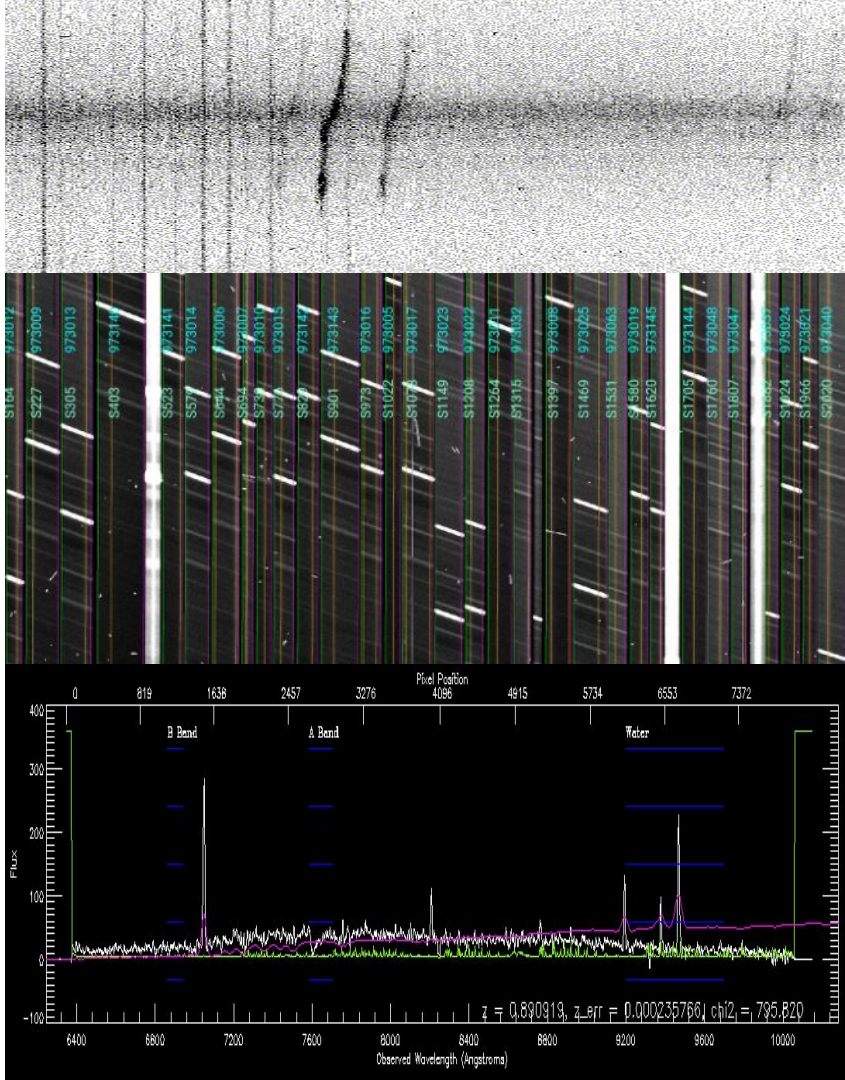
Kinematic Weak Lensing on “Weighing the Giants” Galaxy Clusters



Presenter

Jiyun Di (on behalf of Spectroscopy Team)

Astronomy Group of Prof. Anja von der Linden

Stony Brook University

Friday, March 10, 2023; 11:00

Kinematic Weak Lensing on “Weighing the Giants” Galaxy Clusters

(Photo here)

Spectroscopy Team is advised by **Prof. Anja von der Linden**.

Group Members

Jiyun Di Joined in Sep 2022, 1st-year MA student

Alden Beck Joined in Nov 2022, 4th-year undergrad student; Double-major in Astronomy and Physics

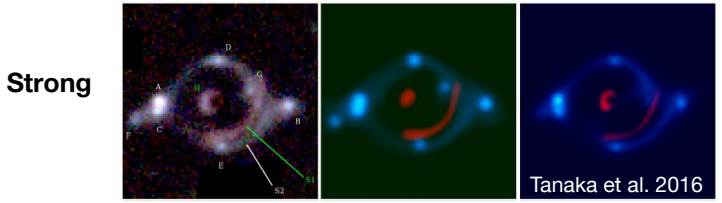
Aaron Burke Joined in Jan 2023, 4th-year undergrad student; Double-major in Mathematics and Physics

