The S-PLUS Calibration Pipeline

And schedule data releases

Felipe Almeida-Fernandes

S-PLUS
14th Collaboration meeting

The S-PLUS Calibration Pipeline

Summary

Calibration Pipeline
Detection
Apertures
Aperture Correction
Reference Catalogs
Model Fitting Calibration
Stellar Locus Calibration
Results

Data Releases
Schedule
Catalogs Format
VACs

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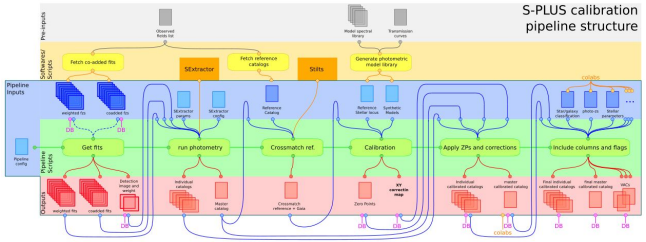
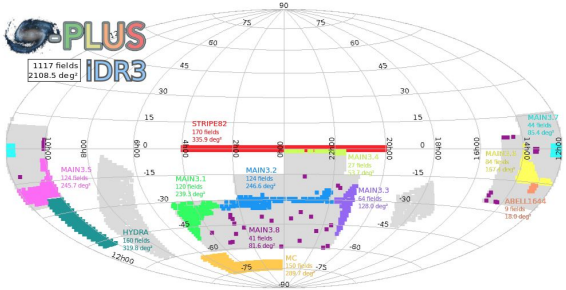
Calibration



The S-PLUS calibration pipeline

- Technique developed for S-PLUS
- New features include:
  - Aperture corrections
  - ISM extinction included in template fitting
  - Gaia scale calibration
  - CCD ZP offsets correction
- We caught up with observations
  - Calibration will no longer cause delays in DRs

Data Releases



Internal data release 3 - iDR3

- Already available for members of the collaboration
- 1818.8 sq deg (+ 289.7)
- >50 Million detections

Public Data Release 2 - DR2

- Subset of iDR3
- March 2021
- 950.5 sq deg
- >30 Million detections

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The Calibration Pipeline

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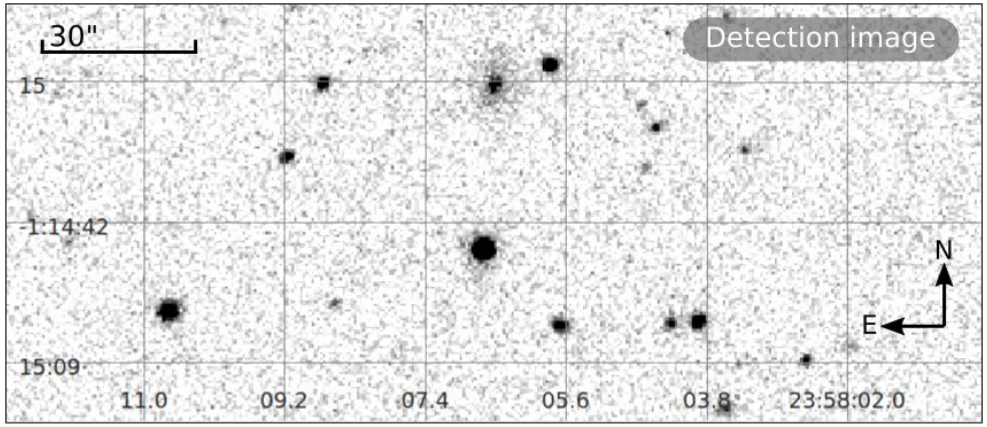
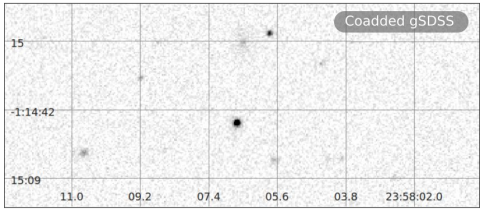
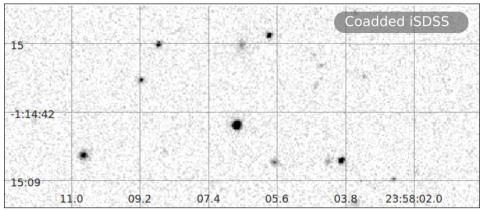
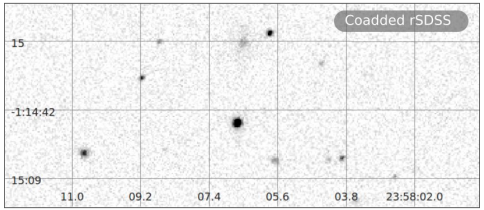
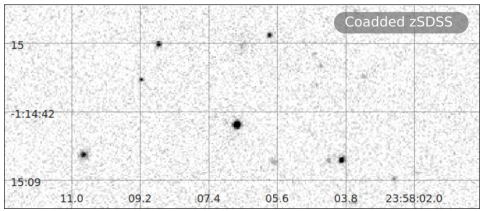
Detection Image











Detection image obtained from filters: **G, R, I, Z**

SExtractor is used both for source **detection** and **photometry**.

Only **dual mode** catalogs are currently **available**.

Single mode catalogs will be generated in the **near future**.

