Laboratorio di Astronomia

Modern Instruments

Laurea in Astronomia
AA 2025/26

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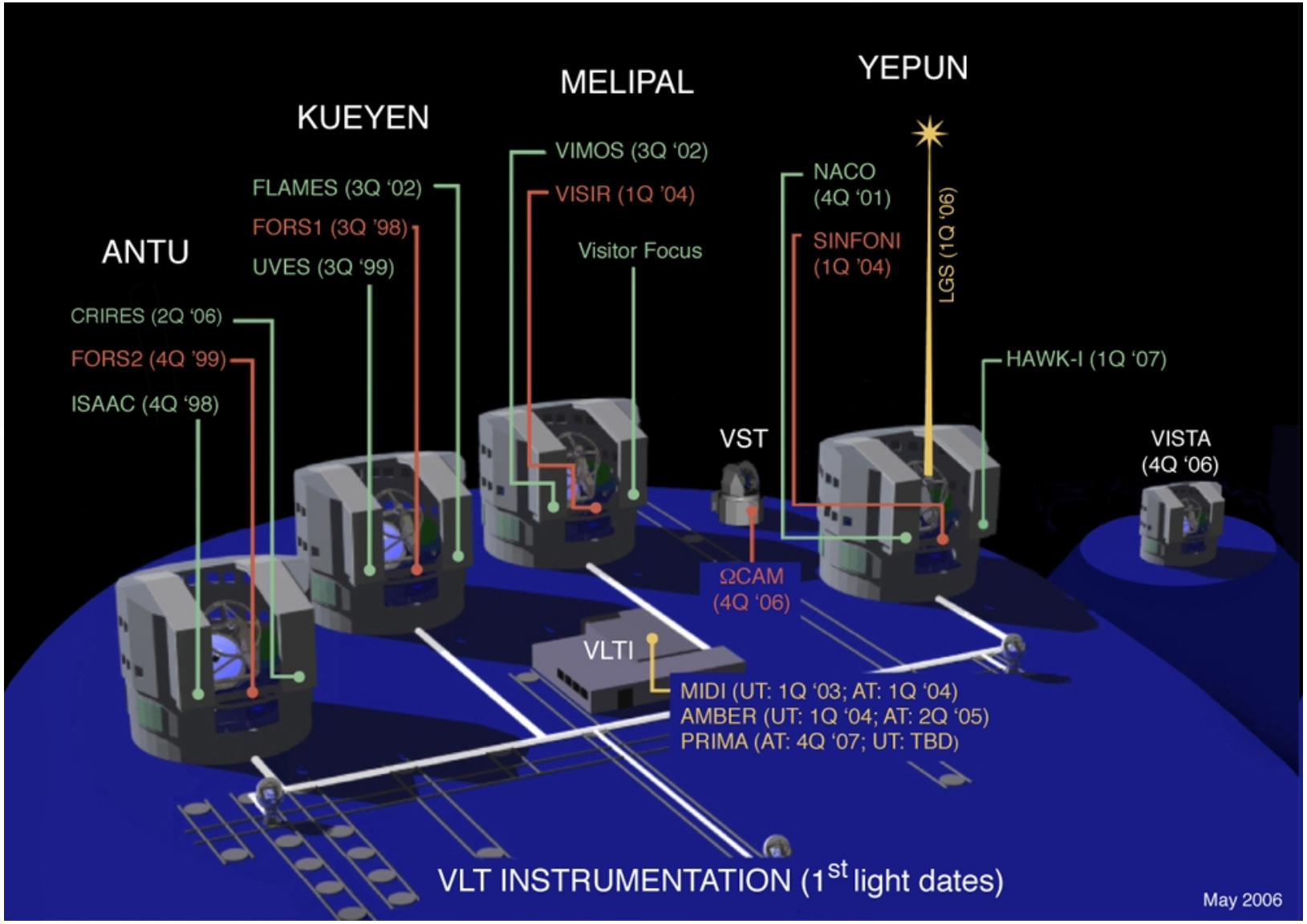
Dipartimento di Fisica ed Astronomia

Outline

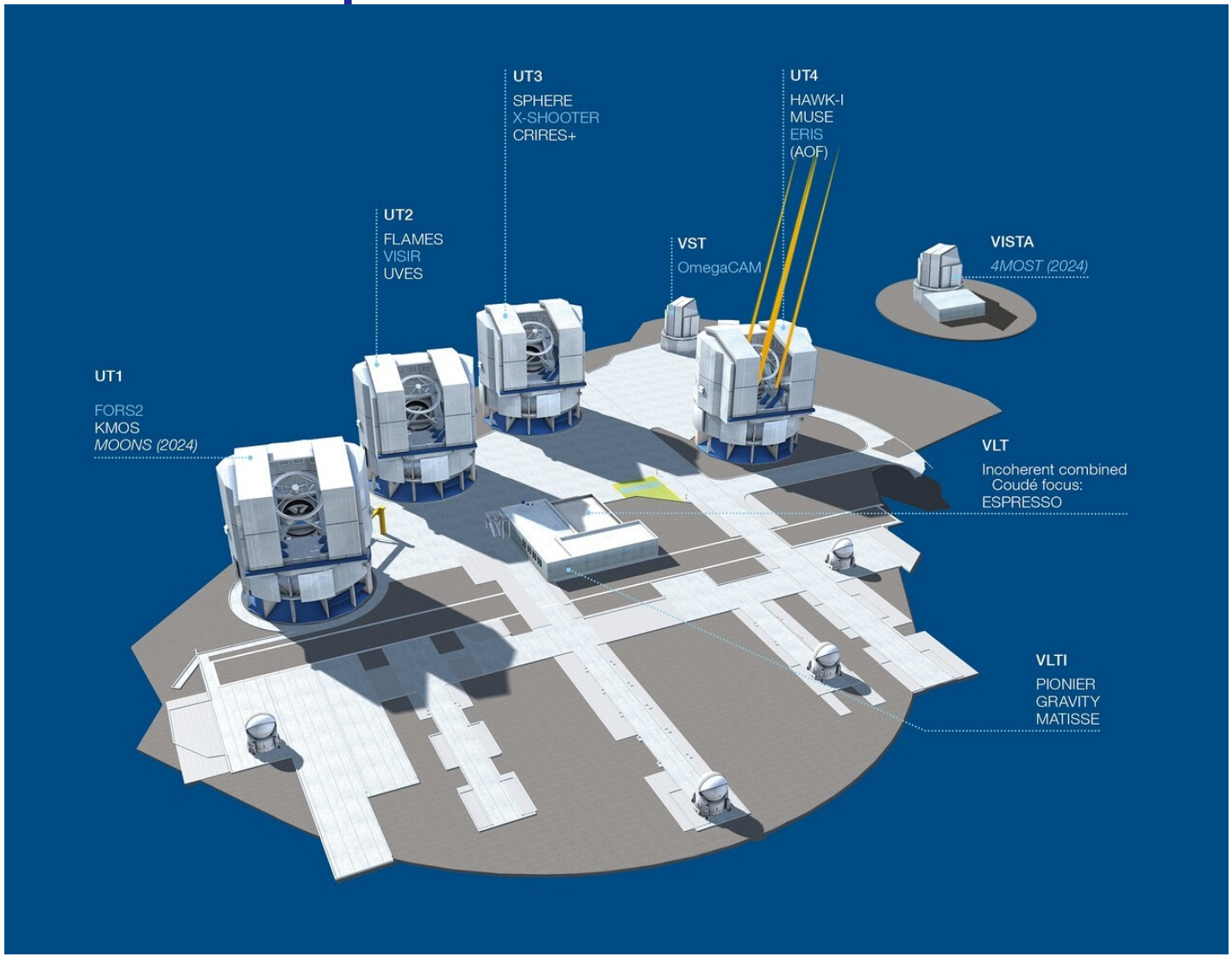
- ✓ Instruments at ESO – Paranal
- ✓ How a spectrum looks like
- ✓ Visual bands
- ✓ IR bands
- ✓ Observing modes: MOS, IFU, Long Slit, imaging
- ✓ Wide Field Immagers
- ✓ 2nd Generation Instruments

Instruments at ESO - Paranal



Instruments at ESO – Paranal

updated Oct 2024



Instruments at ESO – Paranal

old...

Telescope	Focus			
	Nasmyth A	Cassegrain	Nasmyth B	Interferometric
UT1 (Antu)	CRIRES	FORS2	Visitor	AMBER
UT2 (Kueyen)	FLAMES	XSHOOTER	UVES	MIDI
UT3 (Melipal)	ISAAC	VISIR	VIMOS	VLTI Visitor Instrument
UT4 (Yepun)	HAWK-I	SINFONI	NACO	
AT1				AMBER
AT2				MIDI
AT3				VLTI Visitor Instrument
AT4				
VISTA		VIRCAM		
VST		OmegaCAM		

ails please refer to the Call for Proposals for Period 87.

Instruments at ESO – Paranal

updated Oct 2024

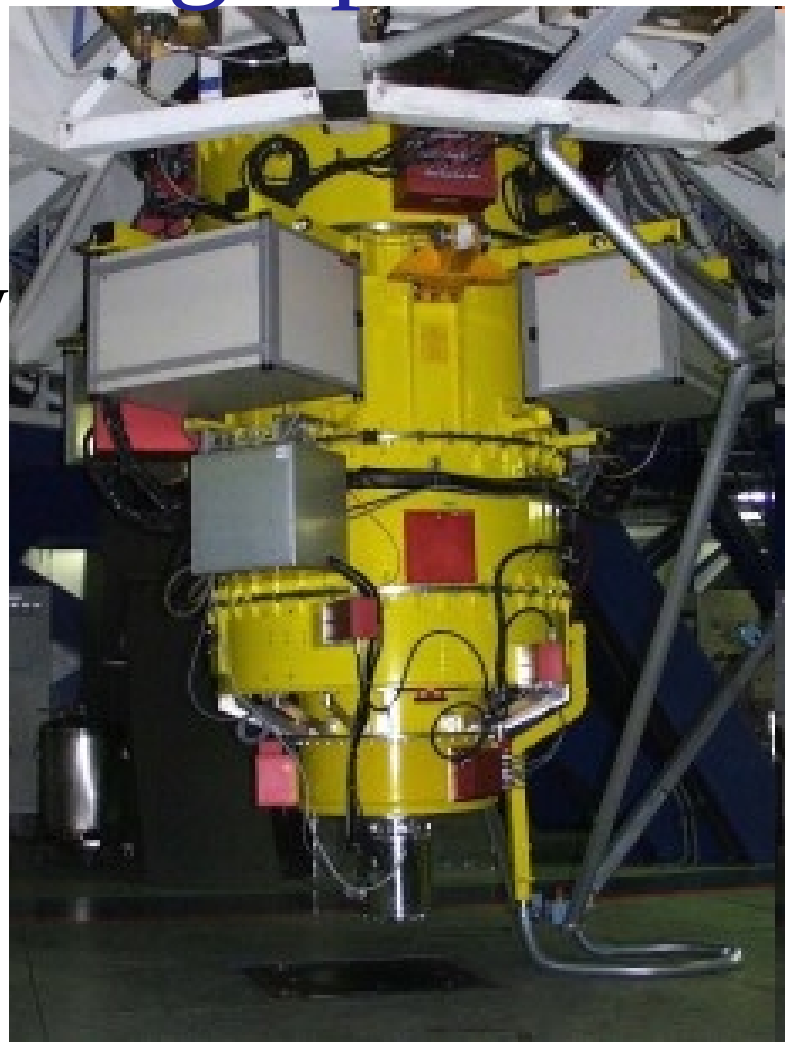
Telescope	Focus				
	Nasmyth A	Cassegrain	Nasmyth B	Incoherent Combined Coudé	Interferometric
UT1 (Antu)	Visitor focus	FORS2	KMOS	ESPRESSO	GRAVITY
UT2 (Kueyen)	FLAMES	VISIR	UVES		MATISSE
UT3 (Melipal)	SPHERE	XSHOOTER	CRIRES		PIONIER
UT4 (Yepun)	HAWK-I	ERIS	MUSE		Visitor foci

AT1					GRAVITY
AT2					MATISSE
AT3					PIONIER
AT4					Visitor foci

FORS (1&2): FOcal Reducer and low dispersion Spectrograph

Observing modes

- IMAging
- LSS Long Slit Spectroscopy
- MXU Multi Object Spec. (mask)
- MOS Multi Object Spec. (moving slits)
- Image Polarimetry
- Spectro-polarimetry



Imaging

- wavelength range 330-1100 nm (check out FORS1 and FORS2 differences)
- two possible pixel scales: 0.25''/pixel or 0.125''/pixel
- field sizes are 6.8' x 6.8' and 4.25' x 4.25' respectivelly
- Limiting magnitudes are (1 hour in standard observing) U=25.9 B=27.6 V=27.3 R=26.6 I=25.8

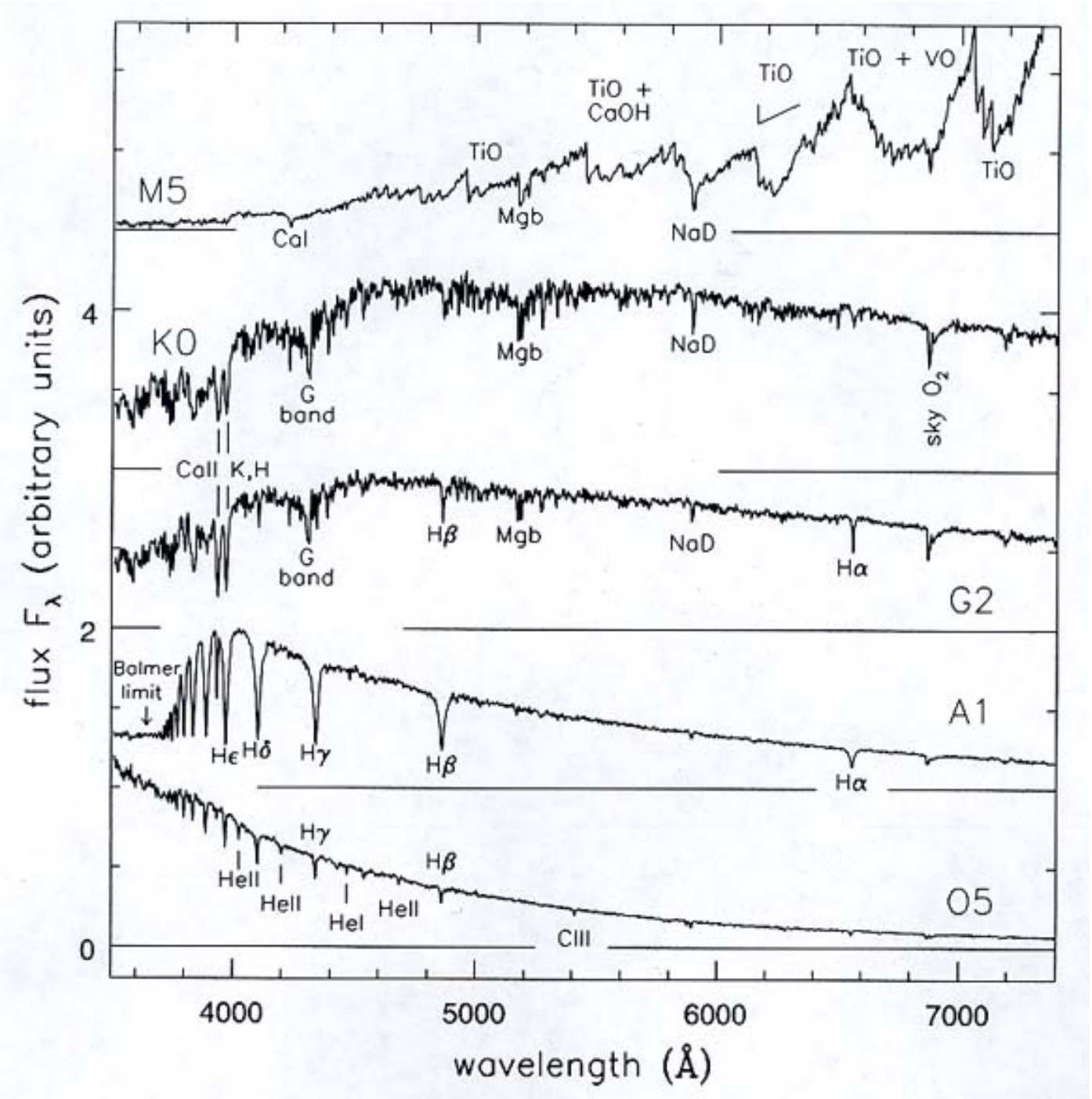
FORS1: Filters

Filter name+ESO number	eff. wavelength (nm)	FWHM (nm)
u_HIGH+112	361	50.5 (1)
b_HIGH+113	440	103.5 (2)
v_HIGH+114	557	123.5
g_HIGH+115	470	160.5
U_BESS+33 (3)	336	36.0
B_BESS+34 (3)	429	88.0
V_BESS+35	554	111.5
R_BESS+36	657	150.0
I_BESS+37	768	138.0
u_GUNN+38 (3)	359	33.5
v_GUNN+39 (3)	398	46.0
g_GUNN+40 (4)	506	79.5
r_GUNN+41 (3)	653	81.5
z_GUNN+42 (3)	910	130.5
GG375+30 (5)	n/a (edge filter)	n/a
GG435+31 (5)	n/a (edge filter)	n/a
OG590+72 (5)	n/a (edge filter)	n/a

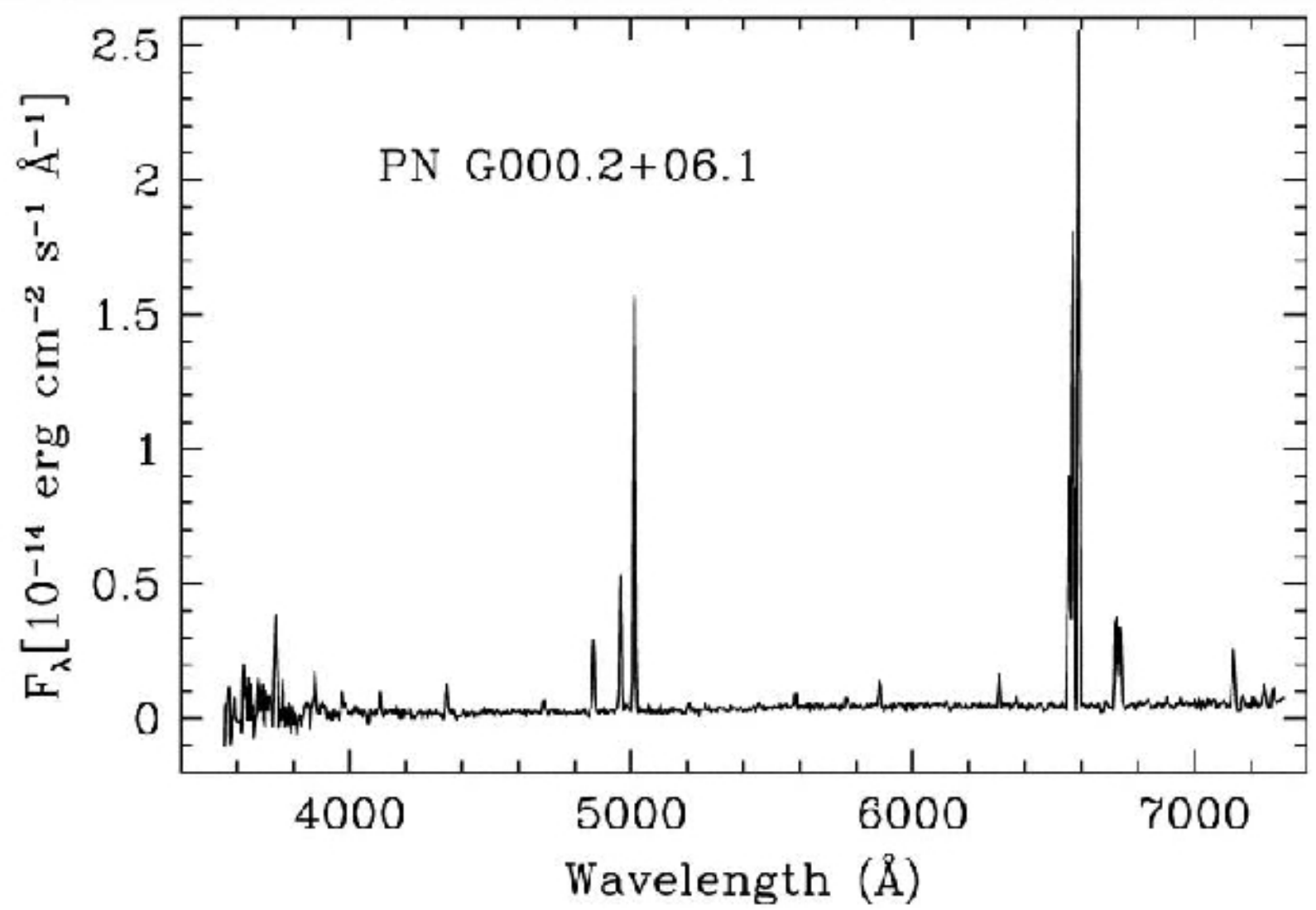
Long Slit Spectroscopy

- Slit width: 0.28”, 0.40”, 0.51”, 0.70”, 1.00”, 1.31”, 1.60”, 2.00”, 2.50”
- two possible pixel scales: 0.25"/pixel or 0.125"/pixel
- Slit length is 6.8' or 4.25' respectivelly

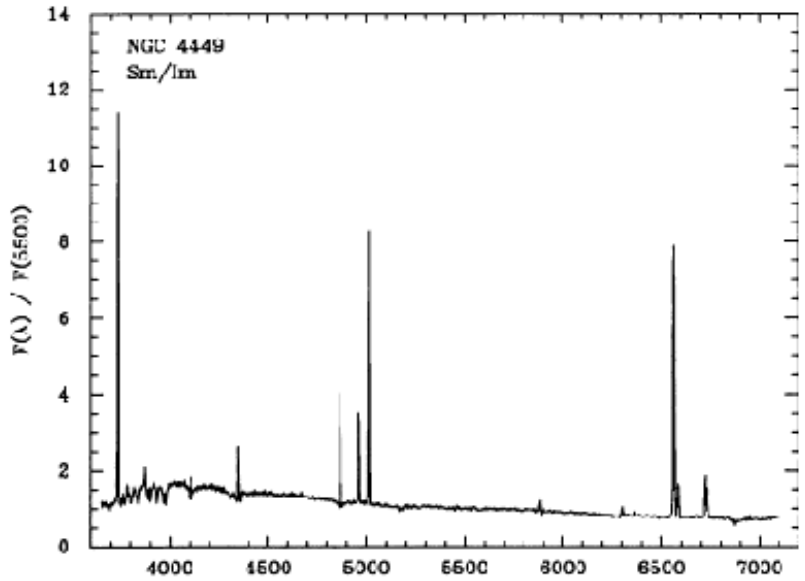
Spettri

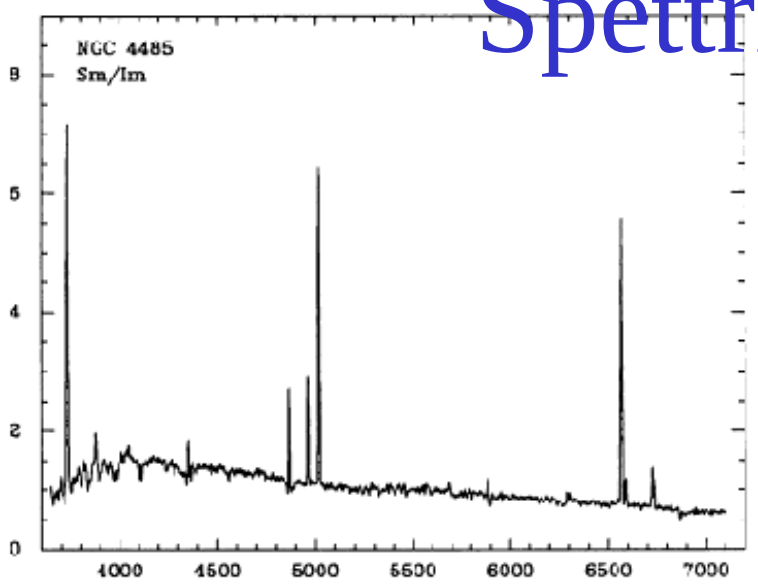

M5
TiO
TiO + CaOH
TiO
TiO + VO
TiO
CaI
Mgb
NaD
K0
G band
Mgb
NaD
sky O_2
CaII K,H
G band
Hβ
Mgb
NaD
Hα
G2
Balmer limit
Hε
Hδ
Hγ
Hβ
Hα
A1
Hγ
HeII
HeII
HeI
HeII
Hβ
CIII
O5
flux F_λ (arbitrary units)
0
2
4
4000
5000
6000
7000
wavelength (Å)