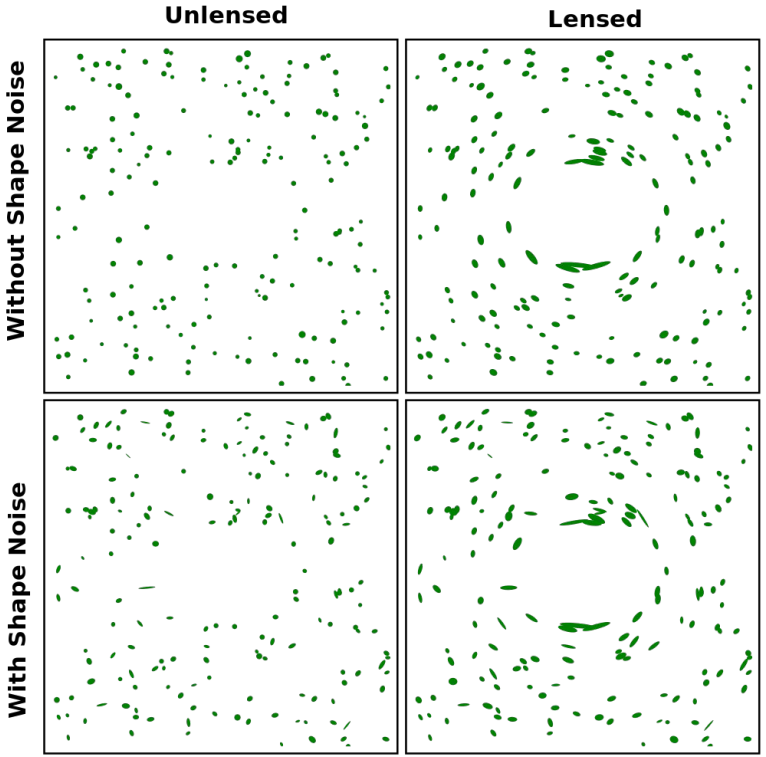
Kinematic Weak Lensing on “Weighing the Giants” Galaxy Clusters

Weak lensing = result of weakly distorted galaxies (vs. strong lensing: >1, very deflected images for one galaxy source)

Kinematic WL = a new method for reducing shape noise (relying on spectroscopy, needs disk galaxy rotation and Tully-Fisher relation; goal: intrinsic orientations of galaxy disks)

Big issue: We don’t know if **a elliptical galaxy is being lensed** or **if it is just naturally elliptical.**





Credits: WikiPedia/TallJimbo

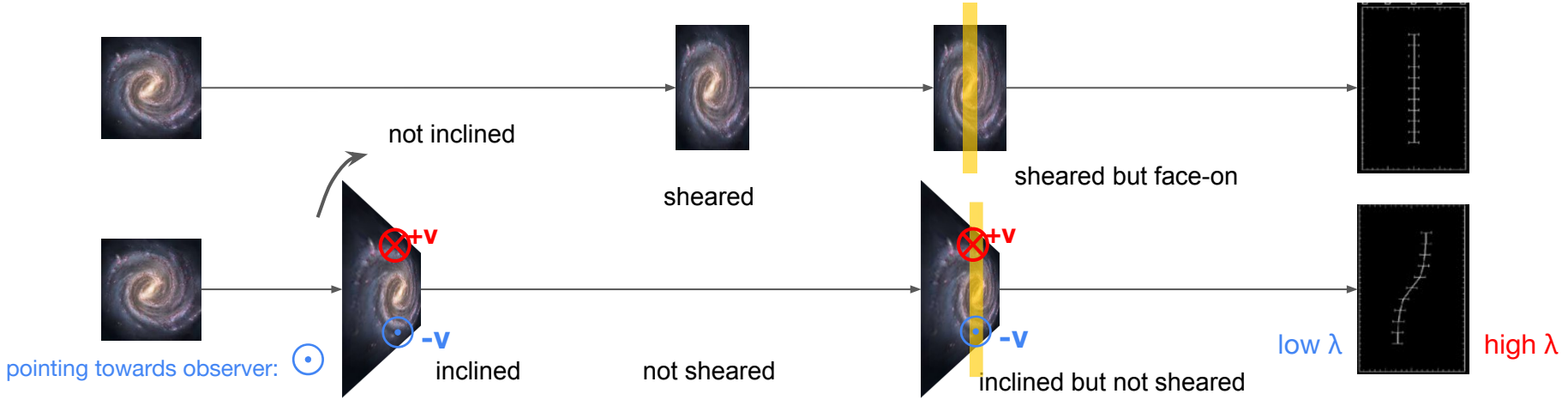
Solve for: Is an elliptical galaxy being lensed or just naturally elliptical?

Rotation Curves

The orientation of the lensed galaxy can be determined from the rotation curve.

