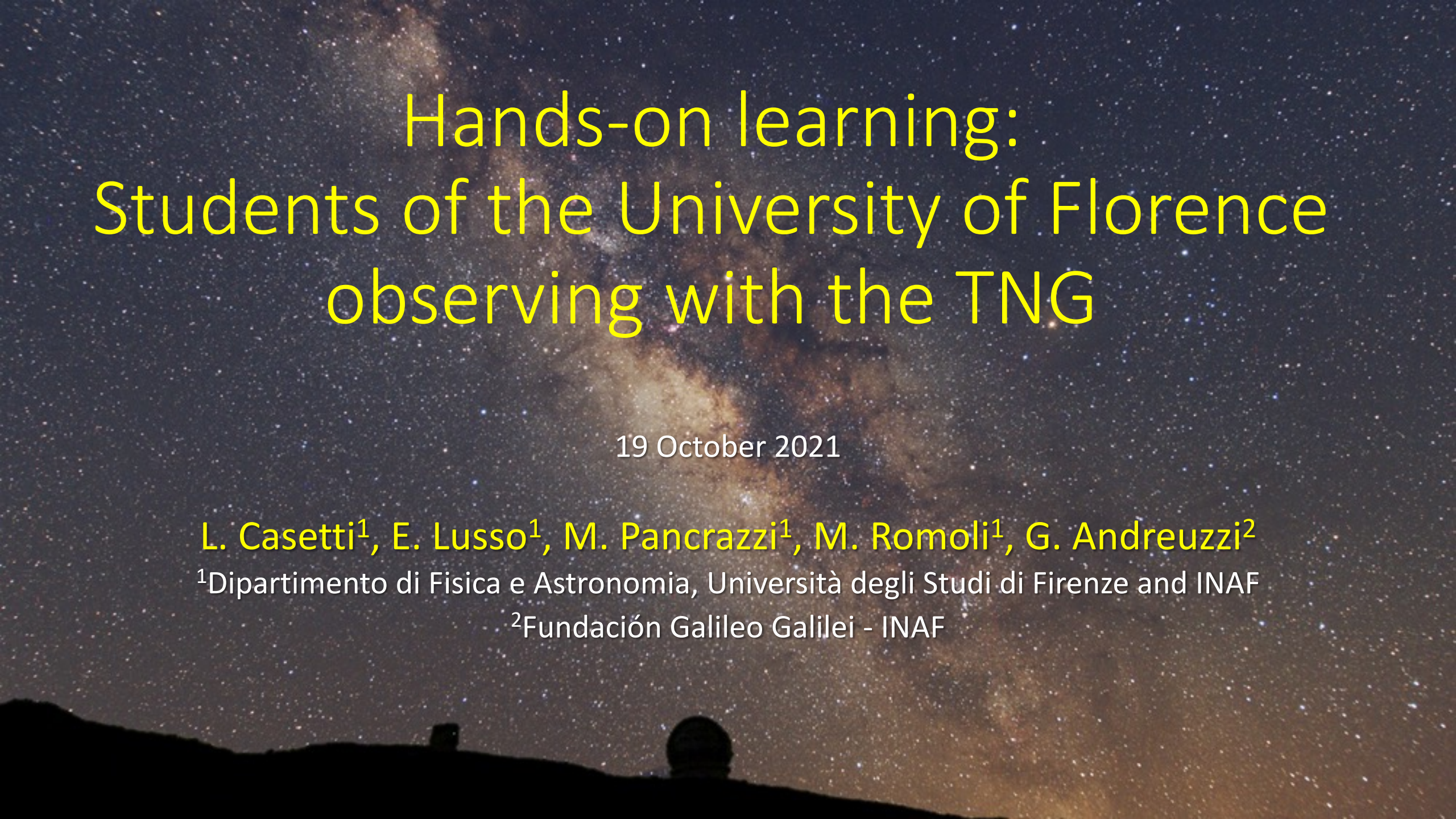

Hands-on learning: Students of the University of Florence observing with the TNG

19 October 2021

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Summary

- Description of the context at Università di Firenze
- Educational aims of the experimental course of Complementi di Astronomia
- Description of the observing campaigns and data analysis
- Outcome of the didactic experience

A little history……

- Legacy: Astrophysics didactic experiments at Università di Firenze Two lab courses held by Prof. Landini, Righini and Stanga
- 1995-2011 *Esperimentazioni di Fisica III* for all third year physics students with : HR diagram – Muon mean lifetime– Michelson interferometer (Observations at *Osservatorio di Loiano (Bo)*)
- 2001 New organization of university degrees: *triennale* and master degrees (Physics and Astrophysics)
- 2011 Esperimentazioni Fisica III: from HR diagram to Hubble Law verification
- 2013 Revision of *Laurea triennale*: new optional course: Complementi di Astronomia 2013
- In 2017 the Magini donation to the Arcetri Observatory allowed to organize the first trip to La Palma within the course activity

Complementi di astronomia course

- Optional course of *Laurea triennale* and Master degree
- First introduction to experimental astronomy
  - Theory of diffraction
  - Telescopes
  - Focal plane instrumentation
  - Spectroscopy with gratings
  - CCD detectors

  - Students' short seminar on major telescopes

  - Radio astronomy techniques (Stanga, Romoli) till 2018
  - X-ray astronomy (Lusso) from 2019

  - Observing campaigns at Loiano and TNG

Complementi di astronomia course

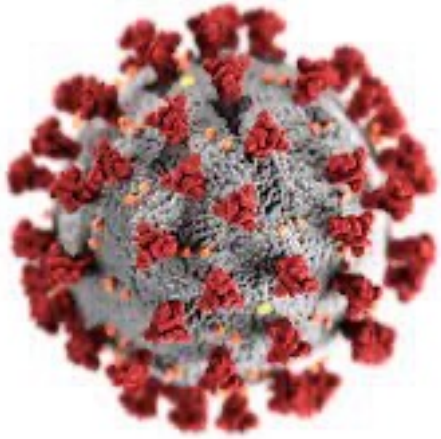
Choice of observing targets made by students

Observing campaign at Loiano Observatory

Observing campaign at TNG since 2017

Data analysis:

- Performed inside the computer classroom at the Dept. of Physics and Astronomy using Python first and then Matlab (university students' and teachers' license),
- use of students' laptop from home during covid-19 pandemic
- now about to switch back to Python



Covid-19 pandemic outbreak

- No campaigns in 2020
- Remote campaigns from Loiano and TNG in 2021
- 2022 ?

