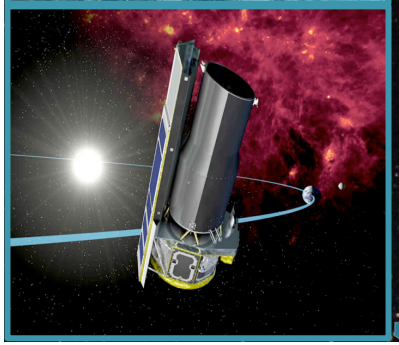


Pushing today's facilities

Waiting and preparing for E-ELT

UO5 – ELT MOS

Angela Bongiorno

Laura Pentericci

(INAF-Osservatorio Astronomico di Roma)

and

the VANDELS team

VANDELS

A deep VIMOS survey of the CANDELS UDS and CDFS fields

Unveiling the astrophysics of high-redshift galaxy evolution

VANDELS

A deep VIMOS survey of the CANDELS UDS and CDFS fields

Unveiling the astrophysics of high-redshift galaxy evolution

Co-PIs: Ross McLure (Edinburgh), Laura Pentericci (Rome)

79 Co-Is
10 countries
~30 INAF (5 inst.)

O. Almaini, *University of Nottingham, UK*
R. Amorin, *INAF-Rome, Italy*
S. de Barros, *UC Riverside, USA*
I. Balestra, *INAF-Trieste, Italy*
E. Bell, *Michigan, USA*
†M. Bolzonella, *INAF-Bologna, Italy*
†A. Bongiorno, *INAF-Rome, Italy*
N. Bourne, *University of Edinburgh, UK*
†R. Bowler, *University of Edinburgh, UK*
V. Bruce, *University of Edinburgh, UK*
M. Brusa, *University of Bologna, Italy*
F. Buitrago, *University of Edinburgh, UK*
K. Caputi, *Groningen, Netherlands*
P. Cassata, *LAM, France*
†M. Castellano, *INAF-Rome, Italy*
S. Charlot, *IAP, France*
M. Cirasuolo, *University of Edinburgh, UK*
G. Cresci, *INAF-Arcetri, Italy*
S. Cristiani, *INAF-Trieste, Italy*
†O. Cucciati, *University of Bologna, Italy*
†F. Cullen, *University of Edinburgh, UK*
†E. Curtis-Lake, *University of Edinburgh, UK*
M. Dickinson, *NOAO, USA*
S. Faber, *University of California, USA*
G. Fazio, *Harvard, USA*
H. Ferguson, *STScI, USA*
S. Finkelstein, *Texas, USA*
F. Fiore, *INAF-Rome, Italy*
F. Fontanot, *INAF-Trieste, Italy*
P. Franzetti, *INAF-Milan, Italy*
J. Fynbo, *DARK, Denmark*
†A. Galametz, *MPE, Germany*
B. Garilli, *INAF-Milan, Italy*
A. Georgakakis, *MPE, Germany*
M. Giavalisco, *UMASS, USA*
†A. Grazian, *INAF-Rome, Italy*
†L. Guaita, *INAF-Rome, Italy*
W. Hartley, *ETH, Switzerland*
A. Iovino, *INAF-Brera, Italy*
M. Jarvis, *University of Oxford, UK*
S. Juneau, *CEA, France*
W. Karman, *Groningen, Netherlands*
S. Kim, *PUC, Chile*
A. Koekemoer, *STScI, USA*
O. Le Fèvre, *LAM, France*
J. Lotz, *STScI, USA*
F. Mannuci, *INAF-Arcetri, Italy*
†E. Marmol-Queraltó, *University of Edinburgh, UK*
D. McLeod, *University of Edinburgh, UK*
J. Medez-Abreu, *University of St Andrews, UK*
M. Mignoli, *INAF-Bologna, Italy*
M. Moresco, *University of Bologna, Italy*
[illegible]. Mortlock, *University of Edinburgh, UK*
M. Nonino, *INAF-Trieste, Italy*
M. Pannella, *CEA, France*
C. Papovich, *Texas, USA*
P. Popesso, *MPE, Germany*
L. Pozzetti, *INAF-Bologna, Italy*
D. Rosario, *MPE, Germany*
P. Rosati, *University of Ferrara, Italy*
M. Salvato, *MPE, Germany*
C. Schreiber, *CEA, France*
M. Scodeggio, *INAF-Milan, Italy*
†V. Sommariva, *University of Bologna, Italy*
D. Stark, *Arizona, USA*
†M. Talia, *University of Bologna, Italy*
L. Tasca, *LAM, France*
T. Treu, *UCSB, USA*
E. Vanzella, *INAF-Bologna, Italy*
V. Wild, *University of St Andrews, UK*
C. Williams, *UMASS, USA*
G. Zamorani, *INAF-Bologna, Italy*

VANDELS: motivation

ESO call for public spectroscopy surveys with VIMOS
- letter of intent: October 2013; full proposal: March 2014

Proposal focused on two key aspects:

- ✓ Legacy value to astronomy community
- ✓ Different science from previous VIMOS surveys

(e.g. VUDS, VVDS, zCOSMOS, VIPERS)

VANDELS: motivation

ESO call for public spectroscopy surveys with VIMOS
- letter of intent: October 2013; full proposal: March 2014

Proposal focused on two key aspects:

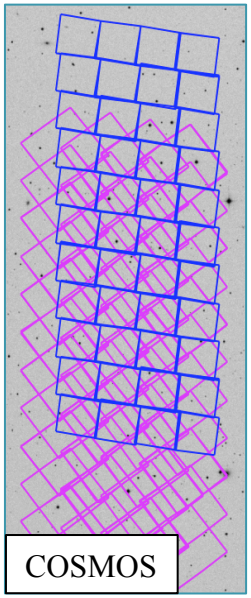
- ✓ Legacy value to astronomy community
- ✓ Different science from previous VIMOS surveys
  (e.g. VUDS, VVDS, zCOSMOS, VIPERS)

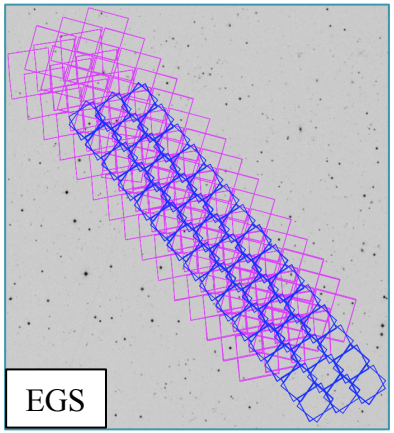
Four key elements:

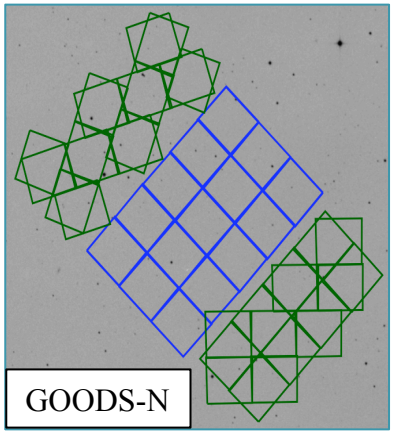
- ✓ Small area (0.2 sq. degrees), best available multi-wavelength data
- ✓ Medium resolution spectra (MR grism)
- ✓ Ultra-long integrations, minimum 20-80 hrs per source
- ✓ Pre-selection biased to very high redshift (85% of targets at z>3)

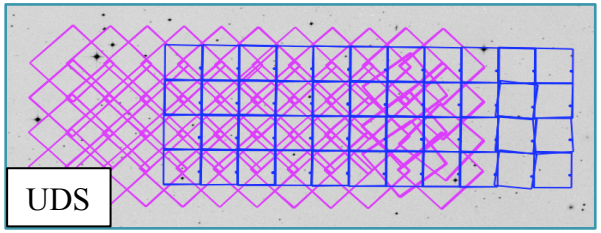
VANDELS: survey fields

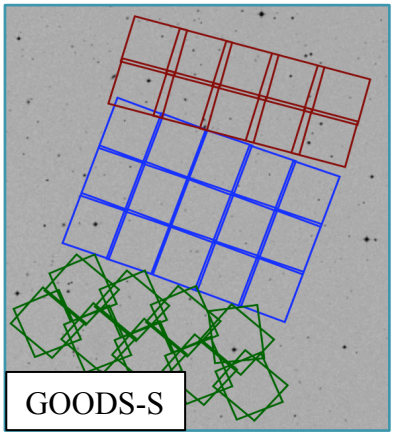
HST optical/near-IR imaging survey covering 0.2 square degrees split over 5 survey fields





