ESO observing programme GCAV: Galaxy Clusters At Vircam (198.A-2008, PI. M. Nonino)

Abstract

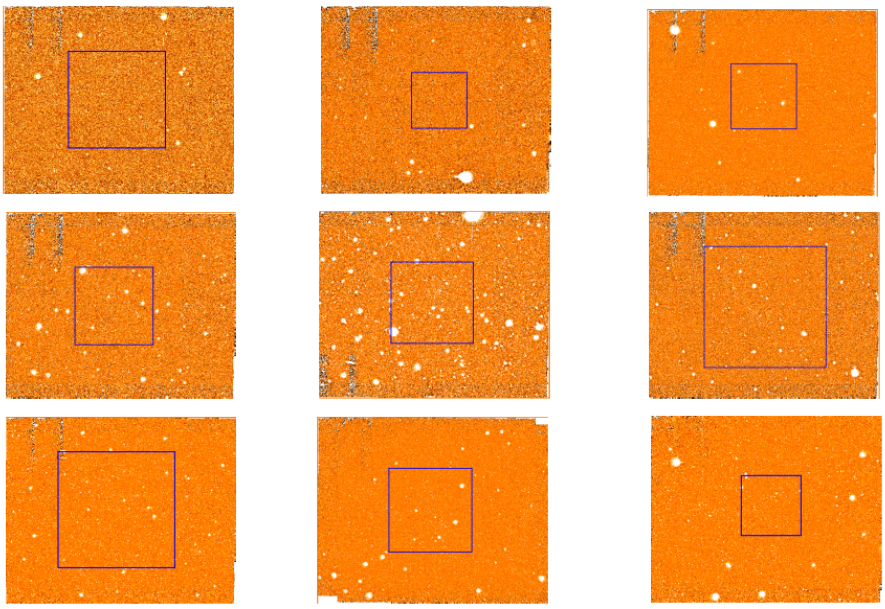
We release coadded tiles, images and related source lists, at tile level from data collected for the ESO Programme 198.A-2008 from Oct 2016 to the end of Sep 2017 with VISTA/VIRCAM in Y,J,Ks filters. The 198.A-2008 aims at observing 20 massive galaxy clusters which have also been observed during many ground based and space based (e.g. CLASH, RELICS and HFF) programs. This release concerns 9 clusters. For two clusters, RXCJ1514.9-1523 and RXCJ2129.6+0005 with complete observations during P98 and P99, deep stacks in Y,J and Ks filters with merged catalogues are also released. This is the first release of data for the 198.A-2008 Programme and contains 112 OBs (i.e. 92% of the observed OBs) collected in P98 and P99 with ESO grade A and B.

Overview of Observations

Observations for the ESO Programme 198.A-2008 are carried out in Obs mostly1hr long in Y, J and Ks, in a pattern of 6 pointed observations with on sky exposures of 48 min in Y and J and 42 min in Ks. For each single Y and J exposure, DIT is set to 30s., NDIT 2 and NJITTER 8, while for KS DIT is 10s., NDIT 6 and NJITTER 7.
With the Tile 6n offset pattern and the adopted DIT, NDIT and NJITTER most of the pixels in the coadded image at OB level receive the contribution of at least 2 observations. The area covered for each cluster is ~1.75 deg^2.

The following finding charts show the observed fields for each cluster. The box is 10 Mpc physical size (at cluster redshift, Planck cosmology, e.g. Aghanim et al. 2018).

Top row (left to right): Abell 2744, ACT-CLJ0102-49151, WHLJ24.3324-8.477, central row (l.t.r.) MACSJ0416.1-2403, PLCK G287+32.9,RXCJ1514.9-1523, bottom row (l.t.r.) RXCJ2129.6+0005, RXCJ2248.6-4431, RCS2J232727.6-020437.



