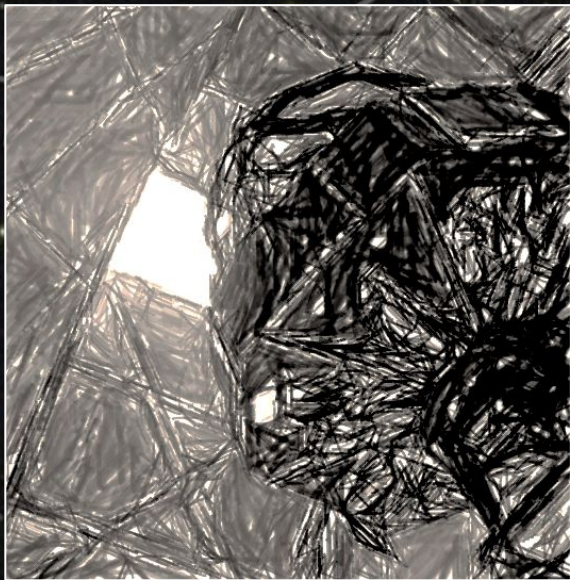


# T80-South and its survey

Science, status of observatory  
and observations

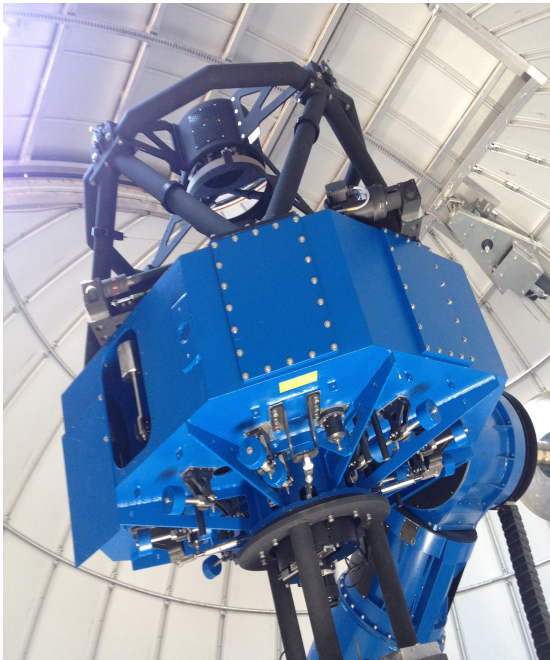


**Claudia Mendes de Oliveira & Fábio R. Herpich**

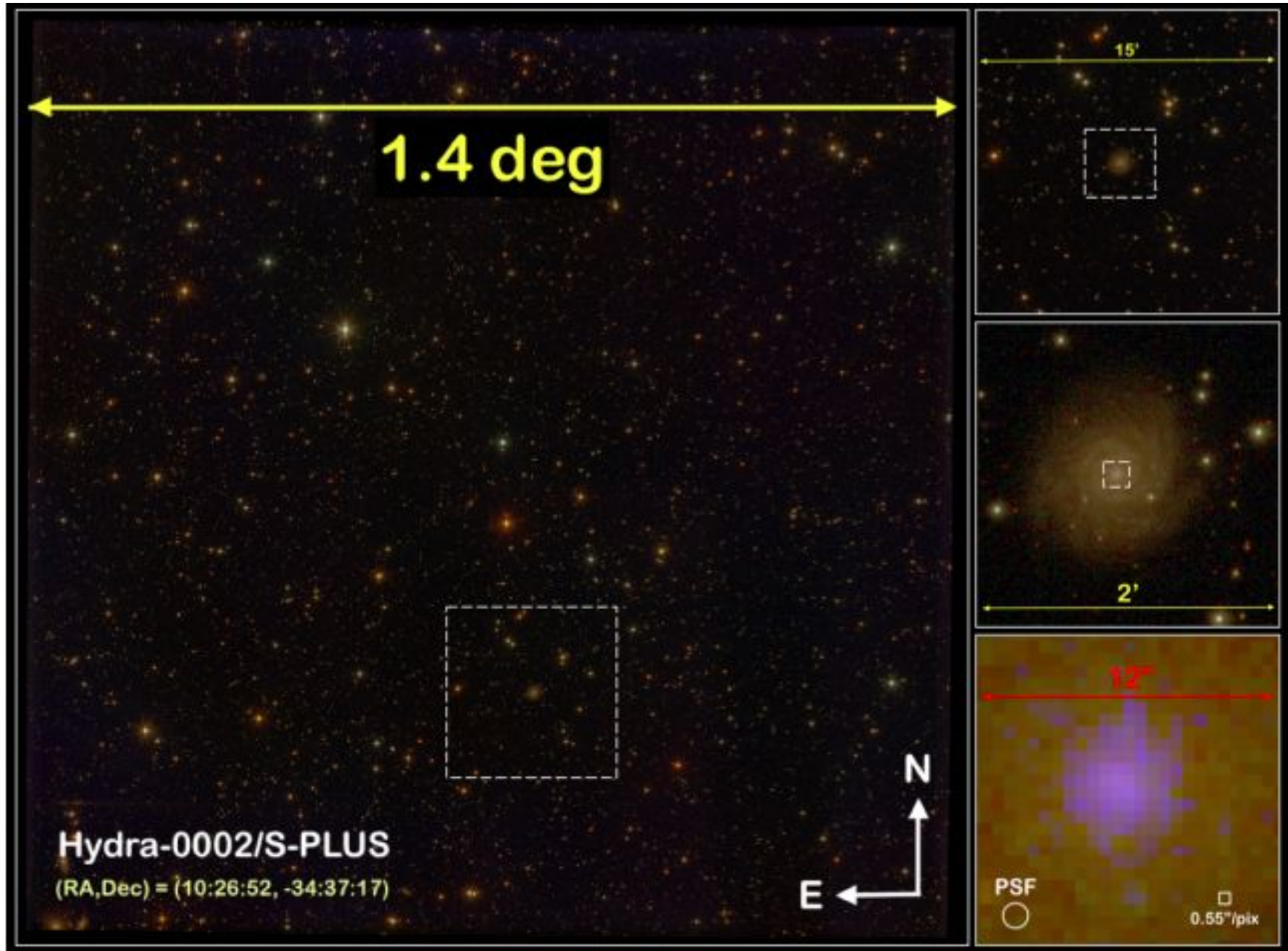


# Southern Photometric Local Universe Survey

Coverage:  $\sim 9300 \text{ deg}^2$   
Telescope: 86cm (T80S)  
Plate scale: 0.55 arcsec/pixel  
FoV:  $1.4 \times 1.4 \text{ deg}^2$



# Field of view of T80-South images



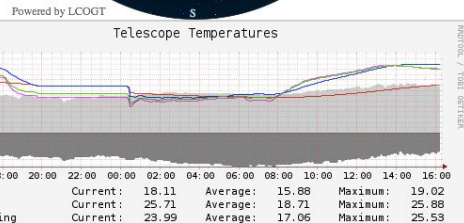
Temperature (indoor, outdoor, telescope, mirrors, camera), Dew point, Humidity, Cloud sensor, Sky brightness, Rain sensor, Pressure, All sky camera

# T80S TelOps Site

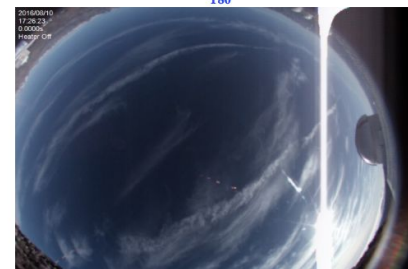
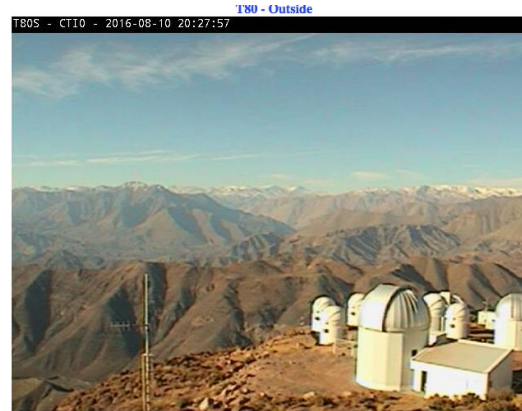
## T80 Telops page

Red means outdated information.  
All times are UT

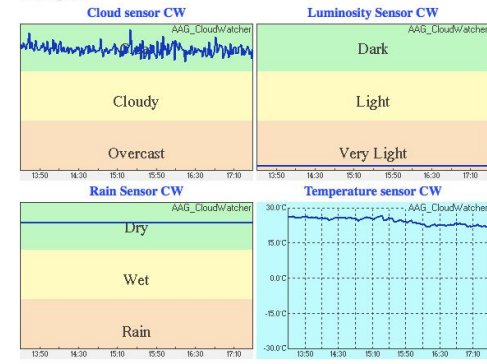
### Observatory



TIME	
UTC	20:29:21
LST	13:05:07
MOON & SUN	
Moon Phase	43 %
Moon Altitude	65 deg
Next Moon Rise	15:25:18
Next Moon Set	03:48:40
Sun Altitude	-12 deg
Next Dawn	10:58:36
Next Dusk	22:41:24
MOUNT	
State	Stopped
Position (ra, dec)	13:01:24.527 -29:54:23.852
M1 Fan	OFF
M1 temperature	18.21 deg_C
M2 temperature	25.69 deg_C
Front Ring temperature	23.88 deg_C
Mirror Cover	Closed
Last Update	2016-08-10 20:25:19
DOME	
State	Stand
Dome Slit	CLOSED
Dome Flap	CLOSED
Azimuth	89.90
East Fan	OFF
Last Update	2016-08-10 20:27:13
SCHEDULERS	
SEQUENTIAL	



T80	
Temperature	16.00 deg_C
Humidity	17.30 %
Wind Speed	3.40 m / s
Sky Transparency	353.00 deg
Pressure	78620.00 Pa
Weather Station Last Update	2016-08-10 20:20:46
Transparency Last Update	2016-08-10 20:21:54
<a href="#">Seeing Monitor</a>	
Seeing	1.36 arcsec
Last Update	2016-08-10 10:37:02
<a href="#">RASICAM</a>	
Sky Transparency	
Last Update	

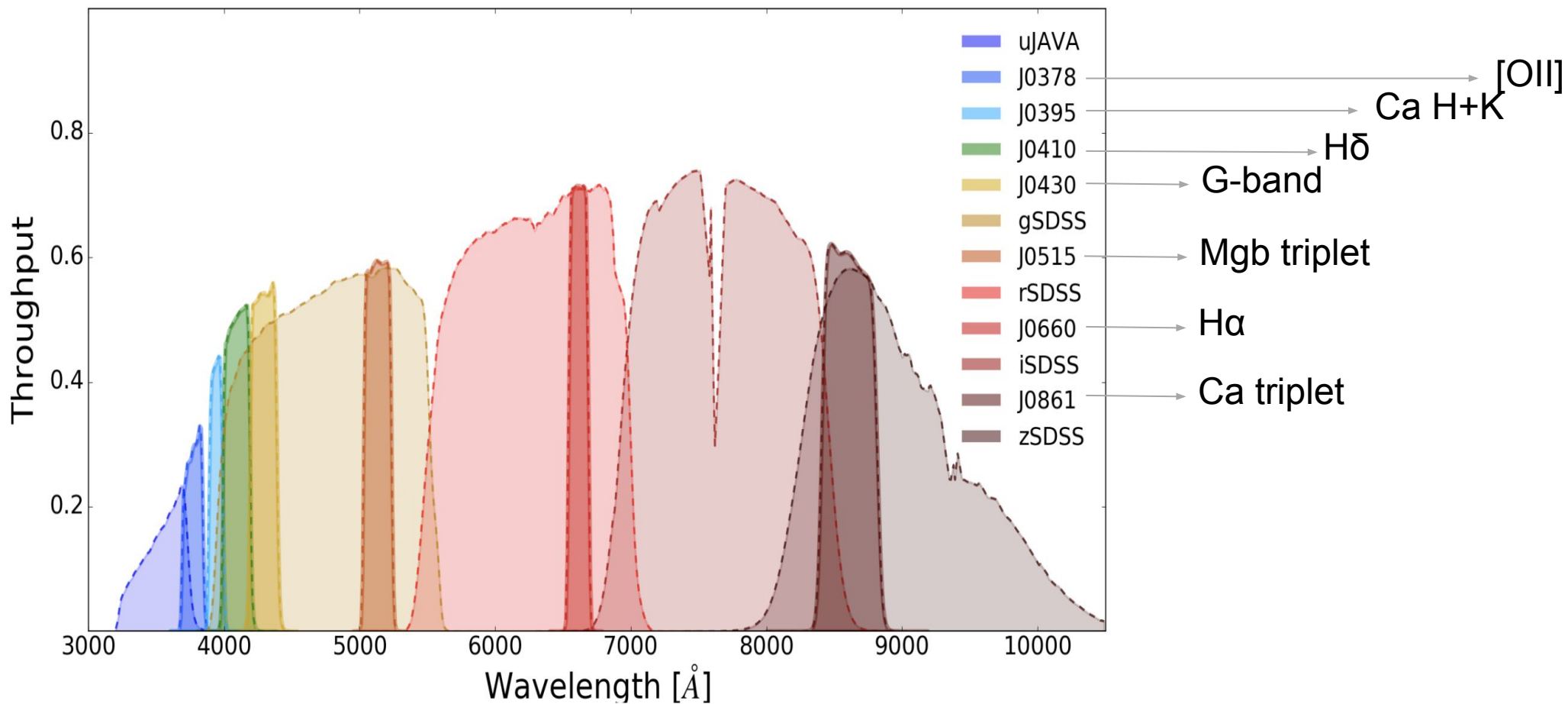


Telescope and dome are fully automated

Different sub-surveys done in a given night depending on weather and seeing conditions

