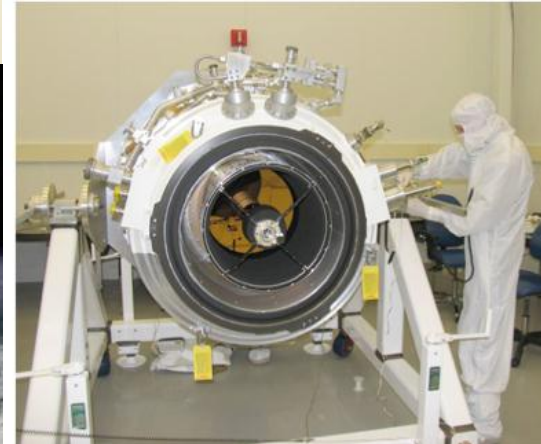
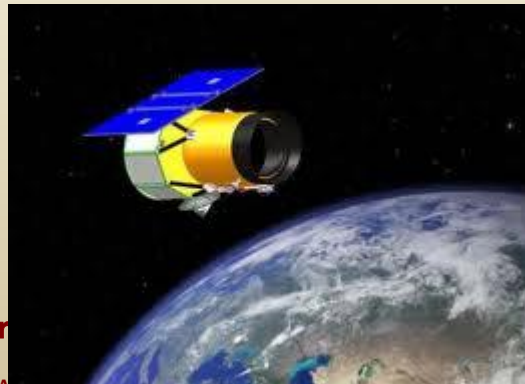
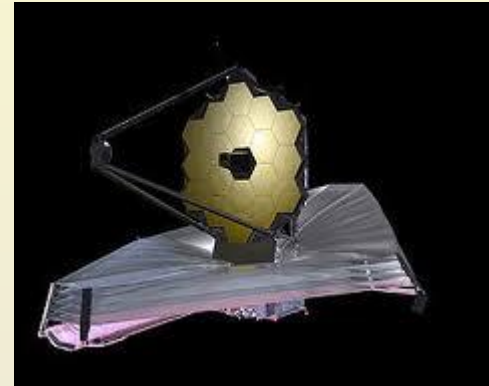
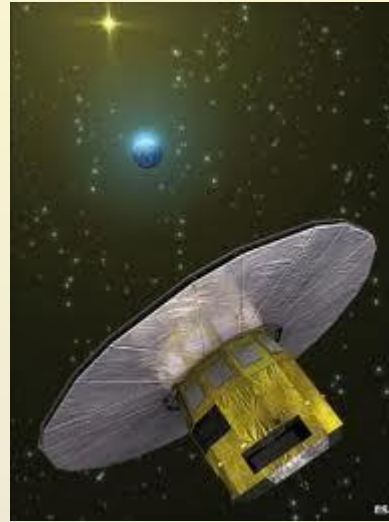
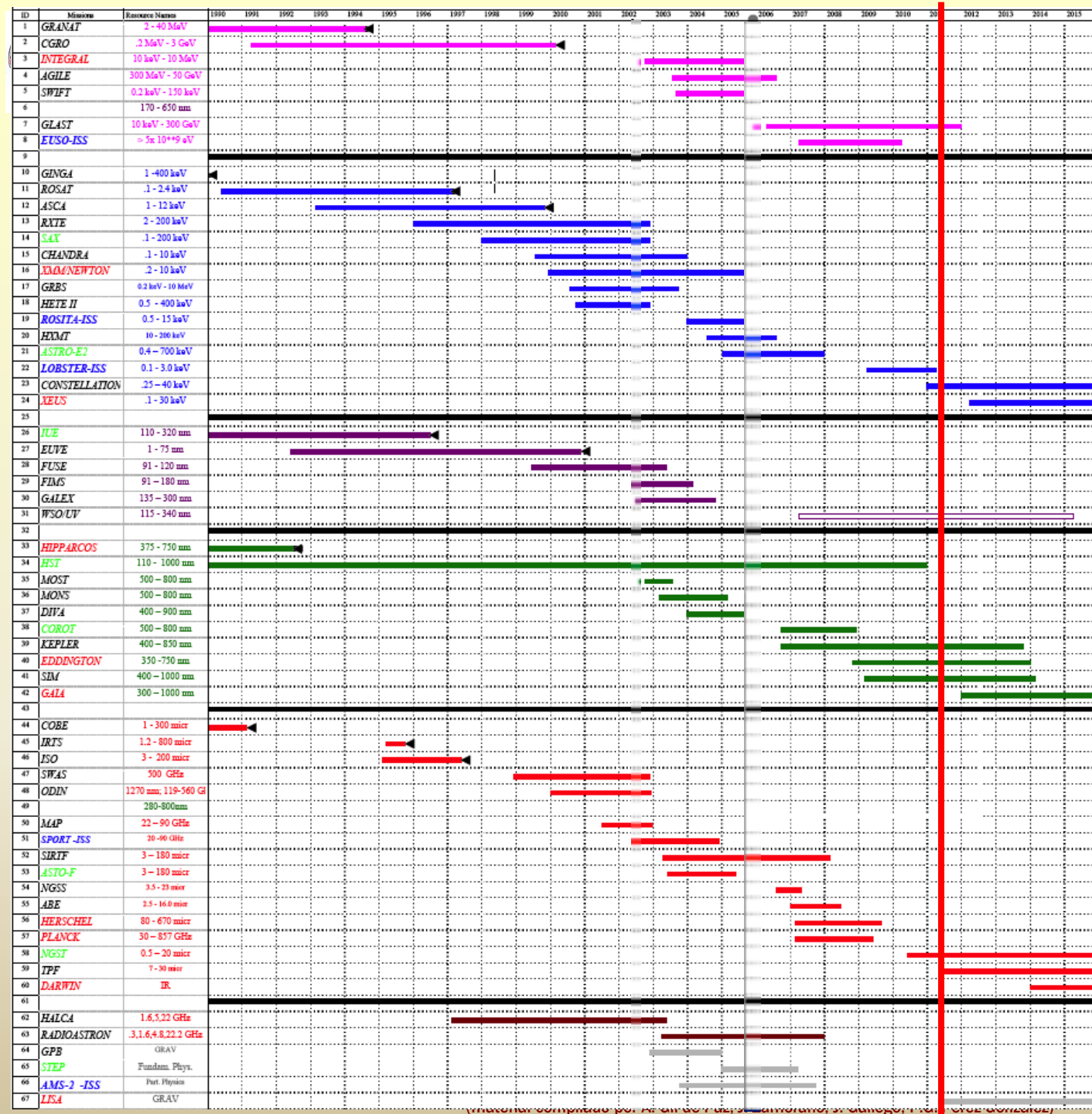




Tema 4: telescopios espaciales





Past/Present/
Future Space
Observatories:



Scheme (1/3)

Covering the basics:

- **Why observing from Space?**

***Image quality,
low bckg.,
transparency***

vs.

Costs & risks

HST



- **Description of the Observatory**
- **Preparing a *HST* proposal:**
 - ***Constraints, APT, etc.***
- **Using Archival Data: MAST**



Scheme (2/3)

GALEX



- **Description of the Observatory**
- **Preparing a GALEX proposal**
- **Bright-star and background limitations**
- **Using Archival Data**

Spitzer and WISE



Herschel



- **Description of the Observatories**
- **Preparing proposals: *Using Spot / Hspot***
- **Constraints, pipeline, & latents**
- **Using the Spitzer Archive: *Leopard/SHA***

**Instrumentación Astronómica
Curso 2011/2012**

(material compilado por A. Gil de Paz, J. Zamorano, J. Gallego, P.G. Pérez-González)



Scheme (3/3)

Past:

- Using IUE, IRAS, ISO data



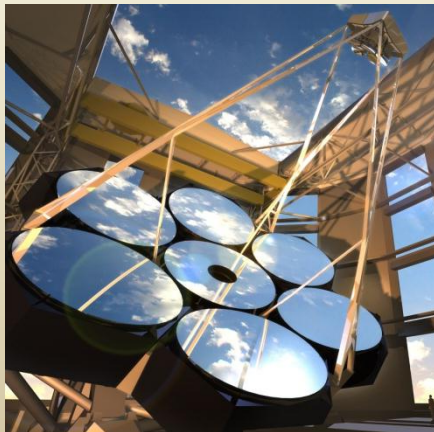
Future:

- James Webb Space Telescope (JWST), Gaia, SPICA, WSO-UV, ...

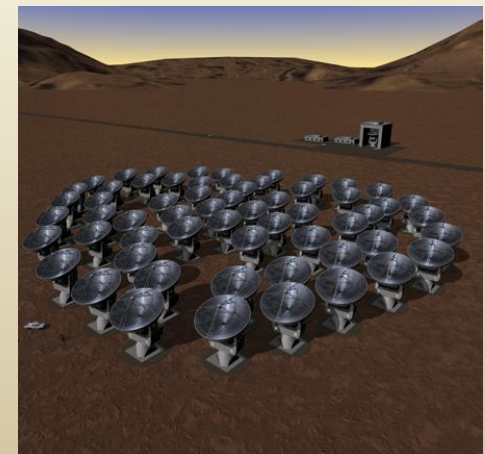


Synergy with ground based data:

- ***HST - Keck/VLT***



- ***JWST-ALMA***



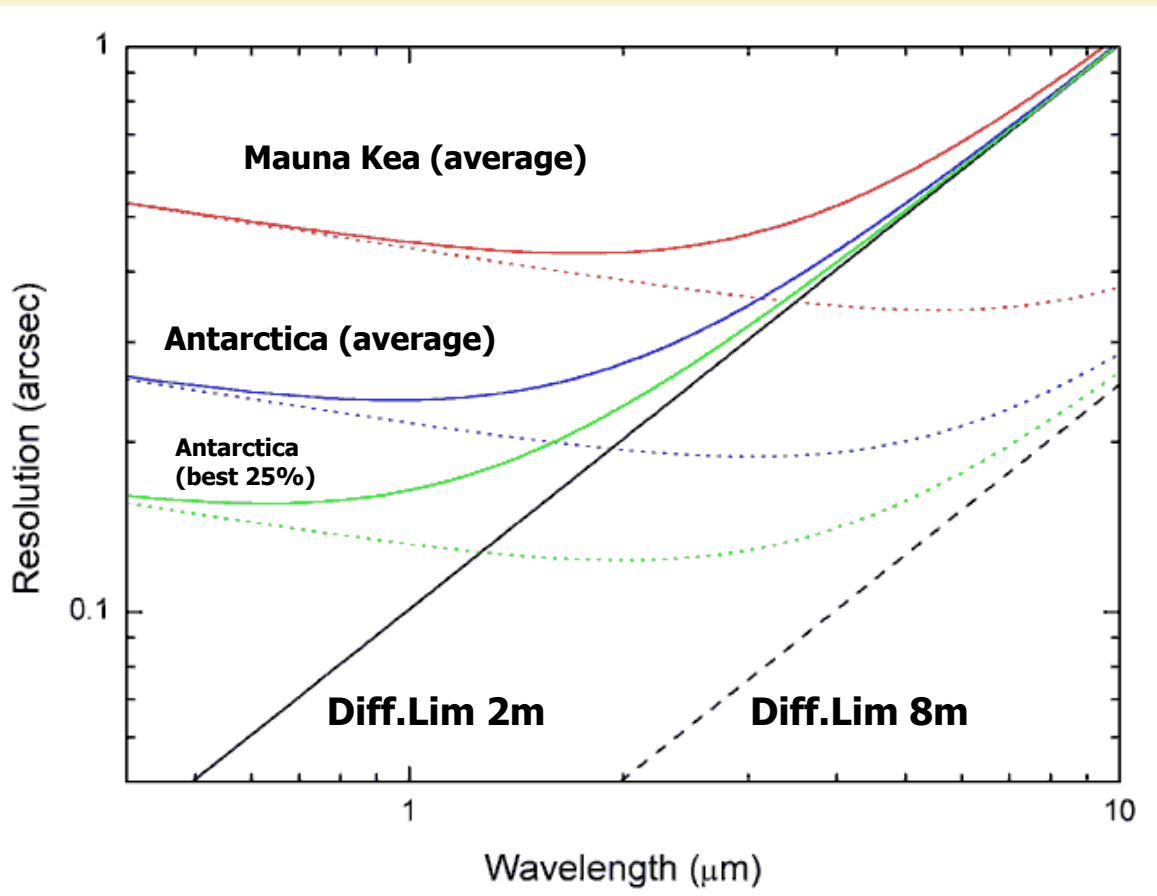


Space Astronomy: Why?



No atmosphere

- Better image quality (no atmospheric *seeing*)
 $\text{FWHM}_{\text{seeing}} \sim \lambda^{-0.2}$; Diffraction limit = λ/D





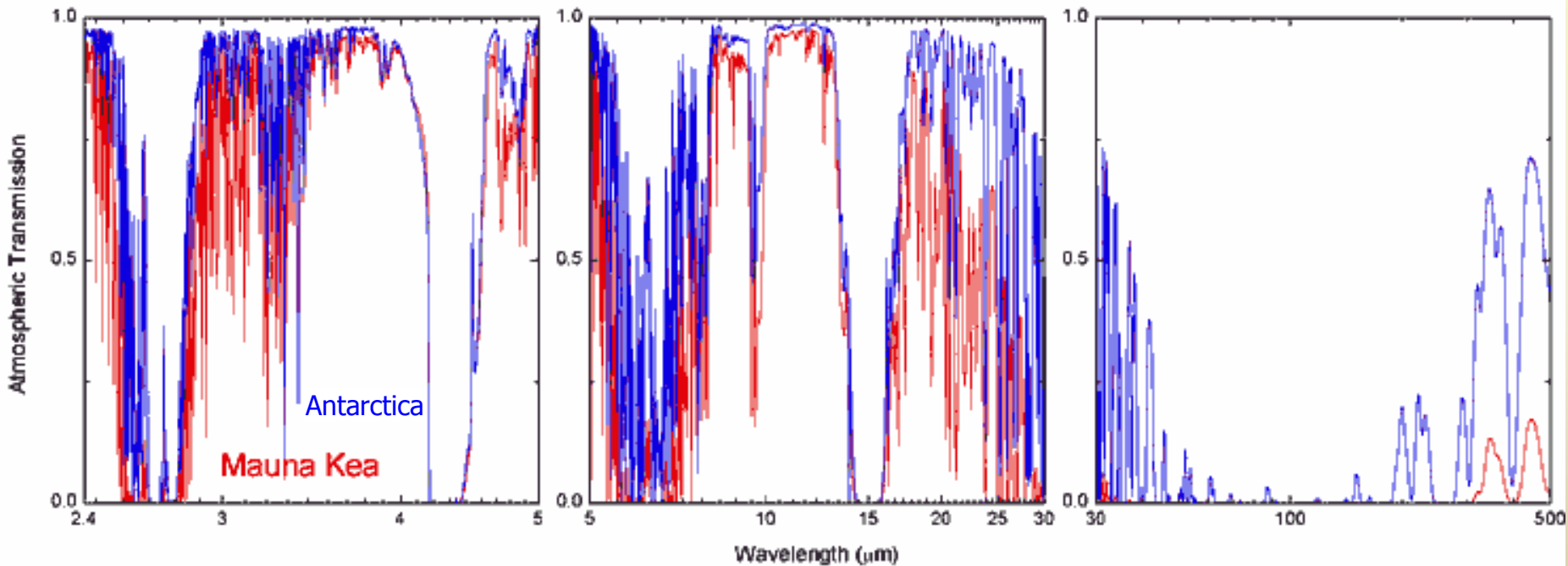
Space Astronomy: Why?

Ups



No atmosphere

- Better transparency & no cloudy nights





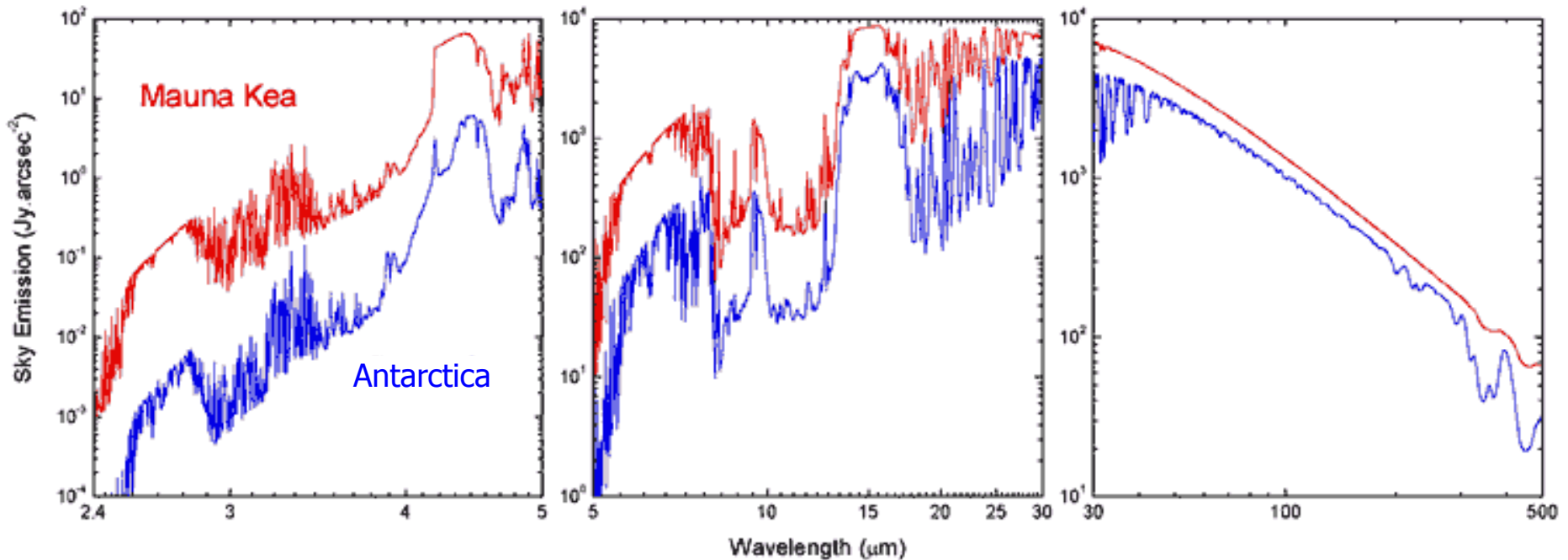
Space Astronomy: Why?

Ups



No atmosphere

- Less (scattered and thermal) background

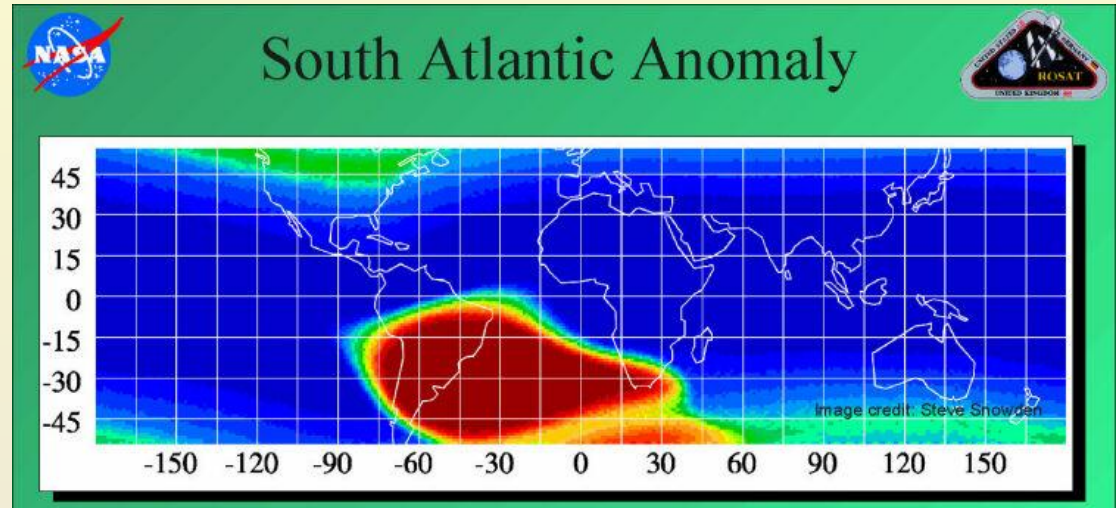
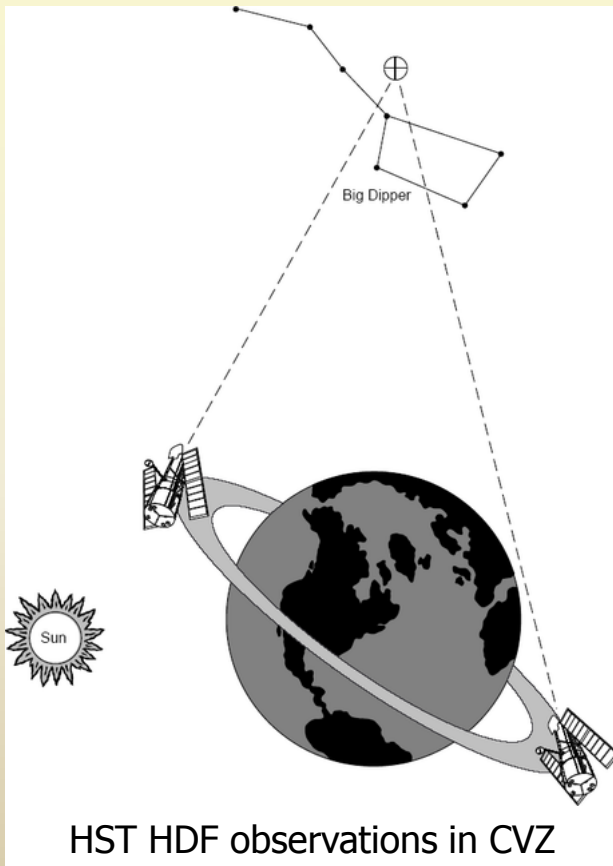




Space Astronomy: Why?



