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The VIMOS-VLT deep survey

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The VIMOS-VLT Deep Survey
Olivier Le Fèvre, LAM, Marseille

Evolution of galaxies, LSS, AGNs from 
z~5 to present

Instrumentation: VLT-VIMOS

Spectroscopy Survey: first results

What’s next?
VVDS survey team

French-Italian team:

- Laboratoire d’Astrophysique (Marseille): Adami, Ilbert, Le Brun, Le Fèvre, Marinoni, Mazure, Meneux, Tresse
- IAP (Paris): Bertin, Charlot (MPA), Colombi, McCracken, Mellier
- OABr (Milan): Guzzo, Iovino, Pollo, Chincarini, Rizzo
- OAC (Naples): Arnaboldi, Busarello, Merluzzi, Radovich, Ripepi
- OMP (Toulouse): Contini, Mathez, Pello, Picat
VVDS: VIMOS-VLT Deep redshift Survey

- Trace galaxies and AGNs evolution across long time base
- What are the timescales associated to physical phenomena at work?
- Quantify
  - LF, SFR evolution
  - $\xi(r)$ evolution
  - Merging rate evolution
  - AGN contribution to evolution
  - link between galaxy evolution & LSS
- Measure evolution in a consistent way
  - Inside a single survey, large z baseline
  - Well defined selection function
- Compare to model predictions
  - Constraints on cosmological parameters

O. Le Fèvre
Zurich - Aug. 2003

Evolution of the luminosity density / star formation rate

VIRMOS cone simulation
(S. Colombi et al.)
VVDS strategy

- **5 fields**, 2x2 deg$^2$ each, $\sim$100Mpc @ $z$$\sim$1
  - 0226-04, 1003+02, 1400+00, 2217+00, CDFS
- Purely magnitude selected sample
- Combined visible light / weak lensing studies
- Multi-wavelength analysis: VLA, XMM, Chandra, GALEX, SIRTF, HST
- **150000 redshifts** $0<z<5+$
VVDS strategy

Imaging Survey: 5 fields 2x2deg²

Build VLT-VIMOS

guaranteed VLT nights

Redshift Survey

Imaging Catalog
UBVRIK
3 millions objects

VIRMOS Wide z<1.3
100000 z - I<22.5 AB
+B&K selected

VIRMOS Deep z<5+
50000 z - I<24 AB
+B&K selected

VIRMOS Ultra-deep
a few 1000 z - I<25 AB

Coordination w/ other surveys (XMM-VLA-HST)

HST-COSMOS-ACS: 640 orbits
VIRMOS-CFH12K deep imaging survey

- 16 deg² in 4 fields 2×2 deg²
  - ~100 h⁻¹ Mpc at z~1
- I_AB~25.3, B_AB~28 (3σ, φ3 arcsec)
  - Depth: no bias propagated to spectroscopic survey
- Instruments
  - CFHT12K (30x40 arcmin²): BVRI
  - ESO-MPI 2.2m WFI: U
  - ESO-NTT: (J) K’
- Data processing 5 Tb processed:
  - Terapix (IAP, Mellier)

multi-color catalog: ~3x10⁶ objets

See astro-ph/: Le Fèvre et al., McCracken et al.

Used for the VIRMOS-DESCART Lensing survey (Mellier et al.)
VIMOS on VLT-UT3

- Multi-Slit Imaging-Spectrograph
  - 0.37-1 microns
- Designed for large surveys
- Wide Field: 4x7x8 arcmin^2
- Spectral R~200-5000
- High Multiplex: >800 Slits
- Wide Field IFU: 54x54 arcsec^2 (6400 lenses-fibers)
VIMOS at the ESO VLT measures the distance of 1001 distant galaxies in one single observation 28/09/2002.

Multi-Slit mode

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

Low res.:
- 50x FORS1
- 20x FORS2
- 6x Keck-DEIMOS

High res.:
- Keck-DEIMOS
### VVDS current observations status

Total number of spectra acquired in **18 nights, fall 2002** (clear, out of 29 allocated)

<table>
<thead>
<tr>
<th>Field</th>
<th>$I_{AB}&lt;22.5$</th>
<th>$I_{AB}&lt;24$</th>
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<td>9188</td>
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<td>1000+03</td>
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<td>CDFS</td>
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<tr>
<td>Total end 2002</td>
<td>9444</td>
<td>11297</td>
</tr>
</tbody>
</table>
$N(z), I_{AB} \leq 22.5$

![Graph showing redshift distribution with semi-analytic (Galics) and PLE models, mean redshift $<z> = 0.62$, median redshift $z_{med} = 0.59$.](image)
N(z), $I_{AB} \leq 24$

