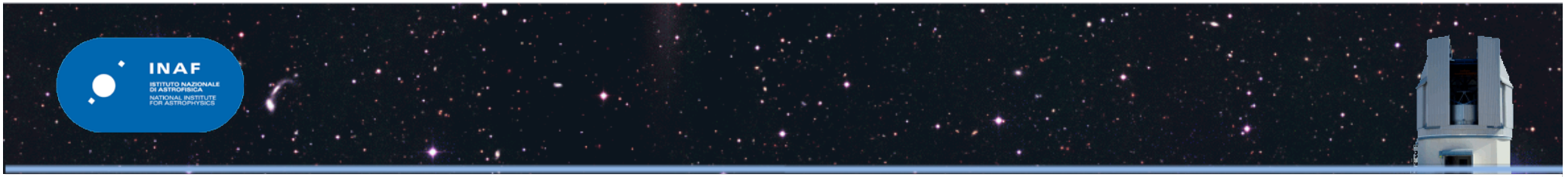


The SUDARE/VOICE INAF VST GT Survey

Galaxy Evolution, AGN Variability and Supernova Host Galaxies with VST

Mattia Vaccari

SKA South Africa Post Doctoral Fellow
University of the Western Cape, Cape Town
mattia@mattiavaccari.net www.mattiavaccari.net

Enrico Cappellaro, Giovanni Covone, Giuliano Pignata, Maria Teresa Botticella
Lino Grado, Luca Limatola, Lucia Marchetti, Maurizio Paolillo, Mario Radovich
Massimo Capaccioli, Alberto Franceschini, Nicola Napolitano
ESO Surveys Workshop - 15-18 Oct 2012

The SUDARE/VOICE INAF VST GT Survey The Deaths of Stars & The Lives of Galaxies

- A Supernova Search Survey (SUDARE) and a Medium-Deep Extragalactic Imaging Survey (VOICE) long identified as projects to be pursued within the INAF VST GT Program

- In 2009 SUDARE and VOICE proposed as separate projects

- SUDARE wanted access to well-known extragalactic fields and would provide substantial amounts of imaging data at sub-arcsec resolution

- VOICE to observe where optical imaging of deep Spitzer/VISTA fields was still shallow and to fill in where SUDARE-only imaging depth would not be satisfactory (CDFS/ES1)

- In 2010 SUDARE and VOICE merged to maximize science output of INAF VST GT and multi-wavelength synergies

- SUDARE observations have been ongoing for a year

Extended CDFS Field

Extant Optical Data

MUYSC 32-band imaging to 26 (AB) over 0.25 deg^2

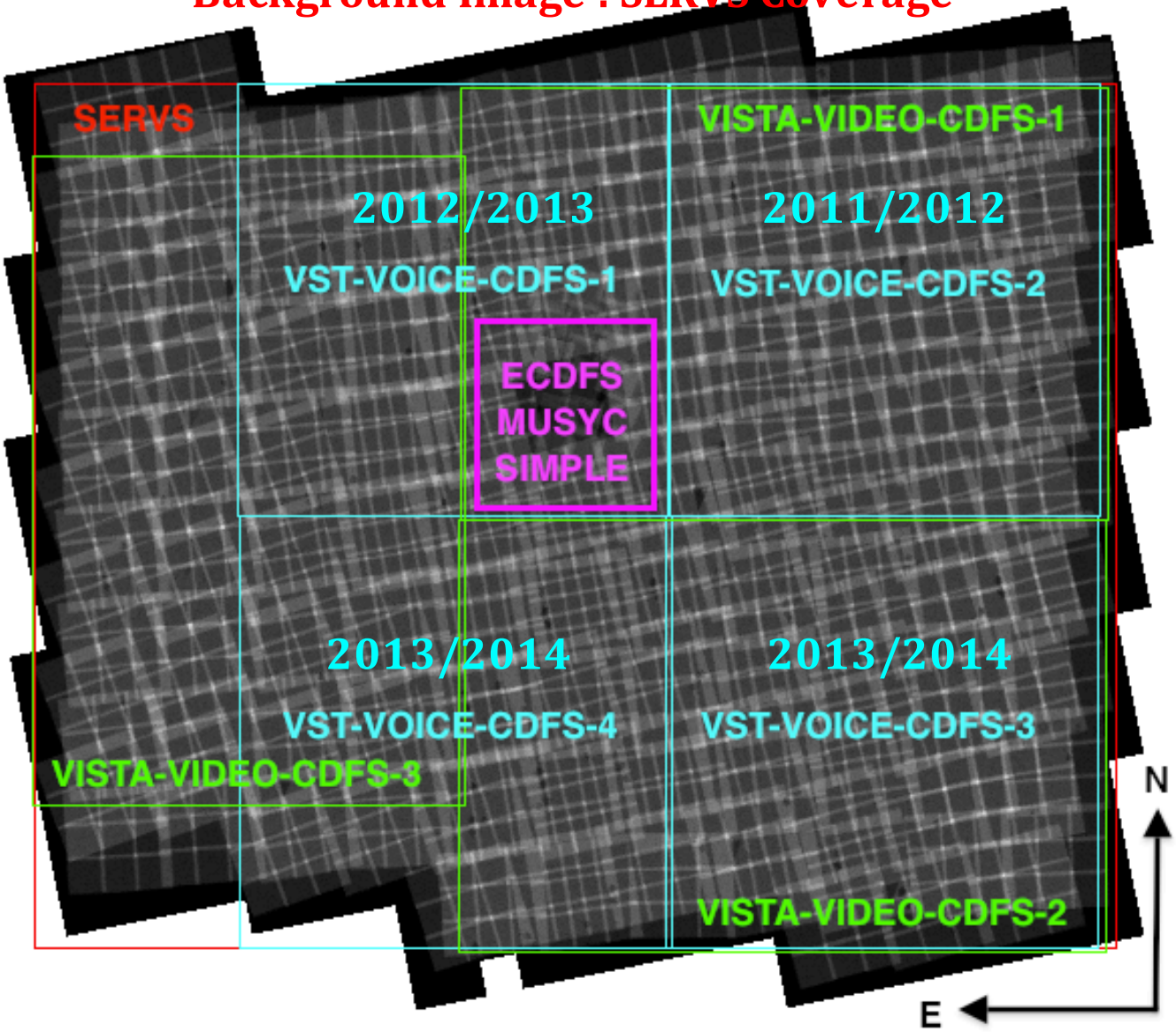
SWIRE ugri imaging to 24 (AB) over 4 deg^2

