

# INSTRUMENTATION ON THE VLT

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Neon 2008

# La Silla Paranal



# Paranal

Telescope	Focus			
	Nasmyth A	Cassegrain	Nasmyth B	Interferometric
UT1 (Antu)	CRIRES	FORS2	ISAAC	AMBER MIDI
UT2 (Kueyen)	FLAMES	FORS1	UVES	
UT3 (Melipal)	Visitor	VISIR	VIMOS	
UT4 (Yepun)	HAWK-I	SINFONI	NACO	
AT1				AMBER
AT2				MIDI
AT3				

# La Silla

Telescope	Focus			
	Nasmyth A	Cassegrain	Nasmyth B	fibre fed from Cassegrain
3.6m telescope	n/a	EFOSC2 up to P80	n/a	HARPS
NTT	SOFI	n/a	EMMI up to P80 EFOSC2 P81 onwards	n/a
2.2m telescope	n/a	WFI	n/a	FEROS

# A lot to cover!!

- ..will not present all information (modes, sensitivities, etc.)
- ..will skip some modes of some instruments, eg. polarimetry.
- ..will only mention future instruments at the end

For further information see ESO web pages.

# Format of talk

- ▣ Will divide instruments into 4 different categories
- ▣ Based on looking at instruments back-to-front!
  - Starting with detectors

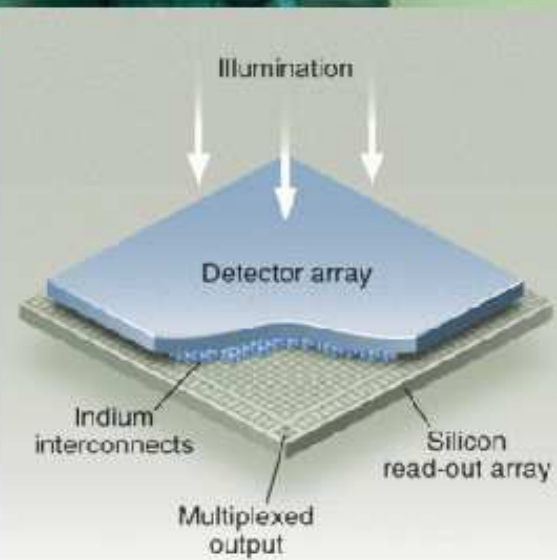
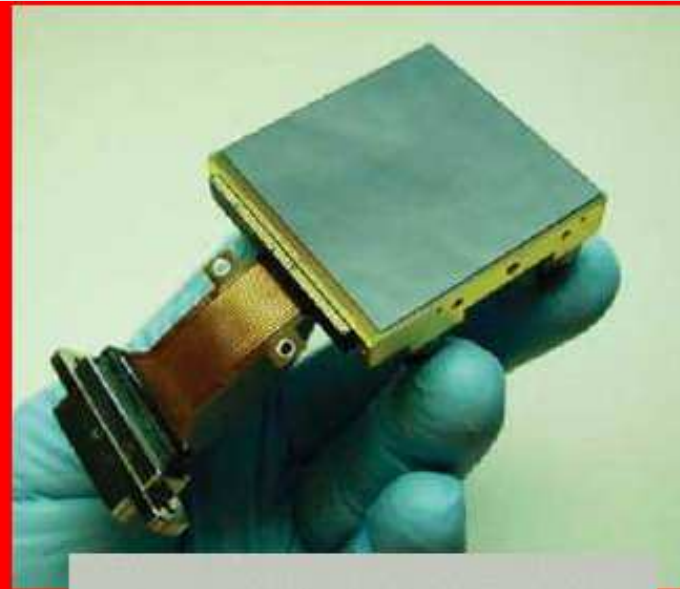
# detectors - the great limitation!

current astronomical detectors measure the 2-D position, intensity and time of photon arrivals

- not energy
- not angle
- not polarisation

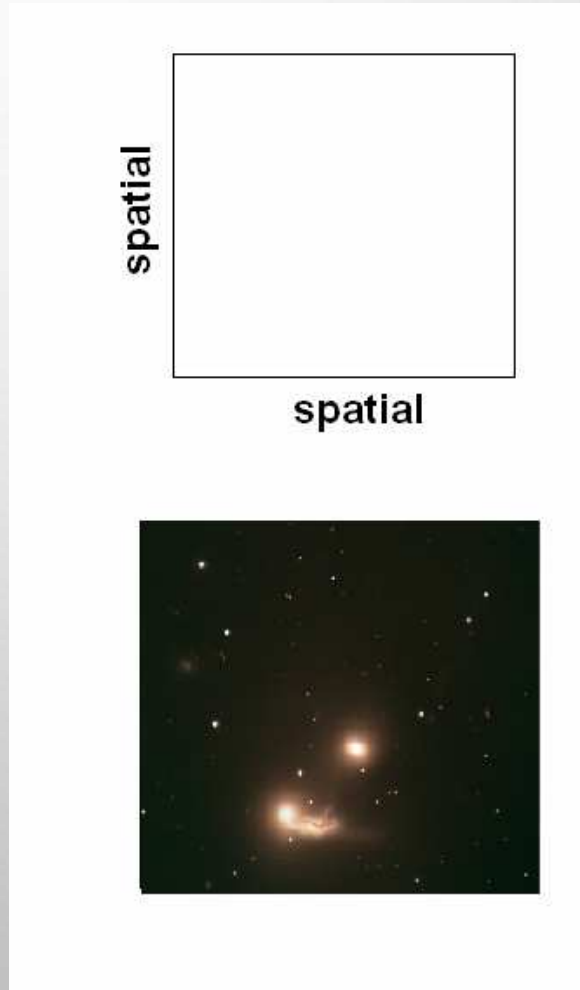
Optics/mechanics must encode the photon quantity to be measured into a 2-D position or intensity.

