HI and UV galaxy morphometrics

Galaxy morphology in the Hydra Cluster data

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Galaxy Morphometrics in HI

- Morphology is a complex feature of galaxies.
- Difficult to boil down into simple numbers.
- Morphometrics = attempt to put numbers on appearance (i.e. tail length of fish, point system for deer)
- Originally developed for other purposes, can this be adapted for HI?

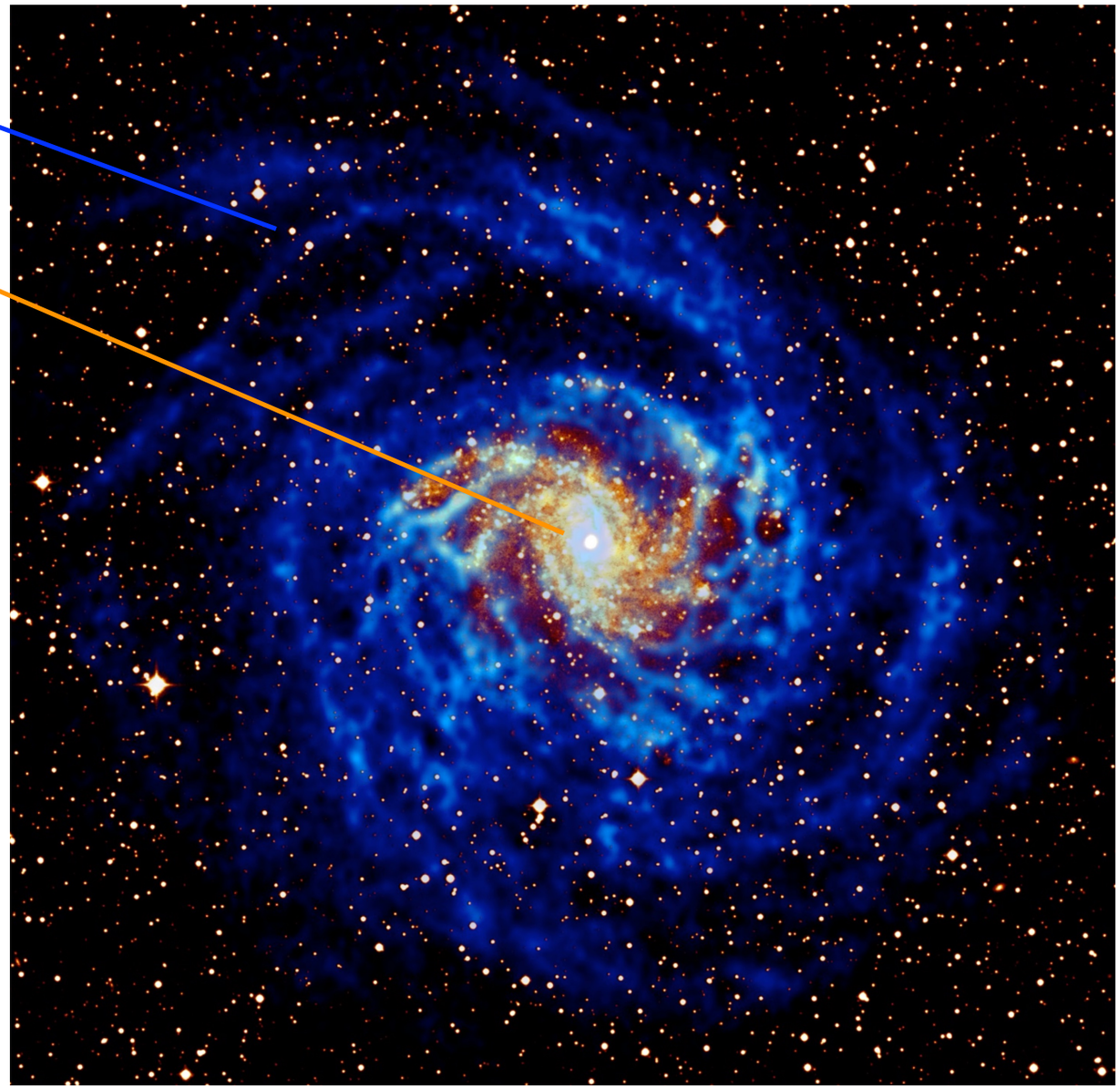
A Spiral Galaxy

Gas

Stars

PSF

Beam



Number of resolution elements

$N_{opt} = N_{HI}$

Boomsma et al. 2008, A&A, 490, 555

Same quantity of morphological information, not the same dynamic range!

