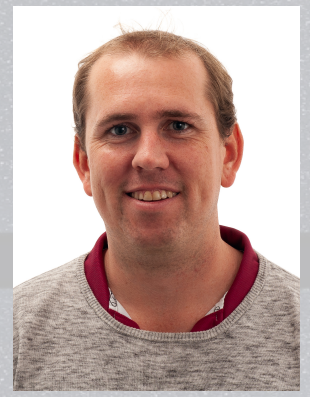
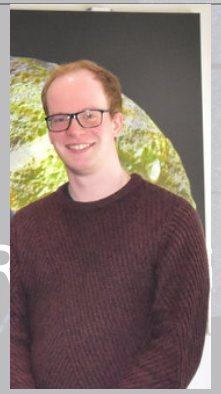
Light Curves from Full-Frame Images for Asteroseismology

DEREK L. BUZASI (FLORIDA GULF COAST UNIVERSITY) & T'DA





Zeta Capricorn
Beta
Beta T
Alpha Tucanae
Alpha Reticuli
Large Magellanic Cloud
Mensae
Zeta Reticuli
Gamma Hydri

What are TASC/TASOC?

TASC = TESS Asteroseismic Science Consortium

- Overall scientific collaborative effort formed around the asteroseismic activities of the TESS mission
- Maintain a database (TASOC) with TESS photometry data + processed and analyzed data and software tools

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TASOC = TESS Asteroseismic Science Operations Center

- Provides asteroseismological data from TESS to astronomers who are members of the TASC
- Facilitates international collaborations

https://tasoc.dk

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- » Targets
  - » Proposals
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  - » WG-5: OB-stars
  - » WG-7: Red Giants
- » Coordinated Activities Wikis
  - » TESS Data for Asteroseismology
  - » TASC-GI Coordination
  - » Ground-based Coordination
- » My account

Welcome to TESS Asteroseismic Science Operations Center

News

18th Dec 2018: Data Search has opened - with ASCII!

You can now search for TESS data through the TASOC website as easily as you have been able to search in the TIC. Just click the "Data Search" tab at the top of the page.
You will be able to download all data from sectors 1 and 2, both from the SPOC and TASOC. And you will be able to get all lightcurves in ASCII format as well.

12th Nov 2018: Help for reading FITS files

We have added some small code-snippets on how to load in FITS files in various languages (Python, IDL, Matlab) under "Documentation and Help".

In the future, the plan is that the TASOC website will also provide ASCII versions of light curves, as an alternative to the FITS files. These do use more disk-space than their FITS counterparts and will contain less information, so we would recommend to use FITS if possible.

6th Nov 2018: Second data release

We are pleased to announce the second release of TESS data for asteroseismology from the TASC Coordinated Activity T'DA.
For this release 79 TOI targets from TESS sectors 1 and 2 have been analysed. These targets are primarily of interest to TASC WGs 1+2 (planet hosting stars and solar-like oscillators). Please note that this data is optimized for asteroseismology, and therefore the planetary transit signals have been intentionally removed.

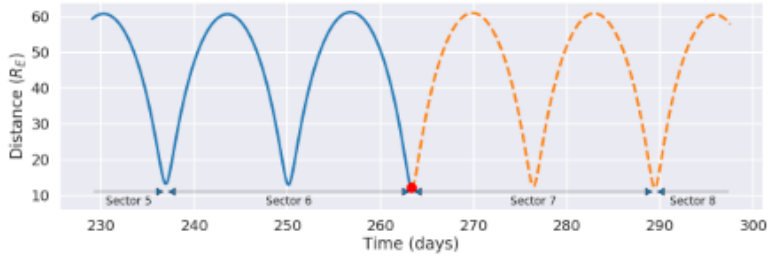
TESS mission clock

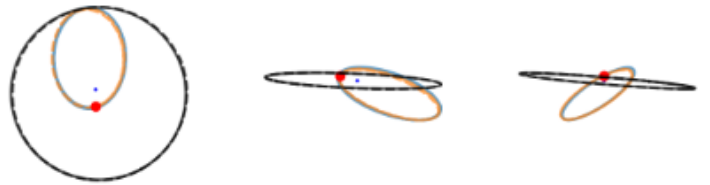
Mission Clock:

263	07	17	20
Days	Hours	Min	Sec

Launch: Wed Apr 18 2018 18:51:00 GMT-0400 (Eastern Daylight Time)

Where is TESS right now?





TESS Data for Asteroseismology = T'DA

Key responsibility is algorithm development for extraction of light curves for

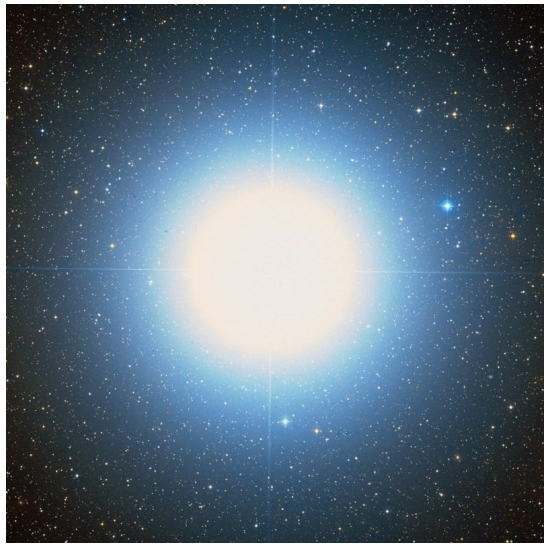
- Full-Frame Images (FFIs)
- Raw short cadence images
- Saturated images

Work done individually, via remote collaboration, and in a series of hands-on workshops

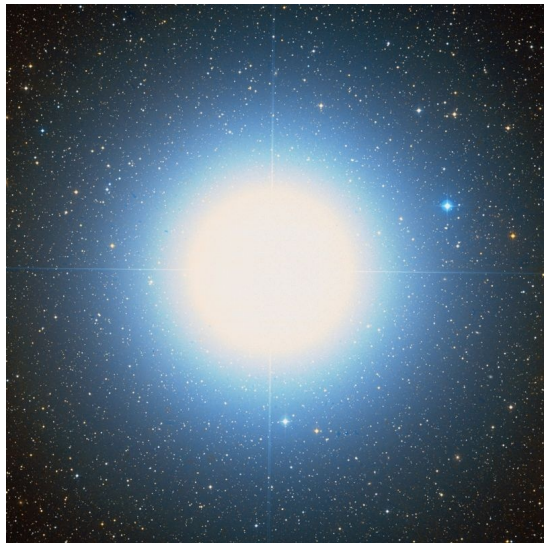
The View from 10000 m

American

American



American



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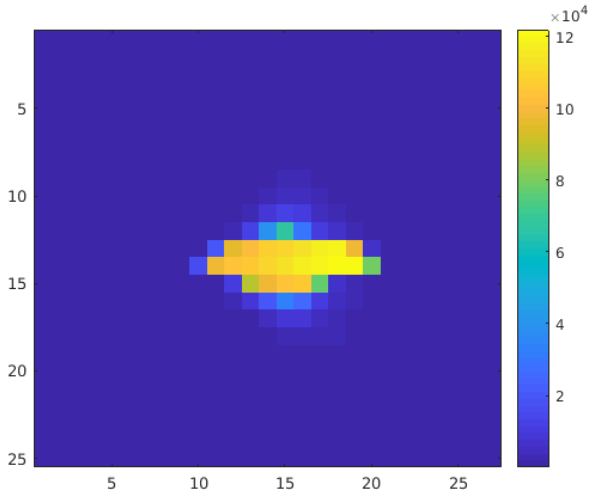
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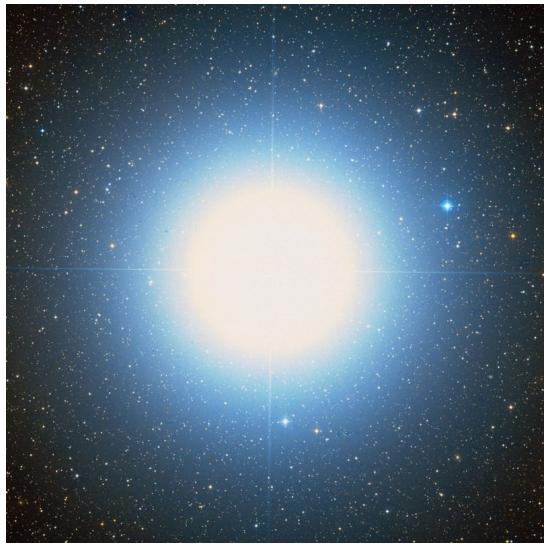
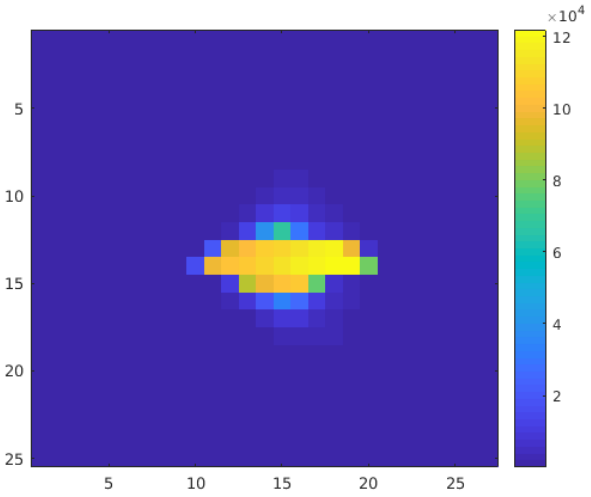
25



American


×10^4
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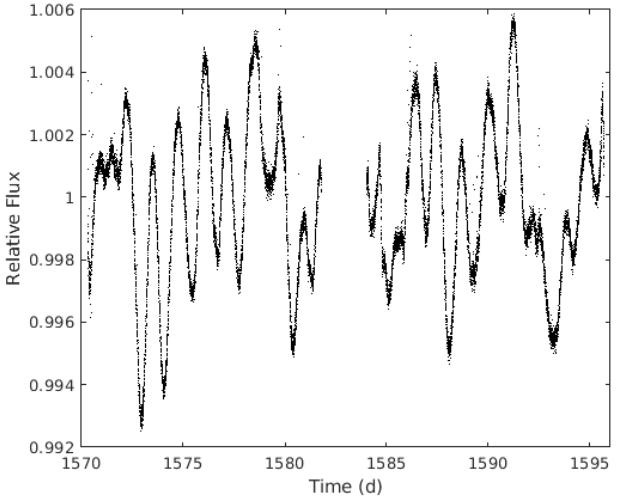
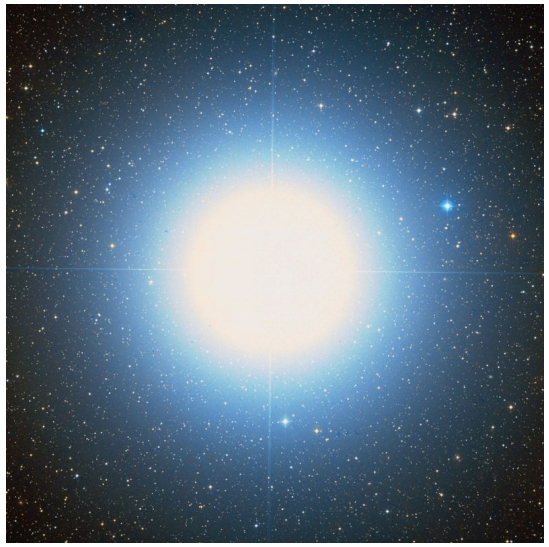
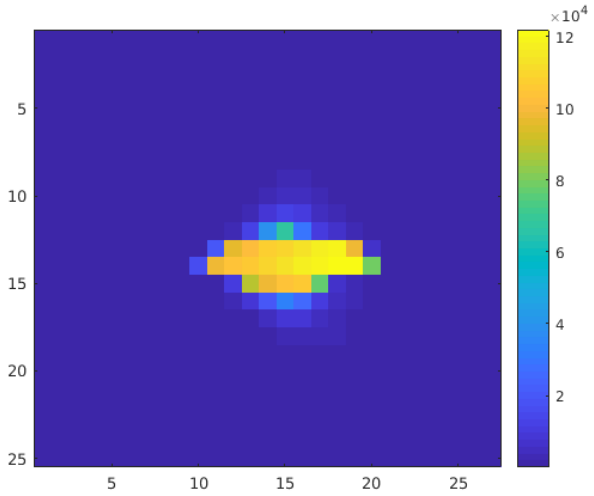
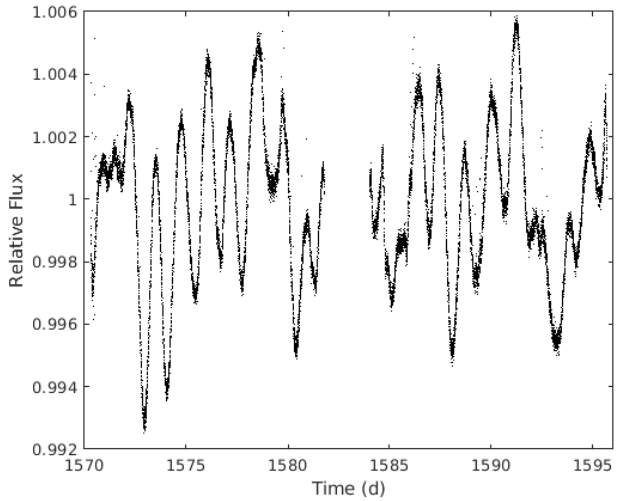
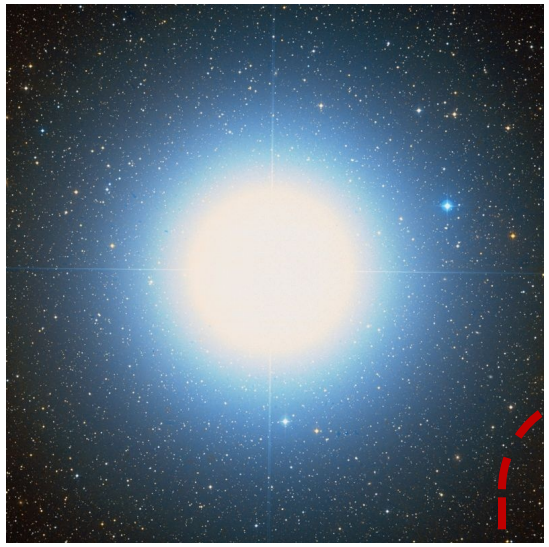