# Detectors



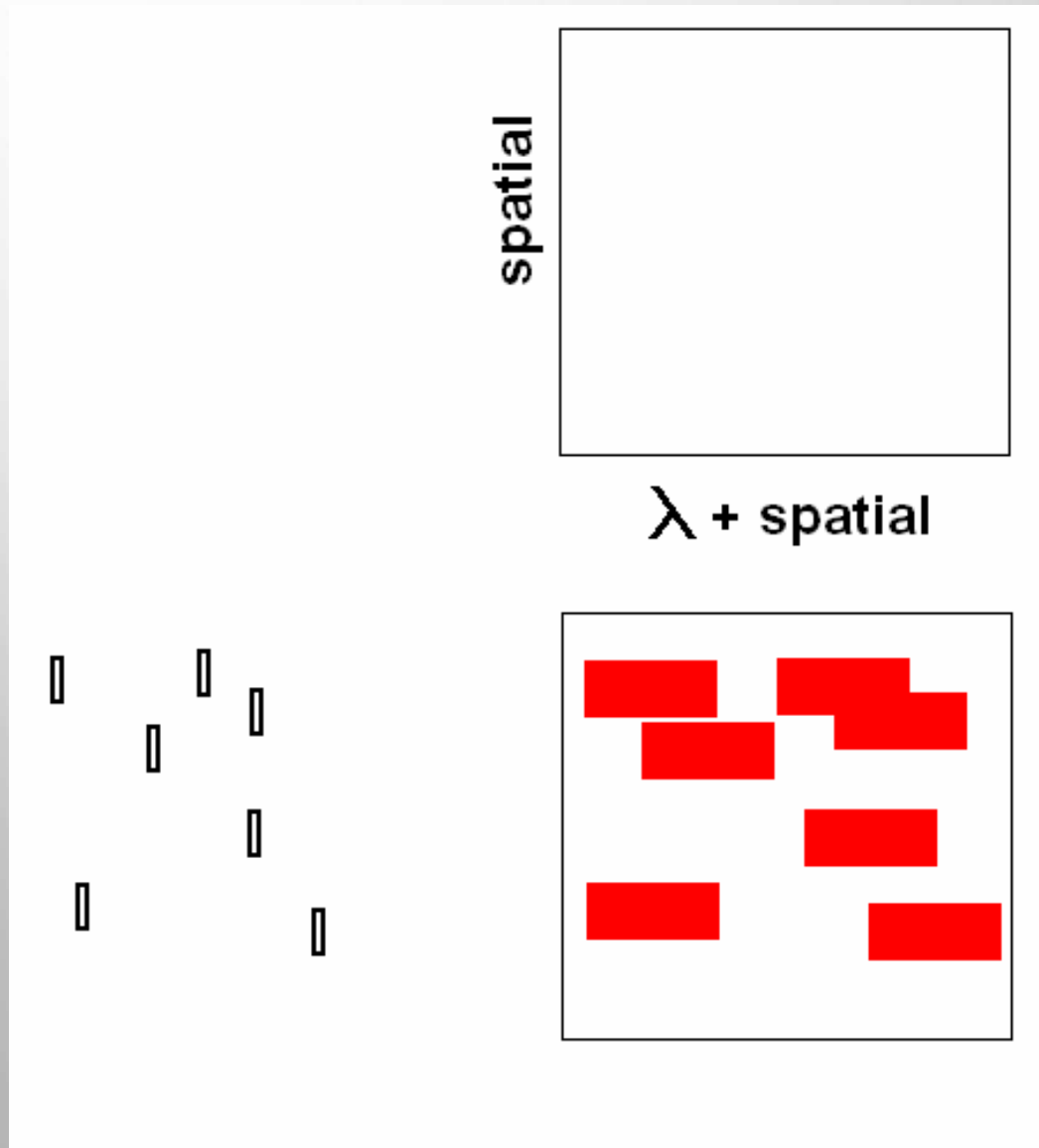


# 1. Imaging



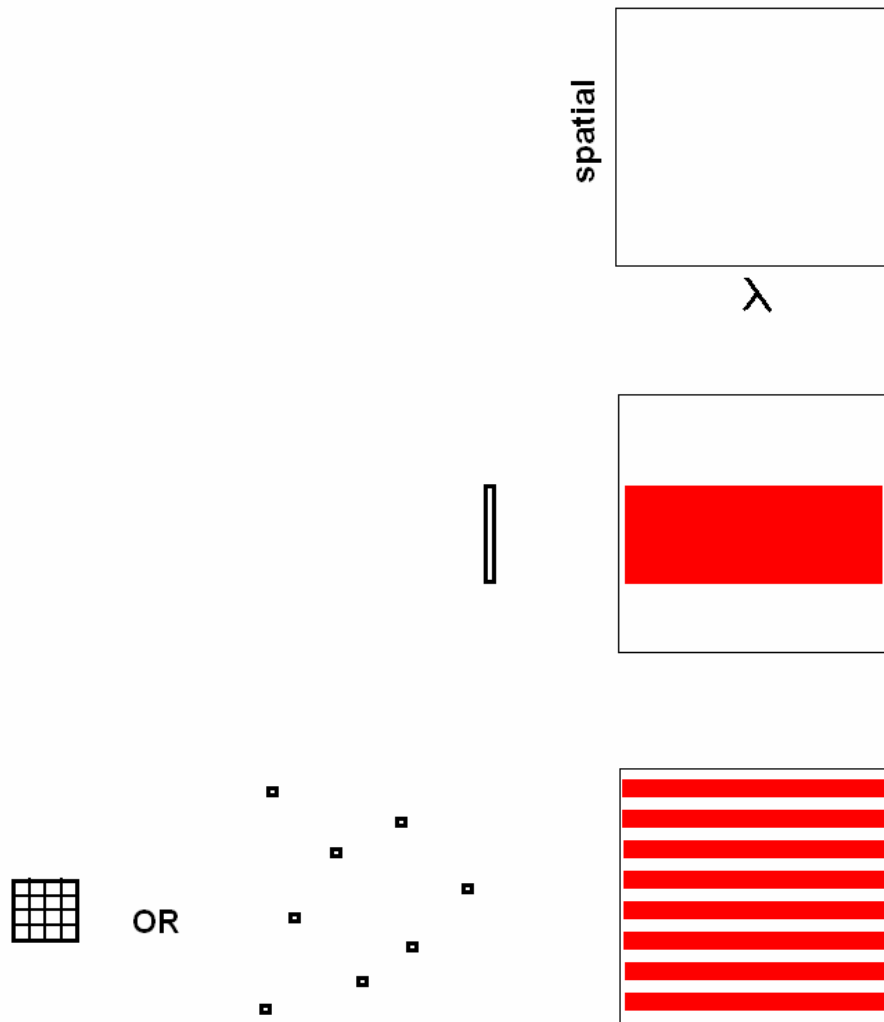
- FORS1 / FORS2
- VIMOS
- HAWK-I
- ISAAC/SOFI
- VISIR
- NACO
- WFI (2.2m) and VST(2.4m)
- VISTA (4m)

## 2. multi-slit spectroscopy



- FORS1 / FORS2
- VIMOS

# 3. long slit, multi-object or IFU spectroscopy



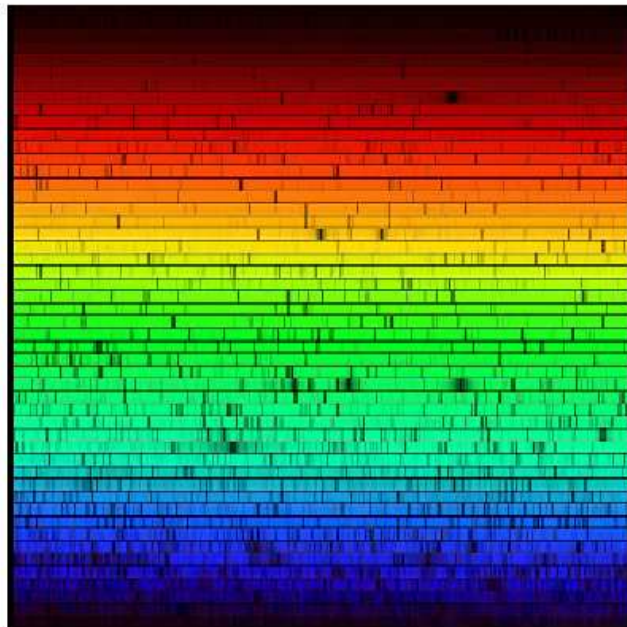
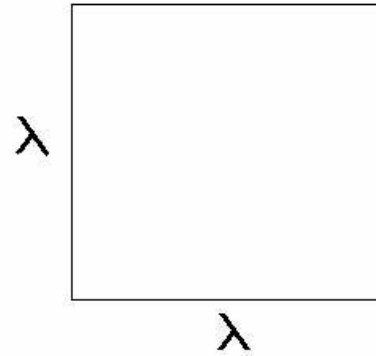
## LONG SLIT

- FORS1 / FORS2/ EFOSC2
- CRIRES
- UVES
- ISAAC/SOFI
- X-shooter
- NACO
- VISIR

## IFU or MOS

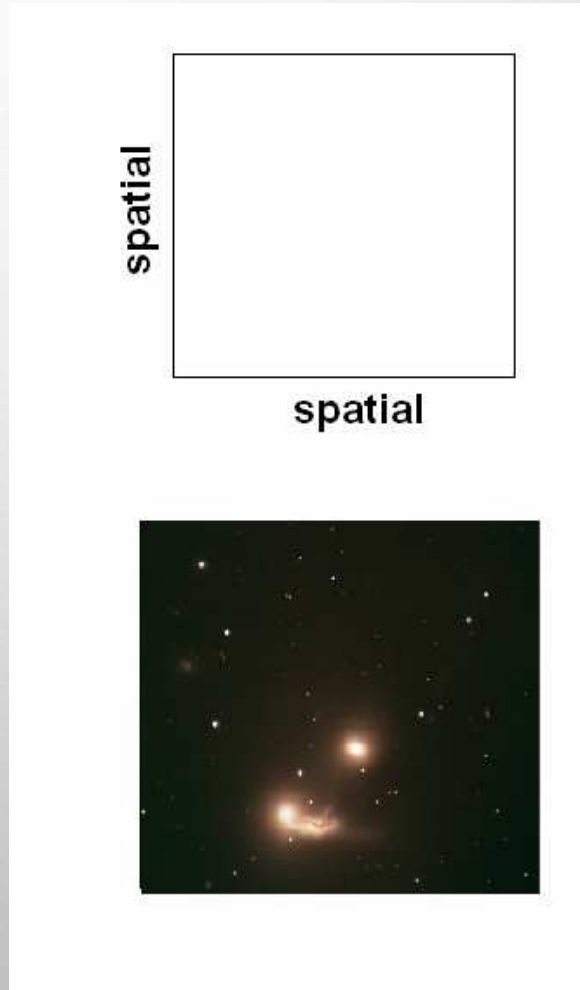
- FLAMES
- VIMOS
- SINFONI

# 4. Cross dispersed spectroscopy



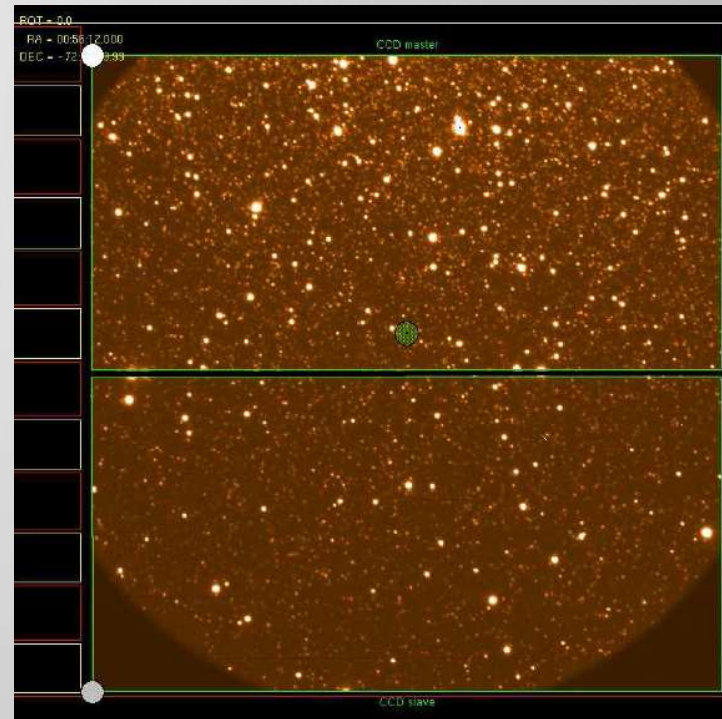
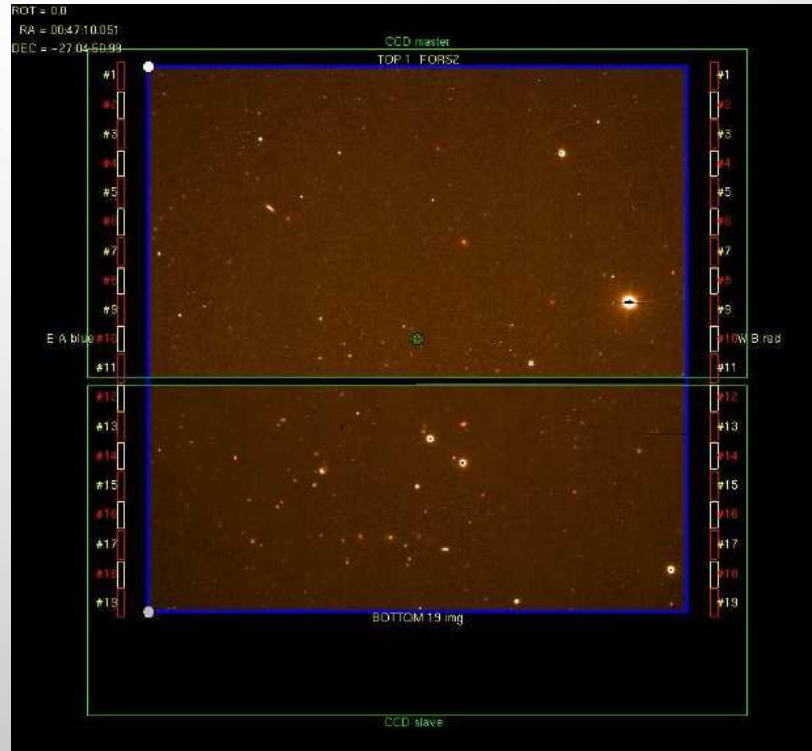
HARPS  
FEROS  
UVES

