

A night sky filled with stars, with a large telescope dome in the foreground. The dome is white and has a dark, cylindrical structure on top. The sky is dark blue and black, with many small white stars. The horizon is visible at the bottom, showing a dark landscape.

# Early Science from the Southern African Large Telescope

Steve Crawford  
SALT Science Data Manager



What types of  
Observations do we  
make?

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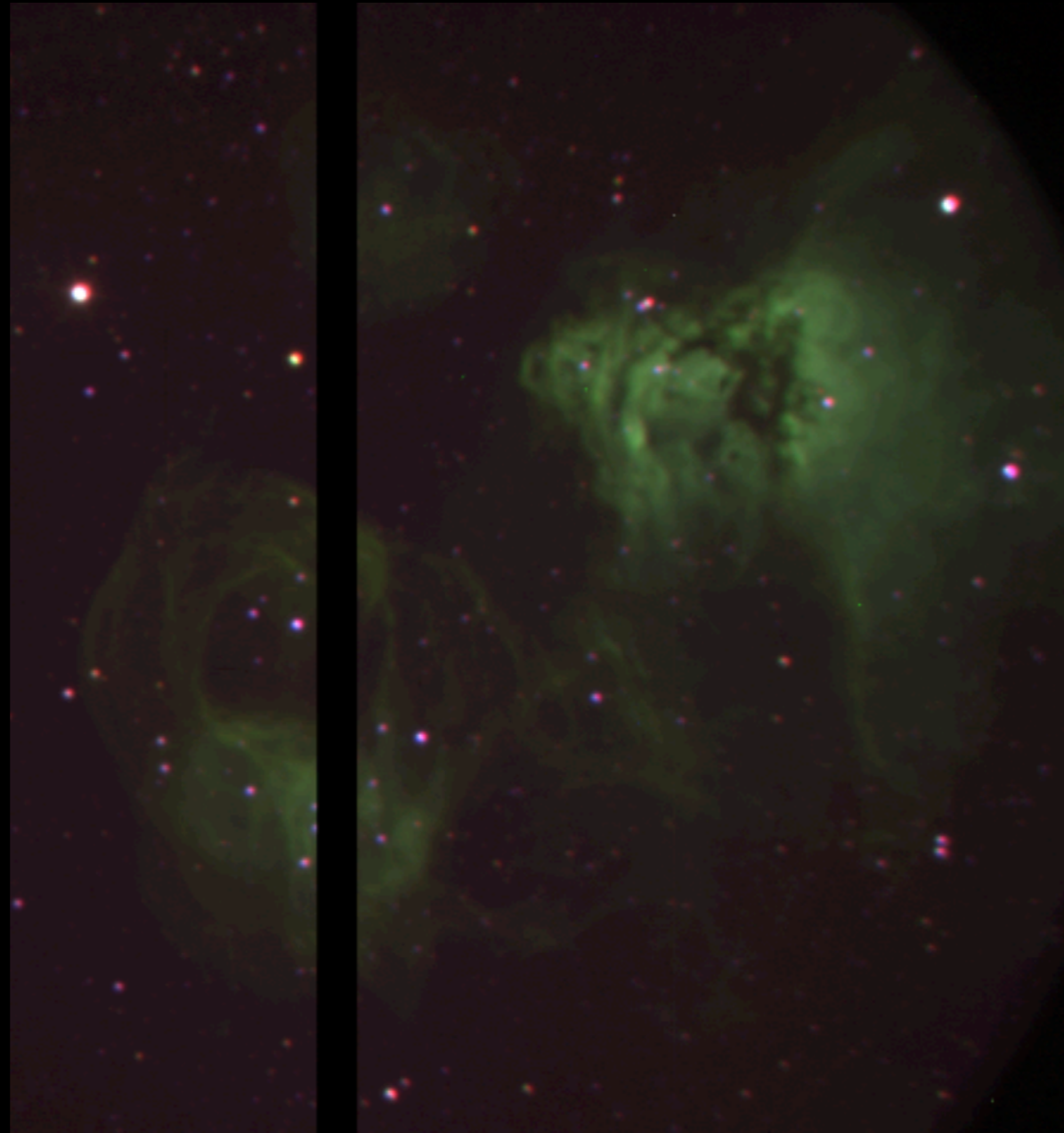
Imaging

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Imaging

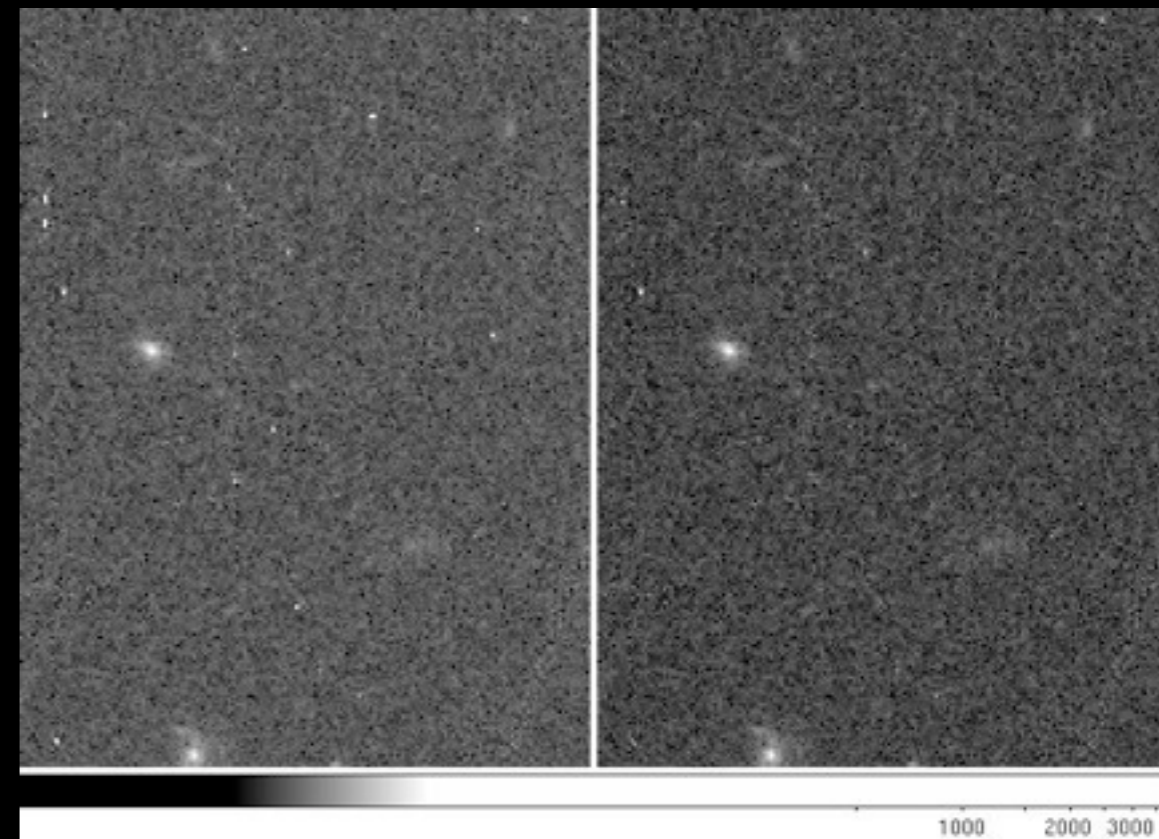
Spectra

# Imaging



# SALTICAM

Multi-mode imaging and acquisition camera. In full-frame mode, it has an 8x8' FOV. In slotmode, high-speed photometry (20 Hz) can be performed over a smaller field of view.



Darragh O'Donoghue

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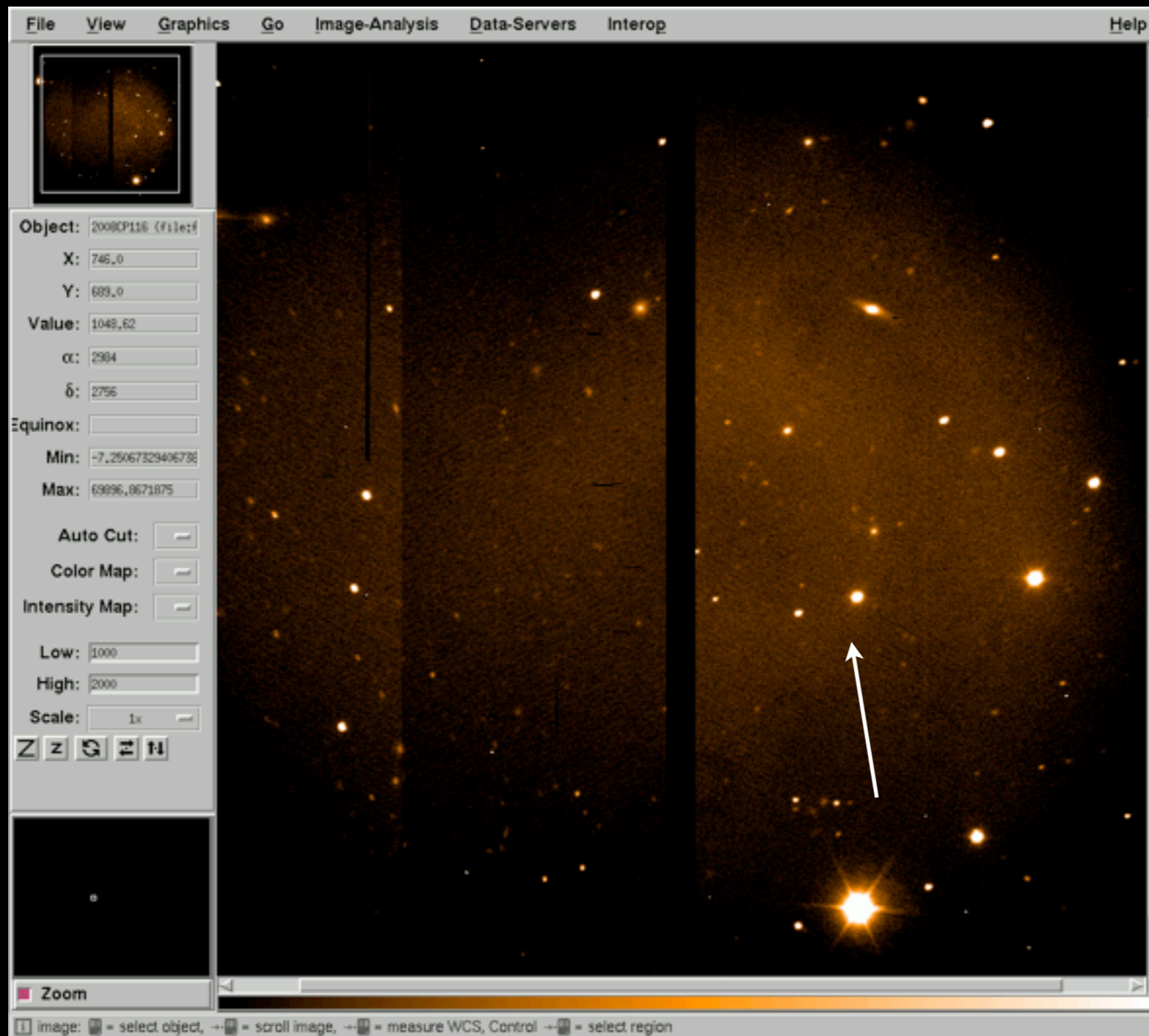
Multi-mode imaging and acquisition camera. In full-frame mode, it has an 8x8' FOV. In slotmode, high-speed photometry (20 Hz) can be performed over a smaller field of view.

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# Near Earth Asteroids

Apostolos Christou, Tomek Kwiatkowski, Amanda Gulbis  
(UKSC, Poland, SAAO)

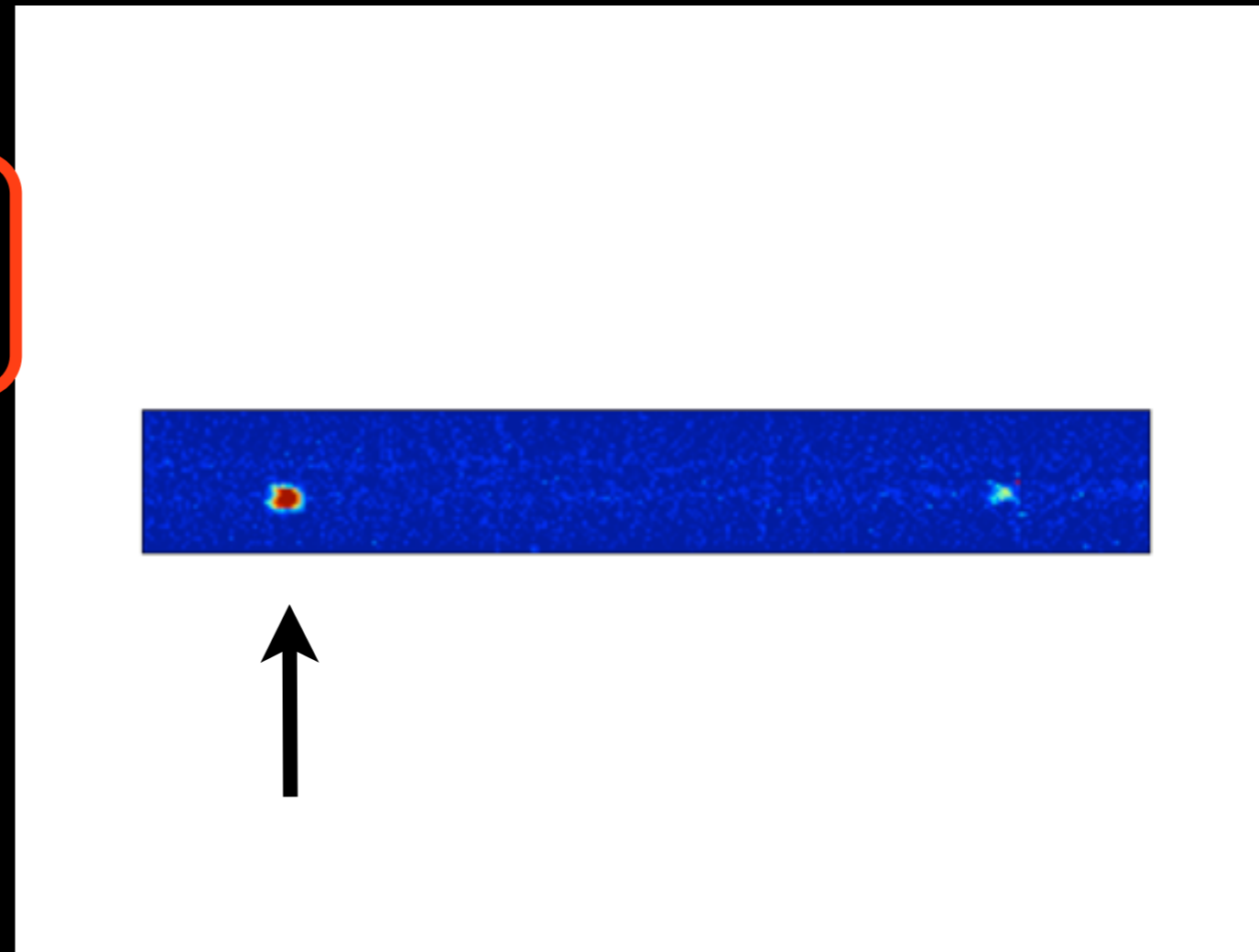
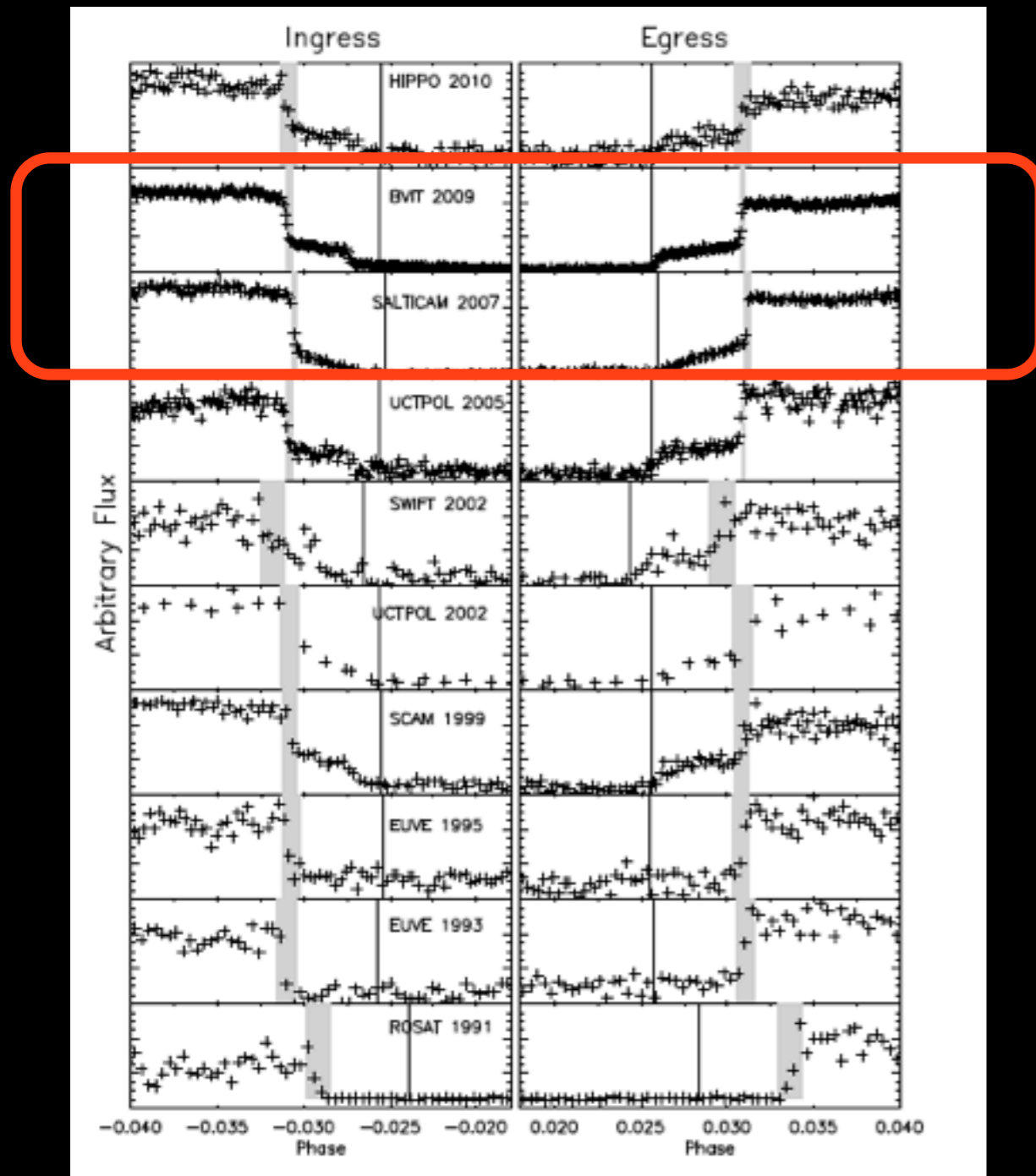






# Finding Planets

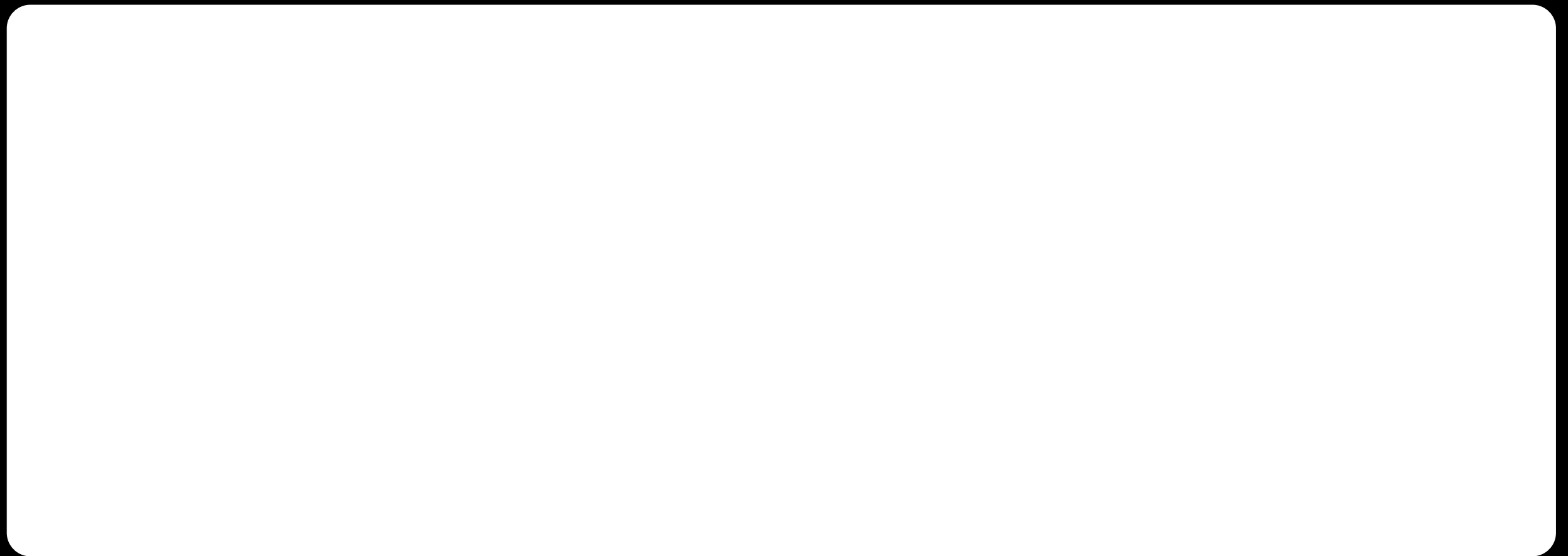
Steven Potter, Encarni Romero Colmenero  
(SAAO)