Existence of Continuous Viewing Zones (CVZ)



In high orbits (Earth-trailing, L2)

- Longer lasting (& fixed) CVZ
- Lower thermal background from Earth
- No South Atlantic Anomaly passages

Instrumentación Astronómica
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Space Astronomy: Why?

Downs



Higher risks

- Not 100% launch and deploy successful rates (e.g. HETE, Abrixa, ASTRO-E, WIRE)
- Telescope & instruments never tested under exact working conditions (e.g. HST).
- Difficult to repair if something fails. Impossible for satellites in high orbits.

Limited lifetime

- Instrument consumables (cooling: NICMOS, ISO, *Spitzer*, *HSO*)
- Propellant (to compensate for atmospheric drag -Compton GRO- or angular momentum build up -JWST-)
- Gyros (despite redundant systems).



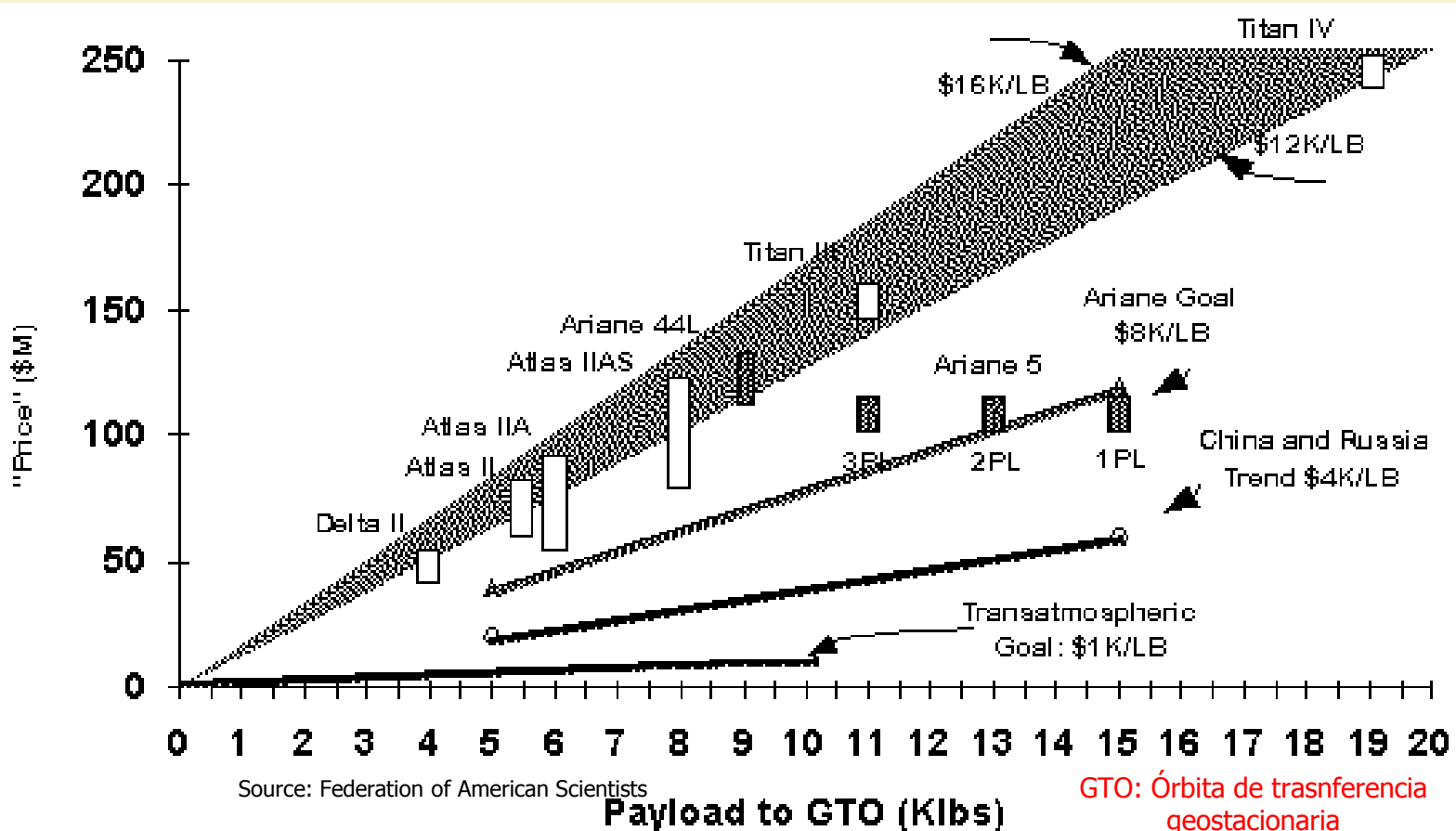
Space Astronomy: Why?

Downs



Higher costs

- For both telescope & instruments plus launch cost.
- Example: All four VLTs cost $\sim 1/7$ HST.





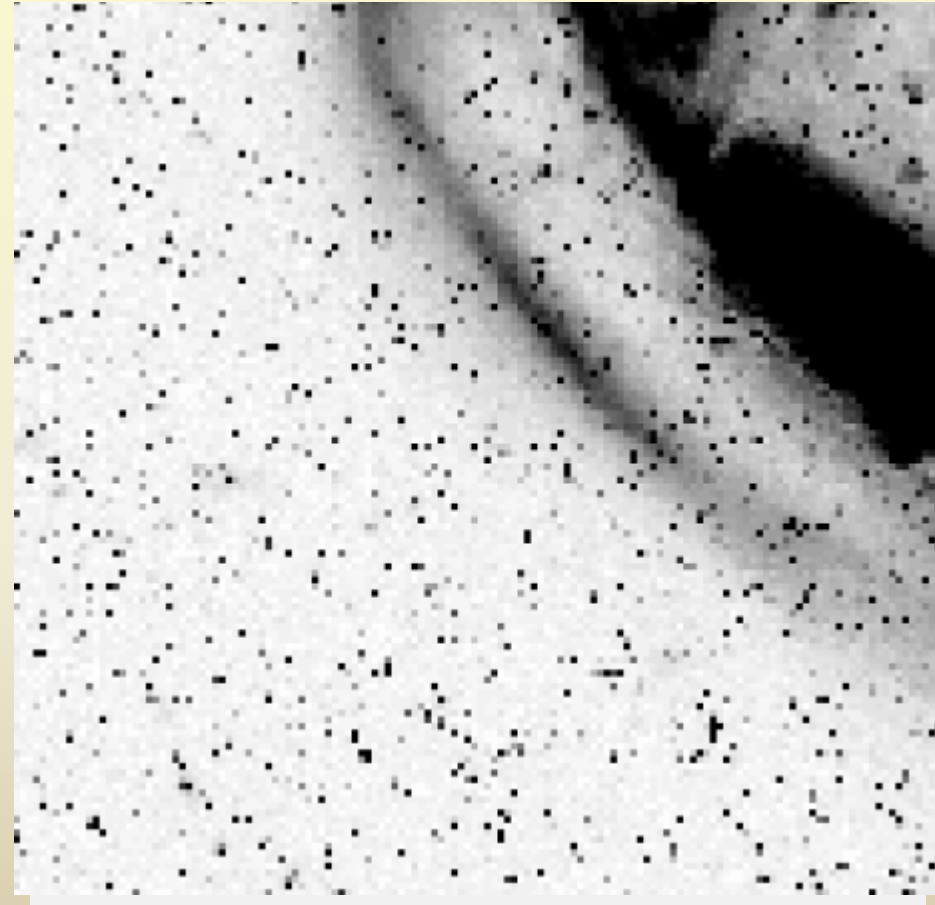
Space Astronomy: Why?

Downs



Higher rates of high-energy particles:

- Cosmic-rays events in HST detectors are several times higher than in the ground (1.5-3% ACS/WFC pixels affected in 1000s).
- This situation is worse in high orbits (5%-10% pixels expected to be affected in a JWST 1000s exposure) where there is no protection by the Van Allen belts.



Single 600s-long HST ACS/WFC raw image



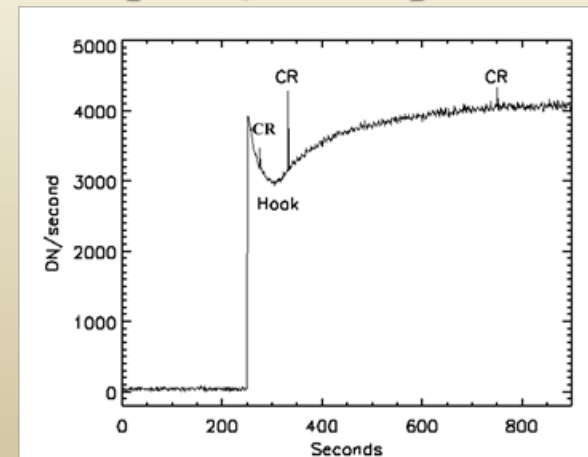
Space Astronomy: Specifics

These Ups and downs determine the specifics of the analysis methods used in Space Astronomy:

- High-spatial res. & Diff. Lim. images: PSF phot. (HST, *Spitzer*)
- Low background: Highly Poissonian statistics (HST & GALEX)
- High cosmic-rays rates: (HST CR-SPLIT)

Specifics of the instrumentation used in Space Observatories exploring new windows (UV, FIR):

- Count-rate, color, and position-dependent PSF (GALEX & MIPS)
- Multiple time constant response (MIPS 70 & 160um photoconduct.)
- Confusion limits (GALEX & MIPS)





NASA's Hubble Space Telescope - HST

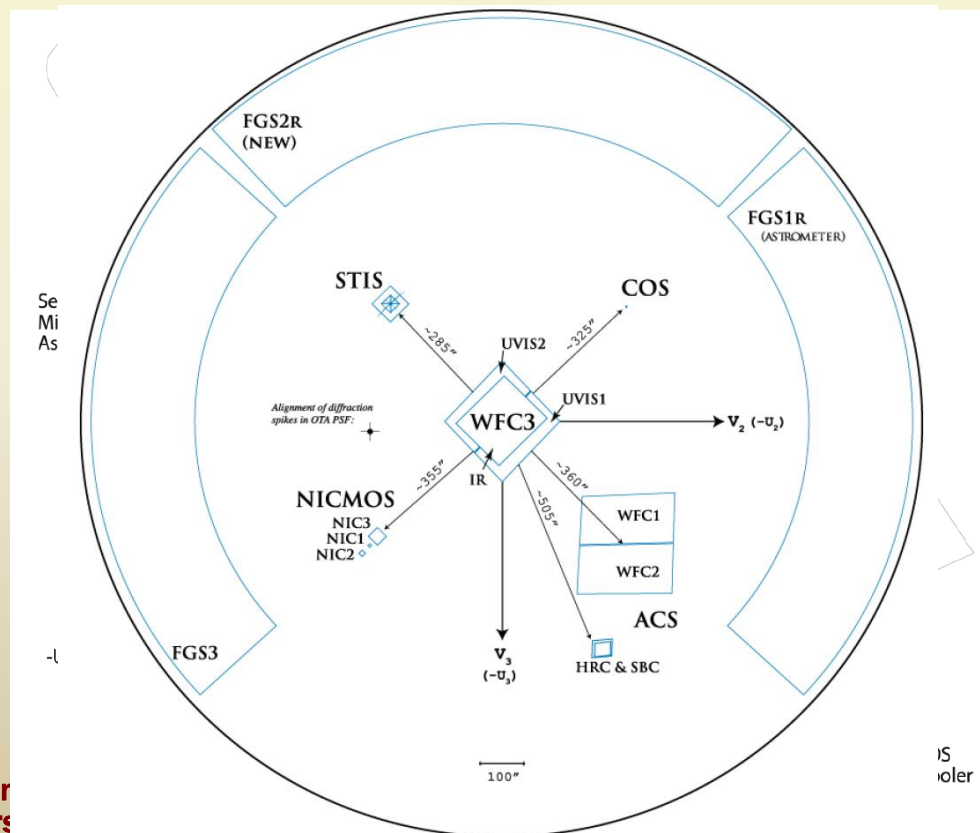
**Instrumentación Astronómica
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Hubble Space Telescope

- 2.5-m telescope in a low orbit (600 km) deployed in 1990.
- Functioning "legacy" instruments: ACS, STIS, NICMOS
- Replaced instruments: FOC, FOS, GHRS, WF/PC, WFPC2
- Last generation instruments (2009): COS, WFC3



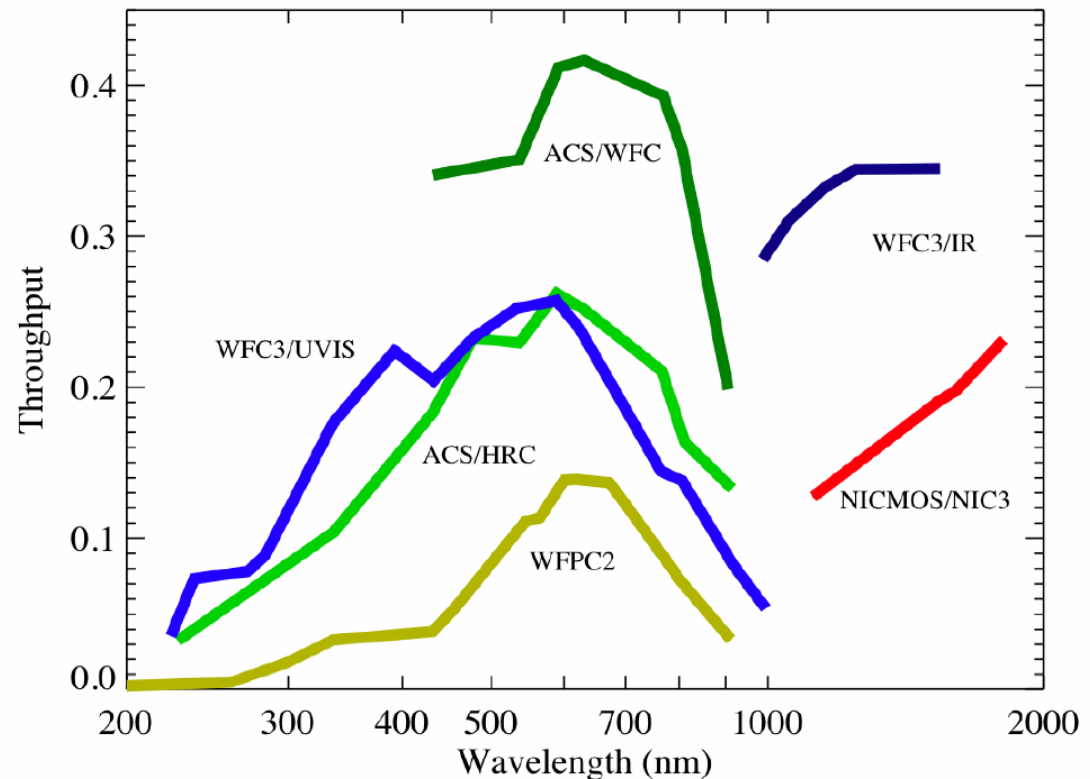


HST Instruments

Newest instruments: (Installed in 2009 - SM4)

COS (Cosmic Origins Spectrograph): Low and medium-resolution spectrograph in the UV range (1150-3200 AA).

WFC3 (Wide Field Camera 3): Imaging from 0.2-1.7 microns. It replaced the aging WFPC2. Some redundancy with ACS.





HST Instruments

UV imaging:

	WFC3/UVIS	ACS/HRC	STIS/NUV-MAMA
FOV Area (arcsec ²)	162" x 162" (26183)	29" x 26" (754)	25" x 25" (625)
Broadband Throughput @ 230, 330 nm	0.07, 0.18	0.05, 0.10	0.026, 0.002
Pixel Scale (arcsec)	0.040	0.027	0.025
Number of Pixels	4k x 4k	1k x 1k	1k x 1k
Read Noise (e-)	3	4.7	None
Dark Current (e-/pix/s)	1.0x10 ⁻⁴	5.8x10 ⁻³	1.4x10 ⁻³
Number of Filters	13 10 full-field 3 quad	6 3 full-field 3 UV polarizers ¹	9 8 full-field (inc. 2 ND), 1 quad ND



HST Instruments

Optical imaging:

	WFC3/UVIS	ACS/WFC	ACS/HRC
FOV Area (arcsec ²)	162" x 162" (26183)	202" x 202" (40804)	29" x 26" (754)
Broadband Throughput ¹ @ V, I, z	0.26, 0.14, 0.08	0.41, 0.36, 0.20	0.23, 0.16, 0.13
Pixel Scale (arcsec)	0.040	0.049	0.027
Number of Pixels	4k x 4k	4k x 4k	1k x 1k
Read Noise (e-)	3	5	4.7
Dark current (e-/pix/s)	1.0x10 ⁻⁴	2.6x10 ⁻³	5.8x10 ⁻³
Number of Filters	49 32 full-field 17 quad	27 12 full-field 15 ramp	21 ² 13 full-field, 3 polarizers 5 ramp



HST Instruments

Near-infrared imaging:

	WFC3/IR	NIC3	NIC2	NIC1
FOV Area (arcsec ²)	123" x 136" (16728)	51" x 51" (2601)	19" x 19" (361)	11" x 11" (121)
Broadband Throughput @ 1.1, 1.6 μm	0.29, 0.33	0.13, 0.20	0.14, 0.20	0.12, 0.18
Wavelength Range	0.9- 1.7 μm	0.8 - 2.5 μm	0.8 - 2.5 μm	0.8 - 1.8 μm
Pixel Scale (arcsec)	0.13	0.200	0.075	0.043
Number of Pixels	1k x 1k	256 x 256	256 x 256	256 x 256
Read Noise (e-)	16	29	26	26
Number of Filters	15	16	19 16 standard, 3 polarizers	19 16 standard, 3 polarizers



HST Instruments

UV spectroscopy:

		COS/FUV	COS/NUV	STIS/FUV	STIS/NUV
Spectral Coverage (Å)		1150 - 1775 (M) 1230 - 2050 (L)	1700 - 3200	1150 - 1700	1600 - 3100
Effective Area (cm ²)					
@ 1300Å (FUV),		2800 (M)	900 (M)	400 (M)	350 (M)
2500Å (NUV)		2400 (L)	750 (L)	1700 (L)	900 (L)
Resolving Power	H	N/A	N/A	114,000	114,000
$R = \lambda/d\lambda$	M	20,000 - 24,000	16,000 - 24,000	10,000 - 46,000	10,000 - 30,000
	L	2400 - 3500	1500 - 2800	1000	500
Number of Pixels Along Dispersion		32768	1024	1024 (2048)	1024 (2048)
Background (cts/s/resel)		4.3×10^{-5}	1.9×10^{-3}	350×10^{-5}	17×10^{-3}
Background Equivalent Flux (ergs/cm ² /s/Å)		$(0.5 - 8) \times 10^{-18}$	$(1.3 - 3.8) \times 10^{-16}$	20×10^{-18}	13×10^{-16}

Optical spectroscopy: STIS (COS does not cover the optical)



Proposing for HST – Cycle 20

Feasibility:

- Reasonable number of orbits (compared with the expected scientific return and number of people involved). Use ETC.
- The assumptions for determining the number of orbits are well justified and the overheads are properly accounted for.

Need for HST:

- *HST* (and only *HST*) can address this particular science topic.
- Available in the MAST archive? If so, justify additional time.

Flexibility:

- Long & frequent visibility windows and no unnecessary timing or orientation constraints.