# 1. Imaging



- FORS1 / FORS2
- VIMOS
- HAWK-I
- ISAAC/SOFI
- VISIR
- NACO
- WFI (2.2m) and VST(2.4m)
- VISTA (4m)

# 1. Imaging FORS1/FORS2



6.8' x 6.8' 0.25"/pixel

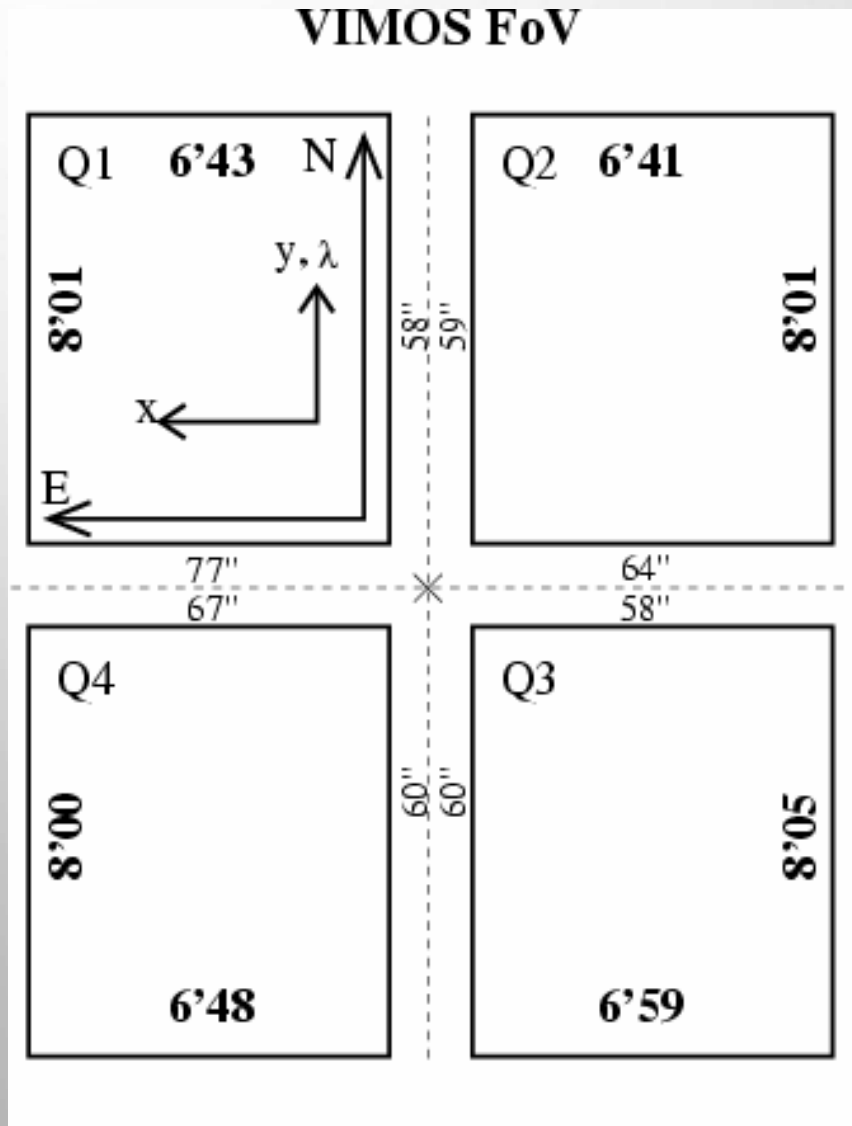
4.2' x 4.2' 0.125"/pixel

FORS 1 : u,b,v,g (high throughput) + Bessel V,R,I

FORS 2 : BVRlz

+ many special NB filters

# 1. Imaging - VIMOS



widest field imager on VLT

4 x 2k x 2k quadrants

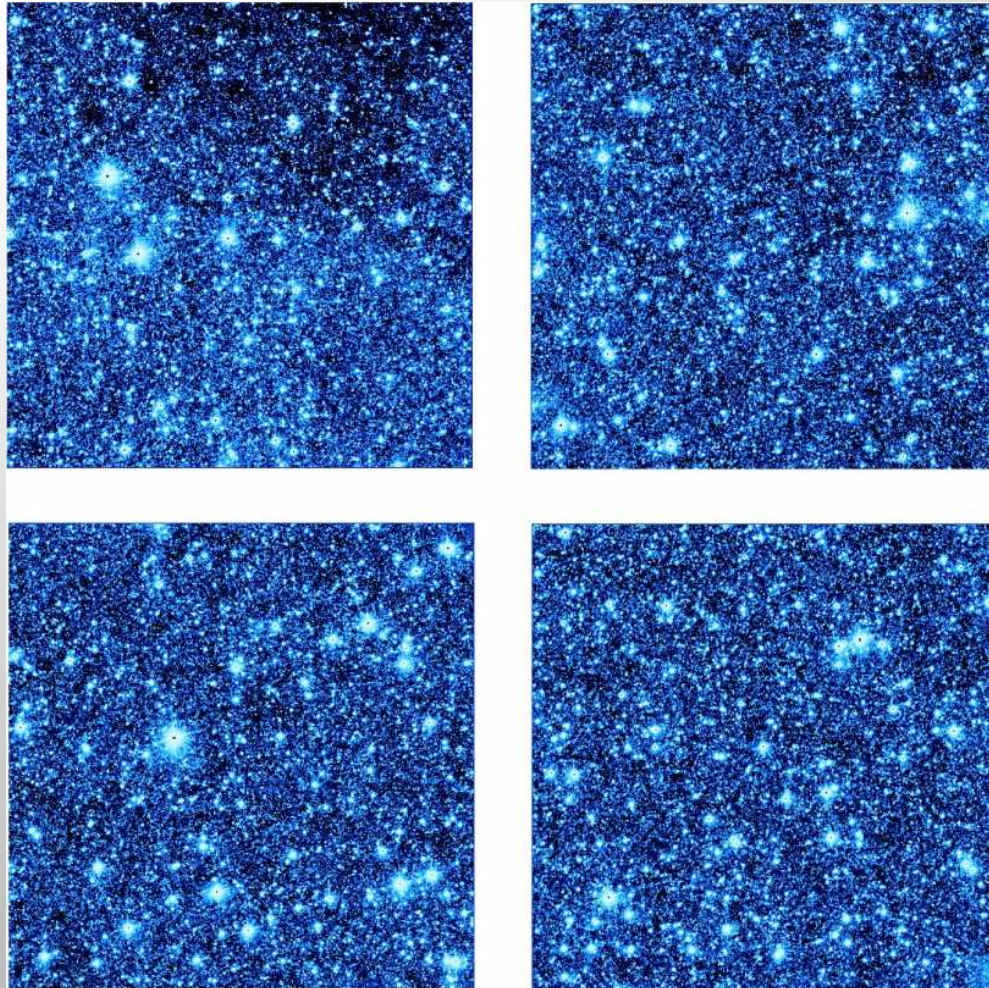
0.21" per pixel

U B V R I z

upgrade to red-sensitive CCDs being considered

$V=27.7 \quad 5 \sigma / 1 \text{hr}$

# 1. Imaging HAWK-I/ISAAC/VISIR



7.5', 0.1" pixels



1.2'

+ L and M  
(ISAAC)



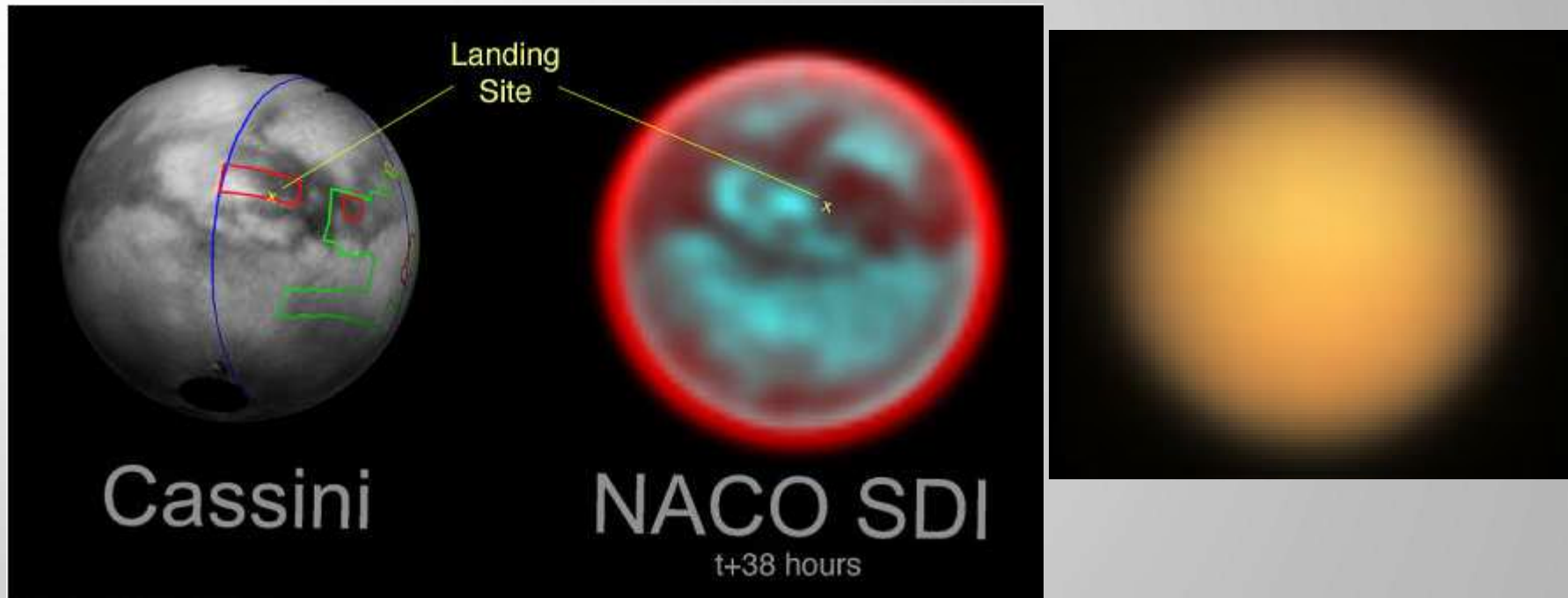
0.33'

