20 years of MegaCam scientific operations on CFHT



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MegaCam in MegaPrime on CFHT atop Maunakea





20 years of MegaCam observing in numbers

- 236 observing runs, 3057 nights (42% of the telescope time)
- 312103 science images
- 1309 individual PI programs (from one hour to tens of hours long)
- 1 Legacy Survey: CFHT Legacy Survey, 2003-2008, 450 nights: Dark Energy, Dark Matter, Galaxy Evolution

• 7 Large Programs:

0	The Pan-Andromeda Archaeological Survey (PandAS)	2009-2012	50 nights	Local Group
0	The Next Generation Virgo Cluster Survey (NGVS)	2009-2012	150 nights	Local Universe
0	The CFHT Legacy for the u-band all-sky universe (Luau)	2013-2016	60 nights	The Galaxy
0	Mass Assembly of early-type GaLAxies with Structures (MATLAS)	2013-2016	50 nights	Local Universe
0	VESTIGE: Virgo Environmental Survey Tracing Ionised Gas Emission	2017-2021	50 nights	Local Universe
0	Canada-France Imaging Survey (CFIS-UNIONS)	2017-2024	415 nights	The Galaxy, Local Universe, Cosmology
0	The Classical and Large-a Distant Solar SYstem (CLASSY) Survey	2022-2024	50 nights	Solar System

- All MegaCam observations captured since first light in service mode (Queued Service Observations, the "QSO Team")
- A highly dedicated team of CFHT engineers and technicians, and an extensive yearly preventive maintenance plan



MegaCam data processing with Elixir and MegaPipe

- CFHT aimed from the start at providing science ready data shortly after observing (real-time + within 2 weeks)
- Processing & Calibration: MegaCam users receive fully detrended individual images from CFHT (Elixir pipeline)
- Archive & Curation at the Canadian Astronomy Data Centre (CADC):
 - Archiving of all raw and Elixir MegaCam frames
 - Stacking and catalog production on public MegaCam datasets with MegaPipe





Single raw image



Single detrended image



Stack of several dithered images



MegaCam enhancements throughout the years

• Telescope and instrumental improvements (2011-2014)



Dome venting



Faster readout (40s vs 60s)



• Data acquisition and processing optimization (2008-2016)



Modern user interfaces





Low Surface Brightness



MegaCam refereed articles & bibliographic impact

CFHT published articles per instrument 2004-2021

Row Labels	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Grand Total
BEAR	4	1						1							1				7
CAMIRAS		1	1		1														3
CCD				1	1		2					1						1	6
CFH12K	21	21	8	22	18	9	10	9	5		2	2	4	4	2	3	2	3	145
CFHTIR	6	4	8	1	4	1	1	2							1	1			29
Coude f/4	7	3	1	4	4	4	3	1		1				1	1	1			31
Coude f/8		1	2		1														4
ESPaDOnS		1	6	6	12	5	19	15	28	29	25	40	28	47	46	36	49	45	437
FaNTOmM			1			2		1											4
FTS	1																		1
GRACES												1	2	2	1	2	1	1	10
GriF				1					1										2
HRCAM									1							1			2
Lapoune		2	1		2	1	1												7
Megacam	1	6	32	56	46	72	67	82	63	85	103	96	141	138	144	151	151	149	1583
MOS	5	3	2	3	5	1	2	1	1		2		1		1		1	2	30
MOSFP	2	1	1				1	1											6
MuSiCoS			1																1
OASIS	1	1	2			2		1											7
OSIS		1					1	1											3
Plates						1													1
PUEO	3	2	10	3	3	2	5	2	2		2	1	1			1		1	38
SILEID							1												1
SIMON							_				1								1
SITELLE											-		1	1	4	5	4	8	23
SPIRou													-	-	-	5	2	5	7
TRIDENT					1												2	5	1
		1	2		1		2												
		1	2			2	2	10	22	10		10	22	24	22	20	22	24	222
WIRCAM				1	6	3	18	18	22	16	37	18	22	34	33	28	32	34	322
	55	54	79	99	105	104	133	135	124	133	172	159	200	227	234	229	242	249	2733

2004-2021 Impact (Normalisation ApJ)

EAR	8.38	
AMIRAS	1.79	
CD	4.47	
FH12K	232.26	
FHTIR	29.18	
Coudef4	33.29	
Coudef8	3.69	
SPaDOnS	420.81	
aNTOmM	1.95	
TS	7.84	
GRACES	12.9	
GriF	1.14	MegaCam represents 74%
IRCAM	4.13	
apoune	5.28	of the CFHT impact
/legacam	3255.99	(\cdots) $(7,000,0)$ $(1,0)$
AOS	44.83	(WITH ~63,000 CITATIONS)
NOSFP	6.86	
/luSiCoS	0.24	
DASIS	9.92	
DSIS	0.81	In recent years the CADC
lates	0.39	archive has passed the
UEO	44.46	archive has passed the
ILFID	0.6	new observing programs
IMON	0.27	new observing programs
ITELLE	23.44	for the number of
PIRou	15.02	
RIDENT	1.81	published papers
JH8K	5.71	
VIKCAM	212.27	
UIAL	4389.73	Source, Dennie Crobtree (UUA)



The 5 most cited MegaCam papers (major dataset)

The Supernova Legacy Survey: measurement of Ω_M , Ω_Λ and w from the first year data set

Astier et al, 2006 A&A, 447, 31A Citations=2221, Impact=48.1

The Cosmic Evolution Survey (COSMOS): Overview

Scoville et al, 2007, ApJS, 172, 1S Citations=1464, Impact=32.9

The COSMOS2015 Catalog: Exploring the 1 < z < 6 Universe with Half a Million Galaxies

Laigle et al, 2016, ApJS, 224, 24L Citations=741, Impact=26.8

Accurate photometric redshifts for the CFHT legacy survey calibrated using the VIMOS VLT deep survey

Ilbert et al, 2006, A&A, 457, 841 Citations=1204, Impact=25.7

Cosmos Photometric Redshifts with 30-Bands for 2-deg²

Ilbert et al, 2009, ApJ, 690, 1236I Citations=1016, Impact=21.9



Science with MegaCam and CFHT total impact



CFHT word cloud from all article titles



CFHT & world (2019): total impact (no HST & Sloan)

Source: Dennis Crabtree (HIA)



Tracking Maunakea observing conditions



- 20 years of MegaCam observing: 236 observing runs, 3057 nights, 312103 science images
- The past 5 years of Maunakea quality observing conditions (seeing < 1" + ~photometric) amount to just 4 hours per 10 hour-long night on average across the year (40%)
- Service mode makes the best of the observing conditions at any given time



The Ultraviolet Near Infrared Optical Northern Survey





- 202 scientific collaborators (mostly Canada, France, Hawaii, Japan), and growing
- UNIONS is critical to the Euclid core science (photometric redshifts)
- Follow the UNIONS scientific activities at <u>www.skysurvey.cc</u>





MegaCam and the interstellar medium



The Diffuse Galactic Light (cirrus) detected in the optical provides a new way to trace dust properties as well as the structure of the interstellar medium at very small scales

Far-IR IRAS and Planck maps top at the 5 arcminutes resolution but span the whole sky: science calls for deep giant photometrically calibrated Low Surface Brightness (LSB) mosaics in the optical over hundreds of deg²



Exploring the Diffuse Galactic Light in LSB mode





MegaCam and the beautiful Universe





MegaCam and the CFHT astronomy calendar





Hawaiian Starlight by CFH12K and MegaCam





To Infinity... and beyond!



