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Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

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Discovering vanishing objects in POSS I red images using the Virtual Observatory

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A bright triple transient that vanished within 50 min

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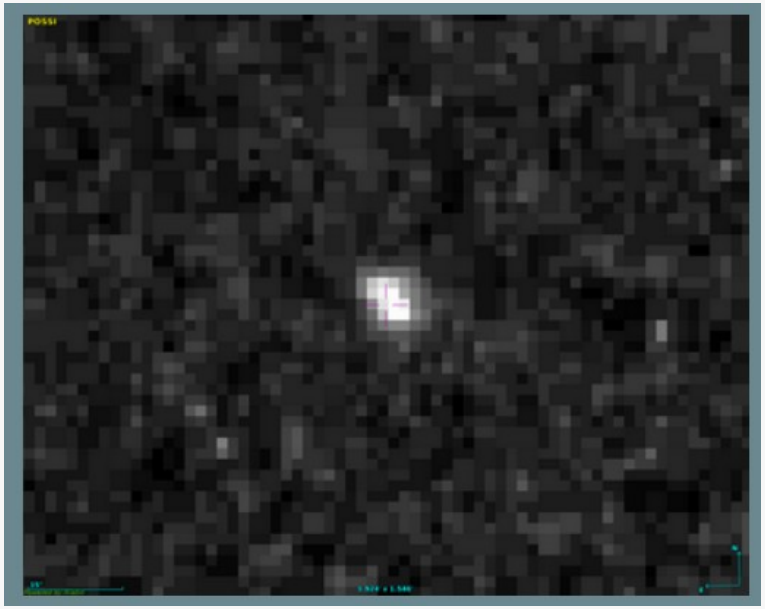
CENTRO DE ASTROBIOLOGÍA · CAB
ASOCIADO AL NASA ASTROBIOLOGY PROGRAM

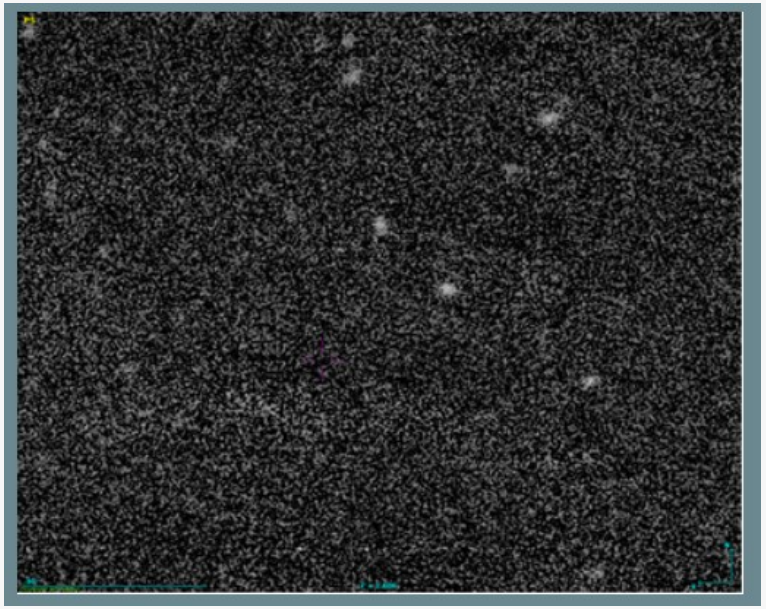
MINISTERIO DE CIENCIA E INNOVACIÓN
AGENCIA ESTATAL DE INVESTIGACIÓN
Ayuda PID2020-112949GB-I00

CSIC INTA

Vanishing objects

- Objects detected in old surveys that are not identified in modern surveys.
- **Included:** large amplitude variables fading below the detection limit or new classes of objects with unknown physics.
- **Excluded:** Solar System objects.





The goal

Perform an automated search for vanishing objects using the **POSS I** digitized plates and the **Gaia EDR3** and **Pan-STARRS DR2** catalogues taking advantage of **Virtual Observatory** tools and services.

The workflow

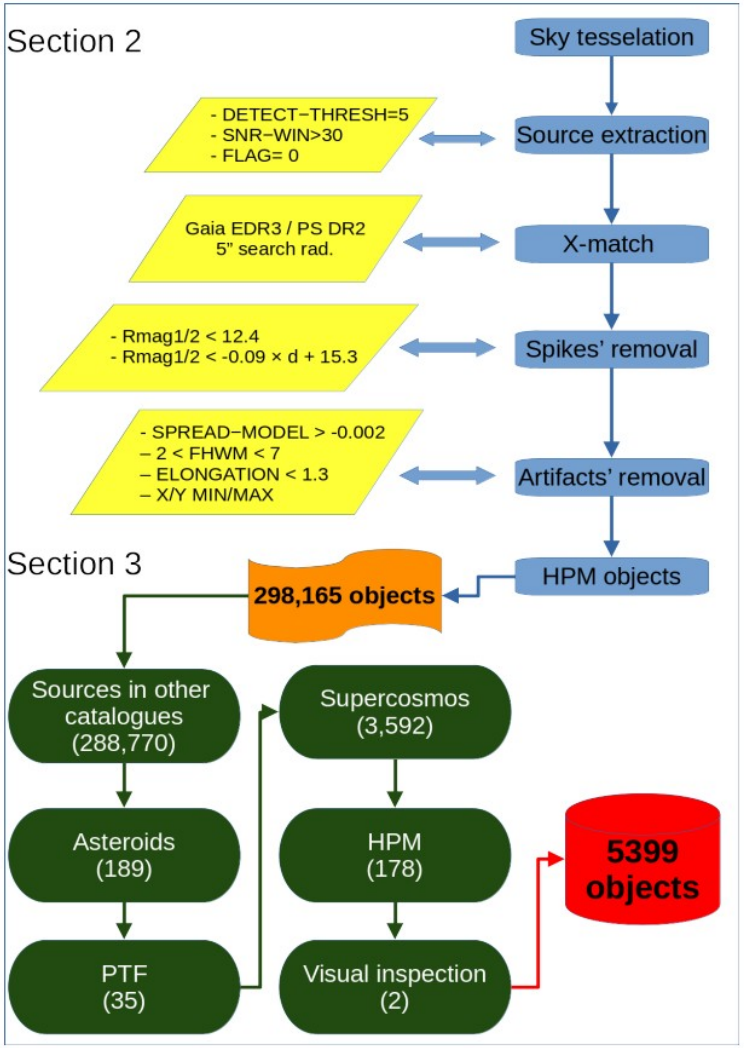
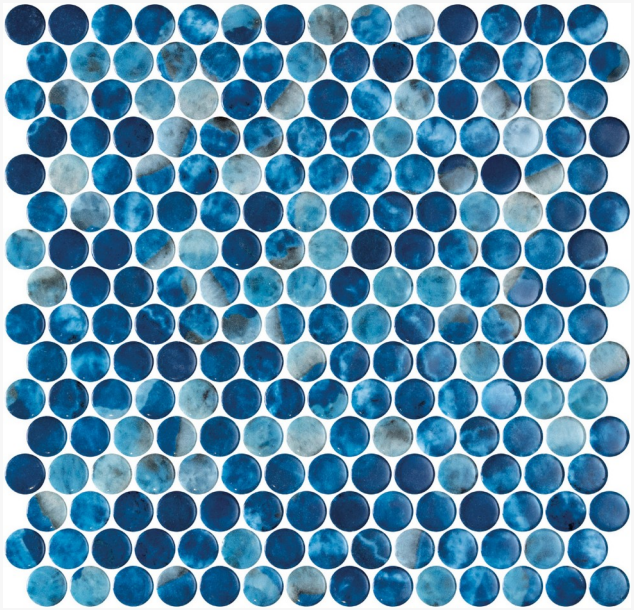


