THE VVDS PROJECT: CLOSING UP AND LESSONS LEARNED

Bianca Garilli

ex IFCTR-CNR,

ex IASF-CNR sez. Milano,

ex IASF-INAF sezione Milano

Presently IASF-Milano, INAF

The name and the director of an institute can change,
the people and the projects remain

FIRST CONCEPTION

IASF Milano

ESO Workshop on science with the VLT

June 28-July 1 1994

NIRMOS: A WIDE FIELD NEAR-IR MULTISLIT IMAGING-SPECTROGRAPH FOR THE VLT

O. Le Fèvre[1], P. Felenbok[1], F. Hammer[1], L. Tresse[1], B. Delabre[2], P. Vettolani[3], Y. Mellier[4], J.P. Picat[4], S.J. Lilly[5]

WFIS: A WIDE FIELD VISUAL MULTISLIT IMAGING-SPECTROGRAPH FOR THE VLT

G. Vettolani[1], B. Delabre[2], O. Le Fevre[3], F. Hammer[3], G. Zamorani[4]

A science driven instrument, with a precise scientific goal

We would like, however, to stress another point which is worth mentioning. *Whilst studies as the ones above described have been the major driving force for building 8 meter class telescopes, in the present instrumentation plan of VLT there is almost no room for this kind of work. Not to build an instrument like the one here proposed, or a more clever one but with the same goals, means to throw out European research from the field of observational cosmology.*

Existing redshift surveys (1994)

- **0<z<0.3**
  - Several thousands of galaxy redshifts (2dF, ESP, LCRS). SLOAN planned
- **0.3<z<1.5**
  - Few thousands of galaxy redshifts (CFRS, CNOC at lower z)
- **z~3-4**
  - Few hundreds of galaxies (Steidel et al.) pre-selected (Ly-break)
- **z>4**
  - Few tens of galaxies, Ly-break or Lyα emission

Next step: explore the universe at z>0.5, big volumes, high number of galaxies

« next generarion » Deep Redshift Surveys

- *Galaxy properties: luminosity, color, environment*
- *And their evolution: several redshift intervals*
- *Minimize cosmic variance: several independent fields*
- *At least 50 galaxies per measurement*

– **LF: 50 × 10 × 3 × 3 × 4 × 7 = 126000 galaxies**

per bin mag.bin colors env. fields time steps

- **Previous Samples: ~10^3 galaxies**

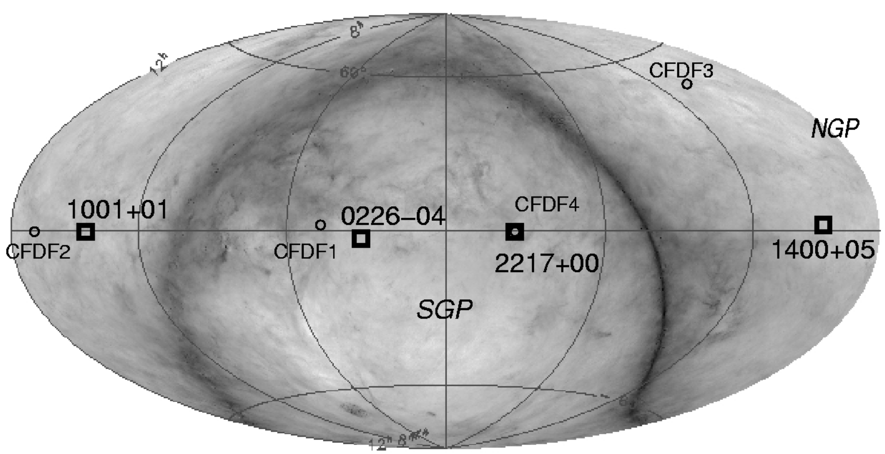
VVDS Strategy

100000 redshifts 0<z<5+

- *Magnitude selected sample*
  - *Complete census of galaxy population at all epochs*
  - *Simple selection function, bias under control*
  - *Drawback: stellar contamination, most galaxies at 0.5<z<1.5,*