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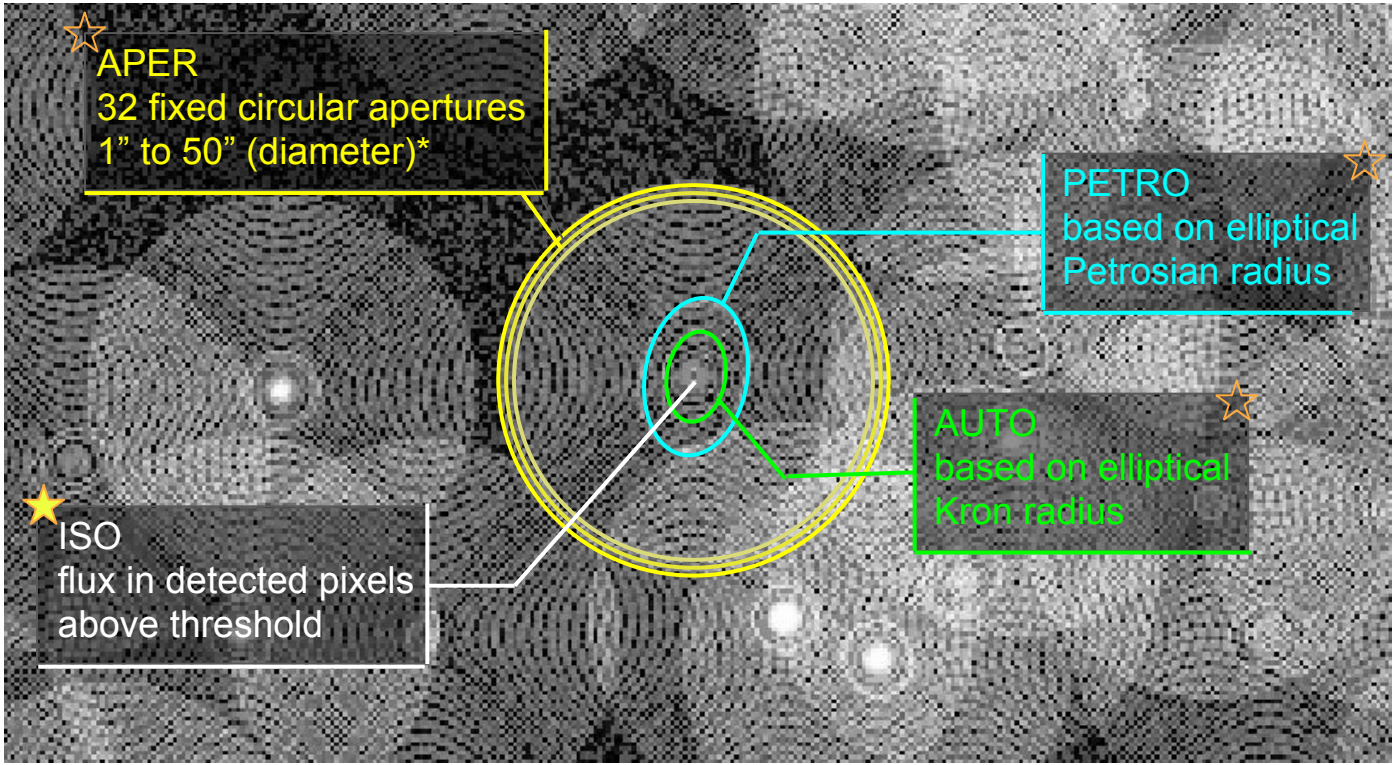
Photometry - Different Apertures



* Of the fixed apertures, only 3” and 6” are given in the final catalogs

☆New feature
☆Modified

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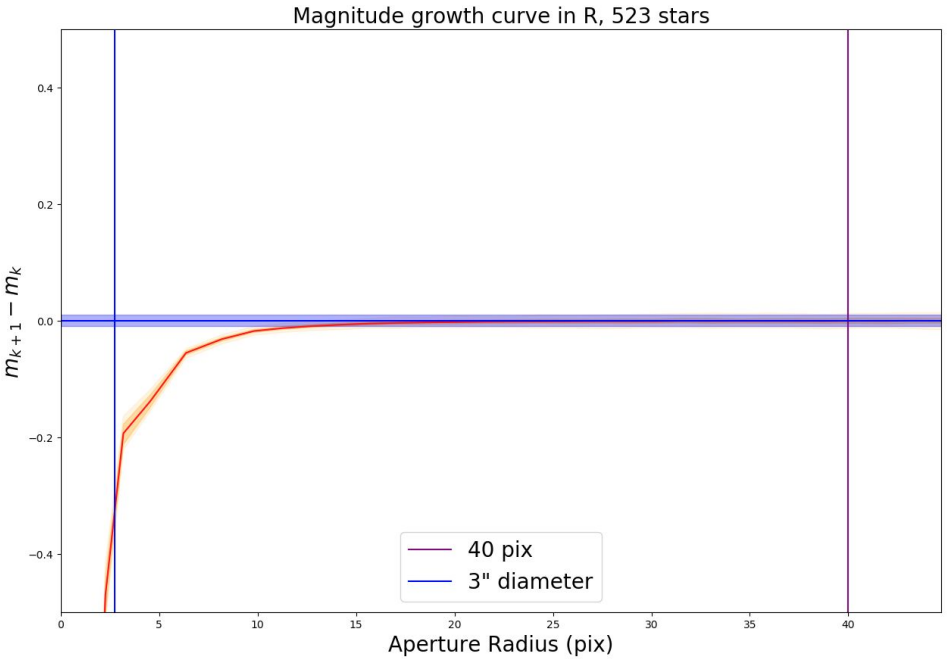
★ Aperture Correction for Point Sources



For any given aperture, a **fraction of the flux** is **lost** due to the **PSF**