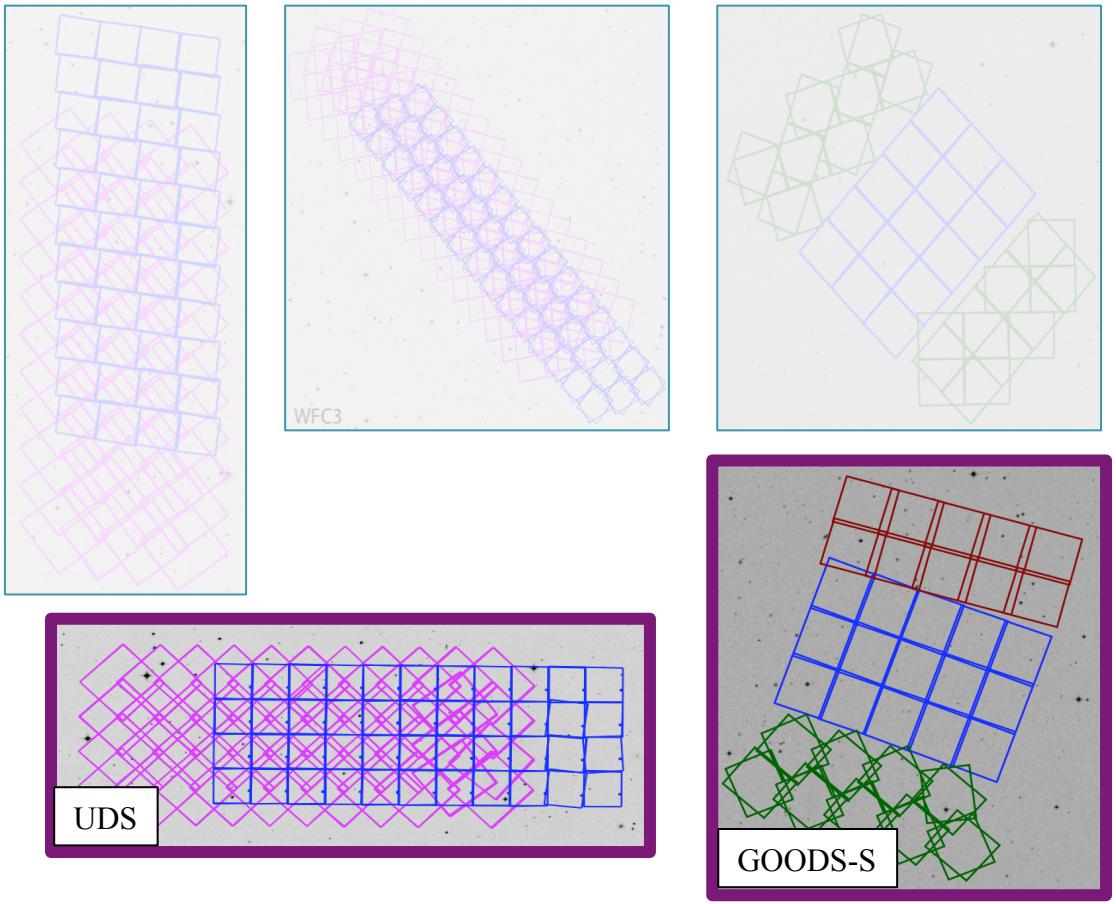






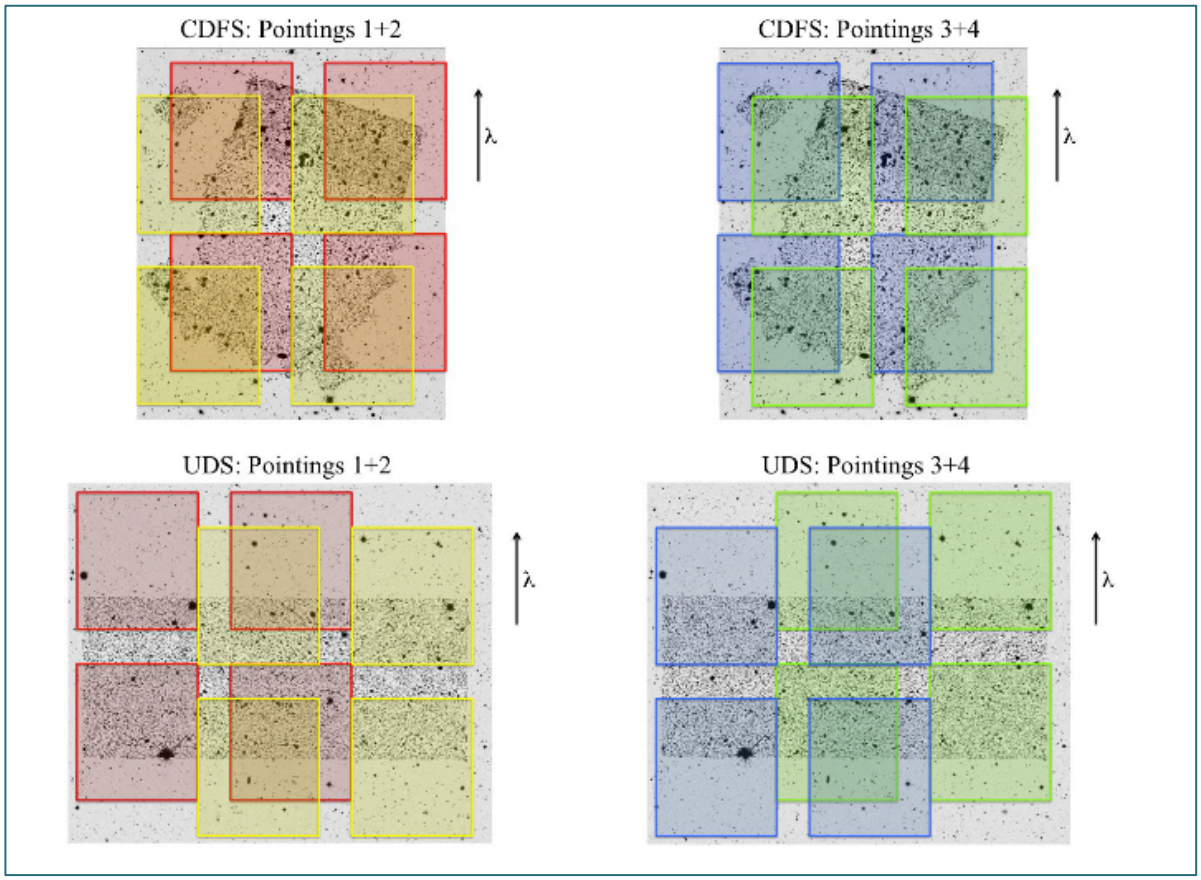
VANDELS: survey fields

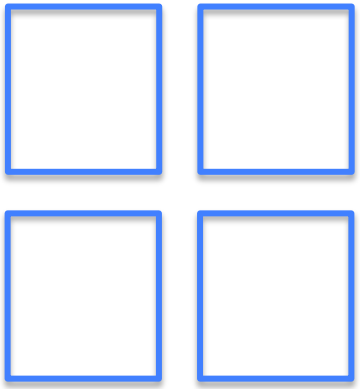
HST optical/near-IR imaging survey covering 0.2 square degrees split over 5 survey fields



VANDELS targets the two southern CANDELS fields, exploiting unrivalled 15+ band (0.3mm-4.5mm) photometry and near-IR grism spectra (3D-HST)

VANDELS: observations





VIMOS FOOTPRINT

- ✓ 8 Pointings in total, designed to cover HST imaging area (75% of slits allocated to HST area)
- ✓ Each pointing targeted four times, 20 hours each: bright targets get 20 hours, faint targets get 80 hours

VANDELS: targets

Primary Targets

- ✓ Star-forming galaxies at $2.5<z<5.0$ ($H_{AB}<24$)
- ✓ Passive galaxies at $1.5<z<2.5$ ($H_{AB}<22.5$)
- ✓ Lyman-break galaxies at $3.0<z<7.0$ ($H_{AB}<26.5$)

Ultra-long integrations: 20-80 hrs per source

Very high S/N

VANDELS: targets and science goal

Primary Targets

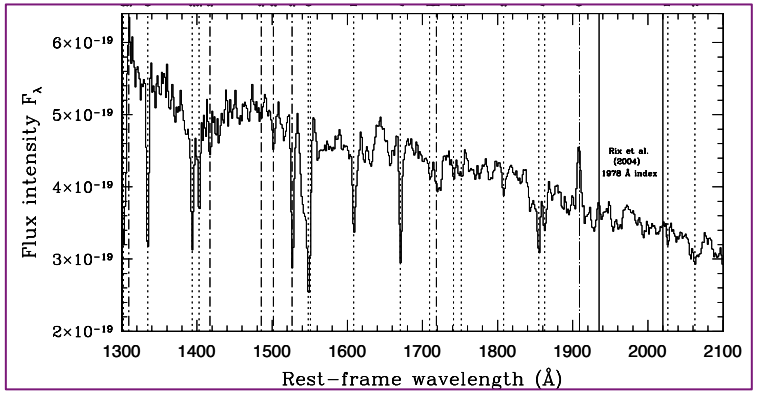
- ✓ Star-forming galaxies at 2.5<z<5.0 (H_{AB}<24)
- ✓ Passive galaxies at 1.5<z<2.5 (H_{AB}<22.5)
- ✓ Lyman-break galaxies at 3.0<z<7.0 (H_{AB}<26.5)

Ultra-long integrations: 20-80 hrs per source

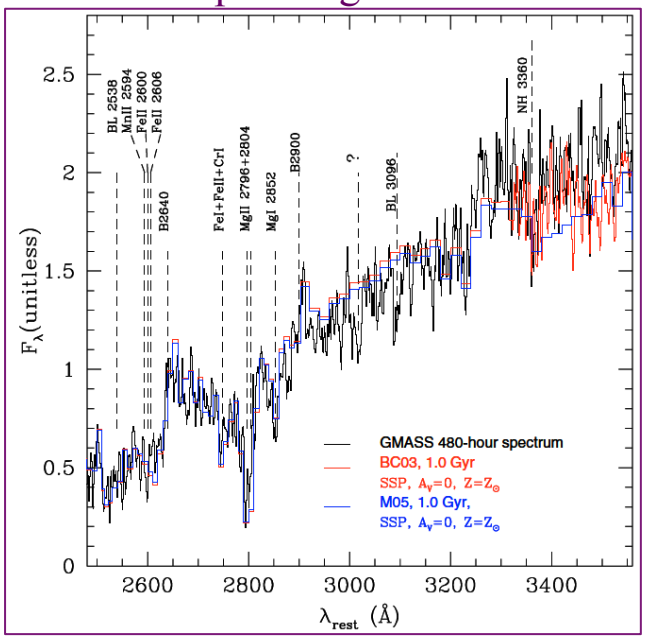
Very high S/N

Ultra deep optical VIMOS + HST near-IR grism spectroscopy + 0.3um-4.5um photometry will unable us to measure the *physical* tracers of galaxy evolution: age, mass, dust, SFR, outflows, stellar + gas metallicity

