VVV Survey - ESO Phase 3 - Data Release 4

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Data Collection	VVV
Release Number	4
Data Provider	Dante Minniti
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Abstract

The VVV Survey data delivered to ESO in this end-of-survey product of the "VVV" collection includes the VISTA tile images that were processed by the Cambridge Astronomical Survey Unit (CASU). These data files were successfully uploaded via the Phase 3 to the ESO Archive before December 16, 2016. The data are from ESO programme 179.B-2002, with the VIRCAM instrument, using ZYJHKs filters, including multiple epochs in the Ks band, with total sky coverage of 560 sq deg.

Overview of Observations

This Phase 3 release contains observations from 1 October 2013 up to 15 October 2015 and some additional observations from 1-2 September 2013 and 10-11 September 2010 that had not been included in the previous release. We refer to this product as DR4. This adds to the previous release, DR3, that all the rest of the VVV data up to 30 September 2013. All the approved VVV data processed by v1.3 of the CASU pipeline, including images and merged source catalogs, have now been released.

The new data are mainly continuing time series Ks observations of the VVV area. In addition, a second epoch of contemporaneous observations in J+H+Ks and separately Z+Y were undertaken in order to provide some information on colour variability of VVV sources, adding to the multi-colour data taken near the start of the survey. In addition DR4 includes higher cadence observations of 8 tiles within the survey region. These 8 tiles have ~320 to 330 epochs each over the whole survey duration from 2010-2015, see Table 1. This compares with typically 50 to 80 epochs for the remaining 340 VVV tiles. The number is larger in the bulge region (typically ~75 epochs) and than the disk region (~55 epochs) because the bulge region was prioritised, with the aim of measuring periods of RR Lyrae stars.

The list for this Phase 4 release DR4 has 11452 tile images, adding to the 18011 in DR3. If we count these plus associated confidence maps and catalogues they are approximately 8 TB of data in uncompressed FITS format. The photometric calibration procedures for the J, H and Ks images are now believed to be highly reliable but we caution that the calibration of the Z and Y images is known to be less accurate in fields within 2 degrees of the Galactic

equator, owing to high extinction. Quality control of such a large dataset is never perfect, so visual inspection of the images is always recommended when studying individual sources.

The VVV photometric dataset is divided into different disk and bulge tiles. The tile nomenclature goes from d001 to d152 in the disk, and from b201 to b396 in the bulge. The coordinates of the tile centers are listed in Tables 1 and 2 below, for the bulge and disk, respectively. These Tables contain the tile ID, Equatorial coordinates RA and DEC (J2000), and Galactic coordinates l and b in degrees. The map with the field IDs is shown in Figures 1a and 1b, overlapped on the extinction map of the inner Milky Way from Schlegel et al. 1997.

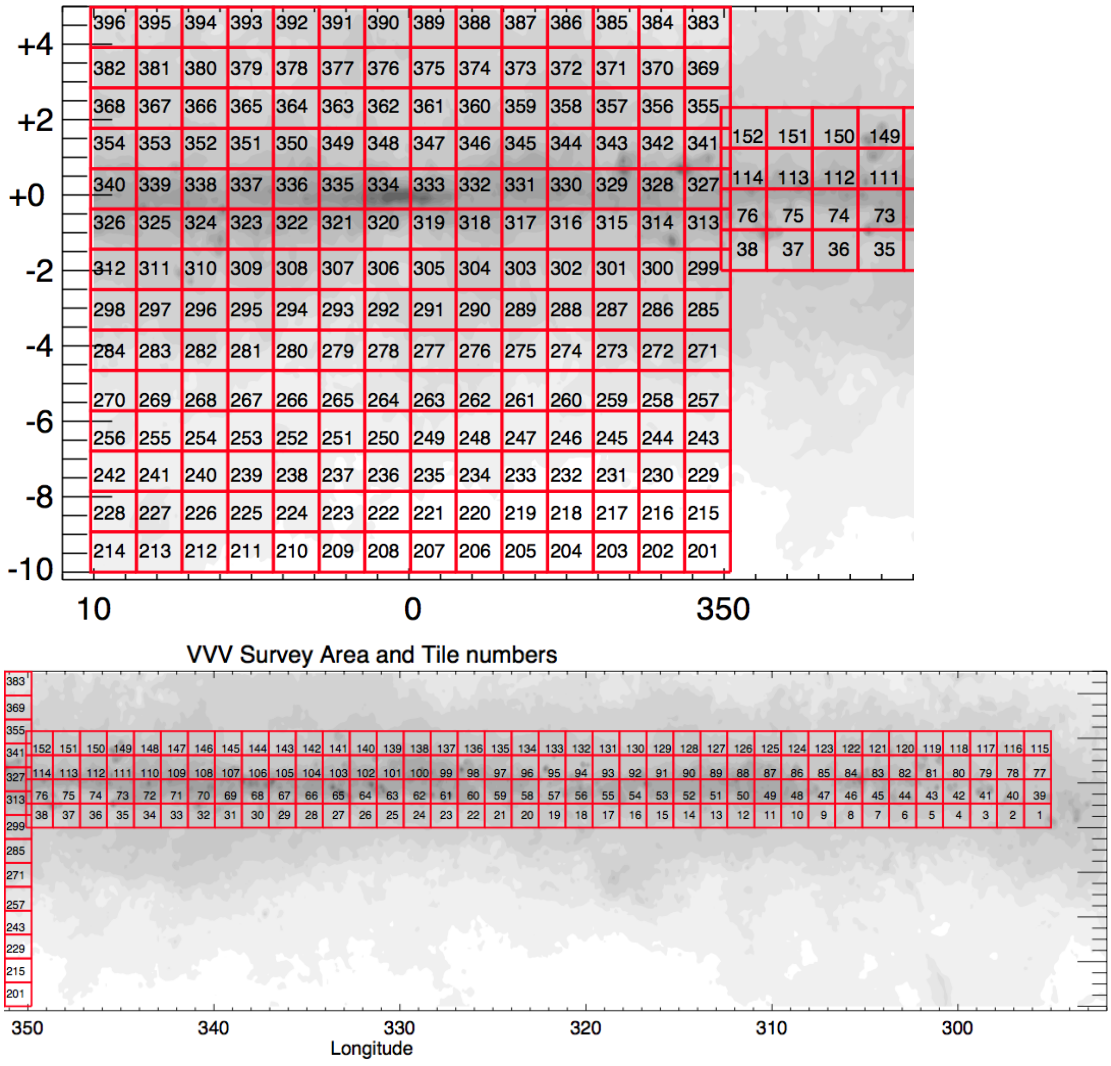

Figure 1. Maps showing the VVV tile numbers for: (a) bulge; and (b) disk.

