

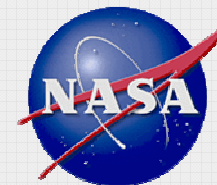
# **A New Search for Optically Faint GEO Debris**

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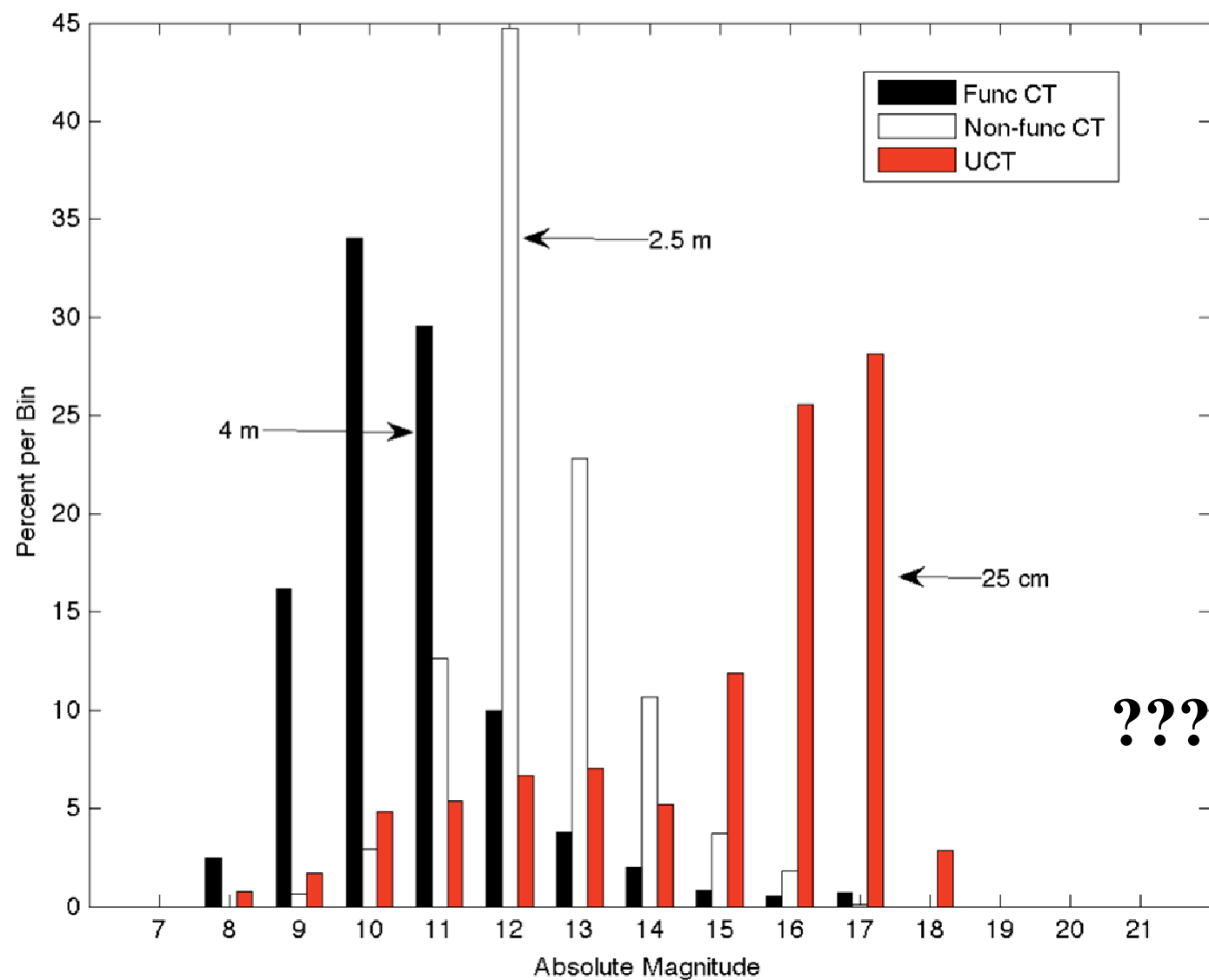
Susan M. Lederer (NASA/JSC), Edwin Barker (LZ Technologies),  
Heather Cowardin (ESCG), Kira Abercromby (CalPoly),  
Jiri Silha (Comenius University)