Organization of La Palma campaign

- Target: third year students of undergraduate courses (*Laurea triennale* in Physics and Astrophysics) and some students of the master degree.
- November: presentation of the course inside the *Introduction to astrophysics* course
- December: manifestation of interest
- February: organization of the trip and beginning of the course
- Campaign in March/April in the week after Easter (during spring break). 5 days length
- Data analysis from April to June

2018 – 12 students

2017 – 12 students

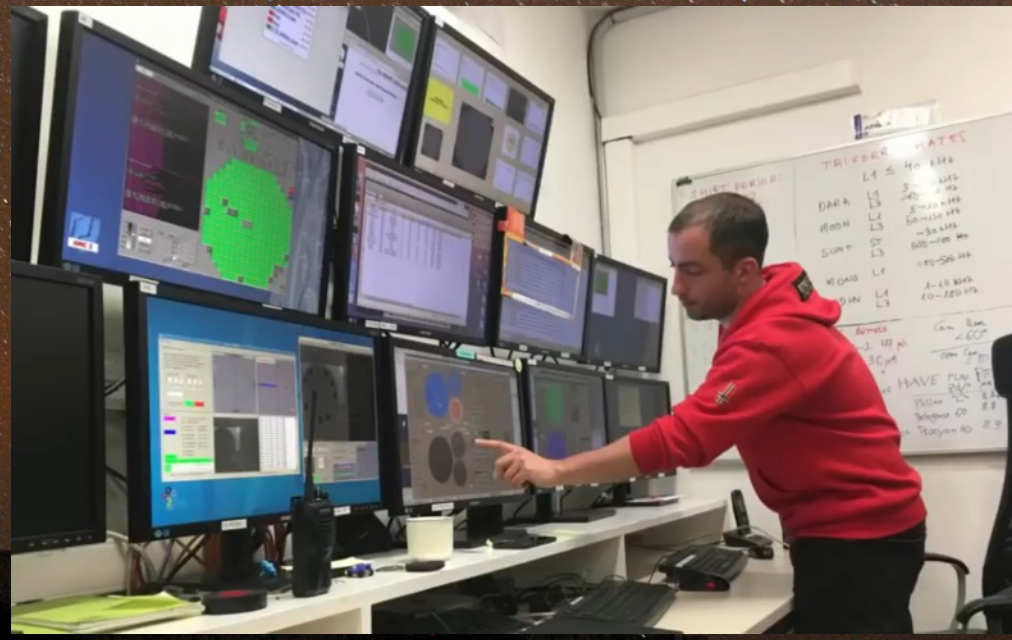
Grupos 2017 -> 2019

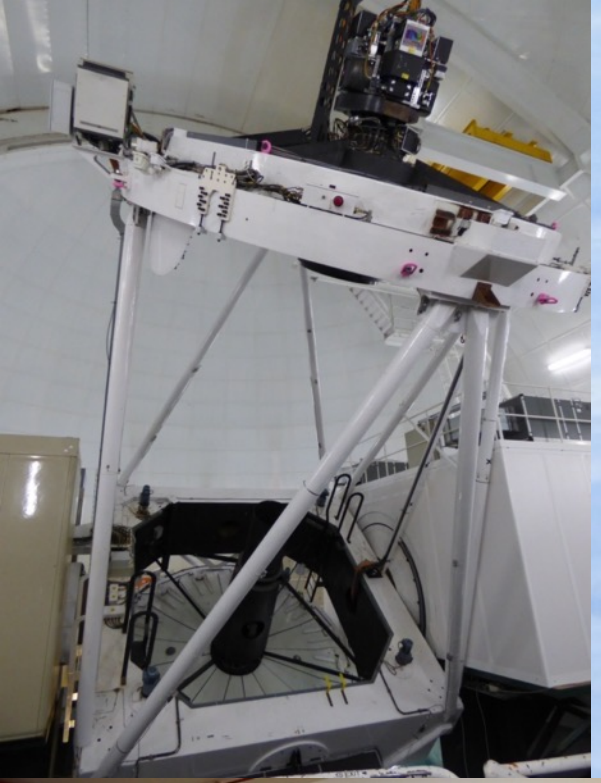
2019 – 16 students

Telescopio Nazionale Galileo (TNG)

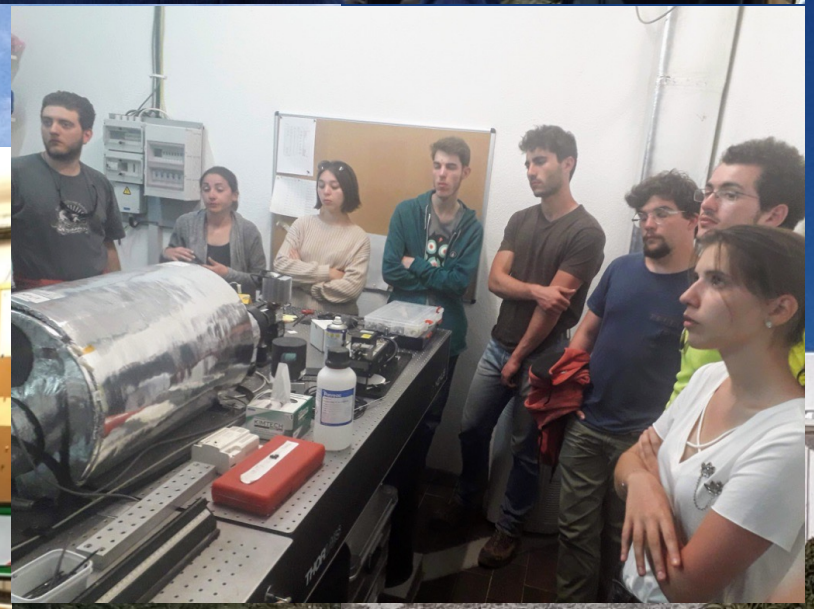
Gran Telescopio Canarias (GTC)

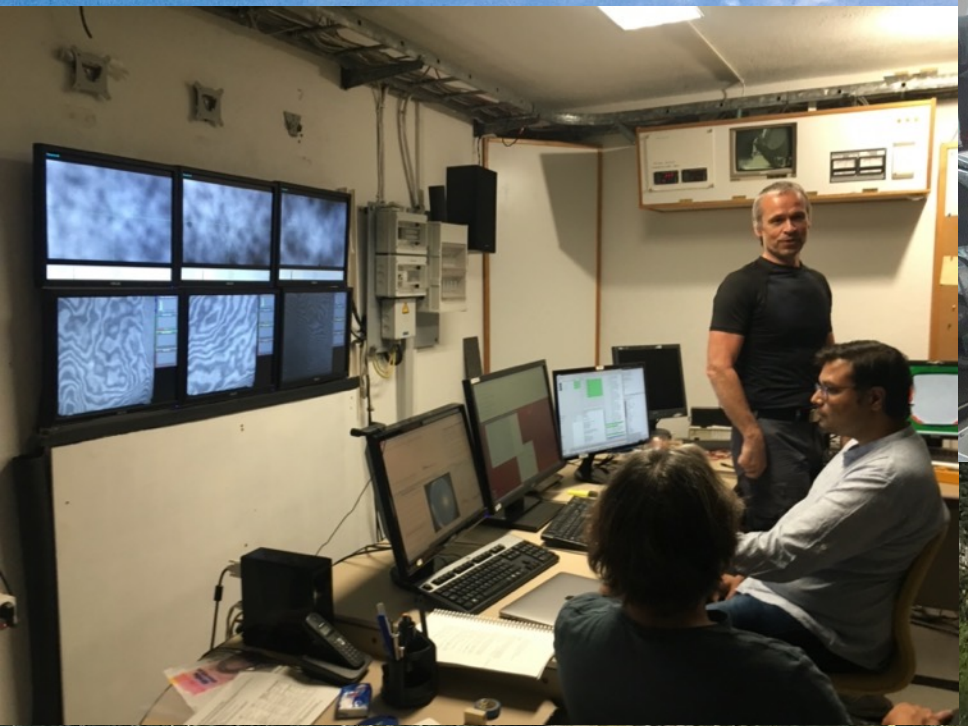
MAGIC





William Herschel Telescope (WHT)





