1 Title: GCAV: Galaxy Clusters at Vircam

PI: Nonino Mario, INAF-OATs, Italy, M. Annunziatella, INAF-OATs, I. Balestra University-Sternwarte Muenchen, P. Bergamini, INAF-OANa/Padova University, A. Biviano, INAF-OATs, S. Borgani, Trieste University, M. Brescia, INAF-OANa, S. Cavuoti, INAF-OANa/Napoli University, I N. Chiu, ASIAA, D. Coe, STScI, N. Czakon, ASIAA, G. De Lucia, INAF-OATs G. De Rosa, STScI, W. Dawson, University of California Davis, F. Fontanot, INAF-OATs, B. Frye, University of Arizona, L. Girardi, INAF-OAPd ,M. Girardi, Trieste University, A. Grado, INAF-OANa, D. Gruen, Stanford University, A. Man, ESO, E. Medezinski, Princeton University, A. Mercurio, INAF-OANa, P. Monaco, Trieste University, T. Mroczkowski, ESO, G.Riccio, OANa P. Rosati, Ferrara University, B. Sartoris, Trieste University, S. Seitz, University-Sternwarte Muenchen, A. Stroe, ESO,B. Terni, INAF-OATS/Bologna University, K. Umetsu, ASIAA, T. Venturi,INAF-IRA, A. Zacchei, INAF-OATs

1.1 Abstract

Galaxy Clusters At Vircam (GCAV) is an infrared, Y, J, K_s, 560 hrs survey (including overheads) for a sample of **20** clusters of galaxies, evenly distributed over the 0h-24h Right Ascension, and which will mainly explore galaxy evolution over a large, and largely unexplored, diversity of cluster environments. By the time GCAV will begin, all the selected clusters will already have been observed by HST (ACS/WFC3-NIR) within the CLASH (Cluster Lensing And Supernovae Search with Hubble), HFF (Hubble Frontier Fields), Relics programmes. Furthermore a wealth of ground based ancillary data, from optical imaging and spectroscopy to radio observation, is available for most of the proposed clusters.

The total area coverage is $\approx 30deg^2$ and the expected depths are $\approx 24.5, 24, 23$ for Y, J and Ks respectively, (5σ point sources).

The survey is expected to be carried out in the periods P98, P99, P100, P101, P102, P103 and P104 in $\leq 1''.2$ conditions. The total execution time requested per period is: *33.8h* in **P98**, *99.3* in **P99**, *82.6* in **P100**, *94.1h* in **P101**, *72.2h* in **P102**, *101.3h* in **P103**, *76.4h* in **P104** .

The wide area coverage coupled with the expected depths will also allow legacy science, e.g. search of high redshift quasar and L,T dwarfs, infrared Galactic star counts and colour, search of lensed quiescent galaxies.

First data release is expected by August 2020.

2 Survey Observing Strategy

We will target 20 clusters of galaxies in the redshift range $0.2 \leq z \leq 0.9$. Targets have been divided in three groups, according to their redshift. The observing time required in the three filters has been accordingly chosen to reach galaxy stellar mass limit of $\approx 10^9 M_\odot$. Using the Survey Area Definition tool (SADT), the Observing Blocks have been prepared. We positioned the cluster core close to the center of the pointings. In this way, VISTA observation will allow to probe a range of different environments, from the dense core to the far outskirts of the target clusters.

In Fig 1. the target fields in Galactic coordinates.

2.1 Scheduling requirements

Using SADT, Phase 2 Preparation tool (P2PP v3) and observability a detailed plan of GCAV Observations has been prepared. Except Image Quality and moon phase, there are no stringent requirements on observation

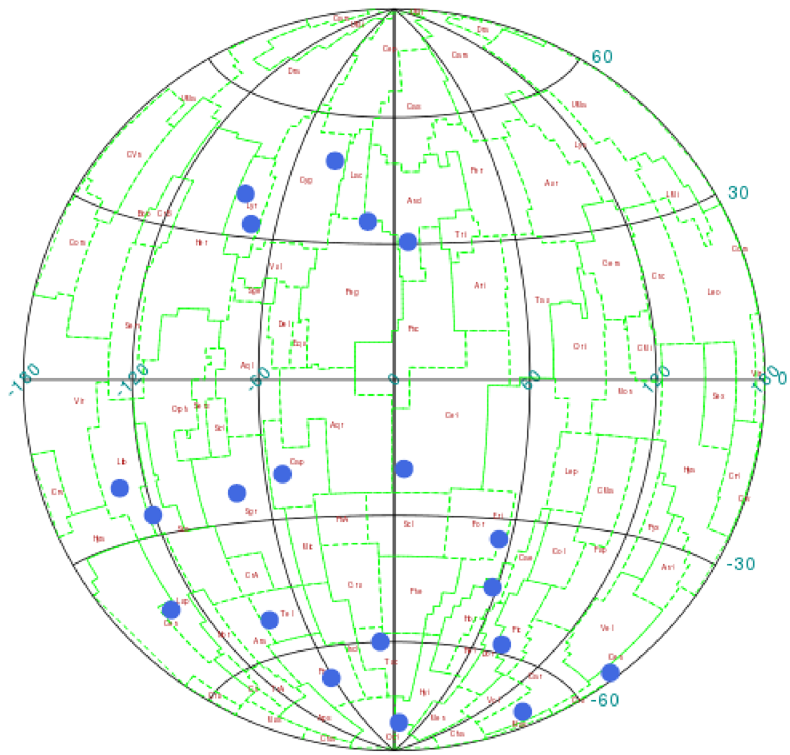

Figure 1: Galactic distribution of GCAV targets.

scheduling. Variations in transparency will be taken into account in the stacking process, which will also take into account variations of seeing down to the single image level. The proposed scheduling for GCAV observations is summarized in Tables 1,2,3 and 4, and in Fig 2.

