

WISE properties of planetary nebulae from the DSH catalogue

M. Kronberger^{1,*}, G. H. Jacoby², D. Harmer³, D. Patchick¹

¹ Deep Sky Hunters Collaboration

² GMTO Corporation, 813 Santa Barbara St, Pasadena, CA 91101

³ NOAO, 950 N Cherry Ave, PO Box 26732, Tucson AZ 85726-6732

* [email:](mailto:matthias.kronberger@gmx.at) matthias.kronberger@gmx.at

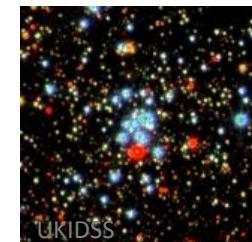
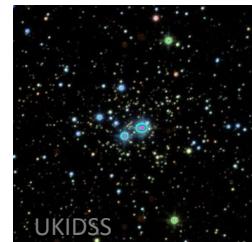
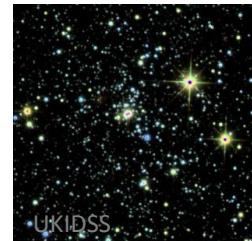
1. Introduction
2. WISE and planetary nebulae
3. WISE properties of DSH planetary nebulae
4. WISE as a tool of discovering new PNe
5. Special cases
6. Summary & Conclusions

1. Introduction

The Deep Sky Hunters:

A group of (mostly) amateur astronomers hunting for unknown Deep Sky objects using various resources (DSS, SDSS, WISE, 2MASS, VIZIER,)

- Foundation date: June 2003
- Number of members: 370
- Communication: via yahoo newsgroup (<http://groups.yahoo.com/neo/groups/deepskyhunters/info>)
- Emphasis: Initially on open clusters and other stellar aggregates



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**Astronomy
&
Astrophysics**

**New galactic open cluster candidates from DSS
and 2MASS imagery^{*,**}**

M. Kronberger¹, P. Teutsch^{1,2}, B. Alessi¹, M. Steine¹, L. Ferrero¹, K. Graczewski¹, M. Juchert¹, D. Patchick¹,
D. Riddle¹, J. Saloranta¹, M. Schoenball¹, and C. Watson¹

¹ Deepskyhunters Collaboration
e-mail: deepskyhunters@yahoo.com
² Institut für Astrophysik, Leopold-Franzens-Universität Innsbruck, Austria
e-mail: Philipp.Teutsch@uibk.ac.at

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ABSTRACT

An inspection of the DSS and 2MASS images of selected Milky Way regions has led to the discovery of 66 stellar groupings whose morphologies, color-magnitude diagrams, and stellar density distributions suggest that these objects are possible open clusters that do not yet appear to be listed in any catalogue. For 24 of these groupings, which we consider to be the most likely to be candidates, we provide extensive descrip-

A grayscale astronomical image showing a dense field of stars. The image is labeled "2MASS" in the bottom right corner.

A grayscale astronomical image showing a dense field of stars. The image is labeled "UKIDSS" in the bottom right corner.

A grayscale astronomical image showing a dense field of stars. The image is labeled "UKIDSS" in the bottom right corner.

1. Introduction

The Deep Sky... However, something new came up in Oct 2003!

- Dana Patchick
- Oct 20, 2003
- [View Source](#)

Hi folks,

While poking around in Cygnus, I came across this image of a tiny nebula and its identity is a mystery to me.

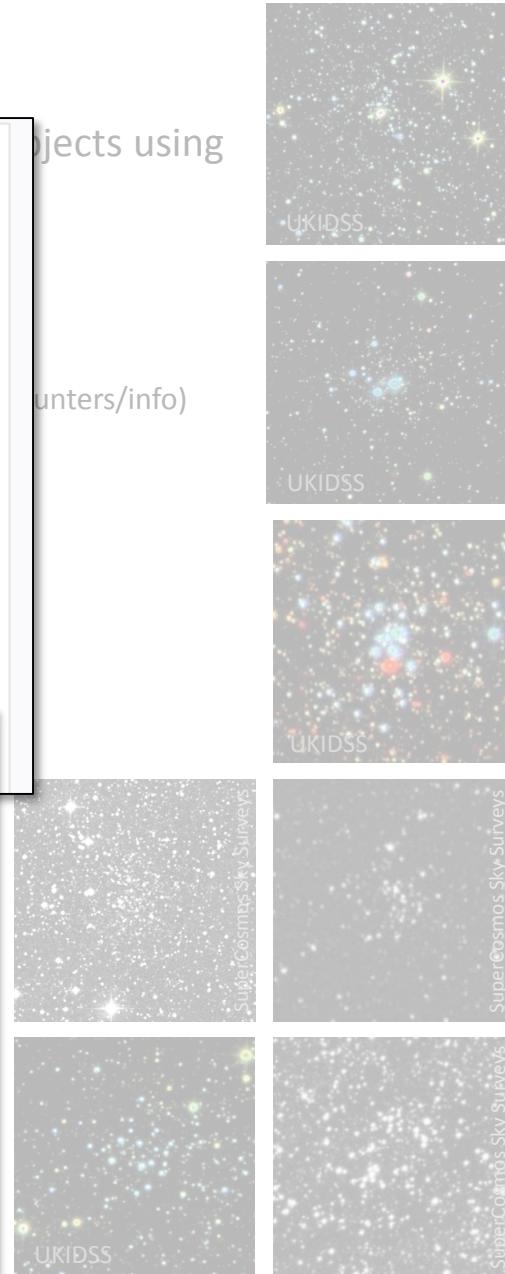
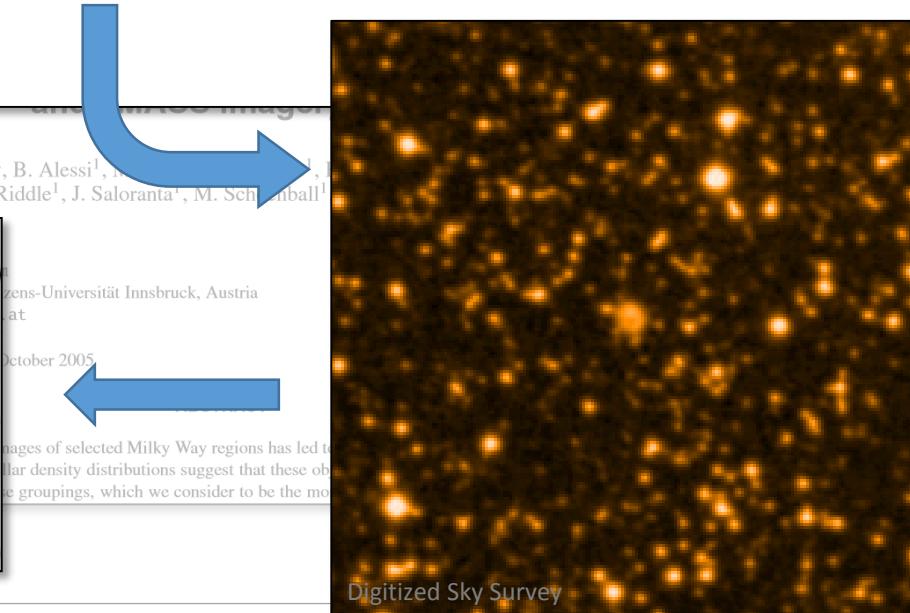
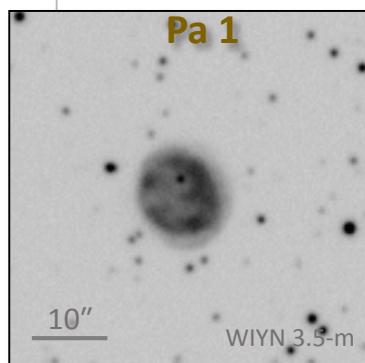
It was found on a blue DSS plate, which the link below reproduces an image 7' x 7' in size.

J2000 coordinates are 19 47 03 +29 30 25. Kent Wallace has kindly checked and agrees that this position is pretty close.

Looks like it could be a planetary nebula, around 10 to 15 seconds of arc in diameter.

http://archive.stsci.edu/cgi-bin/dss_search?v=poss2ukstu_blue&r=19+47+03++&d=%2B29+30+25&e=J2000&h=7&w=7&f=gif&c=none&fov=NONE&v3=

Regards,
Dana

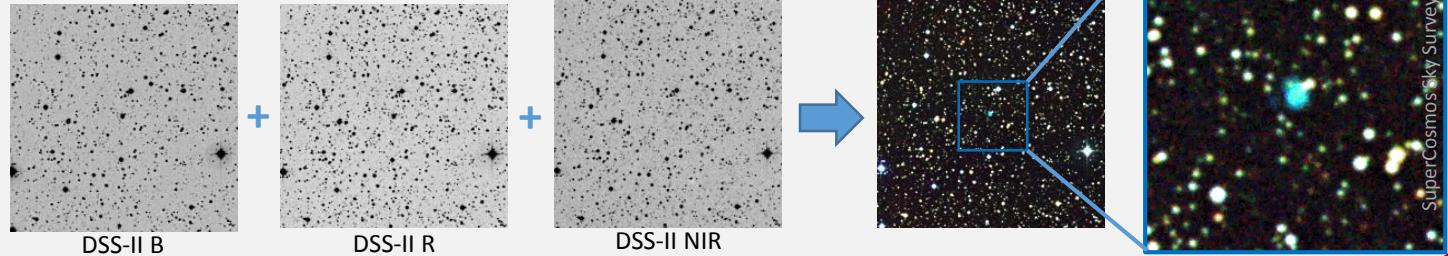


1. Introduction

The DSH PN candidate validation queue

1 Look out for PN-like objects

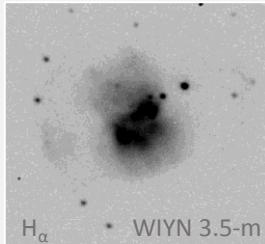
- publicly available Sky Surveys (mostly DSS)
- amateur [S II]-H_α-[O III] imagery



3 Contact Astronomers



4 Get narrowband images

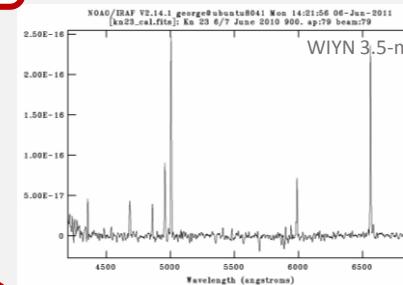


WIYN 3.5-m
KPNO 2.1-m
KPNO 4-m
SPM 0.84-m
OHP 1.2-m
...