Relative Flux
1.006
1.004
1.002
1
0.998
0.996
0.994
0.992
1570
1575
1580
1585
1590
1595
Time (d)

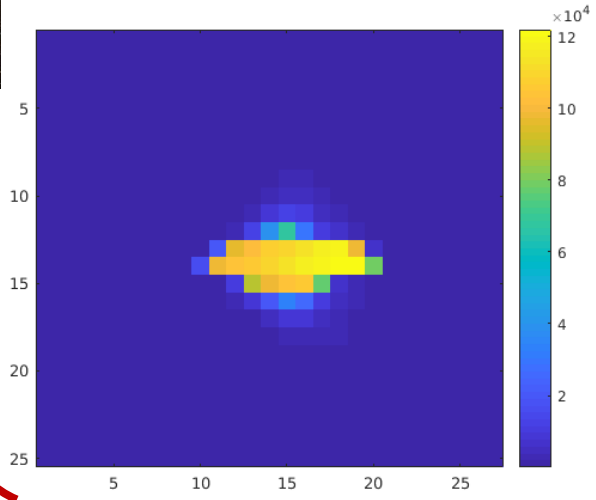


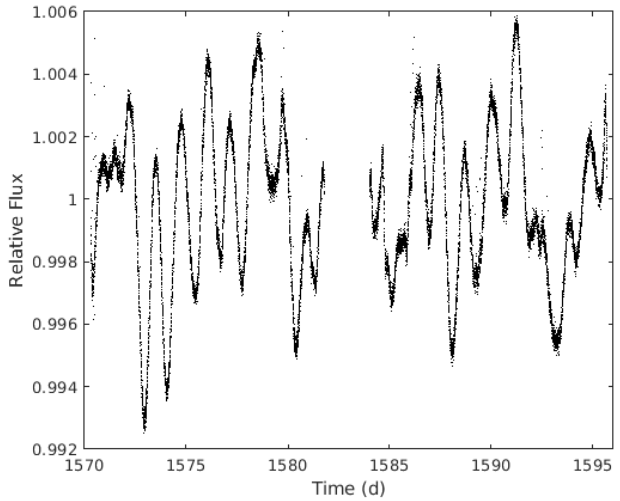




EB?
SPB?
δ Scu?
roAp?
RG?







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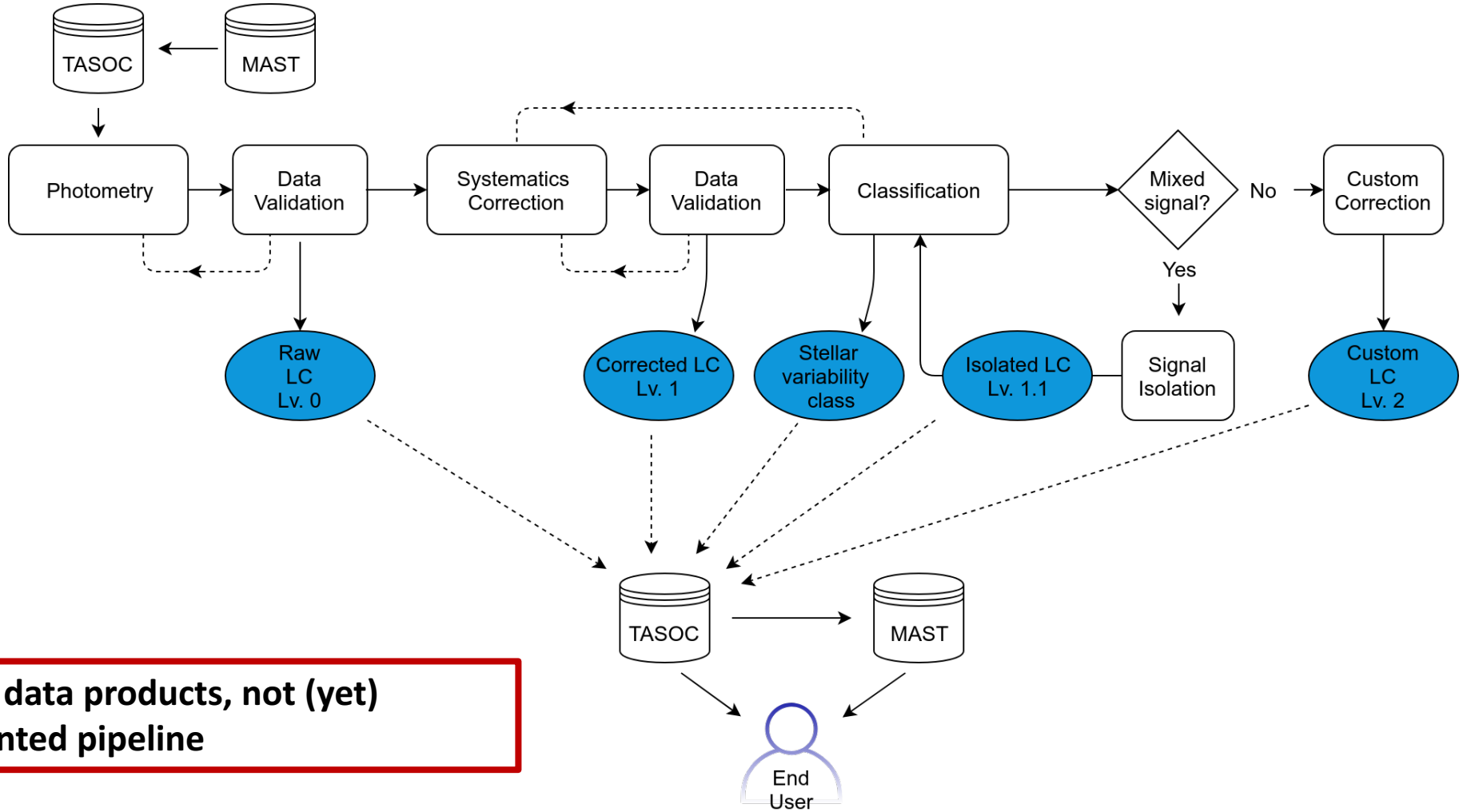
From FFI to End User



Deliverables: data products, not (yet) fully documented pipeline

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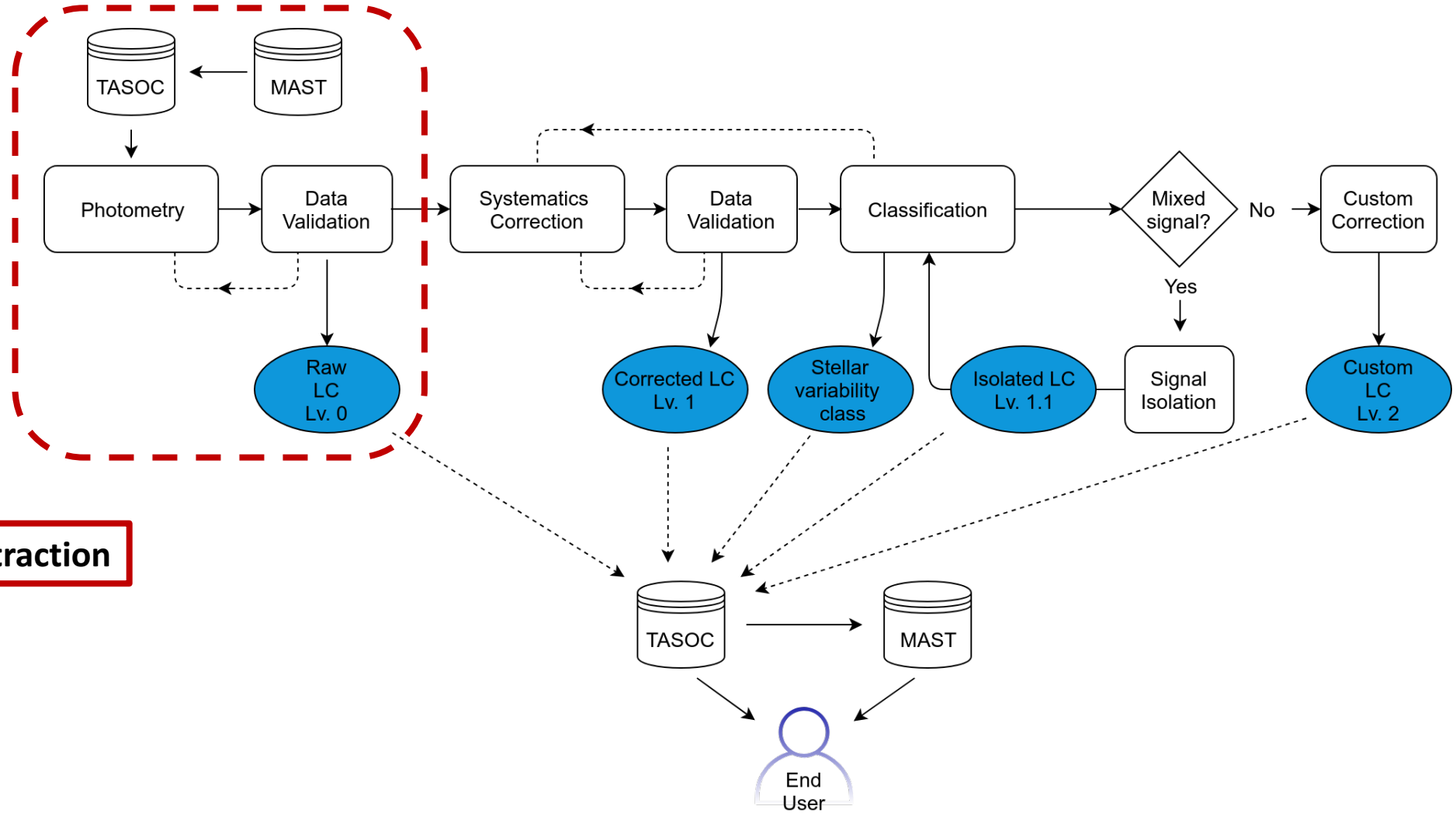
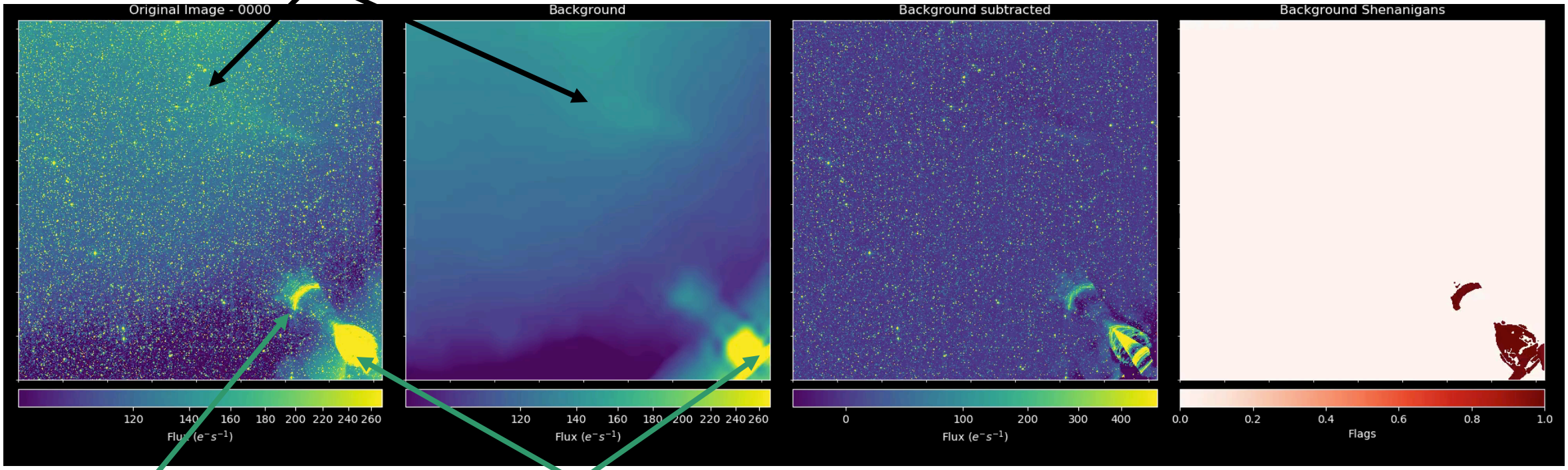


Lightcurve extraction

Background estimation

Earth/Moon scattered light
(“The Toast”)



Lens-flares from Mars (“JJ Abrams events”)

Scattered light from stars outside FOV (“Corner-glow”)

Used for photometry

Flags are propagated through to final light curves

Lightcurve Extraction

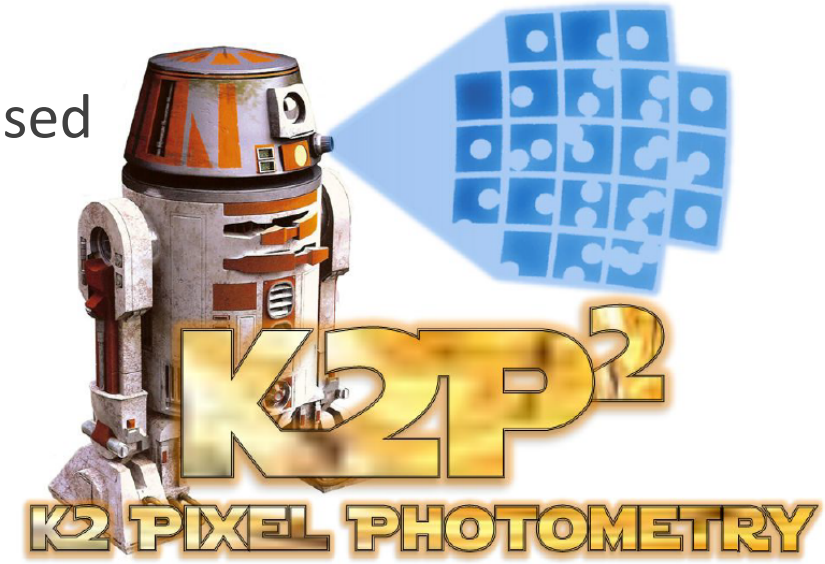
Based on K2P2 Algorithm (Lund+ 2015, Handberg & Lund 2017)