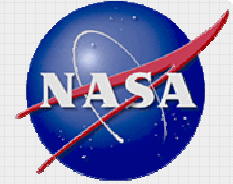
*Presented at 29<sup>th</sup> IADC Berlin: 11-14 April 2011.*

*Work supported by NASA's Orbital Debris Program Office,  
Johnson Space Center, Houston, Texas.*



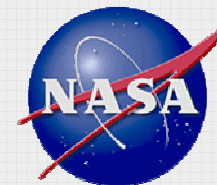
## 0.6-m MODEST 2007-2009 Detections





## **What is the distribution of faint debris?**

- **Does debris distribution continue to increase with fainter optical brightness?**
- **In particular, what is distribution fainter than  $R = 20$  (roughly 10 cm in diameter).**
- **Requires large telescope and excellent image quality.**
- **Goal: reach the faintest limiting magnitude possible from the ground.**

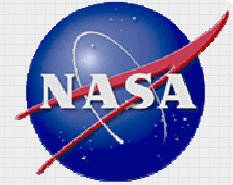


## 6.5-m Magellan Telescopes

Las Campanas Observatory, Chile

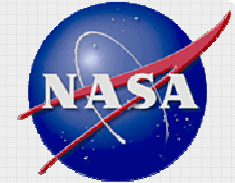


*Collaboration of Carnegie Institution, University of Arizona, Harvard University,  
University of Michigan, and Massachusetts Institute of Technology.*



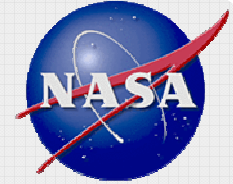
## Magellan 1 telescope – Walter Baade





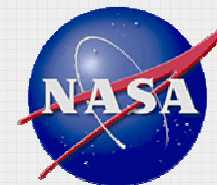
## First Observing Run

- **9 hours of time spread over 3 nights – 25-26-27 March 2011 UT.**
- **Last two nights photometric – seeing at start of observation sequence usually 0.6-0.7 arc-seconds FWHM.**
- **Software modifications required to enable tracking at GEO debris rates.**
- **MODEST observed simultaneously on same fields from Cerro Tololo 100 km to south.**



## **Instrument: IMACS f/2 camera**

- **IMACS: Inamori-Magellan Areal Camera & Spectrograph**
- **IMACS f/2 camera used in imaging mode – 8 CCD mosaic**
  - 0.4 arc-second pixels in binned 2x2 mode.
  - 24 arc-minute diameter unvignetted field of view (FOV) – widest FOV on Magellan.
  - Sloan R filter.
  - 35 second cadence for 5 second exposures.
- **Small field of view, but very deep probe. Limiting magnitude in 5 seconds estimated to be fainter than 22<sup>nd</sup> R magnitude.**
- **Telescope and instrument best suited for specialized debris studies.**