DEEP: 17.5≤IAB≤24, 1.2 deg²

WIDE: 17.5≤IAB≤22.5, 10deg²

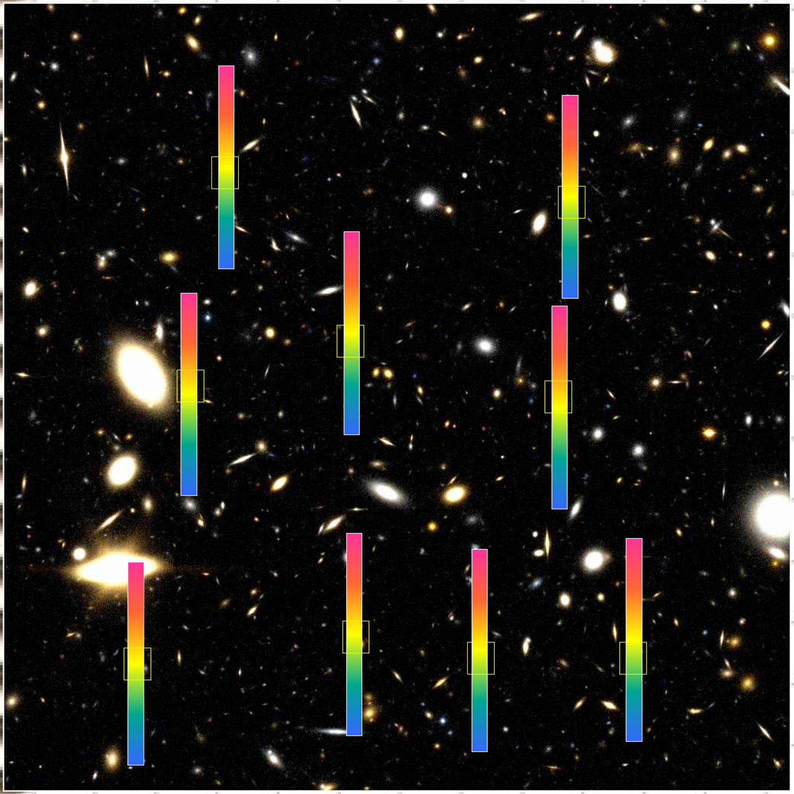


- *Minimize cosmic variance*
  - *N fields, 2x2 deg² each, ~100Mpc @z~1*

5 fields

- 0230-04
- 1000+03 (Now the COSMOS field)
- 1400+05
- 2217+00
- CDFS

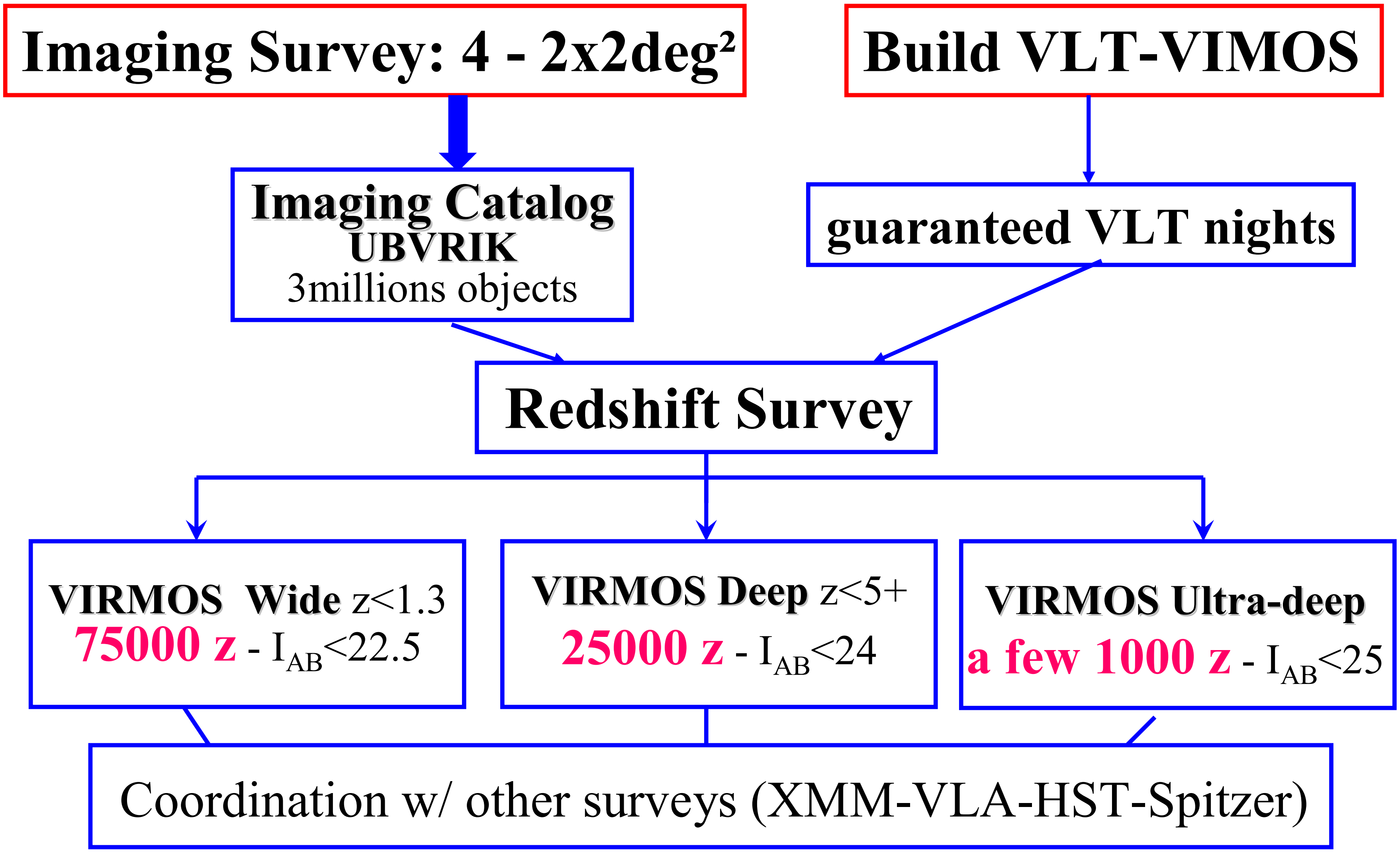
How to make a survey



- Multicolor Imaging
  Magnitudes, colors, Morphologies
- Sample selection
  - color, magnitude, etc.
- Multi-object Spectroscopy
  - Redshift
  - Line ratios
  - Mass
  - Star Formation Rate
  - environment

Need for an efficient Multi Object Spectrograph

CFHTLS dir not exist! MOS did not exist



VIMOS @ VLT
Multi Object Spectrograph

- Multi-Object Imaging-Spectrograph **ESO-VLT**
  - Visible, 0.37-1 microns: **VIMOS (UT3)** 2kx4k CCDs
  - NIR, 1-1.6 microns: NIRMOS
- Conceived for big surveys
- Large FOV: 224arcmin^2
- High multiplexing: 600-800 slits
- Spectral resolution R~200-5000

START & PLAN

Phase A: June 1995-june 1996, competition with australian led consortium

Contract signature: August 1997

VIMOS and NIRMOS: Status Report

J.-G. CUBY and R. GILMOZZI, ESO

The Messenger, vol. 91, p. 16-17, 03/1998

At its meeting in Milan in October 1996, the STC recommended the procurement of 2 instruments for imaging and massive multi-object spectroscopy, VIMOS and NIRMOS, as conceptually designed by the VIRMOS consortium. The STC further recommended that ESO reduce the overall development time to ensure that these new instruments are competitive, with respect to e.g. DEIMOS on the Keck telescope and GMOS on the Gemini Telescope.

Status

The contract between ESO and the VIRMOS consortium was signed in August 1997. The Preliminary Design Review of VIMOS and of the Mask Manufacturing Unit (MMU) took place in November. The Final Design Review will take place in July 1998.

The planning is the following:

Instrument	UT	Preliminary Acceptance in Chile
VIMOS & MMU	#3	May 2000
NIRMOS	#4	April 2001

