Fabry-Perot Interferometry: an outstanding niche technique for emission line mapping of galaxies and other extended objects at high resolution

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Ciencia con los telescopios óptico-infrarrojos de CAHA y ORM en la próxima década

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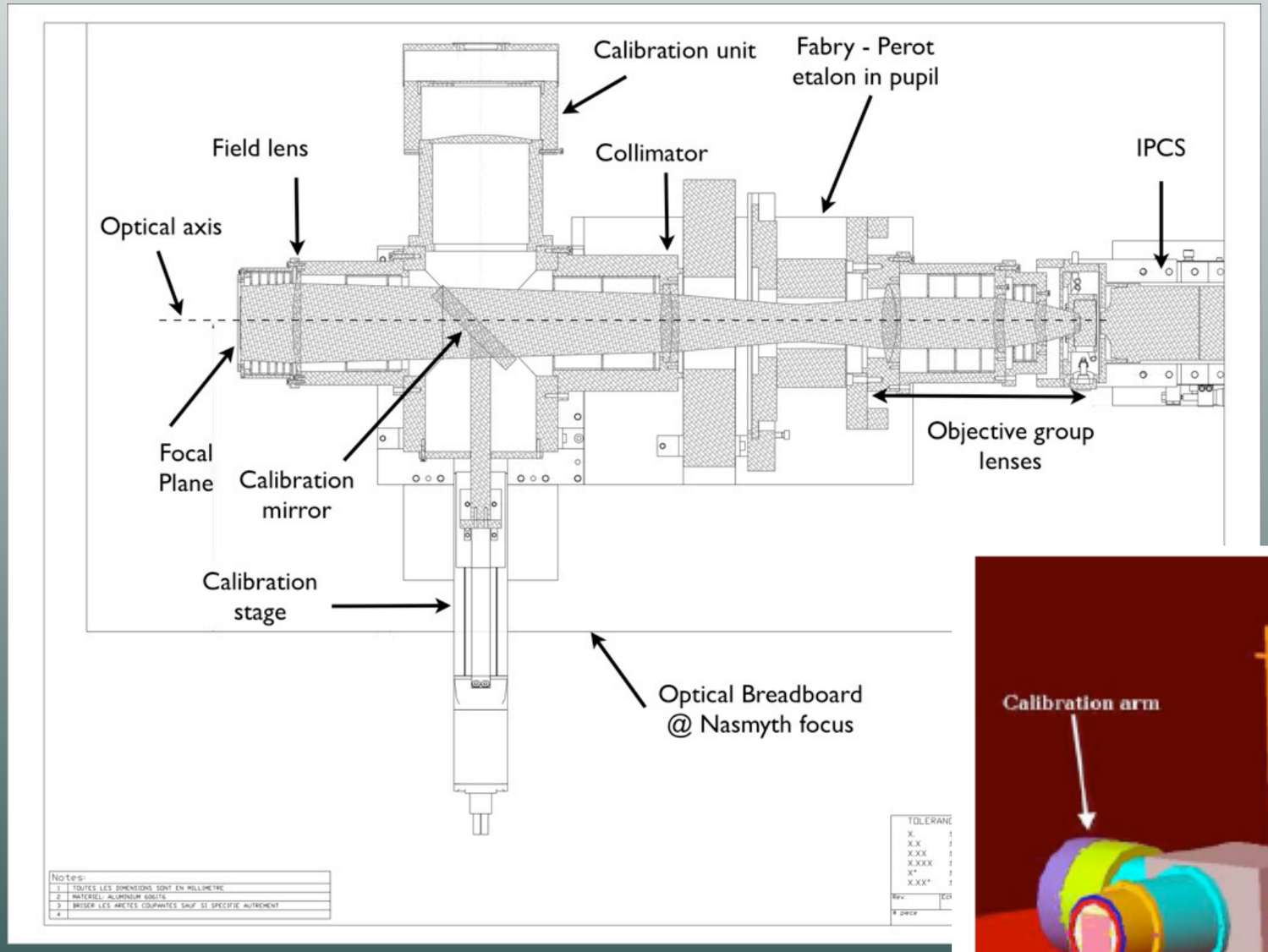
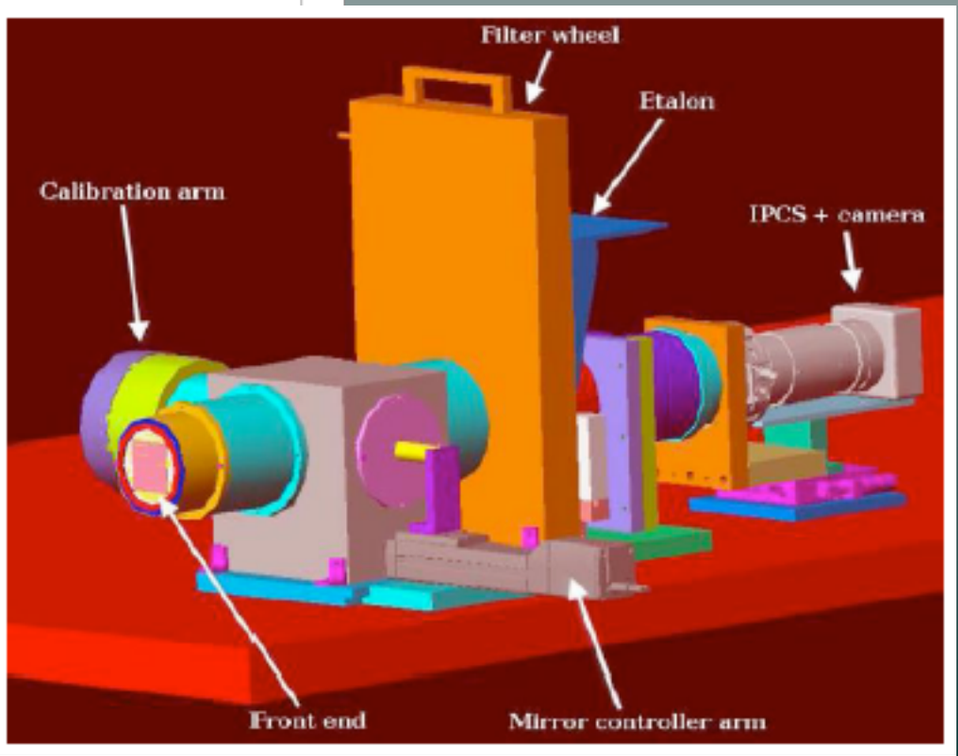
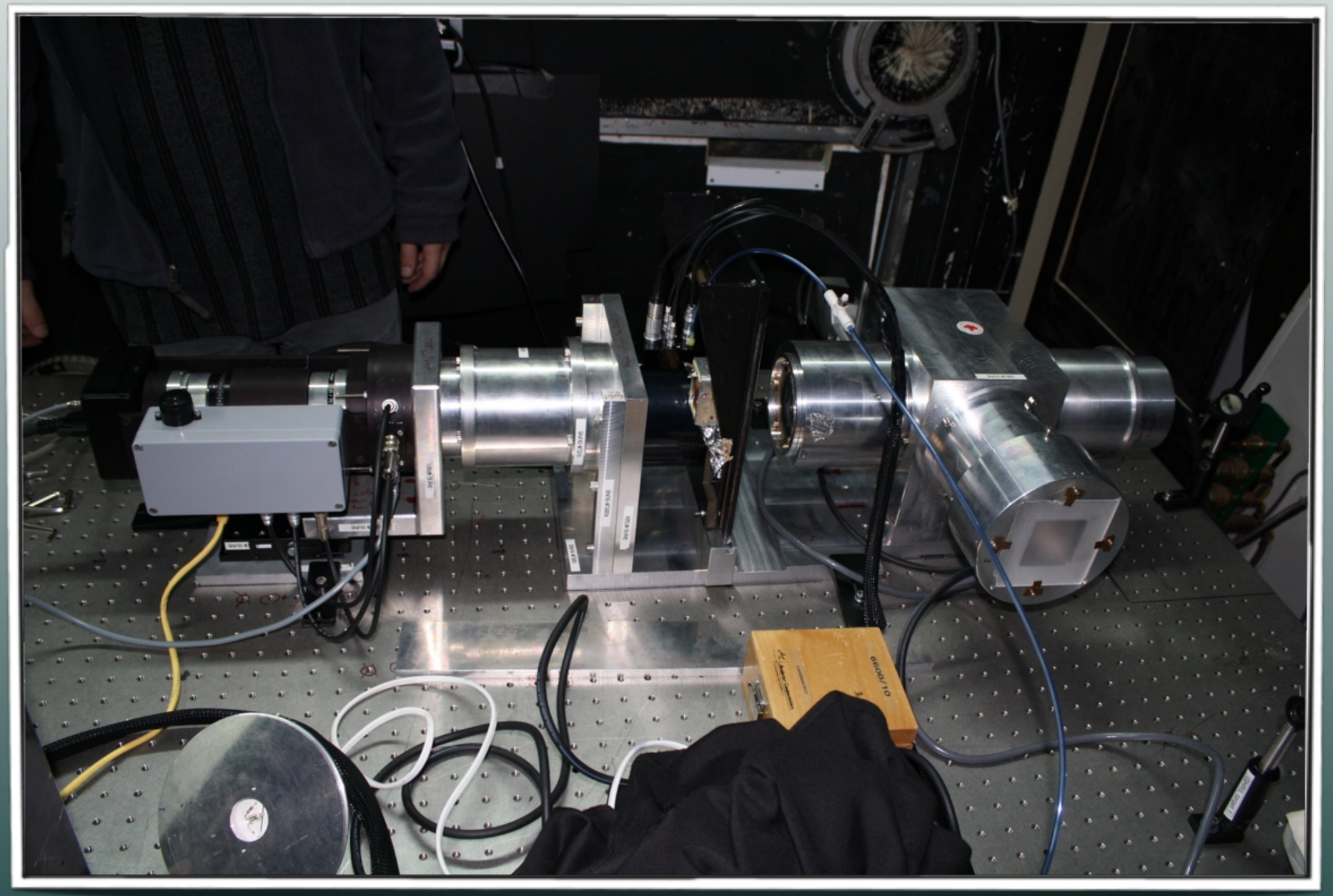
   - 2.4. Expanding shells
   - 2.5. Planetary Nebulae
3. Conclusions

GHαFaS : **G**alaxy **Hα Fa**bry-Perot **S**ystem

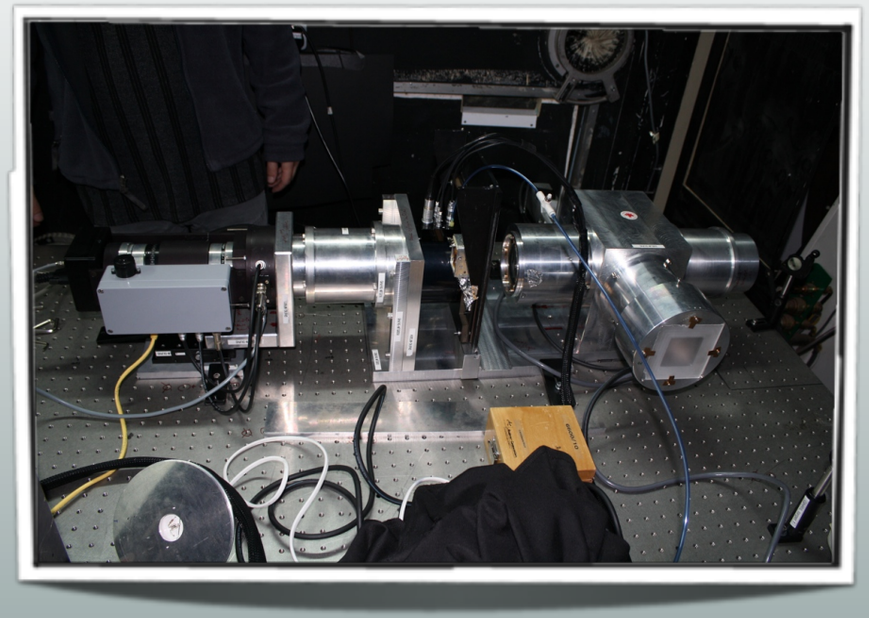




1.1 The characteristics.



1.1 The characteristics.



- F.O.V. = 3.4 arcmin^2
- CCD acquisition mode
  - low res: 512X512 pix^2 @ 100 fps ⇒ pixel scale ≈ 0.4 "/pix
  - high res: 1024X1024 pix^2 @ 60 fps ⇒ pixel scale ≈ 0.2 "/pix
- IPCS: no read-out noise ⇒ no flat field needed.
- Spatial resolution : seeing limited
- Etalon: FSR ~ 400km/s scanned in 48 channels (Nyquist criterion)

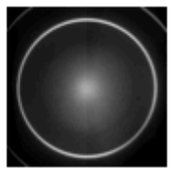
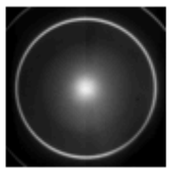
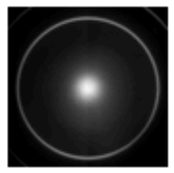
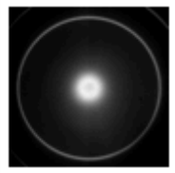
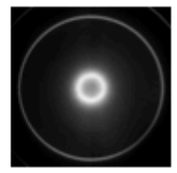
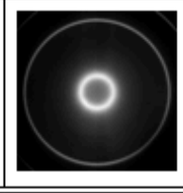
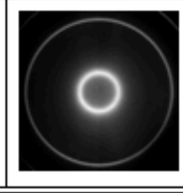
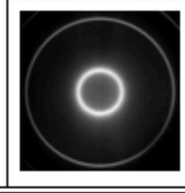
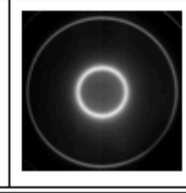
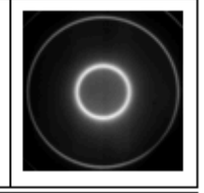
⇒ Velocity res. ≈ 8 km/s

Hernandez et al. 2008, PASP.

