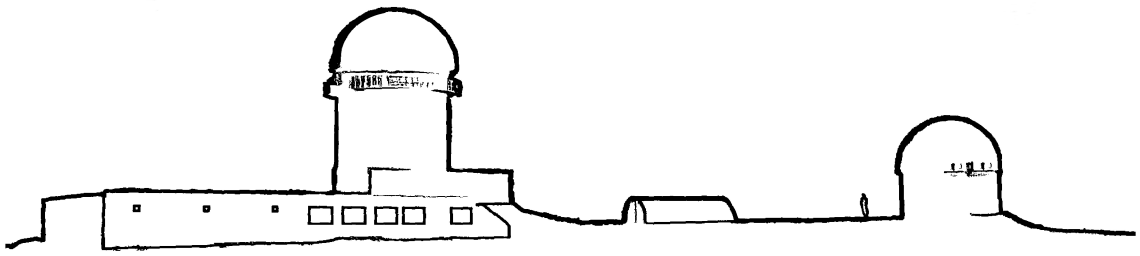
Javalambre
Physics of the Accelerating Universe
Astrophysical
Survey

The J-PAS Survey:
a picture of the sky in 56 colors

Silvia Bonoli
and the J-PAS collaboration

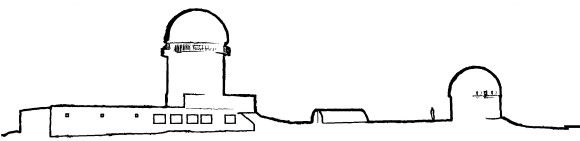
Bologna - 12 January 2016

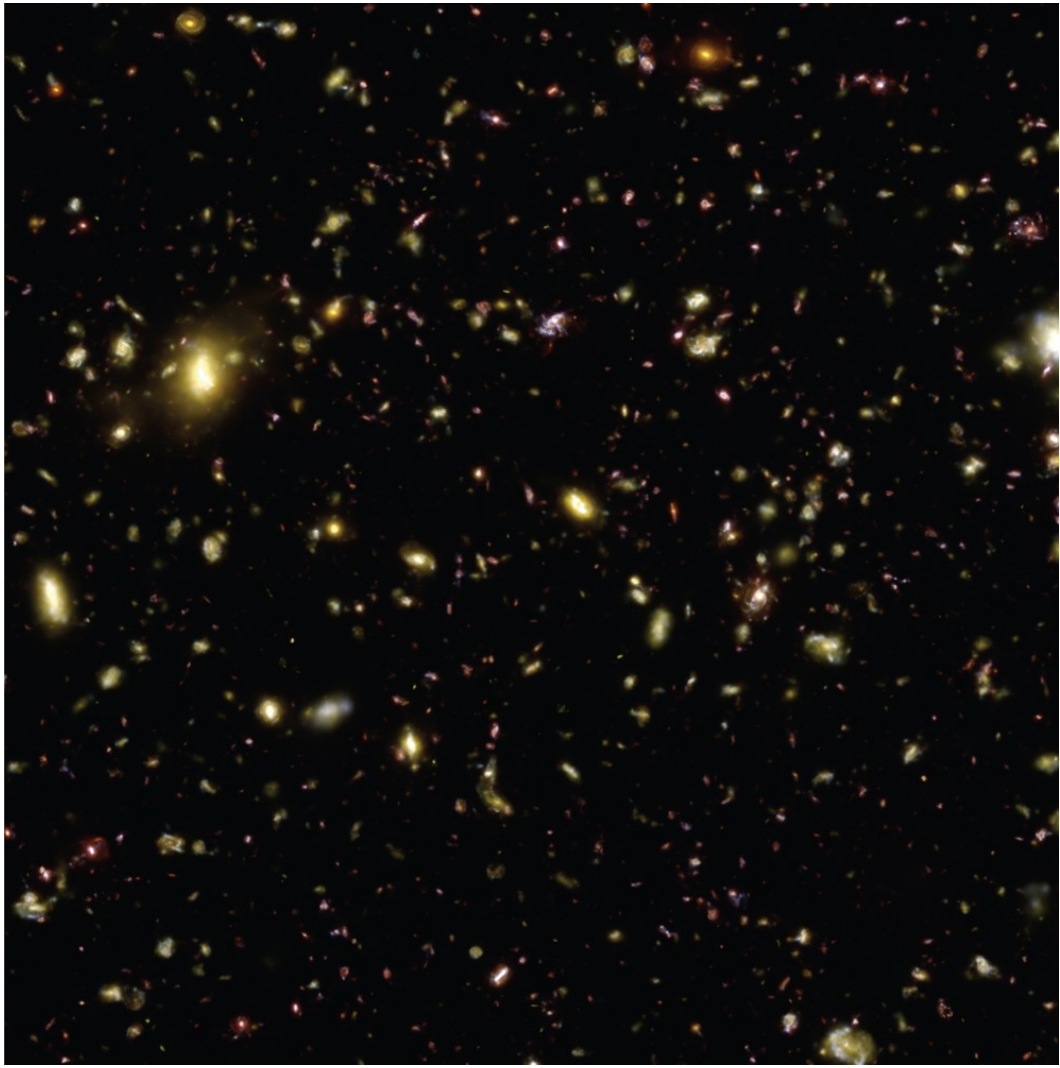


CEFCA

Outline

- ✔ Introduction
- ✔ The J-PAS survey
- ✔ The J-PLUS survey
- ✔ Forecasts (Special focus on Quasars)





The Hubble deep field

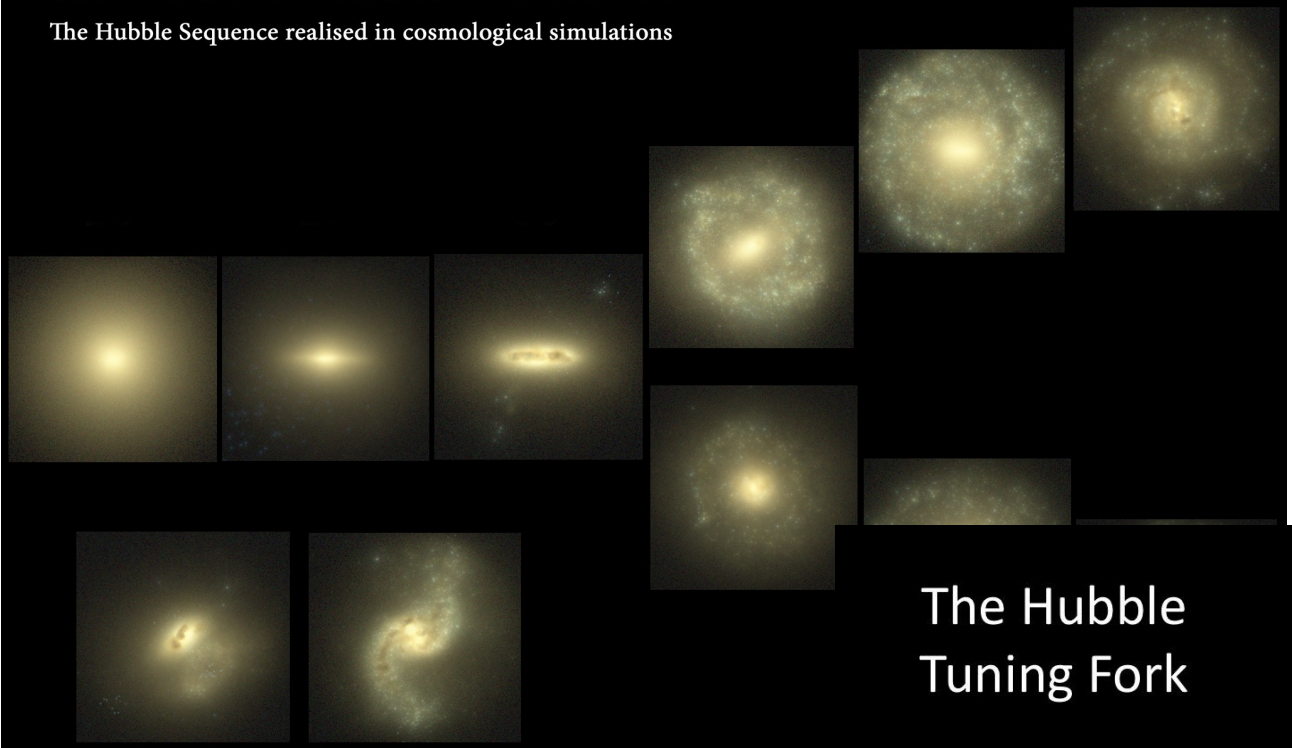
The *Illustris* simulation

A hydrodynamic simulation
of a $\sim(100\text{Mpc})^3$ volume

The Eagle Simulations

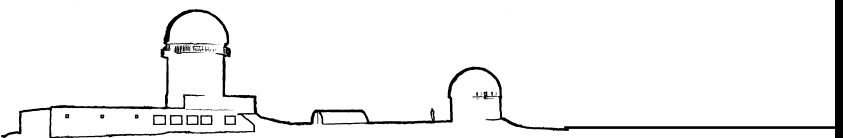
EVOLUTION AND ASSEMBLY OF GALAXIES AND THEIR ENVIRONMENTS

The Hubble Sequence realised in cosmological simulations

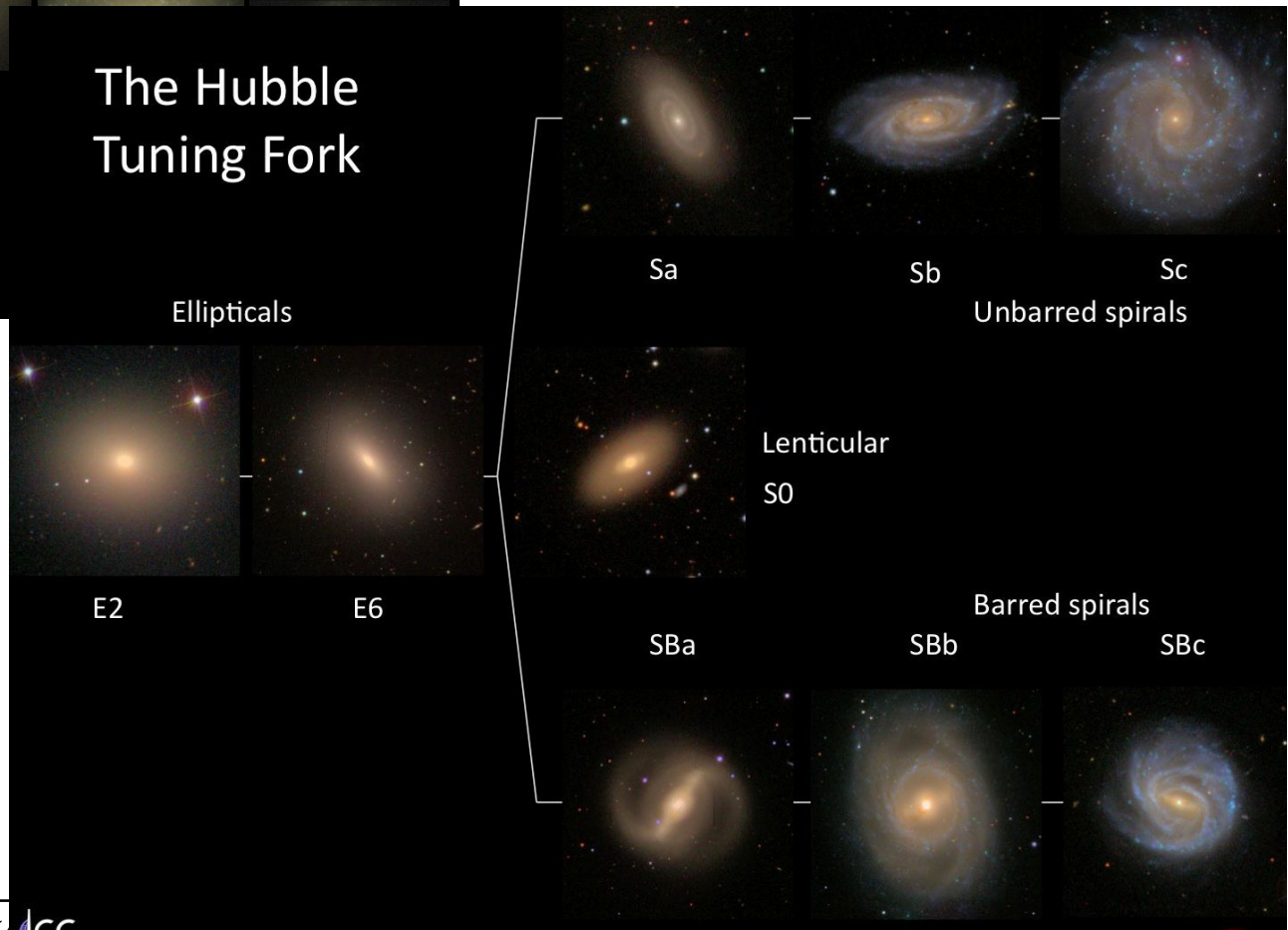


The *Eagle* project

A hydrodynamic simulation of a ~$(100\text{Mpc})^3$ volume

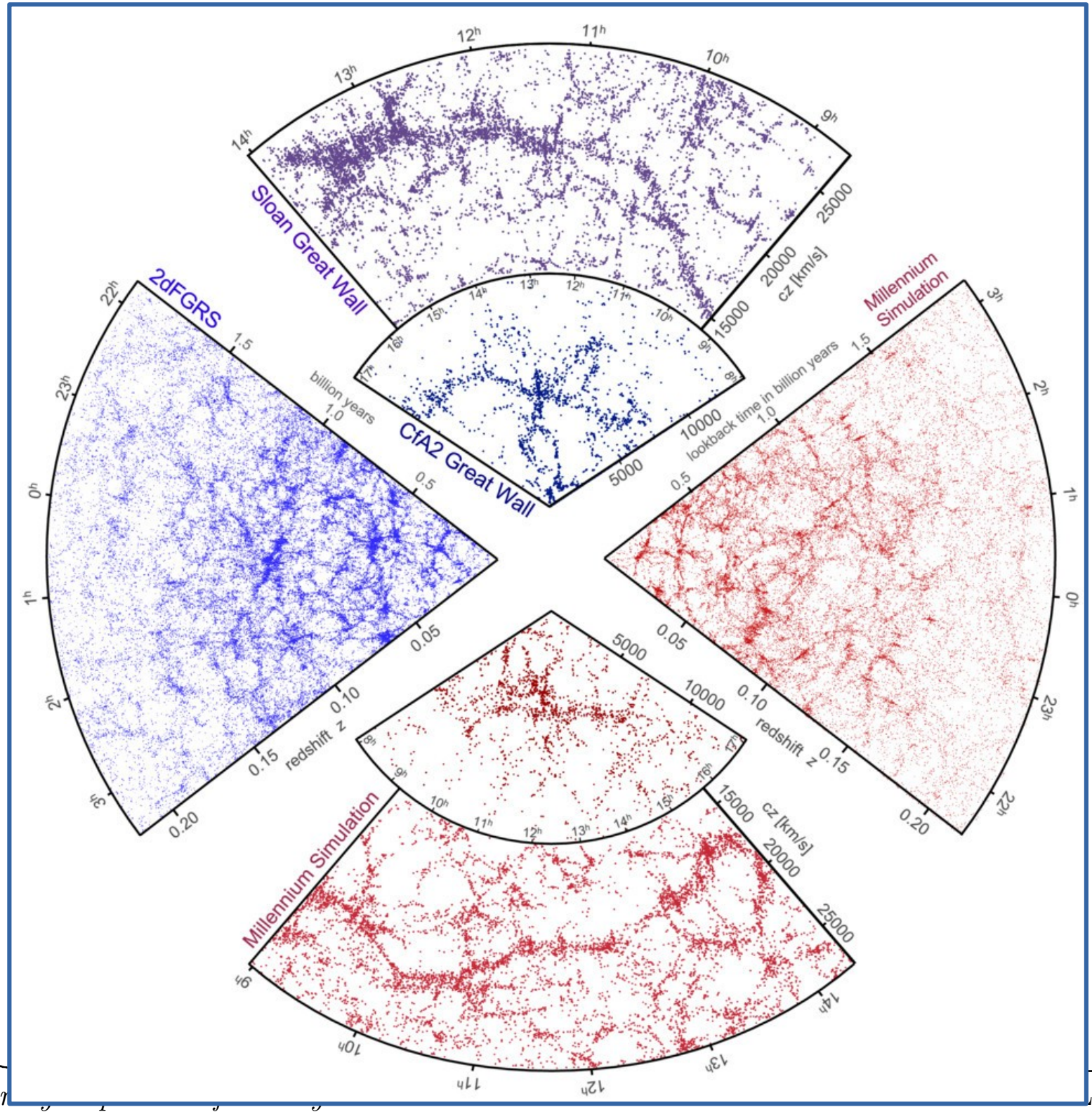


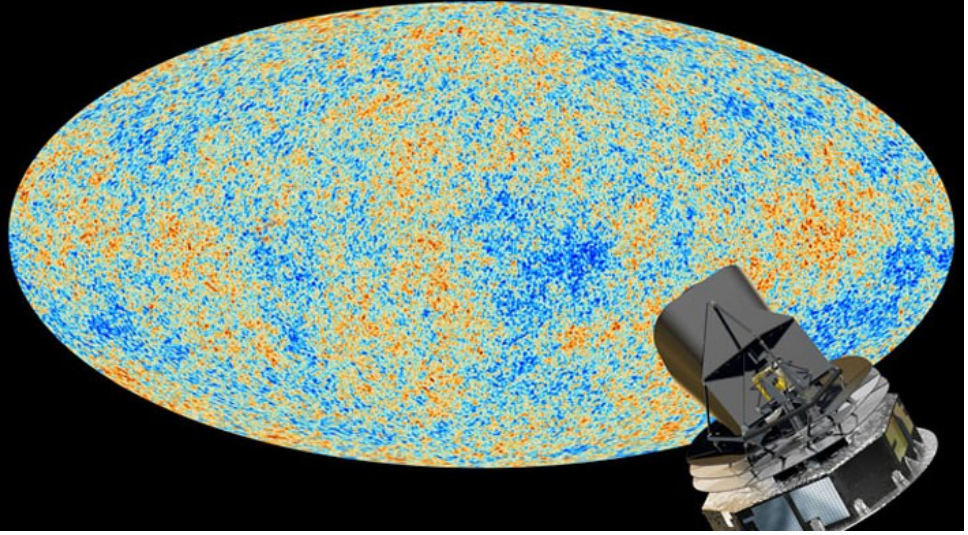
The Hubble Tuning Fork



Credit: Karen L. Masters (ICG Portsmouth). Galaxies: SDSS gri colour images as used in Galaxy Zoo.

GALAXY ZOO

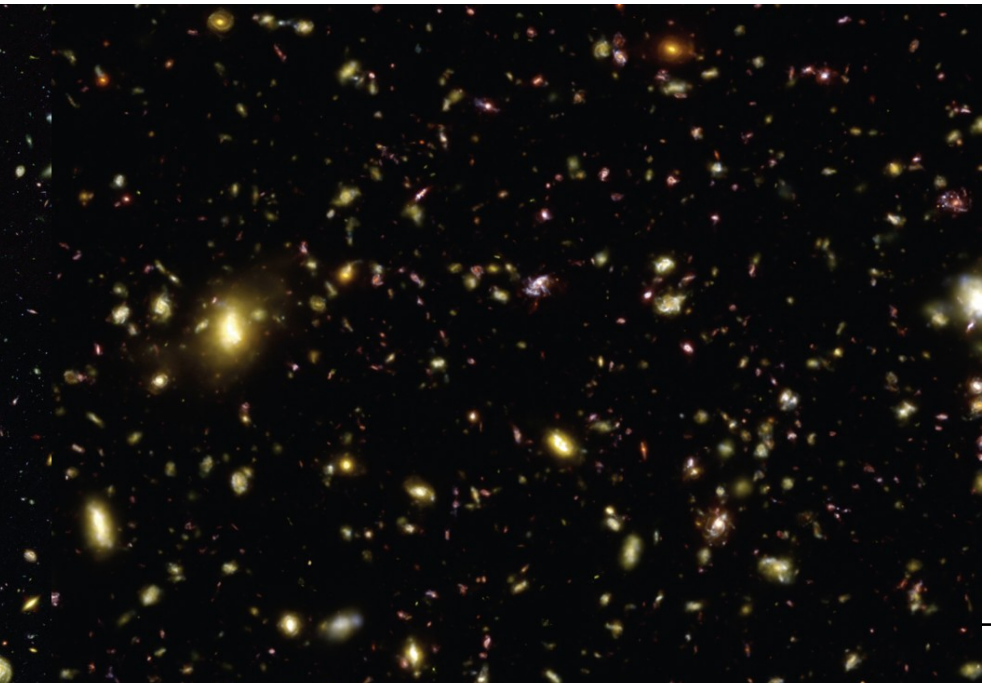

Sloan Great Wall
2dFGRS
CfA2 Great Wall
Millennium Simulation
Millennium Simulation
billion years
lookback time in billion years
redshift z
cz [km/s]

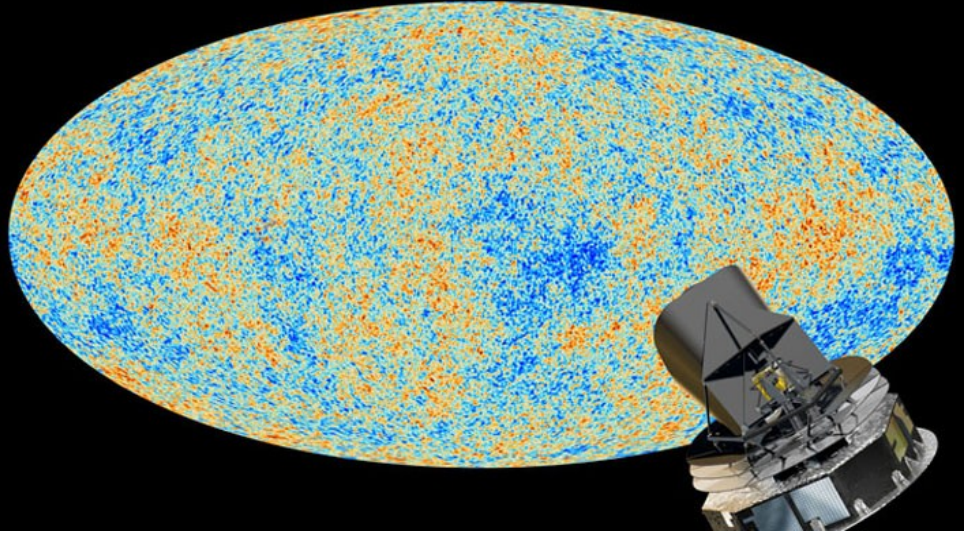


CMB

↓ **?**

The Universe we see

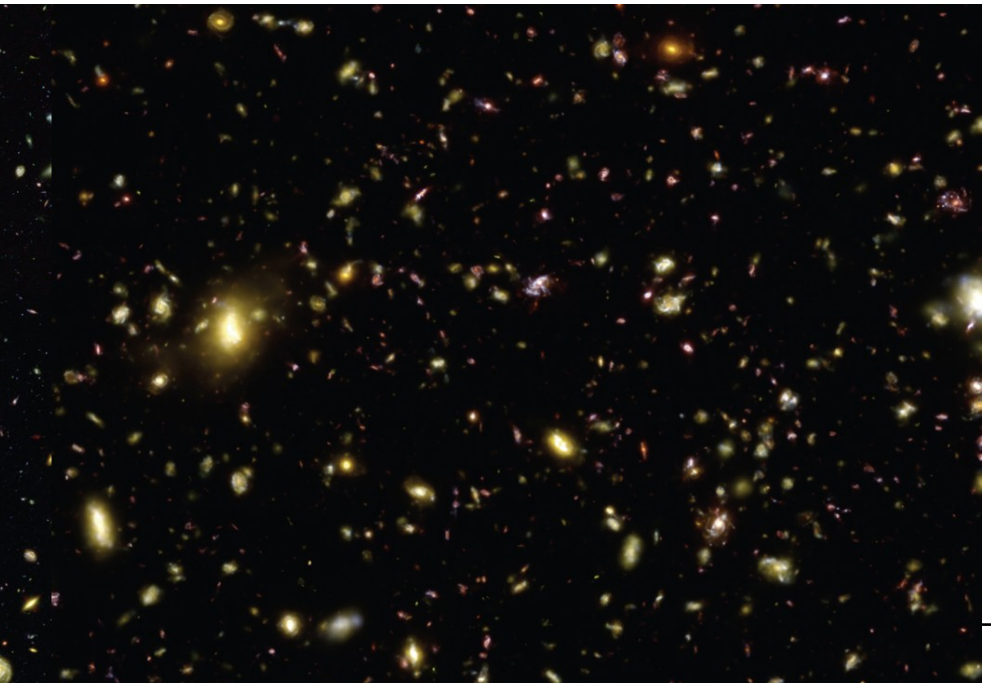


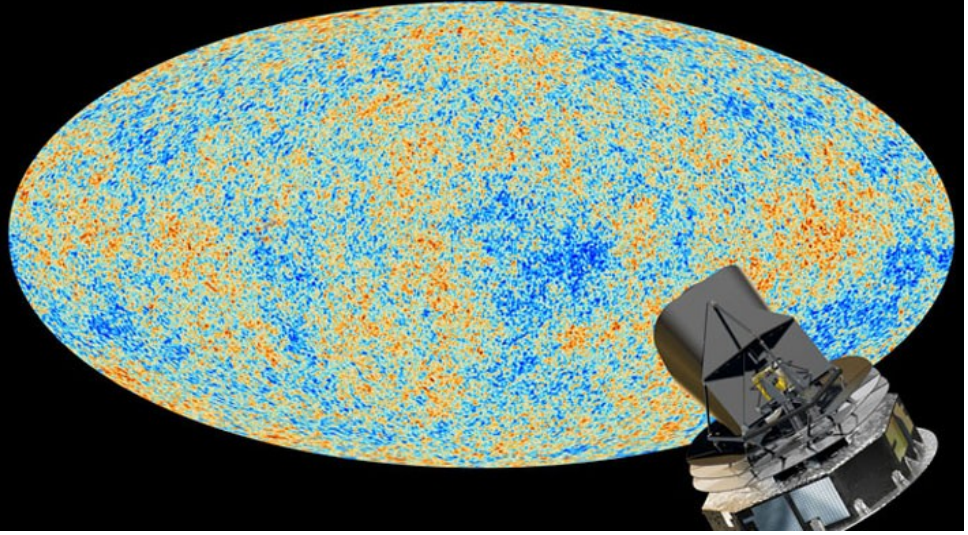


ΛCDM & GR

+

Physically motivates assumptions for gas and stellar physics





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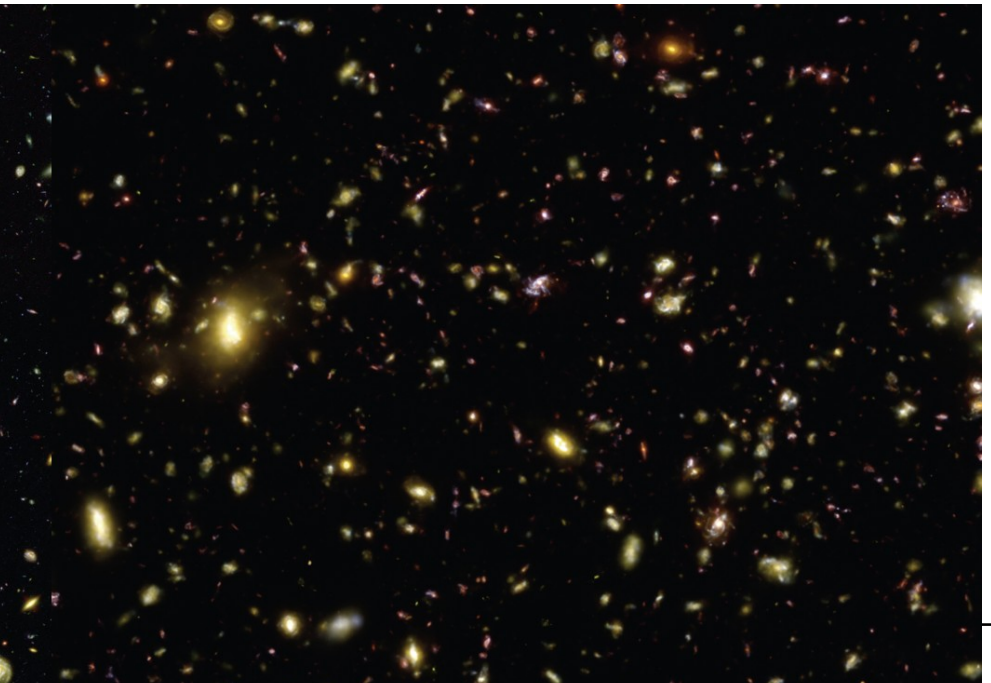
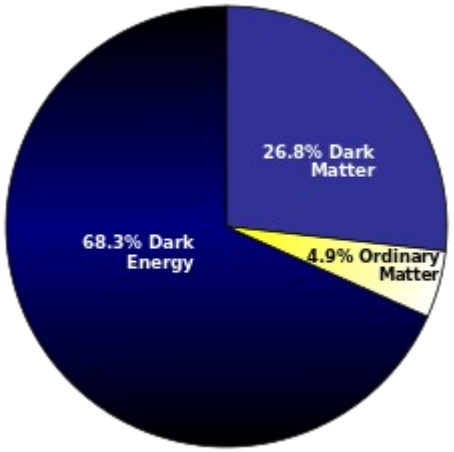


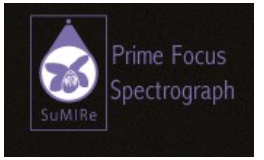


Nature of Cosmic Acceleration and Dark Matter? Modifications of GR?

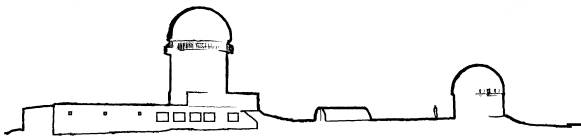
Open questions in galaxy formation:

- details of reionization
- processes of quenching / galaxy transformation
- details on feedback
- origin of supermassive black holes

...