Table 1: Scheduling plan and observing requirements for P98

Period	Target name	RA	DEC	Filter setup	Tot. exp. time [hrs]	Tot. exec time [hrs]	Seeing/FLI/ transparency
P98	RXCJ2248	22:48:45	-44:32:00	J	0.8	1.05	1.″2/1.0/THIN
P98	RXCJ2248	22:48:45	-44:32:00	Ks	3.5	5.1	1.″1/1.0/THIN
P98	Total for target RXCJ2248	22:48:45	-44:32:00		4.3	6.16	
P98	RCS2J2327.6-0204	23:27:30	-02:04:00	J	0.8	1.05	1.″2/1.0/THIN
P98	RCS2J2327.6-0204	23:27:30	-02:04:00	Ks	4.9	7.15	1.″1/1.0/THIN
P98	Total for target RCS2J2327.6-0204	23:27:30	-02:04:00		5.7	8.2	
P98	ACT-CLJ0102-4915	01:03:00	-49:16:30	J	0.8	1.05	1.″2/1.0/THIN
P98	ACT-CLJ0102-4915	01:03:00	-49:16:30	Ks	5.6	8.15	1.″1/1.0/THIN
P98	Total for target ACT-CLJ0102-4915	01:03:00	-49:16:30		6.4	9.2	
P98	WHLJ243324-8.47	01:37:30	-08:27:30	J	0.8	1.05	1.″2/1.0/THIN
P98	WHLJ243324-8.47	01:37:30	-08:27:30	Ks	6.3	9.2	1.″1/1.0/THIN
P98	Total for target WHLJ243324-8.47	01:37:30	-08:27:30		7.1	10.25	
	Total for P98				23.5	33.81	

2.2 Observing requirements

GCAV targets are well spread in Right Ascension, ensuring efficient use of VIRCAM/VISTA (e.g. Fig 3). Observations in Y and J could be carried out with seeing $\leq 1.''2$ while observations in Ks band should be carried out with seeing $\leq 1.''0$, except for observations at high (≥ 1.4) airmass, where the seeing is allowed to $\leq 1.''4$ in Y and J, and $\leq 1.''2$ in Ks. Requirements have been relaxed in Ks band for P98, seeing $\leq 1.''(1)$ and THIN, to allow early observation. We allow for Ks band observations to start 60 min *before* twilight, while Y and J bands observations are expected to start at 30 min and 60 min after twilight respectively. All OBs prepared with P2PP have duration of 1h03m15s in Y and J (DIT=30s and NDIT=2, with NJITTER=8) and 1h01m15s in Ks (DIT=10s, NDIT=6 and NJIITER=7). This will allow for 48 min (Y,J) and 42m (Ks) on sky (exposure time). The resulting number of images for each OB will be enough for the background estimation and subtraction steps in the reduction pipeline. Observations in all filters should not be carried out in worst than clear sky condition, with Y and J bands observations in dark/grey time and Ks band in bright time.

3 Survey data calibration needs

The standard calibrations (darks, flats, linearity checks, etc.) acquired within the VISTA calibration plan will be used during data reduction, and no futher special calibration are required. Since all the proposed clusters will also have accurate HST photometry, to anchor the absolute photometry at least in Y and J bands, there are no needs for special photometric calibration observations. For each of the proposed clusters preliminary photometric calibrarion will be done against 2MASS/GAIA sources in the VISTA field of view.

Table 2: Scheduling plan and observing requirements for P99

Period	Target name	RA	DEC	Filter setup	Tot. exp. time [hrs]	Tot. exec time [hrs]	Seeing/FLI/ transparency
P99	PLCKG287.0+32.9	11:51:00	-28:05:00	Y	4.0	5.27	1.″2/1.0/CLR
P99	PLCKG287.0+32.9	11:51:00	-28:05:00	J	4.0	5.27	1.″2/1.0/CLR
P99	PLCKG287.0+32.9	11:51:00	-28:05:00	Ks	2.8	4.09	1.″0/1.0/CLR
P99	Total for target PLCKG287.0+32.9	11:51:00	-28:05:00		6.8	14.63	
P99	RXCJ1514.9	15:15:00	-15:21:23	Y	6.4	8.43	1.″2/1.0/CLR
P99	RXCJ1514.9	15:15:00	-15:21:23	J	5.6	7.38	1.″2/1.0/CLR
P99	RXCJ1514.9	15:15:00	-15:21:23	Ks	3.5	5.11	1.″0/1.0/CLR
P99	Total for target RXCJ1514.9	15:15:00	-15:21:23		15.5	20.92	
P99	RXCJ2129	21:29:45	00:05:00	Y	5.6	7.38	1.″2/1.0/CLR
P99	RXCJ2129	21:29:45	00:05:00	J	4.8	6.33	1.″2/1.0/CLR
P99	RXCJ2129	21:29:45	00:05:00	Ks	3.5	5.1	1.″0/1.0/CLR
P99	Total for target RXCJ2129	21:29:45	00:05:00		13.9	18.81	
P99	RXCJ2248	22:48:45	-44:32:00	Y	8.0	10.54	1.″2/1.0/CLR
P99	RXCJ2248	22:48:45	-44:32:00	J	5.6	7.38	1.″2/1.0/CLR
P99	RXCJ2248	22:48:45	-44:32:00	Ks	1.4	2.04	1.″0/1.0/CLR
P99	Total for target RXCJ2248	22:48:45	-44:32:00		15.0	19.96	
P99	Abell 2744	00:15:30	-30:00:00	Y	3.2	4.22	1.″2/1.0/CLR
P99	Abell 2744	00:15:30	-30:00:00	J	3.2	4.22	1.″2/1.0/CLR
P99	Abell 2744	00:15:30	-30:00:00	Ks	3.5	5.1	1.″0/1.0/CLR
P99	Total for target Abell 2744	00:15:30	-30:00:00		9.9	13.54	
P99	MACSJ0416.1-2403	04:16:20	-22:06:00	Y	3.2	4.22	1.″2/1.0/CLR
P99	MACSJ0416.1-2403	04:16:20	-22:06:00	J	2.4	3.17	1.″2/1.0/CLR
P99	MACSJ0416.1-2403	04:16:20	-22:06:00	Ks	2.8	4.08	1.″0/1.0/CLR
P99	Total for target MACSJ0416.1-2403	04:16:20	-22:06:00		8.4	11.47	
	Total for P99				69.5	99.33	

