

A night sky filled with stars, framed by the dark silhouette of a building on the left and right. The sky transitions from a deep blue at the top to a warm orange glow near the horizon, where a bright light source is visible. The text is centered in the upper half of the image.

MUSE lève le voile sur l'Univers distant

Johan Richard

Centre de Recherche Astrophysique de Lyon

AG du CLEA

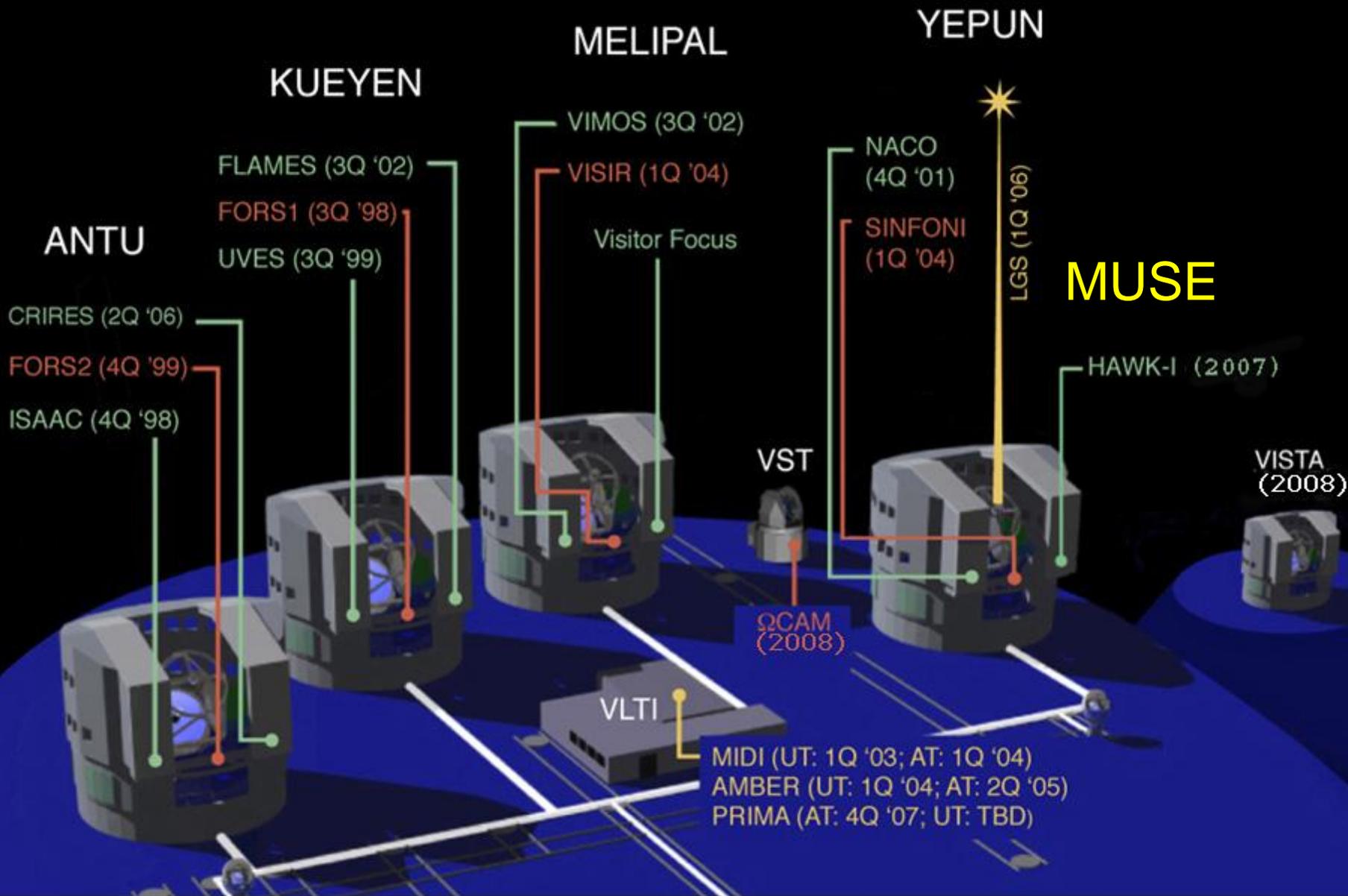
15 mars 2015

Le VLT (Very Large Telescope)



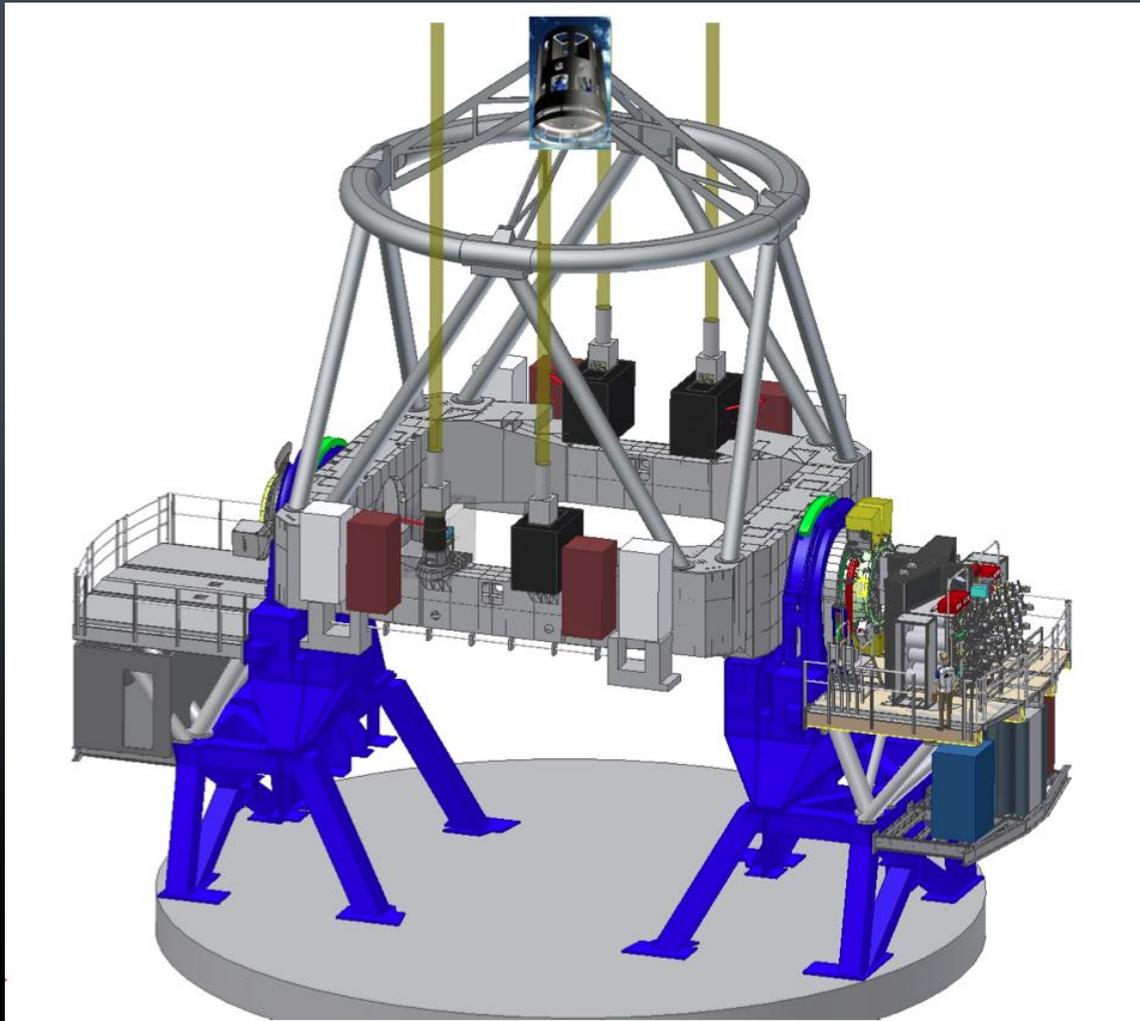
Le VLT (Very Large Telescope)







Le VLT (Very Large Telescope)



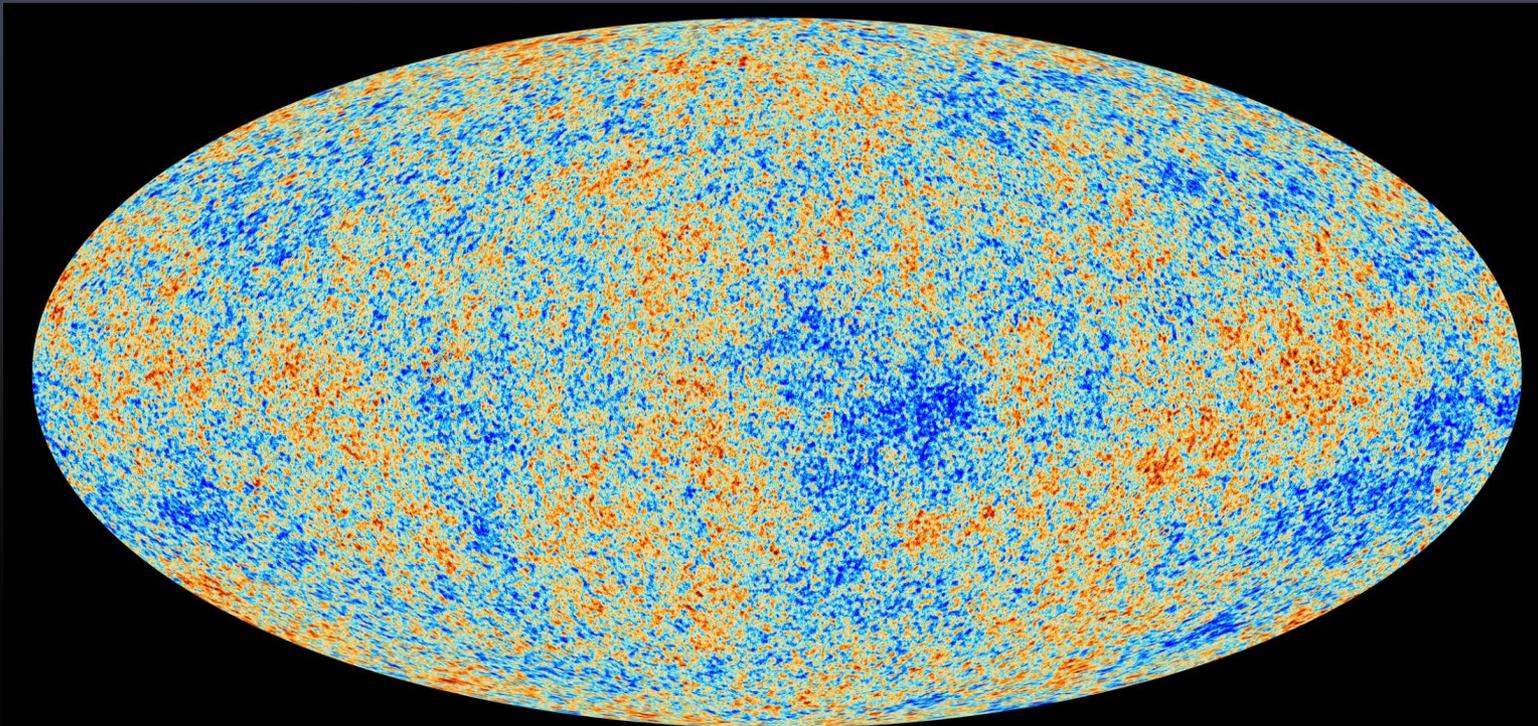
ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich

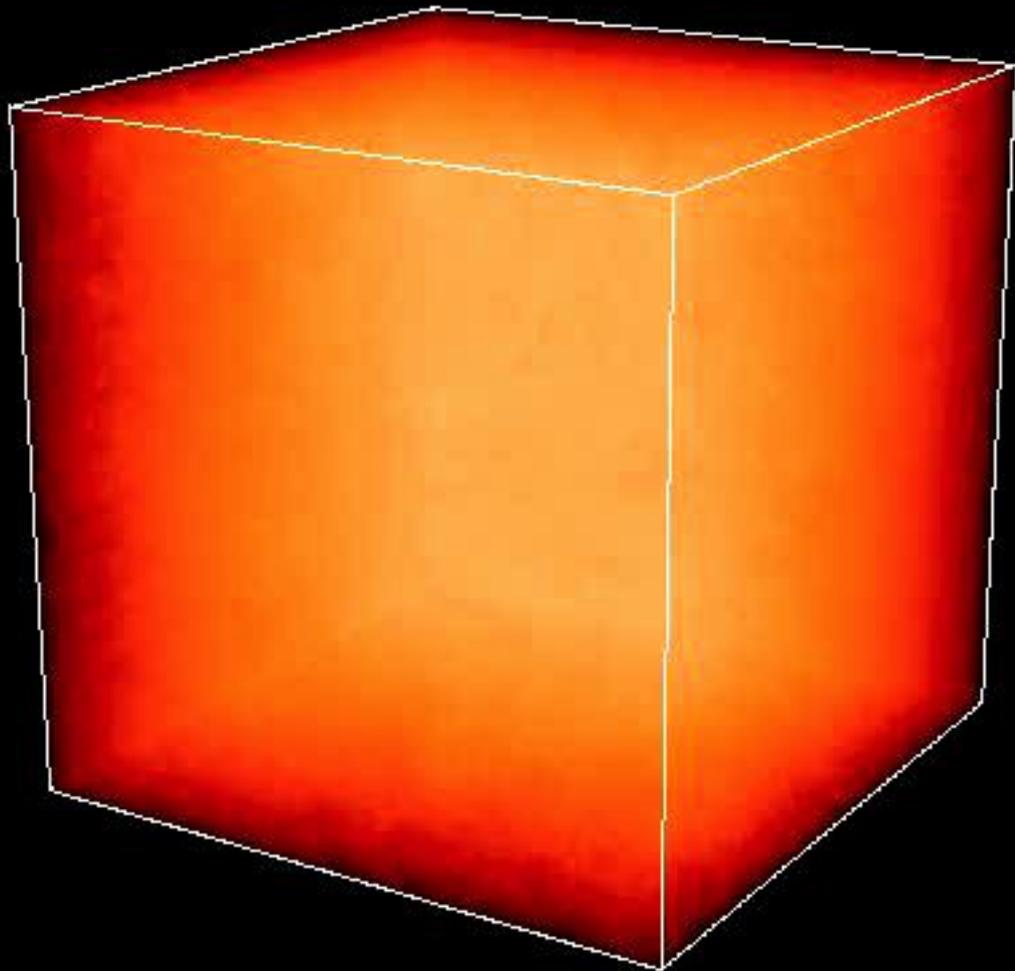
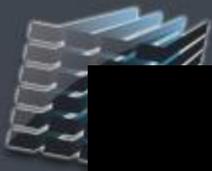


Quelle Science ?

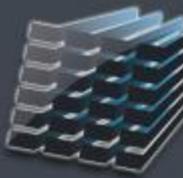
- **Le modèle du Big Bang et les grandes questions de l'astrophysique contemporaine**
- **MUSE, une machine à remonter le temps**

- L'Univers a été très dense et très chaud
- L'univers avait des structures

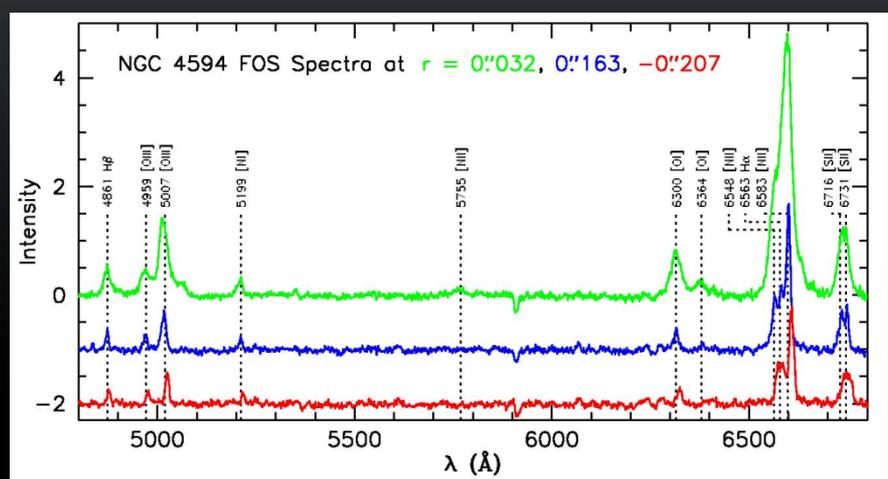
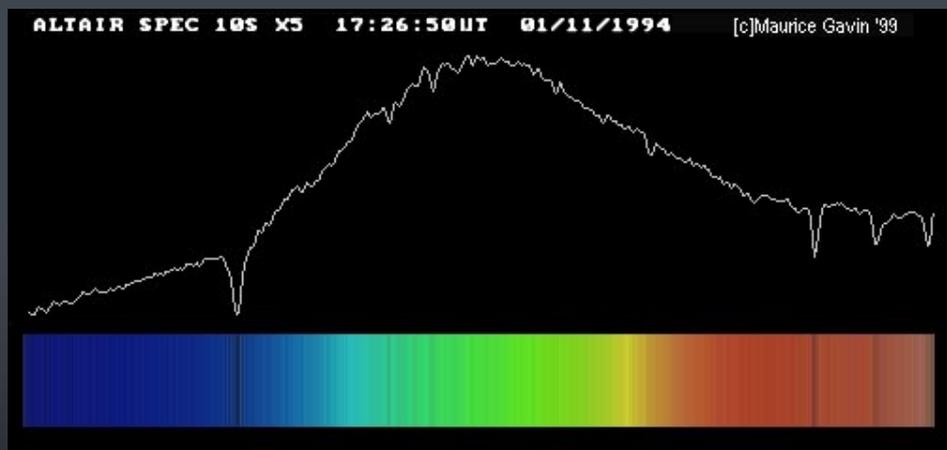
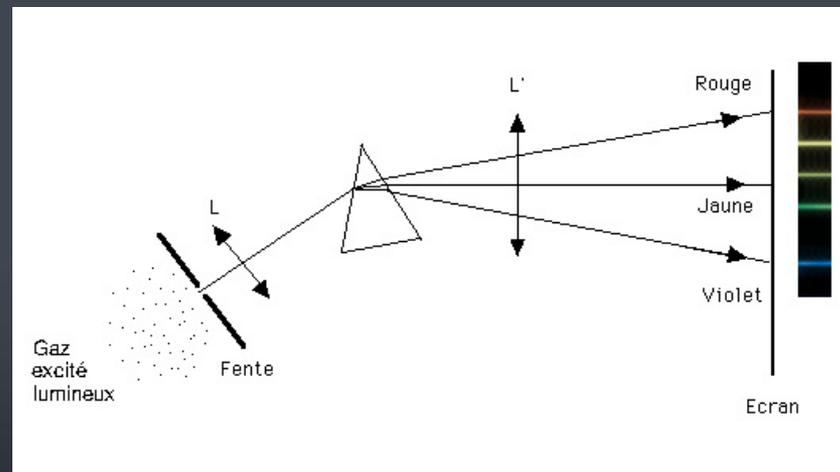




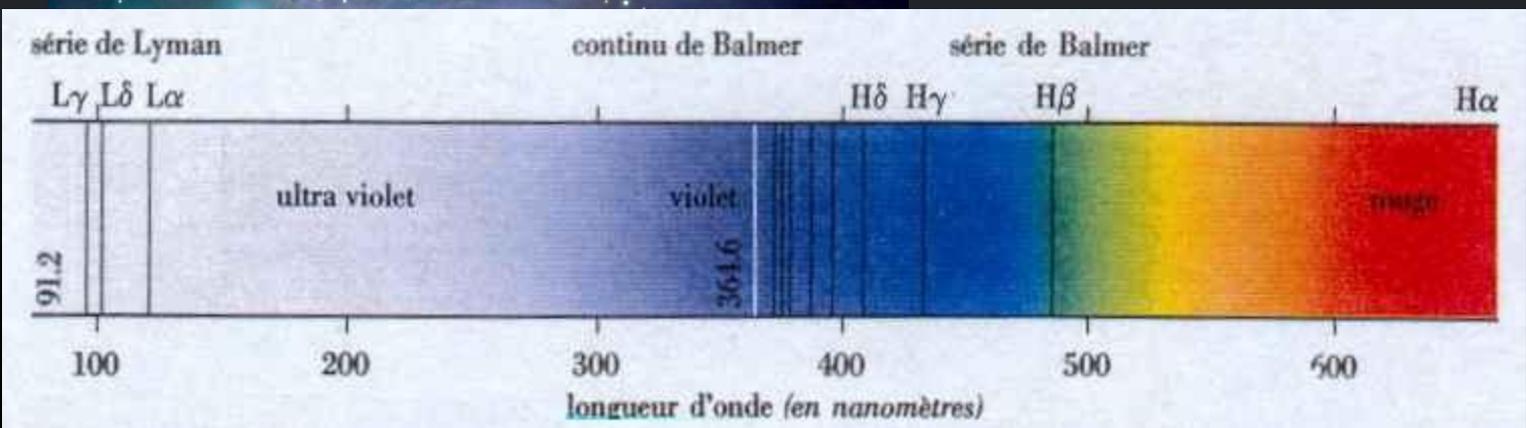
ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich



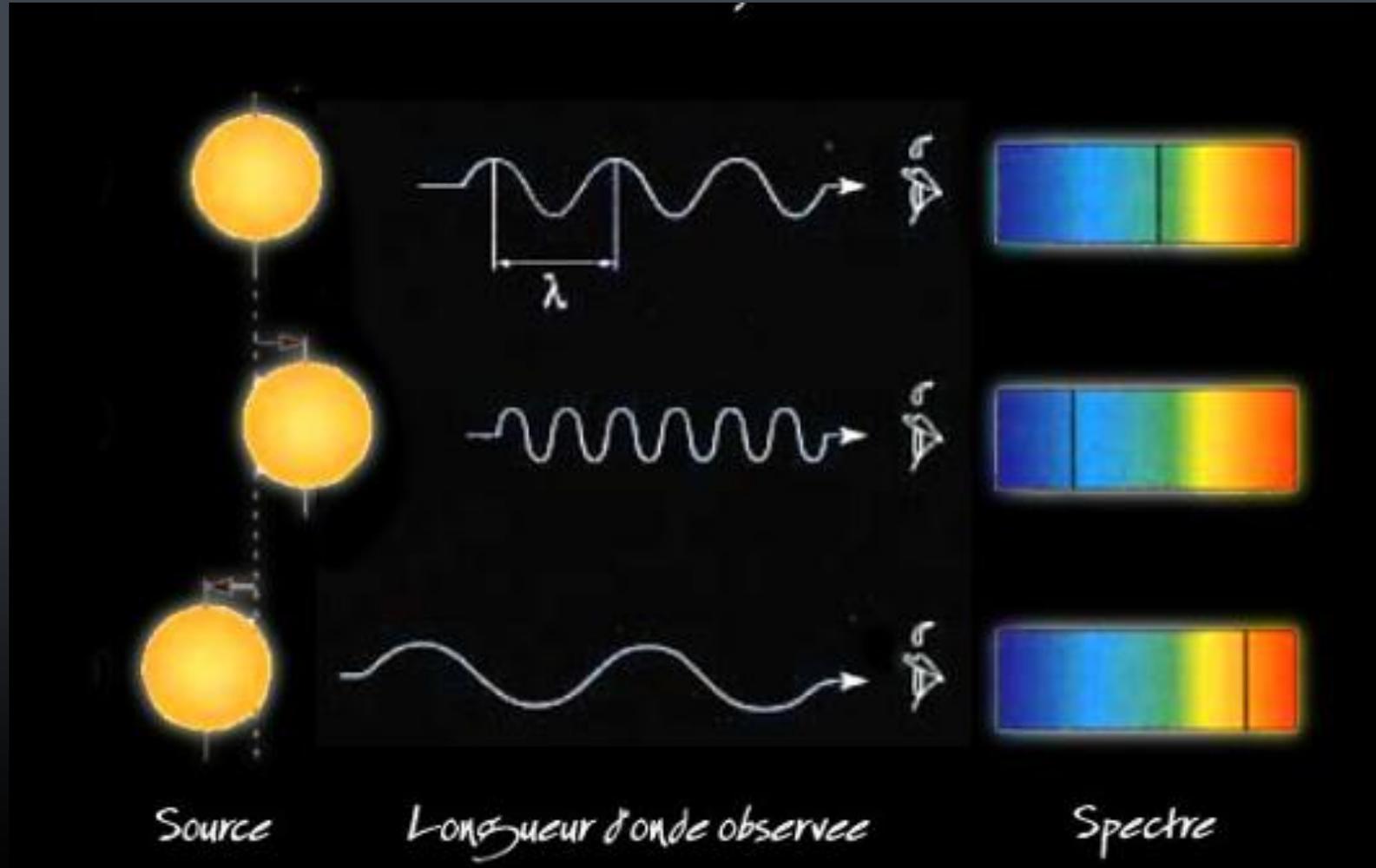
Spectroscopie



La formation des étoiles



Effet Doppler et vitesse radiale des galaxies



1929, Edwin Hubble



ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich

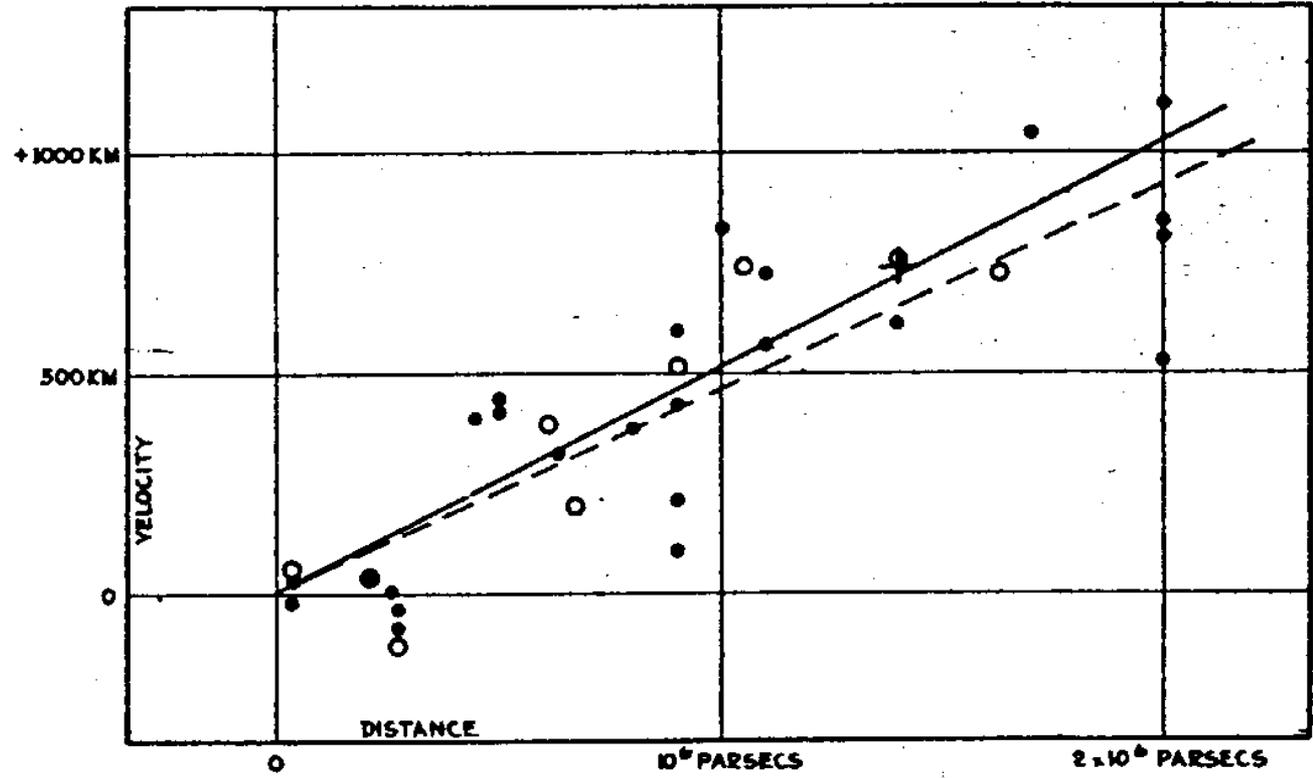
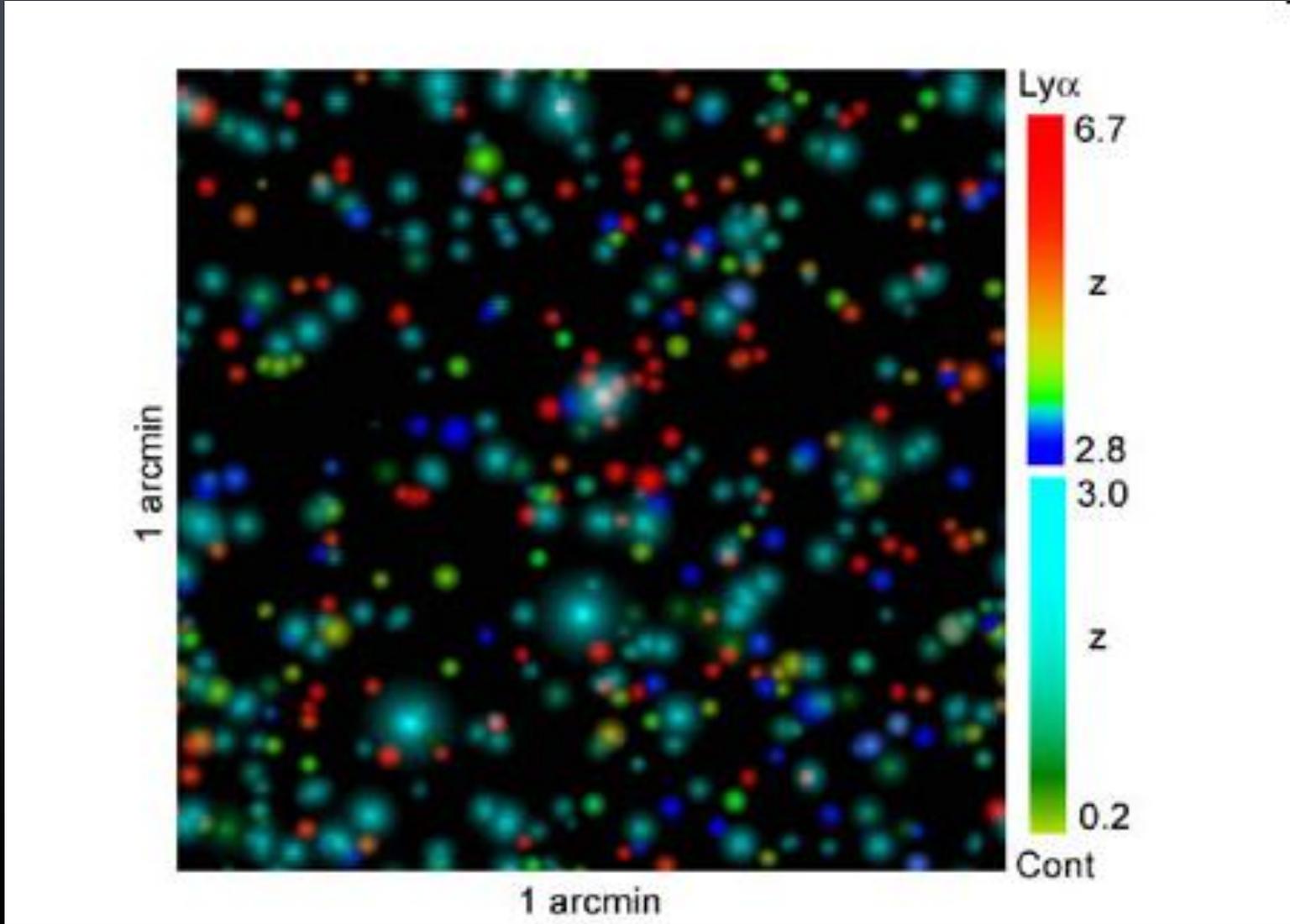
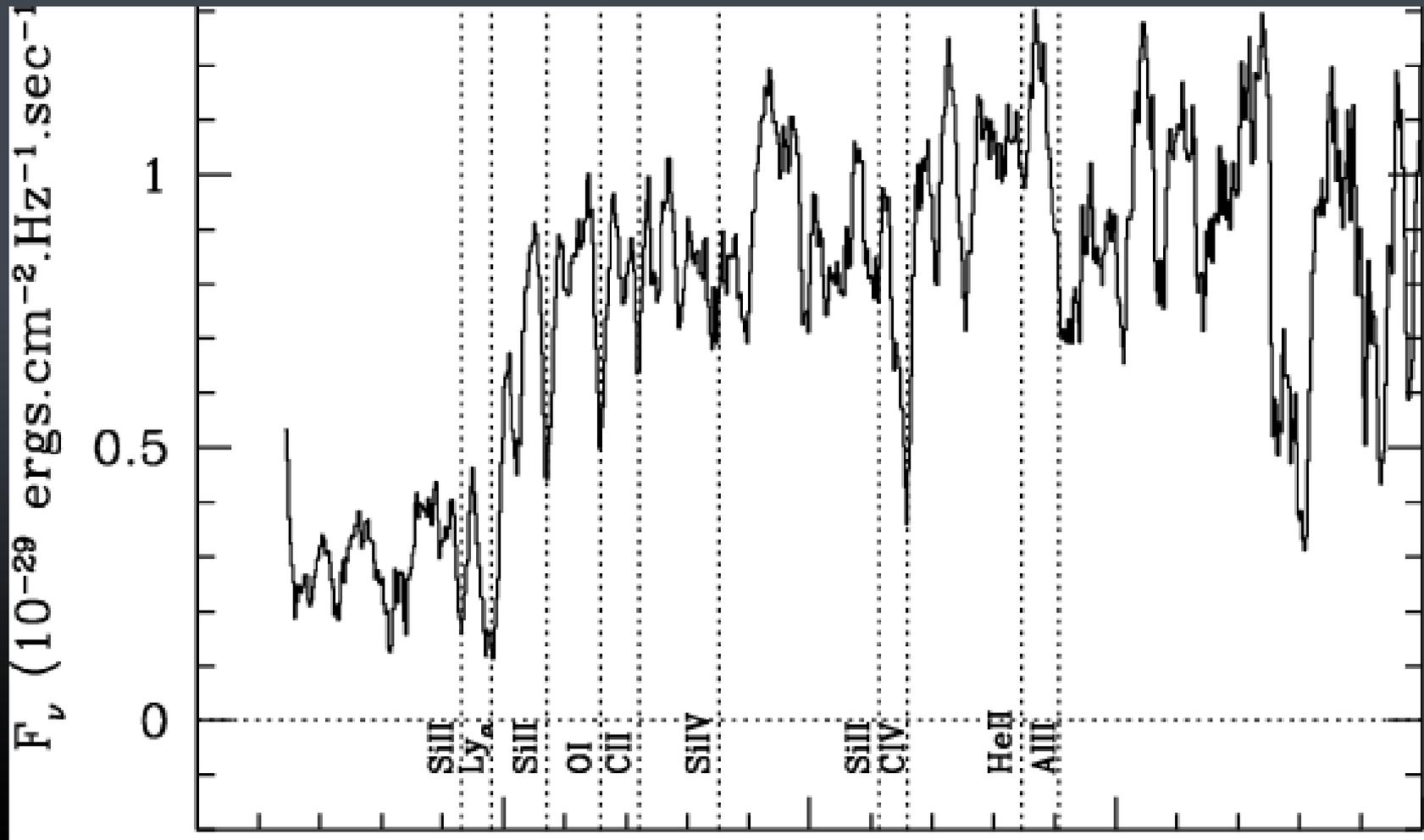


FIGURE 1

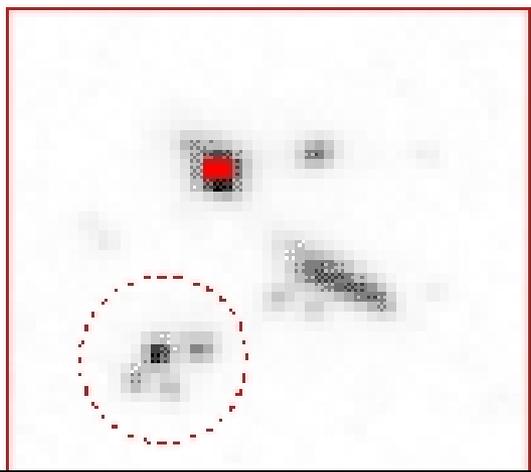
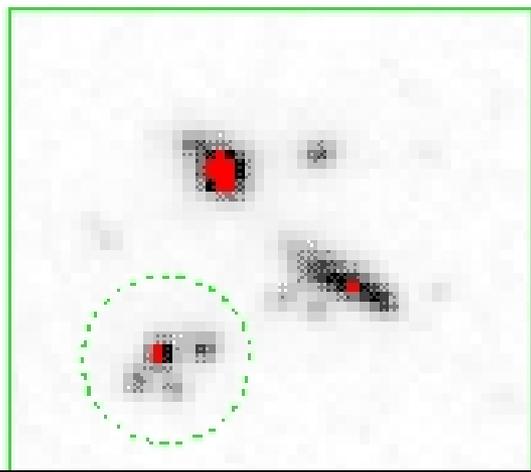
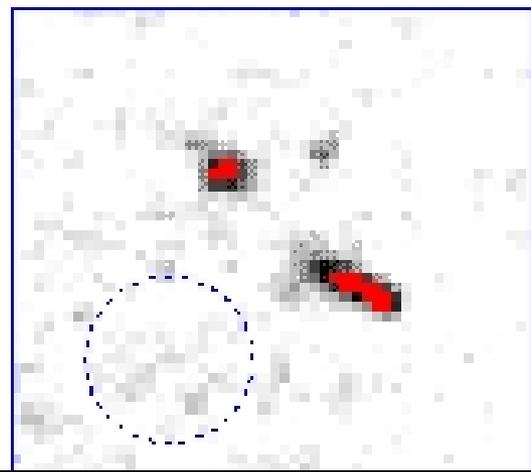
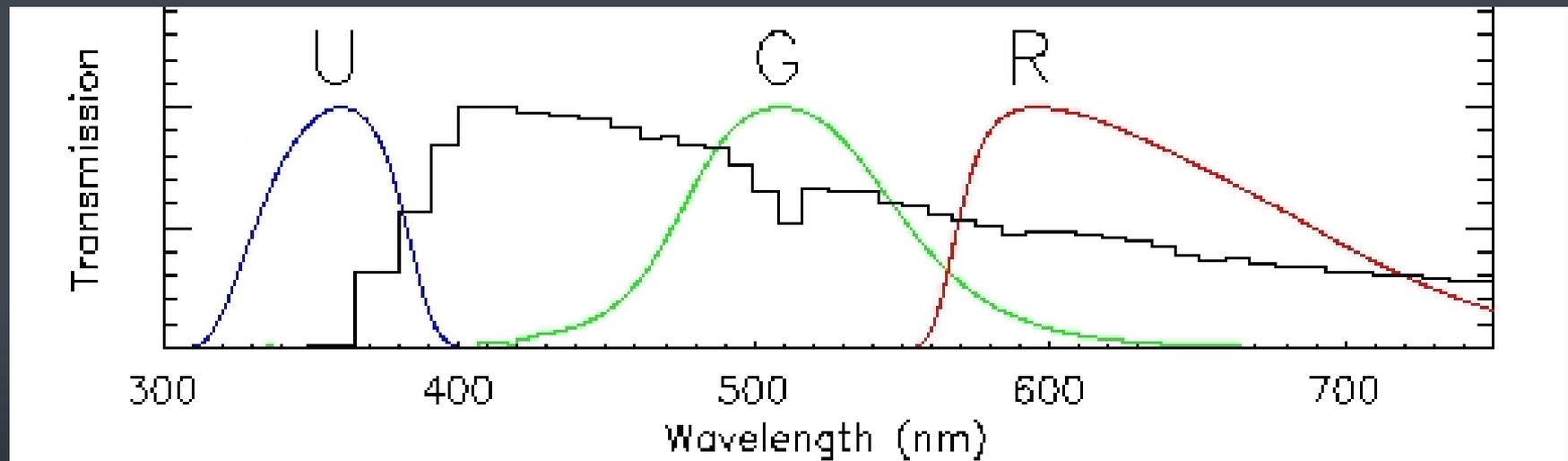
Décalage vers le Rouge (*redshift*)



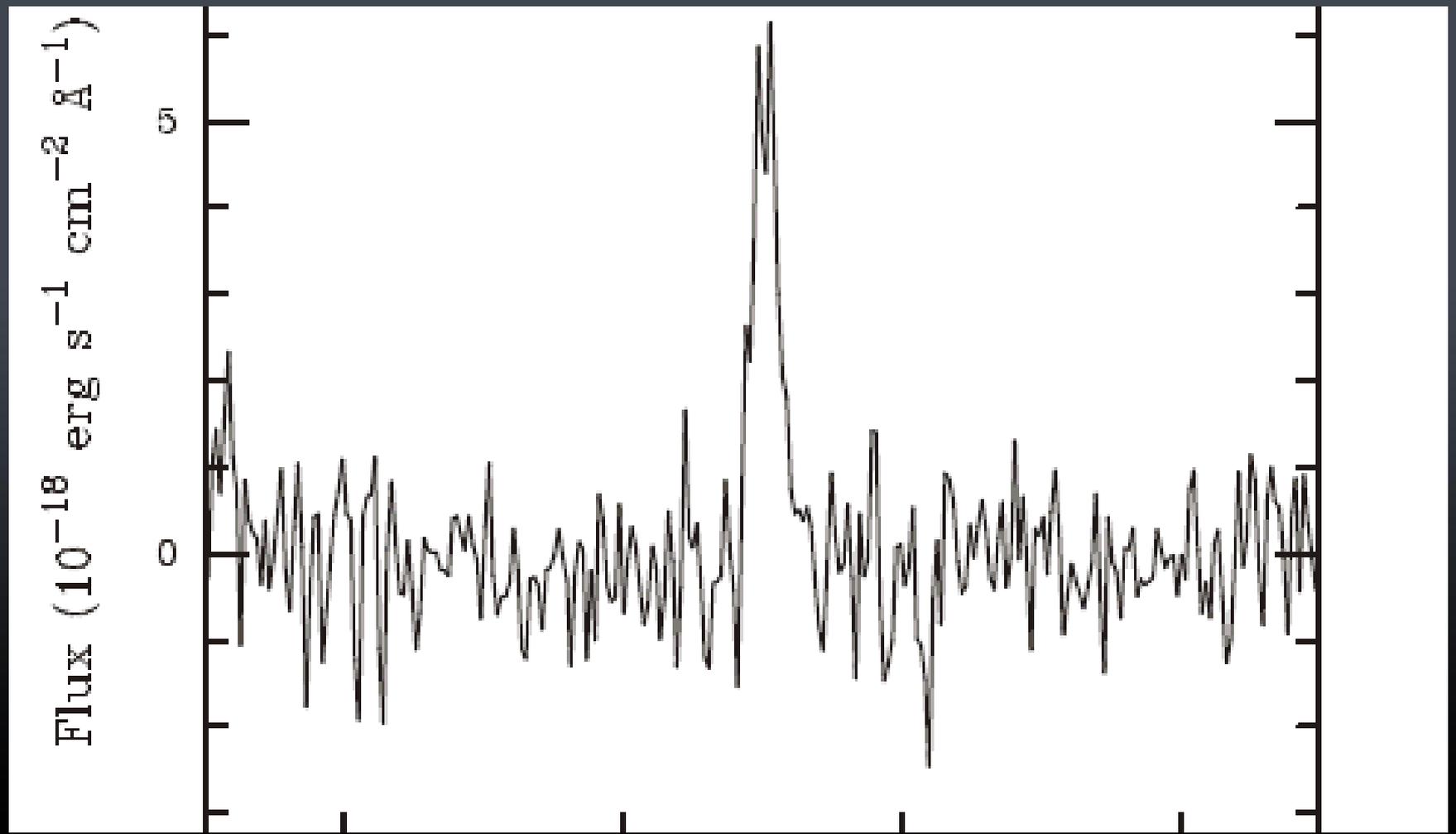
Les galaxies à cassure de Lyman (Lyman-break)



