large particles and comet mass upper limit Provide dust flux measurement of 10^{-9} g to 10^{-4} g particles

Trajectory Overview

JPL

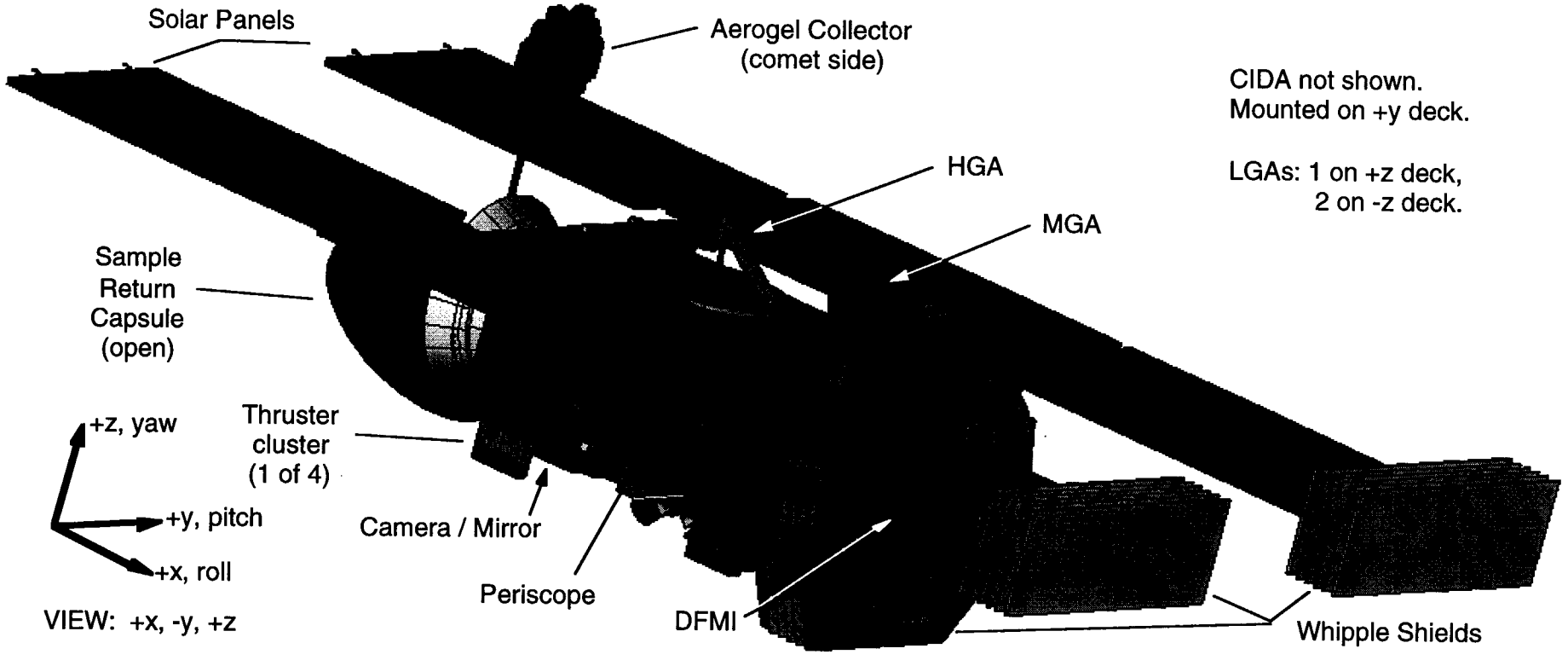


Loop 1 : As Flown v. Plans



LMA Spacecraft w/ SRC

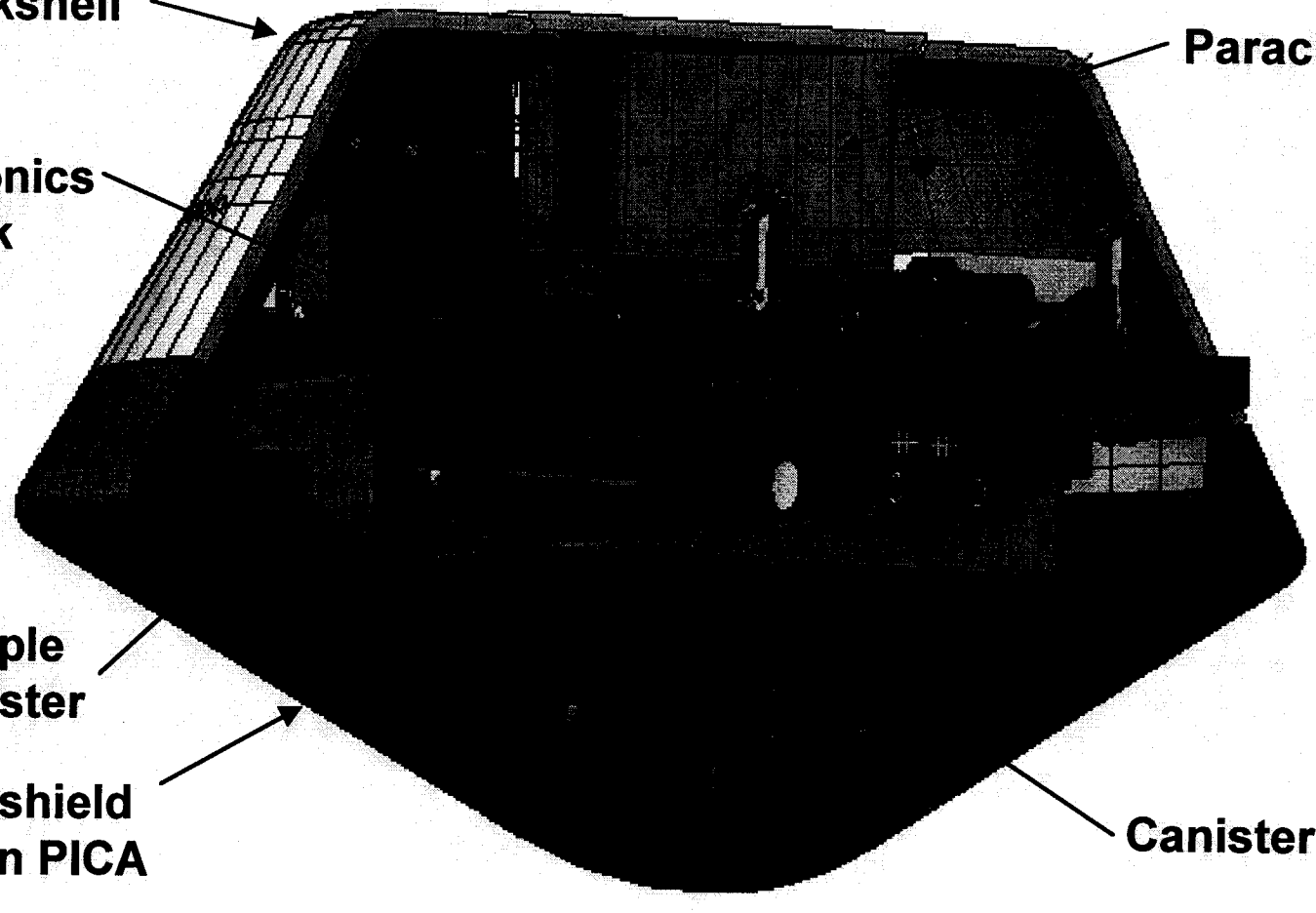
JPL



CIDA not shown.
Mounted on +y deck.