Release Content

Table 1. Summary of the released images and source lists per cluster at OB level:

Cluster ID	RAJ2000,DECJ2000	Filter	N. OBs	Total exptime (sec.)	Exptime per pixel (sec.)	Psf FWHM, min:max, arcsec	MagLim (AB), min:max	Size images+source lists (Gb)
Abell 2744	00:15:30,-30:00:00	Y	4	11760	3920	0.87-1.25	23.08-23.35	-
		J	6	17280	5760	0.76-1.06	23.25-23.73	-
		Ks	5	12600	4200	0.68-0.92	22.31-22.51	100.70
ACT-CLJ0102-49151	01:02:56,-49:16:28	J	1	2880	960	1.13	22.80	-
		Ks	8	20460	6820	0.74-0.94	22.24-22.53	60.41
WHLJ24.3324-8.477		Ks	8	20160	6720	0.82-0.97	22.18-22.40	53.70
MACSJ0416.1-2403	04:16:20,-24:06:00	J	2	5760	1920	0.96-1.1	23.24-23.42	-
		Ks	2	5040	1680	0.76-0.78	22.17-22.34	26.86
PLCK G287.0+32.9	11:50:49,28:05:07	Y	5	14400	4800	0.72-0.97	23.14-23.61	-
		J	5	14400	4800	0.75-1.16	23.12-23.40	-
		Ks	4	10080	3360	0.78-1.06	22.13-22.23	94.04
RXCJ1514.9-1523	15:15:00,-15:21:23	Y	8	23040	7680	0.71-1.24	23.05-23.61	-
		J	7	20160	6720	0.76-1.27	22.90-23.70	-
		Ks	5	12600	4200	0.67-0.92	22.37-22.53	134.40
RXCJ2129.6+0005	21:29:45,00:05:00	Y	7	20160	6720	0.71-1.13	23.11-23.55	-
		J	6	17280	5760	0.88-1.02	23.00-23.37	-
		Ks	5	12600	4200	0.69-0.92	22.20-22.40	120.92
RXCJ2248.6-4431	22:48:45,-44:31:50	Y	6	17280	5760	0.70-1.02	23.22-23.82	-
		J	6	17280	5760	0.67-1.23	22.92-23.9	-
		Ks	5	12600	4200	0.79-1.02	22.26-22.45	114.16
RCS2J232727.6-020437	23:27:27,-02:04:40	J	1	2880	960	0.87	23.13	-
		Ks	6	15120	5040	0.80-1.20	22.1-22.47	46.99
							Total	752.18

N. OBs means number of released scientific image; for each image the associated weightmap and source list are also released. The Total exposure time is on sky and refers to the sum of the observed OBs, each OB being (on sky) 2880s long in Y and J and 2520s long in Ks. Psf-FWHM is for bright, unsaturated point sources.
Notice that the images have been coadded to a 0".2 pixel scale.
The following images summarize the distribution of Psf-FWHM and MagLim depths for the released tiles.