Observing Plan

Piggy-Backing on SUDARE for 2011/2012 & 2012/2013

VOICE Ramping Up from 2013/2014 onwards

Background Image : SERVS Coverage



Extended ES1 Field

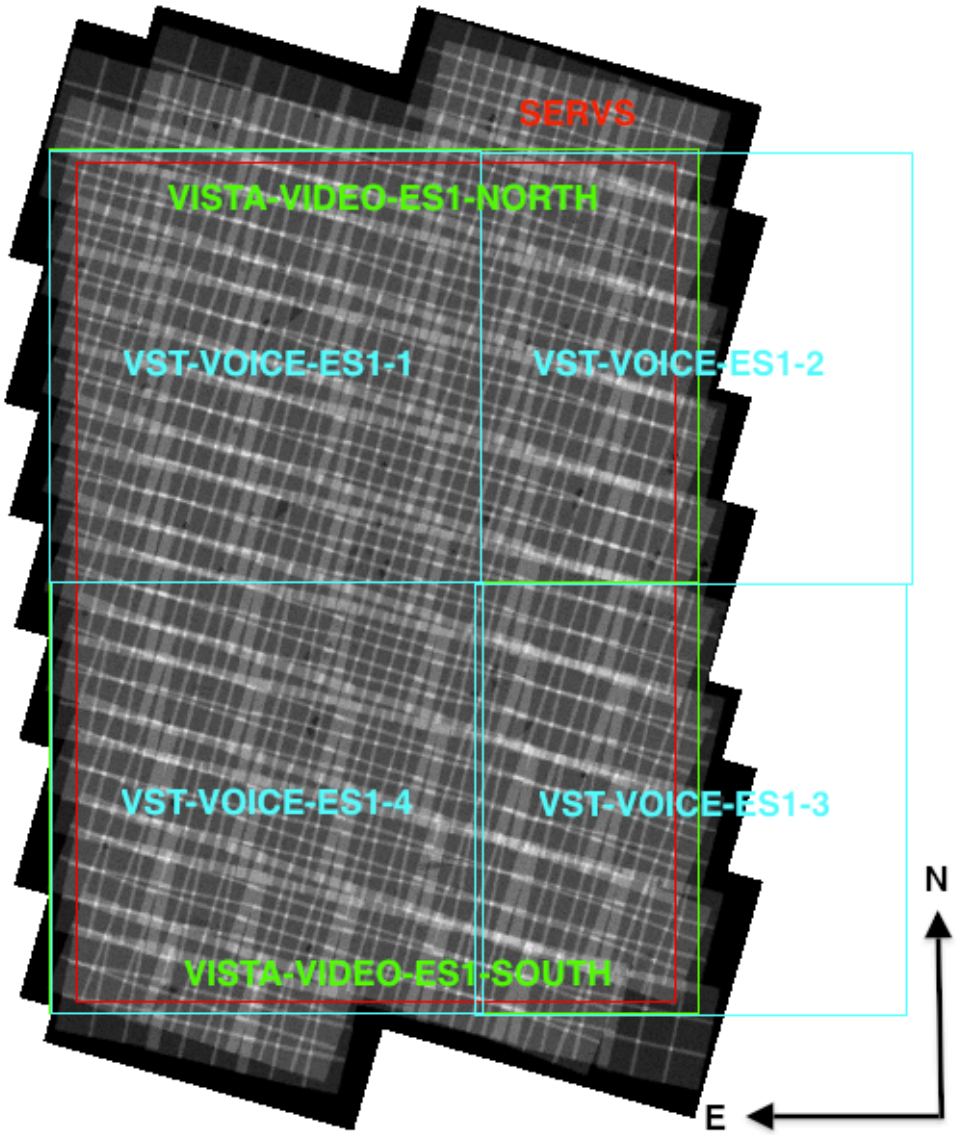
Extant Optical Data

ESIS BVRI imaging
to 24.5 (AB) over 4 deg^2

Observing Plan

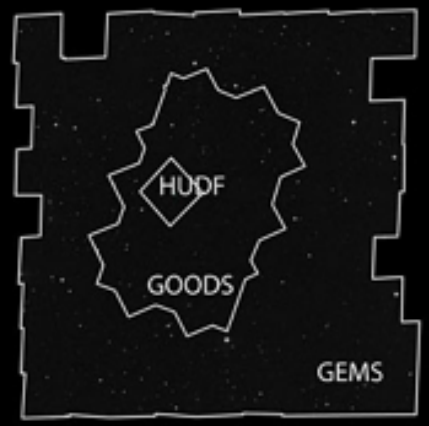
TBC
After Survey Review in 2014

Background Image : SERVS Coverage

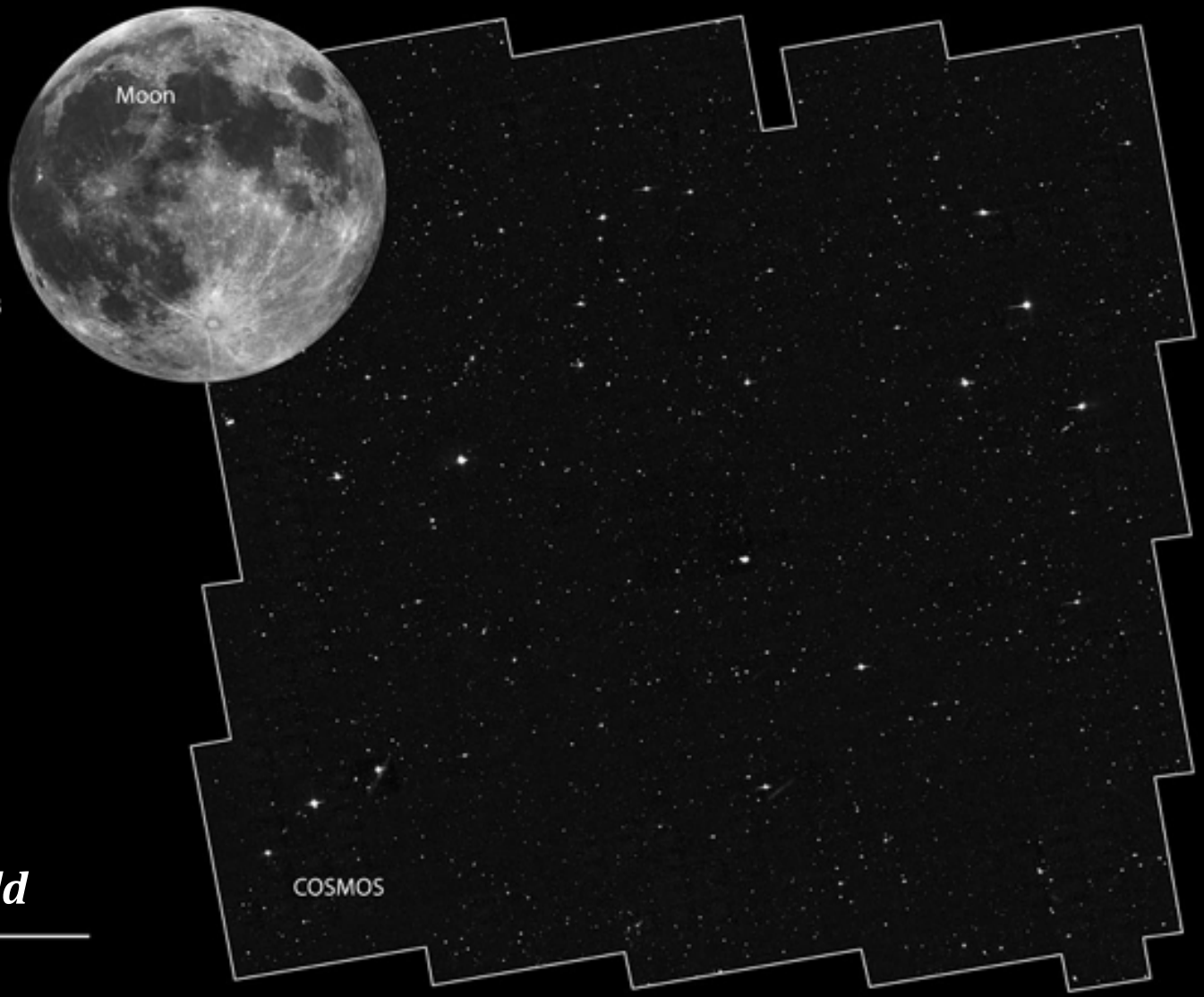


COSMOS Field

"It will be like being on the Moon and being able to recognize buildings in New York and trucks on Broadway"
Nick Scoville, 2003



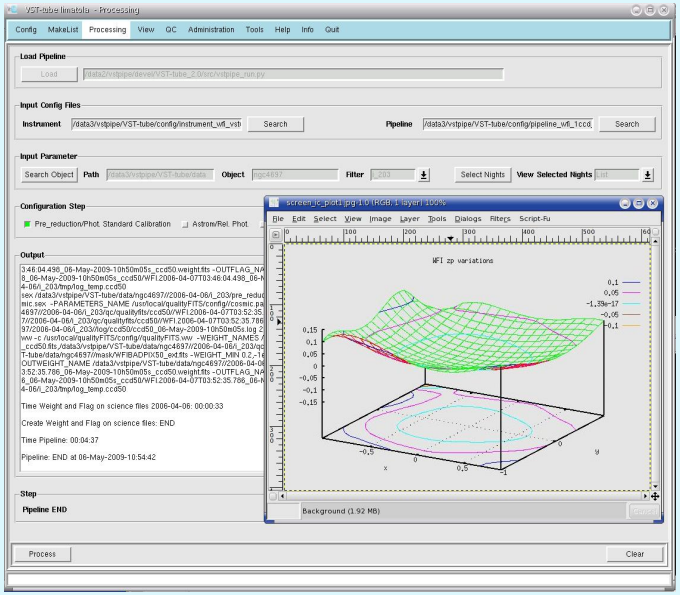
SUDARE Extension in Chilean Time
NB : UltraVISTA Field

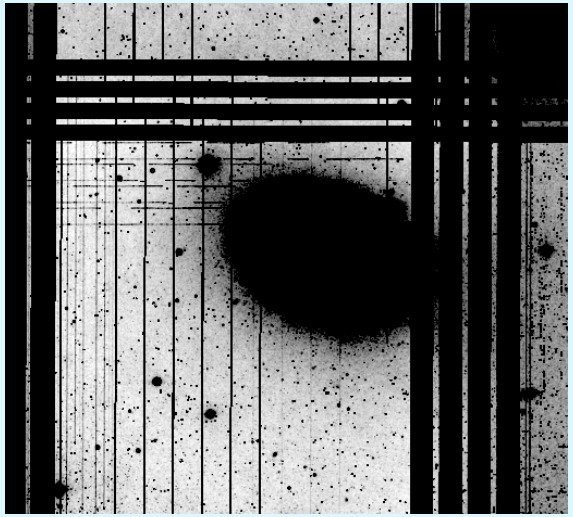


Vst Tube

Pipeline Developed in Naples by **Grado & Limatola**

- *From raw to fully calibrated images (multi-instrument support)*
- *Tailored on surveys needs*
- *GUI to facilitate processing and administration*
- *Includes a growing set of analysis tools*
- *Supported surveys: VEGAS, ACCESS, SUDARE, VOICE, STEP, STREGA, COSMOS (Chilean GTO)*



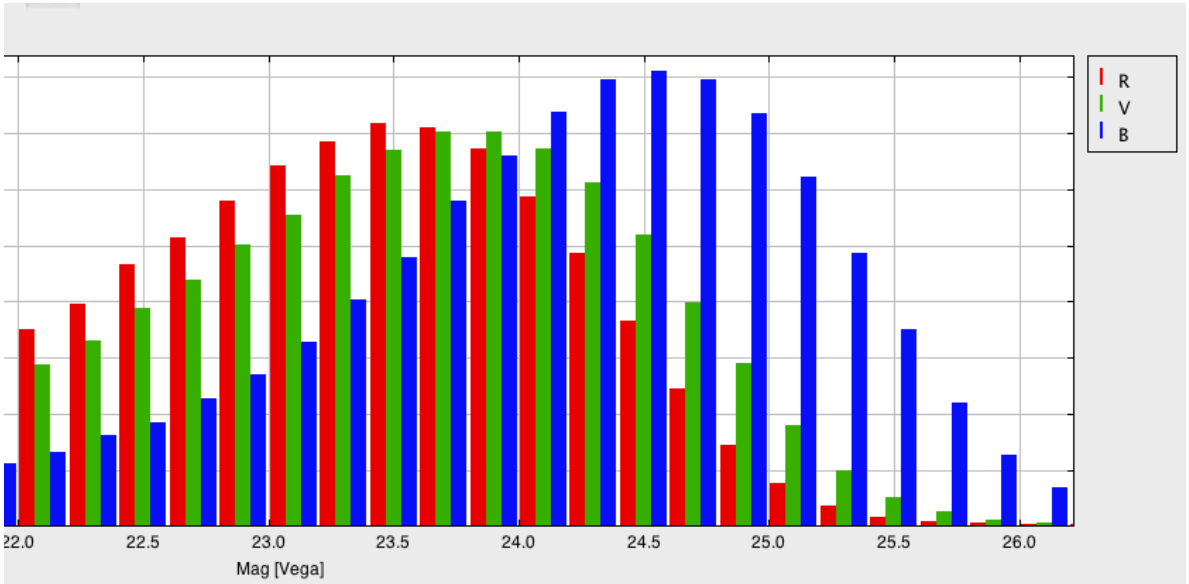


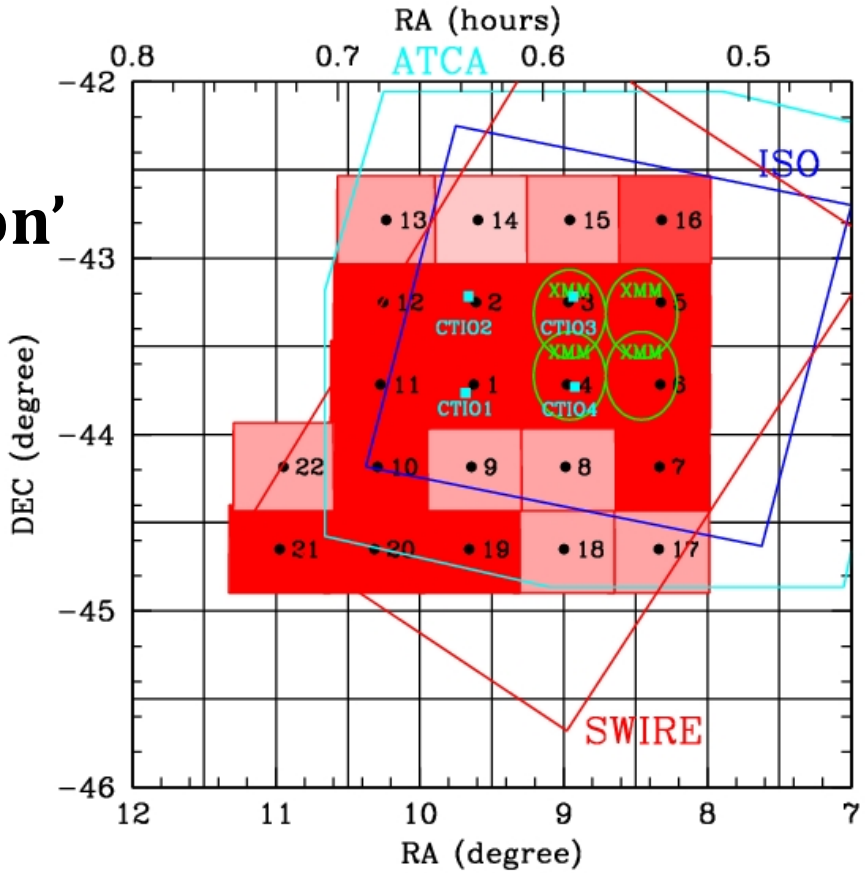
True noise map propagation
NGC4697 Weight map section

VST-Tube ESIS Data Reduction

ESIS WFI BVR Imaging Data over 4.5 deg^2
ESO Large Program (PI : Franceschini, Observed 2001-2006)
http://www.astro.unipd.it/esis

Completing ESIS Data Reduction
Prototyping VOICE Data Reduction
Integration within Spitzer 'Data Fusion'