## Magellan Target: Titan debris 1968-081

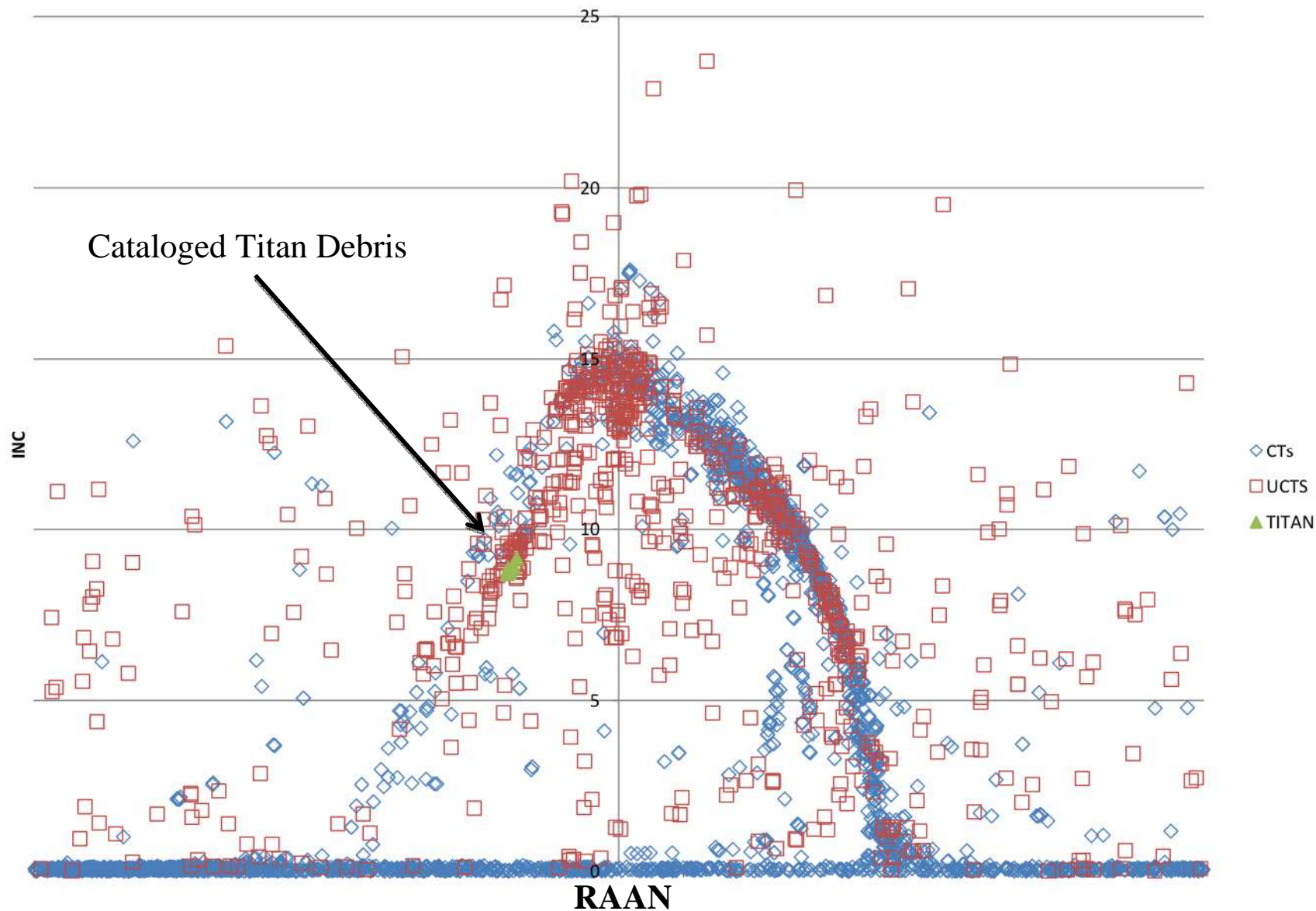
- **Fragmentation of Titan 3C Transtage at GEO – occurred 21 Feb 1992.**
  - *NASA History of On-Orbit Satellite Fragmentations (14<sup>th</sup> Edition, 2008)*
- **8 debris objects plus Titan 3C Transtage in catalog.**
- **All clustered in RAAN-INC space.**
- **Objective of this run – is there optically faint debris on circular orbits associated with this fragmentation?**
- **Observed two Titan debris fragments: 25001 and 33513.**
- **Observed ‘pseudo objects’ with same orbit as 25001 and 33513, but different mean anomalies – typical offset step 15 degrees.**
  - 30 x 5 second exposures while tracking at pseudo object rate.
  - 30 x 5 second exposures with telescope tracking off.