Aperture corrections are obtained for **each field** and **filter**

Hundreds of stars are **used** in each case

★ G_PSTOTAL = G_APER_3 + AC_G

★New feature

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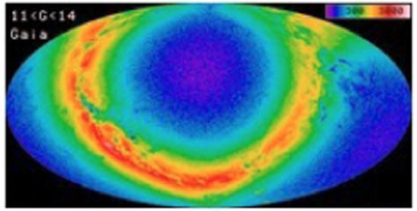
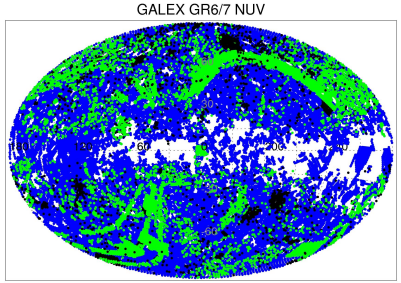
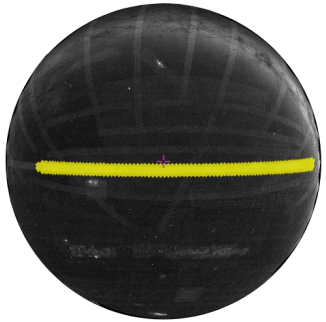
Reference Catalogs



★ **ATLAS Refcat2**
All-Sky
Tonry et al. 2018



★ **GALEX GR6/GR7**
Almost All-Sky
Bianchi et al. 2017



SDSS Standard Stars Catalog for STRIPE82*
Only STRIPE82
Ivezić et al. 2007

*12 STRIPE 82 fields are not covered by Ivezic's catalog. SDSS DR14 is used instead

For **each field**, the crossmatch yields **thousands** of **stars** suitable **for calibration**

- An advantage of the **large FoV** of the S-PLUS images

★New feature

The S-PLUS Calibration Pipeline

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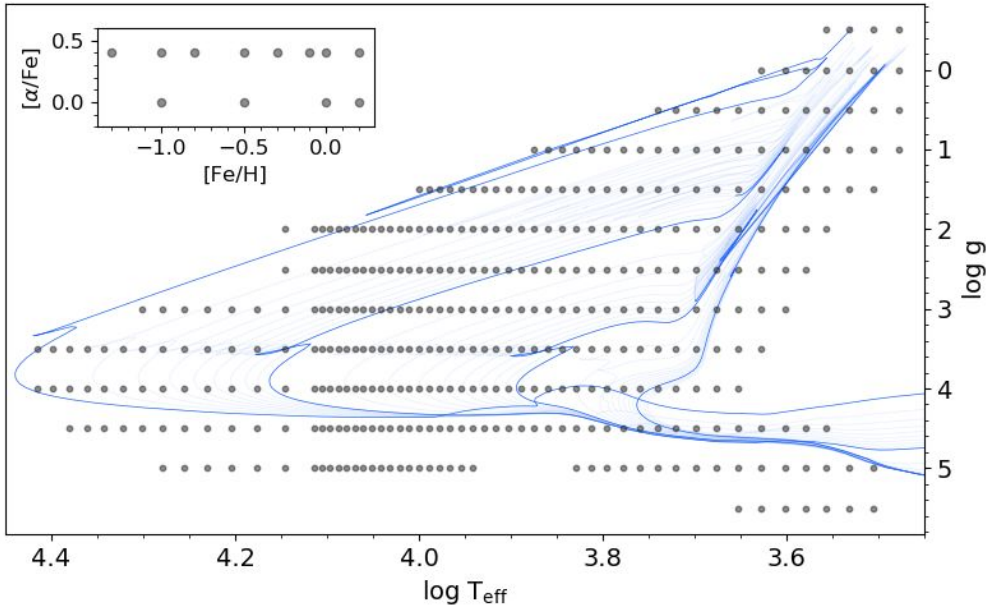
Model Fitting - Theoretical Models ★



Theoretical Stellar Templates of Coelho 2014:

- ★ Grid that covers the whole parameters space
- ★ ISM extinction included as a free parameter
- ★ Pre-convoluted to the filter systems of:
  - SDSS, PanSTARRS, GAIA, GALEX, Skymapper, DES and S-PLUS

★New feature

The S-PLUS Calibration Pipeline

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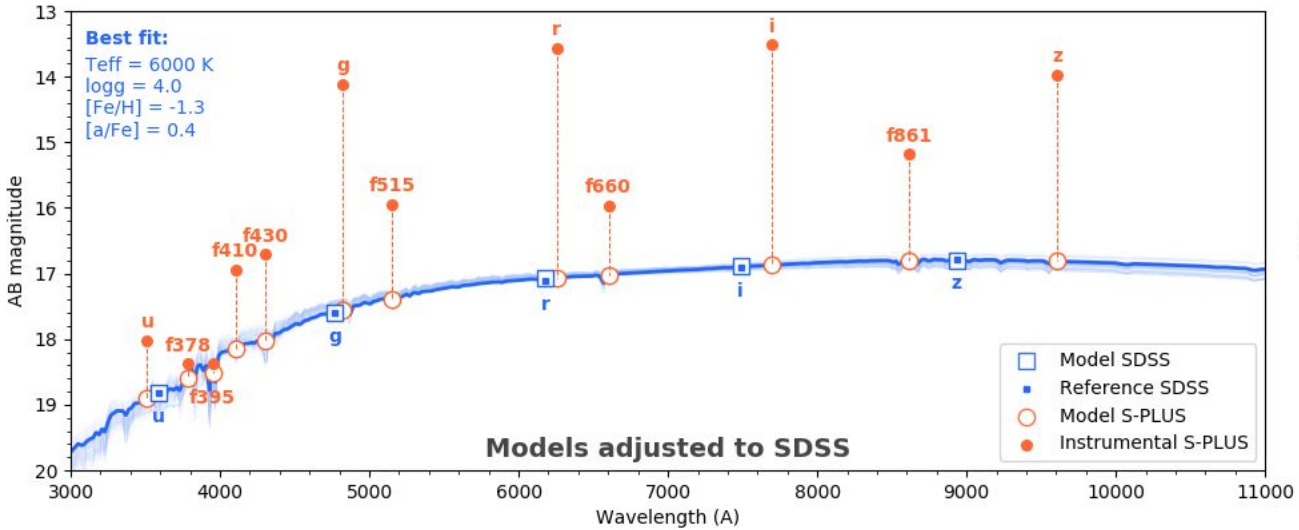
Model Fitting - External Calibration