VST Data Reduction Challenges

Data Reduction currently driven by SN search needs

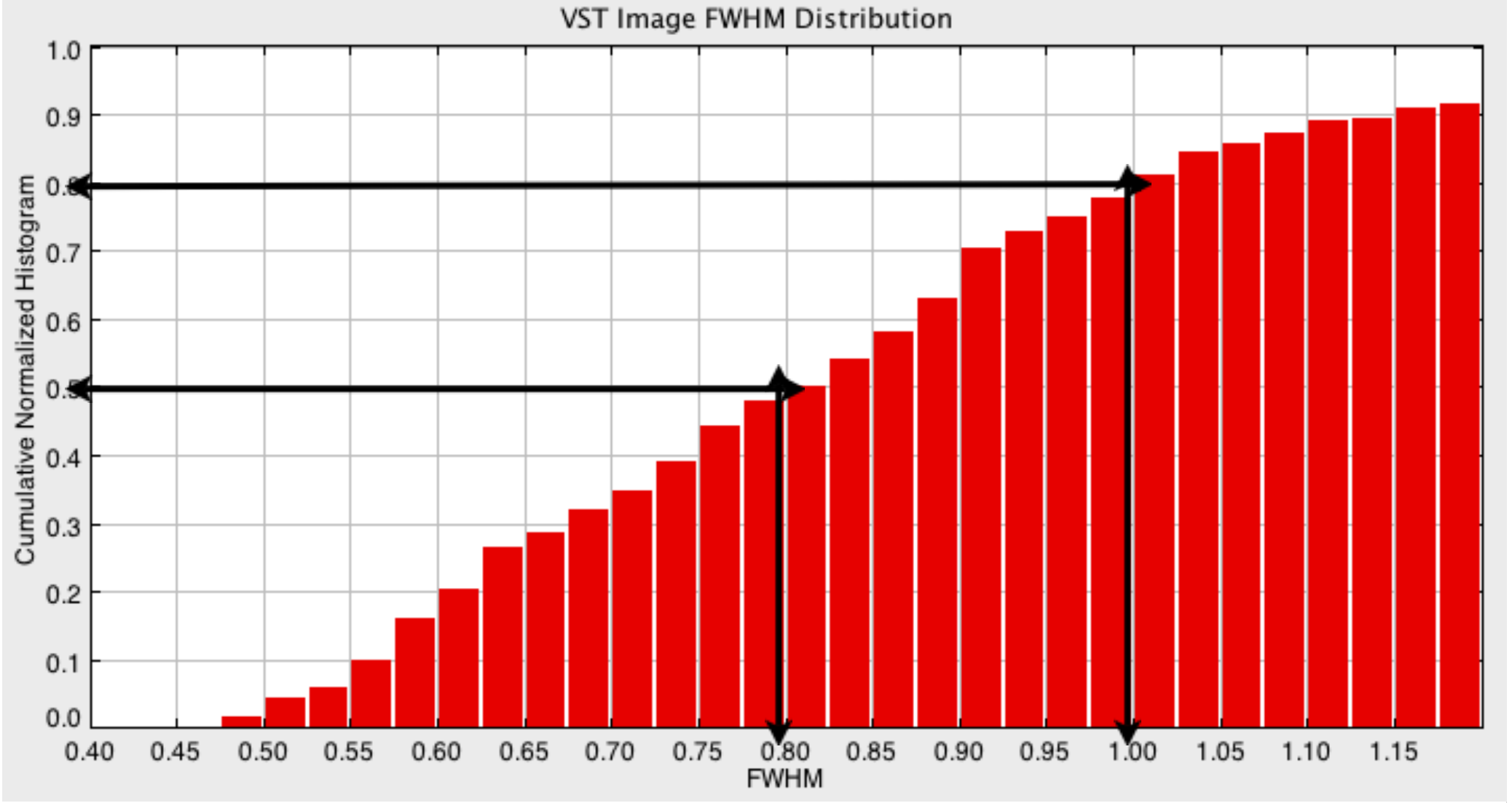
Single Epochs as well as Deep Stacks (Reference Images) routinely produced

Still early days, but learning from other VST GT projects as well as KIDS-ATLAS

CDFS-2 gri Three-Color Image

Mattia Vaccari

VST Image FWHM Distribution



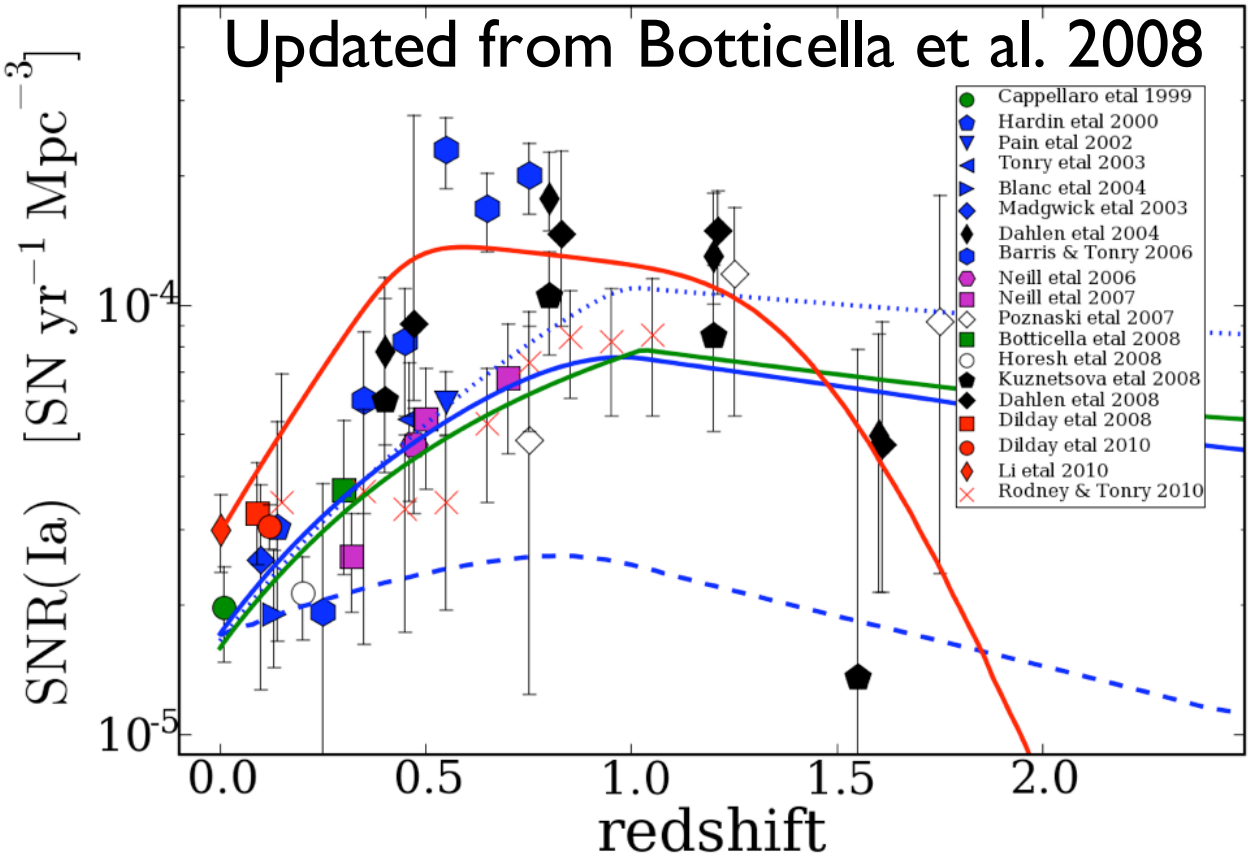
Can achieve sub-arcsec resolution ~80% of the time

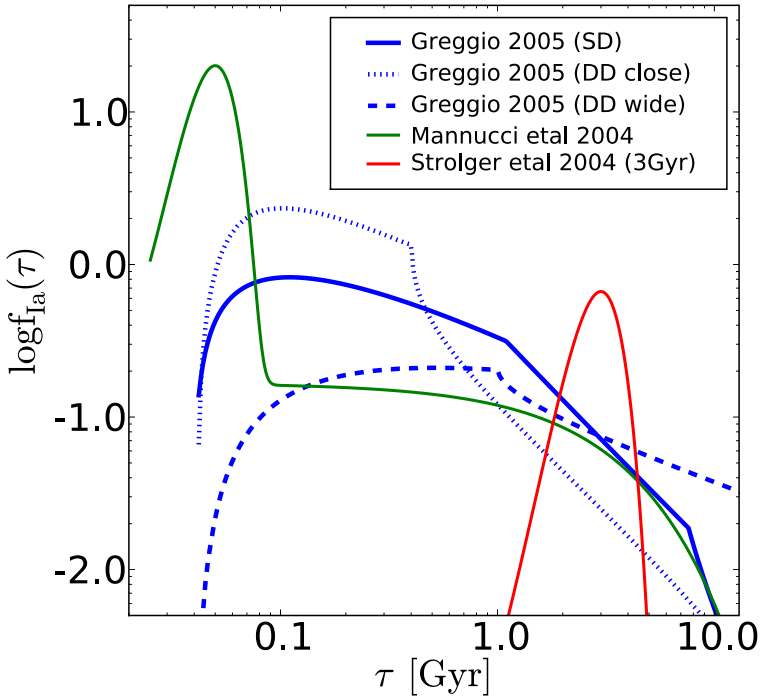
Supernova diversity and rate evolution
SUDARE - Cappellaro/Pignata

Why SN rates?

- Link progenitor and stellar evolution scenarios
- Probe star formation history and nucleosynthesis
- Test scenarios for compact objects formation (NS and BH) or extreme events (GRB)
- Support search programs for neutrinos & GW

SNIa Rate Evolution





Measuring SNIa Rates & Confronting SN DTD Models

Supernova diversity and rate evolution
SUDARE

Fields : CDFS 03 32 13 -27 50 00 (PI : Cappellaro - INAF GT)
COSMOS 10 00 28 +02 12 21 (PI : Pignata - Chilean Time)

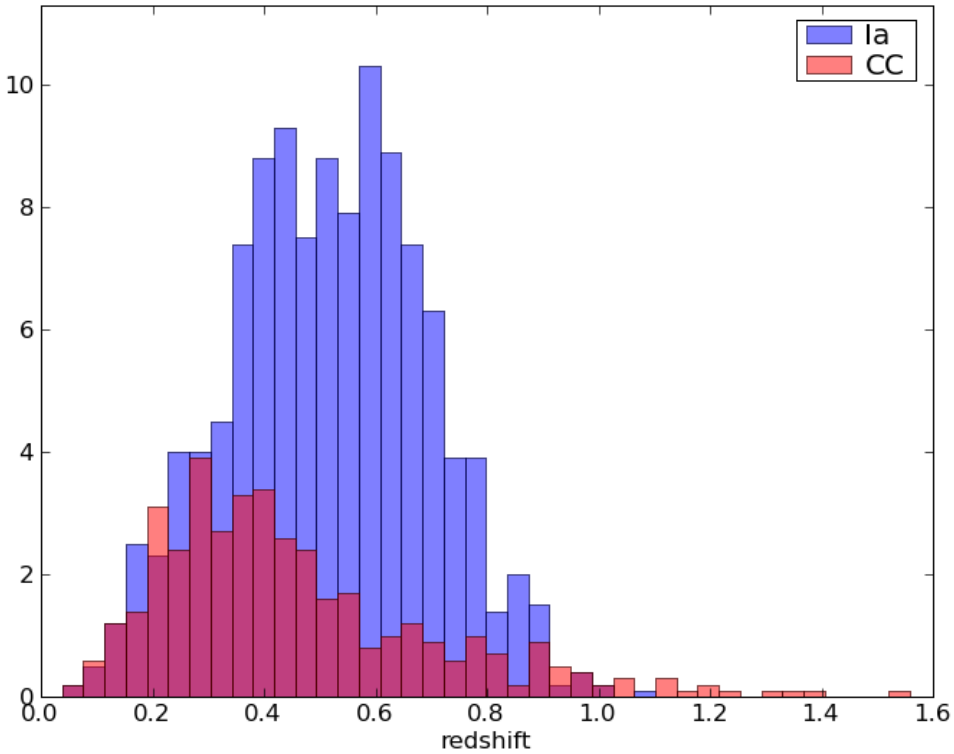
r-band exposure every 3 day
g,i band colors once 10 days

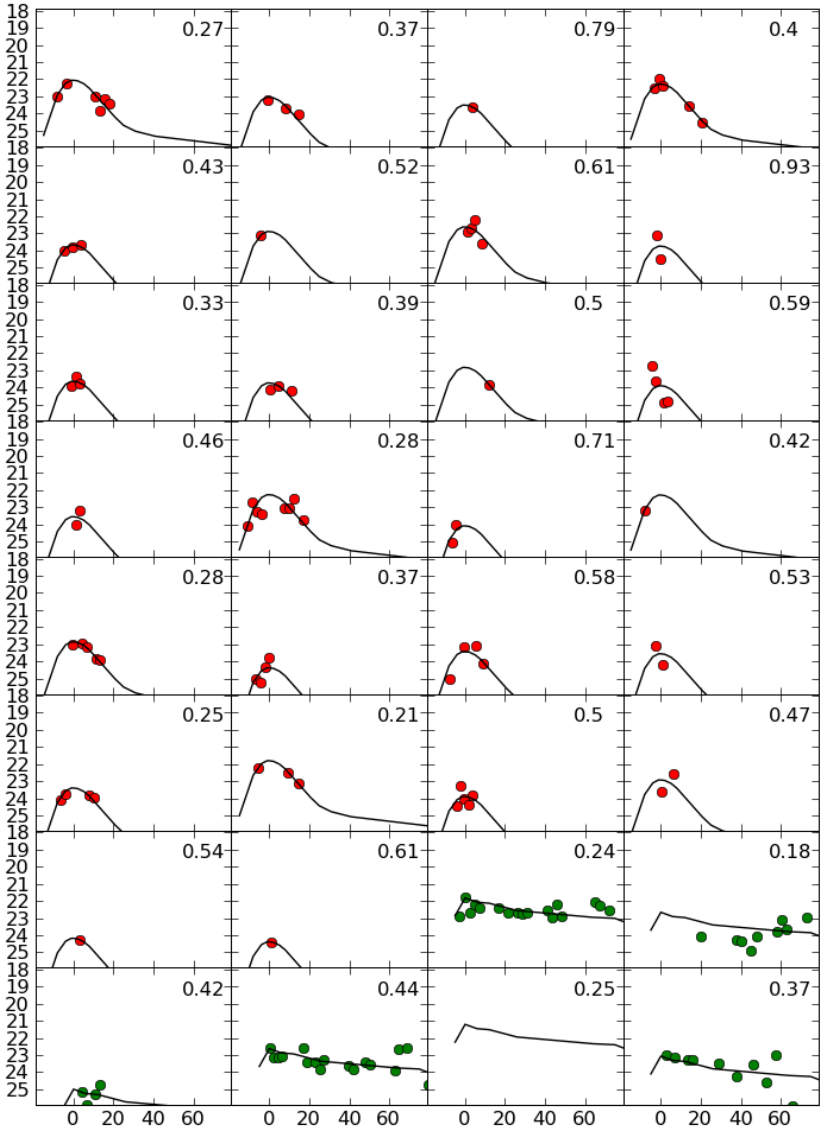
Synergy with VOICE by Covone, Vaccari et al.

	x field & x year	x field & x year
		exposures : 30 min
Search run	45 hr	epochs : (up to) 60 in r and 15 in gi
Color photometry	25 hr	
Time request :		70 hr / yr / field

SN Search Simulation

Expected Detections
50 SNe / field / season
(200-300 in 4 years)





SN Search Process

- All new epochs are compared against two different references.
For the image difference with psf match we use Andrew Becker's ***hotpants*** (http://www.astro.washington.edu/users/becker/hotpants.html)

- Variable objects are searched with ***sextractor***. Source are assigned a score based on different measured parameters (eg. FWHM, flux radius, distance from saturated stars, etc.)