- Preliminary
  - Reduce and understand incompleteness, $1.5 < z < 3$

- 20% galaxies with $z > 1$ ($\sim 3000$ expected $z < 3$ from existing observations)

- DEEP2 vs. VVDS selection
Incompleteness, \( I_{AB} \leq 24 \)

- **Tricky domain**: \( 1.5 < z < 3 \)
- **Include good UV galaxy templates in z measuring machine**
  - Use VVDS sample to build templates, self-trained

**Photometric redshifts from (U)BVRI(zK)**

- **Deeper than spectroscopic redshifts**
- **Use spectroscopic sample to validate**
- **Use photometric redshifts to quantify incompleteness**

\[
\text{Phot-z from BVRI, } I_{AB} \leq 24
\]
Luminosity function to z=1.5

VVDS-0226-0430

Flags = 1,2,3,4,8,9 and $\Omega_m = 0.30$, $\Omega_A = 0.70$

Preliminary!

2595 galaxies from IAB$\leq$24 sample

$>1$ magnitude evolution at z$\sim$1

Ilbert, Zucca et al., in prep.
Luminosity density

$\text{VVDS-0226-0430}$

Flags = 1,2,3,4,8,9 and $\Omega_m=0.3$, $\Omega_A=0.7$, $h=0.7$

- Directly observed (SWML)
- Estimated (STY parameters)

Wait for incompleteness analysis

$5x$

Tresse et al., in prep.
N(z), I_{AB} \leq 24, 0226-04 & CDFS
Distribution of galaxies

0226-04

CDFS
Correlation function

VIRMOS F02
$z = [0.1-0.8]$

VIRMOS F02
$z = [0.8-1.6]$

Low $r_0 \sim 2-2.5\text{Mpc}$ over redshift range
*but not the same population at low and high z*

Guzzo, Meneux, Pollo, in prep.
Other VVDS products

- Deep QSO survey: Probing ~3 magnitudes deeper in LF than 2DFQZ or SDSS
- Cluster survey
- R~3000 spectra of 10000 galaxy sample with clean selection
- K-limited and EROs surveys
- Lyman-break galaxies at z~3-4
- Galaxy-galaxy lensing survey

Marinoni et al., in prep
What’s next?

- **Spectroscopic survey**
  - only 10 GTO nights scheduled on VLT in 2003 (ESO strategy ???)
  - Emphasis on 02hr and 10hr fields
- **Multi-wavelength datasets**
  - Combine redshift survey with radio (VLA), far-IR (SIRTF-SWIRE), near-IR, visible (CFHTLS), UV (Galex), X-rays (XMM-LSS)
- **High resolution imaging: HST-COSMOS Legacy**
HST-COSMOS

PI: N. Scoville (Caltech)

- **Image 2deg² of VVDS 1003+02 field**
  - I band first, possibly g band next period
- **Legacy program**
  - Will be immediately public
- **640 HST orbits with ACS**
- **Depth $I_{AB}=27 \ (10\sigma)$**
- **50x50Mpc² @ z=0.5, 170x170Mpc² @z=3**
- >3000 HDFN !
- **70000 redshifts with VLT-VIMOS**

Link galaxy evolution to LSS evolution
Summary

• VVDS: major on-going deep survey of $>10^5$ galaxies
  – 21000 spectra so far
  – $N(z)$
  – strong LF, LD evolution from $z \sim 1.5$

• Detailed census of galaxy population up to $z \sim 5$

• Link between LSS and galaxy evolution

• Large reference database for population studies

Mapping the luminous high redshift universe on large scales
Measuring redshifts

- **Automated pipeline for 1D spectra extraction & calibration** (VIPGI, Scodeggio, Garilli, et al.)
  - 5 (wide) 10 (deep) exposures stack per pointing
  - One pointing of ~600 spectra processed in minutes

- **Measuring redshifts:**
  - large redshift range $0 < z < 5$: difficult to train automated software
  - First blind pass with correlation / PCA tool (KBRED, Scaramella et al.)
  - Visual check of all spectra
  - 2/3 spectra treated “automatically”
  - 1/3 needs manual intervention
VIPGI

2D sky corrected, combined spectrum

1D, calibrated spectrum

Slit profile

λ calibration
KBRED: cross correlation + PCA

Correl peaks

PCA reconstruction

Best redshift guess
Observed galaxies: CDFS

2447 observed objects in CDFS
Completeness

current is ~85%
known deficiency in 1.5<z<3: lack of templates in 1500<λ<2500Å, now fixed
What do we expect?

VIRMOS cone simulation (S. Colombi et al.)
What’s next: HST-COSMOS