Robust method for defining pixel masks

Identify **all** targets in a given frame, making use of catalog information

Allows for asymmetric masks

PSF & difference imaging also implemented but not yet used



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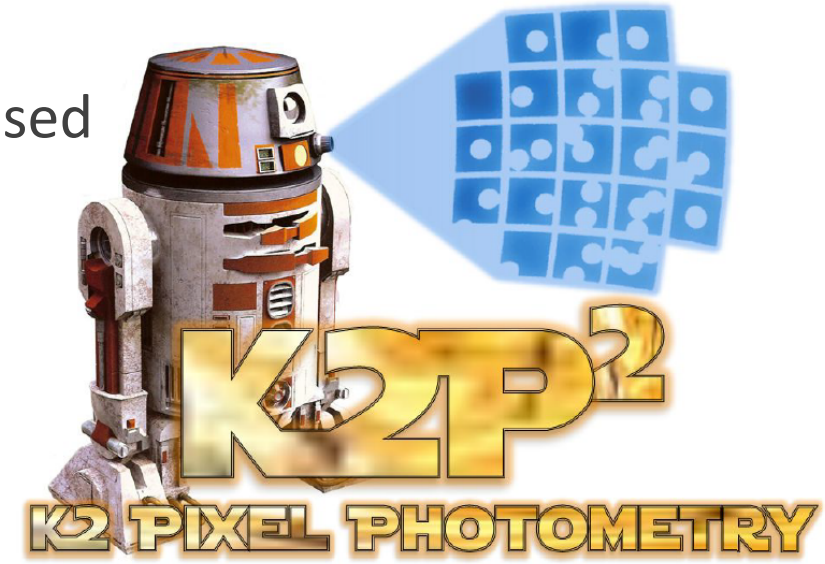
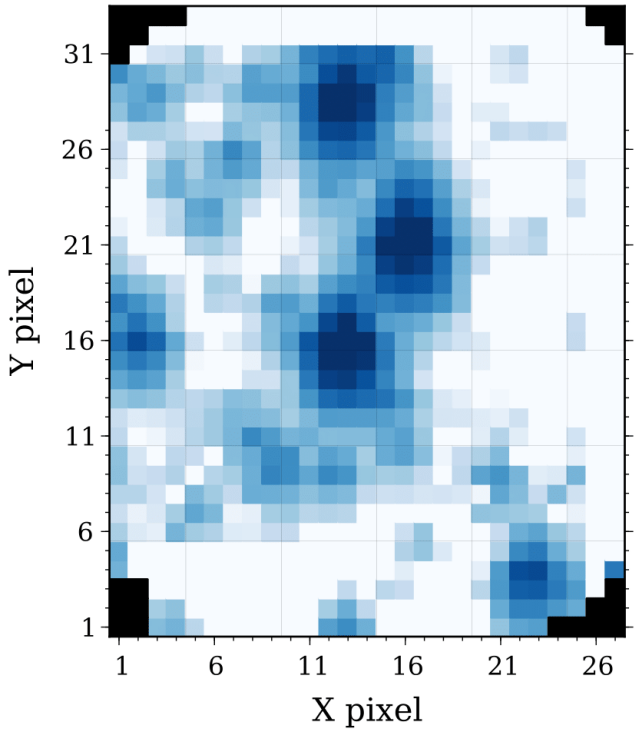
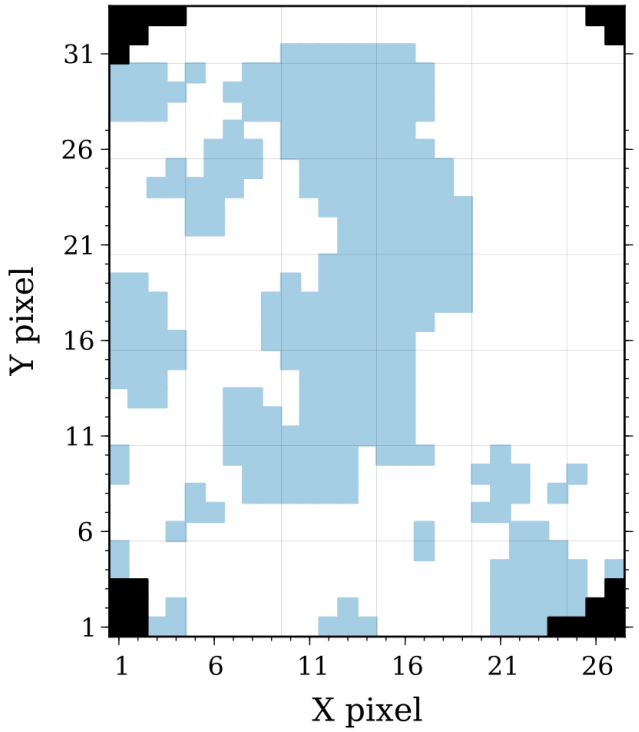
For Bloody Bright Stars, stay tuned for Tim White's talk



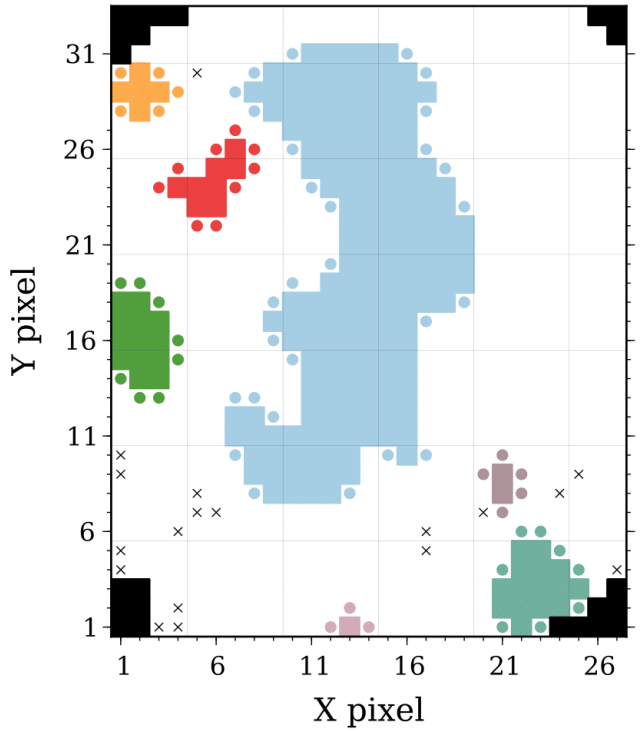
Lightcurve Extraction



Summed Image →

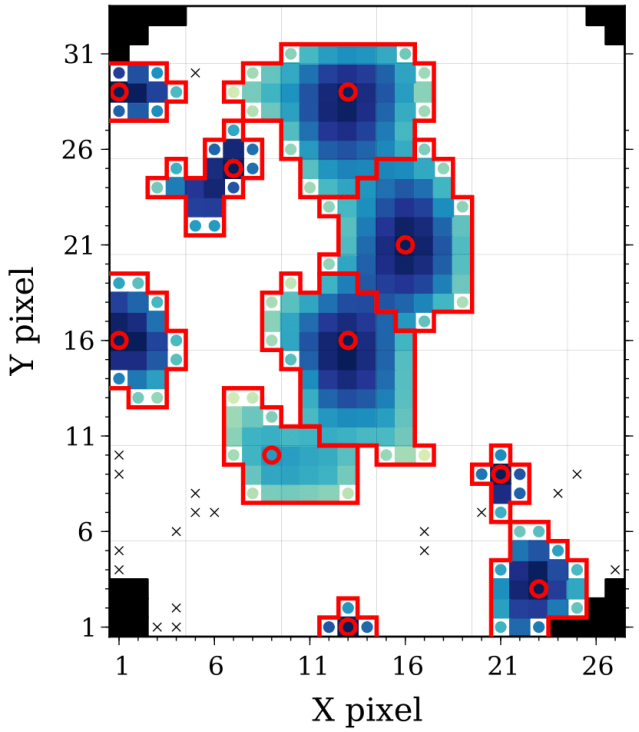


Pixel Selection →



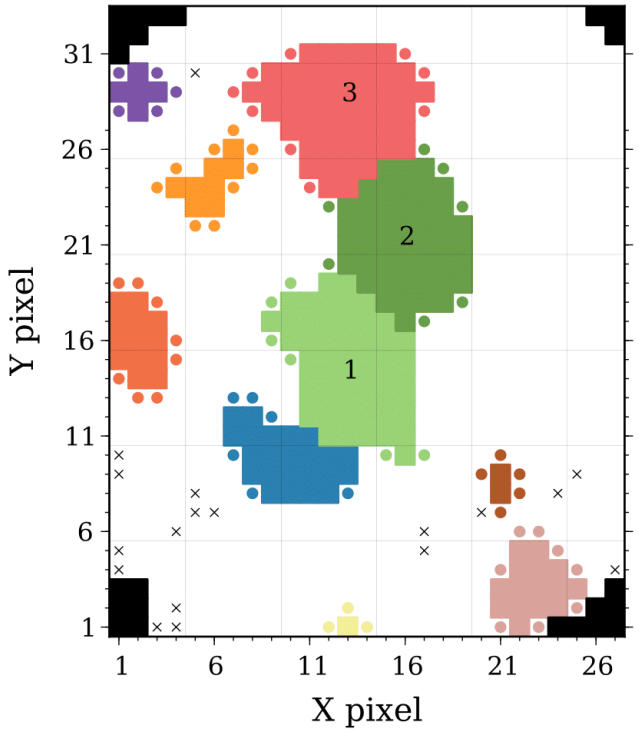
Identify Pixel Clusters

Lightcurve Extraction



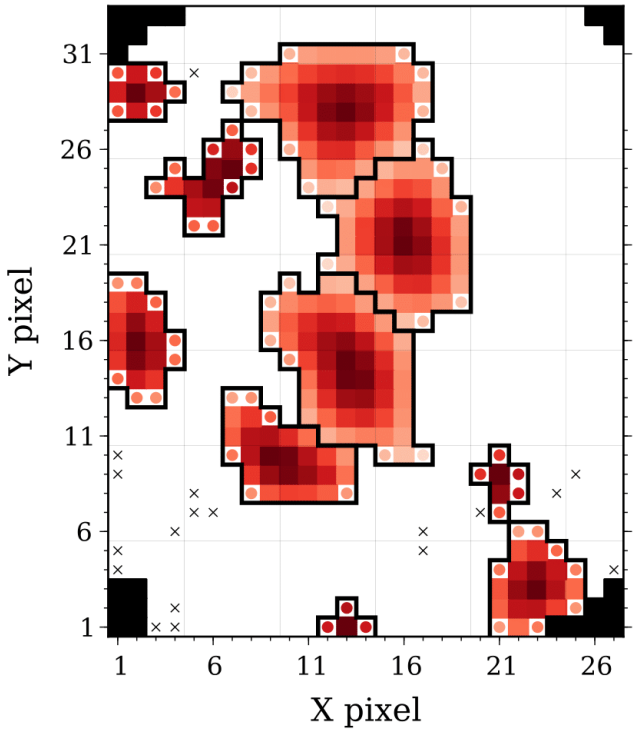
Segment Clusters (watershed)