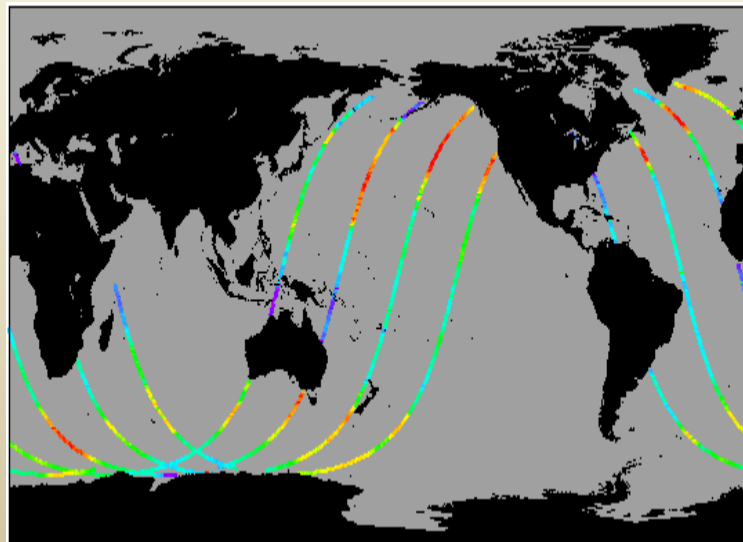


Proposing for HST: Constraints

- **Orbit:** 96 min long. Most objects partially occulted by the Earth (up to 44 min/orbit). CVZ within 24° the orbital poles.

(Note: CVZ should not be requested for background-limited broad-band imaging or observations with timing constraints, special orientation requirements, or ToO)

- **SAA:** although precession cycle is 56 days (so objects can be in the CVZ for many days in a row), the SAA limits the longest continuous observation to 5-6 orbits.
- **Pointing constraints:** within 60° of the Sun, 20° of the Earth and 9.5° of the Moon. Additional constraints for the ACS/SBC MAMA detector apply.
- **Other constraints:** Between 2005 and 2009
(SM4) HST in 2-gyros mode.





HST Phase I: APT

First steps:

- Documentation: Call for Proposals, HST Primer, and relevant instrument (ACS, NICMOS, WFC3 ...) handbook.
- Get Scientific Justification LaTeX/Word/PDF template
- Software: Proposer Tool + Visualizer (APT: Astronomer's proposal Tool)

(See APT training materials!)

APT Training Materials

http://www.stsci.edu/hst/proposing/apt/using_apt

Getting Started Latest Headlines GALEX Science Team ... pbwiki :: magpopitp ... SDSS tools RyC-login Mapquest-Spain

Google hst apt

SPACE TELESCOPE SCIENCE INSTITUTE

The Institute | HST | JWST | Community Missions | Data Archives | Outreach | Resources

APT

APT Training Materials

Since APT is highly graphical, the best way to learn it is to watch someone use it. So we have provided a series of short training movies which will help get you started. These have been very well received by those that used them. There are also equivalent text documents which should be helpful for printing, and quick reference. APT and the stand alone VTT also have documentation available from the "Help" menu (the right most menu on the menu bar).

Here is a [test movie](#). If you have any trouble with the movies please read the [tips for viewing movies](#).

General APT Training Materials:

These are the available formats:			
Title	Text	Movie	ECF Mirror of Movie
General Overview of APT GUI:	Yes	6 mins.	6 mins.
Annotated Snapshot of the GUI Features:	Yes	-	-
Editing with the Tree Editor:	-	3 mins.	3 mins.
Reviewing Diagnostics:	Yes	3.5 mins	3.5 mins
Using Starview to Overlay Archival Data in the VTT:	Yes	-	-

Phase I Specific APT Training Materials:

The [Phase I Proposal Roadmap](#) contains all of these links in a high level step-by-step proposal writing procedure.

These are the available formats:			
Title	Text	Movie	ECF Mirror of Movie
Phase I Getting Started in APT:	Yes	12 mins.	12 mins.
How to Analyze Scheduling Constraints with APT:	Yes	6 mins.	6 mins.
How to Ingest Fixed Targets in Phase I:	Yes	3.5 mins.	3.5 mins.

Phase II Specific APT Training Materials:

The [Phase II Proposal Roadmap](#) contains all of these links in a high level step-by-step proposal writing procedure.

These are the available formats:			
Title	Text	Movie	ECF Mirror of Movie
Getting started in Phase II:	Yes	8 mins.	8 mins.
Understanding the Phase II PDF Proposal Preview:	Yes	-	-
Running the Orbit Planner:	Yes	5.5 min	5.5 min
Annotated Snapshot of the Orbit Planner Features:	Yes	-	-
Running the Visit Planner:	Yes	5 mins.	5 mins.



HST Phase I: APT

The screenshot shows the Astronomer's Proposal Tools (APT) software interface. The title bar reads "Astronomer's Proposal Tools". The menu bar includes "File", "Edit", "Tools", and "Help". The toolbar contains icons for "Form Editor", "Spreadsheet Editor", "Orbit Planner", "Visit Planner", "VTT", "PDF Preview", "Errors and Warnings", "Submit", "Run All Tools", and "Stop". Below the toolbar is a "New Proposal" button and a "What's New?" button with a "New!" starburst. A "Roadmap" button with a compass icon is also present. The main content area displays the title "Astronomer's Proposal Tools" and the version "Version 15.0 Beta (Sun Nov 20 23:49:22 EST 2005)". A list of acknowledgments follows:

- Copyright 2002 - 2005 United States Government as represented by the Administrator of the National Aeronautics and Space Administration. All Rights Reserved.
- This software has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.
- This software has made use of the SIMBAD database, operated at CDS, Strasbourg, France.
- This software uses portions of the .ISky library which is maintained by the European Southern Observatory.
- This product includes code licensed from RSA Data Security.
- This product includes software developed by the Apache Software Foundation (<http://www.apache.org/>).

At the bottom right, a status bar shows a green checkmark and the text "No errors & warnings (Click for Details)".



HST archive: MAST (Multimission Archive at STScI)

- Images can be retrieved from MAST or using *Starview* or Aladin Sky Atlas (includ. in APT).

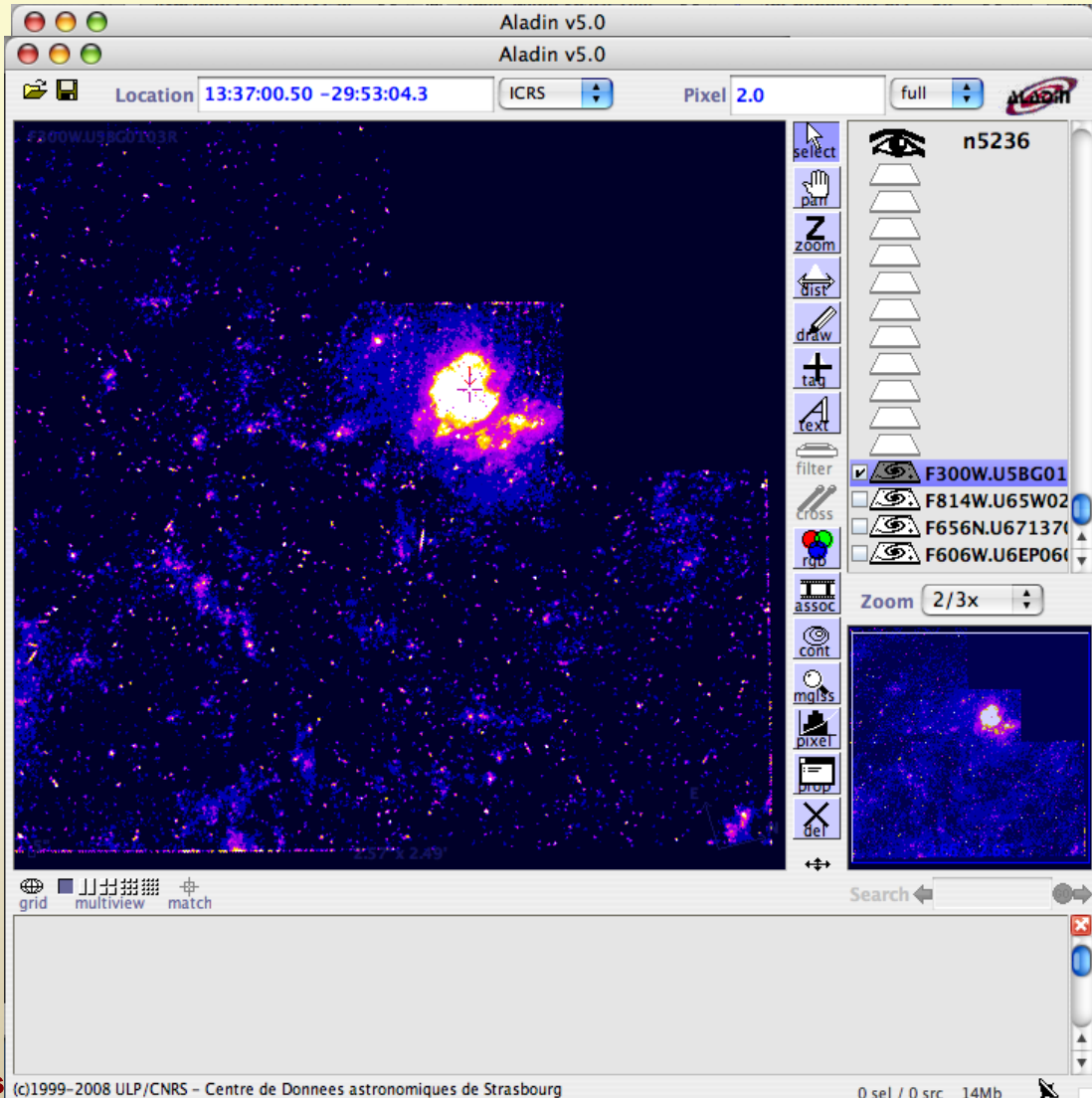
- Data formats (see the instruments data handbooks):

Multiextension FITS: Science, data quality and error arrays

- Extensions: RAW, FIT, CRJ, DRZ (ACS & STIS), *_raw*, *_ima*, *_cal*, *_mos* (NICMOS), *_d0f*, *_c0f* (WFPC2)

- WFPC2 associations: 27000 combined WFPC2 images created from associations of 90000 individual WFPC2 frames.

- Images are VO compliant.





NASA's Galaxy Evolution Explorer - GALEX

**Instrumentación Astronómica
Curso 2011/2012**

(material compilado por A. Gil de Paz, J. Zamorano, J. Gallego, P.G. Pérez-González)



Galaxy Evolution Explorer

POPIA: Instrument.
22 Nov 2010

Satellite:

- Developed by Orbital Science Corporation, launched by Pegasus-XL on April 28th 2003
- Circular orbit, altitude: 700 km, inclination: 29° , period: 98 min

Telescope:

M1=50cm; M2=22cm, Richey-Chrétien design

Instrument (SODA):

- Simultaneous imaging in two UV bands (FUV & NUV; ~ 1500 & 2200 \AA)
- Circular FOV of 1.2° in diameter. FWHM $\sim 5''$ at a scale of $1.5''/\text{pixel}$

Mission:

Limited by funding.



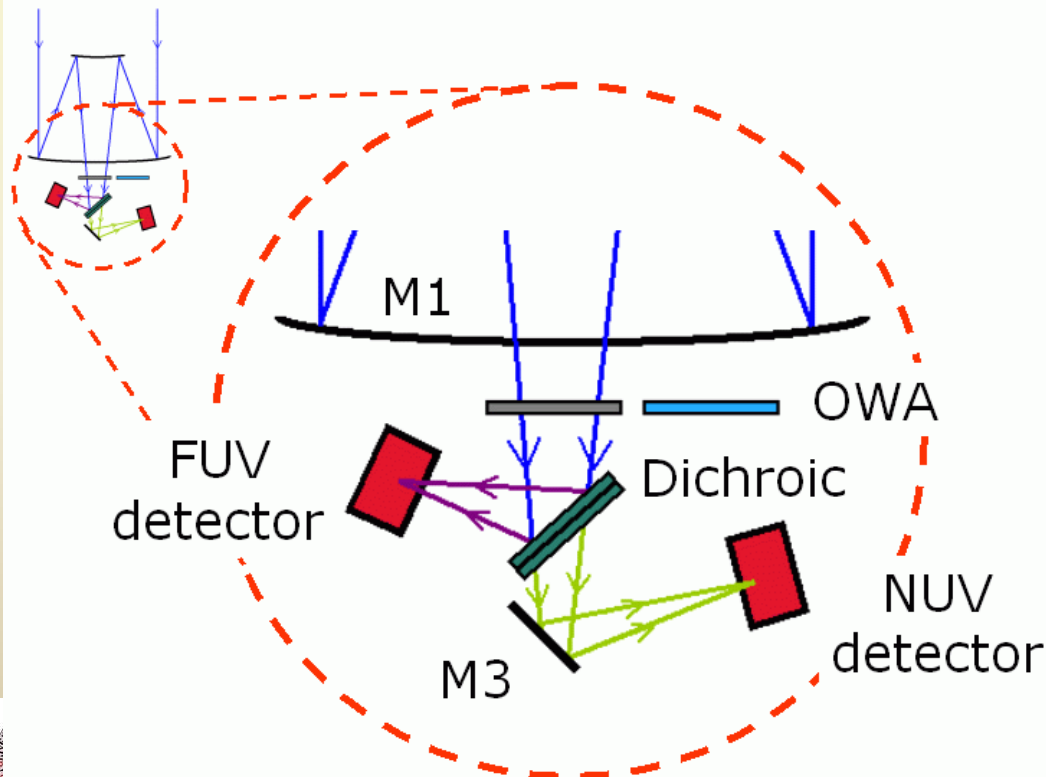
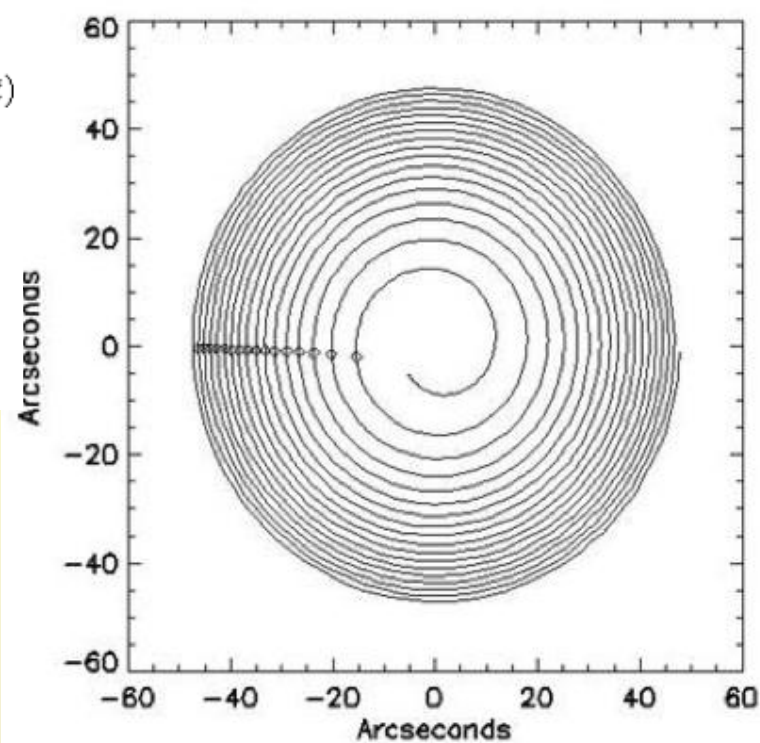


GALEX

Observing strategy:

avoids saturation and preserves detector fatigue

$$\begin{aligned} \omega_x &= K_1 t^n \omega \sin(\omega t) + K_2 \omega \cos(\omega t) \\ \omega_y &= -K_1 t^n \omega \cos(\omega t) + K_2 \omega \sin(\omega t) \\ \omega_z &= 0 \\ K_1 &= 2.2442 \text{ rad} \\ K_2 &= 0.1000 \text{ rad} \\ n &= 0.40 \\ \omega &= 0.05236 \text{ rad/s} \end{aligned}$$



- GALEX moves in a dither spiral pattern of 1' amplitude during the observation.
- Initial telemetry data plus bright-stars tracks in the field (1.2° in diameter) are used for trajectory reconstruction.

nómica

Curso 2011/2012

(material compilado por J. Zamorano, J. Gallego, P.G. Pérez-González)

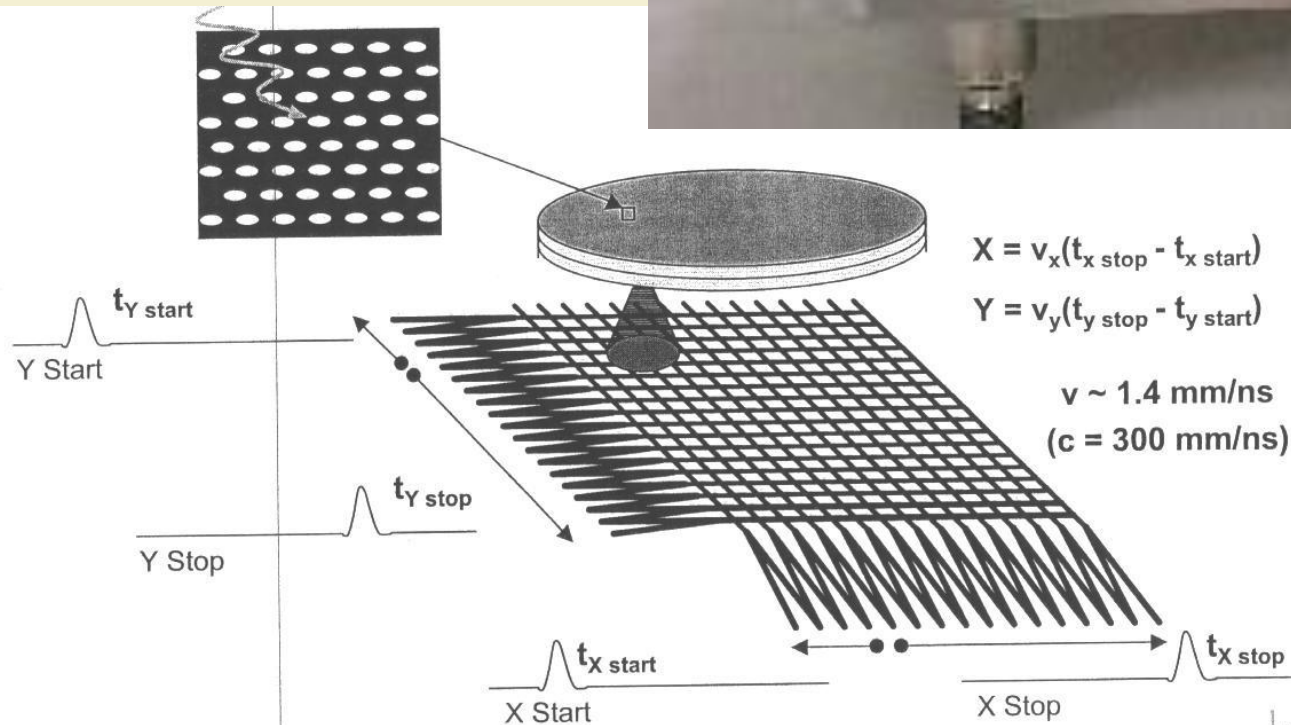
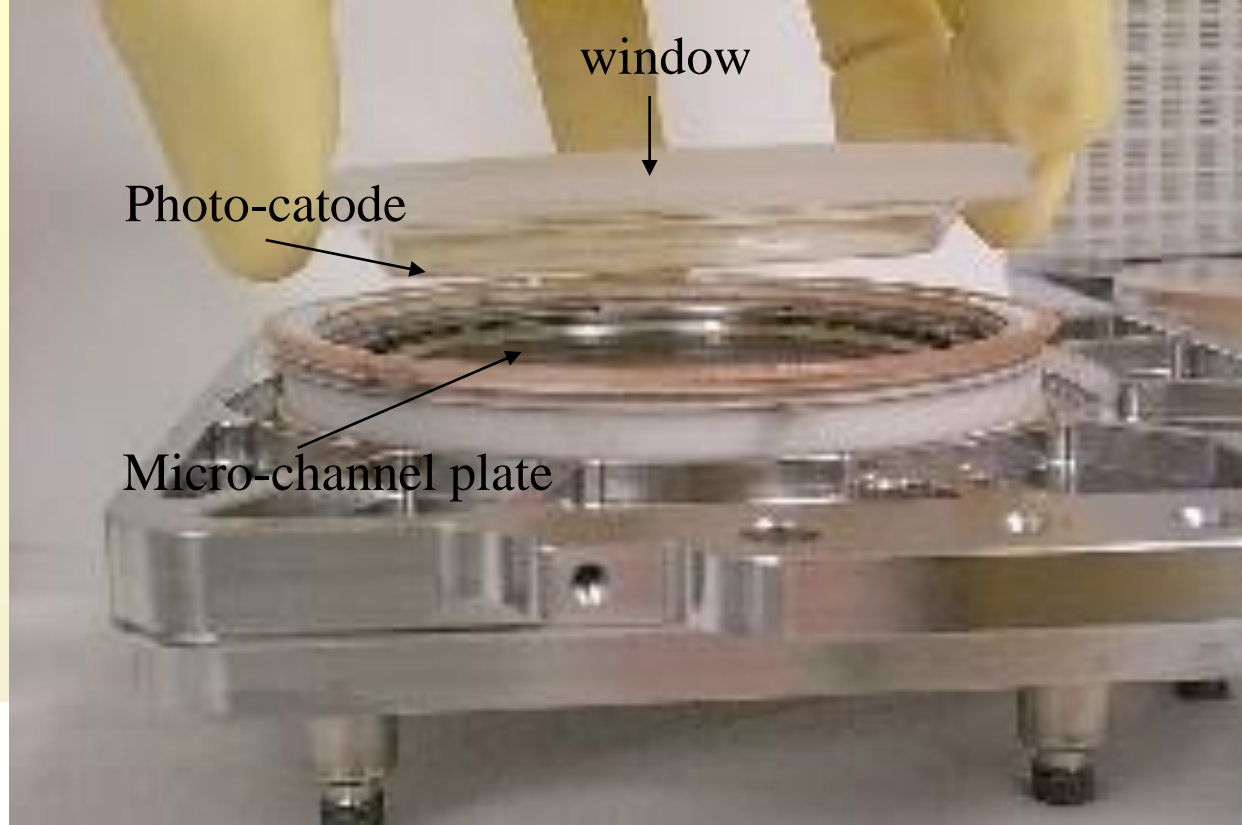




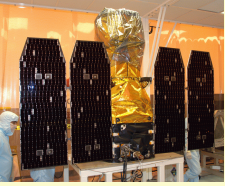
GALEX

GALEX single instrument: SODA

- Micro-channel plate detectors with crossed delay-line anodes.