# Spectroscopy



# Basic Spectrograph

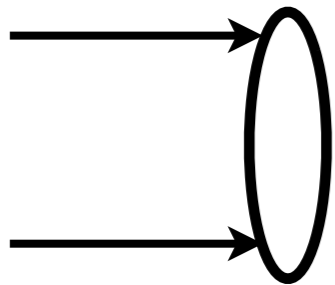




# Basic Spectrograph

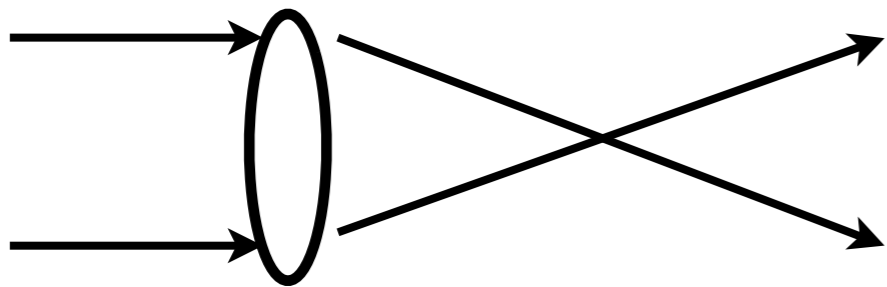


# Basic Spectrograph



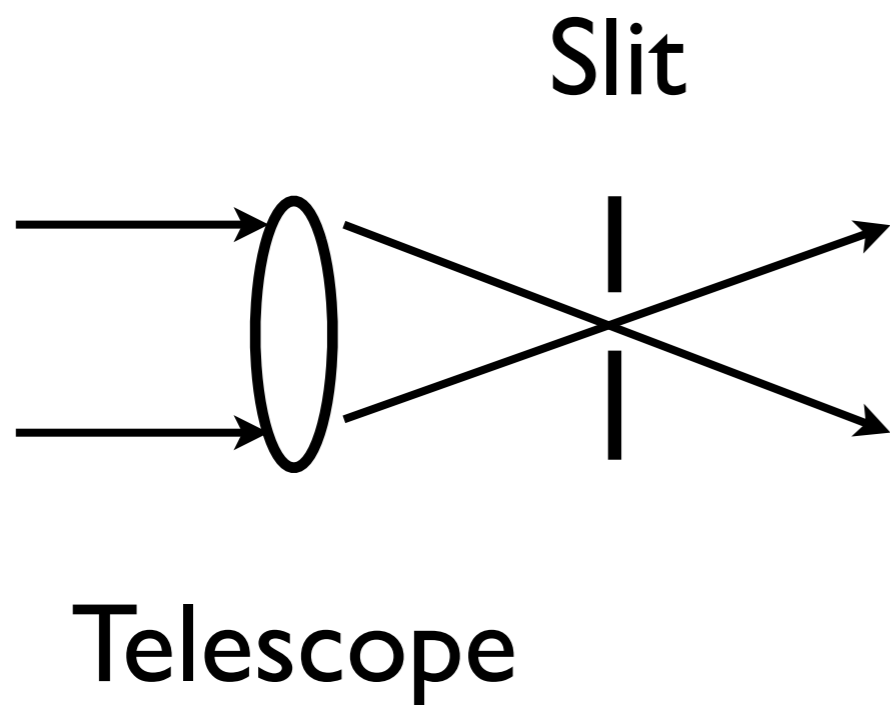
Telescope

# Basic Spectrograph

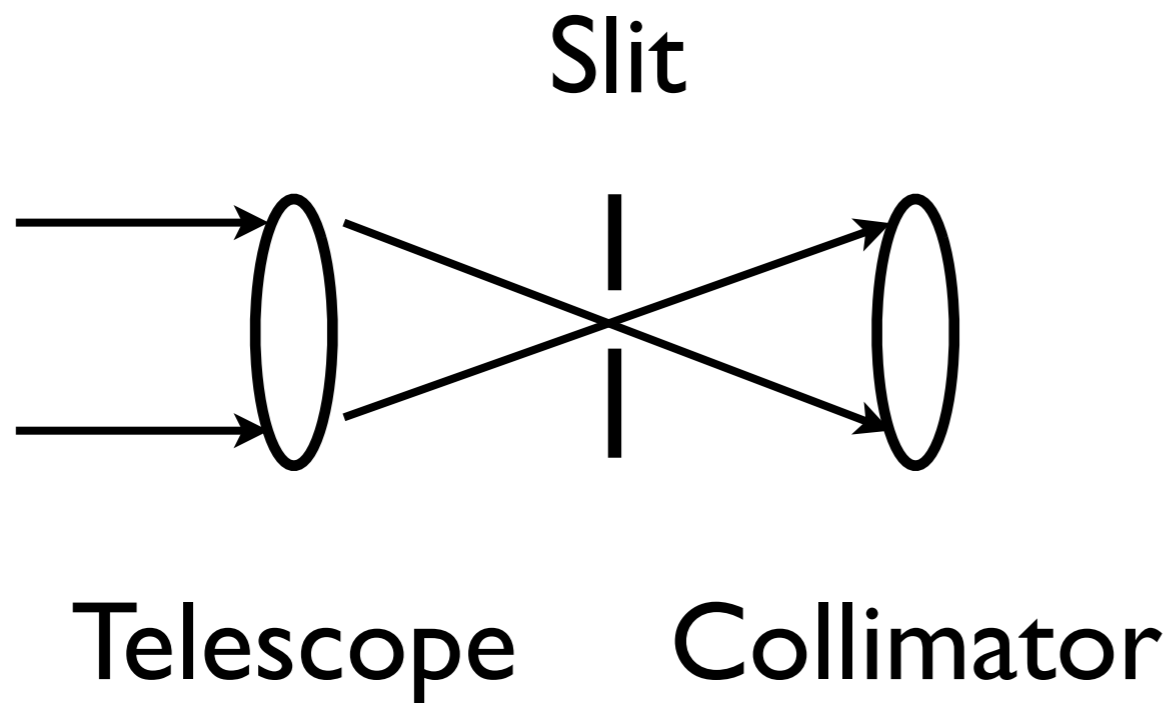


Telescope

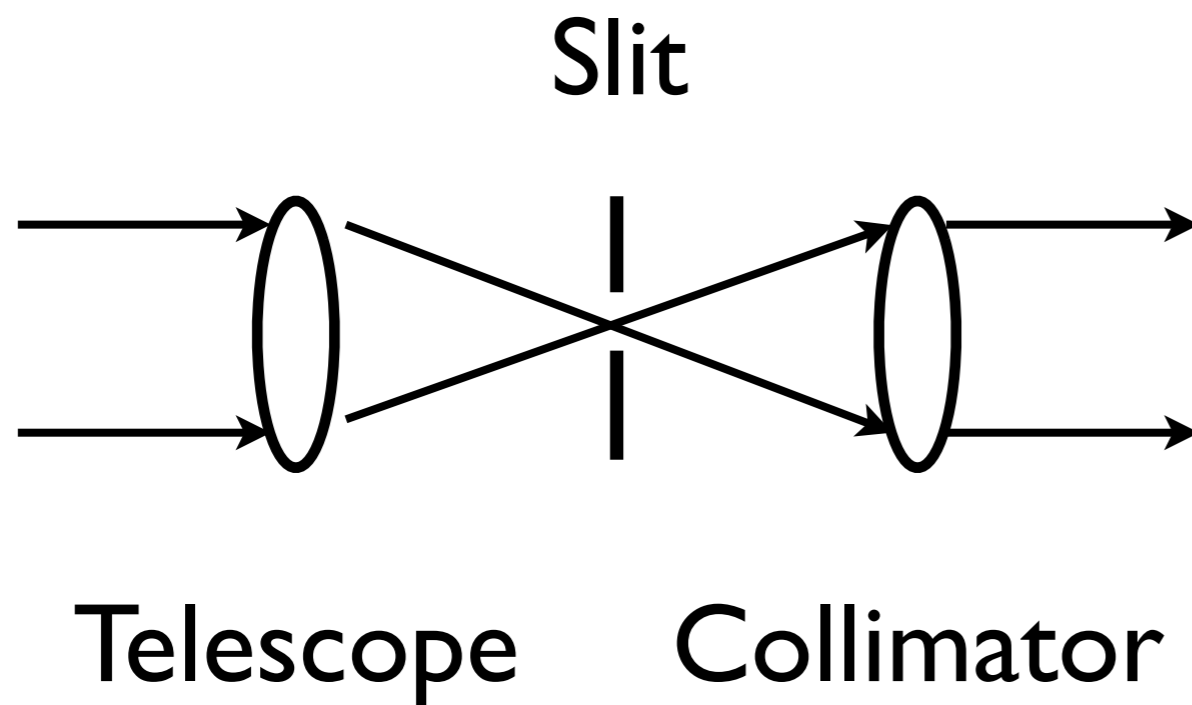
# Basic Spectrograph



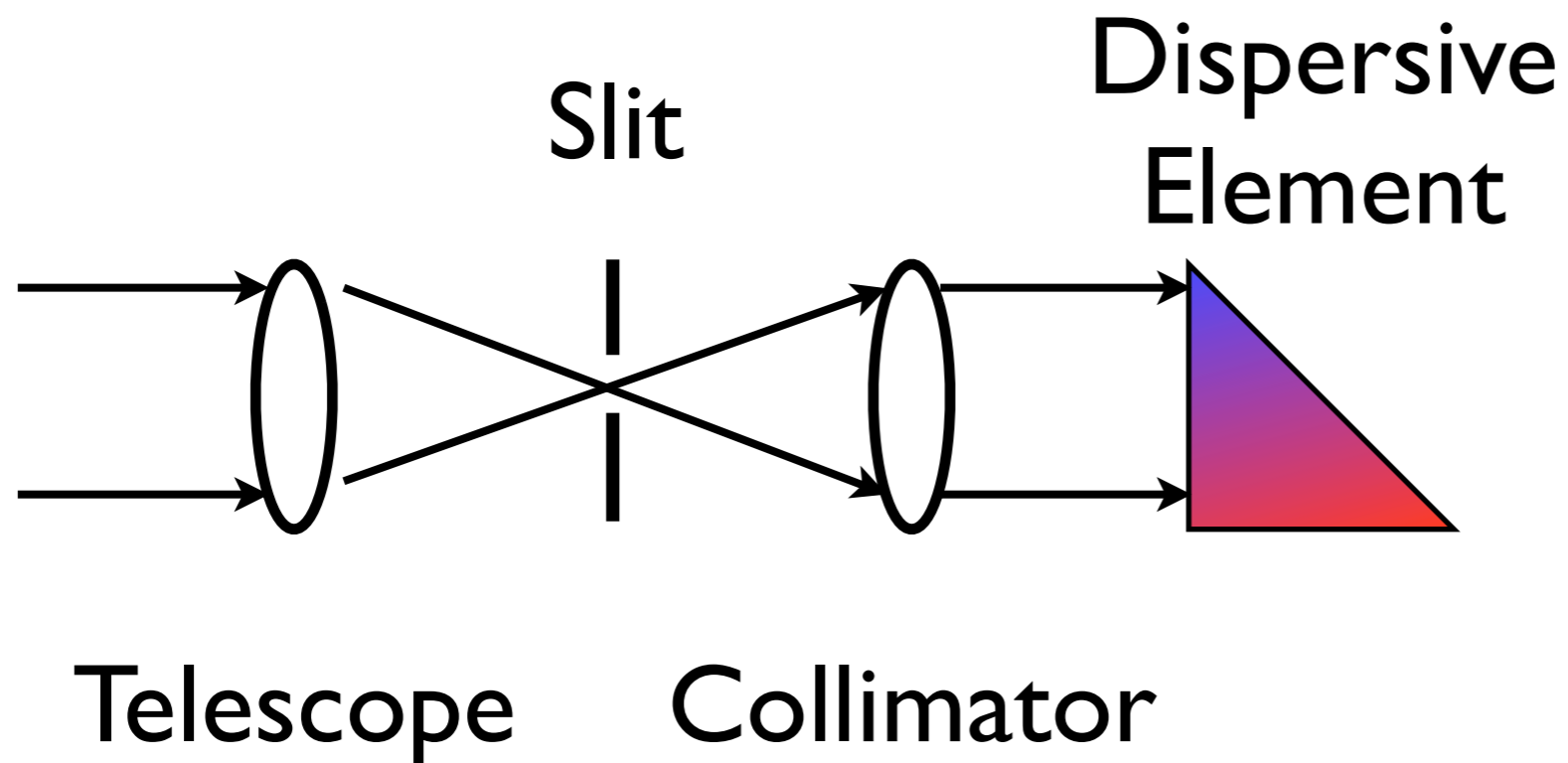
# Basic Spectrograph



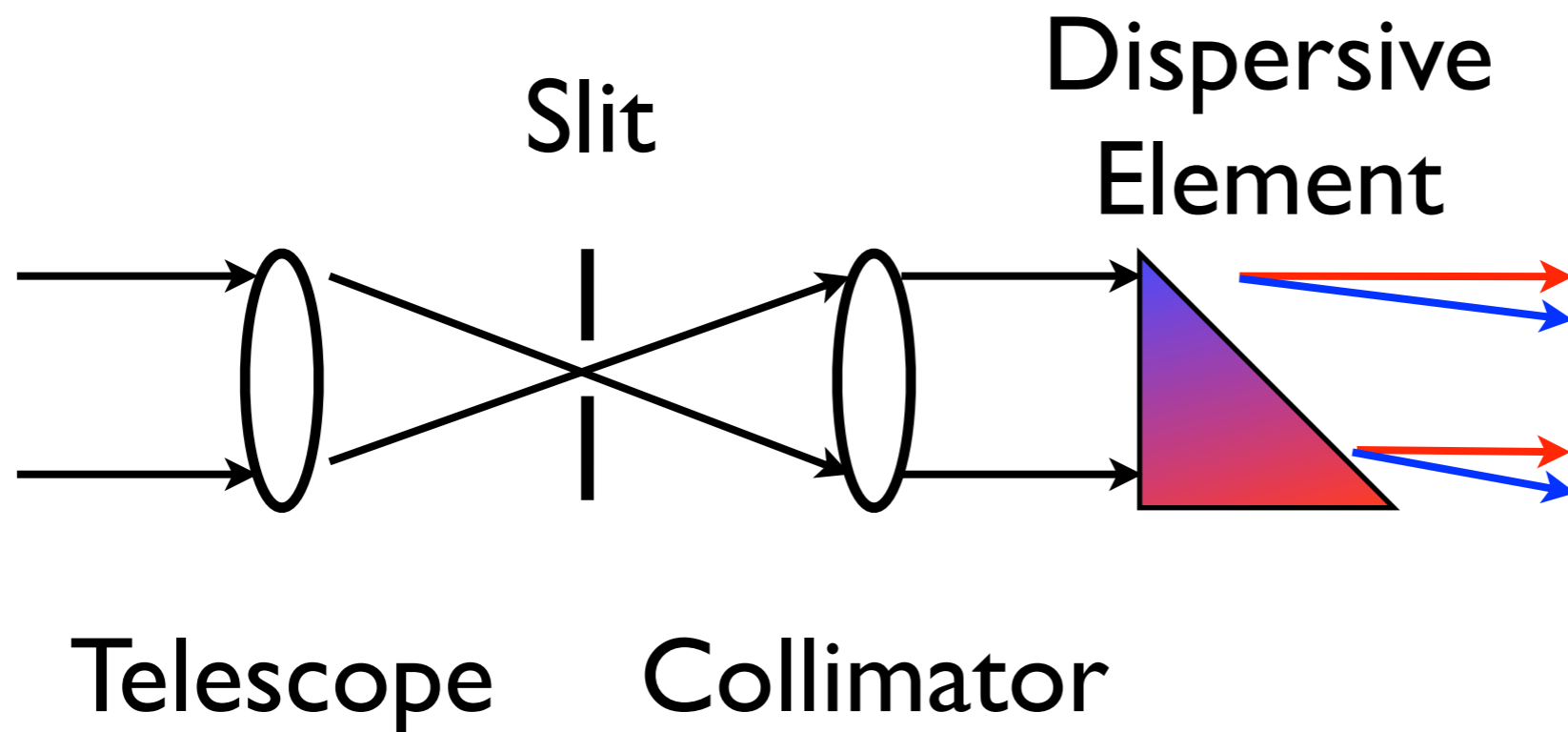
# Basic Spectrograph



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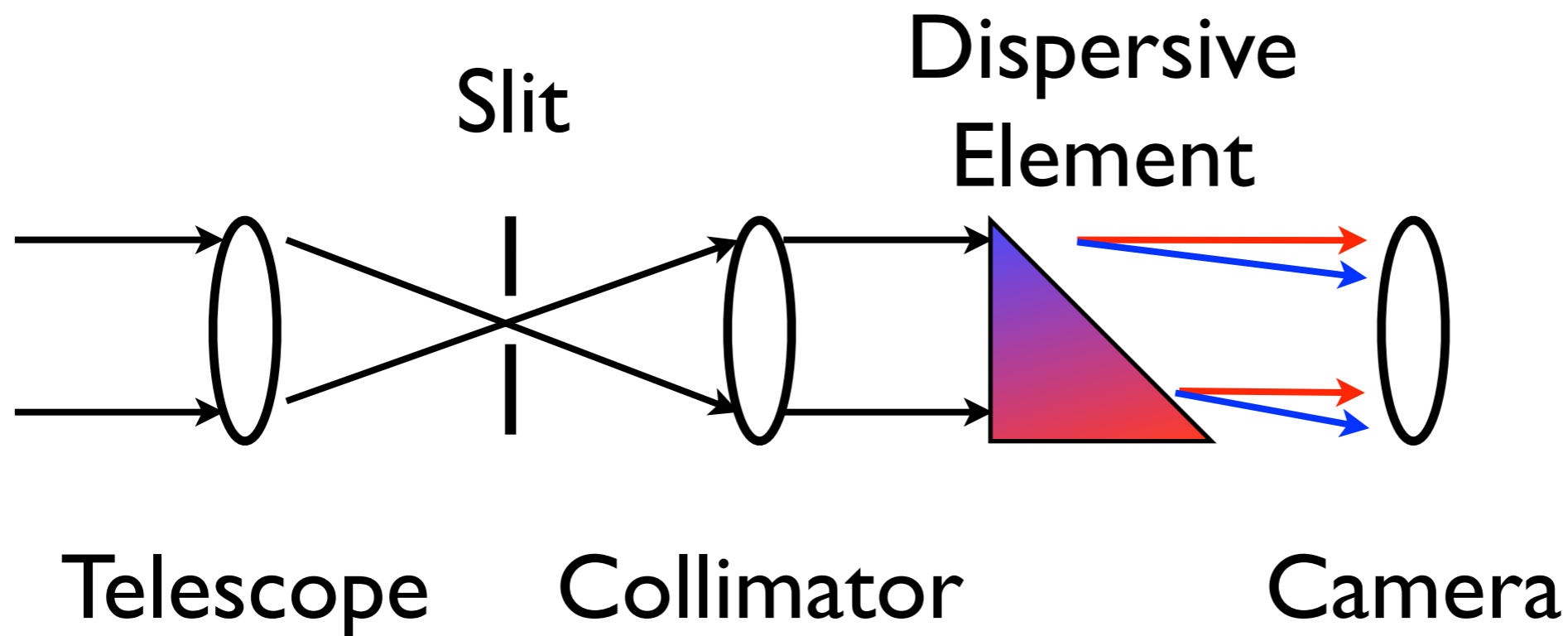


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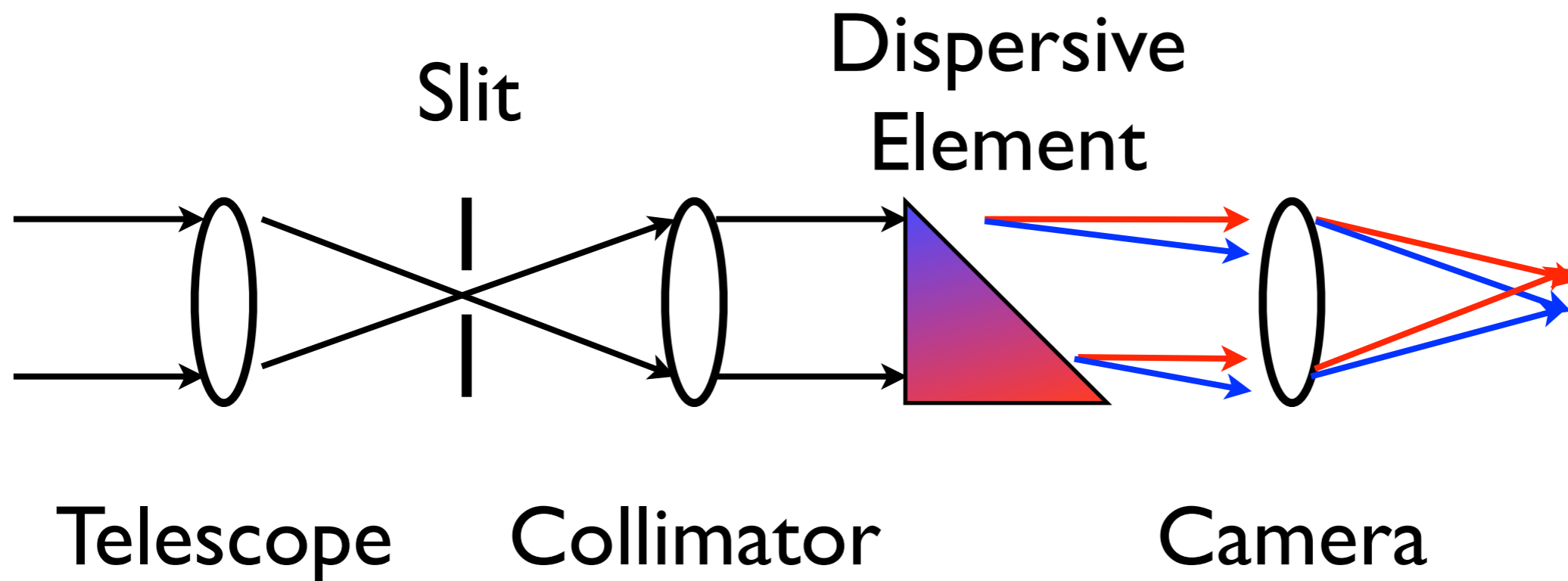




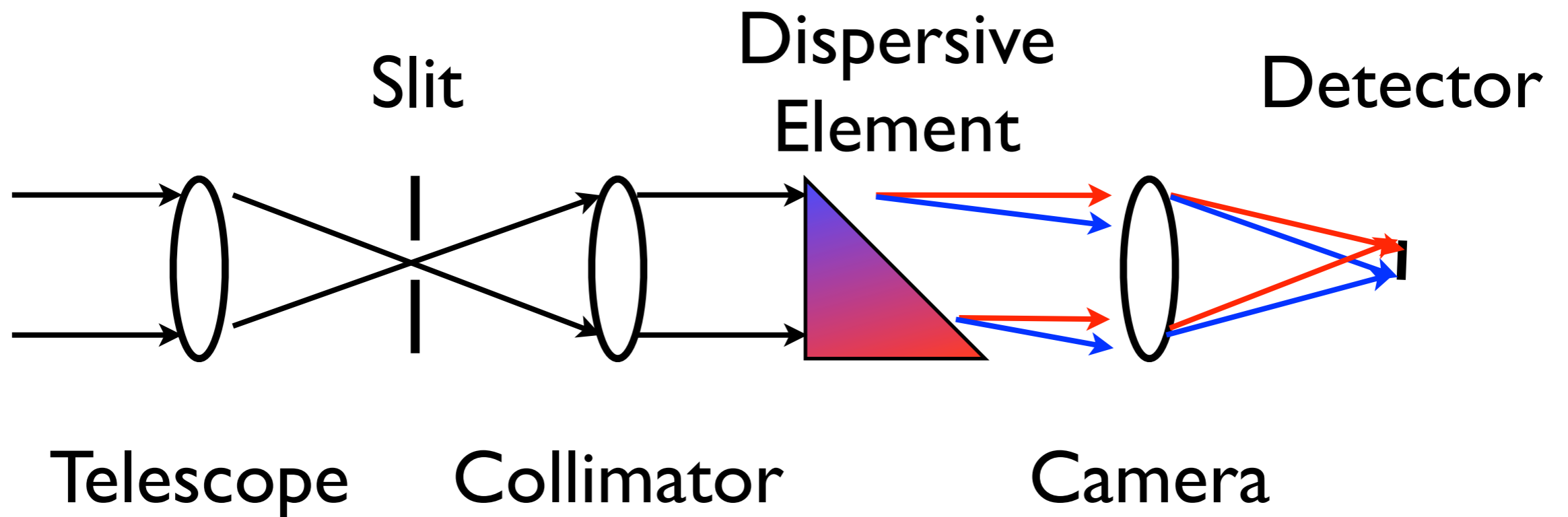
# Basic Spectrograph



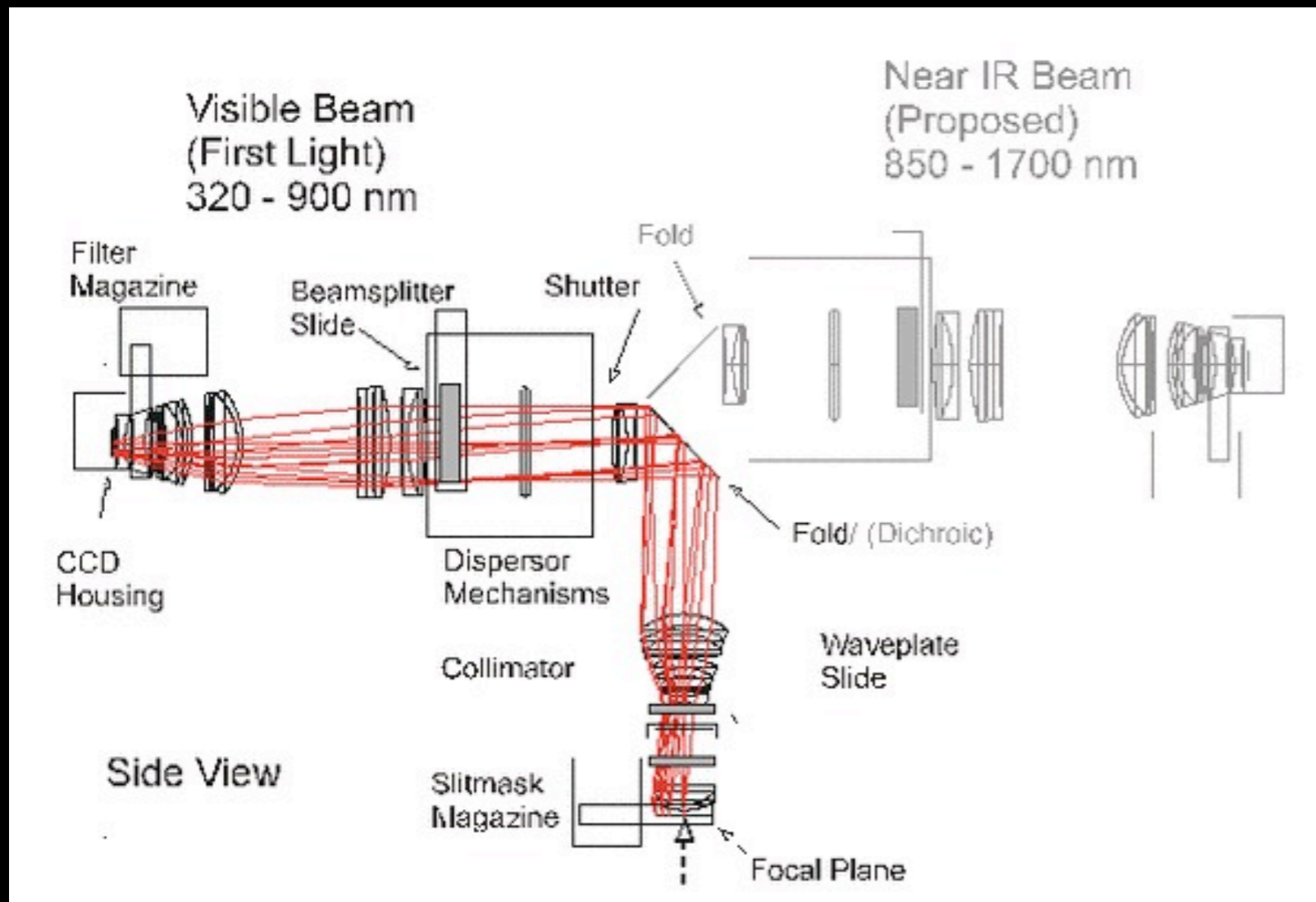
# Basic Spectrograph



# Basic Spectrograph



# Robert Stobie Spectrograph

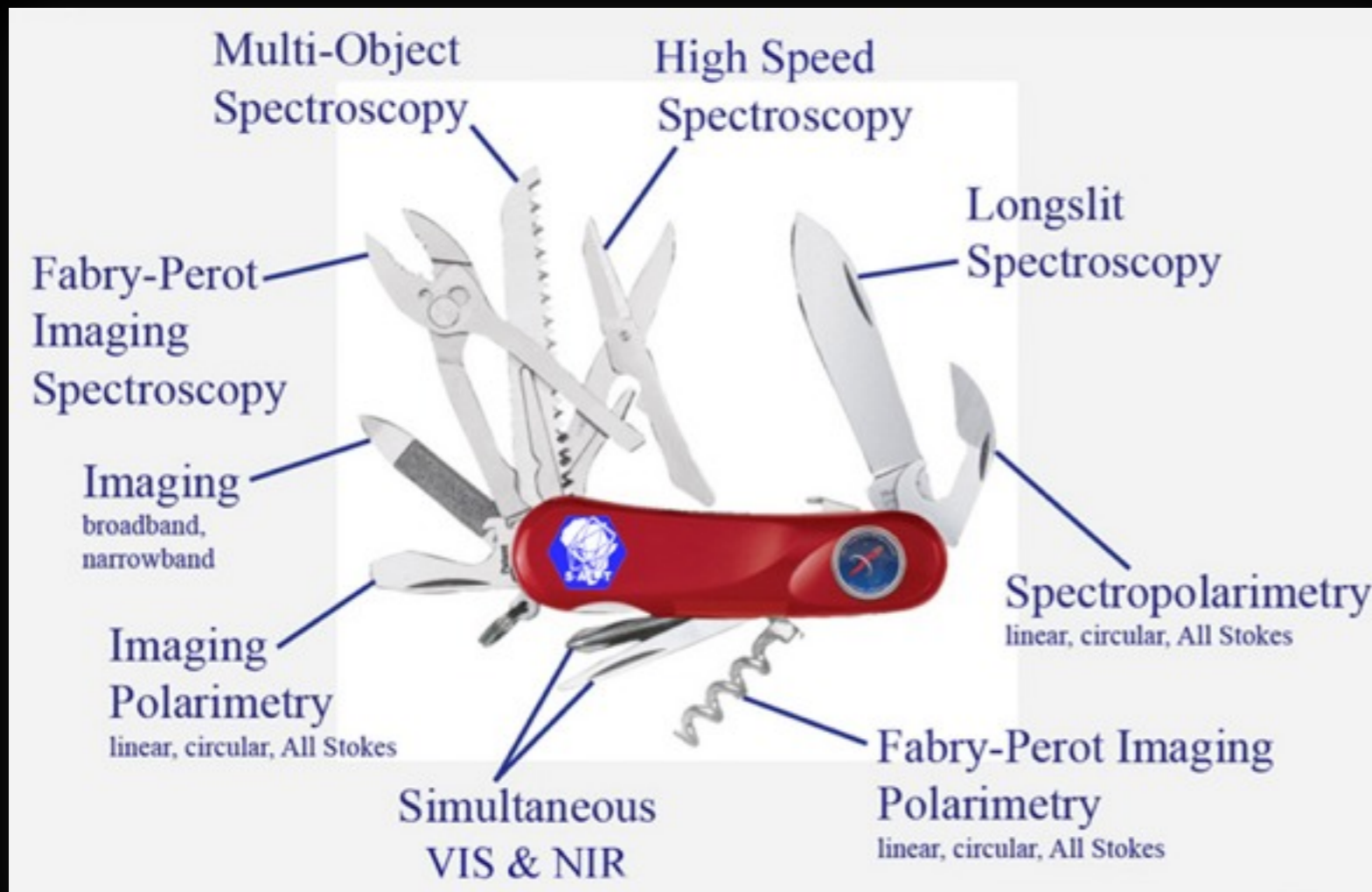


## Highlights of RSS:

- UV Spectroscopy down to 3200 Å
- High throughput and resolution VPH gratings
- Fabry-Perot Modes
- Polarimetry
- High Speed