→



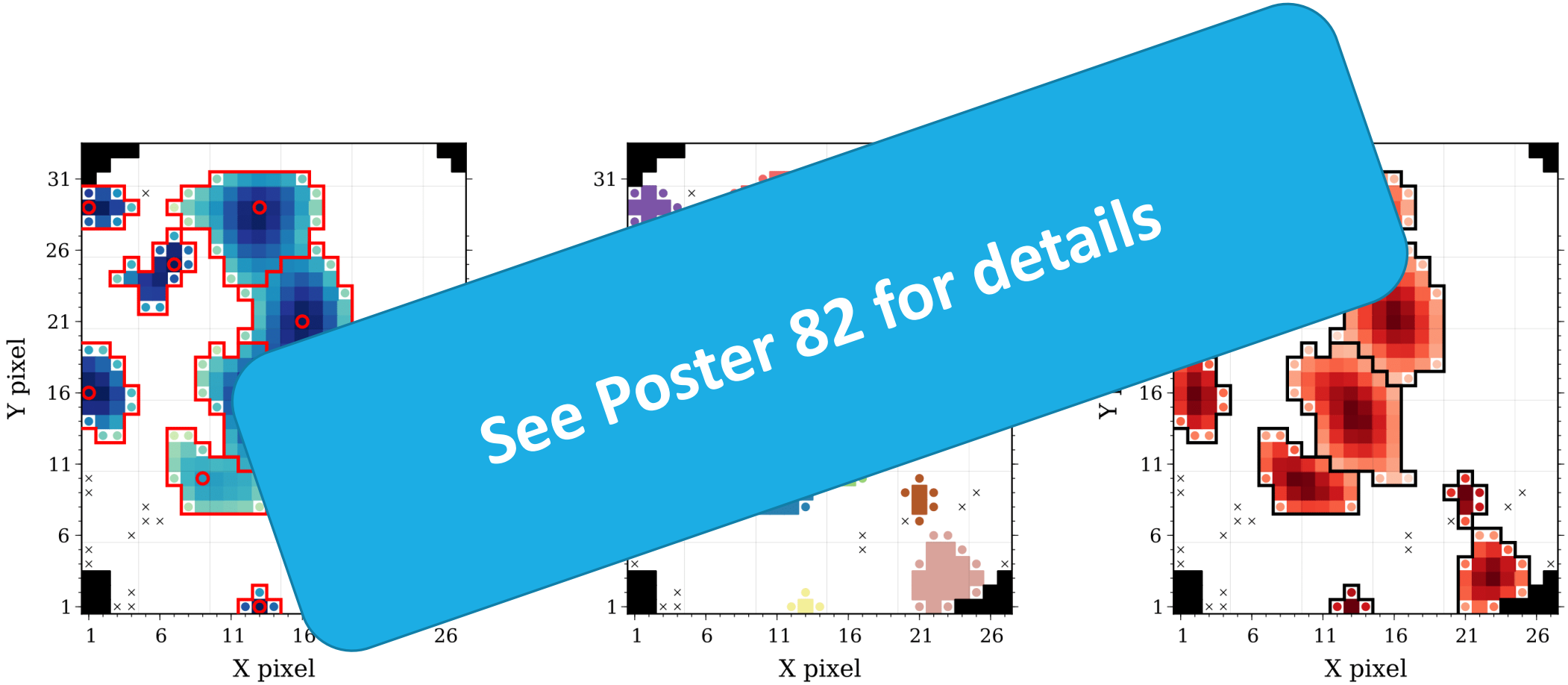
Masks

→



Catalog crosscheck

Lightcurve Extraction



Segment Clusters (watershed) → Masks → Catalog crosscheck

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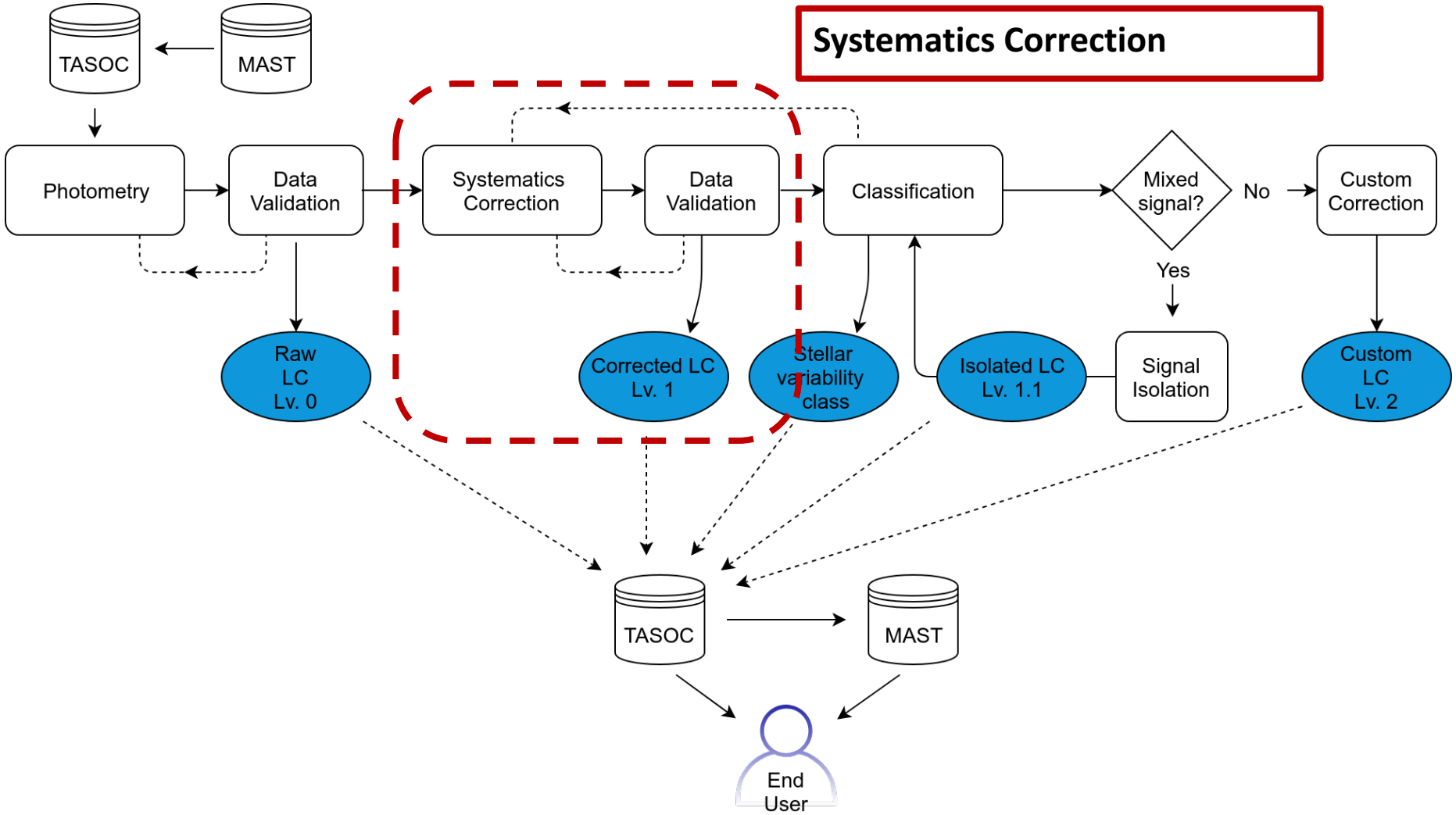
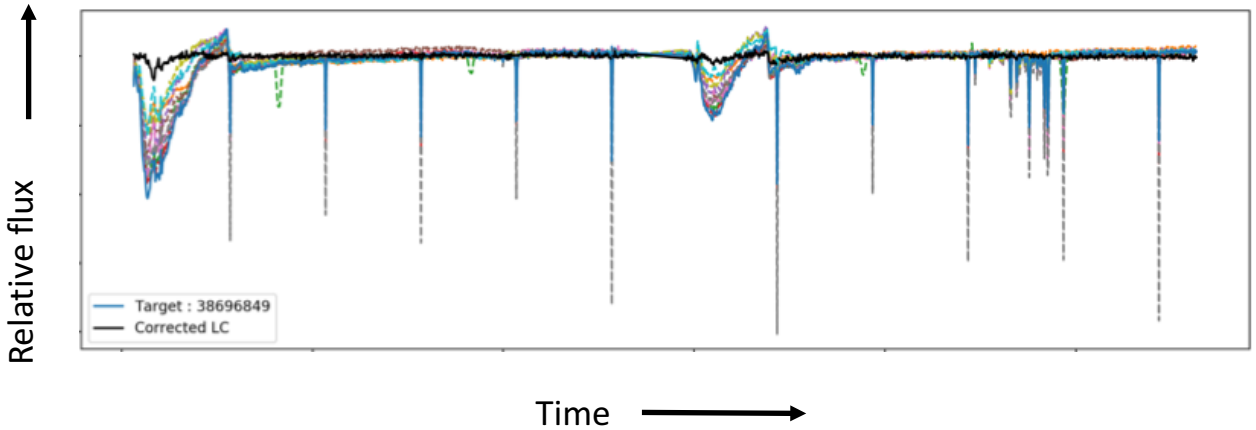
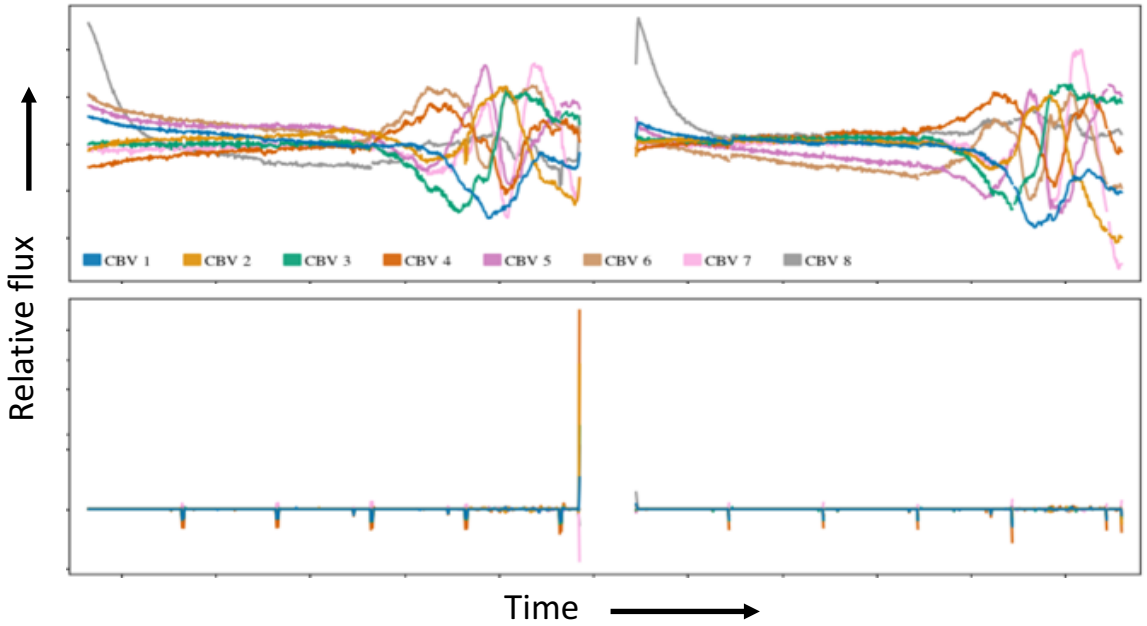


Systematics Correction

Ensemble: construct average weighted light curve from nearby neighbors

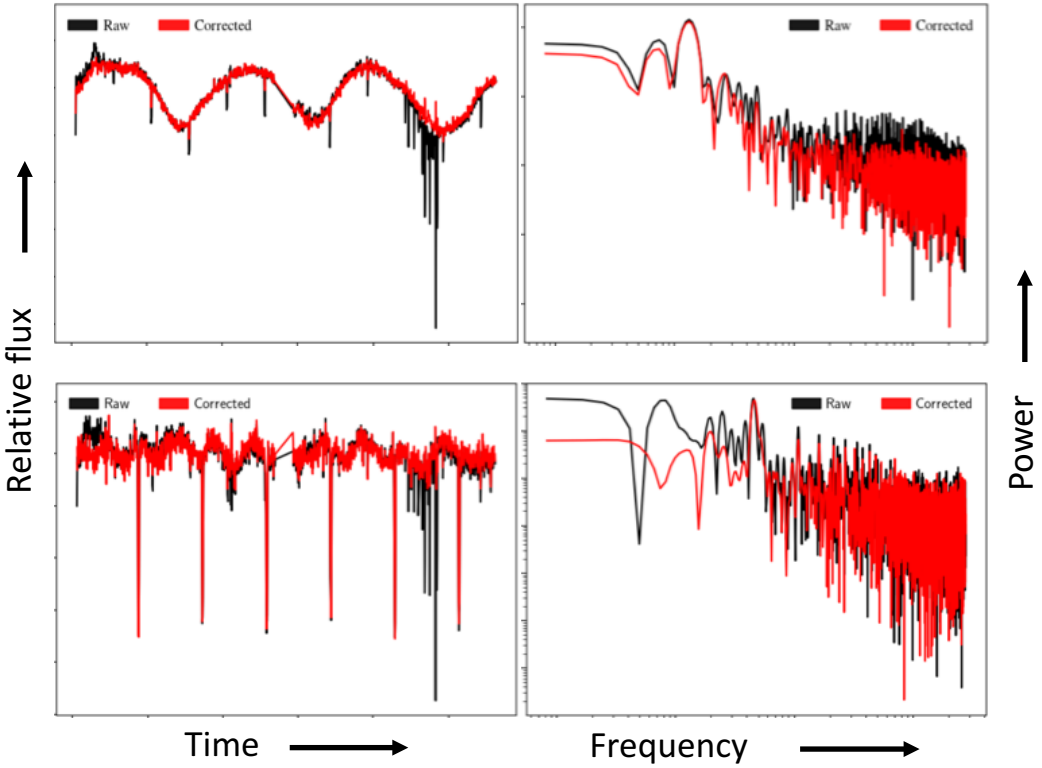


CBV: construct sets of co-trending basis vectors for CCD regions

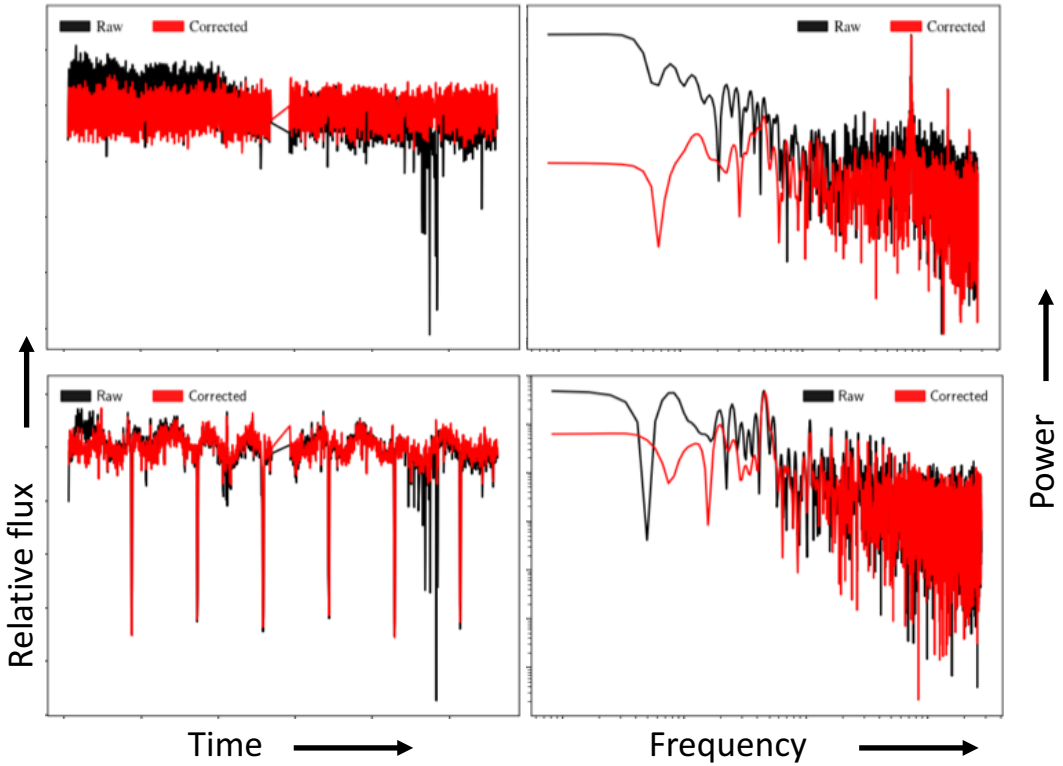


- **CBV corrections complete on S1+2**
- **Ensemble will run next**
- **~ 0.5 s/target**

