MIRIS Pa α Observation

1. Observation data
2. Status of data reduction
3. Scientific analysis : Comparison with IPHAS H α data in Cepheus (Q2)

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Instrument Specification

◆ MIRIS (Multi-purpose IR Imaging System)

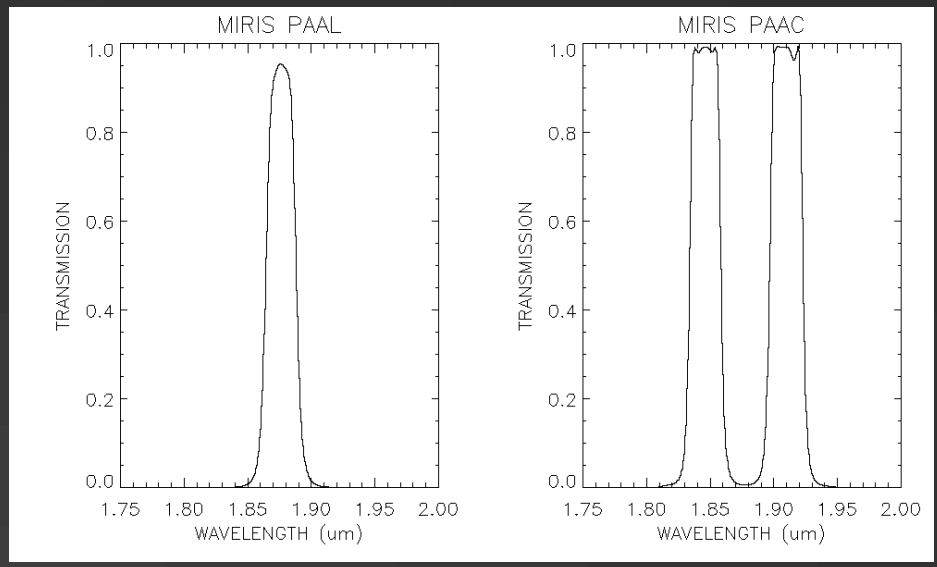
+ The primary payload of the Korean science and technology satellite 3, launched on 2013.

+ Specifications

- Pixel scale : 51.6" × 51.6"
- Field of view : 3.67° × 3.67°
- Filters : I (1.05 μm), H (1.6 μm),

  Pa α line (1.875 μm),

  Pa α dual continuum (1.84 & 1.91 μm)



+ Main Goals

- Pa α emission line survey of the whole Galactic plane.
- Cosmic Infrared Background (CIB) observation in NEP & SEP.

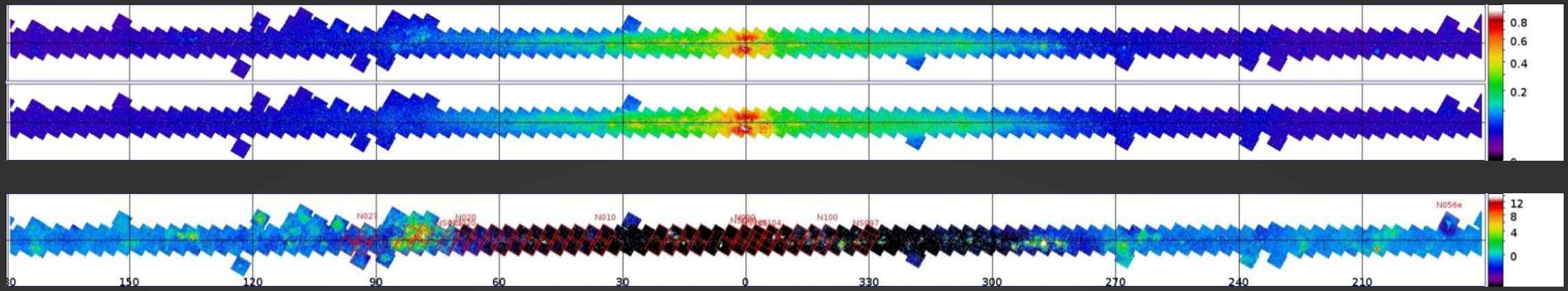
1. Observation data

1.1 Observation Data

◆ MIRIS Pa α Galactic Plane Survey (MIPAPS)

+ Cover the whole plane (360°) with the width of −3° < b < +3° .

+ Total 235 fields with the average exposure of ~20 minutes (per filter).



Top : Pa α line filter (PAAL) image (mJy/arcsec^2)

Middle : Pa α dual continuum filter (PAAC) image (mJy/arcsec^2)

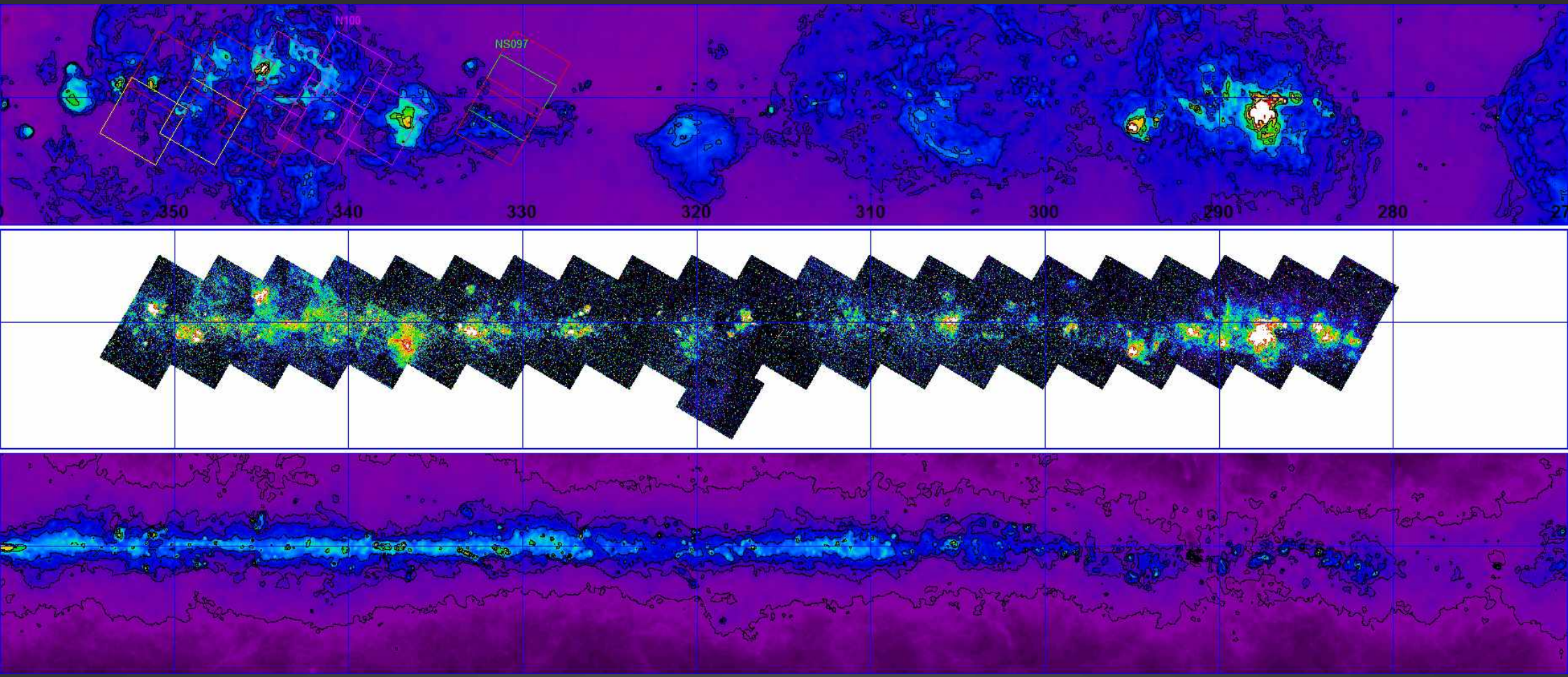
Bottom : Pa α emission line (PAAL−PAAC) image (10^{-19} W/m^2/arcsec^2) (preliminary)

+ The 1st data release on June, 2017. (http://miris.kasi.re.kr/miris/)

+ Need correction of edge-shadowing (by filter-wheel position offset) for b02 orbit data.

1.1 Observation Data

- l = +280° to +350°



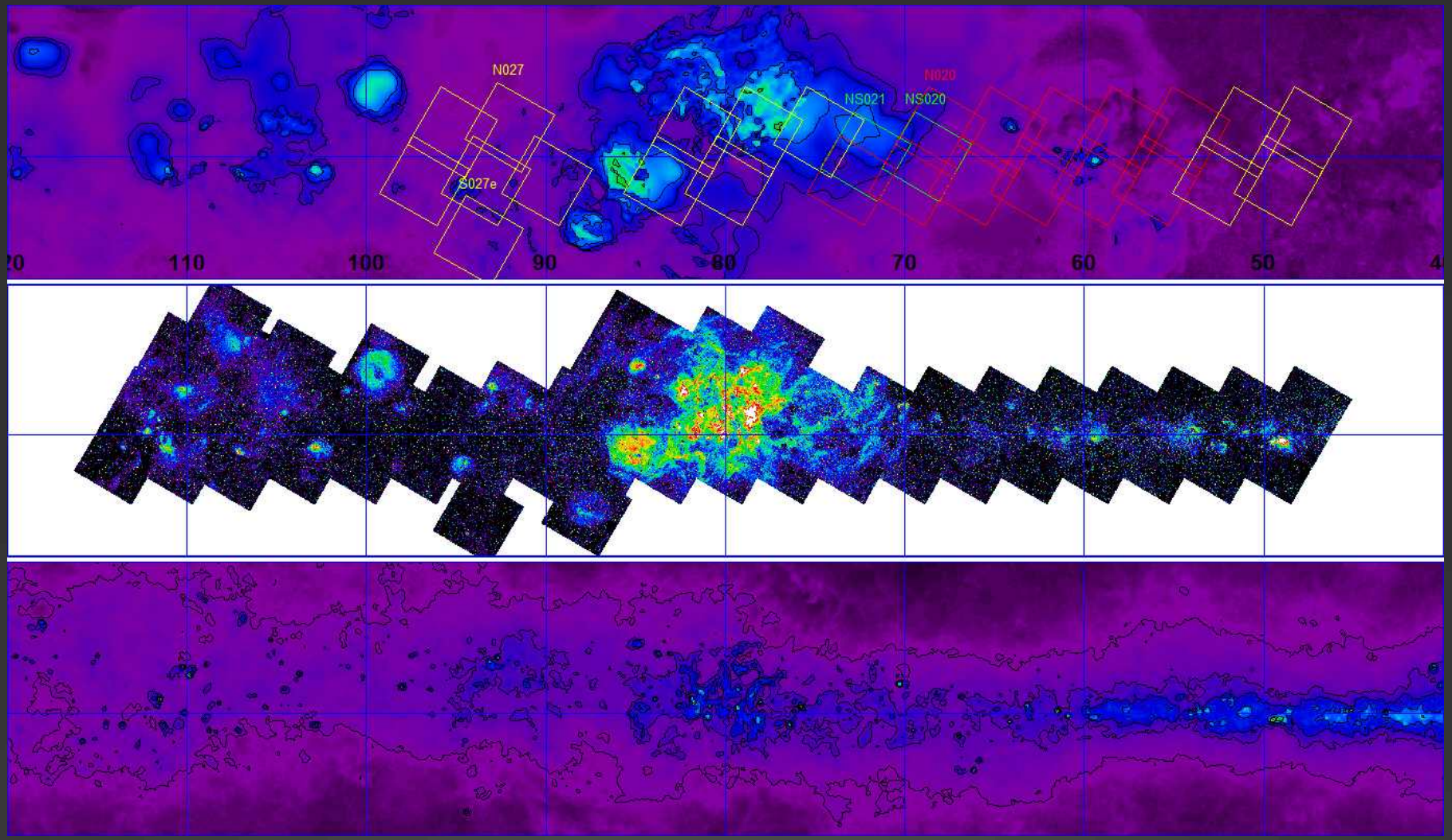
Top : H α image (Finkbeiner, 2003)

Middle : MIRIS Pa α image

Bottom : SFD E(B-V) dust image (Schlegel+ 1998)

1.1 Observation Data

- l = +050° to +110°



Top : H α image (Finkbeiner, 2003)

