Cosmic Origins Spectrograph
Hubble Space Telescope

Scientific Observations with the Cosmic Origins Spectrograph

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Outline

I. Observing with COS

II. COS Science Themes

Observing with COS

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Overview

• COS is an ultraviolet (1150 – 3200 Å) spectrograph designed to maximize sensitivity for point or point-like source observations at low (R~2000) and moderate (R~20,000) spectral resolutions
• FUV (1150 – 2050 Å) sensitivities exceed comparable STIS modes by 10 to 20; NUV (1700 – 3200 Å) by 2
• COS and STIS will provide a powerful, *complementary* UV spectroscopy capability for HST

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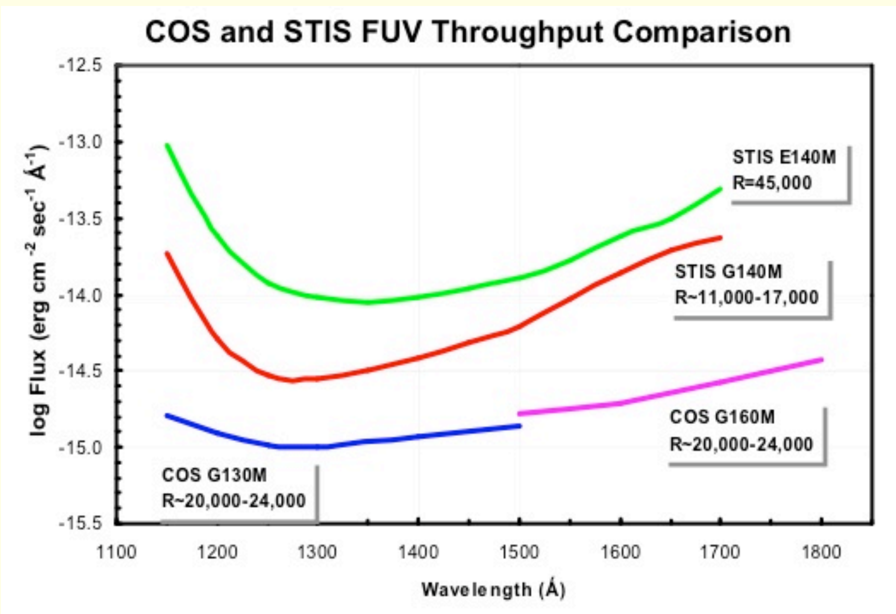
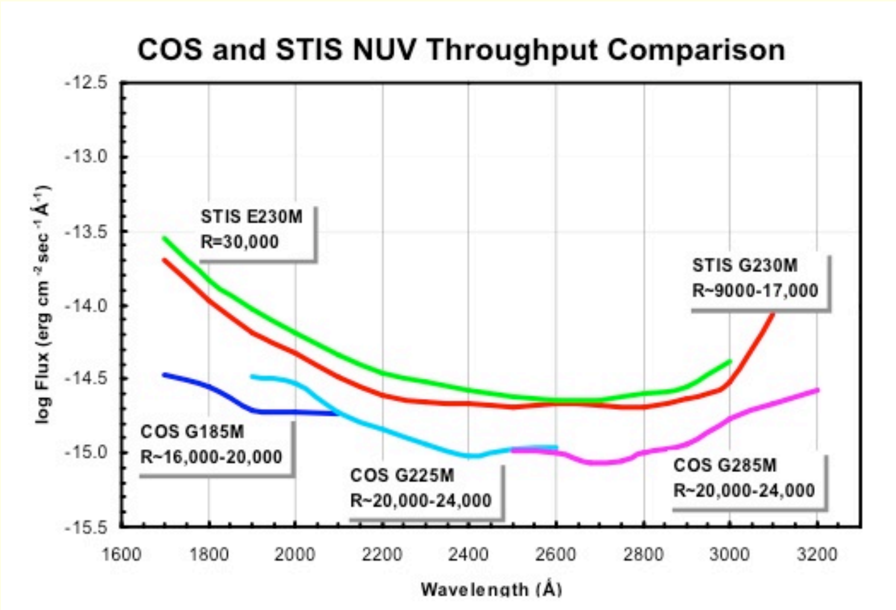
COS Sensitivities

- Limiting magnitude for S/N=10 in 3600 sec (R=10,000)
- FUV gains >10 in sensitivity, 70 in observing speed
- COS gains: faint targets (discovery), observing times (survey)