- A face-on galaxy ⟷ expect to see no rotation
- An **inclined** galaxy ⟷ expect to see **a rotation curve**:
  - One side of the galaxy should be redshifted (λ↑), the other blueshifted (λ↓)
  - An extreme case: an edge-on ⟷ a straight slope line

If we see a galaxy is elliptical but does not have a rotation curve, we know that **it has been lensed**.



"Flowchart" of This Project

…

For each galaxy cluster

…other ~50 galaxy clusters

✓ Spectra Data from Observatory Archives
(e.g. Keck/DEIMOS, VLT-UT3/VIMOS)

✓ Raw spec `fits` data

`PypeIt`

Wavelength calibrated, coadded spectra on CCD

A new feature contributing to `PypeIt`:
`pypeit_to_specpro`
By Alden

~100 1D+2D spec combos sliced from `PypeIt`'s output (one spec by one galaxy)

`SpecPro`

Velocity curves of emission lines

TBD

Galaxy's intrinsic morphology
(True inclination angle, without thinking of gravitational lensing distortion)

...

`SpecPro`

Redshift Catalog of targeted galaxies

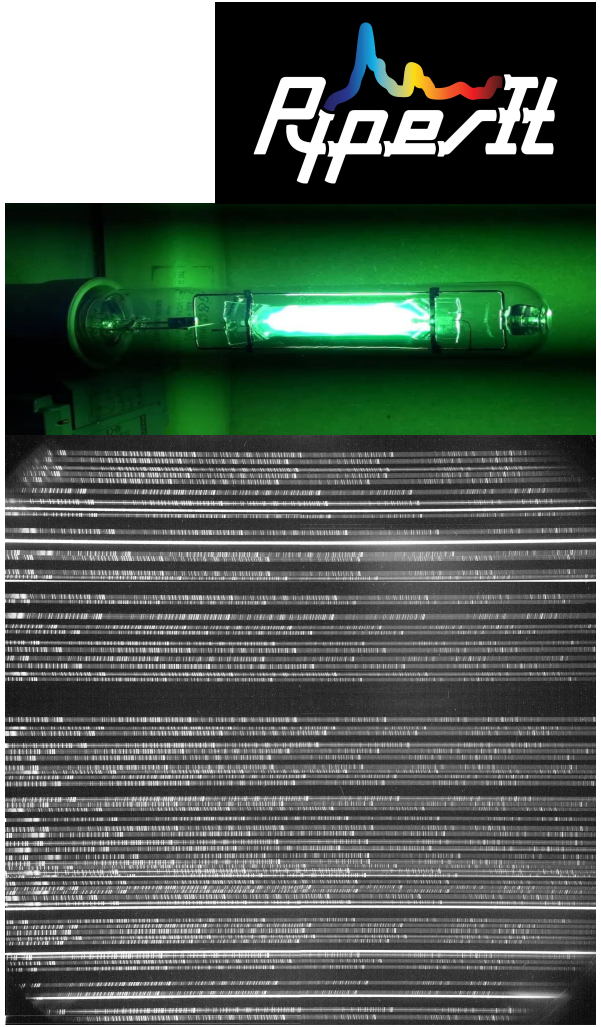
Provide samples to modeling lensing

PypeIt

One of *the latest Python-based reduction of the popular multi-object spectrograph instruments*

PypeIt runs the wavelength calibration using arc lamp images, tilts, and flats:

1. Arc: Given wavelengths of arc-lamps at rest frame, finds the wavelength for each pixel in the science image.



A raw CCD arc image of Cluster A2261.
Each horizontal strip is a spectrum passed through a slit on designed mask.