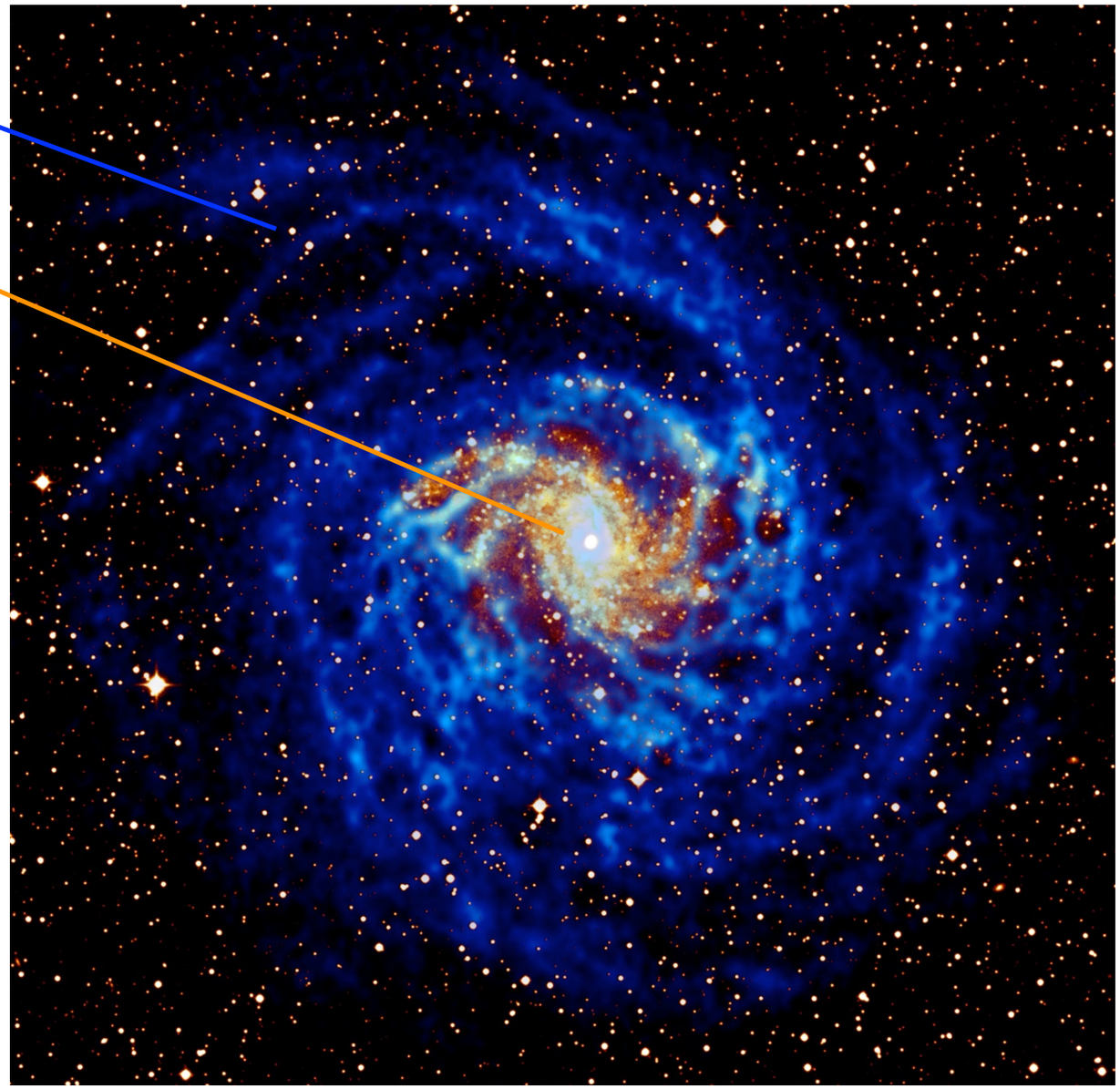
A Spiral Galaxy

Gas

Stars

PSF

Beam



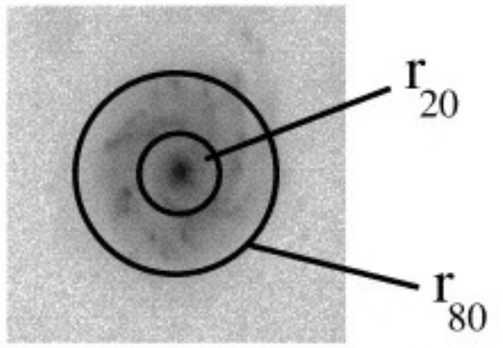
Number of resolution elements

$N_{opt} = N_{HI}$

Boomsma et al. 2008, A&A, 490, 555

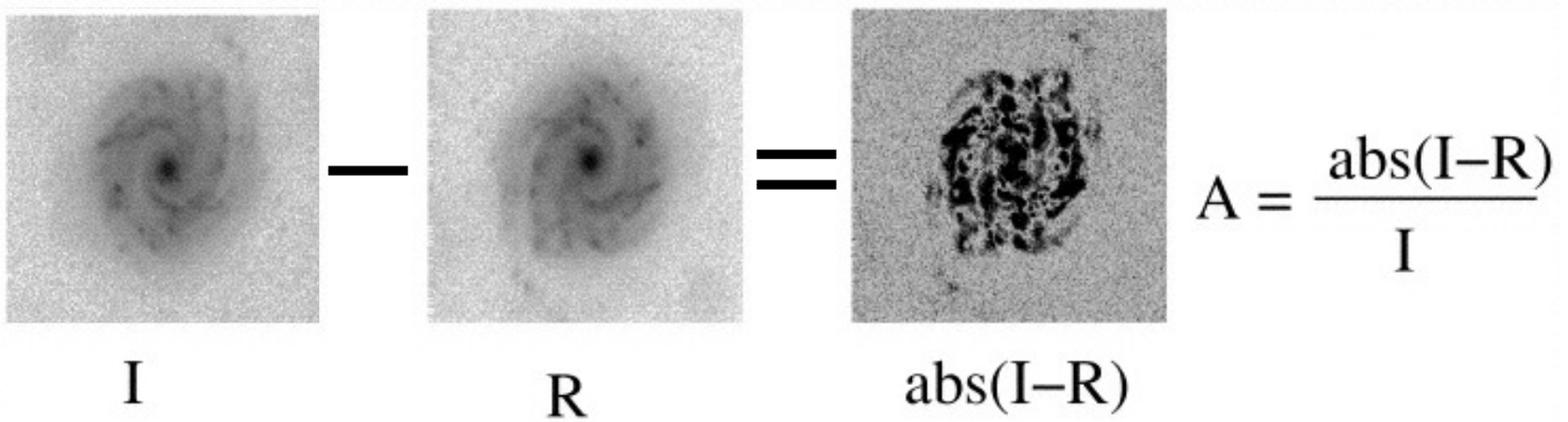
In the Ultraviolet same size disk as HI and higher dynamical range!

CAS



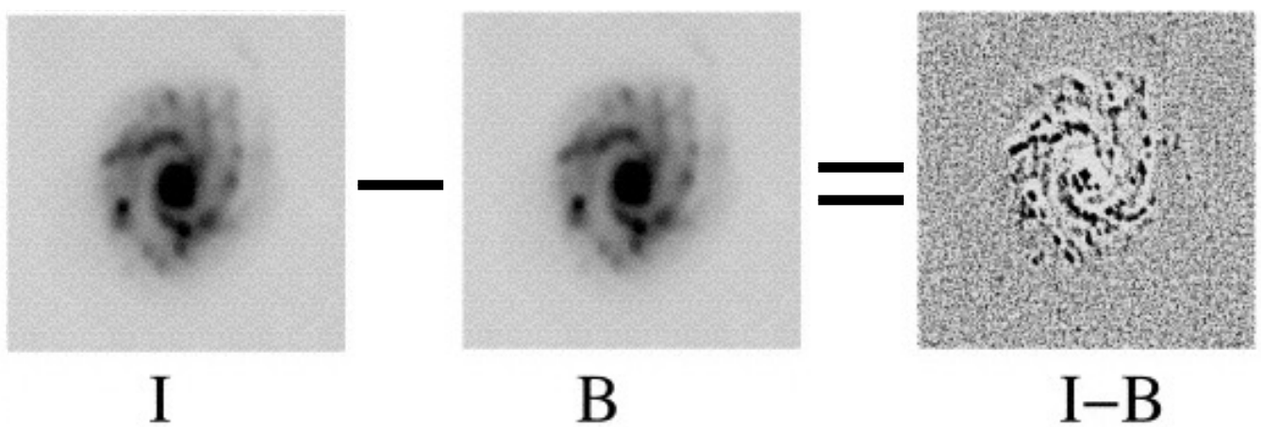
$$C = 5 \log\left(\frac{r_{80}}{r_{20}}\right)$$

Concentration (**C**)



$$A = \frac{\text{abs}(I-R)}{I}$$

Asymmetry (**A**)

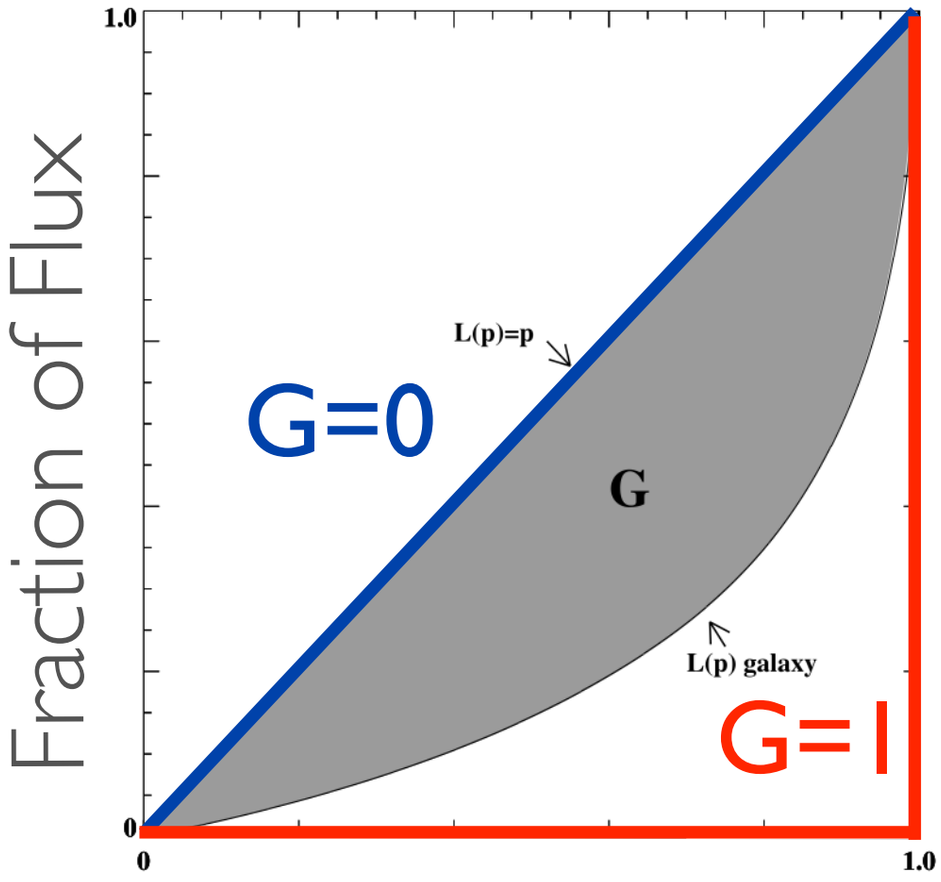


$$S = \frac{I-B}{I}$$

Smoothness (**S**)

