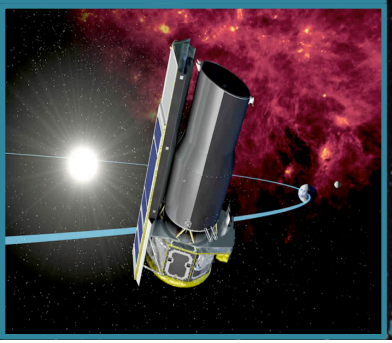
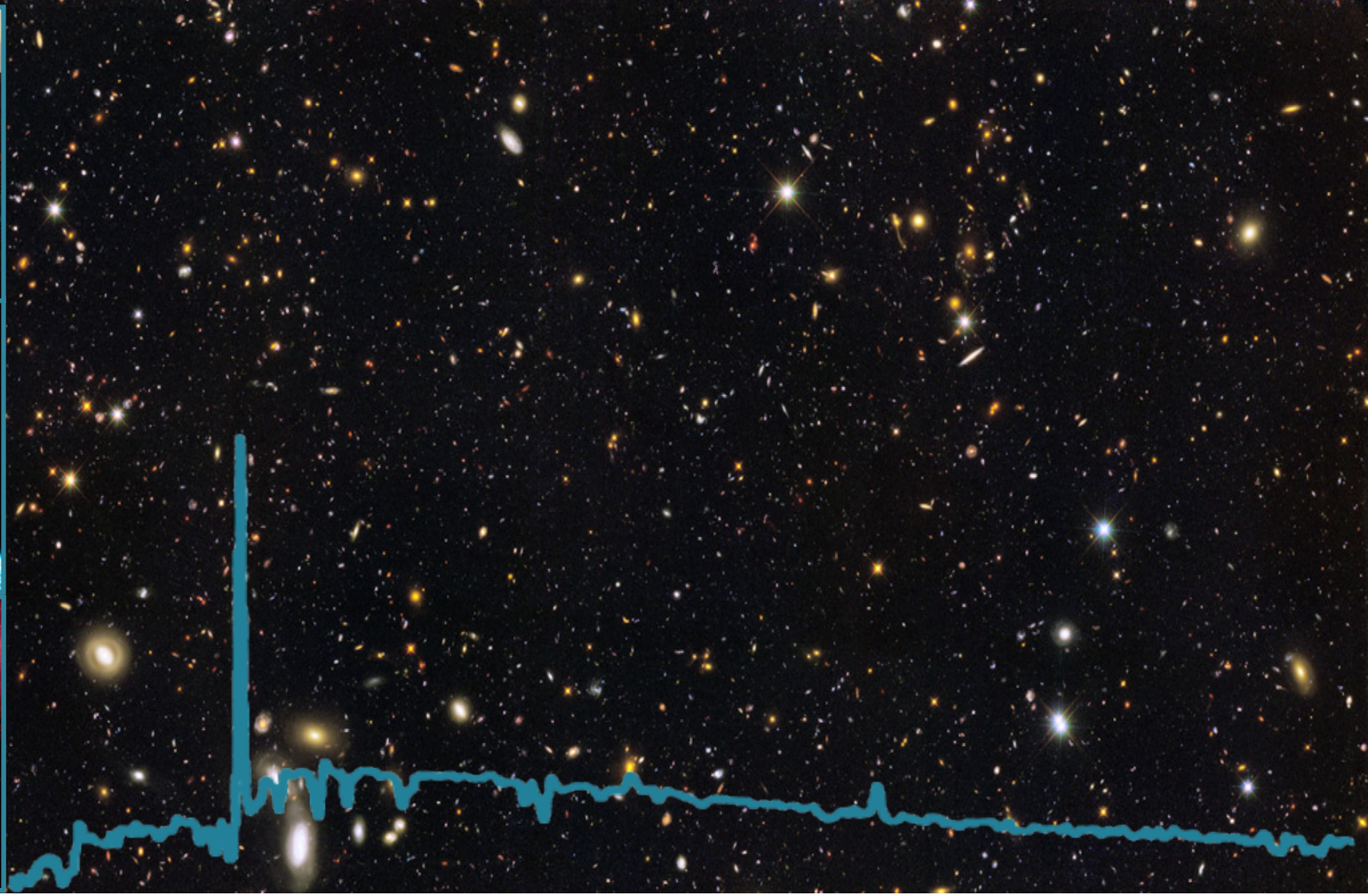




VANDELS

A deep VIMOS survey of the CANDELS UDS and CDFS fields

New ESO public VIMOS spectroscopy survey of the UDS and CDFS fields

R. McLure & L. Pentericci

What is it?

- 912 hours of VIMOS visitor time: 2015-2018
- 20-80 hour integrations focused on z>3 star-forming galaxies
- Science goals: ages, masses, metallicities and outflows at high-z
- Raw data immediately public
- Regular releases of reduced data (DR1 in June 2017)
- Full details can be found at: vandels.inaf.it

VANDELS

A deep VIMOS survey of the CANDELS UDS and CDFS fields

New ESO public VIMOS spectroscopy survey of the UDS and CDFS fields

R. McLure & L. Pentericci

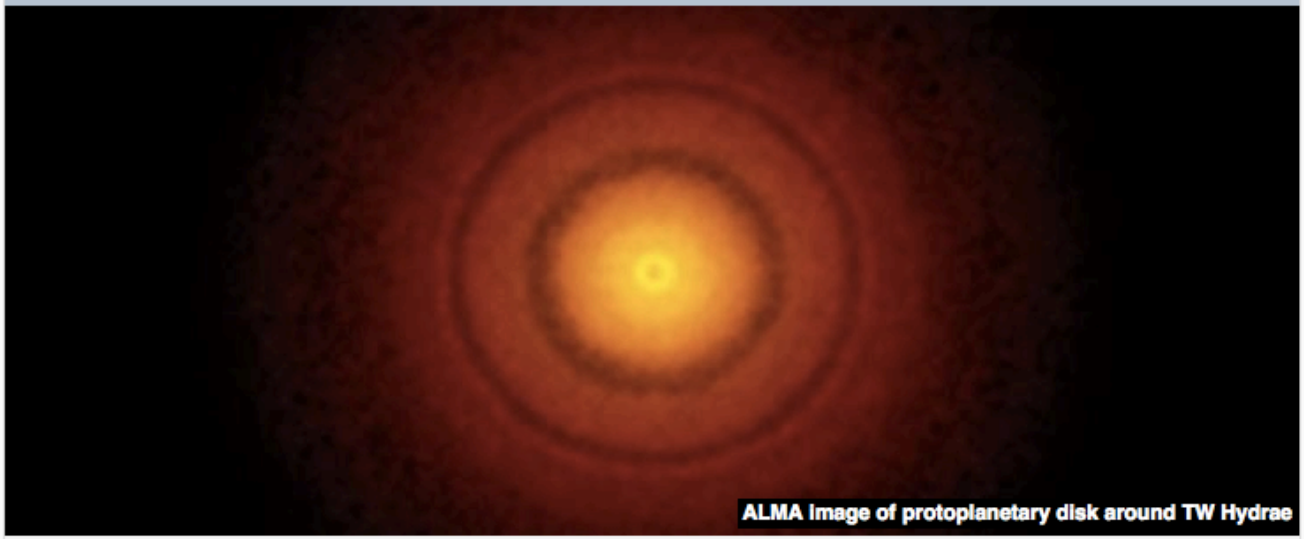
VANDELS: overview

Survey began observations in August 2015, first of ~~four~~ three observing seasons ran from Aug 2015 – Jan 2016:

European Southern Observatory

ESO Science Newsletter June 2016

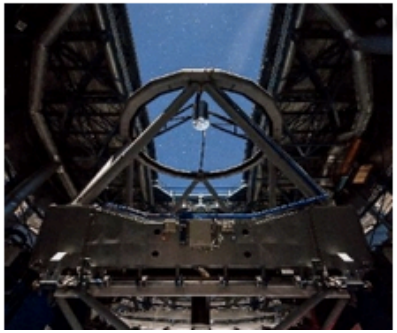
16 Jun 2016



ALMA image of protoplanetary disk around TW Hydrae

This newsletter is a summary of recent ESO Science Announcement items. Follow the links or visit ESO Science Announcements to read more.

Science Announcements



VIMOS to be Decommissioned in 2018

16 Jun 2016.

The planning for the near future of the VLT instrumentation was discussed at the Scientific Technical Committee (STC) meeting in April 2016. With the return of CRIRES+ currently planned for the first quarter of 2018, a VLT Nasmyth focus needs to be freed. ESO has investigated the available options, which essentially come down to FLAMES, UVES and VIMOS.

somewhat inconvenient…

VANDELS: overview

Survey began observations in August 2015, first of three observing seasons ran from Aug 2015 – Jan 2016:

Proposal was focused on two key aspects:

⊙Legacy value to astronomy community

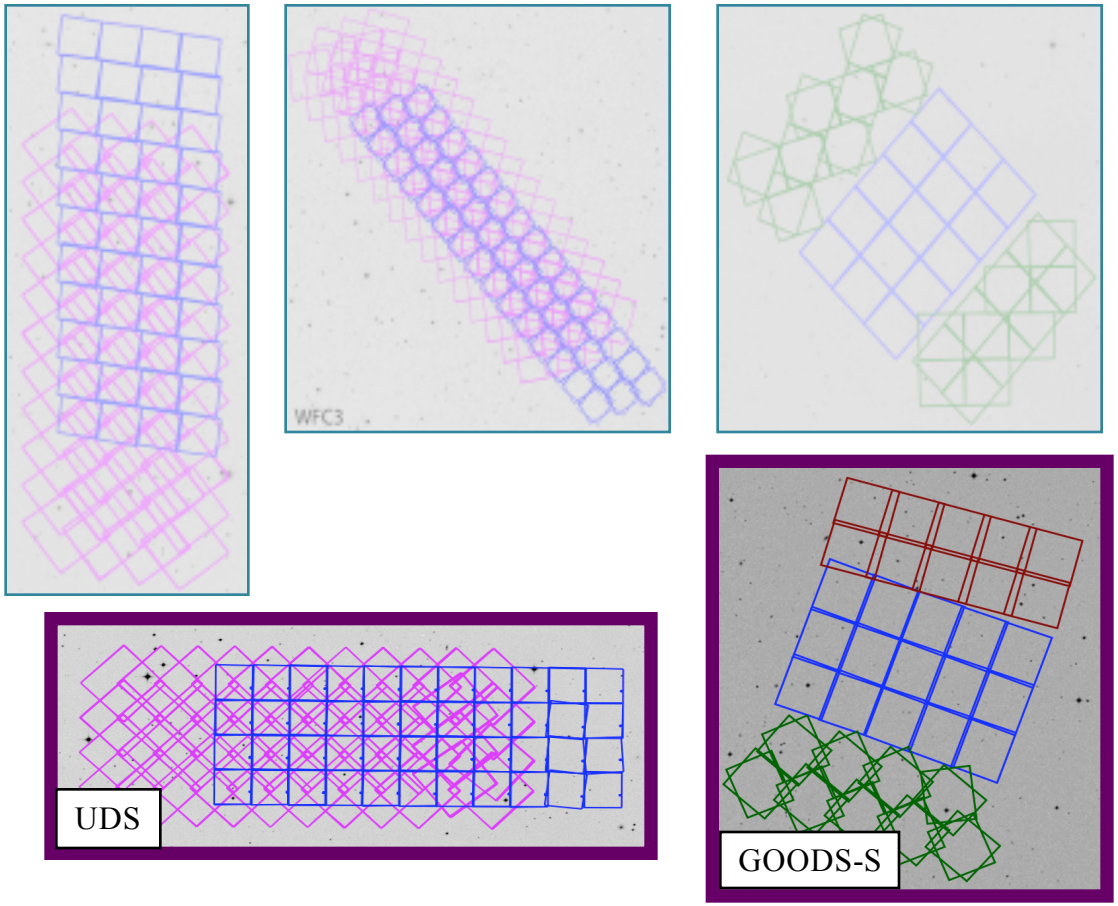
⊙Different science from previous VIMOS surveys
(VUDS VVDS zCOSMOS VIPERS)

Four key elements of VANDELS:

- ⊙ Small area (0.2 sq. degrees), best available multi-wavelength data
- ⊙ Ultra-long integrations, minimum 20 hours per source (80 hour max)
- ⊙ Medium resolution spectra (MR grism)
- ⊙ 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



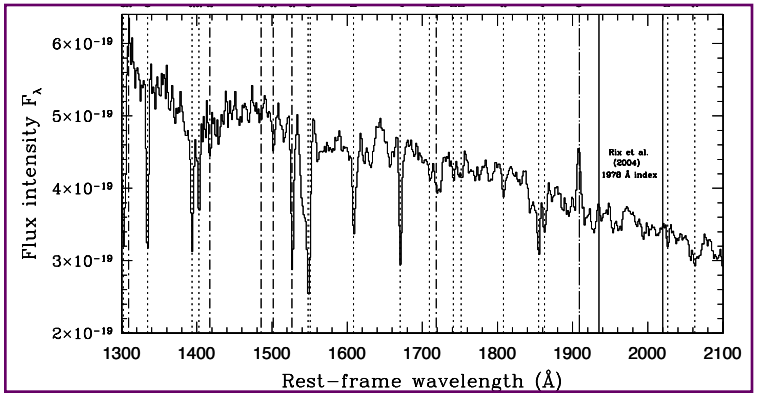
VANDELS targets the two southern CANDELS fields, exploiting unrivalled 15+ band (0.3μm-4.5μm) photometry and near-IR grism spectra (3D-HST)

VANDELS: motivation

Primary Targets

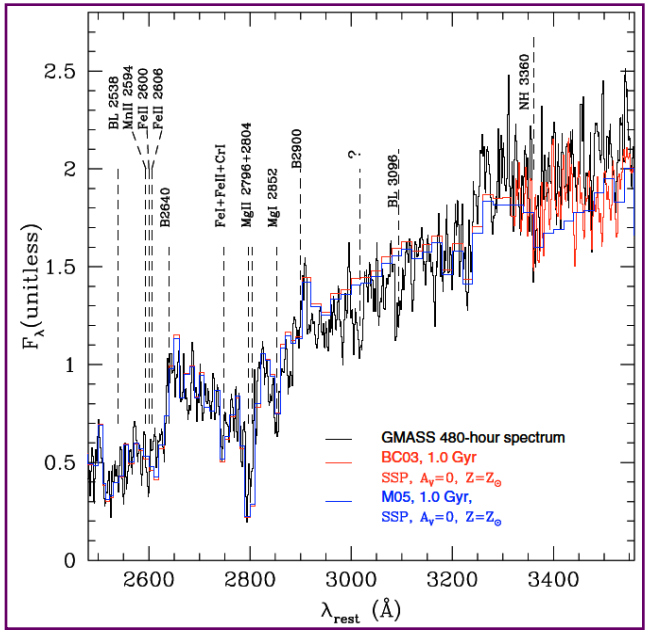
- Star-forming galaxies at $2.4<z<5.5$ ($H_{AB}<24$)
- Passive galaxies at $1.0<z<2.5$ ($H_{AB}<22.5$)
- Lyman-break galaxies at $3.0<z<7.0$ ($H_{AB}<27$)

Absorption line metallicities



Combine ultra-deep optical spectroscopy with 0.3μm-4.5μm photometry to measure *physical* tracers of galaxy evolution: age, mass, dust, SFR, outflows, stellar metallicity….

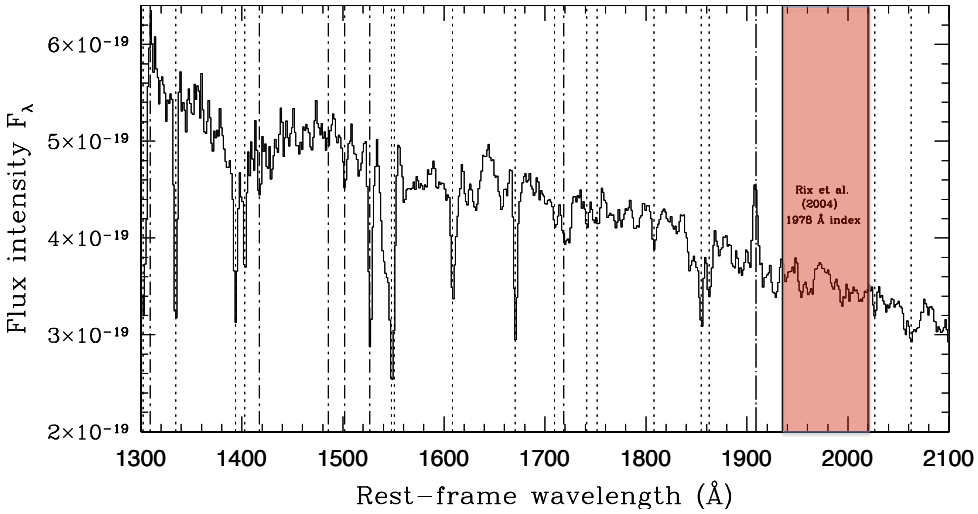
UV+optical age constraints



Provide sufficient signal-to-noise and resolution to measure physical properties from *individual* spectra as well as stacks

VANDELS: main science case

Primary science case is focused on determining physical properties of star-forming galaxies at 2.4<z<5.5:



metals

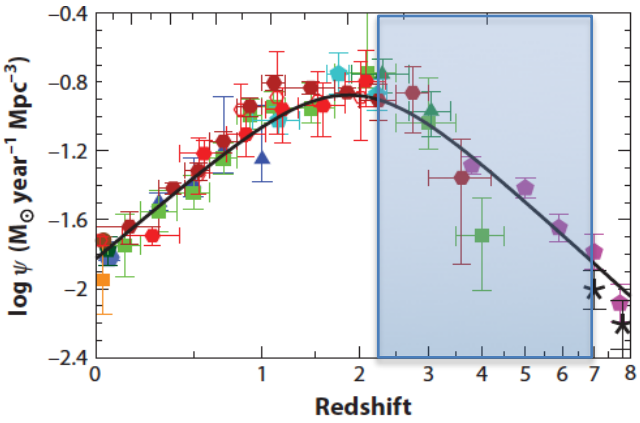
↓

dust

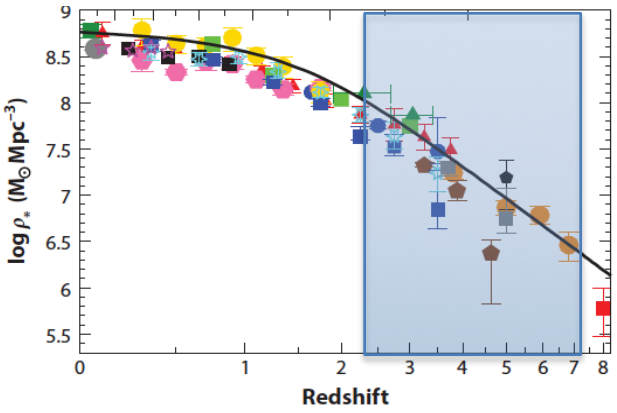
↙ ↘

mass SFR

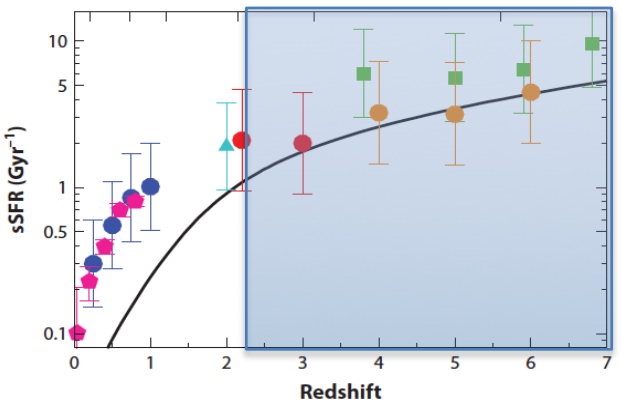
VANDELS



VANDELS



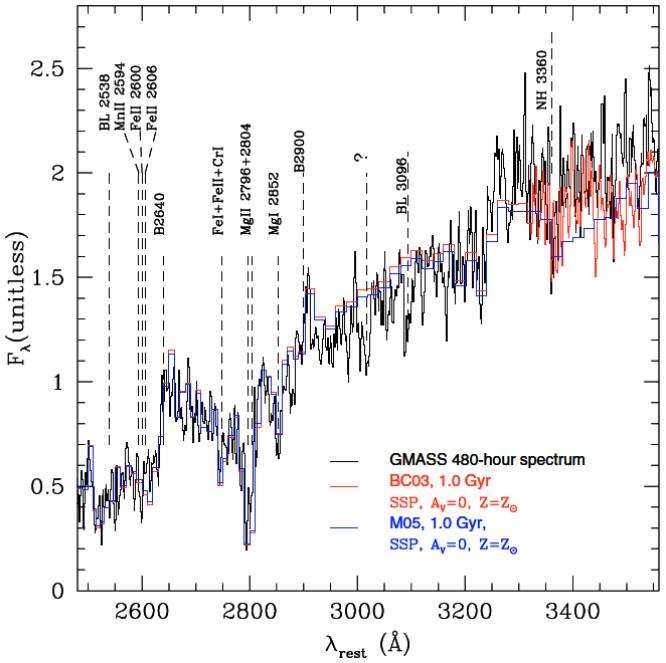
VANDELS



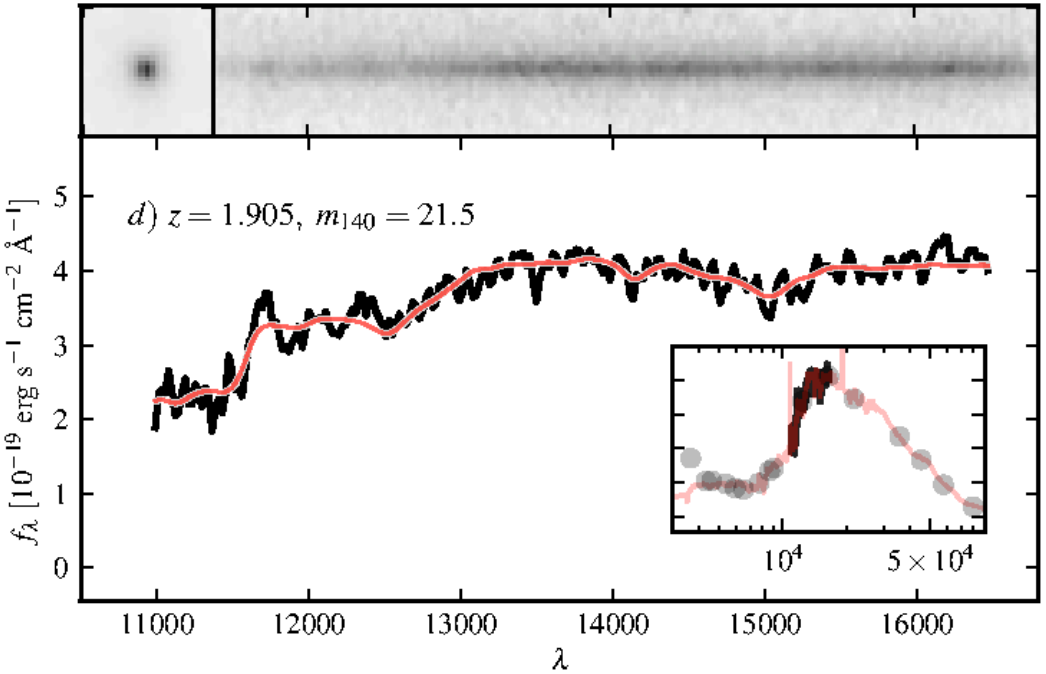
Madau & Dickinson (2014)

VANDELS: main science case

Primary science case : detailed investigation of the descendants of high-z star-formers: passive galaxies at 1.0<z<2.5



Cimatti et al. (2008)



3D-HST (van Dokkum et al.)

