from Tom Brown (head of HST Mission office at STScI), yesterday:

"This morning, the Wide Field Camera 3 was restored to normal operations, and we are planning to return the instrument to science observations in a couple of days, following routine calibrations.

Analysis has shown that last week's anomaly was within the CCD Electronics Box (CEB) for the UVIS channel. The analysis also demonstrated that it would be safe to reset the electronics and recover the instrument to an operational state, to see if these steps cleared the error. These steps were performed this morning, with all telemetry values returned to normal. To be clear, there was no need to switch the instrument to its redundant electronics. The investigation will continue to determine the cause for the corrupted telemetry that triggered the suspension of operations last week; although the observatory was not passing through the South Atlantic Anomaly at the time of the anomaly, this event might have been triggered by something as simple as a cosmic ray."

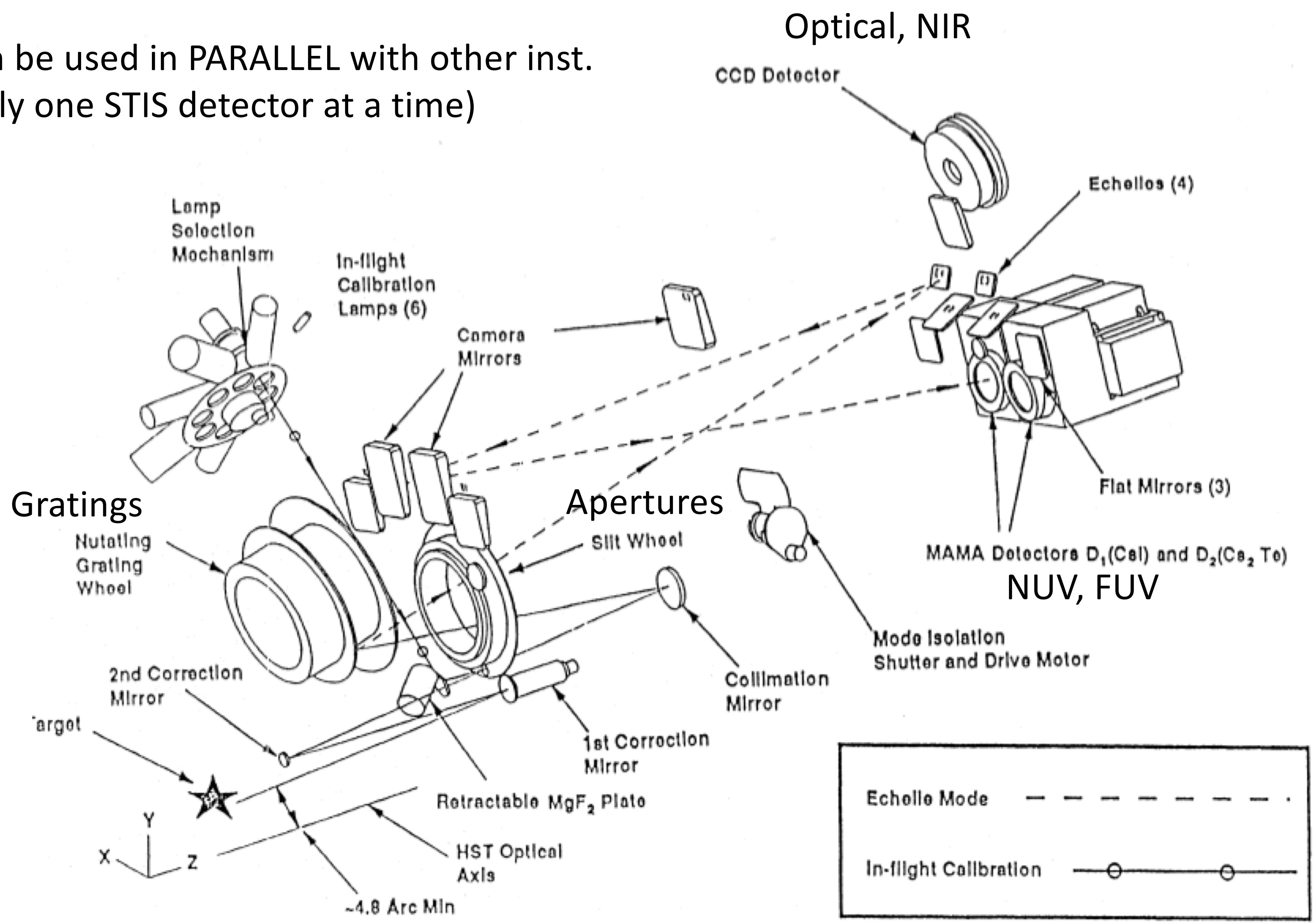
Spectroscopy: STIS and COS

Space Telescope Imaging Spectrograph (STIS)

- Launched 1997, Refurbished during SM4
- Spectral coverage **and** imaging in UV, Optical and NIR
- Spectroscopy:
  - First order gratings: 1150-10,300 Å (low to medium resolution 500-17,000) – long slit spectroscopy (spatially resolved)
  - **High res** Echelle spectroscopy in the UV (1150-3100 Å)
    (R ~ 30K-114K, $\Delta\lambda$ = 800-200 Å)
- Imaging through a small complement of broad-band filters

STIS: Design

Can be used in PARALLEL with other inst.
(only one STIS detector at a time)



Science with STIS: SMBHs

Kinematics of the gas in the nuclear region of M84: Bower+1998

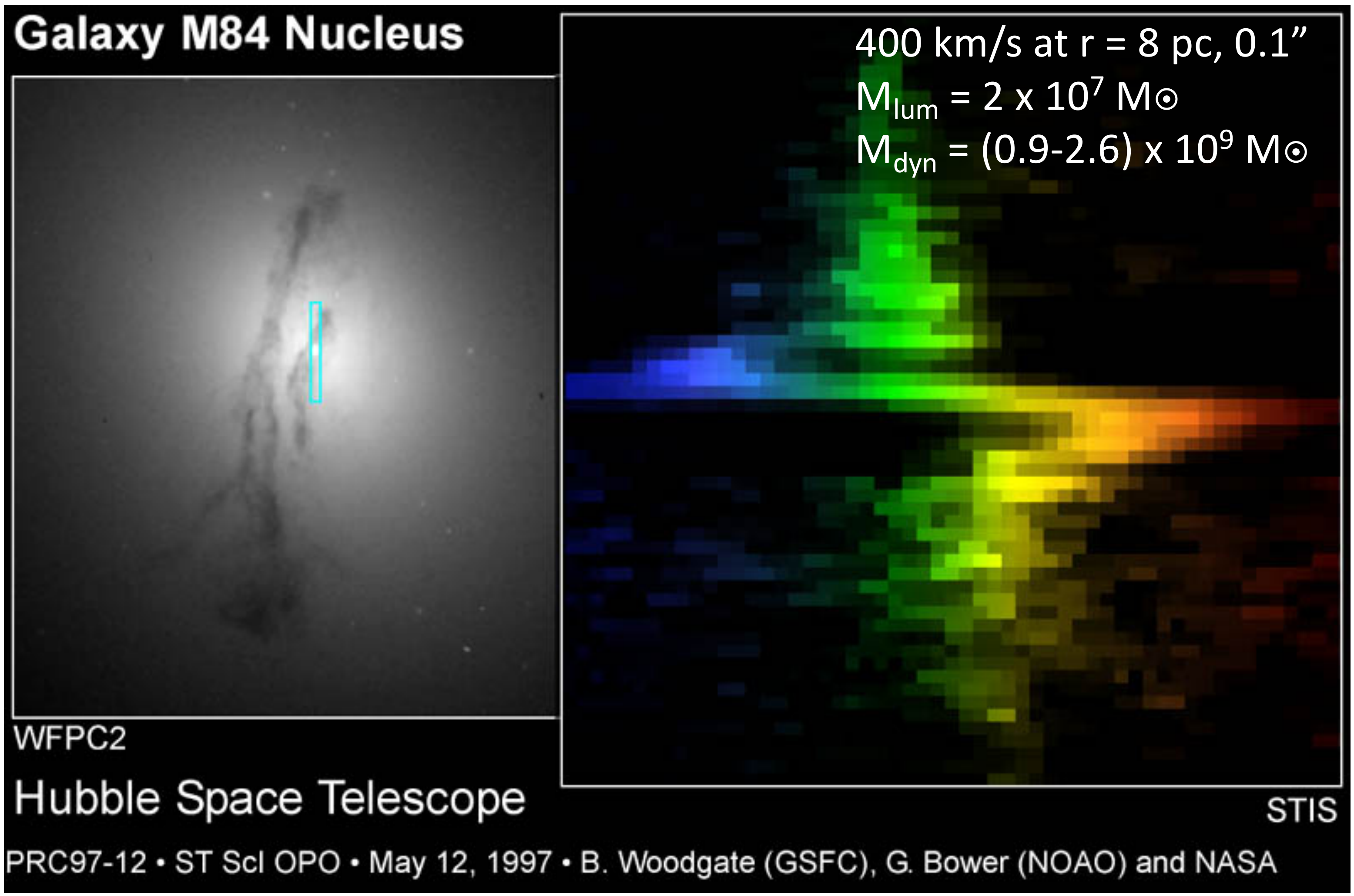
G750M grating, 52x0.2 Long-Slit Spectrum

6295-6867 Å ~ 570 Å (in one tilt get → Hα, NII and SII)

[N II] 6583 Å emission line.

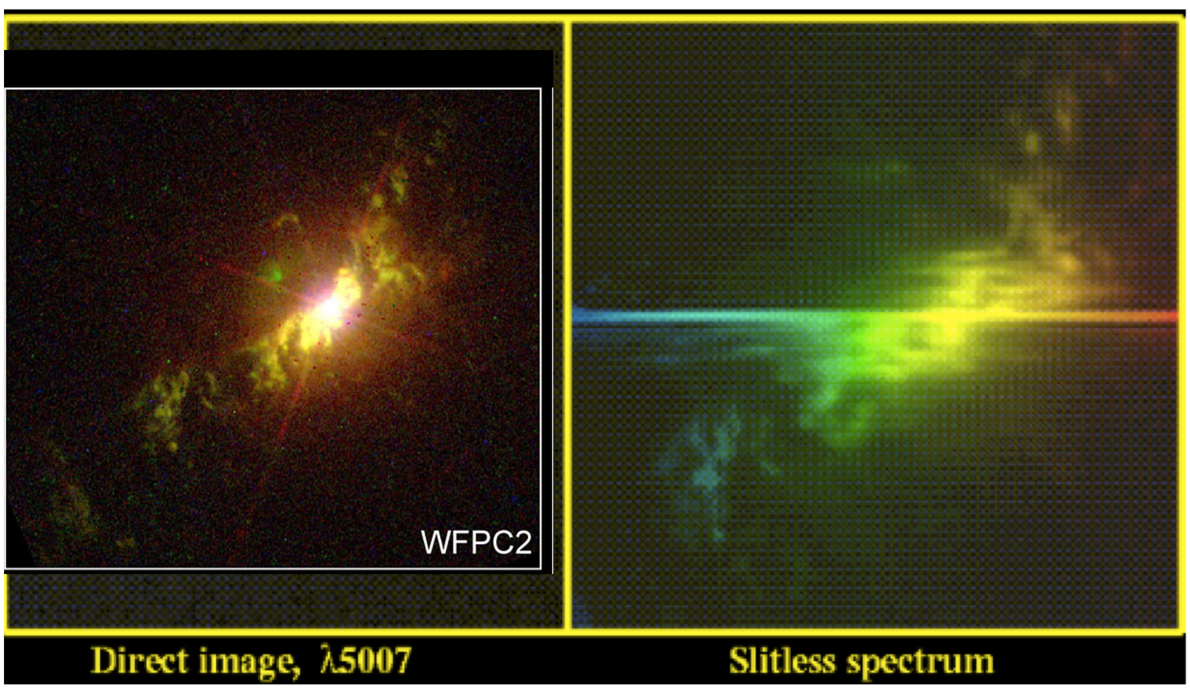
- Structure of accretion disks?
- Accuracy of BH mass determination?
- Outflows?
- Metallicity?