Absorption line metallicities



UV+optical age constraints

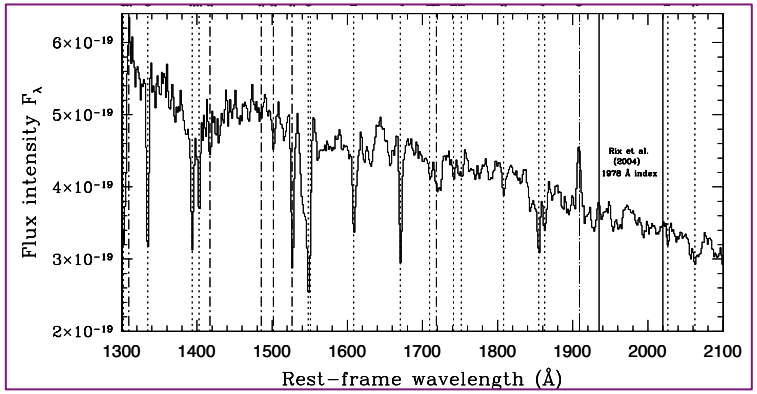


VANDELS: targets and science goal

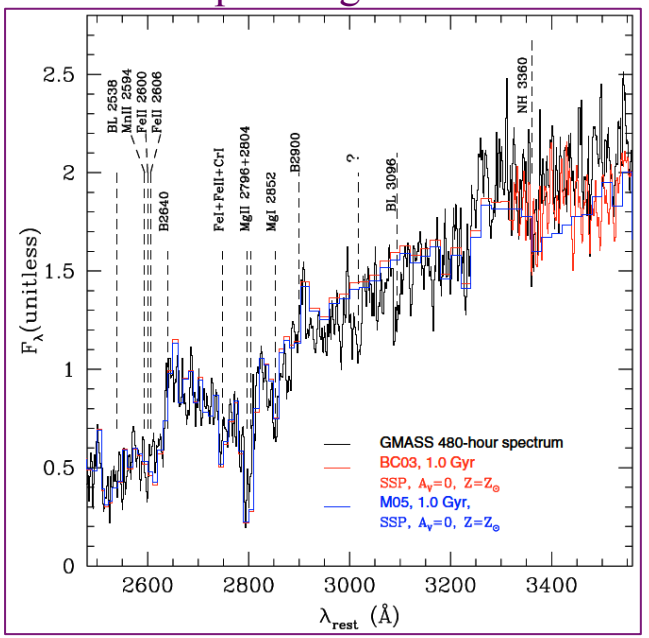
Primary Targets

- ✓ Star-forming galaxies at 2.5<z<5.0 (H_{AB}<24)
- ✓ Passive galaxies at 1.5<z<2.5 (H_{AB}<22.5)
- ✓ Lyman-break galaxies at 3.0<z<7.0 (H_{AB}<26.5)

Absorption line metallicities



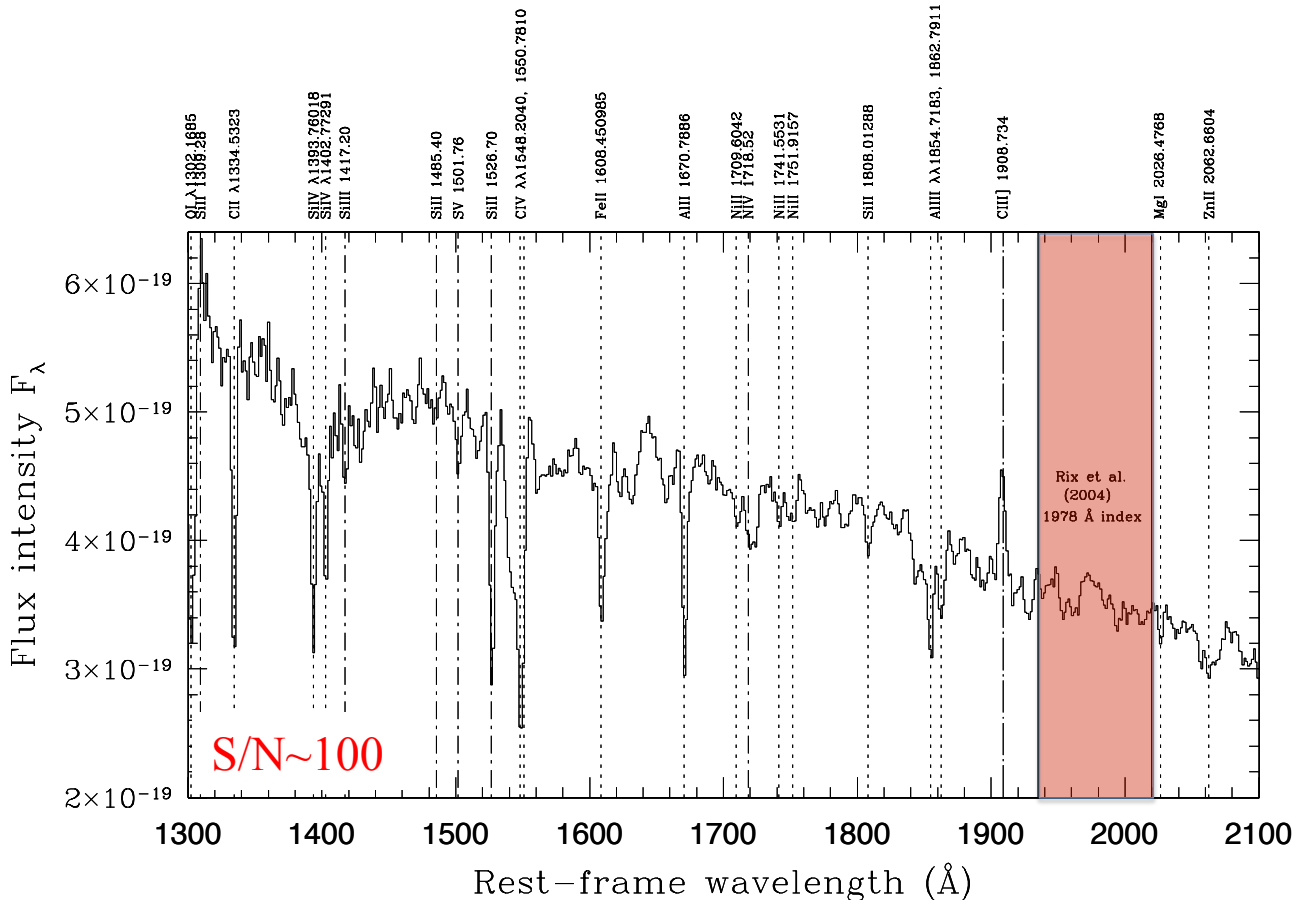
UV+optical age constraints



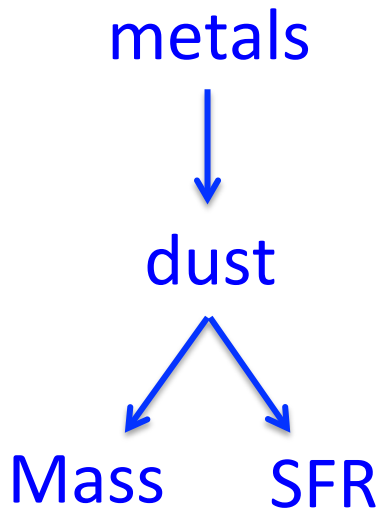
Fundamental aim is to **move** beyond **redshift measurement** and extract ***physical*** information from the spectra