Hyper Suprime-Cam
@ Subaru



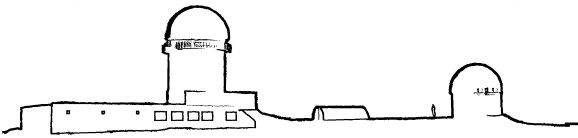
Type Ia Supernovae

BAO

Principal probes of cosmology

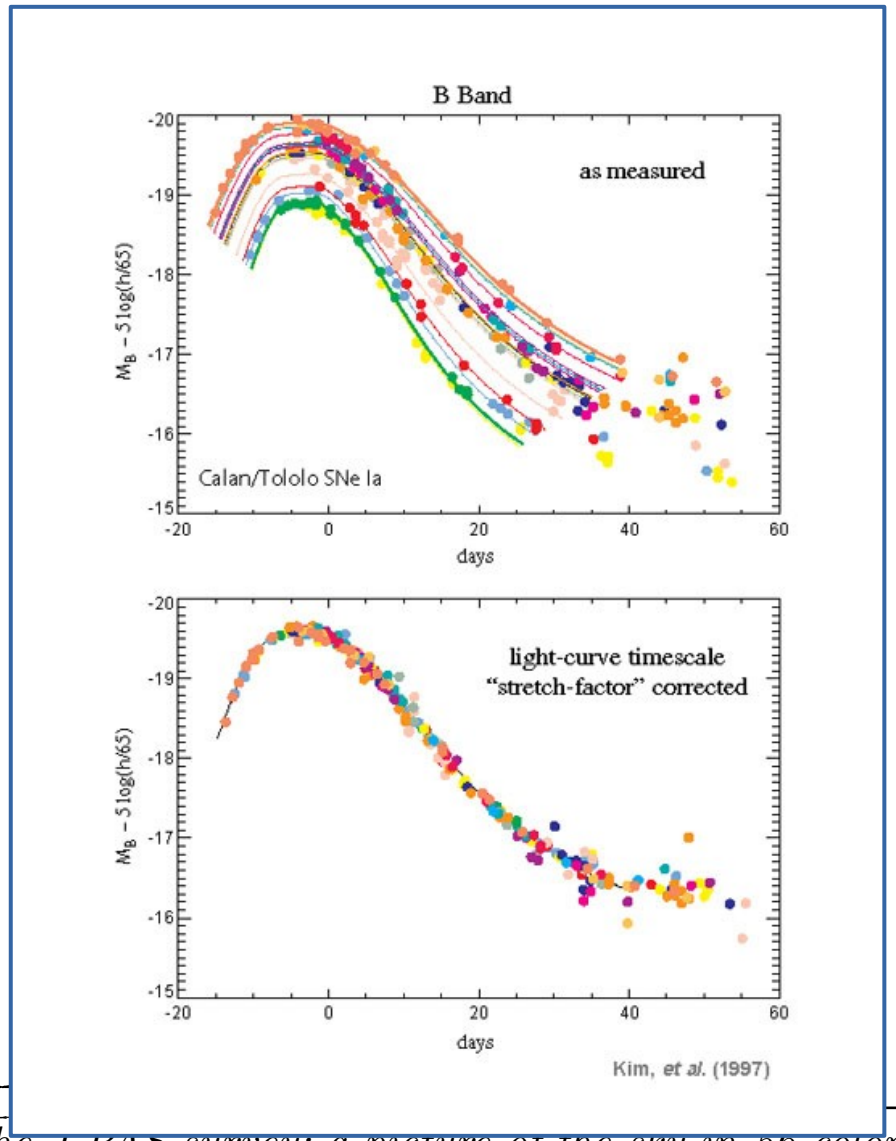
Clusters

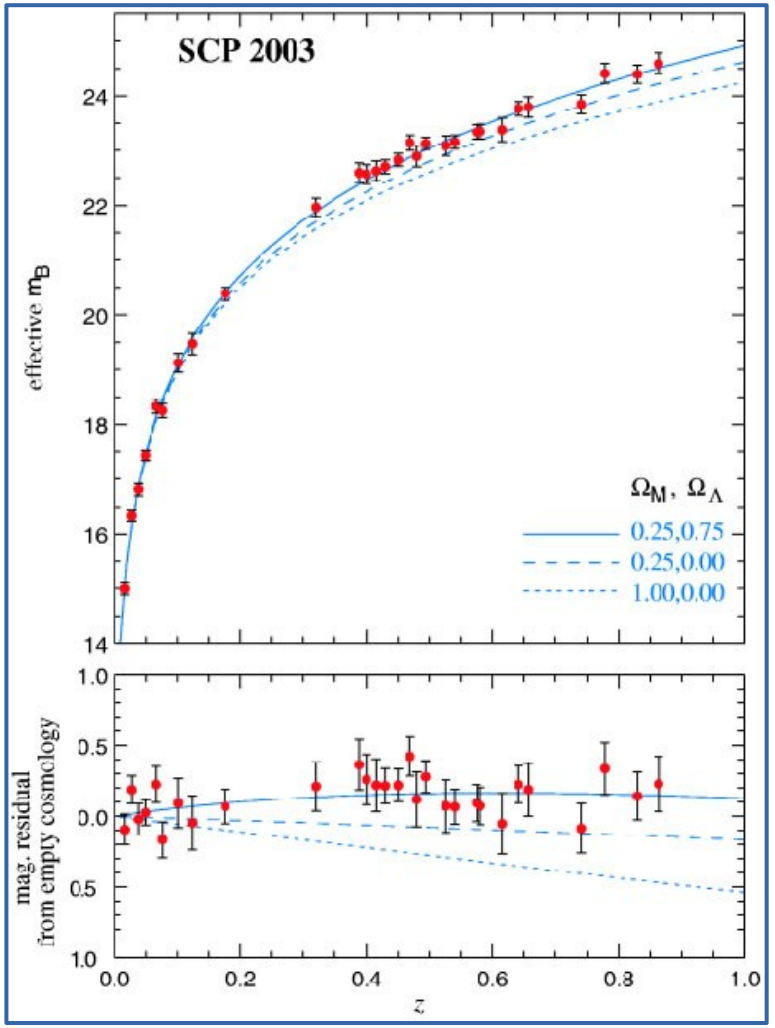
Weak Lensing



Type Ia Supernovae

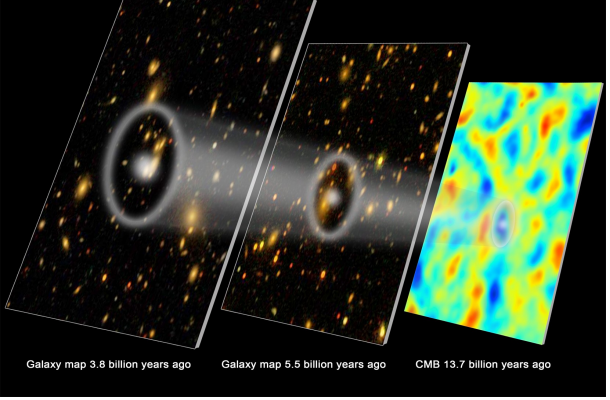
Standard candles





Requirements: Spectroscopic follow-up, understanding of systematics

BAO

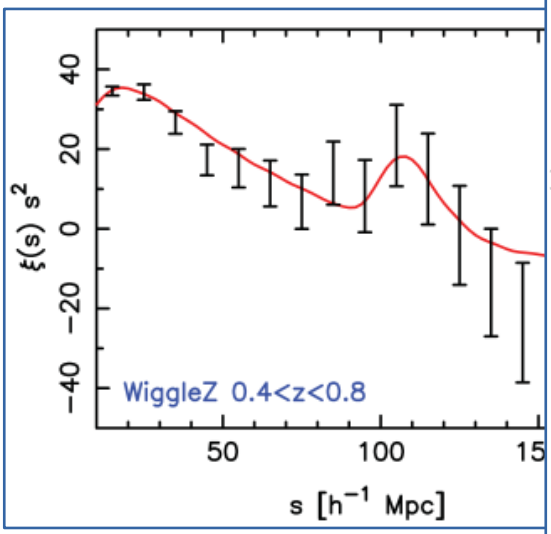


Credit: Eric Huff, the SDSS-III team, and the South Pole Telescope team

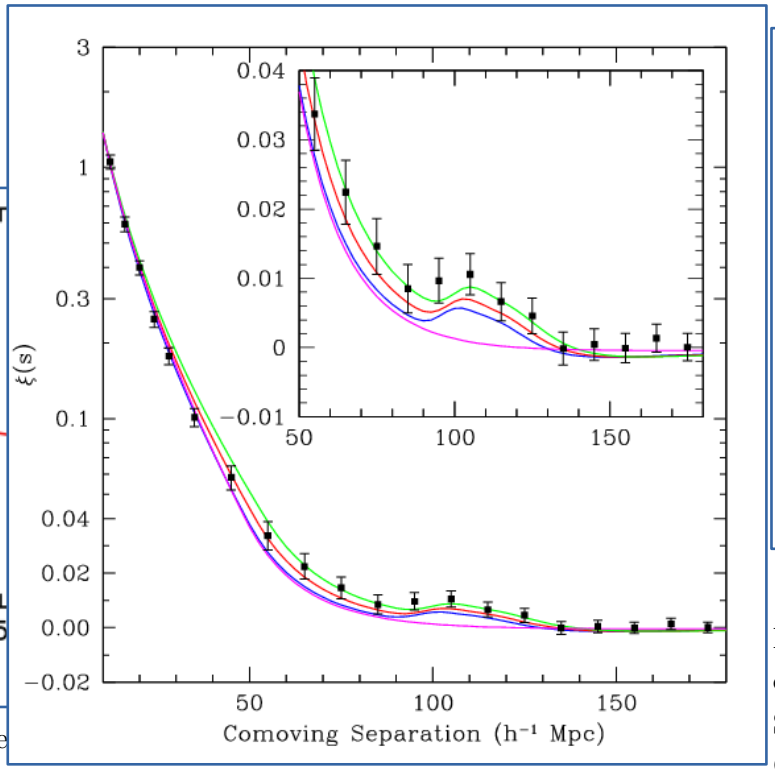
Standard ruler

Ruler: the sound horizon at the epoch of recombination

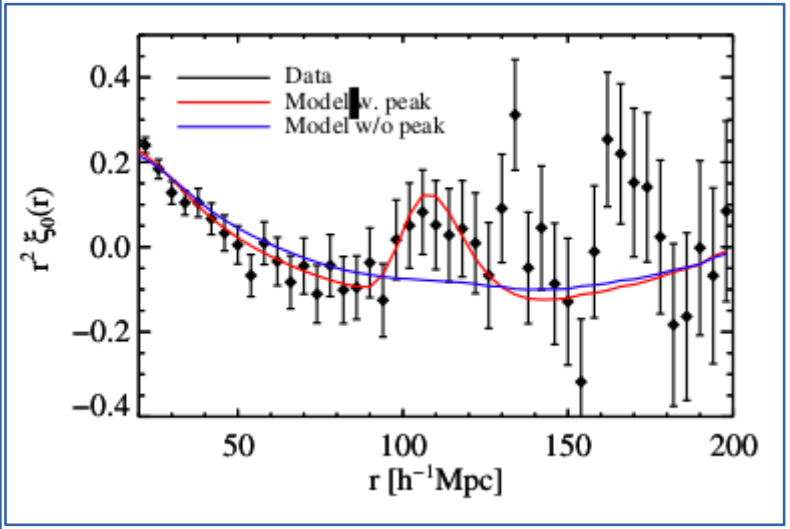
Enhancement in the correlation function of matter at ~150 Mpc



Measurement of the BAO peak from the clustering of **Emission Line Galaxies** in the WiggleZ survey (0.4<z<1)
Blake et al. 2011

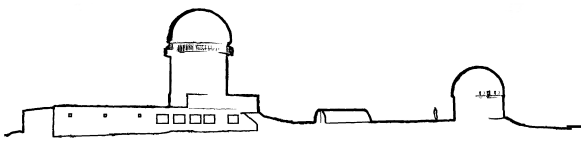


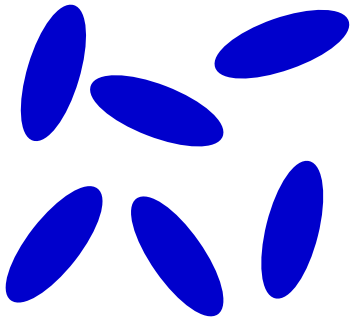
BAO from the correlation function of SDSS **Luminous Red Galaxies** (0.1<z<0.5)
Eisenstein et al 2005



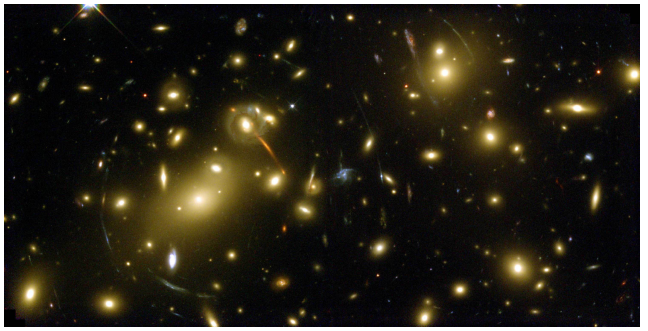
BAO peak from the **Lyα forest** in the BOSS survey
Busca et al. 2013

Requirements: large volumes. Ideally at multiple redshifts. Very good z precision.

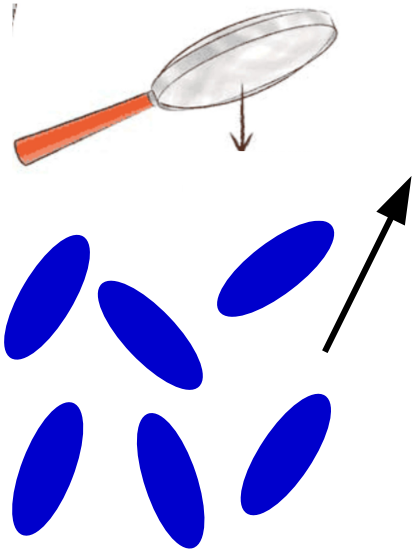


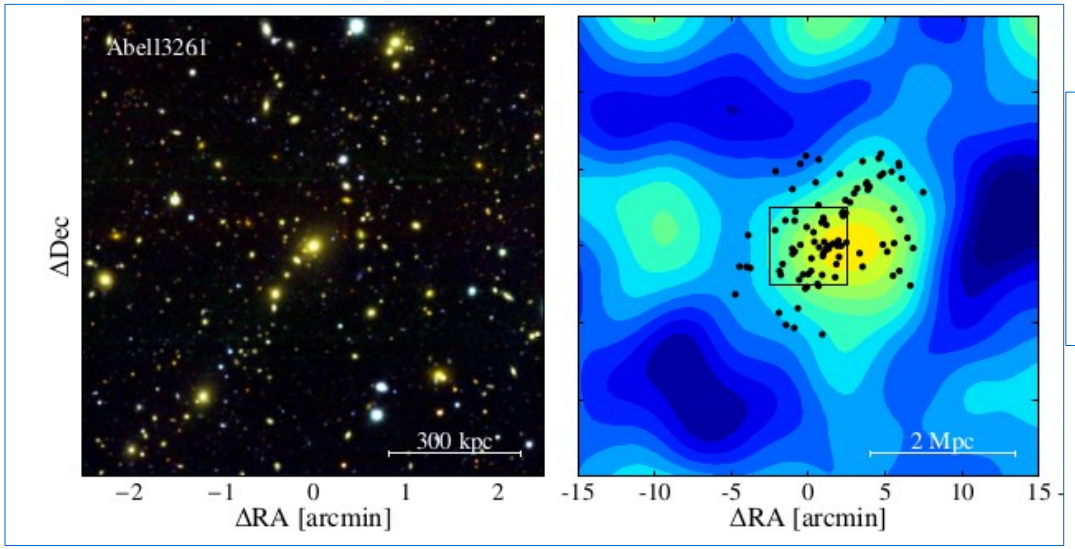


Distortion in the shape of distant galaxies due to matter overdensities along the line of sight



Abell 2218

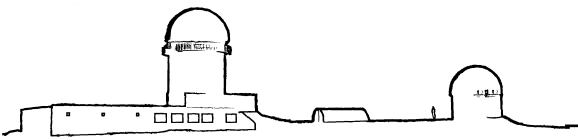




Weak lensing mass map from DES science verification data (Melchior et al. 2015)

Requirements: Superb-quality images, proper treatment of intrinsic alignment, good redshifts to separate foreground and background objects

Weak Lensing

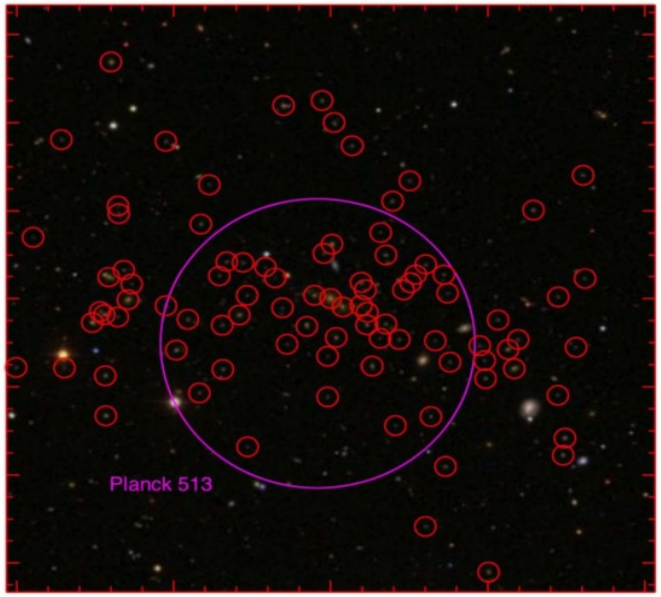


Cluster abundances for constraining the growth of structure

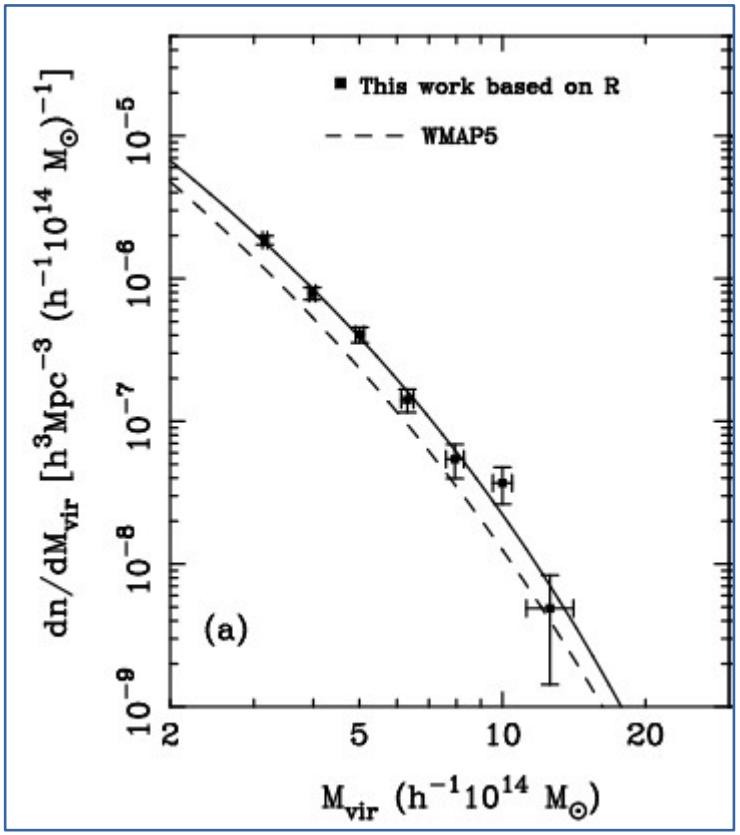
Richness: number of galaxies in a specified luminosity and color range within a fiducial radius.

- Optical/IR galaxy richness
- X-ray
- SZ in CMB
- lensing

Requirements: large number density of galaxies, calibration observable/mass relation.

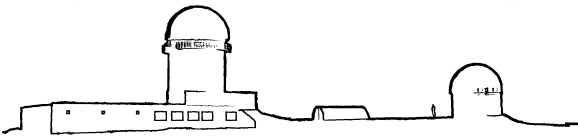


Rozo et al. 2014 – Sloan and Planck



Wen et al. 2014 – Rich clusters MF@ z~0.2

Clusters



Photometric

- Large Volumes
- High number density
- Evenly sampled (no pre-selection)
- Deep

vs.

Spectroscopic

- Precise z
- Provide SED

Photometric

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- High number density
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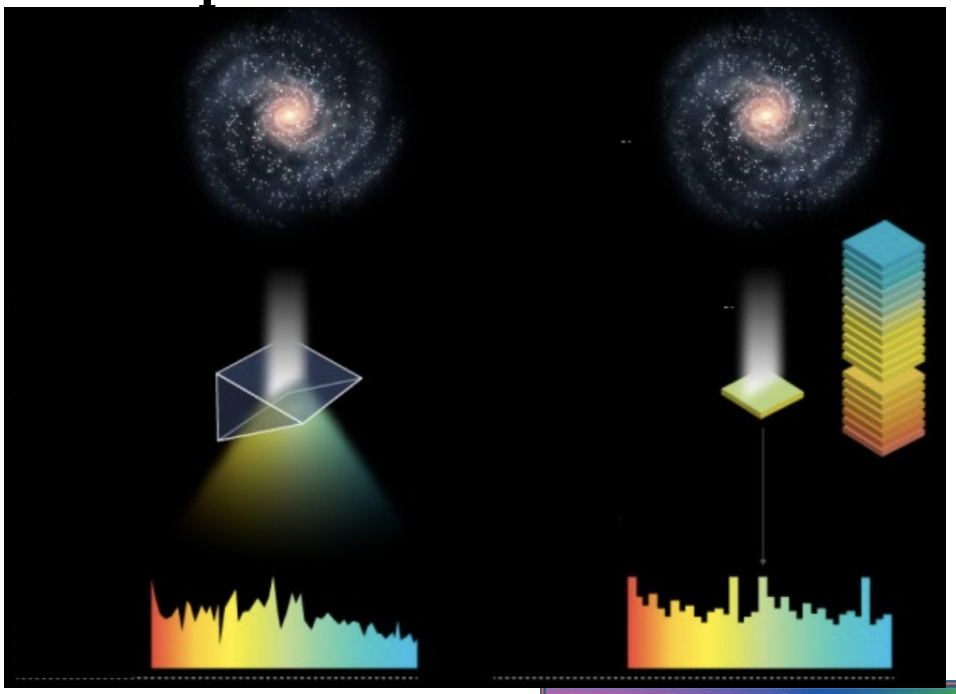
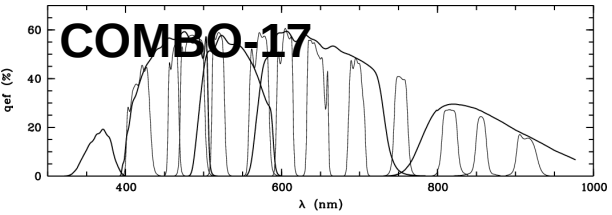
vs.

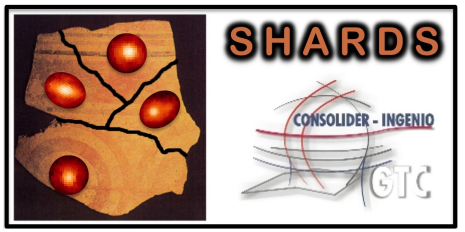
Spectroscopic

- Precise z
- Provide SED

Spectro-Photometric







ALHAMBRA SURVEY

Javalambre
Physics of the Accelerating Universe
Astrophysical
Survey

The Javalambre-PAU Astrophysical Survey

A Spanish-Brazilian collaboration,

the J-PAS survey will scan

~8500 deg² of the northern sky

with 54 narrow-band filters covering

the whole optical range

from the dedicated 2.5m telescope in

the *sierra of Javalambre*

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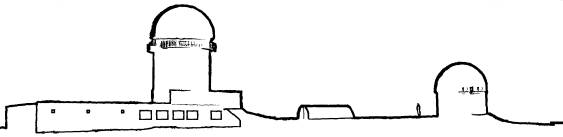
The Javalambre Observatory

In the "Sierra de Javalambre" @1960m

now officially a Spanish "scientific and technical facility" (soon available for 20% open-time)

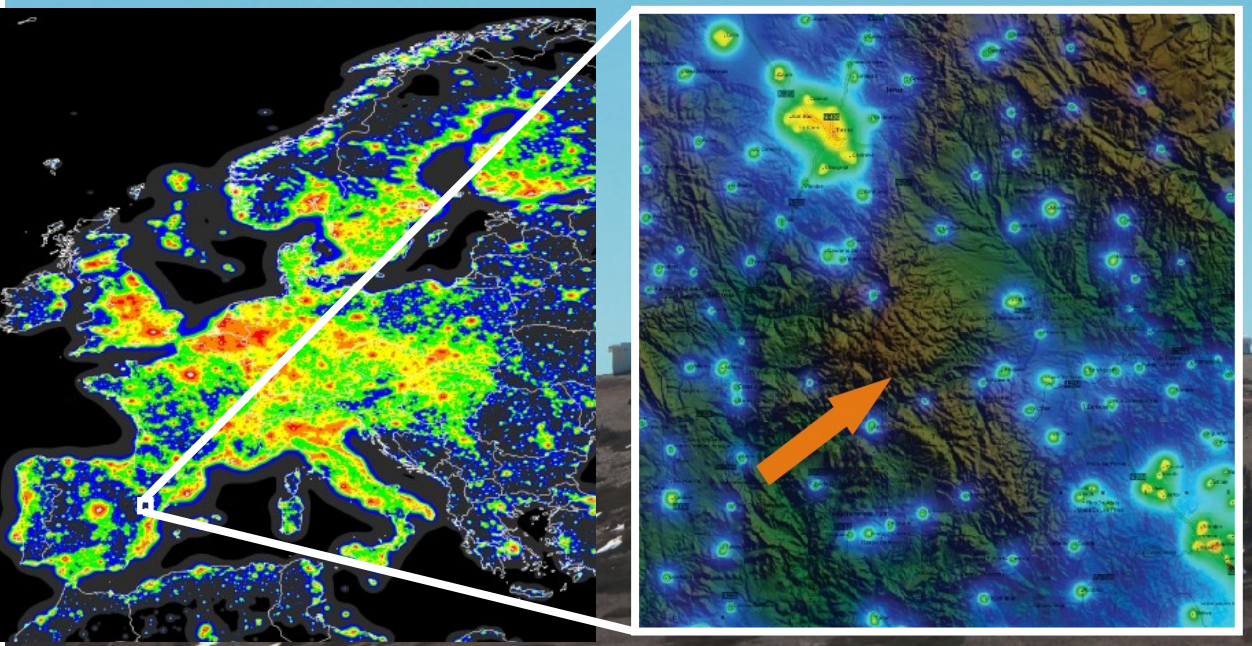


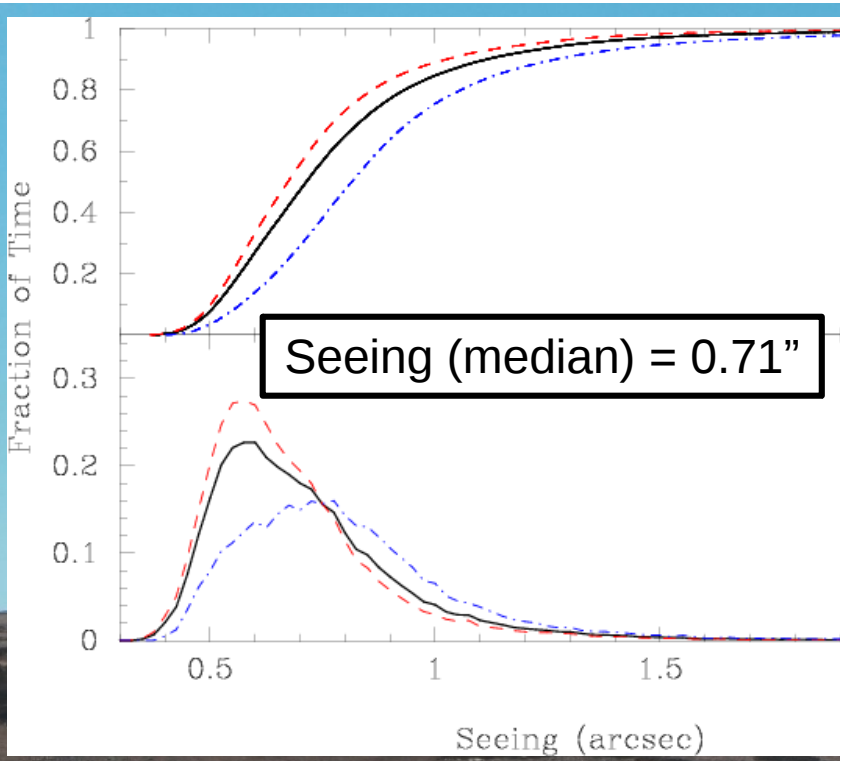
The Javalambre Observatory

In the "Sierra de Javalambre" @1960m

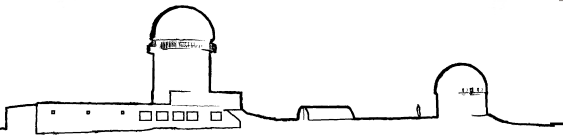
now officially a Spanish "scientific and technical facility" (soon available for 20% open-time)

Comparable (at similar altitudes) to Mauna Kea or La Silla





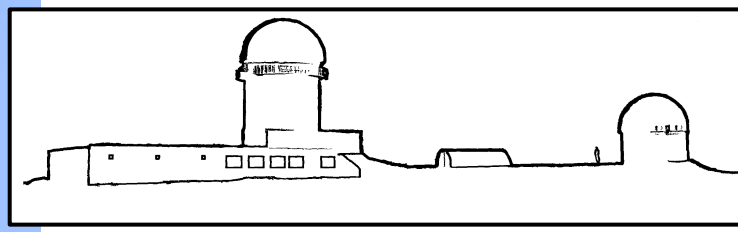
Seeing (median) = 0.71"



