Next generation wide and deep Spectroscopic redshift surveys with the ESO-VLT

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- Why spectroscopic redshift surveys?
- Still major questions ahead
  - Galaxy formation and evolution: an unsolved puzzle
  - Cosmology: what is the content of the Universe?
- Needs
  - Survey large volumes to large lookback times
  - Assemble large samples
  - Understand and minimize selection biases
- Pushing ahead with new surveys
  - Ultra-Wide
  - Ultra-Deep
Deep redshift surveys are a central tool to modern Astrophysics

- Deep redshift surveys (z>0.3) have shaped our current understanding:
  - CFRS (1995)
  - LBG surveys (Steidel et al. 1996+)
  - DEEP/DEEP2 (2005+)
  - VVDS (2005+)

- Compare high redshift to low redshift spectroscopic surveys
- Knowledge of the sources: physical informations available
- Redshift information with ~100km/s accuracy enables to look for 3D distribution
- A basis for robust selection for detailed follow-ups
- Important serendipitous capabilities
Deep spectroscopic surveys at ESO

- 10 years ago: EFOSC, EMMI, OPTOPUS/MEFOS,
  - **ESP**, 3000z, z~0.3

- Now at the VLT, several surveys covering up to z~6
  - **VIMOS**: **VVDS** (50000z, up to z=5), **zCOSMOS** (25000z, up to z=3), **GOODS** (7000z), **UDF** (5000z)
  - **FORS2**: **GMASS**, **UDF**
  - **FLAMES/GIRAFFE, SINFONI**: follow-ups
VIMOS - VLT-UT3

A highly efficient high redshift machine in operations since 2002 on the VLT
VIMOS at the ESO VLT measures the distance of 1001 distant galaxies in one single observation 28/09/2002.

VIMOS at the VLT observes 150 galaxies at once at high spectral resolution (R~4000).

Low res.

High res.

1 spectrum of 1001

9500 Å

5500 Å

Hydrogen+Oxygen Hβ+[OIII] z=0.19

Oxygen [OII] doublet z=0.71
VIMOS VLT Deep Survey

<table>
<thead>
<tr>
<th>Field</th>
<th>I_{AB}&lt;22.5 WIDE 16+ deg^2</th>
<th>I_{AB}&lt;24 DEEP 1deg^2</th>
<th>I_{AB}&lt;24.75 Ultra-Deep 600 arcmin^2</th>
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</thead>
<tbody>
<tr>
<td>0226-04</td>
<td>~14000 (Public)</td>
<td>~1000 (on-going)</td>
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</tr>
<tr>
<td>1000+03</td>
<td>~5000</td>
<td>~5000</td>
<td></td>
</tr>
<tr>
<td>1400+05</td>
<td>~11000</td>
<td></td>
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</tr>
<tr>
<td>2217+00</td>
<td>~15000 (Public)</td>
<td>~1600 (Public)</td>
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</tr>
<tr>
<td>CDFS</td>
<td>~31000</td>
<td>~15500</td>
<td>~1000</td>
</tr>
<tr>
<td>Total</td>
<td>~31000</td>
<td>~15500</td>
<td>~1000</td>
</tr>
</tbody>
</table>

- R~230, 5500-9300Å
- ~50000 spectra

40+ papers published so far
VVDS-Wide
35000 redshifts

- Measuring the growth rate, using $\xi(rp,\pi)$ at $z=0.8$
- $\beta=0.7\pm0.24$
From 8 deg$^2$ (Guzzo et al., 2008, Nature)

VVDS-UltraDeep
1000 redshifts

- Magnitude selected $I_{AB}\leq24.75$
- 18h integration in blue + 18h in red
- Towards a complete census of star forming galaxies
  - No apriori
  - Serendipitous: 200 Ly$\alpha$ emitters

No pb to cross the ‘redshift desert’
Deep spectroscopic surveys: enable follow-ups

- Select galaxies from a large and unbiased sample before to study the physics of galaxy assembly

SINFONI obs. of VVDS galaxies $1<z<2$
Epinat et al., arXiv:0903.1216 (today)
Deep spectroscopic surveys: serendipitous power

- VVDS target
- Slits: 1”x5-20”
- Serendipitous Lyα @ 1216Å
- Target spectrum
- Photometrically invisible Lyα emitter

- 1200 slits, 3.3 arc min², 3500-9500Å, 65000s
- 8000 slits, 22.2 arc min², 5500-9500 AA, 16000s

200 LAEs identified 2<z<6.5 (Cassata et al., in prep.)
Next surveys at the VLT
three realistic LEGACY surveys

1. VIMOS Ultra-Wide
2. VIMOS Ultra-Deep
3. VIMOS Extremely Deep

Capitalize on:
- New CCDs on VIMOS: 2x the QE at 9500A (Urgent !)
- New sky subtraction techniques enable 2x smaller slits = 2x number of objects (Scoddegio et al., Messenger March 09)
VIMOS Ultra Wide Survey
SDSS-like at $z \sim 1$

- Cosmology: probe the world model
  - 5-7y before space IDEM (JDEM+EUCLID, launch 2017 ?)
- BAO, growth rate, clusters
- $I_{AB} = 22.5$, 1000 gal/0.06 deg$^2$ in 30 min
- 300 deg$^2$ in 3000h (w/ overheads)
  - $5 \times 10^6$ galaxies
  - Scales $> 500$Mpc
- Need 300 nights = 5 years project @ 60n/y
A critical time in the galaxy assembly process

- Contribution of mergers, accretion, feedback,...

Current samples are <1000

Smart pre-select

- No color-color apriori
- Limited use of photoz

AB~25, 15h blue + 15h red

- 1000 galaxies / 0.06 deg² in 30h

100,000 galaxies, ~6deg² in 4000h (w/ overheads): need 400n

Targets for follow-up: KMOS, JWST

Photo-z are becoming reliable (but be aware of caveats)
VVDS+WIRDS, 2009, in prep.
VLT extremely-deep field (⇔ z~10)

- First bursts of star formation
- Requirements:
  - H~26, select from UltraVista survey
  - ~1000 objects
- Combine VLT facilities
  - VIMOS
  - KMOS
- 100h integrations per setup
  - VIMOS 100h blue + 100h red for 1000 galaxies
  - KMOS do galaxies not identified by VIMOS (z>6.7): 100h for 24 galaxies: 2000h
- Prepare for JWST surveys
Summary
Next generation surveys with the VLT

- High science impact: dedicate VLT-VIMOS for very large redshift surveys
  - z~1, IAB~22.5
  - z~3-6, AB~25
  - z>6 , AB~26
- Dedicate follow-up
  - KMOS
- Legacy, public
- Long term
  - New instrument on 8m very wide field MOS with 10000 slits/fibers: complementary to a space facility and to 8m wide field imaging telescopes (LSST): new dedicated telescope or on existing UT?
  - z+J band multi-slit spectrograph on the VLT
  - EELT wide field MOS

<table>
<thead>
<tr>
<th>VLT Survey</th>
<th>Area / #z</th>
<th>Nights</th>
</tr>
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<tbody>
<tr>
<td>UltraWide</td>
<td>~300 deg² / 5x10^6 z</td>
<td>~300</td>
</tr>
<tr>
<td>UltraDeep</td>
<td>~10 deg² / 10^5 z</td>
<td>~400</td>
</tr>
<tr>
<td>ExtremelyDeep</td>
<td>~0.1 deg² / 10^3 z</td>
<td>~300</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>~1000</td>
</tr>
<tr>
<td></td>
<td>~5 years of VLT UT3</td>
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