See also:
Barth Cycle 22
13662
(NGC 1275)

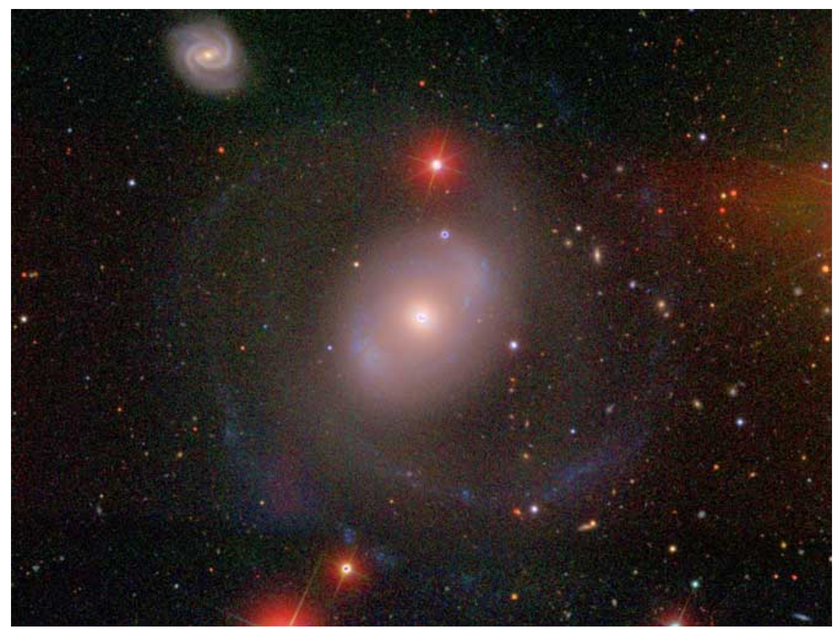


Science with STIS: AGN

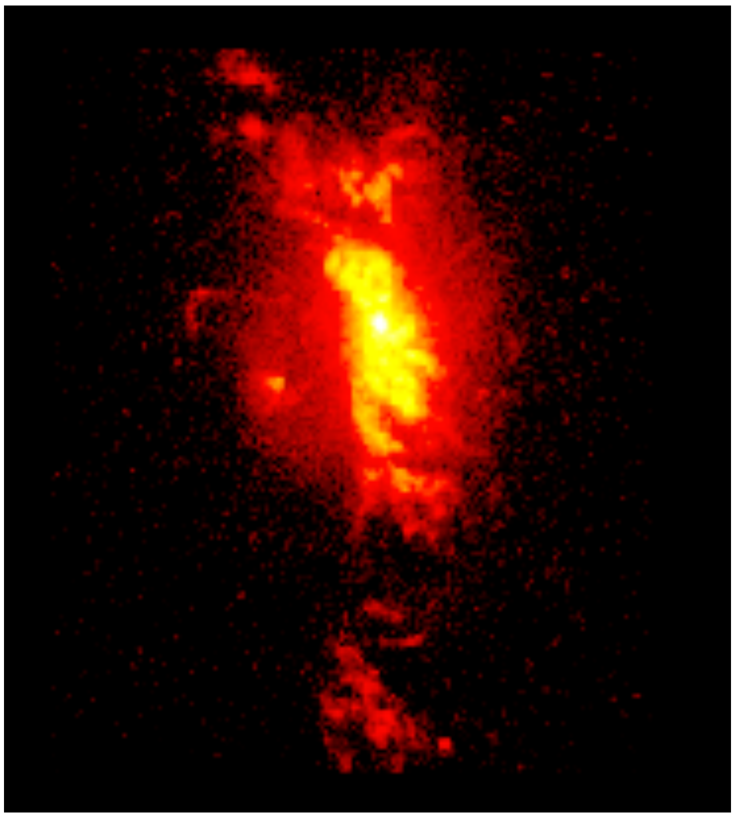
- Properties of gas knots in the narrow line region of NGC 4151
- Relate spatially resolved kinematics to the physical gas conditions (e.g. strength of emission lines)
- Co-evolution of BHs and galaxies
- Burke-Spolaor GO14046 : black hole recoils (high dispersion absorb. lines & evidence for active nucleus emission in gas knots)

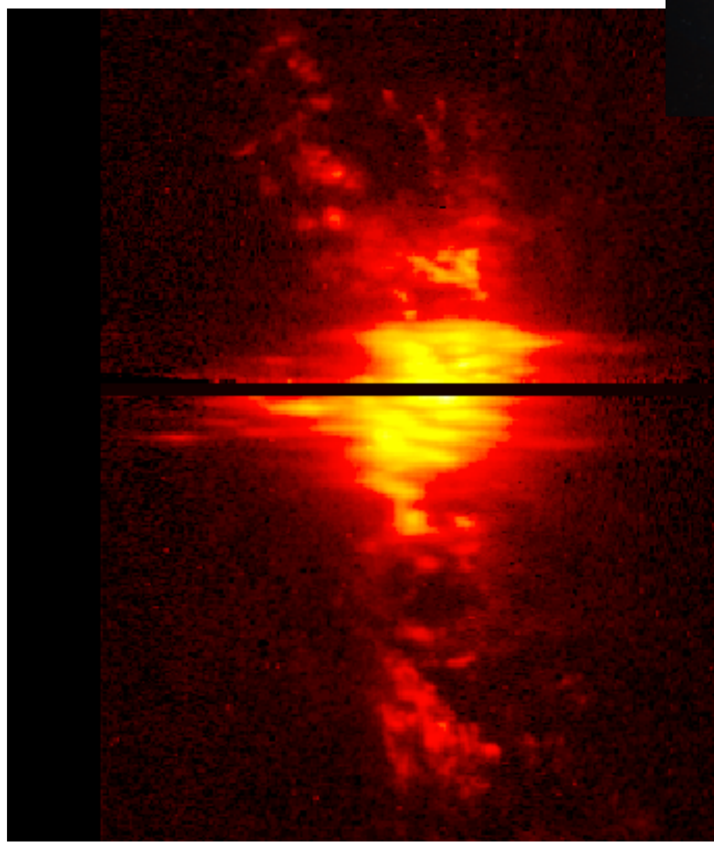


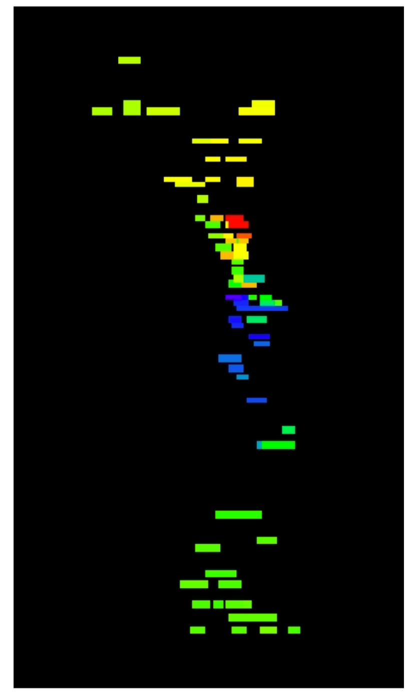
Hutchings + 1998 (Richard Green)



NGC 4151







WFPC-2 OIII image

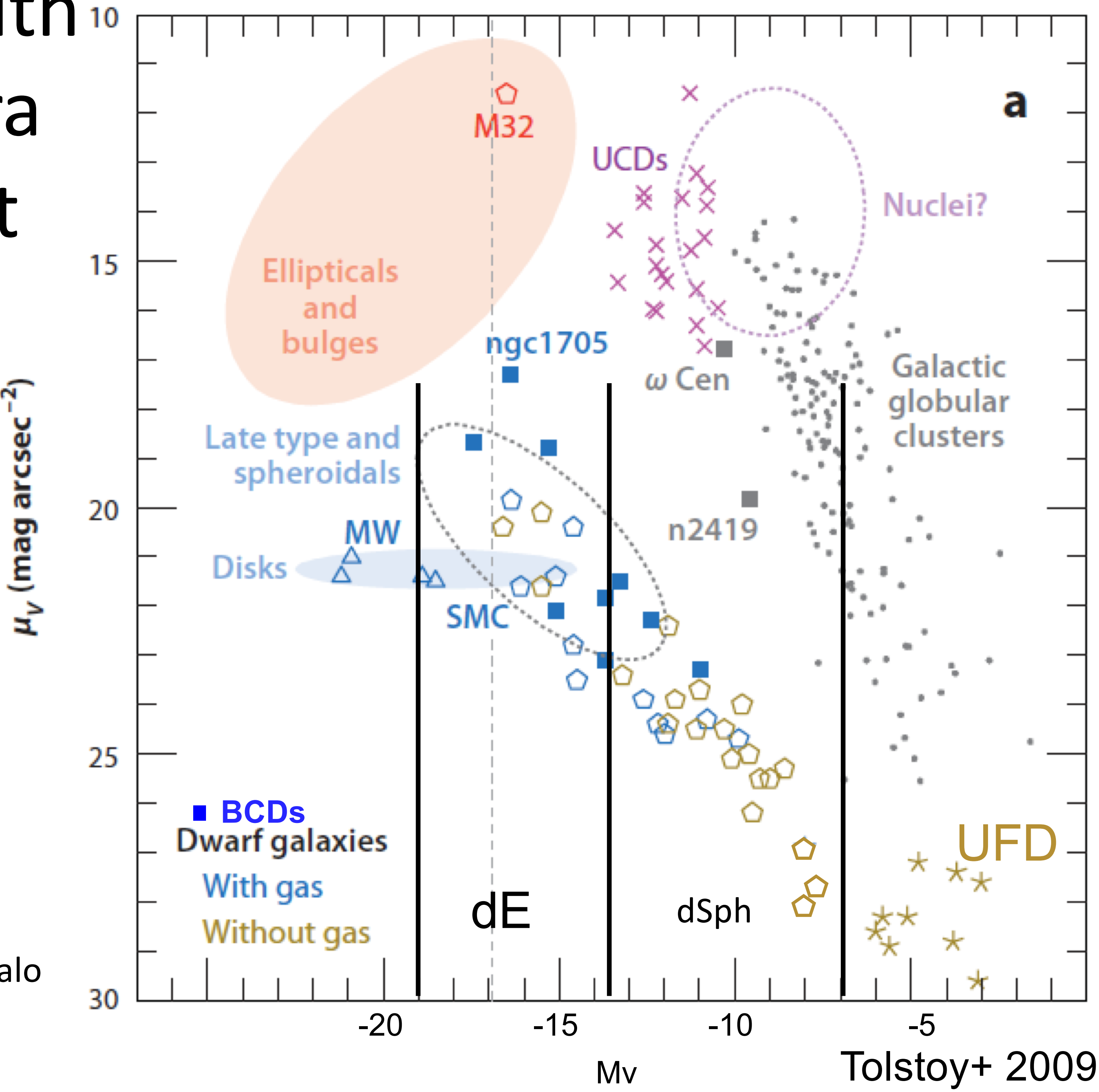
G430L slitless spectrum, centered on the [OIII] 5007 emission line.

