# Observational evidence of star formation stochasticity in the CALIFA dataset

Nicolás Romero Díaz[1]
Advisor: Jaime Forero-Romero[1]

[1]Departamento de Física
Universidad de los Andes

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# Table of Contents



# Table of Contents



# Stochasticity in star formation

**Where does stochasticity arise?**

- Star formation
  - Initial Mass Function (IMF)
    - $m_{min}$ – $m_{max}$
    - Relative abundance
  - Cluster Mass Function (CMF)
  - Sampling of mass functions – SFR
  - Low SFR $\rightarrow$ Stochasticity[1]

[1] Fumagalli et. al. 2011

# Stochasticity in star formation

- Example: weighted die
  - Smaller numbers are more likely

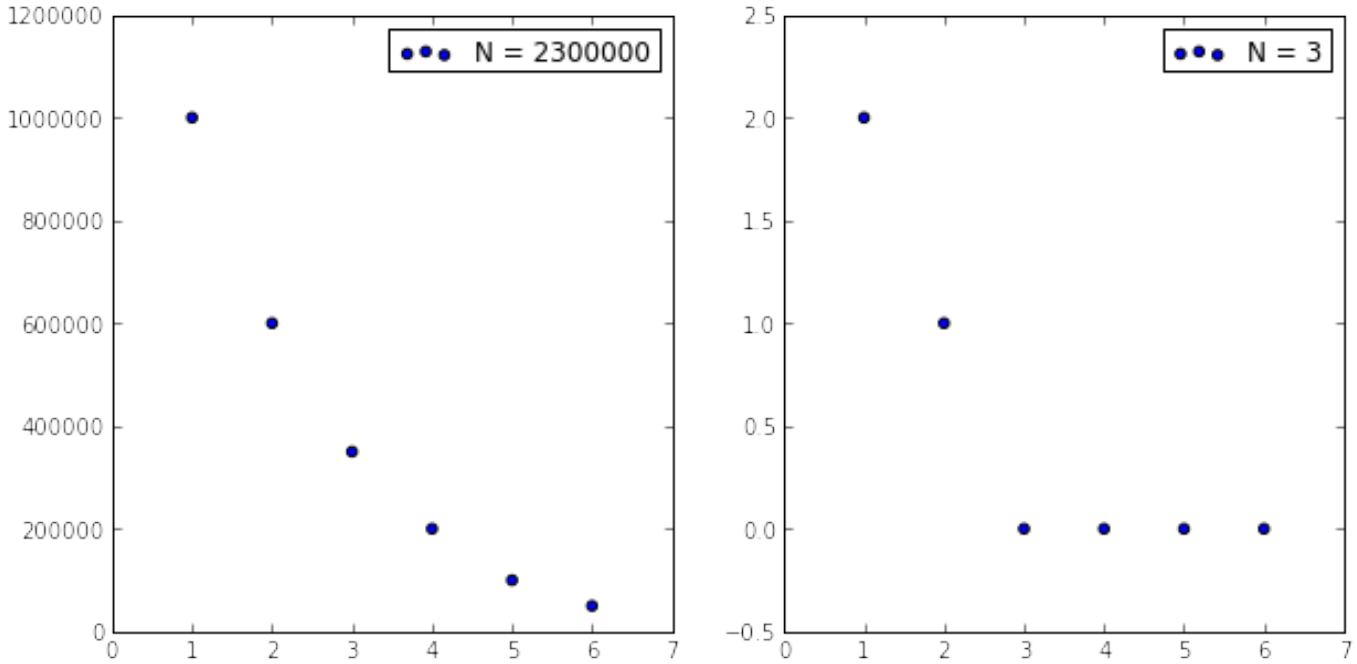



Figure: Left: Die is cast many times. Right: Die is cast 3 times

# Motivation

## General objective

"Look for observational evidence of stochasticity in star formation processes in the data published by CALIFA".

## Specific objectives

- Develop a simple theoretical model to measure the effects of stochasticity in the EW of the $H_\alpha$ and $O_{II}$ emission lines
- Analize data from the CALIFA survey collaboration
- Compare results between the observed data and the theoretical model
- Conclude if there is enough evidence to claim that stochastic effects have been detected in CALIFA data

# Measuring stochasticity

**How does stochasticity translate into observable quantities?**

- Stochasticity causes fluctuation $\frac{H_\alpha}{H_\beta}$ [2]
- SLUG: Stochastically Light Up Galaxies
- "We find that stochasticity alone induces a broad distribution in $L_\alpha$ and EW at a fixed SFR, and that the widths of these distributions decrease with increasing SFR" [3]

[2] Fumagalli et. al. 2011

[3] Forero-Romero, Dijkstra, 2012

# Measuring stochasticity

- Balmer decrement
  - Interstellar dust
  - $\frac{H_\alpha}{H_\beta} = 2.85 \rightarrow \frac{H_\alpha}{H_\beta} \geq 2.85$[4]
  - Interstellar reddening