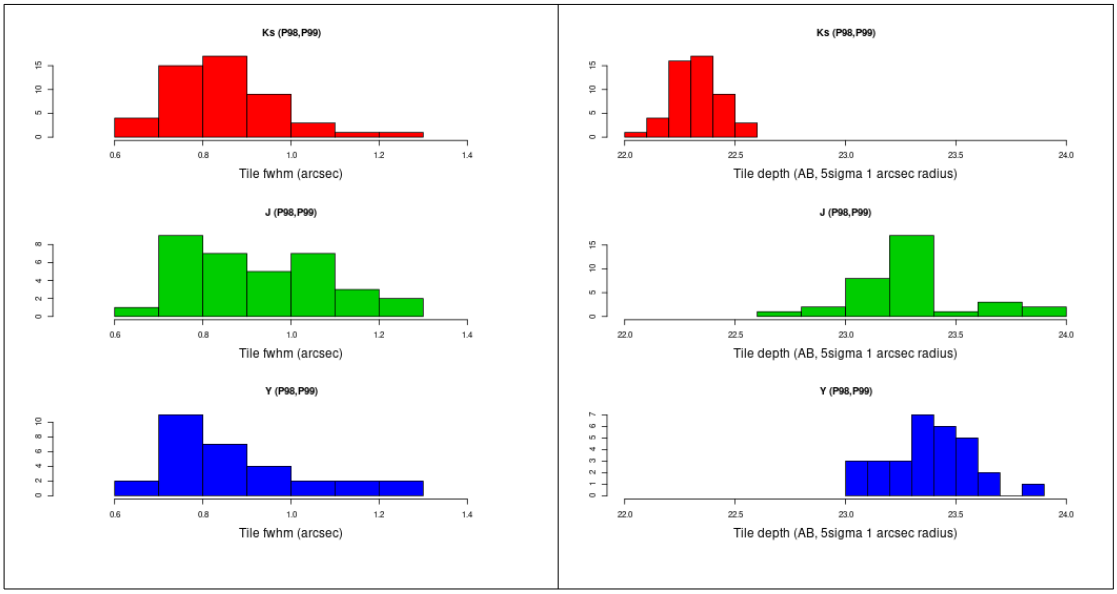


Table 2: Summary of the deep-stack images

Cluster ID	Fil-ter	Totale exp-time	Exptime/pixel	Psf FWHM (arcsec)	MagLim AB	Size images+merged catalogues (Gb)
RXCJ1514.6-1523	Y	23040	7680	0".80	23.87	-
	J	20160	6720	0".90	24.26	-
	Ks	12600	4200	0".76	23.28	-
RXCJ2129.6+0005	Y	20160	6720	0".81	24.39	-
	J	17280	5760	0".95	24.15	-
	Ks	12600	4200	0".80	23.15	-
						40.37

The limiting mag is 5 sigma within 1" radius aperture and includes aperture correction to 5" aperture radius:
MagLim = ZP -2.5*log10(5*sqrt(pi*25)*skynoise) – APCORR1

Release Notes

Data reduction has been performed with a pipeline written in Julia (www.julialang.org , version 0.6) which develops e.g. Nonino et al. 2009 , and performs the following steps:

- Dark correction, subtracting the associated dark image, created from median combination of nightly darks, and matching the DIT value of the given science exposures.
- De-striping, which removes the low-level horizontal striping due to VIRCAM detector readout electronic.
- Flat field correction, dividing by a median of twilight sky images also compensating for different gain in the different detectors.
- Creation of statics masks which flag pixels with substantial deviates in the dark and flat calibration images. These pixels are assigned weight 0.

- Astrometric solution is performed against GAIA DR2 sources (https://gea.esac.esa.int/archive), using Scamp (v2.0.4,Bertin 2006) The systematics in the coadded images are at the level of 10 mas and less, and rms ~20 mas with respect to GAIA sources. The density of used GAIA sources per VIRCAM ranges from ~100 to 500 depending upon the cluster.
- Photometry: the zero point of each coadded tile has been derived from comparison of aperture corrected magnitudes of bright but unsaturated sources with the aperture corrected magnitude from the source lists delivered by the VISTA Data Flow System (Irwin et al. 2004, Hambly et al. 2008, Cross et al., 2012). For a very detailed analysis of the VISTA photometric system, including Vega to AB conversion, we refer to Gonzales-Fernandez et al. (2018, MNRAS,474). The comparison of bright unsaturated sources results in a median and mean rms of 0.037 indicative of the limits of photometric systematics of the released data. Further comparisons of aperture corrected magnitudes against VIKING, VHS observations partly overlapping released clusters confirm this result.
- Background subtraction: this step is performed using the astrometric solutions to mask each pixel, in the dark and flat corrected images, which in the coadded stack has been mapped into a detected object. Defect such as satellite tracks have been masked with the mask incorporated in the single image weight map.
- Tile and deep stacks are obtained using a slightly modified version of Swarp (v2.19.1, Bertin et al. 2002).
- Psf obtained via PSFex (v3.9.1,Bertin, 2011).

The Astromatic tools used in the pipeline are called via shared libraries.

Data Reduction and Calibration

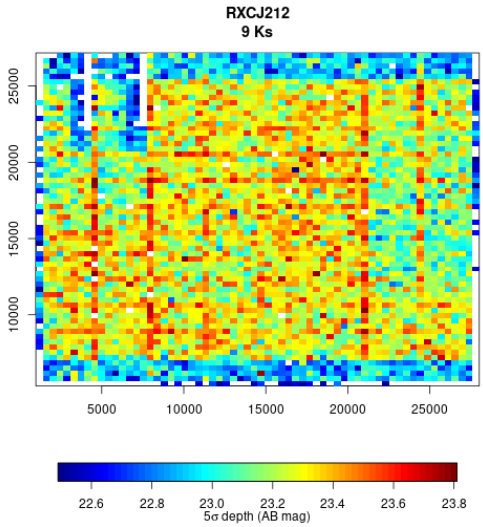
Released source lists have been obtained using Sextractor (v2.19.5, Bertin & Arnouts 1996). Purity has been preferred to completeness, in order to minimize spurious detections. Running Sextractor on the inverted images (additive inverse) result in a fraction of < .001 of spurious sources, due to noise in the image background, see also Know Issues below, for the selected parameters.
Relevant parameters:

- DETECT_MINAREA 9
- DETECT_THRESH 4
- THRESH_TYPE RELATIVE
- FILTER Y
- FILTER_NAME gauss_1.5_3x3.conv
- DEBLEND_NTHRESH 32
- DEBLEND_MINCONT 0.00005
- CLEAN Y
- CLEAN_PARAM 1
- MASK_TYPE CORRECT
- PHOT_AUTOPARAMS 2.5,3.5
- BACK_SIZE 256
- BACK_FILTERSIZE 2
- BACKPHOTO_TYPE LOCAL
- BACKPHOTO_THICK 24

Data Quality

- The astrometry has been performed using GAIA2 as reference: systematics and random errors are listed in the header of the images CSYER1, CSYER2, CRDER1, CRDER2 (units degrees).
- Adopted conversions to AB (Gonzales-Fernandez et al. 2018, D3, D4 and D6): Y_AB(+0.600), J_AB(+0.916), Ks_AB(+1.827)
- Magnitudes from aperture radii of 1",1".5,2",2".5,3",4" and PSFMag have been corrected to aperture radius 5", for each stacked tile and for the six deep-stacks.
- Magnitudes have **NOT** been corrected for Galactic extinction.

- The matched catalogues for RXCJ1514.9 and RXCJ2129 have been obtained using a matching radius of 1" (see Riccio et al 2017, PASP for matching procedure details). The two catalogues also include sources which have no matching in one or two other bands.
- In this release **No** illumination correction has been applied.
- Since purity has been preferred to depth source lists and source lists are nearly 100% complete for point sources.
- The uniformity of the MagLim, which has been obtained placing 10000 apertures over the whole images, but retaining only those not contaminated by sources, as from the segmentation map, and with all pixels having weight != 0 is exemplified in the following figure



Known issues

Varying quantum efficiency in detector 16 result in problematic regions in the coadded images as can be seen in the 5 sigma depth figure (top left region). In the current release, the most common source of spurious objects in source lists is associated with diffraction halos and filter-reflection ghosts around bright stars; these are easily recognized in the parent images since they are mostly localized around bright stars.

Previous Releases

Data Format

Files Types

The naming convention for the released data is
science image
gcav_$CLUSTER_NAME$_$FILTER$_$OBID$_$CREATION_DATE$_g2sw.fits
associated weight image
gcav_$CLUSTER_NAME$_$FILTER$_$OBID$_$CREATION_DATE$_g2sw.weight.fits
associated source source list
gcav_$CLUSTER_NAME$_$FILTER$_$OBID$_$CREATION_DATE$_g2sw_cat.fits
For the two complete clusters the science, weight map and matched catalogues are respectively
gcav_$CLUSTER$_$FILTER$_$CREATION_DATE$_g2sw.fits
gcav_$CLUSTER$_$FILTER$_$CREATION_DATE$_g2sw.weight.fits
gcav_$CLUSTER$_YJKs_cat.fits

Catalogue Columns

Table 3. Complete list of supplied columns for sources released with each tile.