Science with STIS: Ultra Compact Dwarfs

UCDs, M/L ~ 2-4 M⊙
M ~ 1-5e7 M⊙
Re ~ 10-22 pc
σ = 24-37 km/s

GCs: M/L ~ 1-2 M⊙
M < 4e6 M⊙
Re ~ 3-5 pc
σ = 5-10 km/s

dE:
M > 1e7 M⊙
Re ~ 8 pc core, 300 pc halo



Tolstoy+ 2009

Isolated compact stellar systems in the Fornax Cluster
HST Proposal 8685 Cycle 9
Drinkwater

We have discovered a new population of compact objects in the centre of the Fornax Cluster. These objects have spectra typical of old stellar systems, but are unresolved in ground- based imaging. They are all at least 10 times more luminous than any Galactic globular clusters, but fainter than any known compact dwarf galaxies. They may be a new class of intermediate object, neither globular clusters nor dwarf galaxies but something in between. We request HST imaging of a sample of these objects to measure their light profiles and determine their structure. We need the high resolution imaging of HST to measure the radii of these objects which we will combine with ground-based spectroscopy to determine their mass-to-light ratios. This will allow us to compare them to known compact objects such as globular clusters and the nuclei of dE galaxies to establish if they do indeed represent a new class of hitherto unknown stellar system.;

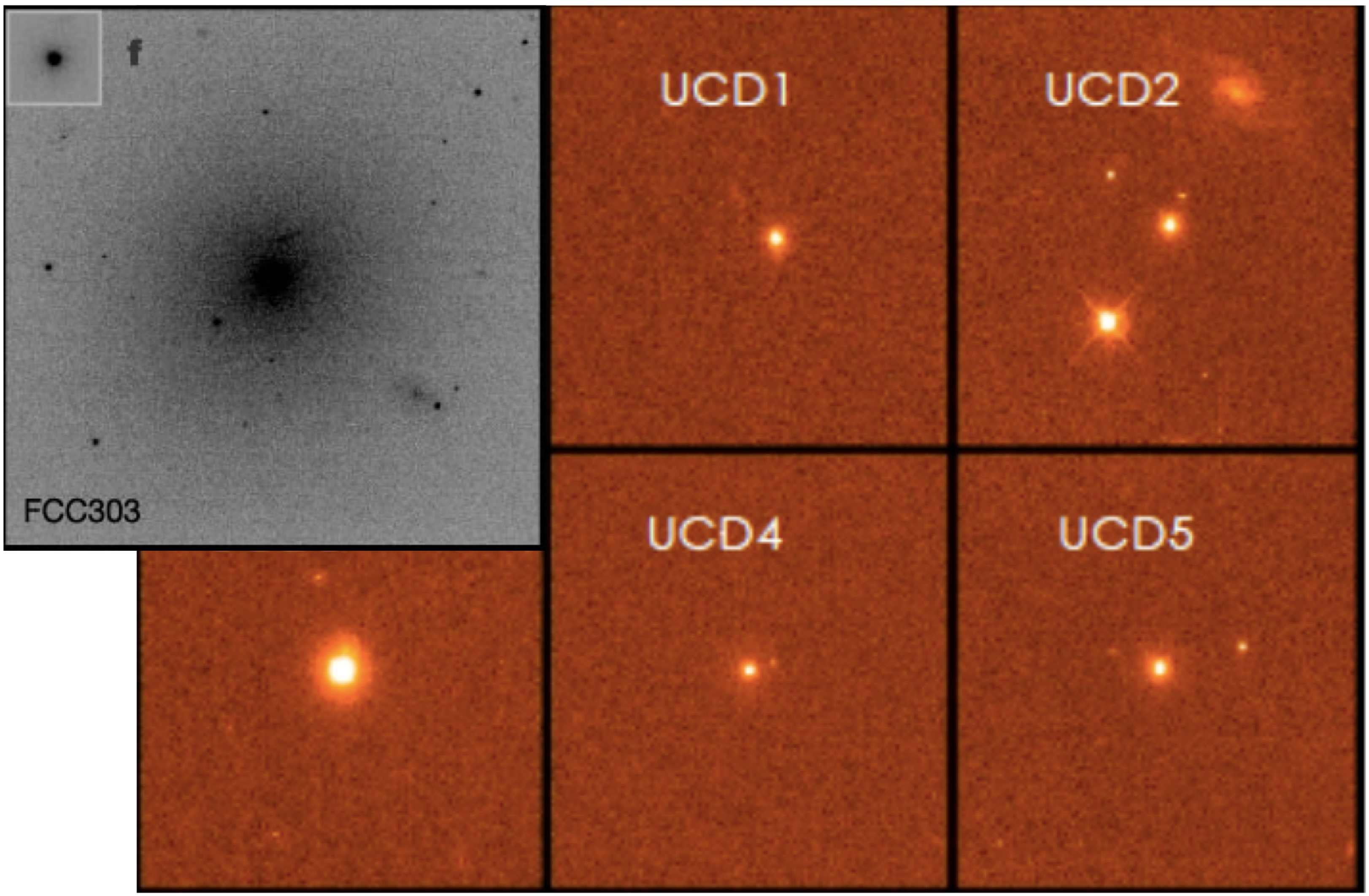
Discovery of UCDs with STIS: Imaging

Drinkwater + 2003 Nature : 5 UCDs and 1 dE in the Fornax Cluster

Optical Imaging Mode with CCD, unflitered (optical)

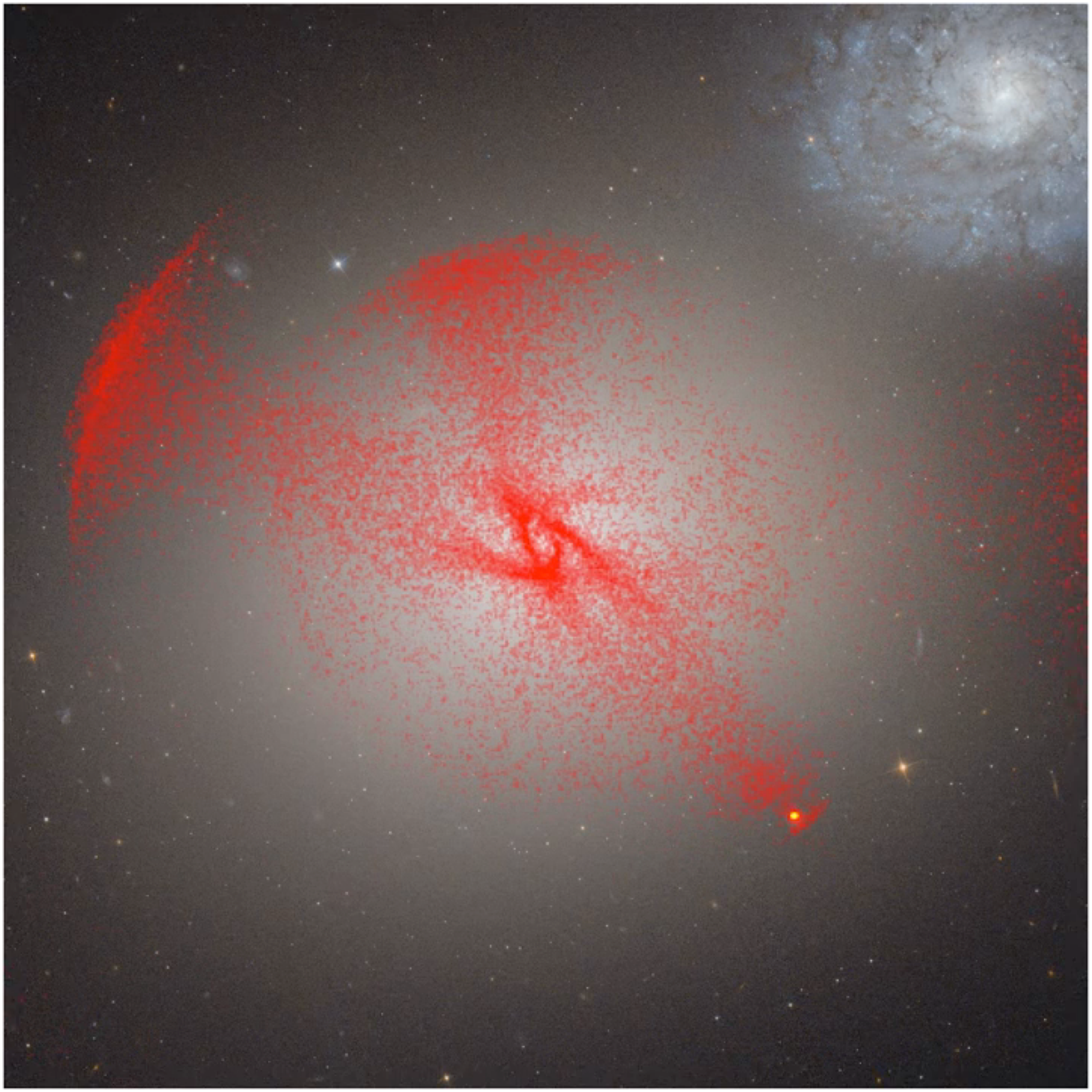
Evidence → UCDs as stripped nuclei of dEs, formed in Clusters

Don’t need wide field imaging here. (75 pc)