- Best template for each star is derived by minimizing the chi2
  - First, using the reference magnitudes.
- Templates used to predict S-PLUS calibrated magnitudes

$$\chi^2_{\mathrm{ext},i} = \sum_{m \in \mathcal{R}} \left(\frac{m_{\mathrm{mod},i} - m_{\mathrm{ref}}}{\delta m_{\mathrm{ref}}} \right)^2$$

The S-PLUS Calibration Pipeline

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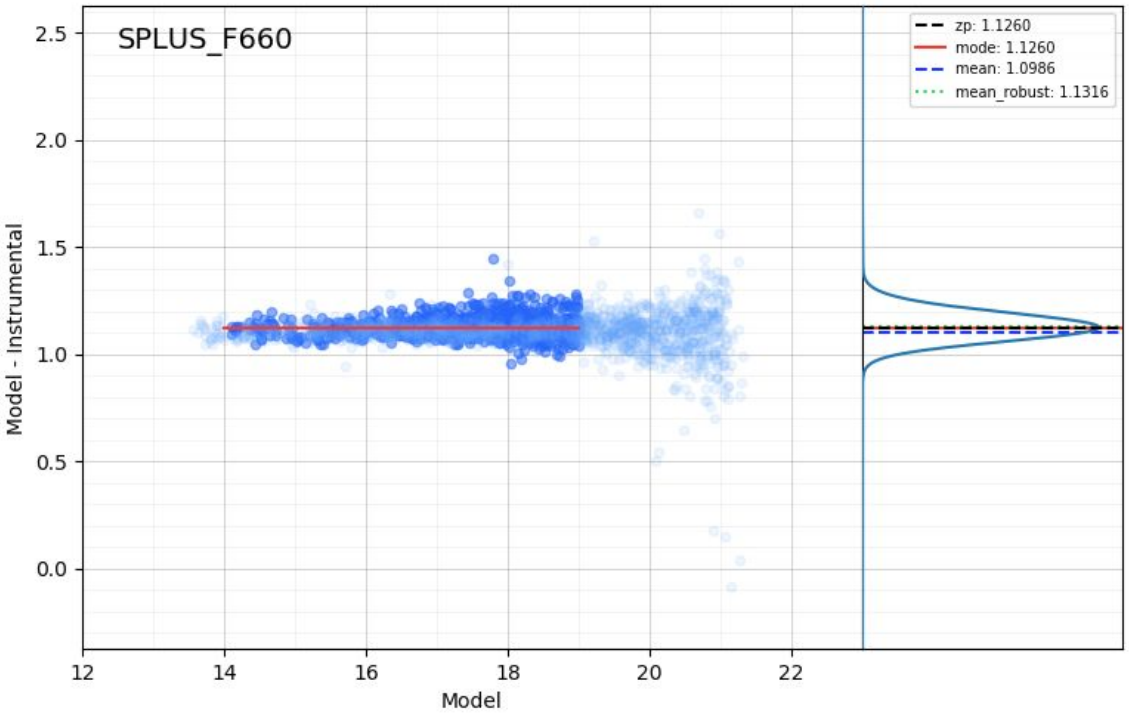
Model Fitting - External Calibration



- Photometric Zero Points are derived from the difference between instrumental and model predicted S-PLUS magnitudes.
  - Obs: an instrumental ZP of 20mag is already included

The S-PLUS Calibration Pipeline

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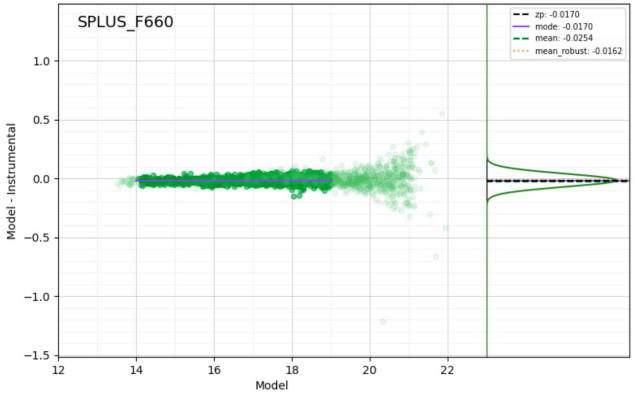
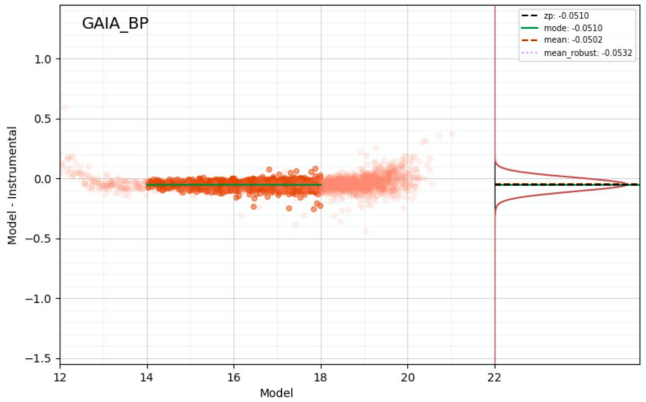
Model Fitting - Internal and Gaia Calibration



Internal Calibration

☆ We fit models to the S-PLUS calibrated magnitudes to refine the calibration

- Use of 12 bands to better constrain the templates



Calibration to Gaia Standard

★ We fit models to the S-PLUS calibrated magnitudes to predict Gaia magnitudes

- The Gaia offsets are added to bring S-PLUS calibration to the same magnitude scale of Gaia