Table 3: Scheduling plan and observing requirements for P100

Period	Target name	RA	DEC	Filter setup	Tot. exp. time [hrs]	Tot. exec. time [hrs]	Seeing/FLI/ transparency
P100	RXCJ2248	22:48:45	-44:32:00	Ks	2.1	3.06	1.″0/1.0/CLR
P100	RCS2J2327.6-0204	23:27:30	-02:04:30	Y	5.6	7.38	1.″2/1.0/CLR
P100	RCS2J2327.6-0204	23:27:30	-02:04:30	J	4.0	5.27	1.″2/1.0/CLR
P100	Total for target RCS2J2327.6-0204	23:27:30	-02:04:30		9.6	12.65	
P100	Abell 2744	00:15:30	-30:00:00	Y	2.4	3.17	1.″2/1.0/CLR
P100	Abell 2744	00:15:30	-30:00:00	J	1.6	2.11	1.″2/1.0/CLR
P100	Total for target Abell 2744	00:15:30	-30:00:00		4.0	5.28	
P100	MACSJ0416.1-2403	04:16:20	-22:06:00	Y	4.8	6.33	1.″2/1.0/CLR
P100	MACSJ0416.1-2403	04:16:20	-22:06:00	J	4.0	5.27	1.″2/1.0/CLR
P100	MACSJ0416.1-2403	04:16:20	-22:06:00	Ks	4.2	6.13	1.″0/1.0/CLR
P100	Total for target MACSJ0416.1-2403	04:16:20	-22:06:00		13.0	17.73	
P100	MACSJ0553.4-3342	05:53:20	-33:42:10	Y	2.4	3.17	1.″2/1.0/CLR
P100	MACSJ0553.4-3342	05:53:20	-33:42:10	J	2.4	3.17	1.″2/1.0/CLR
P100	MACSJ0553.4-3342	05:53:20	-33:42:10	Ks	2.1	3.06	1.″0/1.0/CLR
P100	Total for target MACSJ0553.4-3342	05:53:20	-33:42:10		6.9	9.4	
P100	RXCJ0600.1-2007	06:00:15	-20:07:30	Y	4.0	5.27	1.″2/1.0/CLR
P100	RXCJ0600.1-2007	06:00:15	-20:07:30	J	3.2	4.22	1.″2/1.0/CLR
P100	RXCJ0600.1-2007	06:00:15	-20:07:30	Ks	2.8	4.08	1.″0/1.0/CLR
P100	Total for target RXCJ0600.1-2007	06:00:15	-20:07:30		10.0	13.57	
P100	SMACSJ0723.3-7327	07:23:20	-73:25:20	Y	2.4	3.17	1.″4/1.0/CLR
P100	SMACSJ0723.3-7327	07:23:20	-73:25:20	J	2.4	3.17	1.″4/1.0/CLR
P100	SMACSJ0723.3-7327	07:23:20	-73:25:20	Ks	2.1	3.06	1.″2/1.0/CLR
P100	Total for target SMACSJ0723.3-7327	07:23:20	-73:25:20		6.9	9.4	
P100	PLCKG287.0+32.9	11:51:00	-28:05:00	Y	4.0	5.27	1.″2/1.0/CLR
P100	PLCKG287.0+32.9	11:51:00	-28:05:00	J	2.4	3.17	1.″2/1.0/CLR
P100	PLCKG287.0+32.9	11:51:00	-28:05:00	Ks	2.1	3.06	1.″0/1.0/CLR
P100	Total for target PLCKG287.0+32.9	11:51:00	-28:05:00		8.5	11.5	
	Total for P100				61	82.59	