2 Check Databases



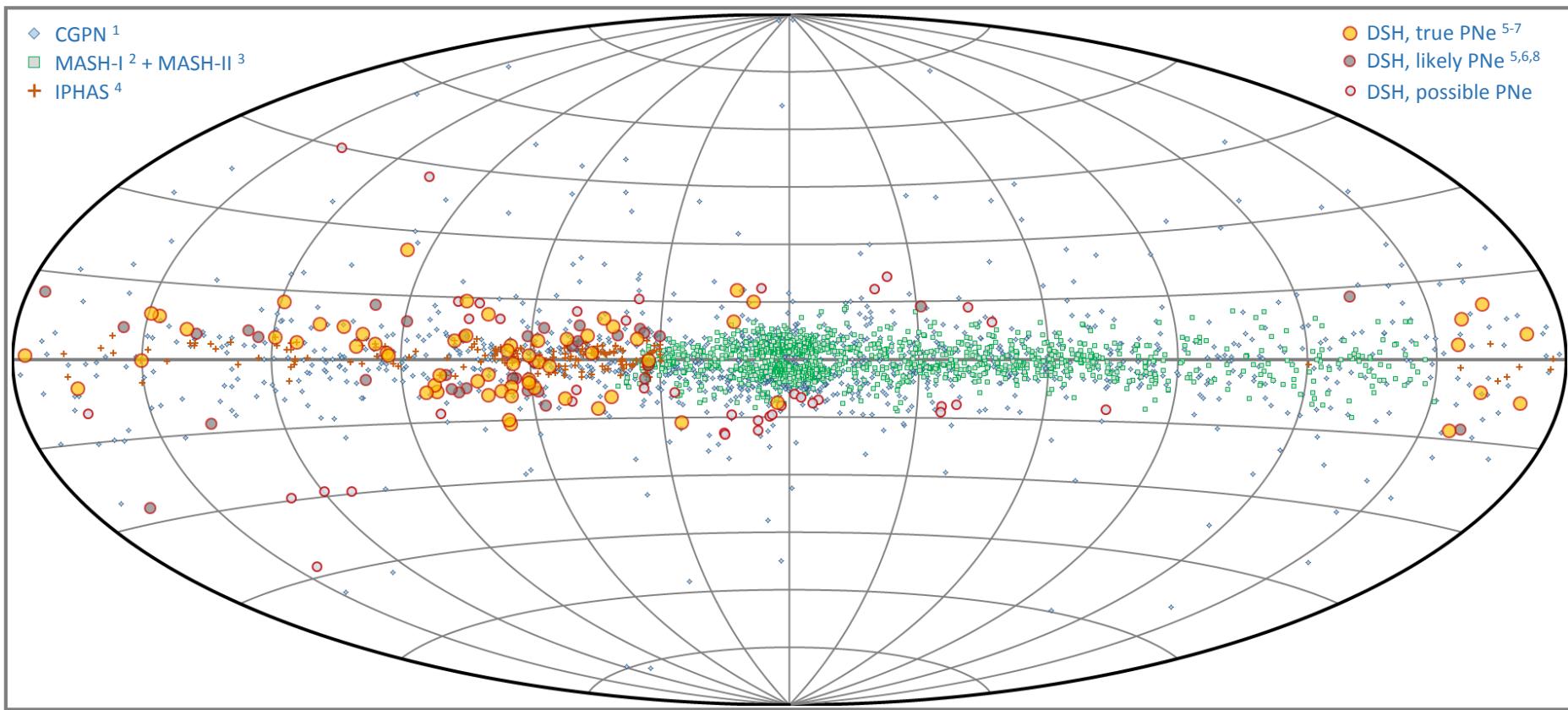
5 Validate candidates spectroscopically



WIYN 3.5-m
SAAO 1.9-m
SPM 2.1-m
OHP 1.2-m

1. Introduction

Distribution of DSH PNe and candidates in the sky



¹ L. Kohoutek, A&A 378, 843 (2000)

² Q. A. Parker et al., MNRAS 373, 79 (2006)

³ B. Miszalski et al., MNRAS 384, 525 (2008)

⁴ L. Sabin, this contribution

⁵ G. Jacoby et al., PASA 27, 156 (2010)

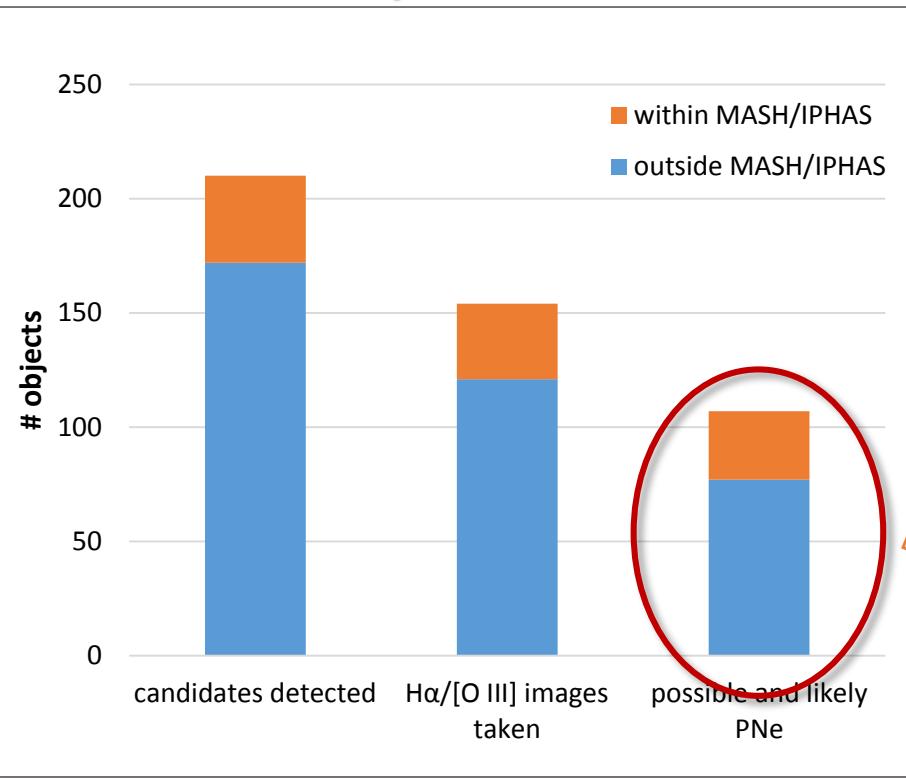
⁶ M. Kronberger et al., IAUS 283, 414 (2012)

⁷ D. Frew et al., in preparation

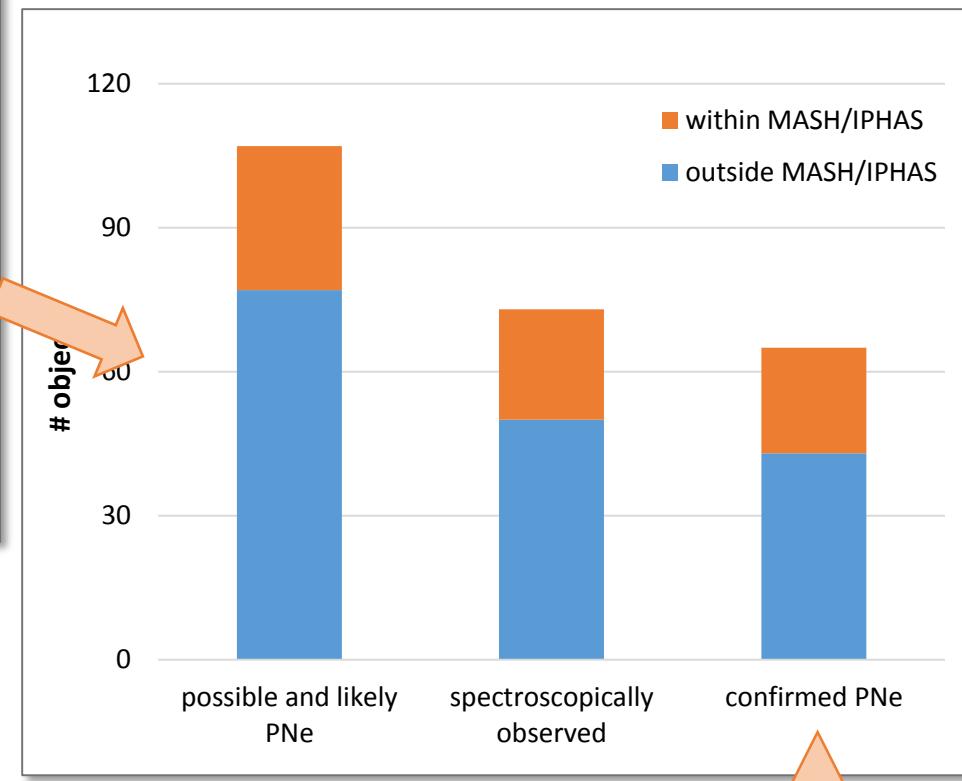
⁸ M. Kronberger et al., poster B03, this contribution

1. Introduction

The DSH PN survey: current census



→ Most candidates located in areas complementary to IPHAS and MASH



Overall detection efficiency $\approx 60\%$

2. WISE and planetary nebulae

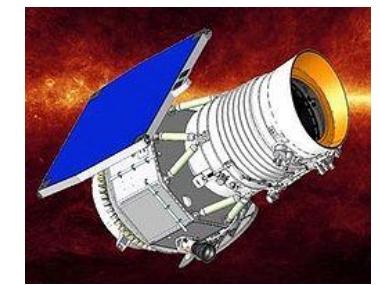
The Wide-field Infrared Survey Explorer (WISE)



<http://irsa.ipac.caltech.edu/Missions/wise.html>

Technical data

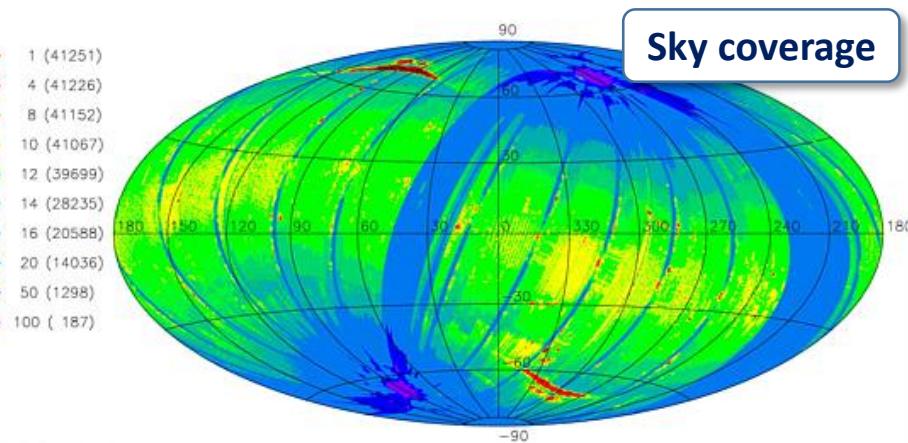
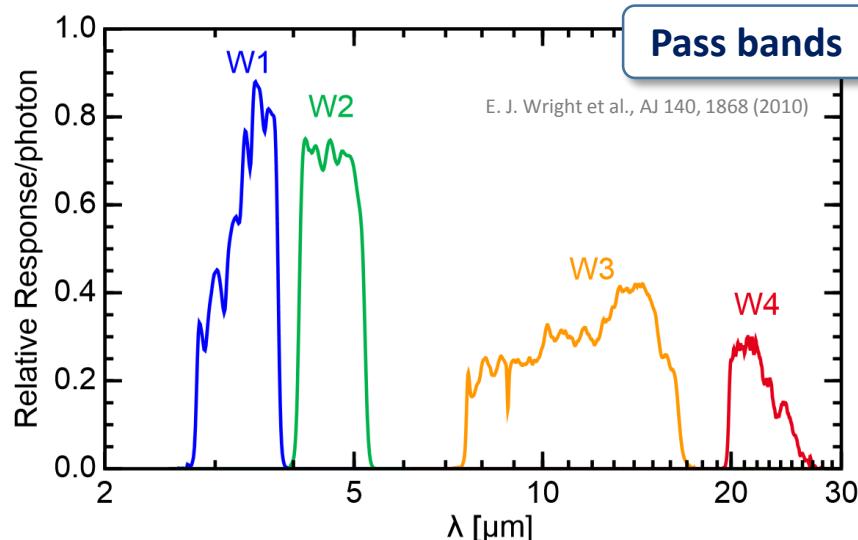
- Mission period: 2010/01 –2011/02 (12 + 22um: 2010/01 - 2010/08)
- Bands: 3.4 um, 4.6 um, 12 um, 22 um
- angular resolution: 6.1“, 6.4“, 6.5“, 12.0“
- Sensitivities: < 0.08 mJy, 0.11 mJy, 1 mJy, 6 mJy
→ 100x more sensitive than Akari and IRAS at these wavelengths!



<http://www.jpl.nasa.gov/news/news.php?feature=2183>

Statistics

- >99% of the sky observed at least 2x in all bands
- Source catalogue: 563 million objects



2. WISE and planetary nebulae

Where does the emission observed with WISE originate from?

