archival data retrieval and analysis in the time domain (& accreting-only symbiotic binaries)

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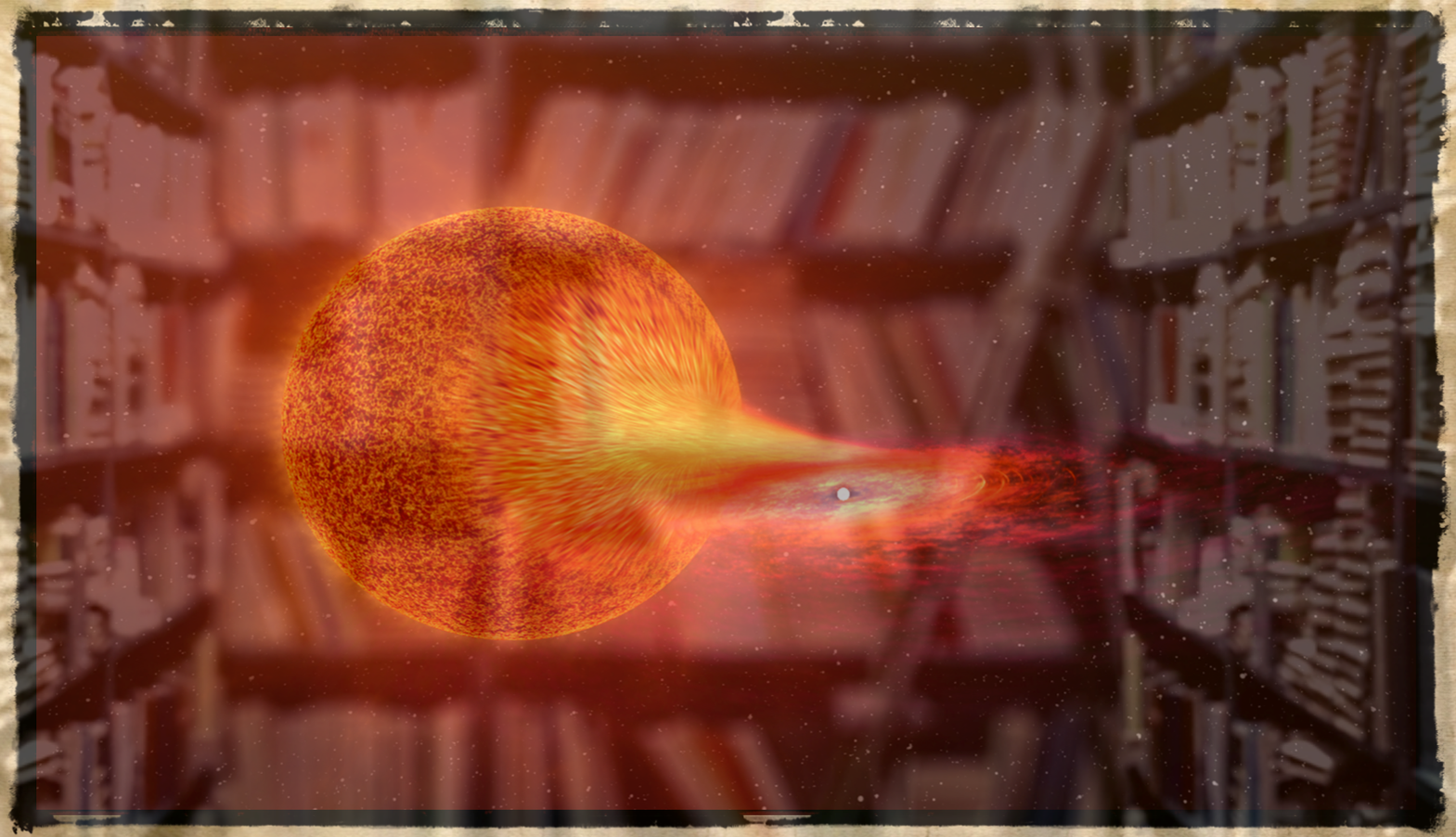
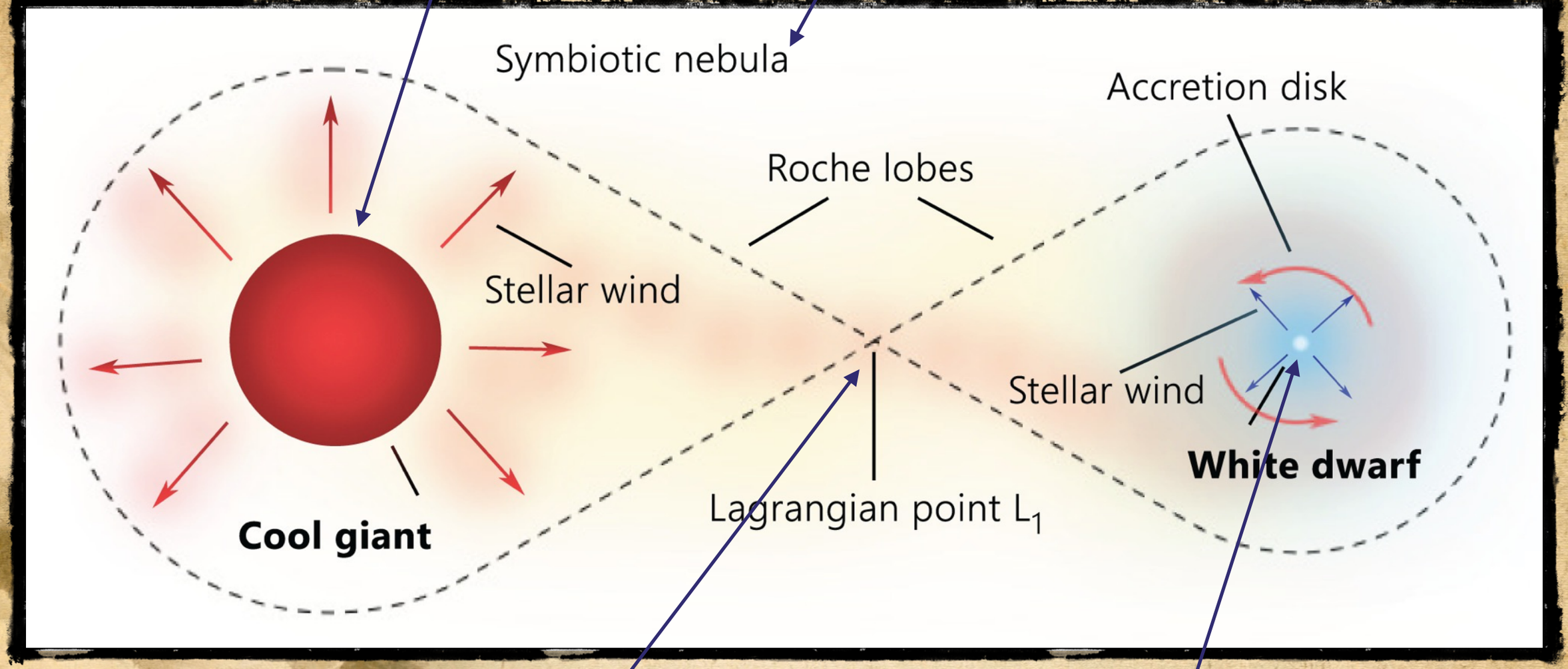


symbiotic binaries

cool evolved G–M (or S/C) I–III
(usually M III)
that has left the main sequence

dense wind of the cool giant,
illuminated by the hot component

Merc et al. 2019



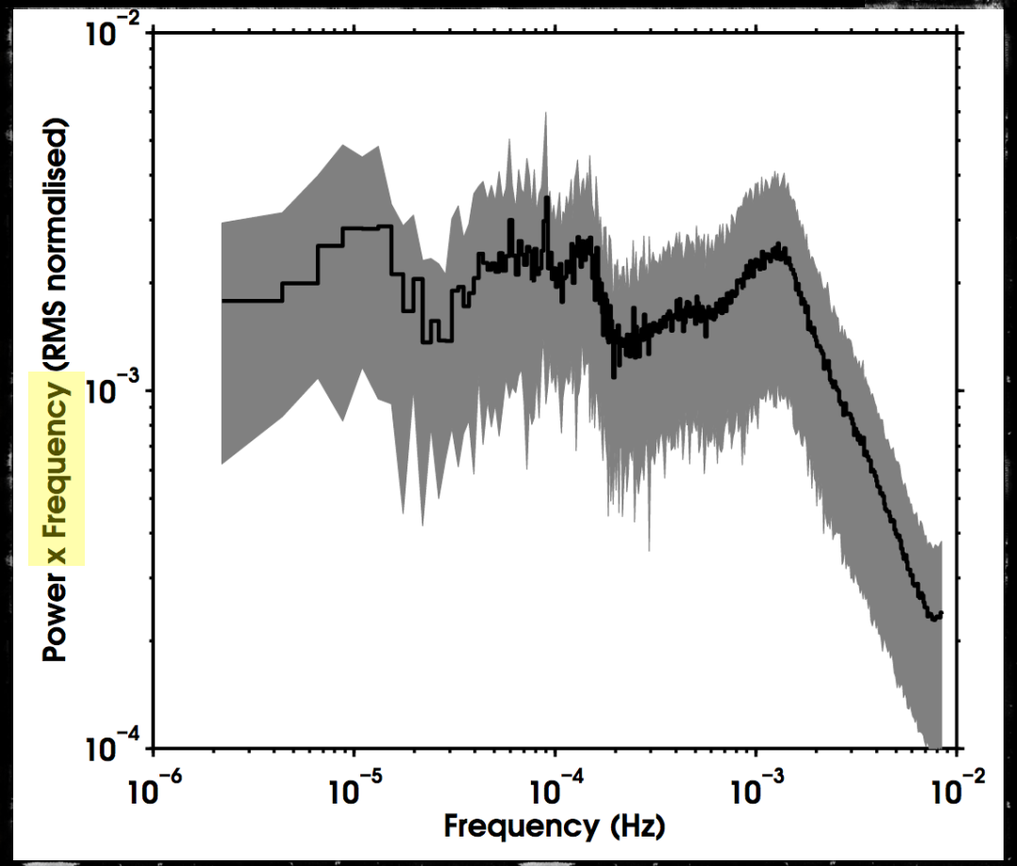
BHL wind accretion,
Roche lobe overflow,
or a hybrid (Mohamed & Pod. 2007)

accreting white dwarf (often shell burning),
or rarely an accreting neutron star,
or in principle an accreting black hole (e.g., ULXs),
or controversially an accreting main sequence star

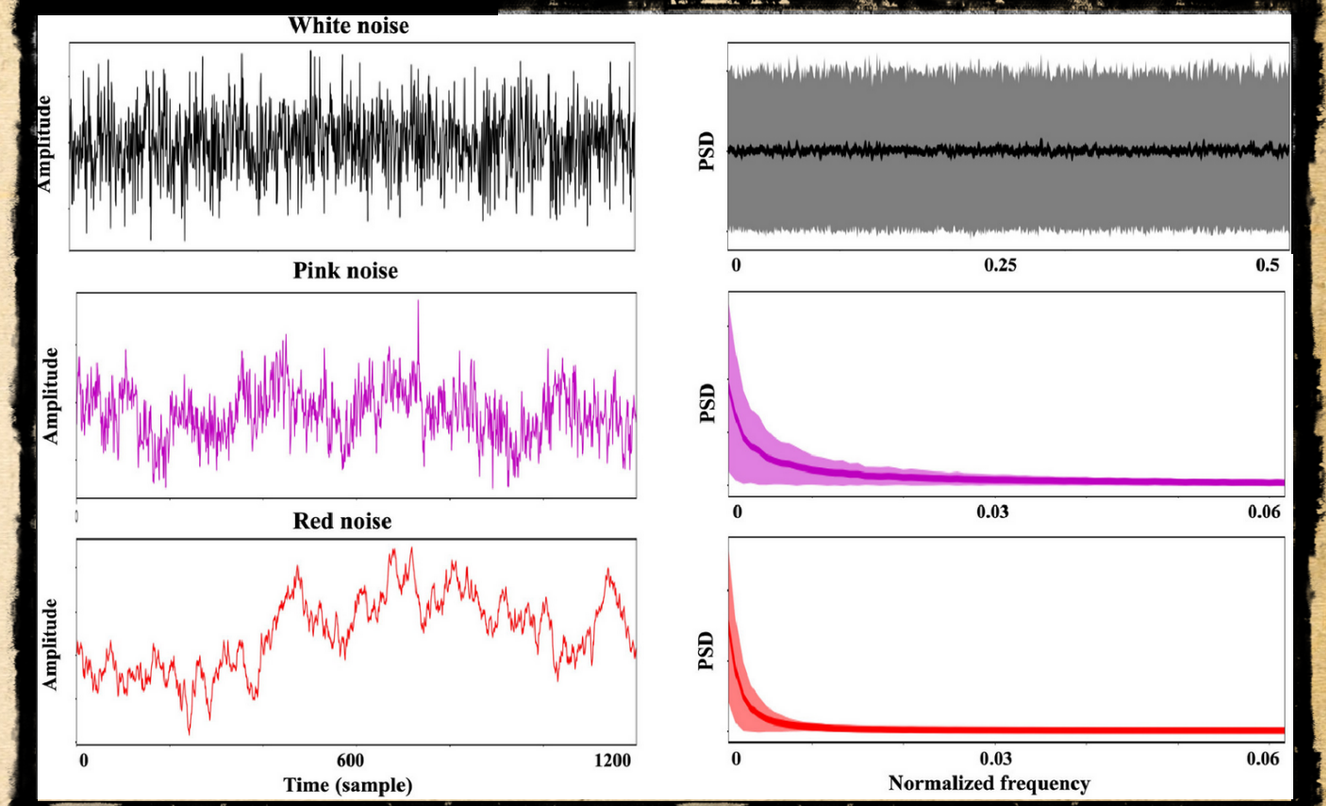
Accretion disk flickering

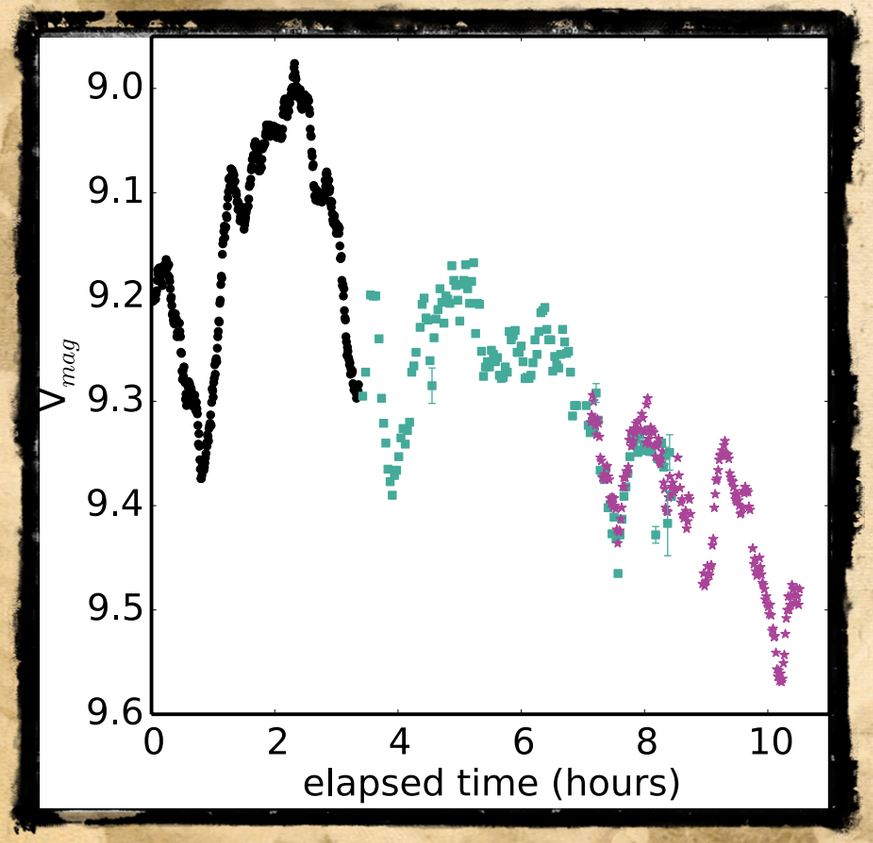
Uttley et al. 2001, 2005; Scaringi et al. 2014, etc.

