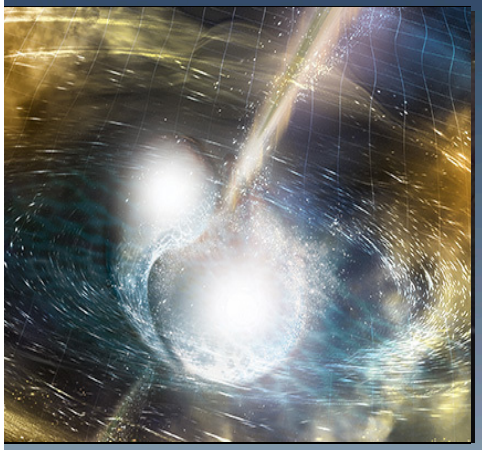
National Aeronautics and Space Administration

Astrophysics






IRTF Future Directions Workshop
Tucson AZ
February 12-14, 2018

Hashima Hasan
Astrophysics Division
Science Mission Directorate

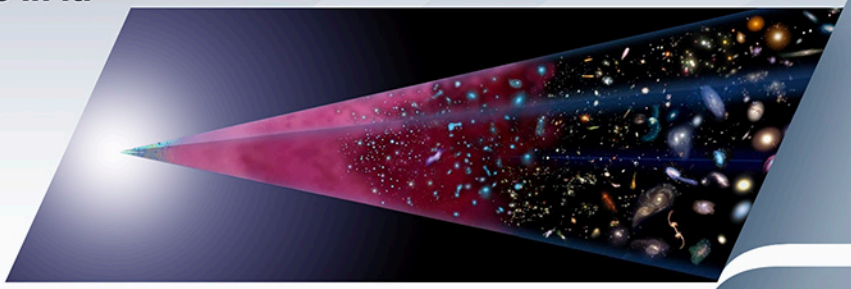
NASA Astrophysics

A Balanced Plan
A Strategic Vision

Why Astrophysics?

Astrophysics is humankind's scientifice endeavor to understand the universe and our place in it.

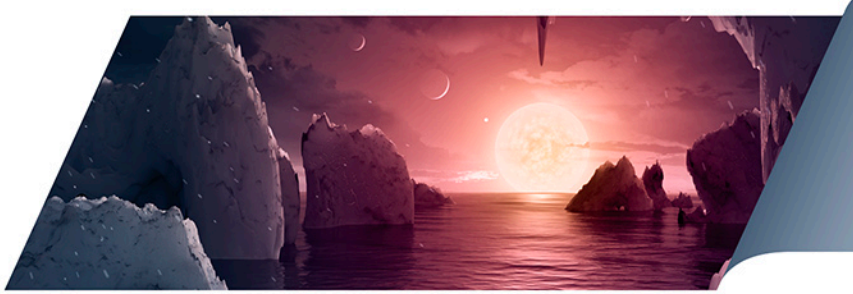
How did our universe begin and evolve?



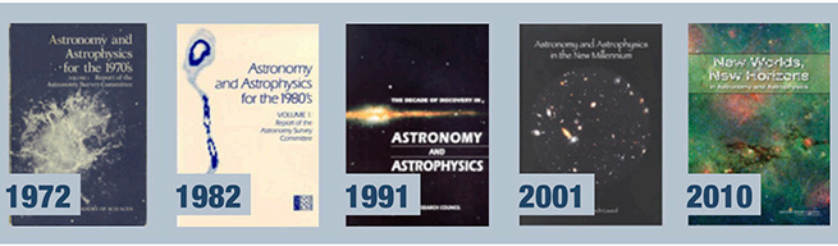
How did galaxies, stars, and planets come to be?



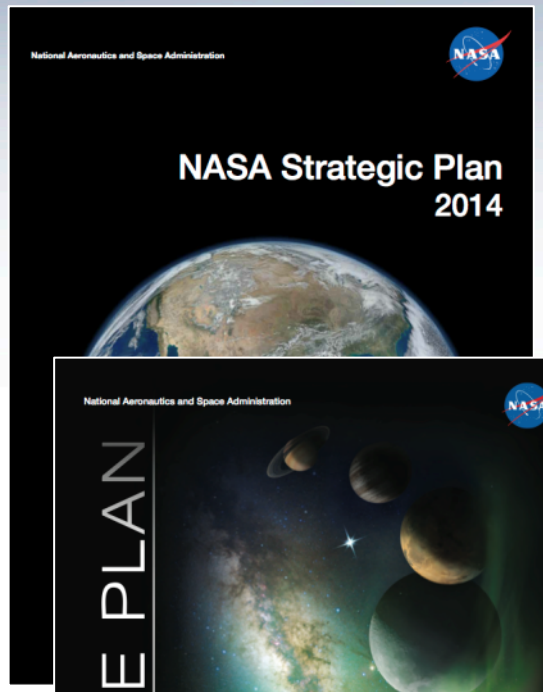
Are we alone?



