An Investigation of Lyman Continuum Emitting Green Peas Using *HST*-COS

Alex Haughton, October 18th, 2022

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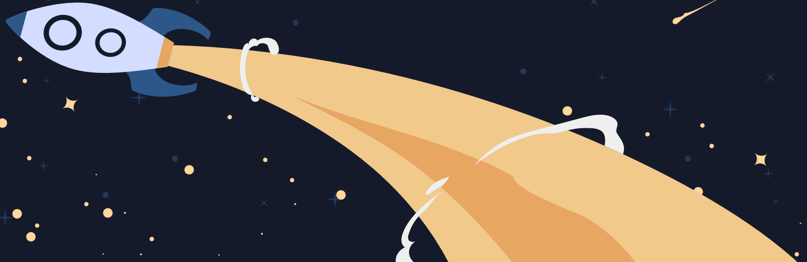
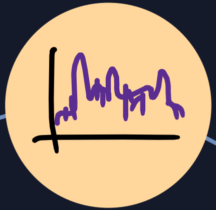


Outline

Green Peas

Compact galaxies that remind you to eat your veggies



Analysis of LyC Emitters

No joke here, this is serious business

HST-COS Spatial Disperson

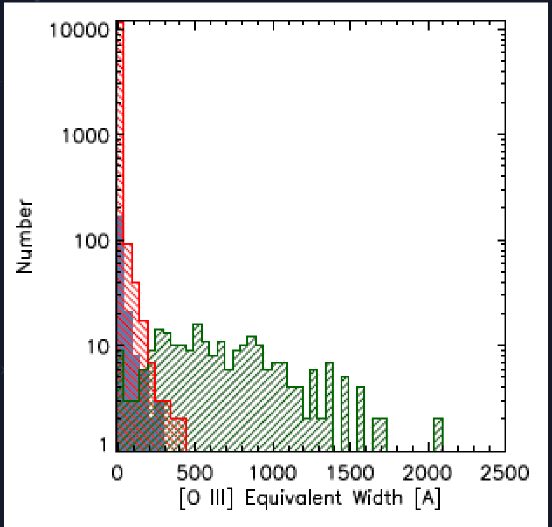
Pulling spatial data from where it shouldn't be pulled form

INFUSE

Rockets go boom

Green Peas are compact galaxies discovered through a Citizen Science project with SDSS.

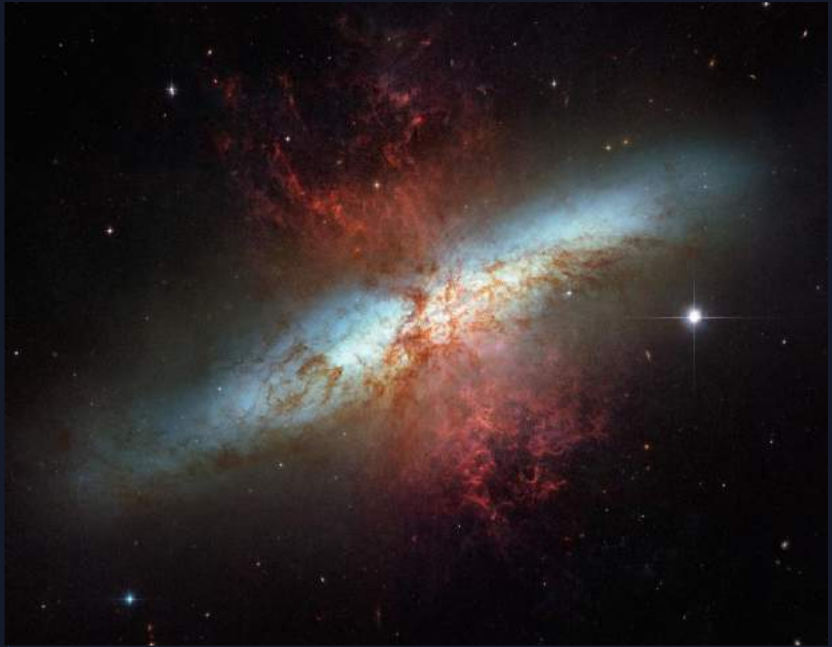
Compact:
Less than 3”



Strong [OIII] line

Cardamone et al. (2009)

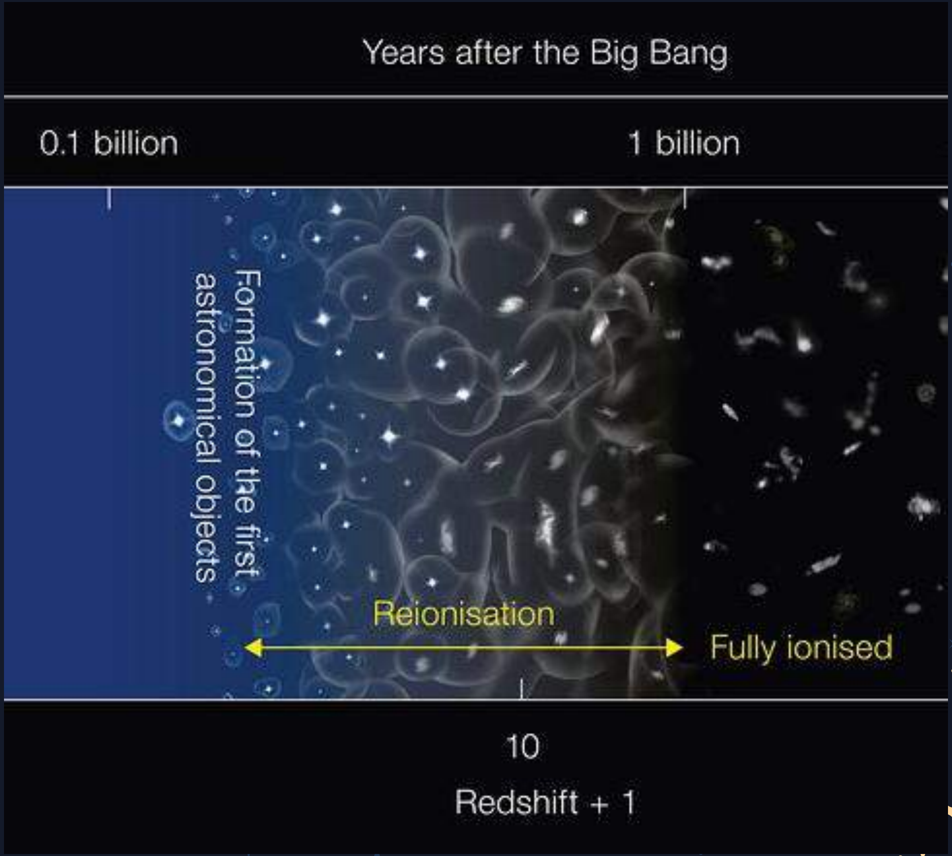
Green Peas are highly ionized starbursts at about z~0.3, bright in the FUV... and they are often Lyman continuum emitters.



Courtesy NASA

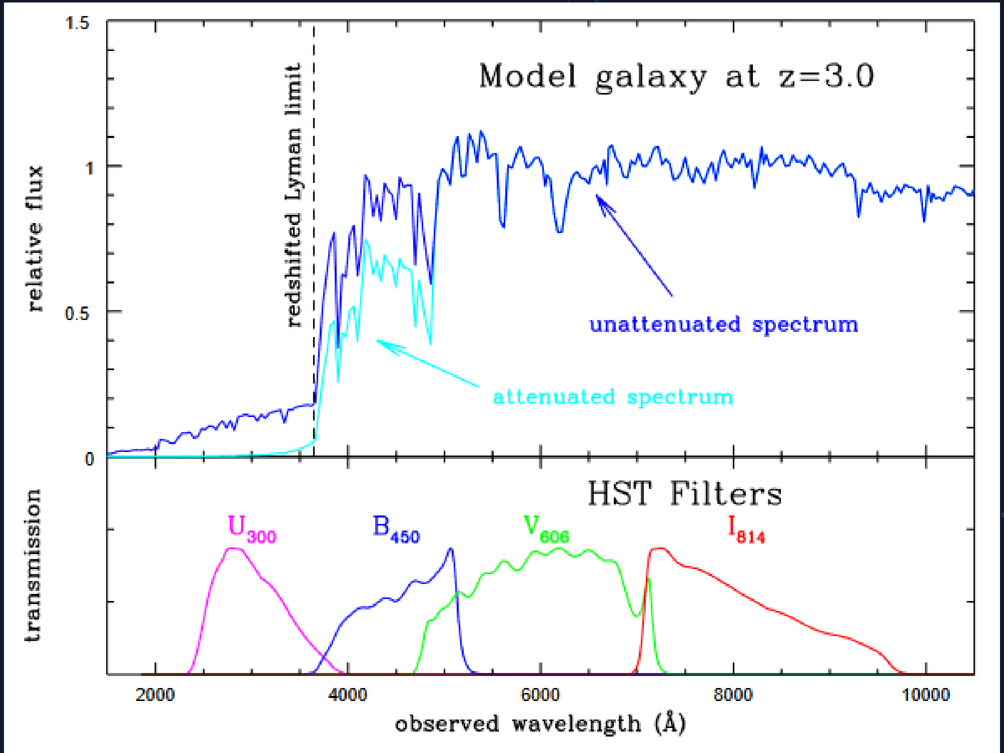
Not a Green Pea; but a pretty starburst (M 82)

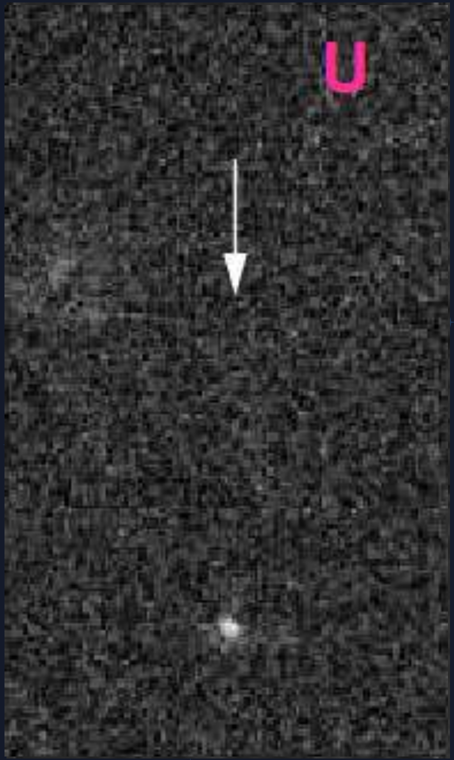
We are searching for Lyman continuum photons responsible for reionizing the Universe.



Courtesy ESA

Finding Lyman continuum photons is challenging due to the presence of neutral hydrogen.