Scaringi et al. 2012 (PSD of a CV, MV Lyr)



Omidvarnia et al. 2021



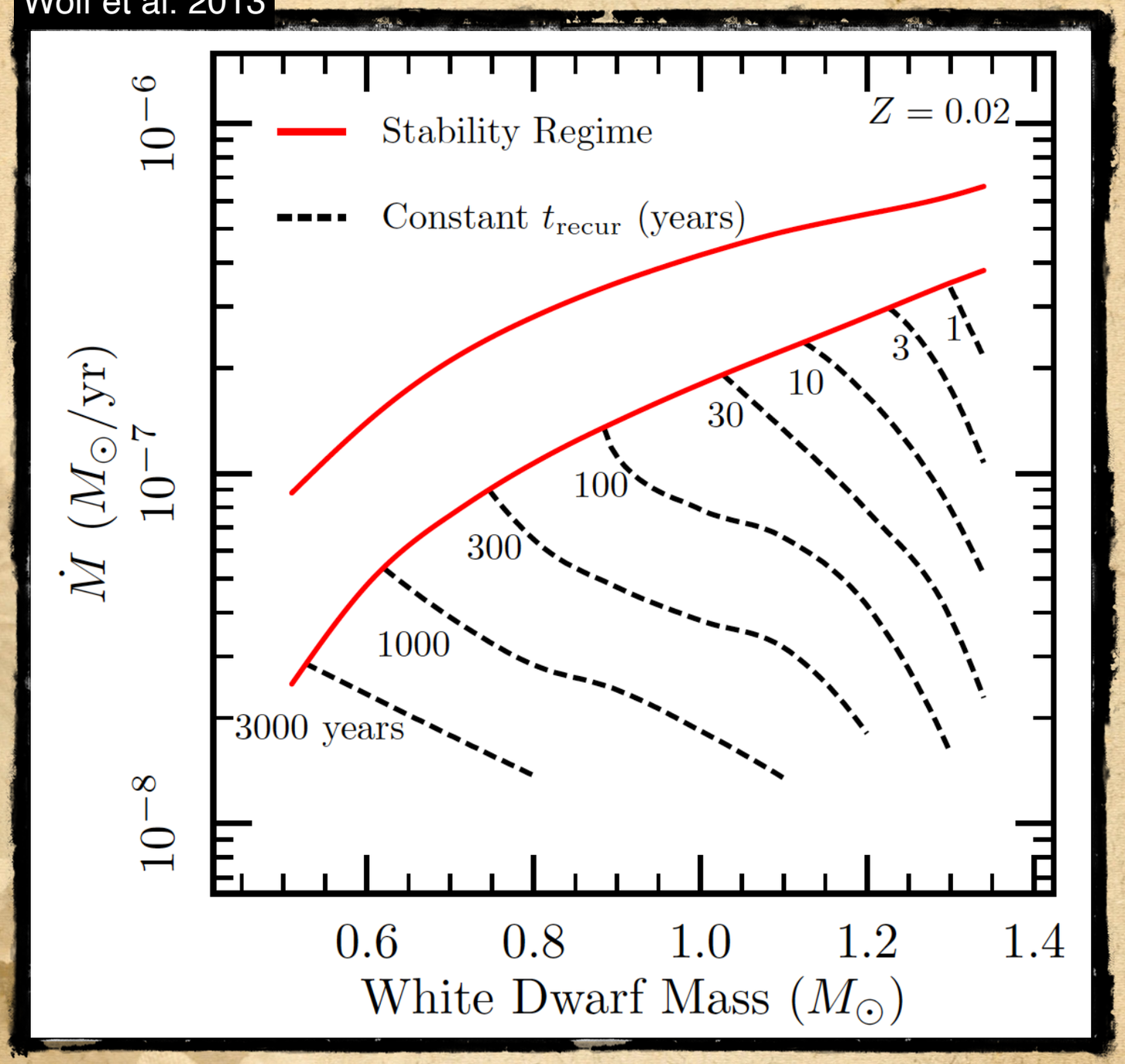


obscuration mechanisms:

1. shell burning is too luminous
2. cool giant is too luminous
3. no accretion disk

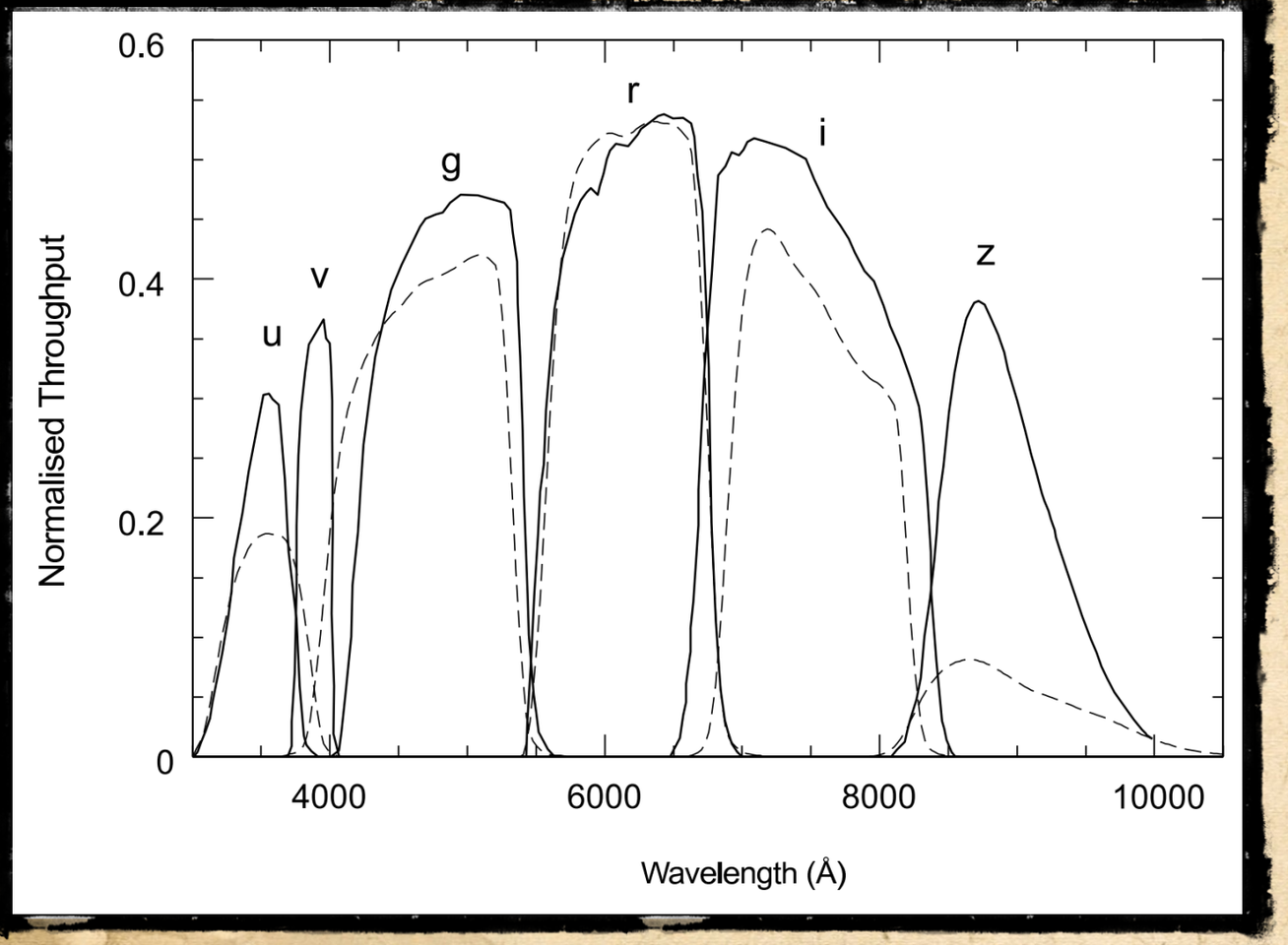
burning vs. accreting only

Wolf et al. 2013



accreting-only status before 2021:
only 10 or 11 optical flickerers, up to maybe another 10 UV flickerers, and 23 (overlapping with flickerers, and 9 are neutron star accretors) hard X-ray emitters

Murphy et al. 2009



Mukai et al. 2016

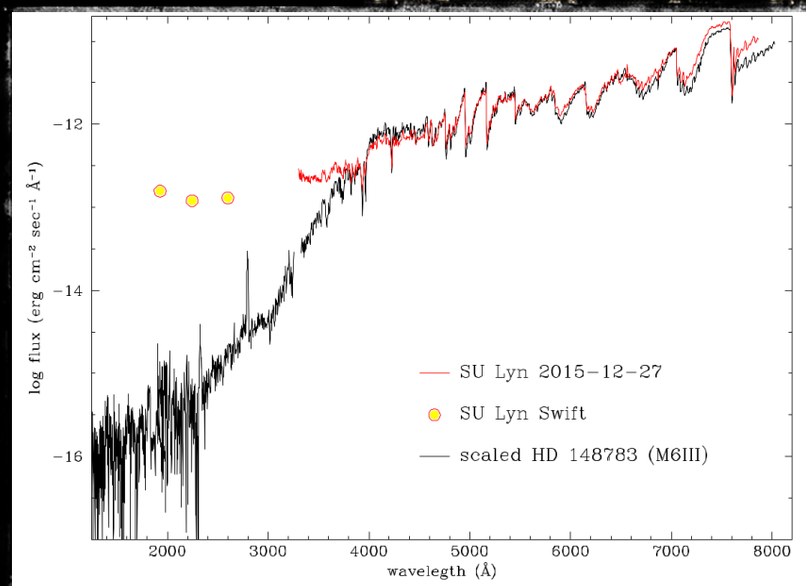


Figure 4. Low resolution optical spectrum of SU Lyn with *Swift* UVOT points, compared with optical and IUE spectra of MIII

The SkyMapper Southern Sky Survey (Main Survey, DR2)

8 min — 8 min

u v g r u v i z u v

20 min

building a sample of luminous red objects

$(J\text{-}K_s)_0 > 0.85$
$M_J < 0$
$J < 14.0$
No other SkyMapper source within 6 arcsec

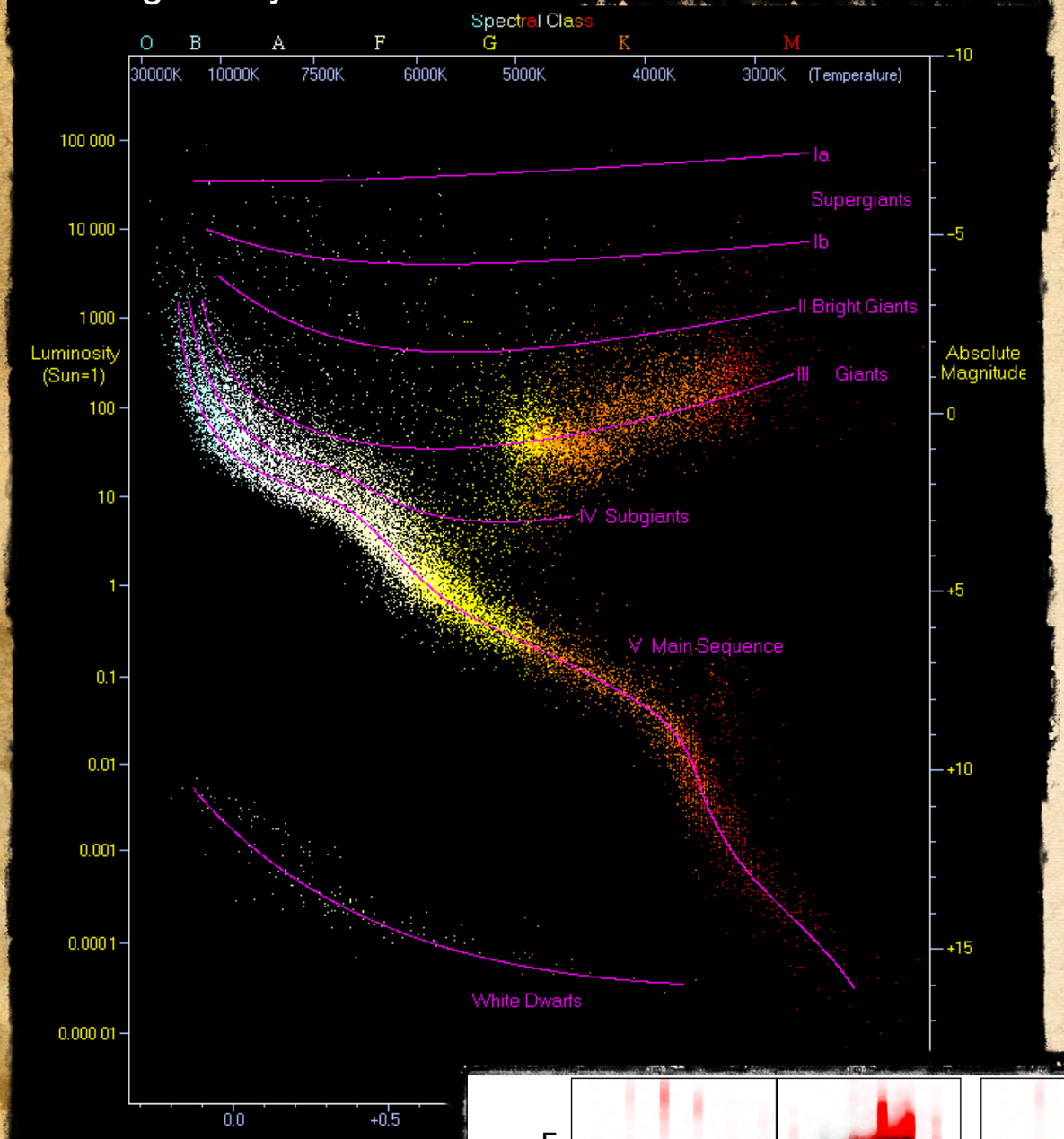
SkyMapper u_ngood > 0, v_ngood > 0, g_ngood > 0
2MASS AAA data quality
Converged Bailer-Jones et al. (2018) distance exists

