HST Frontier Fields

www.stsci.edu/hst/campaigns/frontier-fields

Director's Discretionary time campaign to observe 4 (6) strong-lensing clusters and adjacent blank fields with ACS/WFC3-IR in Cycle 21, 22, (+23)

- Discover new population of z=5-10 galaxies,10-100x fainter than any known
- Characterize stellar populations of faint galaxies at the earliest times.
- Do astrophysics at z > 8 by finding galaxies magnified enough for spectroscopic follow-up and/or stretched out enough to measure sizes and internal structure.
- Provide, for the first time, a statistically meaningful morphological characterization of star forming galaxies at z>5.

a sneak peak of JWST + TMT science with HST

Jennifer Lotz - TMT

Hubble Deep Field Initiative
Science Working Group

Is there a science case for new deep fields with HST?

James Bullock (Chair, UCI), Mark Dickinson (NOAO), Steve Finkelstein (UT), Adriano Fontana (INAF, Rome), Ann Hornschemier Cardiff (GSFC), Jennifer Lotz (STScI), Priya Natarajan (Yale), Alexandra Pope (UMass), Brant Robertson (Arizona), Brian Siana (UC-Riverside), Jason Tumlinson (STScI), Michael Wood-Vasey (U Pitt)

- Define **the science case and a set of science goals** for a new set of ultra-deep imaging fields with sensitivity depths comparable to those of the HUDF and HUDF-09 infrared follow-up. Provide an assessment of the urgency of pursuing this science.

- Solicit **input from the astronomical community** in defining the science goals and recommendations.

- Recommend the locations and number of fields, the suite of filters, and exposure times that should be obtained to meet the science goals.

- Assess **the prospects for near-field science** that can be achieved with these deep- field observations.

Summer 2012:

Hubble Deep Field Initiative working group formed, community input solicited;

32 white papers reviewed, covering a broad range of topics/approaches (UDFs, grism, UV, clusters..)

HST Frontier Fields: Process

Fall 2012:

HDFI SWG presented a unanimous recommendation
for a joint strong-lensing cluster + parallel blank field strategy

December 2012:

--Frontier Fields announced in Cycle 21 call for proposals
--STScI Implementation team starts cluster selection, coordination with Spitzer implementation team.
--Community input solicited on cluster selection, filter choice, general input via email exploder, website, and AAS flyer.

January/Feb 2013:

--All six clusters announced; email to interested community members sent.
--WFC3/IR F140W filter added to parallel field observations (suggested by community)
--Blank field positions announced; finding charts/ regions files available on website.
-- Call for preliminary lensing maps for FF released; 5 groups chosen.

March 1 2013:

~35 HST Cycle 21 proposals received to use or supplement the Frontier Fields data