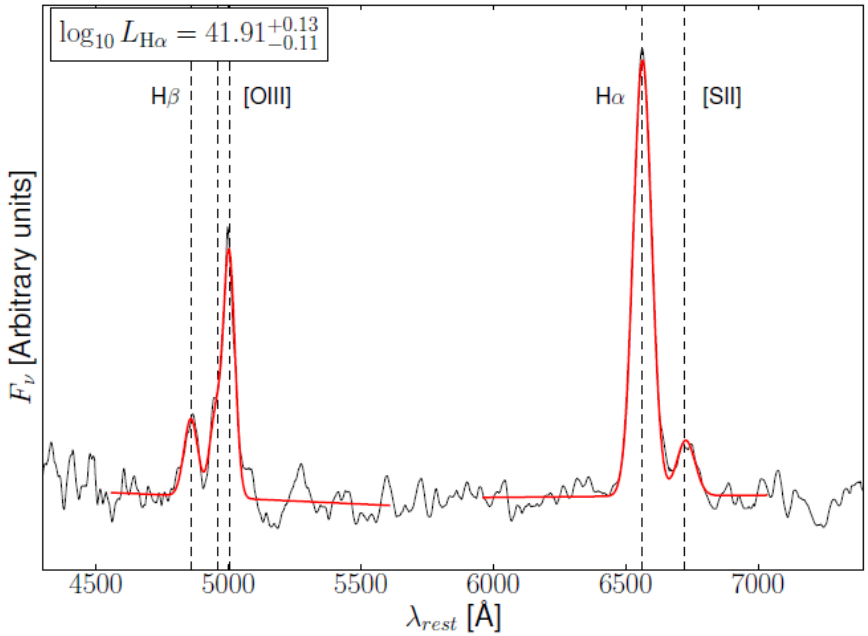



Figure: https://arxiv.org/pdf/1206.1867v2.pdf, Domínguez et. al. 2012

[4]Osterbrock, Astrophysics of Planetary Nebulae and Active Galactic Nuclei, University Science Books, 1989

# Table of Contents



# The CALIFA survey

- $\sim$ 600 galaxies
- "Largest and most comprehensive wide-field IFU survey of galaxies carried out to date"[5]

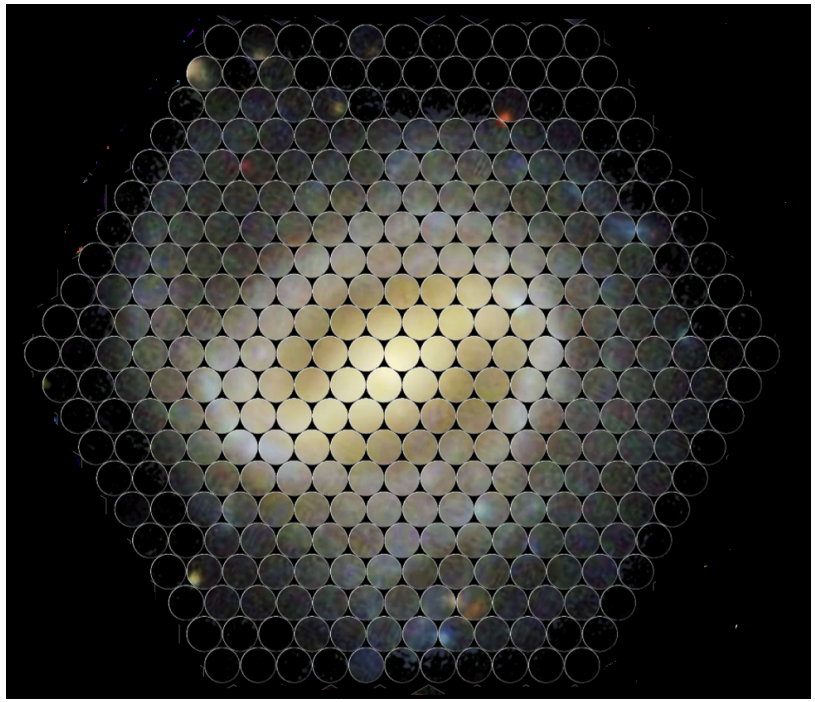


Figure: http://califaserv.caha.es/CALIFA/DATA/Figs/CALIFA_HexDR2.png

[5] Sánchez, et. al. 2011

# The CALIFA datacubes

- 2 setups[6]
- V500
  - 3745 – 7500 Å
  - $\lambda/\Delta\lambda \sim 850$
- V1200
  - 3700 – 4800 Å
  - $\lambda/\Delta\lambda \sim 1650$

