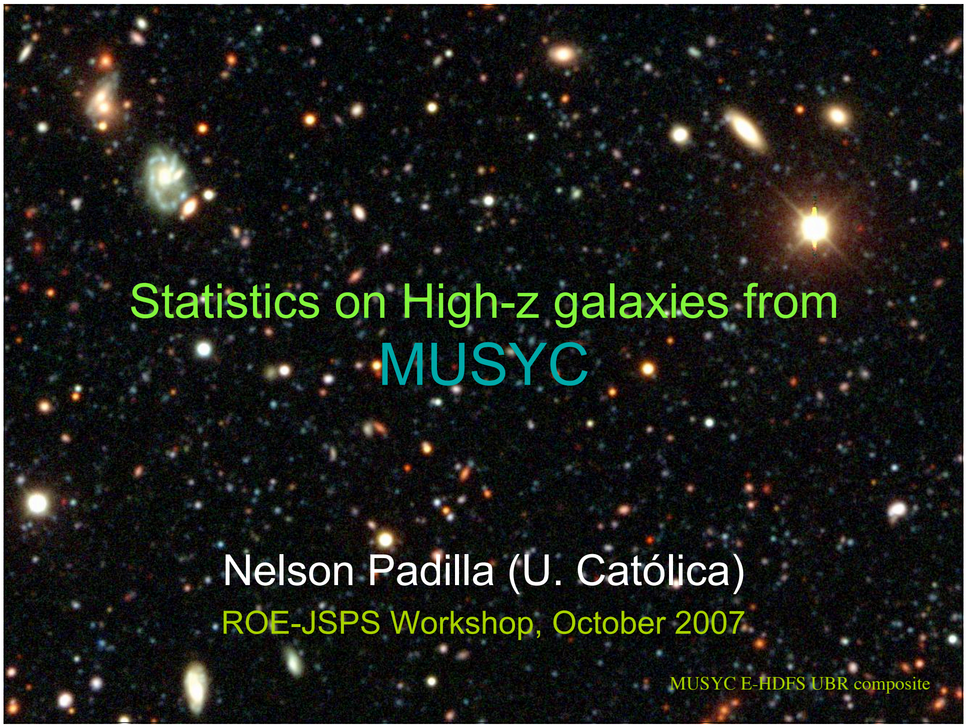


Statistics on High-z galaxies from MUSYC

Nelson Padilla (U. Católica)

ROE-JSPS Workshop, October 2007

MUSYC E-HDFS UBR composite

Outline

- First review what is MUSYC
- Show a few pictures of MUSYC
- Three particular projects
- Summary

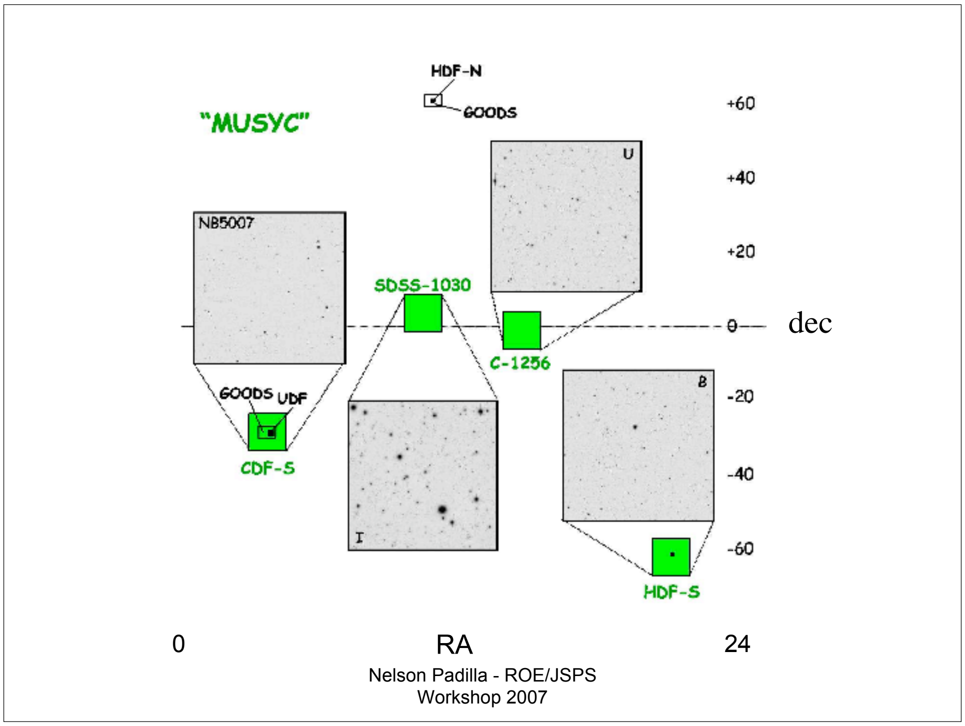
MUSYC
(Multiwavelength Survey by Yale-Chile)