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COS FUV Channel

• Two detector segments, similar in look and feel to FUSE detectors, but at much higher effective area, lower (effectively zero) background, scattered light
• In medium resolution modes, a single exposure covers a 300 Å bandpass at R = 20,000 – 24,000
• Points to consider when planning observations:
  – Binned-up G130M and G160M have higher throughputs than G140L and may be preferred for most observations
  – Full instrument performance (resolution, wavelength calibration, throughput) is achieved for point sources within 0.5" of aperture center
  – The BOA aperture has degraded spectral resolution performance (R~12,000 for M modes); STIS may be better
  –Time-tagged (32 ms) data and tag-flash observing mode for most targets

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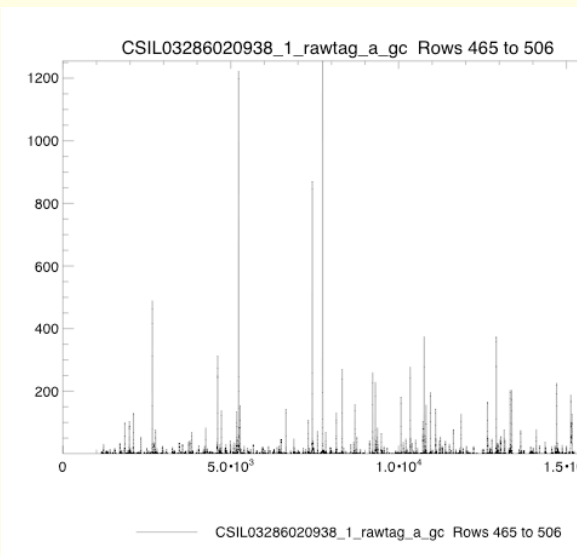
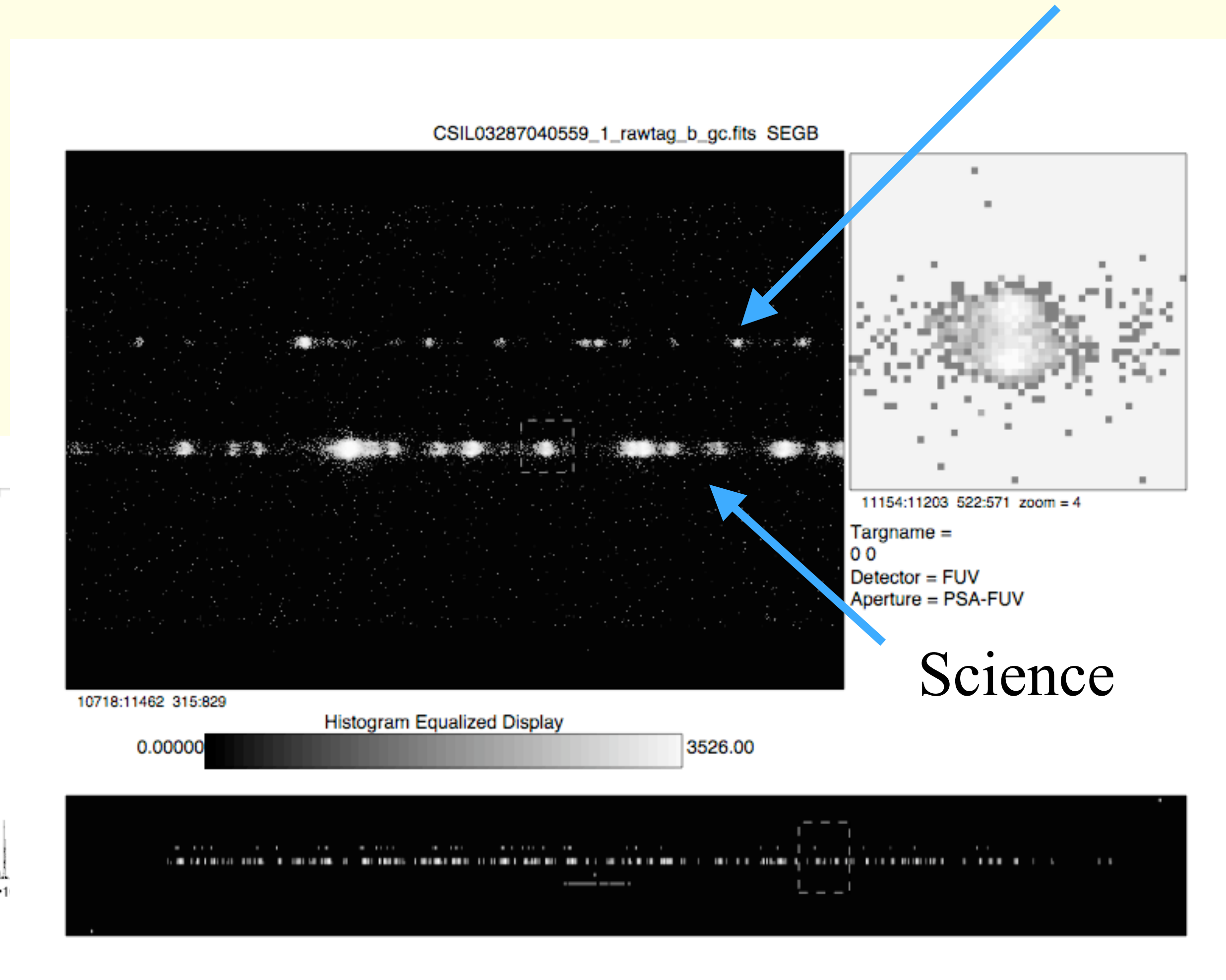
COS FUV Channel