[6] Sánchez et. al. 2011

# Table of Contents



# Data analysis

- Fit spectral lines
  - Strong emission lines
  - Weak emission lines

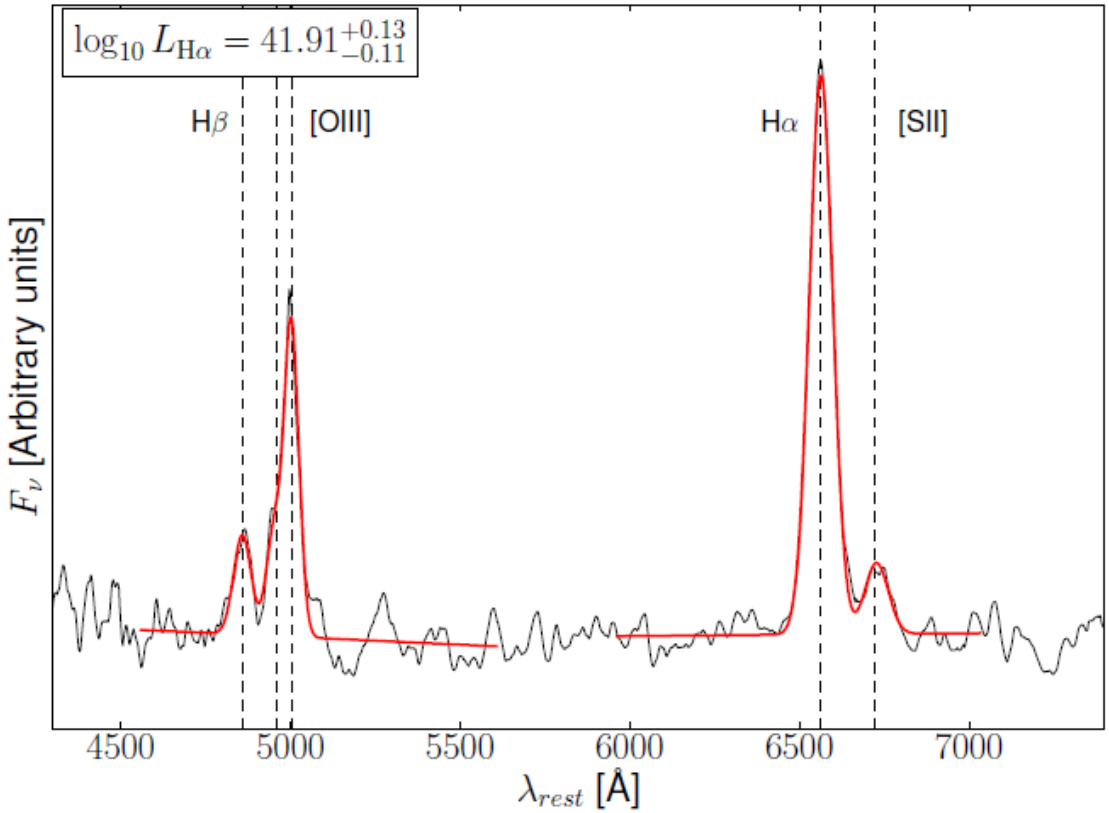



Figure: Spectral fit

# Data analysis

- Pipe3D: analysis pipeline[7]
- *"The final product of the data reduction from both surveys is a regular grid datacube, with x and y coordinates that indicate the right ascention and declination of the target, and the z coordinate a common step in wavelength..."*