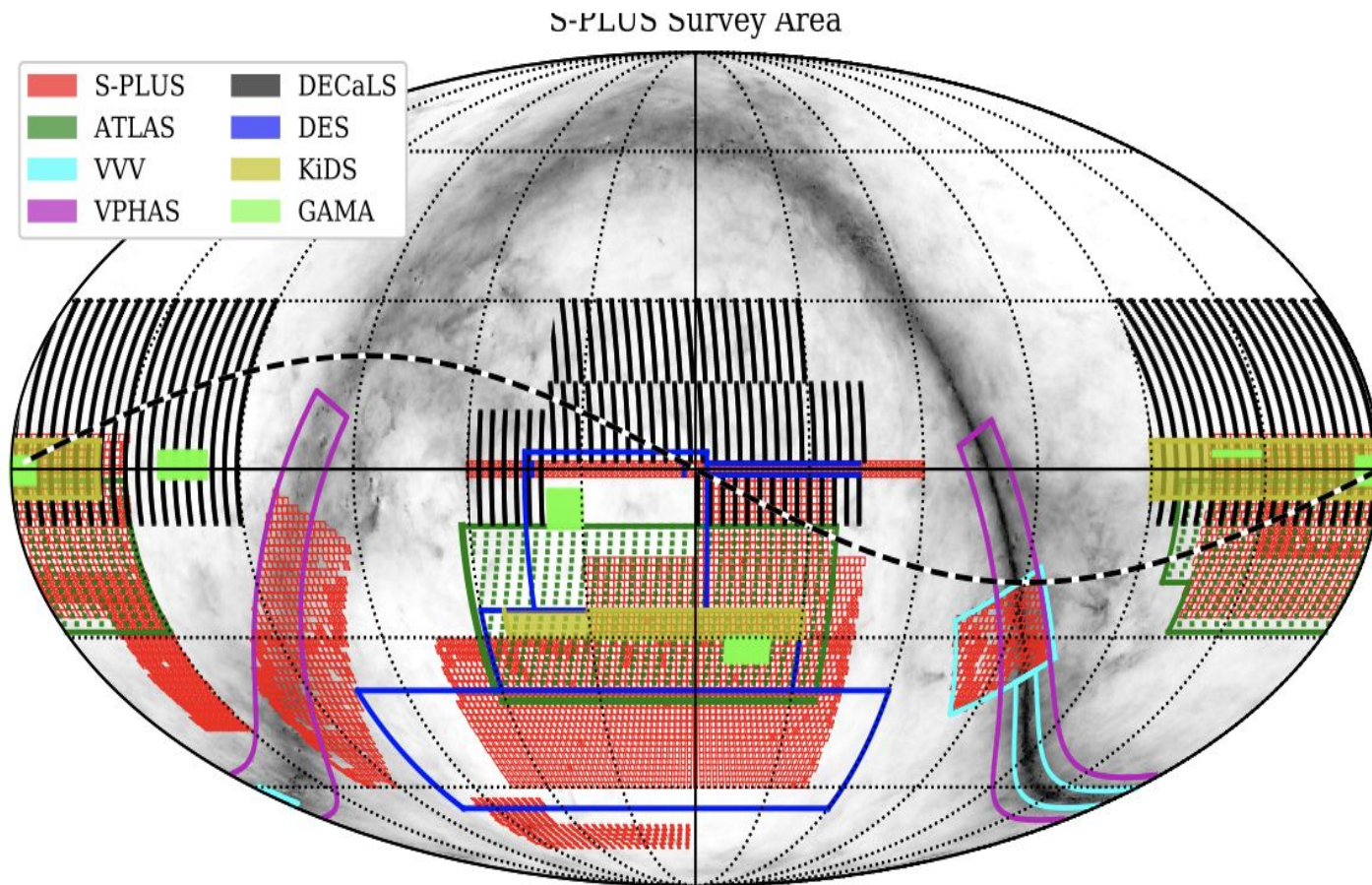
Pre-reduction done immediately after the object is observed, final reduction takes 1-4 weeks

# JAVALAMBRE filter system

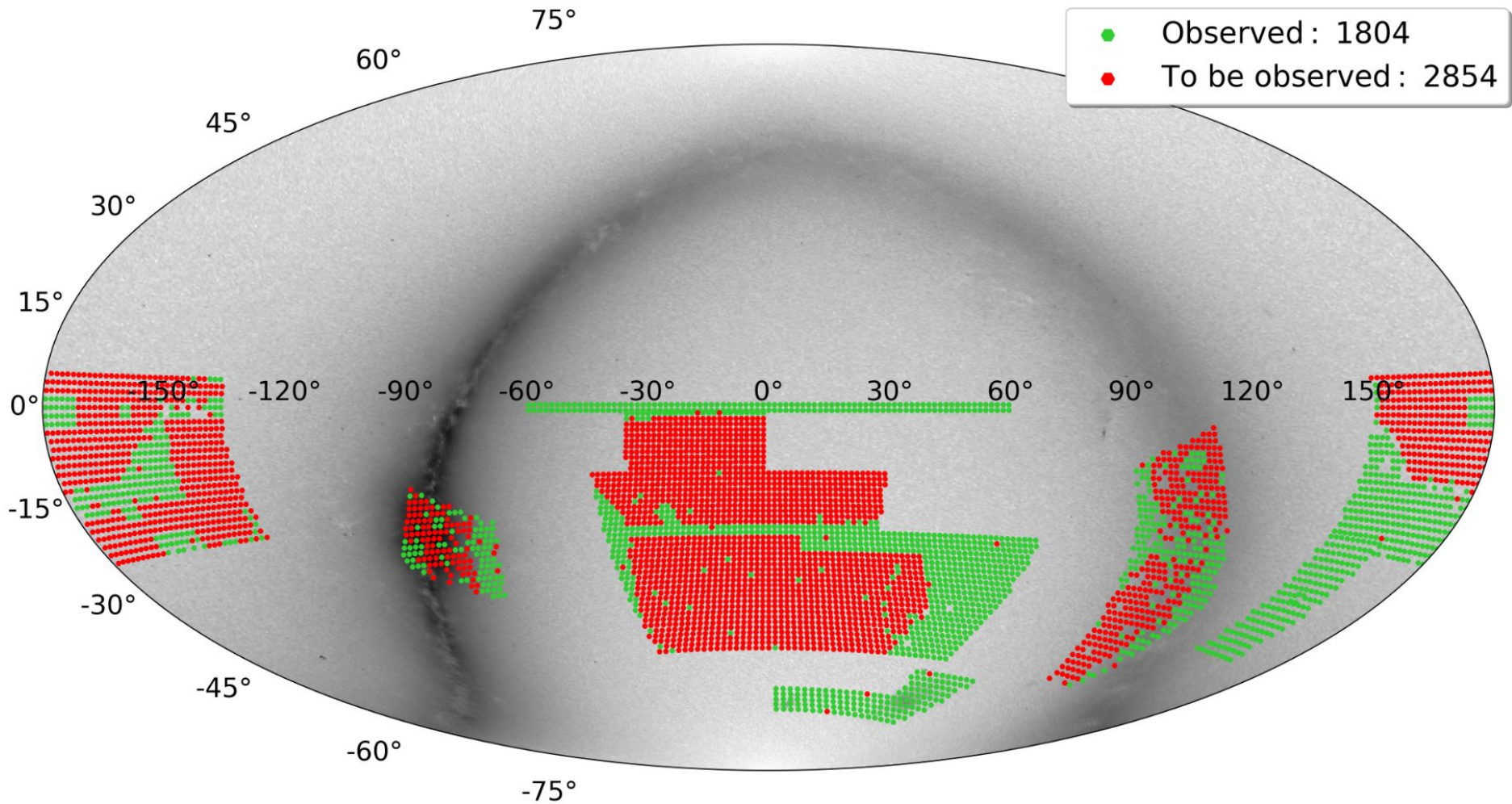


**Figure 6.** The Javalambre 12-filter system. The y-axis shows the total efficiency of the S-PLUS filters, obtained through the multiplication of the average filter transmission curves, the atmospheric transmission, the CCD efficiency, and the primary mirror reflectivity curves. Different filters are coloured according to the labels shown in the legend at the right.

# S-PLUS Survey Area



In red + green the survey footprint  
In green what has been observed so far

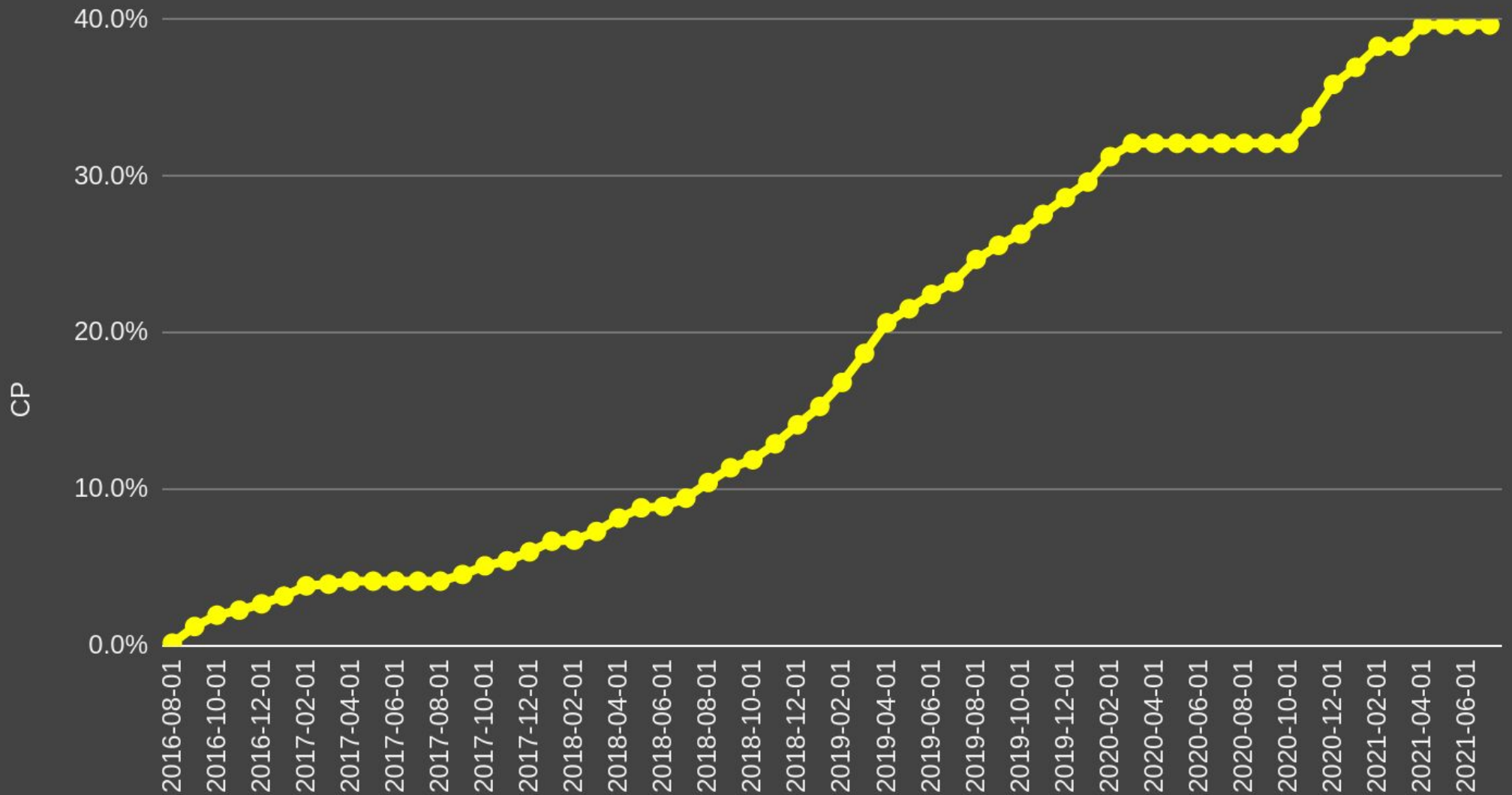


It should be possible to ask for prioritizing target observations that may lead to fast turn-around science