Middle : MIRIS Pa α image

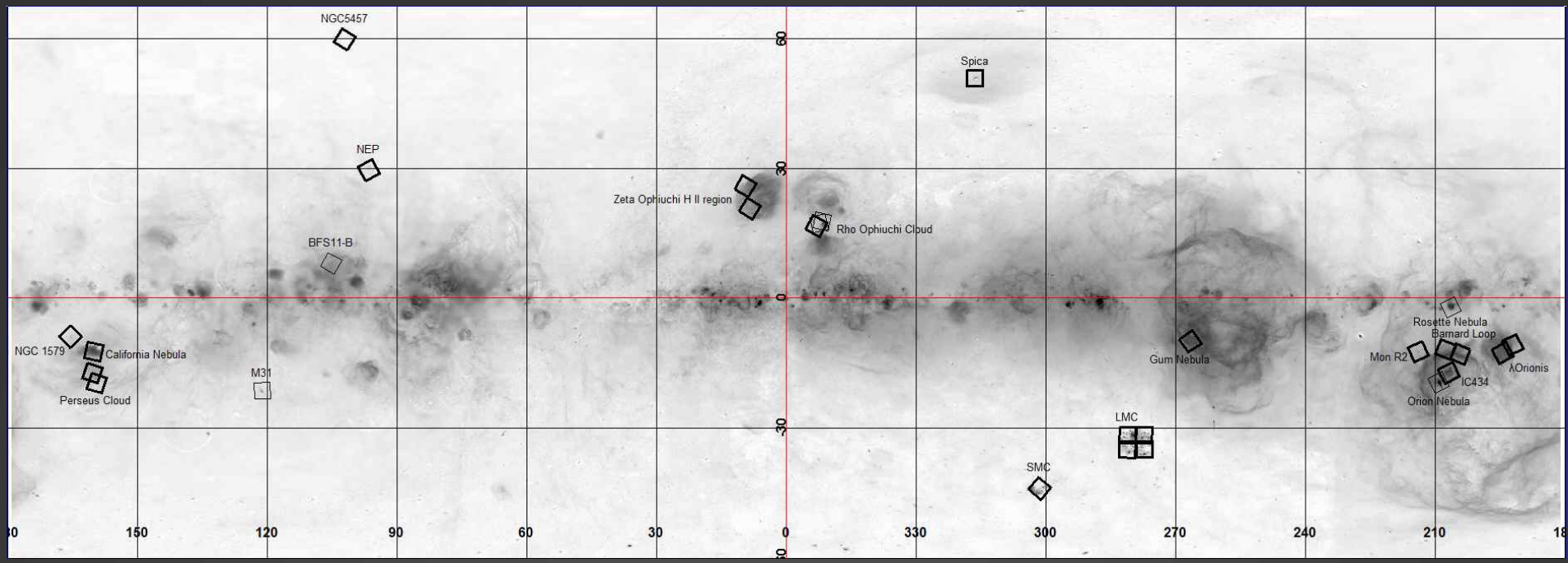
Bottom : SFD E(B-V) dust image (Schlegel+ 1998)

1.2 Observation Data

◆ Pointing observations

+ Cover 19 targets (total 26 fields) located away from the Galactic plane.

- Nearby H II regions : M42, Rosette nebula, Lambda Orionis, California nebula, IC434, Barnard Loop, Gum nebula, Spica nebula, Zeta Ophiuchus.
- Star-forming clouds : Rho Ophiuchus, BFS11-B, Perseus cloud, NGC1579, Mon R2 cloud.
- Nearby galaxies : M31, SMC, LMC, NGC5457.
- North eclipse pole (NEP).



Positions of Pa α pointing observations on H α all sky map

2. Status of data reduction

2.0 Status of data reduction

Green : completed
Orange : ongoing

◆ Flux calibration

+ Point sources, Extended sources, Check PAAL/PAAC PSF radial profile.
+ Check detector-counting variation.

◆ Edge-shadowing by filter-wheel position offset

+ Check the status of affected data.
+ Crop or correct for b02 orbit data by stray light simulations.

◆ Background increment & contamination features by stray light

+ Check the degree of background increment by Moon.
+ Check and correct on individual data analysis.

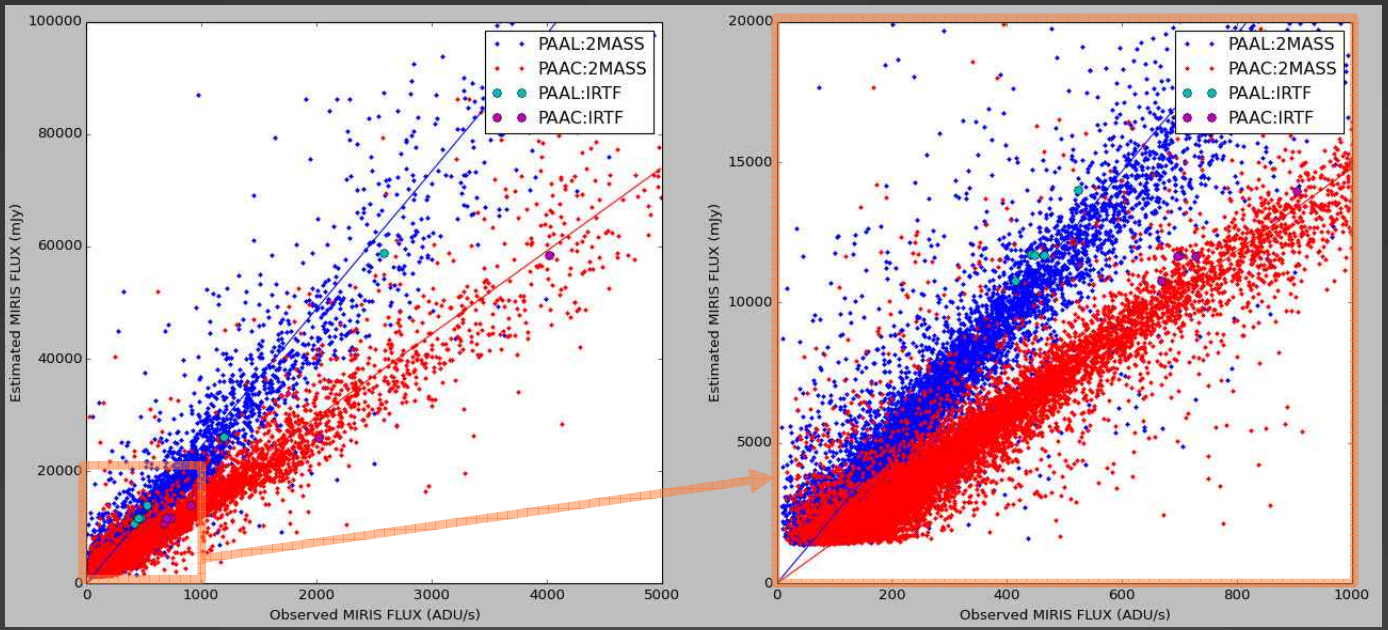
◆ Stellar continuum subtraction

+ PSF estimation (by StarFinder) and PSF matching (by Photutils).
+ Mask and fill by using point source catalog.
+ Find more effective method.
+ For the whole plane image.

2.1 Status of data reduction

◆ Flux calibration

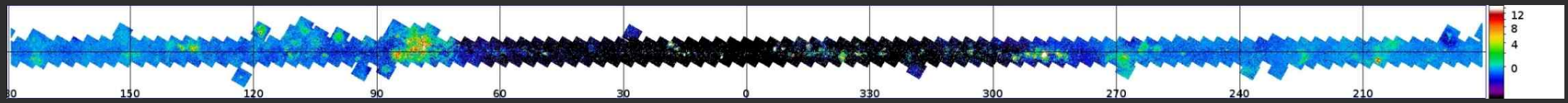
+ MIRIS sources : extraction and aperture photometry (ADU/sec) by SExtractor.
+ 2MASS sources : H<7 & K<7 from 2MASS point source catalog.
  → Matching sources : 16676 (PAAL), 15344 (PAAC) from the whole Galactic plane.
+ Estimate mJy flux at MIRIS PAAL/PAAC from 2MASS H & K magnitude (interpolation).
+ Obtain calibration factor from ADU/sec to mJy by linear fitting.
  → PAAL : 24.5, PAAC : 14.8.



Observed flux (ADU/sec) vs. Estimated flux (mJy)

2.1 Status of data reduction

◆ Flux calibration



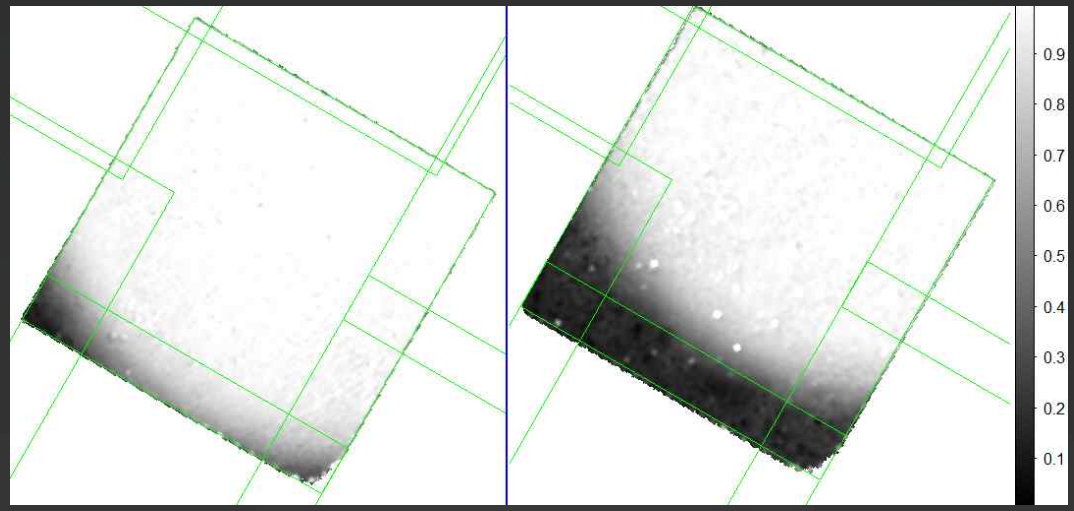
Pa α emission line (PAAL-PAAC) image (10^{-19} W/m^2/arcsec^2) (preliminary)

+ Effects by detector-counting variation or unknown factors.
  - Why is PAAC background much larger than PAAL background around GC?
  - Why is MIRIS ADUs more under-estimated for brighter pixels, PAAC?

+ Need to work
  - Find the cause and correct.

2.2 Status of data reduction

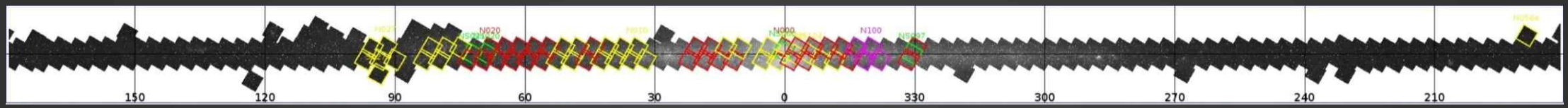
◆ Edge-shadowing by filter-wheel position offset



+ Check the status of affected data.

- MIPAPS : total 602 orbit data (~30%) were affected.

  >50% dimmed (143 orbits), 20-50% dimmed (203 orbits), <20% dimmed (256 orbits).



- Pointing observations : total 3 target data were affected.

  <45% dimmed (Rho Ophiuchus), <20% dimmed (LMC, Zeta Ophiuchus)

+ Need to work

- Crop or correct for 602 orbit data by stray light simulations.

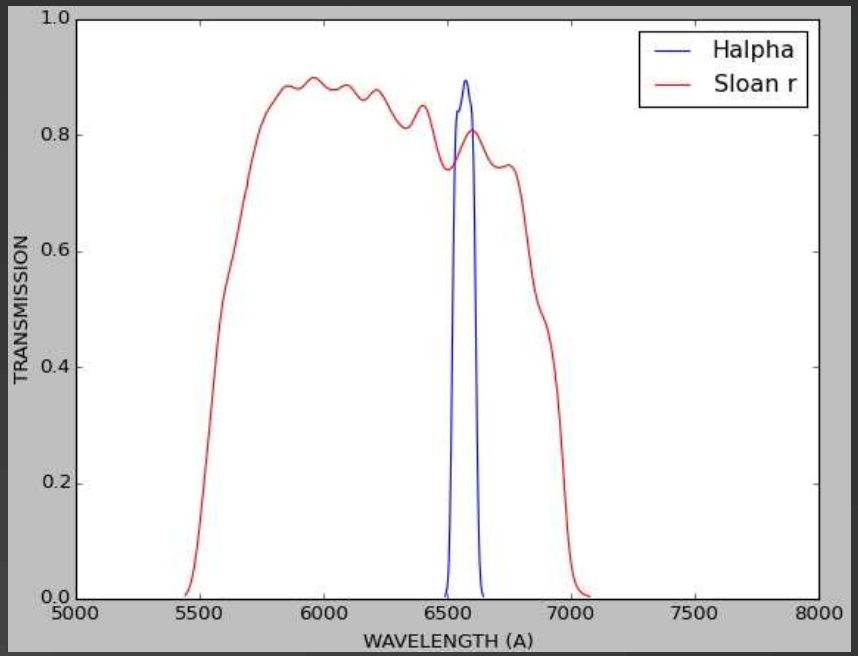
3. Scientific analysis : Comparison with IPHAS $H\alpha$ data in Cepheus (Q2)

3.1 Data : IPHAS Hα

◆ Isaac Newton Telescope (INT) Photometric Hα Survey (IPHAS)

+ The 2nd data release : the first quality-controlled and globally calibrated data (Barentsen+ 2014).