Enduring National Strategic Drivers

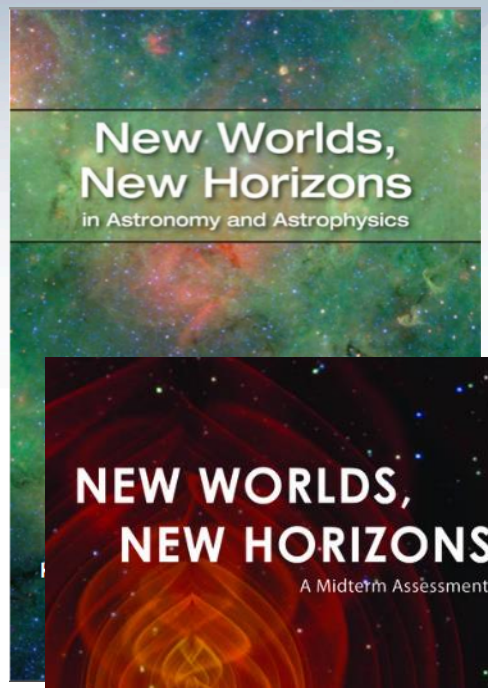


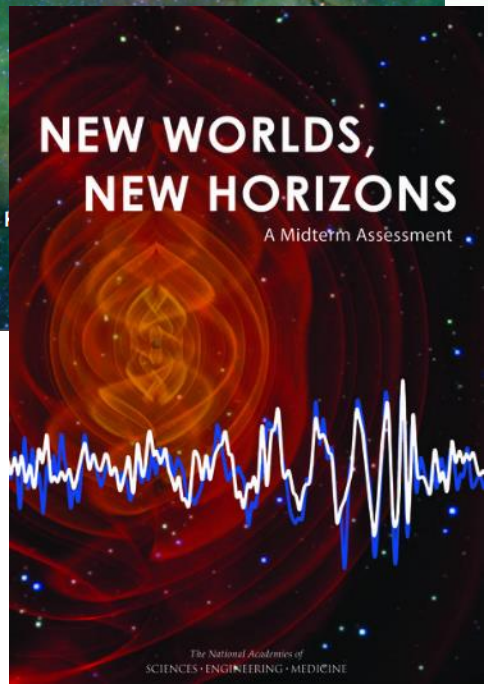
Astrophysics Strategic Planning

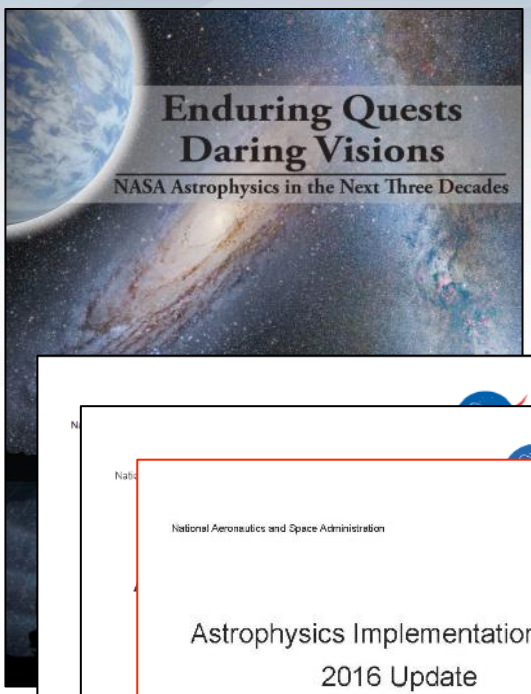


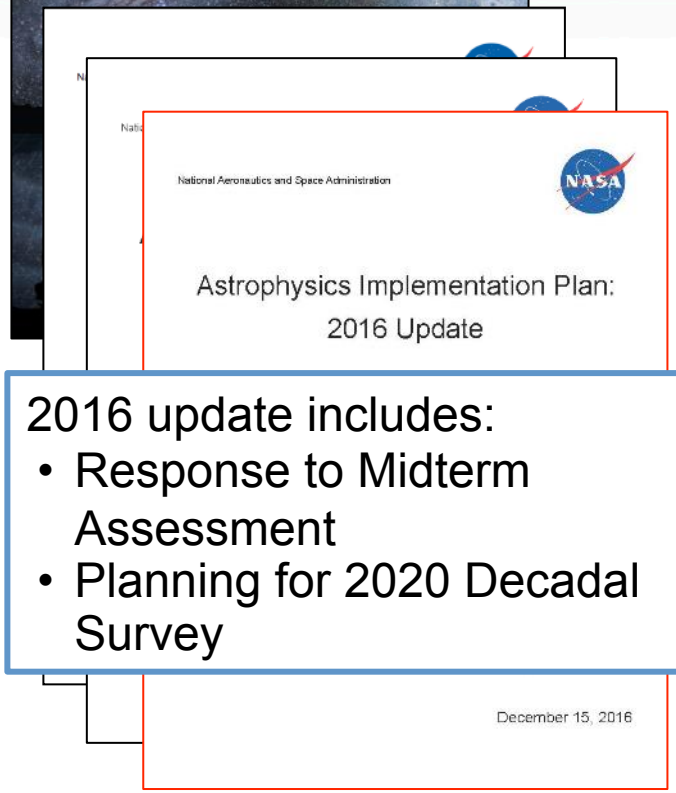


To be updated in 2018 (per GPRAMA)









2016 update includes:

- Response to Midterm Assessment
- Planning for 2020 Decadal Survey

https://science.nasa.gov/astrophysics/documents

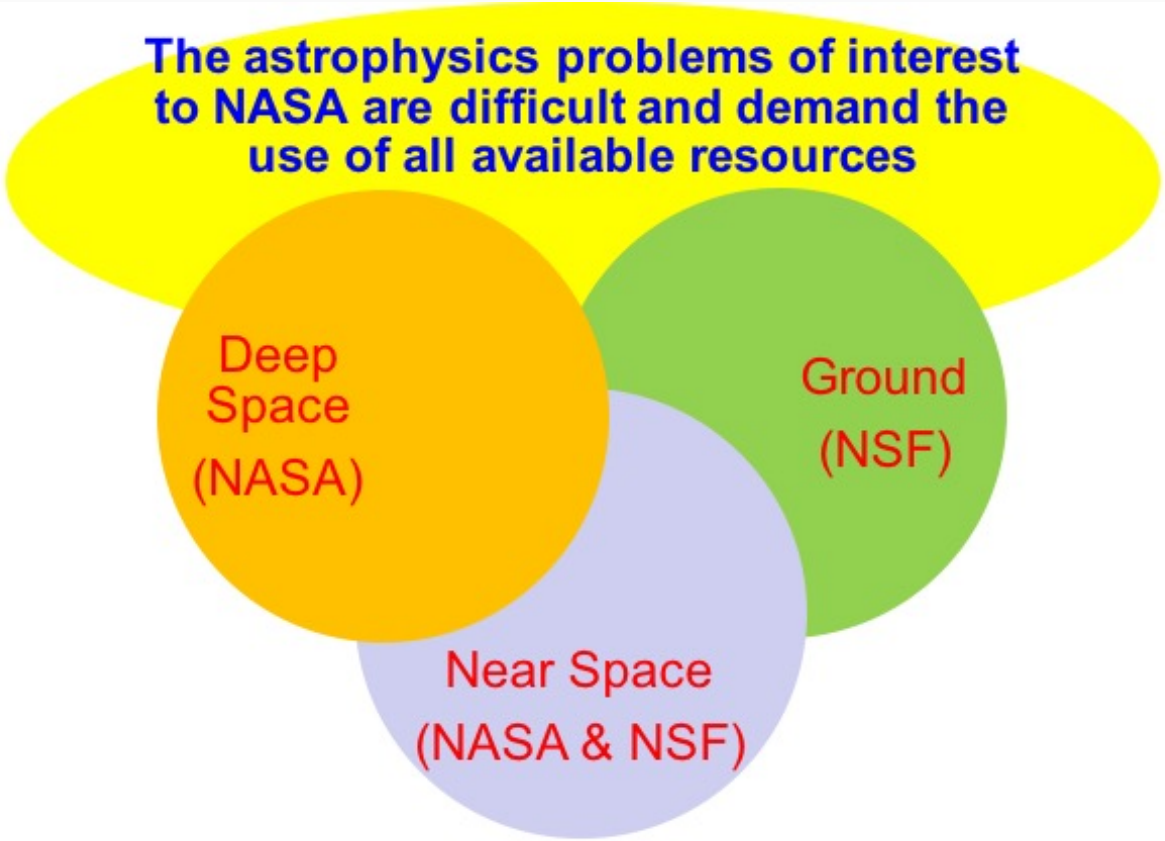
Current Program:
an integrated strategic plan