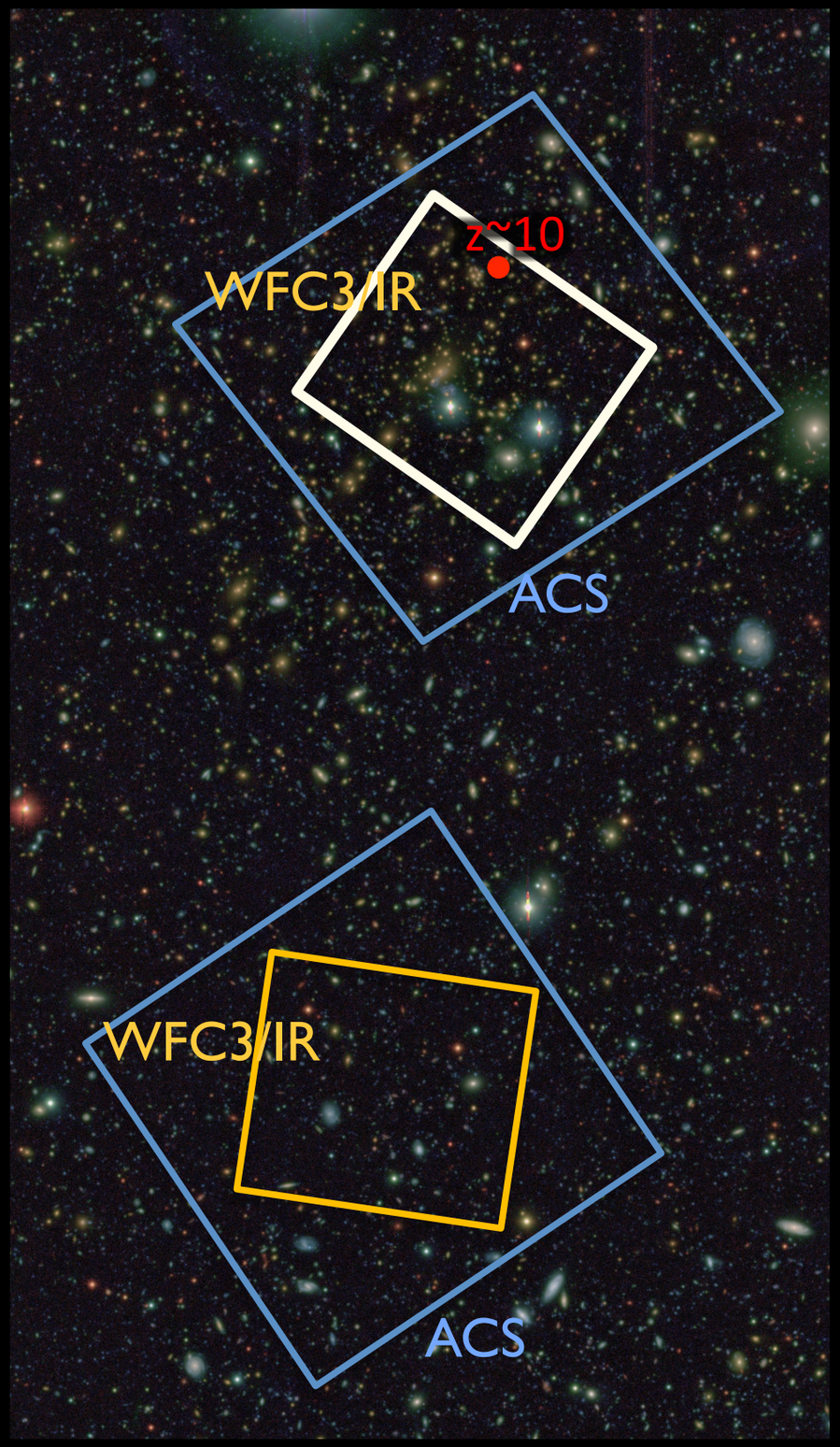
May 2013:

-- 10 HST Cycle 21 proposal selected (3 GO/7 archival)

Fall 2013:

First Frontier Field will be observed (Abell 2744).

HST Frontier Fields: Science



Current high redshift frontier with HUDF2012 and parallel fields is z = 8-11.

But we only see the brightest and most massive galaxies.
The **progenitors of today's typical L* galaxies** are fainter than HUDF limits.
⇒ Need to go intrinsically deeper than HUDF

Lensed z ~ 7-10 galaxies which are magnified enough **to study their physical properties** (sizes, color gradients, spectroscopy) are rare.

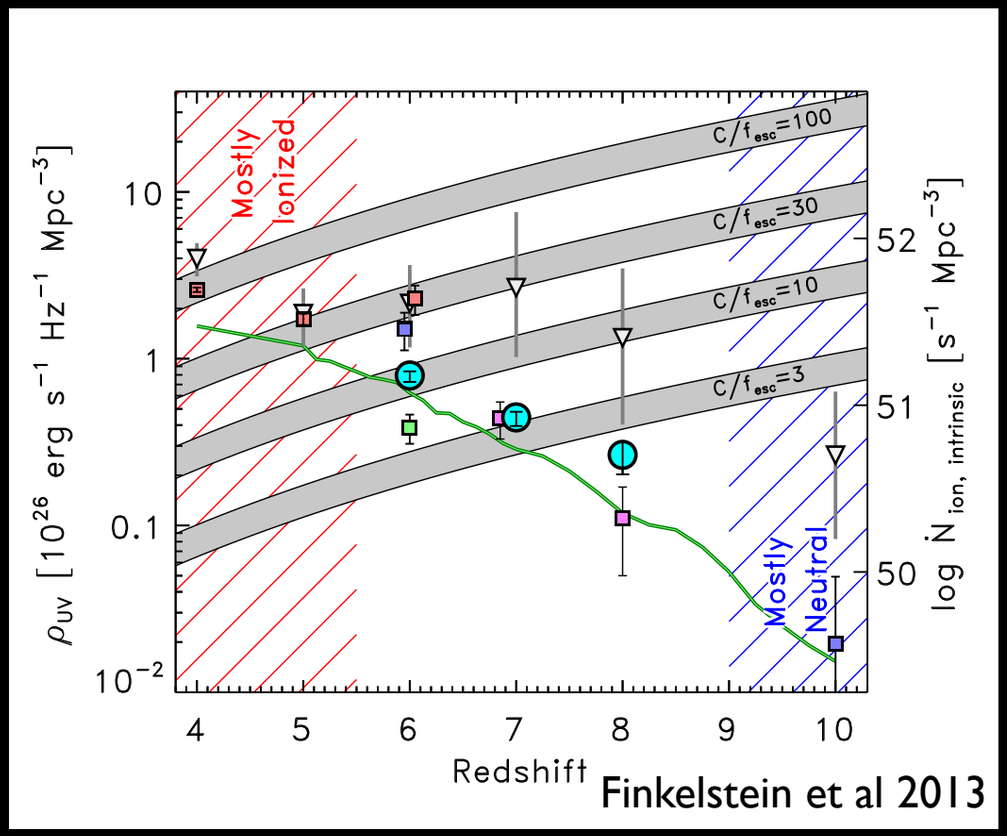
Cosmic variance is a concern, especially at z > 7.