LGAs: 1 on +z deck,
2 on -z deck.

Stardust Sample Return Capsule (SRC) JPL

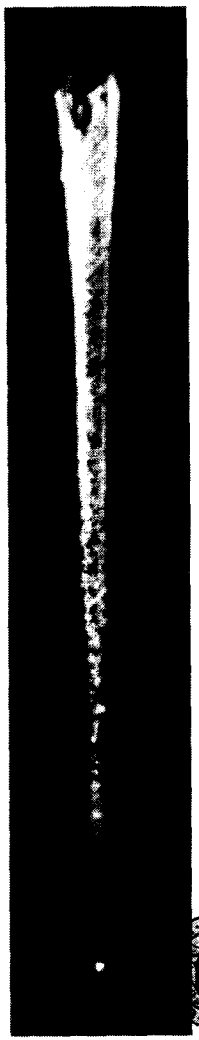


AREOGEL

JPL

Coma & Interstellar Dust Collection

To collect the particles without damaging them, STARDUST will use an extraordinary substance called aerogel - a silicon-based solid with a porous, sponge-like structure in which 99 percent of the volume is empty space. Aerogel is 1,000 times less dense than glass, another silicon-based solid. When a particle hits the aerogel, it will bury itself in the material, creating a carrot-shaped track up to 200 times its own length, as it slows down and comes to a stop - like an airplane setting down on a runway and braking to reduce its speed gradually. Since aerogel is mostly transparent - sometimes called blue smoke - scientists will use these tracks to find the tiny particles.