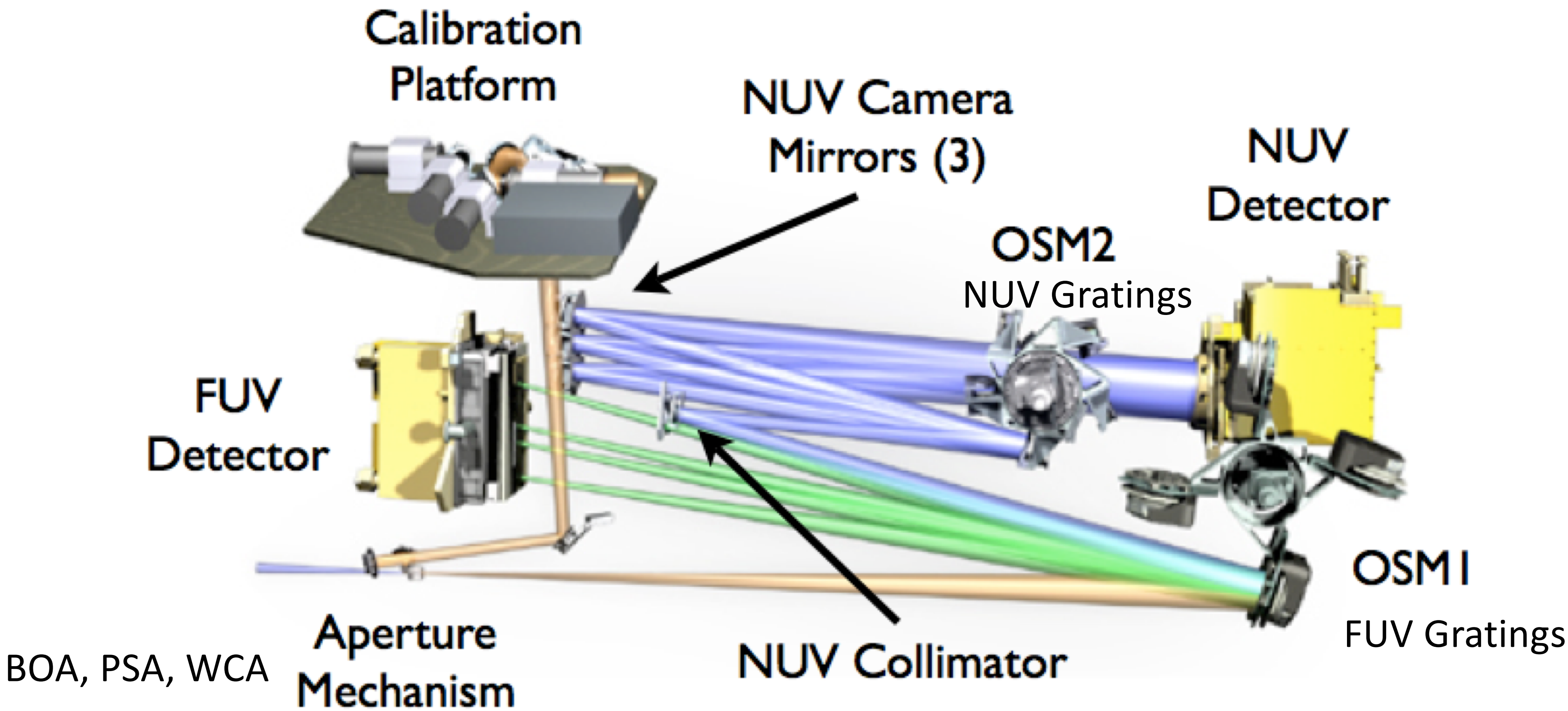
Seth+
2014

UCDs can
Harbor
Black holes
~ 2e7
M60-UCD1

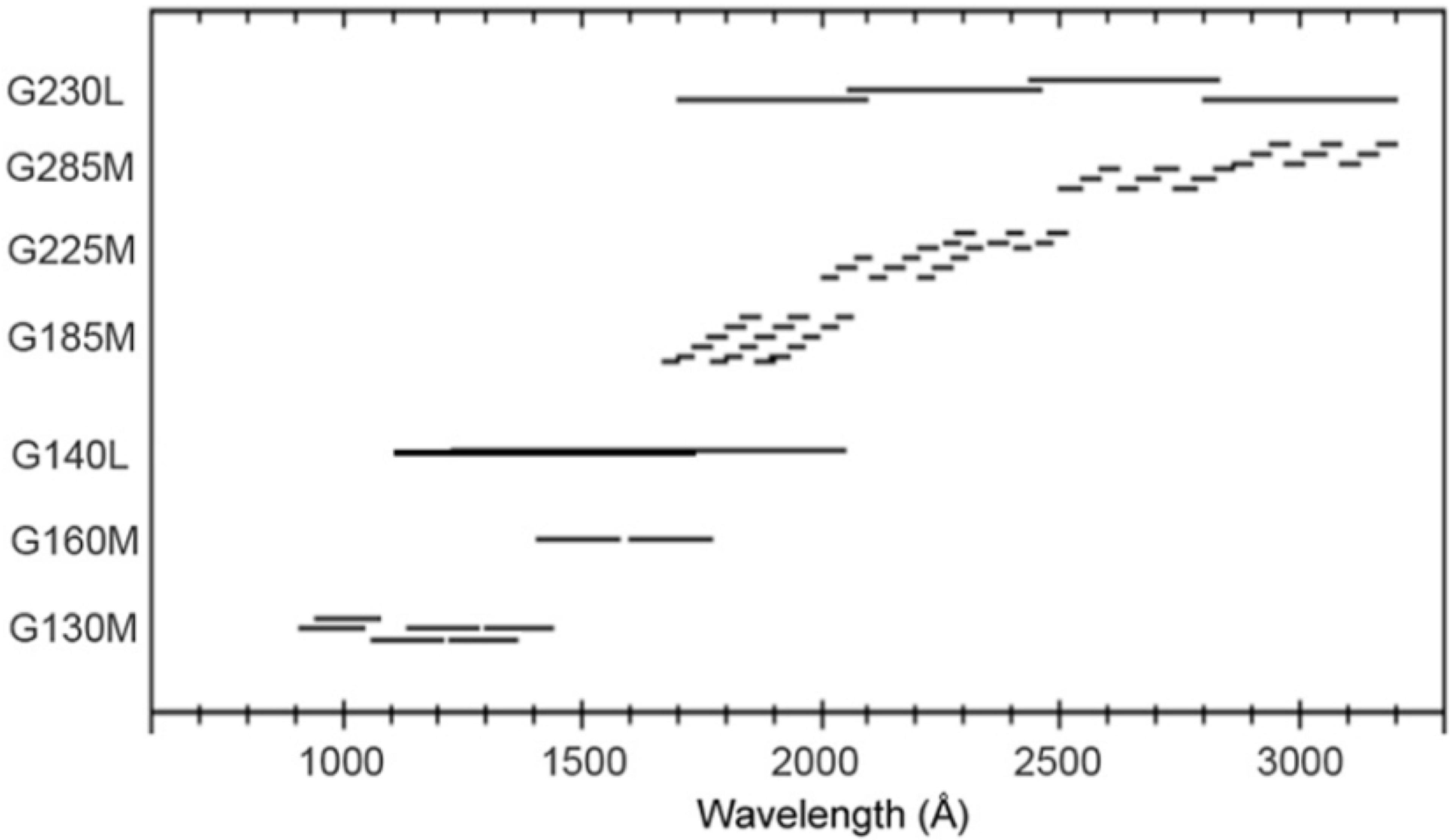


Cosmic Origins Spectrograph (COS)

- Installed in 2009 : SM4
- Exclusively UV, increasing UV sensitivity x 10
- Optimized for **faint point sources** (e.g. QSOs, HII regions)
- Two independent observing channels (NUV and FUV), 7 diffraction gratings (3 FUV, 4 NUV) + NUV imaging



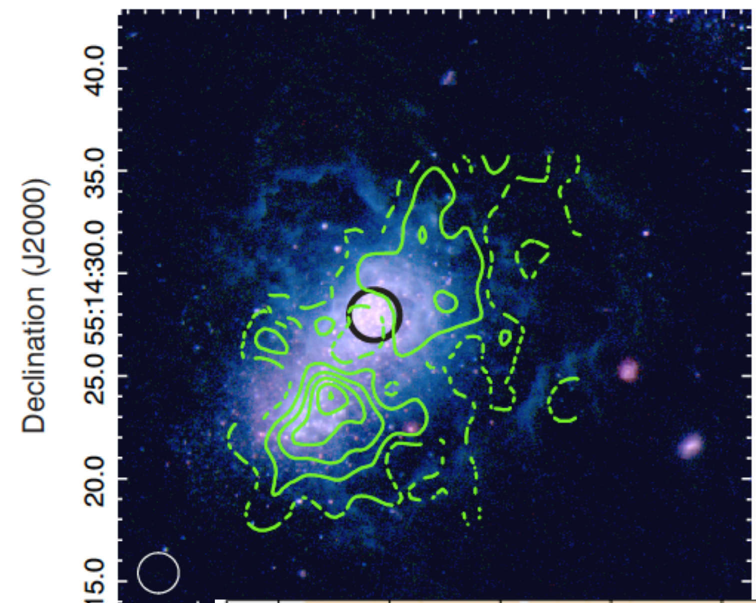
COS Wavelength Coverage

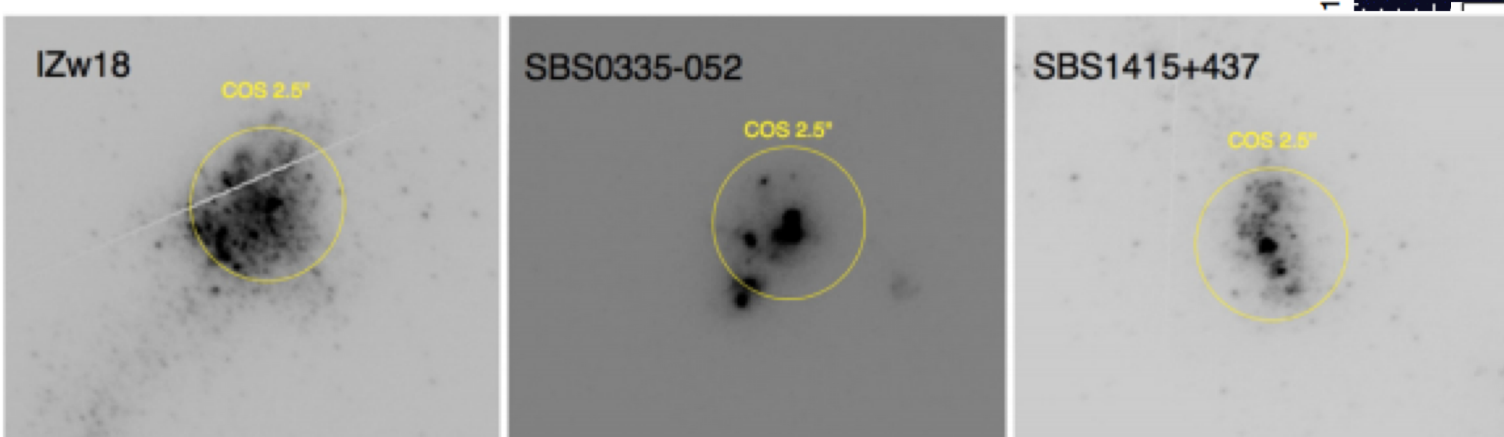


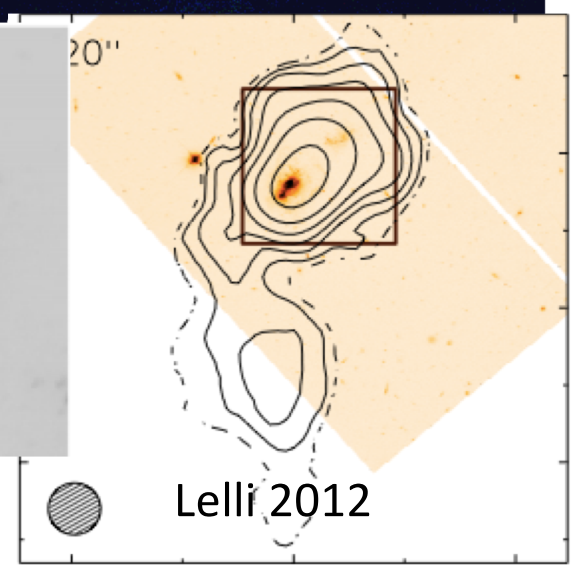
Extra Galactic Science with COS: Low Metallicity Blue Compact Dwarfs