SkyMapper class_star > 0.9, flags_psf = 0, nch_max = 1
2MASS gal_contam = 0, ext_key = 0, cc_flg = '000', ext_key = 0

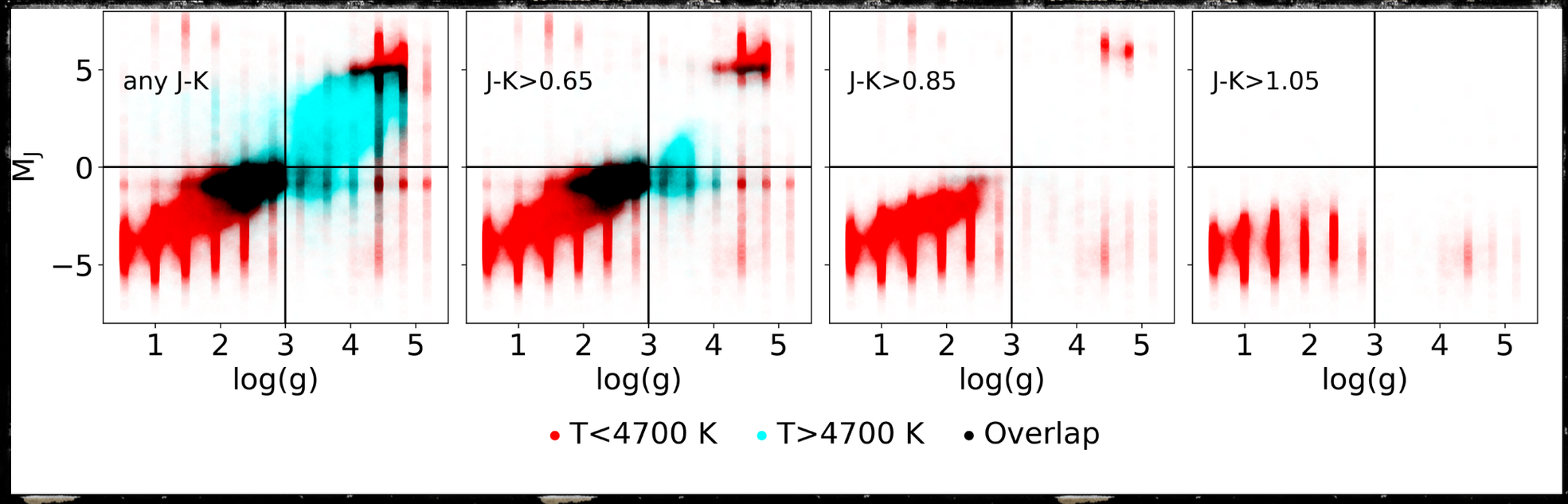
2 arcsec crossmatch to 2MASS and Gaia
3 arcsec crossmatch to ALLWISE

And sufficient data to reconstruct ≥1 nightly color snapshot from individual measurements with SkyMapper used_in_clip = True or False, but not null.

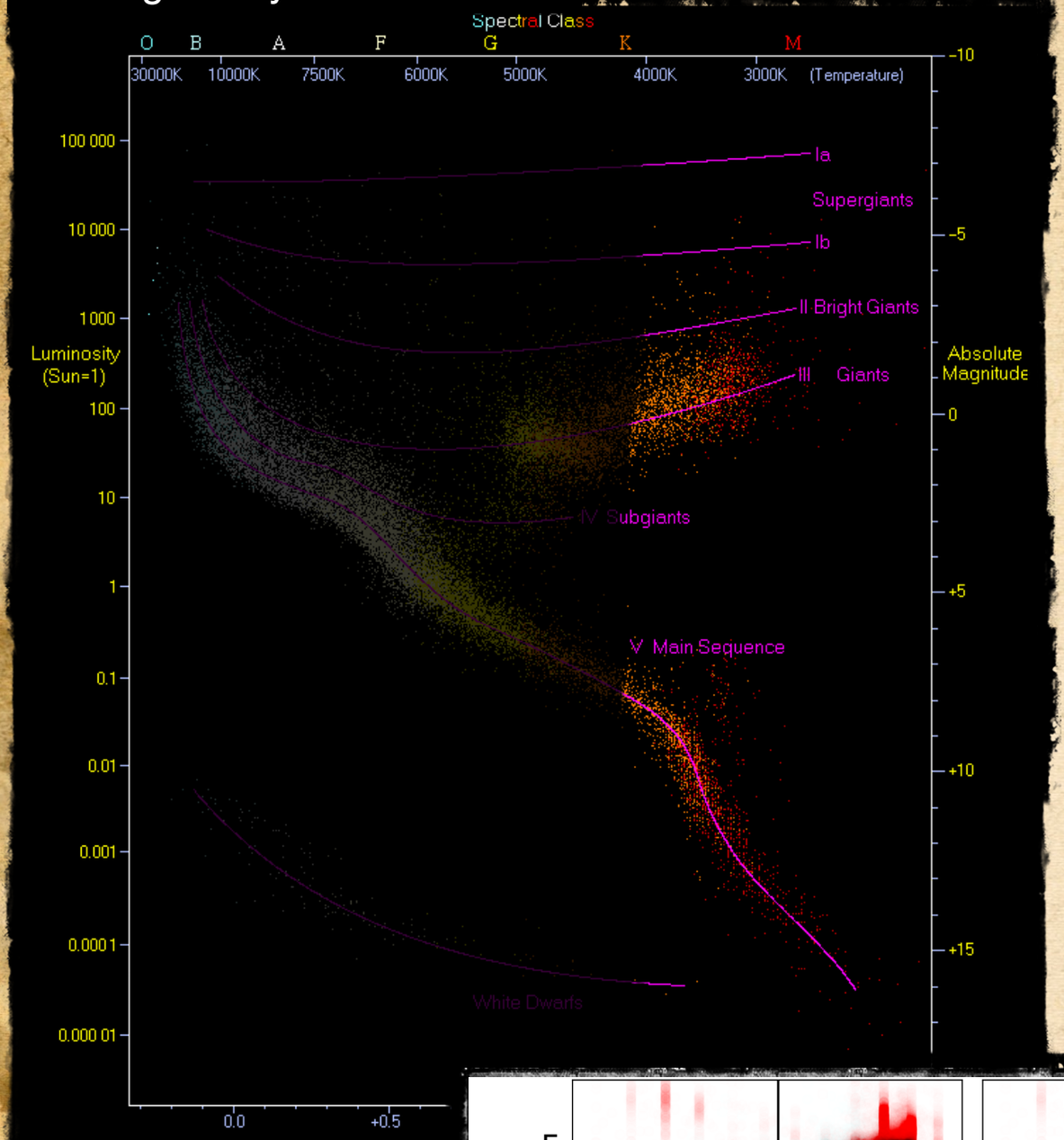
HR diagram by Richard Powell



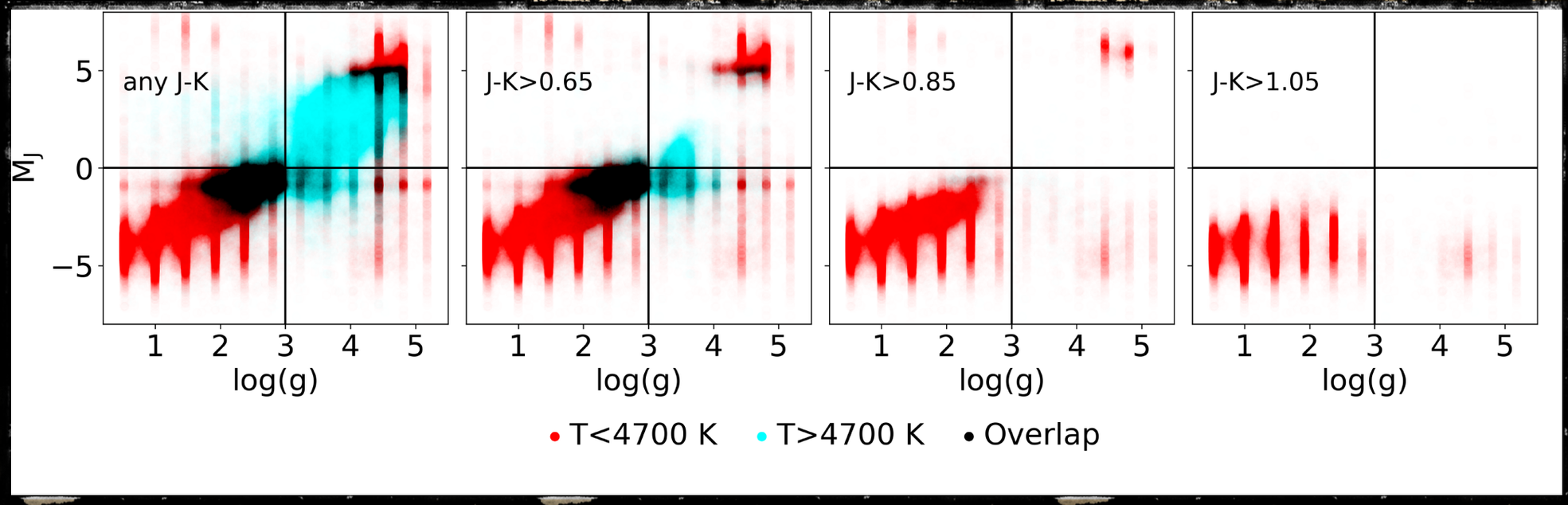
Tested on LAMOST and RAVE



HR diagram by Richard Powell



Tested on LAMOST and RAVE



```
SELECT
   m.object_id, g.source_id, m.raj2000,  m.dej2000, m.glon,
   m.glat, m.u_ngood, m.u_nclip, m.v_ngood, m.g_ngood,
   m.r_ngood, m.i_ngood, m.z_ngood, w.w1mpro, w.w1sigmpro,
   w.w2mpro, w.w2sigmpro, t.j_m, t.j_msigcom, t.h_m,
   t.h_msigcom, t.k_m, t.k_msigcom, m.u_psf, m.e_u_psf, m.v_psf,
   m.e_v_psf, m.g_psf, m.e_g_psf, m.r_psf, m.e_r_psf, m.i_psf,
   m.e_i_psf, m.z_psf, m.e_z_psf, m.prox, t.prox AS tprox,
   m.allwise_dist, g.parallax, g.parallax_error,
   g.astrometric_excess_noise, g.astrometric_excess_noise_sig,
   g.pmra, g.pmra_error, g.pmdec, g.pmdec_error, m.ebmv_sfd
FROM
    dr2.master m
JOIN
    ext.twomass_psc t ON m.twomass_key=t.pts_key
JOIN
    ext.gaia_dr2 g ON m.gaia_dr2_id1=g.source_id
JOIN
    ext.allwise w ON m.allwise_cntr=w.cntr
WHERE
    m.twomass_dist < 2.0 /* cross-matching radii (arcsec) */
    AND m.gaia_dr2_dist1 < 2.0
    AND m.allwise_dist < 3.0
    AND m.prox > 6.0
    AND t.ph_qual = 'AAA' /* quality cuts */
    AND t.gal_contam = 0
    AND t.ext_key IS NULL
    AND t.cc_flg = '000'
    AND m.class_star > 0.9
    AND flags_psf = 0
    AND m.u_ngood > 0
    AND m.v_ngood > 0
    AND m.g_ngood > 0
    AND m.nch_max = 1
    AND (t.j_m - t.k_m) > 0.85 /* 2MASS initial color cut */
    AND t.j_m < 14.0 /* Select for high 2MASS SNR */
```

ADQL query in TOPCAT

```
SELECT
   m.object_id, g.source_id, m.raj2000,  m.dej2000, m.glon,
   m.glat, m.u_ngood, m.u_nclip, m.v_ngood, m.g_ngood,
   m.r_ngood, m.i_ngood, m.z_ngood, w.w1mpro, w.w1sigmpro,
   w.w2mpro, w.w2sigmpro, t.j_m, t.j_msigcom, t.h_m,
   t.h_msigcom, t.k_m, t.k_msigcom, m.u_psf, m.e_u_psf, m.v_psf,
   m.e_v_psf, m.g_psf, m.e_g_psf, m.r_psf, m.e_r_psf, m.i_psf,
   m.e_i_psf, m.z_psf, m.e_z_psf, m.prox, t.prox AS tprox,
   m.allwise_dist, g.parallax, g.parallax_error,
   g.astrometric_excess_noise, g.astrometric_excess_noise_sig,
   g.pmra, g.pmra_error, g.pmdec, g.pmdec_error, m.ebmv_sfd
FROM
    dr2.master m
JOIN
    ext.twomass_psc t ON m.twomass_key=t.pts_key
JOIN
    ext.gaia_dr2 g ON m.gaia_dr2_id1=g.source_id
JOIN
    ext.allwise w ON m.allwise_cntr=w.cntr
WHERE
    m.twomass_dist < 2.0 /* cross-matching radii (arcsec) */
    AND m.gaia_dr2_dist1 < 2.0
    AND m.allwise_dist < 3.0
    AND m.prox > 6.0
    AND t.ph_qual = 'AAA' /* quality cuts */
    AND t.gal_contam = 0
    AND t.ext_key IS NULL
    AND t.cc_flg = '000'
    AND m.class_star > 0.9
    AND flags_psf = 0
    AND m.u_ngood > 0
    AND m.v_ngood > 0
    AND m.g_ngood > 0
    AND m.nch_max = 1
    AND (t.j_m - t.k_m) > 0.85 /* 2MASS initial color cut */
    AND t.j_m < 14.0 /* Select for high 2MASS SNR */
```