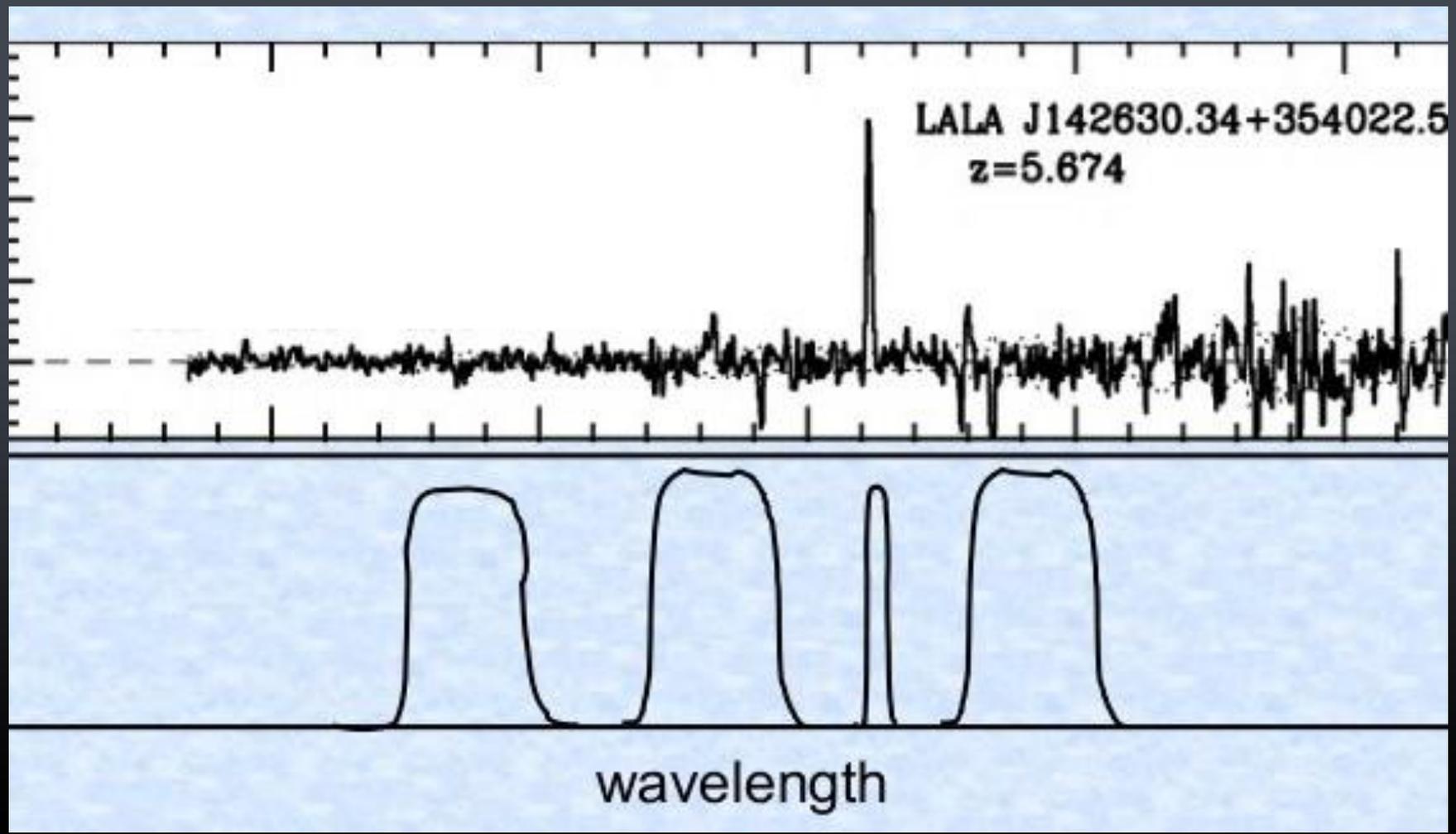
Les galaxies à cassure de Lyman (Lyman-break)



Les galaxies de type émetteurs Lyman-alpha



Les galaxies de type émetteurs Lyman-alpha

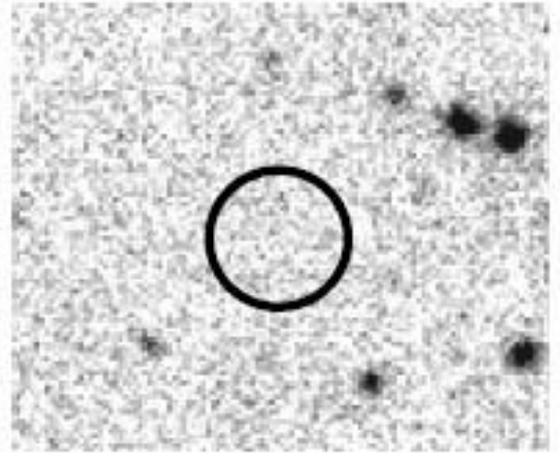
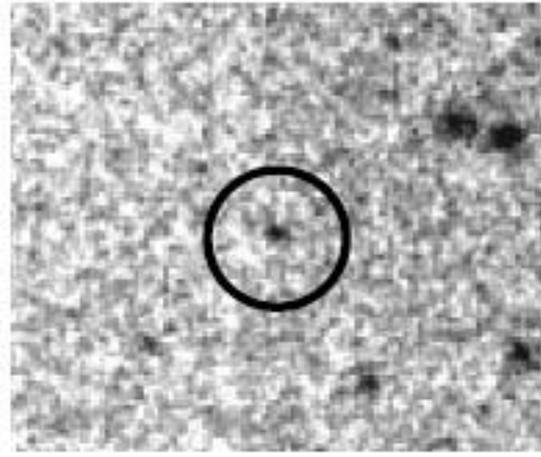
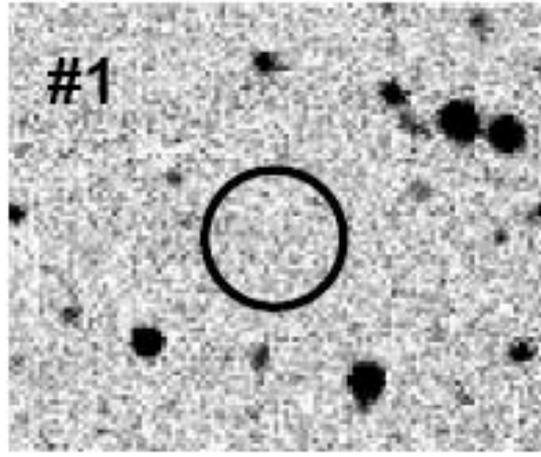


Les galaxies de type émetteurs Lyman-alpha

combined optical

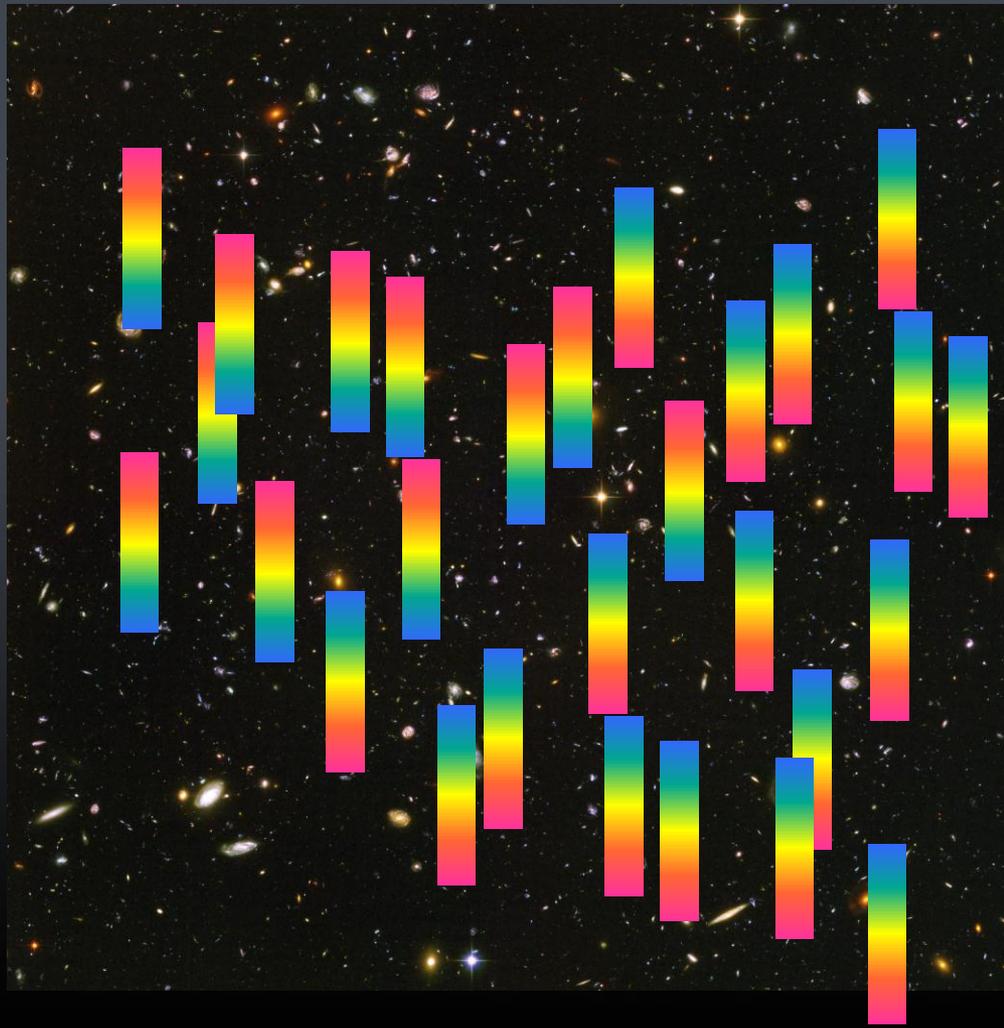
UNB

J



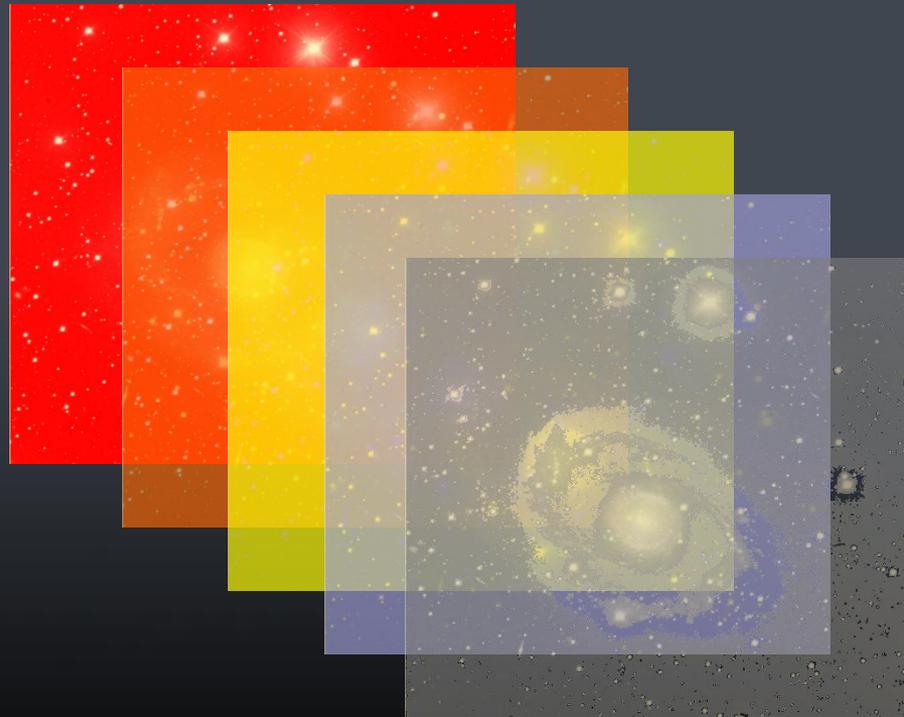


Spectroscopie Multi-Object

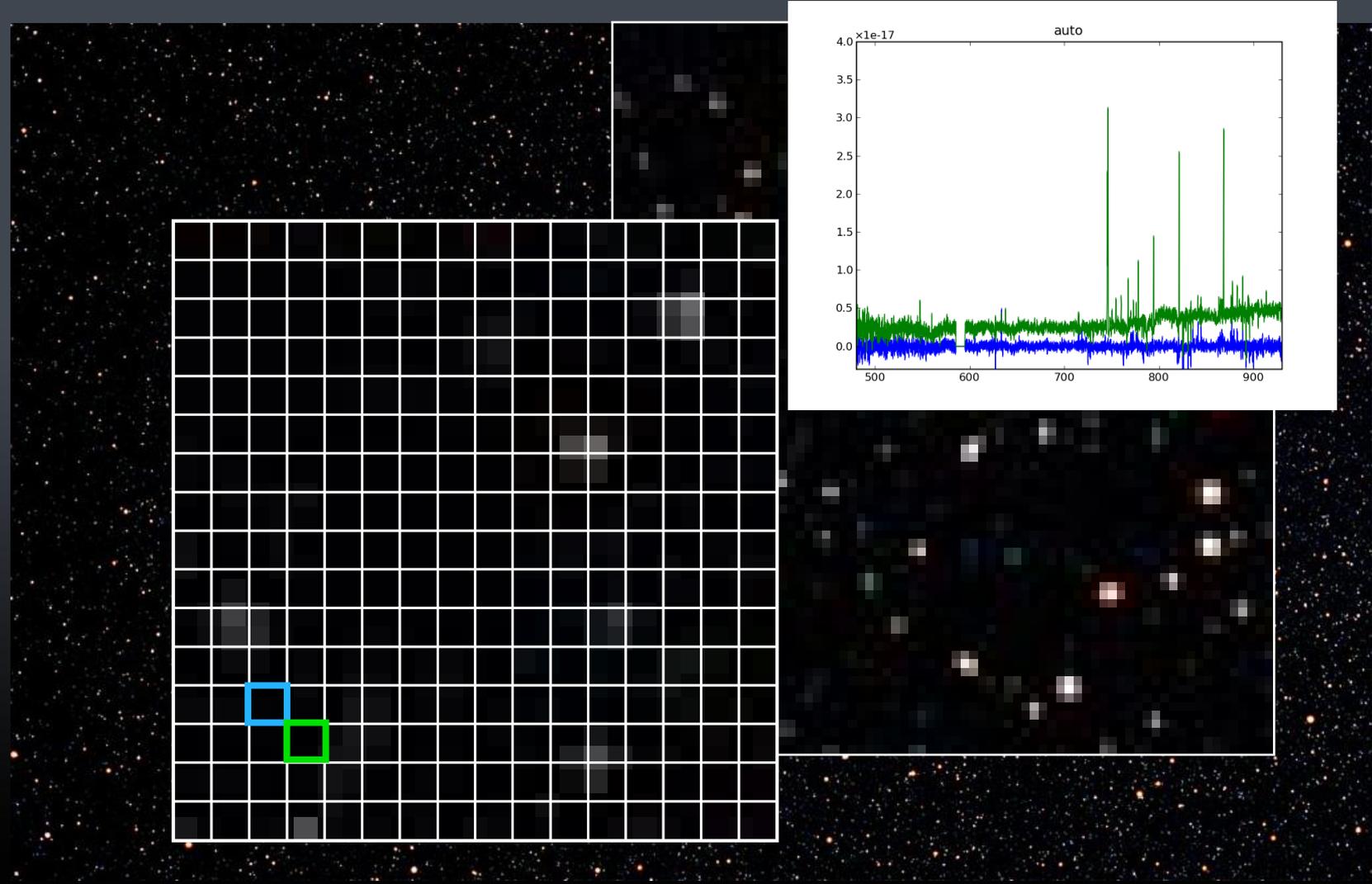


- Les galaxies de type Lyman-break tracent les galaxies les plus massives
- Les galaxies de type Lyman-alpha tracent les galaxies jeunes qui forment beaucoup d'étoiles
- Les deux techniques ne fournissent que des candidats
- Le suivi spectroscopique est difficile à réaliser et reste très coûteux en temps de télescope

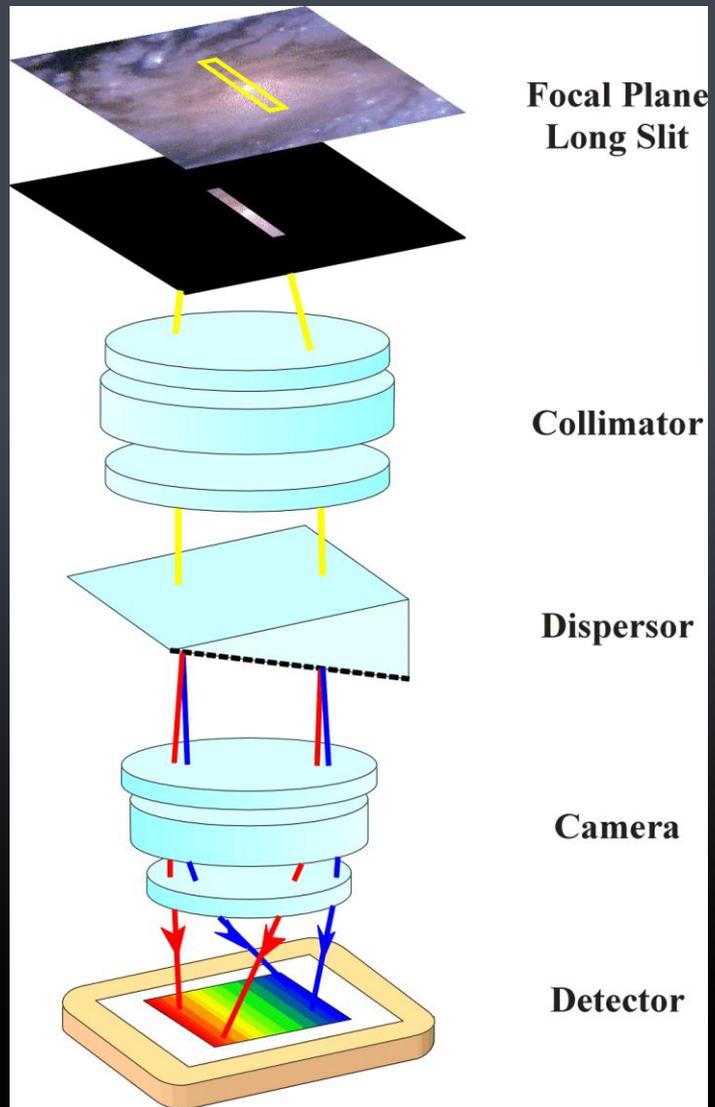
Image / Spectrographe 3D



Chercher l'aiguille ...



Spectroscopie



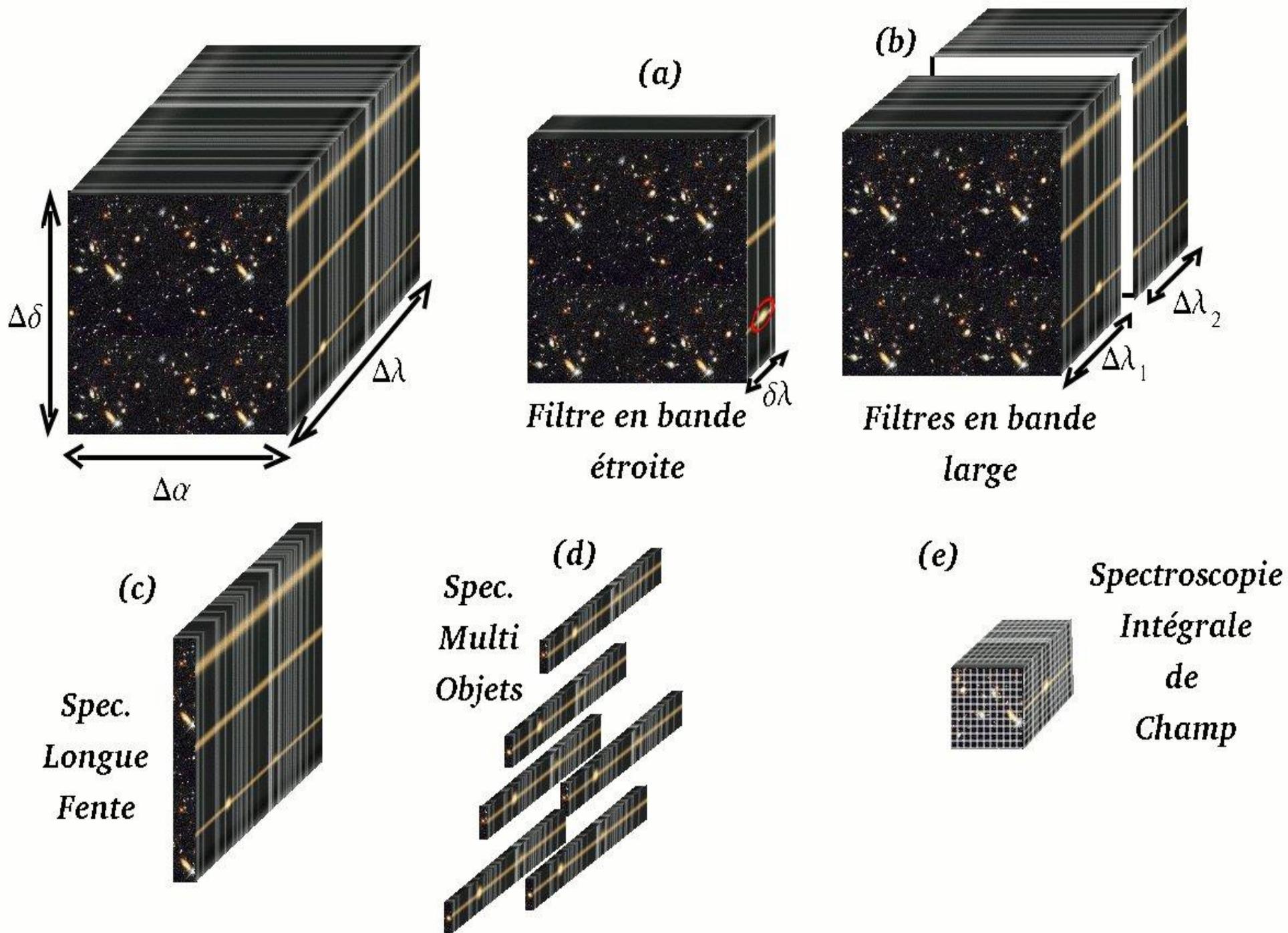
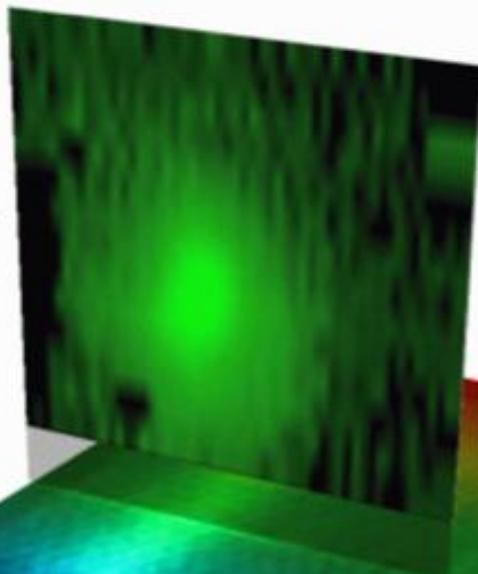
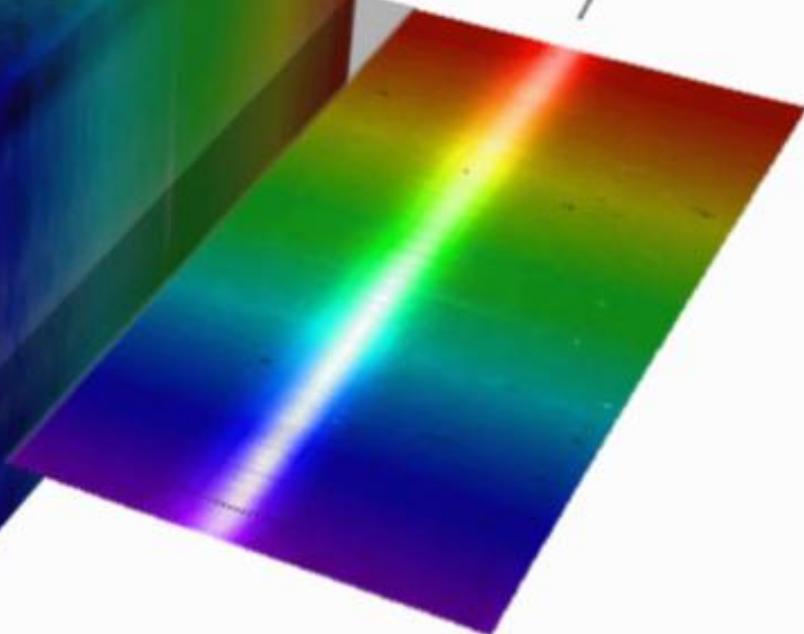


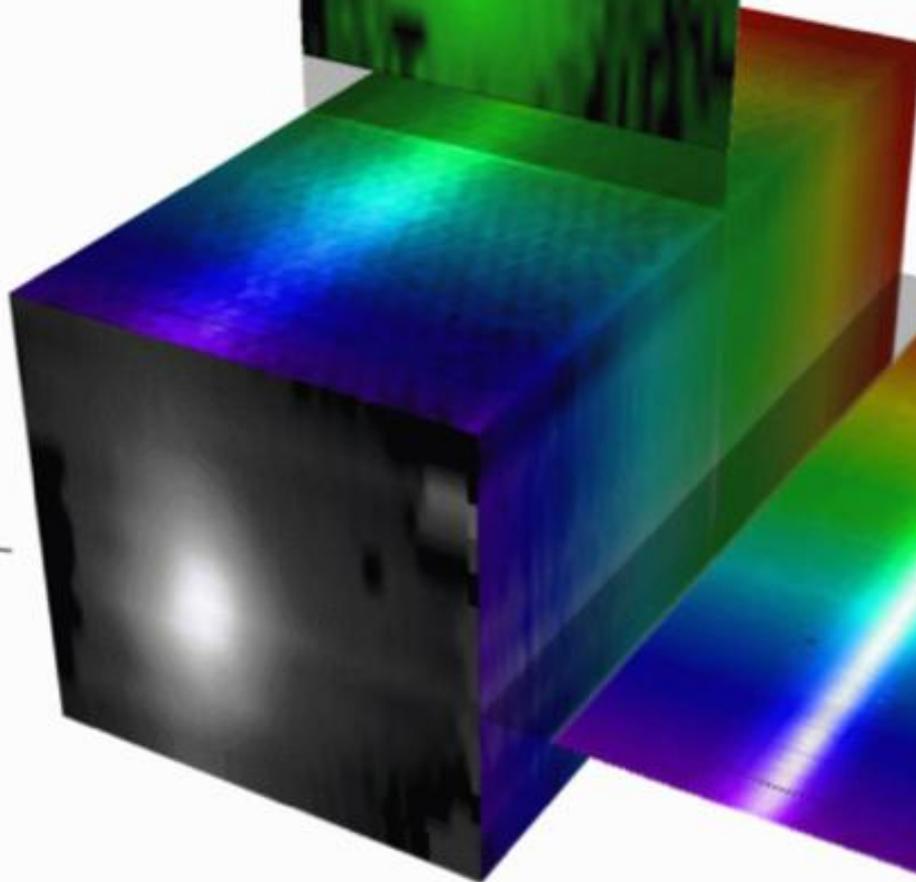
Image slice at a single infrared wavelength



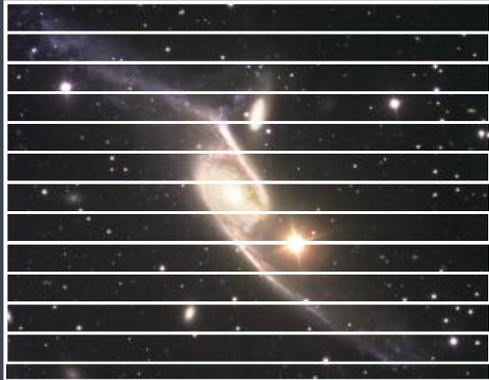
Spectral slice showing the spectra across the entire galactic nucleus



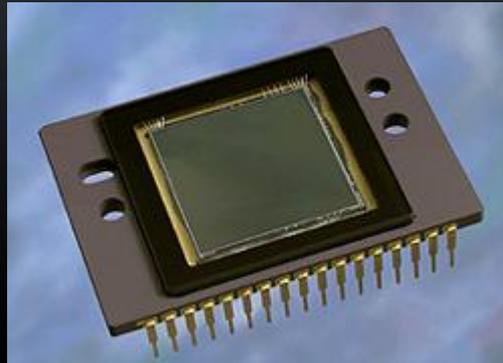
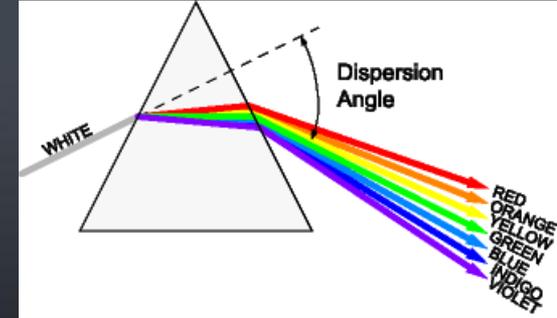
Galactic nucleus seen in combined infrared light

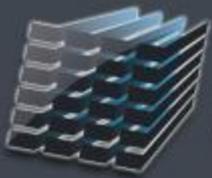


Le principe



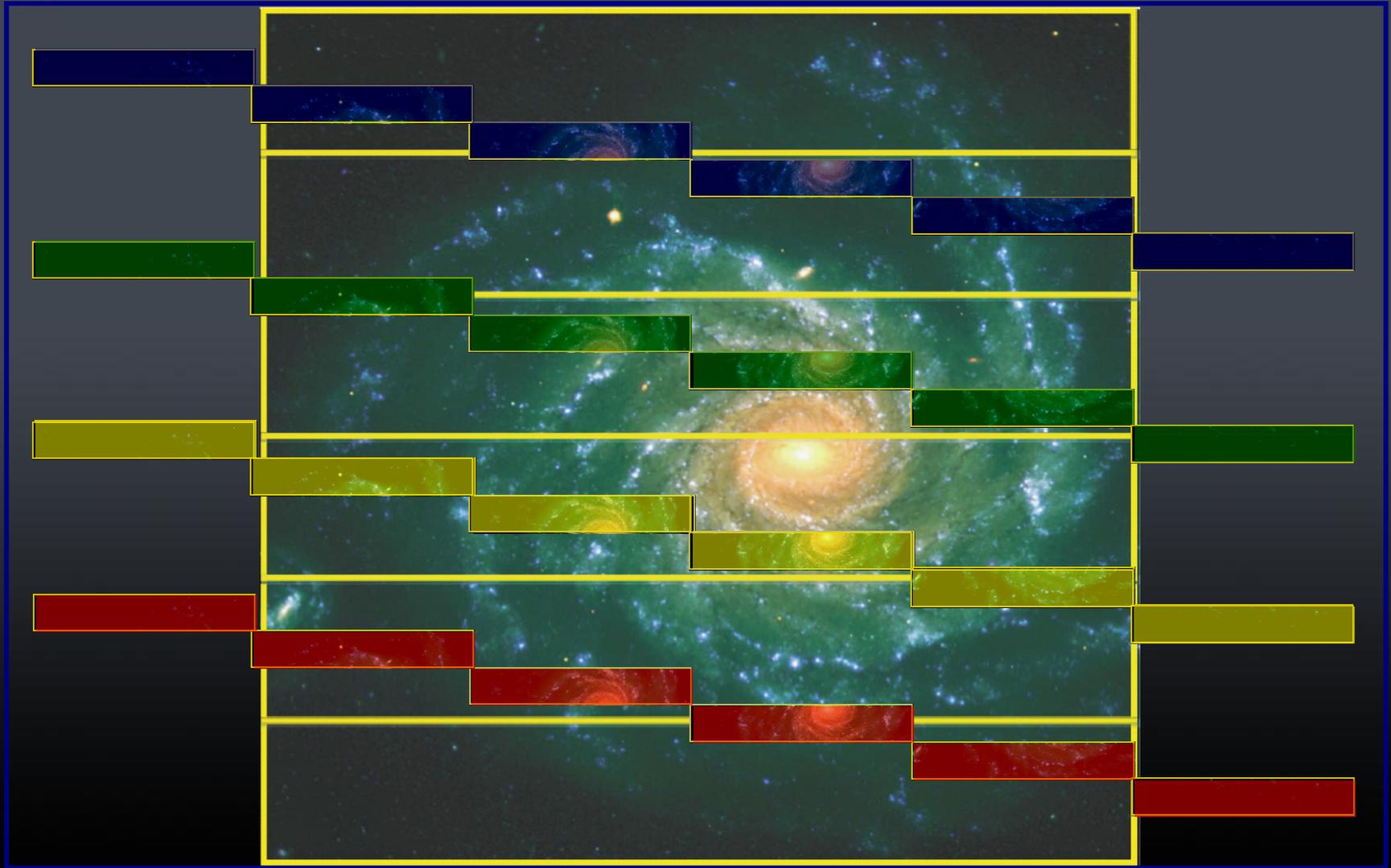
- Découper le champ de vue en « tranches »
- Chaque tranche est comme une fente
- Disperser la lumière avec un disperser
- Capter la lumière avec un détecteur





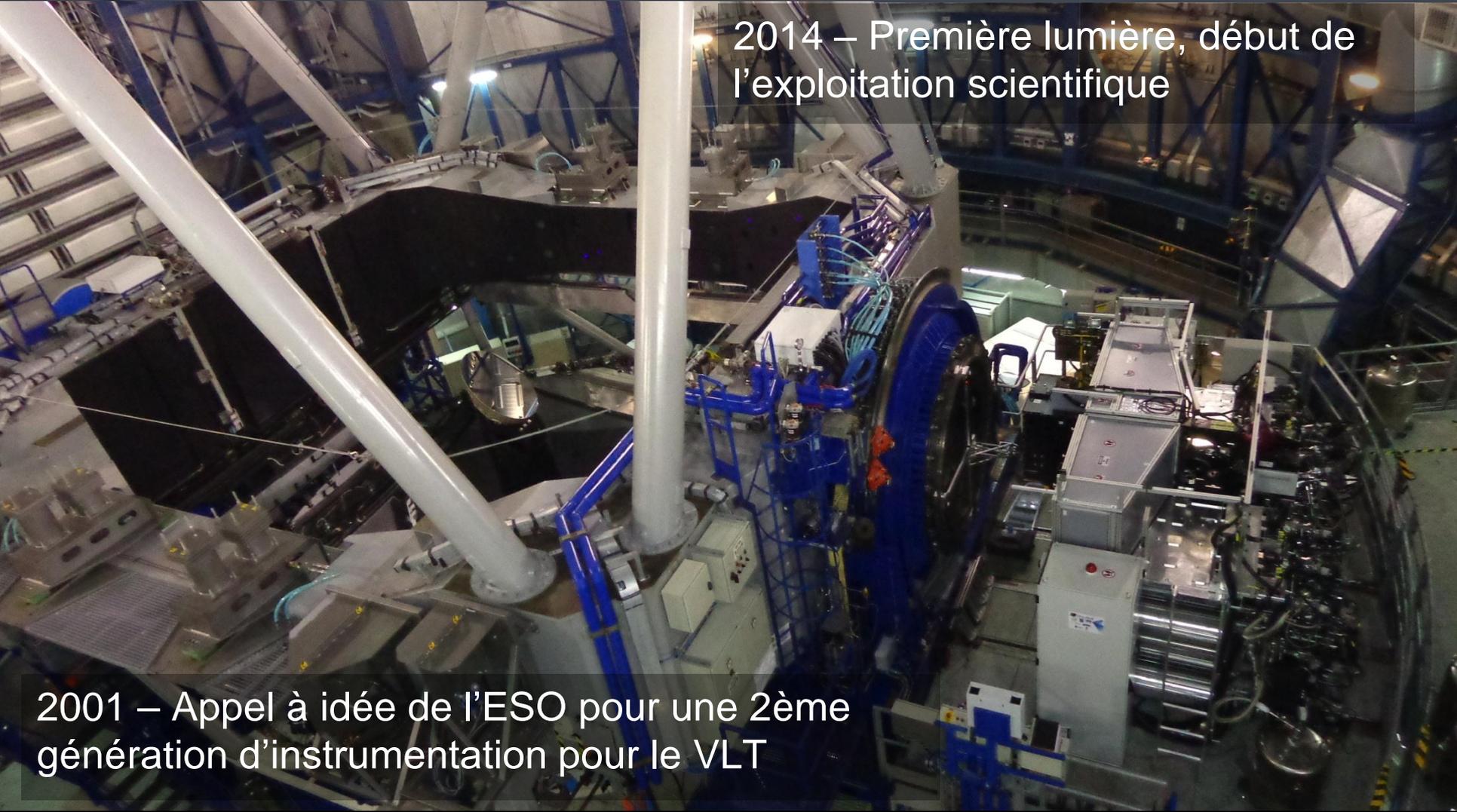
MUSE

Spectroscopy 3D



ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich





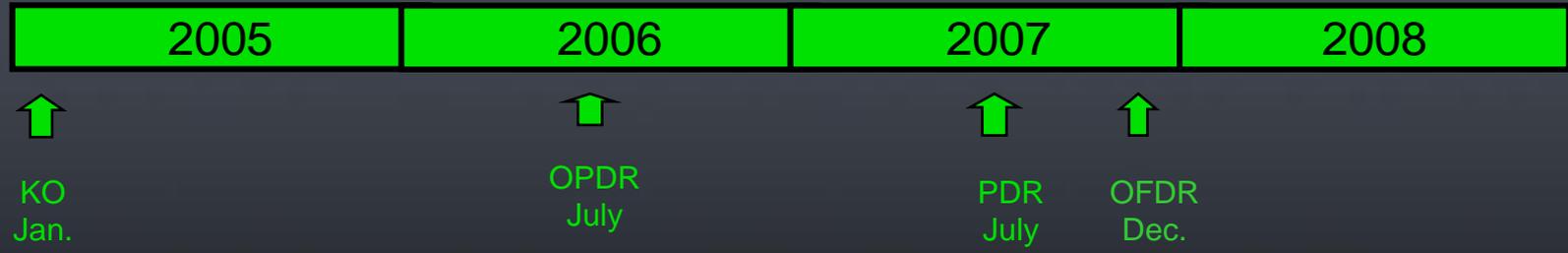
2014 – Première lumière, début de l'exploitation scientifique

2001 – Appel à idée de l'ESO pour une 2ème génération d'instrumentation pour le VLT

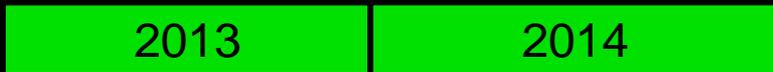
Pre-Phase A & Phase A

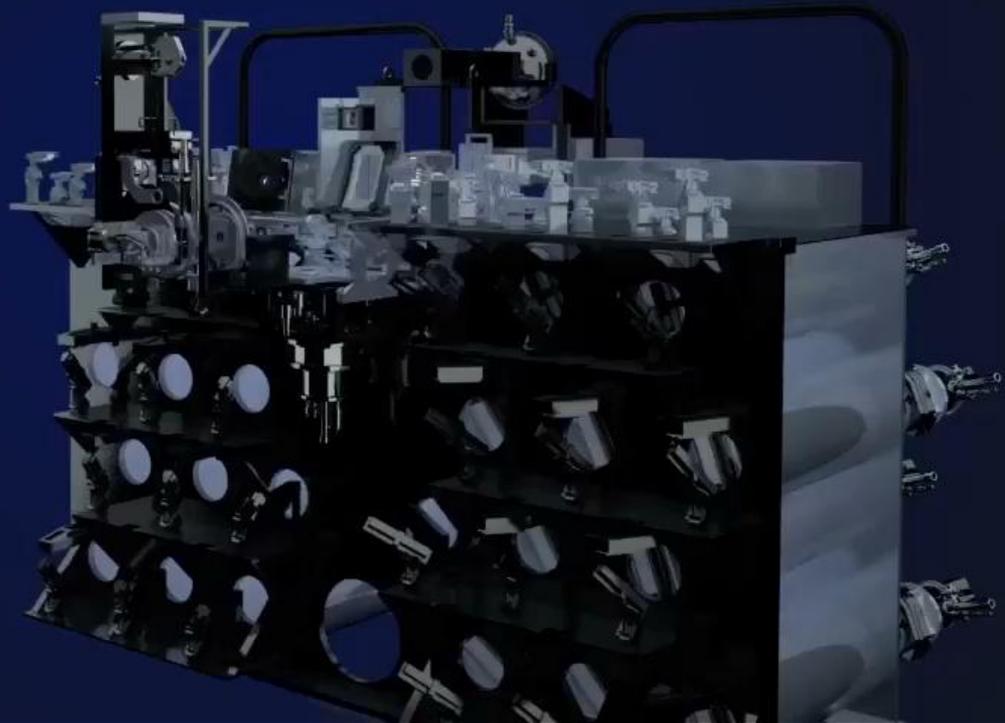


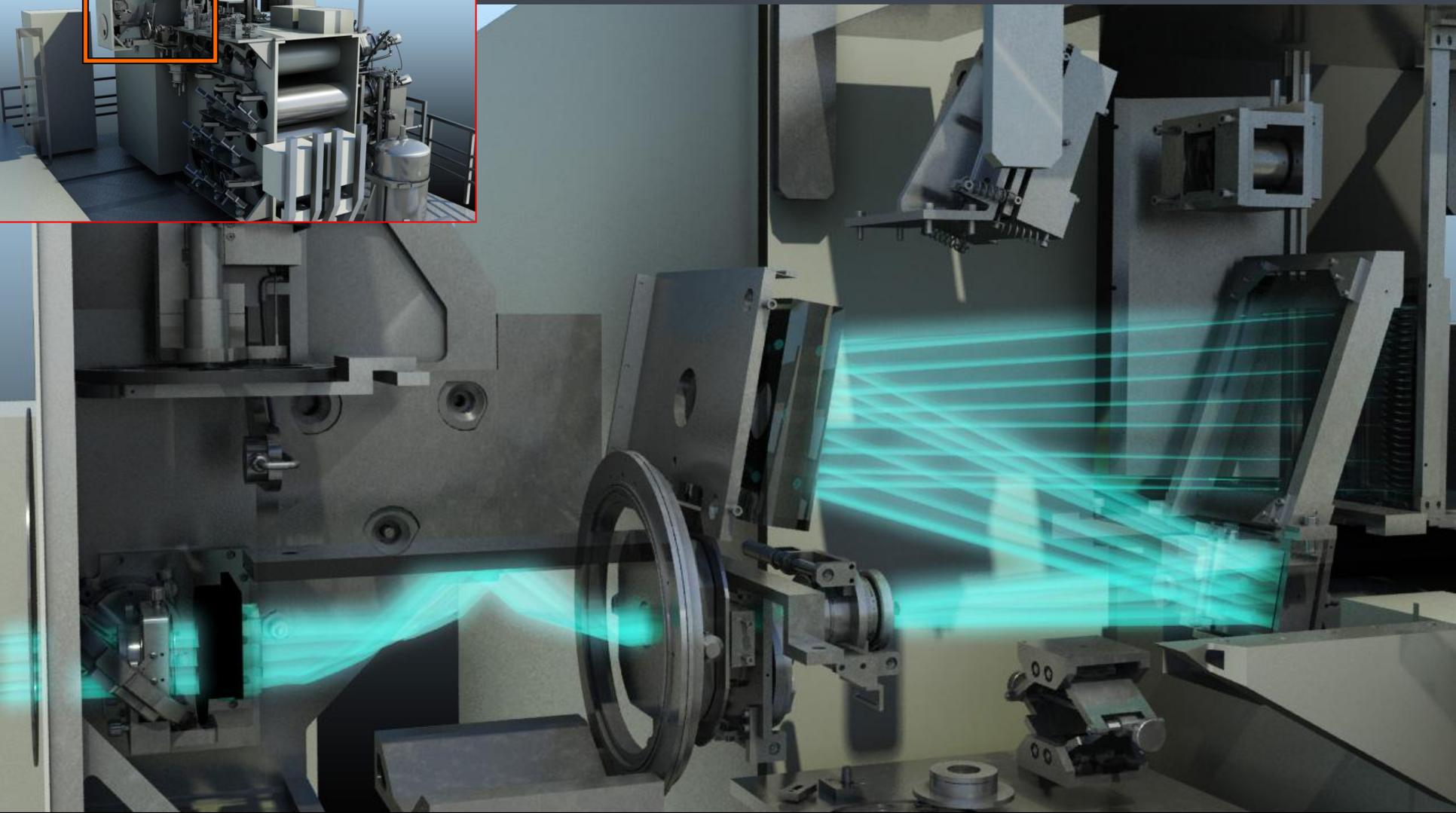
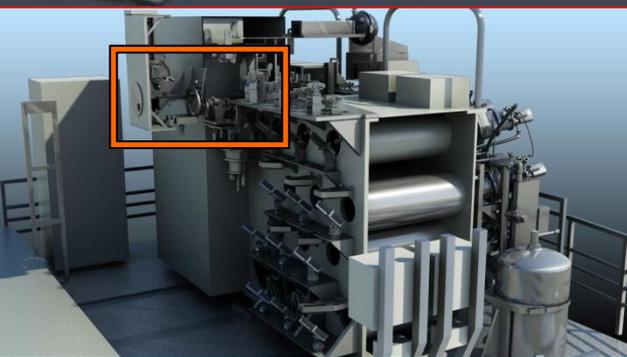
Design Phase



