

CANDELS

Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey

Co-PIs:

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Space Telescope Science Institute



CANDELS

Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey

CANDELS Team:

100 scientists

12 countries

Major nodes: UCSC, STScI, ROE,
NOAO, UCI, UMich, MPIA



Exposure Strategy

- ❖ “Wedding cake” strategy: three layers of J+H

UDFs: 50-100 orbit depth over
~10 sq arcmin

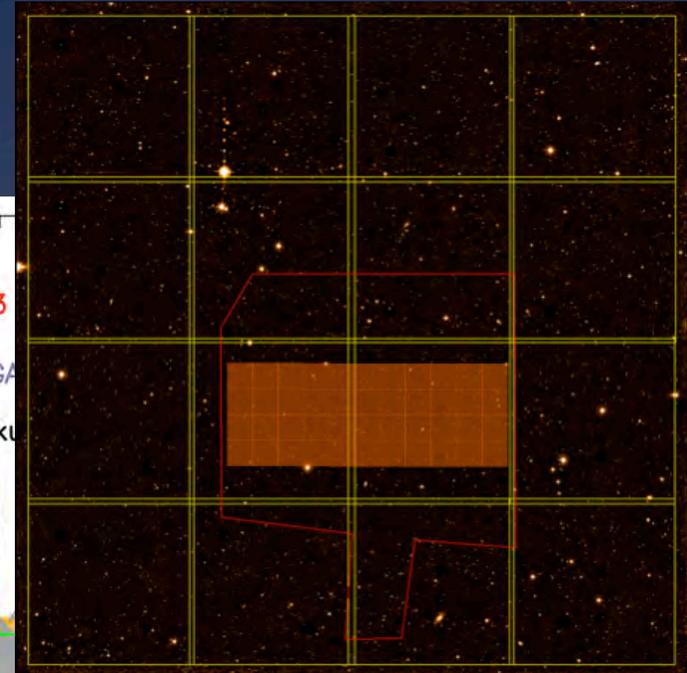
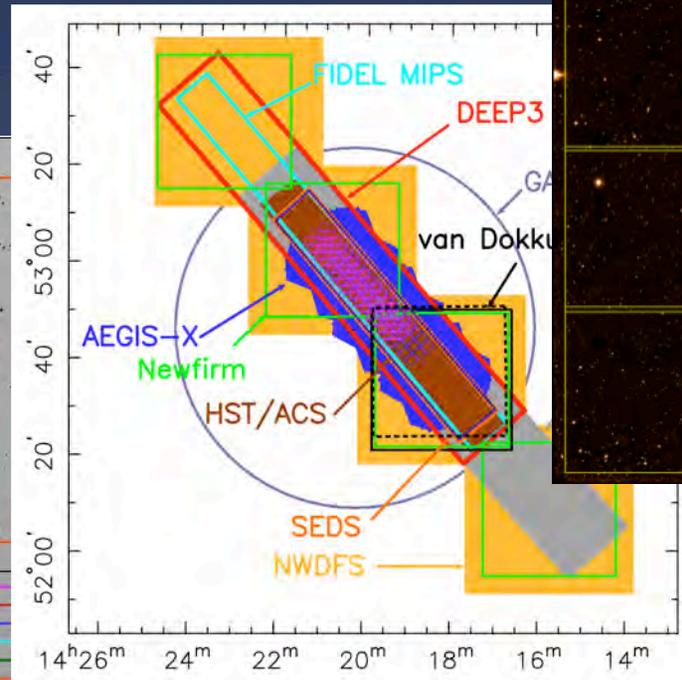
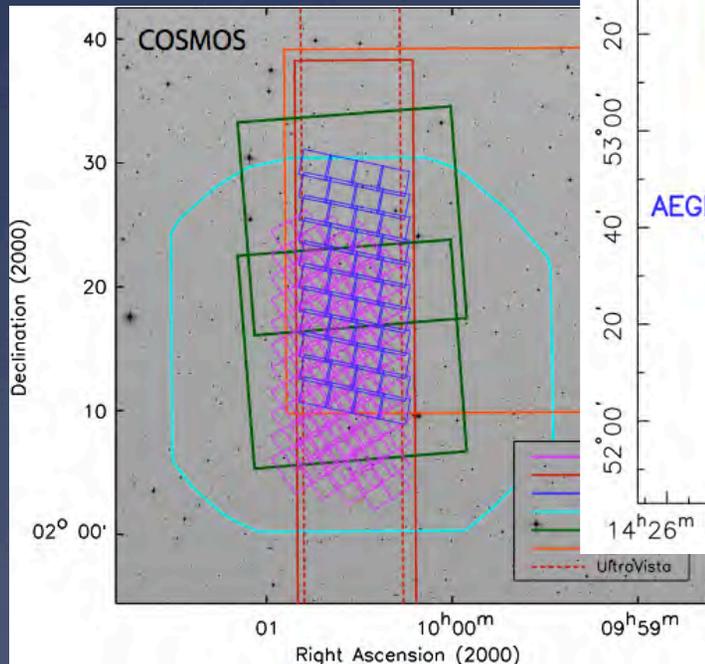
DEEP: 8 orbit depth over
~120 sq arcmin

WIDE: 2 orbit depth over
~700 sq arcmin



Exposure Strategy

- ❖ Five famous fields
- ❖ **Wide:** COSMOS, EGS, UDS



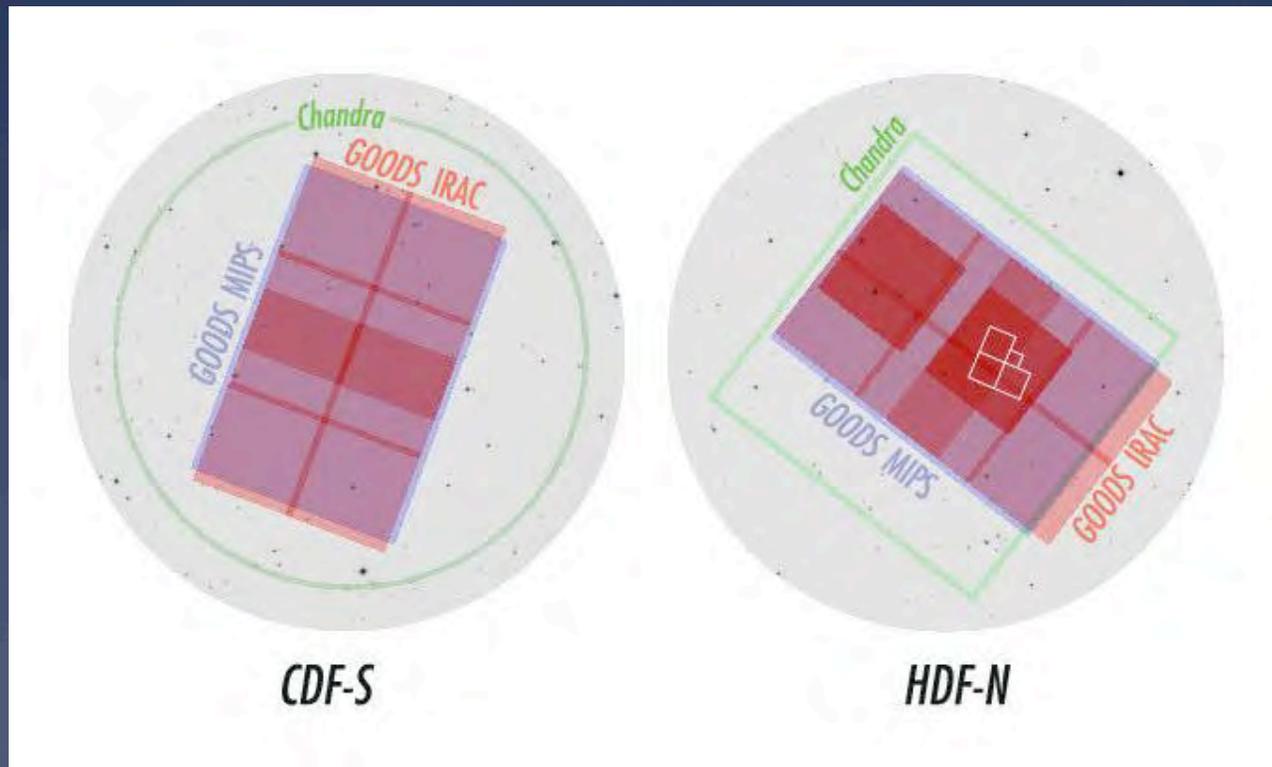
UDS/UKIDSS/SXDS:
2^h 18^m -5 deg

AEGIS:
14^h 18^m +53 deg

COSMOS:
10^h 00^m +2 deg

Overview

- ❖ Five famous fields
- ❖ **Deep**: GOODS-S, GOODS-N



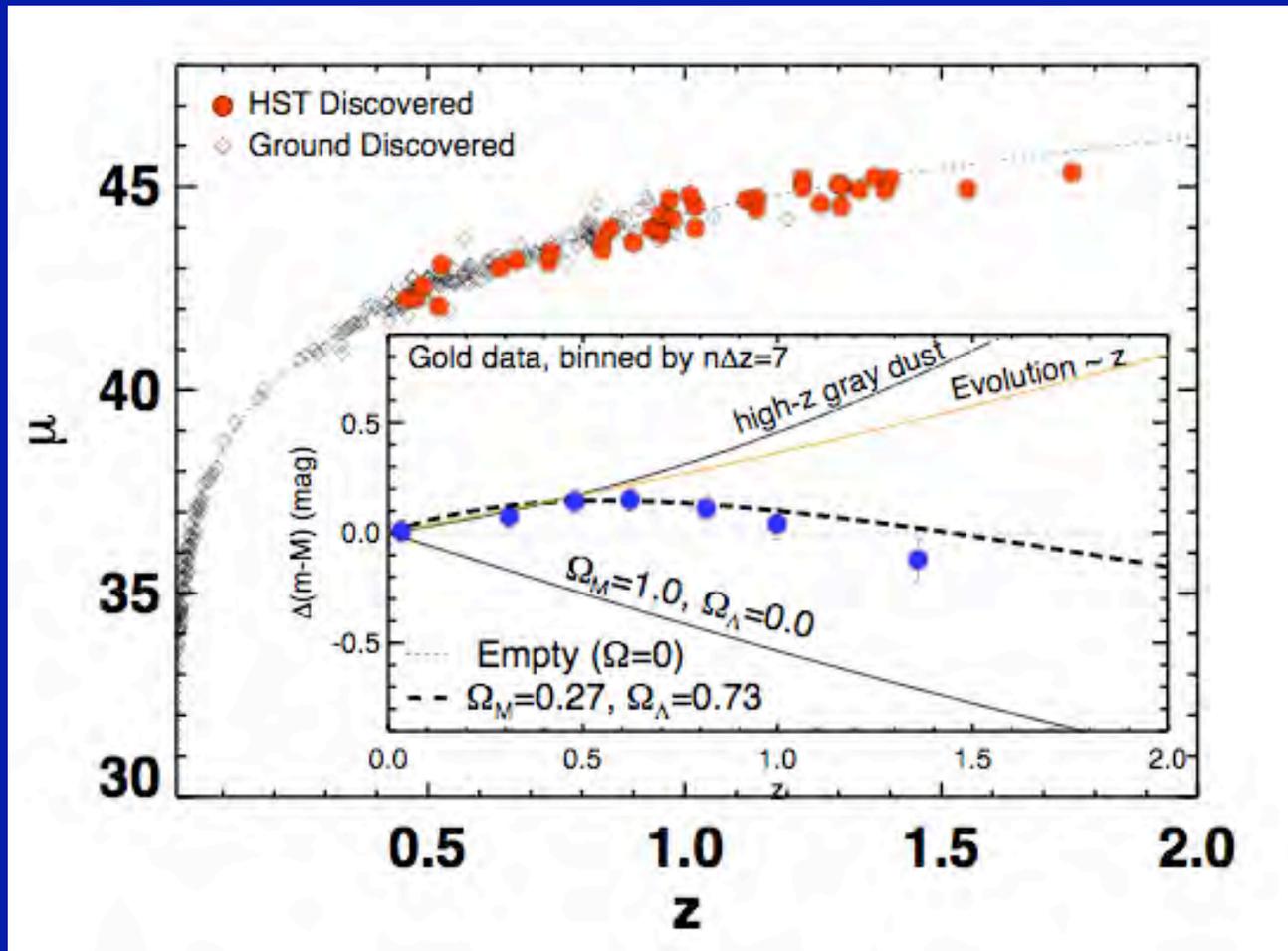
GOODS-S:
03^h 32^m -28 deg

GOODS-N:
12^h 37^m +62 deg

Highlights/Summary

- ❖ Imaging data for **250,000 galaxies** from $z = 1.5 - 8$: Wide and Deep
- ❖ WFC3 bridges the **Balmer break** out to $z \sim 2.5$
- ❖ WFC3 cuts through **dust**
- ❖ Spitzer Extended Deep Survey (SEDS): IRAC 26 AB ($5-\sigma$); means **stellar masses** measured to $\sim 10^9 M_{\odot}$ to $z \sim 7$
- ❖ Overlapping **ACS parallels**: panchromatic imaging from V \rightarrow H; new ACS imaging in UDS, deeper/multicolor ACS imaging in COSMOS and EGS **photoz's!**
- ❖ UV in GOODS-N: 100 orbits of F275W, F336W
- ❖ Every pointing observed at least twice:
 - ◆◆ Search for **variable AGN**
 - ◆ First search for **SNe beyond $z \sim 1.5$**

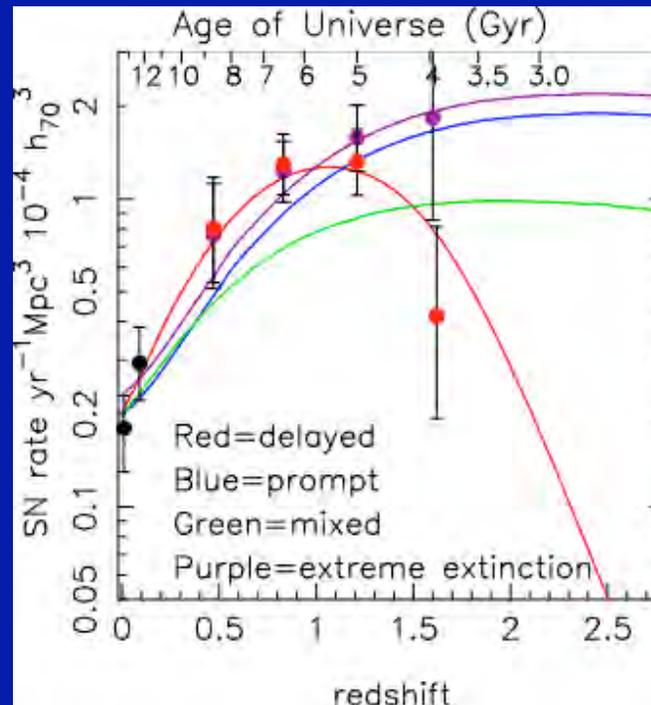
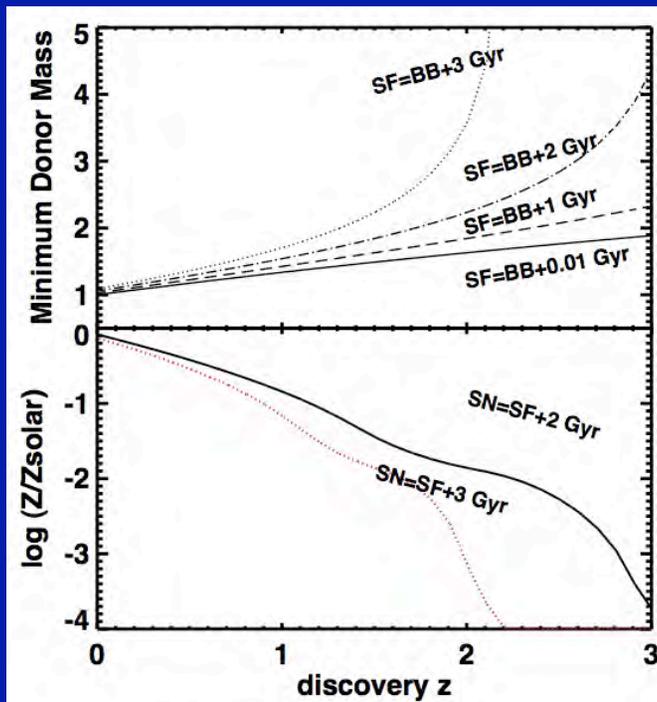
Supernova Cosmology



- Refine the only constraints we have on the time variation of w , on a path to more than doubling the strength of this crucial test of a cosmological constant by the end of HST's life.