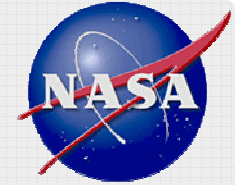




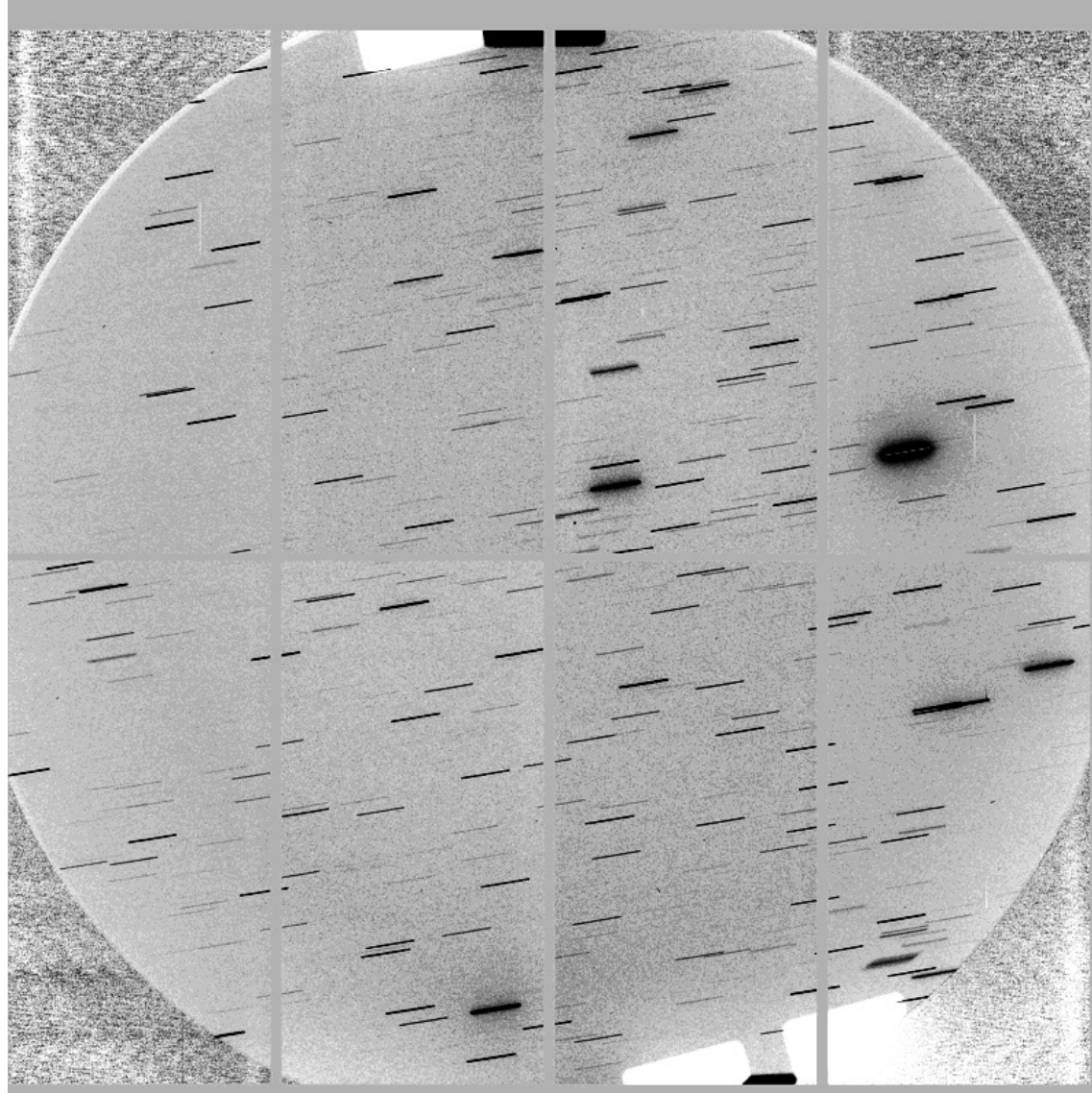
# MODEST 2007-2009: RAAN vs Inc

*assuming circular orbits*

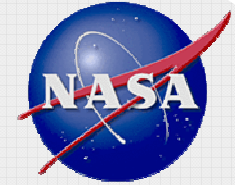




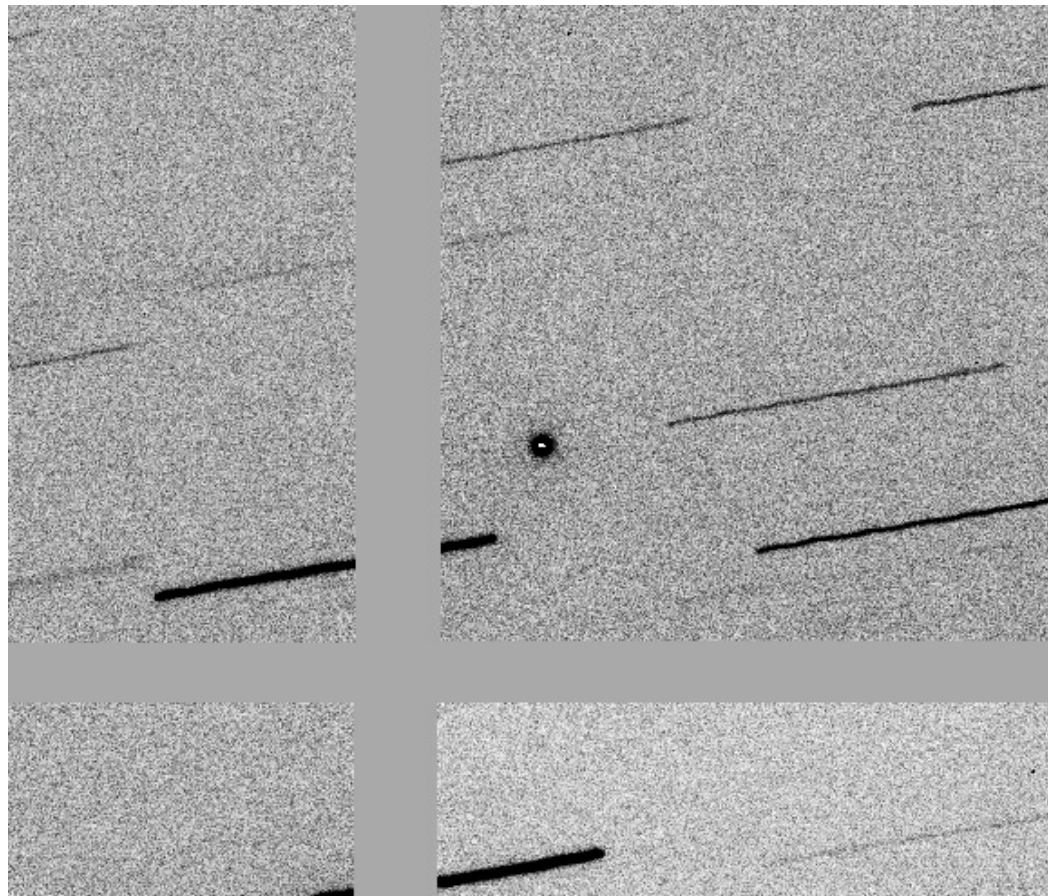
