The Manchester-Athens Wide-Field Camera (MAWFC): A new 30deg diameter narrow-band optical camera

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IAASARS

THE UNIVERSITY of MANCHESTER

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The motivation...

The sky at high galactic latitudes is host to a wide range of extensive phenomena that emit faintly in optical lines over a range of excitations. These features remain largely unexplored for the majority of the observing programmes of the World's largest telescopes which have been concentrated on achieving high angular resolution over small fields.

•the foreground, very diffuse, line emission from the galactic plane needs accurate evaluation down to resolutions of 1 arcmin to improve the interpretation of the Cosmic Microwave Background (CMB).

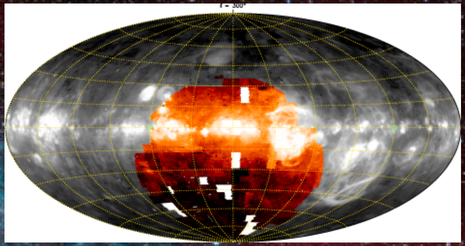
•the 100 degree long non-thermal radio spur apparently projecting from the Galactic centre. The question still remains as to whether or not this is a nearby supernova remnant or the more dramatic ejection of relativistic particles from the Galactic nucleus into the Galactic halo. Remarkably, no optical identification has yet occurred.

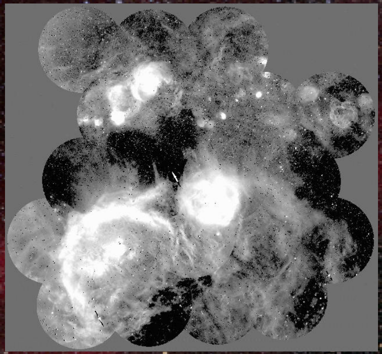
•The complexity of the nearest HII 30 degree diameter, `bubble' in Eridanus also needs evaluating with far deeper emission line observations to distinguish between its radiatively ionized and more filamentary, collisionally ionized components. It is the extremely large angular sizes of these phenomena that inhibits their observation.

Previous Wide-Field Surveys

WHAM (Wisconsin H-Alpha Mapper) – 1995/2012

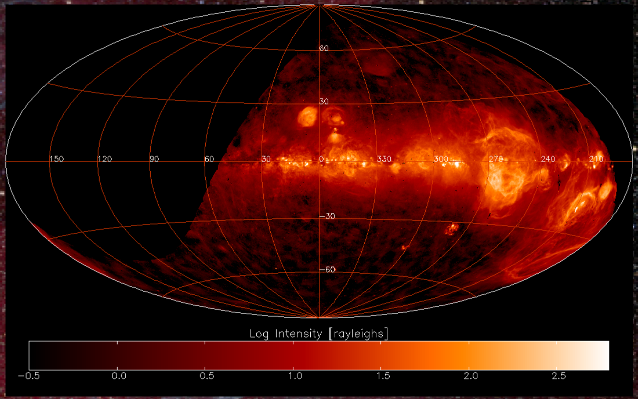
It is specialized to observe the warm ionized interstellar gas of our Galaxy.
FOV=10deg, 1.6’ resolution
Covered the Northern Galactic plane.





VTSS (Virginia Tech Spectral-Line Survey) – 1996/2001

It is specialized to study the distribution and kinematics of diffuse, ionized gas in the Milky Way.
FOV=1deg, 8-12km/s resolution spatially beam of the sky. Higher sensitivity, lower angular resolution than SHASSA.

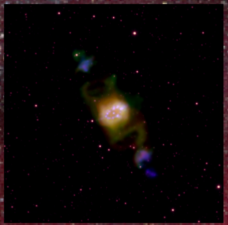


SHASSA (Southern H-Alpha Sky Survey Atlas – 2000/2003

It is specialized to observe the warm ionized interstellar gas of our Galaxy.
FOV=13deg, 0.8’ resolution [0.6m telescope]

IPHAS - 2003/08 & VPHAS – 2011 [Photometric Hα Surveys]

Both specialized to observe emission line objects (WR, OB stars etc.)
IPHAS – at 2.5m INT Northern (La Palma), Hα, r, i down to 20mag
FOV=0.3deg, 0.33” resolution
VPHAS – at 2.6m VST South (Paranal), u,g,r,I,Hα
FOV=1deg, 0.21” resolution(32 x 2kx4k ccd - OmegaCam)



The past…..

1st version - Wide Field Filter Camera (WFFC) -1977

Johnson, Kaye, Meaburn, 1978, Applied Optics, 17, 442

32 deg, narrowband filters, ipcs camera, 8’ resolution

2nd version – Manchester Wide Field Camera (MWFC) -1996

Boumis et al. 2001, MNRAS, 320, 61

21x30 deg, narrowband filters, LN ccd camera, ~3.3’ resolution

3rd version – Manchester Wide Field Camera (MWFC) -2001

Dickinson 2002, PhD thesis

~32 deg, narrowband filters, Apogee ccd camera, ~7’ resolution

Manchester Wide Field Camera

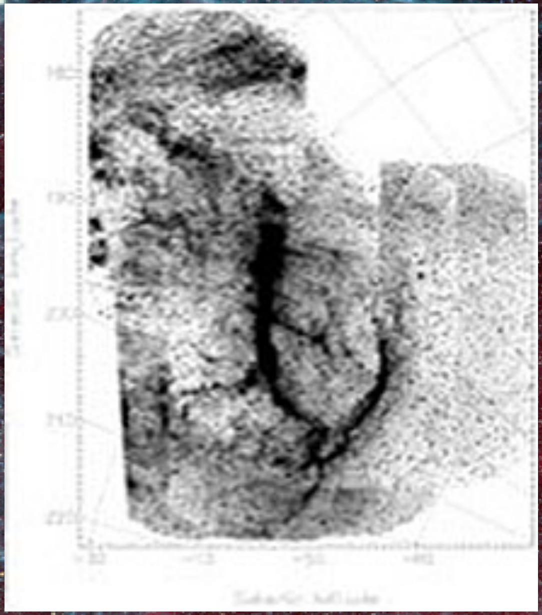
2nd version -1996

Boumis et al. 2001, MNRAS, 320, 61

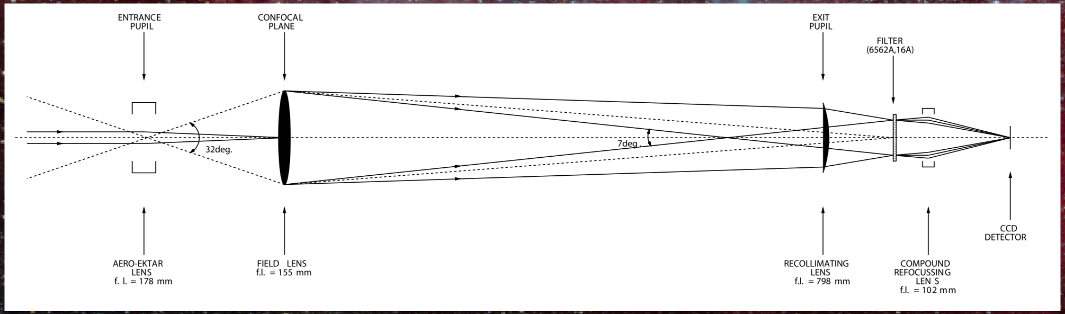
21x30 deg, narrowband filters, ccd camera, ~3.3' resolution

It is concluded that these filamentary arcs are the superimposed images of separate shells (driven by supernova explosions and/or stellar winds) rather than the edges of a single`superbubble' stretching from Barnard's Arc (and the Orion Nebula) to these high galactic latitudes.