Property	Value
Telescope	2.5-m INT
Instrument	Wide Field Camera (WFC)
Detectors	Four 2048 × 4100 pixel CCDs
Pixel scale	0.33 arcsec pixel^{-1}
Filters	r, i, Hα
Filter properties	See Table 2
Magnitude system	Vega
Exposure times	30 s (r), 10 s (i), 120 s (Hα)
Saturation limit	13 (r), 12 (i), 12.5 (Hα)
Detection limit (5σ, mean)	21.2 (r), 20.0 (i), 20.3 (Hα)
PSF FWHM (median)	1.1 arcsec (r), 1.0 arcsec (i), 1.1 arcsec (Hα)
Survey area	~1860 deg^2
Footprint boundaries	$-5° < b < +5°, 29° < \ell < 215°$
Observing period	2003 August–2012 November
Website	www.iphas.org



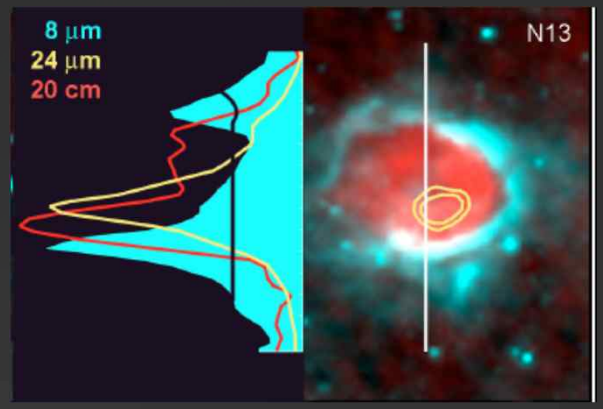
3.1 Data : WISE H II region catalog

◆ Previous observations of H II regions

+ Ionized Hydrogen gas : H α , radio recombination line (RRL), radio continuum.

+ PAHs and/or VSGs : ~10 μm MIR.

+ VSGs or BGs : ~20 μm MIR.



Deharveng+ 2010

◆ WISE catalog of Galactic H II regions (Anderson+ 2014)

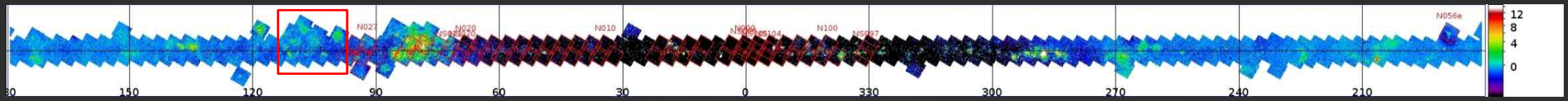
+ WISE has sufficient sensitivity (6 mJy at 22 μm) to detect the MIR emission from H II regions located anywhere in the Galactic disk.

+ The most complete catalog : total 8399 sources (WISE 12 μm + 22 μm)

- Known (1524) : hydrogen recombination line (H α or RRL) detected.
- Candidate (1986) : radio continuum detected, but no H α or RRL detected.
- Group (650) : overlapped with other Known sources.
- Radio quiet (4124) : no radio, H α or RRL detected (only 10μm & 20μm MIR detected).

3.1 Cepheus region

◆ Cepheus region (l = 96–116°)



+ Free from the filter-wheel offset and detector-counting variation effects.
+ No large background increment of Lunar/Earth stray light.
+ Moderately bright Pa α features.

◆ WISE H II region sources

+ 49 Known, 50 Candidate, 21 Group, 92 Radio quiet.

◆ MIPAPS Pa α sources

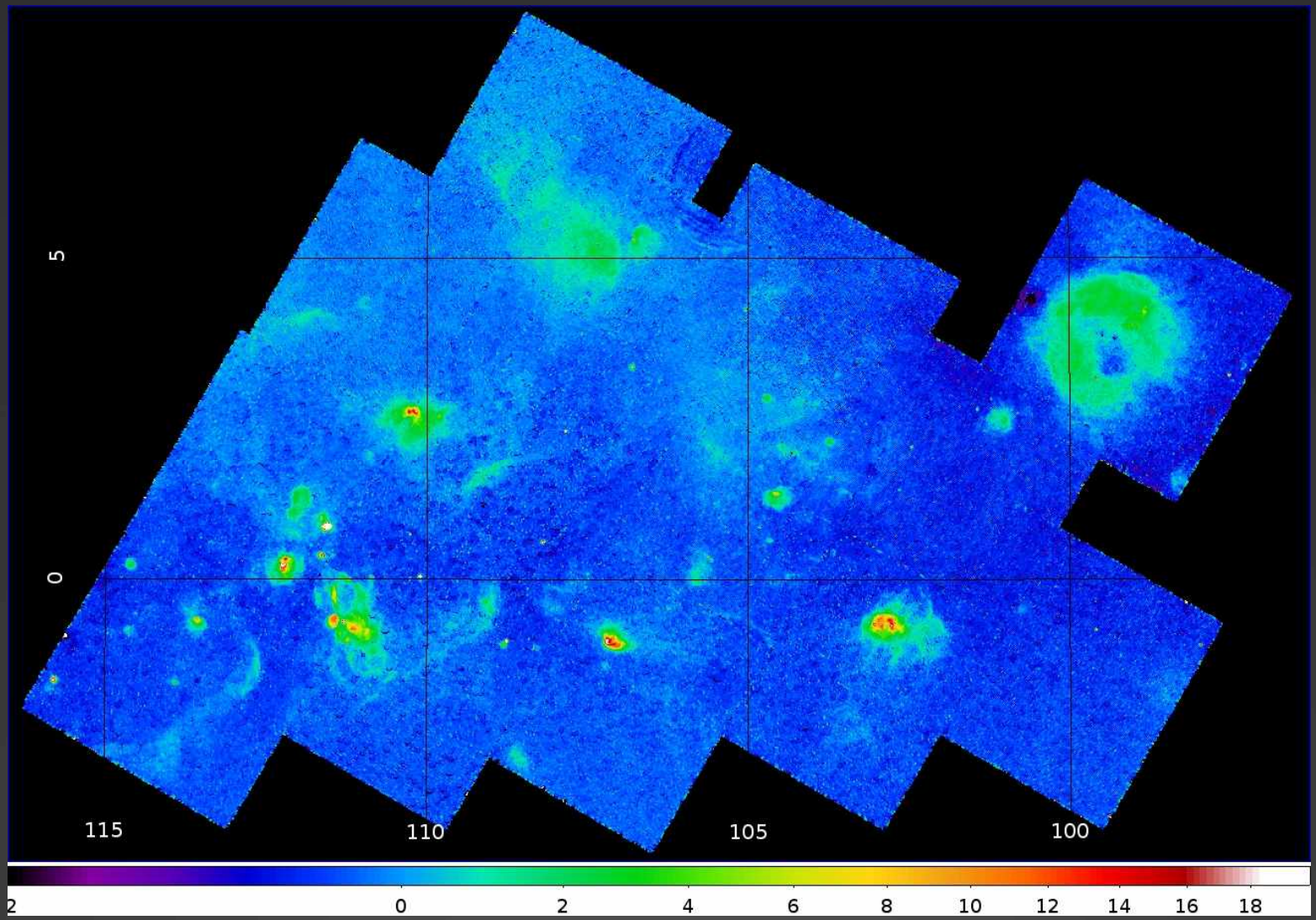
+ 35 large features, 32 point-like blobs.

- Visual inspection for Pa α & H α detections → Scientific potential of MIPAPS Pa α data.
- Photometry of Pa α & H α fluxes → Estimations of dust extinction, distance-spectral type.
- E(B-V) maps from Pa α to H α ratio → Morphological information.

3.2 Mosaic images in Cepheus

◆ Continuum-subtracted Pa α mosaic images from MIPAPS

+ Use 14 fields data (PAAL, PAAC filters) : flux-calibrated by comparing 2MASS point source catalog.

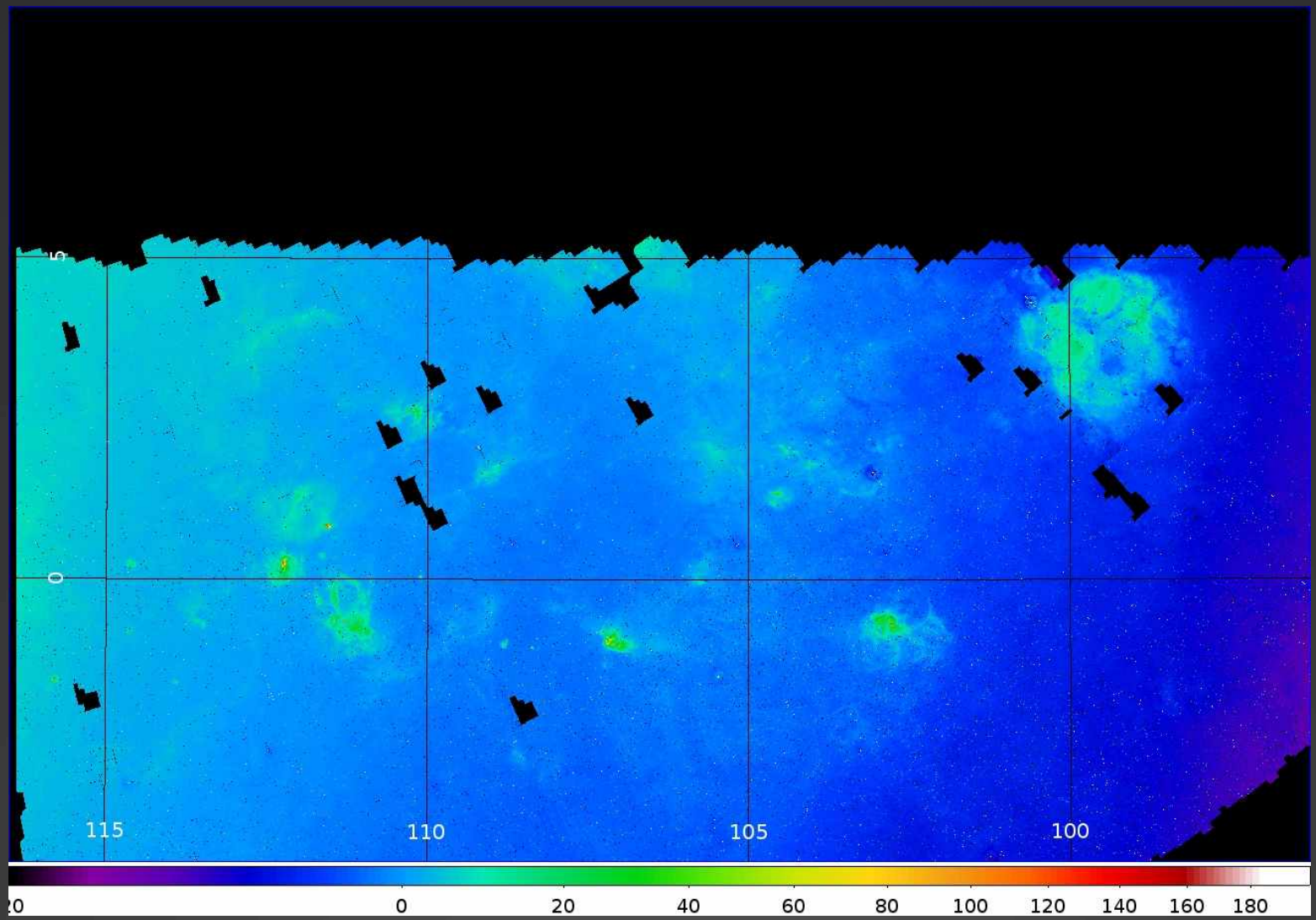


MIPAPS Pa α image (10^{-19} W/m^2/arcsec^2)

3.2 Mosaic images in Cepheus

- Continuum-subtracted H α mosaic images from IPHAS

+ Use 7840 fields data (halpha, r filters) : 15 pixel binning (pixel size = 4.9 arcsec).