We are executing a balanced strategic program for Astrophysics

- Operating missions, large and small, continue to deliver paradigm changing science
- New missions are in development
- Future planning to support the next Decadal Survey is under way

Astrophysics Problems of Interest

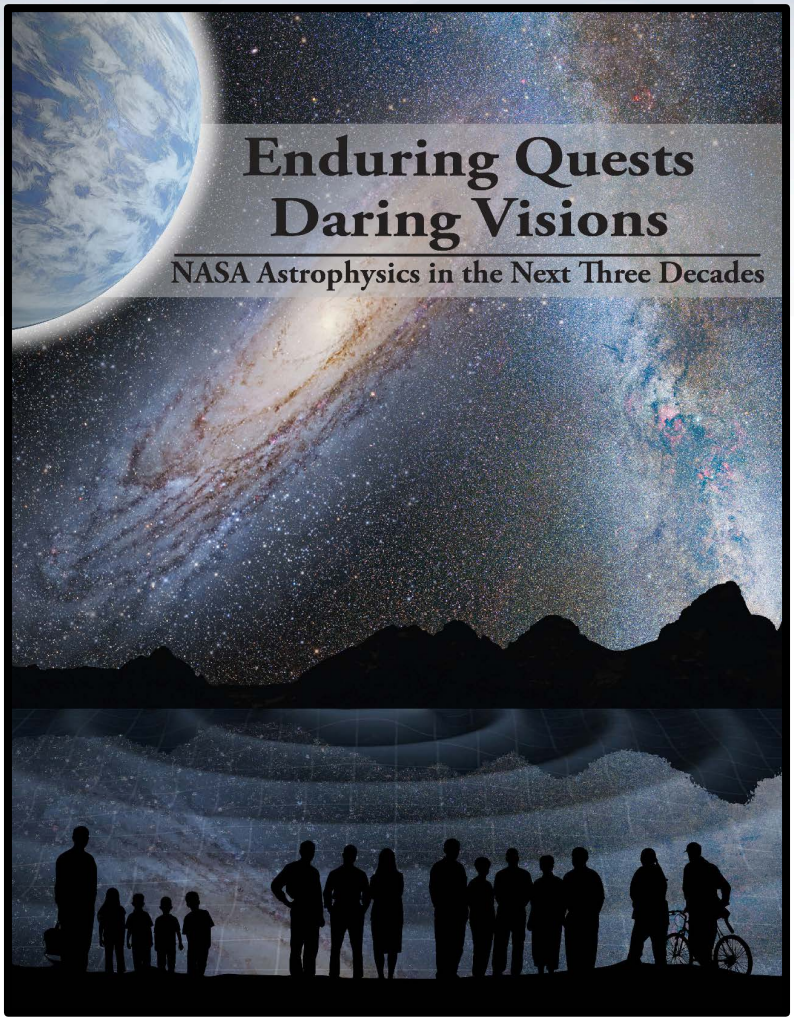
- *Observational astrophysics is a photon starved discipline, demanding high performance from all systems and subsystems utilized for on-sky observations and detections.*



"Enduring Quests, Daring Visions"

NASA Astrophysics in the Next Three Decades

"Observations from these powerful ground-based electromagnetic, cosmic ray, and gravitational wave observatories will make crucial contributions to achieving the scientific goals of the Roadmap, in concert with capabilities that can be realized uniquely from space (2013)."



Role of Ground Based Astronomy for Astrophysics

- Strategic support for current flight missions to:
  - Achieve their science goals
  - Enhance their scientific output
  - Provide data for mission planning
  - Provide preparatory data for planned missions
  - Data for future mission planning
- Current NASA funded ground based facilities for astronomy
  - 50% observing time on IRTF
  - 1/6th observing time on WM Keck Observatory (two 10-m telescopes) for all NASA (Astrophysics, Planetary, etc.)
  - Large Binocular Telescope Interferometer
  - NN-EXPLORE (WYIN telescope)- precision radial velocity spectrometer
  - Other Telescopes as needed (UKIRT, Pan-STARRS, Palomar 5-m)

Astrophysics Science on IRTF

- Exoplanets
  - Characterization of exoplanet populations around giant and low mass stars
  - Atmospheric chemistry of exoplanets
  - Role of protoplanetary and planetary disks in planet formation, including disk accretion and chemistry
  - Connection between low mass stars and free-floating planets
- Stellar and Substellar Astrophysics
  - Determining stellar abundances
  - Characterization of low mass stars, including low mass IMFs of stellar clusters and star forming regions, physical properties, role of magnetic files
  - Stellar ages of Young Stellar Objects (YSOs)
  - Chemistry of protostellar winds
  - Evolution of late-type stars
  - Supernova physics, IR characterization of SN Ia's

Astrophysics Science on IRTF

- Galactic
  - Composition of hot and cold molecular clouds
  - Chemical composition of the Galactic thin and thick disk
  - Determining the evolved stellar population of the Galaxy, including near the Galactic Center
  - Characterization of Galactic Cepheids in the IR

- Extragalactic
  - NIR spectroscopy of evolved stars in nearby Local Group Galaxies
  - Determining black hole masses of galaxies
  - Studying AGNs, including monitoring dusty AGNs, looking at the role of star formation in AGNs, and determining the IR Spectral Energy Distribution (SEDs) of AGN
  - Using dusty quasars to feedback and galaxy evolution