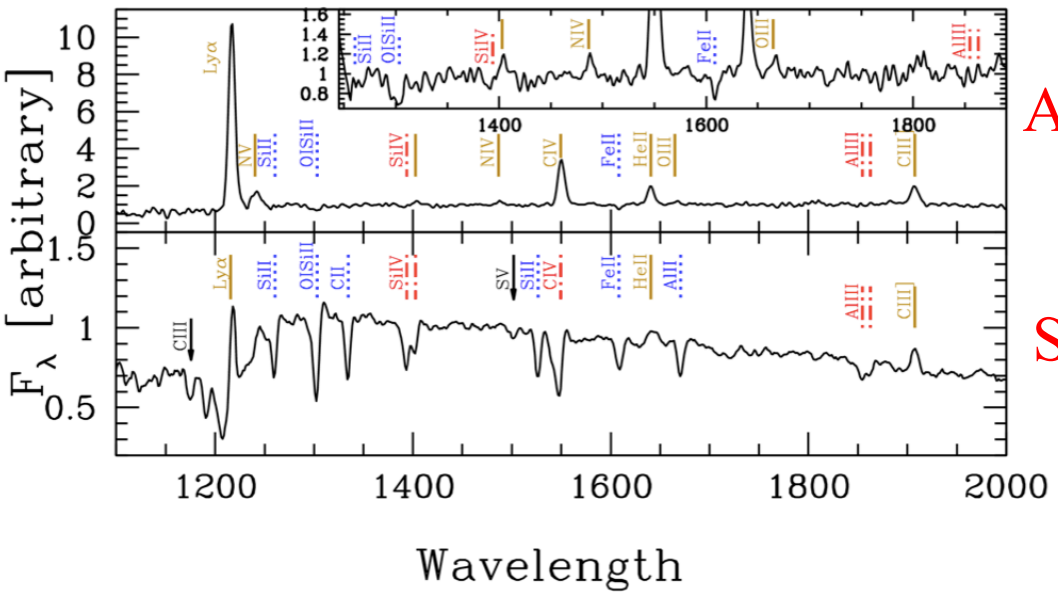
- Possible to constrain ages from UV breaks (2600/2800 Angs) and Balmer break from VANDELS spectra plus 3D-HST spectra plus photometry

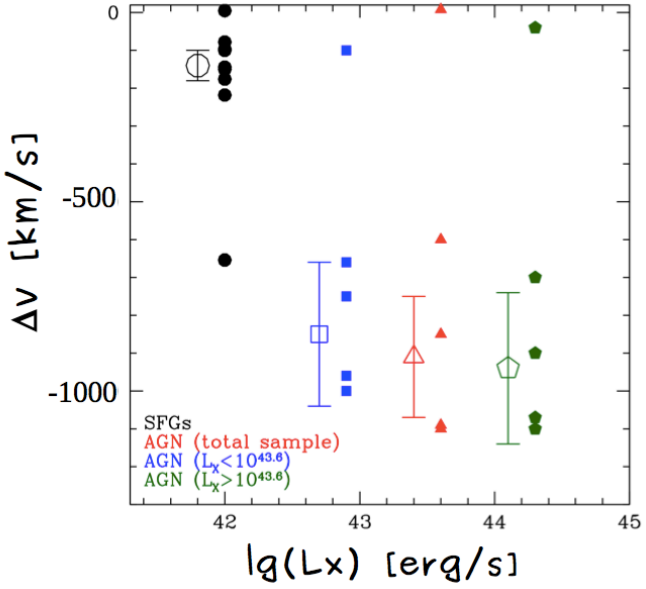
- Full spectrophotometric fitting (photometry+spectra) offers prospect of delivering accurate stellar ages, masses and metallicities of massive quiescent galaxies at z~2

VANDELS: science case summary

- For star forming galaxies and AGN : outflow/inflow velocity measurements from emission and absorption lines – feedback, build-up of mass-metallicity relation

Talia et al. (2016, in prep)

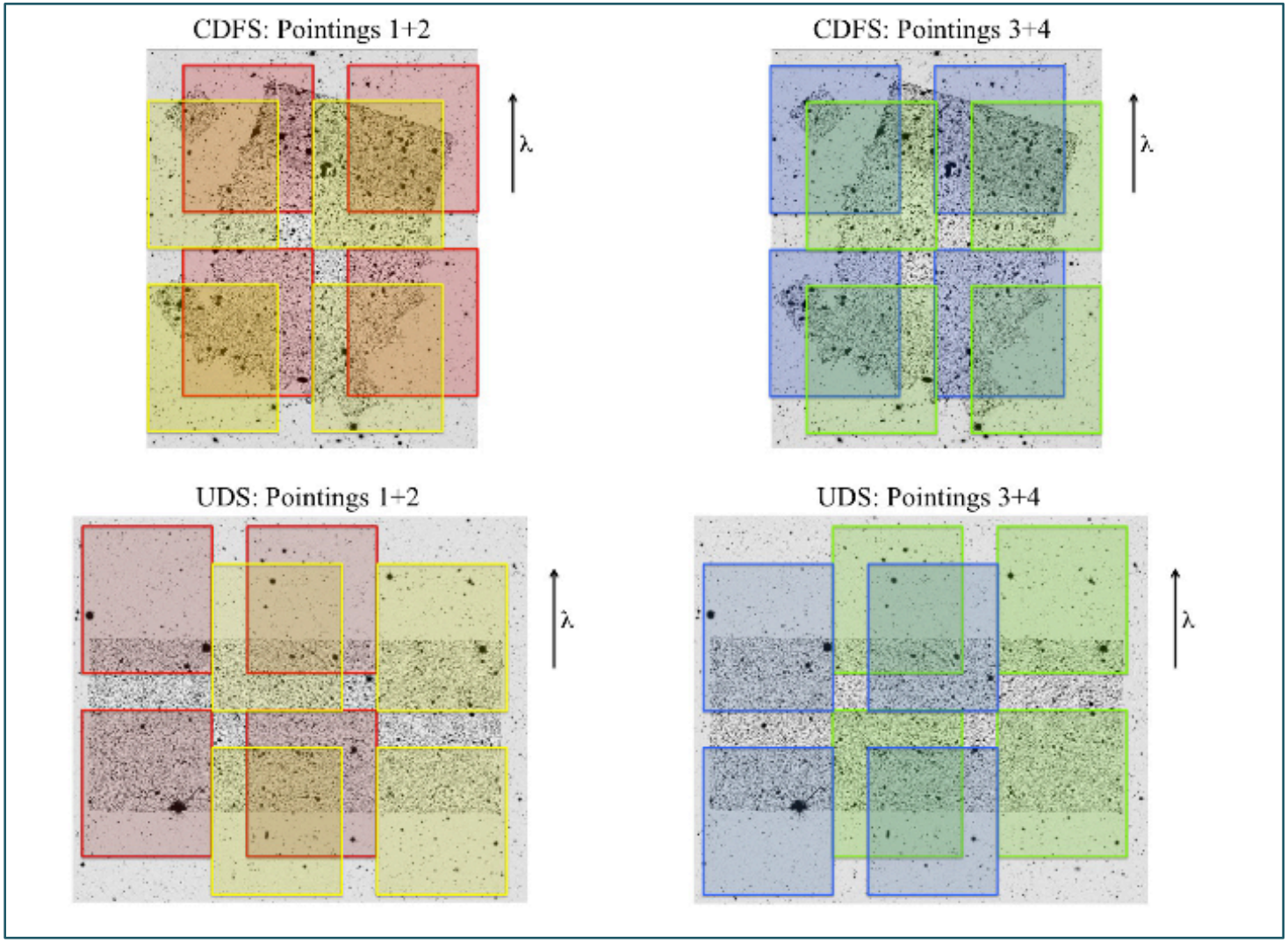


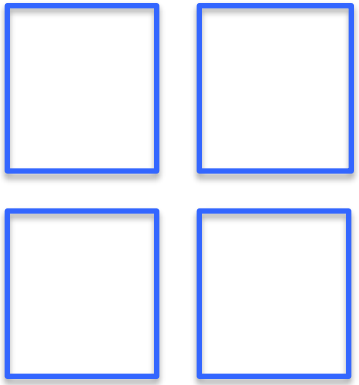


Additional science cases

- Quantify impact of nebular line emission at high redshift
- Unbiased measurement of Lyα emitter fraction into epoch of reionization
- Comparison with physical properties of AGN and Herschel sources

VANDELS: observations



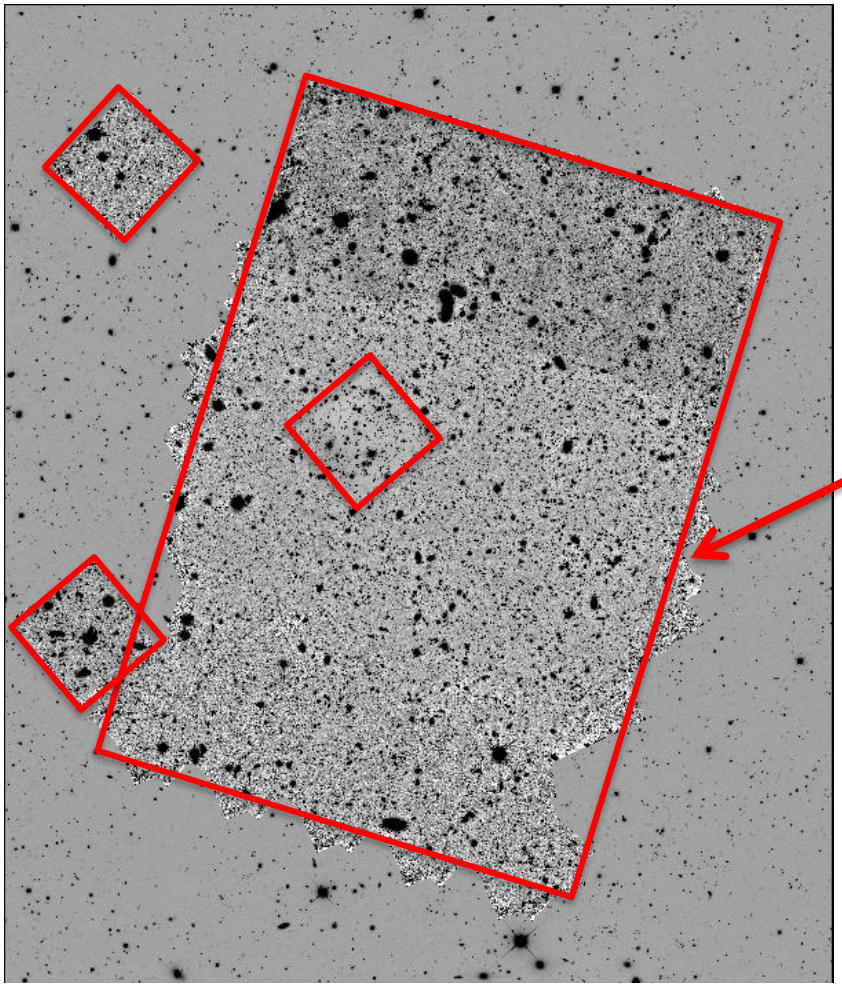


VIMOS FOOTPRINT

Each pointing targeted four times, for 20 hours each:
bright targets get 20 hours, faint targets get 80 hours

VANDELS: photo-z pre-selection

VANDELS exploits the multi-wavelength photometry in UDS and CDFS to do uniquely robust photometric redshift pre-selection….