1.2 The calibration.

Neon lamp

$\lambda_{cal} = 6598.9$ Å

Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 9	Channel 10
									

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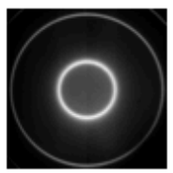	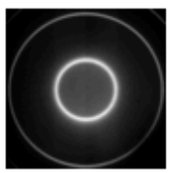	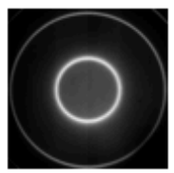	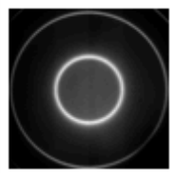	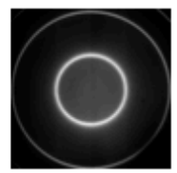	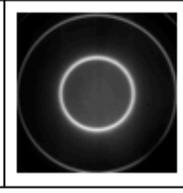	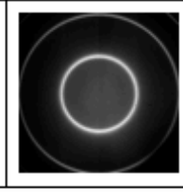	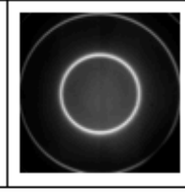	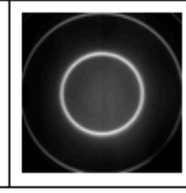	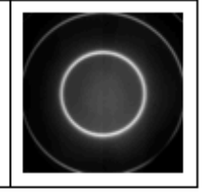

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					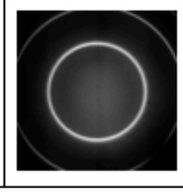	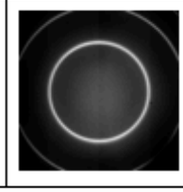	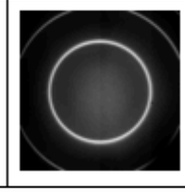	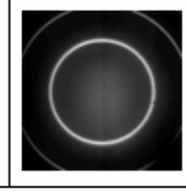	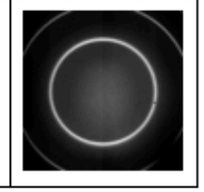

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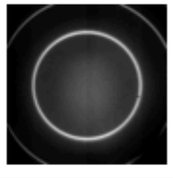
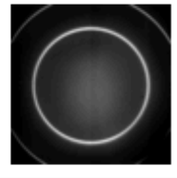
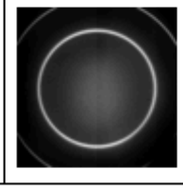
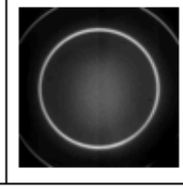
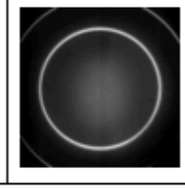
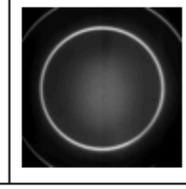
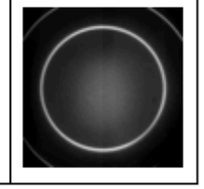
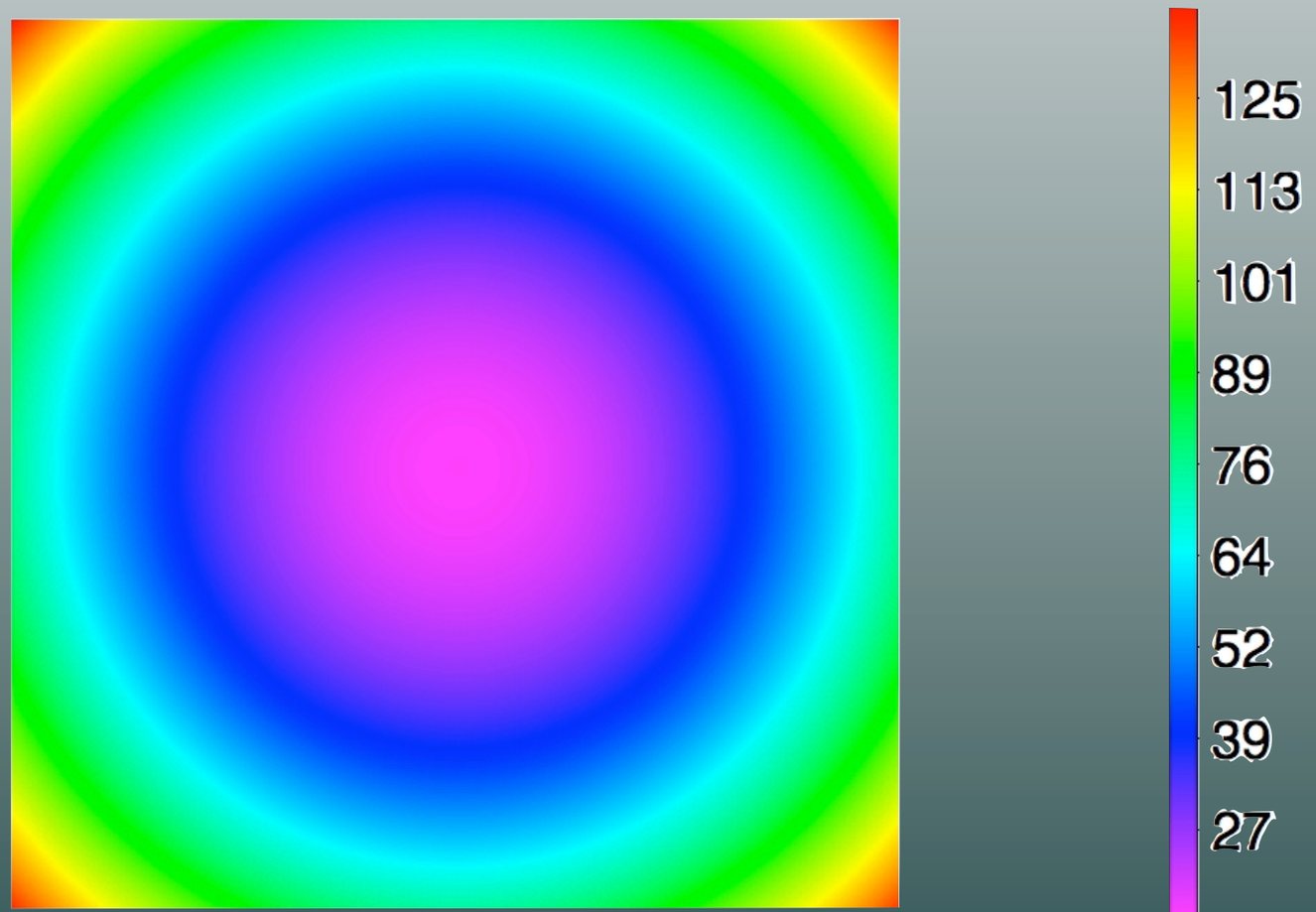
									

Channel 41	Channel 42	Channel 43	Channel 44	Channel 45	Channel 46	Channel 47	Channel 48