IRTF Instrument use for Astrophysics

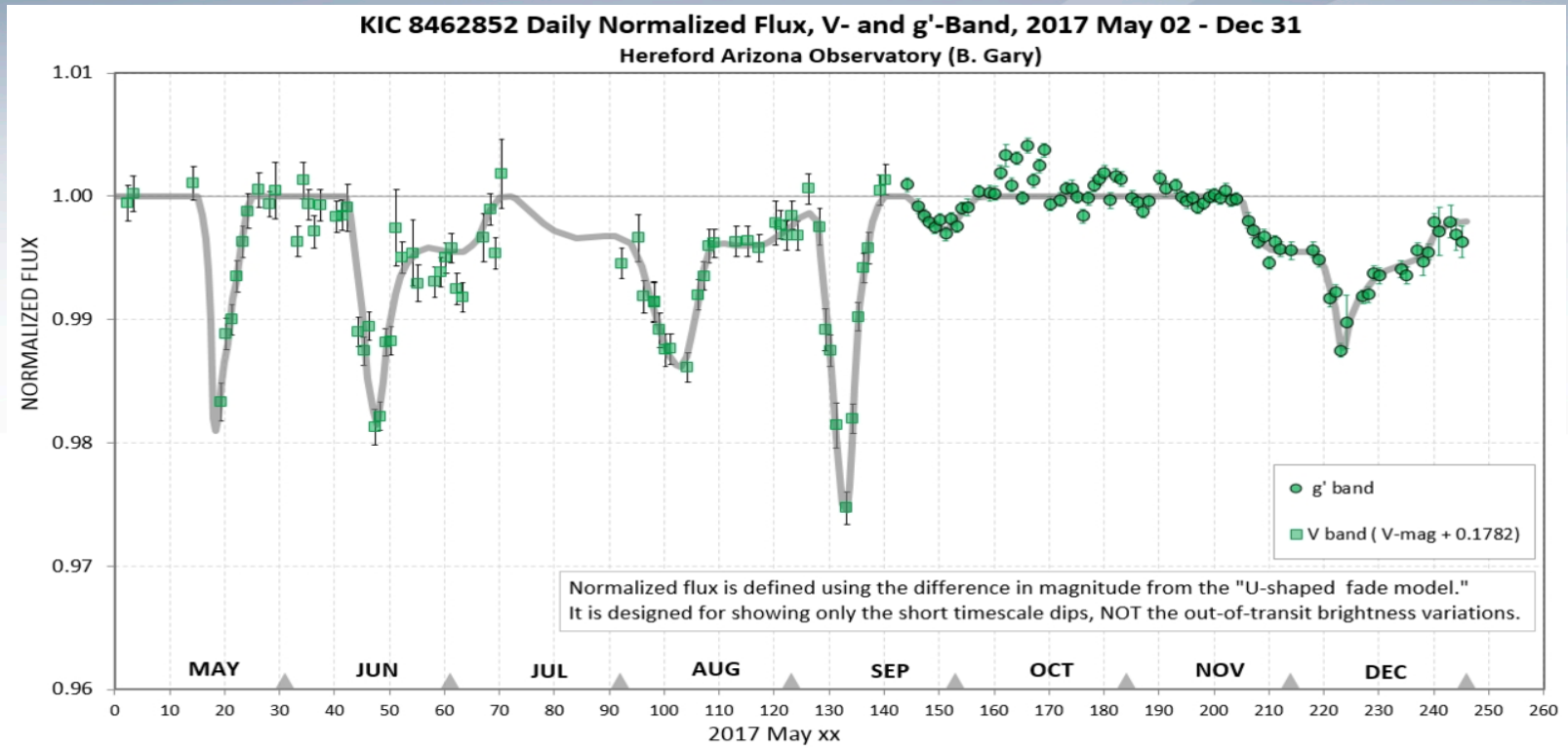
Currently, facility instruments iSHELL and SpeX are used the most by astronomers

- SpeX (R~50 - 2000 and 1-5um imaging, depending on program) gets a about 60% of the time
- iSHELL (R~20,000-75,000) gets about 30% of the time
- remainder ~10% of time goes to visitor instruments (mostly TEXES R~10,000-100,000 MIR)

SpeX is the workhorse instrument and iSHELL more specialized (comets, planetary atmospheres, star and planet forming disks, stars)

Science Examples

Astrophysics Success with IRTF



- **Tabby's Star or Boyajian's Star (KIC 8462852)** was observed at IRTF by Casey Lisse, Massimo Marengo, and Michael Sitko, and they were one of the teams suggesting comet swarms to account for the brightness variations. No alien megastructure was needed. This paper was published Dec. 20, 2015 in ApJL, only 50 days after the observations were made. This paper was published even before Boyajian's discovery paper was published.

Dust Formation in V2362 Cygni:
Coordinated IRTF/SpeX, VNIRIS, BASS, SPITZER and SWIFT Observations



David K. Lynch, Ray W. Russell, Richard J. Rudy (The Aerospace Corp.), Charles E. Woodward (U. Minnesota), Mike Sitko (U. Cincinnati) and J. Rayner (U. Hawaii)

David A. Hardy (www.astroart.org/) & PPARC.

IRTF Spectral Library : Cool Stars
(Rayner, Cushing & Vacca 2009)

http://irtfweb.ifa.hawaii.edu/~spex/IRTF_Spectral_Library/

PROPERTIES

- 212 stars with optical MK classification (FGKM-SC stars)
- Mostly near-solar metallicities
- 0.8-2.4 μm all stars, most 0.8-5 μm
- R ~ 2000, S/N ≥ 100 typical
- Continuum shape is preserved
- Spectra are absolute flux calibrated (2MASS)

APPLICATIONS

- Physics of cool stellar and sub-stellar atmospheres
- IR classification of optically embedded and cool stars
- IR evolutionary population synthesis studies
- Synthetic photometry

Extended IRTF Spectral Library (Villaume *et al.* 2016)

.***PROPERTIES***

- 284 stars OBAFKM SpT
- Non-solar metallicities, -1.7 < [Fe/H] < 0.6
- 0.7-2.5 μm, supplemented with optical spectroscopy
- R ~ 2000, S/N ≥ 100 typical
- Continuum shape is preserved

.***EXTENDED APPLICATIONS***

- Physics of hot stellar atmospheres
- Improved IR evolutionary pop. synthesis studies (non-solar metallicities)

Examples of Application of IRTF Spectral Library

- Substantial population of low mass stars found in luminous elliptical galaxies using ***IRTF Spectral Library*** to construct stellar population synthesis model of the observed spectra. (Pieter G. Van Dokkum & Charlie Conroy ***Nature 16 Dec 2010, 468, 940).***