- One of two detector segments, 15384x1024 pixels per segment
- Note background (10 cts/sec/segment!)
- PtNe spectrum from thermal vacuum tests: 1304 – 1445 Å





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COS NUV Channel

- MAMA detector similar to STIS (is in fact the STIS flight spare)
- In M modes, three spectral stripes cover 3x35 Å non-contiguous regions at R= 16,000 – 24,000
- Points to consider when planning observations:
  - COS sensitivity about 2x STIS in NUV but wavelength coverage per exposure more limited; choice depends on science
  - Bright object protection limits target fluxes in PSA to global fluxes $\leq 2\times10^{-12}$ erg cm^{-2} s^{-1} Å^{-1} (FUV) and $\leq 2\times10^{-11}$ erg cm^{-2} s^{-1} Å^{-1} (NUV); O9V star; local count rate limits also apply
  - COS has a limited (2.5") imaging mode: broadband (1700 – 3200 Å), highly sensitive; 2 pixel FWHM at 0.024"/pixel

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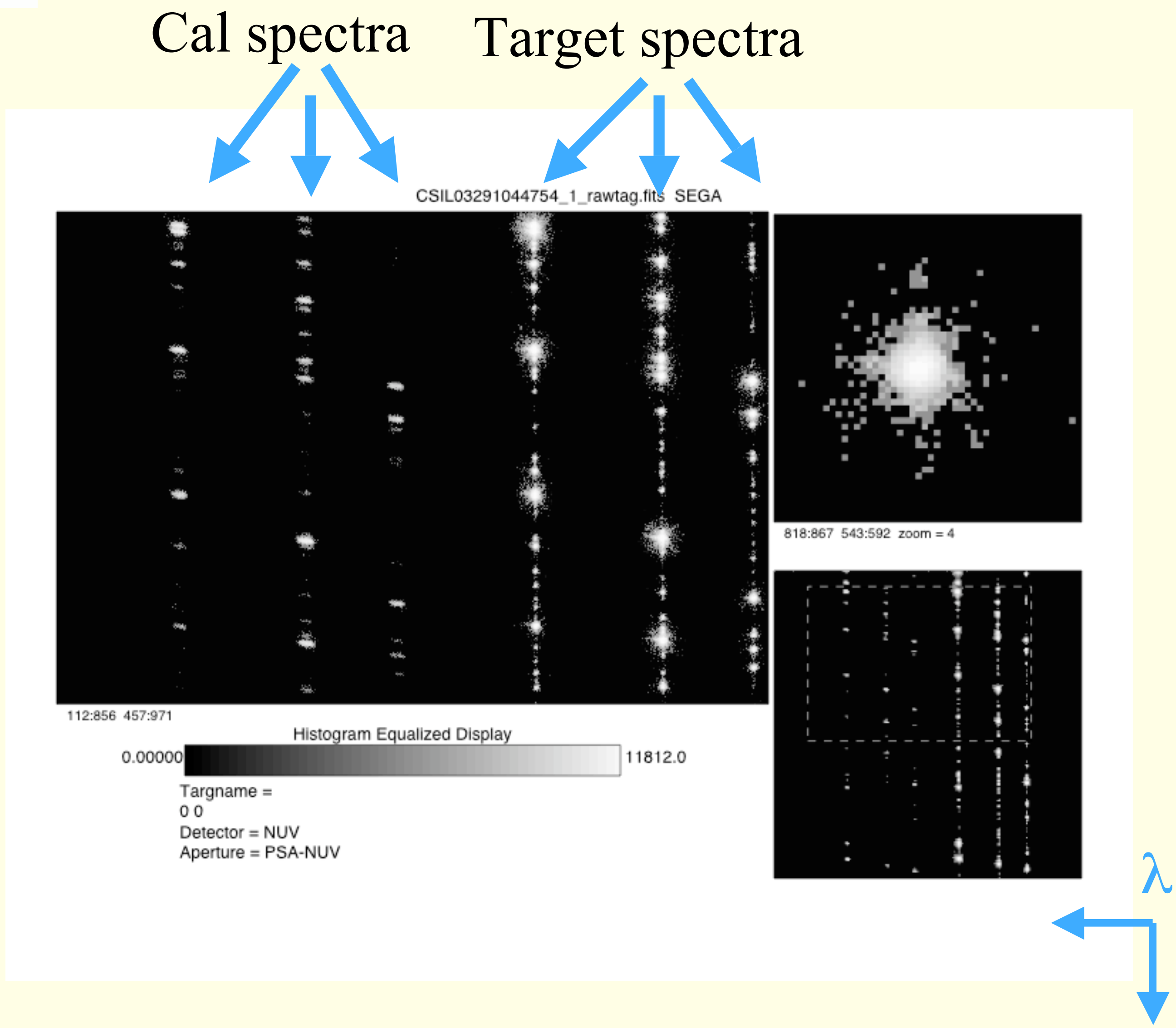