Pre-matched (but no pre-match for Bailer-Jones Bayesian distances)

```
SELECT
   m.object_id, g.source_id, m.raj2000,  m.dej2000, m.glon,
   m.glat, m.u_ngood, m.u_nclip, m.v_ngood, m.g_ngood,
   m.r_ngood, m.i_ngood, m.z_ngood, w.w1mpro, w.w1sigmpro,
   w.w2mpro, w.w2sigmpro, t.j_m, t.j_msigcom, t.h_m,
   t.h_msigcom, t.k_m, t.k_msigcom, m.u_psf, m.e_u_psf, m.v_psf,
   m.e_v_psf, m.g_psf, m.e_g_psf, m.r_psf, m.e_r_psf, m.i_psf,
   m.e_i_psf, m.z_psf, m.e_z_psf, m.prox, t.prox AS tprox,
   m.allwise_dist, g.parallax, g.parallax_error,
   g.astrometric_excess_noise, g.astrometric_excess_noise_sig,
   g.pmra, g.pmra_error, g.pmdec, g.pmdec_error, m.ebmv_sfd
FROM
    dr2.master m
JOIN
    ext.twomass_psc t ON m.twomass_key=t.pts_key
JOIN
    ext.gaia_dr2 g ON m.gaia_dr2_id1=g.source_id
JOIN
    ext.allwise w ON m.allwise_cntr=w.cntr
WHERE
    m.twomass_dist < 2.0 /* cross-matching radii (arcsec) */
    AND m.gaia_dr2_dist1 < 2.0
    AND m.allwise_dist < 3.0
    AND m.prox > 6.0
    AND t.ph_qual = 'AAA' /* quality cuts */
    AND t.gal_contam = 0
    AND t.ext_key IS NULL
    AND t.cc_flg = '000'
    AND m.class_star > 0.9
    AND flags_psf = 0
    AND m.u_ngood > 0
    AND m.v_ngood > 0
    AND m.g_ngood > 0
    AND m.nch_max = 1
    AND (t.j_m - t.k_m) > 0.85 /* 2MASS initial color cut */
    AND t.j_m < 14.0 /* Select for high 2MASS SNR */
```

from survey documentation:
chose larger of the two

```
SELECT
   m.object_id, g.source_id, m.raj2000,  m.dej2000, m.glon,
   m.glat, m.u_ngood, m.u_nclip, m.v_ngood, m.g_ngood,
   m.r_ngood, m.i_ngood, m.z_ngood, w.w1mpro, w.w1sigmpro,
   w.w2mpro, w.w2sigmpro, t.j_m, t.j_msigcom, t.h_m,
   t.h_msigcom, t.k_m, t.k_msigcom, m.u_psf, m.e_u_psf, m.v_psf,
   m.e_v_psf, m.g_psf, m.e_g_psf, m.r_psf, m.e_r_psf, m.i_psf,
   m.e_i_psf, m.z_psf, m.e_z_psf, m.prox, t.prox AS tprox,
   m.allwise_dist, g.parallax, g.parallax_error,
   g.astrometric_excess_noise, g.astrometric_excess_noise_sig,
   g.pmra, g.pmra_error, g.pmdec, g.pmdec_error, m.ebmv_sfd
FROM
    dr2.master m
JOIN
    ext.twomass_psc t ON m.twomass_key=t.pts_key
JOIN
    ext.gaia_dr2 g ON m.gaia_dr2_id1=g.source_id
JOIN
    ext.allwise w ON m.allwise_cntr=w.cntr
WHERE
    m.twomass_dist < 2.0 /* cross-matching radii (arcsec) */
    AND m.gaia_dr2_dist1 < 2.0
    AND m.allwise_dist < 3.0
    AND m.prox > 6.0
    AND t.ph_qual = 'AAA' /* quality cuts */
    AND t.gal_contam = 0
    AND t.ext_key IS NULL
    AND t.cc_flg = '000'
    AND m.class_star > 0.9
    AND flags_psf = 0
    AND m.u_ngood > 0
    AND m.v_ngood > 0
    AND m.g_ngood > 0
    AND m.nch_max = 1
    AND (t.j_m - t.k_m) > 0.85 /* 2MASS initial color cut */
    AND t.j_m < 14.0 /* Select for high 2MASS SNR */
```

tested first on symbiotics w/ with extended nebulae/jets, hence no 2mass prox constraint

```
SELECT
   m.object_id, g.source_id, m.raj2000,  m.dej2000, m.glon,
   m.glat, m.u_ngood, m.u_nclip, m.v_ngood, m.g_ngood,
   m.r_ngood, m.i_ngood, m.z_ngood, w.w1mpro, w.w1sigmpro,
   w.w2mpro, w.w2sigmpro, t.j_m, t.j_msigcom, t.h_m,
   t.h_msigcom, t.k_m, t.k_msigcom, m.u_psf, m.e_u_psf, m.v_psf,
   m.e_v_psf, m.g_psf, m.e_g_psf, m.r_psf, m.e_r_psf, m.i_psf,
   m.e_i_psf, m.z_psf, m.e_z_psf, m.prox, t.prox AS tprox,
   m.allwise_dist, g.parallax, g.parallax_error,
   g.astrometric_excess_noise, g.astrometric_excess_noise_sig,
   g.pmra, g.pmra_error, g.pmdec, g.pmdec_error, m.ebmv_sfd
FROM
    dr2.master m
JOIN
    ext.twomass_psc t ON m.twomass_key=t.pts_key
JOIN
    ext.gaia_dr2 g ON m.gaia_dr2_id1=g.source_id
JOIN
    ext.allwise w ON m.allwise_cntr=w.cntr
WHERE
    m.twomass_dist < 2.0 /* cross-matching radii (arcsec) */
    AND m.gaia_dr2_dist1 < 2.0
    AND m.allwise_dist < 3.0
    AND m.prox > 6.0
    AND t.ph_qual = 'AAA' /* quality cuts */
    AND t.gal_contam = 0
    AND t.ext_key IS NULL
    AND t.cc_flg = '000'
    AND m.class_star > 0.9
    AND flags_psf = 0
    AND m.u_ngood > 0
    AND m.v_ngood > 0
    AND m.g_ngood > 0
    AND m.nch_max = 1
    AND (t.j_m - t.k_m) > 0.85 /* 2MASS initial color cut */
    AND t.j_m < 14.0 /* Select for high 2MASS SNR */
```

Asynchronous!

```
SELECT
   m.object_id, g.source_id, m.raj2000,  m.dej2000, m.glon,
   m.glat, m.u_ngood, m.u_nclip, m.v_ngood, m.g_ngood,
   m.r_ngood, m.i_ngood, m.z_ngood, w.w1mpro, w.w1sigmpro,
   w.w2mpro, w.w2sigmpro, t.j_m, t.j_msigcom, t.h_m,
   t.h_msigcom, t.k_m, t.k_msigcom, m.u_psf, m.e_u_psf, m.v_psf,
   m.e_v_psf, m.g_psf, m.e_g_psf, m.r_psf, m.e_r_psf, m.i_psf,
   m.e_i_psf, m.z_psf, m.e_z_psf, m.prox, t.prox AS tprox,
   m.allwise_dist, g.parallax, g.parallax_error,
   g.astrometric_excess_noise, g.astrometric_excess_noise_sig,
   g.pmra, g.pmra_error, g.pmdec, g.pmdec_error, m.ebmv_sfd
FROM
    dr2.master m
JOIN
    ext.twomass_psc t ON m.twomass_key=t.pts_key
JOIN
    ext.gaia_dr2 g ON m.gaia_dr2_id1=g.source_id
JOIN
    ext.allwise w ON m.allwise_cntr=w.cntr
WHERE
    m.twomass_dist < 2.0 /* cross-matching radii (arcsec) */
    AND m.gaia_dr2_dist1 < 2.0
    AND m.allwise_dist < 3.0
    AND m.prox > 6.0
    AND t.ph_qual = 'AAA' /* quality cuts */
    AND t.gal_contam = 0
    AND t.ext_key IS NULL
    AND t.cc_flg = '000'
    AND m.class_star > 0.9
    AND flags_psf = 0
    AND m.u_ngood > 0
    AND m.v_ngood > 0
    AND m.g_ngood > 0
    AND m.nch_max = 1
    AND (t.j_m - t.k_m) > 0.85 /* 2MASS initial color cut */
    AND t.j_m < 14.0 /* Select for high 2MASS SNR */
```

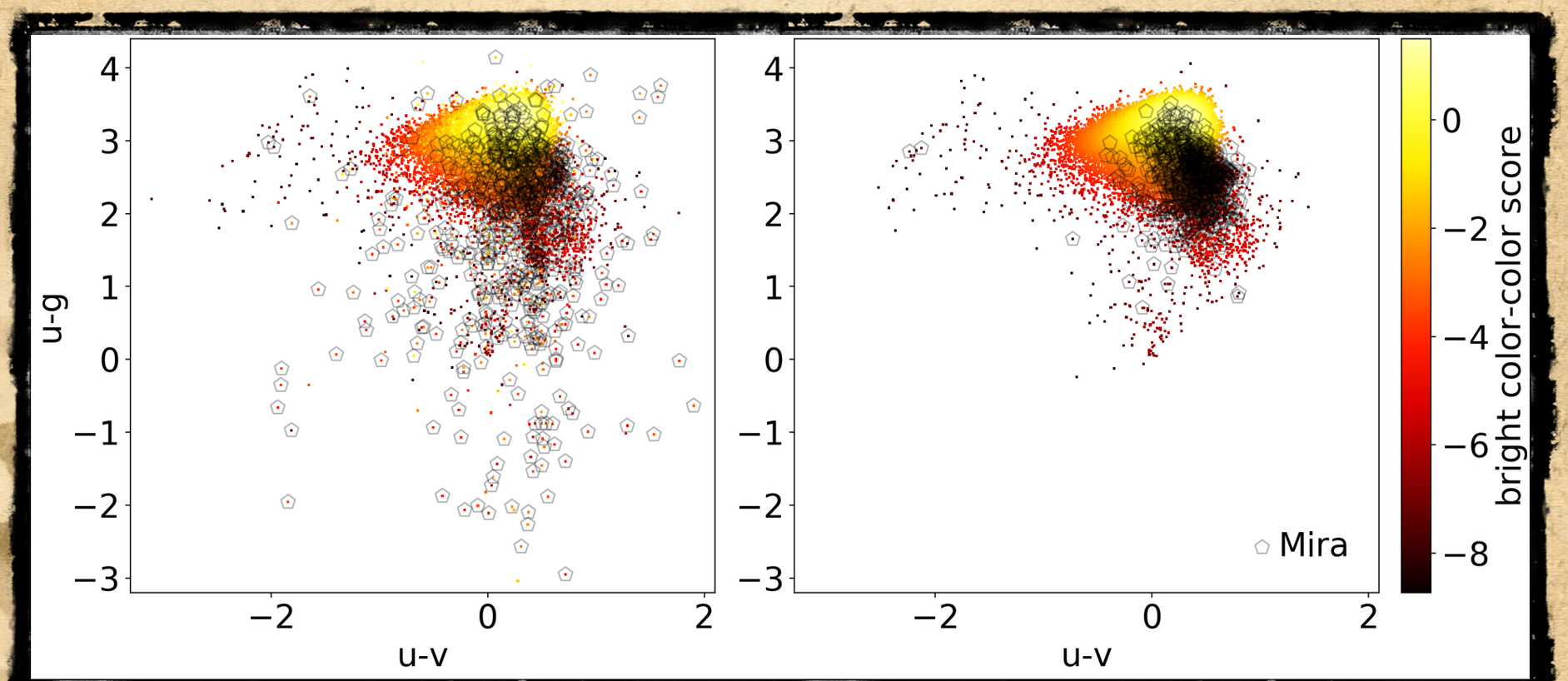
No distance cut here

*TAP query: from [Bailer-Jones et al. 2018 catalog of Bayesian distances] join [local table] on [Gaia source ID from SkyMapper pre-match]

*with ARI-Gaia TAP endpoint, because it accepted table uploads up to 1 million rows (now 10 million)

*Sped up by retrieving only indexed columns
    *otherwise it timed out!

*only 13 out of 71 known symbiotics with *uvg* photometry were cut by the cuts described up until now


u-g
u-v
u-v
Mira
bright color-color score
4
3
2
1
0
−1
−2
−3
−2
0
2
−2
−4
−6
−8

*need to get variability and recalculate colors from full photometry table of individual measurements

*don’t want to retrieve individual measurements for millions of M dwarfs, so need to incorporate distances into selection

*SkyMapper didn’t have Bailer-Jones distances in the schema

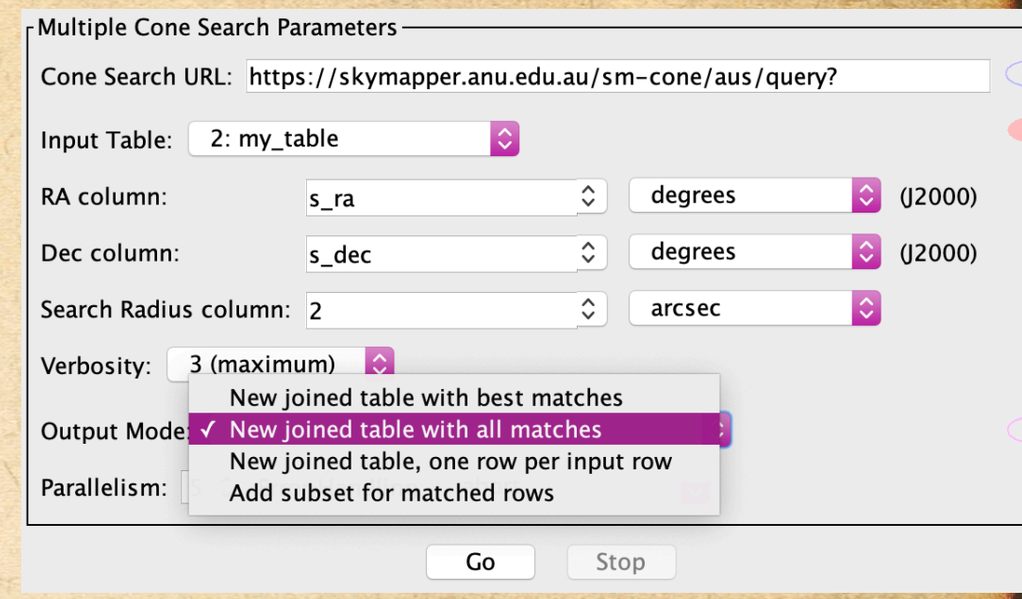
*SkyMapper TAP endpoint doesn’t accept table uploads

