

GALANTE: finding all the Galactic O+B+WR stars in the northern hemisphere... and more

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Talk structure

I. Motivation.

- ★ Spectroscopic surveys of OB stars: GOSSS and WEAVE.
- ★ Photometric surveys of the Galactic Plane: EGAPS and Gaia.

2. GALANTE.

- ★ Project description.
- ★ Future plans.

3. Dealing with the enemy.

- ★ Extinction laws.
- ★ GALANTE and extinction.

GOSSS description

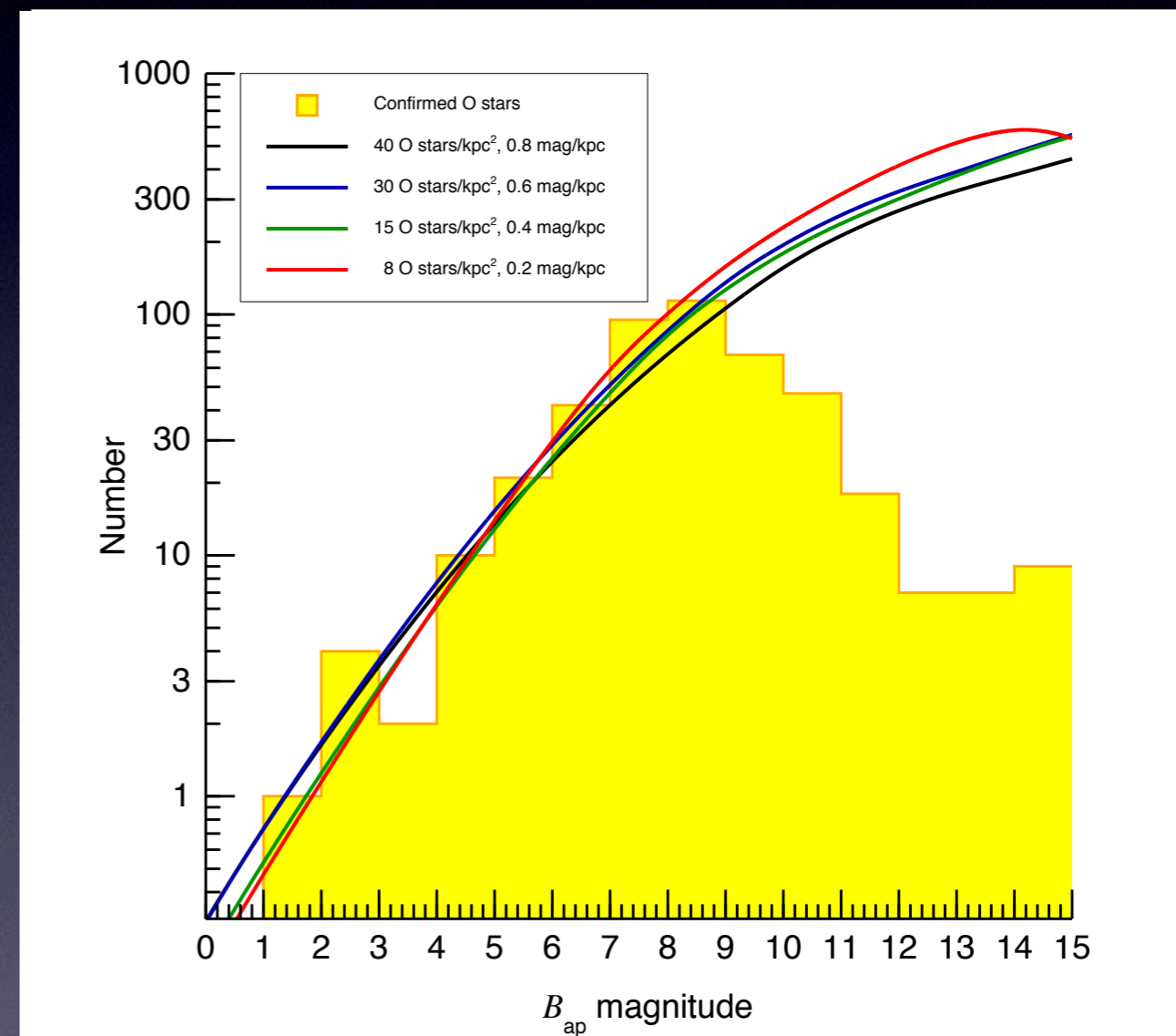
- Long-slit spectroscopy of OB stars with $R \sim 2500$ and $S/N > 200$ in 3900-5100 Å.
- Initial selection from the Galactic O-Star Catalog (GOSC).
- Telescopes and spectrographs:
 - ★ OSN 1.5 m (Albireo): $\delta > -20^\circ$, $B < 11$
 - ★ LT 2.0 m (FRODOspec): $\delta > -35^\circ$, $B < 11$
 - ★ CAHA 3.5 m (TWIN): $\delta > -20^\circ$, $11 < B < 14$
 - ★ WHT 4.2 m (ISIS): $\delta > -35^\circ$, $11 < B < 14$
 - ★ GTC 11.4 m (OSIRIS): $\delta > -30^\circ$, $14 < B < 17$
 - ★ OPD 1.6 m (B&C): $\delta < +40^\circ$, $B < 11$
 - ★ LCO 2.5 m (B&C): $\delta < +20^\circ$, $B < 13$
 - ★ SOAR 4.1 m (GHST): $\delta < +20^\circ$, $13 < B < 15$
 - ★ Gemini South 8.1 m (GMOS): $\delta < +20^\circ$, $13 < B < 16$
- 2230 stars (3723 spectra) processed (+ ~500 unproc.), compl. for $B < 8$.
- 590 O type-systems in three major papers (I:2011, II:2014, III:2016).

WEAVE: the instrument

- Double-arm optical Multi-Object Spectrograph for the 4.2 m WHT.
- ~950 fibers (+20 mIFUs and 1 LIFU).
- 2 degrees diameter FOV.
- Low resolution mode ($R \sim 5000$): 3700 - 10 000 Å.
- High resolution ($R \sim 20\,000$).
- Survey-oriented.

WEAVE: Galactic Plane Stellar, Circumstellar, and Interstellar Physics

- OBA-stars-centered survey with $\sim 10\%$ of WEAVE survey time.
- Also ISM in emission, Cepheids, evolved low-mass stars, and other young stars.
- $R \sim 5000$, whole optical range.
- Galactic Plane with longitudes from 20 deg. to 225 deg.
- 1200 sq. deg.
- $2-3 \cdot 10^5$ targets: selection?

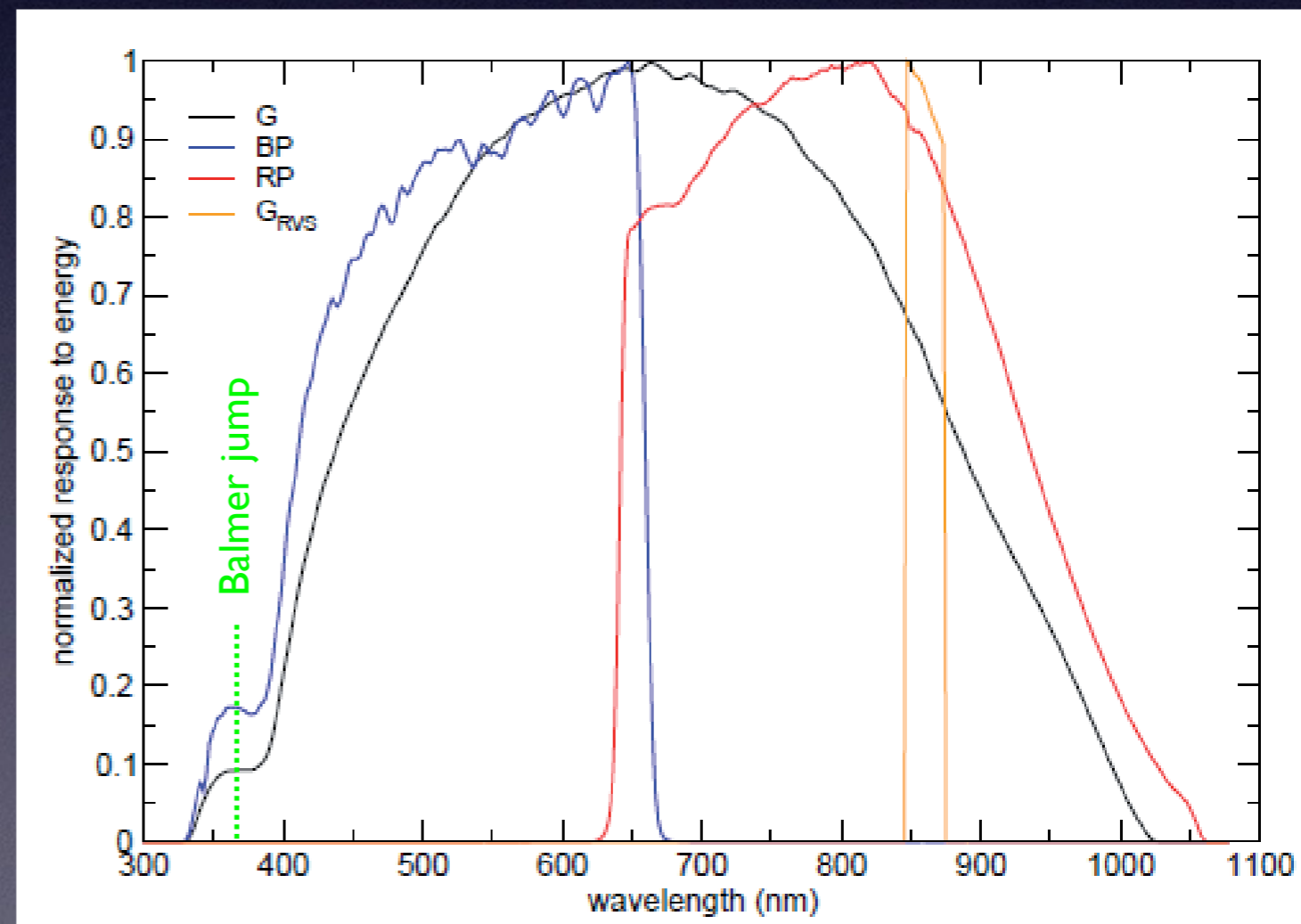


EGAPS

- Galactic Plane: IPHAS + UVEX + VPHAS+.
- $u' + g' + r' + i' + H\alpha + (\text{He I } 5876)$.
- $360^\circ \times 10^\circ$ started in 2003 (N) 2011 (S), continuing.
- 13-21 magnitudes, FOV 0.3 (N) 1.0 (S) sq. dg.
- Issues:
 - ★ Saturation.
 - ★ Calibration (FOV, gaps, u' band).

Gaia

- Whole sky.
- (Spectro)photometry from 3 instruments:
 - ★ Astrometric (G).
 - ★ RVS (RVS).
 - ★ Photometric (BP+RP).
- Issues:
 - ★ BP and the Balmer jump.
 - ★ Crowding.
 - ★ Nebular contamination.



Why GALANTE?

- Some problems with photometric surveys for OB stars:
 - ★ Saturation.
 - ★ Filter selection.
 - ★ Footprint.
 - ★ Field of view and old instrumentation.
 - ★ Long-term instrument stability and repeatability.