- The candidate catalog (typically containing a thousand objects) is cross-matched (using ***stilts***) with a reference catalog of sources (derived from a stacked deep image) and with archival SWIRE optical catalogs

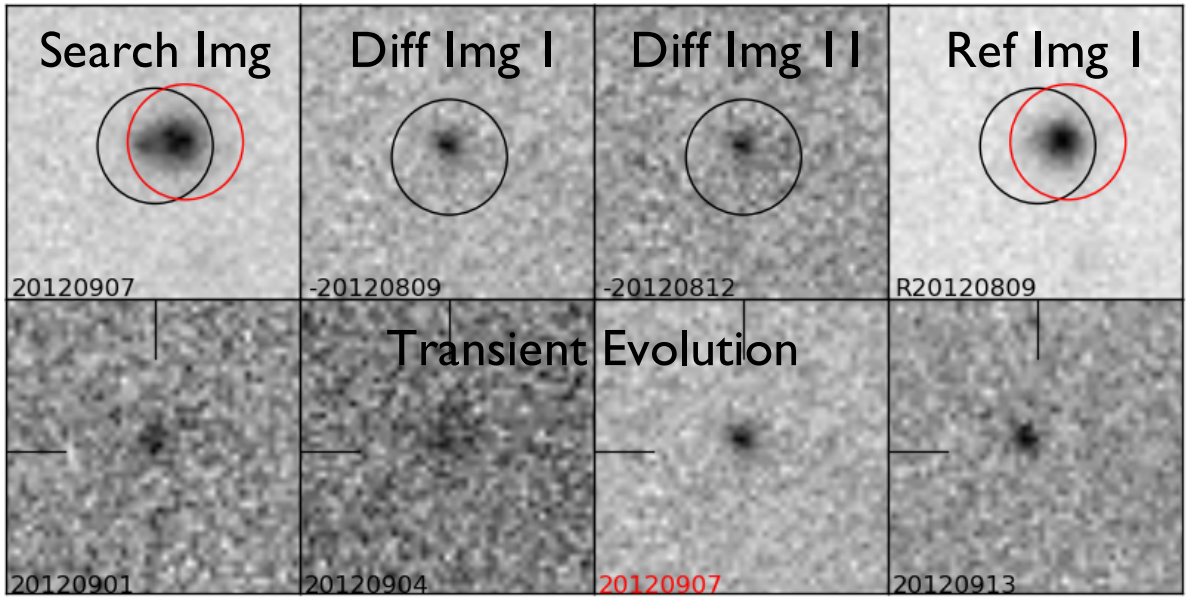
- Best ranked candidates (typically a hundred) are visually inspected

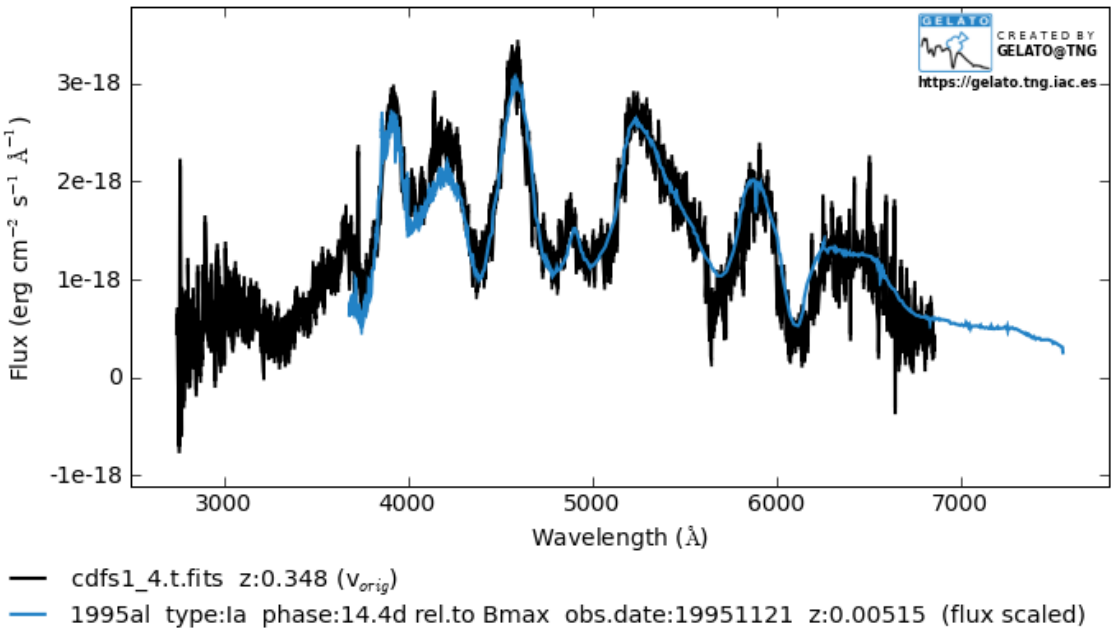
- Selected SN candidates (typically five to ten per image) are included in the follow up list

#4 RA= 3:35:16.368 DEC=-27:29:49.21 [105]

	xc	yc	fwhm	fl rad	mag auto	mag aper	cl star
dif1	2551.37	10730.98	4.78	2.59	22.84	22.85	0.93
dif2	2551.30	10730.99	4.27	2.27	23.48	23.39	0.71
_ref	2556.61	10731.65	8.07	3.97	20.69	20.76	0.02

d= 0.35
z= ---





First confirmed SN candidates (CBET 3236)

SN 2012ez A in VOICE-CDFS-1 field

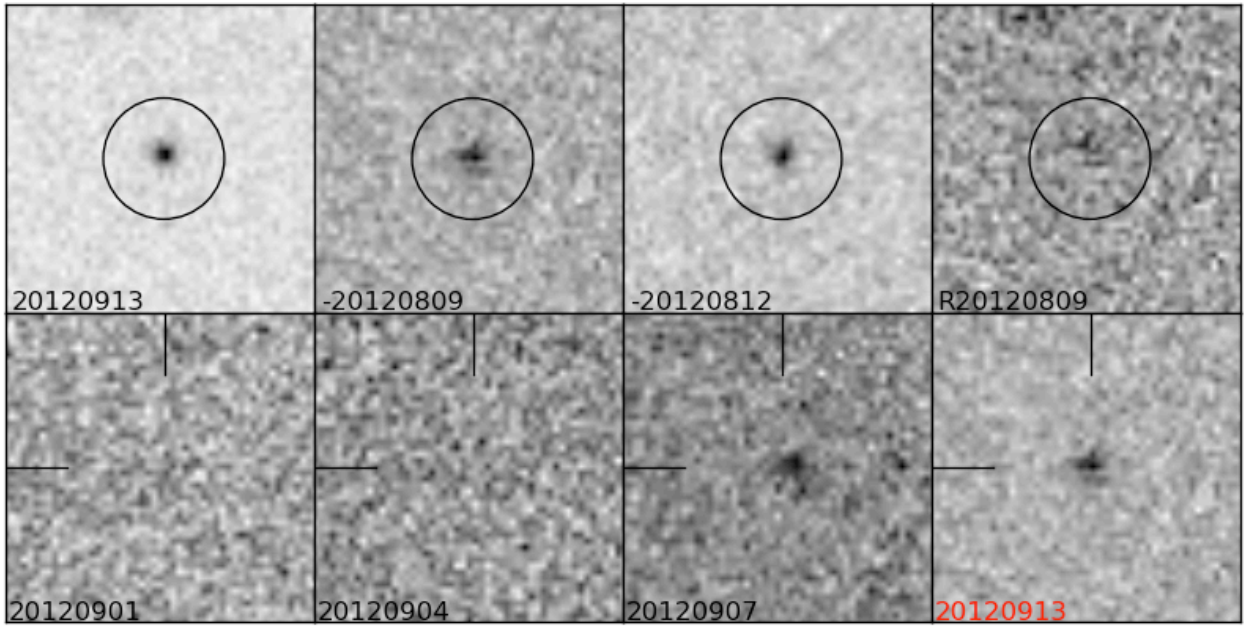
2012 UT	R.A.	Decl.	Mag.	Offset
Sep. 8.30	3:35:16.368	-27:29:49.21	23.2	1".1 E, 0".1 S

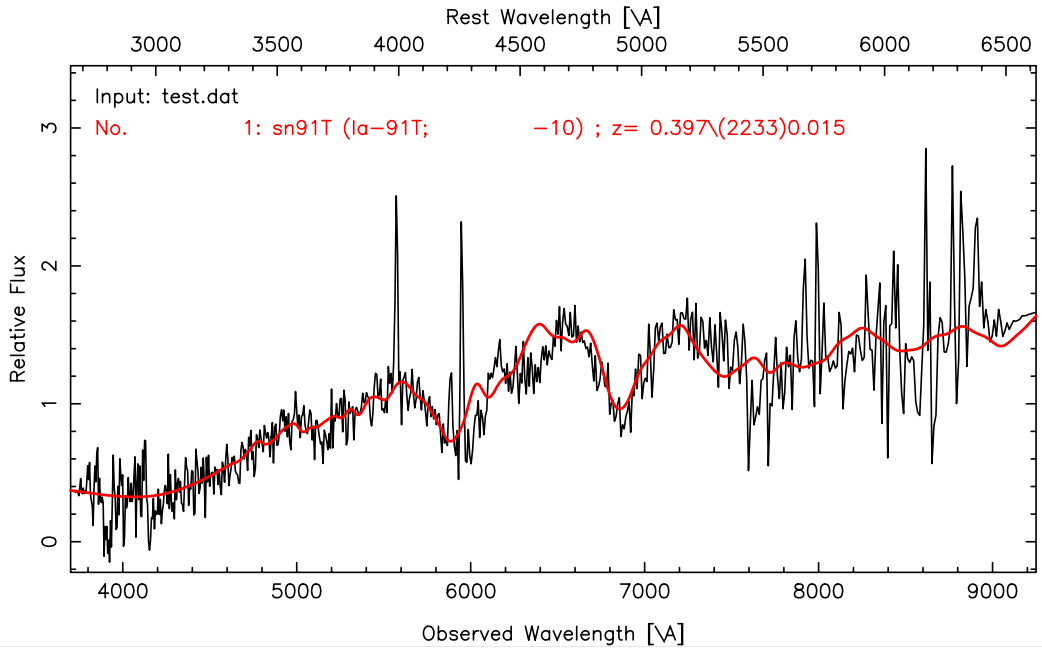
A spectrogram of 2012ez, obtained on Sept. 14.28 UT with the ESO Very Large Telescope Antu (+ FORS2; range 370-920 nm, resolution 10 nm), shows the typical features of a normal type-Ia supernova. Adopting a redshift z =0.348, as measured from a number of narrow lines of the host galaxy, the best fit with the GELATO tool (Harutyuyan et al. 2008, A.Ap. 488, 383) in a library of supernova spectra is with SN 1995al at fourteen days past maximum (Anupama et al. 1997, A.J. 114, 2054). The ejecta expansion velocity, derived from the position of the Si II doublet, is 11300 km/s.