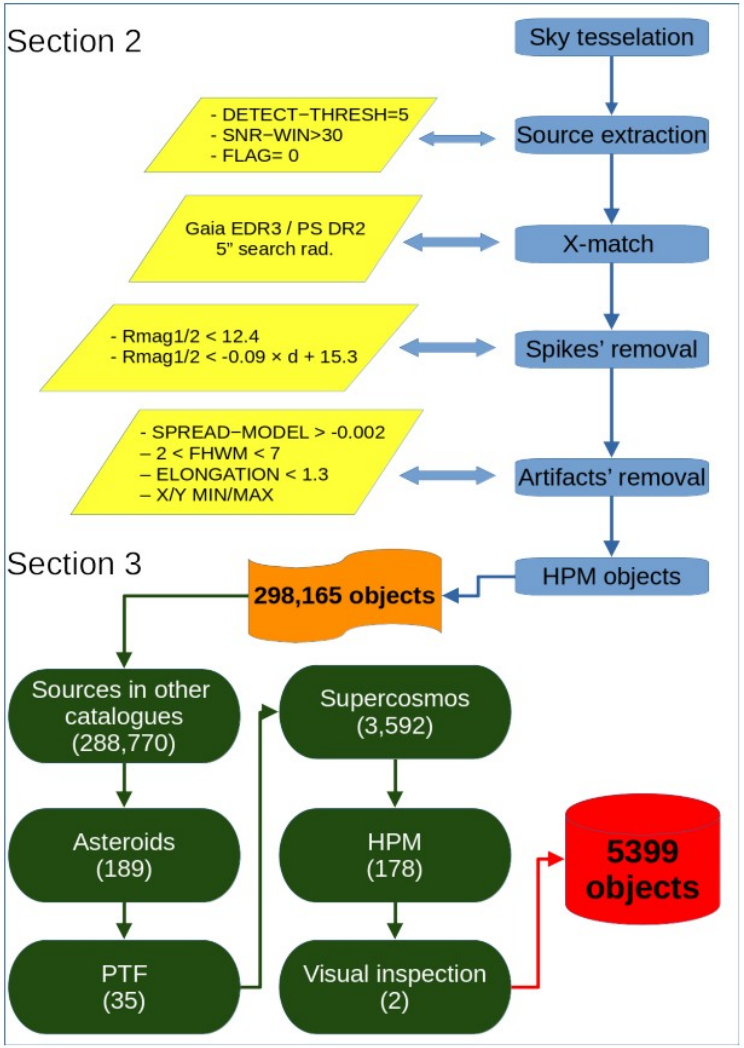
Figure 8. Flowchart of the candidate selection and analysis. See Sect. 2, and Sect. 3 for details.