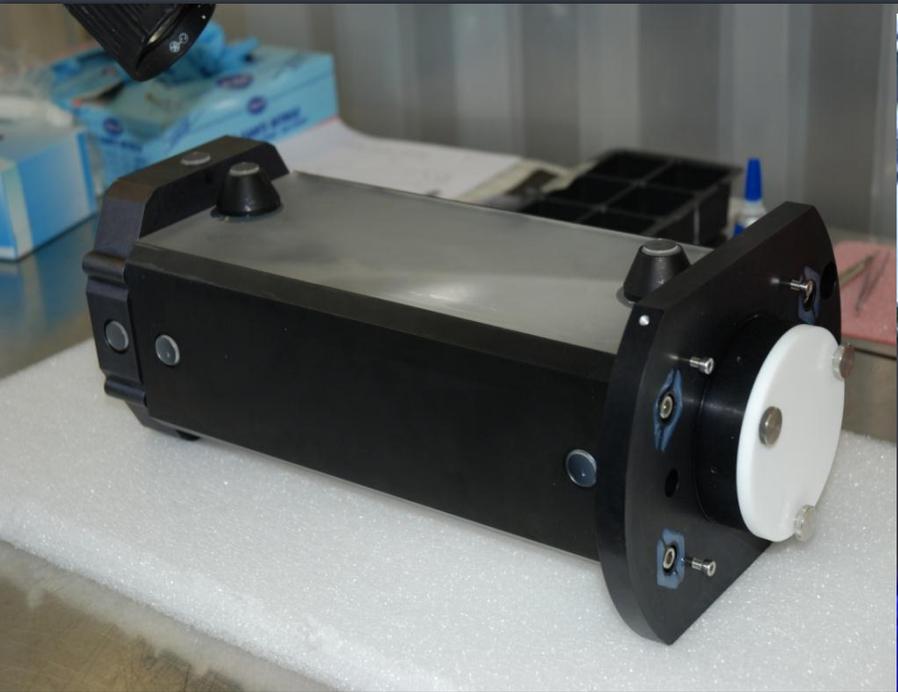
Manufacturing Assembly Integration and Test Phase



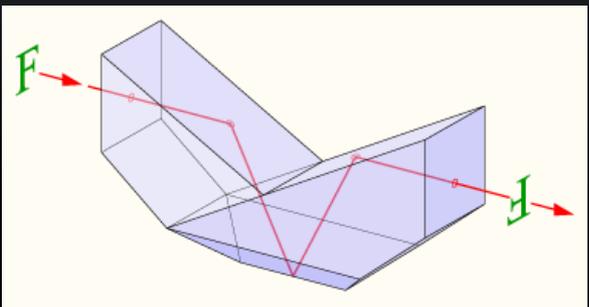




- **Au cour de la nuit le ciel « bouge » ! Pour faire de longues poses il est nécessaire que le télescope « suive » le mouvement. Mais comme la monture du télescope n'est pas équatoriale, le champ (image) observé tourne sur lui-même.**
- **Il faut compenser cette rotation c'est le rôle du dé-rotateur.**



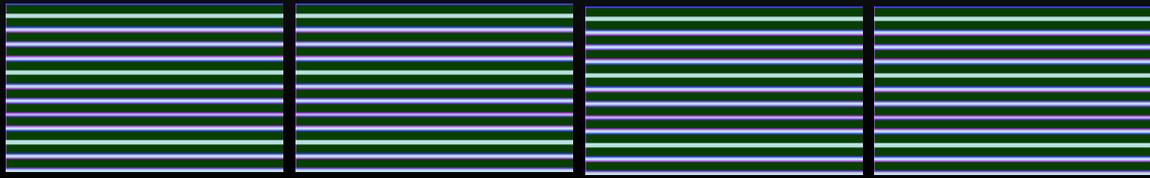
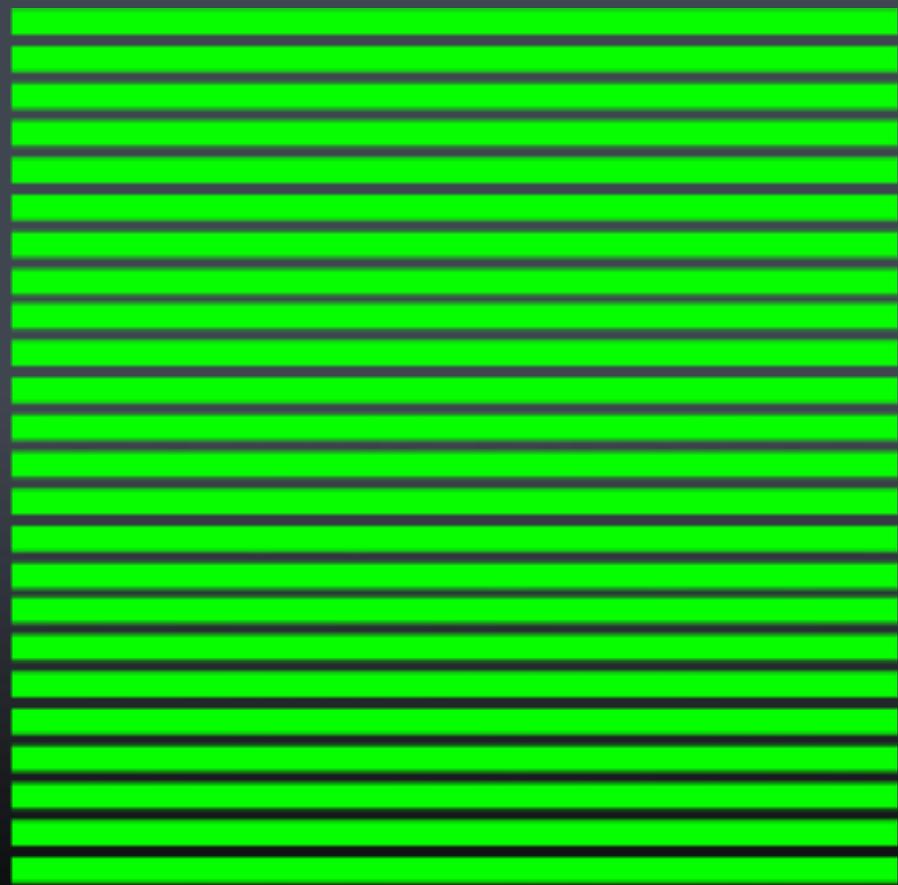
Prisme Abbe – Koenig





Le séparateur

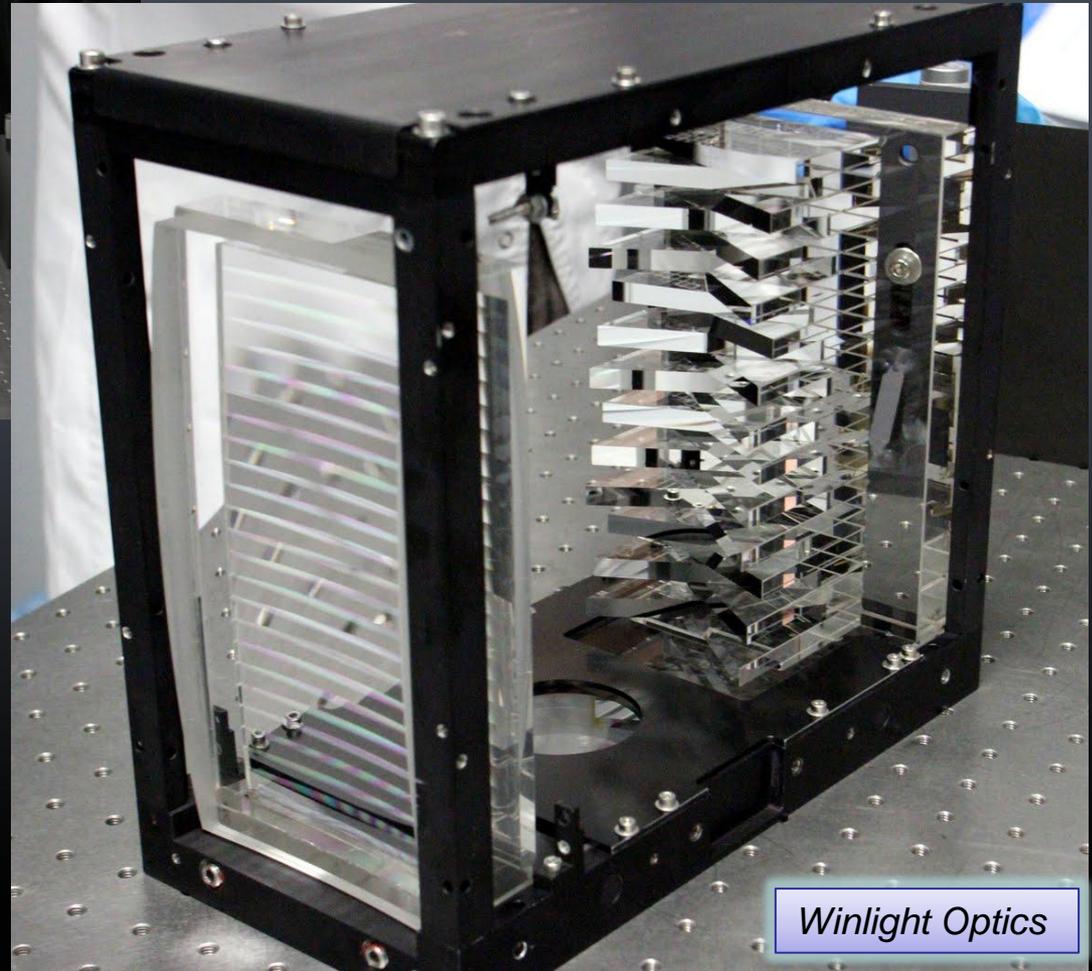
- Le séparateur découpe le champ en 24 parties horizontales
- Chaque spectrographe (IFU) découpe une section en 4x12 « fentes »



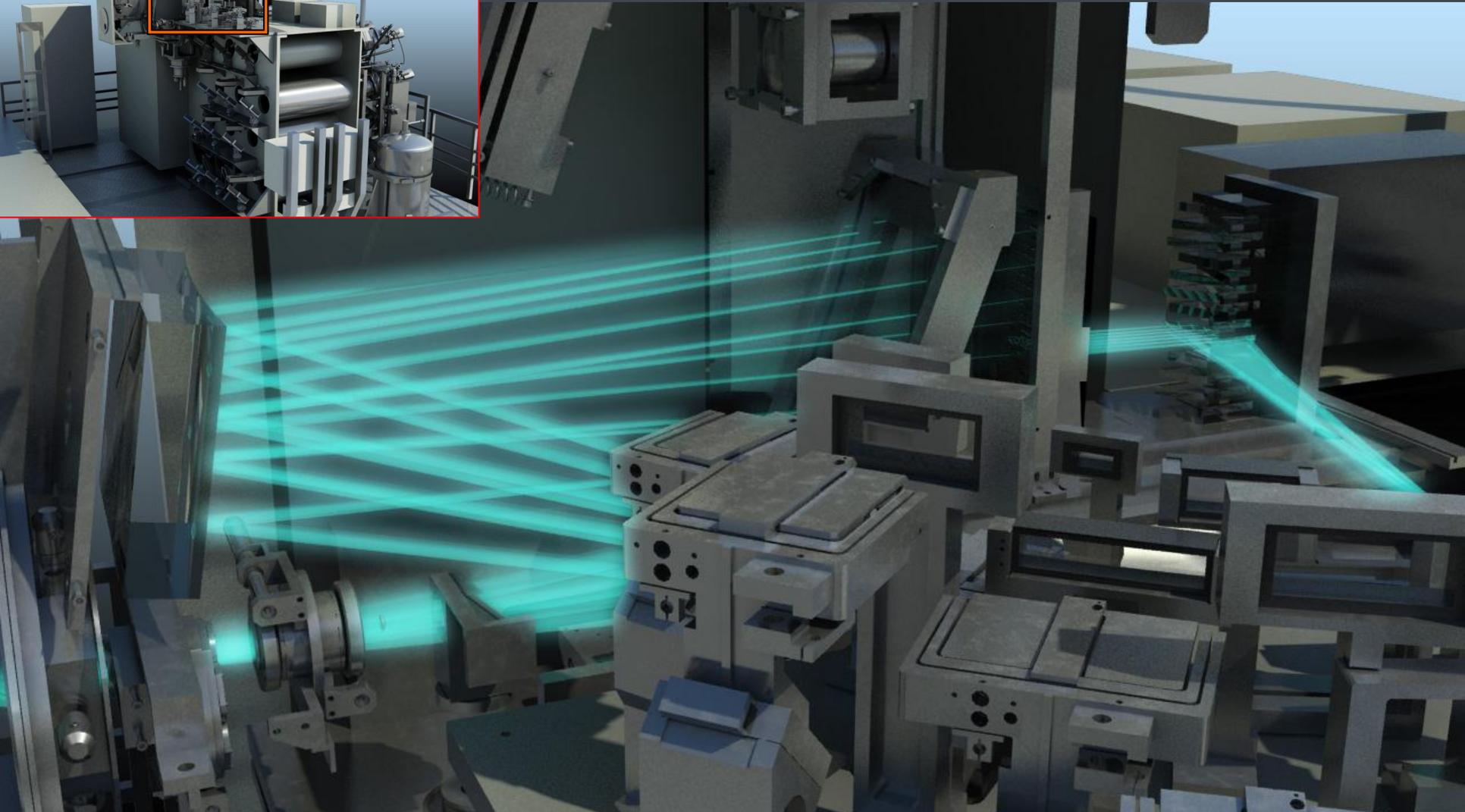
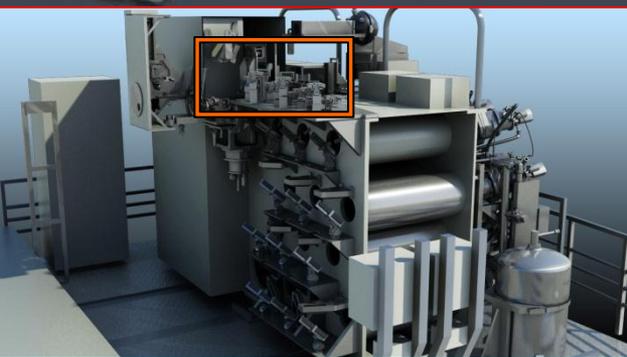
Découpeur de champ

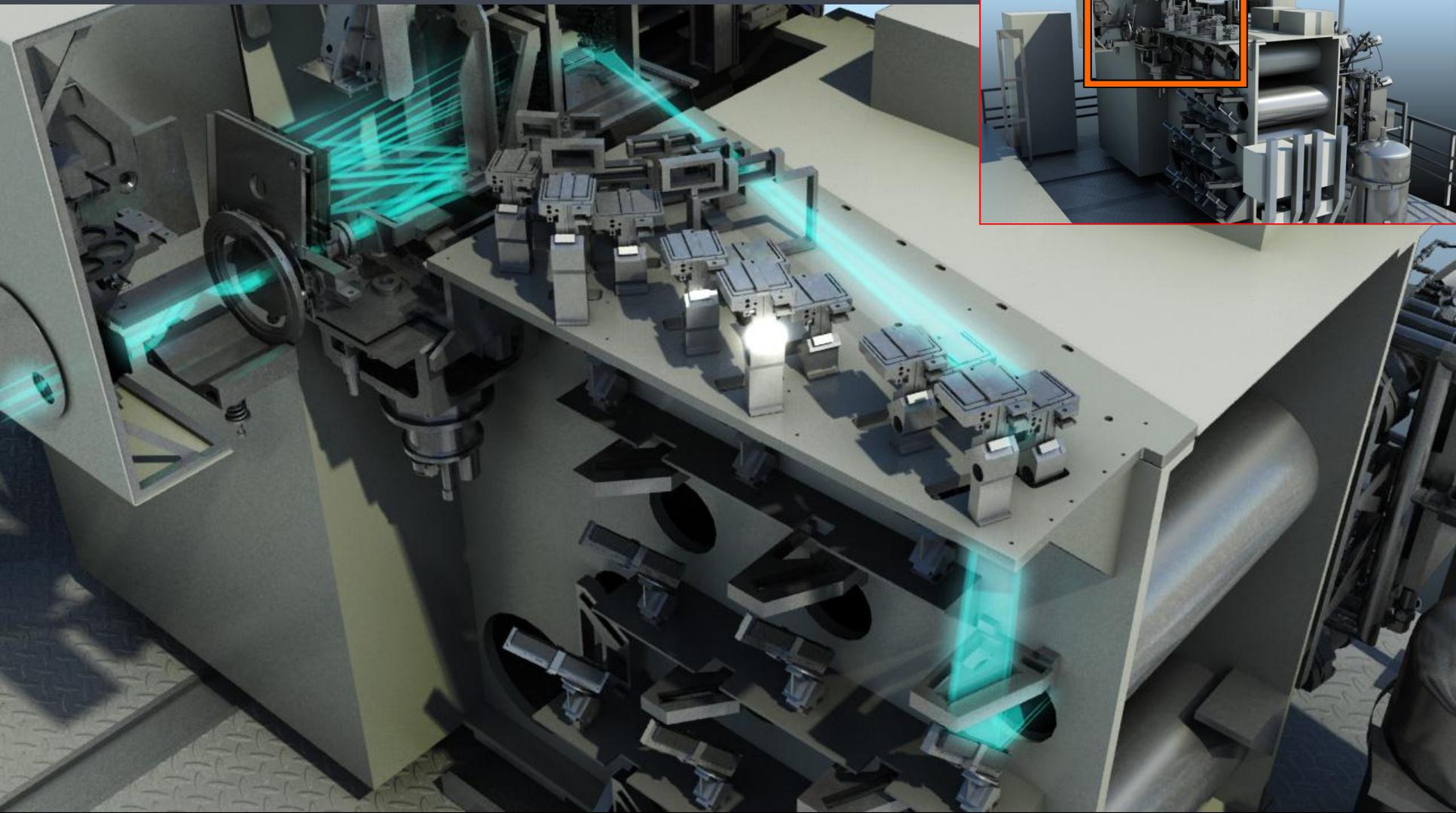


Livraison du FSU au CRAL en Fév 2013
F. Laurent (CRAL) & Y. Salaun (Winlight)

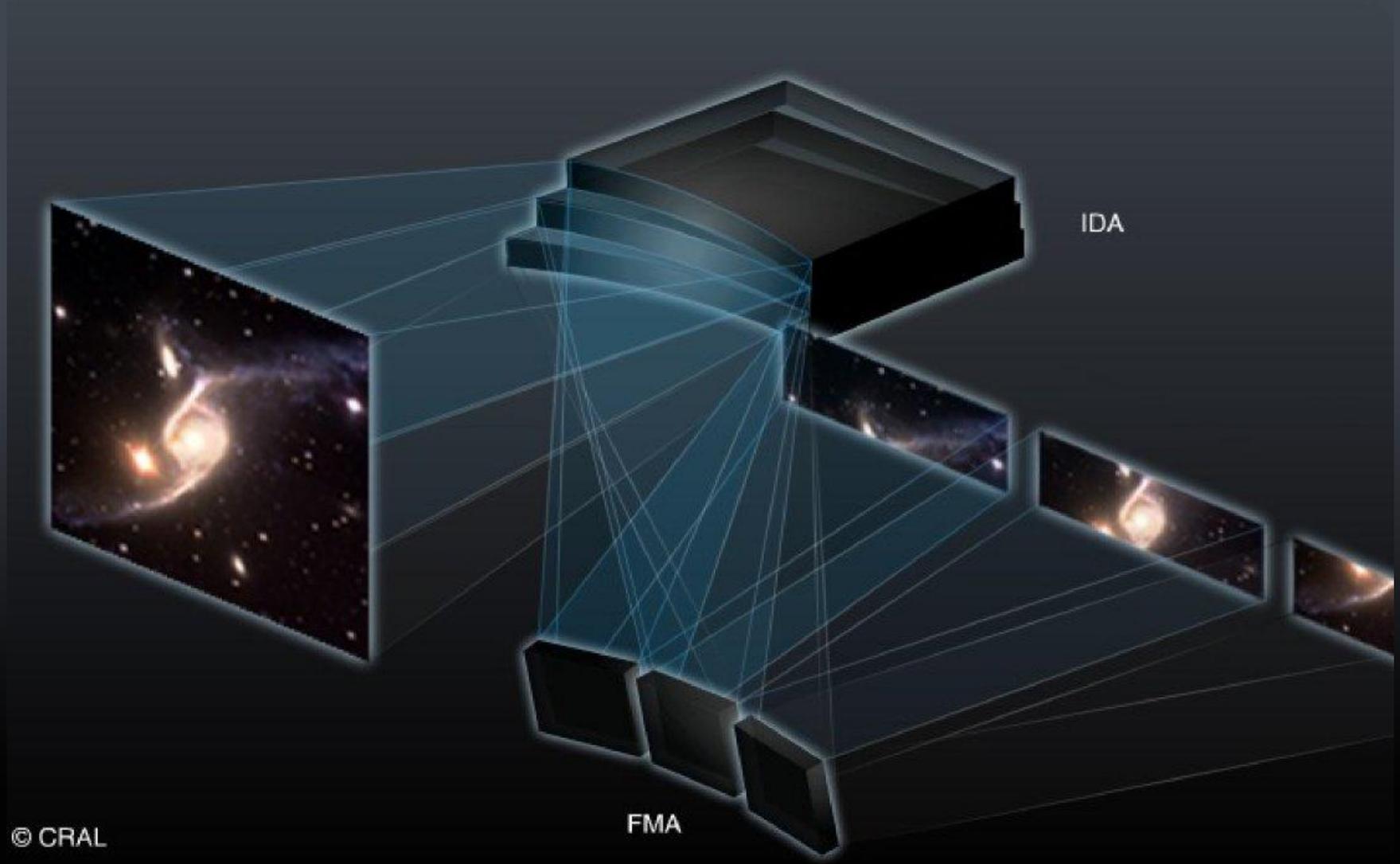


Winlight Optics





Principe du découpeur de Champ (slicer)



Slicer x 24

FMA: 48 miroirs sphériques 6x2 mm elliptiques

IDA: 4 piles de 12 miroirs sphériques hors-axe 33x0.9 mm rectangulaires

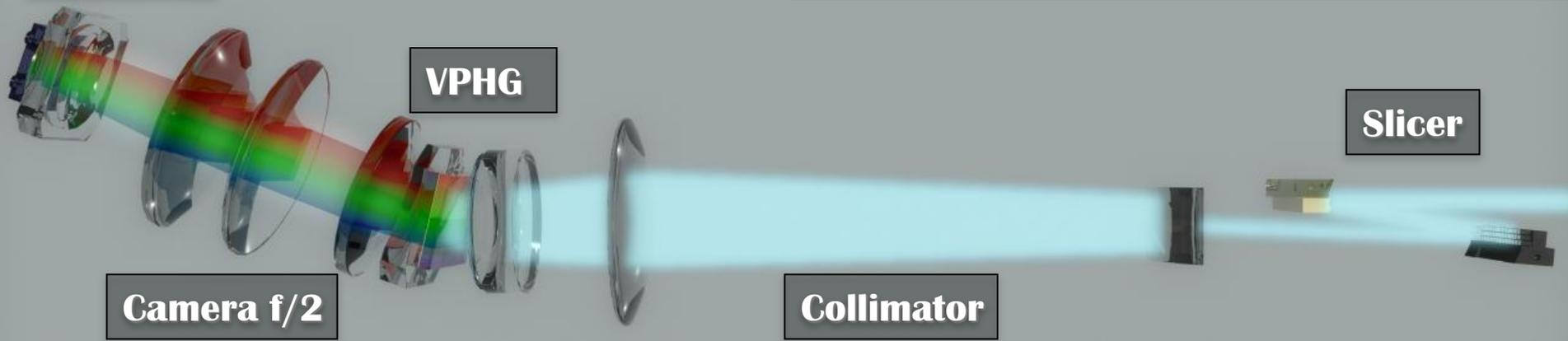
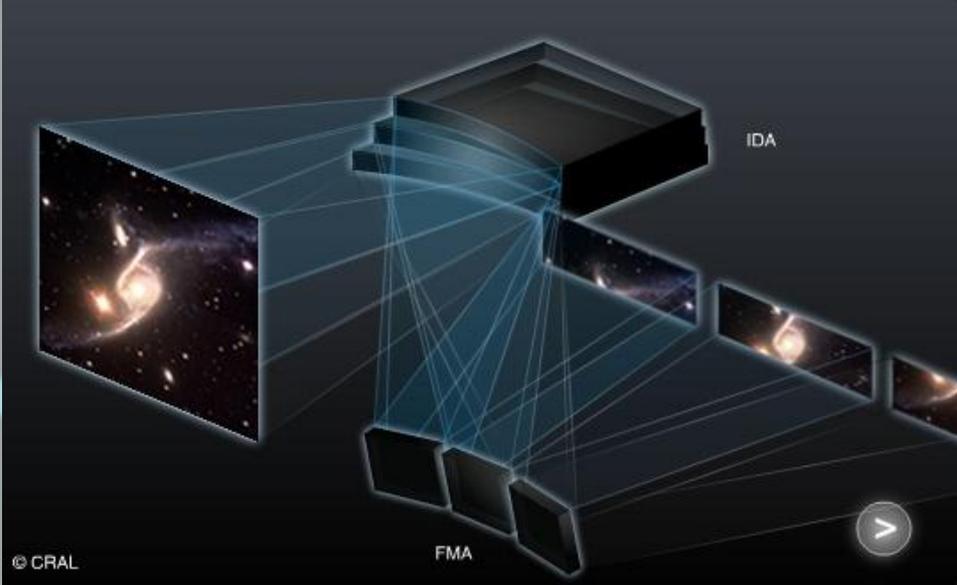
Winlight Optics

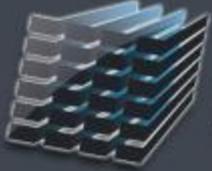


Integral Field Unit (IFU)



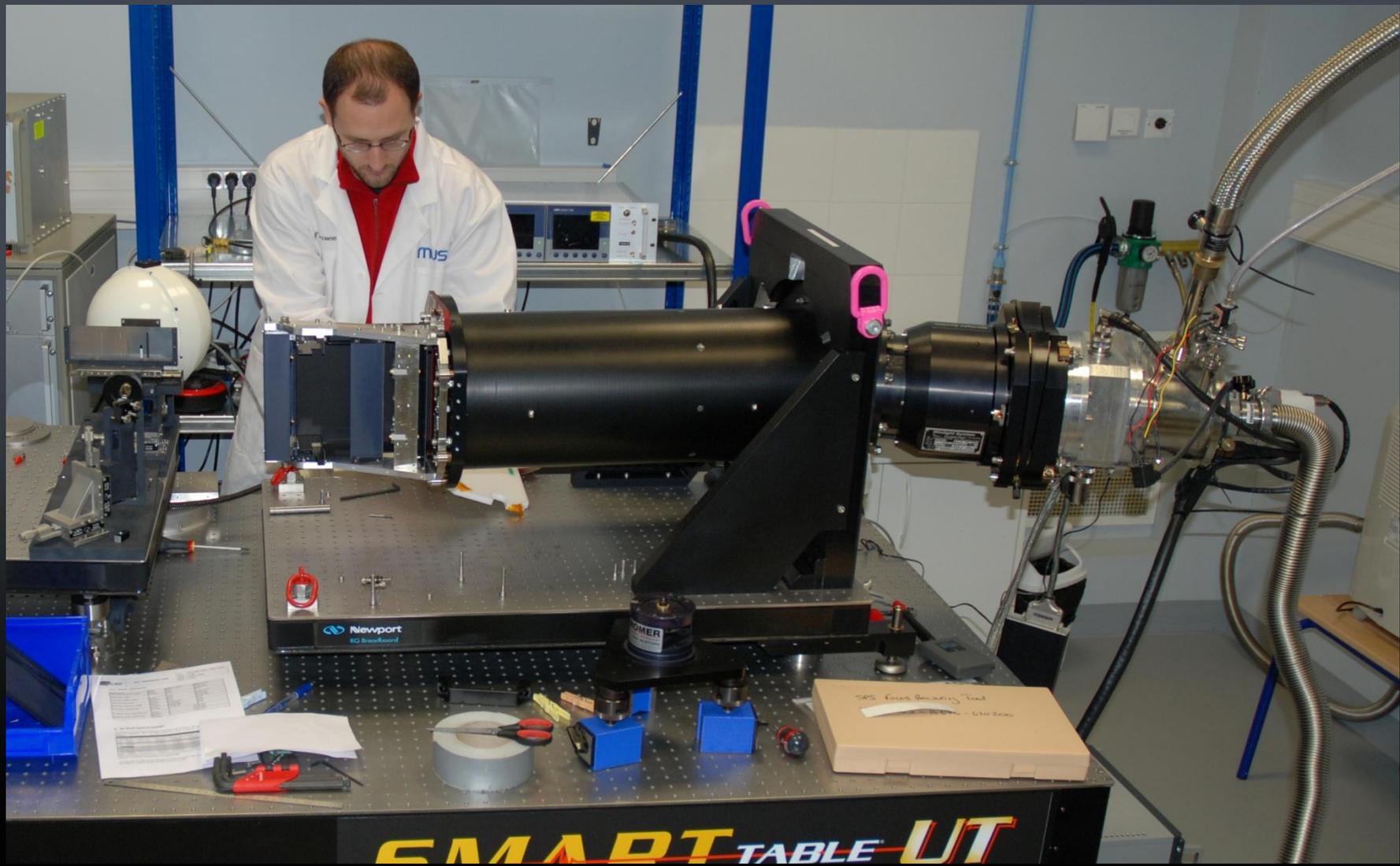
CCD 4k²





MUSE

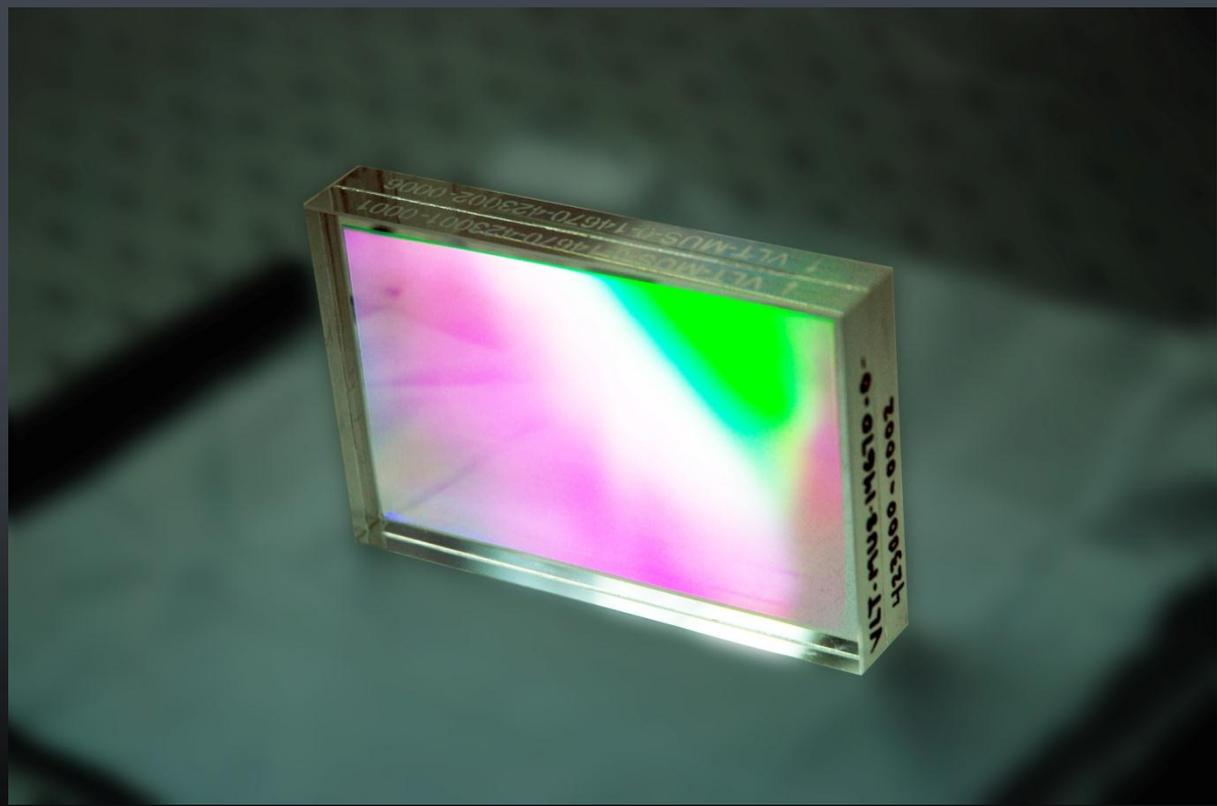
Integral Field Unit (IFU)



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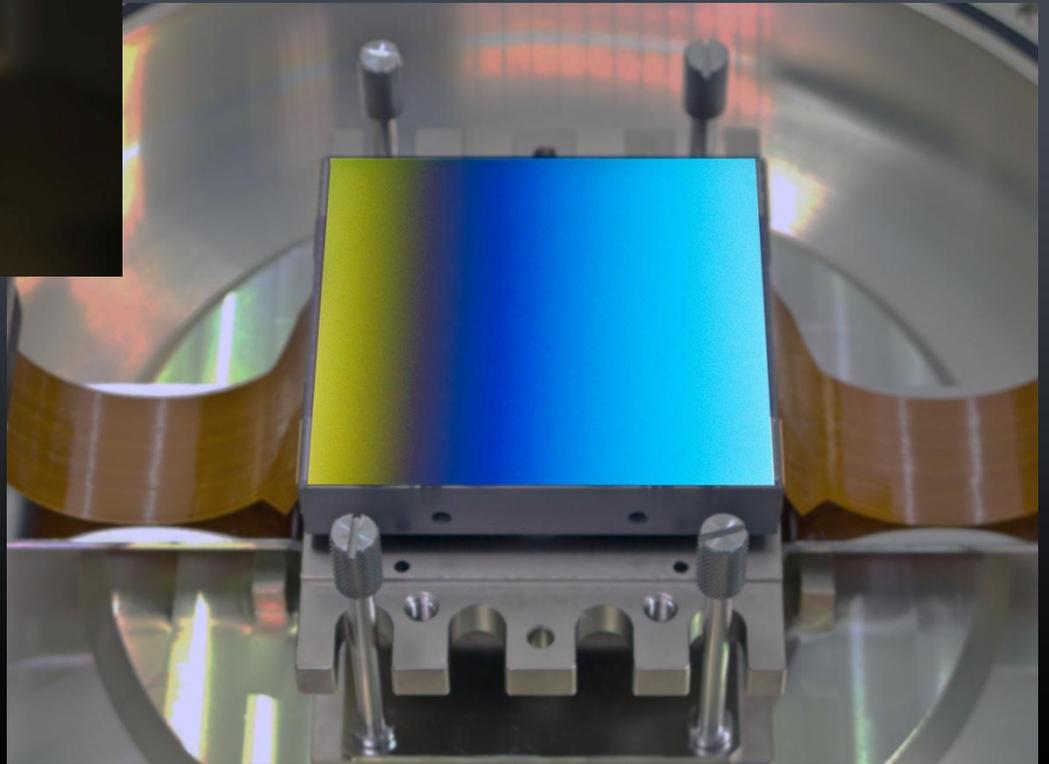
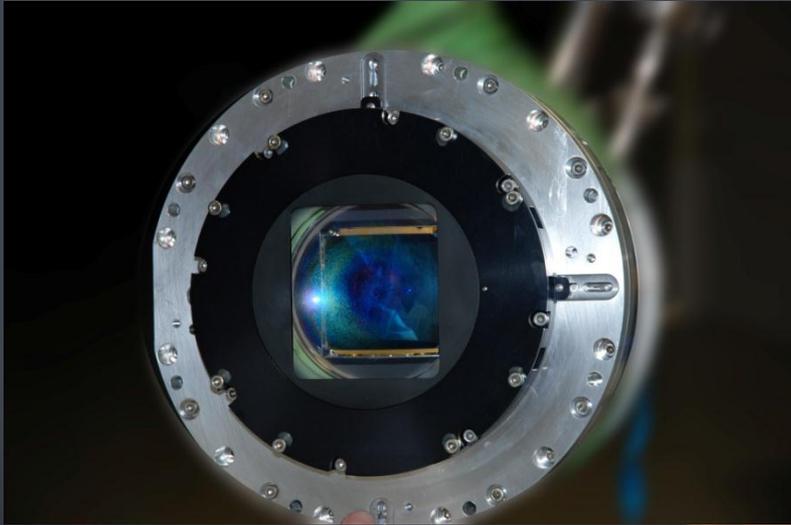
« Disperseur » : VPHG



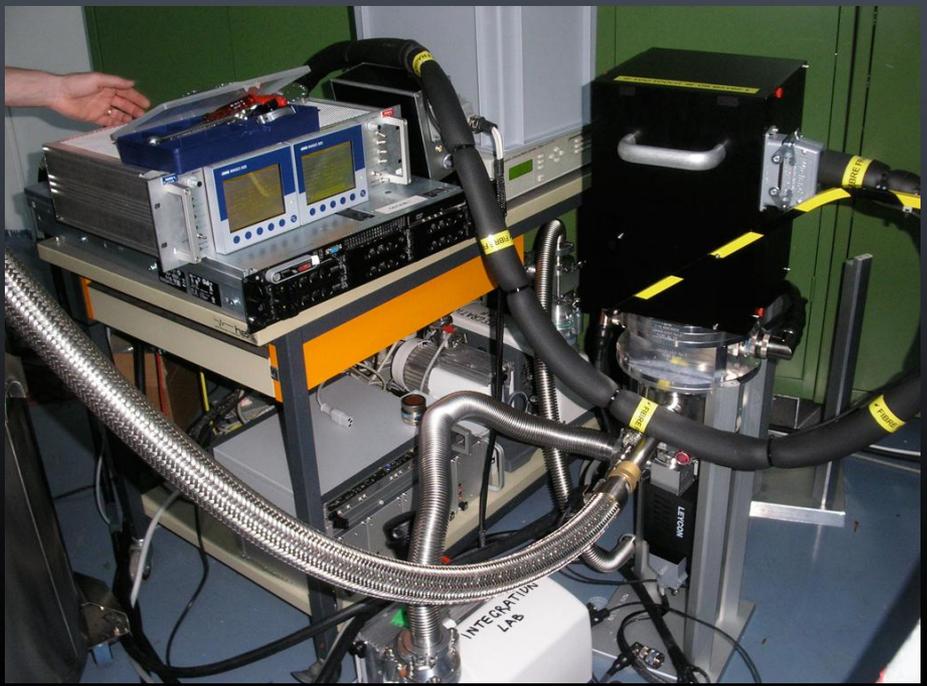
ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich

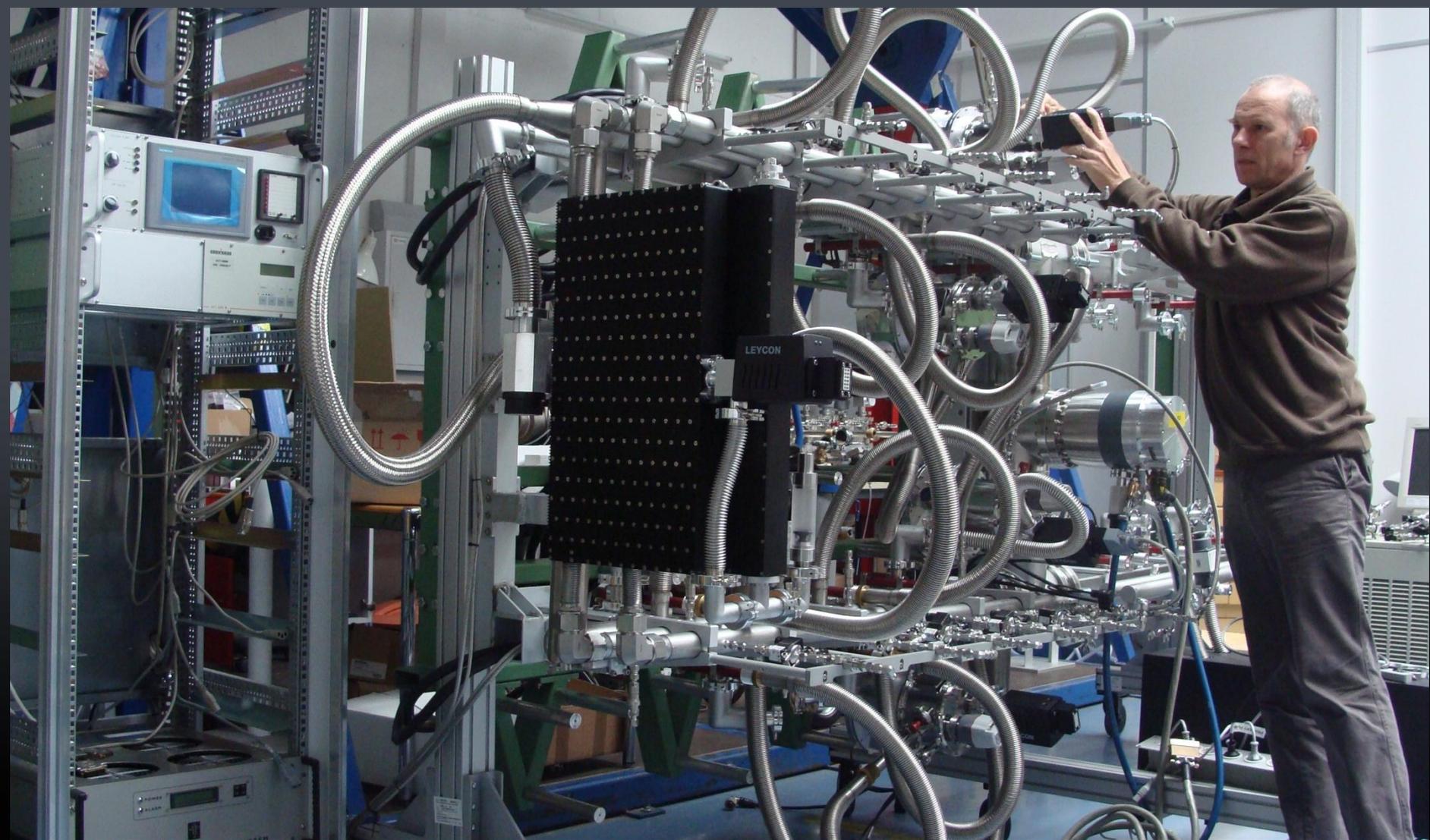


Détecteur



ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich



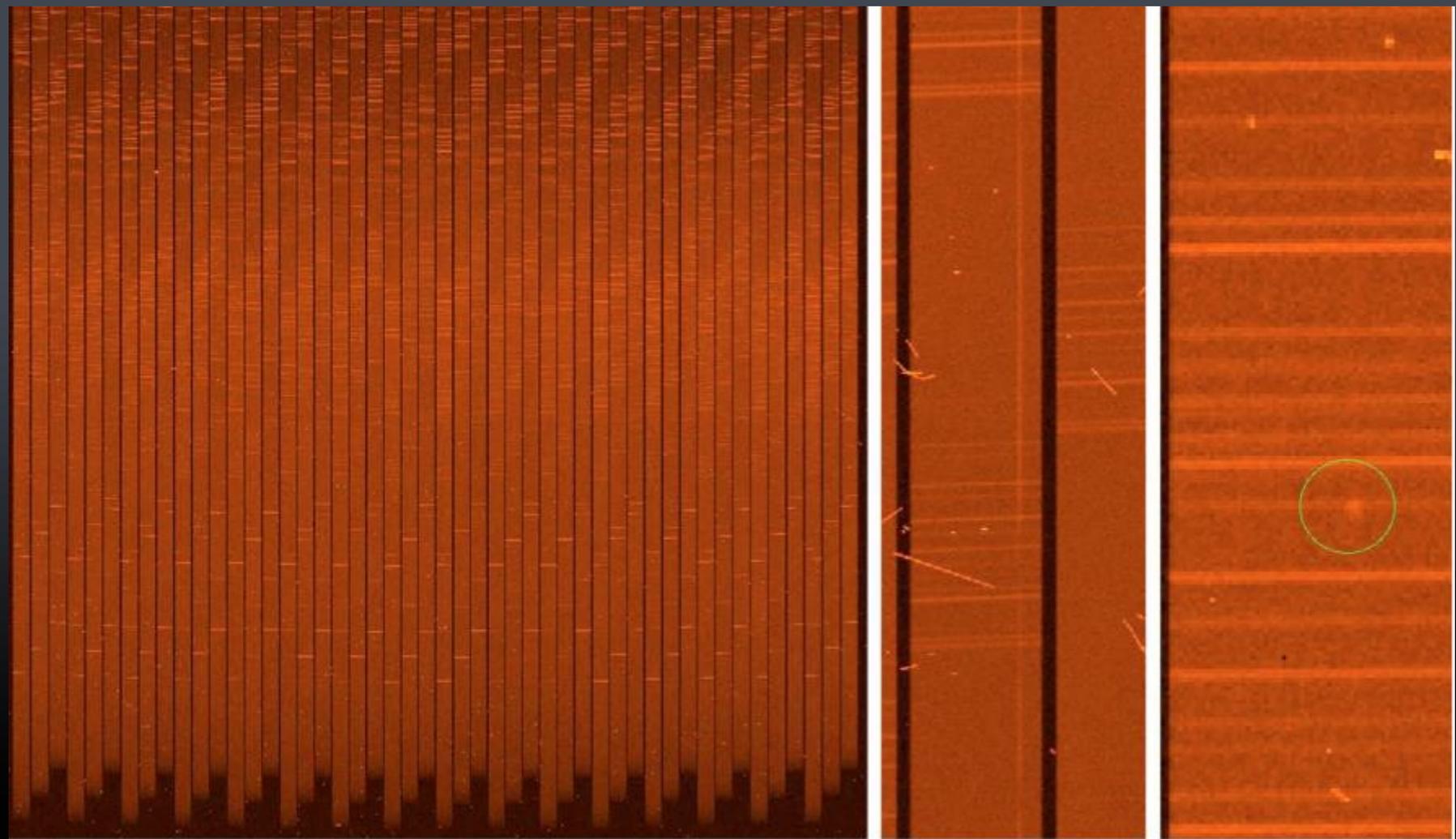


Structure





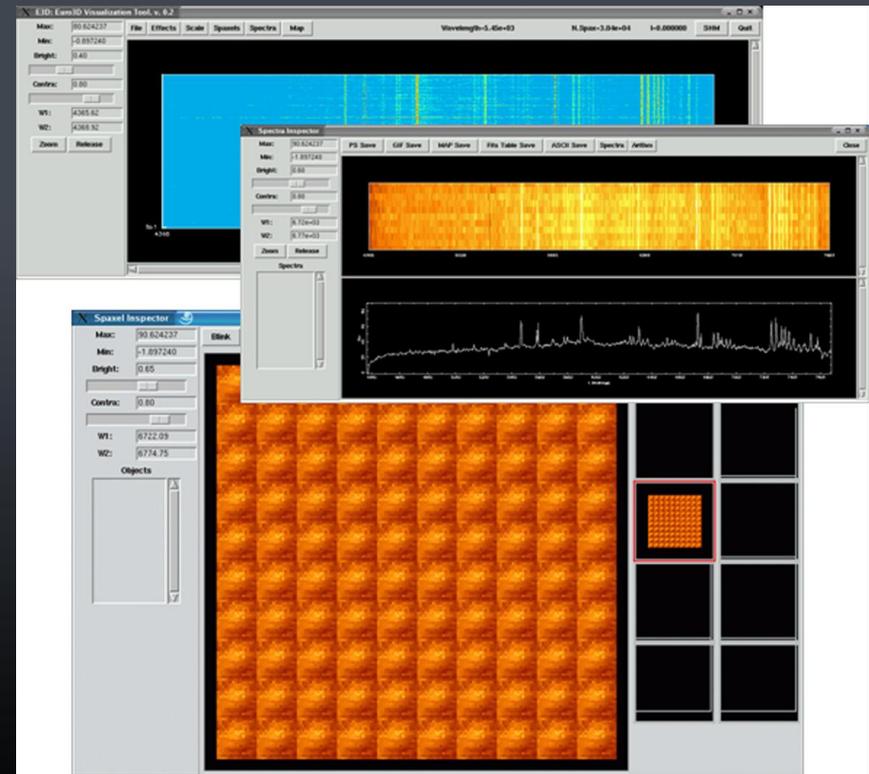
- **Collecte des données**
- **Réduction des données**
- **Analyse des données**





Le défi de la réduction et du traitement des données

- Volume
 - Un exposition = $4 \cdot 10^8$ pixels
 - Un champ profond = 80 expositions
- Complexité
 - Ex: Optimiser la somme de 80 expositions;
 - Ex: traitement en fonction de l'évolution du champ, de la longueur d'onde, du temps... (un pb. 4D)
 - Ex: Extraction de spectre dans les environnements stellaires denses
 - ...





Septembre 2013: MUSE est testé et prêt à quitter Lyon pour le Chili





Septembre 2013: MUSE est testé et prêt à quitter Lyon pour le Chili



ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich

Octobre 2013: livraison de 24 tonnes et 200 m³ de materiel sur le site de l'ESO à Paranal





Octobre à Décembre 2013:
Réintégration et tests



18 Janvier 2014: Transfert du camp de base vers UT4



ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich



19 Janvier 2014: MUSE se pose sur la plateforme Nasmyth de Yepun





L'étoile de Kapteyn

Kapteyn b and c: Two Exoplanets Found Orbiting Kapteyn's Star

Jun 3, 2014 by Sci-News.com

« PREVIOUS | NEXT »

Published in
Astronomy

Tagged as
Dwarf galaxy

Astronomers led Dr Guillem Anglada-Escude from Queen Mary University of London, UK, have announced the discovery of two exoplanets circling a very old nearby star known as Kapteyn's star.

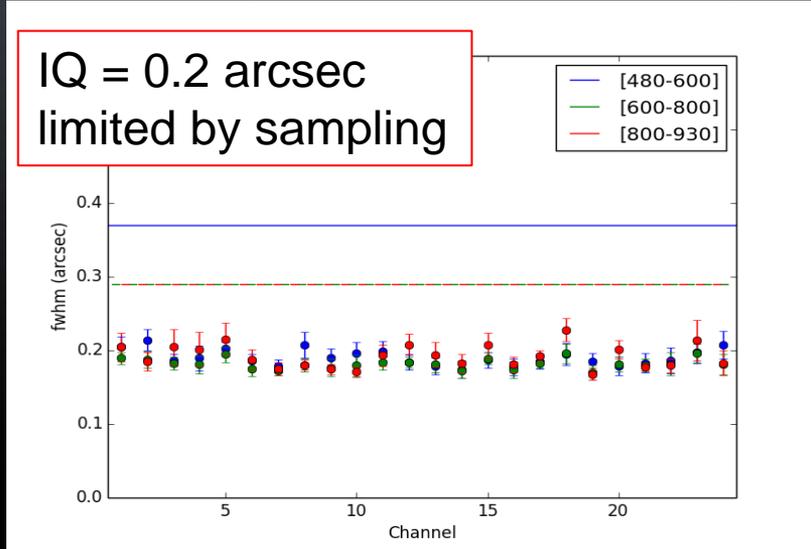
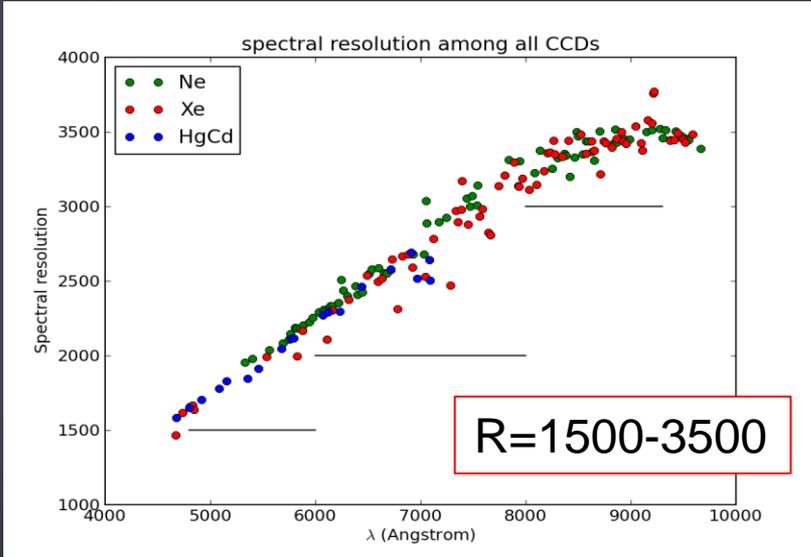
Right now, this red dwarf star is 13 light-years away and is the 25th nearest star to the Sun. It has a magnitude of 9 and can be seen in the southern constellation of Pictor with an amateur telescope or binoculars.

2001: la lumière débute son voyage
2001: nous proposons à l'ESO de réaliser MUSE

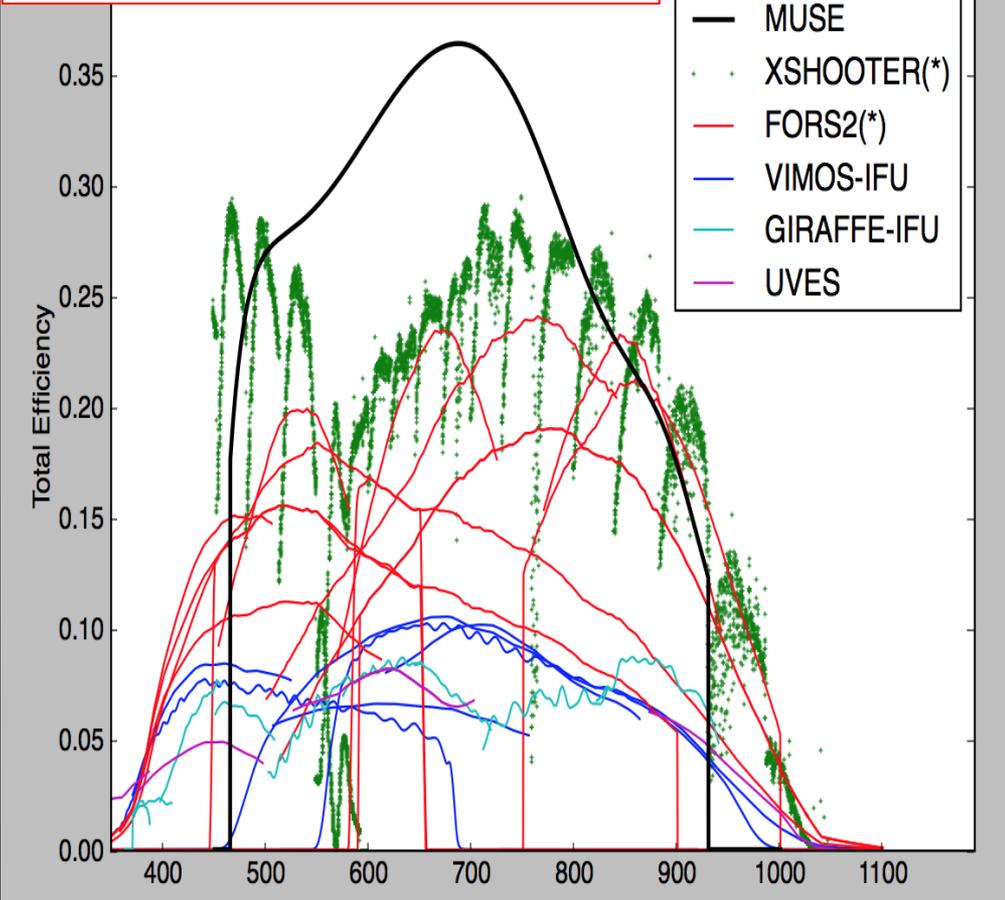
13 ans plus tard, la lumière est capturée par le canal 06 de MUSE



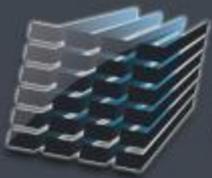
Mesures des performances



The most efficient of the VLT spectrographs in 500-850nm



(*) 17% Slit loss included in FORS2 & XSHOOTER (e.g. 1 arcsec slit with 0.8 arcsec seeing)

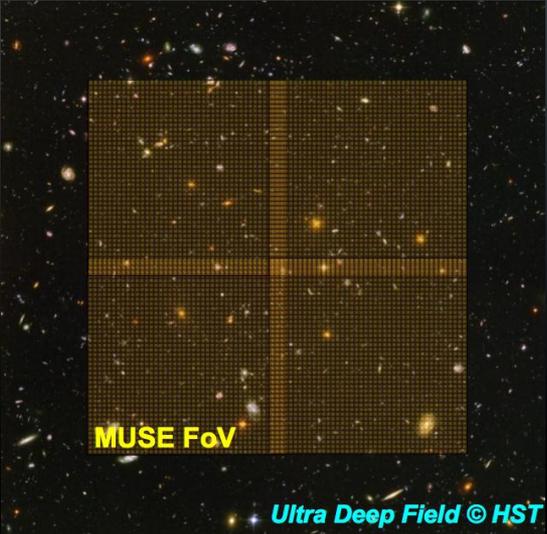
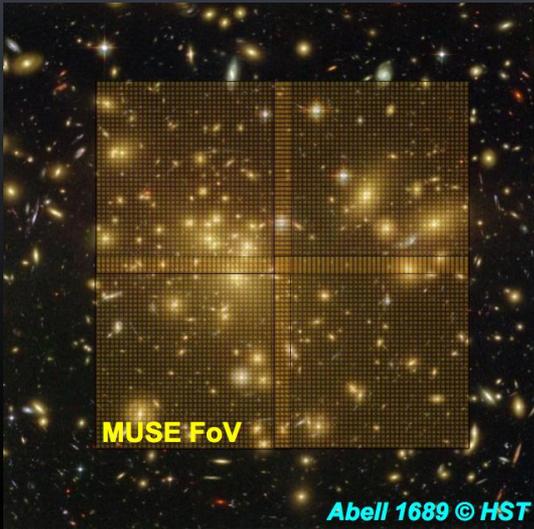
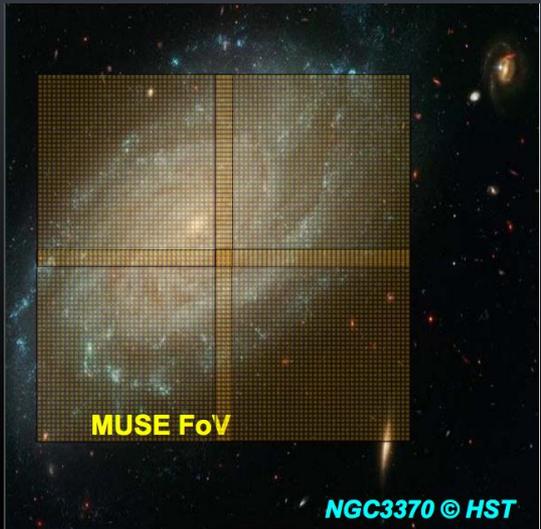
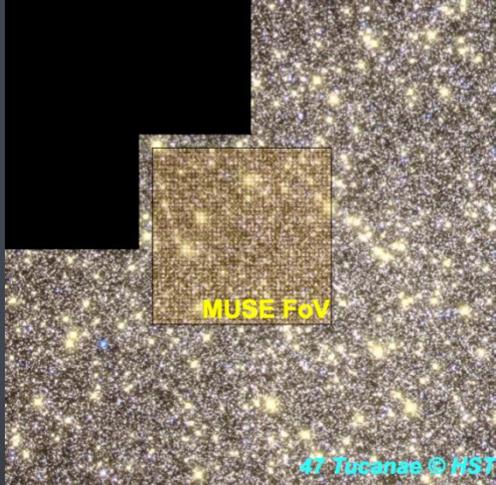
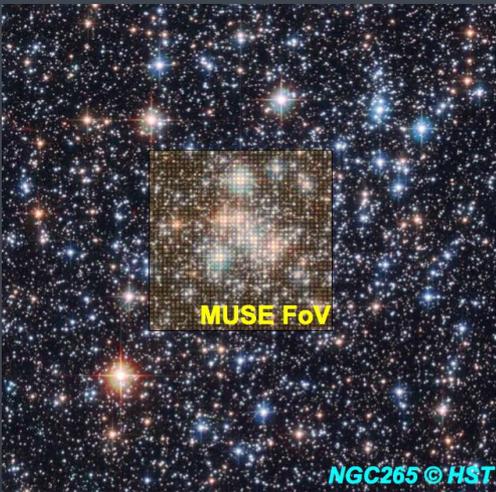


MUSE MUSE: carte d'identité



Name: MUSE
Category: integral field spectrograph
Size: 1x1 arcmin²
Spatial sampling: 0.2"
Image Quality: <0.2"
Coverage: 4650-9300 Å
Resolution: 1500-3500
Throughput: 35% end-to-end



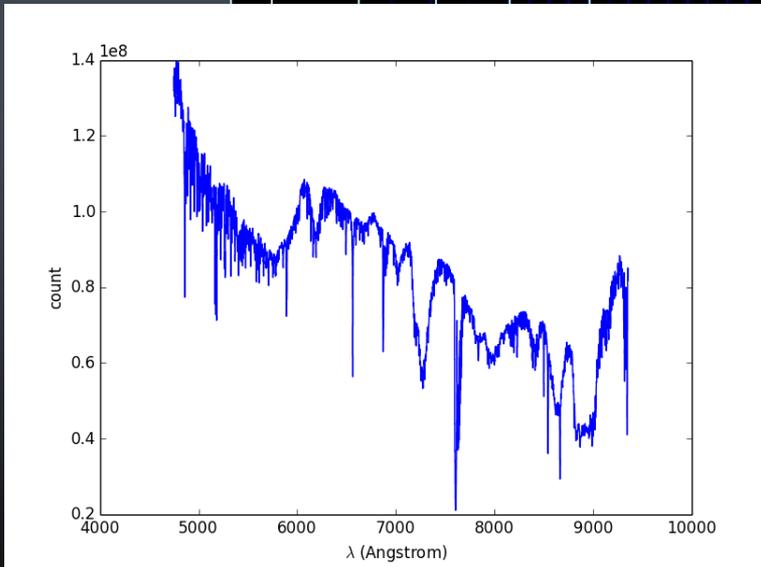
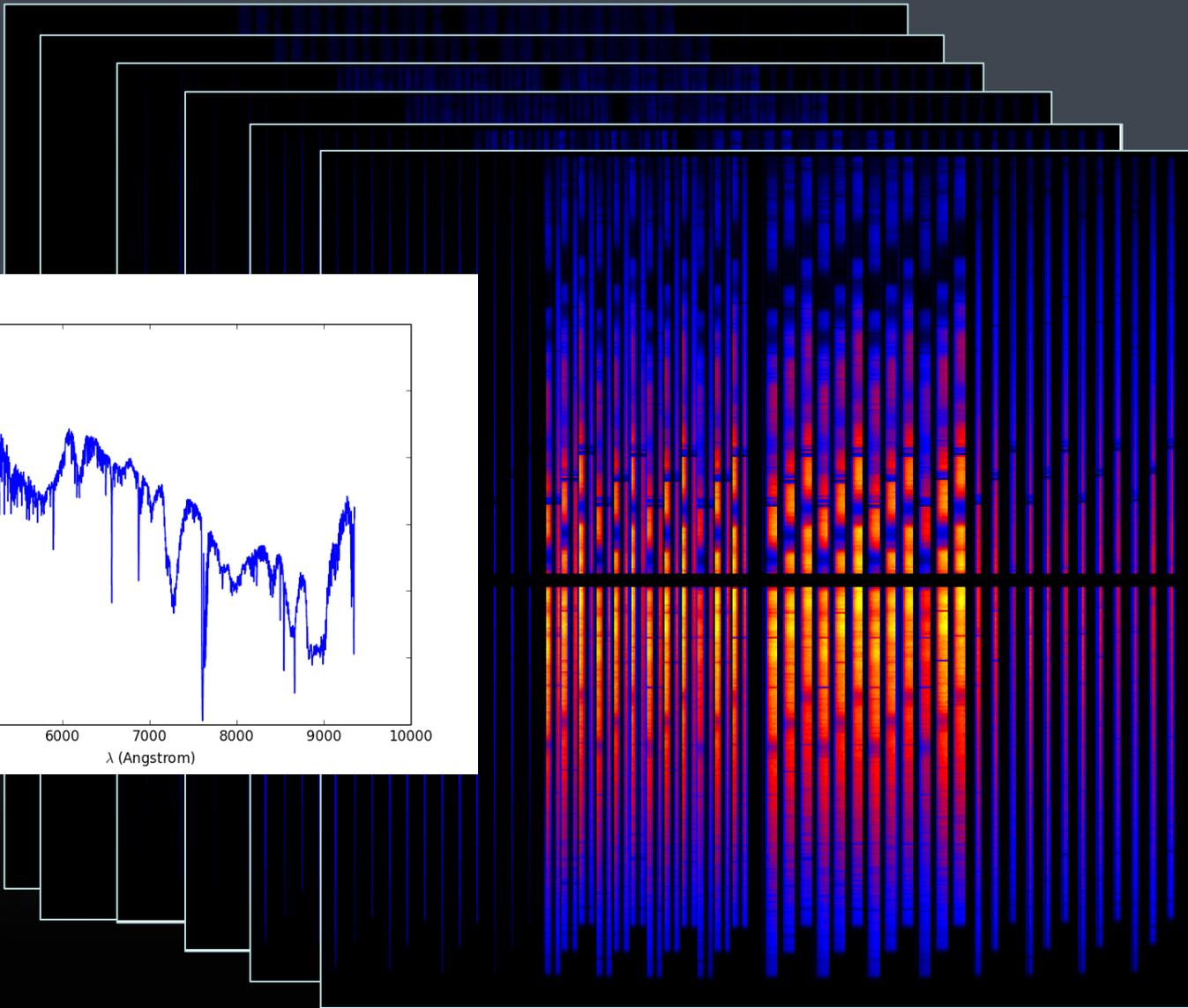


Premiers Résultats

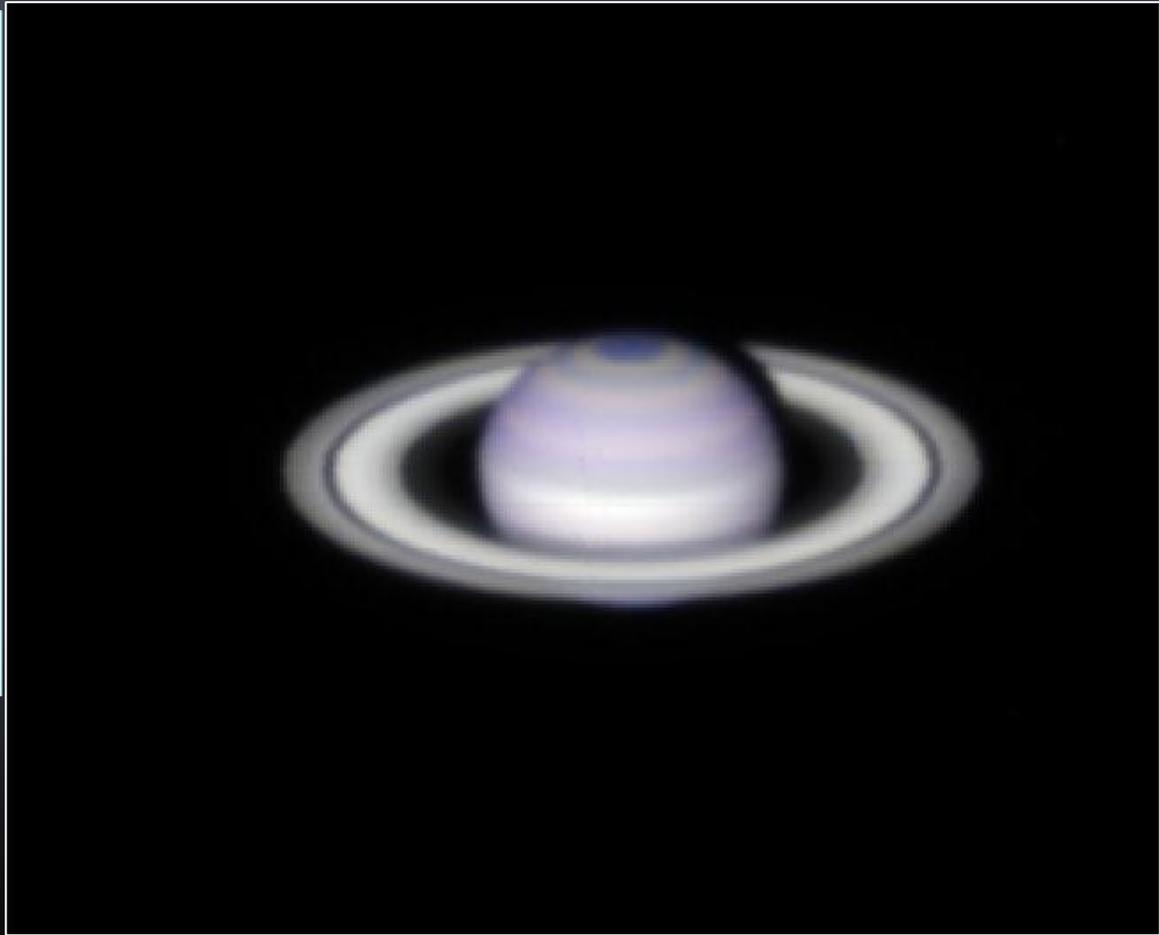
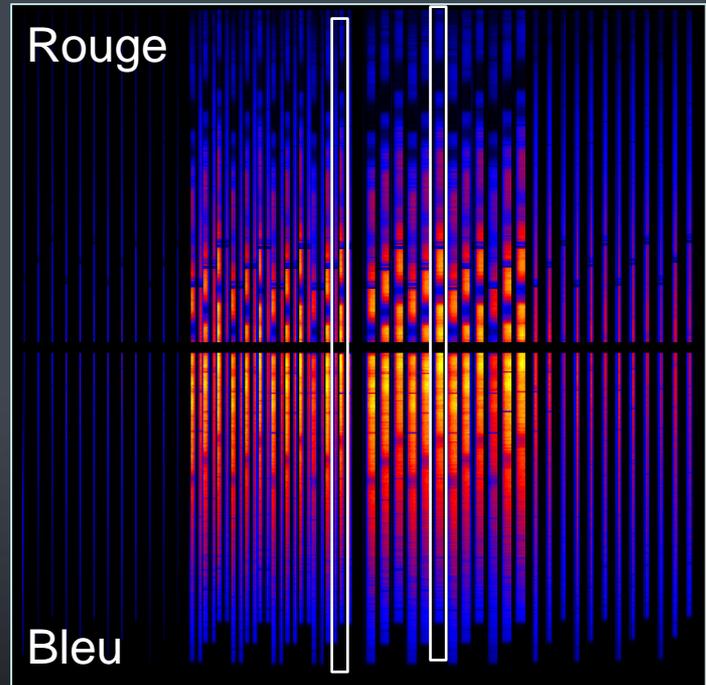




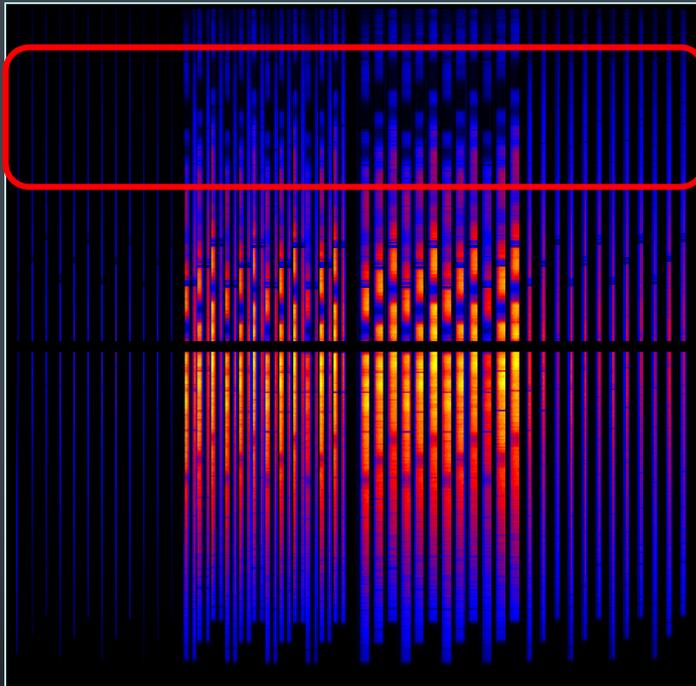
Première observation: Saturne



Première observation: Saturne

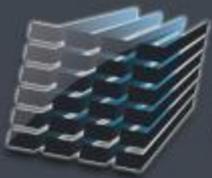


Première observation: Saturne



CH₄





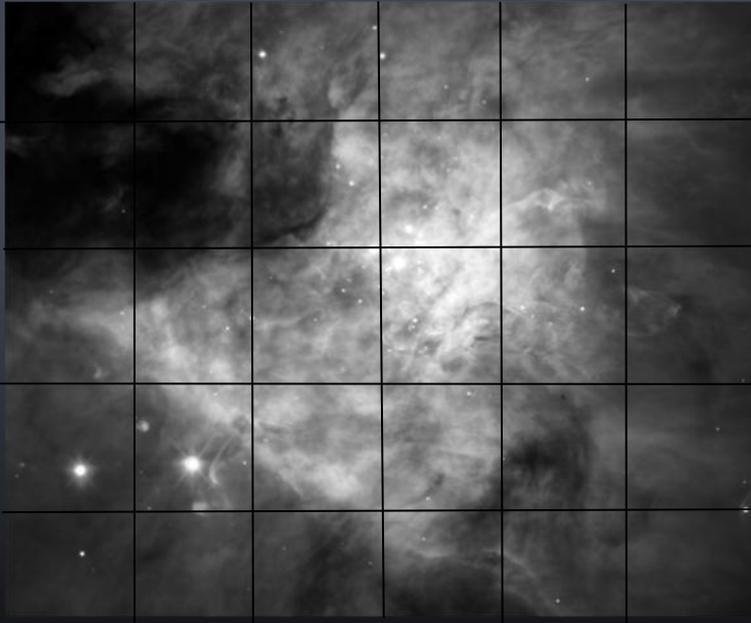
MUSE

Mouvement du gas dans les galaxies: La galaxie à anneau polaire NGC 4650A

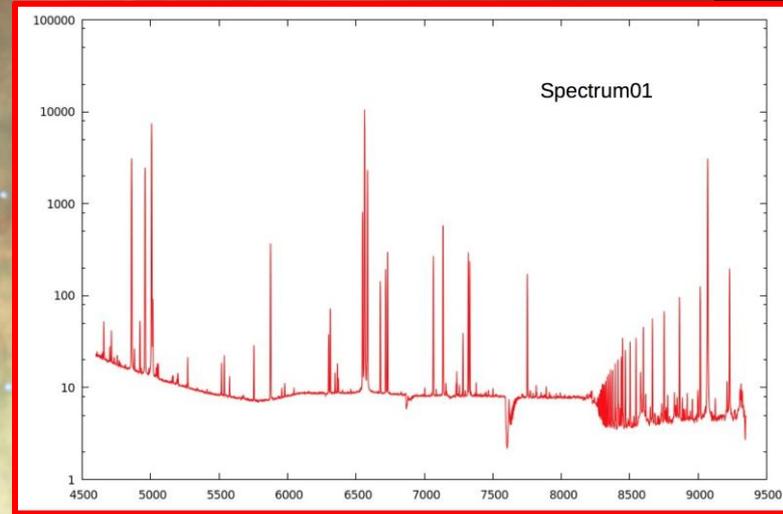


www.eso.org

Une grande mosaïque de la nébuleuse d'Orion



- 60 poses
- temps d'intégration par pose: 5 sec
- 5 millions de spectres



H β +OIII Cont 5300 H α +NII

Le potentiel de découverte de MUSE

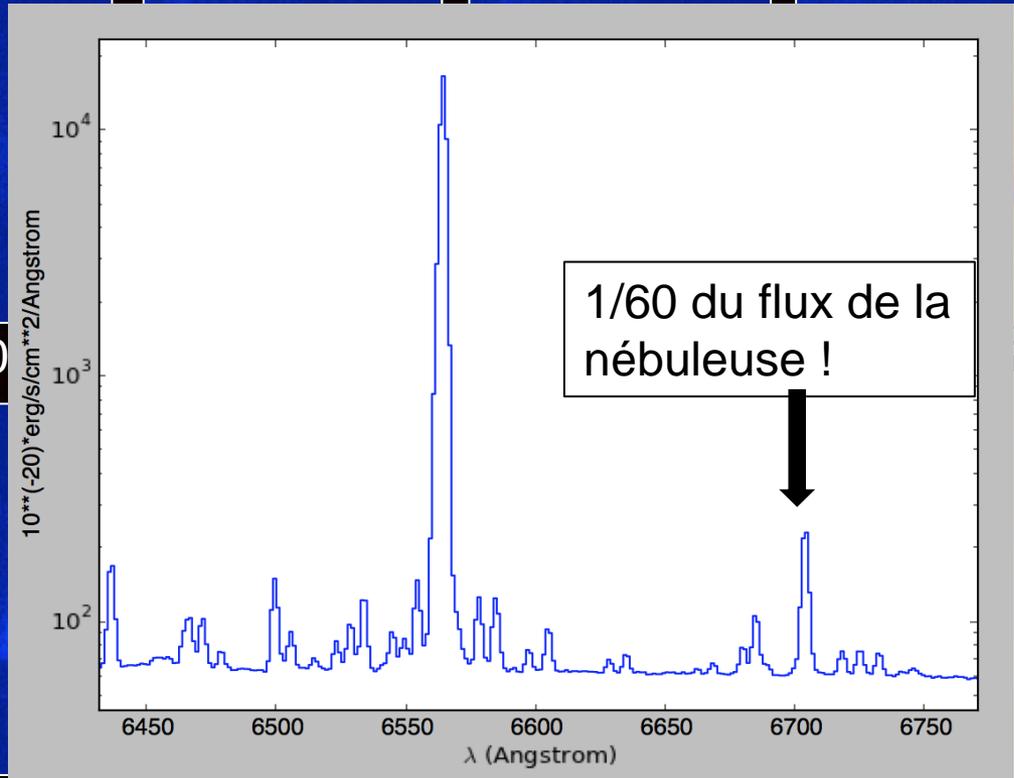
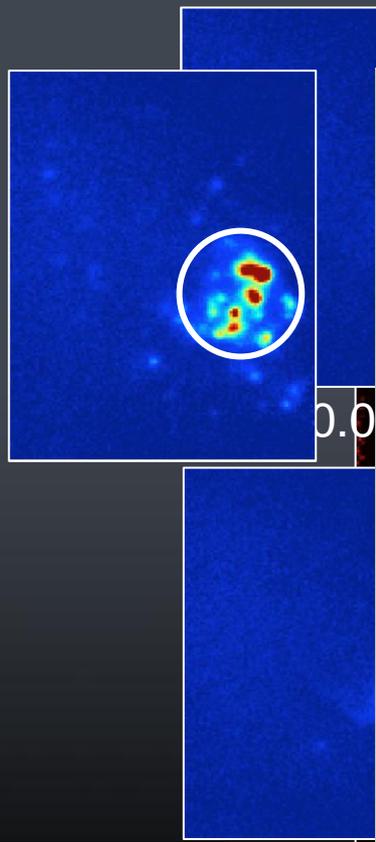
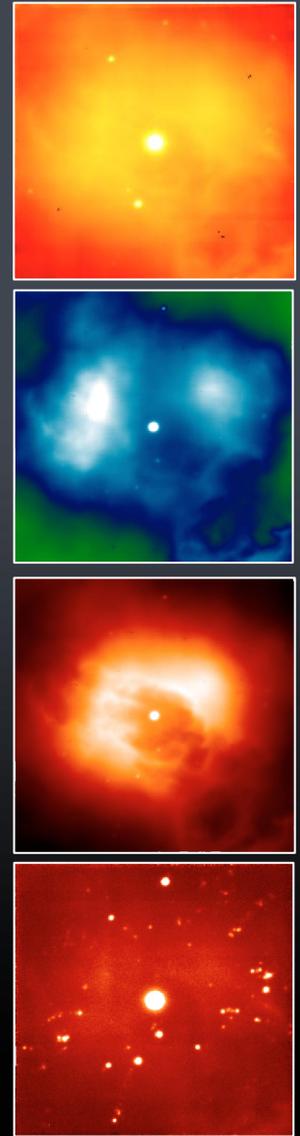


La nébuleuse
planétaire NGC 4361

Tache#13 de Comm2A:
impact de la séquence
d'observation sur la
mesure de la réponse
spectrale

Observée le 01/05/14,
temps d'intégration 1
mn

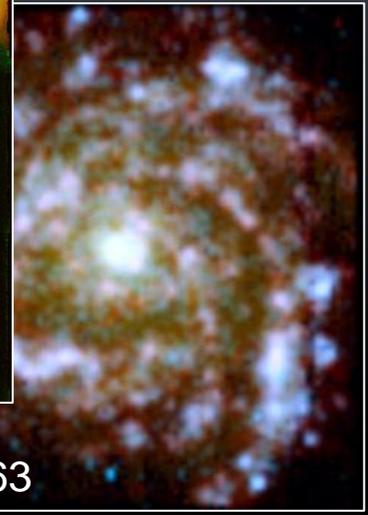
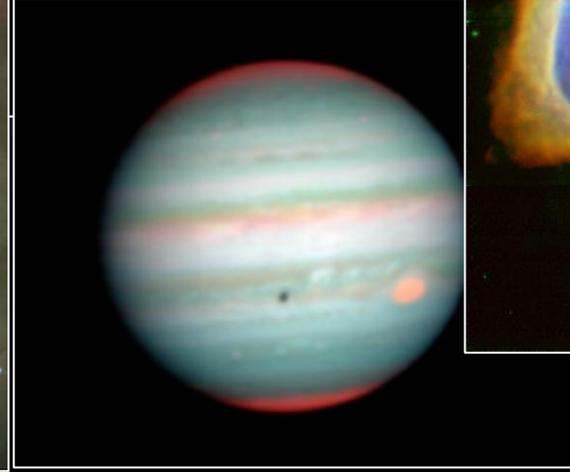
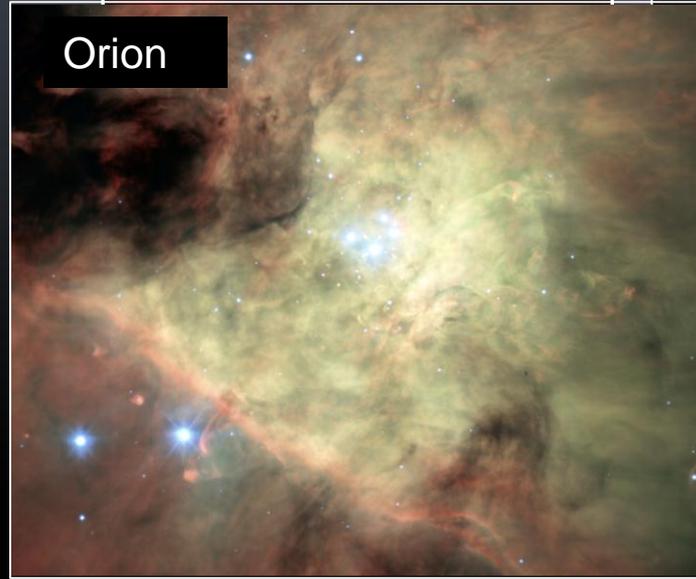
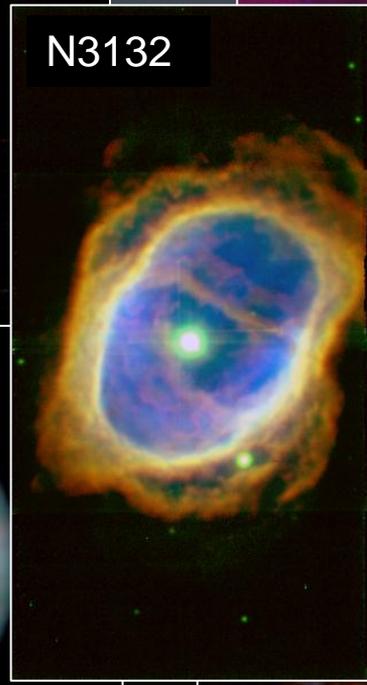
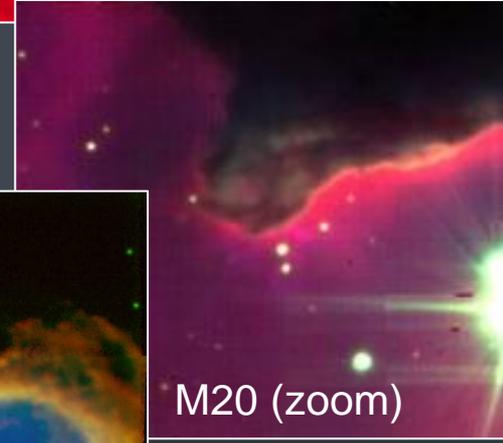
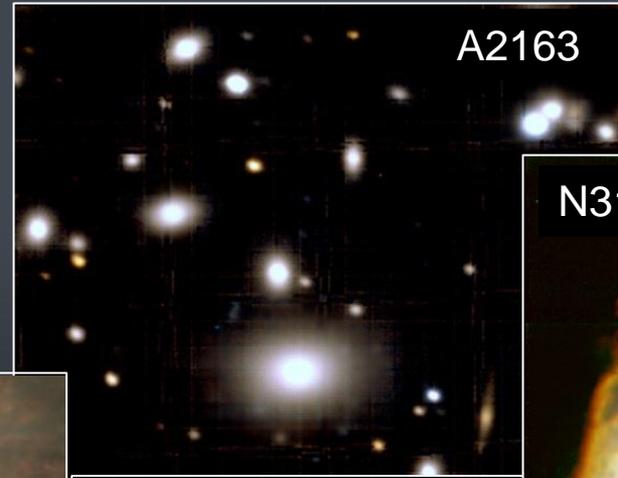
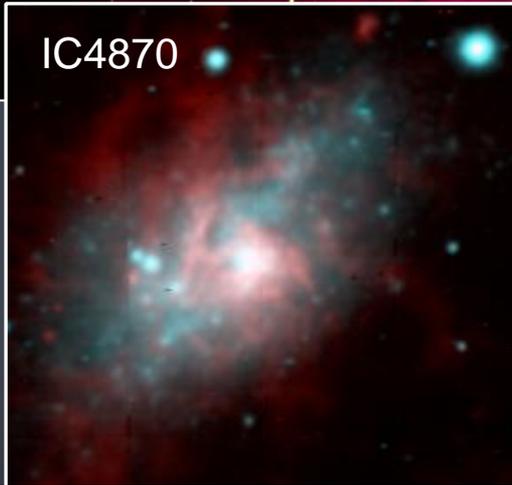
Exploration de la nébuleuse planétaire 4361 avec MUSE

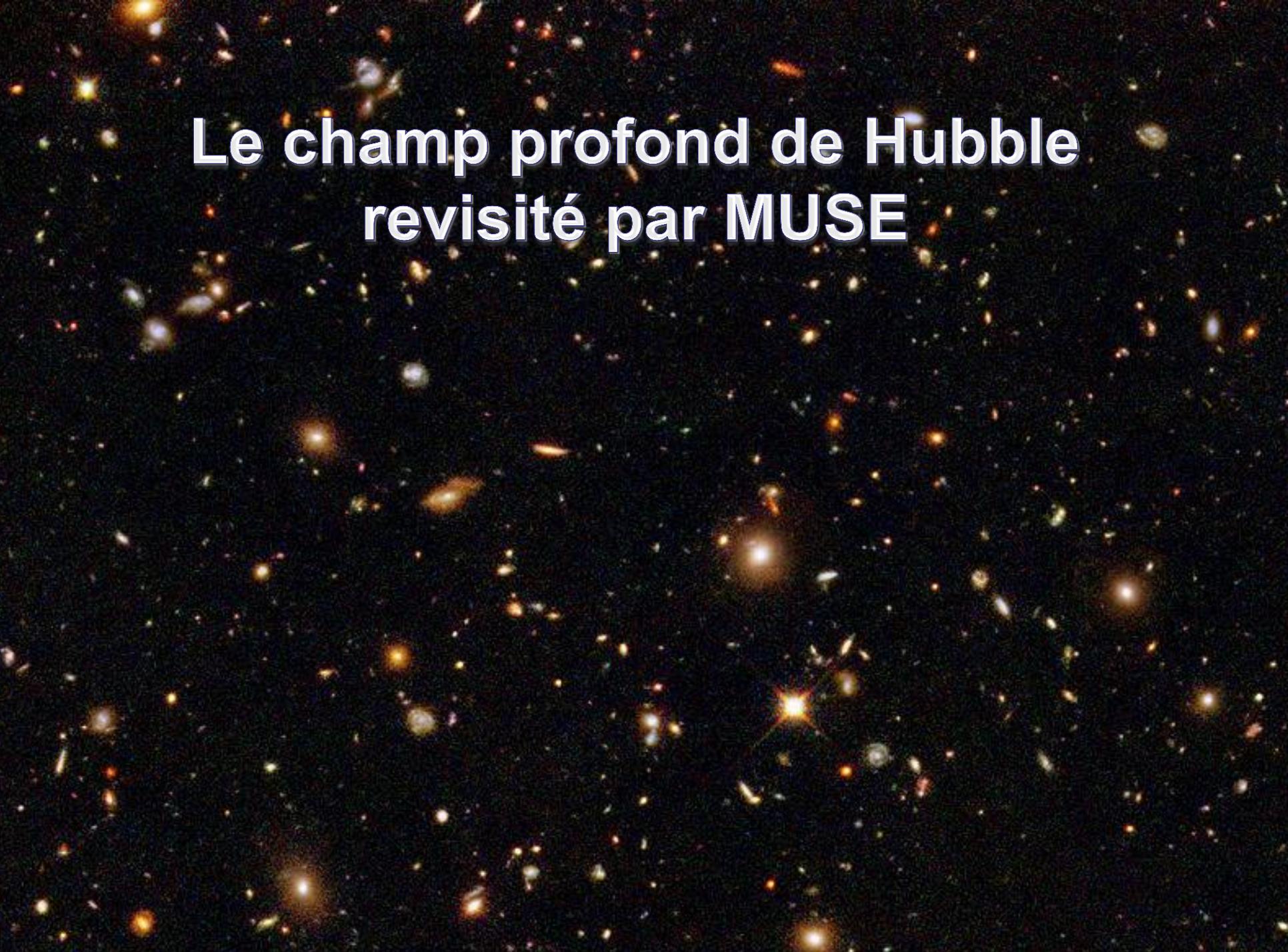


6705.00 A 6706.25 A 6707.50 A

Wavelength (Angstrom)
 $H\alpha$ (6563 A) $H\beta$ (4861 A) $H\gamma$ (4340 A)

M20 (1/12 strip)



The background of the slide is a vast field of galaxies, likely from the Hubble Deep Field. The galaxies are scattered across the frame, appearing in various colors including yellow, orange, red, and blue. Some are bright and clear, while others are faint and distant. The overall appearance is a rich, multi-colored population of galaxies.

