

# **GALEX**

## **Galaxy Evolution Explorer**

### **(2003 – 2012/13)**

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# Mission Statement:

- Explore 10 billion years of stellar and galactic evolution.
  - What was the history of star formation in the universe?
  - What do nearby galaxies look like in ultraviolet light?
  - When and where did stars and elements we see today have their origins?

# Talking Points:

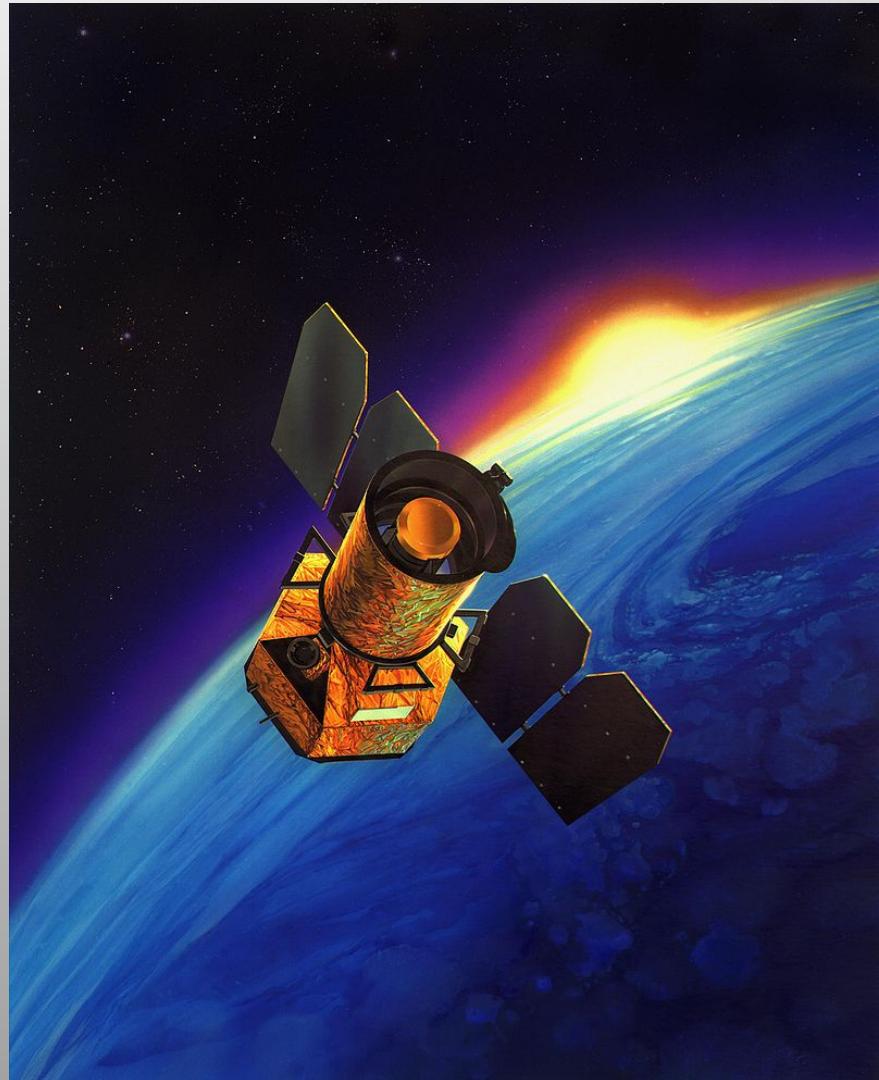
- Brief Overview
- Technical Specifications
- Data
- Significant Science/Discoveries

# Overview: What is Galex?

- Earth orbiting space telescope
- Two bands of UV light

Why space?

Why UV?



# Overview: Timeline

- Joint collaboration between the US, France and South Korea
- 150.6 million dollars (2011)
- Launched on April 28, 2003
- 29 month mission
  - Operations extended for almost 9 years
- Placed into standby mode on February 7, 2012
- Decommissioned June 28, 2013

# Overview: Imaging Surveys

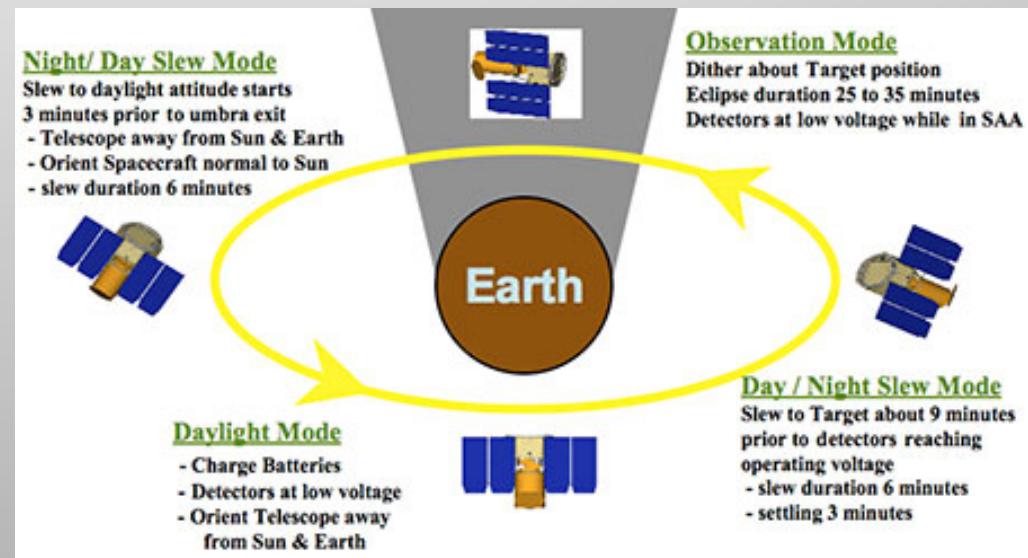
Main GALEX Mission Surveys			
	Exposure Time	Sky Coverage	Depth
Survey	(seconds)	(deg <sup>2</sup> )	(m <sub>AB</sub> )
All-sky Imaging	~100 (up to 800)	27,000	20.5
Medium Imaging	1,000-10,000	5,000	23.5
Deep Imaging (DIS)	>10,000	365	25.0