Sky tessellation

- Circular regions of 30' radius
- ~ 300 000 regions



The workflow



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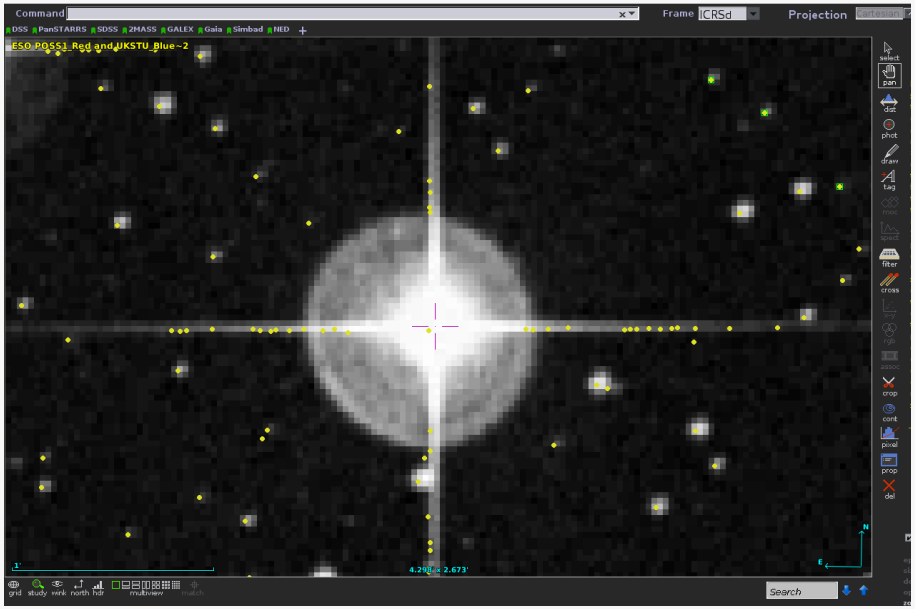
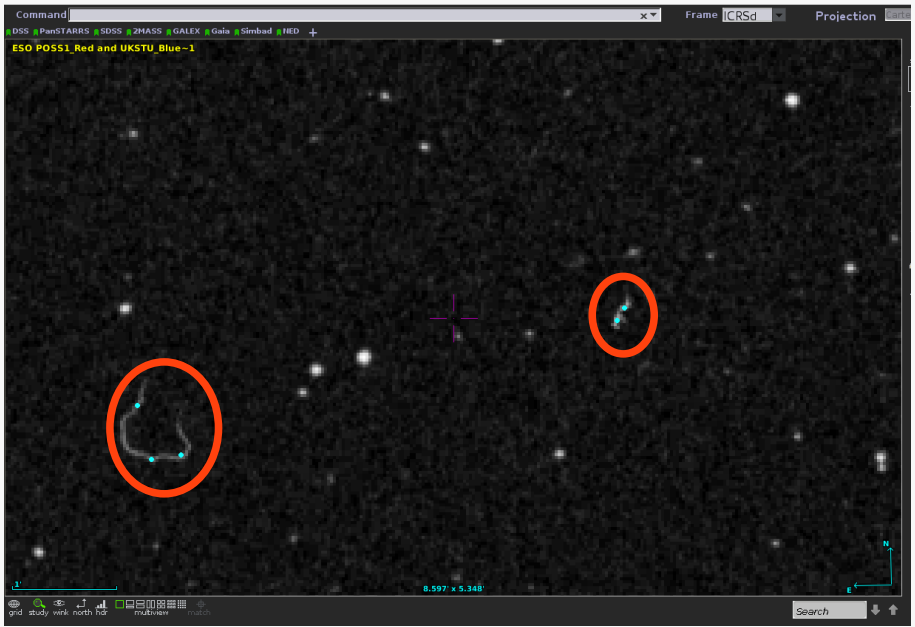




High proper motion objects

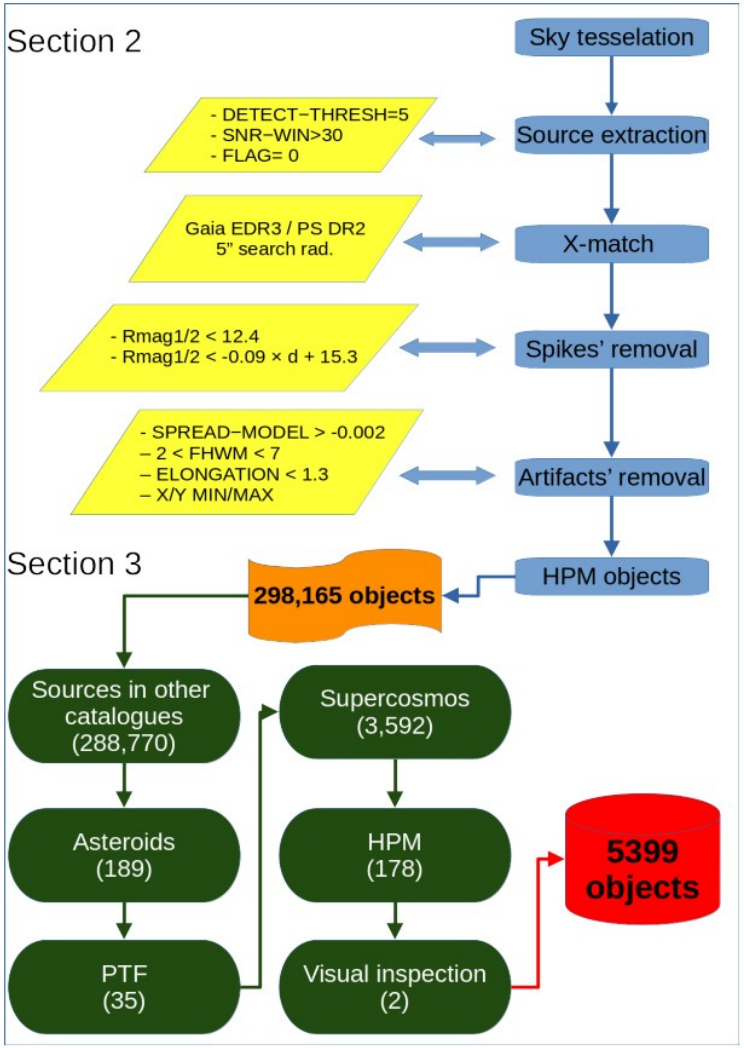


Figure 8. Flowchart of the candidate selection and analysis. See Sect. 2, and Sect. 3 for details.