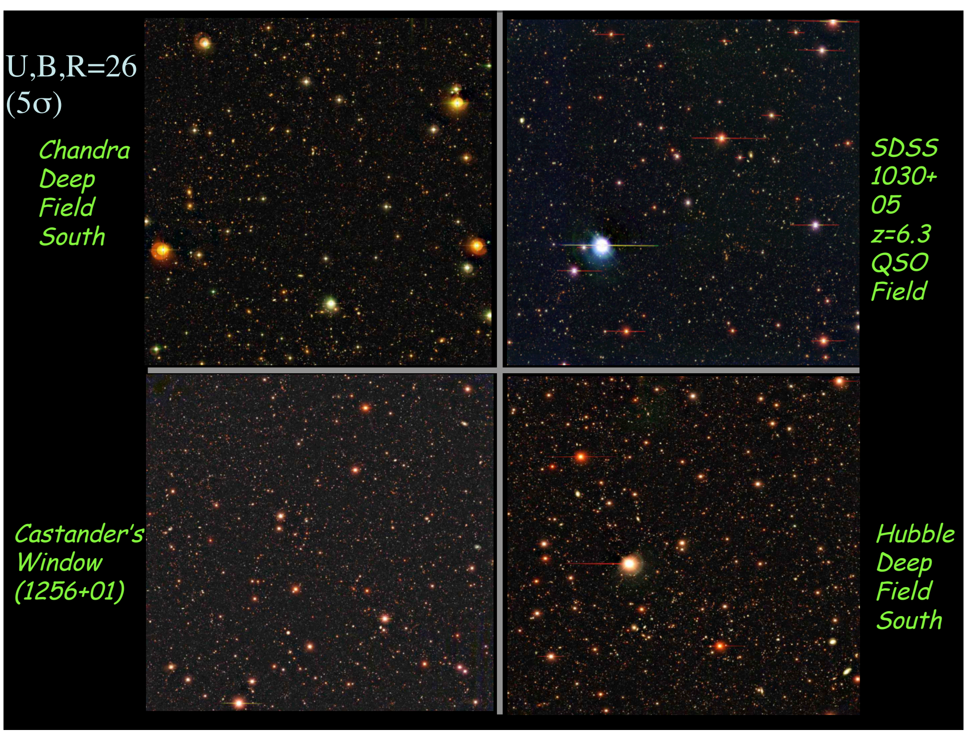
Eric Gawiser (Yale)
Martin Altmann (U. Chile)
Felipe Barrientos (P.U. Catolica)
Francisco Castander (Barcelona)
Daniel Christlein (U. Chile/Yale)
Paolo Coppi (Yale)
Marijn Franx (Leiden)
Lucía Guaita (P.U. Catolica)
Leopoldo Infante (P.U. Catolica)
Sheila Kannappan (U.T. Austin)
Paulina Lira (U. Chile)
Charles Liu (CUNY/AMNH)
Sebastian Lopez (U. Chile)
Danilo Marchesini (Yale)
José Maza (U. Chile)
Rene Méndez (U. Chile)
Nelson Padilla (P.U. Catolica)
Mónica Rubio (U. Chile)
María Teresa Ruiz (U. Chile)
Ezequiel Treister (ESO)
Meg Urry (Yale)
Bill van Altena (Yale)
Pieter van Dokkum (Yale)
Sukyoung Yi (Yonsei)