#27 RA= 3:34:59.022 DEC=-27:51:55.43 [60]

	xc	yc	fwhm	fl rad	mag auto	aper	cl star
dif1	3666.64	4419.02	4.66	2.36	23.42	23.39	0.94
dif2	3666.74	4419.63	3.92	1.92	23.55	23.41	0.96

d= ---
z= ---





First confirmed SN candidates (CBET 3236)

SN 2012fa in VOICE-CDFS-1 field

2012 UT	R.A.	Decl.	Mag.	Offset
Sep. 14.24	3:34:59.022	-27:51:55.43	23.4	--

A spectrogram of 2012fa, which is located at the center of a very faint galaxy, was obtained on Sept. 15.27 (as above). Cross-correlation with a library of supernova spectra using the Supernova Identification tool (SNID; Blondin and Tonry 2007, Ap.J. 666, 1024) shows that the object is very similar to the bright type-Ia supernova 1991T at ten days before maximum (Ruiz-Lapuente et al. 1992, Ap.J. 387, L33) when placed at a redshift, z, of about 0.4. As for SN 1991T at this phase, the Si II doublet is barely visible.

VST SN Search Image Acquired Sep 14th

acquisition
transfer to Naples
calibration with VST-Tube
transfer to Padova
SN candidate detection
web publishing
spectroscopic observation with FORS2
SN candidate confirmation & classification

UT2 SN Candidate Confirmation Sep 15th

Data calibration (VST-Tube)	Grado, Limatola, Capaccioli
SN Search tools	Cappellaro, Botticella, Pignata
Galaxy characterisation	Vaccari, Covone, Paolillo, Marchetti
Transient characterisation	Benetti, Pastorello, Tomasella, Turatto

Vst Optical Imaging of the Cdfs & Es1

Survey Specs:

VST ugri Optical Survey of the CDFS & ES1 Fields (4 + 4 deg^2) to m_{AB}~26

Extant & Future Ancillary Data:

- GALEX (FUV & NUV)
- Spitzer IRAC & MIPS 3.6-160 micron 7-band (SWIRE)
- NIR (VISTA-VIDEO ZYJHK)
- MIR (Spitzer-SERVS IRAC 3.6 and 4.5 micron)
- FIR/SMM (Herschel-HerMES 100/160/250/350/500 micron)
- ATCA (ATLAS) 1.4 GHz Medium-Deep Radio Continuum
- MeerKAT (MIGHTEE) 1.4 GHz Ultra-Deep Radio Continuum
- PRIMUS/CSI Optically/Spitzer-Selected Spectroscopic Follow-Up
- Photometric redshifts available on smaller areas (0.25 deg^2, Cardamone+ 2010) and/or based on shallower data (m_{AB}~24, Rowan-Robinson+ 2012)

VOICE Science Rationale

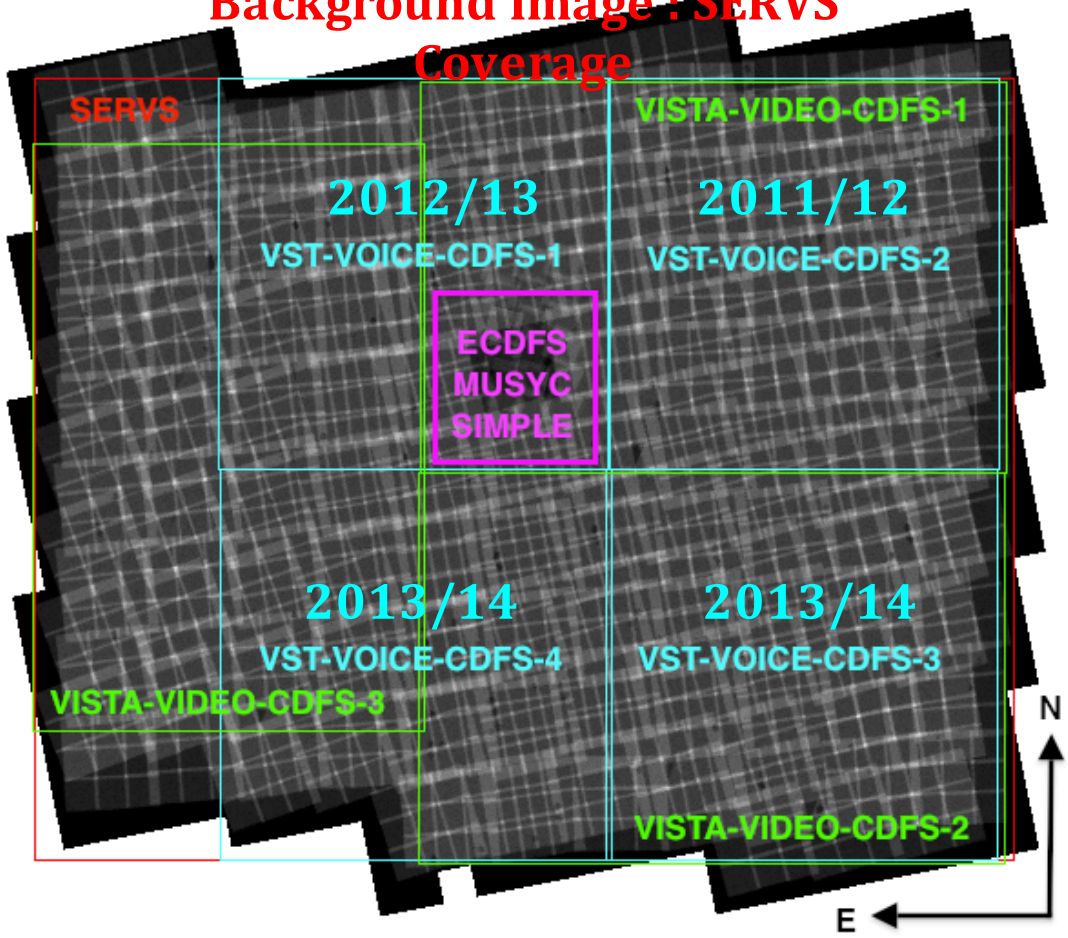
Science Goals

z<0.5
- morphological mix as a function of
  - stellar mass
  - star formation rate
  - local environment
- constrain the mass assembly history of galaxies and their star formation rates

z~0.5
weak lensing to detect massive clusters (10^{14} M_{sun}) and determine 2D total mass distribution

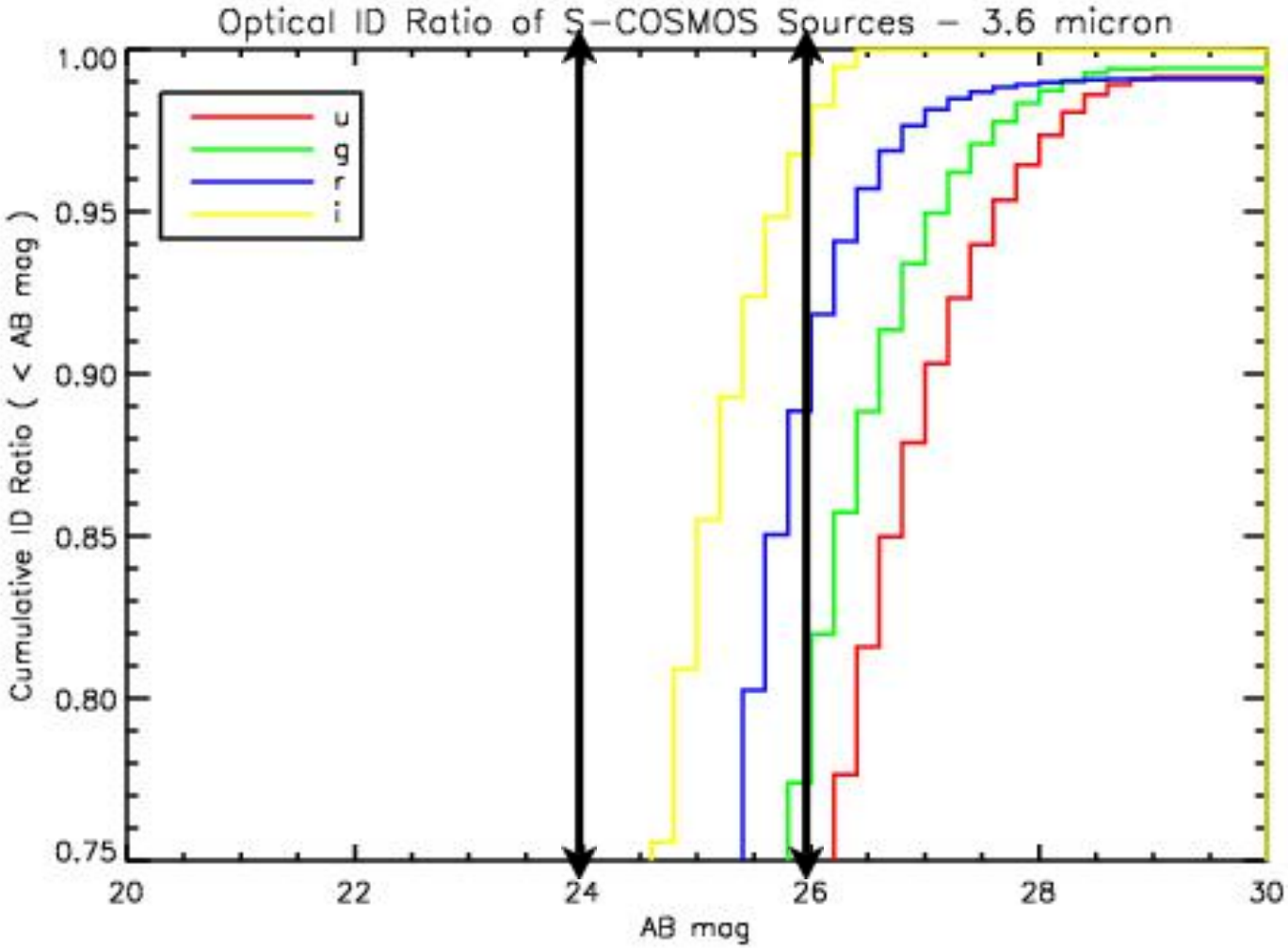
z>0.5
(combined with NIR/MIR/FIR/SMM/Radio) large sample of ~M* galaxies enabling studies of cosmic star formation history