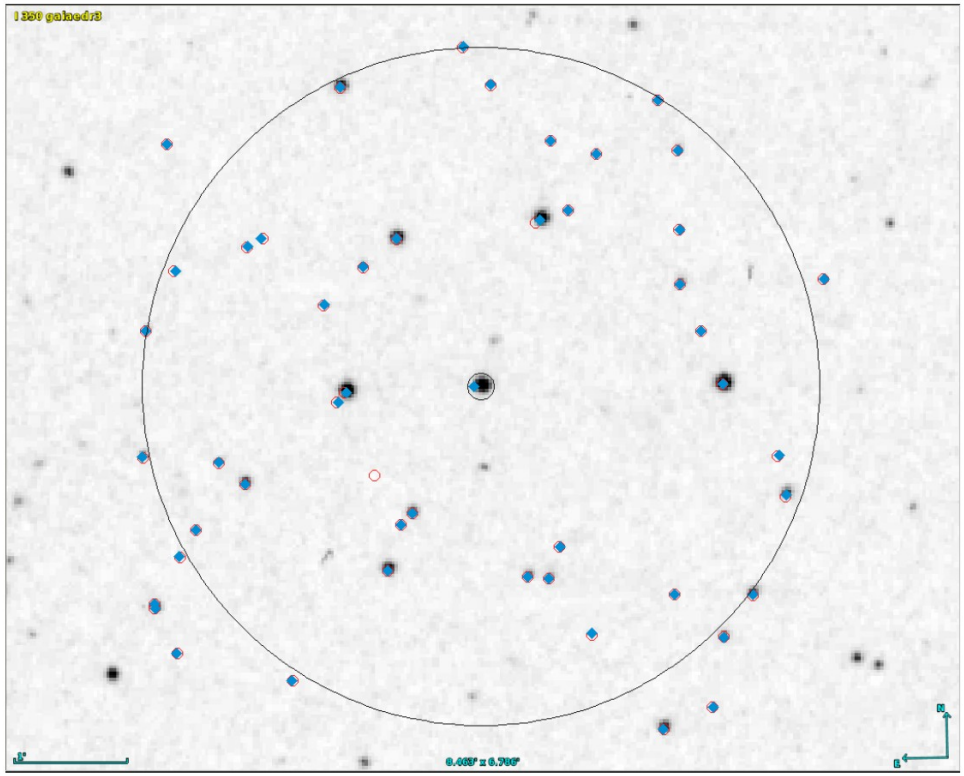


Figure 3. Example of a high proper motion source (centre of the image). Red open circles represent Gaia counterparts at J2016.0 epoch. Solid blue diamonds indicate the position of the same sources at the POSS I epoch. The isolated red circle at lower left of centre really coincides with the POSS I source at the centre of the image if the POSS I epoch is considered (blue diamond inside the inner circle). The outer and inner black circles correspond to the 3 arcmin and 5 arcsec search radius, respectively.

The workflow: HPM not in Gaia

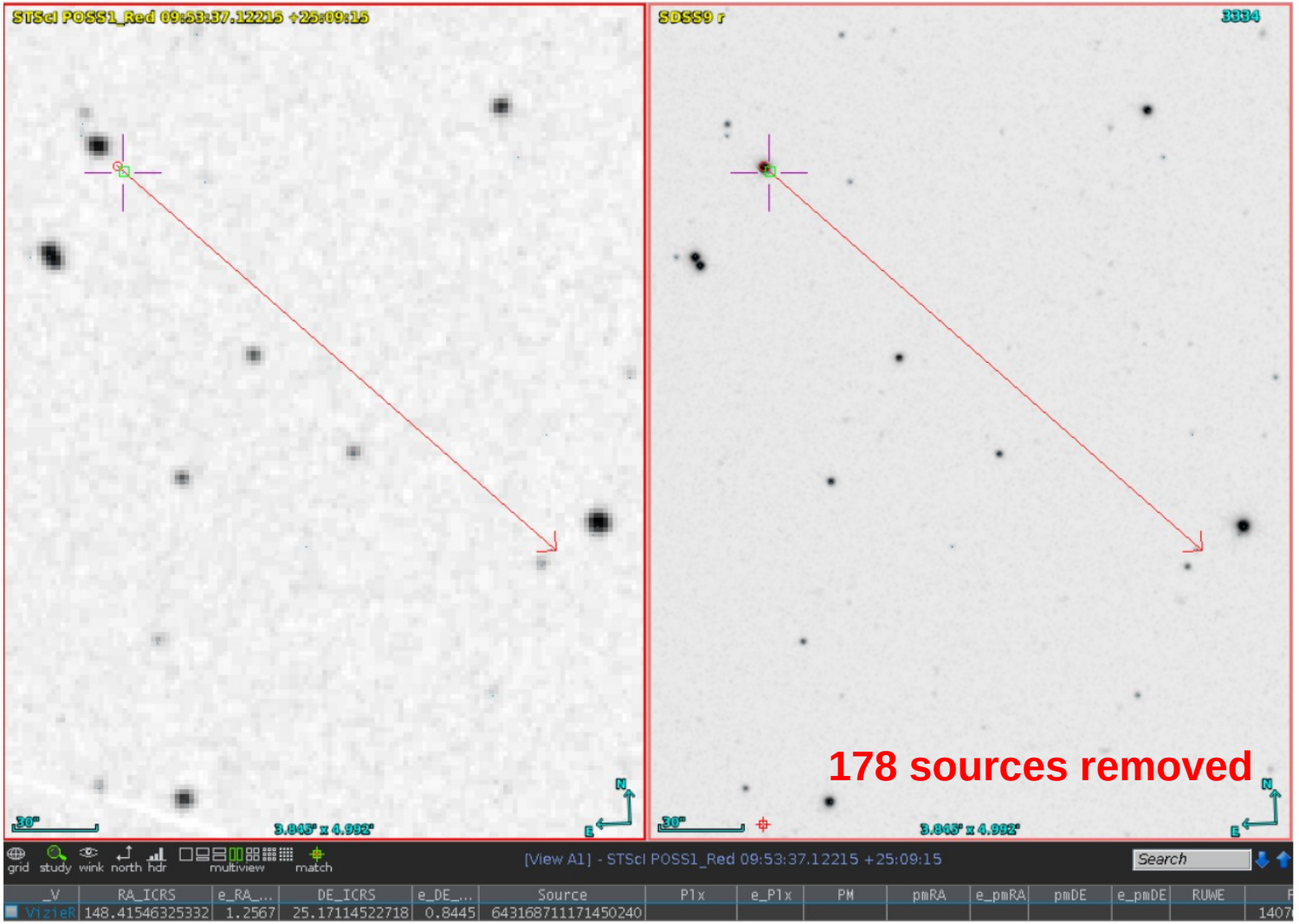


Figure 6. LP 371-1, the object marked with a cross in the SDSS image, is a high proper motion star as reported in Simbad (PMRA: -154 mas yr^{-1}; PMDEC: -140 mas yr^{-1}; red line) but without proper motion information in *Gaia* EDR3 (table shown at the bottom). See text for more details.

