Winds and Outflows in WiFeS and SALT + BIRD Kinematics

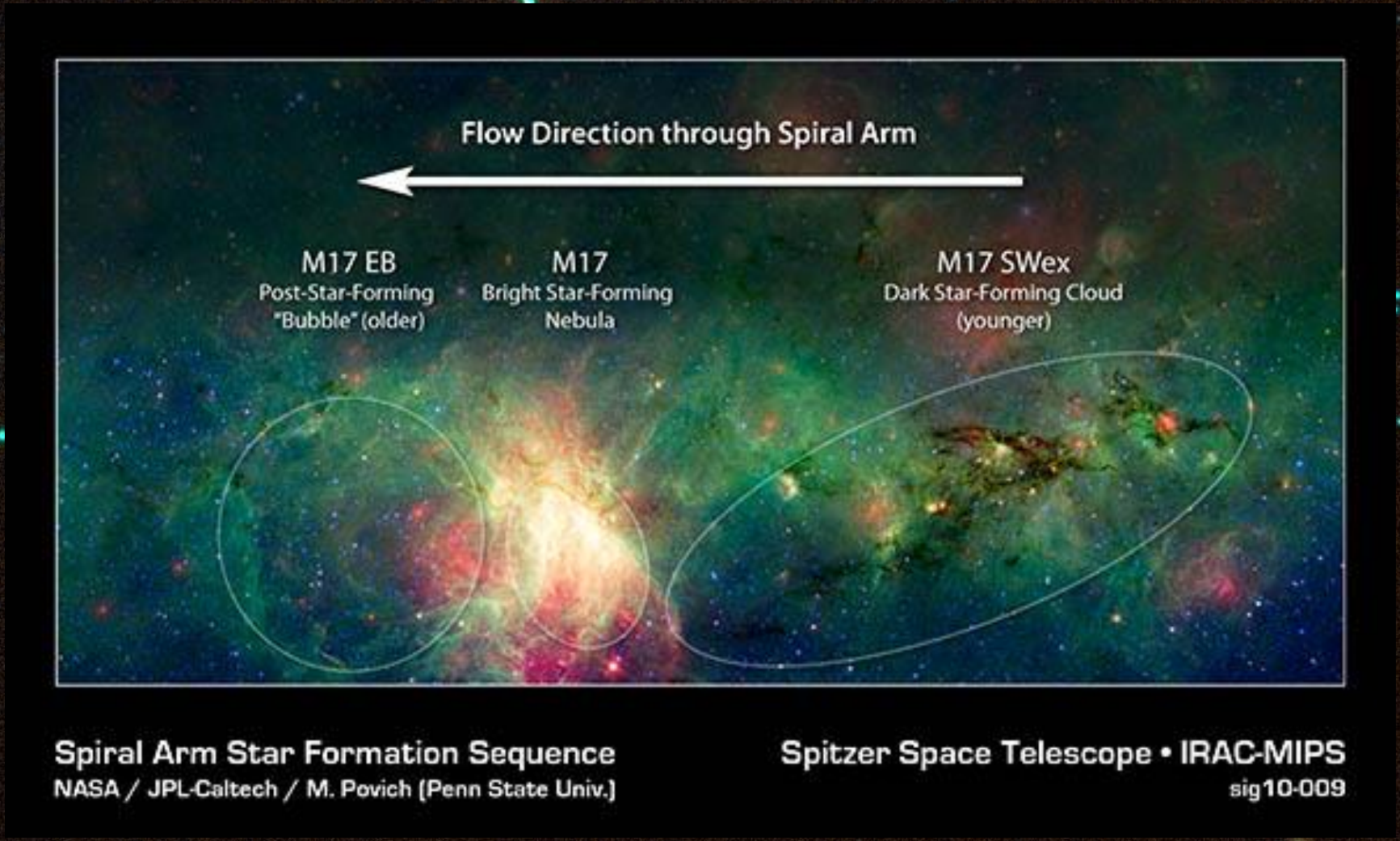
Moses Mogotsi

South African Astronomical Observatory

Star Formation & Baryon Cycle: Multi-wavelength

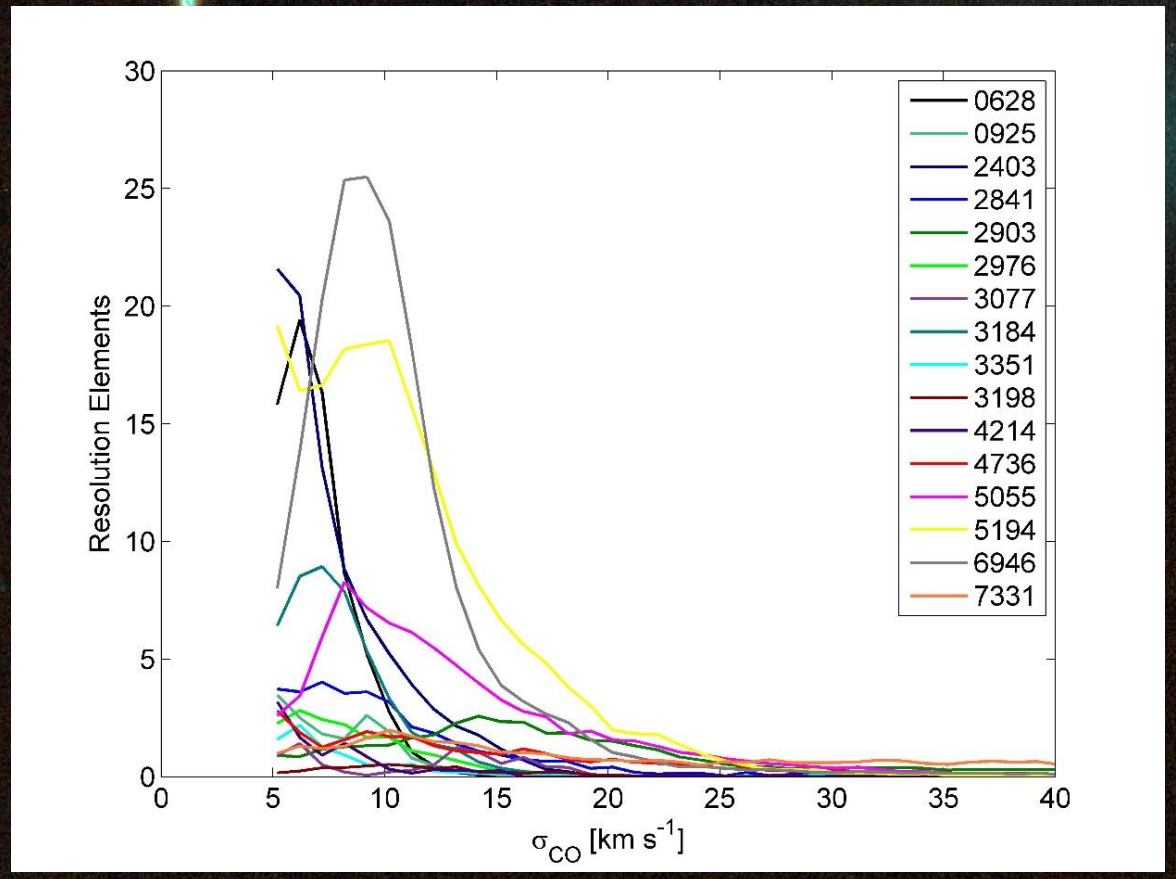
- Optical, NIR, UV, mm, Radio
- SF Dynamics:
  - Star formation processes, Disk & Cloud Stability, SF Law, Environmental Effects
    - THINGS+HERACLES+SINGS (Mogotsi+2016, Romeo & Mogotsi 2017, Caldu-Primo+), WIYN + SINGG + WISE (Mogotsi PhD thesis, Mogotsi+ in prep), ALMA
- SF Feedback:
  - Feedback: Winds & Outflows, Turbulence, Gas dynamics
    - SALT (see TALK), WiFeS & SINGG (see TALK), THINGS+HERACLES+SINGS (Mogotsi+2016, Mogotsi MSc thesis), MeerKAT (MHONGOOSE)
- SF Fuelling:
  - Gas accretion
    - MeerKAT (MHONGOOSE)

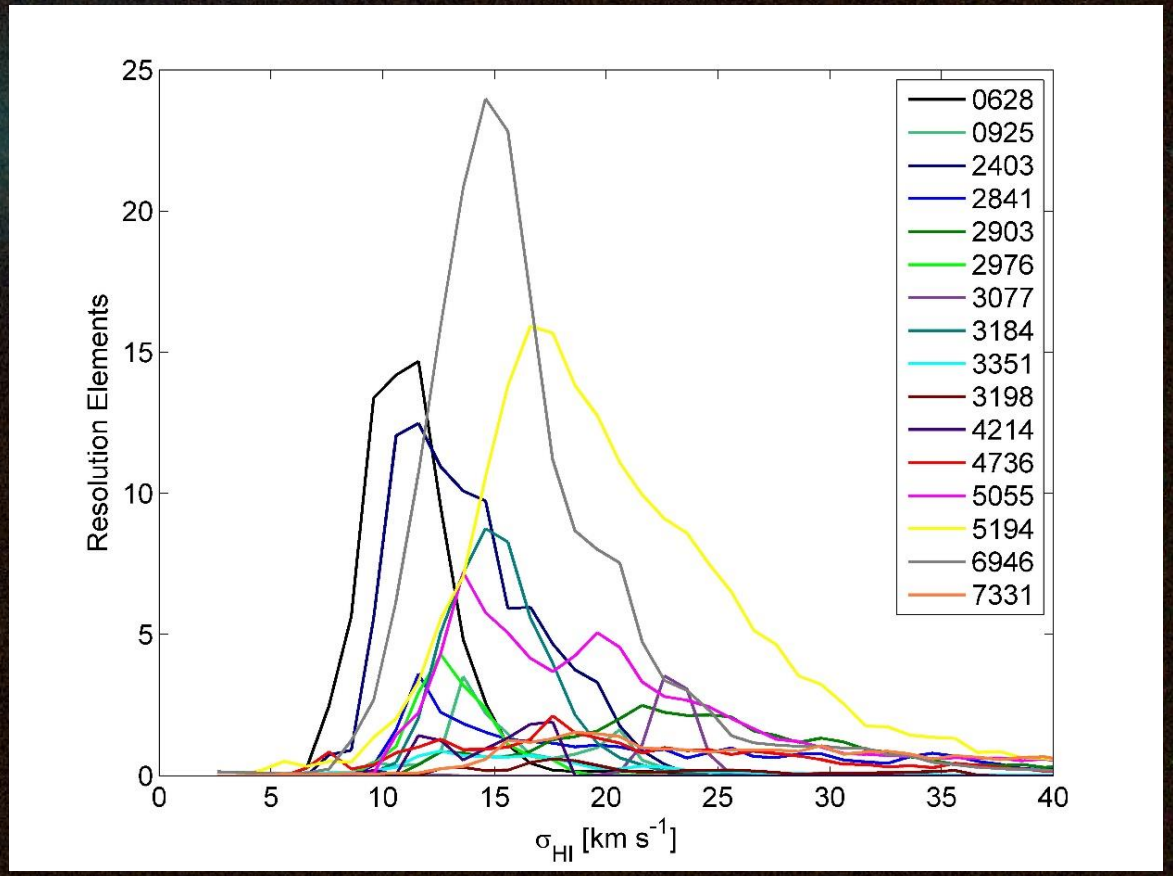
Star Formation



Feedback

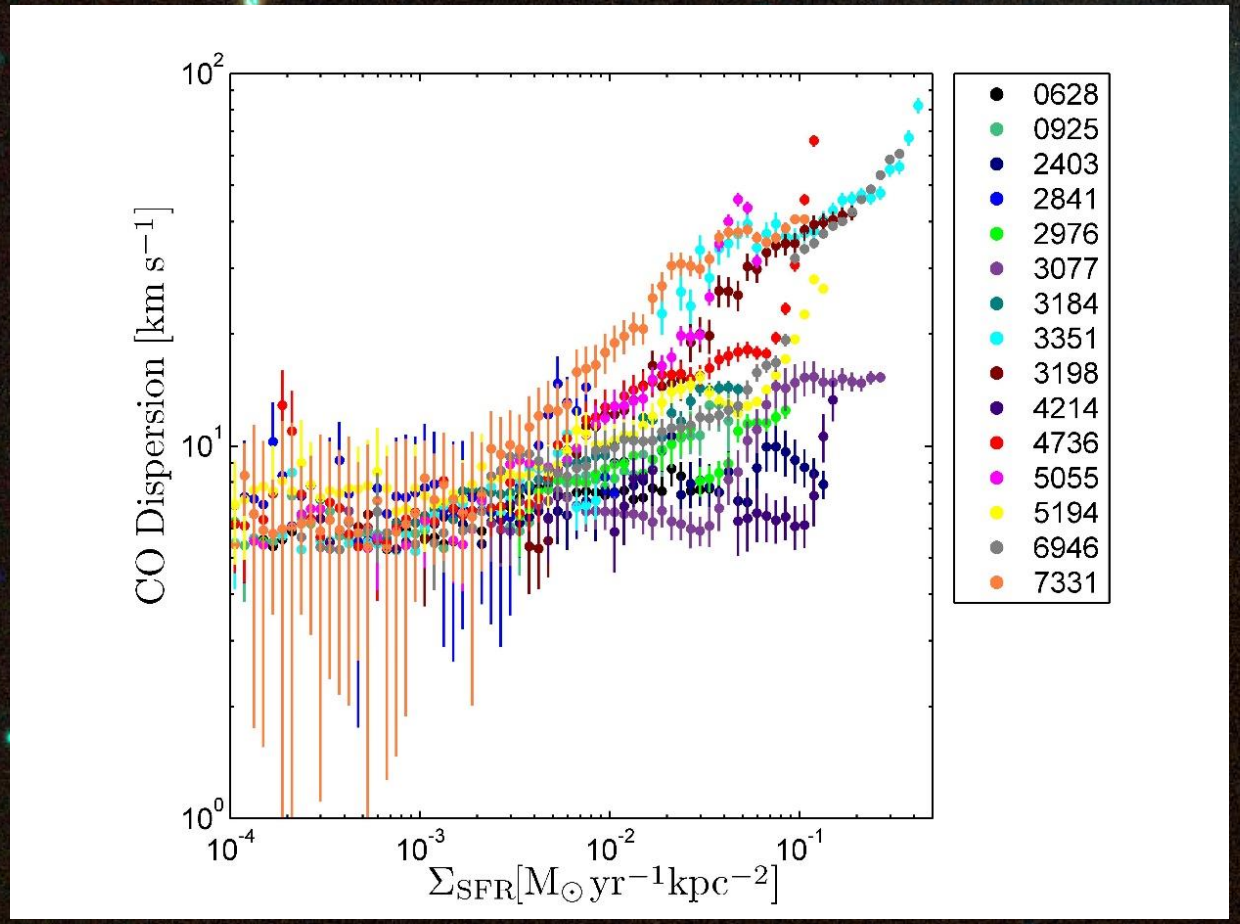
Mogotsi (MSc Thesis)