VANDELS: main science case

1. metallicity of star-forming galaxies at 2.5<z<5.5

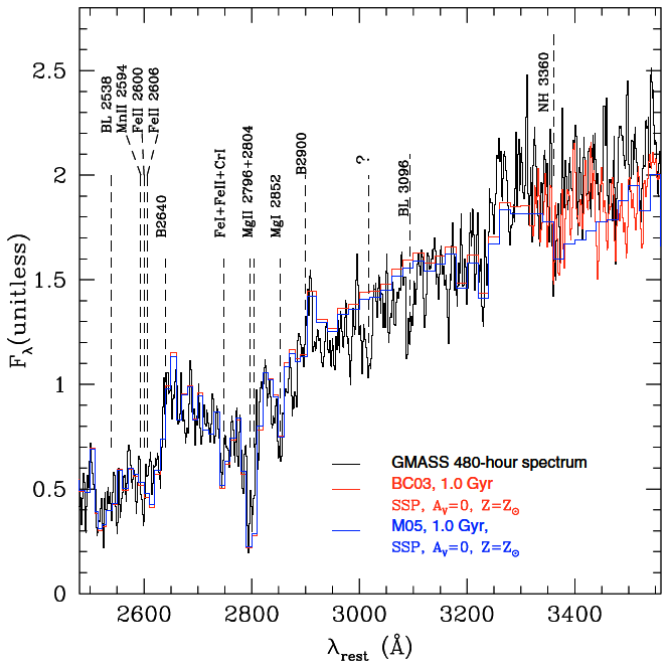


Halliday et al. (2008), stack of 75 GMASS galaxies at z~2

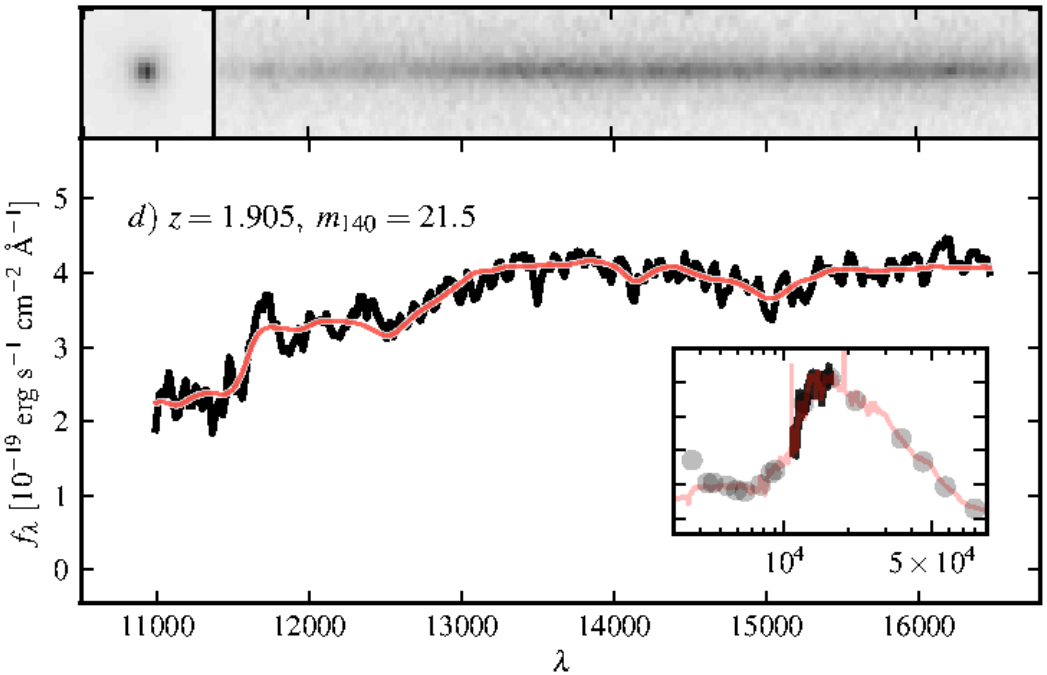


VANDELS: main science case

2. Detailed investigation of the descendants of high-z SFG: passive galaxies at 1.5<z<2.5



Cimatti et al. (2008)



3D-HST (van Dokkum et al.)

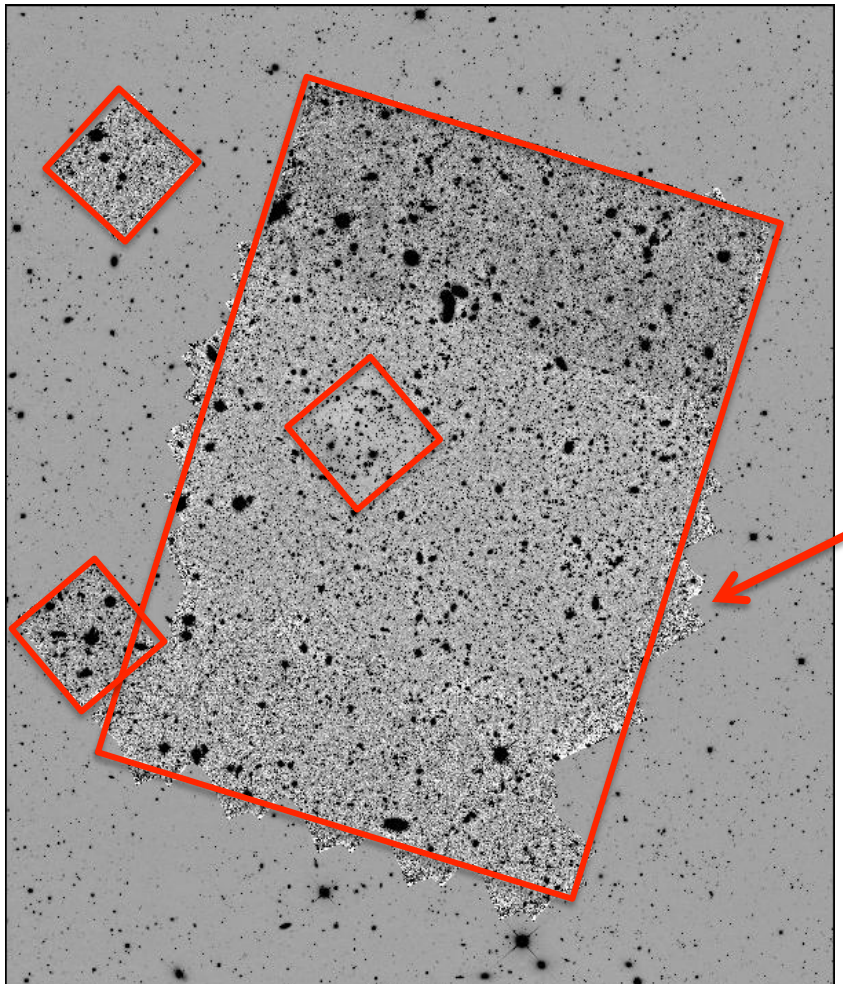
- ✓ It is possible to constrain ages from UV breaks (2600/2800 Angs) from VANDELS and Balmer break from 3D-HST spectra
- ✓ Through spectrophotometric fitting (photometry+spectra) we can derive accurate stellar ages, masses and metallicities of massive quiescent galaxies at z~2

VANDELS: photo-z pre-selection

- A key point of VANDELS is to PRE-SELECT the targets using robust photo-z
- This is possible thanks to the wide multi-wavelength photometric coverage available in UDS and CDFS

VANDELS: photo-z pre-selection

- A key point of VANDELS is to PRE-SELECT the targets using robust photo-z



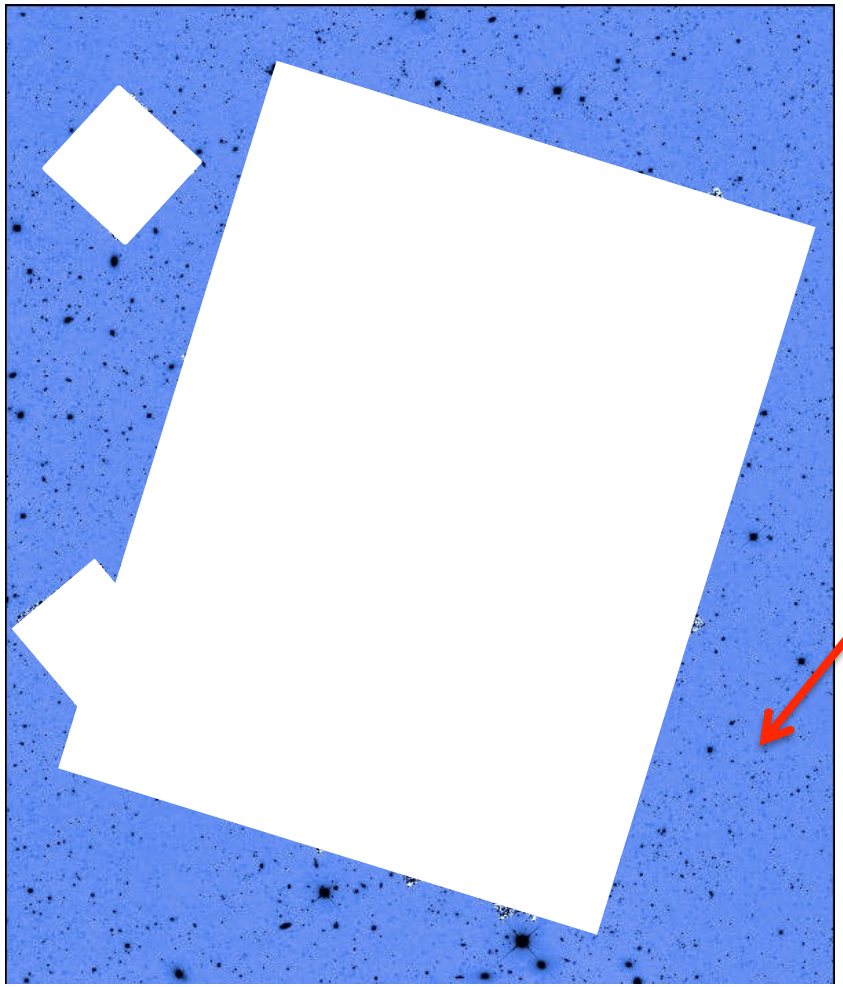
VANDELS CDFS FIELD

WIDE multi-λ photometric coverage:

- In area covered by CANDELS HST imaging we use the Guo et al. (2013) TFIT catalogues featuring aperture matched, 14-band photometry 0.3-4.5um

VANDELS: photo-z pre-selection

- A key point of VANDELS is to PRE-SELECT the targets using robust photo-z



VANDELS CDFS FIELD

WIDE multi-λ photometric coverage:

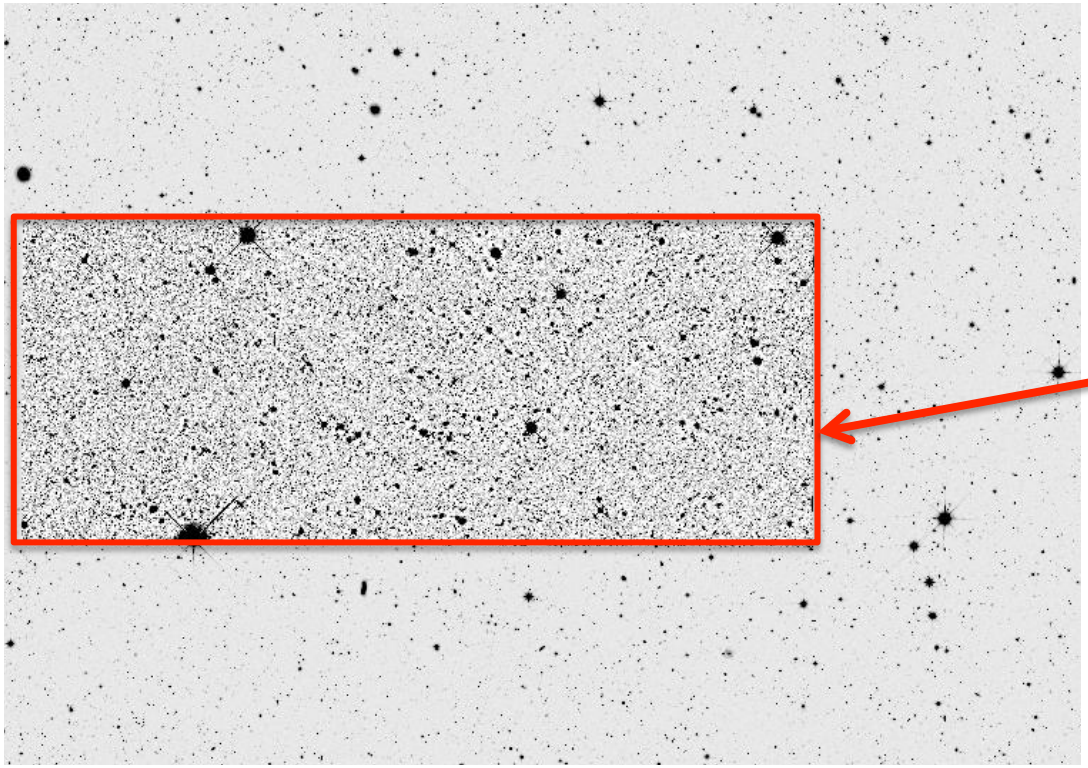
- For extended CDFS region we use a new VANDELS catalogue, which uses a combination of 16-band photometry: VIMOS U, R-band, Subaru $BVRizz_{nb}$, GEMS HST V_{606} , $z_{850:}$, CFHT J and K, H from VISTA VIDEO Survey and IRAC

For the test runs we employed the Hsu et al. 2015 catalogue based on MUSYC +TENIS

VANDELS: photo-z pre-selection

- A key point of VANDELS is to PRE-SELECT the targets using robust photo-z

WIDE multi-λ photometric coverage:



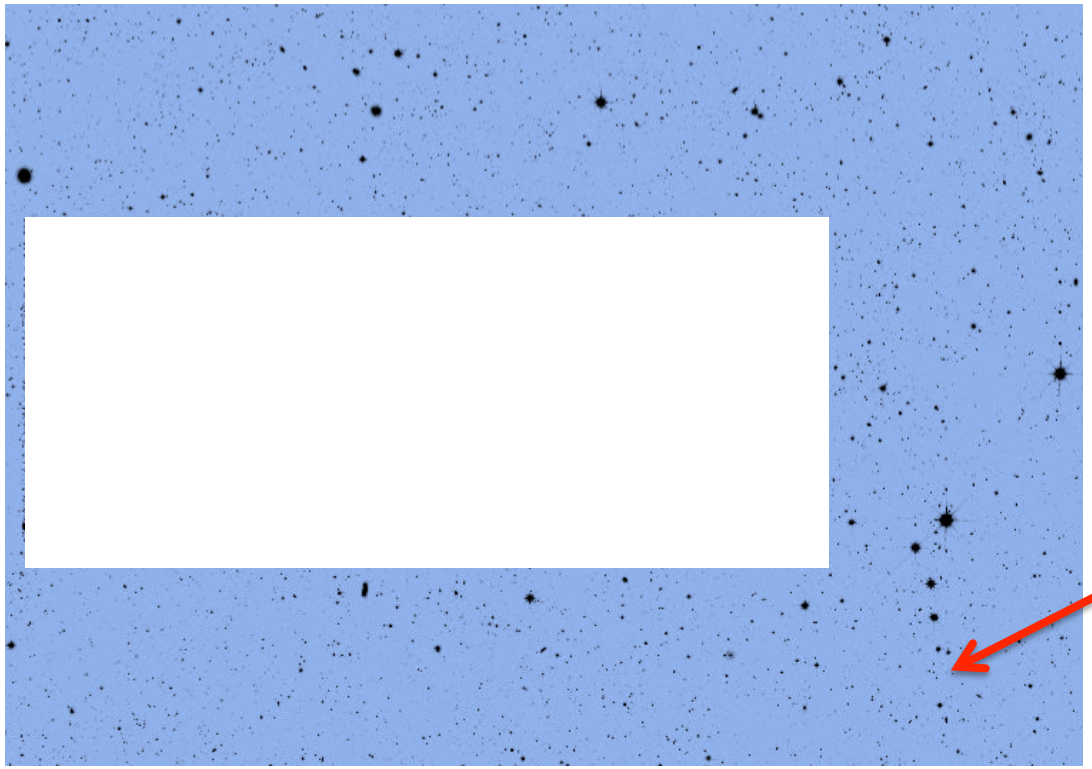
VANDELS UDS FIELD

- Within CANDELS HST region, we exploit Galametz et al. (2013) TFIT catalogue, which features 15-band aperture matched photometry covering 0.3-4.5um

VANDELS: photo-z pre-selection

- A key point of VANDELS is to PRE-SELECT the targets using robust photo-z

WIDE multi-λ photometric coverage:

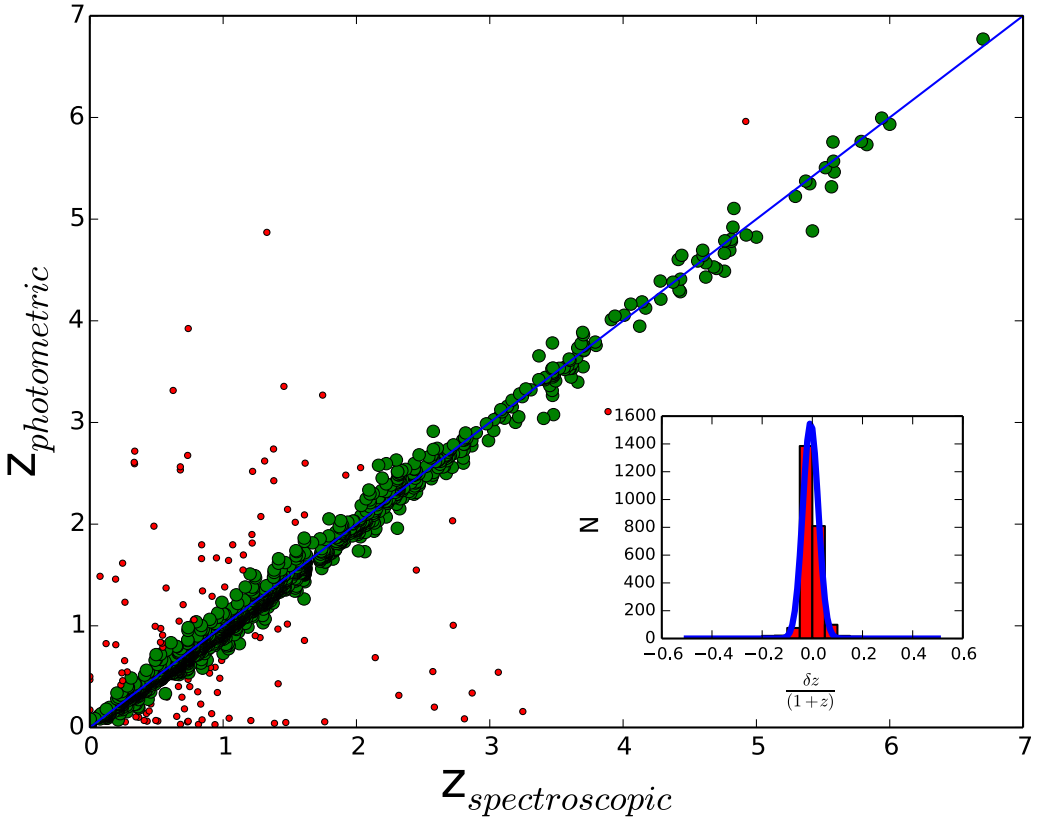


VANDELS UDS FIELD

- Within extended UDS region, Edinburgh VANDELS catalogue using 13-band photometry: CFHT U-band, Subaru BVRizz$_{nb}$, VIDEO Y-band, JHK from UKIDSS UDS, IRAC from SEDS