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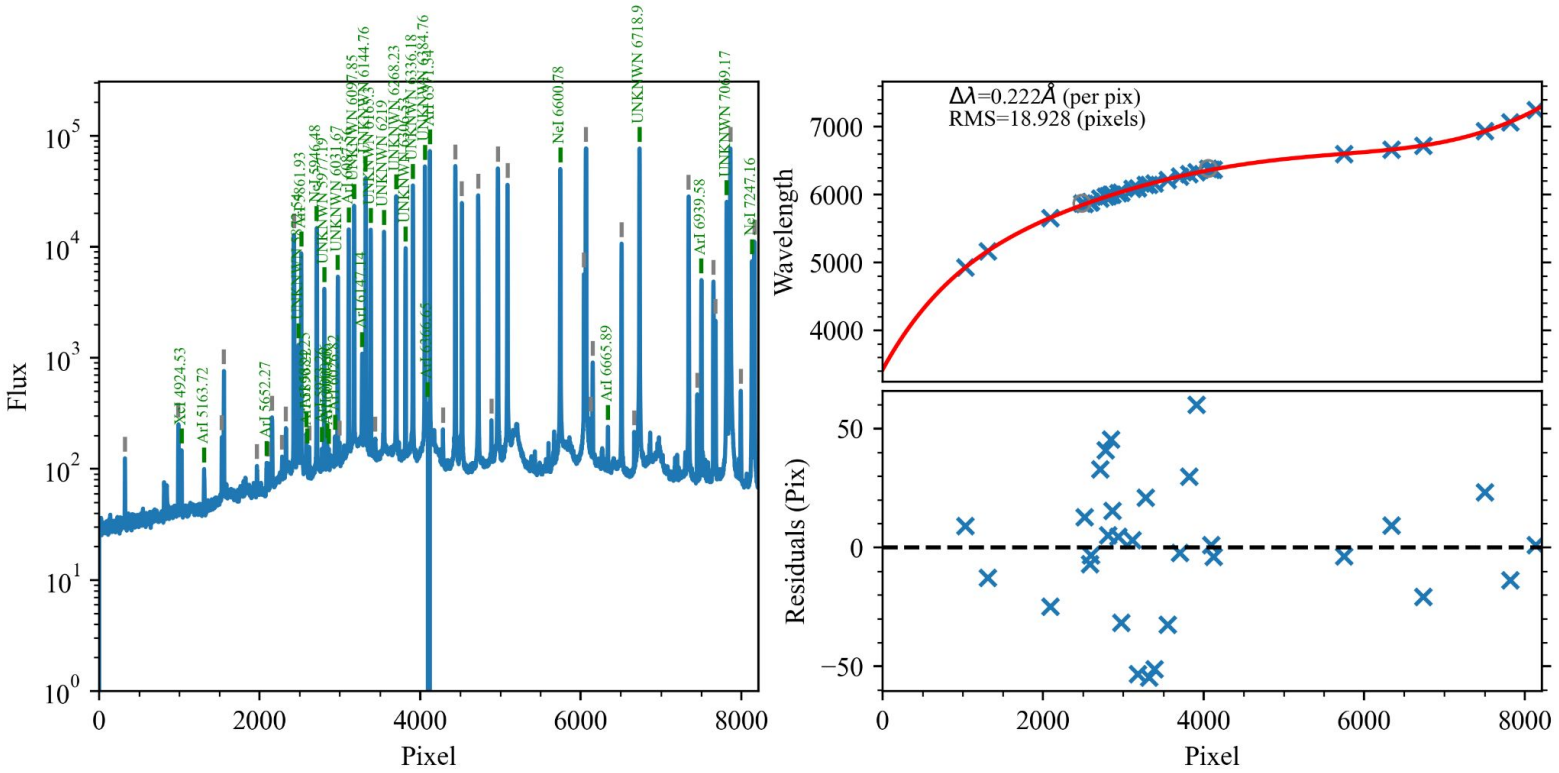

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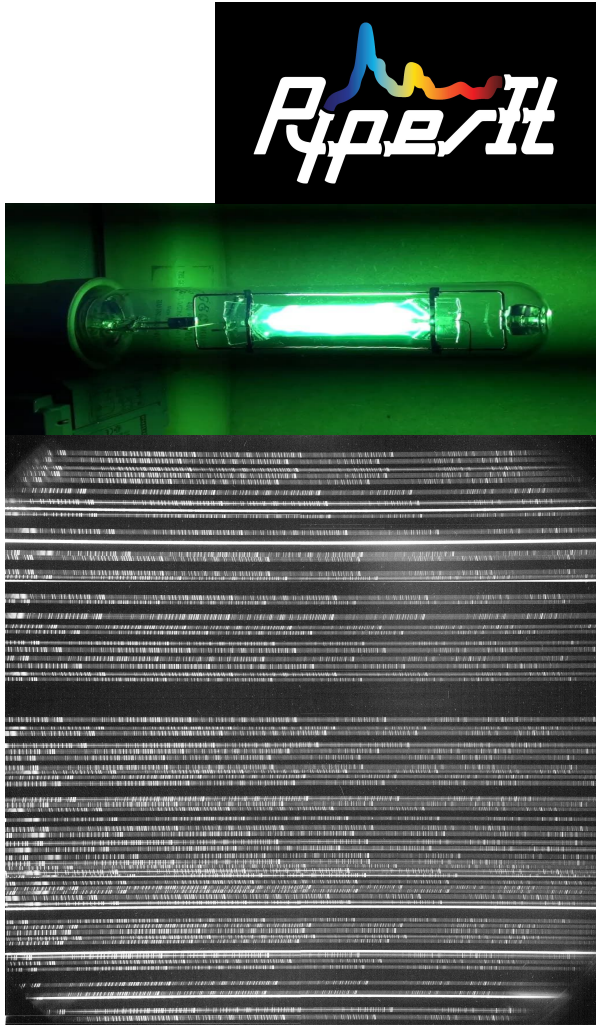
1. Arc: Given wavelengths of arc-lamps at rest frame, finds the wavelength for each pixel in the science image.
2. Tilts: Off-focal position on CCD may result non-vertical spread of light.
3. Flats: other corrections on classical imaging problems.
4. Slit-marking: identify which slit corresponds to which row on image, what galaxy we targeted, and what position coordinates they are.