[7] Sánchez et. al. 2016

# Preliminary results

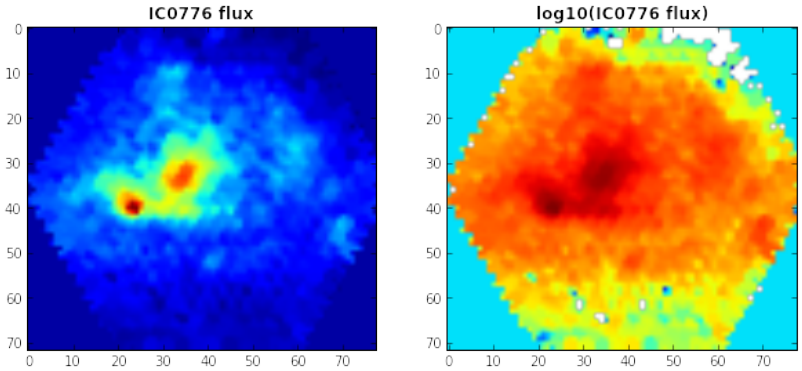



Figure: IC0776

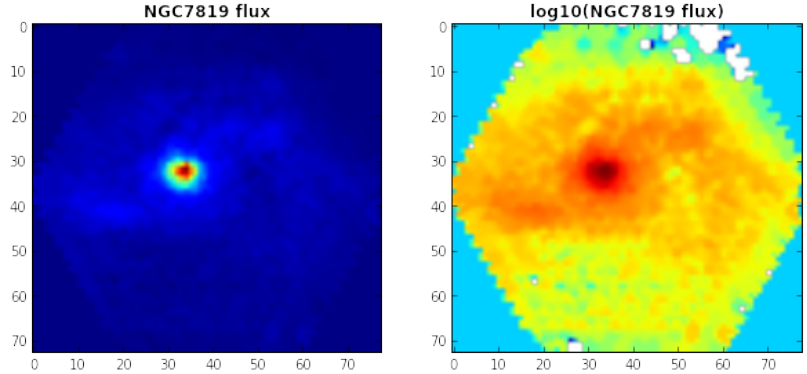



Figure: NGC7819

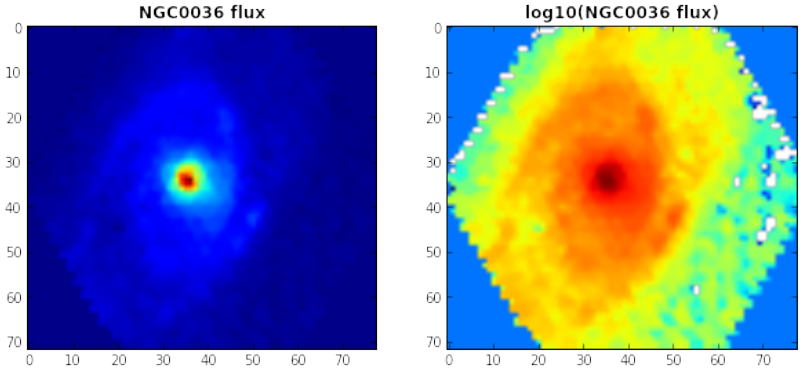



Figure: NGC0036

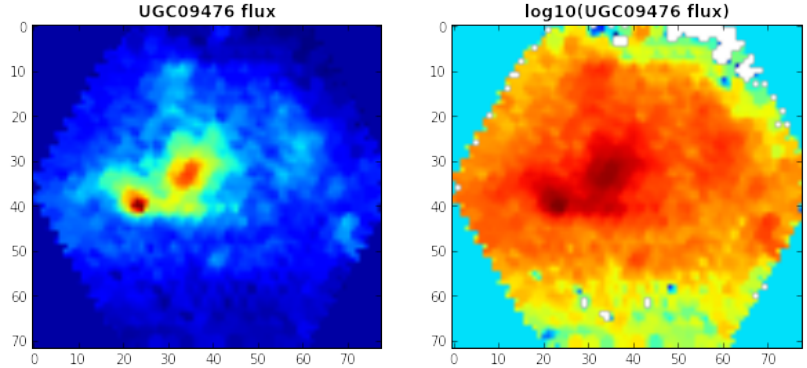
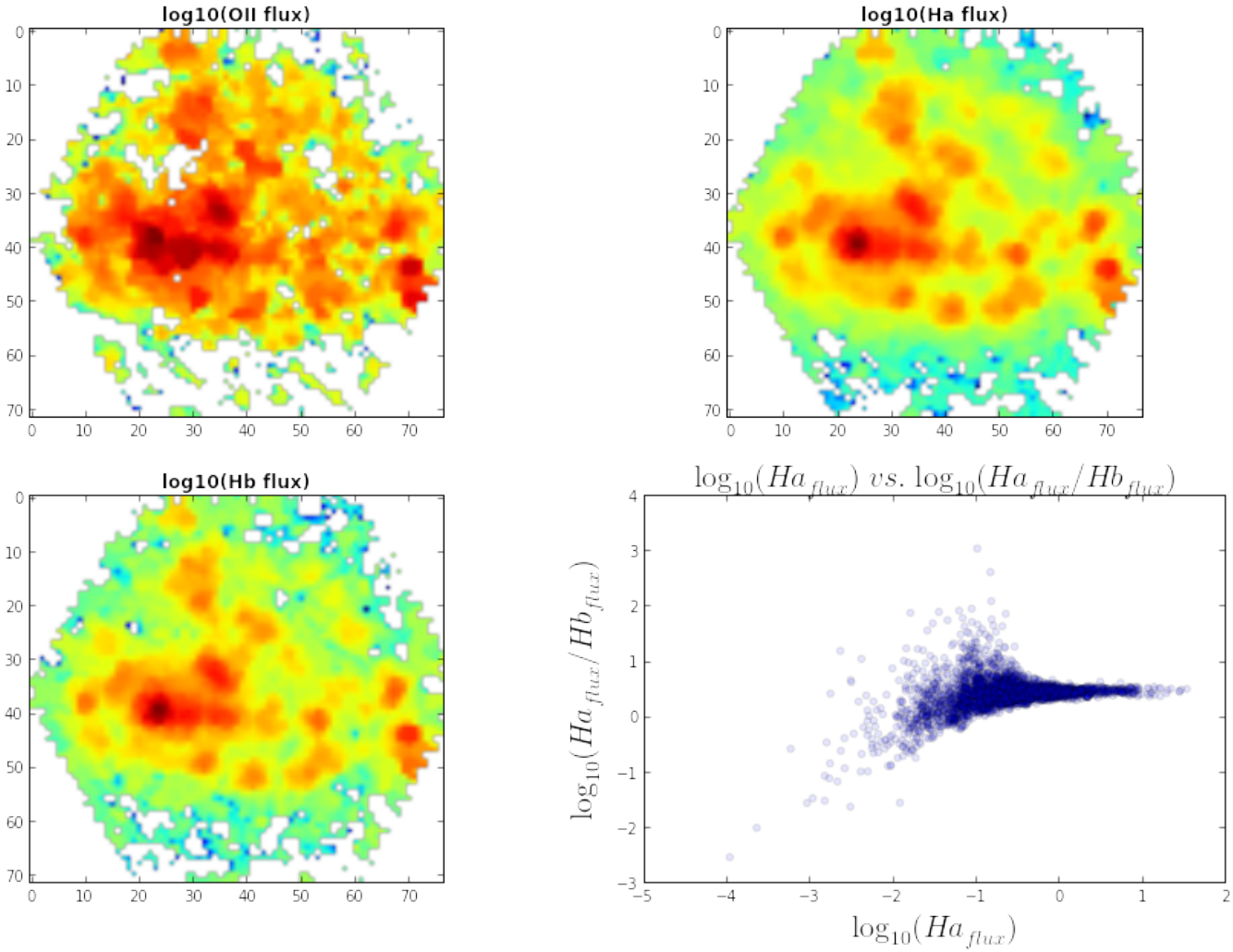