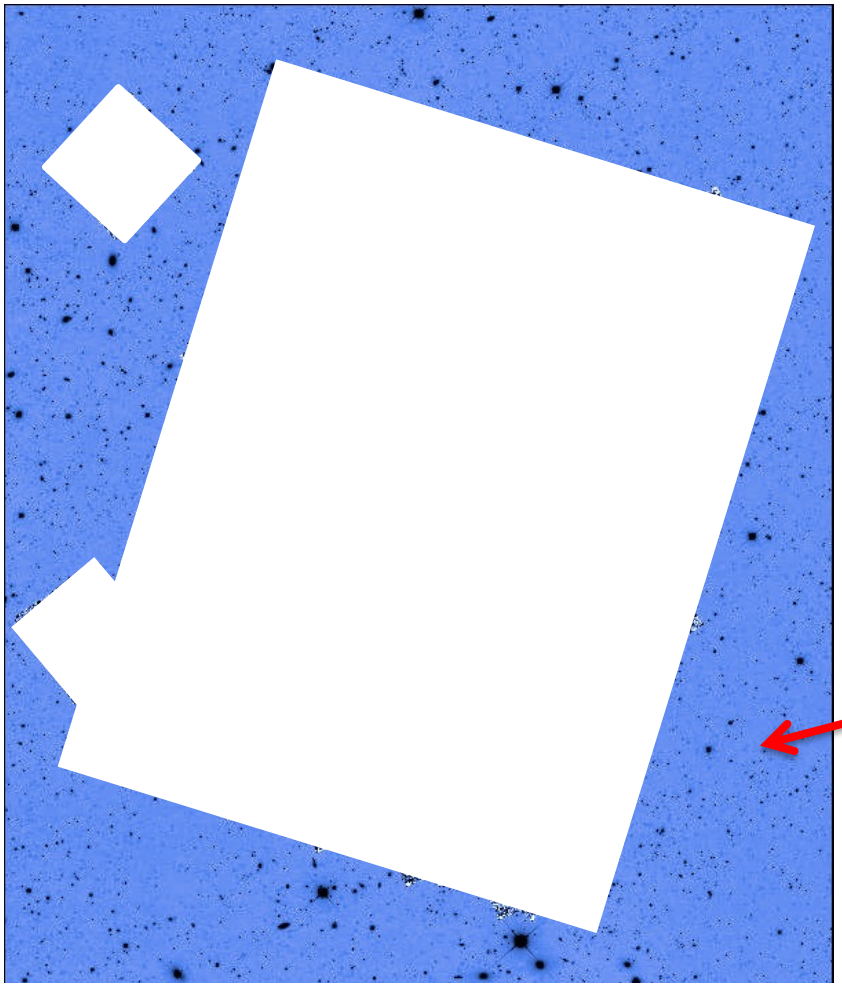


VANDELS CDFS FIELD

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

VANDELS: photo-z pre-selection

VANDELS exploits the multi-wavelength photometry in UDS and CDFS to do uniquely robust photometric redshift pre-selection….



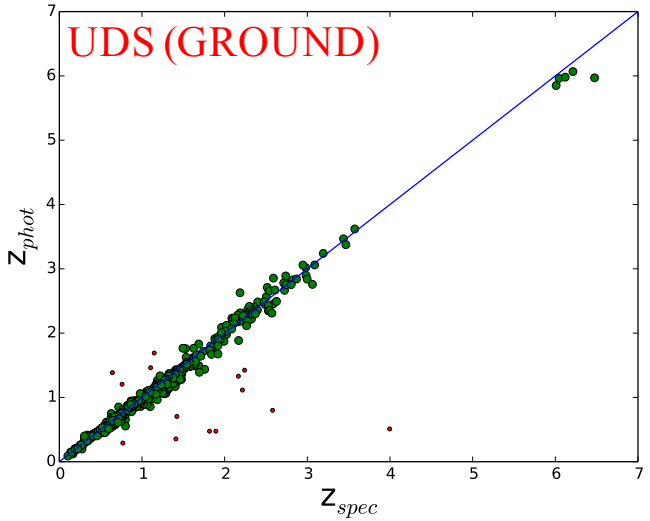
VANDELS CDFS FIELD

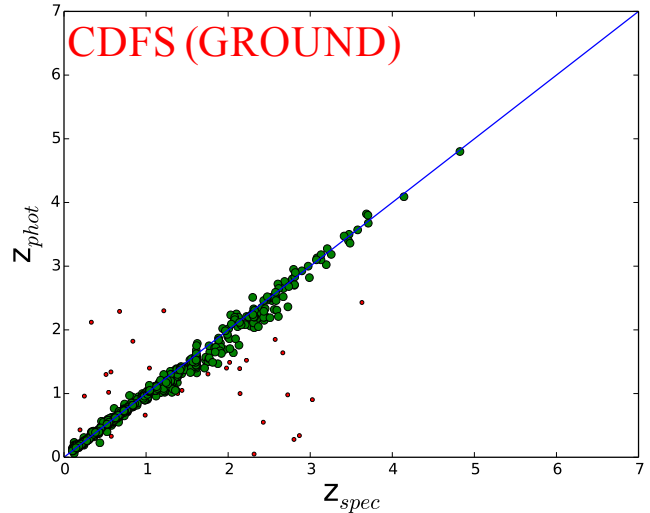
For extended CDFS region, Edinburgh VANDELS catalogue, utilizing a combination of 16-band photometry:

VIMOS U+R imaging
GEMS HST imaging in V_{606} and z_{850}
Subaru medium band imaging (7 bands)
J+K imaging from TENIS survey on CFHT
Y+H imaging from VISTA VIDEO survey
IRAC "supermap" of all CDFS Spitzer programmes

VANDELS: photo-z pre-selection

VANDELS exploits the multi-wavelength photometry in UDS and CDFS to do uniquely robust photometric redshift pre-selection….





HST regions:

Official CANDELS photo-z catalogues (Dahlen et al. 2013)

WIDE regions:

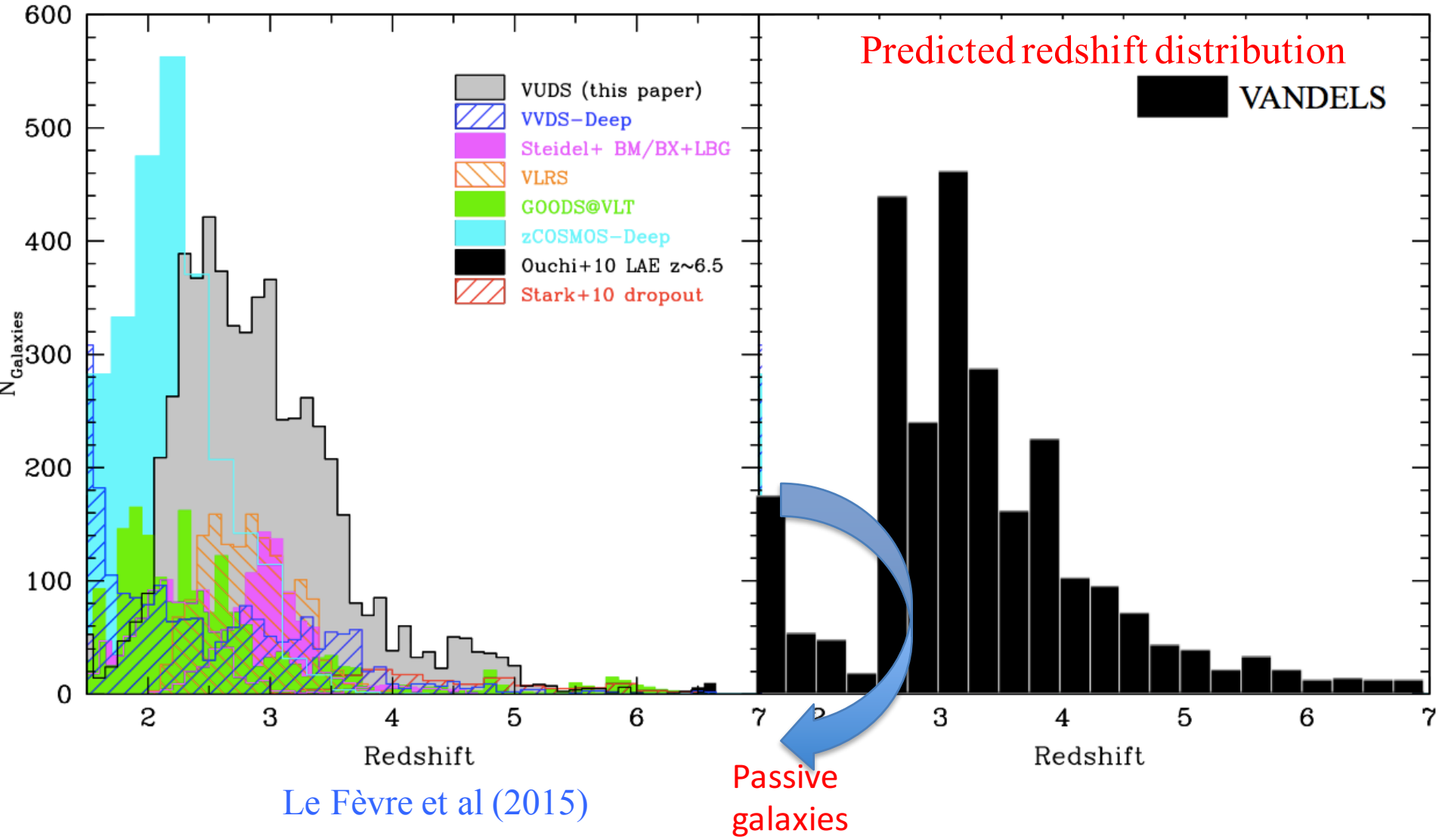
- Photo-z results based on new ground-based multi-wavelength photometry catalogues
- 14 independent photo-z runs (11 individuals)
- median photo-z results comparable with HST results

$\sigma_{MAD}=0.017$

outlier fraction < 2%

Realistic aim is for < 5% redshift interlopers

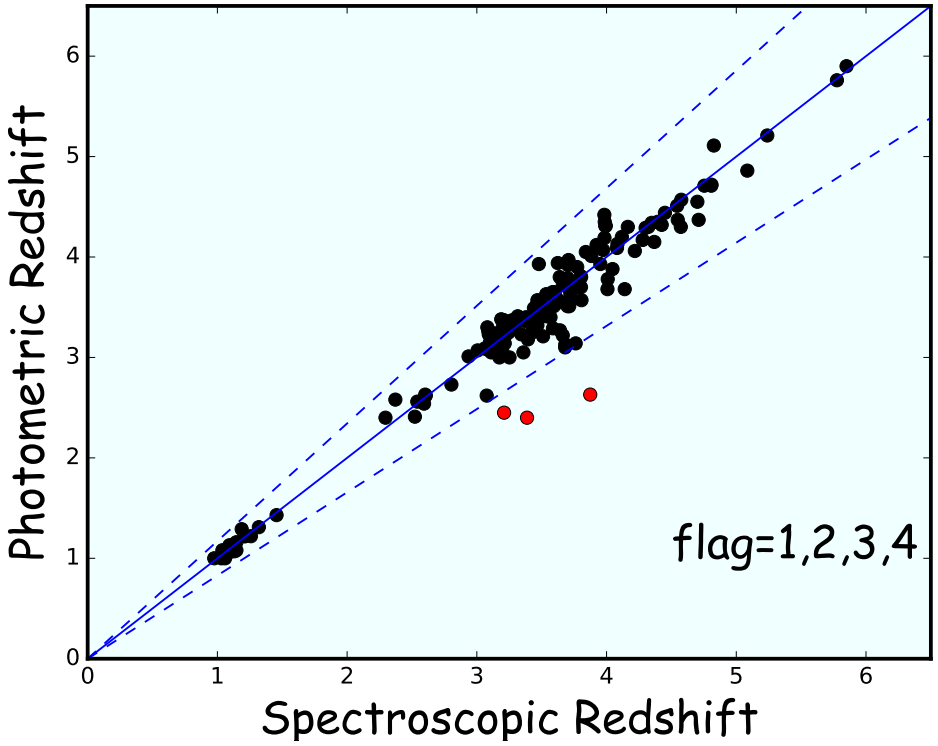
VANDELS: photo-z pre-selection



Le Fèvre et al (2015)

So, how well has selection worked?

Spectroscopic redshifts for ≈200 completed 20-hour targets from season one



flag 1 = I want to believe
flag 2 = definitely maybe
flag 3 = solid
flag 4 = bullet proof

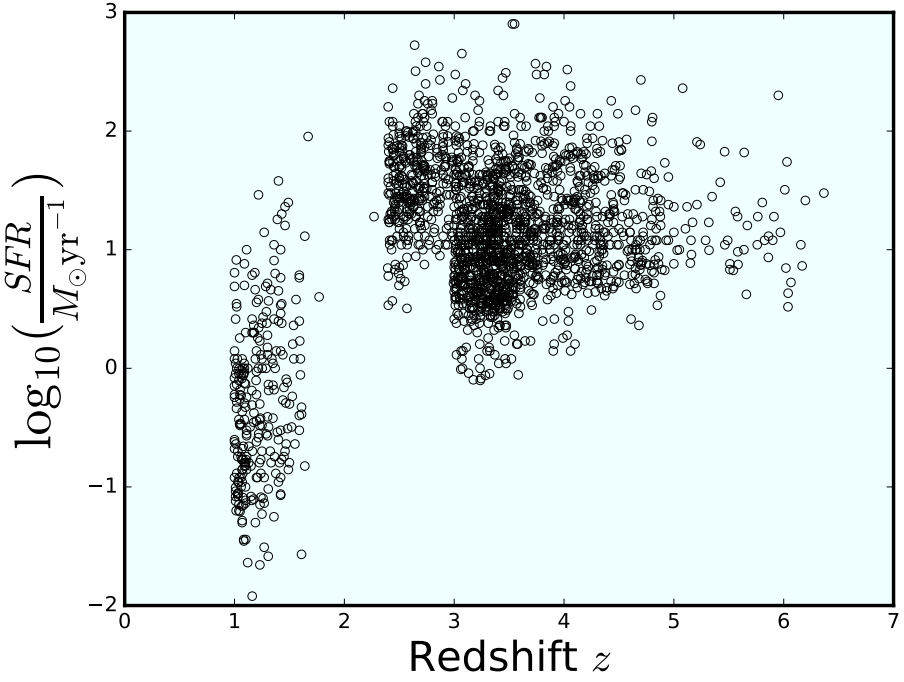
no outliers
$dz_{NMAD} = 0.025$

So far, so good:
object classification + z_{phot} accuracy of 20hr targets is acceptable

Remains to be seen what the 40+ hr targets look like…..