☆New feature
☆Modified

The S-PLUS Calibration Pipeline

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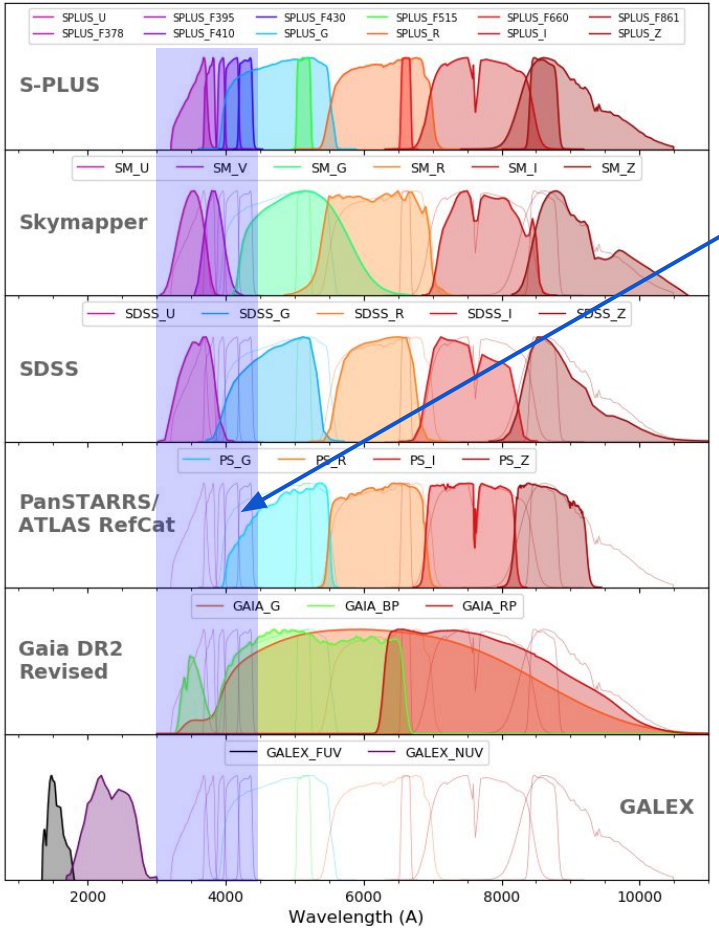
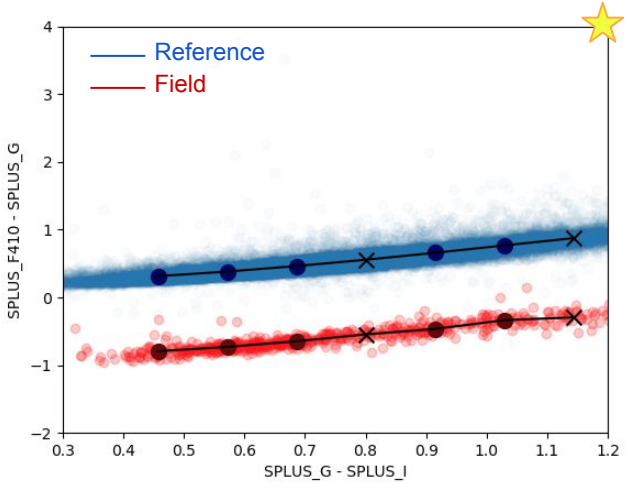
Model Fitting - Stellar Locus Calibration ★



If ATLAS RefCat is the only reference available for the field, the blue bands are not properly covered.

5 Bluer bands are calibrated using an S-PLUS reference Stellar Locus:



★New feature

The S-PLUS Calibration Pipeline

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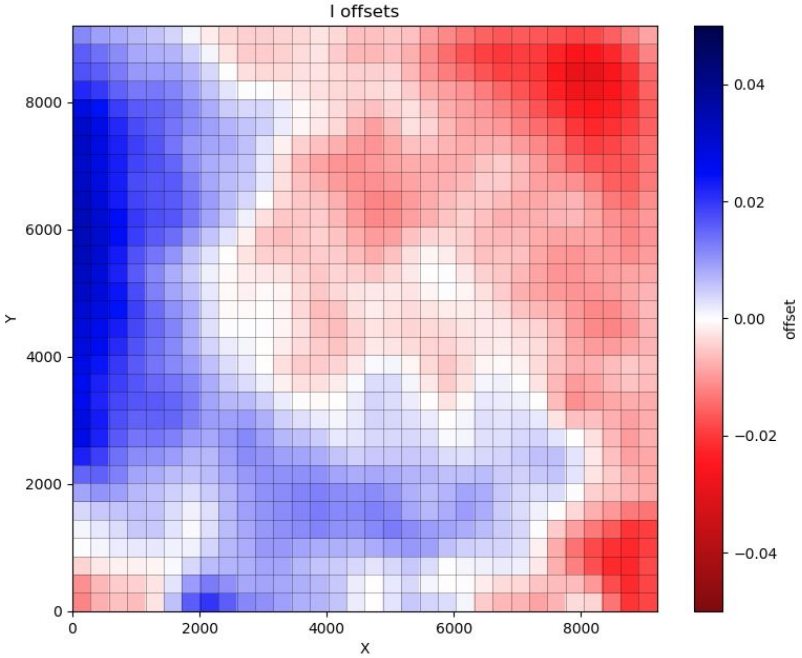
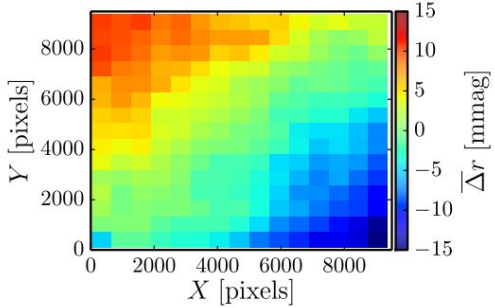
CCD correlated corrections ★



A similar issue was reported and corrected by J-PLUS (same reduction pipeline)



López-Sanjuan et al. 2019

We find that fluctuations around the ZP correlates with the source's XY position in the CCD

★ Correction maps are produced and applied as the first step after the photometry.