The workflow: HPM not in Gaia

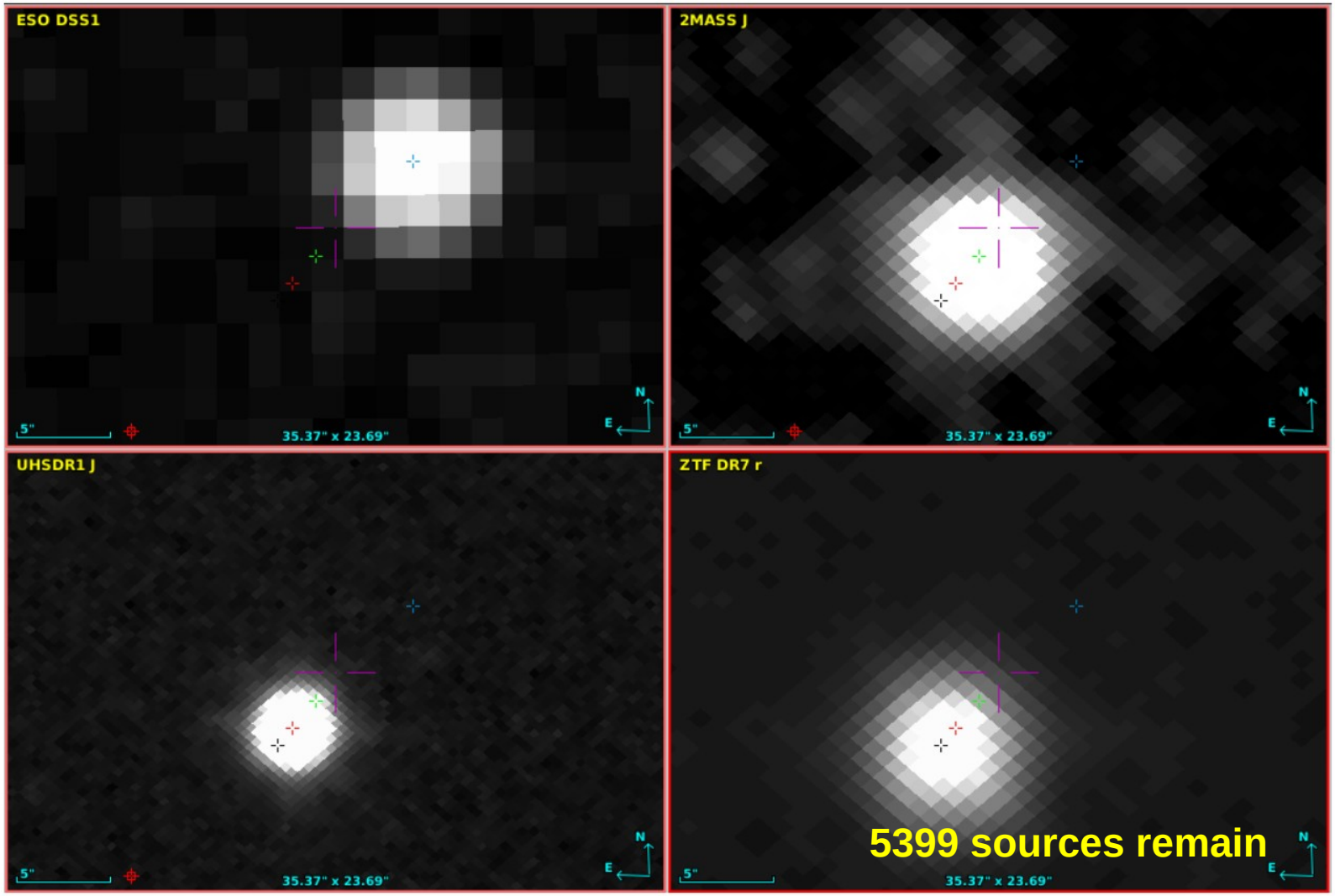
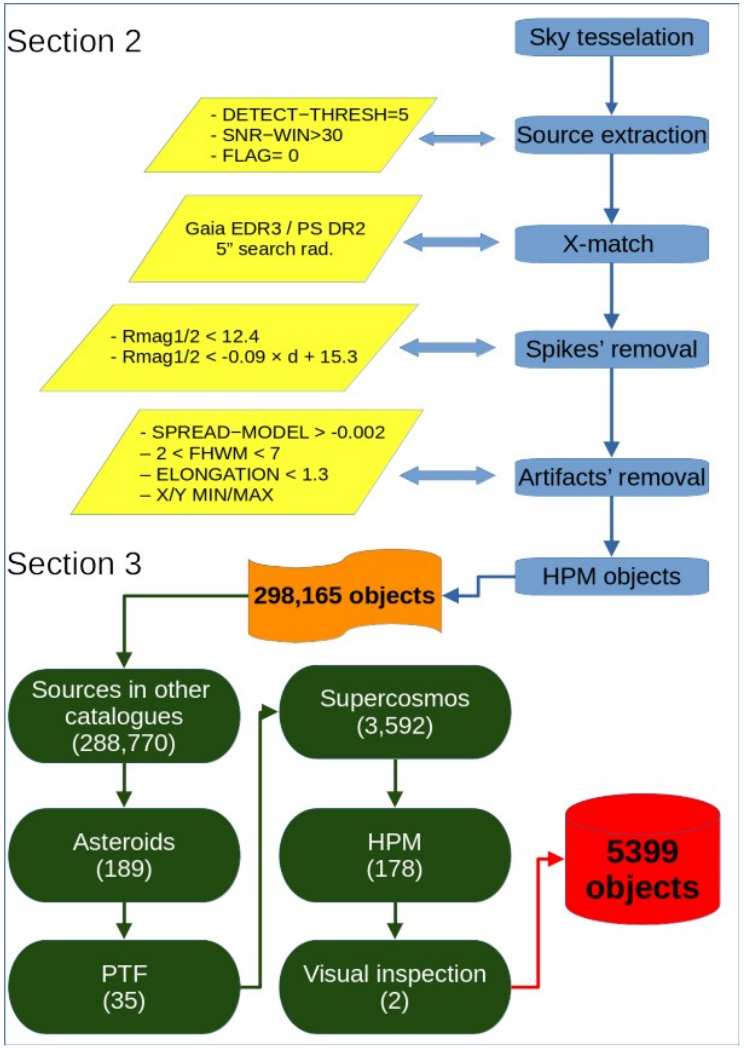


Figure 7. Example of a high proper motion object not reported either in *Gaia* EDR3 or Simbad. The blue/green/red/black crosses mark the position of the source in POSS I/2MASS/UKIDSS/ZTF images, respectively.