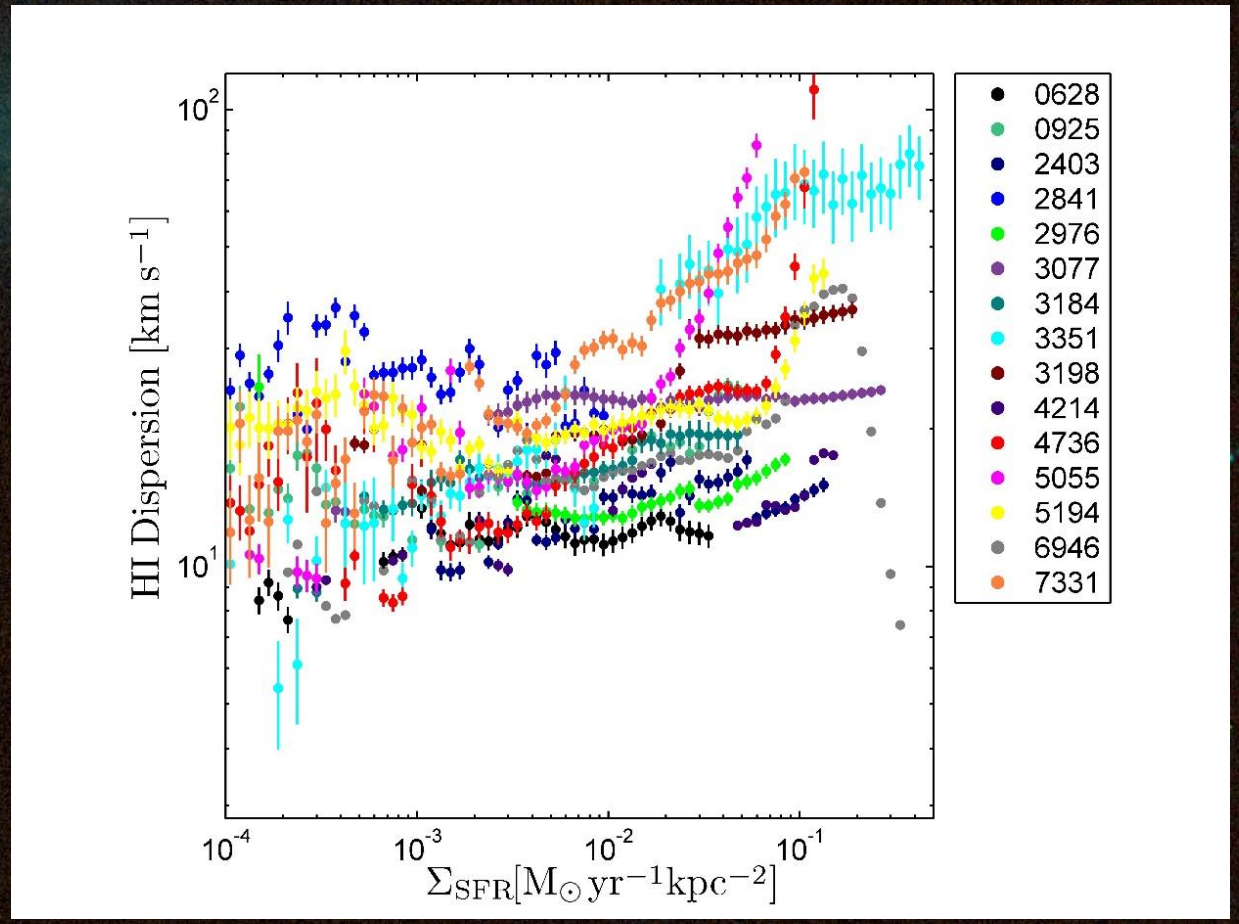




Feedback

Mogotsi (MSc Thesis)

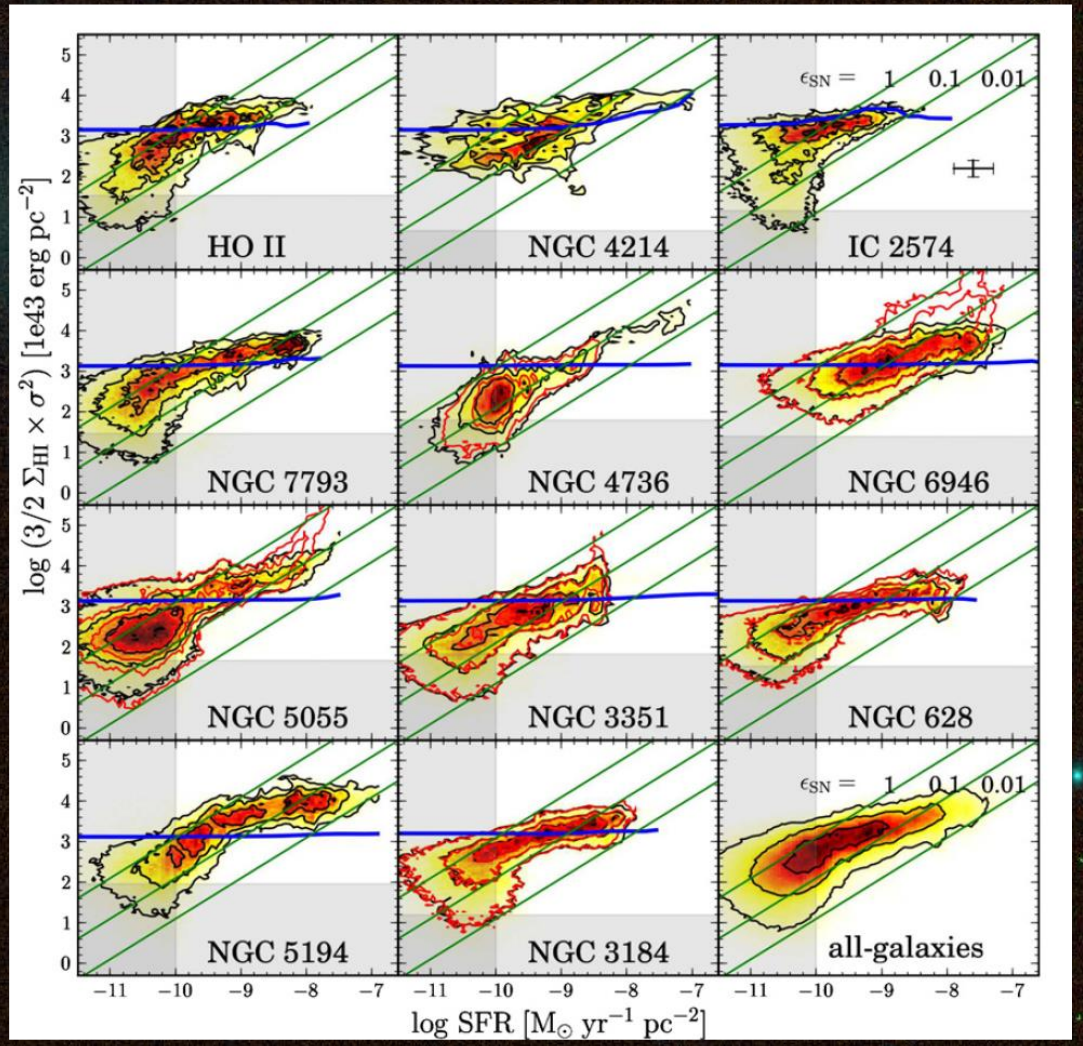




Feedback

- What drives the energetics of the ISM?
  - Does SF feedback explain all of it?
  - SN Feedback?
    Stellar Winds?
  - Magnetic Fields?

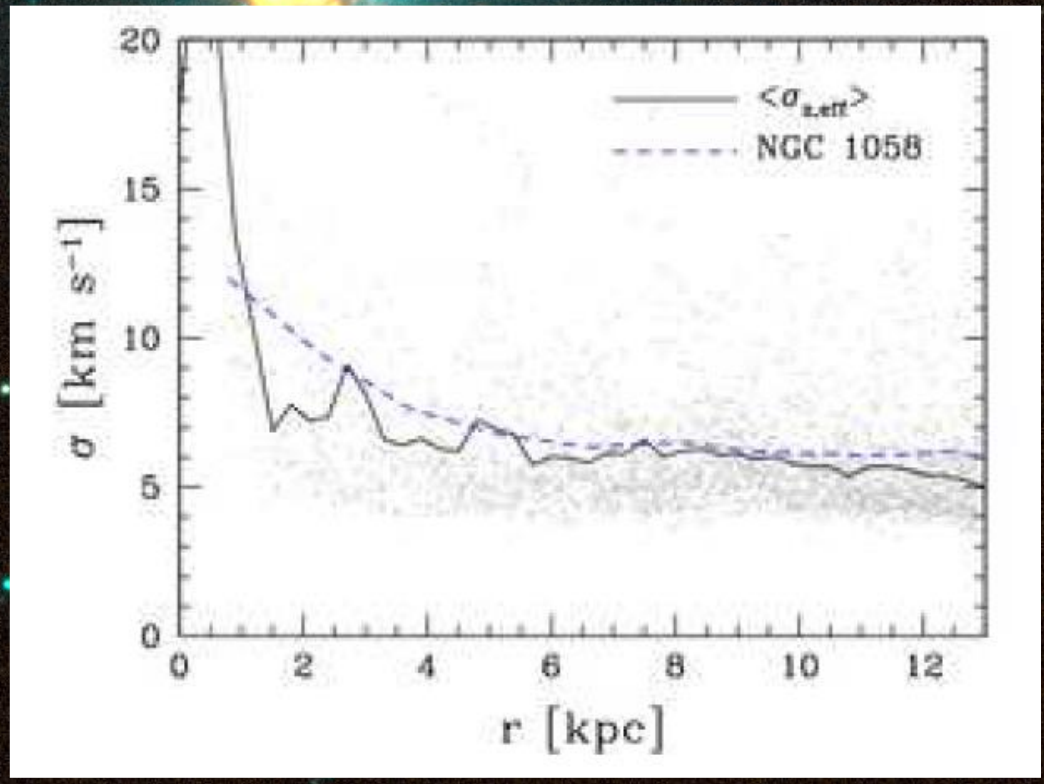
Tamburro + (2009)



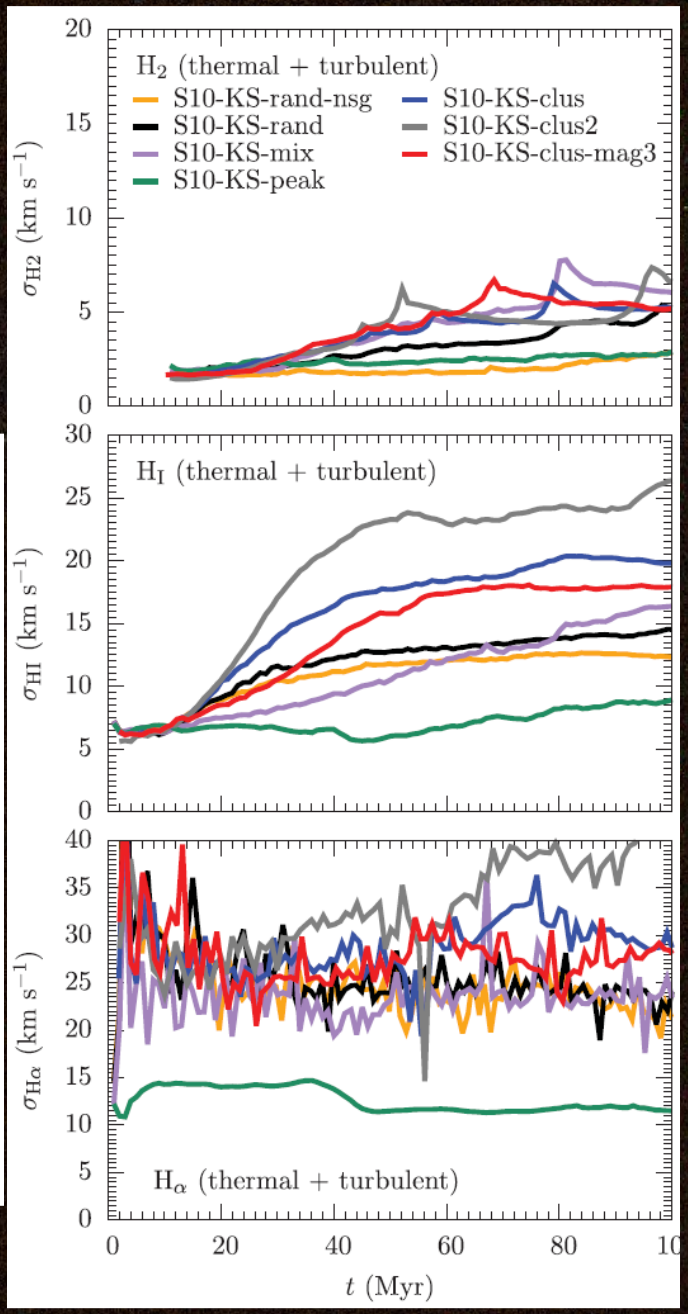
Feedback

- What drives the energetics of the ISM?
  - Does SF feedback…
  - SN Feedback? Stellar Winds?
  - Magnetic Fields?
- Test Simulations!

Agertz + (2010)



Girichidis + (2016)



Feedback : Winds!

- Galactic, SN, stellar winds, outflows…
- Low redshift starbursts and SF galaxies can have much lower outflow velocities than LIRGS, high-z galaxies

Schwartz & Martin 2004

Galaxy	v-v_{sys} (km s^{-1})
NGC 1569	−24
NGC 1614	−149
	+70
NGC 4214-2	−23
NGC 4449	−34
M82	−91
	−35
	+4
	+45
	+86
NGC 2363	...
NGC 4214-1	...
NGC 5253	...
I Zw 18	...

Galaxy	v-v_{sys} (km s^{-1})
NGC 1569	−24
NGC 1614	−149
	+70

MHONGOOSE

- MeerKAT HI Observations of Nearby Galactic Objects : Observing Southern Emitters (de Blok+)

- How do galaxies get their gas?
- How is star formation regulated?
- How are outer disks & the cosmic web linked?

- Deep HI Observations
- 6000h – 30 galaxies [originally]
- 1650h – 30 galaxies [revised]
- MeerKAT
- SINGG-derived precursor sample (96 galaxies)
  - Sample (30) has been chosen
  - Ancillary Data, characterize final sample

MHONGOOSE Update

- 6000h – 30 galaxies [originally]
- 1650h – 30 galaxies [revised]
- MeerKAT updated sensitivity –
  - For HI to reach: 0.074mJy/beam [@5 km/s] needed 200hrs
  - Now to reach 0.074mJy/beam [@ 5 km/s] need 55hrs

SINGG

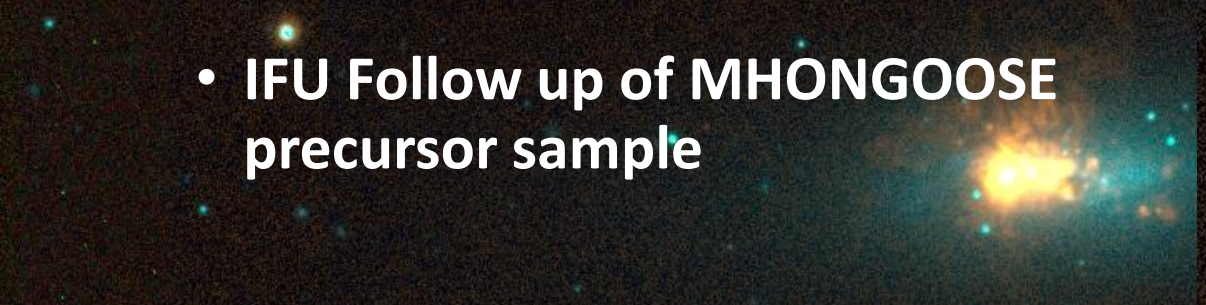
- Survey for Ionization in Neutral Gas Galaxies
  - Meurer et al. (2006),
  - Hanish et al. (2006),
  - UV subsample: Wong 2007

- H-alpha, R-band, UV photometry
- WISE NIR Data
  - (Jarrett priv. comm)