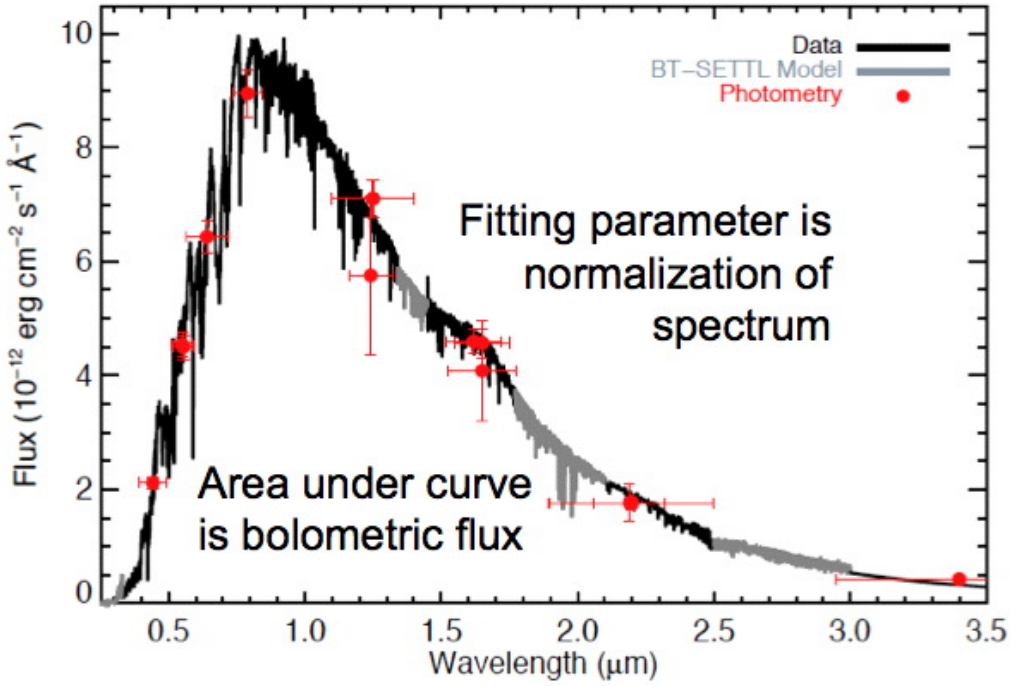
- A gapped primordial disk around LkCa15 was discovered using ***IRTF Spectral Library*** data which showed that the excess infrared emission above the photosphere of LkCa15 is a black body continuum which can only be due to optically thick material in an inner disk around the star (Espaillat et al. ***2008, ApJ 682, L125***)

A thermometer for Goldilocks:

improved parameters for *Kepler* M dwarfs and their planets

Andrew Mann & Eric Gaidos

angular radius + bolometric flux → effective temperature
parallax + bolometric flux → luminosity
angular radius + parallax → stellar radius



Bolometric fluxes of cool (<4700K) calibrator stars (Boyajian et al.) were recalculated using Spex + visible spectra instead of template

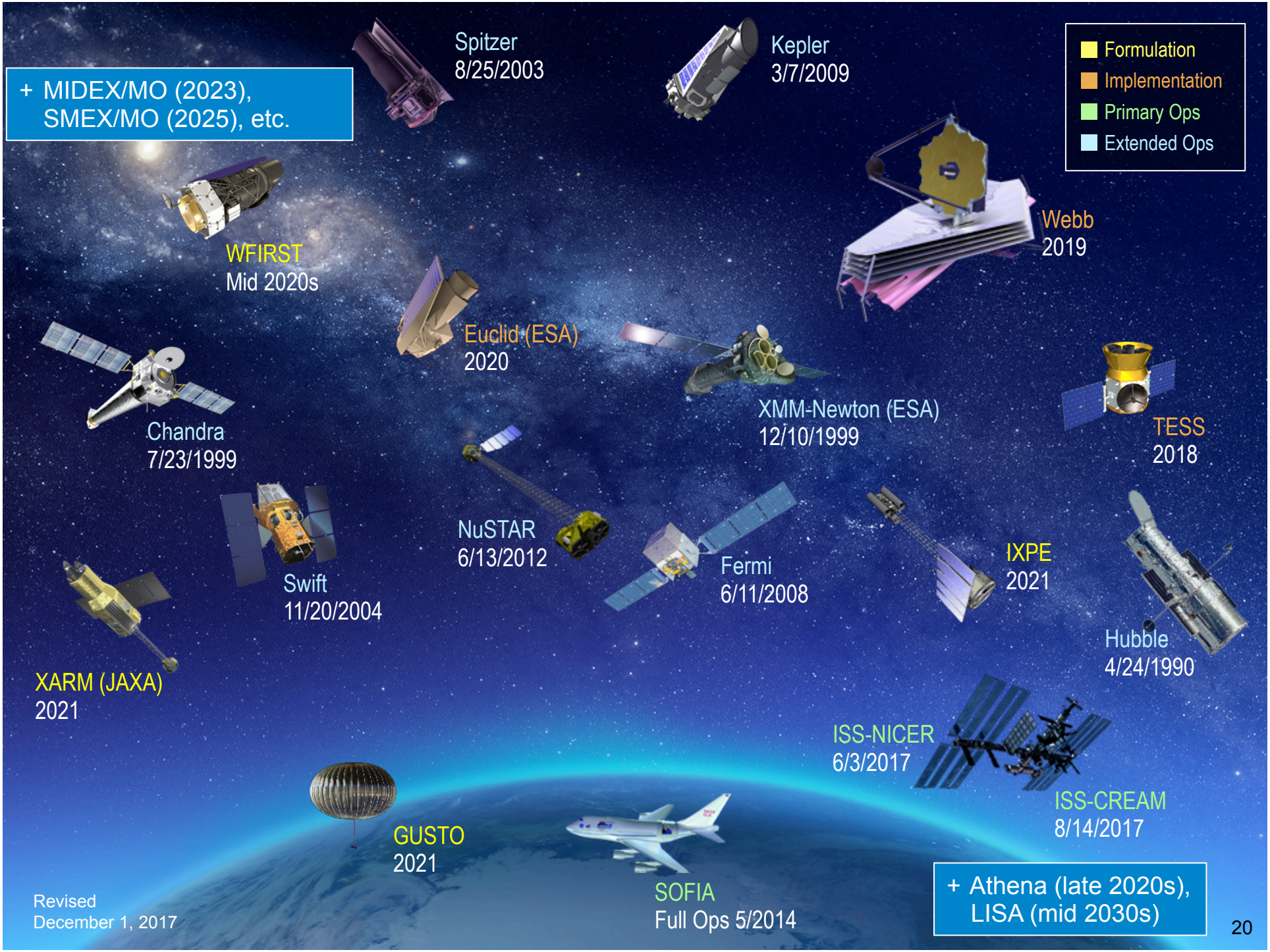
SpeX

Astrophysics Charge to Workshop

In the context of current and upcoming ground based facilities and NASA Astrophysics missions what unique capabilities can IRTF and new science instruments offer to strategically support Astrophysics missions?

Some possible areas to consider

- Exoplanets
  - The new iShell instrument will be very powerful for characterizing M star host stars and with Plavchan's gas cell for enabling PRV for bright targets.
  - Robo-AO at IRTF which would enable rapid, diffraction limited imaging to validate TESS exoplanet candidates
- Stellar and Substellar Astrophysics/Extragalactic
  - iShell will be a valuable tool for Galactic sources, e.g. star forming regions and bright brown dwarfs
- Time Domain Astronomy
  - As we get more ToO targets from Gravitational Wave targets from LIGO+Space missions, IRTF could play a role.