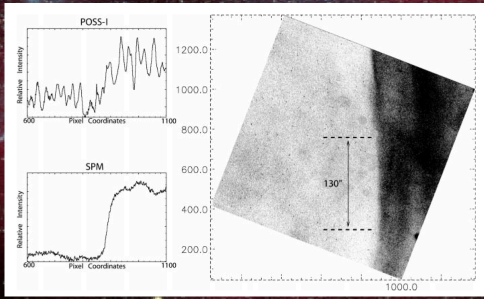
Deep Hα imagery of the Eridanus shell



Deep Hα imagery of the Orion Nebula



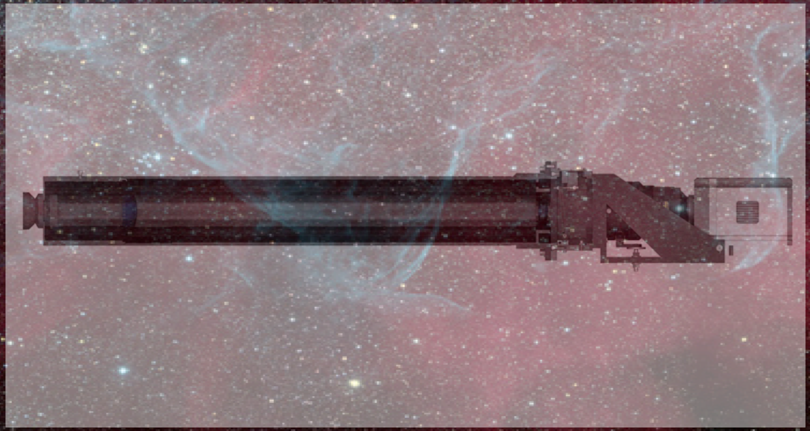
Upper limit PM=.13"/yr 1951 R 1996 Hα



Manchester-Athens Wide Field Camera

The proposed project was to design and construct a state-of-the-art, wide-field (~30 degree diameter), narrow-band, optical filter camera – The `Manchester-Athens Wide Field Camera' (MAWFC).

- The standalone camera is the first scientific instrument for astronomy that was constructed and tested completely in Greece
- We will conduct a large-area sky survey that will provide maps at less than 1 arcmin resolution, in order to investigate the very extensive, but faint, line emission regions over the whole sky.
- We will make deep observations of the northern sky in the optical emission lines of Hα, [O III] and Hβ, from astronomical sites. The successful outcome will have a significant impact on topical astronomical areas of research



Manchester-Athens Wide Field Camera

Observational technical information:

- Over a period of ~7 to 8 months, using dark time to minimize background contributions (2 weeks/month), we will make deep observations of the northern-sky.

- With a FOV of ~30-degree diameter, we can cover the northern hemisphere with ~75 individual pointings, with adequate overlap between fields for calibration of baselines.

- For each pointing, we will require at least ~10 of 20 min exposures to provide deep (≥3 hour) observations using narrow-band (~10-20 A) Hα, Hβ and [O III] filters, and shorter observations in continuum bands (~100 Å wide) to remove stellar contamination. The total integration time required is ~700 hours, which should be readily achieved on a timescale of ~7 to 8 months.

Manchester-Athens Wide Field Camera

Analysis information:

- We will use the ratio of Hα and Hβ brightnesses to estimate the dust extinction at Hα (see e.g. Casassus et al. 2004)

- Absolute calibration will be achieved using standard nebular sources (e.g. the California nebula) or via the publically available Wisconsin H-Alpha Mapper (WHAM) Fabry-Perot data on large angular scales (Haffner et al. 2003).

- The images will then be combined, with appropriate background corrections, to make a large mosaic map. Combining this with other surveys (WHAM and SHASSA) will allow an accurate full-sky map of Hα, with an angular resolution of ~1 arcmin. This will be complementary to high-resolution Galactic plane surveys in Hα such as the IPHASS/VPHAS surveys, and will become a Legacy Survey to be used for many years to come for studying diffuse Galactic emission (e.g. Dobler, Draine \& Finkbeiner, 2009).

- The calibrated sky maps will be made publically available.

A possible future extension to the survey would be to map other lines (e.g. [S II] etc.) or to map the Southern sky with particular emphasis on the environment of the Magellanic Clouds.

Manchester-Athens Wide Field Camera

Commissioning Plan

• 2014 March: Starting Point (17 months instead of 26 - 312.000 EUR)

• 2014 March - August: Personnel hired (3 postdocs, 1 IT technician), Optical design, equipment decided – quotation & orders. Scientific studies & starting Pipeline development.

2014 August – 2015 February: Mechanical design, equipment quotations, orders & deliveries. Tests the equipment in the Optical lab and Pipeline development.

•2015 January – March:: Manufacture of all mechanical parts, equipment delivery and tests in the optical lab. Pipeline development.

•2015 April-May:: Commissioning of MAWFC in the optical lab, testing period in Penteli hill – First light on sky (1st of April).

•2015 June-October: Commissioning of MAWFC at Krioneri Observatory, tests on sky, starting observations campaign and data analysis. Finalize Pipeline and present first results.

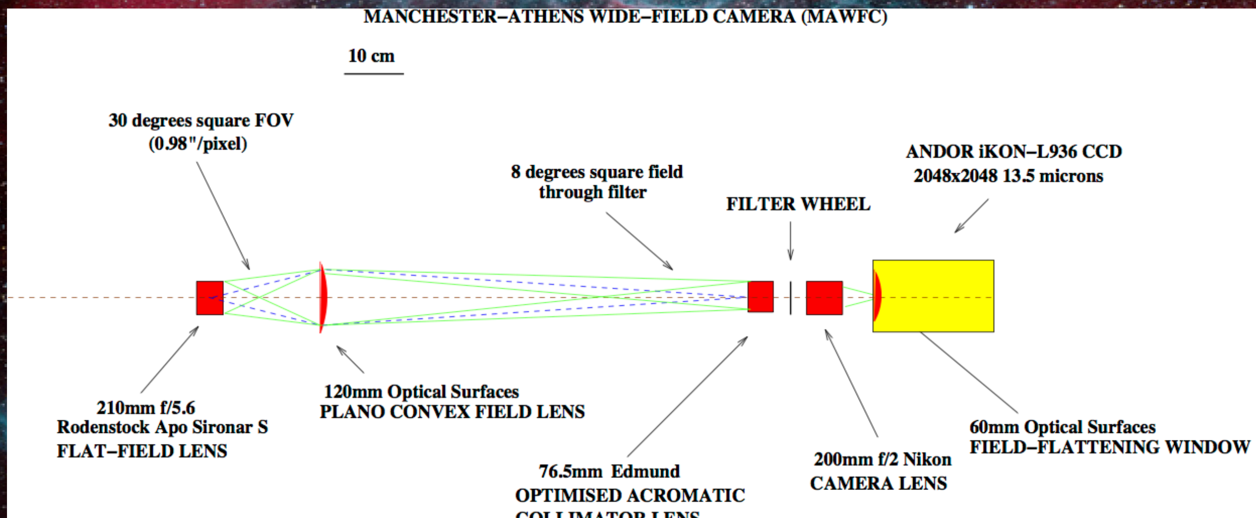
Manchester-Athens Wide Field Camera

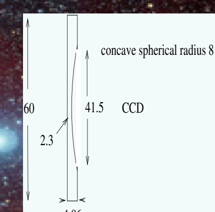
4th version -2015

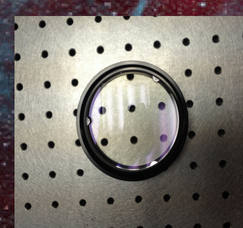
Boumis et al. 2015, MNRAS, in prep.