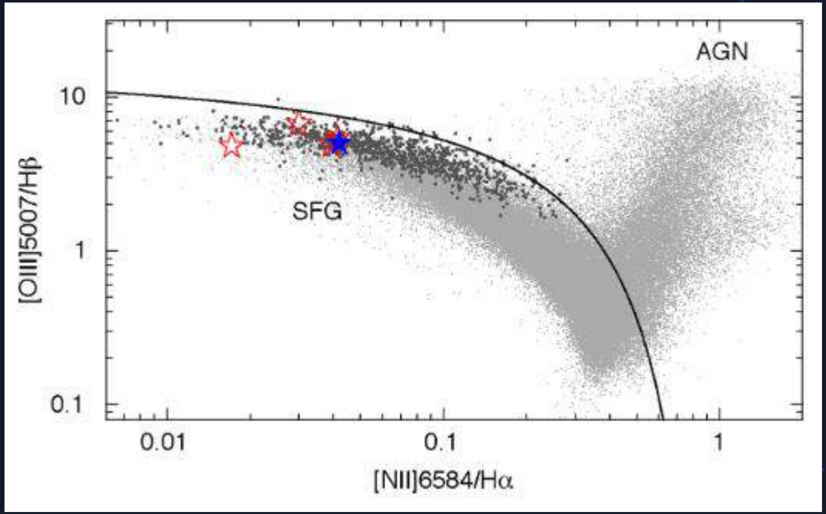




Dickinson (1998)

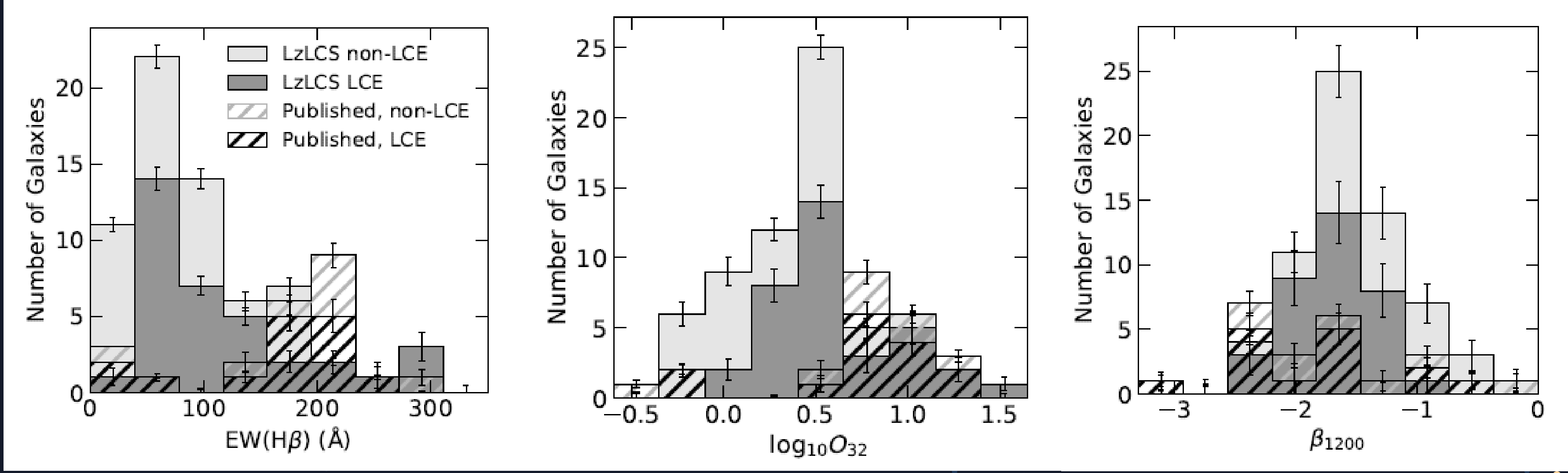
Popular search criteria for LCEs include the [OIII]/[OII] ratio, Hβ equivalent width, and UV spectral slope β.

Red stars (and blue star) are GPs



Izotov et al. (2016)

The Low Redshift Lyman Continuum Survey (LzLCS) broadened search criteria to find new, more diverse LCEs.

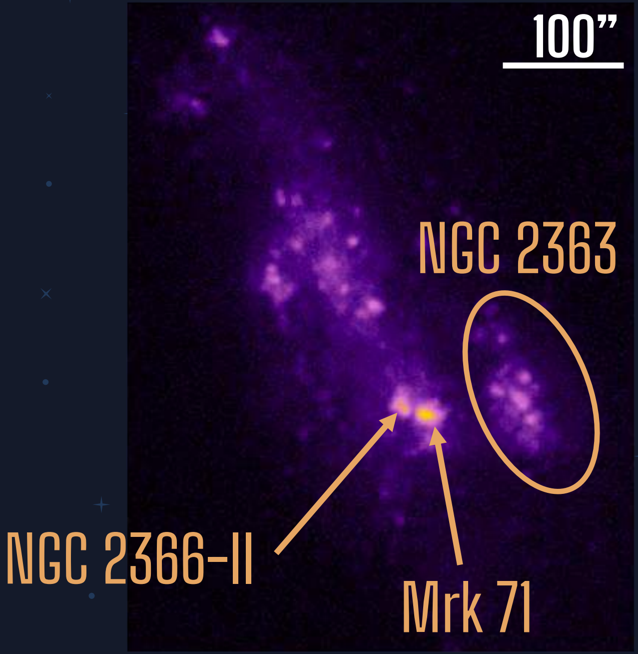


Dark grey are new LCEs, black slashes 'old' LCEs

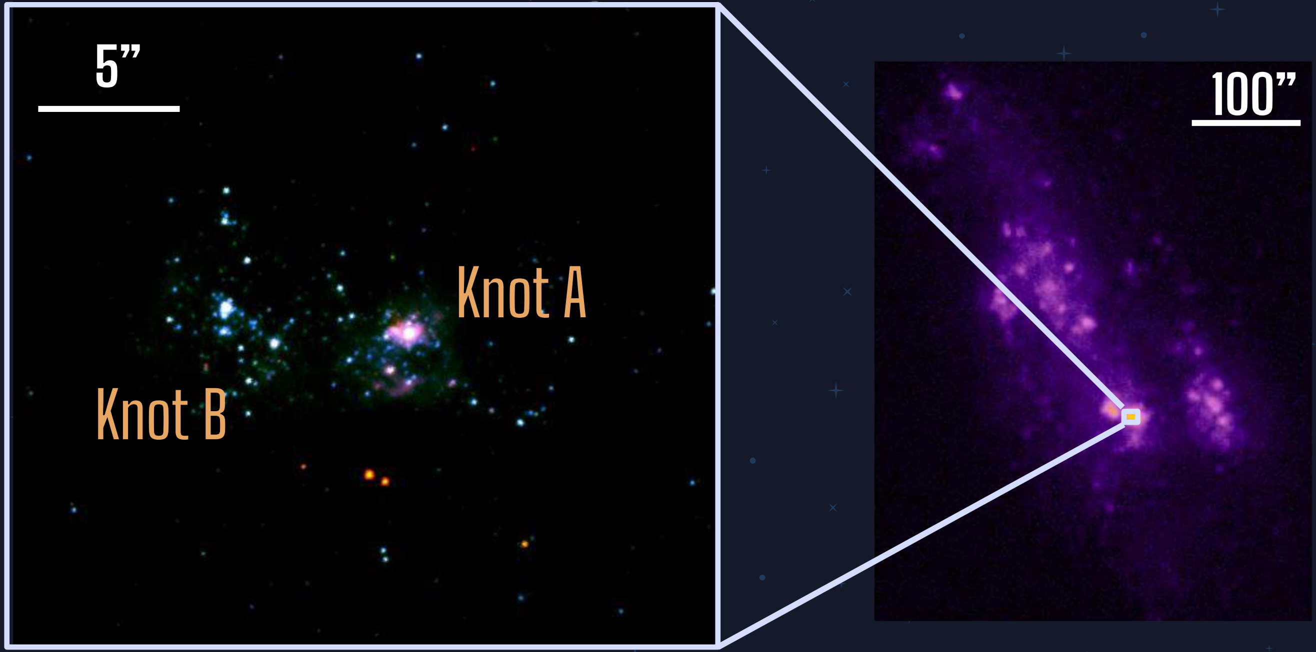
Flury et al. (2022)

NGC 2366 is a local irregular dwarf galaxy that exhibits many of the same traits as GPs.

- High [OIII]/[OII] ratio
- High Hβ equivalent width
- Bright in the FUV



Mrk 71, a super star cluster with two knots, is responsible for the GP characteristics of NGC 2366.

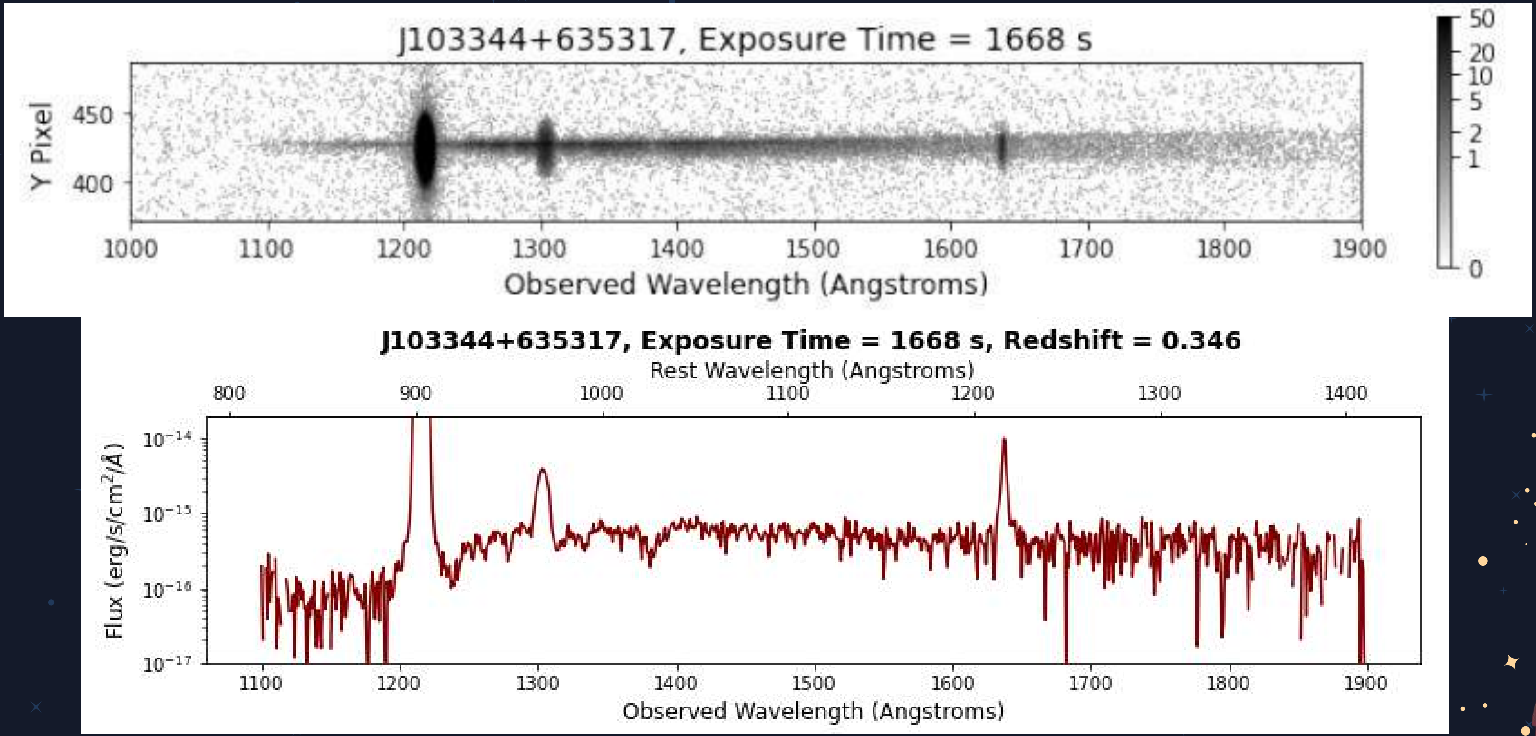


Micheva et al. (2017)

We want to know what GPs are; specifically, what they look like and why they are LCEs.