+ MIDEX/MO (2023), SMEX/MO (2025), etc.
Spitzer 8/25/2003
Kepler 3/7/2009
Formulation
Implementation
Primary Ops
Extended Ops
WFIRST Mid 2020s
Webb 2019
Euclid (ESA) 2020
Chandra 7/23/1999
XMM-Newton (ESA) 12/10/1999
TESS 2018
NuSTAR 6/13/2012
Swift 11/20/2004
Fermi 6/11/2008
IXPE 2021
Hubble 4/24/1990
XARM (JAXA) 2021
ISS-NICER 6/3/2017
ISS-CREAM 8/14/2017
GUSTO 2021
SOFIA Full Ops 5/2014
+ Athena (late 2020s), LISA (mid 2030s)
Revised December 1, 2017



NASA Astrophysics

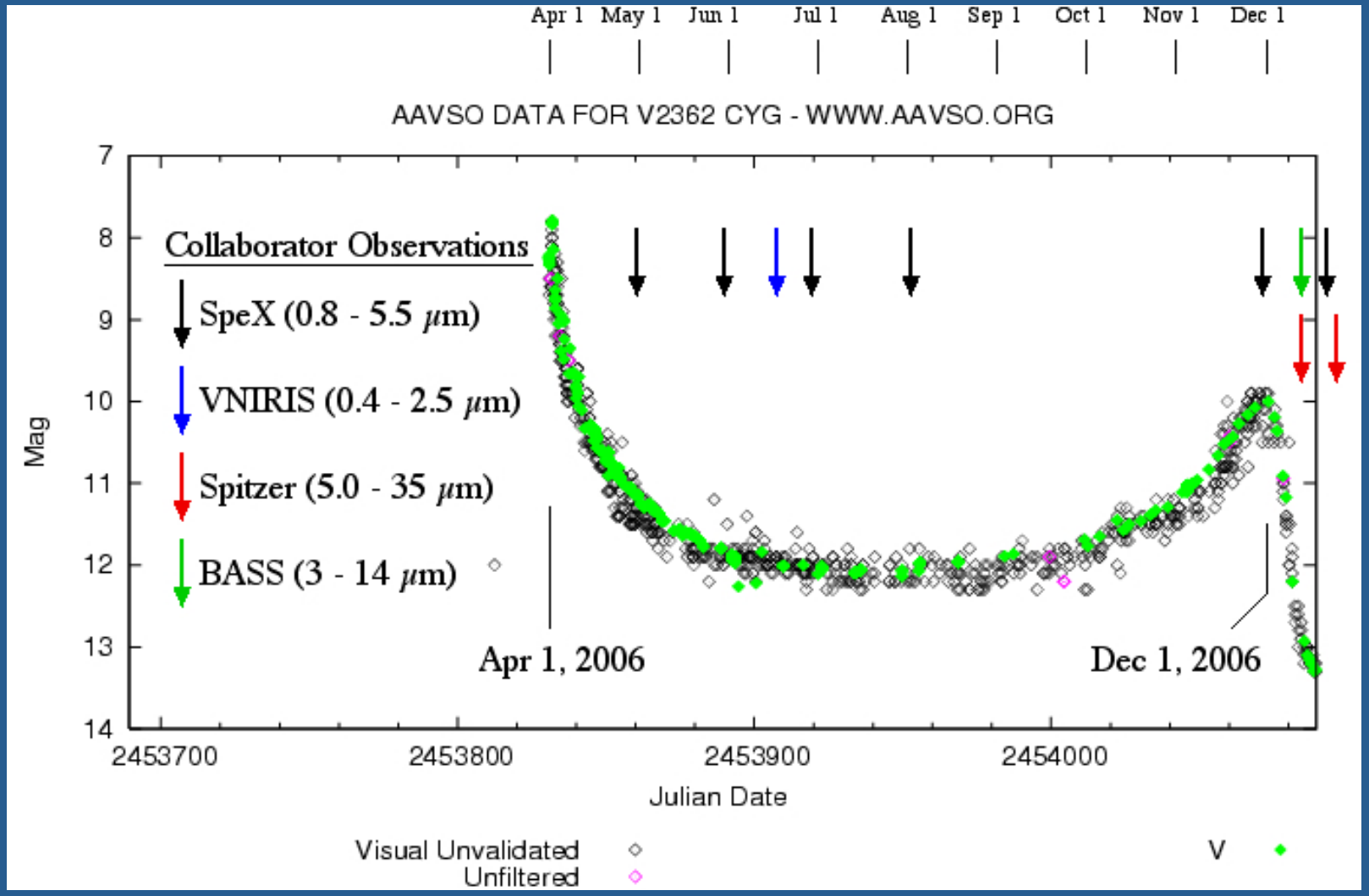
Backup

A nova is thermonuclear runaway on the surface of a white dwarf that has accreted material from a secondary star through its inner Lagrange point in a close binary system.

- Novae are important to study because:
- They produce heavy elements and inject them into the interstellar medium.
- They involve exotic nuclear reactions that cannot be reproduced on Earth.
- Some novae are thought to be progenitors of Type Ia supernovae, important for cosmological reasons.
- All novae are different: White dwarf mass and composition, secondary composition, accretion rate, etc.