+ N and Q  
(VISIR)

Y,J,H,Ks, CH4, H2, BrG, NB1060/1190/2090 (H-I)

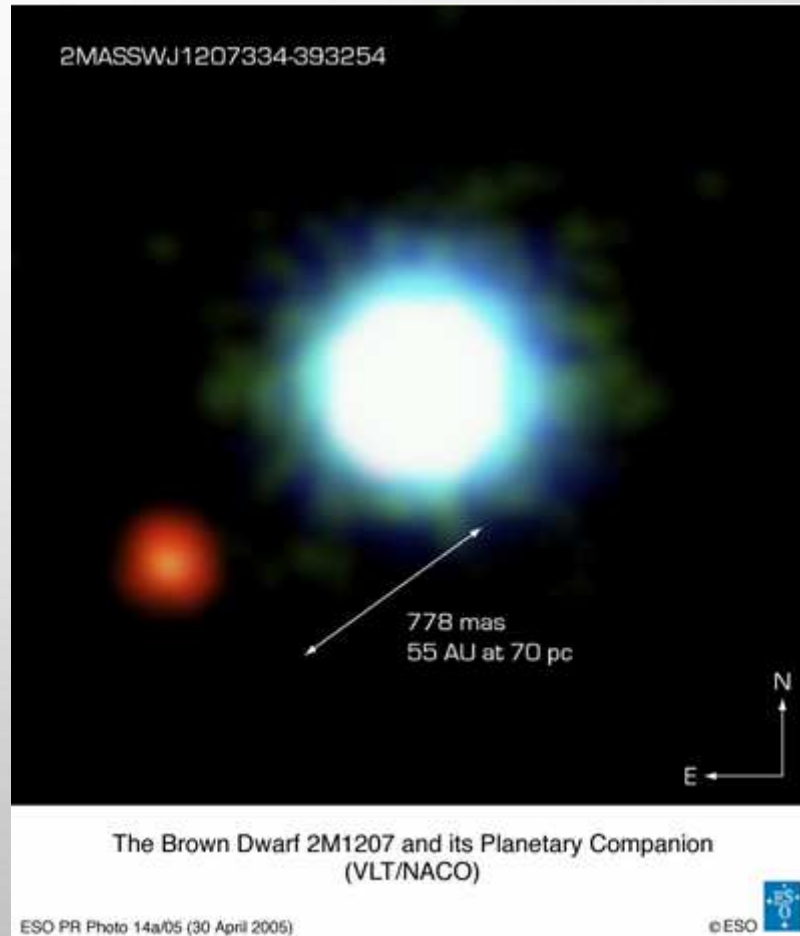


# 1. Imaging - NAosCOnica



- Adaptive optics with Laser/Natural Guide Star
- Small field of view limited by anisoplanatism to  $\sim 15''$  at K
- 1-5 microns, narrow and broadband imaging
- other modes : coronagraphy, polarimetry, sparse-aperture