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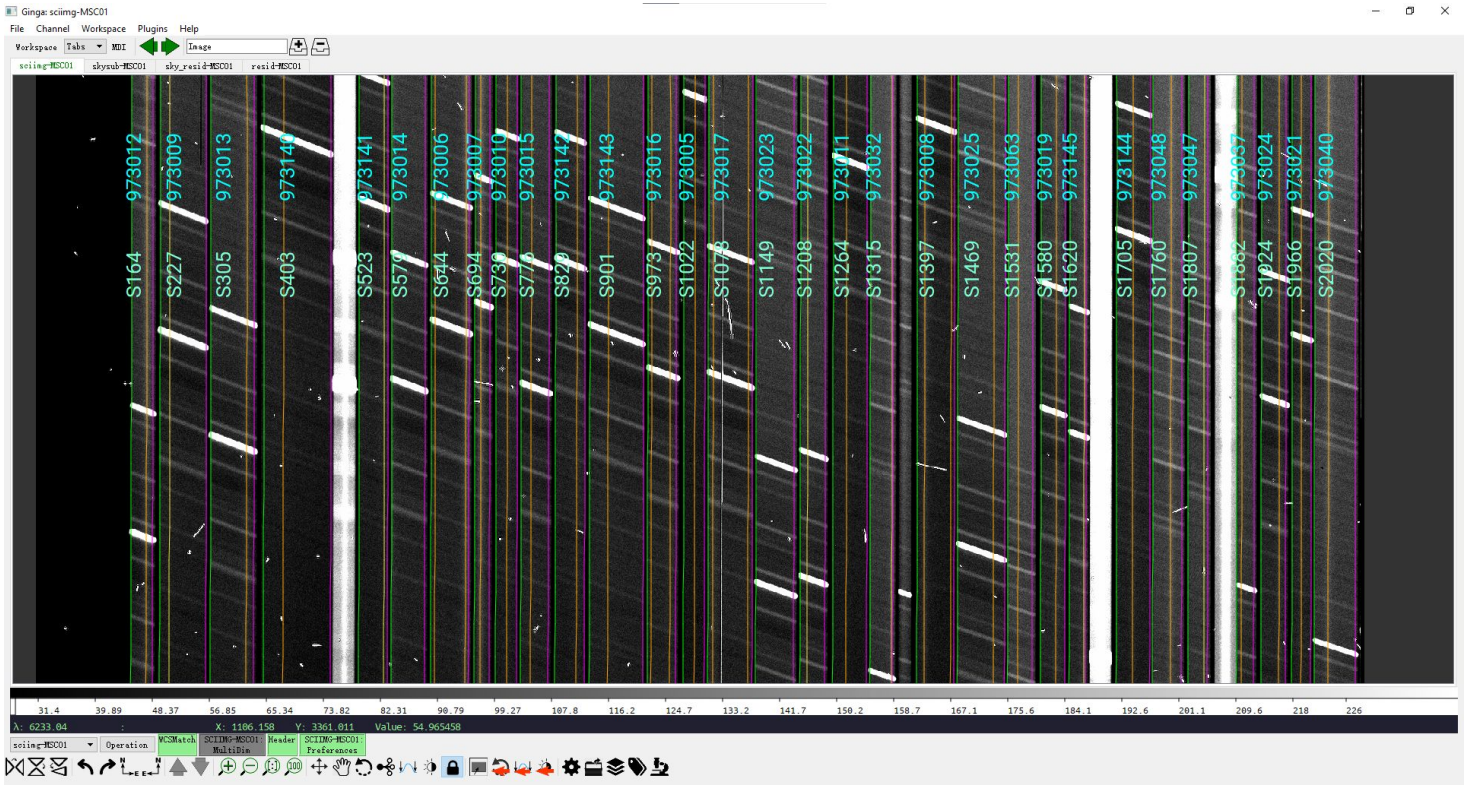