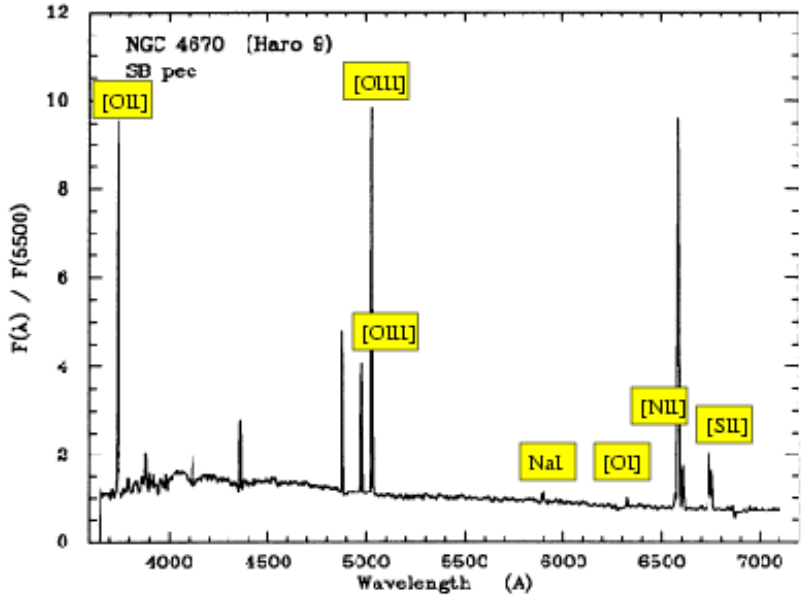
Spettri

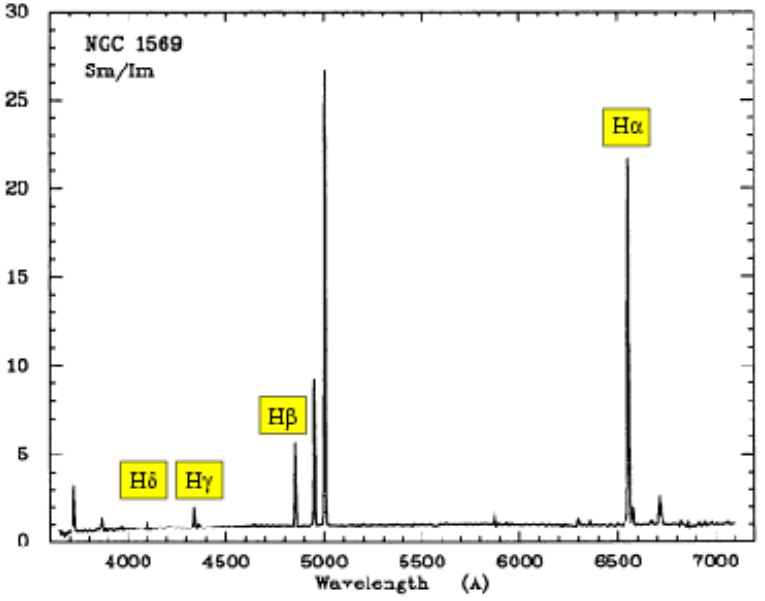

PN G000.2+06.1
F_λ[10^{-14} erg cm^{-2} s^{-1} Å^{-1}]
2.5
2
1.5
1
0.5
0
4000
5000
6000
7000
Wavelength (Å)

Spettri


NGC 4449
Sm/Im
F(λ) / F(5500)
Wavelength (A)


NGC 4485
Sm/Im
Wavelength (A)


NGC 4670 (Haro 9)
SB pec
[OII]
[OIII]
[OIII]
NaI
[OI]
[NII]
[SII]
F(λ) / F(5500)
Wavelength (A)


NGC 1569
Sm/Im
Hα
Hβ
Hδ
Hγ
Wavelength (A)

Spettri

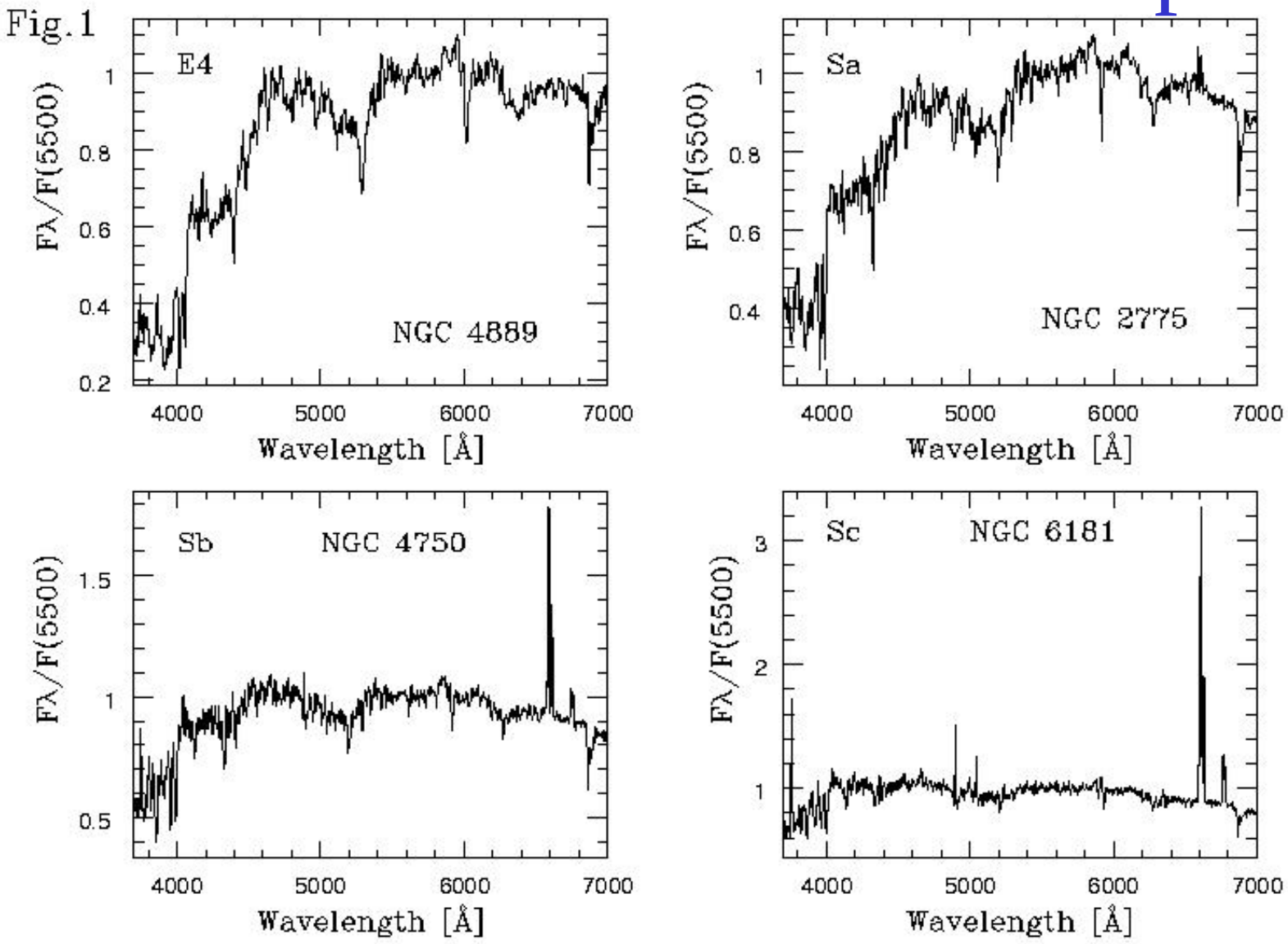
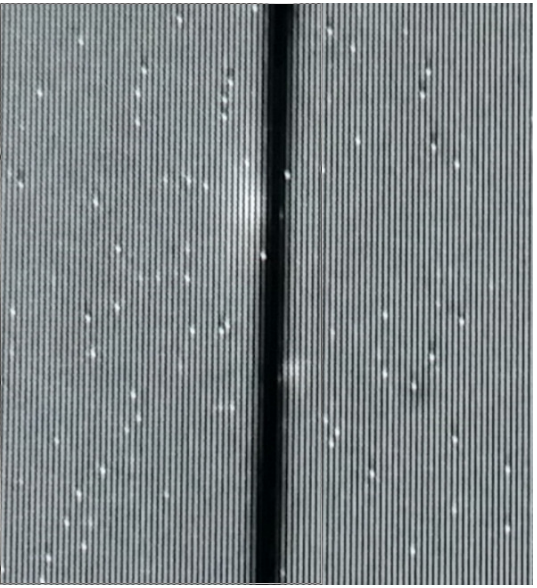
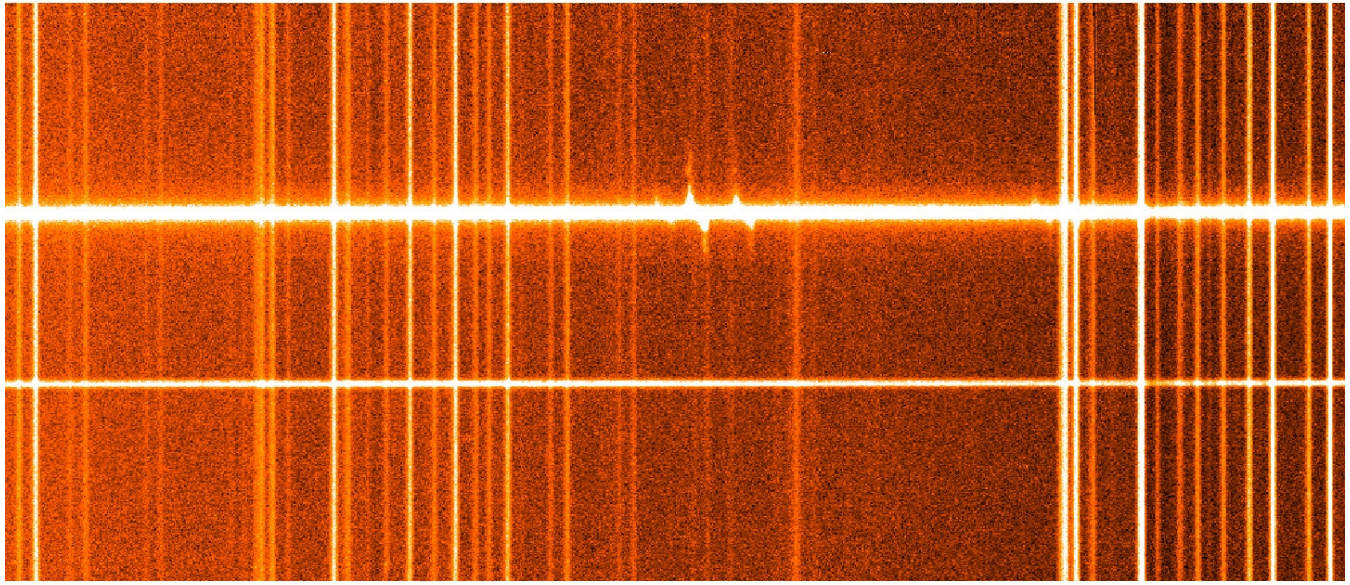


Fig.1
E4
NGC 4889
Sa
NGC 2775
Sb
NGC 4750
Sc
NGC 6181
Fλ/F(5500)
Wavelength [Å]
4000
5000
6000
7000

Spettri





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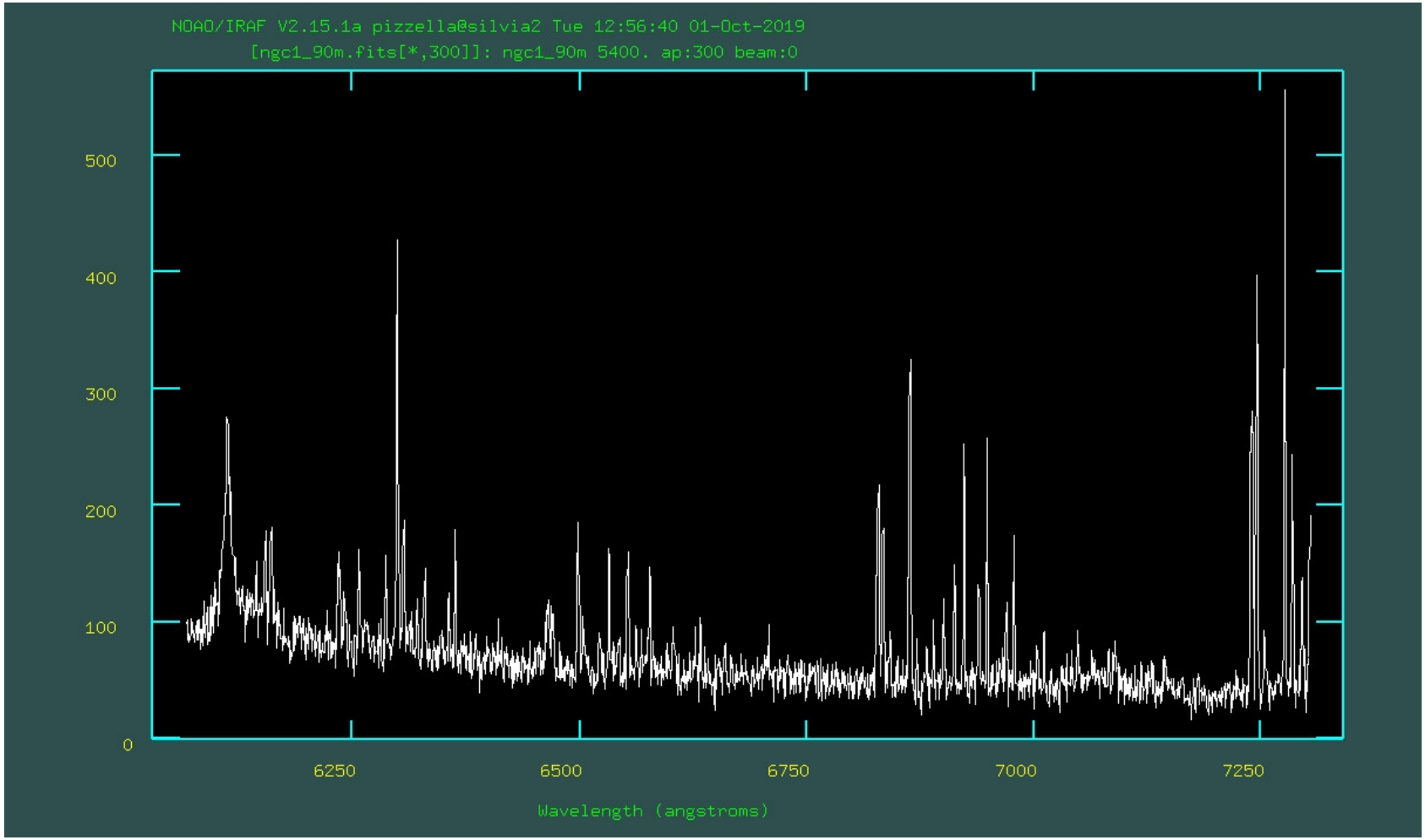
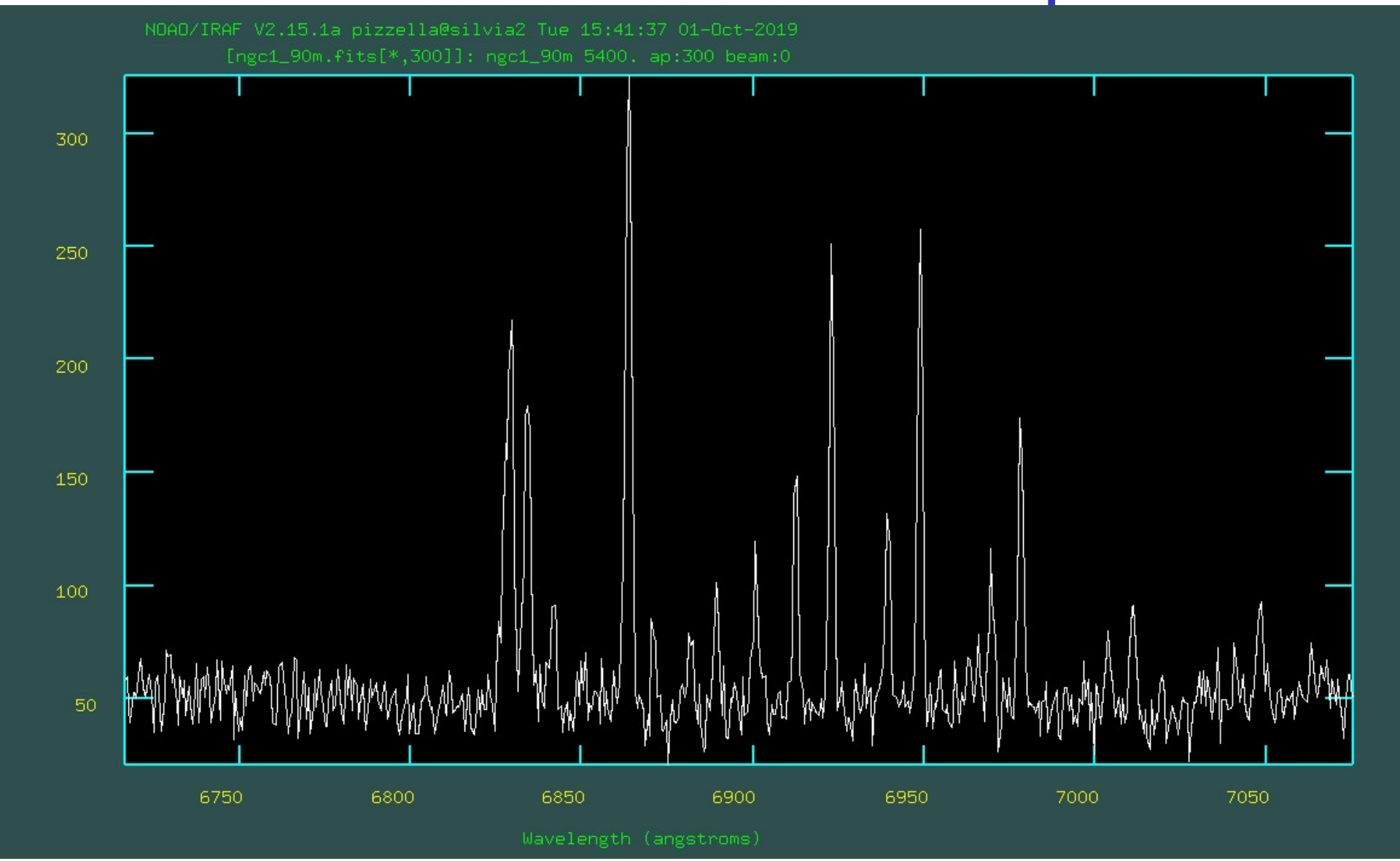

NOAO/IRAF V2.15.1a pizzella@silvia2 Tue 12:56:40 01-Oct-2019
[ngc1_90m.fits[*,300]]: ngc1_90m 5400. ap:300 beam:0
500
400
300
200
100
0
6250
6500
6750
7000
7250
Wavelength (angstroms)

Spettri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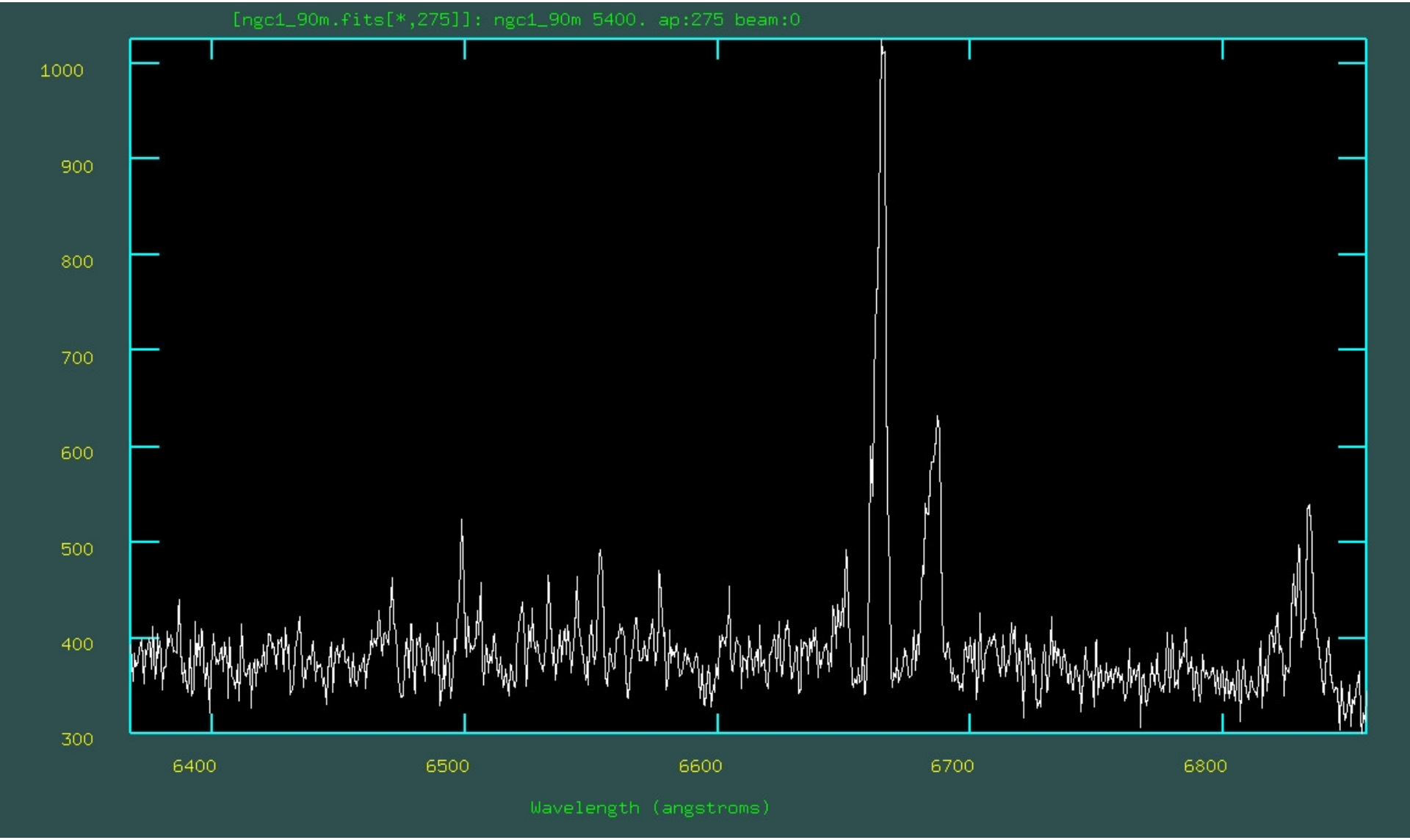
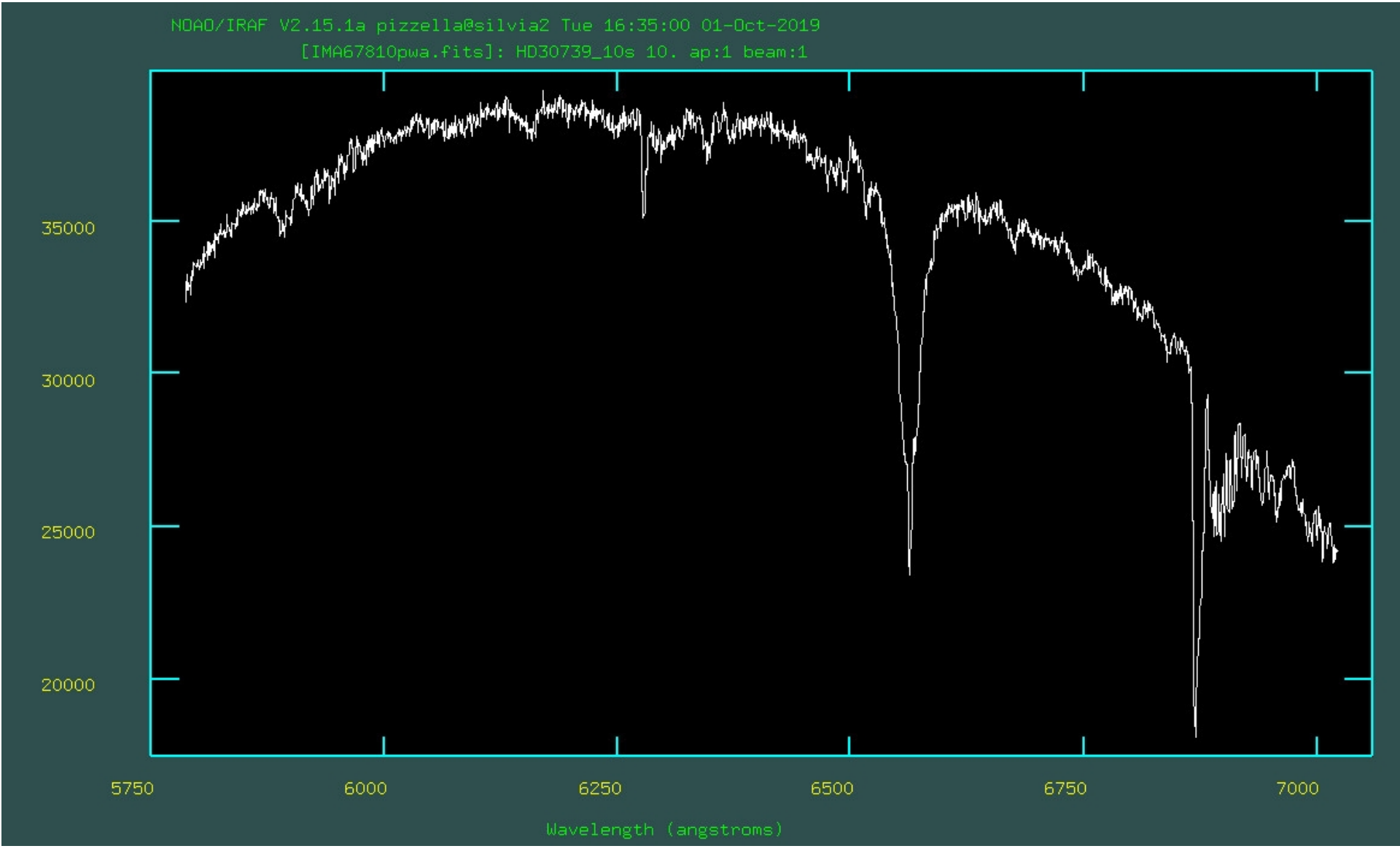
300
250
200
150
100
50
6750
6800
6850
6900
6950
7000
7050
Wavelength (angstroms)