Swedish Solar Telescope

Laser guide star tests

Night sky observation and photography

Dawn at Roque

OBSERVING AT THE TNG

Imaging and spectroscopy of normal and active galaxies with DOLORES

Imaging with broadband filters

- Measure the apparent diameter of the galaxies

  as redshift-independent distance estimator (rough but easy!)

  optional/to be implemented: surface density profiles, spatial variation of color, color images…

Long-slit spectroscopy

- Measure the redshift

  to estimate the Hubble constant/check the Hubble-Lemaître law

- Measure emission lines width and flux

  to estimate the black hole mass (AGNs) or the star formation rate

  optional/to be implemented: rotation curves…

Students' tasks

Before the observing night

- Choose observing targets and prepare the detailed observing plan

  …under the teachers' supervision

In the control room

- Operate the DOLORES interface/interact with the telescope operator

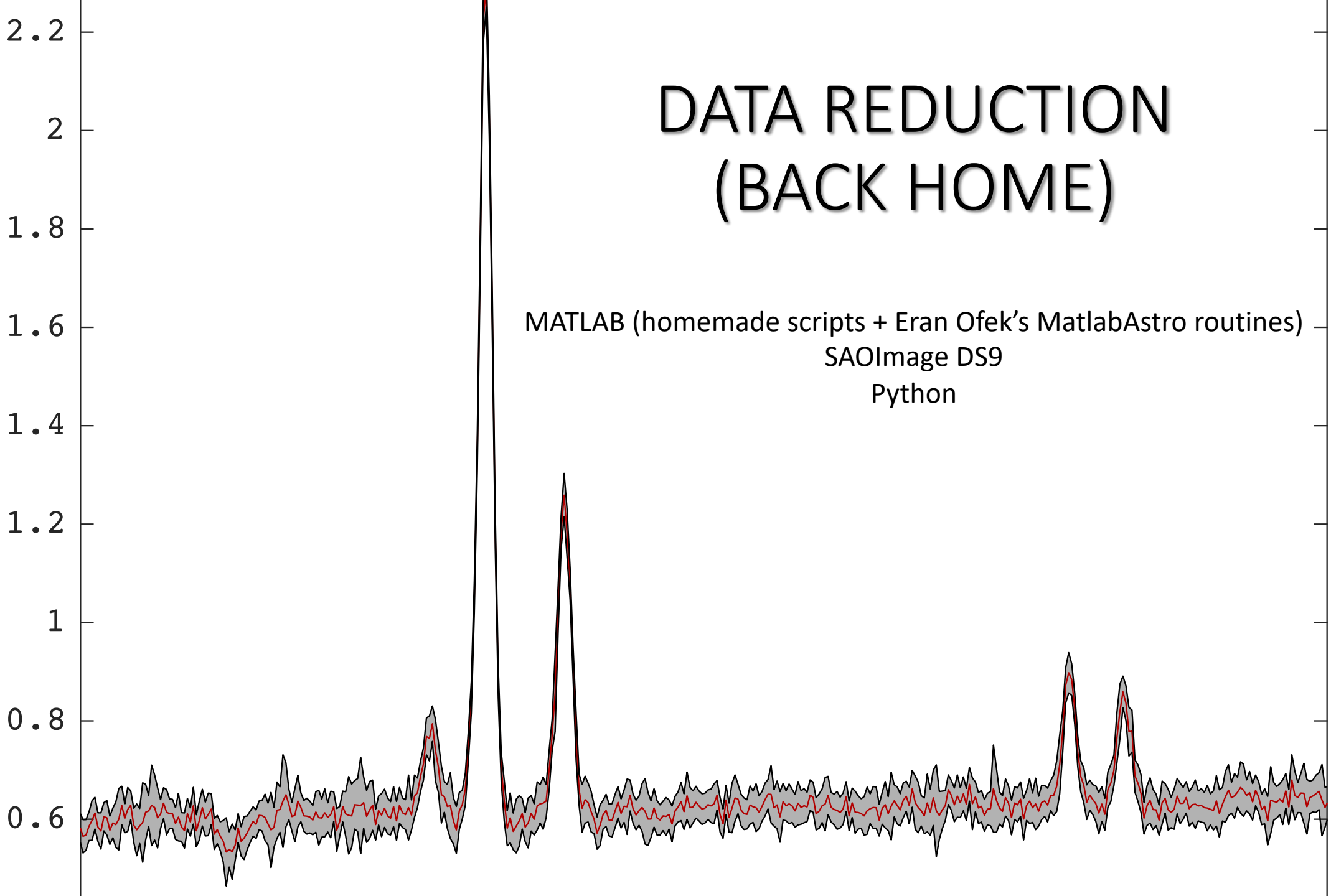
  …under Gloria Andreuzzi's supervision

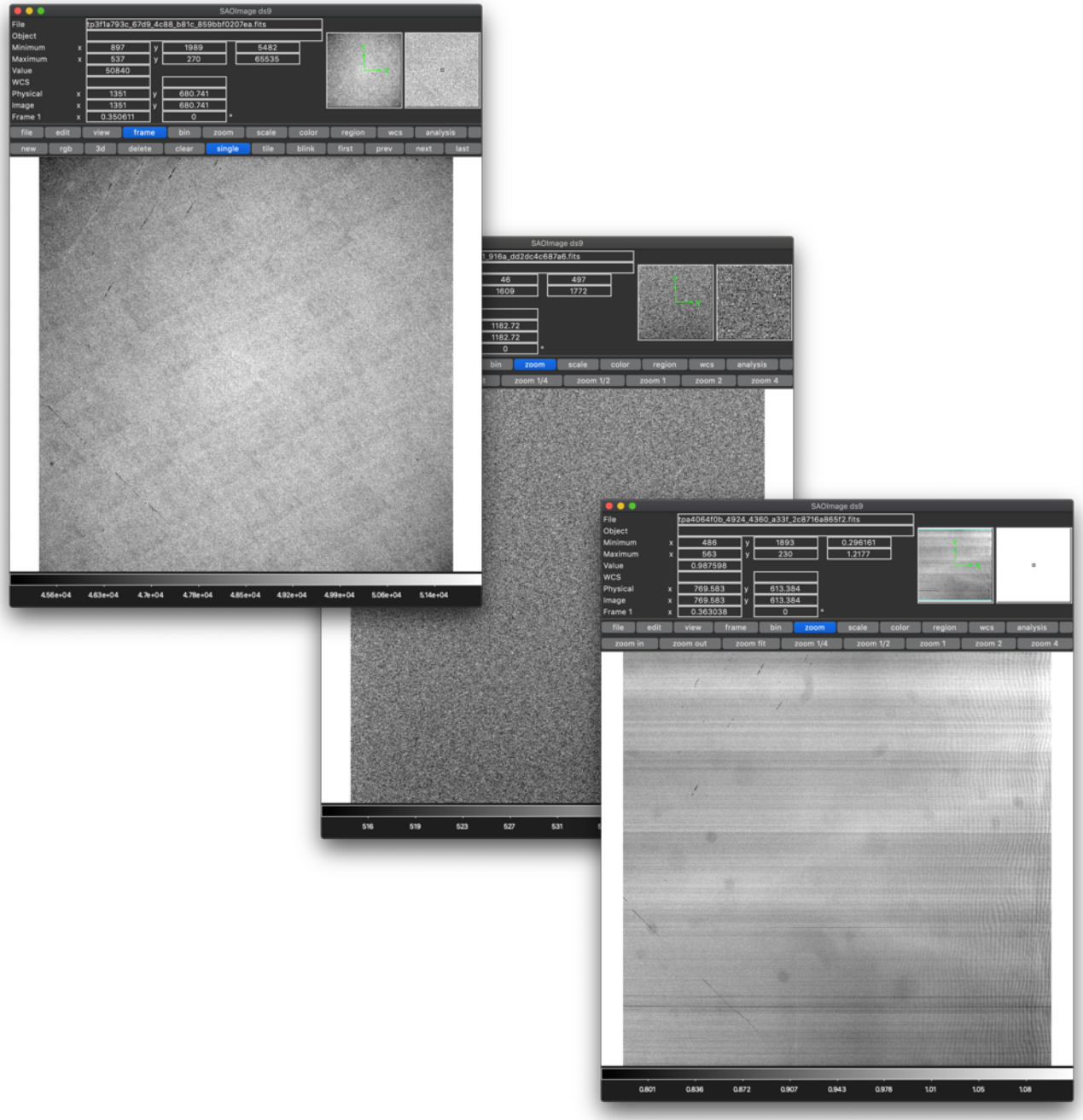
- Take real-time decisions

  change of integration times, switching to backup targets…

DATA REDUCTION (BACK HOME)