Location

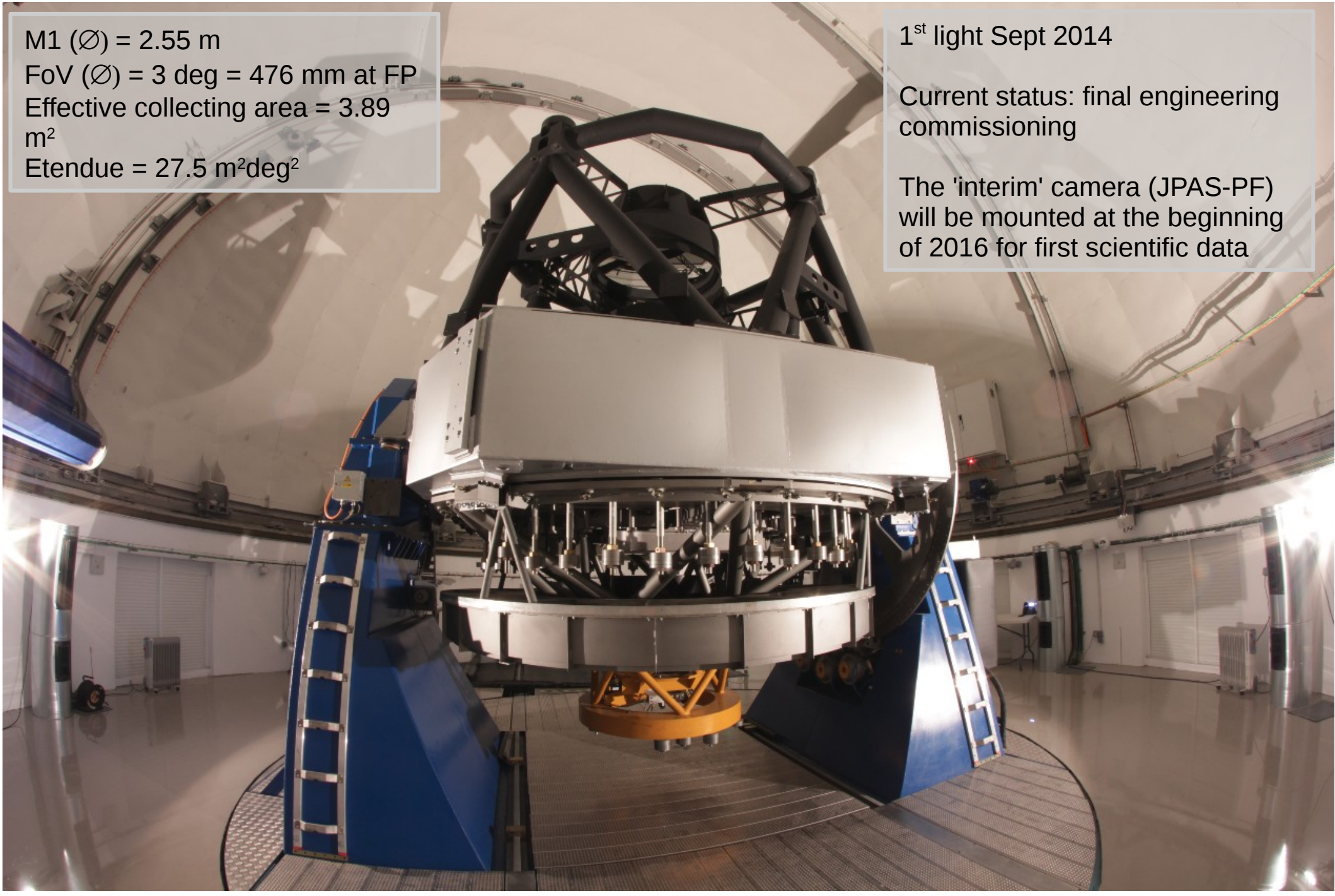
CEFCA

Centro de Estudios de Física del Cosmos de Aragón



The telescope

T250



M1 (∅) = 2.55 m
FoV (∅) = 3 deg = 476 mm at FP
Effective collecting area = 3.89 m^2
Etendue = 27.5 $m^2 deg^2$

1st light Sept 2014

Current status: final engineering commissioning

The 'interim' camera (JPAS-PF) will be mounted at the beginning of 2016 for first scientific data

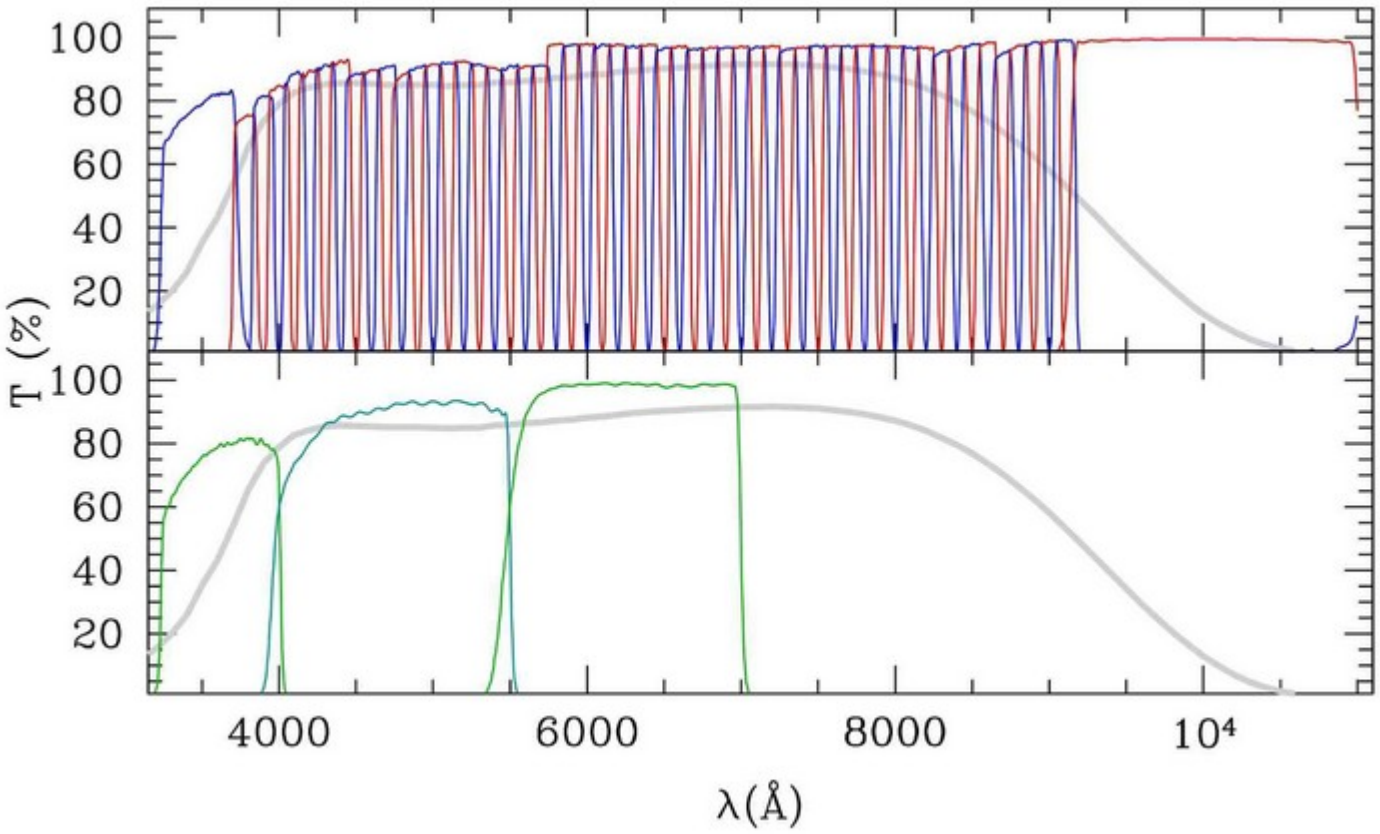
The filter system

- 54 NB filters
(FWHM~145Å; Δλ~10nm)
From 3785Å to 9100Å

- 1 Blue MB filter
(FWHM~260Å; λ_c~3600Å)

- 1 Red BB filter
(FWHM~620Å; λ_c~9500Å)

- Sloan u, g, r



Pseudo-spectrum (R~50) in every pixel of the sky down to M_{AB} ~ 22.5-24

The filter system

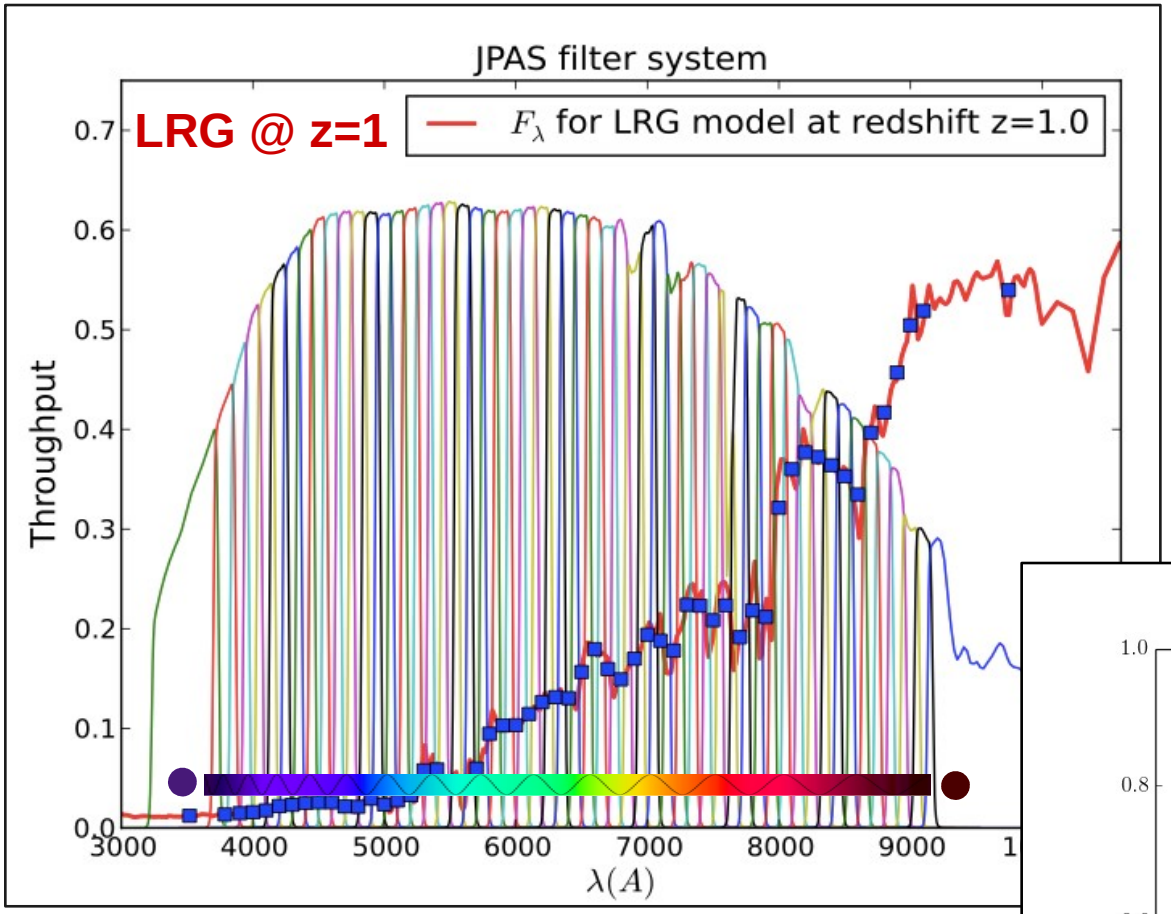
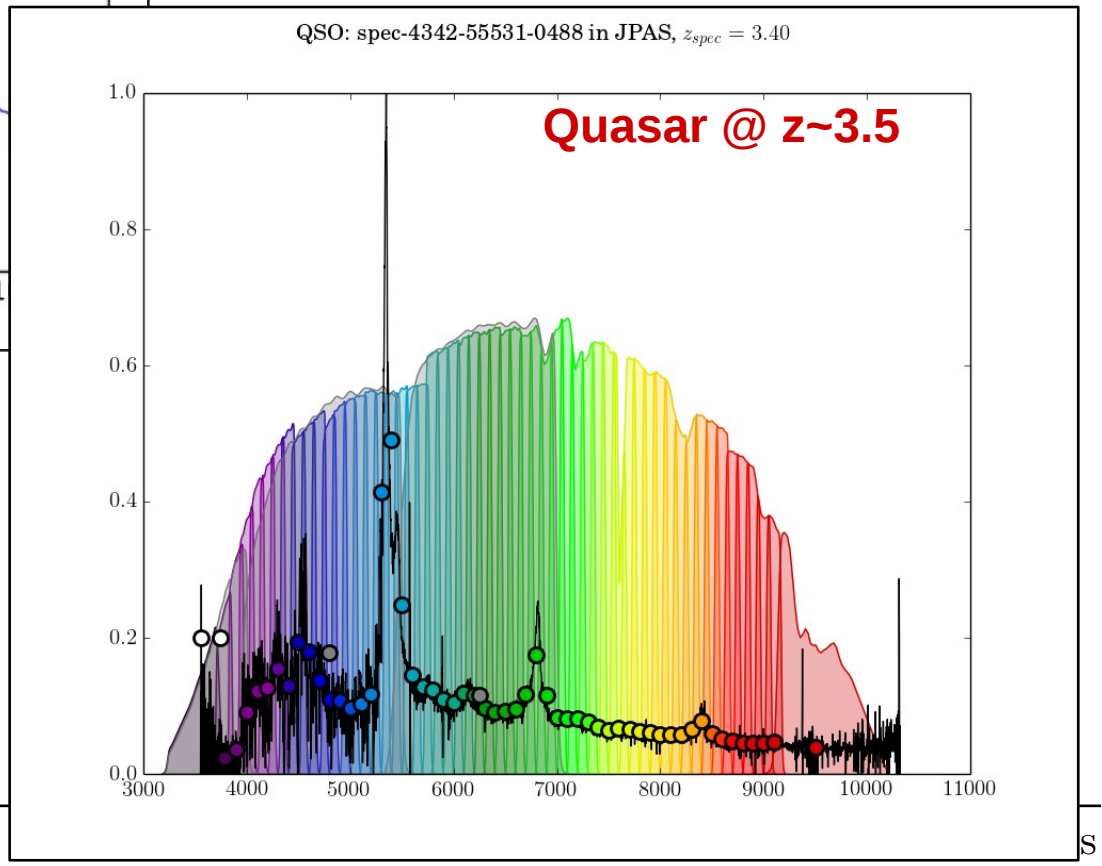


Photo-z precision as good as 0.003(1+z)



200M galaxies
90M LRG+ELG
Ms of quasars

The camera JPCam

1.2 Giga pixels
(14 CCD of 9200x9200)
0.22 arcsec/pixel
4.5 deg²

Subsistemas principales

Actuator System
NTE SENER

Filter and Shutter Unit
(TBD)

JPCam interface with T250

Filter and Shutter Unit
- Filter Unit
- Shutter Unit
- Anti-cond. Sys.
- e-Box

Actuator System
- ISS
- Hexapod
- CSS
- e-Box

Camera
e2v

e2v camera
- Cryostat
- Image acquisition system

The camera JPCam

1.2 Giga pixels
(14 CCD of 9200x9200)
0.22 arcsec/pixel
4.5 deg²

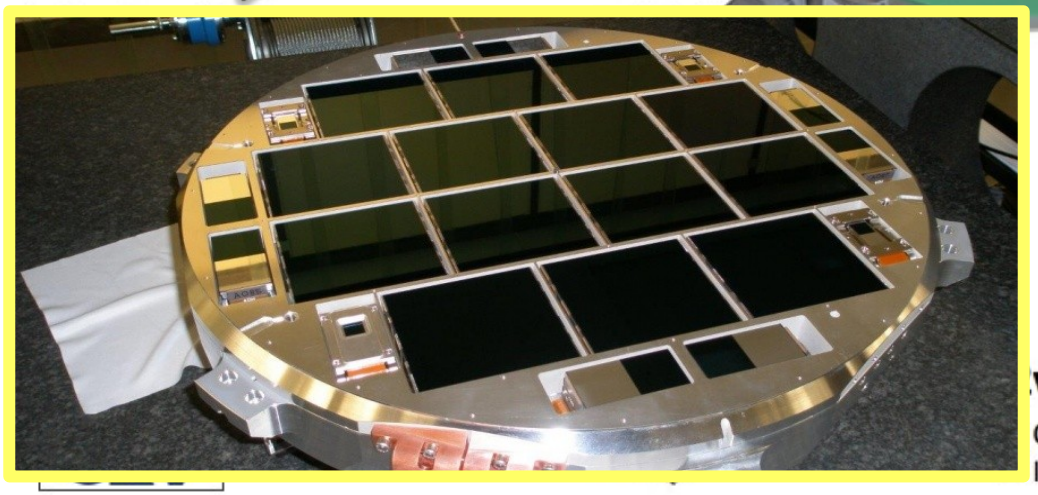
Subsistemas principales

Actuator System
NTE SENER

Filter and Shutter Unit
(TBD)

JPCam interface
with T250

Filter and Shutter Unit
- Filter Unit
- Shutter Unit
- Anti-cond. Sys.
- e-Box



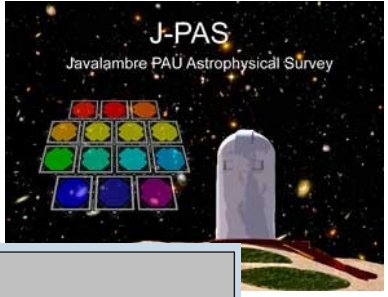
v camera
Cryostat
Image acquisition system

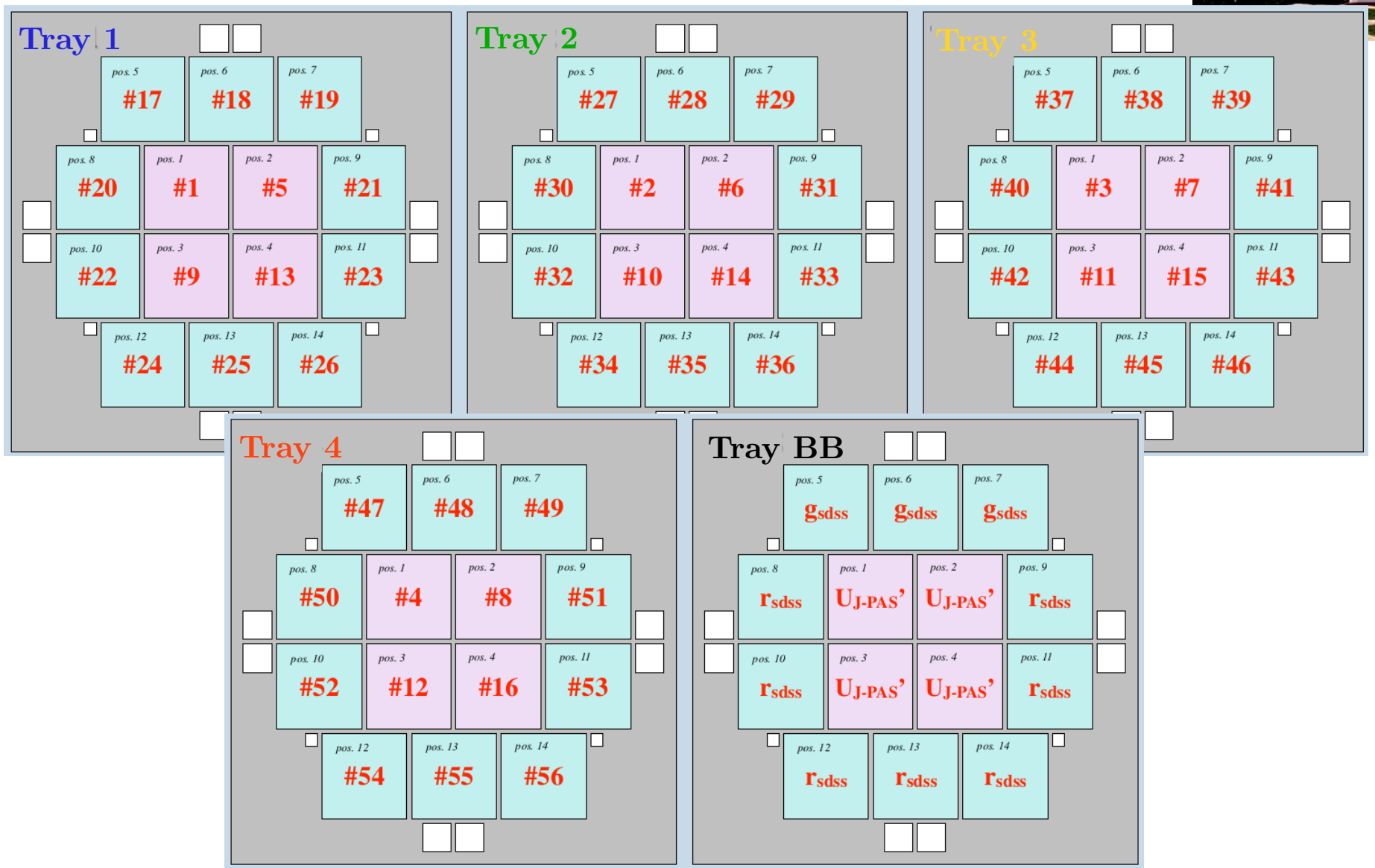
The camera JPCam

1.2 Giga pixels
(14 CCD of 9200x9200)
0.22 arcsec/pixel
4.5 deg²

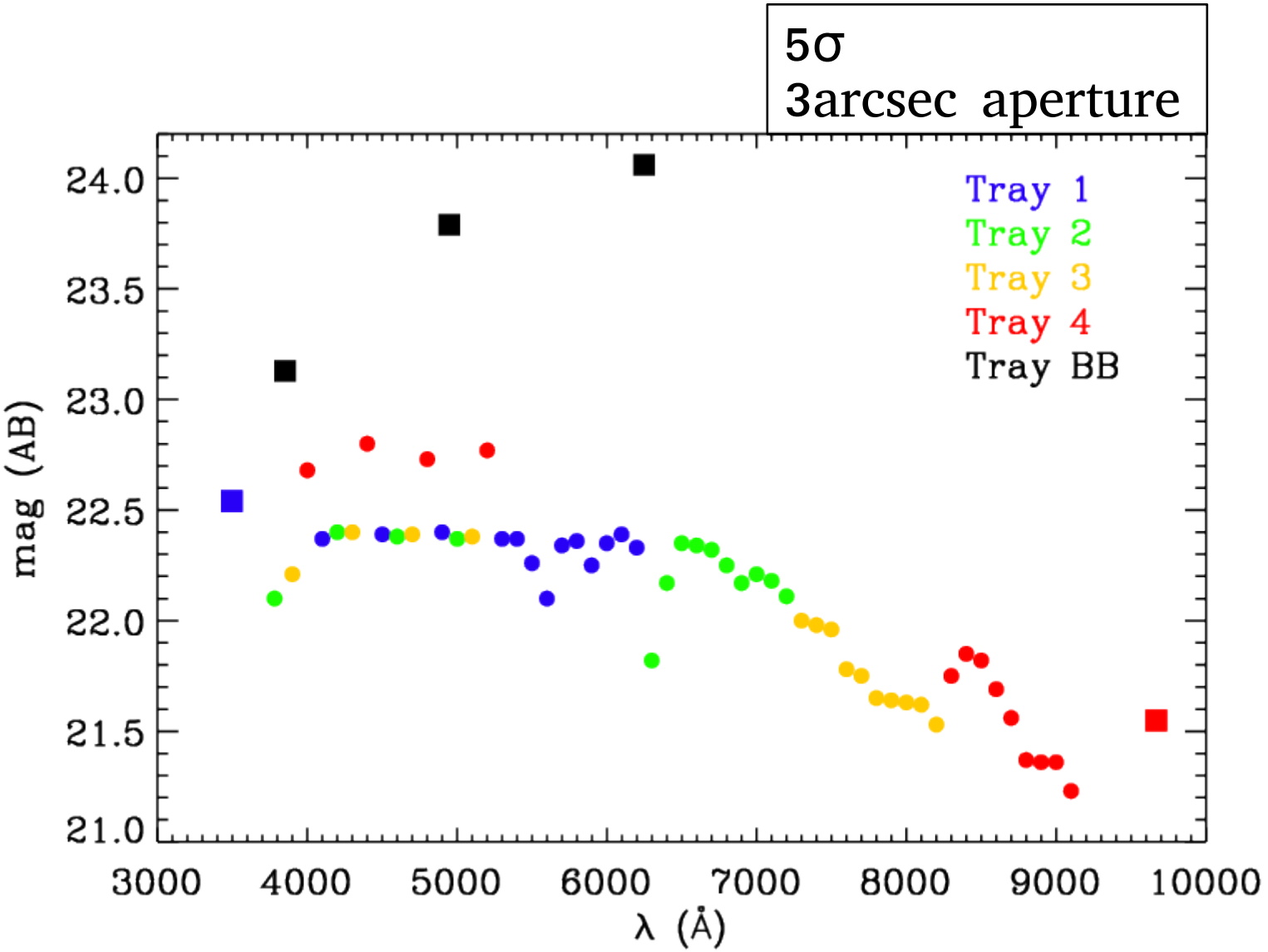
	Telescope		Camera				
	Size	**FoV**	**# CCDs**	**CCD format**	**# of pixels**	**Resolution**	**Filters**
LSST	8.4m	9.6 sq. deg.	189	4096 x 4096	3.2 Gpixels	0.2"/pix	u, g, r, i, z, y
PanStarrs	1.8m	6.7 sq. deg.	60	4600 x 4600	1.3 Gpixels	0.26"/pix	g, r, i, z, y
JPCam	**2.5m**	**4.9 sq. deg.**	**14**	**9231 x 9216**	**1.2 Gpixels**	**0.23"/pix**	**54NB + 2BB**
HyperSuprimeCam	8.2m	1.8 sq. deg.	112	2048 x 4096	940 Mpixels	0.18"/pix	r, i, z, y
VIS (Euclid)	1.2m	0.5 sq. deg.	36	4096 x 4096	520 Mpixels	0.1"/pix	R, I, Z
DECam	4m	3 sq. deg.	62	2048 x 4096	500 Mpixels	0.27"/pix	g, r, i, z, y
Megacam	3.6m	1 sq. deg.	32	2048 x 4096	340 Mpixels	0.19"/pix	u, g, r, i, z
Omegacam	2.6m	1 sq. deg.	32	2048 x 4096	340 Mpixels	0.21"/pix	u, g, r, i, z
JPAS-Path Finder	**2.5m**	**0.45 sq. deg.**	**1**	**10580x10560**	**110 Mpixels**	**0.23"/pix**	**g, r, i + NBs**
T80Cam	**0.8m**	**2.1 sq. deg.**	**1**	**10580x10560**	**110 Mpixels**	**0.5"/pix**	**u, g, r, i, z + 7NB**
SuprimeCam	8.2m	0.25 sq. deg.	10	2048 x 4096	80 Mpixels	0.2"/pix	g, r, i, z, y

The camera + filters

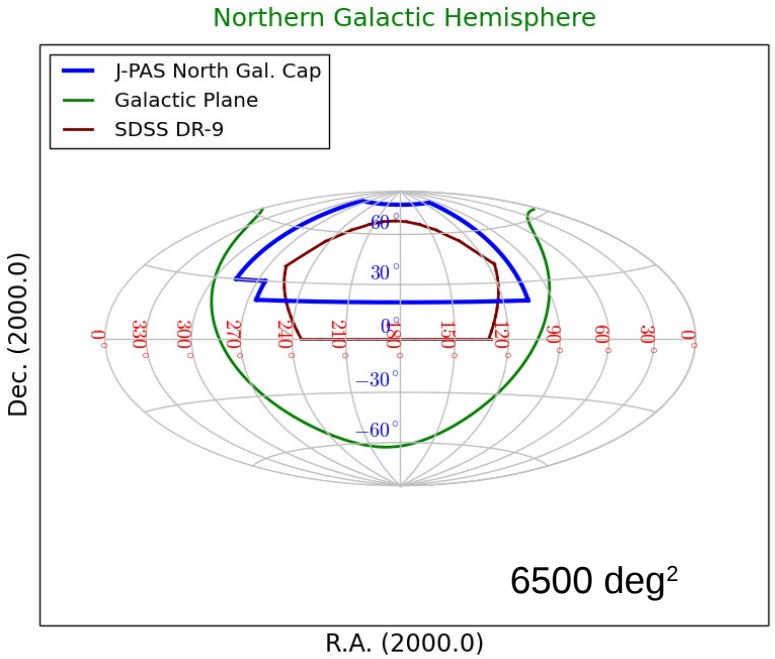


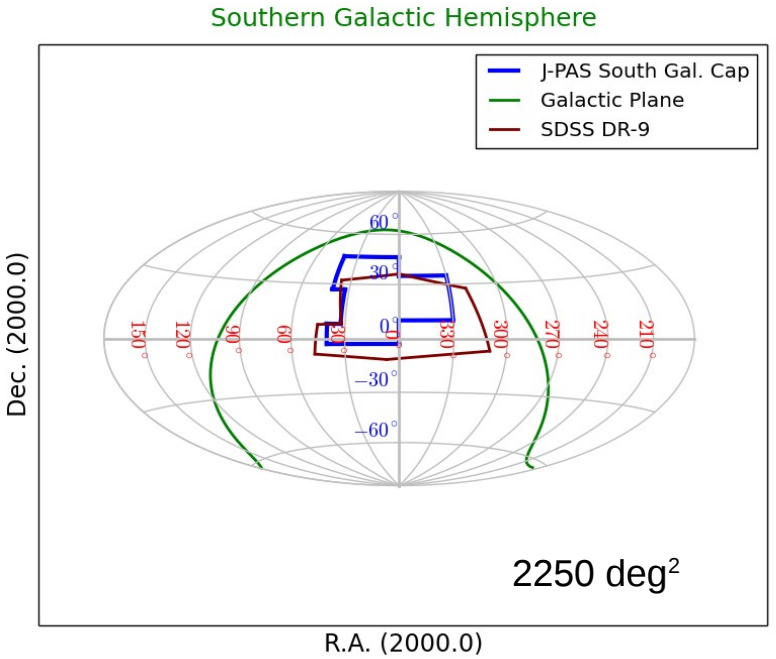


Limiting magnitudes



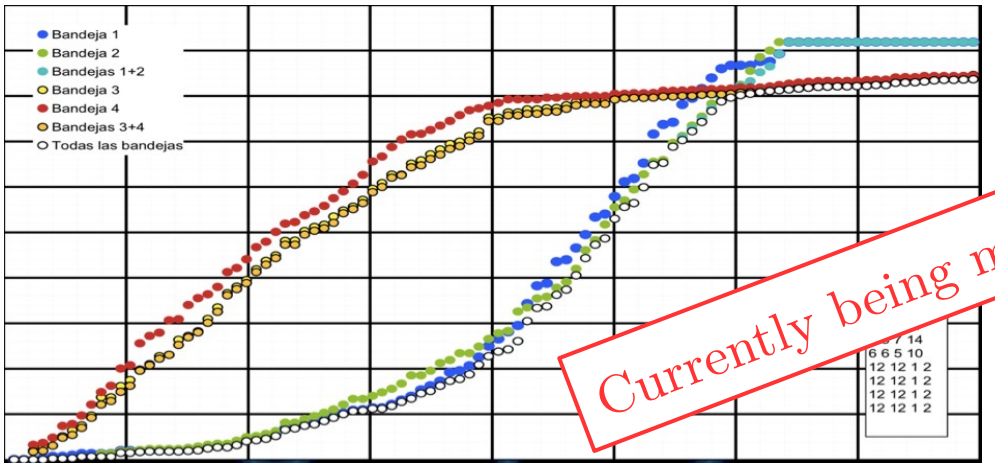
Footprint and Survey strategy



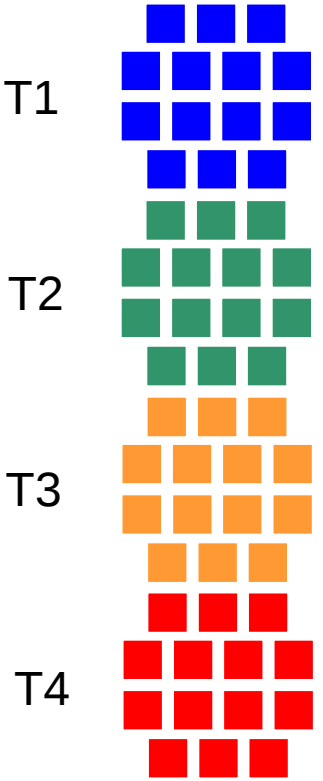


Compromise between visibility from the OAJ and galactic extinction

14 different filters in each tray
at least 4 (60 sec) exposures in each filter (2+1+1)