Systematics Correction

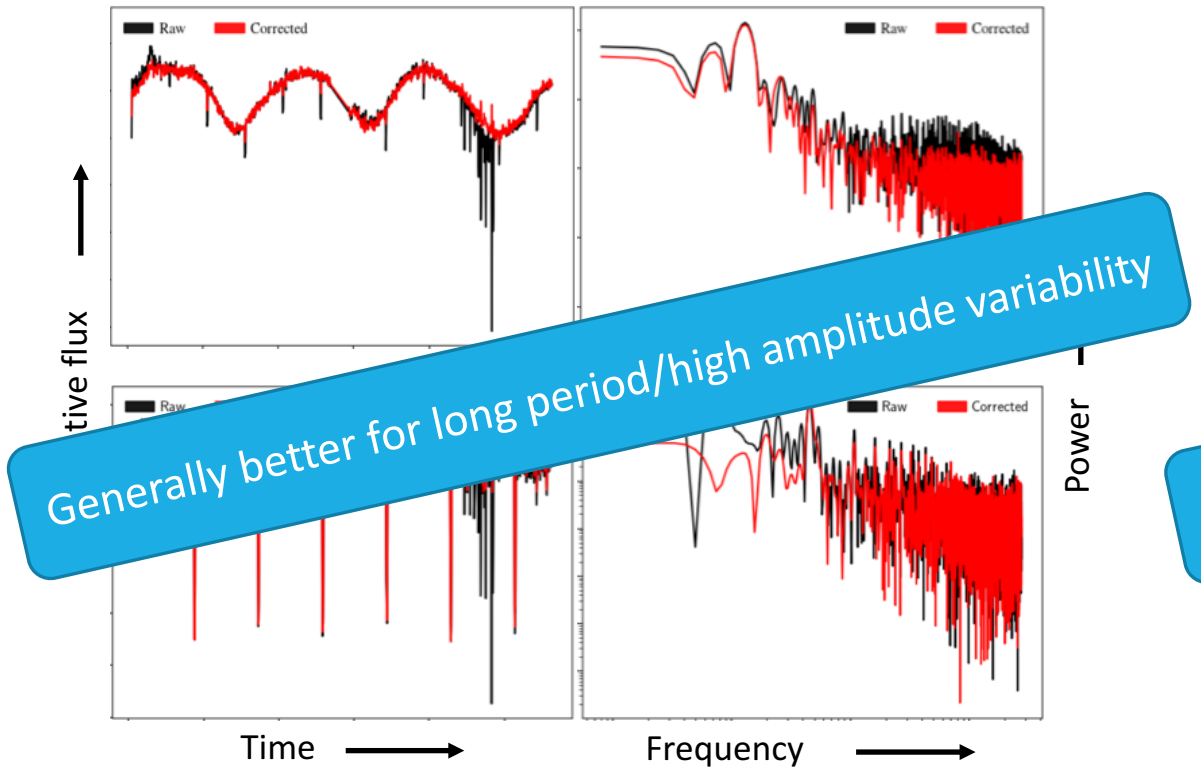


Ensemble

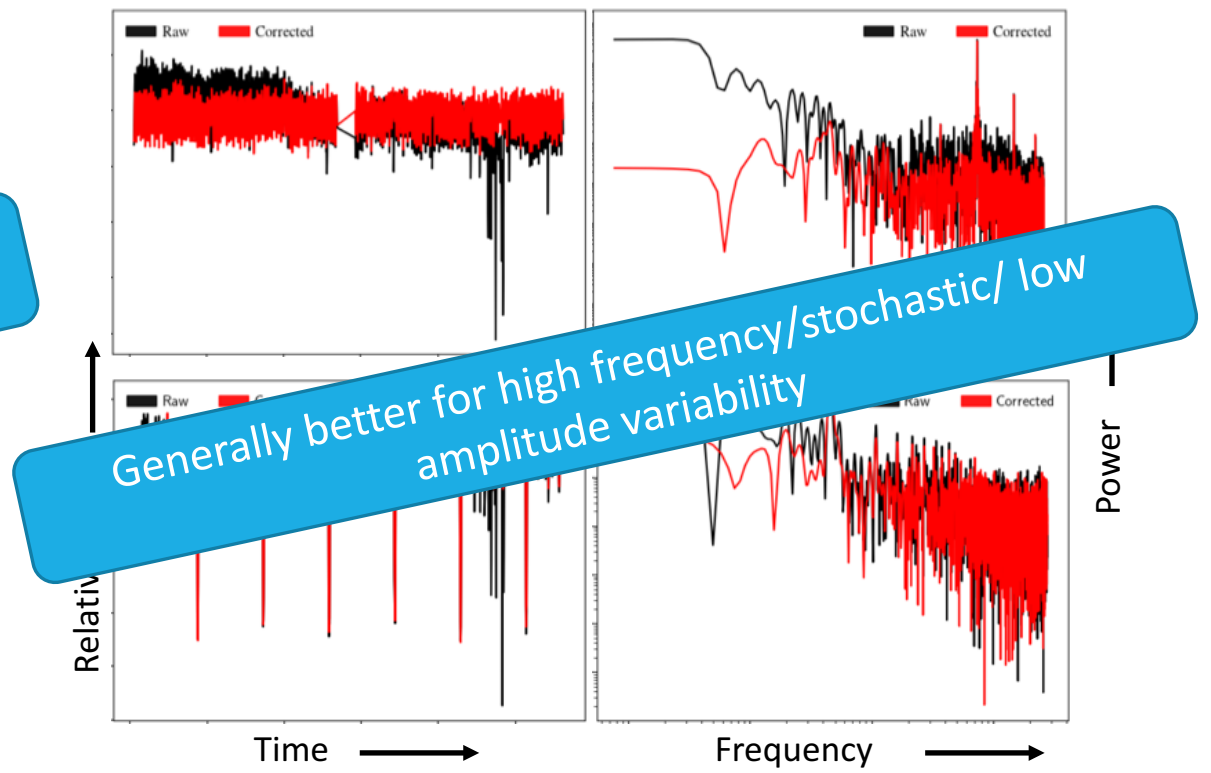


CBV

Systematics Correction



Ensemble



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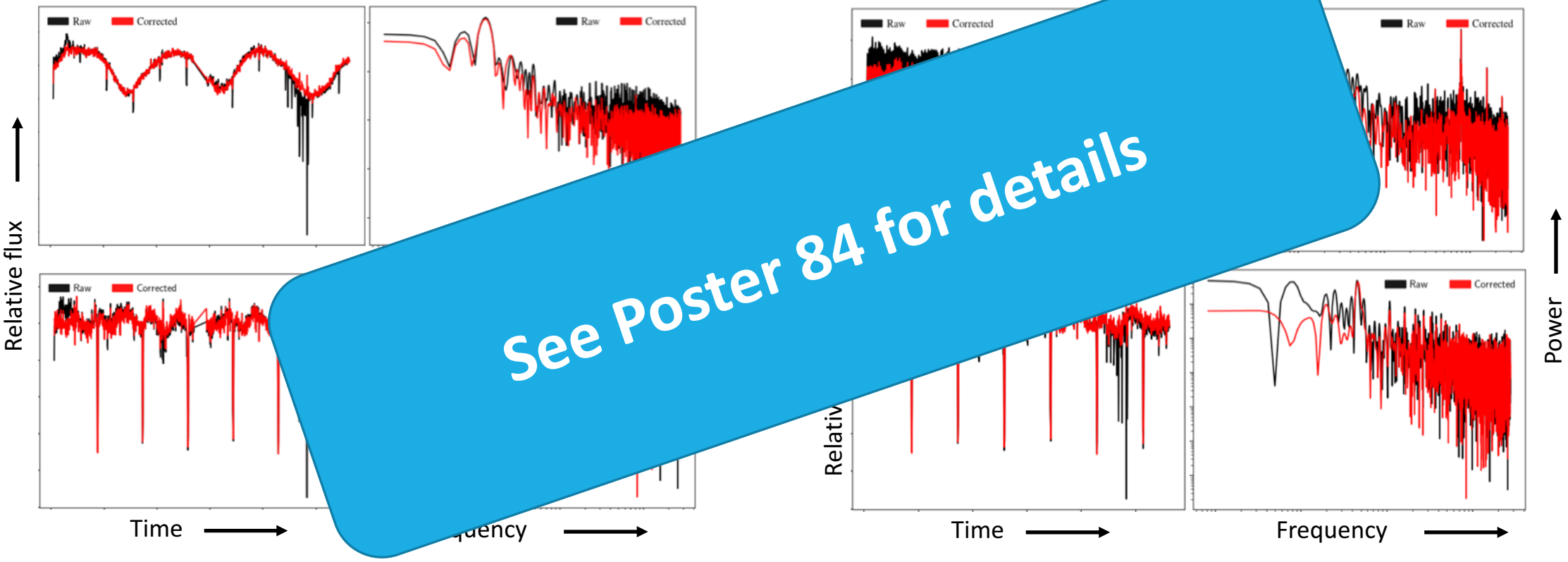

Ensemble **CBV**

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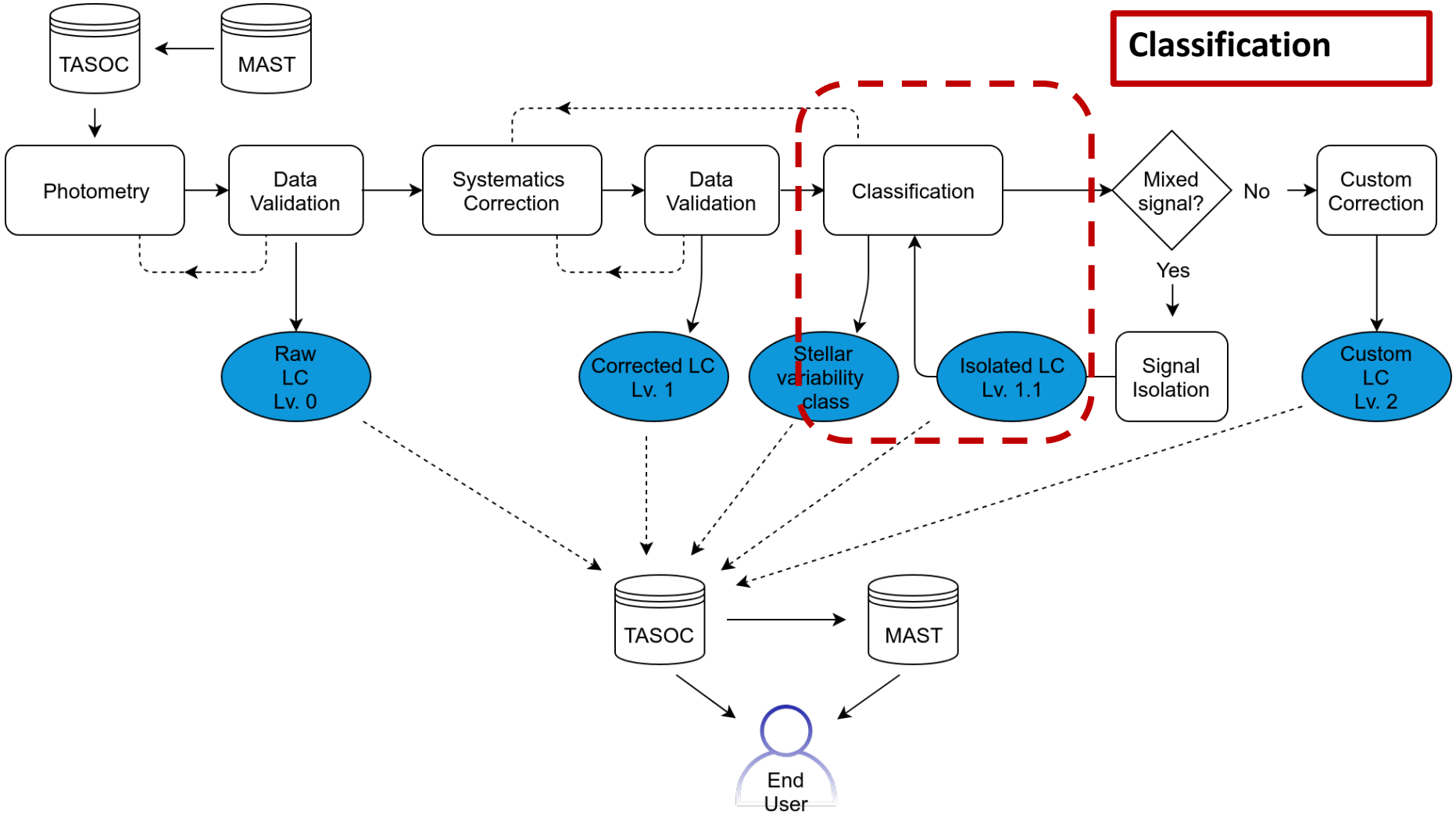