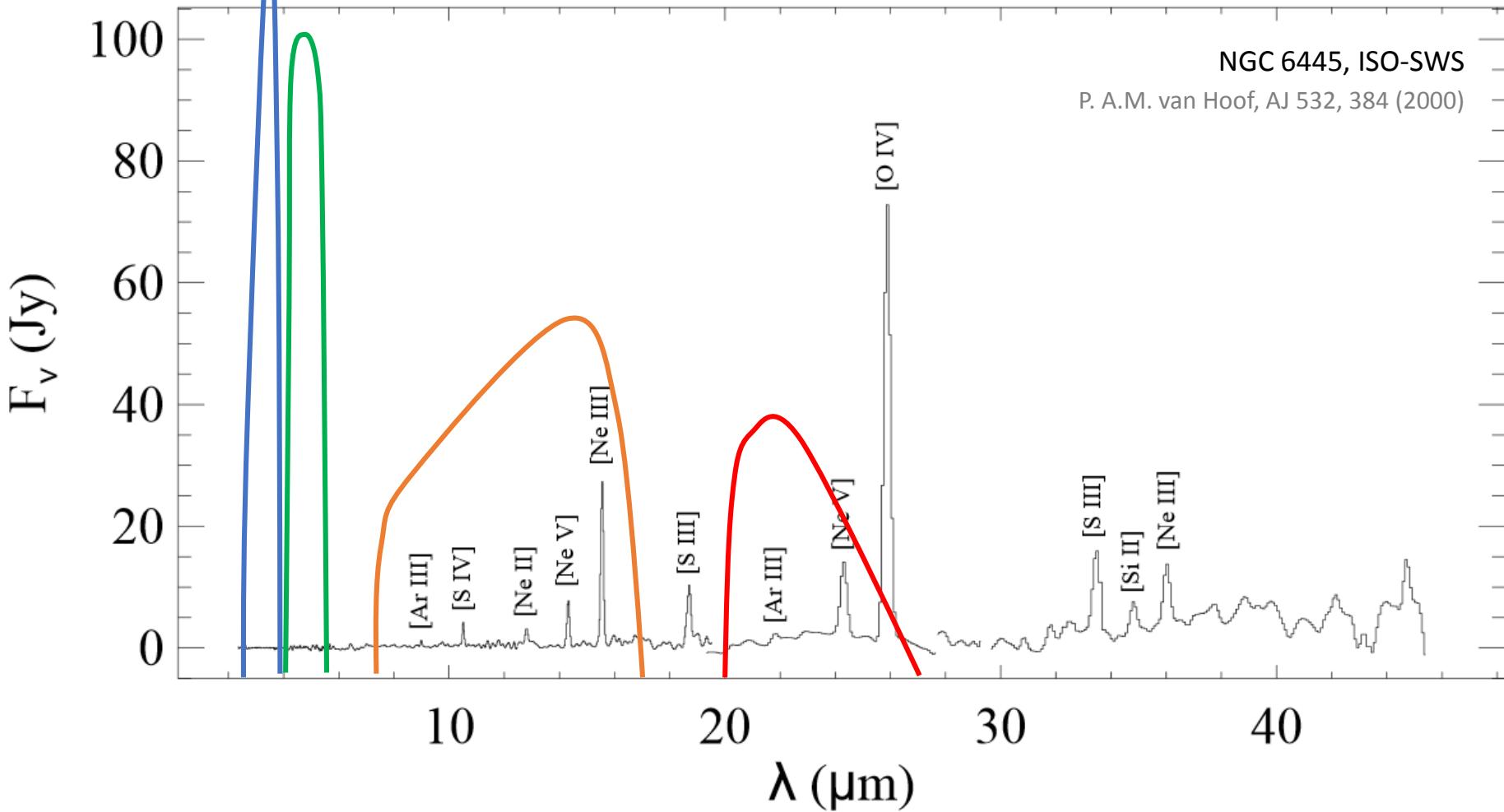


FIG. 2.—*ISO-SWS spectrum of the planetary nebula NGC 6445*

2. WISE and planetary nebulae

Where does the emission observed with WISE originate from?

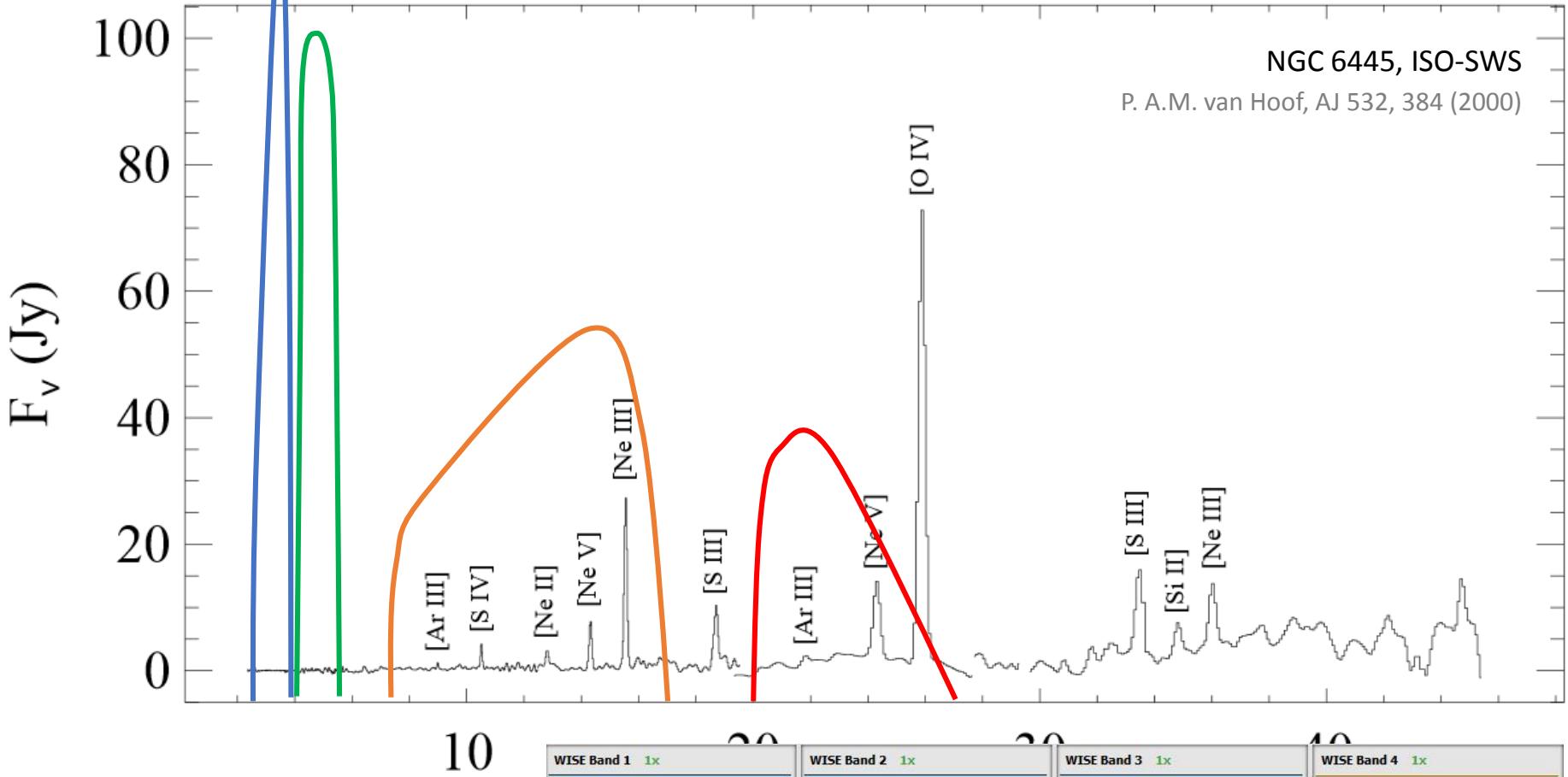
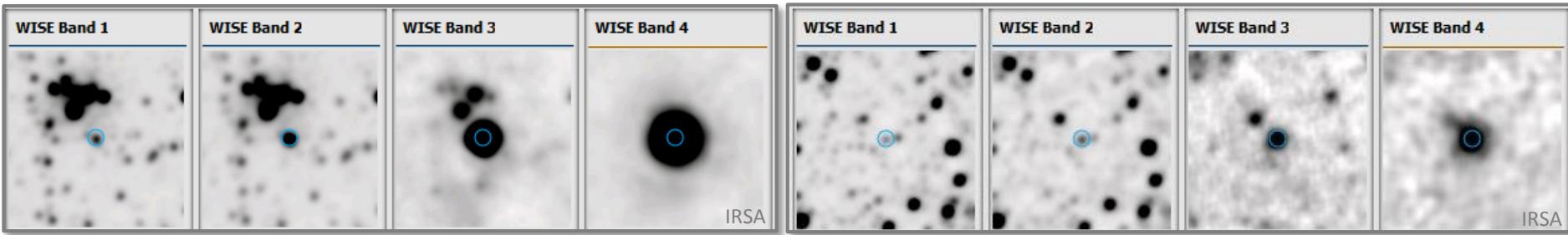
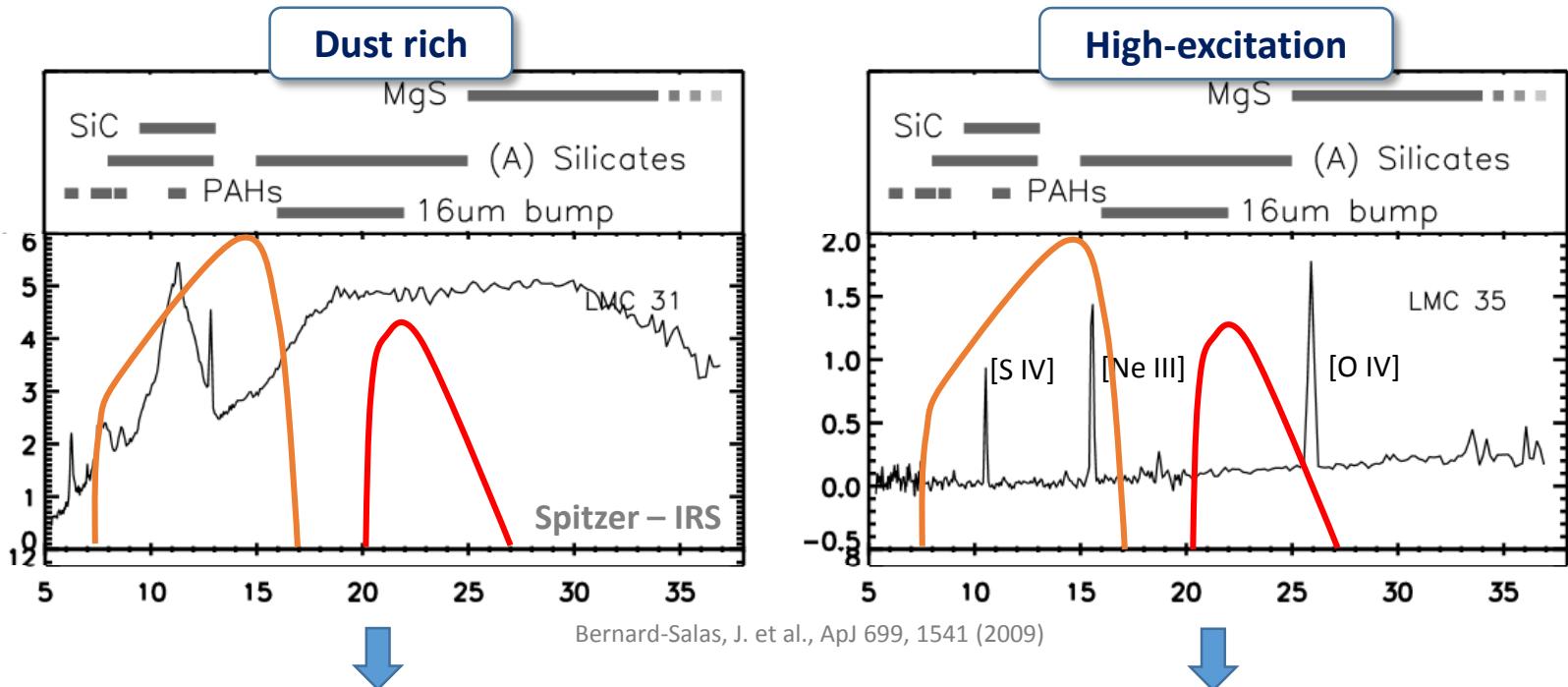


FIG. 2.—ISO-SWS s1

2. WISE and planetary nebulae



- **W1+2:** some line emission + CSPN, little continuum
 - **W3:** PAH + continuum, high-excitation lines
 - **W4:** Continuum + some [O IV]
-
- PNe considerably brighter in W3 & W4 than in W1 & W2
 - Dust-rich PNe usually brighter than high-excitation PNe