- James + 2014, Lebouteiller 2013
- Metallicity of galaxies and evolution with Z .
- FUV abs lines: HI, CII, NI, OI to determine abundances of neutral gas using SF regions as the absorber (Aloisi 2003)

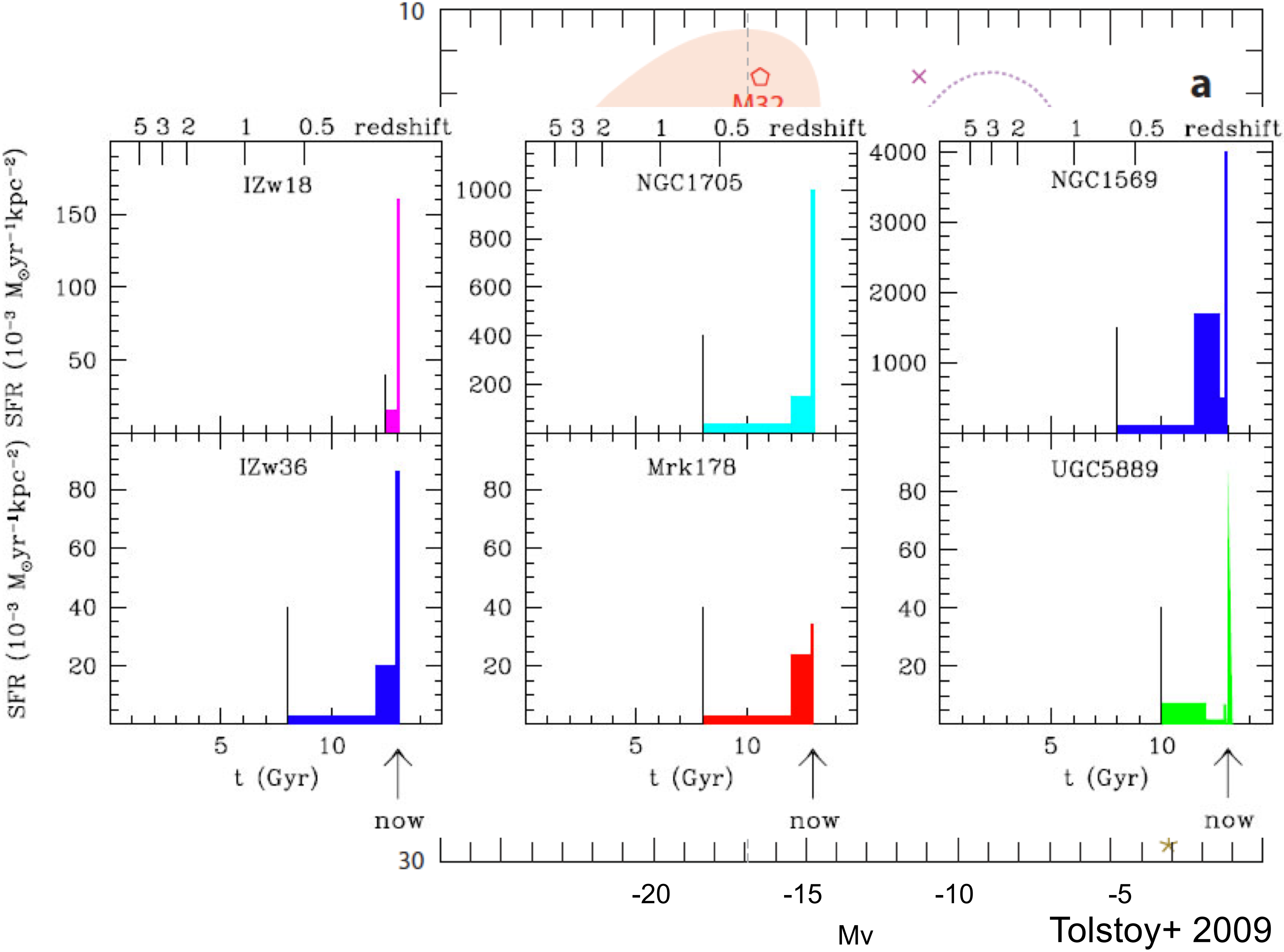
Lebouteiller 2013







See also: Aloisi Cycle 17, Green,J Cycle 18, Wofford, Cycle 22



Tolstoy+ 2009

Imaging: COS NUV

- Entire NUV bandpass allowed
- <u>Highest spatial resolution of any instrument</u>, but field of view is small (2 arcsec)
- Only sources within a radius of 0.05” of the aperture center have all their light imaged
- Spatially resolving faint, compact and/or time variable targets

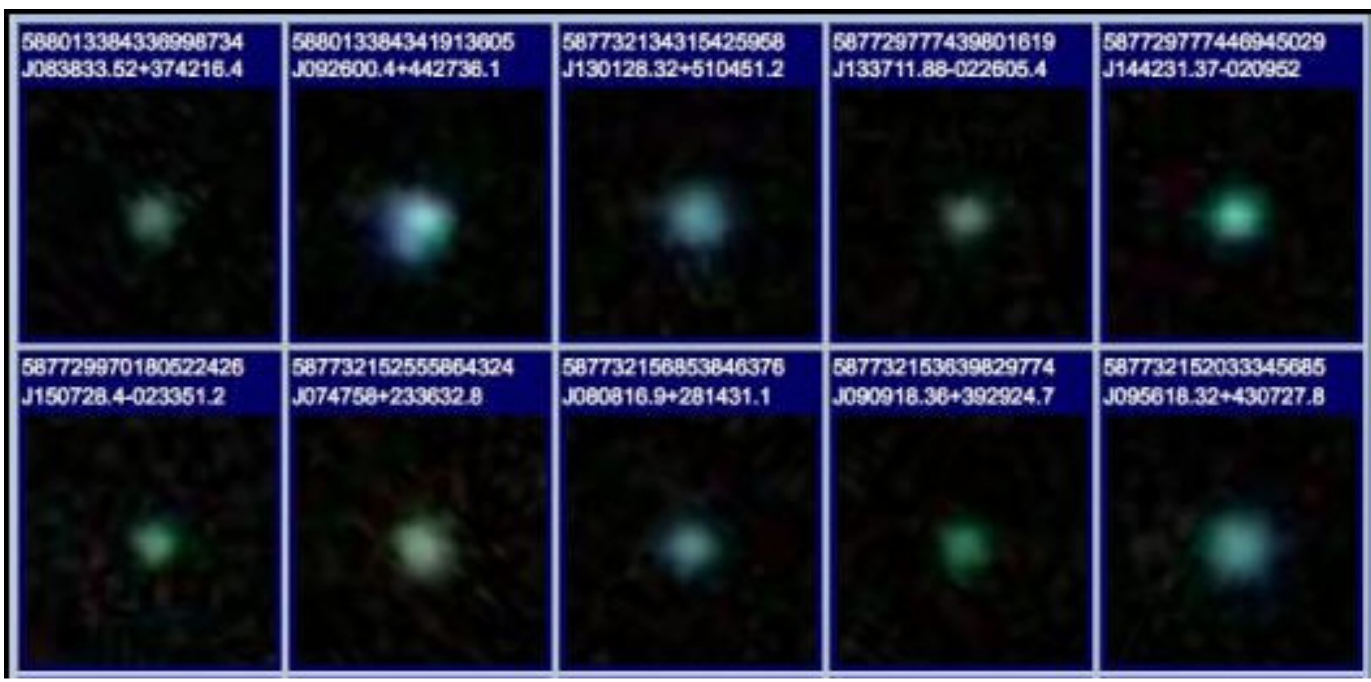
Imaging & Spectra: COS NUV

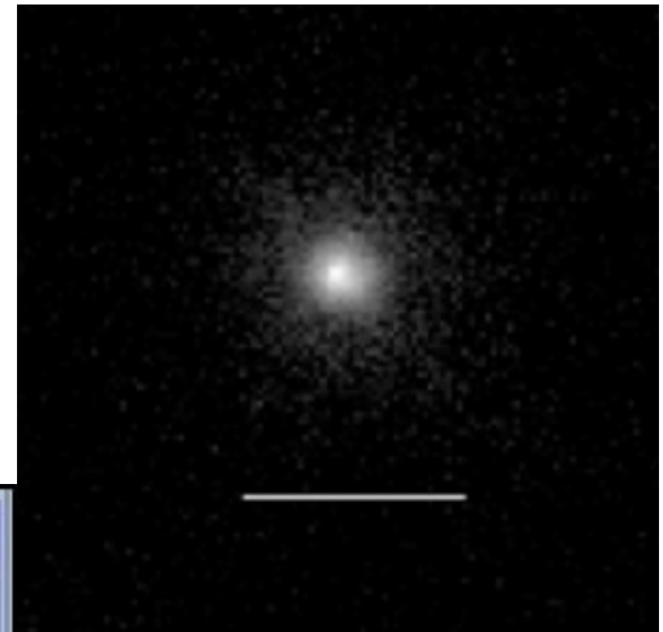
GREEN PEAS : Type of Luminous Blue Compact Galaxy

Least massive and most actively star forming galaxies in the universe → Lya escape fraction?