# S-PLUS progress - Completeness

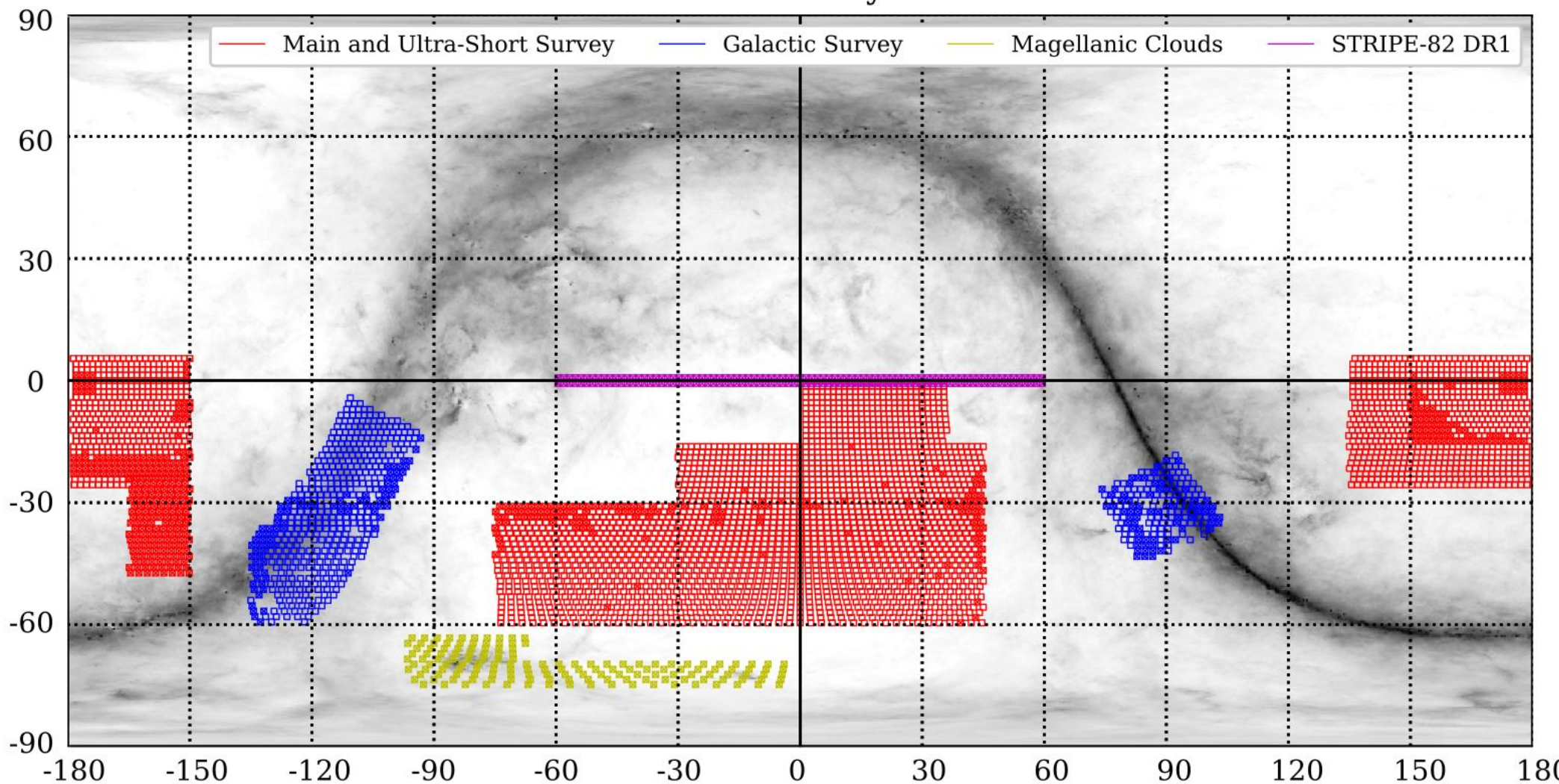
Cumulative completeness



# 9300 deg<sup>2</sup> in 5 sub-surveys

- **MainSurvey**
- **Ultra-short survey**
- **Variability fields**
- **Galactic Survey**
- **Marble Fields**
- **MC**

S-PLUS Survey Area



# Niches of S-PLUS



- Photo-zs of galaxies and quasars
  - 3D catalogue of the nearby universe.
  - Cosmological studies using a large sample of quasars.
  - LSS, clusters and associated structures, filaments.
  - Galaxies and satellite populations, interacting galaxies
- Milky Way science and the Magellanic cloud
  - $T_{\text{eff}}$ , Fe/H, C/Fe, chemical abundances for Ms of stars,
  - Chemically peculiar stars
  - Stellar components of the MW
  - Stellar populations in the MCs
  - cross correlations with other wavelengths.
- Sinergies with DES and LSST, in the nearby Universe. And Gaia.

# Photometric redshifts (photo-zs) with S-PLUS

M.L. Buzzo and E. Vinicius-Lima

Le PHARE - Template-Fitting

- Precision of 1%, 2% and 3% for  $r < 17$ ,  $r < 19$  and  $r < 21.3$

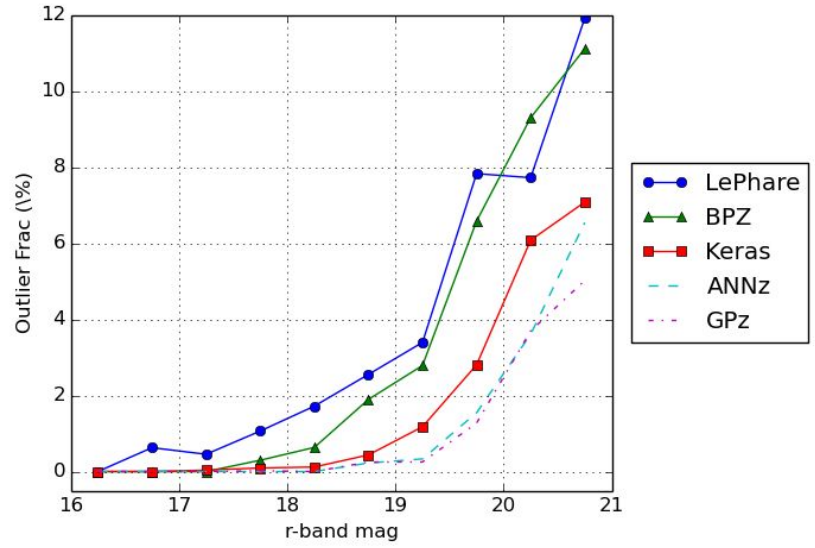
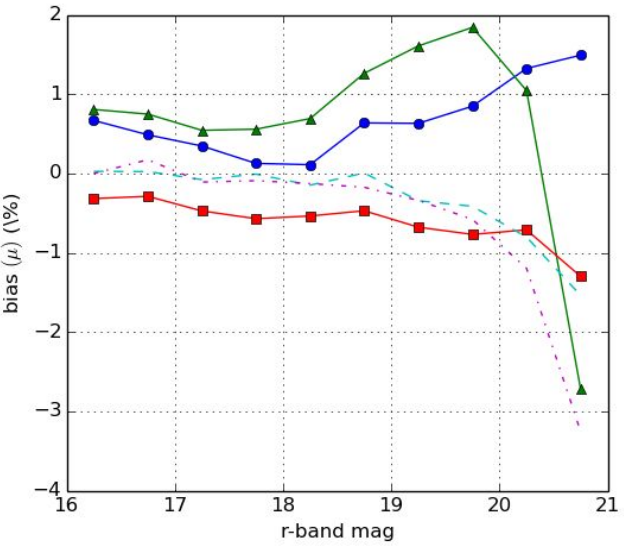
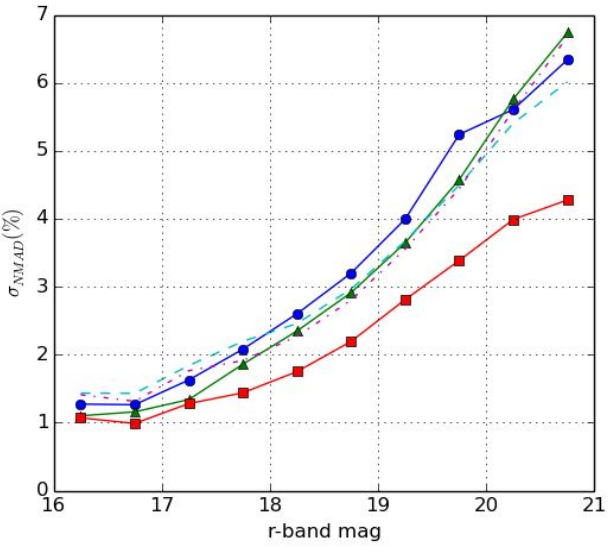
**Photo-z + Spectral Types + Physical Properties**