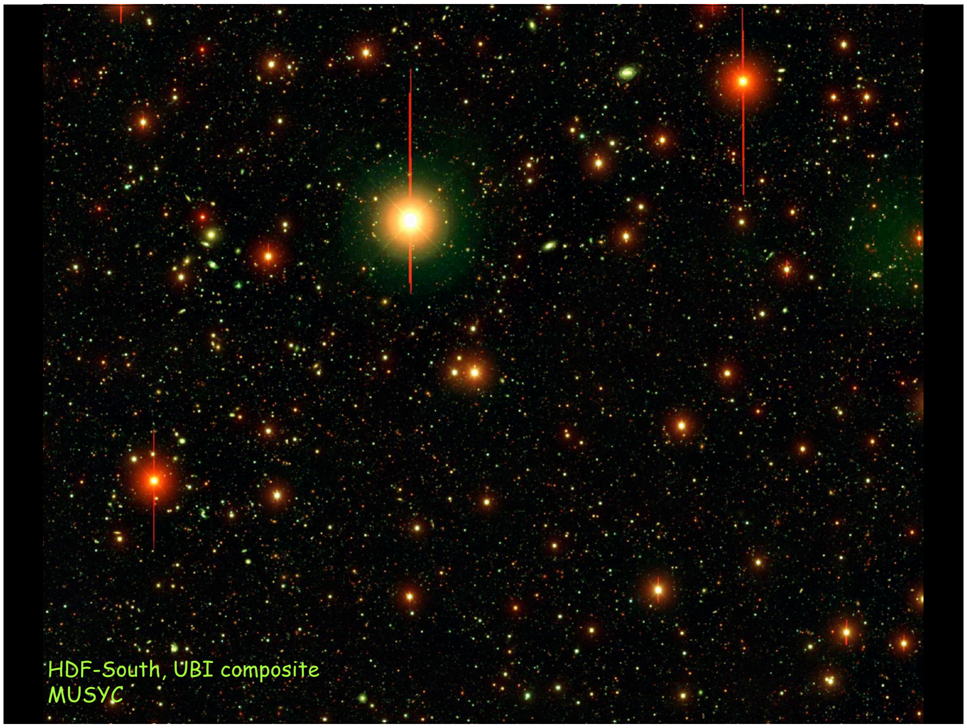
MUSYC

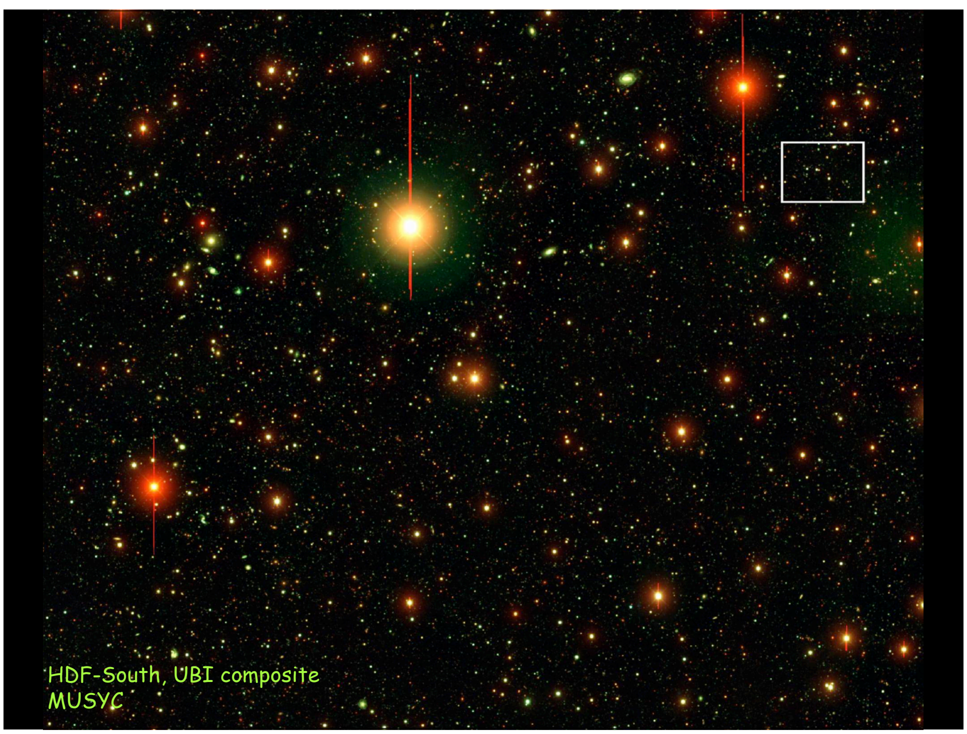
- Square degree comprised of four 30'x30' fields (E-CDFS, E-HDFS, SDSS1030+05, Castander's Window 1255+01)
- Deep UBVRIzJHK + NB5000Å imaging (to 5σ depths of U,B,V,R_{AB}=26, K_{AB}=23, NB5000=25)
- Spitzer-MIPS+IRAC/HST-ACS/GALEX/XMM/Chandra coverage in 3/4 fields
- Spectroscopic follow-up with VLT+VIMOS, Magellan+IMACS, Gemini+GNIRS