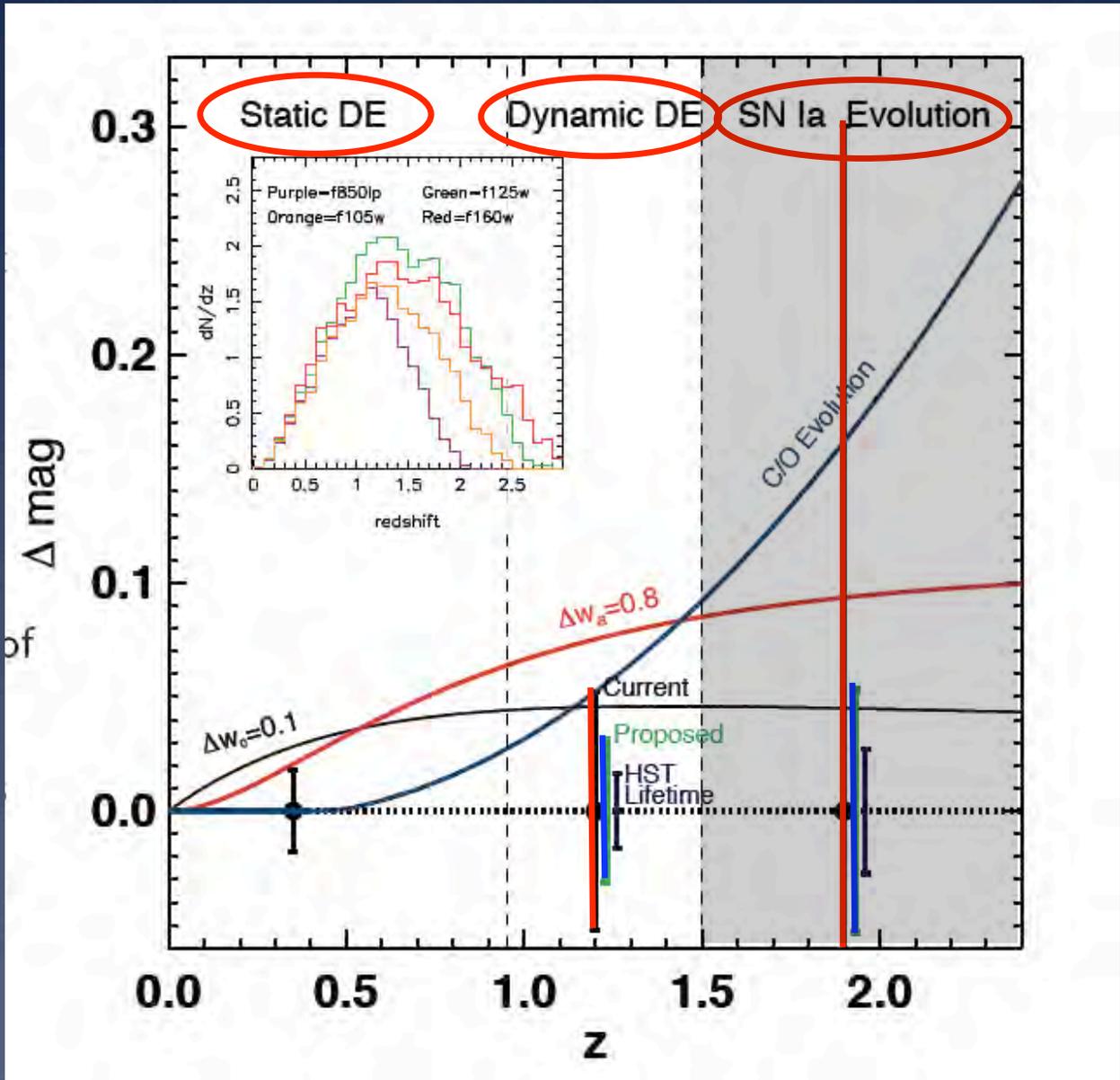
Supernova Cosmology

- Obtain a direct, explosion-model-independent measure of the evolution of Type Ia supernovae as distance indicators at $z > 1.5$, independent of dark energy.

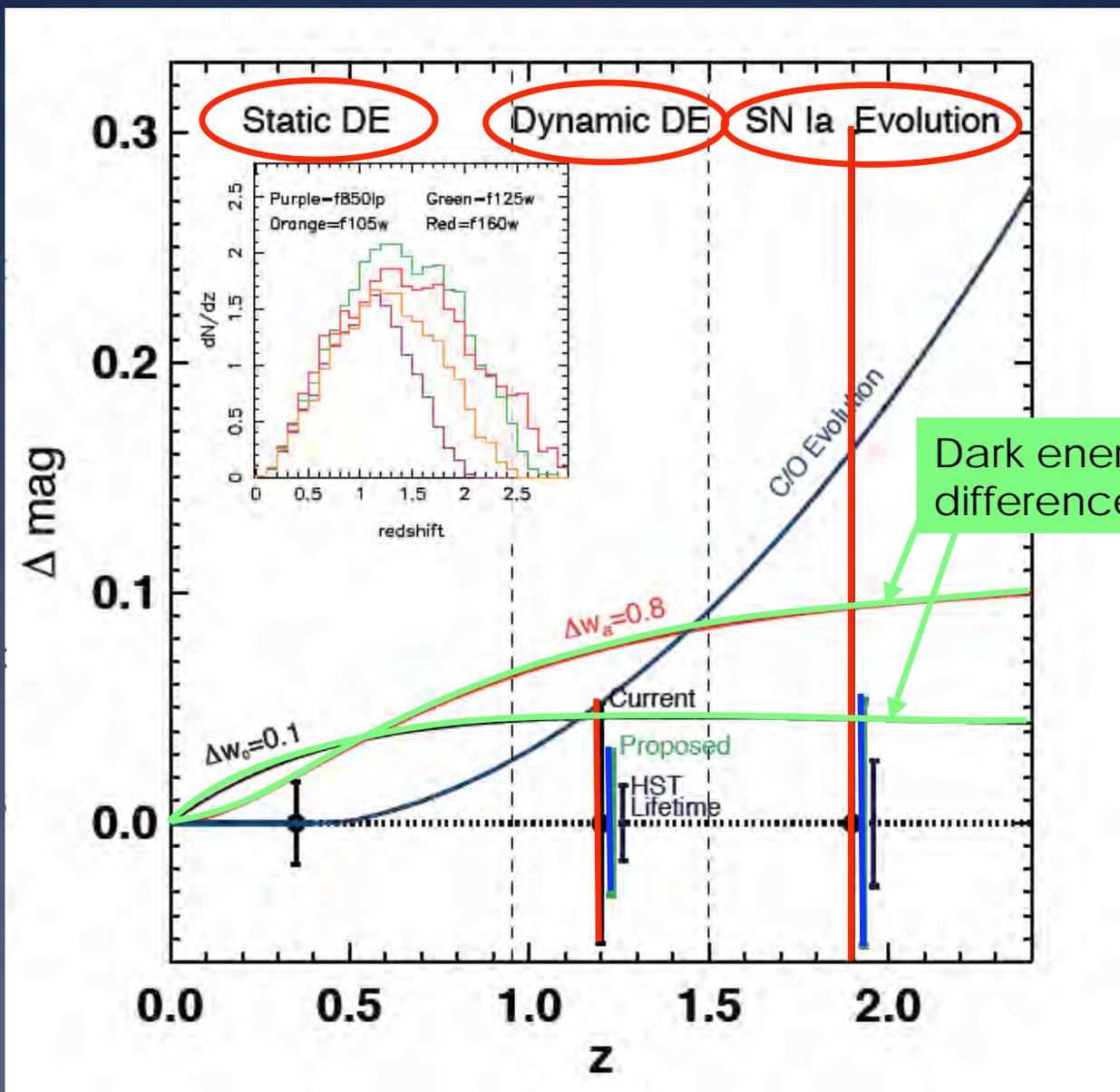


- Provide the first measurement of the SN Ia rate at $z > 1.5$ to distinguish between prompt and delayed SN Ia production and their corresponding progenitor models.

