Counterparts to X-ray sources from the Chandra Galactic Bulge Survey (GBS)

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Outline

- GBS
- VVV
- Cross-matching GBS and VVV
- Results
- Conclusion

The Chandra Galactic Bulge Survey
(P. Jonker et al, 2011)

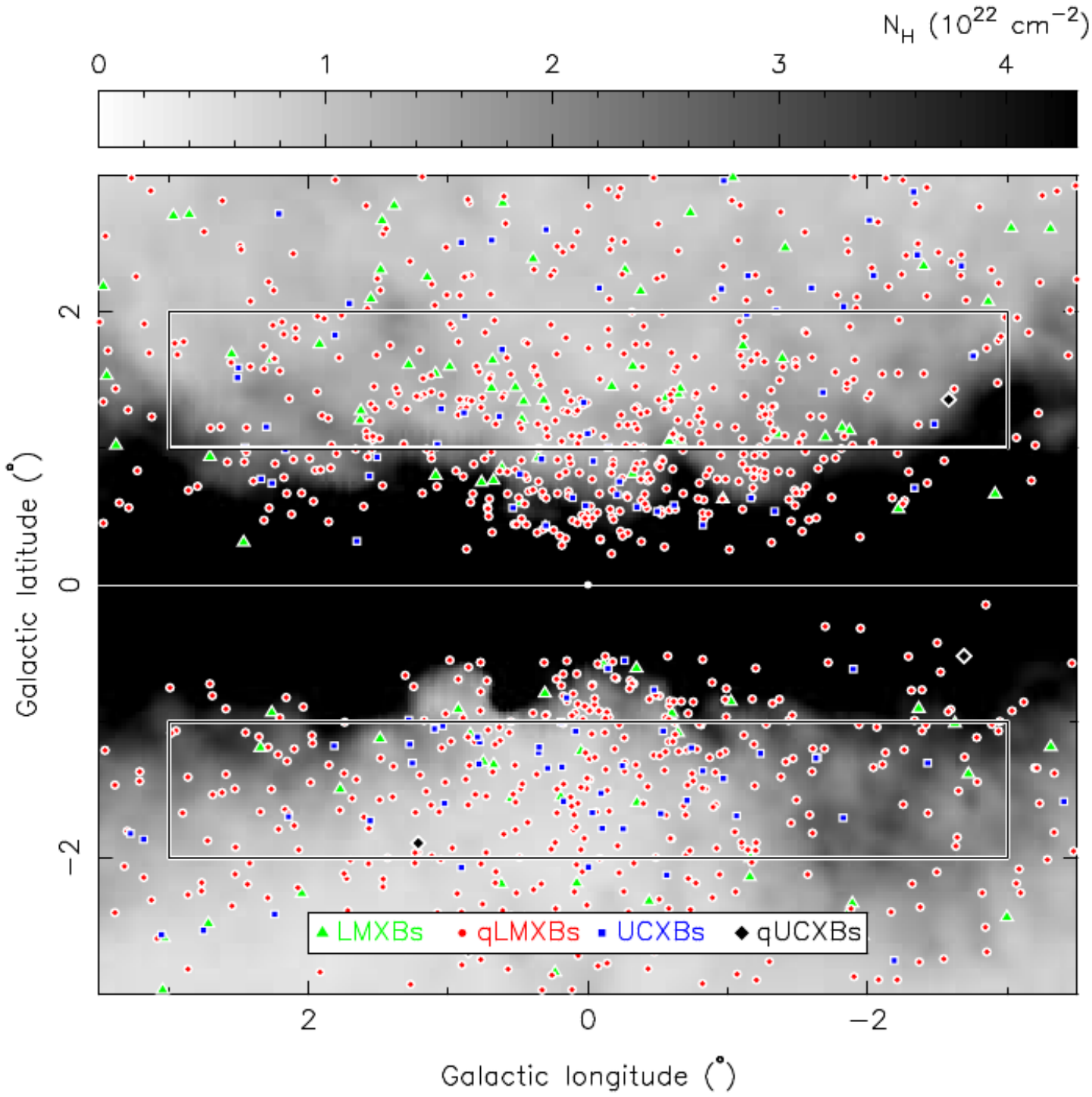
1. Main goals :

- Determine accurate mass measurements of rare X-ray binaries
- Study binary formation and evolution by finding binaries in the bulge (prediction to find ~6 LMXBs, ~120 qLMXBs, ~32 UCXBs, ~1 qUCXB, ~62 non mag CV, ~152 IPs, ~596 RS CVns, ~160 W UMa and ~9 Be X-ray Binaries)
- Select binary objects for optical spectroscopy

2. Chandra and optical (r, i, Hα) imaging of two strips 6^o x 1^o, centered at 1.5^o above and below the Galactic centre

3. Accurate X-ray positions (using X-ray counts)

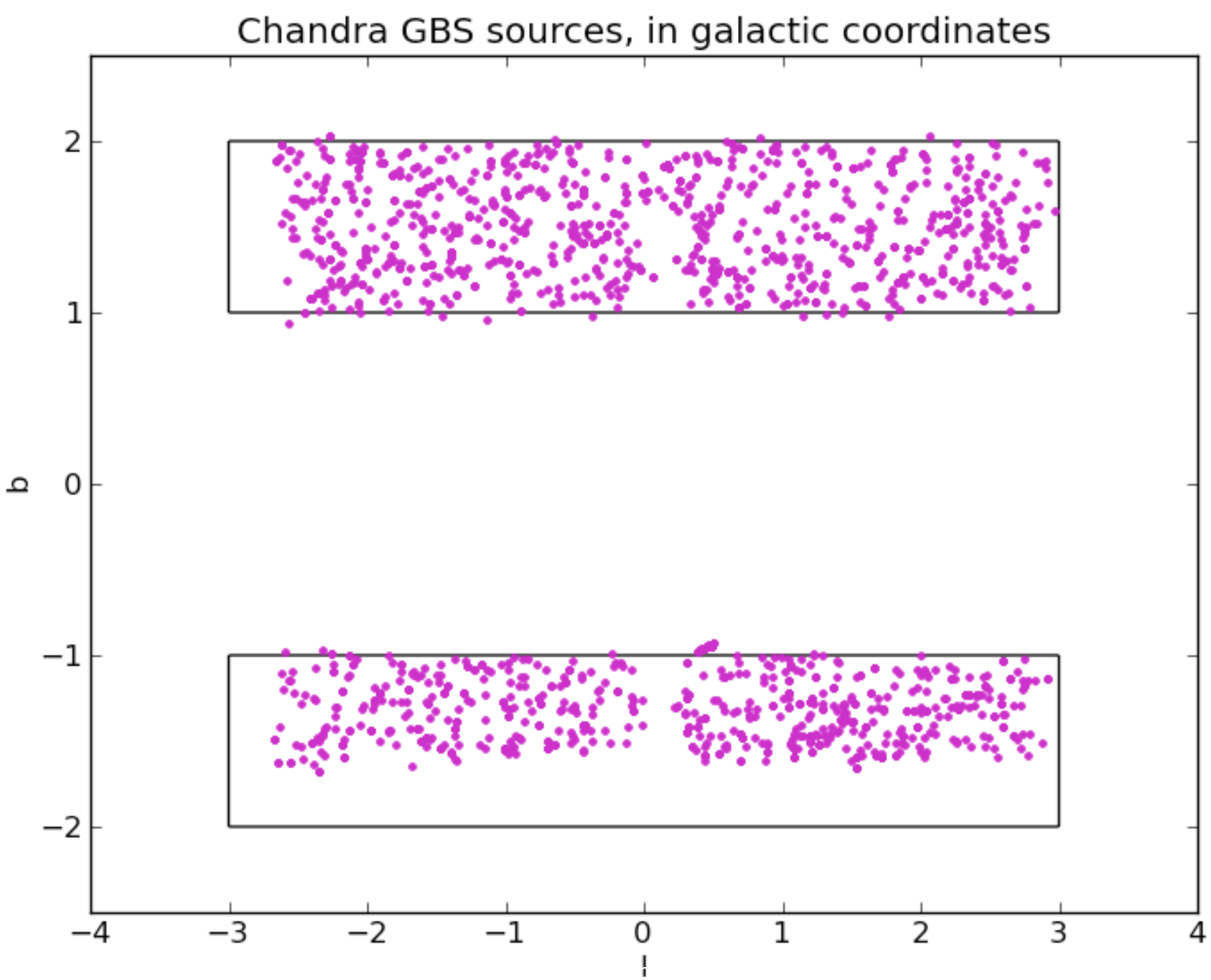
Simulation of X-ray Binaries Population (G. Nelemans)