3. DSH PNe: WISE properties

The WISE properties of medium-to-high Galactic latitude PNe were studied by a subsample of the DSH PN catalogue:

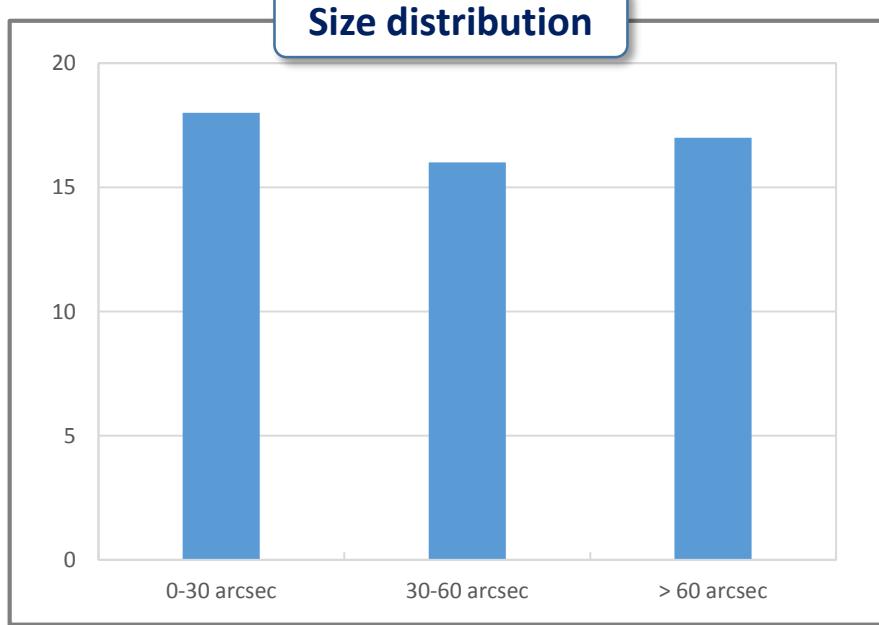
Sample constraints

- True and Likely PNe
- Location: outside of $|b| = 5^\circ$
- Discovery method: visual surveying of DSS and SDSS images
→ „quasi-homogeneous sample“

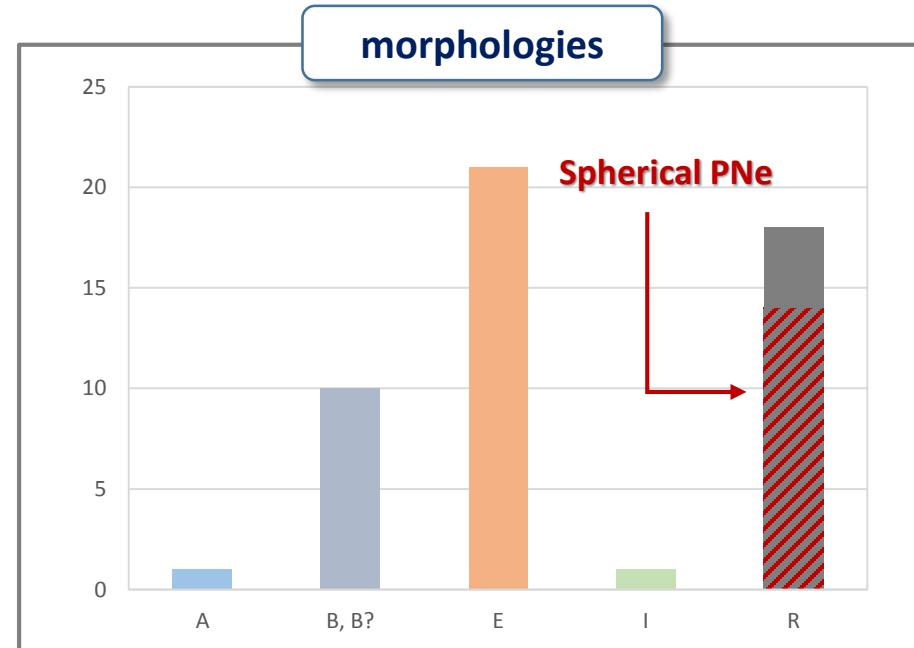
Sample properties

- Total number: 52 Objects
- All main morphological classes (A,B,E,I,R) represented
- Sizes: almost stellar to several arcminutes
- $\approx 25\%$ spherical, uniform shells

Size distribution



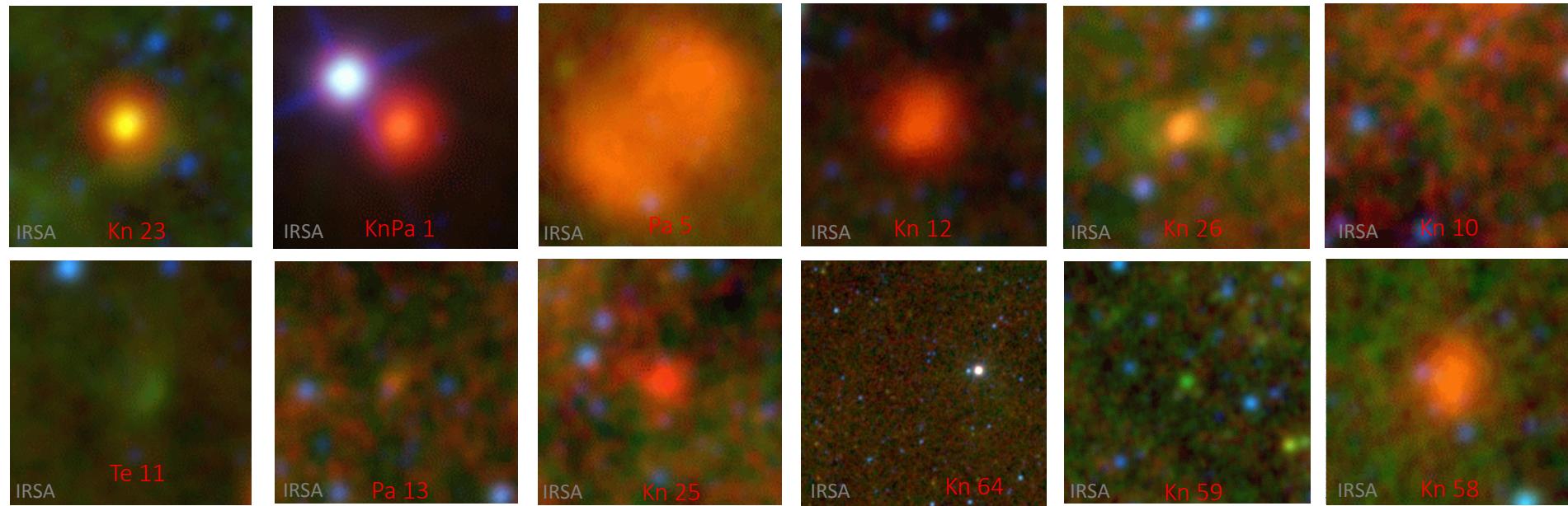
morphologies



Morphological classification in accordance with MASH catalogue (Q.A. Parker et al., MNRAS 373, 79 (2006))

3. DSH PNe: WISE properties

Asymmetric PNe (A,B,I)



R = W4

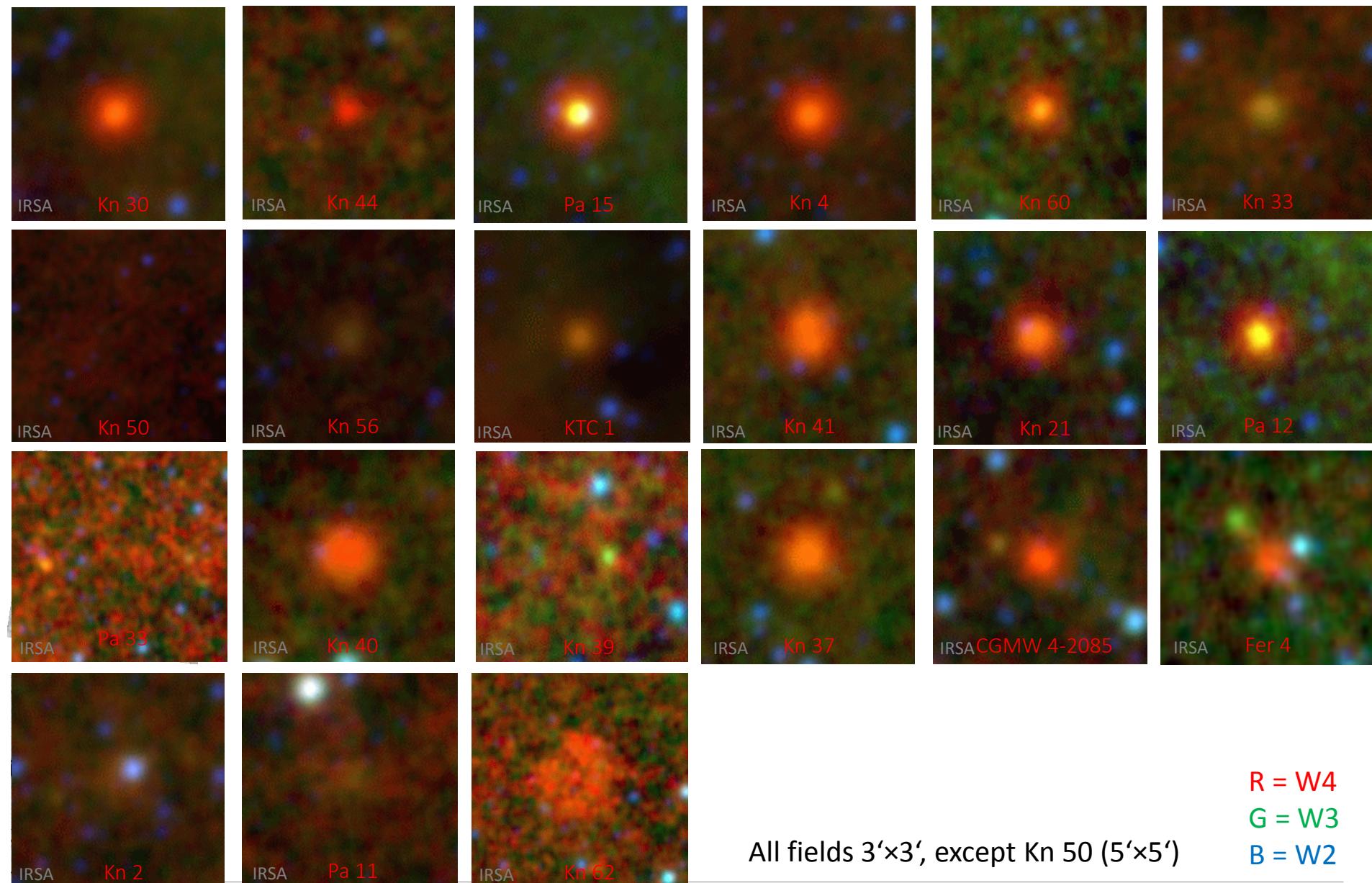
G = W3

All fields 3'×3', except Kn 64 (20'×20')

B = W2

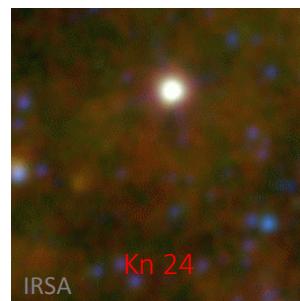
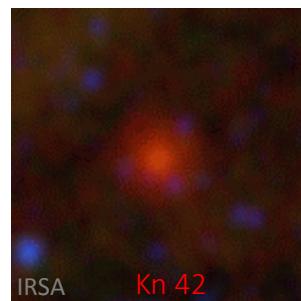
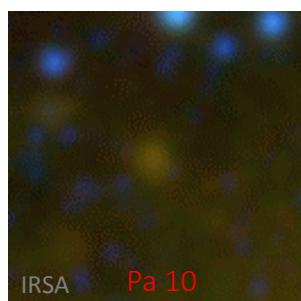
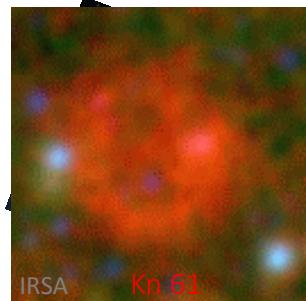
3. DSH PNe: WISE properties