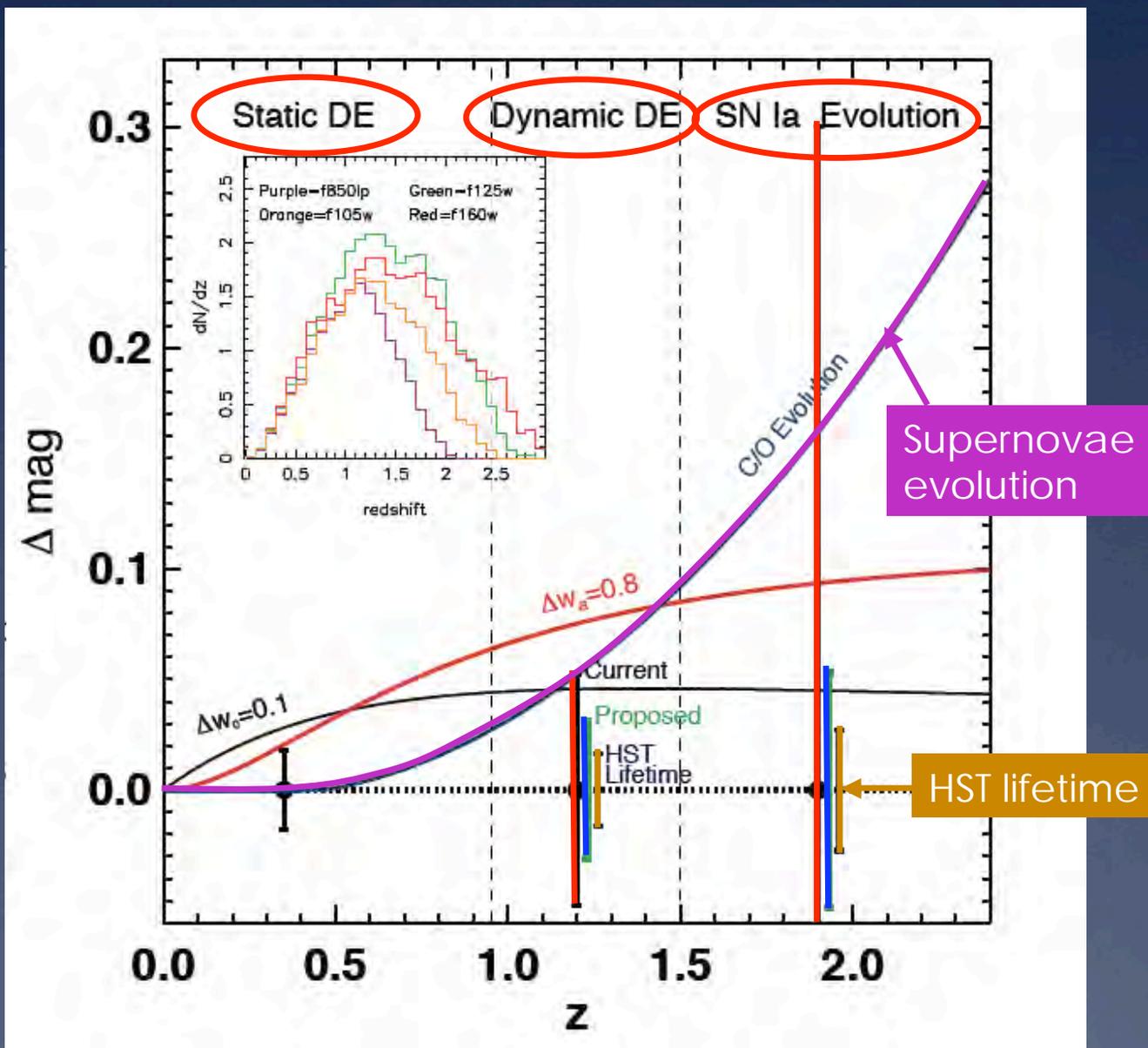
Supernovae Prospects



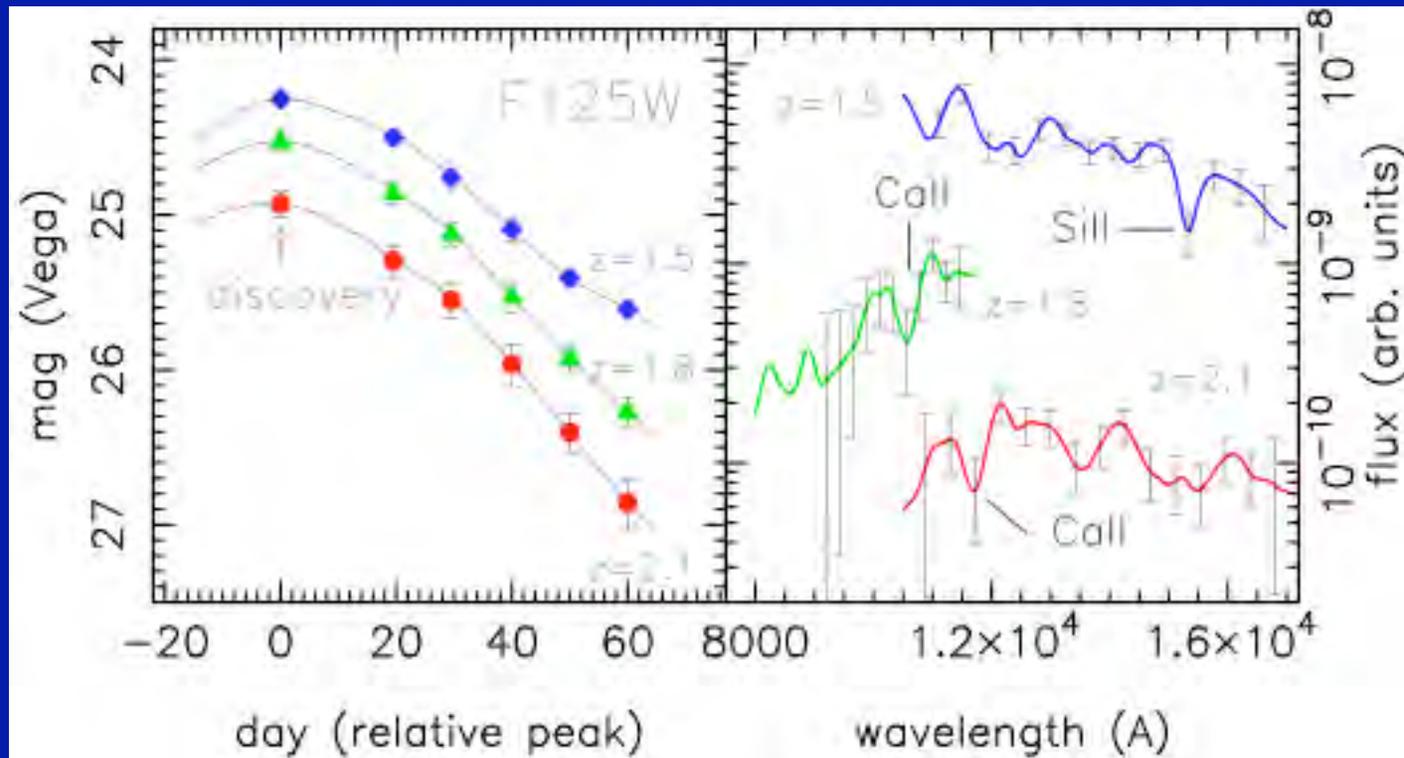
Supernovae Prospects



Supernovae Prospects

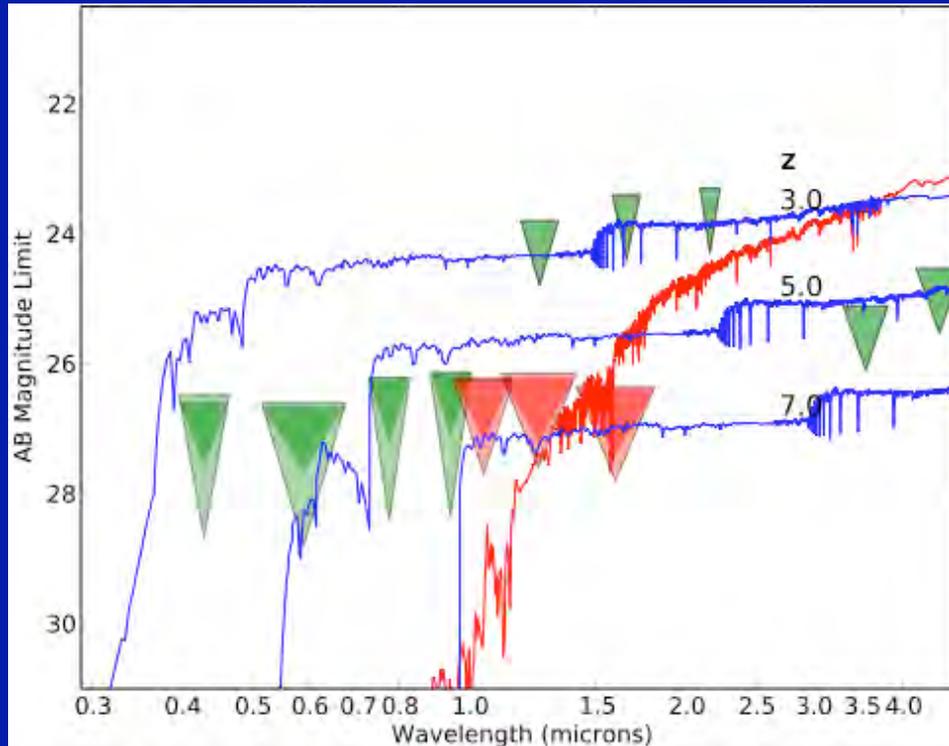


Supernova Cosmology



Combined CANDELS/CLASH followup program provides light curves and grism spectra.

Cosmic Dawn



- Greatly improve the estimates of the evolution of stellar mass, dust and metallicity at $z = 4-8$ by combining WFC3 data with very deep Spitzer observations.

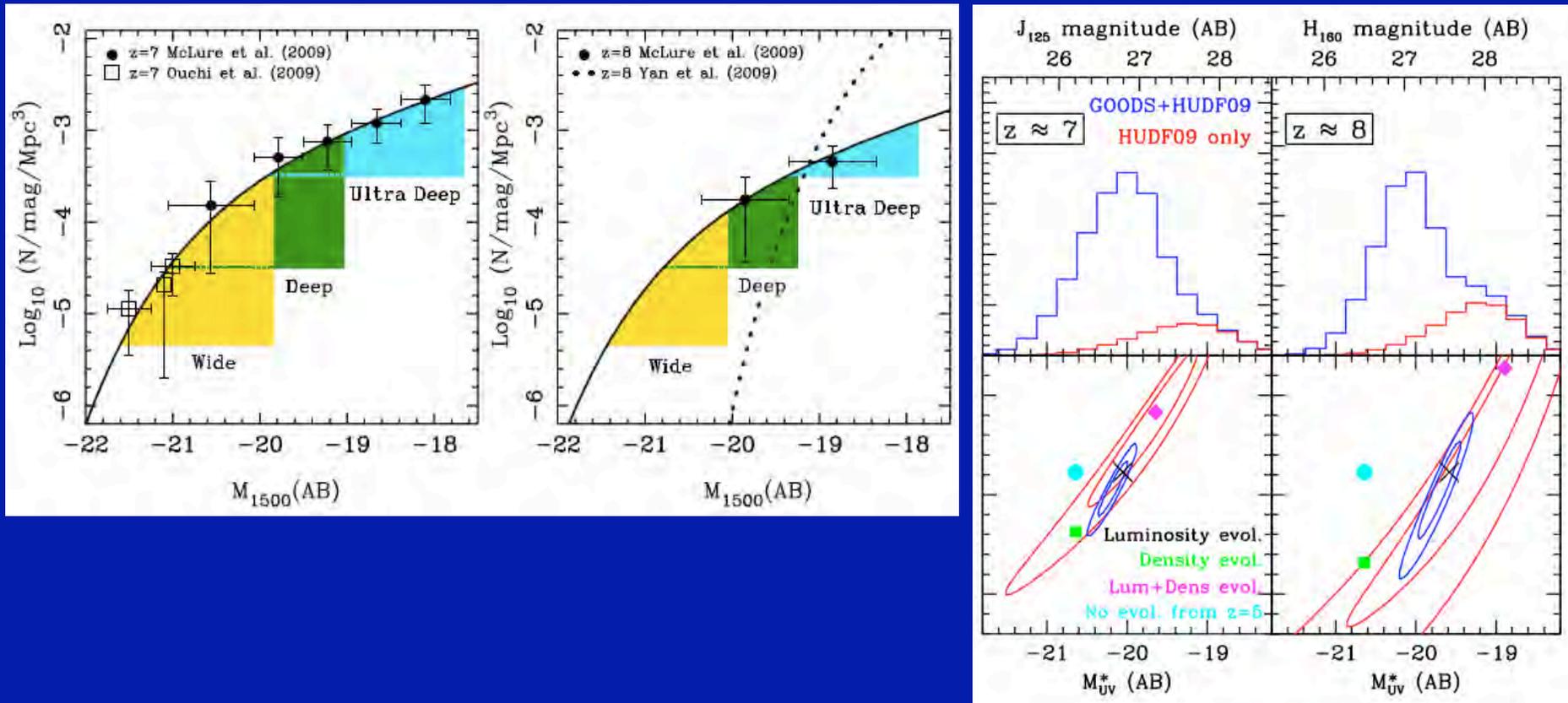
Magnitude and Mass Limits

	Area sq deg	# WFC3 tiles	Exposure, orbits			Eff. Exposure, orbits			
			Y	J	H	V	I	z	
Wide	0.2	162	--	2/3	4/3	4/3	8/3	--	Plus existing ACS
Deep	0.04	30	3	4	4	>3	>14	5	Incl existing ACS
UDF	0.004	3	~40	~40	~50	50+	50+	50+	Incl existing ACS

	Point source limits	5- σ AB mag			5- σ AB mag			
Wide		--	27.0	7.1	28.7	28.6	--	Plus existing ACS
Deep		27.8	28.0	28.0	>29	>30	29	Incl existing ACS
UDF		29.1	29.5	29.3	30+	30+	29.4+	Incl existing ACS

	Stellar mass @ z~2	M_{1500} , z~7
Wide	$10^9 M_{\odot}$	~ -20
Deep	$4 \times 10^8 M_{\odot}$	~ -19 ← $10^9 M_{\odot}$
UDF	$1.4 \times 10^8 M_{\odot}$	~ -18

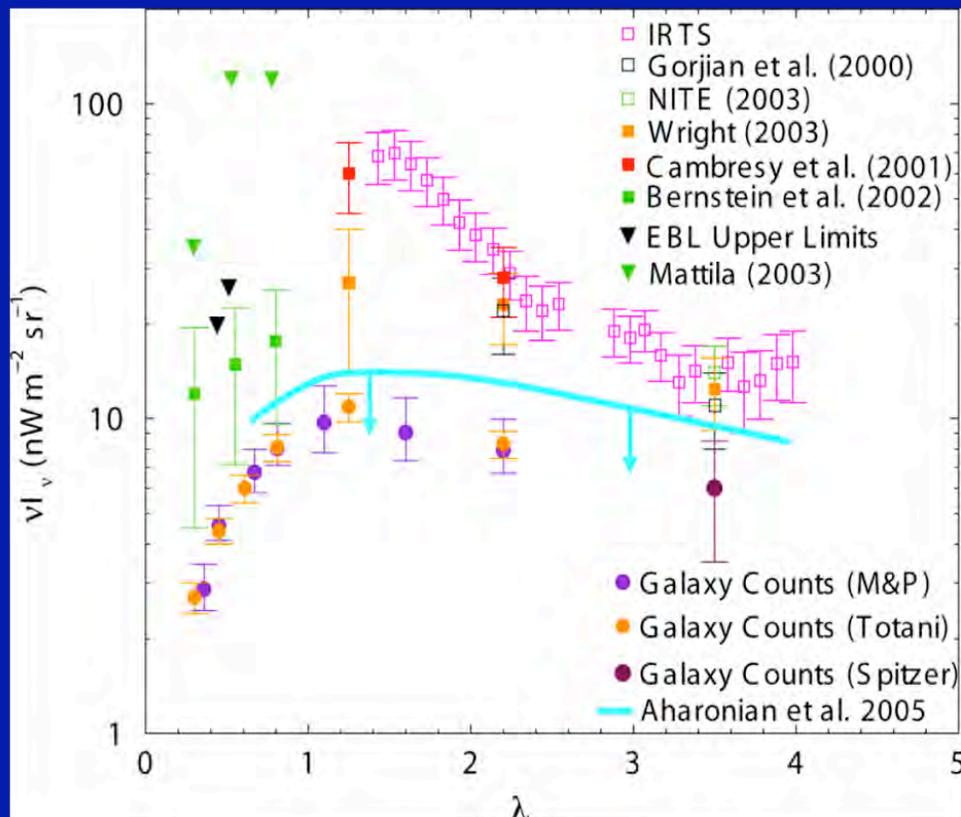
Cosmic Dawn



- Improve by $\sim 10x$ the constraints on the bright end of the luminosity function at $z \sim 7$ and 8, and make $z \sim 6$ measurements robust using proper 2-color Lyman break selection.

Cosmic Dawn

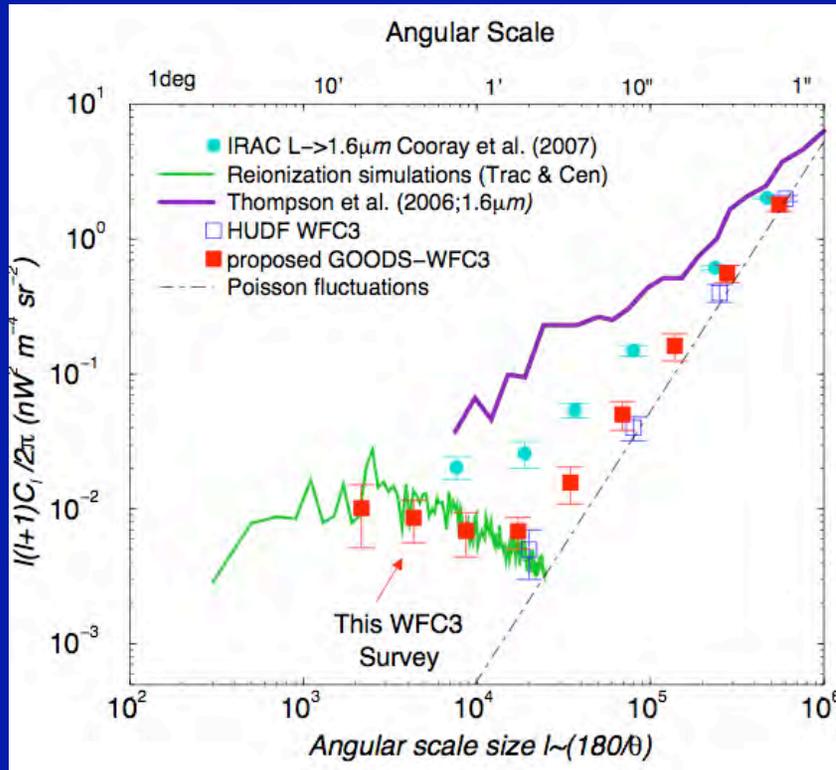
- Measure fluctuations in the near-IR background light, at sensitivities sufficiently faint and angular scales sufficiently large to constrain re-ionization models.