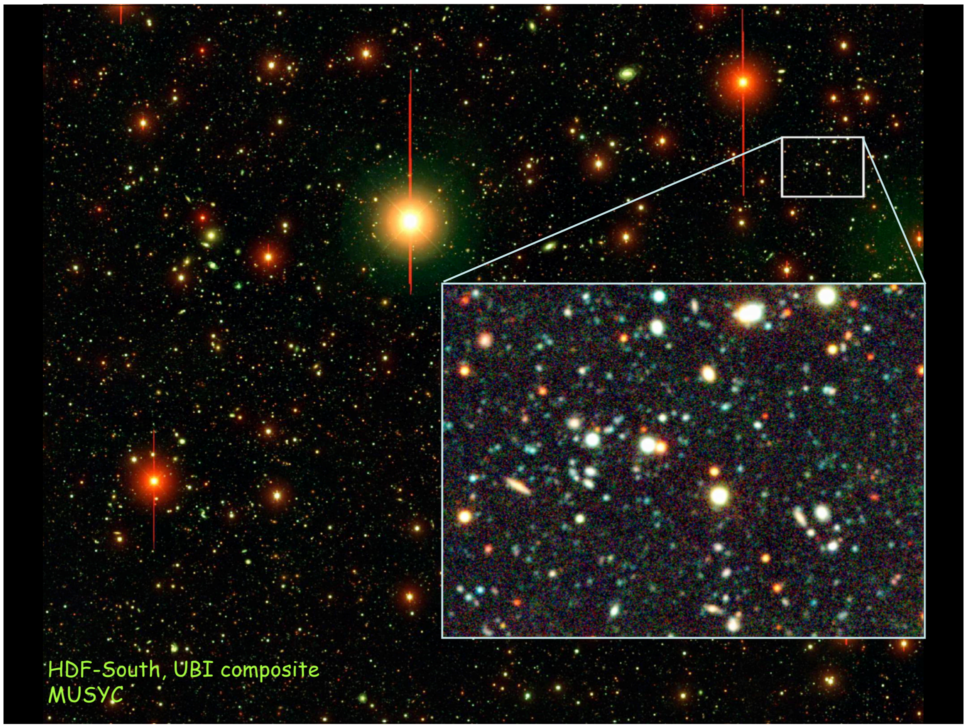
Nelson Padilla - ROE/JSPS
Workshop 2007

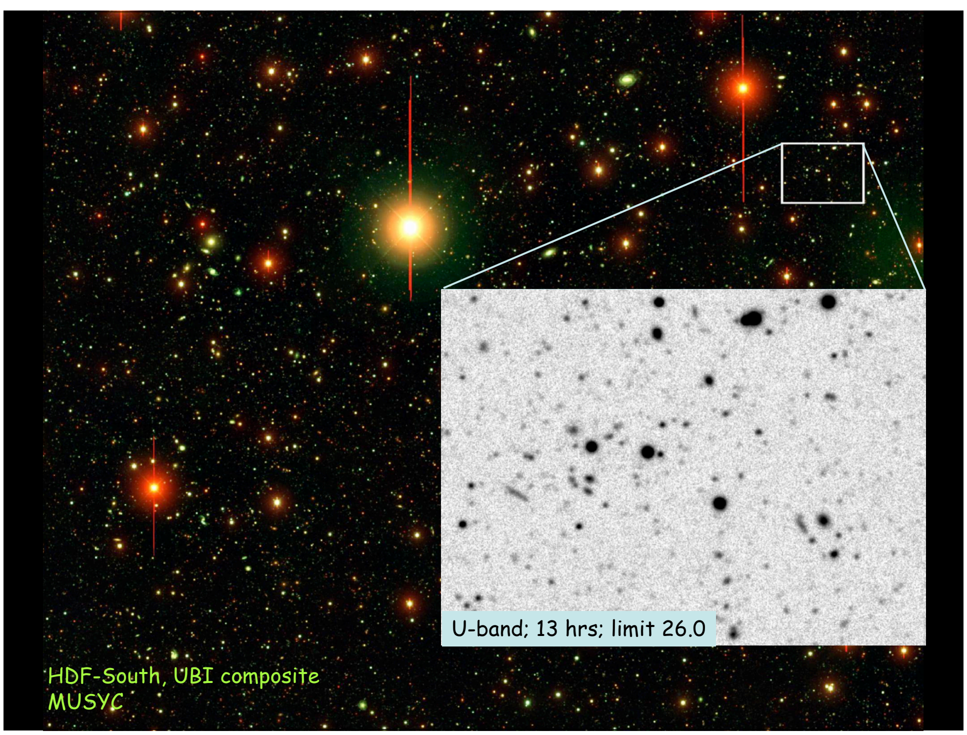

HDF-N
GOODS
"MUSYC"
+60
+40
+20
NB5007
SDSS-1030
U
dec
C-1256
GOODS UDF
-20
B
CDF-S
-40
I
-60
HDF-S
0
RA
24
Nelson Padilla - ROE/JSPS
Workshop 2007


U,B,R=26
(5σ)
Chandra Deep Field South
SDSS 1030+ 05 z=6.3 QSO Field
Castander's Window (1256+01)
Hubble Deep Field South


HDF-South, UBI composite
MUSYC


HDF-South, UBI composite
MUSYC


HDF-South, UBI composite
MUSYC


U-band; 13 hrs; limit 26.0
HDF-South, UBI composite
MUSYC

277,341 objects in square-degree optical catalog

5σ Point Source Limits (AB mags):

Field	# Obj.	BVR	U	B	V	R	I	z	NB5000
E-CDFS	84410	27.1 0.85”	26.0	26.9	26.4	26.4	24.6	23.6	25.5
E-HDFS	62968	26.3 0.95”	26.0	26.1	26.0	25.8	24.7	23.6	24.0
SDSS 1030	69619	26.5 0.85”	25.8	26.0	26.2	26.0	25.4	23.7	24.8
CW 1255	60344	26.5 1.15”	26.0	26.2	26.1	26.0	25.0	24.1	24.4

BVR-selected catalogs complete to R=25 (total mag.)

A square degree imaged to the spectroscopic limit!

MUSYC: A Square-degree Survey of the Formation and Evolution of Galaxies and their Central Black Holes

Science Projects:

1. Evolved galaxies at 2<z<3 (van Dokkum et al.)
2. Properties of K-selected galaxies at z<2 (Lira et al.)
3. Clustering of galaxies at intermediate and high redshifts (Padilla et al.)
4. Census of galaxies at z=3 (Gawiser et al.)
5. AGN demographics at 0<z<6 (Urry et al.)
6. Proper motion + color survey for white and brown dwarfs (Méndez et al.)
7. Galaxy luminosity functions down to z=3.5 (Christlein et al.)
8. Recent star formation in ellipticals (Yi et al.)

Etc.

Nelson Padilla - ROE/JSPS
Workshop 2007

i) Evolution of dark matter halo masses from clustering of z<1 MUSYC galaxies

(Padilla et al. 2007)

18<R<24.3

Stellarity parameter c < 0.8 (SExtractor)

Photo-z: hybrid, $0.2<z_{ph}<1$

~55,000 galaxies

Errors ~ 0.06*(1+z) in redshift

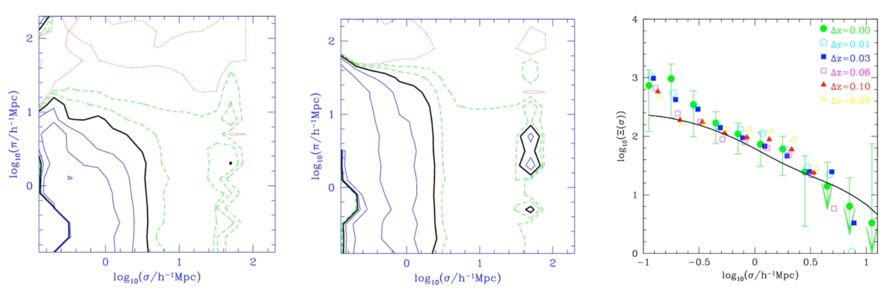
Flux and Volume limited samples

5 photo-z slices

Calibration: using mocks.

One method to obtain $r_0(z)$

Calculate $\xi(\sigma,\pi)$ for different errors in redshift and integrate over the direction of the line of sight to eliminate it (as in Phleps et al., 2006). First test using gaussian error distributions plus 5% catastrophic errors.

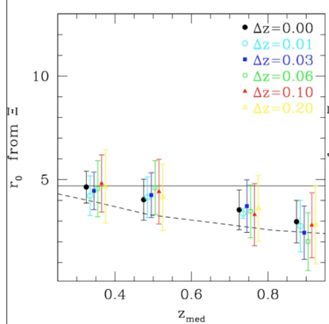


$\xi(\sigma,\pi)$ for $\Delta z=0.0$ $\xi(\sigma,\pi)$ for $\Delta z=0.1(1+z)$ $\Xi(\sigma)$ for various Δz

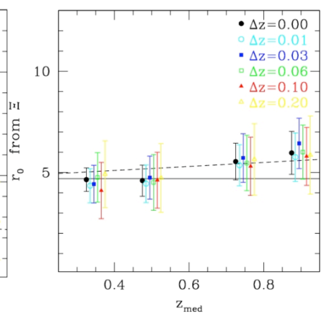
RESULTS FROM THE MOCK CATALOGUE:

Gaussian errors in photo-z, plus 5% catastrophic errors

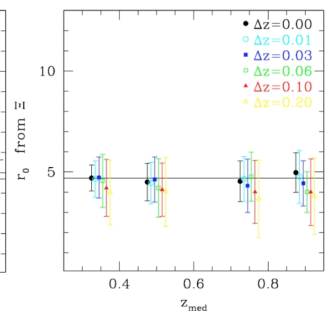
DM clustering ev.