**Le champ profond de Hubble
revisit  par MUSE**

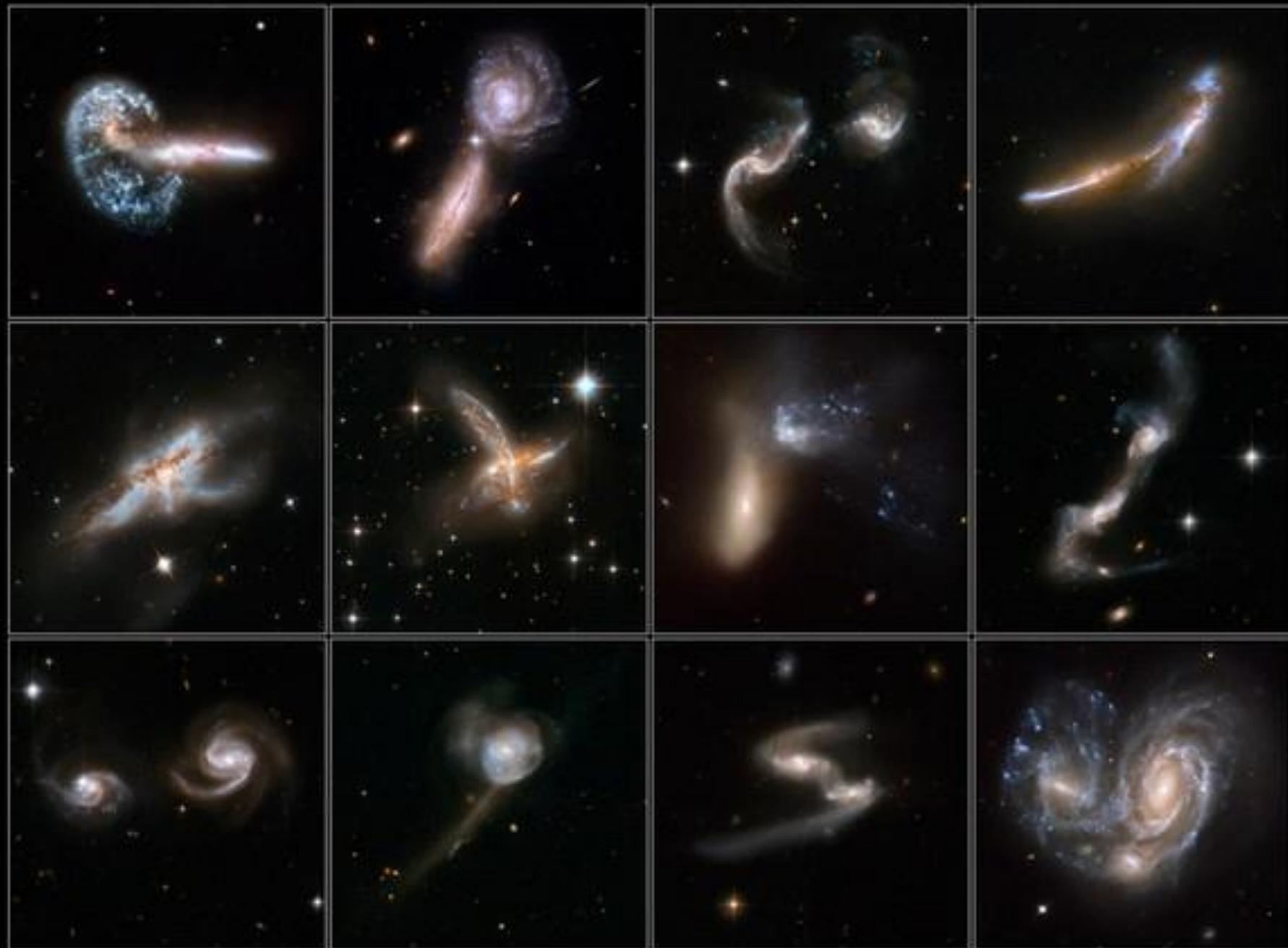
1995: le télescope Hubble observe l'Univers lointain





Interacting Galaxies

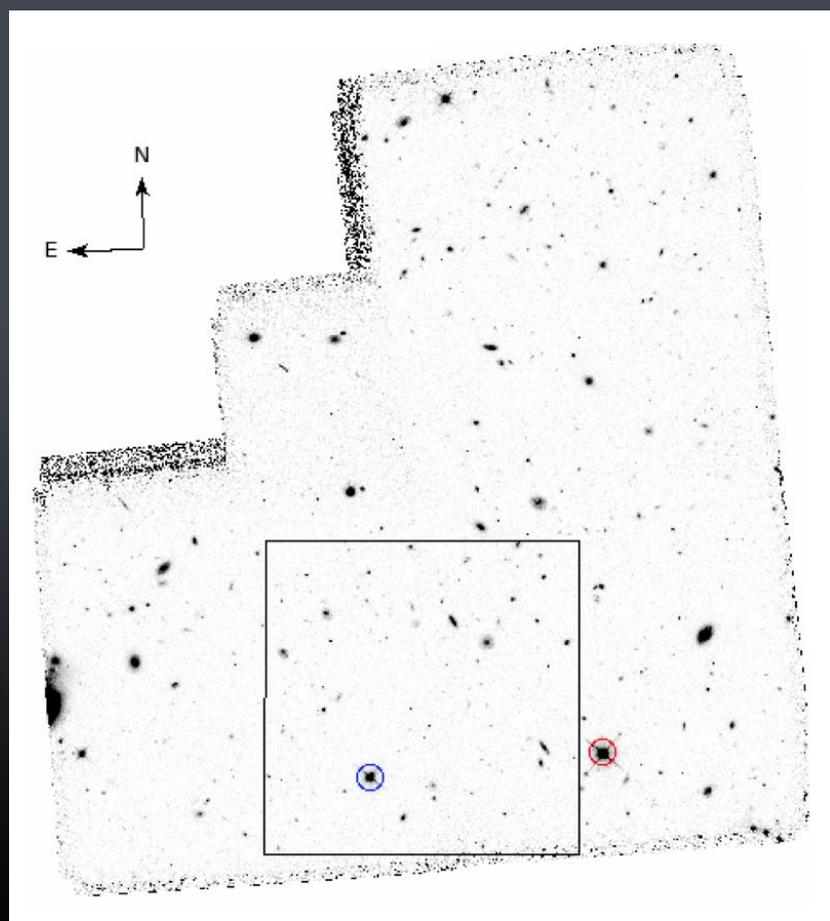
Hubble Space Telescope • ACS/WFC • WFPC2





Le champ profond de Hubble Sud

- Hubble:
 - Williams R. et al (2000), Casertano, S. et al. (2000)
 - Magnitude limite: $AB_{F814W} > 29$
- MUSE
 - Juillet 2014
 - 27 heures (54 exposures)

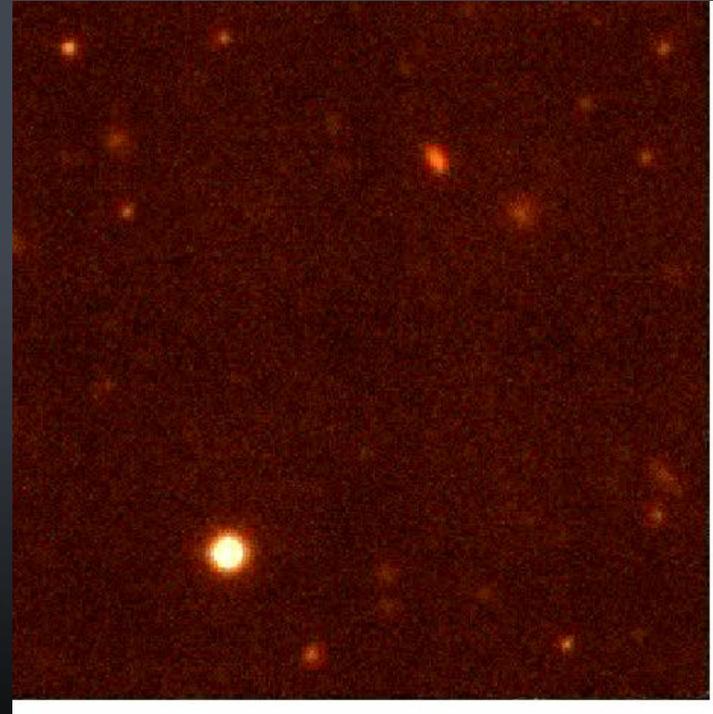




Visite du cube MUSE du champ profond de Hubble

Un cube d'Univers en
4000 images
Depuis le bleu: 480 nm
Jusqu'à l'infra-rouge: 930 nm

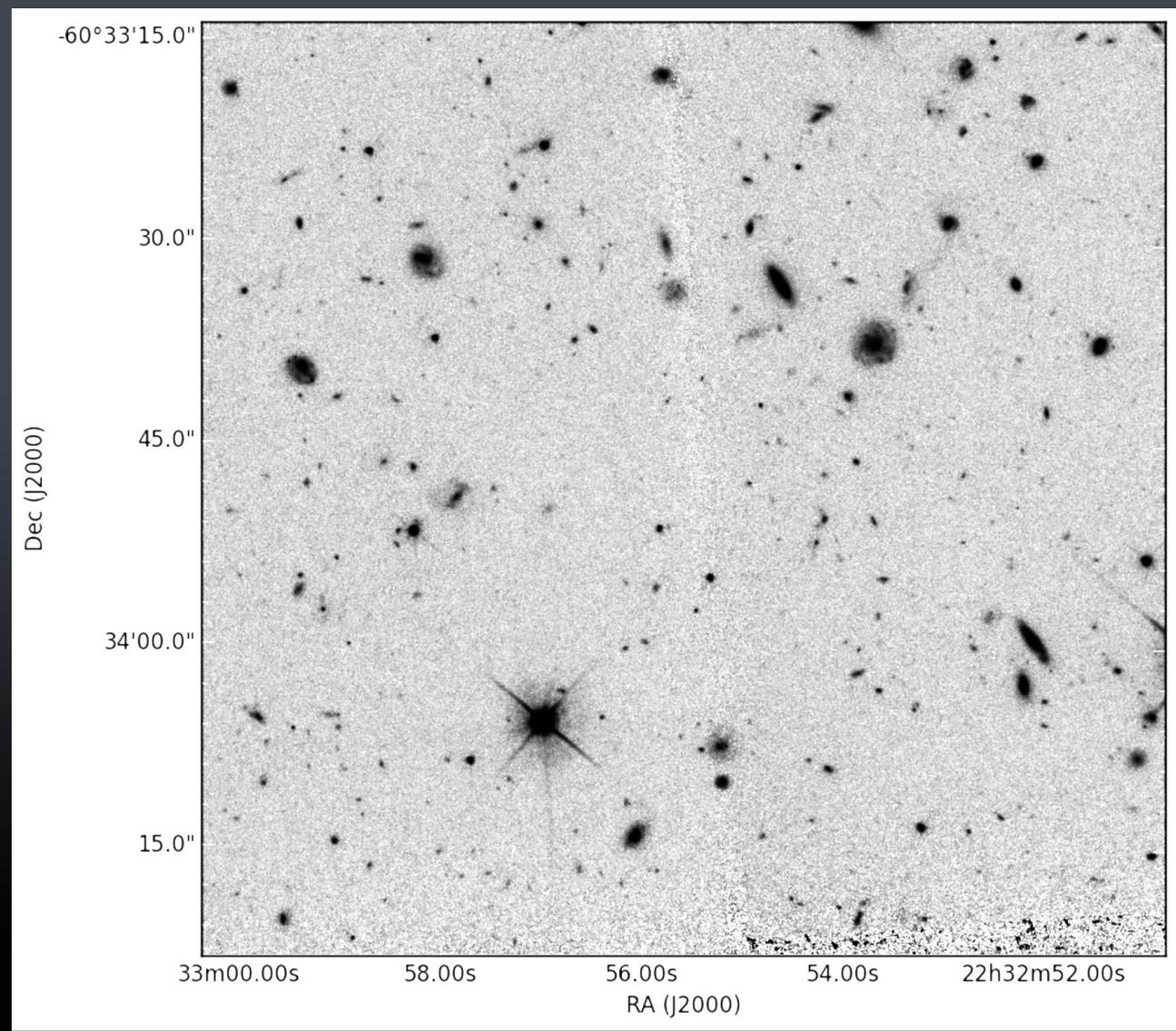
De $t=0$ à 12 milliards d'années (pour la raie de Lyman)





Census of MUSE HDFS Field

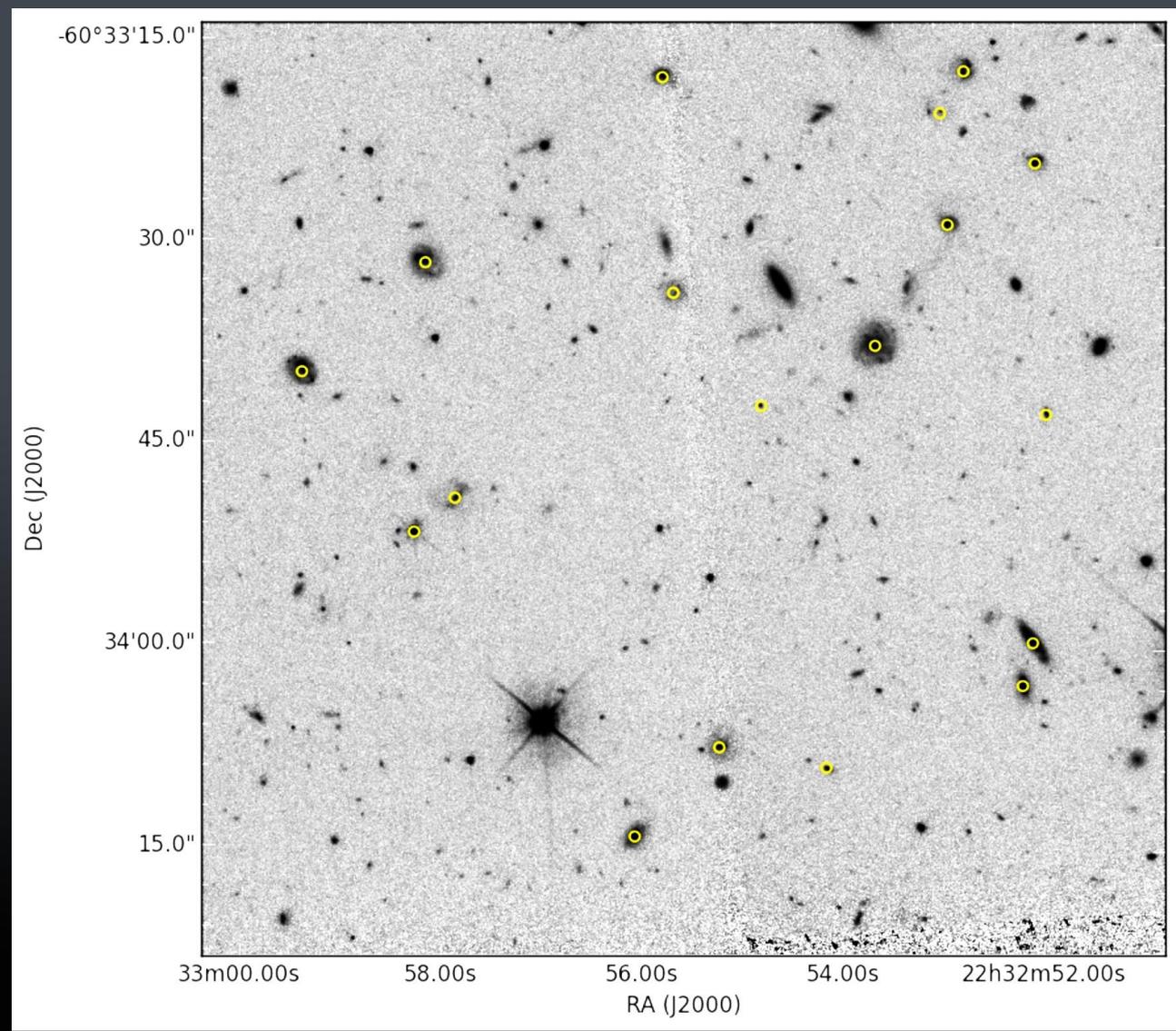
✓ HST WFPC2 F814W





Census of MUSE HDFS Field

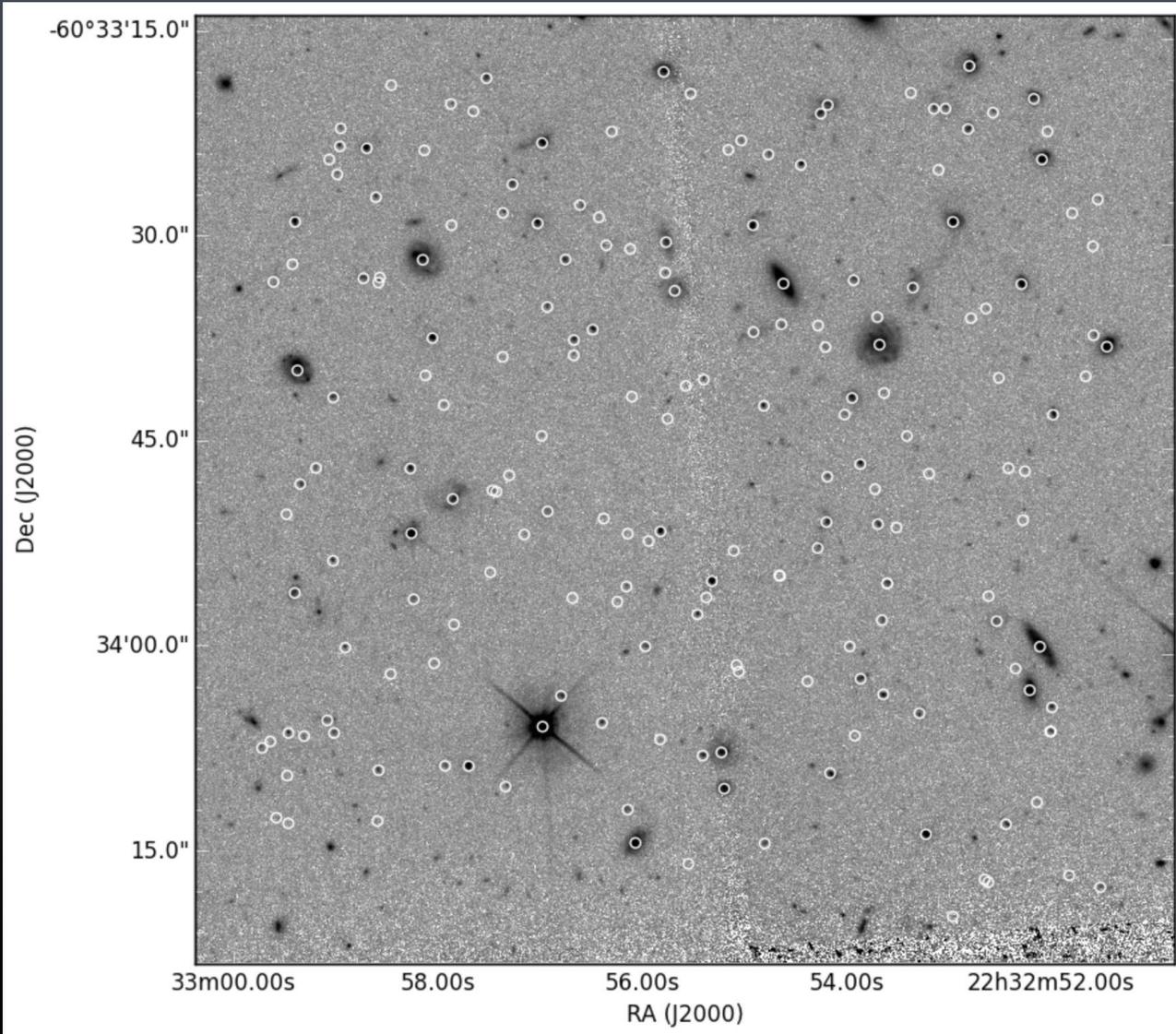
- ✓ HST WFPC2 F814W
- ✓ 18 Known Spectroscopic Redshifts





Census of MUSE HDFS Field

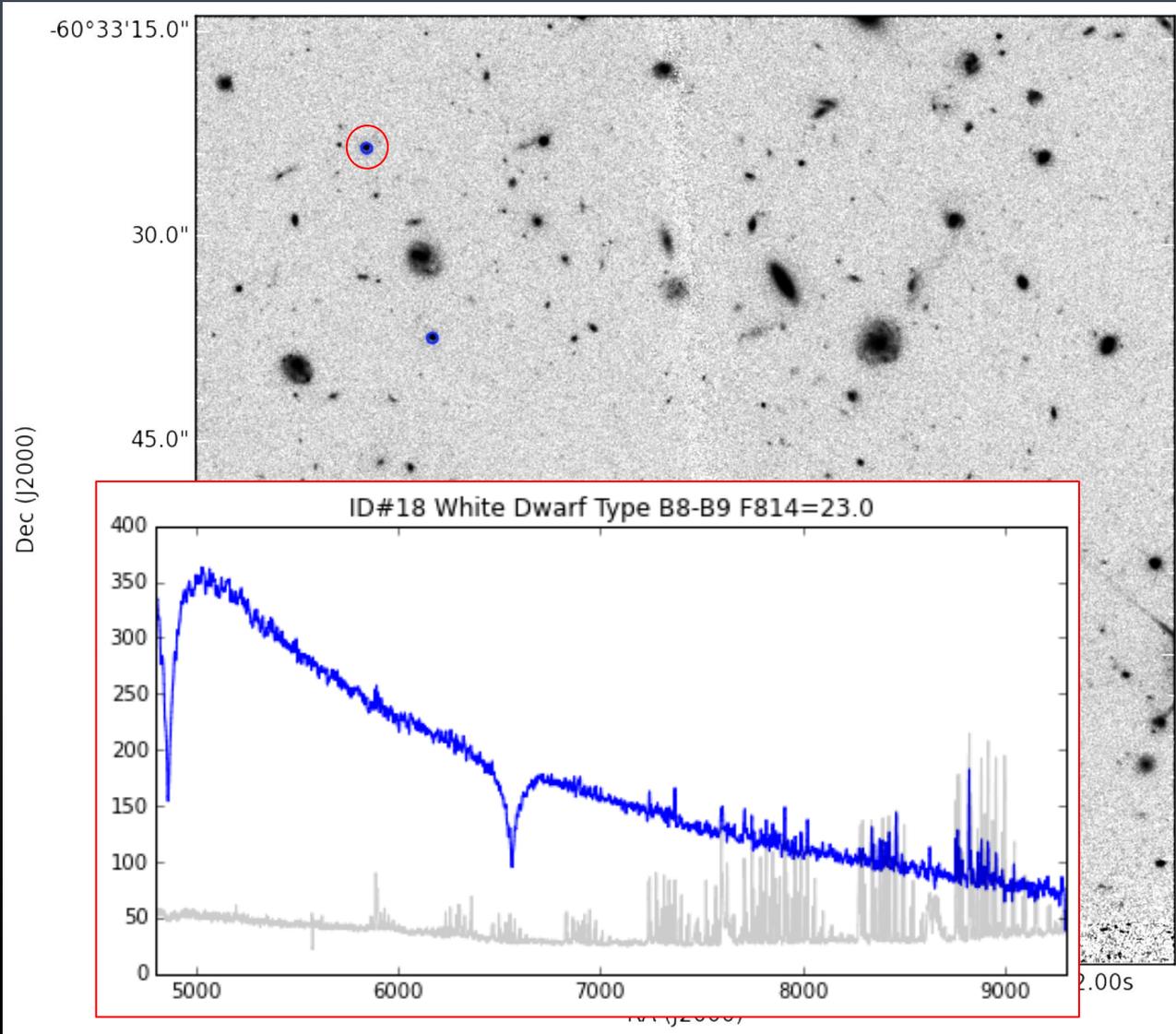
- ✓ HST WFPC2 F814W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube



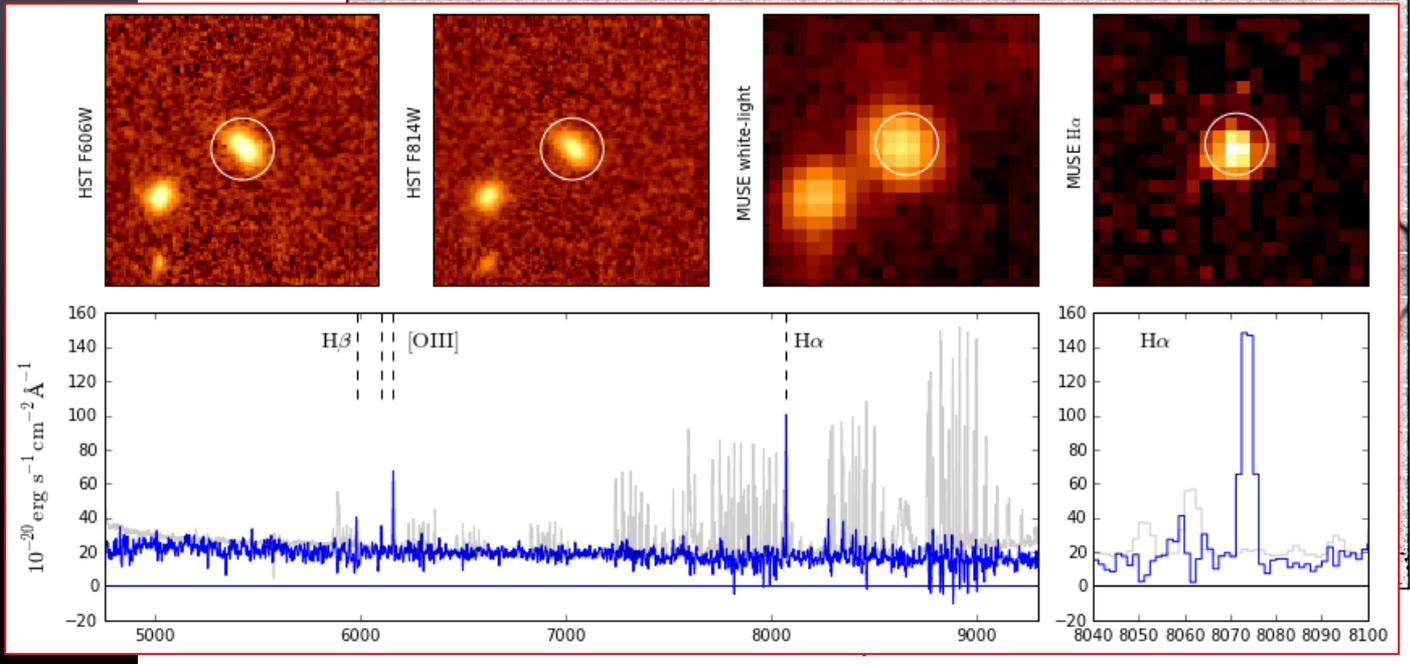
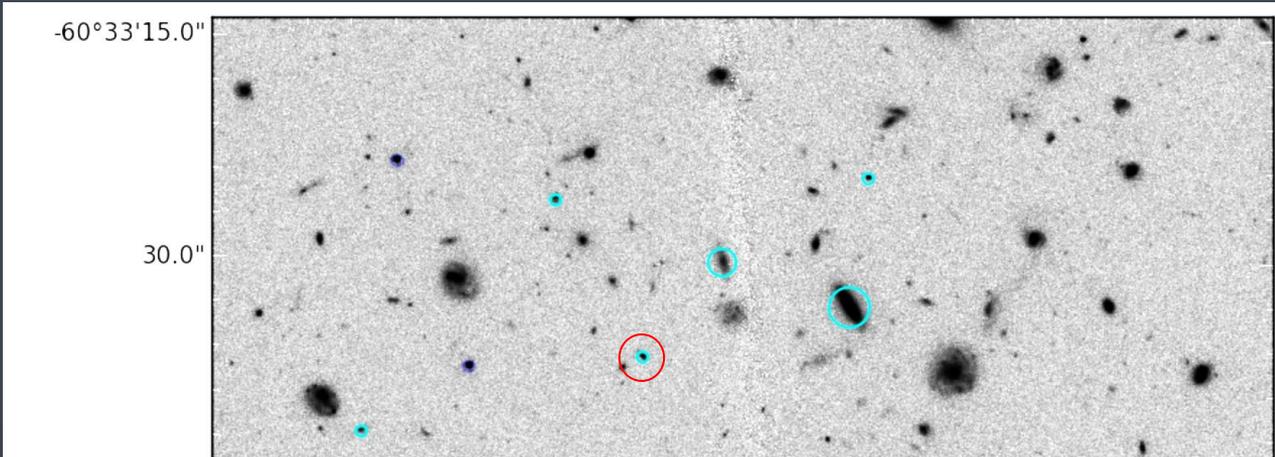


Census of MUSE HDFS Field

- ✓ HST WFPC2 F814W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
 - ✓ F814W = [18.6 – 23.9]
 - ✓ 7 already identified using proper motion (Kilic et al, 2005)



- ✓ HST WFPC2 F814W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
- ✓ 7 nearby galaxies
 - ✓ $Z = [0.12 - 0.28]$
 - ✓ $I_{814} = [21.2 - 25.9]$

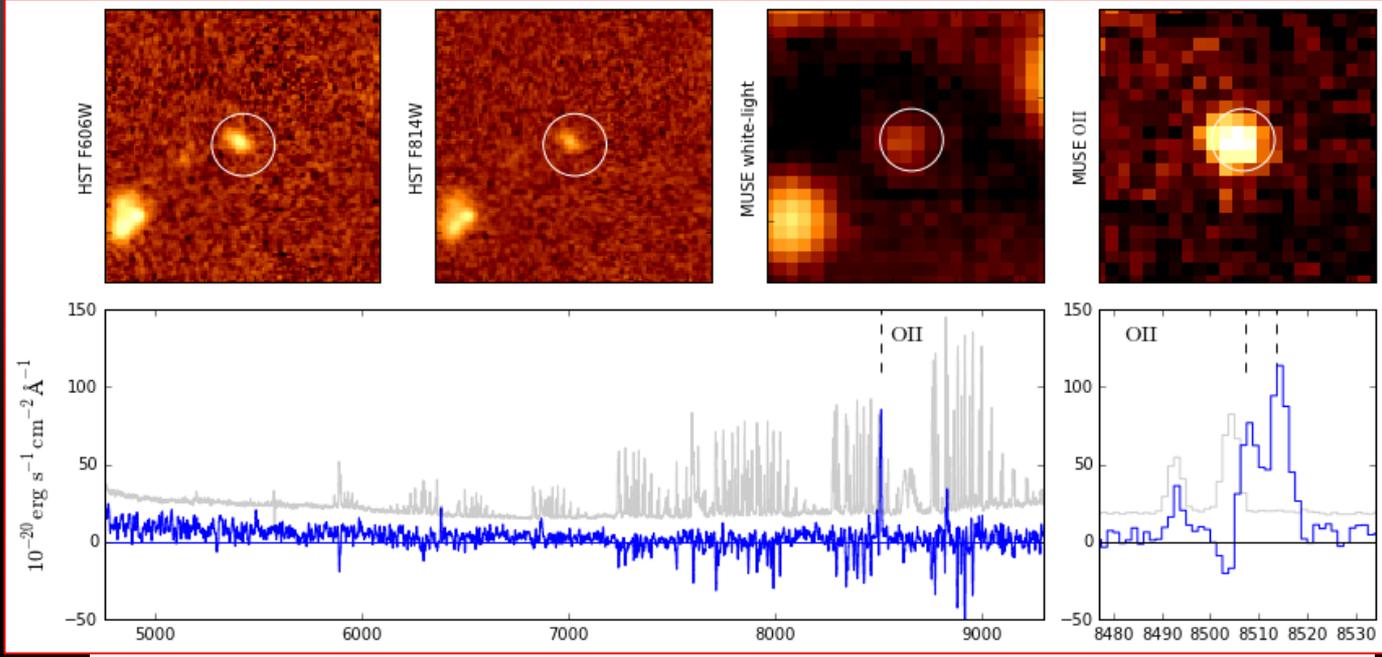
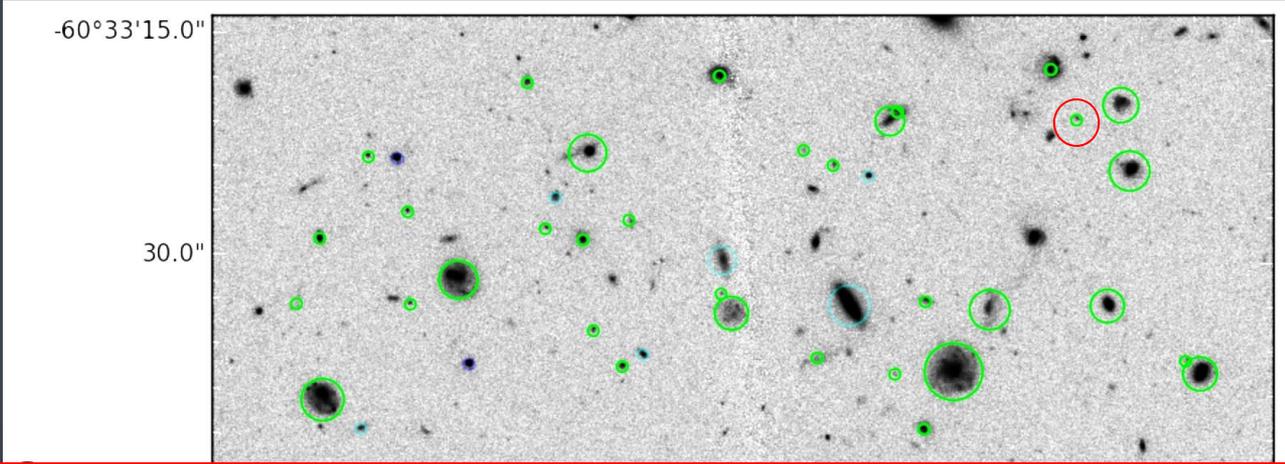


ID#53

$Z = 0.23$
 $I_{814} = 24.9$
 $M \approx 2 \cdot 10^7 M_{\odot}$

Census of MUSE HDFS Field

- ✓ HST WFPC2 F814W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
 - ✓ $Z = [0.29 - 1.48]$
 - ✓ $I_{814} = [21.5 - 28.5]$



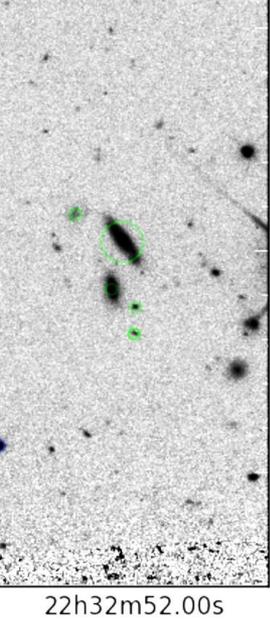
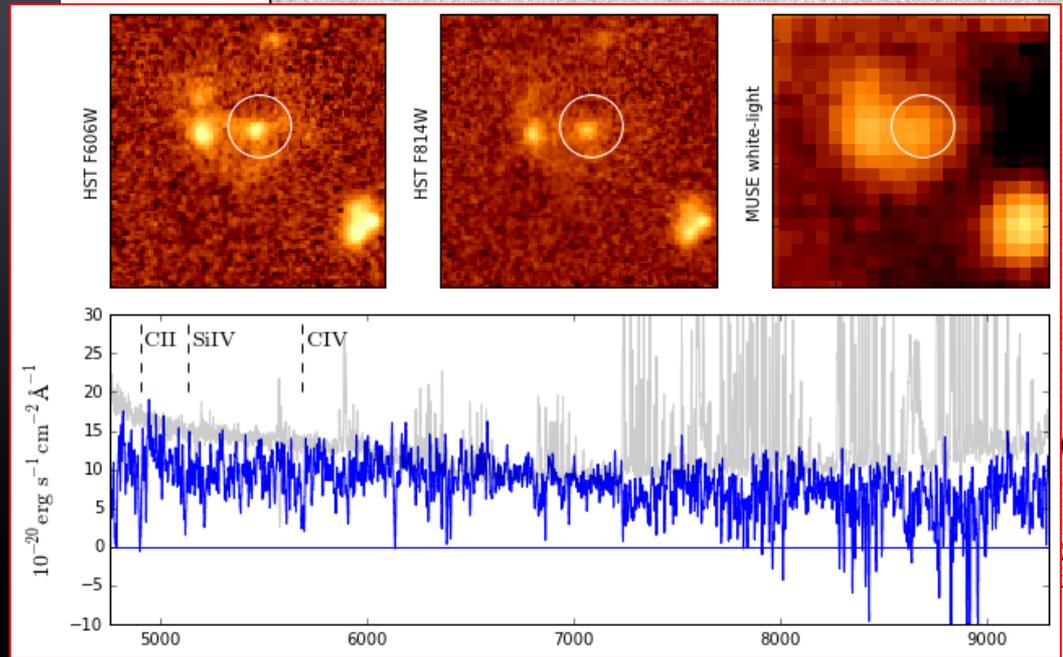
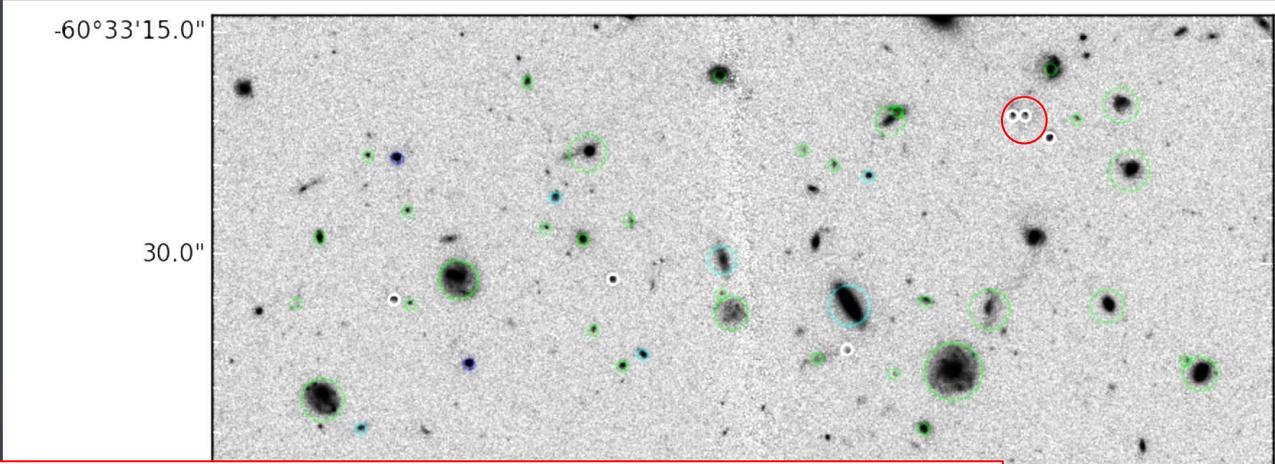
ID#160