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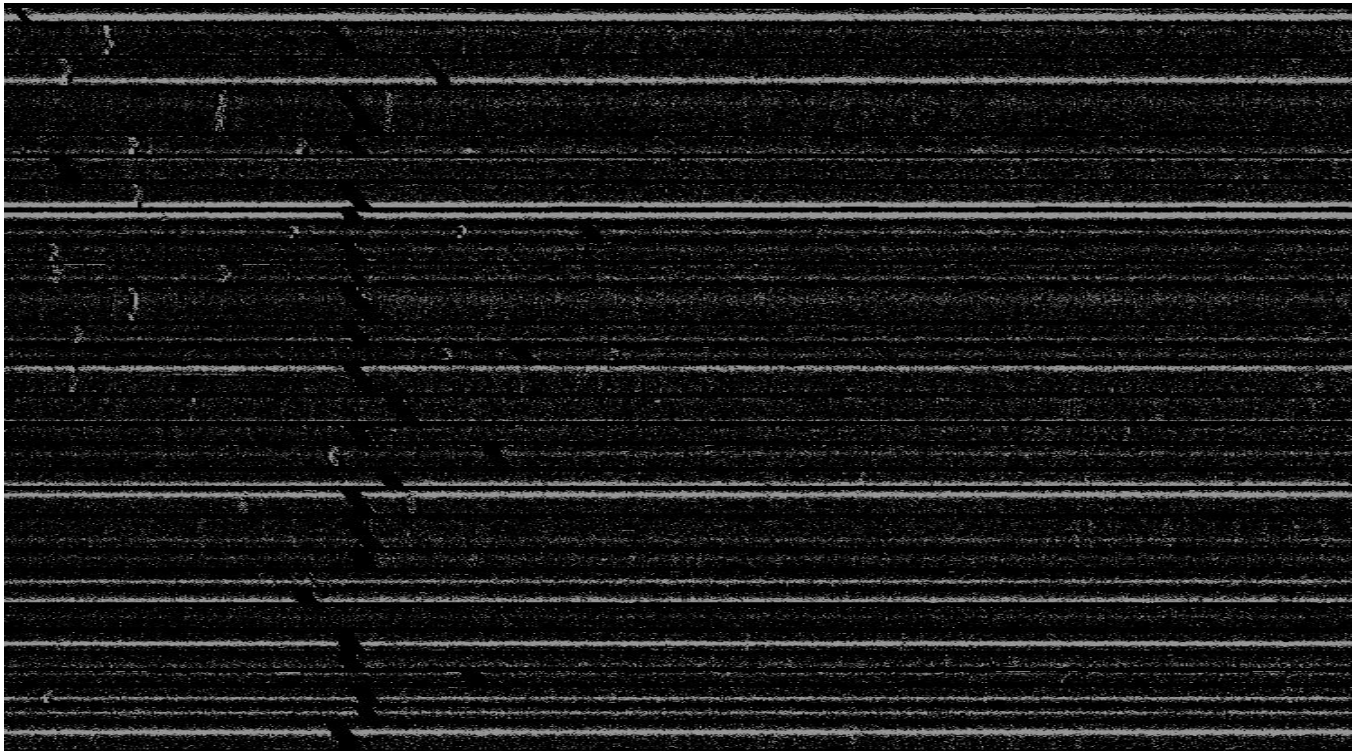

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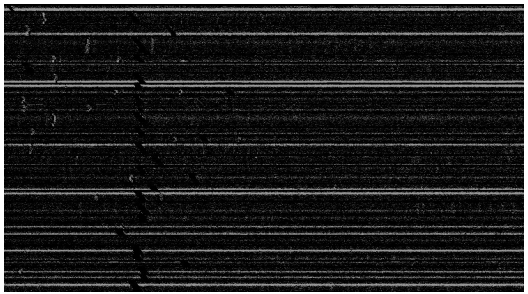
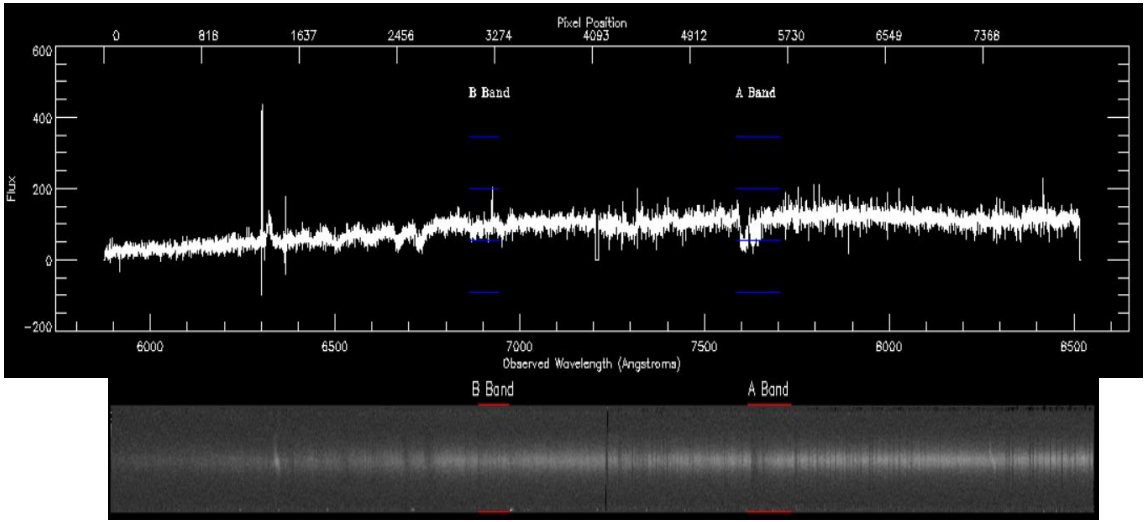
Our original pipeline for slit-cutting to one 1D+2D combo per slit and converting `PypeIt` outputs to IDL `SpecPro` acceptable spec files