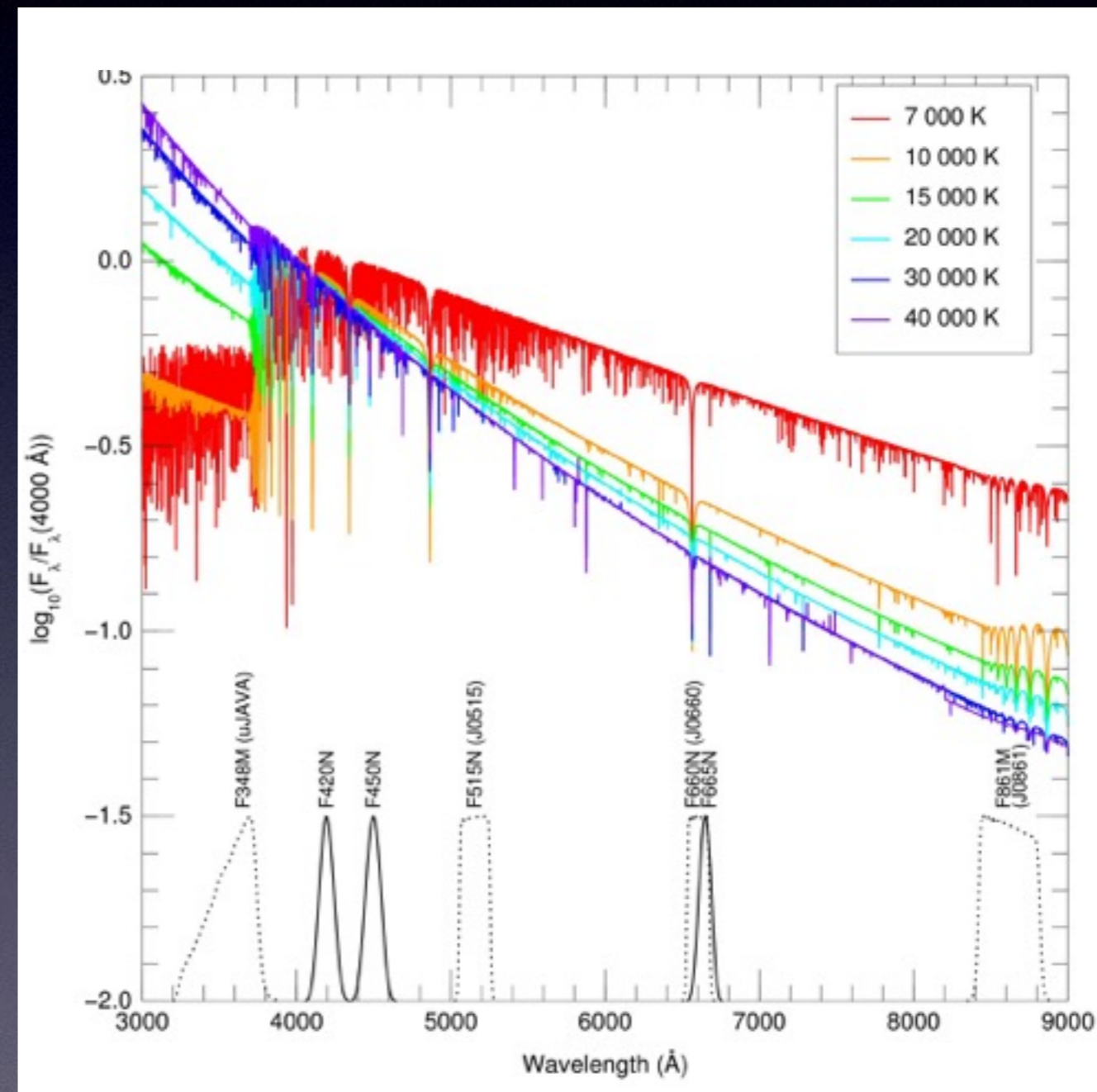
Javalambre: observatory and projects

- New observatory in Teruel, Spain.
- CEFCO: Centro de Estudios de Física del Cosmos de Aragón.
- Two telescopes: T250 and T80.
- Exclusive for wide-field optical imaging surveys.
- T80:
 - ★ 1.4 deg x 1.4 deg without gaps.
 - ★ 9216x9232 px, 0.55"/px.
 - ★ In operation.
 - ★ Low read-out noise, up to 0.1" exposures.

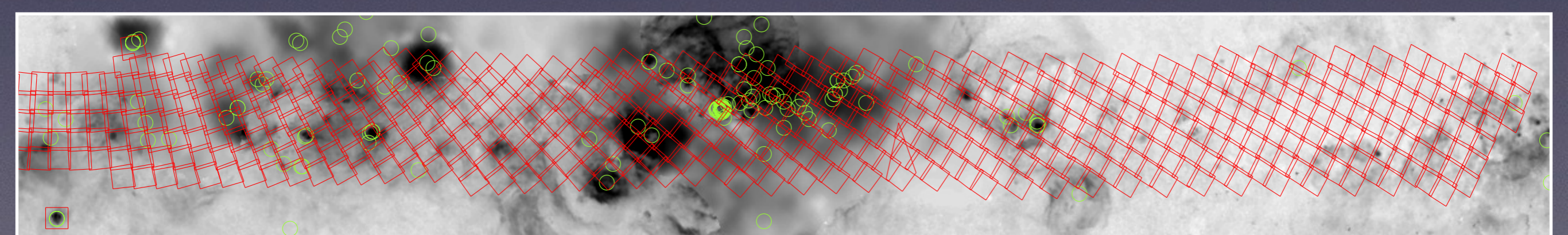
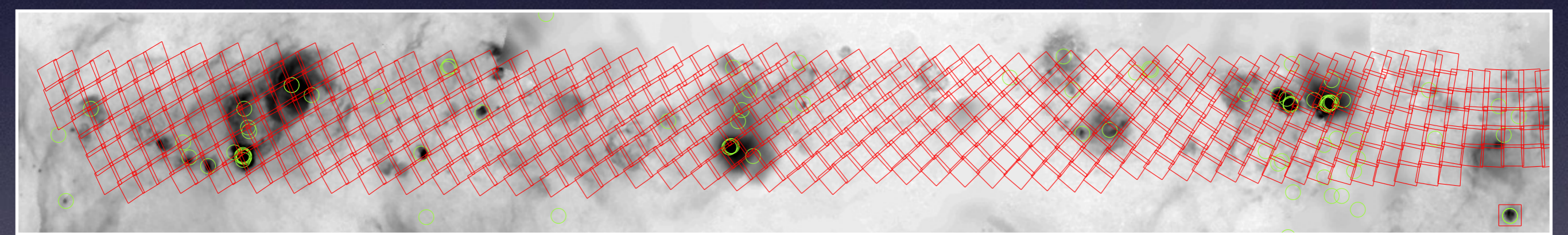
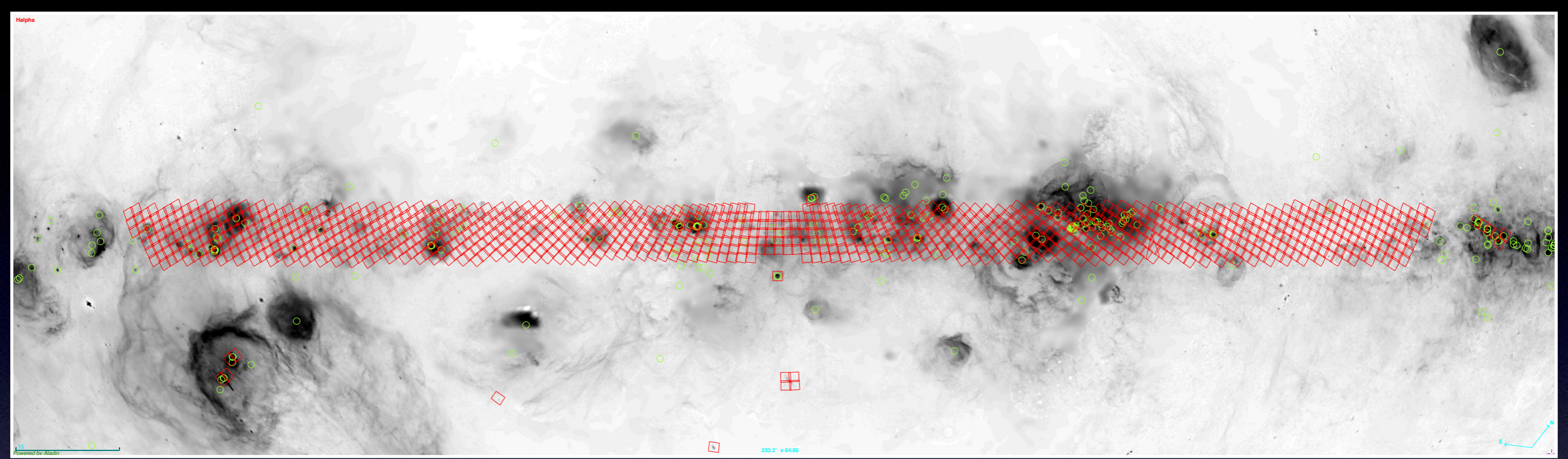


The GALANTE survey

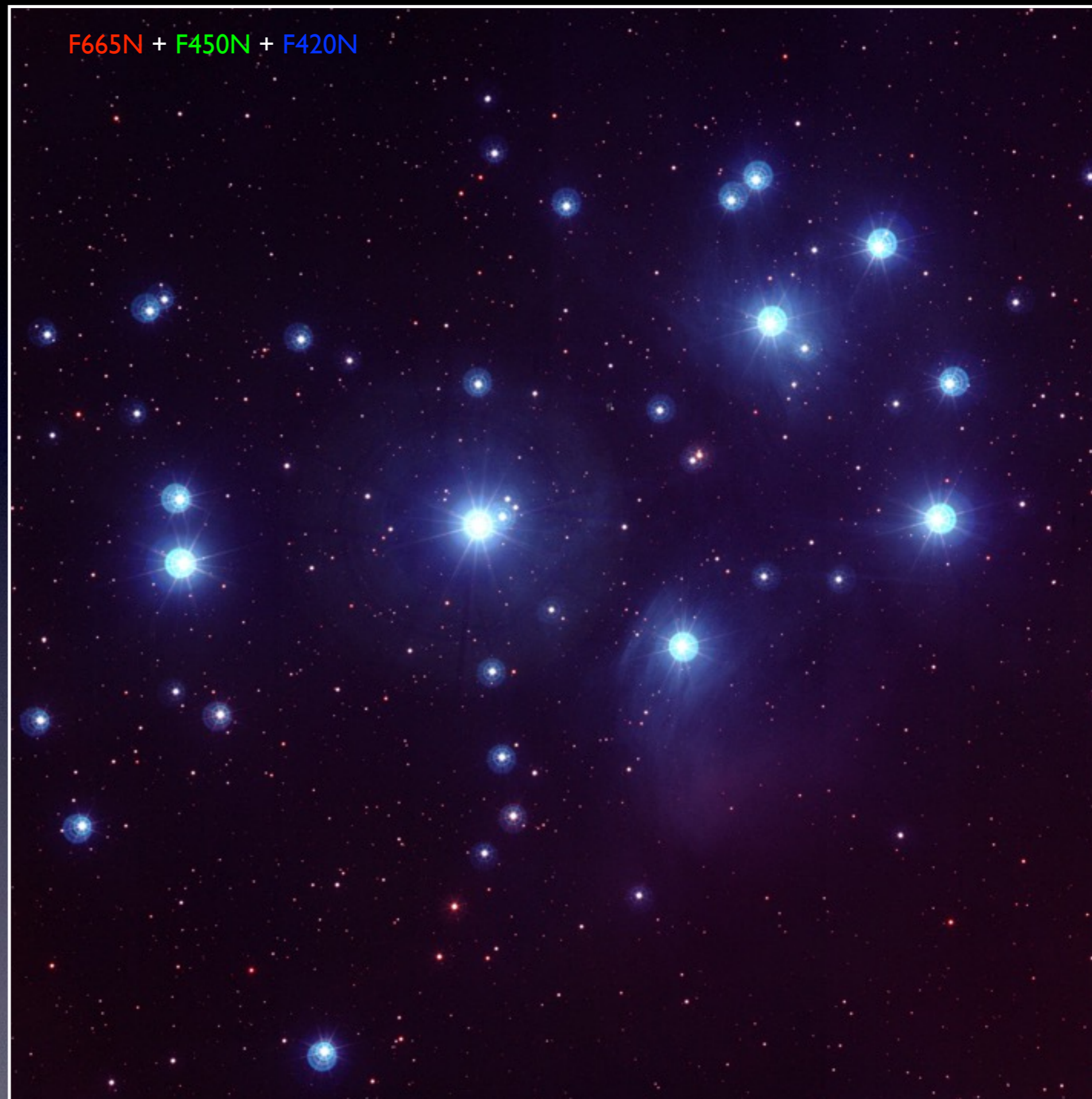
- Northern Galactic Plane.
- ~3 nights/month in the T80.
- Exp. times from 0.1 to 50/100 s.
 - ★ Saturation at mag ~3 (PSF to ~0).
 - ★ S/N ~100 at mag 17 (det. to ~19).
- Seven filters:
 - ★ F348M + F420N + F450N.
 - ★ F515N + F861M.
 - ★ F660N + F665N.