30 deg, narrowband filters, ccd camera, ~1’ resolution

Optical layout / design (2014 March – August)

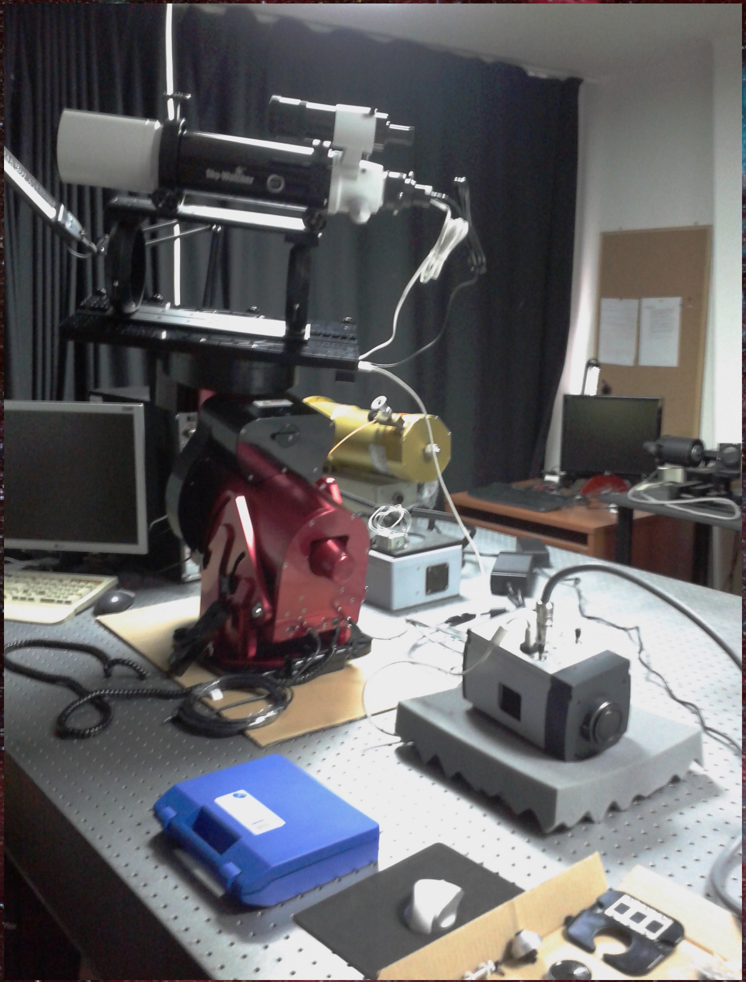


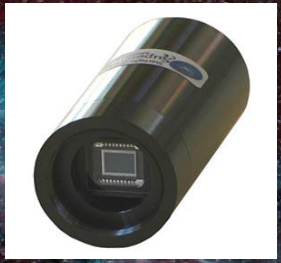




Manchester-Athens Wide Field Camera

Testing in the Optical lab (Aug 2014 – Feb 2015)



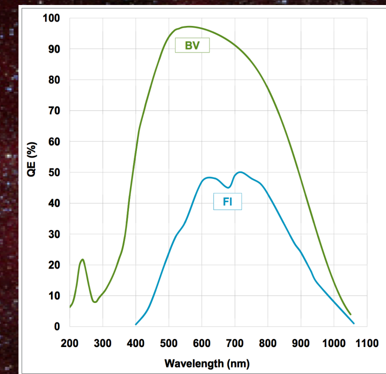


Guiding telescope
Skywatcher ED80 (f/7.5)
Guiding ccd
Starlight Superstar (1.4kx1.0k, 4.65μm
QE~50%)
Equat. Mount: Paramount ME II

Manchester-Athens Wide Field Camera

Testing in the Optical lab (Aug 2014 – Feb 2015)

Andor iKon-L ccd
2k x 2k, 13.5µm
-100 C Peltier cooler
QE > 90%

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bias_04.fits,DATE = 2015-01-09T16:18:56
bias_05.fits,DATE = 2015-01-09T16:19:00
bias_06.fits,DATE = 2015-01-09T16:19:03
bias_07.fits,DATE = 2015-01-09T16:19:07
bias_08.fits,DATE = 2015-01-09T16:19:10
bias_09.fits,DATE = 2015-01-09T16:19:14
bias_10.fits,DATE = 2015-01-09T16:19:17
bias_11.fits,DATE = 2015-01-09T16:19:21
ecl> imstat bias*
#                IMAGE      NPIX      MEAN    STDDEV       MIN
MAX
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1448.
          bias_02.fits   4194304     1361.     5.339     1333.
1388.
          bias_03.fits   4194304     1361.     5.356     1248.
1448.
          bias_04.fits   4194304     1361.     5.362     1325.
1392.
          bias_05.fits   4194304     1361.     5.333     1332.
1388.
          bias_06.fits   4194304     1361.     5.361     1255.
1515.
          bias_07.fits   4194304     1361.     5.353     1334.
1388.
          bias_08.fits   4194304     1361.     5.338     1333.
1387.
          bias_09.fits   4194304     1361.     5.359     1276.
1502.
          bias_10.fits   4194304     1361.     5.383     1334.
1390.
          bias_11.fits   4194304     1361.     5.359     1331.
1389.

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dark_03.fits,EXPOSURE = 4.
dark_04.fits,EXPOSURE = 8.
dark_05.fits,EXPOSURE = 15.
dark_06.fits,EXPOSURE = 30.00001
dark_07.fits,EXPOSURE = 60.00002
for_trace_dark.fits,EXPOSURE = 300.(followed saturated frame)
for_trace_light.fits,EXPOSURE = 3. (saturated exposure)

ecl> imstat dark*
#                IMAGE      NPIX      MEAN    STDDEV       MIN
MAX
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1466.
```

```
 flat22b.fits[850:1349,50:449]    200000    36192,     3801,
31894,    42151,

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bias_03.fits,DATE = 2015-01-09T17:12:07
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bias_05.fits,DATE = 2015-01-09T17:12:15
bias_06.fits,DATE = 2015-01-09T17:12:19
bias_07.fits,DATE = 2015-01-09T17:12:22
bias_08.fits,DATE = 2015-01-09T17:12:26
bias_09.fits,DATE = 2015-01-09T17:12:33
bias_10.fits,DATE = 2015-01-09T17:12:36

ecl> imstat bias*
#                IMAGE      NPIX      MEAN    STDDEV       MIN
MAX
          bias_01.fits   4194304     1362.     5.333     1337.
1390.
          bias_02.fits   4194304     1362.     5.335     1334.
1388.
          bias_03.fits   4194304     1362.     5.367     1336.
1391.
          bias_04.fits   4194304     1362.     5.385     1334.
2273.
          bias_05.fits   4194304     1362.     5.372     1337.
1391.
          bias_06.fits   4194304     1362.     5.329     1270.
1473.
          bias_07.fits   4194304     1362.     5.305     1335.
1390.
          bias_08.fits   4194304     1361.     5.371     1335.
1388.
          bias_09.fits   4194304     1361.      5.36     1333.
1388.
          bias_10.fits   4194304     1362.     5.339     1334.
1391.

Statistics BAD column 1516 and adjacent columns
===============================================
ecl> imstat flat10a.fits[1516:1516,1567:1966]
#                IMAGE                  NPIX      MEAN    STDDEV
MIN       MAX
 flat10a.fits[1516:1516,1567:1966]       400     3387.     507.2
1031.     9024.