MATLAB (homemade scripts + Eran Ofek's MatlabAstro routines)
SAOImage DS9
Python



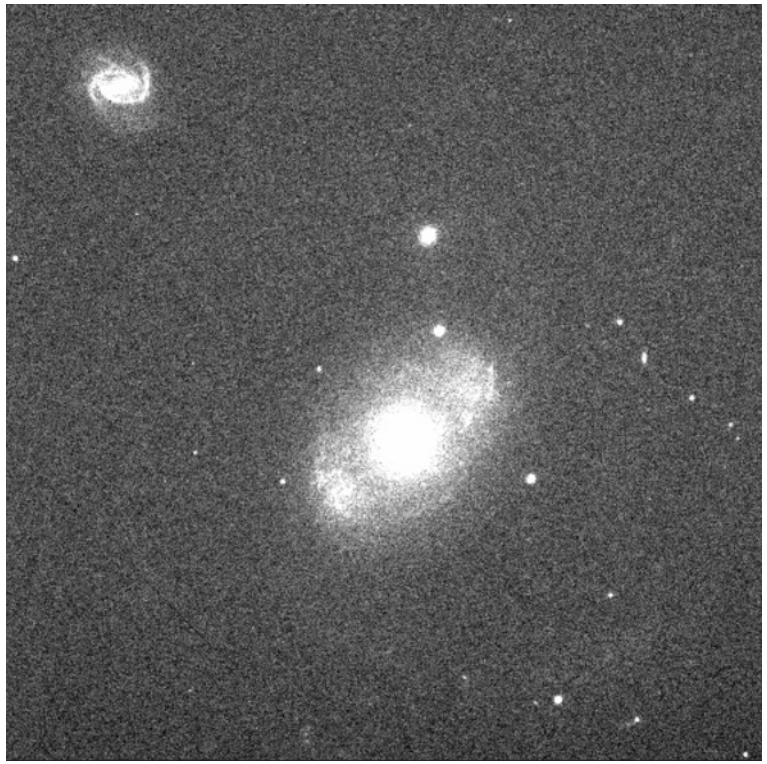


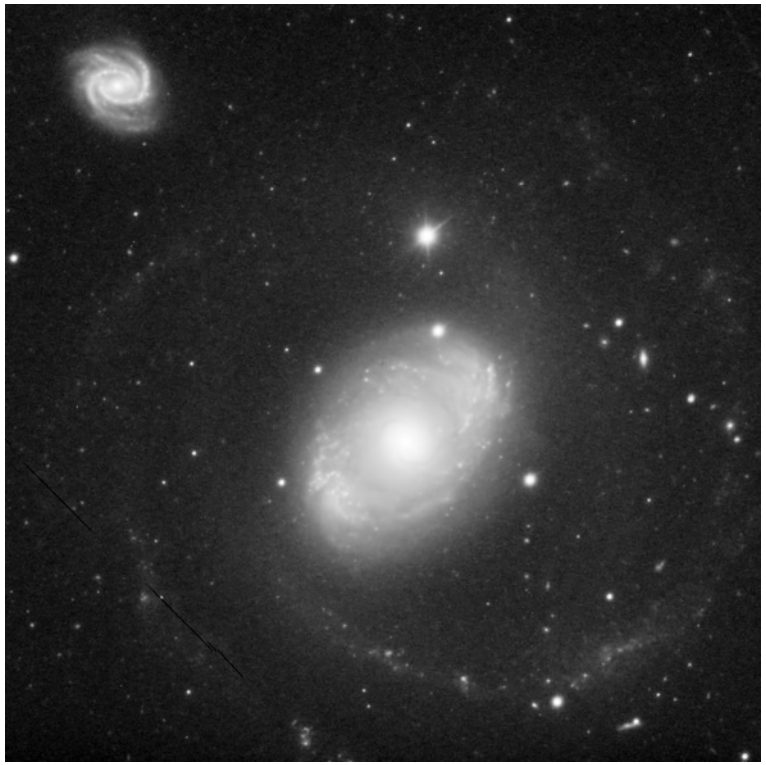
BIAS AND FLATS

- Master bias and flat

  photometric and spectral
- Statistics and readout noise