GALANTE footprint



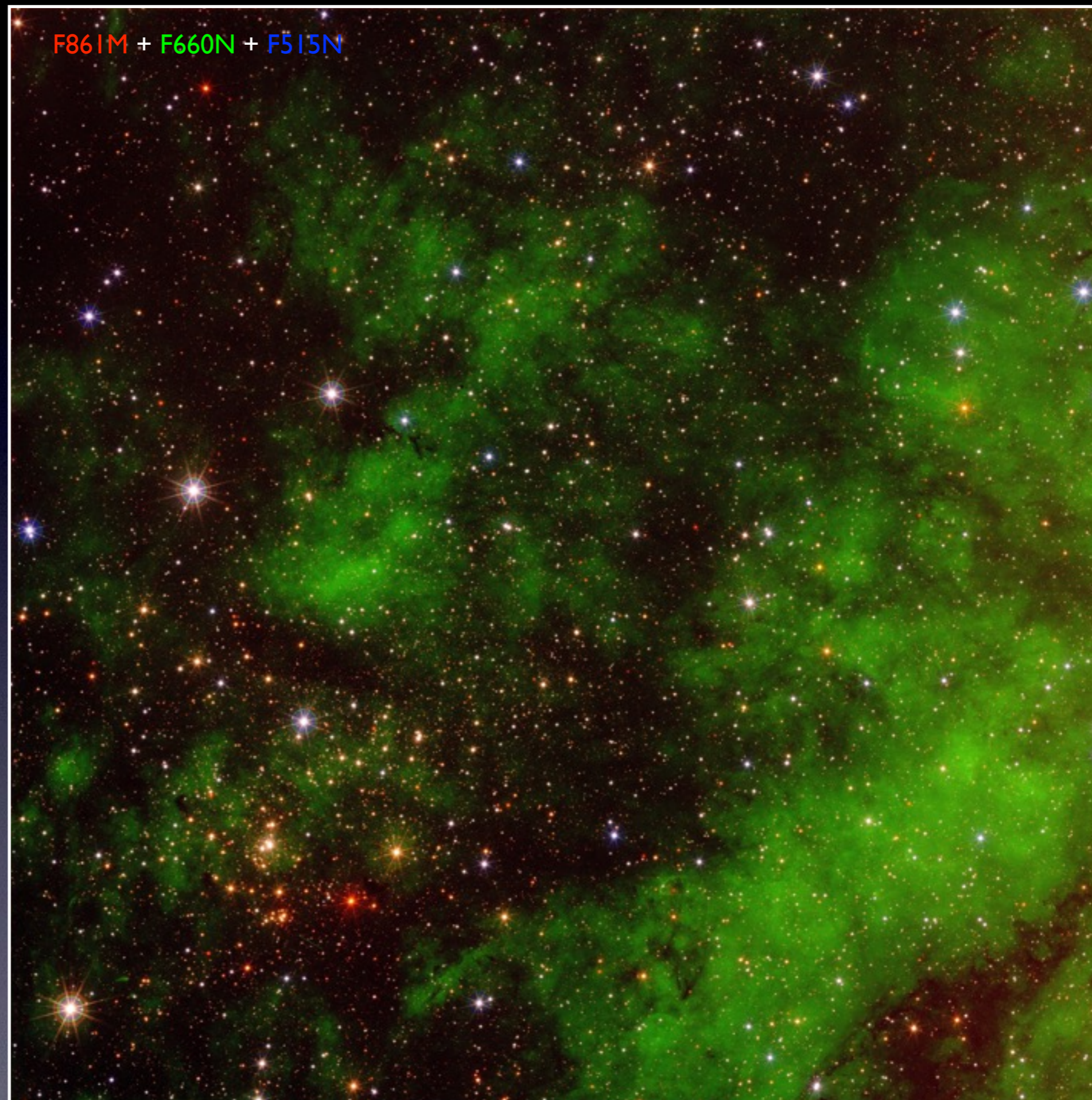
GALANTE T80 images



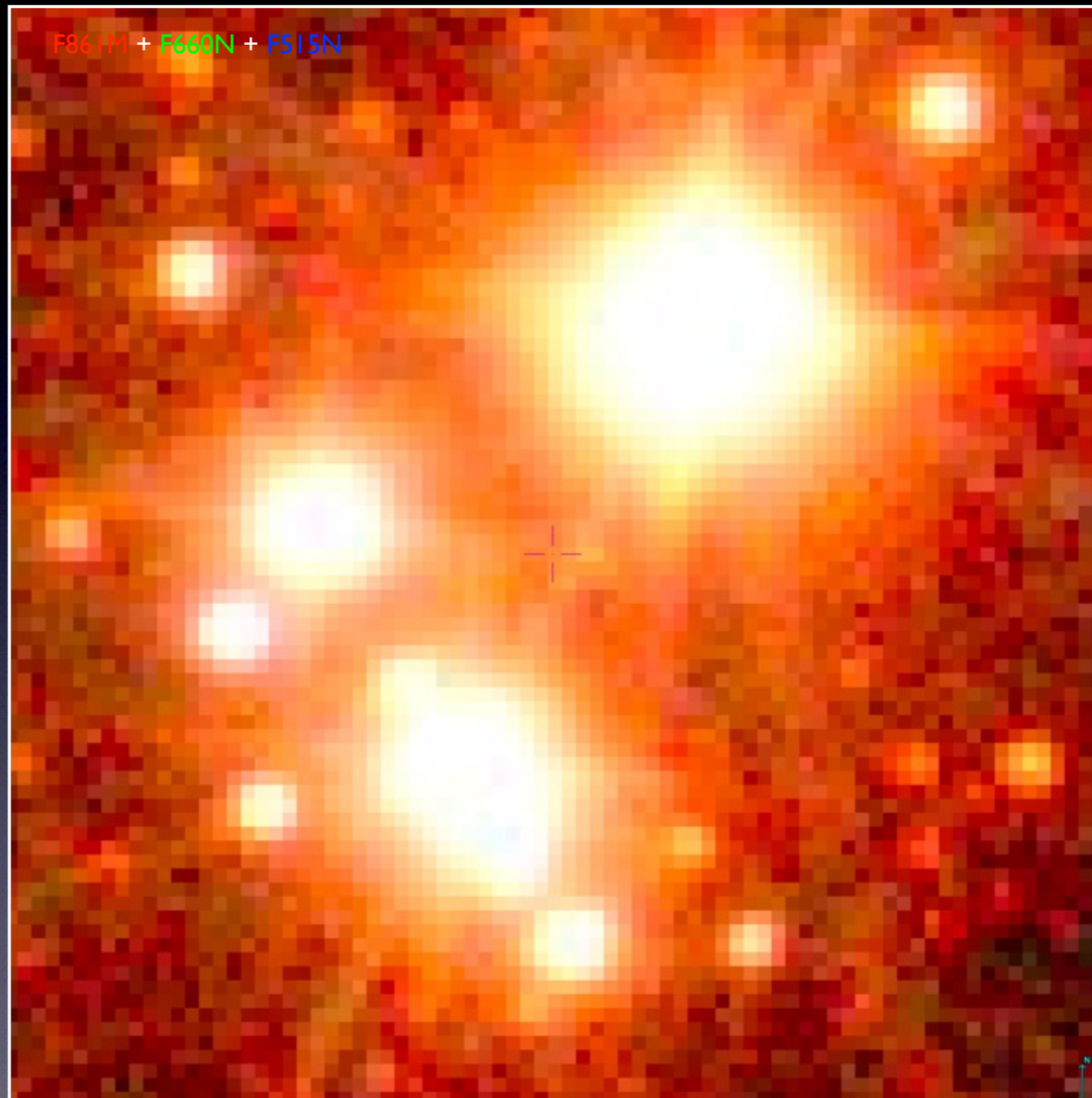
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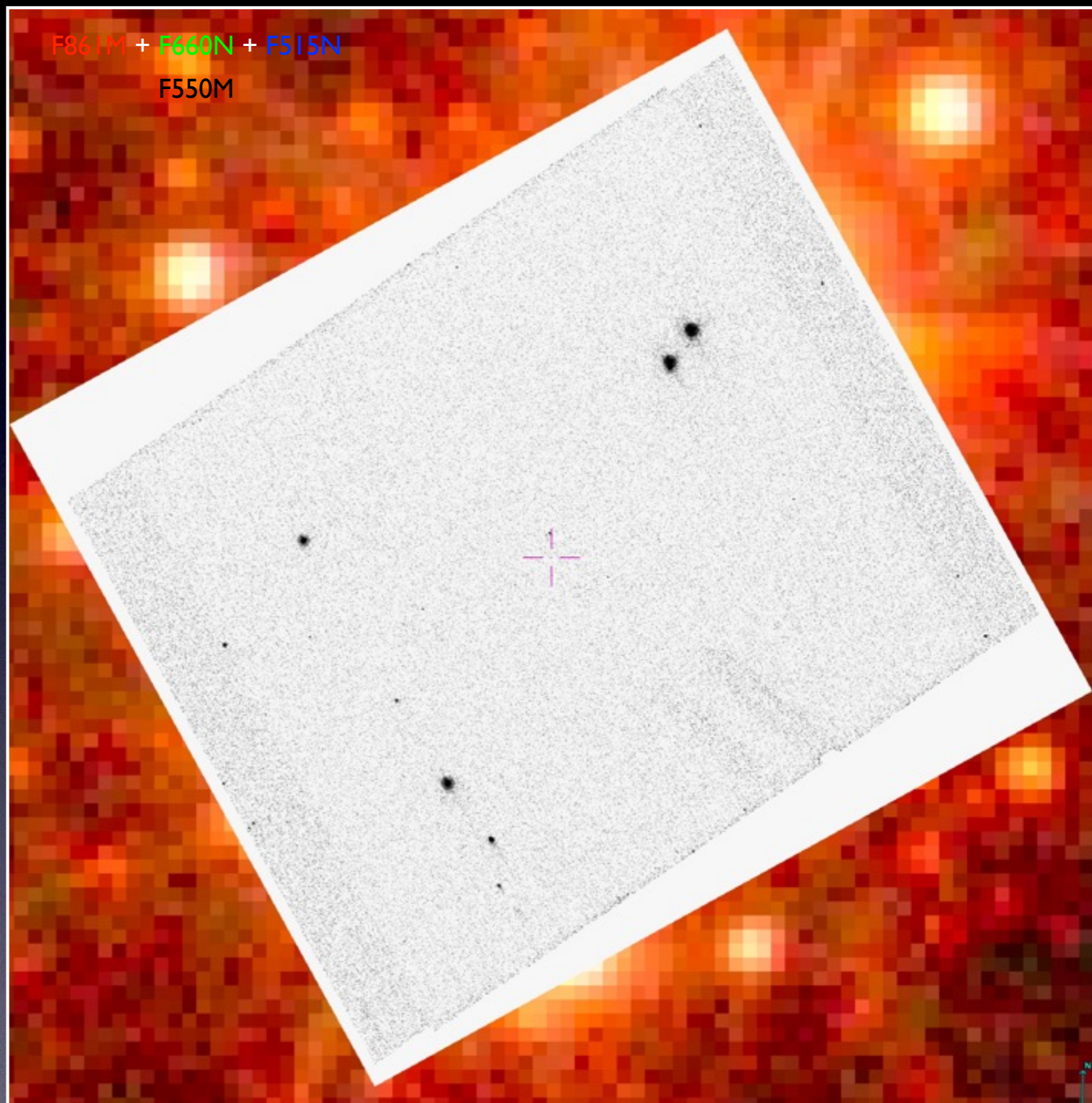
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ACS/HRC