Extragalactic background:

- Integrated galaxy counts below previous detection limits form a lower EBL bound
- Gamma-Ray bursts (e.g. Aharonian et al. 2005) form upper bound
- Direct detections are difficult due to the EBL's faint intensity
- Detections currently conflict

WFC3 Fluctuation Measurements



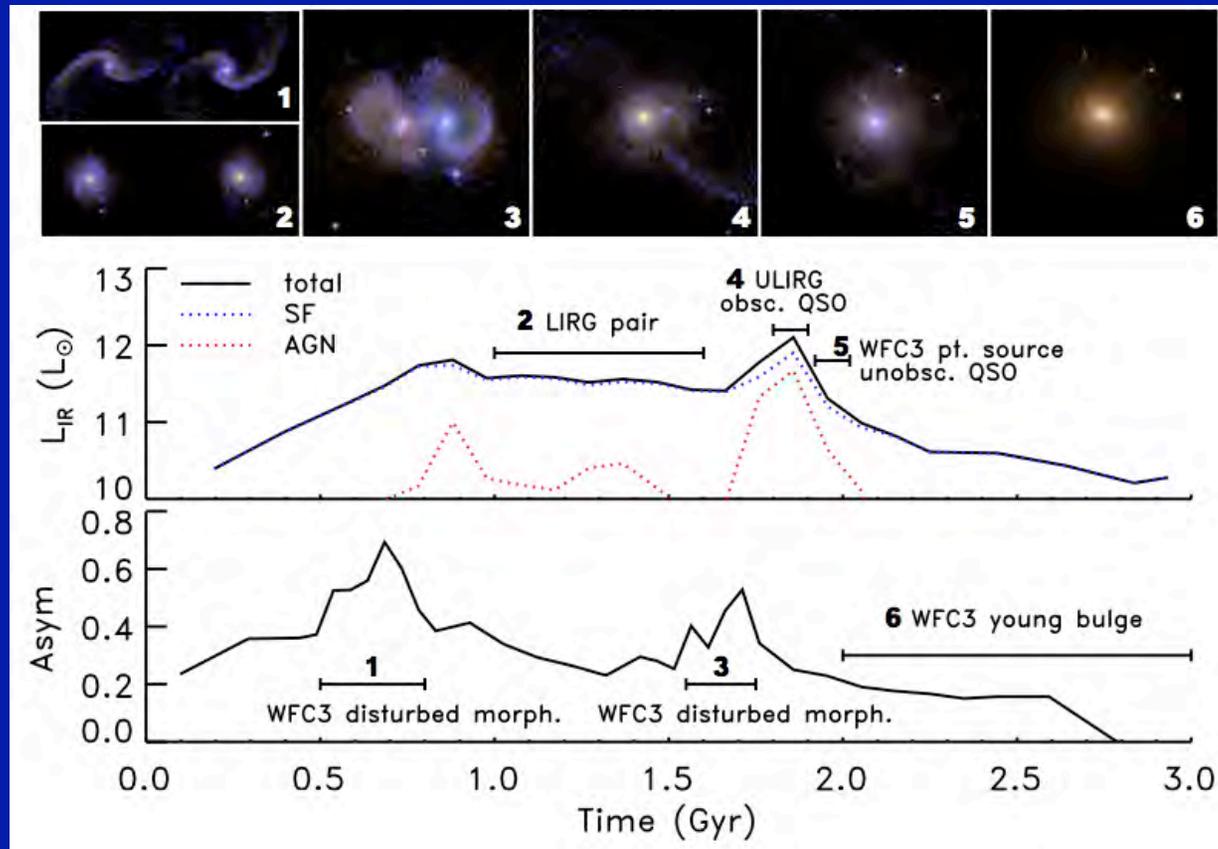
Reionization Simulation from Trac and Cen 2007

- The large angle ($\theta \sim 1/30^\circ$) peak (green curve) is a linear-theory prediction of clustering of reionization sources.
- Small scale power is sensitive to the slope and normalization of the luminosity function.
- large area surveys with WFC3 can (barely) reach large angle peak

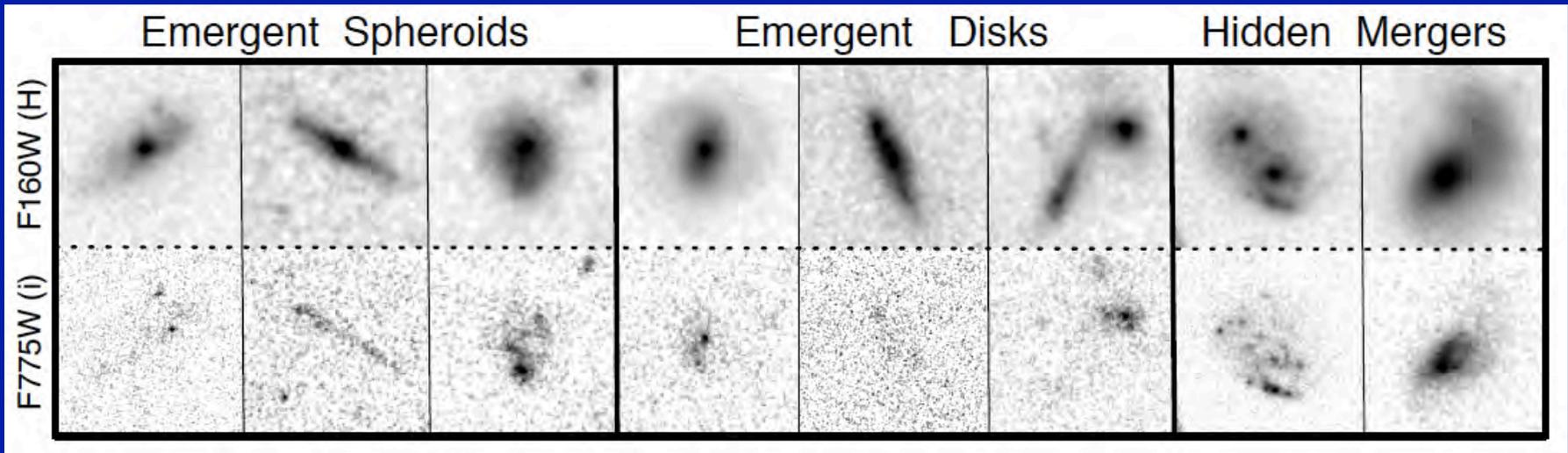
Large θ ←←←←← →→→→→ Small θ

Cosmic high-noon

- Test models for the co-evolution of black holes and bulges via the most detailed census of interacting pairs, mergers, AGN, and bulges, aided by the most complete and unbiased census of AGN from Herschel, improved Chandra observations, and optical variability.

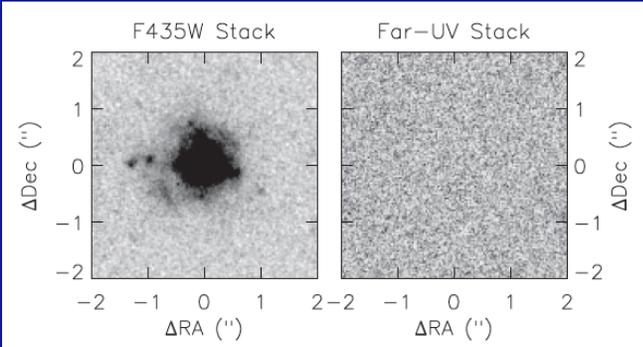


Cosmic high-noon

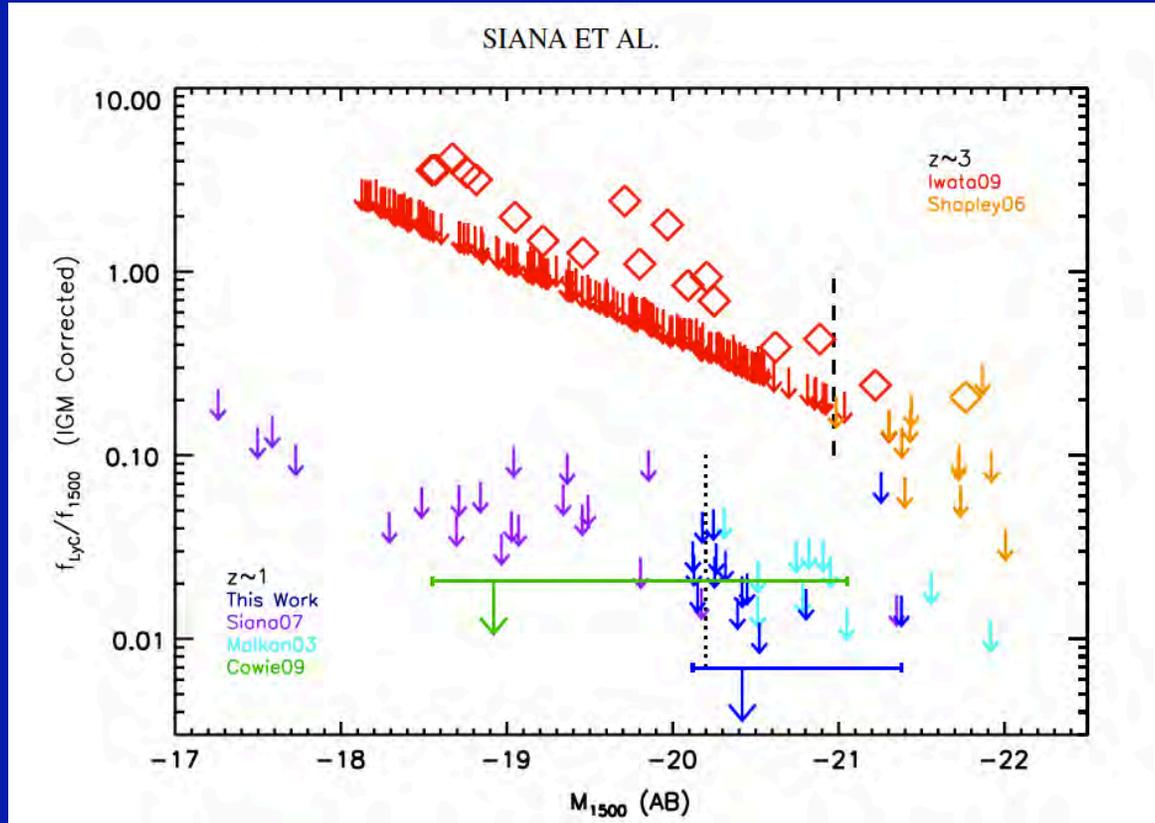


- Detect galaxy subclumps and measure their stellar mass, constraining their dynamical-friction migration to the center leading to bulge formation.
- Reveal the presence passively evolving bulges out to $z > 3$, measure the bulge/disk ratio, constrain the ages of bulge and disk populations.
- Measure rest-frame optical morphologies of galaxies up to $z \sim 2$ and beyond, and combine with ACS data to quantify UV-optical color (age) gradients.

UV observations



Siana et al. 2010
15 galaxies at $z \sim 1.3$
None detected
Tension between ground-based measurements and HST upper limits.



- Constrain the Lyman-continuum escape fraction for galaxies at $z \sim 2.5$.
- Compare Lyman-break galaxies at $z \sim 2.5$ to higher-redshift counterparts.
- Estimate star-formation rates in dwarf galaxies to $z > 1$ to test whether dwarfs are “turning on” as the UV background declines at low redshift.

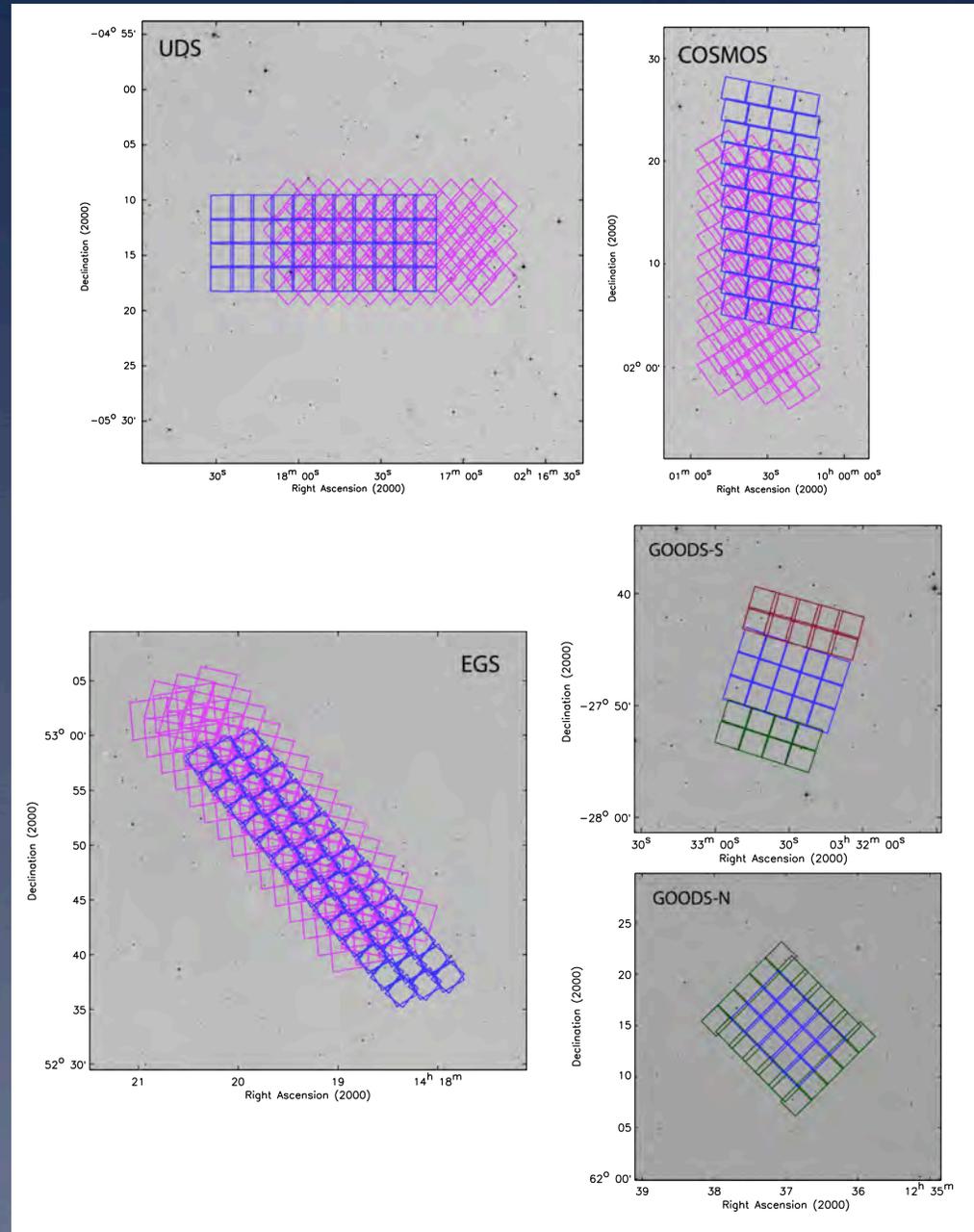
CANDELS Fields

* Orbit Totals:

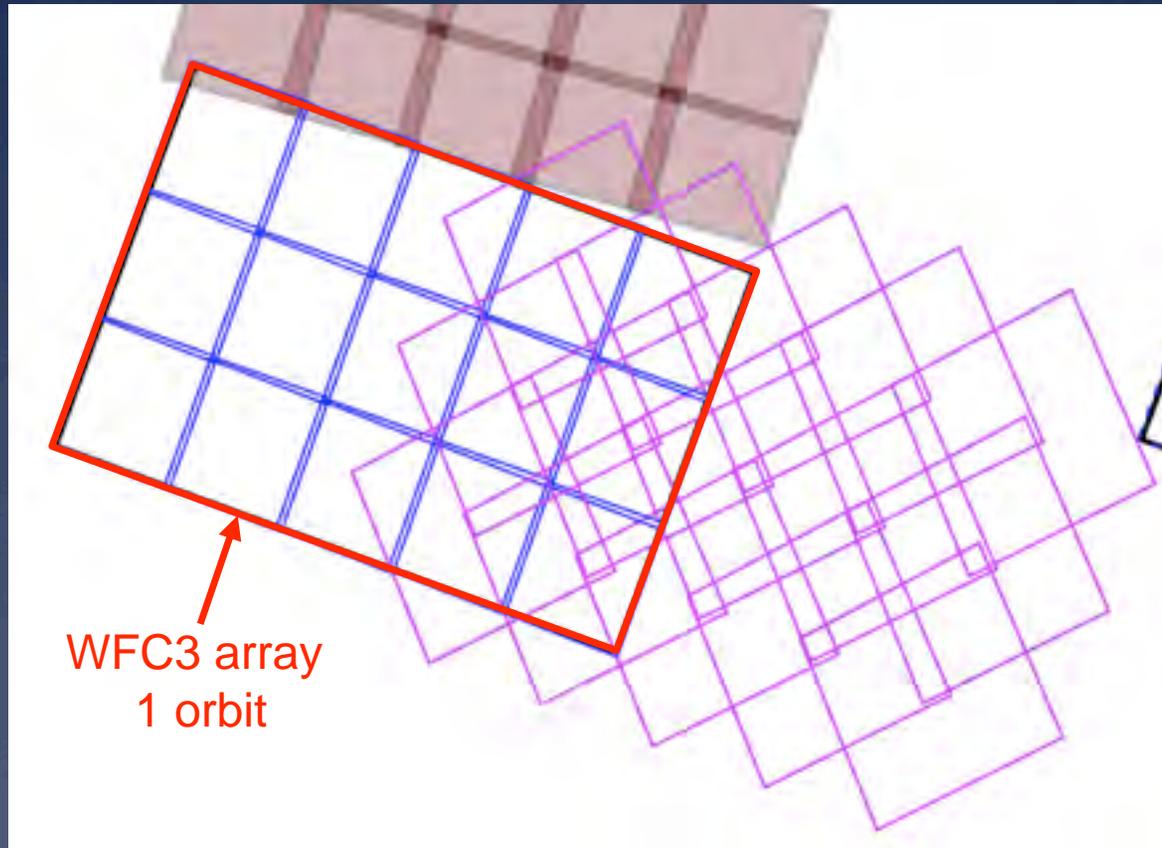
- * GOODS: 483
- * EGS: 90
- * UDS: 88
- * COSMOS: 88
- * SNe Follow-up: 152

* Submitted Phase II Files

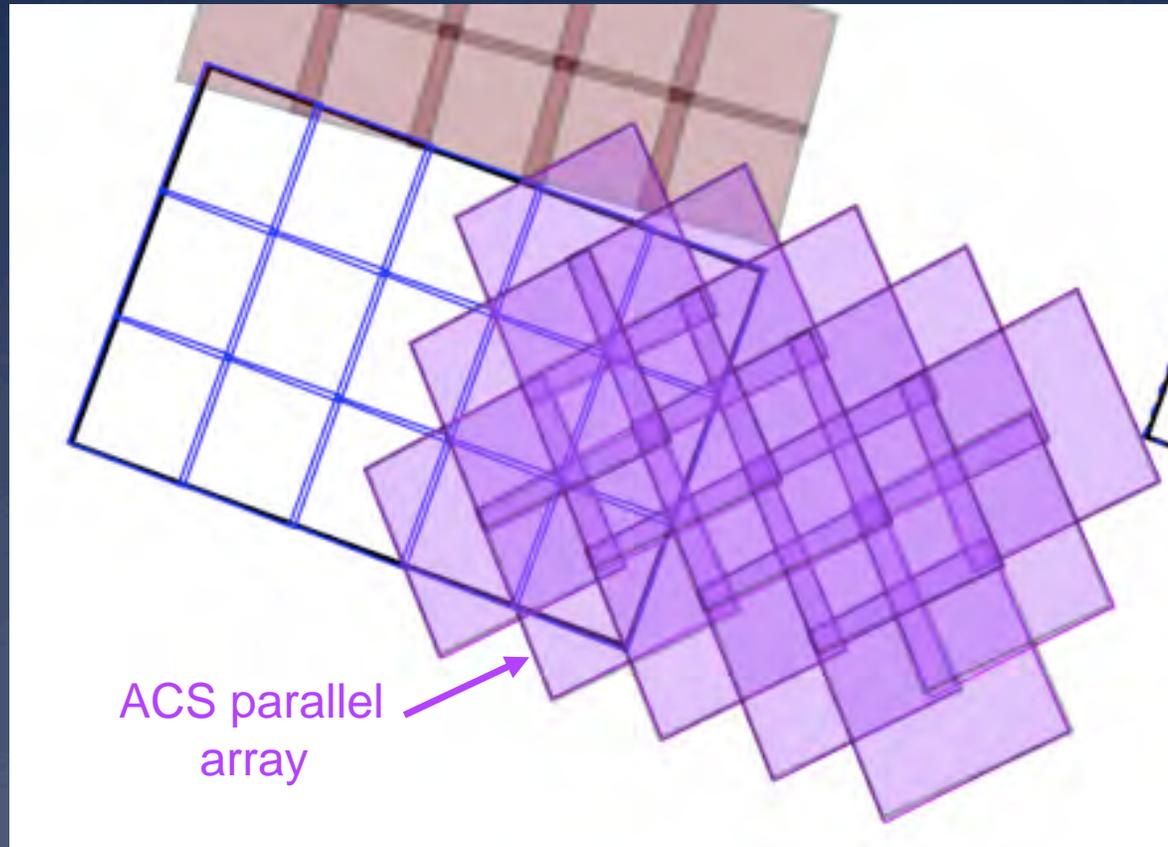
- * GOODS-S: 12060-12062
- * EGS: 12063
- * UDS: 12064