No	Column Name	Column Description
1	SOURCENAME	IAU-formatted name, prefixed with “GCAV”
2	SOURCEID	Running object number
3	RA2000	Right ascension of barycenter (J2000)
4	DEC2000	Declination of barycenter (J2000)
5	MAG_AUTO	Kron-like elliptical aperture magnitude
6	MAGERR_AUTO	RMS error for Kron-like elliptical aperture magnitude
7	KRON_RADIUS	Kron aperture
8	MAG_ISO	Isophotal magnitude
9	MAGERR_ISO	RMS error for isophotal magnitude
10	MAG_APER1	Aperture corrected magnitude within 1” radius
11	MAG_APER2	Aperture corrected magnitude within 1”.5 radius
12	MAG_APER3	Aperture corrected magnitude within 2” radius
13	MAG_APER4	Aperture corrected magnitude within 2”.5 radius
14	MAG_APER5	Aperture corrected magnitude within 3” radius
15	MAG_APER6	Aperture corrected magnitude within 4” radius
16	MAG_APER7	Aperture magnitude within 5” radius
17	MAG_APER8	Aperture magnitude within 7”.5 radius
18	MAG_APER9	Aperture magnitude within 10” radius
19	MAGERR_APER1	RMS error for aperture 1
20	MAGERR_APER2	RMS error for aperture 2
21	MAGERR_APER3	RMS error for aperture 3
22	MAGERR_APER4	RMS error for aperture 4
23	MAGERR_APER5	RMS error for aperture 5
24	MAGERR_APER6	RMS error for aperture 6
25	MAGERR_APER7	RMS error for aperture 7
26	MAGERR_APER8	RMS error for aperture 8
27	MAGERR_APER9	RMS error for aperture 9
28	FRAD90	Fraction-of-light radius at 90%
29	FLAGS	Sextractor flag
30	CLASS_STAR	Sextractor Star/Galaxy classification (0-galaxy,1-star)
31	FWHM_IMAGE	FWHM assuming a gaussian core (pixels)
32	BACKGROUND	Background at centroid position
33	A_IMAGE	Isophotal major axis
34	B_IMAGE	Isophotal minor axis
35	THETA_IMAGE	Isophotal image position angle
36	MAG_PSF	Magnitude from PSF-fitting

37	MAGERR_PSF	RMS error from PSF-fitting
38	MAG_MODEL	Magnitude from model-fitting
39	MAGERR_MODEL	RMS error for model-fitting magnitude
40	SPREAD_MODEL	Spread parameter from model-fitting
41	SPREADERR_MODEL	RMS error for spread parameter from model-fitting
42	MAG_POINTSOURCE	Point source total magnitude from fitting
43	MAGERR_POINTSOURCE	RMS error for fitted point source total magnitude
44	MAG_PETRO	Petrosian-like aperture magnitude
45	MAGERR_PETRO	RMS error for Petrosian-like aperture magnitude
46	PETRO_RADIUS	Petrosian radius

Table 4. Complete list of supplied columns for sources released with deep stacks merged catalogue.

No	Column Name	Column Description
1	SOURCENAME	IAU-formatted name, prefixed with “GCAV”
2	SOURCE_ID	GCAV internal source id
3	RAJ2000	Reference Right ascension (J2000)
4	DECJ2000	Reference Declination (J2000)
5	Y_SOURCEID	Y Running object number
6	Y_RA2000	Y Right ascension of barycenter (J2000)
7	Y_DEC2000	Y Declination of barycenter (J2000)
8	Y_MAG_AUTO	Y Kron-like elliptical aperture magnitude
9	Y_MAGERR_AUTO	Y RMS error for Kron-like elliptical aperture magnitude
10	Y_KRON_RADIUS	Y Kron aperture
11	Y_MAG_ISO	Y Isophotal magnitude
12	Y_MAGERR_ISO	Y RMS error for isophotal magnitude
13	Y_MAG_APER1	Y Aperture corrected magnitude within 1” radius
14	Y_MAG_APER2	Y Aperture corrected magnitude within 1”.5 radius
15	Y_MAG_APER3	Y Aperture corrected magnitude within 2” radius
16	Y_MAG_APER4	Y Aperture corrected magnitude within 2”.5 radius
17	Y_MAG_APER5	Y Aperture corrected magnitude within 3” radius
18	Y_MAG_APER6	Y Aperture corrected magnitude within 4” radius
19	Y_MAG_APER7	Y Aperture magnitude within 5” radius
20	Y_MAG_APER8	Y Aperture magnitude within 7”.5 radius
21	Y_MAG_APER9	Y Aperture magnitude within 10” radius
22	Y_MAGERR_APER1	Y RMS error for aperture 1
23	Y_MAGERR_APER2	Y RMS error for aperture 2
24	Y_MAGERR_APER3	Y RMS error for aperture 3
25	Y_MAGERR_APER4	Y RMS error for aperture 4
26	Y_MAGERR_APER5	Y RMS error for aperture 5