Elliptical PNe



3. DSH PNe: WISE properties

Round, non-spherical PNe



R = W4

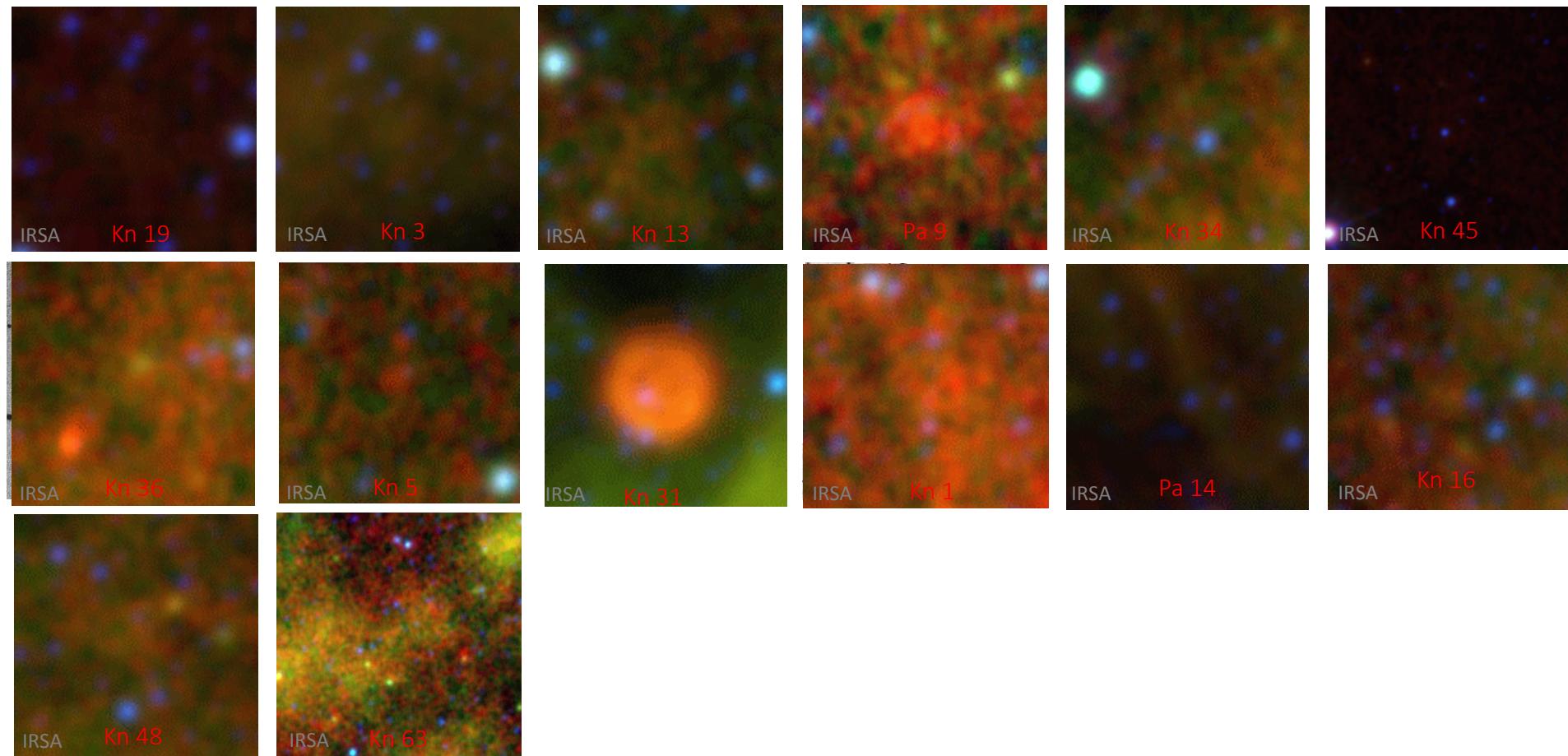
G = W3

B = W2

All fields 3'×3', except Kn 24 (5'×5')

3. DSH PNe: WISE properties

Spherical PNe



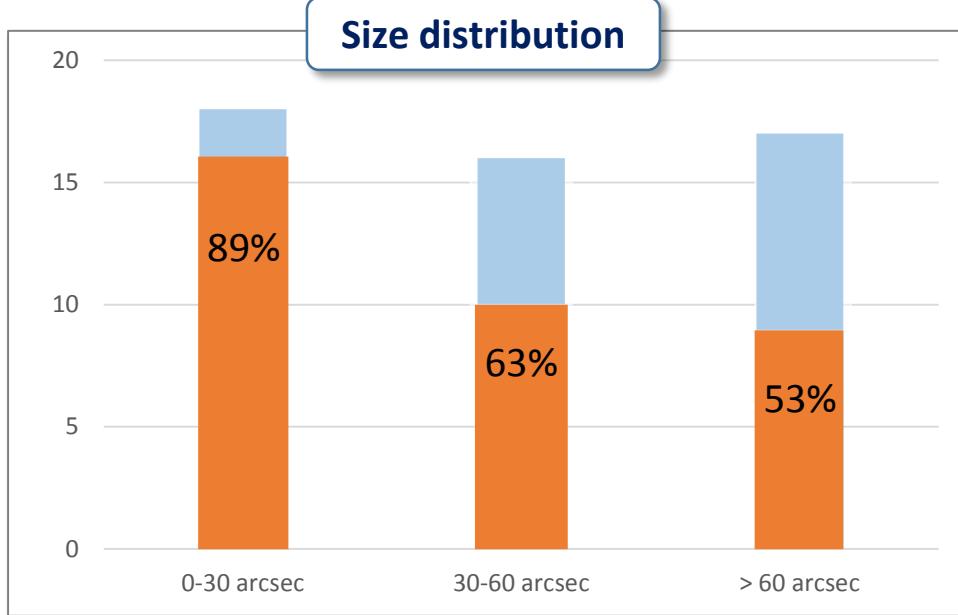
R = W4

G = W3

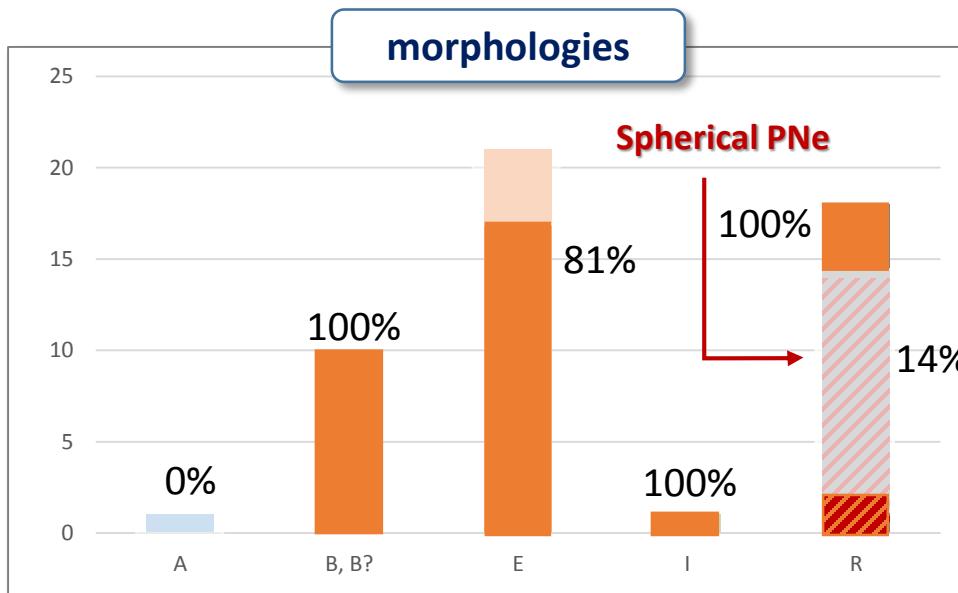
B = W2

All fields 3'×3', except Kn 45 and Kn 63 (10'×10')

3. DSH PNe: WISE properties – summary of results



- Objects $< 30''$ almost entirely visible in WISE
- Larger objects less likely to show up



- Most asymmetric, elliptical and non-spherical round PNe are detected in WISE imagery
- Most spherical PNe are invisible on WISE imagery

3. DSH PNe: WISE properties – comparison with MASH PNe

Comparison of DSH data with statistics for MASH PNe outside of $|b| = 5^\circ$

Size dependence

Size	# total	% of WISE detections	DSH sample
0-30 arcsec	133	90 %	89 %
30-60 arcsec	40	60 %	63 %
> 60 arcsec	42	38 %	53 %

Dependence on morphology

Type	# total	% of WISE detections	DSH sample
A	7	43 %	(0 %)
B	14	64 %	100 %
E	106	81 %	81 %
I	2	100 %	(100 %)
R, non-Sph	39	95 %	100 %
R, Sph	36	39 %	14 %
S	11	91 %	-

Brackets: only one object in sample

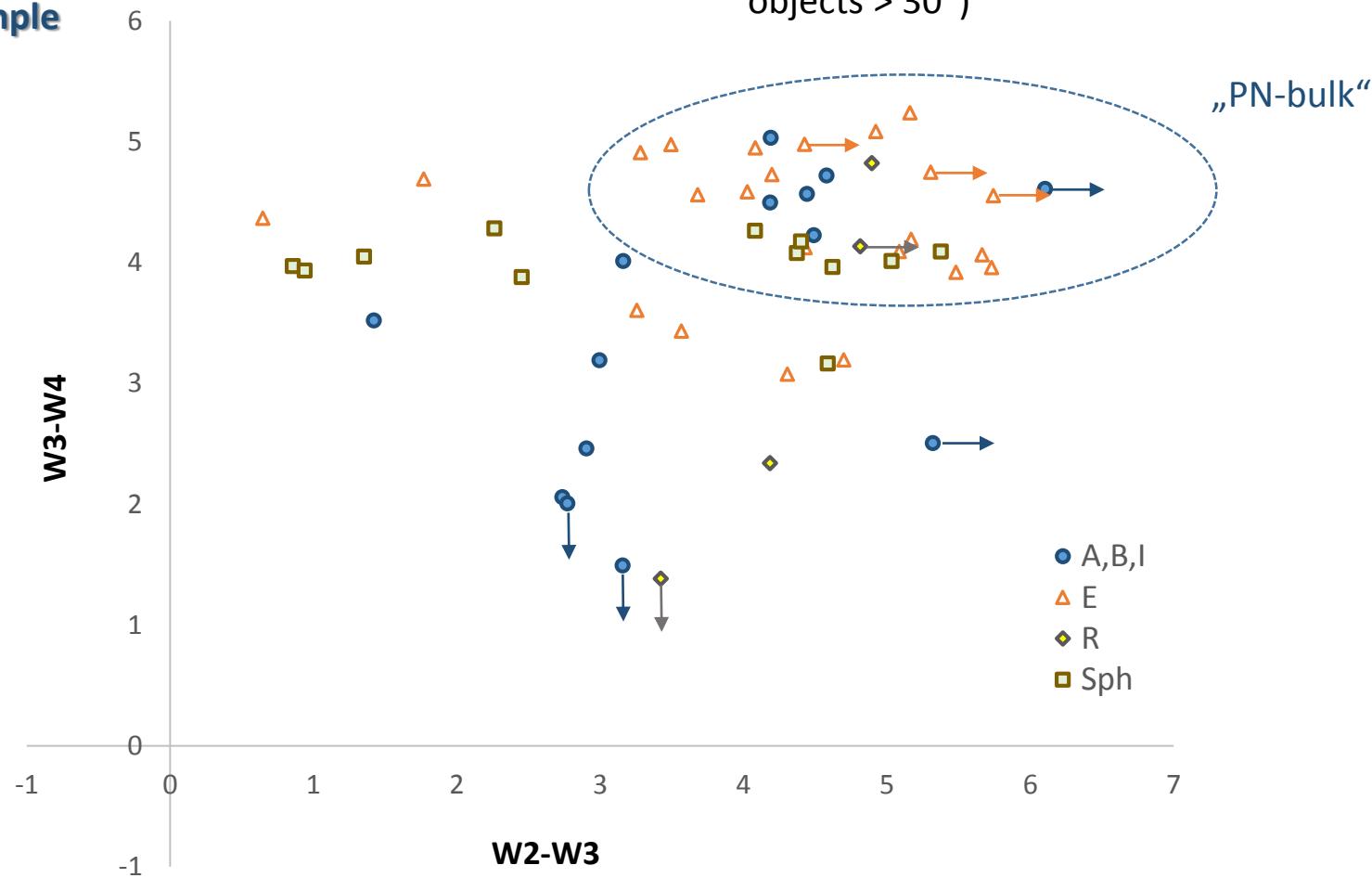
- Very similar size dependence between MASH and DSH sample
- Very good agreement for elliptical and non-spherical round PNe
- Spherical PNe significantly less likely to be detected in WISE imagery