Spettri


[ngc1_90m.fits[*,275]]: ngc1_90m 5400. ap:275 beam:0
1000
900
800
700
600
500
400
300
6400
6500
6600
6700
6800
Wavelength (angstroms)

Spettri


NOAO/IRAF V2.15.1a pizzella@silvia2 Tue 16:35:00 01-Oct-2019
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35000
30000
25000
20000
5750
6000
6250
6500
6750
7000
Wavelength (angstroms)

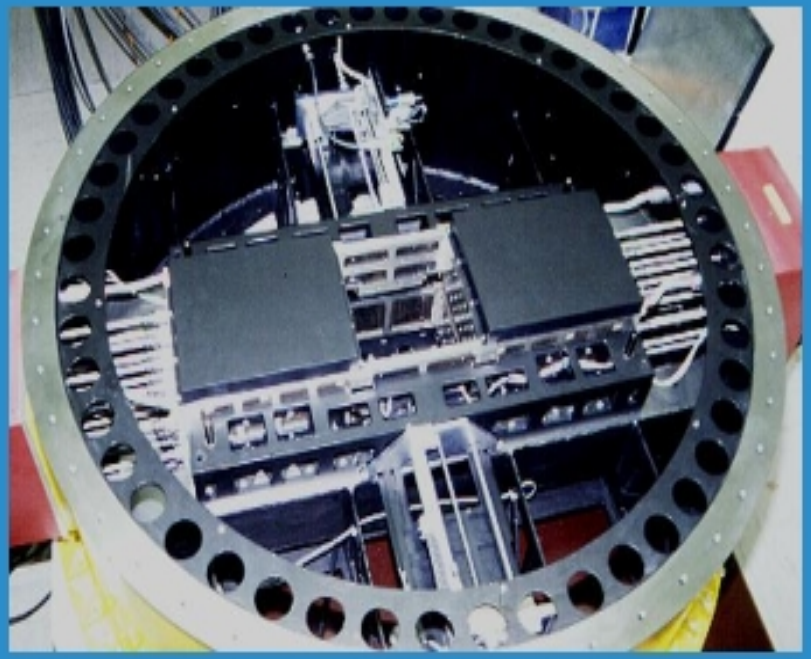
FORS1: Grisms

Grism name + ESO number	Lambda Central	Wavelength range	Dispersion	Order separation
	[nm]	[nm]	[Å/mm]	filter
GRIS_600B+12	465	330 - 621	50	none
GRIS_600V+94	585	443 - 737	49	GG435 or GG375
GRIS_600R+14	627	501 - 769	45	GG435
GRIS_300V+10 (1)	590	330 - (660)	112	none
GRIS_300V+10 (1)	590	385 - (750)	112	GG375
GRIS_300V+10	590	445 - 865	112	GG435
GRIS_150I+17 (1)	720	330 - (650)	230	none
GRIS_150I+17 (1)	720	385 - (750)	230	GG375
GRIS_150I+17 (1)	720	445 - (870)	230	GG435
GRIS_150I+17	720	600 - 1100	230	OG590
holographic:				
GRIS_1200B+97	435	366 - 511	24.0	none
GRIS_1200g+96	488	417 - 564	24.3	none

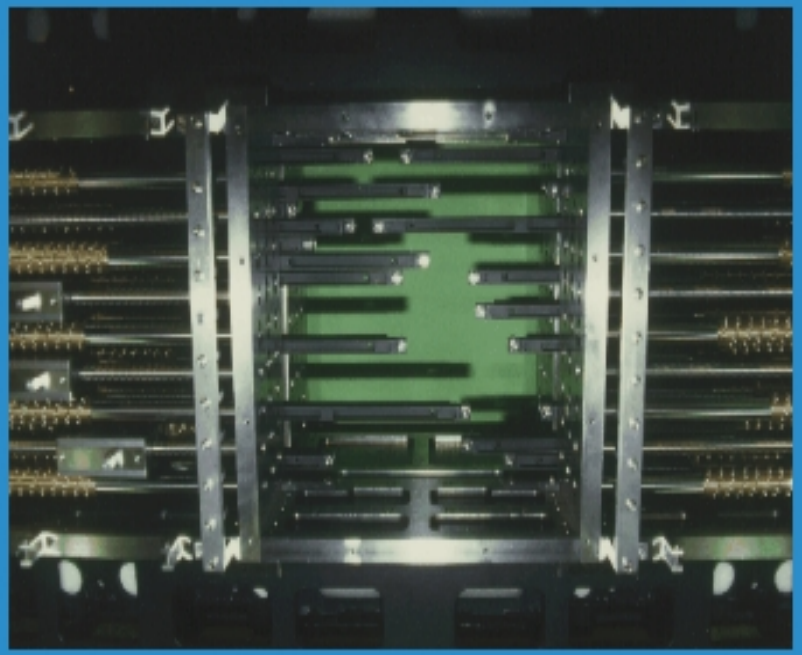
FORS2: Grisms

Grism name + ESO number	Lambda Central	Wavelength range (MIT)	Dispersion	Order separation
	[nm]	[nm]	[Å/mm]	filter
GRIS_600B+22	465	330 - 621	50	none
GRIS_600I+25	795	663 - 939	44	OG590
GRIS_300V+20 (1)	590	330 - (650)	110	none
GRIS_300V+20 (1)	590	385 - (750)	111	GG375
GRIS_300V+20	590	445 - 870	112	GG435
GRIS_300I+21	860	600 - 1100	108	OG590
GRIS_200I+28	745	560 - 1100	162	OG550 (cemented)
GRIS_150I+27 (1)	720	330 - (650)	225	none
GRIS_150I+27 (1)	720	385 - (750)	230	GG375
GRIS_150I+27 (1)	720	445 - (880)	230	GG435
GRIS_150I+27	720	600 - 1100	230	OG590
holographic:				
GRIS_1400V+18 (3)	520	456 - 586	20.8	none
GRIS_1200R+93 (3)	650	575 - 731	25.0	GG435
GRIS_1028z+29 (3)	860	773 - 948	28.3	OG590
GRIS_600RI+19 (3)	678	512 - 845	55	GG435
GRIS_600z+23 (3)	901	737 - 1070	54	OG590
2nd order:				
GRIS_600I+25 (2)	425	369 - 488	19	FILT_465_250+82
GRIS_600z+23 (2,3)	466	389 - 546	20	FILT_465_250+82

FORS1: MOS



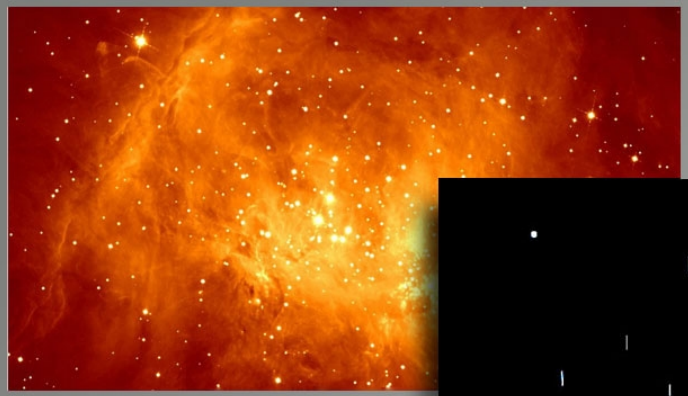
the MOS unit as seen from above.



MOS slit jaws in more detail

- 19 Slits, length 22”, width >0.3”, set up <25s

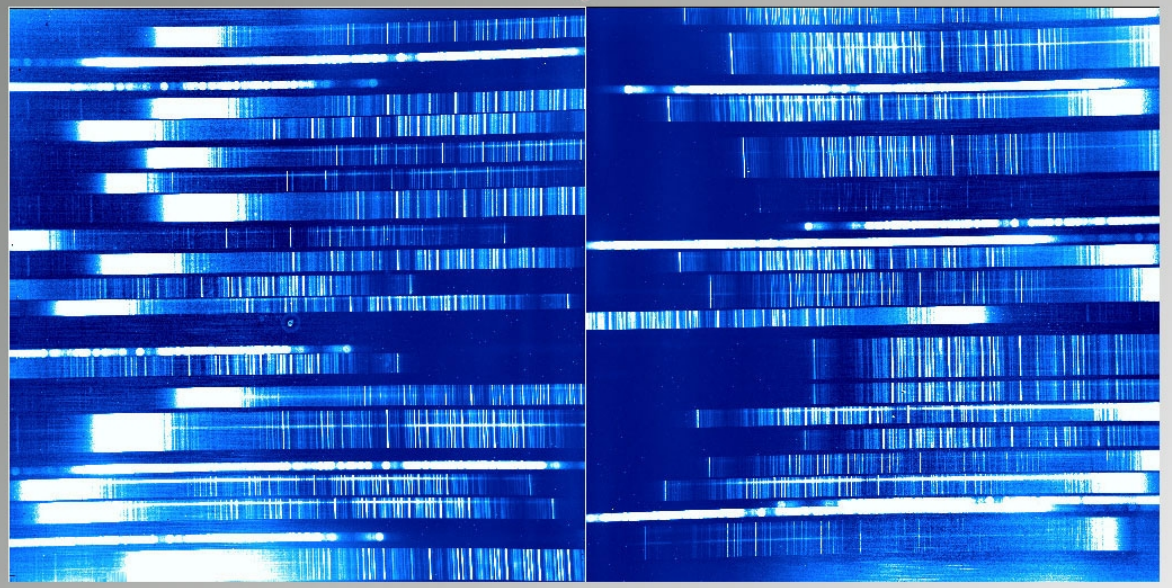
Spectral Observations of Multiple Objects Using MOIRCS



(1) Take an image of the region of interest and choose targets for spectroscopy.

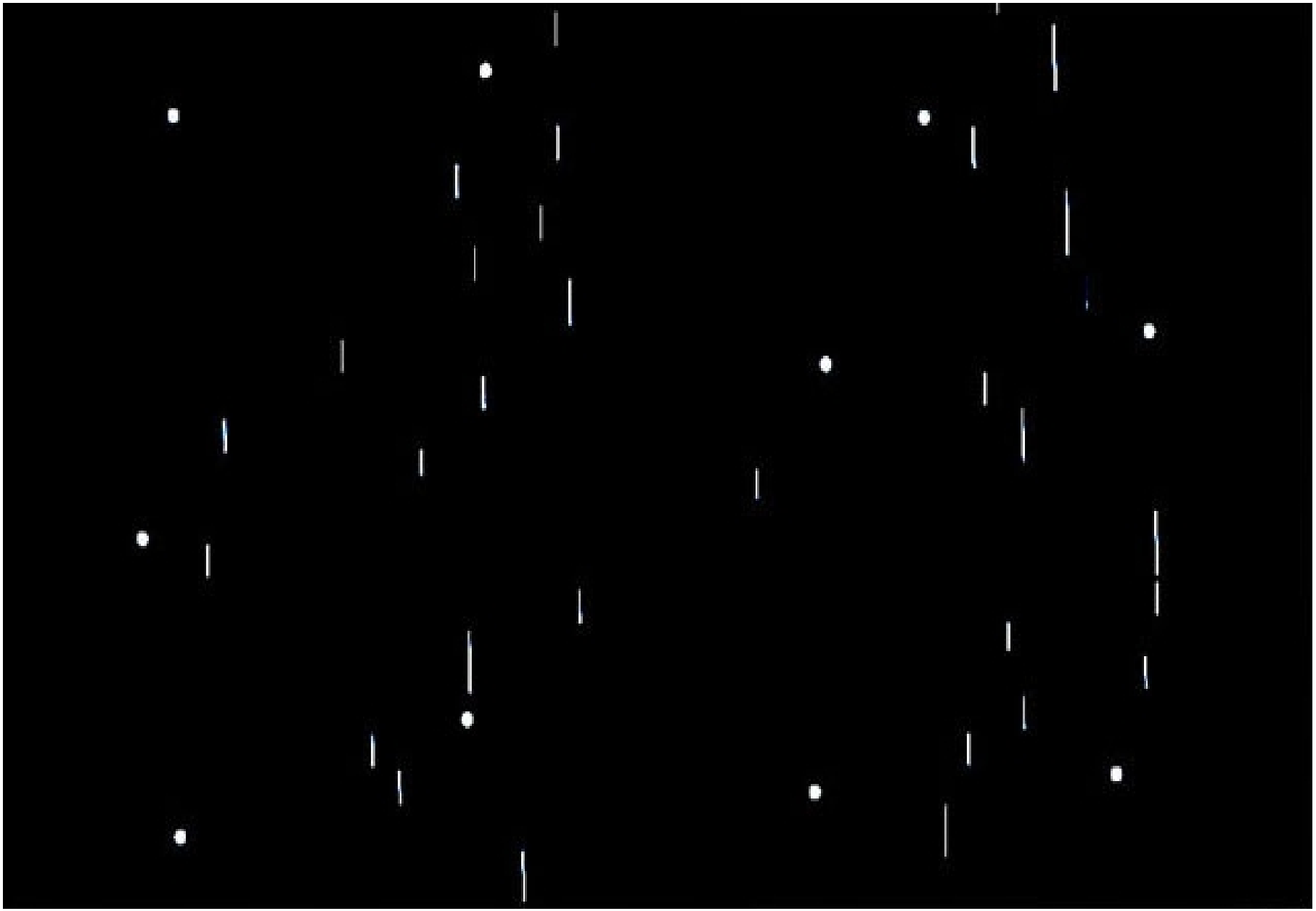


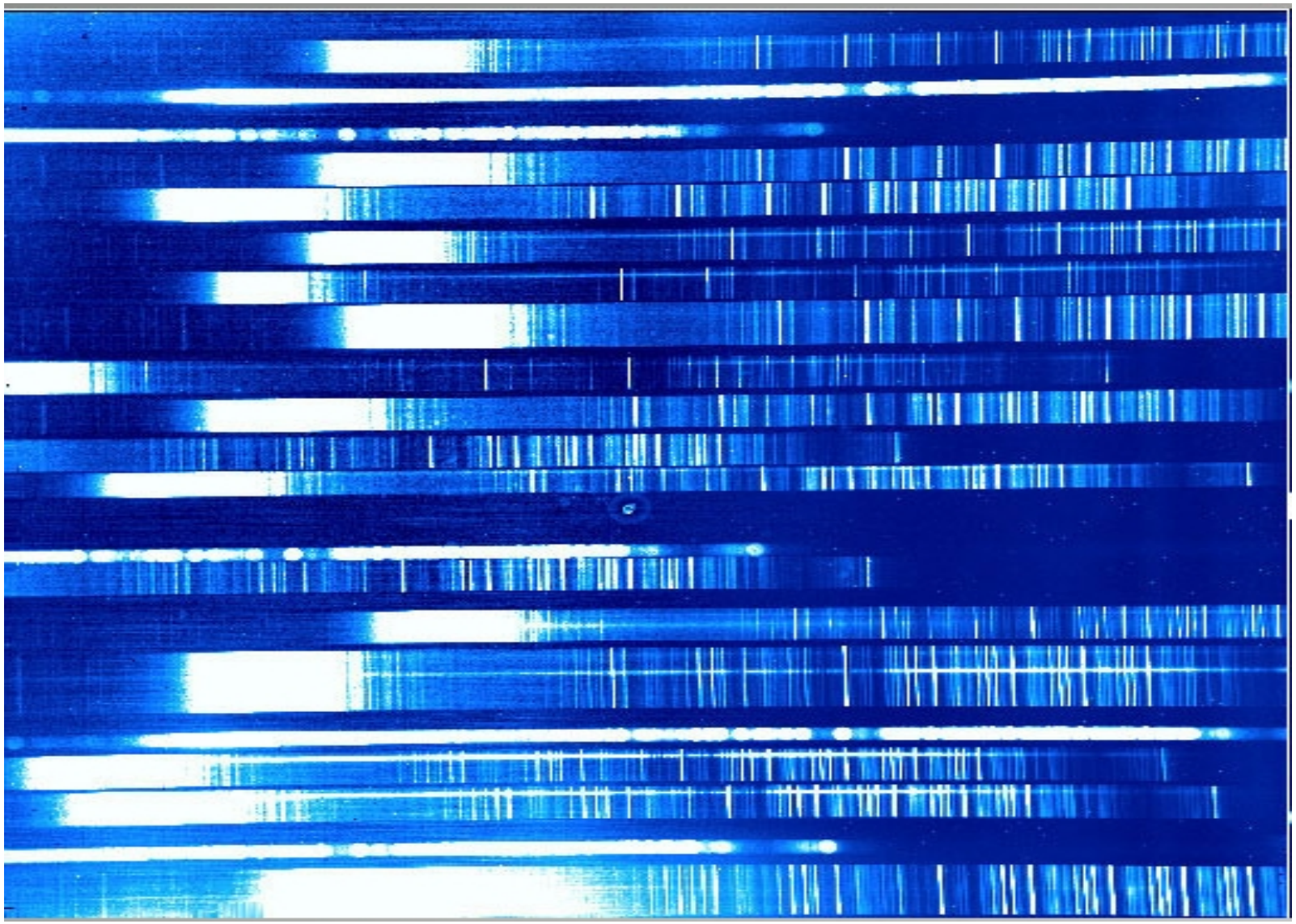
(2) Cut slits in a mask made of an aluminum panel at the position of the target objects. Cut holes in the mask at the position of bright stars to help align the mask with the target objects.



(3) Raw spectroscopic data from MOIRCS. Two infrared detectors record spectra from the left and right side of the mask.

FORS1: MOS



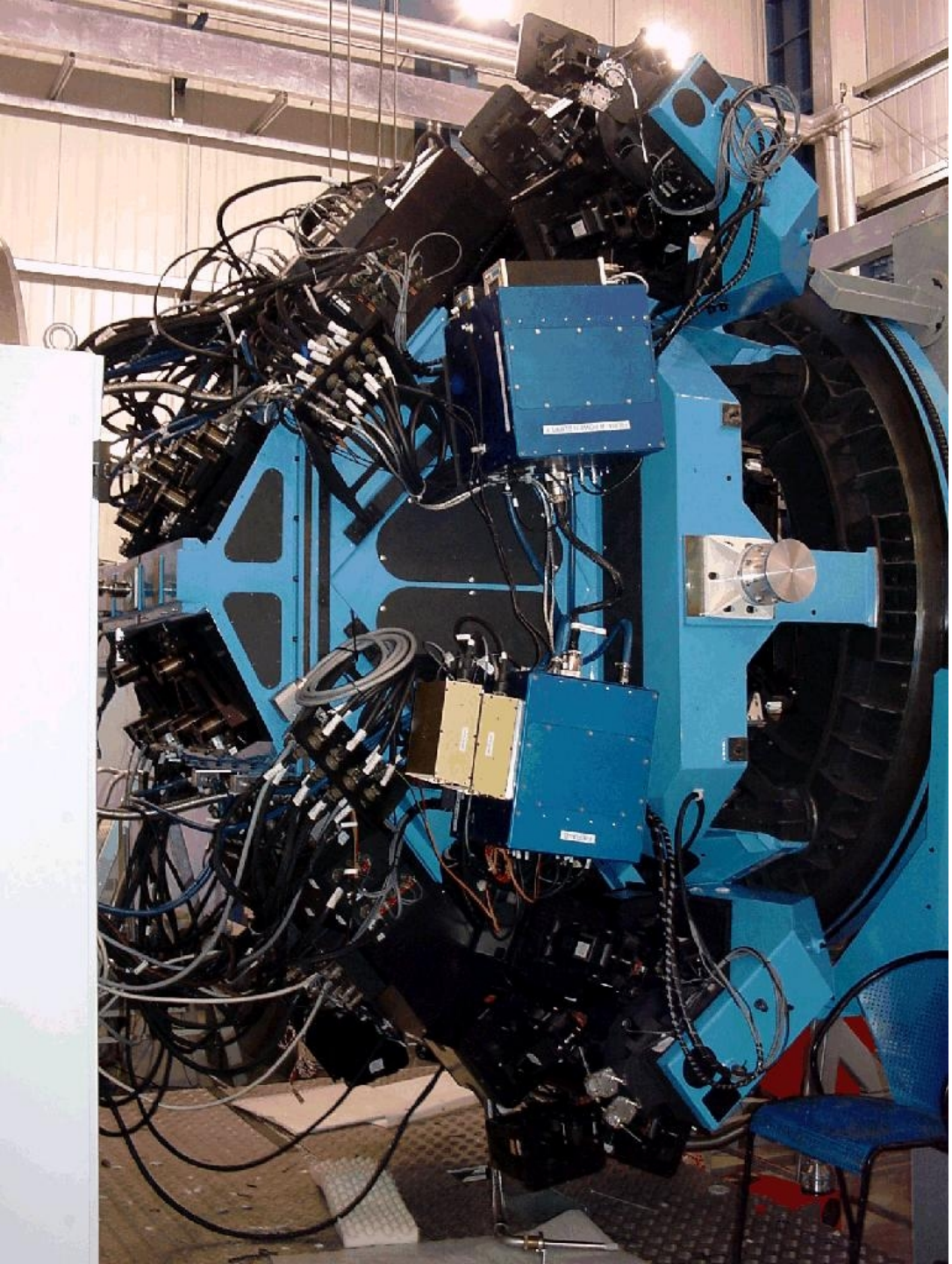


FORS1 spectroscopic modes

Instrument Mode	Rs = λ/Δλ	Mag-limit
MOS - movable slits [1]	260-1700	R=24.0-22.8
Longslit Spectroscopy [2]	260-1700	R=24.0-22.8
Spectropolarimetry [3]	260-1700	R=19.2-17.2

FORS2 spectroscopic modes

Instrument Mode	Rs = λ/Δλ	Mag-limit
MOS - movable slits [1]	260-2600	R=24.2-23.3
MXU - exchangeable masks [2]	260-2600	R=24.2-23.3
Longslit Spectroscopy [3]	260-2600	R=24.2-23.3
HIT spectroscopy [4]	660-780	--



VIMOS

- Visible Imaging Multi-Object Spectrograph
- Is composed by 4 identical spectrographs, each looking at one of the 4 quadrants

VIMOS is basically a MOS instrument for extragalactic targets.