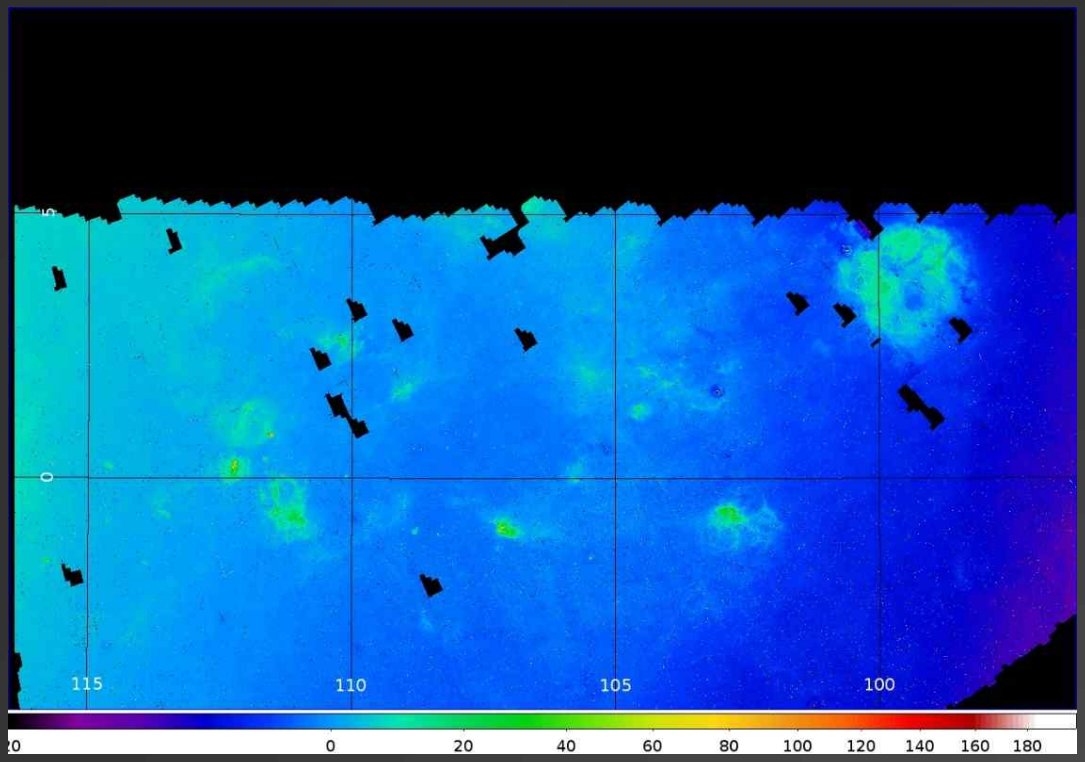
IPHAS H α image (10^{-19} W/m^2/arcsec^2)

3.2

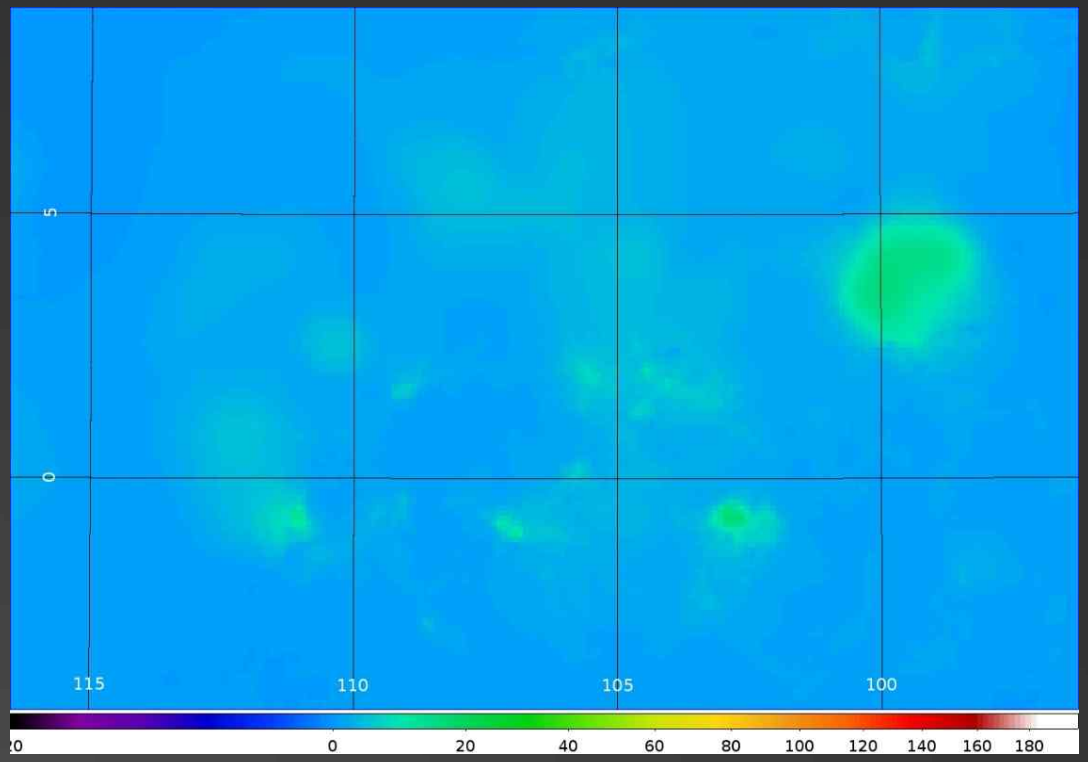
Mosaic images in Cepheus

- Continuum-subtracted $H\alpha$ mosaic images from IPHAS

+ Comparison with the previous $H\alpha$ image (Finkbeiner 2003).



IPHAS $H\alpha$ image
(10^{-19} W/m^2/arcsec^2)

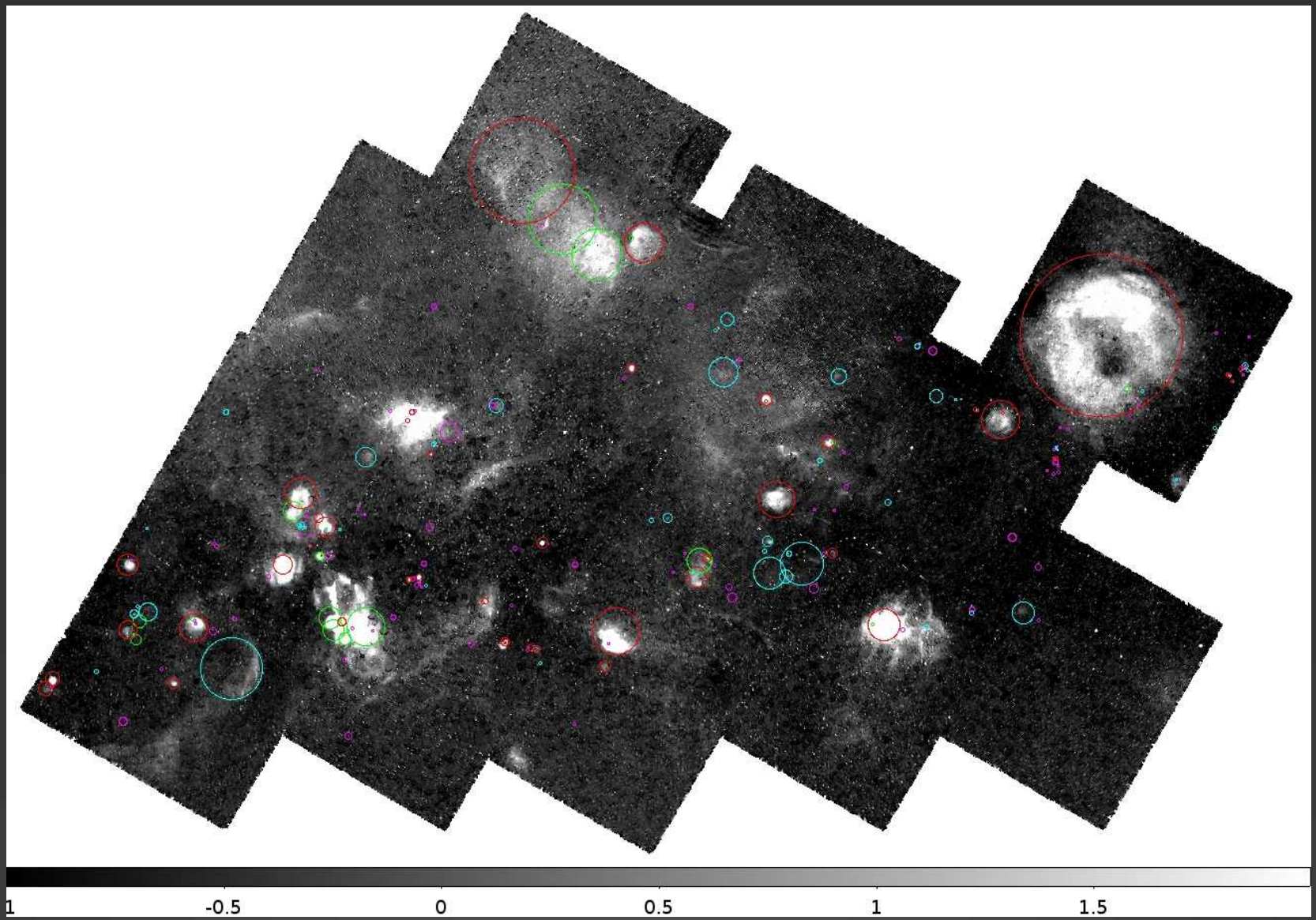


Finkbeiner's $H\alpha$ image
(10^{-19} W/m^2/arcsec^2)

3.2

WISE H II region sources

- 49 Known, 50 Candidate, 21 Group, 92 Radio quiet



MIPAPS Pa α image (10^{-19} W/m^2/arcsec^2)

3.2 WISE H II region sources

◆ Results of visual inspection & flux photometry

Name	Positions	Radius	Paa feature	Overlapped with PS	IPHAS	Paa Int	Paa Flux	Ha Int	Ha Flux	E(B-V)	Dist.	Lyc Flux	SpType
WK01	G097.311+03.269	116	Y		Y	0.79	0.34	0.18	0.07	1.93	9200	47.68	O9.3V
WK02	G097.444+03.083	95	Y		Y	0.27	0.11	0.84	0.34	0.53	10400	47.04	>O9.5V
WK03	G097.515+03.173	122	Oy		Y	4.73	2.56	2.79	1.48	1.40	7500	48.29	O8.0V
WK04	G097.528+03.184	68	On		Y								
WK05	G099.484+03.801	4539	Y	partially	Y	1.84	1109.90	11.86	7032.08	0.15	860	48.81	O6.5V
WK06	G100.205+01.885	166	Oy		Oy	0.22	0.12						
WK07	G101.016+02.590	101	On		Y								
WK08	G101.065+02.499	1066	Oy	partially	Y	1.16	31.88	1.05	28.84	1.17	7300	49.32	O4.7V
WK09	G101.439+02.653	136	Y		Y	1.77	1.05	1.02	0.61	1.41	7200	47.86	O9.1V
WK10	G102.877-00.695	913	Oy	partially	Y	5.51	164.49	14.34	430.46	0.62	5800	49.73	<O3.0V
WK11	G103.686+00.425	290	Oy	partially	Y	0.49	0.91	0.12	0.22	1.87	7400	47.91	O9.0V
WK12	G103.743+02.162	342	Oy		Y	1.33	4.27	1.84	6.00	0.94	2700	47.54	>O9.5V
WK13	G104.546+01.255	1007	Y	partially	Y	1.11	30.99	2.85	79.48	0.63	3100	48.46	O7.4V
WK14	G104.700+02.784	102	On		Y								
WK15	G104.716+02.813	353	Oy	partially	Y	1.29	4.39	0.44	1.51	1.67	7800	48.60	O7.1V
WK16	G105.635+00.345	227	Oy	largely	Y								
WK17	G105.779+00.048	584	Oy	partially	Y	1.01	10.84	3.82	40.87	0.43	5200	48.42	O7.6V
WK18	G106.605+05.252	1107	Oy	partially	partial, Y	0.91	36.25						
WK19	G106.809+03.310	256	Y		Y	1.40	2.94	1.20	2.46	1.21	7000	48.25	O8.1V
WK20	G107.034-00.801	1323	Oy	partially	Y	2.31	127.25	8.26	454.64	0.45	4300	49.33	O4.7V
WK21	G107.209-01.334	326	Y		Y	0.47	1.29	2.03	5.60	0.35	4100	47.27	>O9.5V
WK22	G108.191+00.586	307	Y		Y	9.14	10.13	2.65	2.92	1.77	4400	48.49	O7.4V
WK23	G108.273-01.066	195	Y	largely	Y								
WK24	G108.375-01.056	187	Oy	largely	Y								
WK25	G108.503+06.356	2940	Oy	partially	no data	0.43	116.98						
WK26	G108.752-00.972	42	On		N								
WK27	G108.758-00.989	46	On		Oy								
WK28	G108.764-00.952	237	Oy		Y	11.38	9.85	14.50	13.24	0.96	5600	48.54	O7.2V
WK29	G108.770-00.974	38	On		Oy								
WK30	G109.068-00.322	180	Oy		Oyw	0.85	0.85						
WK31	G109.104-00.347	95	Oy		Y	2.19	0.71						
WK32	G109.927+01.981	179	Y		Y	0.29	0.17	0.64	0.35	0.74	5000	46.64	>O9.5V
WK33	G110.099+00.042	192	Y		Y	11.62	15.71	11.99	16.30	1.10	5500	48.75	O6.6V
WK34	G110.211+02.616	140	Oy	partially	Oy	6.17	3.84						
WK35	G110.252+00.009	153	Y	partially	Y	1.07	0.40	1.10	0.44	1.07	6400	47.29	>O9.5V
WK36	G110.286+02.488	117	On		N								
WK37	G111.286-00.660	236	Y		Y	7.85	4.88	19.75	13.05	0.60	3400	47.73	O9.2V
WK38	G111.558+00.804	573	Oy	partially	Y	30.81	126.62	17.78	73.53	1.40	2600	49.06	O5.7V
WK39	G111.612+00.371	54	Oy		Y	18.11	1.96	7.65	0.65	1.69	7200	48.19	O8.3V
WK40	G111.653+00.950	273	Oy	partially	Oyw	2.24	5.22						
WK41	G111.802+00.526	96	Y		Y	0.41	0.14	0.10	0.04	1.86	5000	46.77	>O9.5V
WK42	G111.946+01.336	880	Oy	partially	Y	1.01	24.43	2.40	58.01	0.67	2800	48.28	O8.0V
WK43	G112.212+00.229	542	Y	partially	Y	6.10	56.25	22.43	206.86	0.44	4600	49.03	O5.8V
WK44	G113.595-00.749	783	Oy	partially	Y	1.61	23.44	1.39	20.41	1.19	4400	48.75	O6.7V
WK45	G113.900-01.613	327	Y		Y	0.54	2.82	1.06	5.66	0.75	4800	47.82	O9.1V
WK46	G114.605-00.801	522	Oy	partially	Y	0.44	3.67	0.68	5.77	0.88	3400	47.66	O9.4V
WK47	G114.626+00.219	593	Y	partially	Y	1.40	6.25	3.85	17.16	0.59	4900	48.16	O8.4V
WK48	G115.785-01.561	402	Y		Y	3.89	12.82	6.96	23.26	0.81	4400	48.41	O7.6V
WK49	G115.885-01.707	406	Y		Y	0.51	1.42	0.94	2.59	0.80	4500	47.48	>O9.5V