Ken Nordsieck, Ted Williams

# Robert Stobie Spectrograph

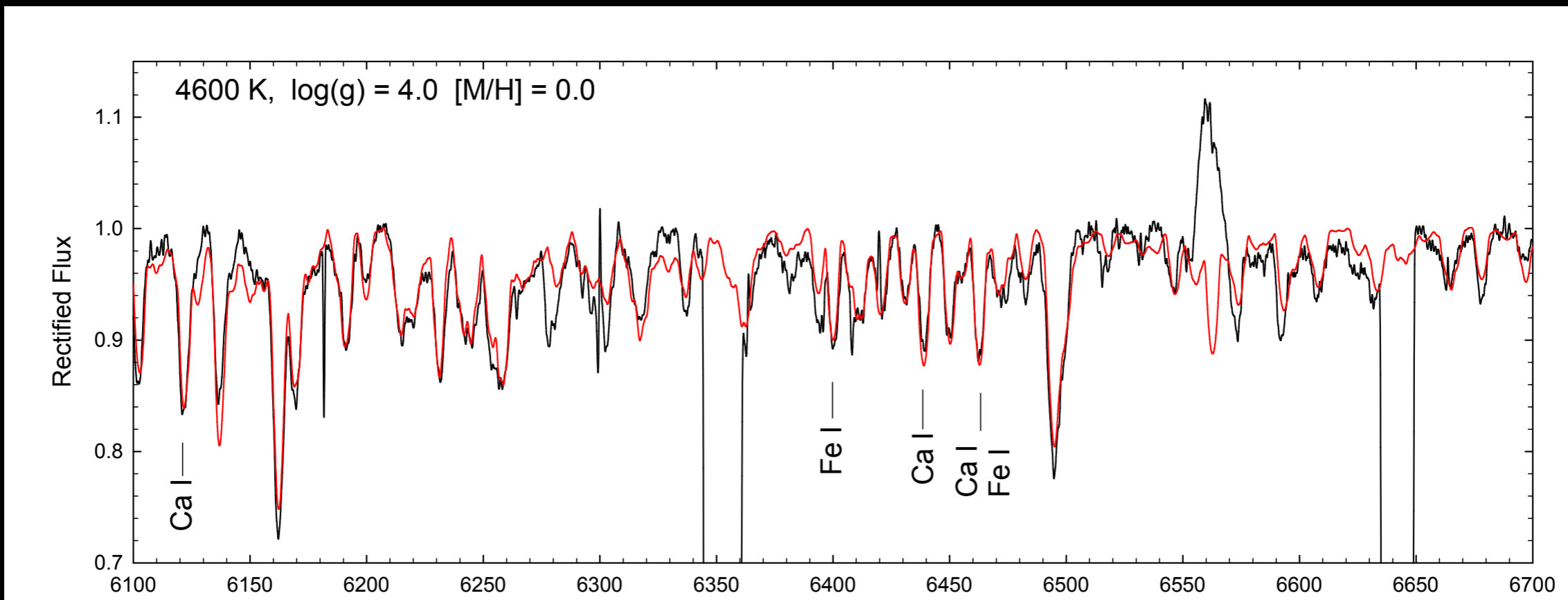


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Ken Nordsieck, Ted Williams

# Finger Print Objects



Chris Koen (UWC)

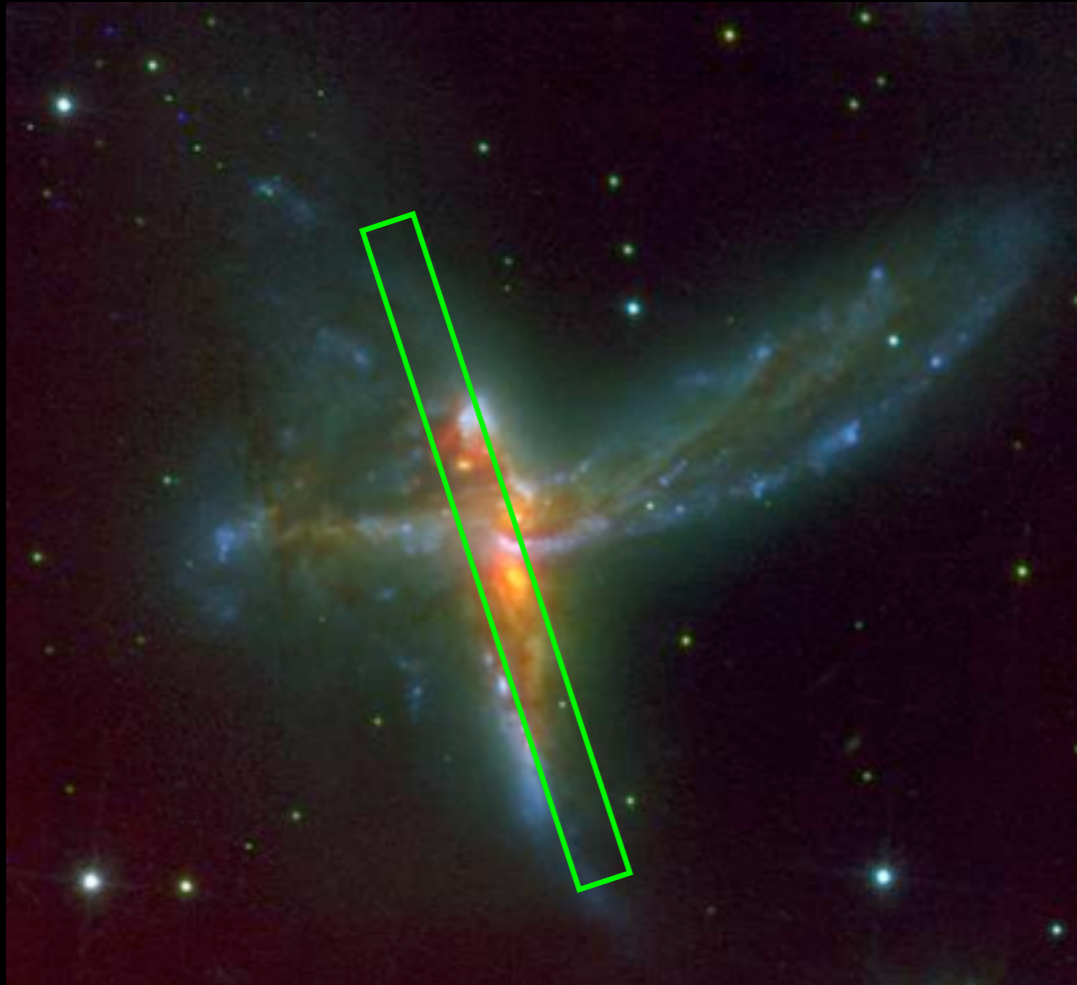
Every wiggle corresponds to an element

# Measure Motions



Petri Vaisanen(SAAO)

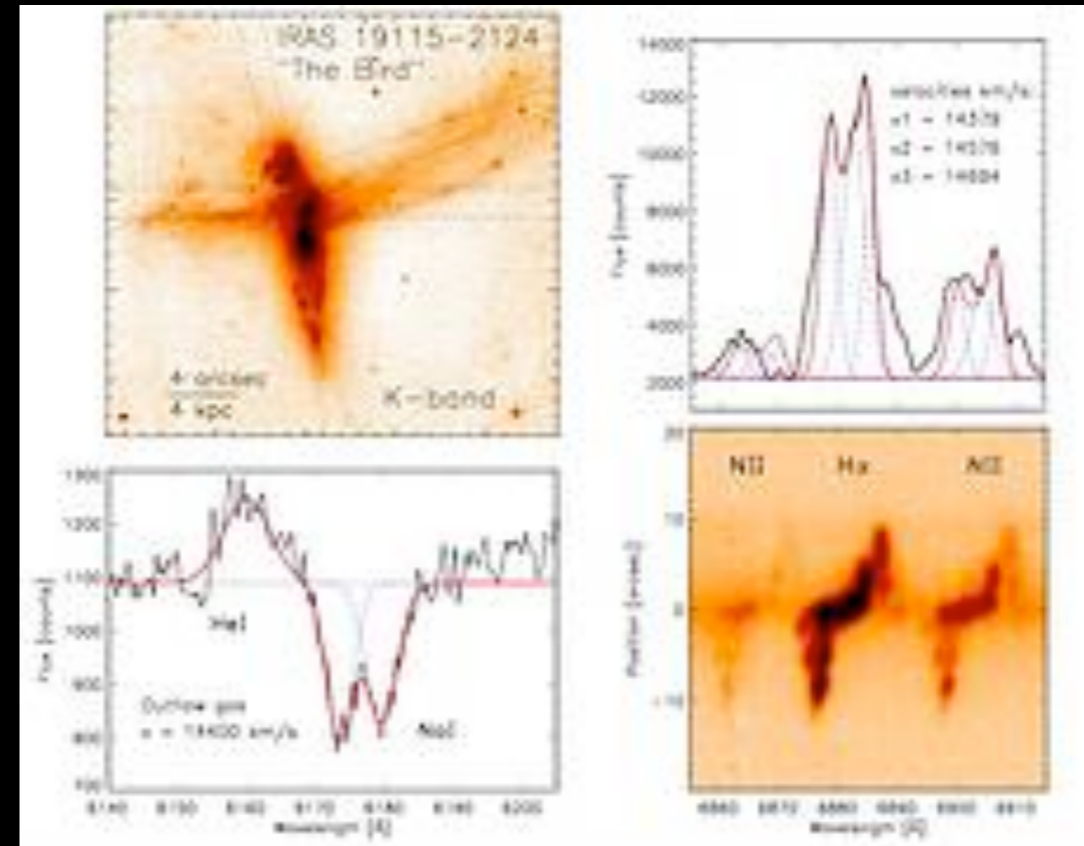
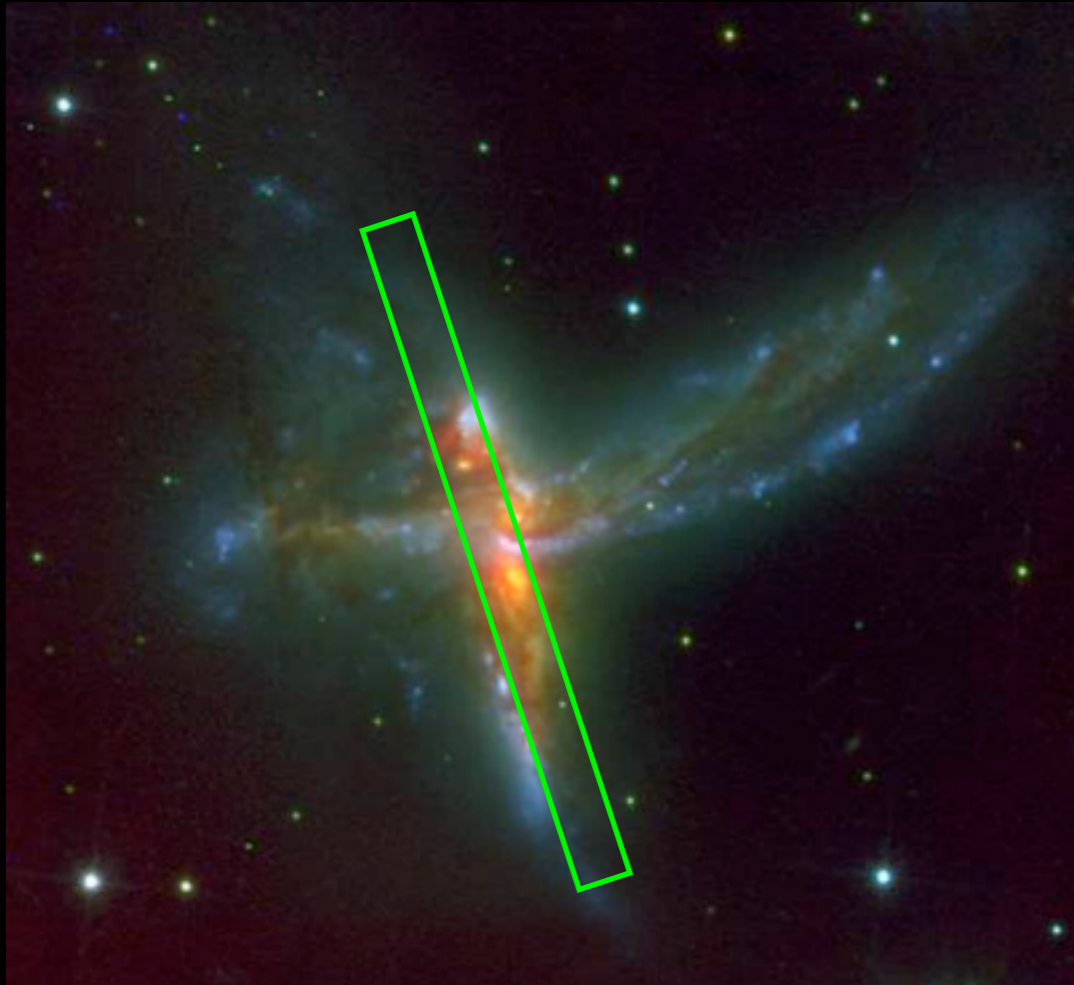
# Measure Motions



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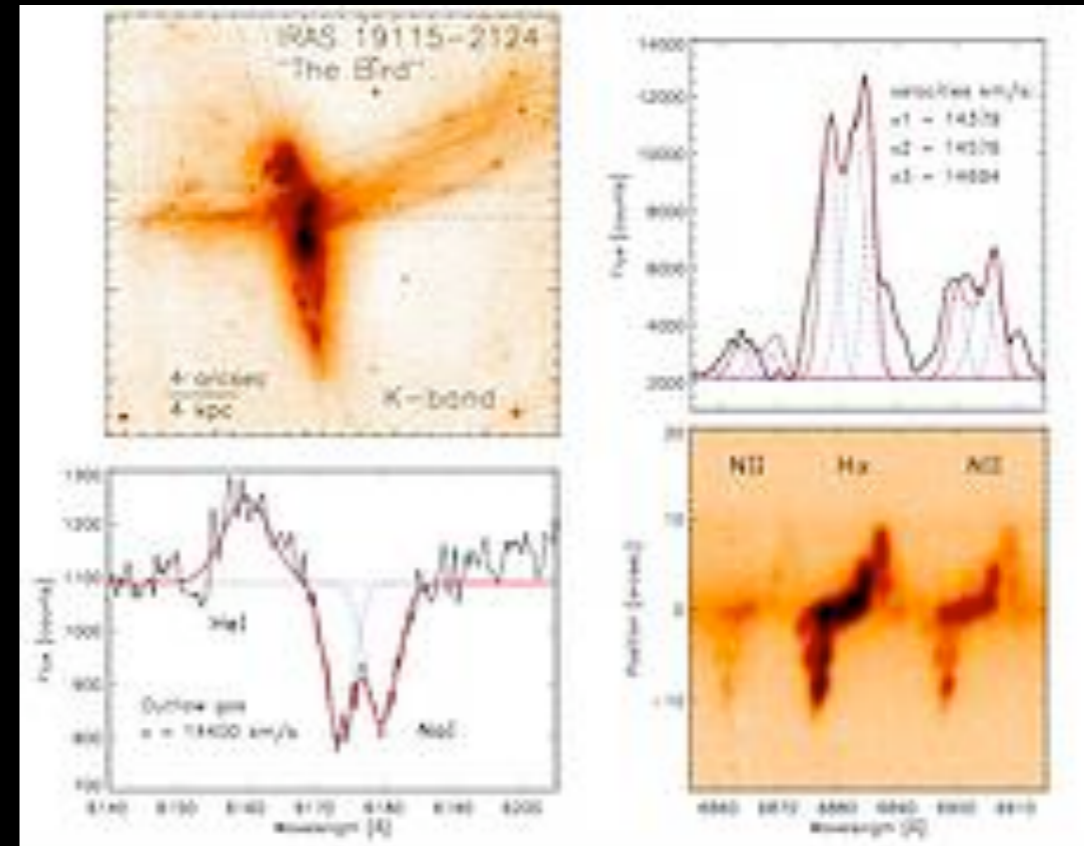
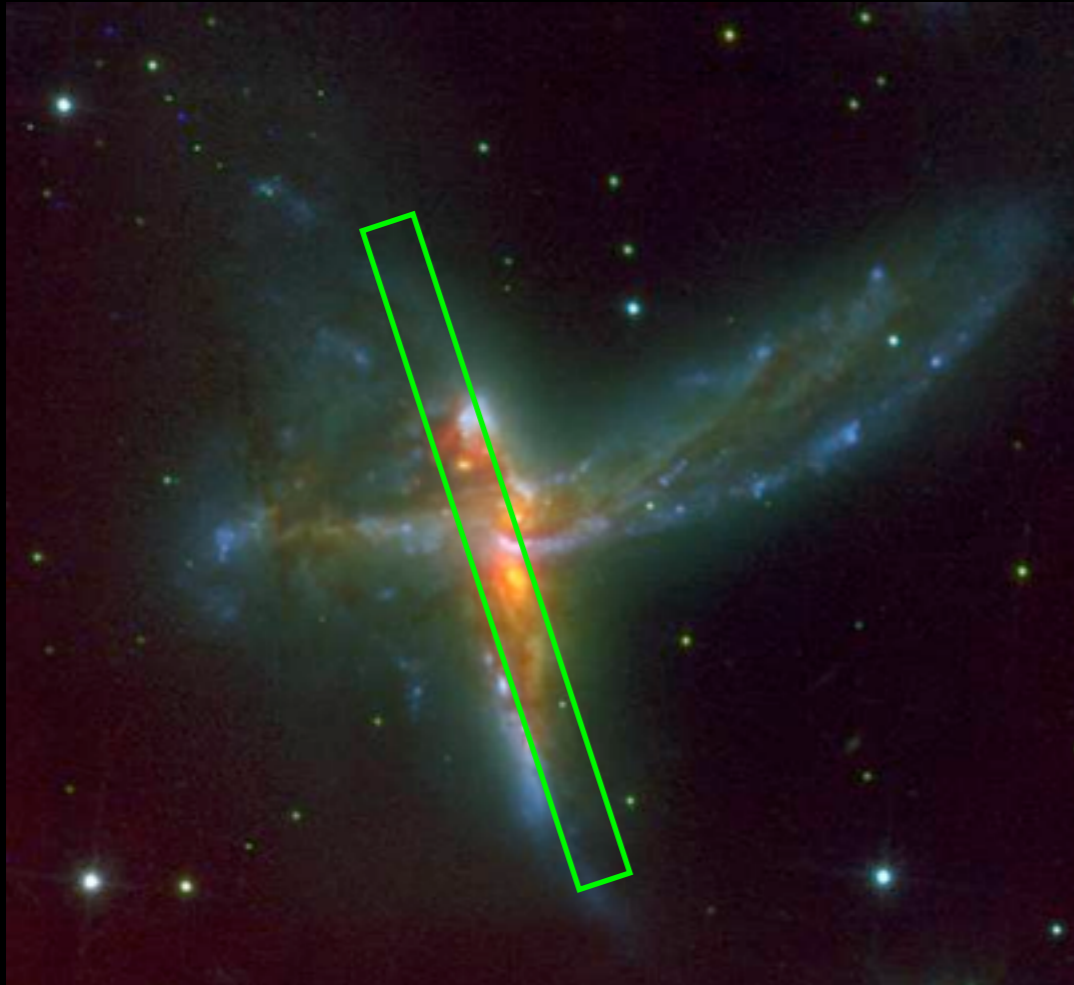


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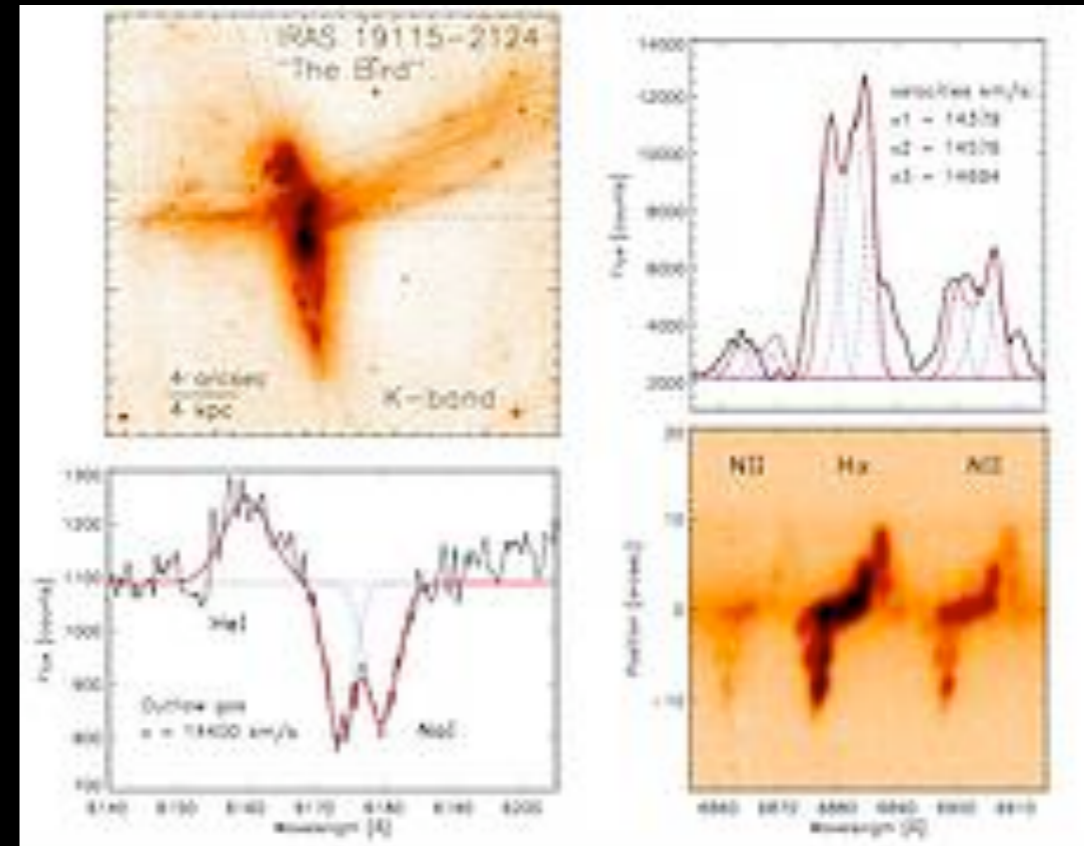
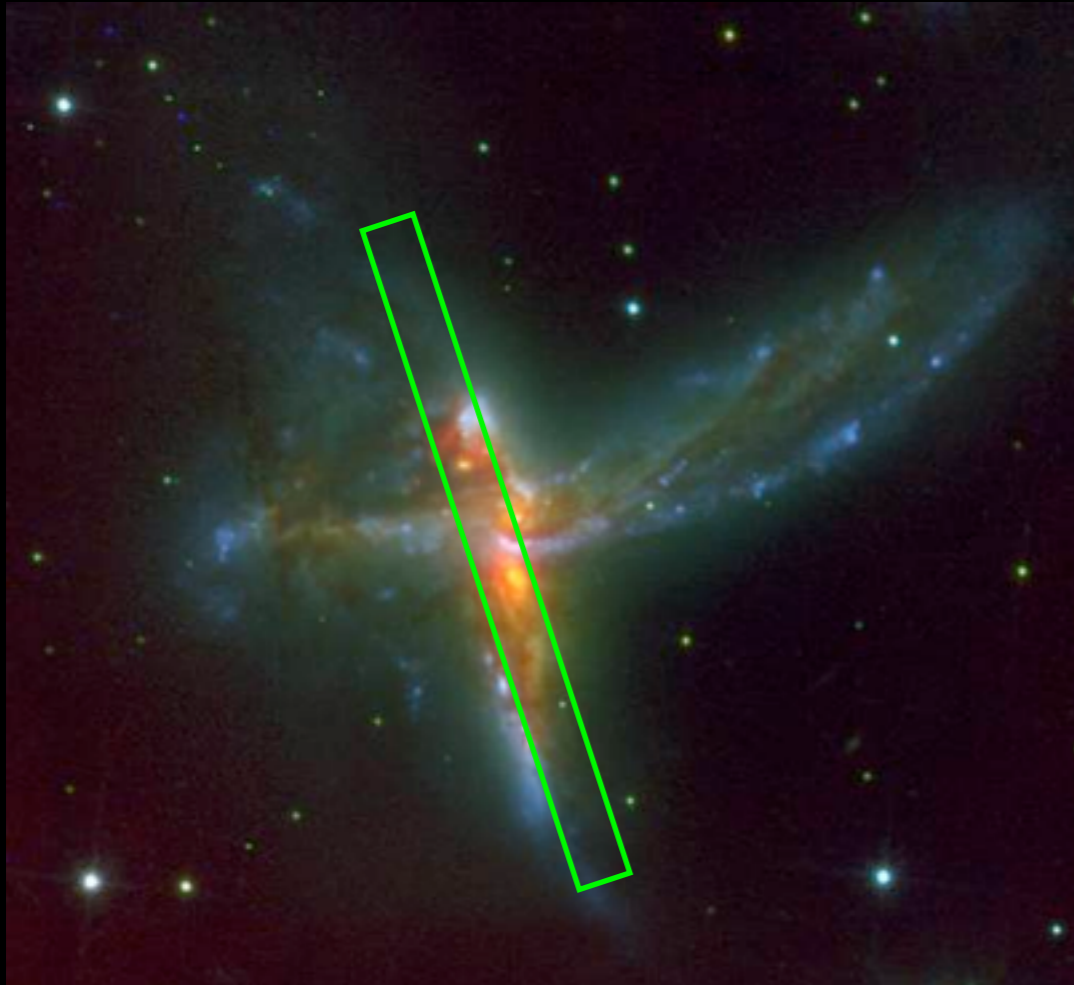
# Measure Motions



↑  
Distance

Petri Vaisanen(SAAO)