## Additional Surveys:

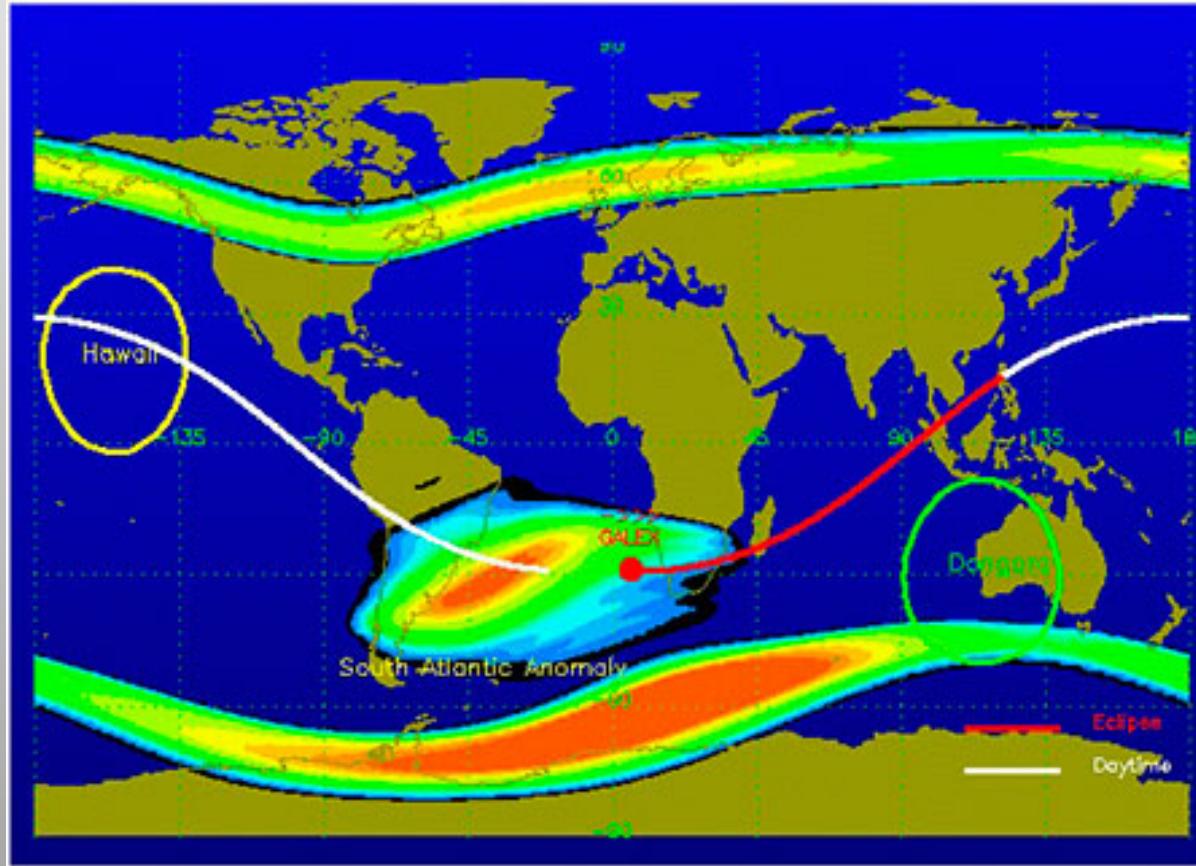
- **Nearby Galaxy Survey (NGS), 1000-1500s:**
  - Targeting Spitzer Nearby Galaxies Survey (71 targets) + others
- **Calibration Imaging (CAI):**
  - Observed several white dwarfs for calibration, however most saturated detectors
  - Absolute calibration rests solely on observations of LDS749B

# Technical Specifications: Orbit

- 690 km altitude orbit
- 29 degree inclination
- 98.6 minute orbital period
- 14-15 observational eclipses daily



# SAA: South Atlantic Anomaly



Source: [Caltech - Galex - Technical Documentation](#)

# Tech. Specs: Telescope

TABLE I  
THE GALEX OPTICAL PRESCRIPTION

Parameter	Value
Telescope:	
Type .....	Ritchey-Chrétien
Coatings .....	MgF <sub>2</sub> -coated Al
Primary diameter .....	500 mm
Secondary diameter .....	230 mm
Focal length .....	2998 mm
Focal ratio .....	6
Plate scale .....	68".80 mm <sup>-1</sup>
Grism (CaF <sub>2</sub> ):	
Width (inscribed diameter) .....	124 mm
Thickness (center) .....	5.9 mm
Wedge .....	1°37'
Blaze angle .....	2°33'
Ruling .....	75 lines mm <sup>-1</sup>
Imaging window (CaF <sub>2</sub> ):	
Diameter .....	124 mm
Thickness .....	6 mm
Dichroic (fused silica):	
Diameter .....	110 mm
Thickness .....	4 mm
Wedge .....	0°119'
Blue-edge filter (MgF <sub>2</sub> ):	
Diameter .....	74 mm
Thickness .....	2.5 mm
Red-blocking mirror:	
Diameter .....	110 mm

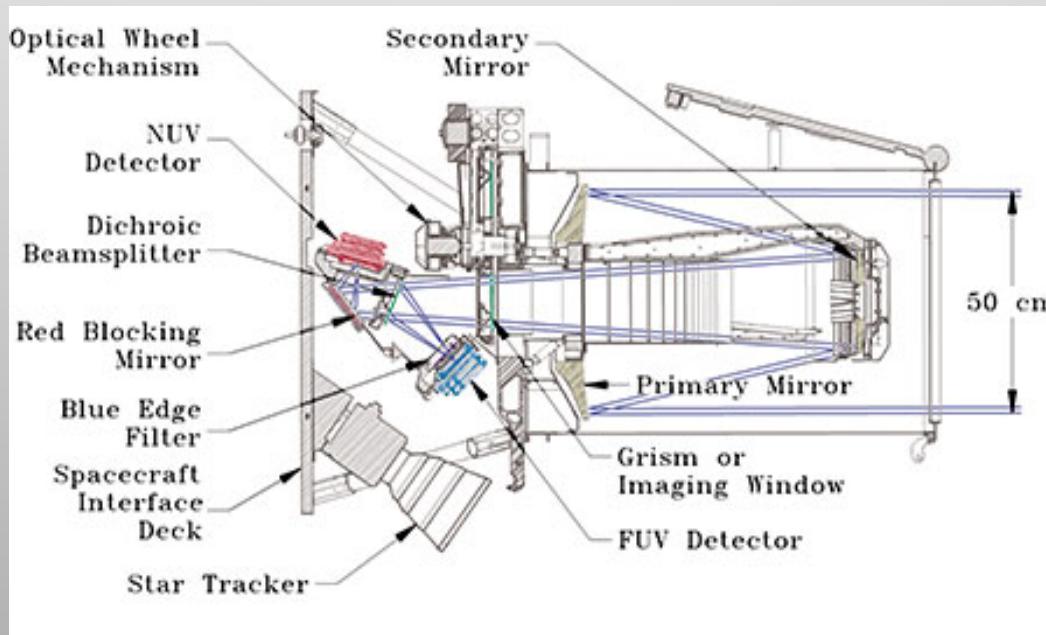
- Ritchey-Chrétien telescope
- 50 cm primary diameter
- 23 cm secondary
- 6 focal ratio
- 280 kg