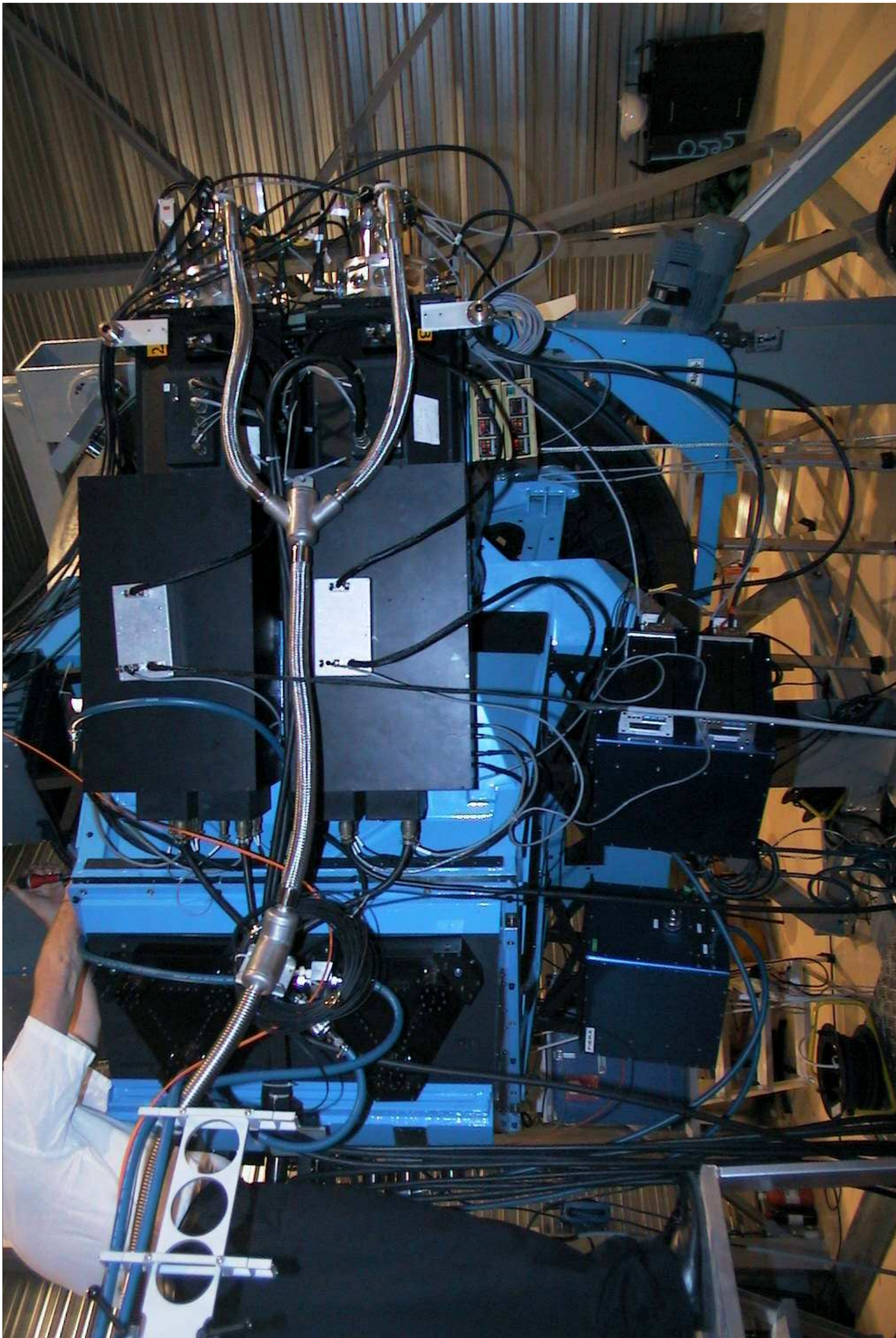
VIRMOS CONSORTIUM

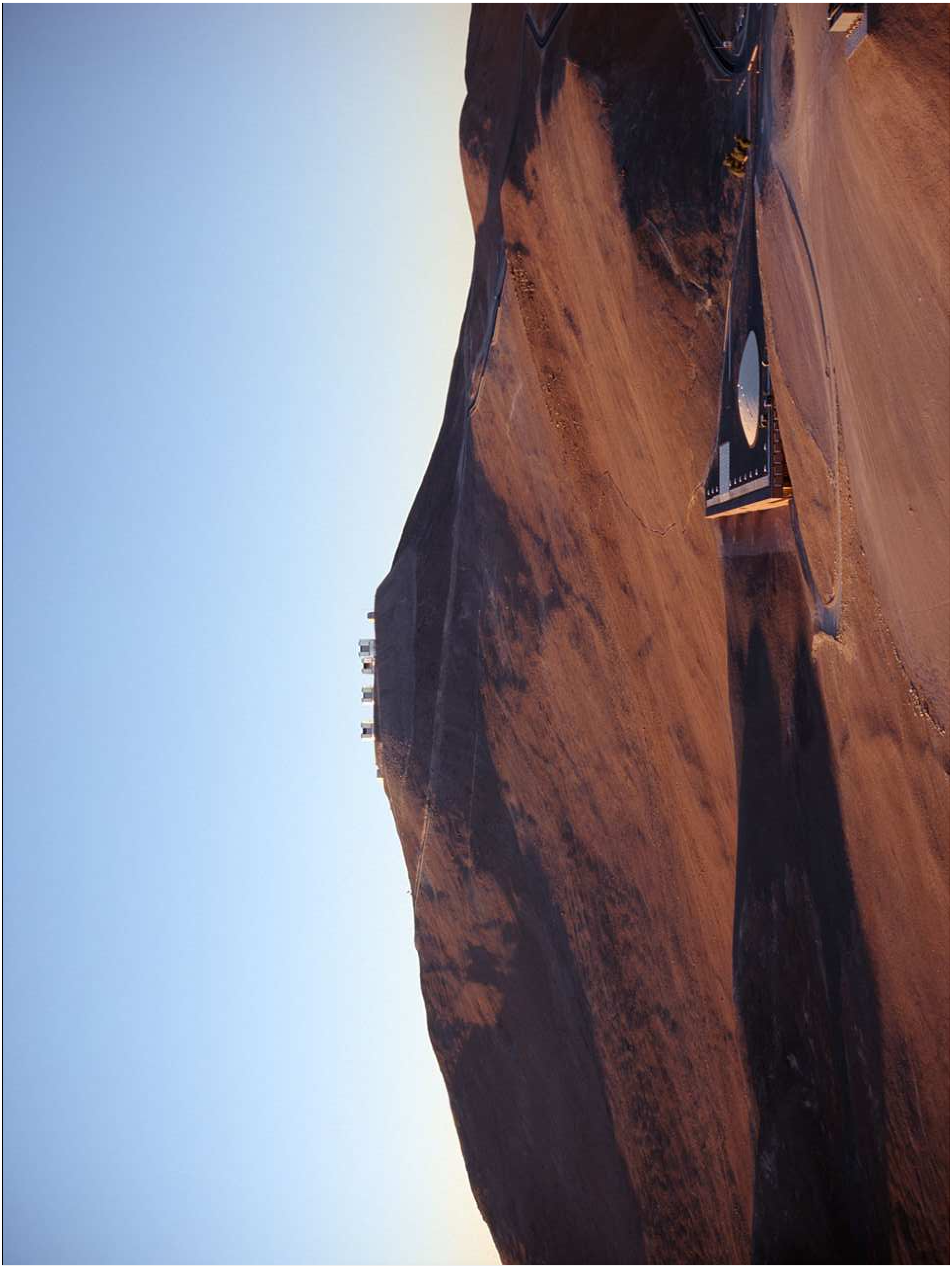
- *PI: Le Fevre (LAM-Marseille)*
- *CO-PI: Vettolani (IRA-Bo)*
- *Participants*
  - *OAMP: Project Office & optics*
  - *OA Capodimonte: Mechanics & electronics*
  - *OA Brera: filters & grisms*
  - *IASF-Mi: MMU & s/w activities coordination*
  - *IRA Bologna: observataion s/w*
  - *OA Bologna: DRS*
  - *OAMP: Instrument control s/w*
  - *OHP: Integration facility*
  - *Detectors provided by ESO*
- *For a total of 66 persons (8 women)*