July 25, 2011

The Chandra Galactic Bulge Survey
(P. Jonker et al, 2011)

4. High extinction and high density of sources in the bulge → Multi-wavelength data is required to distinguish between true counterparts and field stars
5. 1234 unique X-ray sources detected by Chandra in that region (magenta points)
6. Southern part of GBS area is to be covered by Chandra in the very near future


Chandra GBS sources, in galactic coordinates
b
l
2
1
0
−1
−2
−4
−3
−2
−1
0
1
2
3
4

VISTA Variable in the Via Lactea (VVV)

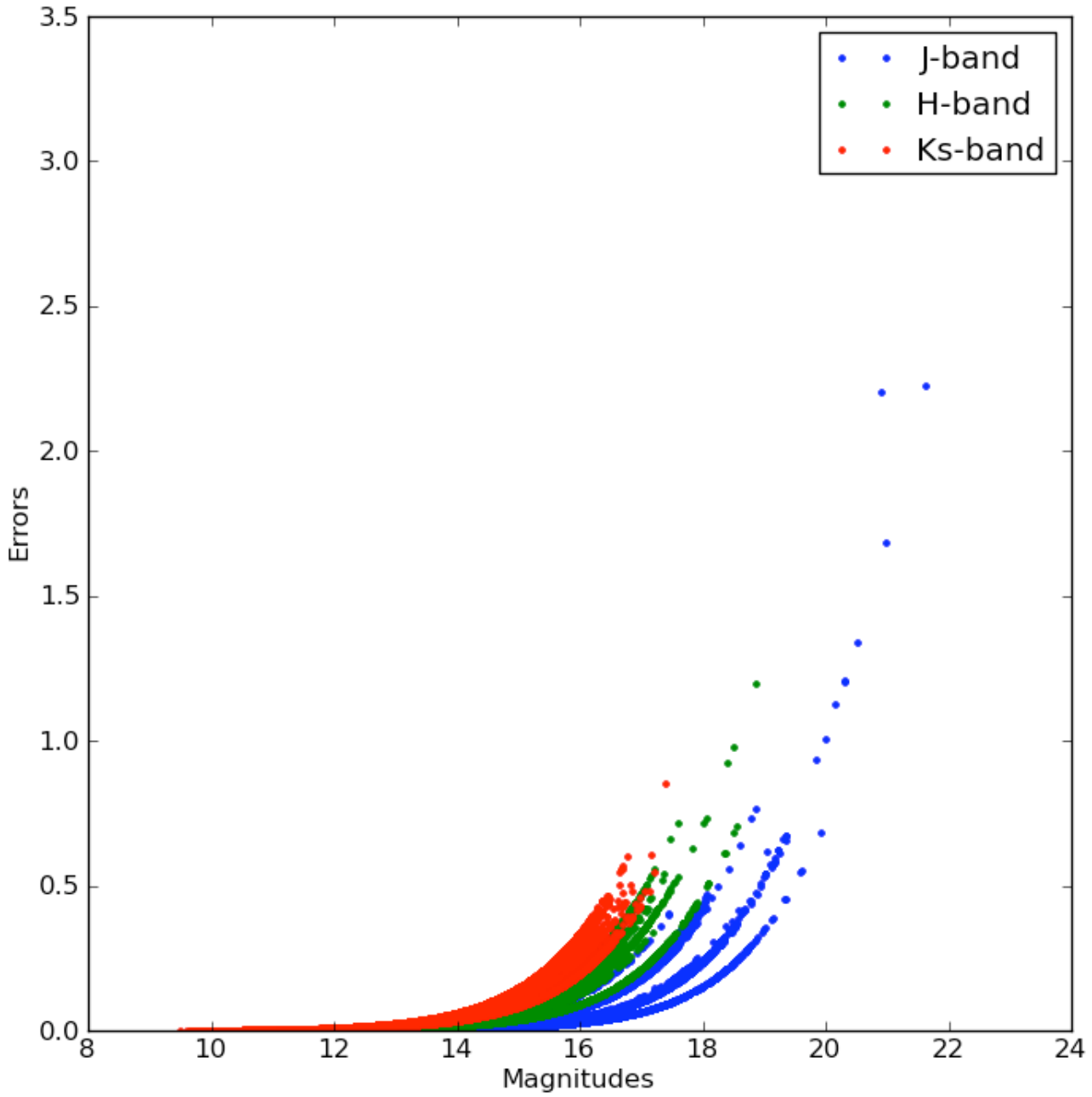
- Main goal is to construct a 3-D map of the surveyed region by using variable stars
- Total area covered: 520 deg^2 of the Galactic bulge and plane
- Broad-band filters used: Z Y J H Ks
- VVV overlaps with GBS ➔ used to get near-infrared data of the 1234 X-ray sources