Figure: UGC09476

# Preliminary results

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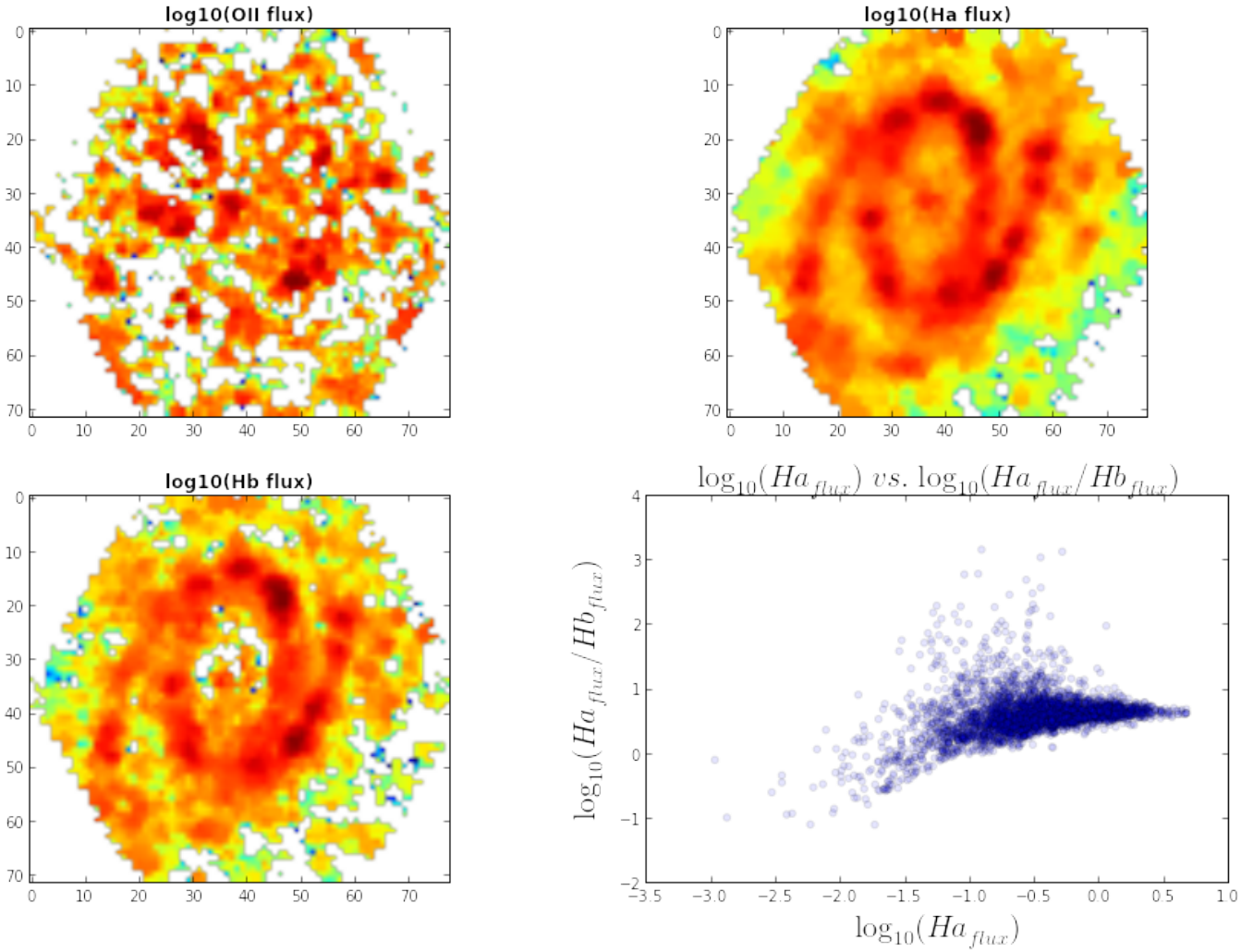


Figure: NGC0036

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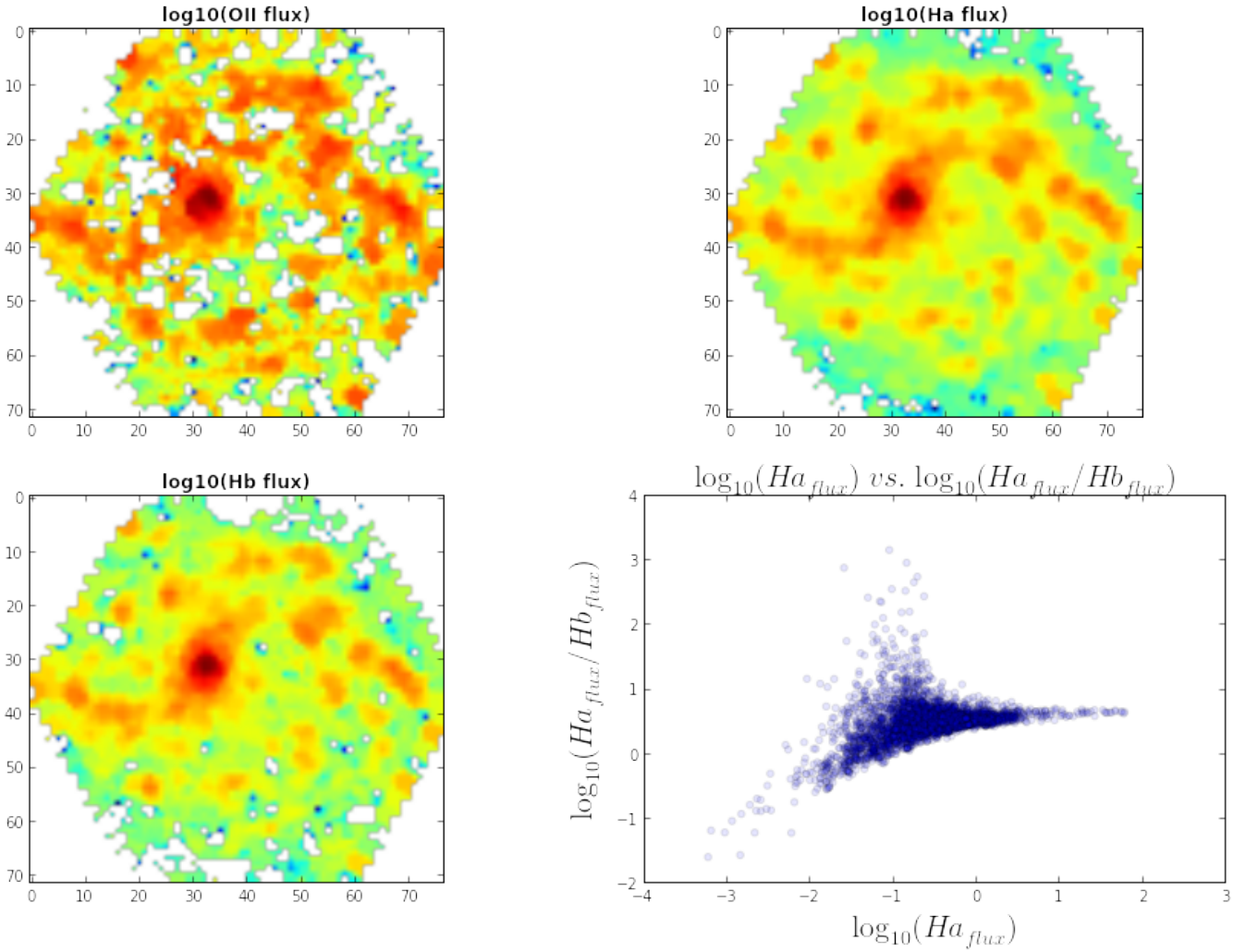