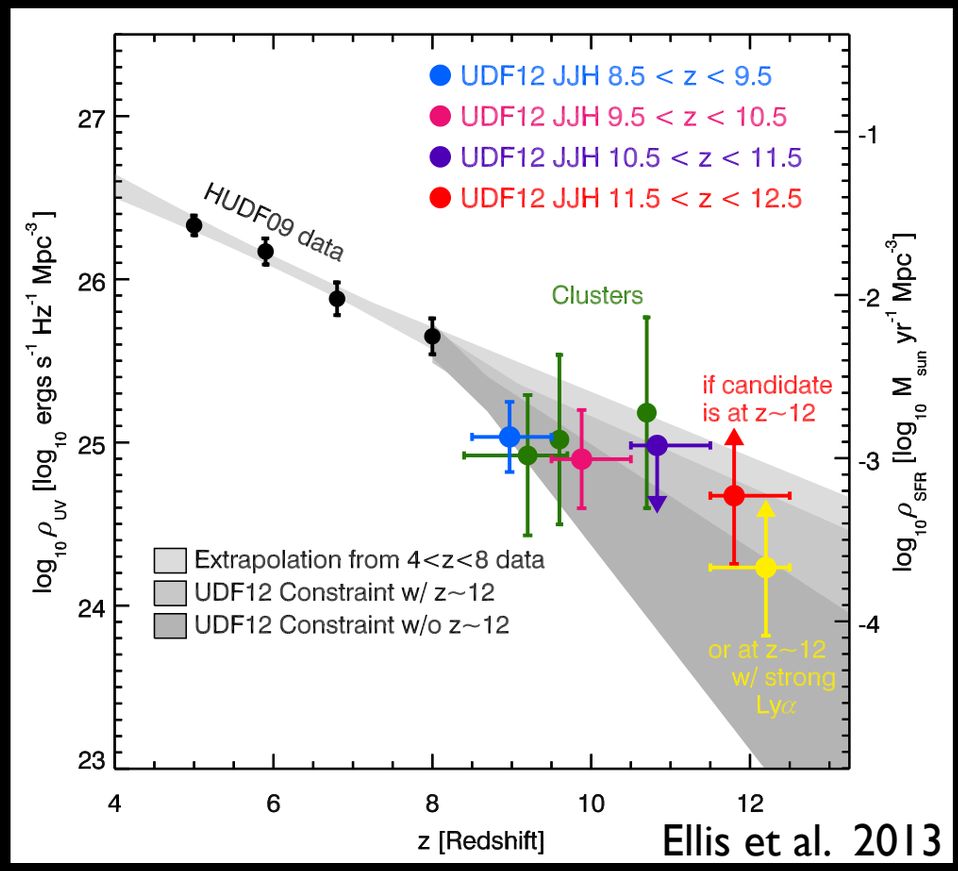
Unlensed z ~ 5-7 galaxies bright enough for **studies of internal structure** are also rare.

⇒ Need to go wider than 3 WFC3 pointings.