# Tech. Specs: Scale



Source: [Caltech - Galex - Technical Documentation](#)

# Tech. Specs: Cross Section



# Tech. Specs: Instruments

- Two UV Bands:
  - FUV: 133.4 – 178.6 nm\*
  - NUV: 177.1 – 283.1 nm
- Spatial Resolution:
  - FUV: 4.3 arcseconds (FWHM)
  - NUV: 5.3 arcseconds (FWHM)
- Field of View:
  - FUV: 1.28 arcminutes
  - NUV: 1.24 arcminutes
- Generate approximately 3.2 GB of data daily

\* Stopped taking data in May 2009

TABLE 2  
SUMMARY OF MEASURED PERFORMANCE PARAMETERS FOR *GALEX*

Item	FUV Band	NUV Band
Bandwidth <sup>a</sup> .....	1344–1786 Å	1771–2831 Å
Effective wavelength <sup>b</sup> .....	1528 Å	2271 Å
Field of view .....	1°28'	1°24'
Peak effective area .....	36.8 cm <sup>2</sup> at 1480 Å	61.7 cm <sup>2</sup> at 2200 Å
Zero point ( $m_0$ ) .....	18.82	20.08
Image resolution .....	4.3' FWHM	5.3' FWHM
Spectral resolution ( $\lambda/\Delta\lambda$ ) .....	200	90
Detector background (typical):		
Total .....	78 counts s <sup>-1</sup>	193 counts s <sup>-1</sup>
Diffuse (cm <sup>-2</sup> ) .....	0.66 counts s <sup>-1</sup>	1.82 counts s <sup>-1</sup>
Hot spots .....	47 counts s <sup>-1</sup>	107 counts s <sup>-1</sup>
Sky background (typical) <sup>c</sup> .....	2000 counts s <sup>-1</sup>	20000 counts s <sup>-1</sup>
Limiting magnitude (5 $\sigma$ ) <sup>d</sup> :		
AIS (100 s) .....	19.9	20.8
MIS (1500 s) .....	22.6	22.7
DIS (30000 s) .....	24.8	24.4
Linearity:		
Global (10% rolloff) .....	18000 counts s <sup>-1</sup>	
Global (50% rolloff) .....	91000 counts s <sup>-1</sup>	
Local (10% rolloff) <sup>e</sup> .....	108 counts s <sup>-1</sup>	295 counts s <sup>-1</sup>
Pipeline image format .....	3840 × 3840 elements with 1.5 pixels	

<sup>a</sup> The bandpass is defined by wavelengths with effective area at least 10% of the peak.

<sup>b</sup> From eq. (3) of Fukugita et al. (1996).

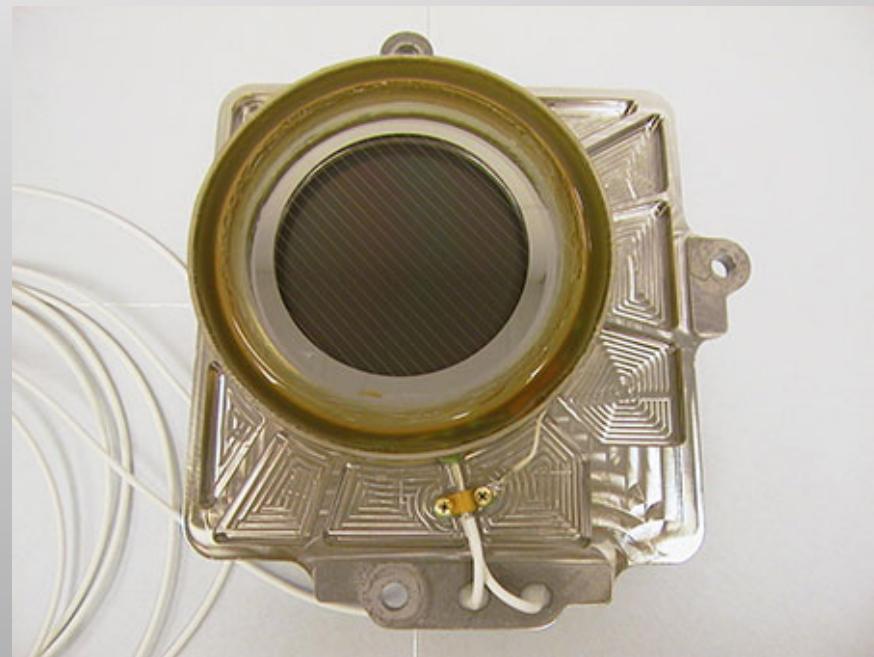
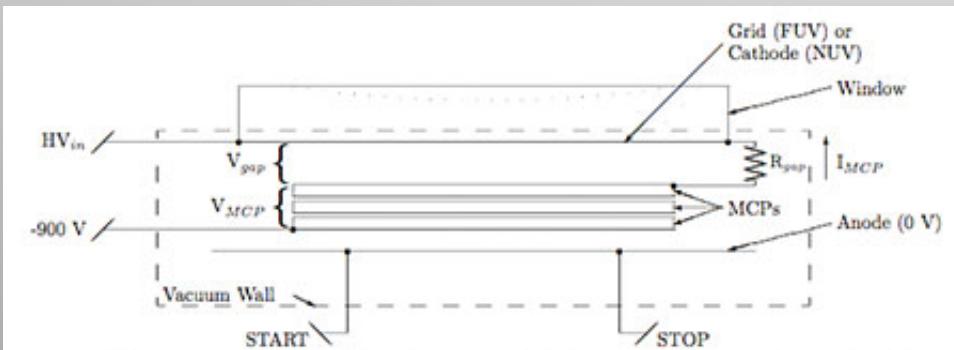
<sup>c</sup> These correspond to 690 and 745 photons s<sup>-1</sup> cm<sup>-2</sup> sr<sup>-1</sup> Å<sup>-1</sup>, respectively.

<sup>d</sup> Approximate All-sky (AIS), Medium (MIS), and Deep (DIS) Imaging Survey depths.

<sup>e</sup> These are worst-case values for point sources.