DSH PNe: WISE properties – comparison with MASH PNe

[W2-W3,W3-W4] colour-colour diagram:

- Only objects with clear detections in W3 or W4
- Multiple detections possible (especially for objects $> 30''$)

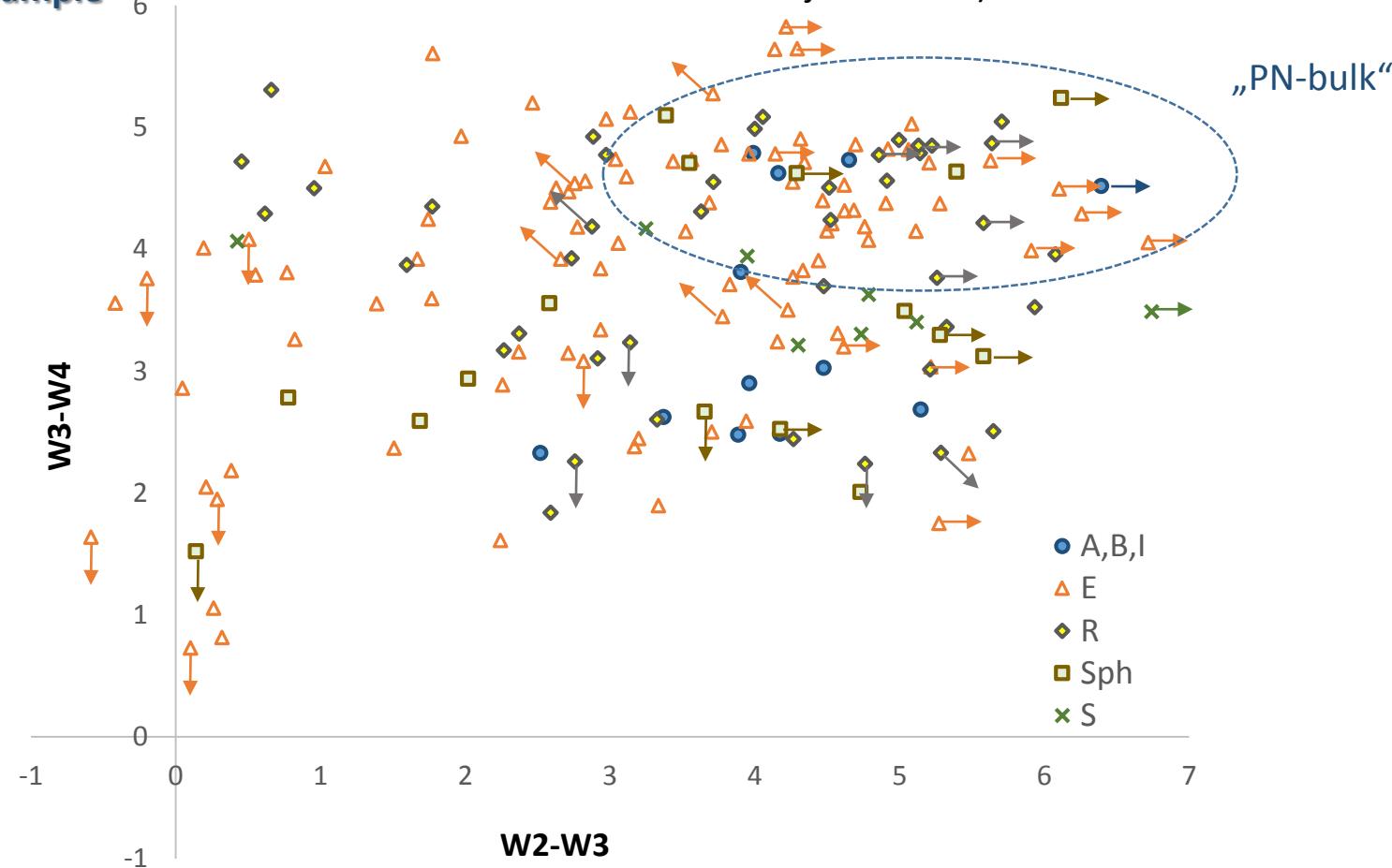
DSH sample



DSH PNe: WISE properties – comparison with MASH PNe

[W2-W3,W3-W4] colour-colour diagram:

MASH sample



- Only objects with clear detections in W3 or W4
- Multiple detections possible (especially for objects $> 30''$)

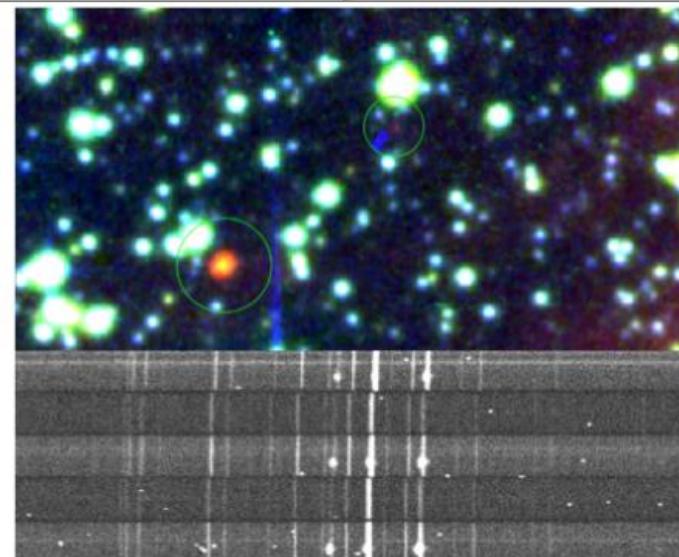
→ No fundamental (photometric) differences between different PN types, but large scatter in the data!

4. WISE as a tool for discovering new PNe

4. PN discoveries and characteristics at non-optical wavelengths

Jacoby & Van de Steene (2004) undertook an on/off-band bulge survey at [SIII] 9532Å, discovering 94 candidate PN. Also large numbers of PN candidates have been selected via their IRAS colours but confirmatory success rates have been low (e.g. Suarez *et al.* 2006, Ramos-Larios *et al.* 2009) so this is an inefficient technique. Mid-IR space-telescope images from Spitzer and WISE now allow detection of very reddened PN which may be invisible optically (eg. Cohen *et al.* 2005, Kwok *et al.* 2008; Phillips & Ramos-Larios 2008). Furthermore, Carey *et al.* (2009) and Mizuno *et al.* (2010) have noted 416 compact (<1 arcmin) ring, shell and disk-shaped sources in the Galactic plane in 24μm Spitzer MIPS/GAL images. Our belief is that many of these will turn out to be strongly reddened, high-excitation PN with only a minority being circumstellar nebulae around massive stars (Wachter *et al.* 2010). Note that PN can be quite strong mid-IR emitting objects because of PAH emission, fine structure lines, H₂ lines (UWISH2 survey, Froebrich *et al.* 2011) and thermal dust emission within the nebulae and in circumnuclear disks.

Parker , Q. A. et al., IAUS 283, 9 (2012):

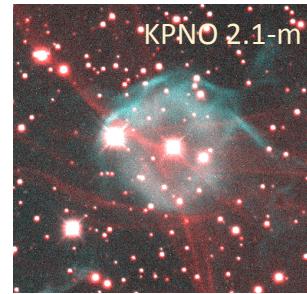
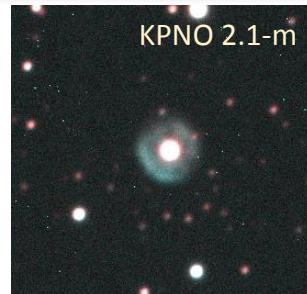


→ Mid-IR data can be a powerful tool
to discover new PNe!

Figure 2. Upper panel: RGB colour montage from SuperCOSMOS H α , broad-band red and B $_j$ image of 2×1 arcmin region covering two newly discovered Galactic PN (circled) selected purely on the basis of their GLIMPSE colours. Lower panel: 3×1 arcsecond spectral slices from WiFeS red arm data centred on the brighter newly discovered PN interleaved with sky regions with the nod & shuffle technique. Wavelength increases from left to right. Note the [NII]>H α ratio from the PN emission lines clearly visible as compact knots in three consecutive image slices.

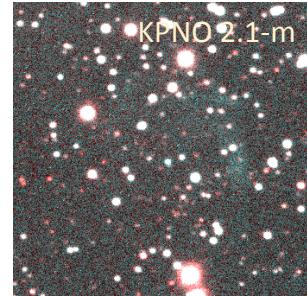
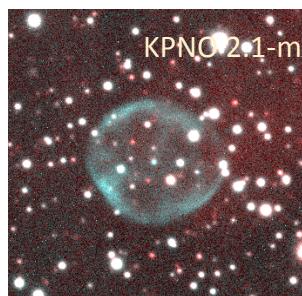
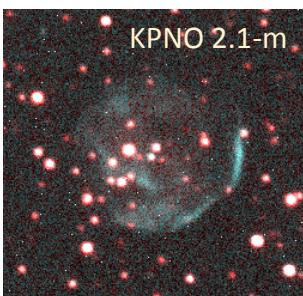
4. WISE as a tool for discovering new PNe

- WISE survey for new PN candidates started outside of the MASH and IPHAS survey areas
- Project mostly followed up by D. Patchick
- Strategy: Combining WISE with DSS imagery to look for poss. CSPN + nebulosity

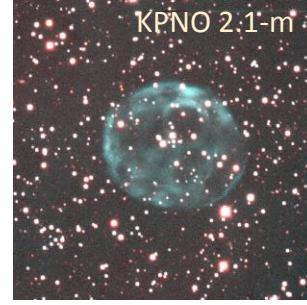
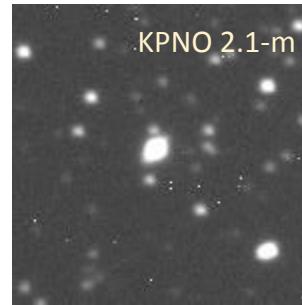
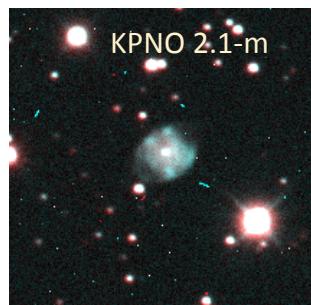
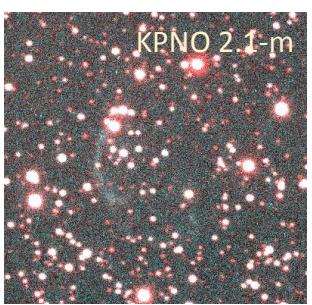
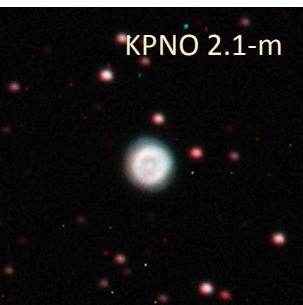
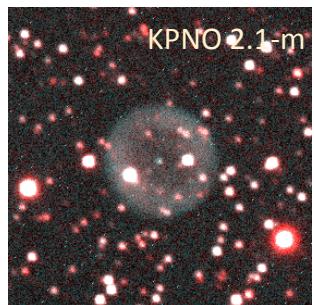