VANDELS: initial results

The full VANDELS sample consists of >2100 targets, designed to sample the star-forming population at 2.5<z<5.5 and their passive descendants at 1<z<2.



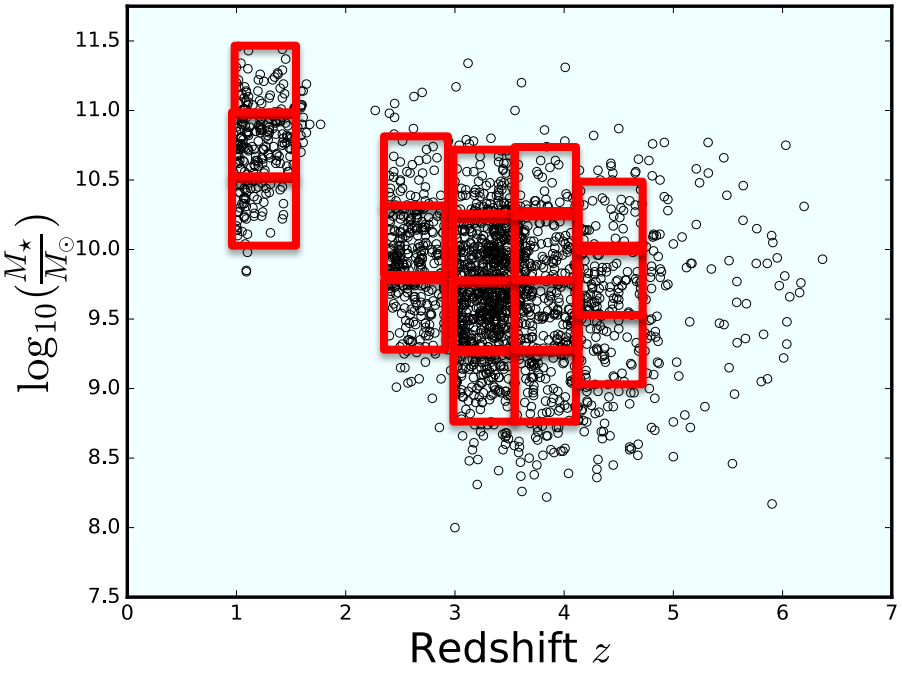
Final sample will span: 3 dex in stellar mass

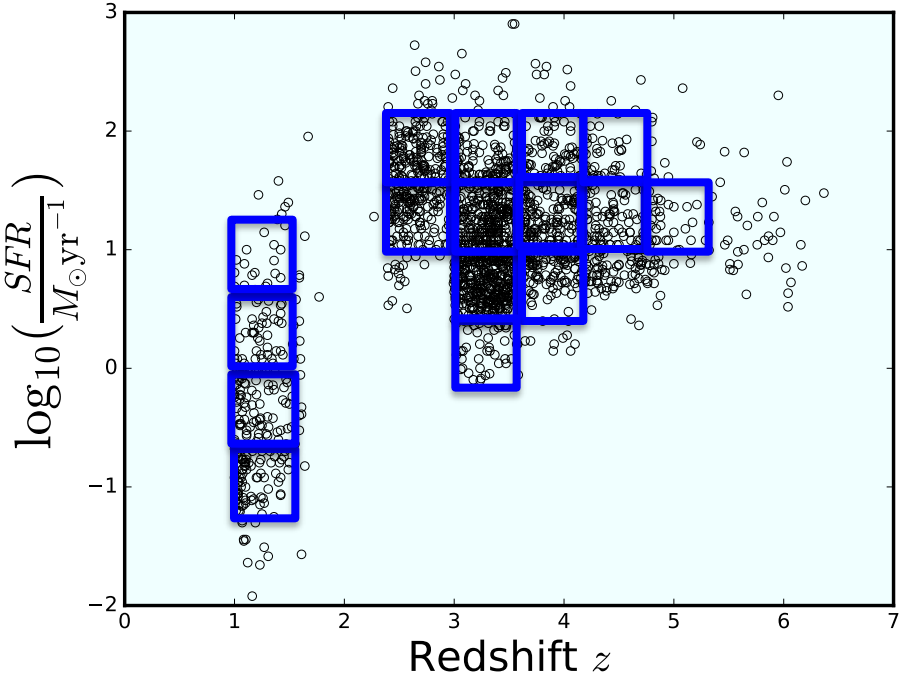
4 dex in star formation rate

Provide good sampling of SF "main sequence" at 2.5<z<5.5

VANDELS: initial results

The full VANDELS sample consists of >2100 targets, designed to sample the star-forming population at 2.5<z<5.5 and their passive descendants at 1<z<2.

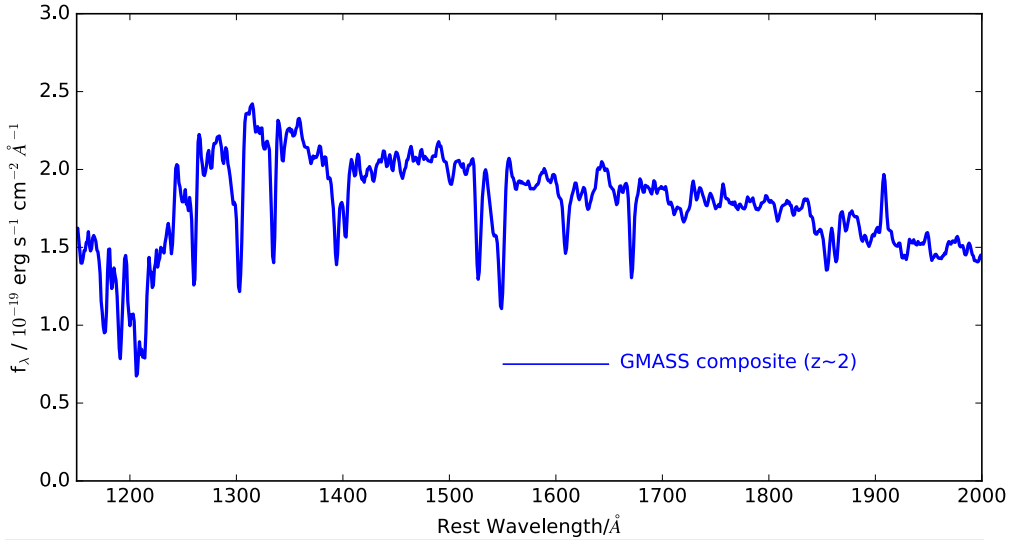




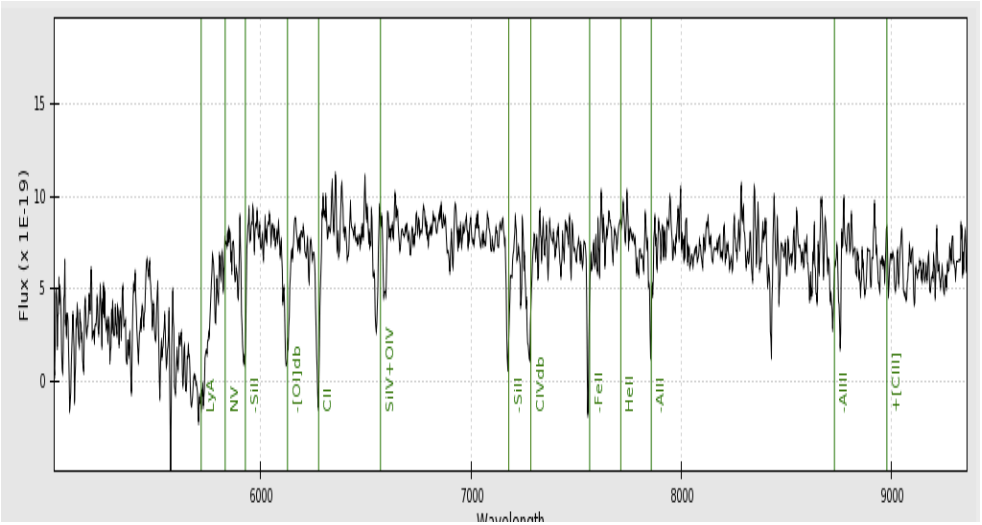
High SNR will allow detailed studies of individual targets, but clearly many opportunities to explore the properties of composite spectra as function of z, mass, metallicity, SFR….

VANDELS: initial results

Key science goal is to study the stellar metallicities of star-forming galaxies at 2.5<z<5.5, initial data of the season one look promising in this regard.



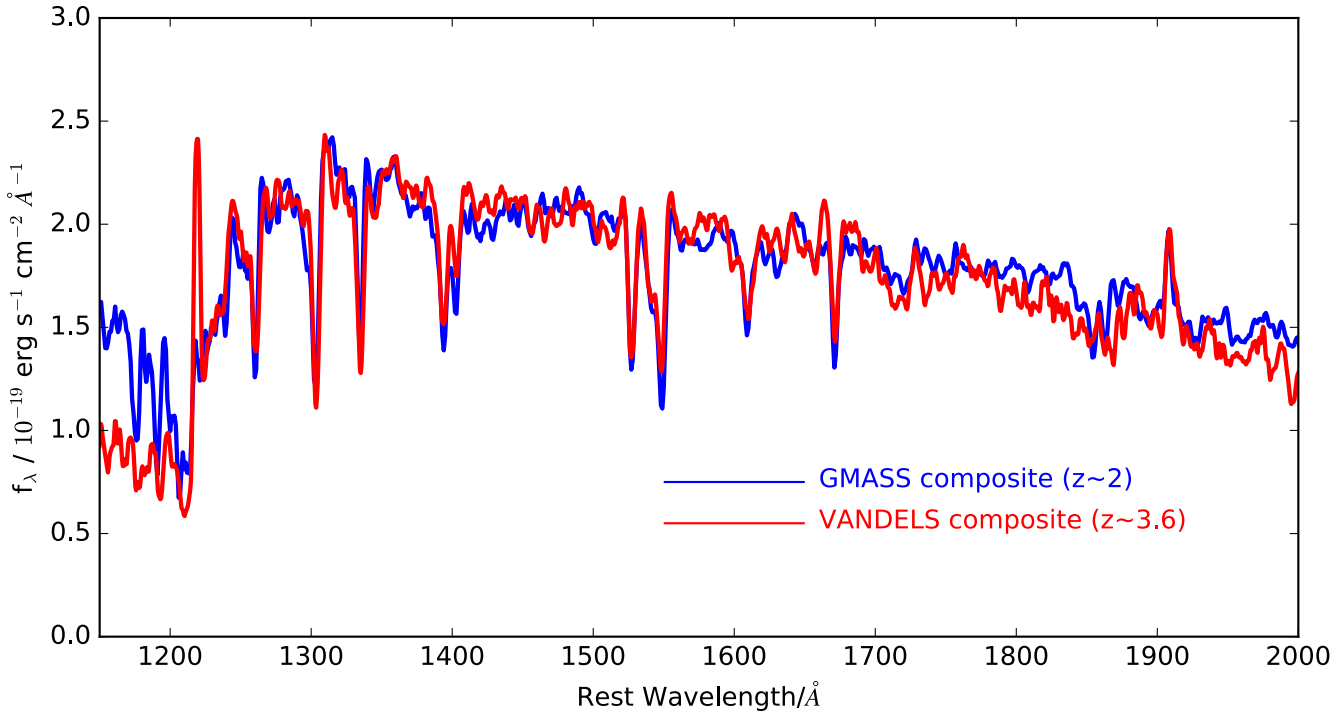
Stack of 75 star forming galaxies at z=2 from GMASS (Halliday et al. 2008)



Spectrum of a bright VANDELS source from season 1.