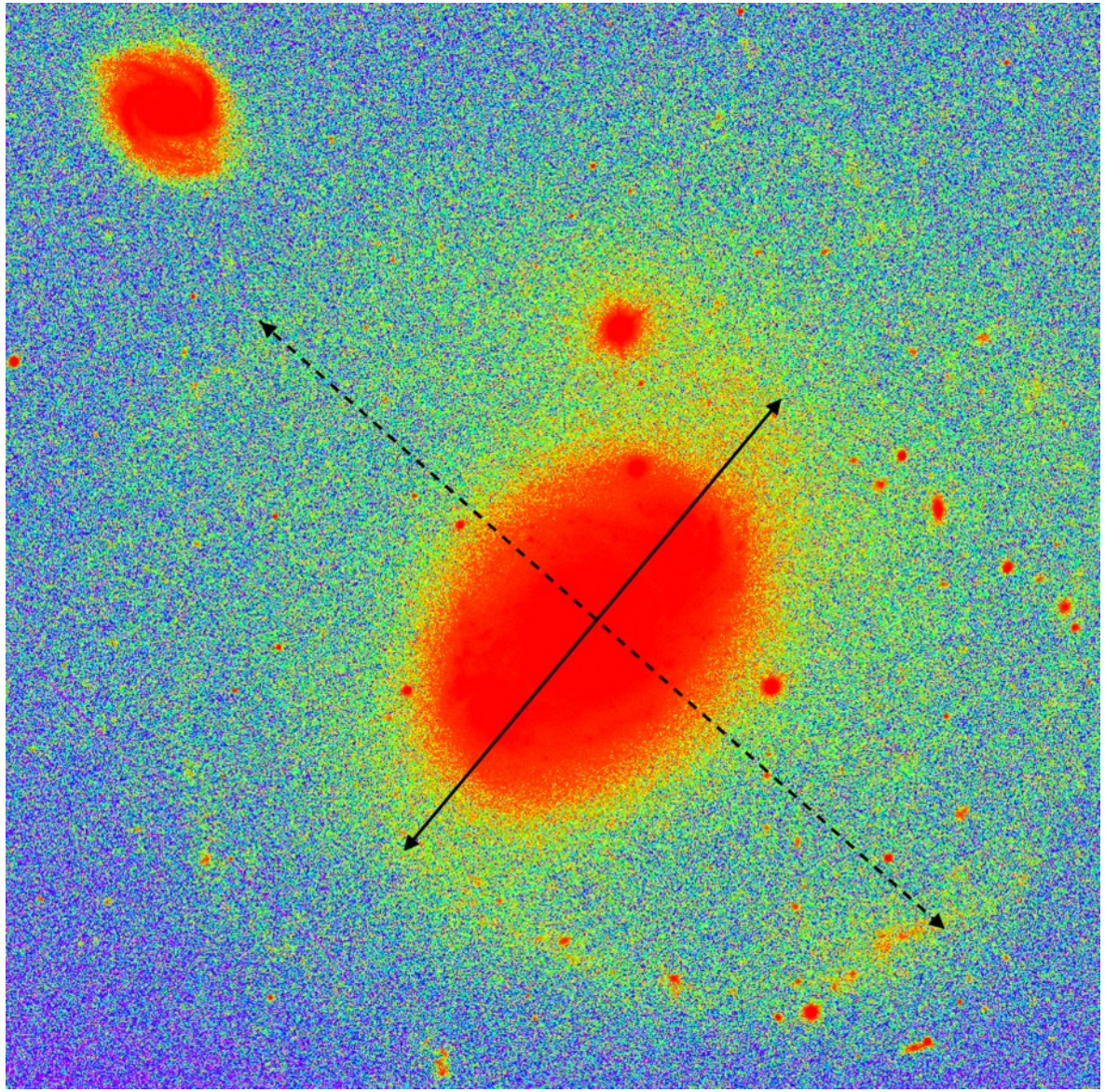
FROM RAW TO CALIBRATED FRAMES



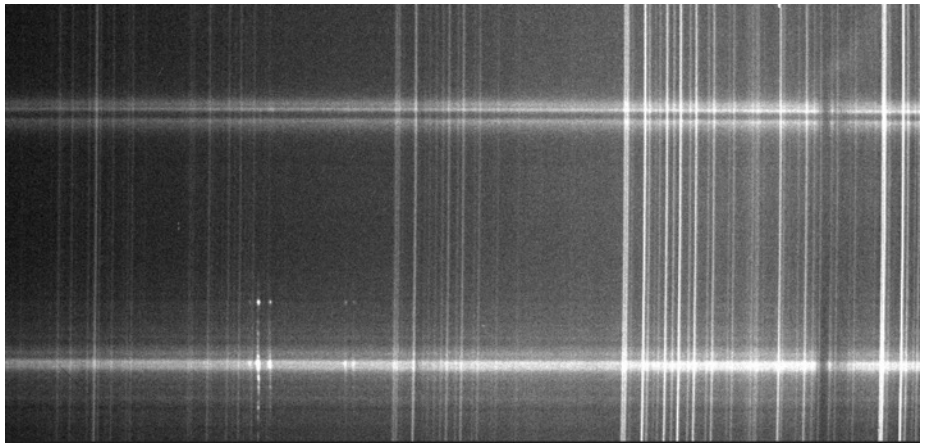


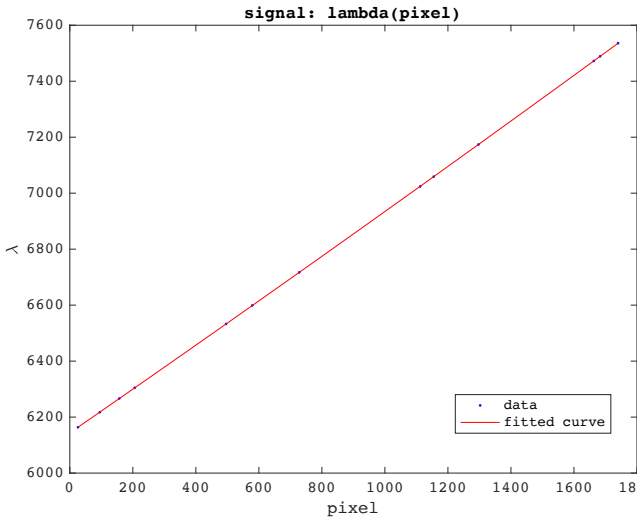
DIAMETER AND DISTANCE

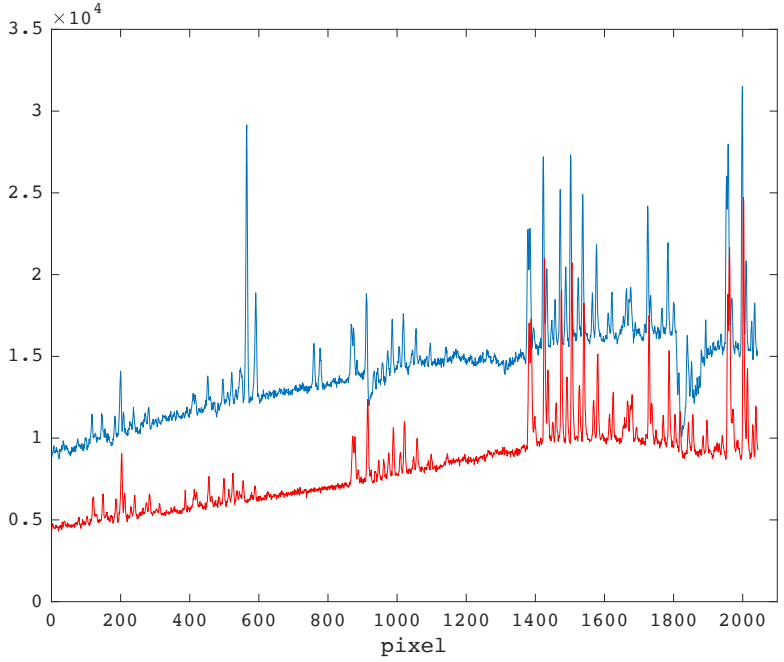
relative error on distance ≈ 50%



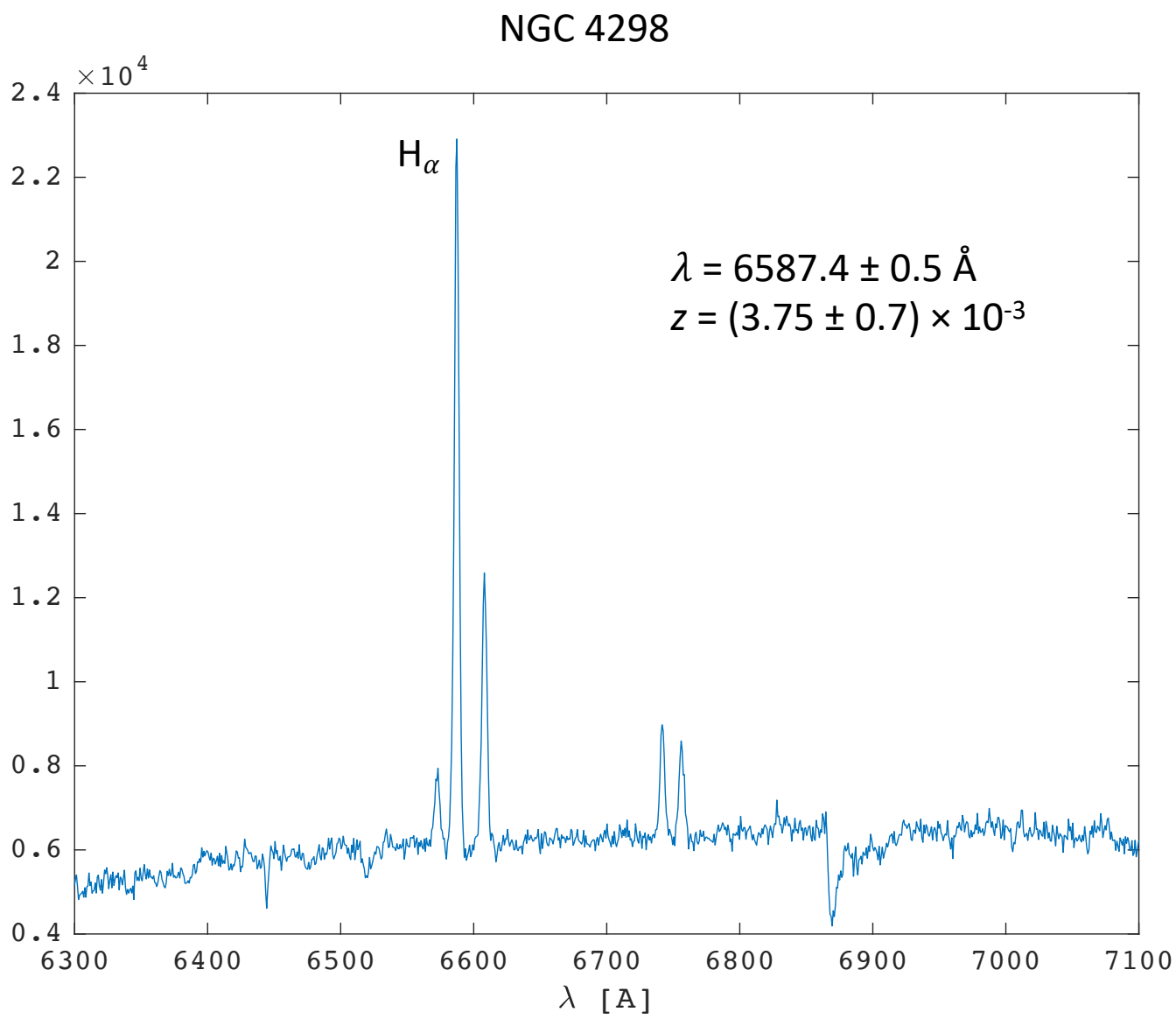