VANDELS: photo-z pre-selection

- A key point of VANDELS is to PRE-SELECT the targets using robust photo-z



CDFS photometric redshifts

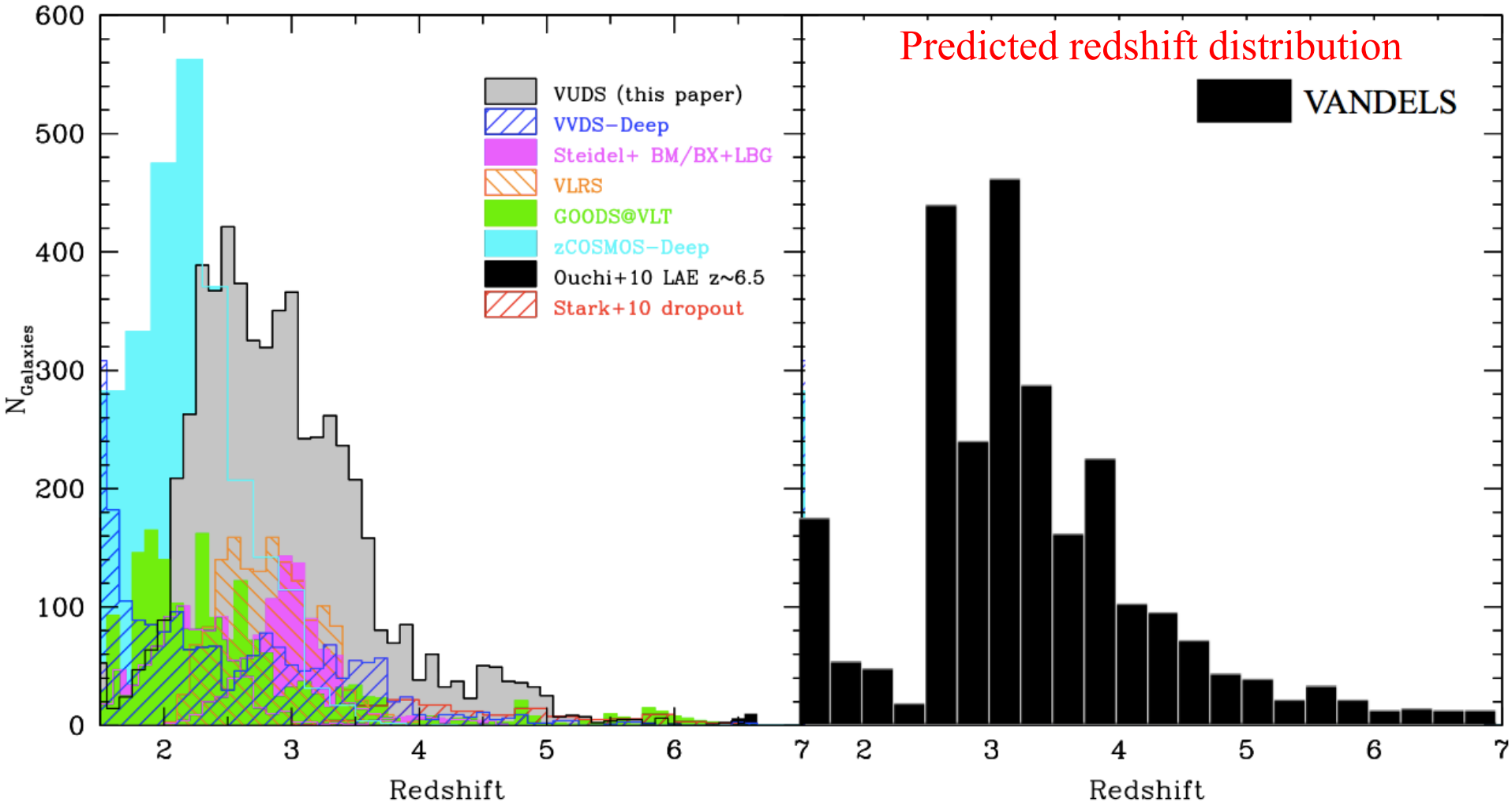
σ=0.013

Outlier fraction < 4%
down to H_{AB}=26

Aim is for <100 low-redshift interlopers in final sample of 2600 galaxies

VANDELS: photo-z pre-selection

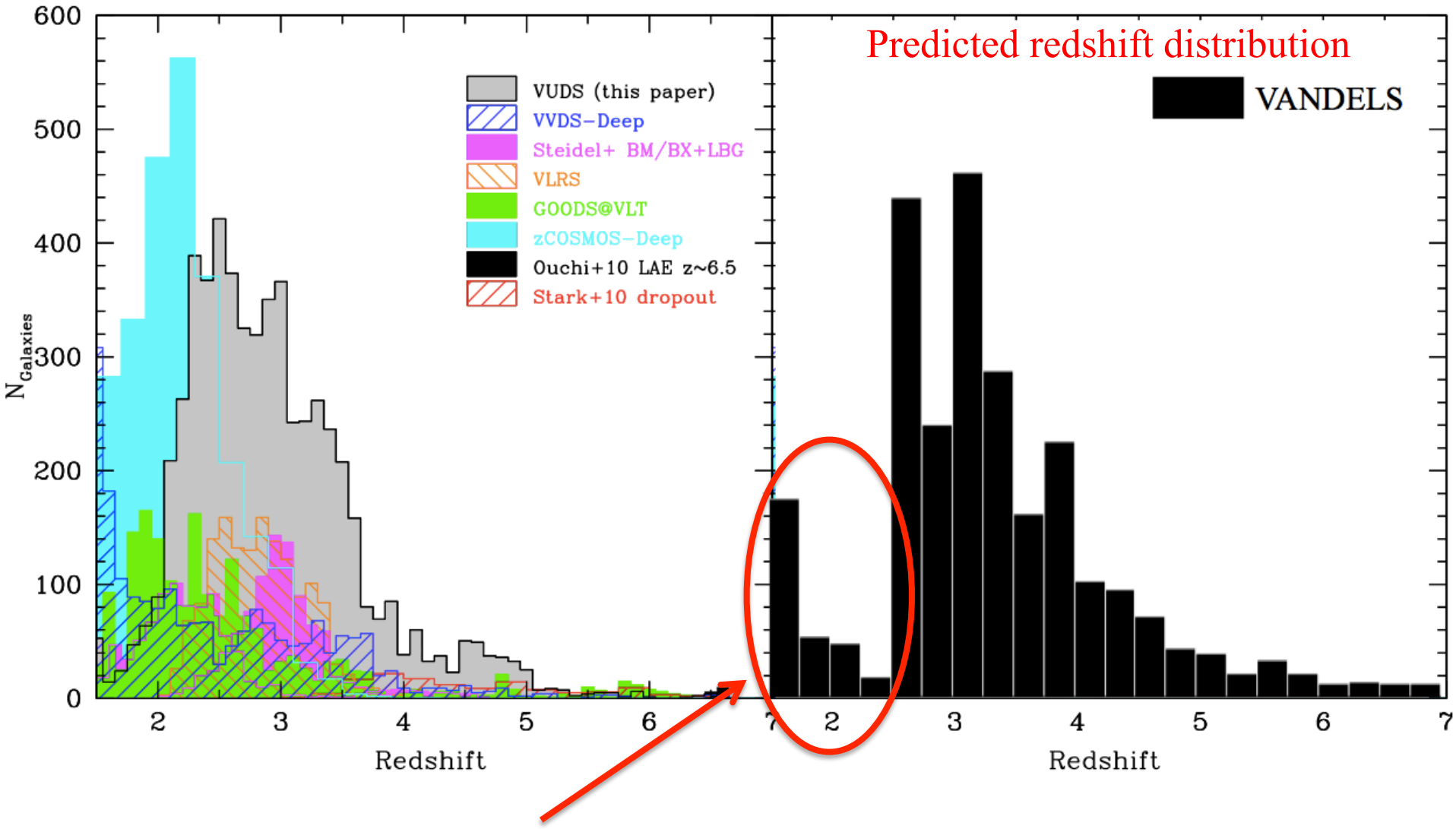
- A key point of VANDELS is to PRE-SELECT the targets using robust photo-z



The VANDELS selection function should ensure that ~ 20% of the final sample are at z > 4 with ~ 200 galaxies at z > 5

VANDELS: photo-z pre-selection

- A key point of VANDELS is to PRE-SELECT the targets using robust photo-z



Passive galaxy sub-sample at 1.5<z<2.5

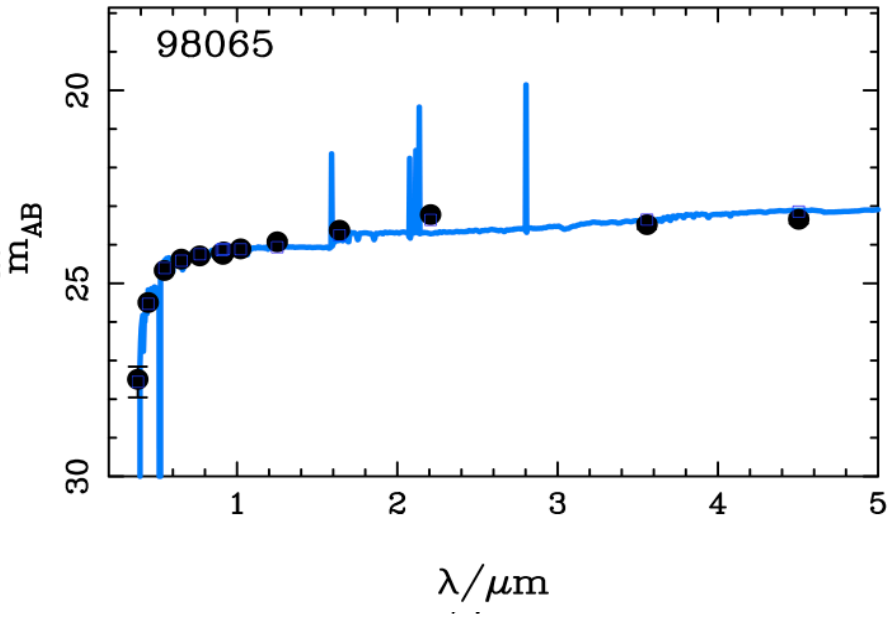
VANDELS: test observations

- ✓ Allocated two observing runs in Nov/Dec 2014 to test the observing strategy
- ✓ Obtained ~10 hours of integration in both UDS and CDFS on two masks