VANDELS: initial results

Key science goal is to study the stellar metallicities of star-forming galaxies at 2.5<z<5.5, initial data of the season one look promising in this regard.

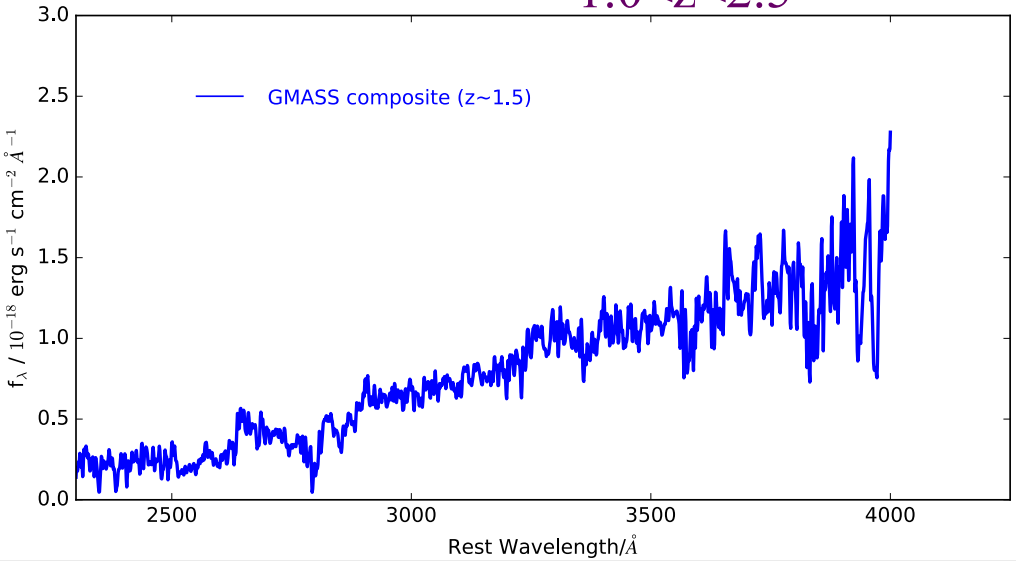


Median: z=3.6, M*~5x$10^9 M_\odot$, SFR~10 $M_\odot yr^{-1}$, sSFR~3 Gyr^{-1}

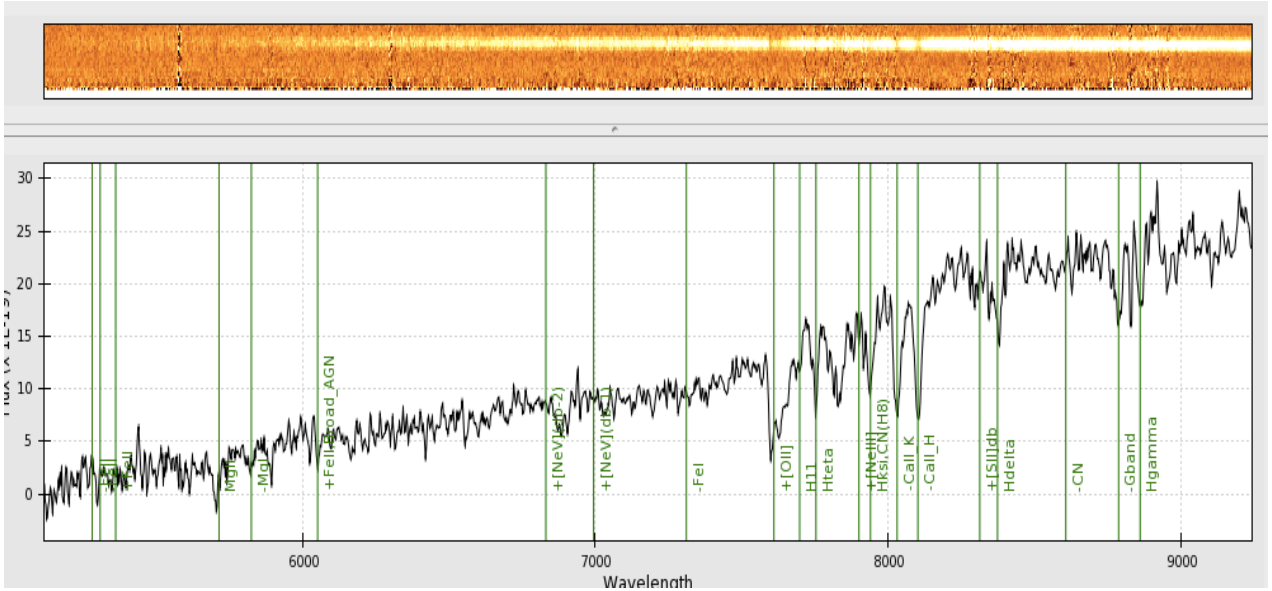
Rough stack of 50 LBGs in the redshift range 3.0<z<4.0. Final sample will contain ~1100 LBGs in this redshift range, allowing sub-division by redshift, mass, SFR…..

VANDELS: initial results

Key science goal is to study the stellar metallicities, ages, SFHs of passive galaxies at 1.0<z<2.5



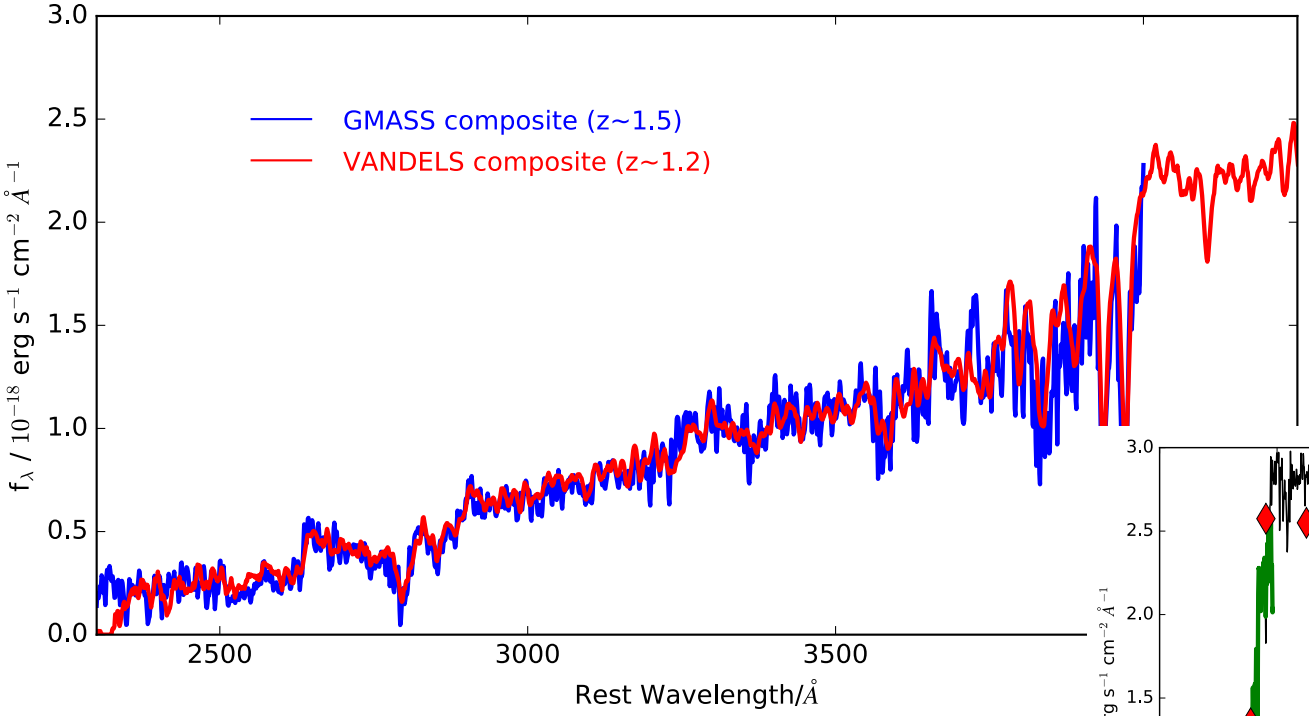
State of the arte: stack of 13 early type galaxies at z=1.5 from GMASS (Cimatti et al. 2008)



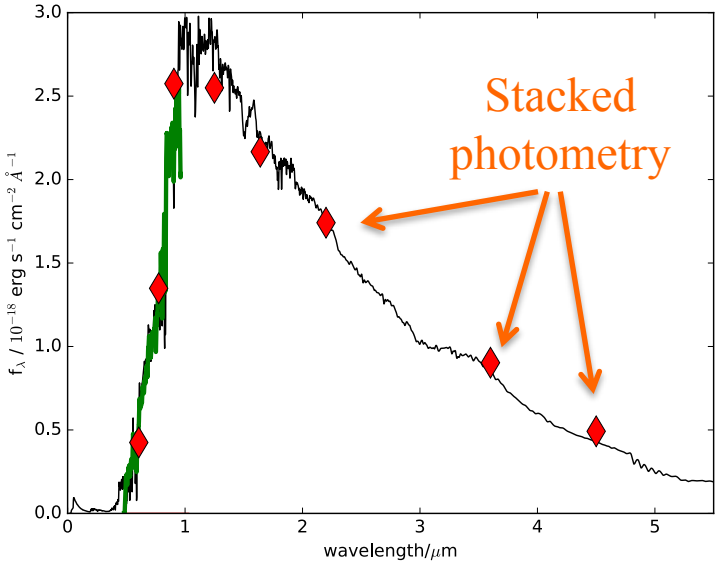
Spectrum of a bright passive galaxy from VANDELS season 1 oservations

VANDELS: initial results

Key science goal is to study the stellar metallicities, ages, SFHs of passive galaxies at 1.0<z<2.0. Again, initial stacks of the season one data look promising.



For slightly fainter objects we will derive stacks: this stack contains N=20 passive objects,



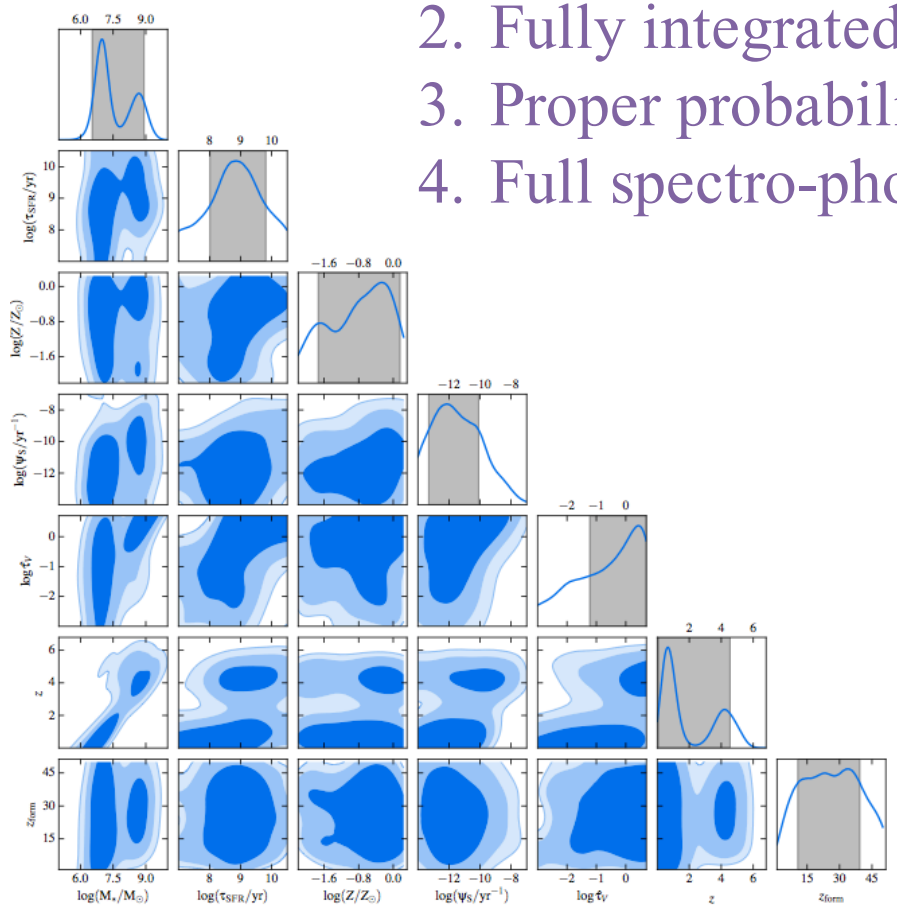
To fully exploit the data we clearly need to employ full spectro-photometric fitting:

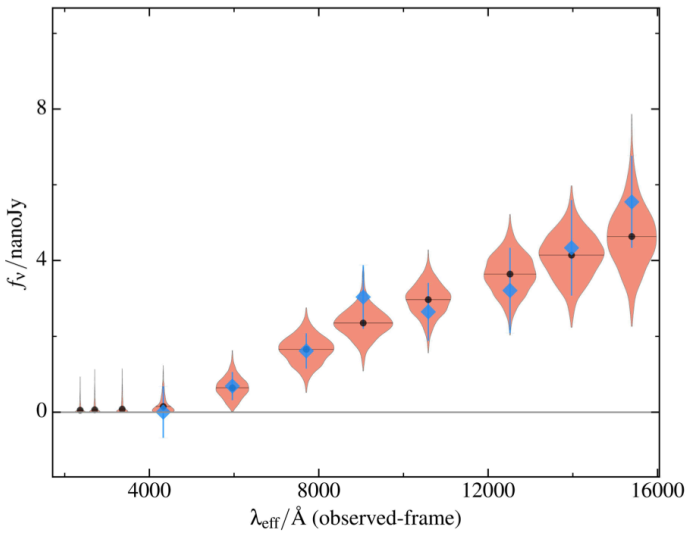
BEAGLE

(BayEsian Analysis of GaLaxy sEds)

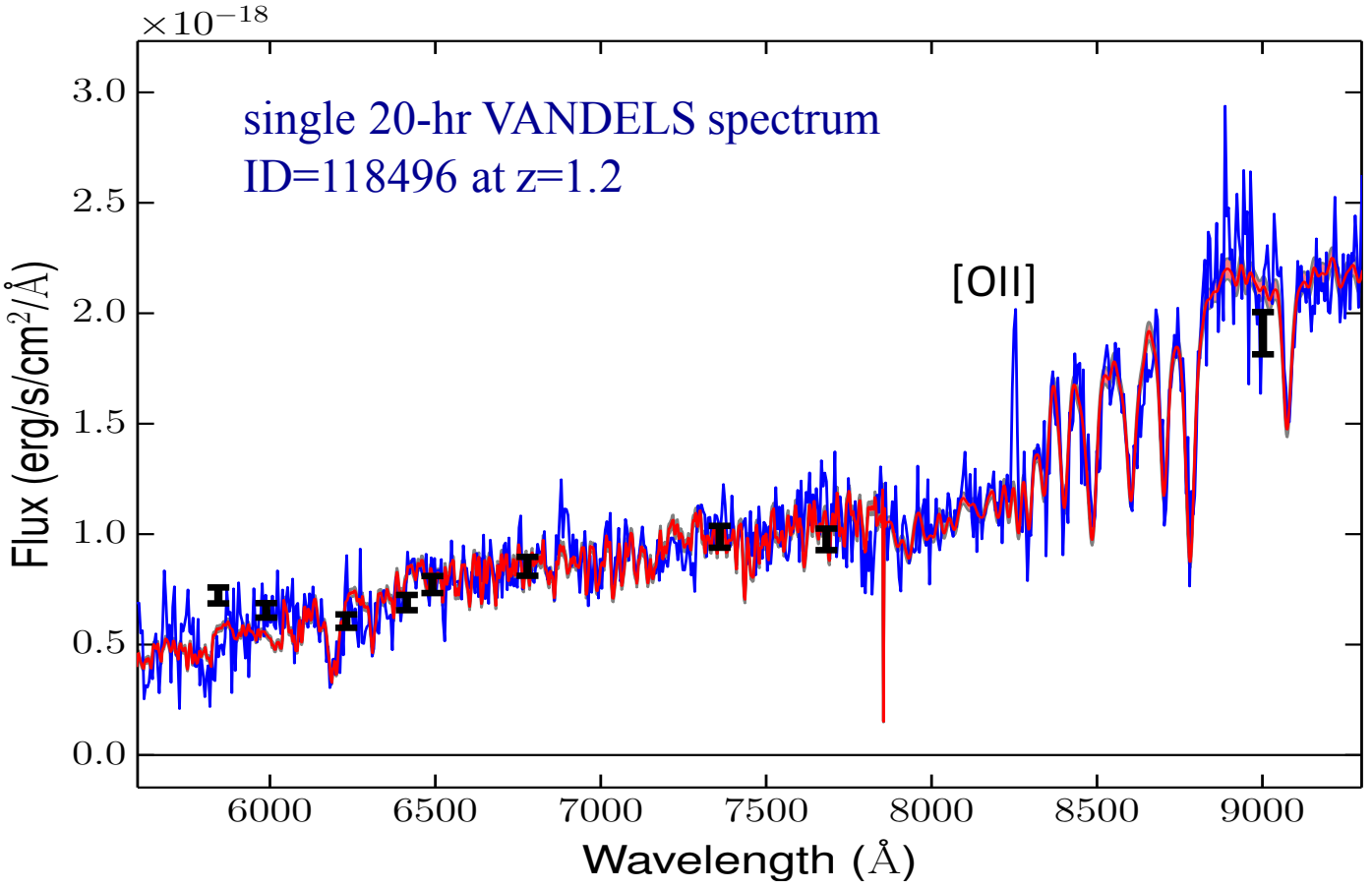
Chevallard & Charlot (2016)

1. CB15 stellar population models
2. Fully integrated with CLOUDY for nebular emission
3. Proper probability distributions for fitted parameters
4. Full spectro-photometric fitting