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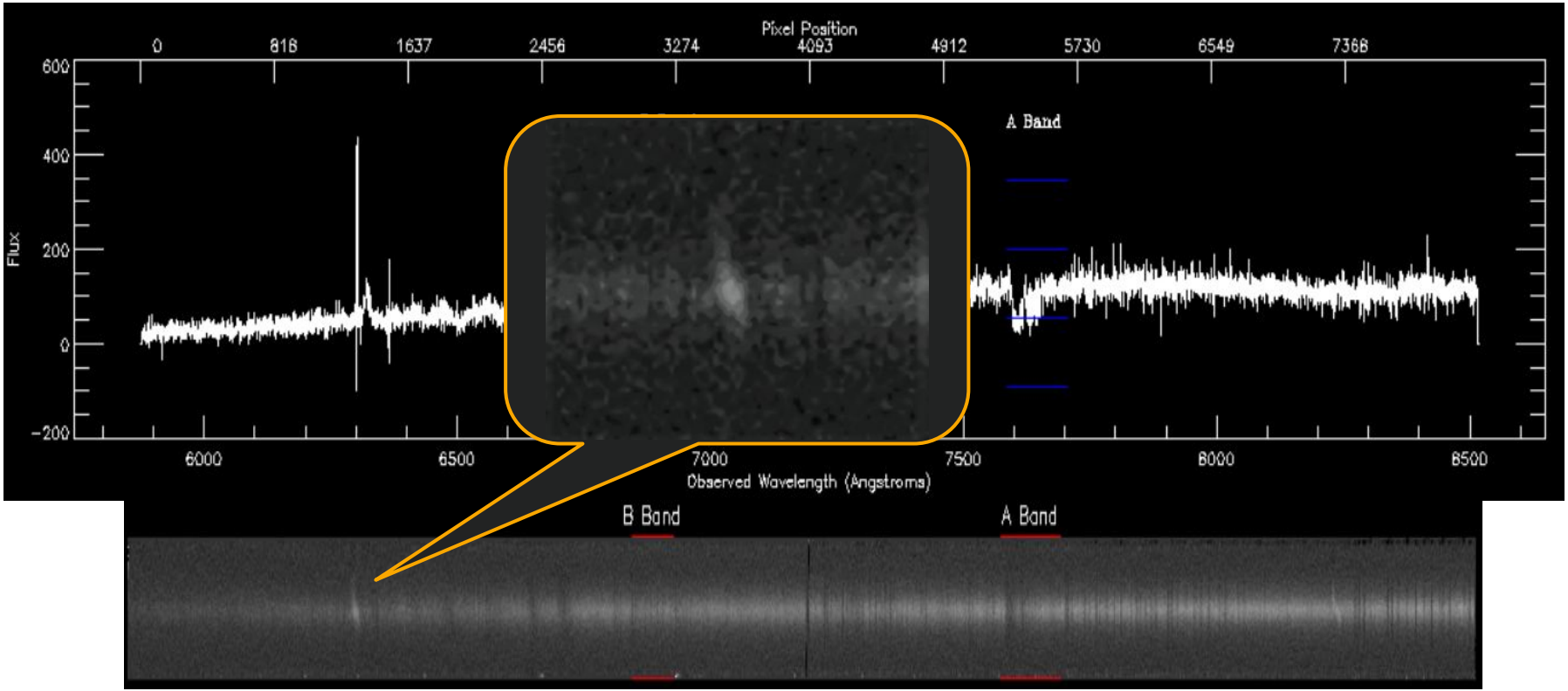