Lum. Dependence



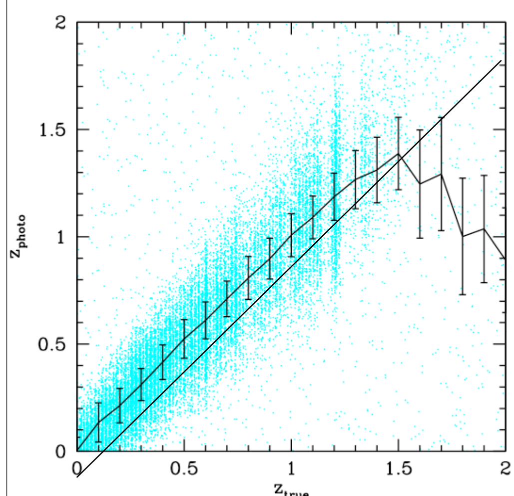
No evolution



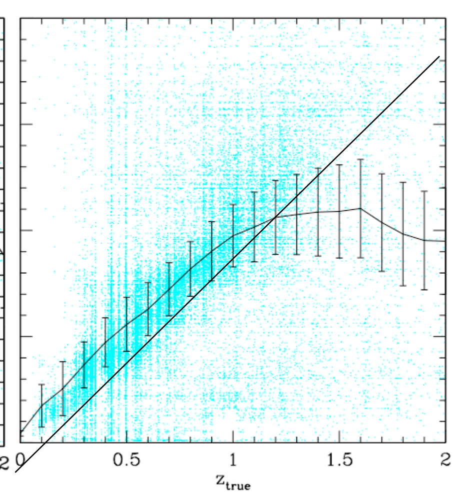
Nelson Padilla - ROE/JSPS
Workshop 2007

More realistic modelling of the photo-z errors:

Instead of Gaussian,



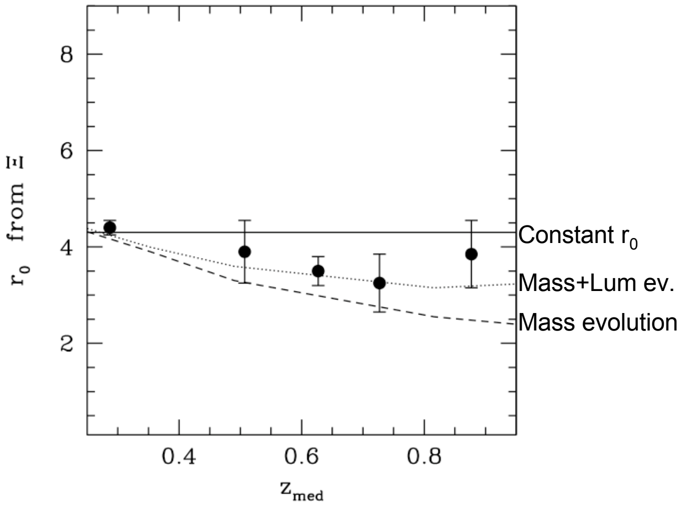
using the actual photometry from the SAM



Nelson Padilla - ROE/JSPS
Workshop 2007

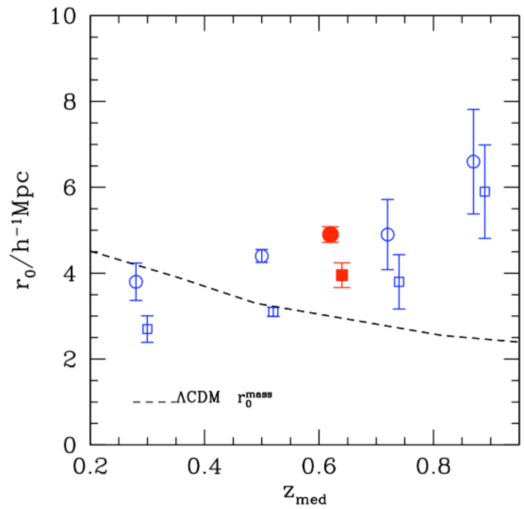
RESULTS FROM THE MOCK PHOTO-Z CATALOGUE:

Applying integration limits obtained from the spec vs photo-z plot:



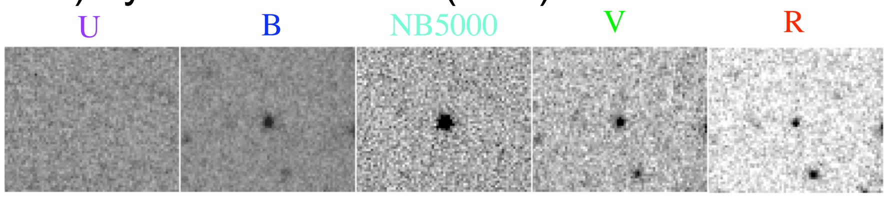
Nelson Padilla - ROE/JSPS Workshop 2007

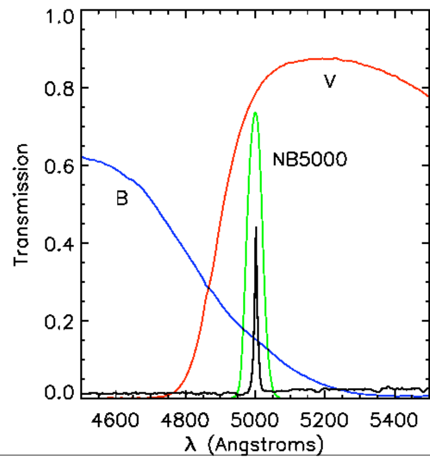
Results from E-HDFS + E-CDFS + SDSS1030+05