Background Image : SERVS Coverage



NB : Most survey science only kicking in close to survey completion

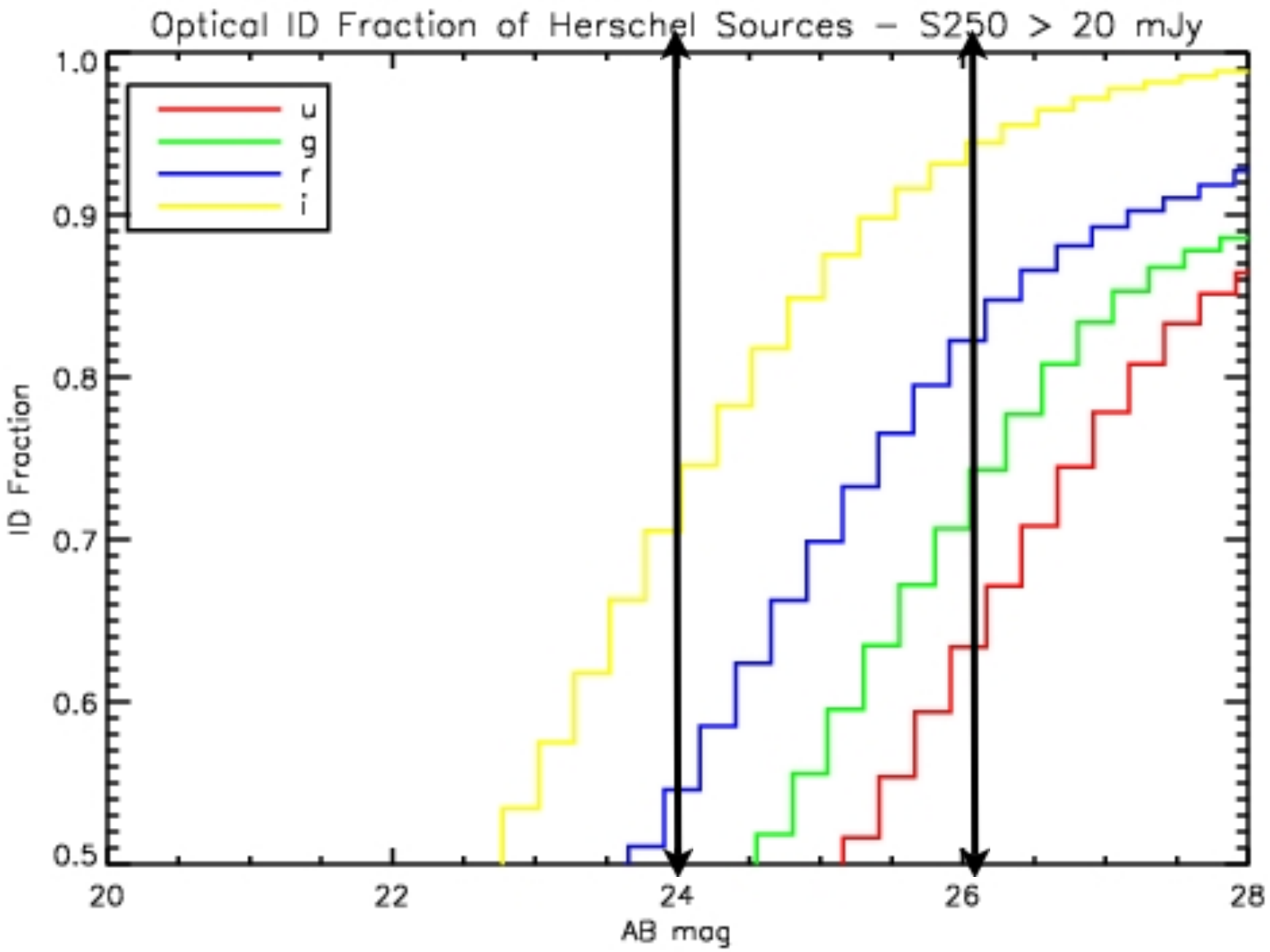
Spitzer Optical IDs



Multi-Band Deeper Ancillary Data (Moving from 24 to 26 in AB) are key to detect the bulk of the Spitzer population (and search for high-z dropouts)

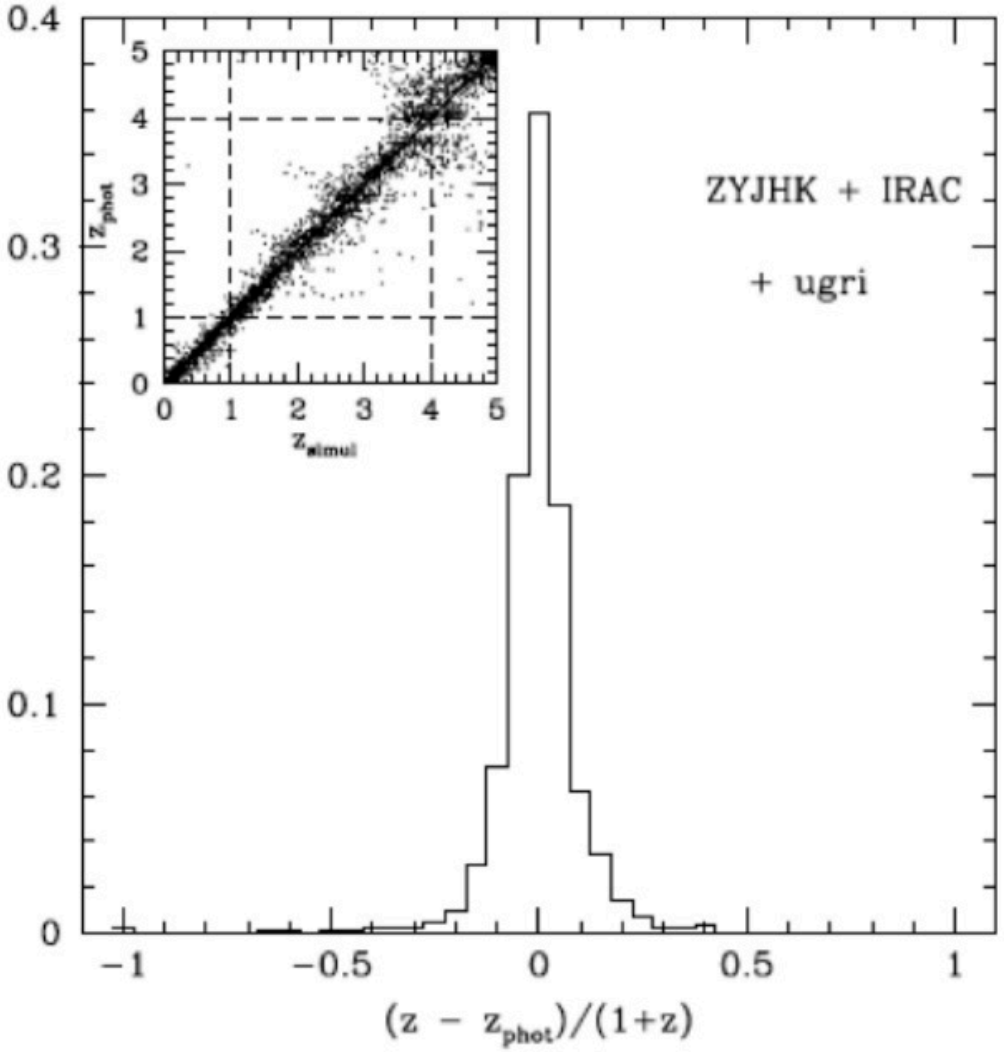
Herschel Optical IDs

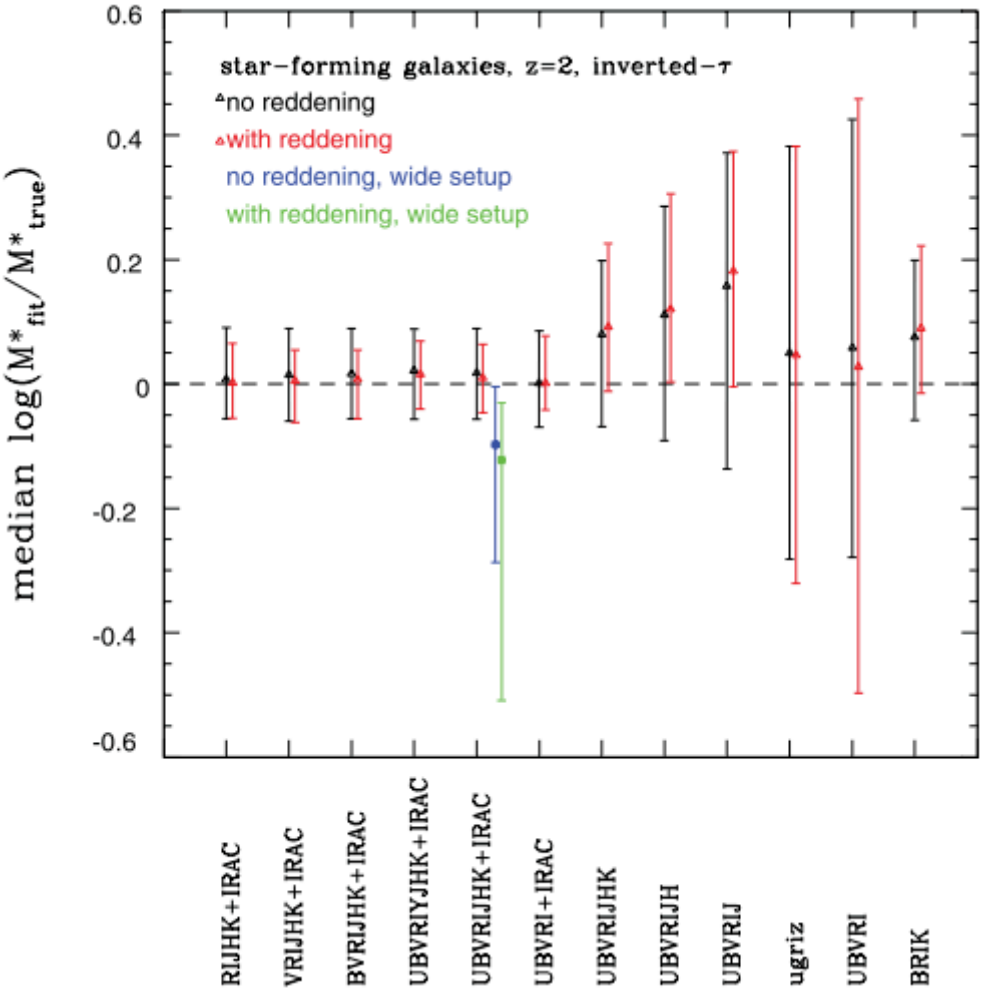
Detect Herschel Sources Down To Herschel Confusion Limit



Based on Xu's M

Phot-z's & Stellar Masses





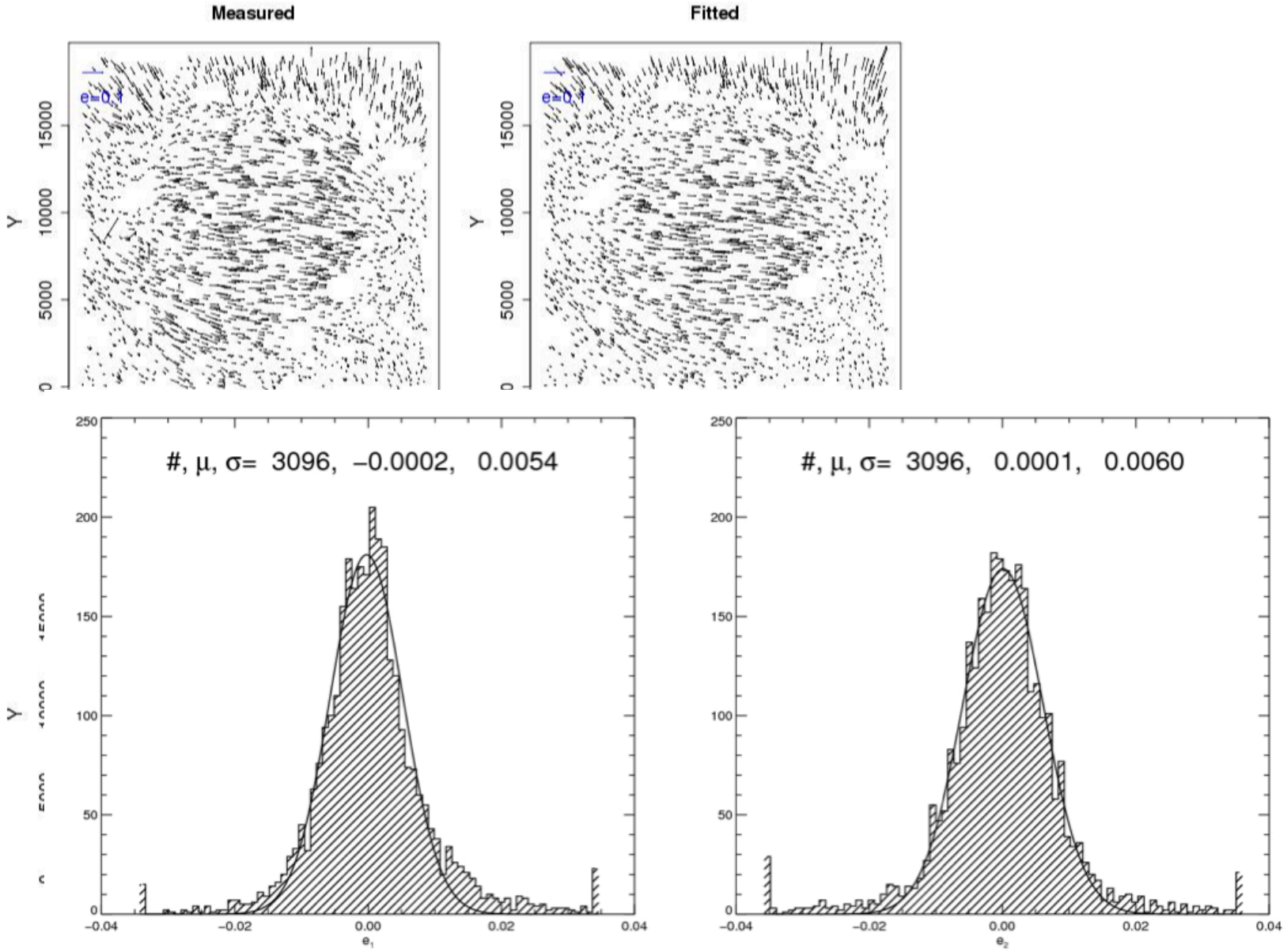
Simulations by Janine Pforr et al. 2012 using Maraston Models