# Tech. Specs: Detectors

GALEX Detector Schematic



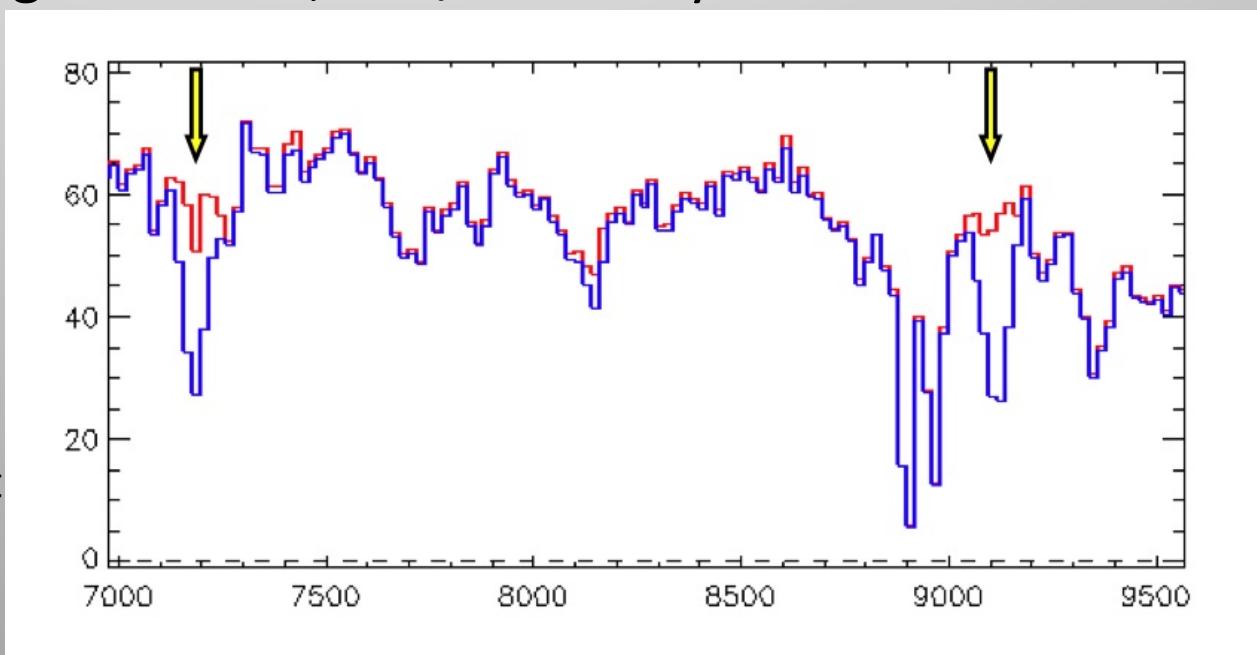
GALEX FUV Detector

# Tech. Specs: Detector Gain Sag

- Conversion of UV photons to electrons
  - Unfortunately, process degrades over time with prolonged exposure, bright sources, and/or nearby sources

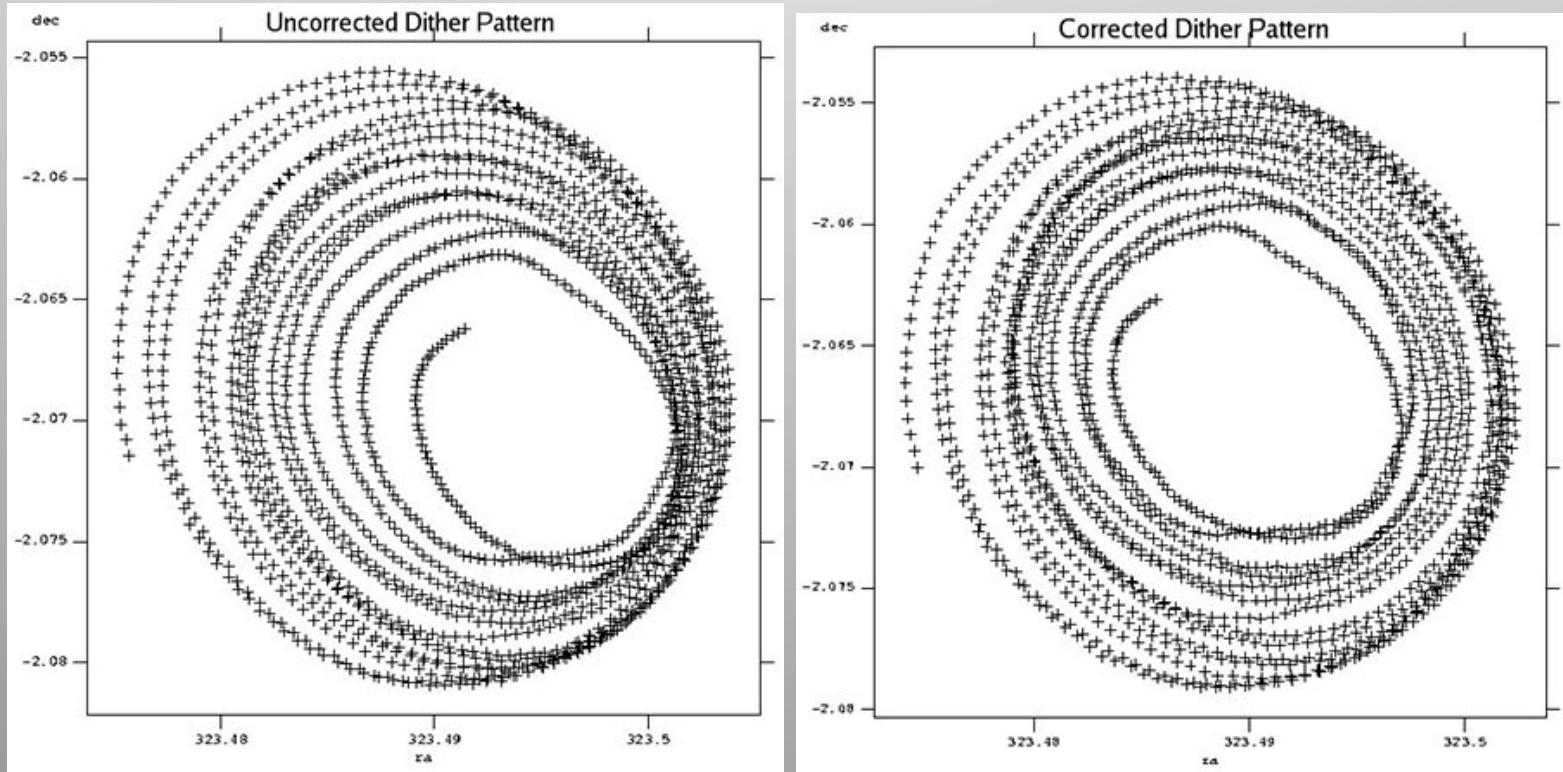
Red: All photon events  
Blue: Photon events within pulse height range 4-30