Preliminary results

- ≈ 25 new possible and likely PNe detected
- Sizes: almost stellar objects to several arcmin
- Many rings and asymmetric PNe, spherical objects clearly underrepresented

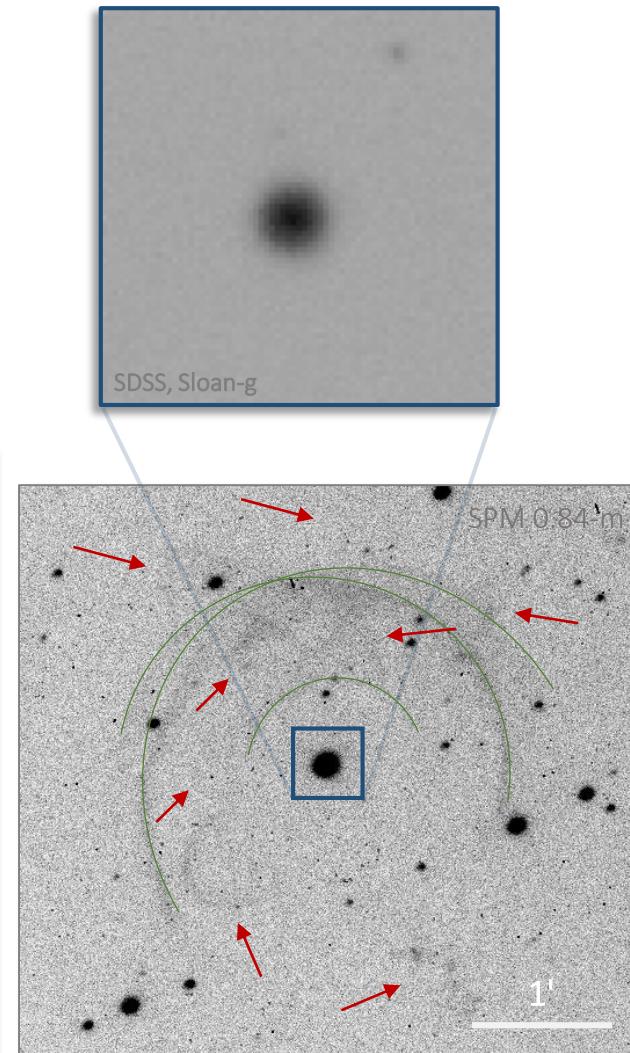
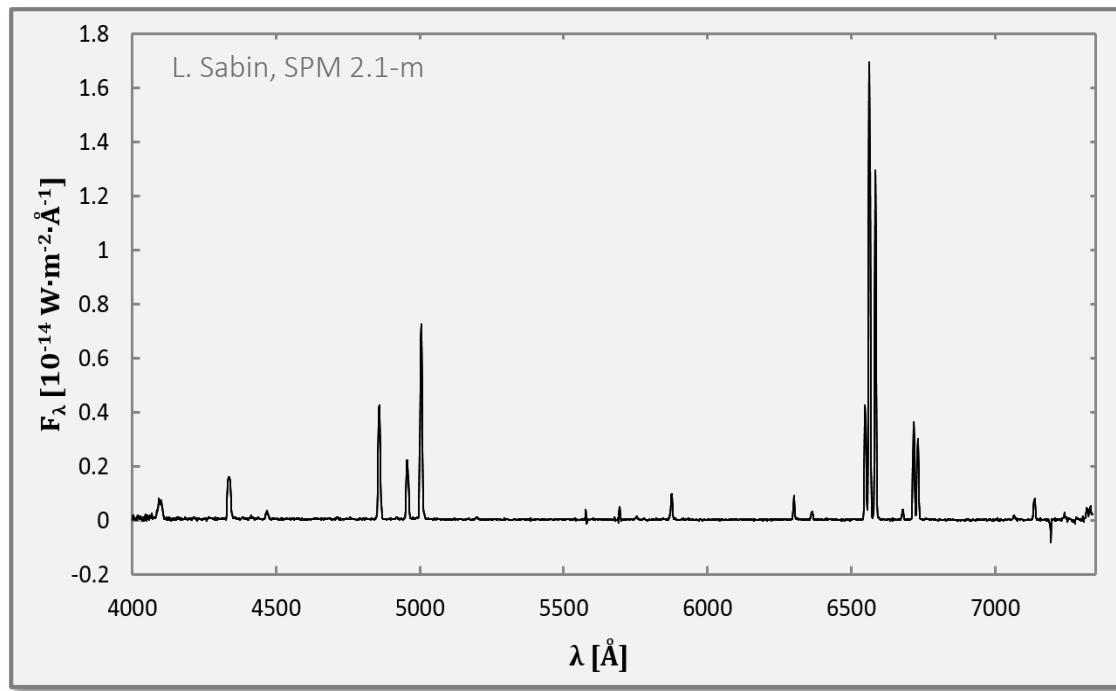


See also poster B03!



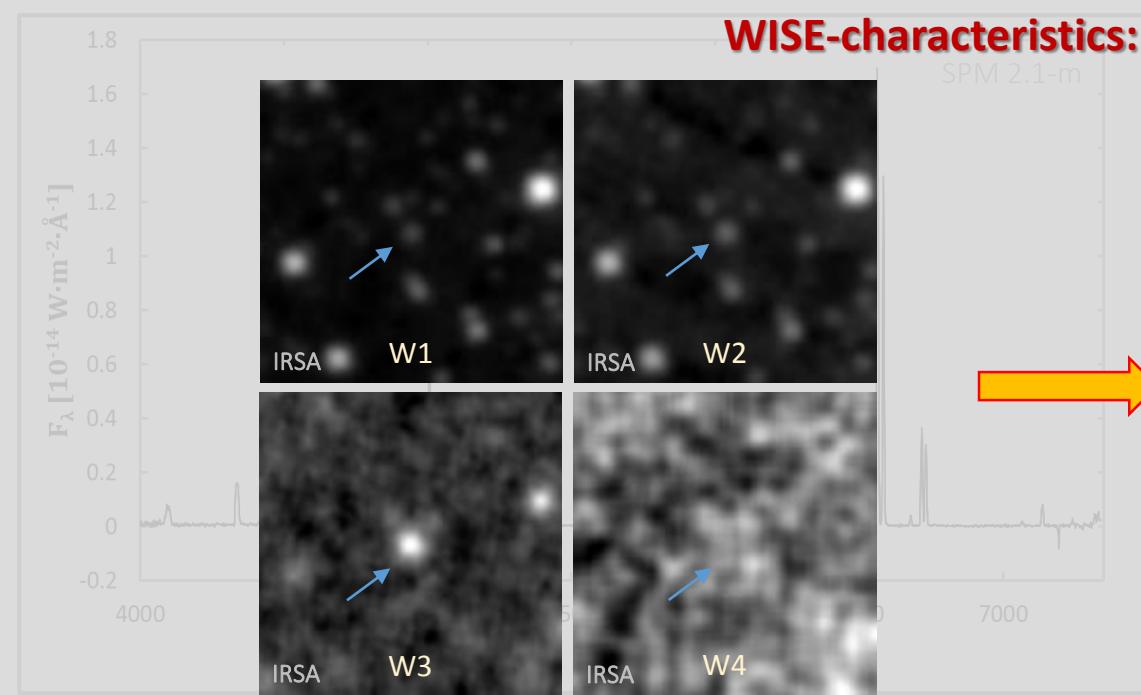
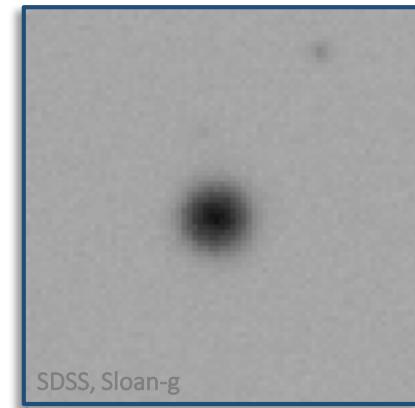
Kn 59

- High-Galactic latitude object ($b = +25.45^\circ$)
- PN-like, Medium-excitation spectrum
- **Morphology:**
 - small, bright core $4'' \times 4''$
 - halo $228'' \times 174''$ with multipolar characteristics



Kn 59

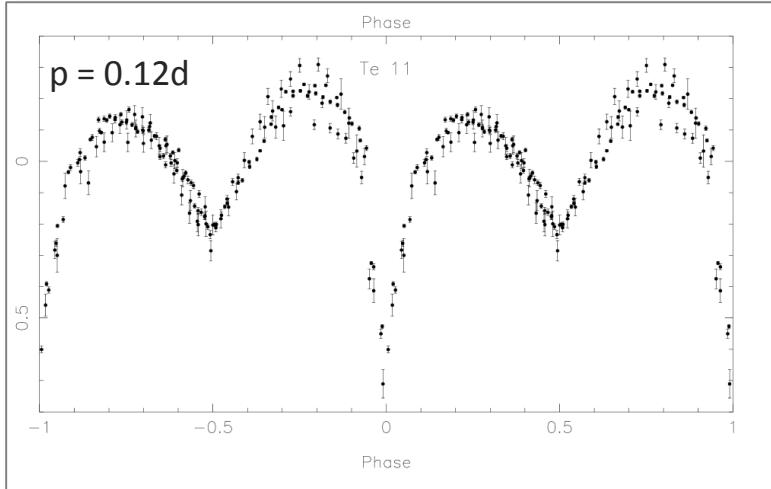
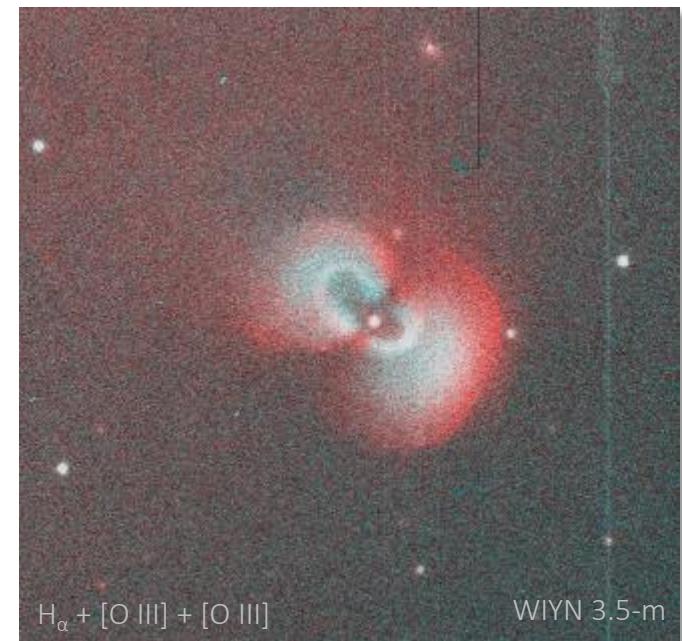
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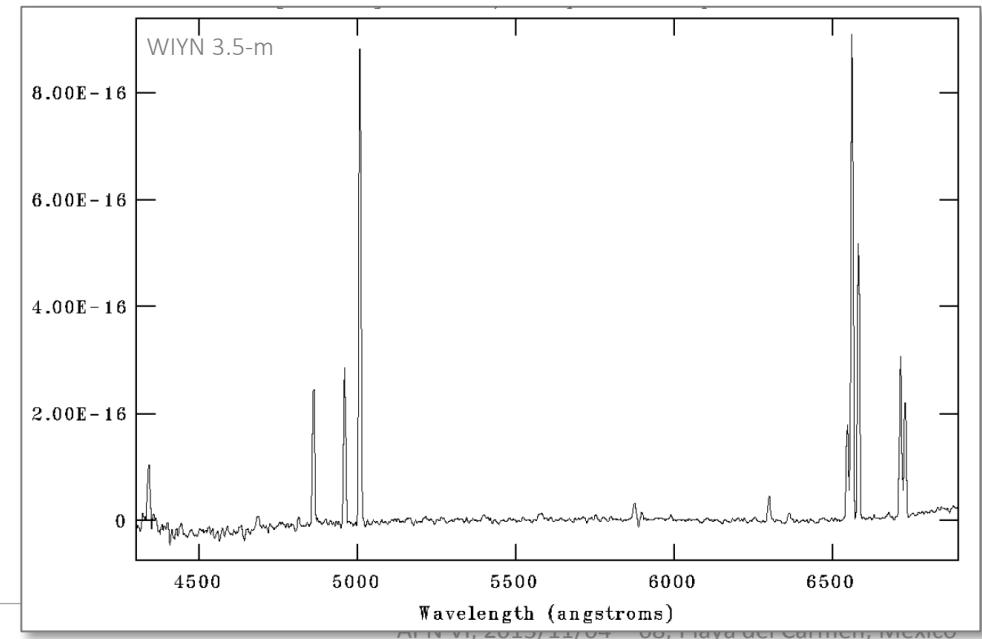
5. Special cases

Te 11

- PN spectrum but very peculiar morphology
- Strong ISM interaction, poss with Barnards' Loop
- CS: fairly red, eclipsing binary
- PN or symbiotic star?