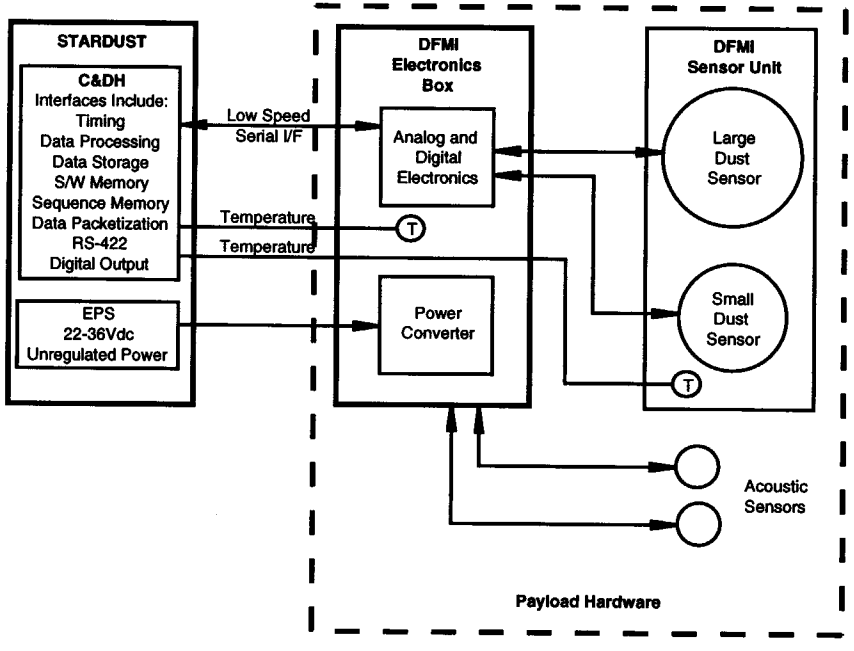


Dr. Peter Tsou, Deputy PI

CIDA - MPI fur Kernphysik

Dr. Jochen Kissel with CIDA

University of Chicago - Dust Flux Monitor Instrument



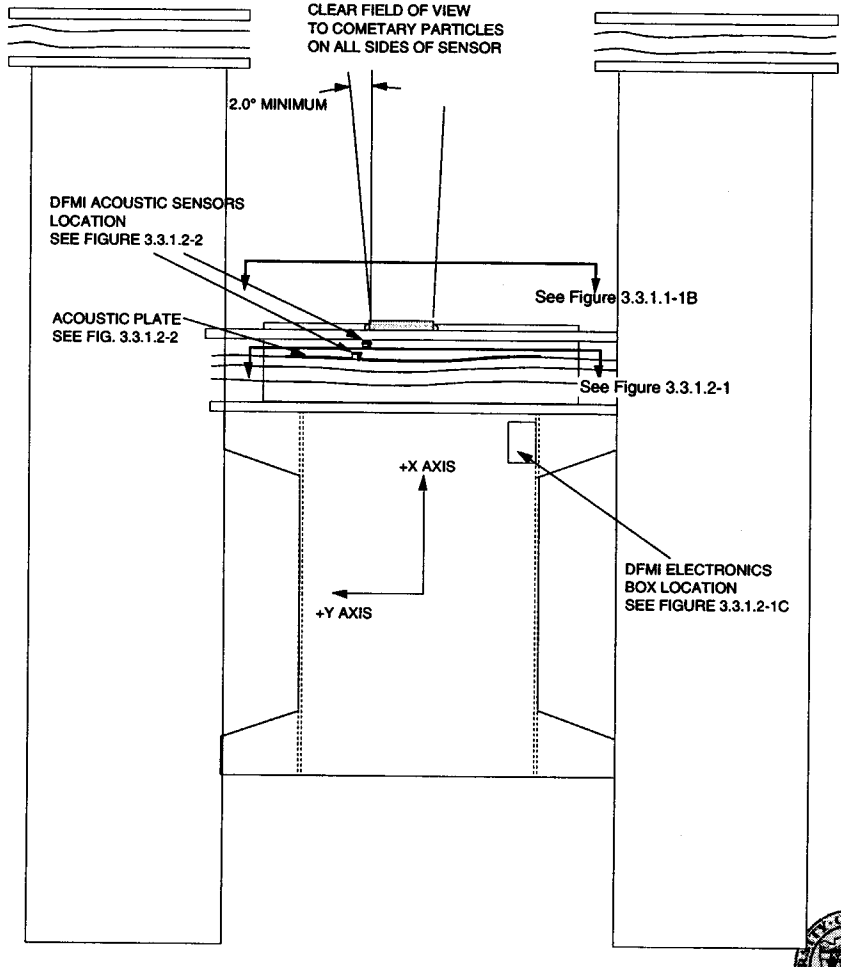
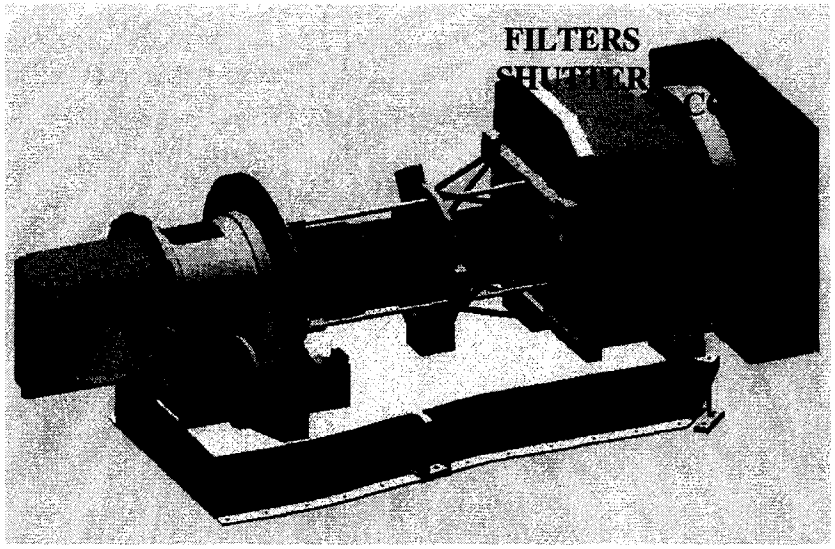


FIGURE 3.3.1.1-1 DFMI LAYOUT ON SPACECRAFT
(NO SCALE)

JPL CAMERA

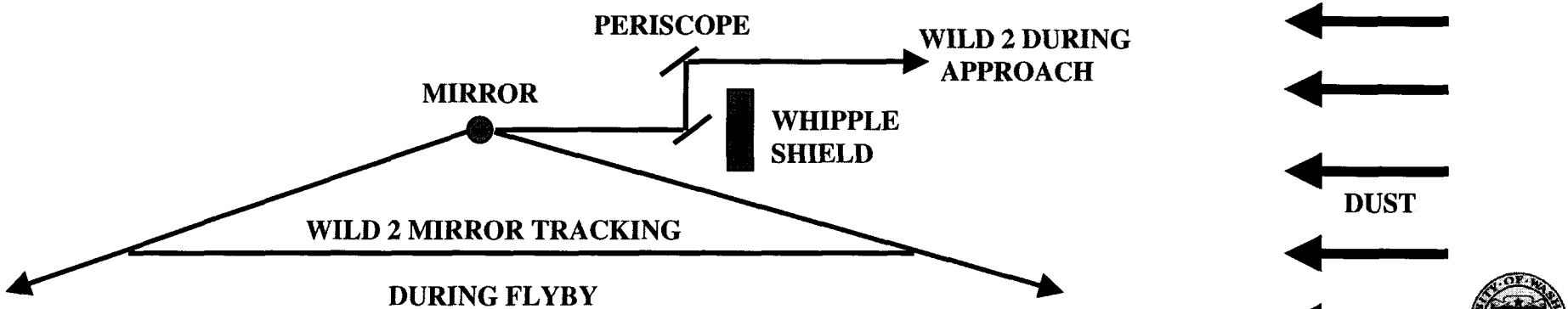


CHARACTERISTICS

- 200 mm VGR WA Optics
- 1024 x 1024 Cassini CCD
- 60 μrad / pixel
- 1 Deg-of-freedom Mirror (200 deg)
- 8 Filters

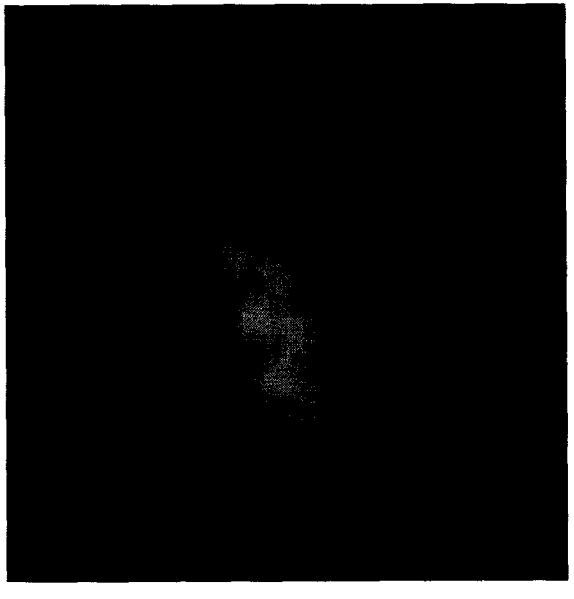
5140 ±	60	C_2 (Blue)
5800 ±	20	Yellow Continuum
5900 ±	1000	Hi Res (Nucleus)
6340 ±	60	O[^{1}D]
6650 ±	75	NH_2
7000 ±	2000	Navigation
7130 ±	30	Red Continuum
8700 ±	150	Near IR