- NUV thermal vacuum data
- Note that calibration lamp lines are not in focus
- "Tag-flash" will be the standard mode for on-orbit time-tag observations

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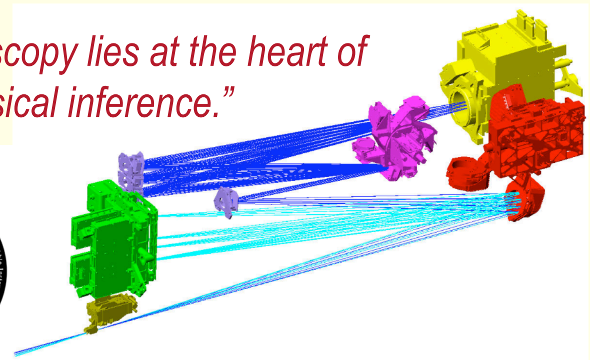
COS Science Themes

COS Science Themes

- What is the <u>large-scale structure</u> of matter in the Universe?
- How did <u>galaxies</u> form out of the intergalactic medium?
- How were the <u>chemical elements</u> for life created in massive stars and supernovae?
- How do <u>stars and planetary systems</u> form from dust grains in molecular clouds in the Milky Way?
- What are <u>planetary atmospheres and comets</u> in our Solar System (and beyond) made of?

"Spectroscopy lies at the heart of astrophysical inference."



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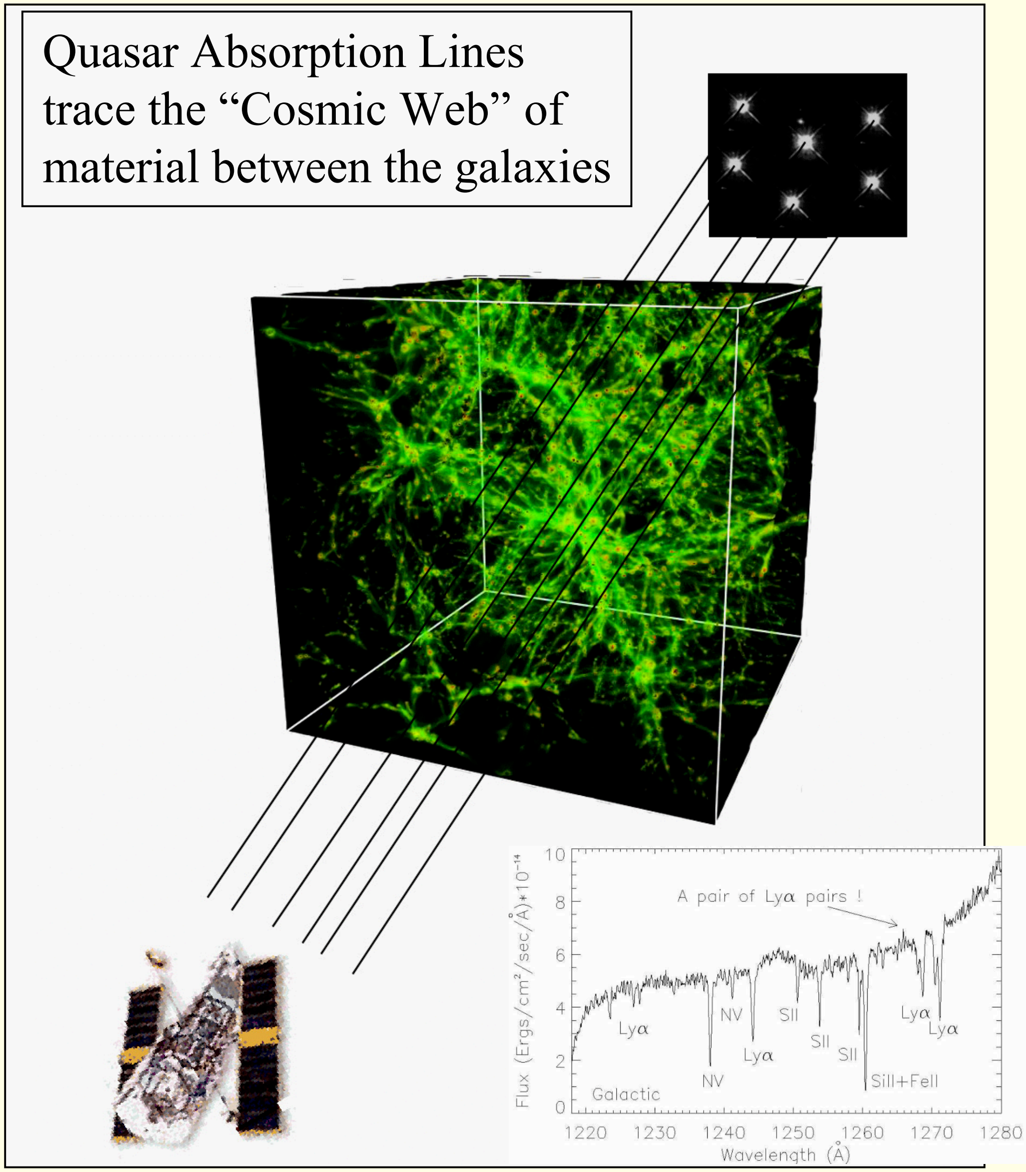