B. Miszalski et al., APN V, 328 (2011)



M. Kronberger et al., WISE properties of PNe from the DSH catalogue

5. Special cases

Te 11

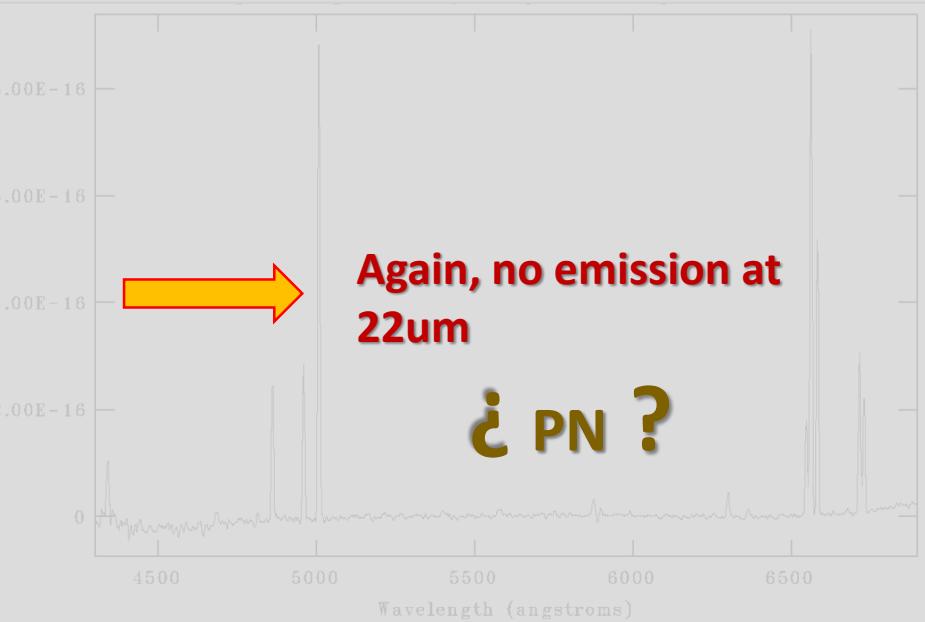
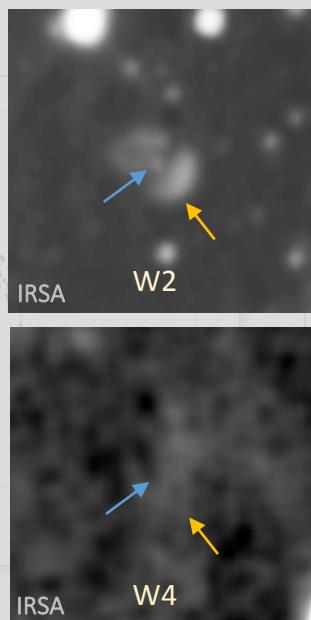
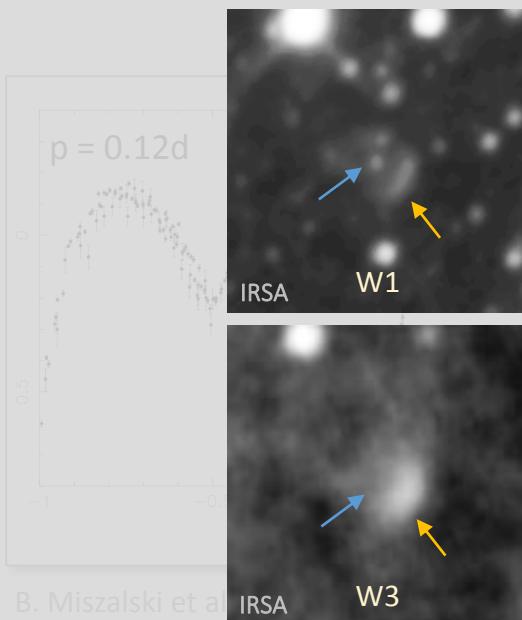
- PN spectrum but very peculiar morphology
- Strong ISM interaction, poss with Barnards' Loop
- CS: fairly red, eclipsing binary
- PN or symbiotic star?



WISE-characteristics:

$H_{\alpha} + [\text{O III}] + [\text{O III}]$

WIYN 3.5-m



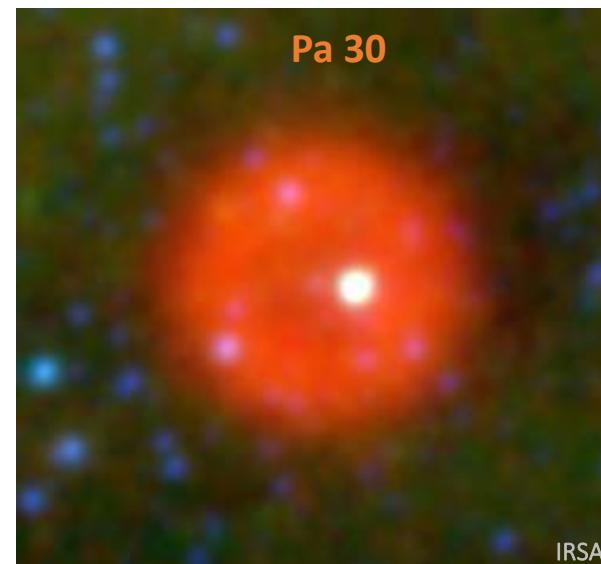
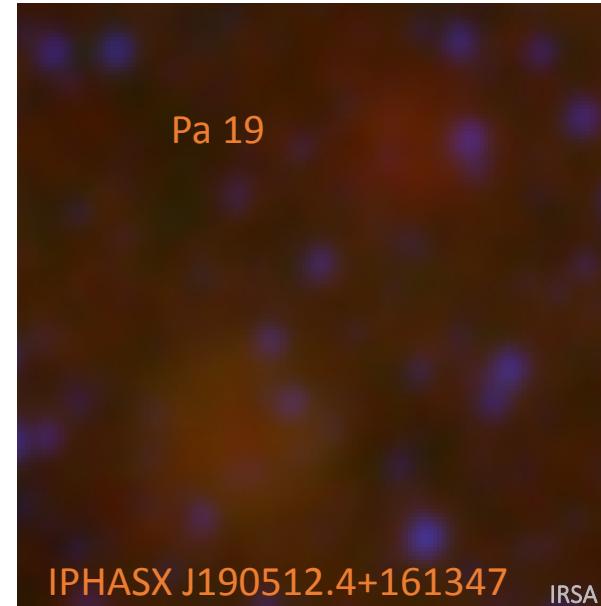
Pa 19 & Pa 30

- Located within IPHAS survey area
- characteristics:
 - W4-bright
 - blue CS (DSS):
 - **Pa 19:** B \sim 17.2, B-R \approx -0.2
 - **Pa 30:** B \sim 15.5, B-R \approx -0.3
 - **→ Low reddening**
- **No nebulosity on IPHAS imagery**

KPNO 2.1-m H _{α} + [O III] images taken June - October 2013

→ faint shells dominated by [O III] emission

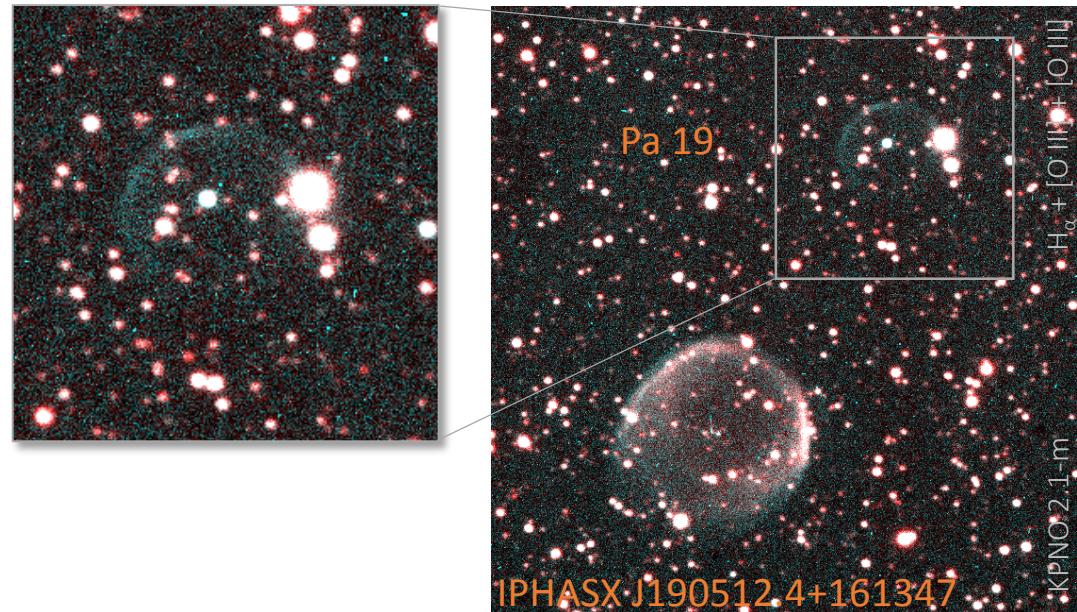
⌚ PNe ?



5. Special cases

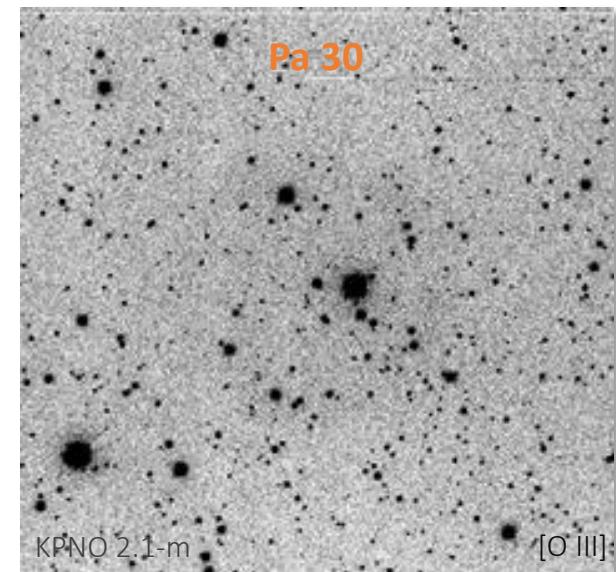
Pa 19 & Pa 30

- Located within IPHAS survey area
- characteristics:
 - W4-bright
 - blue CS (DSS):
 - **Pa 19:** B \sim 17.2, B-R \approx -0.2
 - **Pa 30:** B \sim 15.5, B-R \approx -0.3
 - Low reddening
- **No nebulosity on IPHAS imagery**



KPNO 2.1-m H_{α} + [O III] images taken June - October 2013

→ faint shells dominated by [O III] emission



⌚ PNe ?

6. Summary and conclusions

- The WISE properties of a subsample of the DSH True and Probable PNe were studied.
- Results:
 - Larger PNe are less likely to have a WISE detection than smaller PNe
 - elliptical, non-spherical round, and asymmetric PNe: Similar detection probabilities and photometric properties
 - Spherical shells are significantly less often detected than all other PN types
- 25 new PN candidates detected in a directed survey of the Milky Way using WISE imagery, many of them without optical counterpart on DSS, IPHAS or MASH

→ **WISE is an excellent all-sky tool to detect new PNe and to reveal possible mimics**

→ **Not all PNe detectable with optical methods will show up also in WISE!**

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