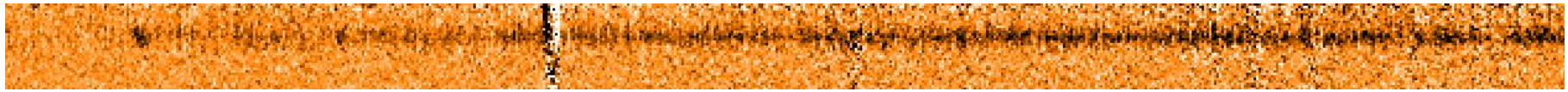
VANDELS: test observations

- ✓ Allocated two observing runs in Nov/Dec 2014 to test the observing strategy
- ✓ Obtained ~10 hours of integration in both UDS and CDFS on two masks

Example 2D spectra from UDS mask:



FIELD: UDS (EXTENDED AREA)
ID: 98065
CLASS: 2.5<z<5.5 SF
z_{phot} = 3.27
z_{spec} = 3.24

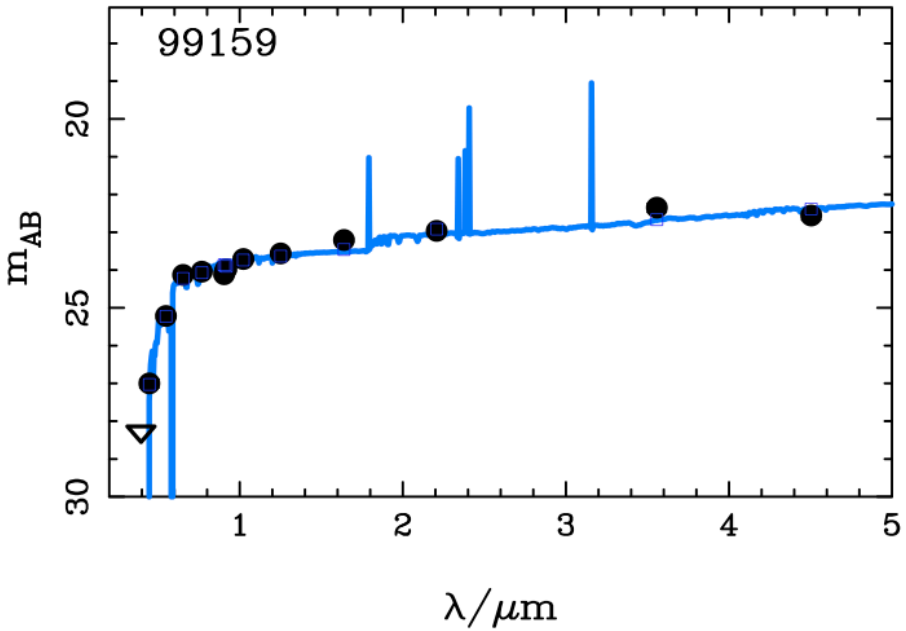


SF at z=3.24

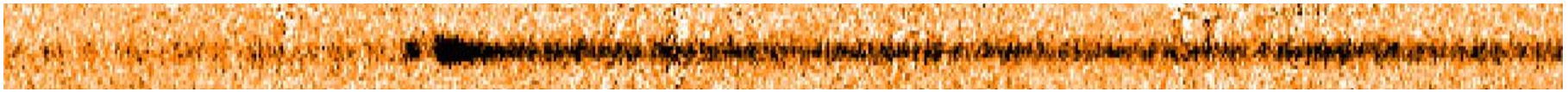
VANDELS: test observations

- ✓ Allocated two observing runs in Nov/Dec 2014 to test the observing strategy
- ✓ Obtained ~10 hours of integration in both UDS and CDFS on two masks

Example 2D spectra from UDS mask:



FIELD: UDS (EXTENDED AREA)
ID: 99159
CLASS: High-z AGN
z_{phot} = 3.81
z_{spec} = 3.97

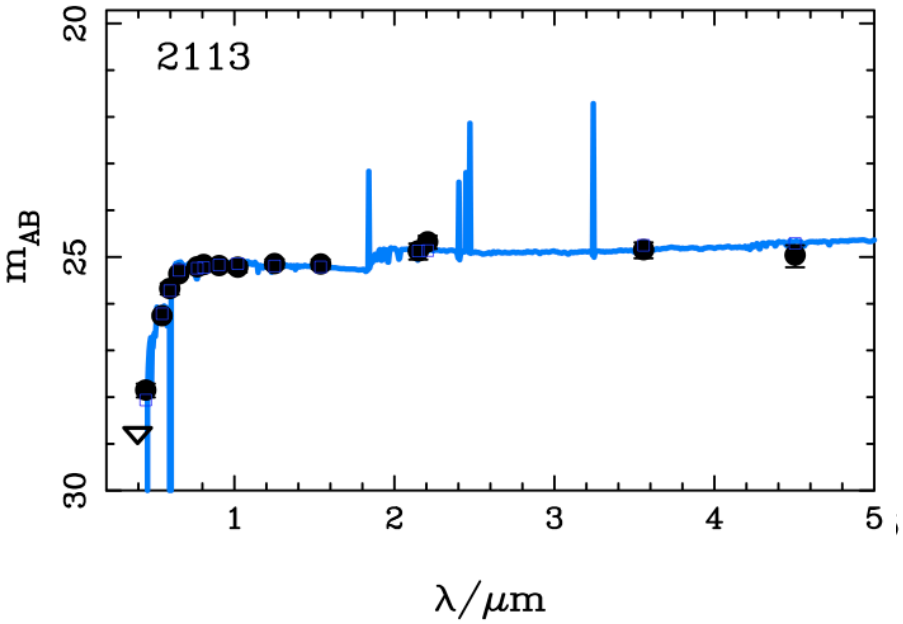


Type 1 AGN at z=3.97

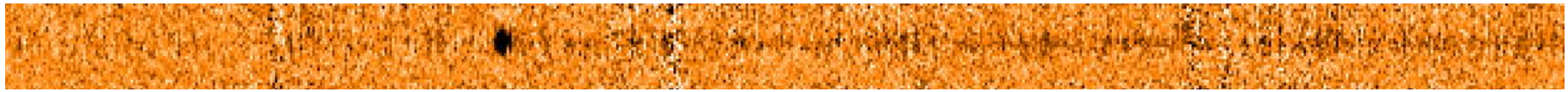
VANDELS: test observations

- ✓ Allocated two observing runs in Nov/Dec 2014 to test the observing strategy
- ✓ Obtained ~10 hours of integration in both UDS and CDFS on two masks

Example 2D spectra from UDS mask:



FIELD: UDS (CANDELS AREA)
ID: 2113
CLASS: 3.0<z<7.0 LBG
z_{phot} = 3.94
z_{spec} = 4.03

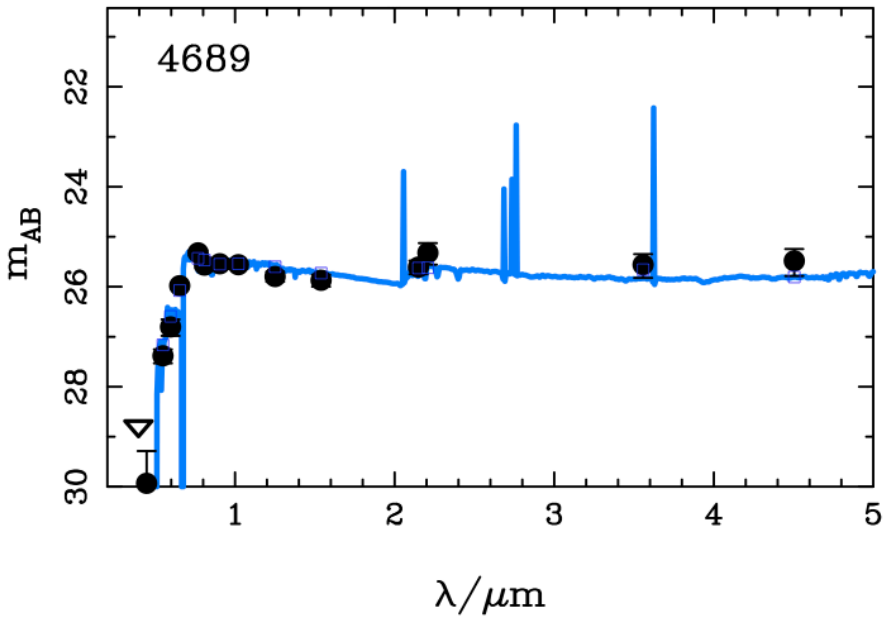


LAE at z=4.03

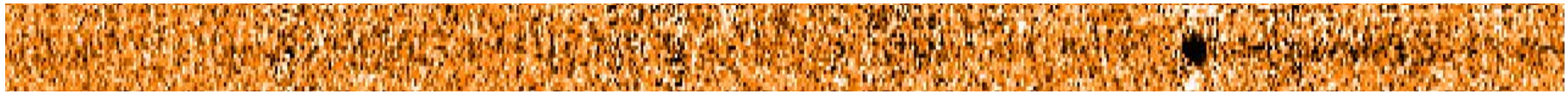
VANDELS: test observations

- ✓ Allocated two observing runs in Nov/Dec 2014 to test the observing strategy
- ✓ Obtained ~10 hours of integration in both UDS and CDFS on two masks