★New feature

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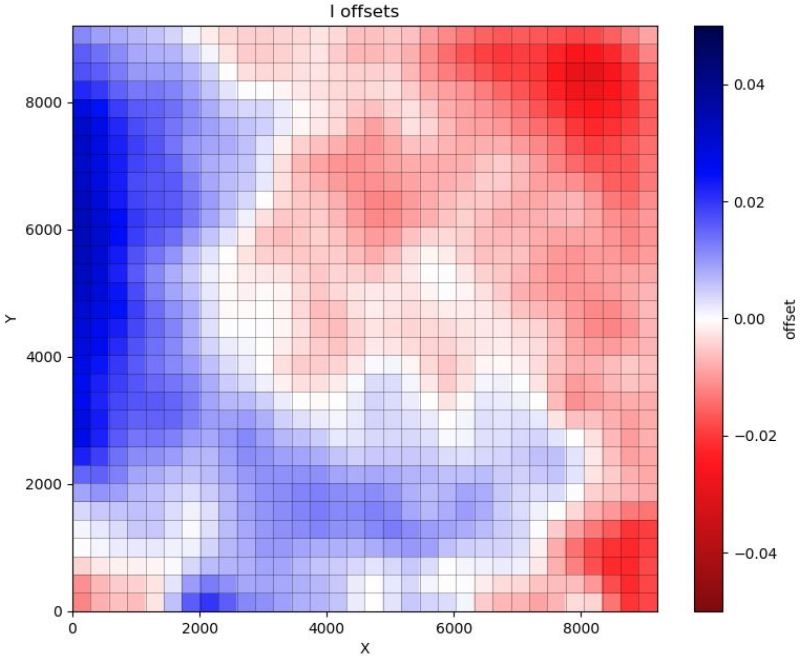
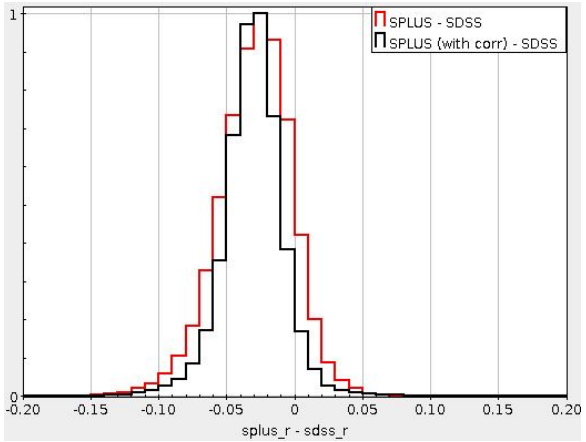
CCD correlated corrections ★



The correction improves the agreement between S-PLUS and SDSS



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Results

The S-PLUS Calibration Pipeline

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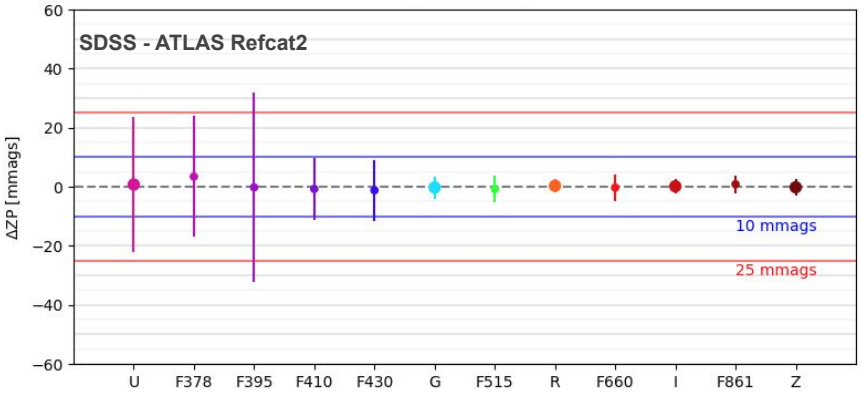
Internal Consistency

ZP comparison using different reference catalogs



internal ZP accuracy better than:

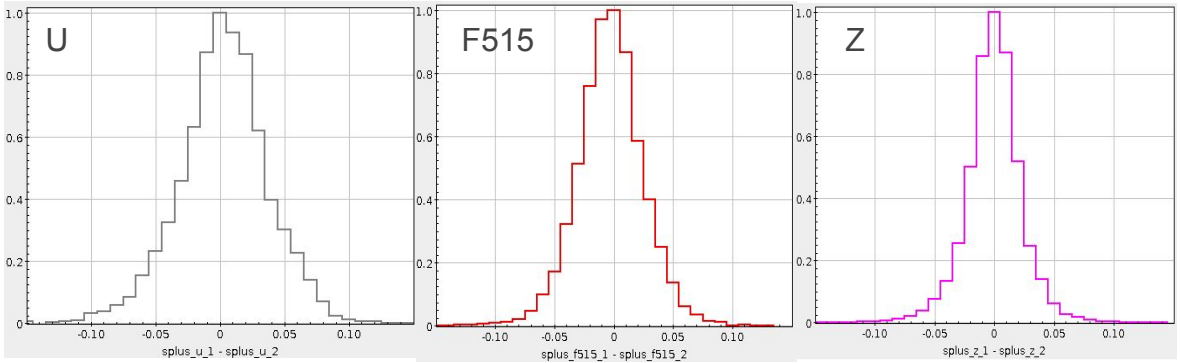
5 **mmags** for
G, F515, R, F660, I, F861, Z