Table 4: Scheduling plan and observing requirements for P101

Period	Target name	RA	DEC	Filter setup	Tot. exp. time [hrs]	Tot. exec. time [hrs]	Seeing/FLI/ transparency
P101	Abell 1300	11:32:00	-19:55:00	Y	2.4	3.17	1.″2/1.0/CLR
P101	Abell 1300	11:32:00	-19:55:00	J	1.6	2.11	1.″2/1.0/CLR
P101	Abell 1300	11:32:00	-19:55:00	Ks	2.1	3.06	1.″0/1.0/CLR
P101	Total for target Abell 1300	11:32:00	-19:55:00		6.1	8.34	
P101	PLCKG004.5-19.5	19:17:00	-33:31:20	Y	3.2	4.22	1.″2/1.0/CLR
P101	PLCKG004.5-19.5	19:17:00	-33:31:20	J	3.2	4.22	1.″2/1.0/CLR
P101	PLCKG004.5-19.5	19:17:00	-33:31:20	Ks	2.1	3.06	1.″0/1.0/CLR
P101	Total for target PLCKG004.5-19.5	19:17:00	-33:31:20		8.5	11.5	
P101	RCS2J2327.6-0204	23:27:30	-02:04:30	Y	4.8	6.33	1.″2/1.0/CLR
P101	RCS2J2327.6-0204	23:27:30	-02:04:30	J	4.8	6.33	1.″2/1.0/CLR
P101	RCS2J2327.6-0204	23:27:30	-02:04:30	Ks	2.8	4.08	1.″0/1.0/CLR
P101	Total for target RCS2J2327.6-0204	23:27:30	-02:04:30		12.4	16.74	
P101	Abell 2744	00:15:30	-30:00:00	Y	2.4	3.17	1.″2/1.0/CLR
P101	Abell 2744	00:15:30	-30:00:00	J	1.6	2.11	1.″2/1.0/CLR
P101	Abell 2744	00:15:30	-30:00:00	Ks	3.5	5.11	1.″0/1.0/CLR
P101	Total for target Abell 2744	00:15:30	-30:00:00		7.5	10.39	
P101	ACT-CLJ0102-4915	01:03:00	-49:16:30	Y	4.8	6.33	1.″2/1.0/CLR
P101	ACT-CLJ0102-4915	01:03:00	-49:16:30	J	4.0	5.27	1.″2/1.0/CLR
P101	Total for target ACT-CLJ0102-4915	01:03:00	-49:16:30		8.8	11.6	
P101	WHLJ243324-8.47	01:37:30	-08:27:30	Y	4.8	6.33	1.″2/1.0/CLR
P101	WHLJ243324-8.47	01:37:30	-08:27:30	J	4.0	10.27	1.″0/1.0/CLR
P101	Total for target WHLJ243324-8.47	01:37:30	-08:27:30		8.8	11.6	
P101	Abell 370	02:40:00	-01:35:00	Y	2.4	3.17	1.″2/1.0/CLR
P101	Abell 370	02:40:00	-01:35:00	J	1.6	2.11	1.″2/1.0/CLR
P101	Abell 370	02:40:00	-01:35:00	Ks	2.1	3.06	1.″0/1.0/CLR
P101	Total for target Abell 370	02:40:00	-01:35:00		6.1	8.34	
P101	SPT-CLJ0254-585	02:54:15	-58:58:00	Y	4.8	6.33	1.″2/1.0/CLR
P101	SPT-CLJ0254-585	02:54:15	-58:58:00	J	3.2	4.22	1.″2/1.0/CLR
P101	SPT-CLJ0254-585	02:54:15	-58:58:00	Ks	3.5	5.1	1.″0/1.0/CLR
P101	Total for target SPT-CLJ0254-585	02:54:15	-58:58:00		11.5	15.65	
	Total for P101				69.7	94.16	

Table 5: Scheduling plan and observing requirements for P102

Period	Target name	RA	DEC	Filter setup	Tot. exp. time [hrs]	Tot. exec. time [hrs]	Seeing/FLI/ transparency
P102	ACT-CLJ0102-4915	01:03:00	-49:16:30	Y	3.2	4.22	1″.2/1.0/CLR
P102	ACT-CLJ0102-4915	01:03:00	-49:16:30	J	2.4	3.17	1″.2/1.0/CLR
P102	ACT-CLJ0102-4915	01:03:00	-49:16:30	Ks	2.1	3.06	1″.0/1.0/CLR
P102	Total for target ACT-CLJ0102-4915	01:03:00	-49:16:30		7.7	10.45	
P102	WHLJ243324-8.47	01:37:30	-08:27:30	Y	3.2	4.22	1″.2/1.0/CLR
P102	WHLJ243324-8.47	01:37:30	-08:27:30	J	2.4	3.17	1″.2/1.0/CLR
P102	WHLJ243324-8.47	01:37:30	-08:27:30	Ks	1.4	2.04	1″.0/1.0/CLR
P102	Total for target WHLJ243324-8.47	01:37:30	-08:27:30		7.0	9.43	
P102	Abell 370	02:40:00	-01:35:00	Y	3.2	4.22	1″.2/1.0/CLR
P102	Abell 370	02:40:00	-01:35:00	J	3.2	4.22	1″.2/1.0/CLR
P102	Abell 370	02:40:00	-01:35:00	Ks	2.8	4.08	1″.0/1.0/CLR
P102	Total for target Abell 370	02:40:00	-01:35:00		9.2	12.52	
P102	SPT-CLJ0254-585	02:54:15	-58:58:00	Y	3.2	4.22	1″.2/1.0/CLR
P102	SPT-CLJ0254-585	02:54:15	-58:58:00	J	3.2	4.22	1″.2/1.0/CLR
P102	SPT-CLJ0254-585	02:54:15	-58:58:00	Ks	1.4	2.04	1″.0/1.0/CLR
P102	Total for target SPT-CLJ0254-585	02:54:15	-58:58:00		7.8	10.48	
P102	MACSJ0553.4-3342	05:53:20	-33:42:10	Y	1.6	2.11	1″.2/1.0/CLR
P102	RXCJ0600.1-2007	06:00:15	-20:07:30	Y	4.0	5.27	1″.2/1.0/CLR
P102	RXCJ0600.1-2007	06:00:15	-20:07:30	J	3.2	4.22	1″.2/1.0/CLR
P102	RXCJ0600.1-2007	06:00:15	-20:07:30	Ks	2.1	3.06	1″.0/1.0/CLR
P102	Total for target RXCJ0600.1-2007	06:00:15	-20:07:30		9.3	12.55	
P102	SMACSJ0723.3-7327	07:23:20	-73:25:20	Y	1.6	2.11	1″.4/1.0/CLR
P102	Abell 1300	11:32:00	-19:55:00	Y	4.0	5.27	1″.2/1.0/CLR
P102	Abell 1300	11:32:00	-19:55:00	J	4.0	5.27	1″.2/1.0/CLR
P102	Abell 1300	11:32:00	-19:55:00	Ks	1.4	2.04	1″.0/1.0/CLR
P102	Total for target Abell 1300	11:32:00	-19:55:00		9.4	12.58	
	Total for P102				53.6	72.23	