*so, need a workaround…

*multiple cone search (Multicone) in TOPCAT, crossmatching our sample to the SkyMapper dr2.photometry TAP cone-search endpoint with a right outer join

*separated into pieces to avoid timing out the multicone query

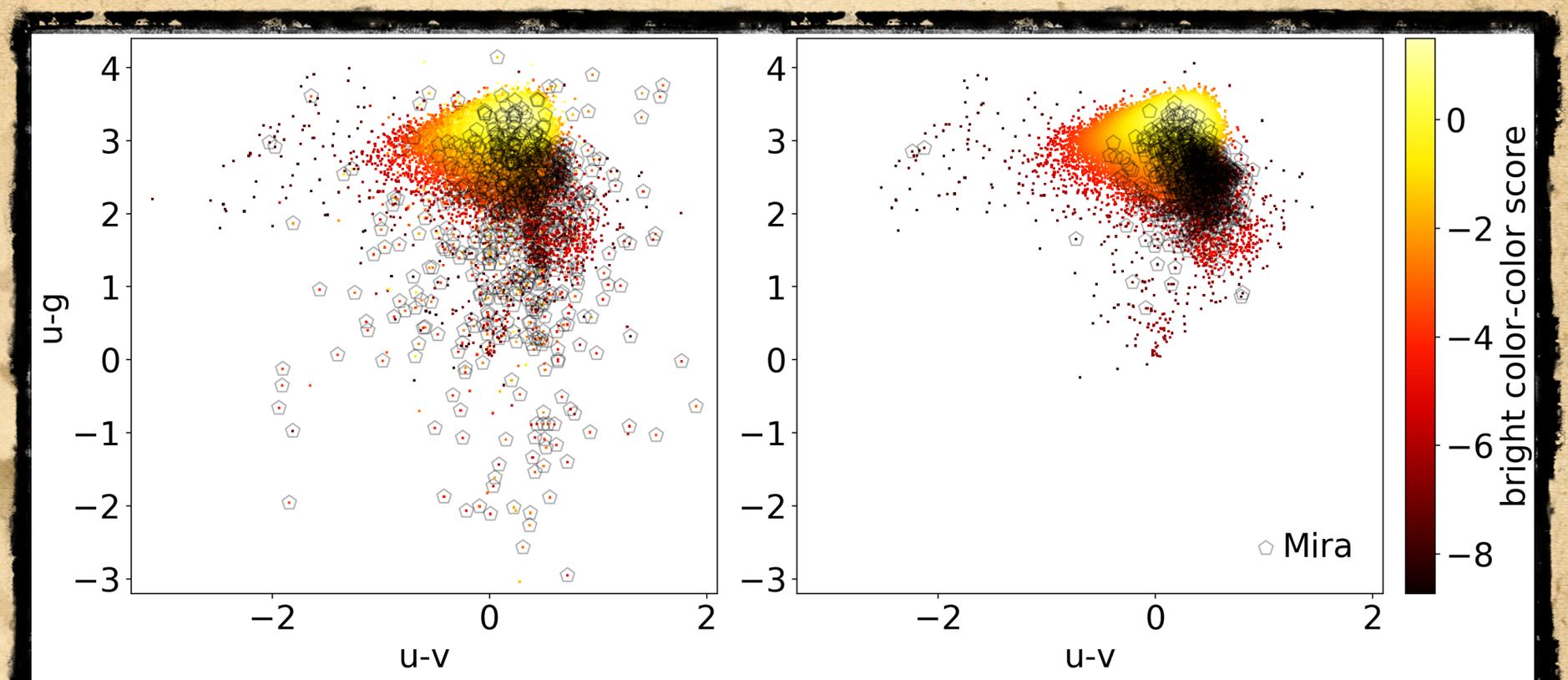
*downloaded full dr2.image table (needed date of observation)

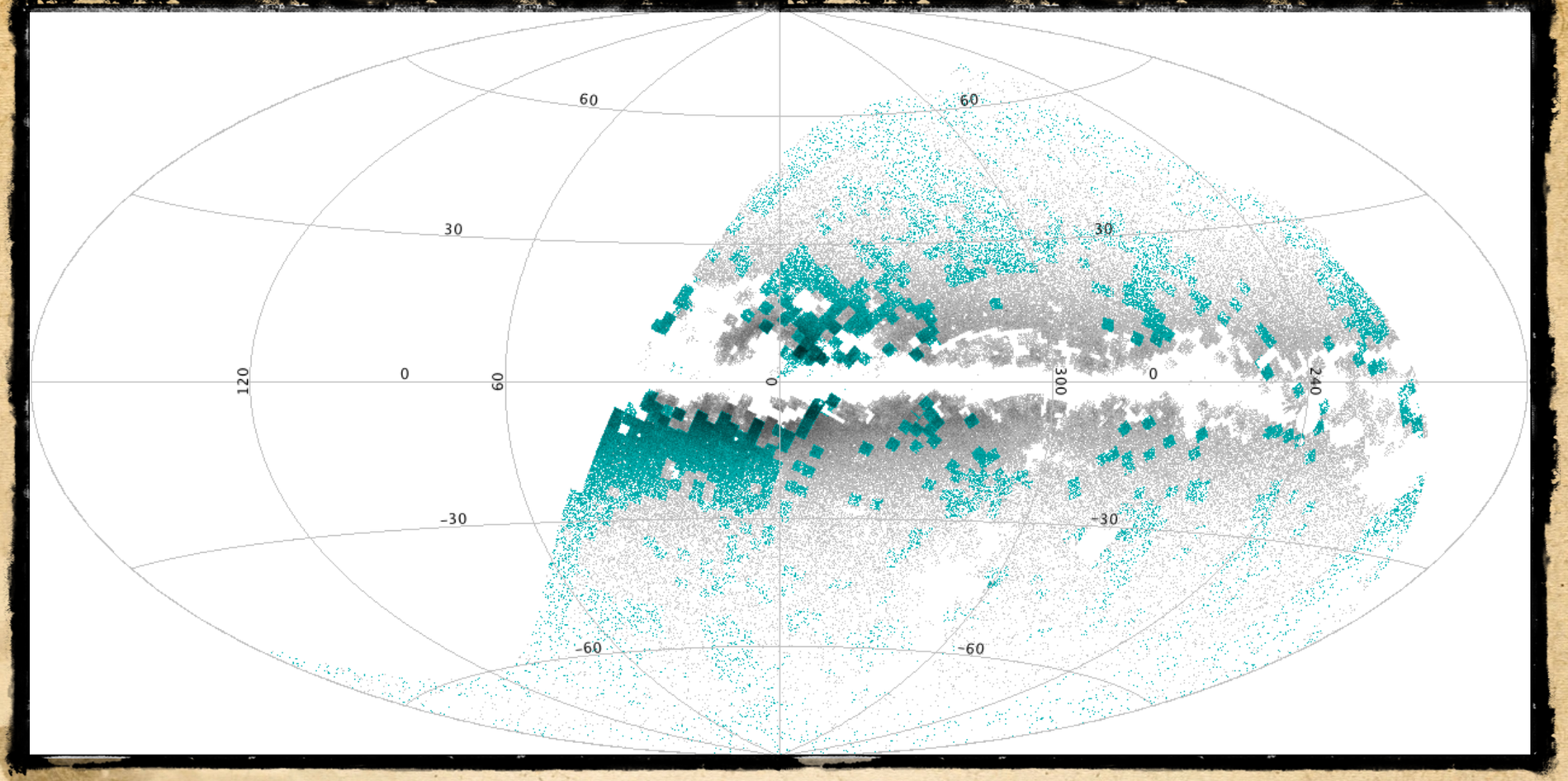


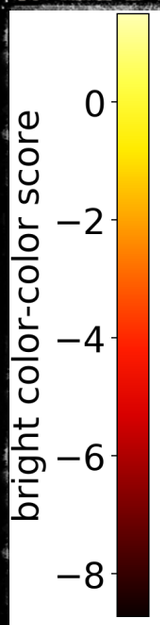
*joined our full table of measurements (millions of rows)to the image table,
locally in TOPCAT

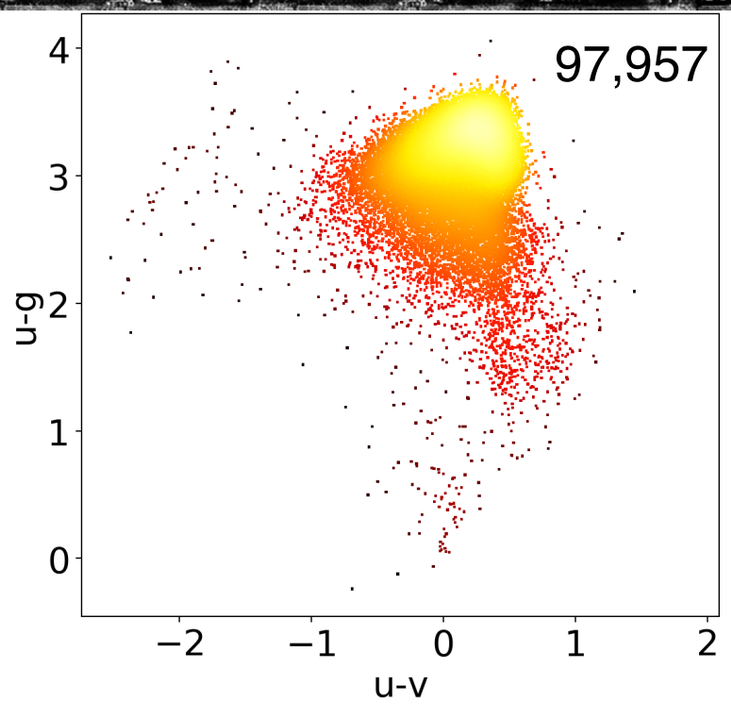
*+quality control cuts

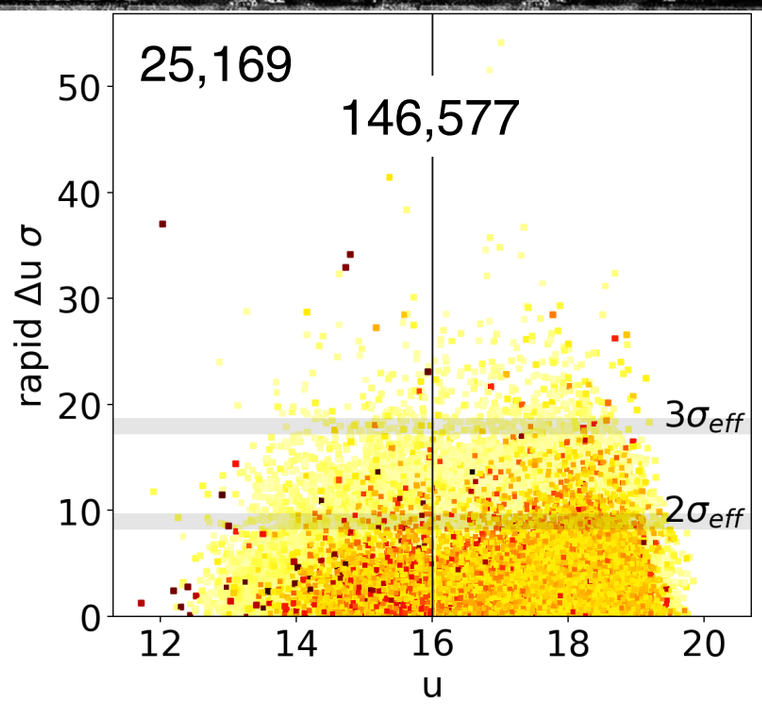
*then computed, for each object, a weighted average of nightly u-v and u-g colors in pandas

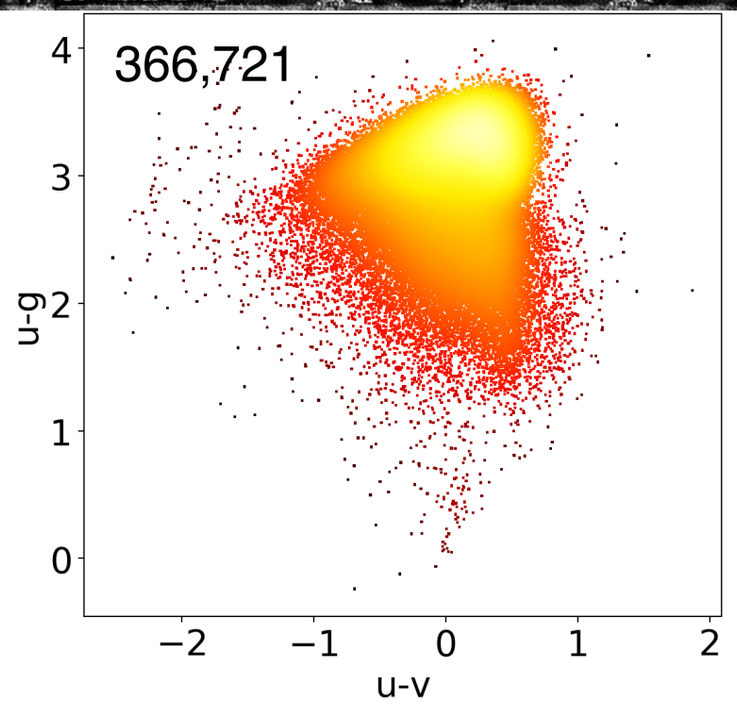

u-g
u-v
u-v
Mira
brightness-color-color score
4
3
2
1
0
−1
−2
−3
−2
0
2
0
−2
−4
−6
−8