Typical z ~ 0.0258
Typical size ~ 5 kpc
Typical mass ~ 3 x 10^8 Msun
Typical SFR ~ 10 Msun/yr → **Very strong in [O III]**

First discovered by Galaxy Zoo in SDSS: Cardamone 2009



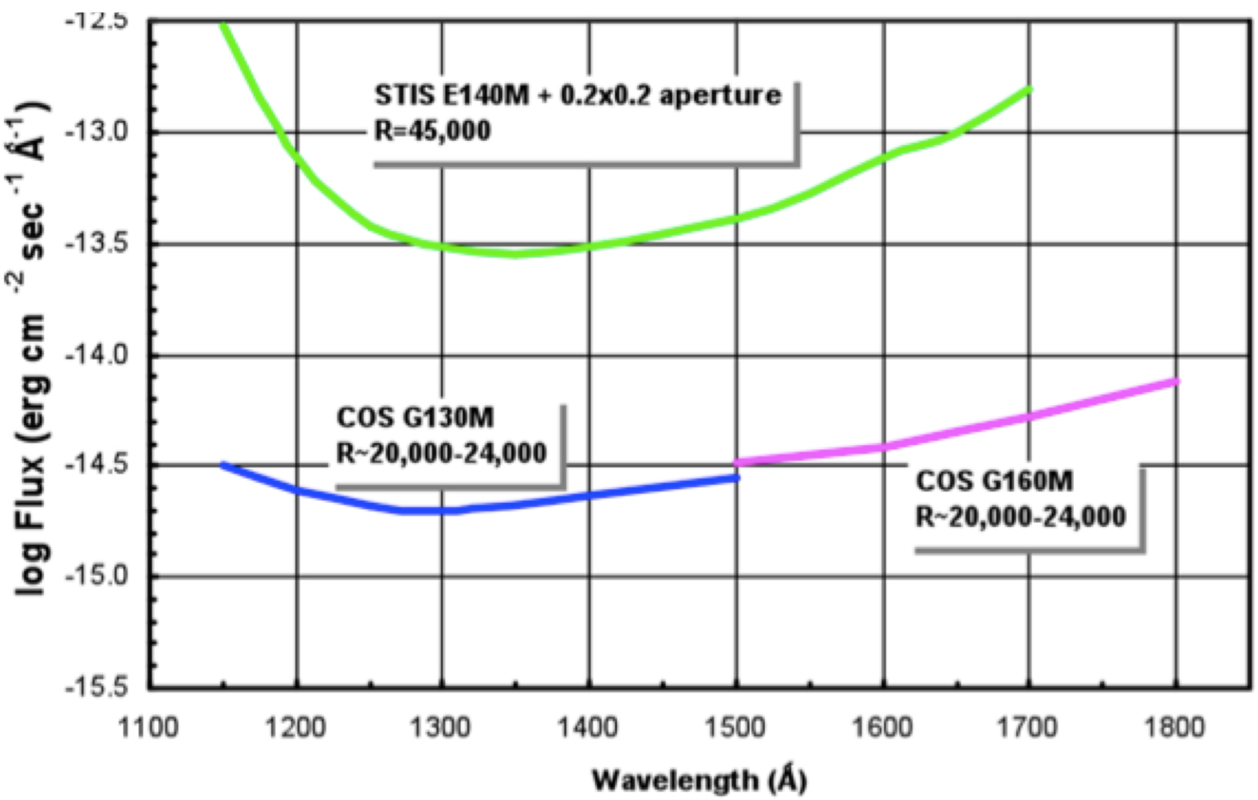


COS NUV imaging
GP_J1219
PI Henry GO 12928
Henry+2015

Also
PI Malhotra GO 14201

COS vs STIS or Tandem Observations

- throughput of COS in FUV > STIS FUV MAMA (10-30x)
- Resolution 20,000 x wavelength coverage (~300 Å) yields discovery space for faint FUV point sources that is 10-70 x greater than STIS

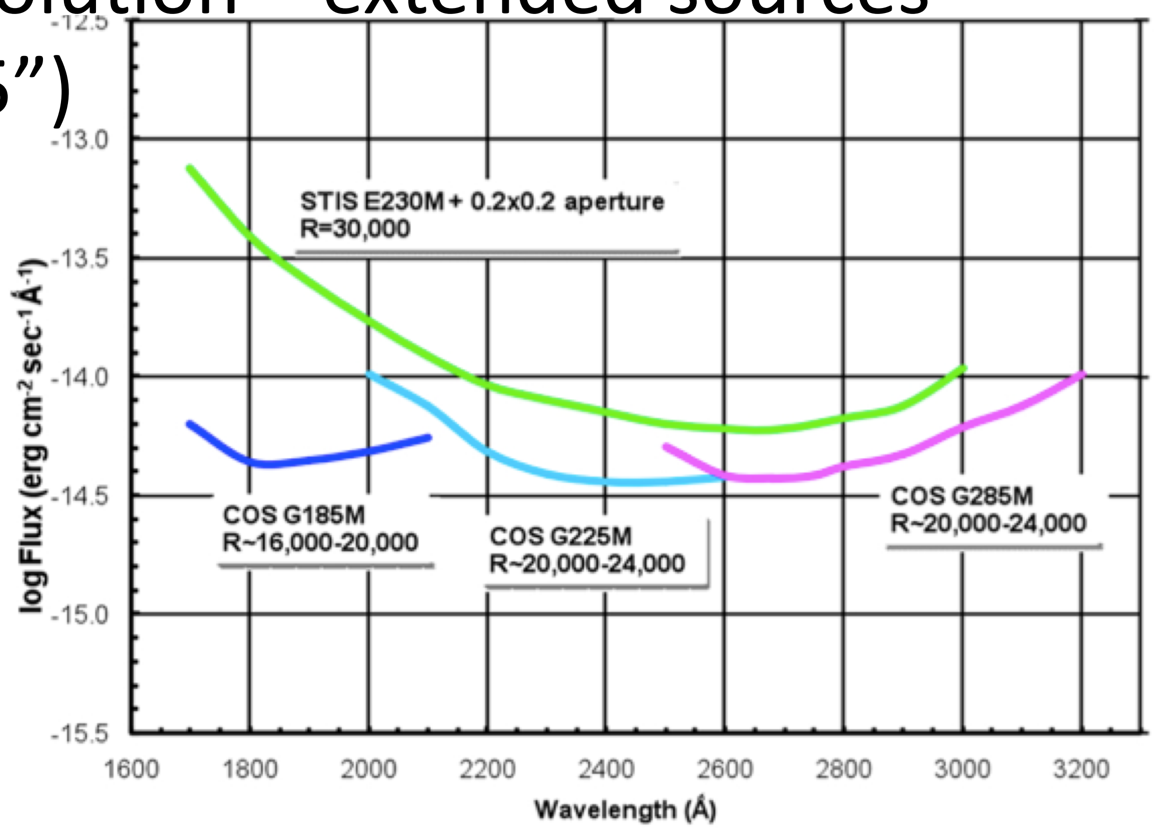


COS vs STIS in NUV

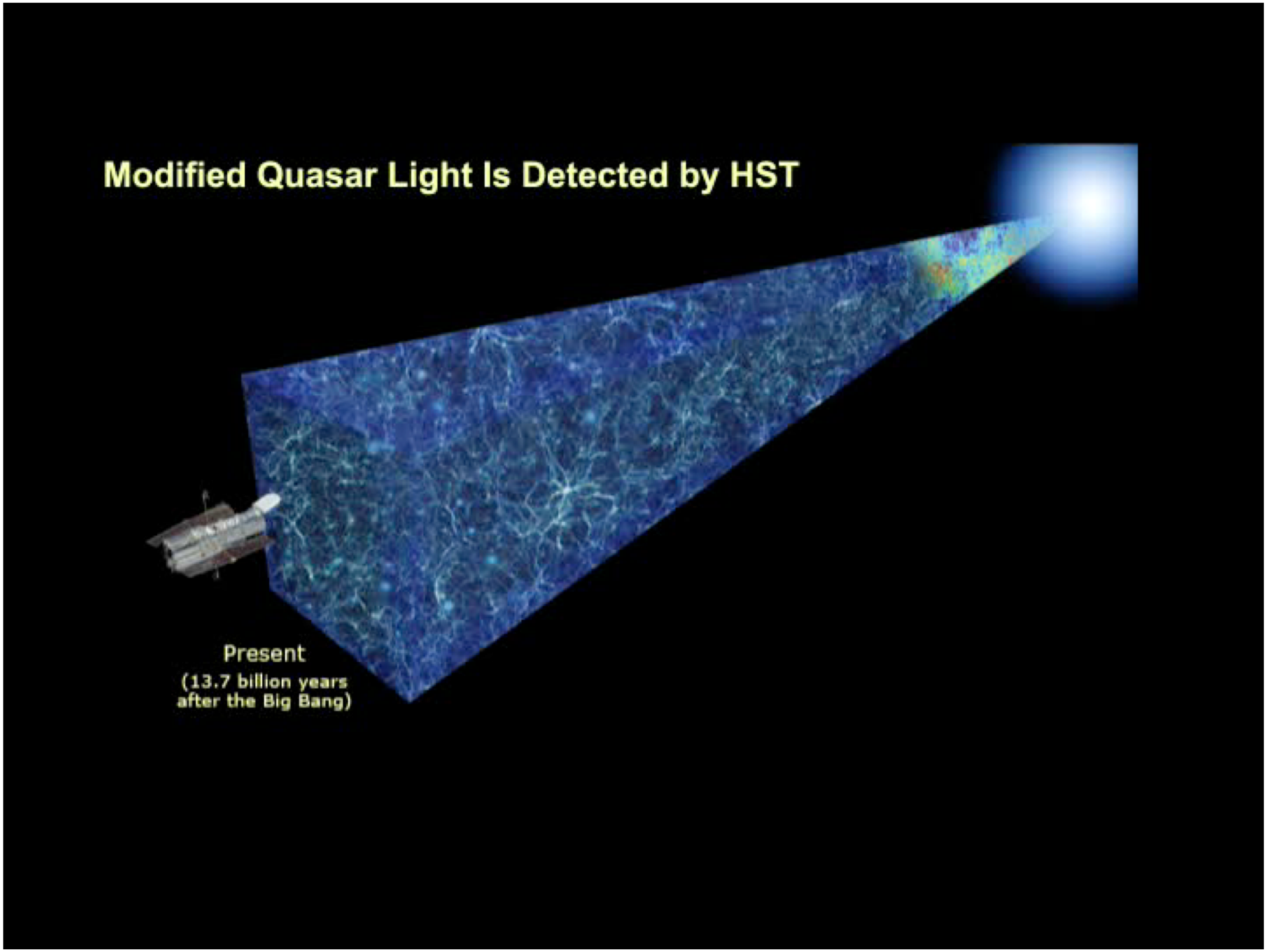
- In the NUV they are more comparable
- COS uses 3 contiguous stripes – if want broad NUV spectrum, better to use STIS
- STIS better spatial resolution – extended sources (COS vignetting > 0.05")
- Since STIS is less