Figure: NGC7819

# Preliminary results

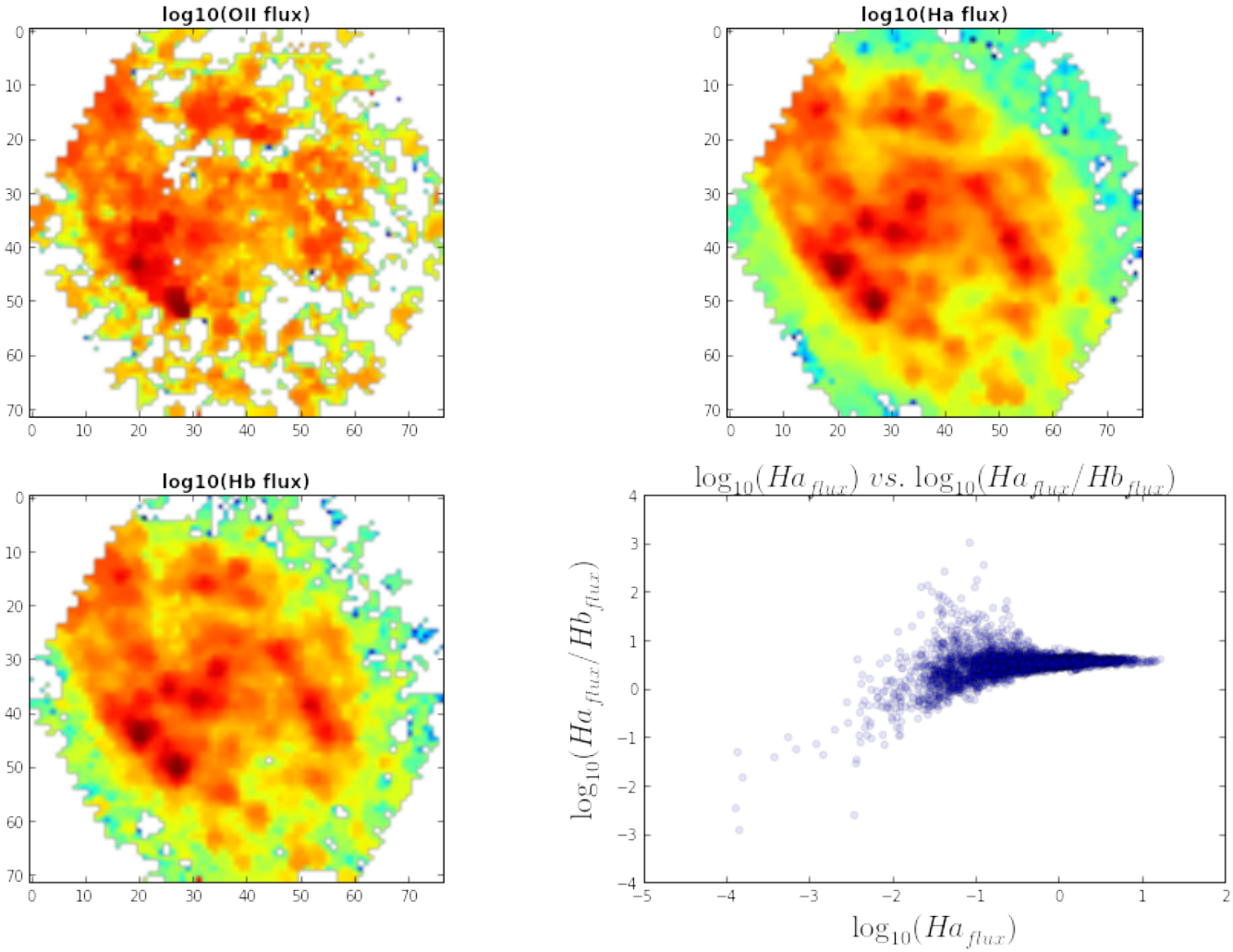
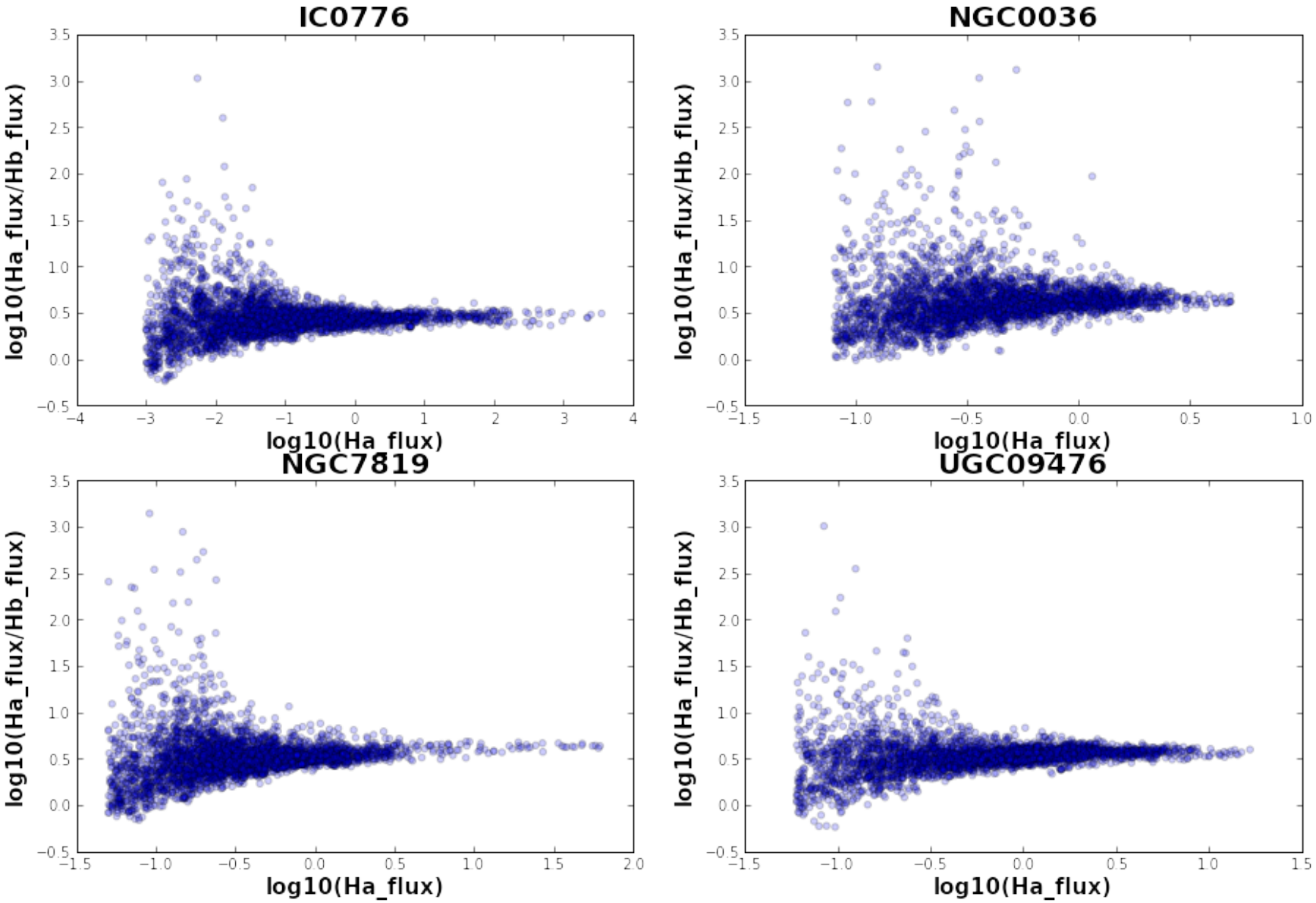