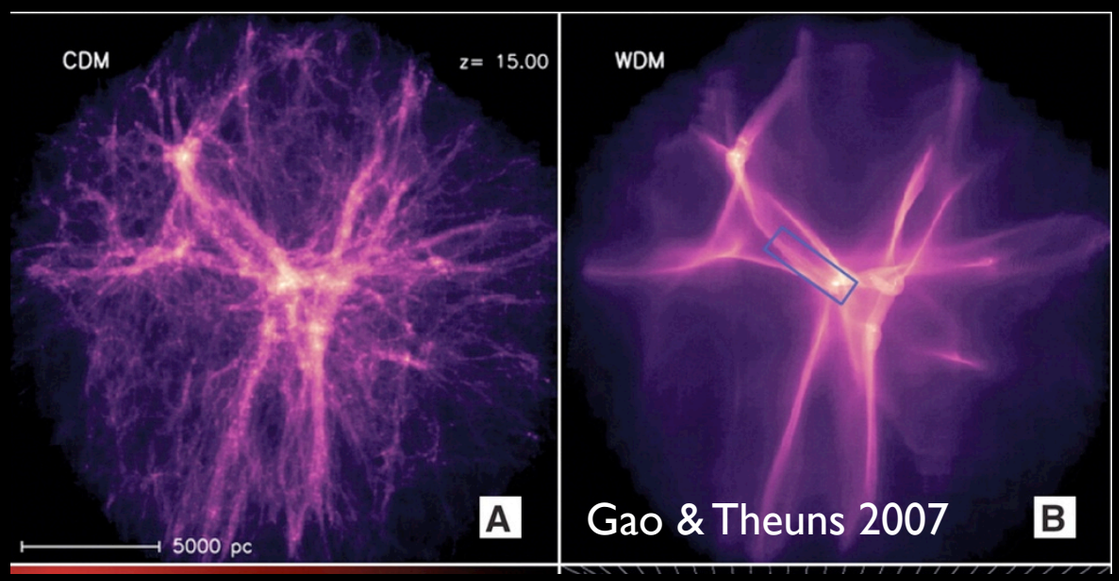
6 Lensed Fields + 6 parallel "Blank Fields"
= New Parameter Space