# Measure Motions

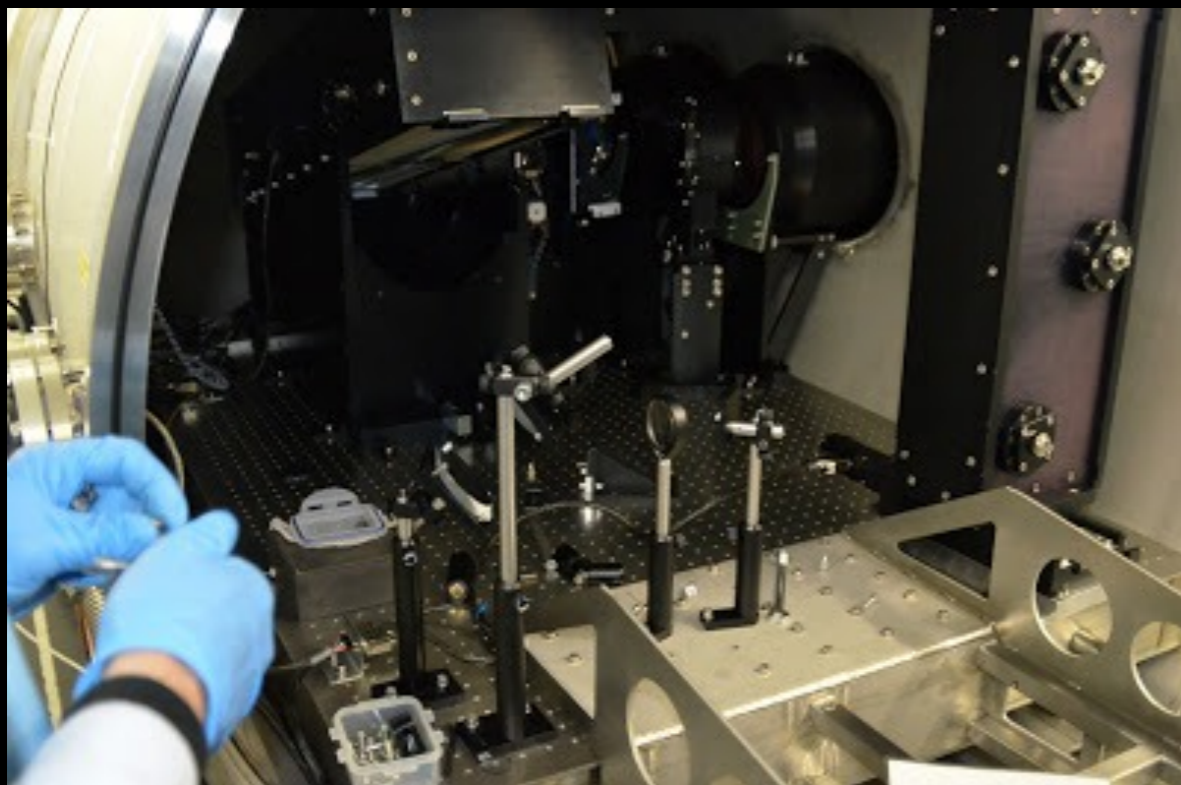
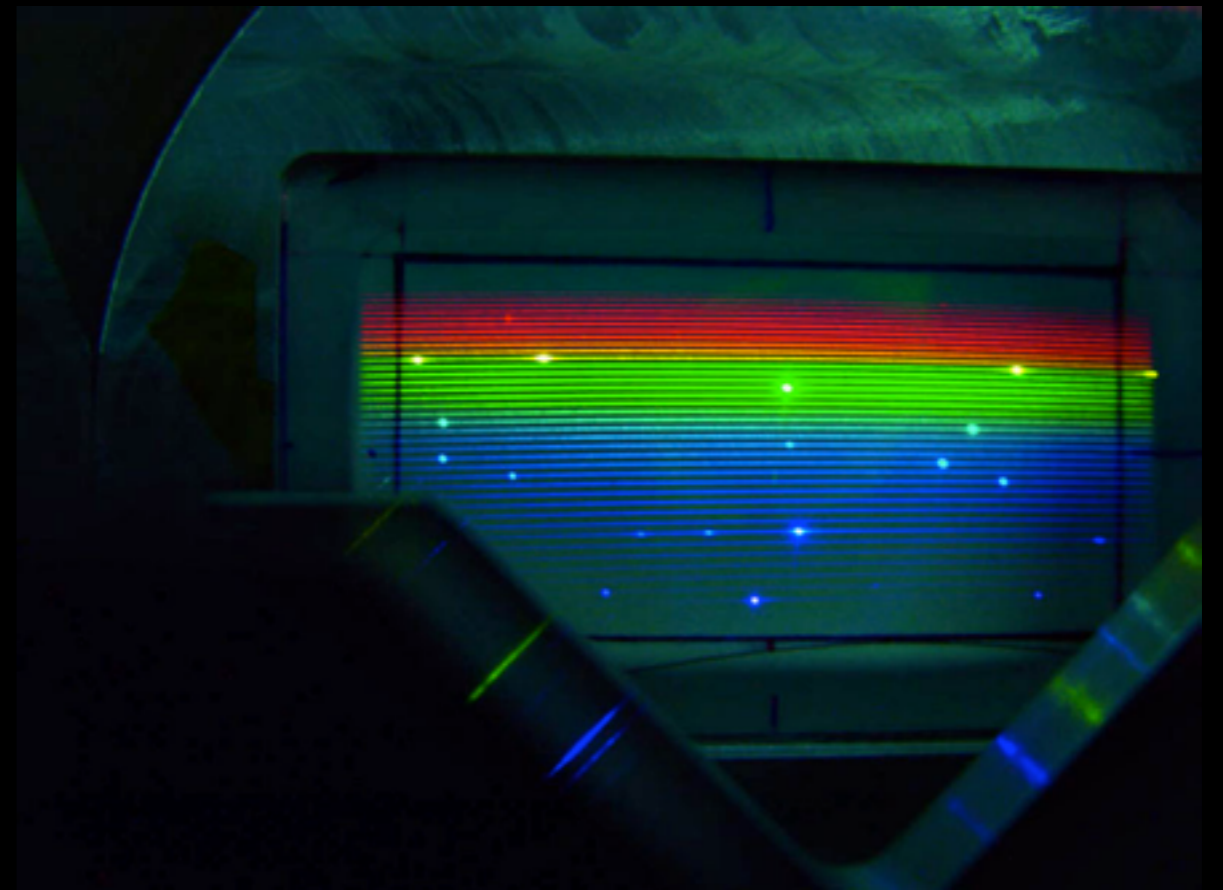
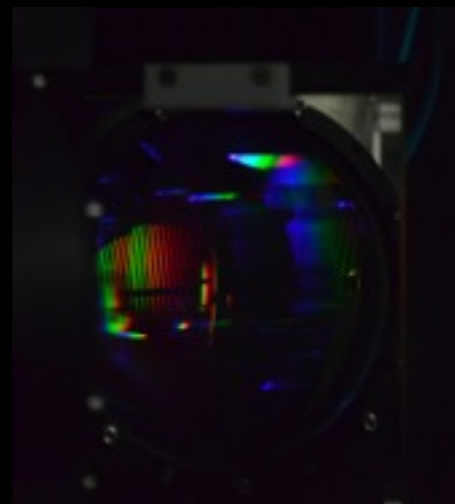
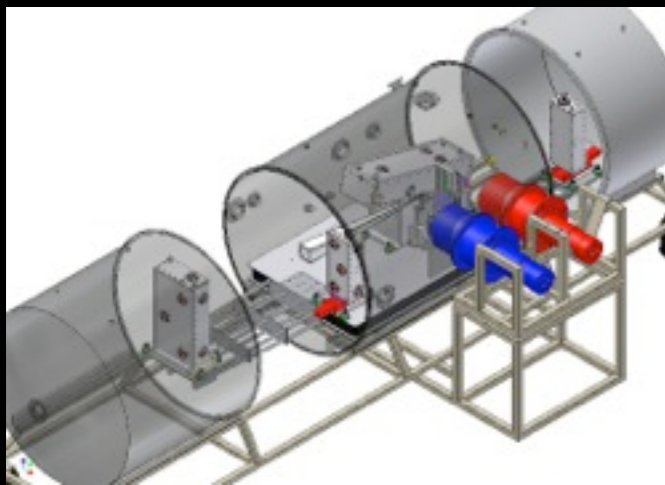


↑  
Distance

→  
Velocity

Petri Vaisanen(SAAO)

# High Resolution Spectrograph



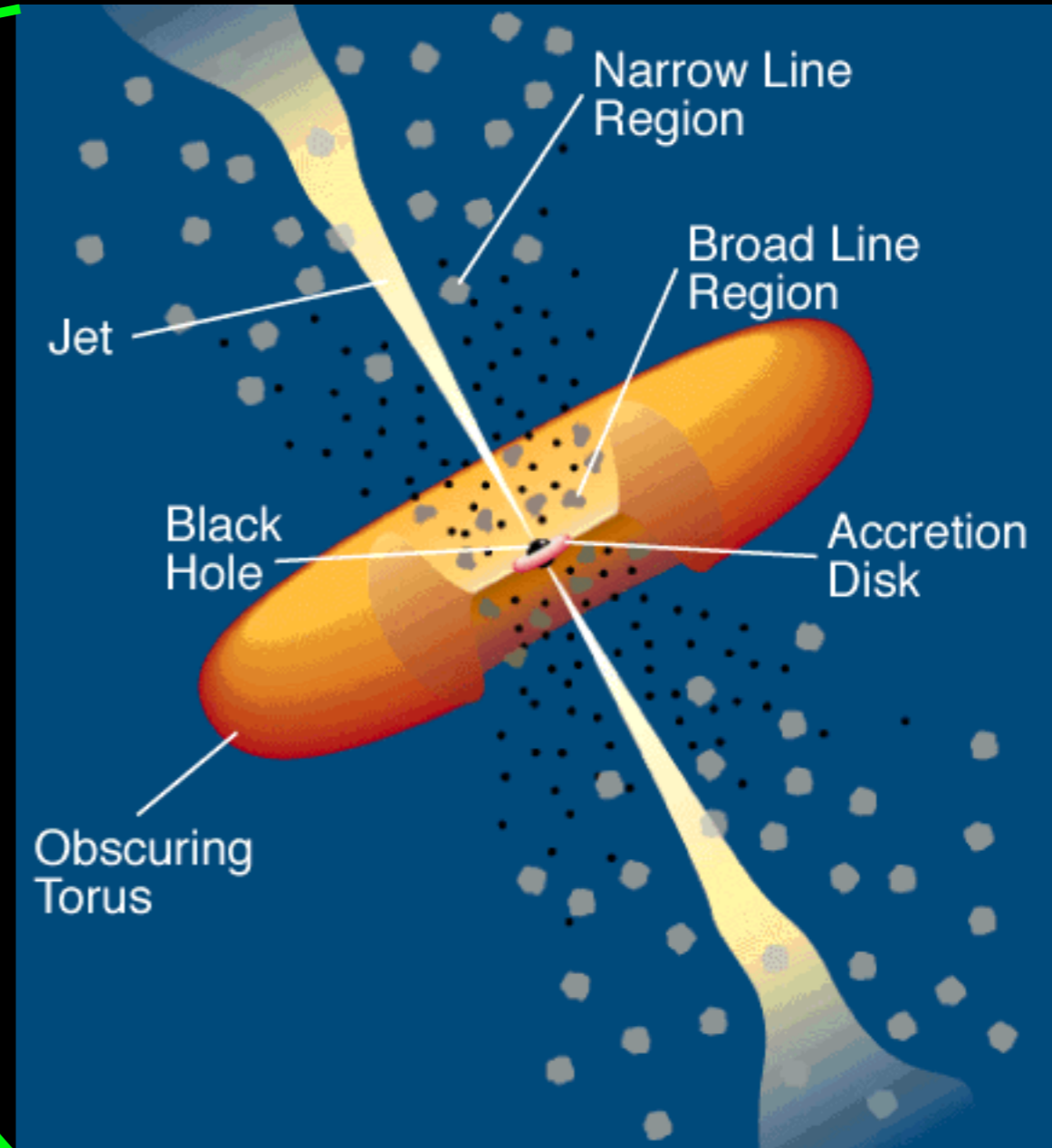
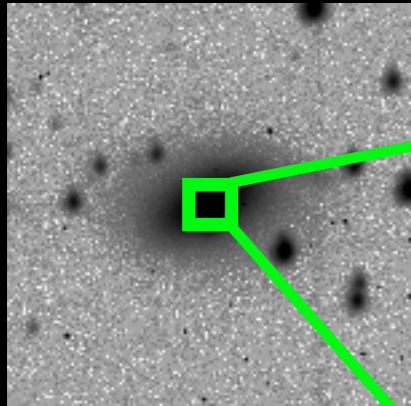
# From Idea to Answer

# Step #1: Think of a question to ask

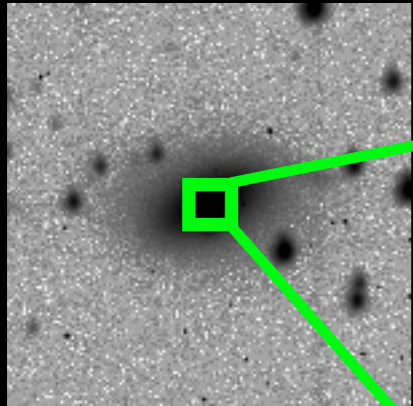
How big are black holes?

Encarni Romero Colmenero and I along with our collaborators in the US and South Korea proposed to measure the size of a super massive black hole in a nearby galaxy.

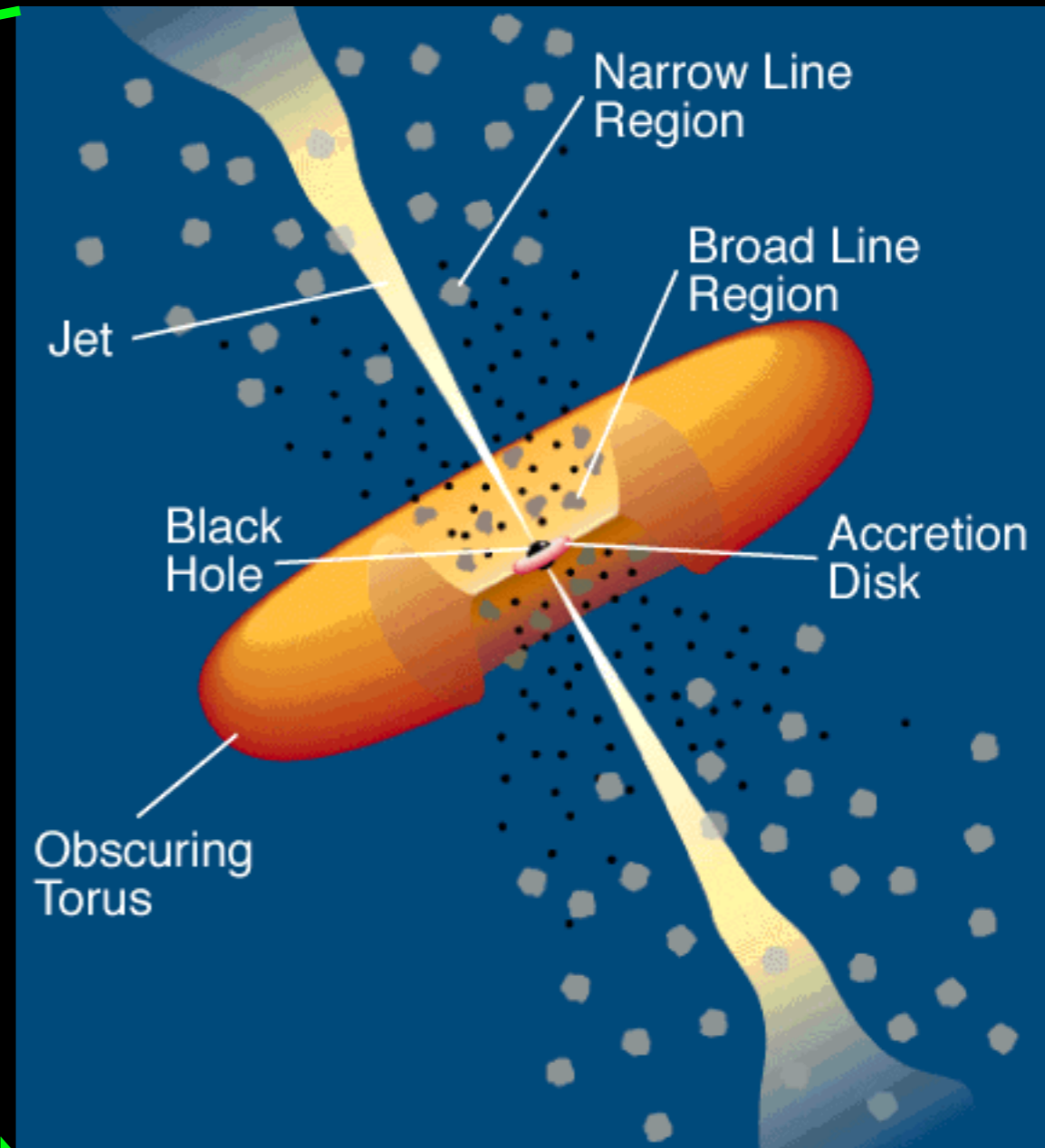
# Echo Mapping



# Echo Mapping



- New gas falls into BH
- BH brightens
- Lights up the nearby broad-line region
- Measure the time it takes BLR to 'react' to give size





# Step #2: Propose for your project

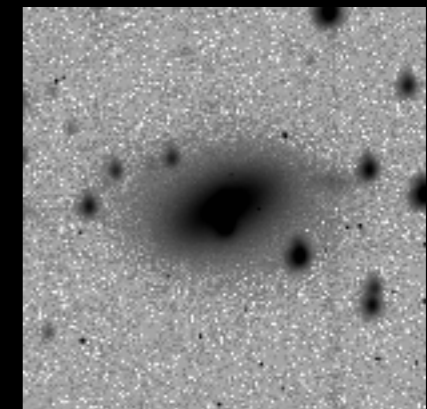
The screenshot displays the PIPTManager web interface. The browser address bar shows 'za.ac.salt.pipt.manager.PIPTManager'. The page title is '\* High Speed Photometry of the Newly Discovered mCV 1GR... (2007-1-RSA-017) - PIPT (0.65)'. The interface is divided into several sections:

- Proposals:** A sidebar on the left lists proposals, with 'High Speed Photometry of the N...' selected.
- Co-ordinates:** A form for entering coordinates for a 'Sidereal target'.
  - RA: 14 h 41.2 s
  - Dec: 55° 21'
  - Equinox: 2000.0
  - Sidereal Movement:  $\Delta RA/\Delta t$  and  $\Delta Dec/\Delta t$  (both in arcseconds/year)
  - Epoch (UT):
- Magnitudes:** A 'Vmag Range' section with 'min (bright)' and 'max (dim) 19.0'.
- Periodic Target Ephemeris (show)**
- Finding Charts (Guidelines)**
- Summary:** A yellow box at the bottom right contains:
  - Proposal
  - Effective exposure time: 50010 s
  - Overhead time: 9116 s
  - Total charged time: 59126 s

# Step #3: Got Time?

## Time to get to Work

We were allocated 20 hours to observe **MGC-6-30-015**, a galaxy with an active galactic nuclei at its center



Now it was time to update to submit our Phase 2 with the specifications for our observing program. Once it was uploaded to the science database, observations could begin for our target.

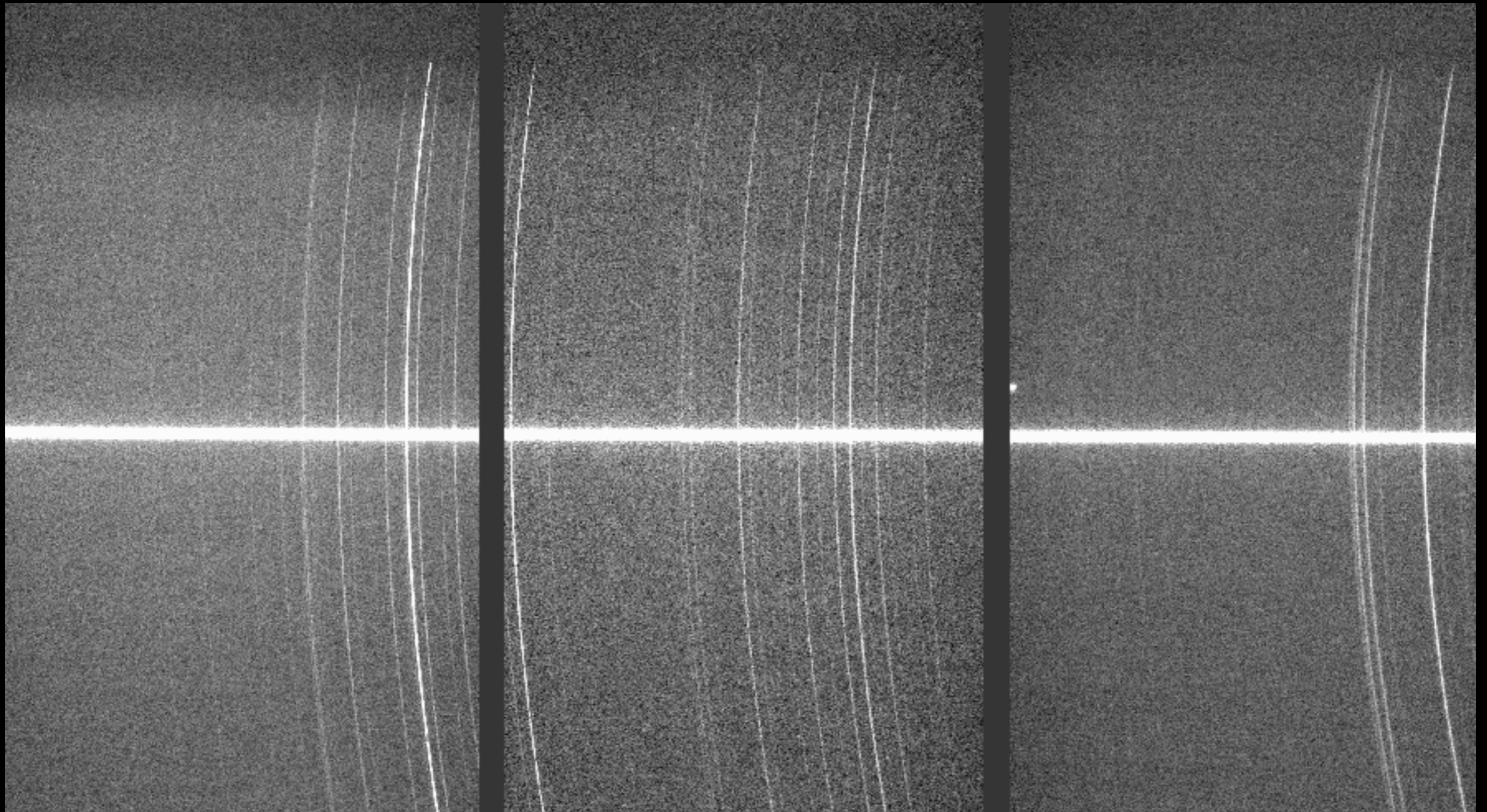
# Step #2: Our Observations

Observe the source every 3-5 days with SALT to look for changes in the spectra as well with the smaller telescopes to monitor changes in its brightness.

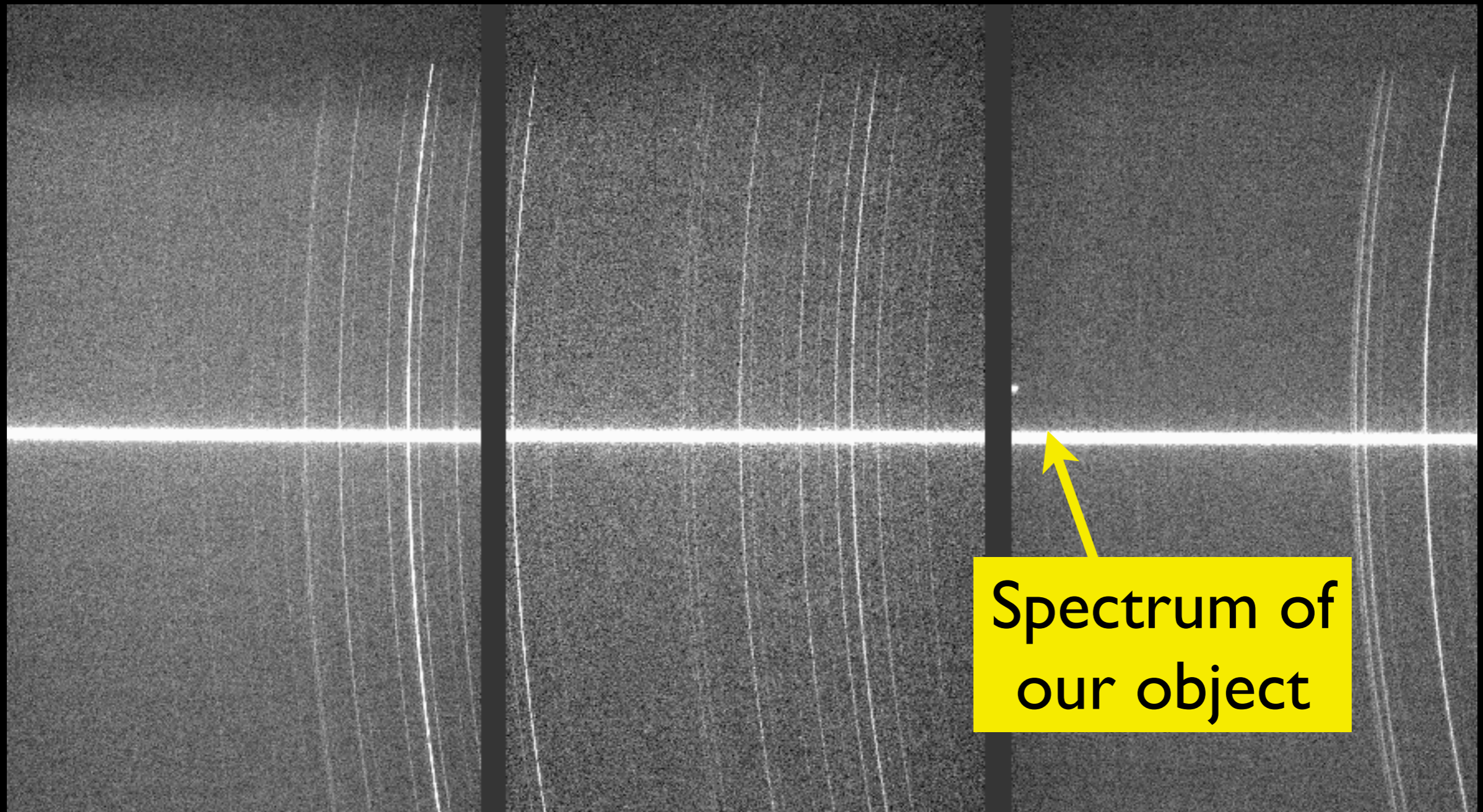
At the end of the semester, we had 32 spectra over 70 nights.