Table 6: Scheduling plan and observing requirements for P103

Period	Target name	RA	DEC	Filter setup	Tot. exp. time [hrs]	Tot. exec time [hrs]	Seeing/FLI/ transparency
P103	RXCJ1347.5-1145	13:47:30	-11:45:30	Y	4.0	5.27	$1''.2$/1.0/CLR
P103	RXCJ1347.5-1145	13:47:30	-11:45:30	J	3.2	4.22	$1''.2$/1.0/CLR
P103	RXCJ1347.5-1145	13:47:30	-11:45:30	Ks	2.8	4.09	$1''.0$/1.0/CLR
P103	Total for target RXCJ1347.5-1145	13:47:30	-11:45:30		10.0	13.56	
P103	PLCKG308.3-20.2	15:18:25	-81:30:10	Y	4.0	5.27	$1''.4$/1.0/CLR
P103	PLCKG308.3-20.2	15:18:25	-81:30:10	J	3.2	4.22	$1''.4$/1.0/CLR
P103	PLCKG308.3-20.2	15:18:25	-81:30:10	Ks	2.8	4.09	$1''.2$/1.0/CLR
P103	Total for target PLCKG308.3-20.2	15:18:25	-81:30:10		10.0	13.56	
P103	Abell 2163	16:15:50	-06:10:00	Y	6.4	8.43	$1''.2$/1.0/CLR
P103	Abell 2163	16:15:50	-06:10:00	J	5.6	7.38	$1''.2$/1.0/CLR
P103	Abell 2163	16:15:50	-06:10:00	Ks	3.5	5.11	$1''.0$/1.0/CLR
P103	Total for target Abell 2163	16:15:50	-06:10:00		15.5	20.92	
P103	PLCKG004.5-19.5	19:17:00	-33:31:20	Y	6.4	8.43	$1''.2$/1.0/CLR
P103	PLCKG004.5-19.5	19:17:00	-33:31:20	J	6.4	8.43	$1''.2$/1.0/CLR
P103	PLCKG004.5-19.5	19:17:00	-33:31:20	Ks	5.6	8.17	$1''.2$/1.0/CLR
P103	Total for target PLCKG004.5-19.5	19:17:00	-33:31:20		18.4	25.1	
P103	RXCJ2211.7-0350	22:11:40	-03:49:45	Y	6.4	8.43	$1''.2$/1.0/CLR
P103	RXCJ2211.7-0350	22:11:40	-03:49:45	J	4.8	6.33	$1''.2$/1.0/CLR
P103	RXCJ2211.7-0350	22:11:40	-03:49:45	Ks	3.5	5.11	$1''.0$/1.0/CLR
P103	Total for target RXCJ2211.7-0350	22:11:40	-03:49:45		14.7	19.87	
P103	Abell 370	02:40:00	-01:35:00	Y	2.4	3.17	$1''.2$/1.0/CLR
P103	Abell 370	02:40:00	-01:35:00	J	1.6	2.11	$1''.2$/1.0/CLR
P103	Abell 370	02:40:00	-01:35:00	Ks	2.1	3.06	$1''.0$/1.0/CLR
P103	Total for target Abell 370	02:40:00	-01:35:00		6.1	8.34	
	Total for P103				74.7	101.35	

Table 7: Scheduling plan and observing requirements for P104

Period	Target name	RA	DEC	Filter setup	Tot. exp. time [hrs]	Tot. exec time [hrs]	Seeing/FLI/ transparency
P104	RXCJ2211.7-0350	22:11:40	-03:49:45	Y	1.6	2.11	1″.2/1.0/CLR
P104	RXCJ2211.7-0350	22:11:40	-03:49:45	J	1.6	2.11	1″.2/1.0/CLR
P104	RXCJ2211.7-0350	22:11:40	-03:49:45	Ks	1.4	2.04	1″.0/1.0/CLR
P104	Total for target RXCJ2211.7-0350	22:11:40	-03:49:45		4.6	6.26	
P104	ACT-CLJ0102-4915	01:03:00	-49:16:30	Y	4.8	6.33	1″.2/1.0/CLR
P104	ACT-CLJ0102-4915	01:03:00	-49:16:30	J	4.8	6.33	1″.2/1.0/CLR
P104	ACT-CLJ0102-4915	01:03:00	-49:16:30	Ks	2.1	3.06	1″.0/1.0/CLR
P104	Total for target ACT-CLJ0102-4915	01:03:00	-49:16:30		11.7	15.72	
P104	WHLJ243324-8.47	01:37:30	-08:27:30	Y	2.4	3.17	1″.2/1.0/CLR
P104	WHLJ243324-8.47	01:37:30	-08:27:30	J	2.4	3.17	1″.2/1.0/CLR
P104	Total for target WHLJ243324-8.47	01:37:30	-08:27:30		4.8	6.34	
P104	MACSJ0553.4-3342	05:53:20	-33:42:10	Y	3.2	4.22	1″.2/1.0/CLR
P104	MACSJ0553.4-3342	05:53:20	-33:42:10	J	3.2	4.22	1″.2/1.0/CLR
P104	MACSJ0553.4-3342	05:53:20	-33:42:10	Ks	2.1	3.06	1″.0/1.0/CLR
P104	Total for target MACSJ0553.4-3342	05:53:20	-33:42:10		8.5	11.5	
P104	SMACSJ0723.3-7327	07:23:20	-73:25:20	Y	3.2	4.22	1″.4/1.0/CLR
P104	SMACSJ0723.3-7327	07:23:20	-73:25:20	J	3.2	4.22	1″.4/1.0/CLR
P104	SMACSJ0723.3-7327	07:23:20	-73:25:20	Ks	2.1	3.06	1″.2/1.0/CLR
P104	Total for target SMACSJ0723.3-7327	07:23:20	-73:25:20		8.5	11.5	
P104	RXCJ1347.5-1145	13:47:30	-11:45:30	Y	4.0	5.27	1″.2/1.0/CLR
P104	RXCJ1347.5-1145	13:47:30	-11:45:30	J	3.2	4.22	1″.2/1.0/CLR
P104	RXCJ1347.5-1145	13:47:30	-11:45:30	Ks	2.1	3.06	1″.0/1.0/CLR
P104	Total for target RXCJ1347.5-1145	13:47:30	-11:45:30		9.3	12.54	
P104	PLCKG308.3-20.2	15:18:25	-81:30:10	Y	4.0	5.27	1″.4/1.0/CLR
P104	PLCKG308.3-20.2	15:18:25	-81:30:10	J	3.2	4.22	1″.4/1.0/CLR
P104	PLCKG308.3-20.2	15:18:25	-81:30:10	Ks	2.1	3.06	1″.2/1.0/CLR
P104	Total for target PLCKG308.3-20.2	15:18:25	-81:30:10		9.3	12.54	
	Total for P104				56.7	76.4	