- It can take images but these are basically only necessary to prepare the masks

- It can work in

Integral Field Unit

mode:

3 MODES:

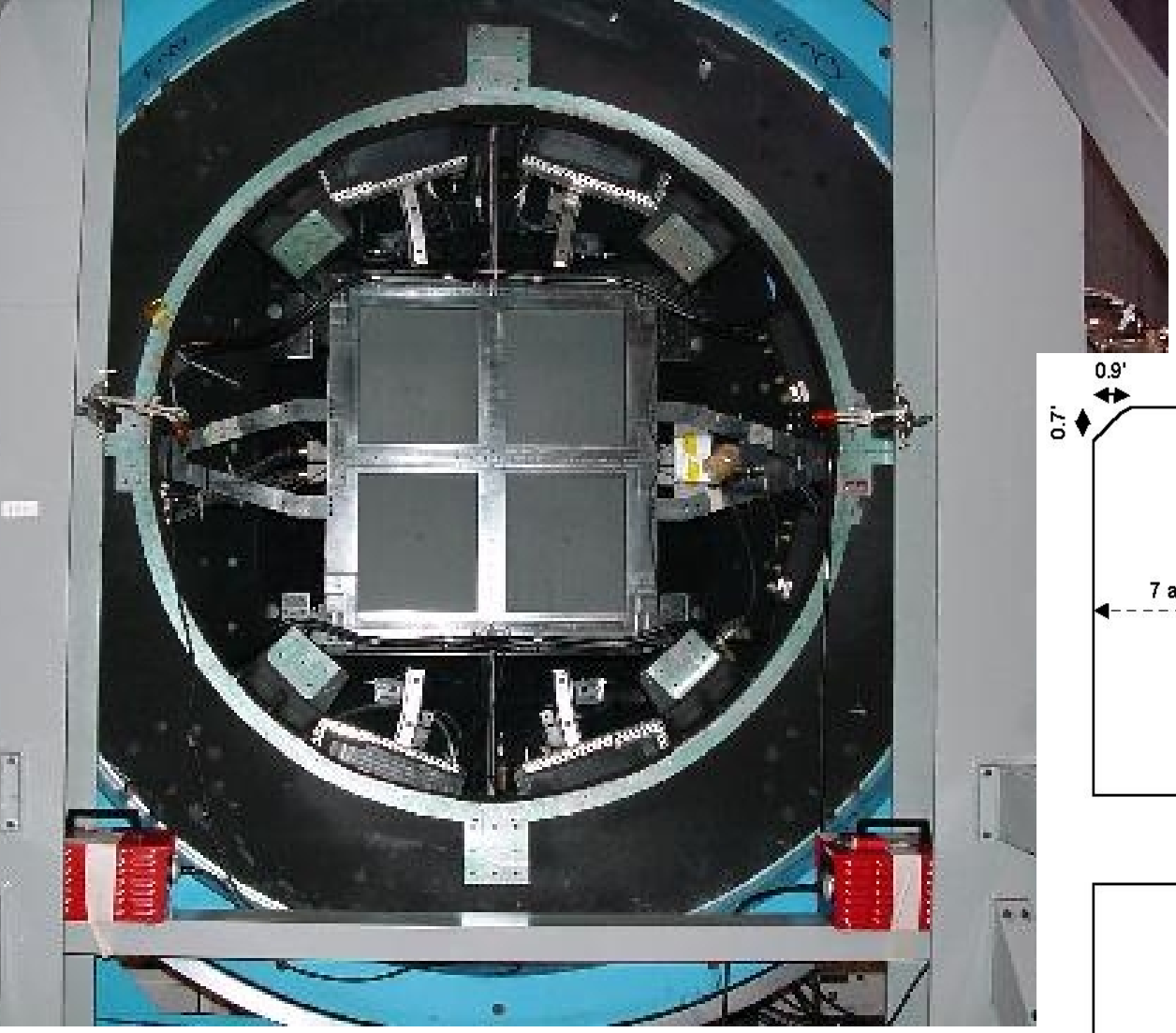
Imaging

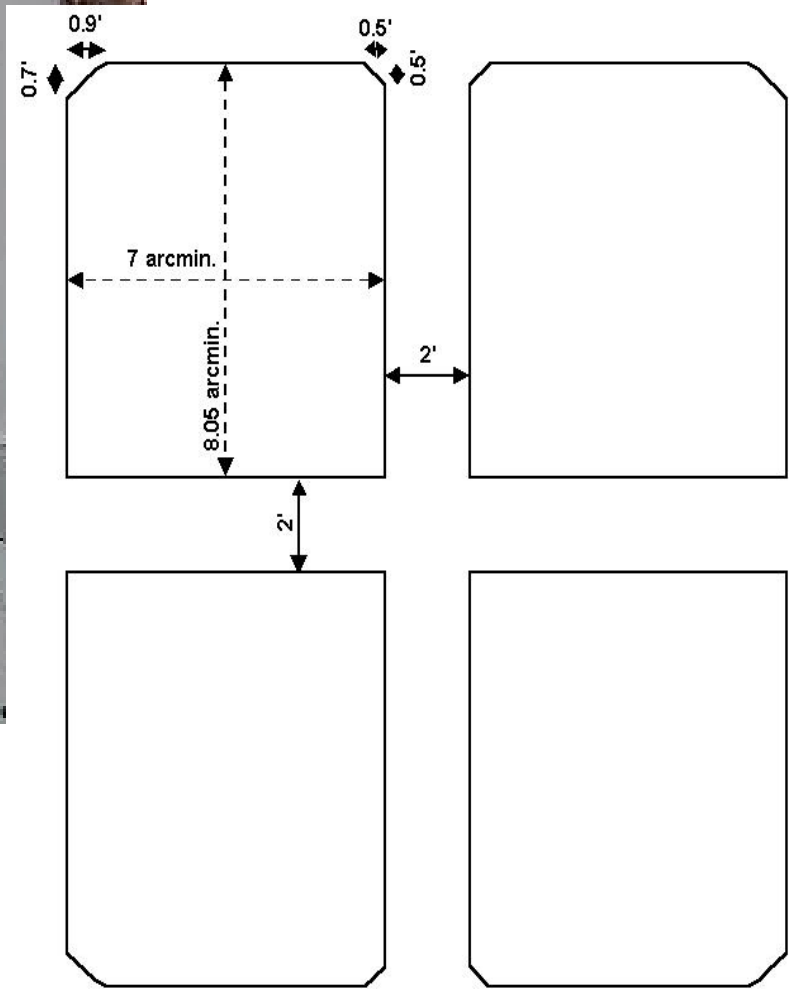
MOS

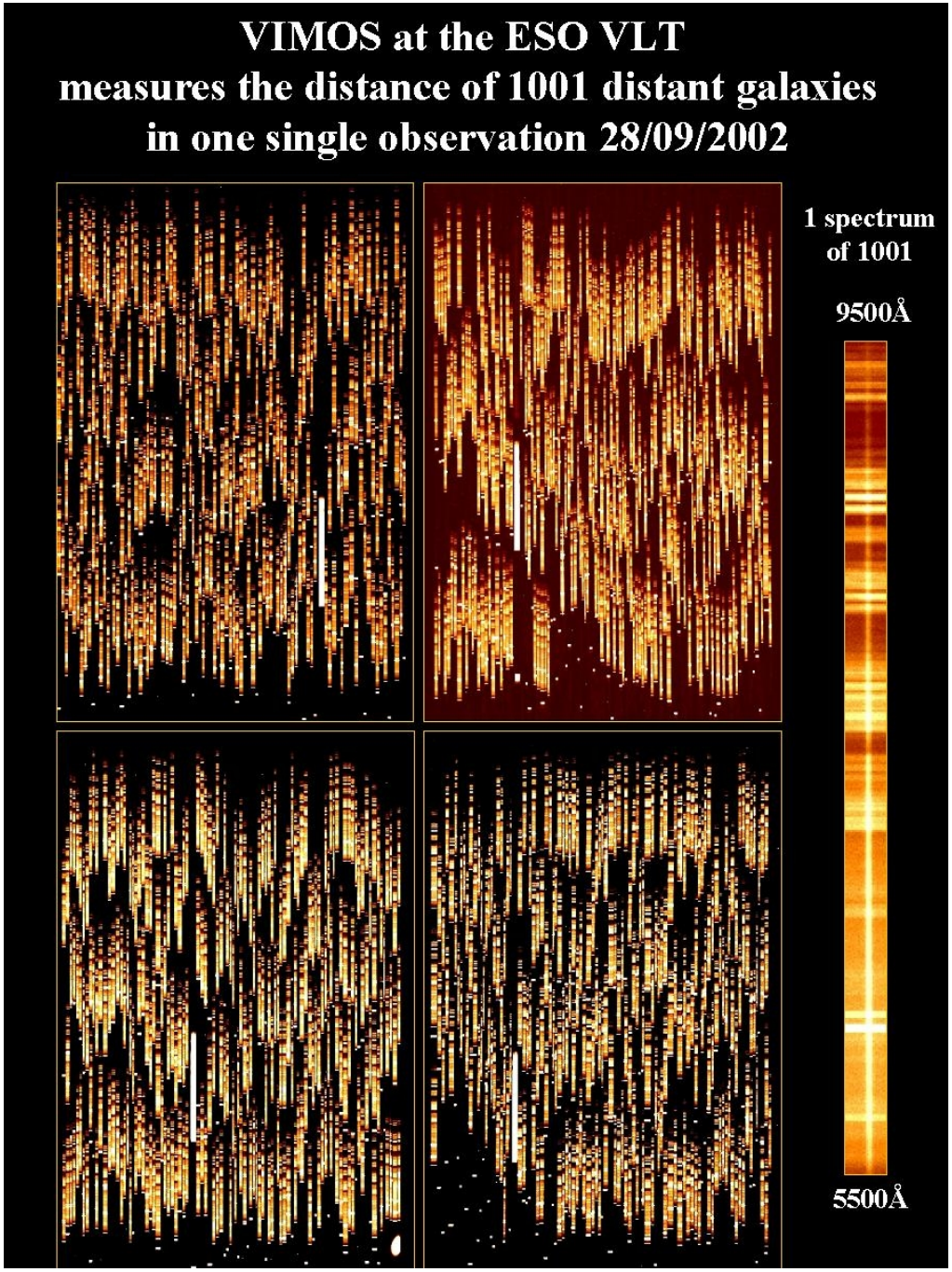
IFU



IMAGES



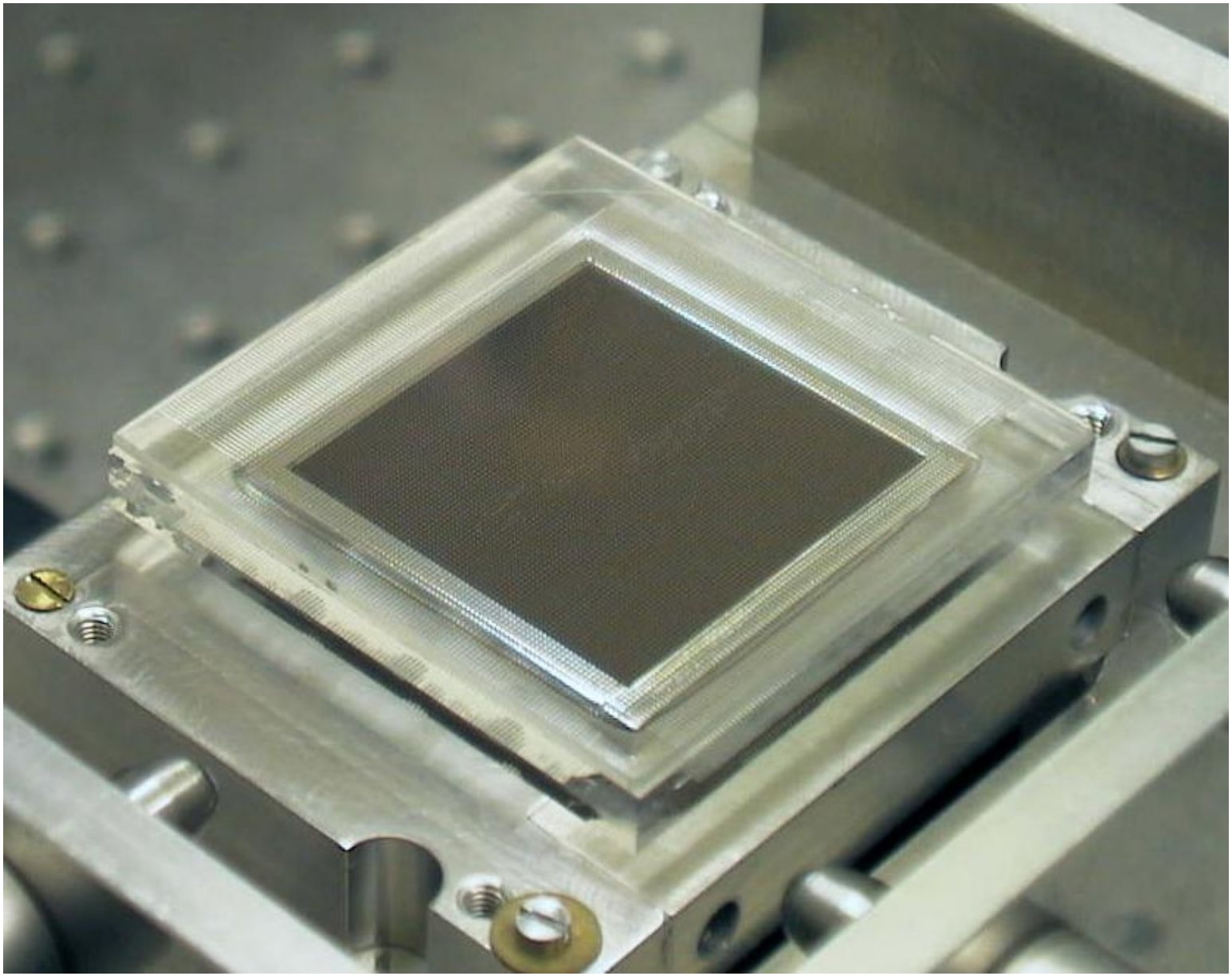


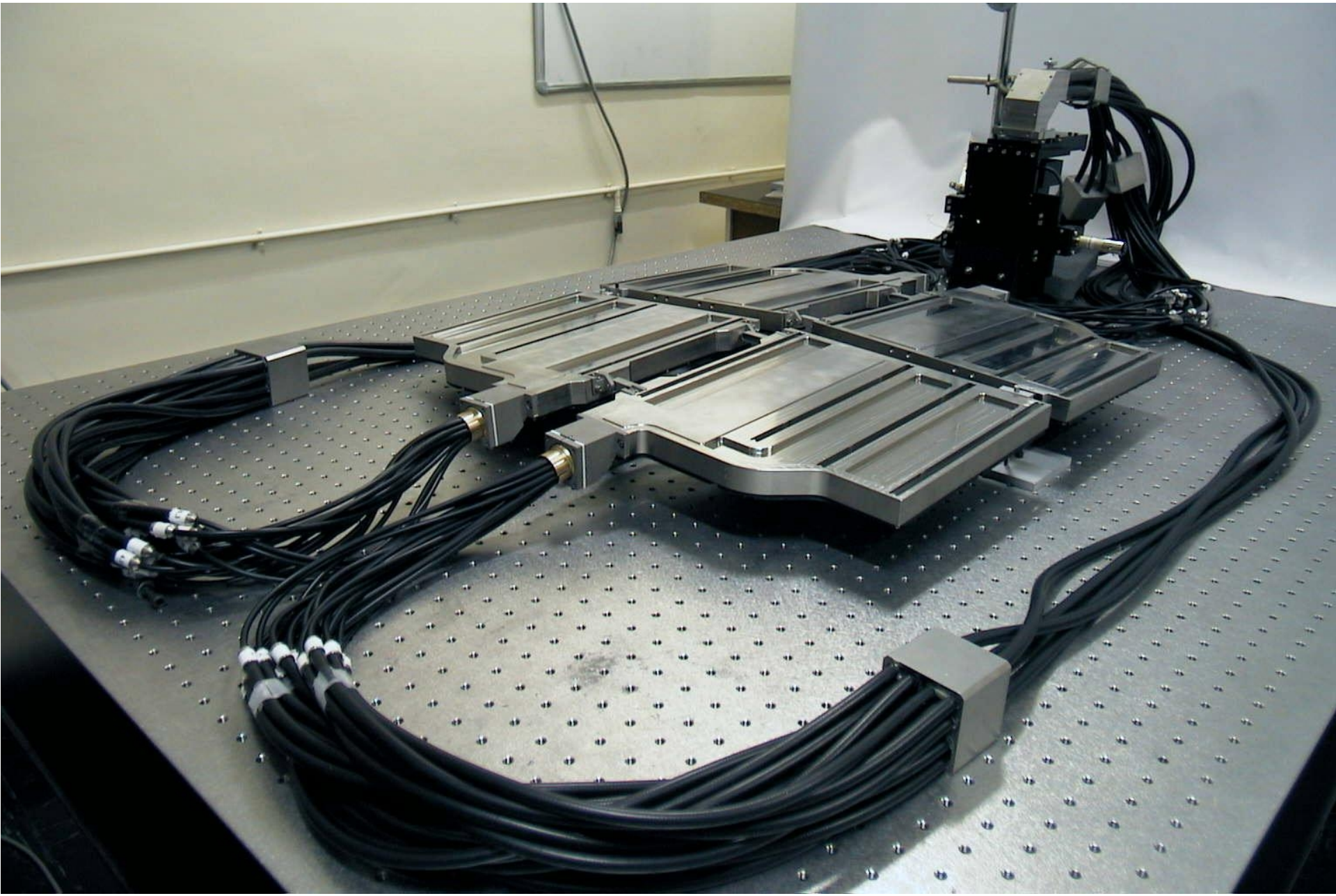


MOS

- Preimaging is mandatory. Is the only way to prepare good masks
- Up do 250 slits in each quadrant (1000 slits in total) in low resolution.
- Up to 50 slits in high resolution (200 slits in total)
- There is a special software to prepare masks

IFU



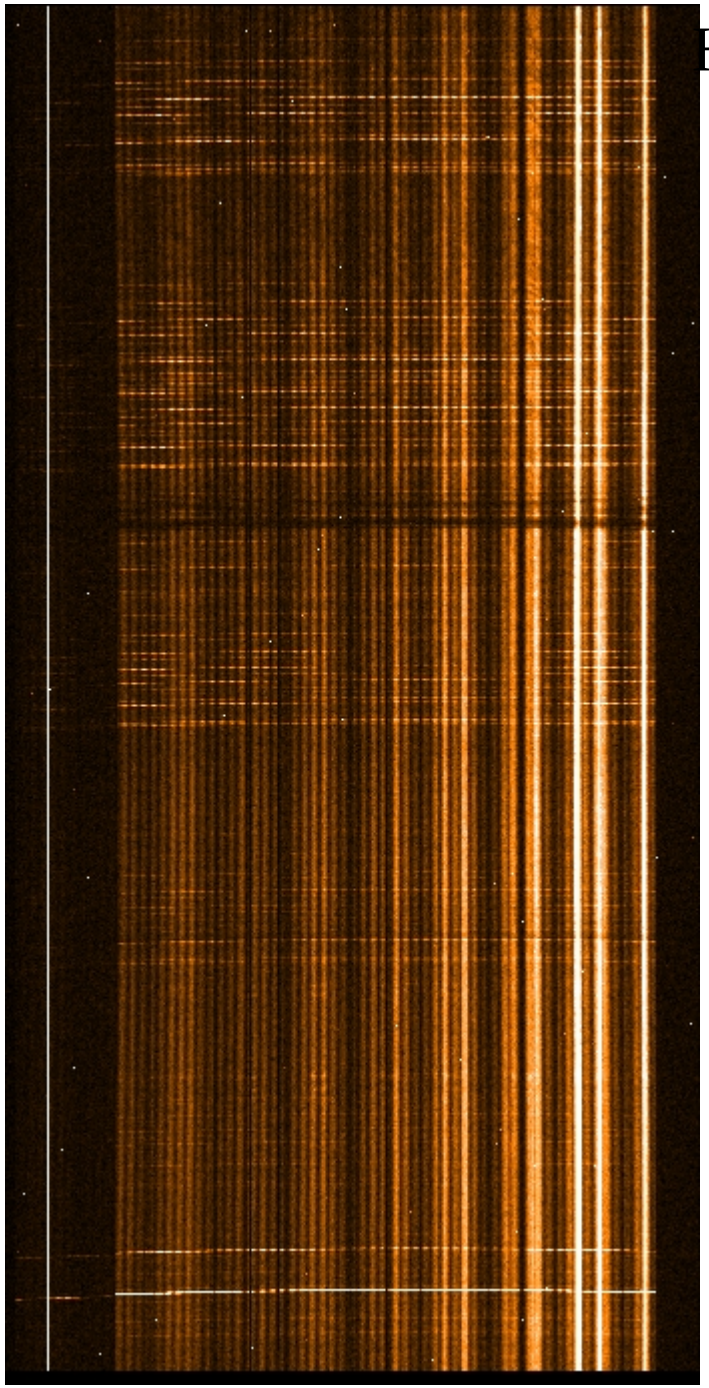


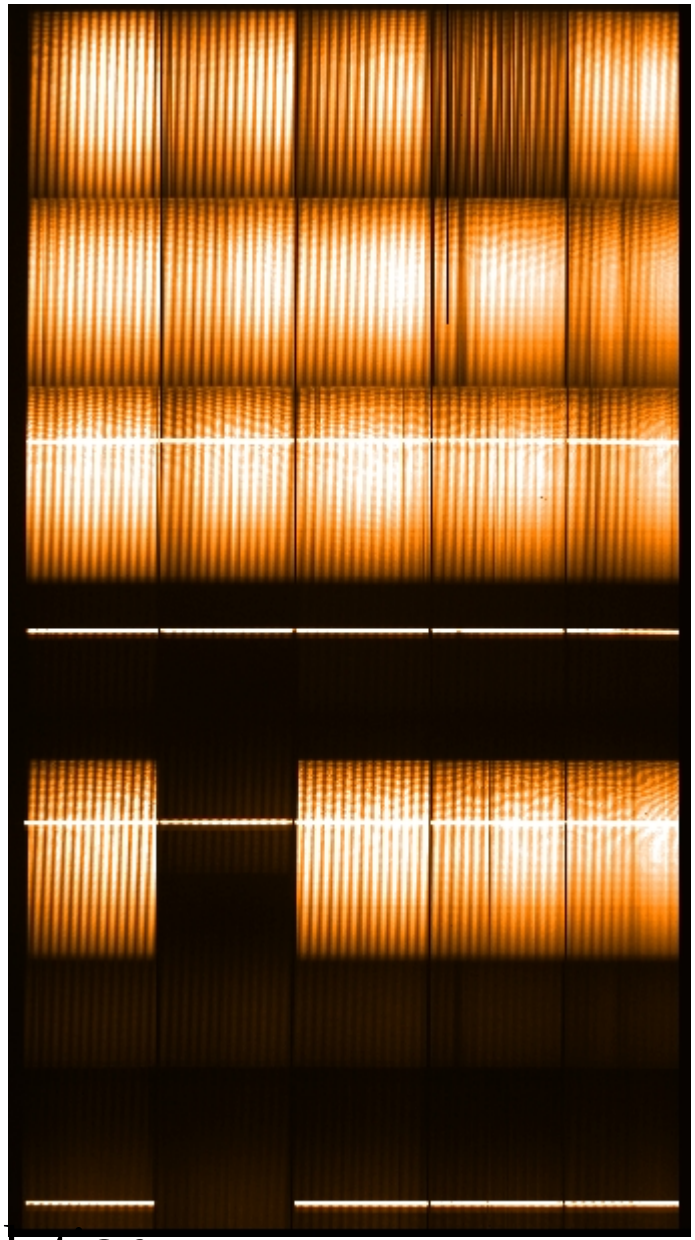
Two resolutions and scales
0.33” each fiber
0.67” each fiber

high spectroscopic resolution → 40x40 fibers (1600)
low spectroscopic resolution → 80x80 fibers (6400)

field of view= 54”x54” (0.67+LR); 27”x27” (0.33”+LR or 0.67”+HR); 13”x13” (0.33”+HR)

High resolution





Low resolution

VIMOS Modes and Setups

			Wavelength	Spectral	Dispersion	Spectral
Mode	Scale	FOV	range (nm)	Resolution	A /pix	multiplex
IMG *UBVRIz*	0.205''/pix	4 x 7' x 8'	--	--	--	--
MOS LR Blue	0.205''/pix	4 x 7' x 8'	370 - 670	180	5.3	4
MOS LR Red	0.205''/pix	4 x 7' x 8'	550 - 950	210	7.3	4
MOS MR	0.205''/pix	4 x 7' x 8'	500 - 1000	580	2.5	1
MOS HR Blue	0.205''/pix	4 x 7' x 8'	410 - 630	2050	0.5	1
MOS HR Orange	0.205''/pix	4 x 7' x 8'	520 - 760	2150	0.6	1
MOS HR Red	0.205''/pix	4 x 7' x 8'	630 - 870	2500	0.6	1
IFU LR Blue	0.67''/fibre	54" x 54"	400 - 670	220	5.3	4
IFU LR Red	0.67''/fibre	54" x 54"	590 - 915	260	7.3	4
IFU MR	0.67''/fibre	27" x 27"	490 - 1015	720	2.5	1
IFU HR Blue	0.67''/fibre	27" x 27"	415 - 620	2550	0.5	1
IFU HR Orange	0.67''/fibre	27" x 27"	525 - 740	2650	0.6	1
IFU HR Red	0.67''/fibre	27" x 27"	645 - 860	3100	0.6	1
IFU LR Blue	0.33''/fibre	27" x 27"	400 - 670	220	5.3	4
IFU LR Red	0.33''/fibre	27" x 27"	590 - 915	260	7.3	4
IFU MR	0.33''/fibre	13" x 13"	490 - 1015	720	2.5	1
IFU HR Blue	0.33''/fibre	13" x 13"	415 - 620	2550	0.5	1
IFU HR Orange	0.33''/fibre	13" x 13"	525 - 740	2650	0.6	1
IFU HR Red	0.33''/fibre	13" x 13"	645 - 860	3100	0.6	1