$Z = 1.28$
 $I_{814} = 26.7$
 $M \approx 2 \cdot 10^9 M_{\odot}$

Census of MUSE HDFS Field

- ✓ HST WFPC2 F814W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
- ✓ 10 absorption lines galaxies

- ✓ $Z = [0.83 - 2.90]$
- ✓ $I_{814} = [24.9 - 26.2]$

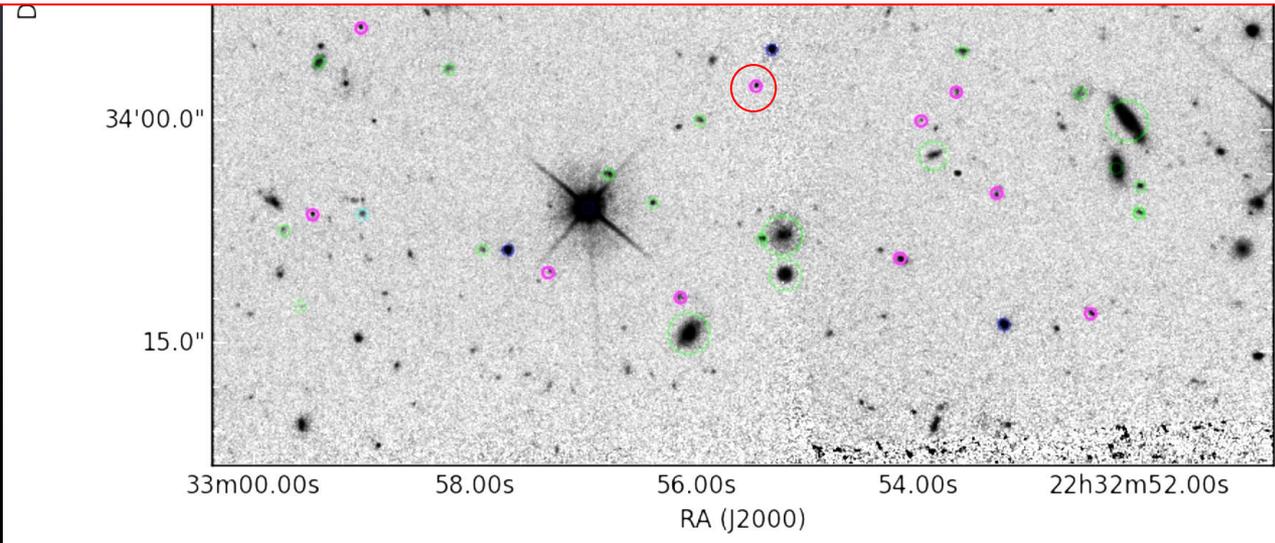
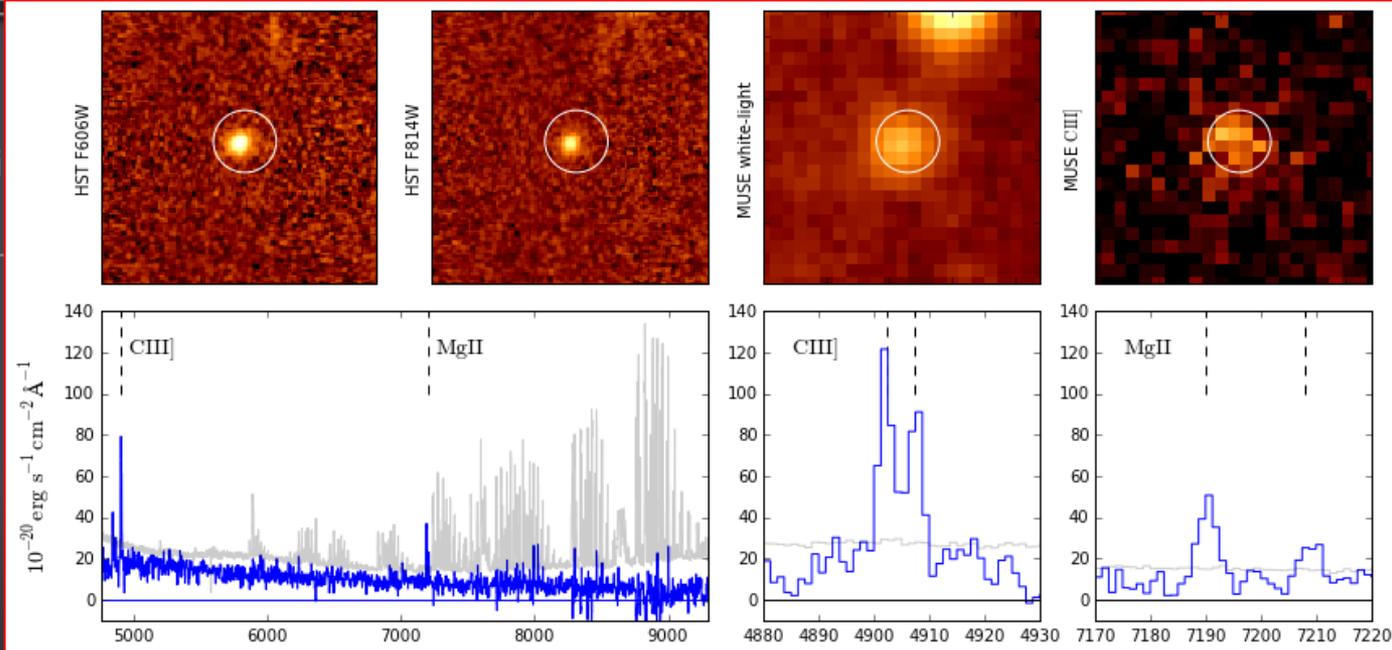


ID#55

$Z = 2.67$
 $I_{814} = 24.8$

Census of MUSE HDFS Field

- ✓ HST WFPC2 F814W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
- ✓ 10 absorption lines galaxies
- ✓ 12 CIII] 1909 emitters
 - ✓ $Z = [1.57 - 2.67]$
 - ✓ $I_{814} = [24.6 - 27.2]$

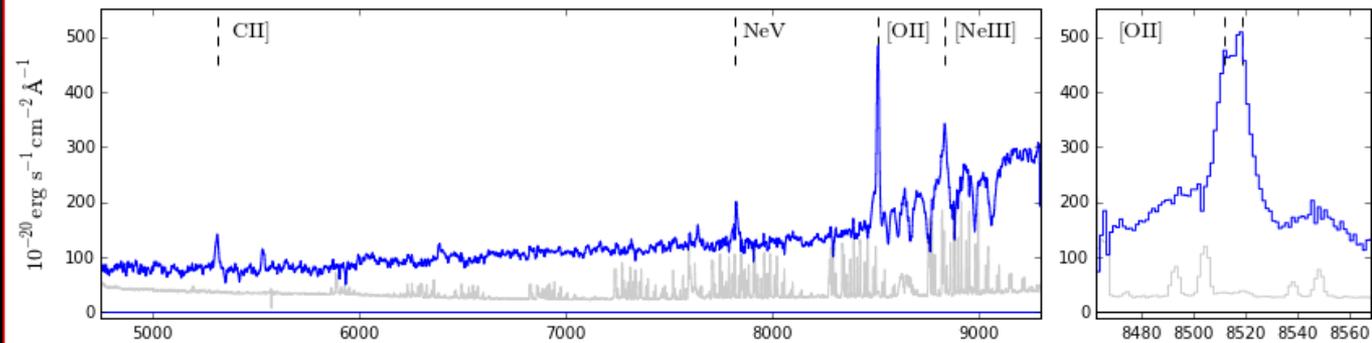
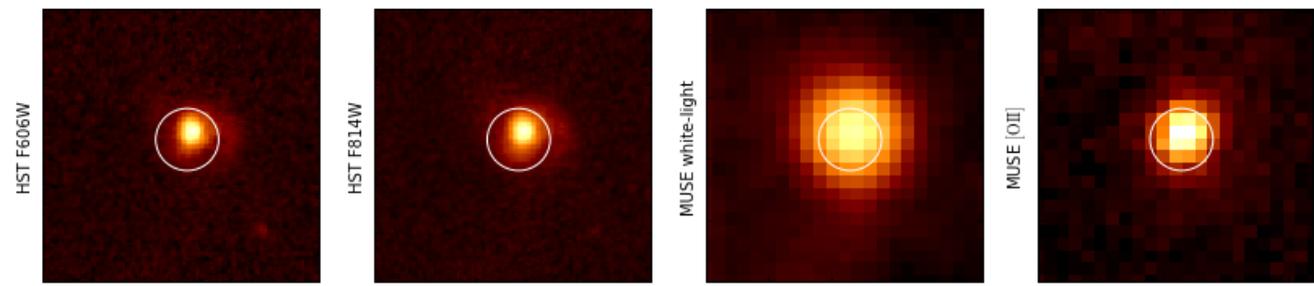
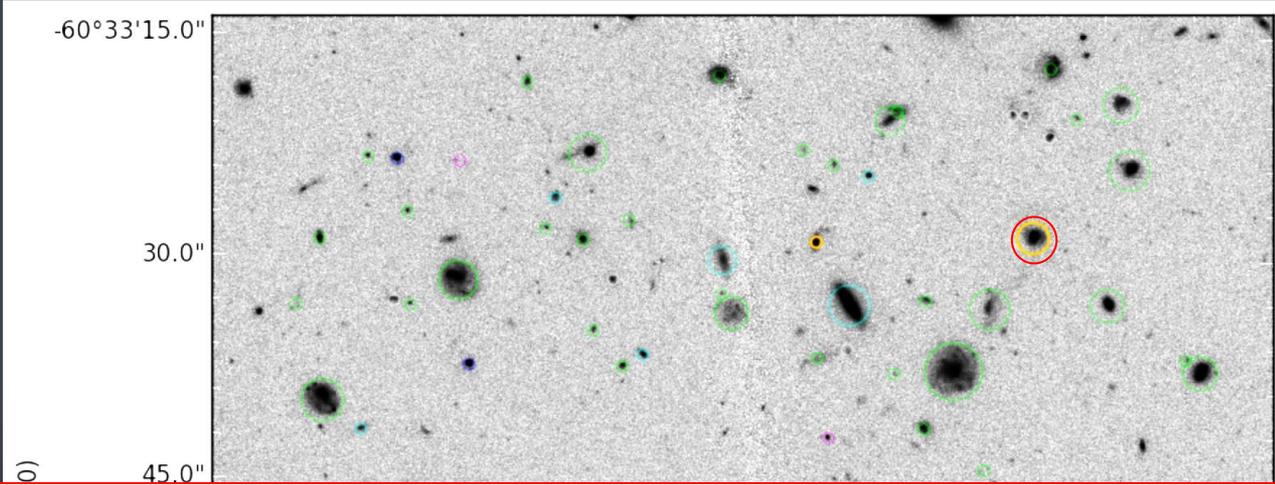


ID#97

$Z = 1.57$
 $I_{814} = 25.9$

Census of MUSE HDFS Field

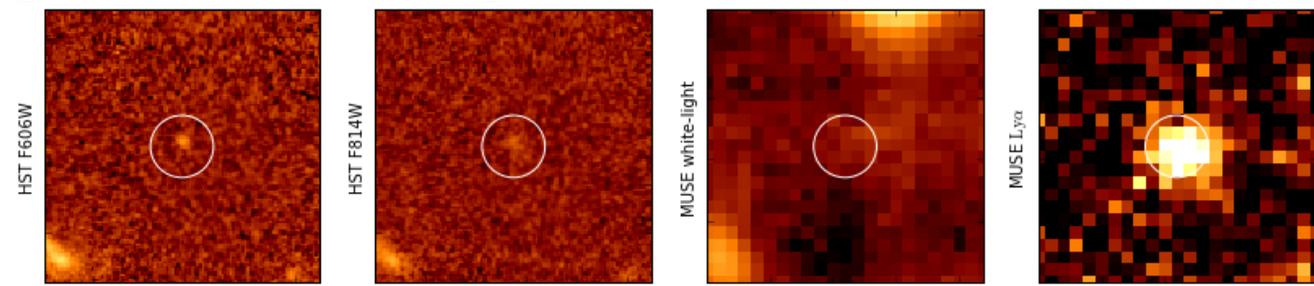
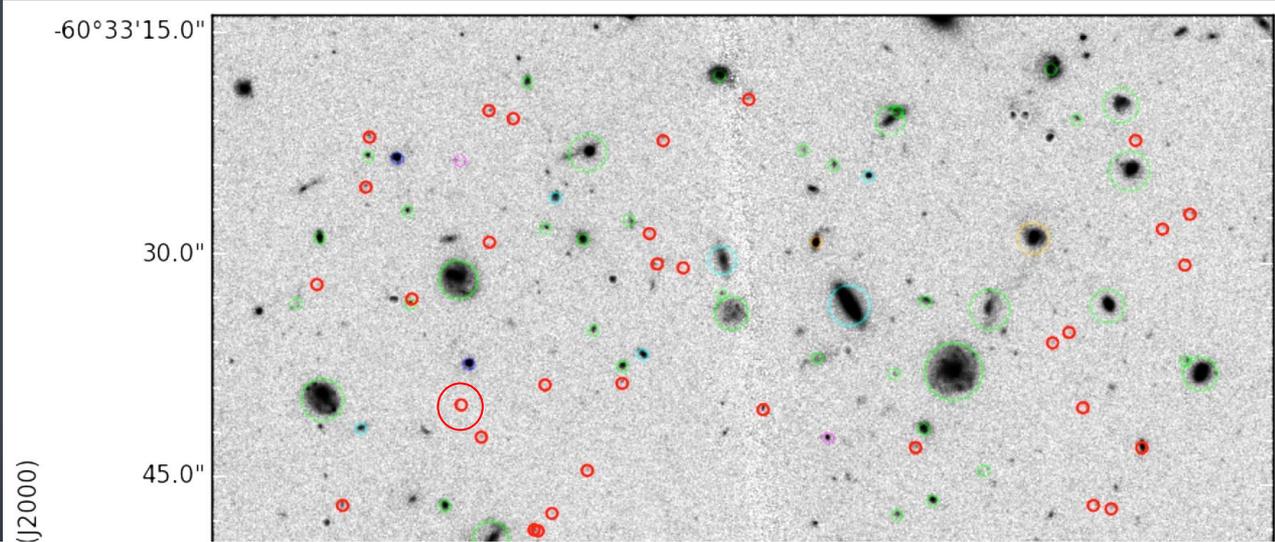
- ✓ HST WFPC2 F814W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
- ✓ 10 absorption lines galaxies
- ✓ 12 CIII] 1909 emitters
- ✓ 2 AGNs
 - ✓ $Z = 1.28$
 - ✓ $I_{814} = 22.6, 23.6$



ID#10

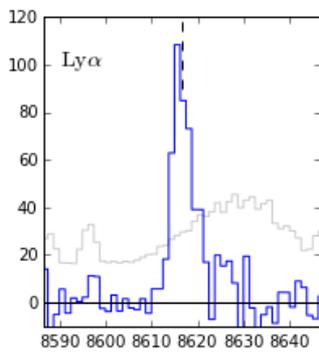
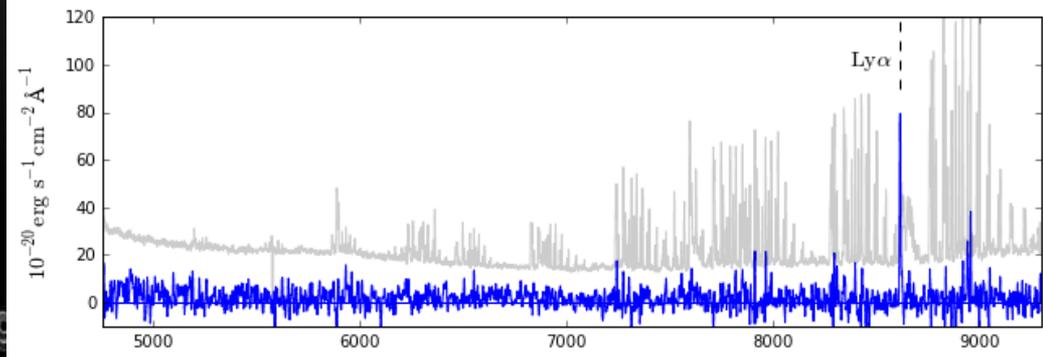
$Z = 1.28$
 $I_{814} = 22.5$

- ✓ HST WFPC2 F814W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
- ✓ 10 absorption lines galaxies
- ✓ 12 CIII] 1909 emitters
- ✓ 2 AGNs
- ✓ 63 Ly α emitters
 - ✓ $Z = [2.95 - 6.28]$
 - ✓ $I_{814} = [24.5 - 29.6]$



ID#290

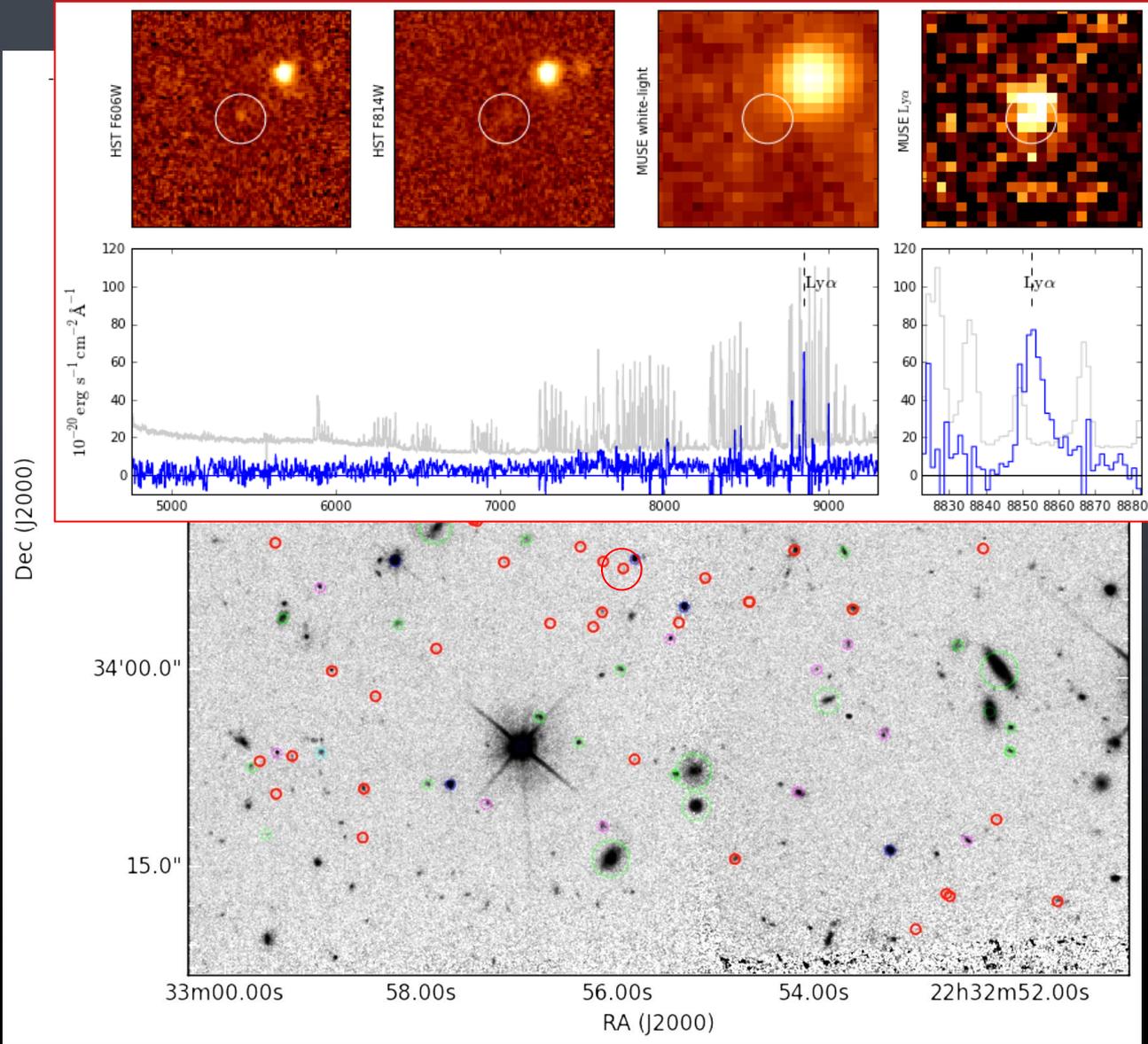
$Z = 6.08$
 $I_{814} = 27.8$



- ✓ HST WFPC2 F814W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
- ✓ 10 absorption lines galaxies
- ✓ 12 CIII] 1909 emitters
- ✓ 2 AGNs
- ✓ 63 Ly α emitters
 - ✓ $Z = [2.95 - 6.28]$
 - ✓ $I_{814} = [24.5 - 29.6]$

ID#430

$Z = 6.28$
 $I_{814} = 28.6$

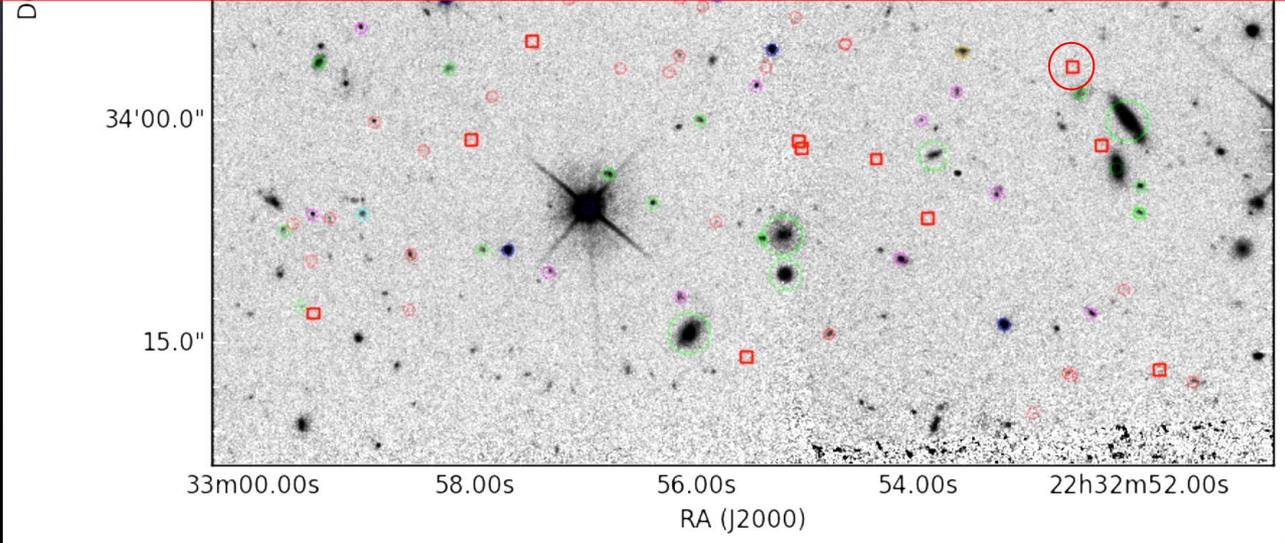
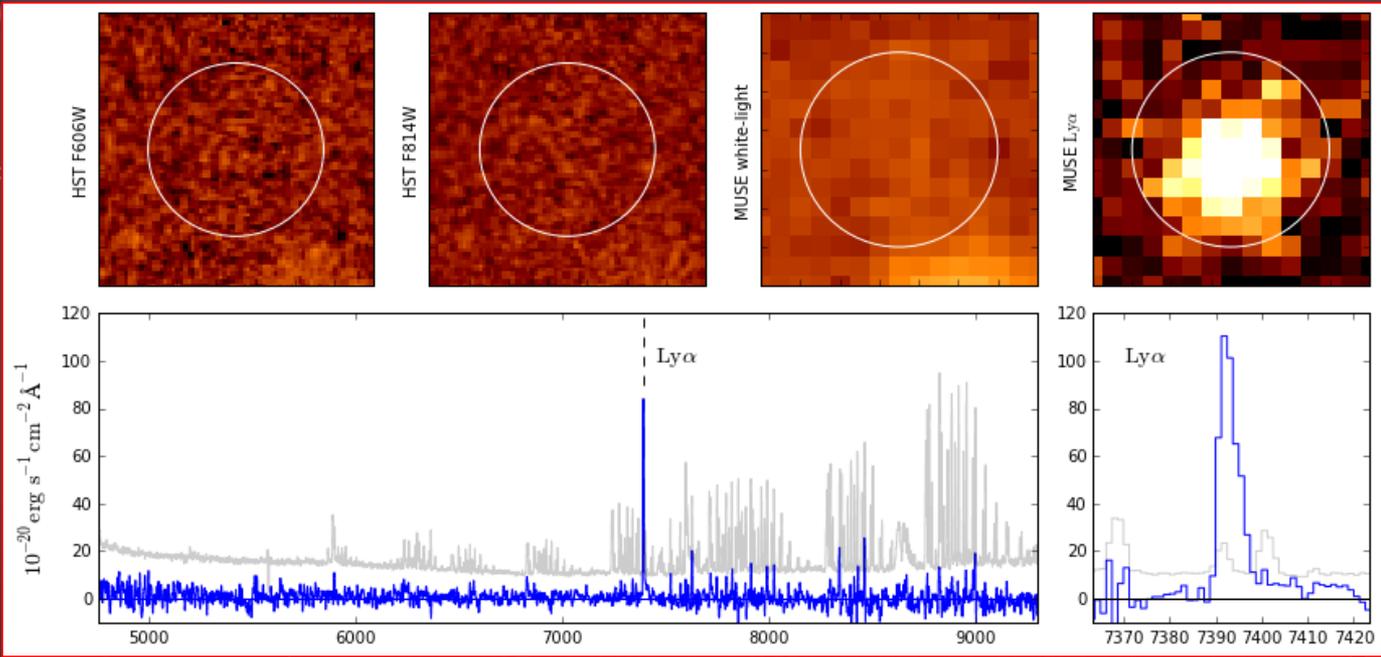


Census of MUSE HDFS Field

ID#553

$Z = 5.08$
 $I_{814} > 29.8$

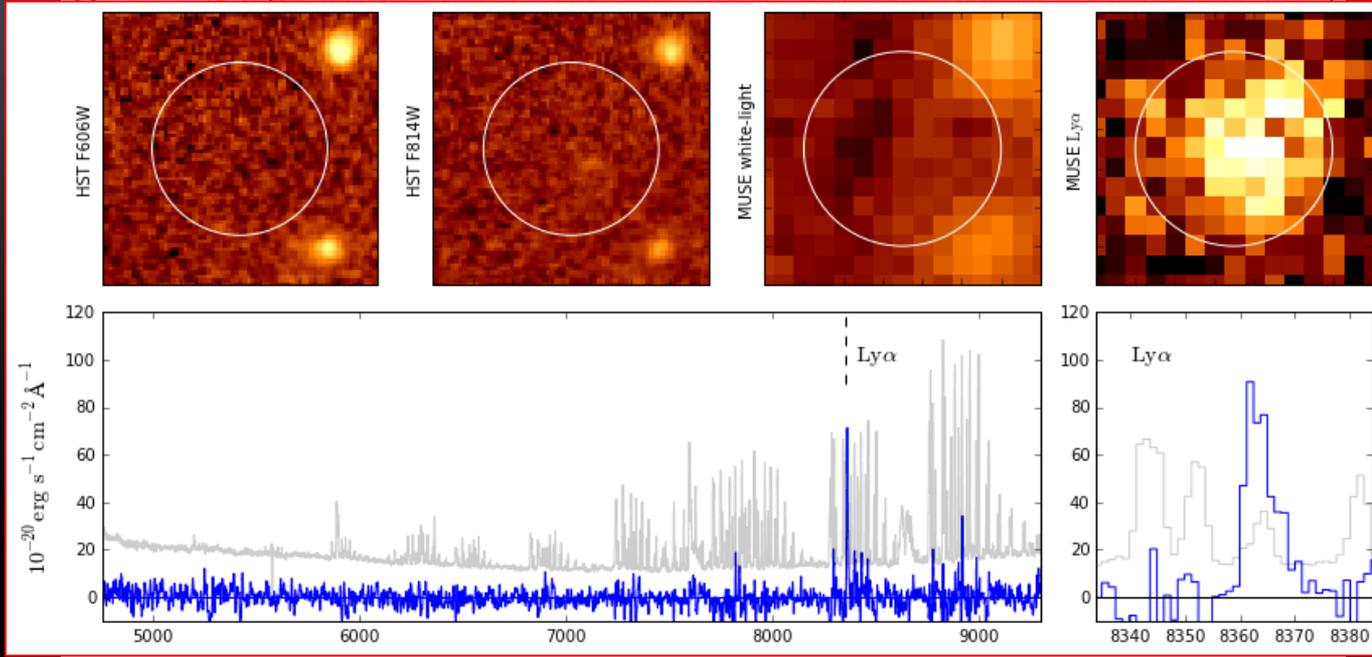
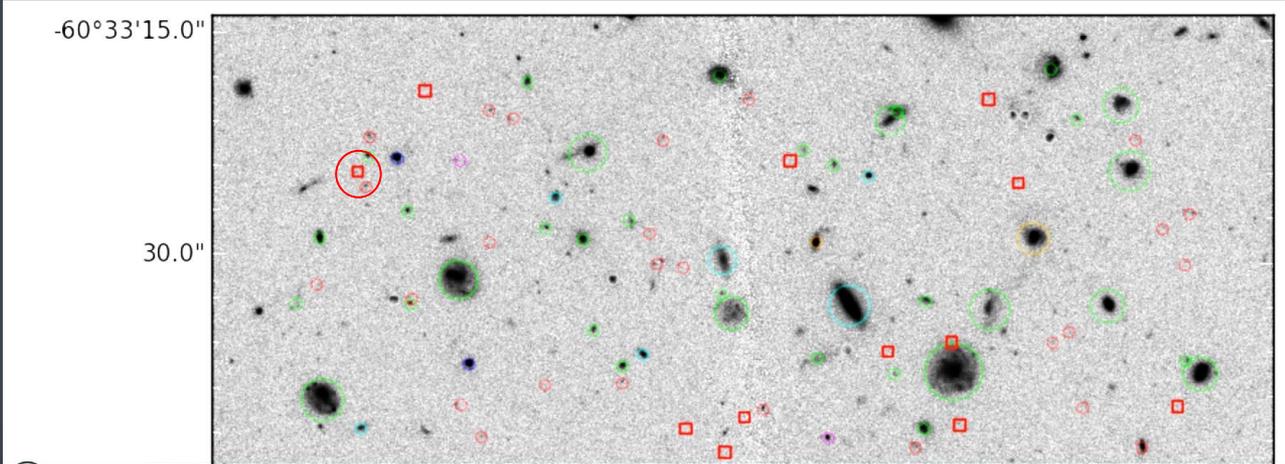
- ✓ HDFS
- ✓ 1000 galaxies
- ✓ 100 Ly α emitters
- ✓ 1000 Ly α emitters
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
- ✓ 10 absorption lines galaxies
- ✓ 12 CIII] 1909 emitters
- ✓ 2 AGNs
- ✓ 63 Ly α emitters
- ✓ 26 Ly α emitters without HST counterpart
 - ✓ $Z = [3.12 - 6.27]$
 - ✓ $I_{814} > 29.8$



Census of MUSE HDFS Field

ID#560
 $Z = 5.88$
 $I_{814} > 29.8$

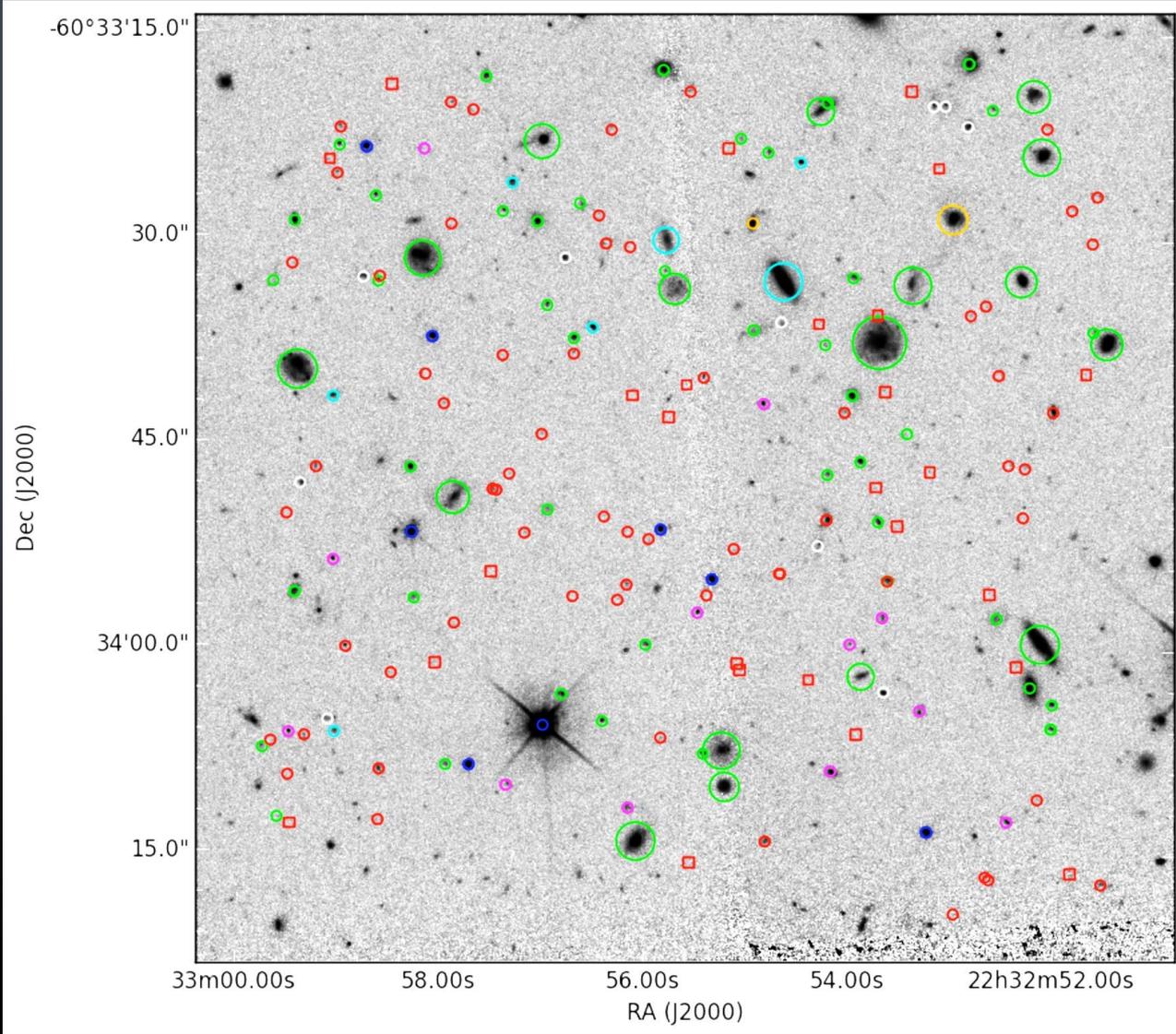
- ✓ HST
- ✓ 18 K
- Red
- ✓ 189
- MUSE
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
- ✓ 10 absorption lines galaxies
- ✓ 12 CIII] 1909 emitters
- ✓ 2 AGNs
- ✓ 63 Ly α emitters
- ✓ 26 Ly α emitters without HST counterpart
 - ✓ $Z = [3.12 - 6.27]$
 - ✓ $I_{814} > 29.8$



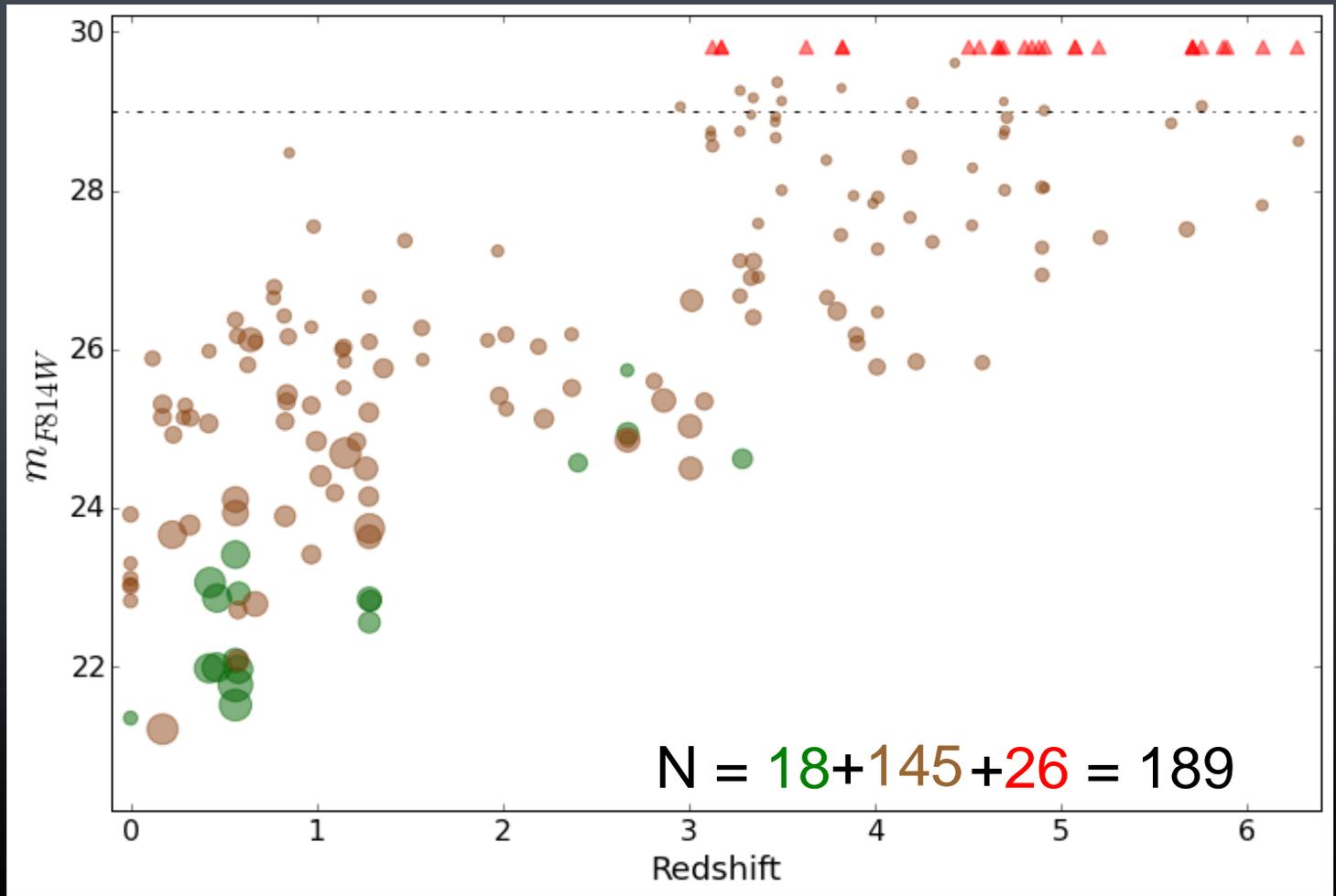


Census of MUSE HDFS Field

- ✓ HST WFPC2 F812W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
- ✓ 10 absorption lines galaxies
- ✓ 12 CIII] 1909 emitters
- ✓ 2 AGNs
- ✓ 89 Ly α emitters

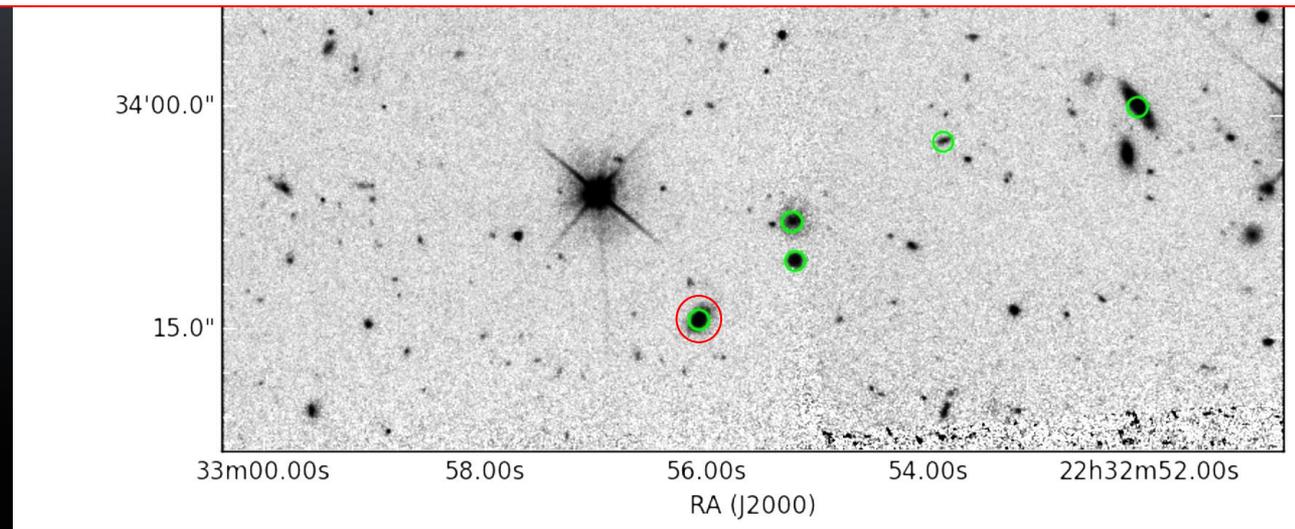
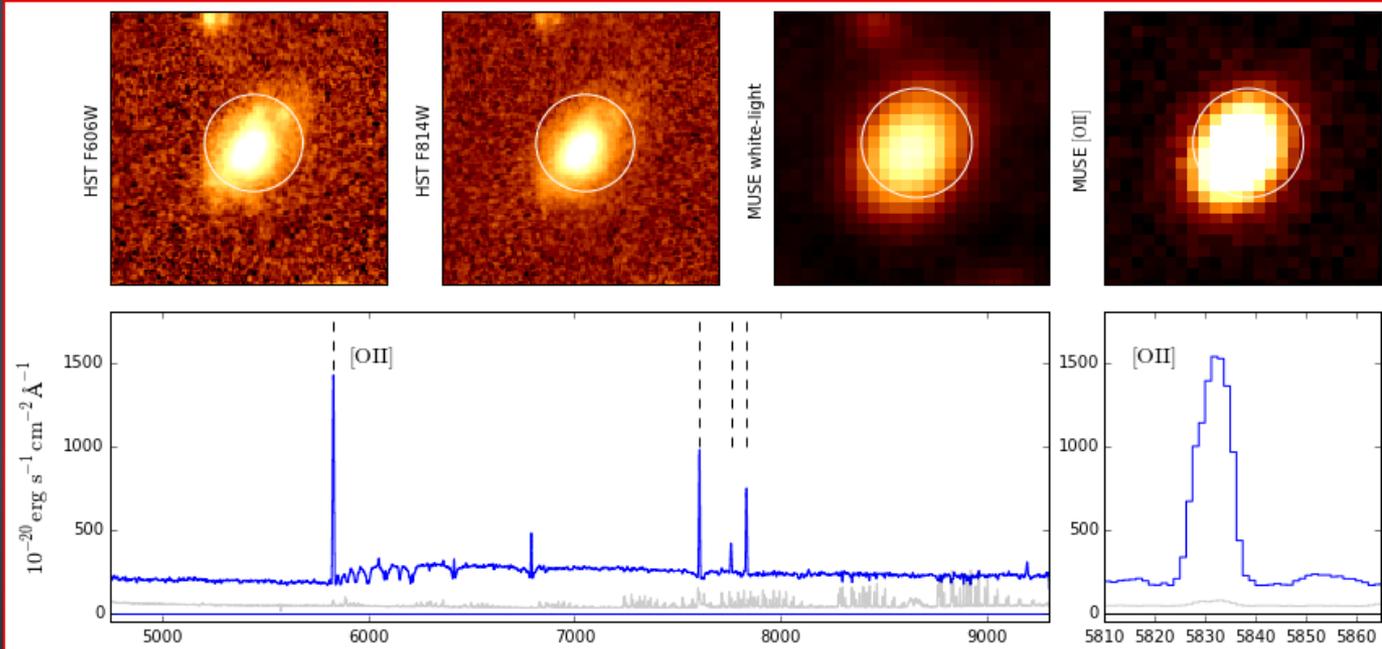