- Periscope - protect optics during approach

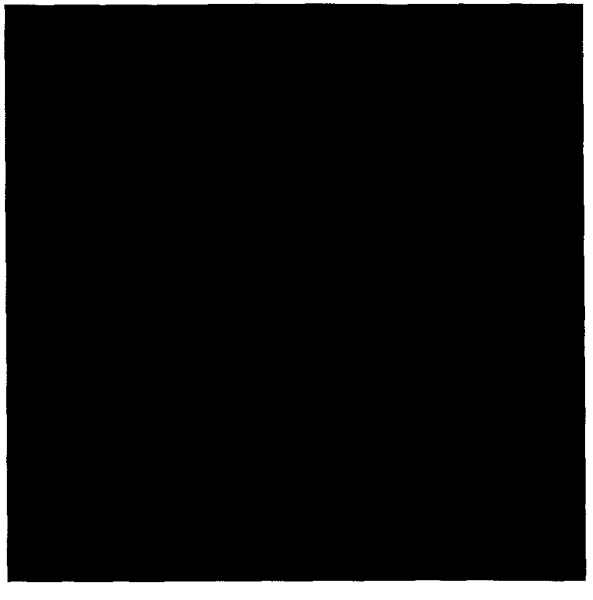


Nav Cam Cleanup

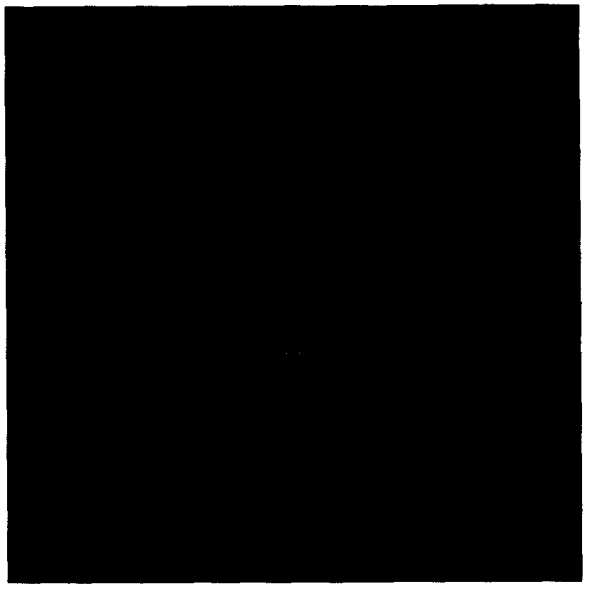
- **Completed Nav Cam Heating Sequence #2**
  - **Removed 60% of Contamination**
  - **Additional Heating Under Study**



PRE-LAUNCH



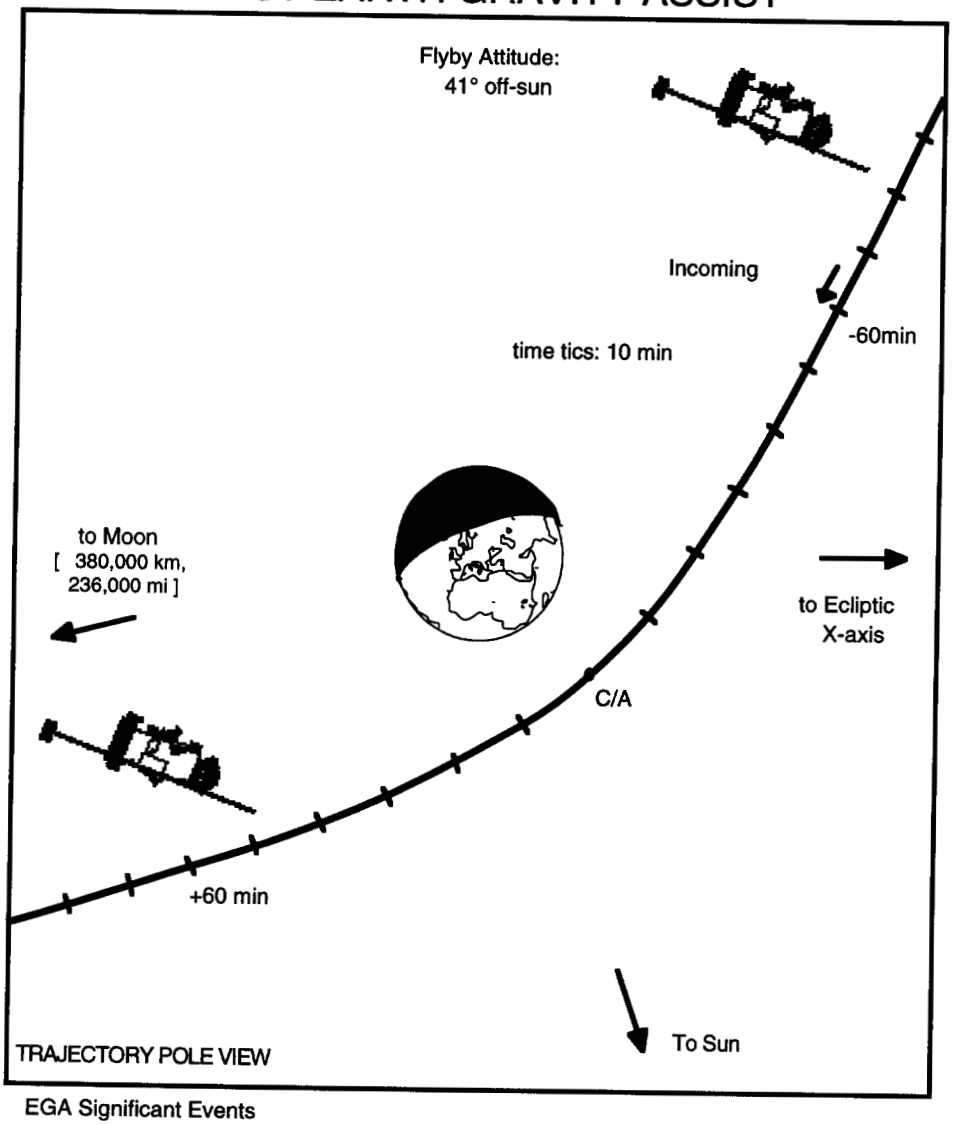
PRE-HEATING



POST-HEATING

EGA Close Flyby (Actual)

STARDUST EARTH GRAVITY ASSIST



EGA Significant Events

TCM-4	Dec. 05, 2000	C/A-41 days
TCM-5	Jan. 05, 2001	C/A-10 days
Earth Flyby*	Jan. 15, 2001	11:14:28 UTC
	Altitude = 6007.6 km [3733.8 mi], Lat = -40.5°, Long = 38.1° E	
	Speed = 10.3 km/s [37,000 kph, 23,000 mph]	
Moon Flyby*	Jan. 16, 2001	02:02:20 UTC
	Range = 97,797 km [60,781 mi]	
CANCELED TCM-6	Feb. 14, 2001	C/A+30 days