#                IMAGE                  NPIX      MEAN    STDDEV
MIN       MAX
ecl> imstat flat10a.fits[1516:1516,1567:1666]
 flat10a.fits[1516:1516,1567:1666]       100     2885.     737.4
1031.     9024.
ecl> imstat flat10a.fits[1514:1515,1567:1666]
 flat10a.fits[1514:1515,1567:1666]       200    11580.     120.3
11271.    11814.
ecl> imstat flat10a.fits[1517:1517,1567:1666]
 flat10a.fits[1517:1517,1567:1666]       100    11943.     134.1
11692.    12416.
ecl> imstat flat10a.fits[1518:1519,1567:1666]
 flat10a.fits[1518:1519,1567:1666]       200    11563.     126.3
11256.    11855.
ecl>
ecl> imstat flat10a.fits[1514:1515,1667:1766]
#                IMAGE                  NPIX      MEAN    STDDEV
MIN       MAX
 flat10a.fits[1514:1515,1667:1766]       200    11255.     119.5
10934.    11526.
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 flat10a.fits[1516:1516,1667:1766]       100     3291.     87.21
3121.     3441.
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11331.    11905.
ecl> imstat flat10a.fits[1518:1519,1667:1766]
 flat10a.fits[1518:1519,1667:1766]       200    11227.     110.9
10984.    11542.

Line 1539
=========
ecl> imstat flat10a.fits[1250:1649,1537:1538]
#                IMAGE                  NPIX     MEAN     STDDEV
MIN       MAX
 flat10a.fits[1250:1649,1537:1538]       800    11915.     148.4
11485.    12279.
ecl> imstat flat10a.fits[1250:1649,1539:1539]
 flat10a.fits[1250:1649,1539:1539]       400    11669.     133.5
11302.    11983.
ecl> imstat flat10a.fits[1250:1649,1540:1541]
 flat10a.fits[1250:1649,1540:1541]       800    11924.     146.7
11521.    12270.

 RATIO MEAN(flat10a.fits[1250:1649,1539:1539]) /
MEAN(flat10a.fits[1250:1649,1540:1541])
                   11669  / 11924 ~ 0.98