Figure: UGC09476

# Preliminary results

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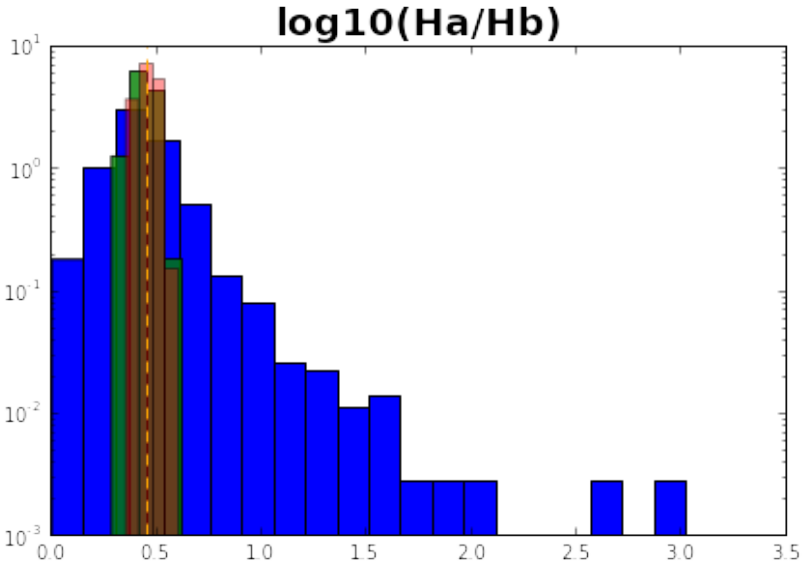