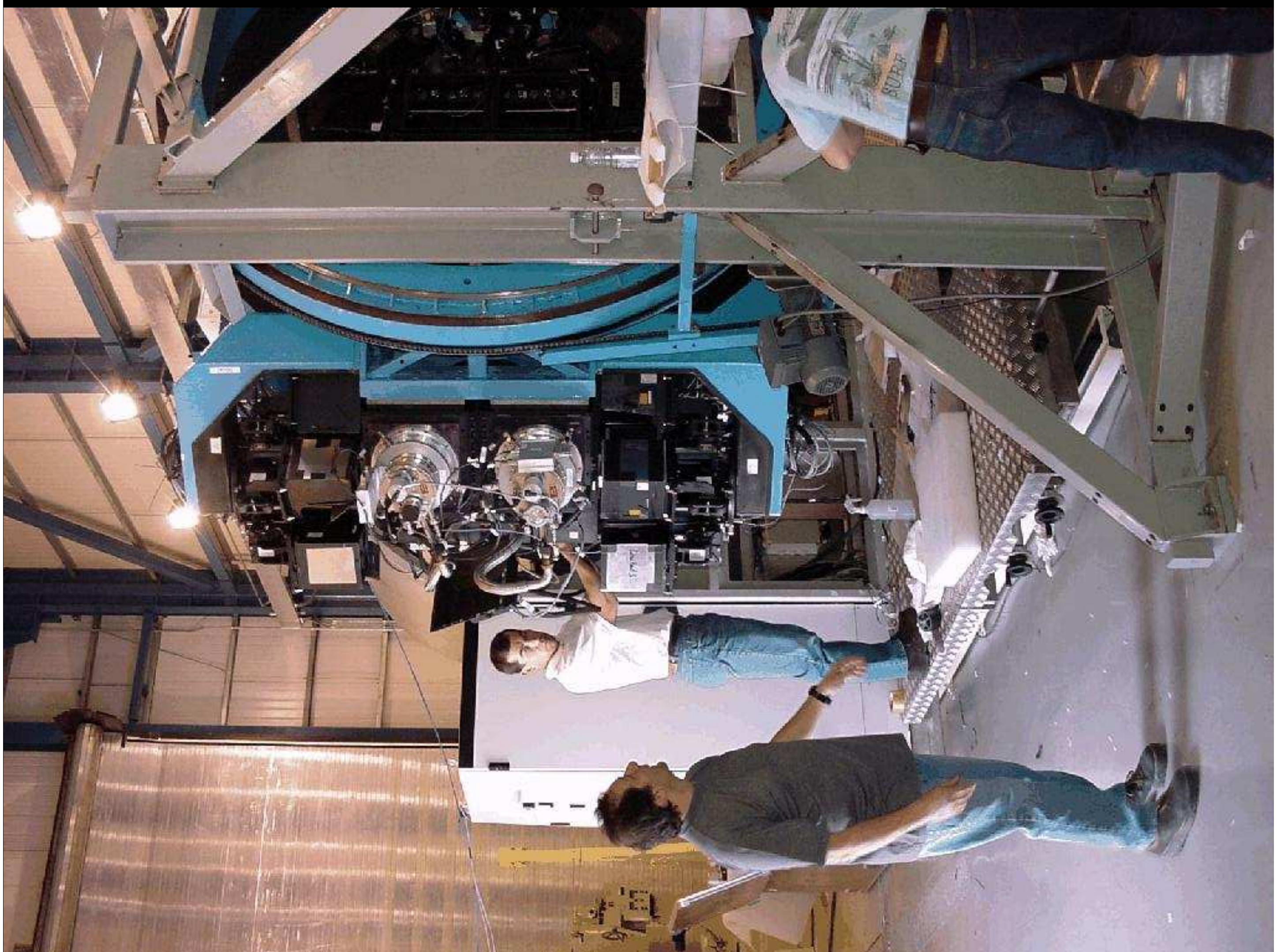
CONSTRUCTION MILESTONES

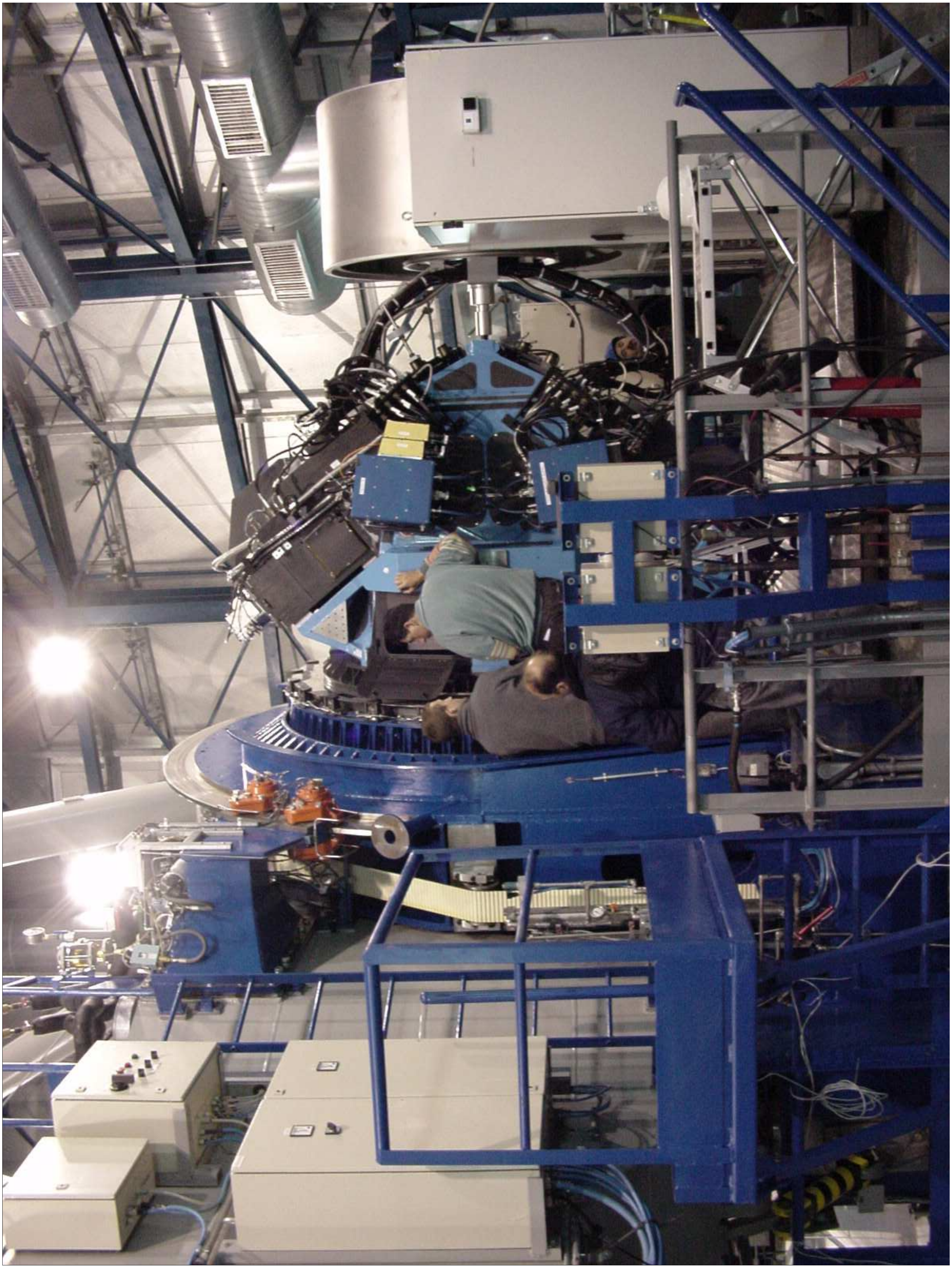
- *Phase A: June 1995-june 1996,*
- *Contract signature: August 1997*
- *Preliminary Design Review: July 1998: ON TIME*
- *Final design review: November 1999: ON TIME*
- *Technical first light: May 2000*
- *August 2000: MMU operational at Paranal ON TIME*
- *December 2001: VIMOS leaves OHP for Paranal : 1.5 years late*
- *February 2002 FIRST LIGHT*
- *September 2002: end of commissioning*
- *2003, VIMOS offered to the community for P71 April-September 2003*