SPECTRUM EXTRACTION, BACKGROUND SUBTRACTION AND WAVELENGTH CALIBRATION





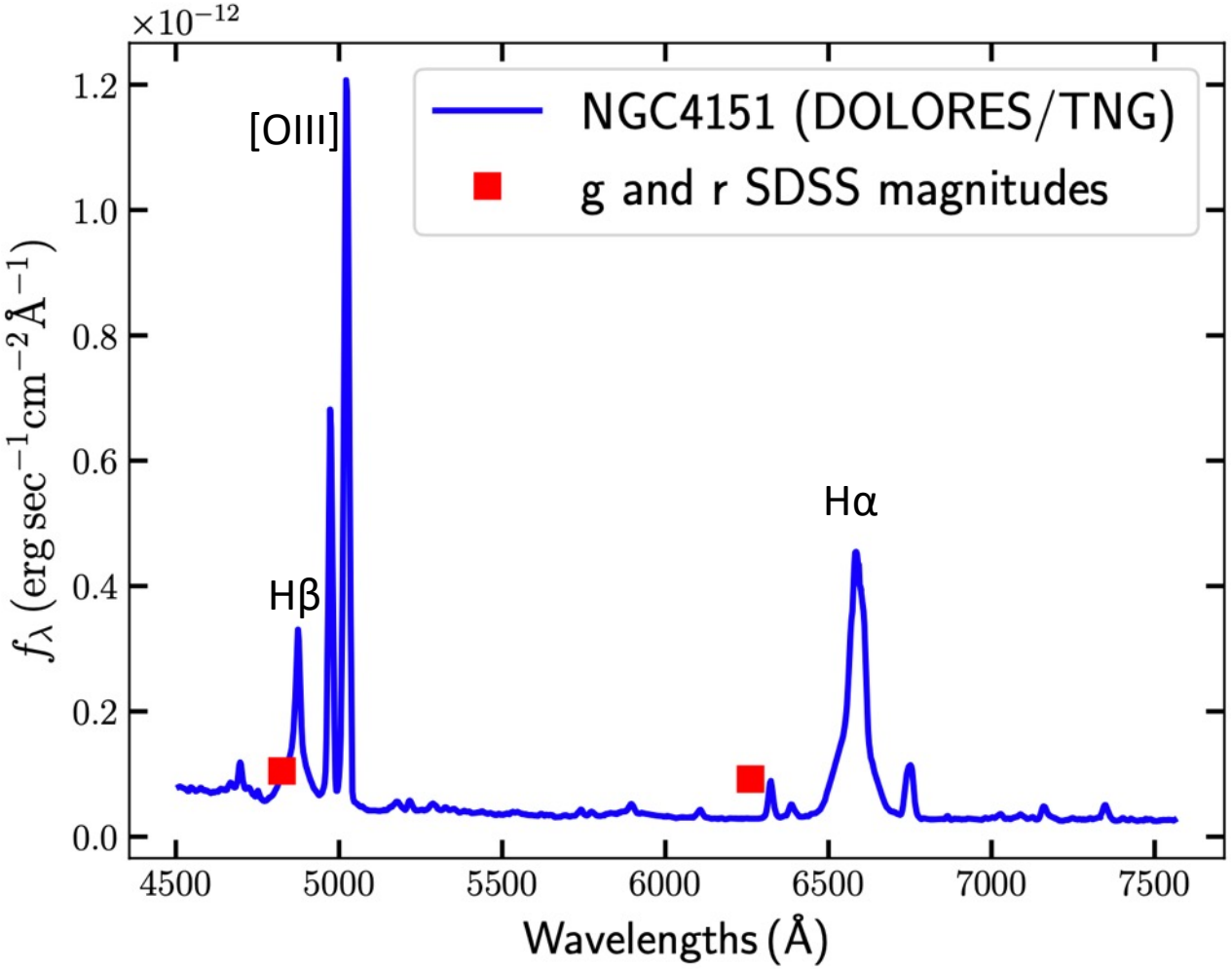


REDSHIFT


NGC 4298
×10^4
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
Hα
λ = 6587.4 ± 0.5 Å
z = (3.75 ± 0.7) × 10^-3
6300
6400
6500
6600
6700
6800
6900
7000
7100
λ [A]