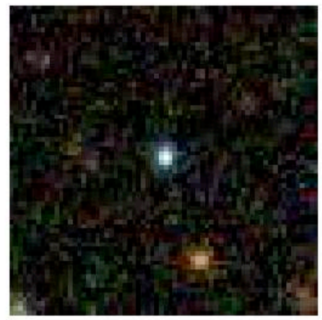


Nelson Padilla - ROE/JSPS Workshop 2007

ii) Lyman a Emitters (LAE) in the E-CDFS

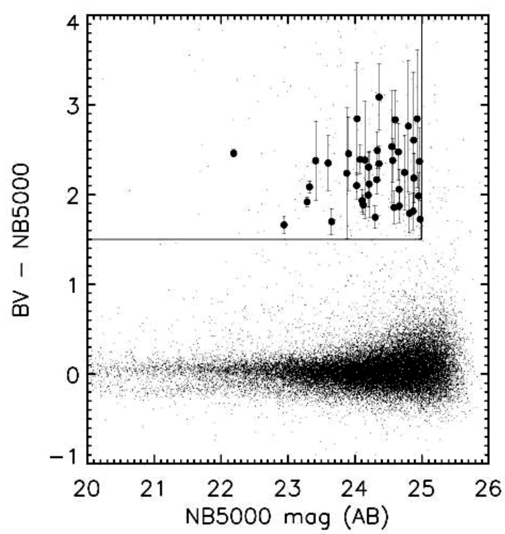






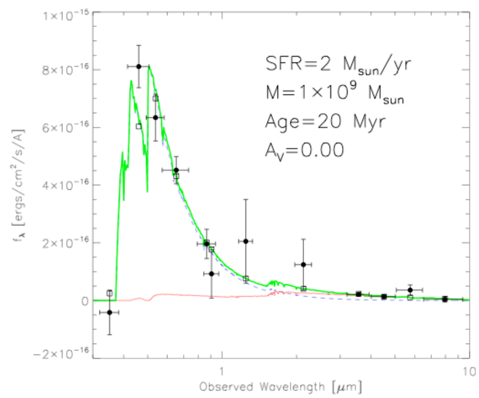
Gawiser et al 2006b, ApJ 642, L13
(MUSYC plus Caryl Gronwall, Robin Ciardullo, John Feldmeier)

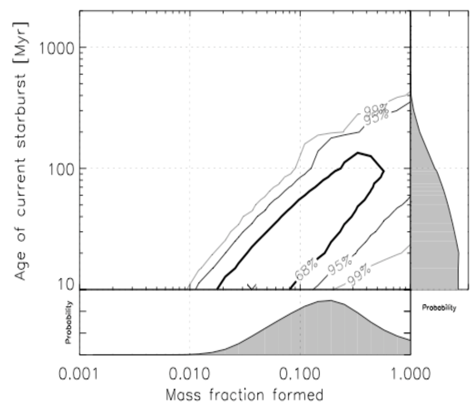
BV - NB5000 selection of LAEs



Stacked SED of LAEs →

formed a considerable fraction of stellar mass in observed starburst → galaxies in "act of formation" (Gawiser et al. Astro-ph/0710.2697)

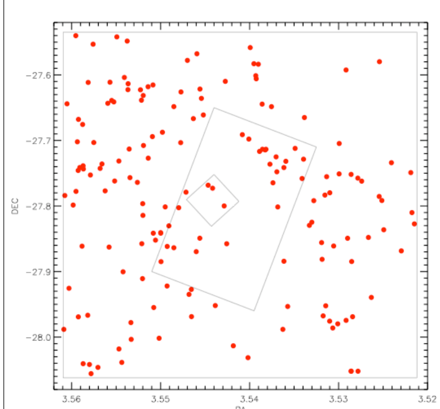


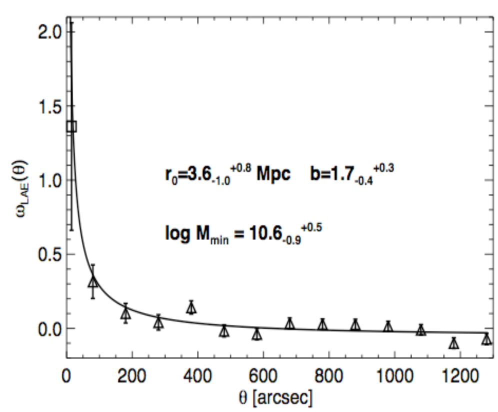


Two population model is a better fit than a single recent burst

LAE clustering in MUSYC-ECDFS

(Gawiser et al 2007, in prep)