# 1. Imaging - NAosCOnica

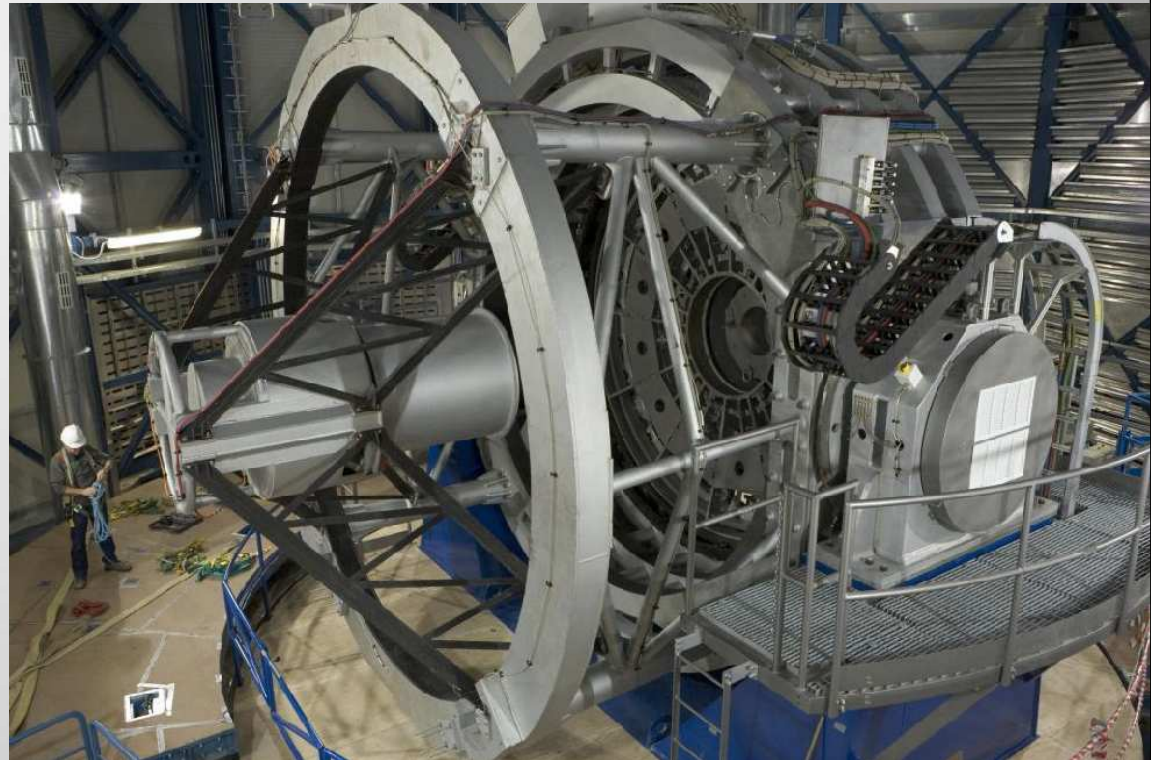


First image of an  
exoplanet outside our  
solar system

# 1.Imaging - VST/VISTA

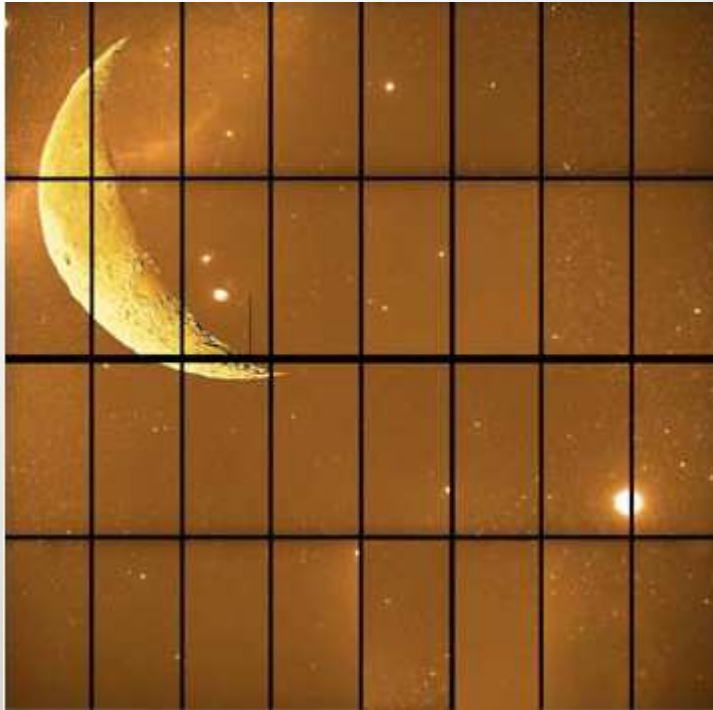


VST 2.4m optical surveys

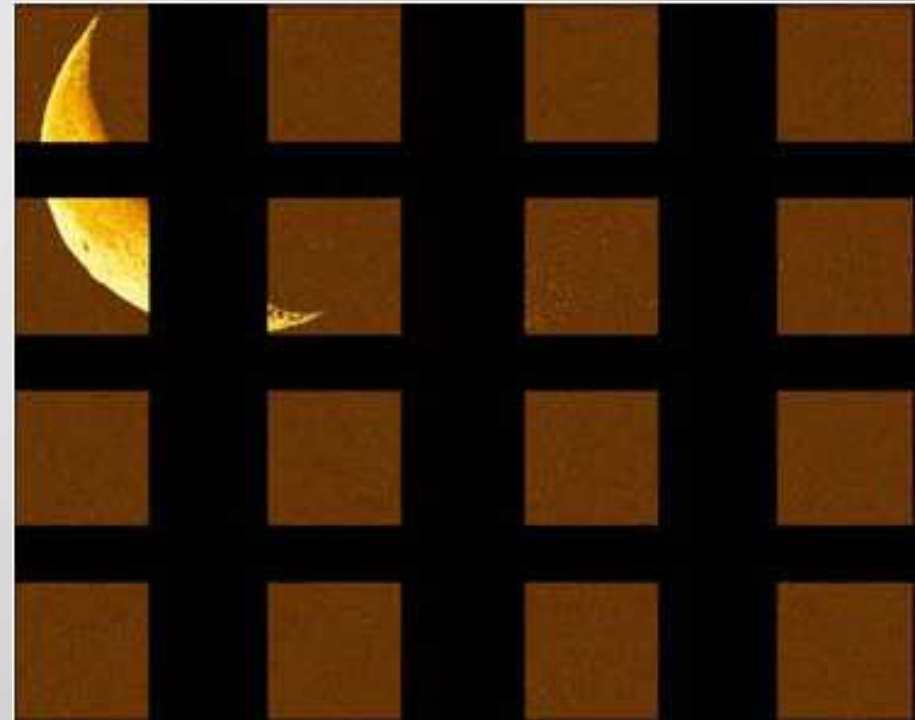


VISTA 4m IR surveys

# 1. Imaging - VISTA/VST

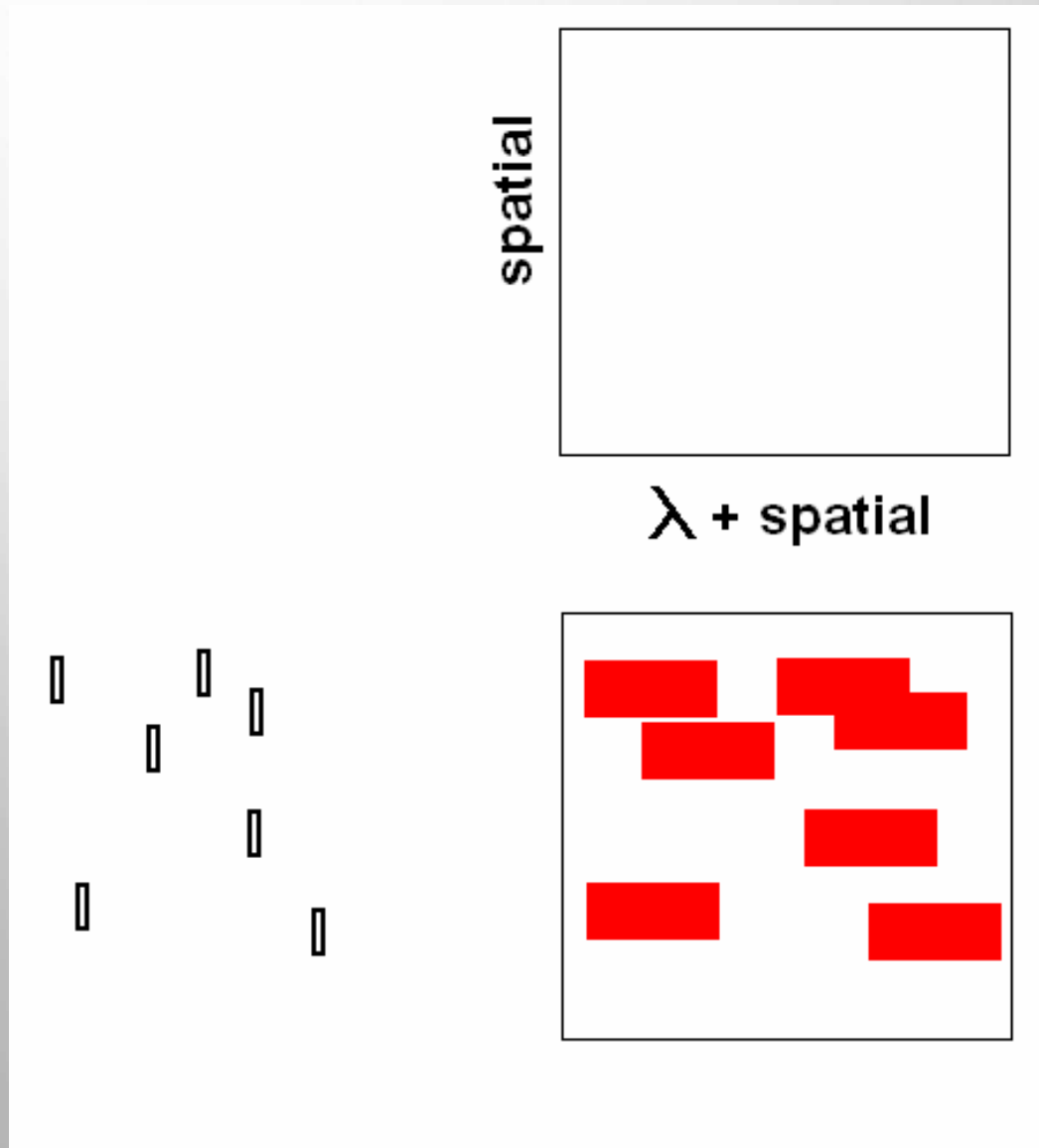


32 2kx4k CCDs  
u',g',r',i',z',  
H $\alpha$ ,B,V  
2009



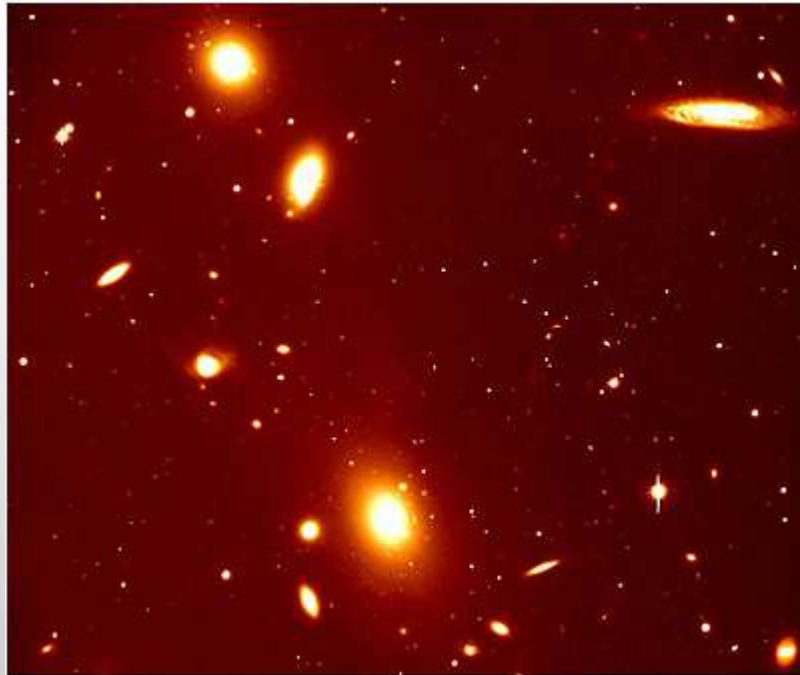
16 2kx2k IR detectors  
Z,Y,J,H,K  
2008