Conselice et al., 2004, APJS, 147, 1-38

Gini



$$G = \frac{1}{|\bar{X}|n(n-1)} \sum_{i}^{n} (2i - n - 1)|X_i|.$$

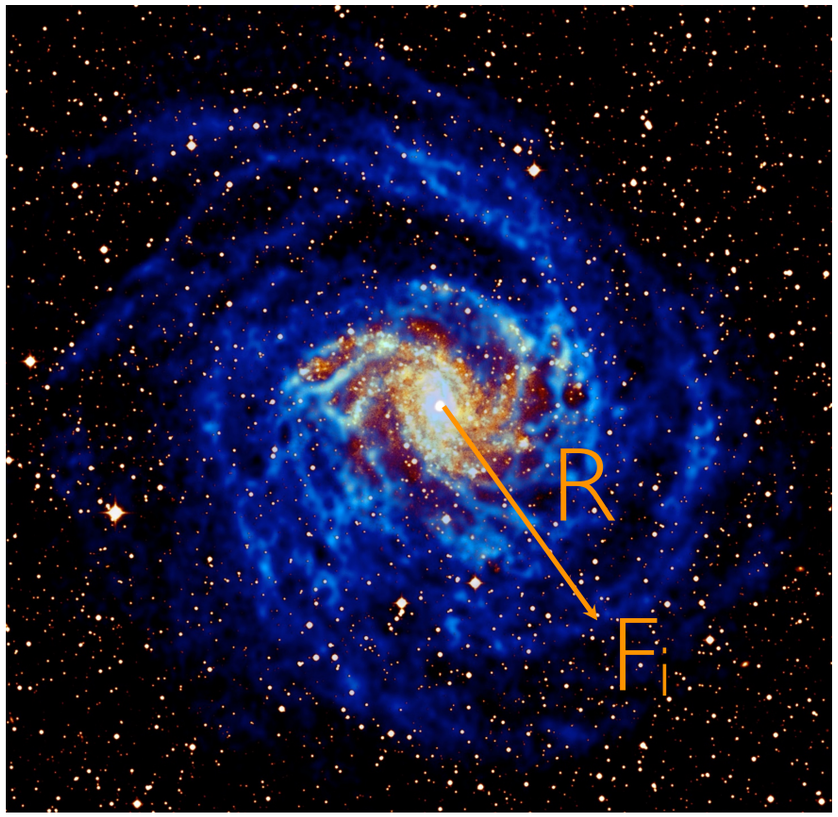
- **Gini** is an economic measure of (in)equality:
  - G=1 all flux in 1 pixel
  - G=0 every pixel same value

G=0

G=1

Lotz et al. 2004 AJ, 128, 163

M_{20}



- Second order moment of pixel i: $M_i = F_i \times R^2_i$
- **M_{20}** : relative contribution of 20% brightest pixels to *total* second order moment.

STATMORPH application (Rodriguez-Gomez, 2019)

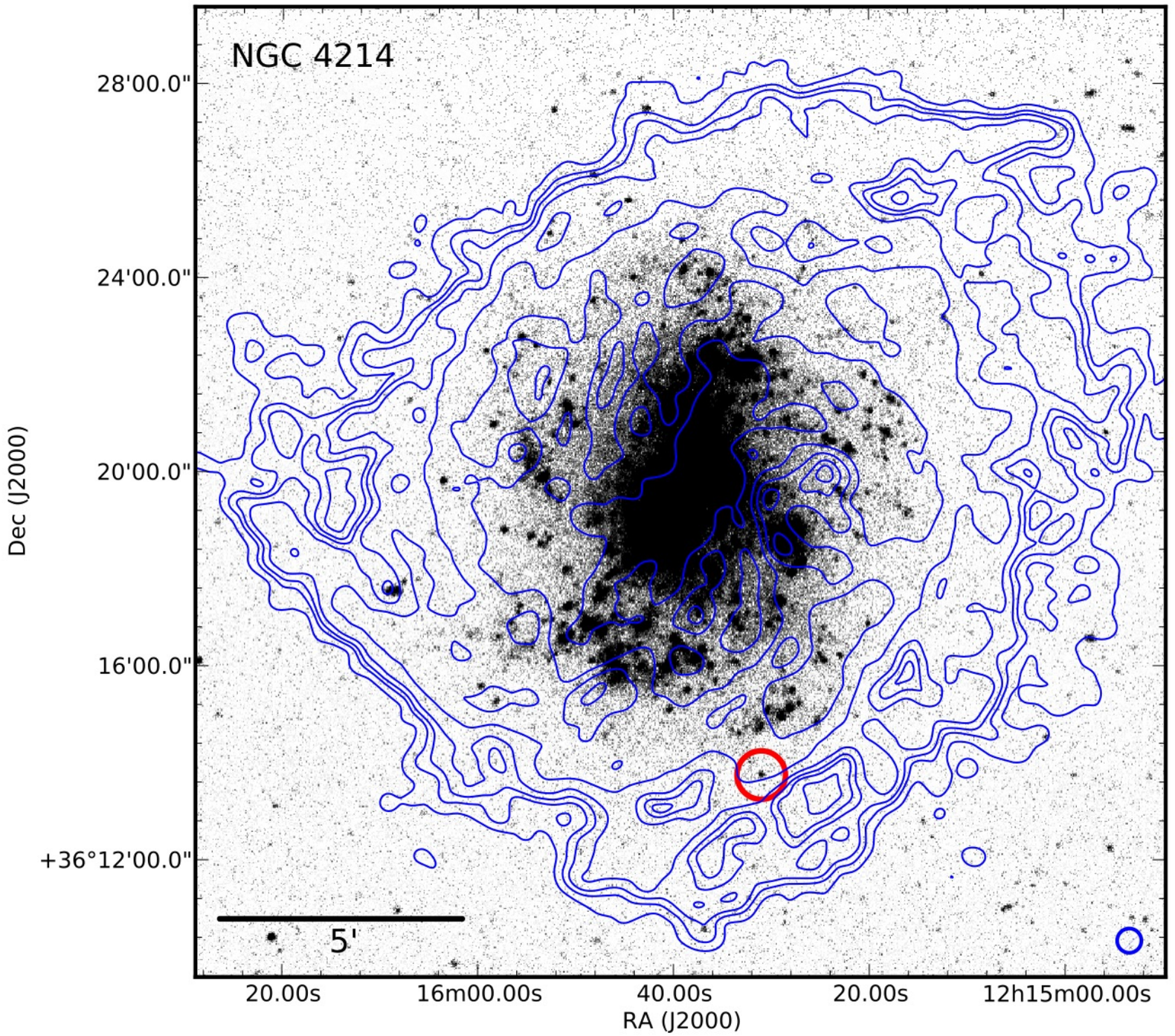
$$M_{\rm tot} = \sum_i^n M_i = \sum_i^n f_i \left[(x_i - x_c)^2 + (y_i - y_c)^2 \right],$$

$$M_{20} \equiv \log 10 \left(\frac{\sum_i M_i}{M_{\rm tot}} \right), \text{ while } \sum_i f_i < 0.2 f_{\rm tot}.$$