- Resolution (PSF) is determined by image reconstruction and time resolution.



GALEX Surveys

SURVEY	Area [deg]	Length [Month]	Expos [ksec]	m lim	log #Gals	Volume	<z>	Comments
All-sky (AIS)	>35000	4	0.1	20.5	7	1.5	0.2	
Medium Imaging (MIS)	1000	2	1.5	23	6.5	~1	0.6	SDSS, 2dF overlap
Deep Imaging (DIS)	80	4	30	25	7	~1	0.85	NDWS, Swire
Ultra-Deep Im. (UDIS)	4	1	200	26	5.5	0.05	0.9	HDF-N, CDF
Nearby Galaxy (NGS)	200	0.5	1.5	27.5 μ	2.5	---	0.01	Spitzer ROC
Guest Investigator	---	4	---	---	---	---	---	Now over





GALEX: Constraints

- Observations are carried out only on the night-side of the orbit.
- GALEX cannot observe close to the sun (avoidance angle 85°), earth limb, moon (40°), planets (2°).
- GALEX detectors saturate and might be potentially damaged by UV-bright stars (FUV=5000 counts/s; NUV=30000 c/s) that are commonly encountered on the Galactic plane, SMC, and LMC.
- GALEX detectors will also saturate and possibly be damaged by over-bright fields with (a) too many moderately UV-bright stars or (b) high backgrounds (FUV=15000 c/s; NUV=50000 c/s).

These constraints limit the objects observable ($\sim 80\%$ of the sky available) and the observing epoch for a given target to 1 month or so.

- Since 2009 the FUV channel is not functioning.



Proposing for GALEX

- Submit Notice of Intent to NASA 1.5 months in advance
- Get a proposal number from the GALEX GI program (GSFC).
- Get LaTeX/Word template for Scientific Justification (Cycle 5)
- Do the targets pass the safety tests? *Try moving the field center!*
- Are they already in the GALEX MAST archive, or are they part of the planned PI-science (*check PI targets*)?
- Generate XML file of targets.

GALEX Cycle 3 Proposal Number

This page is where you will be able to submit a request for a Cycle 3 proposal number.

In addition to a proposal number, you will receive an xml target list and abstract template populated with the information you provide here.

All fields are required.

Principal Investigator Information	
PI's Name	<input type="text"/>
PI's Institution	<input type="text"/>
PI's Email	<input type="text"/>

Your Information	
<input type="button" value="Click to copy PI Info"/>	
Your Name	<input type="text"/>
Your Email	<input type="text"/>

Proposal Information	
Title	<input type="text"/>
Proposal Type	Select Proposal Type ▾

GALEX Archive (Galexview)

ngc300 resolved by NED: [13.7228, -37.6844] r=5d (default)

Search: ngc300

Examples: M101 14 03 12.6 +54 20 56.7 r=0.1d

Search History: [13.7228, -37.6844] r=5d (default)

Histogram [select column header]

Layout: Grid (selected) Thumbnails

Results 1 - 25 of [101 Total] Showing: 25 Per Page

Download	Preview	survey	tilename	dstDegrees	ra_cent	dec_cent	nuv_exptime	fuv_exptime
		G11	G11_061002_NGC0300	0.00148	13.72112	-37.68379	12165.05	12165.05
		NGS	NGA_NGC0300	0.00331	13.72212	-37.68766	1628.05	1628.05
		AIS	AIS_387	0.45172	14.27371	-37.56738	218	218

Transferring data from galex.stsci.edu...

(material compilado por A. Gil de Paz, J. Zamorano, J. Gallego, P.G. Pérez-González)



GALEX Archive: Products

Data products:

<i>Catalogs</i>		<i>NUV, FUV, and merged catalogs</i>
<i>-[n or f]d-cat.fits</i>	FITS binary table	SExtractor catalogs for images. Table of objects extracted by GALEX reduction pipeline. The table contains positions, flux, magnitude, and major/minor axes.
<i>-[n or f]d-[f or n]cat.fits</i>	FITS binary table	NUV (FUV) extractions using FUV (NUV) positions; the latter are taken from the FUV (NUV) source catalog "fd-cat.fits" ("nd-cat.fits").
<i>-xd-mcat.fits</i>	FITS binary table	Merged source catalog. Band-merged table of extracted objects. Contains all objects contained in "[n or f]d-cat.fits" matched to the best candidate. The table contains positions, flux, magnitude, and major/minor axes. By definition, it contains all data from the two single-band catalogs.

(you can use ds9 for the images and fv for the catalogs)

Latest release (aug10): GR6 (AIS~30k tiles, MIS~3500 tiles, NGS~500 tiles, DIS~340 tiles, GI~1300 tiles)

**Instrumentación Astronómica
Curso 2011/2012**

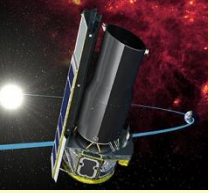
(material compilado por A. Gil de Paz, J. Zamorano, J. Gallego, P.G. Pérez-González)



NASA's Spitzer Space Telescope - Spitzer

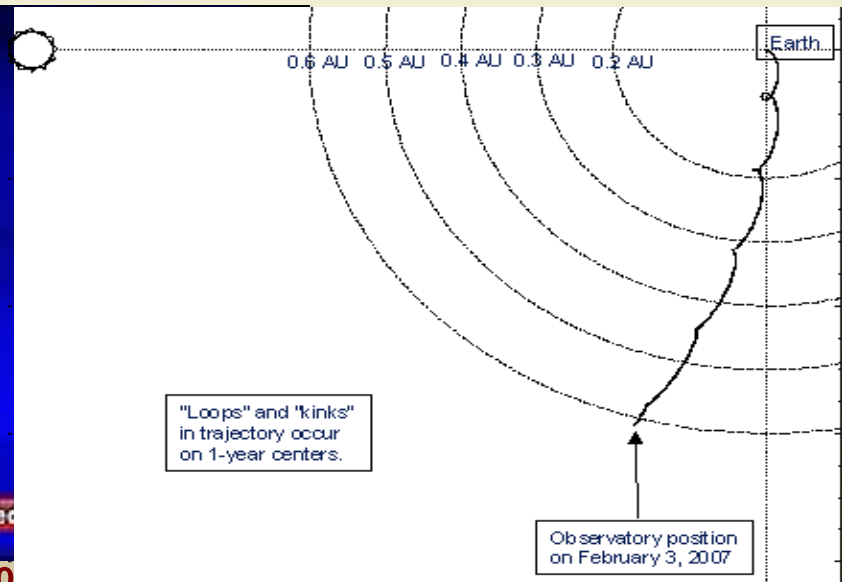
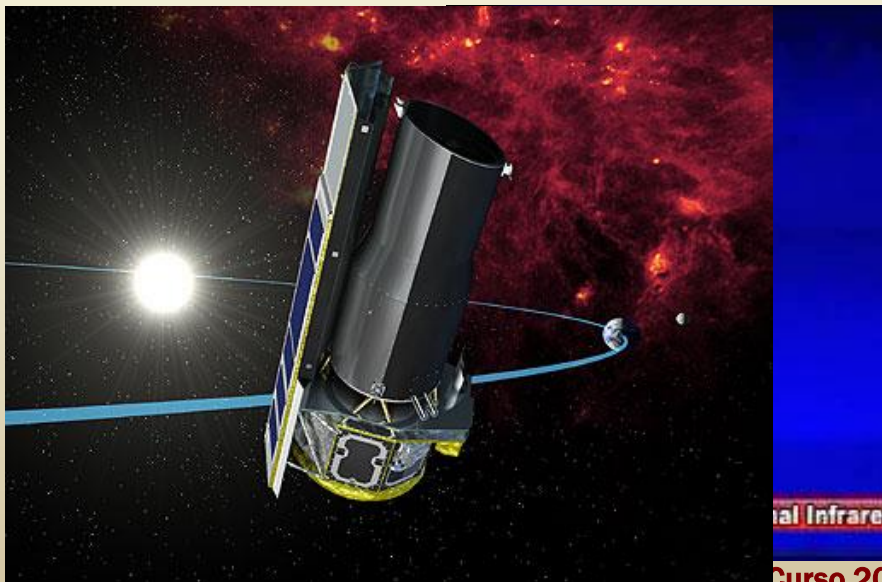
**Instrumentación Astronómica
Curso 2011/2012**

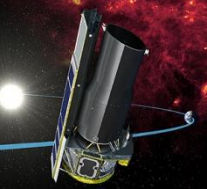
(material compilado por A. Gil de Paz, J. Zamorano, J. Gallego, P.G. Pérez-González)



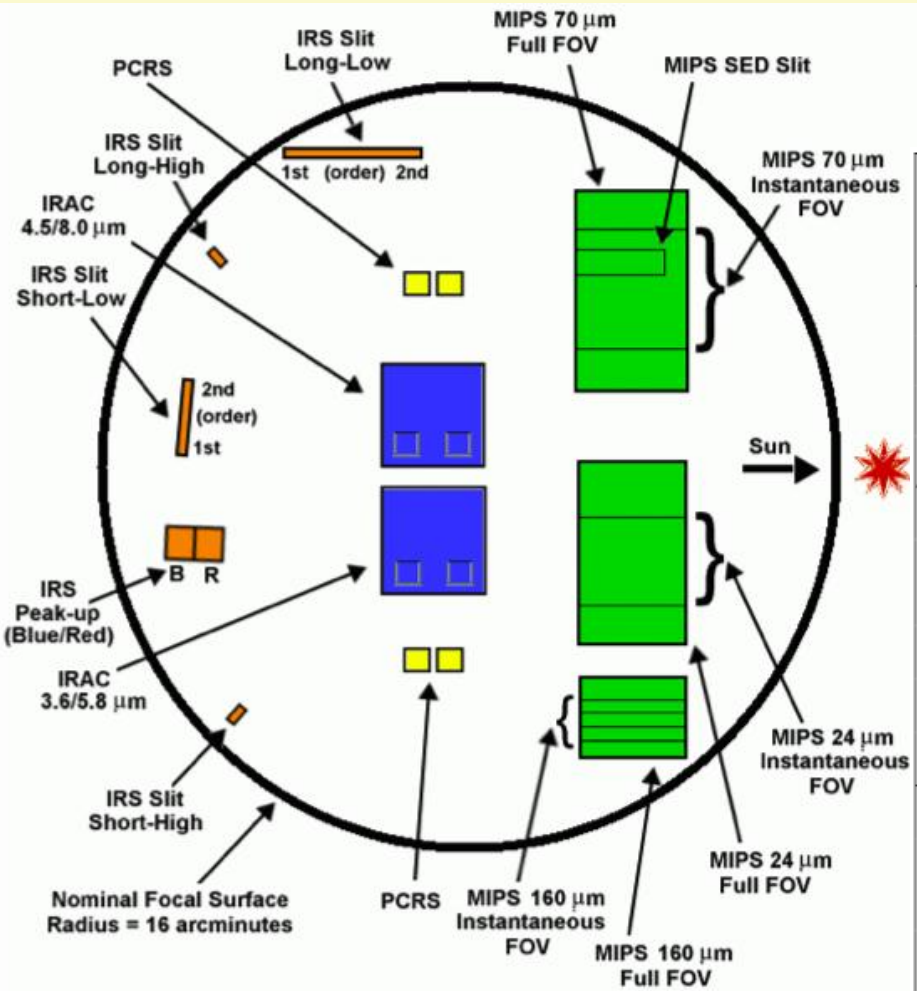
Spitzer Space Telescope

- The Spitzer Space Telescope is NASA's 4th Great Observatory
- It carries an 85-cm telescope and three cryogenically-cooled science instruments: IRAC, IRS, MIPS
- Spitzer was launched on a Delta rocket into an Earth-trailing heliocentric orbit on August 2003. Spitzer cryogenic lifetime requirement was 2.5 yrs, although it finally reached 5 yrs.

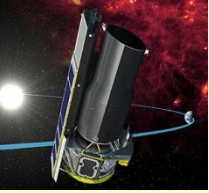




Spitzer Instruments

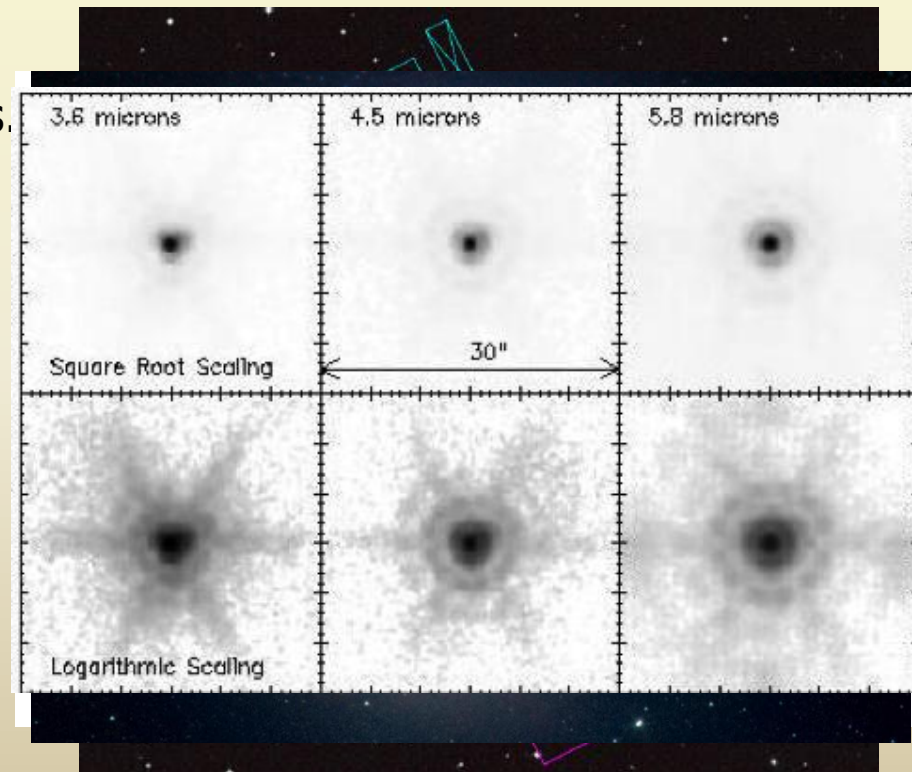


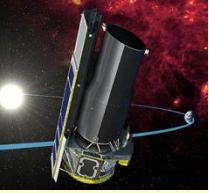
	λ (μm)	Array Type	$\lambda\Delta\lambda$	Field of View	Pixel Size (arcsec)
IRAC	3.6	InSb	4.7	5.21'×5.21'	1.2
	4.5	InSb	4.4	5.18'×5.18'	1.2
	5.8	Si:As(IBC)	4.0	5.21'×5.21'	1.2
	8.0	Si:As(IBC)	2.8	5.21'×5.21'	1.2
IRS	5.2–14.5	Si:As(IBC)	60–127	3.7"×57"	1.8
	13.5–18.5	Si:As(IBC)	~3	1'×1.2'	1.8
	18.5–26	Peak-Up ⁵			
	9.9–19.6	Si:As(IBC)	~600	4.7"×11.3"	2.3
	14.0–38.0	Si:Sb(IBC)	57–126	10.6"×168"	5.1
	18.7–37.2	Si:Sb(IBC)	~600	11.1"×22.3"	4.5
MIPS	24	Si:As(IBC)	5	5.4'×5.4'	2.55
	70	Ge:Ga	4	2.7'×1.4'	5.20
				5.2'×2.6'	9.98
	55-95 ⁸	Ge:Ga	15–25	0.32'×3.8'	10.1
	160	Ge:Ga (Stressed)	5	0.53'×5.33'	16×18



Spitzer Instruments: IRAC

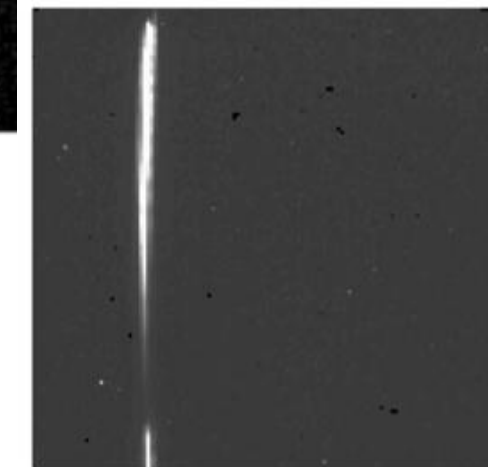
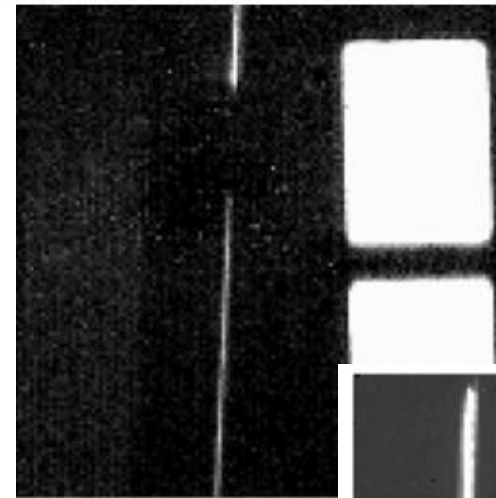
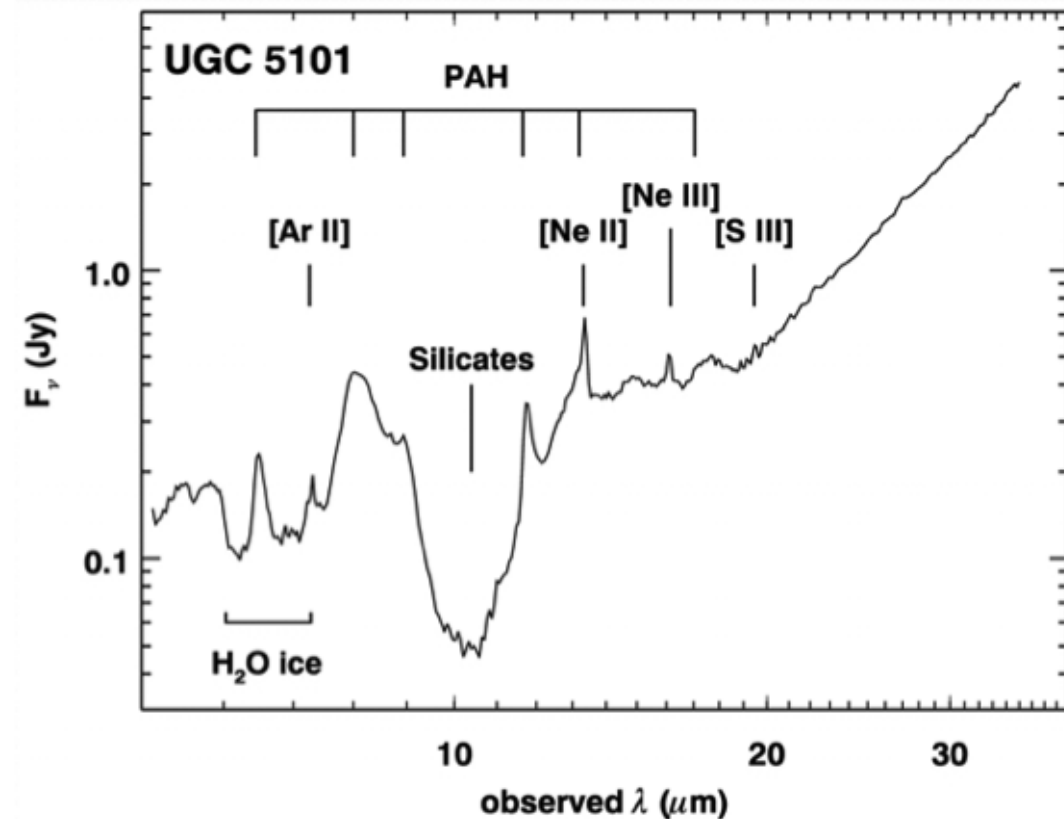
- IRAC allows simultaneous imaging in four NIR-MIR bands: 3.6, 4.5, 5.8, 8.0 μm with a FOV of $5.2' \times 5.2'$. Each two arrays are pointing to the same position in the sky.
- Light in the IRAC1 & IRAC2 bands (3.6 & 4.5 μm) are mostly due to stellar photospheric emission of MS stars & giants.
- IRAC3 & IRAC4 have contribution from PAH features.
- The PSF of the images ranges between 1.7-2" (*Spitzer* is diffraction limited at a wavelength of 5.4 μm).
- Observations in the the first 2 channels are the only current capabilities of Spitzer.