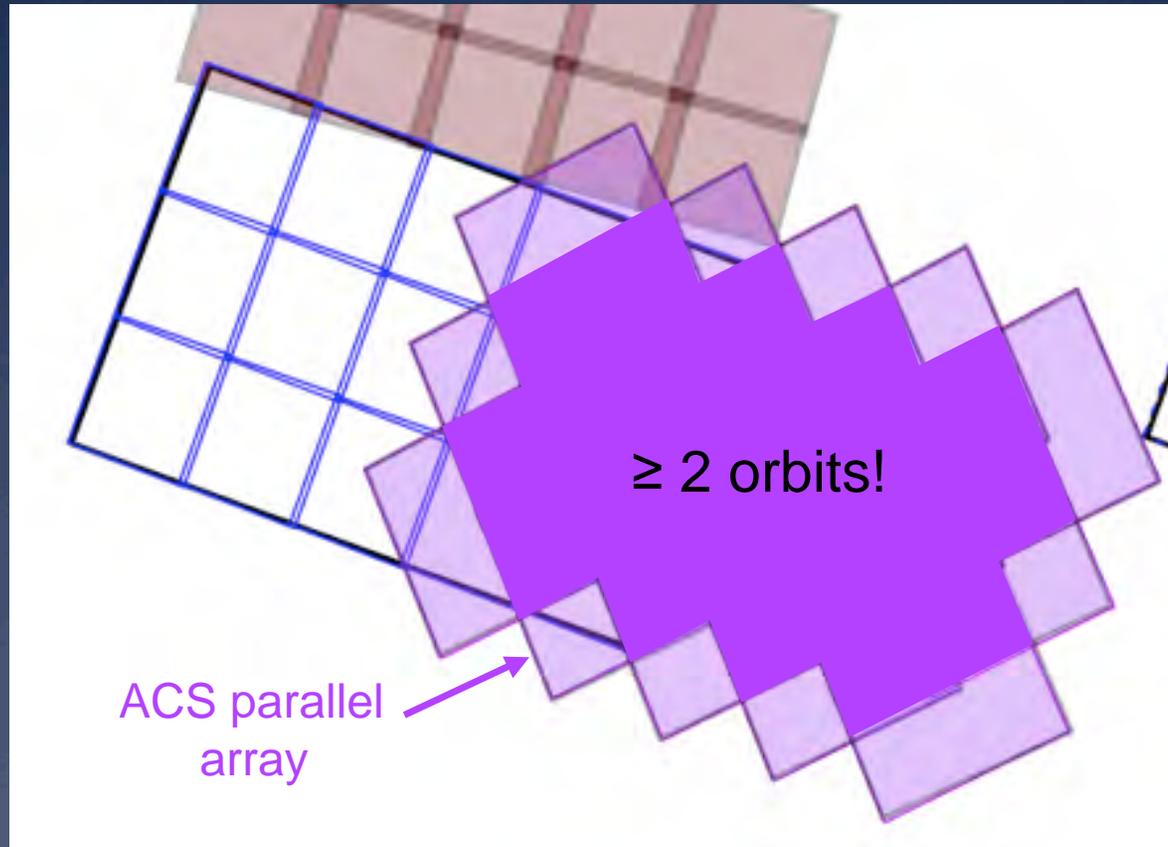
ACS Parallels



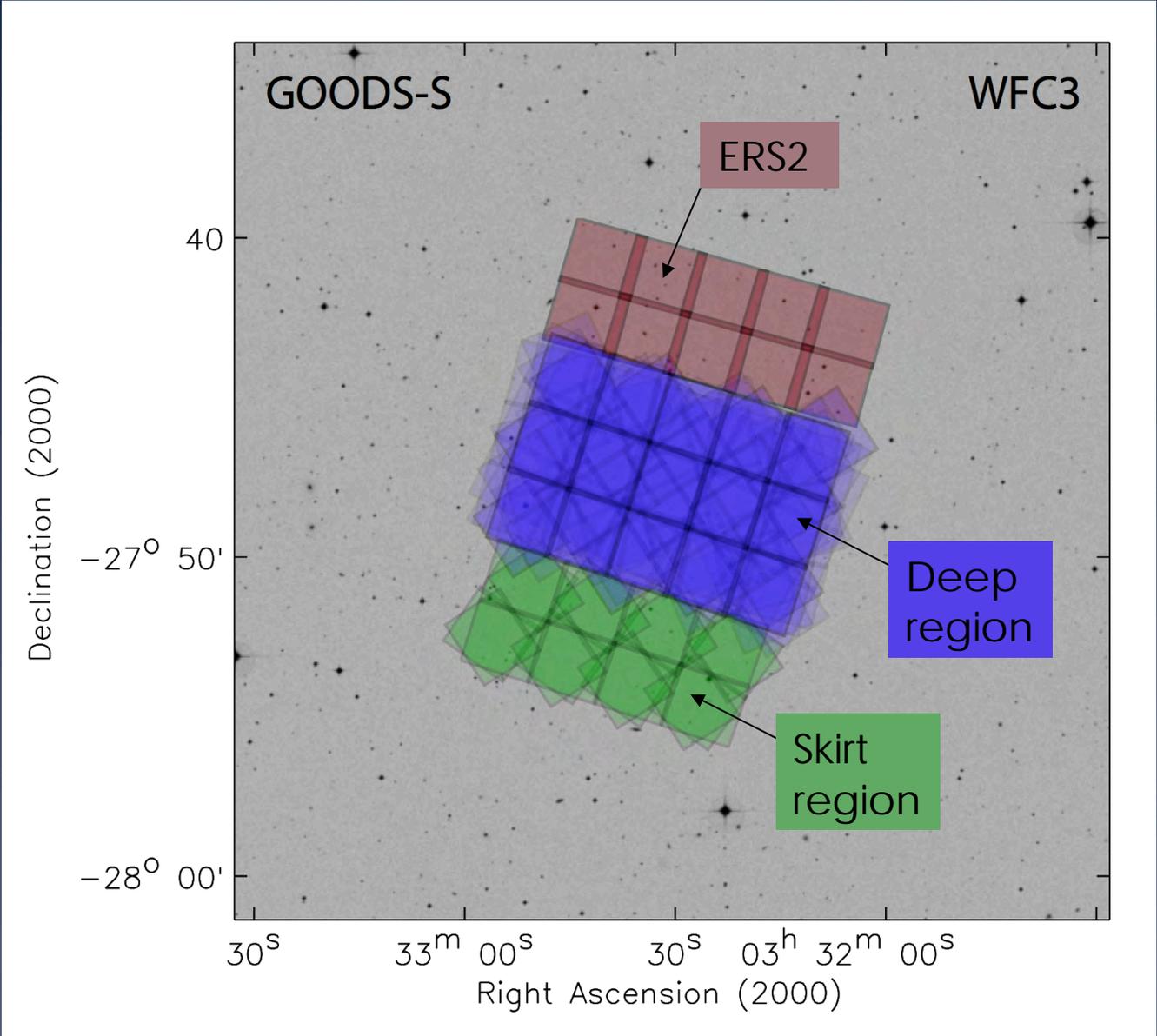
ACS Parallels



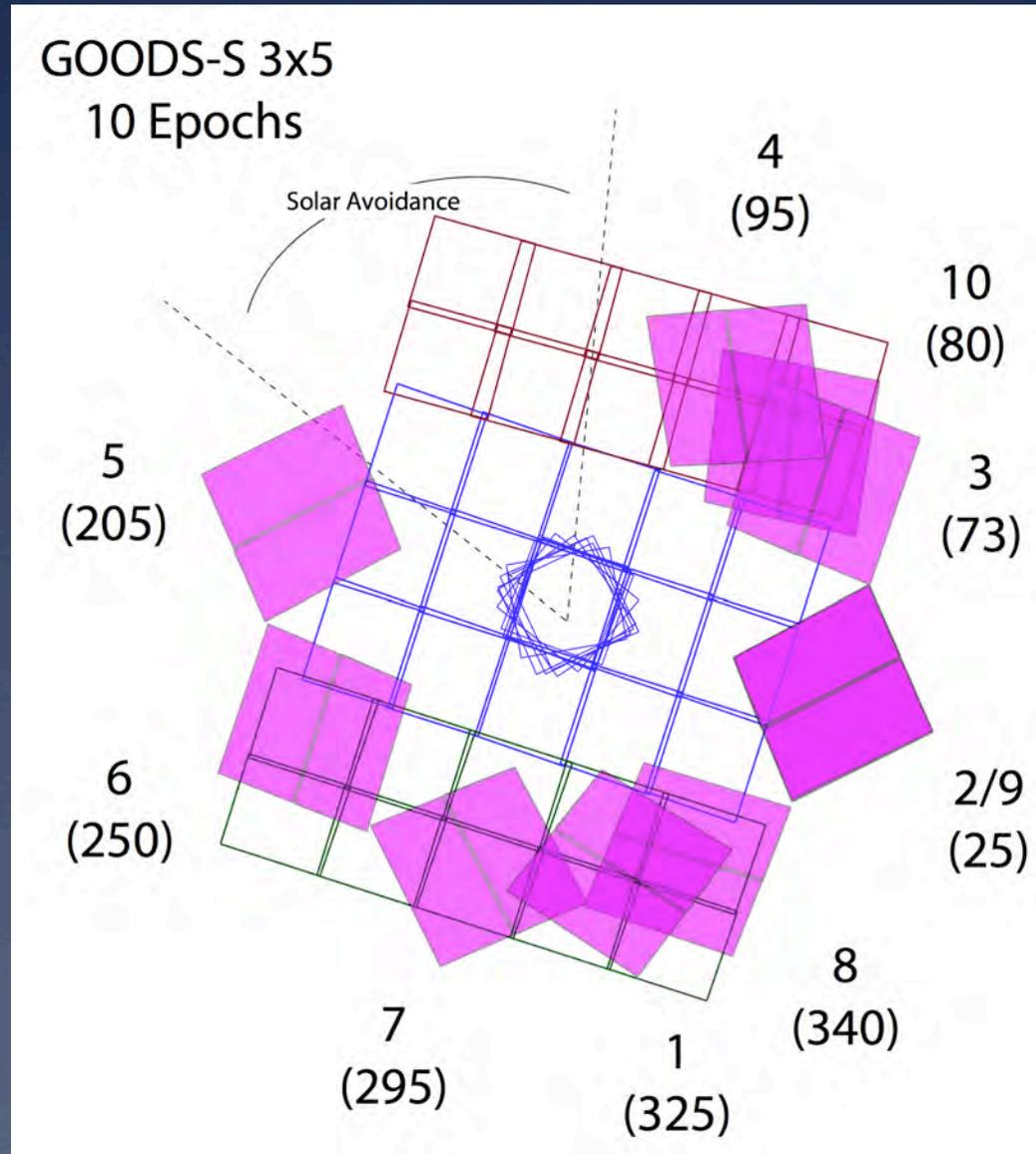
ACS Parallels



Deep Strategy: GOODS-S



GOODS-S Deep Strategy: 10 Epochs

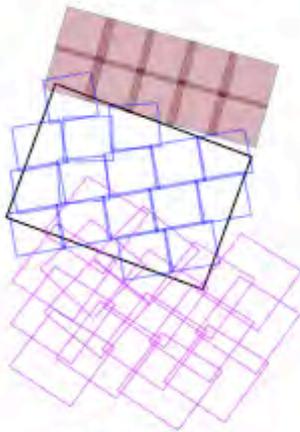


GOODS-S: WFC3 Tiling and ACS Parallels

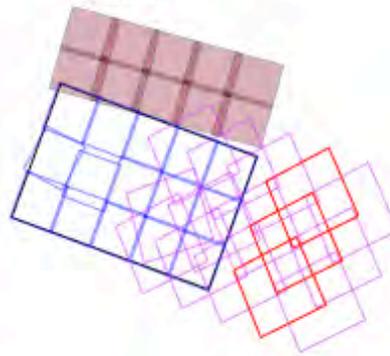
GOODS-S Visits 1-8

— WFC3 — ACS (F814W) — ACS (F850LP) — ACS (F606W)

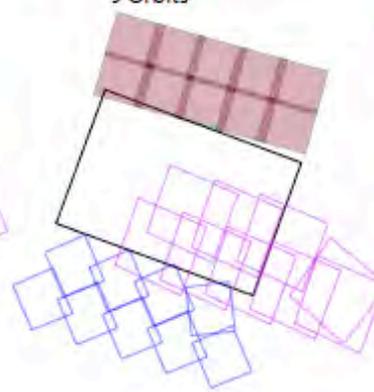
Visit 1
Deep JH Epoch 1
Orient = 325
08 Oct - 13 Oct 10
16 Orbits



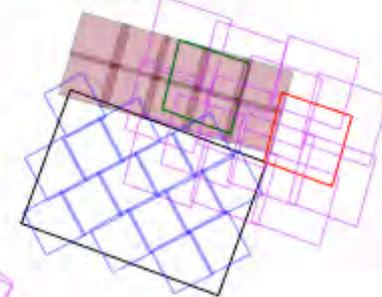
Visit 2
Deep JH Epoch 2
Orient = 25
26 Nov - 01 Dec 10
15 Orbits



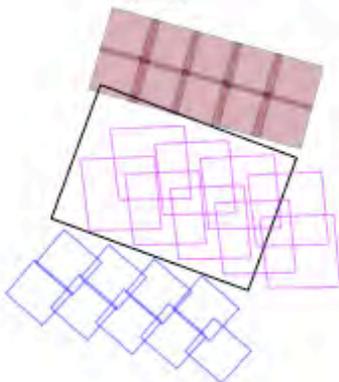
Visit 3
Skirt JH Epoch 1
Orient = 68
07 Jan - 10 Jan 11
9 Orbits



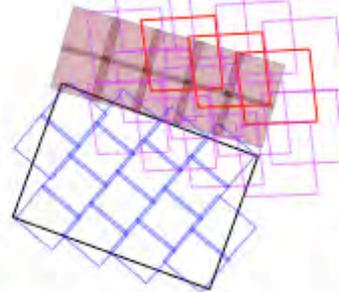
Visit 4
Deep JH Epoch 3
Orient = 73
14 Jan - 19 Jan 11
15 Orbits



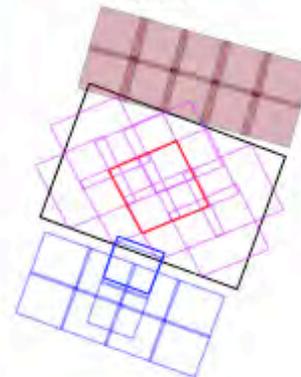
Visit 5
Skirt JH Epoch 2
Orient = 94
27 Feb - 02 Mar 11
9 Orbits



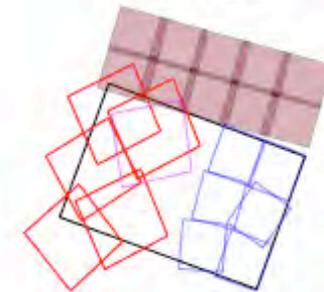
Visit 6
Deep JH Epoch 4
Orient = 95
02 Mar - 06 Mar 11
16 Orbits



Visit 7
Skirt Y
Orient = 115
25 Mar - 29 Mar 11
11 Orbits



Visit 8
Deep Y 1
Orient = 205
27 May - 21 Jun 11
6x3 = 18 Orbits

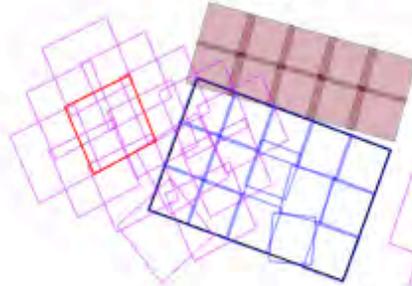


GOODS-S: WFC3 Tiling and ACS Parallels

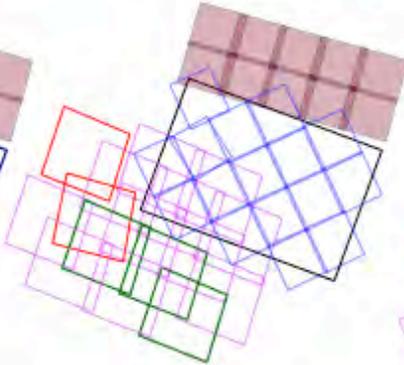
GOODS-S Visits 9-15

— WFC3 — ACS (F814W) — ACS (F850LP) — ACS (F606W)

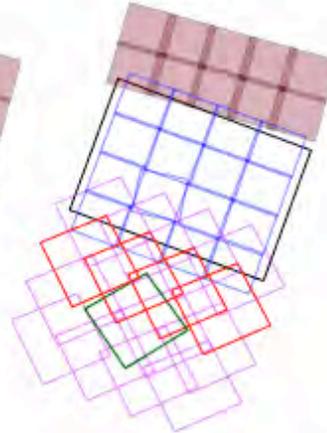
Visit 9
Deep JH Epoch 5
Orient = 205
03 Jun - 20 Jun 11
15 Orbits



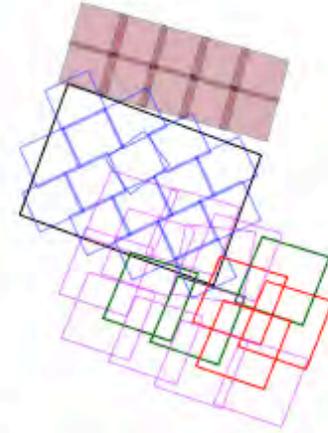
Visit 10
Deep JH Epoch 6
Orient = 250
28 Jul - 06 Aug 11
15 Orbits



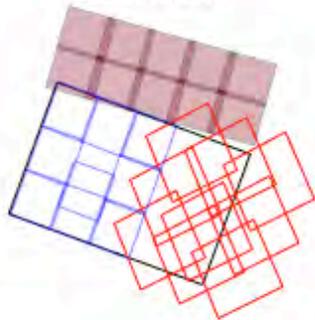
Visit 11
Deep JH Epoch 7
Orient = 295
12 Sep - 23 Sep 11
16 Orbits



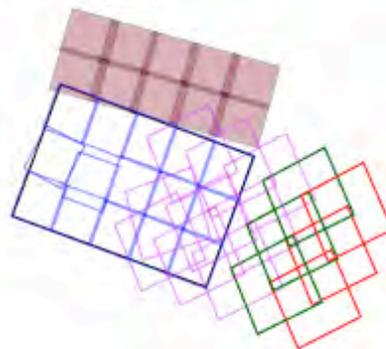
Visit 12
Deep JH Epoch 8
Orient = 340
03 Nov - 07 Nov 11
16 Orbits



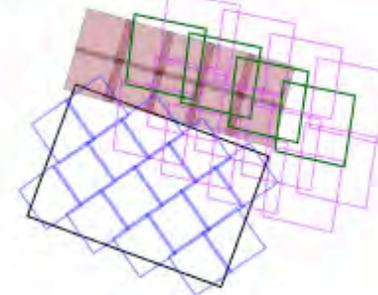
Visit 13
Deep Y 2
Orient = 25
21 Nov - 10 Dec 11
9x3 = 27 Orbits



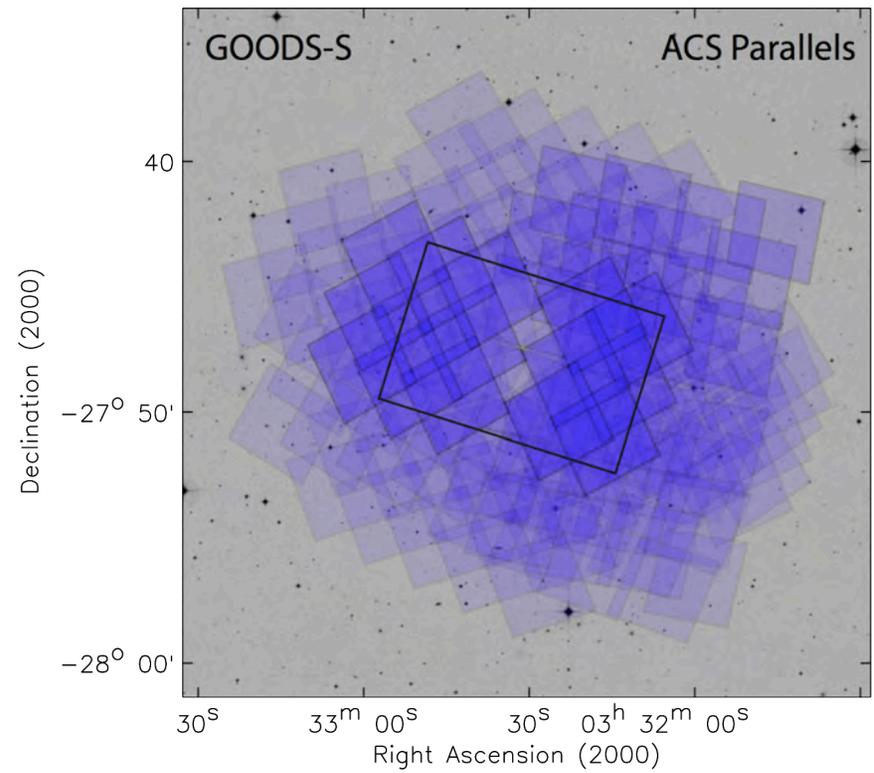
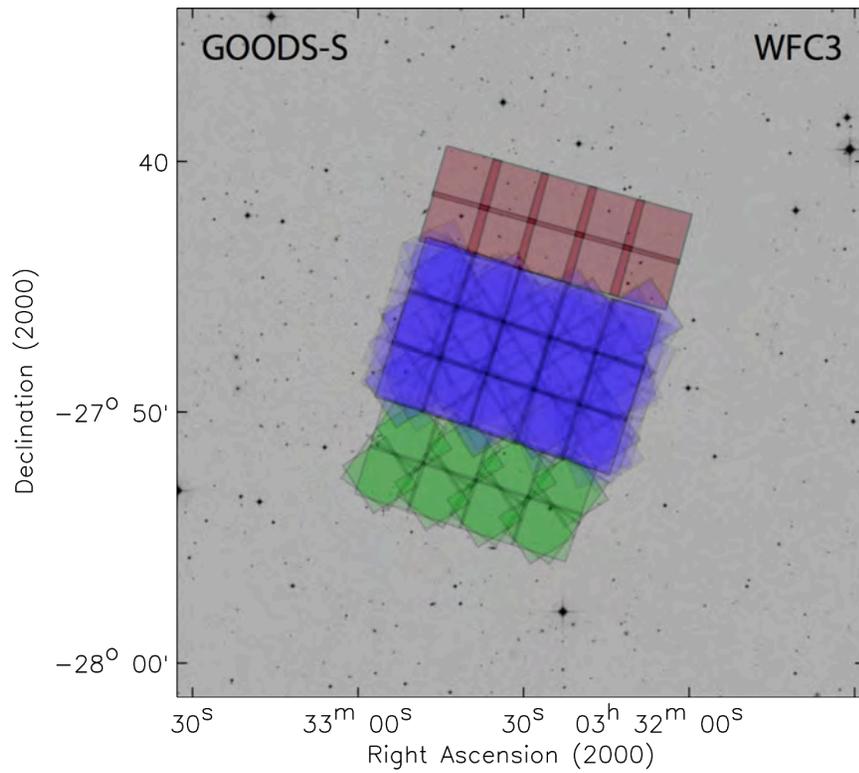
Visit 14
Deep JH Epoch 9
Orient = 25
24 Dec - 29 Dec 11
15 Orbits