Survey speed
~ 1 deg² /yr



Data processing and storage

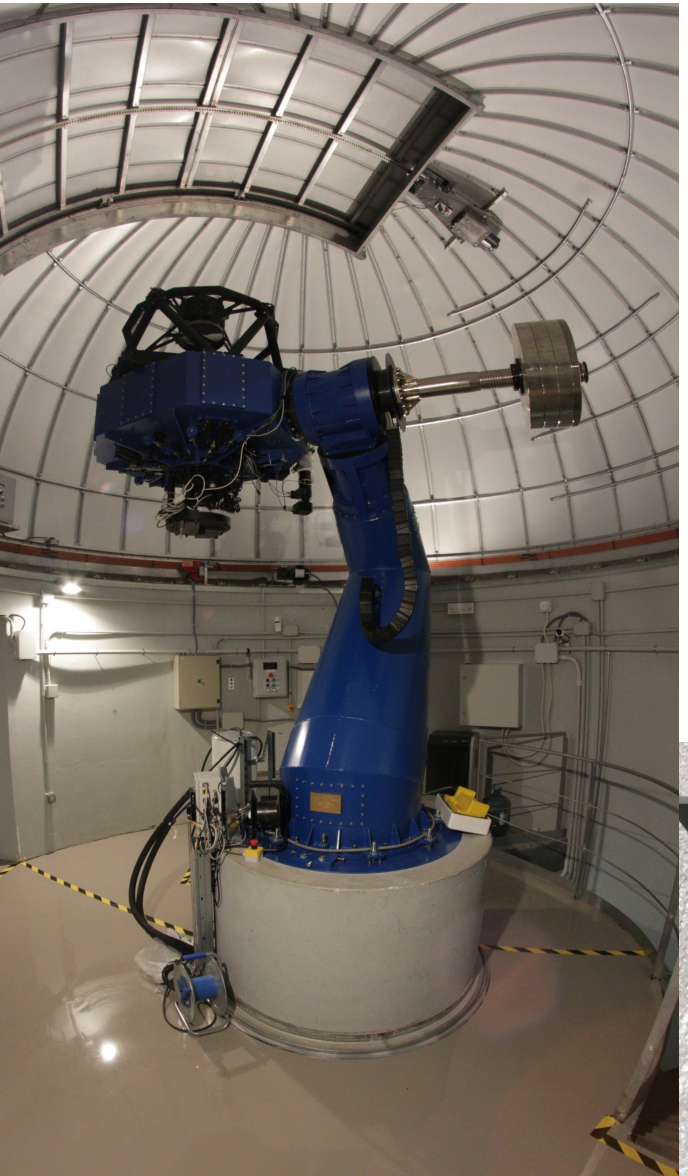
J-PAS: 1.3Tb of data per observing night

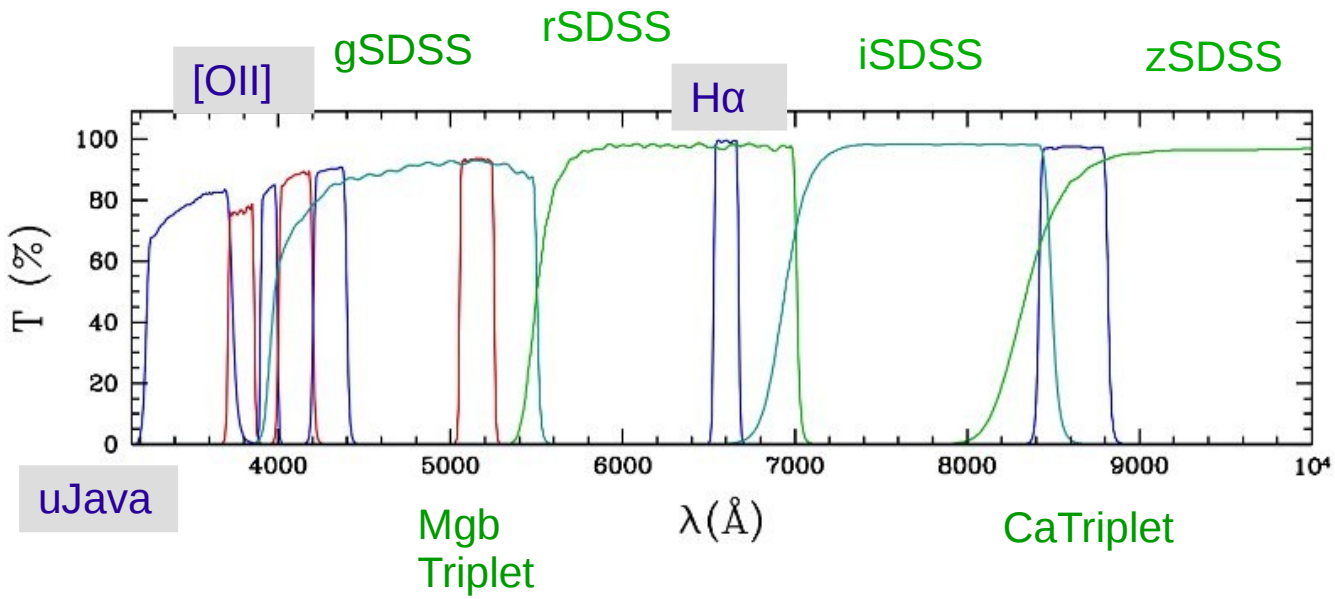
Data reduction, catalogs and storage managed @ CEFCA

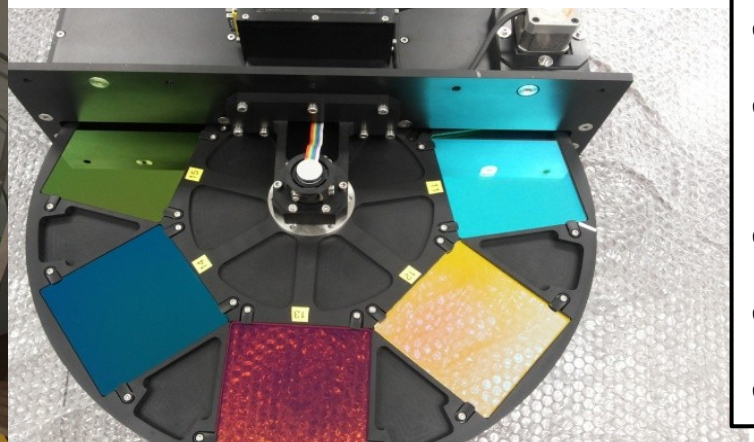
The J-PLUS survey

Javalambre Photometric Local Universe Survey

T80







- ✔ 12 filters
- ✔ ~ 1 mag deeper then SDSS
- ✔ 3 exposures (12 exposures in g,r)
- ✔ 1 CCD of 9200x9200 pixels
- ✔ 0.55 arcsec/pixel
- ✔ ~2 deg^2

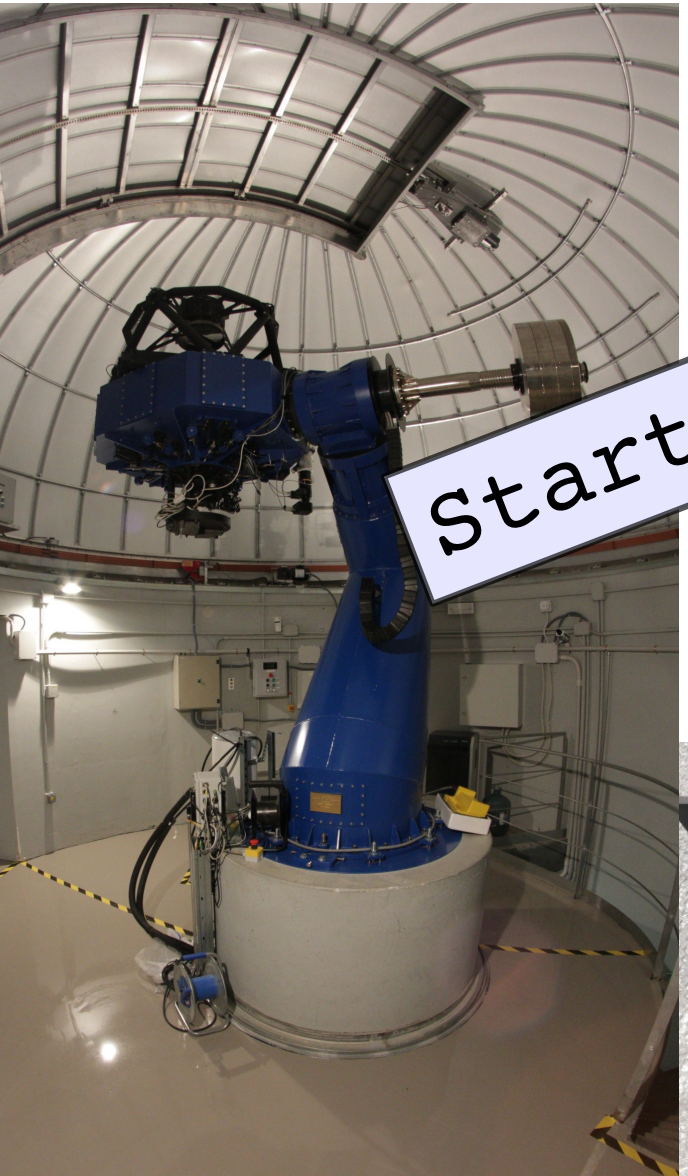
JPCam

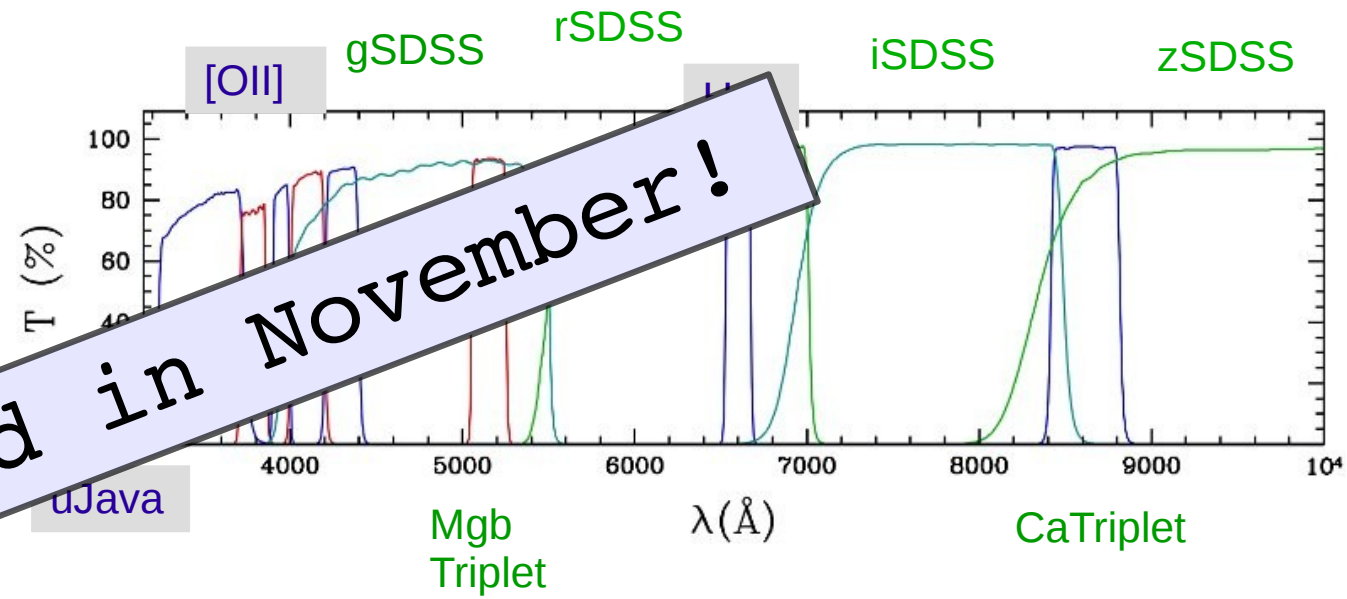
T80Cam

The J-PLUS survey

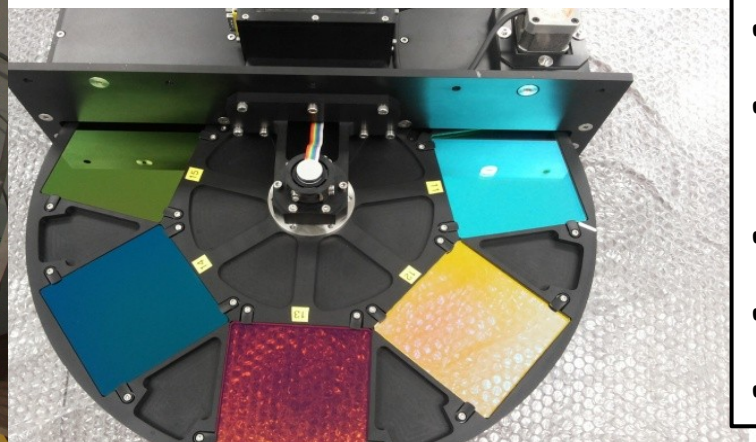
Javalambre Photometric Local Universe Survey

T80





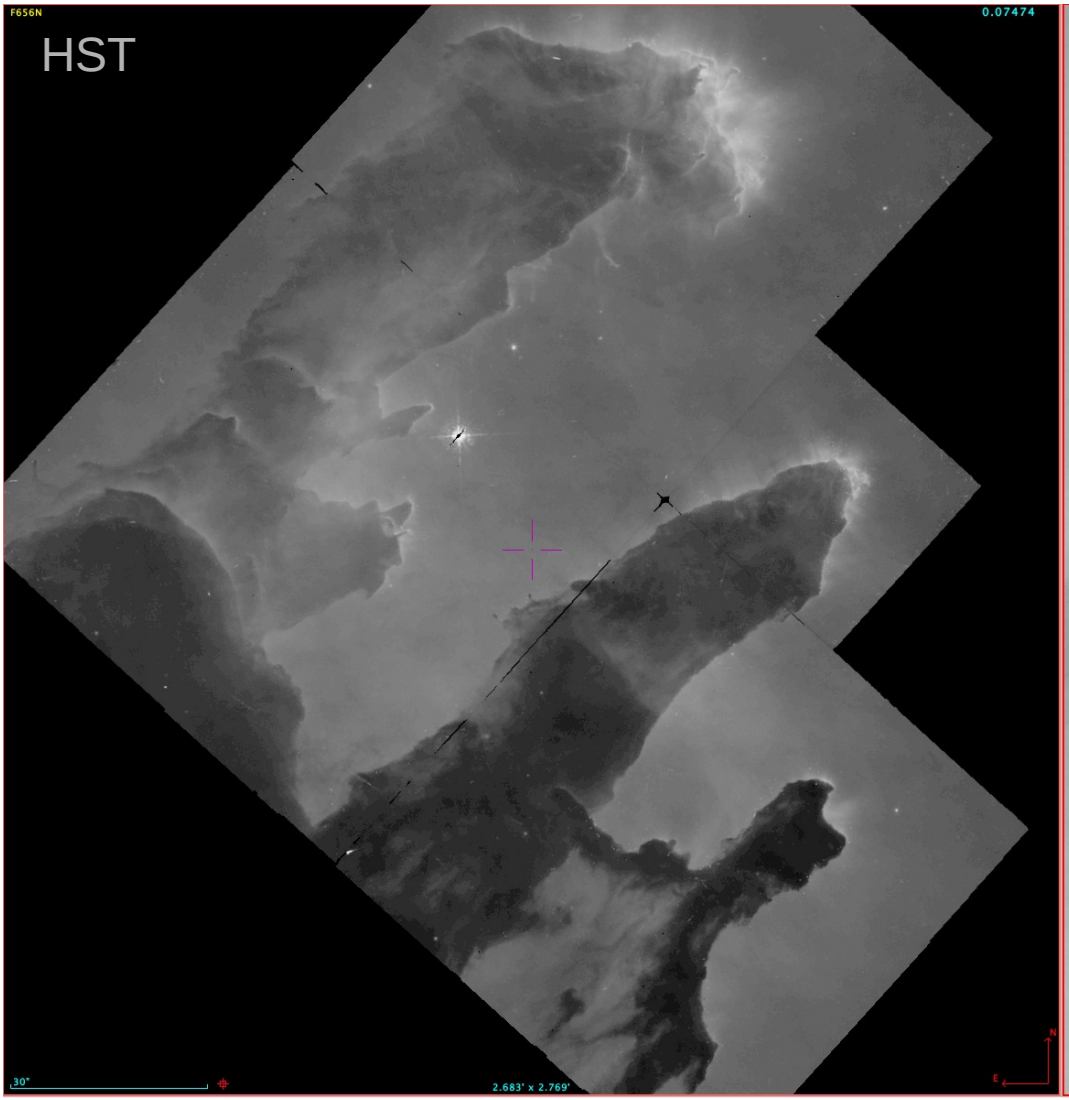
Started in November!

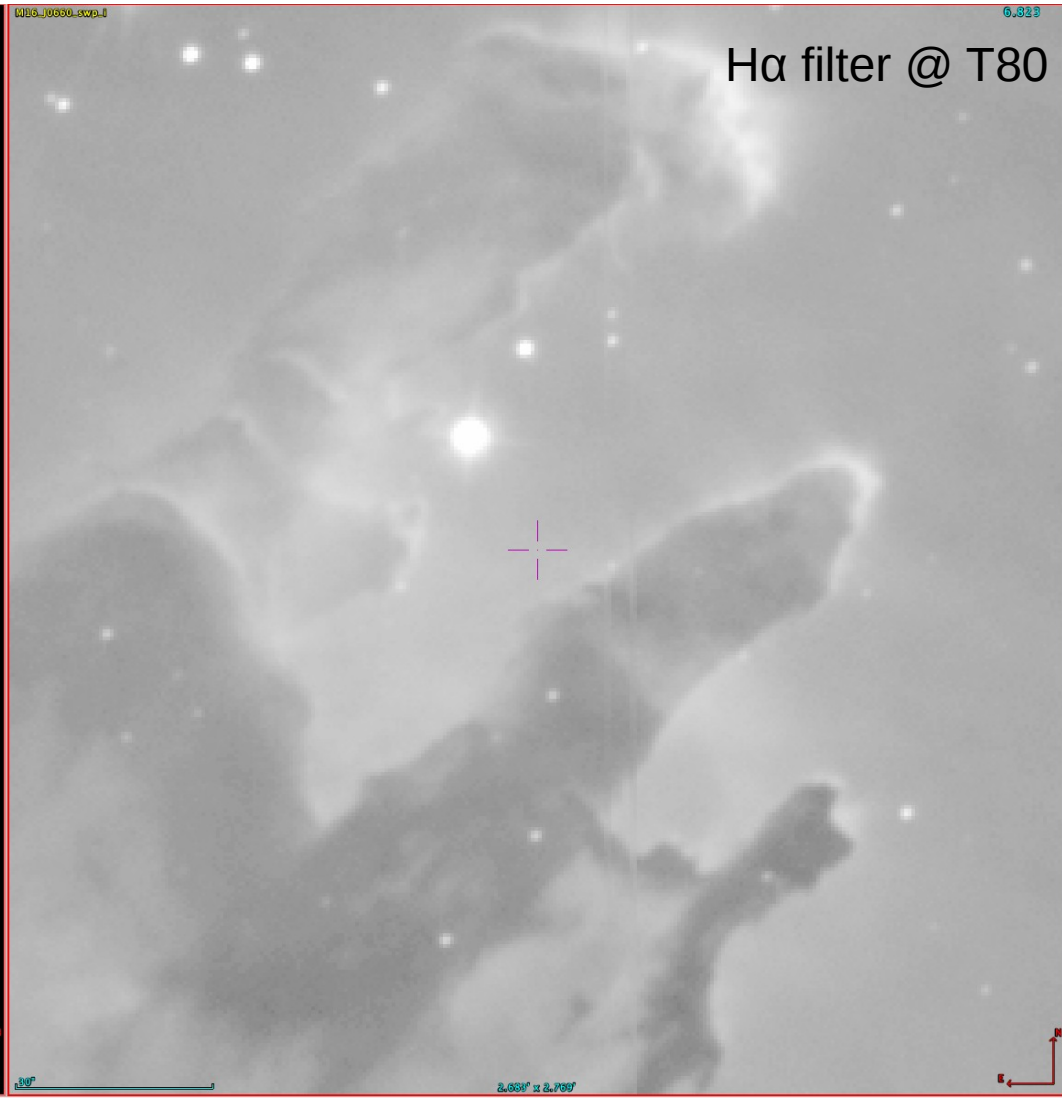


- ✔ 12 filters
- ✔ ~ 1 mag deeper then SDSS
- ✔ 3 exposures (12 exposures in g,r in 4 epochs)
- ✔ 1 CCD of 9200x9200 pixels
- ✔ 0.55 arcsec/pixel
- ✔ 1.4x1.4 deg^2