Release Content

TABLE 1: Tile coordinates and number of epochs at end of survey

ID	RA	Dec	Longitude	Latitude	Z	Y	J	H	Ks
b201	18:04:24.77	-41:44:35.9	350.753	-9.689	2	2	2	2	77
b202	18:08:00.58	-40:27:11.5	352.231	-9.689	2	2	2	2	74
b203	18:11:29.83	-39:09:34.6	353.709	-9.688	2	2	2	2	76
b204	18:14:53.35	-37:51:45.4	355.187	-9.689	2	2	2	2	72
b205	18:18:11.50	-36:33:44.3	356.665	-9.689	2	3	2	2	71
b206	18:21:25.06	-35:15:56.9	358.138	-9.692	3	3	2	2	78
b207	18:24:33.43	-33:57:14.0	359.622	-9.688	3	3	1	1	77
b208	18:27:38.04	-32:38:48.1	1.099	-9.688	1	1	2	2	76
b209	18:30:39.00	-31:20:15.4	2.577	-9.689	2	2	2	2	76
b210	18:33:36.43	-30:01:37.2	4.055	-9.688	2	2	2	2	79
b211	18:36:30.94	-28:42:54.0	5.533	-9.689	2	2	2	2	76
b212	18:39:22.54	-27:24:06.1	7.011	-9.688	5	5	2	3	70
b213	18:42:11.74	-26:05:16.4	8.489	-9.689	4	5	2	2	76
b214	18:44:58.75	-24:46:40.1	9.963	-9.691	2	2	3	4	78
b215	17:59:16.27	-41:13:36.8	350.751	-8.596	2	2	2	2	77
b216	18:02:56.38	-39:56:49.9	352.225	-8.596	2	2	2	2	77
b217	18:06:29.88	-38:39:45.7	353.698	-8.596	2	2	2	2	75
b218	18:09:57.17	-37:22:27.8	355.172	-8.596	2	3	2	2	74
b219	18:13:19.09	-36:04:57.9	356.646	-8.596	3	3	2	2	71
b220	18:16:36.24	-34:47:28.3	358.117	-8.599	2	2	2	2	77
b221	18:19:48.00	-33:29:24.0	359.593	-8.596	3	3	2	2	79
b222	18:22:56.21	-32:11:46.0	1.061	-8.600	2	2	2	2	79
b223	18:25:59.90	-30:53:13.9	2.54	-8.596	2	2	2	2	76
b224	18:29:00.24	-29:34:58.8	4.014	-8.596	2	2	2	2	79
b225	18:31:57.79	-28:16:49.4	5.485	-8.599	3	3	2	2	75
b226	18:34:51.98	-26:58:32.5	6.956	-8.600	2	2	2	2	73
b227	18:37:43.22	-25:39:38.9	8.435	-8.596	4	5	2	2	77
b228	18:40:32.38	-24:21:03.2	9.909	-8.596	2	2	3	3	78
b229	17:54:12.86	-40:41:49.2	350.749	-7.504	3	1	2	2	74
b230	17:57:57.26	-39:25:49.8	352.216	-7.507	1	2	2	2	72
b231	18:01:34.46	-38:09:29.5	353.683	-7.508	4	4	2	2	73
b232	18:05:05.30	-36:52:20.3	355.159	-7.504	3	3	2	2	75
b233	18:08:30.67	-35:35:19.7	356.629	-7.504	2	2	2	2	76
b234	18:11:50.81	-34:18:06.5	358.098	-7.504	1	1	3	4	75
b235	18:15:06.17	-33:00:40.7	359.569	-7.504	2	2	3	3	83
b236	18:18:17.11	-31:43:05.5	1.038	-7.504	2	2	2	2	70
b237	18:21:24.00	-30:25:21.4	2.508	-7.504	2	2	2	2	73
b238	18:24:27.02	-29:07:27.5	3.978	-7.504	2	2	3	3	81
b239	18:27:26.86	-27:49:27.1	5.448	-7.504	2	2	2	2	73
b240	18:30:23.83	-26:31:33.6	6.915	-7.507	2	3	2	2	75
b241	18:33:17.42	-25:13:08.8	8.388	-7.504	2	2	2	2	73
b242	18:36:08.74	-23:54:51.5	9.858	-7.504	3	3	2	2	72
b243	17:49:14.33	-40:09:10.1	350.747	-6.412	2	2	2	2	71
b244	17:53:02.06	-38:53:33.7	352.214	-6.412	2	3	2	2	76
b245	17:56:42.70	-37:37:34.3	353.681	-6.411	3	3	2	2	71
b246	18:00:17.47	-36:21:21.6	355.147	-6.412	2	3	2	2	76
b247	18:03:46.15	-35:04:51.0	356.614	-6.412	2	2	2	2	75
b248	18:07:09.48	-33:48:06.8	358.081	-6.412	2	2	2	2	76
b249	18:10:28.22	-32:31:22.4	359.545	-6.415	2	2	3	3	83
b250	18:13:41.62	-31:13:58.4	1.014	-6.412	2	2	2	2	72
b251	18:16:51.58	-29:56:51.4	2.478	-6.415	2	2	3	3	74
b252	18:19:56.33	-28:37:50.2	3.965	-6.400	2	2	3	3	80
b253	18:22:59.30	-27:21:28.4	5.414	-6.412	3	3	2	2	75
b254	18:25:58.34	-26:03:42.1	6.881	-6.412	2	2	2	2	75