1.2 The calibration.

Neon lamp
λcal = 6598.9 Å

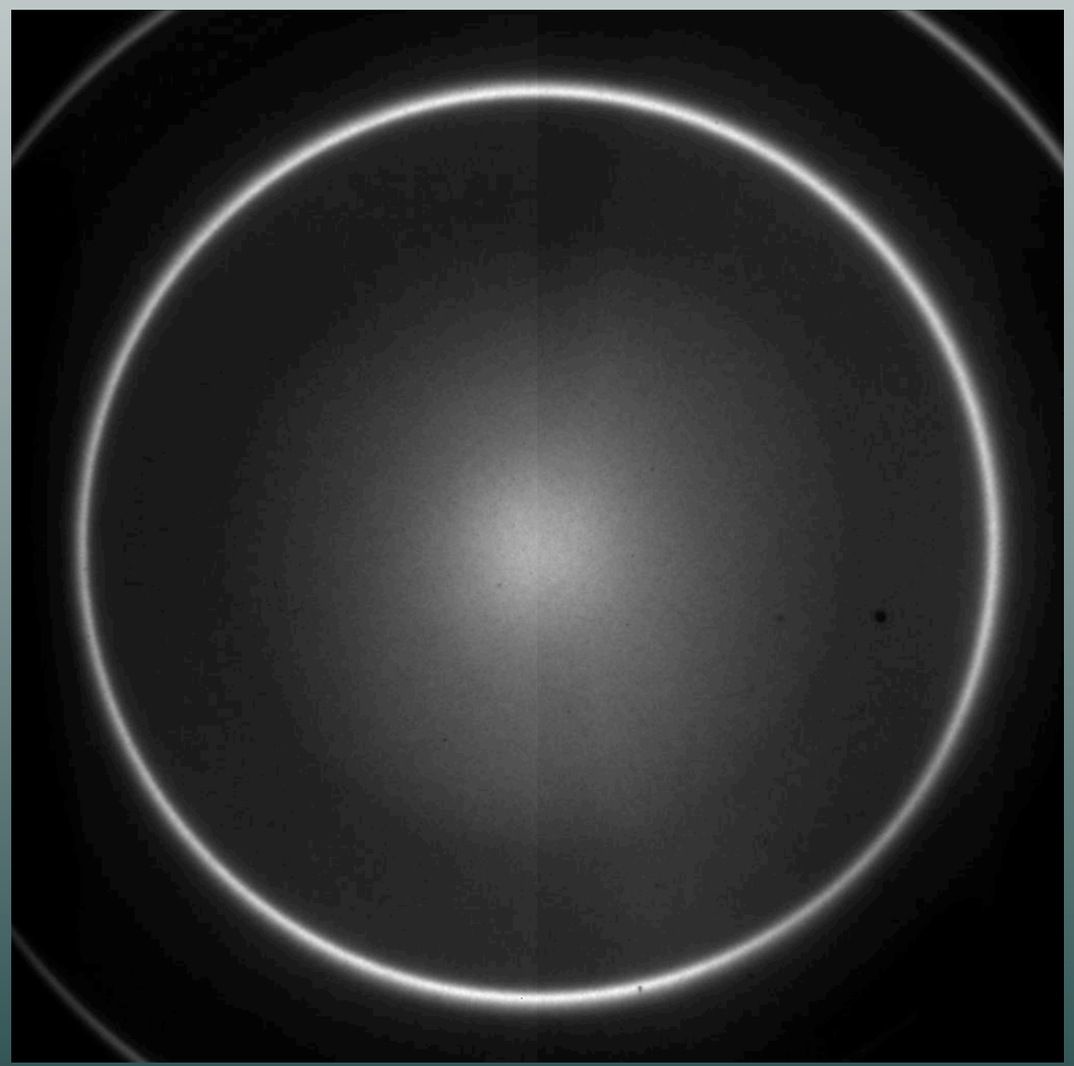


Data cube

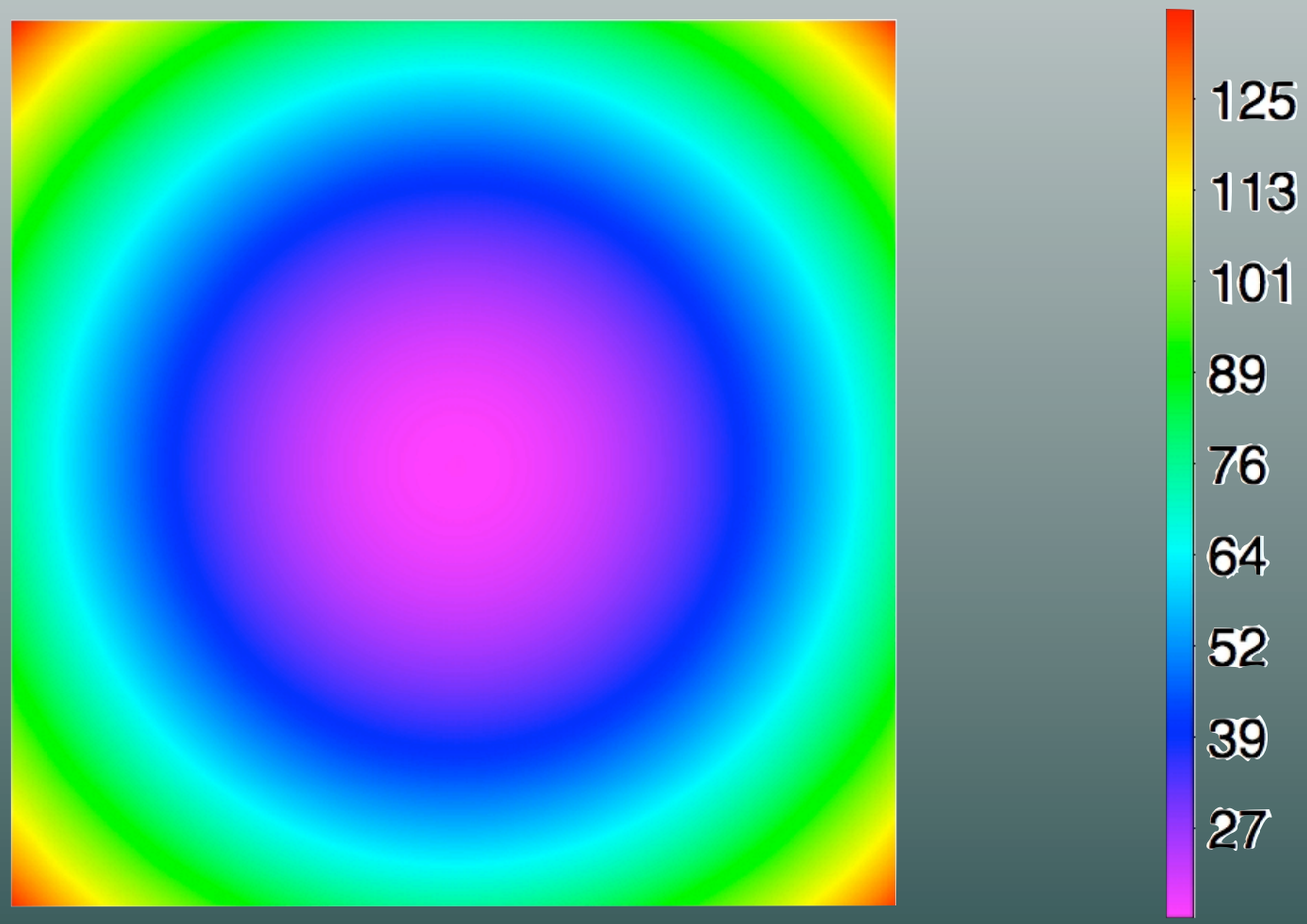
Phase calibration map

1.2 The calibration.

Neon lamp
$\lambda_{cal} = 6598.9$ Å



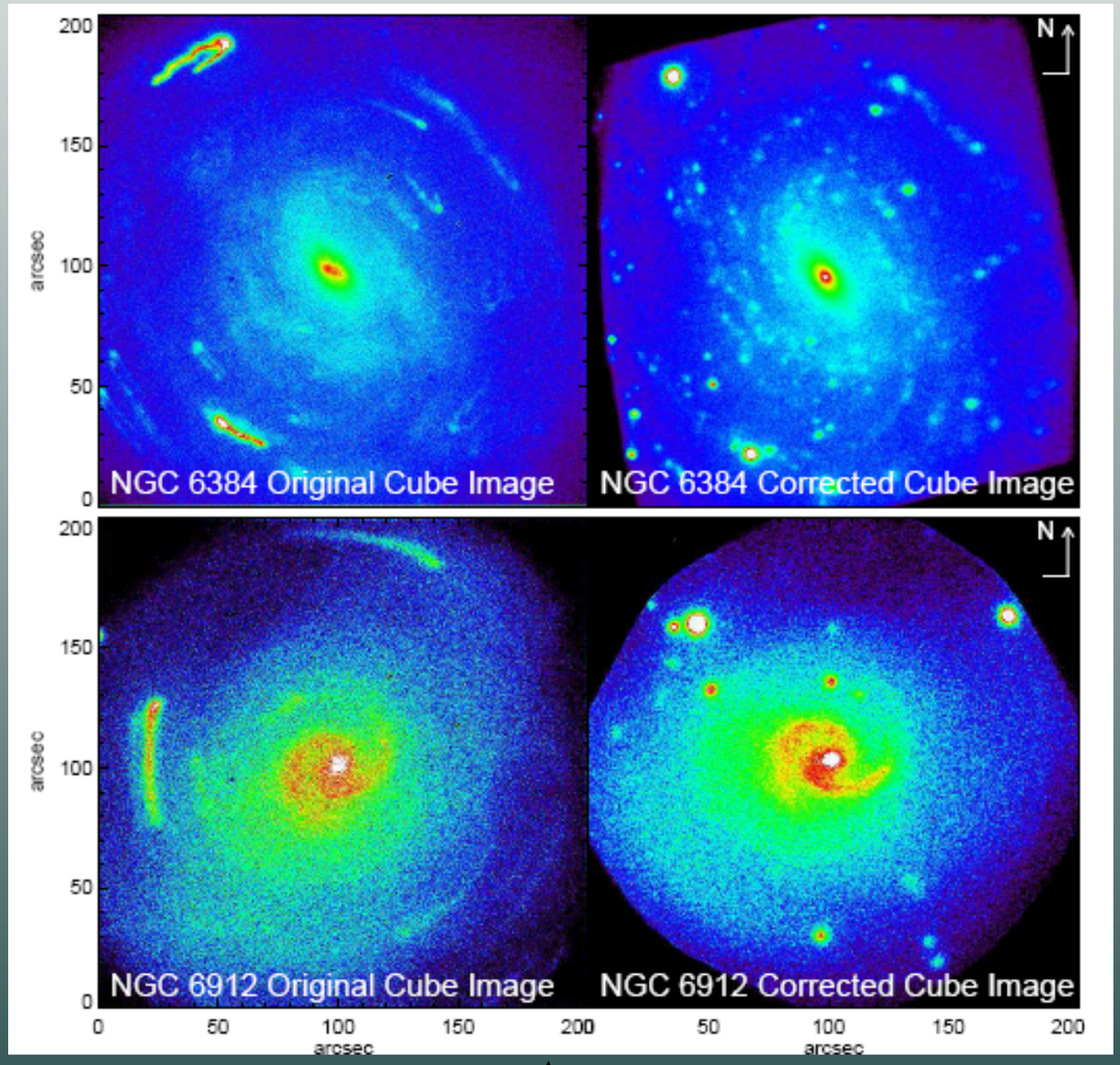
Data cube

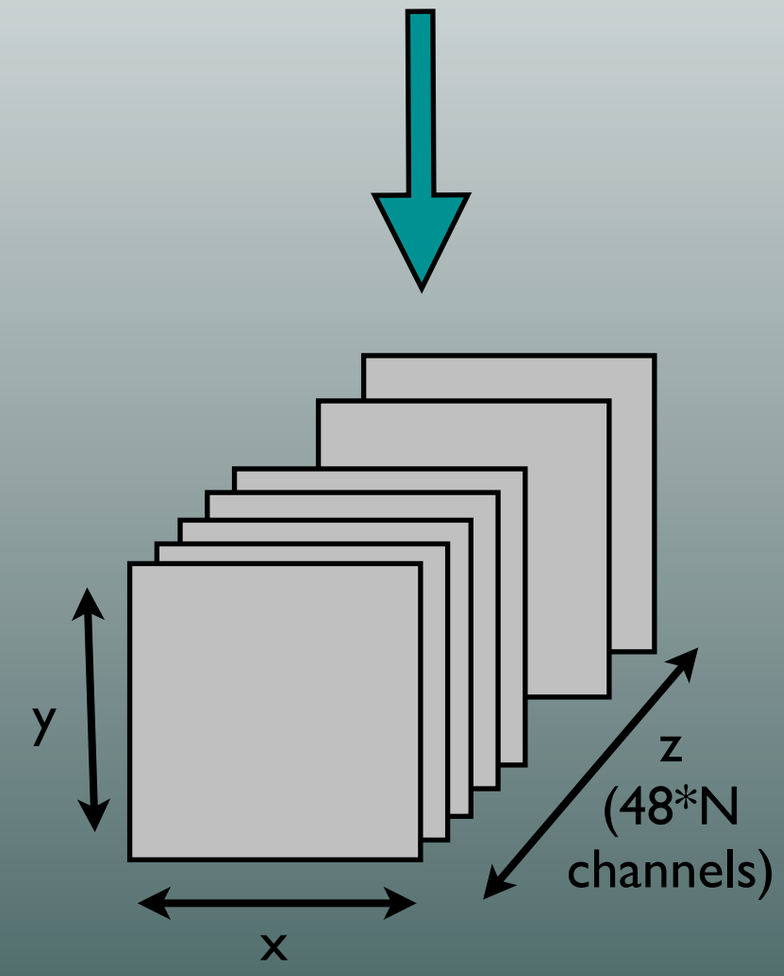


Phase calibration map

1.3 Observations. De-rotation