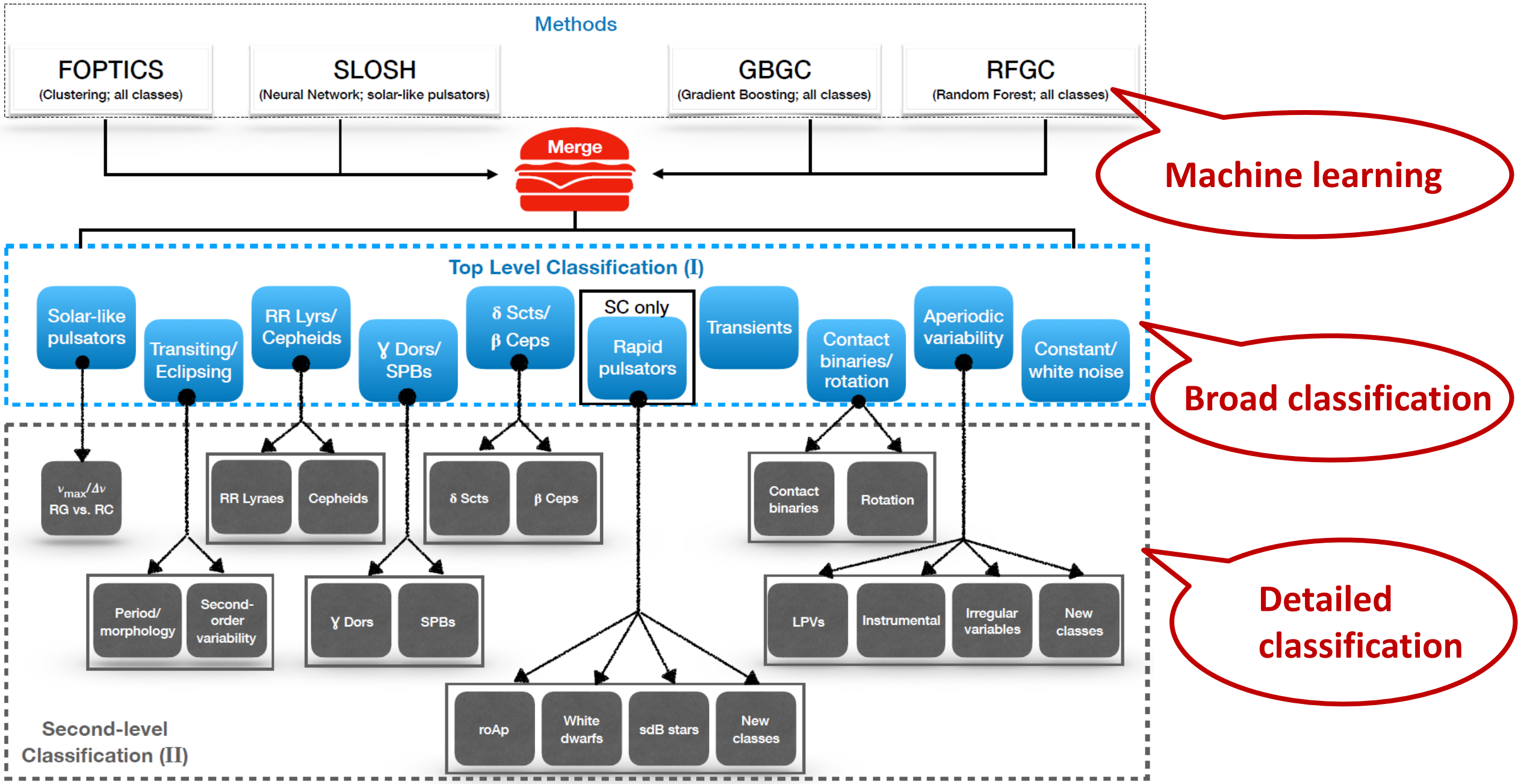
Methods
FOPTICS
(Clustering; all classes)
SLOSH
(Neural Network; solar-like pulsators)
GBGC
(Gradient Boosting; all classes)
RFGC
(Random Forest; all classes)
Merge
Machine learning
Top Level Classification (I)
Solar-like pulsators
Transiting/ Eclipsing
RR Lyrs/ Cepheids
γ Dors/ SPBs
δ Scts/ β Ceps
SC only
Rapid pulsators
Transients
Contact binaries/ rotation
Aperiodic variability
Constant/ white noise
Broad classification
$\nu_{max}/\Delta\nu$ RG vs. RC
RR Lyraes
Cepheids
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Contact binaries
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Period/ morphology
Second-order variability
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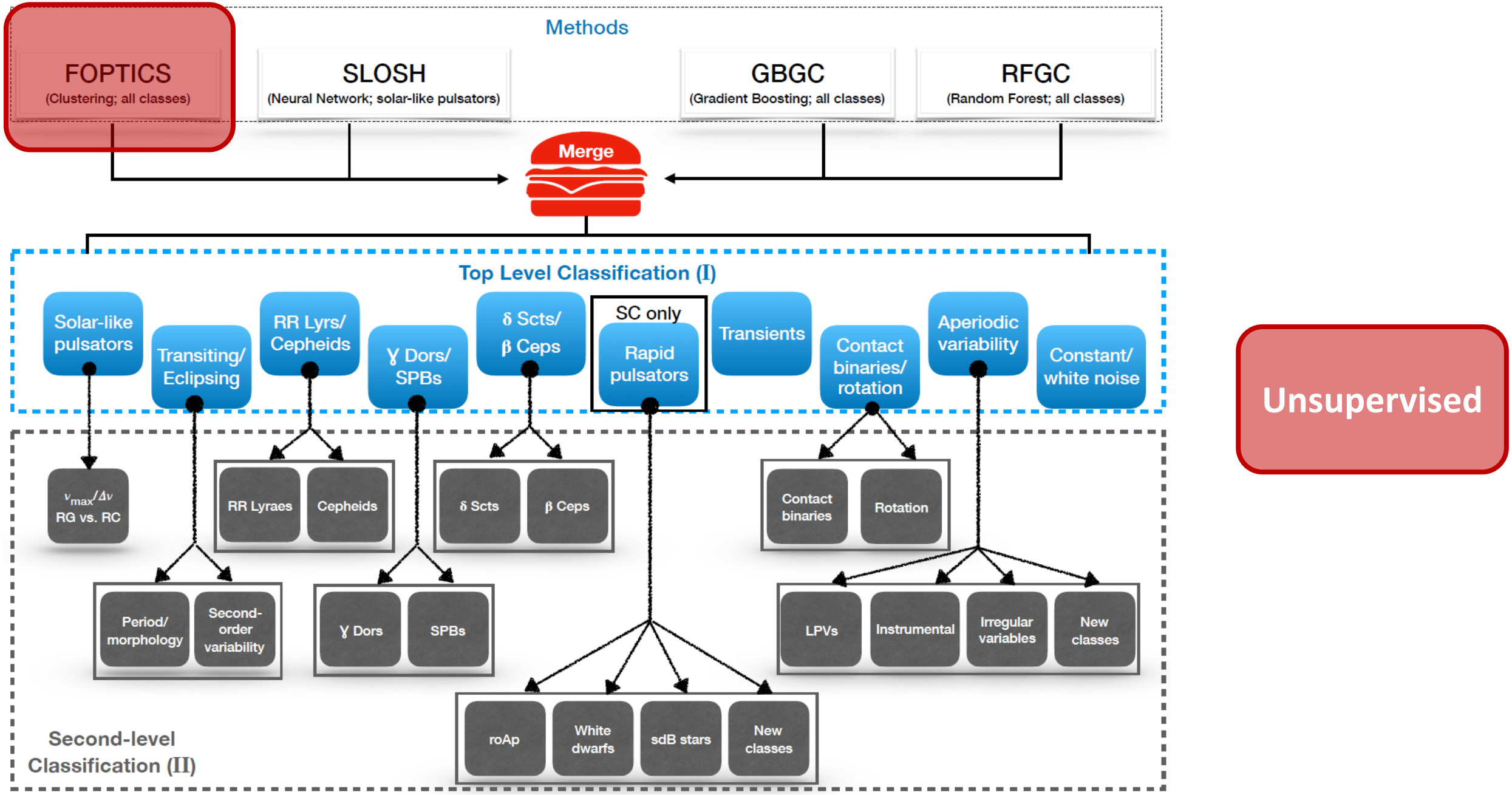
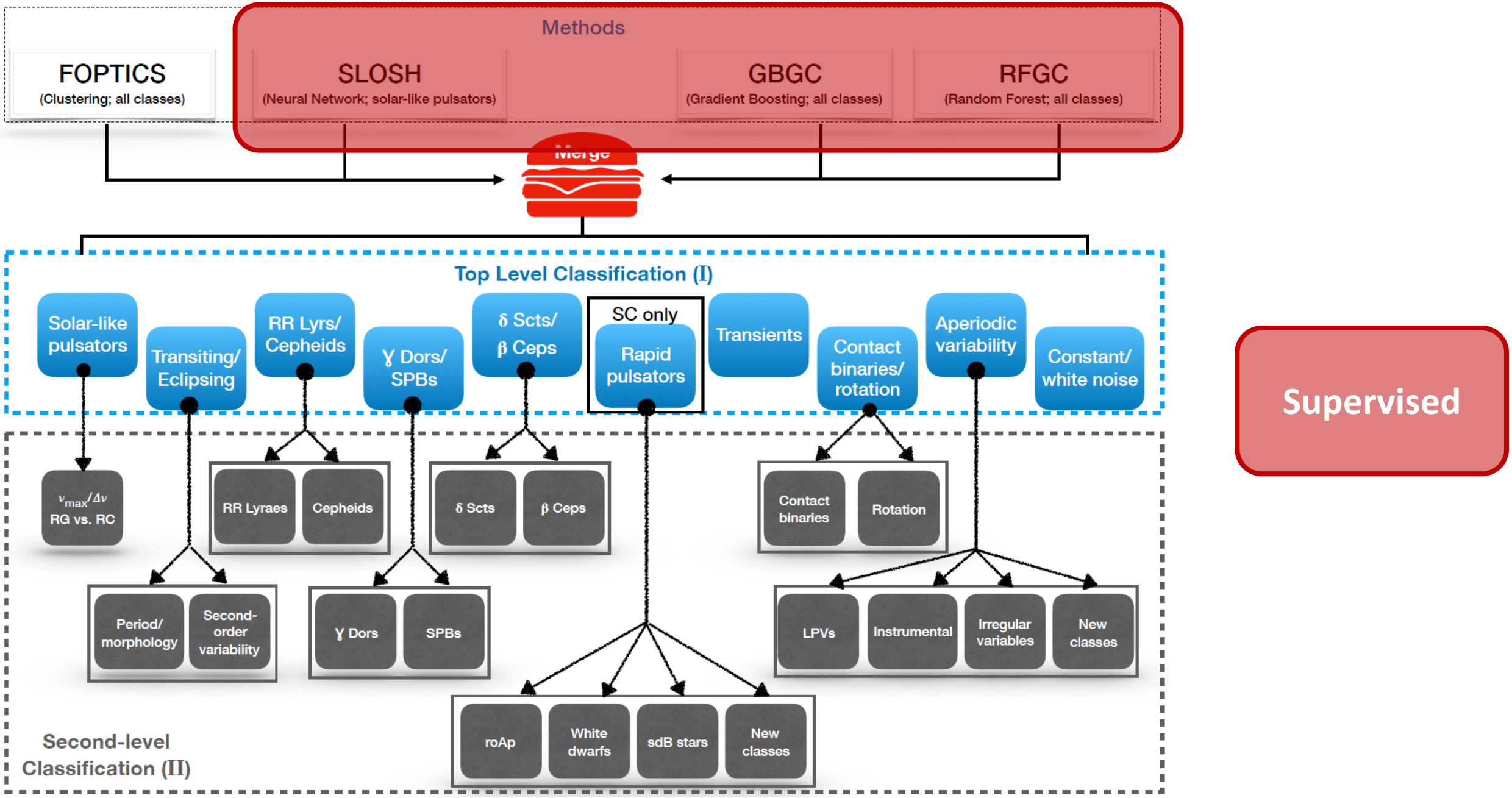
LPVs
Instrumental
Irregular variables
New classes
roAp
White dwarfs
sdB stars
New classes
Second-level Classification (II)
Detailed classification