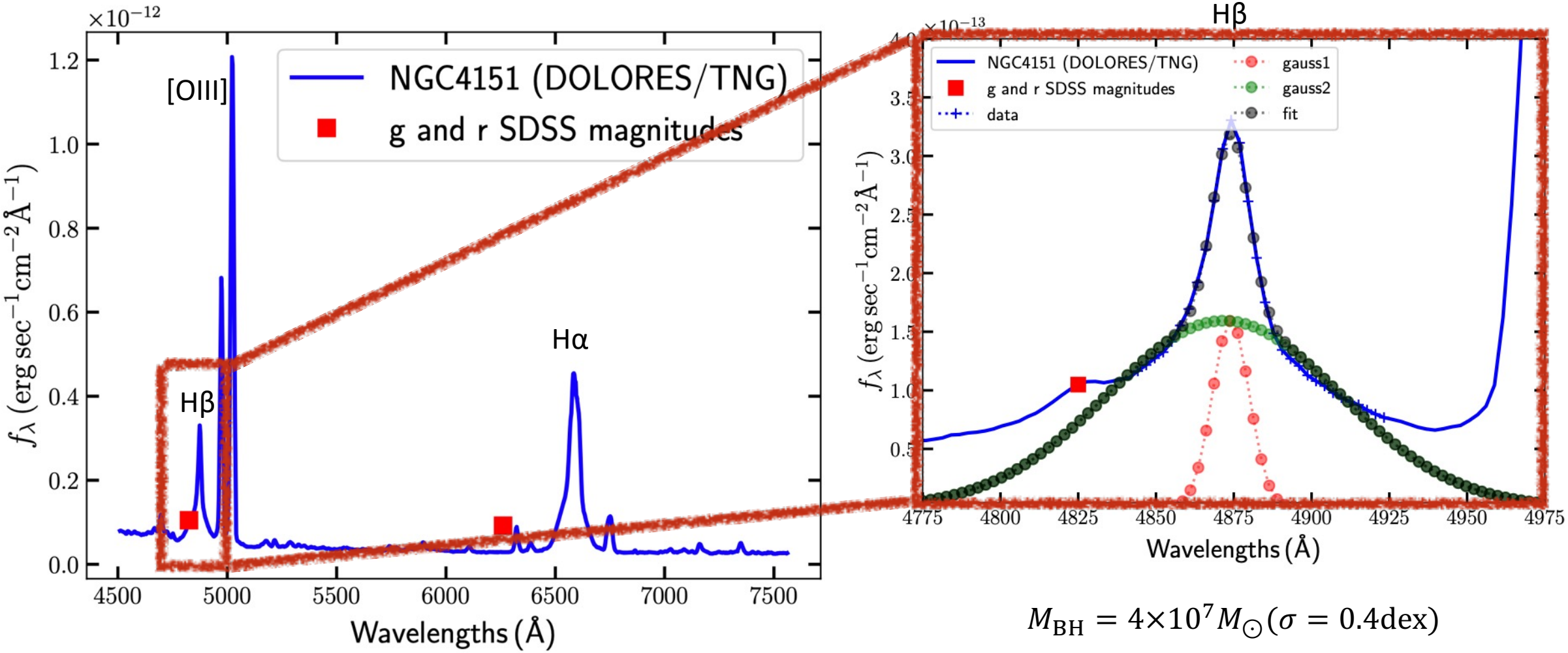
Black hole mass and star formation rate

Flux calibrated spectrum of the Seyfert 1 galaxy NGC4151



Black hole mass and star formation rate

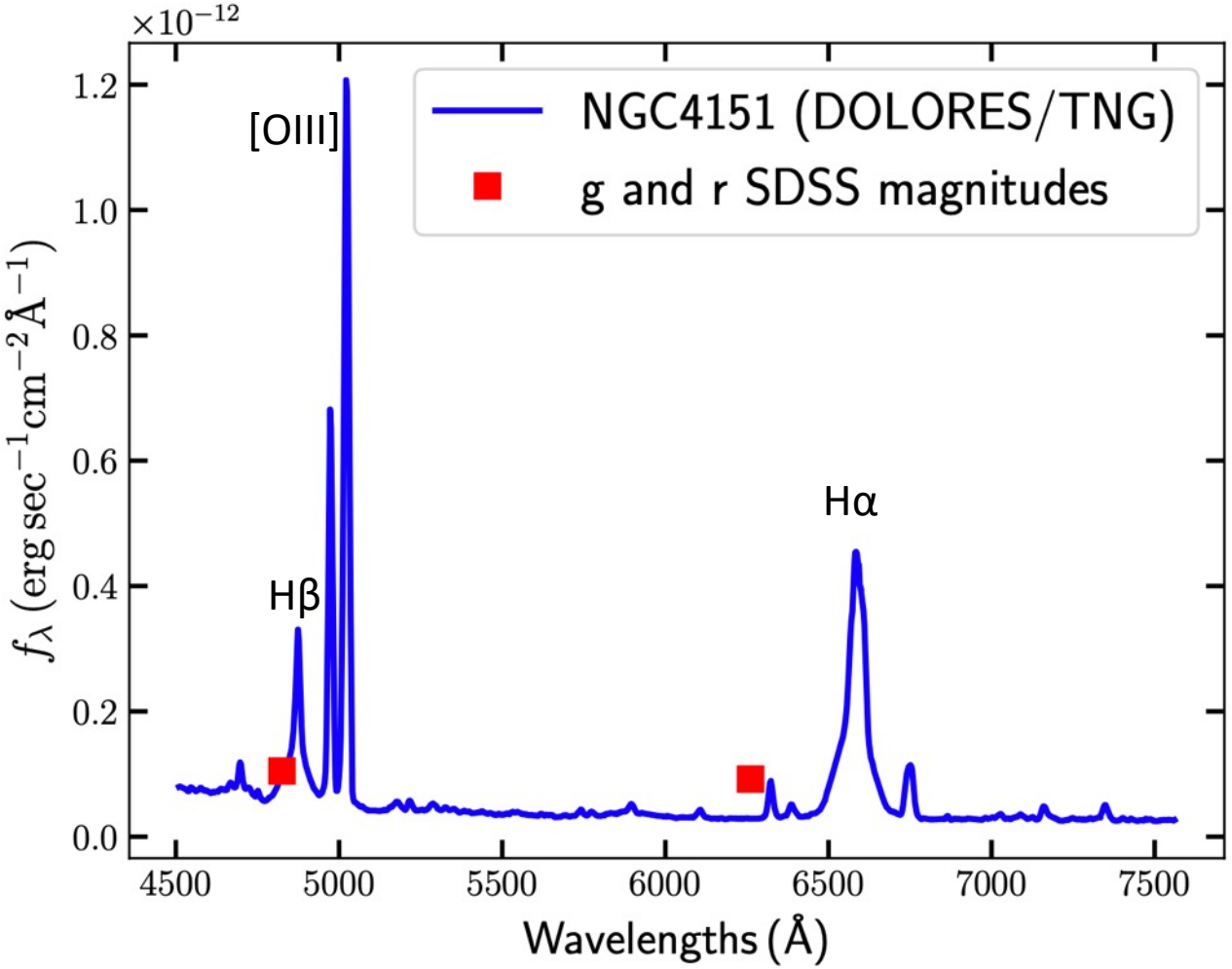
Flux calibrated spectrum of the Seyfert 1 galaxy NGC4151