Best world:  
hybrid  
methods

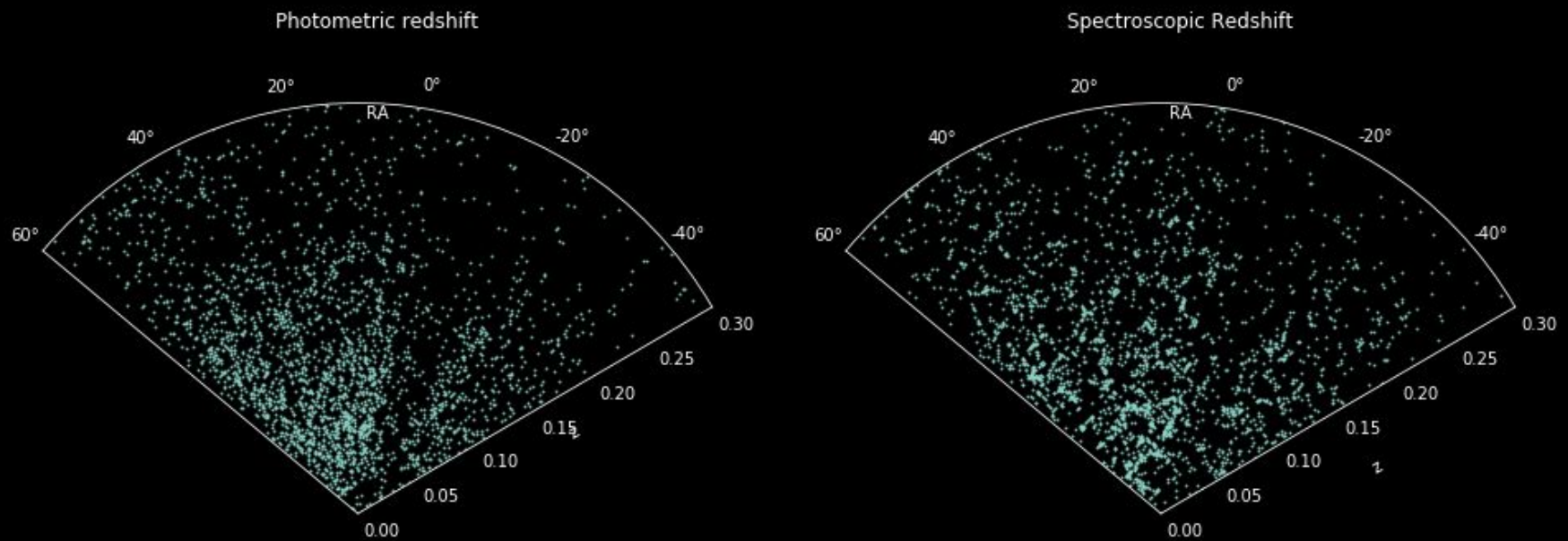
Machine Learning

- Precision of 1.05%, 1.75% and 2.49% for  $r < 17$ ,  $r < 19$  and  $r < 21.3$

**High-Accuracy photo-z**

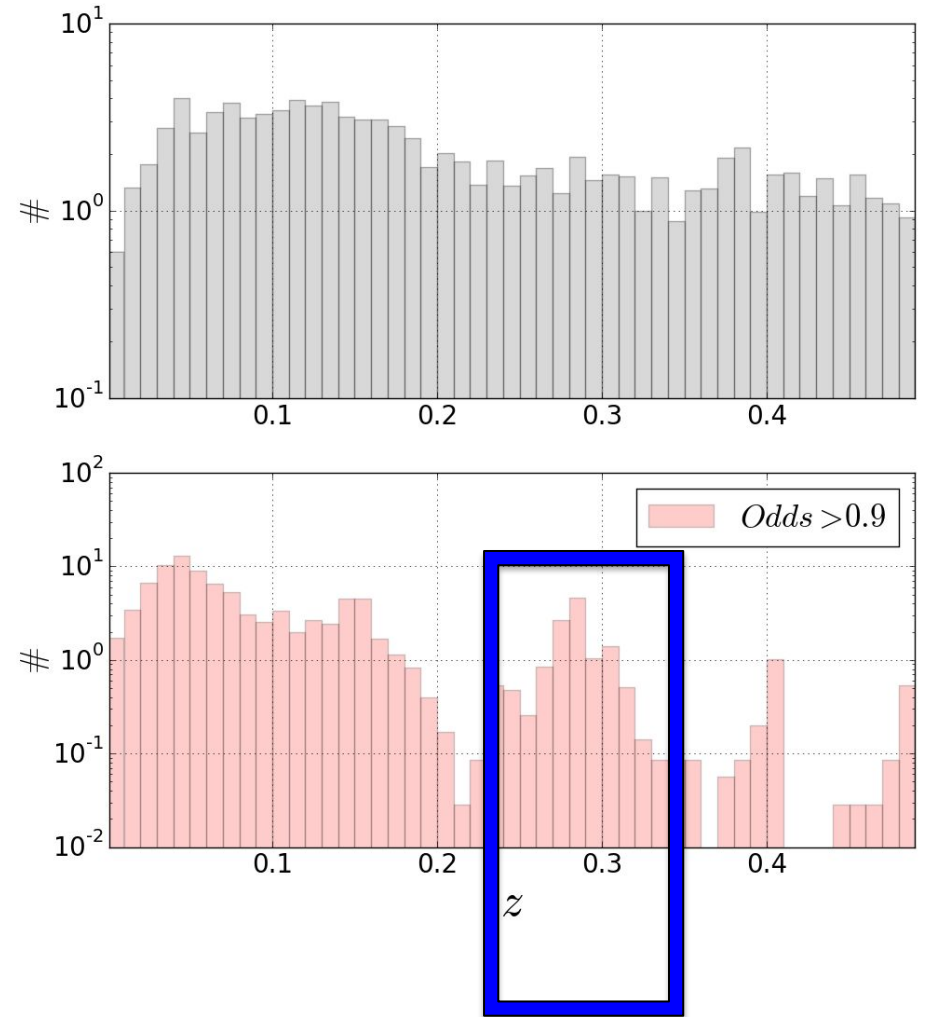
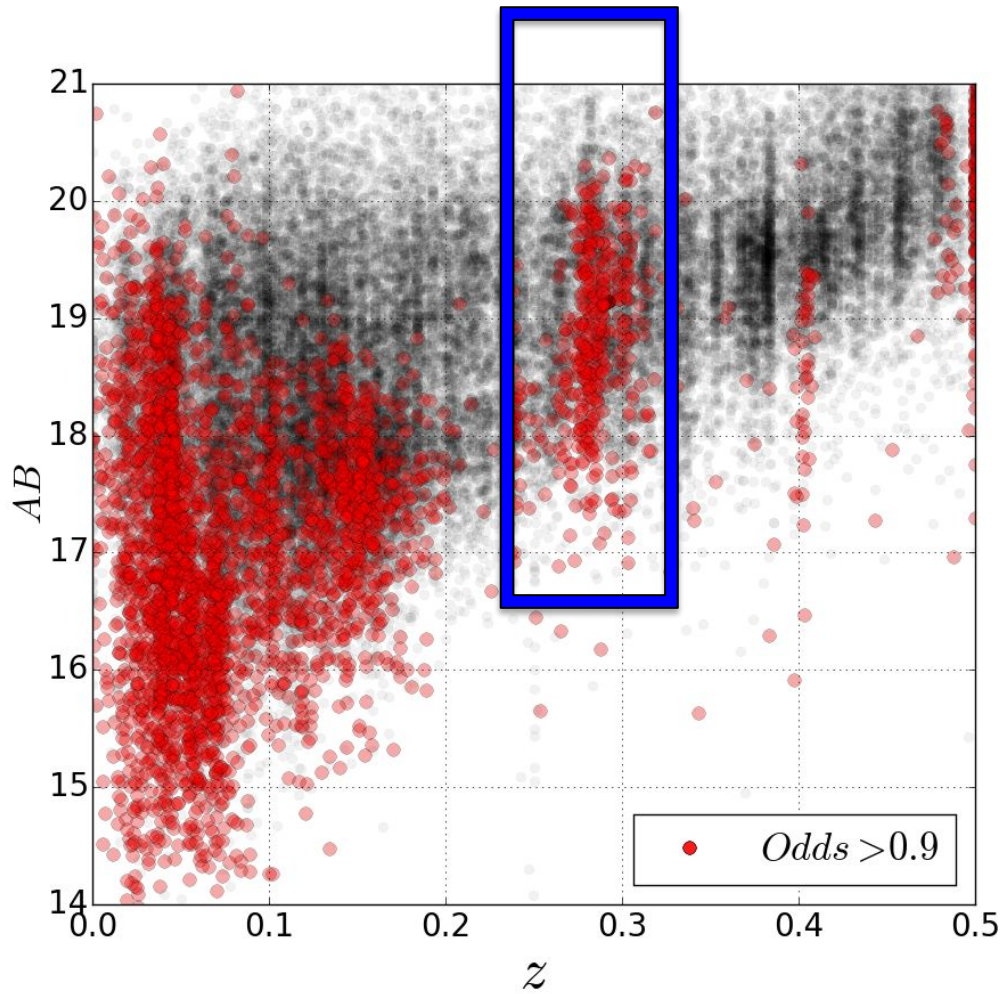


# Large scale structure using S-PLUS photo-zs



**M. L. Buzzo and E. Vinicius-Lima**

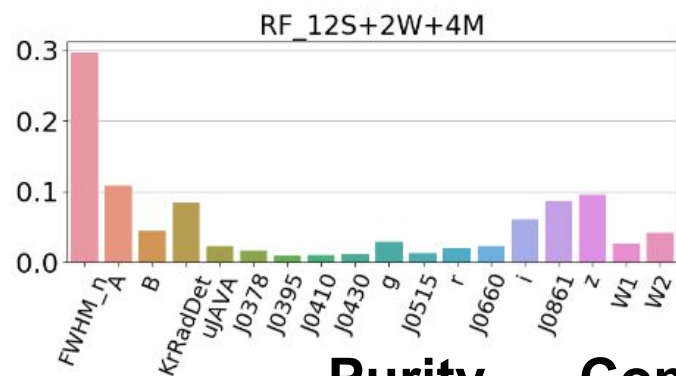
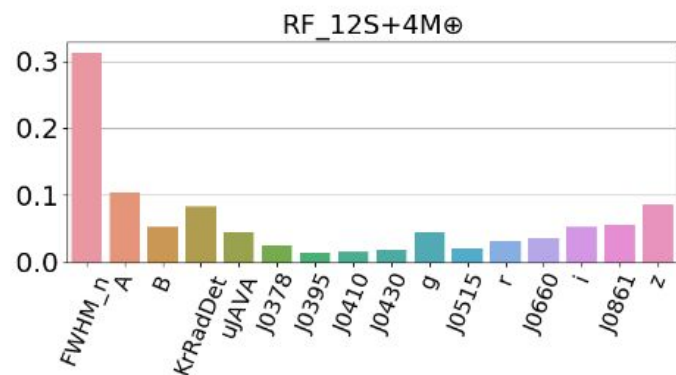
# Redshift Window Opportunity for ELGs at $z \sim 0.3$



Molino et al. 2020

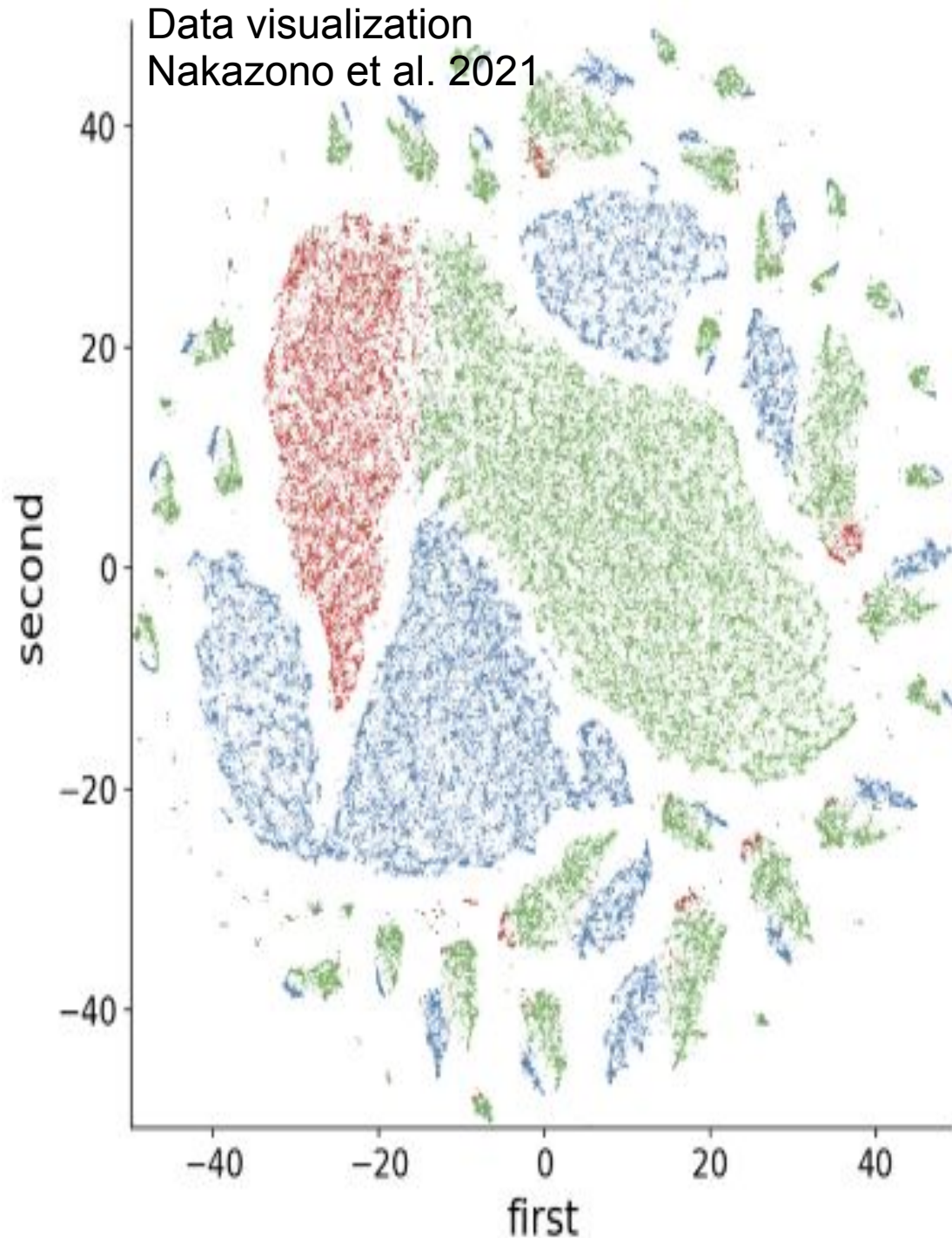
# STAR/QSO/GALAXY classification

With a random forest algorithm on 12 S-PLUS bands + 4 morphological features + 2 WISE bands we achieve:



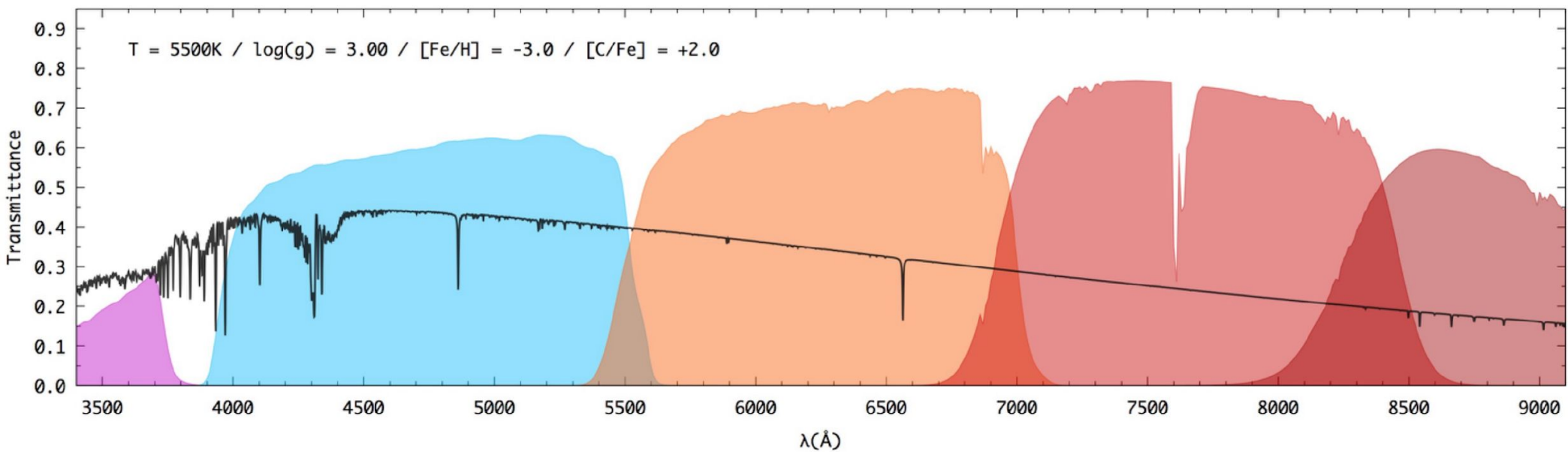
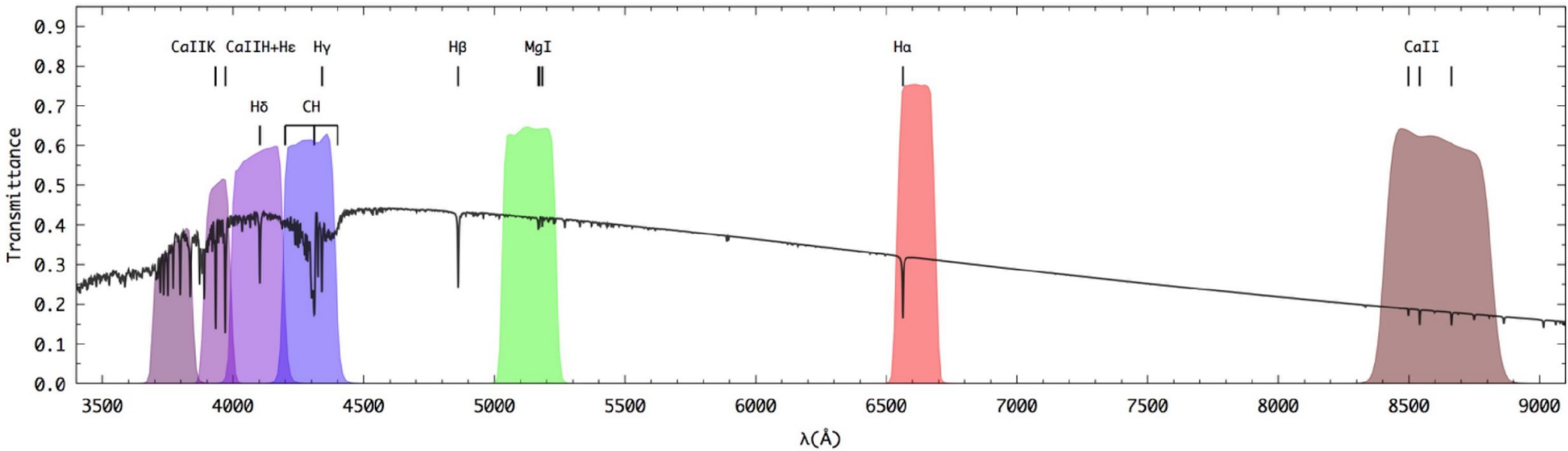
	Purity (%)	Completeness (%)
<b>QSO</b>	95.76	95.88
<b>STAR</b>	99.44	98.22
<b>GALAXY</b>	98.04	98.8

Data visualization  
Nakazono et al. 2021



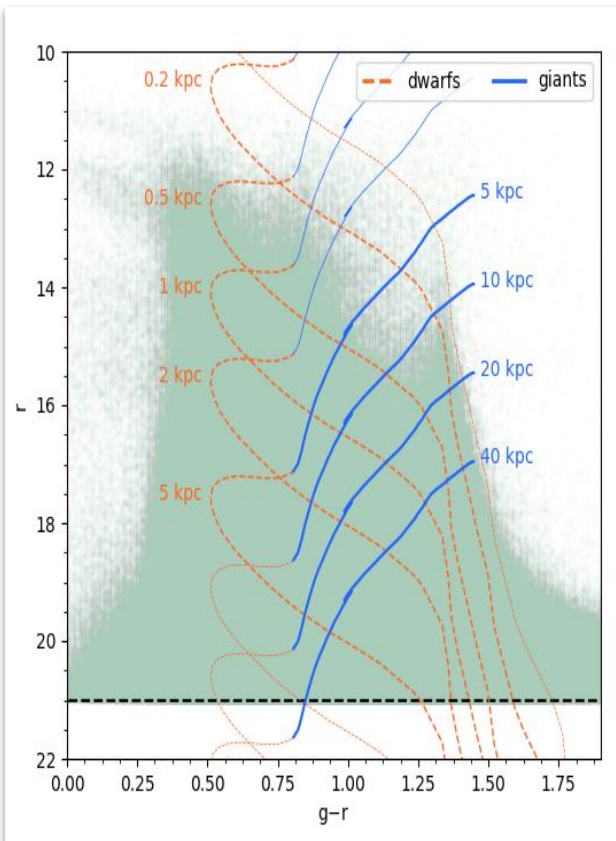
(c) 12 S-PLUS bands + 4 morphological features + 2 WISE bands

# Searching for metal-poor stars (narrow-band vs. broad-band)

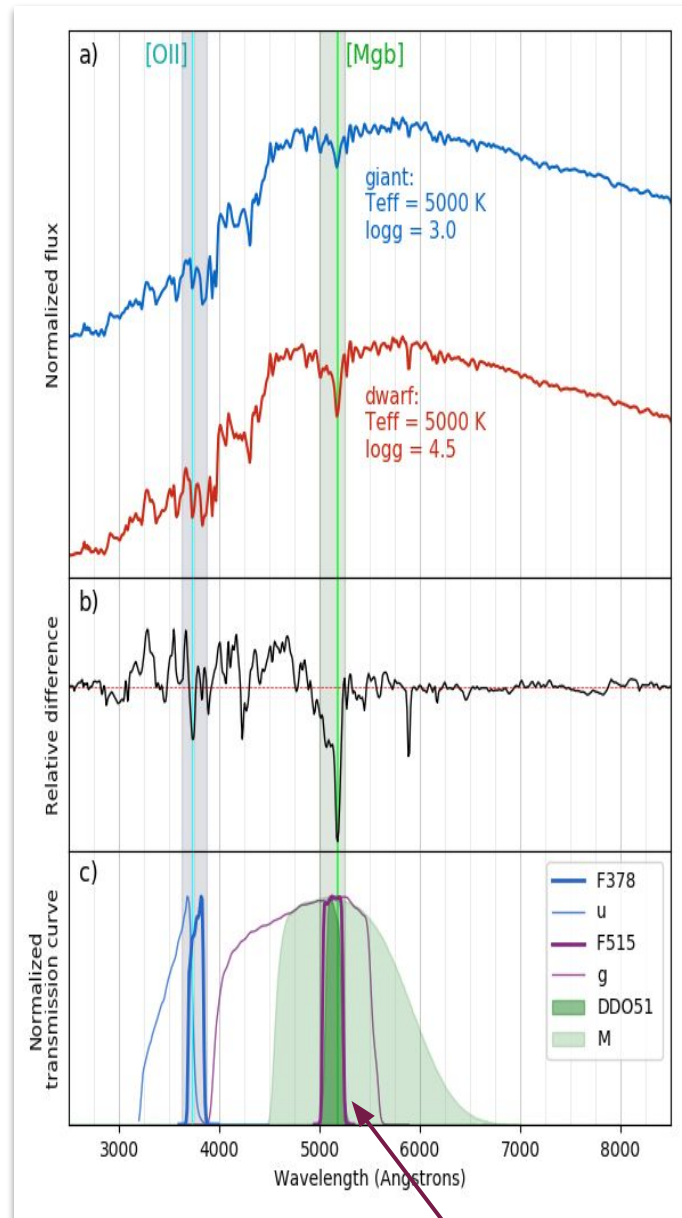




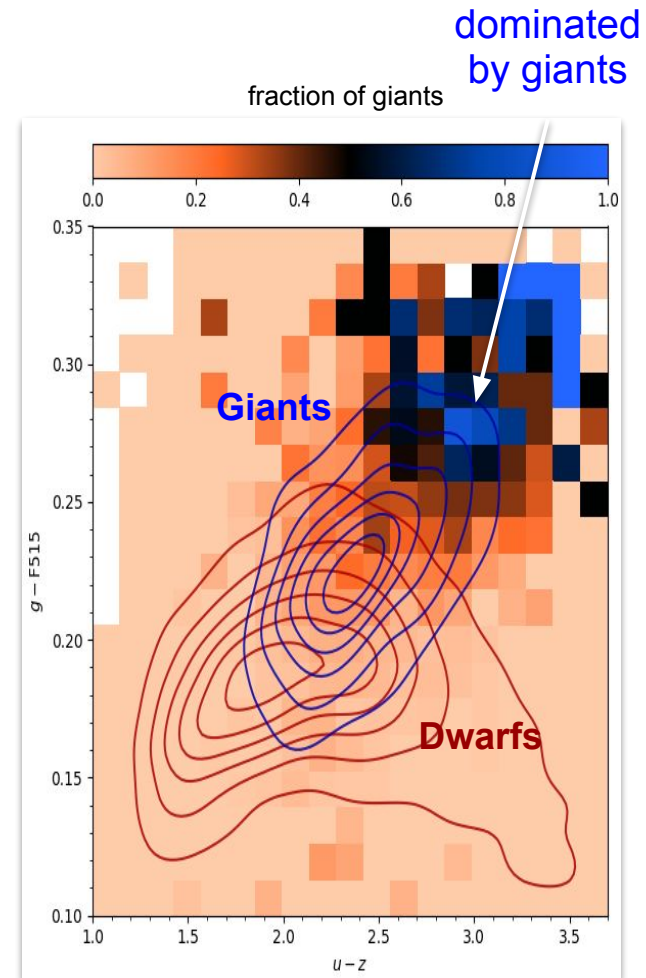
# Dwarf/Giant Separation



S-PLUS observations are a mixture of nearby dwarfs and far away giant stars



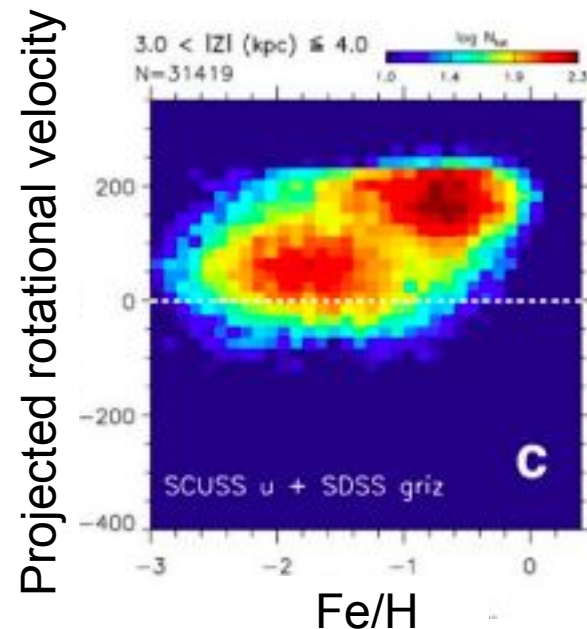
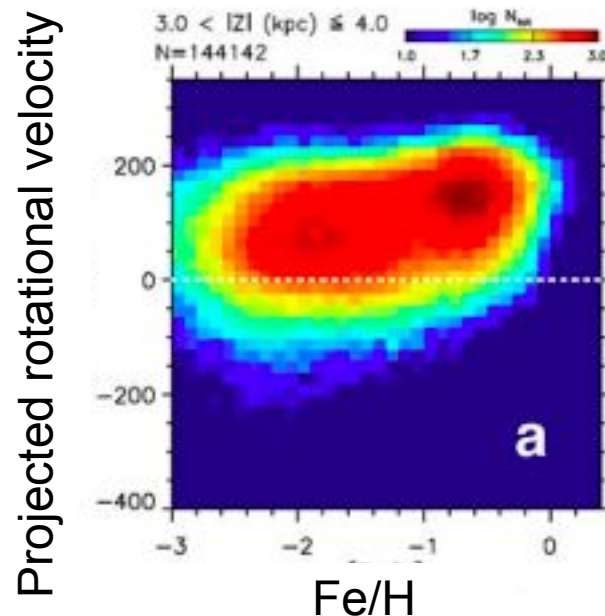
Some narrow band filters (like **F515**) are sensitive to  $\log g$ .



We can use this sensitivity to differentiate between dwarfs and giants.