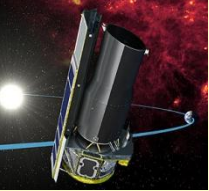




Spitzer Instruments: IRS

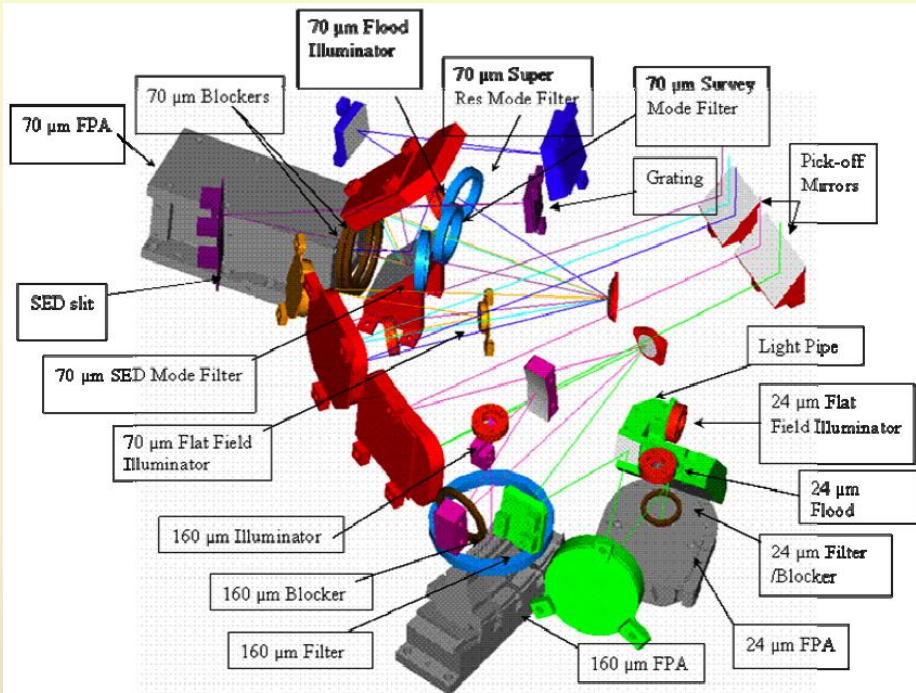
- IRS provides low ($R \sim 60-120$ between 5-38 μm) and moderate resolution ($R \sim 600$ over 10-37 μm) spectroscopy.
- Peak-up also used for imaging (13-19 μm & 19-26 μm).





Spitzer Instruments: MIPS

- MIPS provides imaging at 24, 70, and 160 μm and low resolution ($R = 15 - 25$) spectroscopy between 55 and 95 μm .



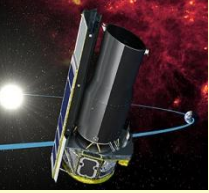
- MIPS observing modes: photometry, super-resolution (sub-pixel sampling dithering), scan mapping, SED spectroscopy, and Total Power mode.
- Emission in MIPS bands arising from dust at different temperatures/sizes.

MIPS Instantaneous Fields of View:

24 μm	5.4x5.4 arcminutes
70 μm	5.25x2.6 or 2.6x1.3 arcminutes
160 μm	0.53x5.33 arcminutes (effective)
SED Slit	3.8x0.32 arcminutes

The MIPS Detector Arrays:

24 μm	Si:As (IBC) 128x128 pixels; 2.55" 4.7 μm bandwidth
70 μm	Ge:Ga 32x32 pixels; 4.99" or 9.84" 19 μm bandwidth SED $R = 15 - 25$ (9.84" pixels)
160 μm	Stressed Ge:Ga 2x20 pixels; 16.0" 35 μm bandwidth

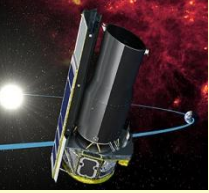


Proposing for Spitzer

- Documentation: Call for Proposals (Cycle 8-WS), Observers Manual, Instruments Data Handbook.

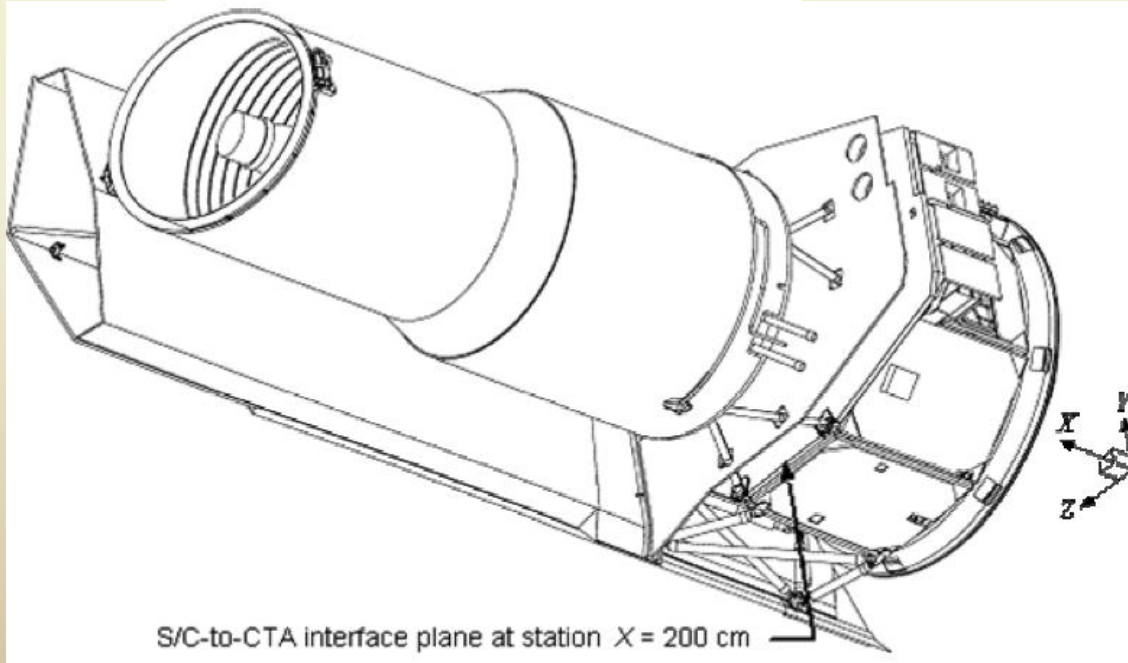
Checklist:

- Targets: Check both the latest *Reserved Observations Catalog* and the *Spitzer* archive. Justify additional time on already observed objects. Determine visibility windows using SPOT (timing constraints allowed).
- Exposure: Estimate required exposure time for the IR background of your object and the instrument expected sensitivity (use PET, *Performance Estimation Tool*).
- **Submit:** Cover sheet, Scientific and Technical justifications (PDF), and AORs (*Astronomical Observation Requests*). All should be submitted through SPOT.

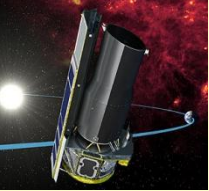


Proposing for Spitzer: Constraints

- **Spitzer is currently in the warm-Spitzer phase:** Only IRAC1 (3.6 μm) and IRAC2 (4.5 μm) observations can now be requested.
- **Pointing constraints:** The angle with the Sun must be $>82.5^\circ$ and $<120^\circ$.
- At any given time, the center of the sunshade (X-Z plane) is kept within $\pm 2^\circ$ of the Sun. Observations must be designed with this lack of roll control in mind. This affects IRS observations but also IRAC & MIPS mapping.



- **Bright limits:** By default the visibility windows are calculated to exclude regions of time when the positions of the Earth, Moon, Jupiter, Saturn, bright asteroids (only solar system objects).



Proposing for Spitzer: SPOT

- SPOT is available for Solaris, Windows, Linux, & Mac OS X as part of the *Spitzer-Pride* software.
- Most SPOT features require network connectivity
- Use example AORs or download previous programs' AORs.



- Get program IDs from *Spitzer's* webpage.
- *Observing Time Estimate* reports: AOR duration (*wall-clock* time: slew & settle time plus on-source time). Maximum AOR duration: 3h for IRS and MIPS, and 6h for IRAC.

Spot -- Spitzer Planning Observations Tool

Observations

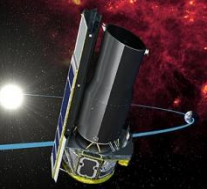
Astronomical Observation Requests (AORs)

Label	Target	Position	Type	T	G	F	Instrument	Duration	Stat	On
IRSS-0038	NGC7331	22h37m 4.1s...	Fixed Single	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRS Spectral Map...	3091	nominal	<input checked="" type="checkbox"/>
IRSS-0075	NGC7331 backg...	22h37m 4.1s...	Fixed Single	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRS Spectral Map...	581	nominal	<input checked="" type="checkbox"/>
IRSM-0038	NGC7331	22h37m 4.1s...	Fixed Single	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRS Spectral Map...	5087	nominal	<input checked="" type="checkbox"/>
IRSM-0076	NGC7331 backg...	22h37m 4.1s...	Fixed Single	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRS Spectral Map...	578	nominal	<input checked="" type="checkbox"/>
IRAC-N3031	NGC3031	9h55m33.17...	Fixed Single	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	IRAC Mapping	6005	nominal	<input checked="" type="checkbox"/>
IRAC-N3031 - A	NGC3031	9h55m33.17...	Fixed Single	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRAC Mapping	6005	nominal	<input checked="" type="checkbox"/>
IRAC-5194_95	NGC5194_95	13h29m56.7...	Fixed Single	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRAC Mapping	2795	nominal	<input checked="" type="checkbox"/>
IRAC-5194_95 - A	NGC5194_95	13h29m56.7...	Fixed Single	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRAC Mapping	2798	nominal	<input checked="" type="checkbox"/>
IRAC-N4236	NGC4236	12h16m42.1...	Fixed Single	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRAC Mapping	2591	nominal	<input checked="" type="checkbox"/>
IRAC-N4236 - A	NGC4236	12h16m42.1...	Fixed Single	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRAC Mapping	2590	nominal	<input checked="" type="checkbox"/>
IRAC-N3627	NGC3627	11h20m15.0...	Fixed Single	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRAC Mapping	1541	nominal	<input checked="" type="checkbox"/>
IRAC-N3627 - A	NGC3627	11h20m15.0...	Fixed Single	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRAC Mapping	1541	nominal	<input checked="" type="checkbox"/>
IRAC-N2403	NGC2403	7h36m51.40...	Fixed Single	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRAC Mapping	4100	nominal	<input checked="" type="checkbox"/>
IRAC-N2403 - A	NGC2403	7h36m51.40...	Fixed Single	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IRAC Mapping	4103	nominal	<input checked="" type="checkbox"/>
IRAC-N5055	NGC5055	13h15m49.2...	Fixed Single	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IRAC Mapping	1799	nominal	<input checked="" type="checkbox"/>
IRAC-N5055 - A	NGC5055	13h15m49.2...	Fixed Single	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IRAC Mapping	1876	nominal	<input checked="" type="checkbox"/>

Target: NGC5195 background Type: Fixed Single Total Duration (hrs): 393.7

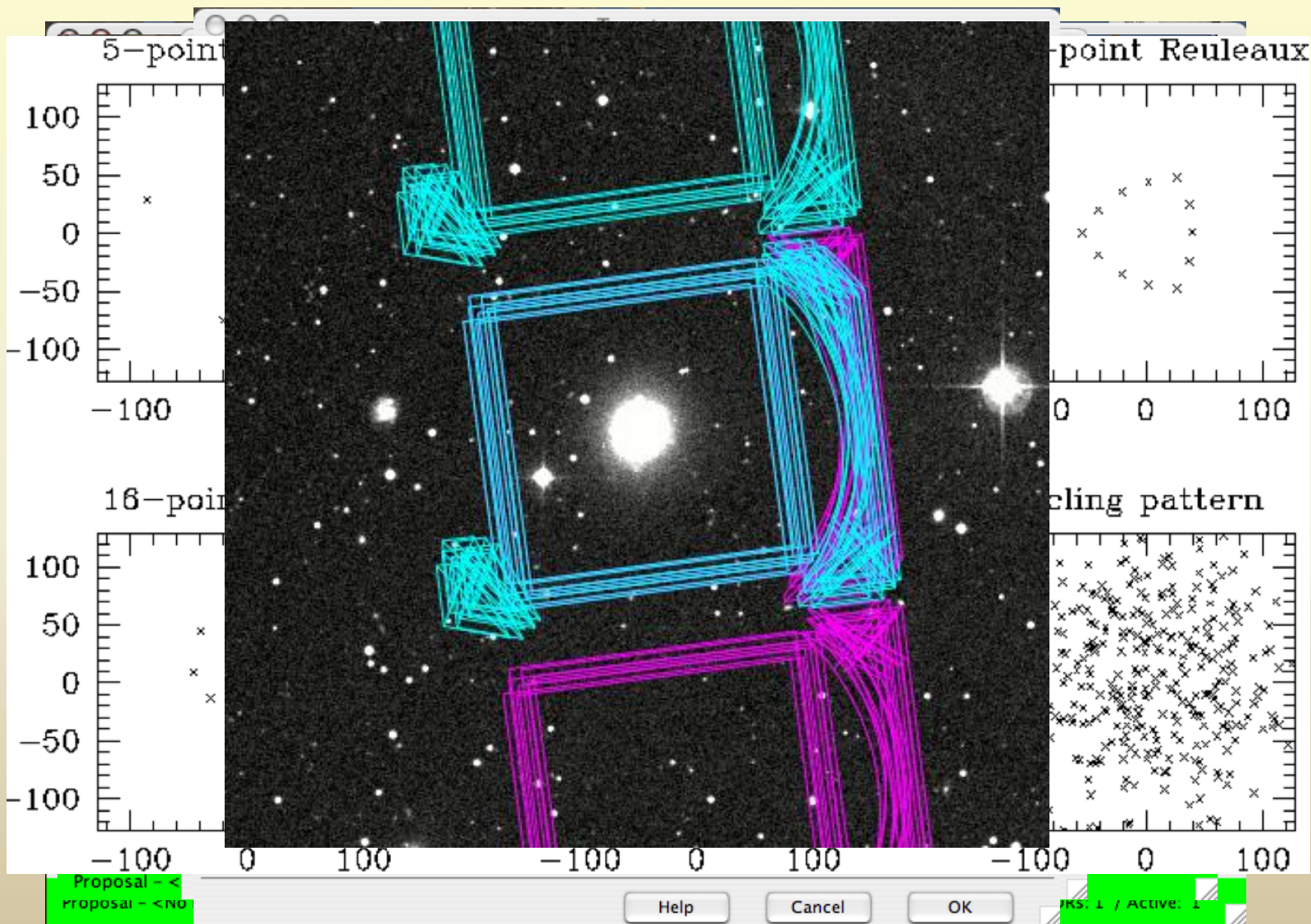
Proposal - File Name: sings.aor Net Down Total AORs: 510 / Active: 510

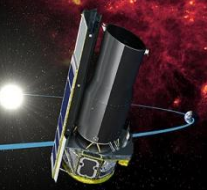
Curso 2011/2012



Proposing for Spitzer: SPOT

Starting from scratch:





Spitzer Archive: Leopard

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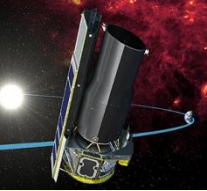
The screenshot shows the Leopard software interface. At the top, there's a menu bar with 'File', 'Edit', 'Select', 'Info', 'Images', 'Overlays', 'Options', 'Window', and 'Help'. Below the menu is a toolbar with icons for various functions. A status bar at the top right shows 'NED Image'. The main window title is 'Leopard'. Below the toolbar, there's a table with the following data:

Flux: 24.298 MJy/yr	Eq-J2000 RA: 13h29m52.41814s	X: 813.500
1 Pixel 1.200"	Eq-J2000 Dec: +47d11m45.8206s	Y: 571.500

Below the table is a 'Mouse Control' section with a dropdown menu set to 'Any' and a note: 'Shift-Left Button: Center the Image at point'. The main image area shows a spiral galaxy with a bright cyan core and a cyan star in the foreground. The image title is 'SPITZER_I1_5504000_0_1_E224586_msaic.fits'. To the right of the image is a 'Base Image' panel with three rows of flux data:

<input checked="" type="checkbox"/>	Flux: 26.344 MJy/yr
<input checked="" type="checkbox"/>	Flux: 13.942 MJy/yr
<input checked="" type="checkbox"/>	Flux: 24.298 MJy/yr

At the bottom, there's an 'Archive Query Results' section for the same file. It shows a legend for download status: 'Partially Queued', 'Fully Queued', 'Partially Downloaded', and 'Fully Downloaded'. Below the legend, it says 'Uncompressed Size: 0' and 'Selected Products: 0'. On the right, there's a 'What to download?' section with checkboxes for 'Post BCD data', 'BCD - Basic data', 'Raw data', and 'Calibration data'. At the very bottom, there's a green bar with 'Logged in as: General User', a 'Net Up' icon, and 'Total AORs: 10 / Total Products: 18'. The bottom of the window has 'OK', 'Cancel', and 'Help' buttons.



Spitzer Heritage Archive

Since Nov.4th Leopard has been replaced by the
"Spitzer Heritage Archive" (SHA)

Position Search

Target Name = NGC628

http://sha.ipac.caltech.edu/applications/Spitzer/SHA/#id=SearchByPosition&Di

NASA / IPAC Infrared Science Archive

IRSA Mission Archive Search Related Data Archives Tools & Services Help

Spitzer Searches History/Tags Catalogs Background Monitor Preferences

Search Again - Click here to refine your search or do another search

Position Search Results

Observation Requests (AOR) Level 2 (PBCD)

Prepare Download Restrict data in other tabs Save Text View Add filters

Target name	RA (J2000)	Dec (J2000)	NAIF ID	Instrument/Mode	AORKEY
<input type="checkbox"/> SN 2003gd	1h36m42.65s	+15d44m20.0s		IRAC Map	1827148
<input type="checkbox"/> NGC0628 SL extranuclear target set	1h36m45.10s	+15d47m51.0s		IRS Map	1169331
<input type="checkbox"/> NGC0628 extranuclear target set 2	1h36m35.50s	+15d50m11.0s		IRS Map	1169792
<input type="checkbox"/> SN 2003gd	1h36m42.65s	+15d44m20.0s		IRAC Map	2349900
<input type="checkbox"/> NGC 0628 A/B	1h37m01.99s	+15d55m05.2s		IRAC Map	1895014
<input type="checkbox"/> NGC 628N	1h36m31.32s	+15d56m52.1s		MIPS Phot	1453132
<input type="checkbox"/> NGC0628	1h36m41.71s	+15d47m01.0s		IRS Map	9487616
<input type="checkbox"/> SN 2003gd	1h36m42.65s	+15d44m20.0s		IRS Stare	1055744
<input type="checkbox"/> NGC 628F	1h37m16.06s	+15d50m29.4s		MIPS Phot	1087616
<input type="checkbox"/> NGC628_SLmap_01	1h36m43.30s	+15d46m14.5s		IRS Map	1480268
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<input type="checkbox"/> NGC0628	1h36m41.71s	+15d46m59.2s		MIPS Scan	5543168
<input type="checkbox"/> NGC 628S	1h36m39.79s	+15d38m11.0s		MIPS Phot	1453158
<input type="checkbox"/> SN 2003gd	1h36m42.65s	+15d44m20.0s		IRS Peakup Image	2350233
<input type="checkbox"/> NGC 628Fm	1h36m07.49s	+15d43m31.4s		MIPS Phot	1087641

Details

Details AOR DoC AOR Footprint

DSS



NASA's WISE Small Explorer

**Instrumentación Astronómica
Curso 2011/2012**

(material compilado por A. Gil de Paz, J. Zamorano, J. Gallego, P.G. Pérez-González)



Wide-field Infrared Survey Explorer

Science Objectives

WISE will provide an all-sky survey from 3 to 25 μm with 500,000 times the sensitivity of COBE/DIRBE and hundreds of times that of IRAS. The survey will help search for the origins of planets, stars, and galaxies and create an infrared atlas whose legacy will endure for decades.