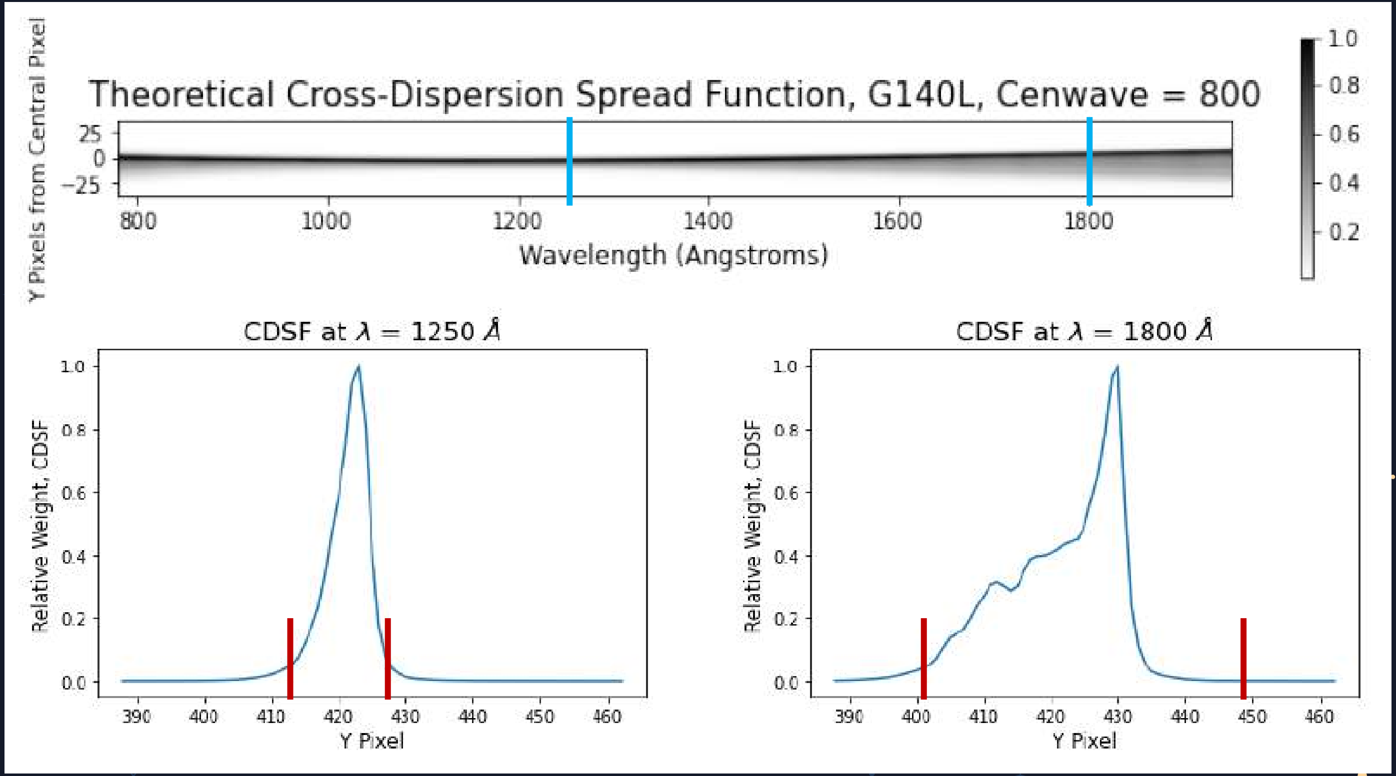
- Looking for ionizing radiation sources
- Green Peas seem to be good sources
- Have a sample of Lyman Continuum Emitters
- A nearby analog suggests one small region could dominate GP-like traits

This is an example of an LzLCS spectrum that we wish to pull spatial data from.



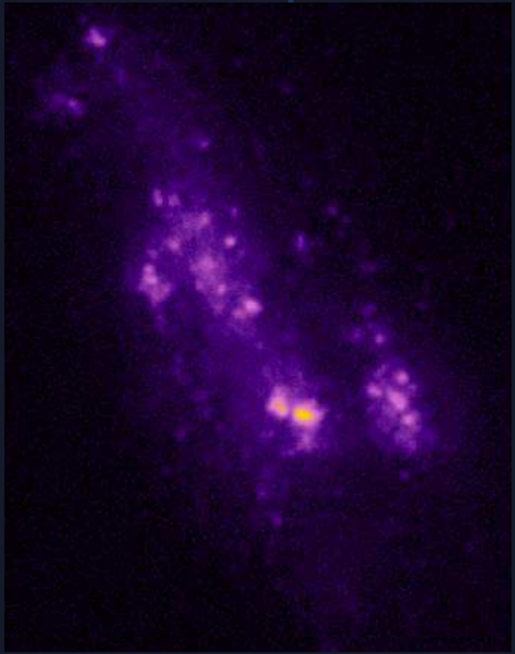
Flury et al. (2022)

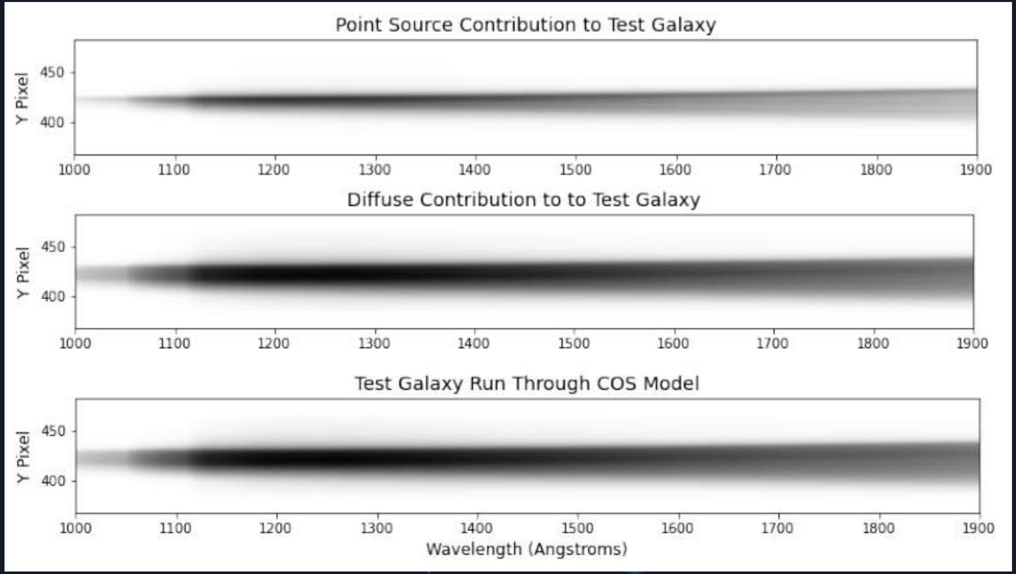
The spatial resolution of G140L varies greatly by wavelength.



95% of light falls between red bars

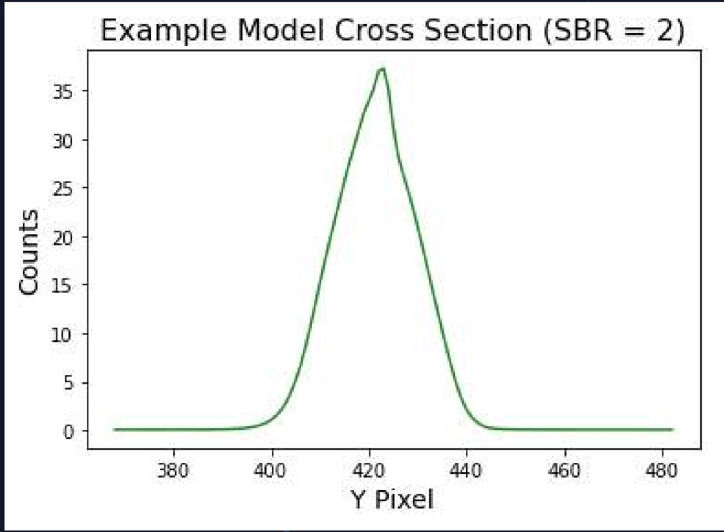
We run an example of NGC 2366, scaled to be at z = 0.3, to see what the detector might look like.