b255	18:28:54.34	-24:45:49.0	8.347	-6.412	2	2	2	2	74
b256	18:31:47.81	-23:27:48.6	9.814	-6.412	3	3	2	2	71
b257	17:44:20.50	-39:35:44.2	350.746	-5.320	2	2	2	2	77
b258	17:48:11.76	-38:20:41.6	352.21	-5.320	2	2	4	4	79
b259	17:51:55.97	-37:05:17.2	353.674	-5.320	2	2	2	3	80
b260	17:55:34.03	-35:49:48.4	355.135	-5.322	3	3	4	3	83
b261	17:59:05.57	-34:33:34.6	356.602	-5.320	2	2	3	3	81
b262	18:02:31.90	-33:17:17.2	358.066	-5.320	2	2	2	2	80
b263	18:05:53.09	-32:00:46.4	359.53	-5.320	2	2	2	2	103
b264	18:09:09.96	-30:44:13.6	0.992	-5.322	2	2	2	2	102
b265	18:12:22.20	-29:27:18.7	2.455	-5.323	2	2	2	2	81
b266	18:15:30.07	-28:09:57.2	3.922	-5.320	1	1	2	2	80
b267	18:18:34.68	-26:52:38.6	5.386	-5.320	2	2	3	3	81
b268	18:21:35.88	-25:35:11.8	6.85	-5.319	2	2	4	3	80
b269	18:24:34.08	-24:17:37.0	8.314	-5.320	2	2	4	4	75
b270	18:27:29.54	-22:59:55.7	9.778	-5.320	2	2	2	2	76
b271	17:39:31.66	-39:01:31.1	350.745	-4.228	2	2	2	2	73
b272	17:43:25.99	-37:47:04.2	352.206	-4.228	2	2	2	2	74
b273	17:47:13.73	-36:32:26.9	353.666	-4.231	2	2	2	2	80
b274	17:50:54.10	-35:17:02.4	355.13	-4.228	2	2	2	3	79
b275	17:54:28.85	-34:01:31.1	356.592	-4.228	2	2	2	2	80
b276	17:57:57.94	-32:45:42.8	358.054	-4.228	3	3	7	7	87
b277	18:01:21.89	-31:29:38.8	359.516	-4.228	3	3	8	9	87
b278	18:04:40.94	-30:13:18.5	0.978	-4.227	2	2	2	2	84
b279	18:07:55.66	-28:56:44.9	2.44	-4.228	2	2	2	2	82
b280	18:11:06.19	-27:39:59.0	3.902	-4.227	3	3	2	3	81
b281	18:14:13.06	-26:23:02.4	5.364	-4.228	2	2	2	2	81
b282	18:17:16.37	-25:05:55.0	6.826	-4.227	2	3	3	3	78
b283	18:20:16.56	-23:48:39.2	8.287	-4.228	2	2	2	3	76
b284	18:23:13.80	-22:31:13.8	9.749	-4.227	2	3	2	2	77
b285	17:34:47.71	-38:26:47.0	350.741	-3.138	2	2	3	3	82
b286	17:38:44.71	-37:12:41.4	352.204	-3.135	2	2	2	2	81
b287	17:42:34.97	-35:58:24.6	353.664	-3.136	2	3	3	3	80
b288	17:46:18.55	-34:43:43.7	355.125	-3.135	2	2	3	3	82
b289	17:49:55.99	-33:28:41.9	356.585	-3.135	2	2	2	2	79
b290	17:53:27.67	-32:13:22.4	358.045	-3.135	2	3	3	2	78
b291	17:56:54.07	-30:57:43.2	359.505	-3.135	1	1	2	3	80
b292	18:00:15.70	-29:41:49.2	0.966	-3.136	2	2	2	3	79
b293	18:03:32.93	-28:25:51.2	2.424	-3.138	2	2	2	2	325
b294	18:06:45.43	-27:09:14.8	3.886	-3.135	3	3	2	2	327
b295	18:09:54.41	-25:52:38.3	5.347	-3.136	3	3	2	2	318
b296	18:12:59.69	-24:35:50.6	6.807	-3.135	2	3	3	3	321
b297	18:16:01.78	-23:18:52.6	8.268	-3.135	2	2	2	2	74
b298	18:19:00.72	-22:01:45.5	9.728	-3.135	5	4	2	2	74
b299	17:30:08.04	-37:51:07.2	350.74	-2.046	2	2	3	3	82
b300	17:34:07.87	-36:37:36.5	352.202	-2.043	2	3	2	2	82
b301	17:38:00.94	-35:24:04.3	353.659	-2.046	2	2	3	3	83
b302	17:41:46.90	-34:09:41.4	355.121	-2.043	2	2	2	3	81
b303	17:45:26.88	-32:55:09.8	356.58	-2.043	1	1	2	2	81
b304	17:49:01.30	-31:40:29.6	358.037	-2.046	2	2	2	2	79
b305	17:52:29.86	-30:25:03.4	359.499	-2.043	3	3	3	2	81
b306	17:55:53.66	-29:09:32.8	0.958	-2.043	2	2	2	2	79
b307	17:59:12.86	-27:53:46.7	2.417	-2.043	3	3	2	2	328
b308	18:02:27.65	-26:37:45.1	3.876	-2.043	3	3	2	2	335
b309	18:05:38.57	-25:21:28.8	5.336	-2.043	3	4	2	2	321
b310	18:08:45.82	-24:05:00.6	6.795	-2.043	3	3	2	2	320
b311	18:11:49.68	-22:48:19.8	8.254	-2.043	2	2	3	2	73
b312	18:14:50.18	-21:31:34.0	9.712	-2.043	4	7	2	2	72
b313	17:25:32.76	-37:14:32.6	350.743	-0.951	2	2	2	2	76