## 2. multi-slit spectroscopy



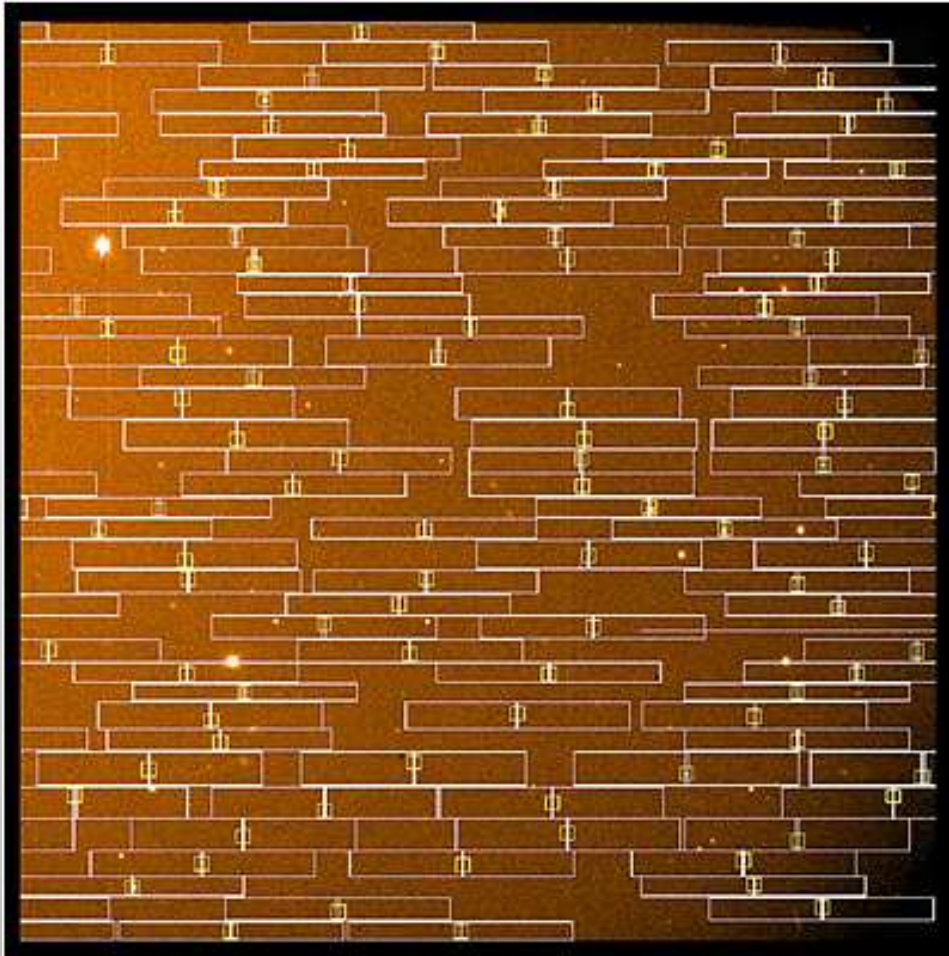
- FORS1 / FORS2
- VIMOS

## 2. multi-slit spectroscopy - VIMOS



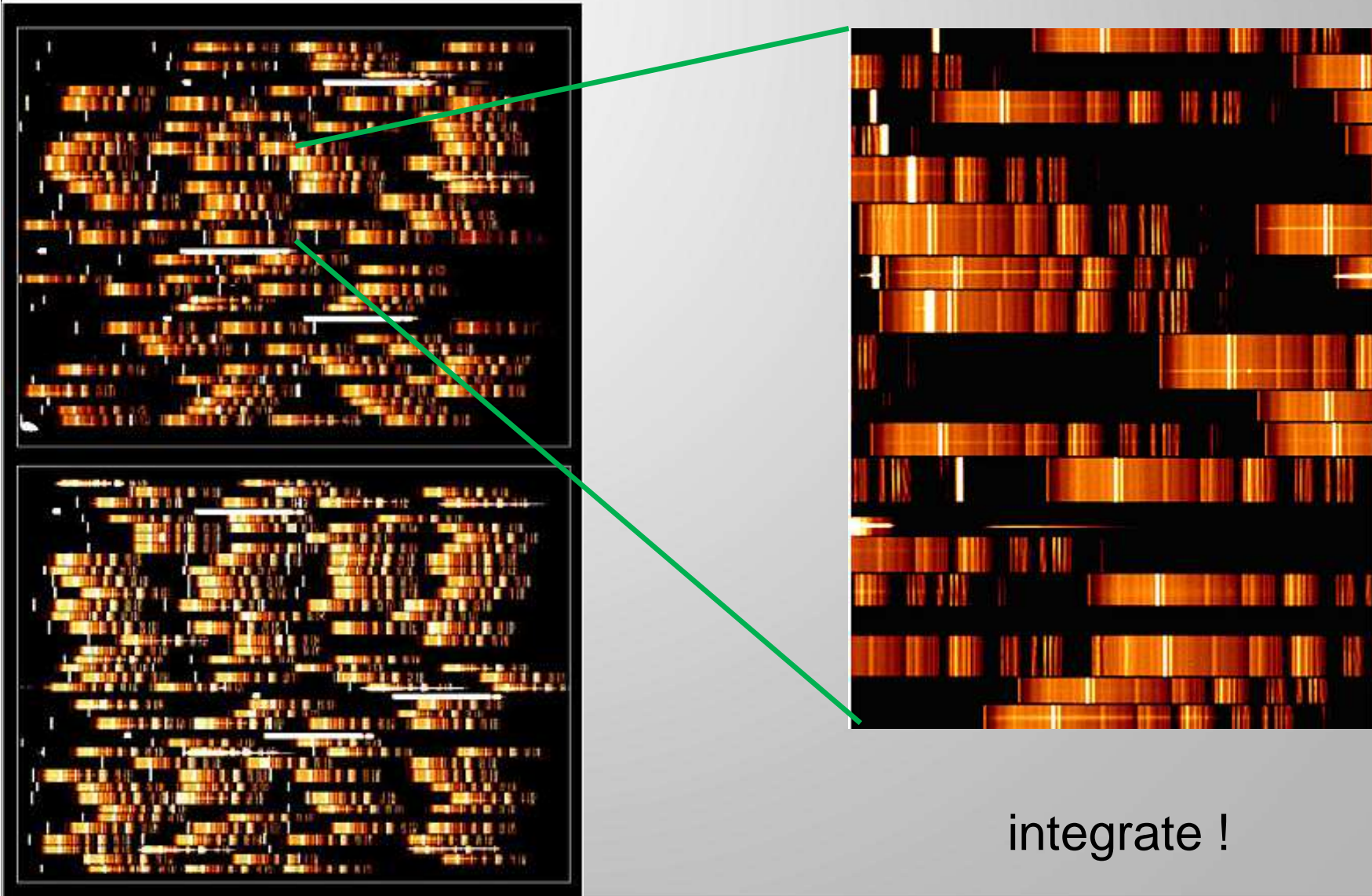
Pre-imaging to locate all the objects of interest precisely in the field

## 2. multi-slit spectroscopy - VIMOS



- use software to prepare positions of slits in the field in Phase II
- use the positions to laser-cut a special mask
- insert the mask into VIMOS
- and.....

## 2. multi-slit spectroscopy - VIMOS



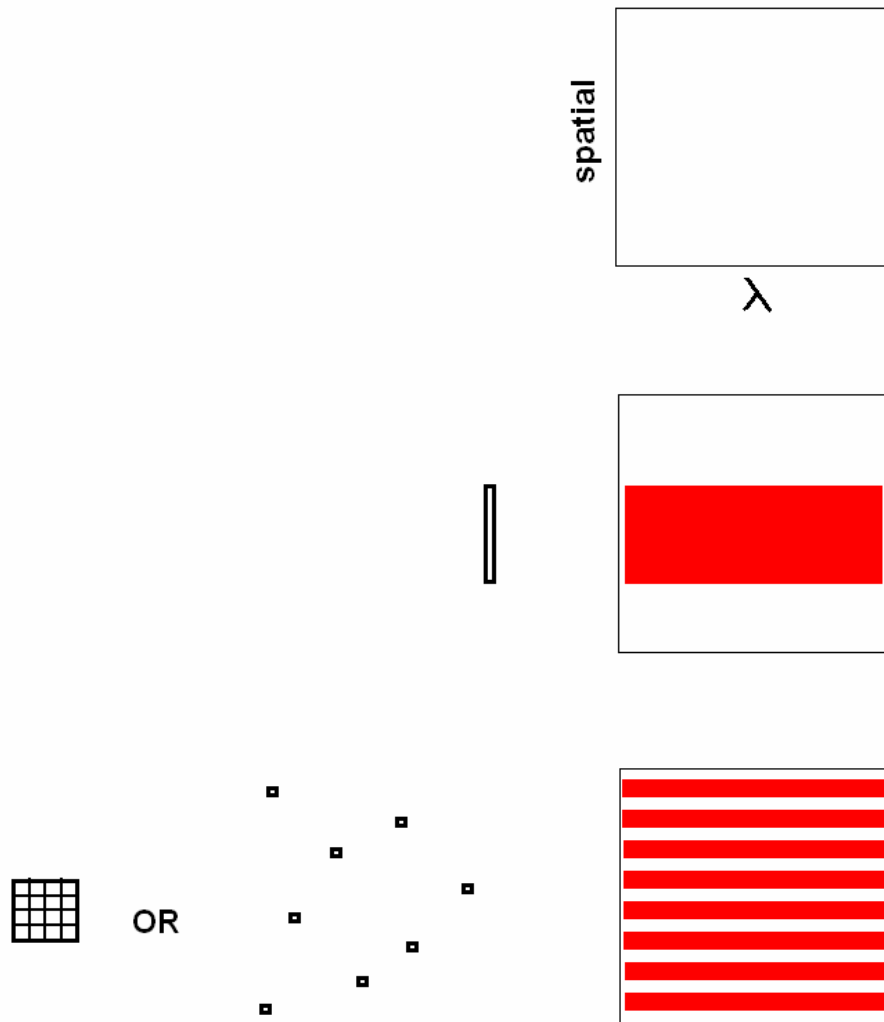
integrate !



## 2. multi-slit spectroscopy - VIMOS

- 4 x 7' x 8' field of view (4 parallel channels)
- 15 masks can be loaded into the instrument
- 8 different resolution grisms available ( $\lambda$  and coverage) from 370 to 1000 nm
- R=180-2500
- up to 500-650 slits per field are feasible, depending on target distribution and grism resolution

# 3. long slit, multi-object or IFU spectroscopy



## LONG SLIT

- FORS1 / FORS2/ EFOSC2
- CRIRES
- ISAAC/SOFI
- NACO
- VISIR

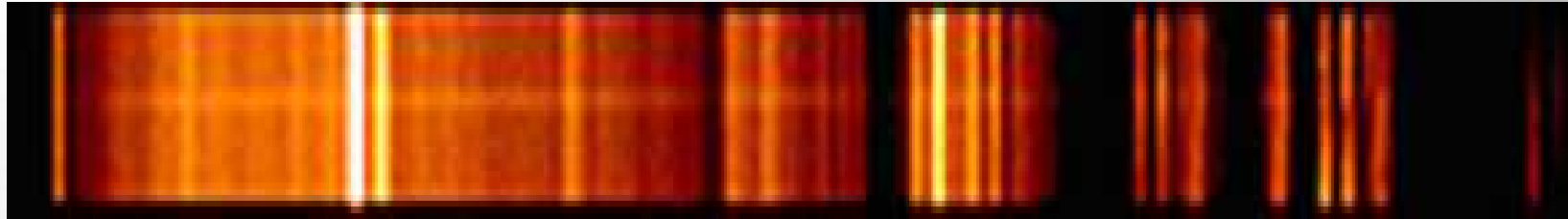
## MOS

- FLAMES

## IFU

- VIMOS
- FLAMES
- SINFONI

# 3. Long Slit Spectroscopy



instrument	Spectral resolution	operating wavelength range	slit length
FORS1/2	260-1700/2600	3300-1100 nm	6.8'
EFOSC2 (NTT)	100-3400	300-1100 nm	4.1'
CRIRES	100,000 (0.2"slit@2um)	1-5 microns	31"
ISAAC	500-3000	1-5 microns	120"
SOFI (NTT)	1000-2200	0.9-2.5 microns	4.8'
VISIR	350-25,000	8-13 (17-24) microns	32" (4.1" for CD)