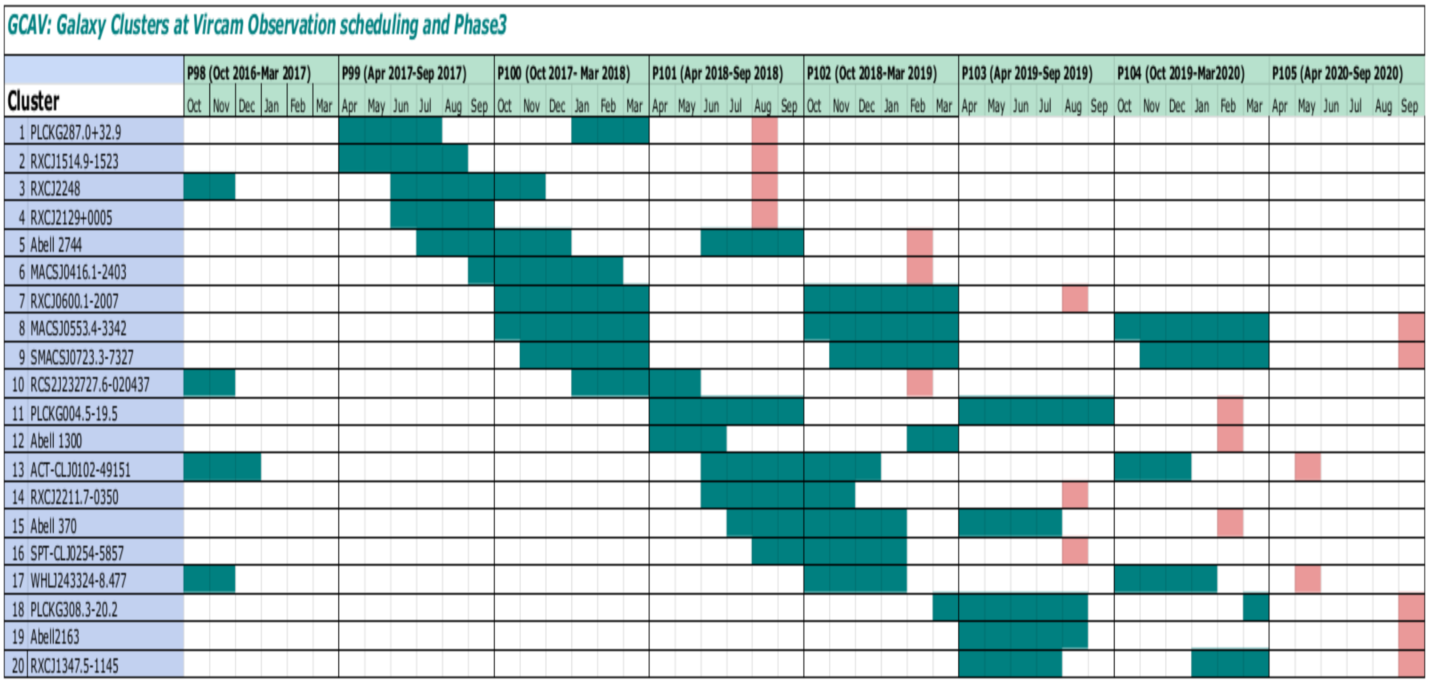

Figure 2: Proposed distribution of GCAV targets observations from P98 to P104. Green shows source observability, while light red are the proposed Phase3, for the products delivery to ESO.

4 Data reduction process

The reduction processes which will be used for GCAV are summarized in Fig 4, and detailed below.

After the download of the raw images from ESO Archive and their ingestion in the storage systems, the images will be processes in the following steps.

- Nightly/run master darks (with the correct DIT/NDIT combinations, including those for flats) and master flats, depending upon their availability, will be created. Master flats will be used to compensate for mean gain/sensitivity variations across the sixteen detectors. These calibration will be inspected to avoid inclusion of failed darks and/or flats. Automatic remote queries will be used to select in the ESO Archive the calibration files and the DP.ID of used/rejected files will be stored in local databases.
- Master darks and master flats will be used to create run wide static masks for science images. This step will be performed using WeightWatcher (Marmo & Bertin, 2008). These masks will used in the pipeline to mask pixels of unreliable pixels and other defective regions in science images which have been reduced using the corresponding master dark and master flat.
- After instrumental signature removal, a first pass for sky estimation and subtraction is done using a sliding window (which excludes the central frame). The width of the window will be set to cope with sky

GCAV Observing time distribution in Right Ascension	Total Execution time (Y+J+K)
00h-02h	113.8
02h-04h	55.3
04h-06h	52.2
06h-08h	49.1
08h10h	0
10h-12h	47.1
12h-14h	26.1
14h-16h	47
16h-18h	20.9
18h-20h	36.6
20h-22h	18.8
22h-24h	92.9

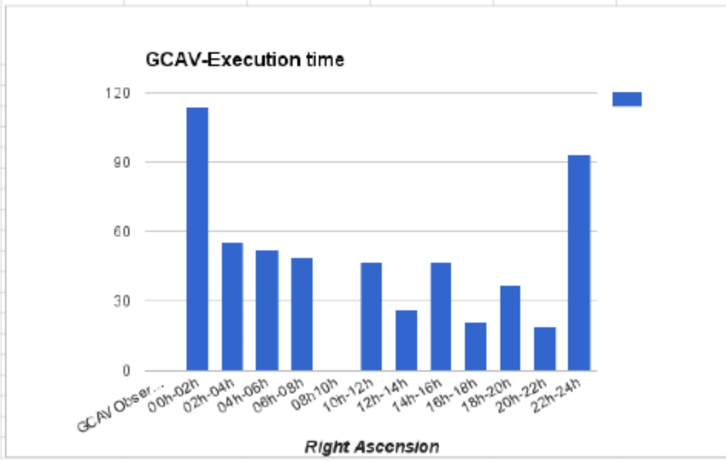

Figure 3: Tabulated and graphical representation of the distribution of GCAV targets in 2h bins of Right Ascension.

variations in time, if any. This is done on OB base.