# Step #3: Data Reduction



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Spectrum of  
our object

# Step #3: Data Reduction

Emission from the Earth's atmosphere

Spectrum of our object

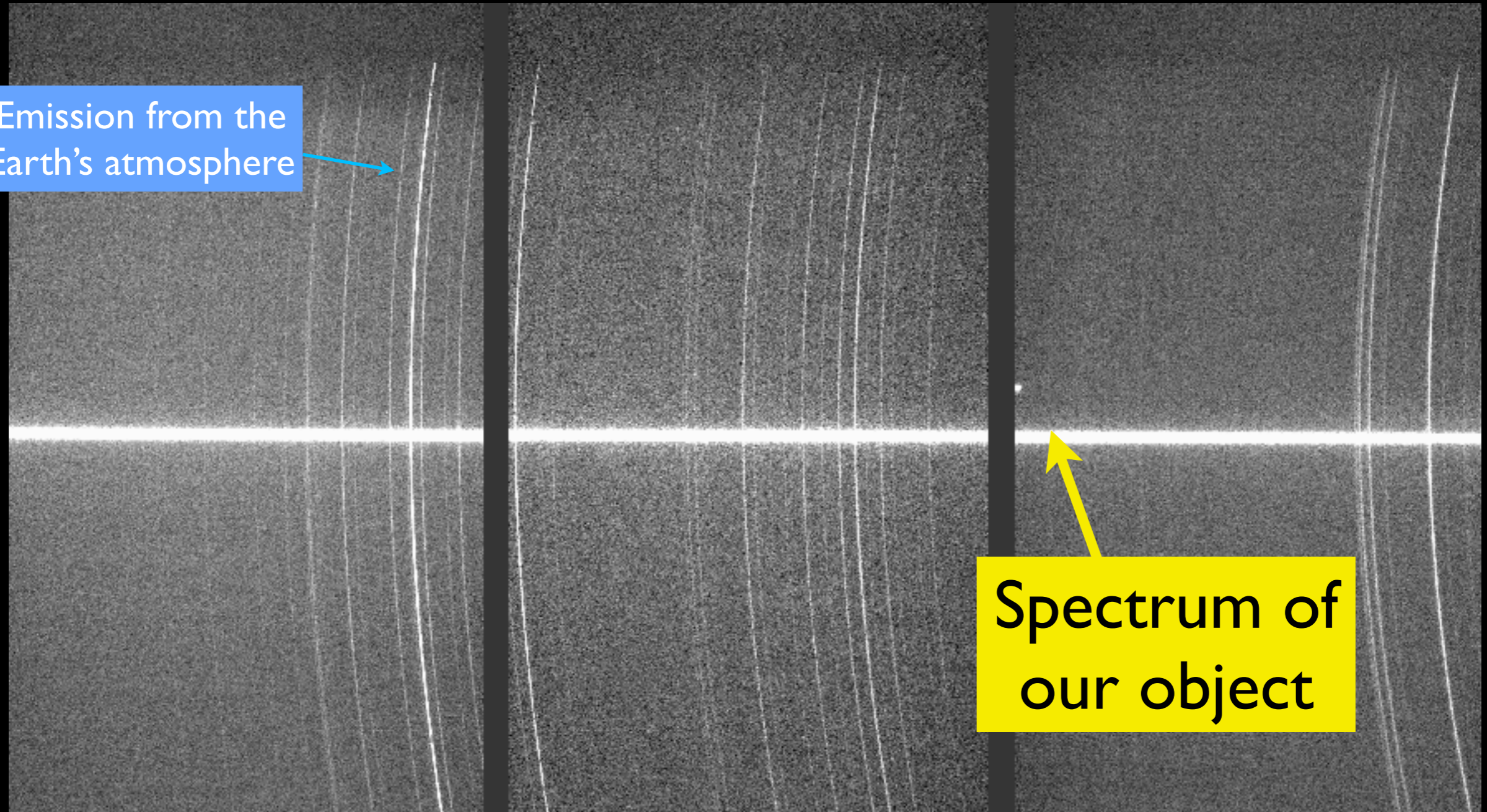


# Step #3: Data Reduction

Emission from the Earth's atmosphere

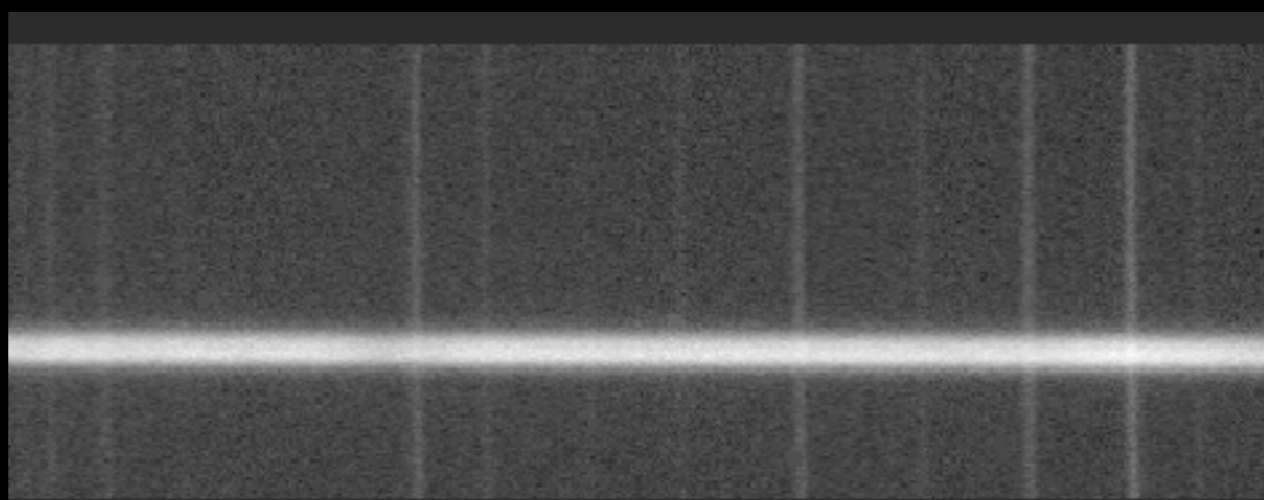


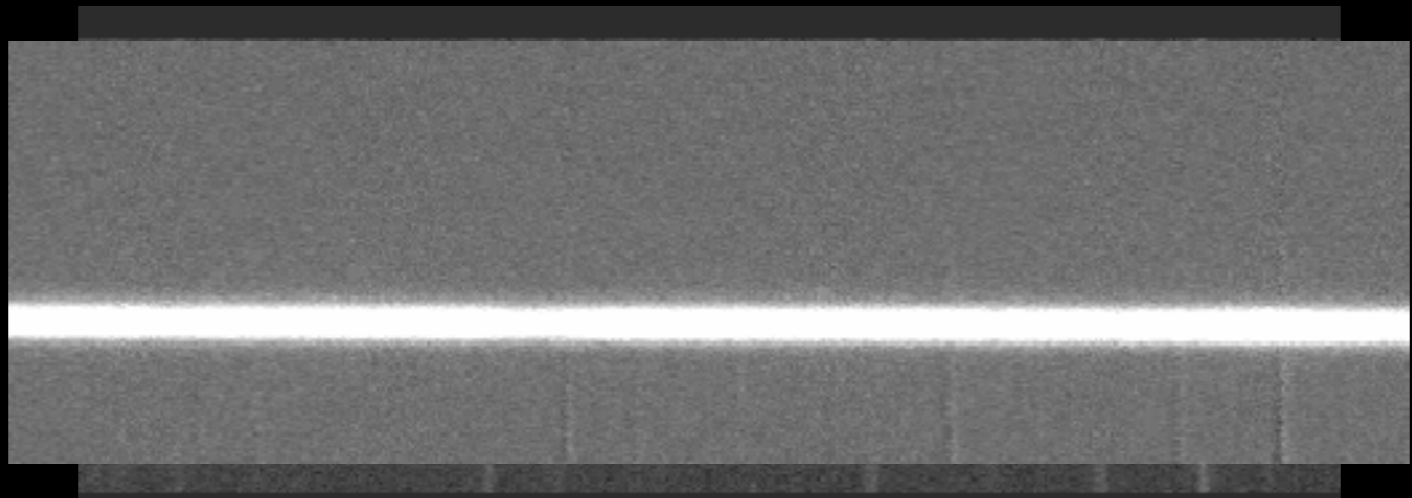
Spectrum of our object

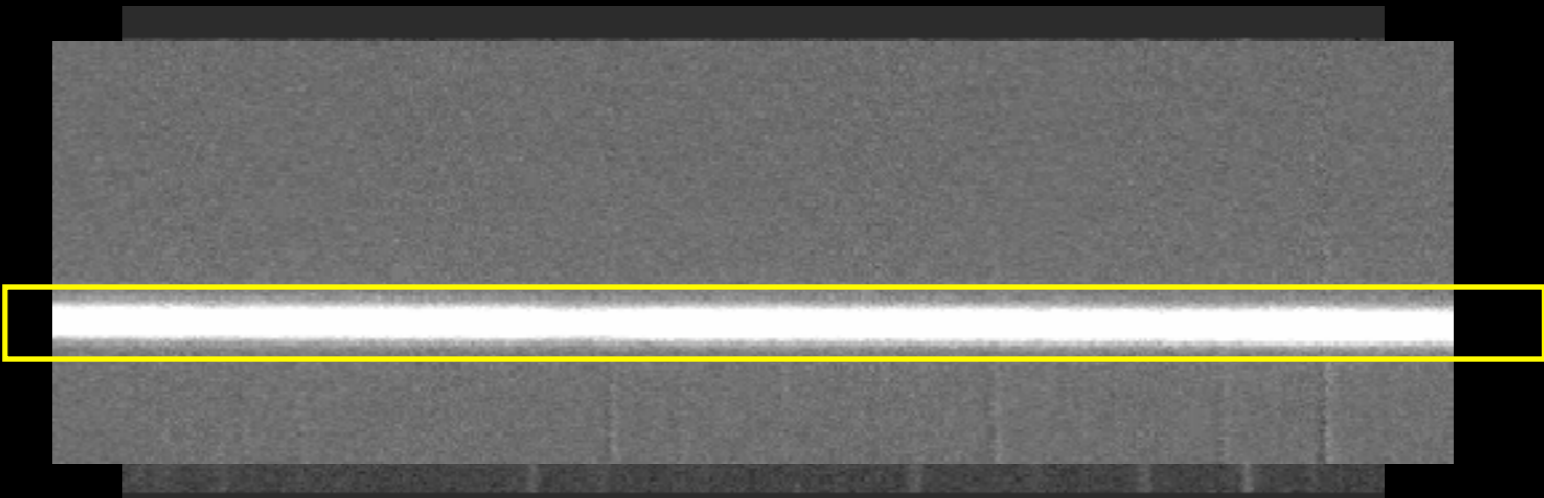


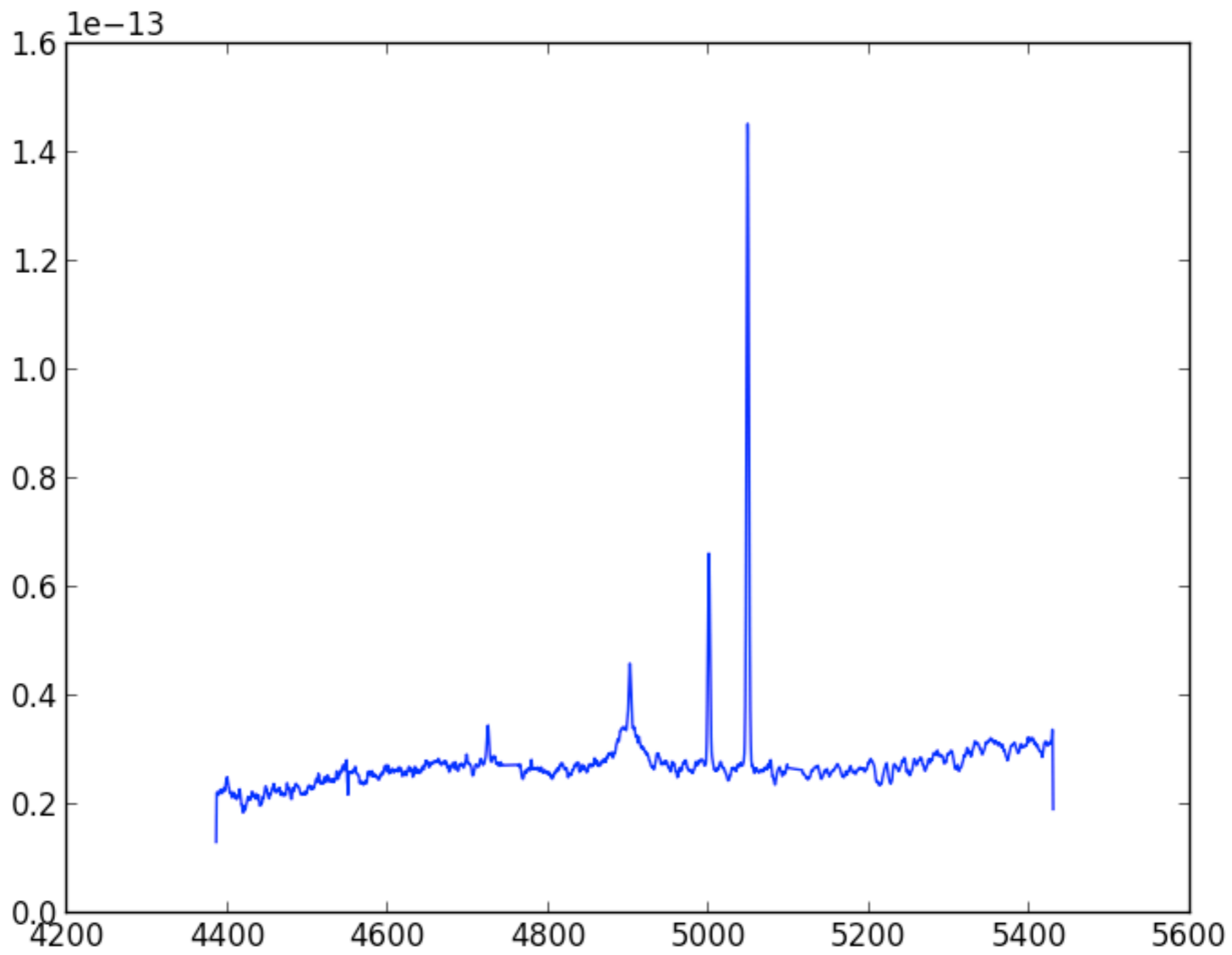




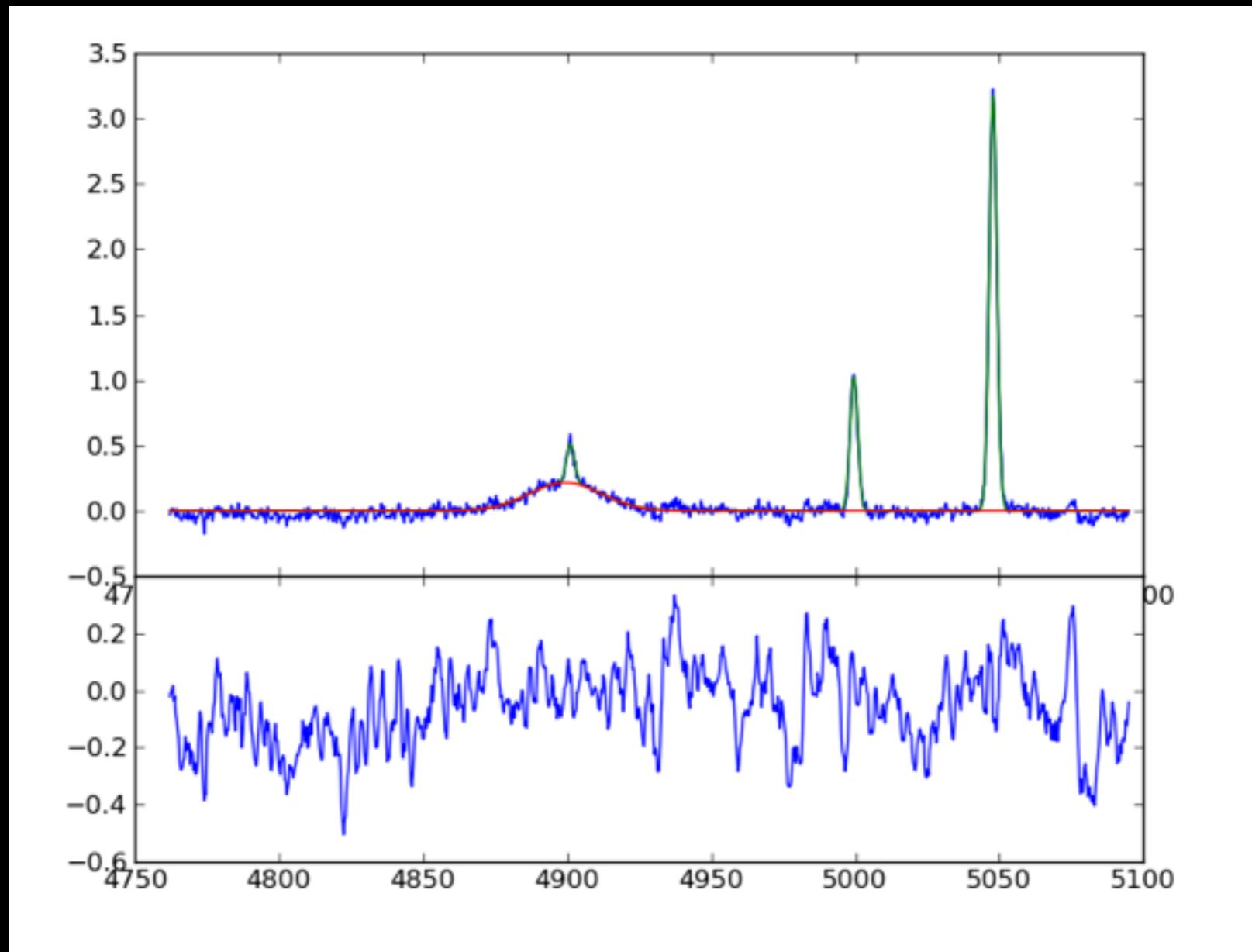




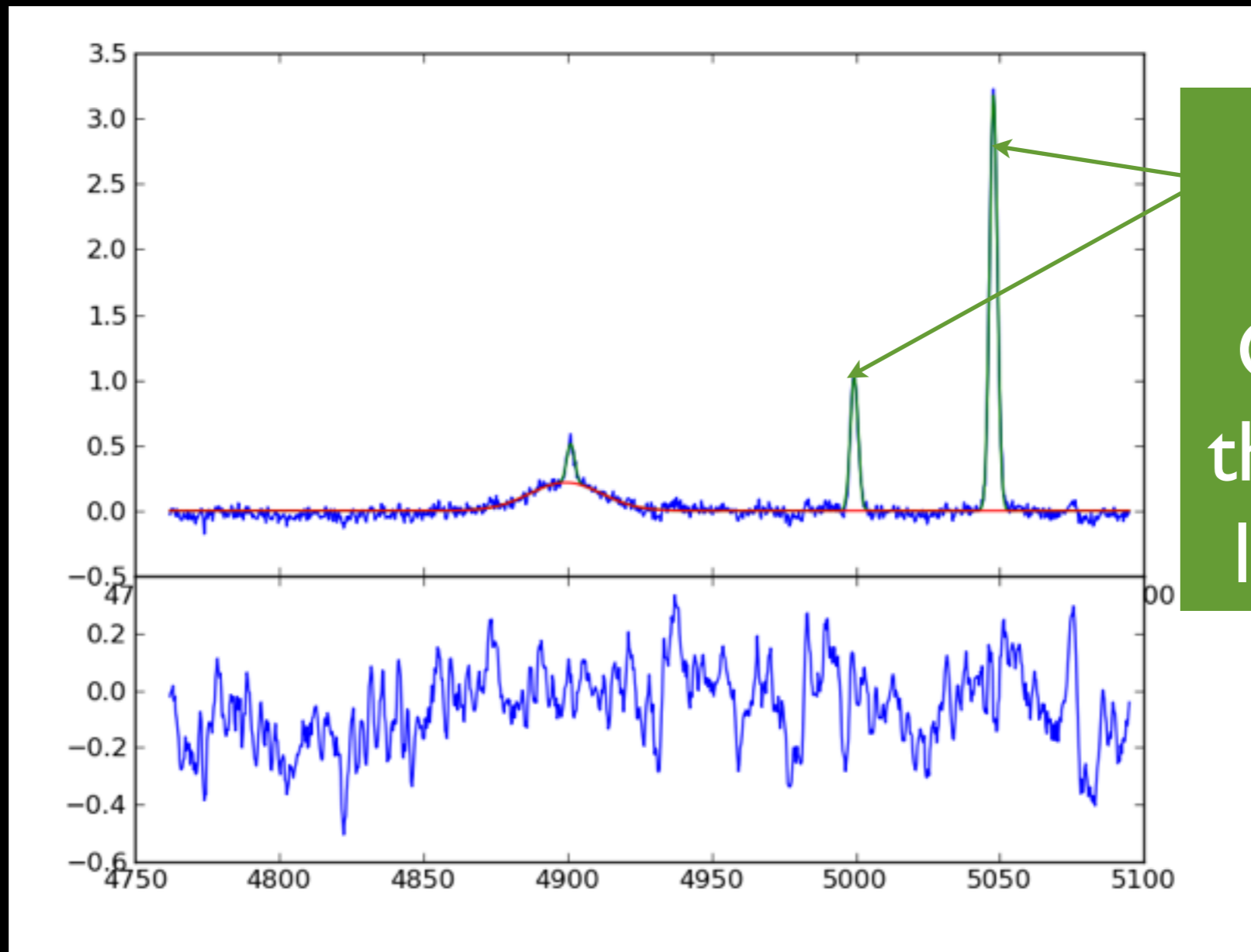




# Step #4: Measuring the Variability



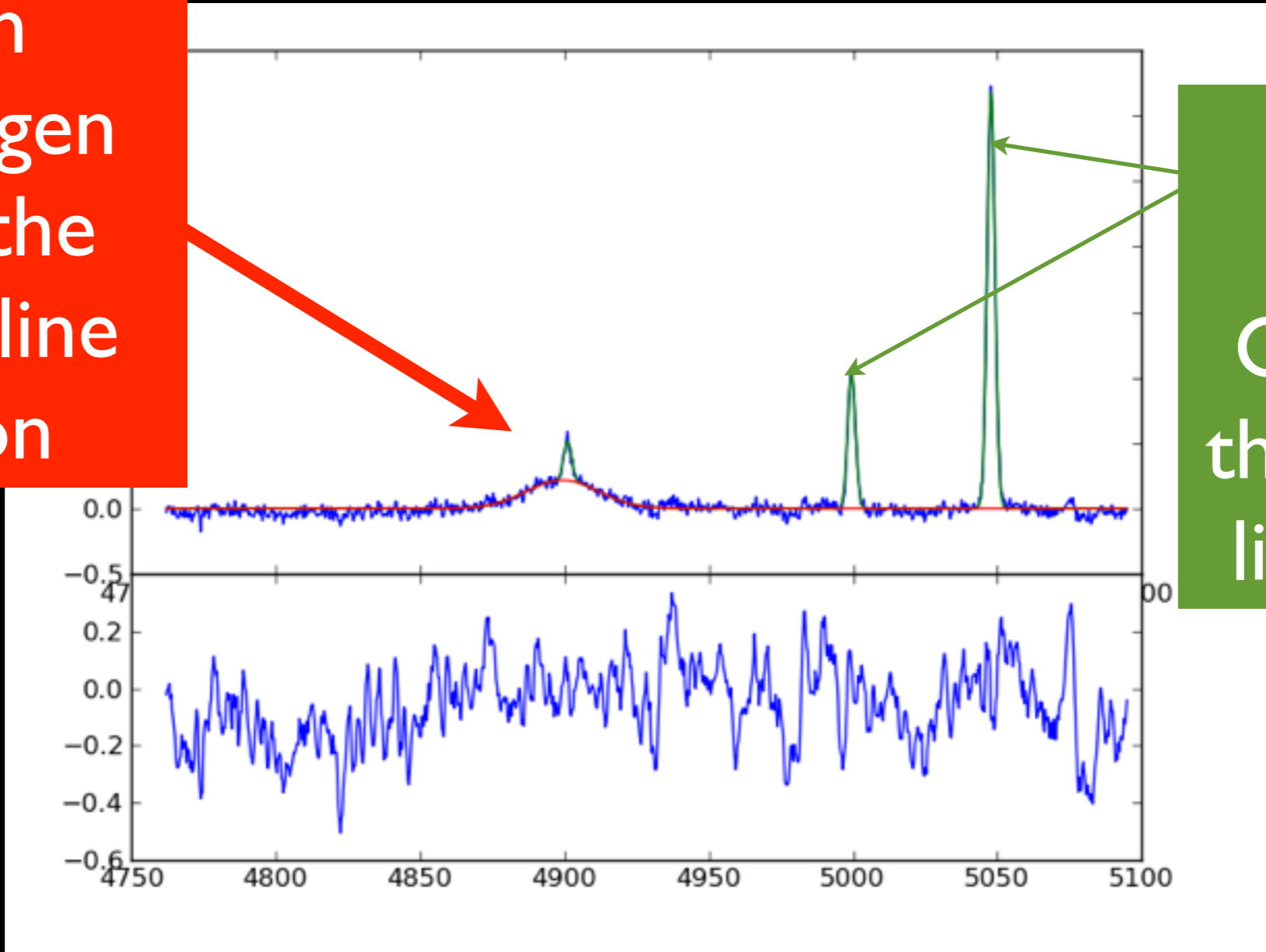
# Step #4: Measuring the Variability



Emission from Oxygen in the Narrow line region

# Step #4: Measuring the Variability

Emission from Hydrogen from the broad line region

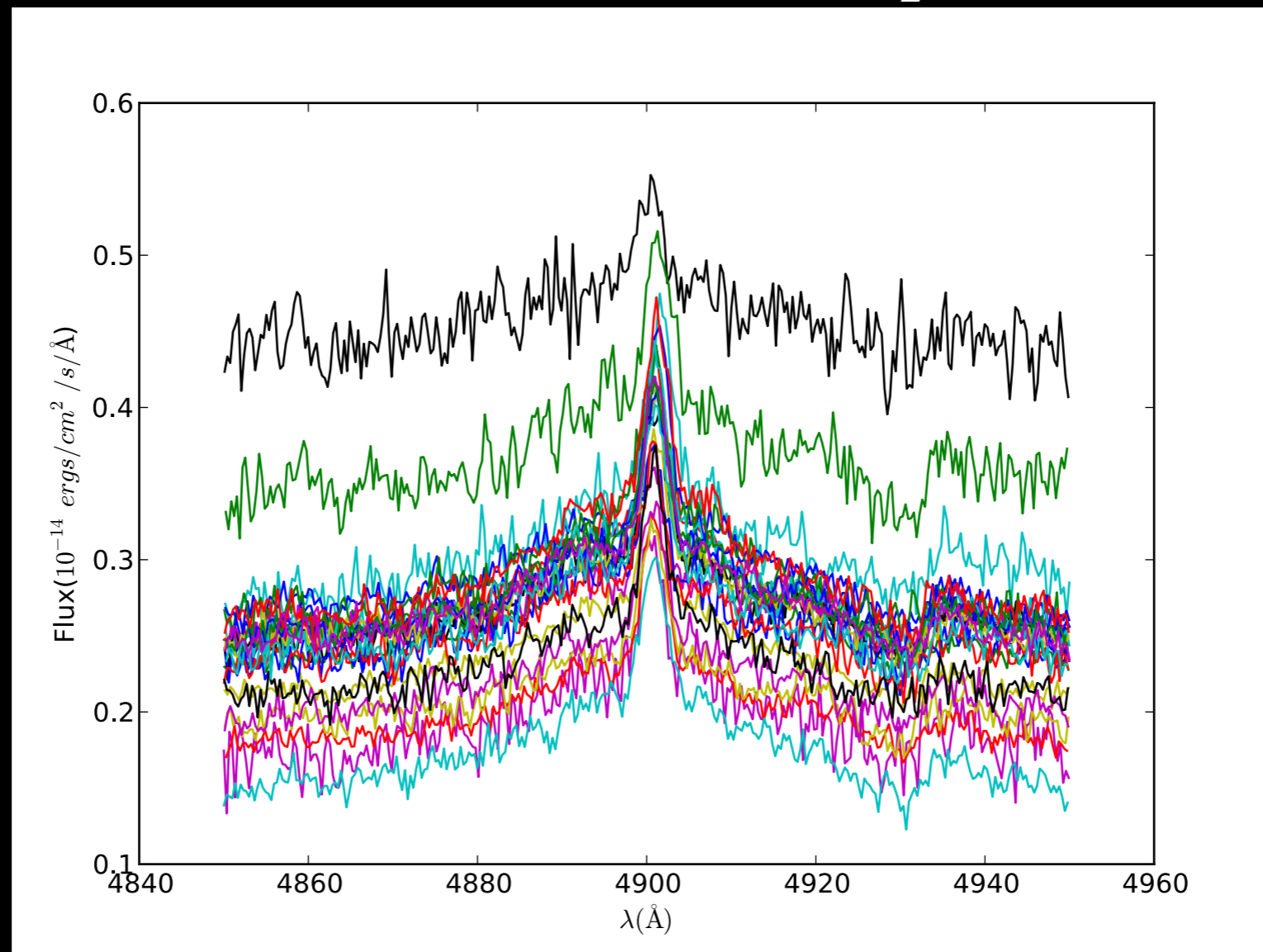


Emission from Oxygen in the Narrow line region

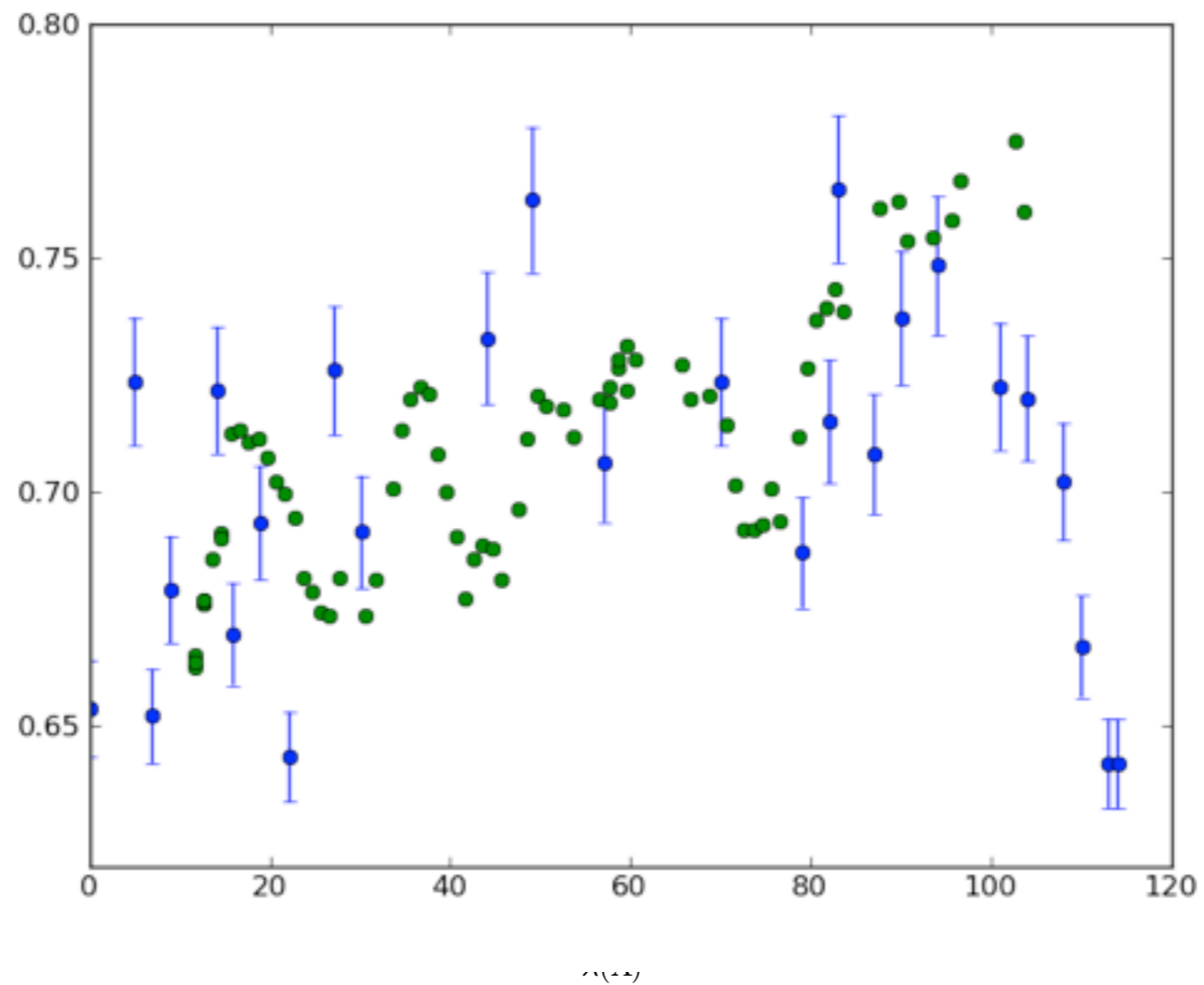
# Measuring the Variability



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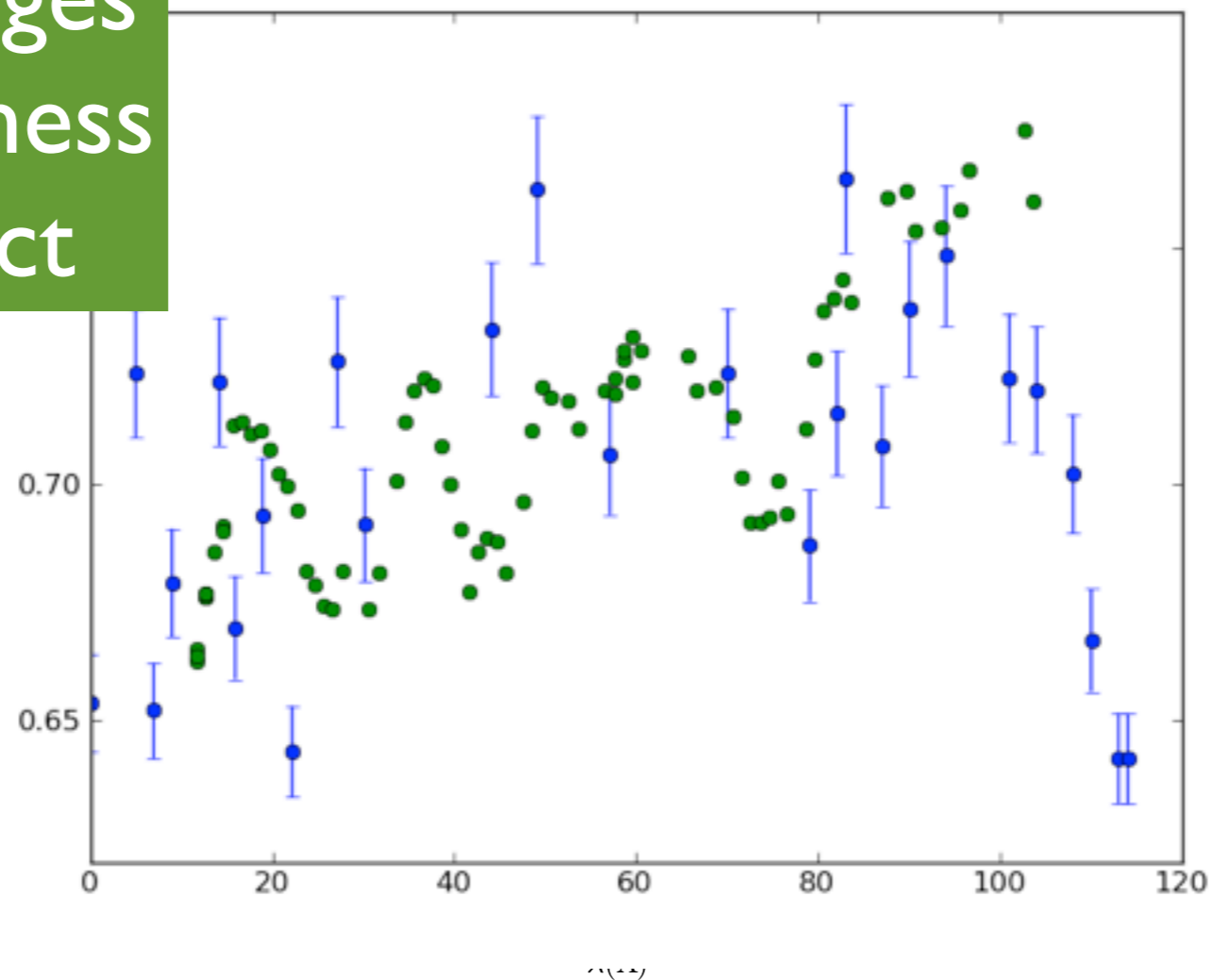


# Measuring the Variability



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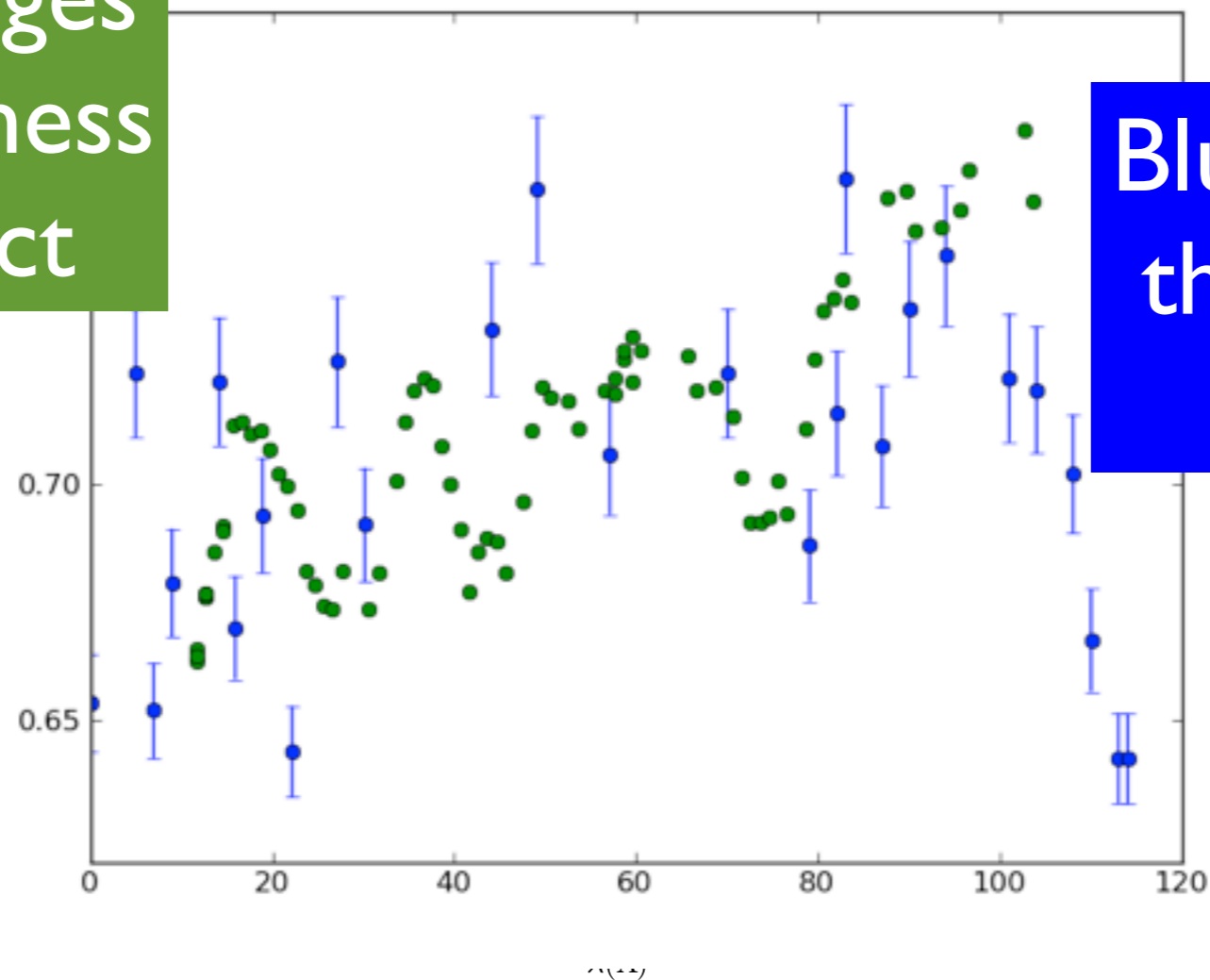
Green: Changes in the brightness of the object



# Measuring the Variability

Green: Changes in the brightness of the object

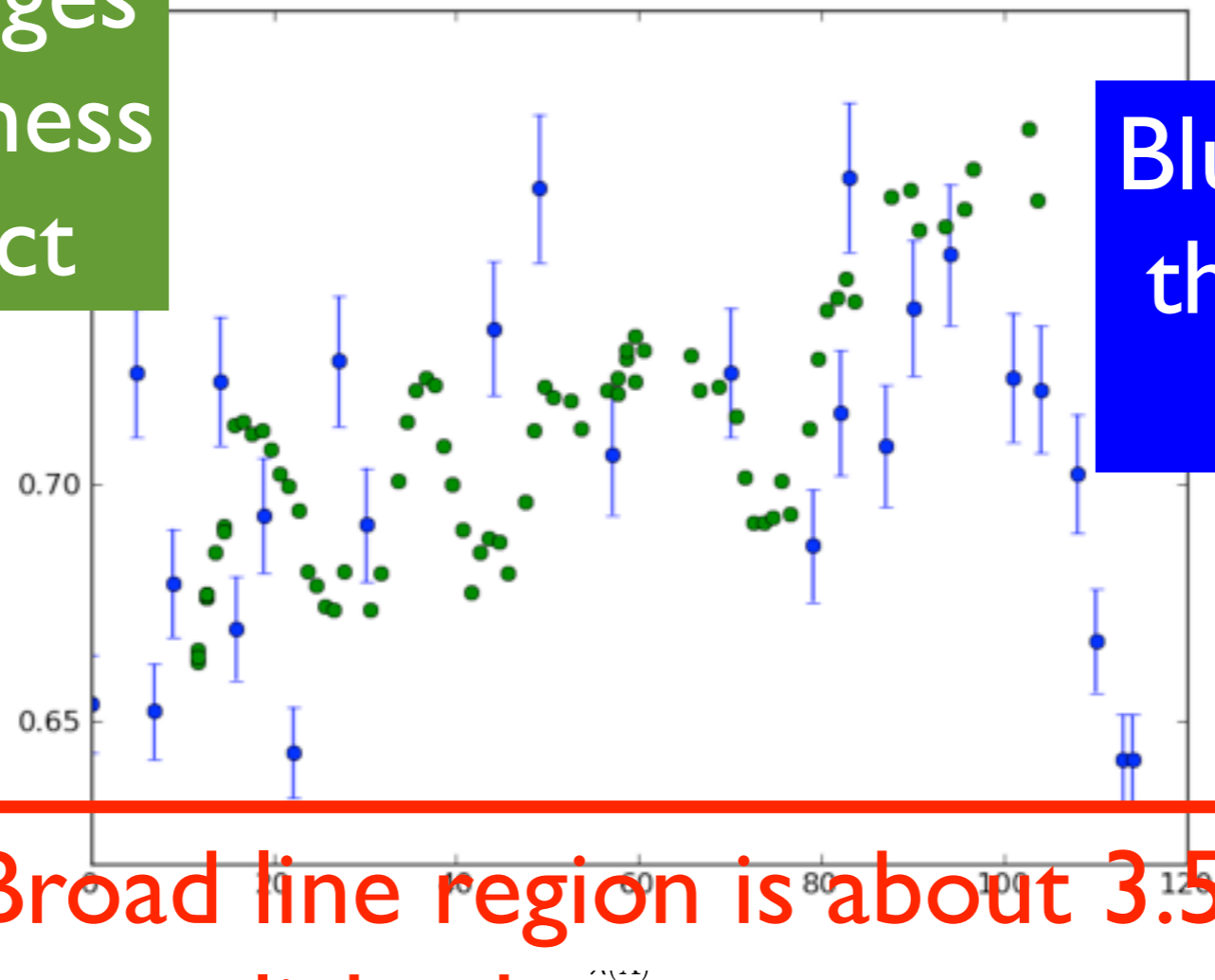
Blue: Changes in the strength of Hydrogen



# Measuring the Variability

Green: Changes in the brightness of the object

Blue: Changes in the strength of Hydrogen



Broad line region is about 3.5 light days across

# Step #5: Publish the Results

Mon. Not. R. Astron. Soc. 000, 1–7 (2002) Printed 15 July 2013 (MN I<sup>A</sup>T<sub>E</sub>X style file v2.2)