Line 1027
=========
ecl> imstat flat10a.fits[1250:1649,1025:1026]
#                IMAGE                  NPIX     MEAN     STDDEV
MIN       MAX
 flat10a.fits[1250:1649,1025:1026]       800    13320.     199.5
12812.    13813.
ecl> imstat flat10a.fits[1250:1649,1027:1027]
 flat10a.fits[1250:1649,1027:1027]       400    13012.     184.1
12507.    13434.
ecl> imstat flat10a.fits[1250:1649,1028:1029]
 flat10a.fits[1250:1649,1028:1029]       800    13314.     194.8
```

flat1a.fits[8	200000	1	1787	12.11	1733	1840
flat1b.fits[8	200000	1.3	1783	12.08	1727	1838
flat2a.fits[8	200000	2	2156	16.08	2091	2227
flat2b.fits[8	200000	2.3	2153	16.06	2084	2228
flat3a.fits[8	200000	3	2889	22.91	2786	2997
flat3b.fits[8	200000	3.3	2907	23.19	2801	3012
flat4a.fits[8	200000	4	4430	35.56	4275	4577
flat4b.fits[8	200000	4.3	4438	35.82	4280	4597
flat5a.fits[8	200000	5	5906	46.41	5689	6095
flat5b.fits[8	200000	5.3	5964	47.09	5750	6174
flat6a.fits[8	200000	6	7437	58.5	7171	7663
flat6b.fits[8	200000	6.3	7391	58.2	7115	7621
flat7a.fits[8	200000	7	8995	68.41	8709	9303
flat7b.fits[8	200000	7.3	8916	68.73	8623	9209
flat8a.fits[8	200000	8	10784	82.02	10413	11113
flat8b.fits[8	200000	8.3	10954	84.04	10588	11287
flat9a.fits[8	200000	9	12750	97.18	12280	13131
flat9b.fits[8	200000	9.3	12751	97.6	12349	13135
flat10a.fits[	200000	10	14648	109.9	14164	15075
flat10b.fits[	200000	10.3	14603	109.2	14102	15053
flat11a.fits[	200000	11	16364	121.7	15850	16858
flat11b.fits[	200000	11.3	16335	122.6	15815	16853
flat12a.fits[	200000	12	17685	132.2	17101	19242
flat12b.fits[	200000	12.3	17310	129.9	16714	17822