- Static mask are also used in the first source extraction pass, via Sextractor (Bertin & Arnouts 1996). In this step a catalog of sources is created for each chip of all input images. Moreover a weight map for each input image is also generated during this step. This will include both the static mask, and defects masked at individual image level, e.g. satellite streaks.

- Once all the images for a given filter and target have been collected, reduced, and source catalogs generated, a first astrometric solution, usually using 2MASS or GAIA is available as reference, is obtained via Scamp (Bertin, 2006). This will solve for shifts and distortions of the original images.

- Using Swarp (Bertin, 2002) a first, median, coadded image is created, from the first pass background subtracted images and the corresponding confidence images. This coadded image and the associated weight image are used to create a segmentation map, which is then dilated (e.g. 20%) to obtain a new mask image, with detected sources pixels set to 0.

- Inverting the previously obtained astrometric solution, each single pixel of each input image is checked against objects as masked in the mask images from first coaddition step. This allows to mask in each detrended image both the objects and defective pixel, as encoded in the associated weight map.

- A new sky estimation is done, using again sliding window, but now the input images are the deterended images with defective pixels and objects pixels masked. These pixels are ignored in the new sky generation step. These new skies are subtracted from the detrended images.

- From the new background subtracted images a new set of catalogs of sources is extracted and a new astrometric and relative photometric solution is carried out.

- The final coaddition is performed again using Swarp. In principle the process of object masking can be iterated over: this will be done if any improvement will be obtained after the first data sets will be obtained and processed.

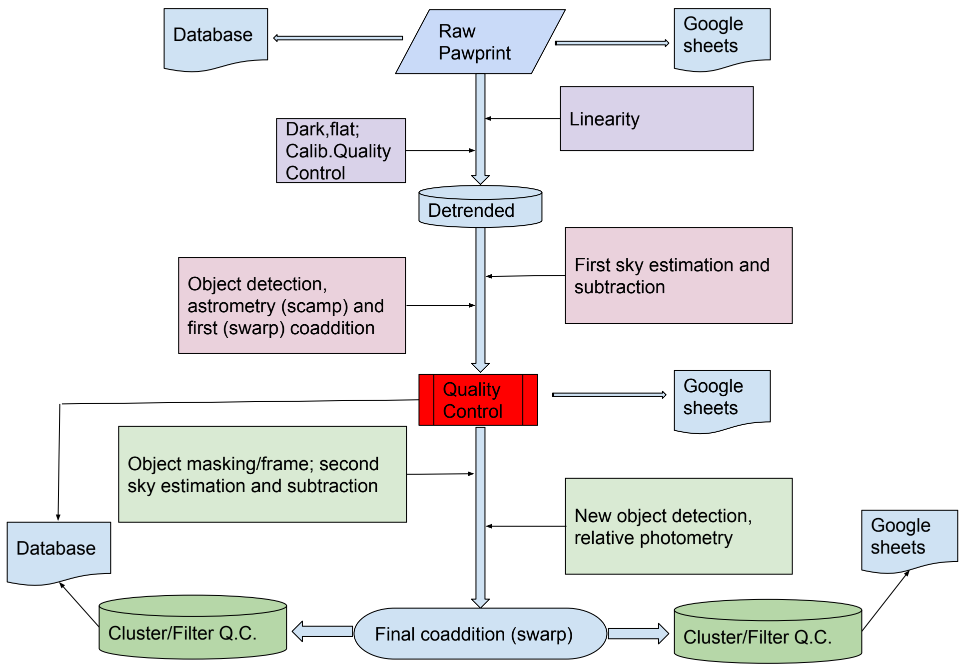

Figure 4: Block diagram with the data-flow from GCAV raw data to the final coadded stacks which will be delivered to ESO. The use of Google sheets, which will be created and updated automatically to store informations on ongoing observations and data processing phases, will lead to fast circulation of informations within the team. The in sync databases (OATs/OANa) will be used to store extended processes informations.

- In addition to the Swarp coadded version a stack of the images will be obtained with *wdrizzle*, Fruchter & Hook, 2002. A Swarp set of stacks will also be created after psfmatching input images, i.e. homogeneizing input image to the worst seeing input image(s), both intra and inter filters, using an approach very similar to the one implemented in *psfmatch* in *sdfred*, (Ouchi, 2004).

5 Manpower and hardware capabilities devoted to data reduction and quality assessment

From the scheduling plan breakdown and assuming no repeated OBs, the survey should result in $\approx$ 23000 science images, i.e $\approx 6Tb$ of total raw data. The team is equipped with large storage systems, with $\approx 25Tb$ in the OATs node and $\approx 600Tb$ in the OAMa node, i.e. 4 to 100 times the whole survey raw science data. Notice that targets will be reduced separately, this will result in a peak of processing storage of less than 2Tb (which includes for target under process: raw data, confidence maps, masks, background subtracted images, space needed by Swarp), with an average $\leq$ 1.5 Tb/cluster. The reduction ,from preprocessing to final coadded images, is expected to run at an pace less than 3hrs/OB.