Summary



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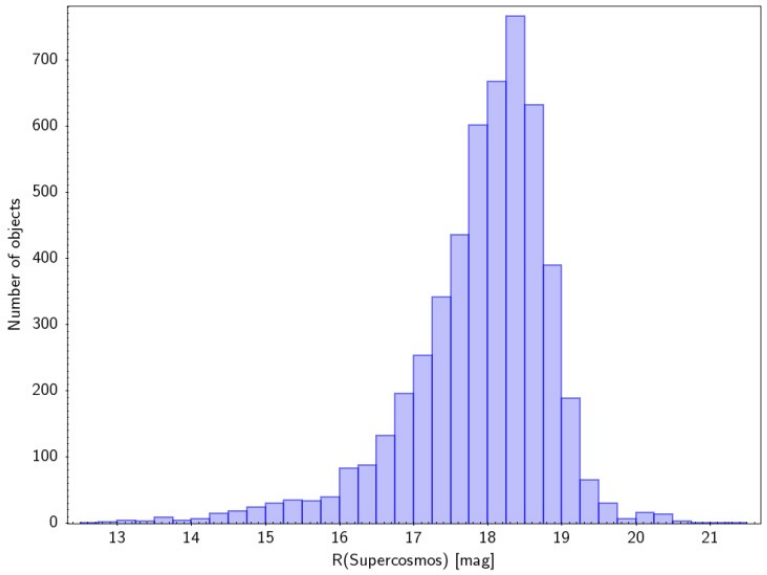


Figure 10. Distribution of the Supercosmos R magnitudes of the final sample (5 399 objects). It peaks at $R \sim 18{,}5$ with 80 % of the target with magnitudes in the range $17 \leq R \leq 19$.

Limiting magnitudes:

Gaia: G= 21mag

Ps: r=21.8 mag

Drop > 2.5 mag

Analysis

Flare stars

- Late-K and cooler spectral types

  ⇒ **The most numerous objects in the Galaxy**

- Large changes in brightness in short timescales (from minutes to hours)
- Unpredictable occurrence

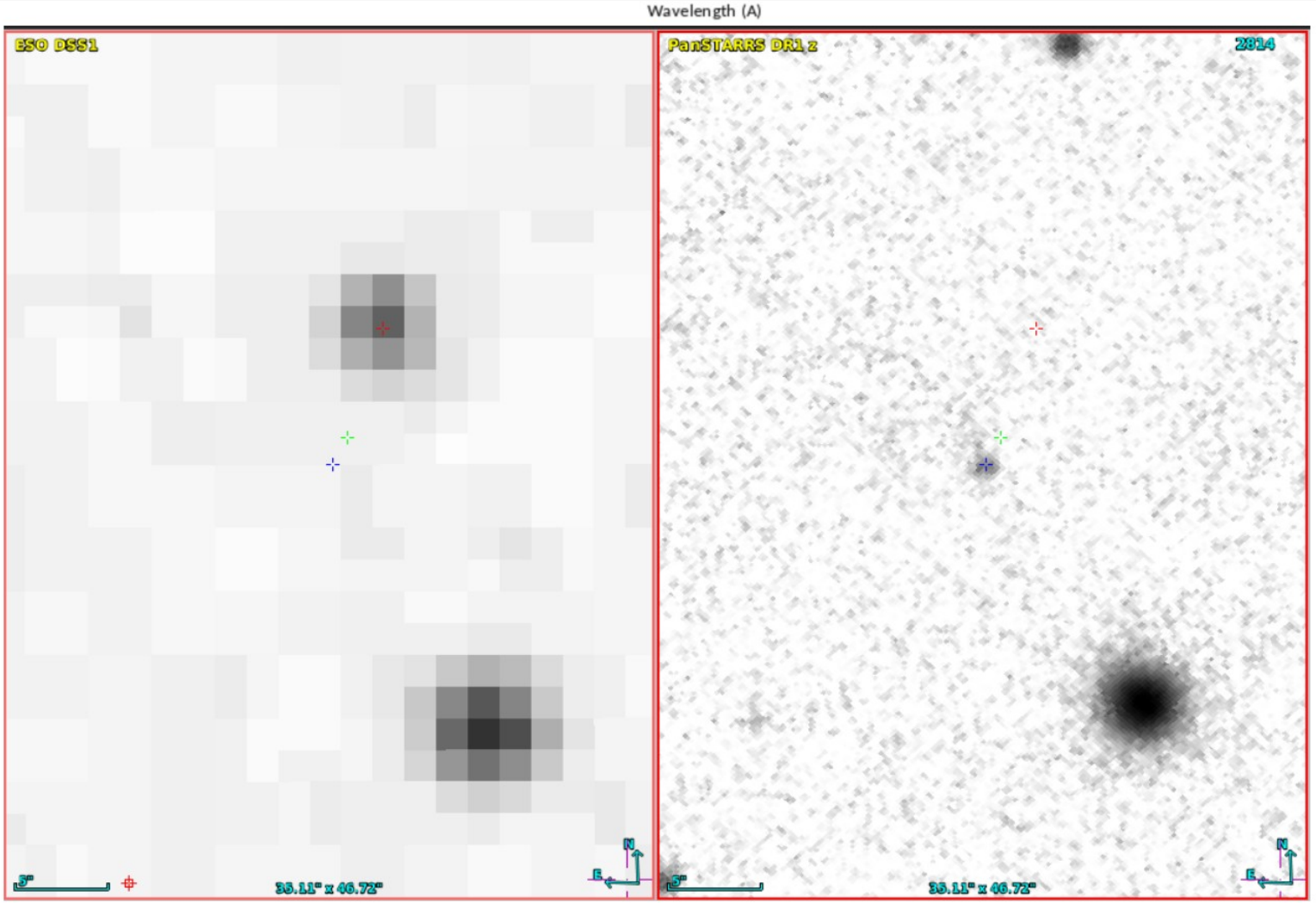
An illustration of a flare star (Image credit: Casey Reed-NASA)