Science Payload

The WISE instrument is a four-channel imager which operates in a single mode, taking overlapping snapshots of the sky. It includes:

- A 40-cm telescope and reimaging optics.
- A scan mirror to stabilize the line-of-sight while the spacecraft scans the sky.
- A 47 arcminute field of view.
- HgCdTe and Si:As 1024^2 detector arrays at 3.4, 4.6, 12, and 22 μm with a plate scale of $2.75''/\text{pixel}$.
- A resolution of $6''$ ($12''$ at 22 μm).
- A two-stage solid-hydrogen cryostat with an expected 10-month lifetime, to cool focal planes and optics.

Mission Overview

Launch: 2009 Dec. 14 at 6:09am PST

- Direct injection launch on a Delta II rocket into a circular, 525-km, Sun-synchronous orbit.
- 6-month survey of entire sky following a 1-month checkout, with estimated cryogen lifetime allowing 3 additional months of survey.





ESA's Herschel Space Observatory

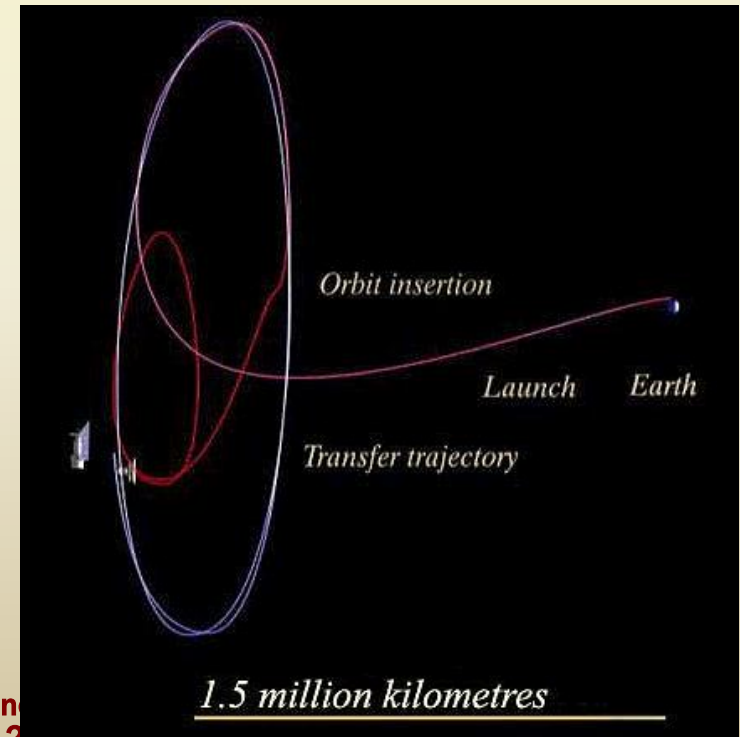
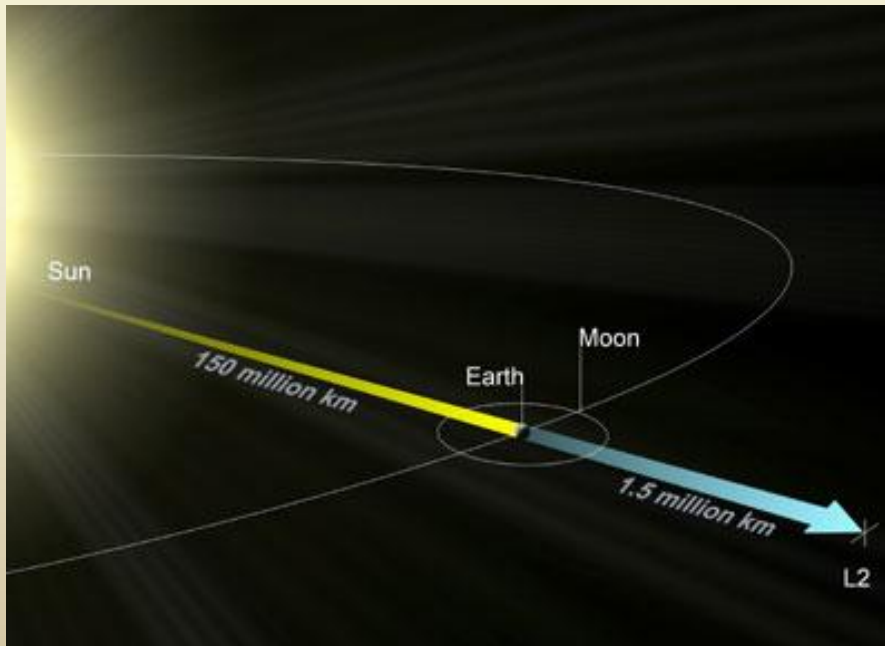
**Instrumentación Astronómica
Curso 2011/2012**

(material compilado por A. Gil de Paz, J. Zamorano, J. Gallego, P.G. Pérez-González)



Herschel Space Observatory

- The Herschel Space Observatory is a 3.5-m radiatively cooled (~ 80 K) telescope observing in the far-infrared and sub-millimeter.
- Herschel (& Planck) was launched on May 19th 2009 (Ariane V).
- It orbits the L2 Sun-Earth-Moon Lagrange point. The mission will have 3 yr of routine operations.

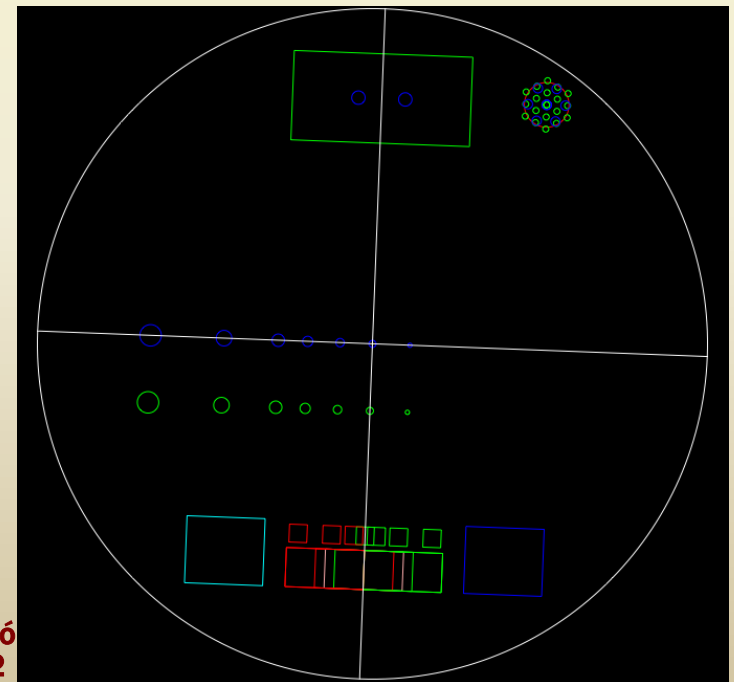
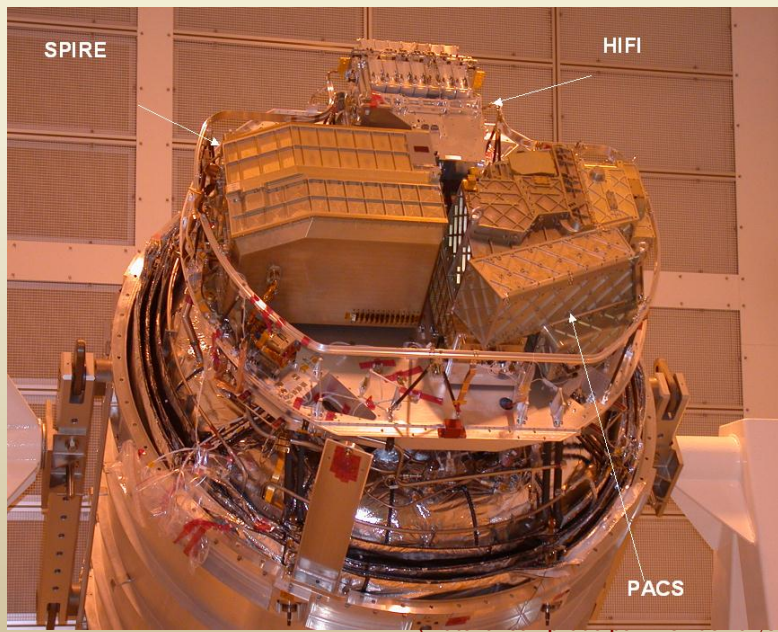




Herschel Space Observatory

Instruments:

- **PACS** (Photoconductor Array Camera and Spectrometer): Simultaneous imager at 70 or 100 and 160 μm plus an IFS
- **SPIRE** (Spectral and Photometric Imaging REceiver): Simultaneous photometer at 250, 350, & 500 μm plus a FTS
- **HIFI** (Heterodyne Instrument for FIrst): Submillimeter high-resol. heterodyne spectrometer



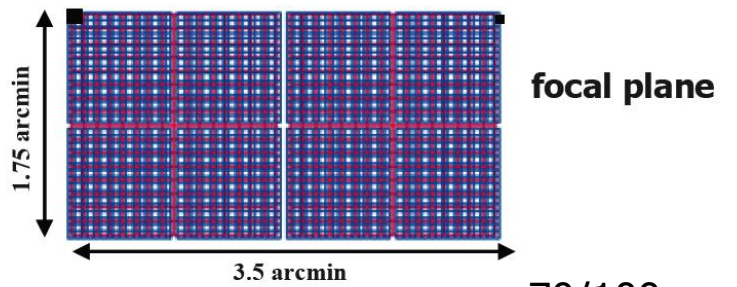
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Zamorano, J. Gallego, P.G. Perez-González)

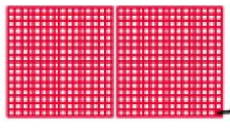


Herschel Space Observatory

PACS (Photoconductor Array Camera and Spectrometer)

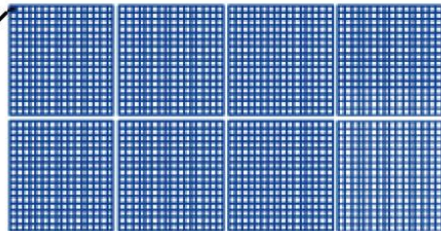


160 μm



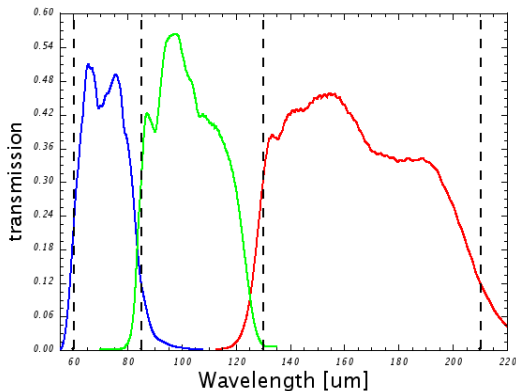
Red photometer
32x16 pixels (2x16x16)

3.2"x 3.2"
on sky

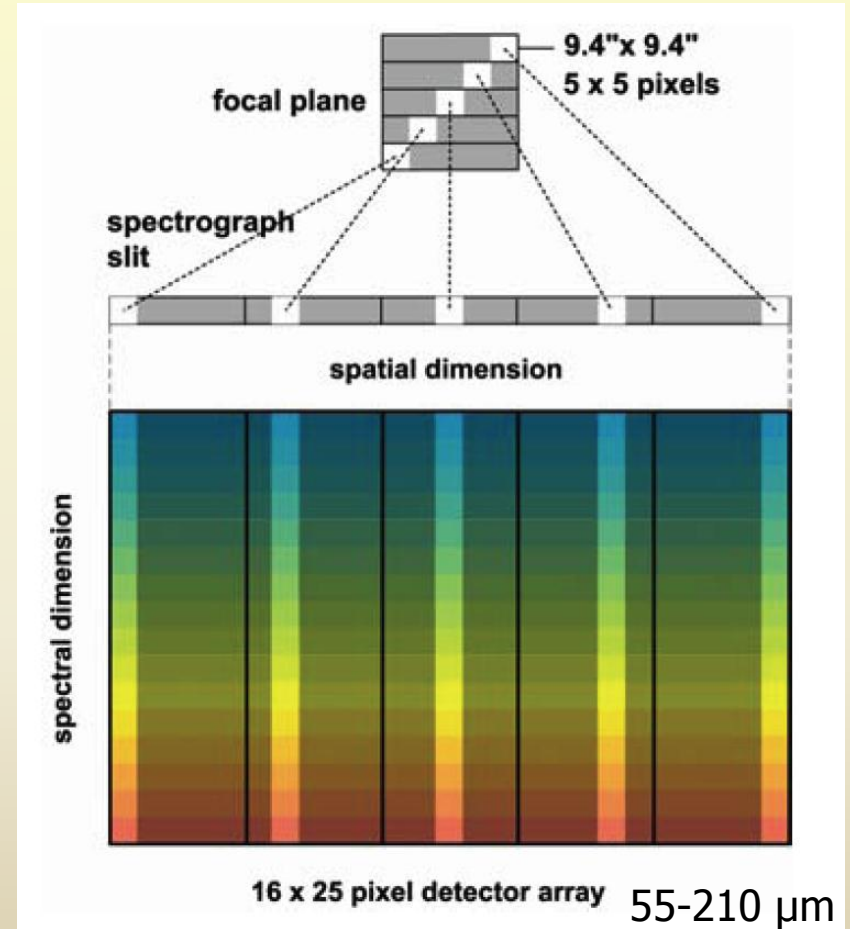


Blue photometer
64x32 pixels (4x2x16x16)

70/100 μm



Photometer

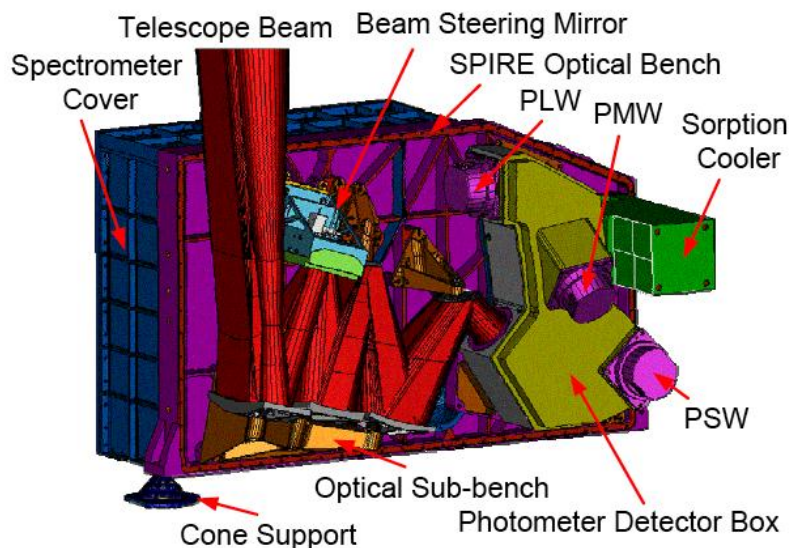


Integral Field Spectrometer



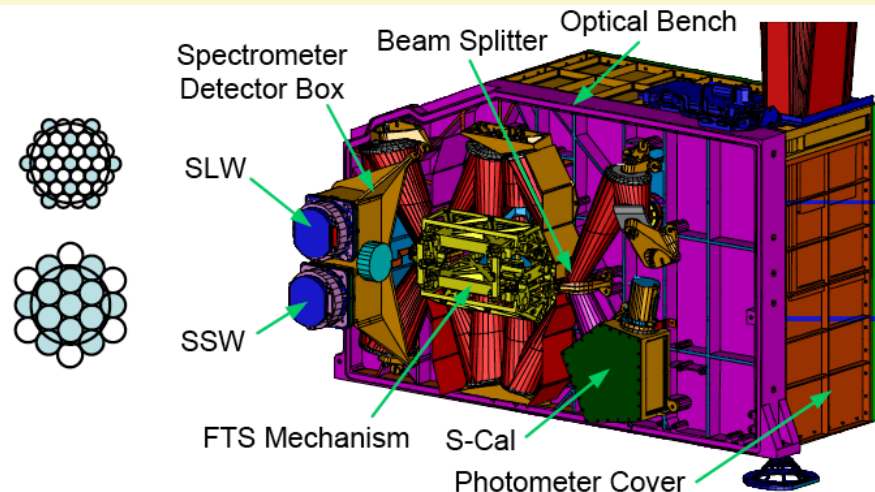
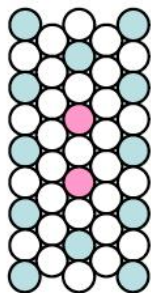
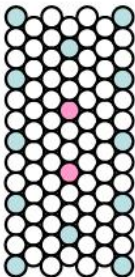
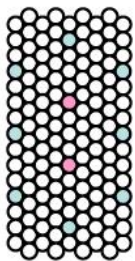
Herschel Space Observatory

SPIRE (Spectral and Photometric Imaging REceiver)



Imaging Photometer

Simultaneous observation in 3 bands
 139, 88, and 43 pixels
 Wavelengths: 250, 350, 500 μm
 $\lambda/\Delta\lambda \sim 3$
 FOV 4' x 8', beams (18", 25", 36")



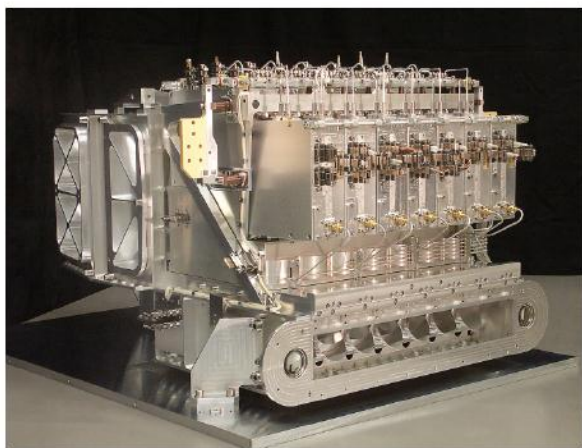
Imaging Fourier Transform Spectrometer

Simultaneous imaging observation of the whole spectral band
 37 and 19 pixels
 Wavelength Range: 194-672 μm
 $\lambda/\Delta\lambda = 1289-372, 206-60, 52-15$ (variable)
 FOV circular 2.6' diameter, beams 16", 34"



Herschel Space Observatory

HIFI (Heterodyne Instrument for First)



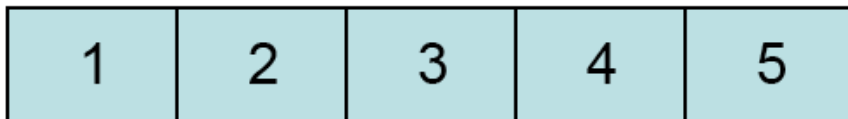
General Features

Broad Coverage of the FIR and Sub-mm
 Instantaneous IF Bandwidth of 4 GHz in Bands 1-5,
 and 2.4 GHz in Bands 6 and 7
 Resolving Power $\nu/\delta\nu$ up to 10^7 , or <0.1 km/s
 Diffraction-limited (11 – 42 arcsec) beam
 Seven bands utilizing low-noise SIS and HEB Mixers.