49 Known sources

Name	Positions	Radius	Paa feature	Overlapped with PS	IPHAS	Paa Int	Paa Flux	Ha Int	Ha Flux	E(B-V)	Dist.	Lyc Flux	SpType
WC01	G097.210+03.245	100	N		N								
WC02	G097.252+03.320	189	Oy		YWW	0.56	0.64	0.10	0.11	2.01	5000	47.44	>O9.5V
WC03	G097.728+02.352	108	On		Y								
WC04	G098.320+01.552	72	On	partially	On								
WC05	G098.855+02.933	91	Oyw		Y	0.16	0.04						
WC06	G100.169+02.026	44	N	totally	N								
WC07	G100.181+02.038	54	N	totally	Y								
WC08	G100.199+02.064	81	Y	largely	Y								
WC09	G100.714-00.527	638	Y	partially	Y	0.25	3.24	0.32	4.04	1.00	5000	47.96	O8.8V
WC10	G101.527-00.515	116	N	partially	Y								
WC11	G101.663+02.820	55	N		N								
WC12	G101.763+02.808	77	N		N								
WC13	G102.051+02.861	380	N	partially	N								
WC14	G102.207-00.736	134	On		Y								
WC15	G102.327+03.681	40	N		Y								
WC16	G102.354+03.635	149	N		Y								
WC17	G102.807+01.204	186	Y		Y	0.19	0.20	0.04	0.04	1.92	5000	46.91	>O9.5V
WC18	G103.578+03.165	445	Y	partially	Y	0.15	0.92	0.21	1.30	0.94	5000	47.41	>O9.5V
WC19	G103.875+01.857	164	On		On								
WC20	G104.153+00.259	1220	Oy	partially	Y								
WC21	G104.355+00.404	157	On		On								
WC22	G104.393+00.049	375	Oy		partial, Y	0.37	0.78	0.62	1.32	0.85	5000	47.32	>O9.5V
WC23	G104.648+00.110	907	Oy	partially	Y								
WC24	G104.675+00.595	305	Y		Y	0.65	1.45	0.40	0.88	1.38	5000	47.68	O9.3V
WC25	G104.728+00.446	126	Oyw	partially	N	0.09	0.04						
WC26	G105.307+04.058	363	On	partially	N								
WC27	G105.365+03.234	829	Oy	partially	Y	0.15	3.20	0.80	17.16	0.24	5000	47.82	O9.1V
WC28	G105.487+03.889	109	On		N								
WC29	G105.852+00.142	129	Oy		Y	0.27	0.14	0.05	0.03	2.01	5100	46.81	>O9.5V
WC30	G106.241+00.957	274	Y	partially	YWW	0.09	0.20						
WC31	G106.499+00.925	123	N		N								
WC32	G108.213-01.293	103	YW		YWW	0.17	0.06						
WC33	G108.902+02.714	410	Oy	partially	partial, Y	0.11	0.59						
WC34	G109.854+02.147	85	On	totally	N								
WC35	G109.874+02.115	129	Oy	partially	YW	1.47	0.75	0.43	0.23	1.75	700	45.76	>O9.5V
WC36	G109.994-00.092	92	N		Y								
WC37	G110.923+01.906	566	Y	partially	Y	0.33	2.92	0.51	4.53	0.89	5000	47.90	O9.0V
WC38	G111.329+00.783	60	On		On								
WC39	G111.873+00.820	60	On	totally	On								
WC40	G111.907+00.800	99	On		On								
WC41	G111.922+00.859	113	On		On								
WC42	G111.947+00.799	104	On		On								
WC43	G111.966+00.839	113	Oy	partially	Oyw	0.47	0.20	0.37	0.15	1.29	5000	46.82	>O9.5V
WC44	G113.009-01.393	1734	Y	partially	Y	0.19	21.36						
WC45	G113.096+02.602	159	Oyw		N	0.09	0.08						
WC46	G114.312-00.510	501	Oy	partially	Oy	0.18	1.40	0.38	2.99	0.72	5000	47.55	>O9.5V
WC47	G114.332+00.788	60	N		N								
WC48	G114.473-00.430	88	Y		YW	0.011	0.003	0.010	0.002	1.15	5000	44.89	>O9.5V
WC49	G114.526-00.543	229	Y	partially	YW	0.23	0.38	0.05	0.08	1.93	5000	47.20	>O9.5V
WC50	G115.105-01.438	124	Y		YW	0.26	0.13						

50 Candidate sources

radius (arcsec), intensity (10^{-19} W/m^2/arcsec^2), flux (10^{-14} W/m^2)

3.2 WISE H II region sources

◆ Results of visual inspection & flux photometry

Name	Positions	Radius	Paa feature	Overlapped with PS	IPHAS	Paa Int	Paa Flux	Ha Int	Ha Flux	E(B-V)	Dist.	Lyc Flux	SpType
WG01	G099.091+02.969	118	Oy		Oy	0.72	0.31	2.29	1.00	0.51	5000	46.86	>O9.5V
WG02	G103.061-00.691	104	Oy		Oy	3.91	1.48	3.55	1.21	1.23	5000	47.66	O9.3V
WG03	G103.659+02.151	120	Oyw		Oyw	0.36	0.12	0.45	0.15	0.98	5000	46.52	>O9.5V
WG04	G105.571+00.296	139	Oy		Oy	0.74	0.44	0.66	0.40	1.16	5000	47.13	>O9.5V
WG05	G105.744+00.298	700	Oy	partially	Oy	0.71	10.98	2.15	33.13	0.54	5000	48.41	O7.6V
WG06	G106.798+05.313	135	Oy	partially	no data	1.49	0.85						
WG07	G107.333+05.061	1440	Oy	partially	partial, Y	1.29	84.61						
WG08	G107.866+05.607	1968	Oy	partially	no data	0.75	91.51						
WG09	G110.927-00.731	1058	Oy	partially	Oy	2.84	100.20	7.58	266.59	0.61	5000	49.38	O4.4V
WG10	G111.196-00.798	73	On		On								
WG11	G111.245-00.924	345	Oy		Oy	0.62	2.34	1.34	4.99	0.72	5000	47.77	O9.2V
WG12	G111.430-00.790	587	Oy	partially	Oy	3.04	33.01	5.12	55.42	0.85	5000	48.94	O6.1V
WG13	G111.478-00.591	620	Oy	partially	Oy	2.91	34.96	5.42	65.36	0.79	5000	48.96	O6.0V
WG14	G111.543+00.775	69	On	largely	OyW								
WG15	G111.601+00.393	62	On		Oy								
WG16	G111.640+00.360	232	Oy		Oy	6.91	11.77	4.95	8.37	1.30	5000	48.58	O7.1V
WG17	G112.071+01.063	533	Oy	partially	Oy	1.30	11.53	1.98	17.66	0.90	5000	48.50	O7.4V
WG18	G113.614-00.615	112	On		Oy								
WG19	G114.437-00.662	381	Oy	partially	Oyw	0.07	0.31						
WG20	G114.496-00.946	282	Oy	partially	Oyw	0.11	0.28	0.30	0.76	0.60	5000	46.83	>O9.5V
WG21	G114.520-00.867	60	On		Oy								

Name	Positions	Radius	Paa feature	Overlapped with PS	IPHAS	Paa Int	Paa Flux	Ha Int	Ha Flux	E(B-V)	Dist.	Lyc Flux	SpType
WR37	G105.227-00.262	262	N	partially	N								
WR38	G105.279-00.113	193	N	partially	Y								
WR39	G105.509+00.230	99	On		N								
WR40	G105.880+04.253	153	On		N								
WR41	G105.962+00.420	70	N		N								
WR42	G106.142+00.129	75	N		N								
WR43	G106.909+03.148	107	N		YWW								
WR44	G107.156-00.988	69	On		On								
WR45	G107.298+05.638	73	On	partially	no data								
WR46	G107.678+00.235	156	Oyw		N	0.07	0.05						
WR47	G107.683-02.239	100	YW		Y	0.03	0.01	0.015	0.005	1.38	6100	45.57	>O9.5V
WR48	G108.184+05.518	88	On		no data								
WR49	G108.394-01.046	34	N	totally	Oy								
WR50	G108.412-01.097	100	N	partially	N								
WR51	G108.603+00.494	138	N		N								
WR52	G108.666-00.391	93	N		N								
WR53	G108.966+02.726	141	On		no data								
WR54	G109.285-00.987	177	On		N								
WR55	G109.621+02.312	533	On	partially	Oy								
WR56	G109.878+04.261	159	N		N								
WR57	G109.919+00.813	221	N		no data								
WR58	G110.016+00.259	150	N		N								
WR59	G110.054-00.107	60	N		N								
WR60	G110.094-00.064	74	N		Y								
WR61	G110.135-00.077	118	N		N								
WR62	G110.160+00.040	50	N		On								
WR63	G110.170+02.630	106	On	totally	On								
WR64	G110.199+00.016	121	N	totally	YW								
WR65	G110.505-00.586	147	On		N								
WR66	G110.548+02.622	104	On	totally	Y								
WR67	G110.812-00.799	79	On		On								
WR68	G110.941+01.018	83	N		N								
WR69	G111.046+01.085	73	N		N								
WR70	G111.125-00.757	88	On		On								
WR71	G111.180-02.419	204	N		YW								
WR72	G111.236-01.238	132	Oy		Y	1.04	0.59	0.78	0.43	1.29	3500	46.96	>O9.5V
WR73	G111.498+00.369	210	Oyw	partially	Y	0.58	0.81	0.35	0.49	1.38	5000	47.43	>O9.5V
WR74	G111.567+00.751	60	On		On								
WR75	G111.670+03.264	89	N		N								
WR76	G111.774+00.689	75	On		On								
WR77	G111.860+00.800	50	On	largely	On								
WR78	G111.861+01.001	89	Oyw		Oyw	-0.06	-0.01	-0.26	-0.06				
WR79	G111.870+00.881	46	On		On								
WR80	G111.893+00.991	87	Oyw		Oyw	0.07	0.02	-0.22	-0.05		5100		
WR81	G111.941+00.677	75	On		On								
WR82	G112.434+00.034	124	On		On								
WR83	G112.970-00.608	114	On		Oyw								
WR84	G113.246+00.511	137	On		Oy								
WR85	G113.284+00.558	93	On		Oy								
WR86	G113.289-00.819	217	N	partially	N								
WR87	G113.566-00.698	77	On		Oyw								
WR88	G113.569-00.657	77	On		Oyw								
WR89	G114.082-01.401	105	N	totally	Y								
WR90	G114.569+00.290	58	On	partially	On								
WR91	G114.677-02.208	227	On		On								
WR92	G115.782-01.689	90	On	partially	N								