T80 + T80Cam

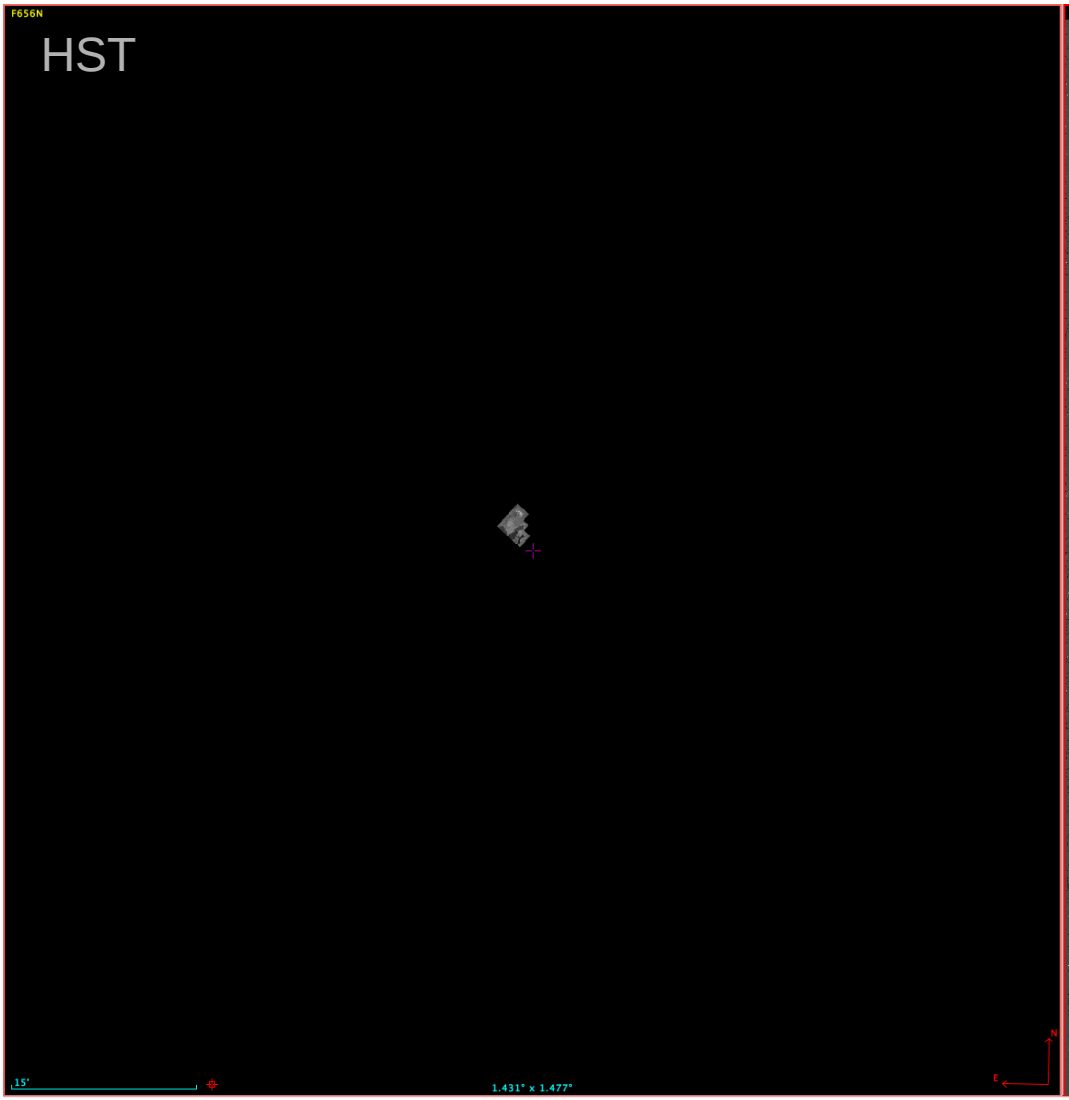
M16

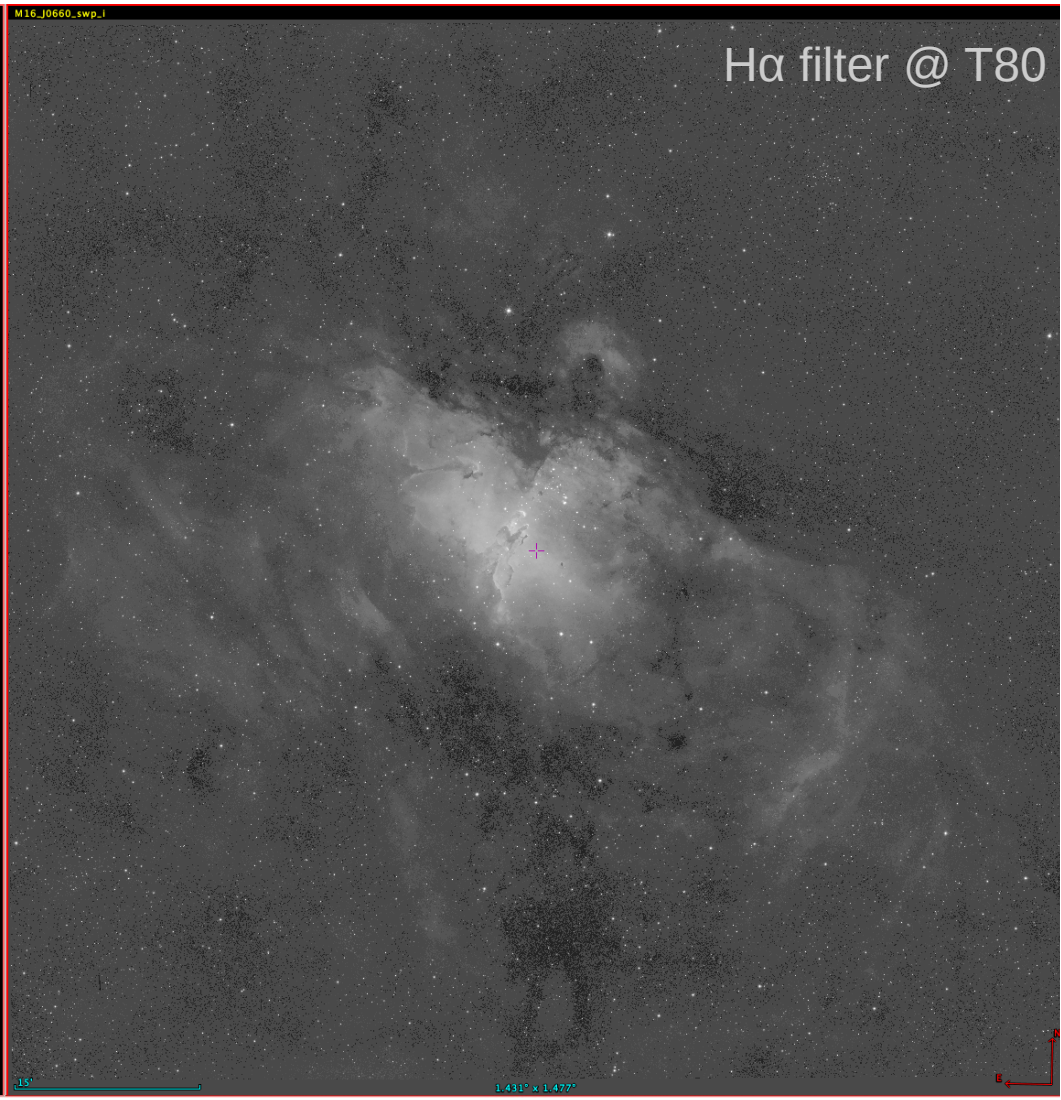




T80 + T80Cam

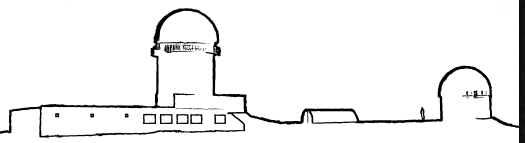
M16





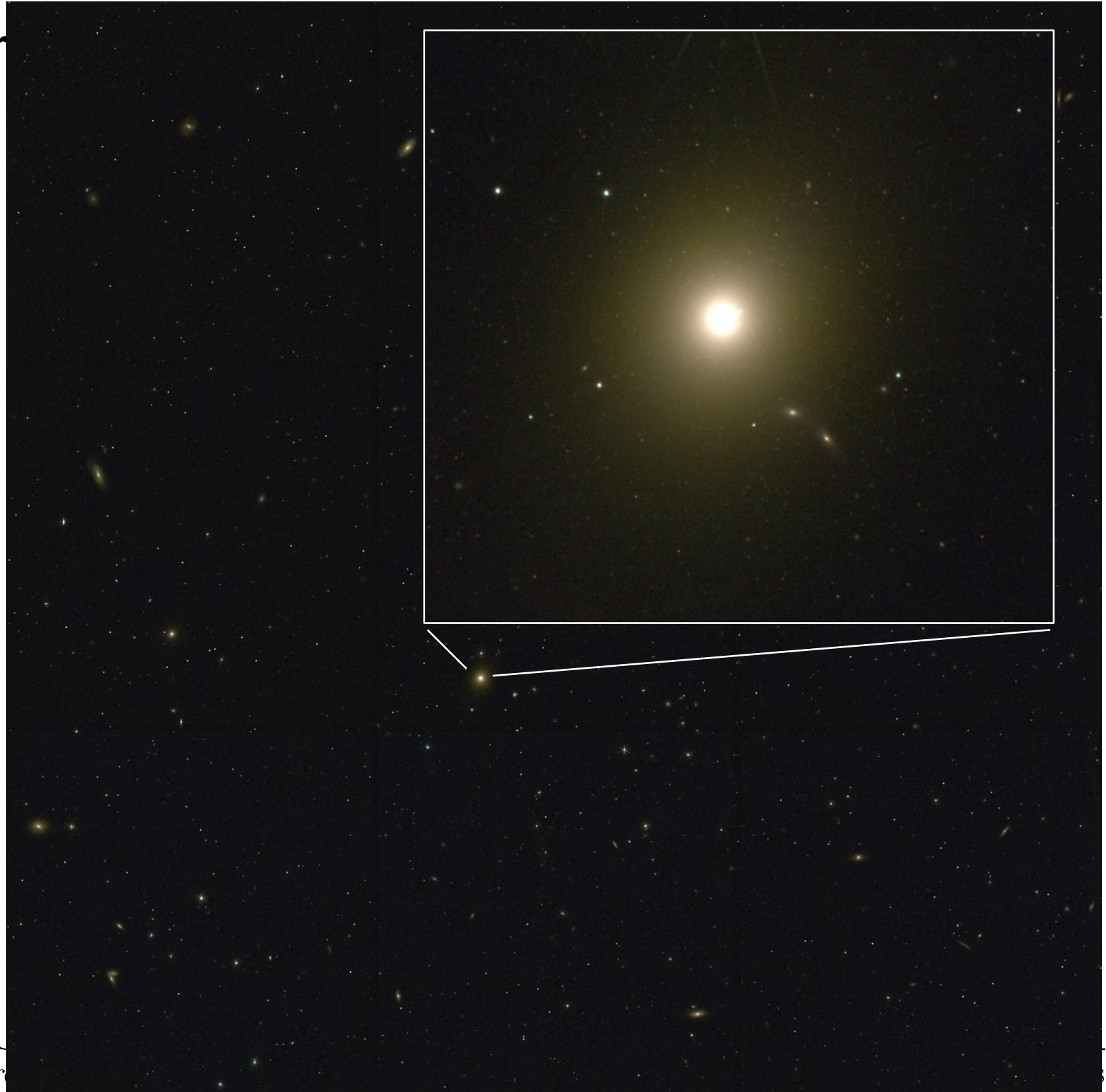
T80 + T80Cam

Mosaic of Virgo

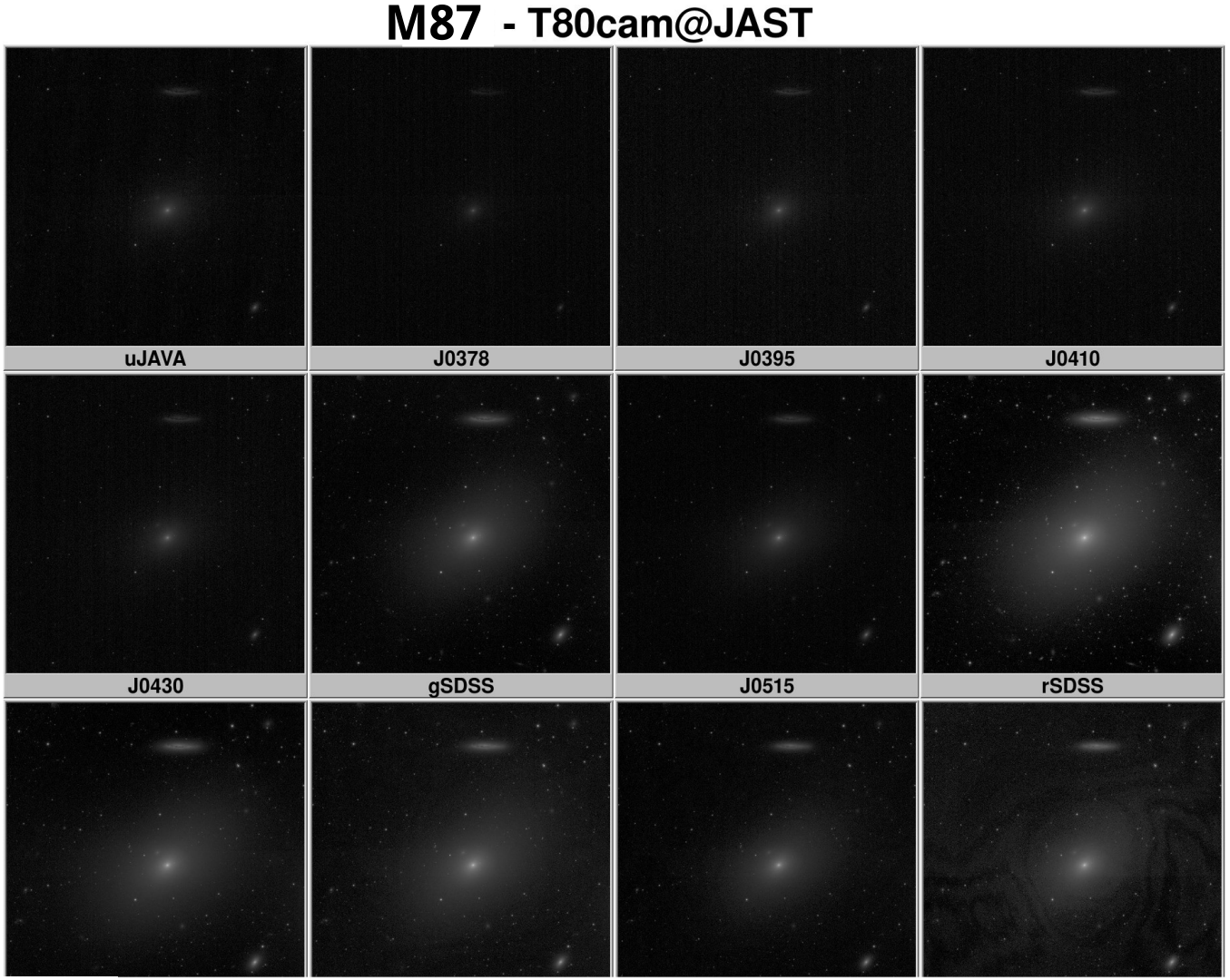


T80 + T80Cam

Mosaic of Virgo



T80 + T80Cam


M87 - T80cam@JAST
uJAVA
J0378
J0395
J0410
J0430
gSDSS
J0515
rSDSS

T80 + T80Cam

M33

T80 + T80Cam

M33

Centro de Estudios de Física del Cosmos de Aragón

CEFCA

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- News
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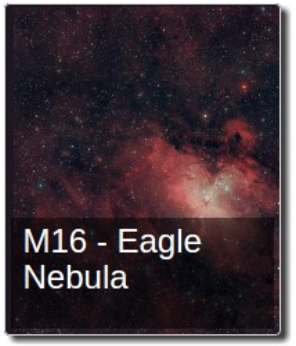
- Research
- Outreach
  - Activities
  - Gallery
  - Videos
  - Images navigator
  - Images tours
  - OAJ visits

IMAGES_NAVIGATOR

Images Navigator



www.cefca.es

Galactica: a facility for amateur astronomy

Type Ia Supernovae

~4000 SNIa
- exposure cadence
- redshift from SN SED or host galaxy
- characterization of environment

BAO

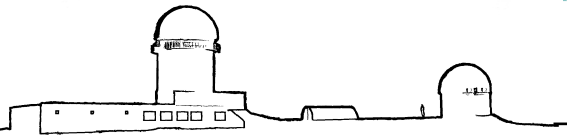
- 90M galaxies (LRG, ELG) with photo-z precision of 0.003(1+z)
- At high-z QSO and LAE

Clusters

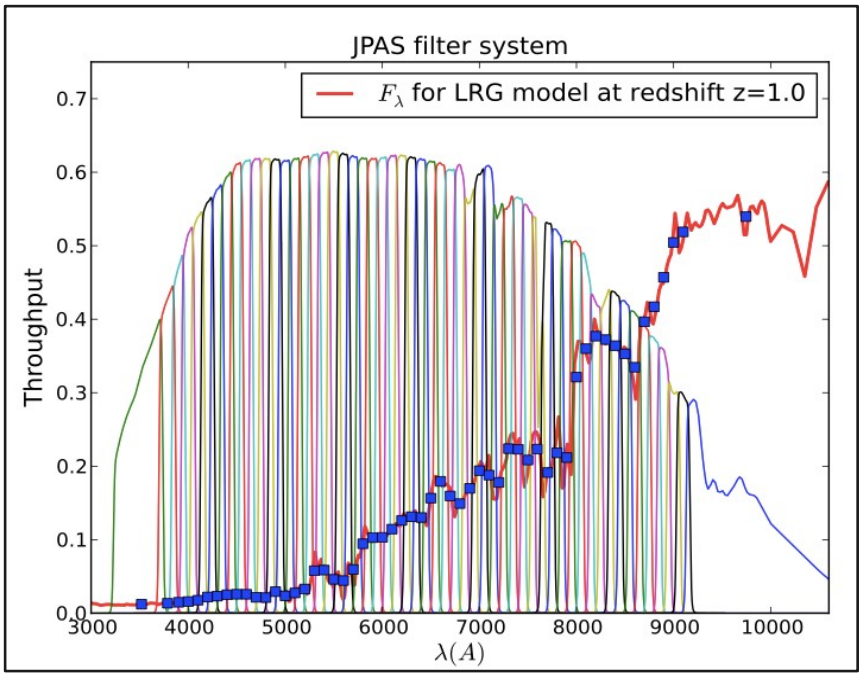
- 700k clusters with more than 10 members – down to ~few 10^{13} M_{sun}
- Combine lensing and optical richness for mass calibration

Weak Lensing

- Very good median seeing @ the OAJ
- BB images taken during best nights
- Redshift precision for lenses and background galaxies



Galaxy evolution



- Low-res spectra → very good photo-z and good sampling of SED

- very large statistics → hundreds of millions of galaxies of all types

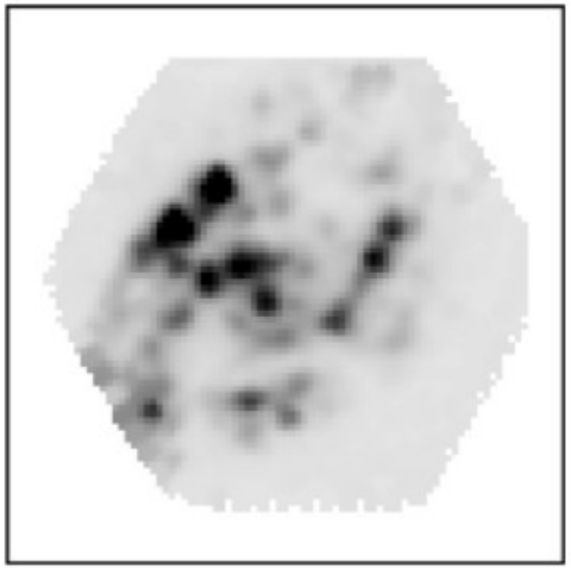
- Uniform spatial sampling → environmental studies at large and small scales

- IFU-like approach → study spatial variation of properties of nearby galaxies

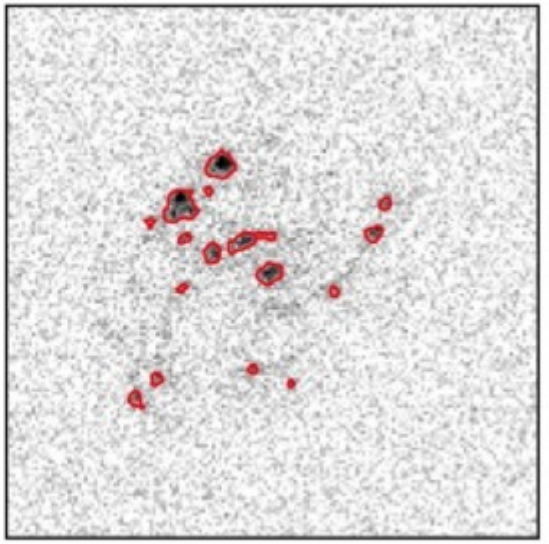
- Stellar population studies as a function of redshift and environment (ages, SFR, presence of AGN)

- Ly-alpha emitters and Ly-break galaxies at z>2

UGC09476
From T80Cam
commissioning data

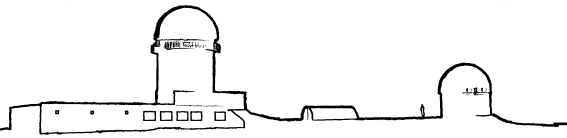


Hα emission from CALIFA
(IFU survey @ Calar Alto)

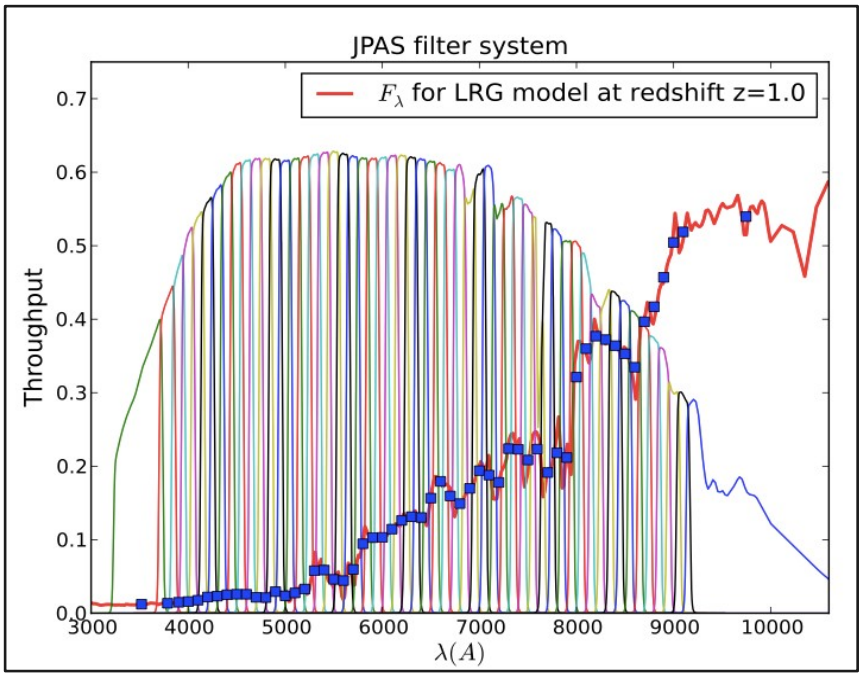


HII regions detected
with J-PLUS filters

Lopez Sanjuan, Rafael Logrono, Vilella Rojo...
@ CEFCA



Galaxy evolution



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Galaxy evolution

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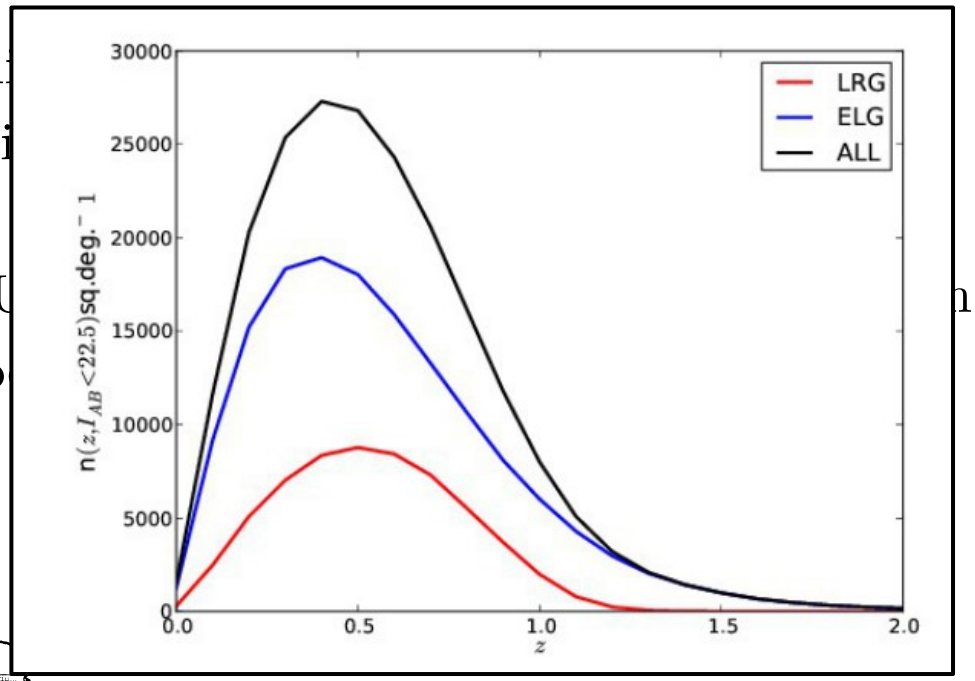
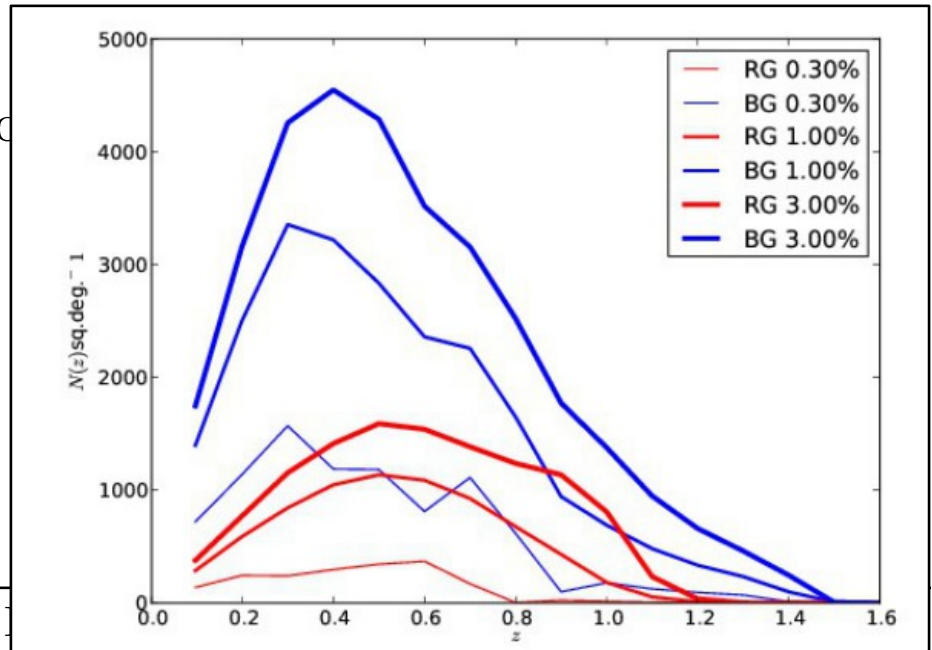
Photo-z error	Red	Blue
0.3%	17M	73M
1%	64M	200M
3%	100M	285M

- Uni
studi

- IFU
prop





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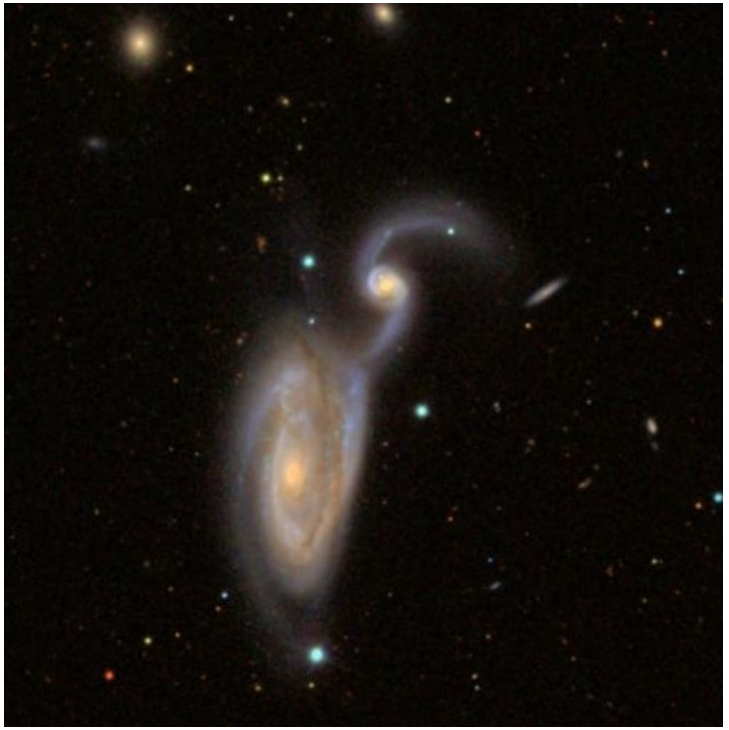

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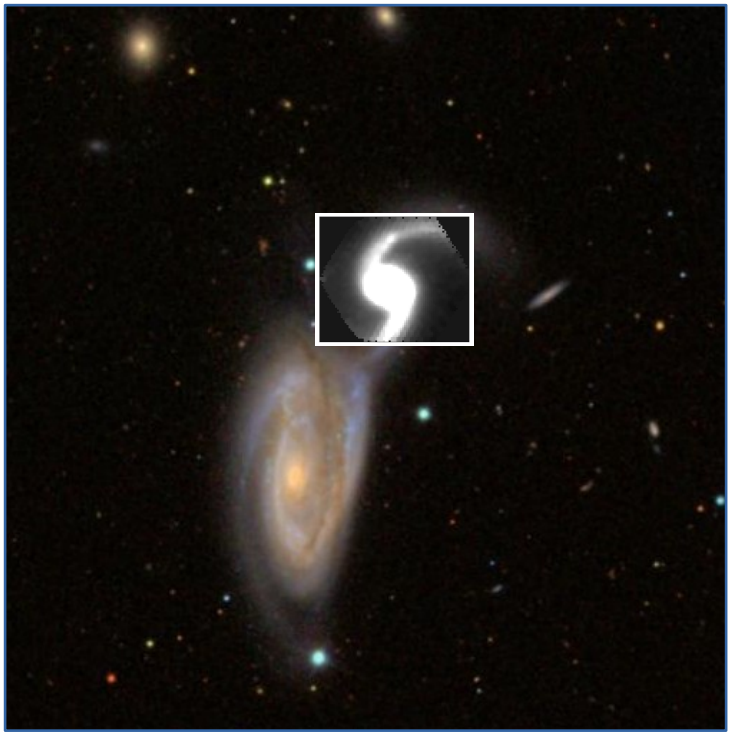

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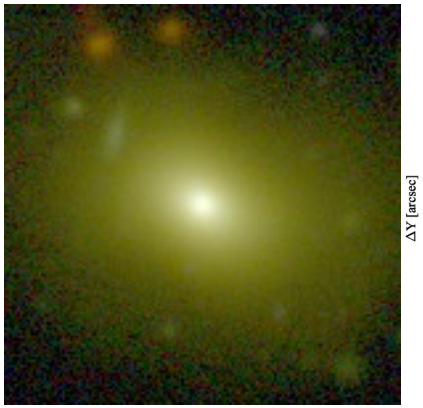
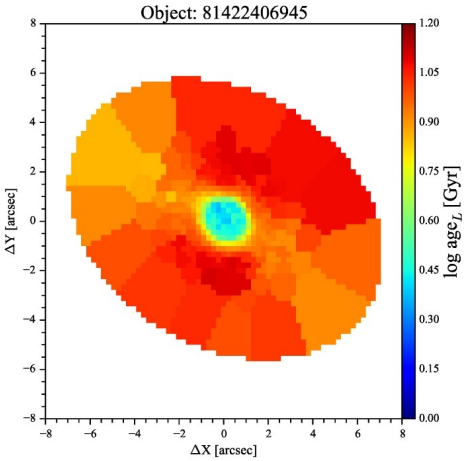
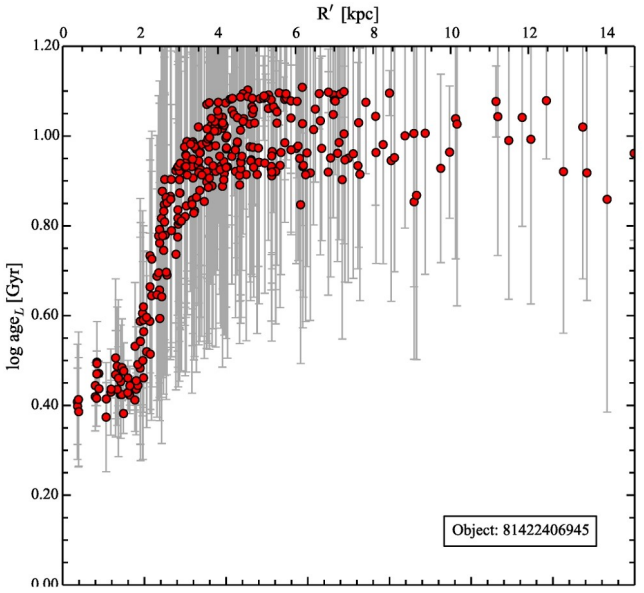
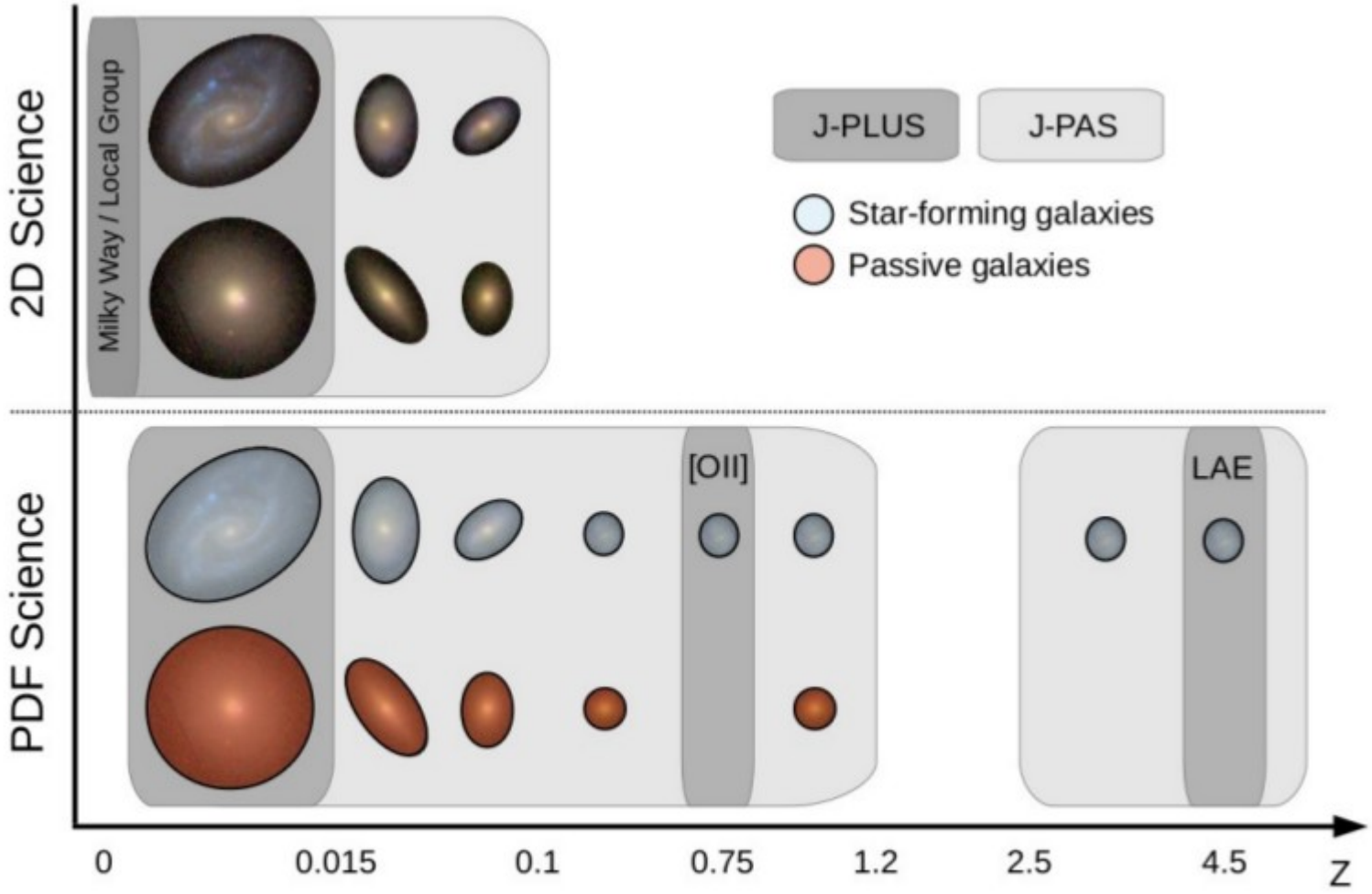






Lopez Sanjuan et al.