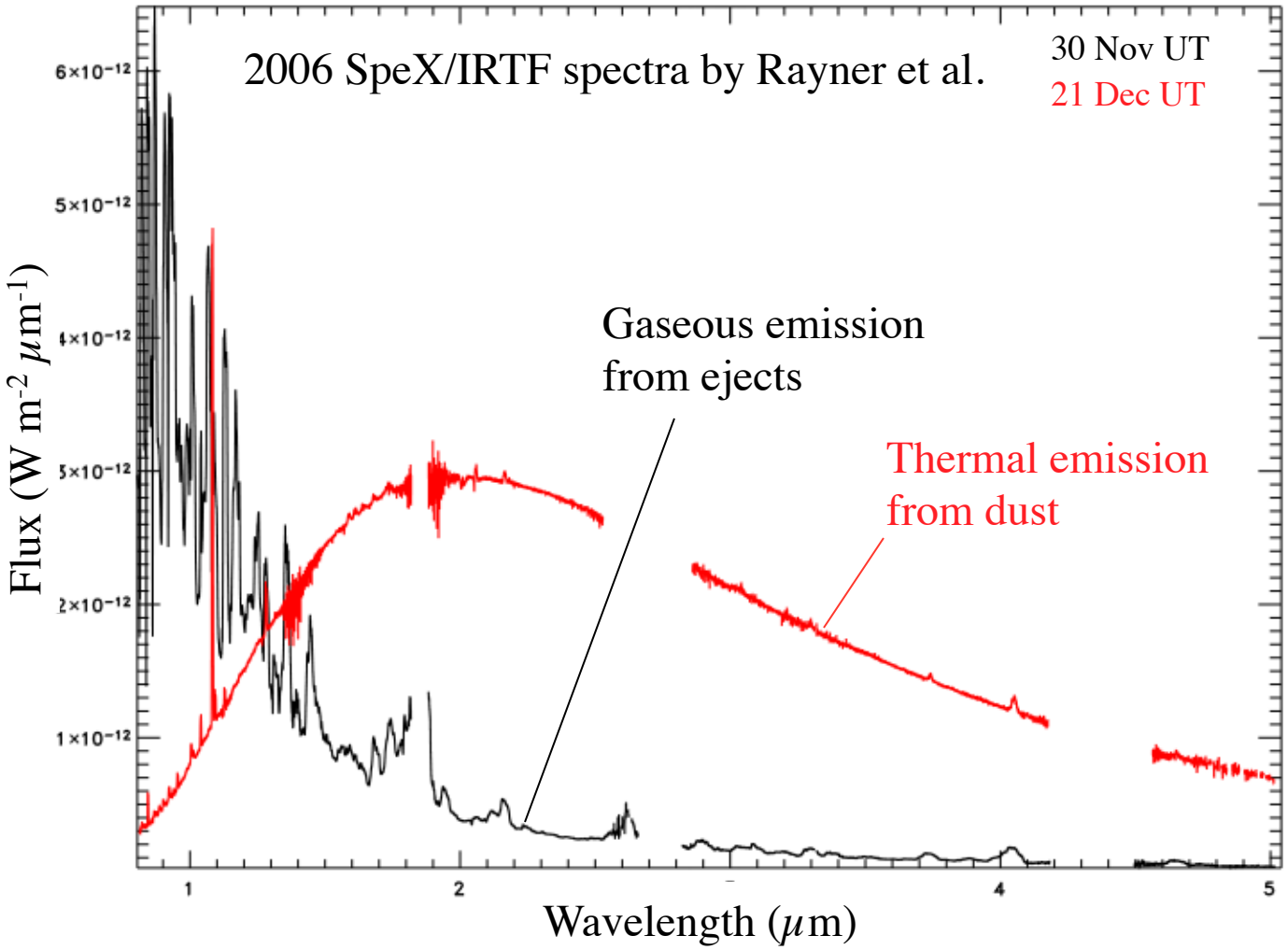
V2362 Cyg is very unusual.

It faded for about 4 months while its spectrum hardened as novae usually do, then unexpectedly brightened again as the themonuclear runaway turned on (based on collaborators' X-Ray data), then formed dust and is now rapidly fading.



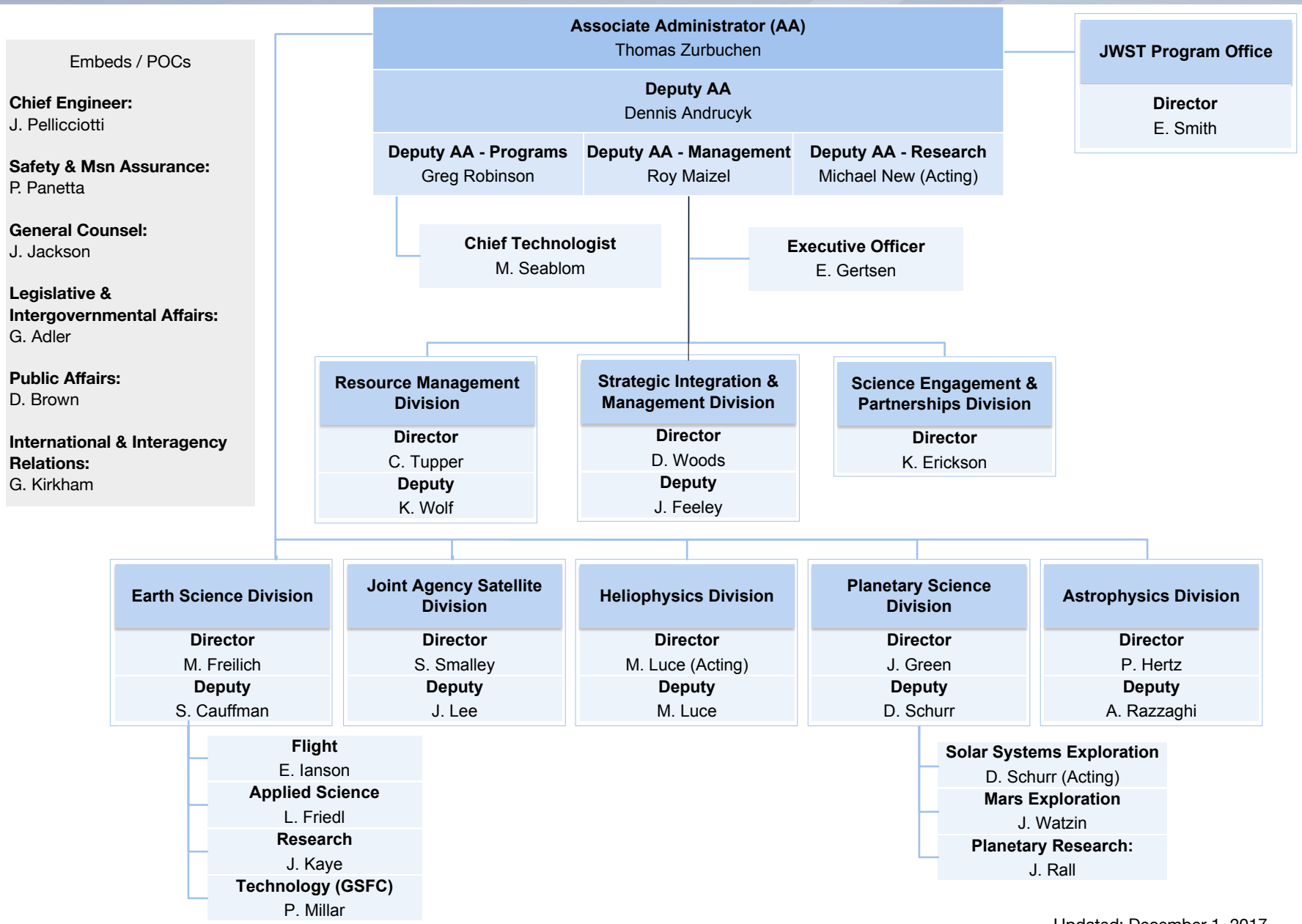
Dust formation was dramatic.