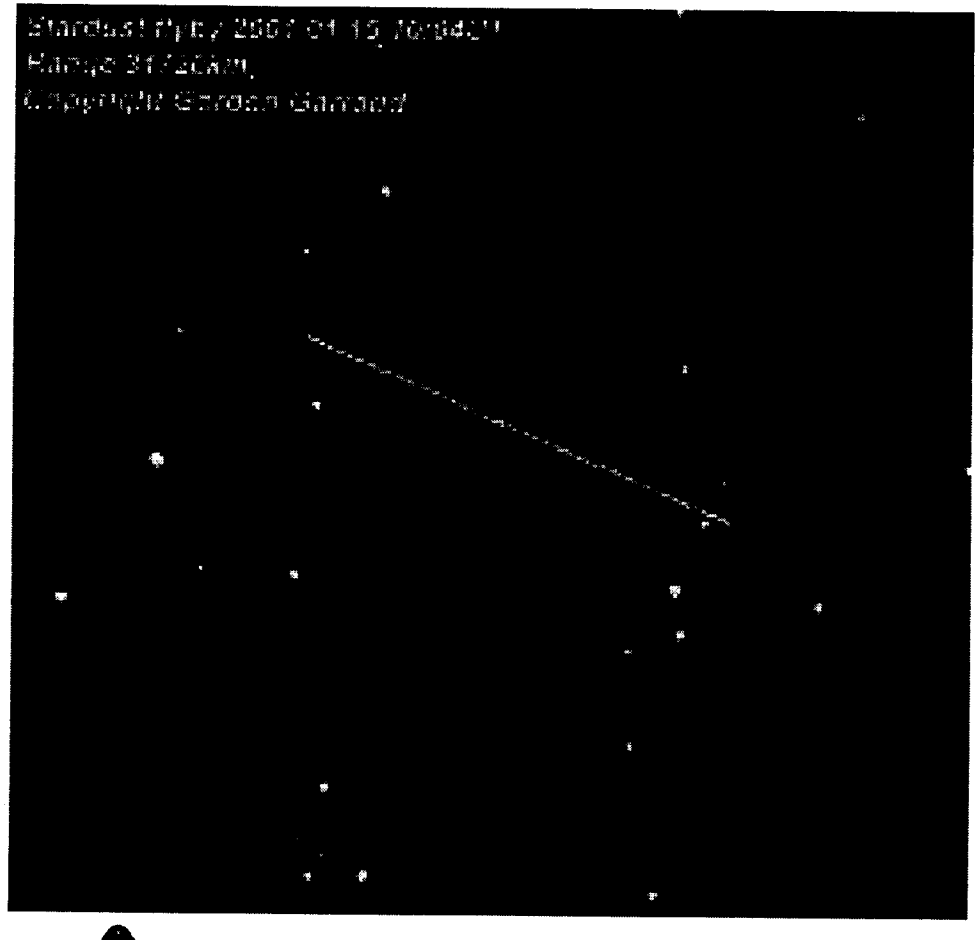
* reconstructed

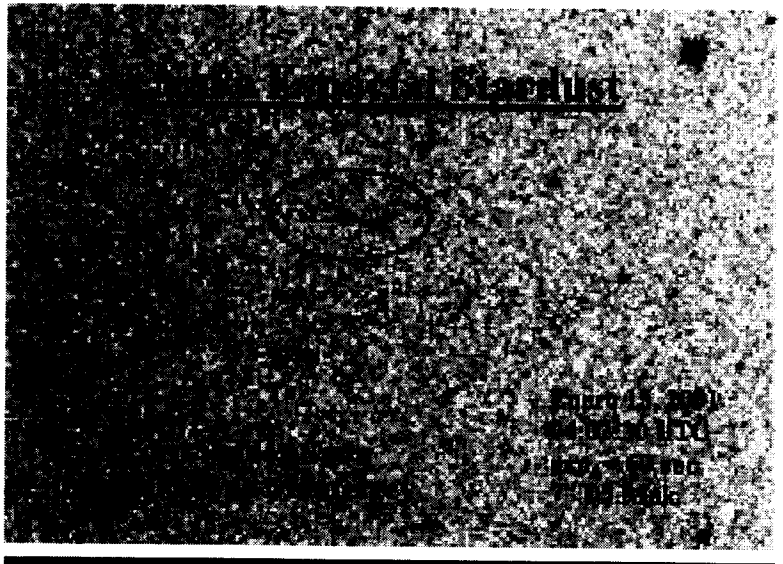
SDU-MD-EH
07 Feb 2001

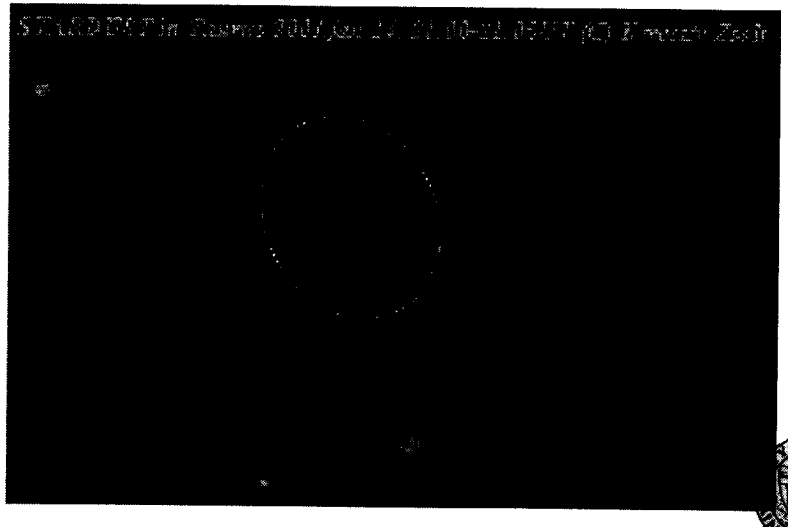
Earth Gravity Assist

JPL

- **EGA ON 15 Jan 2001 03:15 am PST**

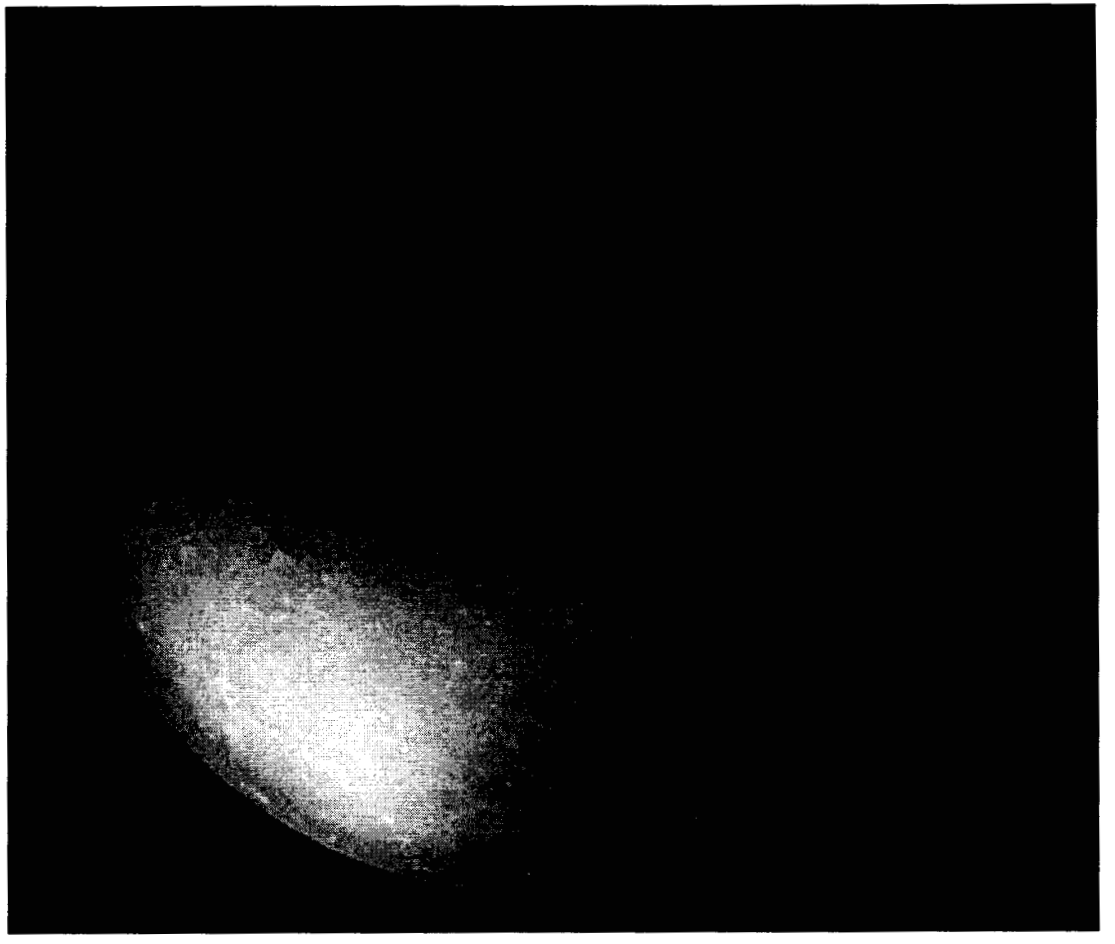






Post EGA Lunar Images

- **21 Lunar & 4 Dark Current Images**
  - **Perfectly Exposed & Pointed**



Late-2003 / Early-2004

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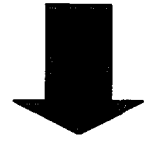