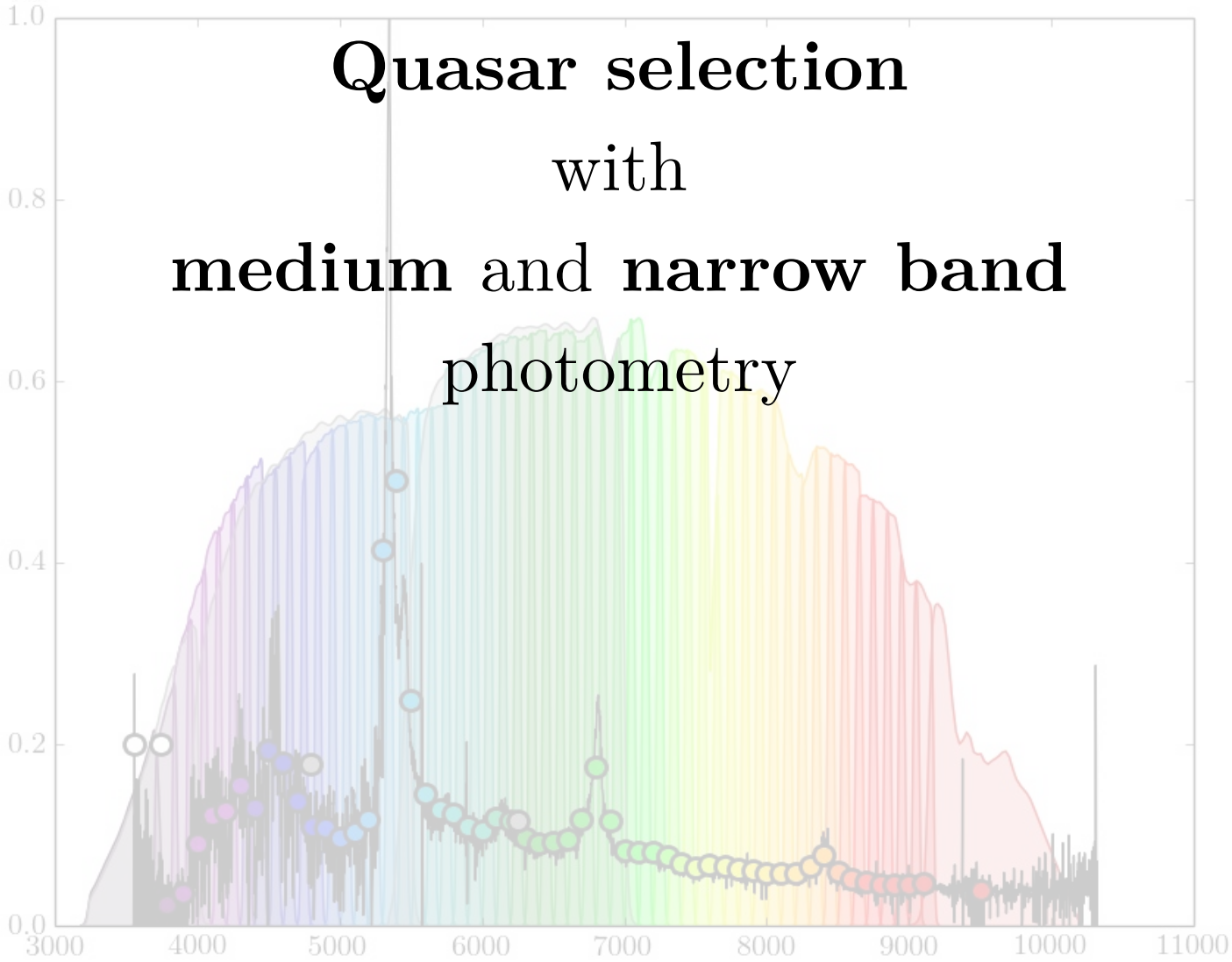

2D Science
Milky Way / Local Group
J-PLUS
J-PAS
Star-forming galaxies
Passive galaxies
PDF Science
[OII]
LAE
0
0.015
0.1
0.75
1.2
2.5
4.5
Z

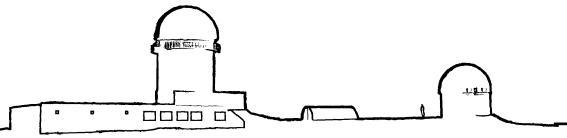
Quasar selection

with

medium and **narrow band**

photometry

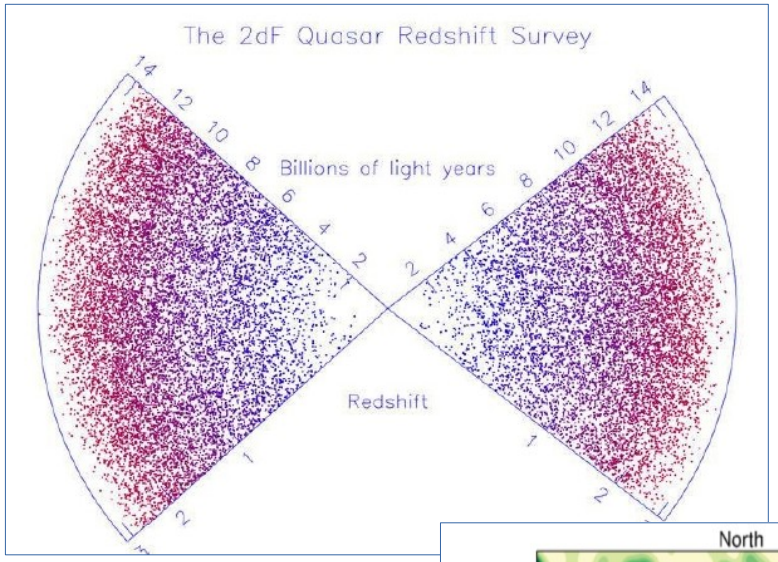


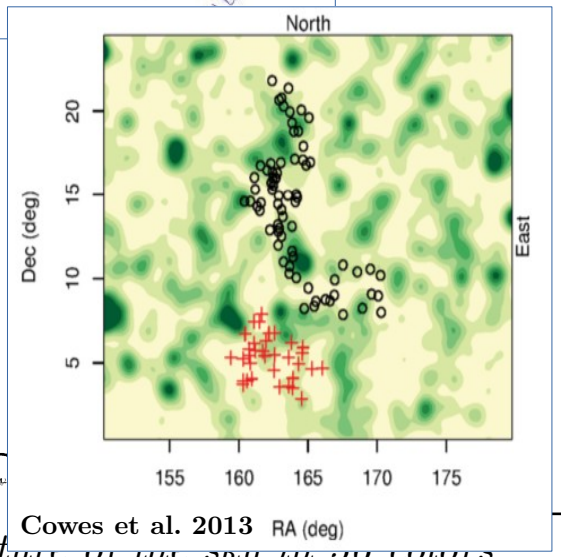


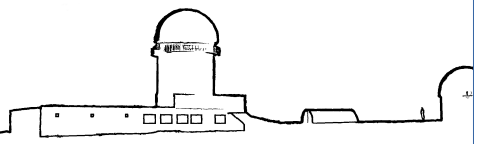
Multipurpose quasars

For cosmology...

Trace the large-scale distribution of structures – test cosmological principle



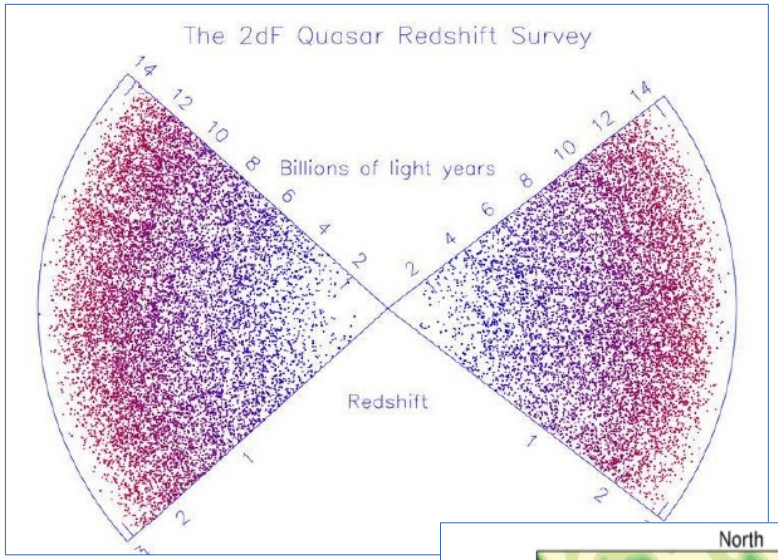


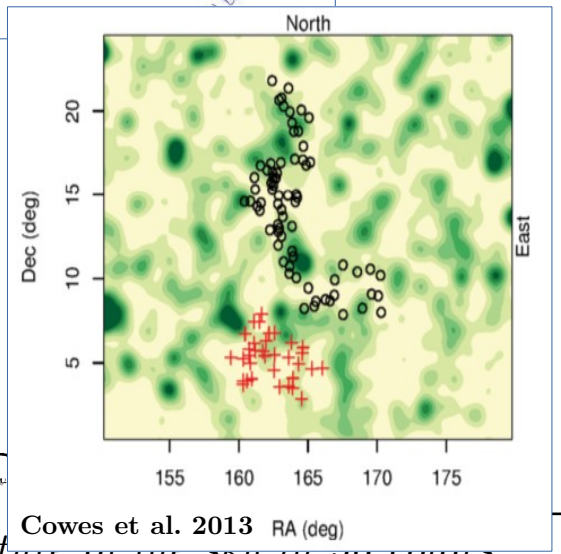


Multipurpose quasars

For cosmology...

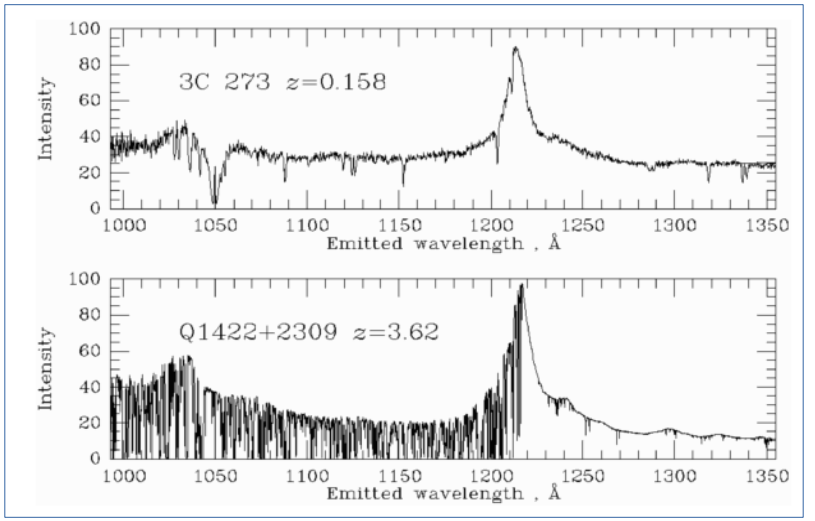
Trace the large-scale distribution of structures – test cosmological principle



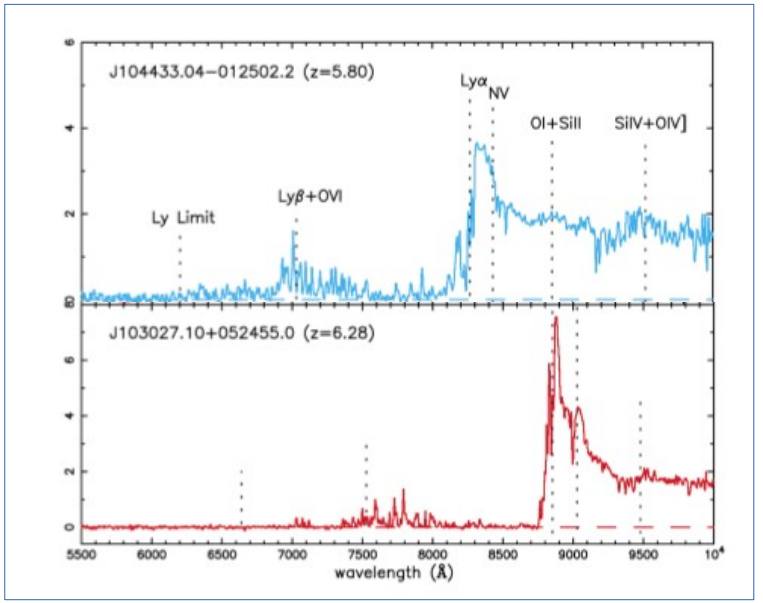


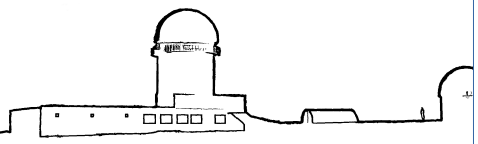
Cowes et al. 2013

Trace the distribution of the IGM and study the end of reionization



Becker al. 2001

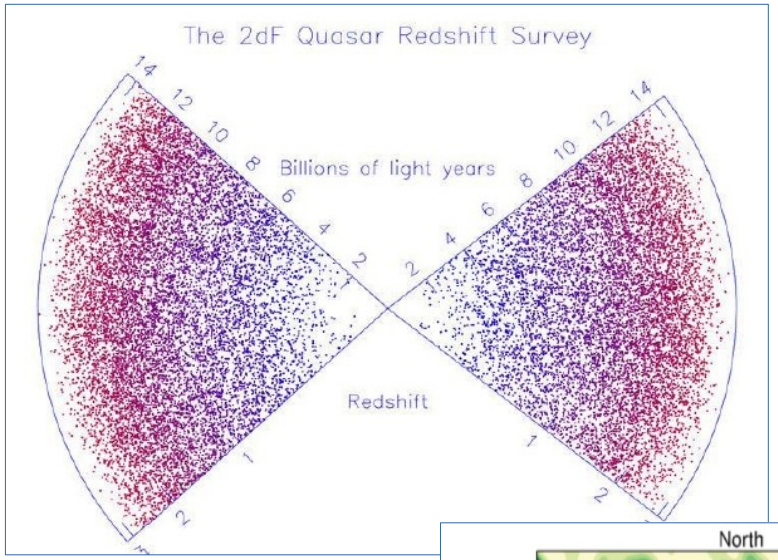


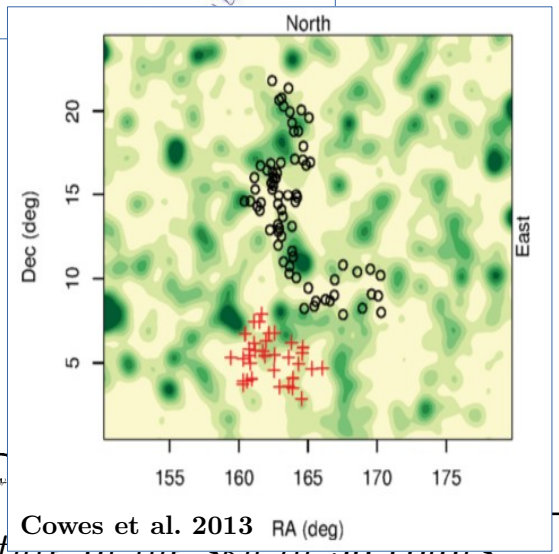


Multipurpose quasars

For cosmology...

Trace the large-scale distribution of structures – test cosmological principle





Cowes et al. 2013

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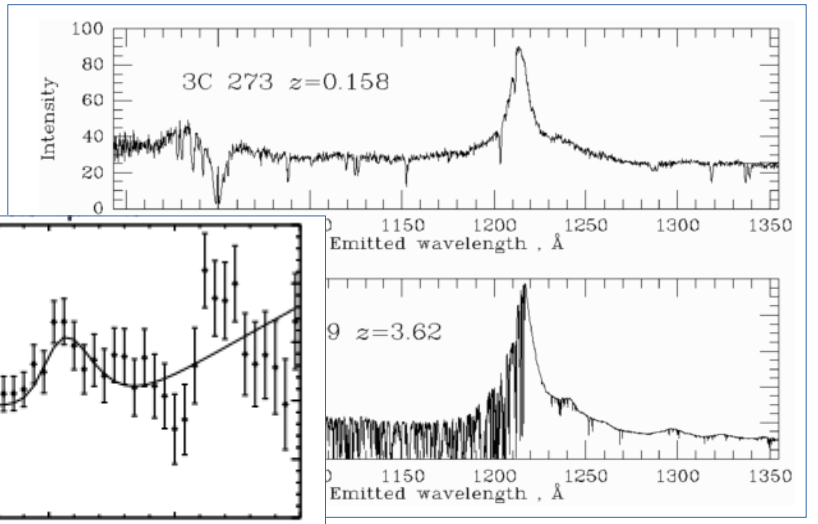
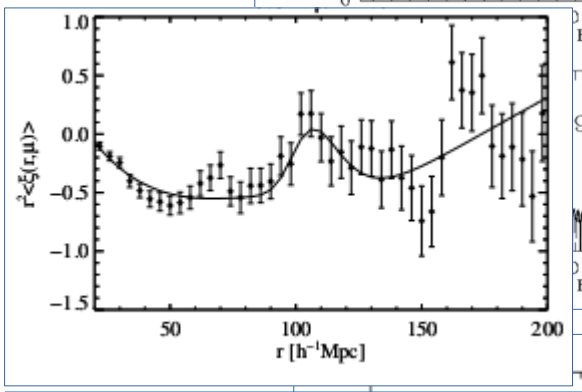
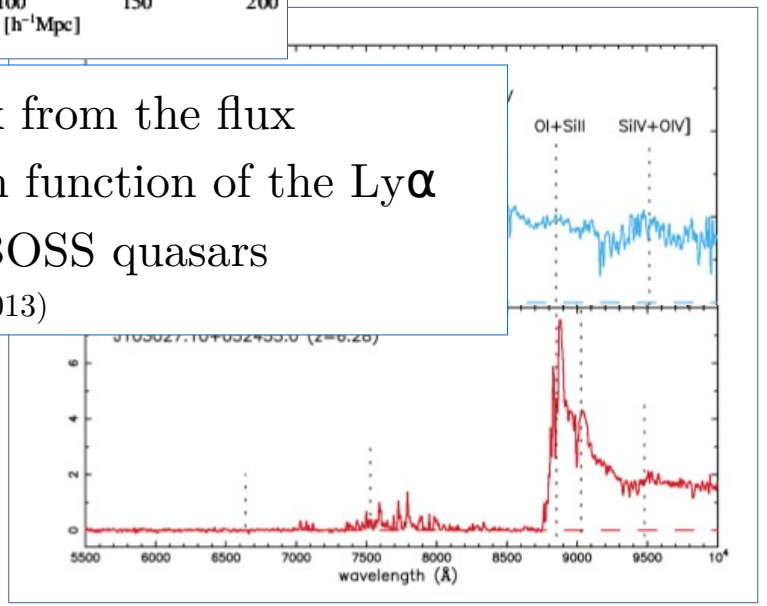
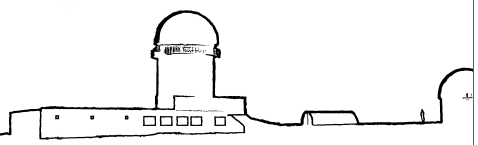




BAO peak from the flux correlation function of the Lyα forest of BOSS quasars
(Busca et al. 2013)



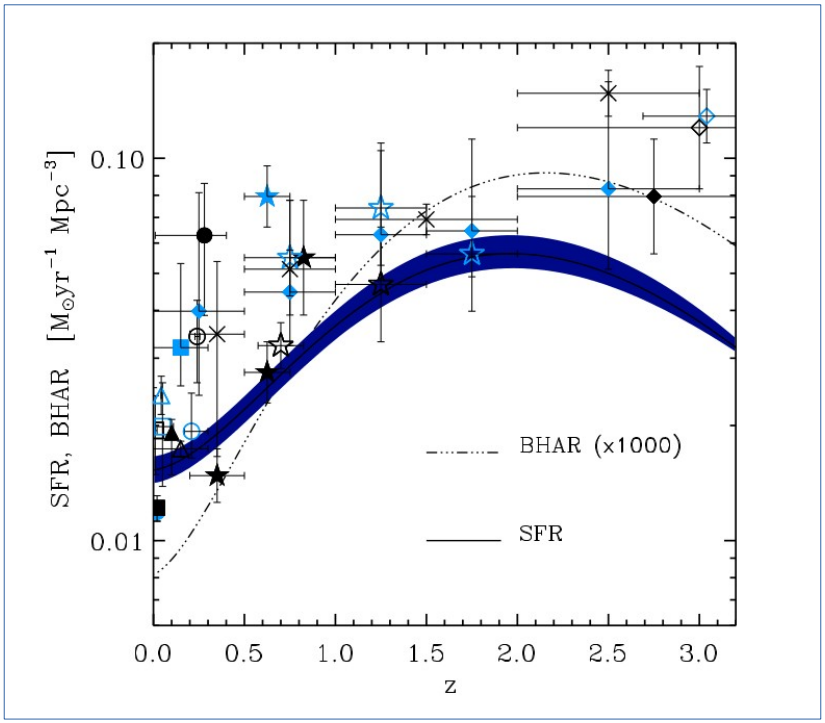


Multipurpose quasars

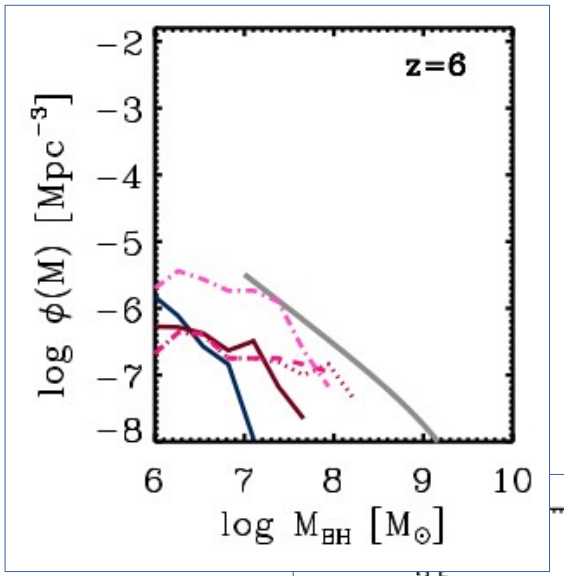
For black hole physics...

Constrain models of black hole "seeds"

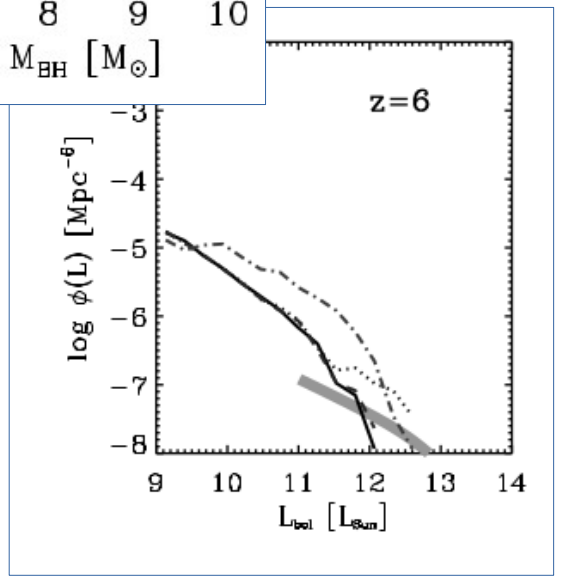
Estimate the mass-growth of supermassive black holes across cosmic time



Merloni & Heinz

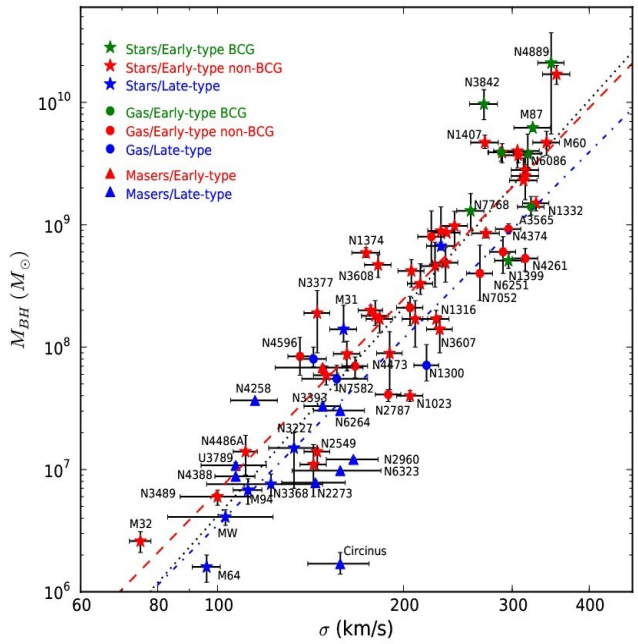


Bonoli et al. 2014



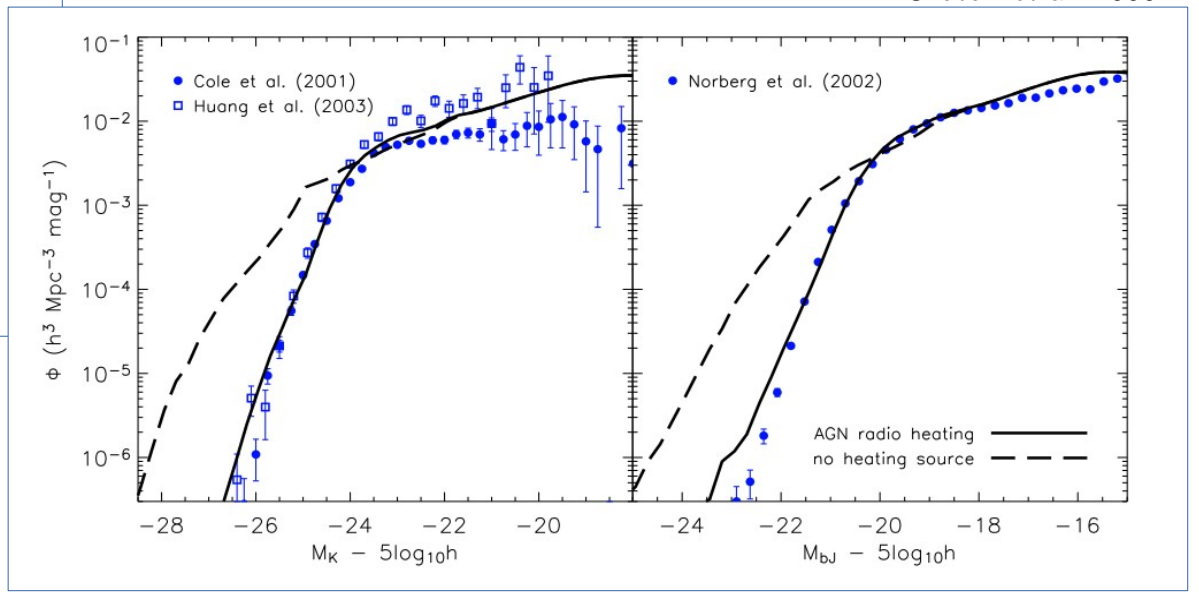
Multipurpose quasars

Study black hole-galaxy co-evolution

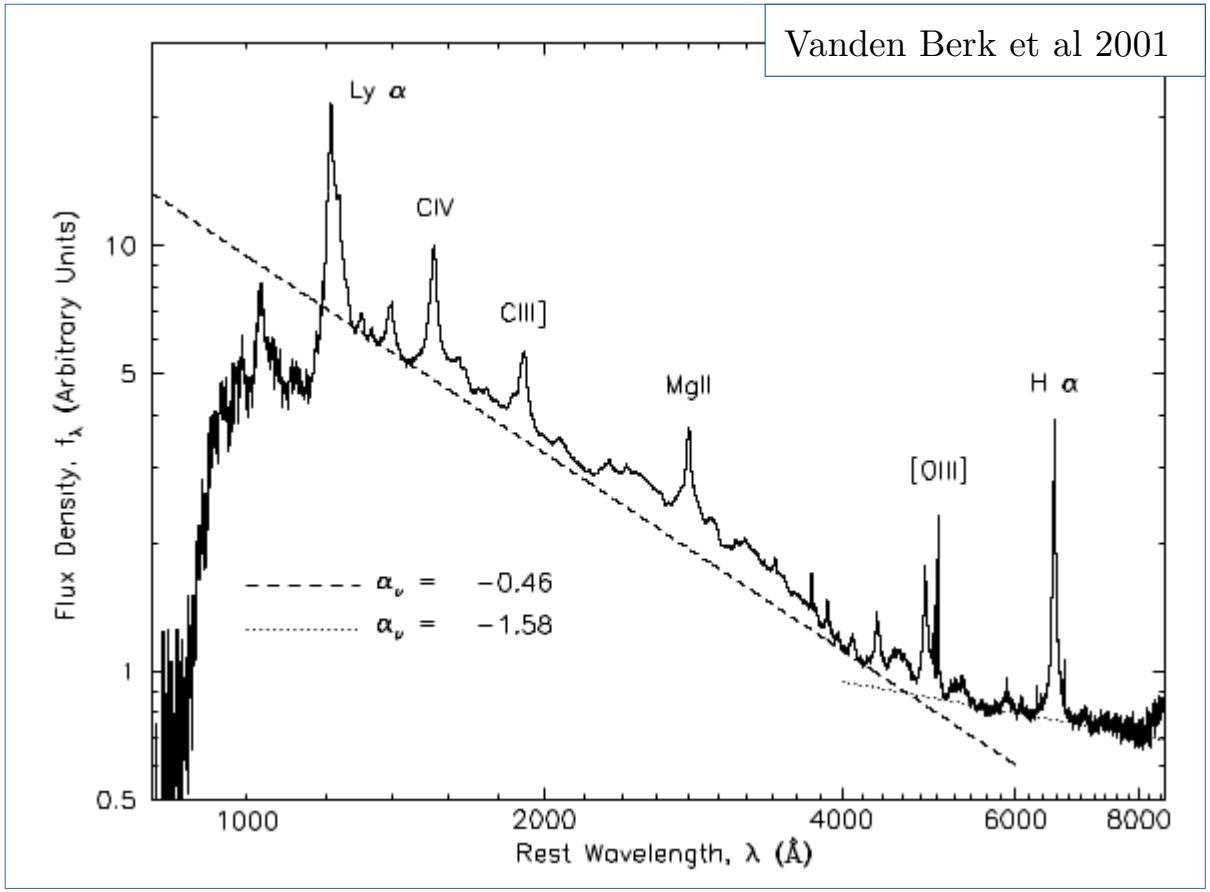


McConnell & Ma

Croton et al. 2006

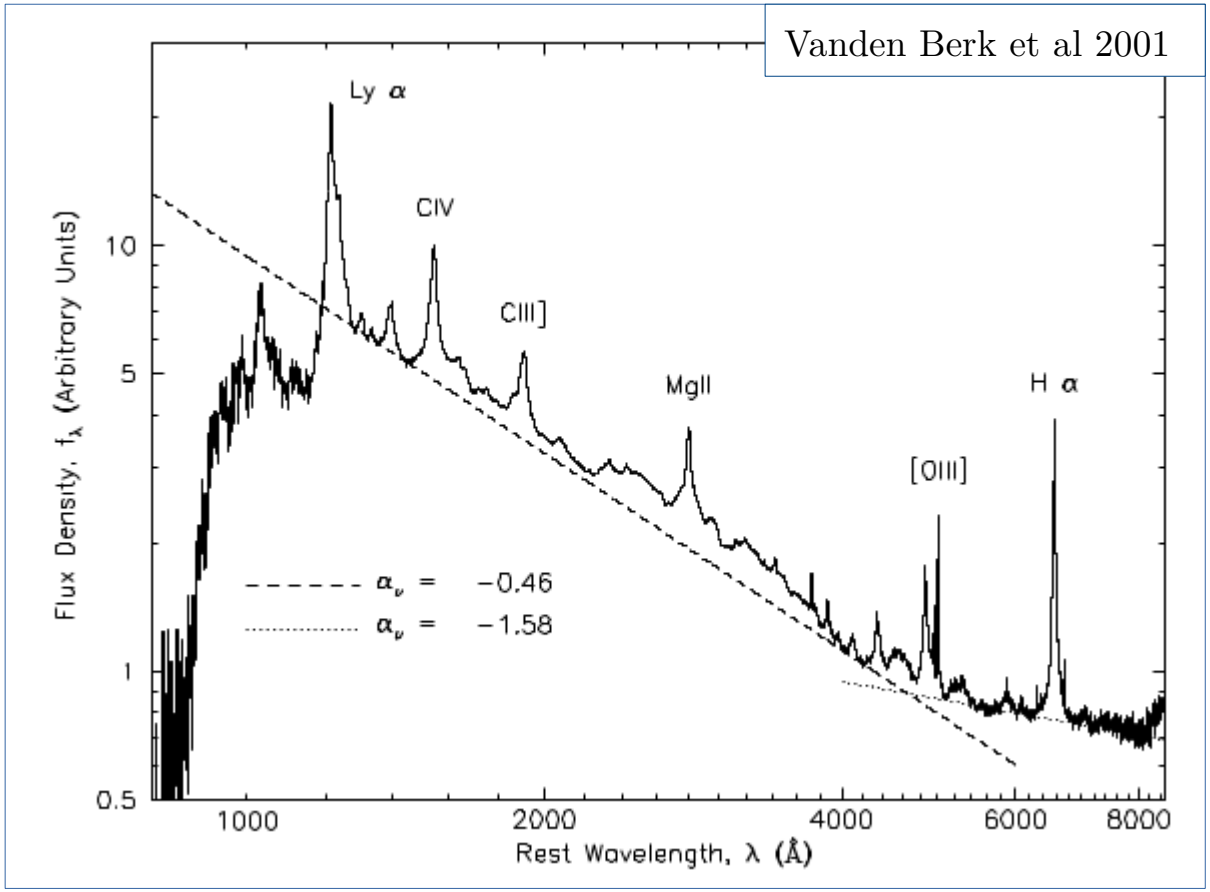


Quasar selection



Very **strong** and **broad** emission lines indicating Doppler widths up to 25000 km/s