Photons are miss interpreted as background events or permanently lost



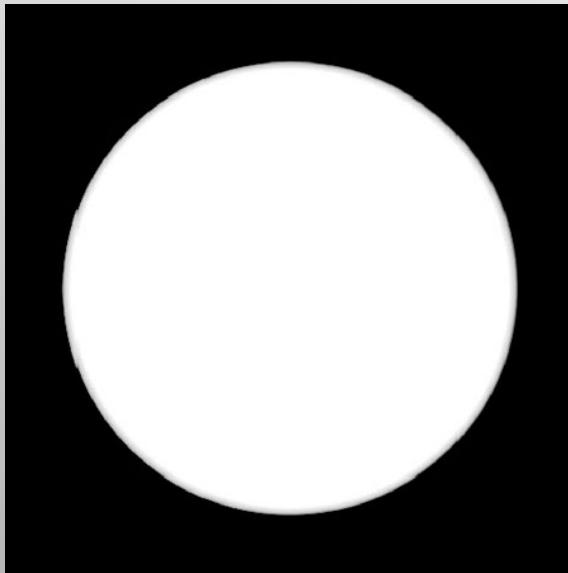
# Tech.Specs: Spiral Dither Pattern

- Solution to gain sag is a spiral observation pattern

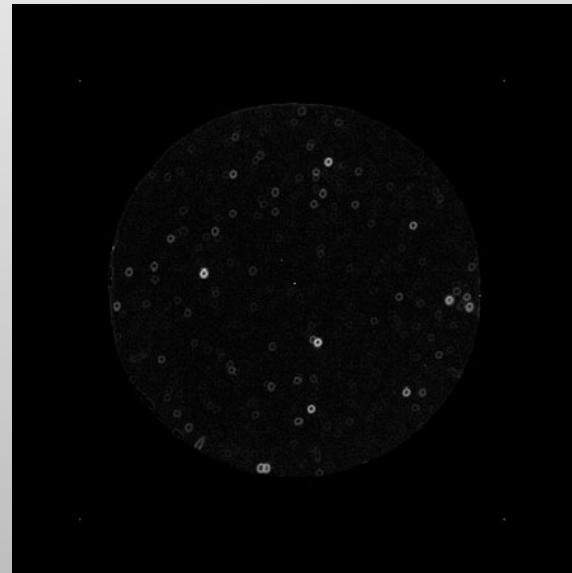


Source: [Caltech - Galex - Technical Documentation](#)

# Tech.Specs: Imaging Pipeline

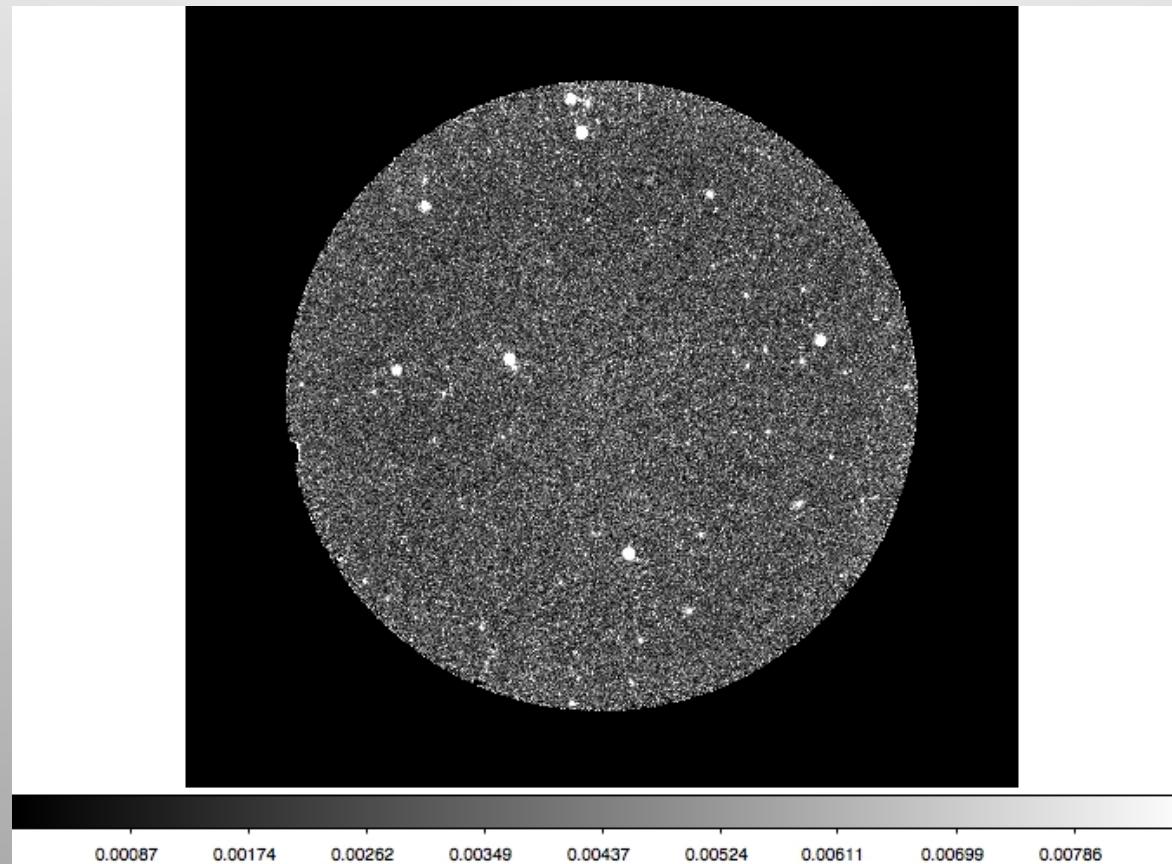


Typical Exposure Map: Intensity represents length of time the detector was looking at a specific part of the sky



Typical Dose Map: Is in detector coordinates so objects appear as donuts due to dither pattern

# Tech.Specs: Imaging Pipeline



Typical count image: Fully map projected, integrated exposure time. Eventually used for source extraction and further science

Source: [Caltech - Galex - Technical Documentation](#)

# Tech. Specs: Dead Time

- Dead time is the period during which there is a loss of exposure due to the detectors reading out a photon event.
  - This is due to system electronics
- Four stims, with known response times, are used to calibrate and estimate effective ‘dead time’ during an observational eclipse.

# Data: GRs

- Data released in 7 GRs (General Releases)
- Each consecutively with more of the sky, better knowledge of systematics and general completeness
  - Changes might include removal of low quality columns (50 between 4/5 and 6/7)
  - Reprocessing of some of the systematics

# Data: GRs

<u>GALEX Surveys</u>								
	AIS	DIS	MIS	NGS	GII	CAI	SPECTRA	TOTAL
<b>GR1</b>	3074	14	112	52	-	-	7	3259
<b>GR2/GR3</b>	15721	165	1017	296	288	20	41	17548
<b>GR4/GR5</b>	28269	292	2161	458	788	38	174	32180
<b>GR6/GR7</b>	<a href="#">34285</a>	<a href="#">720</a>	<a href="#">6964</a>	<a href="#">716</a>	<a href="#">2112</a>	<a href="#">87</a>	<a href="#">311</a>	<a href="#">45195</a>

## GR7 Key Features:

- Data closer to Galactic plane, including bulge area
- Observations of the Magellanic Clouds
- Observations of M31 (complement PanSTARRS)
- Increased coverage of KEPLER field