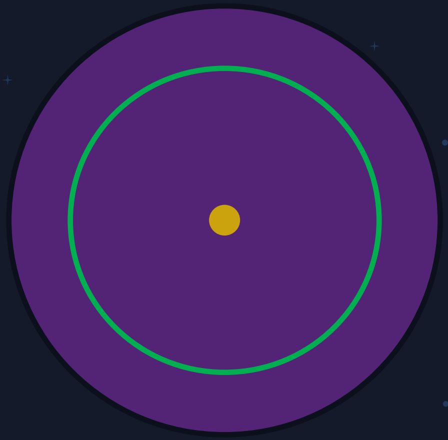


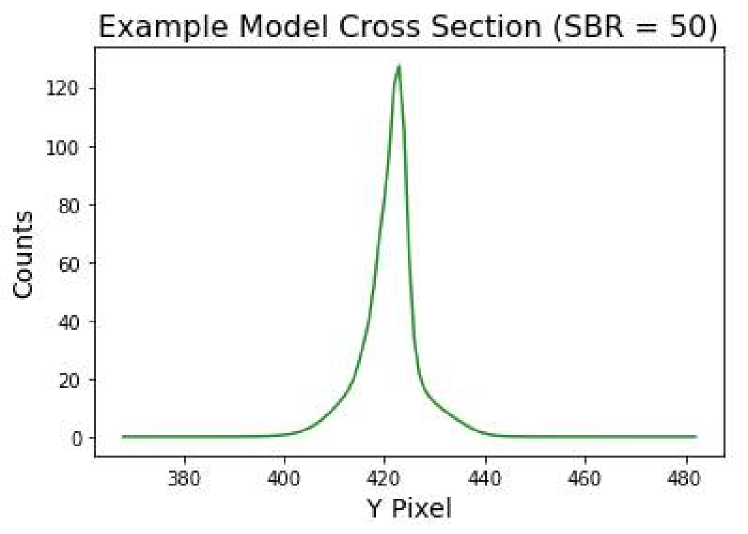
Darkest part is about 0.5 counts over 2000 seconds

We build a test galaxy with a bright central point source surrounded by a diffuse source overfilling the aperture.

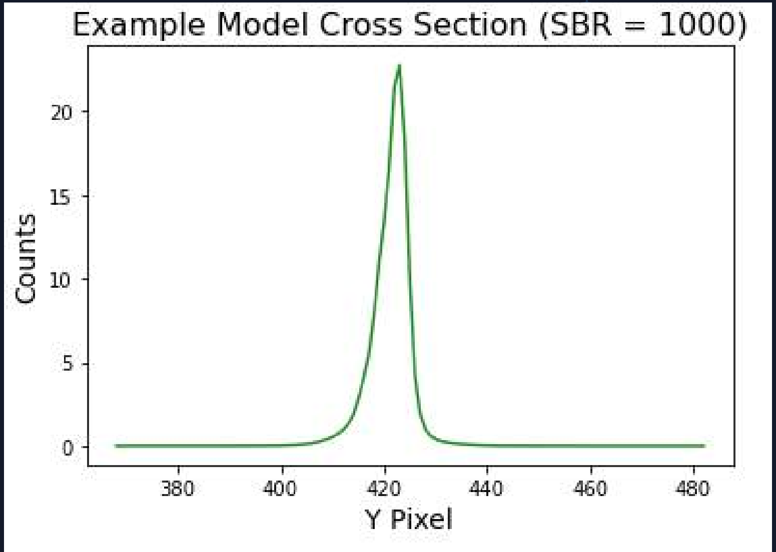


We build a test galaxy with a bright central point source surrounded by a diffuse source overfilling the aperture.

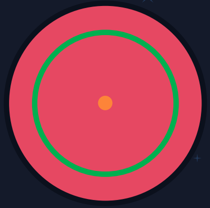




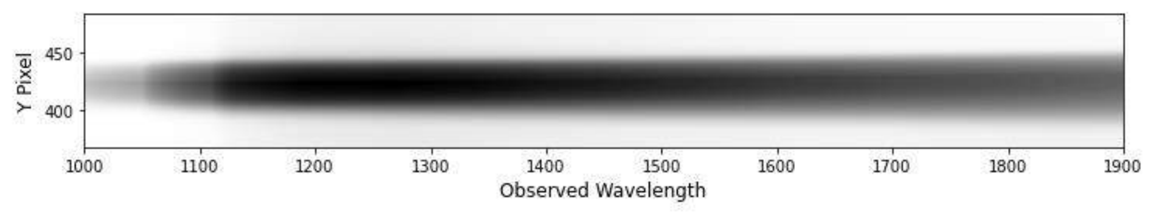
We build a test galaxy with a bright central point source surrounded by a diffuse source overfilling the aperture.

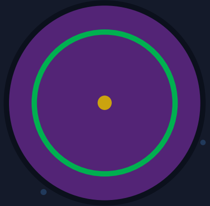


We adjust the surface brightness ratio of the model to generate a series of detector images.

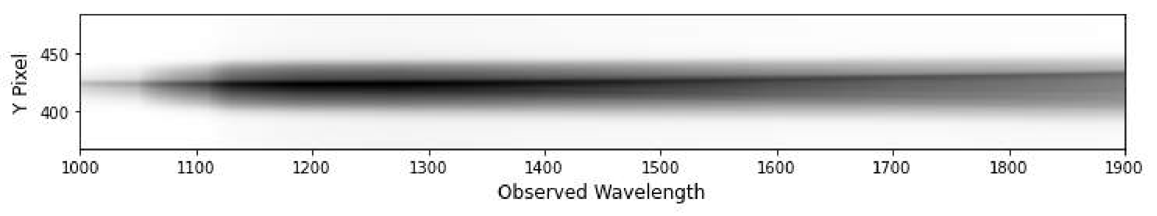


SBR = 2

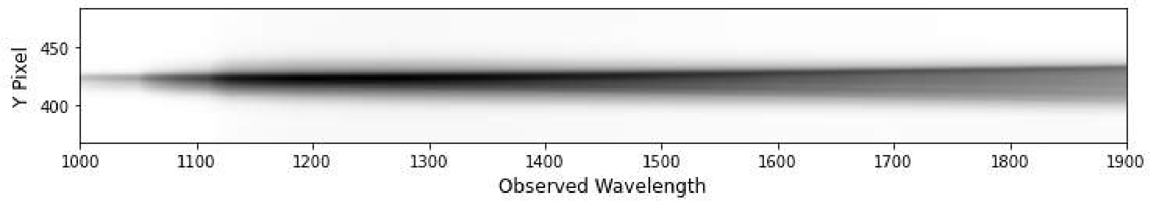




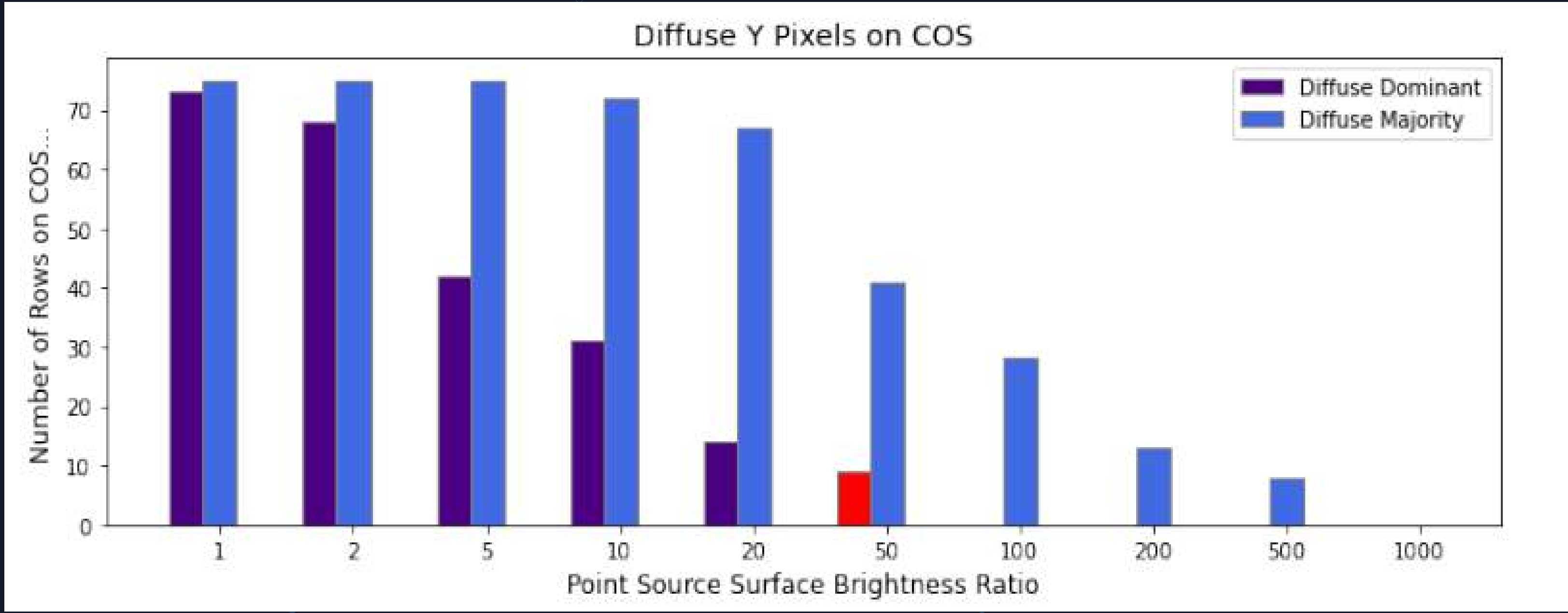
SBR = 50



SBR = 1000

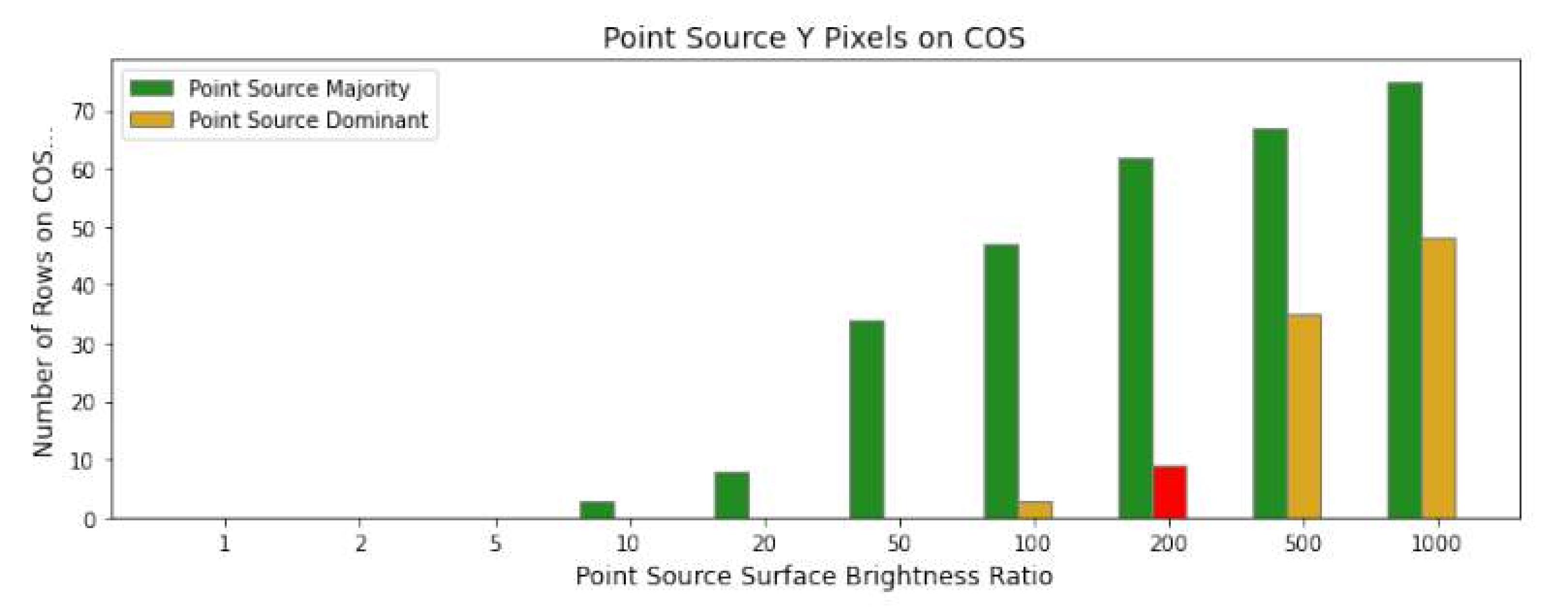


For each pixel, we calculate the percent of counts from the diffuse source versus the point source.