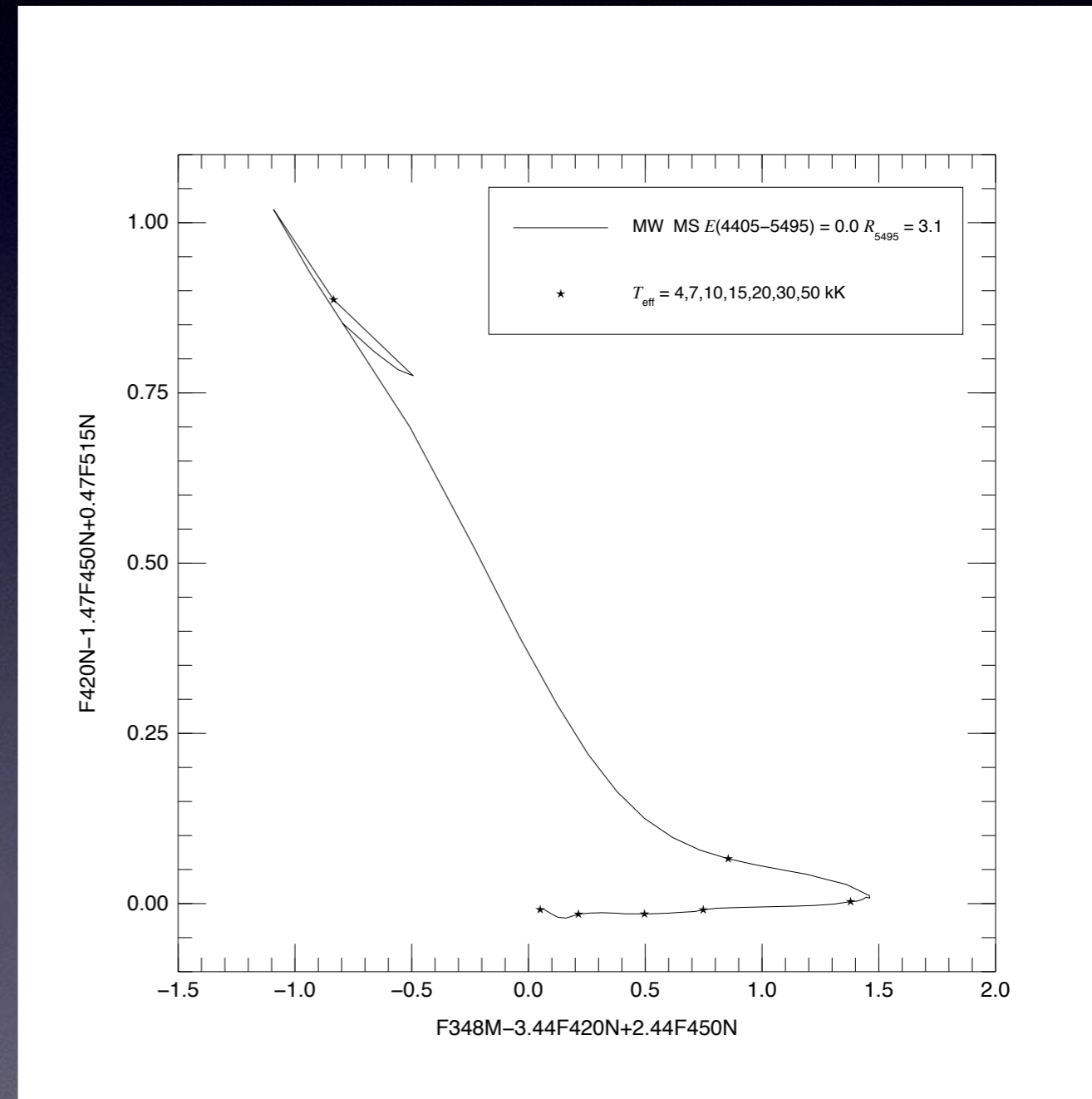


GALANTE calibration

- Large field of view allows for different options:
 - ★ Traditional: standards outside the field plus atmospheric extinction measurements (long exposures at two air masses).
 - ★ Spectrophotometric standards inside the field: 10% of fields have at least one.
 - ★ Tycho-2 + 2MASS + (Gaia G/BP/RP): ~200 stars/field.
 - ★ EGAPS.