Flames

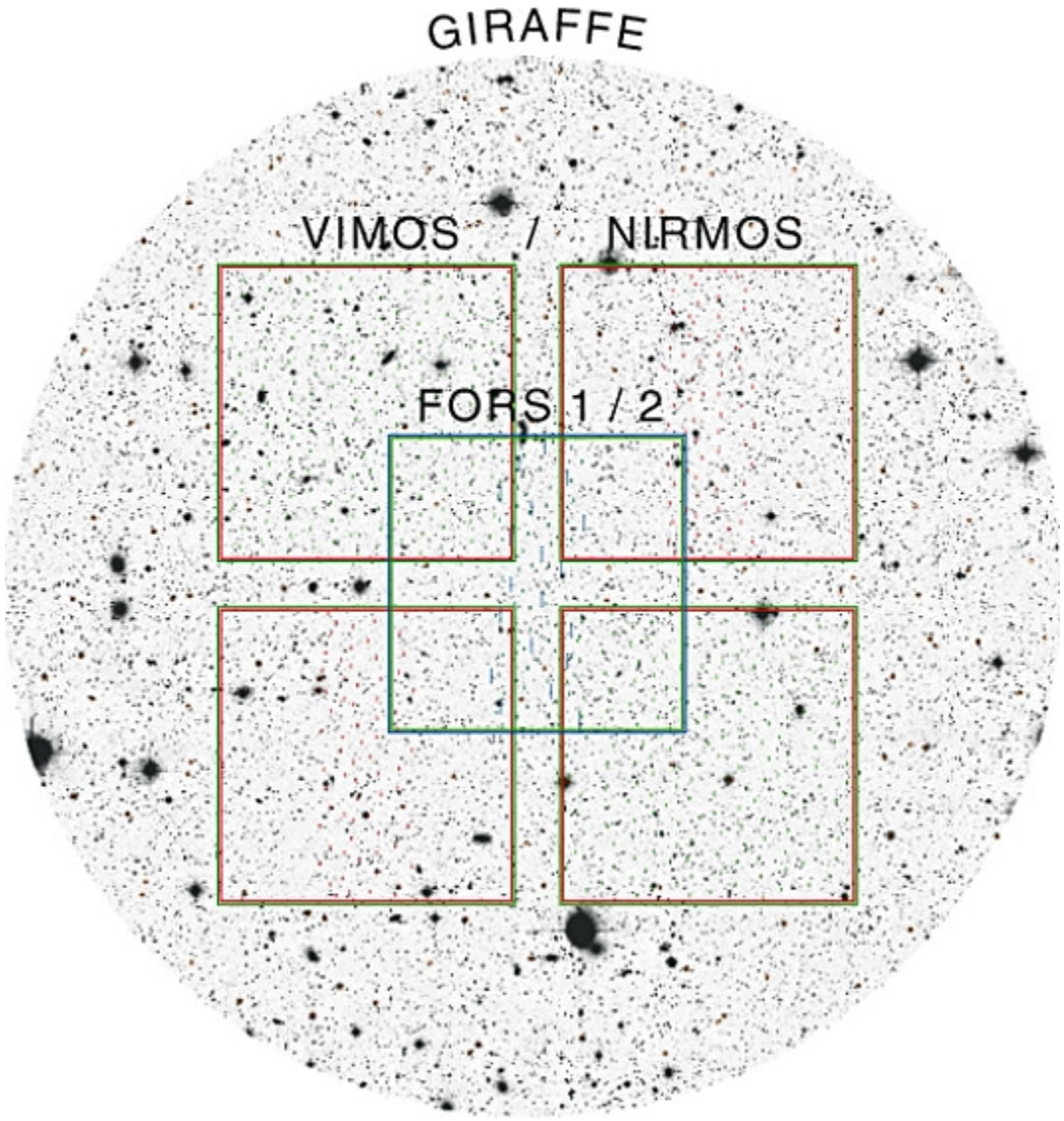
Fiber Large Array Multi Element Spectrograph

-Somehow similar to VIMOS but uses a fiber for each spectrum

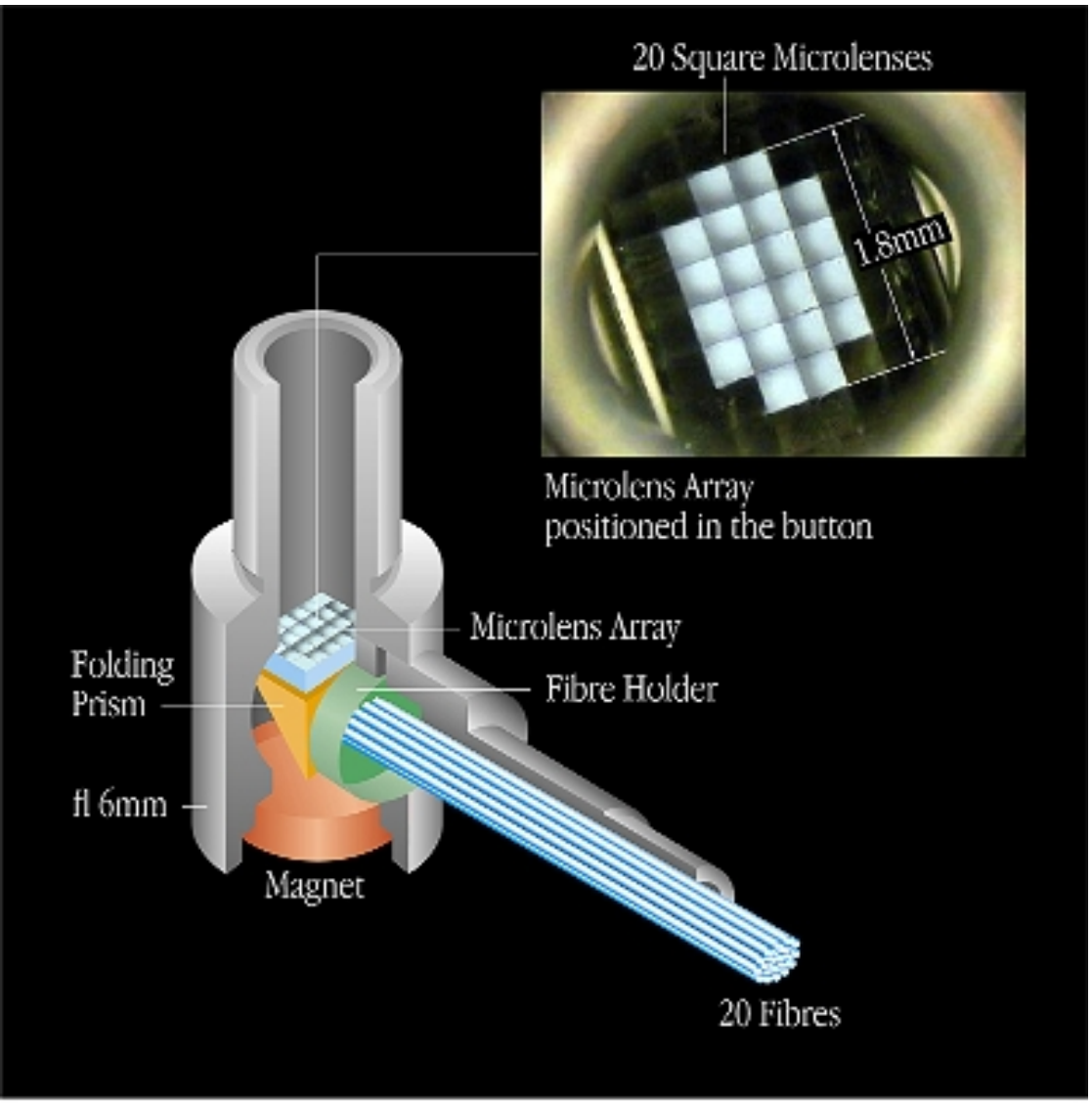
-Mainly for stellar objects

-25’ field of view corrected for atmospheric diffraction

-No need for preimaging. 0.2” astrometry is needed



Field of view of FORS, VIMOS, and Giraffe



Mechanical Design of an IFU

ESO PR Photo 03d/02 (28 January 2002)

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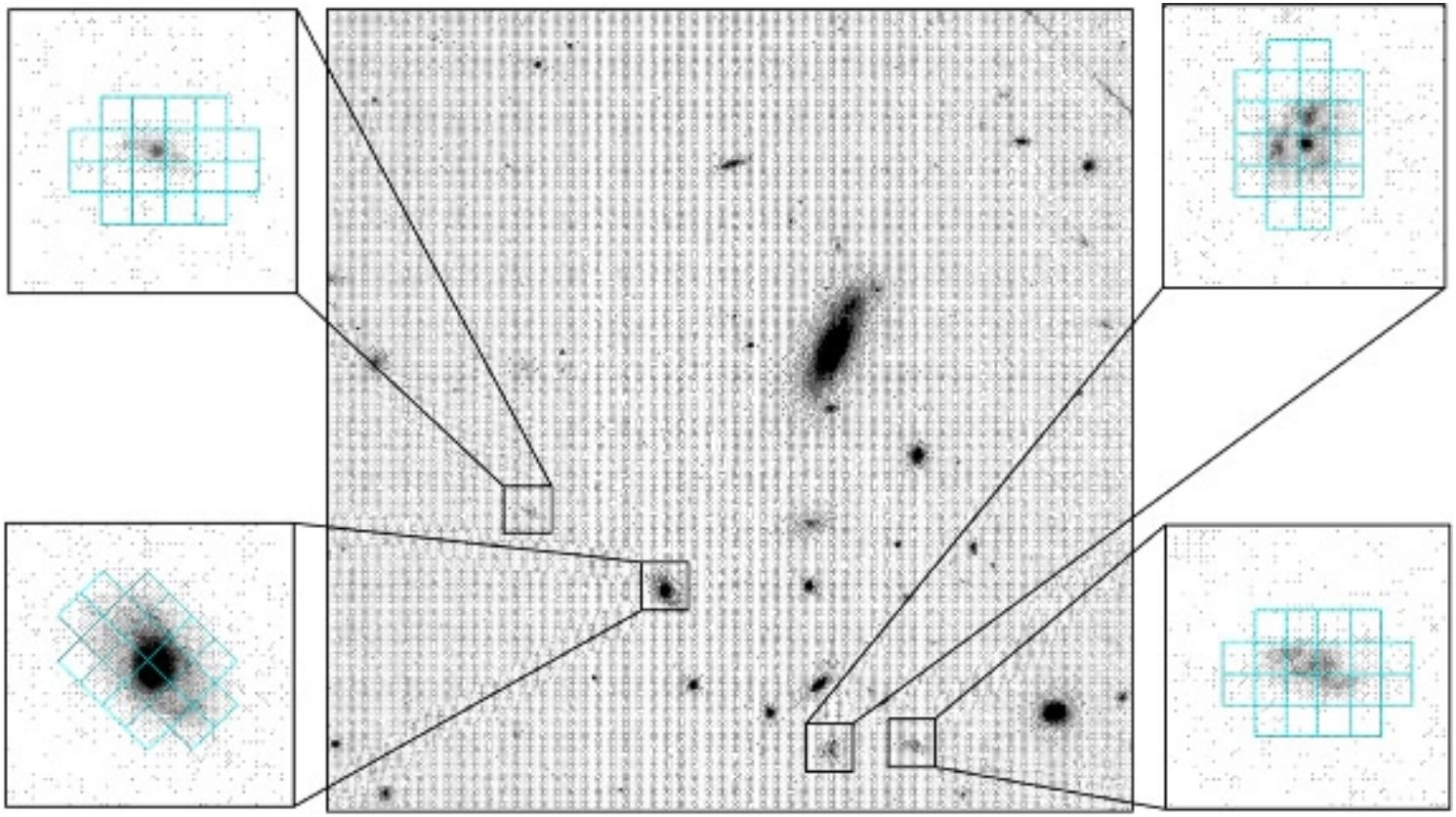
3 modes:

- MEDUSA: 130 fibers. 1 for each star
- IFU: 15 small IFU 2”x3” each
- ARGUS: a single IFU 15”x7” or 7”x4”

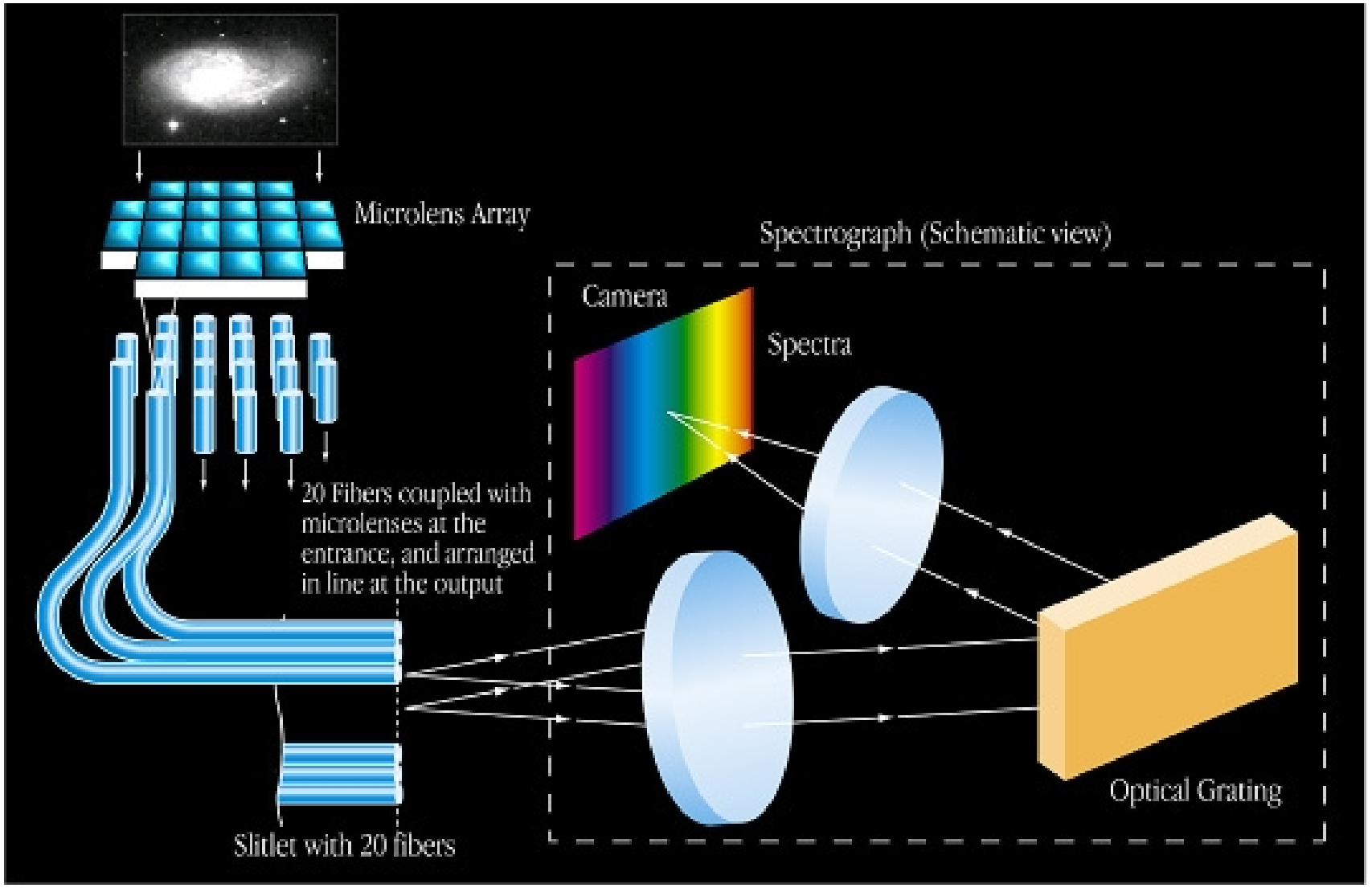
The IFU mode



Observation with Integral Field Units at FLAMES
(Simulation)

ESO PR Photo 03b/02 (28 January 2002)

© European Southern Observatory

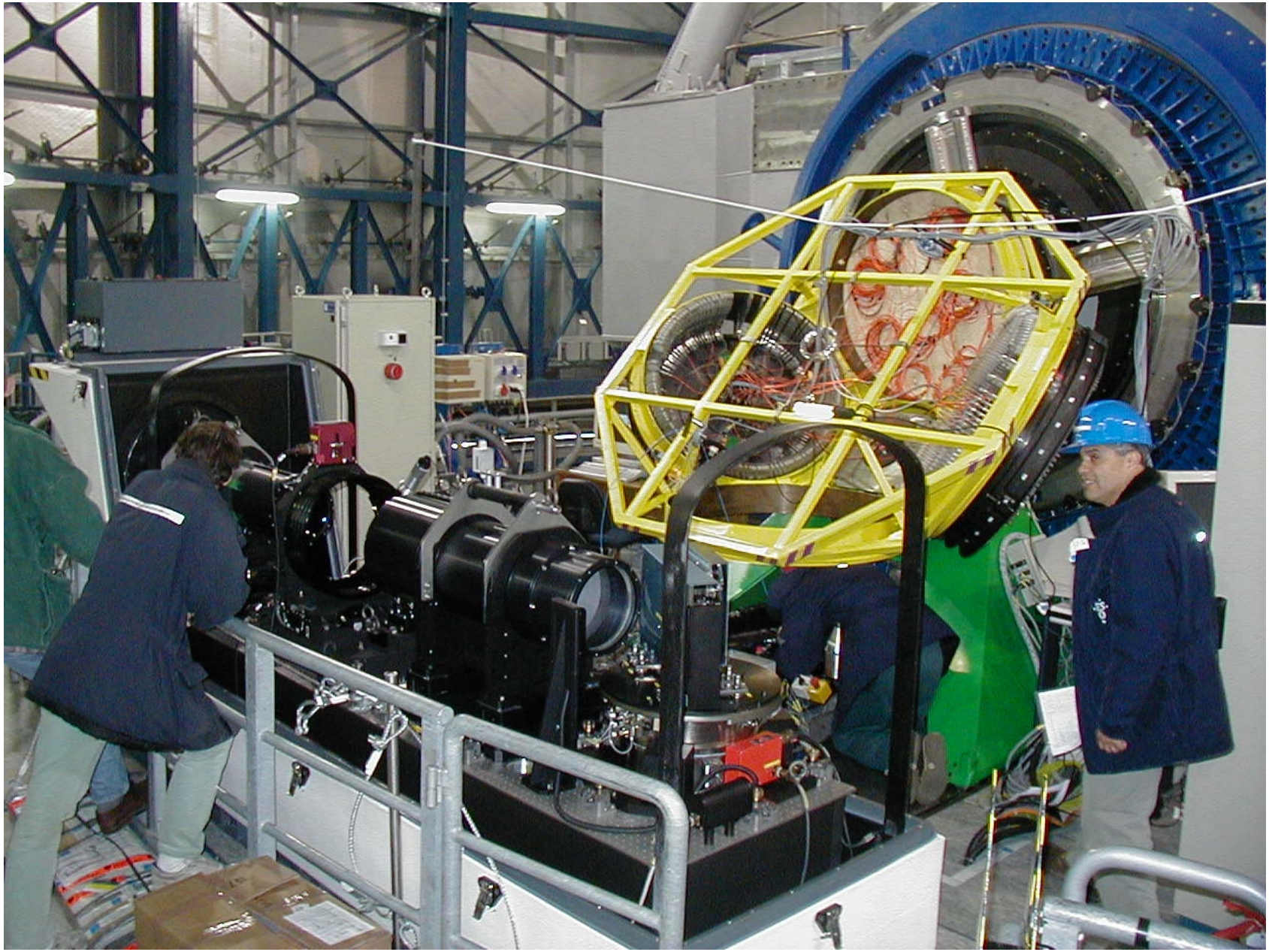


How the IFUs function

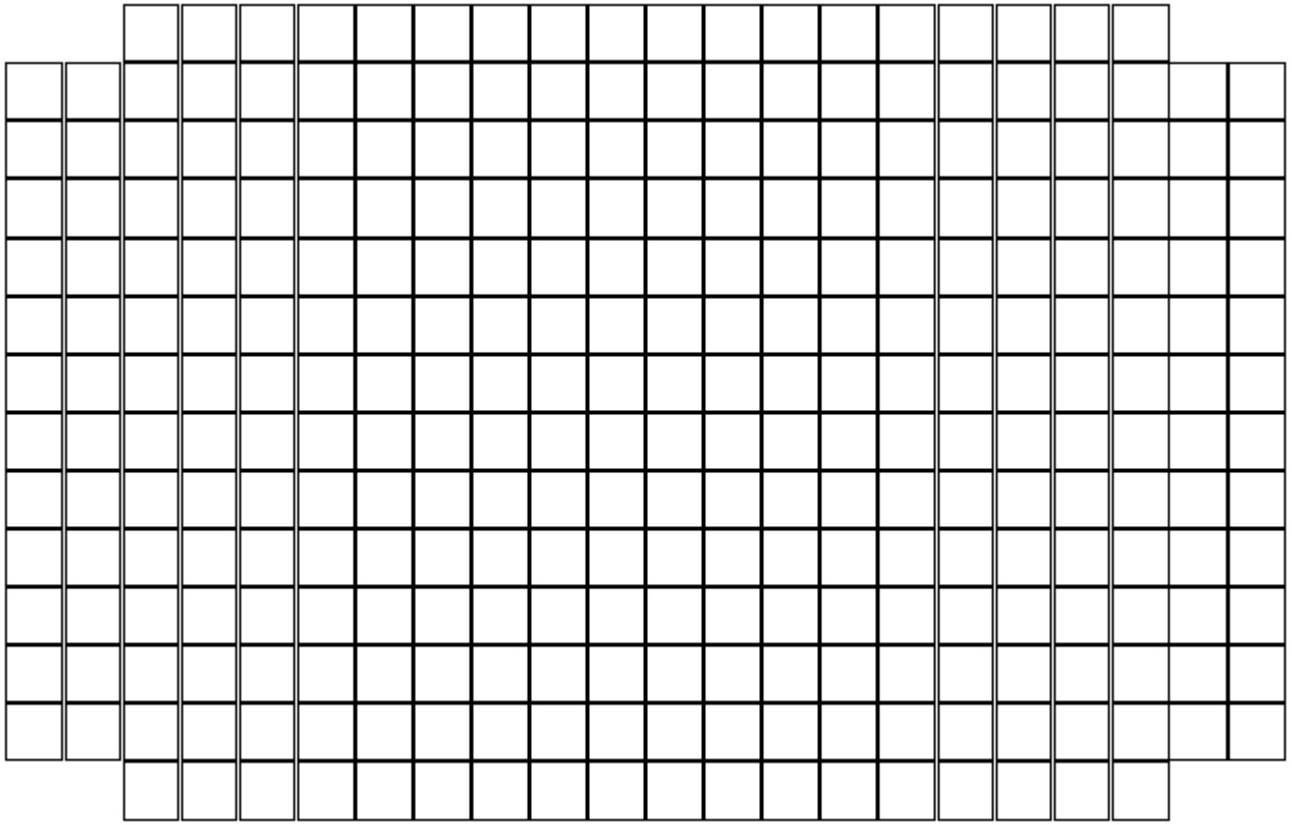
ESO PR Photo 03c/02 (28 January 2002)