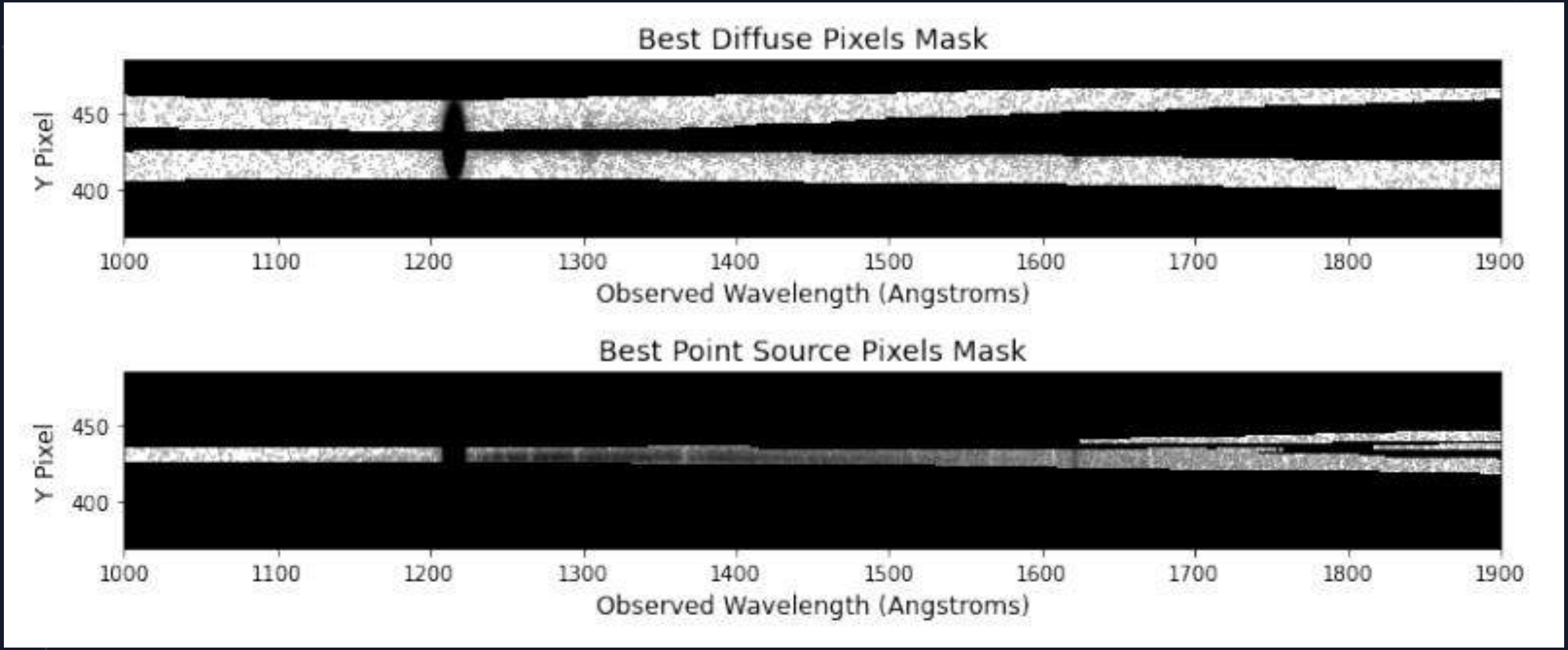
Diffiuse Dominant = >90% diffuse counts
Diffiuse Majority = >50% diffuse coutns

We then select the pixels that are most likely to dominated by a diffuse source to create a diffuse mask for the detector.



Point Source Dominant = >90% point source counts
Point Source Majority = >50% point source coutns

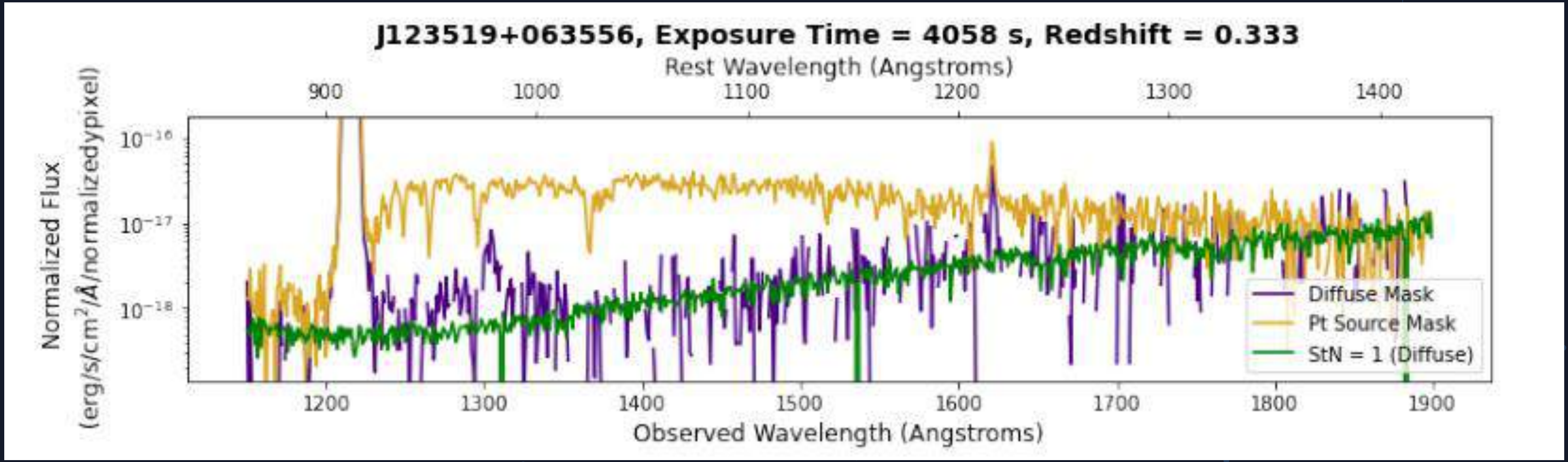
We can then apply these masks to LCEs to see if they show evidence of diffuse emission.



We built a model to determine how to bin LzLCS data in a way to find diffuse emission.

- Used CDSF of COS to simulate detector images of potential galaxies
- Can adjust surface brightness ratio between diffuse and point source regions
- Picked out pixels most likely to be dominated by either a point source or diffuse emission

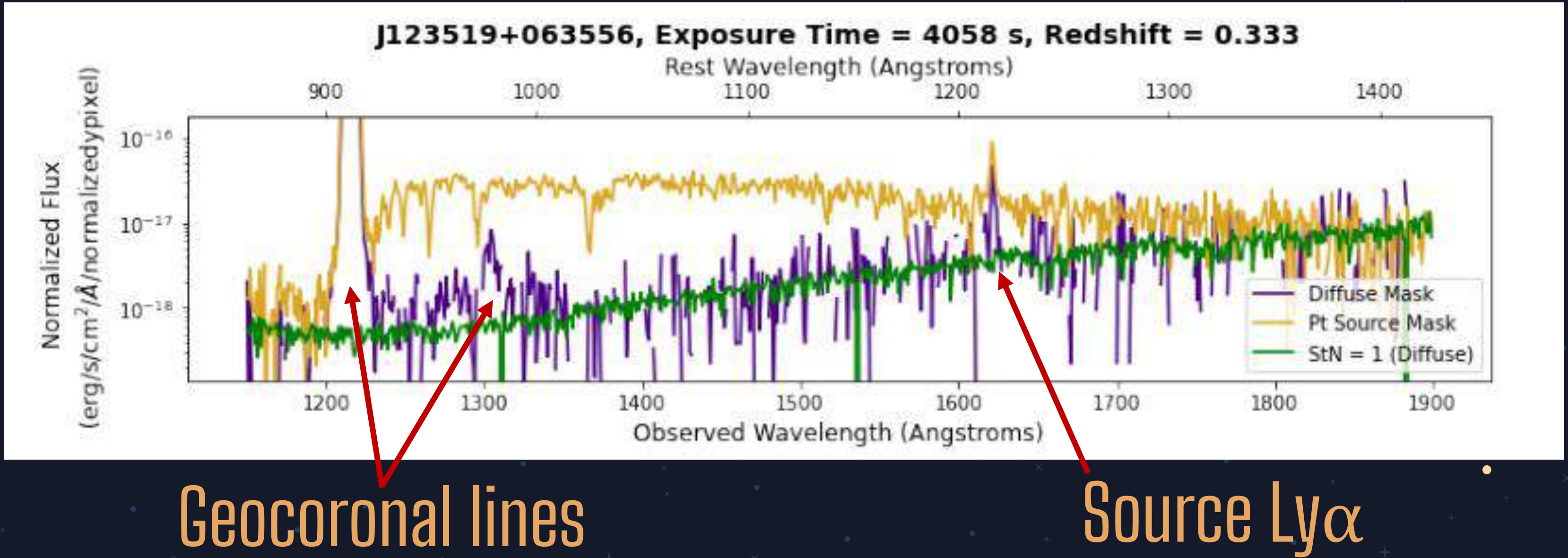
We analyzed the top 14 LCEs from the survey to look for potential diffuse emission; this is an example.