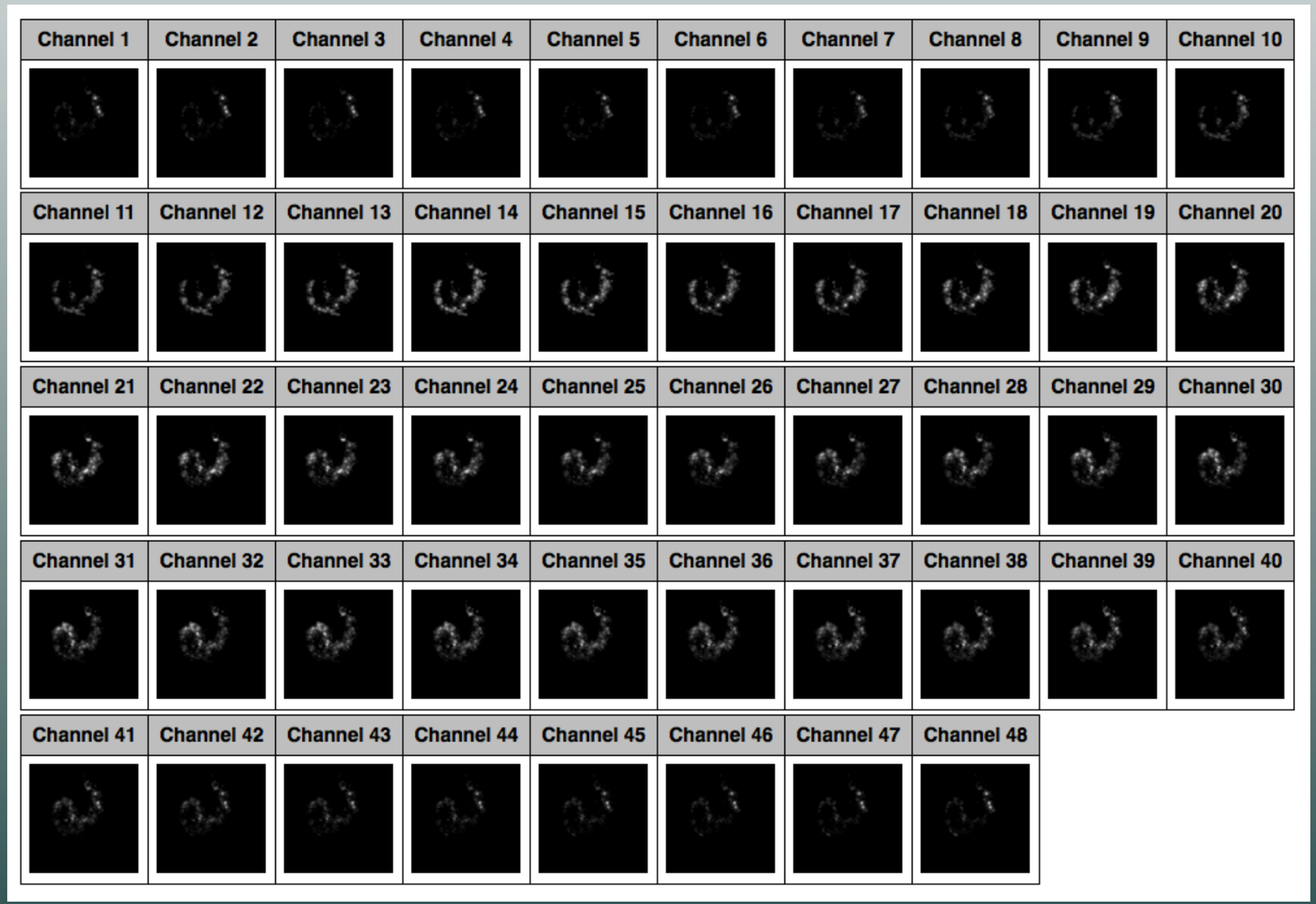
Exposure time
≈ 3 hours/object

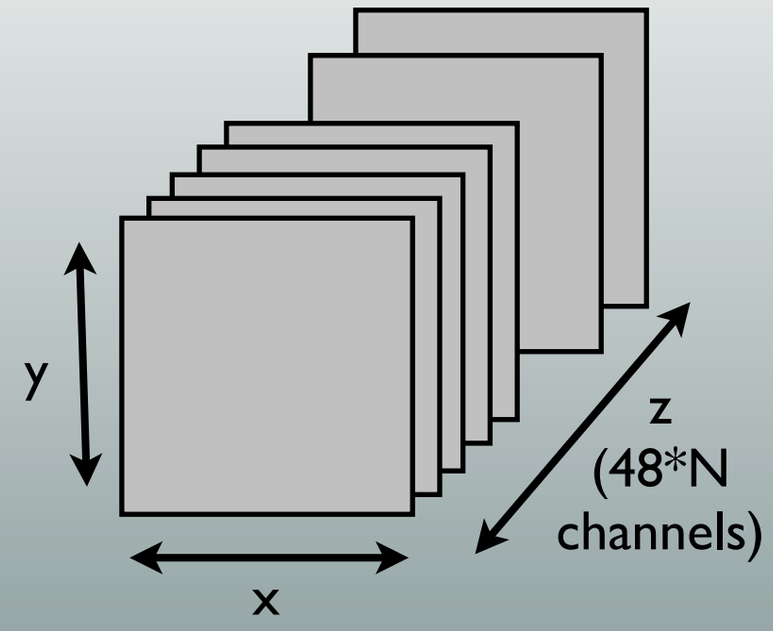




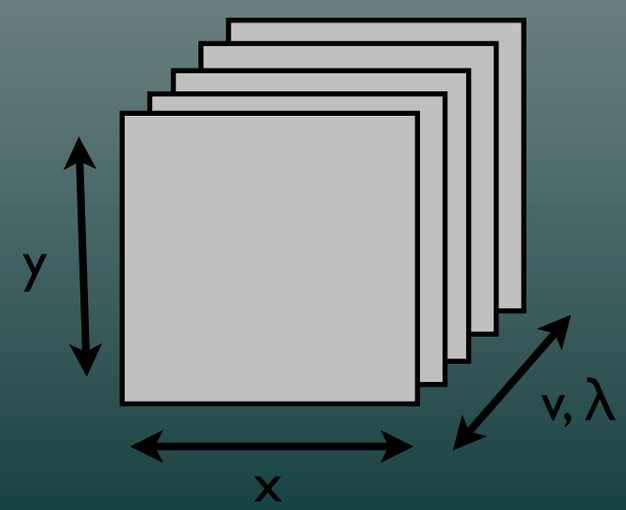
Collapsed data

1.3 Observations.

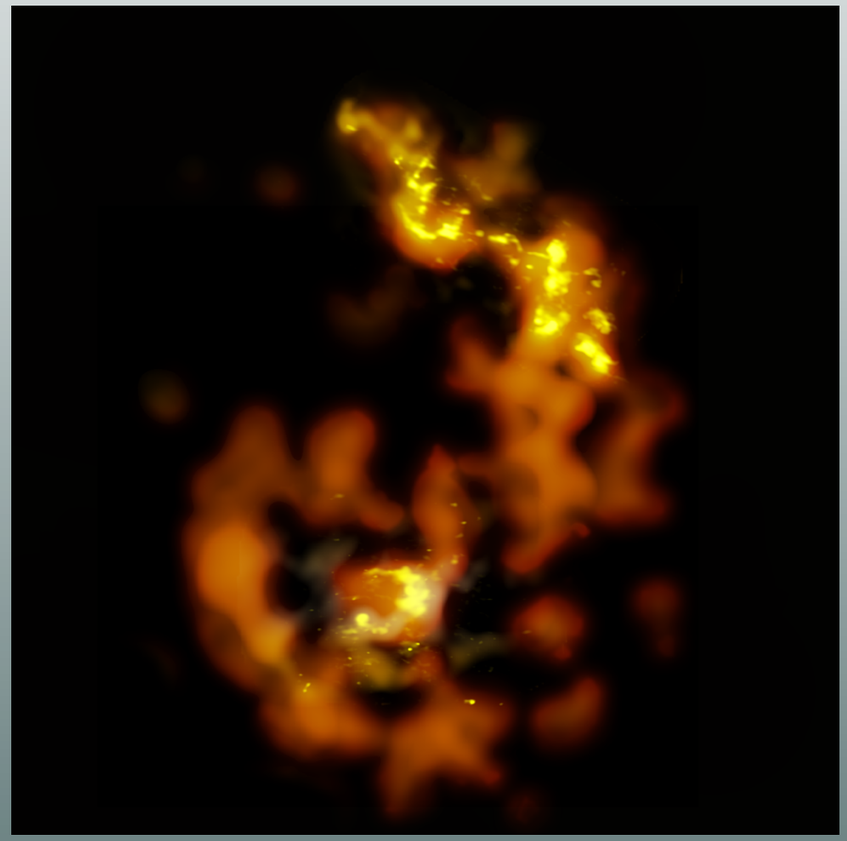




Calibration
&
De-rotation

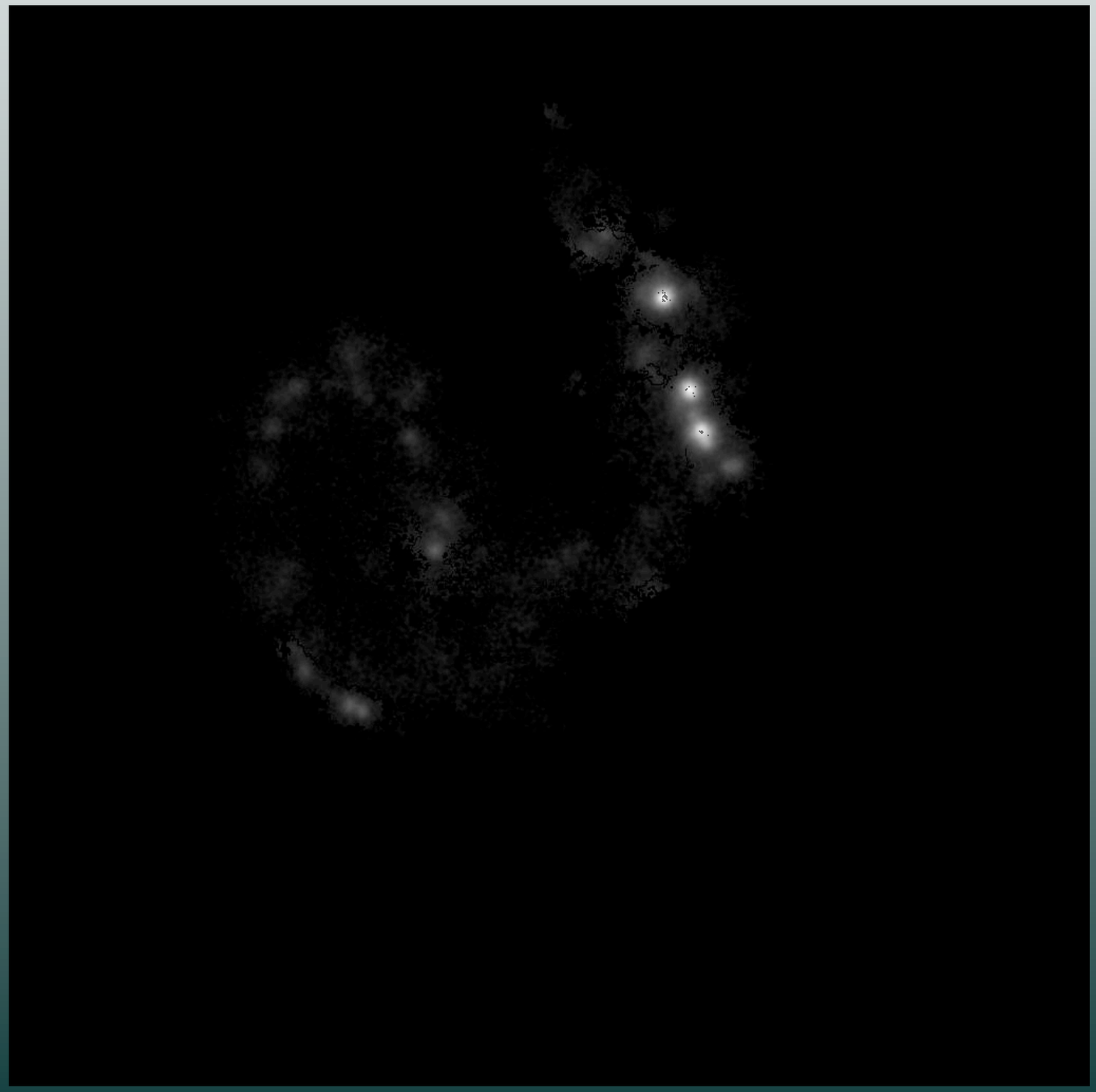


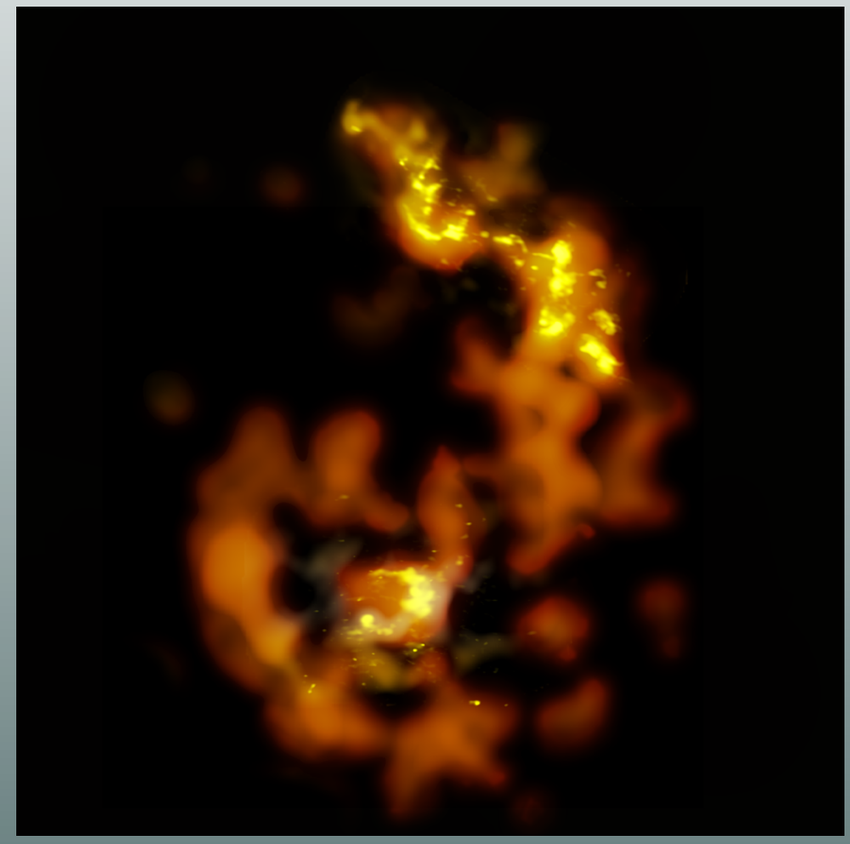
1.3 Observations.