Lotz et al. 2004 AJ, 128, 163

XUV DISKS

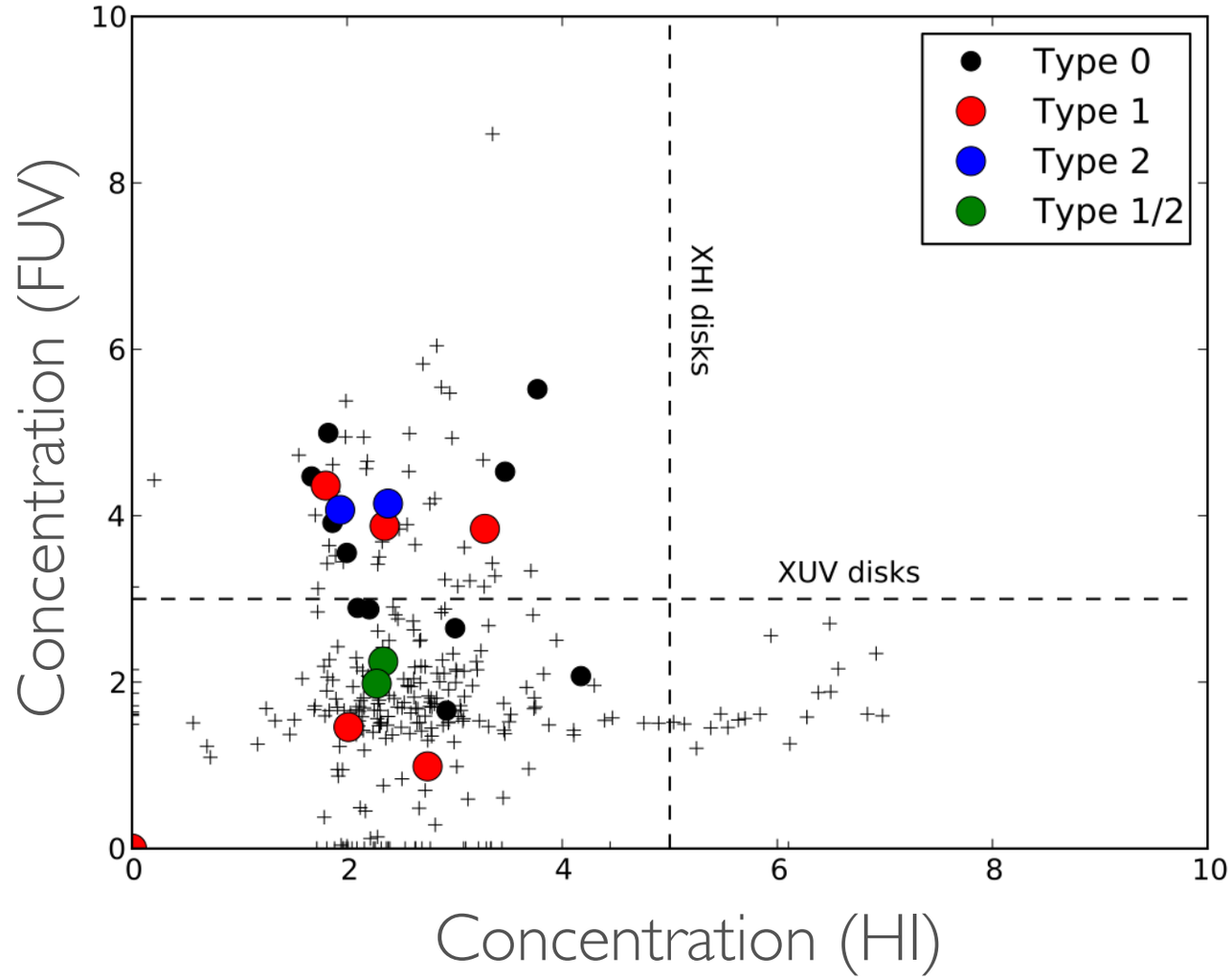
- GALEX discovered extended UV emission around spiral galaxies (Thilker et al. 2007, ApJS, 173, 538).
- Similarities with HI disk
- Full catalogs are becoming available now.
- How well can HI morphology identify XUV disks?
- What can we say about their origin?



Extended Disks

THINGS and SINGS/UV

- High values of concentration.
- High values of C_{FUV} and C_{HI} do not coincide.
- Not an optimal way to identify known XUV disks (identifies some).



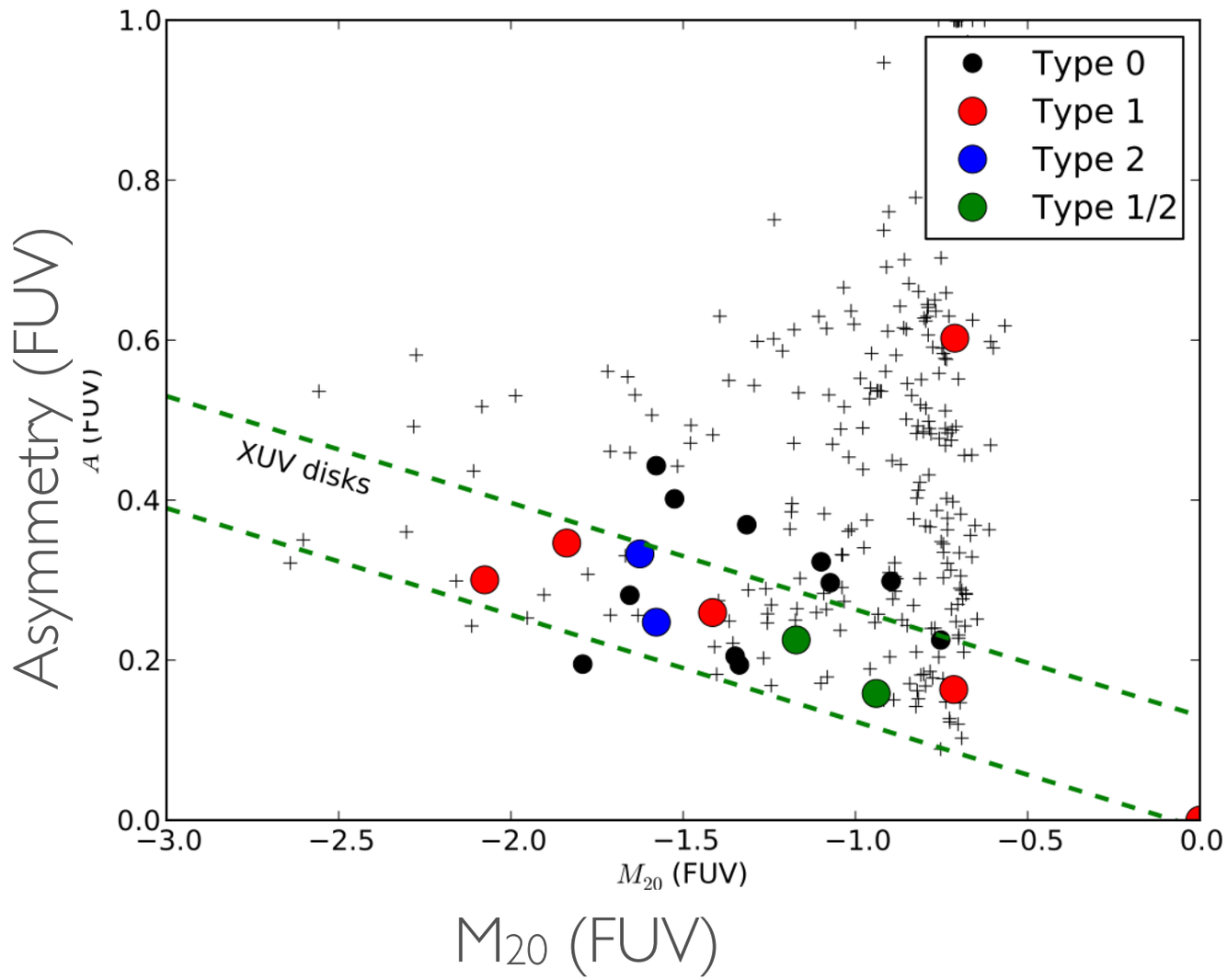
Holwerda et al. 2012c, MNRAS, *in press, ArXiV:1207.4916*

Selecting XUV disks

Identifying eXtended UltraViolet disks

- Compute UV morphometrics over the HI disk.
- Asymmetry-M20 relation selects most XUV disks.
- 80% included, 50% contamination.
- Good first slice.