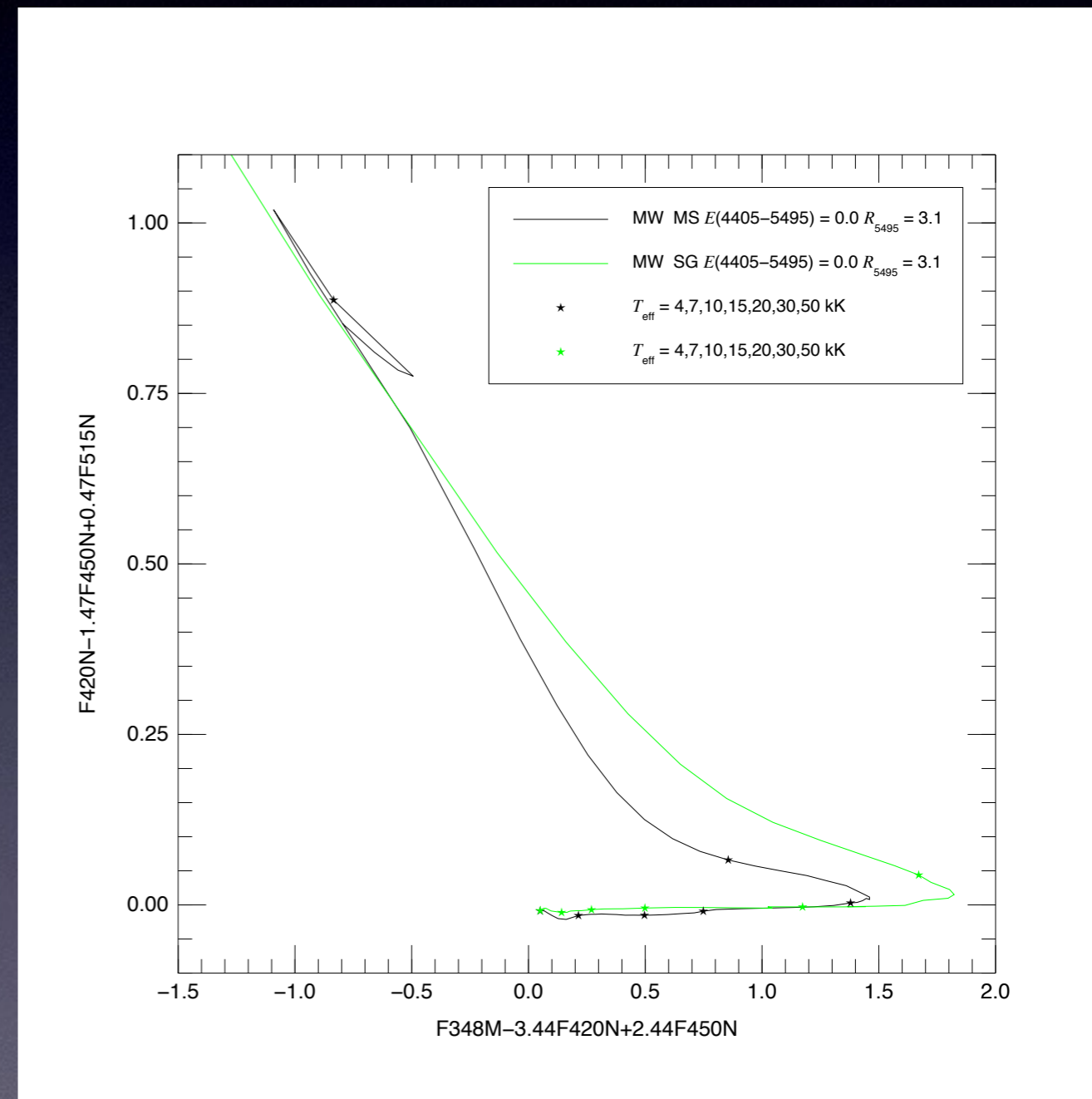
Measuring temperature

- Northern Galactic Plane.
- ~3 nights/month in the T80.
- Exp. times from 0.1 to 50/100 s.
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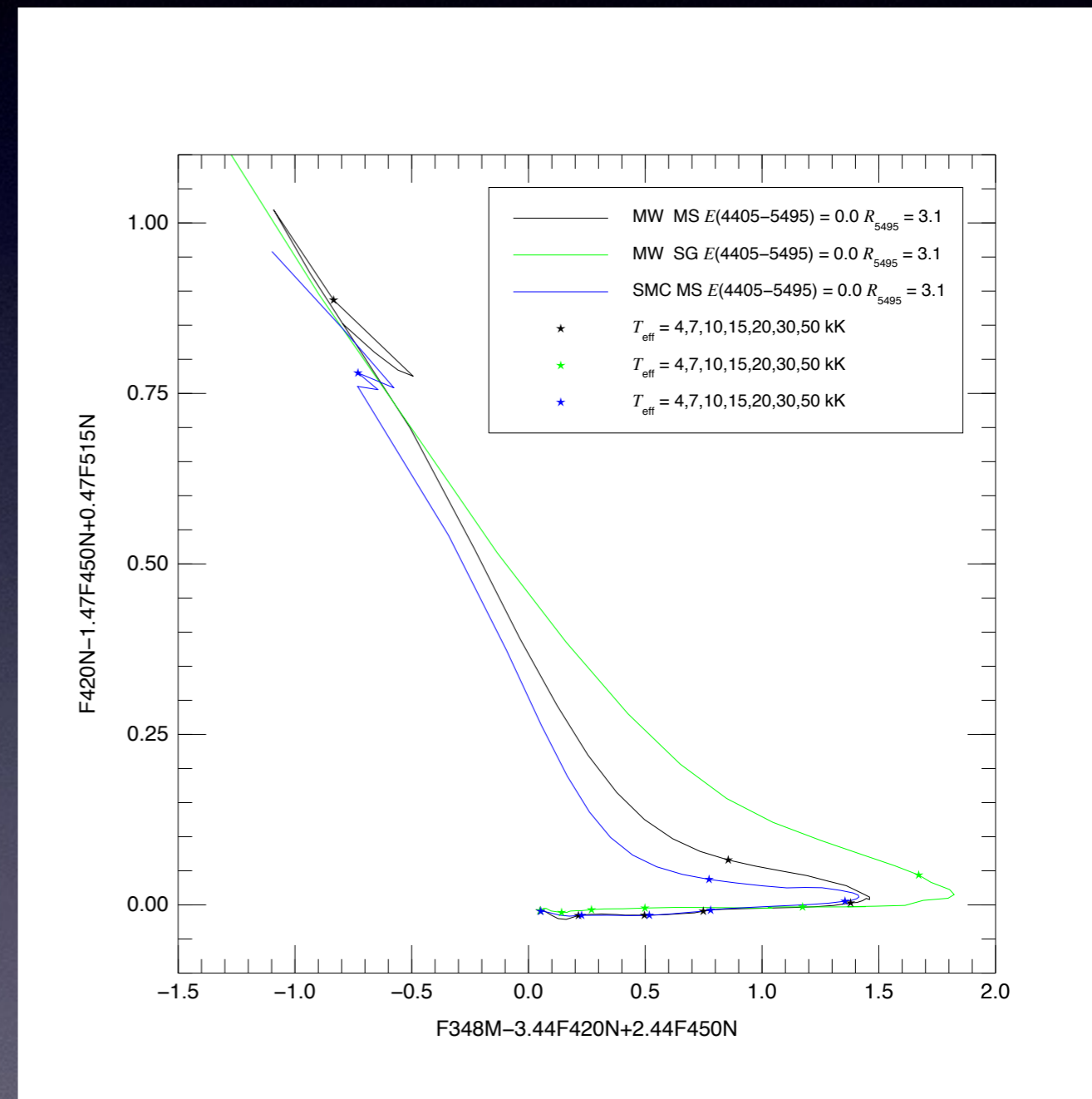
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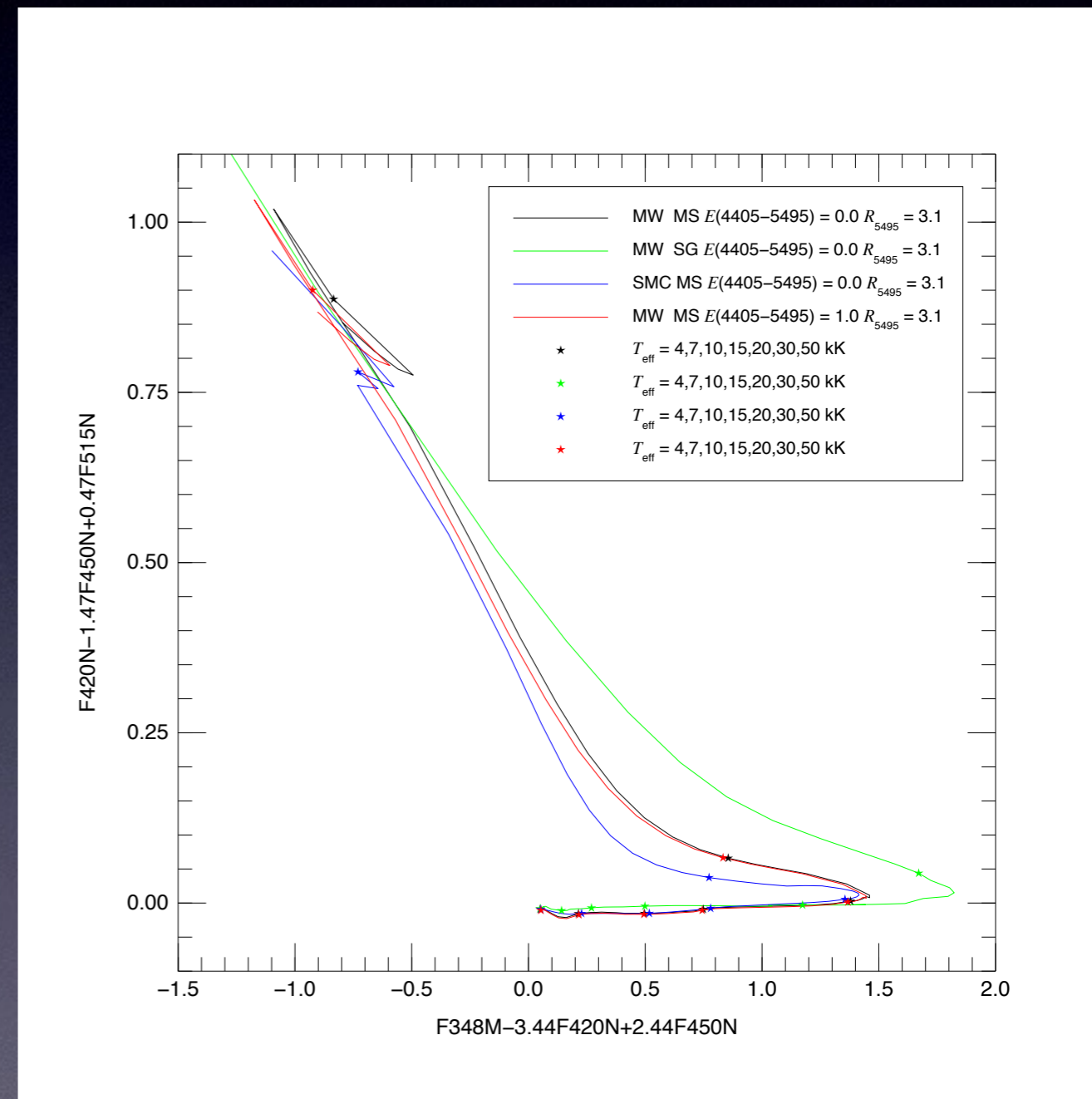
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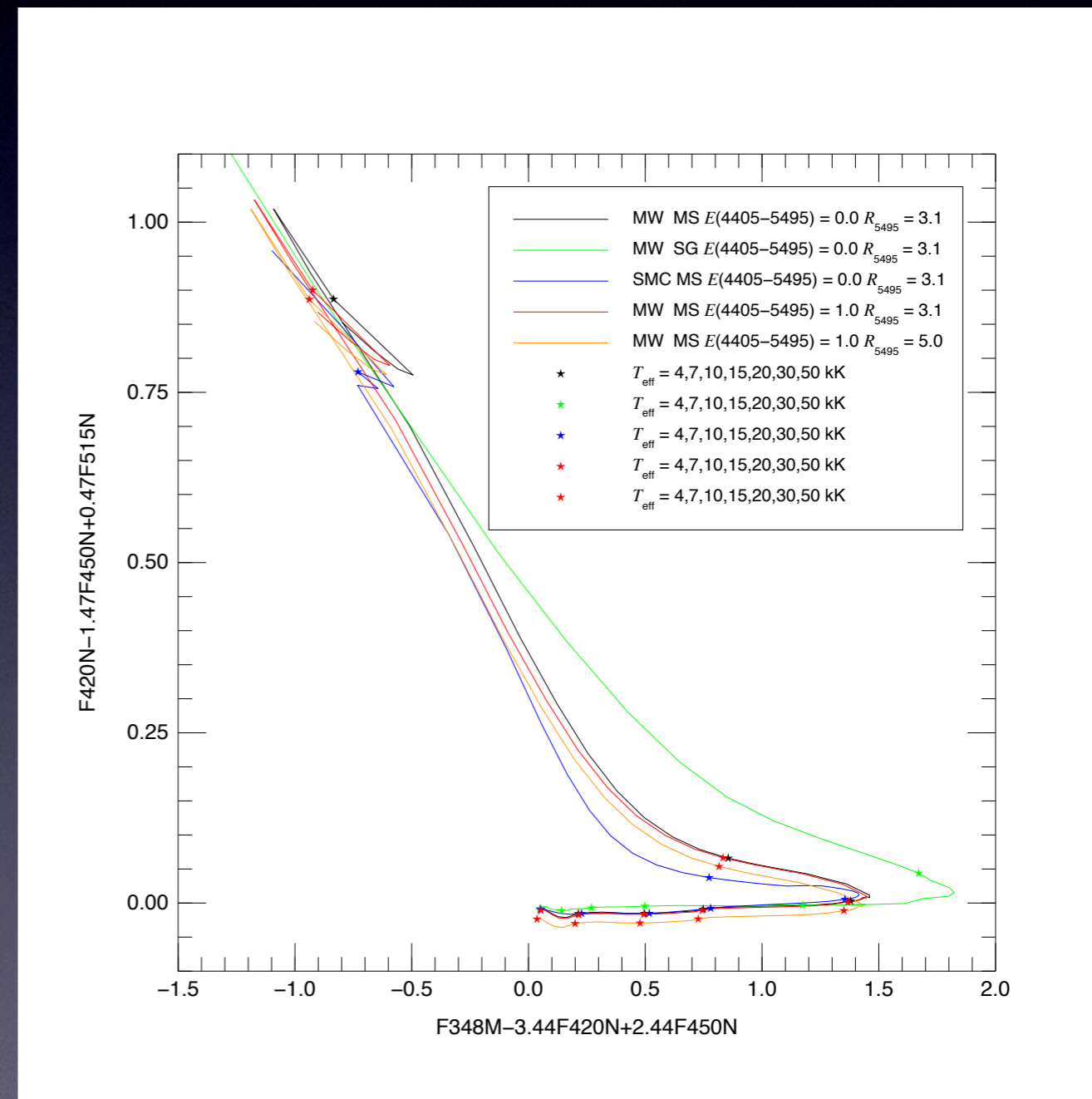
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What will we do with GALANTE?

- Main objectives:
 - ★ Identify all OB stars in the Northern Galactic Plane down to magnitude 17.
 - ★ Estimate T_{eff} for the sample above.
 - ★ Measure $E(4405-5495)$ and R_{5495} for the OBA stars in the sample by cross-matching with 2MASS.
- Sample additional objectives:
 - ★ Magnitude-limited catalog of emission-line stars.
 - ★ The IMF of large-area clusters and associations.
 - ★ Continuum-subtracted H α map with subarcsecond pixels.