HST Frontier Fields: Science

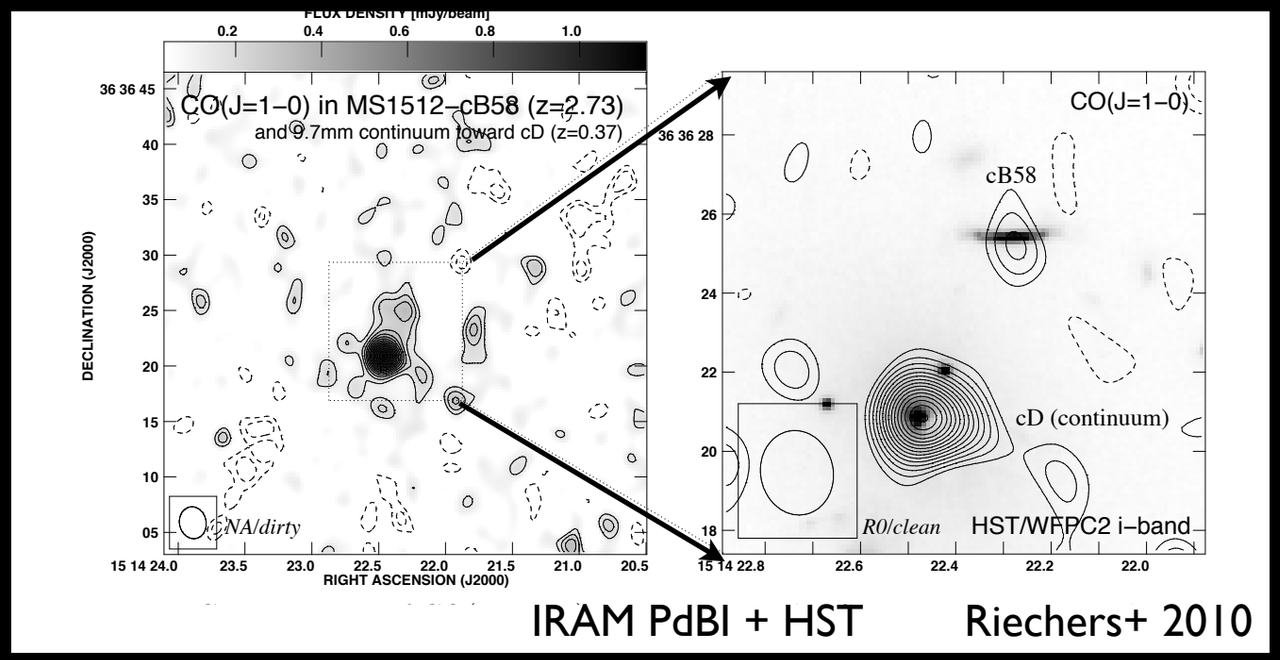




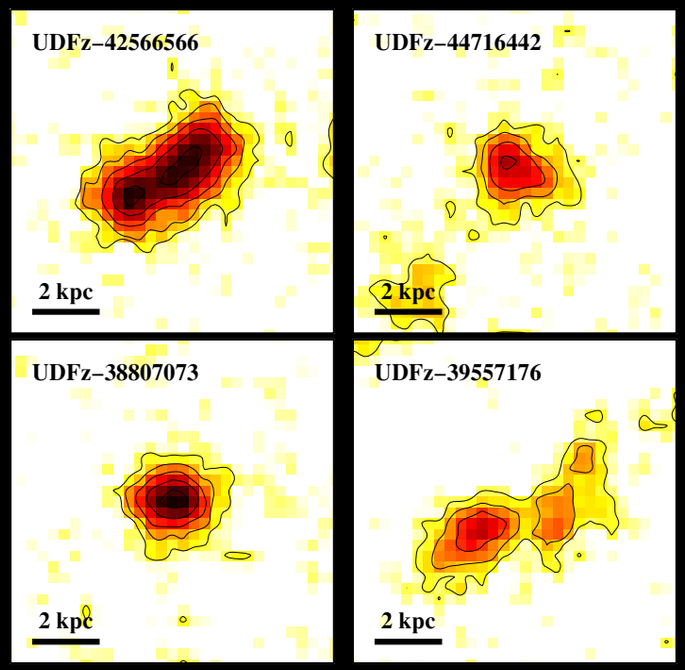
how many galaxies in the 1st billion yrs?
reionization? dark matter halos?
popIII stars?



HST Frontier Fields: Science



IRAM PdBI + HST Riechers+ 2010

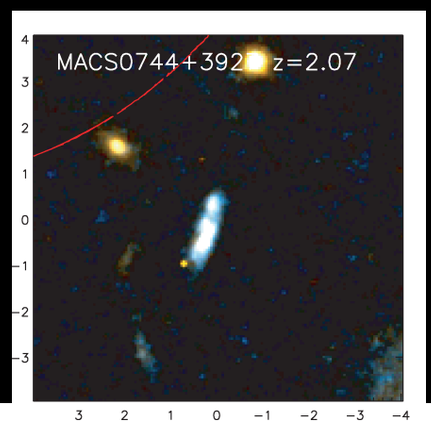


Oesch+ 2010

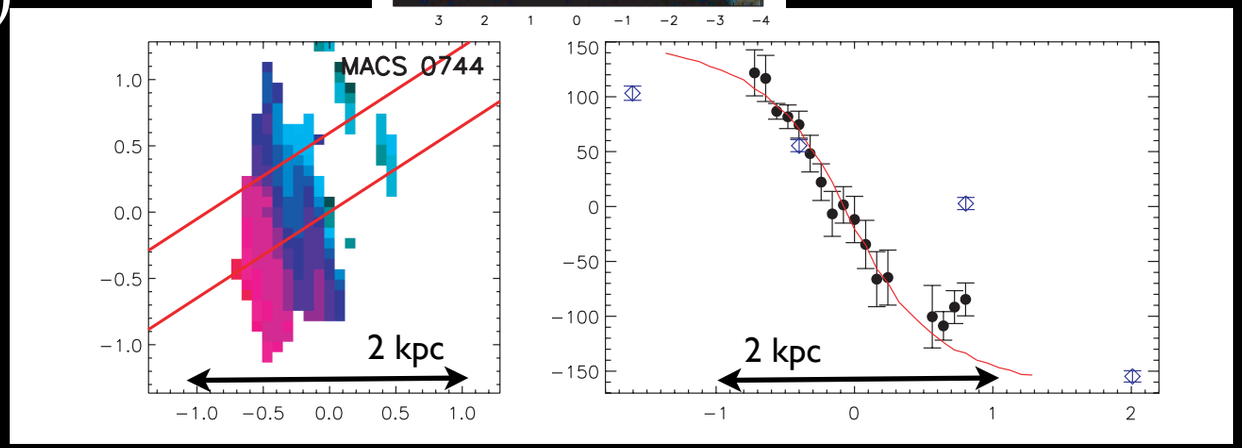
what are the sub-kpc structures of galaxies?