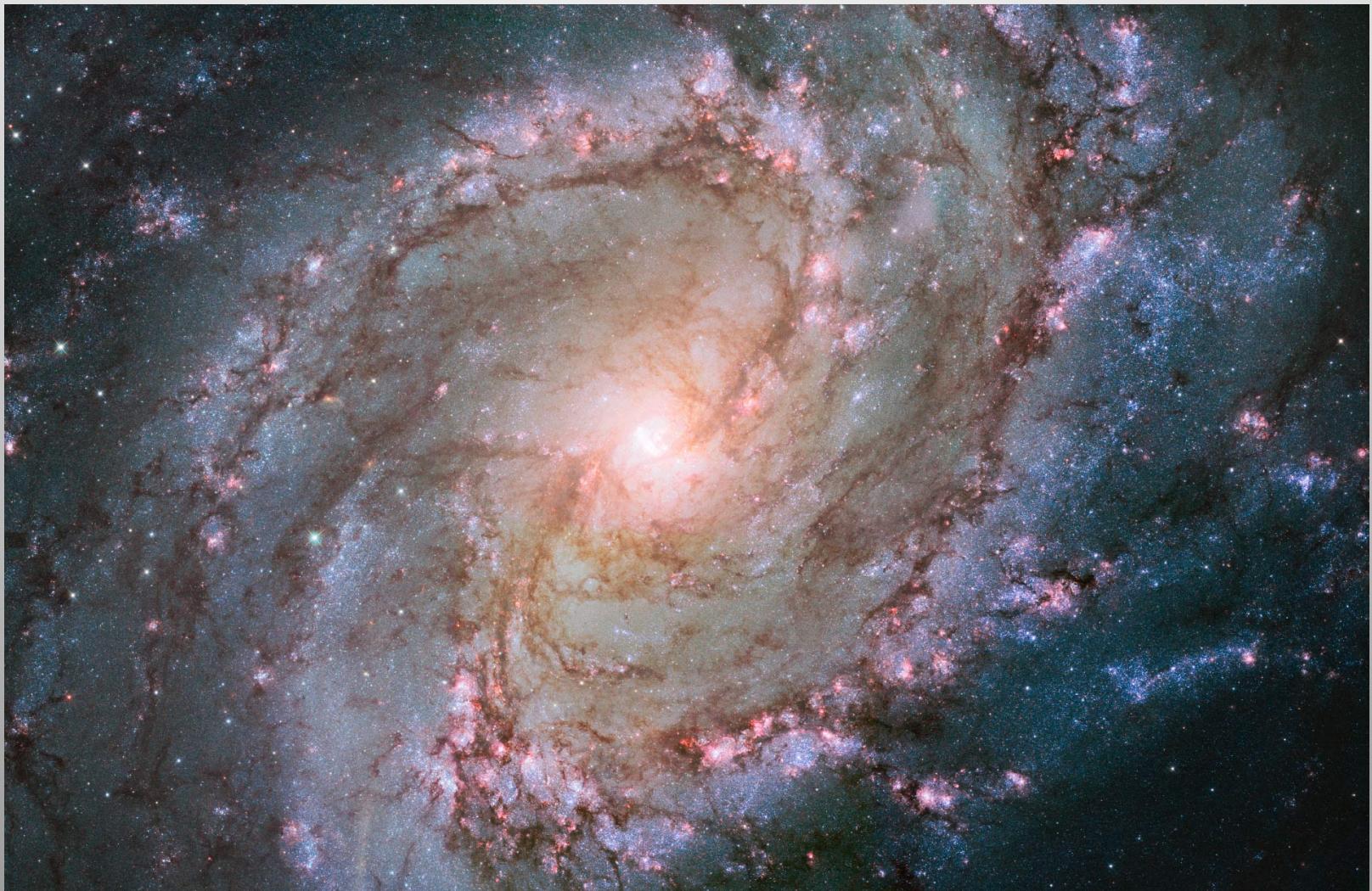
# Data: Location and Access

- Images and source catalogs hosted through [Milkulski Archive for Space Telescopes \(MAST\)](#)
- Selection of tools include:
  - GalexView: interactive graphical tool to search for detections within a specified radius around a position
  - Form-based searches
  - SQL Query
  - CasJobs

# Data: Dangers and Uncertainties

- Detailed Discussion of Imaging Analysis
  - [Astrometric Uncertainties](#)
  - [Point Spread Function](#)
  - [Image Artifacts](#)
- Technical Documentation Available Online
  - Do not use:  
<http://www.galex.caltech.edu/researcher/techdocs.html>
  - Use: <http://www.galex.caltech.edu/wiki/Public:Documentation>