© European Southern Observatory

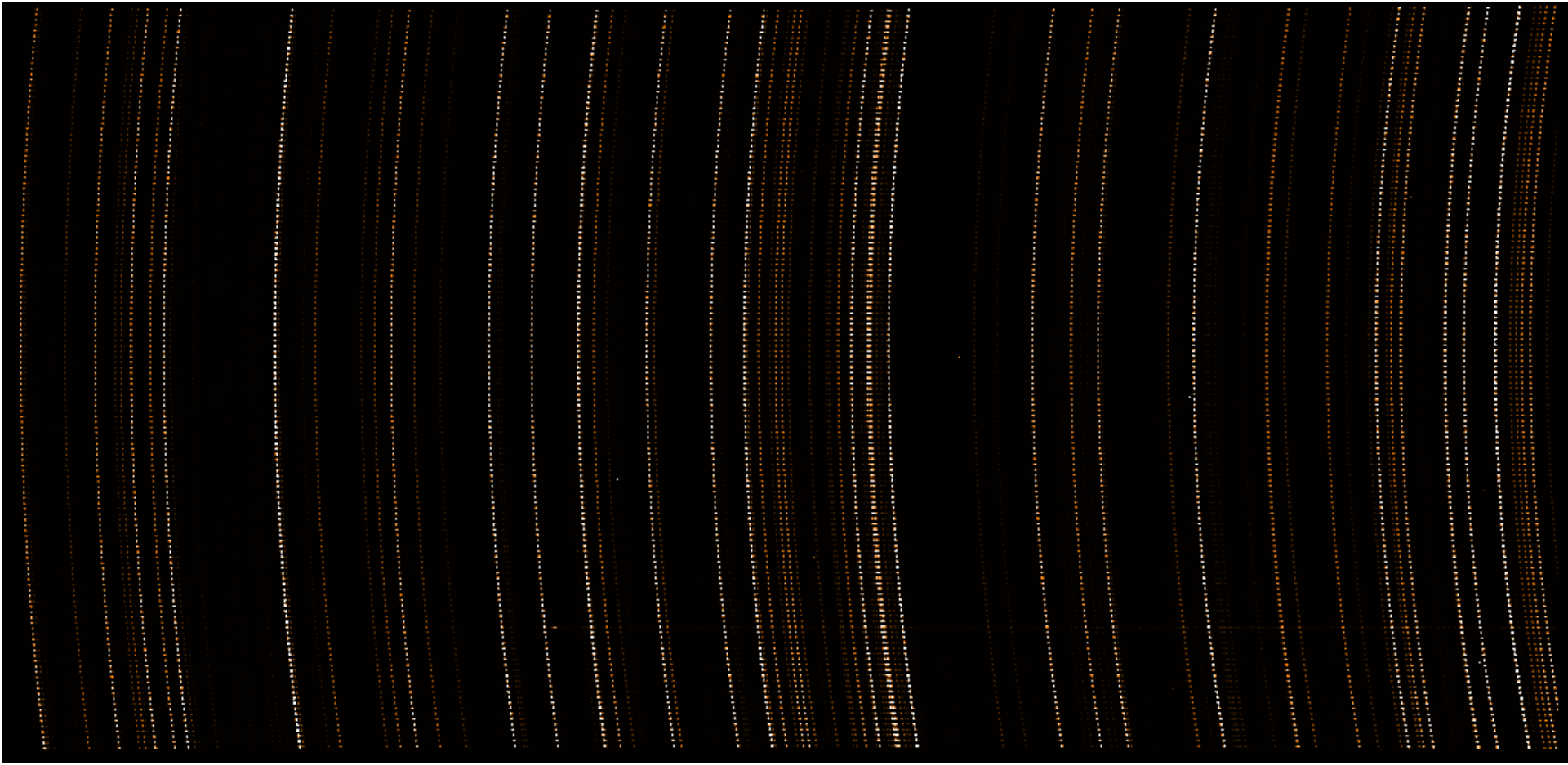
Medusa



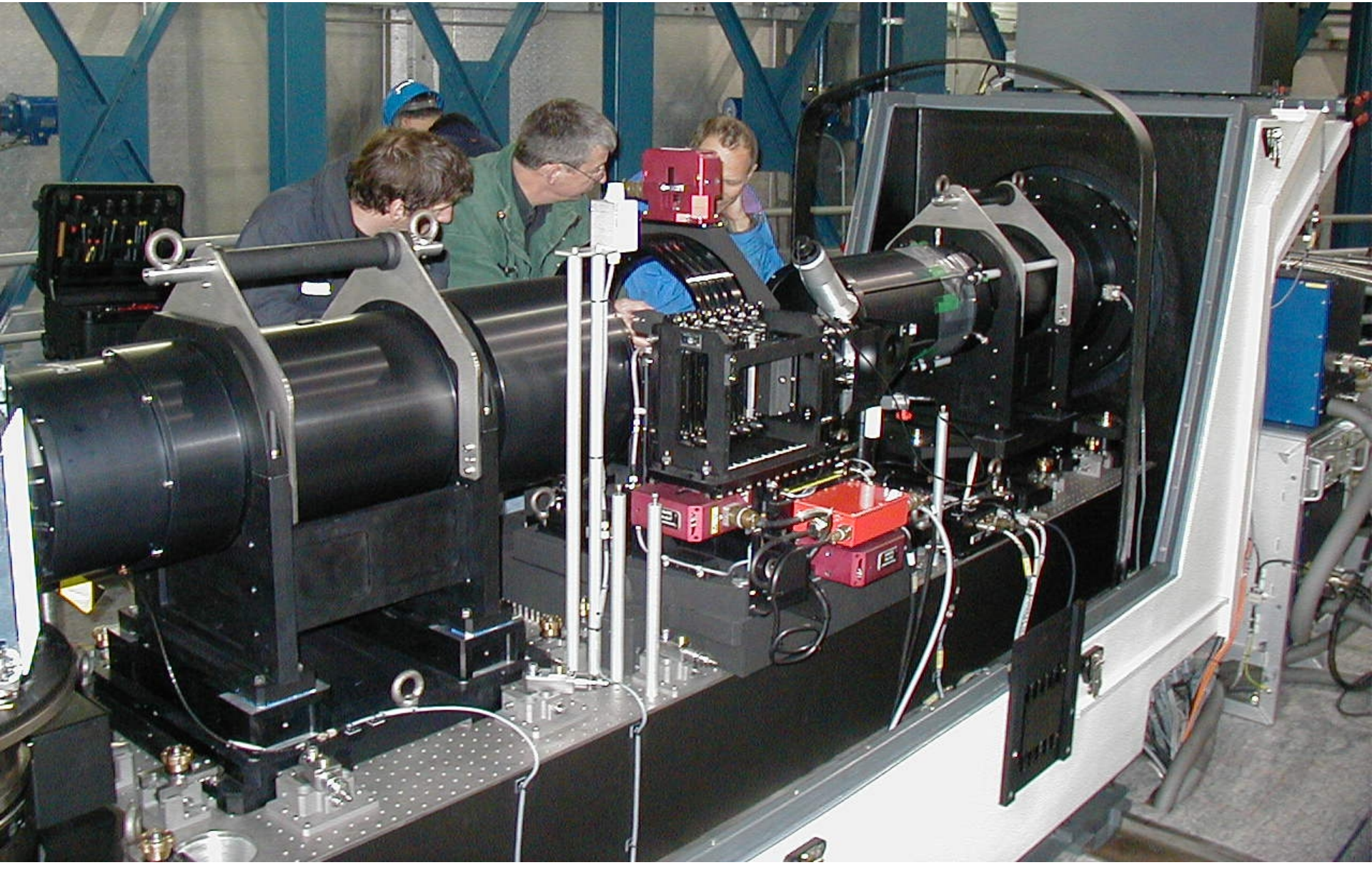
Argus



Example of Arc calibration frame



The Giraffe Spectrograph



Full list of instrument setups in the FLAMES User manual

Spectrograph	Mode	N. Of Objects	Aperture (")	Resolving Power (*)	Spectral Band [nm] (**)
UVES	Red Arm	8	1.0	47000	200
UVES	Red Arm	7 + 1 calibration	1.0	47000	200
GIRAFFE	MEDUSA buttons	130 (w. sky fibres)	1.2	12000 - 24000	λ/12 to λ/24
GIRAFFE	MEDUSA buttons	130 (w. sky fibres)	1.2	7000	λ/9.5
GIRAFFE	IFU	15 (+15 sky fibres)	2 x 3	19000 - 39000	λ/12 to λ/24
GIRAFFE	IFU	15 (+15 sky fibres)	2 x 3	11000	λ/9.5
GIRAFFE	ARGUS	1	11.5 x 7.3 or 6.6 x 4.2	19000 - 39000	λ/12 to λ/24
GIRAFFE	ARGUS	1	11.5 x 7.3 or 6.6 x 4.2	11000	λ/9.5

(*) In HR mode, the resolution and spectral coverage depend on setting used.

(**) λ is the desired observing wavelength.

UVES

UVES is the high-resolution optical spectrograph of the VLT, the light beam from the telescope is split in two arms (UV to Blue, and Visual to Red) within the instrument.

Spectroscopic Modes

Instrument mode	Accessible λ range (nm)	Maximum resolution (λ/Δλ)	Covered λ range (nm)	Magnitude limits
Blue arm	300-500	80,000	80	17-18
Red arm	420-1100	110,000	200-400	18-19
Dichroic #1	300-400	80,000	80	17-18
	500-1100	110,000	200	18-19
Dichroic #2	300-500	80,000	80	17-18
	600-1100	110,000	400	18-19
Iodine cell	500-600	110,000	200	17

ISAAC (dismesso fine 2013)

Infrared Spectrometer And Array Camera

Infrared (1 - 5 μm, J-, H- , K-, L, and M-bands) imager and spectrograph
Can be seen as the IR version of FORS (but no MOS)

Imaging Modes

Instrument Mode	Scale	FOV	limit magnitude
	("/pixel)	(squared ")	
SW Imaging[1]	0.148	152 x 152	J=24, H=23, Ks=22
SW Polarimetry[2]	0.148	3 x 20 x 150[2]	J=23, H=22, Ks=21
LW Imaging	0.071	73 x 73	L~16, M_NB ~ 13
LW Imaging 3.21, 3.28μm	0.148	152 x 152	L ~16

Spectroscopic Modes

Instrument Mode	λ/Δλ	Scale ("/pixel)	limit magnitude range
SW LRes Spectroscopy	500	0.147	18-20.5
SW MRes Spectroscopy	3000	0.147	17.5-19.5
LW LRes Spectroscopy	500	0.147	11-14
LW MRes Spectroscopy	2000	0.147	10-13

SW Spectroscopy - Low Resolution (SWS1-LR)

The pixel scale is 0.147 arcsec/pixel. The slit length is 120 arcsec.

SW Spectroscopy - Low resolution

Spectral domain (µm)	Order	Detector spectral coverage (µm)	Number of grating positions	R(2")	R(1")	R(0.6")	R(0.3")
0.98 - 1.1	5	0.29	1	270	550	900	1800
1.1 - 1.4	4	0.36	1	250	500	860	1700
1.42 - 1.82	3	0.48	1	250	500	840	1600
1.82 - 2.5	2	0.72	1	200	450	750	1500

Use the Exposure Time Calculator (ETC) for performance estimates.

SW Spectroscopy - Medium Resolution (SWS1-MR)

The pixel scale is 0.146 arcsec/pixel. The slit length is 120 arcsec.

SW Spectroscopy - Medium resolution

Spectral domain (µm)	Order	Detector spectral coverage (µm)	Number of grating positions	R(2")	R(1")	R(0.6")	R(0.3")
0.98 - 1.1	5	0.046	3-4	1700	3400	5700	11500
1.1 - 1.4	4	0.059	5	1500	3100	5200	10500
1.4 - 1.82	3	0.079	5	1500	3000	5100	10000
1.82 - 2.5	2	0.122	6	1300	2600	4400	8900

LW Spectroscopy - Low Resolution (LWS3-LR)

The pixel scale is 0.146 arcsec/pixel. The slit length is 120 arcsec.

LW Spectroscopy - Low resolution

Spectral domain (µm)	Order	Detector spectral coverage (µm)	Number of grating positions	R(2")	R(1")	R(0.6")	R(0.3")
2.55 - 4.2	1	1.4	1	180	360	600	1200
4.45 - 5.1	1	1.5	1	250	500	800	1600

Use the Exposure Time Calculator (ETC) for performance estimates.

LW Spectroscopy - Medium Resolution (LWS3-MR)

The pixel scale is 0.146 arcsec/pixel. The slit length is 120 arcsec.

LW Spectroscopy - Medium resolution

Spectral domain (µm)	Order	Detector spectral coverage (µm)	Number of grating positions	R(2")	R(1")	R(0.6")	R(0.3")
2.55 - 4.2	1	0.255	6(5)	1000	2000	3300	6700
4.45 - 5.1	1	0.237	3	1500	3000	5000	10000

NACO=Naos-Conica

Nasmyth Adaptive Optics System

Near-Infrared Imager and Spectrograph

Not very different from ISAAC but with adaptive optics. The AO systems are now giving good performances in the NIR were the distortions of the images is relatively slow.

-Typical spectral resolution are: 400 in J, 500 or 1500 in H, 700 or 1400 in K, 700 or 1100 in L, 550 in SHK (1.3-2.6 micron).

-For short wavelength ($\lambda < 2.5\mu m$), it is possible to perform slitless (14“x14") spectroscopy.

-Otherwise two slit widths are available: 86 and 172mas. The slits' length is 40" for the S/L54 camera and 28" for the S/L27 camera.

Sinfoni

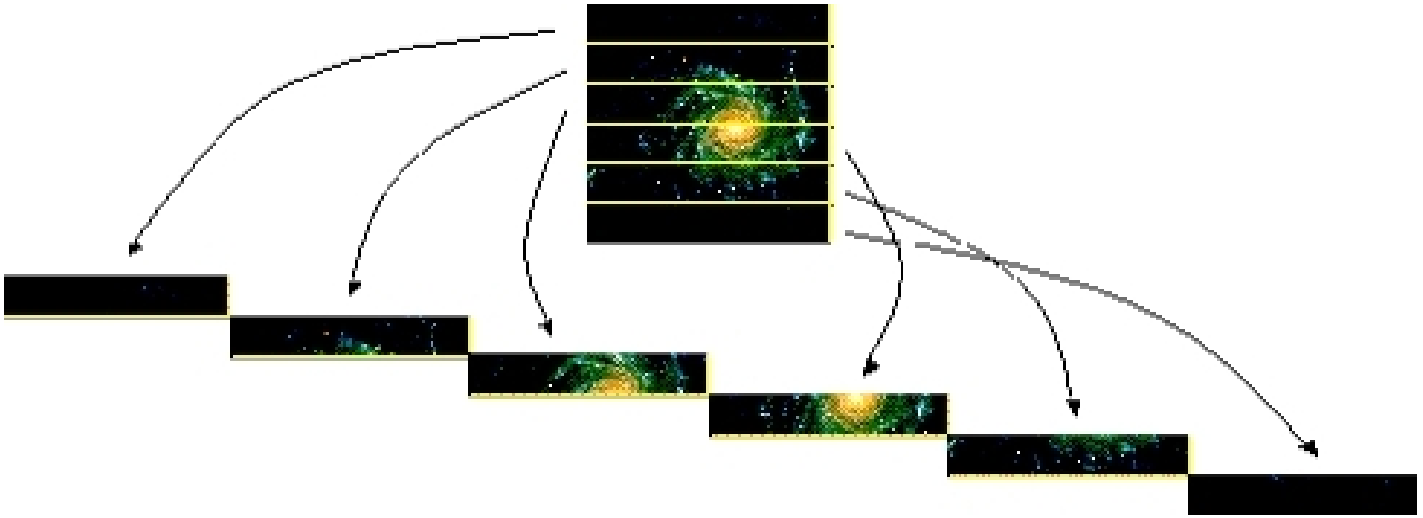
SINFONI is a near-infrared (1.1 - 2.45 μm) integral field spectrograph fed by an adaptive optics module.

The spectrograph operates with 4 gratings (J, H, K, H+K) providing a spectral resolution around 2000, 3000, 4000 in J, H, K, respectively, and 1500 in H+K

Field of View	Spatial Scale	Mode	Limiting Magnitudes
8"x8"	125x250mas	noAO	J=20.2 H=19.9 K=17.9 H+K=19.6
3"x3"	50x100mas	NGS	J=19.4 H=19.6 K=18.8 H+K=19.8
0.8"x0.8"	12.5x 25mas	NGS	J=17.8 H=18.7 K=18.3 H+K=19.2

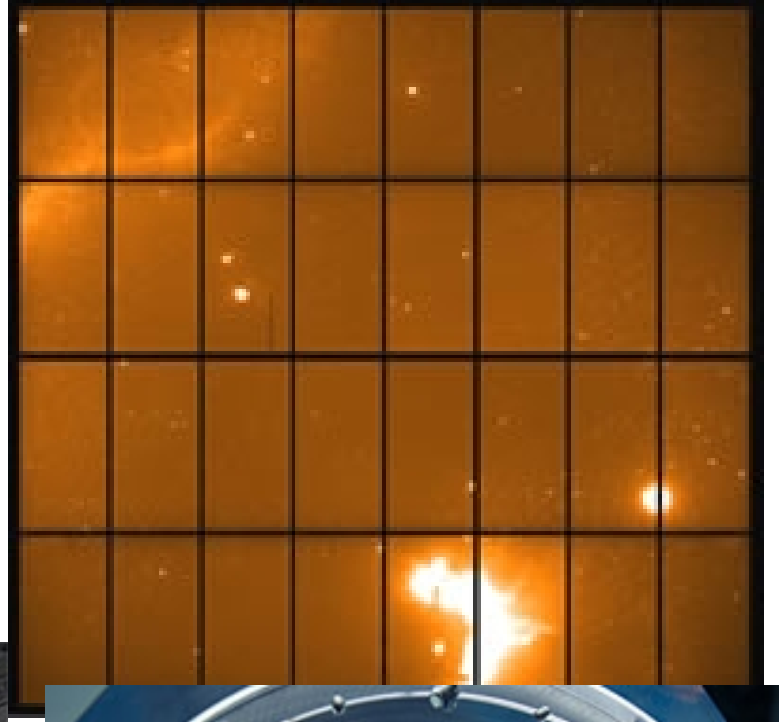
The image slicer

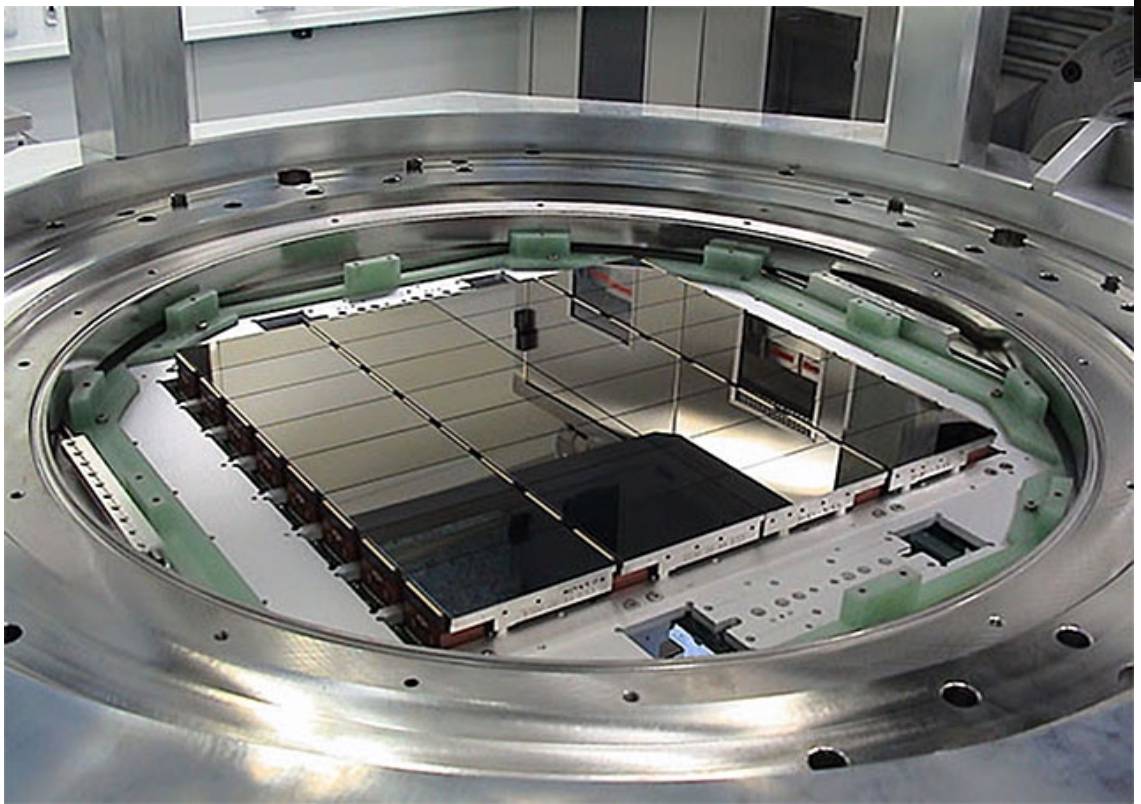
Using fibers is not the only way of building a IFU unit.
Image slicer are a valid alternative. The image is litteraly divided
Into slices which are then alligned along the slit.

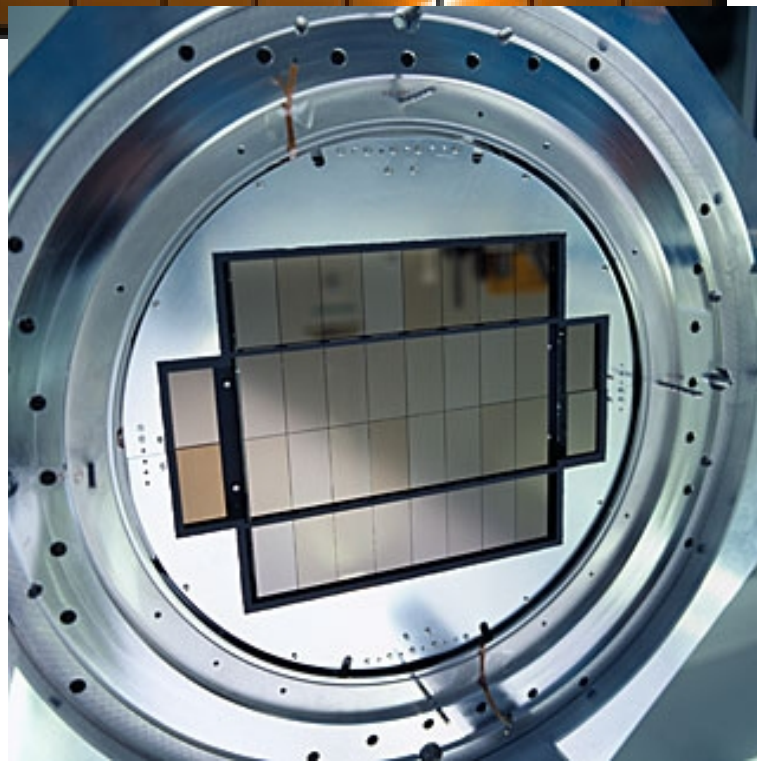


OmegaCAM@VST

32 CCD detectors (2048x4096) that creates images with a total of 268 megapixels = 16k x 16k = 1x1degrees = 26x26 cm, 0.21”/pixel







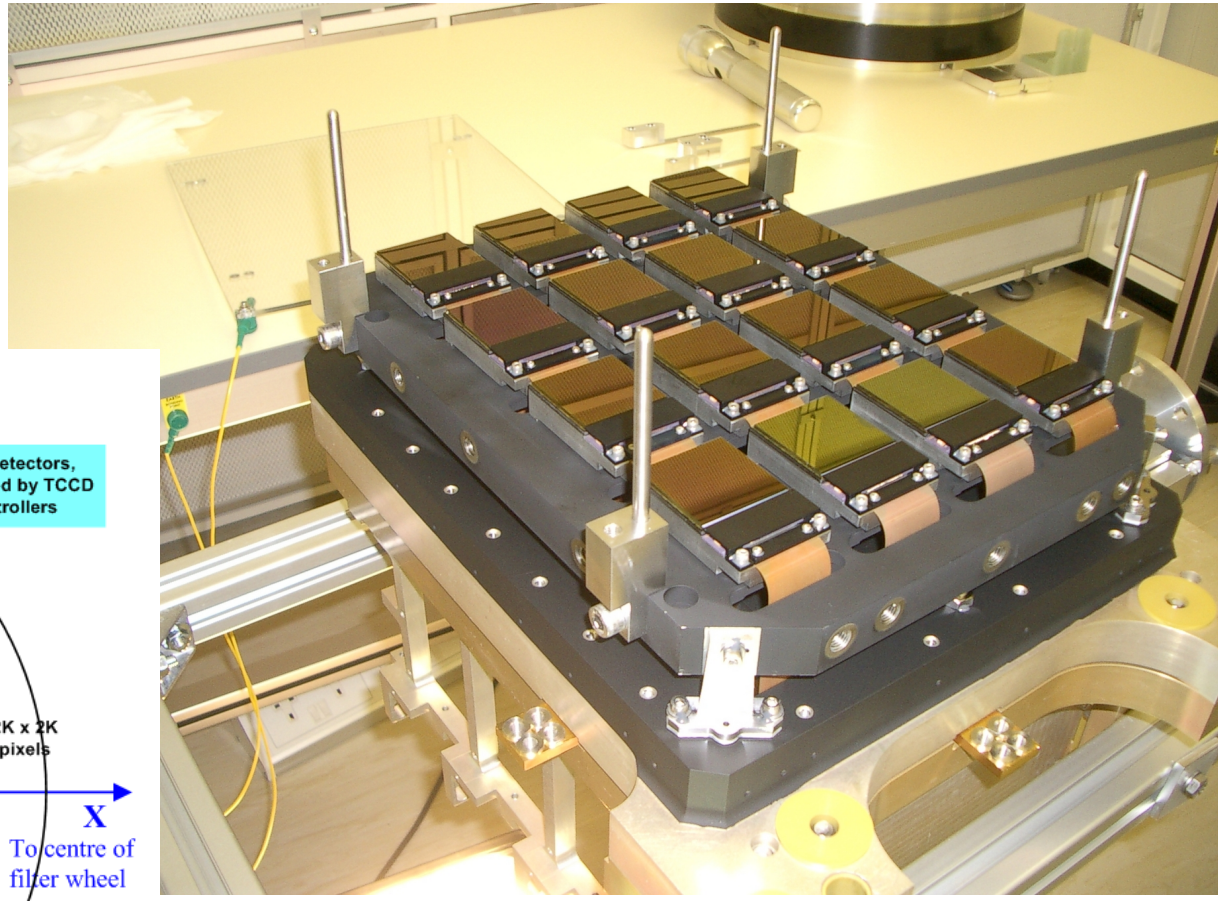
Filter name	System	Lambda	DLambda[a]	ZP [ADU][b]	P2PP ID	Comment[c]
u	SDSD	350	60	22.9	u_SDSS	IF,M
g	SDSS	480	140	24.8	g_SDSS	IF,M
r	SDSS	625	140	24.7	r_SDSS	IF,M
i	SDSS	770	150	24.2	i_SDSS	IF,M
z	SDSS	910	120	22.8	z_SDSS	IF,M
B	Johnson	440	100	24.7	B_JOHN	CG,S
V	Johnson	550	100	24.5	V_JOHN	CG,S
v	Stromgren	411	21		v_STRM	IF,M
H_alpha	---	659,665,672,679	10		H_ALPHA	IF,4Q
z=0.3 H_alpha	---	852,861,869,878	13		NB_852_861_869_878	IF,4Q
Calib	SDSS	u, g, r, i	---		u_g_r_i_SDSS	CG,4Q

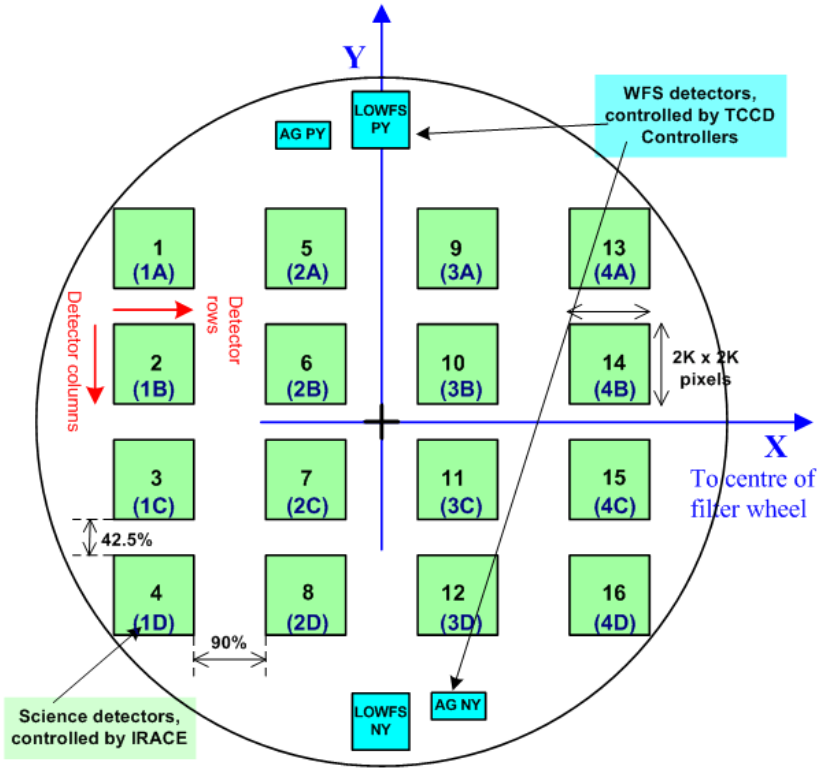
[a] FWHM of filter throughput x mean CCD QE curve

[b] These are the zeropoints derived in the first round of commissioning in April/May 2011. There is a chip-to-chip variation in the ZPs of ~0.1 mag. The detector gain is ~ 2.5 e-/ADU, RON is 5-6 e^-.