sizes and morphologies of high-z galaxies

resolved colors, star-formation, dust (and gas) for 1 < z < 7+ galaxies



Jones+ 2010



HST Frontier Fields: Observations

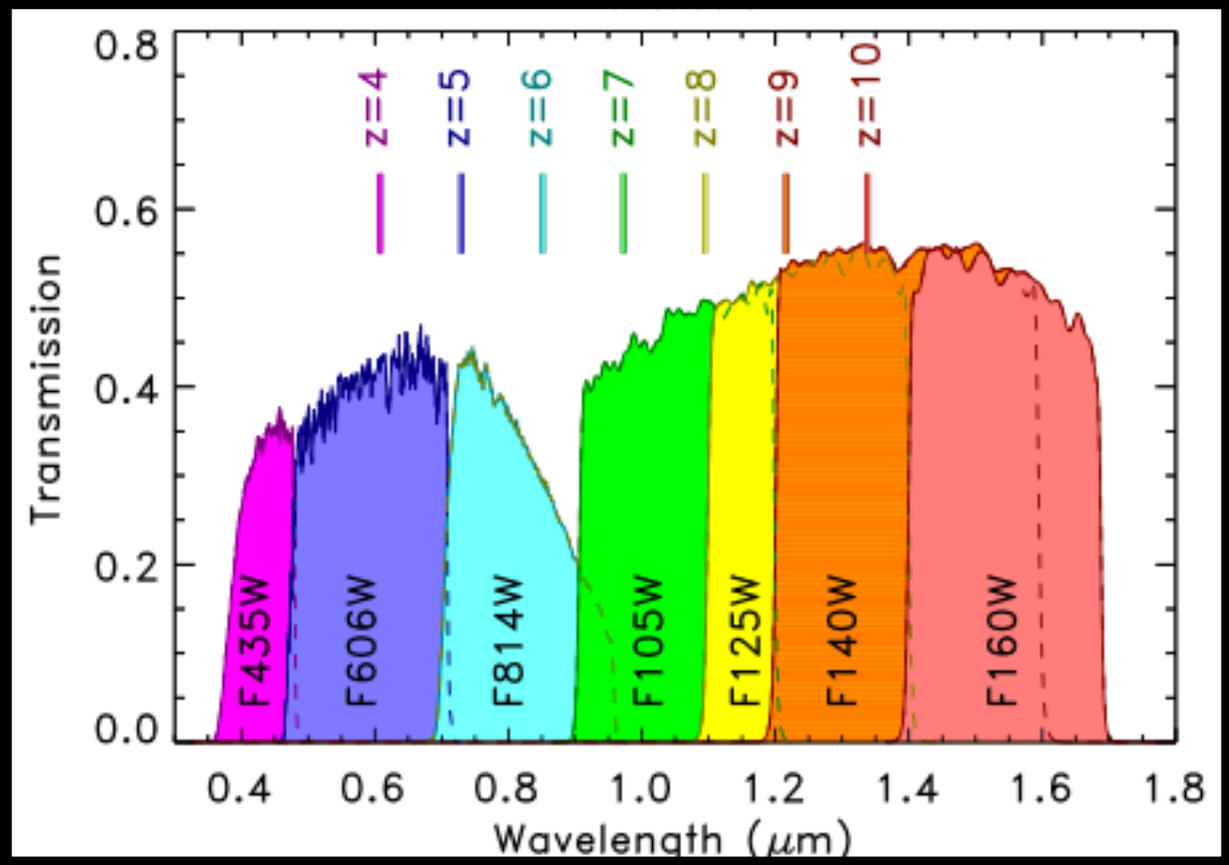
ACS - WFC3/IR in parallel; do 180-degree swap ~6 months later
Imaging in 7 bands to AB~28.7 (5σ point source, 0.4” diameter ap),
140 orbits per field ⇒ 840 orbits for 6 fields