b314	17:29:35.30	-36:01:46.6	352.202	-0.951	2	2	2	2	74
b315	17:33:30.62	-34:48:34.6	353.660	-0.951	2	2	2	2	83
b316	17:37:19.27	-33:34:56.6	355.119	-0.951	2	2	2	2	83
b317	17:41:01.49	-32:20:52.4	356.578	-0.951	2	2	2	2	82
b318	17:44:38.18	-31:06:50.8	358.031	-0.955	2	2	2	2	80
b319	17:48:09.05	-29:51:40.3	359.495	-0.951	3	3	7	6	88
b320	17:51:34.97	-28:36:34.6	0.954	-0.951	2	2	2	2	83
b321	17:54:56.16	-27:21:10.4	2.412	-0.951	2	3	2	2	82
b322	17:58:13.01	-26:05:30.1	3.871	-0.951	3	3	2	2	82
b323	18:01:25.82	-24:49:35.0	5.33	-0.951	2	3	2	2	80
b324	18:04:34.78	-23:33:24.5	6.789	-0.951	2	3	2	2	78
b325	18:07:40.30	-22:17:01.3	8.247	-0.951	4	3	3	3	78
b326	18:10:42.89	-21:00:51.1	9.701	-0.955	3	4	2	2	78
b327	17:21:02.45	-36:37:42.6	350.74	0.139	2	2	2	2	78
b328	17:25:07.06	-35:25:19.6	352.201	0.141	2	2	2	4	80
b329	17:29:04.68	-34:12:39.2	353.66	0.141	3	3	2	4	83
b330	17:32:55.51	-32:59:30.1	355.119	0.141	2	3	2	4	83
b331	17:36:39.58	-31:46:10.6	356.573	0.14	2	2	3	3	81
b332	17:40:18.53	-30:31:55.9	358.036	0.141	2	2	2	3	81
b333	17:43:51.58	-29:17:34.4	359.495	0.141	2	2	2	2	96
b334	17:47:19.25	-28:03:06.8	0.95	0.140	2	2	2	2	92
b335	17:50:42.70	-26:47:51.4	2.412	0.141	2	2	2	2	81
b336	17:54:01.39	-25:32:31.6	3.871	0.141	2	2	2	2	81
b337	17:57:15.93	-24:16:56.2	5.33	0.141	2	2	3	4	83
b338	18:00:26.54	-23:01:04.4	6.789	0.141	2	2	3	4	82
b339	18:03:33.72	-21:44:59.6	8.247	0.141	2	2	3	3	77
b340	18:06:37.80	-20:28:54.5	9.703	0.138	2	2	2	2	76
b341	17:16:36.05	-35:59:49.6	350.743	1.233	2	2	2	2	91
b342	17:20:43.01	-34:48:12.6	352.202	1.233	2	2	2	2	91
b343	17:24:42.67	-33:36:03.2	353.661	1.233	2	2	2	2	83
b344	17:28:35.52	-32:23:24.0	355.12	1.233	2	2	2	2	87
b345	17:32:22.06	-31:10:16.3	356.58	1.233	2	2	2	2	78
b346	17:36:02.66	-29:56:44.5	358.039	1.233	2	2	2	2	77
b347	17:39:37.82	-28:43:00.5	359.496	1.231	2	2	2	2	73
b348	17:43:07.42	-27:28:28.6	0.958	1.233	2	2	2	2	75
b349	17:46:32.38	-26:13:50.5	2.417	1.233	2	2	4	4	82
b350	17:49:52.70	-24:58:52.0	3.876	1.233	2	2	3	3	81
b351	17:53:09.14	-23:43:49.1	5.333	1.231	2	2	2	2	81
b352	17:56:21.43	-22:28:16.7	6.792	1.230	2	2	2	2	82
b353	17:59:29.74	-21:12:13.7	8.254	1.233	2	2	2	2	77
b354	18:02:34.99	-19:56:09.6	9.714	1.233	4	4	2	2	79
b355	17:12:14.18	-35:21:31.3	350.744	2.326	2	2	5	7	80
b356	17:16:23.06	-34:10:28.2	352.204	2.325	2	2	3	3	83
b357	17:20:24.62	-32:58:48.7	353.664	2.326	2	2	2	2	79
b358	17:24:19.42	-31:46:38.6	355.124	2.325	2	2	2	2	79
b359	17:28:07.75	-30:33:59.4	356.585	2.326	2	2	4	3	83
b360	17:31:50.21	-29:20:53.5	358.045	2.325	2	2	2	2	79
b361	17:35:26.93	-28:07:21.7	359.505	2.325	2	2	2	2	77
b362	17:38:58.51	-26:53:25.1	0.966	2.325	2	2	2	2	79
b363	17:42:25.06	-25:39:06.5	2.426	2.326	3	3	2	2	77
b364	17:45:47.14	-24:24:29.5	3.887	2.325	3	3	2	2	77
b365	17:49:04.75	-23:09:32.4	5.347	2.325	2	3	2	2	81
b366	17:52:18.50	-21:54:17.3	6.807	2.325	3	3	3	2	82
b367	17:55:28.46	-20:38:44.9	8.267	2.325	3	3	3	3	74
b368	17:58:35.09	-19:22:55.9	9.728	2.325	3	3	2	3	74
b369	17:07:56.47	-34:42:39.6	350.744	3.418	2	2	5	6	85
b370	17:12:07.25	-33:32:07.1	352.206	3.417	2	2	3	3	84
b371	17:16:10.39	-32:20:58.6	353.668	3.418	2	2	2	3	82
b372	17:20:06.86	-31:09:18.4	355.129	3.418	2	2	2	2	83

b373	17:23:57.19	-29:57:20.5	356.589	3.415	2	2	3	3	83
b374	17:27:41.02	-28:44:24.0	358.054	3.418	2	2	3	4	83
b375	17:31:19.56	-27:31:17.8	359.515	3.417	2	2	2	2	80
b376	17:34:52.54	-26:17:43.4	0.977	3.418	2	2	2	2	84
b377	17:38:20.59	-25:03:49.7	2.439	3.418	2	2	2	2	79
b378	17:41:44.26	-23:49:28.2	3.901	3.418	2	3	2	2	79
b379	17:45:03.46	-22:34:49.4	5.363	3.418	2	2	2	2	81
b380	17:48:18.48	-21:19:51.6	6.825	3.418	2	2	2	2	81
b381	17:51:29.81	-20:04:35.0	8.287	3.418	3	3	3	3	76
b382	17:54:37.66	-18:49:01.6	9.749	3.418	3	3	3	3	77
b383	17:03:42.94	-34:03:25.2	350.743	4.507	2	2	2	3	91
b384	17:07:55.03	-32:53:12.5	352.209	4.510	2	2	2	2	91
b385	17:11:59.88	-31:42:33.1	353.673	4.510	2	2	2	2	89
b386	17:15:57.96	-30:31:19.9	355.137	4.510	2	2	2	2	87
b387	17:19:49.25	-29:19:48.0	356.597	4.509	2	2	2	2	78
b388	17:23:35.30	-28:07:18.8	358.065	4.510	2	2	2	3	80
b389	17:27:15.26	-26:54:33.5	359.53	4.510	2	2	2	2	74
b390	17:30:45.46	-25:43:04.8	0.961	4.508	2	2	2	2	75
b391	17:34:15.58	-24:29:12.8	2.43	4.510	2	2	2	2	80
b392	17:37:40.80	-23:15:26.6	3.891	4.507	2	2	4	4	82
b393	17:41:01.09	-22:00:52.5	5.358	4.510	3	3	2	2	80
b394	17:44:17.50	-20:46:11.3	6.822	4.510	2	2	2	2	79
b395	17:47:30.12	-19:31:10.9	8.286	4.510	2	2	2	2	78
b396	17:50:39.17	-18:15:53.3	9.75	4.510	4	4	2	2	78
d001	11:43:27.74	-63:31:38.3	295.443	-1.648	2	2	2	2	65
d002	11:56:15.41	-63:52:19.9	296.902	-1.648	3	2	2	2	62
d003	12:09:20.18	-64:08:44.5	298.361	-1.648	2	2	2	2	56
d004	12:22:38.06	-64:20:44.2	299.82	-1.648	2	2	2	2	55
d005	12:36:05.54	-64:28:13.4	301.279	-1.648	4	3	2	2	57
d006	12:49:38.06	-64:31:10.2	302.738	-1.648	2	2	2	2	54
d007	13:03:11.21	-64:29:27.6	304.197	-1.648	2	2	2	2	57
d008	13:16:40.42	-64:23:10.7	305.656	-1.648	2	2	2	2	55
d009	13:30:01.27	-64:12:21.6	307.115	-1.648	7	7	2	2	60
d010	13:43:07.58	-63:57:24.8	308.569	-1.652	3	2	2	2	58
d011	13:56:02.26	-63:37:32.7	310.033	-1.648	2	2	2	2	53
d012	14:08:35.52	-63:13:49.8	311.492	-1.648	2	2	2	2	53
d013	14:20:47.04	-62:46:08.5	312.951	-1.648	2	2	4	4	52
d014	14:32:34.58	-62:14:40.9	314.41	-1.648	2	2	3	4	52
d015	14:43:42.53	-61:40:42.2	315.836	-1.652	2	2	4	4	57
d016	14:54:39.50	-61:02:24.0	317.295	-1.652	2	2	4	6	56
d017	15:05:10.61	-60:20:37.0	318.759	-1.648	2	2	4	4	58
d018	15:15:13.66	-59:36:15.5	320.218	-1.648	2	4	2	2	52
d019	15:24:50.21	-58:49:11.6	321.677	-1.648	2	2	8	8	58
d020	15:34:00.86	-57:59:37.7	323.136	-1.648	3	2	8	8	57
d021	15:42:46.42	-57:07:46.9	324.595	-1.648	2	2	2	2	57
d022	15:51:07.87	-56:13:46.2	326.054	-1.648	2	2	3	3	58
d023	15:59:06.12	-55:17:47.8	327.513	-1.648	2	2	2	2	60
d024	16:06:42.36	-54:20:02.0	328.972	-1.648	2	2	3	3	59
d025	16:13:57.77	-53:20:48.1	330.429	-1.651	2	3	2	2	50
d026	16:20:53.06	-52:19:59.5	331.885	-1.652	2	3	2	2	49
d027	16:27:30.36	-51:17:13.9	333.349	-1.648	3	3	4	3	52
d028	16:33:50.04	-50:13:47.6	334.805	-1.651	2	2	2	2	53
d029	16:39:53.11	-49:08:42.0	336.267	-1.648	2	2	2	2	62
d030	16:45:40.30	-48:02:59.6	337.722	-1.650	2	2	3	3	61
d031	16:51:14.42	-46:55:46.9	339.185	-1.648	2	2	2	2	54
d032	16:56:33.77	-45:48:07.9	340.640	-1.649	2	2	2	2	54
d033	17:01:41.93	-44:39:08.6	342.103	-1.648	2	3	2	2	54
d034	17:06:37.75	-43:29:37.0	343.562	-1.648	3	3	2	2	53
d035	17:11:22.70	-42:19:22.8	345.021	-1.649	4	4	2	2	60