## 3. Long Slit Spectroscopy - NACO

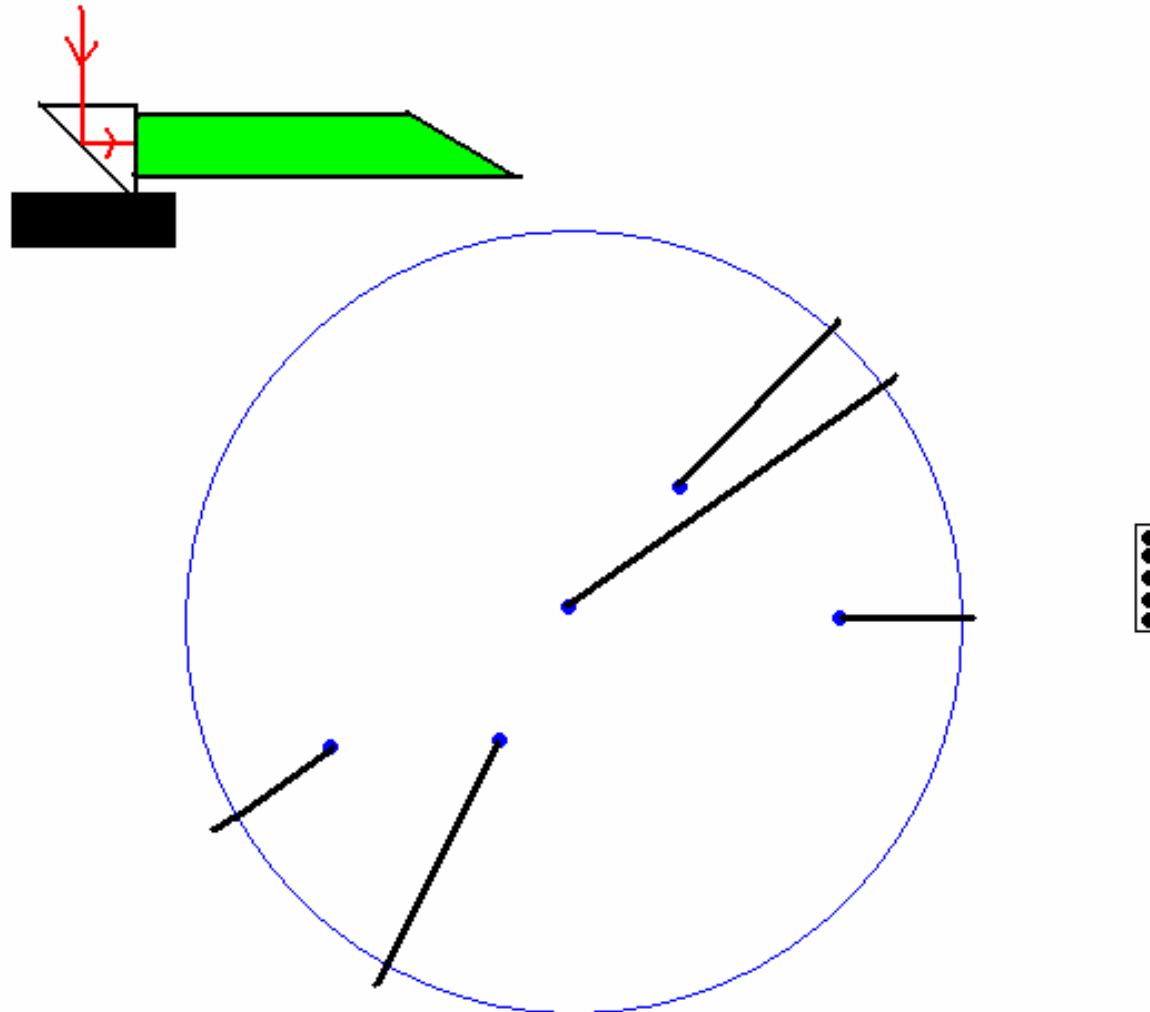
- 0.9 - 4.2 microns
- spectral resolution of 400 -1500 with 86 mas slit and grisms
- spectral resolution of 60-250 with 86 mas slit and prism
- 14, 28, 40" slit lengths depending on grism

# 3. multi-object Spectroscopy - FLAMES

VLT Fibre facility



# 3. multi-object Spectroscopy - FLAMES



# 3. multi-object Spectroscopy - FLAMES

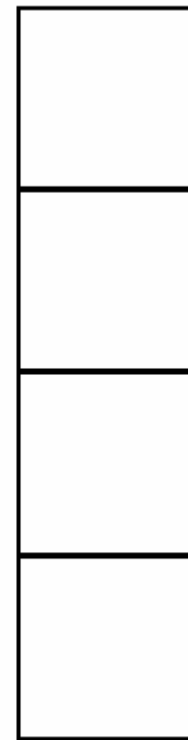
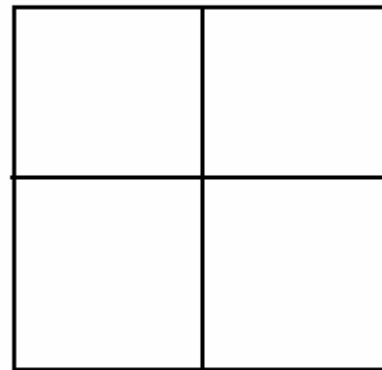
## MEDUSA Mode

1.2" fibres feed the GIRAFFE spectrograph

- 132 fibres over a 25 arcminute field of view
- resolution of 7000 with a coverage of  $\lambda / 7$
- resolution of 20,500 with a coverage of  $\lambda / 22$

# 3. IFU spectroscopy

Integral Field Unit





### 3. IFU spectroscopy

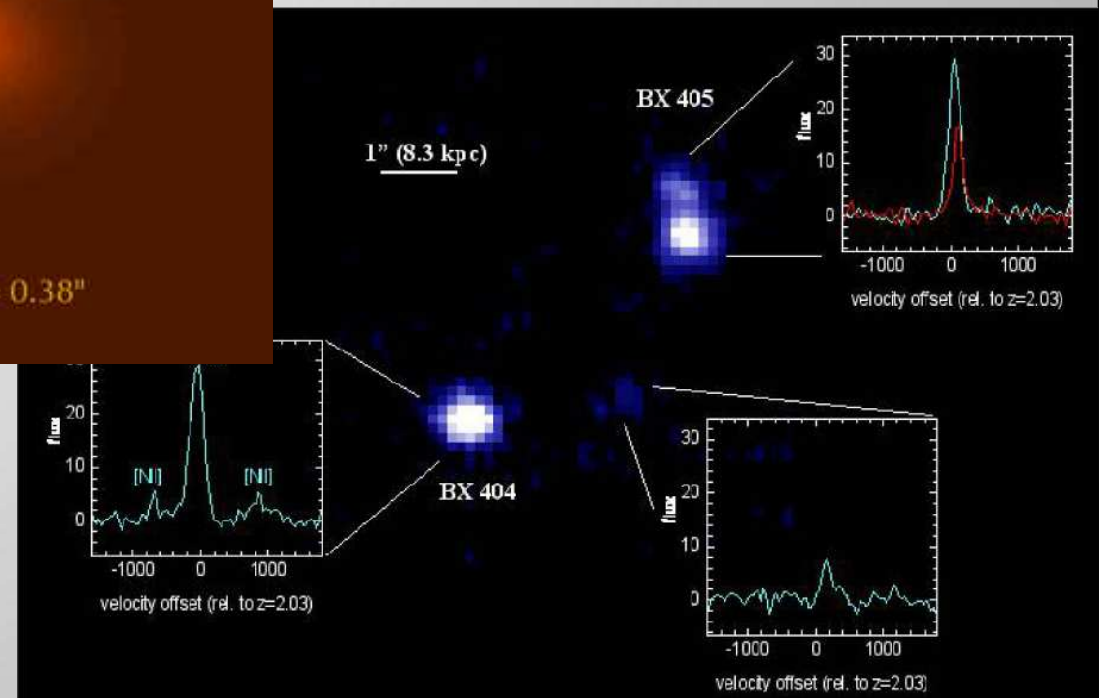
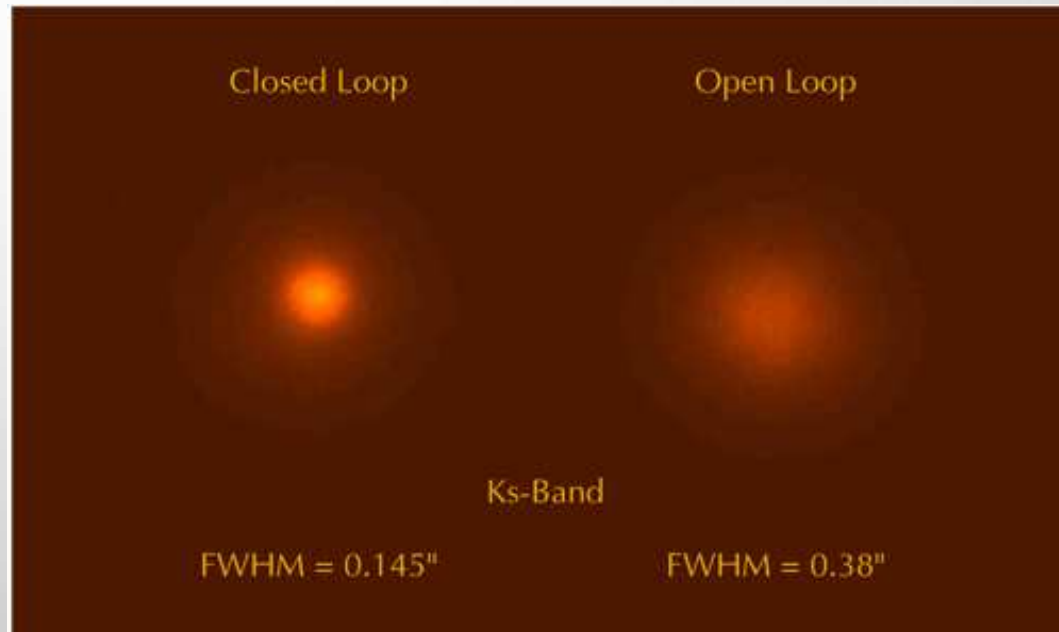
instrument	field of view	pixel size	spectral resolution
VIMOS 6400 fibres visible	54" x 54" 27" x 27"	0.67" 0.33"	220-3,000
FLAMES 15 x 20	15 x 2"x3" deployable	0.52"	11-39,000
308	11.5"x7.3" 6.6"x 4.2"	0.52" 0.30"	11-39,000