21 Group sources

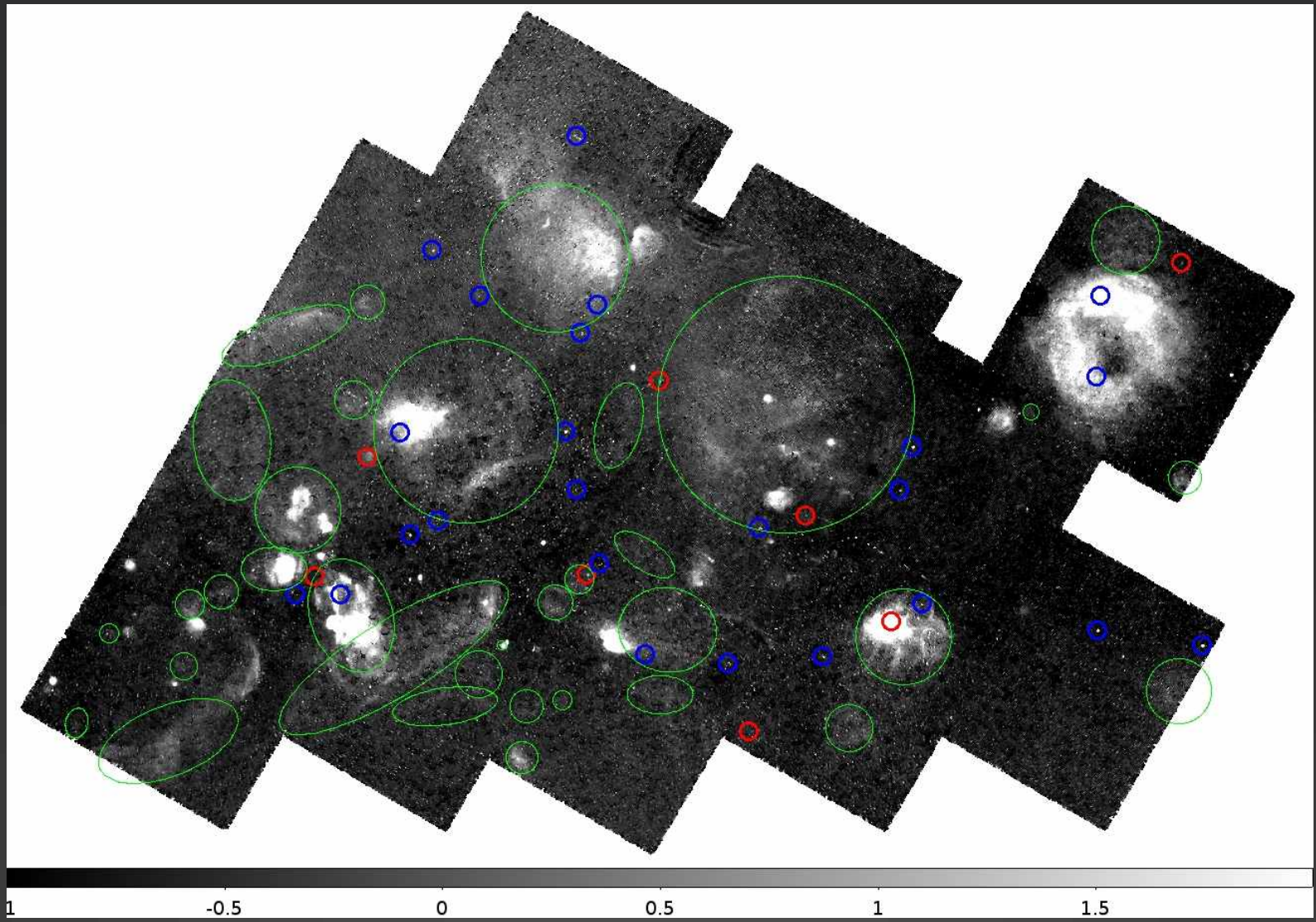
92 Radio quiet sources

radius (arcsec), intensity (10^{-19} W/m^2/arcsec^2), flux (10^{-14} W/m^2)

3.2 MIPAPS Pa α sources

- 35 large features, 32 point-like blobs

+ Point-like blobs : define 24 detections by visual inspection and 6 detections by known catalogs.



MIPAPS Pa α image (10^{-19} W/m^2/arcsec^2)

3.2 MIPAPS Pa α sources

◆ Results of visual inspection & flux photometry

Name	Positions	Radius	Overlapped with PS	WISE	CGPS	IPHAS	Paa Int	Paa Flux	Ha Int	Ha Flux	E(B-V)	Dist.	Lyc Flux	SpType
MLF01	G098.224+01.564	933	partially	Oy	Oy	Oy								
MLF02	G098.337-01.736	1830	partially	Y	Y	Y								
MLF03	G099.138+05.259	1899	partially	Oyw	N	partial, Y								
MLF04	G100.617+02.606	470	partially	Y	Y	Y	0.12	0.81	0.56	3.89	0.30	5000	47.23	>O9.5V
MLF05	G102.606-00.878	2675	partially	Oy	Oy	Oy								
MLF06	G103.450-02.294	1314	partially	Y	Y	Y	0.29	15.88	0.64	34.86	0.71	5000	48.60	O7.1V
MLF07	G104.421+02.718	7198	partially	Oy	Oy	Oy								
MLF08	G106.262-00.769	2735, 2343	partially	Oy	Oy	Oy								
MLF09	G106.376-01.772	1833, 1063	partially	YW	YW	Y								
MLF10	G106.619+00.398	1940, 844	partially	YW	YW	Y								
MLF11	G107.021+02.404	1254, 2459	partially	YW	YW	partial, Y								
MLF12	G107.621-00.000	830	partially	Y	Y	Y	0.26	5.58	0.23	4.97	1.18	5000	48.23	O8.2V
MLF13	G107.892-01.864	539	partially	Y	YW	Y	0.11	1.04	0.56	5.09	0.29	5000	47.34	>O9.5V
MLF14	G107.987-00.347	996	partially	Y	Y	Y	0.36	11.15	0.92	28.60	0.63	5000	48.43	O7.5V
MLF15	G108.014+04.993	4136	partially	Oy	Oy	partial, Y								
MLF16	G108.436-01.956	937	partially	Y	Y	partial, Y	0.04	1.20						
MLF17	G108.517-02.746	893	partially	Y	Y	Y	0.50	12.61	1.02	25.60	0.75	5000	48.51	O7.3V
MLF18	G108.822-01.019	267	partially	Oy	Y	Y	3.86	8.57	6.10	13.64	0.88	5000	48.36	O7.8V
MLF19	G109.188-01.454	1320	partially	YW	YW	Y								
MLF20	G109.397+02.308	5155	partially	Oy	Oy	partial, Y								
MLF21	G109.706-01.955	2953, 1019	partially	YW	YW	Y								
MLF22	G110.502-01.207	7407, 2090	partially	Oy	Oy	Oy								
MLF23	G110.925+04.307	957	partially	Y	Y	Y	0.15	4.38	0.48	13.70	0.52	5000	48.01	O8.7V
MLF24	G111.139+02.784	1073	partially	Y	Y	Y	0.19	6.77	0.69	24.95	0.44	5000	48.18	O8.3V
MLF25	G111.165-00.552	2291, 3242	partially	Oy	Oy	Oy								
MLF26	G112.002+01.069	2397	partially	Oy	Oy	Oy								
MLF27	G112.198+03.790	3778, 1194	partially	Y	Y	Y								
MLF28	G112.365+00.162	1833, 1210	partially	Oy	Oy	Oy								
MLF29	G113.027+02.160	2154, 3398	partially	Y	Y	Y								
MLF30	G113.177-00.202	952	partially	Y	Y	Y	0.11	3.12	0.27	7.62	0.65	5000	47.88	O9.0V
MLF31	G113.660-00.361	834	partially	Y	Y	Y	0.35	7.57	1.17	25.51	0.48	5000	48.24	O8.1V
MLF32	G113.745-01.347	769	partially	YW	YW	Y	0.10	1.80	0.16	2.92	0.87	5000	47.68	O9.3V
MLF33	G113.990-02.507	4112, 1950	partially	Y	Y	Y								
MLF34	G114.906-00.853	540	partially	Y	YW	YW								
MLF35	G115.411-02.236	620	partially	YW	Y	Y								

35 large features

Name	Positions	Corresponding object	Types	Overlapped with PS	WISE	CGPS	IPHAS	Paa Flux	Ha Flux
MPB01	G097.980-01.026	EM* MWC645	Be	PS	PS	N	PS	1.70	1.97
MPB02	G098.265+04.907	PN K 3-60	Planetary Nebula		PS	Y	PS	0.12	0.11
MPB03	G099.530+04.398	HD239712	B2Vnne	PS	PS	N	PS	0.50	
MPB04	G099.594+03.143	[KW97] 59-24	emission-line star		N	N	N	1.22	
MPB05	G099.596-00.793				N	N	N	1.11	
MPB06	G102.309-00.366	TYC3986-137-1		largely	N	N	N	0.67	
MPB07	G102.454+02.068			partially	N	N	N	1.19	
MPB08	G102.657+01.389	WR151 (V* CX Cep)	WN4+O5V	partially	PS	N	PS	0.25	0.24
MPB09	G102.783-00.653	WR153 (HD211853)	WN6+O6I	PS	PS	N	PS(Witham+08)	1.48	
MPB10	G103.853-01.184	WR154 (HD213049)	WC6	PS, partially	PS	N	PS	0.60	
MPB11	G104.111+01.001	PN Bl 2-1	Planetary Nebula	partially	PS	Y	PS	0.12	0.09
MPB12	G104.836+00.806			largely	N	N	N	1.28	
MPB13	G104.994-02.338	HD240010	B1IVnnpe (HAe/B	PS, largely	Y	YW	Y	0.18	2.47
MPB14	G105.323-01.294	WR155 (V* CQ Cep)	WN6+O9II-Ib	PS	PS	N	PS	1.39	0.84
MPB15	G106.391+03.093	EM* GGR71	Be (HAe/Be)	PS	PS	N	Y	0.36	0.46
MPB16	G106.601-01.148	TYC3992-728-1		largely	N	N	N	1.17	
MPB17	G107.313+00.258	TYC3996-514-1		largely	N	N	N	0.60	
MPB18	G107.341+04.278	EM* AS 492	emission-line sta	PS	PS	N	only D, PS	0.66	
MPB19	G107.507+00.085	EM* GGR102	emission-line star		PS	Y	Y	0.25	0.42
MPB20	G107.605+03.835	2MASS22321530+6230118		largely	N	N	N	1.34	
MPB21	G107.673+01.400	V* V525 Cep	Be (HAe/Be)	PS	PS	N	PS	1.08	0.76
MPB22	G107.680+06.886	TYC4272-684-1		largely	N	N	no data	0.42	
MPB23	G107.844+02.315	NGC7354	Planetary Nebula		PS	Y	Y	2.73	3.28
MPB24	G109.177+04.414	BHB; 2MASS22414172+6344505		largely	N	N	N	0.36	
MPB25	G109.824+00.919	WR156	WN8	PS, partially	PS	N	only D, PS	1.36	
MPB26	G109.916+05.112	2MASS22443929+6443220			N	N	N	0.32	
MPB27	G110.255+00.702			partially	N	N	N	1.13	
MPB28	G110.407+02.294	IRAS22577+6209; 2MASS22594539+622		largely	Y	YW	N	0.65	
MPB29	G110.905+01.897	EM* AS 505	B4e (HAe/Be)	PS	Y	N	PS	0.47	
MPB30	G111.334-00.236	WR157 (HD219460B)	WN4.5+B1II	PS	PS	N	PS	0.68	
MPB31	G111.730+00.035	EM* MWC1080	B0eq (HAe/Be, H	PS	PS	N	Y	2.21	1.32
MPB32	G112.026-00.242	2MASS23203291+6041084		largely	N	N	N	0.55	

32 point-like blobs

radius (arcsec), intensity (10^{-19} W/m^2/arcsec^2), flux (10^{-14} W/m^2)

3.3 Scientific potential of MIPAPS Pa α data

◆ WISE H II region sources

+ 49 Known sources.
  - MIPAPS Pa α detections : 42, IPHAS H α detection : 44.
  - Only IPHAS H α detection : 5 (overlapped with other sources).
+ 50 Candidate sources.
  - MIPAPS Pa α detections : 25, IPHAS H α detection : 26.
  - Only MIPAPS Pa α detection : 5 (high extinction).
  - Only IPHAS H α detection : 7 (small size, overlapped with other sources).
+ 21 Group sources.
  - MIPAPS Pa α detections : 16, IPHAS H α detection : 18.
  - Only IPHAS H α detection : 4 (small size, overlapped with other sources).
+ 92 Radio quiet sources.
  - MIPAPS Pa α detections : 6, IPHAS H α detection : 23.
  - Only MIPAPS Pa α detection : 1 (high extinction).
  - Only IPHAS H α detection : 18 (small size, overlapped with other sources).

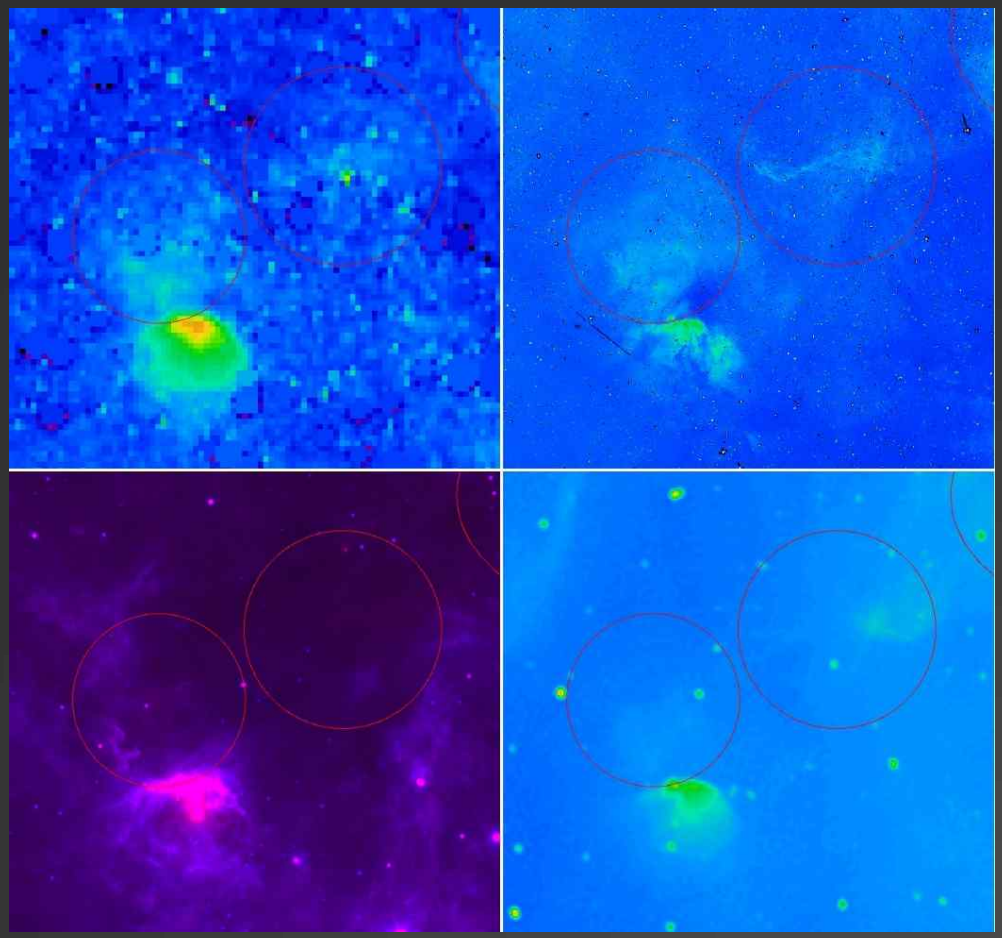
→ MIPAPS Pa α data are expected to identify >1000 candidates as H II regions for the whole plane.