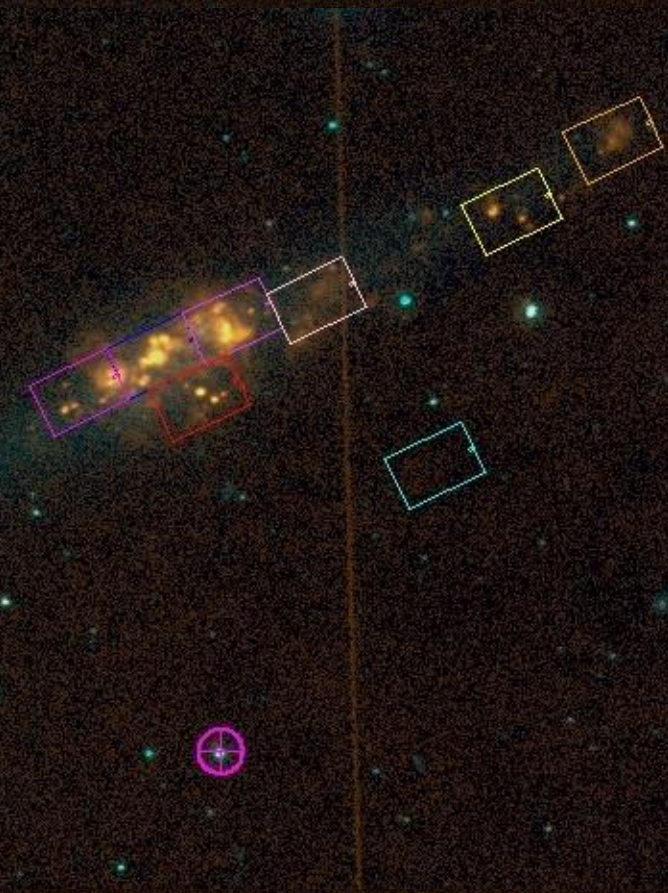
MHONGOOSE-WiFeS

with G. Meurer, + collaborators

- **IFU Follow up of MHONGOOSE precursor sample**

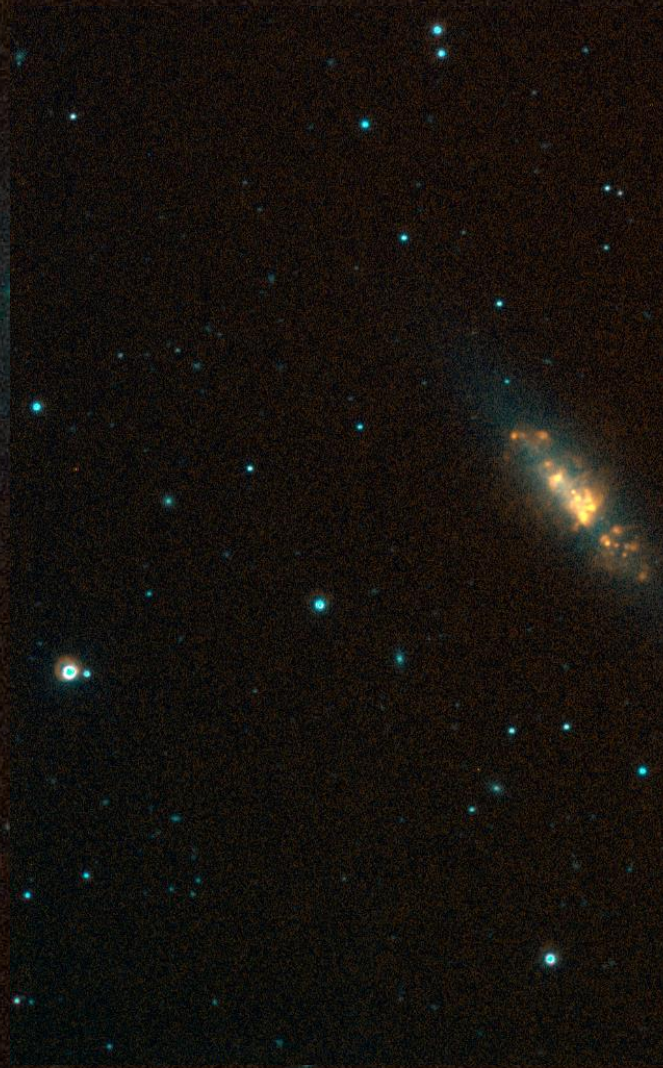


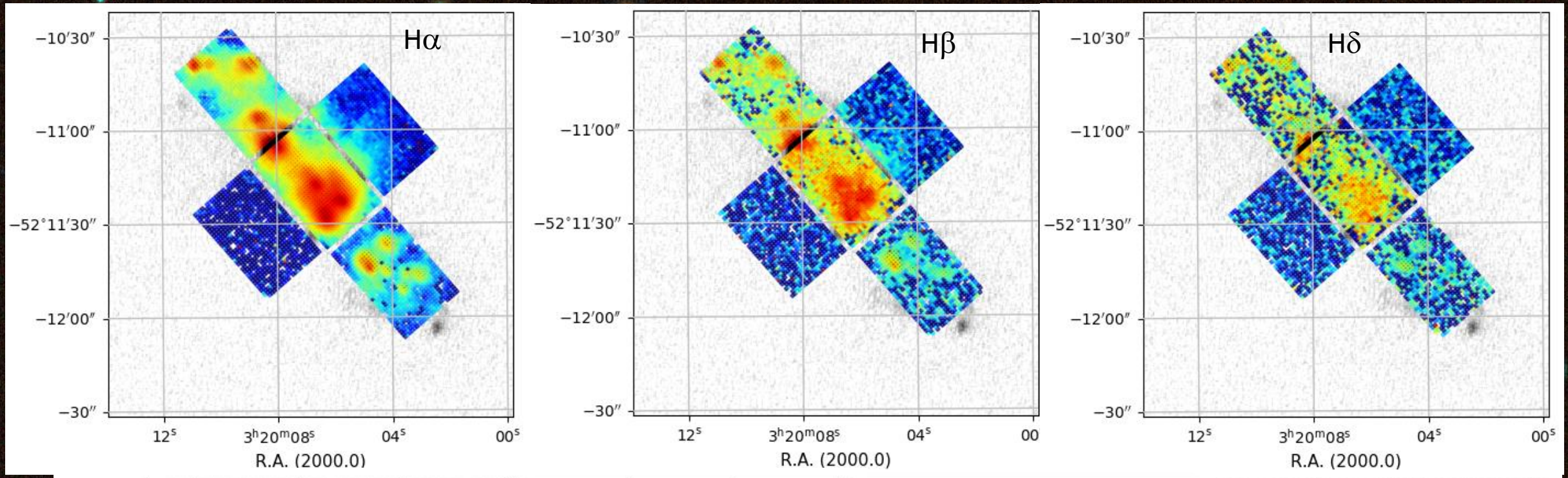
- **Siding Spring: 2.3m ANU Telescope**
- **WiFeS : Dopita et al. (2007)**
- **IFU**
- **FOV: 25” x 38”**
- **1” Res, Seeing-limited**
- **Blue : 320-590nm (0.077nm)**
- **Red : 530-706nm (0.044nm)**

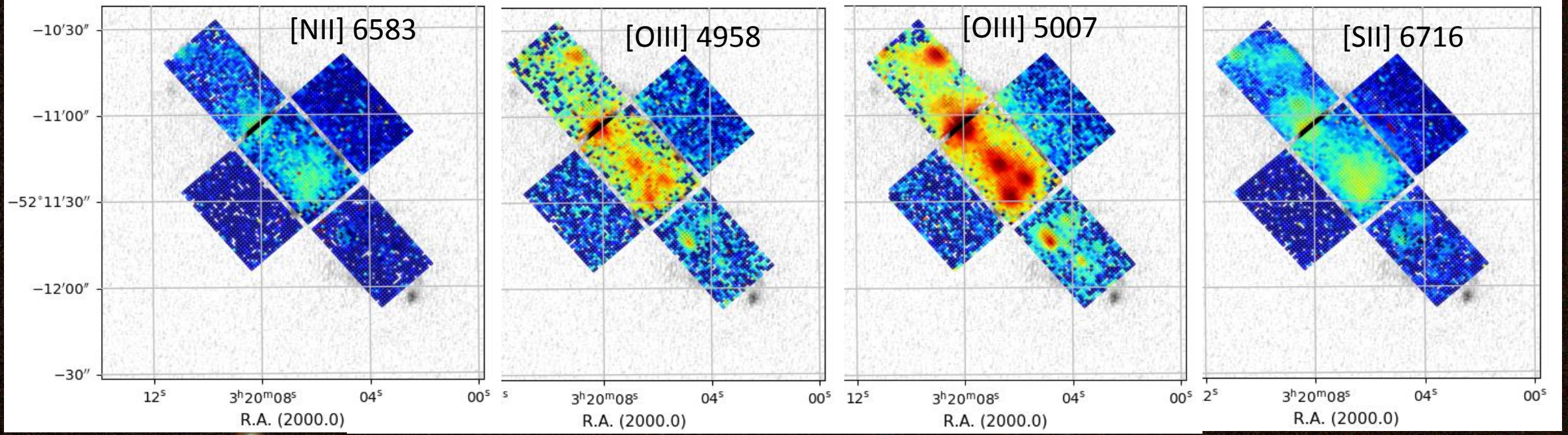


J0320-52

- NGC 1311
- D=6.99 Mpc
- Log MHI = 8.25
- Inc = 74 deg
- W50 = 30km/s

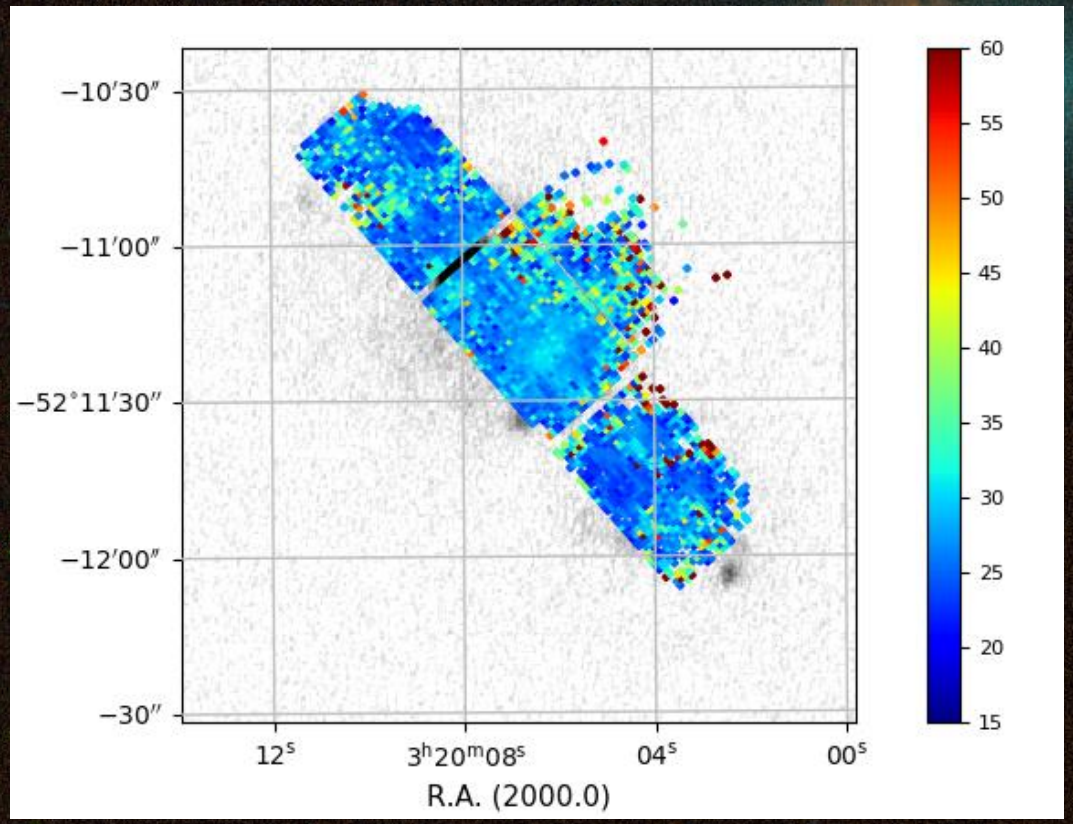



Hα
Hβ
Hδ
−10′30″
−11′00″
−52°11′30″
−12′00″
−30″
12ˢ
3ʰ20ᵐ08ˢ
04ˢ
00ˢ
R.A. (2000.0)

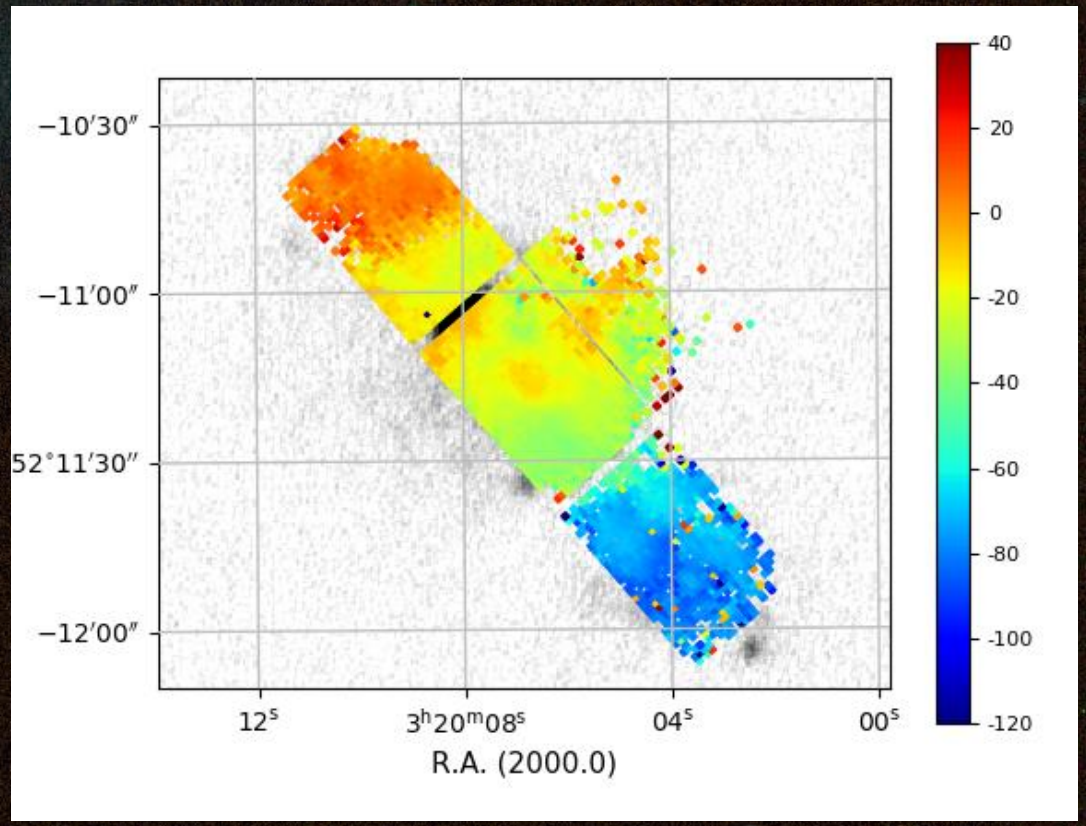

[NII] 6583
[OIII] 4958
[OIII] 5007
[SII] 6716
−10′30″
−11′00″
−52°11′30″
−12′00″
−30″
12ˢ
3ʰ20ᵐ08ˢ
04ˢ
00ˢ
R.A. (2000.0)

J0320-52 Kinematics

Dispersion [km/s]