NIRMOS dropped
GTO cut by 2

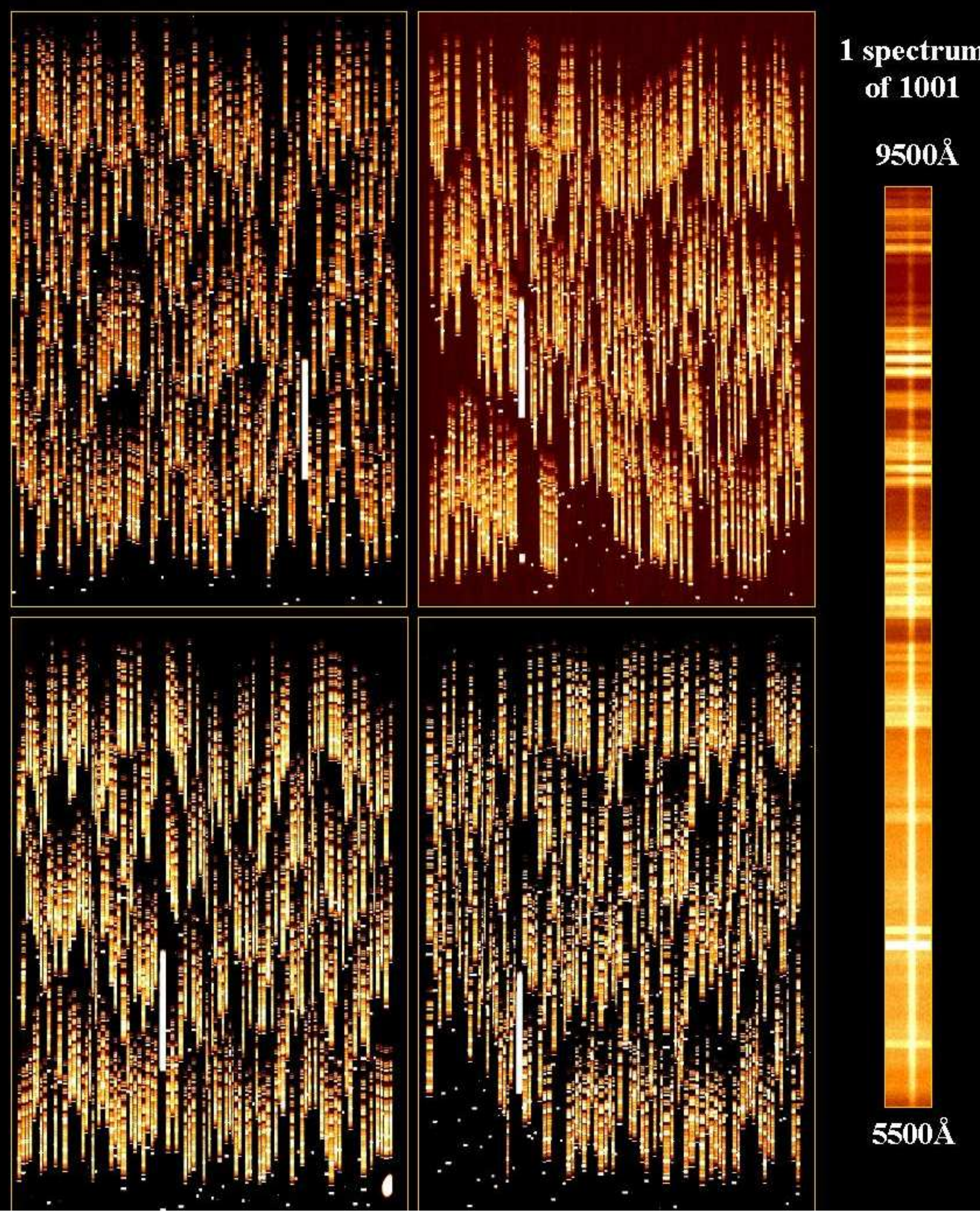








VIMOS at the ESO VLT
measures the distance of 1001 distant galaxies in one single observation 28/09/2002



Deep Redshift Surveys: New generation (2002)

- **In progress**
  - **SDSS:** ~10^6 galaxies, z<0.3
  - **DEEP2:** 50000 redshifts 0.7<z<1.5, I_{AB}=23.5-24.5 (Davis, Faber et al.)
  - **K20**: a few hundred, K≤20 (Cimatti et al.)
  - **GMOS:** ultra deep, I_{AB} =25 (Abraham et al.)
  - **GOODS:** HST imaging, Spitzer, spectro VLT

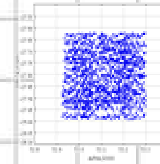
VVDS: ~~100000~~ redshifts 0<z<5, IAB=22.5-24
50000

Observations from september 2002 to september 2004 (+ GO in 2005/6)

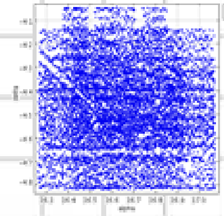
VVDS SAMPLE

- *Surveyed area*
  - *I<= 22.5   9 sq. deg., 5 fields*
  - *I<=24   1.0 sq. deg., 2 fields*