Unsupervised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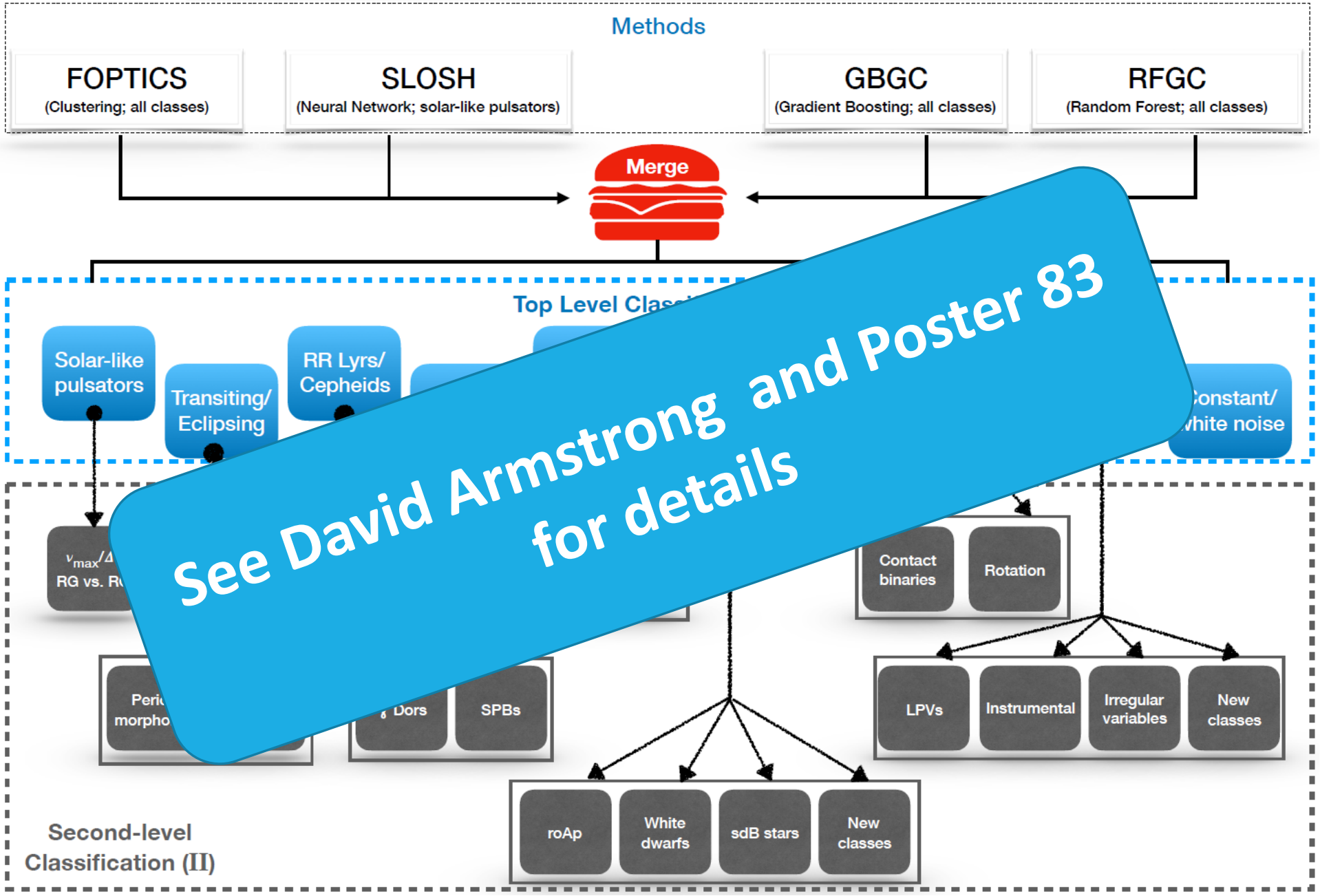
Supervised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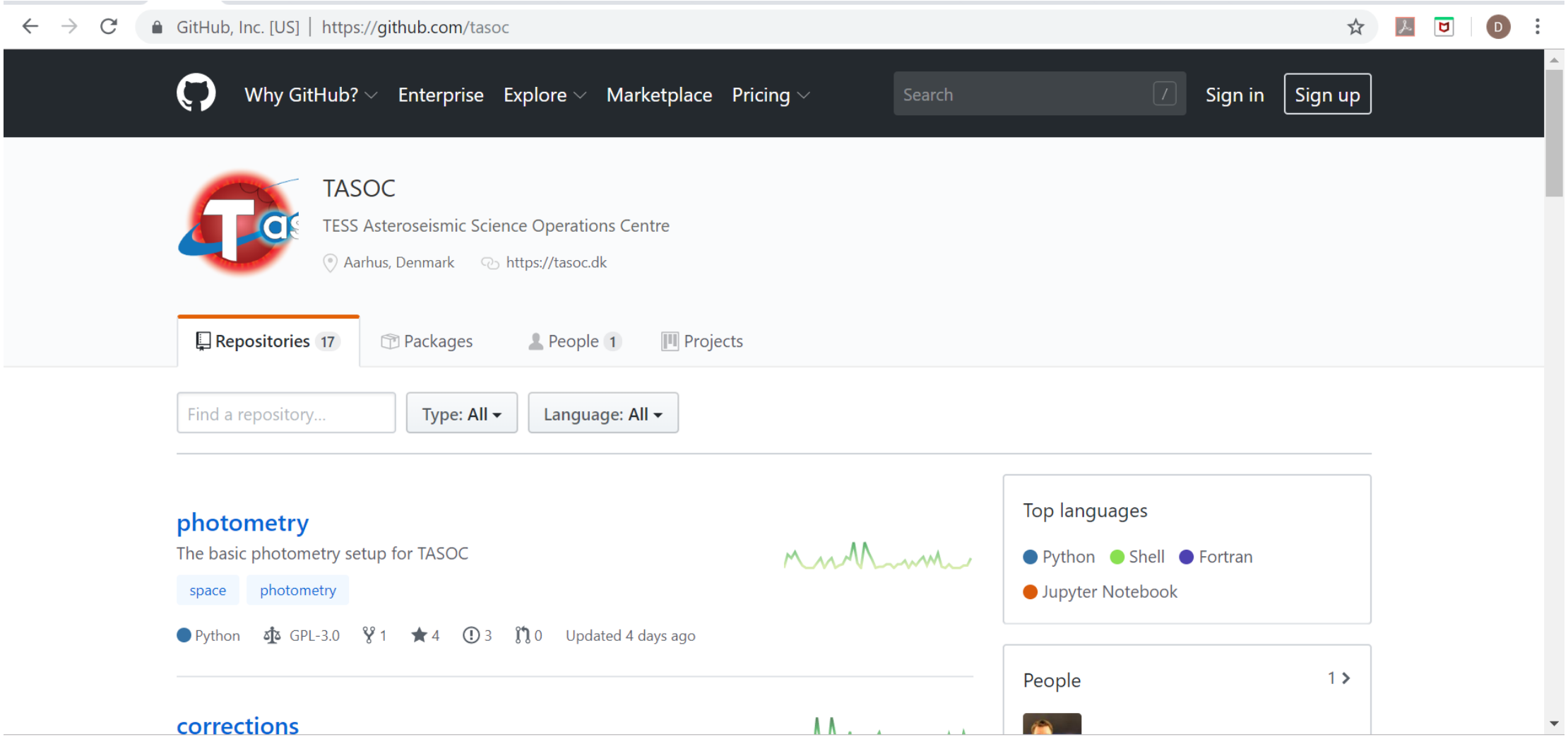
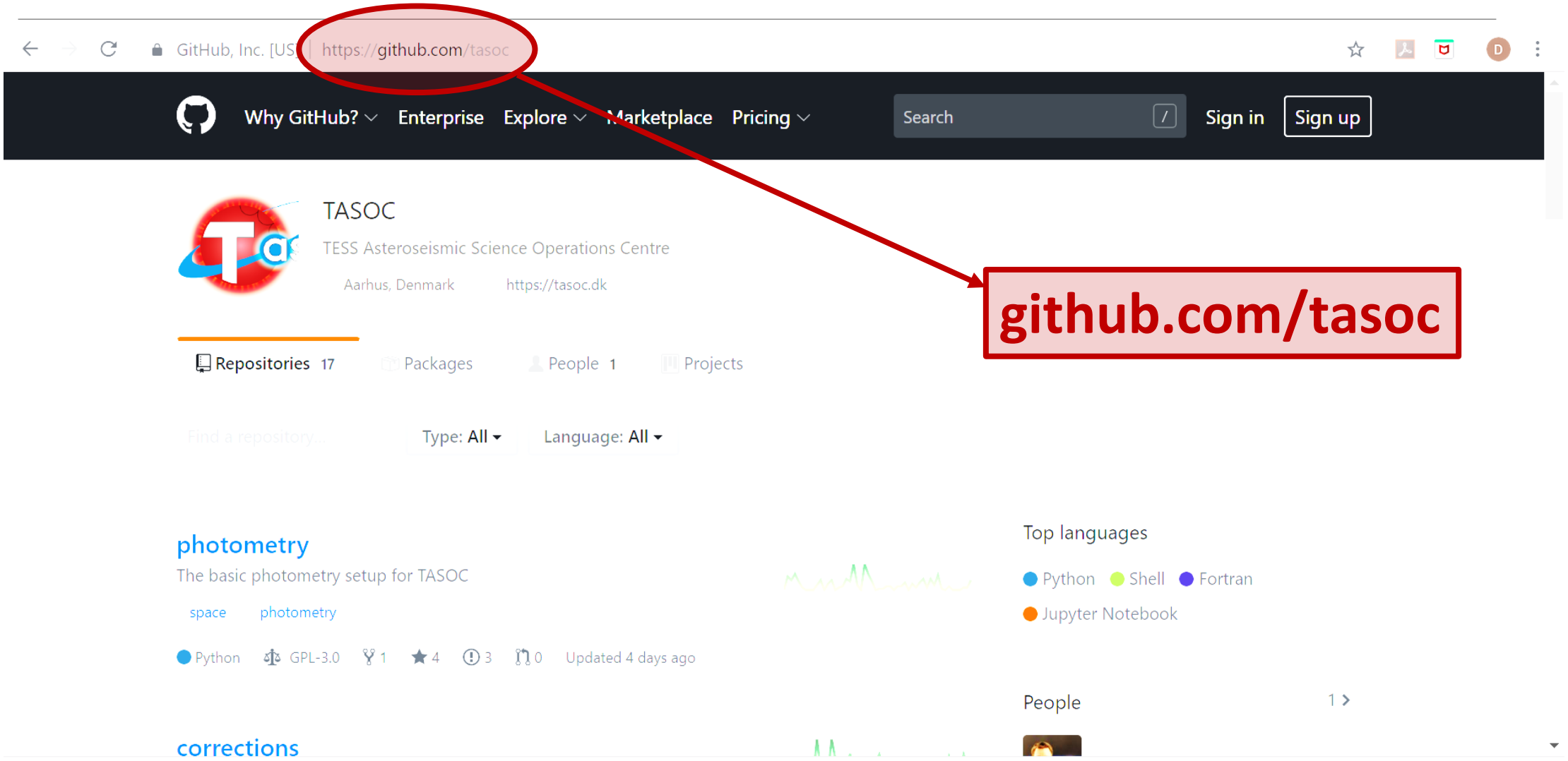
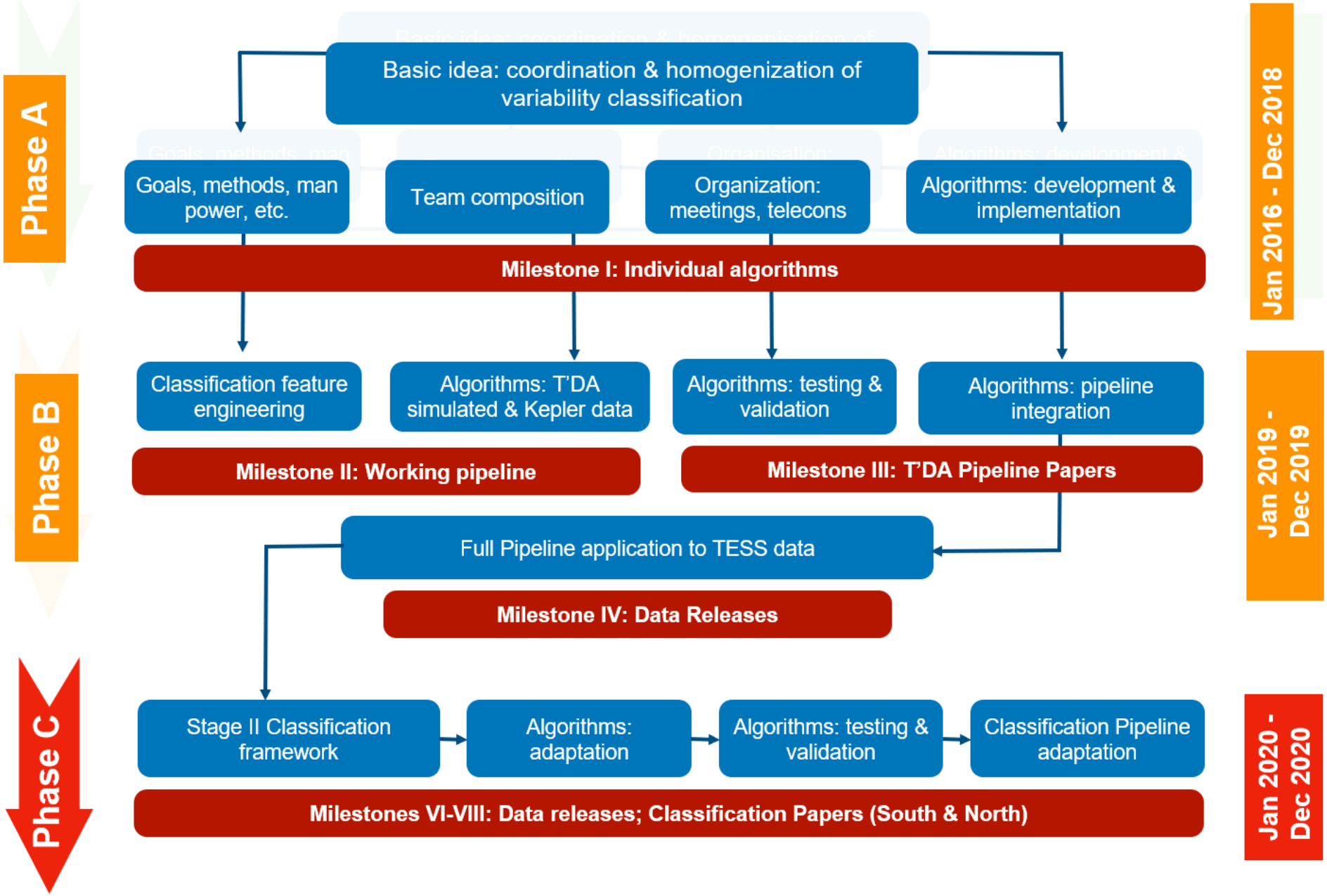
Solar-like pulsators
Transiting/ Eclipsing
RR Lyrs/ Cepheids
onstant/ hite noise
Contact binaries
Rotation
LPVs
Instrumental
Irregular variables
New classes
SPBs
roAp
White dwarfs
sdB stars
New classes
Second-level Classification (II)
See David Armstrong and Poster 83 for details

Open Source Community Development



Open Source Community Development




Phase A
Basic idea: coordination & homogenization of variability classification
Goals, methods, man power, etc.
Team composition
Organization: meetings, telecons
Algorithms: development & implementation
Milestone I: Individual algorithms
Jan 2016 - Dec 2018
Phase B
Classification feature engineering
Algorithms: T'DA simulated & Kepler data
Algorithms: testing & validation
Algorithms: pipeline integration
Milestone II: Working pipeline
Milestone III: T'DA Pipeline Papers
Full Pipeline application to TESS data
Milestone IV: Data Releases
Jan 2019 - Dec 2019
Phase C
Stage II Classification framework
Algorithms: adaptation
Algorithms: testing & validation
Classification Pipeline adaptation
Milestones VI-VIII: Data releases; Classification Papers (South & North)
Jan 2020 - Dec 2020

Limited data release has begun!

https://tasoc.dk

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  - » WG-7: Red Giants
- » Coordinated Activities Wikis
  - » TESS Data for Asteroseismology
  - » TASC-GI Coordination
  - » Ground-based Coordination
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TASOC Data Releases

Here you can find TESS data released by the Coordinated Activity T'DA, which is responsible for light curve preparation for asteroseismology.

Data Release 4 – Sector 1+2 "raw" photometry for Full Frame Images (FFIs) and Target Pixel Files (TPF)

For this release a total of 2,495,083 targets from TESS sectors 1 and 2 have been processed, resulting in 1,733,576 light curve files. A limiting TESS-band magnitude of 15 was adopted for the analysis of FFIs.

Data provided with this release have been extracted using from calibrated target pixel files using the TASOC Photometry pipeline . No subsequent corrections have been applied to the light curves. We are working hard on the implementation of the co-trending component of the T'DA pipeline, but release raw photometry now to allow the community to have a first look at the full data sets.

The TASOC pipeline used to generate the data is open source and available on GitHub .

Please read the full data release notes for more details.

Download

Data Release Notes (TASOC-0004-01).

Figures

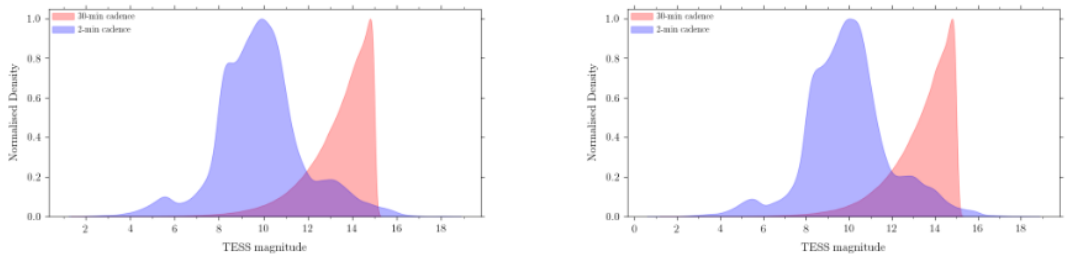


Figure 1: Magnitude distribution for stars covered by this release. Left: targets in Sector 1; Right: Targets in Sector 2. The distributions have been normalised to a maximum of 1.

T'DA Data Release Notes

Data Release 4 for TESS Sectors 1+2

TASOC-0004-01

TESS Data for Asteroseismology (T'DA)

Rasmus Handberg & Mikkel N. Lund, Editors

March 1, 2019

This report is prepared by the Coordinated Activity T'DA of the TESS Asteroseismic Science Consortium (TASC), which is responsible for light curve preparation for asteroseismology.