<u>The Intergalactic Medium</u>

- Available sight lines increased from a score to hundreds
- This facilitates broader surveys, spatial structure maps, probes into the most diffuse clouds and detection of weak metal lines

- Visualization concept from Schiminovich & Martin
- Numerical simulation from Cen & Ostriker (1998)
- Songaila et al. (1995) Keck spectrum adapted by Lindler & Heap

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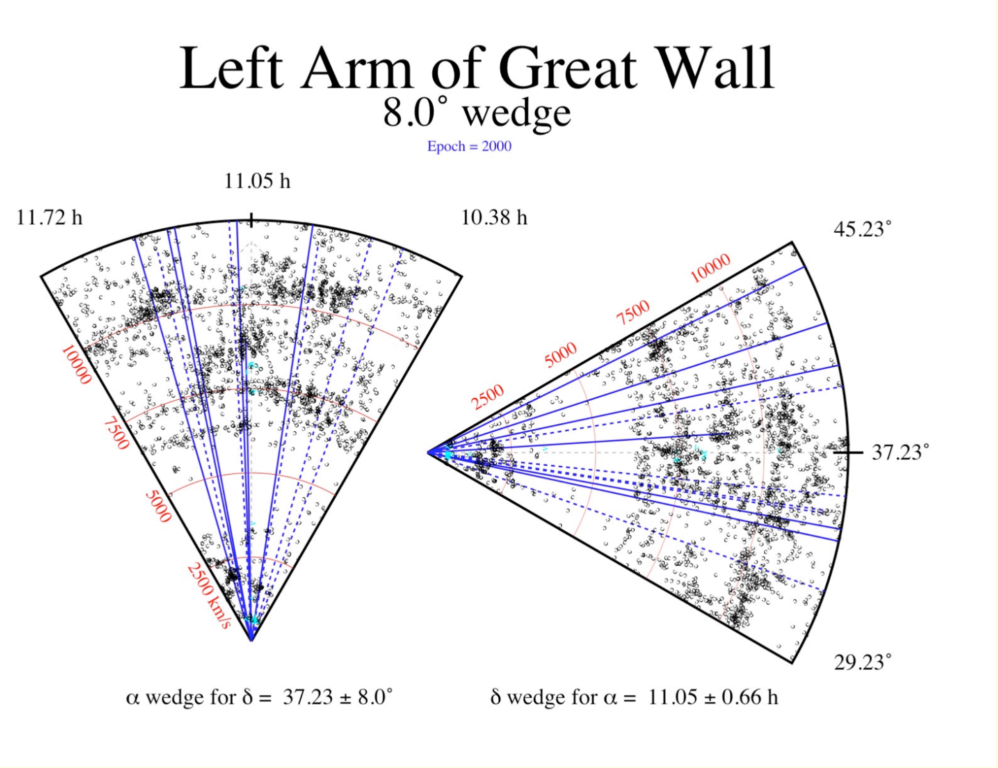
IGM Programs

- Baryon census of the diffuse IGM
- Large-scale structure probes
- Formation of galaxies, galaxy-IGM interactions, feedback
- Chemical evolution and transport
- HeII Gunn-Peterson
- Lyα emission in local starburst galaxies as cosmological templates
- AGN structure and outflows



Spatial mapping of the IGM
Available COS sightlines through the Great Wall; S/N=20 in <5 orbits (S. Penton).