sensitive it can observe

brighter sources



Extra Galactic Science with COS: Baryon Cycle of Galaxies



CU Boulder

Extra Galactic Science with COS: Baryon Cycle of Galaxies

→ probe very low gas densities

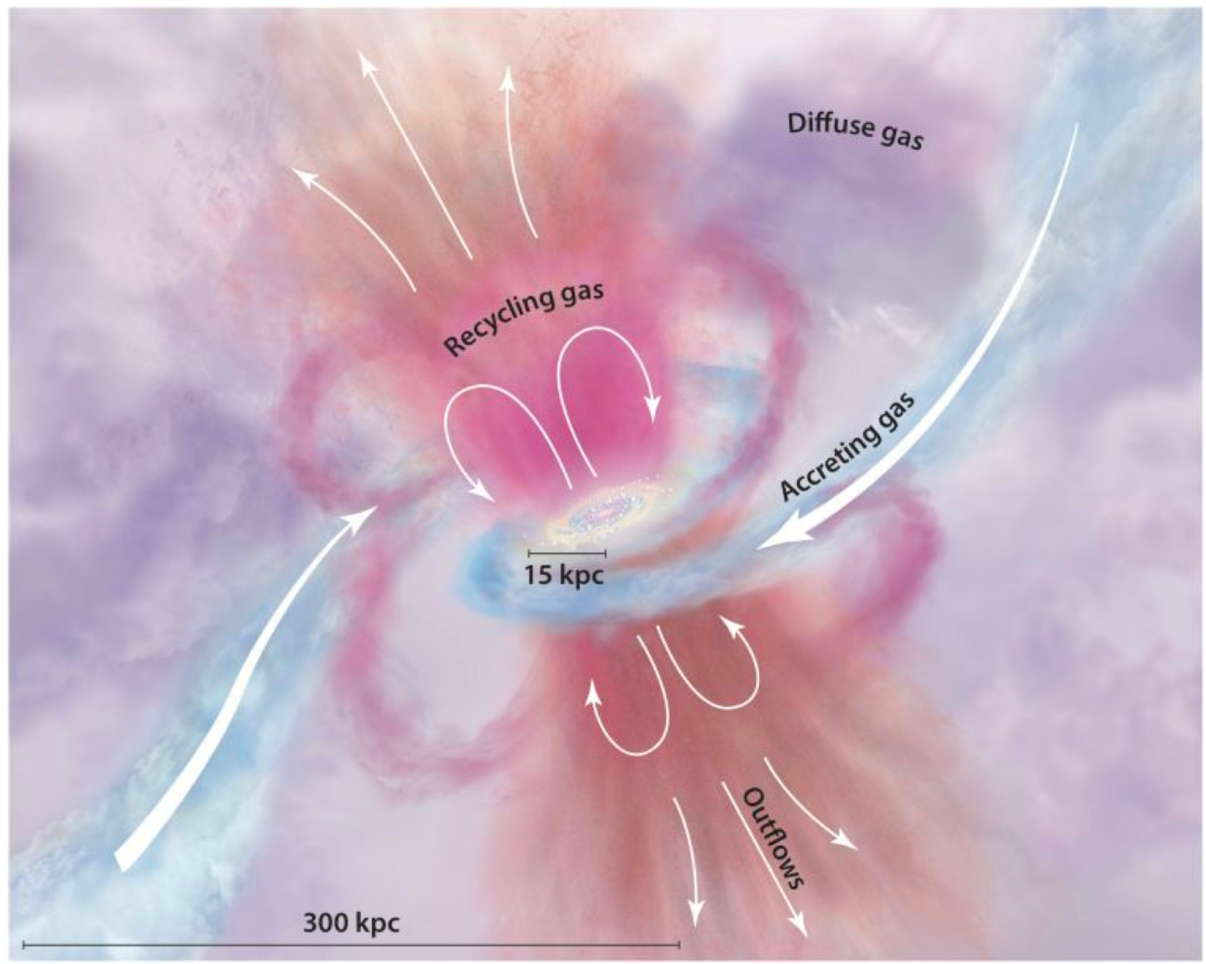
→ Spectra of UV bright QSOs

image: Jess Werk

◆ warm/hot IGM (WHIM) and cold gas

◆ Large Scale Structure (Lyman alpha forest)

◆ Galactic Halos and Winds (e.g. COS-HALOS, COS-Dwarf programs)



Relevant FUV lines

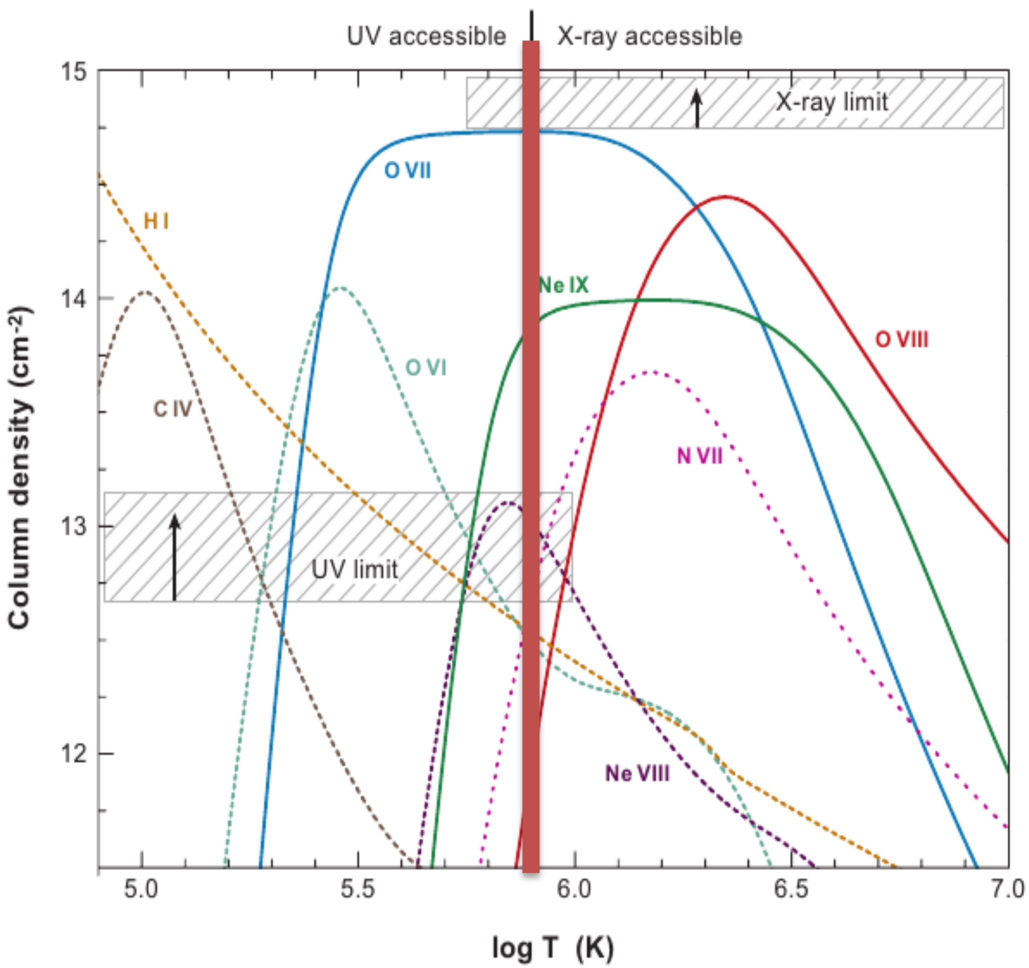


Figure 5

The ion fraction distributions, represented as column densities for a total gas column of 10^{19} cm^{-2} and metallicities of 0.1 $Z_{\odot}$. The UV lines are effective at detecting absorbing gas for $T < 5 \times 10^5$ K and currently have significantly better sensitivity than the X-ray OVII Kα and OVIII Kα lines, which are good diagnostics for gas temperatures ranging from 0.5 to 5×10^6 K. Absorption by OVII, OVIII, and NeIX have been detected at $z = 0$, probably because of the higher metallicity of Galactic Halo gas. The NVII ion (*dotted*), which has a hyperfine line in the radio region, is also shown.

- Low z : FUV G130M and G160M : probe metallicity and ionization conditions
- $10^{5.5}$ OVII, OVI
- 10^5 K gas : CIV, SiIV
- 10^4 K photoionized gas SiII, SiIII
- < 10^4 K cold gas – Lyman alpha damping wings give HI column
- Cool/warm neutral gas: OI, CII

Cool CGM $10^{4\text{-}5}$ K
Warm CGM $10^{5\text{-}6}$ K

Bregman 2007

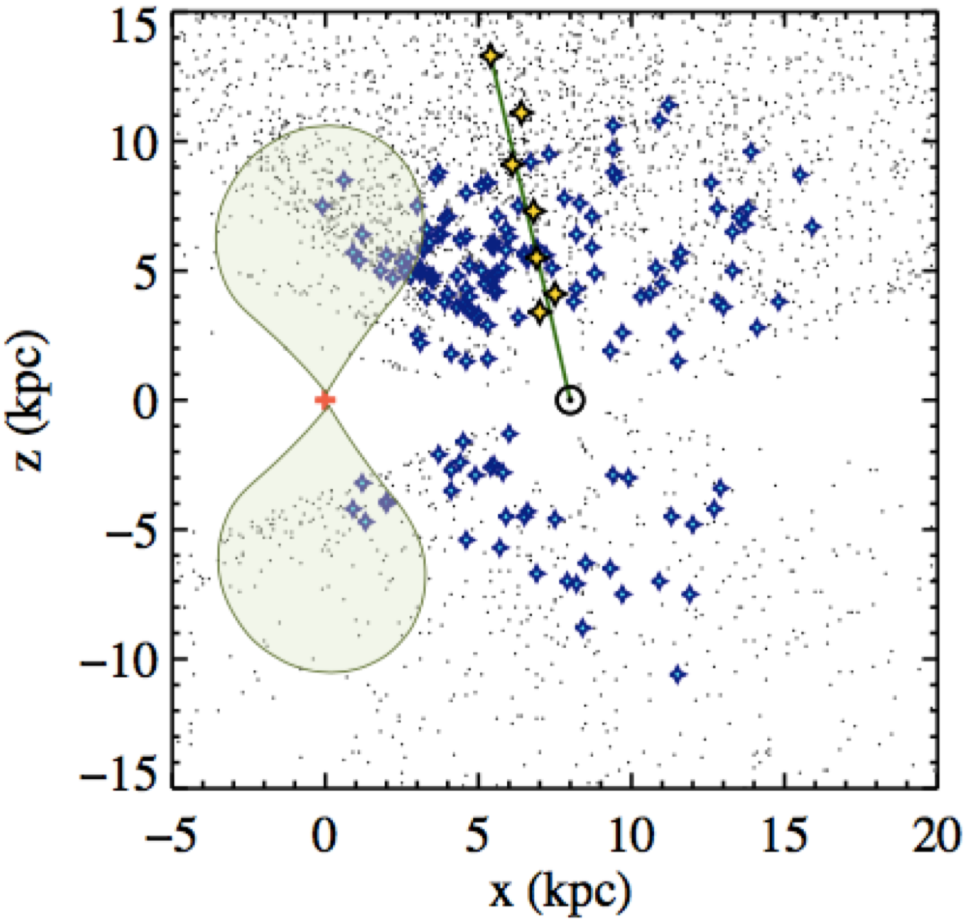


Figure 1: The spatial distribution of blue horizontal branch stars in the x-z plane from the Xue et al. (2011) catalog. The Galactic center lies at the origin of this plot (0,0) and is marked with a red plus sign, and the approximate location and size of the Fermi bubbles, presumably from a powerful wind emanating from the Galactic center, are indicated by the transparent green bubbles. The sun is assumed to lie at a distance of 8 kpc from the Galactic center at z = 0, and is marked by the solar symbol. Blue horizontal branch stars with GALEX FUV magnitudes brighter than 18.5 are shown by blue stars. The sample of seven stars we have selected from this subset, chosen to lie on a fairly tight line of sight (500 pc spread) extending to the most distant UV-bright halo star (at 13 kpc), is shown by the line of yellow stars.