Raw photometry for 2-min (TPF) and 30-min (FFI) cadence targets from TESS Sectors 1 and 2 are released with this note. The data summarised in this report can be queried via the TESS Asteroseismic Science Operation Center (TASOC)[1] data base. We are in the process of also making the data available as a High Level Science Product (HLSP) on The Mikulski Archive for Space Telescopes (MAST)[2].

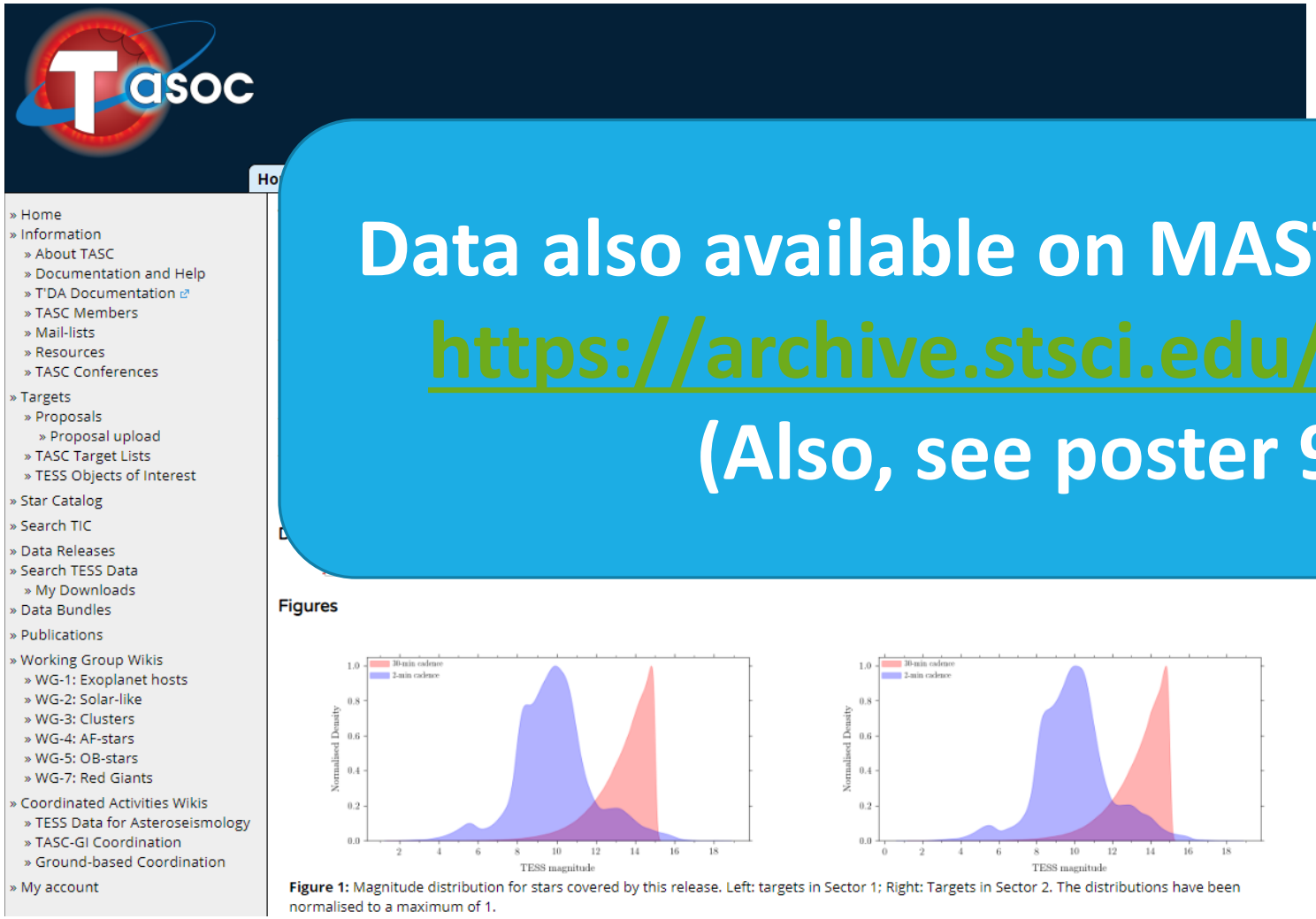
We are working hard on the implementation of the co-trending component of the T'DA pipeline, but release raw photometry now to allow the community to have a first look at the full data sets. The TASOC pipeline used to generate the data is open source and available on GitHub[3].

Before using data from this release we strongly recommend you read through this note, and consult the TESS Instrument Handbook (Vanderspek et al. 2018).

[1] https://tasoc.dk
[2] https://archive.stsci.edu/tess/
[3] https://github.com/tasoc

Limited data release has begun!

https://tasoc.dk

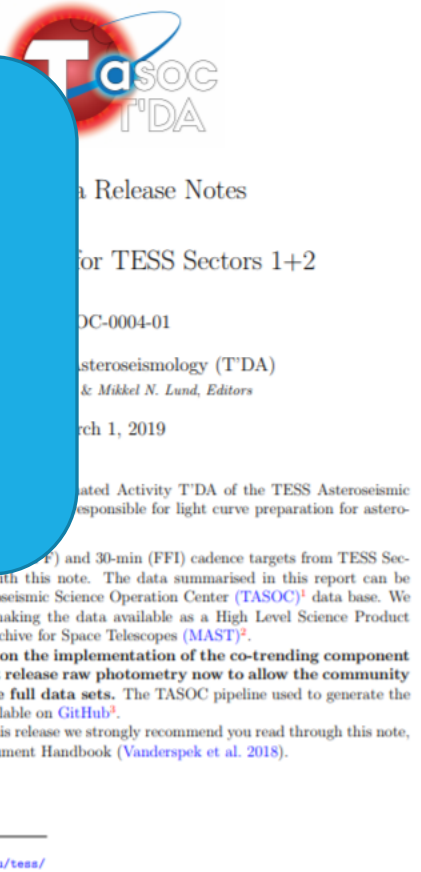


Data also available on MAST as an HSLP

https://archive.stsci.edu/hlsp/tasoc

(Also, see poster 96)

Figure 1: Magnitude distribution for stars covered by this release. Left: targets in Sector 1; Right: Targets in Sector 2. The distributions have been normalised to a maximum of 1.



a Release Notes

for TESS Sectors 1+2

OC-0004-01

steroseismology (T'DA)

& Mikkel N. Lund, Editors

rch 1, 2019

ated Activity T'DA of the TESS Asteroseismic
esponsible for light curve preparation for astero-

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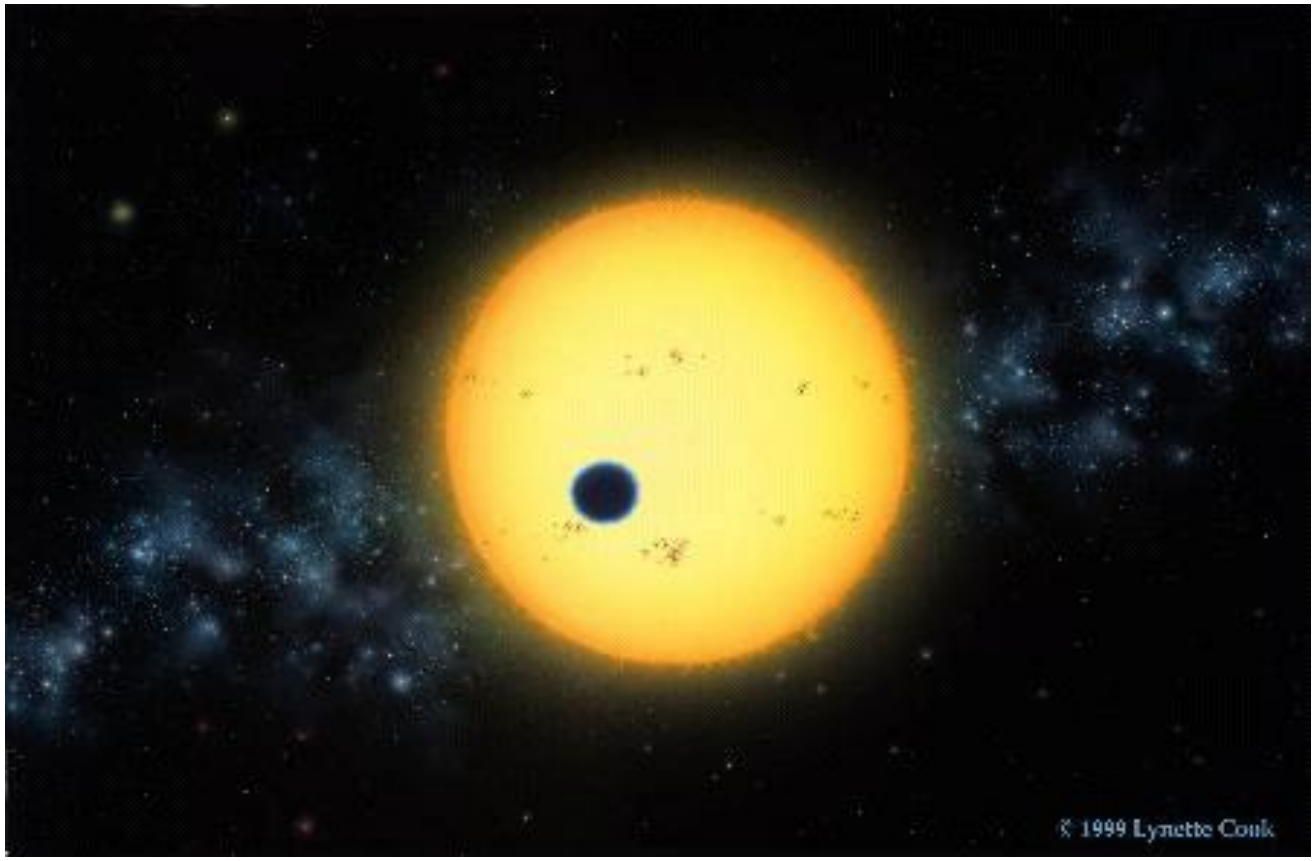
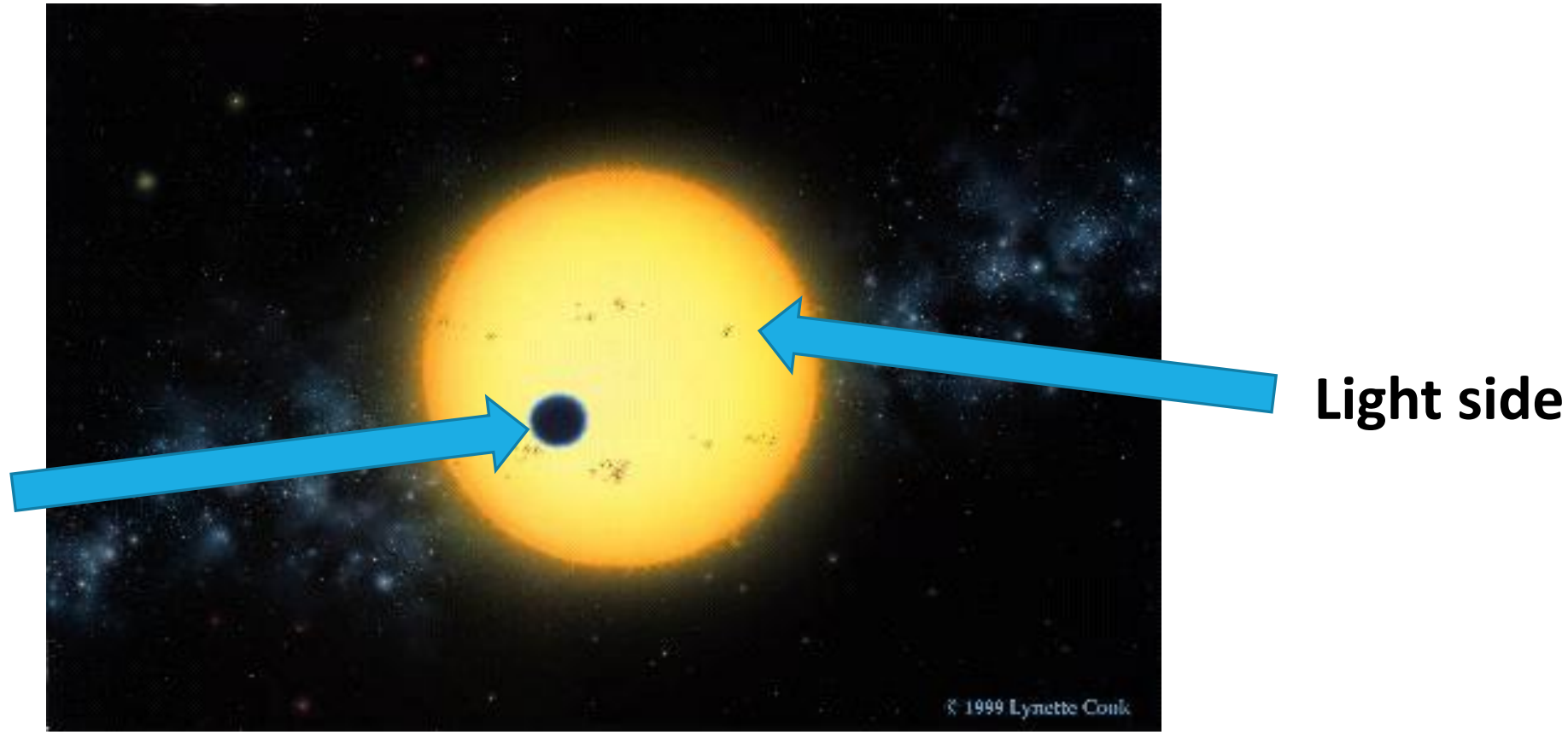
[1] https://tasoc.dk
[2] https://archive.stsci.edu/tess/
[3] https://github.com/tasoc

It’s not too late to become an asteroseismologist!



It’s not too late to become an asteroseismologist!



Takeaways

Products and dates
- First full uncorrected data release (Segments 1+2) complete
- Full corrected date release (Segments 1+2) anticipated by end of August 2019
- Segments 3+4 will follow within a couple of weeks (3.3 million light curves total)
- Further TASOC releases will keep pace with TESS releases

Future Enhancements
- Custom corrected light curves
- Feedback from classification effort to systematics removal

Opportunities for Involvement in TASC
- Projects forming continuously
- Open to entire community

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