Analysis

Other variable stars

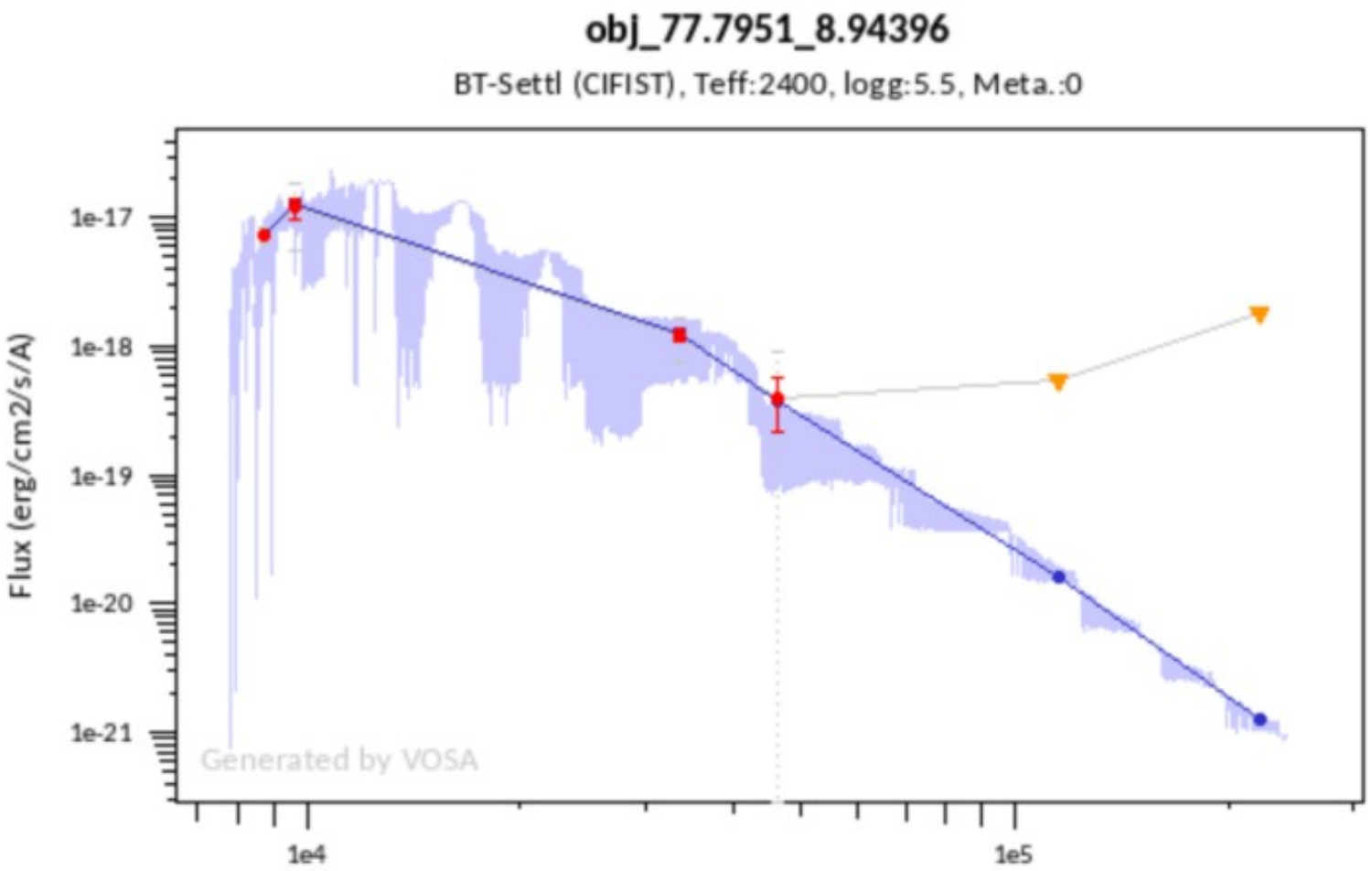
- Although much less numerous, other stellar objects triggering large amplitude variations can also contribute:
  - Stellar sources: LBVs, FUORs, RCB, ILRTs, K giants, CVs, Miras, RV Tau, Cepheids, SN,...
  - Extragalactic: Accretion outbursts in AGNs, highly variable QSOs, microlensing events,...

Findings



SED fitting process. **Bottom:** The candidate brown dwarf as seen in POSS I (red cross) and Pan-STARRS (blue cross). The green cross in between indicates the position of the source in an intermediate epoch (2MASS).