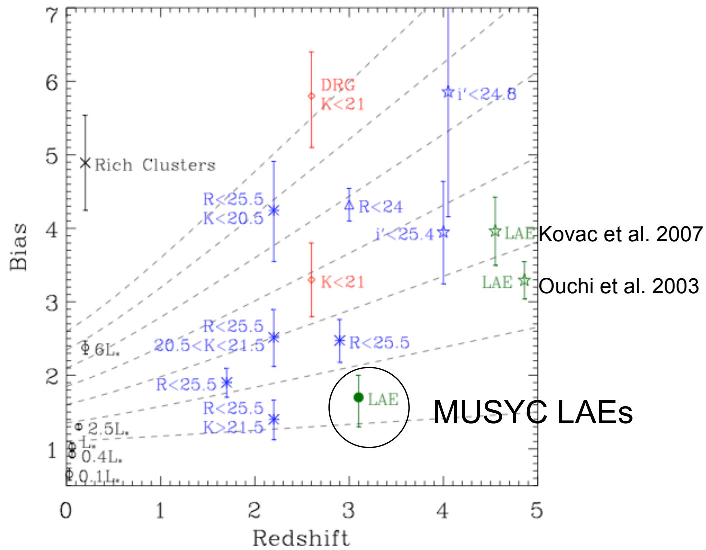


162 LAE candidates

Clustering analysis by H. Francke

LAEs at z=3.1 evolve into ~L* galaxies at z=0

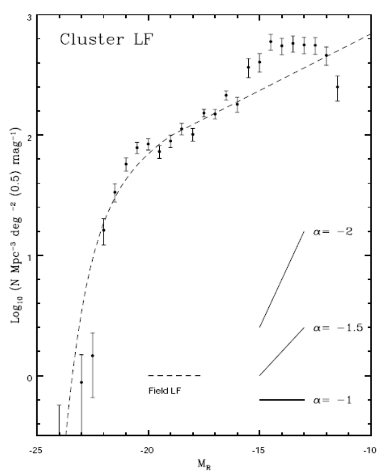
(Gawiser et al. 2007, Astro-ph/**0710.3384**)

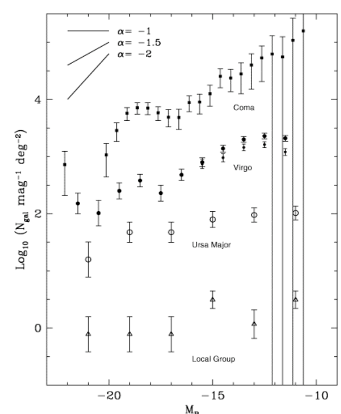


iii) Galaxy LF: The Faint End Mystery

(Christlein et al., 2007)

Galaxy counts in clusters suggest steep faint end...



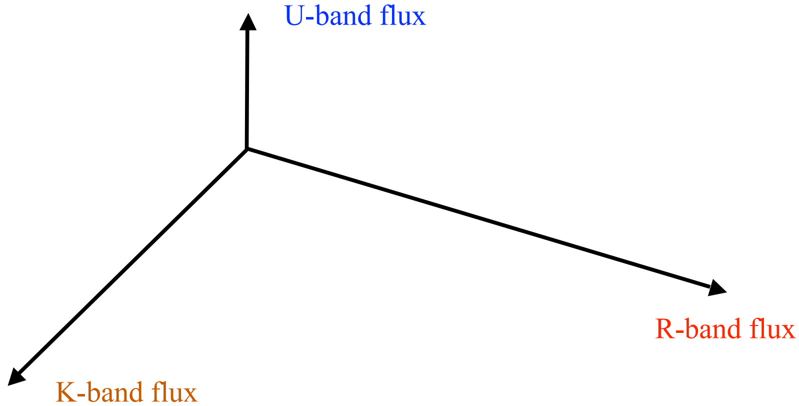


Trentham et al.

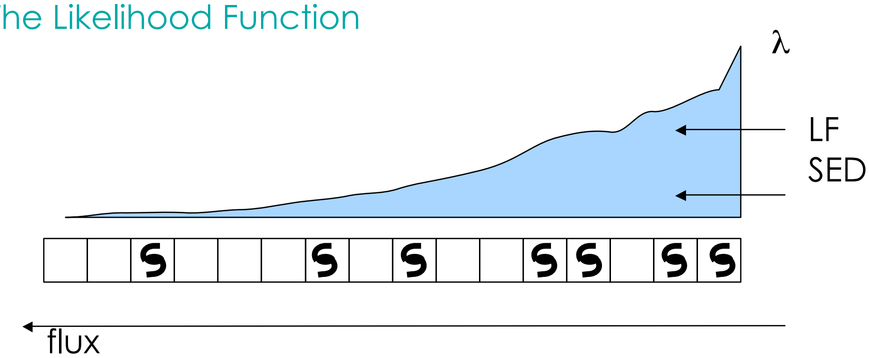
But no spectroscopic confirmation!

Nelson Padilla - ROE/JSPS Workshop 2007

A New Approach: Likelihood Calculation in Photometric Space



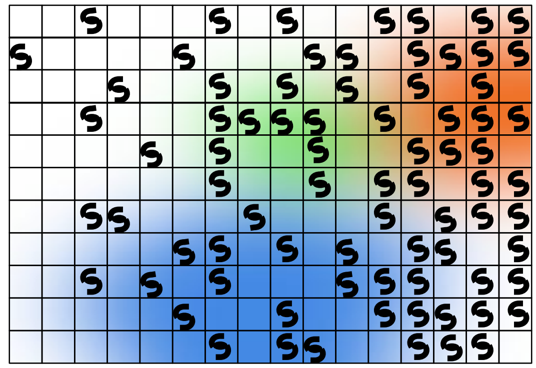
The Likelihood Function



$$L = e^{-\lambda} * e^{-\lambda} * \lambda e^{-\lambda} * e^{-\lambda} * e^{-\lambda} * e^{-\lambda} * \lambda e^{-\lambda} * e^{-\lambda} * \lambda e^{-\lambda} * \ldots$$