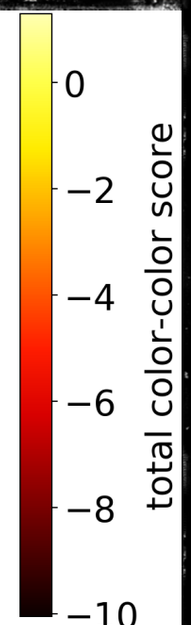

60
30
0
−30
−60
120
60
0
300
240


bright color-color score
0
−2
−4
−6
−8


97,957
u-g
u-v
4
3
2
1
0
−2
−1
0
1
2


25,169
146,577
rapid Δu σ
u
50
40
30
20
10
0
12
14
16
18
20
3σeff
2σeff


366,721
u-g
u-v
4
3
2
1
0
−2
−1
0
1
2

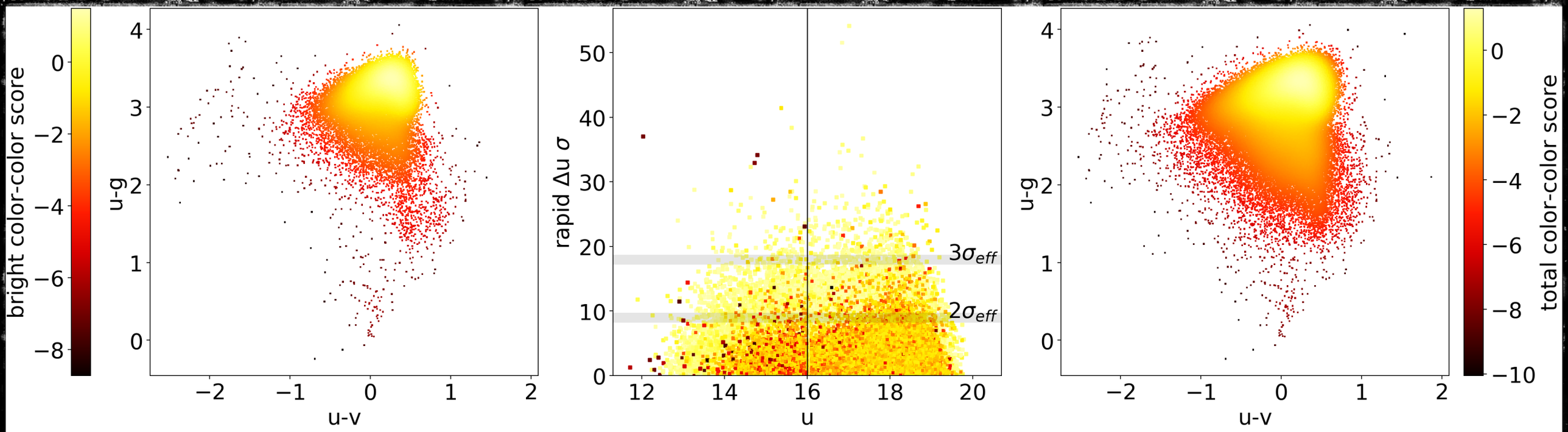

total color-color score
0
−2
−4
−6
−8
−10

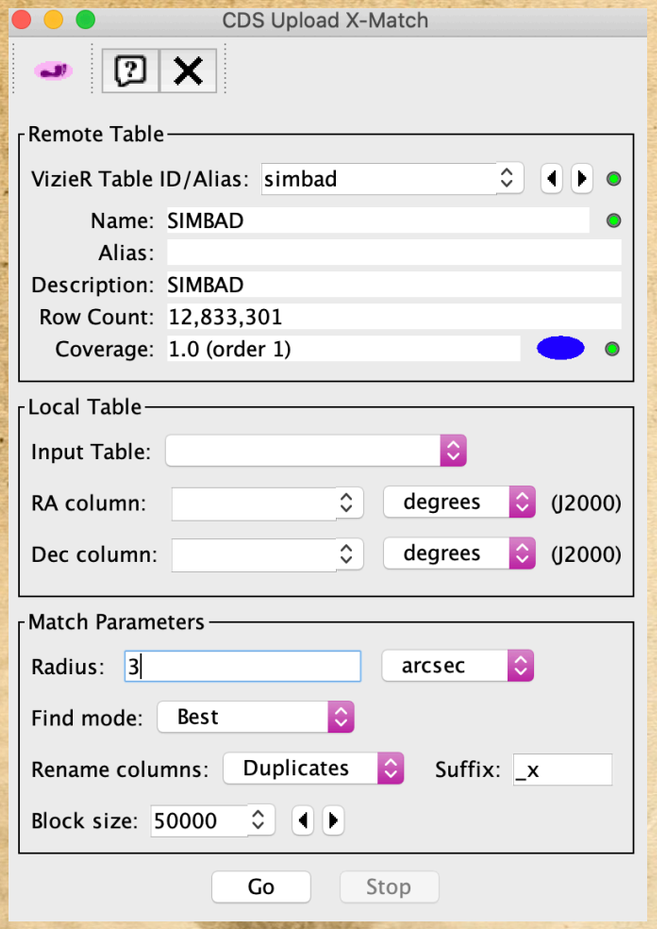
rapid Δu σ of an object is the maximum of

$$\frac{|u_i - u_j|}{\sqrt{(\text{e\_mag\_psf})_i^2 + (\text{e\_mag\_psf})_j^2}}$$

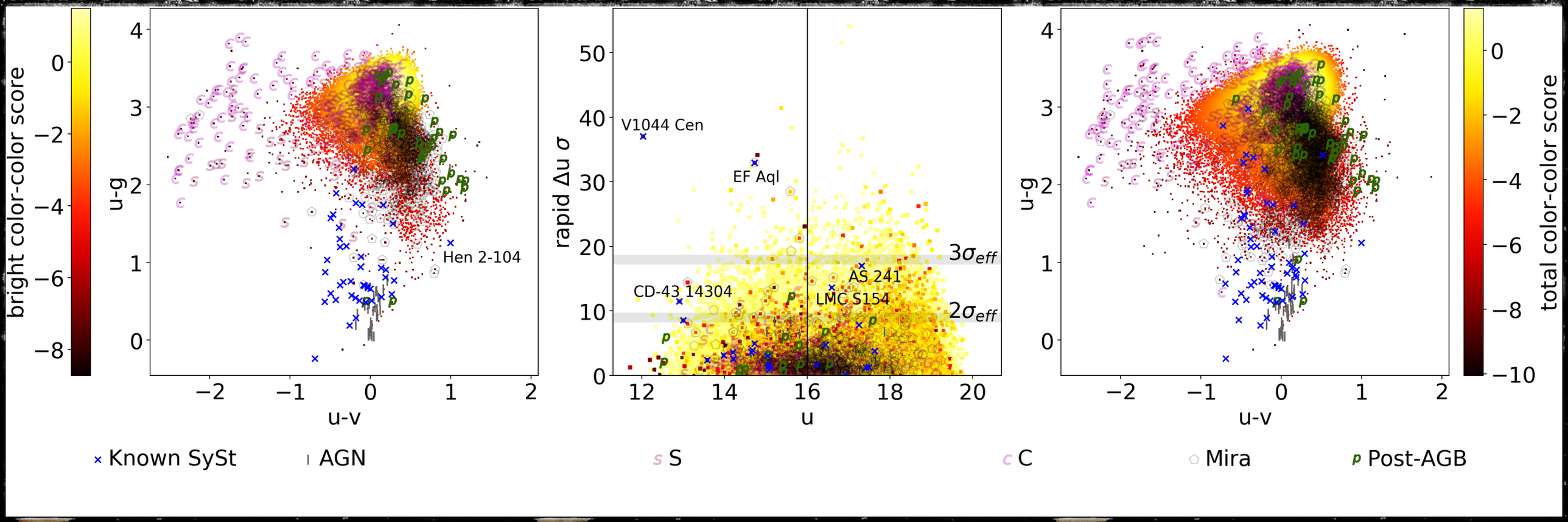
for i,j in exposures [u_1,u_2,u_3] of a single Main Survey *$u_1$vgr$u_2$vizu_3v*

——> effective σ at 99.7%, 95.5%





SIMBAD crossmatch



12 confirmed symbiotics (SkyMapper Symbiotics = SkySy)
+ 10 candidates (SkyMapper Symbiotic Candidates = SkySyC)

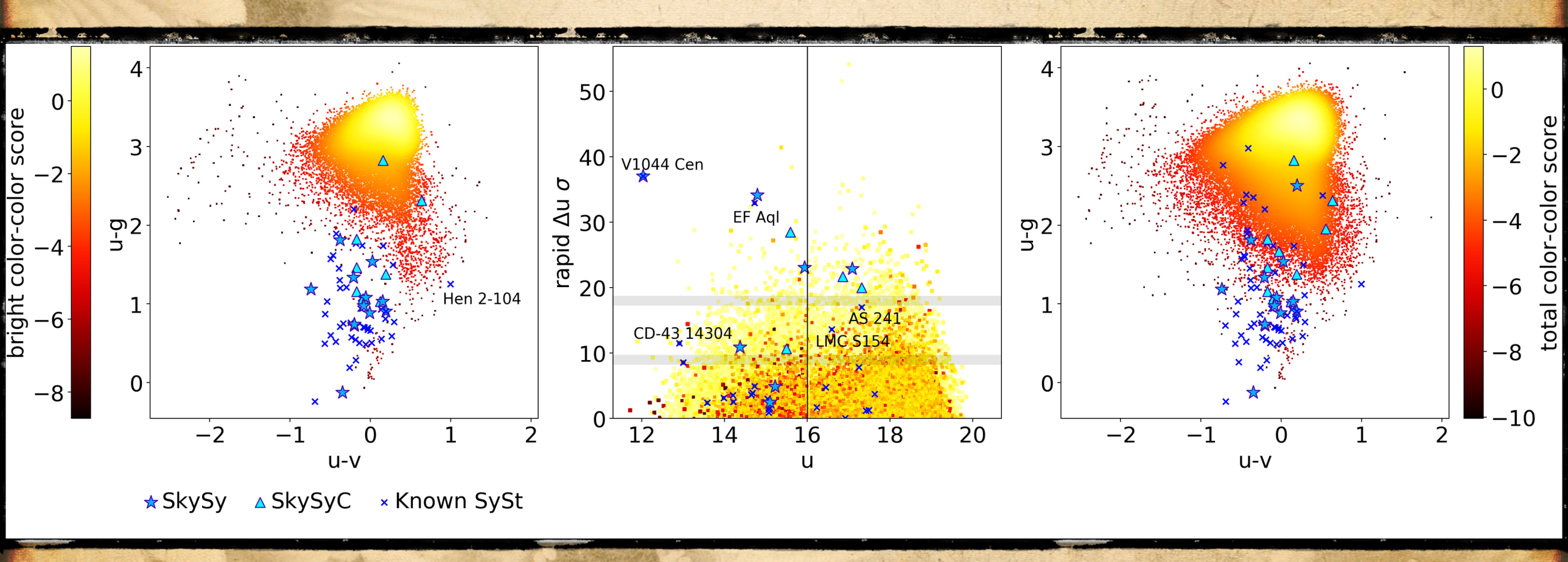
SkySyC criteria:

- cool giant
- Balmer alpha flux > all higher order Balmer lines
  (after extinction correction)
- not an S/carbon star OR has He I
  (see Castelaz et al. 2000)

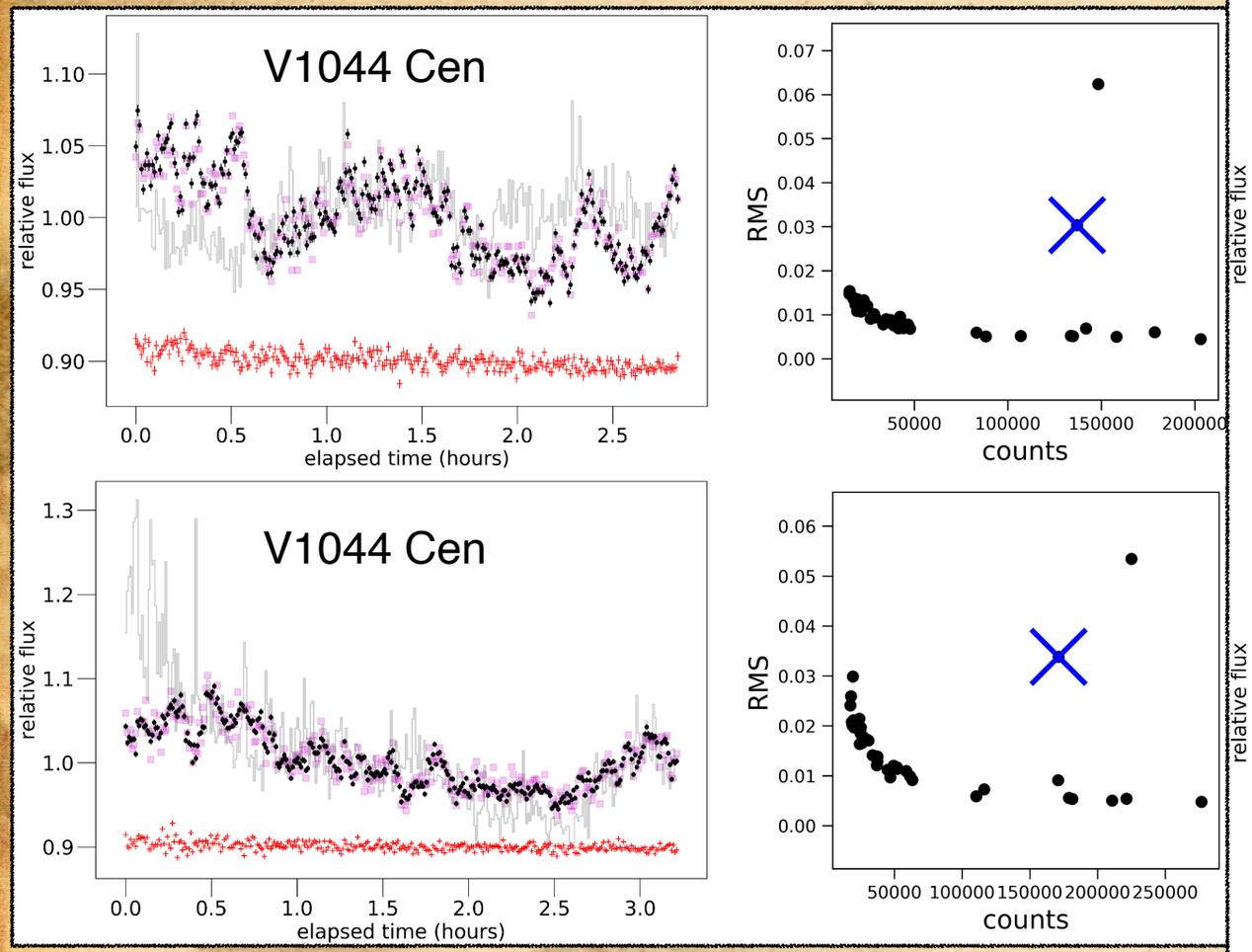
SkySy criteria:

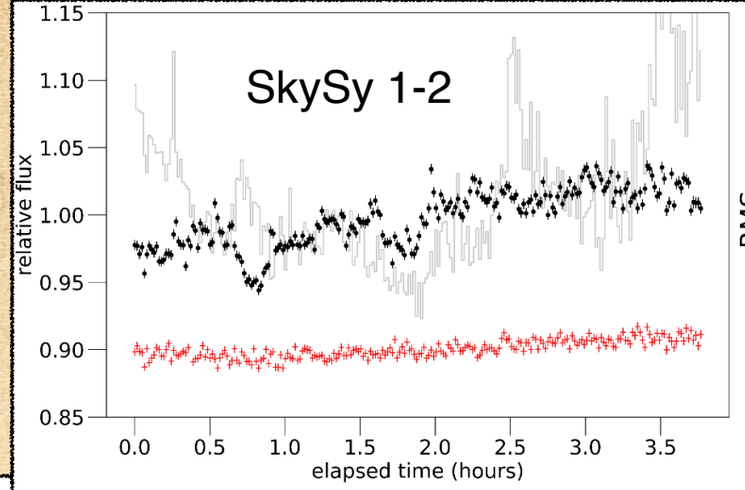
- cool giant and AT LEAST ONE of the following:

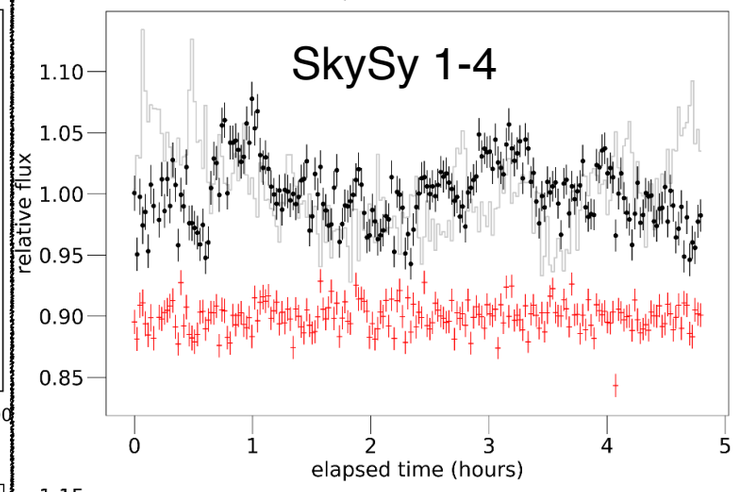
1. emission from >35 eV ion (traditional)
2. extensively validated optical flickering
3. unambiguous X-ray photons above 2.4 keV

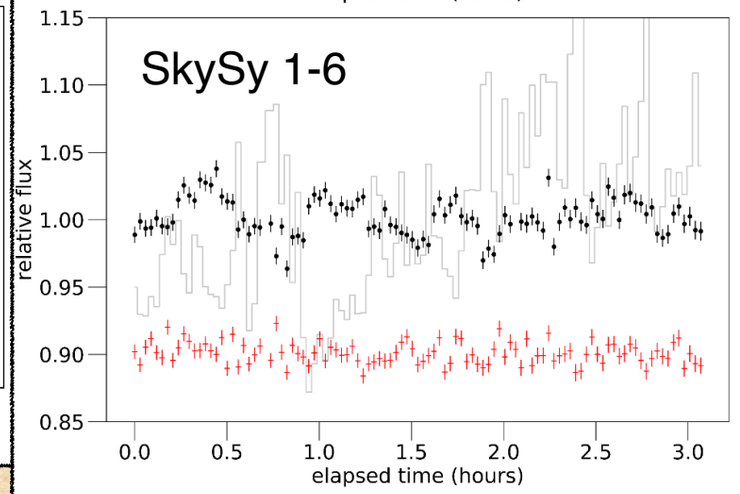


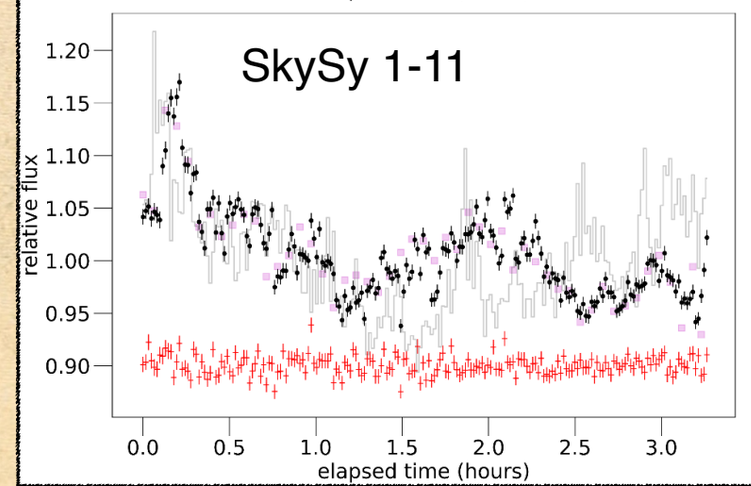
At least 20% of the true population of symbiotics will have optical flickering detectable through SkyMapper.











*What data do I need for my science to work?

*How many output rows do I expect? / how much data do I want to download? Can I split it easily into parts? Do I have the space for it? Does it need to be asynchronous?

*What do the database schema look like? Which columns are indexed?

*Do I need to cross-match to external catalogs? What external data is already available in the schema or through the interface I'm using?

*Do I need/want to be able to cross-match to local tables (table uploads)?

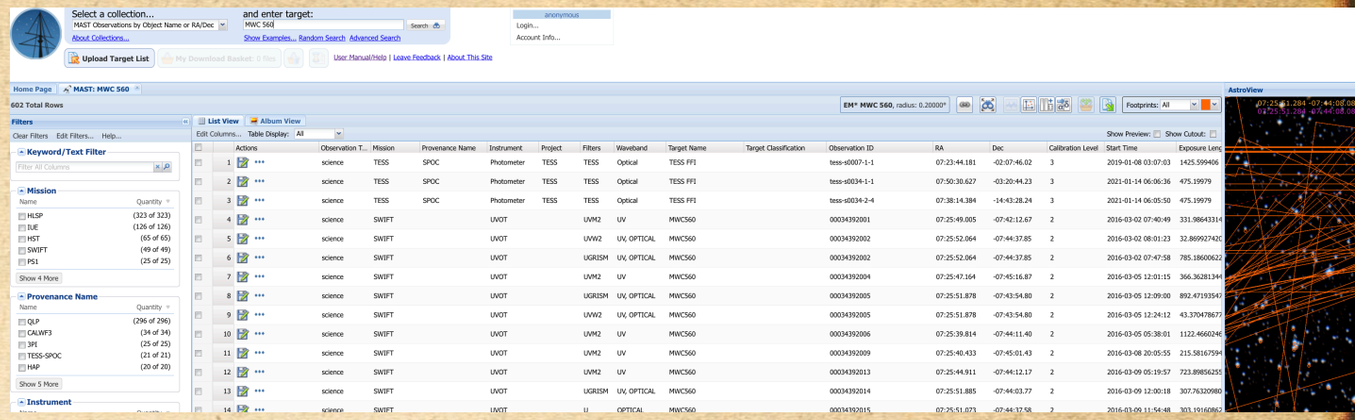
*What is the email address of the archive's help desk?

The MAST ecosystem

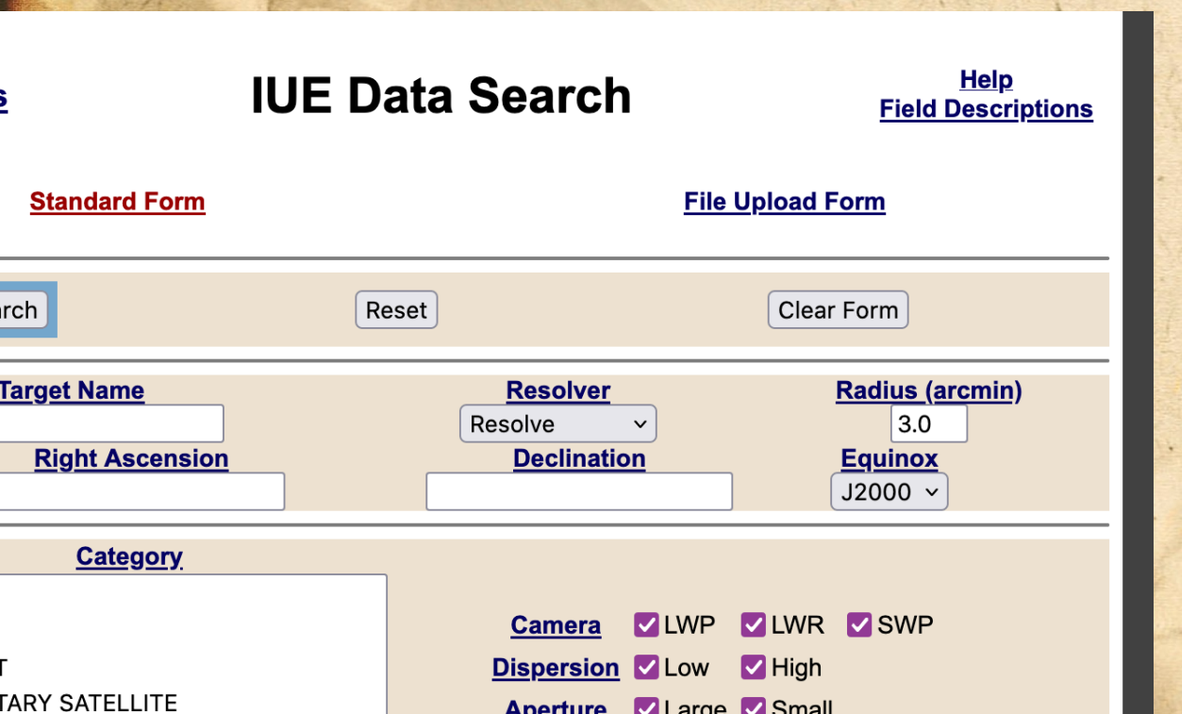
*disclaimers

The MAST ecosystem: data exploration on browser

1. Portal (incl. VO): https://mast.stsci.edu/portal/Mashup/Clients/Mast/Portal.html



2. Mission search forms: https://archive.stsci.edu/searches.html#missions



3. High Level Science Products

The MAST ecosystem: data exploration on browser

3. High Level Science Products (Available in the portal too when possible)

High Level Science Products are observations, catalogs, or models that complement, or are derived from, MAST-supported missions. These include Hubble (HST), James Webb (JWST), TESS, PanSTARRS, Kepler/K2, GALEX, Swift, XMM, and others. HLSPs can include images, spectra, light curves, maps, source catalogs, or simulations. They can include observations from other telescopes, or data that have been processed in a way that differs from what's available in the originating archive. All HLSPs are public immediately with no proprietary periods. **Use the filters below to discover HLSP.** Search HLSP by coordinates or filenames on MAST Classic. Or, see all HLSPs in a simplified, searchable table.

Contribute HLSPs

HLSP filter | *Keyword (HLSP, PI, etc.)* | *Object Type* | *Mission* | *Product Type* | SUBMIT

Items per page: 15 (190 total)

First | Previous | 1 2 3 4 5 | Next | Last

EXOMAST

SEARCH

Search by planet, object of interest or TESS TCE

View Table of Exoplanets

zMAST

Search for extragalactic observations and catalog data from MAST high-level science products (HLSP). Download results for further analysis or quickly view detailed information by individual galaxy—aggregated data, image cutouts, observed SEDs, and observations from CANDELS, GOODS, HFF-DEEPSPACE, 3D-HST.

Search by | Parameter | Coordinates | Object

Select an HLSP.

survey= CANDELS | GOODS | HFF-DEEPSPACE | 3D-HST

Select an observed field. See field footprints.

region= all | COSMOS | EGS | GOODS_North | GOODS_South | UDS

Pick a specific region for more catalog options.

catalog= Summary | Multiband Photometry | Star Formation Rates

+ Add condition

Add a parameter to filter by. See parameter descriptions.
* Different catalogs have different parameters.

SEARCH

The MAST ecosystem: programatic interfaces

1. Default: *astroquery.mast (https://astroquery.readthedocs.io/en/latest/mast/mast.html)
   -python
   -extensive functionality, but can’t access all metadata
   -output row limits for some things

The MAST ecosystem: programatic interfaces

2. Need more access to metadata?

*MAST API, i.e. mashup API (https://mast.stsci.edu/api/v0/, https://mast.stsci.edu/api/v0/_services.html)

-more complex

-output row limit of about 500,000

-access to more, but not all, metadata (e.g., for CAOM, https://mast.stsci.edu/api/v0/_c_a_o_mfields.html)

*http get (https://archive.stsci.edu/vo/mast_services.html#GET)

*CAOM TAP query (https://vao.stsci.edu/caomtap/querymanager.html)

-all CAOM (cross-mission) metadata

-VO-compatible

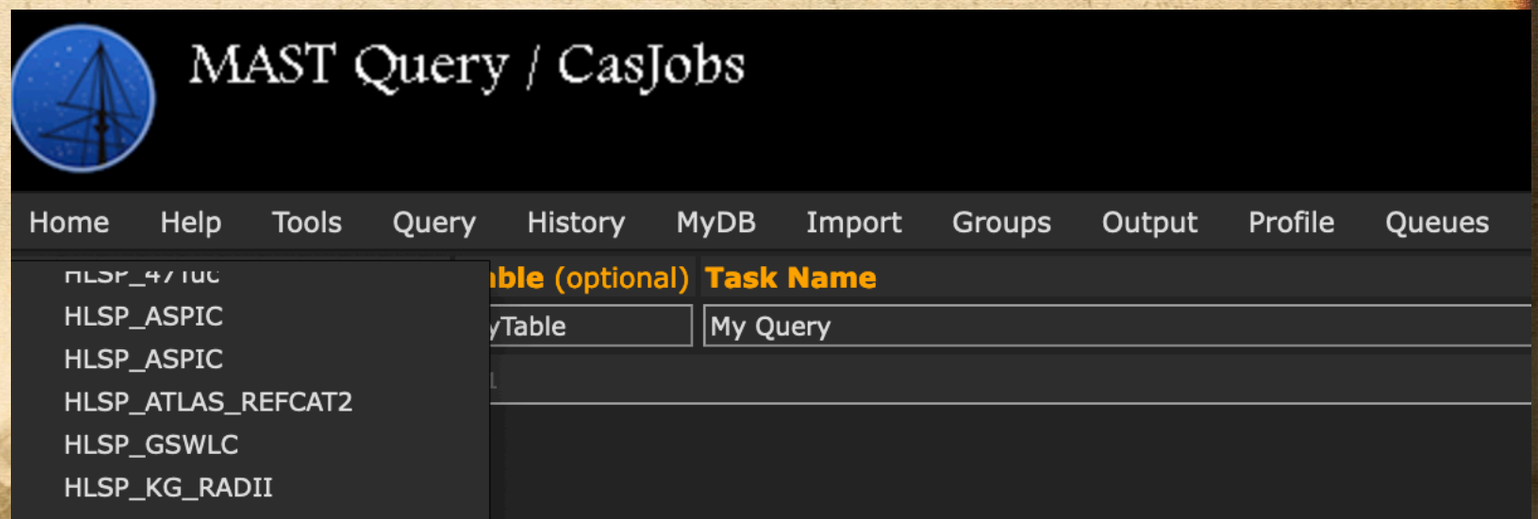
-ADQL queries

-large, async queries

The MAST ecosystem: programatic interfaces

3. Need to cross-match to other archives AND portal shows the data you need is available for VO service? Virtual Observatory TAP endpoints (https://archive.stsci.edu/virtual-observatory)

4. Very large/complex query, >10^6 output rows, need to upload your own large table for crossmatch? Check if your data is available in CasJobs:
   -SQL
   -can handle larger, async queries
   -HLSPs, Kepler, TESS, 2MASS, PanSTARRS,



The MAST ecosystem: cloud interfaces

1. TIKE is a good approximation of the Roman science platform

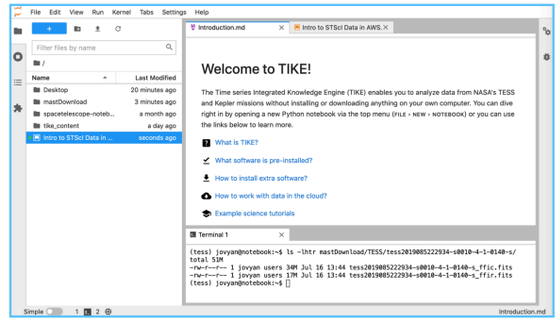
https://timeseries.science.stsci.edu/

The Timeseries Integrated Knowledge Engine (TIKE): cloud-based user interface for analysis of TESS mission data.