d036	17:15:57.60	-41:08:39.1	346.478	-1.651	2	2	2	2	62
d037	17:20:22.10	-39:57:08.3	347.935	-1.650	2	2	2	2	55
d038	17:24:38.88	-38:44:46.3	349.398	-1.648	2	2	2	2	53
d039	11:45:55.20	-62:28:16.3	295.442	-0.556	2	2	4	4	64
d040	11:58:16.78	-62:48:13.0	296.901	-0.556	2	2	2	2	63
d041	12:10:50.64	-63:04:13.4	298.355	-0.560	2	2	2	2	55
d042	12:23:39.43	-63:15:48.6	299.813	-0.560	2	2	2	2	54
d043	12:36:36.00	-63:23:01.7	301.271	-0.560	2	1	2	2	53
d044	12:49:41.07	-63:25:37.0	302.736	-0.556	2	2	2	2	51
d045	13:02:43.30	-63:23:59.6	304.195	-0.556	2	2	2	2	56
d046	13:15:41.95	-63:17:57.8	305.653	-0.556	2	2	2	2	54
d047	13:28:33.10	-63:07:34.3	307.112	-0.556	5	5	2	2	59
d048	13:41:13.61	-62:52:53.0	308.571	-0.556	4	5	2	2	58
d049	13:53:39.77	-62:34:01.2	310.03	-0.556	2	2	2	2	52
d050	14:05:48.53	-62:11:10.0	311.488	-0.556	2	2	2	2	52
d051	14:17:37.68	-61:44:25.4	312.947	-0.556	2	2	2	2	52
d052	14:29:05.40	-61:14:00.2	314.405	-0.556	2	2	2	2	52
d053	14:40:10.13	-60:40:06.2	315.864	-0.556	2	2	3	3	60
d054	14:50:49.58	-60:03:15.5	317.318	-0.560	2	2	3	3	56
d055	15:01:07.25	-59:22:36.8	318.781	-0.556	2	2	3	4	55
d056	15:10:58.73	-58:39:26.6	320.24	-0.556	3	3	2	2	53
d057	15:20:25.78	-57:53:35.2	321.699	-0.556	2	2	2	2	55
d058	15:29:28.82	-57:05:14.3	323.157	-0.556	2	2	7	7	56
d059	15:38:08.11	-56:14:31.9	324.616	-0.556	2	2	2	2	55
d060	15:46:24.77	-55:21:42.1	326.075	-0.556	2	2	2	2	54
d061	15:54:19.25	-54:26:52.1	327.533	-0.556	2	2	2	2	59
d062	16:01:52.94	-53:30:13.0	328.992	-0.556	2	2	3	3	60
d063	16:09:06.70	-52:31:50.9	330.451	-0.556	2	2	3	3	52
d064	16:16:01.46	-51:31:56.3	331.909	-0.556	2	2	2	2	53
d065	16:22:38.40	-50:30:35.6	333.368	-0.556	2	3	3	3	51
d066	16:28:58.06	-49:28:17.4	334.821	-0.560	2	2	3	3	53
d067	16:35:02.30	-48:24:11.9	336.283	-0.559	2	2	2	2	59
d068	16:40:51.17	-47:19:19.2	337.739	-0.560	2	2	3	3	57
d069	16:46:26.50	-46:13:04.8	339.2	-0.559	2	2	3	3	55
d070	16:51:48.14	-45:05:46.0	340.661	-0.556	2	2	2	2	55
d071	16:56:57.60	-43:58:13.1	342.115	-0.560	3	2	2	2	54
d072	17:01:55.61	-42:49:02.6	343.579	-0.556	2	2	2	2	51
d073	17:06:42.65	-41:39:30.6	345.037	-0.556	2	4	2	2	60
d074	17:11:19.82	-40:29:29.8	346.493	-0.559	2	2	2	2	60
d075	17:15:47.26	-39:18:45.0	347.95	-0.560	2	2	2	2	54
d076	17:20:06.07	-38:07:05.5	349.411	-0.559	2	2	3	3	57
d077	11:48:12.67	-61:24:46.4	295.442	0.536	2	2	3	3	62
d078	12:00:07.22	-61:44:12.5	296.896	0.532	2	2	2	2	57
d079	12:12:21.34	-61:59:17.2	298.36	0.536	2	2	2	2	60
d080	12:24:43.03	-62:10:26.4	299.819	0.536	2	2	2	2	60
d081	12:37:12.10	-62:17:23.3	301.278	0.536	2	2	3	4	54
d082	12:49:45.38	-62:20:06.0	302.737	0.536	2	2	3	3	57
d083	13:02:16.94	-62:18:36.0	304.191	0.535	2	2	3	3	64
d084	13:14:47.59	-62:12:47.9	305.65	0.535	2	2	2	2	56
d085	13:27:11.52	-62:02:46.3	307.109	0.535	2	2	2	2	65
d086	13:39:26.02	-61:48:36.7	308.568	0.535	2	2	2	2	62
d087	13:51:29.40	-61:30:19.1	310.031	0.536	2	2	2	2	60
d088	14:03:15.41	-61:08:11.4	311.49	0.536	5	5	2	3	56
d089	14:14:43.73	-60:42:19.1	312.949	0.536	2	2	2	2	58
d090	14:25:52.27	-60:12:52.4	314.407	0.536	2	2	2	2	55
d091	14:36:40.32	-59:39:59.8	315.867	0.536	2	2	3	3	56
d092	14:47:04.90	-59:04:13.8	317.32	0.532	3	3	2	1	53
d093	14:57:09.62	-58:24:42.5	318.784	0.536	2	2	2	2	57
d094	15:06:50.26	-57:42:41.4	320.243	0.536	2	2	2	2	55