Product of Poisson Probabilities

The Likelihood Function in multi-dimensional Photometric Space

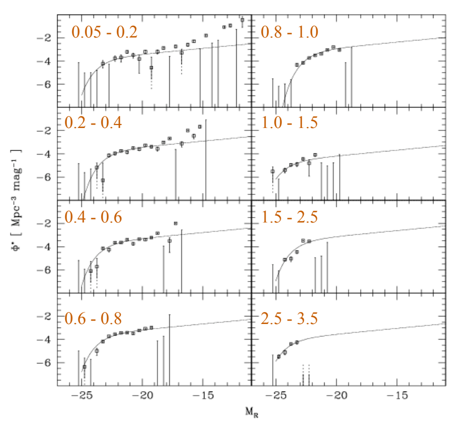


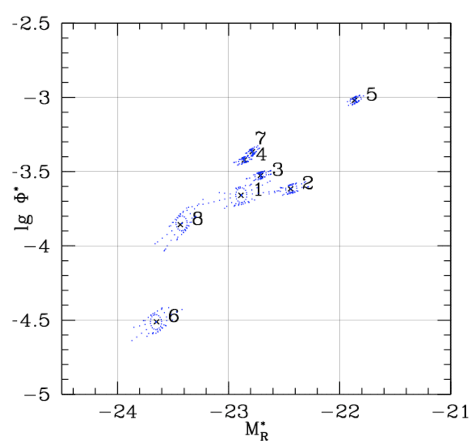
$$\lambda(\vec{f}_i) = \sum_{SED} \int dM_0\, dz_0 \left(\frac{dV_c}{dz}\right) \frac{p_\sigma(\vec{f}_i \mid M_0; SED; z_0)}{\prod_n \Delta_n} \phi(M_0; SED; z_0).$$

No galaxy population isolated => Likelihood is for LFs for ALL populations throughout ENTIRE cosmic history

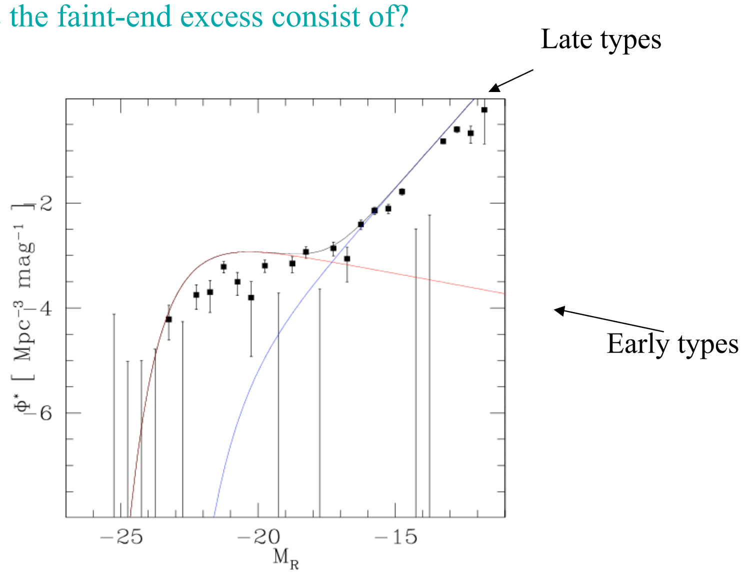
=> approach solution iteratively

LFs as a function of redshift



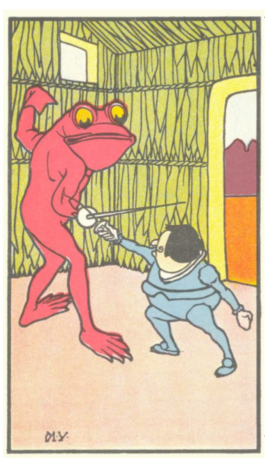


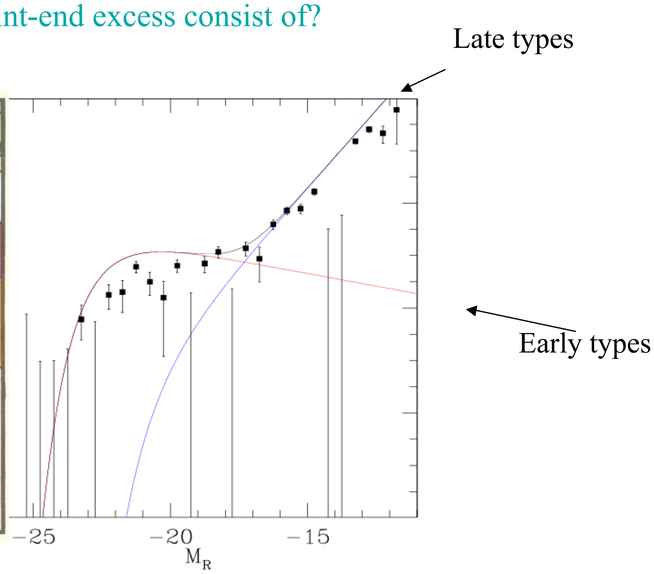
What does the faint-end excess consist of?



Individually-fitted late and early type LFs reproduce the upturn

What does the faint-end excess consist of?





Individually-fitted late and early type LFs reproduce the upturn

Nelson Padilla - ROE/JSPS Workshop 2007

Conclusions

- Clustering of MUSYC galaxies out to z=1 higher than expected for mass in volume limited sample -- luminous galaxies reside in roughly equally massive haloes.
- LAEs are galaxies observed in the act of formation, having formed most or all of their stellar mass ($<10^9 M_\odot$) in the ongoing starburst.
- LAEs have dark matter halo masses of $\sim 10^{11} M_\odot$ and should evolve into $\sim L_*$ galaxies at z=0.
- The LF of MUSYC galaxies shows a steep faint-end at low-z where the sample is composed mostly by faint galaxies.