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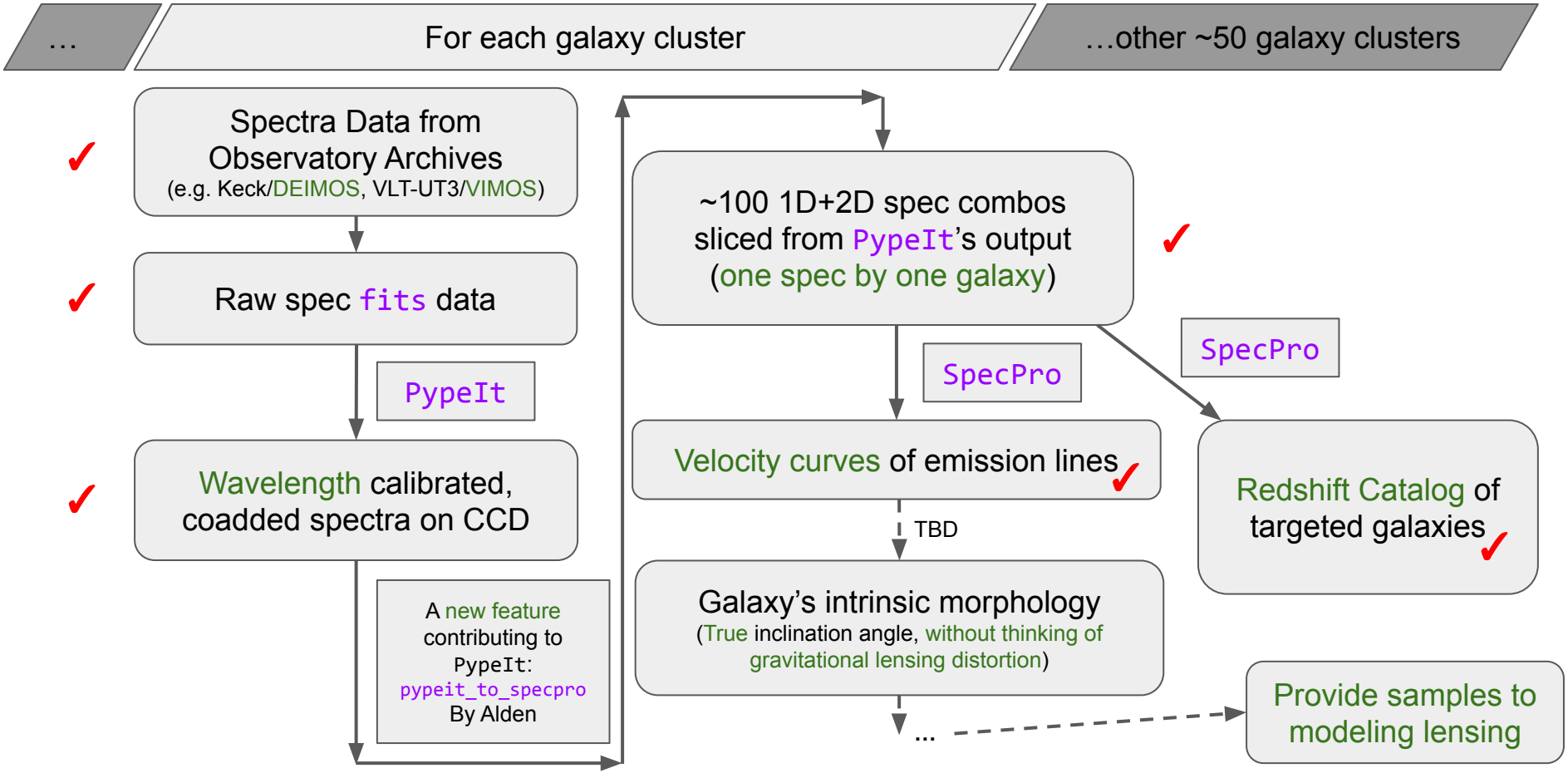

Summary

- Apply the kinematic weak lensing method on the galaxies targeted in the “Weighing the Giants” (von der Linden et al. 2014) project.
- Get the intrinsic shapes of the galaxy before the cluster shear.
- By using a combination of minimally-resolved disk galaxy kinematics and the Tully-Fisher scaling relation, **a spectroscopic weak lensing experiment has the potential to greatly improve on the statistical and systematic errors** of conventional lensing measurements. (Huff et al. 2013)