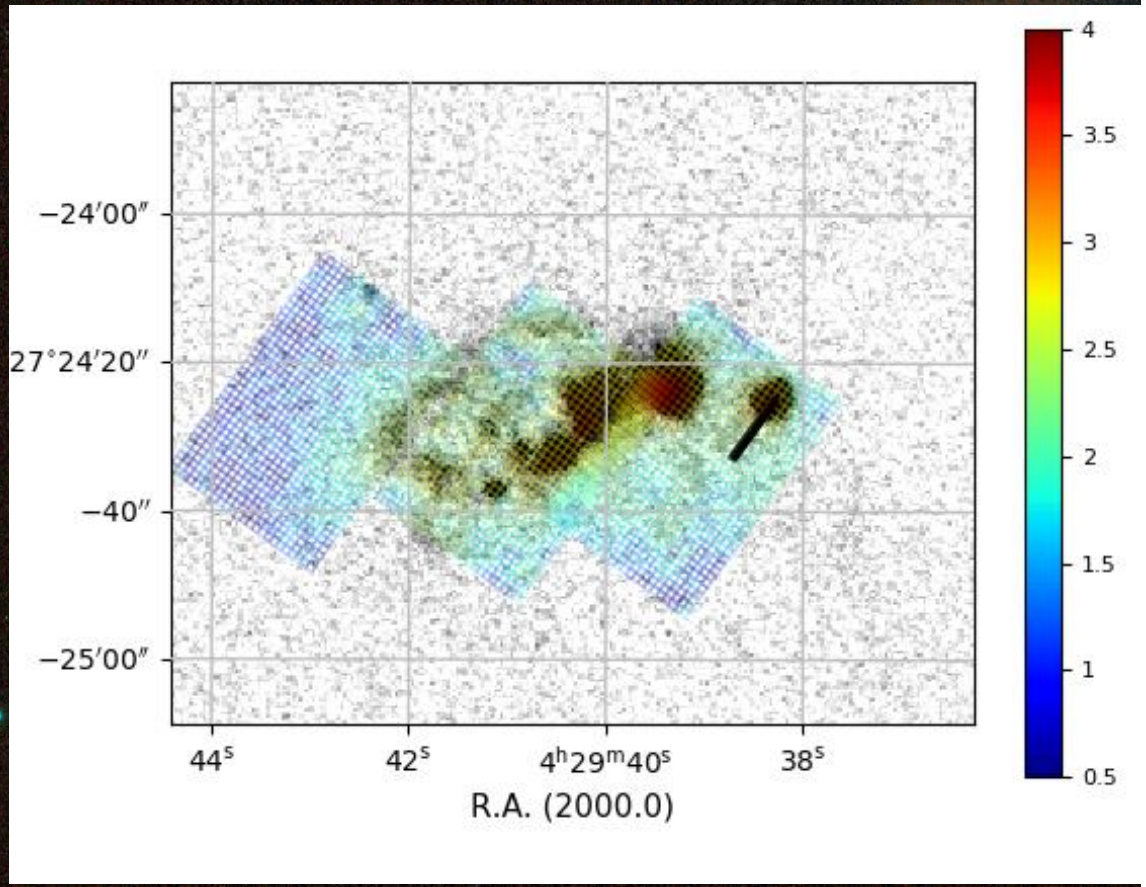
Velocity [km/s]

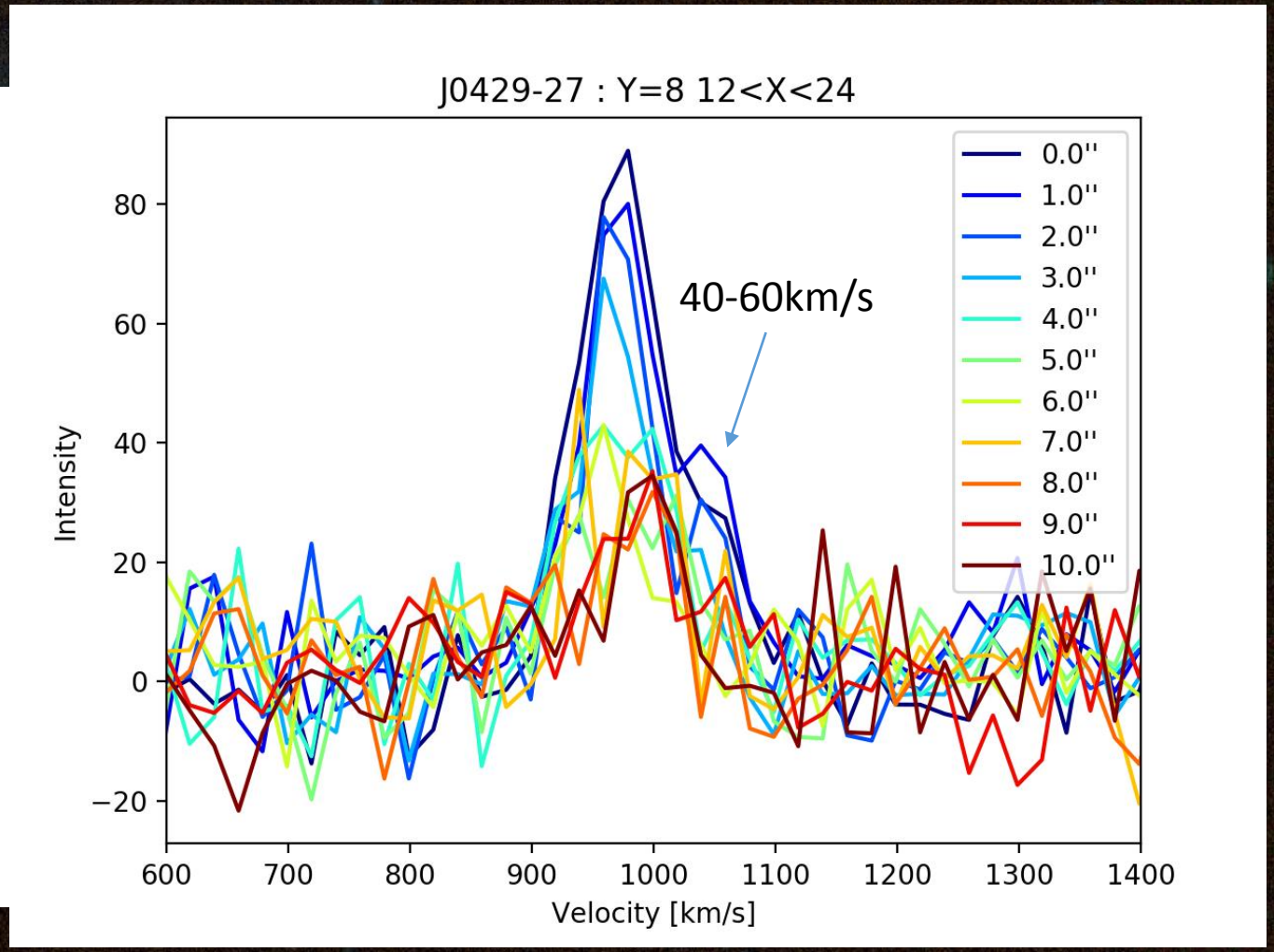


J0429-27

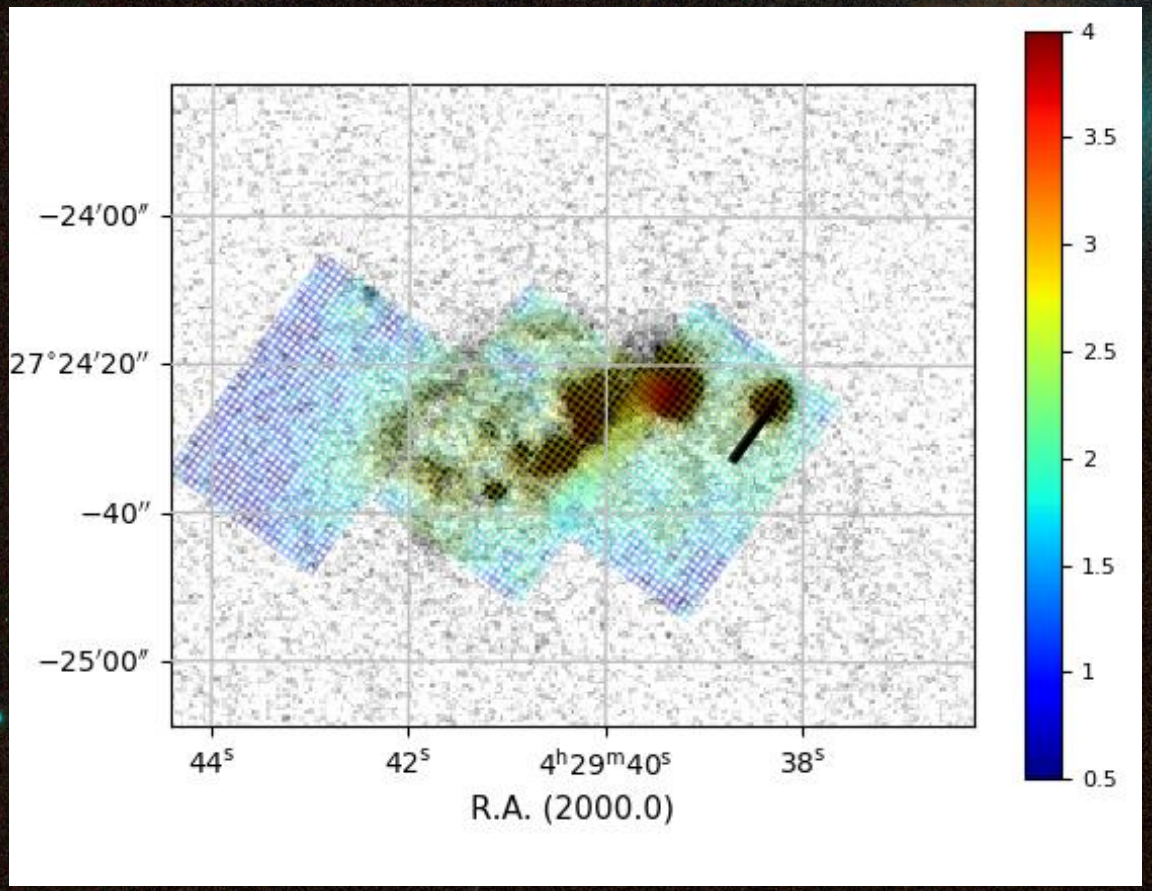
- NGC 1592
- D=13 Mpc
- Log MHI = 8.37
- Inc = 74 deg
- W50 = 73 km/s