d095	15:16:06.77	-56:58:09.8	321.698	0.535	2	2	2	2	58
d096	15:25:02.11	-56:10:59.2	323.157	0.535	2	2	2	2	58
d097	15:33:35.40	-55:21:27.7	324.616	0.535	2	2	2	2	55
d098	15:41:48.34	-54:29:34.1	326.079	0.536	2	2	3	3	59
d099	15:49:39.29	-53:35:52.4	327.538	0.536	2	2	2	2	61
d100	15:57:10.15	-52:40:18.1	328.996	0.536	3	3	3	3	55
d101	16:04:22.06	-51:43:01.6	330.455	0.536	2	2	2	2	69
d102	16:11:15.77	-50:44:08.2	331.914	0.536	2	2	2	2	63
d103	16:17:52.18	-49:43:47.3	333.373	0.536	5	5	2	2	55
d104	16:24:11.50	-48:42:18.0	334.828	0.535	2	2	4	4	55
d105	16:30:16.87	-47:39:04.3	336.291	0.536	2	2	2	2	52
d106	16:36:06.91	-46:34:55.6	337.750	0.536	2	2	2	3	53
d107	16:41:43.13	-45:29:39.8	339.209	0.536	3	3	3	3	59
d108	16:47:06.43	-44:23:26.9	340.667	0.536	3	3	3	3	59
d109	16:52:17.66	-43:16:15.6	342.126	0.536	2	2	3	3	58
d110	16:57:17.59	-42:08:13.2	343.586	0.536	2	2	2	2	51
d111	17:02:06.58	-40:59:24.7	345.044	0.536	2	2	2	2	52
d112	17:06:45.65	-39:49:50.2	346.503	0.536	2	2	5	5	54
d113	17:11:15.31	-38:39:35.6	347.962	0.536	2	2	2	2	52
d114	17:15:36.19	-37:28:41.9	349.421	0.536	2	2	2	2	53
d115	11:50:21.26	-60:21:07.9	295.443	1.628	2	2	2	2	59
d116	12:01:56.33	-60:39:45.4	296.902	1.628	2	2	2	2	58
d117	12:13:43.66	-60:54:30.2	298.362	1.628	2	2	2	2	57
d118	12:25:40.25	-61:05:15.7	299.821	1.628	2	2	2	2	57
d119	12:37:43.90	-61:11:58.2	301.281	1.628	2	2	4	4	55
d120	12:49:51.02	-61:14:34.4	302.741	1.628	2	2	2	2	53
d120	12:49:51.02	-61:14:34.4	302.741	1.628	2	2	2	2	53
d121	13:01:58.46	-61:13:03.0	304.200	1.628	2	2	2	2	58
d122	13:14:00.77	-61:07:41.2	305.655	1.624	2	2	3	2	55
d123	13:26:01.94	-60:57:42.5	307.119	1.628	2	2	2	2	63
d124	13:37:51.91	-60:43:59.9	308.579	1.628	2	2	2	2	61
d125	13:49:30.50	-60:26:23.3	310.039	1.628	2	2	2	2	54
d126	14:00:53.14	-60:05:06.7	311.494	1.627	4	5	2	4	54
d127	14:12:03.53	-59:39:54.4	312.958	1.628	3	4	2	2	56
d128	14:22:54.29	-59:11:18.2	314.418	1.628	2	2	2	2	56
d129	14:33:25.94	-58:39:22.7	315.877	1.628	2	2	2	3	55
d130	14:43:35.86	-58:04:27.1	317.332	1.627	2	2	2	2	51
d131	14:53:28.37	-57:26:08.9	318.796	1.628	2	2	2	2	57
d132	15:02:58.06	-56:45:11.2	320.256	1.628	2	2	2	2	55
d133	15:12:06.53	-56:01:33.6	321.715	1.628	2	2	2	2	57
d134	15:20:54.07	-55:15:27.7	323.175	1.628	2	2	2	2	56
d135	15:29:20.69	-54:27:00.4	324.635	1.628	2	2	2	2	59
d136	15:37:27.18	-53:36:23.8	326.094	1.628	2	2	2	2	56
d137	15:45:14.06	-52:43:46.6	327.554	1.628	2	2	2	2	51
d138	15:52:41.81	-51:49:14.2	329.014	1.628	3	3	3	2	56
d139	15:59:51.34	-50:52:59.2	330.473	1.628	3	3	3	3	62
d140	16:06:43.42	-49:55:05.2	331.933	1.628	2	2	2	3	62
d141	16:13:18.96	-48:55:40.4	333.393	1.628	5	5	2	2	54
d142	16:19:38.50	-47:54:53.6	334.852	1.628	4	3	2	2	54
d143	16:25:43.22	-46:52:47.6	336.311	1.628	2	2	2	2	51
d144	16:31:33.74	-45:49:29.6	337.771	1.628	2	2	2	2	52
d145	16:37:10.78	-44:45:18.0	339.228	1.626	2	2	2	2	57
d146	16:42:35.28	-43:39:52.2	340.688	1.625	2	2	3	3	58
d147	16:47:47.69	-42:33:13.3	342.150	1.628	2	2	3	4	50
d148	16:52:49.08	-41:26:08.9	343.607	1.625	2	2	2	2	51
d149	16:57:39.62	-40:17:47.4	345.069	1.628	2	2	2	2	51
d150	17:02:20.45	-39:08:52.1	346.529	1.628	2	2	5	5	54
d151	17:06:51.91	-37:59:15.0	347.988	1.628	2	2	5	5	55
d152	17:11:14.57	-36:48:57.2	349.448	1.628	2	2	2	2	52