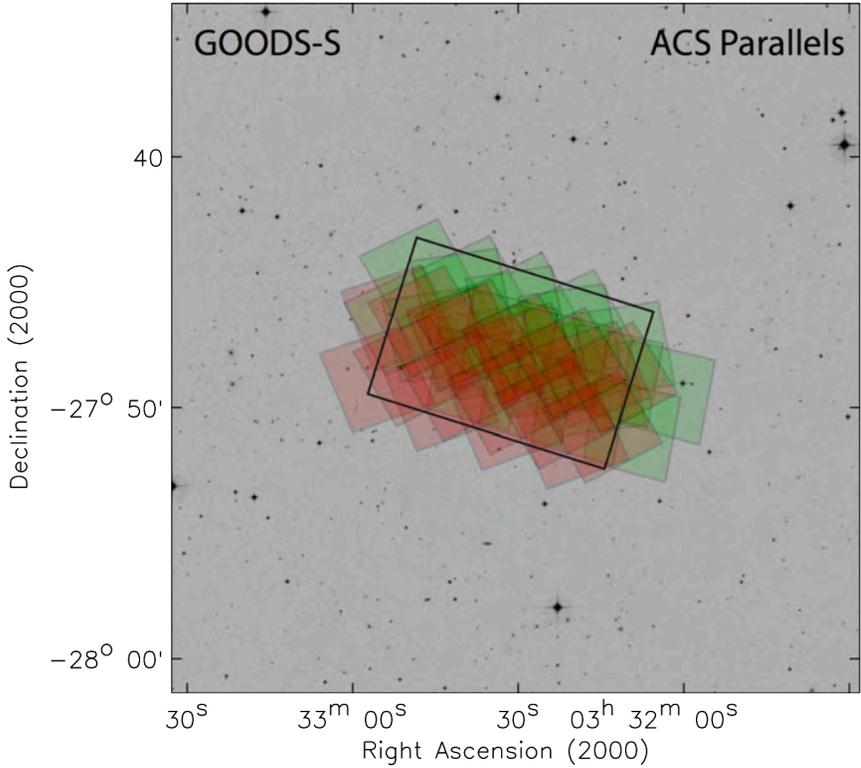
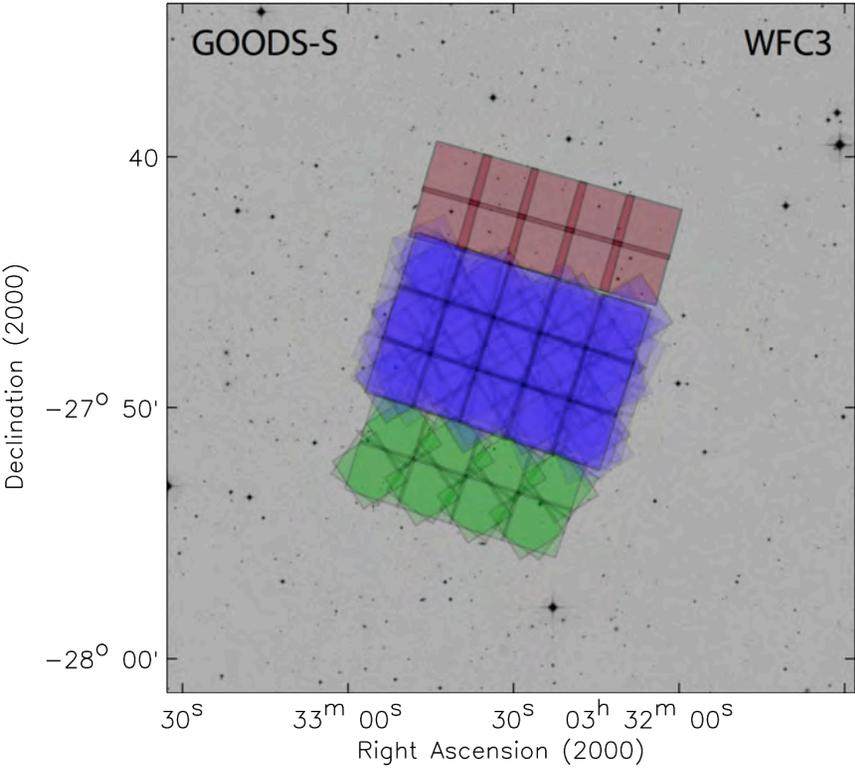
Visit 15
Deep JH Epoch 10
Orient = 80
15 Feb - 19 Feb 12
16 Orbits



