

# Red and brown dwarfs in the ultraviolet



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Madrid

# Why red and brown dwarfs?



**“Red dwarfs”** = field M- and **early-L-type stars**

**“Brown dwarfs”** = field **late-L-** and **T-**type dwarfs and **young late-M-** and **L-**type substellar objects in star-forming regions, open clusters and moving groups

## Topics

- **UV Instrumentation.**
  - WSO-UV Project
  - Space missions
  - Ground based UV observations
- **Stellar physics and evolution.**
  - Star formation
  - Young stars
  - Massive stars
  - Compact objects
  - Close binaries
- **Milky Way and galaxies.**
  - Interstellar and intergalactic medium
  - Galactic astronomy
  - Galaxies
  - Stellar populations
  - Cosmology
- **Planetary atmospheres.**
  - Solar system
  - Exoplanets

# Related talks



Javier **López-Santiago**: *The size of stellar coronae from flaring events*

Néstor **Sánchez**: *Young stellar candidates toward the Orion region selected from GALEX*

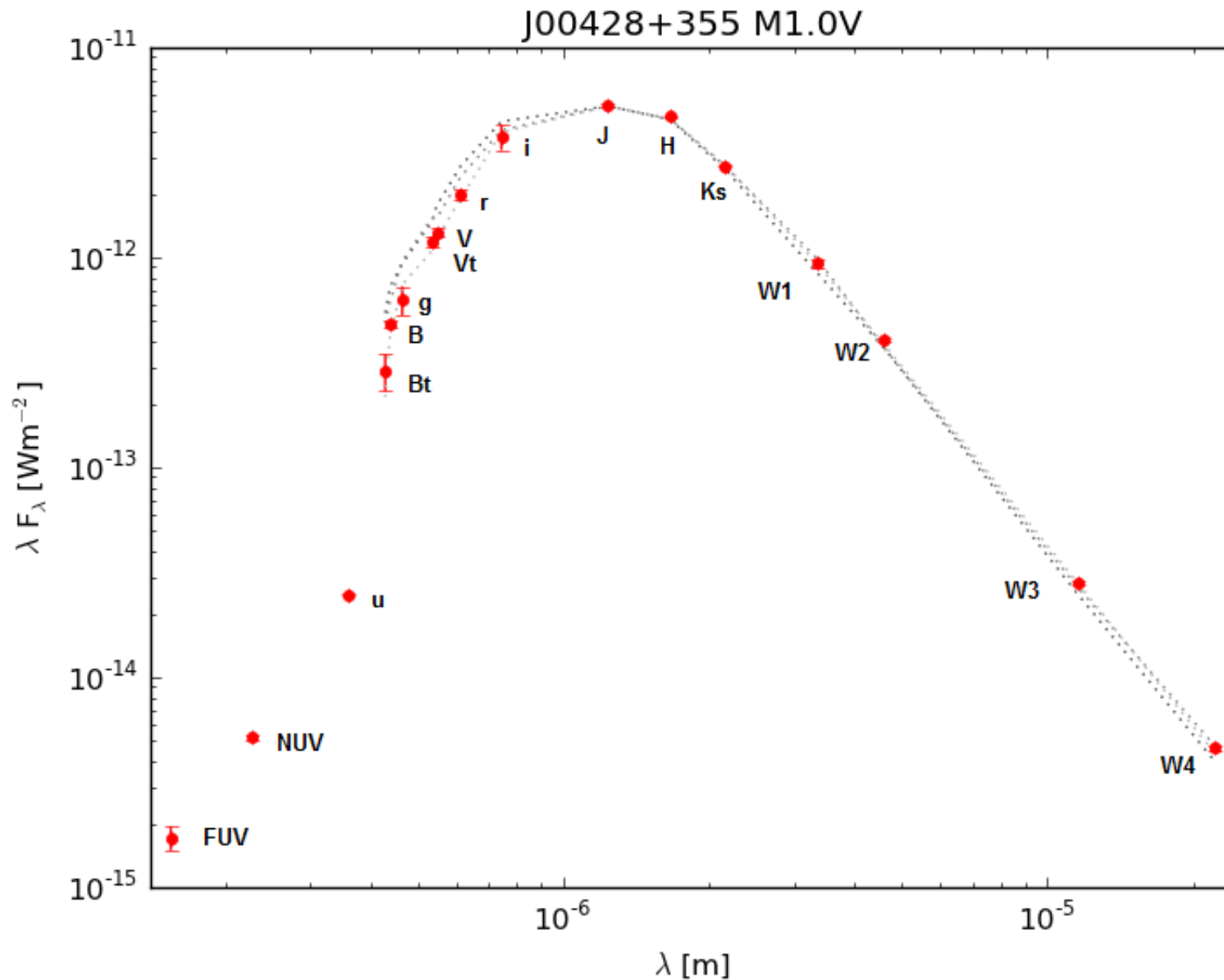
Fátima **López-Martínez**: *Magnetospheric properties of T Tauri stars through C II], Fe II] and Si II] ultraviolet emission lines*

Jordi **Torra**: *Gaia data are coming*

|             |  |  |
|-------------|--|--|
| 12:30-13:00 | The size of stellar coronae from flaring events<br>Javier López Santiago   | Session 2<br>Stellar physics and evolution |
| 13:00-13:30 | Red and brown dwarfs in the ultraviolet<br>Jose A. Caballero   |  |
| 13:30-13:45 | Young Stellar Object candidates toward the Orion region selected from <i>GALEX</i><br>Néstor Sánchez                         |  |
| 13:45-14:00 | Reddening determination and model fitting of early type stars observed by <i>WSO</i><br>Carmen Morales                       |  |
| 14:00-15:30 | Lunch  |  |
| 15:30-15:45 | Magnetospheric properties of T Tauri stars through CII], FeII] and SiII] ultraviolet emission lines<br>Fátima López Martínez | Session 3<br>Stellar physics and evolution |
| 15:45-16:15 | Winds of metal-poor OB stars: prospects for the <i>WSO</i> and ISSIS<br>Miriam García García                                 |  |
| 16:15-16:45 | OB stars models: the role of the UV region<br>Artemio Herrero  |  |
| 16:45-17:15 | Coffee Break   |  |
| 17:15-17:45 | Revisiting the UV-optical-IR extinction law<br>Jesús Maíz  |  |
| 17:45-18:00 | Tracking mass transfer processes: the case of High Mass X-Ray Binary Systems<br>Pere Blay                                    |  |
| 18:00-18:30 | <i>Gaia</i> data in coming<br>Jordi Torra  |  |

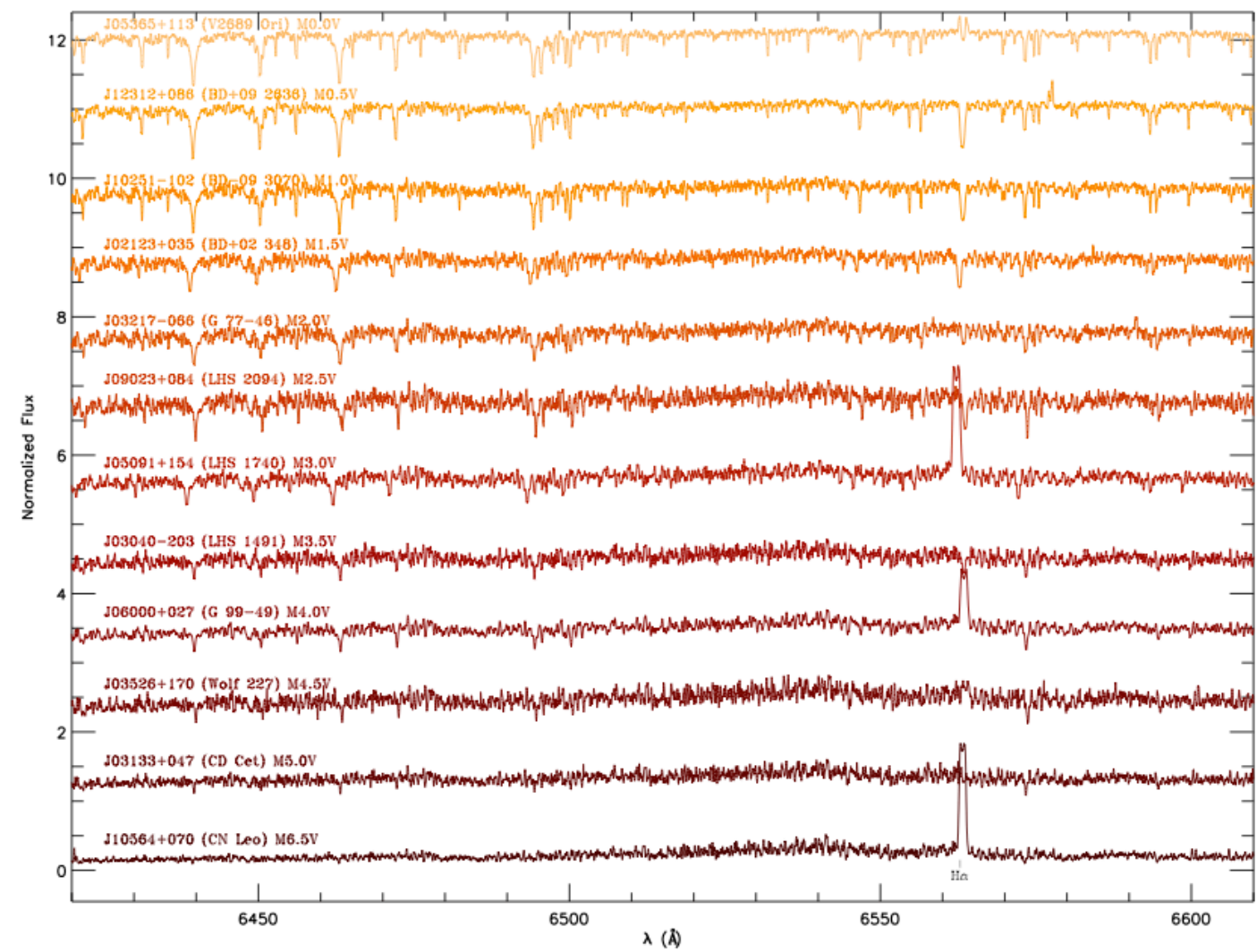
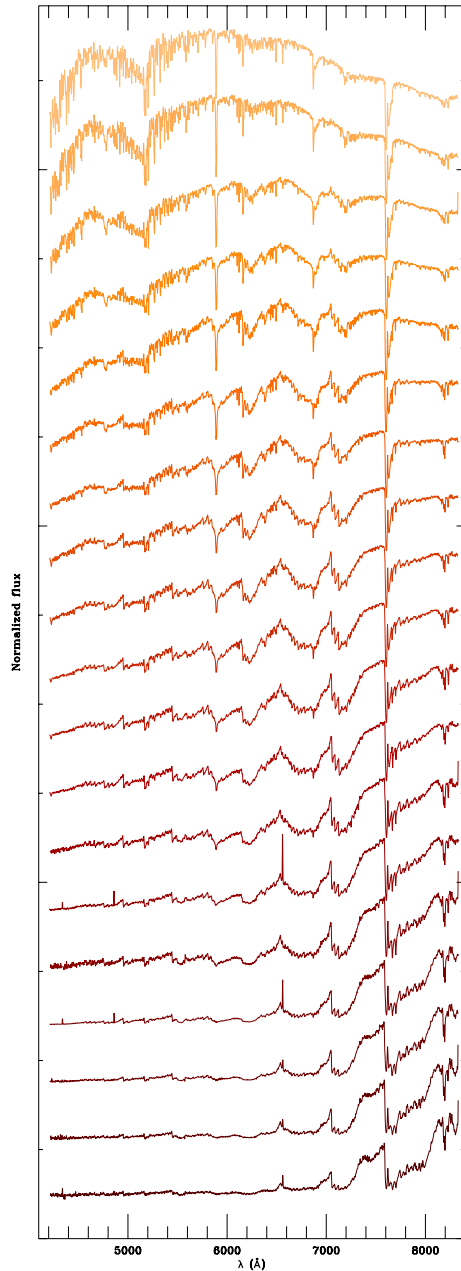
# Field M dwarf photometry