flat13a.fits[	200000	13	18481	137.7	17882	19002
flat13b.fits[	200000	13.3	18581	138.8	18005	19113
flat14a.fits[	200000	14	21982	163.5	21281	22591
flat14b.fits[	200000	14.3	21667	160.8	20942	22297
flat15a.fits[	200000	15	24044	178.3	23265	24744
flat15b.fits[	200000	15.3	24573	180.2	23814	25257
flat16a.fits[	200000	16	26455	175.1	25676	27141
flat16b.fits[	200000	16.3	25295	184.4	24466	26163
flat17a.fits[	200000	17	28101	140.1	27644	28538
flat17b.fits[	200000	17.3	29287	173.7	28761	29815
flat18a.fits[	200000	18	30619	393.5	29898	31404
flat18b.fits[	200000	18.3	30941	479.8	30103	31831
flat19a.fits[	200000	19	31314	602.6	30317	32322
flat19b.fits[	200000	19.3	31756	761	30611	32961
flat20a.fits[	200000	20	34067	2262	31317	37114
flat20b.fits[	200000	20.3	33864	2138	31175	36746
flat21a.fits[	200000	21	36124	3782	31822	42055
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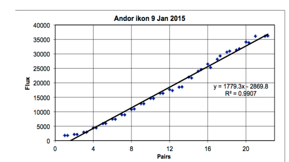
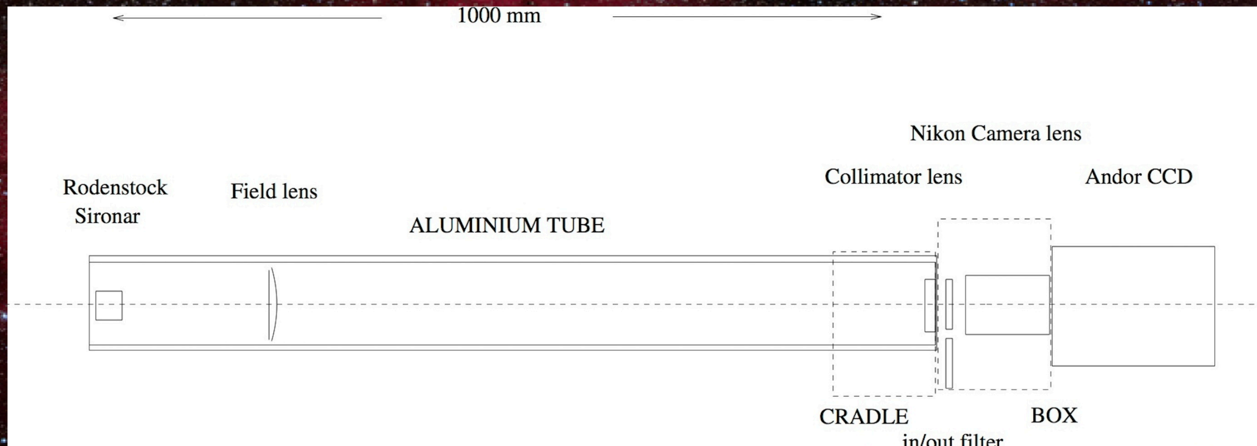
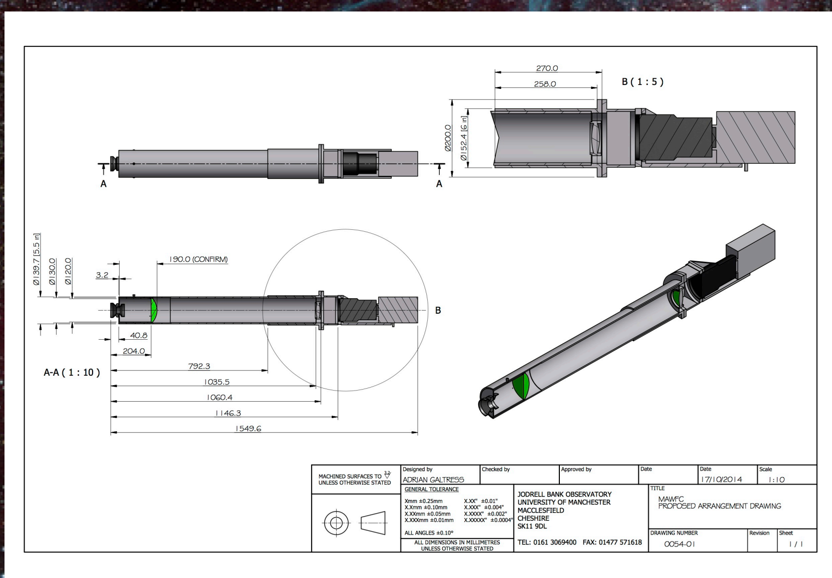
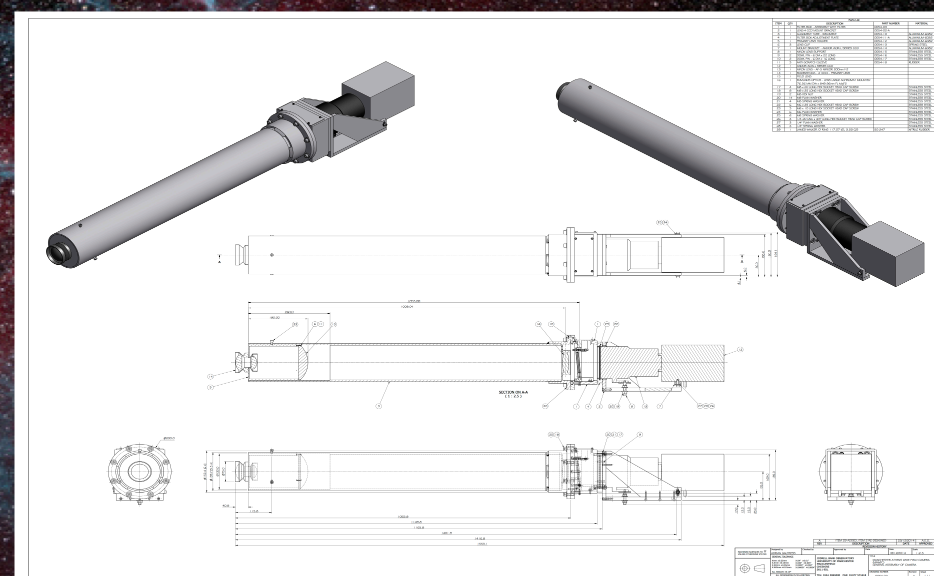


Manchester-Athens Wide Field Camera

Mechanical layout / Design (Sep 2014 - Jan 2015)

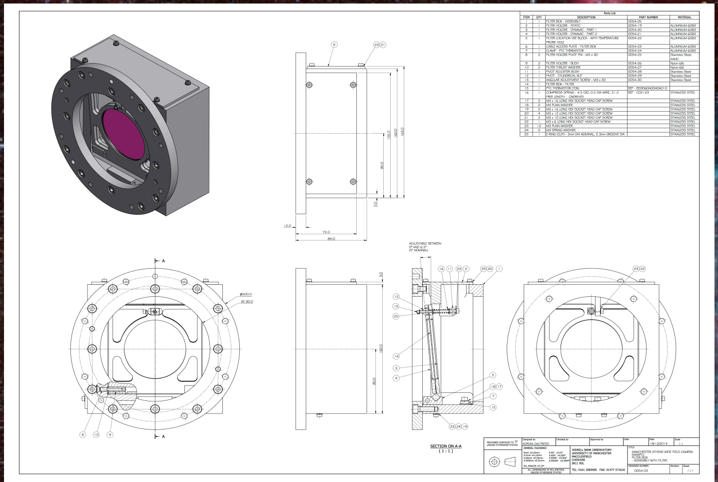


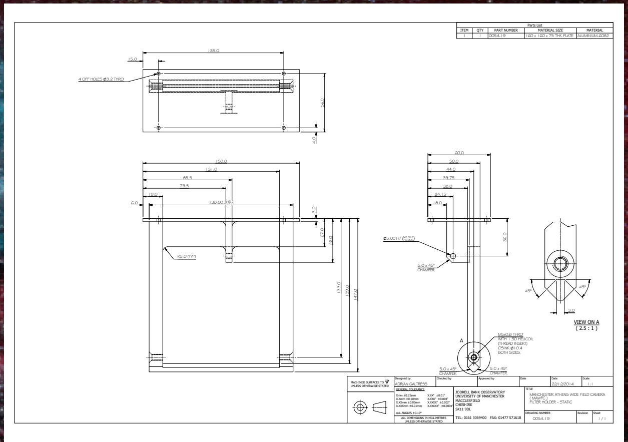


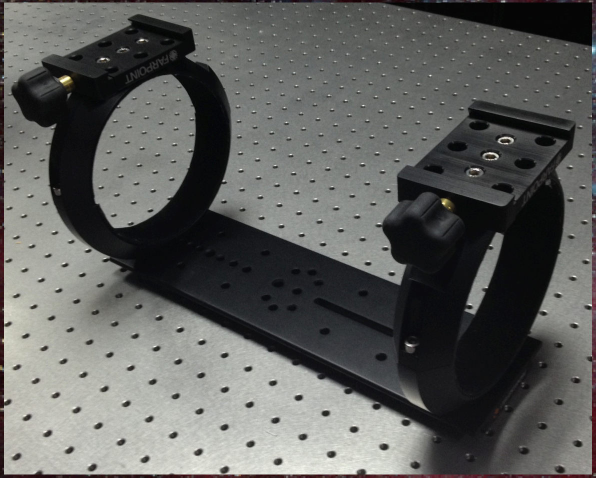


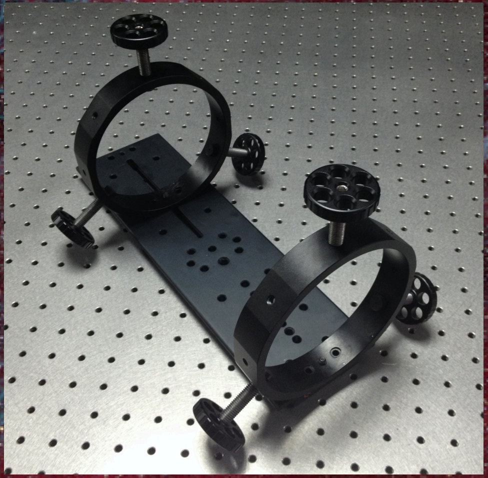
Manchester-Athens Wide Field Camera

Mechanical Design / Parts (Sep 2014 - Jan 2015)



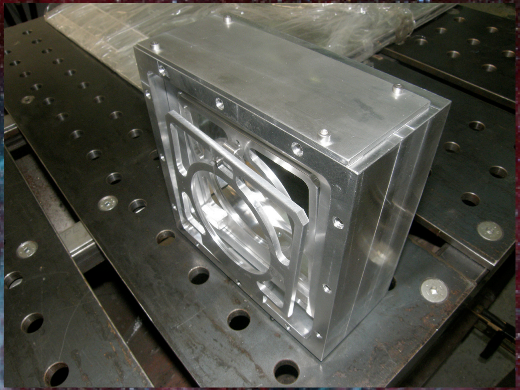


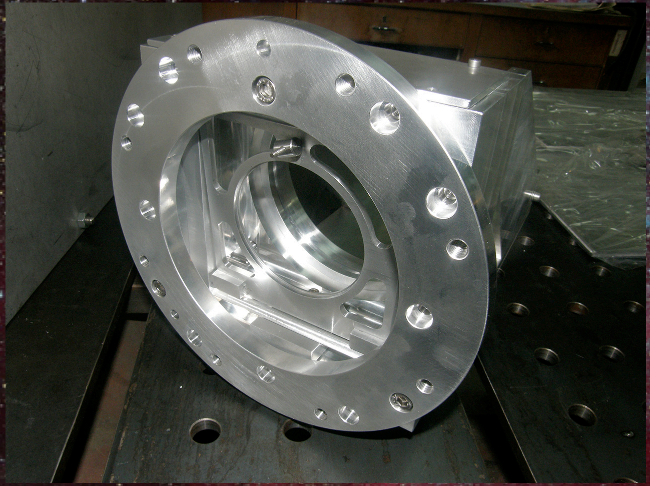


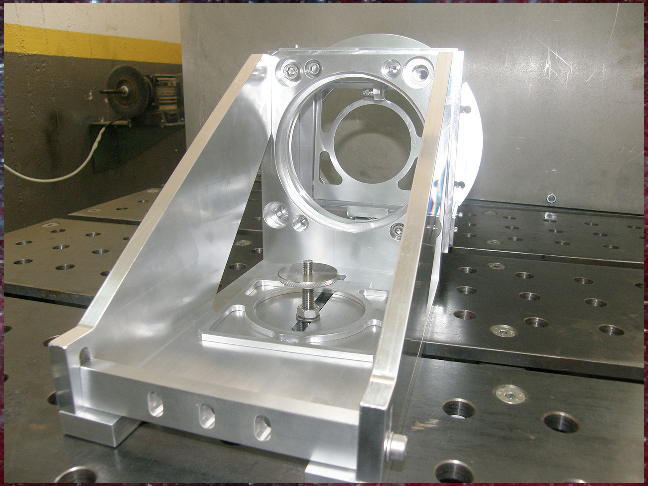


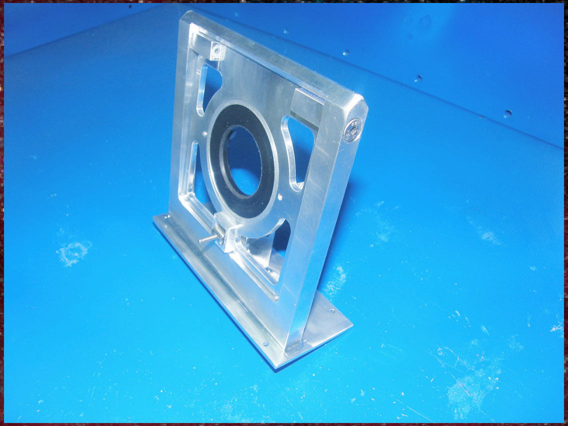
Manchester-Athens Wide Field Camera

Mechanical manufacturing (Jan – Mar 2015)