Yellow is the point source region
Purple is the diffuse region

Green is SNR of 1

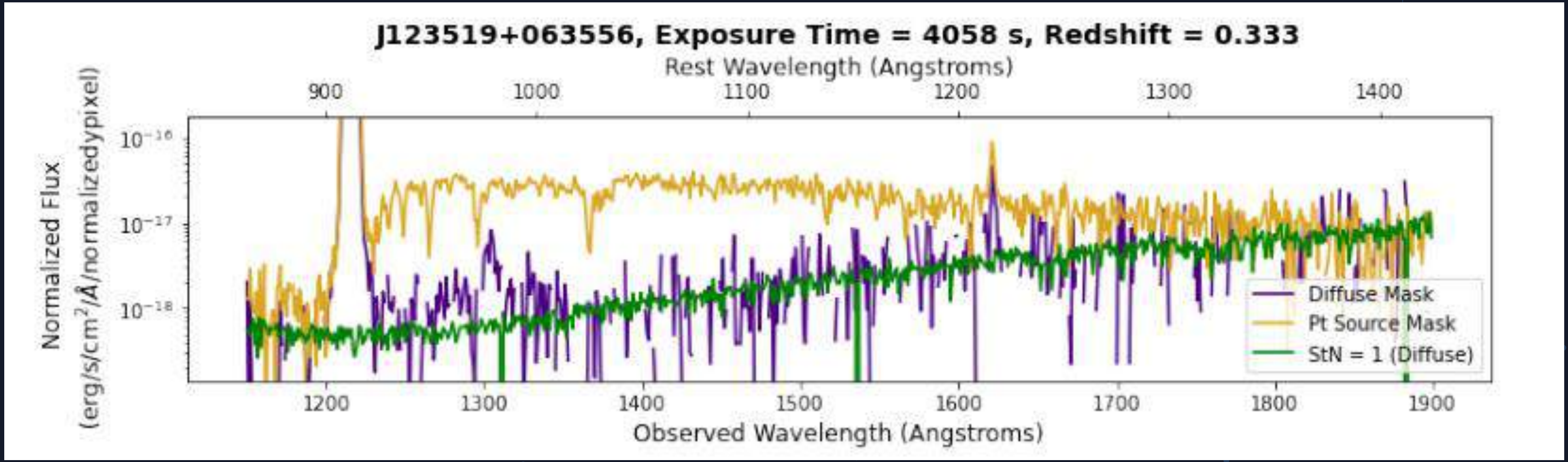
We analyzed the top 14 LCEs from the survey to look for potential diffuse emission; this is an example.



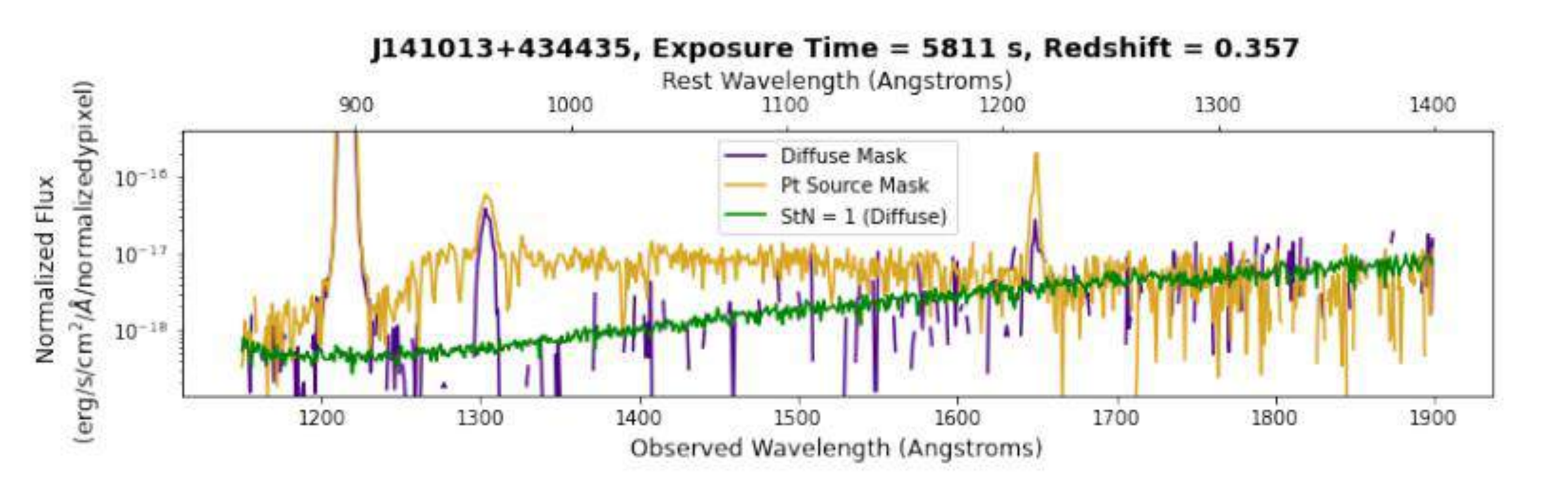
We calculate the median SNR across the spectrum in the diffuse region.

Number of Galaxies (out of 14)	Median SNR in Diffuse Region
6	0.
5	<0.5
3	>0.5

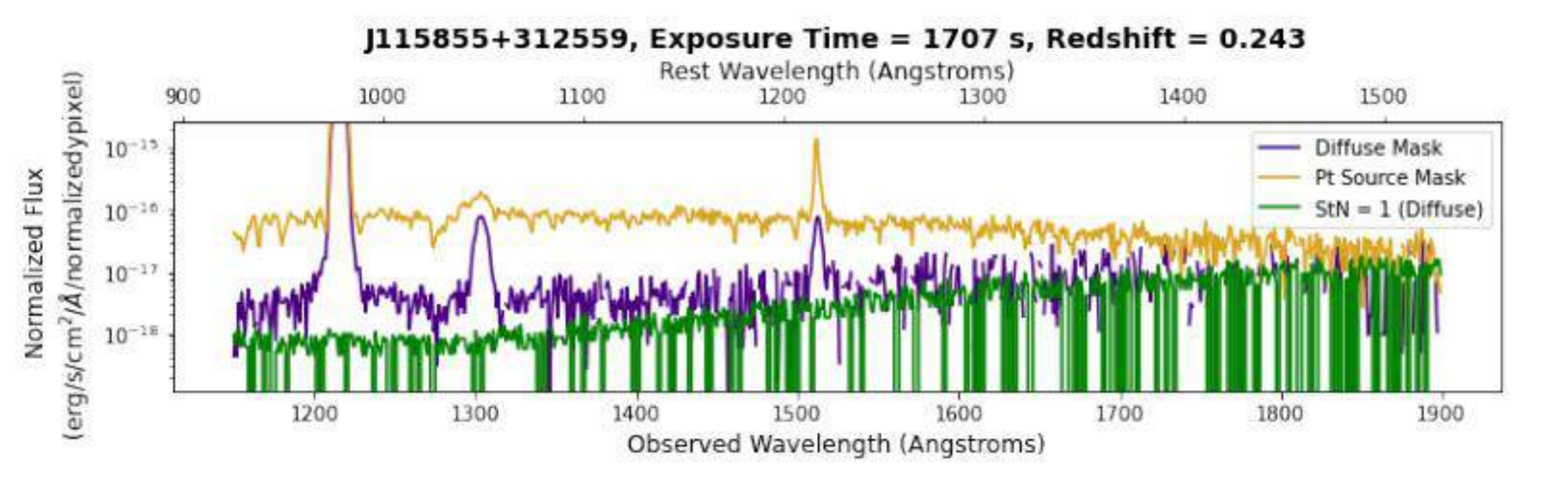
Galaxy A


J123519+063556, Exposure Time = 4058 s, Redshift = 0.333
Rest Wavelength (Angstroms)
900
1000
1100
1200
1300
1400
Normalized Flux
(erg/s/cm^2/Å/normalizedypixel)
10^{-16}
10^{-17}
10^{-18}
Diffuse Mask
Pt Source Mask
StN = 1 (Diffuse)
1200
1300
1400
1500
1600
1700
1800
1900
Observed Wavelength (Angstroms)

Galaxy B


J141013+434435, Exposure Time = 5811 s, Redshift = 0.357
Rest Wavelength (Angstroms)
900
1000
1100
1200
1300
1400
Diffuse Mask
Pt Source Mask
StN = 1 (Diffuse)
Normalized Flux
(erg/s/cm²/Å/normalizedypixel)
10⁻¹⁶
10⁻¹⁷
10⁻¹⁸
1200
1300
1400
1500
1600
1700
1800
1900
Observed Wavelength (Angstroms)

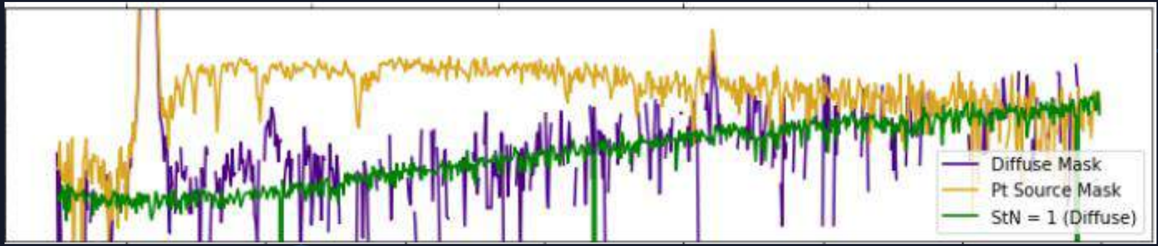
Galaxy C



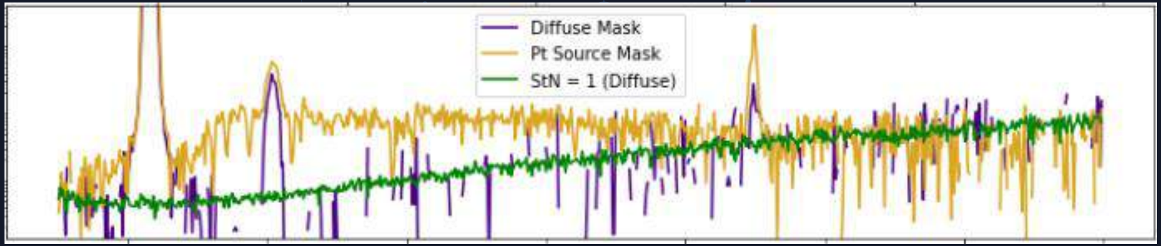
J115855+312559, Exposure Time = 1707 s, Redshift = 0.243
Rest Wavelength (Angstroms)
900
1000
1100
1200
1300
1400
1500
Normalized Flux
(erg/s/cm^2/Å/normalizedypixel)
10^{-15}
10^{-16}
10^{-17}
10^{-18}
Diffuse Mask
Pt Source Mask
StN = 1 (Diffuse)
1200
1300
1400
1500
1600
1700
1800
1900
Observed Wavelength (Angstroms)

Which galaxy appears to have the most diffuse emission?