ALMA CO image

1.3 Observations.





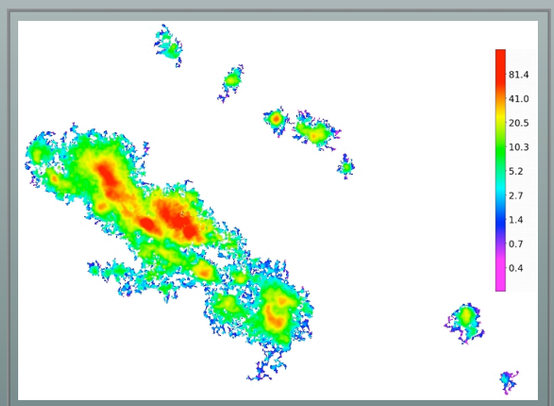
ALMA CO image

1.4 Moment map extraction

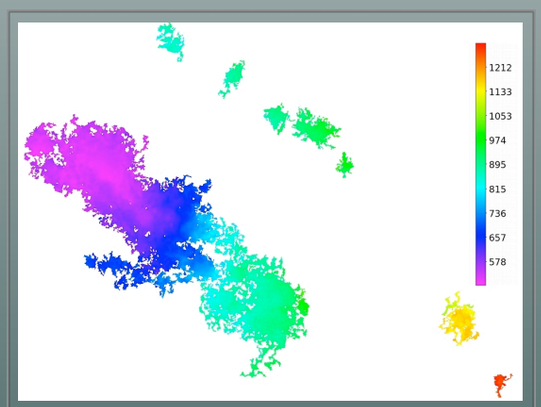
NGC 2146

ADHOC
IDL based codes
GIPSY

Intensity map



Velocity map



2. Science with GHαFaS

Proposals

- GHαFaS interferometry of shocks in Tycho's SN remnant: constraining the cosmic ray precursor (*J. Beckman*)

✓ Disk kinematics and morphology of S^4G spirals (*J. Knapen*)

✓ Star-forming satellites as a probe of environmental effects on galaxies (*P. James*)

✓ The origin of complexity in Planetary Nebulae (*M. Santander*)

✓ Unveiling the gas kinematics of interacting/merging galaxies (*B. Garcia-Lorenzo*)

✓ Kinematics of ionized gas and interstellar dust in HII regions (*U. Lisenfeld*)

✓ "GHαFaS para ver starburst". Dynamical evolution of massive starbursts (*J. Blasco-Herrera*)

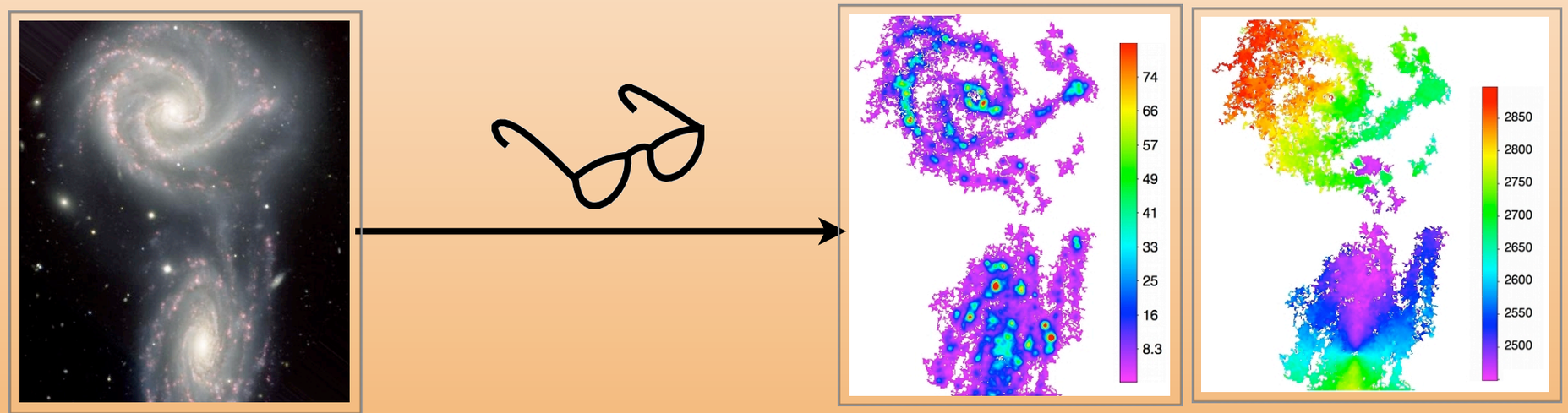
Institutions

IAC / University of Stockholm, GEMINI / Liverpool John Moores University / Observatotio Astronómico Nacional / University of Manchester / Instituto de Astronomía (UNAM) / South African astronomical observatory / ESO-La Silla / Laboratoire d'Astrophysique de Marseille / University of Arizona / University of Alabama / ESO-Garching, Vassar College / Carnegie Institution of Washington / University of Oulu / National Radio Astronomy Observatories / IBM Watson Research Center / California Institute of Technology / Max Planck Institut für Asrtonomie (Heidelberg) / State University of New York / Korea Astronomy and Space Science Institute / University of Montreal / ETH Zurich Institute of Astronomy / Harvard Smithsonian center for Astrophysics / Rutgers the state University of New Jersey / Universidad de Granada / Institute of Astronomy University of Cambridge / Uppsala Astronomical Observatory

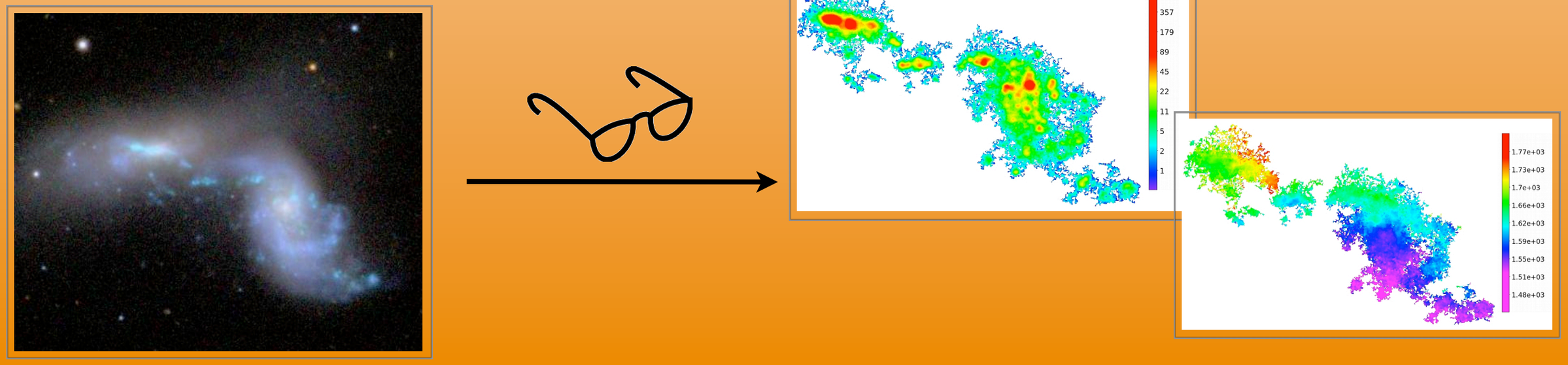
2.1. Unveiling the gas kinematics of interacting/merging galaxies

main goal: study kinematics of interacting galaxies at different stages of the merging process