Holwerda et al. 2012c, MNRAS

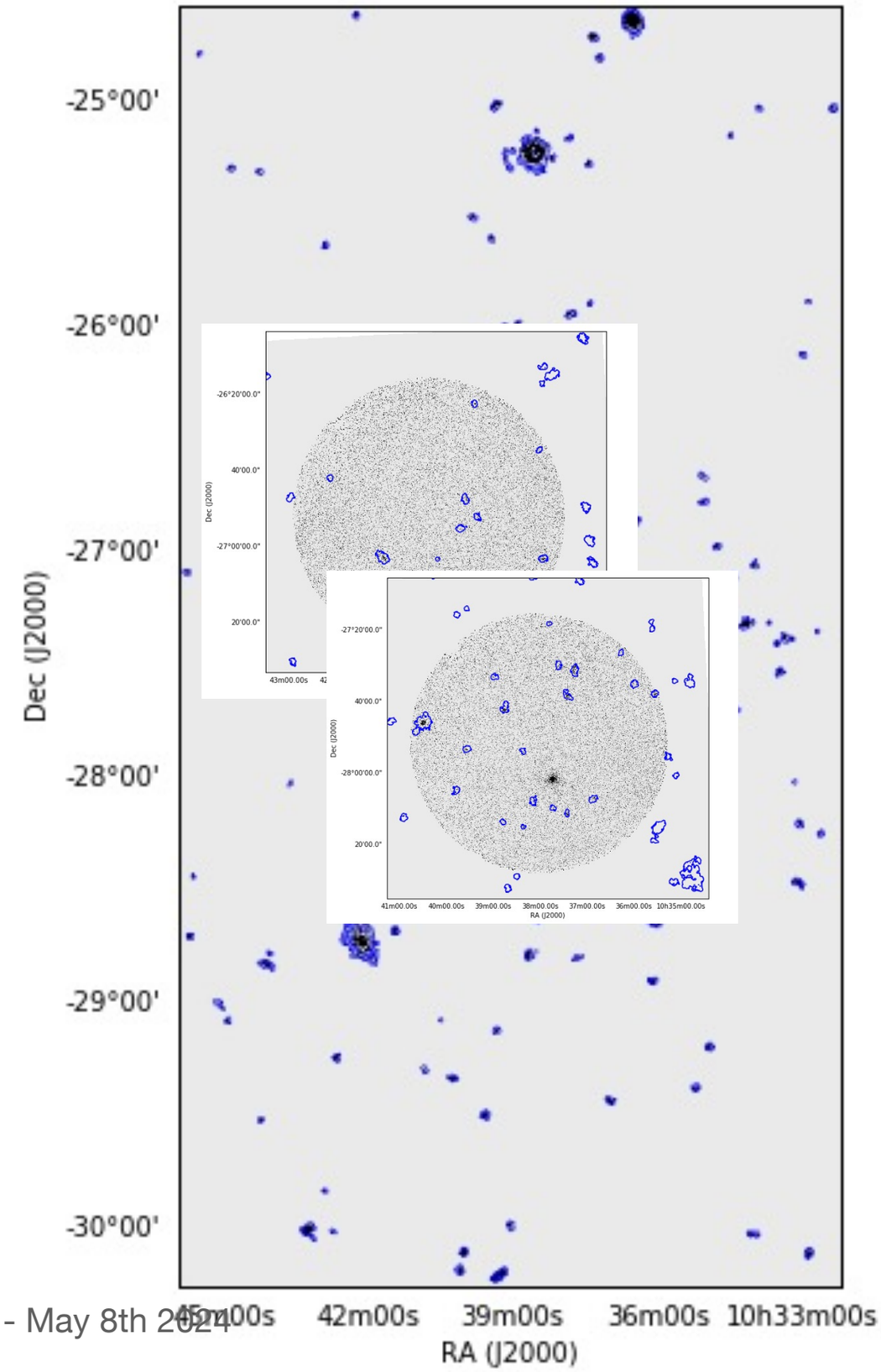


WALLABY

- ASKAP/PAF (radio camera)
- Western Australia
- HI 21-cm
- Similar resolution to GALEX