The files for DR4 include images and their respective photometric catalogues that have passed the Quality Control (QC). We make a distinction between single filter source lists, which are part of this release, and merged multi-band photometric catalogues, which are a distinct data product.

Release Notes

Data Reduction and Calibration

This DR4 is based on the CASU version v1.3 pipeline, which produces publication quality results provided that appropriate checks are made. We note that tiles based on observations after 1st February 2015 were reduced with v1.3.1 of the pipeline. There is no significant difference between v1.3 and v1.3.1: the latter designation in the file headers merely reflects that an error in processing was corrected and the tile images and source lists were re-generated.
The main changes to the pipeline since version 1.1 are as follows.

(i) The magnitude zero point error estimate for tiles is now calculated from the zero-point variation in the component pawprint images;

(ii) All tile catalogues have been re-grouted taking into account both detector level magnitude zero points variations and atmospheric seeing variations. ("Grouting" refers to the process of constructing calibrated tile images and catalogues from the 6 overlapping VIRCAM pawprint images).

(iii) A bug involving how the aperture 2 correction was calculated is now fixed and tile catalogues have now been re-grouted to include this. The change in the associated apermag2 results (source magnitudes in aperture 2) is typically at the level of ~0.05 mag.

(iv) Prior to re-grouting all the stacked pawprint photometric zero-points were recomputed using the latest version of the photometry software.

(v) Post re-grouting all the tile photometric zero-points have also been updated.

Full details of the pipeline procedure and the version changes can be found at:
http://apm49.ast.cam.ac.uk/surveys-projects/vista/data-processing/

The photometric and astrometric calibrations are both derived from the 2MASS Point Source Catalogue. The photometric calibration includes an additional colour term designed to correct for the effect of interstellar extinction on the 2MASS to VISTA photometric transformations. This works well in the J, H and Ks bandpasses and improvements in the pipeline between v1.1 and v1.3 have fixed the calibration of a small number of tiles that previously appeared to have problems at the 0.1 mag level (by comparison with 2MASS and by using the tile overlap regions). Remaining fields with slightly poorer than average photometric calibration in J, H or Ks are solely due to poor and changing weather conditions, which will be apparent from the zero points and the seeing given in the FITS catalogue headers.

Most users will wish to use aperture 1, aperture 2 or aperture 3 magnitudes, which correspond to aperture diameters of 1.0, √2 and 2.0 arcsec respectively. The trade off is between a smaller and more accurate aperture correction for larger apertures vs. increased effects of overlapping apertures on the photometry in crowded fields. The CASU aperture photometry does attempt to deblend the fluxes of adjacent sources with overlapping apertures but the results are not as good as profile fitting photometry (which is much more computationally intensive). Consequently, some users may wish to do their own profile fitting photometry on small portions of the images in this release, in the more crowded fields. See e.g. Mauro et al.(2013). Profile fitting photometry products are planned for a future VVV release.

The team has worked on the quality control using the v1.3 data, as detailed below.

The limiting magnitudes are similar to the ones for DR1 since we cover the same fields. Maps of limiting magnitudes are given in Saito et al. (2012). In addition, the calibration of the VVV Survey photometry was investigated as function of crowding in the bulge and disk fields, using the overlap regions between adjacent tiles and adjacent pawprint.

The VVV saturation limit ranges between Ks=10-12 mag, with Year 1 disk observations featuring a fainter saturation limit due to the slightly longer exposure time, e.g. DIT_{Ks}=10s in multicolor observations, as compared for DIT_{Ks}=4s in the variability study. DIT=4s was used for all Ks observations in the bulge. The saturation limit also varies between the 16 VIRCAM detectors. For brighter magnitudes the 2MASS photometry should be preferred. The photometric limit is typically Ks=17.5mag, but in high density fields like the in the Galactic center region it can be Ks<16 mag (see photometric completeness in Saito et al.2012).

The photometric catalogues contain calibrated aperture photometry, and the limiting magnitudes correspond to the aperture photometry. For some specific scientific purposes it would be better to obtain profile fitting (PSF) photometry, or differential image analysis (DIA) photometry which can give better and deeper photometry in the most crowded regions. The stacked VIRCAM pawprint images can be better for PSF or DIA photometry than the contiguous tile images contained in this release, despite the longer exposure time of the tile images. Stacked pawprint images are publically available at the VISTA Science Archive (surveys.roe.ac.uk/vsa) for data up to 30 September 2013.

Data Quality

The same words of caution as before apply as in previous releases: even though we checked the images for defects, we are still identifying images that need to be reprocessed or reacquired.

The Quality Control for the Phase 3 data from v1.3 was performed with involvement of ESO and of most of the scientists from the VVV Survey Science Team. We checked image defects, telescope problems, seeing, zero points, magnitude limits, ellipticities, airmass, etc. Algorithmic quality control cuts to remove images with low zero points (after correcting for the seasonal trend), seeing that was significantly outside specification, or high average ellipticity were also applied.

Additional quality control procedures identified a small number of tiles or pawprints where telescope guiding had been lost and fields with blurred or distorted image profiles. In addition we also identified some bad tiles where there was a large variation in the seeing or in the zero points between the 6 constituent pawprints, even though the values for the tile had passed the quality threshold. A good cosmetic appearance was required for all of the ZYJHKs master images from the Year 1 campaign to be part of this release. This condition was not required for the rest of the data, since check have shown that cosmetic issues with the sky background on scales of arcminutes have negligible effect on the photometry of point sources.

