STAR FORMATION HISTORY OF EARLY-TYPE GALAXIES

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VIPERS - VIMOS Public Extragalactic Redshift Survey

General goal:

large-scale structure and cosmological parameters at an epoch when the Universe was about half its current age

- measure redshifts for $\sim 10^5$ galaxies at $0.5 < z < 1.2$
- measure galaxy clustering, the growth of structure and galaxy properties etc.
VIPERS Project

VIMOS Multi-Object Spectroscopy at ESO-VLT

VIMOS MOS mode: first faint galaxy spectra, 2 March 2002
Quadrant 1: 93 spectra
Quadrant 3: 134 spectra

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How to achieve the goal?

- 440.5 VLT hours
- $\sim 24 \text{ deg}^2$ over CFHTLS wide fields:
  - W1 $\sim 16 \text{ deg}^2$
  - W4 $\sim 8 \text{ deg}^2$
- $z > 0.5$ color-color pre-selection
### Project status

**SURVEY STATUS AS OF 23/03/2015**

<table>
<thead>
<tr>
<th>Effective Targets</th>
<th>Measured Redshifts</th>
<th>Stellar Contamination</th>
<th>Covered Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>93192</td>
<td>88703</td>
<td>2264 (2.6%)</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
My project:

Star formation history of early-type galaxies
Star formation history of early-type galaxies

Early-type galaxies:

- The best standard cosmic chronometers if we want to move beyond the local Universe
- Evolves smoothly on a timescale much longer than their age difference
- Typically massive galaxies - they formed most of their stellar masses very rapidly at high redshifts
Scientific motivations

- To constrain star formation rate (SFR) for different stellar mass bins based on the two stellar absorption line indices: D4000 and $H\delta_A$
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Kaufmann et al., 2003 used these indicators on SDSS data for the local Universe

Fraction of more recent burst is higher for low-mass galaxies than for high-mass galaxies.
Data

- galaxies from W1 & W4 fields V5.0 (85% of the final probe)
- rest-frame spectra
- zflags 3, 4 (above 99% of the confidence in redshift)
- the result of SED fitting\(^1\) (VIPERS V5.0 release): stellar mass, U, V absolute magnitudes
- PCA (Principal Component Analysis) spectra reconstruction

\(^1\)According to Davidzon et al., 2014
First analysis - schedule

- separation of early-type galaxies,
- parametrization of stacking procedure and validation of data,
- calculation of $H\delta_A$ as a function of $D(4000)$.
Selection of early-type galaxies (A. Fritz)

- Classical approach – a fixed cut in rest-frame $(U - V)$ colours:
  \[(U - V) > 1\]  \( (1) \)

- Bimodal (U-V) color distribution - an evolving cut in $(U - V)$ colours:
  \[(U - V) = 1.1 - 0.25 \times z\]  \( (2) \)

- NUVr classification – a rest-frame $(NUV - r) - (r-K)$ colour selection:
  \[NUV - r' = 1.25 \times (r' - K) - 0.9^2\]  \( (3) \)

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A. Fritz, et al., The VIMOS Public Extragalactic Redshift Survey (VIPERS): A quiescent formation of massive red-sequence galaxies over the past 9 Gyr.
Color-bimodality selection of early-type galaxies (ETGs)

- 8 367 of ETGs with zflag 3, and 4
- 7 733 with additional cut for \(O_{II}\) emission line
- 4 539 after removing spectra with reconstructed gaps in the part of D(4000) and/or H\(\delta_A\)
Stacking procedure

Stacking calibration:
- average combination,
- median scaling,
- preserved equivalent width (EW).
Stacking procedure

Narrow redshift and stellar mass bins:

- 7 redshifts bins:
  \( \Delta z = 0.1 \) from 0.4 to 1.0, and then from 1.0 up to 1.4,

- 8 \( \log(M_{\text{star}}) \) bins:
  \( \Delta \log(M_{\text{star}}) = 0.25 \) dex,
  except \( \log(M_{\text{star}}) < 10.0 \), and \( \log(M_{\text{star}}) > 11.25 \).
Minimal number of spectra

<table>
<thead>
<tr>
<th>mean EW [Å]</th>
<th>σ</th>
<th>min. number</th>
<th>2σ-limit</th>
<th>3σ-limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.381</td>
<td>0.163</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

mean EW [Å]: 1.381
σ: 0.163
min. number: 20
2σ-limit: 20
3σ-limit: 20

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Final sample

- 2- and 3σ-limit (min. 20 spectra) eliminates 5 bins (blue)
- rejecting reconstructed spectra in the part of D(4000) and/or Hδ_A eliminates 3 additional bins
Summary

- **Redshifts and stellar masses bins:**
  - 7 redshifts bins ($\Delta z = 0.1$),
  - 8 stellar masses ($\Delta \log(M_{\text{star}}) = 0.25 \text{dex}$)
- Using spectra with flag 3 and 4 not disturbed by any artifacts
lower mass ETGs have young stellar population than high mass ETGs. The trend of the evolution in preserved for the different redshift range.

stellar population is getting older with lower redshift.
Future work

- to improve stacking procedure and calculations of errors,
- to calculate the $H\delta_A$ as a function of D4000 for different redshifts and stellar mass bins,
- to perform the SED fitting to check the evolution of SFR in the $M_{\text{star}}$ and redshifts function.
Thank you!!!