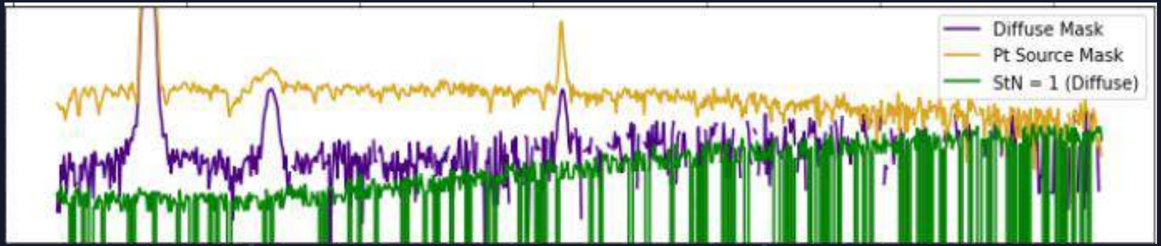
Galaxy A



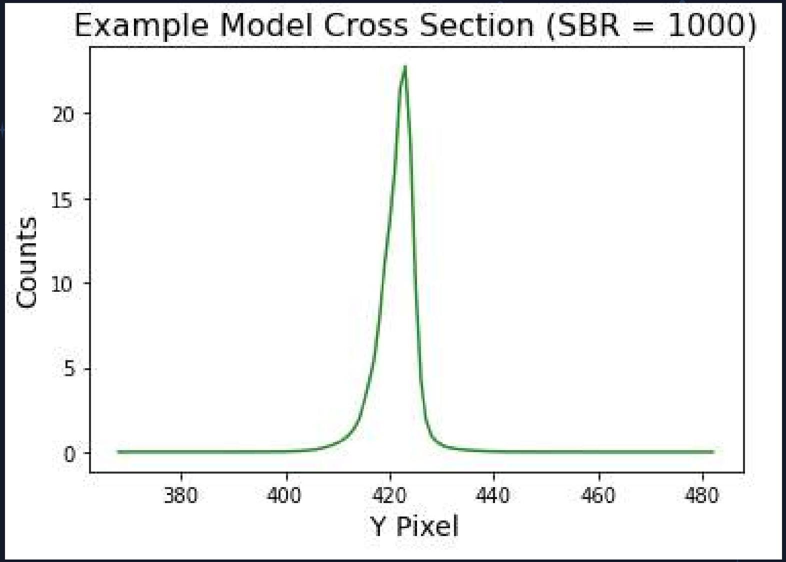
Galaxy B



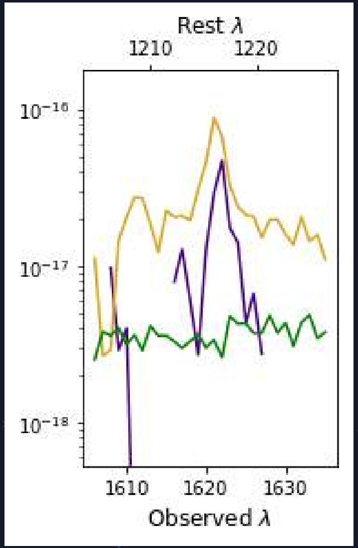
Galaxy C



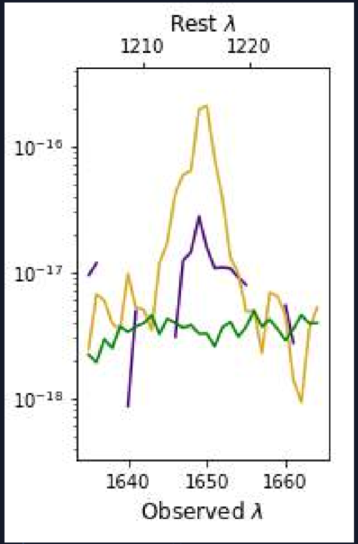
We used the model to calculate the surface brightness ratio; the results match best with ratio of at least 1000.



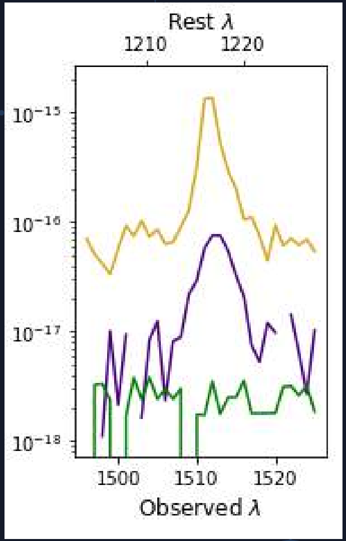
The source Lyα line has a wider cross section, evidence of extended emission.



Galaxy A

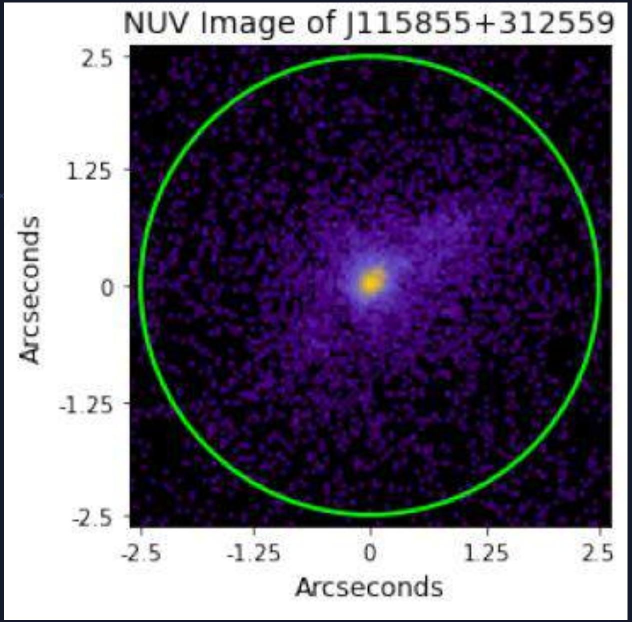


Galaxy B

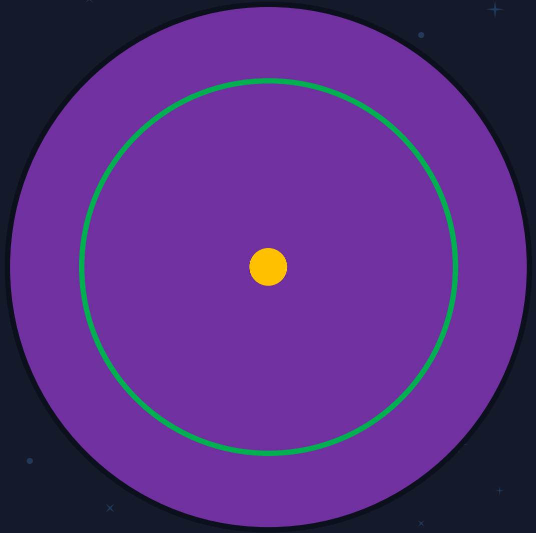


Galaxy C

Using the total Lyα flux and the model-fit SBR, we estimate how much flux we expect to see with a high resolution UV imager.



The Lyα SBR for this galaxy is 12, indicating a diffuse Lyα halo



We expect to see an integrated flux of 4.38×10^{-14} erg/s/cm^2 in approximately a 2.5 arcsecond diameter

We will image these galaxies in HST Cycle 30 as part of a guest observer program led by PI Matthew Hayes.

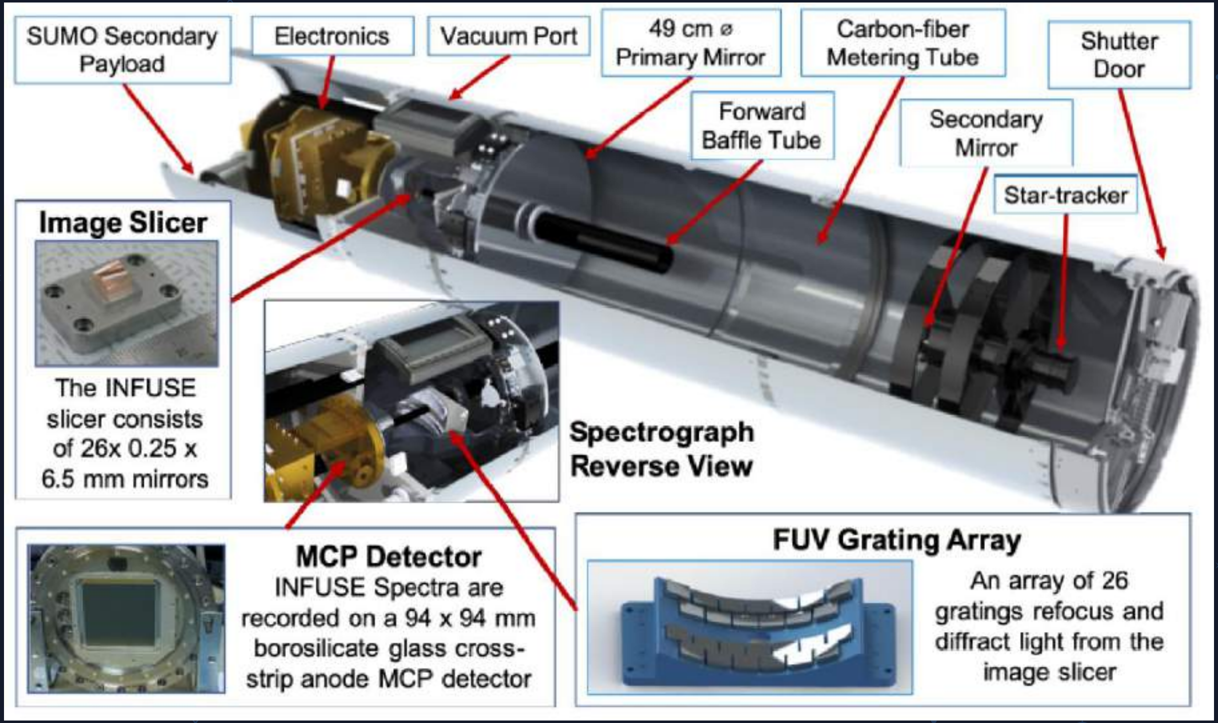
Courtesy NASA

- Look for extended Lyα halo
- Test validity of model

Outside of deeper imaging, there is also further analysis to be done with the existing dataset.