## Reverberation Mapping of MGC-6-30-015

E. Romero Colmenero<sup>1,2</sup> \*, S. M. Crawford<sup>1,2</sup>, J. Woo<sup>3</sup>, and R. Hickox<sup>4</sup>

<sup>1</sup>*South African Astronomical Observatory, P.O. Box 9, 7935 Observatory, Cape Town, South Africa ;*

<sup>2</sup>*Southern African Large Telescope Foundation, P.O. Box 9, 7935 Observatory, Cape Town, South Africa*

<sup>3</sup>*Seoul National University, Seoul, South Korea*

<sup>4</sup>*Department of Physics and Astronomy, Dartmouth College, 6127 Wilder Laboratory, Hanover, NH 03755*

In preparation

### ABSTRACT

We have obtained a direct measurement of the mass of the black hole for the well-known Seyfert 1 galaxy MCG-6-30-15, which is at a redshift of  $z=0.008$ , using a technique called reverberation mapping. Through regularly monitor of the object through repeat spectroscopic observations with the Southern African Large Telescope, we were able to obtain a size for the broad line region of approximately  $3.5 \pm 1$  light days. This was a pilot program for future reverberation mapping campaigns with SALT.

**Key words:** circumstellar matter – infrared: stars.

### 1 INTRODUCTION

The correlation of the mass of the central black hole (MBH)

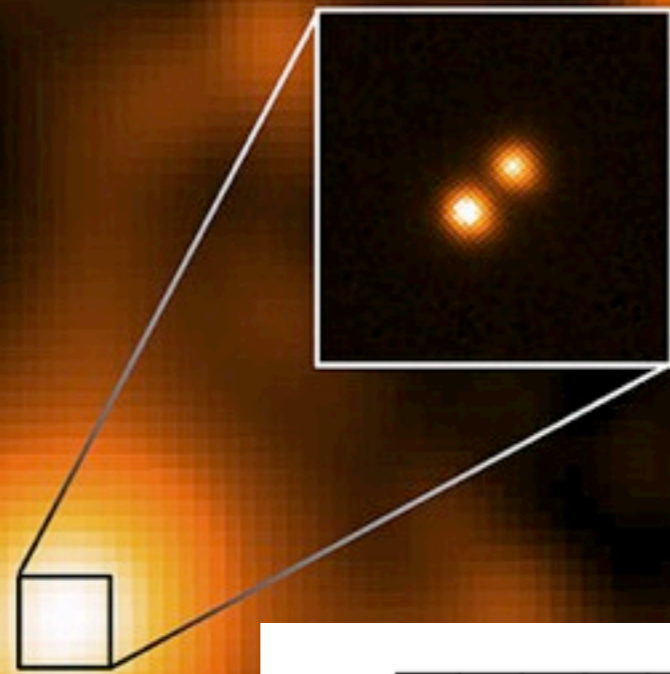
been measured (Wandel, Peterson, Malkan 1999; Kaspi et al. 2000; Peterson et al. 2004; Bentz et al. 2009c; Denney et al 2009; Barth et al. 2011). The main difficulty of reverbera-

In Preparation

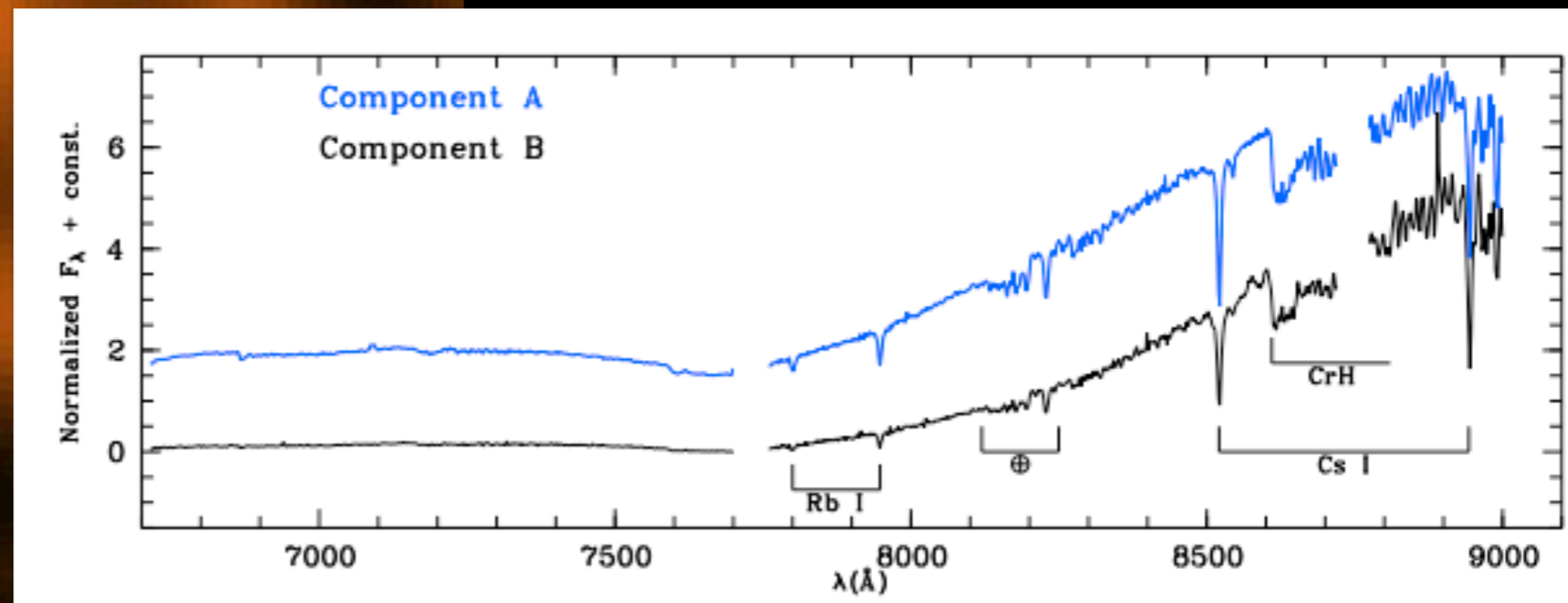
# Science Highlights

# Our Nearest Neighbors

## Alexei Kniazev (SAAO)



Brown dwarf binary  
star located only 6  
light years away!

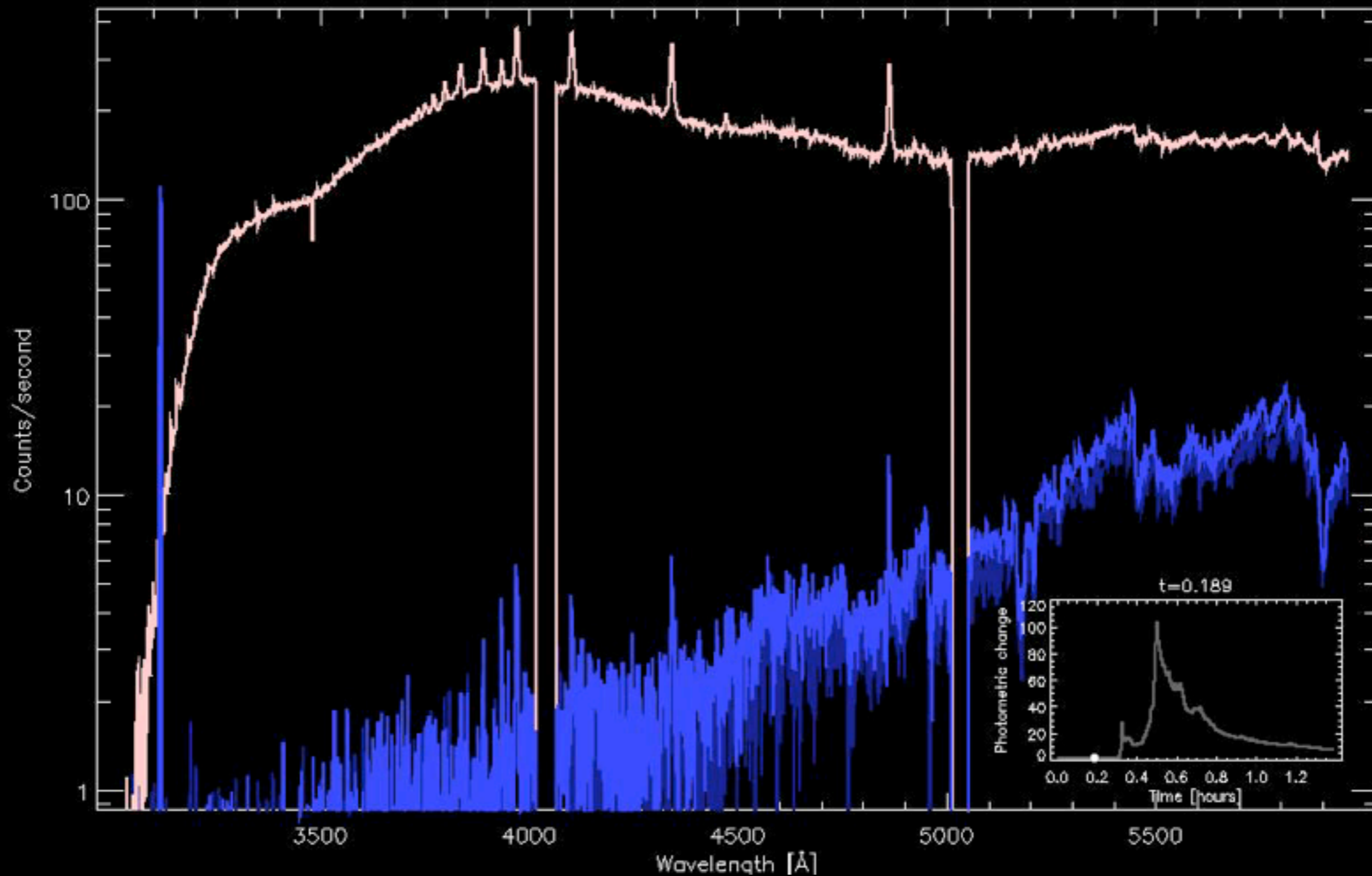




# Mega-Flares

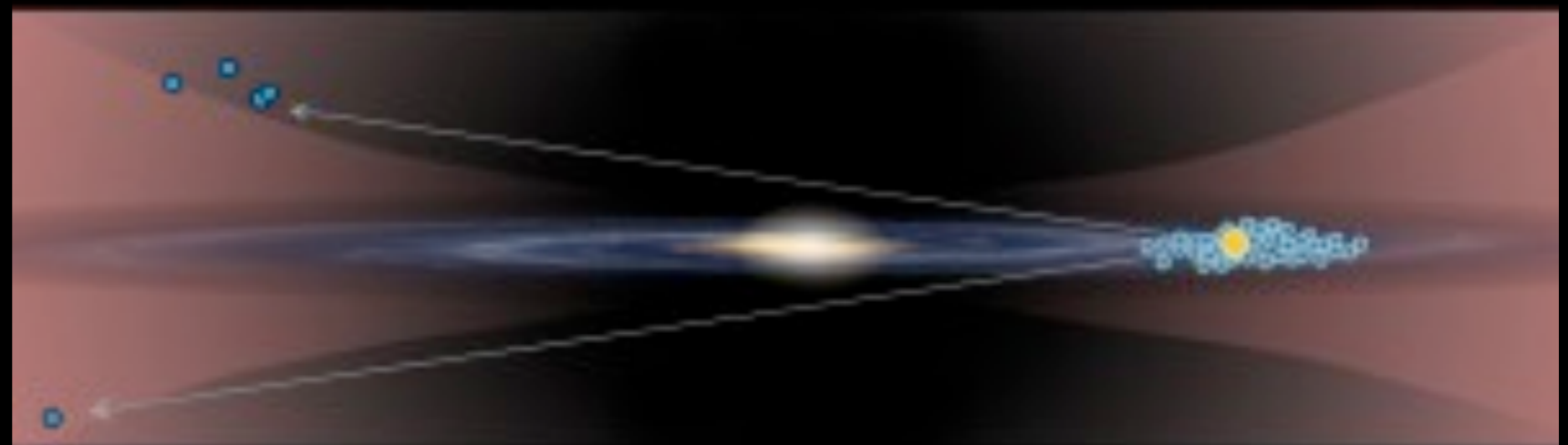
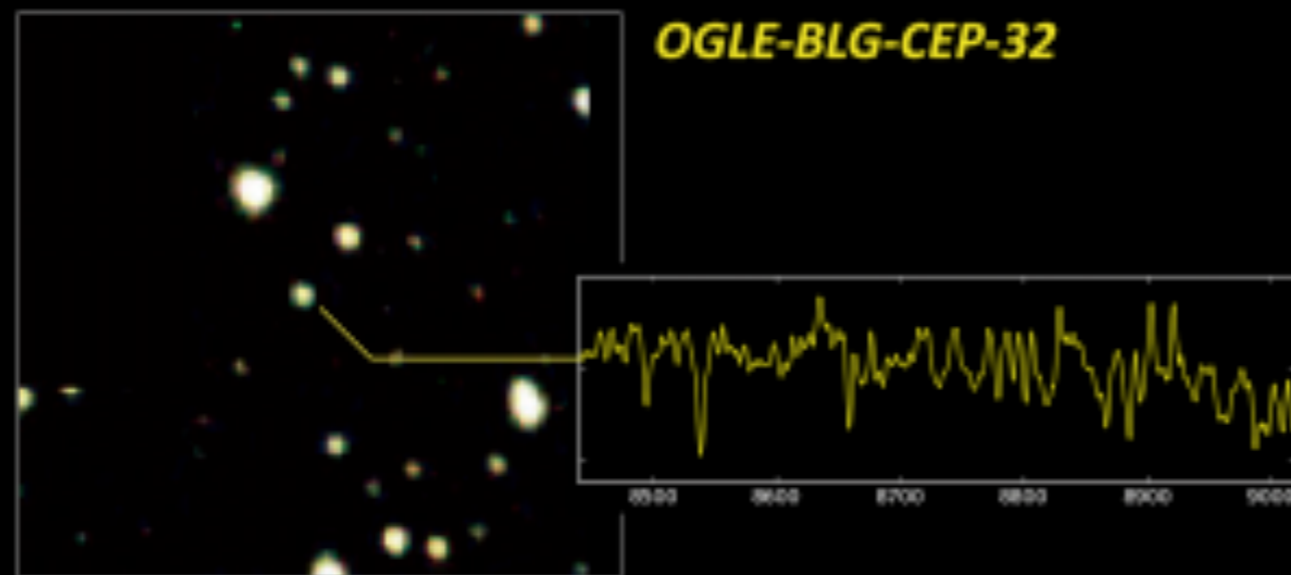
Ben Brown