Holgado (2014)





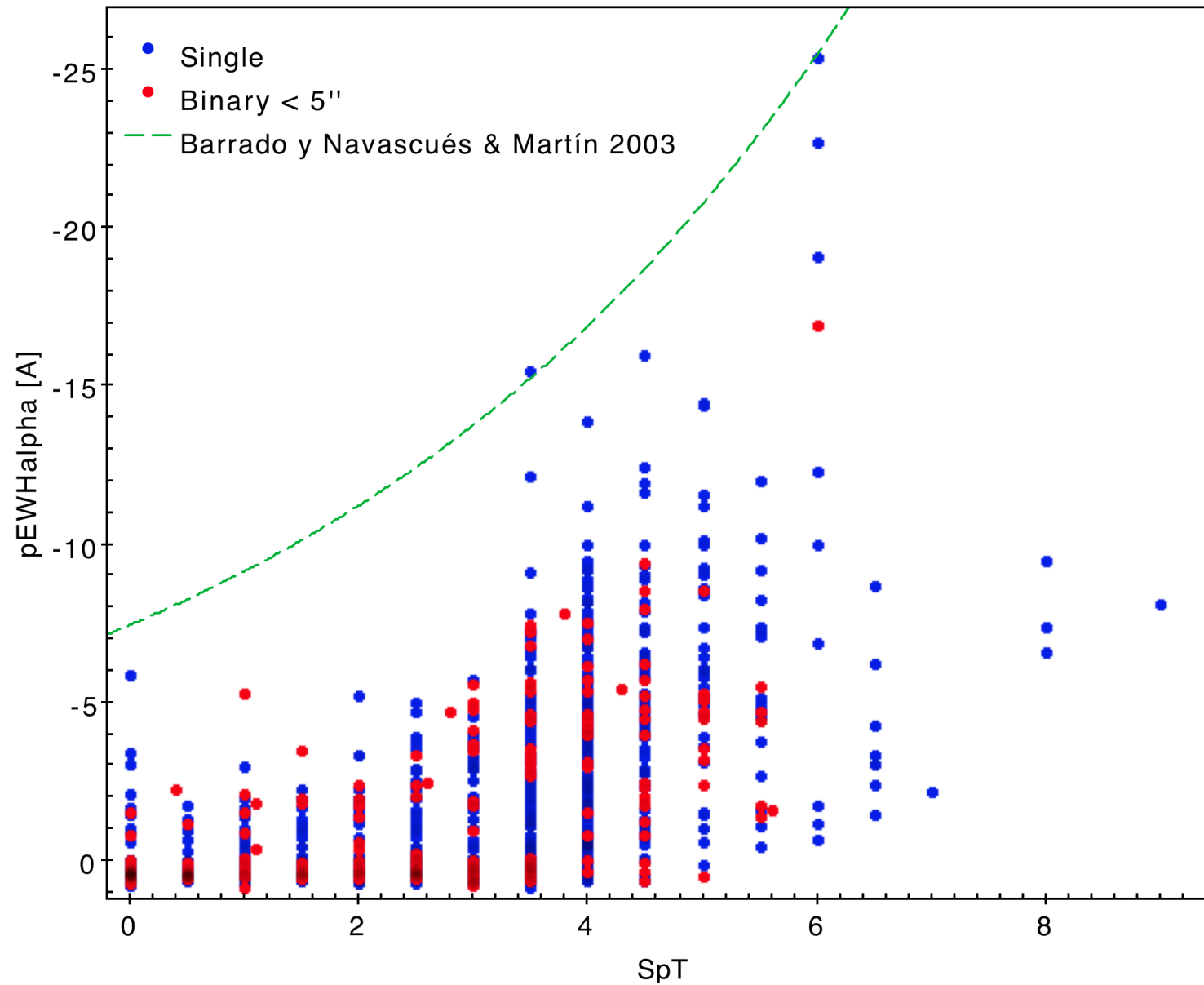
# Field M dwarf spectroscopy



Alonso-Floriano et al. (2014)

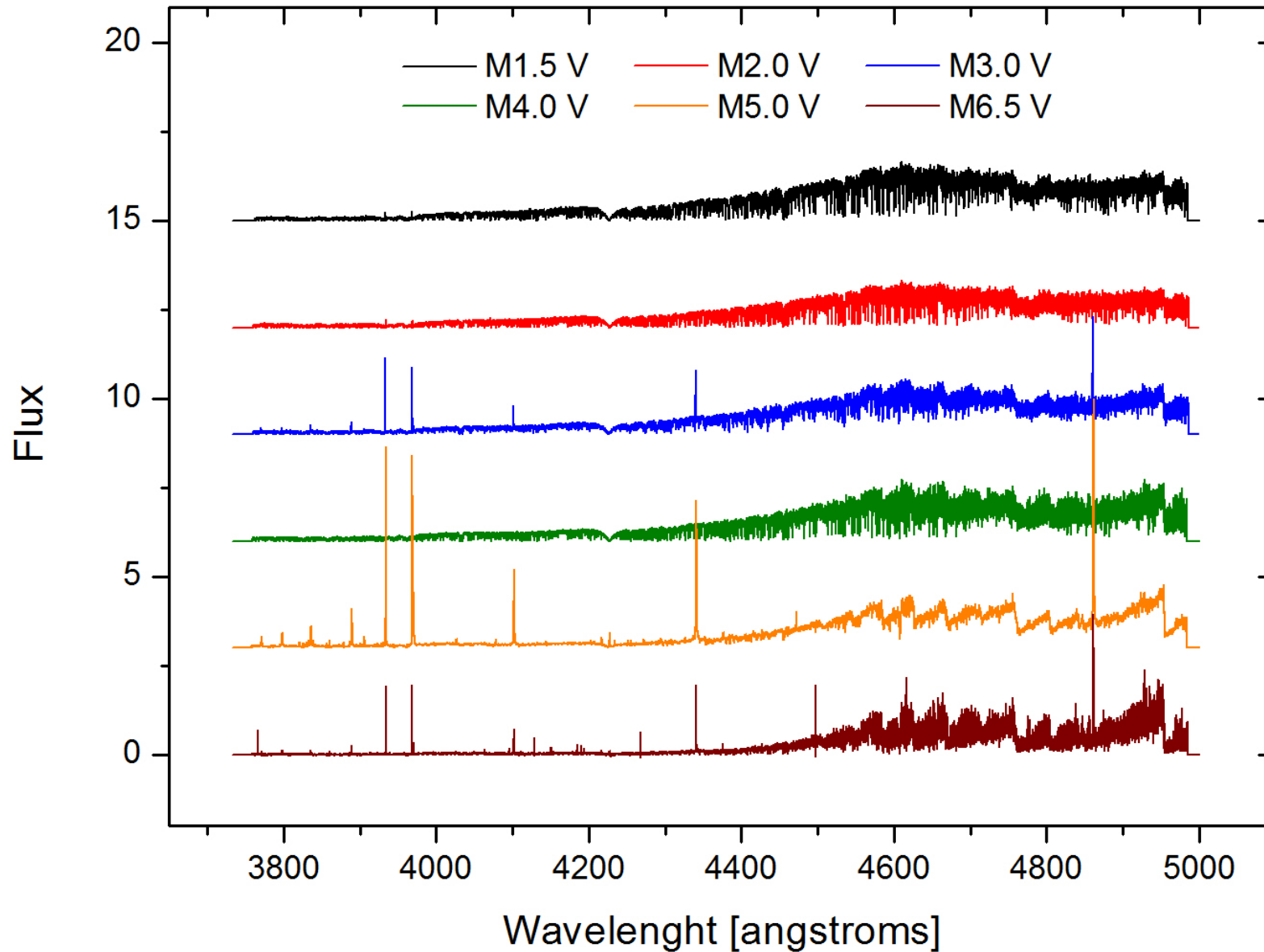
# Field M dwarf spectroscopy

Hidalgo (2014)



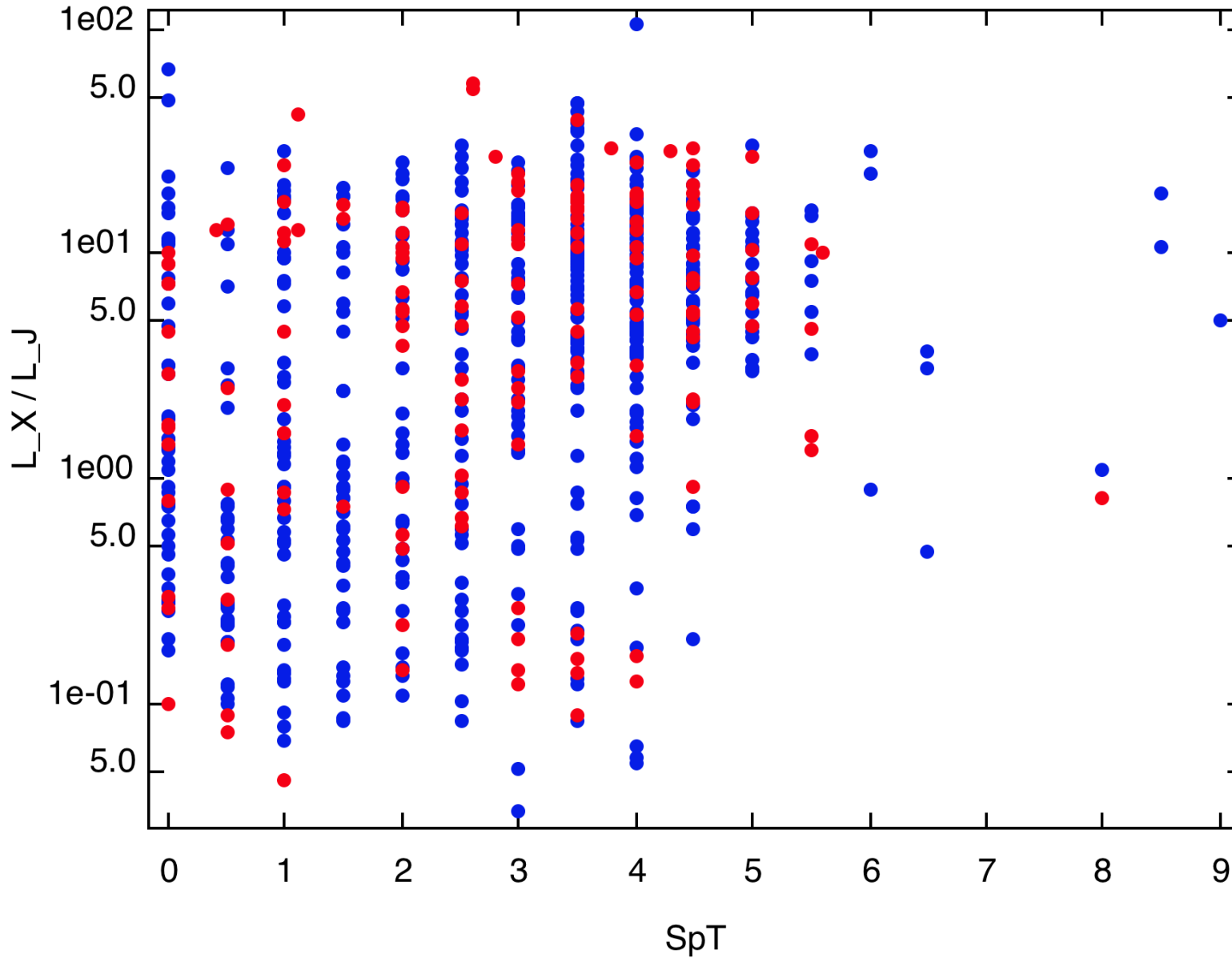
# Field M dwarf spectroscopy

Martínez-Rodríguez (2014)