Cross-matching GBS and VVV

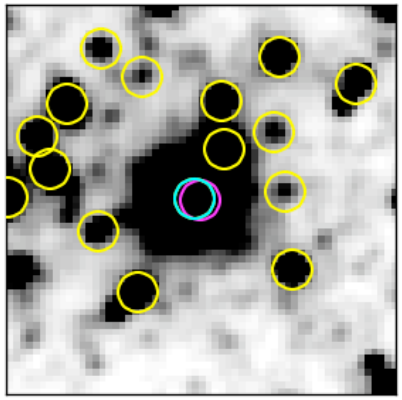
- Search for all J, H and Ks matches in VVV within 5” of X-ray position
- Calculate magnitudes and errors:

$$Mag = ZP - 2.5 \times \log_{10}(flux/exptime) - apcor - percorr$$

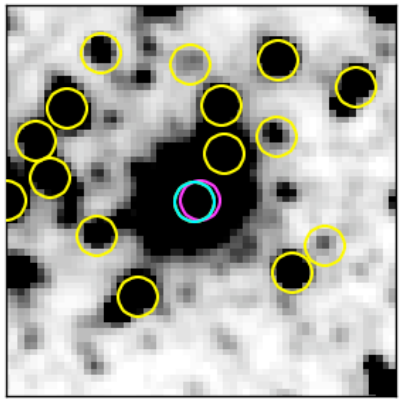
- Band-merge VVV catalogs
- Compare matches in J, H and Ks
- Compare VVV magnitudes with UKIDSS GPS and 2MASS


J-band
H-band
Ks-band
Errors
Magnitudes
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
8
10
12
14
16
18
20
22
24

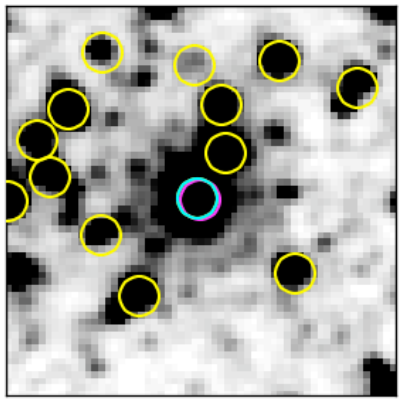
Close-up of 20" x 20" in J-band



Close-up of 20" x 20" in H-band



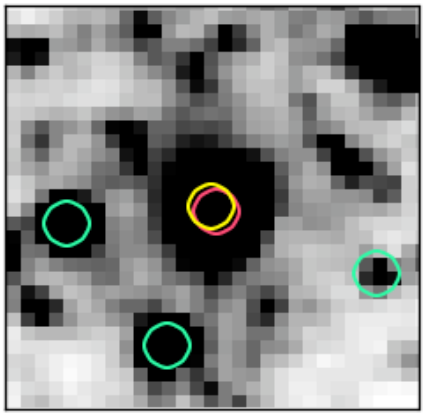
Close-up of 20" x 20" in Ks-band



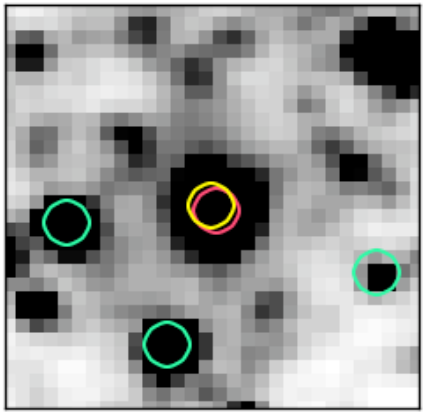
Results

- VVV catalogs do not have the same matches in J, H and Ks (Ks catalogs have more detected sources than J and H)

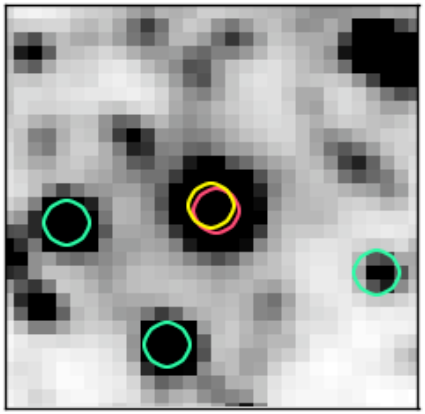
UKIDSS J-band (DR7)	UKIDSS H-band (DR7)	UKIDSS K-band (DR7)	VVV J-band	VVV H-band	VVV Ks-band	MOSAIC (Optical)
625	596	963	1128	1128	1168	1034
50%	48%	78%	91%	91%	94%	83%