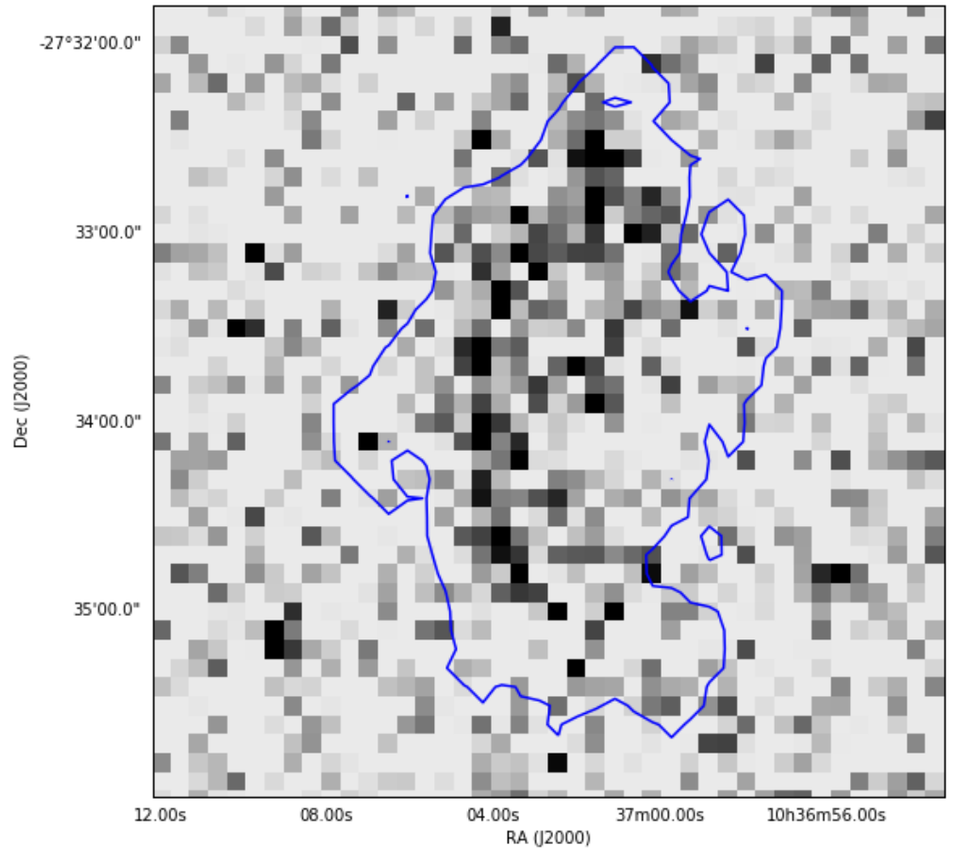
Hydra Cluster data

WALLABY Pilot data



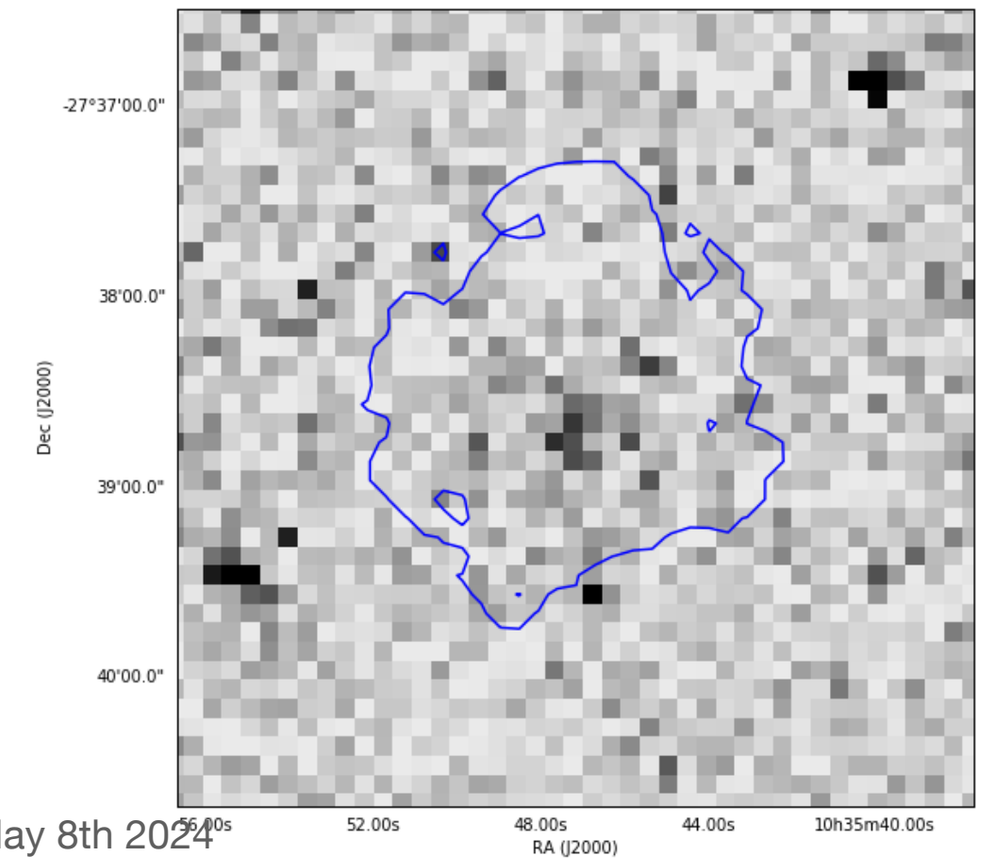
FUV and HI contour

- UV data, deep or shallow, remains fragmented and difficult to assign a source contour to each galaxy.



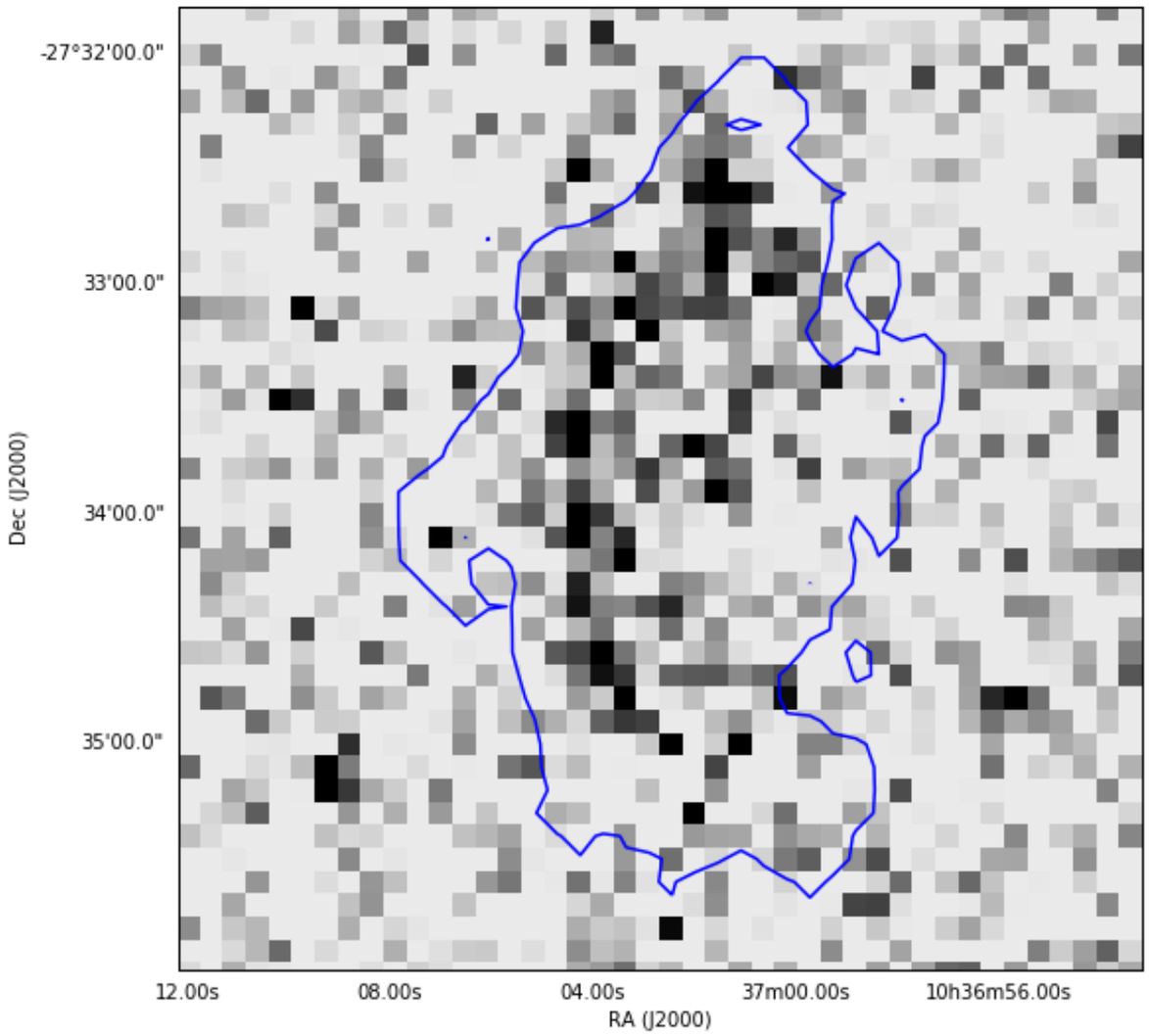
- HI contours are a great indicator of which UV flux belongs to the object and which does not.