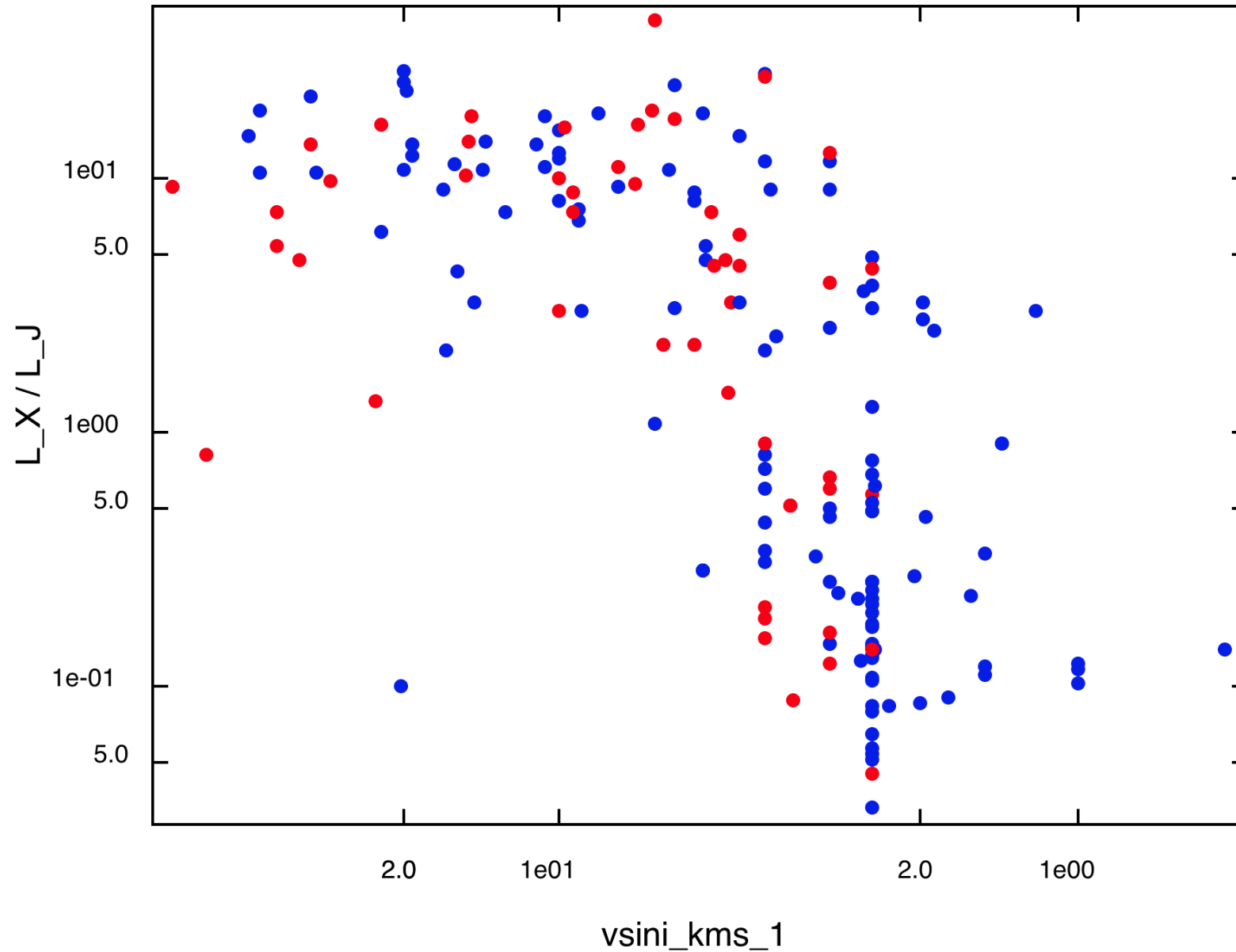
# Field M dwarf X-rays

González-Álvarez (2014)



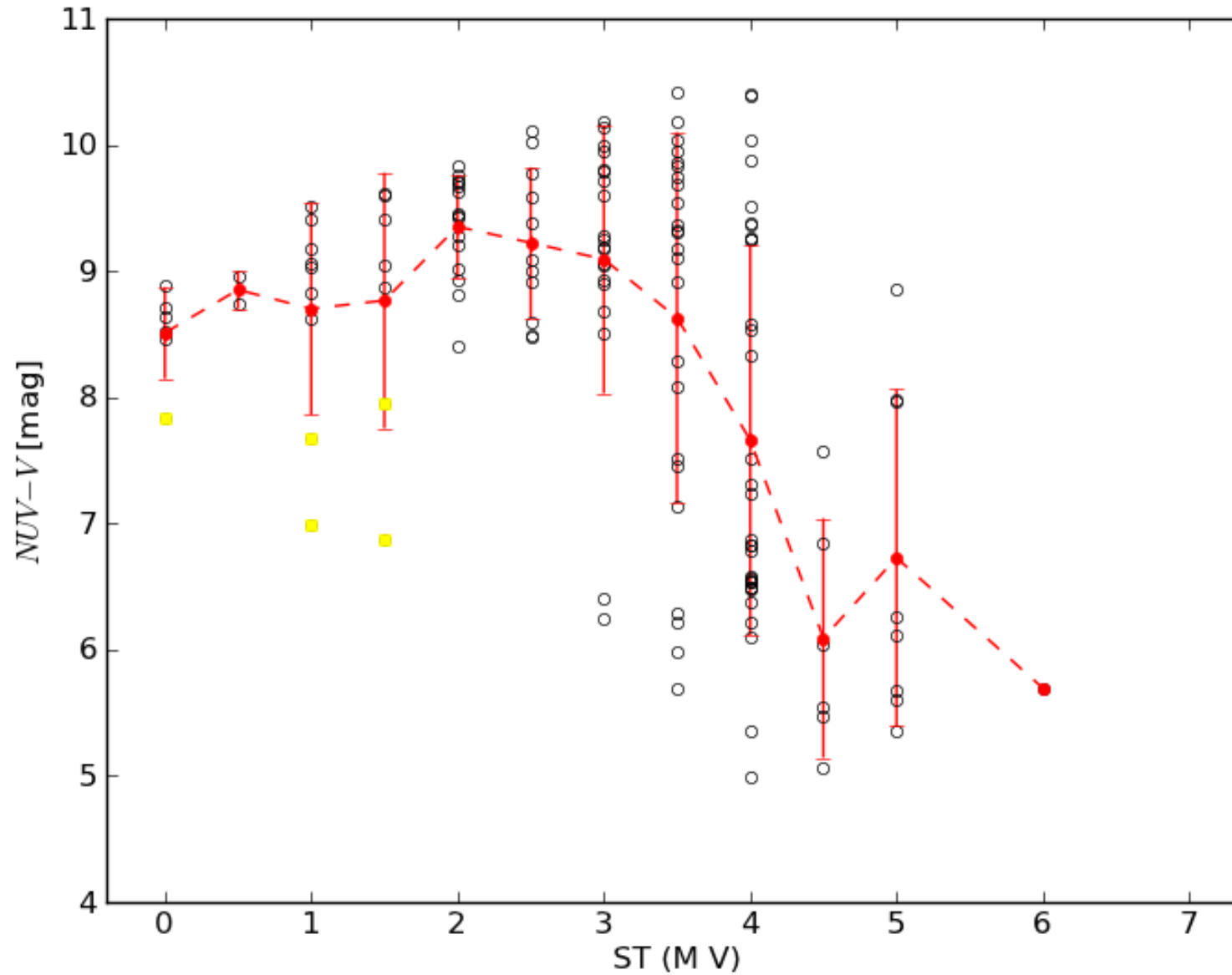
# Field M dwarf X-rays

González-Álvarez (2014)



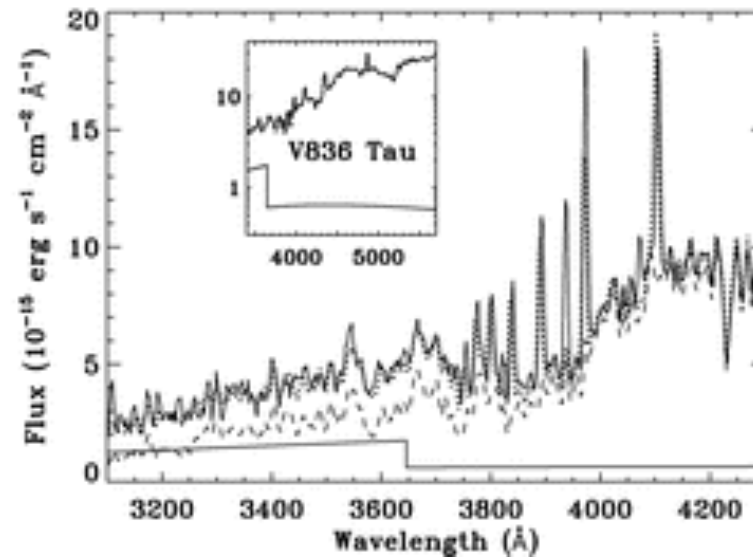
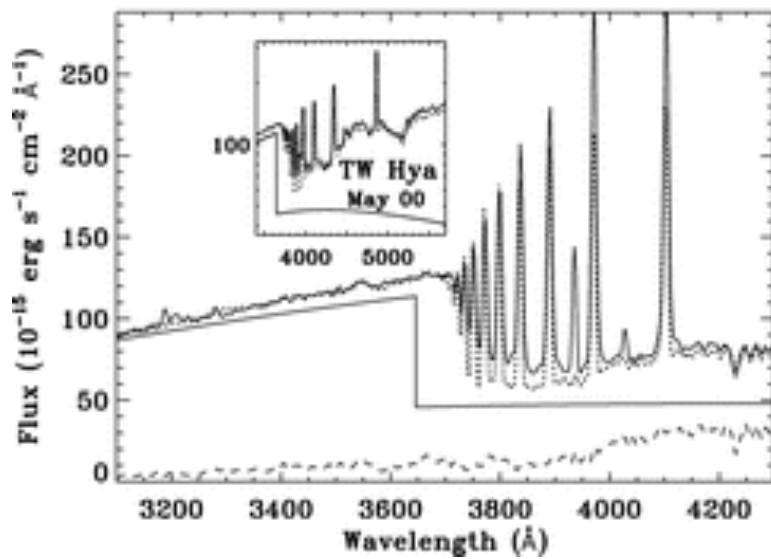
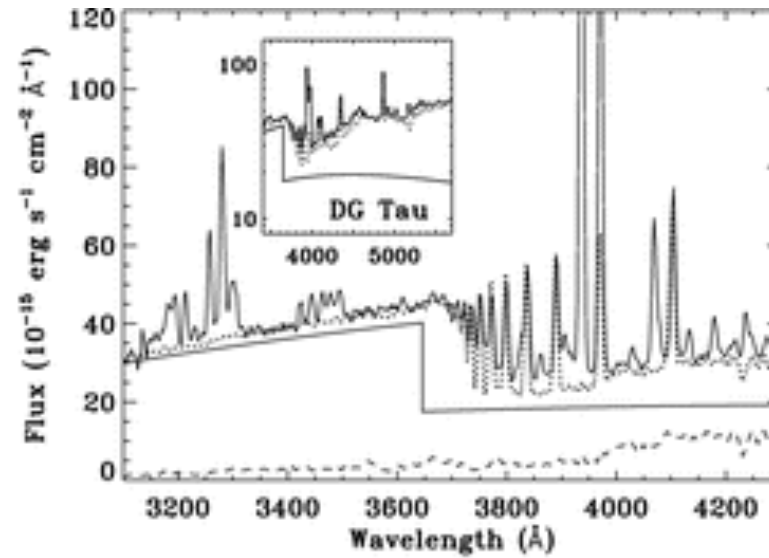
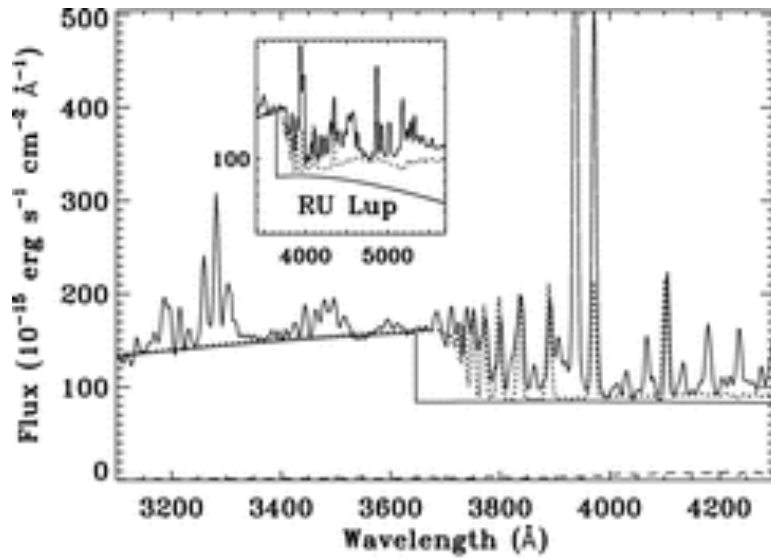
# Field M dwarf photometry