3.3 Scientific potential of MIPAPS Pa α data

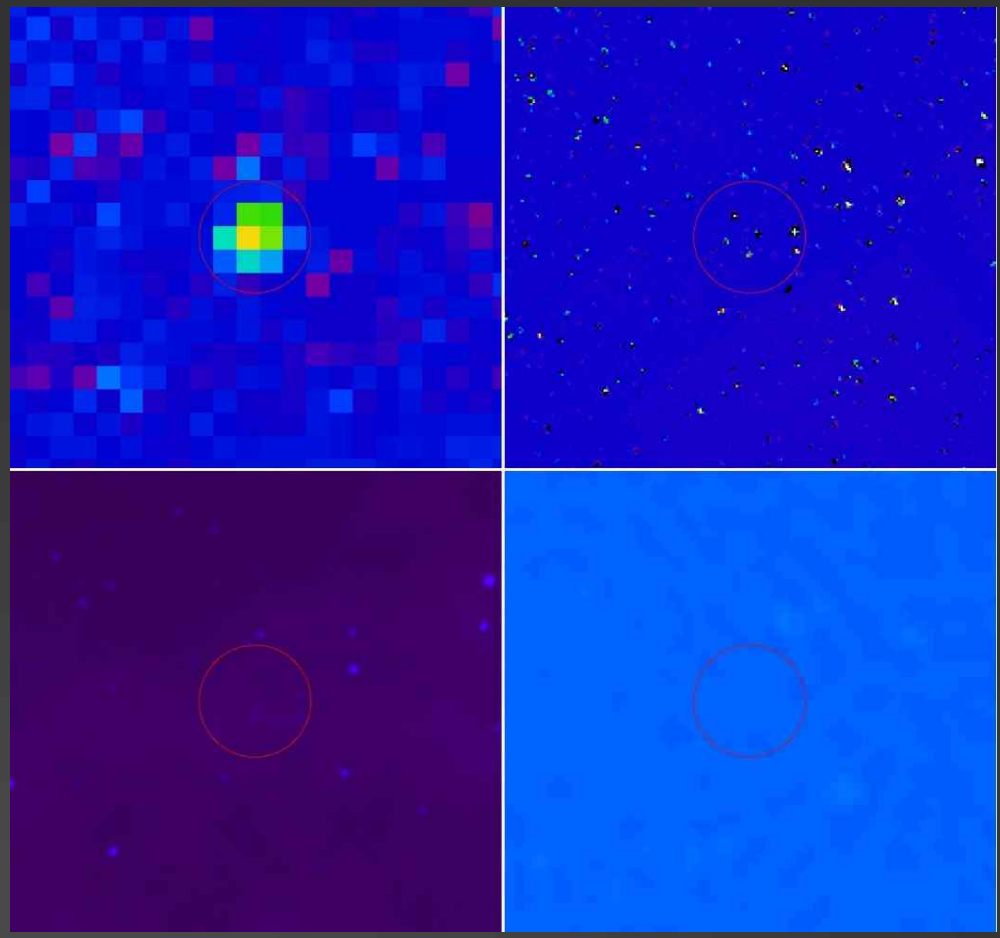
◆ MIPAPS Pa α sources

+ 35 Large features : 13 have no corresponding known sources.

+ 32 Point-like blobs : 14 no counterparts, 3 PNe, 6 WRs, 9 emission-line stars (including 5 Herbigs).



MLF30 & MLF31



MPB05

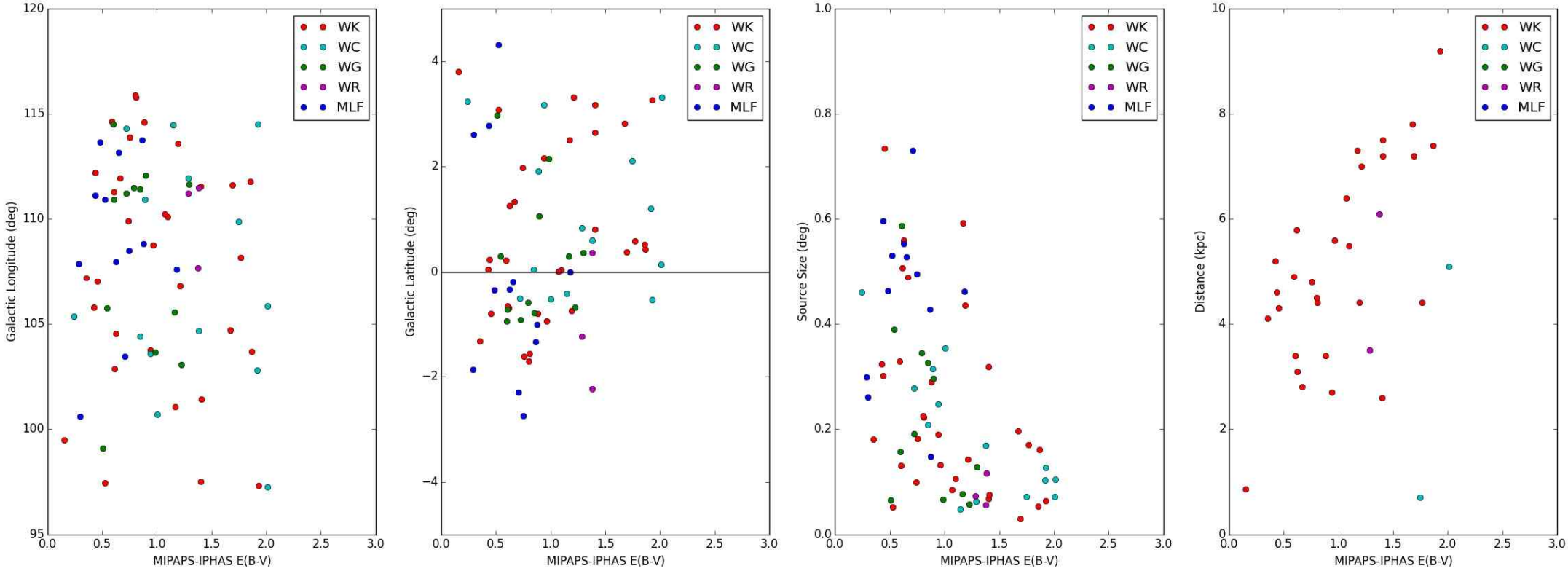
Upper : MIPAPS Pa α , IPHAS H α
Lower : WISE 12 μm (blue) + 22 μm (red), CGPS radio continuum

3.3 Estimations of dust extinction, distance, spectral type

◆ MIPAPS-IPHAS E(B-V)

+ Radiative recombination of Hydrogen (from Draine, Physics of the interstellar and intergalactic medium).

+ Assuming Case B & $T=10^4$ K (general H II region), observed $Pa\alpha / H\alpha$ values give E(B-V).

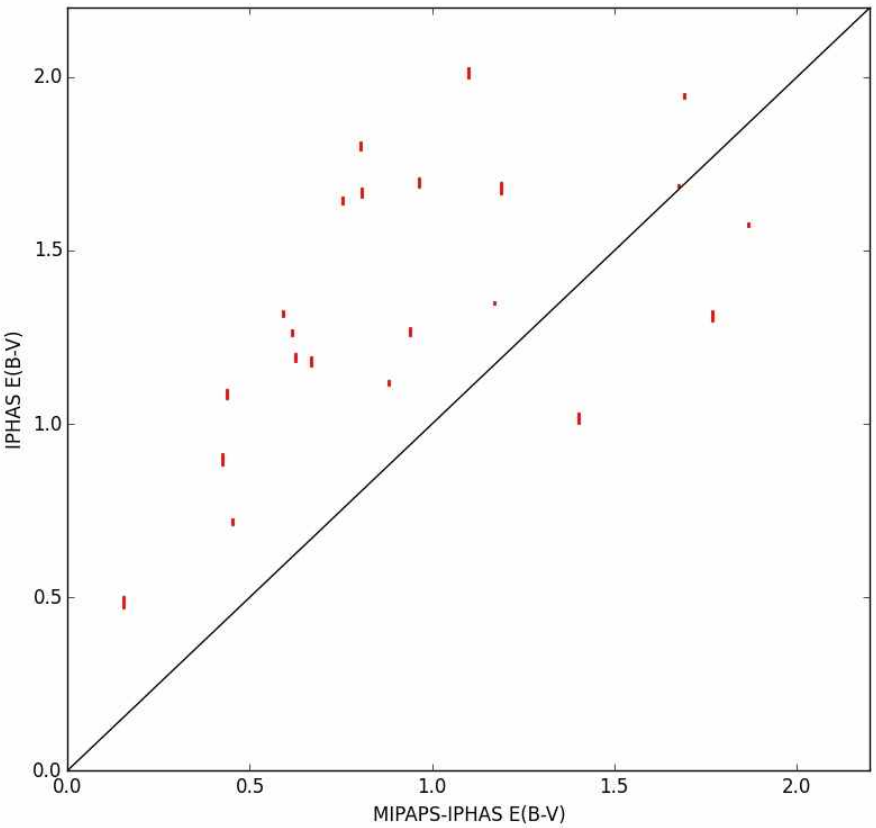


MIPAPS-IPHAS E(B-V) *vs.* source position (l, b), size, distance

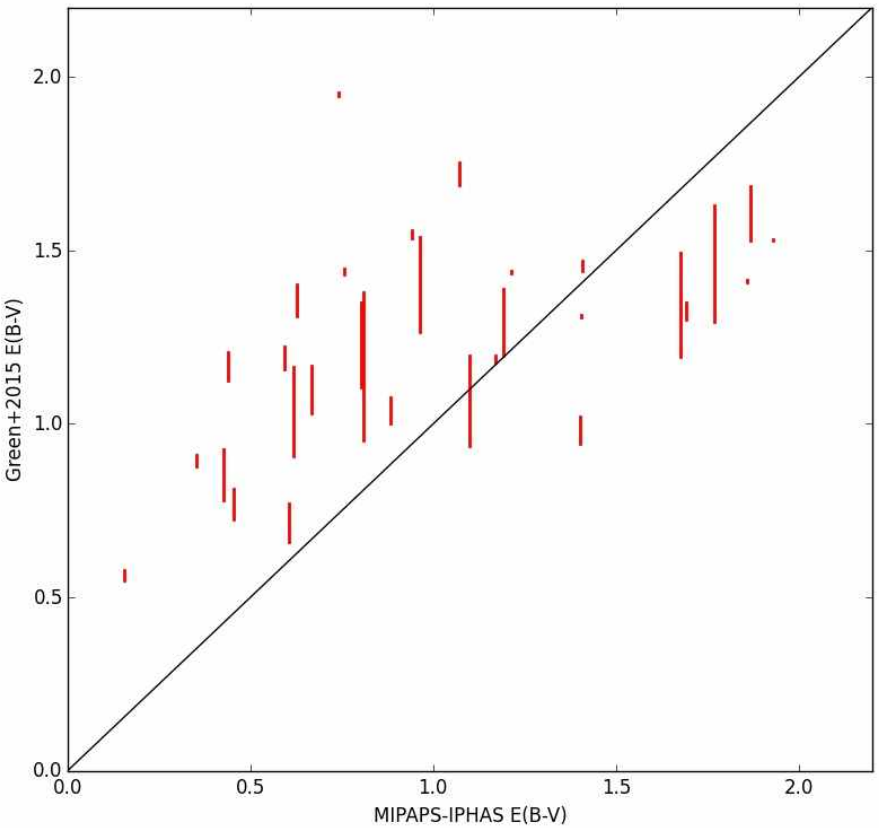
3.3 Estimations of dust extinction, distance, spectral type

◆ MIPAPS-IPHAS E(B-V) (for WISE Known sources)

+ Comparison with other 3D dust extinction data.