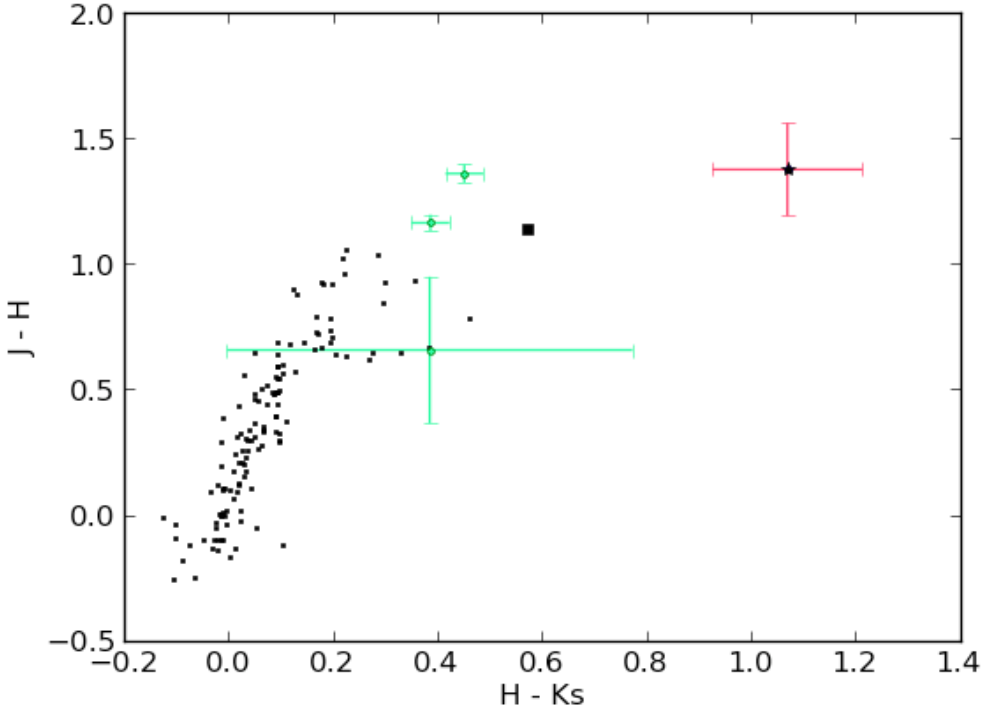
Ks-band

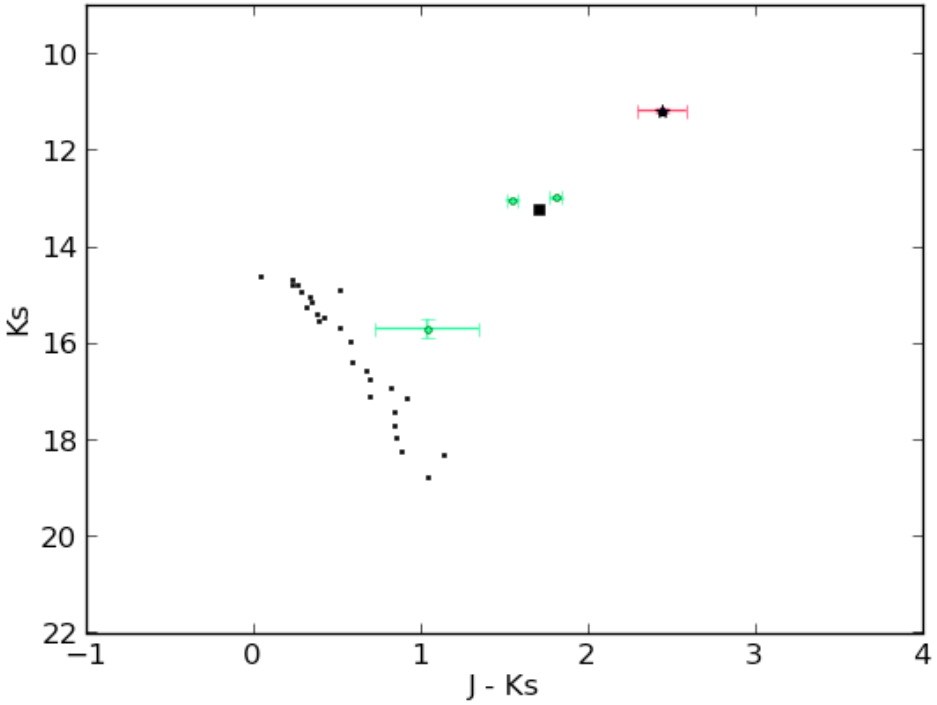


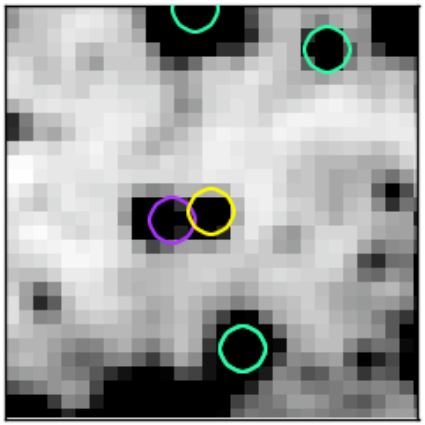
H-band



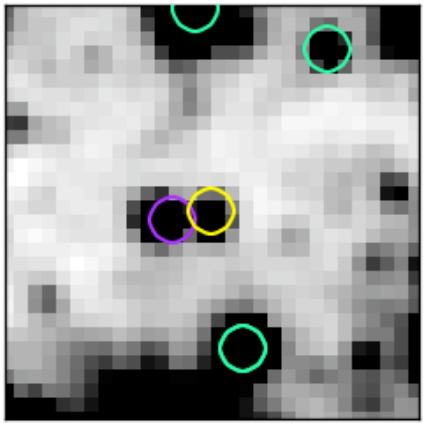
J-band



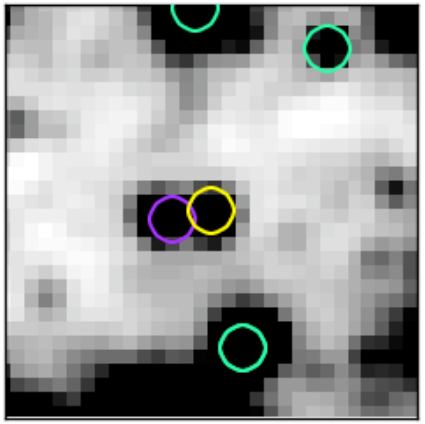