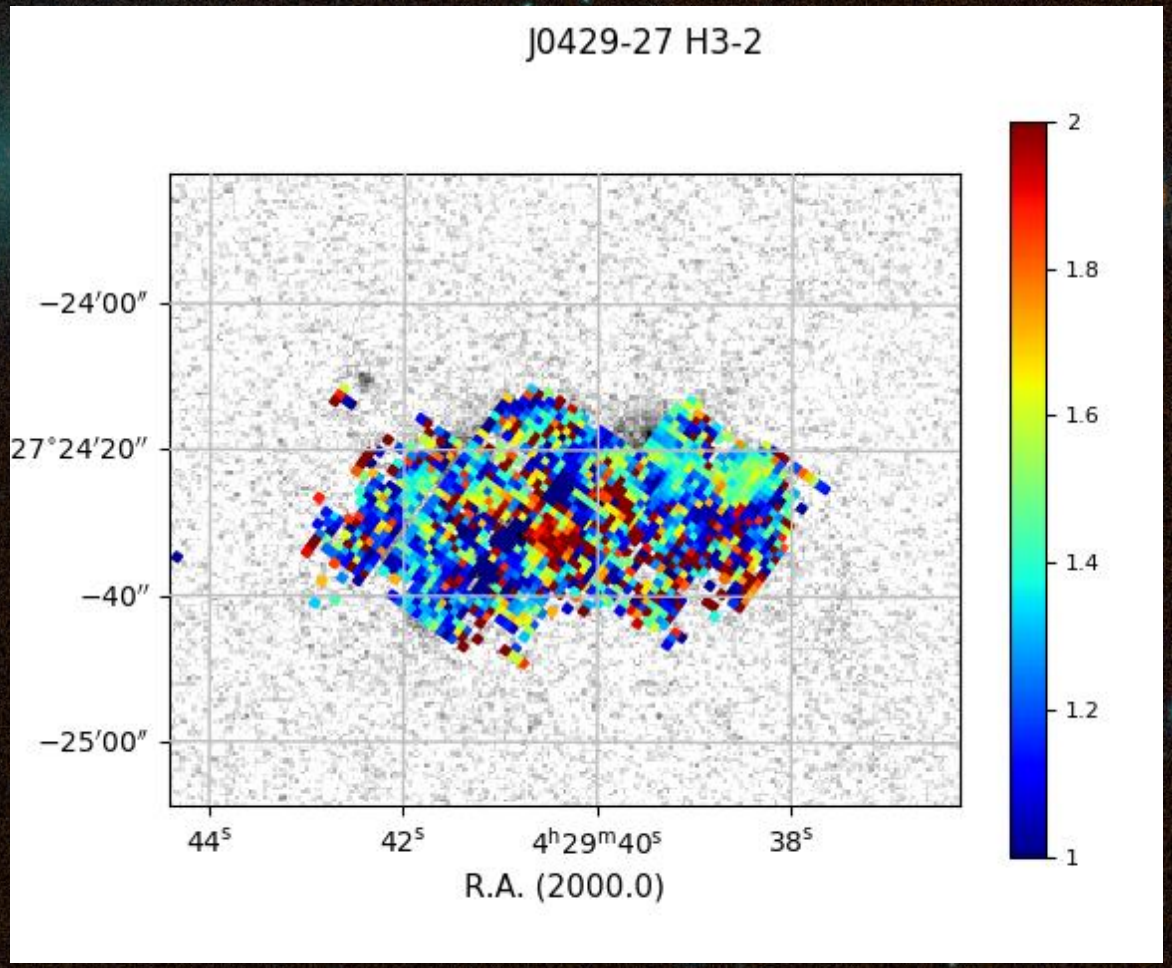
J0429-27 Winds? Profile Analysis



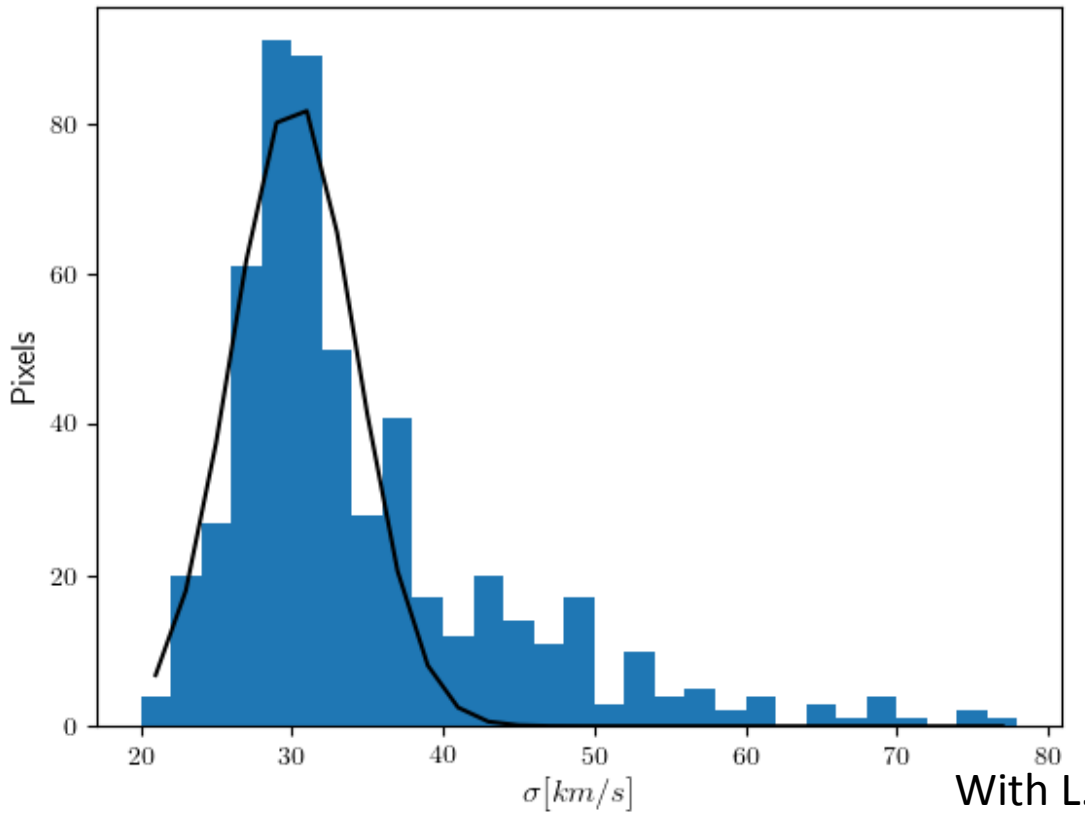


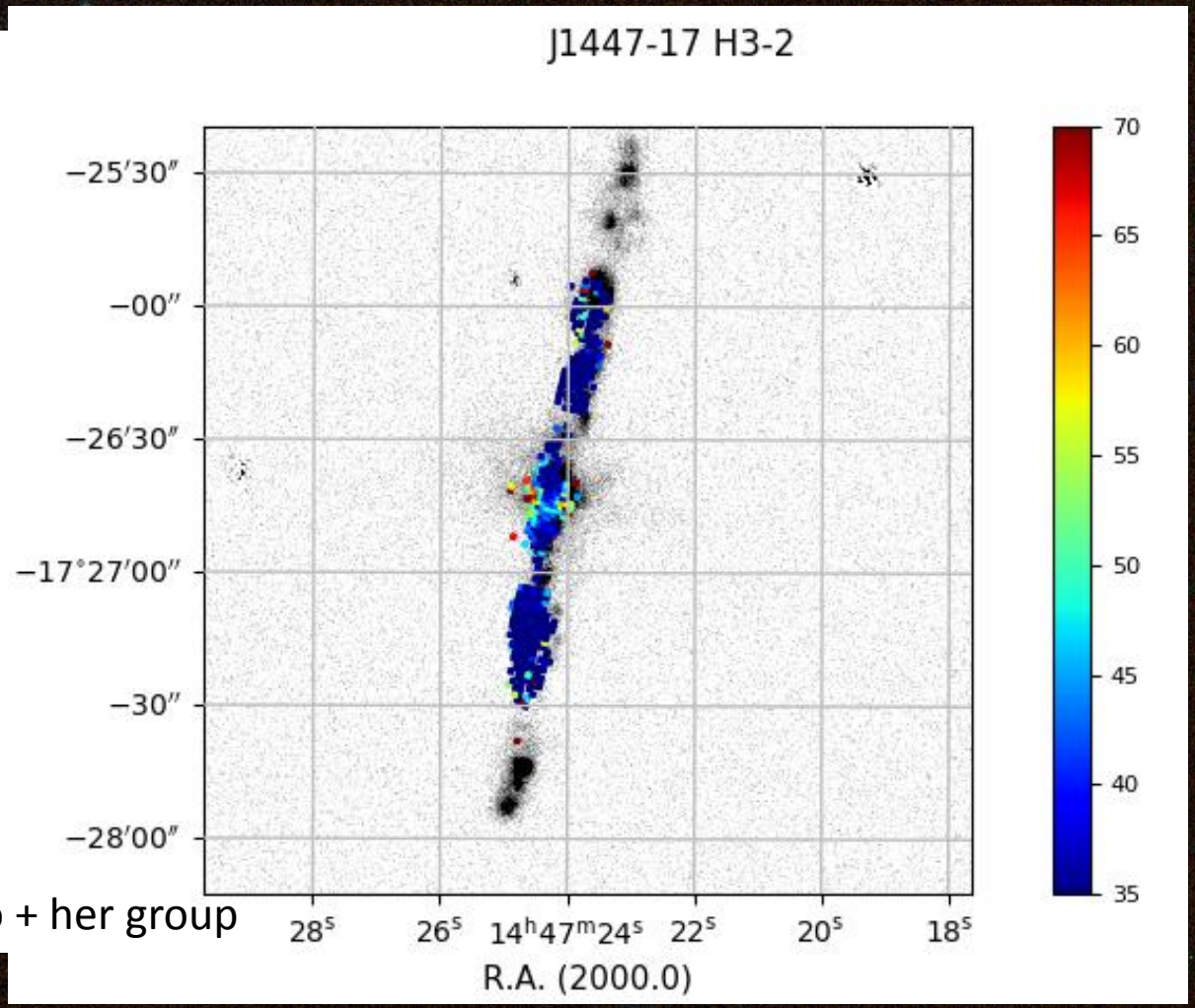
J0429-27 Winds? Profile Asymmetry





J1447-17 Winds? Dispersion Distributions





With L. Hao + her group

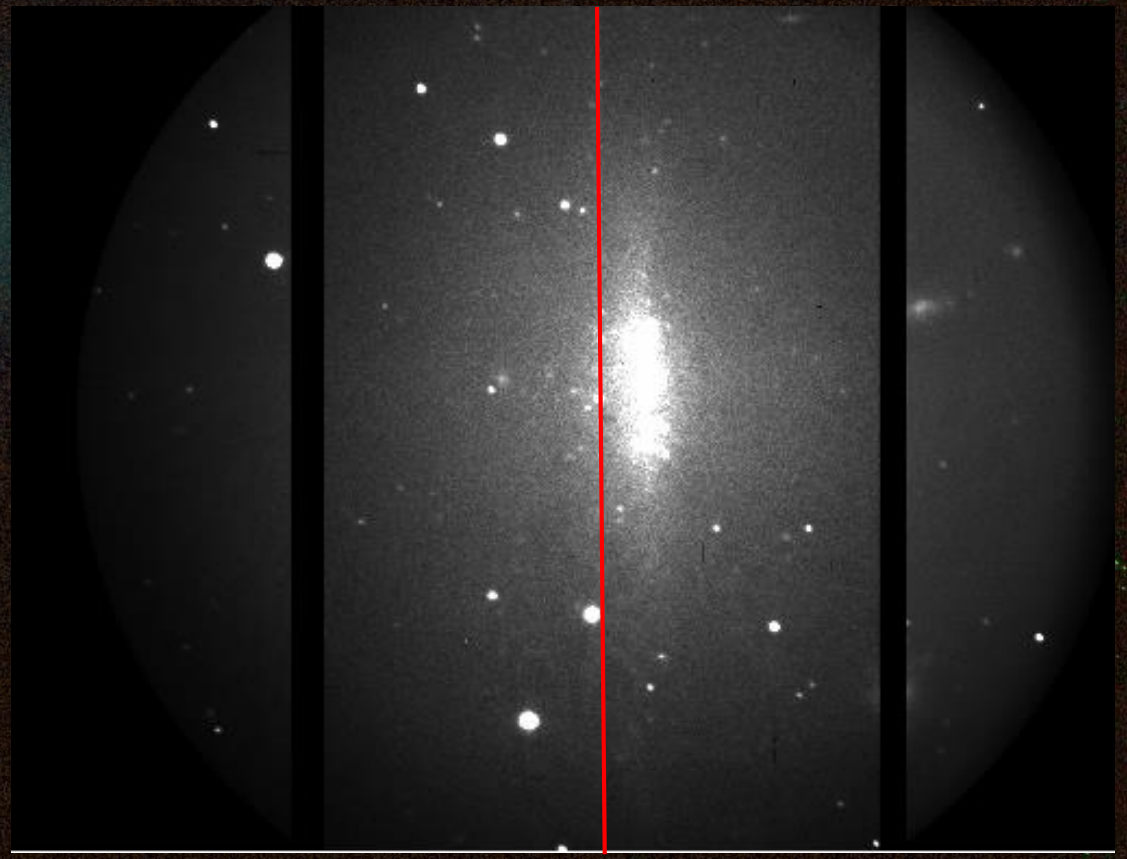
MHONGOOSE-WiFeS

- 4 Observing Runs
- >26 galaxies

- Stacking/smoothing and kinematic analysis
- ISM Characterization
- Stellar Population Analysis

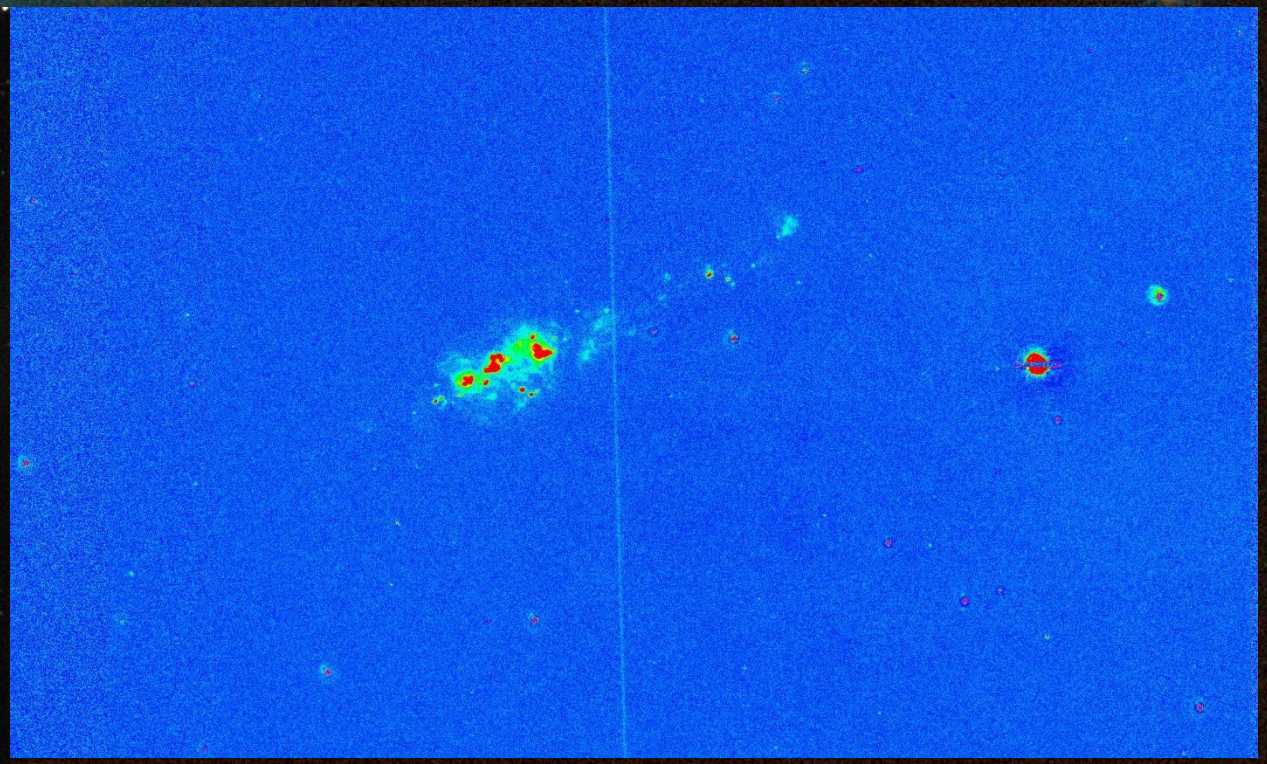
SALT - MHONGOOSE (with P. Väisänen)

- SALT RSS Long-slit Pilot Study
- Kinematics
- Outer Regions of Galaxies
- Diffuse Ionized Gas detection kinematics
- Winds/outflows



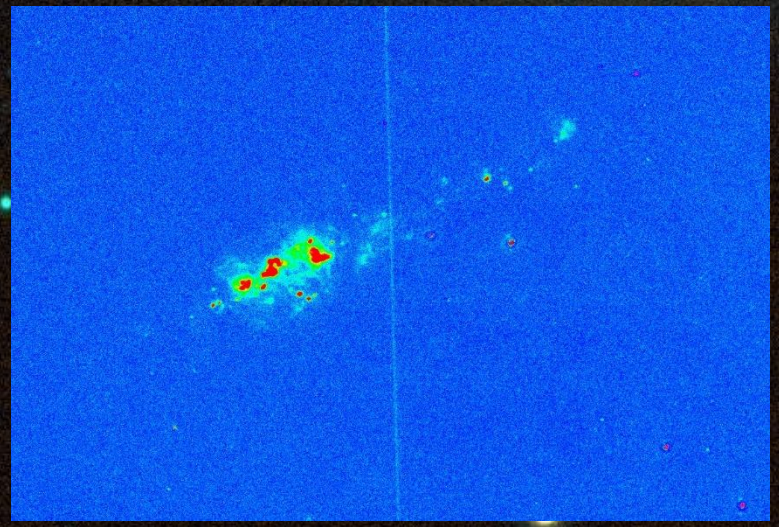
SALT WINDS & OUTFLOWS

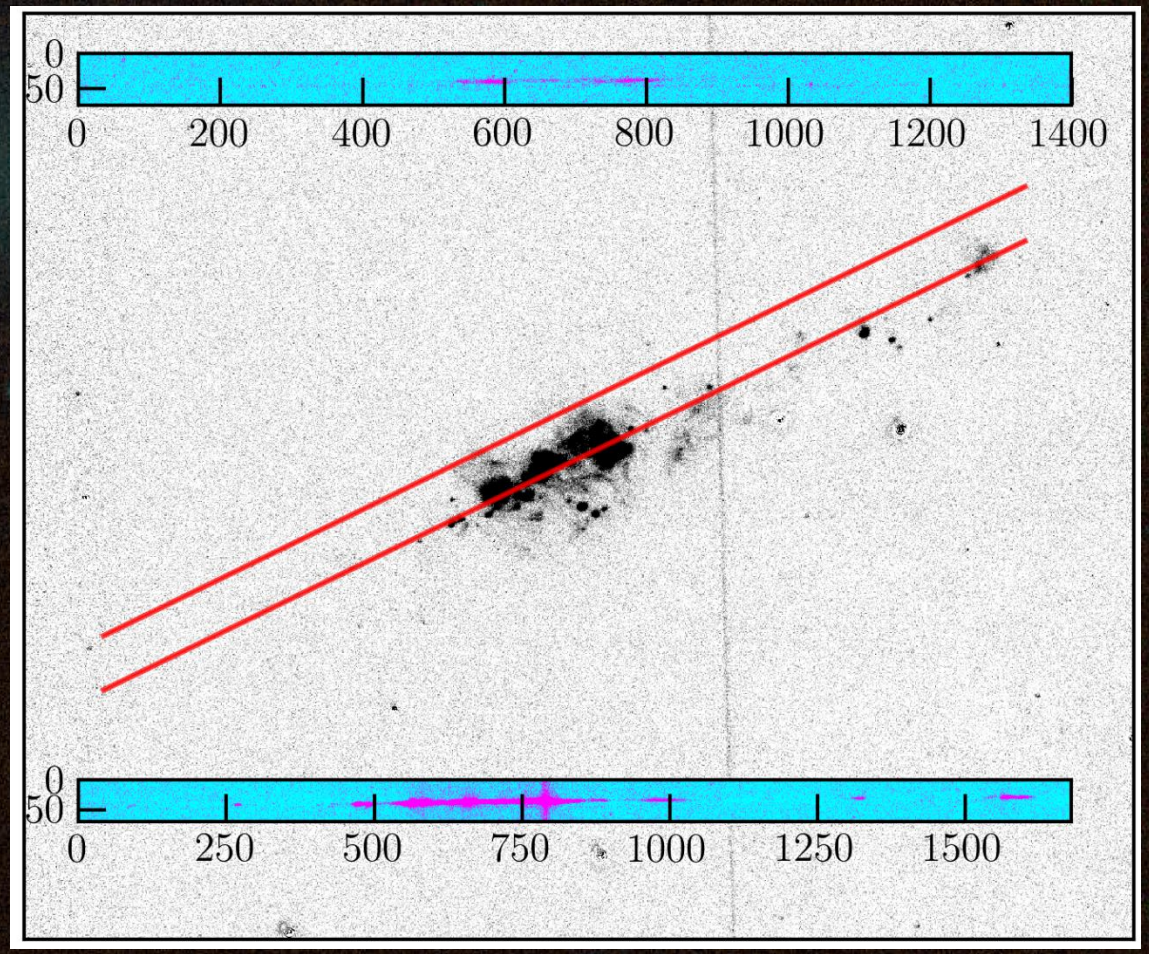
- J1303-17b (UGCA 320)
- D=7.74 Mpc
- Log (MHI) = 9.12 Msol