We use the giants to search for undiscovered overdensities and then characterize the populations

# Mapping stellar components of the Milky Way



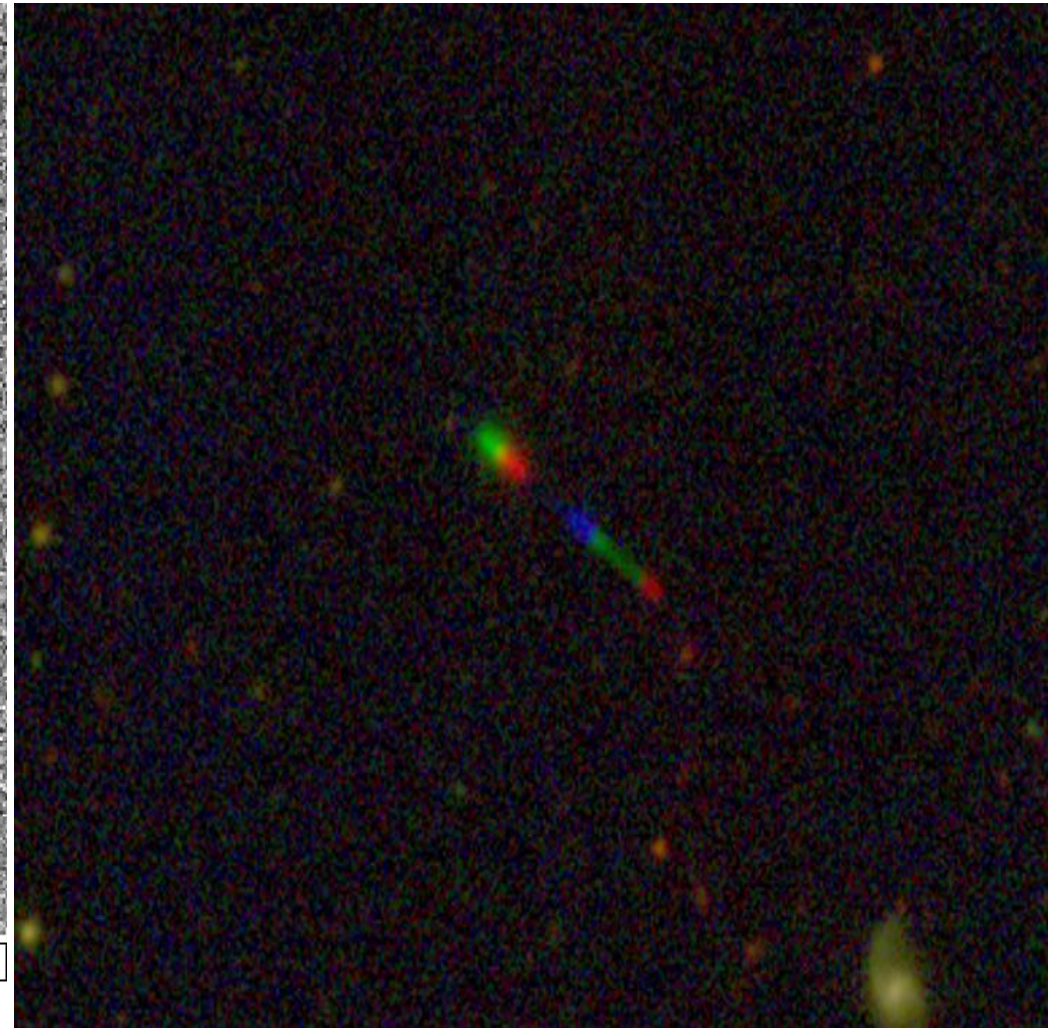
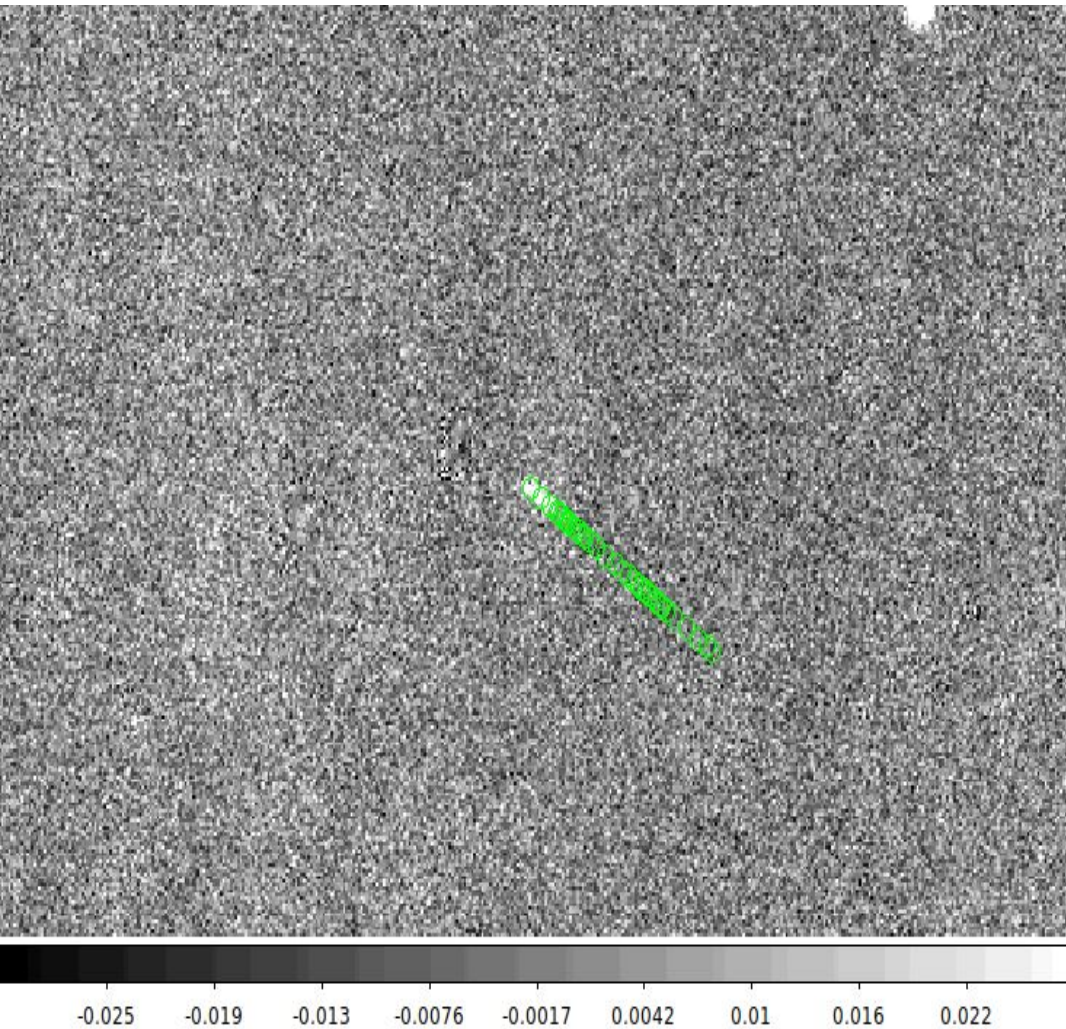
Combining Gaia data with metallicity determinations obtained from broad-band photometry

Distribution of stars at a certain height (3.5 kpc) above the Galactic plane, using 5 sdss bands  
In (a) and in (c) the metallicity determinations were improved by using 3-mag deeper u-band,  
Reaching photometric metallicities as precise as 0.3 dex for bright stars  
(S-PLUS will do better)

## Study of ASTEROIDS

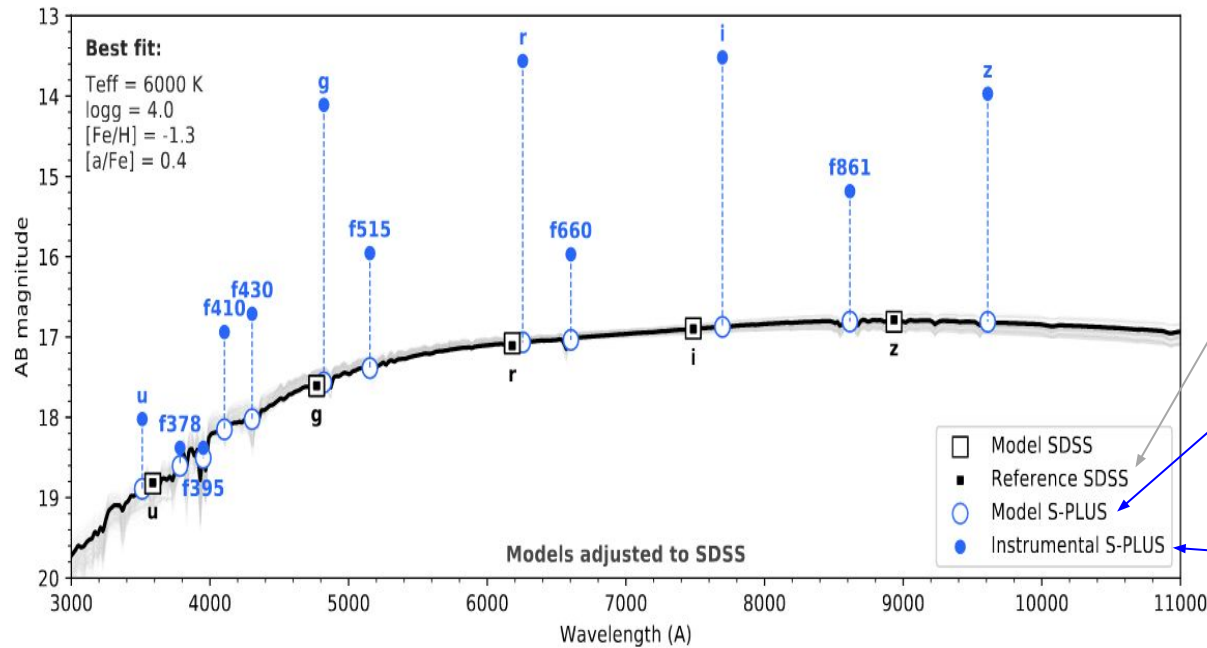
- Positions estimated by the group DiRAC, from the University of Washington
- The gif is the track of the asteroid through the 12 S-PLUS bands, the same used to compose the colored image
- ~200000 asteroids are estimated to be found within S-PLUS images for the full Main Survey

Fabio Herpich, Jorge Carvano et al.

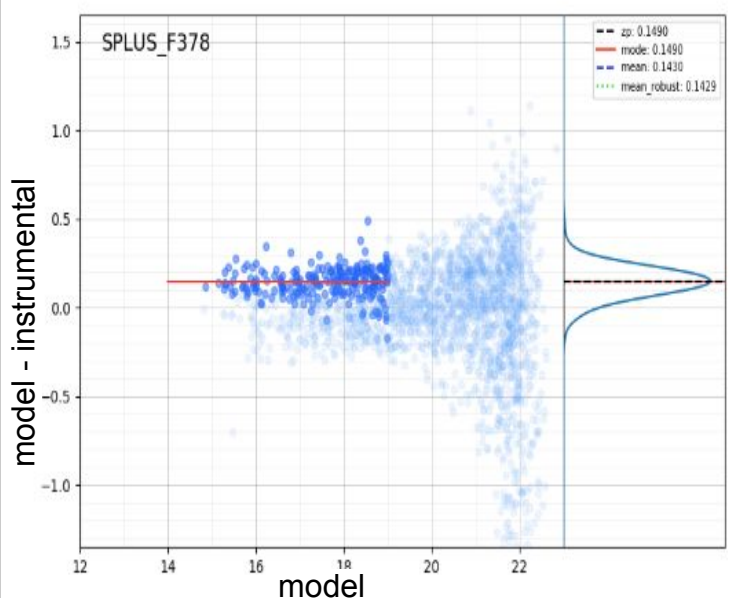


What is new since the last S-PLUS meeting  
in December/2020?