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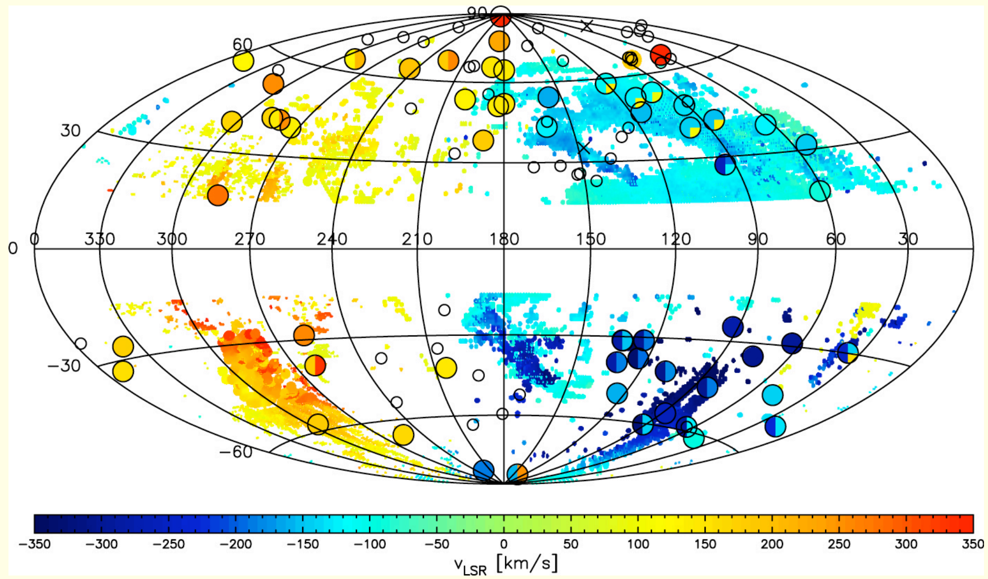
The Warm and Warm-Hot ISM

- Increased number of background targets for MW and extragalactic ISM observations
- Rich set of diagnostic lines; multiple species and ionization states
- Programs include:
  - –Probes of Galactic corona and origins of highly ionized gas
  - –Temperature and structure of the Local Bubble
  - –Extragalactic SNRs; shock processes; metallicity effects
  - –Extragalactic HII regions; near-field cosmology
  - –Local environments of GRBs



The High Velocity H I + O VI Sky
(Sembach et al. 2003, ApJ, 146. 165)

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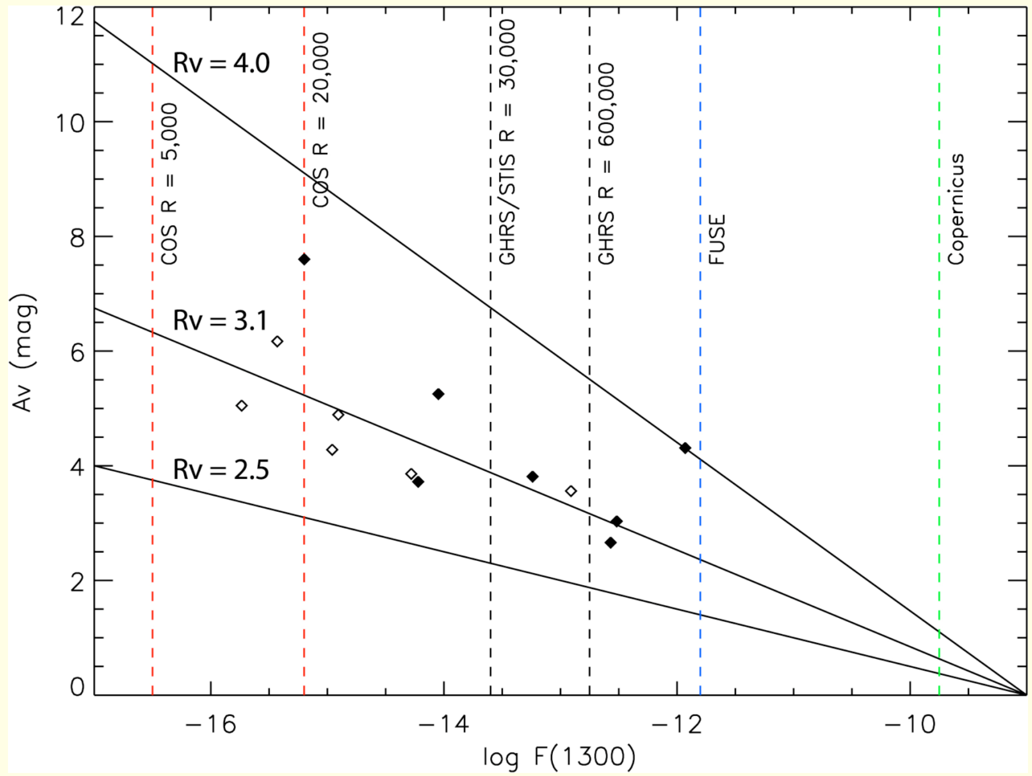
The Cold ISM