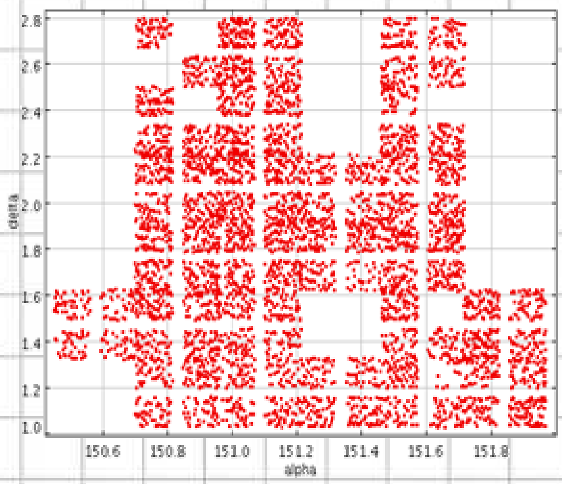
CDFS



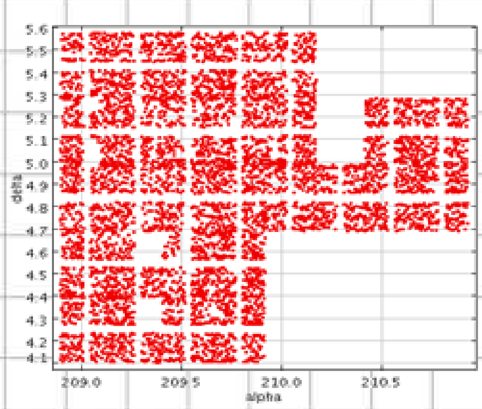
F02



F10



F14



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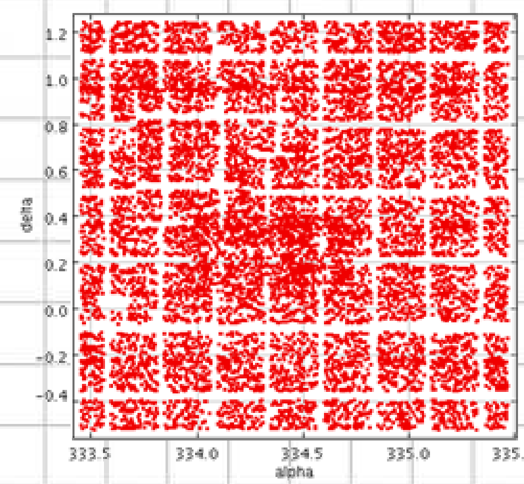
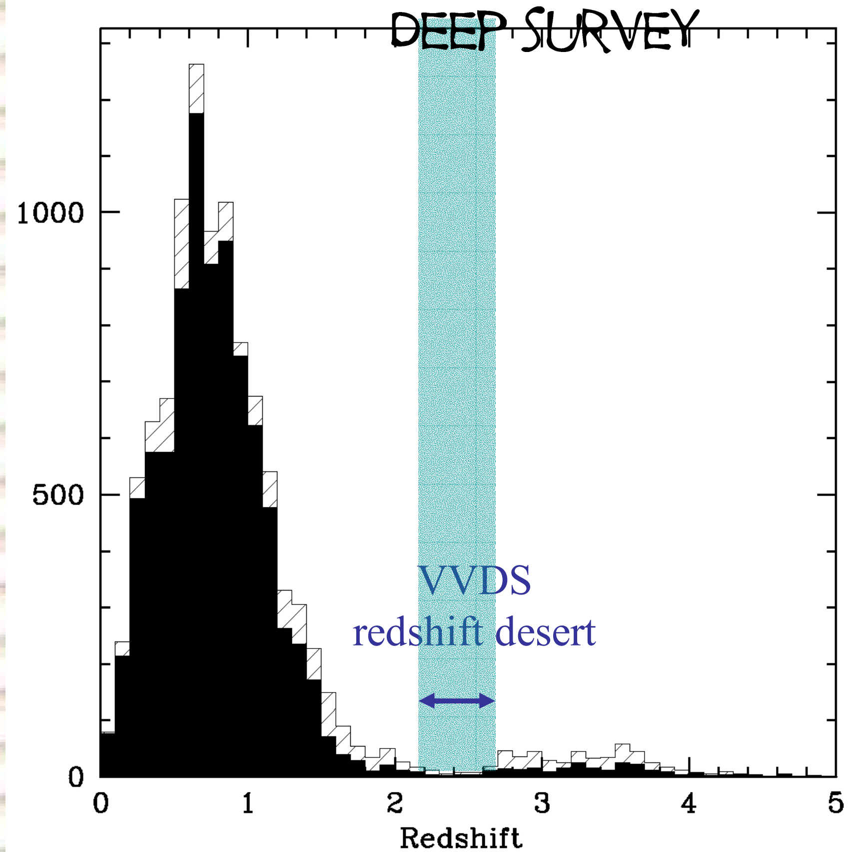
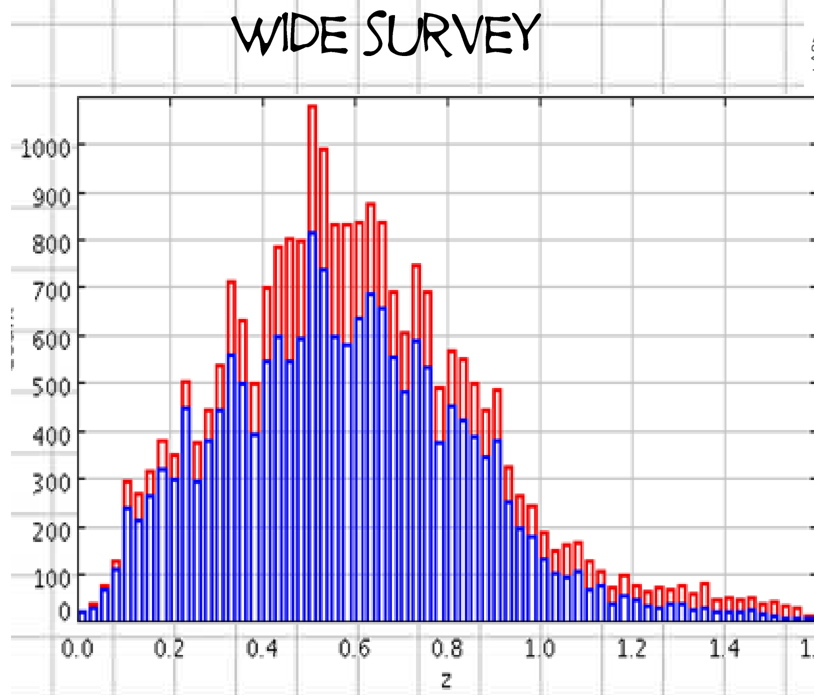
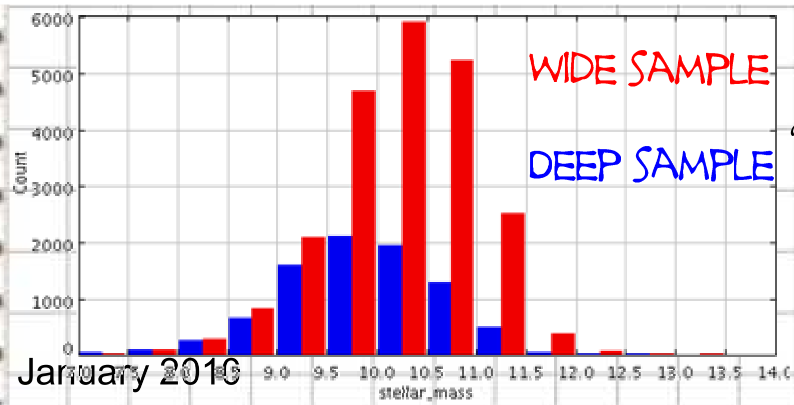


- *49390 redshifts*
- *35875 galaxies*
- *27727 target galaxies, secure (>75%) redshift*
- *455 BL AGNs*

Le Fevre et al. 2005, Garilli et al. 2008







Deep sample:

7000 galaxies, 1sq.deg. 40% sampling

0<=z<=5

galaxy evolution, LSS

Wide sample:

20000 galaxies , 9 sq. deg. 20%sampling

0<=z<=1.2

LSS, massive, red, old, luminous galaxies

Meneux et al. 2008

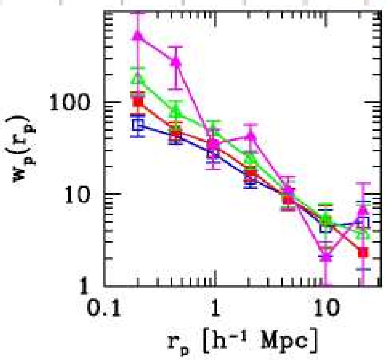
Galaxy clustering as a function of stellar mass

Only done with SDSS data at z<0.3 (Li et al. 2006)

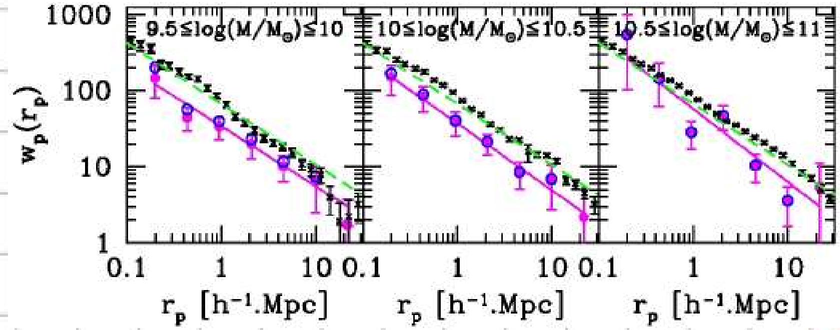
First time done at z~1!

Amplitute and slope of the correlation function increase with stellar mass

evolution of CF for objects M<M*



1. Massive objects: higher dependence on redshift of the linear bias
2. more massive galaxies formed at high redshift in the highest peaks of the density field, less massive objects form at later epochs from the more general dark-matter halos.