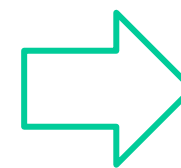
# S-PLUS template fitting calibration



- 1) Fit a synthetic template to the magnitudes in a reference catalogue
- 2) Use the template to predict the reference star magnitudes in the S-PLUS photometric system
- 3) Compare to the instrumental S-PLUS magnitudes to derive zero-points



This technique does not require the observation of standard stars



Time available for observations is increased by 15-20%

Each filter's zero-point is estimated using the template fitting technique for thousands of stars

Almeida-Fernandes et al. 2021

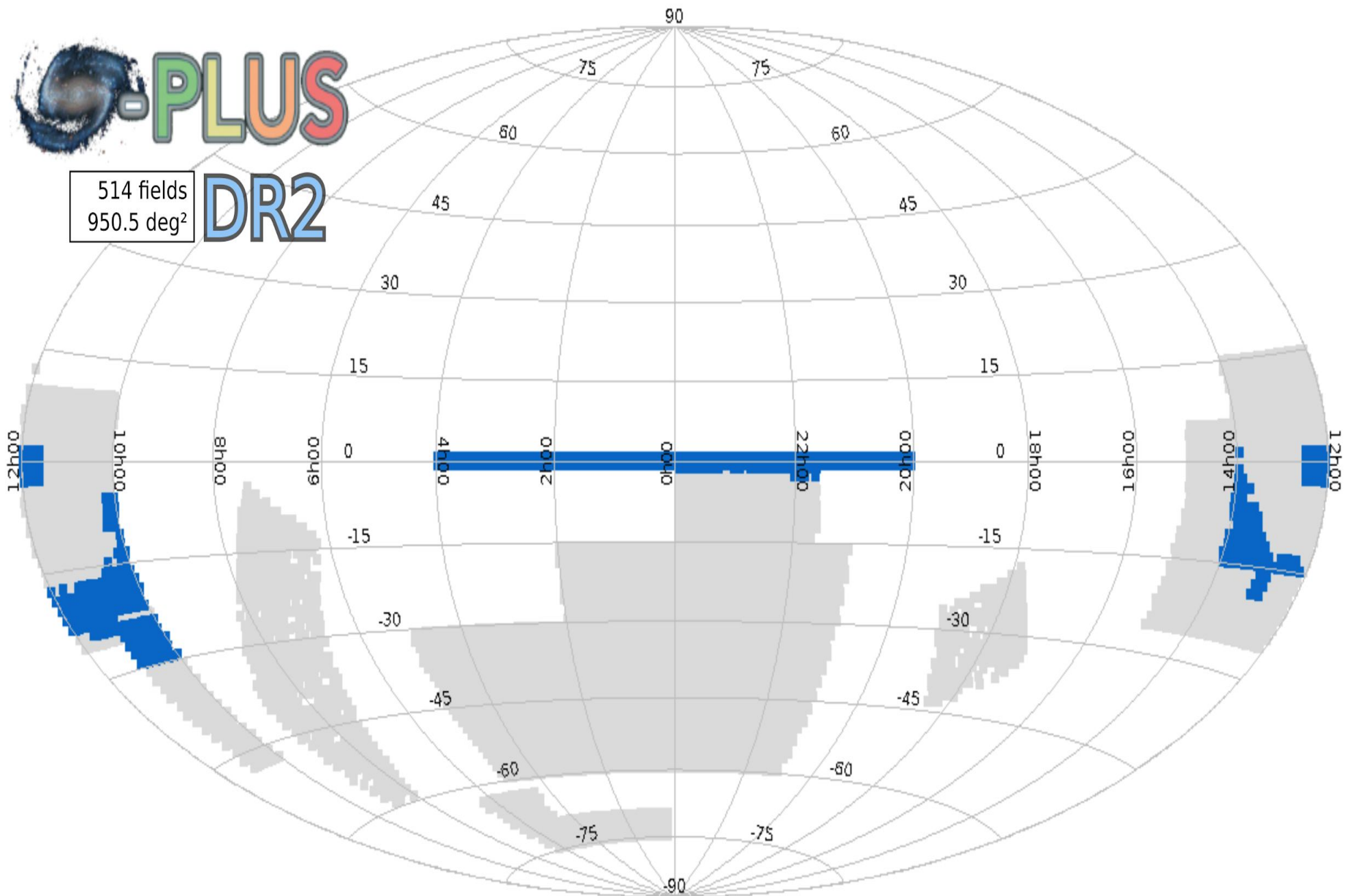
# DR2 – public to the world since March 2021



PLUS

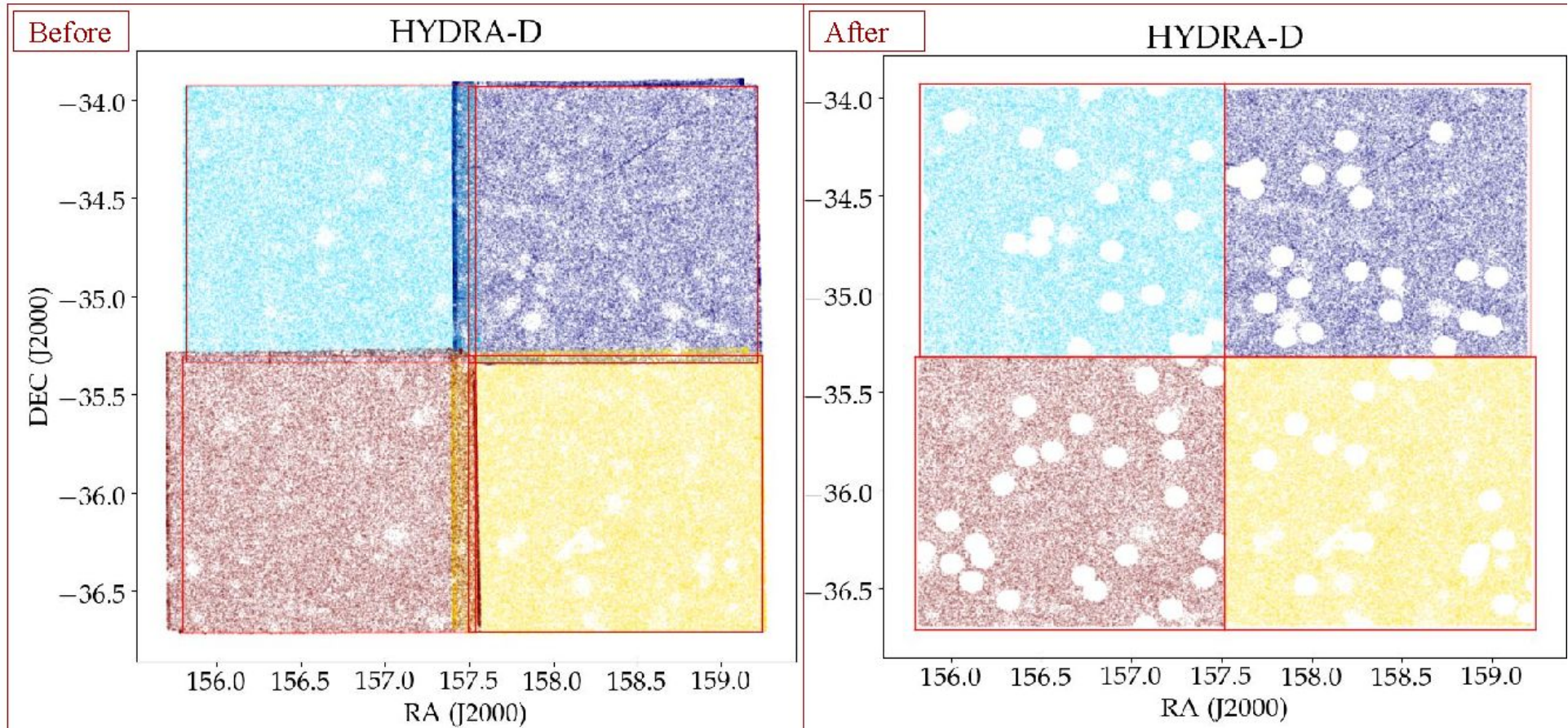
514 fields  
950.5 deg<sup>2</sup>

DR2



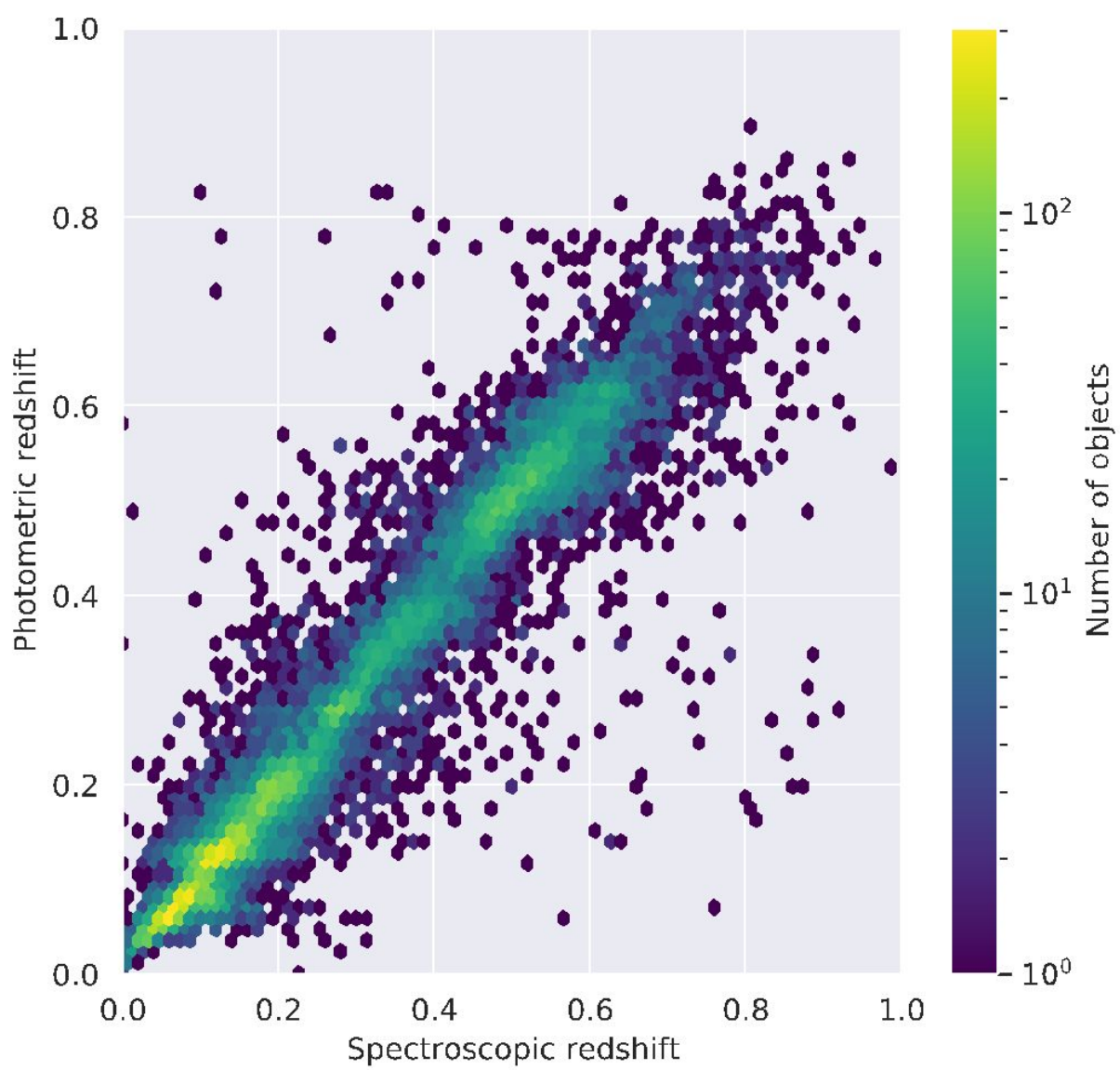
# Border and bright star masking

- Removes artifacts generated by dithering (borders) and by the presence of bright objects.
- Data: iDR3\_n3, with  $s2n\_det\_iso > 5$



- VAC masks
- VAC photozs with template fitting.
- VAC point/extended source separation
- Data curation: maps revealing the variation of main parameters across the survey in every wavelength: depth, seeing values, density of objects, etc..

Buzzo, Overzier et al. 2021



Lima et al. 2021

PhotoZs vs SpecZs - colors show densities of points.