Distance et brillance des galaxies



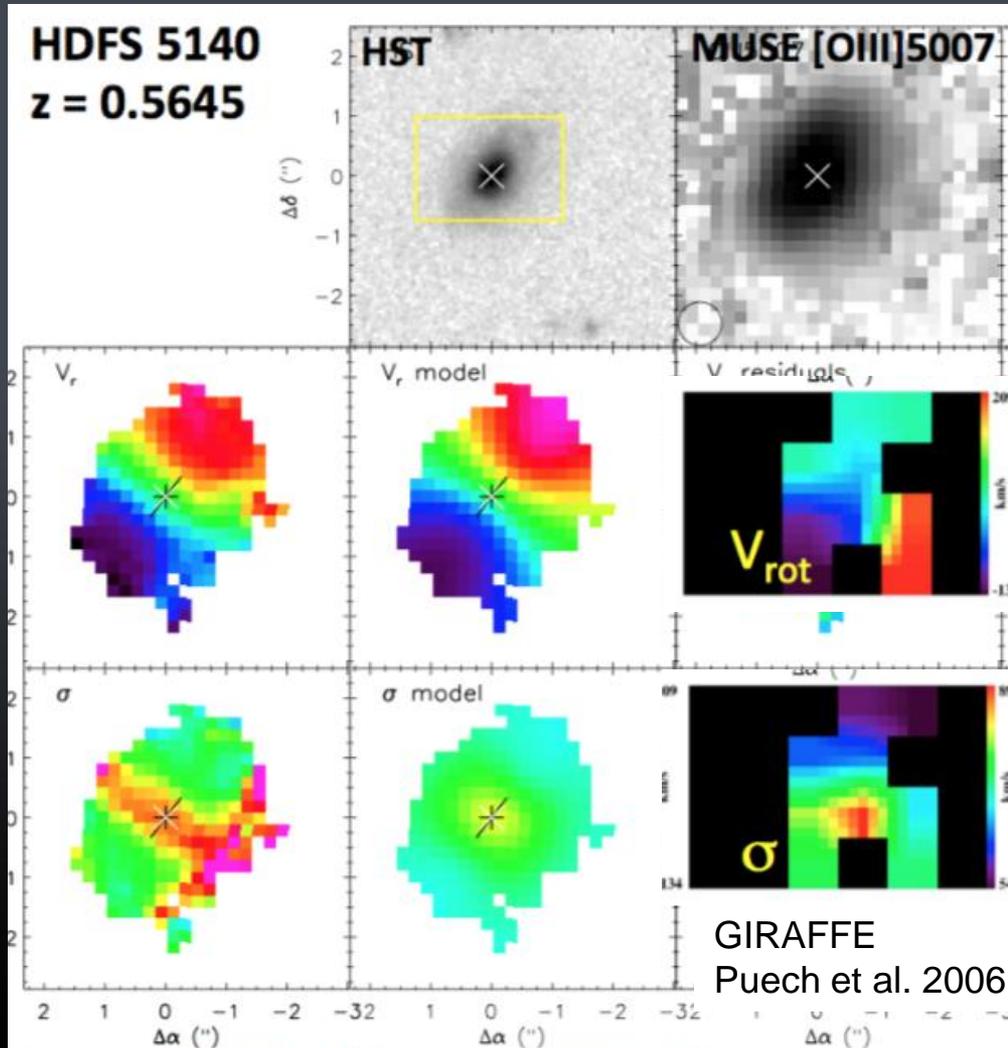
- ✓ HST WFPC2 F812W
- ✓ 18 Known Spectroscopic Redshifts
- ✓ 189 sources identified in MUSE data cube
- ✓ 8 stars
- ✓ 7 nearby galaxies
- ✓ 61 [OII] 3727 emitters
- ✓ 10 absorption lines galaxies
- ✓ 12 CIII] 1909 emitters
- ✓ 2 AGNs
- ✓ 89 Ly α emitters

- ✓ 20 Spatially Resolved Galaxies



ID#9

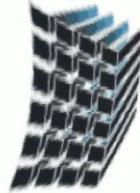
Z = 0.56
 $I_{814} = 22.1$



ID#9

$Z = 0.56$
 $I_{814} = 22.1$

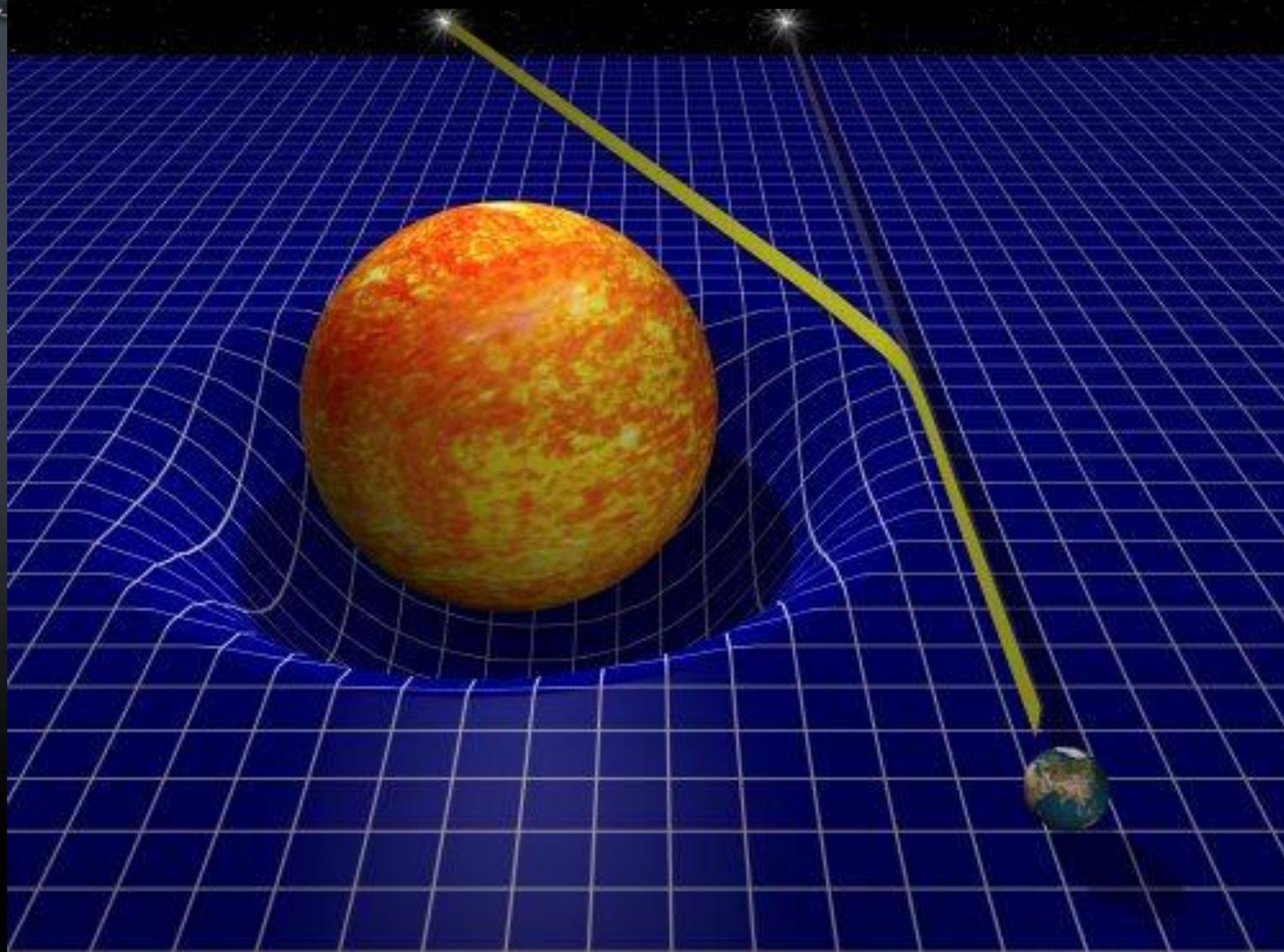
LES MIRAGES DE

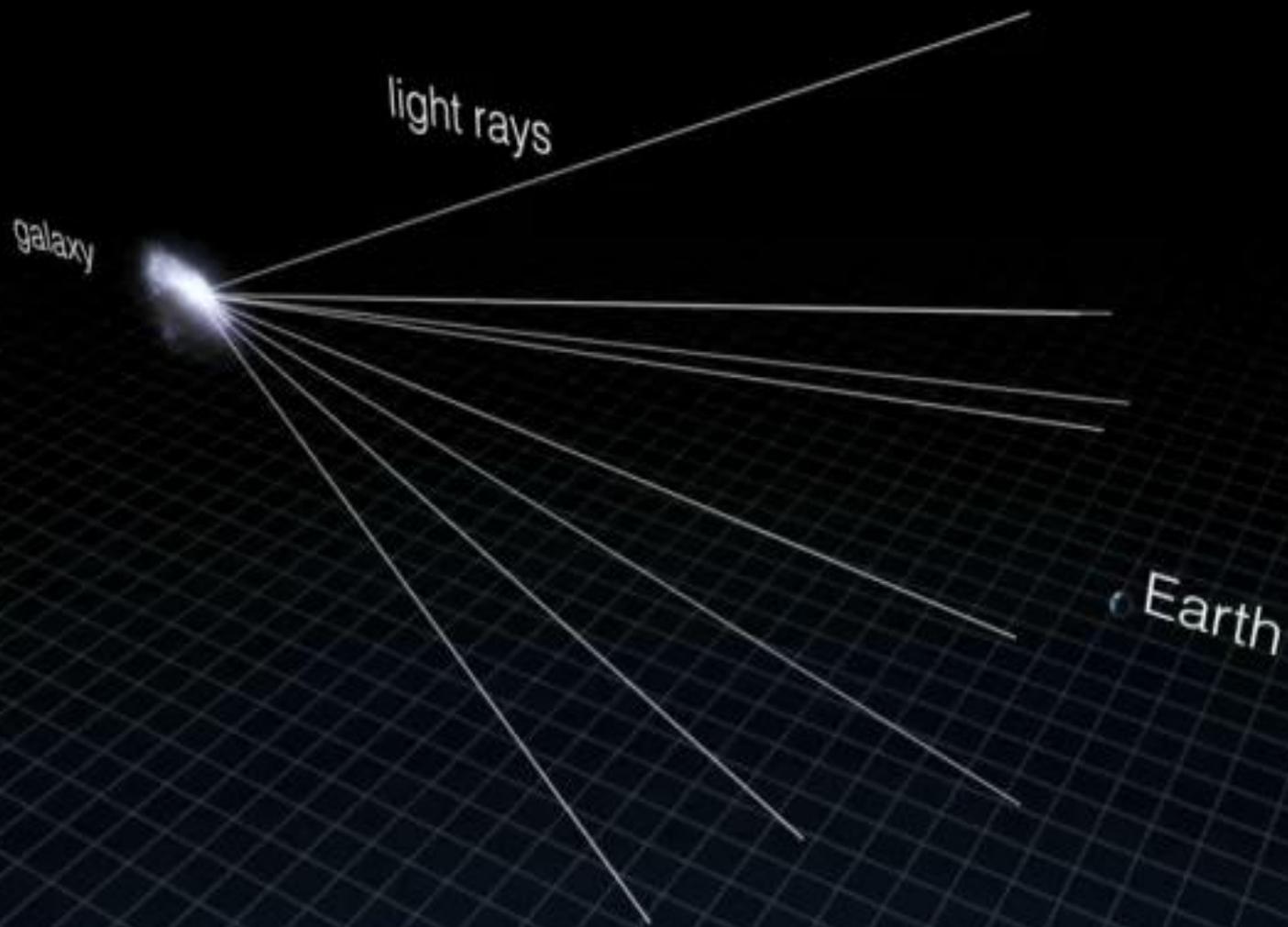


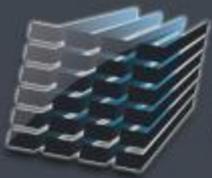
MUSE
multi unit spectroscopic explorer

Position réelle

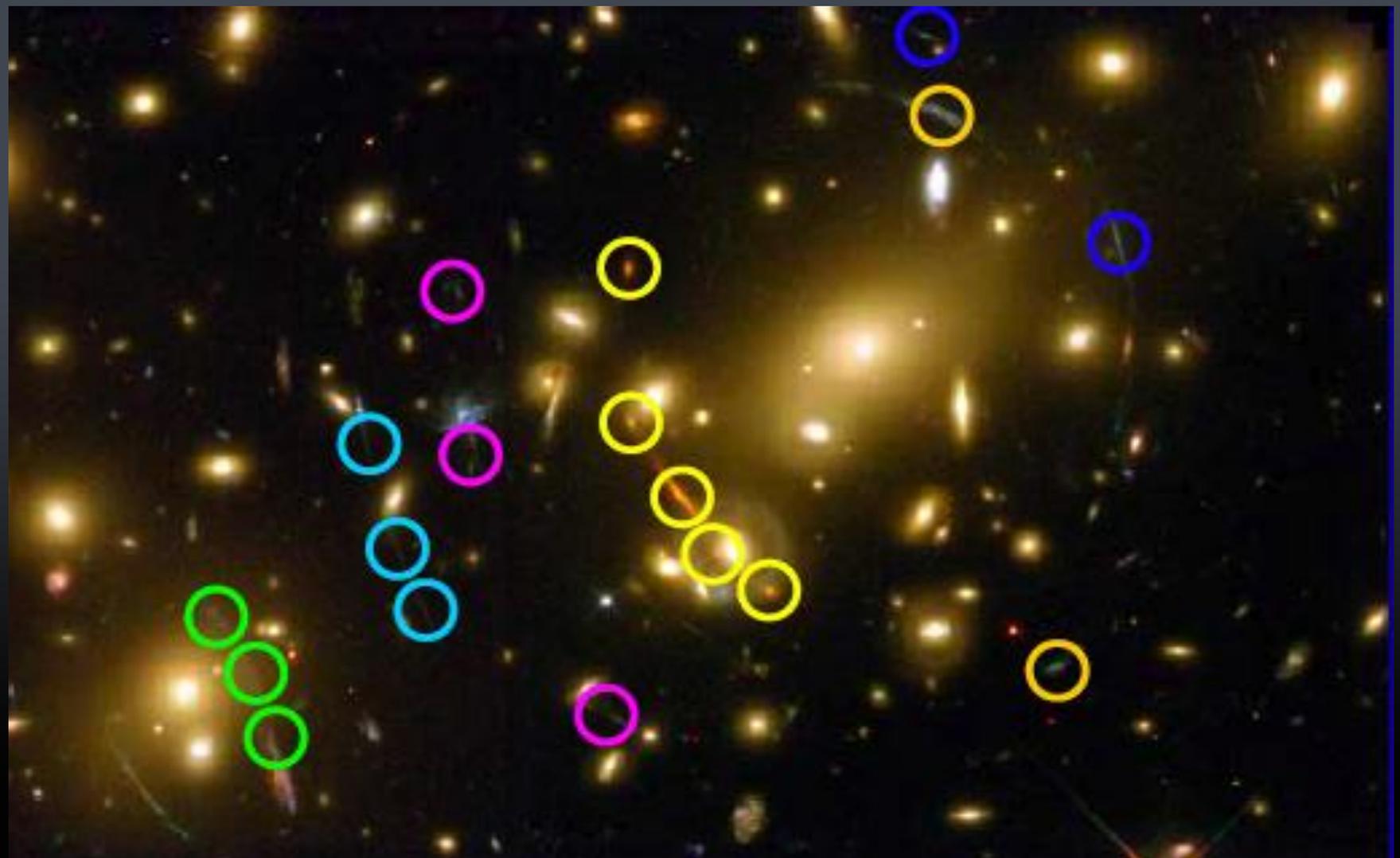
Position observée



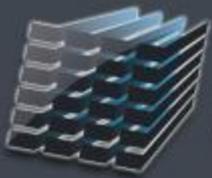




MUSE Modèles d'amas-lentilles

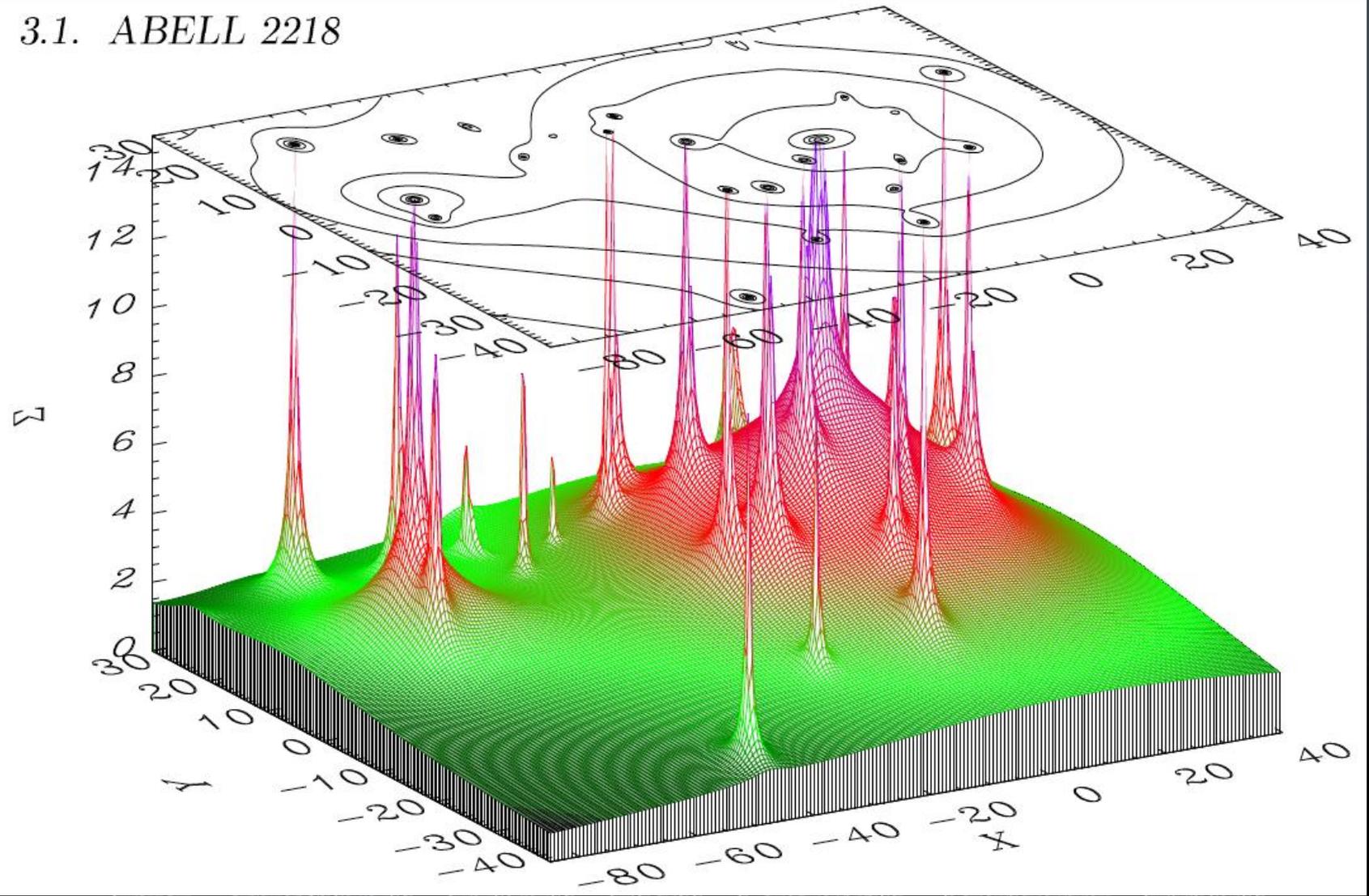


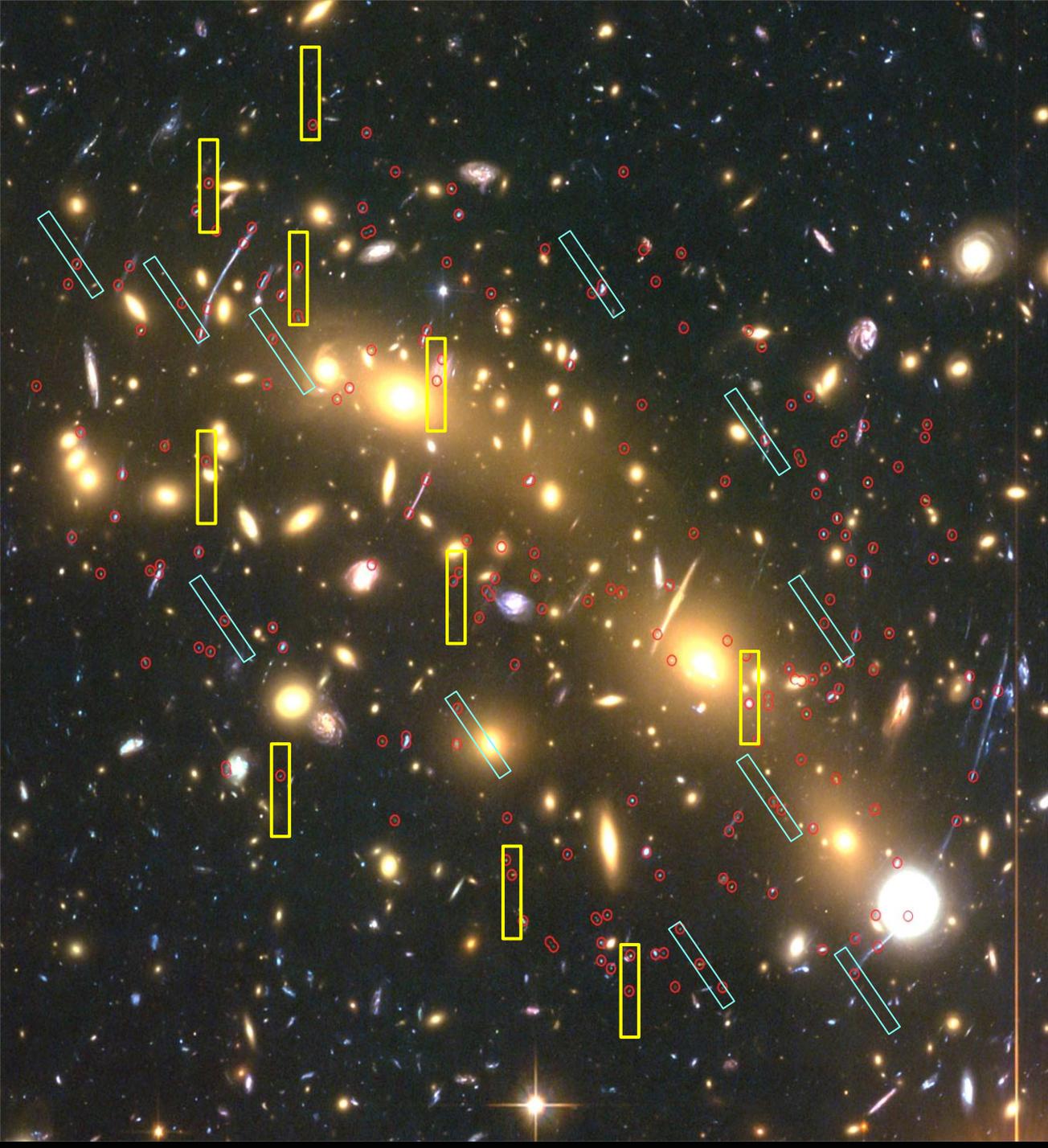
ESO - Gottingen - Leiden - Lyon - Potsdam - Toulouse - Zurich



MUSE Modèles d'amas-lentilles

3.1. ABELL 2218





Spectroscopie multi-objets

Masque 1

Masque 2

...



~~Spectroscopie
multi-objets~~

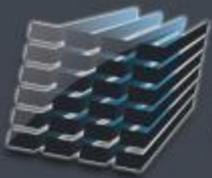
~~Masque 1~~

~~Masque 2~~

~~...~~

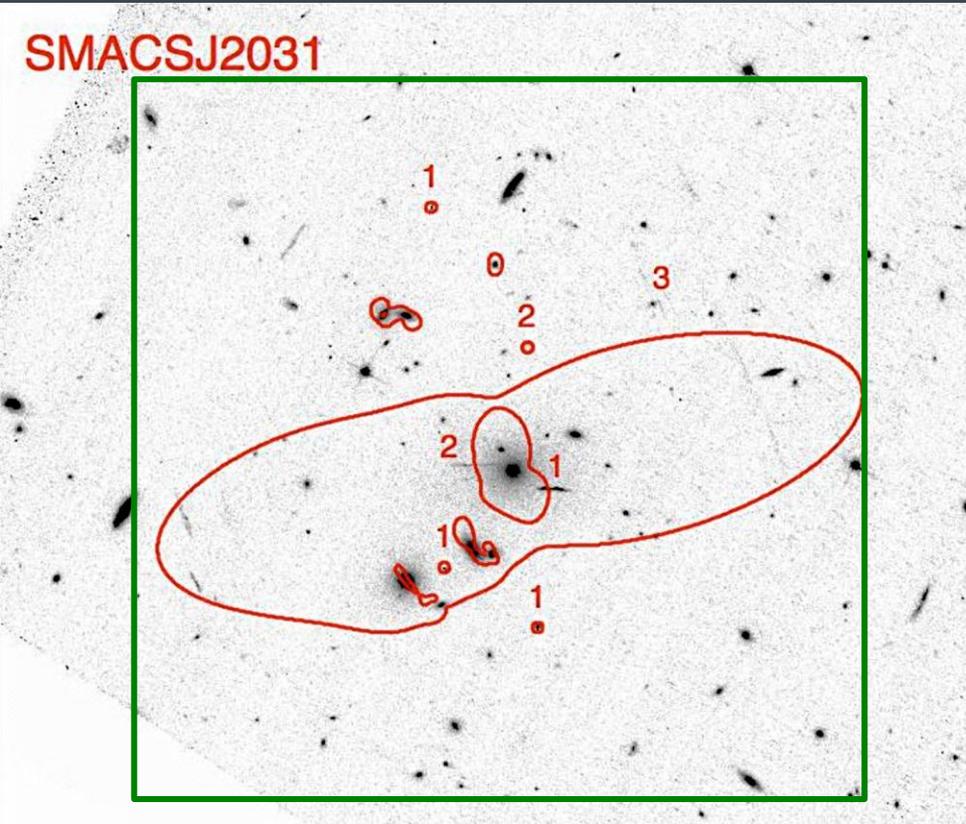


!!



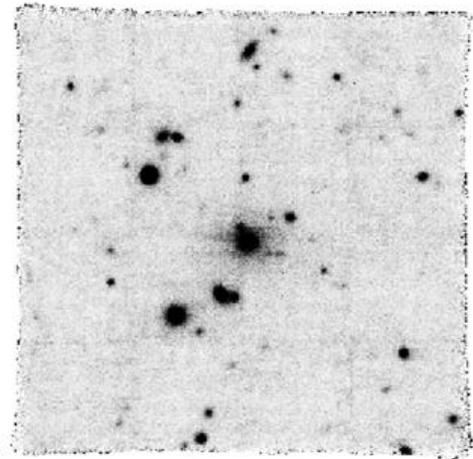
MUSE

Test d'un amas lentille: SMACSJ2031.8-4036

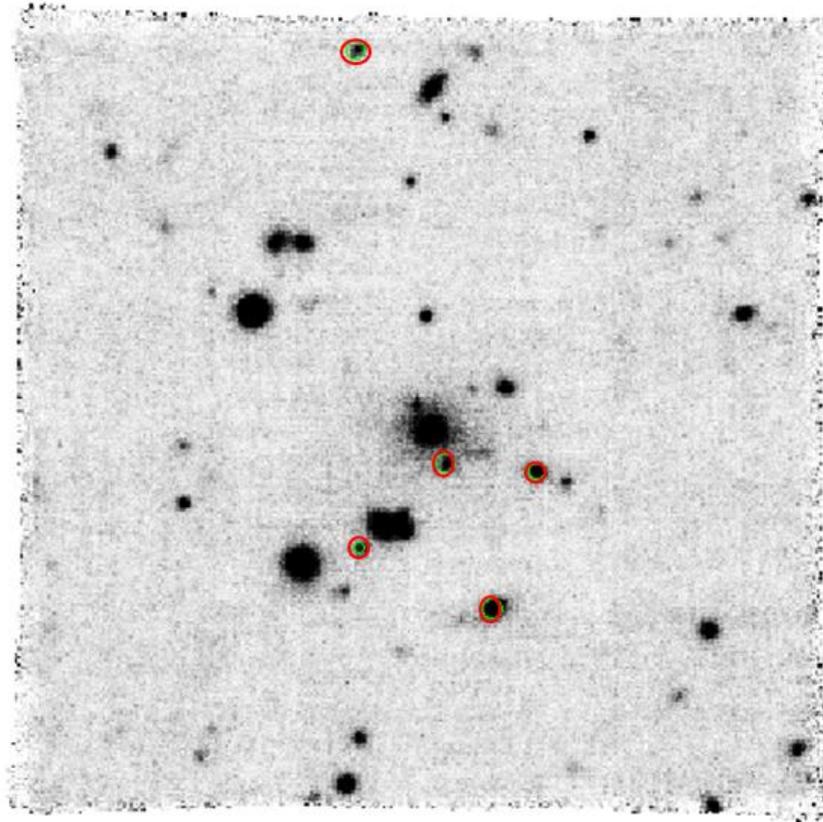


- Amas massif à $z=0.331$
- Images Hubble: 3 systèmes multiples
- 1 mesure de décalage spectral à $z=3.5073$
- MUSE : 10 heures en commissioning

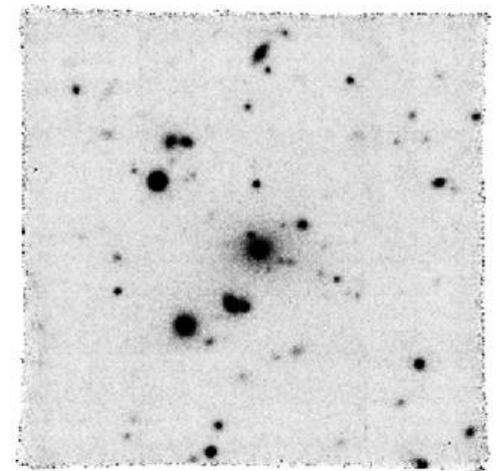
Apparition puis disparition simultanée de 5 images.



$\lambda - 3,75 \text{ \AA}$



$\lambda = 8053,75 \text{ \AA}$



$\lambda + 3,75 \text{ \AA}$

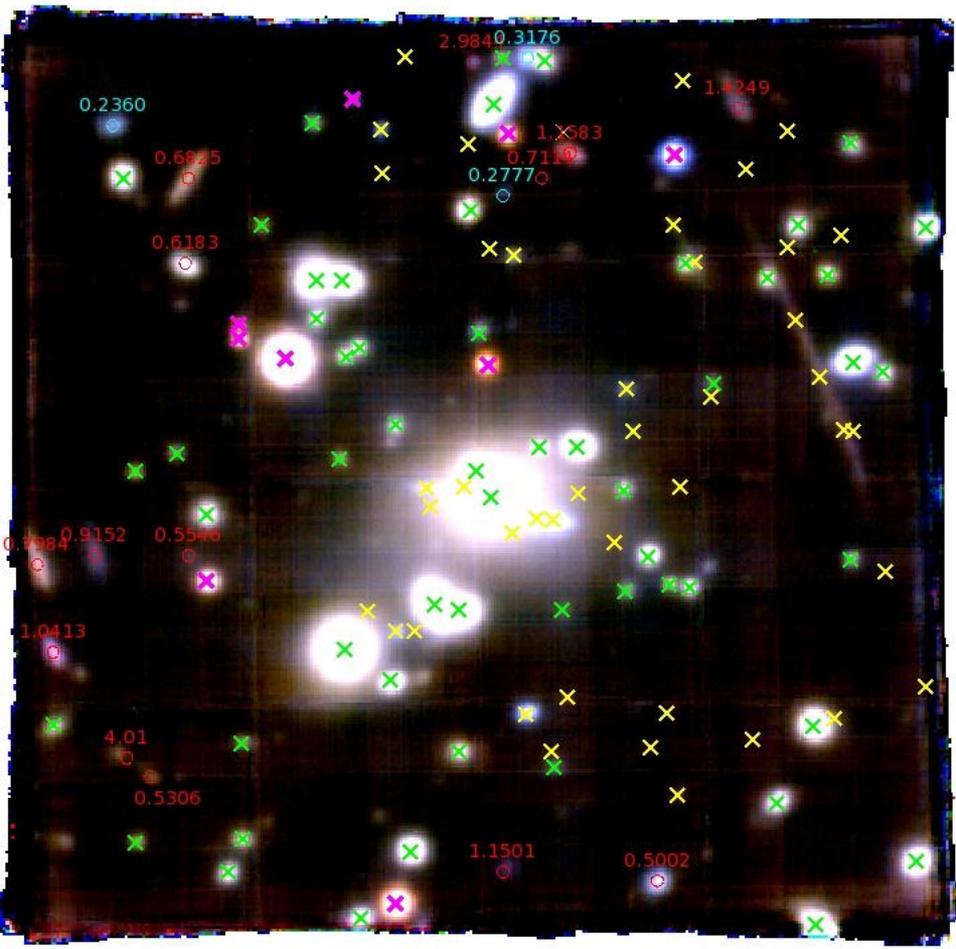


Image dans le continuum

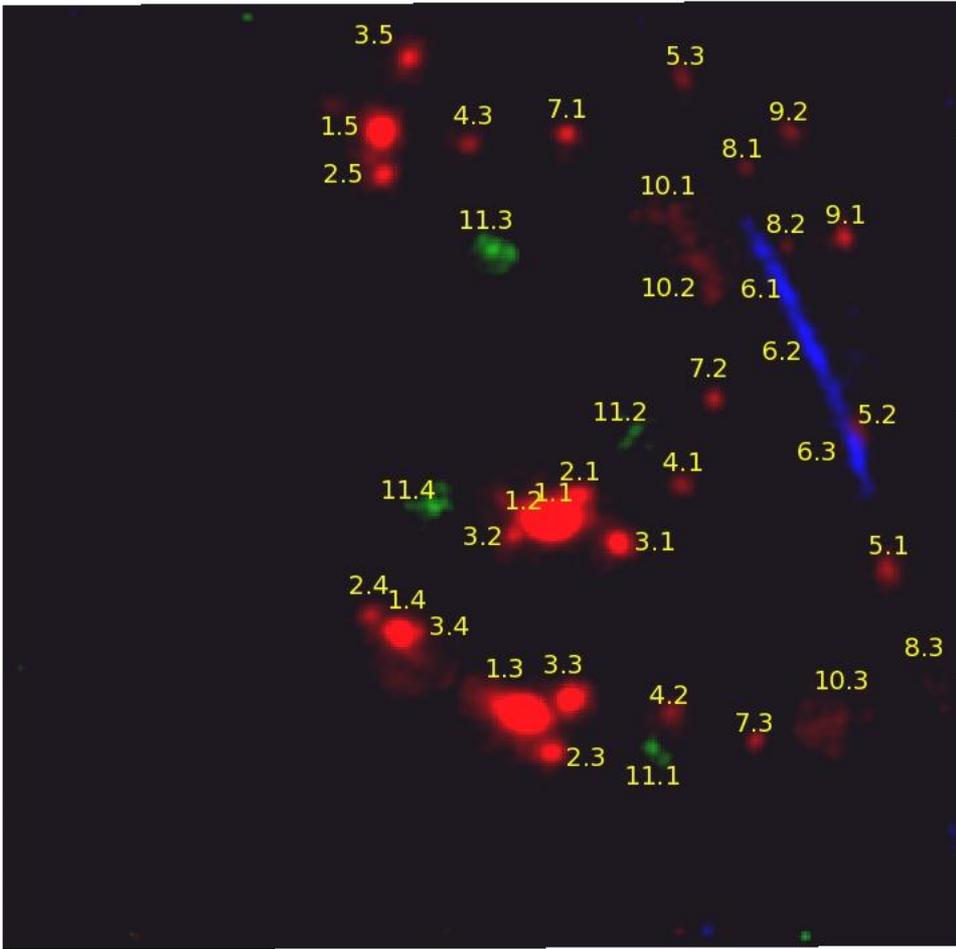
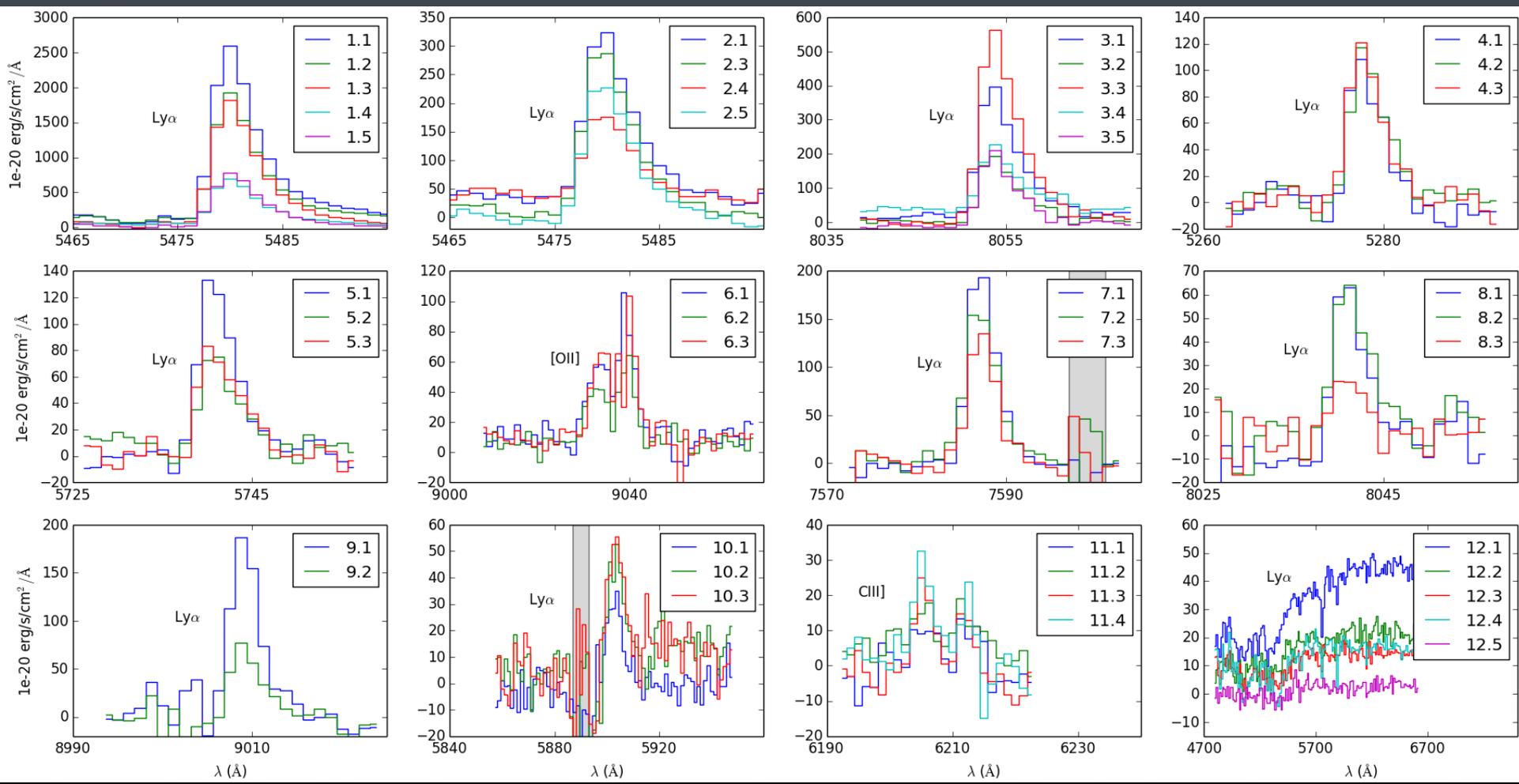


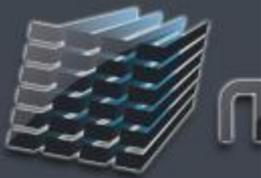
Image des raies en emission

$Ly\alpha$ CIII] [OII]

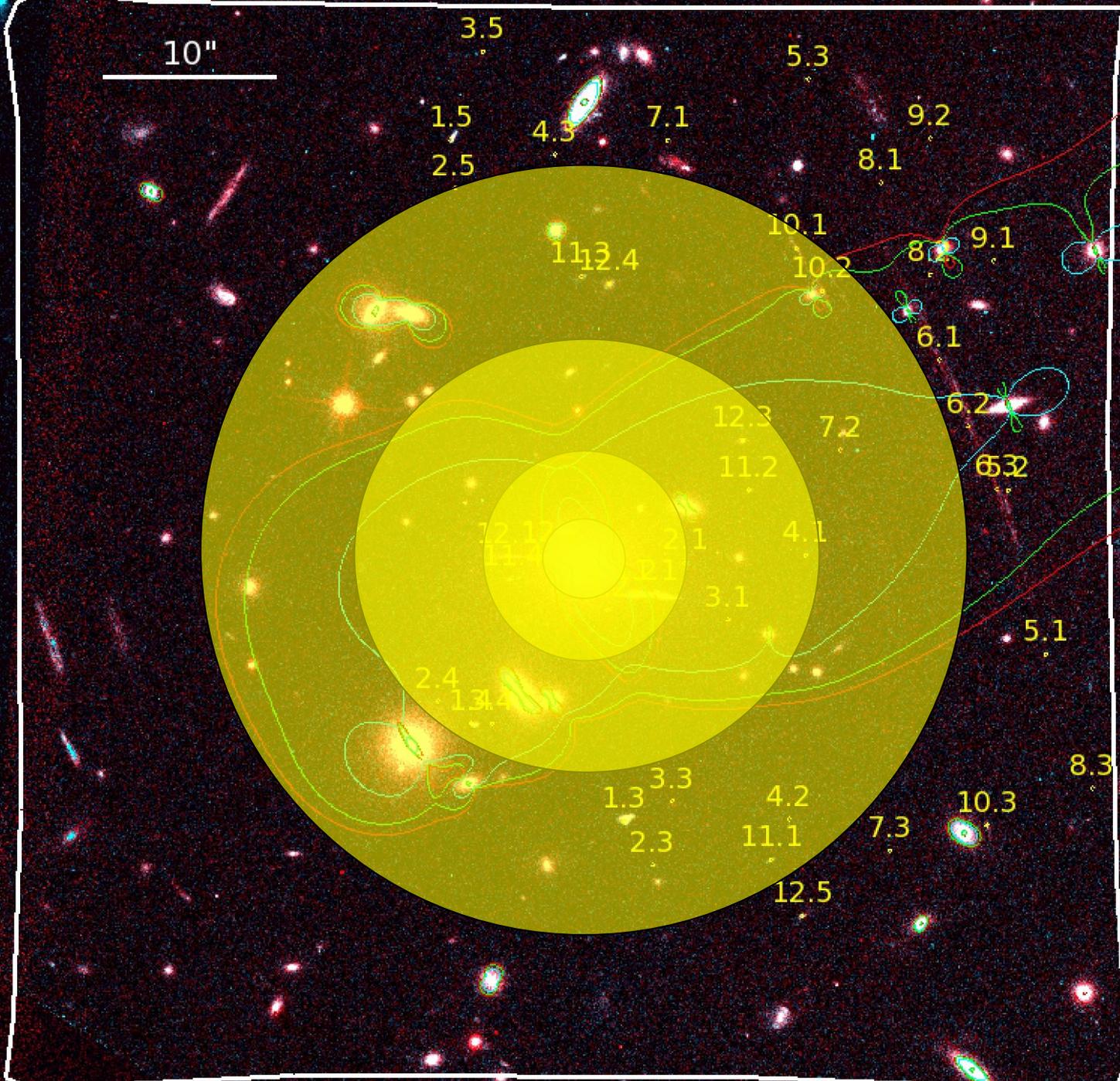


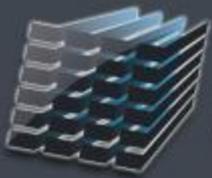
Confirmation et spectroscopie de 11 systèmes multiples