## Magellan data example: SSN 33513



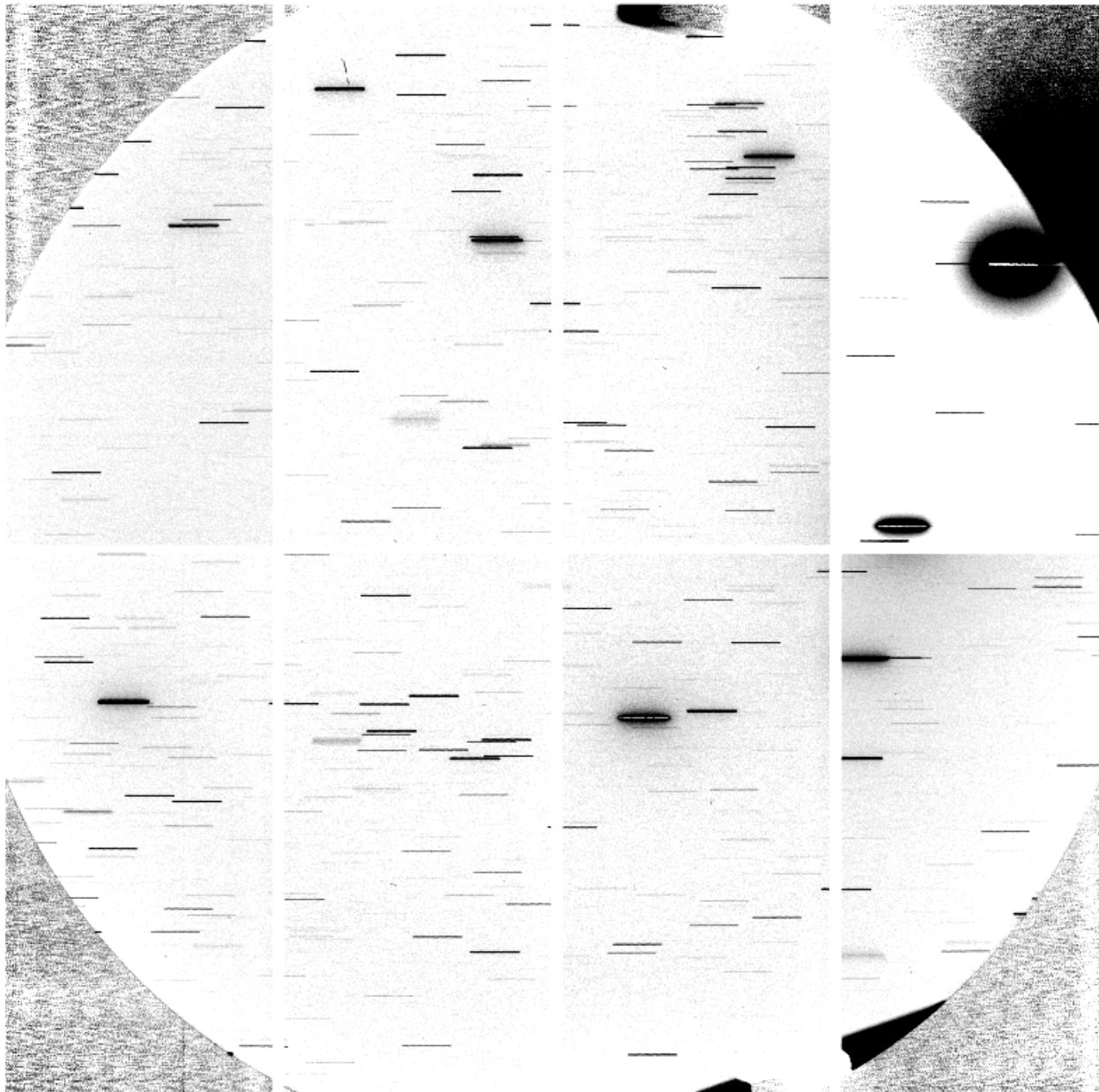
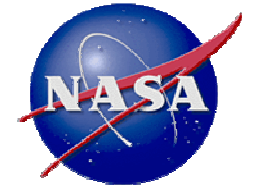


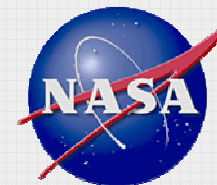


## Titan Debris: SSN 25001



*Detector saturated in 5 second exposure!*





## Future

- **Full reduction and analysis of both Magellan and MODEST data obtained 25-27 March 2011.**
- **Photometric calibration – what is faintest magnitude reached?**
- **‘Shift and add’ reduction to reach faintest levels.**
- **Apply for more time – perhaps 1-2 nights every 6 months. Not guaranteed.**