VST COSMOS Field
Weak Lensing Analysis
(Giovanni Covone & Corinne Tamburis)

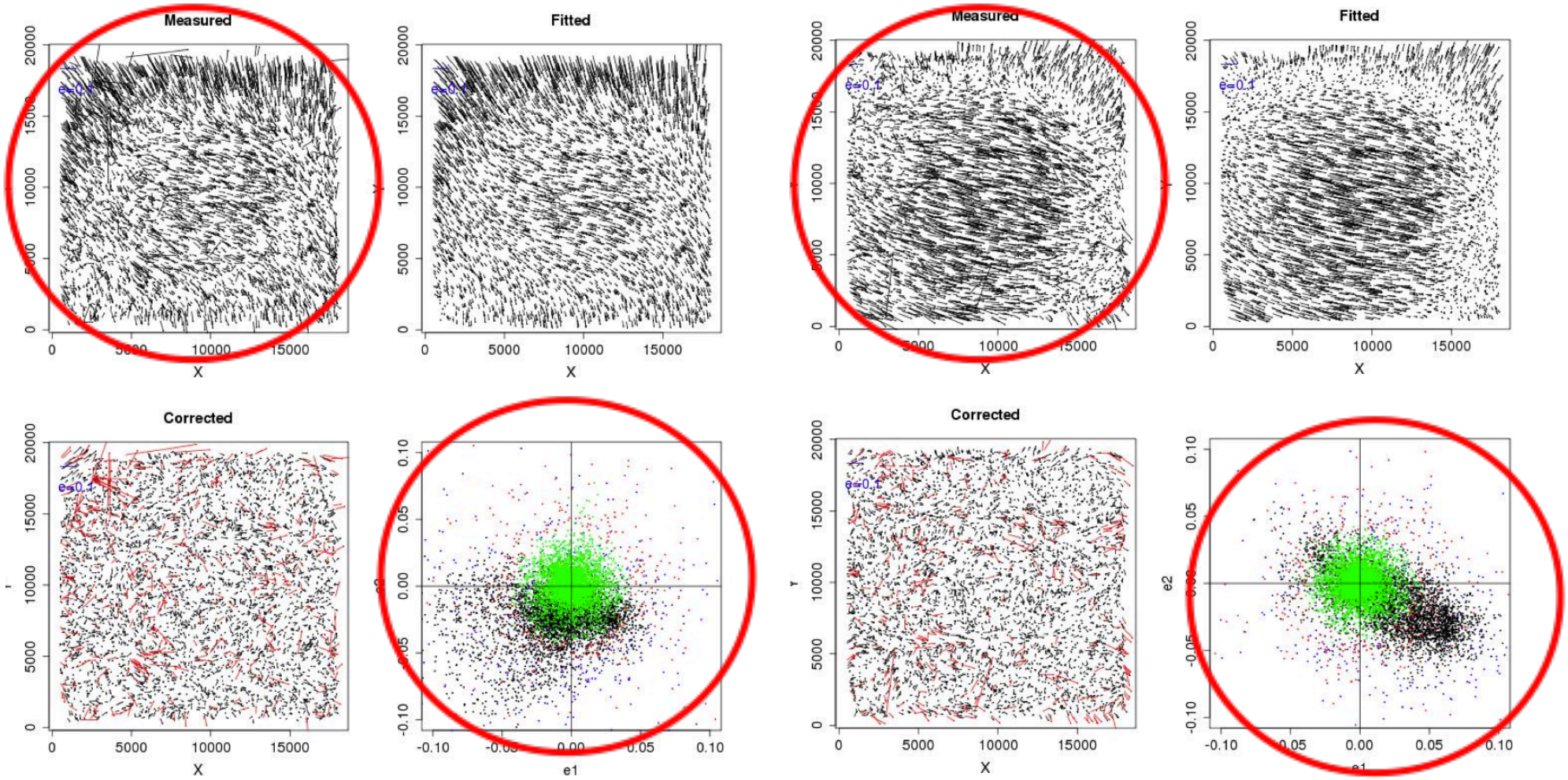
r-band imaging
57 frames (360s) with average seeing <0.8”

Goal compare weak lensing analysis with a complete census of galaxy clusters (from COSMOS collaboration)

VST COSMOS Field
Correcting PSF Anisotropy



Strong Variation of PSF Pattern with Epoch



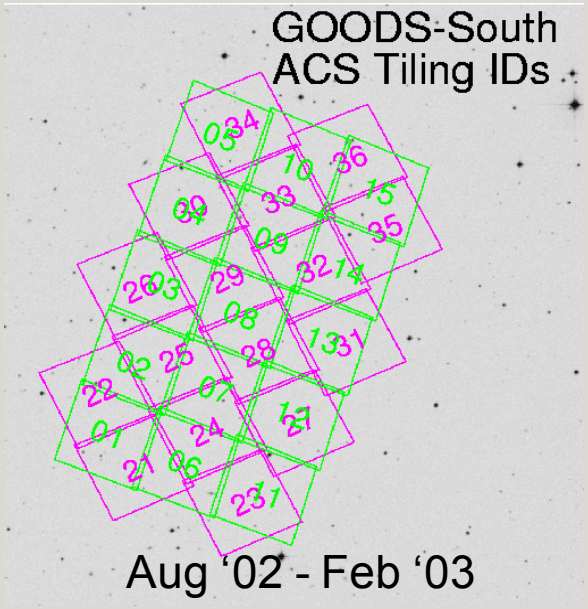
Black : Stars Before Corr
Green : Stars After Corr
Red : Excluded Stars

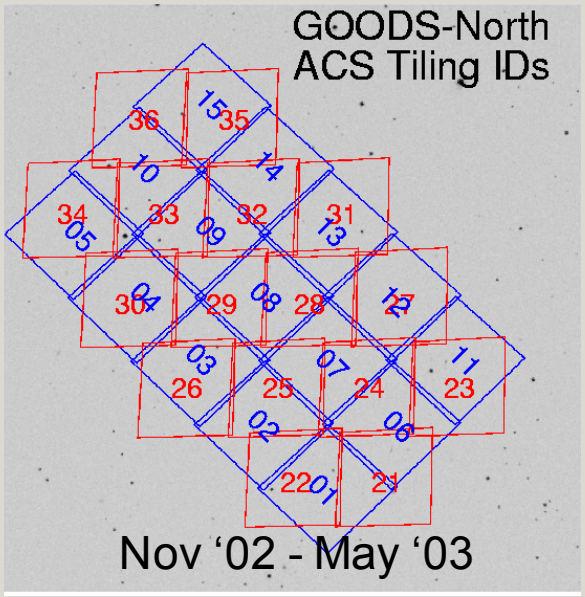
What's Next? Single epoch PSF anisotropy correction!

AGN variability Studies

- Variability selected AGNs are useful where there is poor/no X-ray coverage
- Different selection function w.r.t. other techniques: photometry/spectroscopy/x-rays
  - Useful for X-ray faint, possibly obscured AGNs (peculiar dust to gas ratio?)
  - Identifies AGNs also when the host galaxy contribution is large
- Allows to discover dormant BHs : tidal disruption events

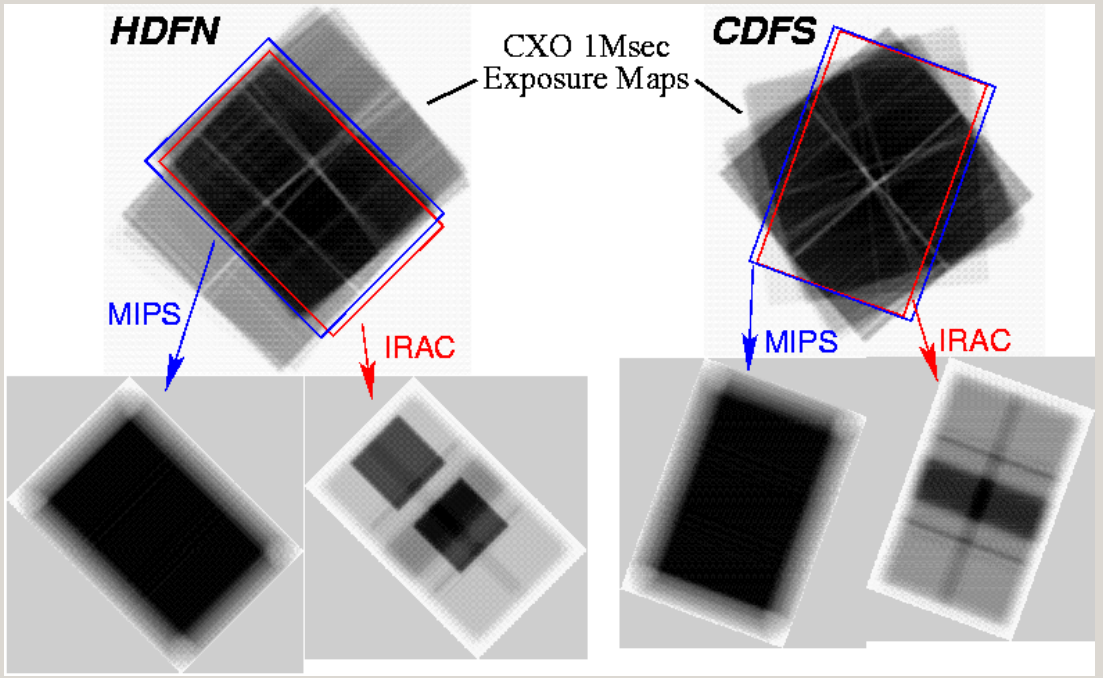
GOODS/ACS Layout and Cadence





5 epochs/field, spaced by 45 days
V,i,z @ 0.5/0.5/1.0 orbits/epoch

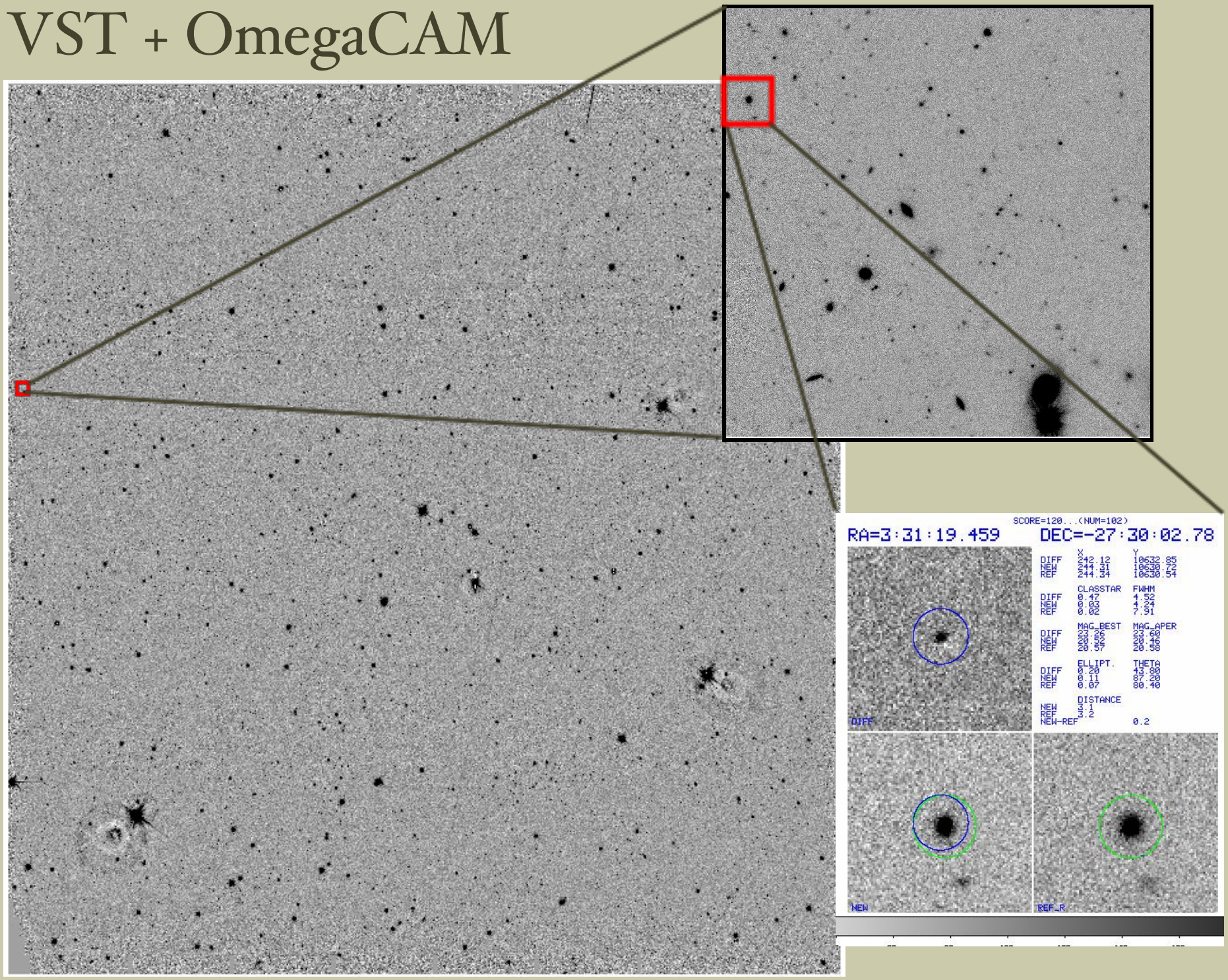
Four new GOODS-N "i+z" epochs in Cycle 12 ('03-'04)
Four new N+S "i+z" epochs in Cycle 13 ('04-'05)