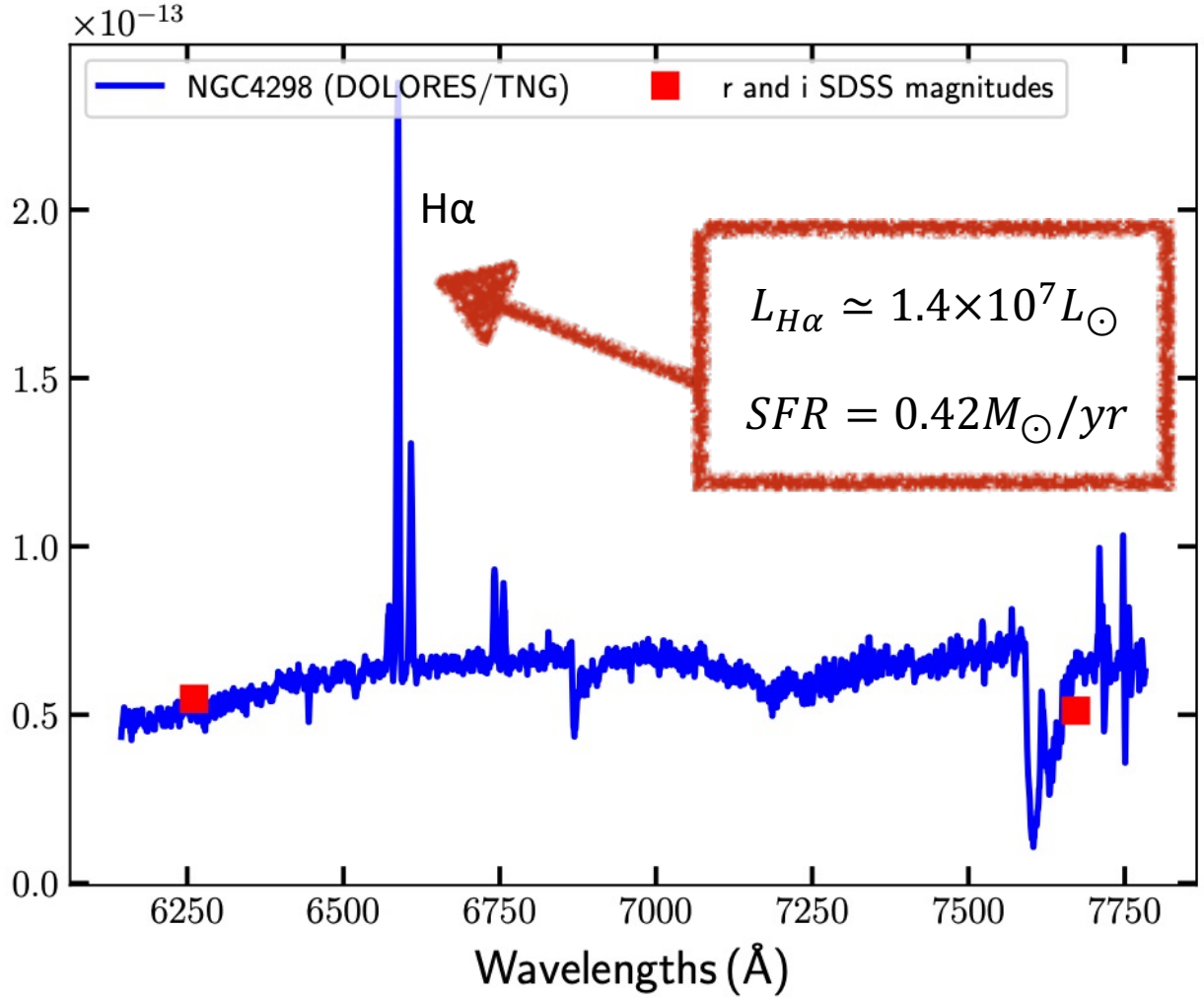
$M_{\mathrm{BH}} = 4{\times}10^{7} M_{\odot} (\sigma = 0.4\mathrm{dex})$

Black hole mass and star formation rate

Flux calibrated spectrum of the Seyfert 1 galaxy NGC4151



Flux calibrated spectrum of the galaxy NGC4298



OUR TNG GALAXY DATABASE

75 galaxies in the full database
(including those observed at Loiano)

2017

NGC 3370, NGC 3899

2018

NGC 5257, NGC 5258

2019

NGC 4151, NGC 4156, NGC 4298, NGC 4302, PGC 053030

2021 *(remote session)*

MRK 141, PGC 030175, NGC 3294, PGC 2097280

Sightseeing and …… some relax

Students' careers

- 40 students in total have visited La Palma

- 2 students with triennale degree using TNG data:
  - *Verifica della legge di Hubble–Lemaître in campo vicino tramite misure fotometriche e spettroscopiche*
  - *Stima della massa del buco nero supermassiccio in NGC 4151*

- 87% of participants involved in astrophysics studies among which:
  - 2 post-docs
  - 15 PhD Students (6 in Firenze)
  - 12 Master degree students
  - 6 Triennale degree students

We wish to thank:

Famiglia Magini
INAF Osservatorio Astrofisico di Arcetri
Dipartimento di Fisica e Astronomia - Università di Firenze
TNG staff
Staff degli osservatori del Roque de Los Muchachos
Magic: Simona Paiano, Daniele Ninci, Andrea Rugliancich
SST: Peter Sütterlin
Artificial stars: Domenico Bonaccini