Plans

- Timeline:
 - ★ Survey started in September 2016.
 - ★ Data taking until 2018B/2019A.
- Possible extensions:
 - ★ Deep surveys of interesting regions.
 - ★ The time domain.
 - ★ Additional filters: Na I D1+D2, TiO, continuum for extinction law...
 - ★ Twin telescope in the South.

Dealing with the enemy

$$A(\lambda) = -2.5 \log_{10} \left(\frac{F_{\lambda}(\lambda)}{F_{\lambda,0}(\lambda)} \right)$$

Extinction as a function
of wavelength

$$A_V = -2.5 \log_{10} \left(\frac{\int P_V(\lambda) F_{\lambda}(\lambda) \lambda d\lambda}{\int P_V(\lambda) F_{\lambda,0}(\lambda) \lambda d\lambda} \right) = V - V_0$$

Extinction in the Johnson
V band

$$A_B = -2.5 \log_{10} \left(\frac{\int P_B(\lambda) F_{\lambda}(\lambda) \lambda d\lambda}{\int P_B(\lambda) F_{\lambda,0}(\lambda) \lambda d\lambda} \right) = B - B_0$$

Extinction in the Johnson
B band

$$E(B - V) \equiv A_B - A_V = (B - V) - (B - V)_0$$

Color excess, reddening

$$R_V \equiv \frac{A_V}{E(B - V)}$$

Ratio of total to selective
extinction

$A(\lambda)$ /amount of extinction

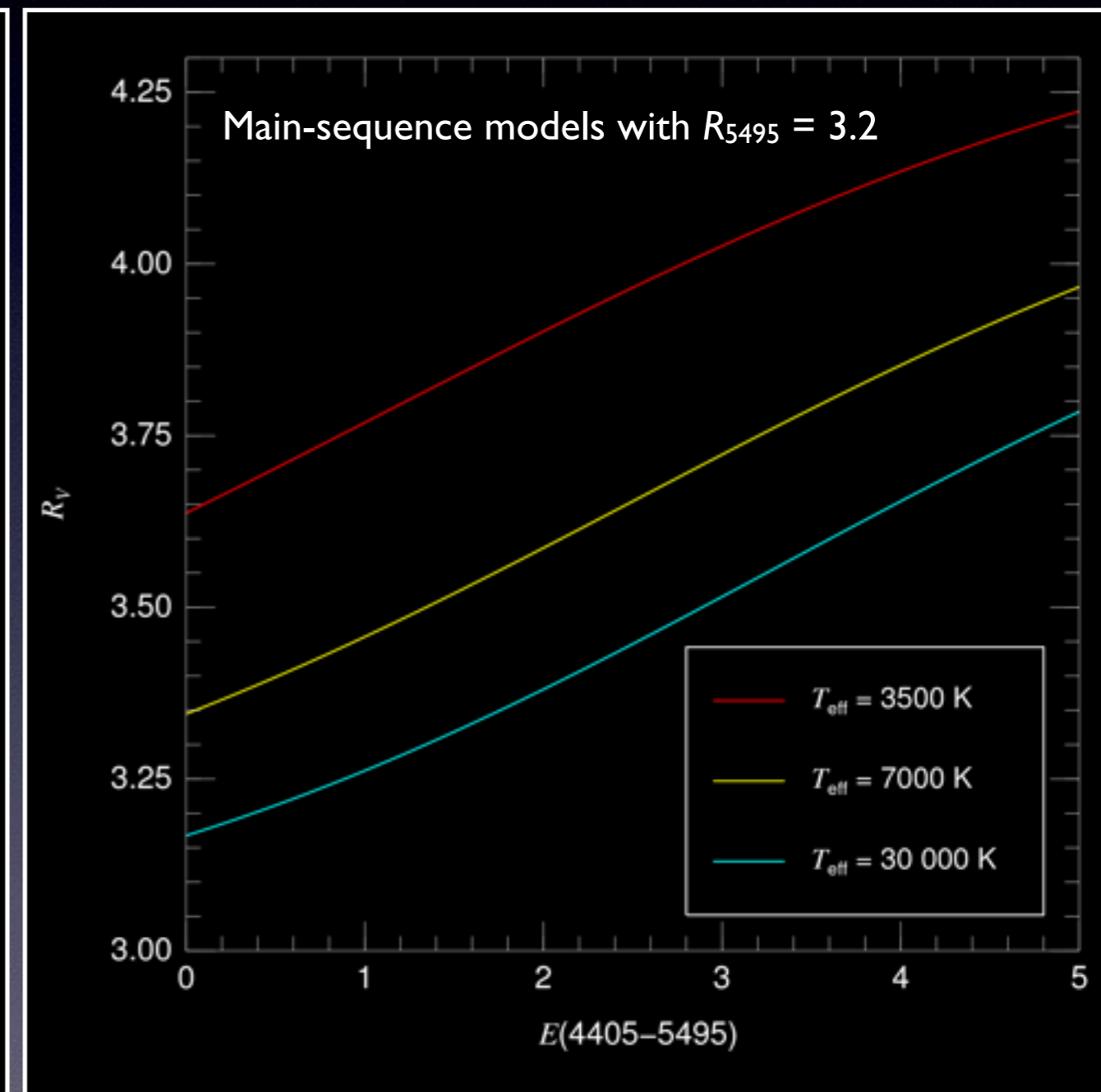
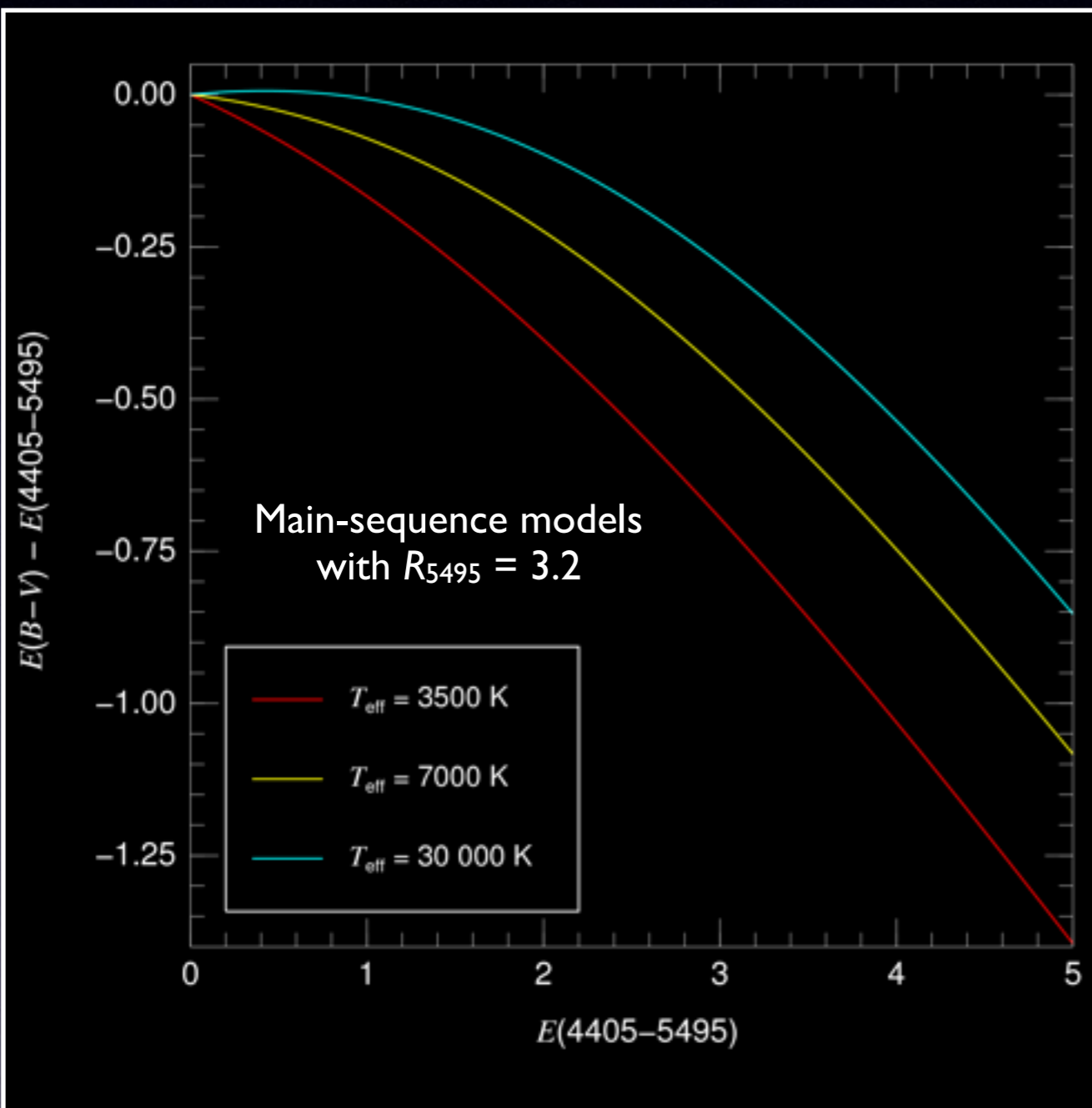
Extinction law

Monochromatic quantities

$$E(B-V) \neq E(4405-5495)$$

$$R_V \neq R_{5495}$$

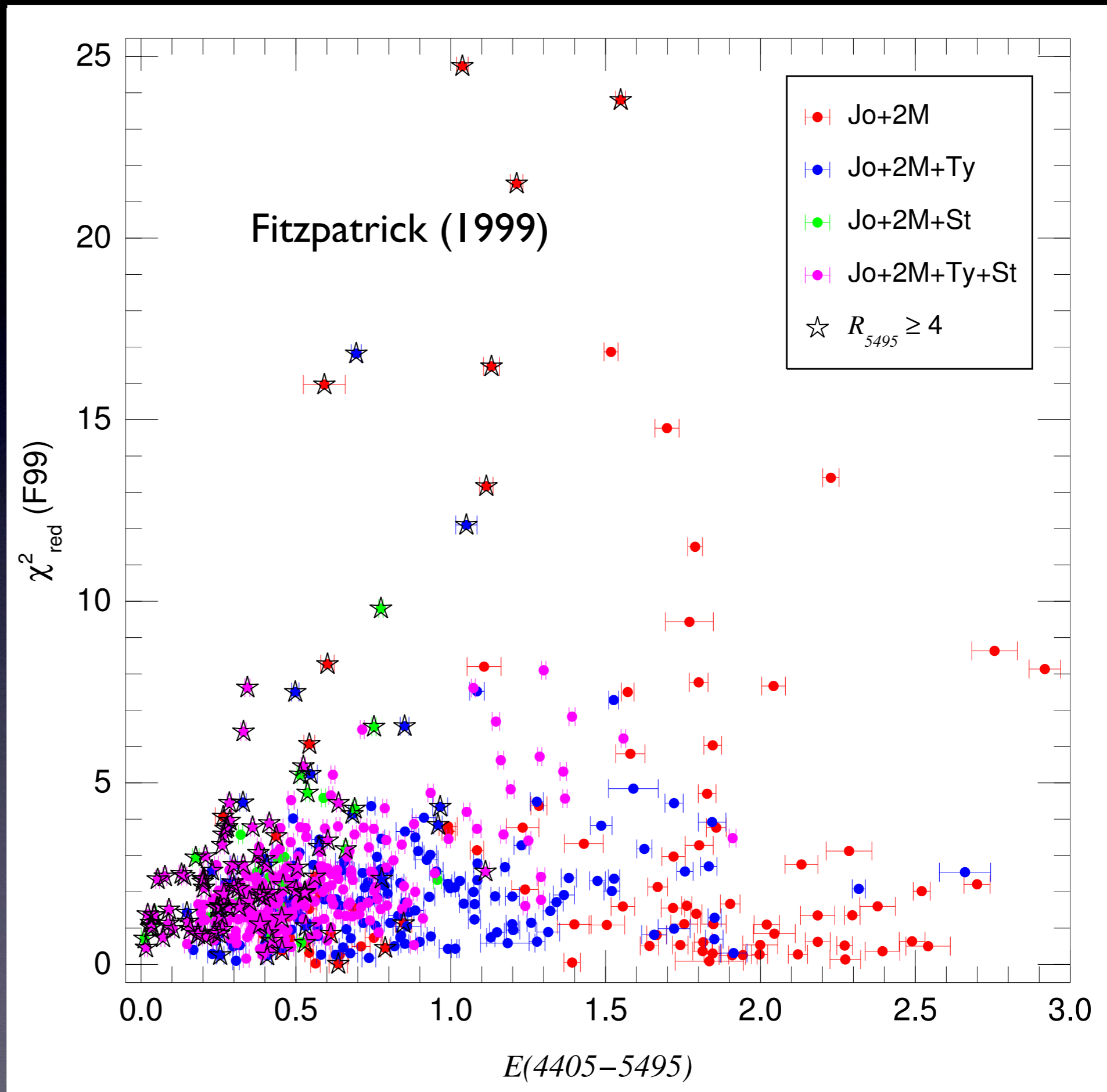
Dependence on input SED and amount of extinction