6 Data quality assessment process

Quality control for both the input data (to the pipeline) and products of the pipeline is mandatory. This will also be carried out via detailed preliminary scientific exploitation e.g. comparison with semi-analytic theoretical

Table 8: Allocation of resources within the team

Name	Function	Affiliation	FTE allocated t
M. Nonino	PI, Data Reduction, OPC reports, OBs submission, Phase 3	INAF-OATs	0.7
M. Annunziatella	OB preparation, PSF photometry	INAF-OATs	0.3
A. Biviano	Depth, Number counts	INAF-OATs	0.2
P. Bergamini (PhD)	Strong lensing	INAF-OANa/UniPd	0.3
M. Brescia	Object classification, Phase 3 catalogs,Database	INAF-OANa	0.3
S. Cavuoti	Photo-z, Phase 3 catalogs	INAF-OANa/UniNa	0.2
I Chiu	Completeness, Depth	ASIAA	0.2
D. Coe	Relics PI	STScI	0.1
G. De Lucia	Semi-analytic models comparison	INAF-OATs	0.2
F. Fontanot	Semi-analytic models comparison	INAF-OATs	0.2
B. Frye	Spec-z	University of Arizona	0.2
M. Girardi	Number counts, depth	UniTs	0.2
L. Girardi	Stars counts and colors.	INAF-OAPd	0.1
A. Grado	Data reduction, Quality Control	INAF-OANa	0.3
D. Gruen	Model-fitting photometry, photo-z, documentation	Stanford University	0.4
A. Man	Photo-z, SED fitting	ESO	0.1
E. Medezinski	Completeness	Princeton University	0.1
A. Mercurio	Catalogs generation, Quality Control, Survey manager	INAF-OANa	0.4
G .Riccio (PostDoc)	Data quality, photo-z	INAF-OANa	0.3
P. Rosati	Spec-z	UniFe	0.1
B. Sartoris	Hydrodynamics simulations comparison	UniTs	0.2
A. Stroe	Calibration data Quality Control	ESO	0.1
B. Terni (PhD)	Counterparts of radio sources	INAF-OATS/UniBo	0.3
K. Umetsu	Weak lensing	ASIAA	0.2
T. Venturi	Radio Observations Coordinator	INAF-IRA	0.3
A. Zacchei	Data Processing Coordinator	INAF-OATs	0.2

models and hydrodynamics simulations, to better define the scientific quality of the data to be released. Table 5 summarizes the contribution of team members aimed at data reduction, data production and quality control. Main test that will be routinely performed:

- Image Quality via point like sources analysis, at image level. This will be done using catalogs from the first pass coadded images, from which point like source will be selected (e.g. using spread model from Sextractor). Ellipticity will also be estimated at the same time. The estimated Image Quality will be compared with the one expected from DIMM estimated seeing.
- Sky brightness, sky noise, point-like sources aperture corrections.
- Transparency variations will be monitored using the very same point sources used for the analysis of on image seeing.
- Galaxy number counts, depth and completeness check: this will be the calibrated magnitude at which at least 50% of point sources (*point source depth*) artificially implanted in the stacked image, in a given filter, will be retrieved using the very same configuration files used for the production of final catalogues in the same filter. We will use different approaches (e.g. *ComExt* (Chiu, 2016)) for artificial sources implantation.
- Stellar locus in color-color plots, and star counts wrt Galactic Models.
- Photo-z, comparison to spec-z which is an integral check for the full multiband exploitation of GCAV products, model-fitting photometry, shape measurements.
- SED fitting and mass estimates for objects with spec/photo-z, and comparison with predictions.

7 External Data products and Phase 3 compliance

The science products that GCAV expects to deliver to ESO are:

1. Due to the nature of GCAV survey, the basic deliverables at image levels will be the coadded images at the OB level for each filter and target and the associated confidence maps. Astrometry calibration is intended at the level of $\approx 100mas$ where major contribution to rms is due to reference catalogues (e.g. 2MASS). If GAIA sources will be available the expected rms is expected to be at least 3 times better, with major contribution due to VISTA sources coordinates. Photometric calibration is intended at the level of $\leq 5\%$. The zeropoints will be in the VISTA system.
2. Fully coadded images per target and per filter and the associated confidence maps. The WCS of the coadded images will be the very same for the three filters for each target, i.e. Y,J, Ks stacks will be co-aligned. These final stacks will be created with the very same images entering the coaddition at the OB level, and the stacks at OB level will be coaligned to the final stacks.
3. Source catalog per cluster: for each cluster a multiband cross-matched catalog will be released with the coadded images. This catalog will be created to assure that each distinct source will have its own unique identifier (*GCAV_J<HHMMSS.ss+DDMMSS.s>*) across the different bands. The photometry will also contain aperture matching to account for different observing conditions among different bands. The format of the relased catalog will be compliant to ESO Phase 3 standards as defined in *https://www.eso.org/sci/observing/phase3/p3sdpstd.pdf*. The entries in the catalogs will be close to those used for the released catalogues from other VISTA Public Surveys (e.g. VIDEO). The cross-matched catalog will also include optical bands derived from archival datasets. Public released spectroscopic datasets will be cross matched with multiband catalogues in order to add spectroscopic data. Multiband catalogues will also be cross matched with HST ACS/WFC3 catalogues as released from Frontier Field, CLASH and Relics surveys. To perform the cross matching among catalogs, also to ensure unique ID for sources, tools described in Riccio et al. 2017 and Mercurio et al 2015. will be used.

4. Single band catalogs: for each cluster and band, the calibrated stacks at the OB level will also be used to extract single-band source lists, which are intended as *general purpose* source lists.

8 Delivery timeline of data products to the ESO archive

As illustrated in Fig 2., and depending on the progress of the observations, stacked images and associated catalogs for the first 5 clusters are expected to be released to ESO by August 2018. Later release schedules are also indicated in Fig 2. The initial release should allow the community to use the data for proposals for *P103* on. The submission of the products will be carried out according to the *Phase 3 Policies for ESO Public Surveys* and following the standards defined in *ESO Science Data Products standard* in order to be as fast as possible delivered to the community.