10"



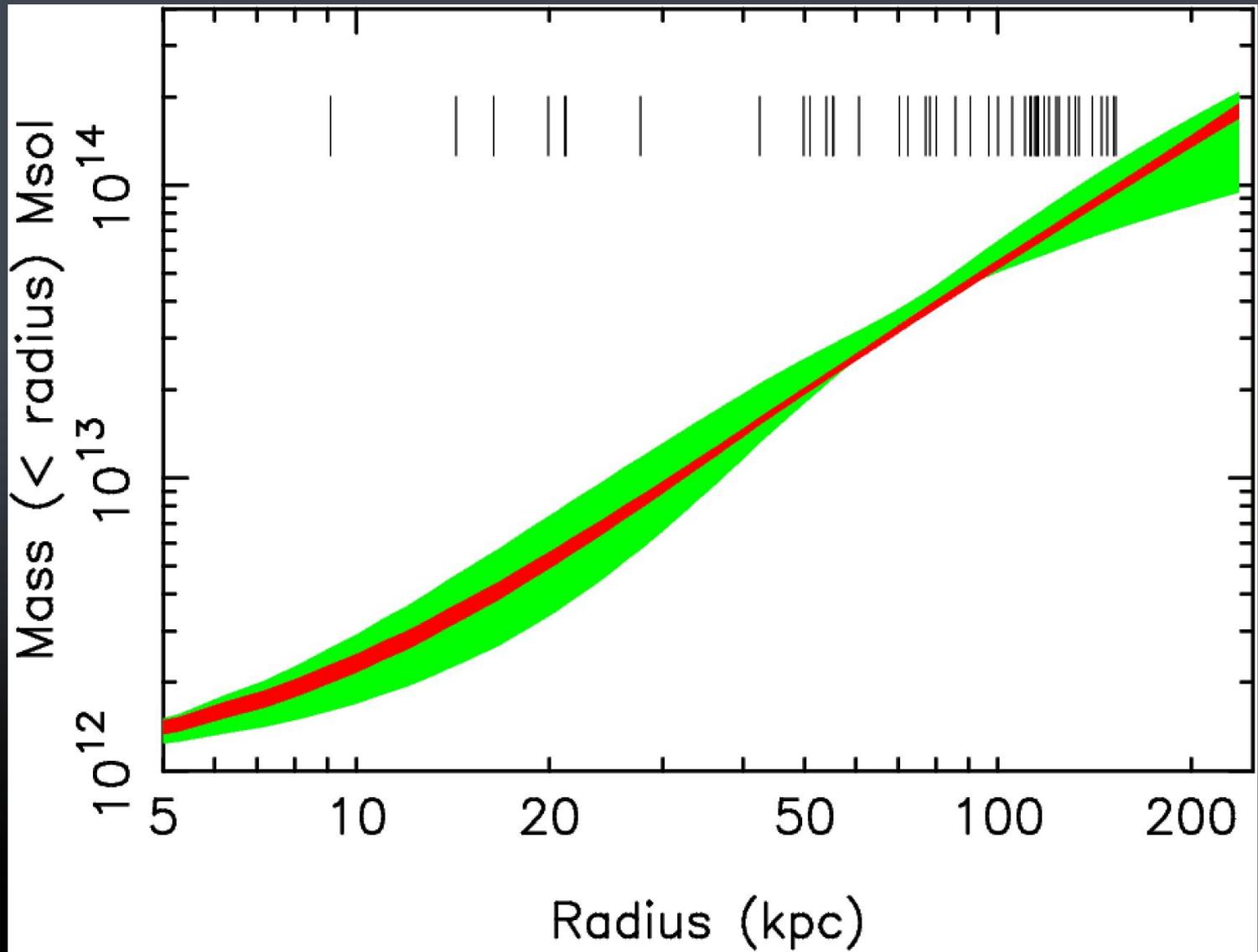


MUSE

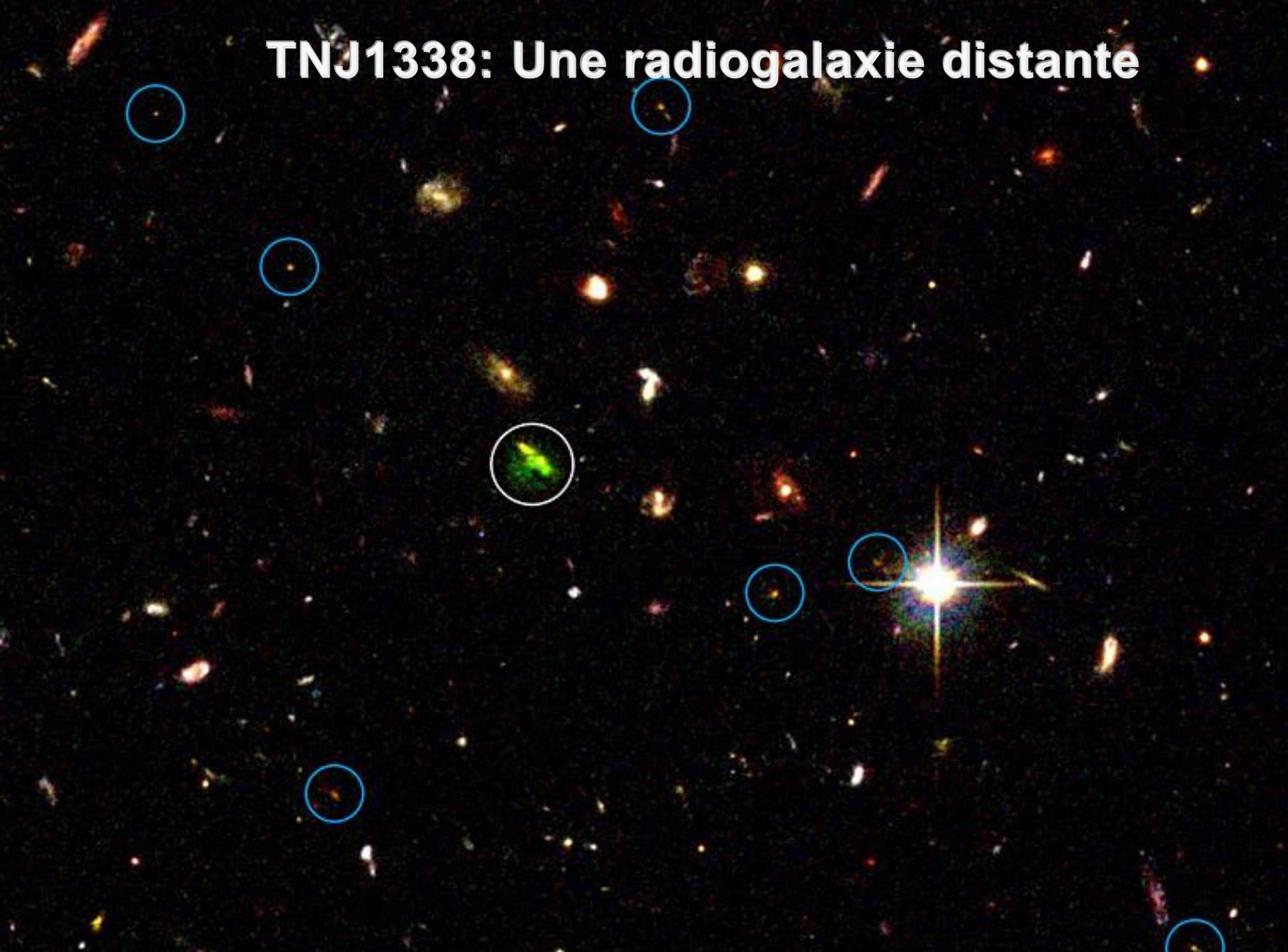
Profil de masse

Avant MUSE ■

Après MUSE ■



TNJ1338: Une radiogalaxie distante



Une radiogalaxie

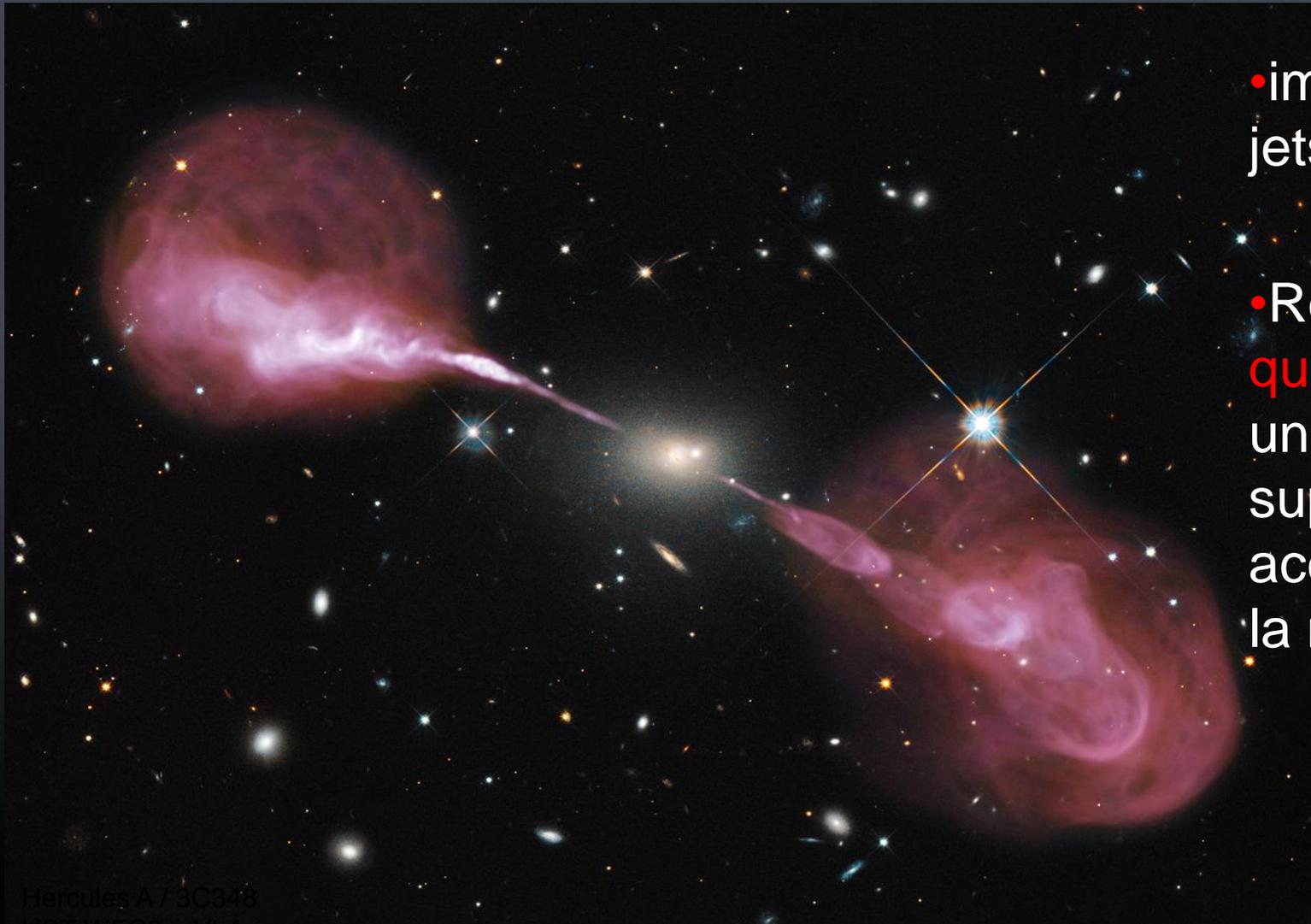


...une
très
grosse
galaxie

(> 10x
la Voie
Lactée)

Hercules A
HST-WE09

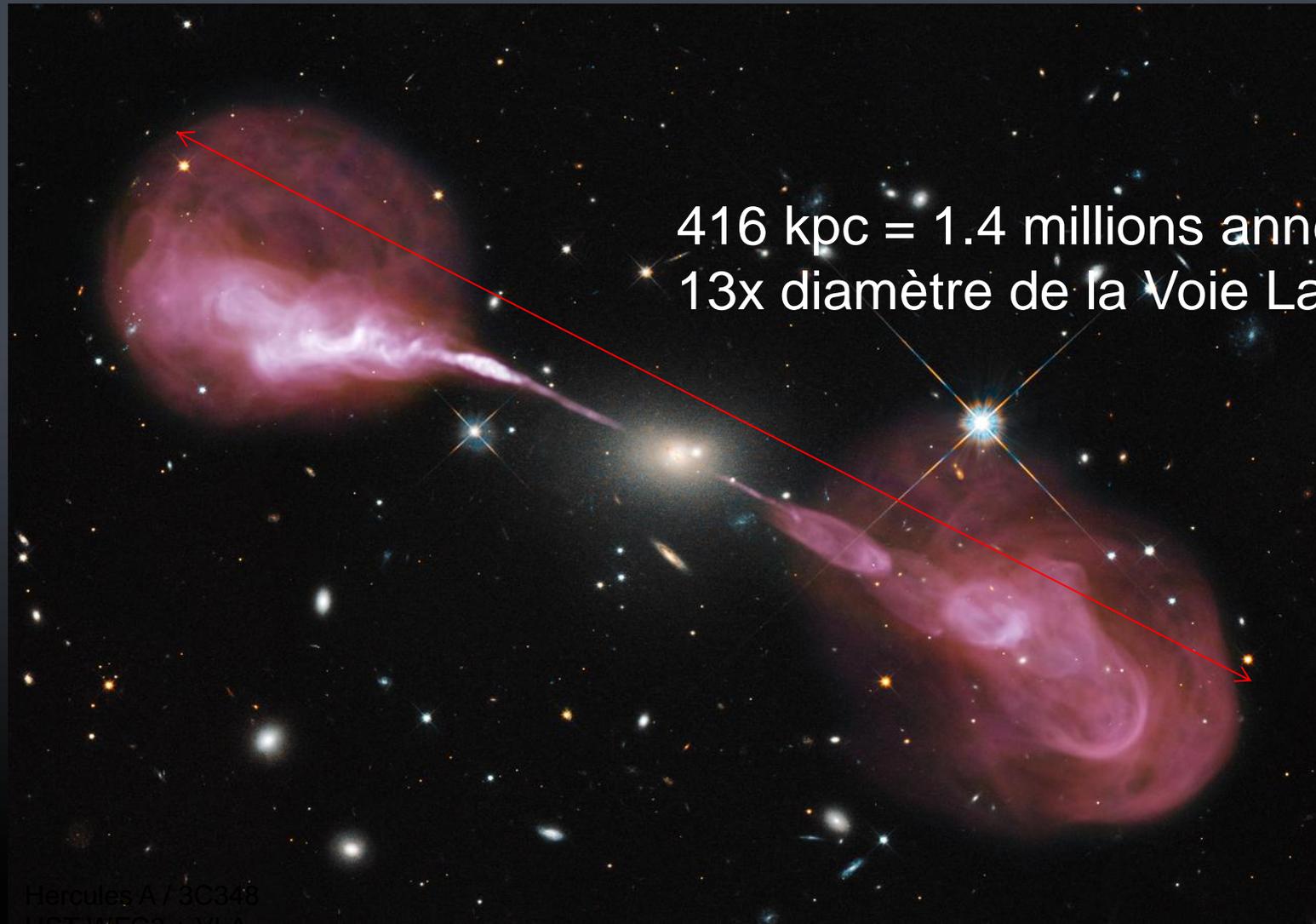
Une radiogalaxie



- immenses jets radio
- Revèlent un **quasar caché**: un trou noir supermassif accrétant de la matière

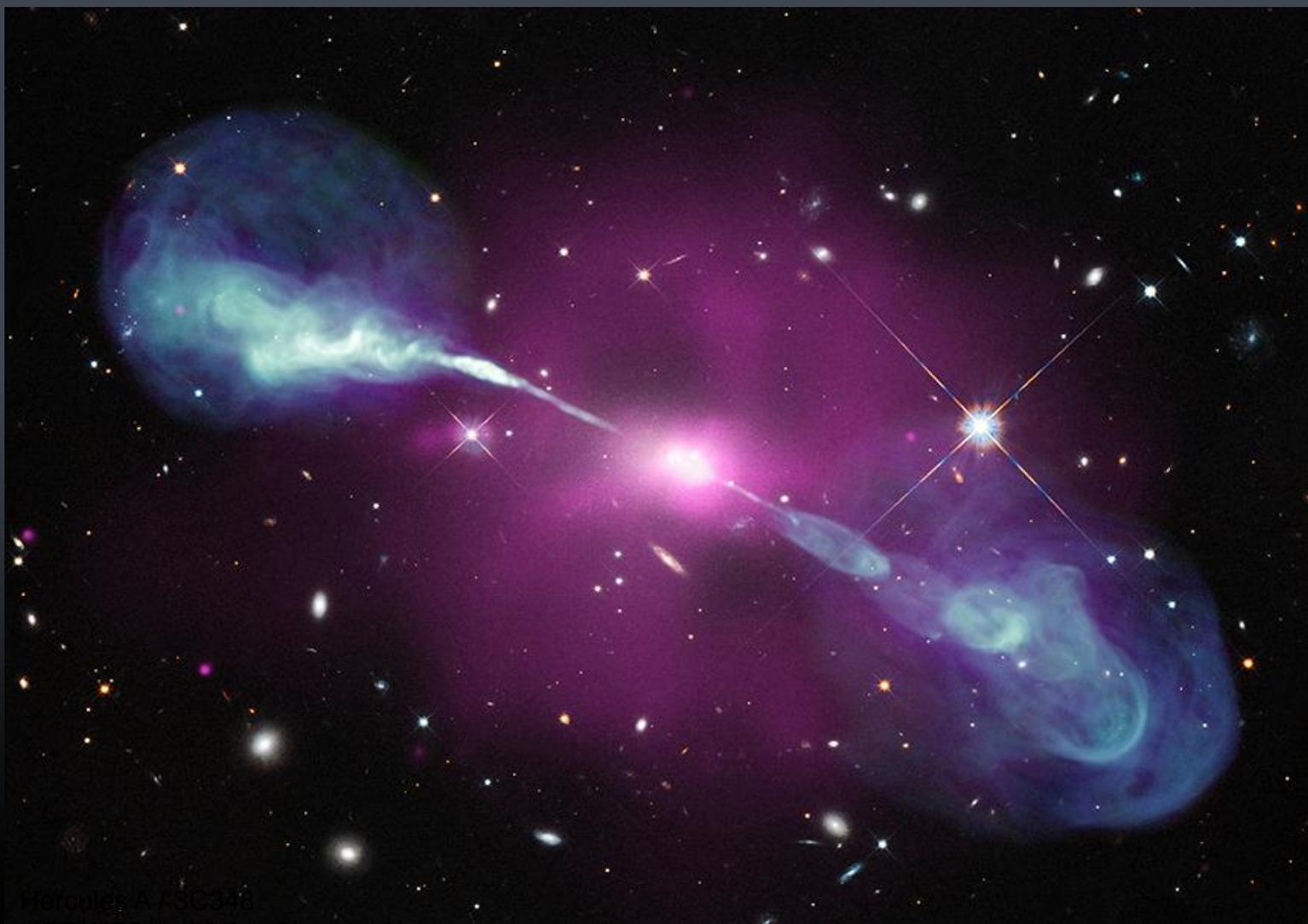
Hercules A / 3C348
HST WFC3 - MIA

Echelles mises en jeu



416 kpc = 1.4 millions années lumière
13x diamètre de la Voie Lactée

Hercules A / 3C348
HST WFC3 - M/A

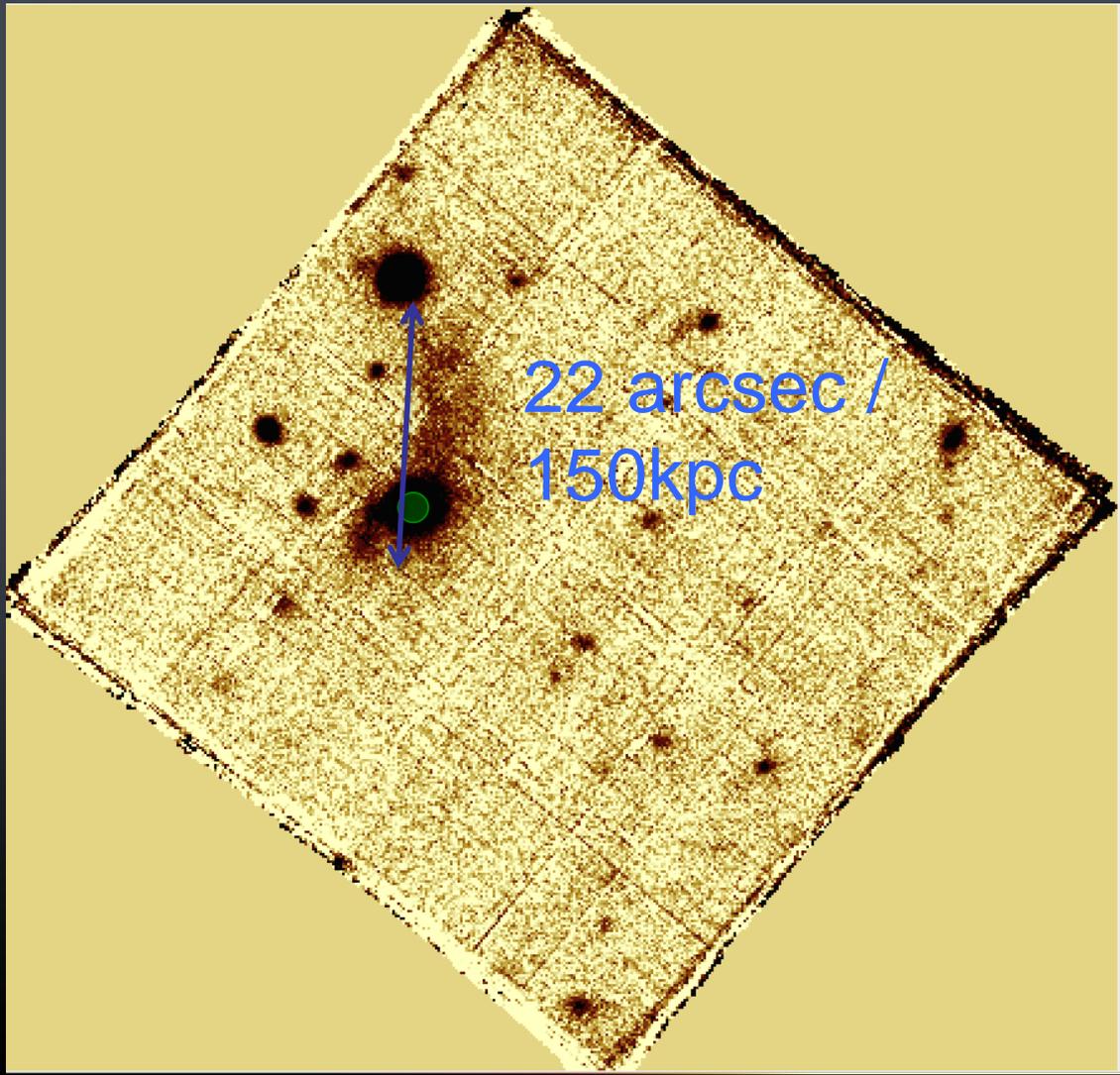


- Les radiogalaxies ne sont pas seules
- Elles se trouvent au centre d'amas de galaxies dans l'Univers proche

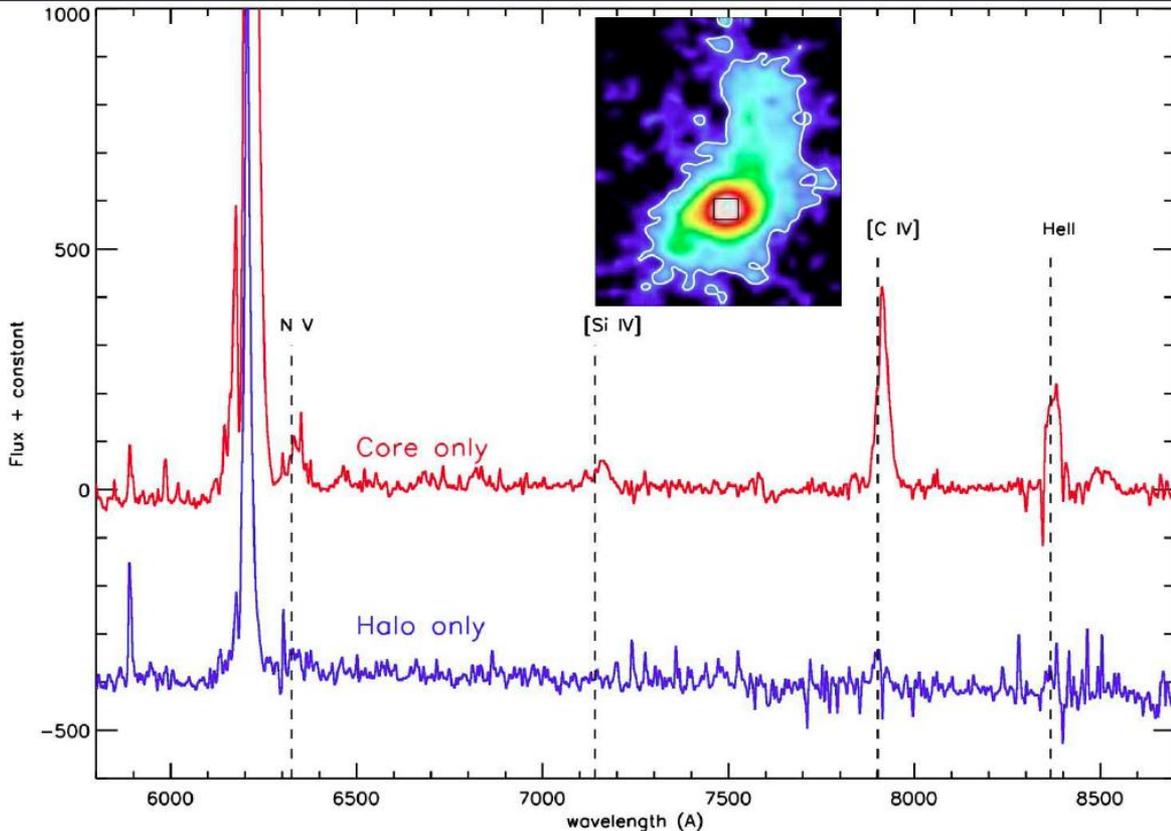
Herbules A1730348

- Une puissante radiogalaxie à $z=4.1$ (quand l'Univers n'était âgé que de 1.5 milliards d'années)
- Ce que l'on connaît:
 - Une des radiogalaxies les plus distantes
 - Elle réside dans un environnement riche en galaxies (proto-amas)
 - Des émetteurs Ly α confirmés par de la spectroscopie
 - Plusieurs candidats Lyman-break à un redshift voisin
 - Elle a un immense halo Ly α
 - Imagerie en bande étroite

Halo



Spectre du halo: source de l'émission dans le halo?



H&K et C IV détectés dans le halo

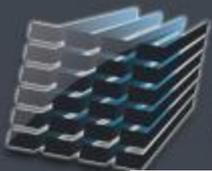
Rapports extrêmes:
Core:

C IV/Ly α ~ 0.082
H&K/Ly α ~ 0.044

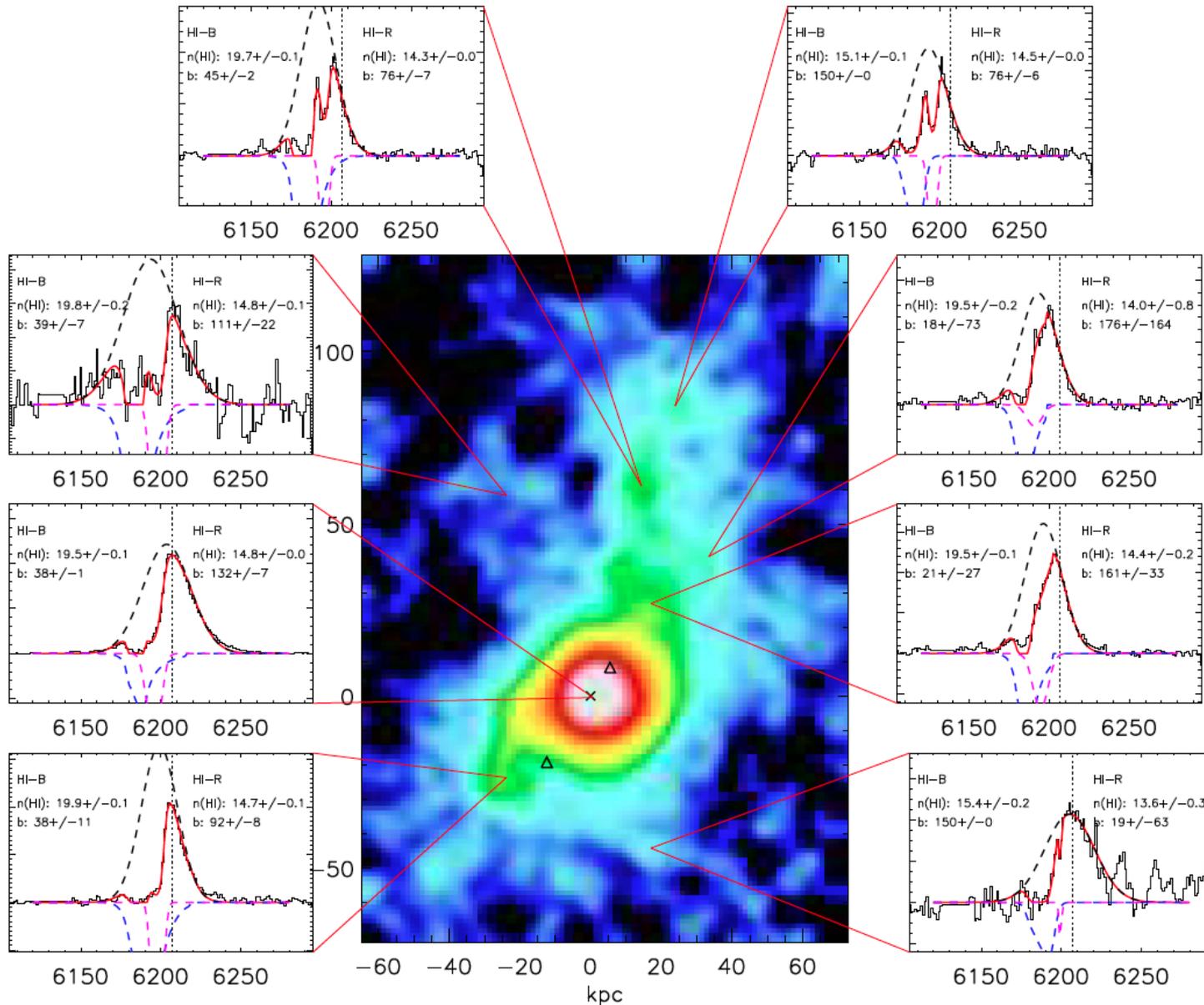
Halo:

C IV/Ly α ~ 0.06
H&K/Ly α ~ 0.09

Ces rapports de raies sont d'avantage en accord avec de la photoionisation stellaire plutôt qu'un trou noir supermassif

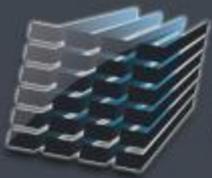


Cinématique du halo



La suite...

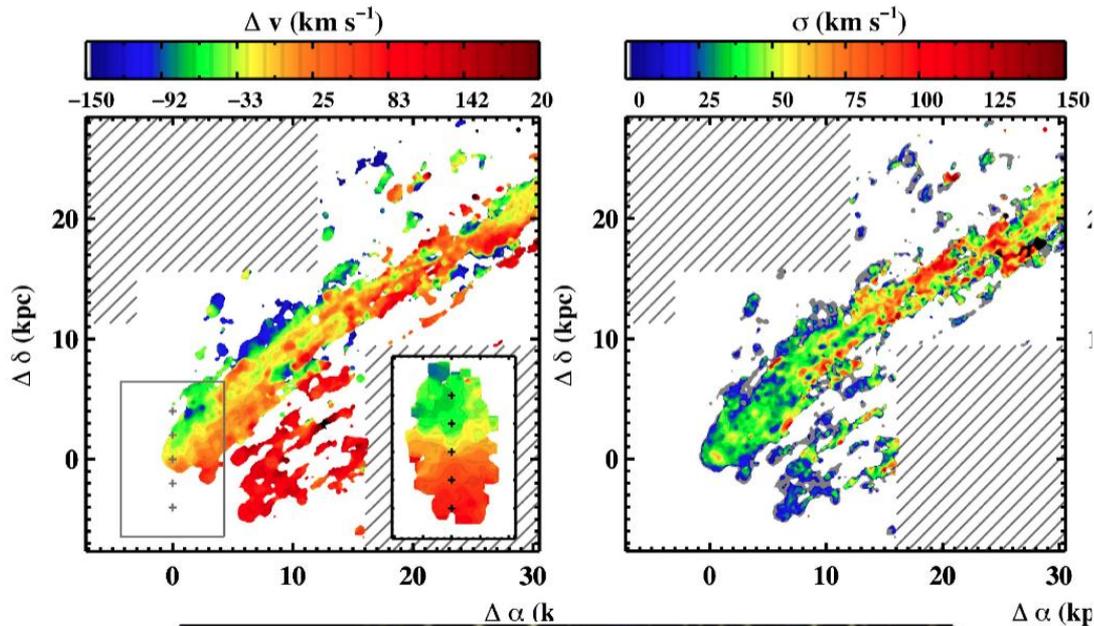
- Exploitation scientifique de MUSE dans le temps garanti (2014-2019): 225 nuits.
- Hubble Ultra Deep Field: plus loin que HDF5
 - Couverture de 3×3 arcmin² à plus de 10h.
 - 1 champ de 1 arcmin², à plus de 30 heures.
 - Objectif: finalisation en 2015
- Mise en place de l'optique adaptative 2016-2017
 - Amélioration de la qualité image de ~50% sans impact sur la transmission
 - Préparation d'un nouveau champ très profond avec une qualité d'image extrême



MUSE

Quelques autres résultats

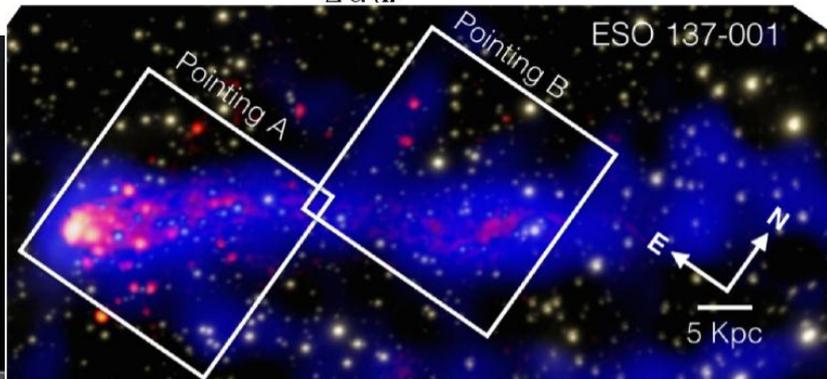
Velocity and velocity dispersion

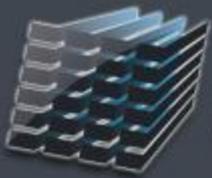


ESO137-001: une galaxie spirale en chute dans l'amas Norma, et qui se fait dépouiller de son gaz par les forces de pression.

Fumagalli, Hau, Slezak

Courtesy of Georges Hau





MUSE

Quelques autres résultats



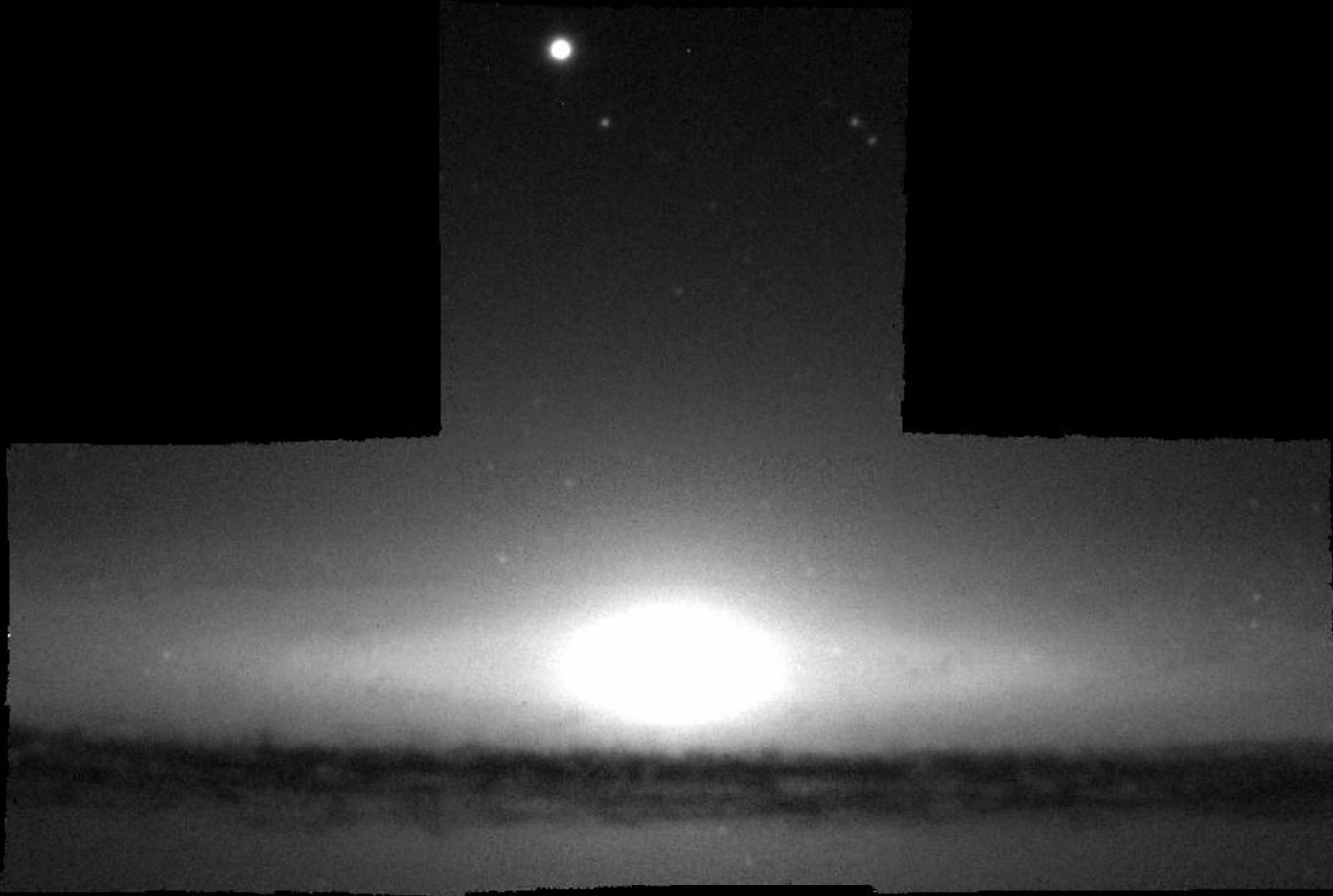
Courtesy of *Anna McLeod*,

ESO - Göttingen - Leiden - Lyon - Potsdam - Toulouse - Zurich



Quelques autres résultats

La galaxie du Sombrero



Courtesy Eric
Emsellem

15 pointés



Quelques autres résultats

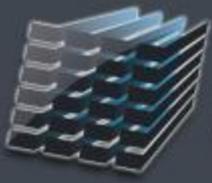


NGC6397
S. Kamann

Commissioning

60s temps de pose
1700 spectres d'étoiles

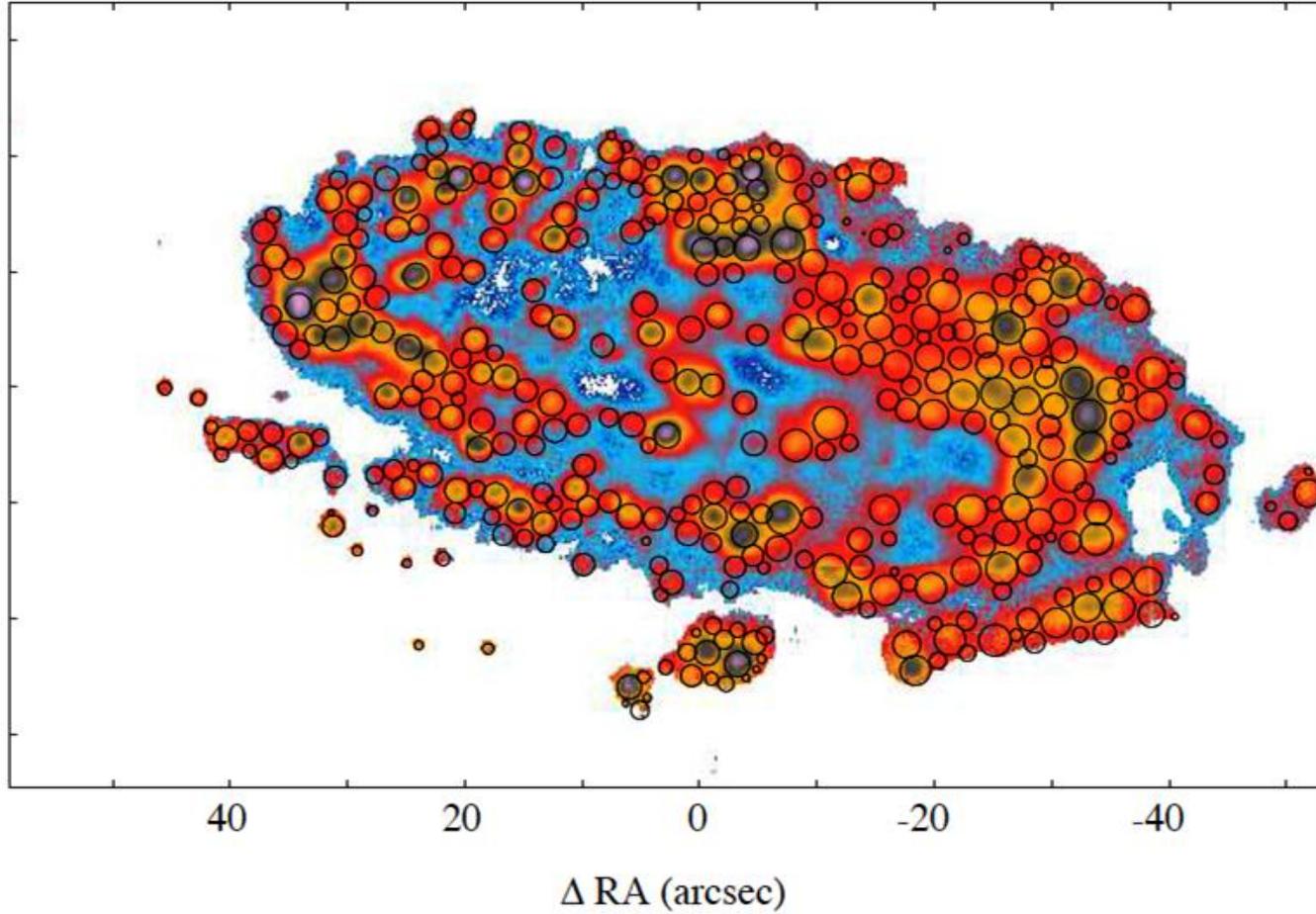
FWHM ~0.5"



MUSE

Quelques autres résultats

Régions HII dans NGC 6754



A. Sánchez

396 régions HII

Etude des gradients
d'abondance et du
mélange des métaux
dans la galaxie