Findings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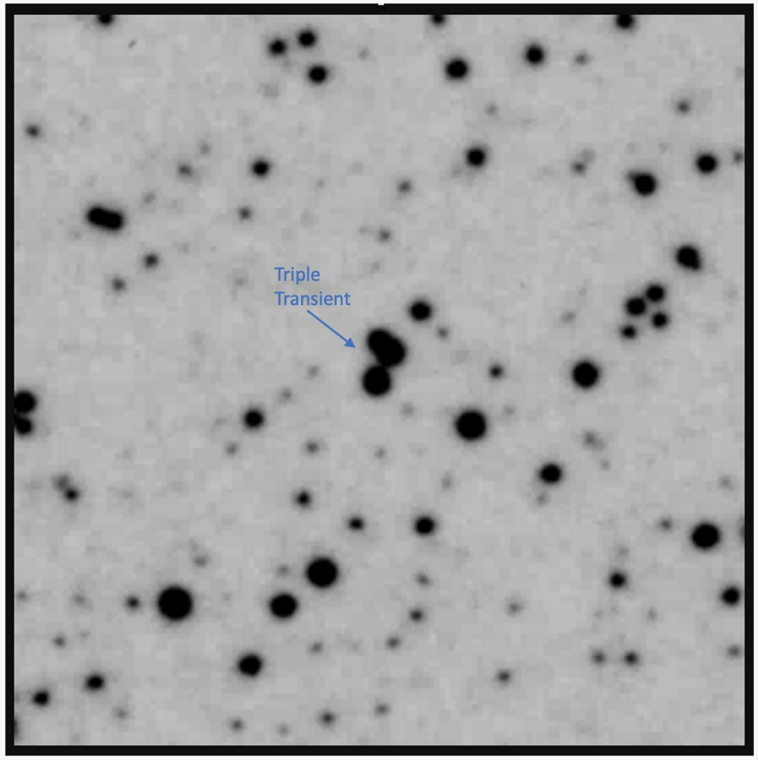
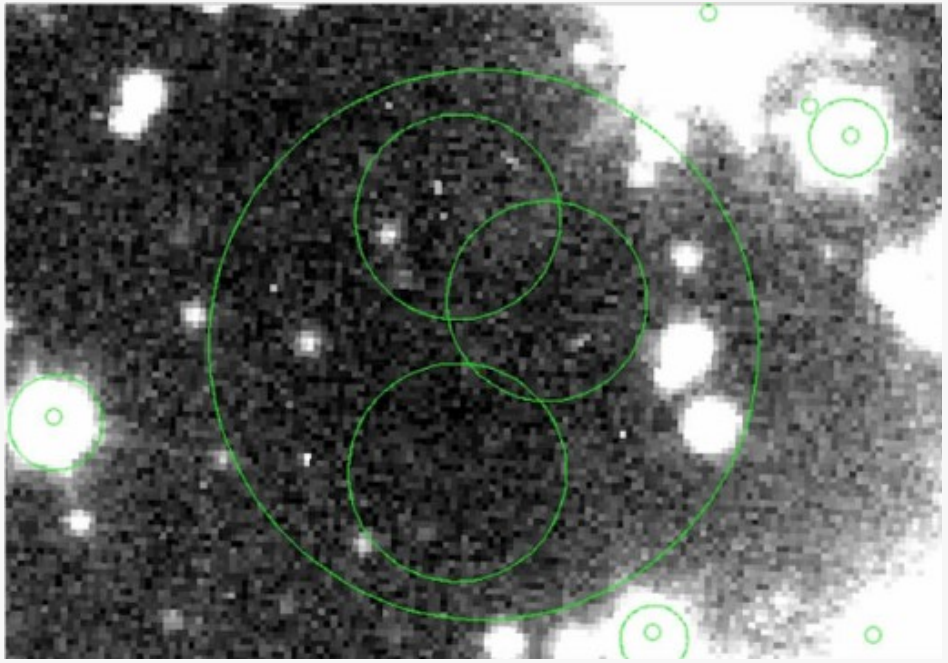
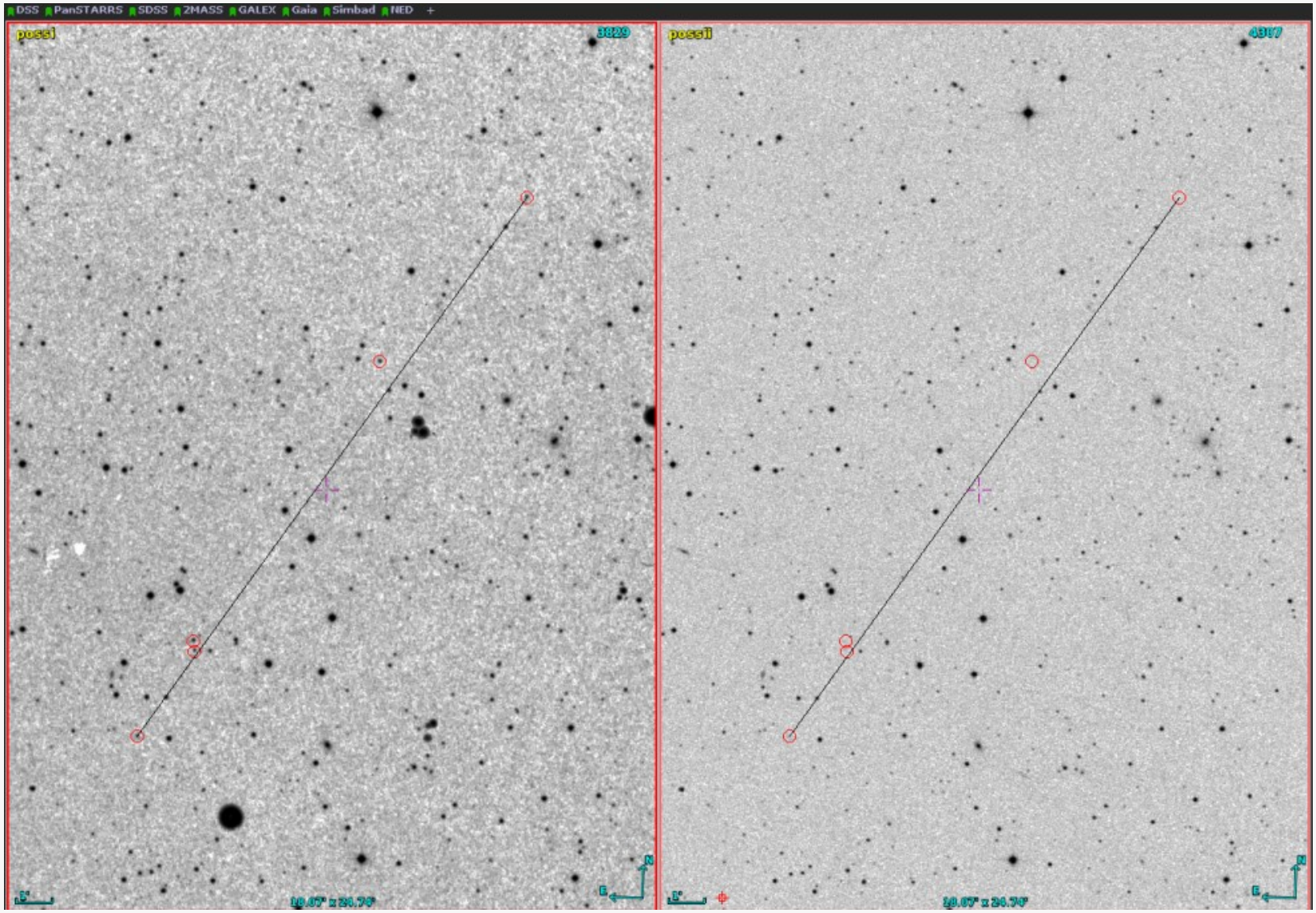
BT-Settl (CIFIST), Teff:2400, logg:5.5, Meta.:0
Flux (erg/cm2/s/A)
1e-17
1e-18
1e-19
1e-20
1e-21
Generated by VOSA
1e4
1e5

Findings





Findings


DSS PanSTARRS SDSS 2MASS GALEX Gaia Simbad NED +
possi
3829
possii
4387

Conclusions

- *The discovery, access and analysis of millions of objects coming from tens of archives covering the electromagnetic spectrum from the ultraviolet to the mid-infrared would have not been possible without the tools and services provided by the Virtual Observatory.*