Mechanical laboratory – University of Patras (MYEDPP)

Manchester-Athens Wide Field Camera

Mechanical manufacturing (Jan – Mar 2015)

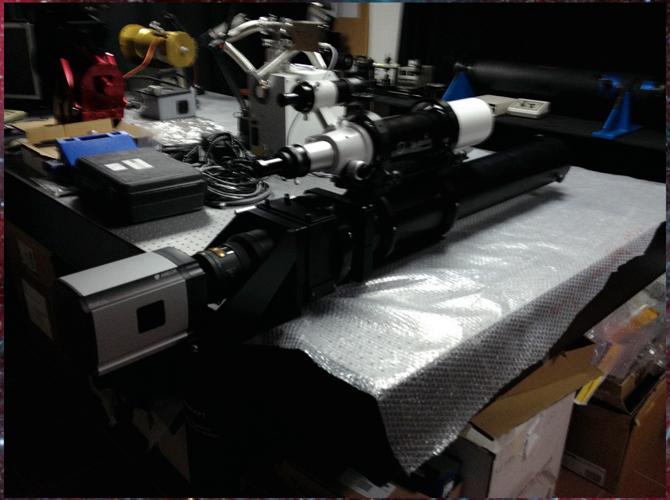
MAWFC completed in the mechanical lab.
Acceptance tests performed successfully

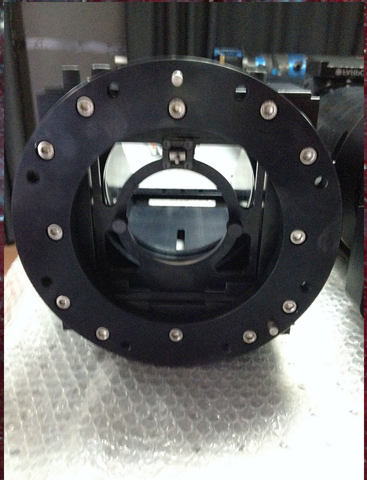
Mechanical laboratory – University of Patras (MYEDPP)

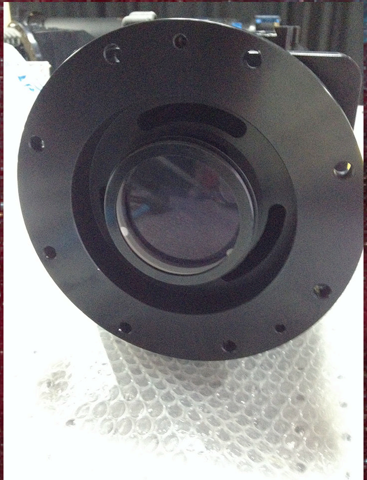
Manchester-Athens Wide Field Camera

MAWFC in the Optical lab (Mar 2015)

Optical tests / Alignments







Manchester-Athens Wide Field Camera

Mechanical 3D layout

Manchester-Athens Wide Field Camera

Mechanical 3D layout

Optical lenses:

- 210mm f/5.6 Flat-field lens
- 120mm plano-convex field lens
- 76.5mm collimator lens
- 200mm f/2 camera lens
- 60mm field-flattening window lens

Manchester-Athens Wide Field Camera

First light on sky tests (1st April 2015)

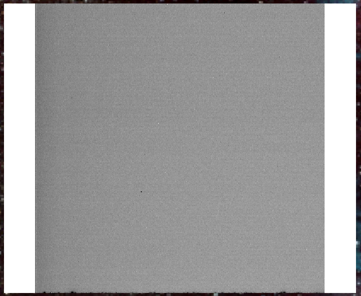
IAASARS head-quarters in Penteli hill

Manchester-Athens Wide Field Camera

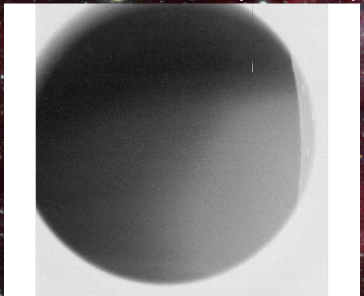
First light on sky tests (1st April 2015)

IAASARS head-quarters in Penteli hill

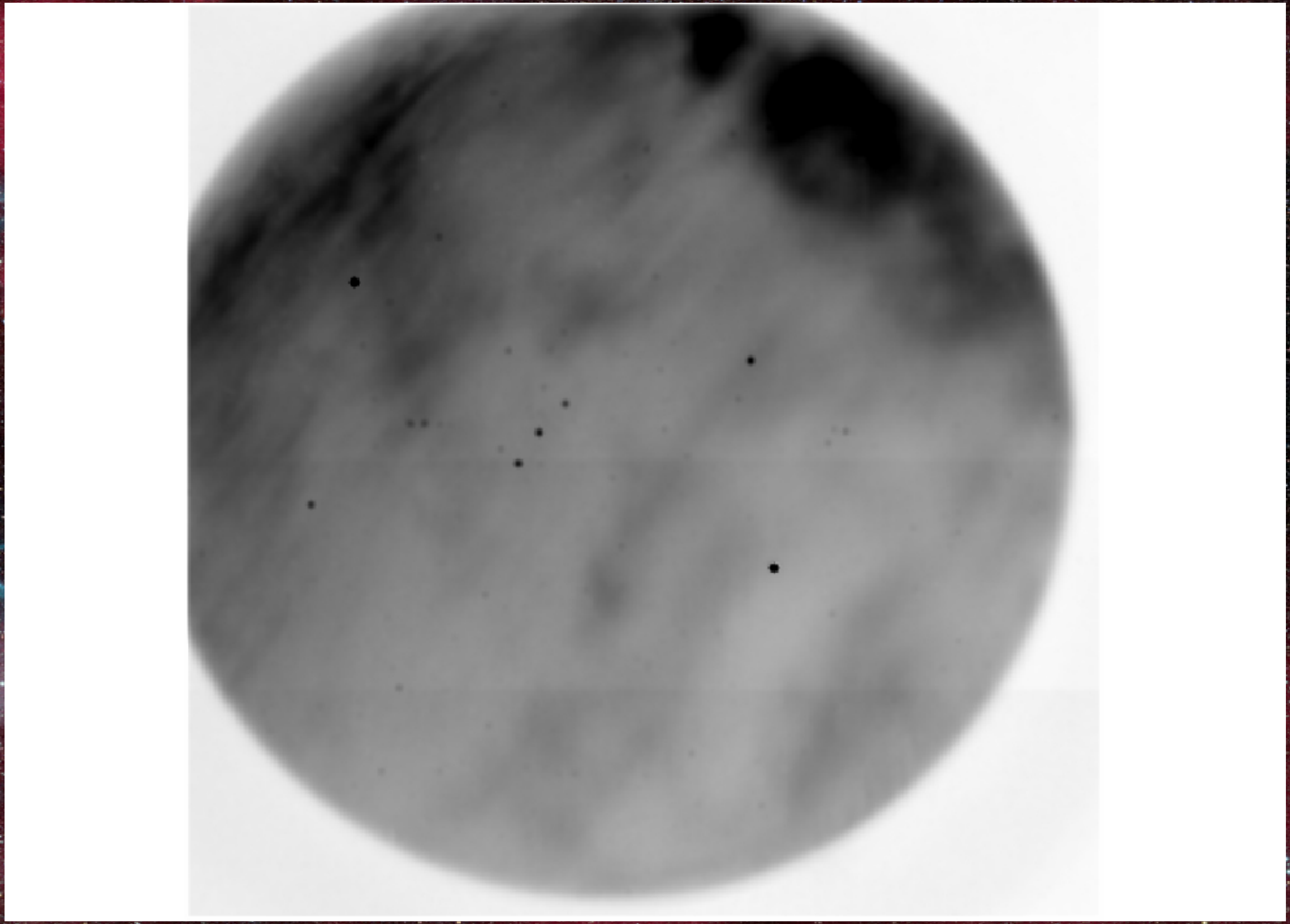
Bias frame (-90 C)



Dark frame (-90 C)



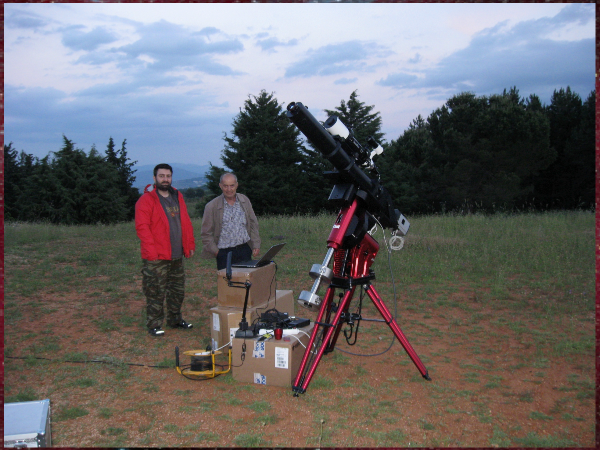
Optics tests



First light image in Orion without a filter

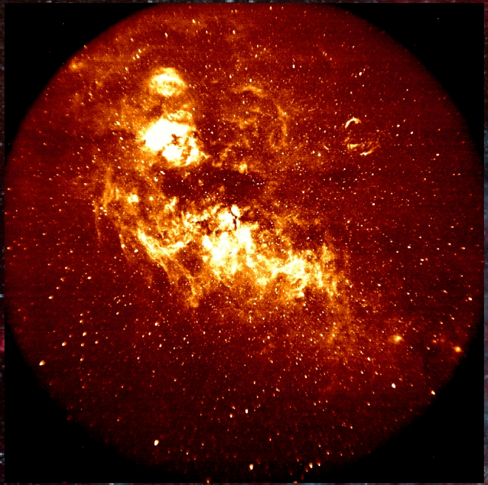
Manchester-Athens Wide Field Camera

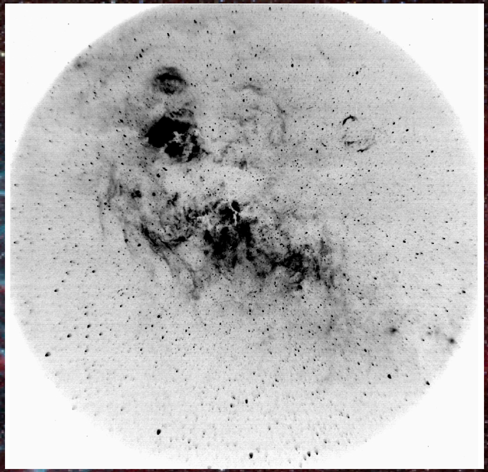
First light on sky tests at Kryoneri Observatory (12th June 2015)



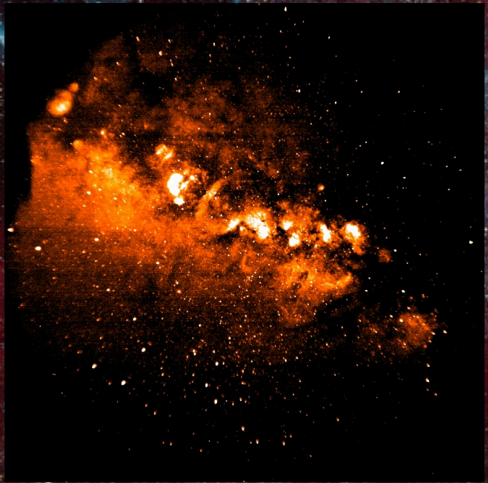
Manchester-Athens Wide Field Camera