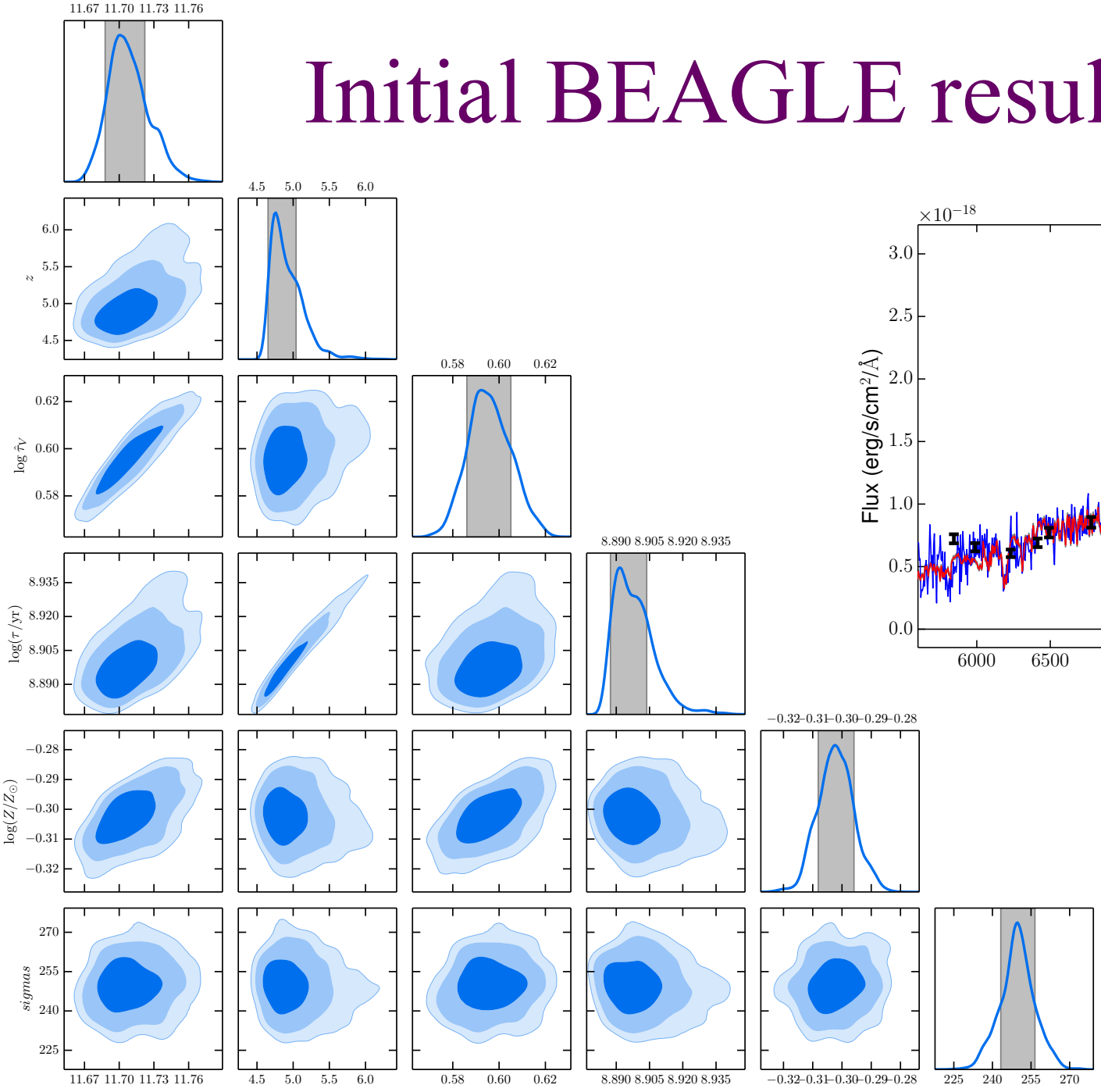


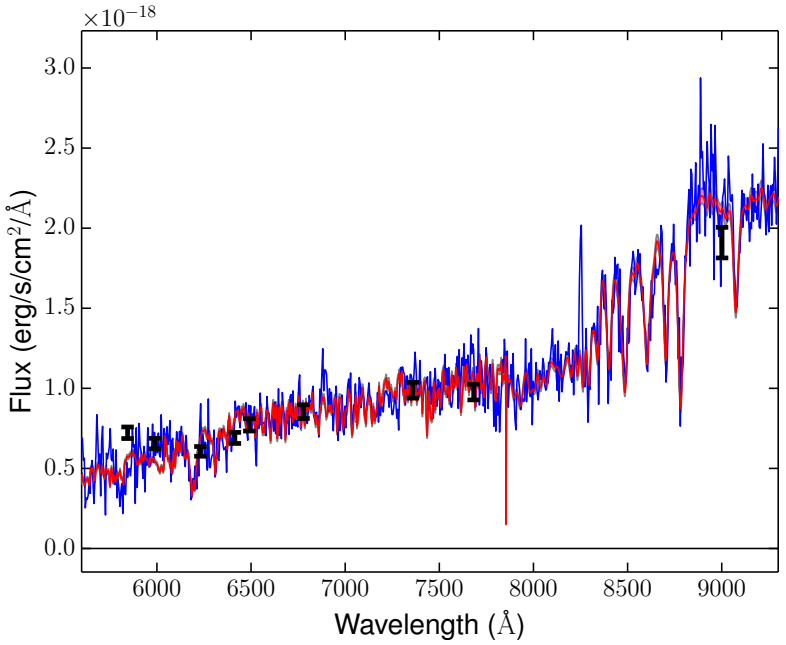
Initial BEAGLE results



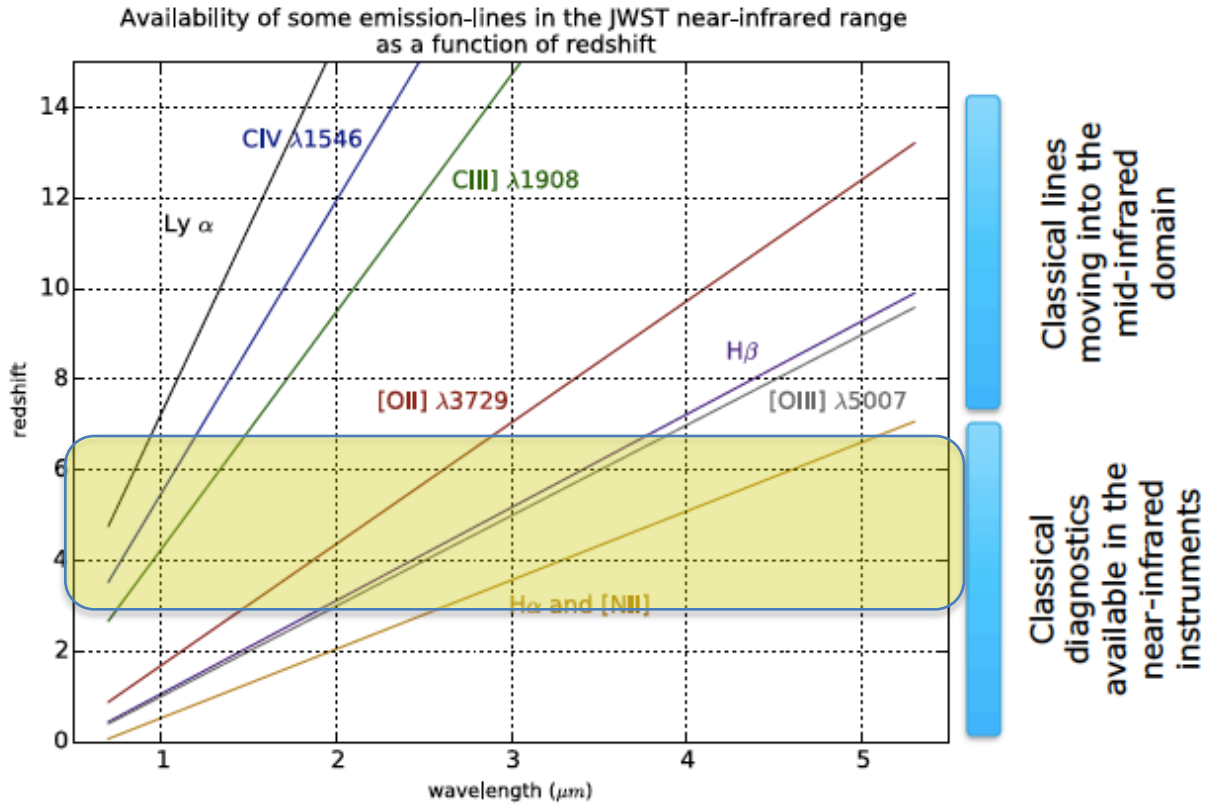
Adam Carnall, IfA Edinburgh

Initial BEAGLE results





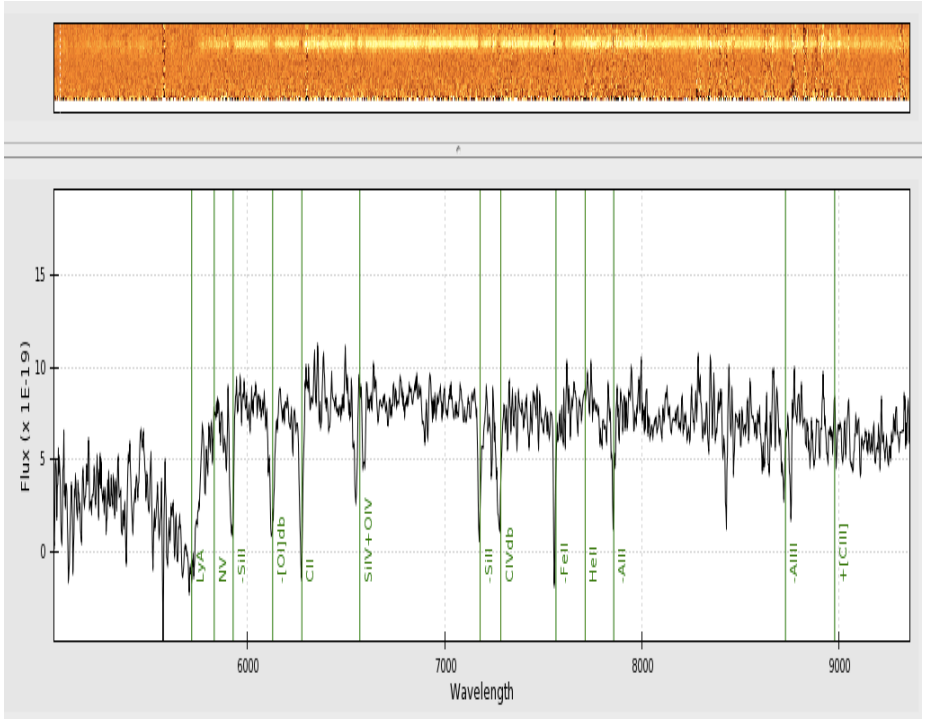
VANDELS targets will be ideal to follow up with JWST/NIRSPEC

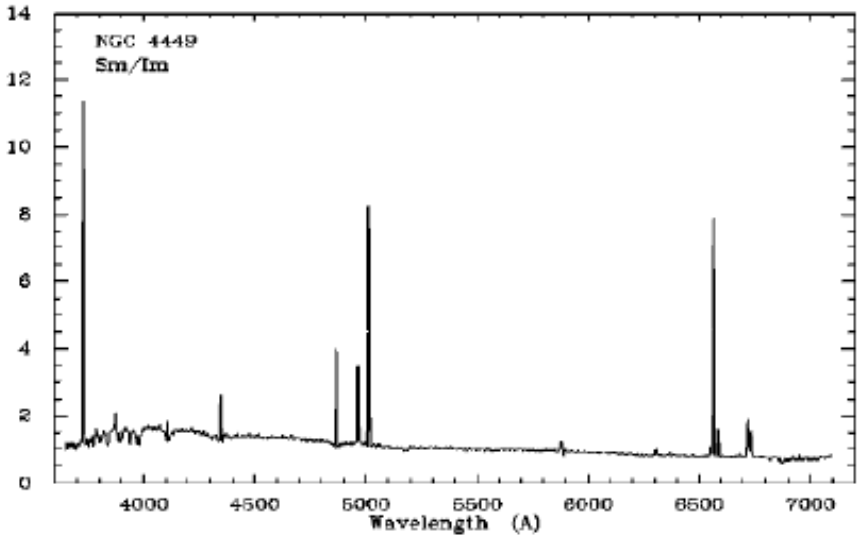


For all our star forming galaxies @ 2.5<z<6.5 NIRSPEC will cover the following emission lines: CIII] [OII] Hβ [OIII] Hα [NII]

What can we learn from the combination of ultradeep VANDELS spectra and NIRSPEC

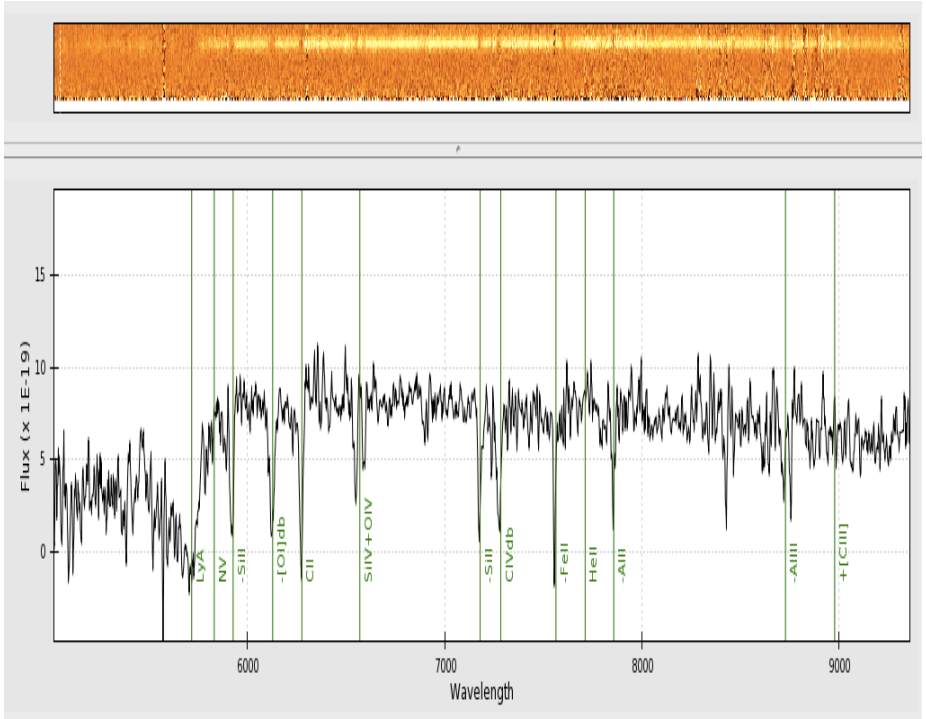
VANDELS:restframe UV NIRSPEC: restframe optical





What can we learn from the combination of ultradeep VANDELS spectra and NIRSPEC

VANDELS:restframe UV



Lyα properties

EW, FWHM, spatial extent

ISM kinematics/Outflows

$\Delta v_{Ly\alpha} \Delta v_{LIS}$ Absorption line profiles

Stellar metallicity

F1370 F1425 (Leitherer), F1460 F1501 (Sommariva) F1978 (Rix)

LyC Properties

LyC flux detectable at $4<z<4.5$

What can we learn from the combination of ultradeep VANDELS spectra and NIRSPEC

Star formation rates
(Balmer lines)

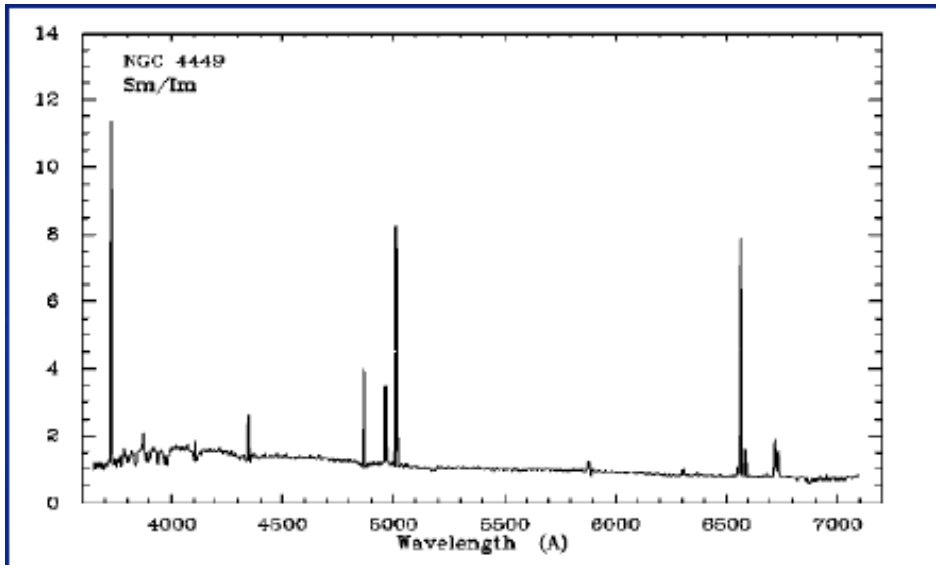
Dust extinction
(Hα/Hβ)

Gas metallicity
O3N2, R23 N2

Ionization parameter
[OIII]/[OII]

Electron temperature
OIII doublet ratio

NIRSPEC: restframe optical



What can we learn from the combination of ultradeep VANDELS spectra and NIRSPEC

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- Lyα escape frac
- Lyα escape vs dust/O32/
- Stellar vs gas metallicity
- Ouflows vs stellar mass
- LyContinuum escape vs O32

…..and much more!!!!

Lyα properties
EW, FWHM, spatial extent

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Summary

- Currently working on data from season one
- Photo-z pre-selection working very well
- SNR of data as predicted, integrating down as $t^{0.5}$
- Initial modelling of composite spectra looks promising
- ESO release of season one data is scheduled for June 2017
- VANDELS targets will be ideal candidates for NIRSPEC observations

- More details can be found at: vandels.inaf.it

VANDELS

A deep VIMOS survey of the CANDELS UDS and CDFS fields

New ESO public VIMOS spectroscopy survey of the UDS and CDFS fields

R. McLure & L. Pentericci