- **ESA Mars Express Orbiter and Beagle 2 Lander**
- **Japanese Nozomi Mars Orbiter**
- **MGS and MS'01 Odyssey Orbital Operations at Mars**
- **STARDUST Wild 2 Encounter**
- **MER-A and MER-B Landings at Mars**
- **Deep Impact & Messenger Launches**
- **Cassini Gravity Wave / Solar Occultation Experiment**
- **Etc., etc.**

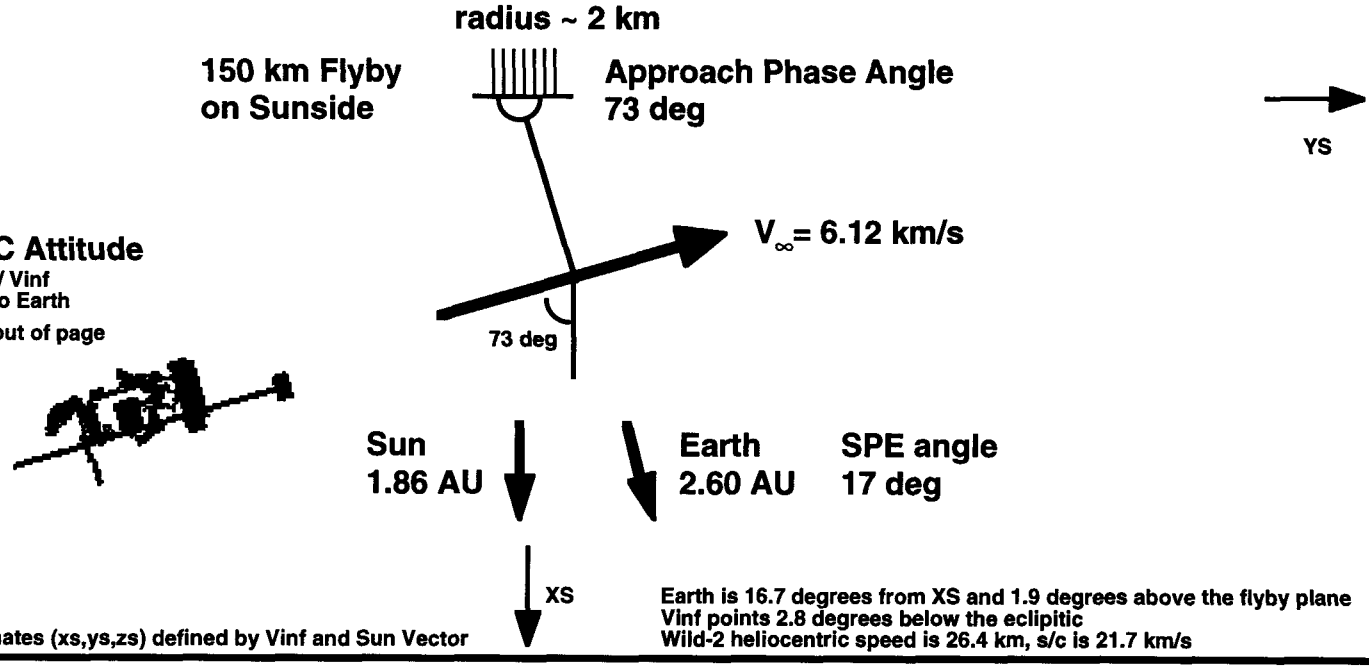


- **New Radiometric Data Type Delta DOR - reduces Nav Tracking**
- **20 Kw transmitters at all 34 m BWG's**
- **New 34 m Station at Madrid**