TIKE Science Platform

Coming in 2021! (stay tuned)

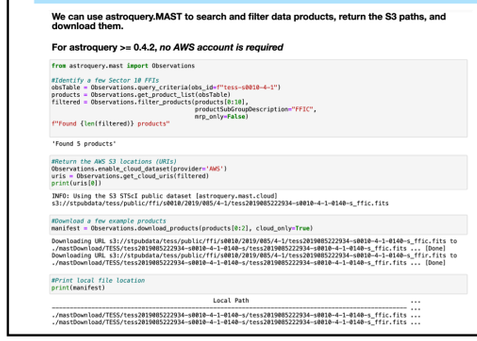
- Over 20 pre-installed community software packages
- Tutorials and example notebooks
- JupyterHub service in same region as MAST AWS Public Datasets: free, high bandwidth to TESS data



MAST AWS TESS data now free to transfer

https://registry.opendata.aws/collab/stsci/

- MAST AWS data no longer uses "requestor pays"
- Astroquery (>= 0.4.2) and other clients no longer need AWS credentials
- High-throughput data access anywhere (cloud or not)

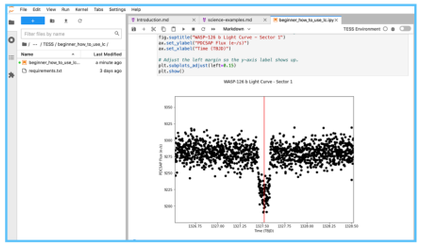


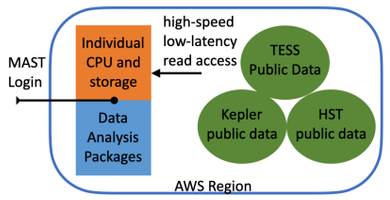
Initial focus on timeseries analyses, e.g. TESS, Kepler

Pre-installed Python packages

- Core scientific packages: numpy, scipy, matplotlib, pandas.
- Core astronomy packages: astropy, astroquery, pyvo.
- Data analysis packages: emcee, george, celerite.
- TESS- or Kepler-focused packages: lightkurve, astrocut, everest.
- Machine learning: tensorflow, scikit-learn.
- Cloud tools: awscli, boto3, s3fs.

Quickly visualize TESS & Kepler data





Computing adjacent to MAST AWS datasets

Access TESS data without transferring it over internet

The table below shows the typical time it takes to sequentially download 30 TESS Full Frame Images (~1 GB) in different environments. These results are a snapshot obtained at a single point in time on Feb 3, 2021.

Environment	Data location	Client	Time	Speed	Diff
TIKE platform	AWS	boto3	9s	907 Mbps	1x
TIKE platform	AWS	httpx	16s	510 Mbps	2x
TIKE platform	MAST	httpx	1m13s	112 Mbps	8x
WiFi	AWS	boto3	5m49s	23 Mbps	39x
WiFi	AWS	httpx	11m31s	12 Mbps	77x
WiFi	MAST	httpx	14m05s	10 Mbps	94x

STScI is hiring!

e.g. Scientist to support TESS archive (Aug 20, 2021)
https://jobregister.aas.org/ad/144258c4

Link to full STScI Job board

STScI

Greg Snyder
Susan Mullally, Geert Barentsen (NASA Ames), Clara Brasseur, Scott Fleming, Joshua Peek, Ivelina Momcheva, Andrew Cortese, Michael Fox, Michael Gough, Brian Hayden, Ru Kein, Jacob Matuskey, Todd Miller, Christine Slocum

The MAST ecosystem: cloud interfaces

2. cloud data access APIs and cutout services/APIs/libraries TBD

-can be demonstrated from within TIKE
-Currently available:
*astroquery.mast AWS cloud services, now free! (https://astroquery.readthedocs.io/en/latest/mast/mast.html)
*prototype client-side cutout library in a branch of Astrocut: https://github.com/spacetelescope/astrocut/tree/s3-support

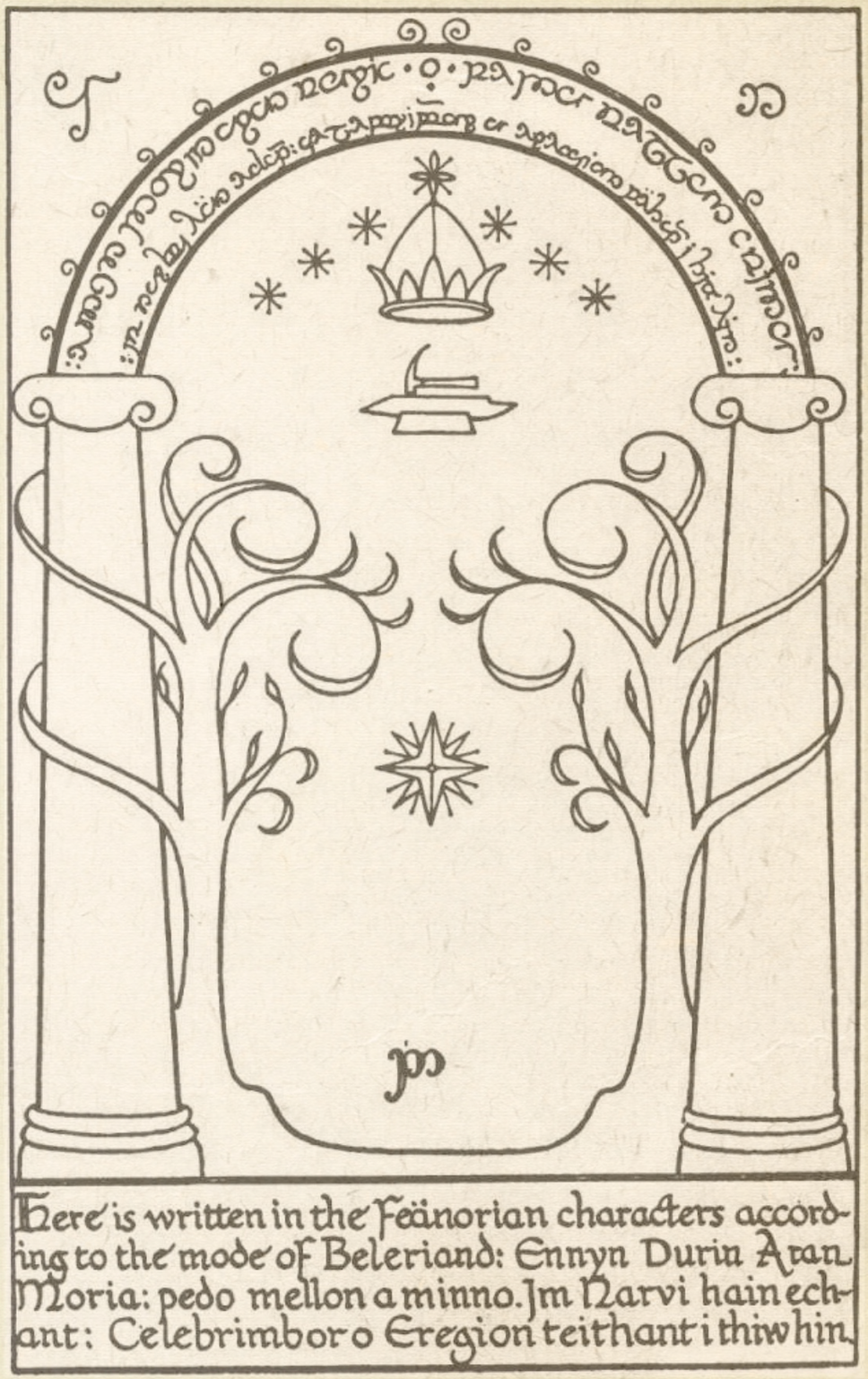
8:30	**Adrian Lucy (STScI)**	**Invited: Archival data retrieval and analysis in the time domain: speak, friend, and enter** ???

‘What does the writing say?’ asked Frodo, who was trying to decipher the inscription on the arch. ‘I thought I knew the elf-letters, but I cannot read these.’

‘The words are in the elven-tongue of the West of Middle-earth in the Elder Days,’ answered Gandalf. ‘But they do not say anything of importance to us. They say only: *The Doors of Durin, Lord of Moria. Speak, friend, and enter*. And underneath small and faint is written: *I, Narvi, made them. Celebrimbor of Hollin drew these signs*.’

‘What does it mean by *speak, friend, and enter*?’ asked Merry.

‘That is plain enough,’ said Gimli. ‘If you are a friend, speak the password, and the doors will open, and you can enter.’



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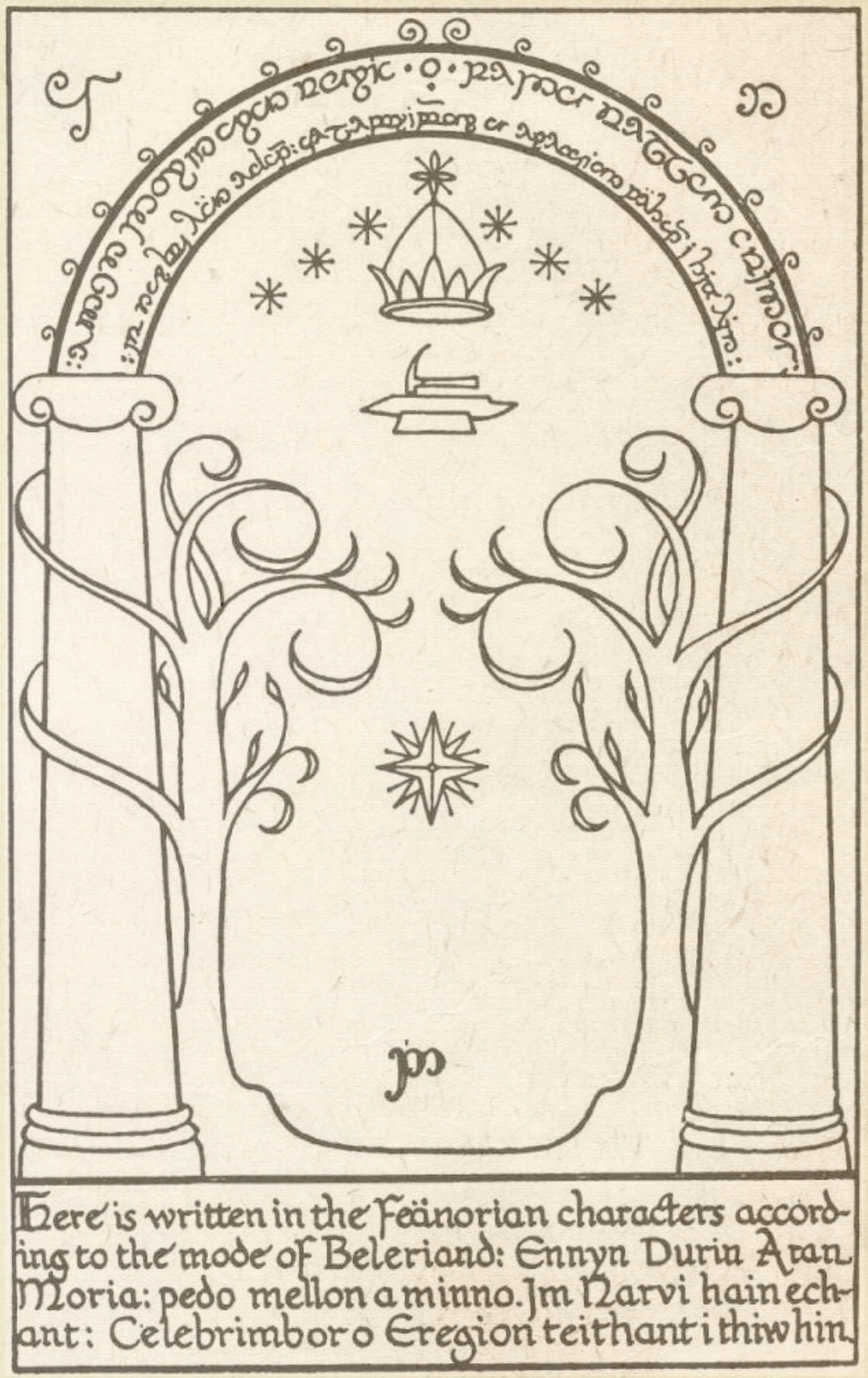
‘What does it mean by *speak, friend, and enter*?’ asked Merry.

‘That is plain enough,’ said Gimli. email archive@stsci.edu and the doors will open, and you can enter.’



Here is written in the Fëanorian characters according to the mode of Beleriand: Ennyn Durin Aran Moria: pedo mellon a minno. Im Narvi hain echant: Celebrimbor o Eregion teithant i thiw hin.

alucy@stsci.edu

Symbiotic/SkyMapper work at 2021PhDT.....17L

Symbiotic collaborators: J. Sokoloski, G. J. M. Luna, K. Mukai, H. Breytenbach, D. Buckley, S. Potter, P. Woudt, P. Groot, B. Paul, N. Nuñez, A. Howell, C.Wolf, R. Manick, M. Shara, D. Zurek

Thank you to everyone at MAST and STScI who has helped me during my onboarding.