10 **mmags** for
F410 and F430

25 **mmags** for
U and F378

~30 **mmags** for
F395

Comparison between overlapping fields



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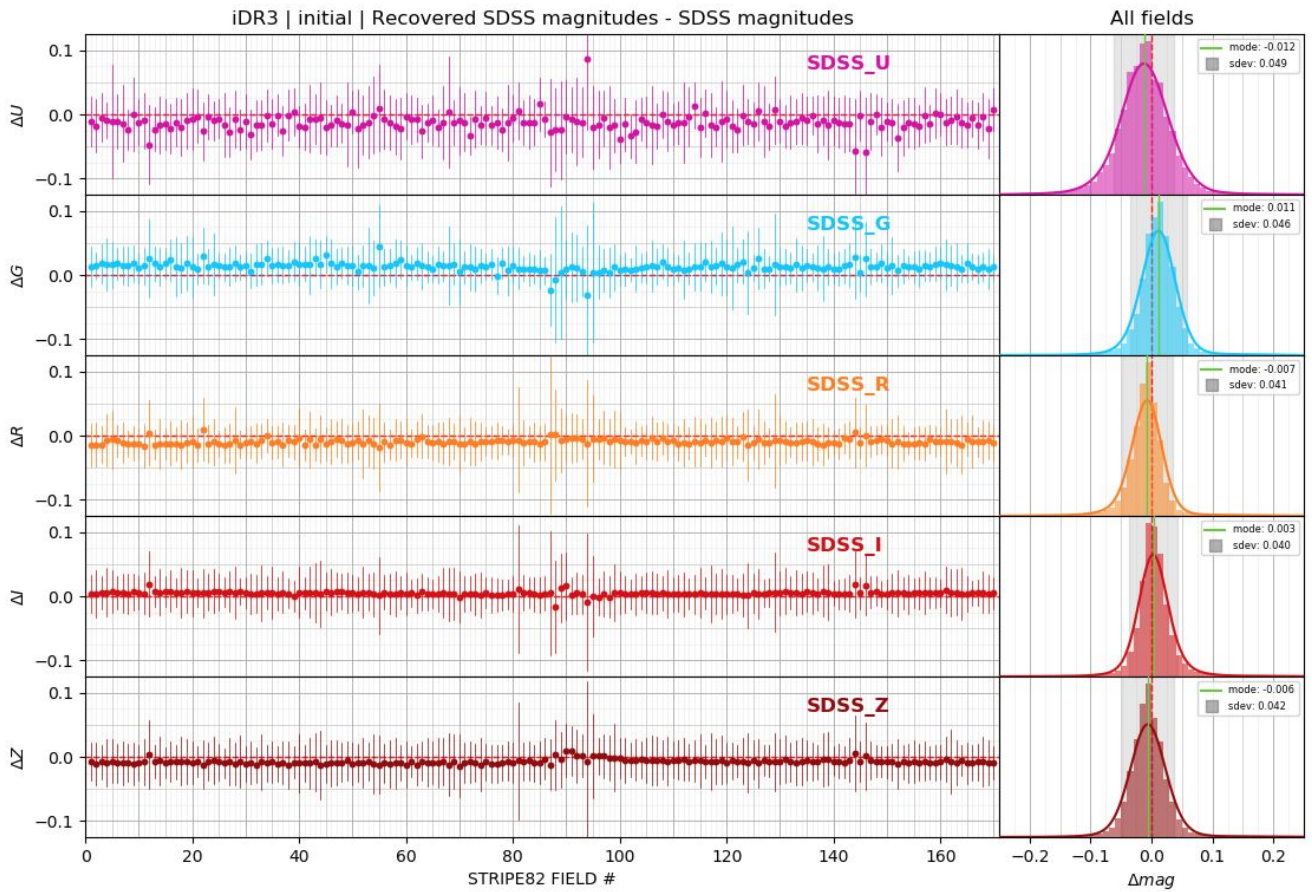
External Consistency - SDSS



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Data Releases

The S-PLUS Calibration Pipeline

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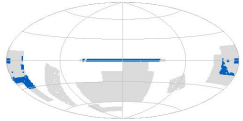
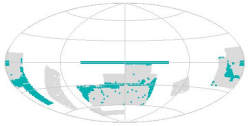
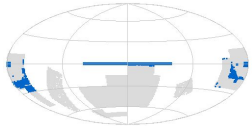
All S-PLUS Data Releases

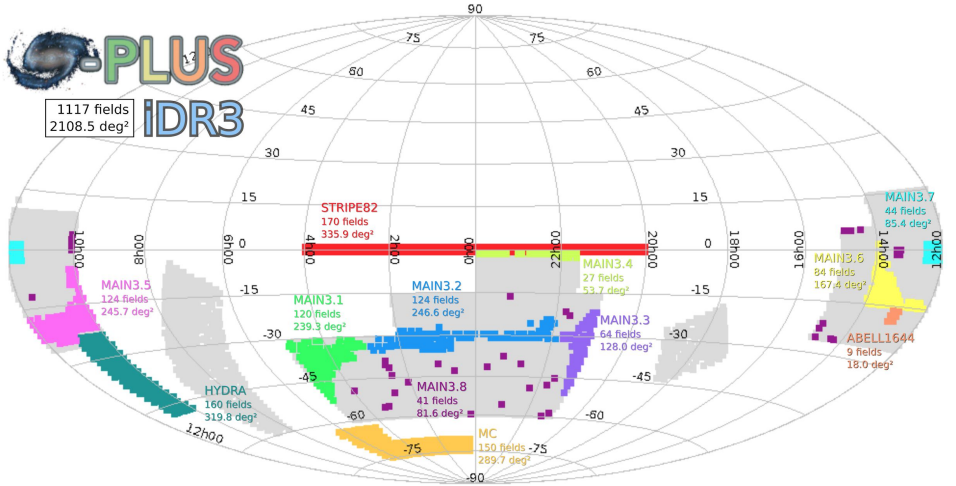
	iD	Release Date	Type	№ Fields	Area [Sq deg]	№ Detections	Footprint RA, DEC
Released	**DR1**	**Mar/19**	**Public**	**170**	**335.9**	**~3 Million**	
	iDR2	Dec/19	Internal	434	858.5	~25 Million	
	iDR3	Sep/20	Internal	967	1818.8	>50 Million	
Scheduled	**DR2**	**Mar/21**	**Public**	**514**	**950.5**	**>30 Million**	
	DR3	**Late 21**	**Public**	**1117**	**2108.5**	**>50 Million**	
	iDR4	Late 21	Internal	TBD	TBD	TBD	