Quasar selection



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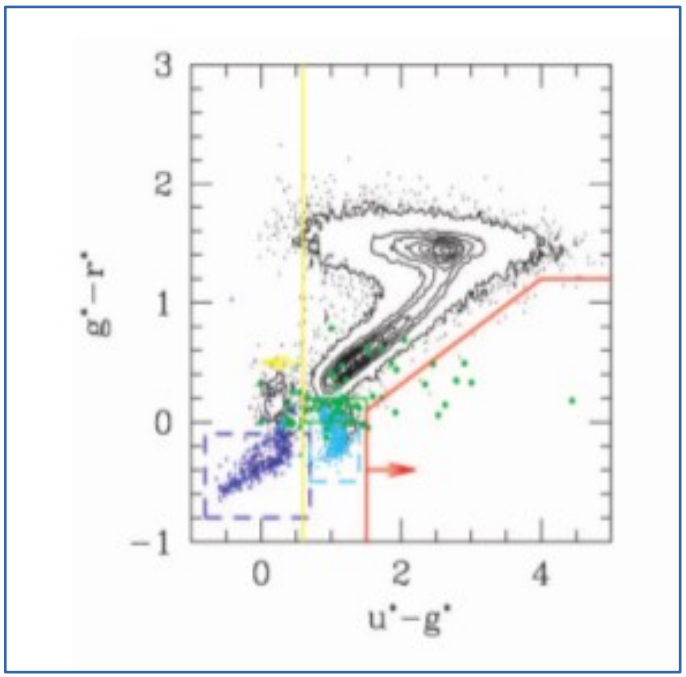
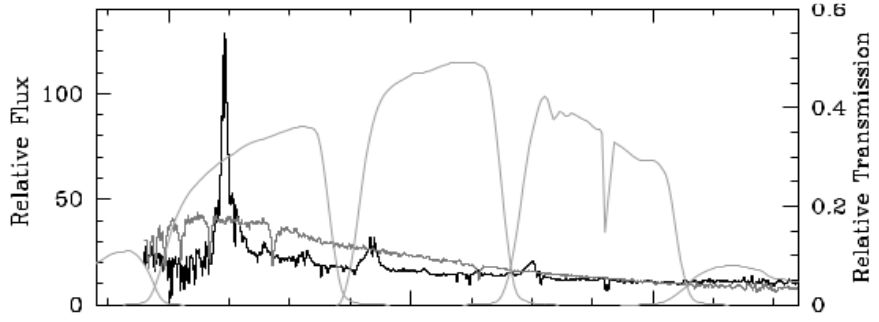
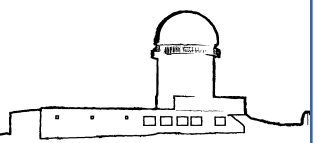


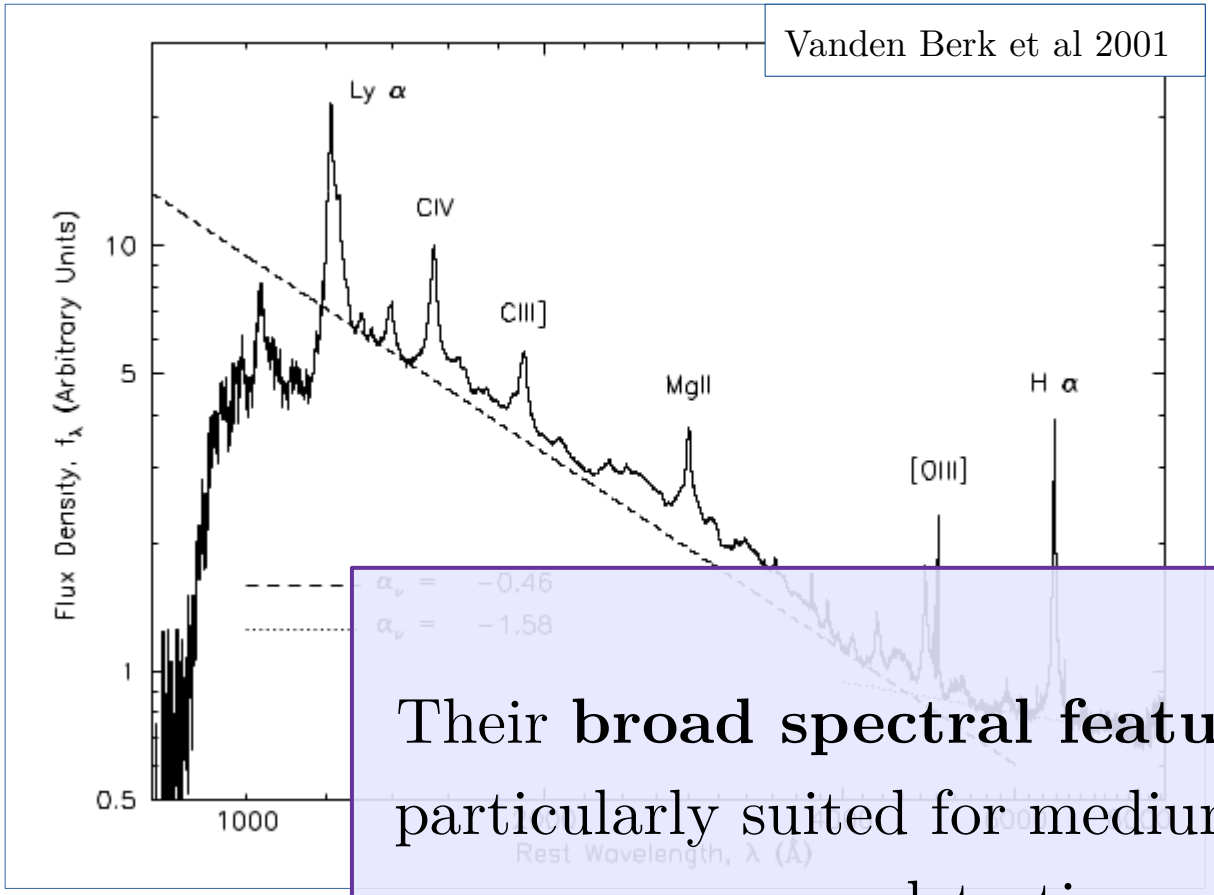
SDSS
Richards et al. 2002

Mid-z (2.5<z<3) problem





Quasar selection



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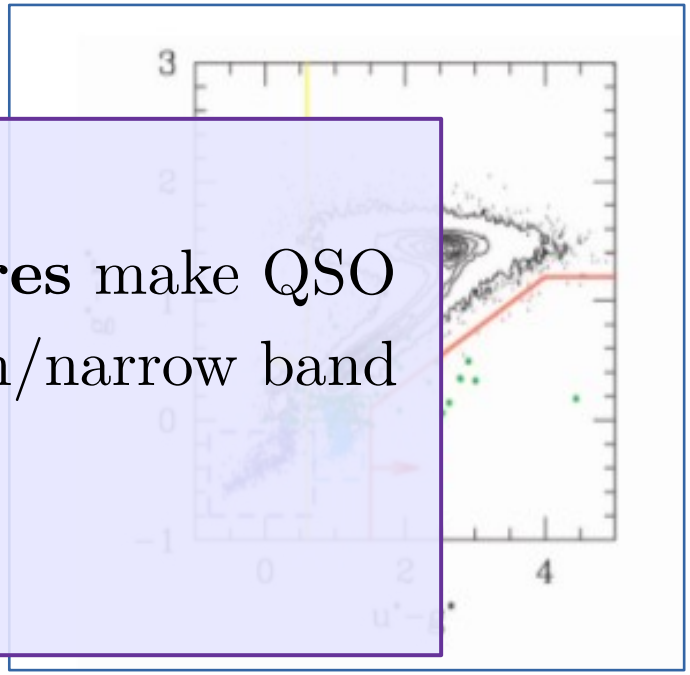
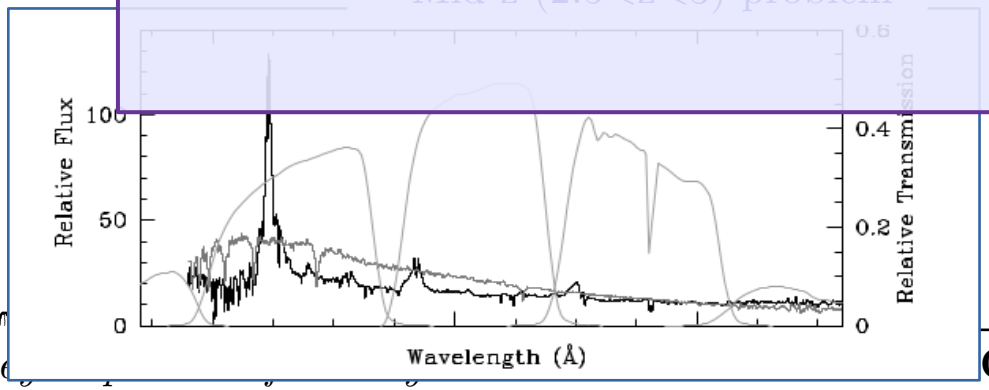
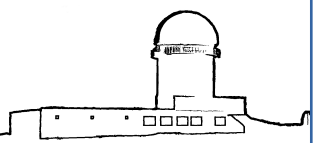


SDSS
Richards et al. 2002

Their **broad spectral features** make QSO particularly suited for medium/narrow band detection

Mid-z (2.5<z<3) problem





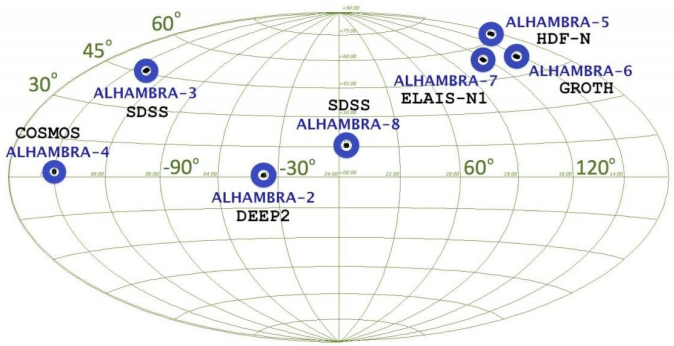
Testing the ground with the ALHAMBRA survey

ALHAMBRA SURVEY

Advance Large Homogeneous Area Medium-Band Redshift Astronomical survey

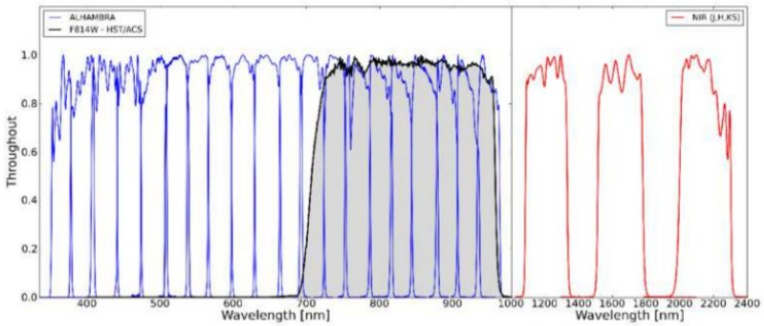
Moles et al. 2008

Benitez et al. 2009



~2.8 deg^2

24.5 mag limit



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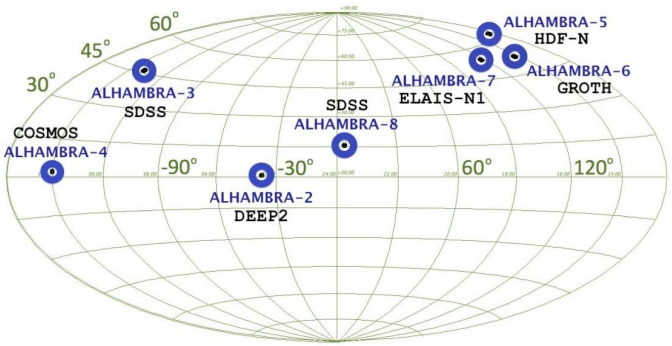

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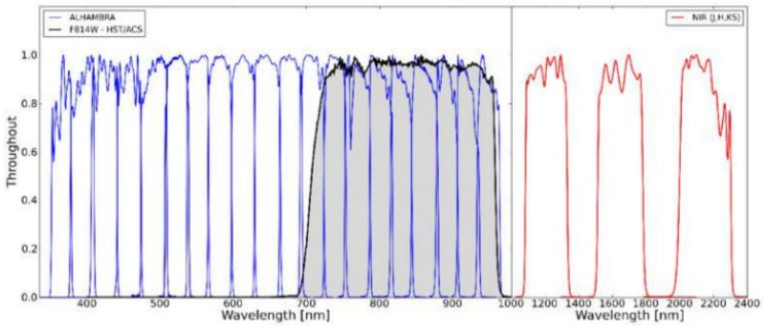

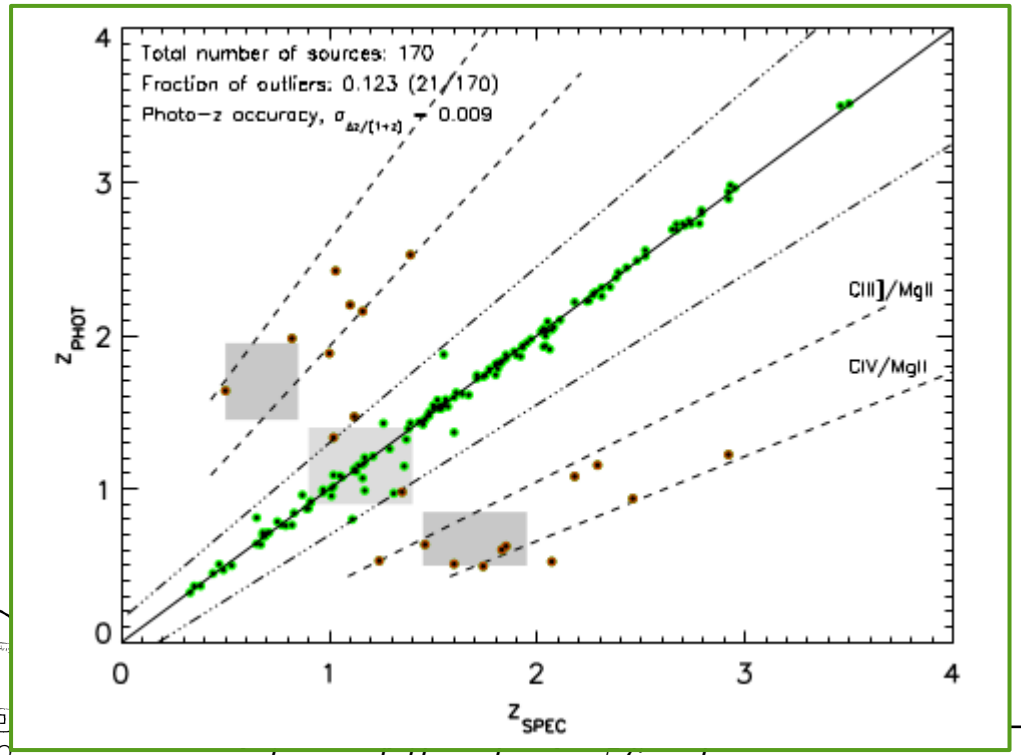

Matute et al. 2012 tested the accuracy of photometric redshifts for the QSO in ALHAMBRA using the LePhare code (Arnouts et al. 1999, Ilbert et al. 2006)

Testing the ground with the ALHAMBRA survey

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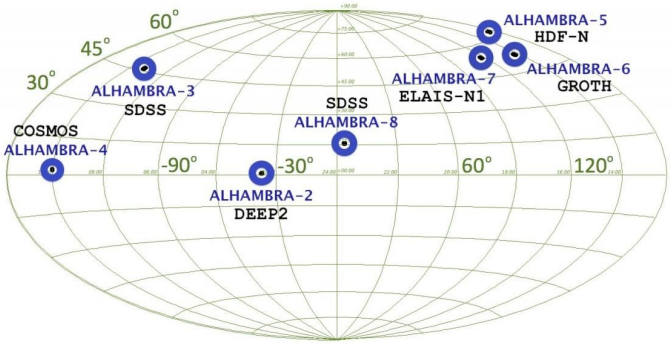

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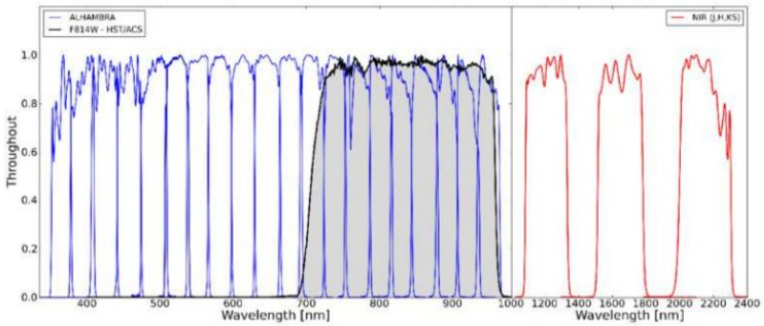

Two-step procedure:

1) Candidates selection
2) "Photometric confirmation"

Quasar studies – testing the ground with the ALHAMBRA survey

ALHAMBRA SURVEY

Advance Large Homogeneous Area Medium-Band Redshift Astronomical survey

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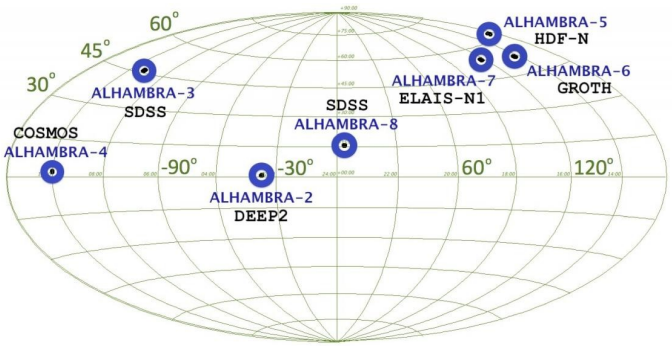

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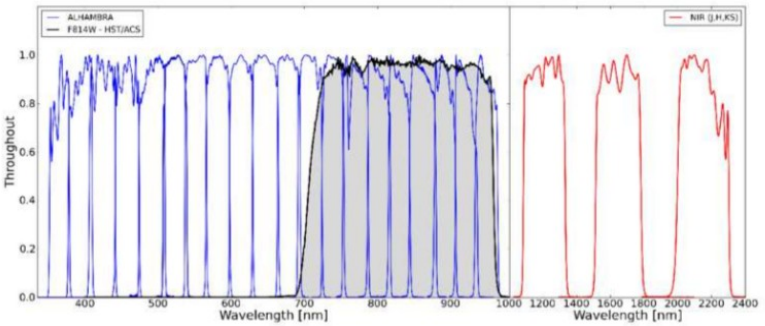


Two-step procedure:

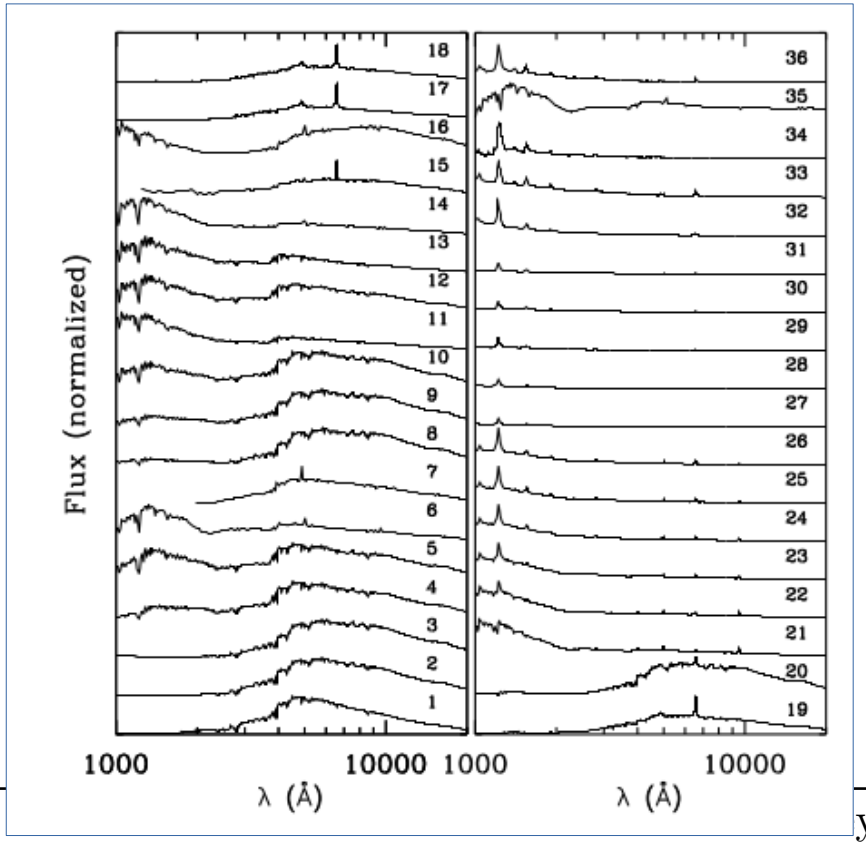
1) Candidates selection

2) "Photometric confirmation"

Using the photometric-redshift code LePhare
(Arnouts et al. 1999, Ilbert et al. 2006)

LePhare is run on the whole catalogue (~440.000 objects), and we get out ~**120.000 candidates**

(No previous cuts in morphology, luminosity or colors)



Quasar studies – testing the ground with the ALHAMBRA survey

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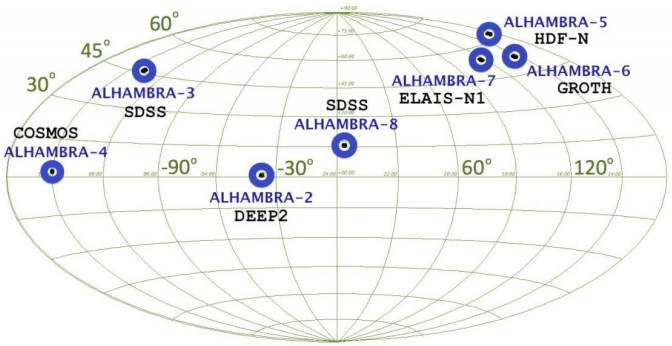

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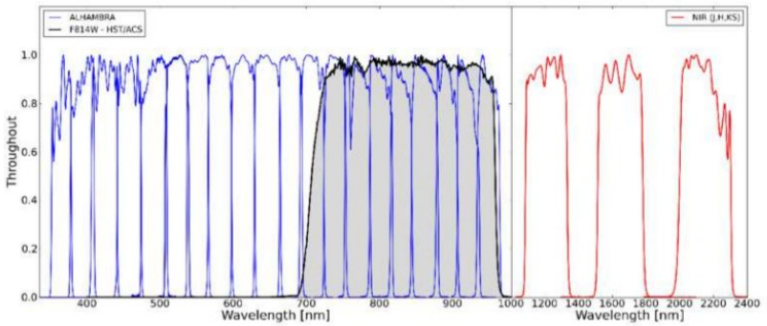


Two-step procedure:

1) Candidates selection

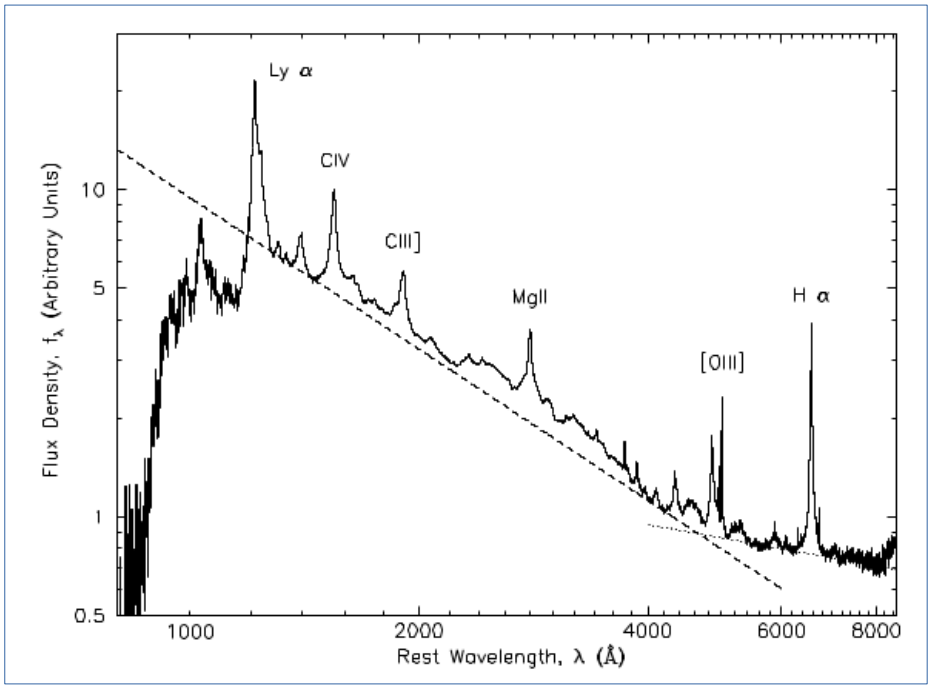
2) "Photometric confirmation"

Looking for emission lines...