Holgado (2014)



# UV excess & activity

Herczeg & Hillenbrand (2007)



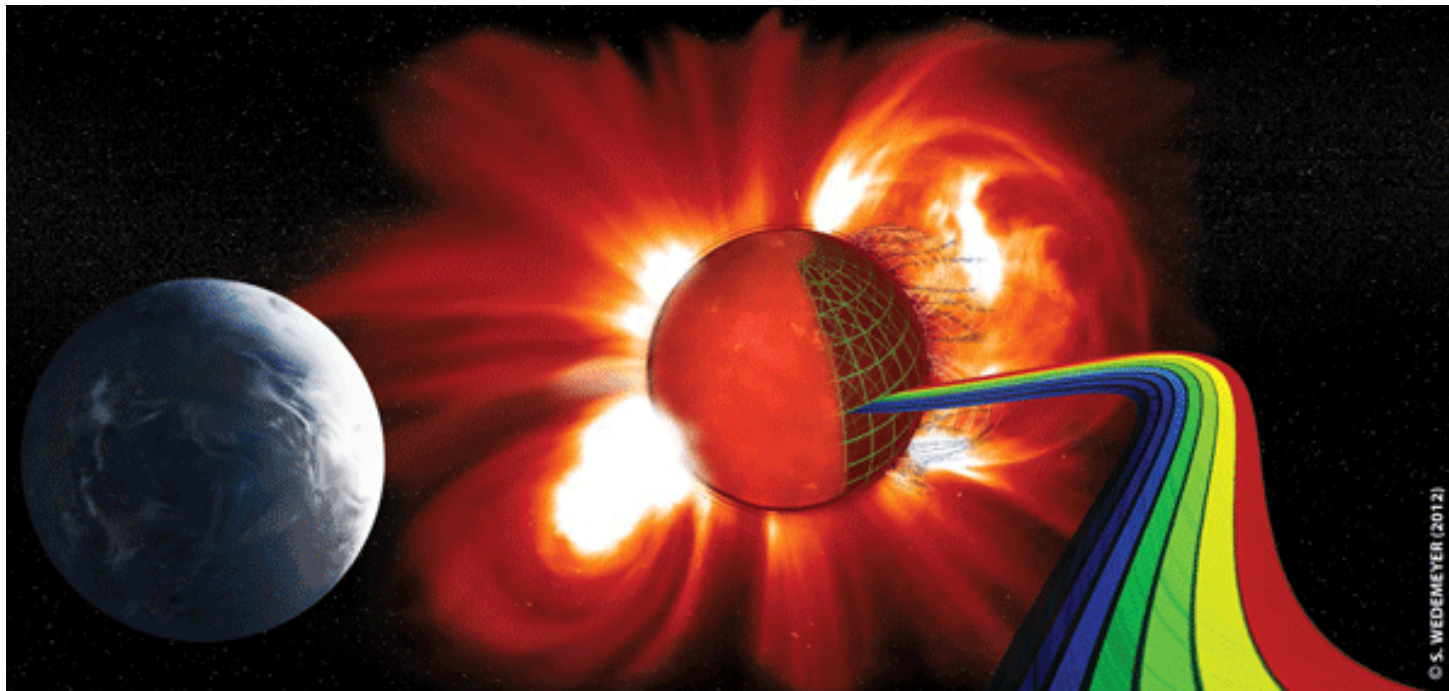


# Field M dwarf activity



Possible origin of UV excesses, H $\alpha$  and other Fátima's emission lines, X-rays, Javi's flares... and all **activity features**:

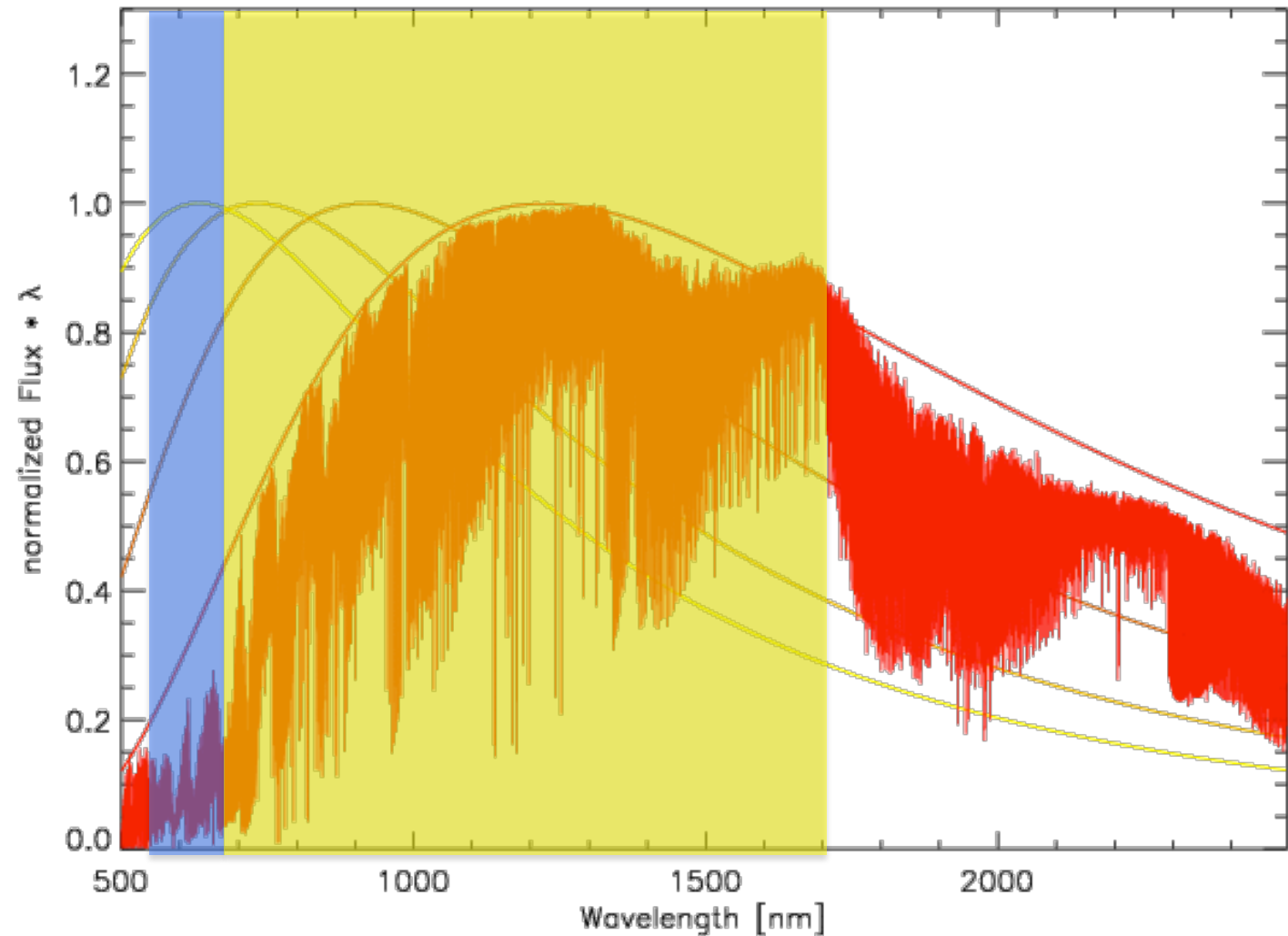
- Close binarity (orbital  $P$  = rotation  $P$ )
- Youth (as in Néstor Orion young stars: accretion and angular momentum evolution  $\rightarrow$  related to **planet formation**)