27	Y_MAGERR_APER6	Y RMS error for aperture 6
28	Y_MAGERR_APER7	Y RMS error for aperture 7
29	Y_MAGERR_APER8	Y RMS error for aperture 8
30	Y_MAGERR_APER9	Y RMS error for aperture 9
31	Y_FRAD90	Y Fraction-of-light radius at 90%
32	Y_FLAGS	Y Sextractor flag
33	Y_CLASS_STAR	Y Sextractor Star/Galaxy classification (0-galaxy,1-star)
34	Y_FWHM_IMAGE	Y FWHM assuming a gaussian core (pixels)
35	Y_BACKGROUND	Y Background at centroid position
36	Y_A_IMAGE	Y Isophotal major axis
37	Y_B_IMAGE	Y Isophotal minor axis
38	Y_THETA_IMAGE	Y Isophotal image position angle
39	Y_MAG_PSF	Y Magnitude from PSF-fitting
40	Y_MAGERR_PSF	Y RMS error from PSF-fitting
41	Y_MAG_MODEL	Y Magnitude from model-fitting
42	Y_MAGERR_MODEL	Y RMS error for model-fitting magnitude
43	Y_SPREAD_MODEL	Y Spread parameter from model-fitting
44	Y_SPREADERR_MODEL	Y RMS error for spread parameter from model-fitting
45	Y_MAG_POINTSOURCE	Y Point source total magnitude from fitting
46	Y_MAGERR_POINTSOURCE	Y RMS error for fitted point source total magnitude
47	Y_MAG_PETRO	Y Petrosian-like aperture magnitude
48	Y_MAGERR_PETRO	Y RMS error for Petrosian-like aperture magnitude
49	Y_PETRO_RADIUS	Y Petrosian radius
50	J_SOURCEID	J Running object number
51	J_RA2000	J Right ascension of barycenter (J2000)
52	J_DEC2000	J Declination of barycenter (J2000)
53	J_MAG_AUTO	J Kron-like elliptical aperture magnitude
54	J_MAGERR_AUTO	J RMS error for Kron-like elliptical aperture magnitude
55	J_KRON_RADIUS	J Kron aperture
56	J_MAG_ISO	J Isophotal magnitude
57	J_MAGERR_ISO	J RMS error for isophotal magnitude
58	J_MAG_APER1	J Aperture corrected magnitude within 1” radius
59	J_MAG_APER2	J Aperture corrected magnitude within 1”.5 radius
60	J_MAG_APER3	J Aperture corrected magnitude within 2” radius
61	J_MAG_APER4	J Aperture corrected magnitude within 2”.5 radius
62	J_MAG_APER5	J Aperture corrected magnitude within 3” radius
63	J_MAG_APER6	J Aperture corrected magnitude within 4” radius
64	J_MAG_APER7	J Aperture magnitude within 5” radius
65	J_MAG_APER8	J Aperture magnitude within 7”.5 radius
66	J_MAG_APER9	J Aperture magnitude within 10” radius

67	J_MAGERR_APER1	J RMS error for aperture 1
68	J_MAGERR_APER2	J RMS error for aperture 2
69	J_MAGERR_APER3	J RMS error for aperture 3
70	J_MAGERR_APER4	J RMS error for aperture 4
71	J_MAGERR_APER5	J RMS error for aperture 5
72	J_MAGERR_APER6	J RMS error for aperture 6
73	J_MAGERR_APER7	J RMS error for aperture 7
74	J_MAGERR_APER8	J RMS error for aperture 8
75	J_MAGERR_APER9	J RMS error for aperture 9
76	J_FRAD90	J Fraction-of-light radius at 90%
77	J_FLAGS	J Sextractor flag
78	J_CLASS_STAR	J Sextractor Star/Galaxy classification (0-galaxy,1-star)
79	J_FWHM_IMAGE	J FWHM assuming a gaussian core (pixels)
80	J_BACKGROUND	J Background at centroid position
81	J_A_IMAGE	J Isophotal major axis
82	J_B_IMAGE	J Isophotal minor axis
83	J_THETA_IMAGE	J Isophotal image position angle
84	J_MAG_PSF	J Magnitude from PSF-fitting
85	J_MAGERR_PSF	J RMS error from PSF-fitting
86	J_MAG_MODEL	J Magnitude from model-fitting
87	J_MAGERR_MODEL	J RMS error for model-fitting magnitude
88	J_SPREAD_MODEL	J Spread parameter from model-fitting
89	J_SPREADERR_MODEL	J RMS error for spread parameter from model-fitting
90	J_MAG_POINTSOURCE	J Point source total magnitude from fitting
91	J_MAGERR_POINTSOURCE	J RMS error for fitted point source total magnitude
92	J_MAG_PETRO	J Petrosian-like aperture magnitude
93	J_MAGERR_PETRO	J RMS error for Petrosian-like aperture magnitude
94	J_PETRO_RADIUS	J Petrosian radius
95	Ks_SOURCEID	Ks Running object number
96	Ks_RA2000	Ks Right ascension of barycenter (J2000)
97	Ks_DEC2000	Ks Declination of barycenter (J2000)
98	Ks_MAG_AUTO	Ks Kron-like elliptical aperture magnitude
99	Ks_MAGERR_AUTO	Ks RMS error for Kron-like elliptical aperture magnitude
100	Ks_KRON_RADIUS	Ks Kron aperture
101	Ks_MAG_ISO	Ks Isophotal magnitude
102	Ks_MAGERR_ISO	Ks RMS error for isophotal magnitude
103	Ks_MAG_APER1	Ks Aperture corrected magnitude within 1” radius
104	Ks_MAG_APER2	Ks Aperture corrected magnitude within 1”.5 radius
105	Ks_MAG_APER3	Ks Aperture corrected magnitude within 2” radius