VIRCAM @ VISTA

16 CCD detectors (2048x2048) that creates images
1x1degrees with a 6 offsets

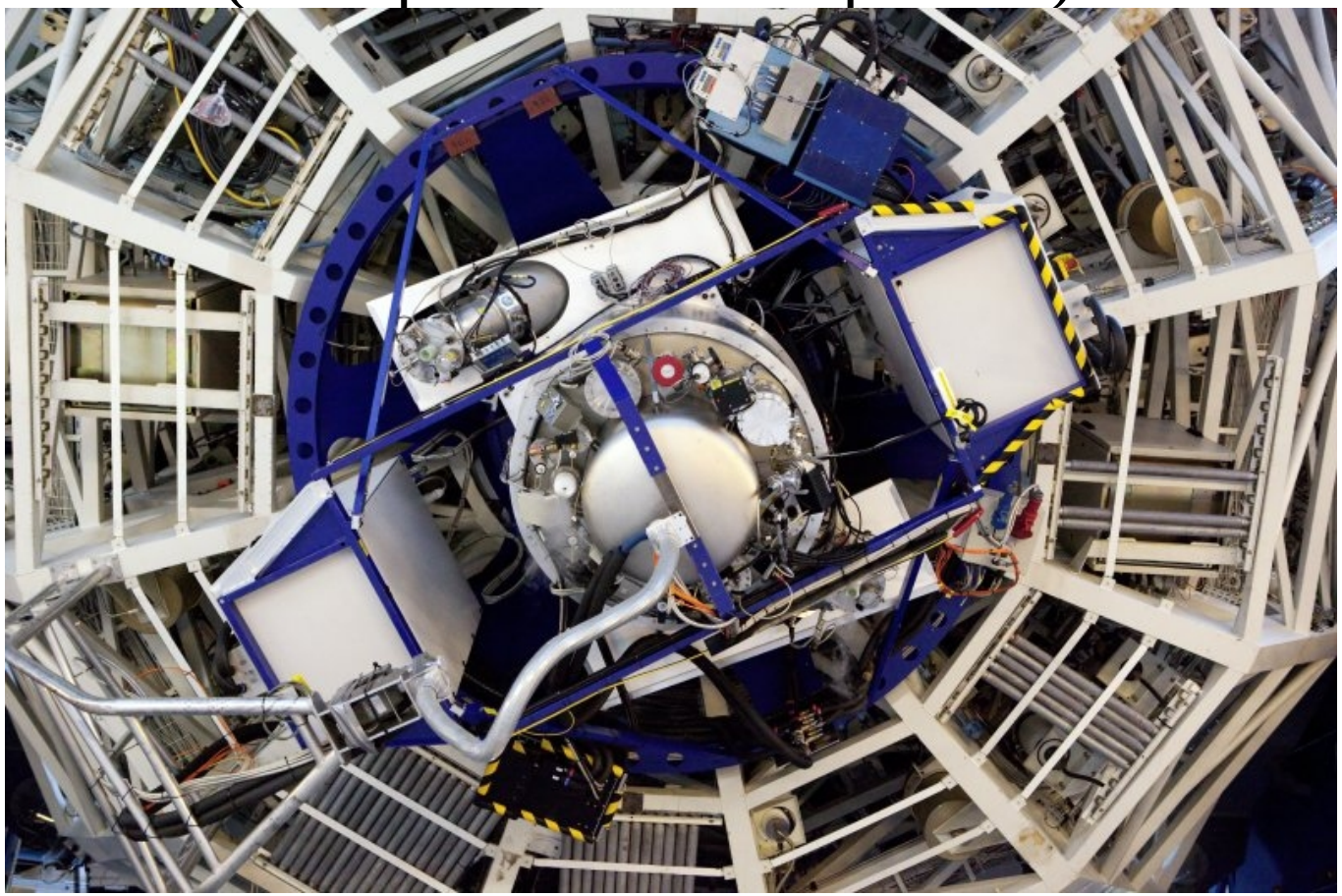




Filter	Wavelength	FHWM	Comment
	micron	micron	
Z	0.88	0.12	in camera
Y	1.02	0.10	in camera
J	1.25	0.18	in camera
H	1.65	0.30	in camera
Ks	2.15	0.30	in camera
NB980	0.98	0.01	in camera, sharing a slot with NB990
NB990	0.99	0.01	in camera, sharing a slot with NB980
NB118	1.18	0.01	in camera

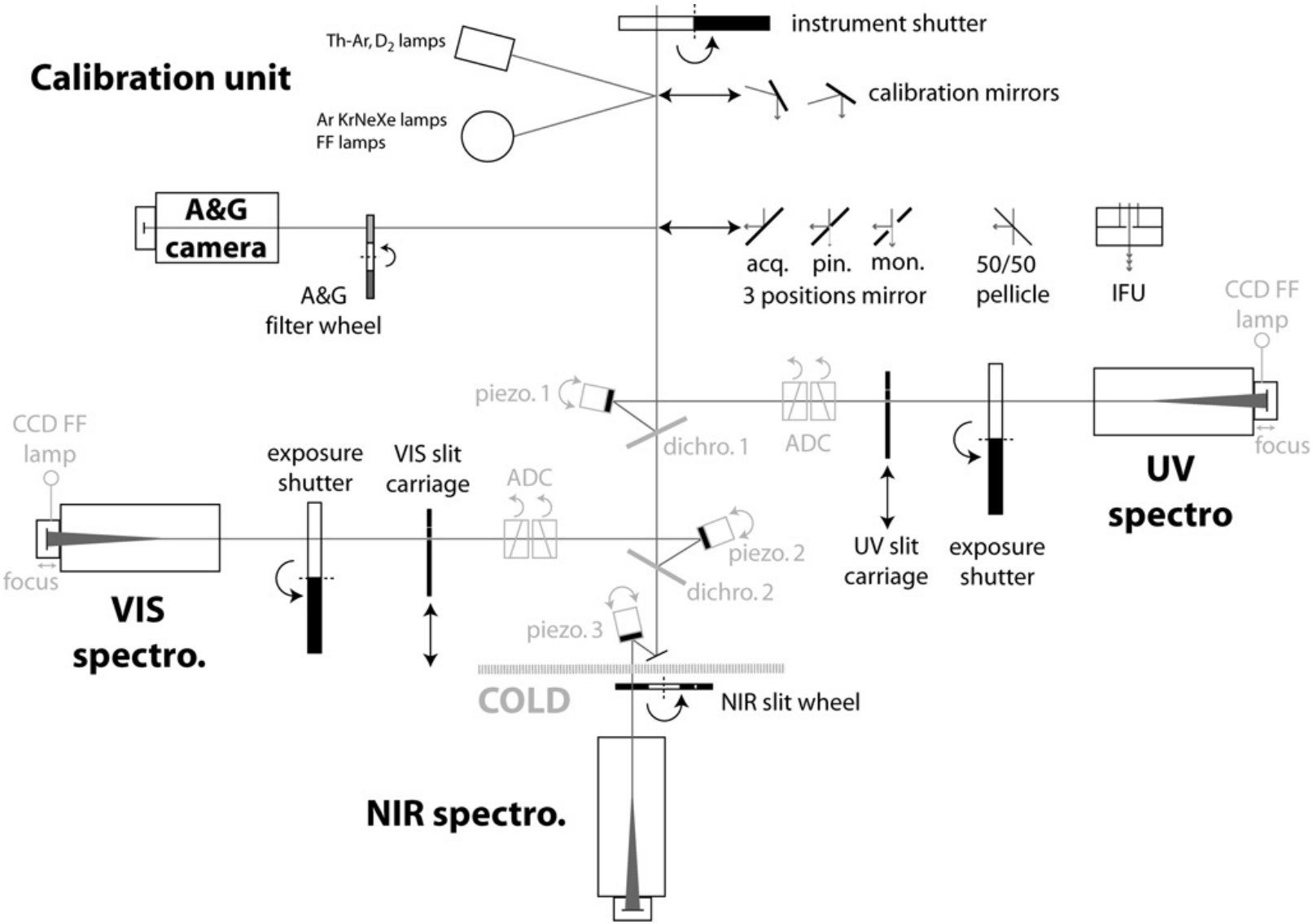
X-shooter (2nd generation VLT)

intermediate resolutions (R=4000-14000, depending on wavelength and slit width) with fixed echelle spectral format (with prism cross-dispersers) in the three arms.



spectrograph resolution [1]

arm	slit width (") [2]	R= (Δλ/&lambda)	sampling (pix/FWHM)	arm	slit width (")	R= (Δλ/&lambda)	sampling (pix/FWHM)	arm	slit width (")	R= (Δλ/&lambda)	sampling (pix/FWHM)
UVB	0.5	9100	3.5	VIS	0.4	17400	3.0	NIR	0.4	9100	3.5
	0.8	6200	5.2		0.7	11000	4.8		0.6	6200	5.2
	1.0	5100	6.3		0.9	8800	6.0		0.9	5100	6.3
	1.3	4000	8.1		1.2	6700	7.9		1.2	4000	8.1
	1.6	3300	9.9		1.5	5400	9.7		1.5	3300	9.9
UVB	IFU [3]	7900	4.1	VIS	IFU [3]	12600	4.2	NIR	IFU [3]	8100	2.6


Calibration unit
Th-Ar, D2 lamps
Ar KrNeXe lamps
FF lamps
instrument shutter
calibration mirrors
A&G
camera
A&G
filter wheel
acq.
pin.
mon.
3 positions mirror
50/50
pellicle
IFU
CCD FF
lamp
focus
UV
spectro
piezo. 1
dichro. 1
ADC
CCD FF
lamp
exposure
shutter
VIS slit
carriage
ADC
piezo. 2
dichro. 2
UV slit
carriage
exposure
shutter
focus
VIS
spectro.
piezo. 3
COLD
NIR slit wheel
NIR spectro.

Exposure time calculator

Exposure Time Calculators & Simulations				
	Observation Domain			
Facility	Optical		Infrared	
	Imaging	Spectroscopy	Imaging	Spectroscopy
La Silla	EMMI EFOSC2 SUSI 2p2 WFI	EMMI EFOSC2 HARPS FEROS	SOFI	SOFI
Paranal UT1	FORS2 FORS(P83+)	FORS2 FORS(P83+)	ISAAC SW LW	CRIRES ISAAC SW LW
Paranal UT2	FORS1	UVES FLAMES+UVES GIRAFFE FORS1 X-SHOOTER		
Paranal UT3	VIMOS	VIMOS MOS IFU	VISIR	VISIR
Paranal UT4			NACO HAWK-I	NACO SINFONI
VLTI Calculators	VisCalc CalVin			
E-ELT	Imaging Spectroscopy			

Input Flux Distribution

ETC Input

Uniform (constant with wavelength)

Blackbody: T = 11000.0

Template Spectra: A0V (Pickles) 0.00

Object Magnitude: 20.0 Band: V

Magnitudes are given per square arcsec for extended sources. Note that some template spectra are defined over a limited wavelength range and may not allow calculations for all instrument configurations.

The object magnitude is not taken into account for the following single line source

Single line

Wavelength: 550.000

Flux: 50.000 $^{-16}$ ergs/s/cm^2 (per arcsec^2 for extended sources)

FWHM: 1.00 (value: 0.50)

Spatial Distribution: Point Source Extended Source

Sky Conditions

Days From New Moon: 3 days Seeing: 1.60 0.80

The sky brightness is determined by the moon phase and the instrument efficiency according to this table.

Instrumental Setup

Resolution: Standard High

Filter: Bessel V

Detector (E2V) : Readout mode: high gain pixels 1x1

Polarimetry Mode:

No Polarimetry

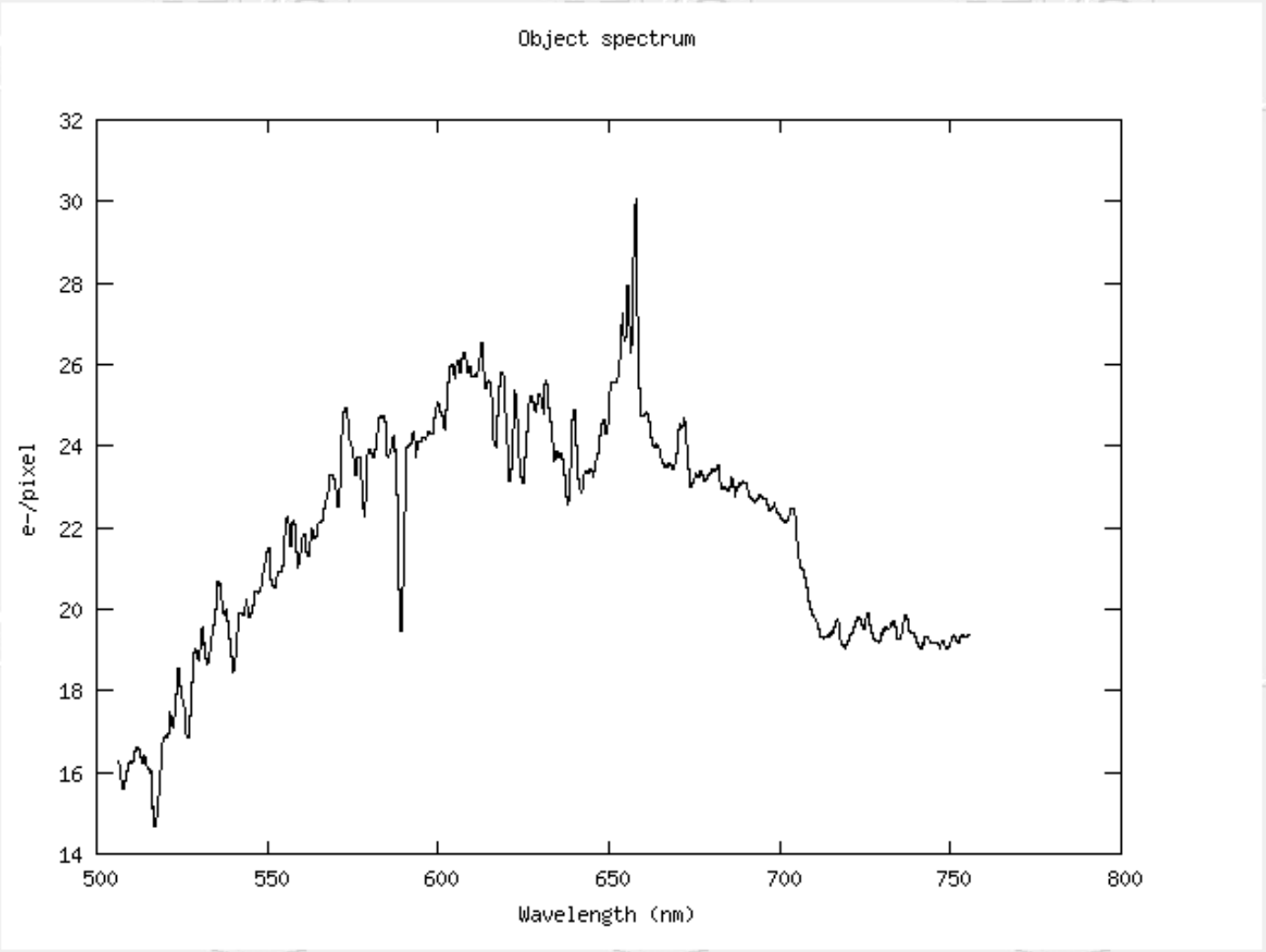
Linear or Circular Polarisation

ETC Output

Spatial distribution	:	Point source
Probability of realisation of seeing	:	65.600 %
Exposure time	:	0.682 seconds
Signal to Noise over the PSF area	:	20.000
Number of pixels for PSF area	:	129.000 pixels
Plate scale	:	0.125 arcsecs/pixel
Electrons in the PSF area (object only)	:	1087.756 e-
Sky background value	:	4.386 e-/pixel
Read-out noise level	:	3.180 e-/bin
Peak pixel value (object+sky)	:	27.561 e-
Detector dark current	:	5.000 e-/pixel/hour
Detector saturation level	:	35390.000 e-
Signal to noise at central pixel	:	3.776

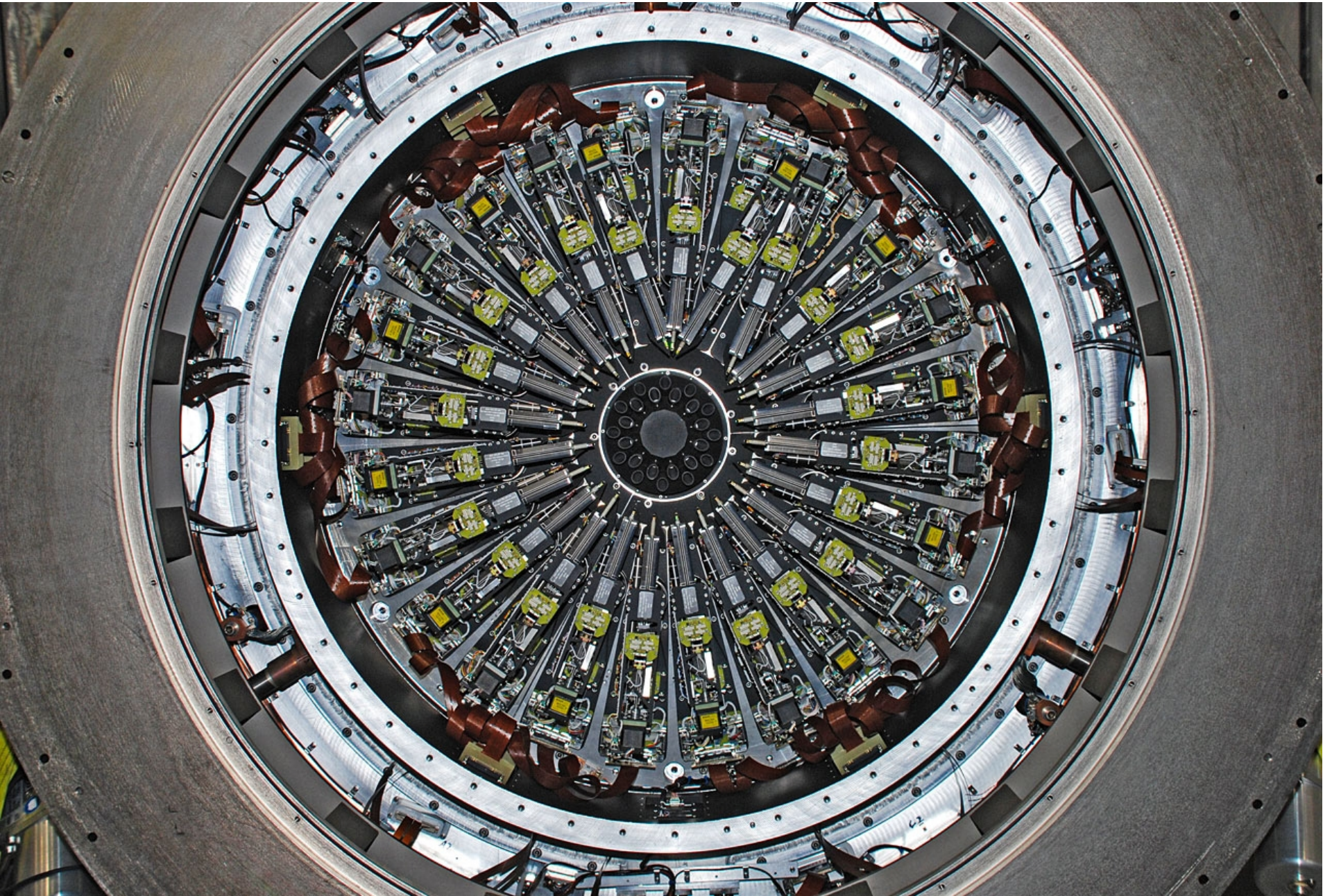
Sa Galaxy spectrum

ETC Output



X label: Wavelength (nm), Y label: e-/pixel

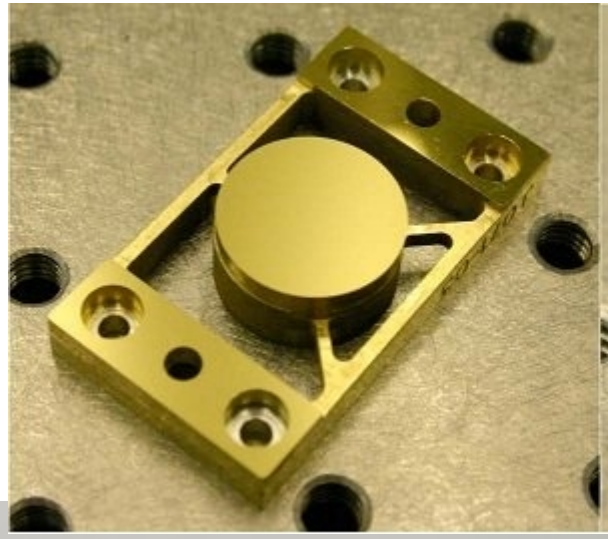
KMOS: K-band Multi-Object Spectrograph



KMOS

3 spettrograph, each with 8, IFU arms, each IFU consists of 14 slides each of 14 pixels

Requirement	Baseline Specification
Optical Throughput (predicted)	J>20%, H>30%, K>30%
Wavelength coverage	0.8 to 2.5 microns
Spectral Resolution	IZ grating R~3200 YJ grating R~3400 H grating R~4000 K grating R~4200 HK grating R~1800
Number of IFUs	24
Extent of each IFU	2.8 x 2.8 sq. arc seconds
Spatial Sampling	0.2 arc seconds
Patrol field	7.2 arcmin diameter circle
Close packing of IFUs	>=3 within 1 sq arcmin
Closest approach of IFUs	>=2 pairs of IFUs separated by 6 arcsec