J1303-17b : SALT WINDS & OUTFLOWS

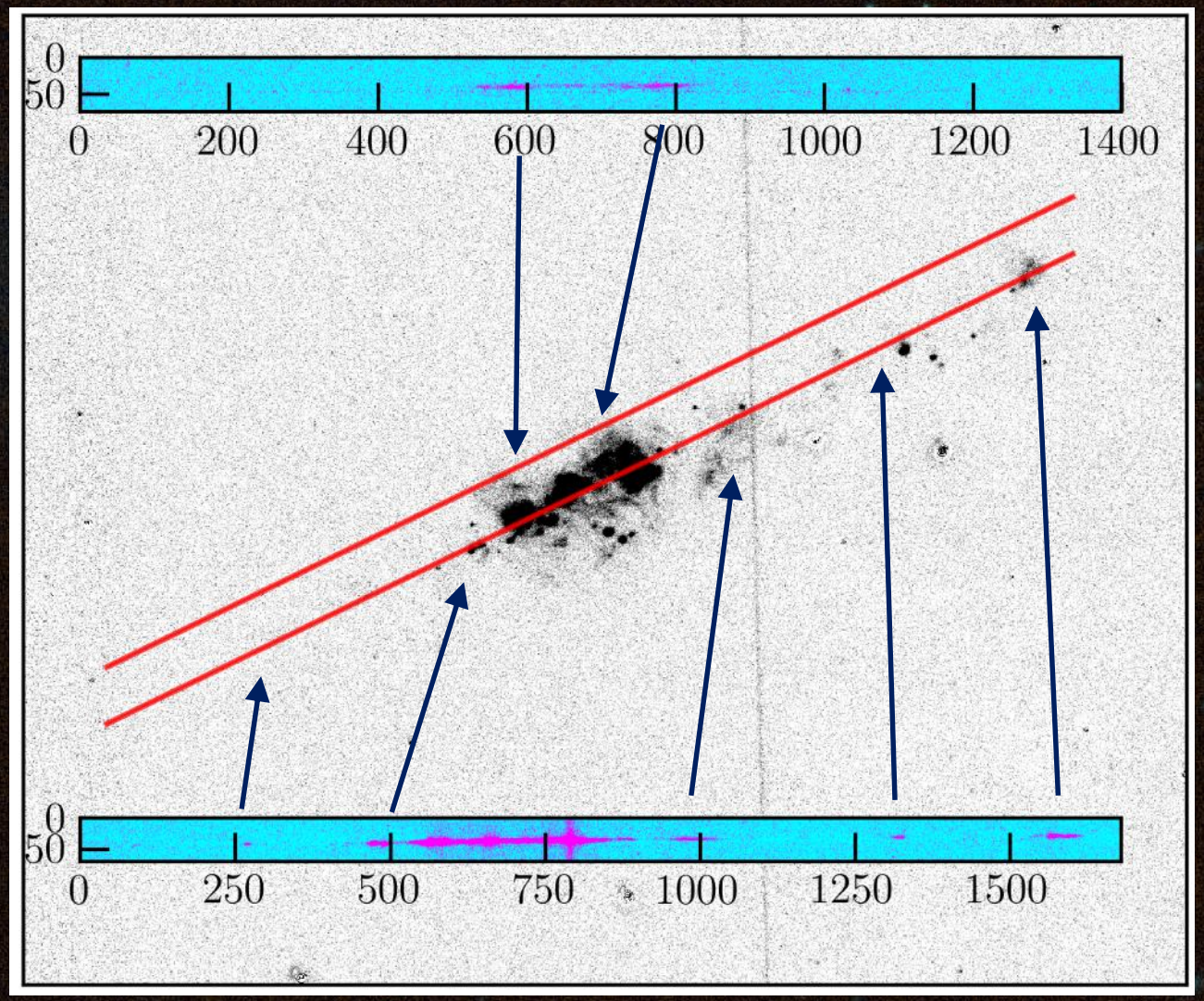
- 3 Slit Positions: Center + Off-plane
- PG2300 : Hα @ ~< R10,000
- PG1800 : Na D, SII,… @ R4,000