106	Ks_MAG_APER4	Ks Aperture corrected magnitude within 2".5 radius
107	Ks_MAG_APER5	Ks Aperture corrected magnitude within 3" radius
108	Ks_MAG_APER6	Ks Aperture corrected magnitude within 4" radius
109	Ks_MAG_APER7	Ks Aperture magnitude within 5" radius
110	Ks_MAG_APER8	Ks Aperture magnitude within 7".5 radius
111	Ks_MAG_APER9	Ks Aperture magnitude within 10" radius
112	Ks_MAGERR_APER1	Ks RMS error for aperture 1
113	Ks_MAGERR_APER2	Ks RMS error for aperture 2
114	Ks_MAGERR_APER3	Ks RMS error for aperture 3
115	Ks_MAGERR_APER4	Ks RMS error for aperture 4
116	Ks_MAGERR_APER5	Ks RMS error for aperture 5
117	Ks_MAGERR_APER6	Ks RMS error for aperture 6
118	Ks_MAGERR_APER7	Ks RMS error for aperture 7
119	Ks_MAGERR_APER8	Ks RMS error for aperture 8
120	Ks_MAGERR_APER9	Ks RMS error for aperture 9
121	Ks_FRAD90	Ks Fraction-of-light radius at 90%
122	Ks_FLAGS	Ks Sextractor flag
123	Ks_CLASS_STAR	Ks Sextractor Star/Galaxy classification (0-galaxy,1-stsar)
124	Ks_FWHM_IMAGE	Ks FWHM assuming a gaussian core (pixels)
125	Ks_BACKGROUND	Ks Background at centroid position
126	Ks_A_IMAGE	Ks Isophotal major axis
127	Ks_B_IMAGE	Ks Isophotal minor axis
128	Ks_THETA_IMAGE	Ks Isophotal image position angle
129	Ks_MAG_PSF	Ks Magnitude from PSF-fitting
130	Ks_MAGERR_PSF	Ks RMS error from PSF-fitting
131	Ks_MAG_MODEL	Ks Magnitude from model-fitting
132	Ks_MAGERR_MODEL	Ks RMS error for model-fitting magnitude
133	Ks_SPREAD_MODEL	Ks Spread parameter from model-fitting
134	Ks_SPREADERR_MODEL	Ks RMS error for spread parameter from model-fitting
135	Ks_MAG_POINTSOURCE	Ks Point source total magnitude from fitting
136	Ks_MAGERR_POINTSOURCE	Ks RMS error for fitted point source total magnitude
137	Ks_MAG_PETRO	Ks Petrosian-like aperture magnitude
138	Ks_MAGERR_PETRO	Ks RMS error for Petrosian-like aperture magnitude
139	Ks_PETRO_RADIUS	Ks Petrosian radius

Acknowledgements

Please use the following statement in your article when using these data:

"Based on data products created from observations collected at the European Organisation for Astronomical Research in the Southern Hemisphere under ESO programme 198.A-2008 (PI: Nonino)"