- Calculate morphometrics with *STATMORPH (Rodriguez-Gomez+ 2019)*

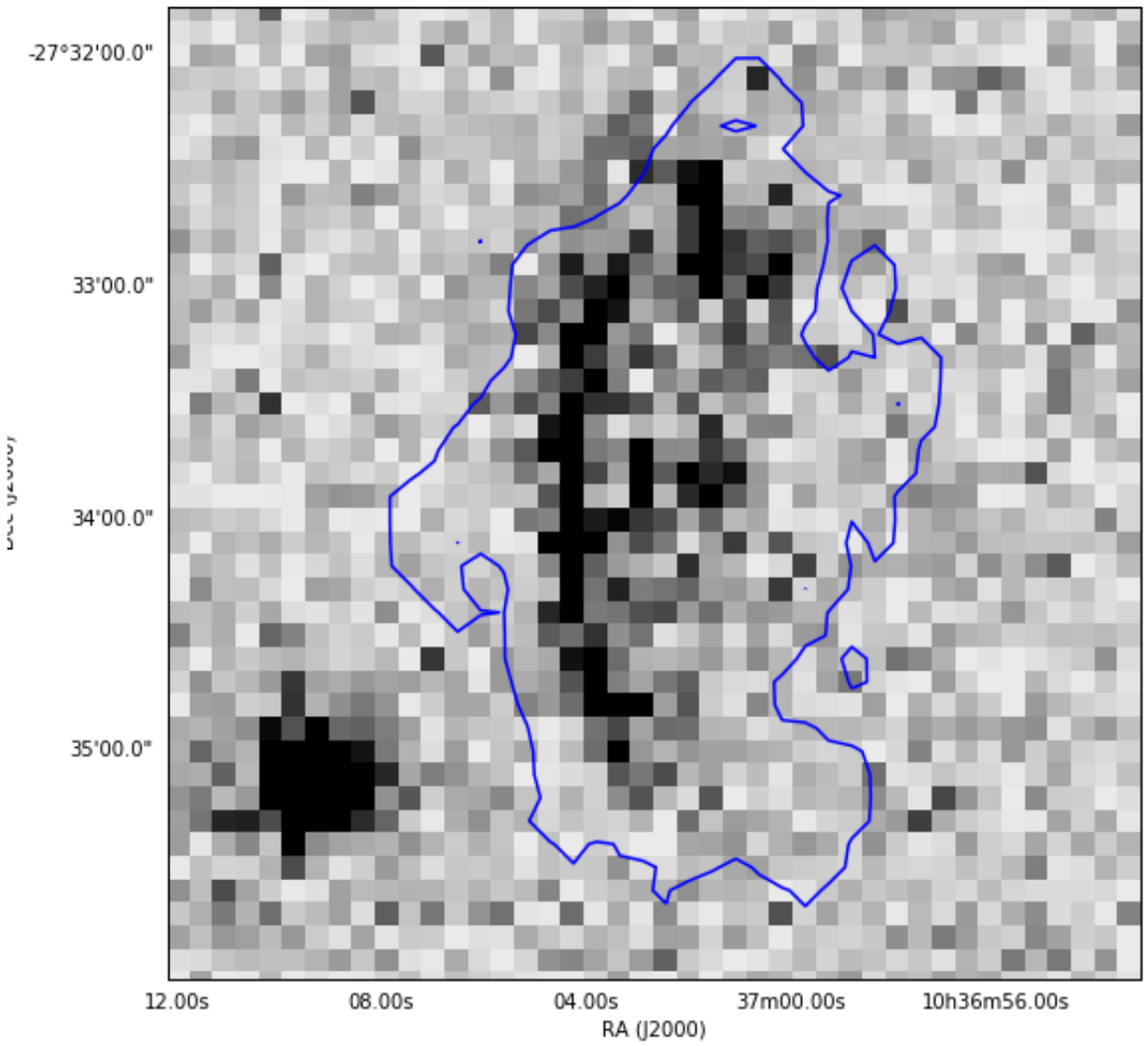


NUV and FUV Morphology

FUV



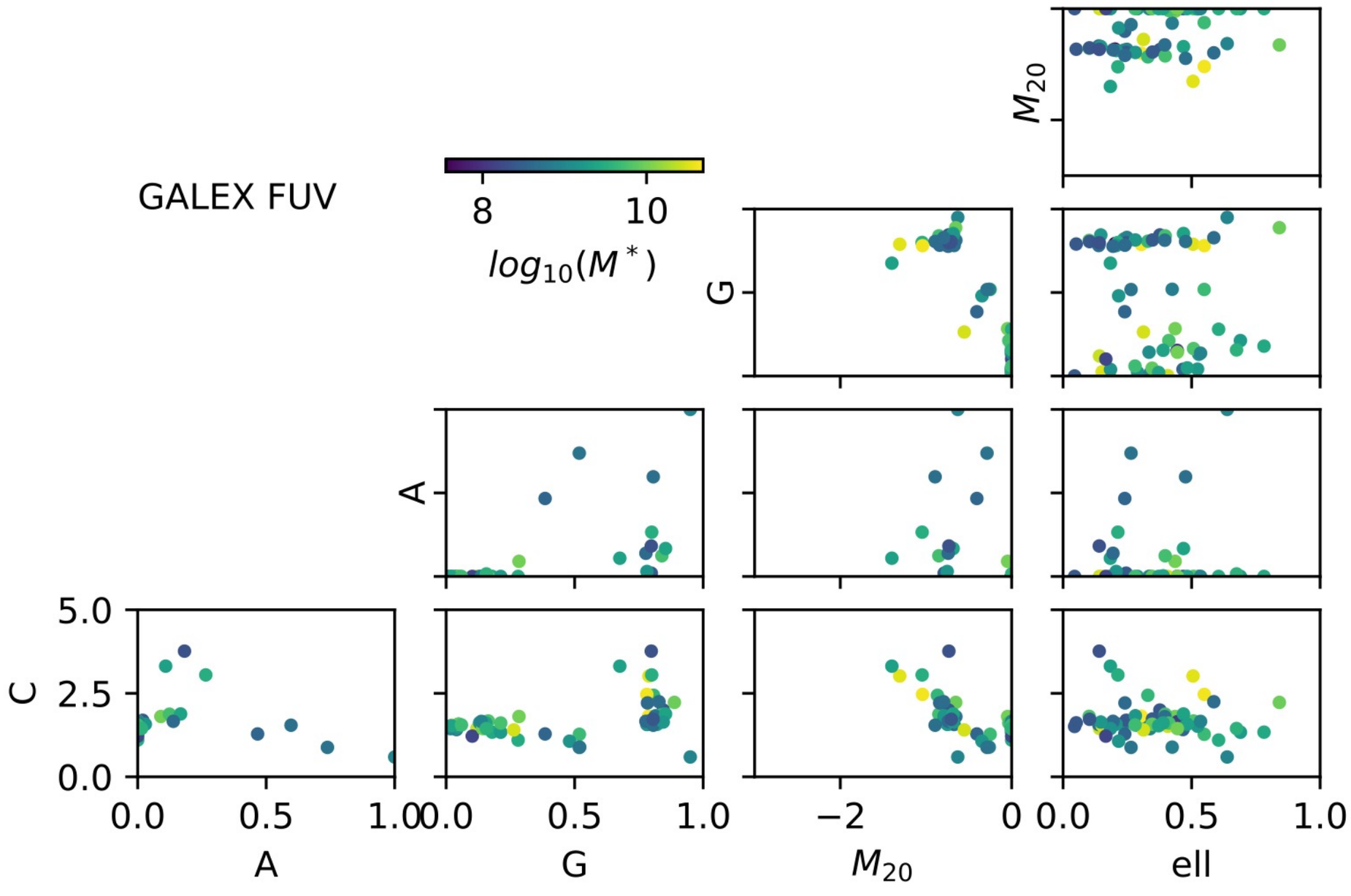
NUV



Morphometric Space

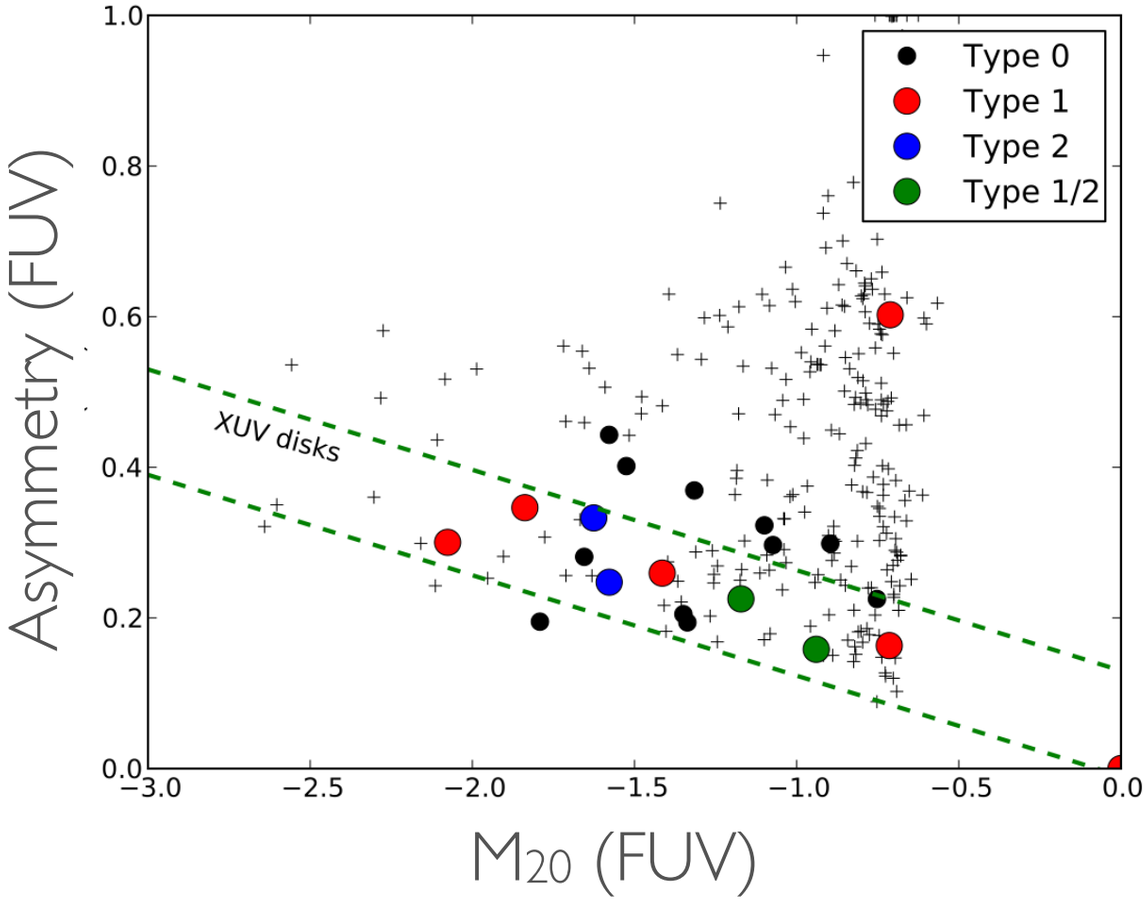
FUV morphometrics

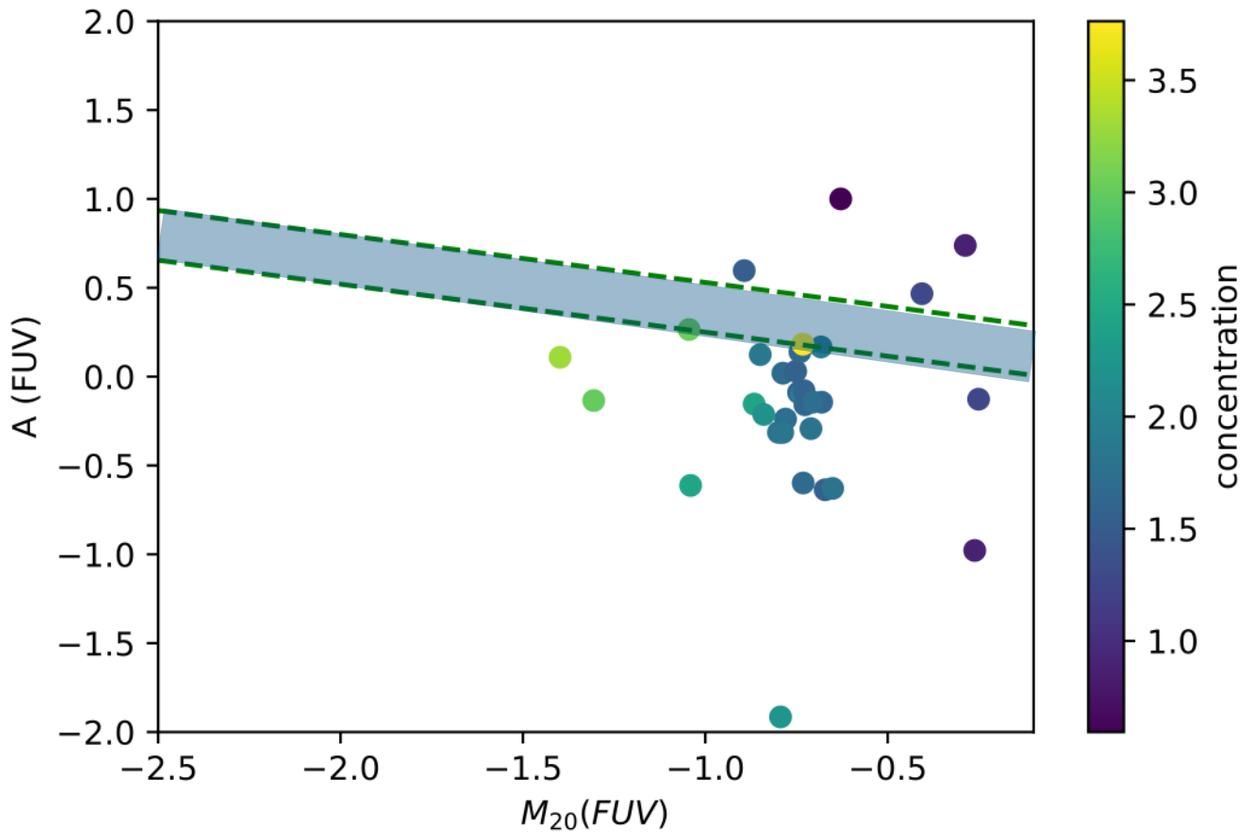
Stellar masses thanks to Ned Taylor!



XUV disks?

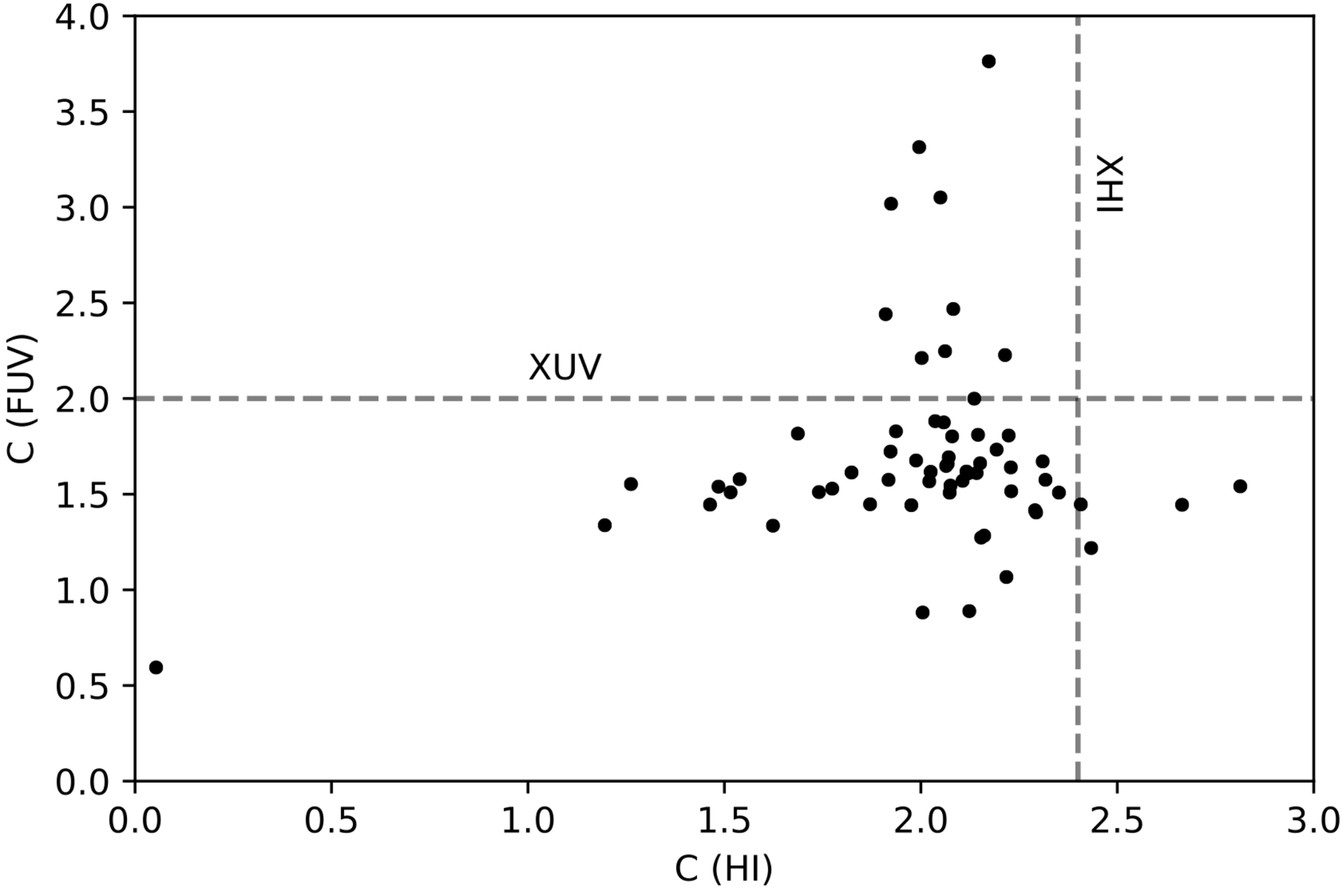
Can we identify XUV disks in WALLABY+UV data?





XUV and XHI disks?

Does concentration point to extended disks?



Morphometrics Space

Preliminary conclusions

- HI-segmented UV Morphometrics looks like a promising parameter space.

- Strongly depends on spatial sampling, signal-to-noise. A sample at the same distance with same instrument is critical.

- Samples are still small until UVEX and full HI all-sky surveys done.

- But the feature space looks promising for XUV disk identification.

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The Future

UVEX, ULTRASAT, HWO