There are a number of well known image defects intrinsic to VISTA, many of which are illustrated with pictures in the CASU web page located at:
casu.ast.cam.ac.uk/surveys-projects/vista/technical/known-issues

Known Issues

The Z and Y calibration is fairly good for fields located >2° off the Galactic equator but at present it remains unreliable for fields at latitudes |b|<2°. It had been hoped that ESO observations of standard fields in all filters in the 1st year of observation would provide data to calibrate the VVV Z and Y data but in the event there was insufficient data at similar times and airmasses to VVV. A dedicated VVV Z and Y band calibration programme in photometric conditions was undertaken in Period 95 to address the problem in the mid-plane, with the intention of using the overlap regions between tiles and between VIRCAM pawprints to propagate a reliable solution across the whole survey area. This improved calibration of the Z and Y data will be provided in a future release.

Data Format

File Types

There are 3 types of file, all in FITS format. Tile images (file names ending in "_st_tl.fits.fz"), associated weight maps (file names ending in "_st_tl_conf.fits.fz") and tile catalogues (file names ending in "_st_tl_cat.fits").

Calibrated magnitudes can be derived from the various aperture fluxes in the catalogues using the equation:
CalMag = MAGZPT – 2.5log10(AperfluxN/EXPTIME) – 0.05(Airmass-1) - APCORN

where the capitalised variables are quantities available in the FITS catalogue headers and the "N" in AperfluxN and APCORN (the aperture flux and aperture correction terms) should be replaced with the chosen photometric aperture (see list of columns below).
Airmass = 0.5(AIRM START + AIRM END).

Catalogue Columns

1	Seq No.	running number for ease of reference, in strict order of image detections
2	Isophotal flux	standard definition of summed flux within detection isophote, apart from detection filter is used to define pixel connectivity and hence which pixels to include. This helps to reduce edge effects for all isophotally derived parameters.
3	X coord	intensity–weighted isophotal centre–of–gravity in X
4	Error in X	estimate of centroid error
5	Y coord	intensity–weighted isophotal centre–of–gravity in Y
6	Error in Y	estimate of centroid error
7	Gaussian sigma	these are derived from the three general intensity–weighted second moments
8	Ellipticity	the equivalence between them and a generalised elliptical Gaussian
9	Position angle	Orientation (east of north) of the elliptical Gaussian, in degrees
10	Areal profile 1	number of pixels above a series of threshold levels relative to local sky.
11	Areal profile 2	levels are set at T, 2T, 4T, 8T . . . 128T where T is the threshold. These
12	Areal profile 3	can be thought of as a sort of poor man’s radial profile. Note that for now deblended, i.e. overlapping images, only the first areal profile is
13	Areal profile 4	computed and the rest are set to -1, flagging the difficulty of computing accurate profiles
14	Areal profile 5	
15	Areal profile 6	
16	Areal profile 7	for blended images this parameter is used to flag the start of the sequence of the deblended components by setting the first in the
17	Areal profile 8	sequence to 0
18	Peak height	in counts relative to local value of sky - also zeroth order aperture flux
19	Error in pkht	
20	Aperture flux 1	The aperture fluxes are sky-corrected integrals (summations) with a soft-edge (ie. pro-rata flux division for boundary pixels). However, for overlapping images they are more subtle than this since they are in practice simultaneously fitted top-hat functions, to minimise the effects of crowding. Images external to the blend are also flagged and not included in the large radius summations. Aperture 1 has a 1.0 arcsec diameter. Each successive aperture increases in size by a factor of sqrt(2) for apertures 1 to 7.
21	Error in flux	
22	Aperture flux 2	Flux in a 1.414 arcsec diameter aperture.
23	Error in flux	
24	Aperture flux 3	Flux in a 2 arcsec diameter aperture.
25	Error in flux	
26	Aperture flux 4	Flux in a 2.282 arcsec diameter aperture.
27	Error in flux	
28	Aperture flux 5	Flux in a 4 arcsec diameter aperture.
29	Error in flux	

30	Aperture flux 6	Flux in a 4.564 arcsec diameter aperture.
31	Error in flux	
32	Aperture flux 7	Flux in an 8 arcsec diameter aperture.
33	Error in flux	
34	Aperture flux 8	Flux in a 10 arcsec diameter aperture.
35	Error in flux	
36	Aperture flux 9	Flux in a 12 arcsec diameter aperture.
37	Error in flux	
38	Aperture flux 10	Flux in a 14 arcsec diameter aperture.
39	Error in flux	
40	Aperture flux 11	Flux in a 16 arcsec diameter aperture.
41	Error in flux	
42	Aperture flux 12	Flux in a 20 arcsec diameter aperture.
43	Error in flux	
44	Aperture flux 13	Flux in a 24 arcsec diameter aperture.
45	Error in flux	
46	Petrosian radius	rp as defined in Yasuda et al. 2001 AJ 112, 1104
47	Kron radius	rk as defined in Bertin and Arnouts 1996 A&A Supp 117, 393
48	Hall radius	rh image scale radius eg. Hall & Mackay 1984 MNRAS 210, 979
49	Petrosian flux	flux within circular aperture to k x rp with k=2
50	Error in flux	
51	Kron flux	
52	Error in flux	
53	Hall flux	
54	Error in flux	
55	Error bit flag	bit pattern listing various processing error flags initially set to the no. of bad pixels within aperture 3 (the 2 arcsec diameter aperture) - note this can be fractional due to soft-edged apertures
56	Sky level	local interpolated sky level from background tracker
57	Sky rms	local estimate of variation in sky level around image
58	Av conf	average confidence level within default rcore aperture useful for spotting spurious outliers in various parameter selection spaces
59	RA	Sexagesimal RA and Dec explicitly put in columns for overlay programs that cannot, in general, understand astrometric solution coefficients. Note r*4 storage precision accurate only to 50 mas.
60	Dec	Astrometry can be derived more precisely from WCS in header and XY in columns 5 and 6
61	Classification	Flag indicating most probable morphological classification: eg. –1 stellar, +1 non–stellar, 0 noise, –2 borderline stellar (Saturated images can be flagged by comparing the peak height + local sky with the SATURATE keyword in the header.)
62	Statistic	
63	MJDoff	Offset (in minutes) of the median epoch of observation of each object from the integer Modified Julian Date of the catalogue given by header keyword MJD_DAY. The epoch is MJD_DAY + MJDoff.

64	Blank64	
65	Blank65	
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Please use the following statement in your articles when using these data: Based on data products from VVV Survey observations made with the VISTA telescope at the ESO Paranal Observatory under programme ID 179.B-2002.

Further Details

More detailed information can be found at: - the CASU webpages
http://casu.ast.cam.ac.uk/surveys-projects/vista/

- by contacting the VVV Science Team Members listed at the VVV Survey webpage

http://vvvsurvey.org

- the VVV Science Team papers:

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