University of Wisconsin



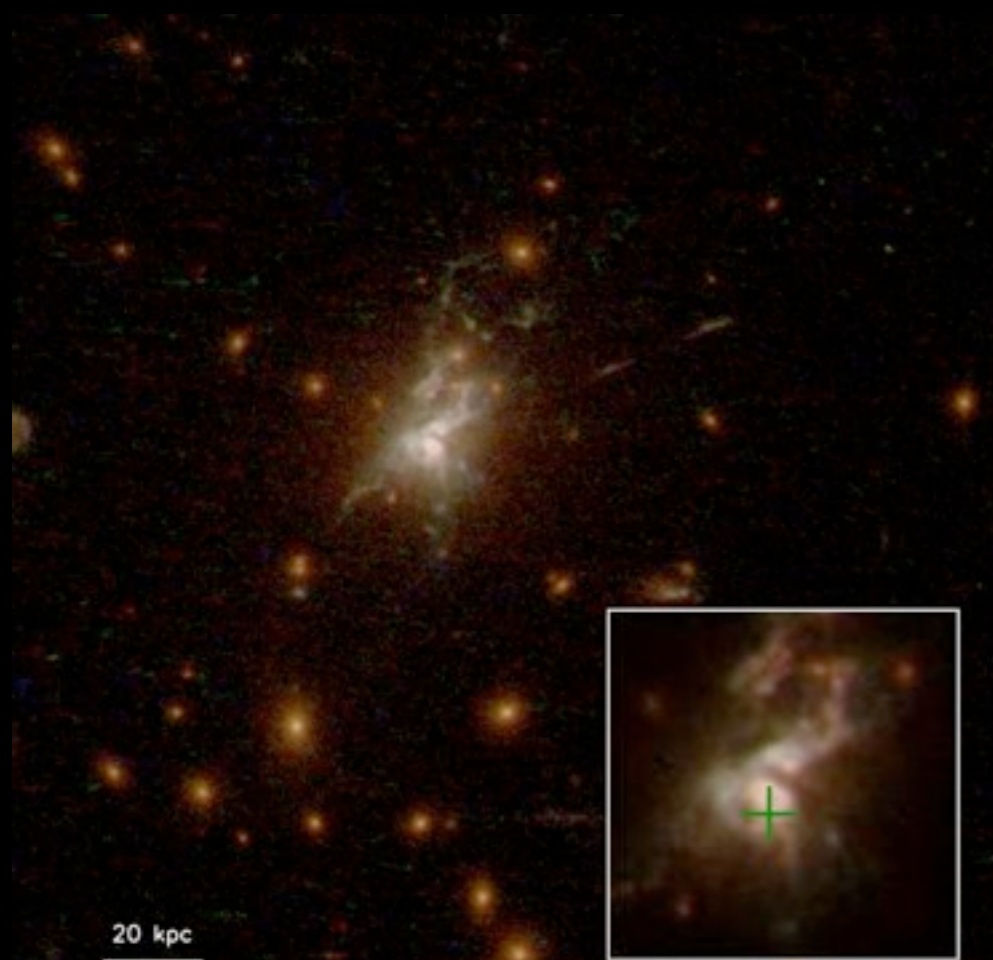
# The Disk of the Milky Way

## Way

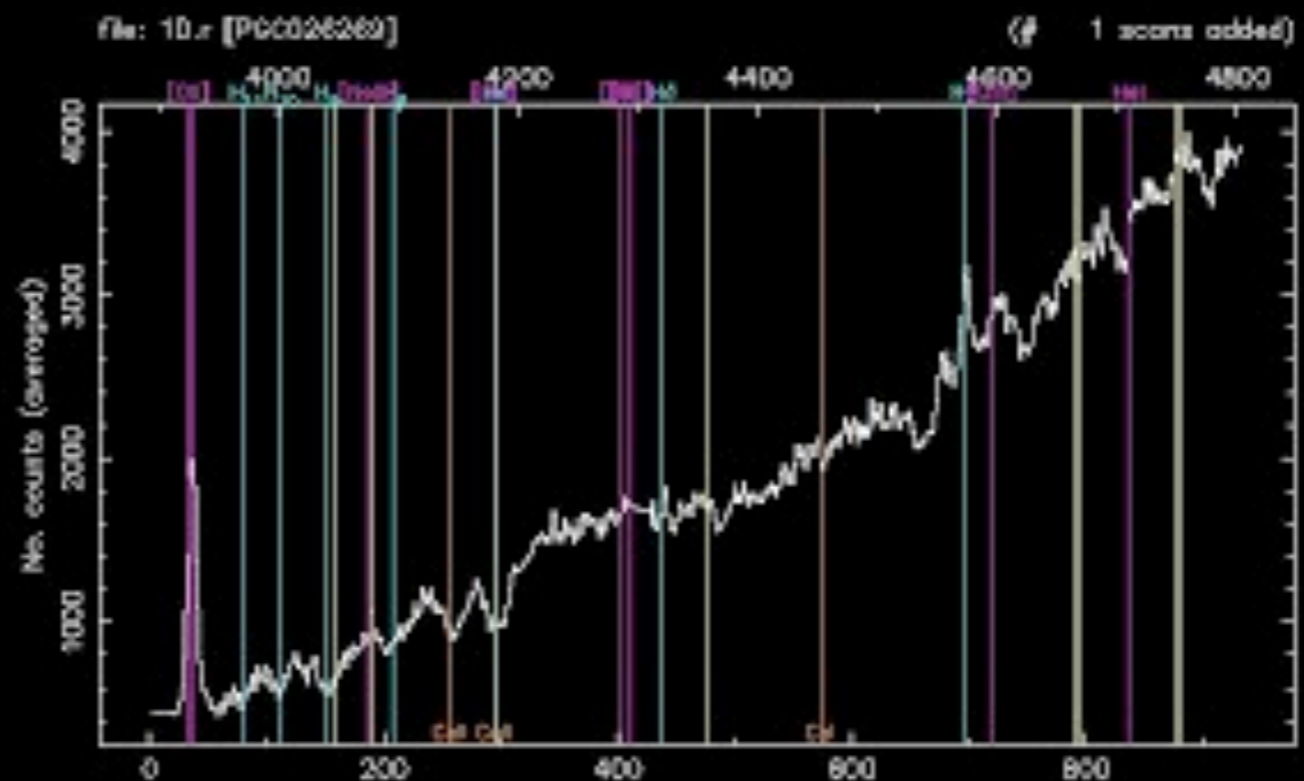


Feast, Whitelock, and Menzies

# Measuring the Ages of Galaxies



Mcdonald et al.



Ilani Loubser (NWU)

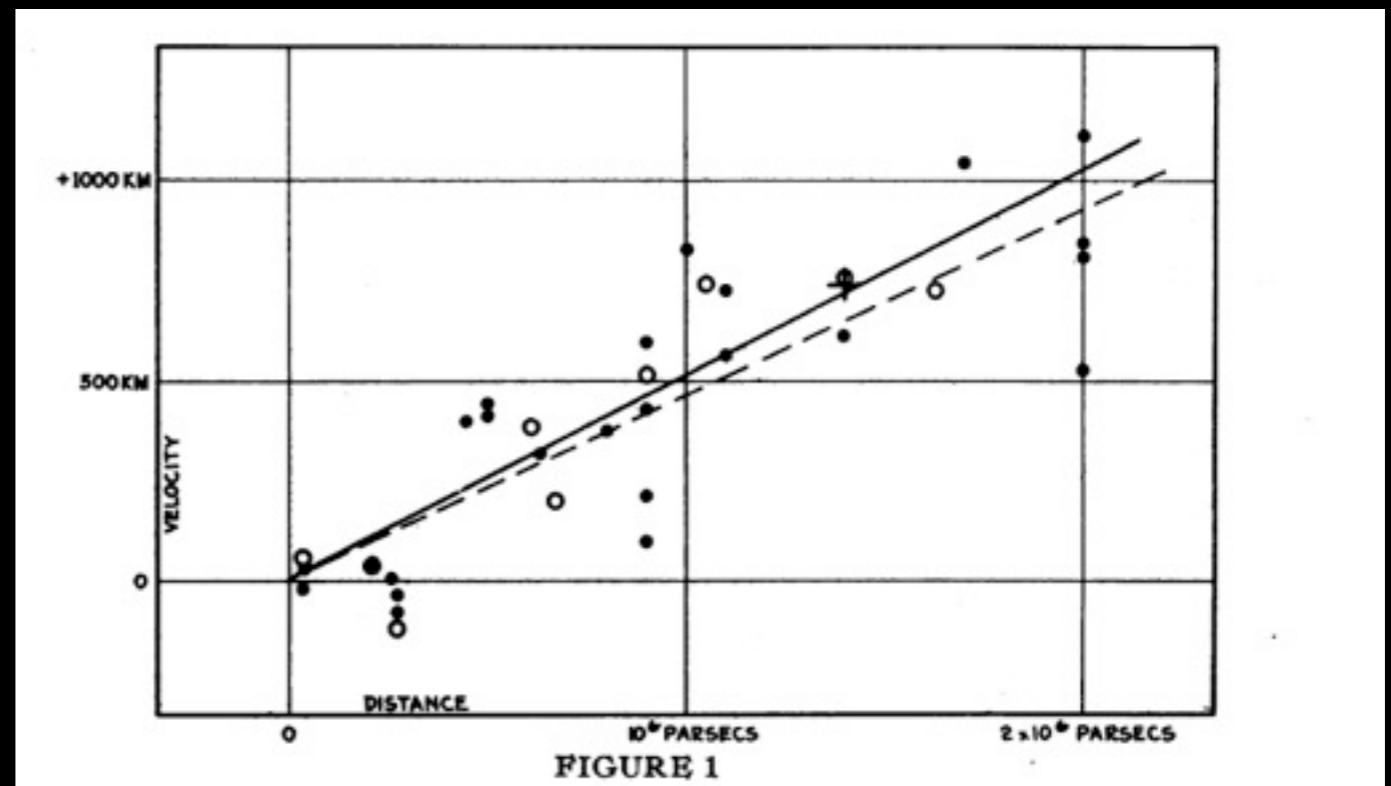
# Mapping the Universe

Type Ia Supernova act as 'standard candles'. They are sources of known brightness.



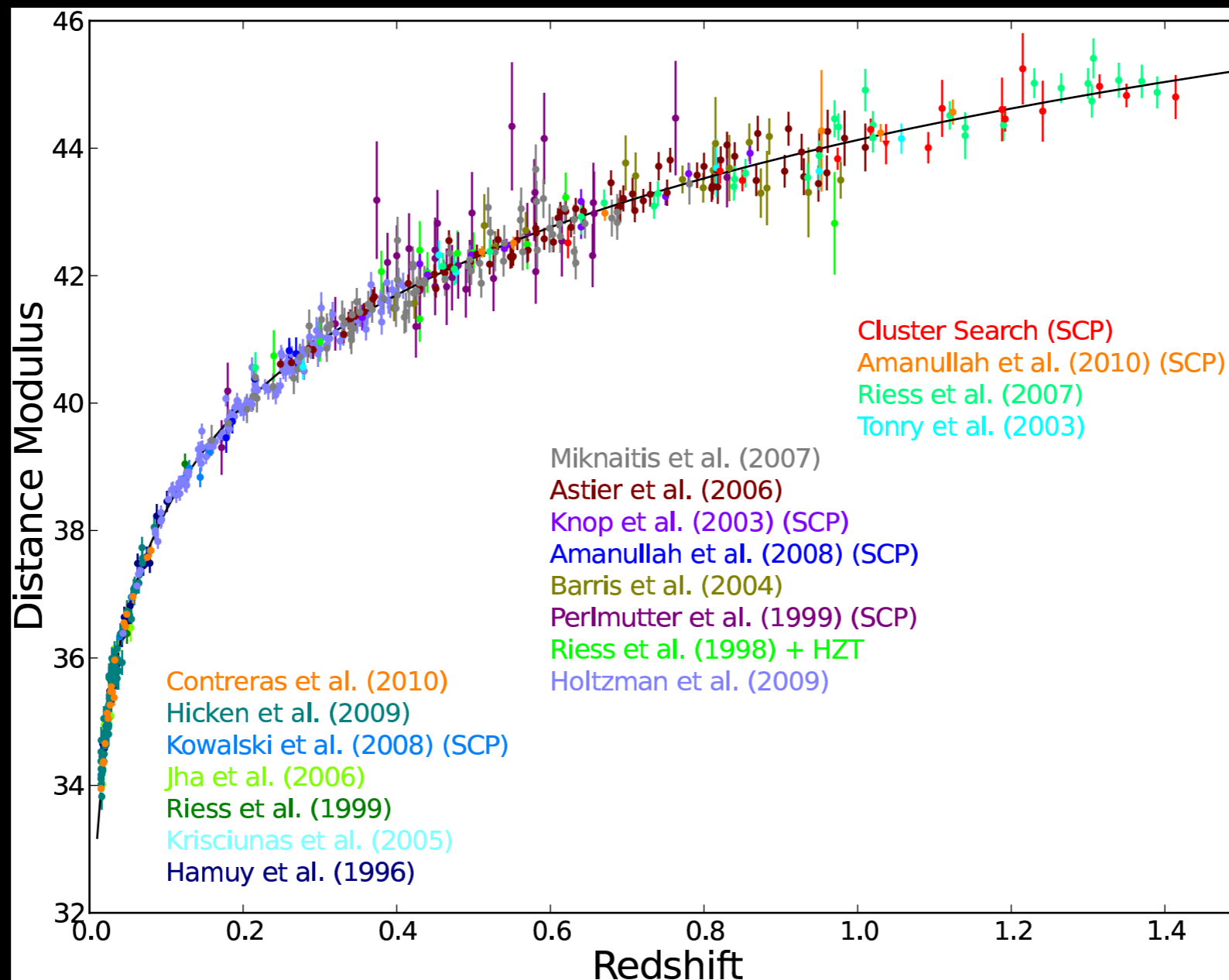
# Expanding (and accelerating) Universe

In 1928, Edwin Hubble found that more distant galaxies were moving faster away from us

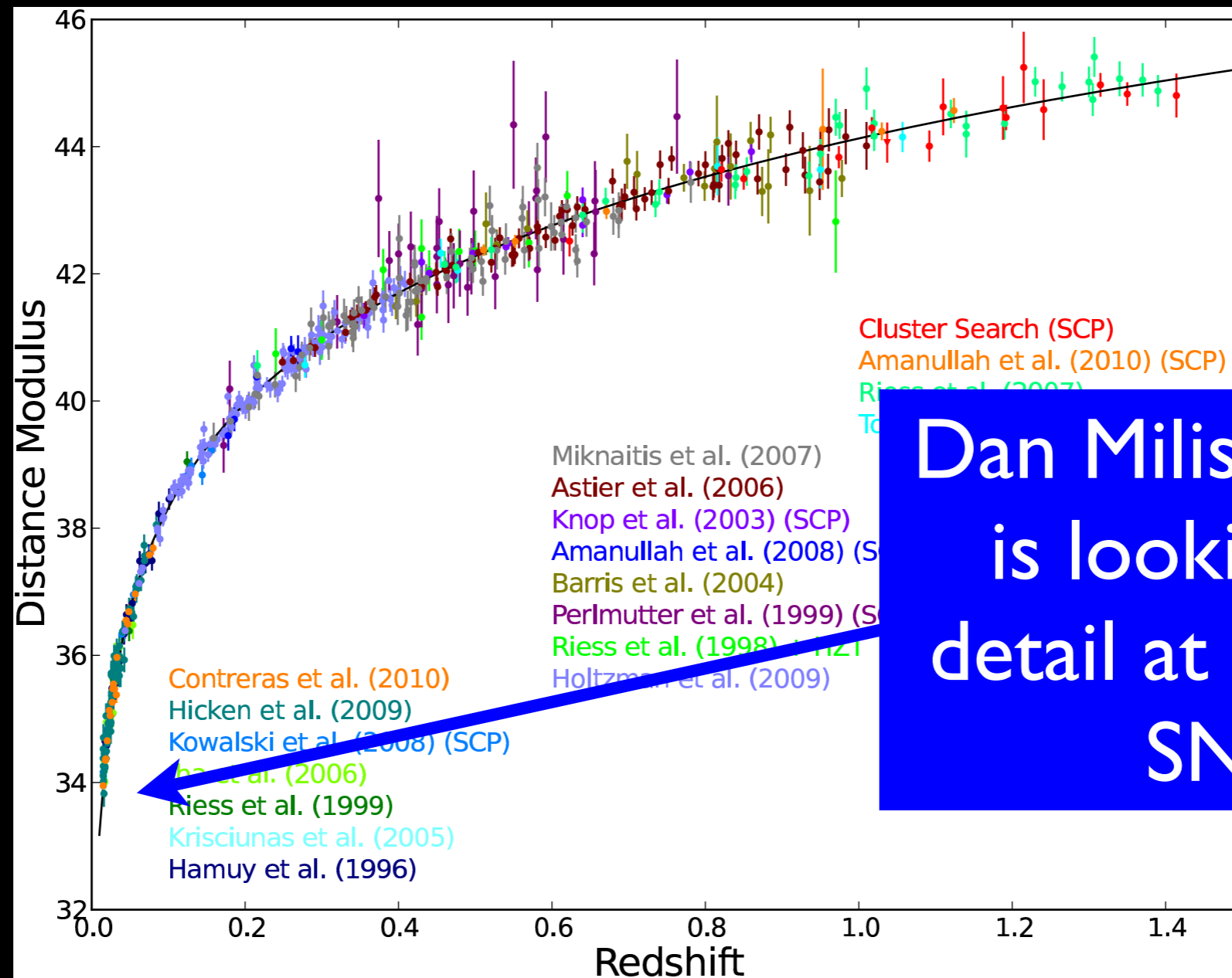


The light from objects moving away from us is shifted to longer wavelengths (towards the red), hence redshift

# Expanding and Accelerating Universe

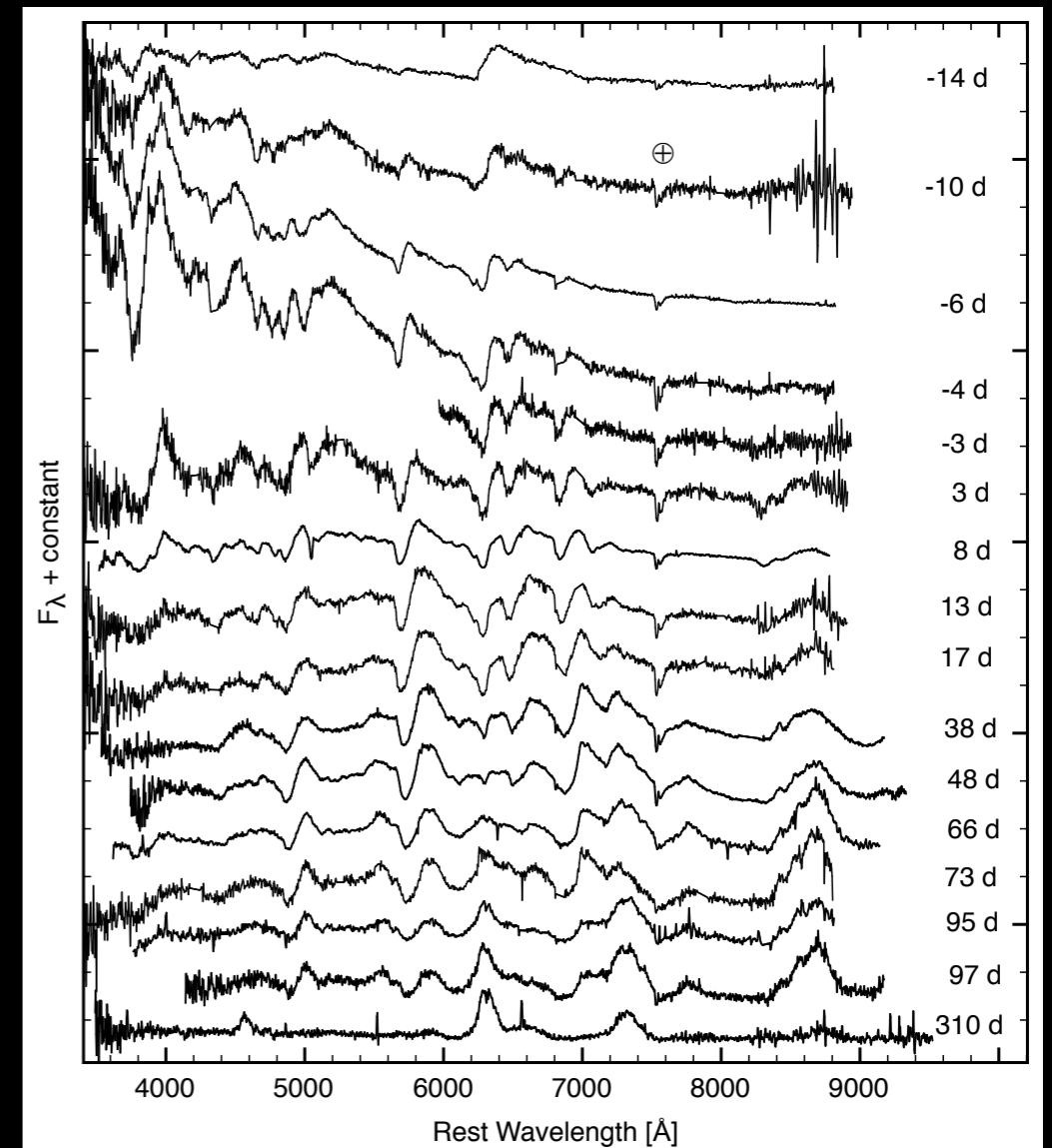
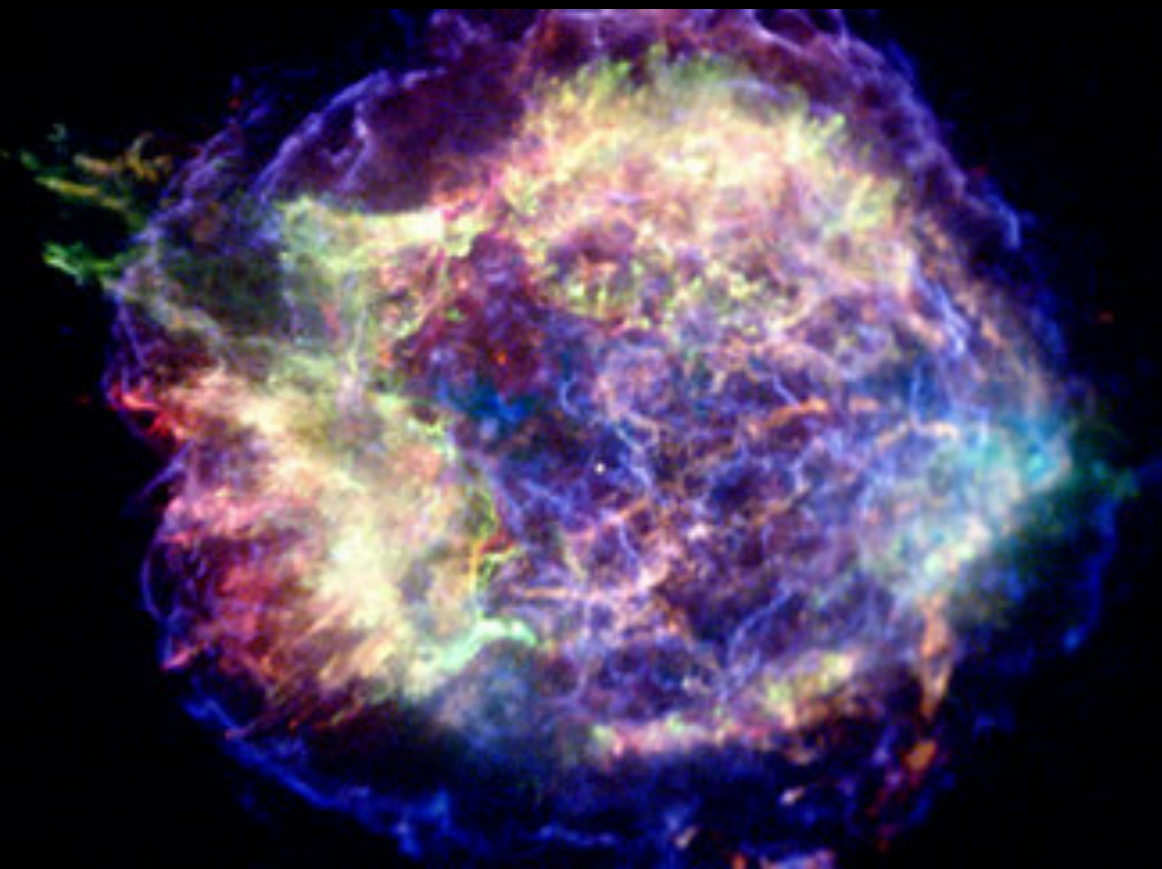