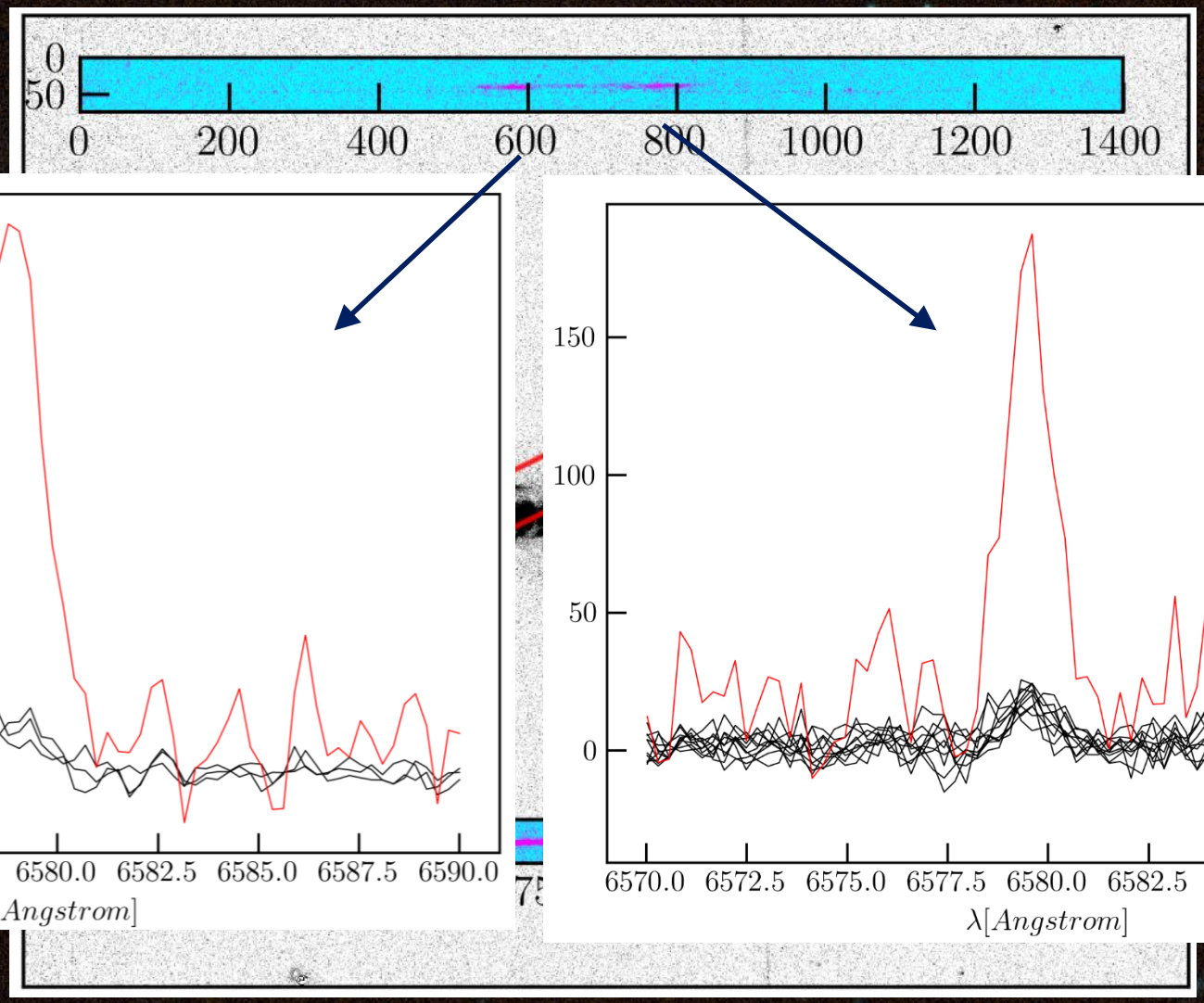
J1303-17b : SALT WINDS & OUTFLOWS

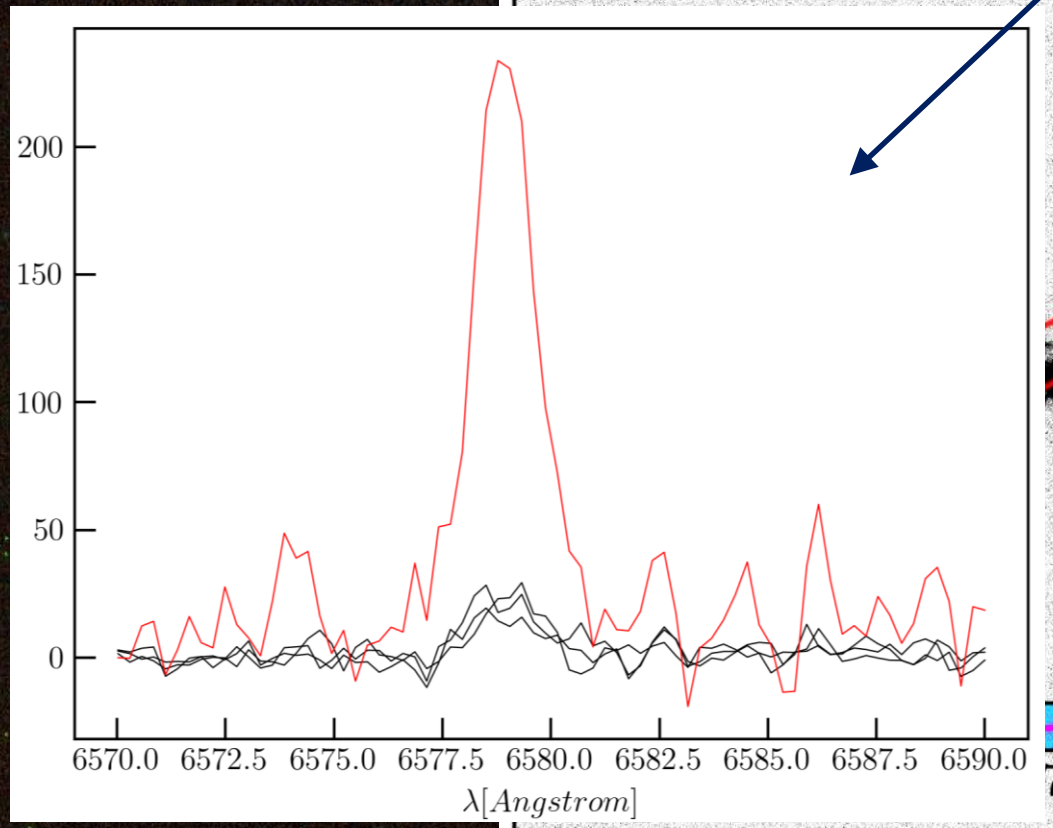
- PG2300 Hα

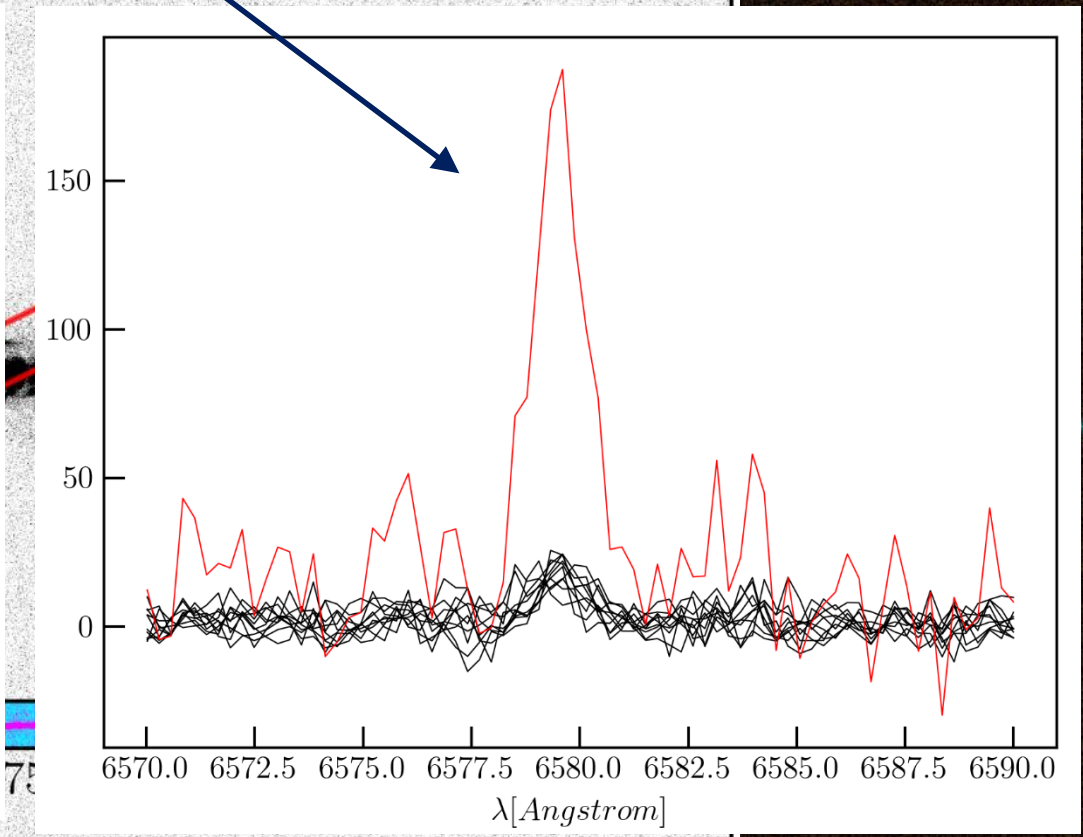


J1303-17b : SALT WINDS & OUTFLOWS

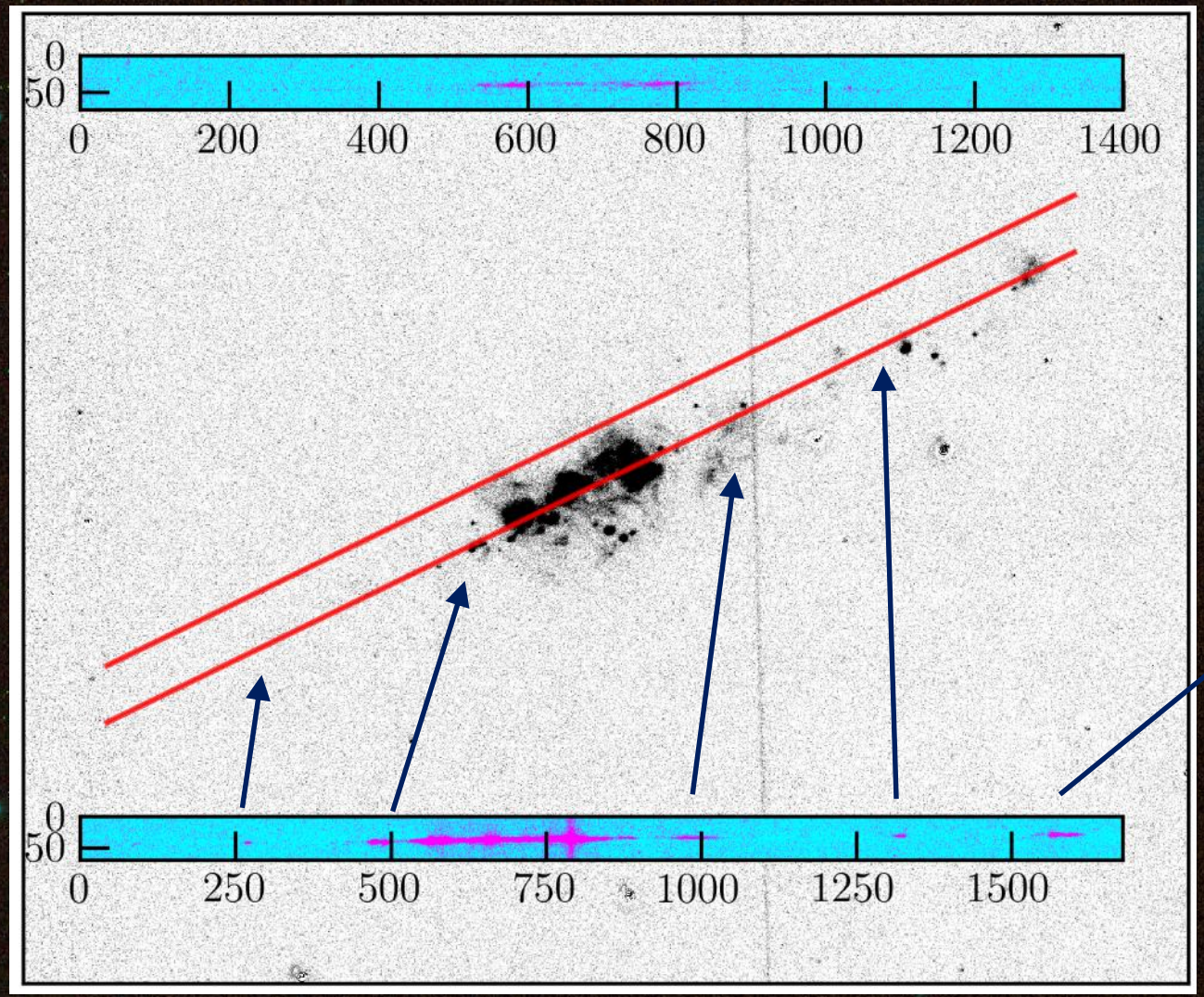
- PG2300 Hα

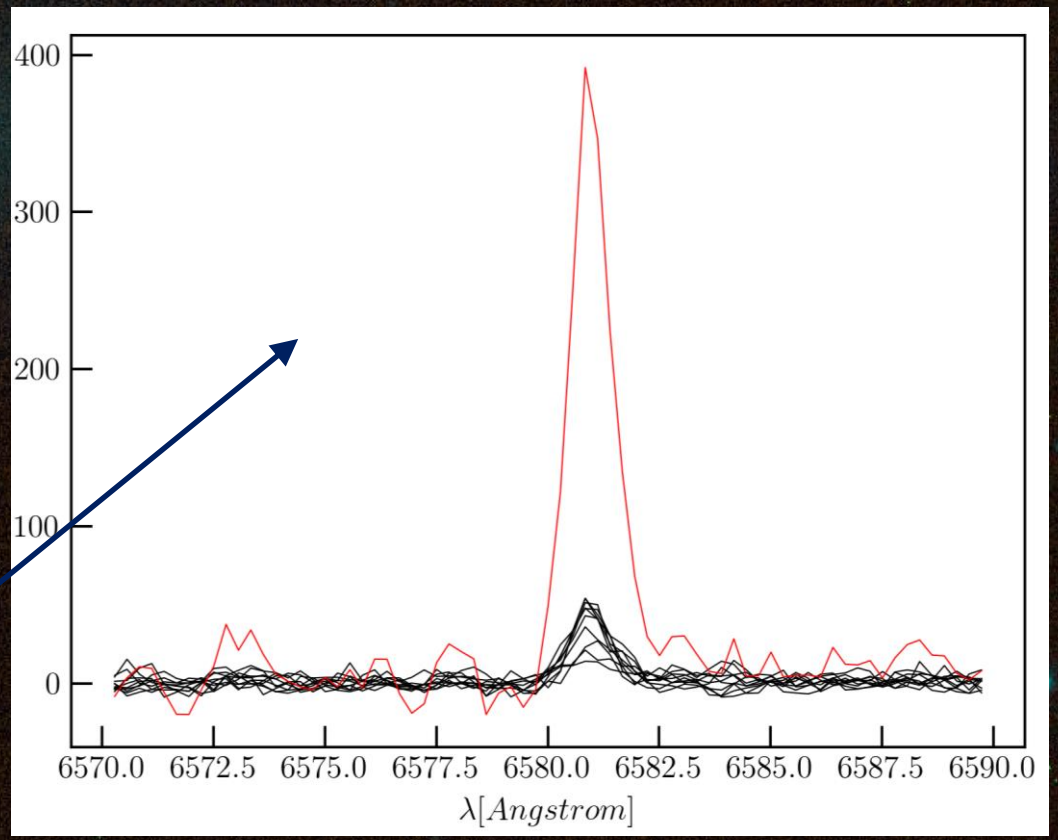






J1303-17b : SALT WINDS & OUTFLOWS

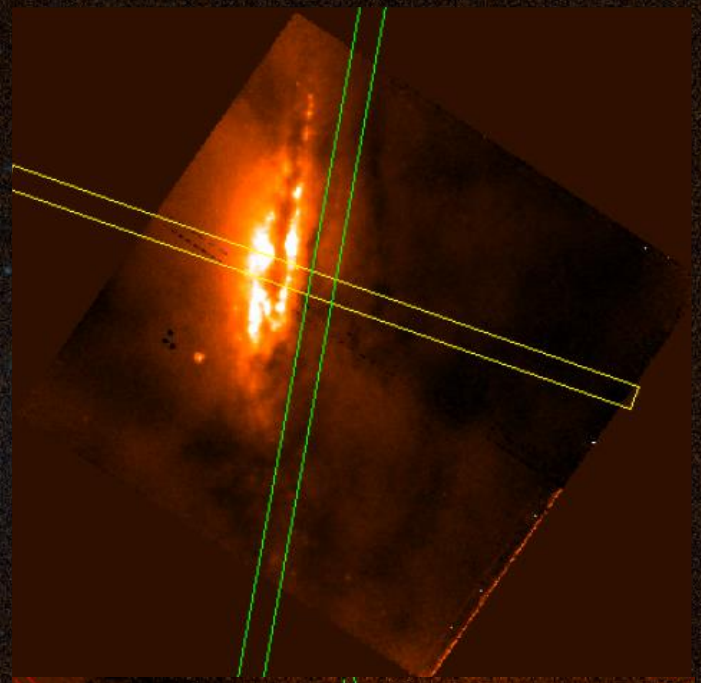


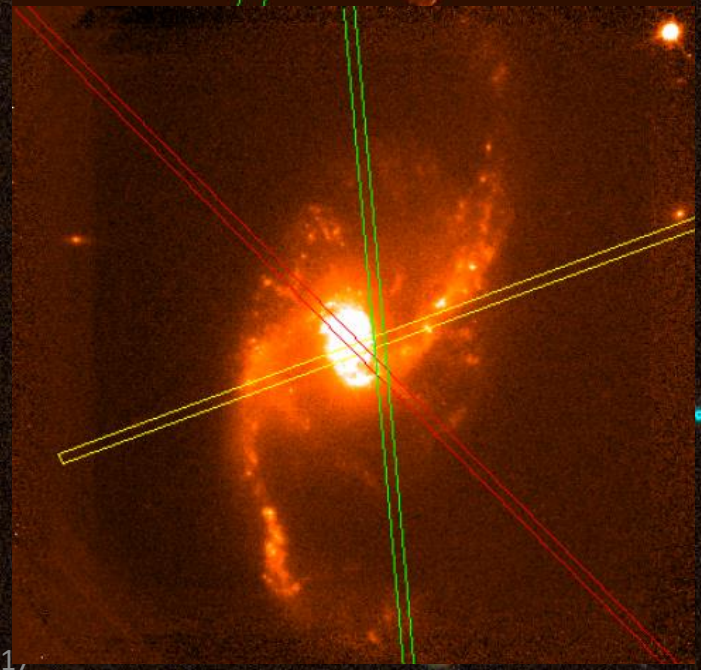


To LIRGS And Beyond!

(Väisänen, Rajin Ramphul, Melaku Sisay* +)

- SALT RSS Observations of LIRGS
- Kinematics, Star Formation, Stellar Population Modelling & ISM Characterization
- Outflow Properties and Kinematics





To LIRGS And Beyond!

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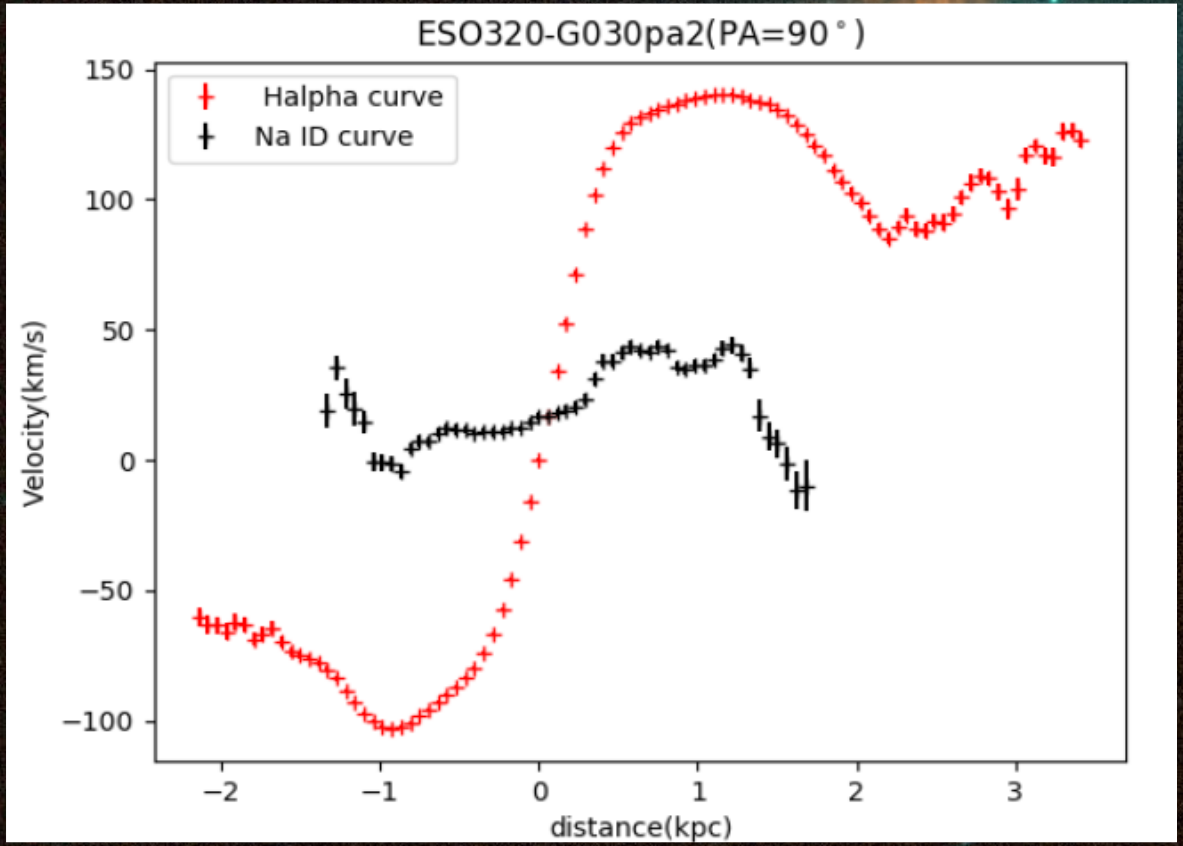
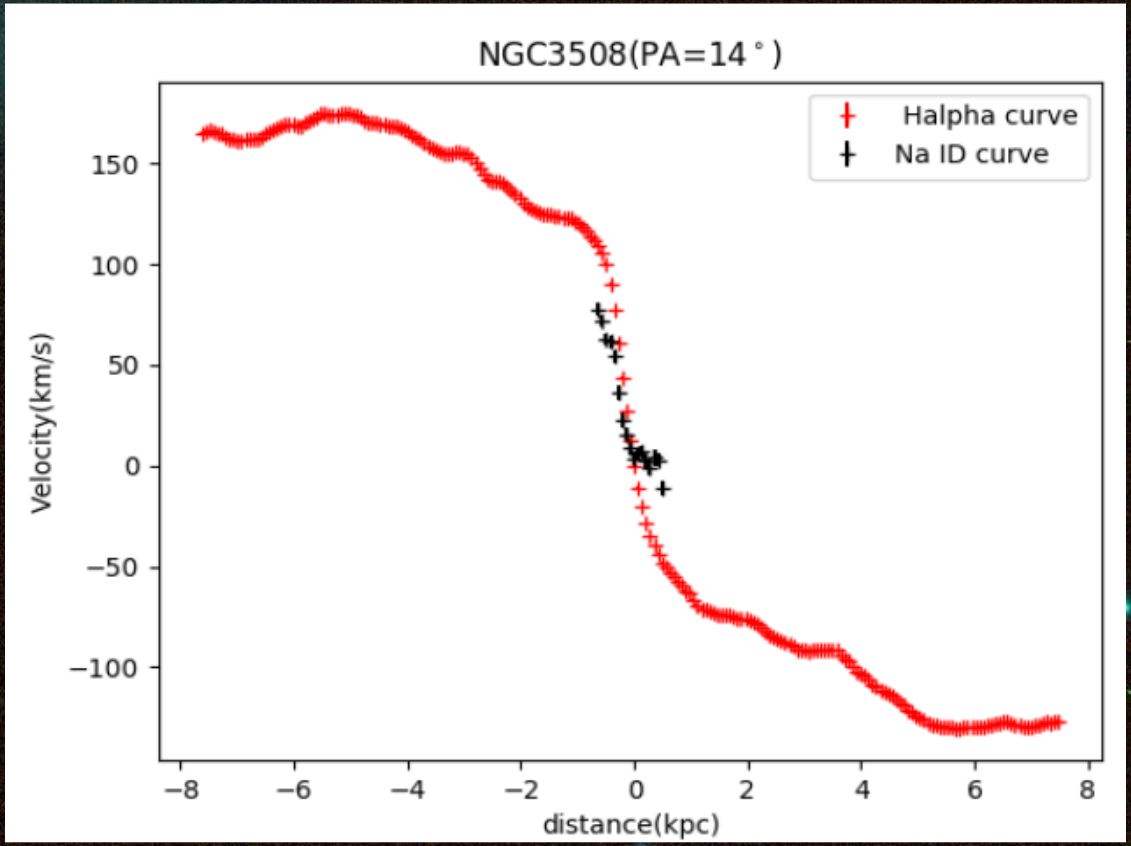
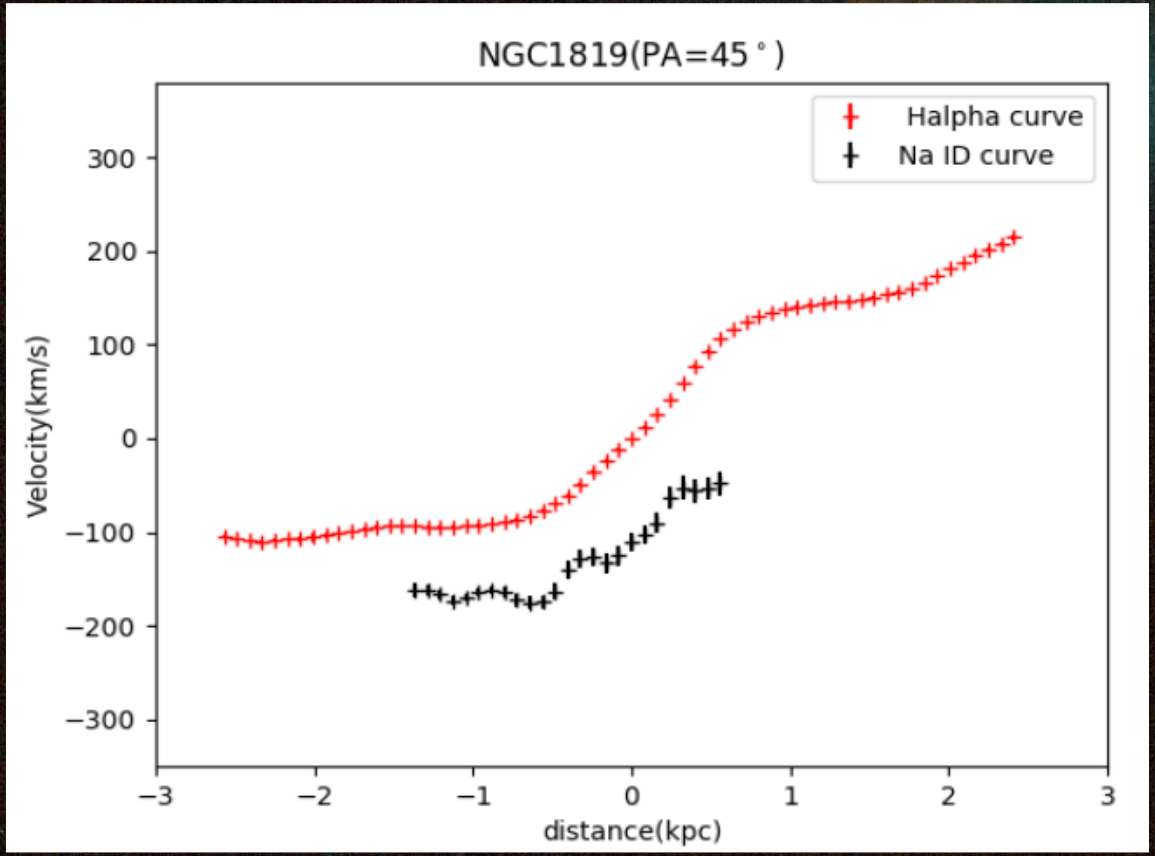
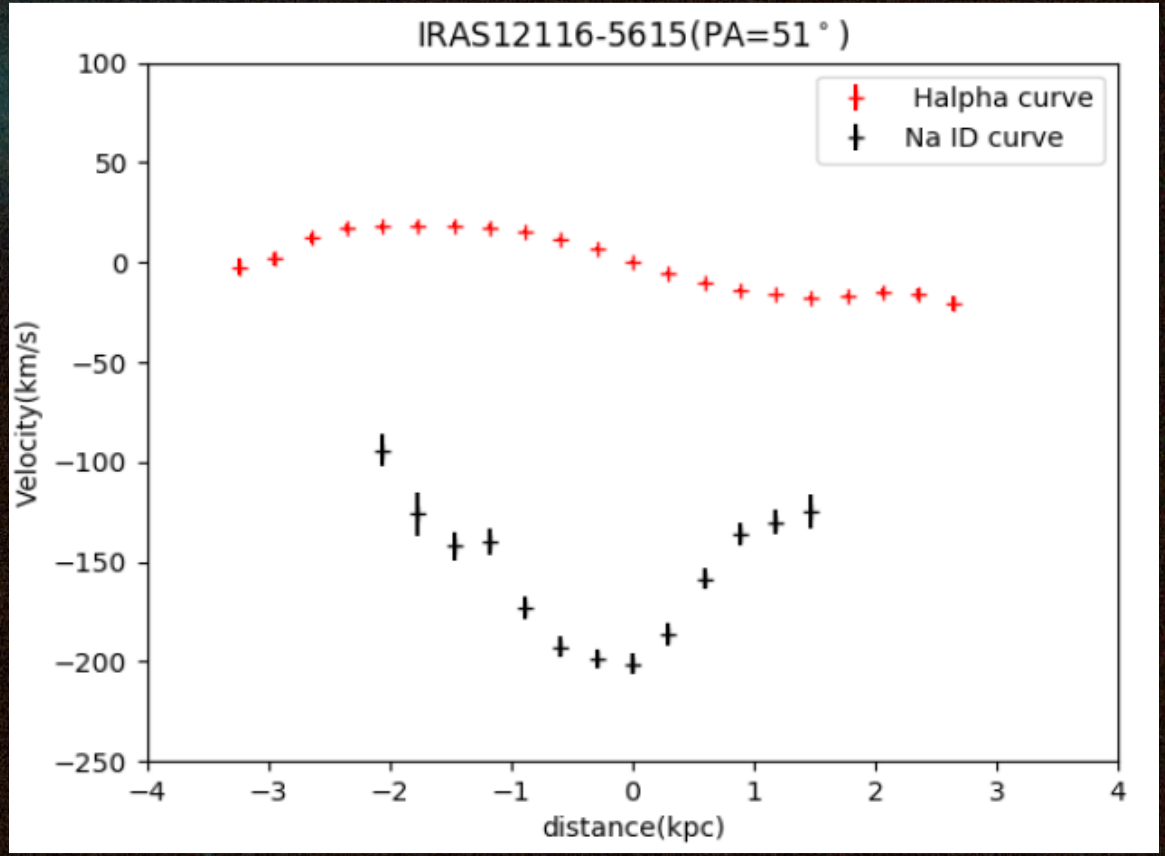