ARP 271

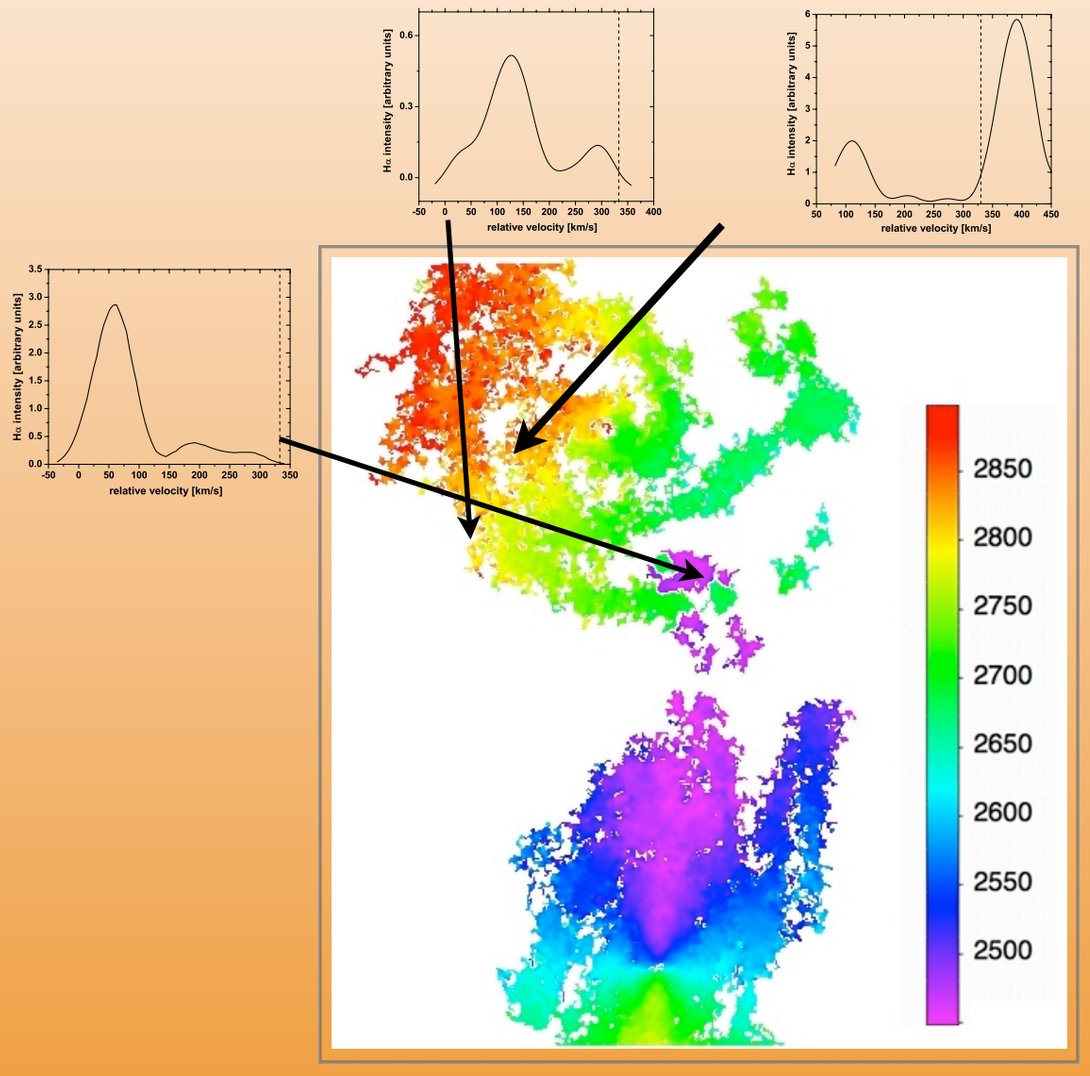


ARP 270

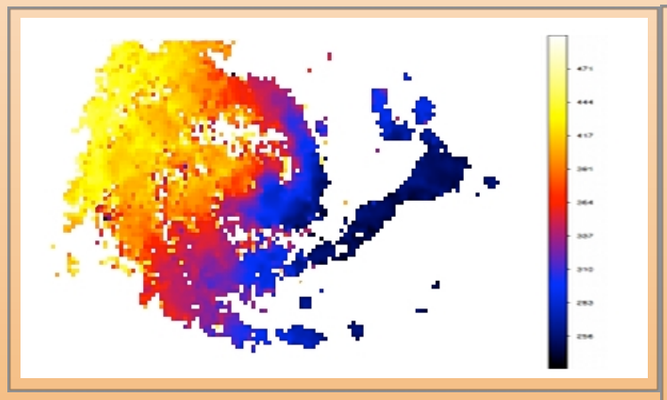


2.1. Unveiling the gas kinematics of interacting/merging galaxies

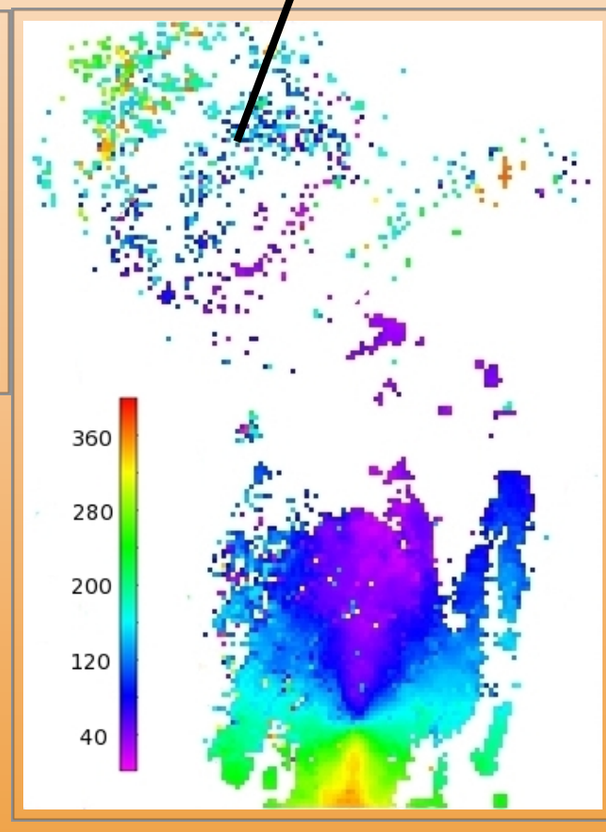
2.1.1. ARP 271 (Font et al., 2011, ApJ.)



Anomalous region



NGC 5427



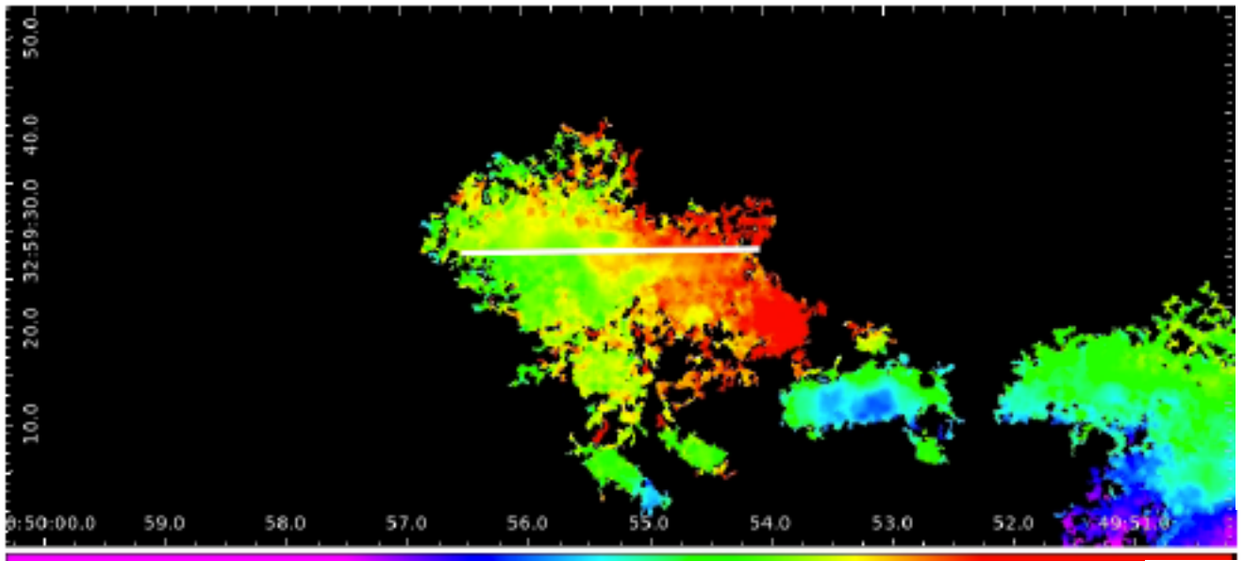
NGC 5426

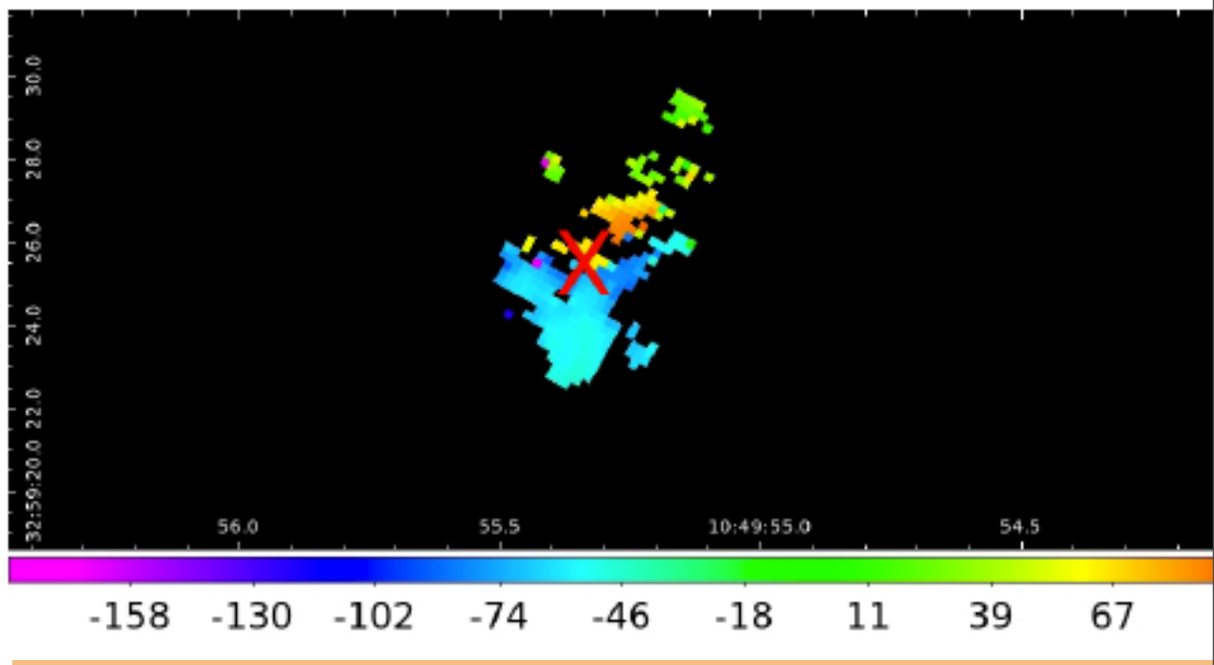
Anomalous component

- Morphology ⇒ Located behind NGC 5427
- Velocity map ⇒ Kinematically related to NGC 5426
- "Rotation curve" ⇒ Gas infalling to NGC 5427

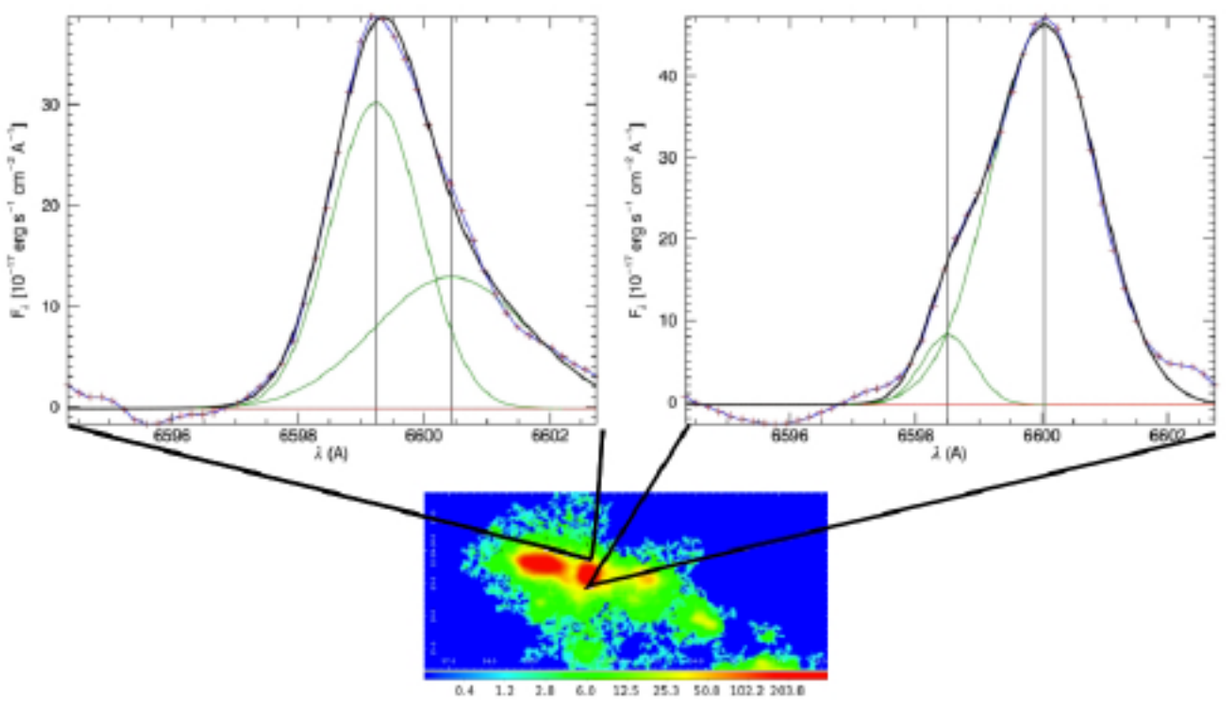
2.1. Unveiling the gas kinematics of interacting/merging galaxies

2.1.2. ARP 270





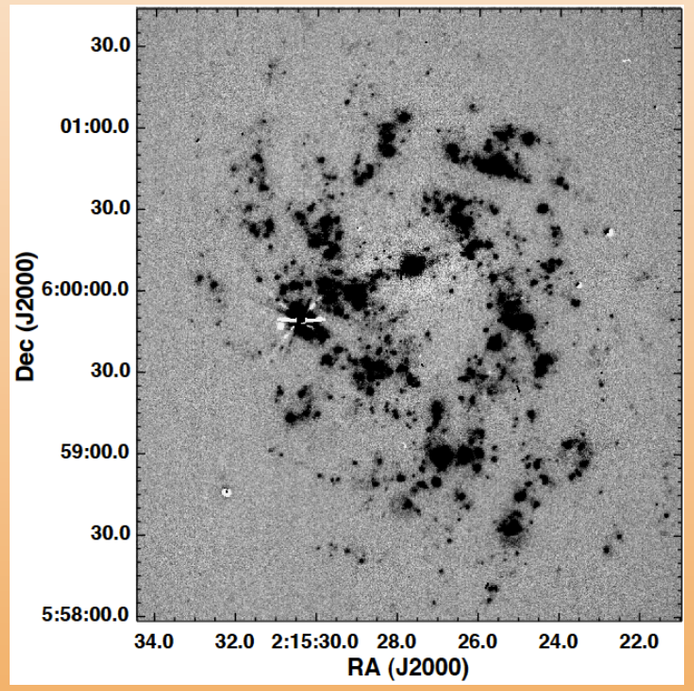
Inflow & Outflow in the inner region of NGC 3396