- COS sensitivity extends probes of dense clouds up to $A_V > 7$
- First spectra of truly translucent clouds, regions where $C^+ \Rightarrow C$ and CO
- Extinction curves to trace dust formation, grain size as gas becomes neutral



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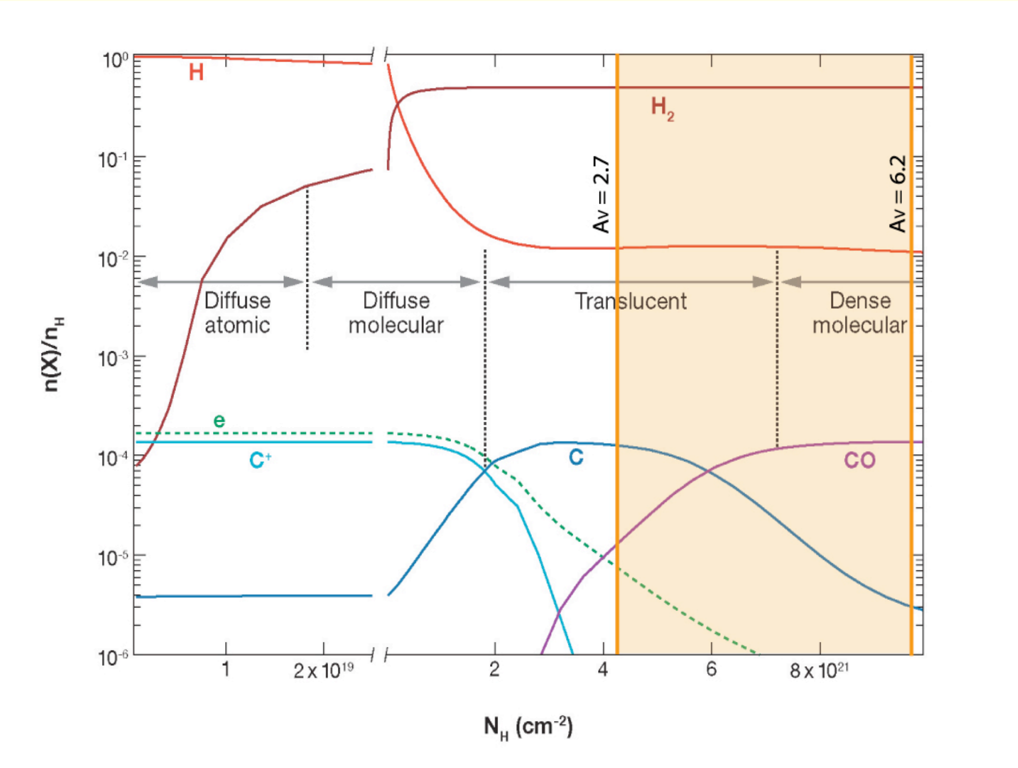