# Expanding and Accelerating Universe



Dan Milisavljevic  
is looking in  
detail at nearby  
SN

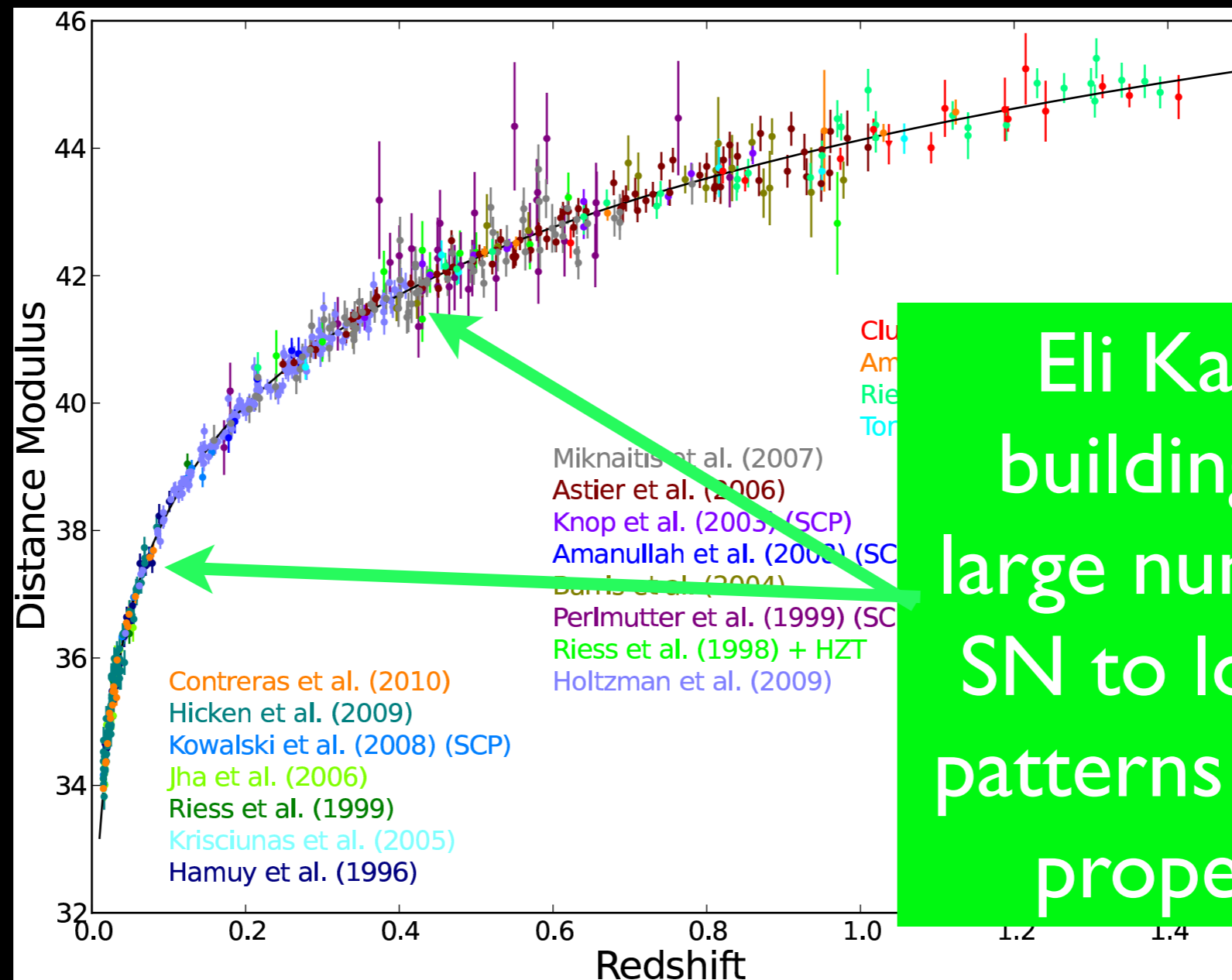
# Super Nova



Dan Milisavljevic  
(Dartmouth)

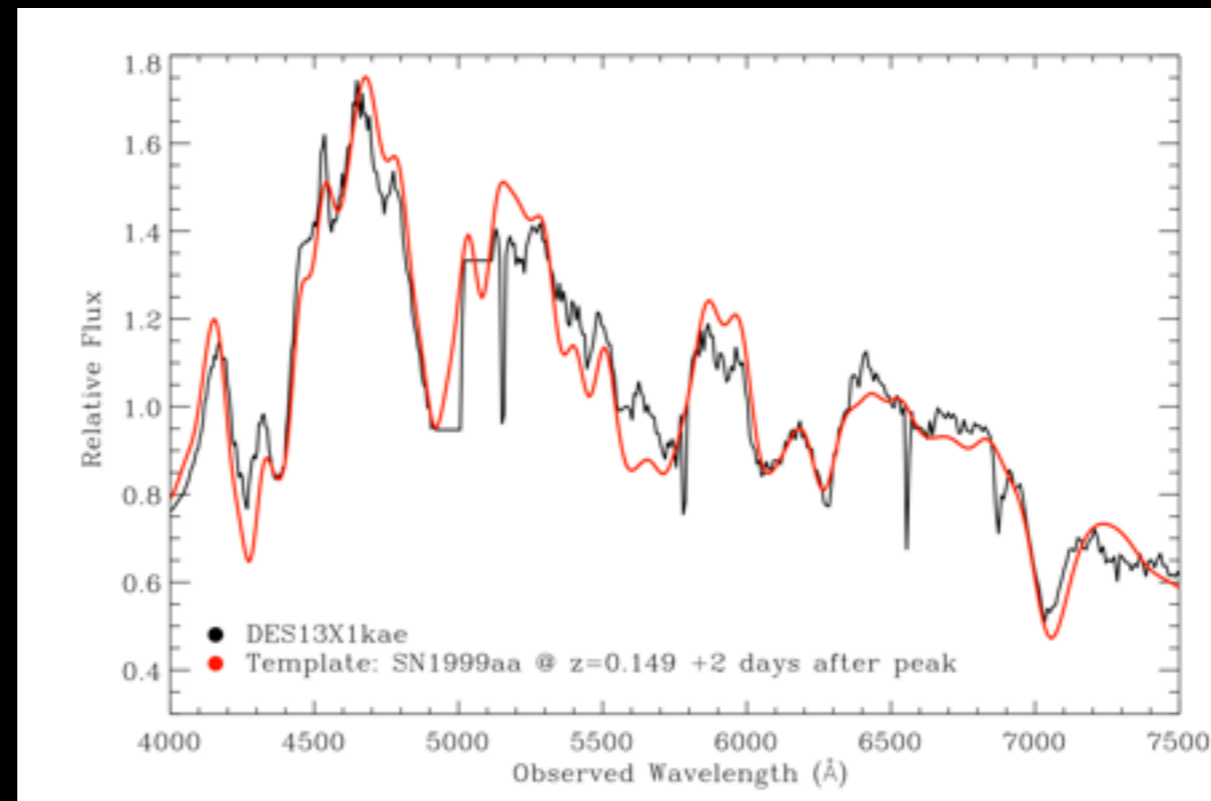
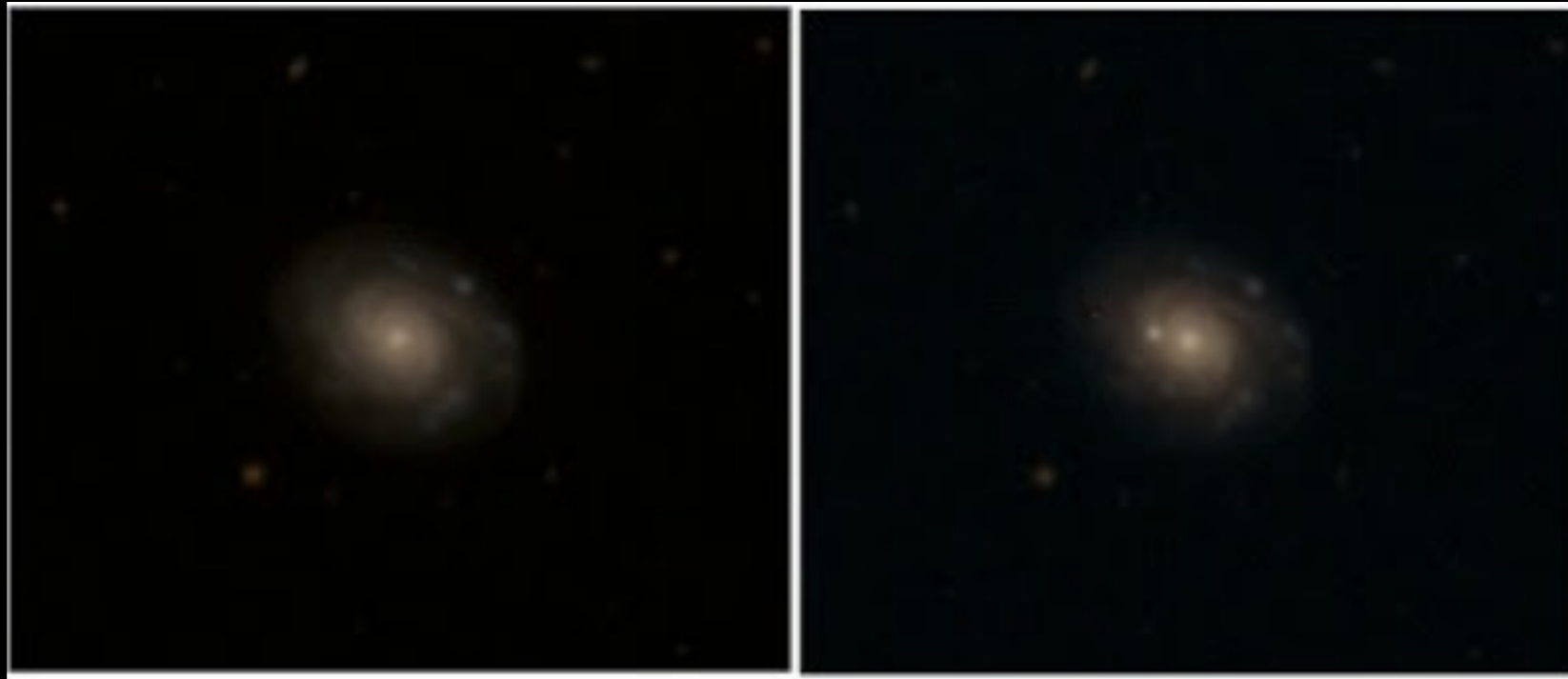


# Expanding and Accelerating Universe

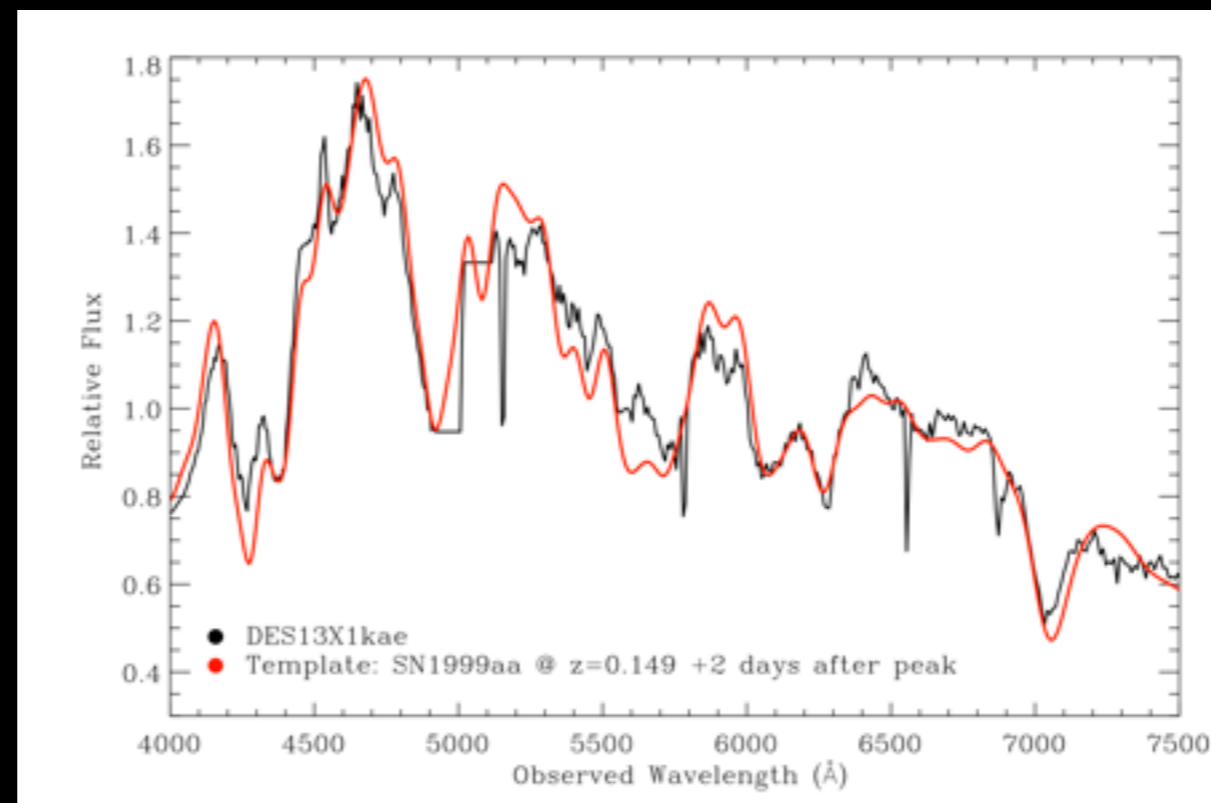


Eli Kasai is building up a large number of SN to look for patterns in their properties

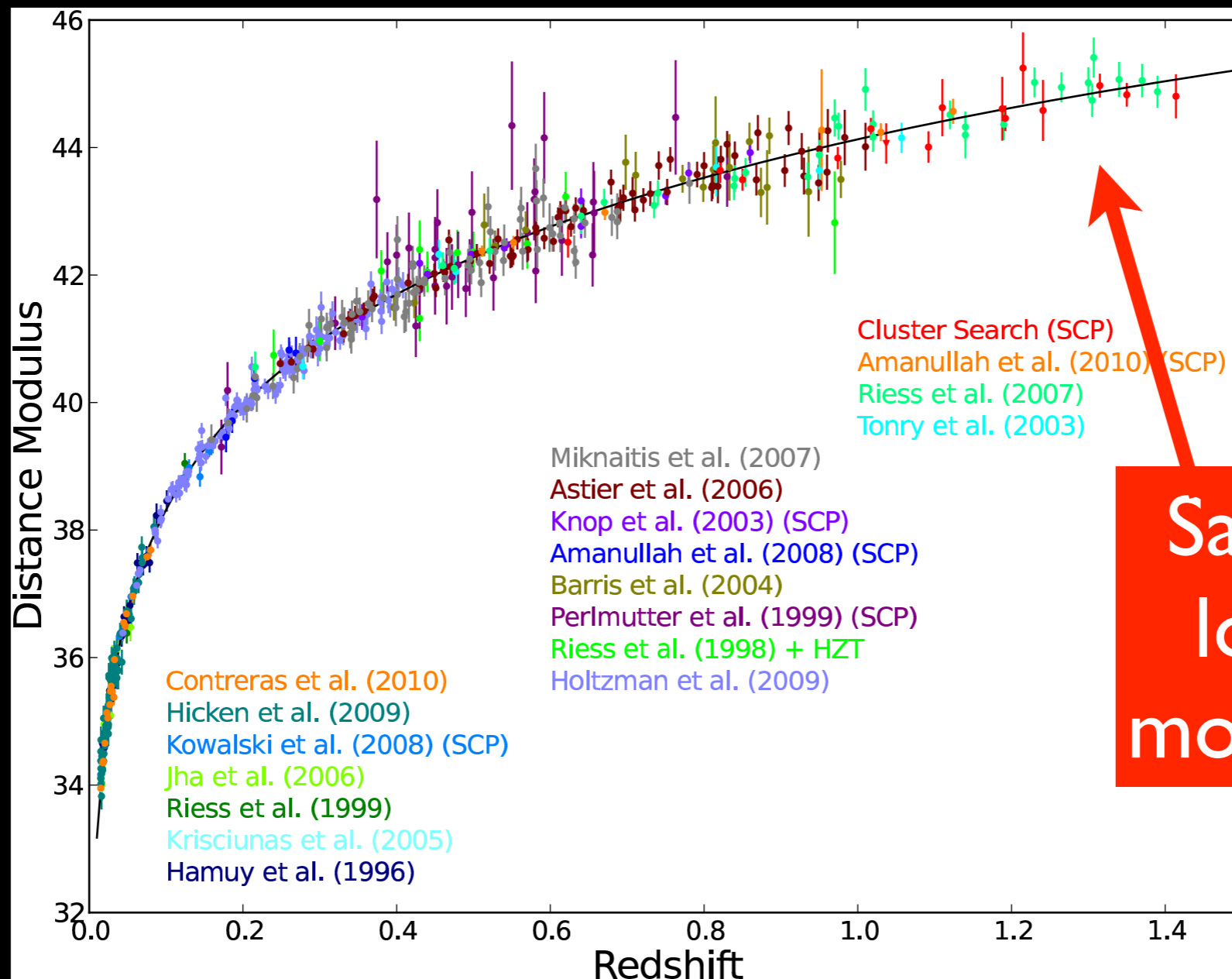
# Dark Energy Survey



# Dark Energy Survey



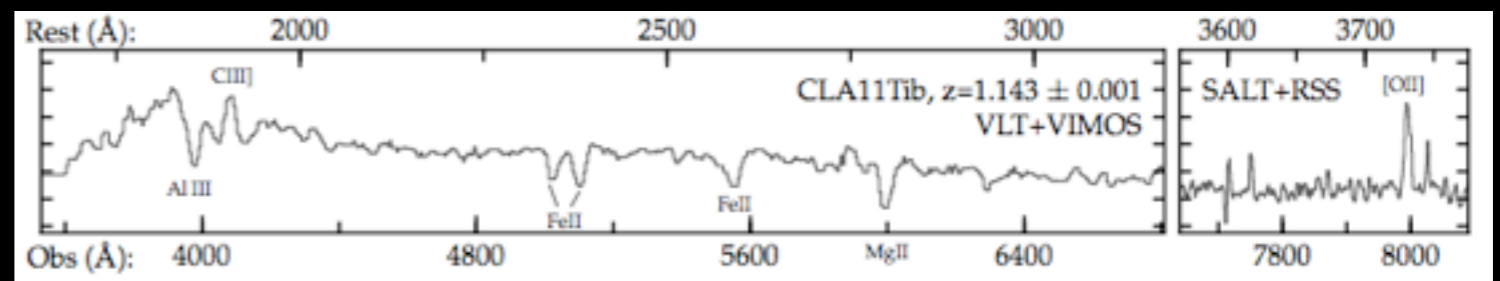
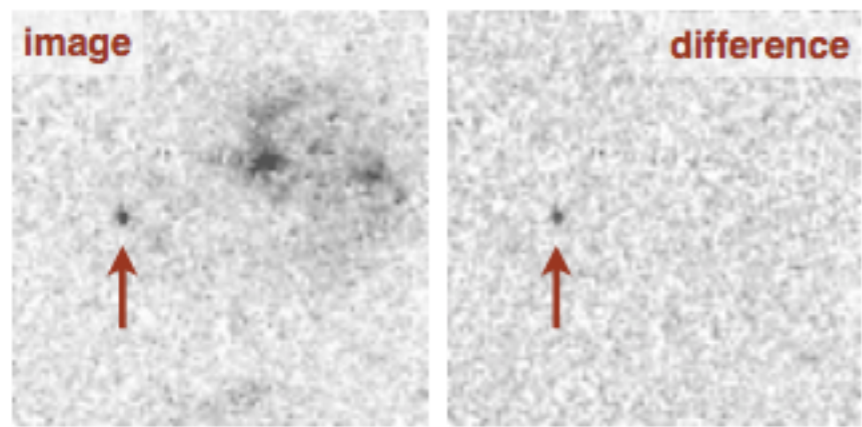
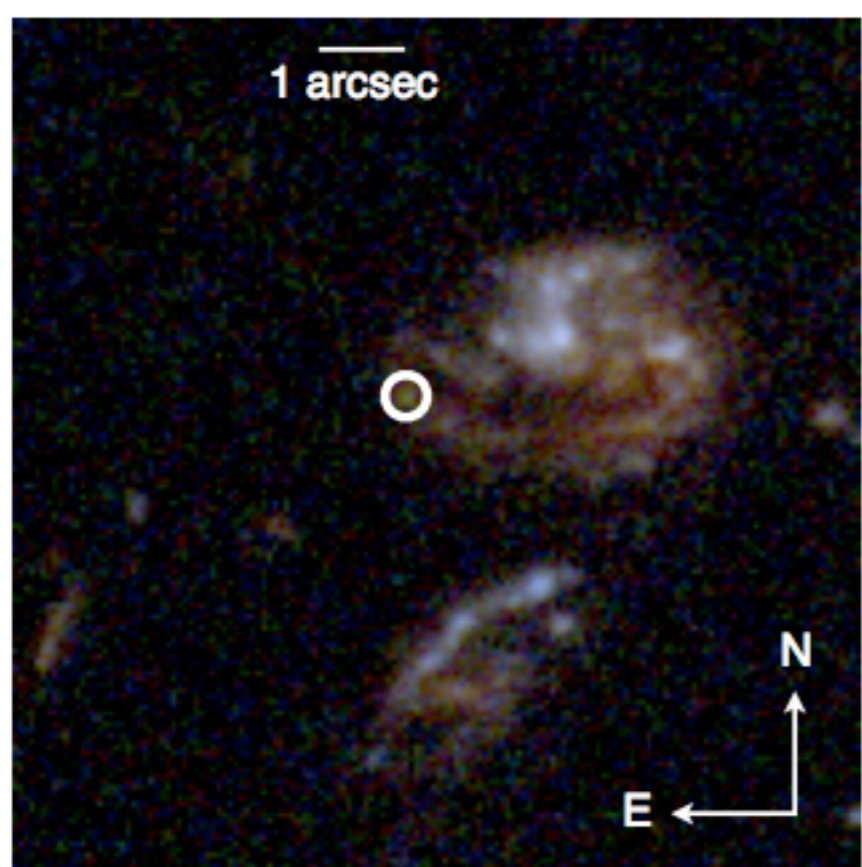
# Expanding and Accelerating Universe



Saurabh Jha are looking at the most distance SN

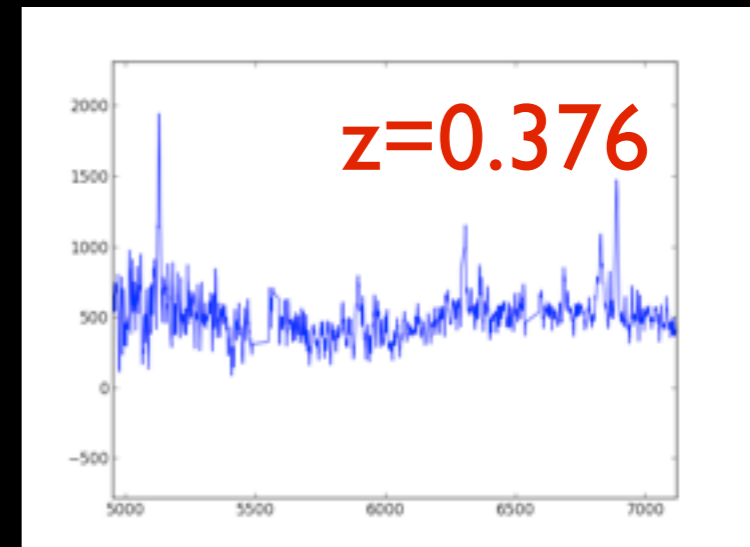
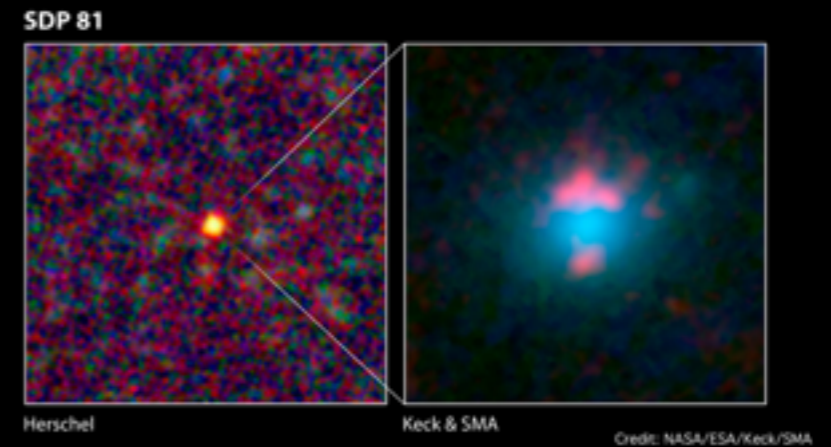
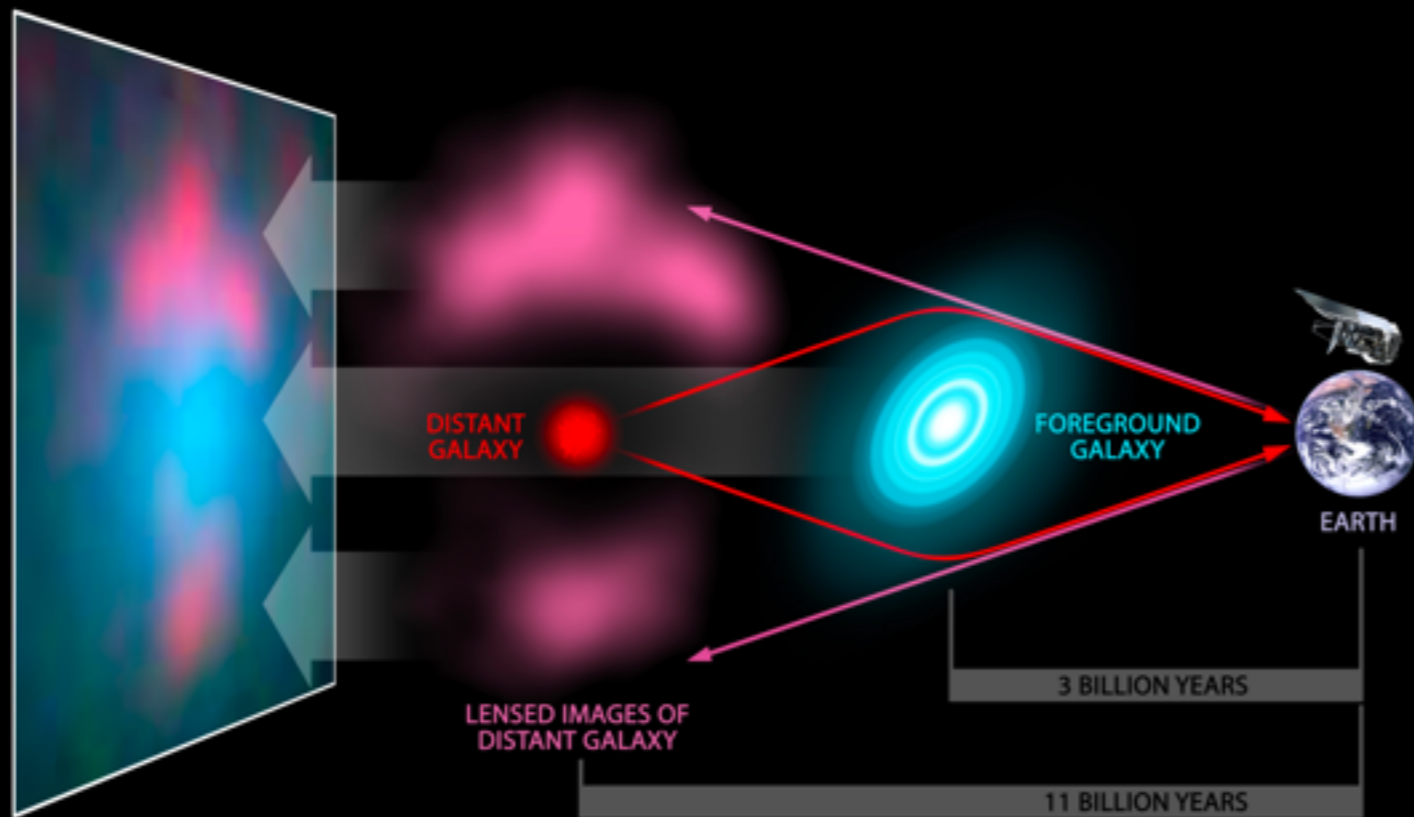
# CLASH Survey

Imaging with the HST to  
discovery the SN and then  
follow-up with SALT and  
other telescopes to measure  
the redshift



# Lensing of Distant Galaxies

Lerothodi Leeuw (UNISA)



# SALT AstronomerScience

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- Paul: Galaxy clusters
- Steve: Galaxy Clusters and Observational Cosmology
- Amanda: Solar system objects
- David: Variable stars
- Darragh: Cataclysmic Variables





Wednesday 21 May 14

# Acknowledgements

- Astronomy Operations: David Buckley, Alexei Kniazev, Encarni Romero-Colmenero , Petri Vaisanen, Christian Hettlage, Paul Kotze, Darragh O'Donoghue
- SALT Technical Operations, and the staff at SAAO in Sutherland and Cape Town.
- Video & Images: Bruno Letarte, Lisa Crause, Janus Brink, Stephen Potter, Anthony Koeslag
- SAAO, NRF, and the SALT Foundation