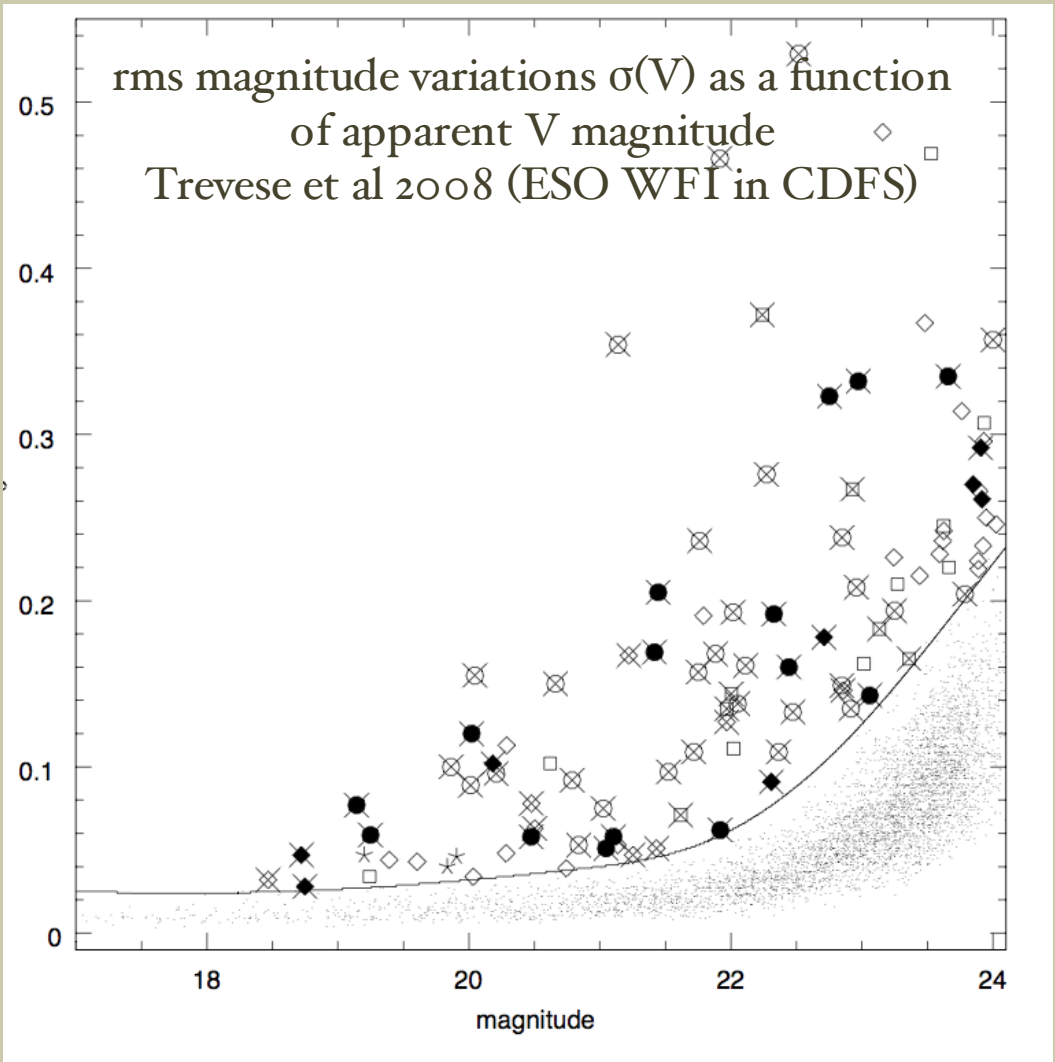
Maurizio Paolillo

VST + OmegaCAM

1 deg - 16384 pix



Catalog Search for AGN Variability

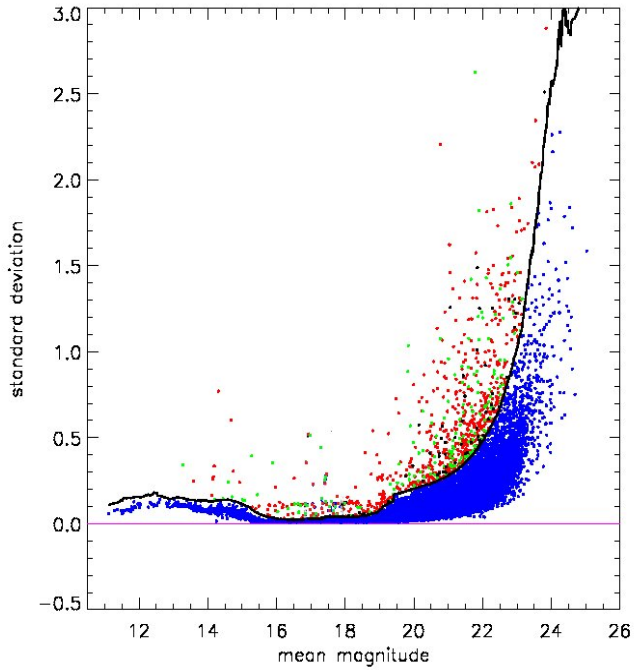


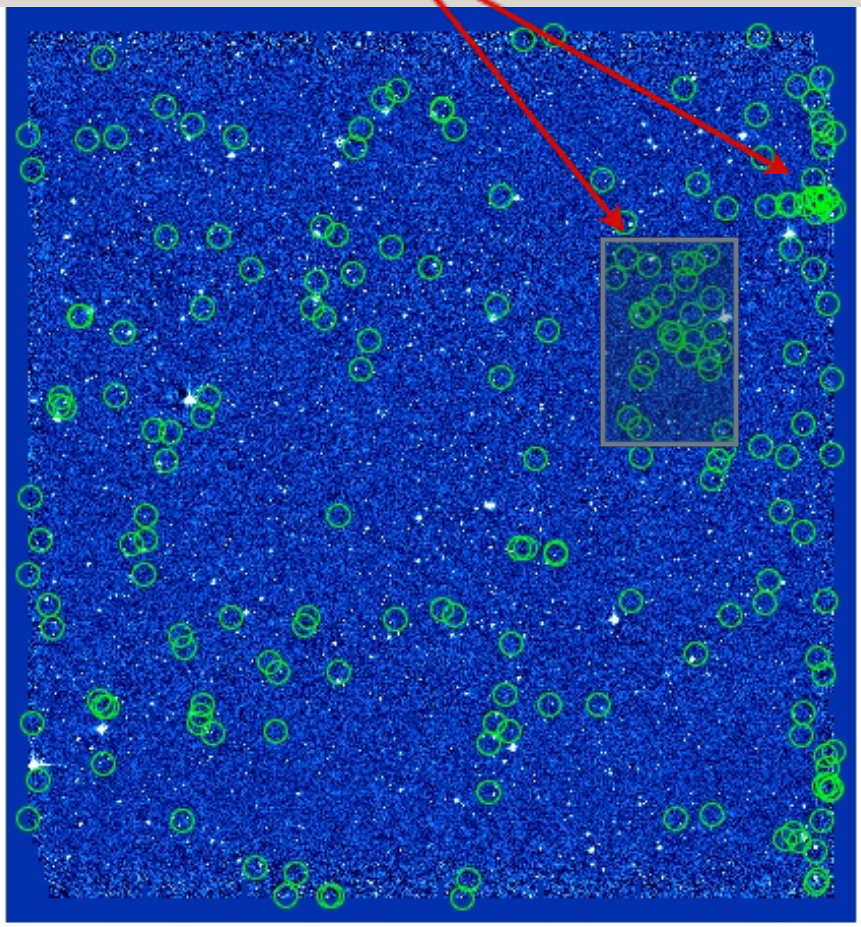
$$\overline{m}_k = \frac{1}{N_{epo}} \sum_i^{N_{epo}} m_k^i$$

$$\sigma_k = [\frac{1}{N_{epo}} \sum_i^{N_{epo}} (m_k^i - \overline{m}_k)^2]$$

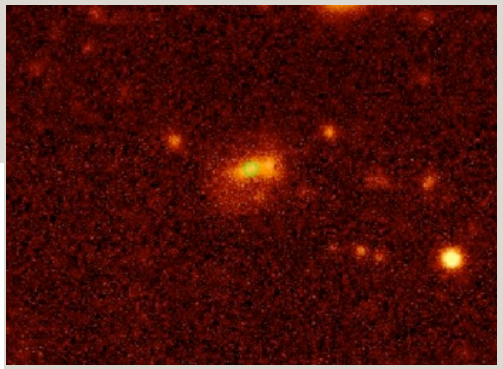
Preliminary results variable sources in the COSMOS field (Maurizio Paolillo & Demetra De Cicco)

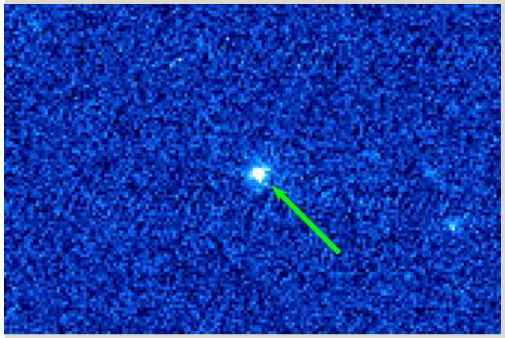
Still contaminants to remove near edges and problematic CCDs

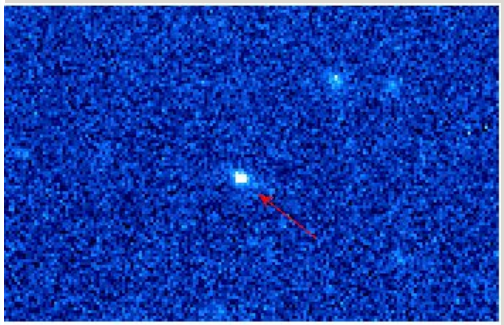




Candidates







Multi-Wavelength Analysis Ongoing

Maurizio Paolillo

To Be Continued...

The VST GT SUDARE/VOICE Survey

The Deaths of Stars & The Lives of Galaxies

Mattia Vaccari

SKA South Africa Post Doctoral Fellow
University of the Western Cape, Cape Town
mattia@mattiavaccari.net **www.mattiavaccari.net**

SUDARE : Under Construction at http://graspa.oapd.inaf.it/

VOICE : http://people.na.infn.it/~covone/voice/voice.html

Enrico Cappellaro, Giovanni Covone, Giuliano Pignata, Maria Teresa Botticella
Lino Grado, Luca Limatola, Lucia Marchetti, Maurizio Paolillo, Mario Radovich
Massimo Capaccioli, Alberto Franceschini, Nicola Napolitano