## 3. IFU spectroscopy - SINFONI

Two key components

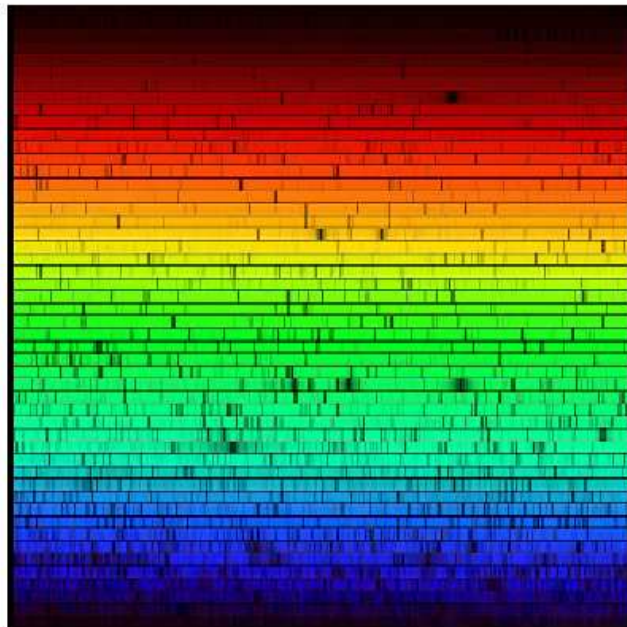
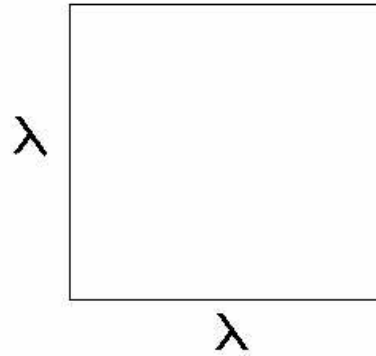
- Adaptive optics module using natural and laser guide stars
- IFU-fed IR spectrograph
  - with 8"x8", 3.2"x3.2", 0.8"x0.8" fields of view
  - 0.25", 0.1" and 0.025" pixels
  - spectral resolution between 1500-4000

# 3. IFU spectroscopy - SINFONI



SINFONI Observations of the Young Starforming Galaxies BX 404/405

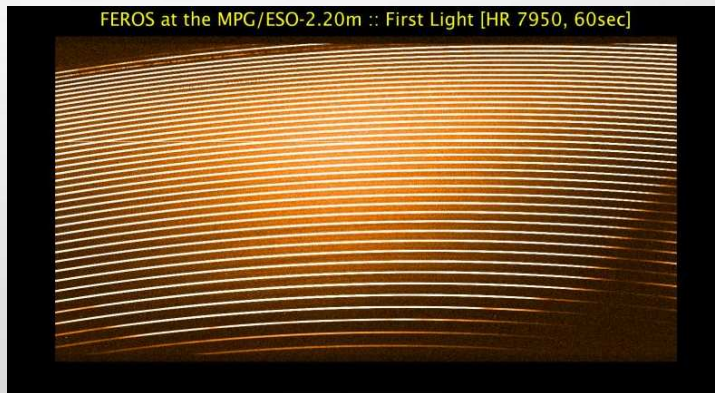
# 4. Cross dispersed spectroscopy



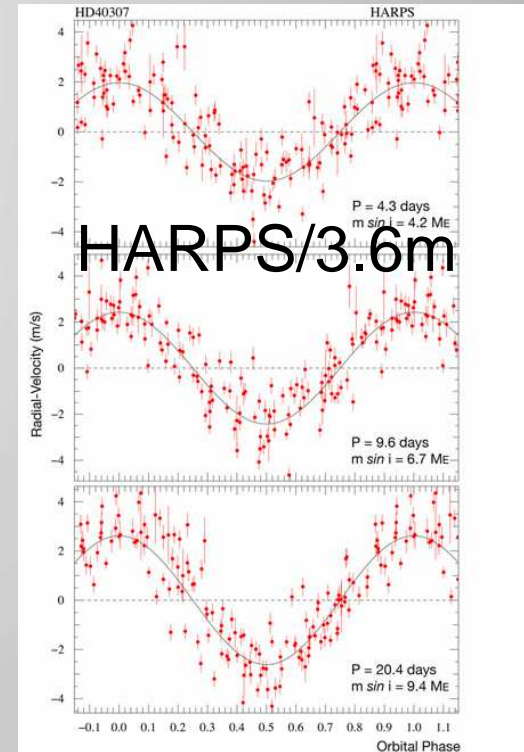
HARPS  
FEROS  
UVES  
X-shooter

# 4. Cross dispersed spectroscopy - FEROS and HARPS

## FEROS/2.2m

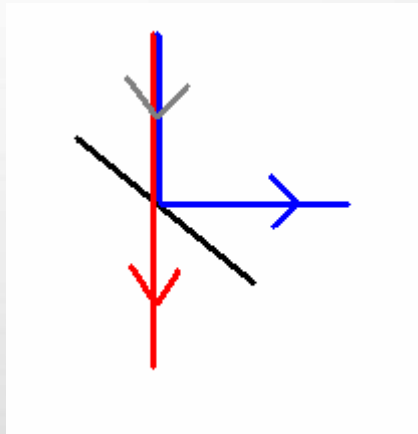


- fibre-fed (obj & sky/cal)
- $R = 48,000$
- 400-900 nm in one exposure
- 20% efficiency
- up to 25 m/s accuracy

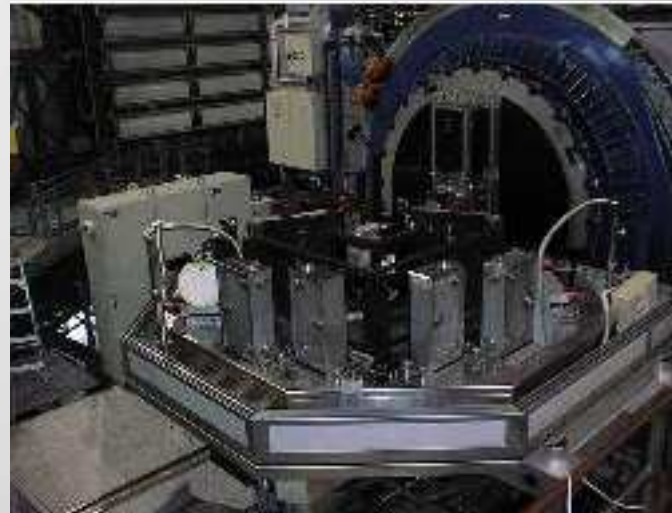


- $R = 115,000$
- 380-691 nm in one exposure
- up to 1 m/s accuracy

## 4. Cross dispersed spectroscopy - UVES



separate red  
and blue arms



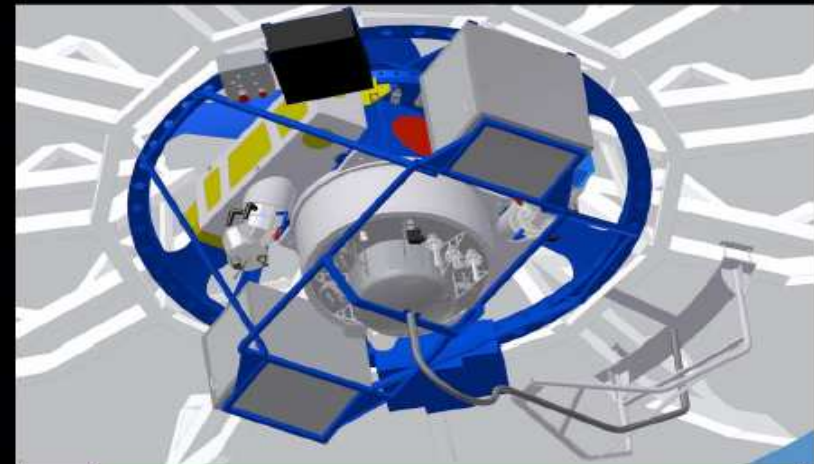
- Resolution of 80,000 and 110,000
- 12-14% total throughput
- image slicers, iodine absorption cell, fibre input (6 obj & 2 sky), long-slit mode

# 4. Cross dispersed spectroscopy - X-shooter

**Goal is 1st light on Melipal Sept 2008**



- Gamma ray bursts
- High z supernovae
- Emission line galaxies
- Metal enrichment of early universe
- Tomography of intergalactic medium



'Point and shoot'  
Spectrograph  
Wideband 300-2500nm  
R ~ 4000-7000  
Slits + small IFU

Few modes  
Large external financial cont.  
System integration at ESO

European Southern  
Observatory

# Conclusion

- large array of instruments and instrument modes available for ESO telescopes
- cover virtually every existing observing mode and associated technology
- new instruments under construction
  - MUSE giant optical IFU for the VLT
  - KMOS 24 deployable IR IFUs for the VLT
  - SPHERE extreme AO imager for the VLT
- see web pages for more information