To LIRGS And Beyond!

(Väisänen, Rajin Ramphul, Melaku Sisay* +)





The Future

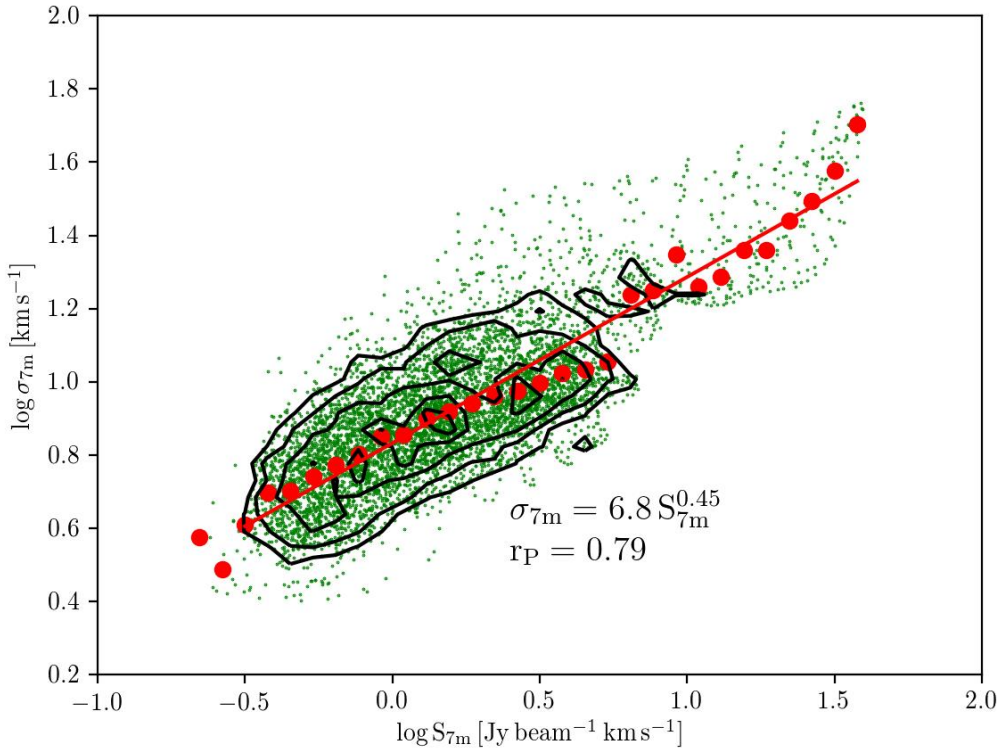
- Further analysis of data

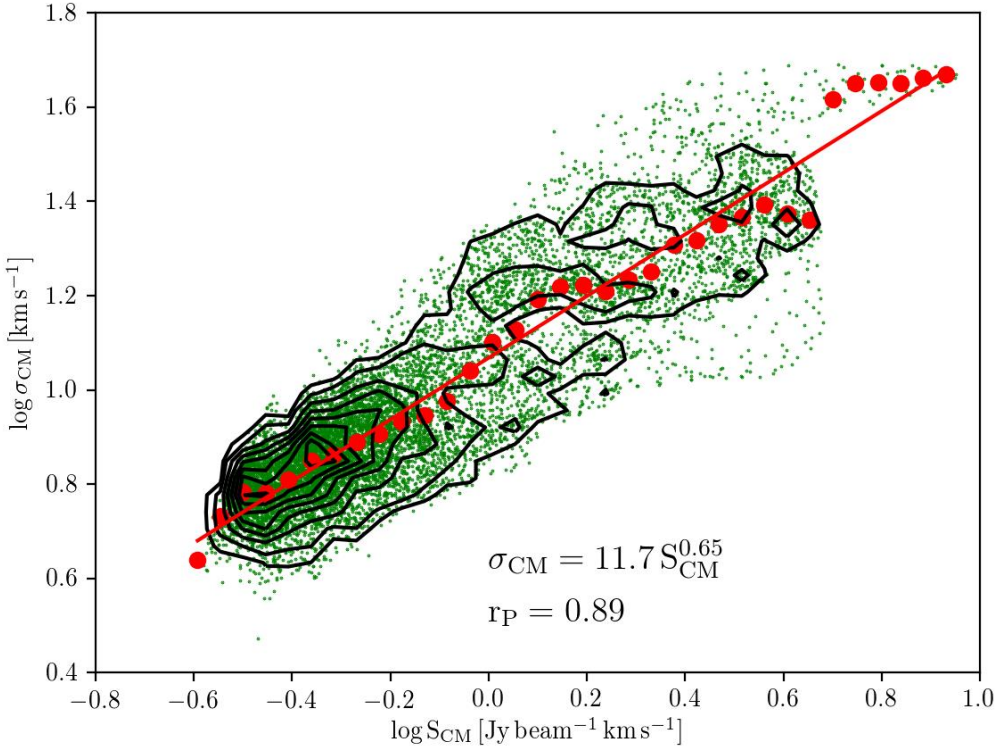
- SUNBIRD complement to MHONGOOSE?
  - Deep HI study of nearby starbursts and LIRGS
    - Environment – diffuse gas in outer regions
    - Neutral gas kinematics, ouflow + ISM dynamics
    - Variability?

Moses Mogotsi, SUNBIRD, Cape Town, 20/11/2017

Winds/Velocities via Gas Dispersions between GMCs at Large scales

Mogotsi et al. in prep





The Bird

(Väisänen, Ramphul, Canizales-Romero and collaborators)

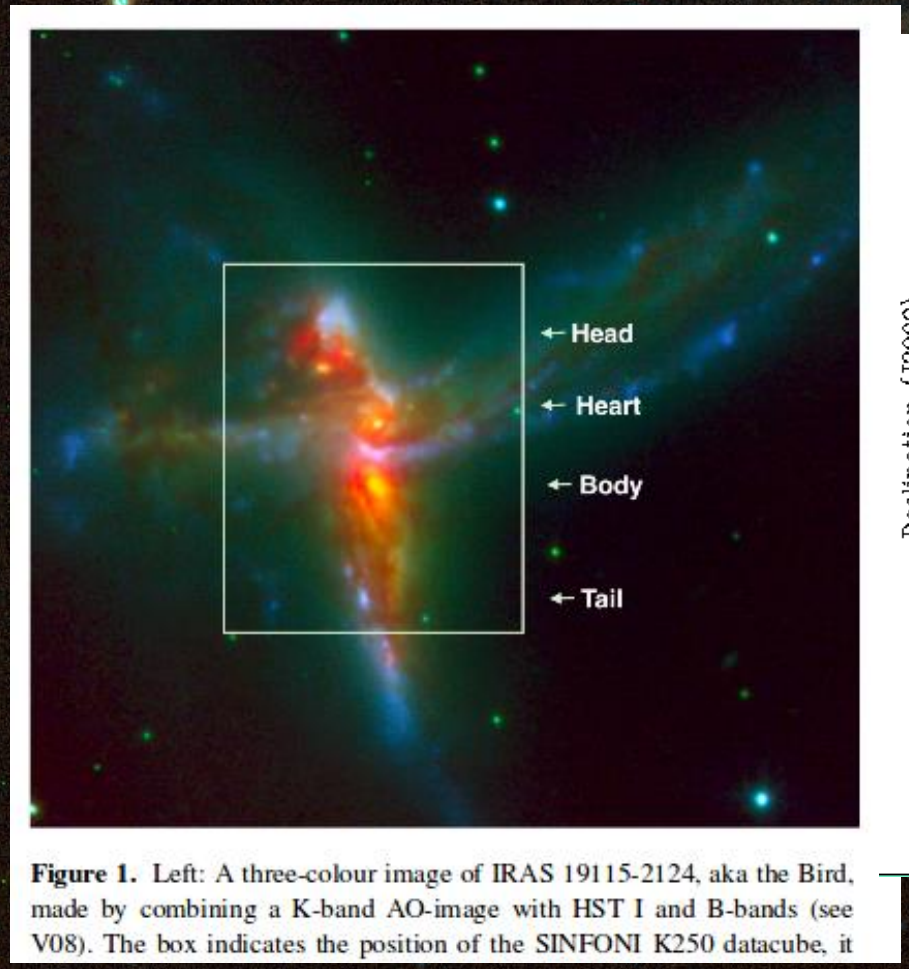
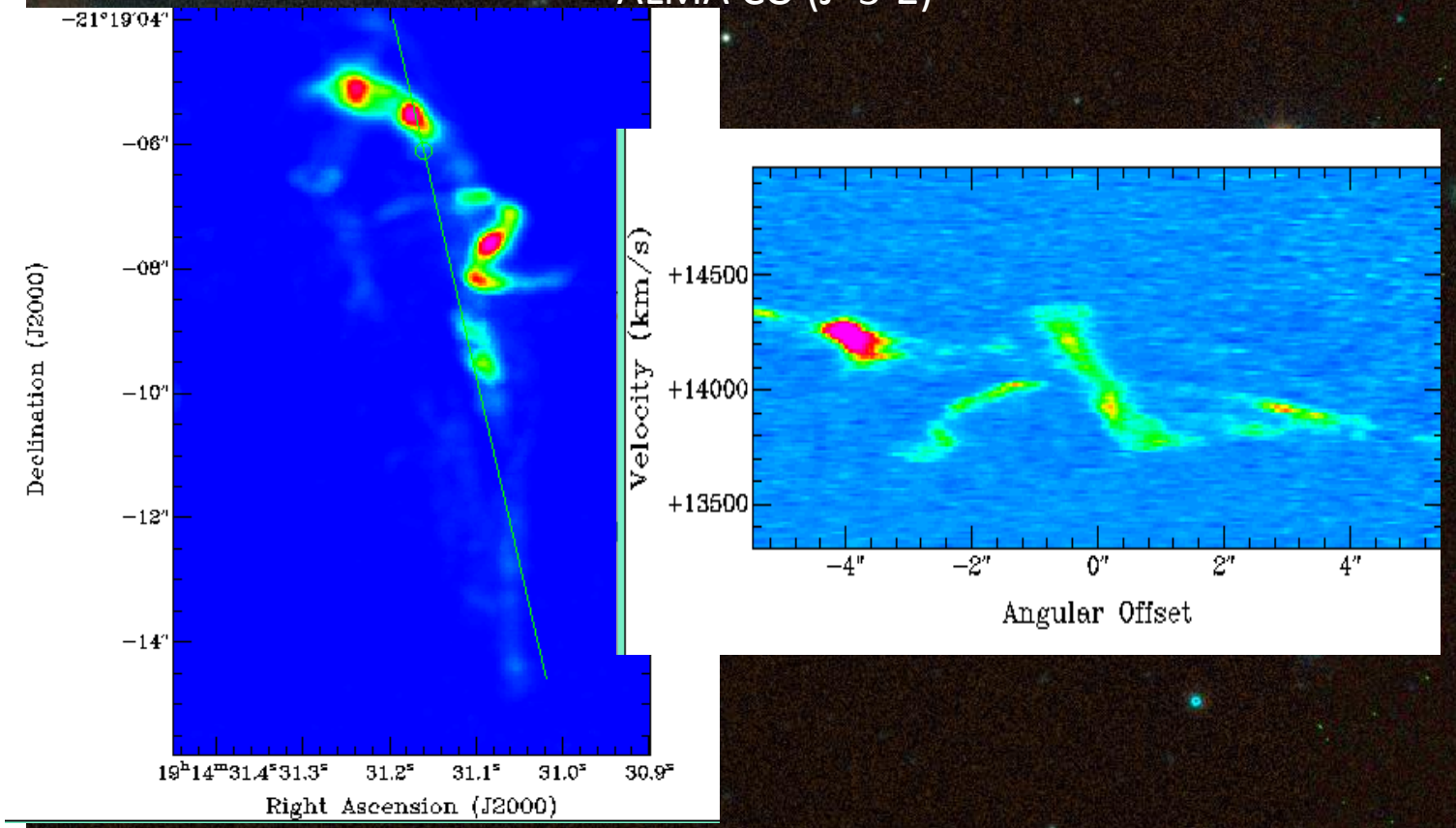


Figure 1. Left: A three-colour image of IRAS 19115-2124, aka the Bird, made by combining a K-band AO-image with HST I and B-bands (see V08). The box indicates the position of the SINFONI K250 datacube, it

Väisänen et al. (2017)

ALMA CO (J=3-2)



Preliminary