# Science: Discoveries

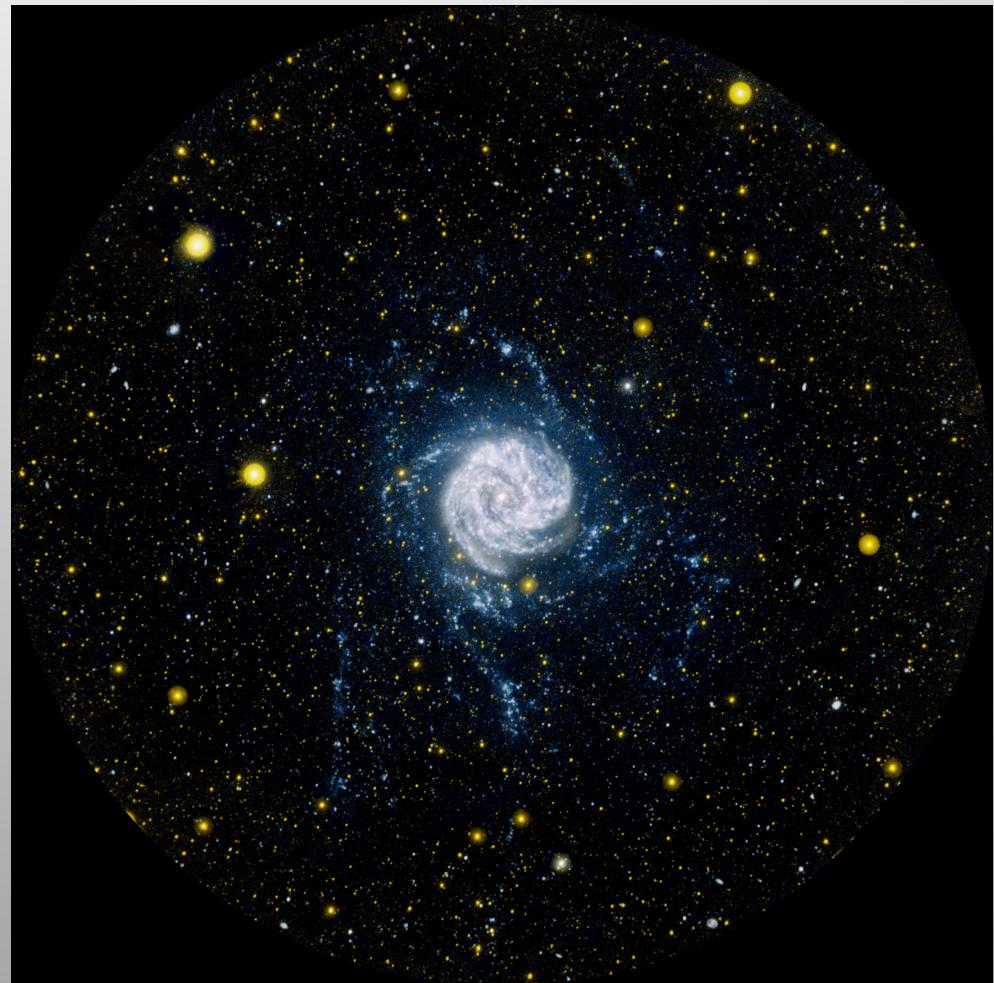


Source: [Hubblesite - HST - Archive](#)

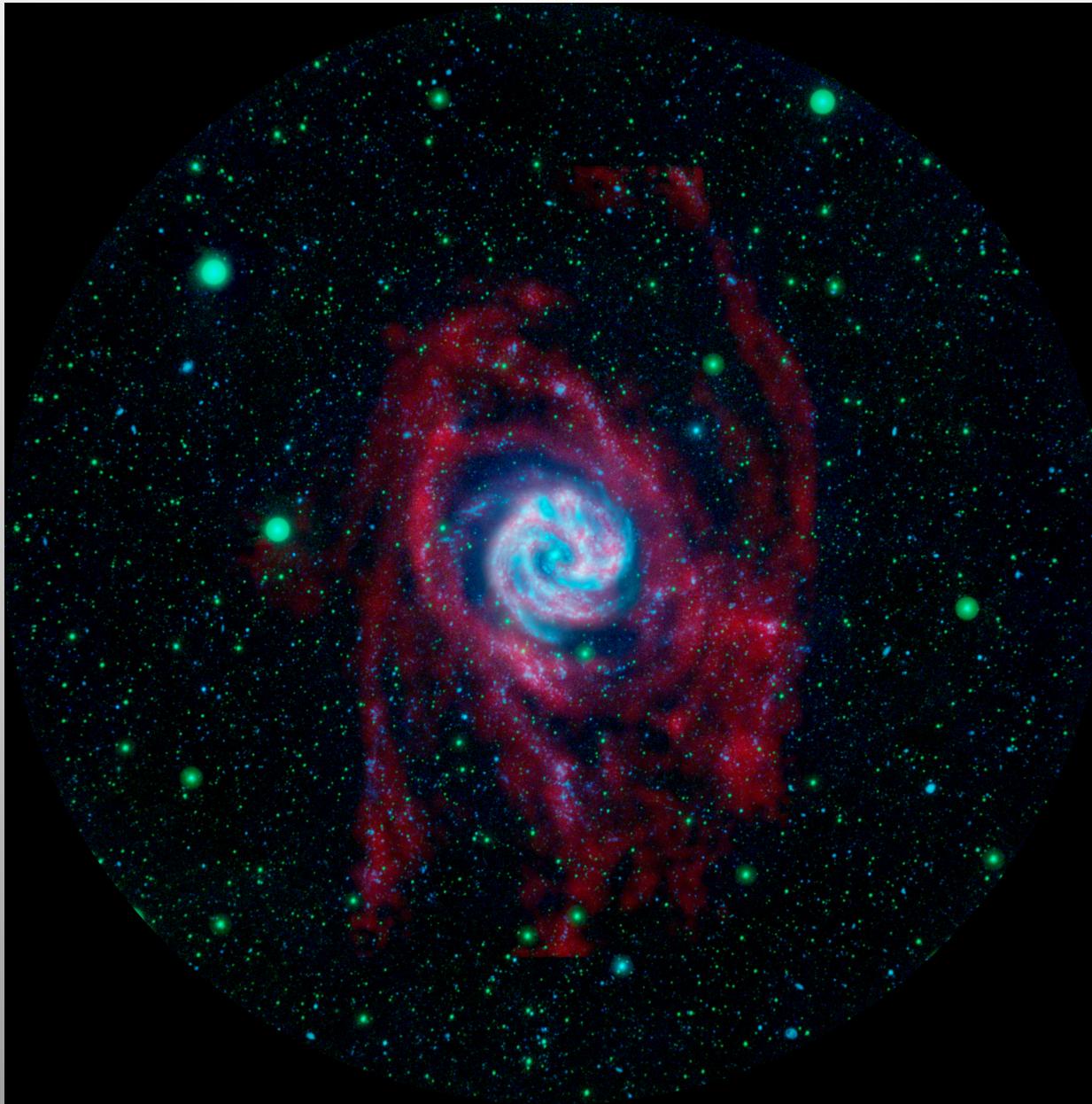
# Science: Discoveries

M83:

- Discovered star formation much further out than previously thought and with great abundance

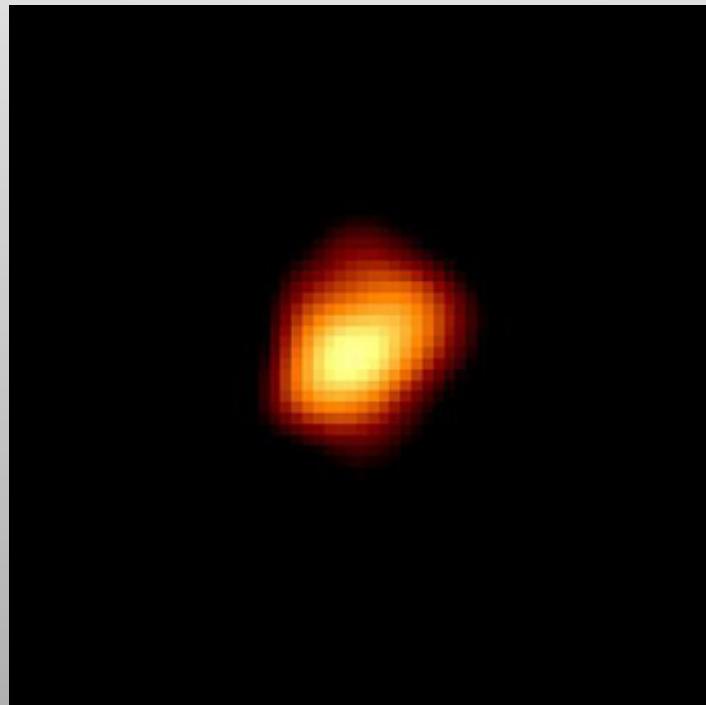


Source: [Caltech – Galex - Media](#)