Sometime between the SpeX observations on Nov 30 and the BASS/IRTF observations on Dec 12, dust formation caused the spectrum to change enormously.



At ≈ 1410 ± 15 K, the observed dust was some of the hottest ever observed.

SMD Organization Chart



Updated: December 1, 2017

Astrophysics Division, NASA Science Mission Directorate

Resource Management
Omana Cawthon+
Clemencia Gallegos-Kelly+
Debra Mcneill+

Director
Paul Hertz

Deputy Director
Andrea Razzaghi

Lead Secretary: Kelly Johnson
Secretary: Kyle Nero
Program Support Specialist: Jackie Mackall

Cross Cutting

Technology Lead: Nasser Barghouty*
Education POC: Hashima Hasan (Lead Comm Team)
Public Affairs Lead: Kartik Sheth
Information Manager: Lisa Wainio*
Strategic Planning: Rita Sambruna

Astrophysics Research

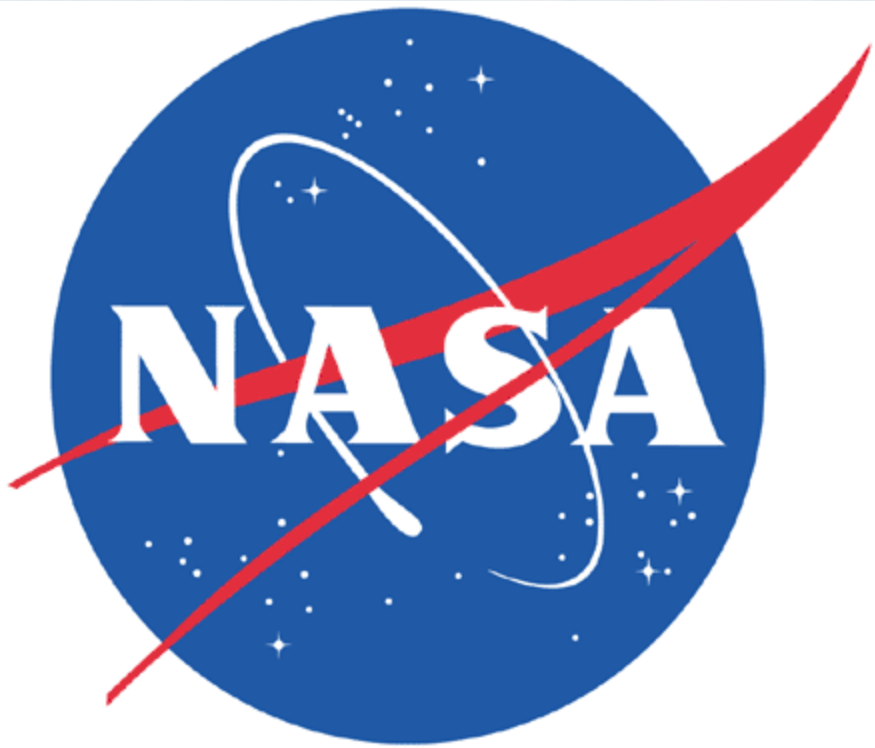
***Program Manager*: Dan Evans**
Program Support: Ingrid Farrell*
Astrophysics Data Analysis: Doug Hudgins
Astrophysics Theory: Keith MacGregor*
Exoplanet Research: Martin Still*
APRA lead: Michael Garcia*
Cosmic Ray, Fund Physics: Thomas Hams*, Vernon Jones, Keith MacGregor*, Rita Sambruna
Gamma Ray/X-ray: Valerie Connaughton*, Dan Evans, Michael Garcia*, Stefan Immler*, Rita Sambruna
Optical/Ultraviolet: Michael Garcia*, Hashima Hasan, Patricia Knezek*, Mario Perez*, Martin Still*
IR/Submillimeter/Radio: Dominic Benford*, Doug Hudgins, William Latter*, Kartik Sheth, Eric Tollestrup*
Lab Astro: Doug Hudgins, William Latter*
Theory & Comp Astro Net: Keith MacGregor*
Roman Tech Fellows: Nasser Bargoughty*
Data Archives: Hashima Hasan
Astrophysics Sounding Rockets: Thomas Hams*
Balloons Program: Vernon Jones(PS), Mark Sistilli (PE)
CREAM: Vernon Jones(PS), Jeff Hayes (PE)

Programs / Missions & Projects

	Program Scientist	*Program Executive*	
Strategic Astrophysics Mission			
WFIRST	**Dominic Benford***	**John Gagosian**	
Exoplanet Exploration (EXEP)			
Program	**Doug Hudgins**	**John Gagosian**	
Keck	Hashima Hasan	Mario Perez*	
Kepler/K2	Mario Perez*	Jeff Hayes	
LBTI	Doug Hudgins	Mario Perez*	
NN-EXPLORE	Doug Hudgins	Mario Perez*	
Cosmic Origins (COR)			
Program	**Mario Perez***	**Shahid Habib**	
Herschel	Dominic Benford*	Jeff Hayes	
Hubble	Michael Garcia*	Jeff Hayes	
SOFIA	Kartik Sheth		Lucien Cox*
Spitzer	Kartik Sheth		Jeff Hayes
Webb^	Hashima Hasan	N/A	
Physics of the Cosmos (PCOS)			
Program	**Rita Sambruna**	**Shahid Habib**	
Athena	Michael Garcia*	Shahib Habib	
Chandra	Stefan Immler*	Jeff Hayes	
Euclid	Eric Tollestrup*	Shahid Habib	
Fermi	Stefan Immler*	Jeff Hayes	
LISA	Rita Sambruna	Shahid Habib	
Planck	Rita Sambruna	Jeff Hayes	
ST-7/LPF	Rita Sambruna	Jeff Hayes	
XMM-Newton	Stefan Immler*	Jeff Hayes	
Astrophysics Explorers (APEX)			
Program	**Linda Sparke**	**Mark Sistilli**	
GUSTO	Thomas Hams*	Lucien Cox*	
IXPE	Eric Tollestrup*	Mark Sistilli	
NICER	Rita Sambruna	Jeff Hayes	
NuSTAR	Stefan Immler*	Jeff Hayes	
Swift	Martin Still*	Jeff Hayes	
TESS	Martin Still*	Mark Sistilli	
XARM	Dan Evans	Shahid Habib	

\+ *Member of the Resources Management Division*
* *Detailee, IPA, or contractor*
^ *Webb is part of the JWST Program Office.*

Dec. 28 2017



Astrophysics Division
Science Mission Directorate
National Aeronautics and Space Administration