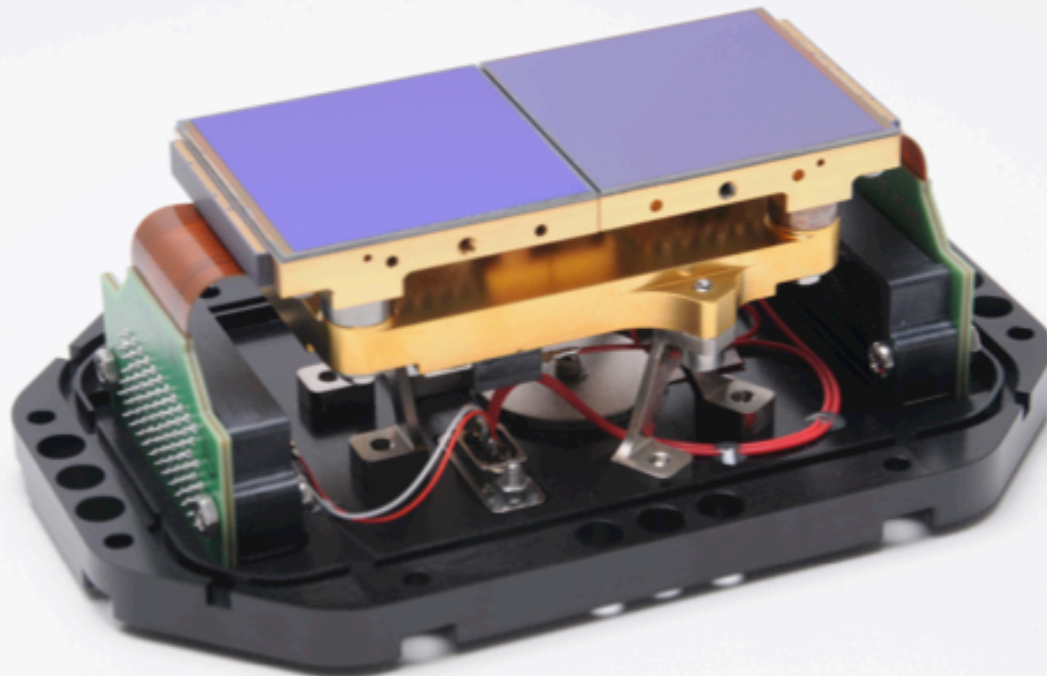
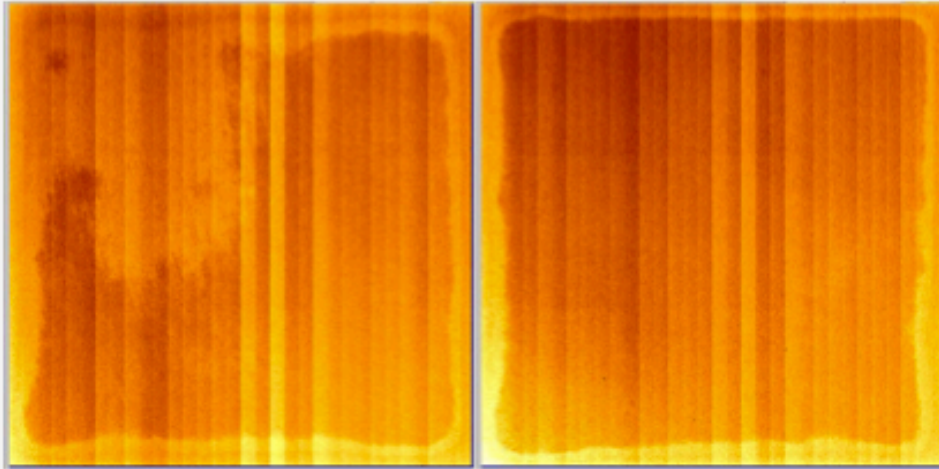
# carmenes



**C**alar **A**lto high  
**R**esolution  
search for **M**  
dwarfs with  
**E**xoearths with  
**N**ear-infrared  
and optical  
**E**chelle  
**S**pectrographs

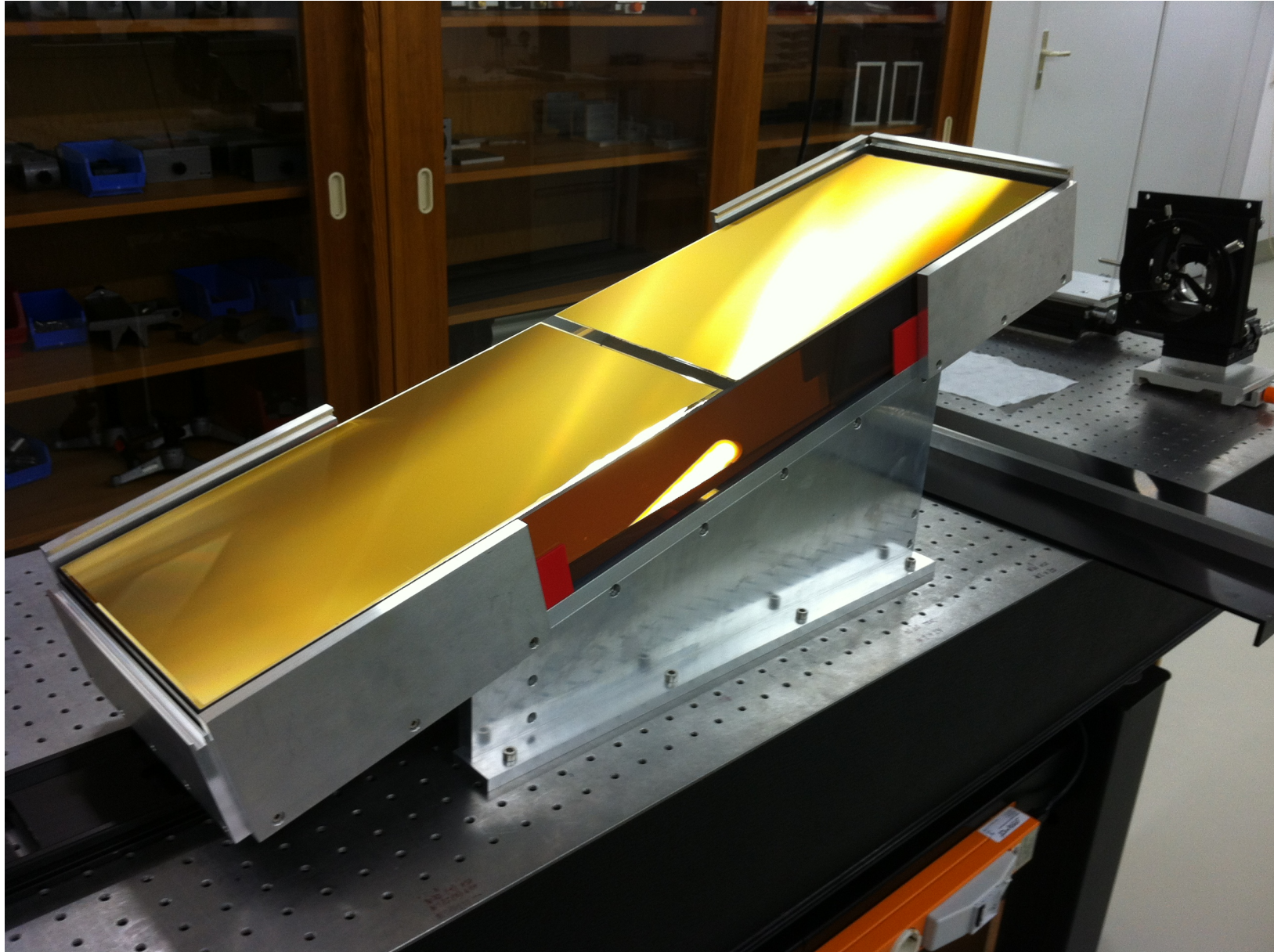


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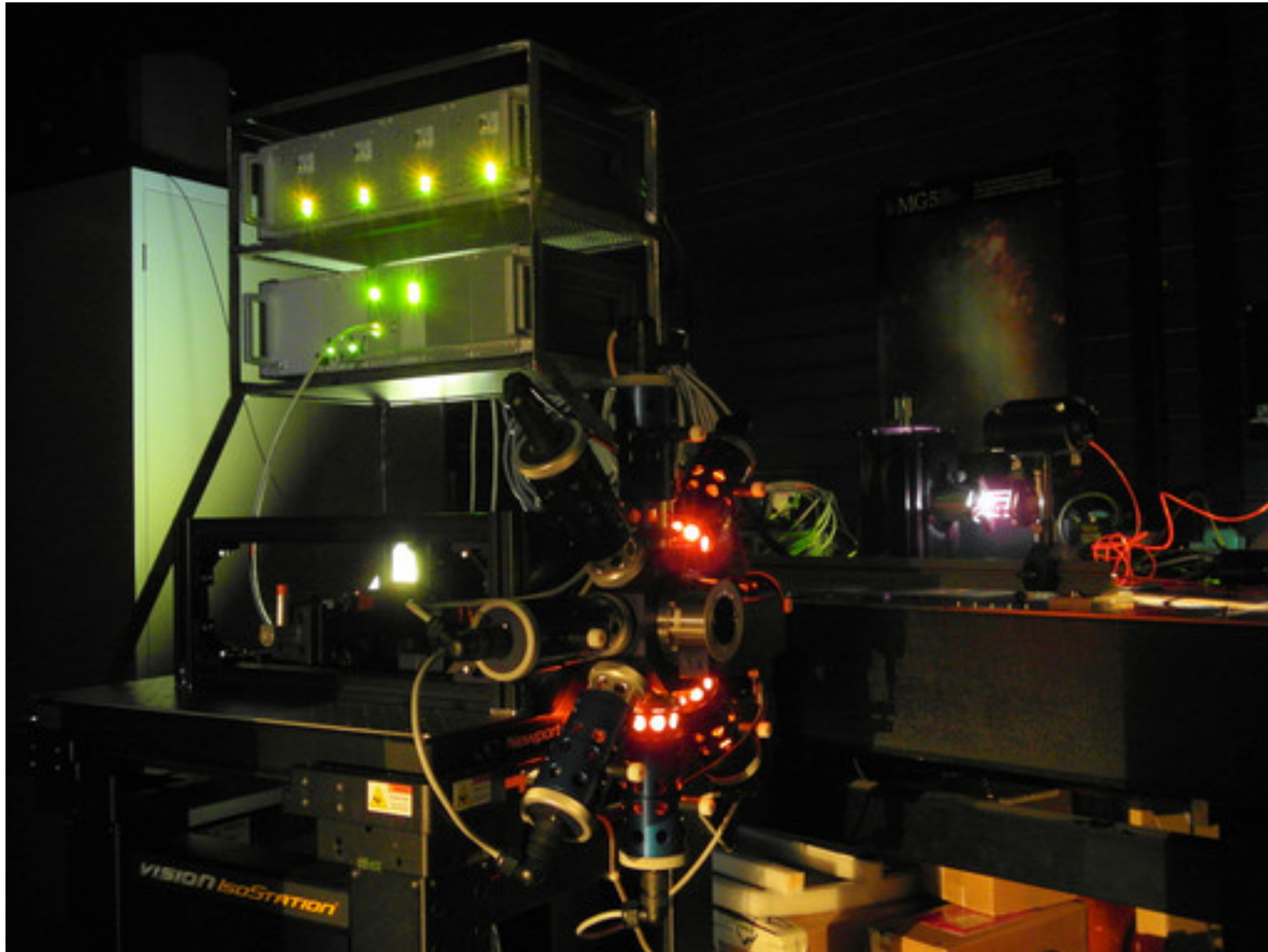