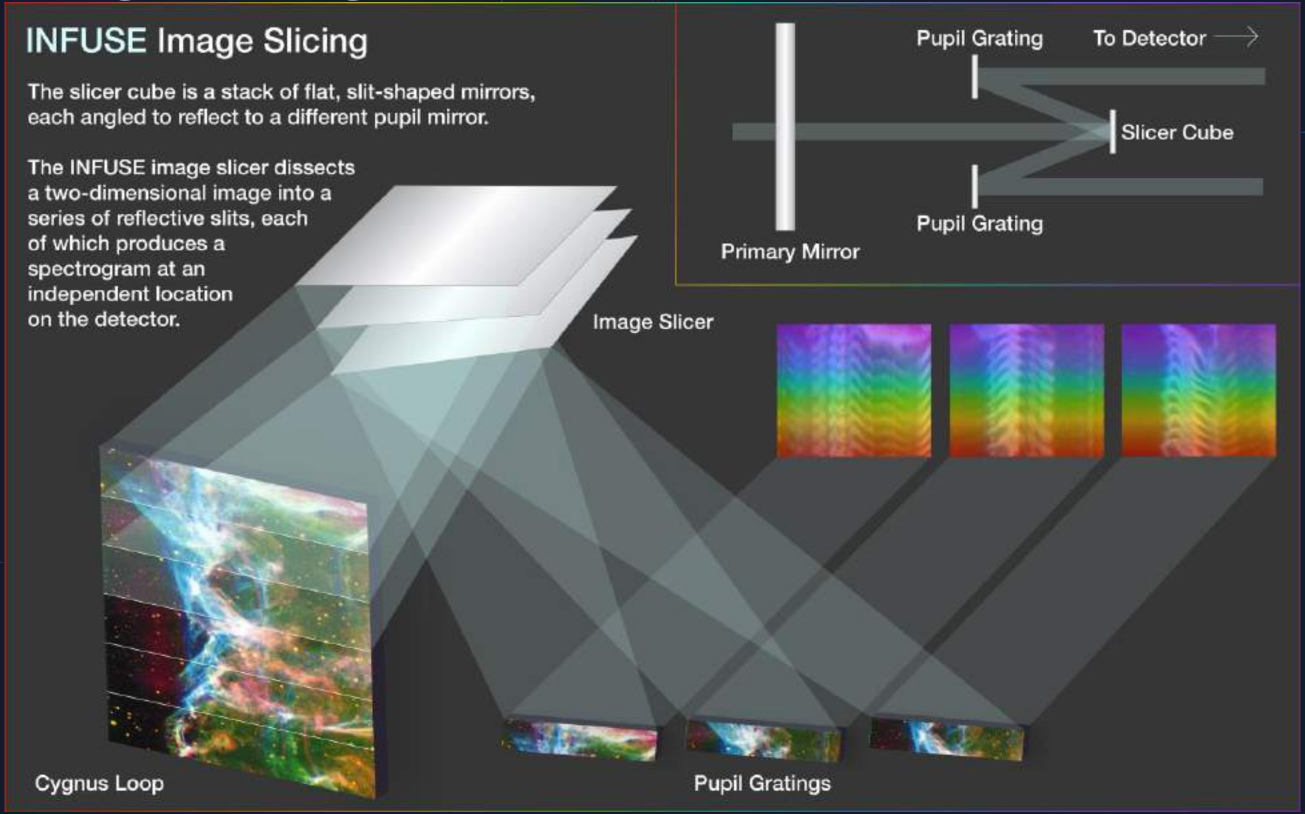
- Analyze diffuse spectrum to see if is only spillover or there is more there (calculate β)
- Perform a deconvolution to verify SBR analysis
- Expand model to include different angular sizes for diffuse emission

We are building a far ultraviolet integral field spectrograph, INFUSE.



Courtesy of Dana Chafetz

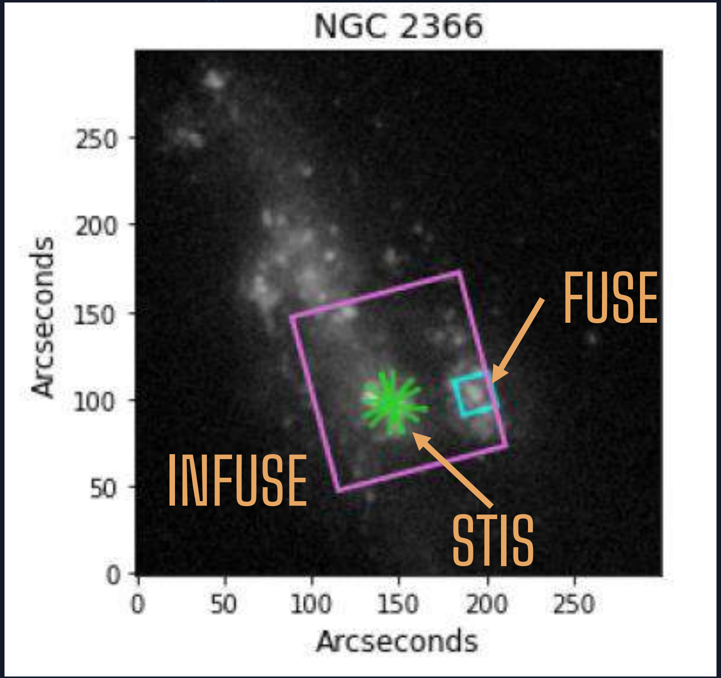
The INFUSE image slicer cuts the image into 26 different slices, each acting as a long slit.

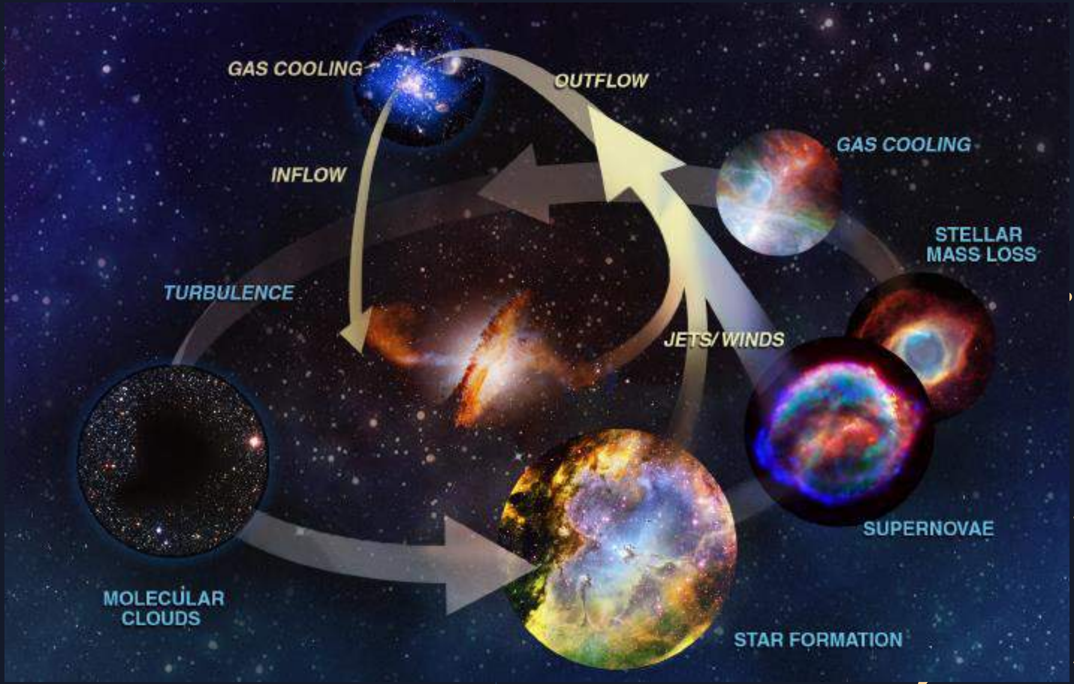


Courtesy of Emily Witt

The primary mirror for INFUSE has been cleaned, bonded to the bulkhead, and we are preparing to ship it to Goddard for coating.

We will look at NGC 2366 with INFUSE, gaining information on super star clusters and feedback mechanisms.





HabEx Report (2019)

Acknowledgements

Courtesy Maitland Bowen

Brian Fleming, Emily Witt, and the team at ARL

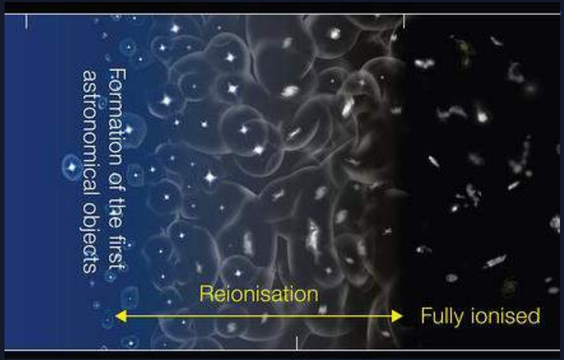
Sajal Gupta and Brian Fleming for edits on my paper

Arika Egan, Katie Blume, and others for feedback on the presentation and practice questions

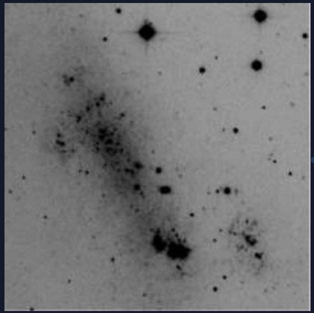
My friends for keeping me sane (esp. Marcel Corchado)

Current observations of LzLCEs appear as point sources; follow up investigations are required.

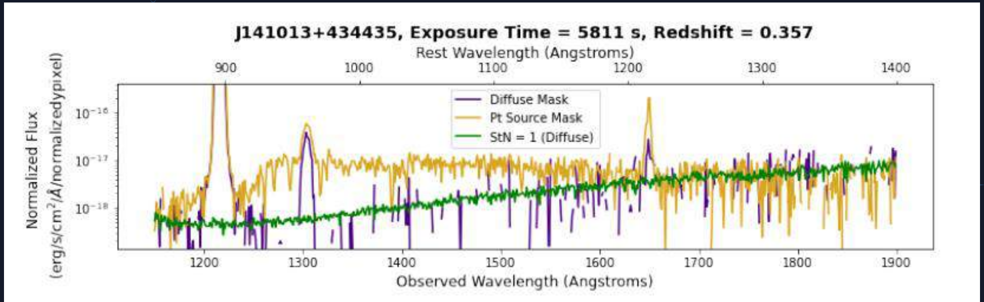
We are searching for Lyman continuum emitters



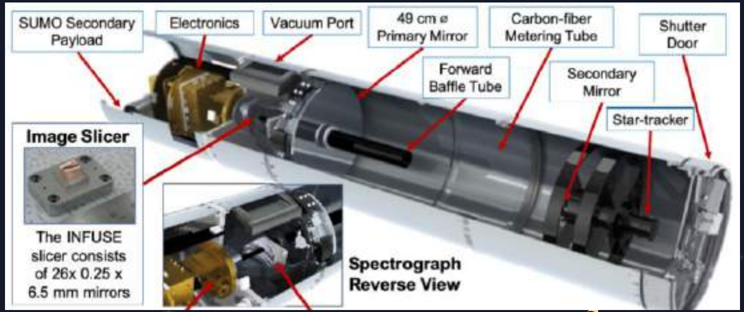
Green Peas are frequently LCEs



NGC 2366 is closer and suggests a compact bright region



We find that observed LCEs appear as point sources



We will follow up with INFUSE and other observations