Werk GO 14140: Using UV-bright Milky Way Halo Stars to Probe Star-Formation Driven Winds as a Function of Disk Scale Height

Galactic-scale winds driven by star formation are a common feature of galaxy formation models, and are observed ubiquitously from the local Universe to z~6. However, empirical constraints on the radial density profile and total spatial extent of these winds have been very challenging to obtain. We have devised a simple experiment using blue horizontal branch (BHB) stars in the halo of the Milky Way that will directly map the extent and density of diffuse, ionized outflows from the Galactic disk to the halo. We propose to take COS FUV spectra of 7 BHB stars that evenly sample the range of scale heights from 3 - 13 kpc, lying perpendicular to the disk of the Milky Way, extending from the position of the sun. This study will allow us to unambiguously track inflowing and outflowing material from the Milky Way via absorption component blueshifts and redshifts, respectively. This program will yield the first direct observational determination of the scale height to which star-formation-driven winds propagate in the halo. We will additionally probe the change in the gas density as it extends into the halo, and approximate a mass of metals as they leave the disk and become integrated into the halo. Our proposed experiment will yield the most detailed constraints on the physical state and energetics of gas in a large-scale galactic wind to date. Such constraints are fundamental to understanding the impact of feedback processes on galaxies and in fueling the buildup of their gaseous environments.

Facts/Info – indisputable.

Problem

SOLUTION to Problem

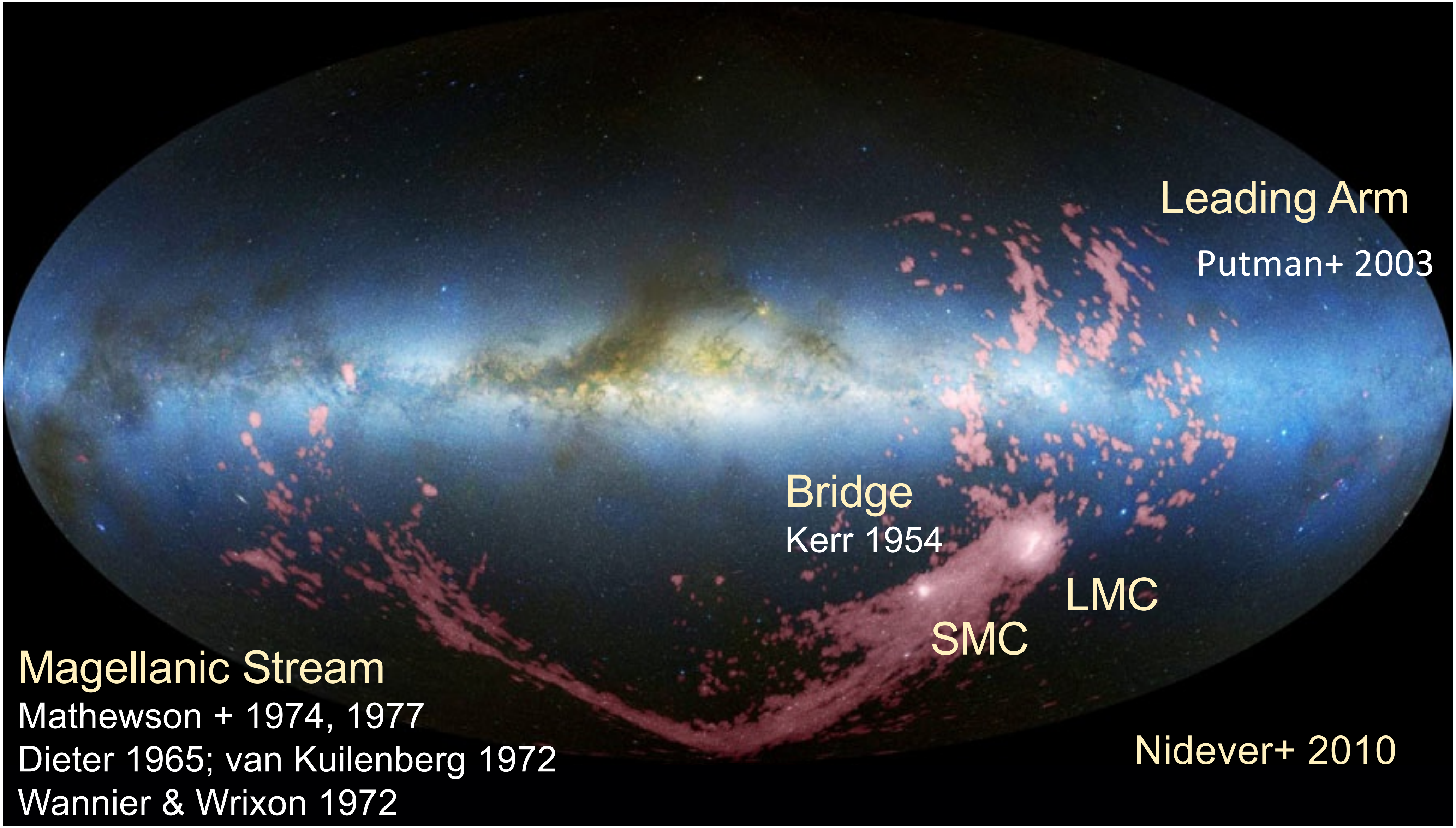
Proposal

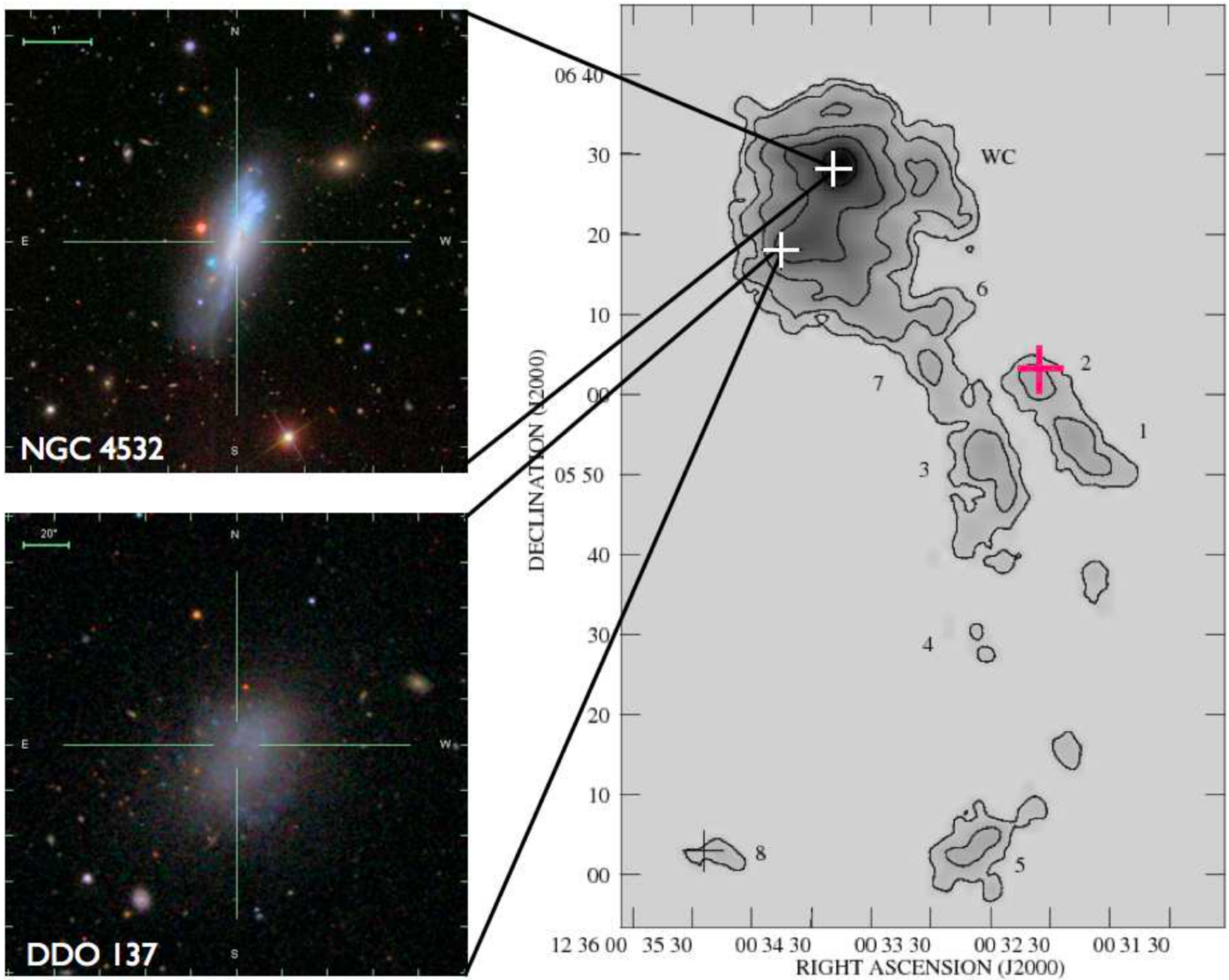
How accomplish goal/Strategy

Why Important?

Why HST & Broader Impact

The Magellanic System




NGC 4532
DDO 137
1'
20"
N
S
E
W
WC
1
2
3
4
5
6
7
8
DECLINATION (J2000)
RIGHT ASCENSION (J2000)
06 40
30
20
10
00
05 50
40
30
20
10
00
12 36 00
35 30
00
34 30
00
33 30
00
32 30
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31 30

Measuring the Properties of Dwarf Streams

PI Putman, co-I Besla

We propose to measure the metallicity and ionization conditions of a gaseous stream trailing behind a pair of dwarf galaxies in the local universe. The NGC 4532/DDO 137 system is a clear analog to the Milky Way's massive satellite galaxies, the Large and Small Magellanic Clouds; however, this system is not in close proximity to a massive spiral galaxy. Furthermore, it is the only other dwarf stream for which the metallicity and ionization conditions can be directly measured due to the fortuitous alignment of a bright background QSO with the HI stream. We will use the data to examine the properties and formation mechanisms of such streams and how they differ with environment. Such information can be used to develop a method to discriminate between cold accreting filaments and streams stripped from low mass galaxies at all redshifts.

Proposal/Goal

Facts. & disguised problem

Solution – but no strategy

Importance/Broader Impact