# carmenes



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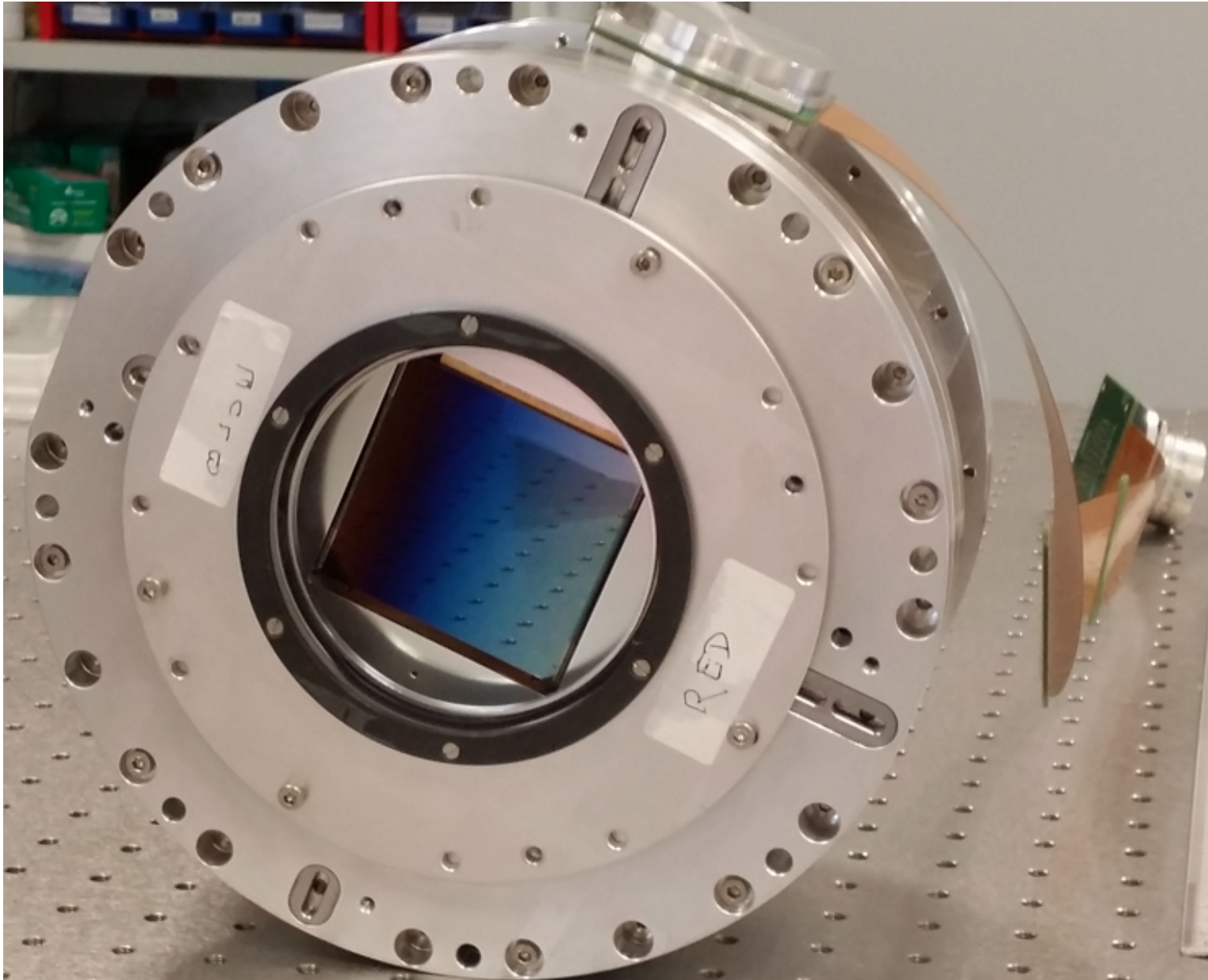


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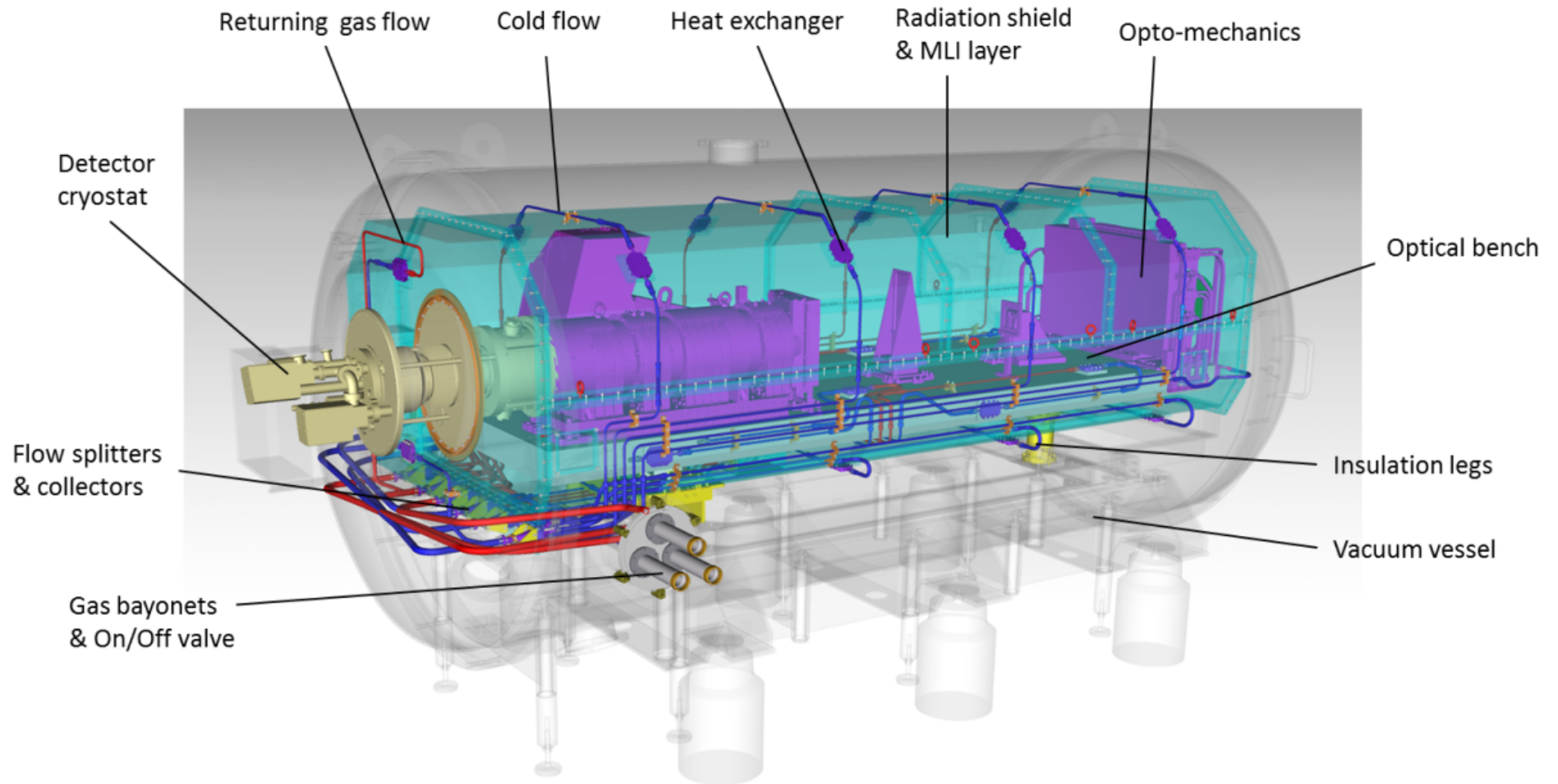


The screenshot displays a desktop environment with several windows:

- Terminal (Konsole):** Shows a shell prompt `pipedev@lalande:~> start_pipe` and the output of a pipeline script. The script prints "Starting pipeline", "Hello?", "Hello?", and "Hello, is there anybody out their?". It then reports "Ups, spectrograph has yet not arrived at Calar Alto. Ok, I'm waiting ..." and "ds9 ...". Finally, it prints "Meanwhile, I show you a simulated spectrum ...".
- SAOImage ds9:** A window showing a 2D spectrogram of a star. The title bar reads "SAOImage ds9". The menu bar includes "View", "Frame", "Bin", "Zoom", "Scale", "Color", "Region", "WCS", "Analysis", and "Help". The main area shows a spectrogram with a color scale at the bottom ranging from 3988 to 36012. A region is selected, and the extracted spectrum is shown in a separate window.
- Extracted Spectrum (Gnuplot window 0):** A plot titled "extracted spectrum" showing intensity versus wavelength [nm]. The x-axis ranges from 500 to 1050 nm, and the y-axis ranges from 0 to 1.2. The plot shows a red line representing the spectrum, with a color scale at the bottom ranging from 3988 to 36012. The plot is titled "extracted spectrum" and has coordinates "887.352, -0.146186" at the bottom left.

The desktop background features the name *J. Lalande (1732-18)* in a cursive font. The system tray at the bottom shows the time "01:25 PM" and the date "2014-06-19".

# carmenes





# WSO-UV synergy 1



**NUV and FUV photometry of the brightest, latest, single M dwarfs** with  $\delta > -23$  deg  $\rightarrow$  Targets for CARMENES exoplanet hunting

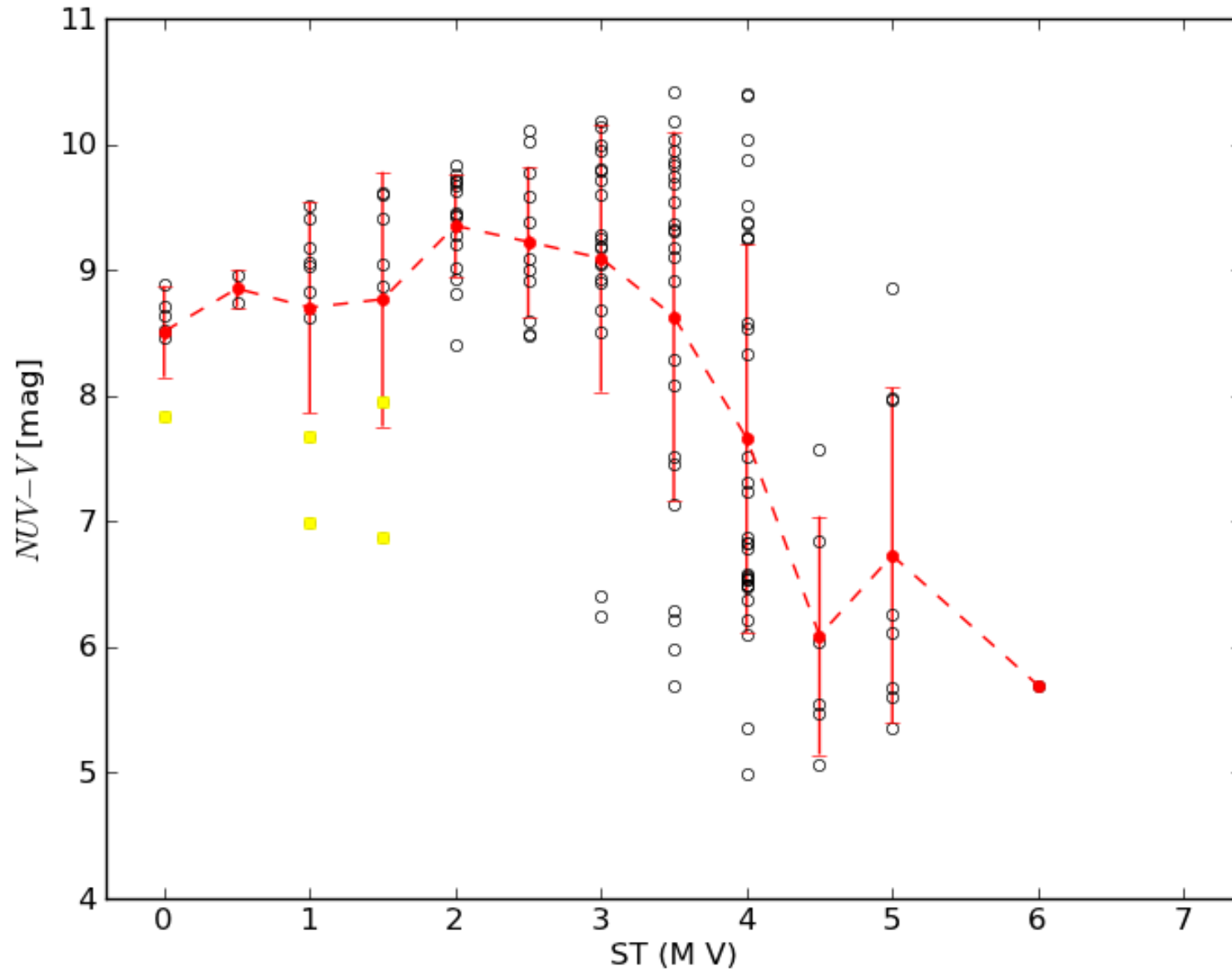
Complement GALEX: SEDs, UV excesses, the **CARMENCITA** legacy catalogue...