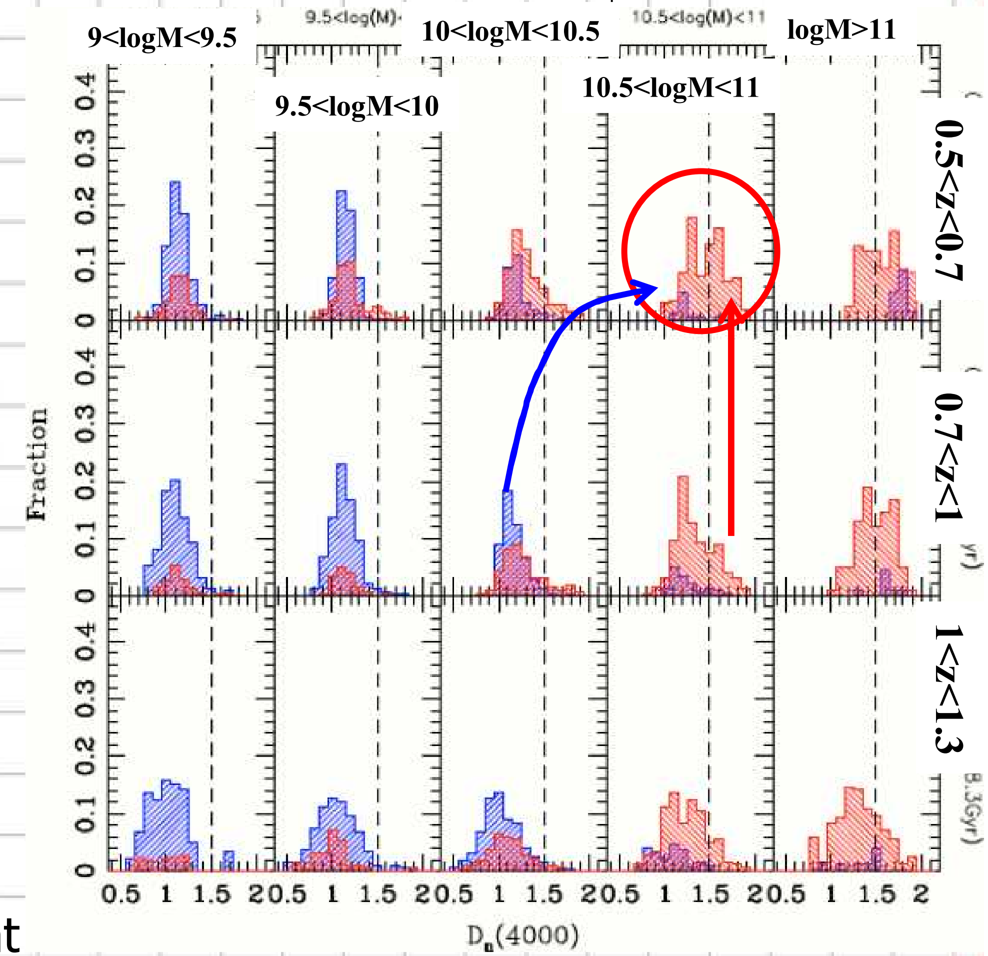
Mass assembly
Vergani et al. 2008

can progenitors justify assembled mass without dry mergers?

Blue histogram: galaxies with high SFR

Red histogram: galaxies with low SFR

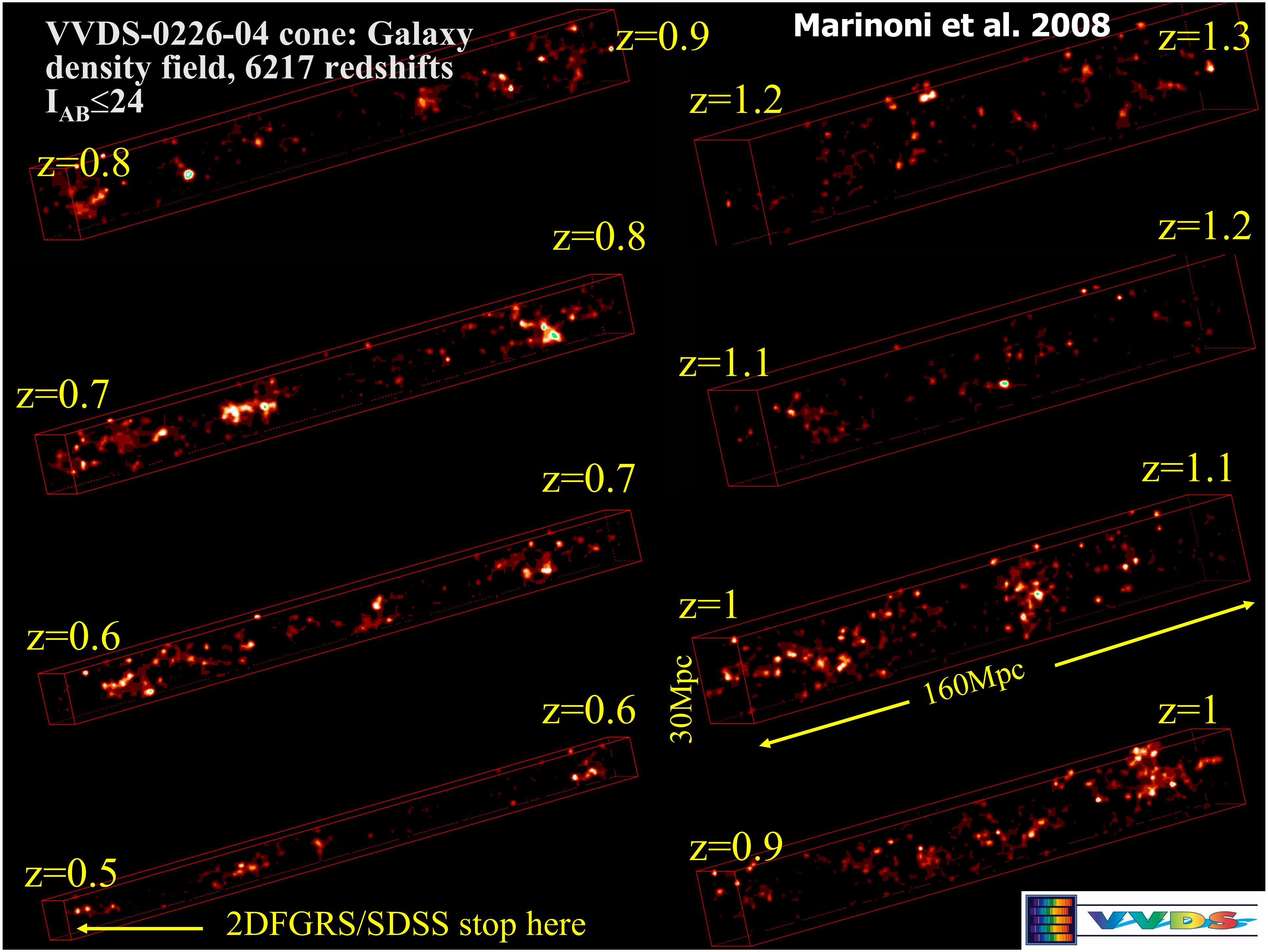
The lower the mass, the more galaxies can efficiently assemble mass. At high mass, they stop (lack of fuel?)