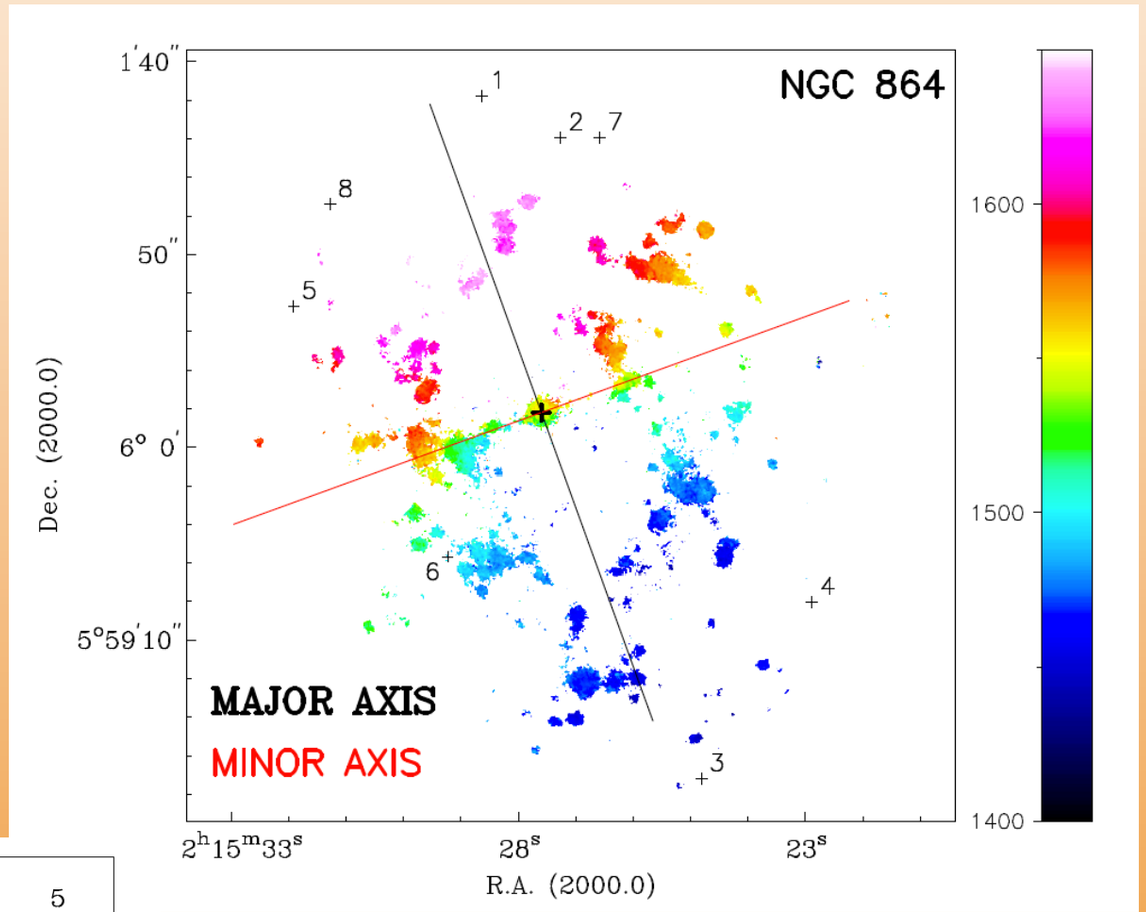


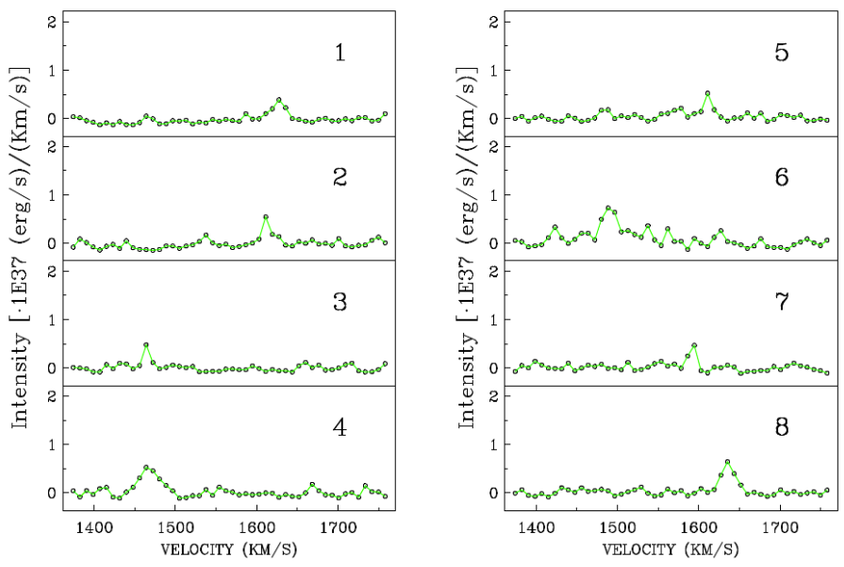
2.2. Disk kinematics and morphology of S^{4}G spirals

main goal: study interplay between dark matter and stars.

NGC 864 (Erroz et al., 2012, in prep.)



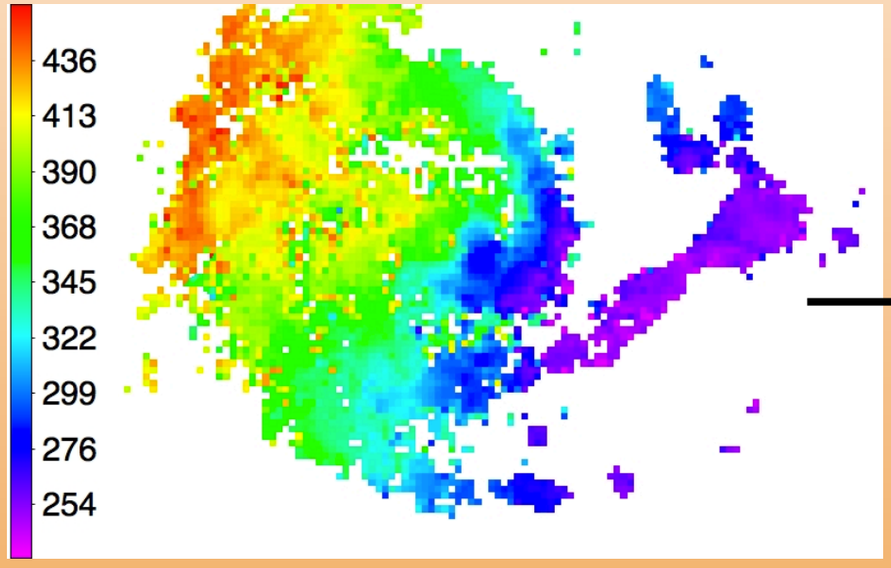


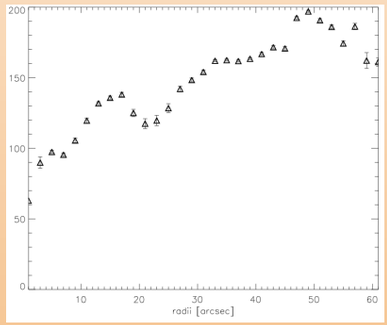


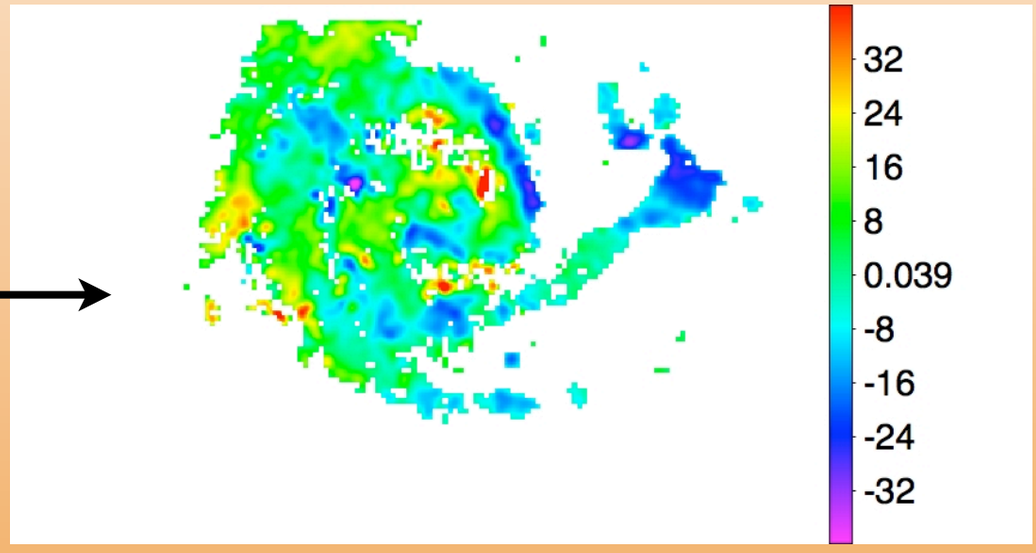
2.3. Resonant structure of spiral galaxies

main goal: Apply a new method to determine the co-rotation radius of disc galaxies.

NGC 5427 (Font et al., 2011, Ap.J.)