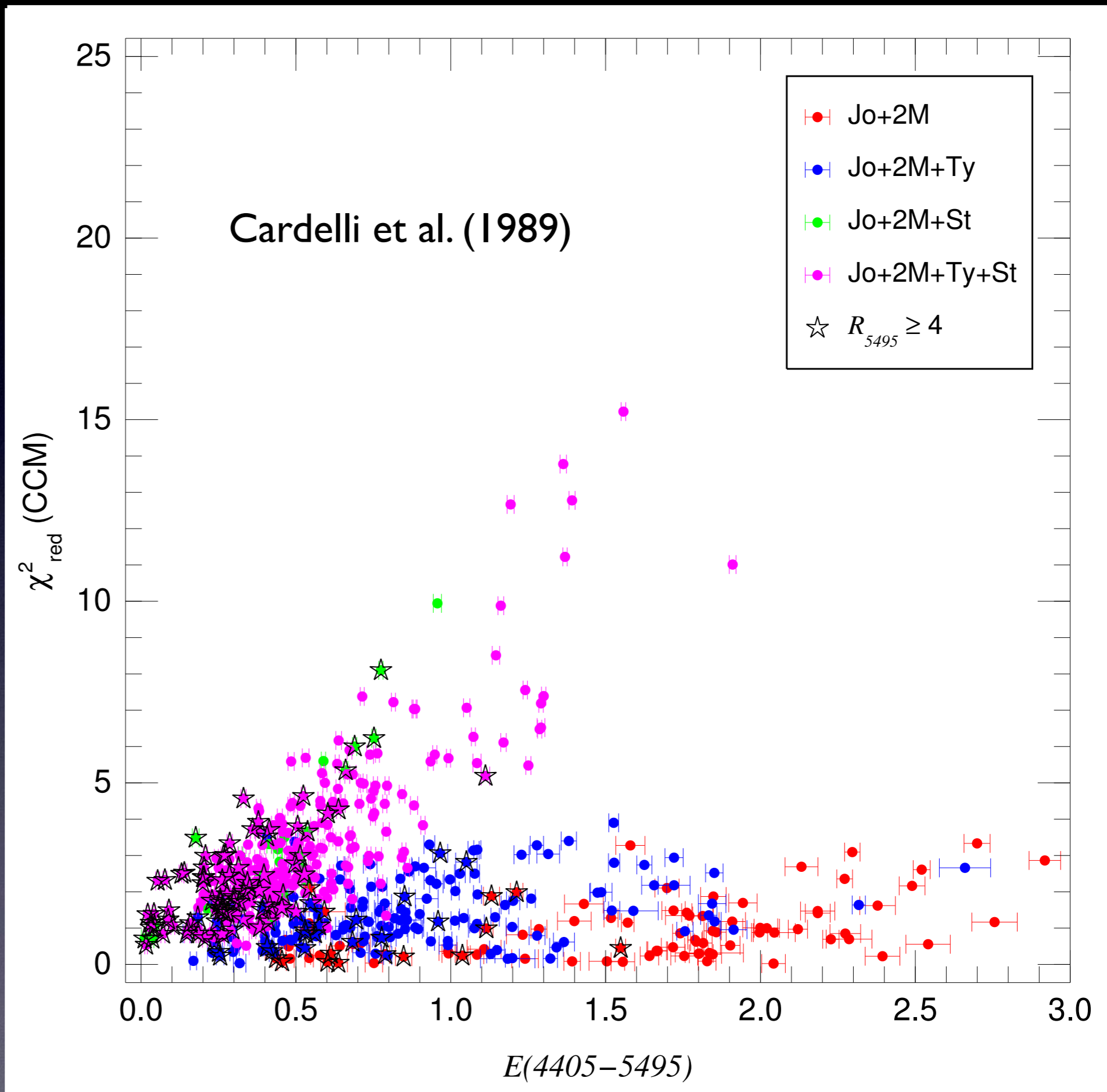
Measuring extinction of OB stars in the Galaxy without GALANTE

- 564 O stars with GOSSS spectral types.
- 2MASS *JHKs* + Johnson *UBV* + Tycho-2 *BV* + Strömbergren *uvby* from literature.
- CHORIZOS fitting $E(4405-5495)$, R_{5495} , and $\log d$ simultaneously, T_{eff} and luminosity class fixed.
- Three families of extinction laws: CCM, F99, and M14.
- Evaluate extinction laws with χ^2_{red} .