Using a newly-developed **line-searching code**

a) Calculates the expected locations of the major QSO broad emission lines, based on the photo-z given by LePhare

b) Searches for excess in the photometry in the bands where emission lines are expected



Quasar studies – testing the ground with the ALHAMBRA survey

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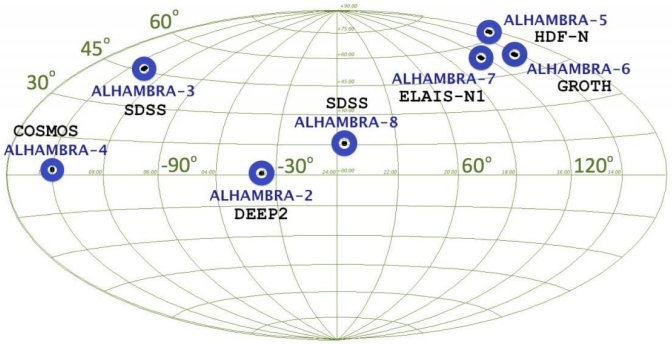

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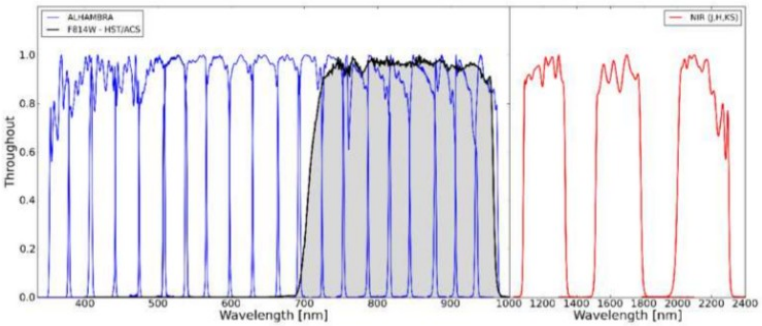


Two-step procedure:

1) Candidates selection

2) "Photometric confirmation"

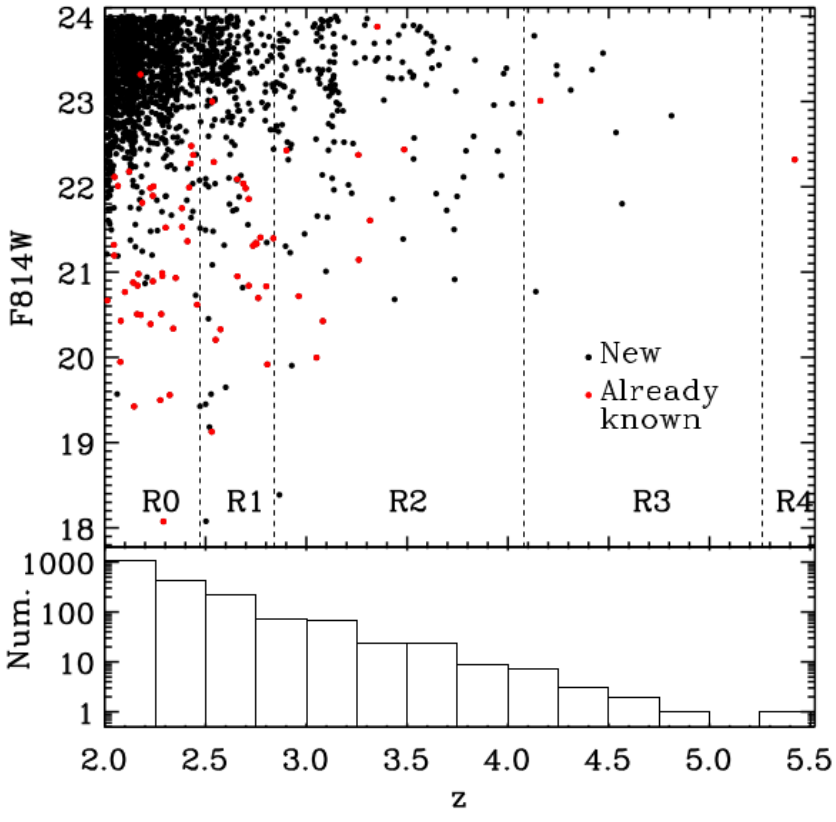
1921 QSO candidates at z>2

1% redshift accuracy

No galaxy or stellar contamination

~55 % completeness – 100% purity

(Chaves-Montero et al., in prep)



Quasar studies – testing the ground with the ALHAMBRA survey

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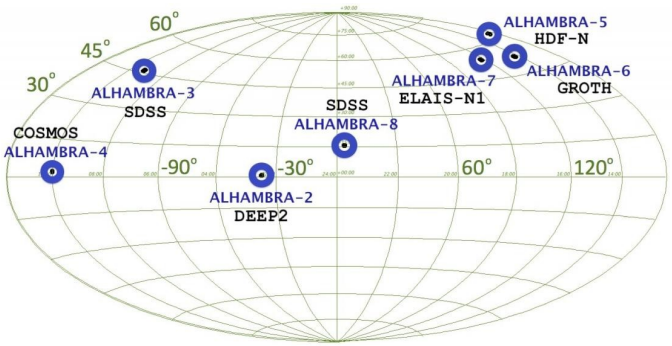

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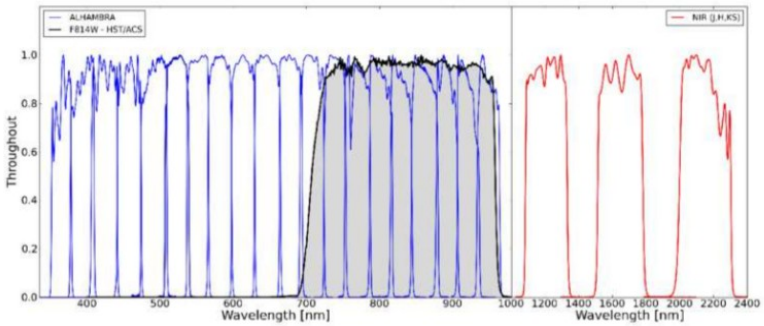
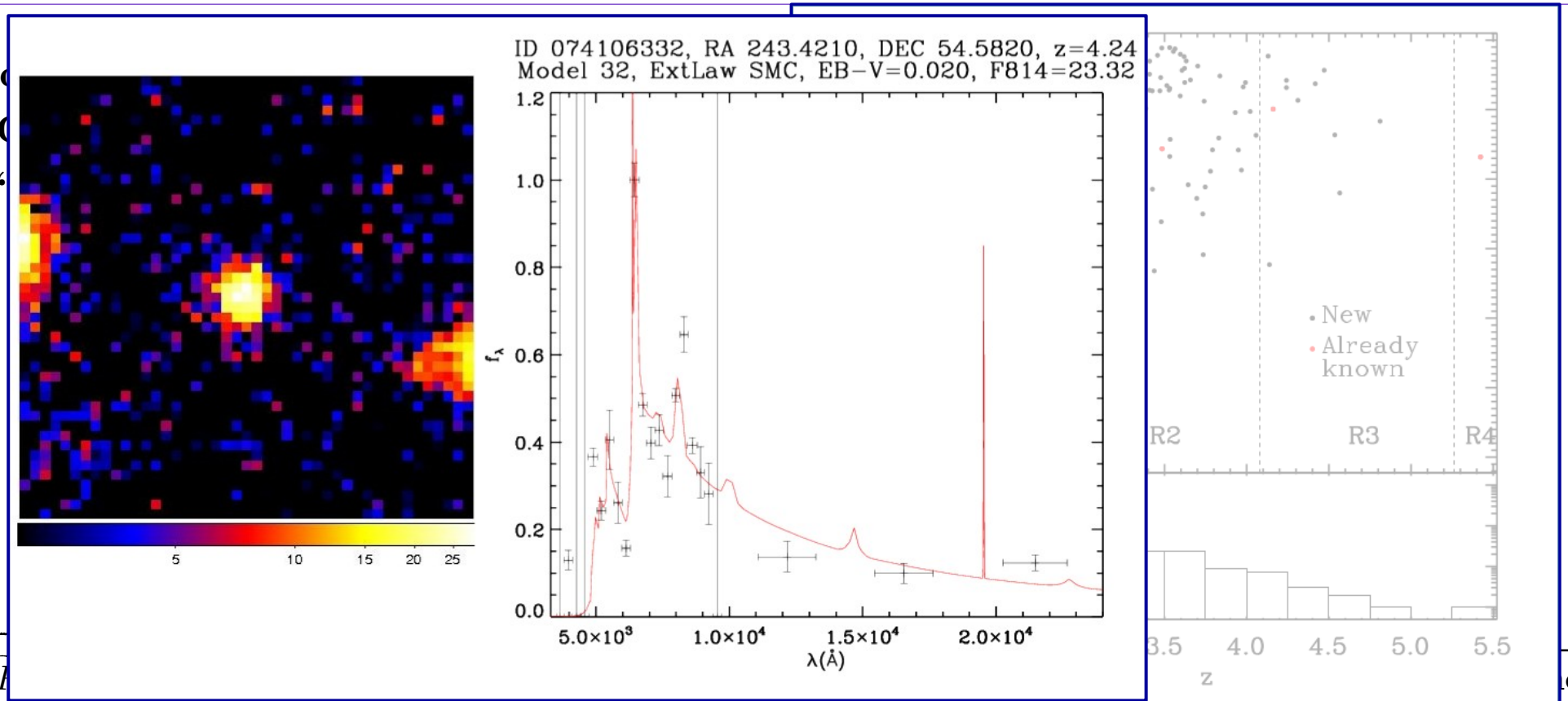


Tw

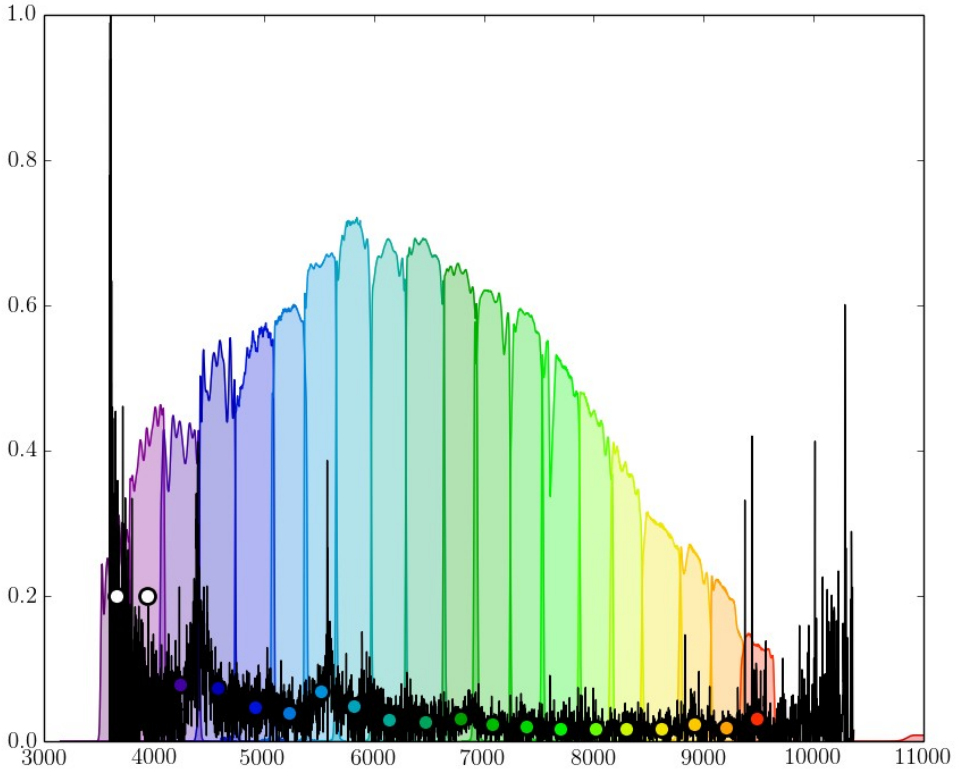
1) (

2) '

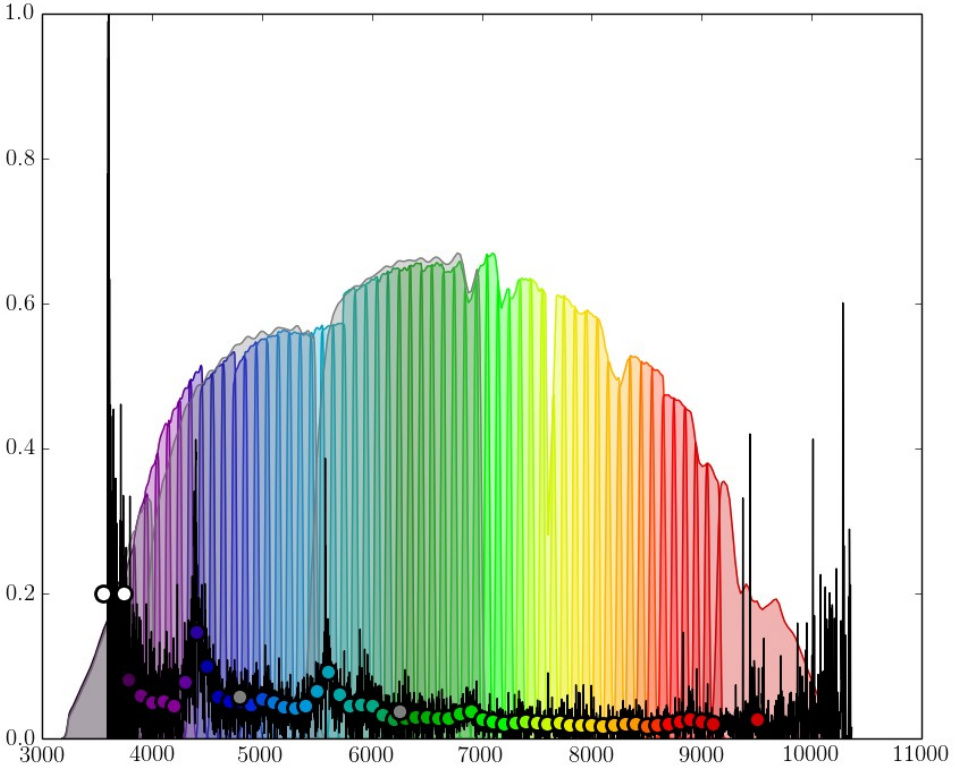


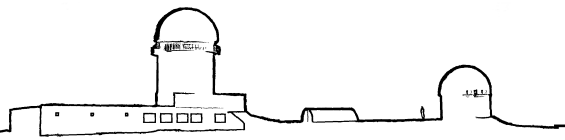
ALHAMBRA SURVEY

QSO: spec-5454-56015-0707 in ALHAMBRA, $z_{spec} = 2.62$



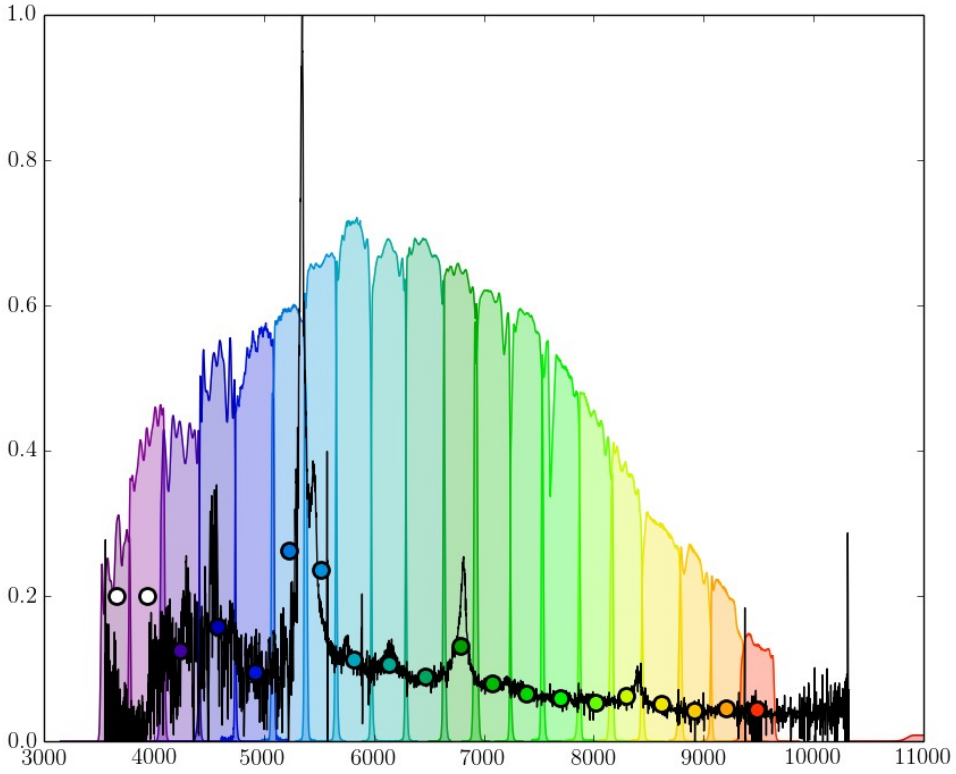
QSO: spec-5454-56015-0707 in JPAS, $z_{spec} = 2.62$



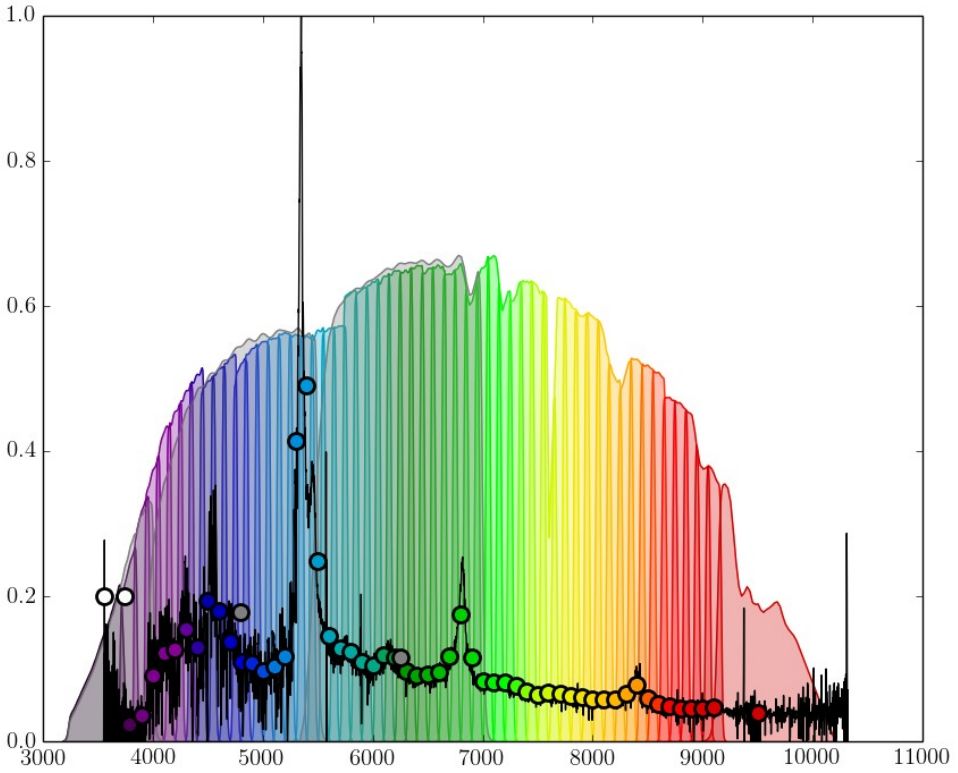


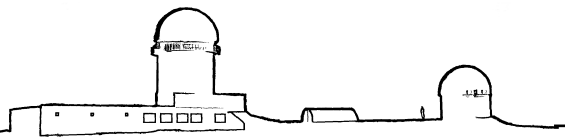
ALHAMBRA SURVEY

QSO: spec-4342-55531-0488 in ALHAMBRA, $z_{spec} = 3.40$



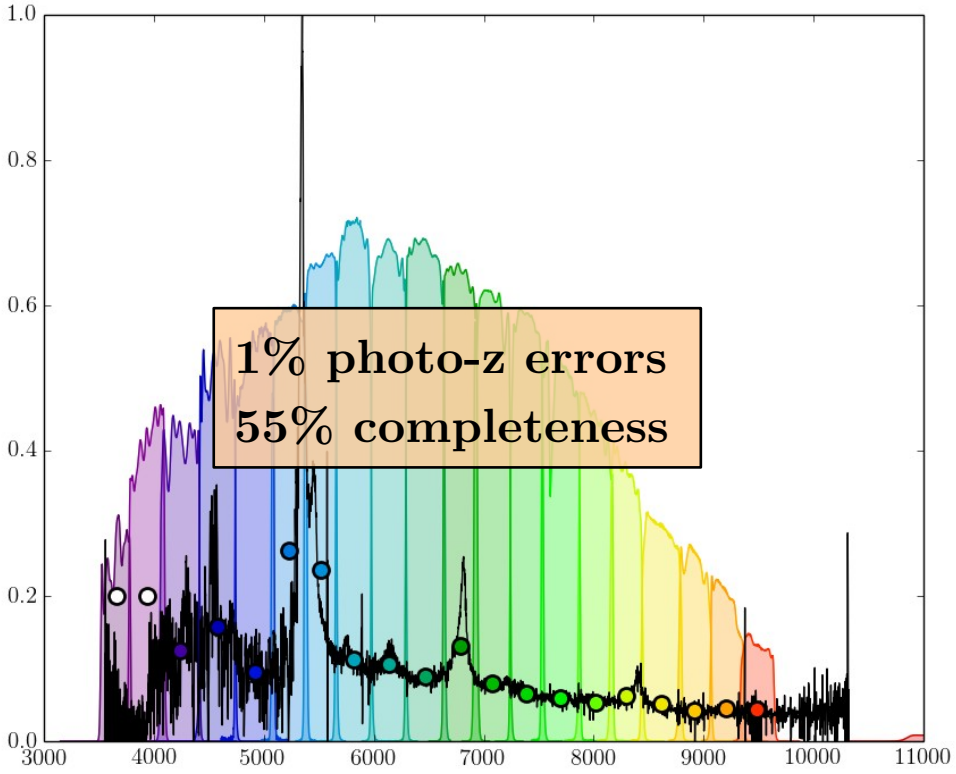
QSO: spec-4342-55531-0488 in JPAS, $z_{spec} = 3.40$



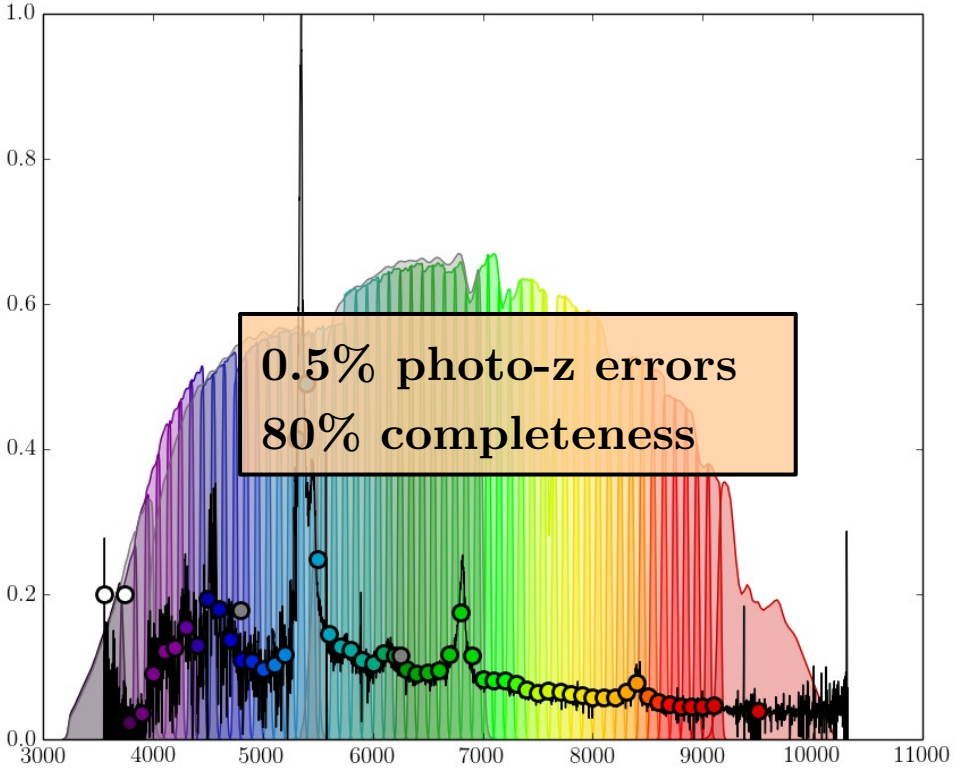


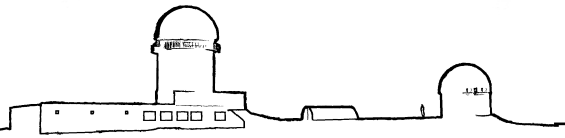
ALHAMBRA SURVEY

QSO: spec-4342-55531-0488 in ALHAMBRA, $z_{spec} = 3.40$



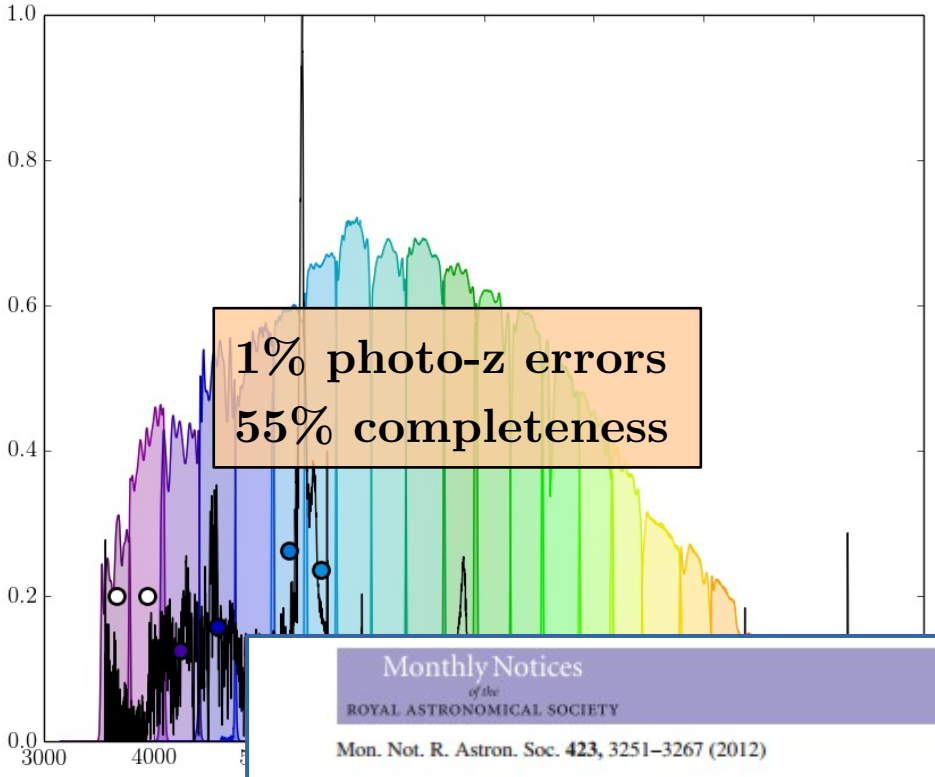
QSO: spec-4342-55531-0488 in JPAS, $z_{spec} = 3.40$



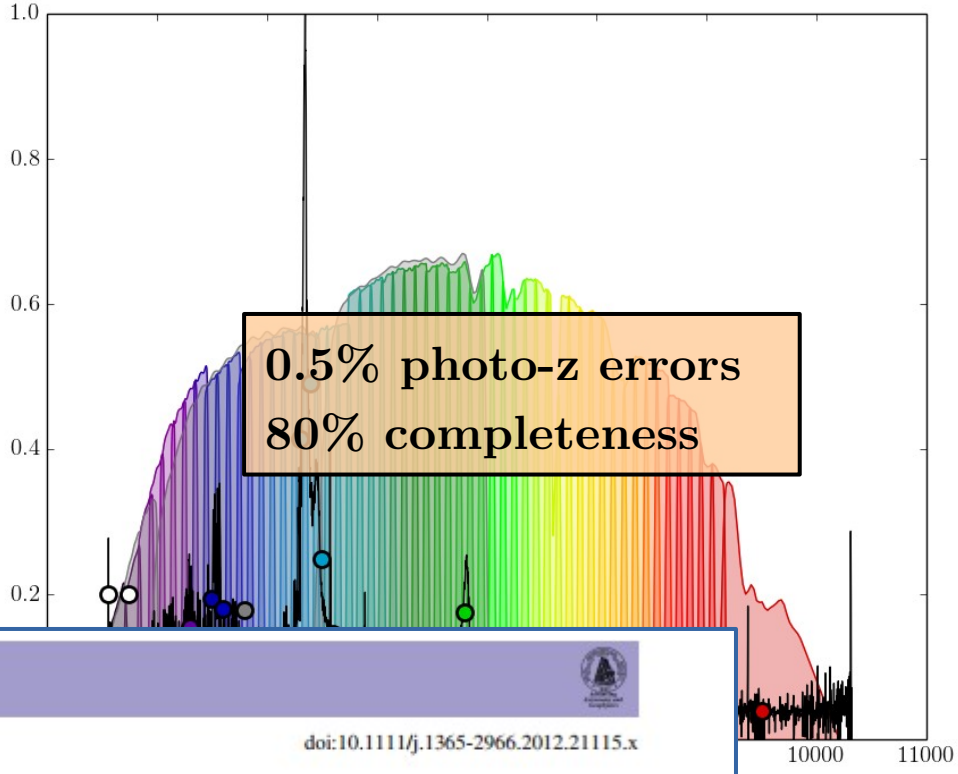


ALHAMBRA SURVEY

QSO: spec-4342-55531-0488 in ALHAMBRA, $z_{spec} = 3.40$



QSO: spec-4342-55531-0488 in JPAS, $z_{spec} = 3.40$

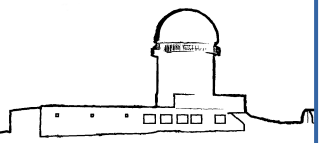


Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

Mon. Not. R. Astron. Soc. **423,** 3251–3267 (2012) doi:10.1111/j.1365-2966.2012.21115.x

Measuring large-scale structure with quasars in narrow-band filter surveys

Abramo et al. 2012



http://www.j-pas.org/ http://www.j-plus.es/

8500 deg² observed from Spain with **2** telescopes

- **54** NB + **5** MB/BB filters
- **4.5** deg² FoV
- Up to mag ~**24**
- **90M** ELG and LRG
- Reaching **0.3%** photo-z precision
- **Millions** of quasars
- **200M** of galaxies
- **4000** SNIa
- **700k** of groups and clusters
- Starts at the end of **2016**

Possible replica in the South

- **12** NB/MB/BB filters
- **2** deg² FoV
- Up to mag ~**23**
- SEDs of **5M** stars
- **Already started!**

Already replica in the South
@Cerro Tololo
Survey S-PLUS

More details in Benitez et al. 2014 - arXiv:1403.5237

Javalambre
Physics of the Accelerating Universe
Astrophysical
Survey

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J-PAS: The Javalambre-Physics of the Accelerated Universe Astrophysical Survey

arXiv:1403.5237

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