SIS Technology

GHz: 480 → 634 → 799 → 959 → 1108 → 1250

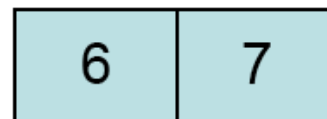
HIFI Bands



μm: 625 → 473 → 375 → 313 → 271 → 240

HEB Technology

1440 → 1684 → 1916

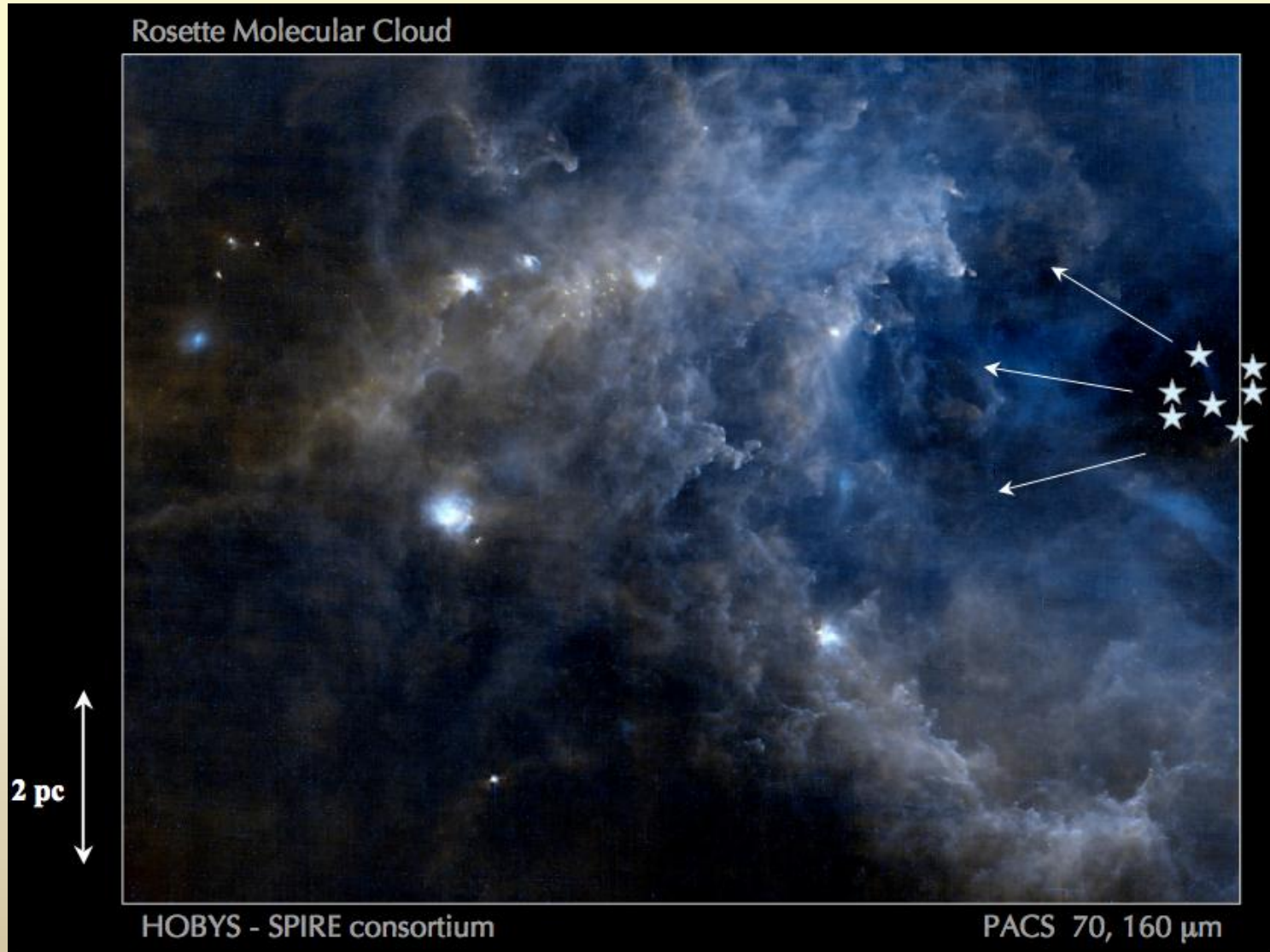


208 → 178 → 157



Herschel Space Observatory

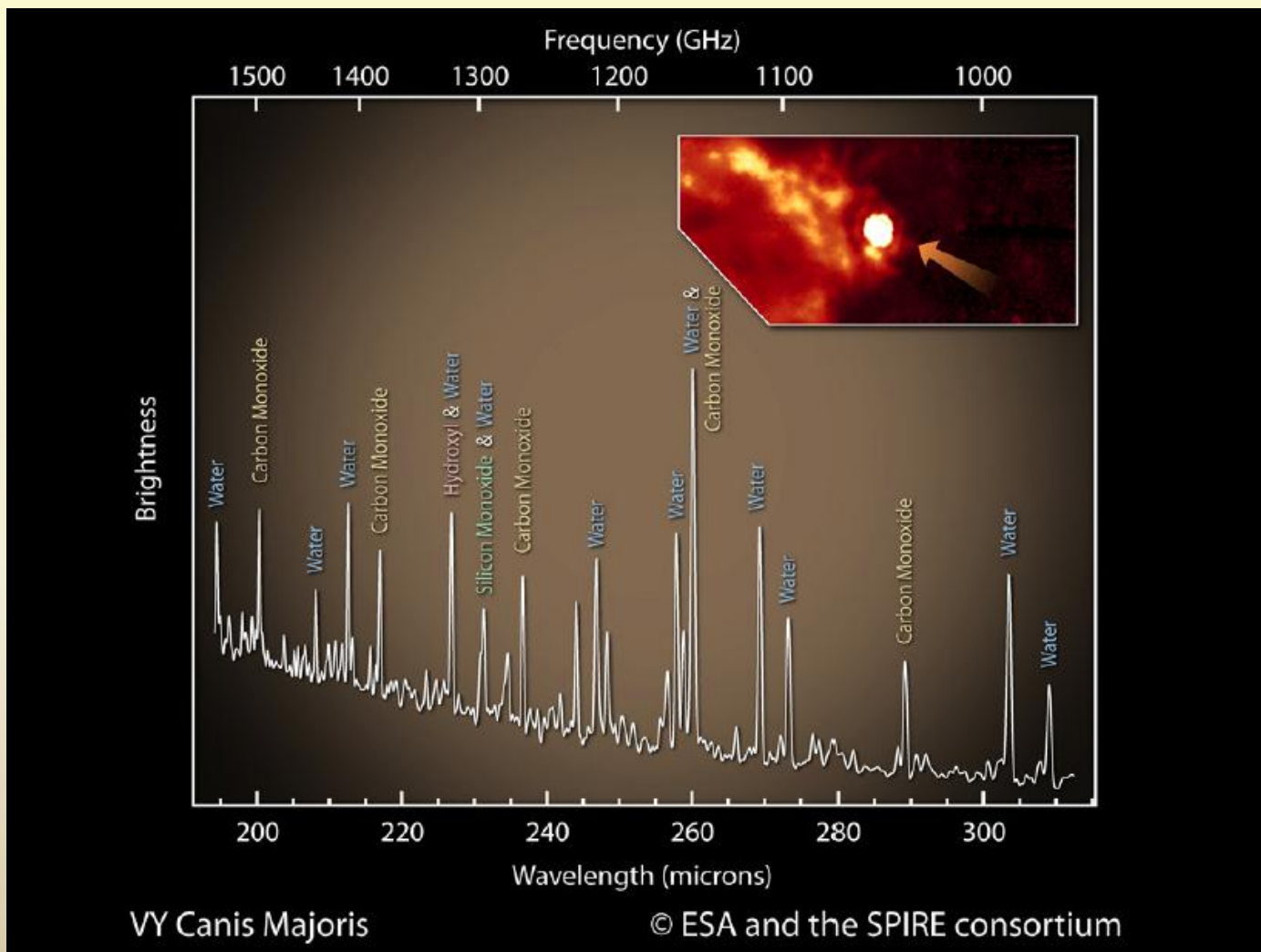
Highlights from Herschel ...





Herschel Space Observatory

Highlights from Herschel ...



Instrumentación Astronómica
Curso 2011/2012

(material compilado por A. Gil de Paz, J. Zamorano, J. Gallego, P.G. Pérez-González)

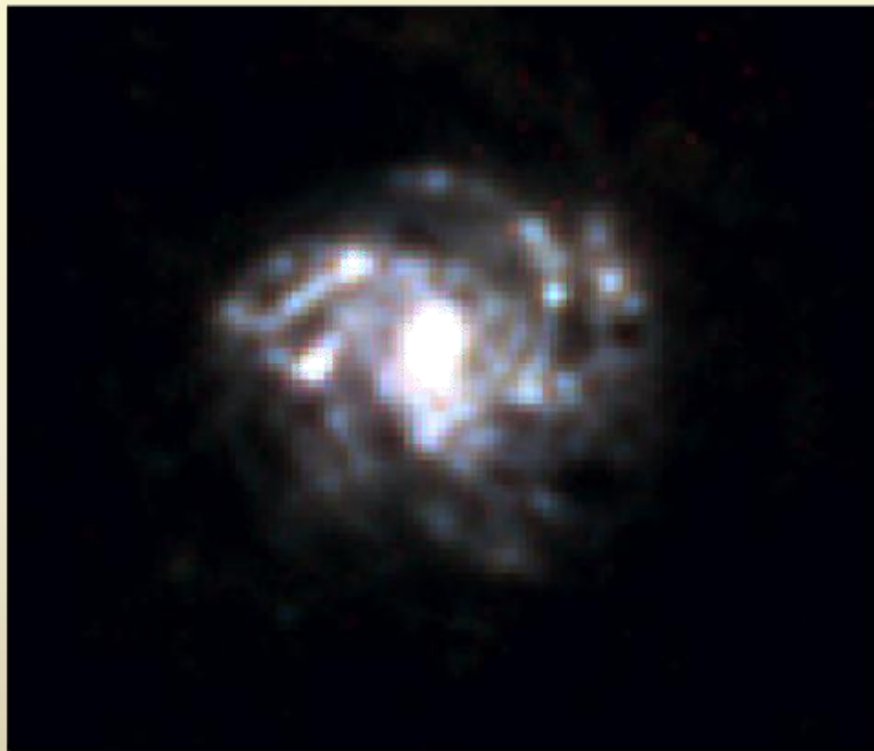
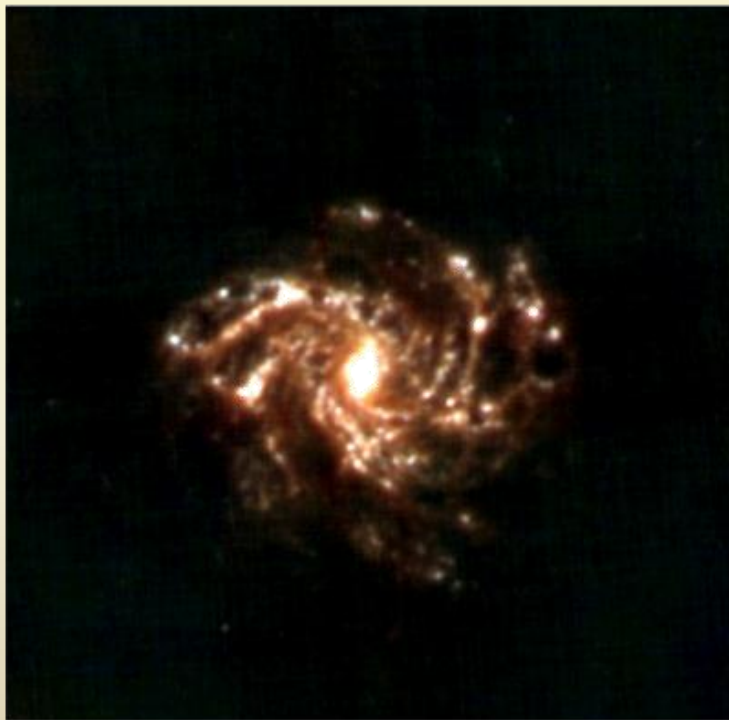


Herschel Space Observatory

Highlights from Herschel ...

NGC6946

SABcd
D=6.8 Mpc



PACS 70/100/160

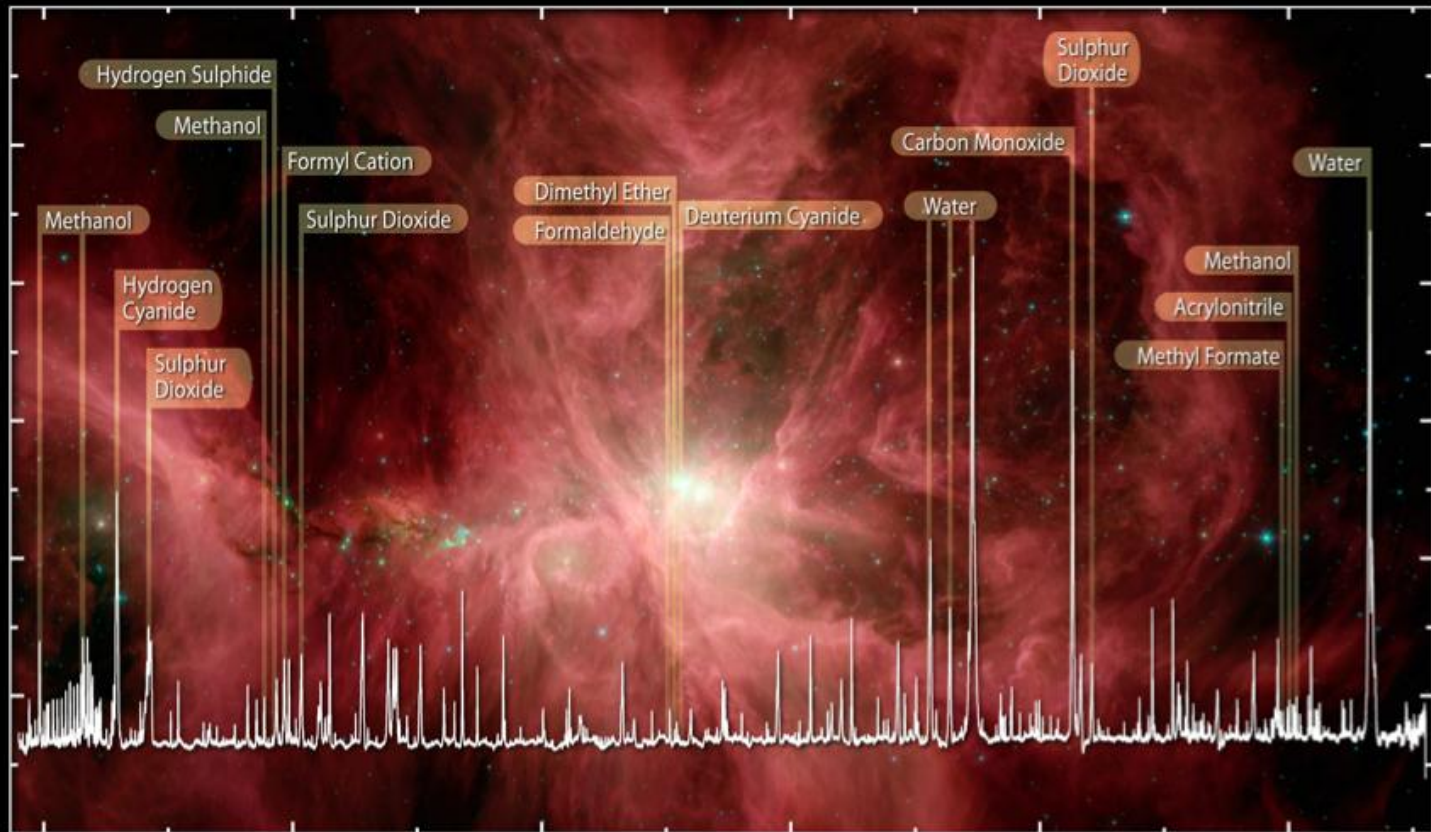
Instrumentación As
Curso 2011/2
do por A. Gil de Paz, J. Zamora

SPIRE 250/350/500



Herschel Space Observatory

Highlights from Herschel ...



HIFI Spectrum of Water and Organics in the Orion Nebula

© ESA, HEXOS and the HIFI consortium
E. Bergin



Herschel Space Observatory

Herschel Science Archive @ ESAC

Herschel Science Archive 3.6

File Interoperability Help

esa Herschel Science Archive European Space Agency

Query Specification Latest Results Shopping Basket Login/Register Logout On-demand Monitor

Not Logged In Idle

Query Specification

Execute Query Cancel Query View/Edit SQL

Sort Criteria Observation Start Time Sort Order Ascending

Close Principal Search Criteria Clear

Observation ID File with Observation ID List Locate File

Proprietary status Any

Search Target By Name Equatorial Galactic Ecliptic

Name for SIMBAD Radius 5 arcmin

Instrument Any

Obs Type Standard Data

All HIFI None Single Point Mapping Spectral Scan	All PACS None Pacs Photometer Range Spectroscopy Line Spectroscopy	All SPIRE None Photometer Spectrometer	All SPIRE PACS None Parallel Mode
-----------------------------------------------------------	-----------------------------------------------------------------------------	----------------------------------------------	--------------------------------------

Open Proposal Clear

CURSO 2011/2012

(material compilado por A. Gil de Paz, J. Zamorano, J. Gallego, P.G. Pérez-González)



Herschel Space Observatory

Proposing for Herschel – Not possible anymore

After 3-5 months of commissioning and 5-6 months of science demonstration phase routine science operations started:

36 months in total - *20,000 hours of science observing time:*

32% Guaranteed time programmes (GT)

68% Open Time programs (OT):

40% in one call for Key Programmes (Oct 07)

60% in two calls for Regular Programmes (<100h)

Tool of use: Herschel-SPOT, aka **HSPOT**

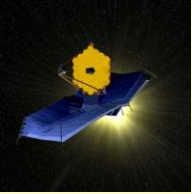
Check first the Herschel's **Reserved Observations List** !!



Misiones futuras / Future Space Observatories

**Instrumentación Astronómica
Curso 2011/2012**

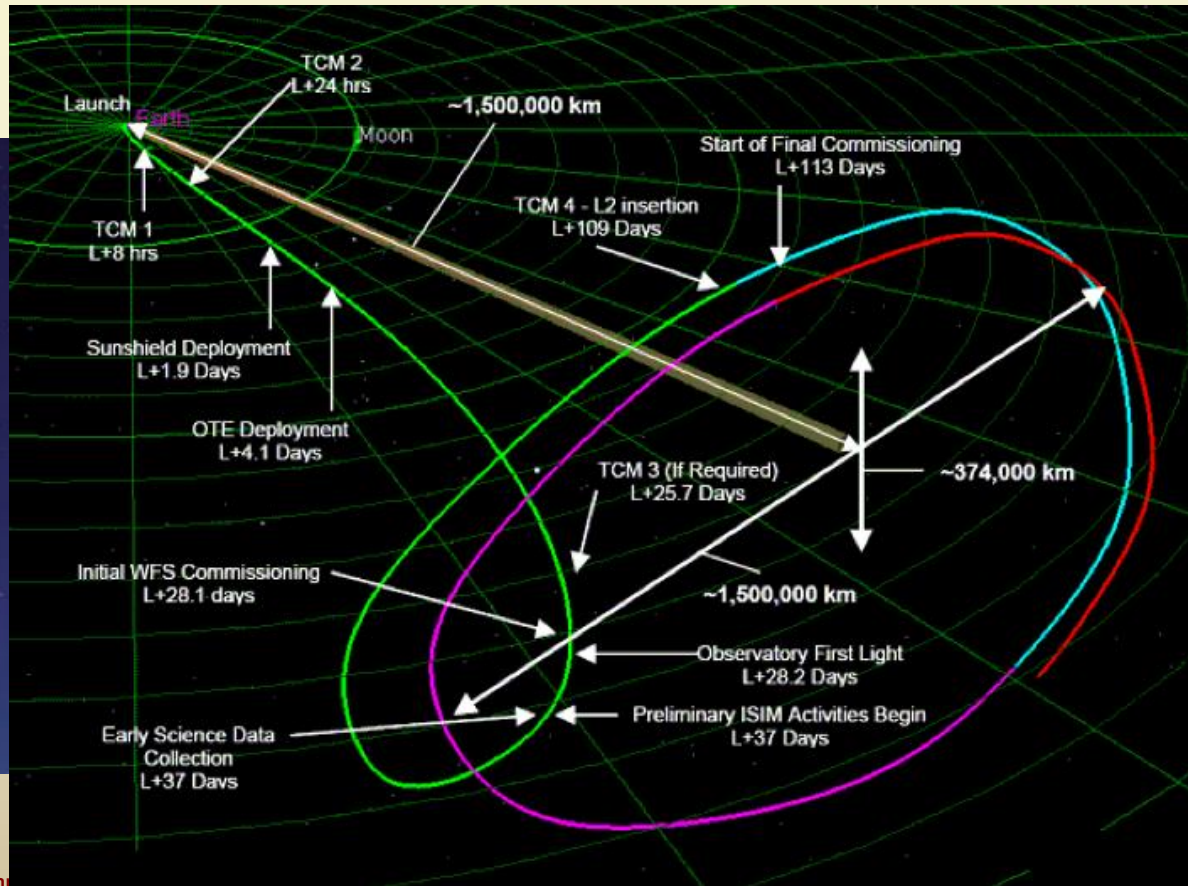
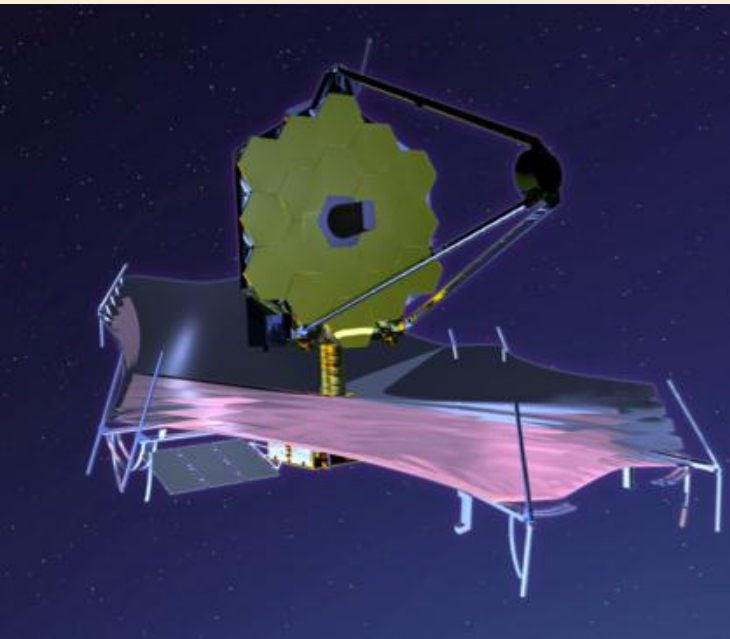
(material compilado por A. Gil de Paz, J. Zamorano, J. Gallego, P.G. Pérez-González)

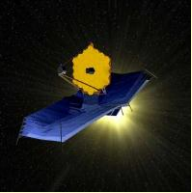


Future missions: JWST

James Webb Space Telescope: Summary

- Developed by an industrial consortium under NASA's supervision in collaboration with ESA (mostly for instrument development).
- High orbit around the L2 Sun-Earth Lagrange point. Launch ~2018 by an Ariane V rocket.