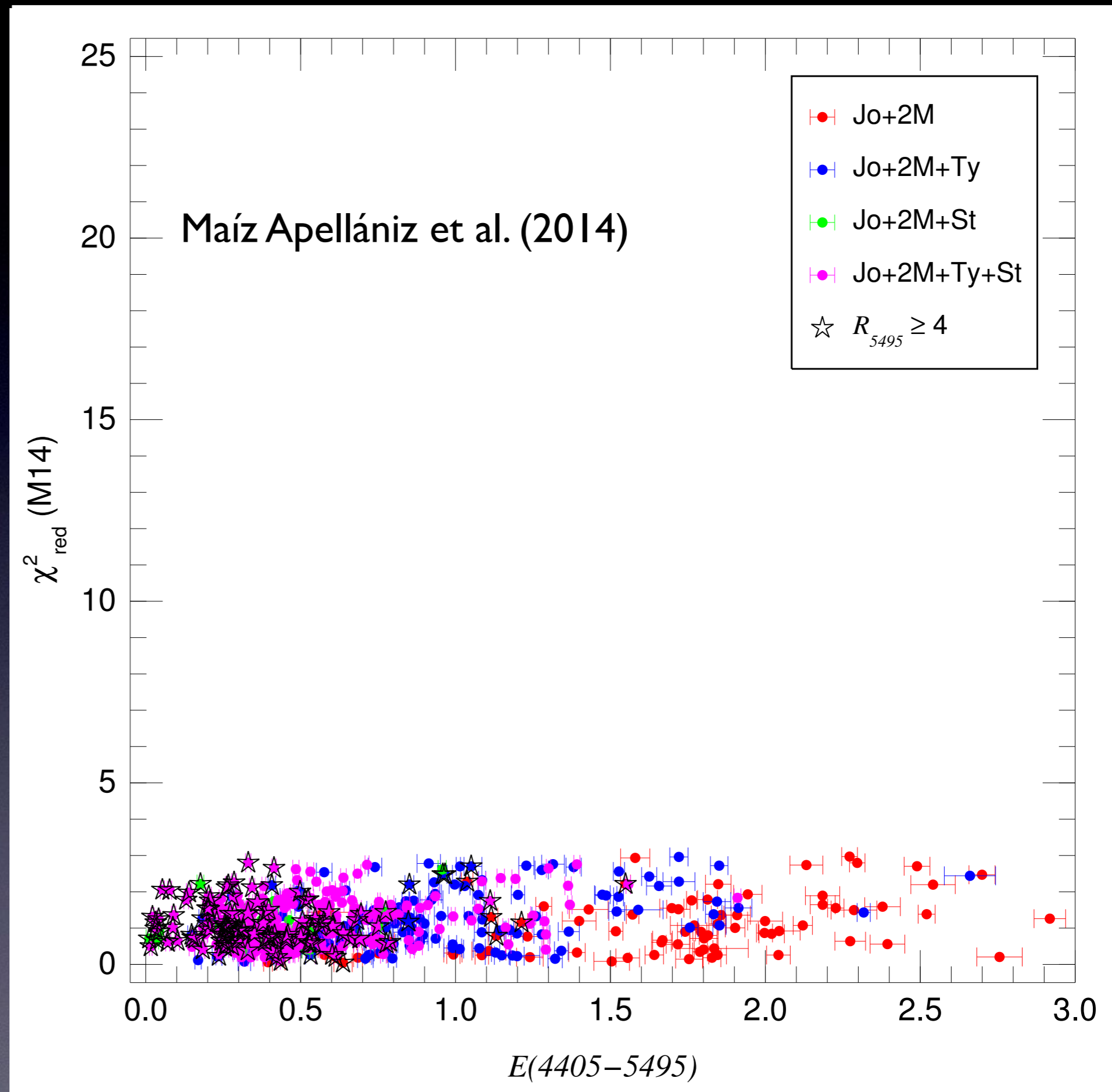
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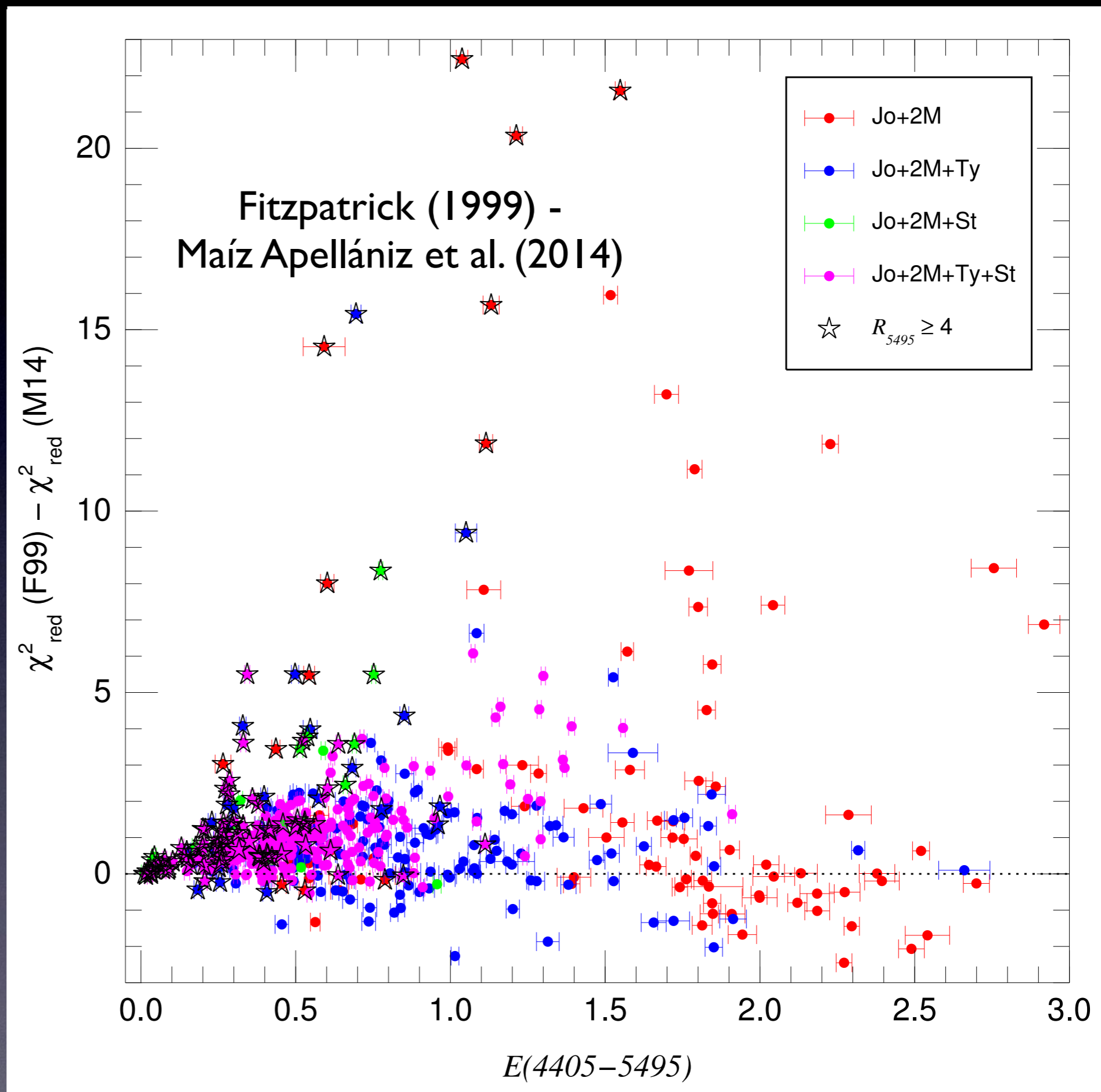
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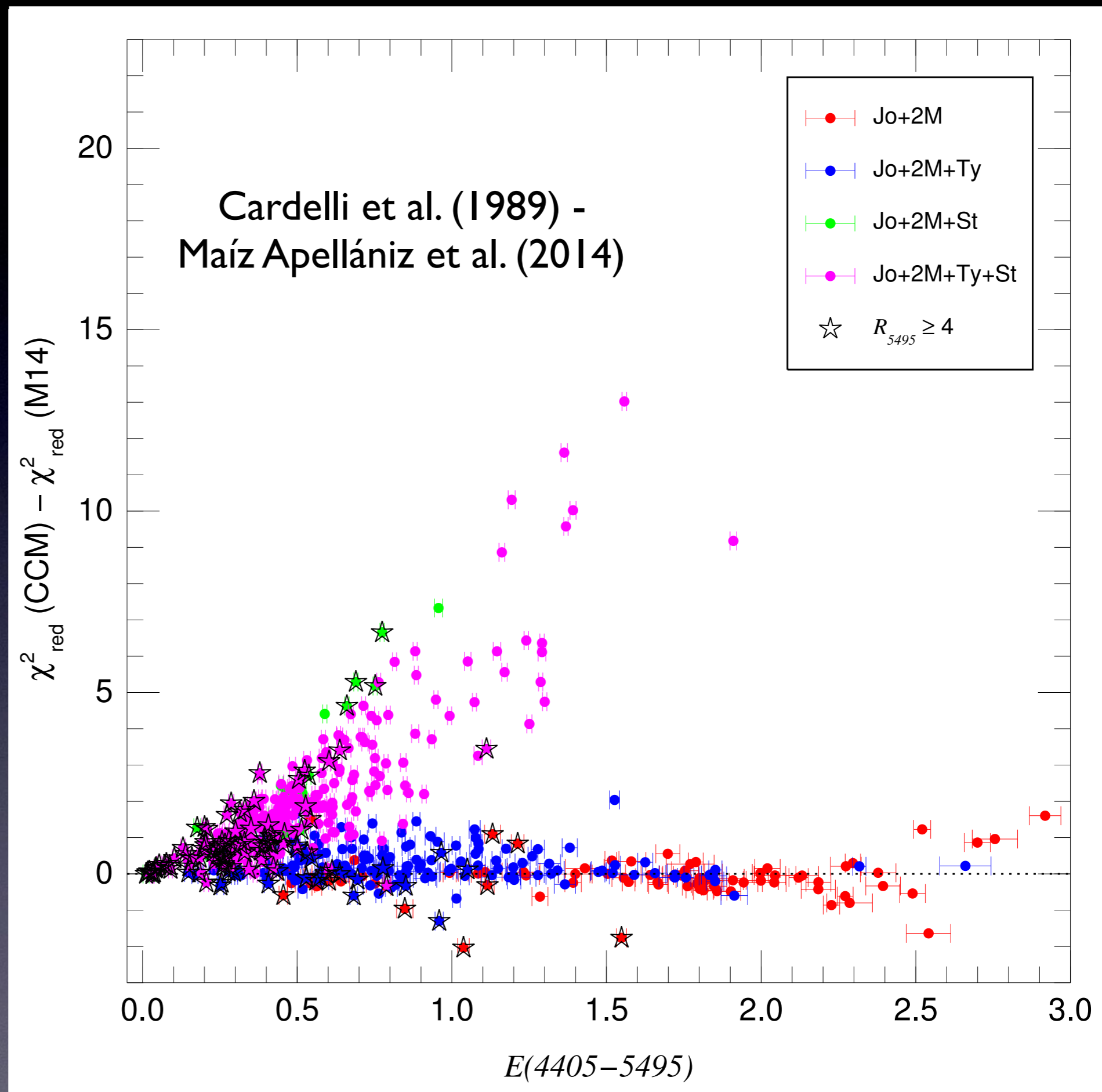
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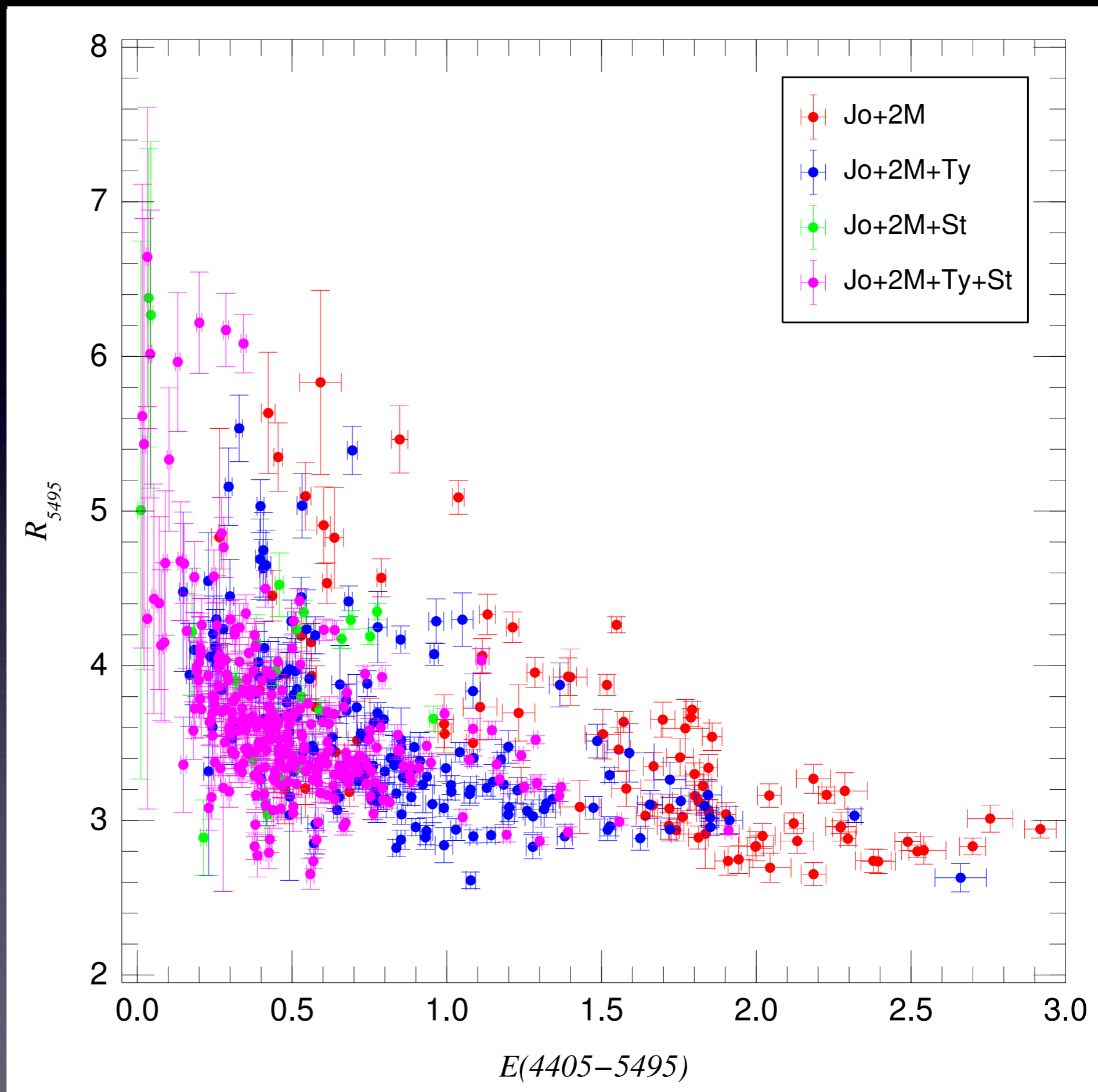
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Measuring extinction of OB stars in the Galaxy without GALANTE



Measuring extinction of OB stars in the Galaxy without GALANTE



GALANTE and extinction

- Limitations of non-GALANTE method:
 - ★ Non-uniformity of photometry.
 - ★ Dynamic range of Johnson *U-B* and Strömngren *u-v*.
 - ★ Spectral types needed: small sample.
- With GALANTE:
 - ★ Consistent photometry.
 - ★ Pure continuum filters: high dynamic range.
 - ★ Photometric points between *V* and *J*.
 - ★ Spectral types not needed: large sample of OB stars.

Summary

- GALANTE: seven filter, 3-17 (0-19) mag, $180^\circ \times 6^\circ$ photometric survey of the northern Galactic Plane.
- September 2016 to 2018B/2019A.
- Main objective: Temperature and extinction for a magnitude-limited sample of Galactic OB stars.
- Other objectives: emission-line stars, clusters +associations IMF, $H\alpha$ map, (your suggestion here)...
- Synergies with Gaia.
- Possible extensions.