Wild-2 Encounter Geometry

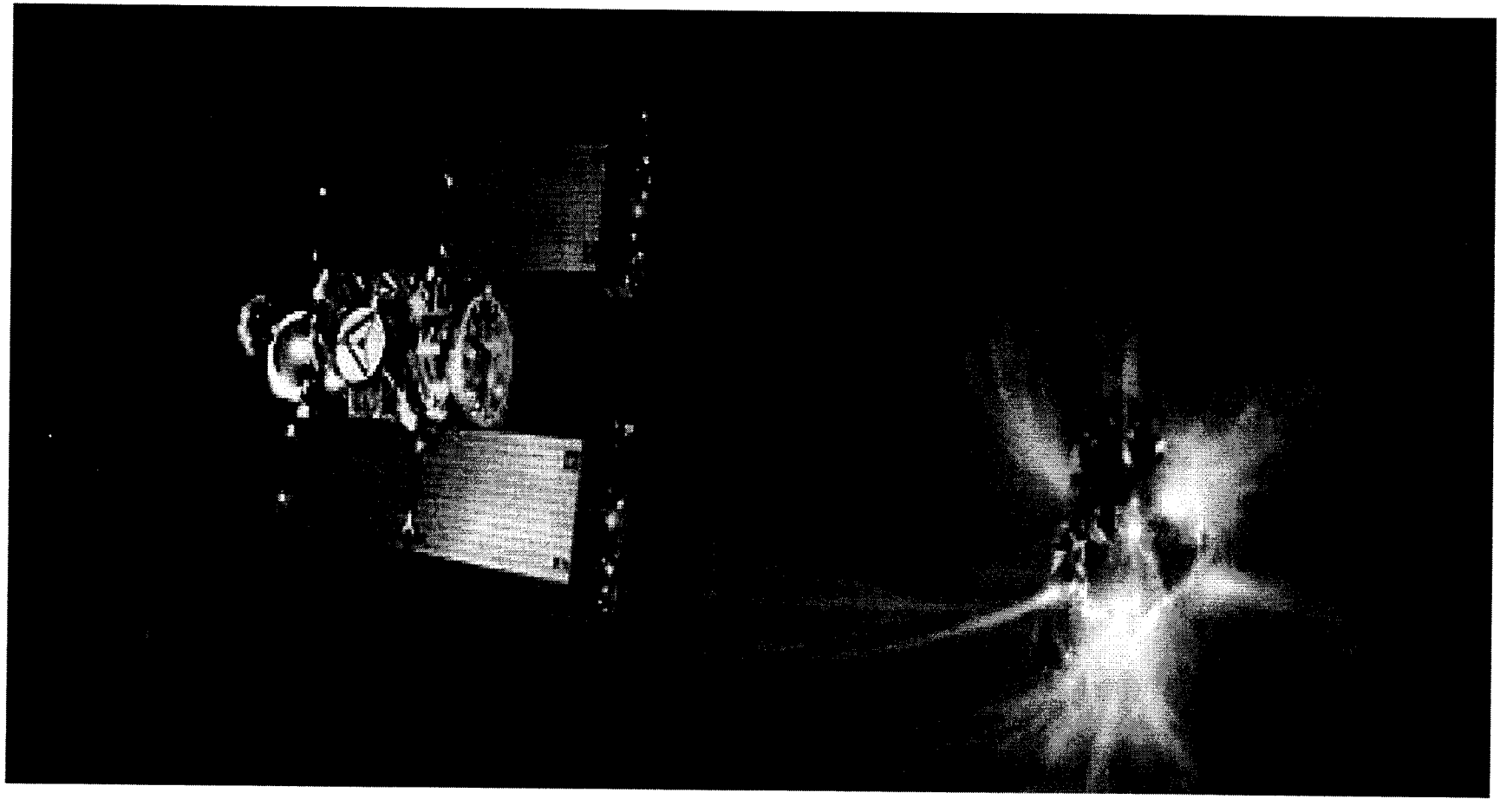
Wild-2 Encounter Geometry

closest approach: 01/02/2004 19:20:00 ET



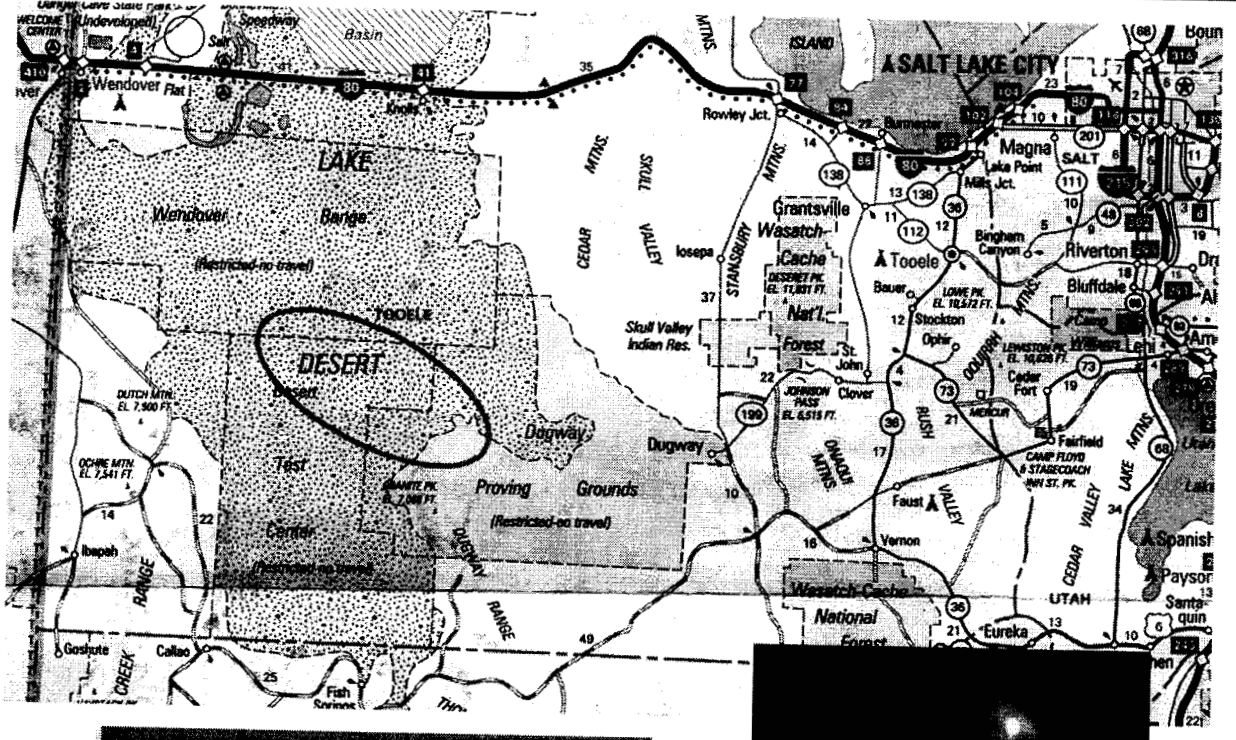
P/WILD 2 ENCOUNTER

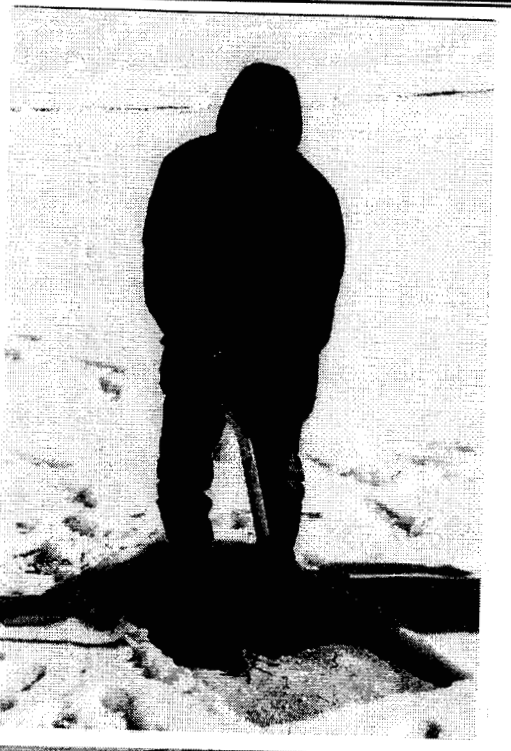
JPL



UTTR Landing - Jan 2006

JPL

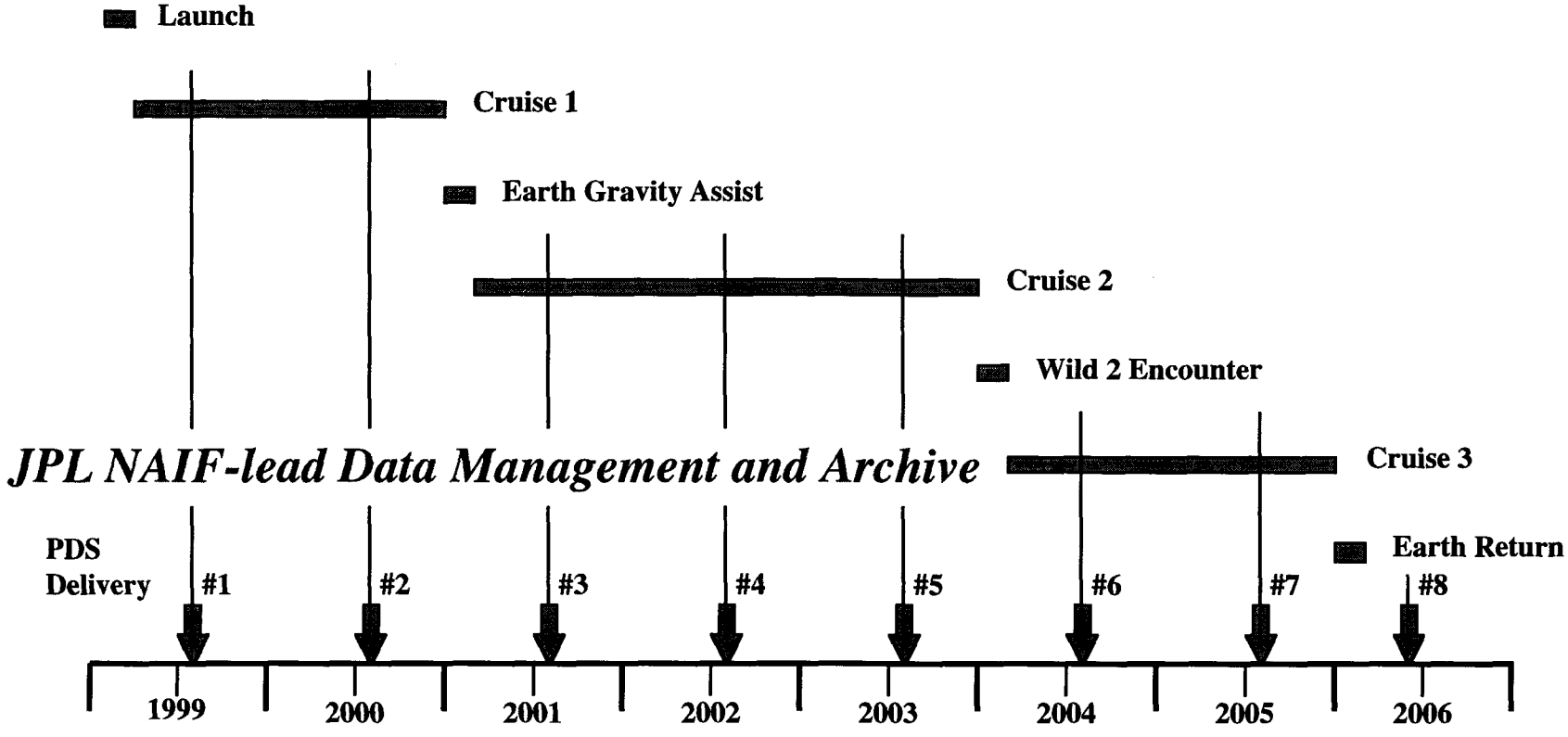




RELEASE OF PROJECT DATA

to the

PLANETARY DATA SYSTEM



Particles to be Delivered to JSC Office of Curation

International Analysis Program will Follow

Bringing Cosmic History to Earth
Education and Public Outreach

Stardust will fly by Comet Wild 2 and, for the first time,
return pristine samples of cometary materials to Earth for analysis
by scientists worldwide.

Education and Public Outreach Approach

Stardust has established partnerships with numerous educational organizations and programs, museums, and science centers to provide opportunities for students, educators, and the general public to learn about small bodies and the mission.

- Challenger Center
- Virginia Space Grant Consortium
- NASA/JPL Ambassadors Program
- JASON Project
- Space Place for Kids
- From the Sun to the Star Nations: Native American Initiative
- Space Explorers, Inc.
- Parents and Children As Co-Travelers
- Omniplex at the Kirkpatrick Planetarium
- Young Astronaut Council
- United States Space Foundation

"Think SMALL In A BIG Way"

A comprehensive Educator's Activity Guide for grades 5–8 focusing on asteroids, comets, and meteorites, the guide contains a dozen fun activities that are tied to mission events and correlated to national science education standards.

"Be a Spacecraft Engineer"

An educational program designed to excite and engage students in science and technology, this activity introduces students to elements of spacecraft design using the Stardust spacecraft and the International Space Station as examples.

STARDUST WEB PAGE

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http://stardust.jpl.nasa.gov

LOCKHEED MARTIN