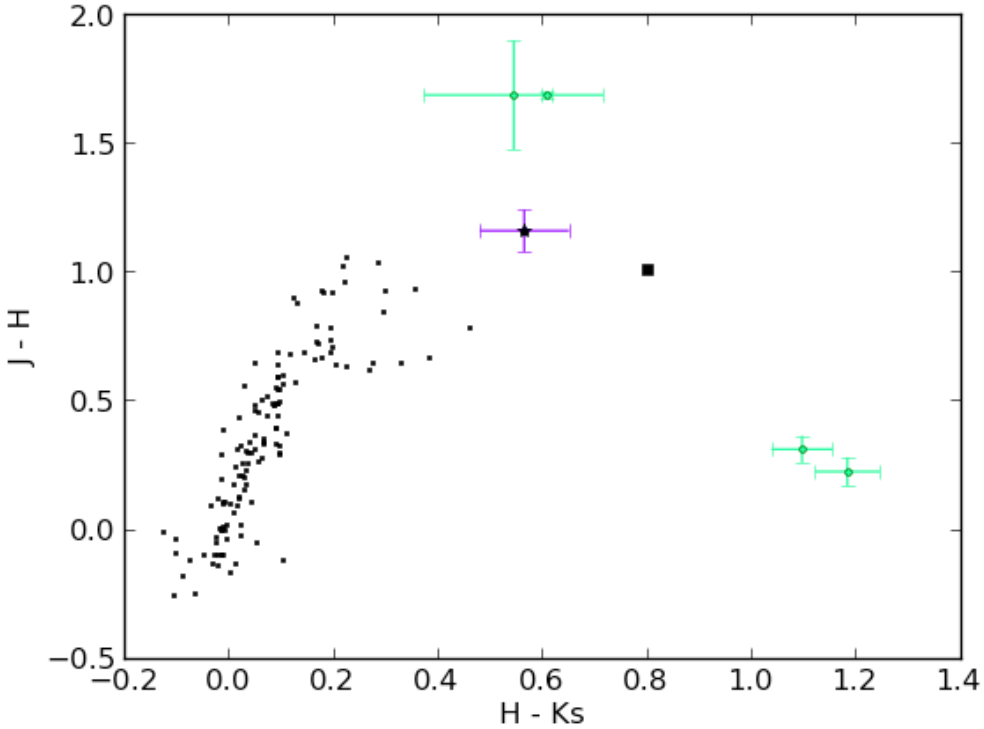
Ks-band

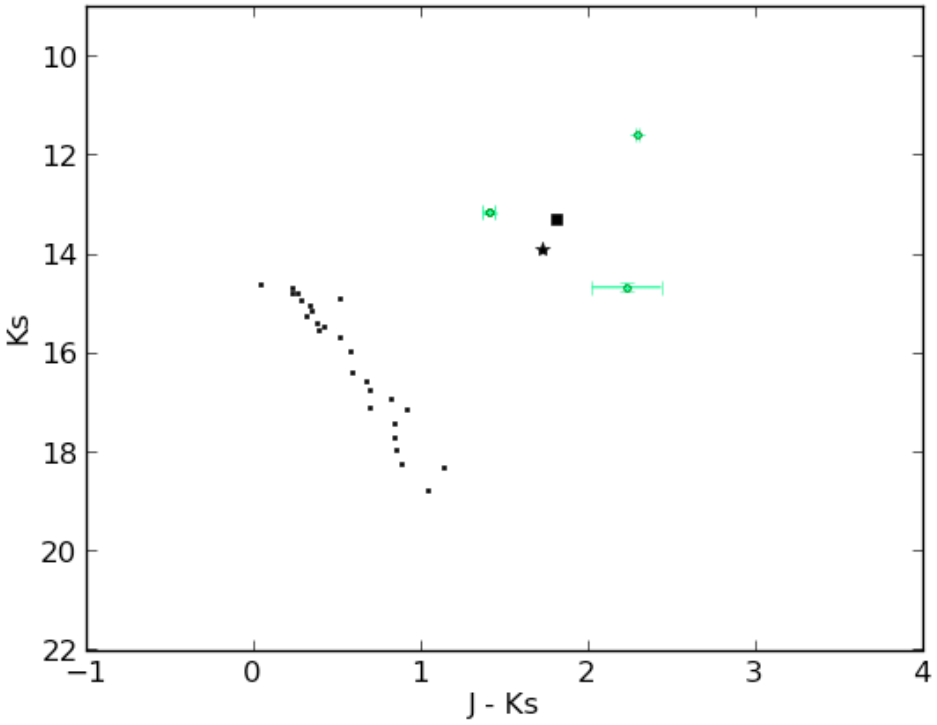


H-band

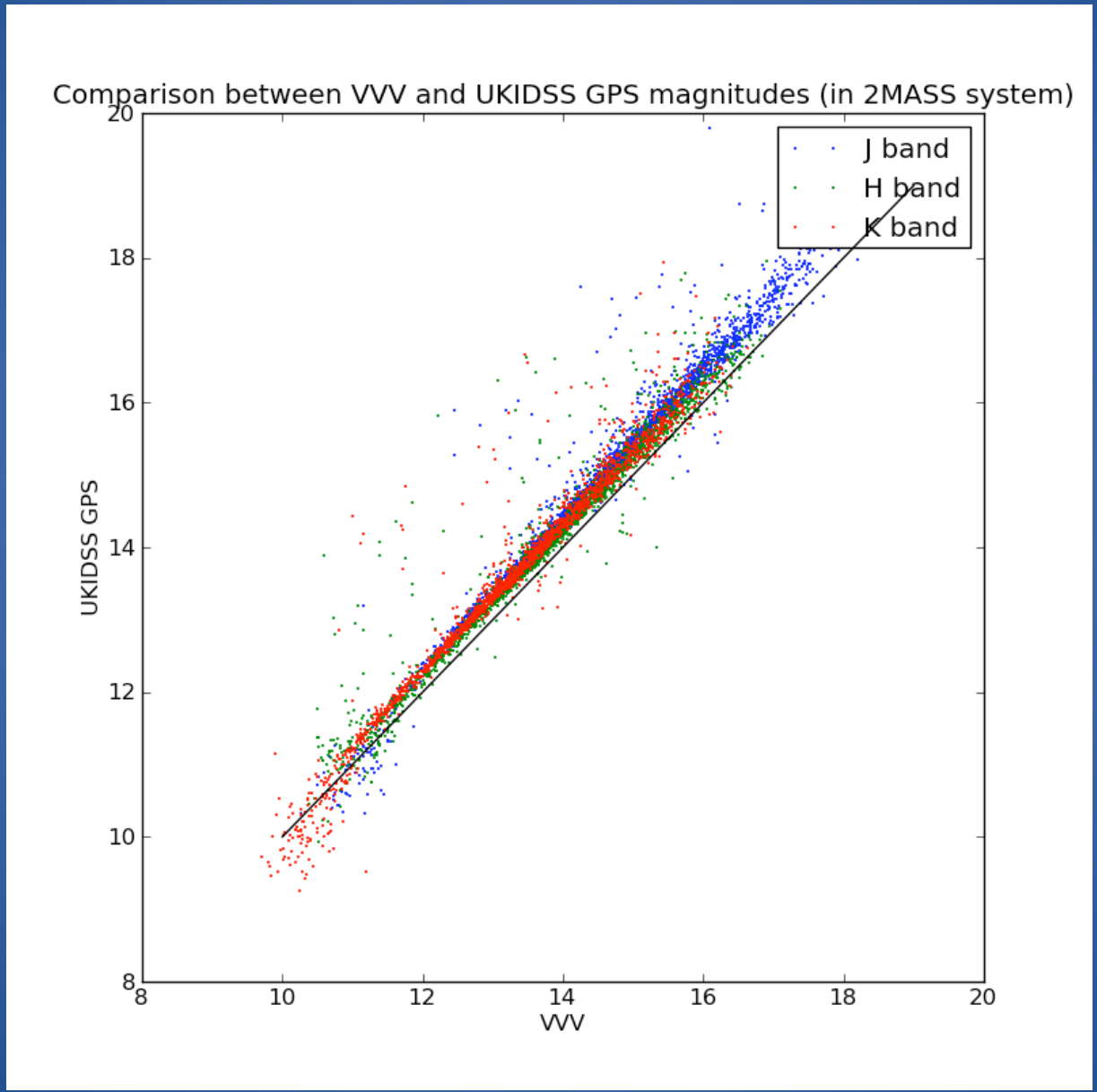


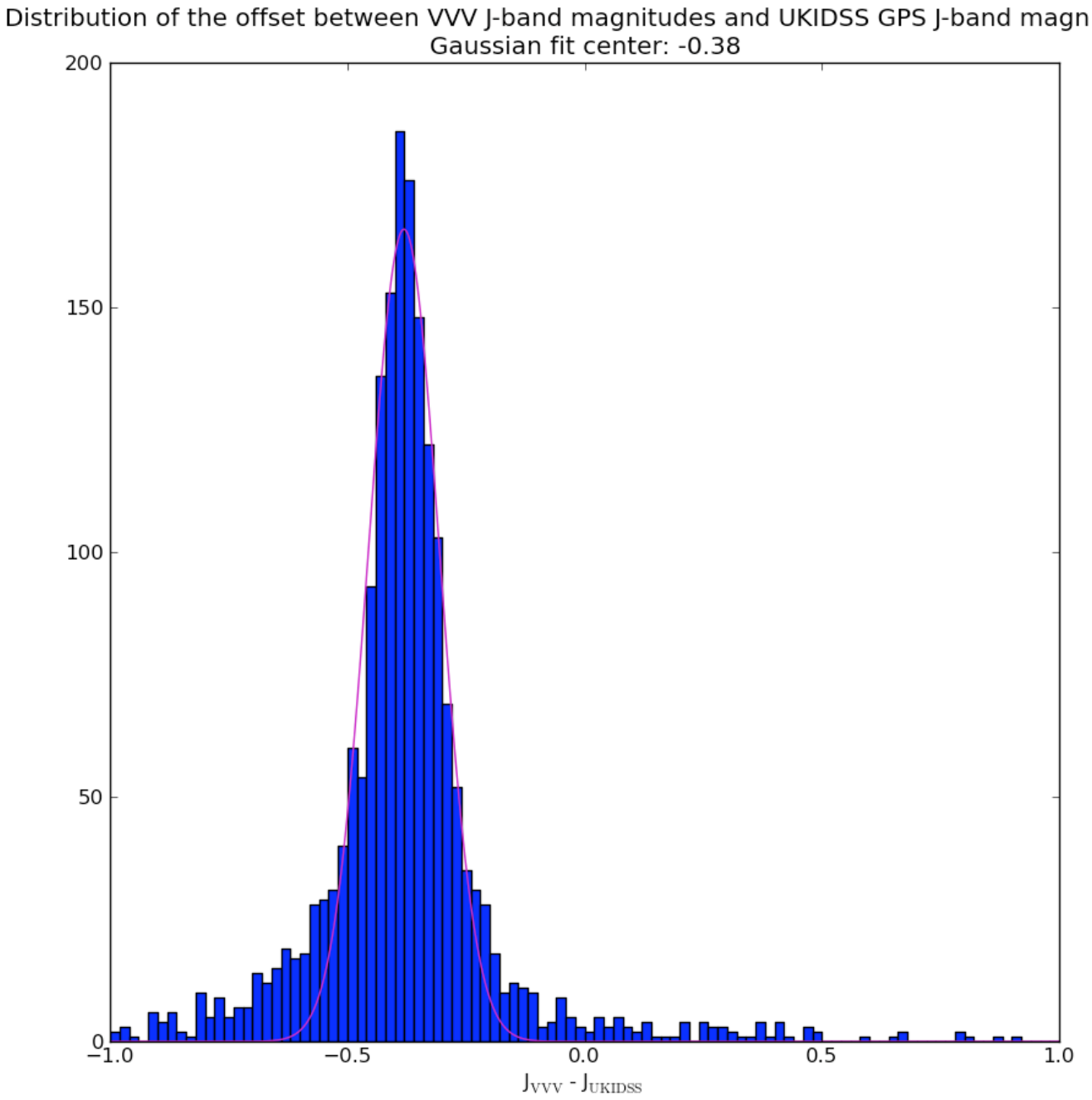
J-band

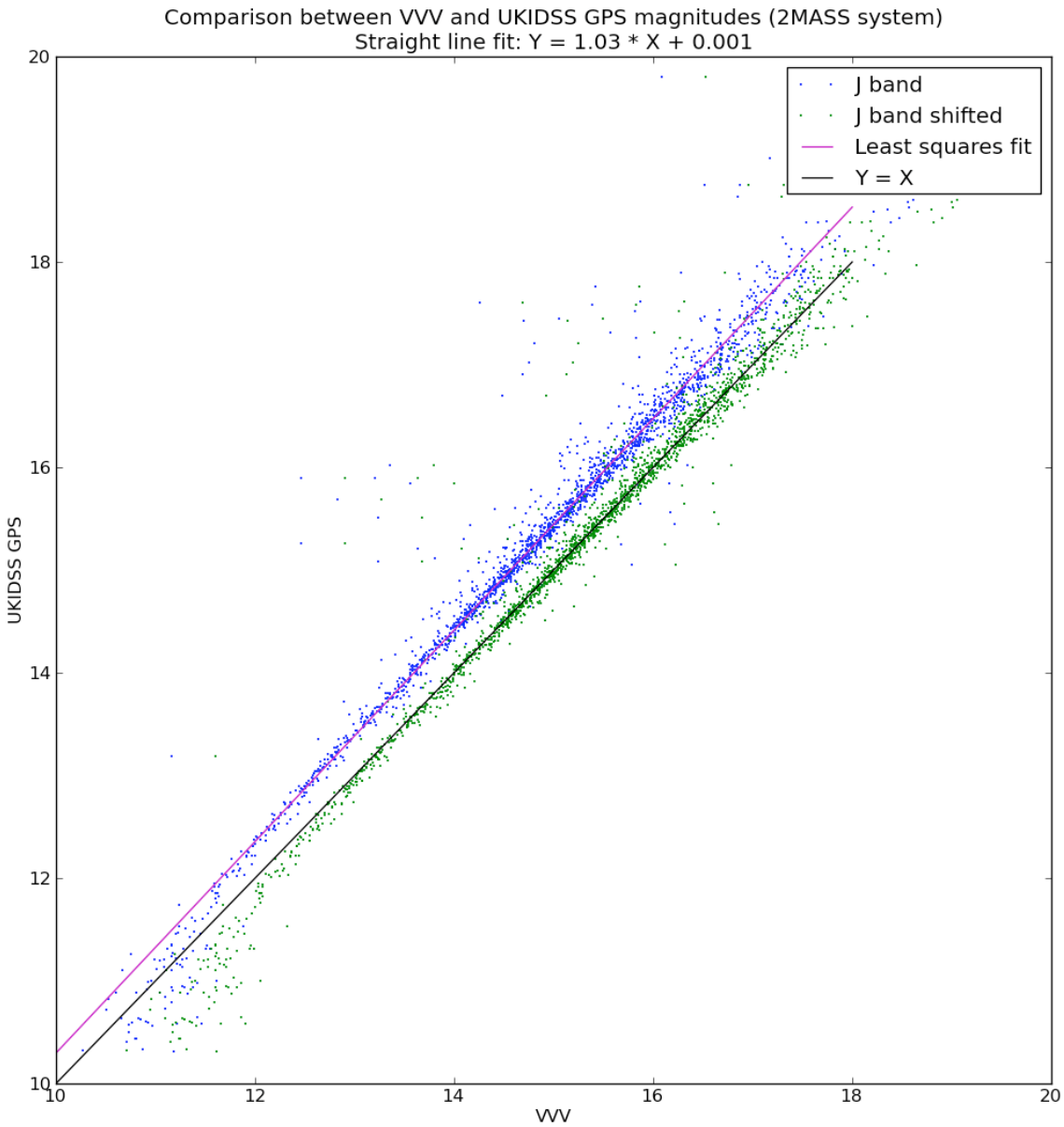