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# Science: Discoveries

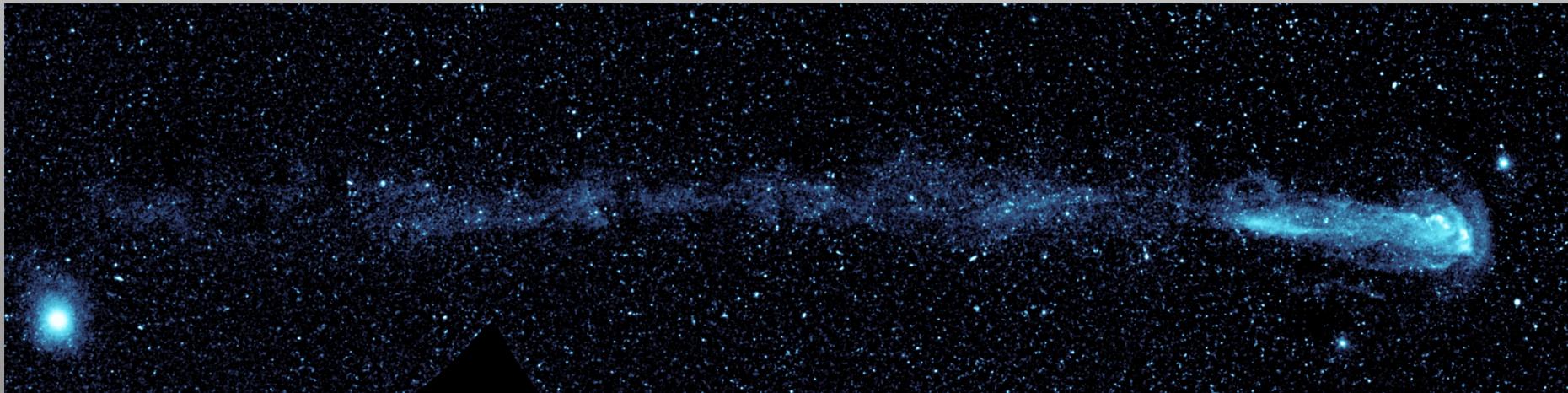


Source: [Hubblesite - HST - Archive](#)

# Science: Discoveries

Mira:

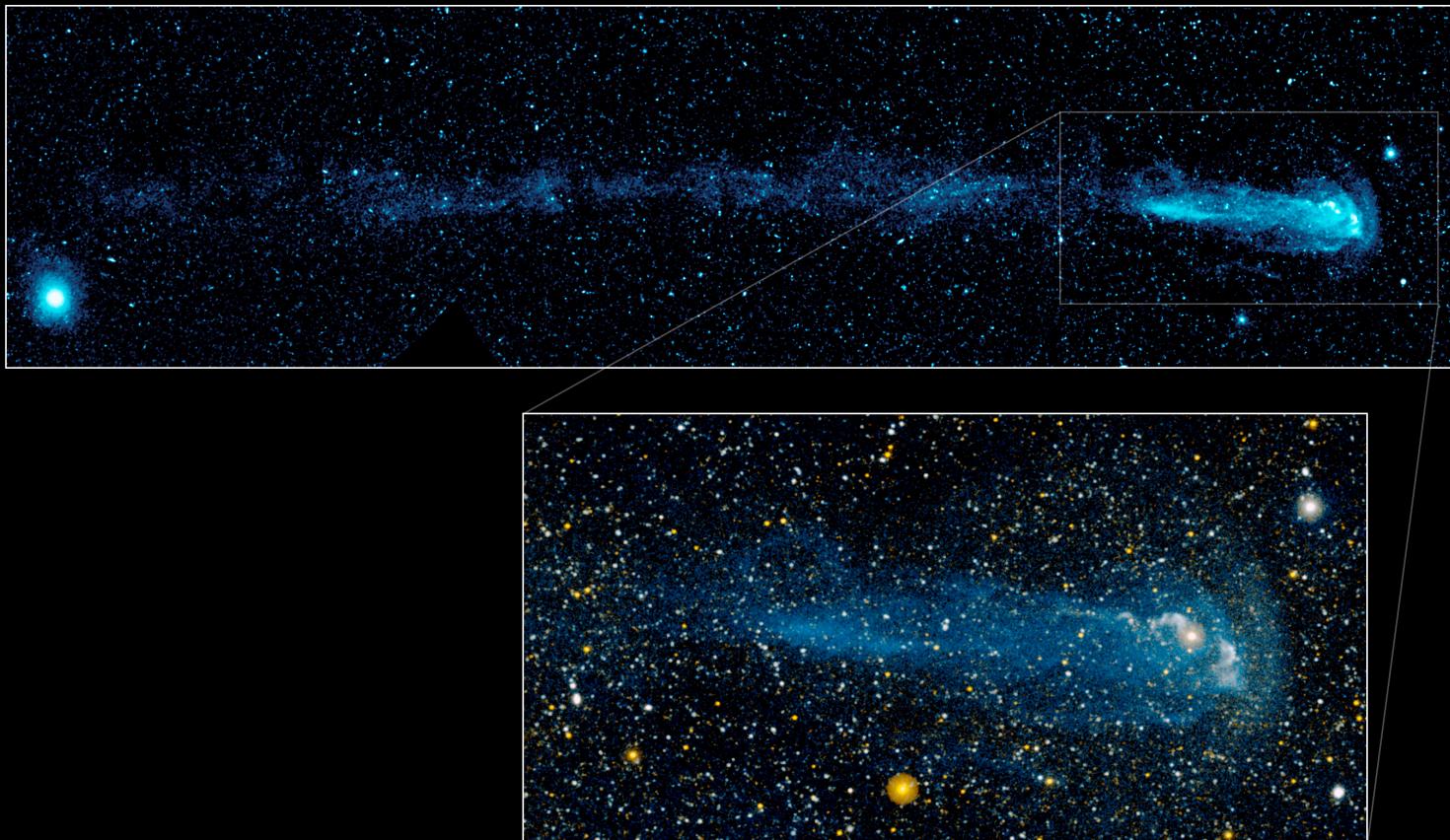
- Mass loss tail spanning 13 lightyears
- Bow shock
- Other examples of runaway stars



Source: [Caltech – Galex - Media](#)

# GALEX

## Galaxy Evolution Explorer



Mira's Turbulent Tail

GALEX • NUV • FUV

Source: [Caltech – Galex - Media](#)

# Science: Publications

- Collection of composite images with descriptions:

[http://www.galex.caltech.edu/media/  
images.html](http://www.galex.caltech.edu/media/images.html)

- List of publications using Galex data:

[http://www.galex.caltech.edu/researcher/  
publications.html](http://www.galex.caltech.edu/researcher/publications.html)