Snow & McCall 2006 ARAA, 44, 367

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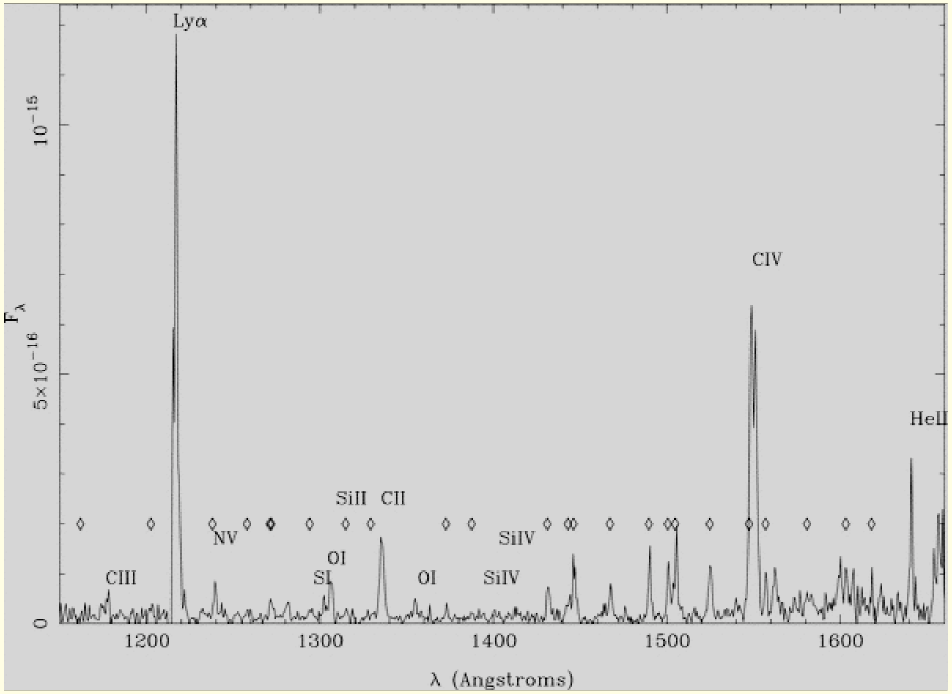
Stars

- Observations of faint targets, such as L and T dwarf chromospheres
- Trace magnetospheric activity as a function of age, metallicity
- Time-tagged (32 ms) observations of time-variable objects, such as interacting binaries, accretion disk systems
- Stellar winds and outflows in massive stars, pre-main sequence stars
- Spectroscopy of faint white dwarfs



STIS spectrum of L-dwarf (M = 0.03 M_{sun}) 2MASSW J1207334-393254 (Gizis et al. 2005).

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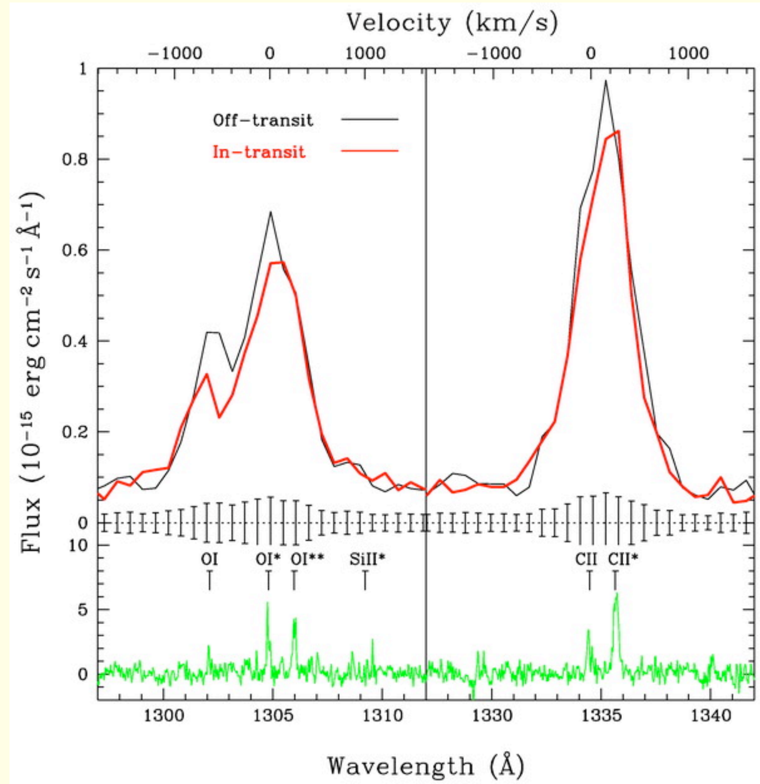
Solar System and Extrasolar Planets

• Improved sensitivity allows for higher spectral (and time) resolution observations of extrasolar planet transits, determination of line widths, velocities, chemical composition of atmospheres

• Number of stellar occultation events for studies of planetary, cometary, and satellite atmospheres will increase by an order of magnitude and with finer resolution capabilities

• Observations of seasonal changes, spatial distributions, chemical composition of atmospheres in the solar system



Vidal-Madjar et al. ApJ 604, L69 (2004); Nature 422, 143 (2003)

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COS Science team

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COS Guaranteed Time Observations

COS GTO program is a mix of programs, united by the theme of cosmic origins.

Phase I forms are available online:

http://www.stsci.edu/hst/proposing/docs/COS-GTO

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For more information:

STScI COS information:
http://www.stsci.edu/hst/cos

Colorado COS web site:
http://cos.colorado.edu/

GSFC HST site:
http://hubble.nasa.gov/index.php