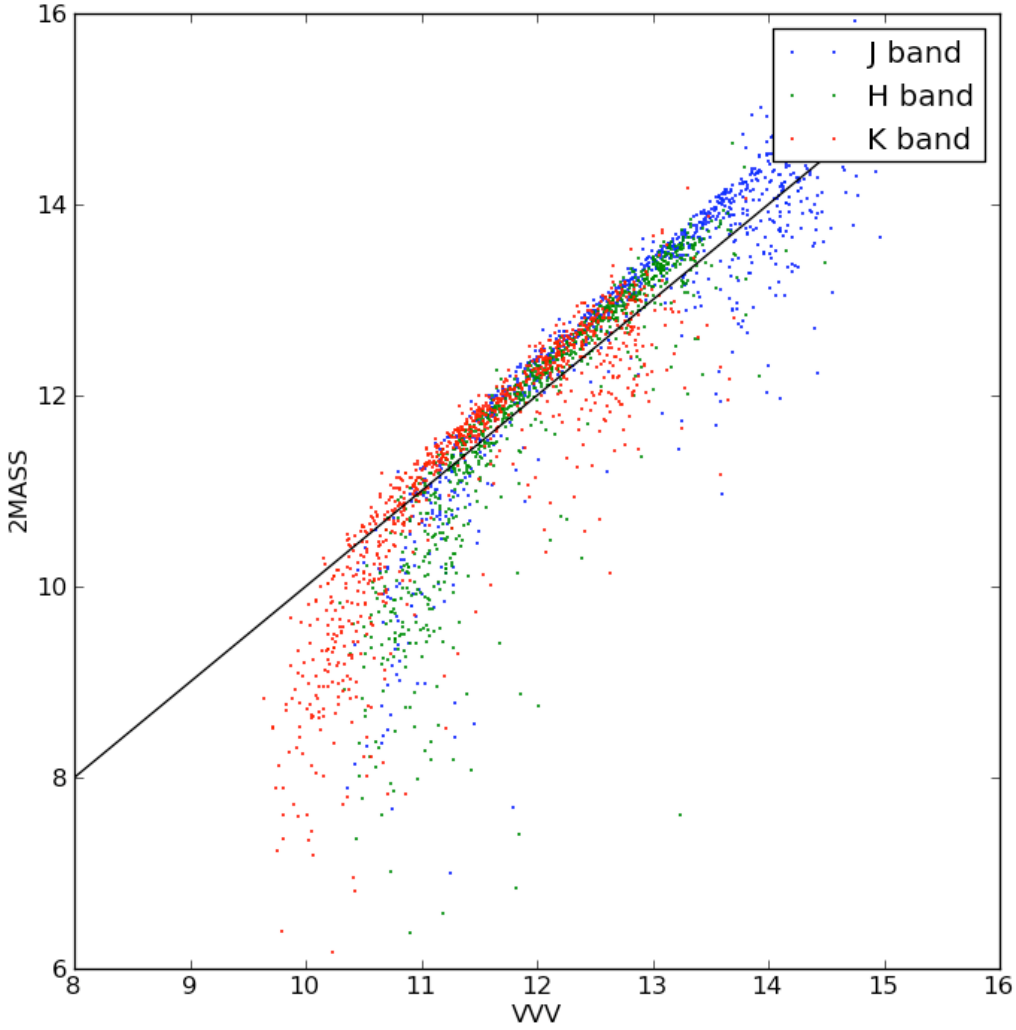
VVV vs UKIDSS



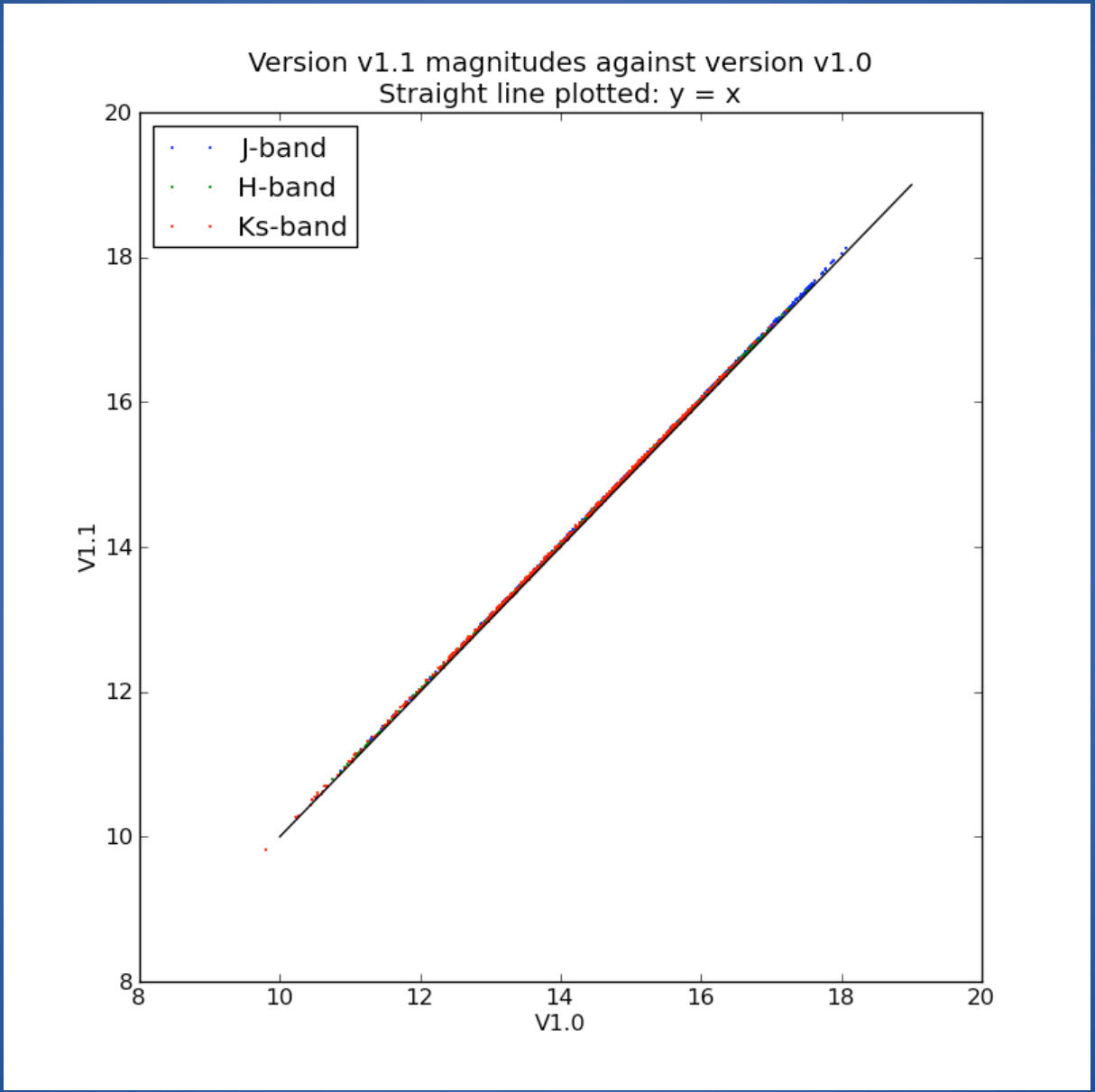

Distribution of the offset between VVV J-band magnitudes and UKIDSS GPS J-band magnitudes
Gaussian fit center: -0.38
200
150
100
50
0
−1.0
−0.5
0.0
0.5
1.0
JVVV - JUKIDSS


Comparison between VVV and UKIDSS GPS magnitudes (2MASS system)
Straight line fit: Y = 1.03 * X + 0.001
J band
J band shifted
Least squares fit
Y = X
UKIDSS GPS
VVV
10
12
14
16
18
20