Another VAC – photoz's from deep learning methods



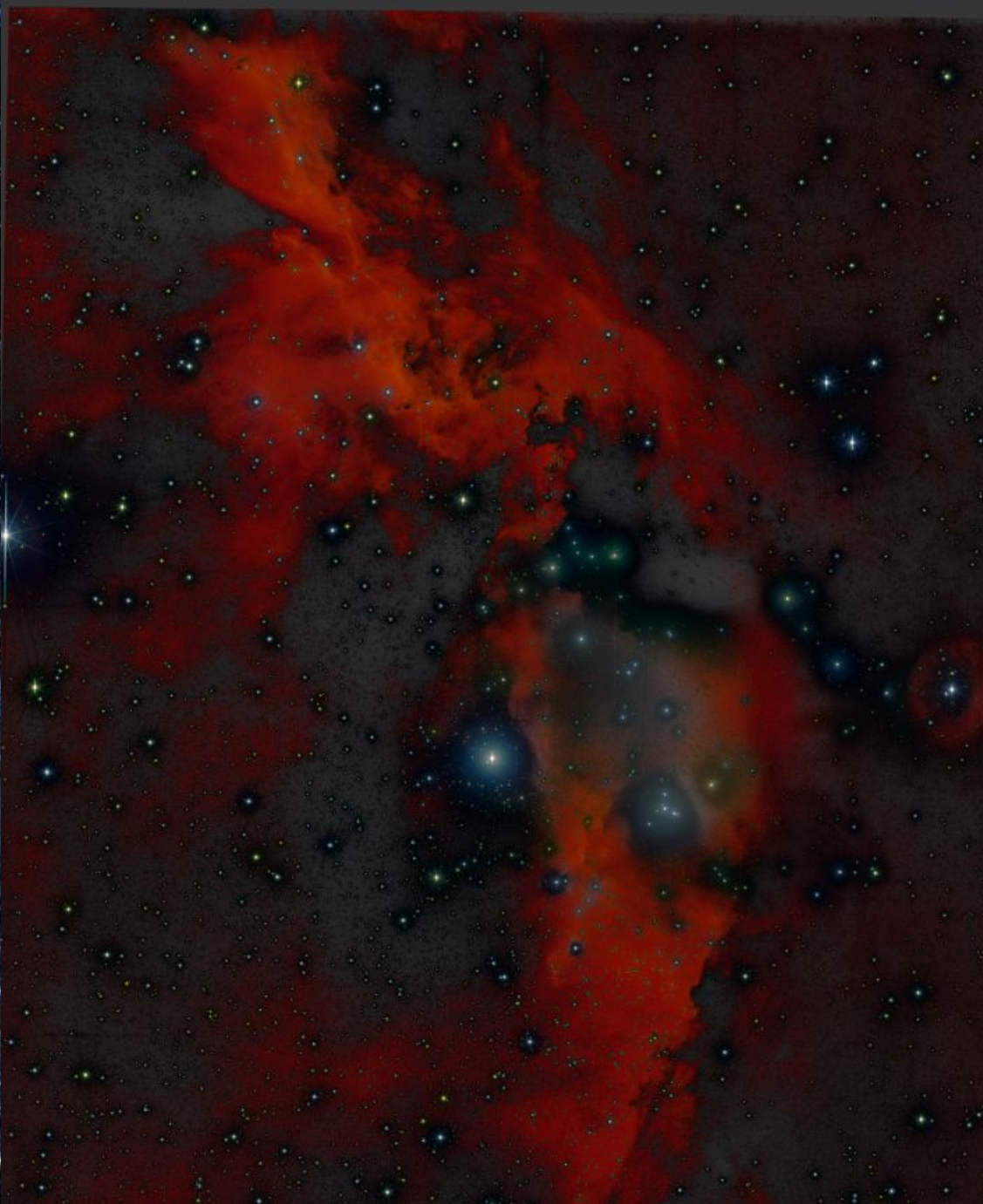


**Halpha**

**Emission**

**Line maps**

(superimposed over a  
color image)



# The Galactic Survey

# New database for S-PLUS

G. Schwarz

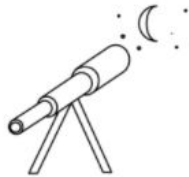
## S-PLUS Cloud

Southern Photometric Local Universe Survey Interface



### Documentation

Read the full documentation on information about all data, tips how to get data, and many more.



### Tools

Access and download public data available, catalogs, images and others.

## Cloud News

02/11/2021

### DR2 Launch Soon!

The official Data Release 2 is coming soon in March

02/11/2021

### Full Documentation available

Read all about our tools and how to make good use of it. [Available Here](#)

02/11/2021

### Splus Cloud Launch

We are officialy launching splus.cloud servers

- **Main database at IAG**
- **Database mirror at the Maua Institute of Technology**

# List of publications

1. **Observations of the First Electromagnetic Counterpart to a Gravitational-wave Source by the TOROS Collaboration.** Díaz, M. C., Macri, L. M., Garcia Lambdas, D., Mendes de Oliveira, C. et al. 2017: AJ, v848, L29
2. **Multi-messenger Observations of a Binary Neutron Star Merger.** Abbot, B. P. et al 2017: AJ, 848, L12
3. **The Southern Photometric Local Universe Survey (S-PLUS): improved SEDs, morphologies, and redshifts with 12 optical filters**  
Mendes de Oliveira et al. 2019: MNRAS, 489, 241 [ADS]
4. **Assessing the photometric redshift precision of the S-PLUS survey: the Stripe-82 as a test-case**  
Molino et al. 2020: MNRAS, 499, 3884 [ADS]
5. **An environmental dependence of the physical and structural properties in the Hydra cluster galaxies** [ADS]  
Lima-Dias et al. 2021: MNRAS, 500, 1323
6. **J-PLUS: Tools to identify compact planetary nebulae in the Javalambre and southern photometric local Universe surveys** [ADS]  
Gutiérrez-Soto et al. 2020: A&A, 633, 123
7. **One Hundred SMUDGes in S-PLUS: Ultra-diffuse Galaxies Flourish in the Field** [ADS]  
Barbosa et al. 2020: ApJS, 247, 46
8. **The S-PLUS: a star/galaxy classification based on a Machine Learning approach**  
Costa-Duarte et al. 2019: MNRAS, submitted [arXiv:1909.08626]
9. **On the discovery of stars, quasars, and galaxies in the Southern Hemisphere with S-PLUS DR1**  
Nakazono et al. 2020: MNRAS, submitted
10. **Searching for active low-mass stars in CMA star-forming region: multi-band photometry with T80S**  
Jane Gregorio-Hetem et al. 2020: AJ, submitted
11. **Photometric redshifts for the S-PLUS Survey: machine learning approach**  
Erik-Vinicius Lima et al. 2021: Astronomy & Computing, submitted

Eight defended theses with S-PLUS data

# S-PLUS projects in the wiki

- #001: S-PLUS Survey Overview Paper (PL: Claudia Mendes de Oliveira)
- #002: Large-scale structures in the local Universe: clustering properties of groups and clusters at extremely low redshifts (PL: Raul Abramo)
- #003: Identification and characterization of WD+M binaries (PL: Tiago Ribeiro)
- #004: Luminous Quasars near the end of Re-ionization (PL: Roderik Overzier)
- #005: Technical documentation for the wiki (PL: Roderik Overzier)
- #006: Identifying Metal-Poor Stars from the SPLUS Survey (PL: Vinicius Placco)
- #007: An accurate photo-z catalogue for nearby galaxy clusters in the South hemisphere (PL: Alberto Molino)
- #008: The Largest Astrometric and Photometric Open Cluster (LAPOC) Catalogue. (PL: Laura Sampedro)
- #009: Configuration of Artificial Neural Network Pipeline for CEMP Candidate Identification (Devin Whitten)
- #010: Blue stars in the Galactic Halo (PL: Marcelo Borges)
- #011: Identifying BSS and BHBs (PL: Rafael Santucci)
- #012: Southern Galactic Halo Age-maps (PL: Rafael Santucci)
- #013: SPLUS mock catalogs using GALFAST code (PL: Rafael Santucci)
- #014: PNe and symbiotics in the Galactic halo and nearby galaxies (PL: Denise Gonçalves)
- #015: Learning about stars from their S-PLUS colors (PL: Tiago Ribeiro)
- #016: Star/galaxy separation in multi-band photometric surveys based on machine learning techniques (PL: Walter Santos)
- #017: The environment of Lyman break analogs (PL: Thiago Gonçalves)
- #018: A Panchromatic (FUV-OPT-MIR) study of the energy output of the Local Universe (PL: Alberto Molino)
- #019: An alternative methodology to calibrate the S-PLUS survey (PL: Laura Sampedro)
- #020: Short period variables (PL: Antonio Kanaan)
- #021: S-PLUS morphology classification (PL: Arianna Cortesi)
- #022: Unveiling the nature of unknown gamma-ray sources (PL: Raniere Menezes )
- #023: Luminosity function of compact groups of galaxies in Stripe 82 (PL: Sergio Torres Flores)
- #024: Star formation in compact groups observed by SPLUS (PL: Sergio Torres Flores)
- #025: Unveiling star-forming early-type galaxies in dense environments using the S-PLUS survey (Riguccini)
- #026: The differential evolution of the star formation in low mass galaxy clusters from the perspective of the S-Plus Survey. (PL: Jose Nilo Castellon)
- #027: Mapping stellar streams and substructures in the galactic halo (PL: Hélio J. Rocha Pinto)
- #028: Nature of the Galactic substructures located in low latitudes fields (PL: Hélio J. Rocha Pinto)

# IAG Course: Astronomical databases and astrostatistics in the era of big data

12-23 July, 2021

The S-PLUS team, in collaboration with Željko Ivezić (University of Washington), will offer a course on how to access and analyse recent astronomical databases

S-PLUS DR2 data will be the main focus of this course.

## IAG Course Astronomical databases and astrostatistics in the era of big data



www.splus.iag.usp.br

### Week 1 12 - 16 / July

#### Accessing Astronomical Databases

*S-PLUS as a case study*

##### Topics

- Astronomical databases
- The ADQL language
- Big data analysis using Topcat
- Python basics for data analysis
- Images photometry
- Introduction to statistics

### Week 2 19 - 23 / July

#### Statistics, data mining and machine learning

##### Topics

- Introduction to Robust Statistics, Big Data, Machine Learning and astroML package
- Bayesian methodology, Model Fitting and Nonlinear Regression
- Density Estimation (histograms, Bayesian Blocks algorithm, Gaussian Mixture models)
- Dimensionality Reduction (PCA, NMF, ICA)
- Clustering and Classification (K means, Gaussian Mixture models, SVM, ROC curves)
- Time series analysis (periodic and stochastic variability)

### Final project 6 weeks to complete

Application of the discussed tools and techniques for a science case chosen by the student

#### Main Lecturers



*Prof. Claudia Mendes de Oliveira, PhD*  
IAG, USP



*Prof. Laerte Sodré Jr., PhD*  
IAG, USP



*Prof. Željko Ivezić, PhD*  
University of Washington

#### Teaching Assistants

TBD

# S-PLUS Outreach Group

(is back in business...)

## Outreach goals for 2021:

### For internal distribution:

- t-shirts and (more) stickers;
- *S-PRESSO* newsletter;

### For all audiences:

- old/new high-res images (re)processed for public downloads
- for wallpapers, posters, and/or printed material;
- explanatory e-folders presenting the project and subprojects for press;
- press releases;
- renew social media accounts.

**and a lot more!**

# Take-home lessons

S-PLUS is a 12-band optical survey done with T80-South, at Cerro Tololo aiming at imaging an area of 9300 sq deg.

S-PLUS area is 40% complete. The data can be used for a number of projects from Solar system and stellar astronomy to Cosmology.

DR1 and DR2 have been released and recently also the VACs (photozs, object classification, masks, etc).

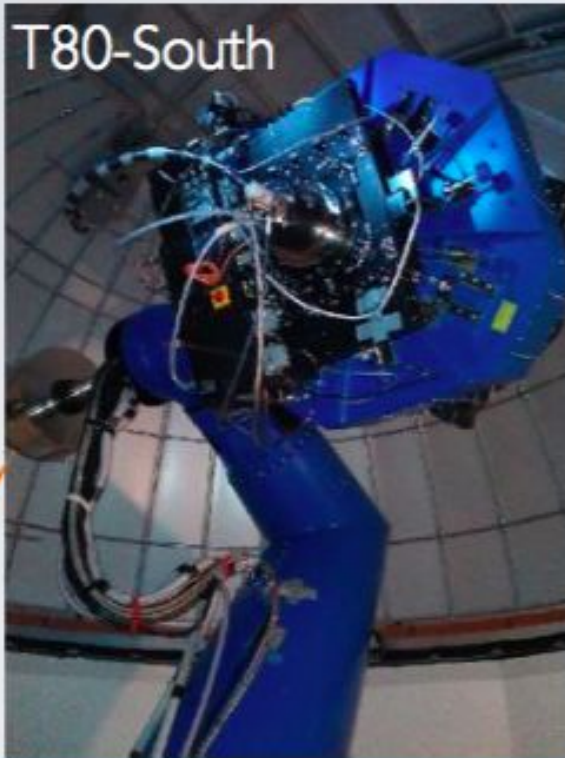




# Two surveys, North and South

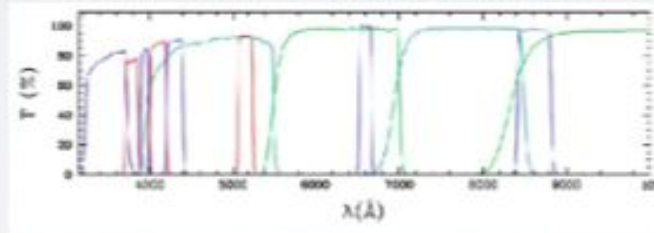
**S-PLUS** P.I. CMdO

**J-PLUS** P.I. Javier Cenarro



T80 and T80-South

- Mirror: 0.8m
- Field of view: 1.4 x 1.4 deg
- 7 narrow and 5 broad bands



Fabricated by AMOS/ASTELCO



# Supporters and Founders of S-PLUS

## SUPPORTERS



## FOUNDERS