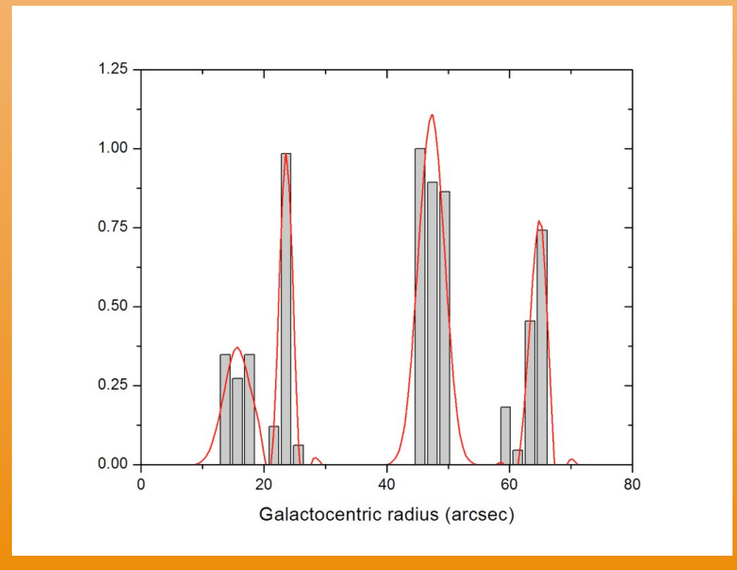






R_{CR} = 47.3 ± 2.1 arcsec

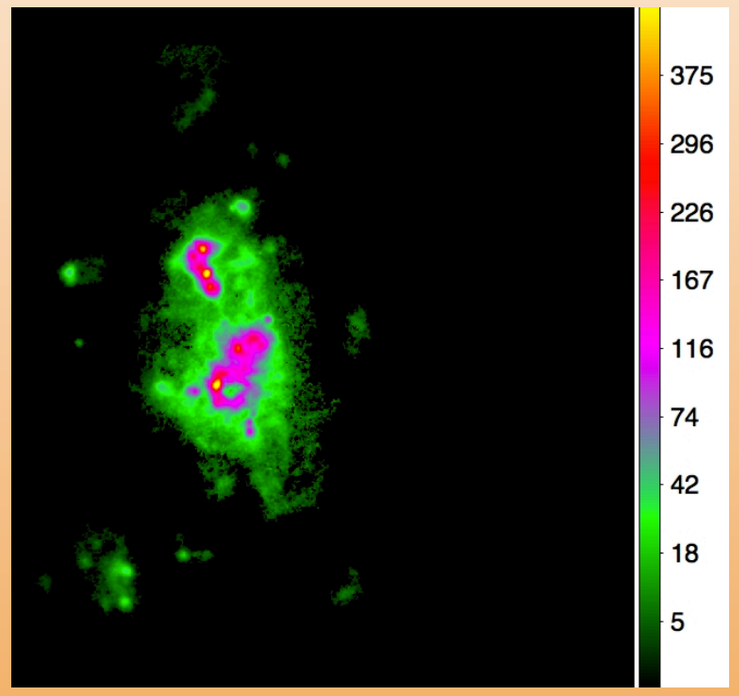
Ω_{PS} = 21.3 ± 1.0 km/s/kpc

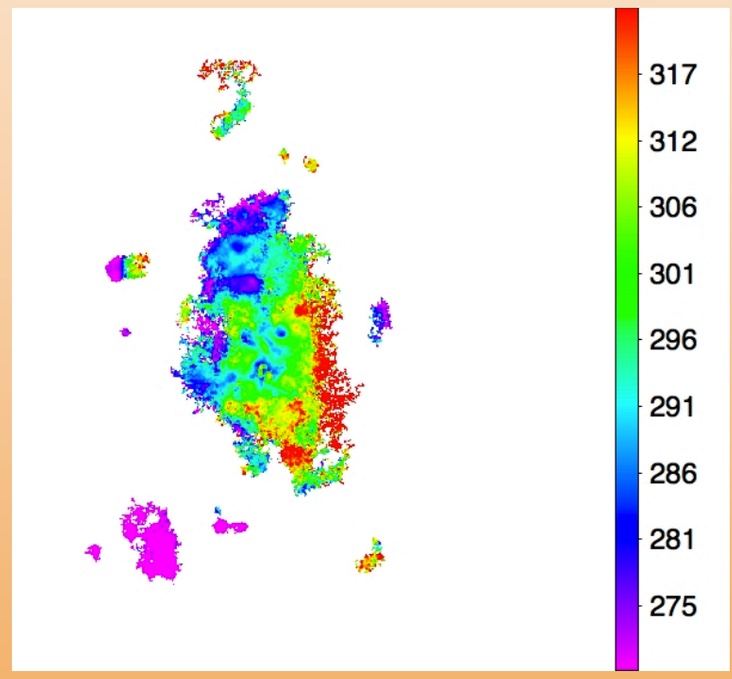


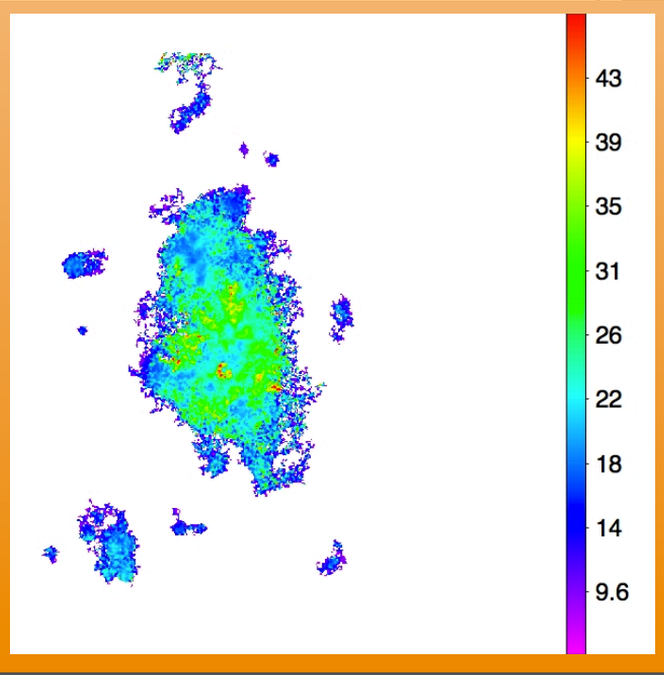
2.4. Kinematics of ionized gas and interstellar dust in HII regions

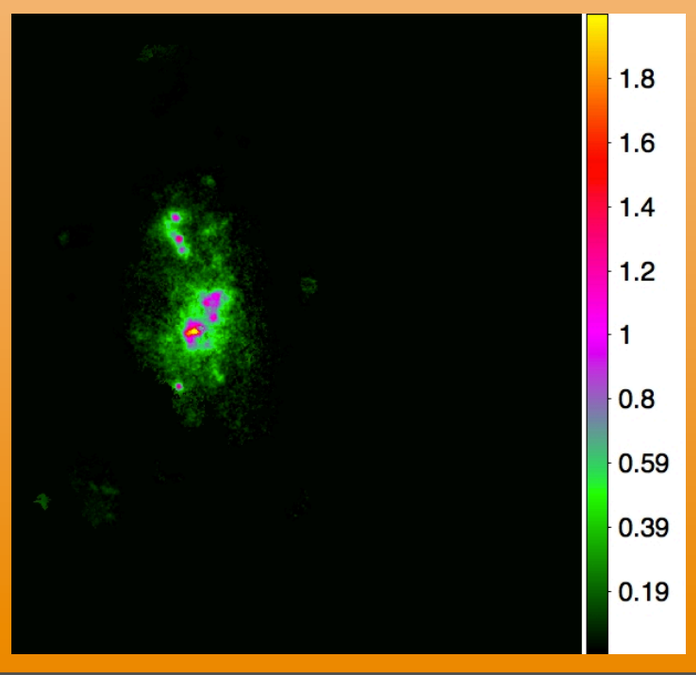
main goal: Study of the expanding shells and comparison with dust emission & extinction distribution.

NGC 4214







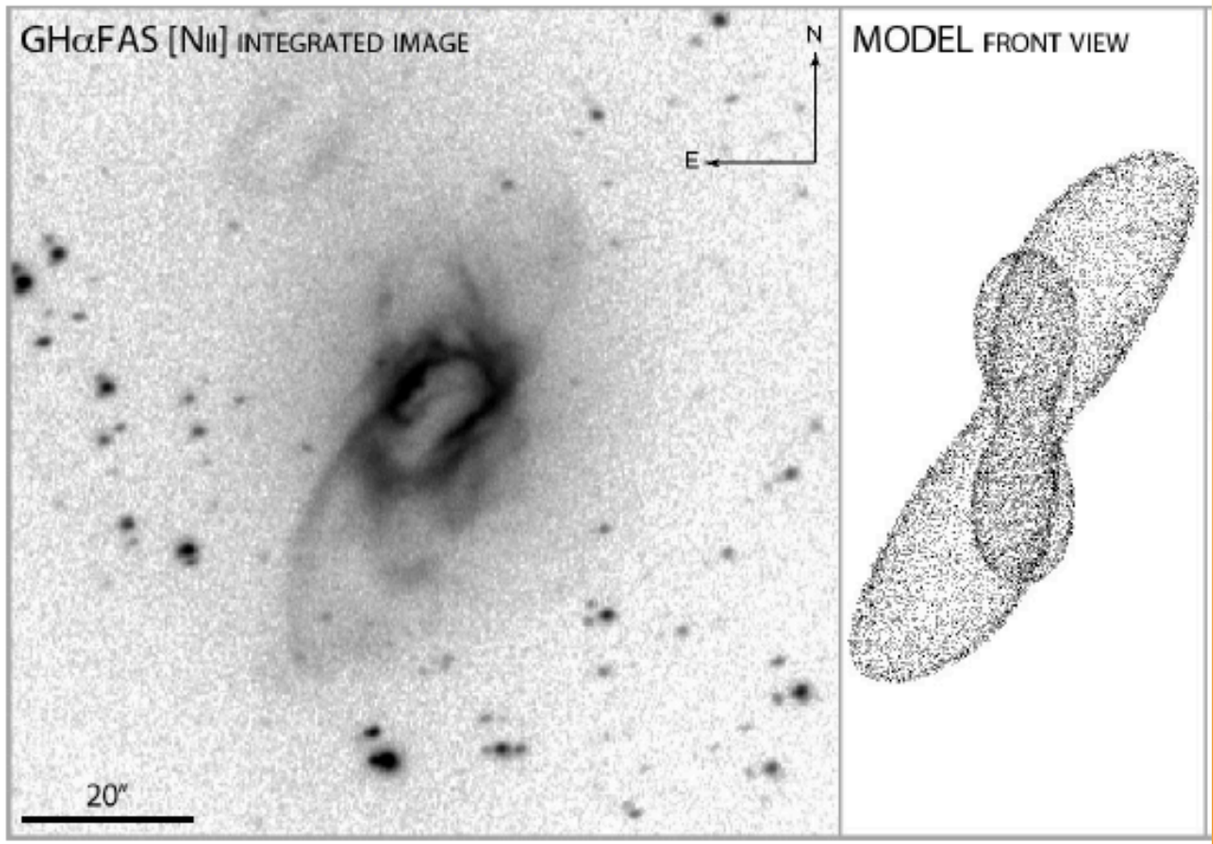


2.5. The origin of complexity in Planetary Nebulae

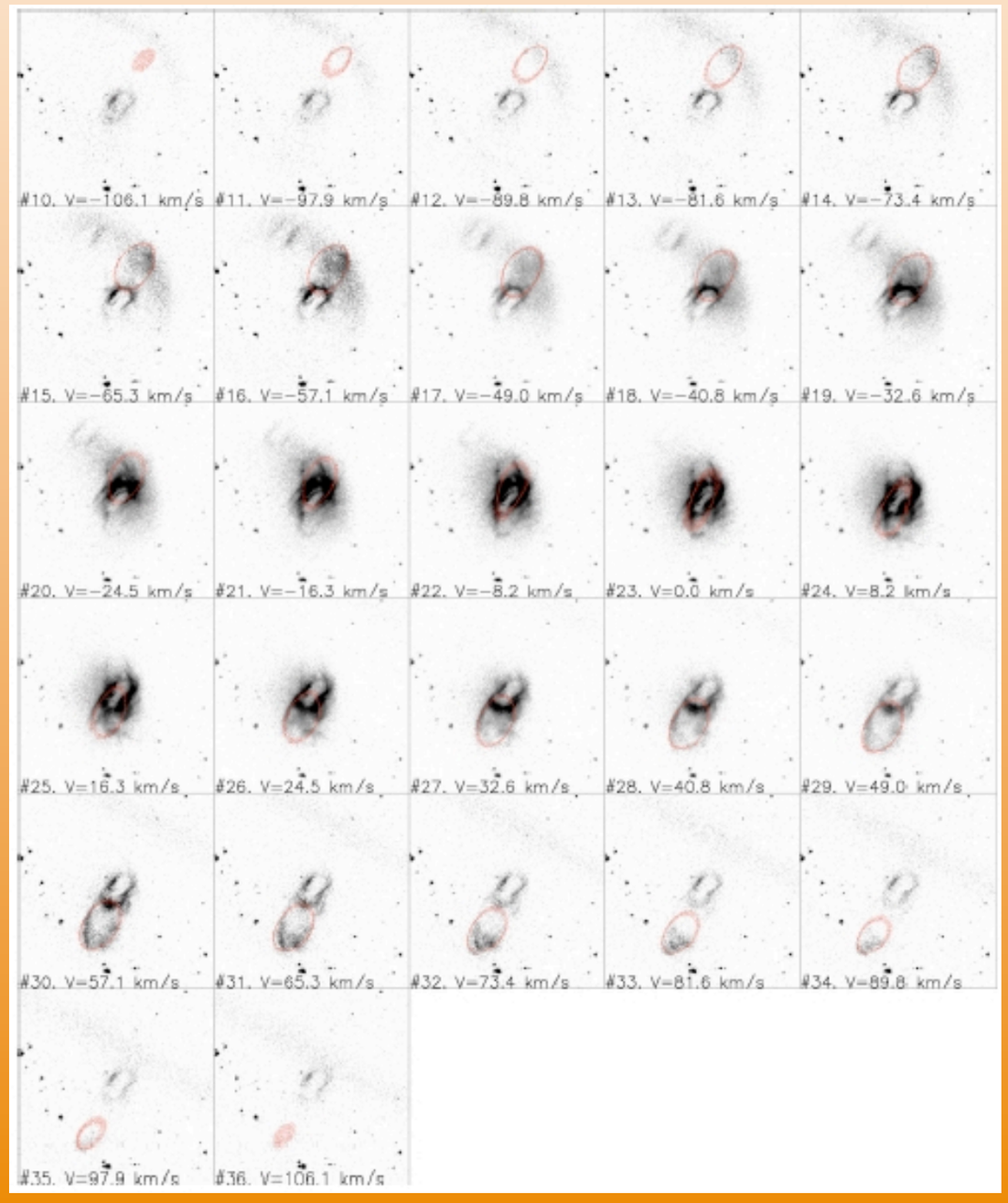
main goal: Study bipolar PN with binary nuclei and complex structure to grasp its origin.

M 1-75 (Santander-García et al., 2010, A&A)

NII emission line



Collapsed GHaFaS data cube and modelled lobes



3. Conclusions

• **GHαFaS** on the WHT is the Fabry-Perot system on the largest telescope, at the moment (A similar instrument is being built for the 4m NTT at ESO La Silla)

• Its field of view, angular resolution, velocity resolution and high sensitivity at low light levels make it highly competitive for kinematic programmes, especially for disc galaxies.

•**GHαFaS** is an approved Visitor Instrument, fully supported by IAC staff, and open to all users.