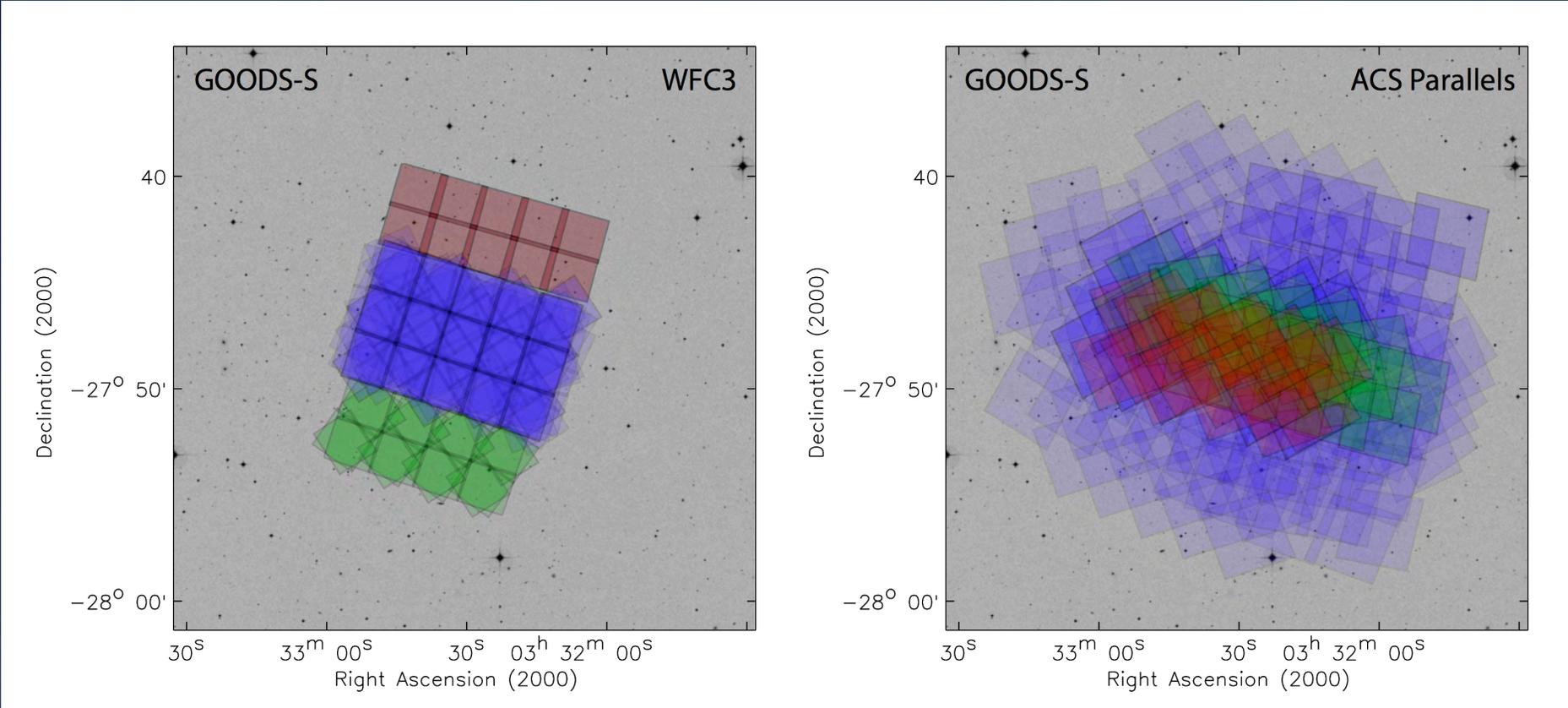
Deep Strategy: GOODS-S



Deep Strategy: GOODS-S



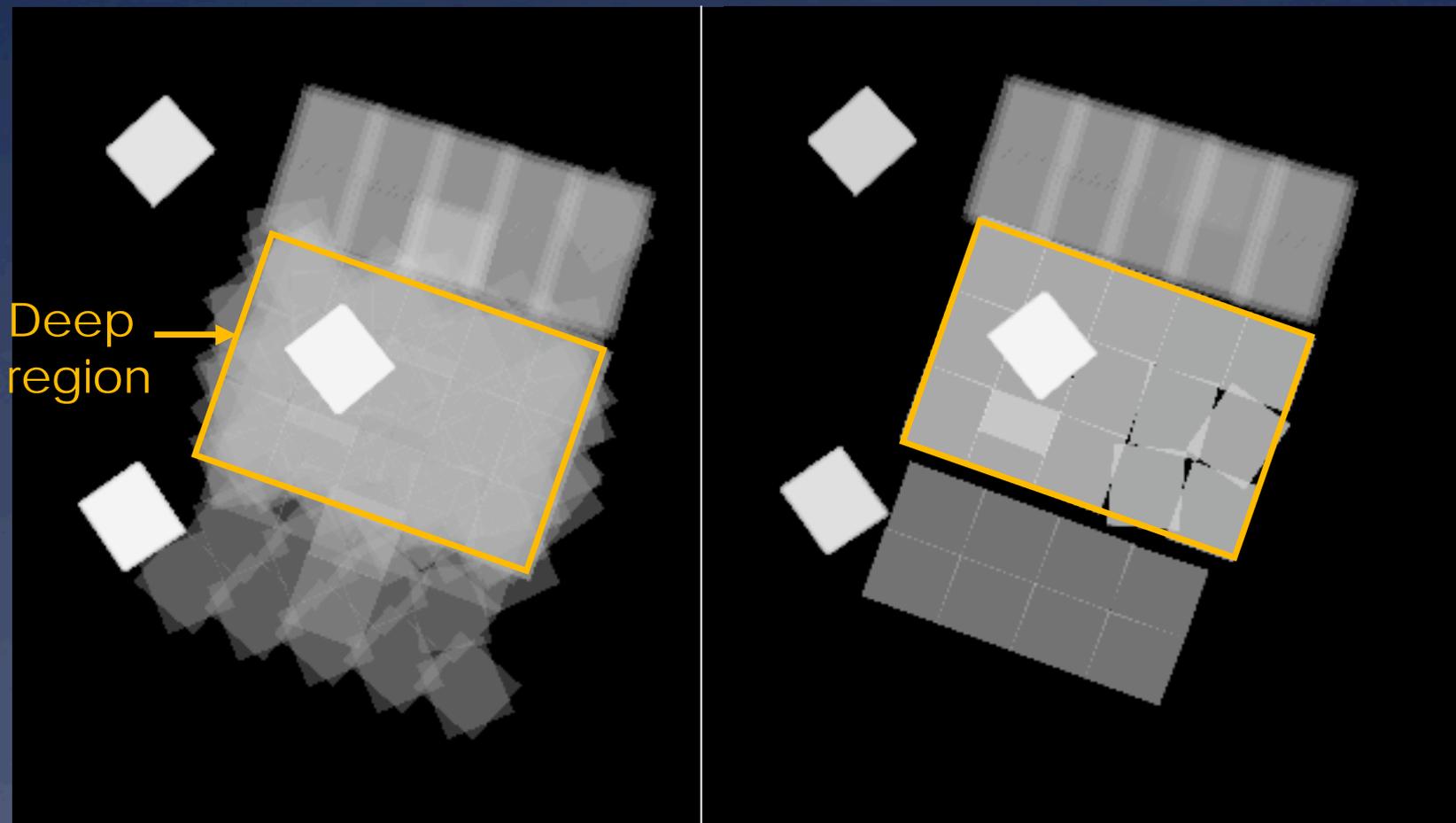
Deep Strategy: GOODS-S



GOODS-S WFC3 coverage: including all data

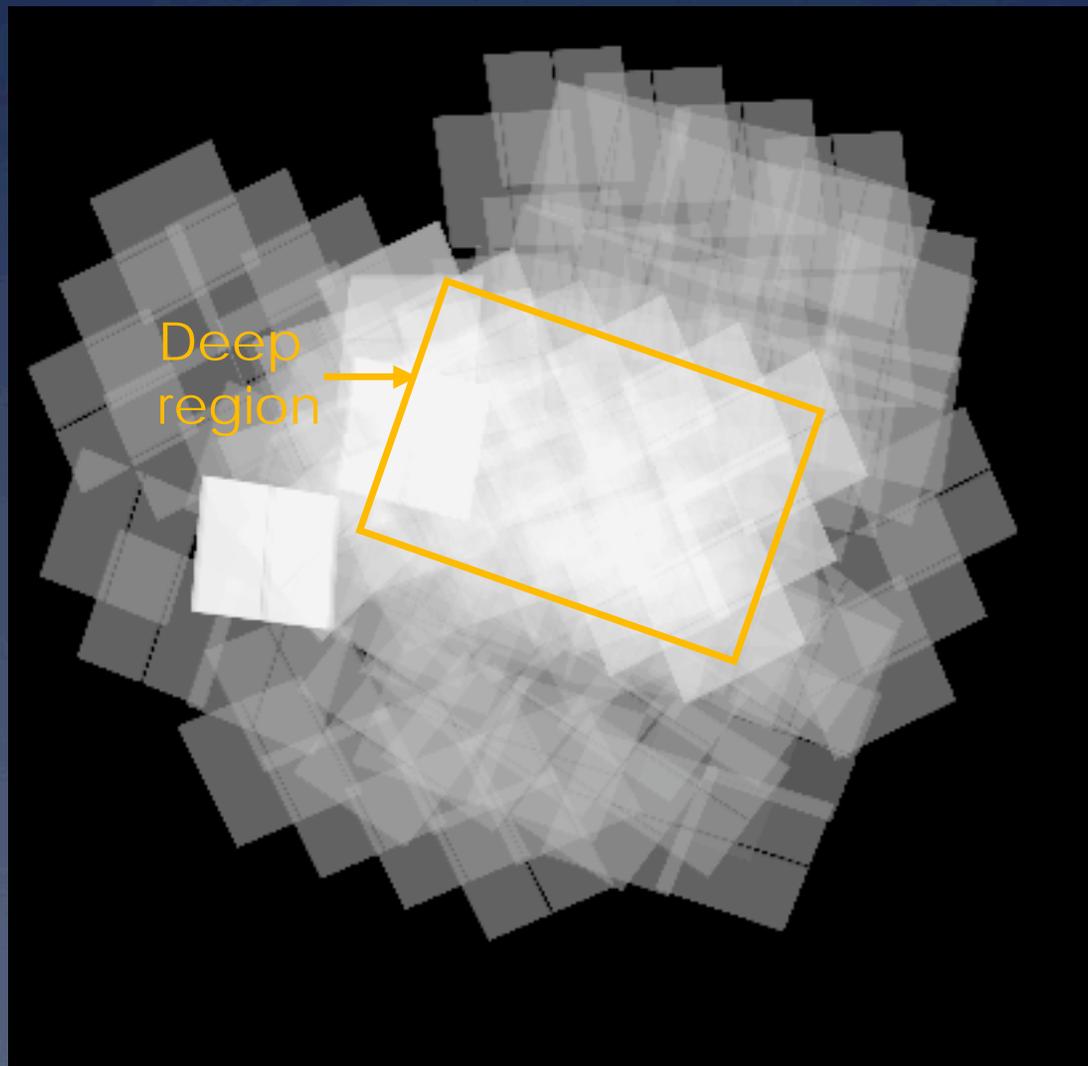
J and H-band

Y-band



GOODS-S ACS parallel coverage, final

F814W, I-band: needed to ID high-z galaxies



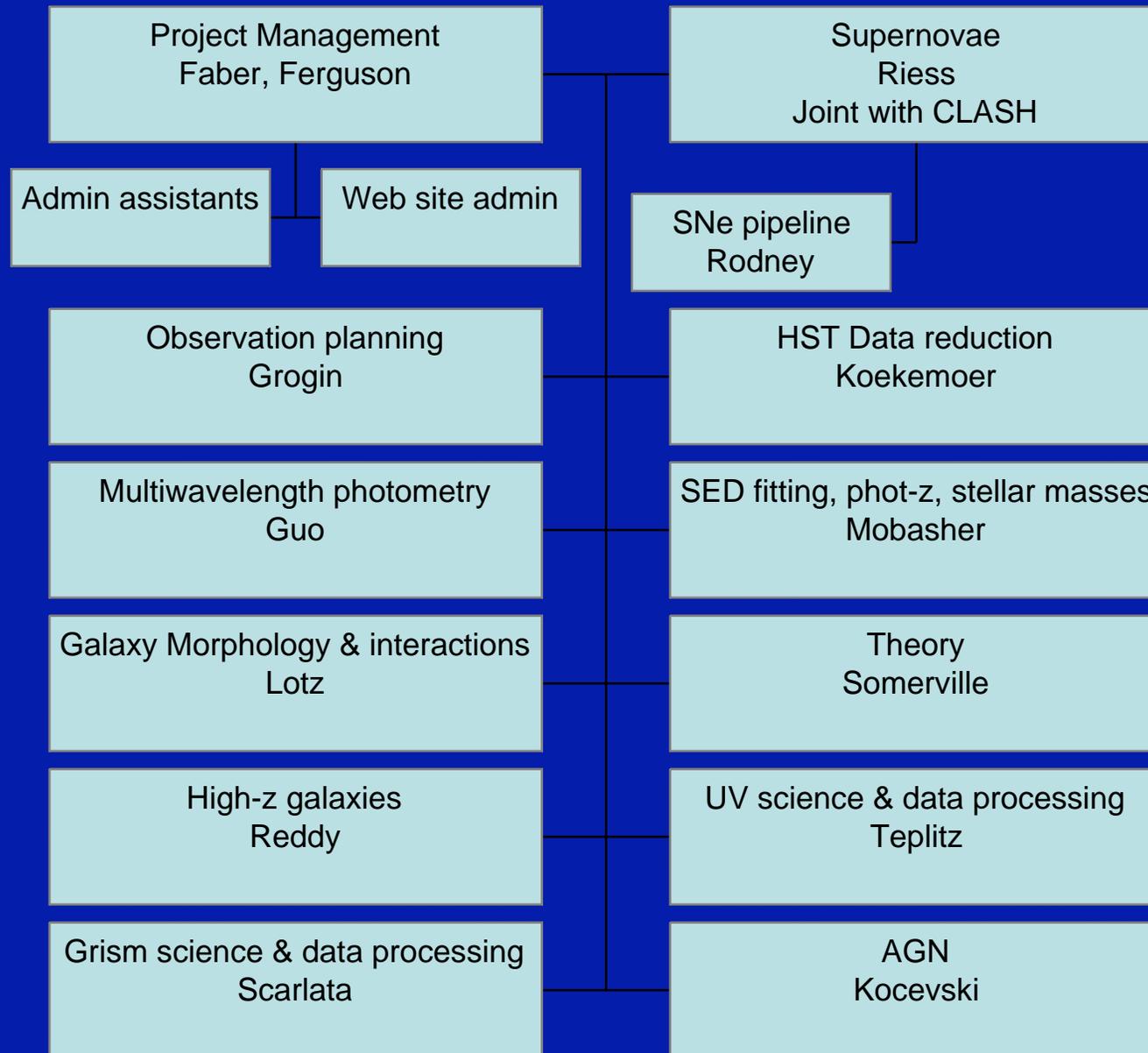


CANDELS data pipeline flowchart v1.

Technical Issues

- We need to reprocess and stack all the existing ACS data on these fields (for high-z galaxies):
 - With better geometric distortion corrections and astrometry than the original GOODS stacks
 - With CTE corrections (Anderson algorithm)
 - Need alignment to WFC3 to within 0.1 pixel
 - Correcting crosstalk for the EBL fluctuations project
- We need to worry about scattered earthshine for the EBL project and for CVZ orbits
- Persistence, blobs, etc. are a challenge for supernovae and EBL fluctuations.

CANDELS Working groups



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nick blantor

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Management

- Weekly Reports
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- Publicity
- Paper Announcements

Working Groups

Infrastructure WGs

- Observations Planning
- HST Data Products
- Multi-wavelength Catalogs
- Optical Spectroscopy
- SED & Photo-z
- Website

Science WGs

- Structure & Morphology
- Supernovae
- Active Galaxies
- UV Science
- Grism Science
- Simulations
- High Redshift

Welcome to the CANDELS Team Wiki

This Wiki is currently hosted and maintained at UC Santa Cruz. The Wiki is open and editable by all members of the CANDELS team. It is organized to enhance the functioning of working groups and will serve as a means of regular communication and documentation for the management and working groups of the collaboration.

This Wiki is based on the [MoinMoin Engine](#). Documentation is accessible through the [HelpContents](#) link in the top navigation bar. The CANDELS webteam also put together a [UsefulTips](#) page with some basic instructions and guidelines on how to use the wiki. Please also take a moment to [update your personal wiki page](#). Feel free to contact our [webteam](#) if you have questions.

Team Management

PI: [SandraFaber](#) Co-PI: [HarryFerguson](#)

- CANDELS Weekly Reports
- Budget
- Travel Info
- Telecon Info
- Publicity
- Paper Announcements
- List of CANDELS co-Is on the wiki
- List of CANDELS collaborators on the wiki

Working Groups

Infrastructure Working Groups

- Observations Planning
- HST Data Products (candels-hstdatawg@stsci.edu)
- Multi-wavelength Catalogs
- Optical Spectroscopy
- SED & Photo-z
- Website

Science Working Groups

- Structure & Morphology
- Supernovae
- Active Galaxies
- UV Science
- Grism Science
- Simulations & Mock Catalogs (candelstwg@stsci.edu)
- High Redshift Science
- EBL

CANDELS

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For Astronomers

- [Science Goals](#)
- [Survey Description](#)
- [Field Maps](#)
- [Observations Schedule](#)
- [Survey Status](#)
- [Publications](#)

Announcements

- NEW** The first CANDELS data in GOODS-S were obtained. -- 10/11/2010.
- The CANDELS test orbit data were obtained. -- 8/10/2010
- 902 orbits of Hubble observing time awarded to the CANDELS survey. - 3/15/2010

Observing Schedule

REGION	EPOCH	ORIENT	ORBITS	START DATE	END DATE	Program	Comments
STST	-	255	1	4-Aug-10	10-Aug-10		test orbit
SD	1	325	16	8-Oct-10	13-Oct-10	12061	Epoch 1
UDS	1	45	44	6-Nov-10	20-Nov-10	12064	
SD	2	25	15	26-Nov-10	1-Dec-10	12061	Epoch 2
UDS	2	45	44	27-Dec-10	10-Jan-11	12064	
SW	1	68	9	7-Jan-11	10-Jan-11	12061	Skirt
SD	3	73	15	14-Jan-11	19-Jan-11	12061	Epoch 3
SW	2	94	9	27-Feb-11	2-Mar-11	12061	Skirt
SD	4	95	16	2-Mar-11	6-Mar-11	12061	Epoch 4
SYW	-	115	11	25-Mar-11	29-Mar-11	12060	Skirt
EGSa	1	187.3	25	2-Apr-11	9-Apr-11	12063	
EGSa	2	164.9	25	24-May-11	29-May-11	12063	
SD	5	205	15	3-Jun-11	20-Jun-11	12061	Epoch 5
SYa	-	205	18	27-May-11	21-Jun-11	12060	2x3 array
SD	6	250	15	28-Jul-11	6-Aug-11	12062	Epoch 6
SD	7	295	16	12-Sep-11	23-Sep-11	12062	Epoch 7
SD	8	340	16	3-Nov-11	7-Nov-11	12062	Epoch 8
SYb	-	25	27	21-Nov-11	1-Dec-11	12060	3x3 array
COS	1	307	44	2-Dec-11	15-Dec-11		
SD	9	25	15	24-Dec-11	29-Dec-11	12062	Epoch 9
COS	2	307	44	23-Jan-12	4-Feb-12		
SD	10	80	16	15-Feb-12	19-Feb-12	12062	Epoch 10
ND/NWa	1/1	180	24	31-Mar-12	4-Apr-12		
ND/NWa	2/2	135	26	23-May-12	29-May-12		
NYa	-	90	18	4-Jul-12	15-Jul-12		
ND	3	87	15	15-Jul-12	19-Jul-12		
ND/NWb	4/1	25	25	5-Sep-12	13-Sep-12		
NYNE	-	0	8	28-Sep-12	2-Oct-12		
ND/NWb	5/2	331	25	30-Oct-12	8-Nov-12		
ND	6	270	15	27-Dec-12	1-Jan-13		
NYb	-	270	27	2-Jan-13	14-Jan-13		
ND	7	225	16	20-Feb-13	25-Feb-13		
EGSb	1	187.3	20	2-Apr-13	8-Apr-13	12063	
NYSW	-	180	8	8-Apr-13	10-Apr-13		
ND	8	180	16	11-Apr-13	16-Apr-13		
EGSb	2	164.9	20	23-May-13	29-May-13	12063	
ND	9	119	16	7-Jun-13	12-Jun-13		
ND	10	62	16	5-Aug-13	10-Aug-13		

Legend of region IDs

STST	GOODS-South Test Orbit (IR in ERS2)
SD	GOODS-South Deep (3x5 transverse)
SW	GOODS-South Wide (2x5 transverse)
SYW	GOODS-South Wide (Y-band + JH filler)
SYa	Western 3x2 of SD (Y-band only)
SYb	Eastern 3x3 of SD (Y-band only)
ND	GOODS-North Deep (3x5 transverse)
NWa	GOODS-North Wide SW (2x5 transverse)
NYSW	GOODS-North Wide SW (Y-band only)
NWb	GOODS-North Wide NE (2x5 transverse)
NYNE	GOODS-North Wide NE (Y-band only)
NYa	Eastern 3x2 of ND (Y-band only)
NYb	Western 3x3 of ND (Y-band only)
EGSa	Initial five-ninths of EGS
EGSb	Remaining four-ninths of EGS
UDS	UDS
COS	COSMOS

Data Release Plans

- **V0.5:**
 - Updated cumulative stacks within 3 months of each epoch
- **V1.0:**
 - Recalibrated, re-aligned stacks within 6 months of final observations on each field.
- **V2.0:**
 - If recalibration is necessary, aim is to release the final version within 1 year of completion of the program.
- **Catalogs:**
 - Generally, release catalogs at the same time as the first publications using the catalogs.
- **Theory component:**
 - Release mock catalogs & images within 1 year of completion of observations.

VAO Collaboration

- **Tentatively:**
 - VOEvents
 - Transients bright enough to be followed from the ground announced as they are discovered
 - Drill-down tool
 - Ability to retrieve cutouts (at selected stages of processing) of sources identified on a plot
 - SED tool
 - Combine photometric data from multi-wavelength catalogs with knowledge of bandpasses, psf & photometric errors
 - Advanced catalog matching

Summary: CANDELS is...

- **Scientifically Ambitious**
 - 19 major science objectives encompassing many areas of galaxy evolution & cosmology
 - Committed to releasing high-level science products rapidly
- **Large**
 - 902 prime orbits using WFC3 & ACS
 - Parallels and CVZ make this the equivalent of 1900
 - ~6700 images & grism spectra
 - 100+ collaborators including students & postdocs
- **Complex**
 - Timing & orientation requirements
 - Real-time data processing for supernova search
 - Stringent requirements for avoiding false SNe candidates
 - Reprocessing thousands of archival ACS images
 - PSF-matched multi-wavelength photometry & morphology
- **And underway!**