MIPAPS-IPHAS E(B-V) vs. IPHAS E(B-V)



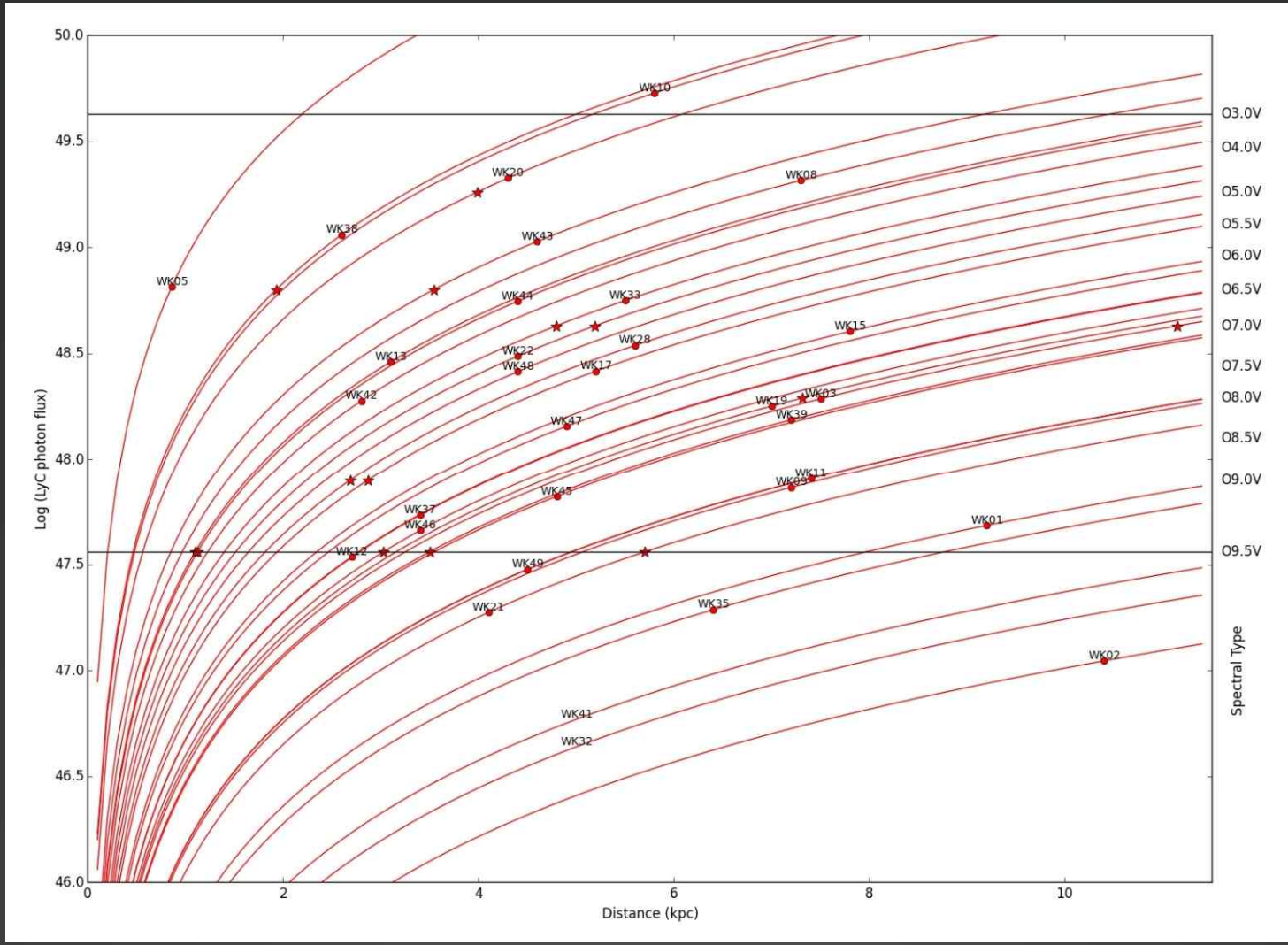
MIPAPS-IPHAS E(B-V) vs. Pan-STARRS1-2MASS E(B-V) (Green+ 2015)

3.3 Estimations of dust extinction, distance, spectral type

◆ Distance-Spectral type of ionizing source (for WISE Known sources)

+ If the distance is known, intrinsic total flux of Pa α (or H α) can be calculated. (→ Lyc photon flux)

+ Lyman continuum photon fluxes as a function of spectral types (Martins+ 2005).

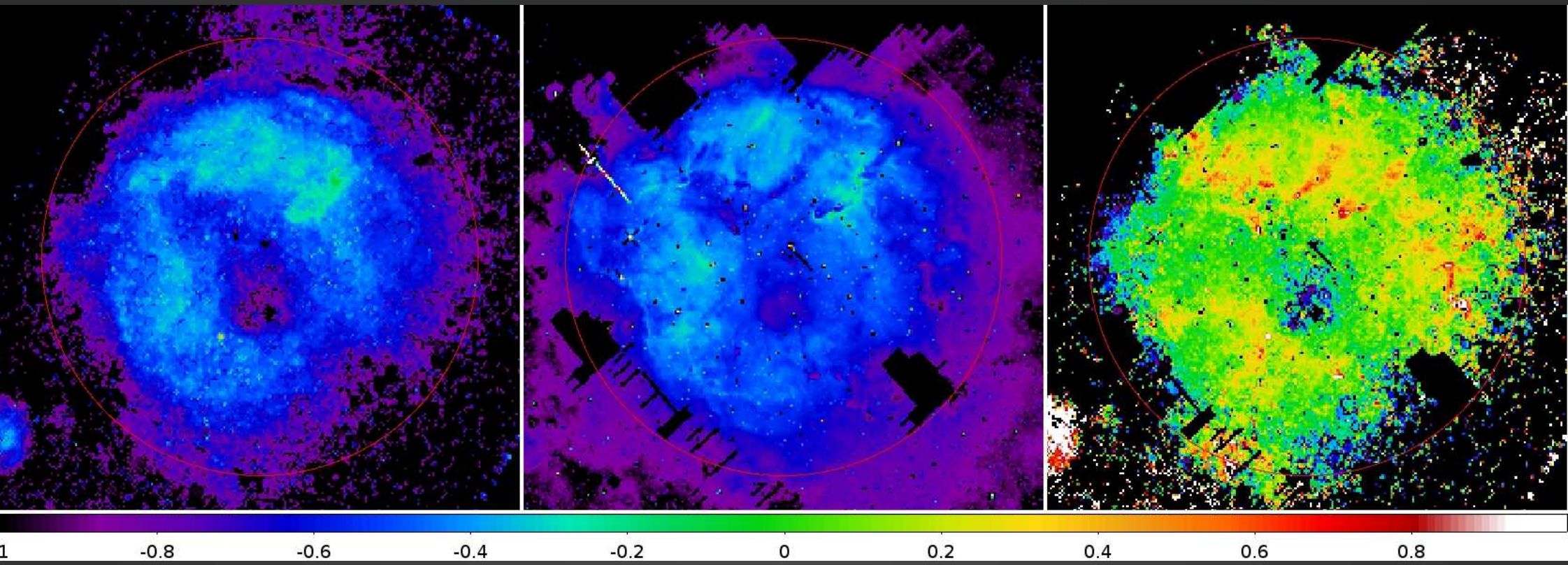


Distance *vs.* Estimated spectral type of ionizing sources

3.3 E(B-V) maps from Pa α to H α ratio

◆ WK05 (Sh2-131)

+ Clumpy high Pa α regions : due to dust extinction by foreground local clouds.
+ Diffuse high H α regions : due to dust scattering.

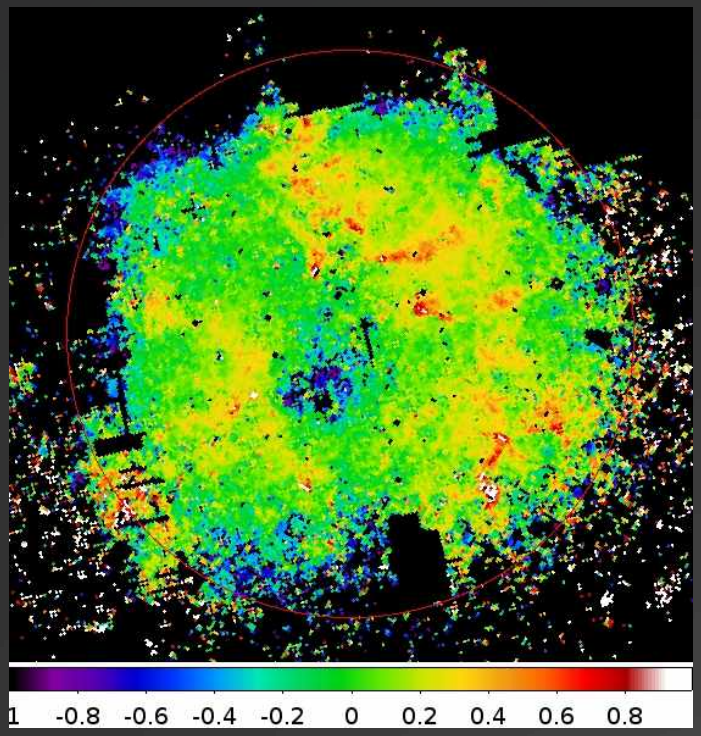


MIPAPS Pa α IPHAS H α MIPAPS-IPHAS E(B-V)

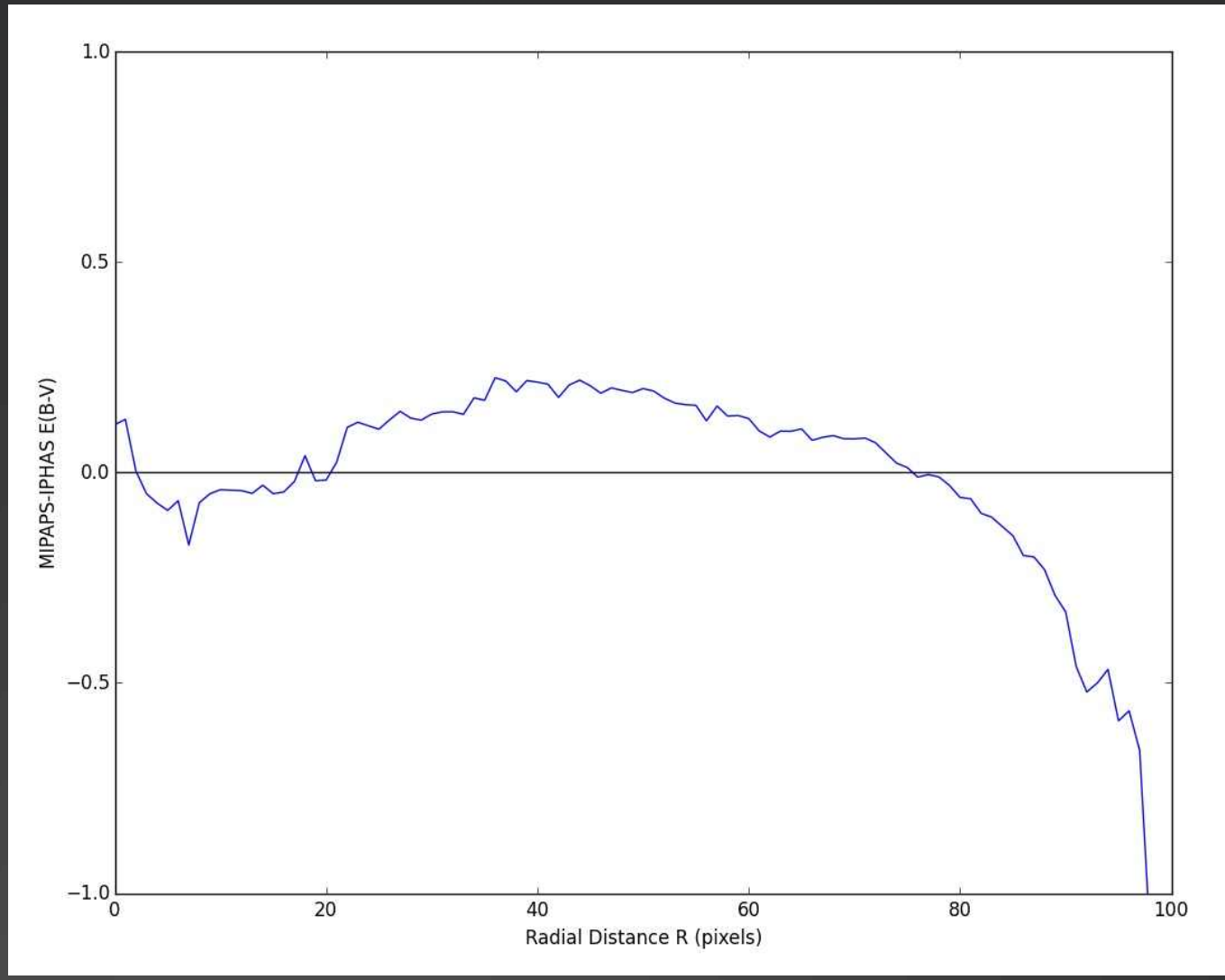
3.3 E(B-V) maps from Pa α to H α ratio

◆ WK05 (Sh2-131)

+ Plot E(B-V) radial profile from the center.



E(B-V) map for WK05



Radial profile of E(B-V)

Next plan

◆ Data release 1 (June, 2017)

+ Cepheus region (Q2) : comparison with WISE, IPHAS.

+ Carina region (Q4) : comparison with WISE, SHS.

◆ Data release 2 : all data including edge-shadowing correction.

+ The whole Galactic plane : MIPAPS Paα source catalog.