+Monitoring: flares, accurate periods... and perhaps transits (Enric's talk)



# Field M dwarf photometry

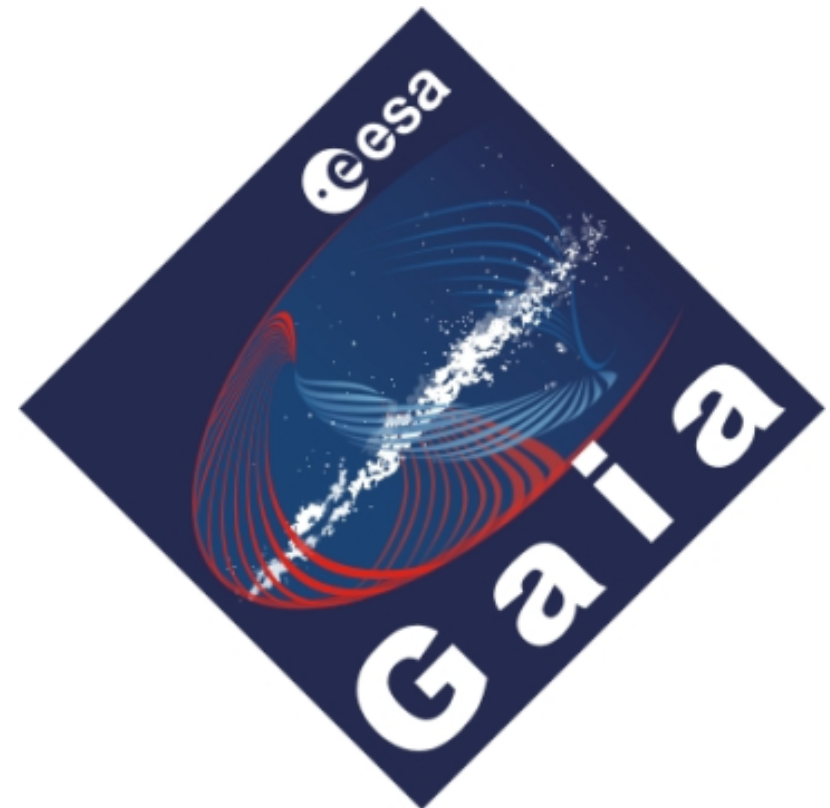
Holgado (2014)





# Gaia and brown dwarfs from Spain

- *Red española de Explotación de Gaia (RecGaia)*
- Network coordinated from Barcelona; researchers from virtually all astronomy centres in Spain
- Several research lines, including **'very low-mass stars, brown dwarfs and exoplanets'** (*BajaMasa*, low mass), with 20+ investigators





# BajaMasa RecGaia research lines

- **EXOS:** exoplanetary systems

- EXOS-1: astrometry of known systems
- EXOS-2: radial velocity of new systems
- EXOS-3: detailed characterisation

- **MLT:** ultracool dwarfs

- MLT-1: late M (H-R diagrams, kinematics...)
- MLT-2: L and T (isolated or companions)

- **YBD:** young brown dwarfs

- Bottom of the (I)MF in young open clusters and stellar associations



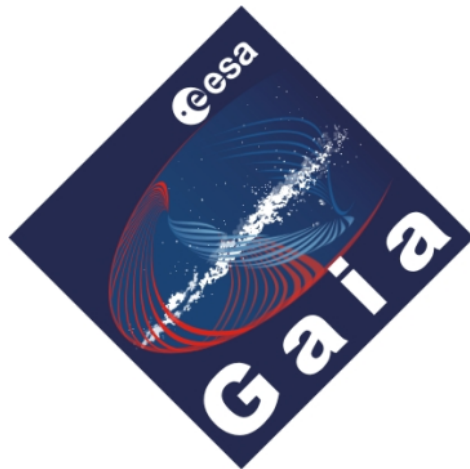
# WSO-UV synergy 2



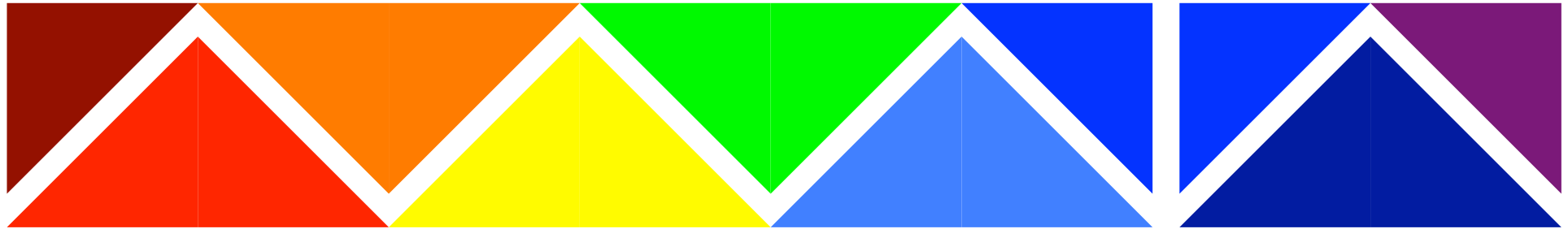
***NUV* and *FUV* photometry of the brightest ultracool dwarfs ( $SpT > M6V$ )**

Complement *GALEX*: SEDs, UV excesses

VO public catalogue with homogeneous astrometry, photometry, spectroscopy, astrophysical parameters ([exoplanets.eu](http://exoplanets.eu), [dwarfarchive.org](http://dwarfarchive.org)): **MAIA**



# WSO-UV synergy 2



## M-, L- and T-dwarf Archive of Interest for Astrophysics

Mem. S.A.It. Vol. 75, 282  
© SAIIt 2008

Memorie della



### Gaia and brown dwarfs from Spain

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**Abstract.** *Gaia* will not observe 50 000 brown dwarfs, but about 100 times less. However, these  $\lesssim 500$  brown dwarfs will be benchmarks for many substellar topics. It is possible to identify them in advance and make the list public to all astronomers worldwide through a virtual observatory-compliant “*Gaia* brown dwarf” catalogue. This *M-, L- and T-dwarf Archive of Interest for Astrophysics* would tabulate precise *Gaia* astrometry, multiband photometry, high- and low-resolution spectroscopy and homogeneously derived astrophysical parameters. Spanish observatories may play a key role in the catalogue preparation.

**Key words.** Astronomical databases: miscellaneous – Catalogues – Stars: brown dwarfs – Stars: late-type



European Research Council

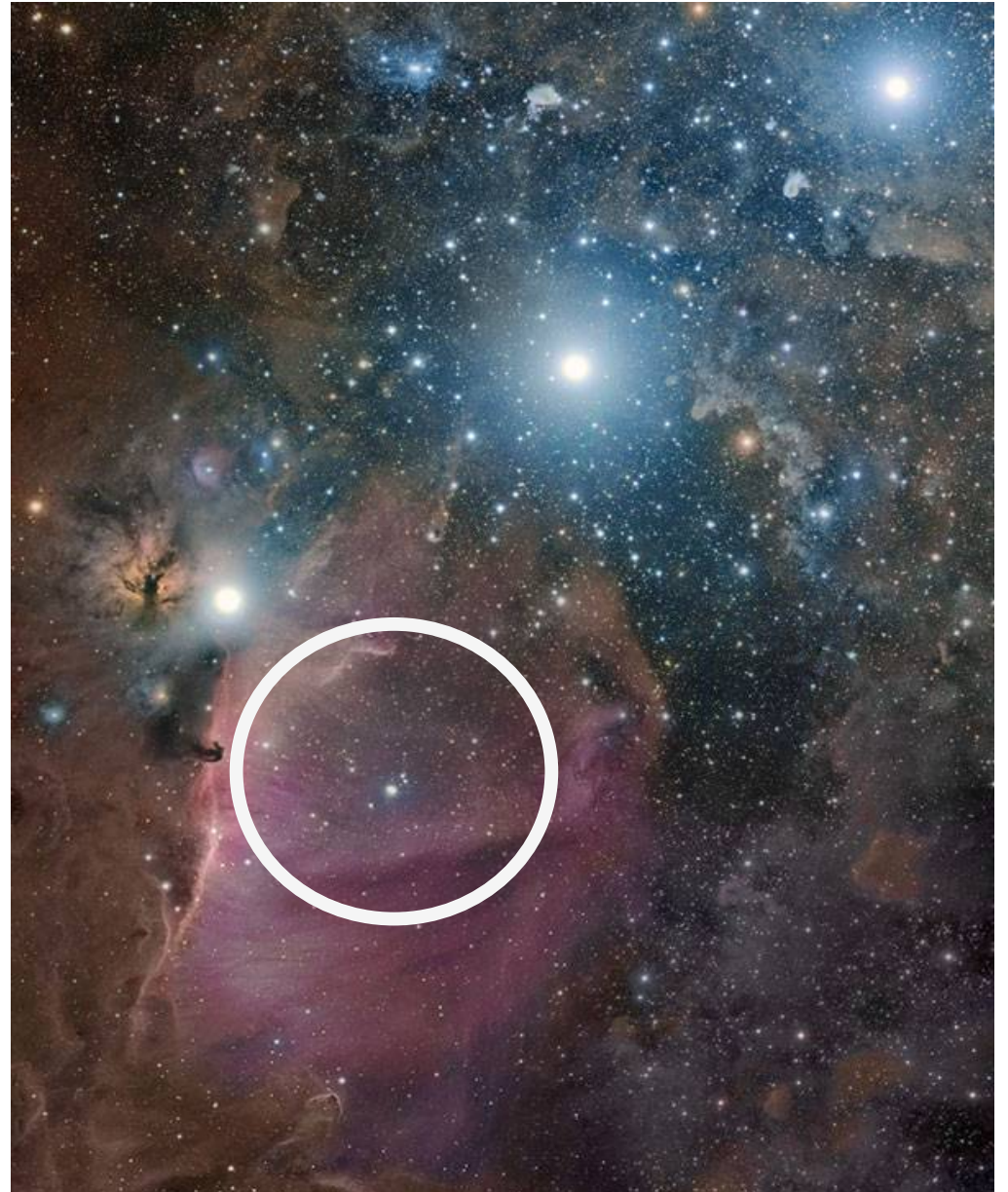
Established by the European Commission



# WSO-UV @ $\sigma$ Orionis

ISSIS/WSO-UV and  
 $\sigma$  Orionis:  
*brown dwarfs in the  
ultraviolet (4)*

Age  $\tau \sim 3$  Ma  
Distance  $d \sim 385$  pc  
Radius  $\rho \sim 30$  arcmin  
Extinction  $A_V < 0.3$  mag