☆ Mod. DR1 pipeline
★ Current pipeline

The S-PLUS Calibration Pipeline

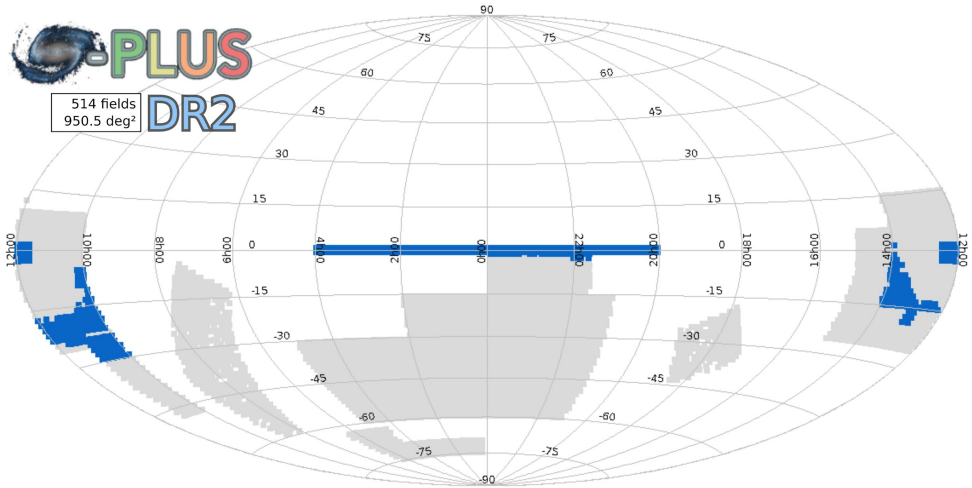
Internal data release 3 - iDR3

- Already available for members of the collaboration
- 1818.8 sq deg (+ 289.7 of MCs)
- >50 Million detections



Public Data Release 2 - DR2

- Subset of iDR3
- March 2021
- 950.5 sq deg
- >30 Million detections



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DR2 and iDR3 catalogs format

The final product of the pipeline are the calibrated multi-filter photometric catalogs of each field.

Each catalog has 283 columns, including astrometry, PSF morphology and photometry in six different apperture with respective errors and S/N.

IDs and position

Field
ID
RA
DEC

Calibration flag

calibration_flag

Detection parameters

X
Y
ISOarea
MU_MAX
A
B
THETA
ELONGATION
ELLIPTICITY
FLUX_RADIUS
KRON_RADIUS
PhotoFlagDet
CLASS_STAR
FWHM
s2n_Det_auto
s2n_Det_petro
s2n_Det_iso
s2n_Det_aper_3
s2n_Det_aper_6
FWHM_n

Individual filters photometry and parameters

For each filter:
U, F378, F395,
F410, F430,
G, F515,
R, F660, I
F861, Z

PhotoFlag_{filter}
CLASS_STAR_{filter}
FWHM_{filter}
{filter}_{aper}
e_{filter}_{aper}
s2n_{filter}_{aper}
nDet_{aper}

For each aperture:
AUTO, PETRO, ISO,
APER_3, APER_6
PSTOTAL

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VACs

The information in the pipeline's output catalogs is basically **astrometry + photometry**

The value added catalogs will include columns that require a subsequent analysis of the data. VACs that will be available soon are:

STAR/GALAXY/QUASAR Classification
Lilianne Nakazono

Photometric Redshifts
Erik Vinicius

Data quality flags
Maria Luiza Buzzo

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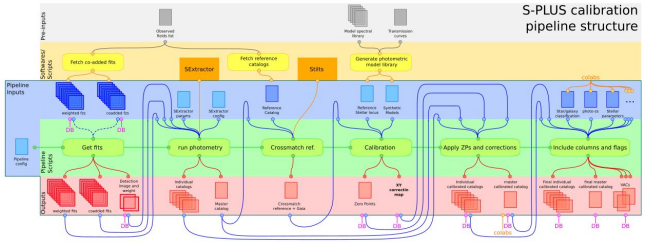
Calibration



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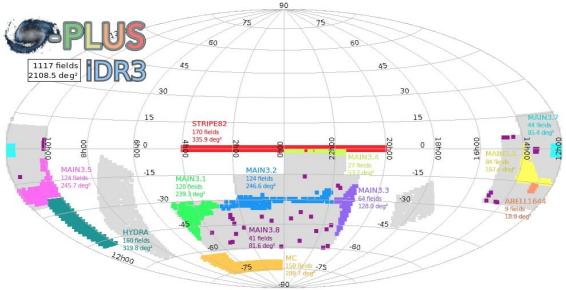
  - Gaia scale calibration
  - CCD ZP offsets correction
- We caught up with observations
  - Calibration will no longer cause delays in DRs

Data Releases



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