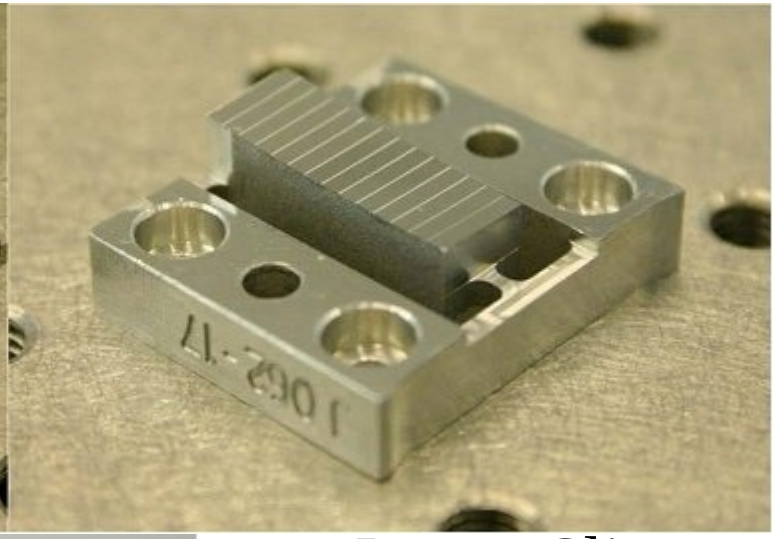
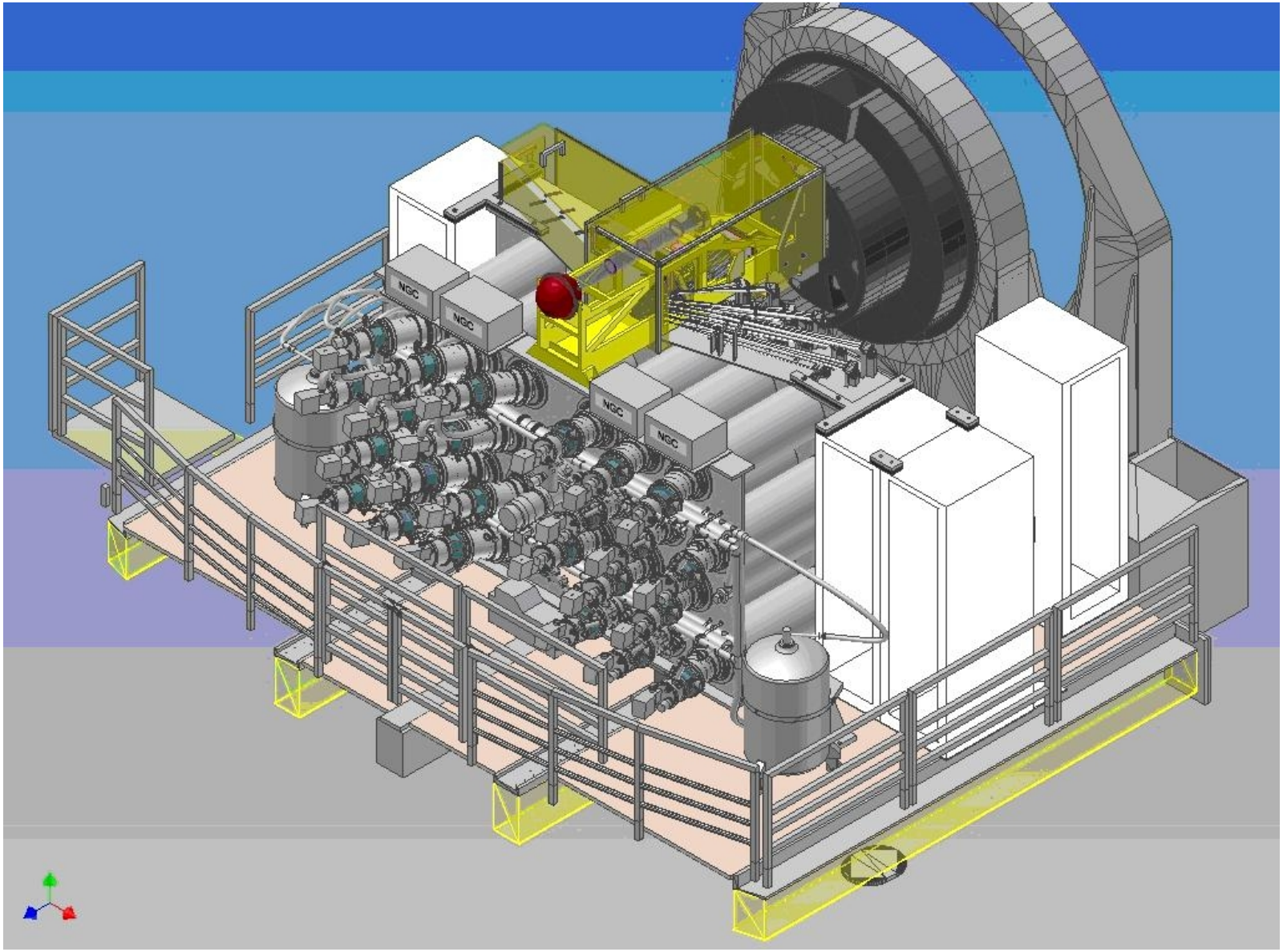


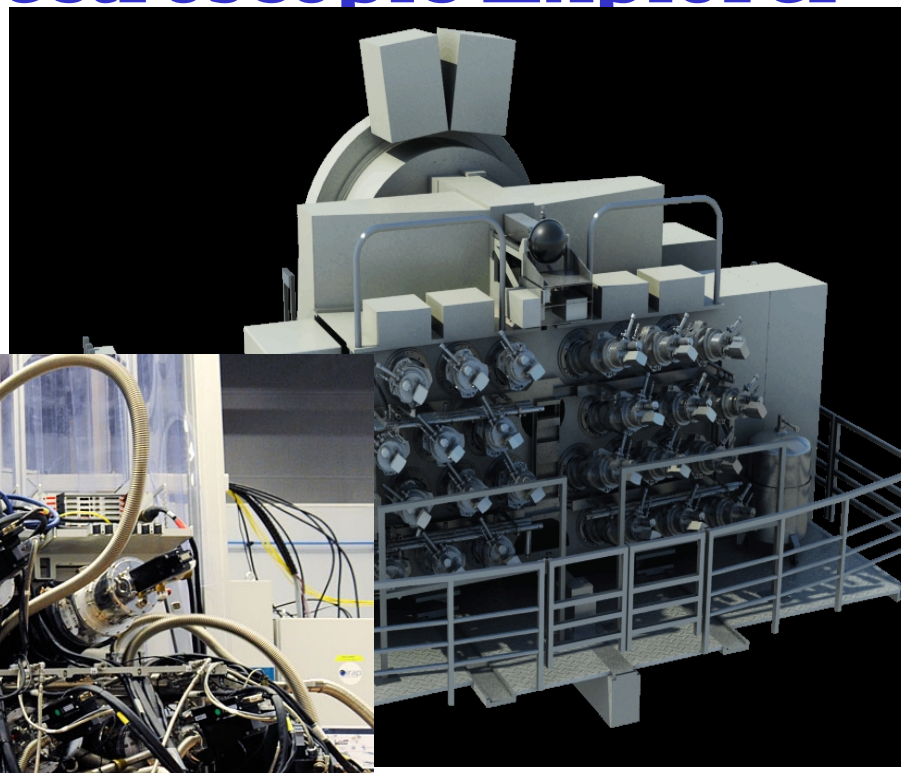
Image Slicer

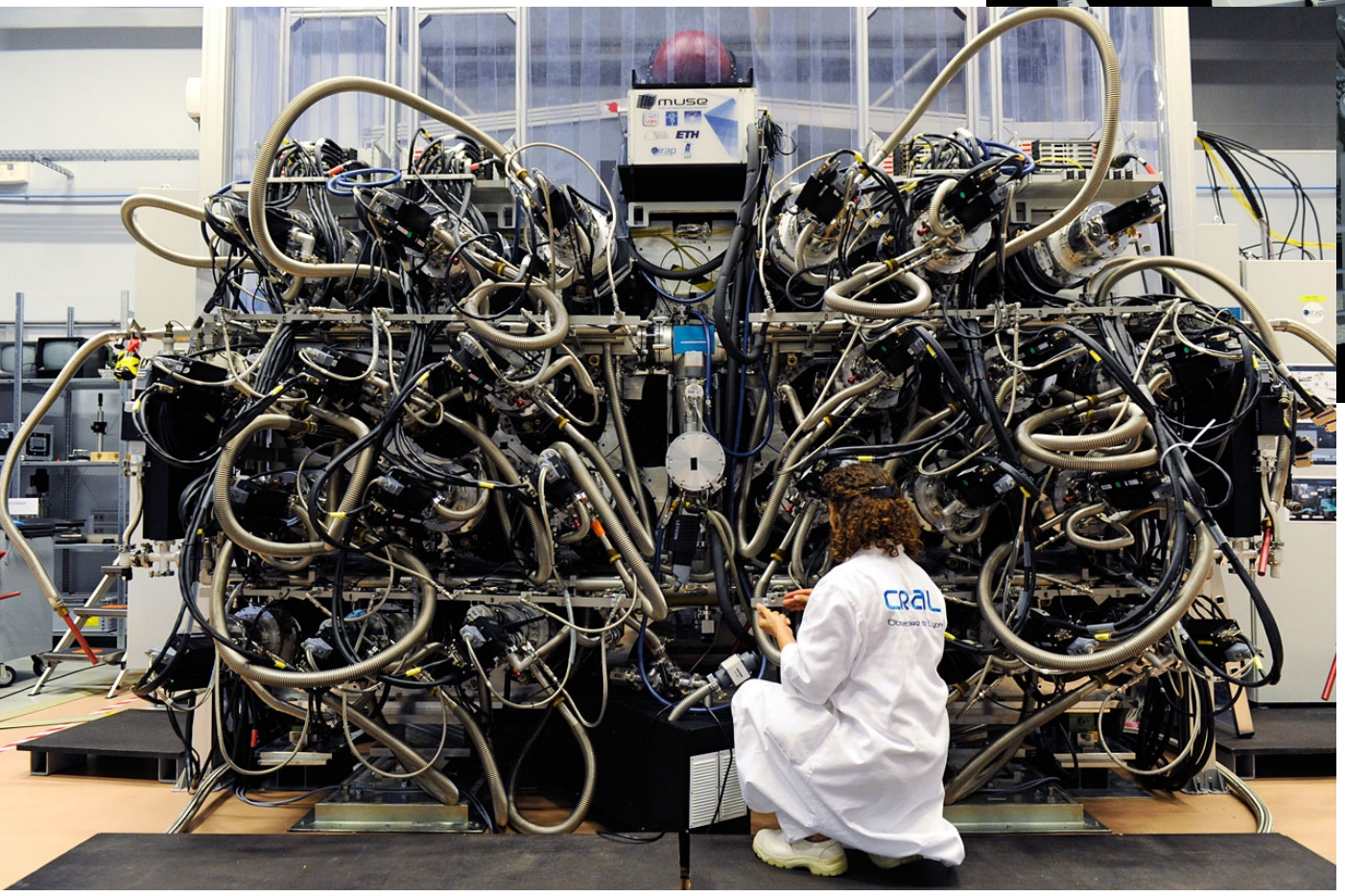


MUSE: Multi Unit Spectroscopic Explorer



MUSE: Multi Unit Spectroscopic Explorer





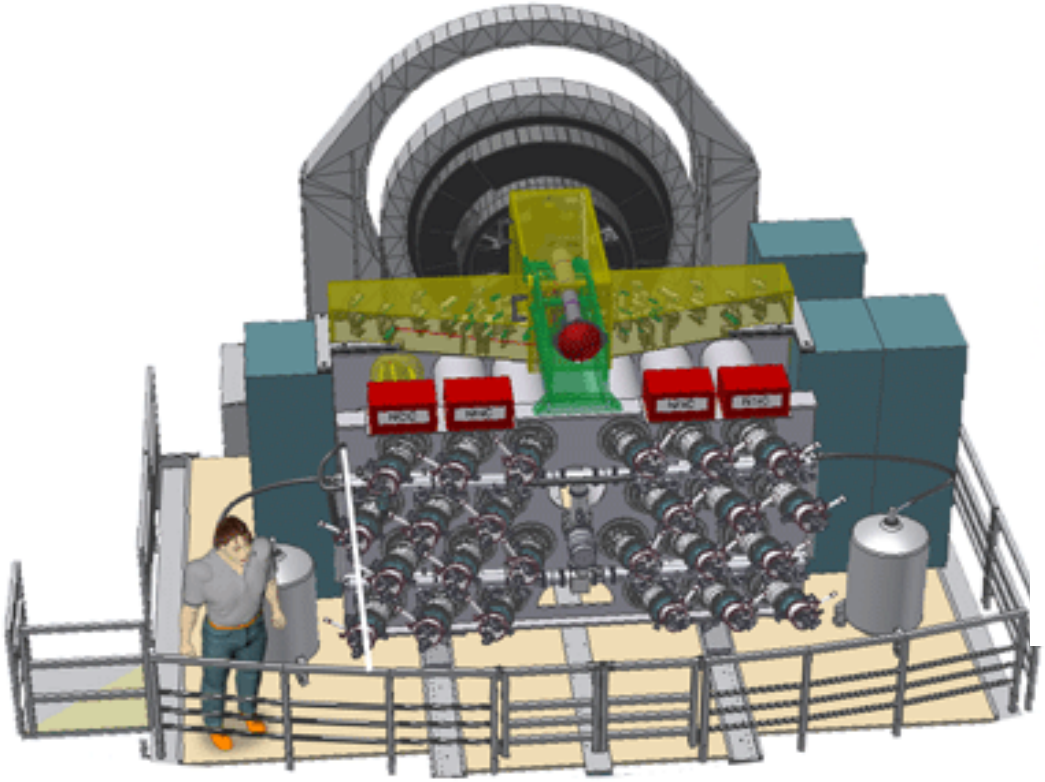
MUSE Multi Unit Spectroscopic Explorer

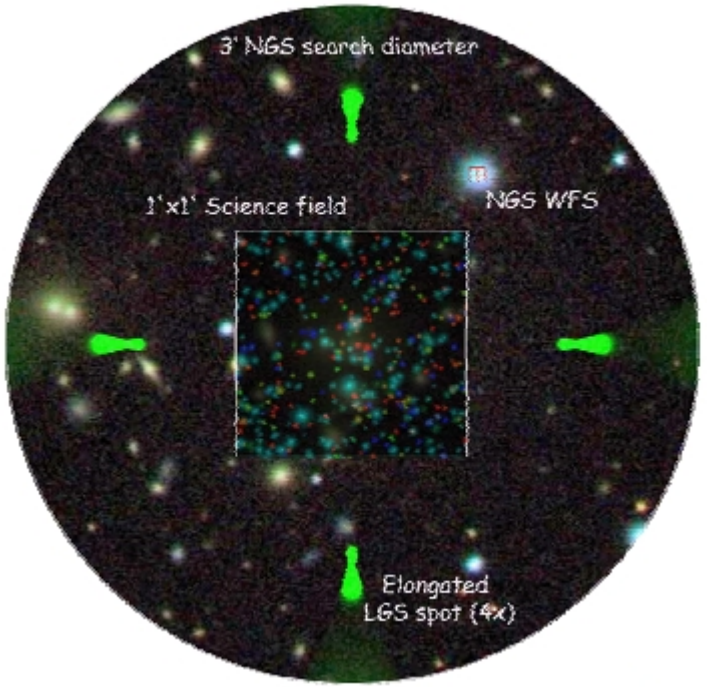
-24 IFU devices.
-two spatial scales
- 4 Laser Guide Stars

- commissioning: 2013

Observational Parameters

Spectral range (simultaneous)	0.465-0.93 μm
Resolving power	2000@0.46 μm
	4000@0.93 μm
Wide Field Mode (WFM)	
Field of view	1x1 arcmin^2
Spatial sampling	0.2x0.2 arcsec^2
Spatial resolution (FWHM)	0.3-0.4 arcsec
Gain in ensquared energy within one pixel with respect to seeing	2
Condition of operation with AO	70%-ile
Sky coverage with AO	70% at Galactic Pole
Limiting magnitude in 80h	I_{AB} = 25.0 (R=3500)
	I_{AB} = 26.7 (R=180)
Limiting Flux in 80h	3.9 10^{-19}erg.s^{-1}.cm^{-2}
Narrow Field Mode (NFM)	
Field of view	7.5x7.5 arcsec^2
Spatial sampling	0.025x0.025 arcsec^2
Spatial resolution (FWHM)	0.030-0.050 arcsec
Strehl ratio	10-30%
Limiting Flux in 1h	2.3 10^{-18}erg.s^{-1}.cm^{-2}
Limiting magnitude in 1h	R_{AB} = 22.3
Limiting surface brightness in 1h	R_{AB} = 17.3 arcsec^{-2}





* Formation of galaxies: high redshift Lyman alpha emitters, reionisation, feedback processes and galaxy formation, ultra-deep surveys using strong gravitational lensing, resolved spectroscopy at intermediate redshifts, late forming population III objects

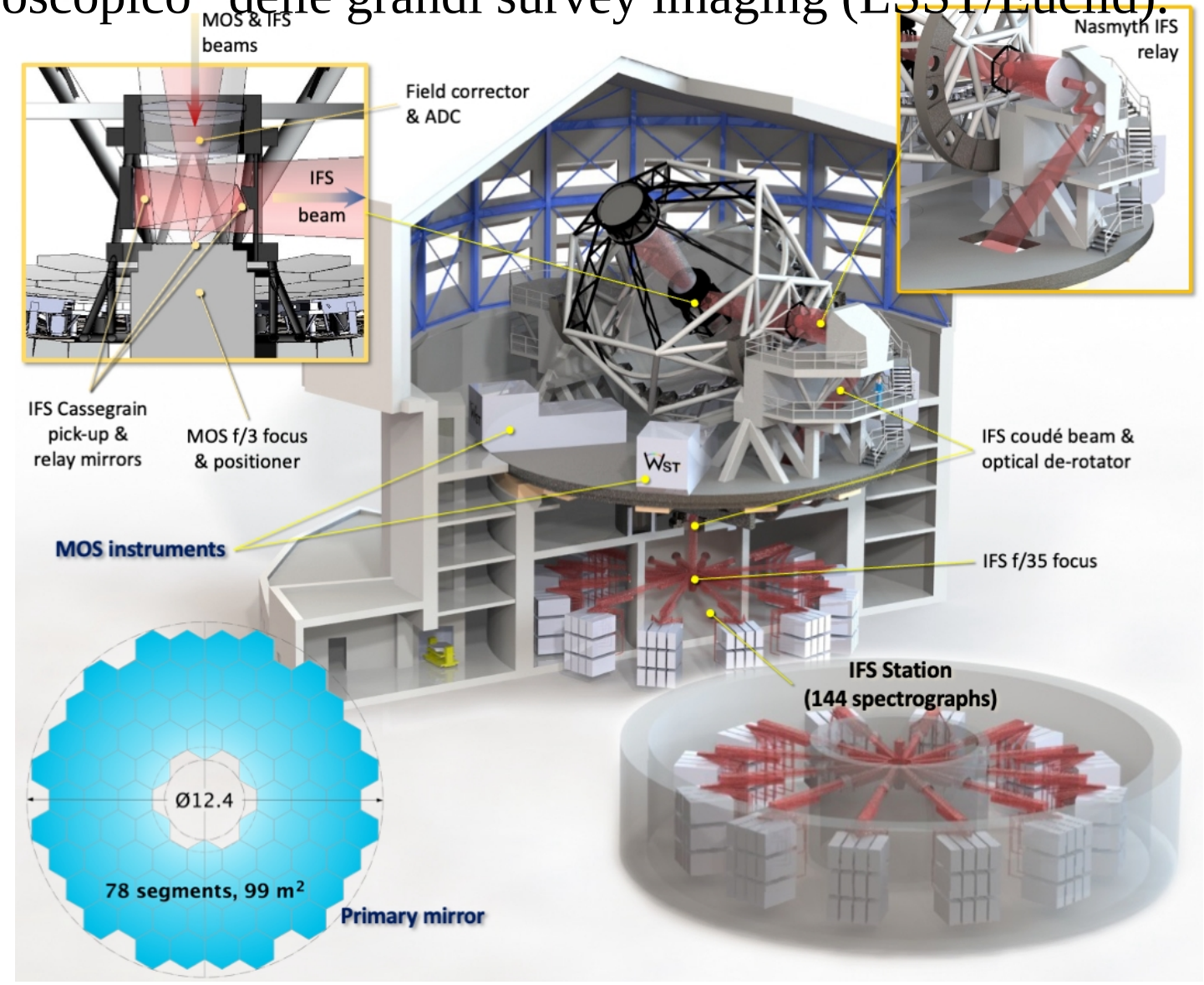
* Nearby galaxies: supermassive black holes in nearby galaxies, kinematics and stellar populations, interacting galaxies, star formation in nearby galaxies

* Stars and resolved stellar populations: early stages of stellar evolution, masive spectroscopy of stellar fields: magellanic clouds, milky ways, local group

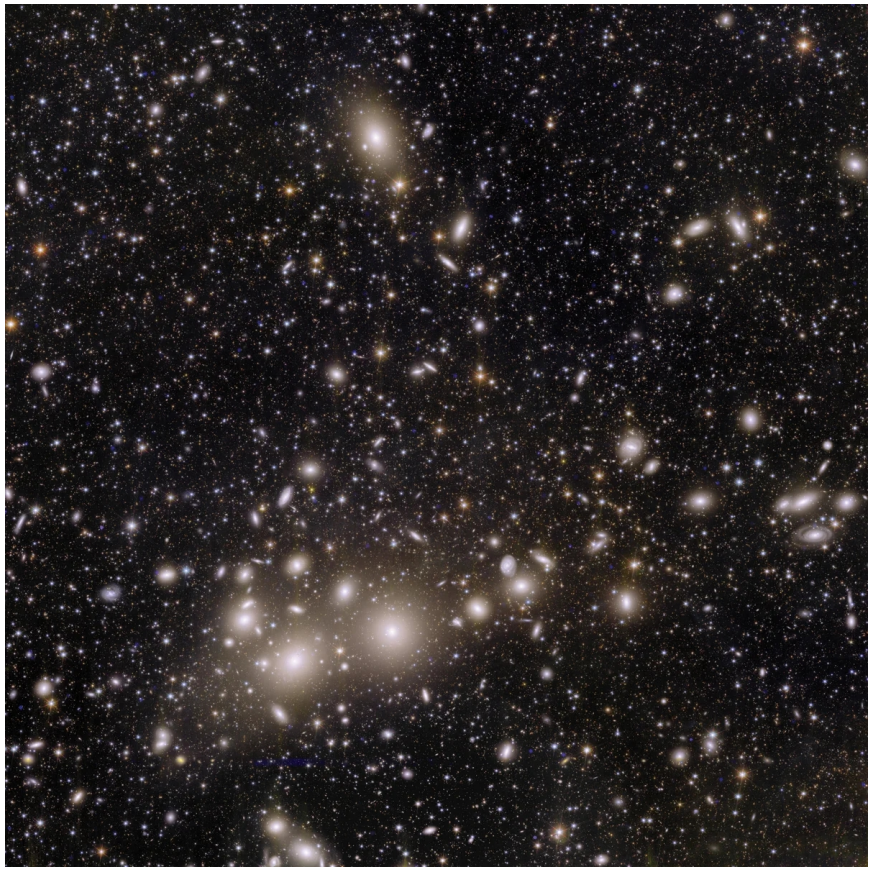
* Solar system: Galilean satellites, Titan, surface heterogeneities of the small bodies, temporal changes in the gas giant planets

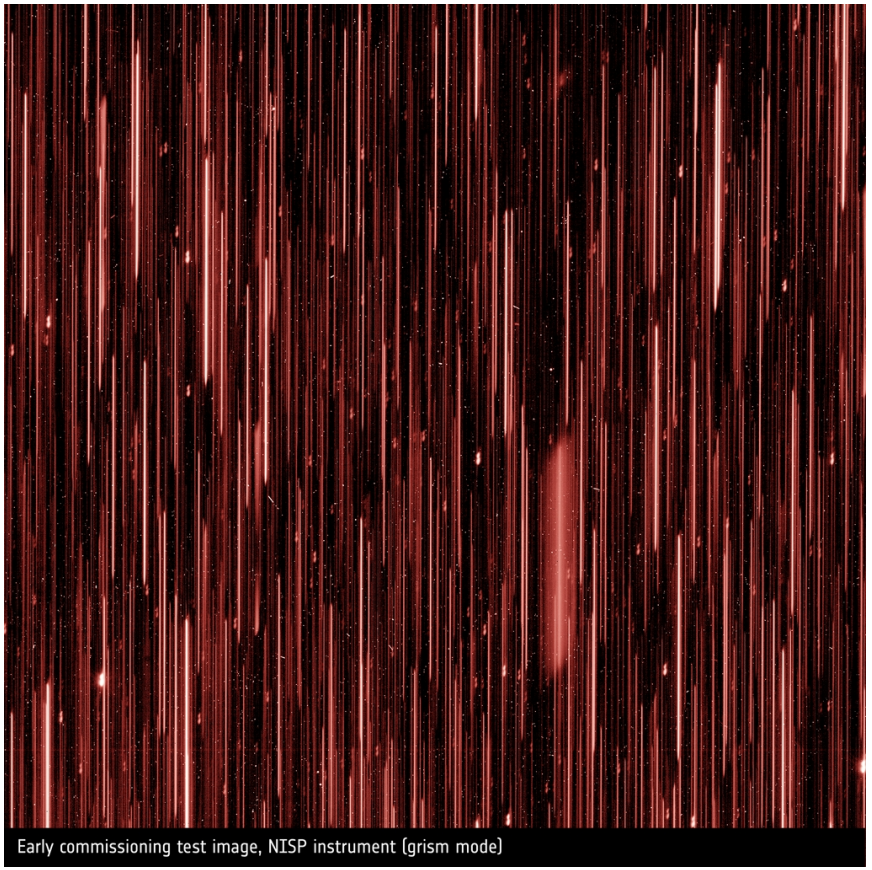
* Serendipity

WST: 12-m class wide-field spectroscopic telescope 3’x3’ IFU. E’ solo una proposta. Esigenza di avere un “successore spettroscopico” delle grandi survey imaging (LSST/Euclid).



Euclid: 1.2m; 0.1”/pix visibile, 0.3”/pix NIR; FOV 42’x42’
Orbita in L2
Telescopio farà solo survey





Early commissioning test image, NISP instrument (grism mode)