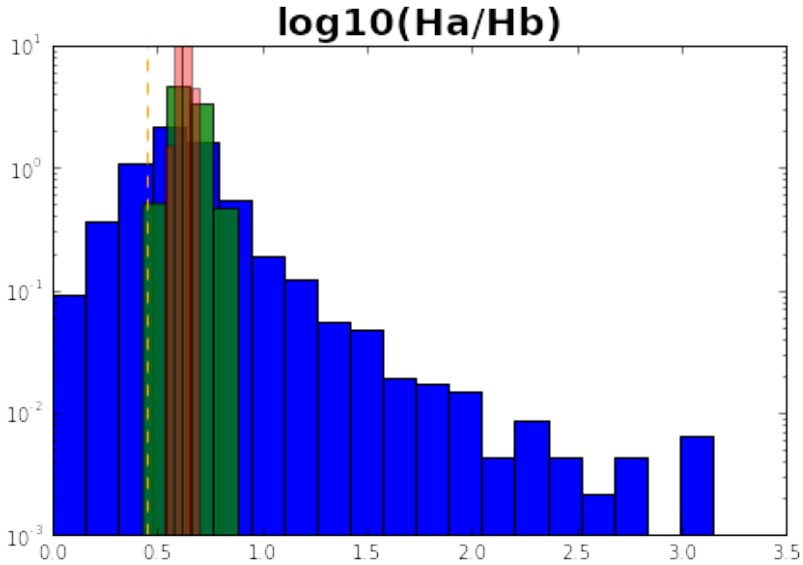


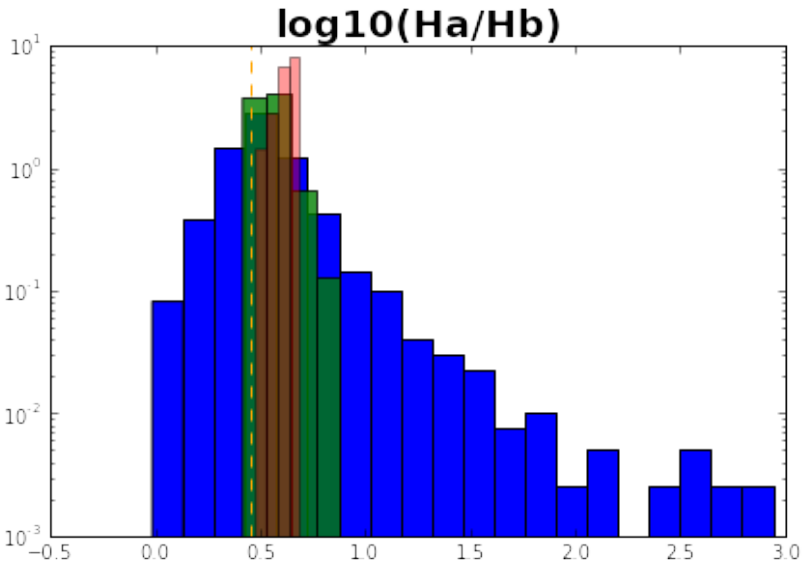


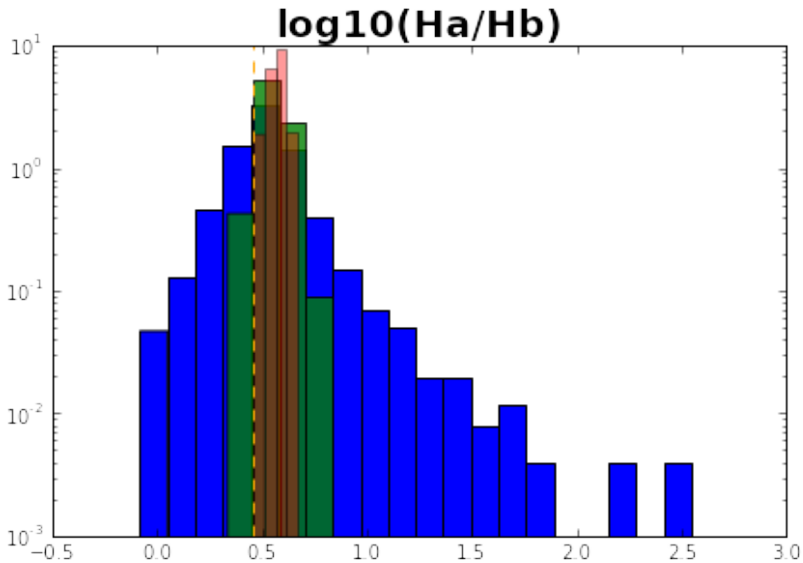


# Remaining work

| Tareas \ Semanas | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | X | X | X | | | | | | | | | | | | | |
| 2 | | | X | X | X | | | | | | | | | | | |
| 3 | | | | | X | X | X | | | | | | | | | |
| 4 | | | | | | | | X | X | X | X | | | | | |
| 5 | | | | | | | | | | | | X | X | | | |
| 6 | | | | | | | | | | | | | X | X | X | |
| 7 | | | | | | | | | | | X | X | X | X | X | X |

- Task 1: Learn to work with CALIFA data
- Task 2: Calculate intensity ratios for a single galaxy
- Task 3: Redact first draft
- Task 4: Analyze results for all galaxies
- Task 5: Compare results found with theoretical predictions
- Task 6: Conclude if stochastic effects are observed
- Task 7: Redact final document