First light on sky tests at Kryoneri Observatory (12th June 2015)

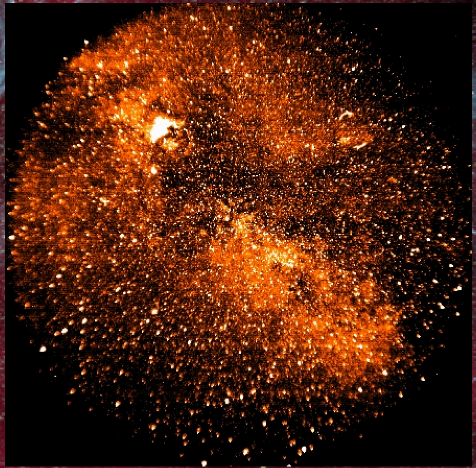




First light Hα image in Cygnus – 20min



First light Hα image in Smith Neb – 20min

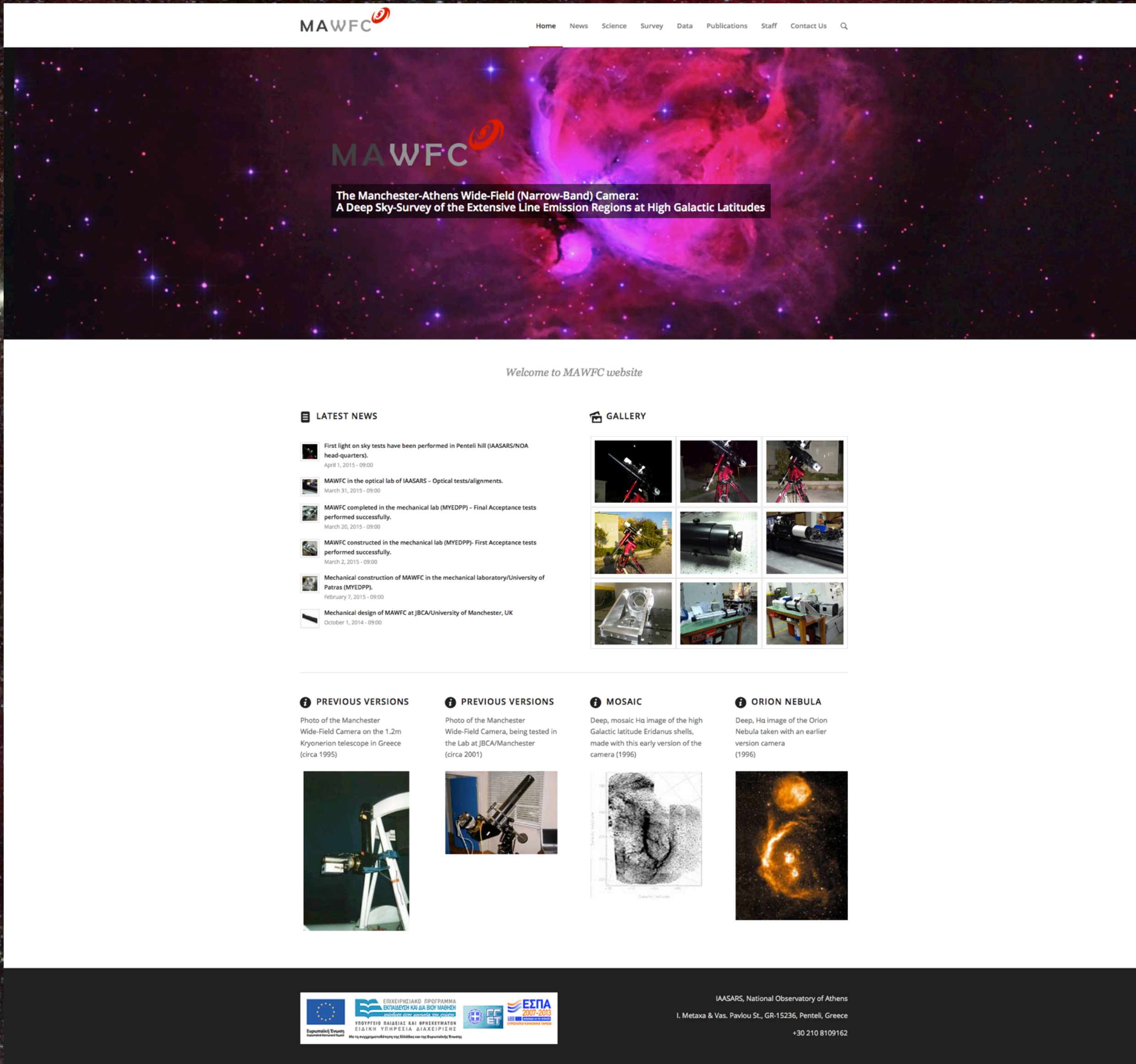


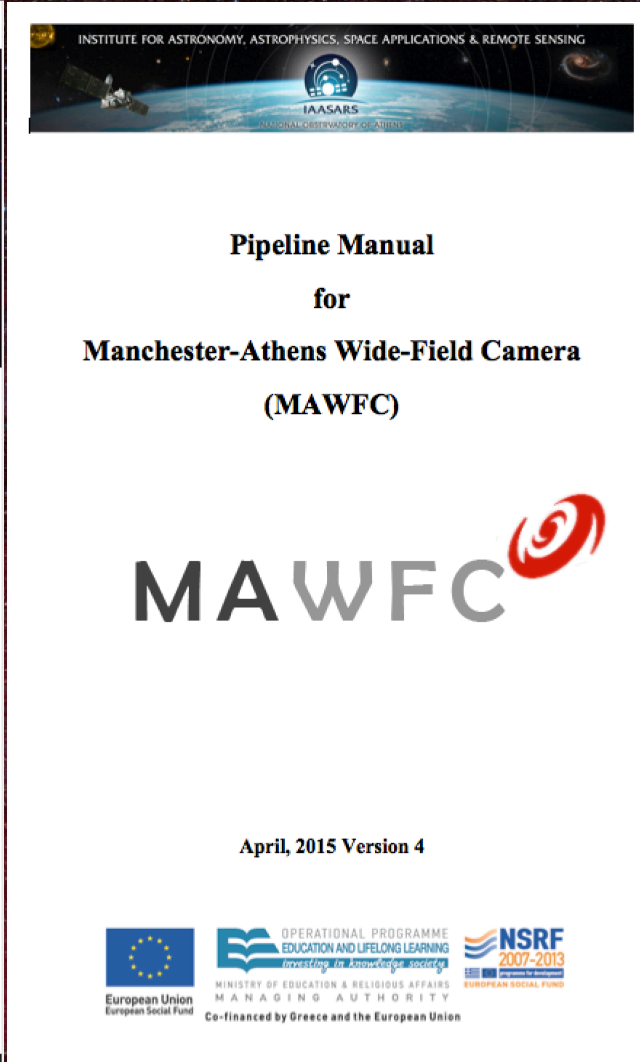
First light [O III] image in Cygnus – 20min

Manchester-Athens Wide Field Camera

MAWFC web page: http://mawfc.astro.noa.gr

MAWFC pipeline:





SUPERNOVA REMNANTS

AN ODYSSEY IN SPACE AFTER STELLAR DEATH

6 - 11 JUNE 2016, CHANIA, CRETE, GREECE

Scientific Topics

- Radiation studies from gamma-rays to radio in Galactic and Extragalactic SNRs
- The search for the binary companions of SN progenitors in SNRs in the Milky Way and Local Group
- Pulsar winds nebulae (including Crab flares)
- Magnetic fields in SNRs and PWNe
- Collisionless shock waves in SNRs
- Jets in SNRs
- SNRs as probes and drivers of galaxy structure
- SNe and SNRs cosmic ray acceleration
- SN ejecta – abundances, clumpiness
- SNe and SNRs with circumstellar interactions

Scientific Organizing Committee (SOC)

P. Boumis (Greece, co-chair), J. Raymond (USA, co-chair), T. Bell (UK), W. Blair (USA), K. Borkowski (USA), A. Decourchelle (France), R. Fesen (USA), D. Green (UK), R. Kothes (Canada), A. Rest (USA), P. Slane (USA)

Local Organizing Committee (LOC)

P. Boumis (Greece, co-chair), A. Bonanos (Greece, co-chair), D. Abartzi (Greece), S. Akras (Brazil), J. Alikakos (Greece), A. Chiotellis (Greece), M. Kopsacheili (Greece) M. Kourniotis (Greece), I. Leonidaki (Greece), M. Pliatsika (Greece), S. Williams (Greece)

http://snr2016.astro.noa.gr

STAR ALLIANCE