VVV vs 2MASS



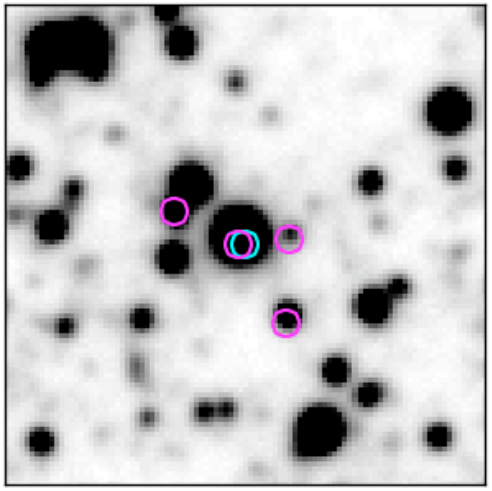
Version v1.0 vs version v1.1



Additional data

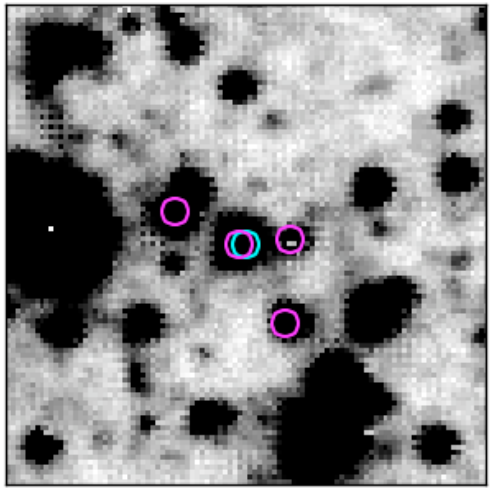
- VVV helped select the optical sources for follow-up with VIMOS (Visible MultiObject Spectrograph, on the Melipal telescope)
- Complementary Optical (r, i, Hα) Survey to GBS (R. Hynes et al), which is mainly a variability survey
- VVV will help us find eclipsers, orbital periods and eventually the variable sources within our selected objects
- SWIFT

VIMOS pre-image



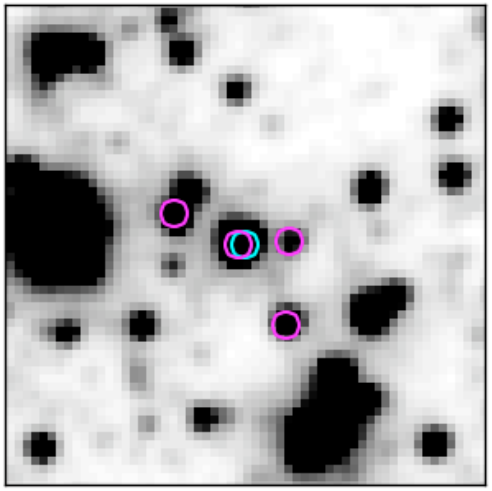
VI_SREI_544377_2011-04-08T08:52:35.675_R_Q4_lo.fits

UKIDSS K-band



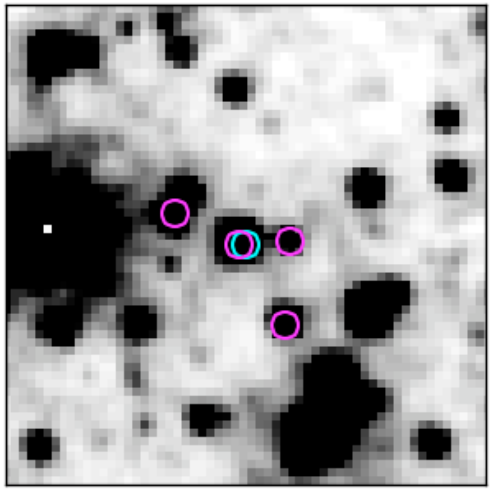
UKIDSS GPS DR6

VVV J-band



v20100327_00864

VVV Ks-band



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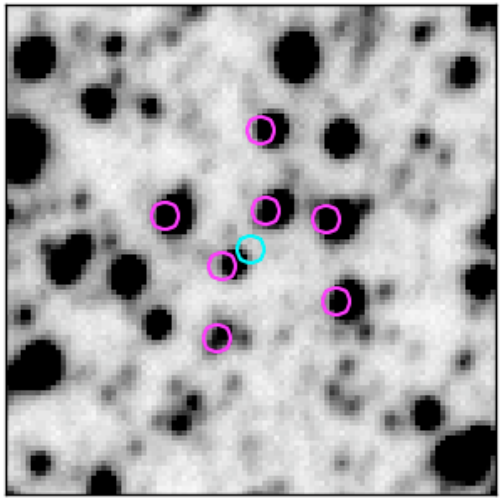
VIMOS pre-image



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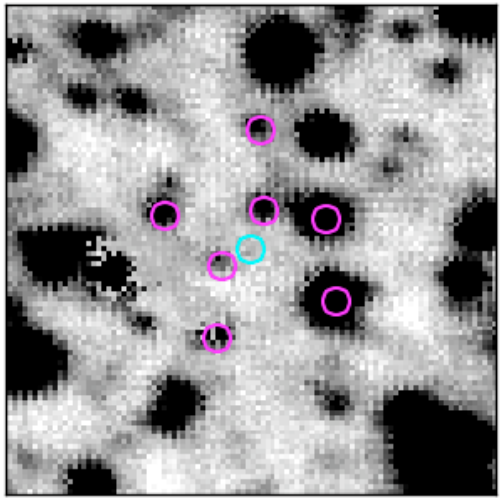
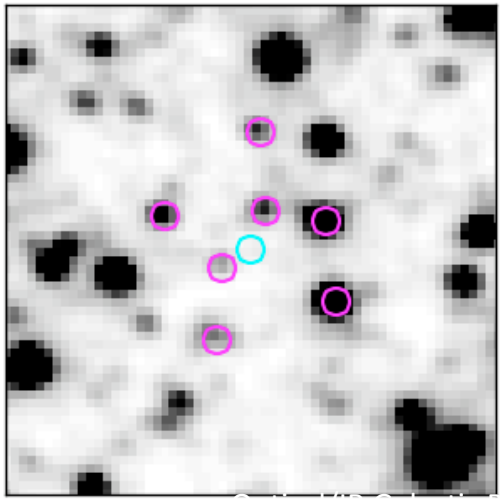
UKIDSS K-band



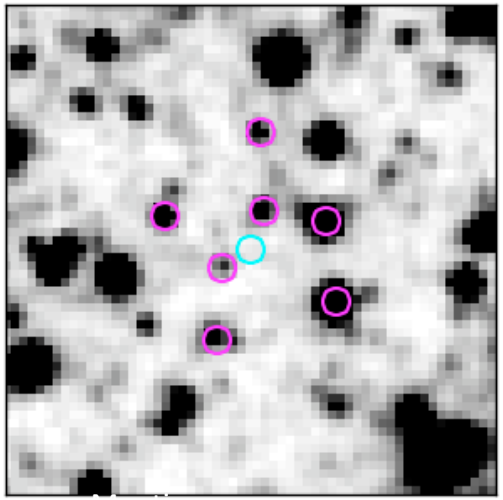
UKIDSS GPS DR6

VVV J-band



v20100407_00319

VVV Ks-band



v20100407_00307

Conclusion

- Early stages of the survey but we can see that it is a step up from previous NIR Galactic Plane surveys.
- Good coverage for now and good images
- NIR helps us the select the sources for follow-up
- Time variability (using several epochs) will help us find accreting objects, which is the main goal of the GBS
- VPHAS+ coverage will overlap with the GBS fields

THANK YOU