Number of progenitors can account for 80% of galaxies, almost 100% for high mass galaxies

No big need for mergers below z~1

Merger rate of high mass galaxies remains roughly constant around 10% since z ~ 1.
DeRavel et al. 2009

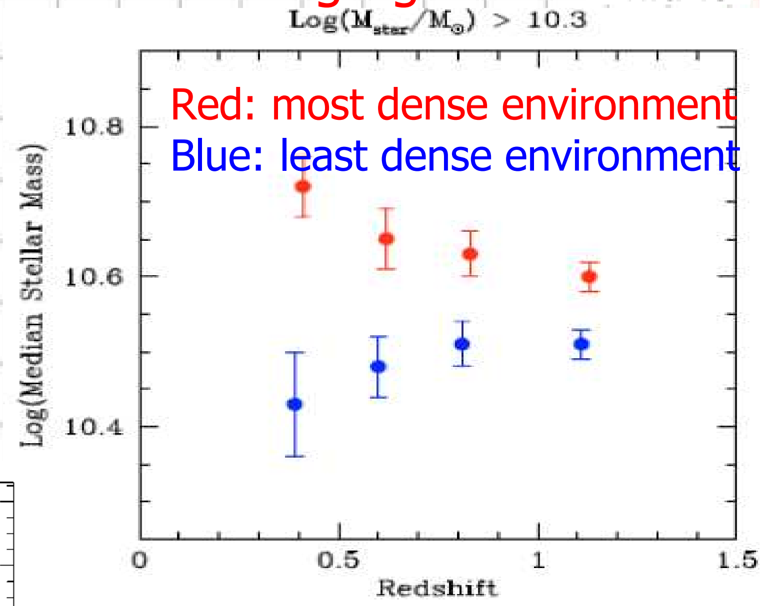

VVDS-0226-04 cone: Galaxy density field, 6217 redshifts
I_AB≤24
Marinoni et al. 2008
z=0.8
z=0.9
z=0.7
z=0.8
z=0.6
z=0.7
z=0.5
z=0.6
2DFGRS/SDSS stop here
z=1.2
z=1.3
z=1.1
z=1.2
z=1
z=1.1
30Mpc
160Mpc
z=0.9
z=1
VVDS

Scodeggio et al. 2009

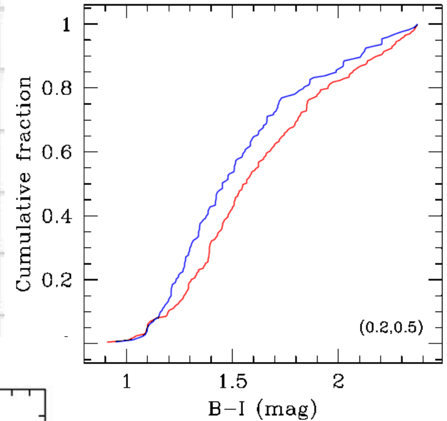
The large scale stellar mass segregation

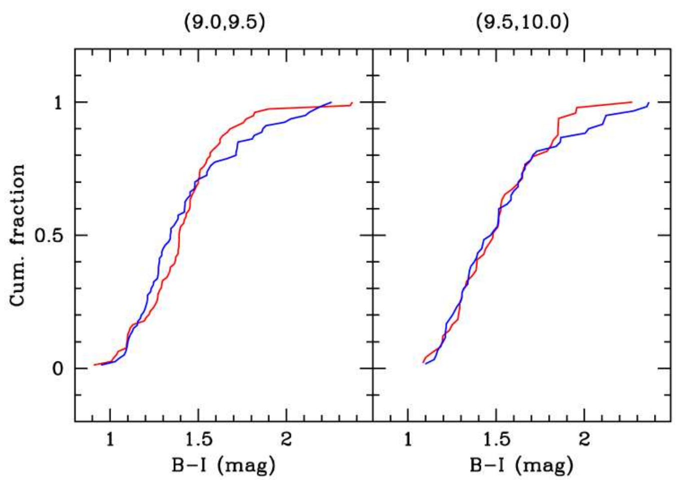
High mass galaxies prefer high denisity environments also at z~1 (at 8 Mpc scale)

SDSS: Evidence for mass dependent galaxy segregation at all scales at z<0.3



The strength of the observed stellar mass segregation decreases marginally with increasing redshift





significant rest-frame color segregation but..

a large fraction is simply a reflection of the stellar mass segregation

AND NOW?

IASF Milano

VVDS has been declared "closed"

Data publicly available at http://cencosw.oamp.fr/

redshift, flags and spectra for 50000 galaxies

Original plan, 1996	Accomplished 2009
• broad redshift range ($0 < z < 5$)	YES
• over sixteen square degrees of the sky	10 deg^2
• four separate fields. ……	YES
• 100,000 spectroscopic redshifts.	50000
• 75,000 redshifts for sources up to AB = 22.5.	40000
• 25,000 redshifts for objects up to AB = 24	10000
• 1,000 redshifts for objects up to AB = 26	NO

A number of interesting scientific results

51 papers, <13> citations/paper/year

2 Nataure papers

>2000 citations

Still a valid idea, infact…

"AFTER VVDS" PROGRAMS

IASF Milano

4 ESO LP approved in the last 4 years

name	PI	All. time	# of galaxies	Area deg^2	Mag (I_{AB})	z range	sampling	Main scope
zCosmos Bright	Lilly	600	20000	1.7	22.5	0.2-1.2	70%	LSS, Environment
zCosmos Deep			10000	1	25 (B_{AB})	1.2-3.0	70% *	Galaxy evolution at med z
UltraDeep	LeFevre	147	1500	0.17	22.5-24.75	1.4-5.0	15%	Galaxy evolution at high z
Vipers	Guzzo	423	80000	24 2 fields	22.5	0.5-1.2	50% *	LSS, cosmological parameters
UltraDeep Large	LeFevre	648	12000	1 3 fields	23-25	2.5-6.7	90% *	Galaxy evolution at high z

And many more around the world: AEGIS, BOSS, WiggleZ, etc

* *Involves pre-selection on color-color diagrams (CFHTLS data)*

Does participation to a large collaboration pay back?

- Drawbacks
  - Service work
  - Internal competition to lead a topic
  - Pressure to get the job done
  - Papers signed by >50 people
- Advantages
  - Sign all project papers
  - several team meetings: opportunity to
    - discuss work within a familiar yet attentive audience
    - Learn on many topics
    - know and be known by several people
    - practise english and presentations
  - Higher chances to participate to large cosmological surveys
- 16 PhD thesis on VVDS
  - 11 PhD students got a post-doc on surveys
- 25 post docs working on VVDS:
  - 12 got a permanent position (3 former phD students), possibly a few more in the future

SUMMARY

Well done

- *A powerful spectrograph*
- *Reduction and analysis tools*
- *Innovataive and comprehensive approach to data handling*
- *Strong scientific driver*
- *Fair number of publications*
- *Interesting and innovative results*
- *A number of follow-up/complementary projects (5 LP)*
- *The group stayed for 15 years, >100 people involved*
- *Excellent opportunities for students/post-docs*
- *A "real equal opportunity" project 31% women*

Could do better

- *NIRMOS cancelled*
- *DataBase management not always to the point*
- *"slow" publication process*
- *Citation number could be better*
- *Data dissemination can be improved*
- *Some people have not been sufficiently motivated*
- *Data set not fully exploited*

GO AND USE THEM!!!

A VERY SUCCESSFUL PROJECT, A WONDERFUL EXPERIENCE

OPTIMOS-DIORAMAS:
A VISIBLE-NIR IMAGER MULTIOBJECT SPECTROGRAPH FOR THE E-ELT