JWST: Instruments

Instrument	Wavelength (μm)	Optical Elements	FPA	Plate Scale (milliarcsec/ pixel)	Field of View
NIRCam (Short Wave)	0.6 - 2.3	fixed filters (R~4, R~10, R~100), coronagraphic spots	Two 2x2 mosaics of 2048x2048 arrays	32	2.2'x4.4'
NIRCam (Long Wave) ¹	2.4 - 5.0	fixed filters (R~4, R~10, R~100), coronagraphic spots	Two 2048x2048 arrays	65	2.2'x4.4'
NIRSpec (prism, R=100)	0.6 - 5.0	transmissive slit mask: 4x384x175 micro-shutter array, 250 (spectral) by 500 (spatial) milliarcsec; fixed slits 200 or 300 mas wide by 4" long	Two 2048x2048 arrays	100	3.4'x3.1'
NIRSpec (grating, R=1000)	1.0-5.0				
NIRSpec (IFU, R=3000)	1.0-5.0				integral field unit
MIRI (imaging)	5 - 27	broad-band filters, coronagraphic spots & phase masks	1024x1024	110	1.4'x1.9' (26"x26" coronagraphic)
MIRI (prism spectroscopy)	5 - 10	R ~ 100			
MIRI (spectroscopy)	5 - 27	integral field spectrograph (R~3000) in 4 bands	Two 1024x1024 arrays	200-470	3.6"x3.6" to 7.5"x7.5"
Short-wavelength FGS-TF	1.2 - 2.4	Order-blocking filters+etalon (R~100)	2048x2048	68	2.3'x2.3'
Long-wavelength FGS-TF ²	2.5 - 5.0	Order-blocking filters+etalon (R~100)	2048x2048	68	2.3'x2.3'

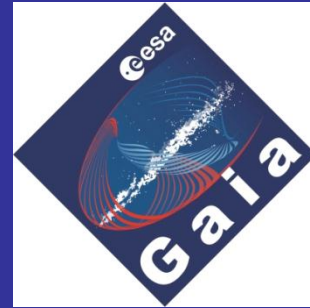


Other Future Missions



WSO-UV (World Space Observatory - UV, formerly Spectrum UV):

- 1.7m UV-optimized telescope working in the range between 120-500 nm. The instrumentation includes:
 - *ISSIS: Deep UV and diffraction-limited opt. imager and slitless spec (led by UCM).*
 - *Long-slit low-resolution ($R \sim 200$) UV spectrograph.*
 - *High-resolution (echelle) spectrograph ($R \sim 55,000$) in the range 1000-3100 Angst.*
- Being built by a consortium of Russian, German, Chinese, & Spanish institutions.
- Scheduled to be launched in 2014.



Gaia (formerly *Global Astrometric Interferometer for Astrophysics*)

- Dual telescope (primary mirror shown above) on a common focal plane.
- Focal plane: 106 CCDs (0.5mx1m).
- Objectives:
 - *Measure the positions of $\sim 10^9$ stars in our MW & Local Group gals. (accuracy $\sim 20 \mu\text{as}$).*
 - *Perform spectral and photometric measurements of all objects.*
 - *Derive space velocities of the Galaxy's stars using the stellar distances and motions -> 3D structural map of the MW.*
- ESA mission to be launched in 2013.



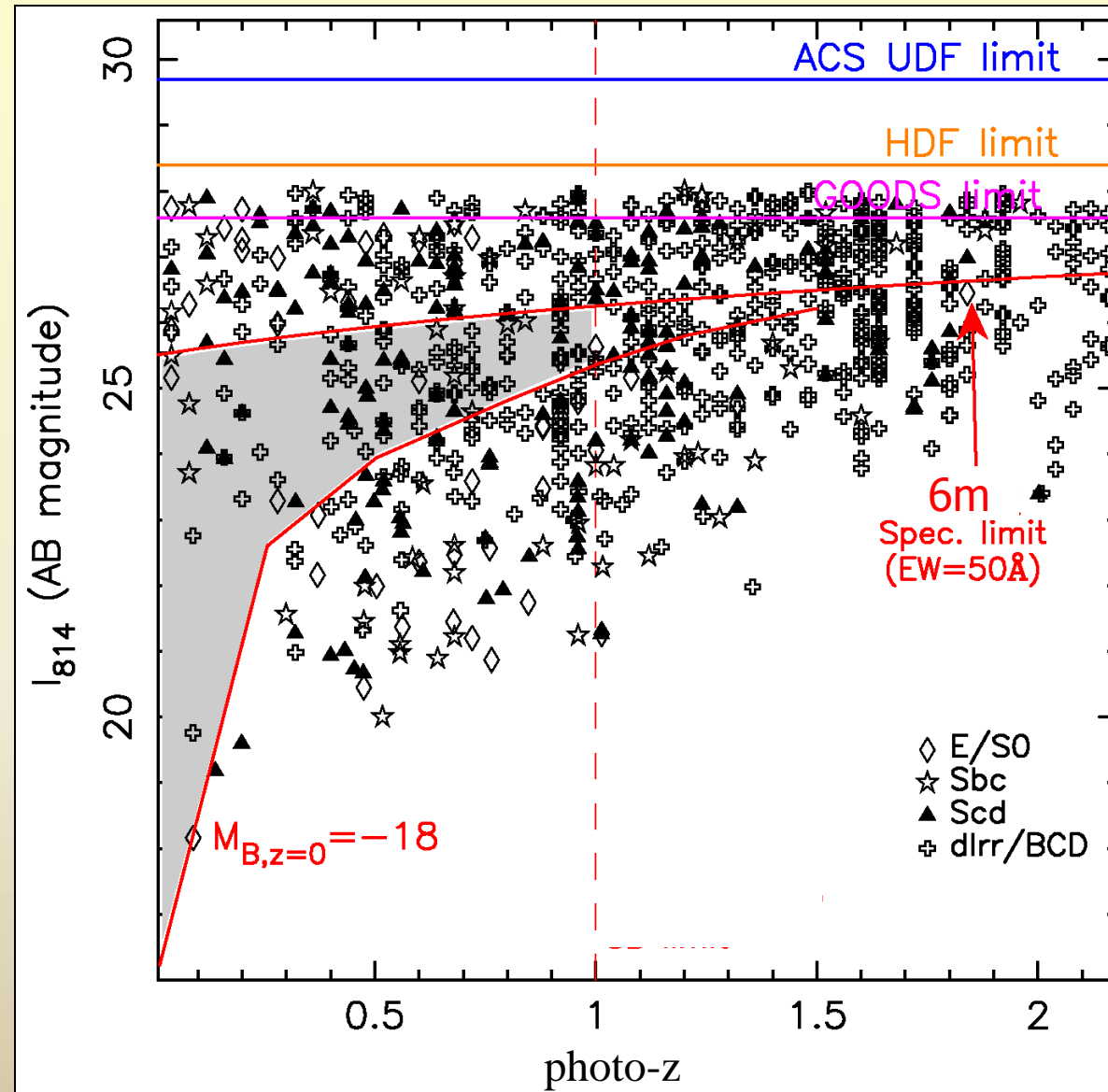
Sinergia con observaciones desde tierra / Sinergy with ground-based Astronomy

**Instrumentación Astronómica
Curso 2011/2012**

(material compilado por A. Gil de Paz, J. Zamorano, J. Gallego, P.G. Pérez-González)



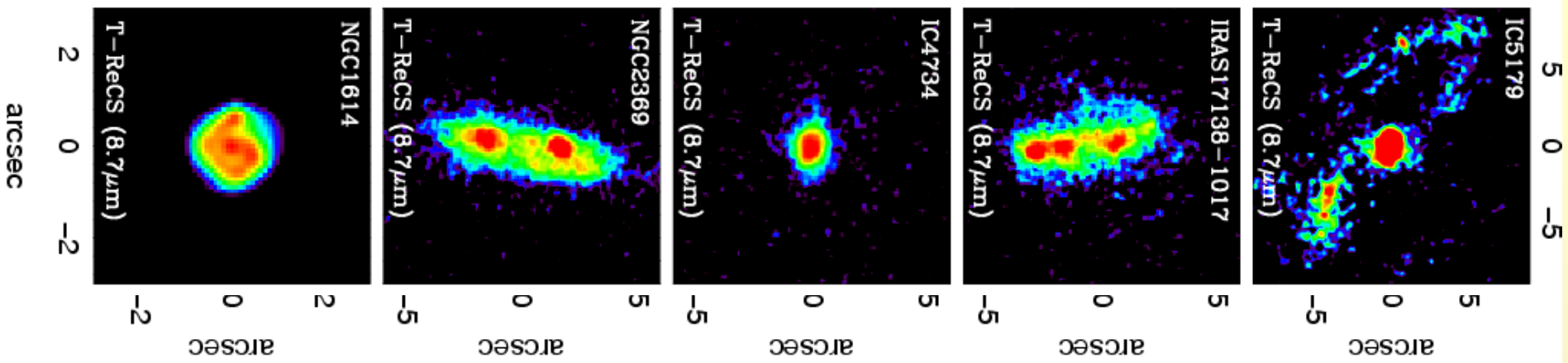
Synergy with ground-based astronomy



Cosmological redshift surveys (HST-Keck/VLT):

- *HST* is not optimized for measuring redshifts of faint distant galaxies (*just a 2.5m!*)
- Redshifts have traditionally come from 8-10m telescopes such as Keck, VLT, Gemini...
- Unfortunately, most sources in deep imaging surveys with HST (HDF, UDF) are well beyond the spectroscopic limit ($I_{AB} \sim 26$).

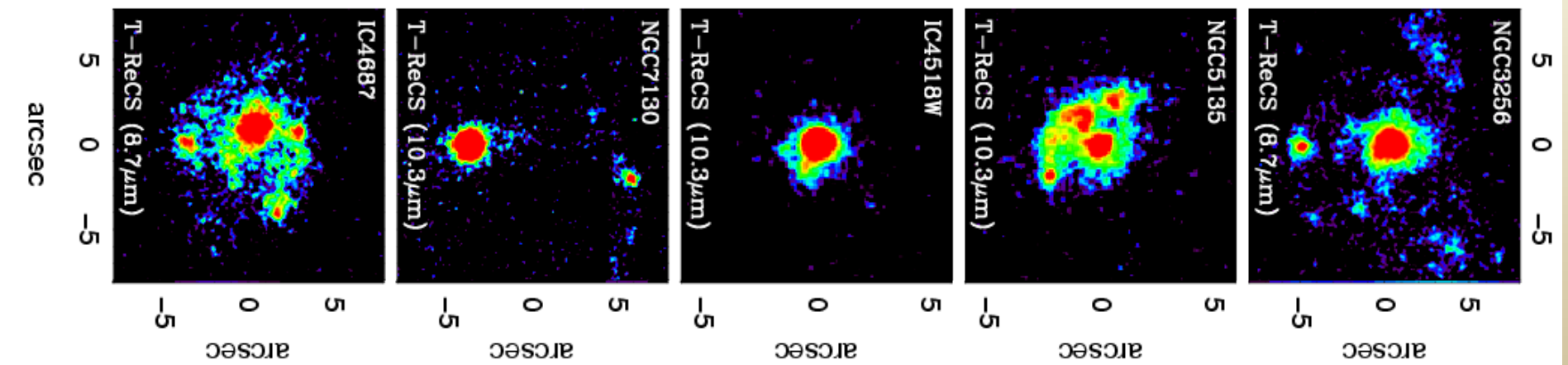
Objective of new 30-m class telescopes (TMT, GMT, E-ELT)

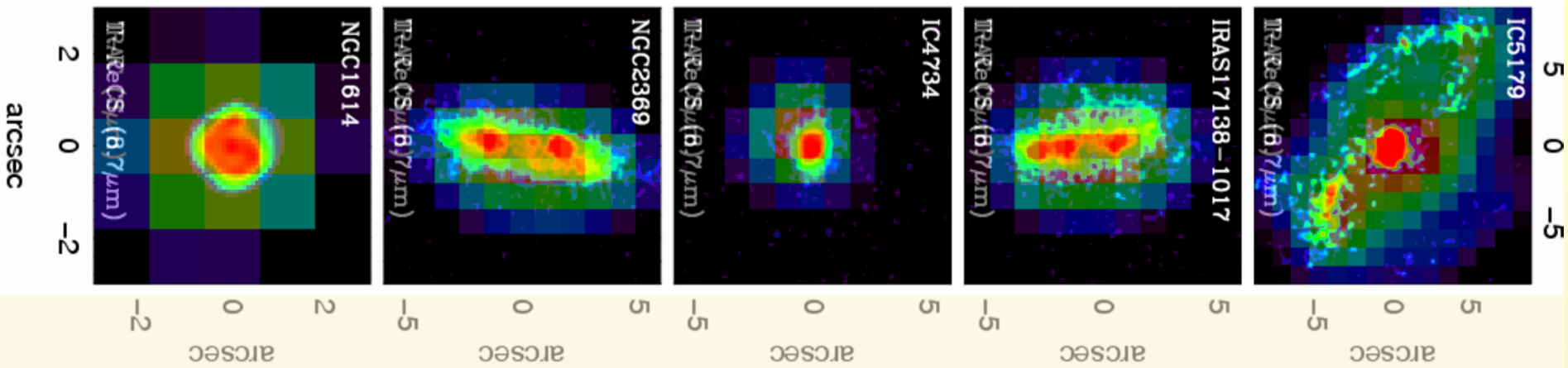


Mid-IR imaging: space (Spitzer/IRAC) vs. ground (Gemini/T-ReCS) observations

Díaz-Santos (2009, PhD)

Credit: Almudena Alonso-Herrero

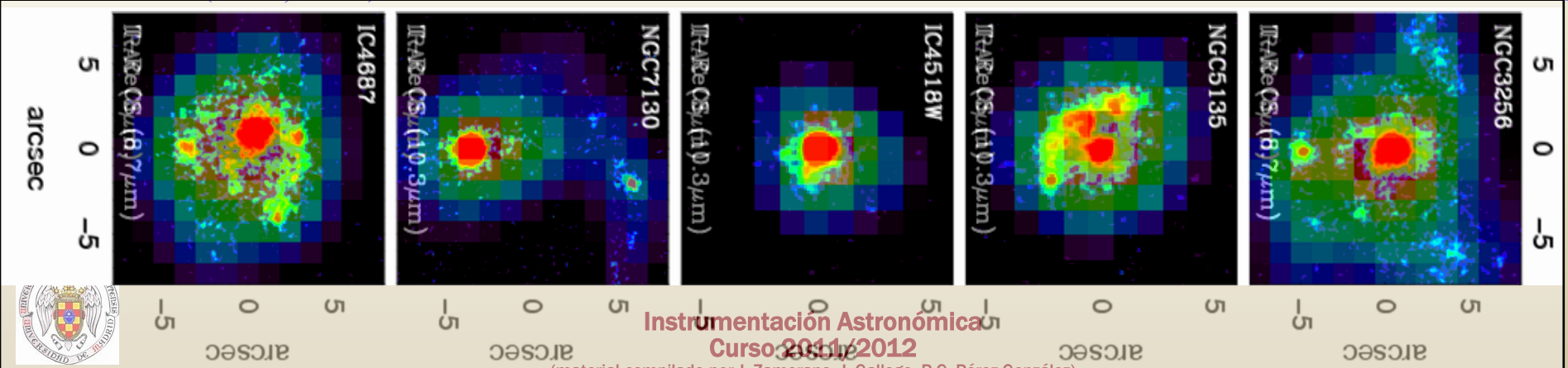




- Only with high spatial resolution can constituent parts of AGN & host galaxy be investigated and de-blended
- Resolution at distance of 30Mpc
 - Spitzer = 450pc (galactic star forming rings, etc.)
 - GTC/CanariCam = 45 pc (nuclear dominated)

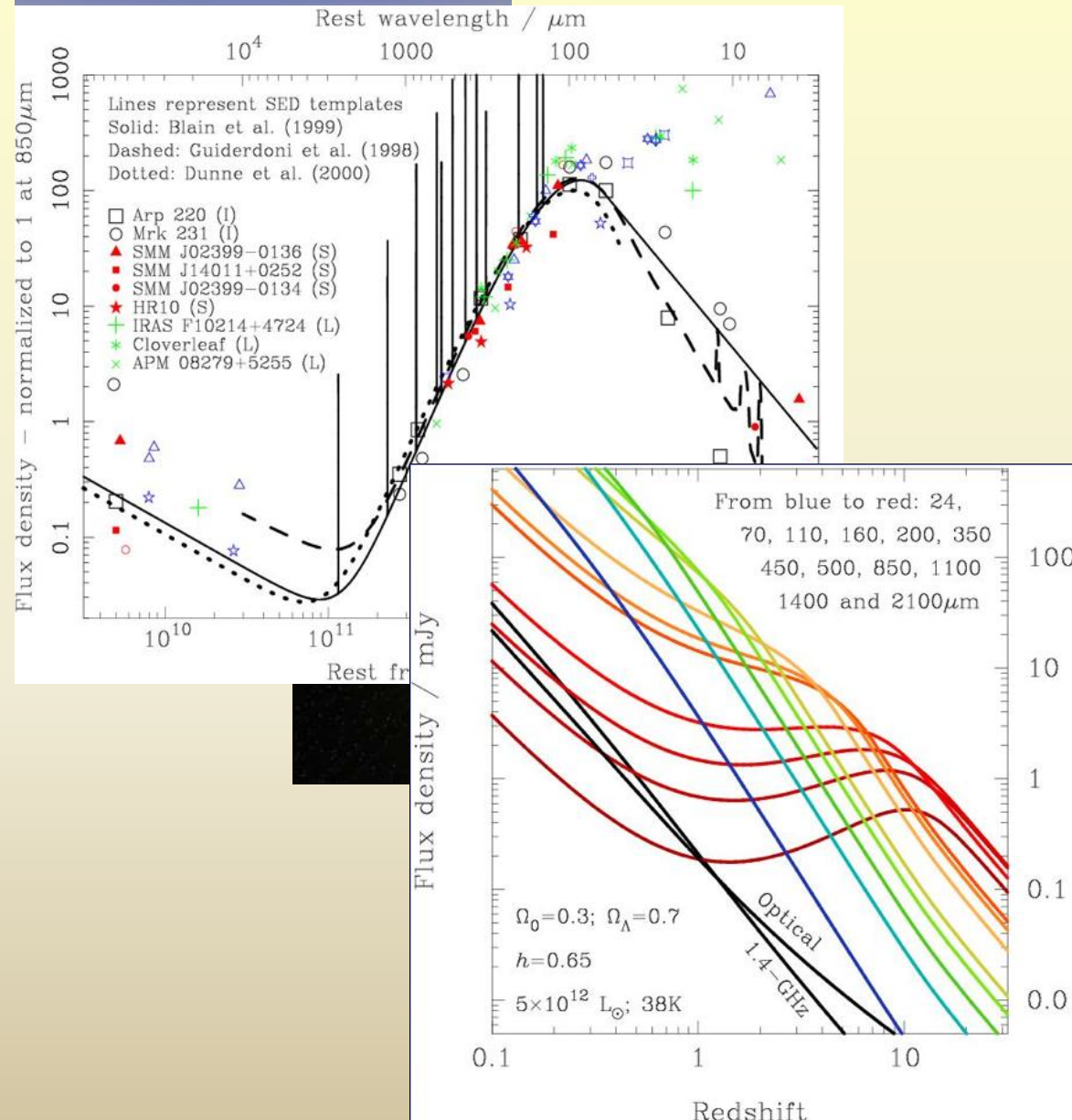
Díaz-Santos (2009, PhD)

Credit: Almudena Alonso-Herrero





Synergy with ground-based astronomy



Future surveys (JWST-ALMA-30m synergy):

- ALMA will provide an unprecedented sample of very distant galaxies thanks to the negative K-correction.
- Targeted JWST programs will allow deriving rest-frame optical properties with superb resolution.
- 30m-class telescopes should provide redshifts for ALMA sources with faint molecular (CO) or [CII] $158 \mu\text{m}$ line emission.

Resumen de contenidos

- **¿Por qué se lanzan telescopios espaciales? Sinergías con telescopios de tierra.**
- **Principales telescopios espaciales (más allá del UV), características, instrumentos,...**
- **Típicos programas de preparación de propuestas.**
- **Archivos de misiones.**
- **Futuras misiones espaciales.**