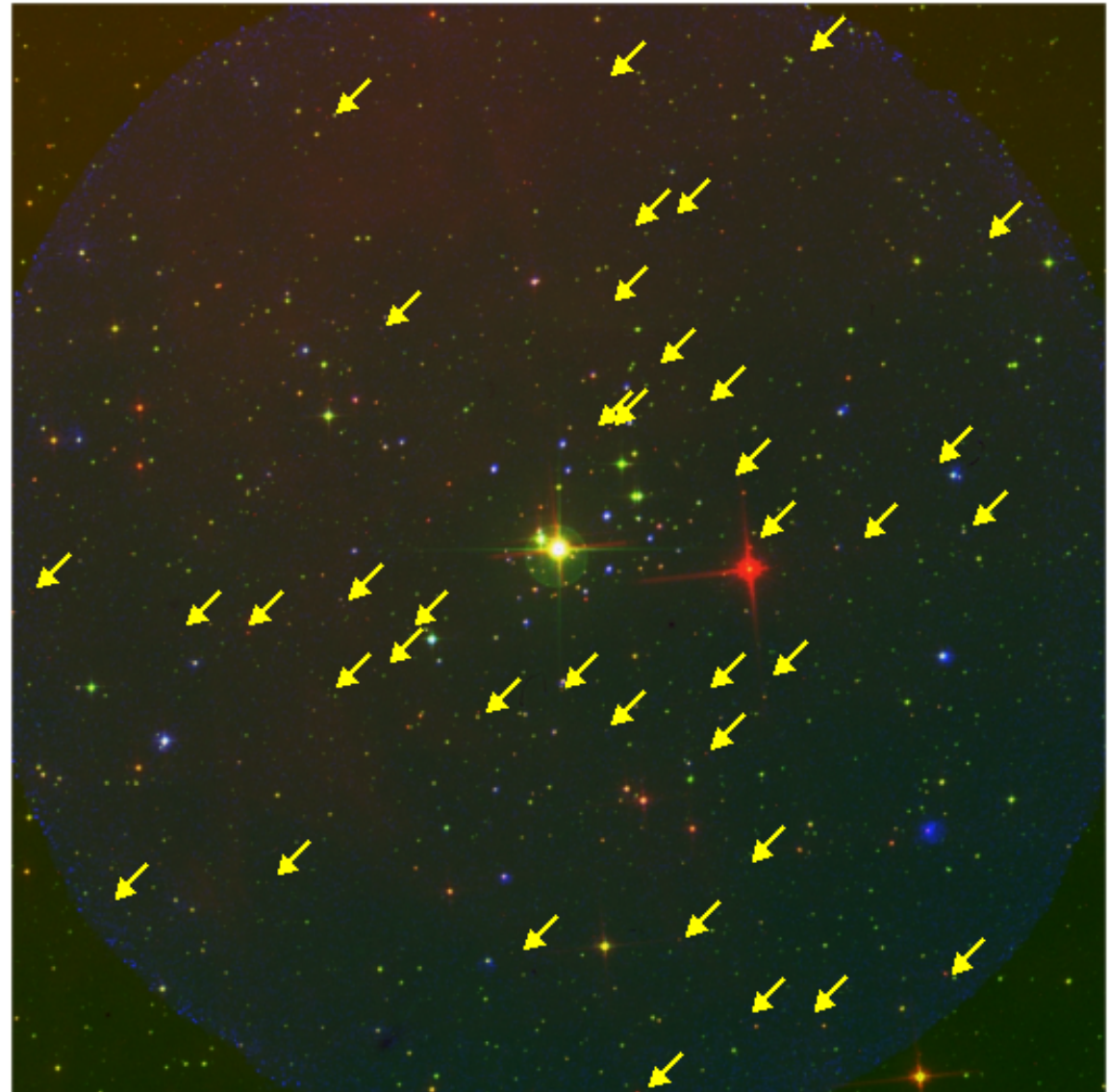
# WSO-UV @ $\sigma$ Orionis



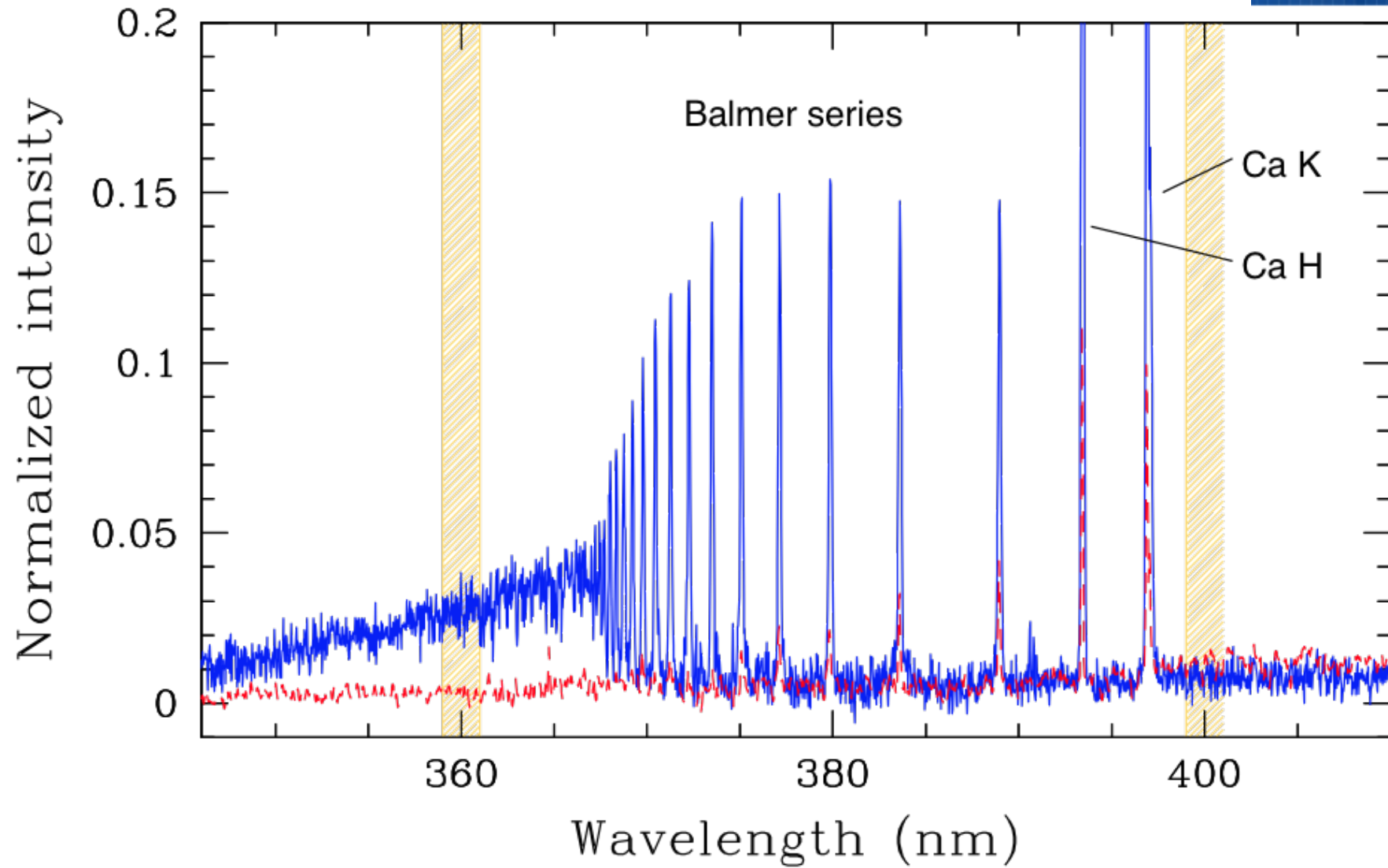
Important because...

A well-studied **mass function**, esp. in the low-mass stellar and substellar domain

Brown dwarfs and  
“isolated planetary-mass objects”  
(IPMOs)



# WSO-UV @ $\sigma$ Orionis



V2728 Ori (Mayrit 495216) : X-shooter/VLT (Rigliaco et al. 2011)

# WSO-UV @ $\sigma$ Orionis

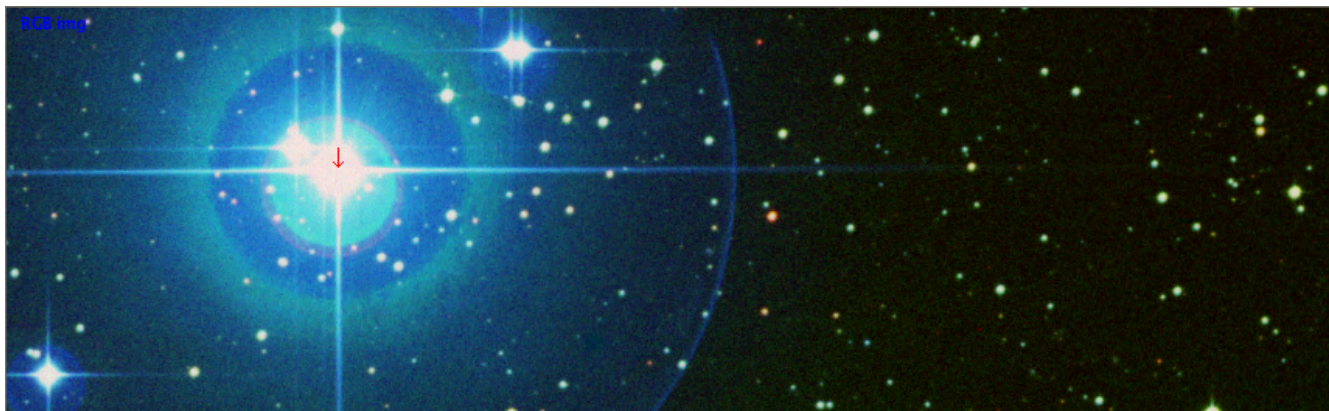


- Default observation:
  - One *brown dwarf* per pointing (no survey)
  - *NUV*  $t_{\text{exp}} \geq 900$  s
  - Open filters (Mg II  $\lambda 280$  nm?)
  - *FUV* impossible!
- Extend SED from *ugriz* to the *NUV*: colour-colour diagrams  $\rightarrow$  UV excess & accretion indication

# WSO-UV synergy 3



- A programme:
  - $N$  brown dwarfs *and* very low-mass stars (NUV, open, 900 s)
  - + 33% overheads  $\sim 1.2$  ks per field
  - Total time =  $1.2N$  ks
  - XMM-Newton comparison: 24-36 ks  $\rightarrow N = 20$ -30 targets (statistics)





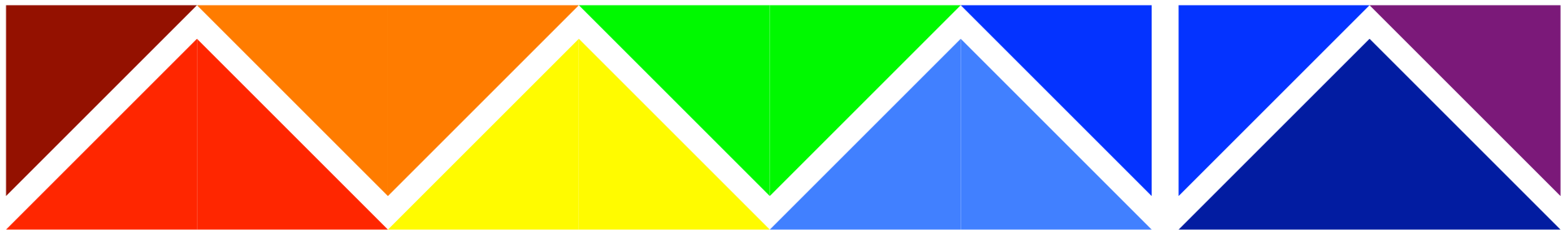
# WSO-UV @ $\sigma$ Orionis (and many other clusters!)



*“Brown dwarfs in UV: a Letter;  
IPMOs in UV: a Science or a Nature”*

Caballero (2009, 2011, 2012, 2014)

# carmenes



**M-**, **L-** and **T-dwarf** **Archive** of **Interest** for **Astrophysics**