Example 2D spectra from UDS mask:



FIELD: UDS (CANDELS AREA)
ID: 4689
CLASS: 3.0<z<7.0 LBG
z_{phot} = 4.52
z_{spec} = 4.62



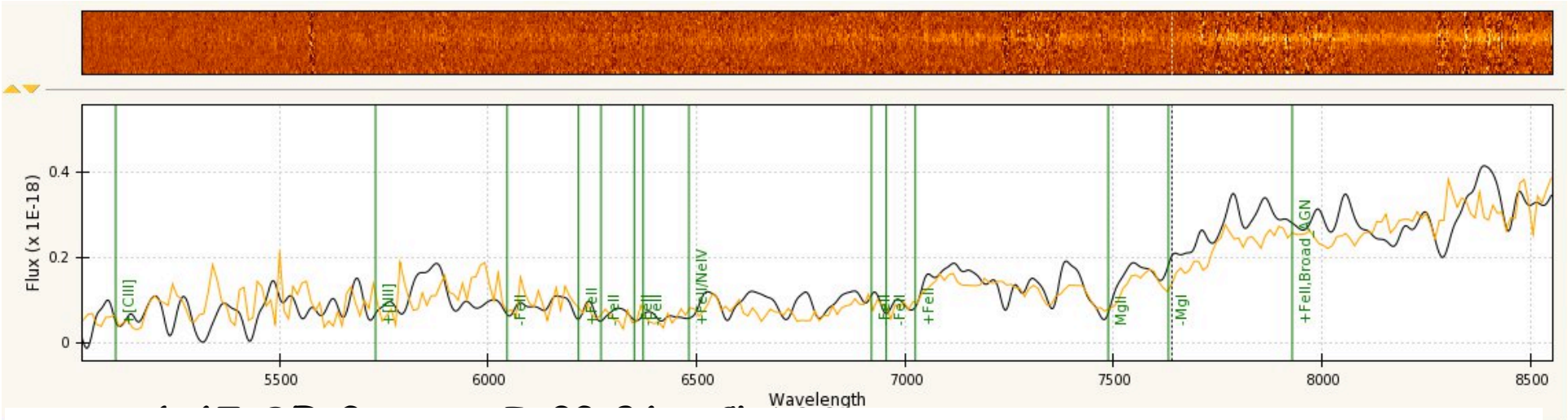
LAE at z=4.62

VANDELS: test observations

- ✓ Allocated two observing runs in Nov/Dec 2014 to test the observing strategy
- ✓ Obtained ~10 hours of integration in both UDS and CDFS on two masks

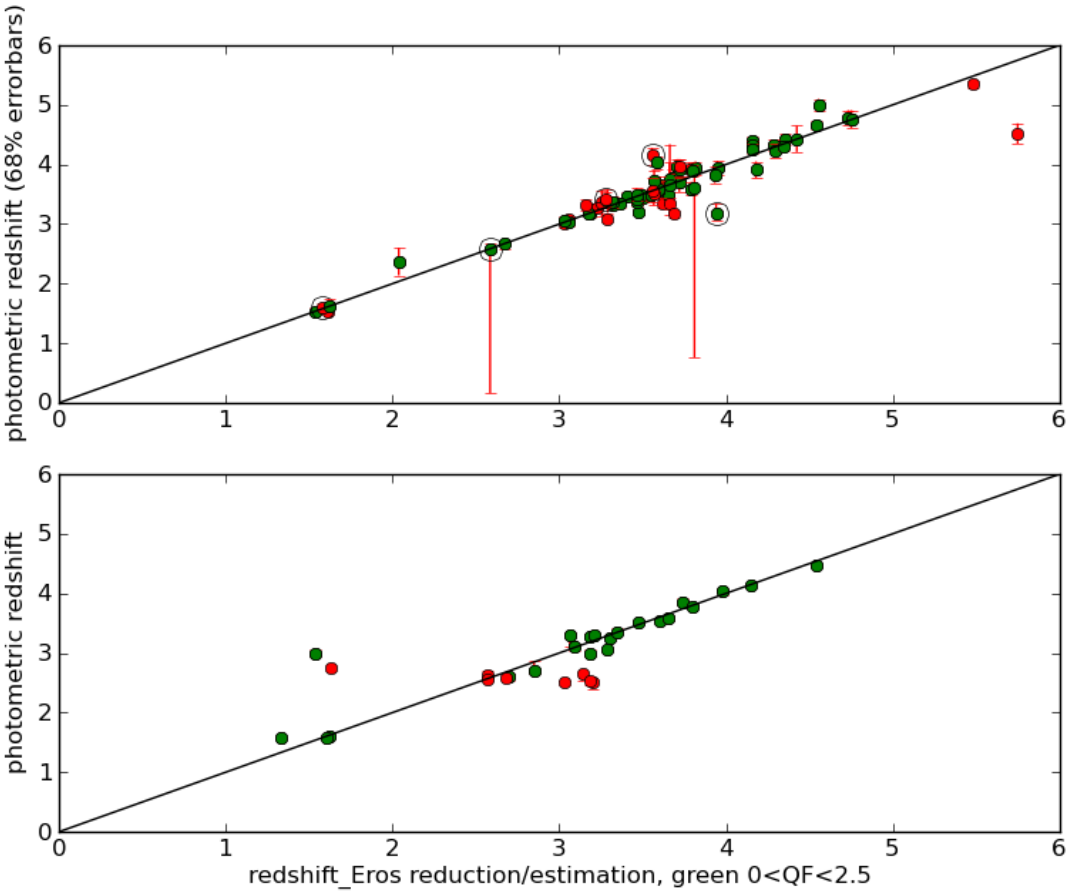
Example 1& 2D spectra from CDFS mask:

FIELD: CDFS (CANDELS AREA)
CLASS: 1.5 < z <1.5 PASSIVE
z_{phot} = 1.522
z_{spec} = 1.67



VANDELS: test observations

- ✓ Allocated two observing runs in Nov/Dec 2014 to test the observing strategy
- ✓ Obtained ~10 hours of integration in both UDS and CDFS on two masks



z_{spec}-z_{phot} comparison from test mask in CDFS
Upper plot: CANDELS area
Lower plot: EXTENDED area

Green = high quality redshift

Red = low quality redshift

Target selection appears to be working well…

VANDELS: schedule

Observations:

- ✓ 912 hours **of visitor mode observations** (spread over 240 nights) to be carried out in four observing seasons (Aug-Dec) during 2015-2018.
- ✓ Science goals: ages, masses, metallicities and outflows at high-z
- ✓ All raw data are immediately public on ESO archive

Data Reduction:

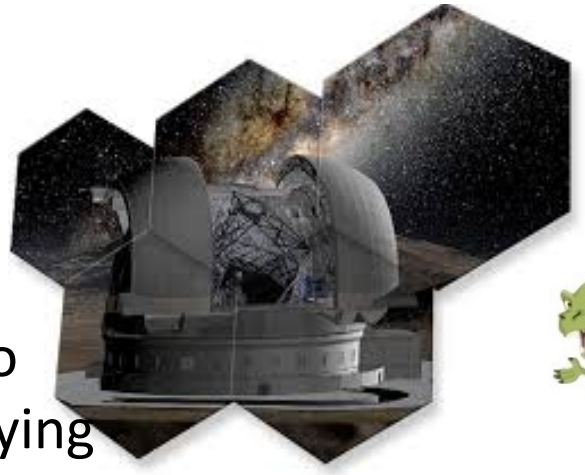
✓ Data reduction is being carried out in Milan, by the team responsible for reducing VIMOS data obtained in VVDS, zCOSMOS, VIPERS and VUDS surveys

✓ Fully calibrated 1d and 2d spectra as well as additional data products will be made available ~9 months after observations

Provisional Data Release Schedule:

		No. of completed spectra			No. of partially complete spectra			
Data release	Date	20-hrs	40-hrs	80-hrs	40-hrs(50%)	80-hrs(25%)	80-hrs(50%)	Total
DR1	Sept 2016	160	160	0	320	320	160	1120
DR2	Sept 2017	320	480	160	320	320	160	1760
DR3	Sept 2018	480	960	320	0	0	320	2080
DR4	Sept 2019	640	1280	640	0	0	0	2560

VANDELS: waiting for E-ELT



- ✓ VANDELS is pushing today's facilities to perform the first survey aimed at studying the physics of high-z galaxies

- ✓ VANDELS will open the road towards our understanding of high-z galaxy physics. The findings will drive future observations using E-ELT

  - E-ELT MOS to push this kind of studies at z>5. VANDELS effort on pre-selection will be precious.

  - VANDELS galaxies at z=3-5 will be the best targets for spatially resolved IFU E-ELT observations