ACS: (70 orbits per position)

F435W:	18 orbits,	28.8 ABmag
F606W:	10	28.8
F814W:	42	29.1

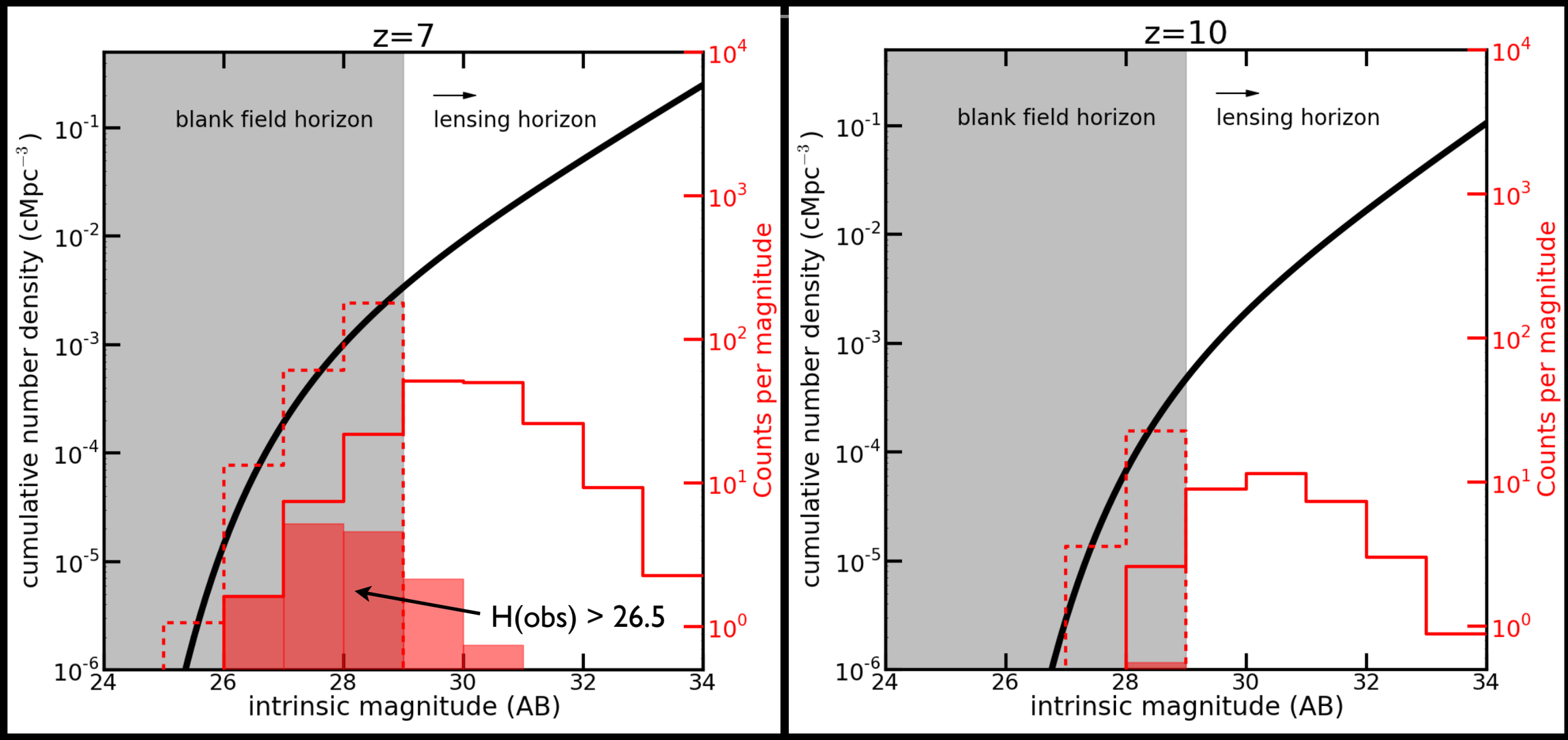
WFC3/IR: (70 orbits per position)

F105W:	24 orbits,	28.9 ABmag
F125W:	12	28.6
F140W:	10	28.6
F160W:	24	28.7



deep multi-band imaging needed to identify z~3-12 galaxies via Lyman break

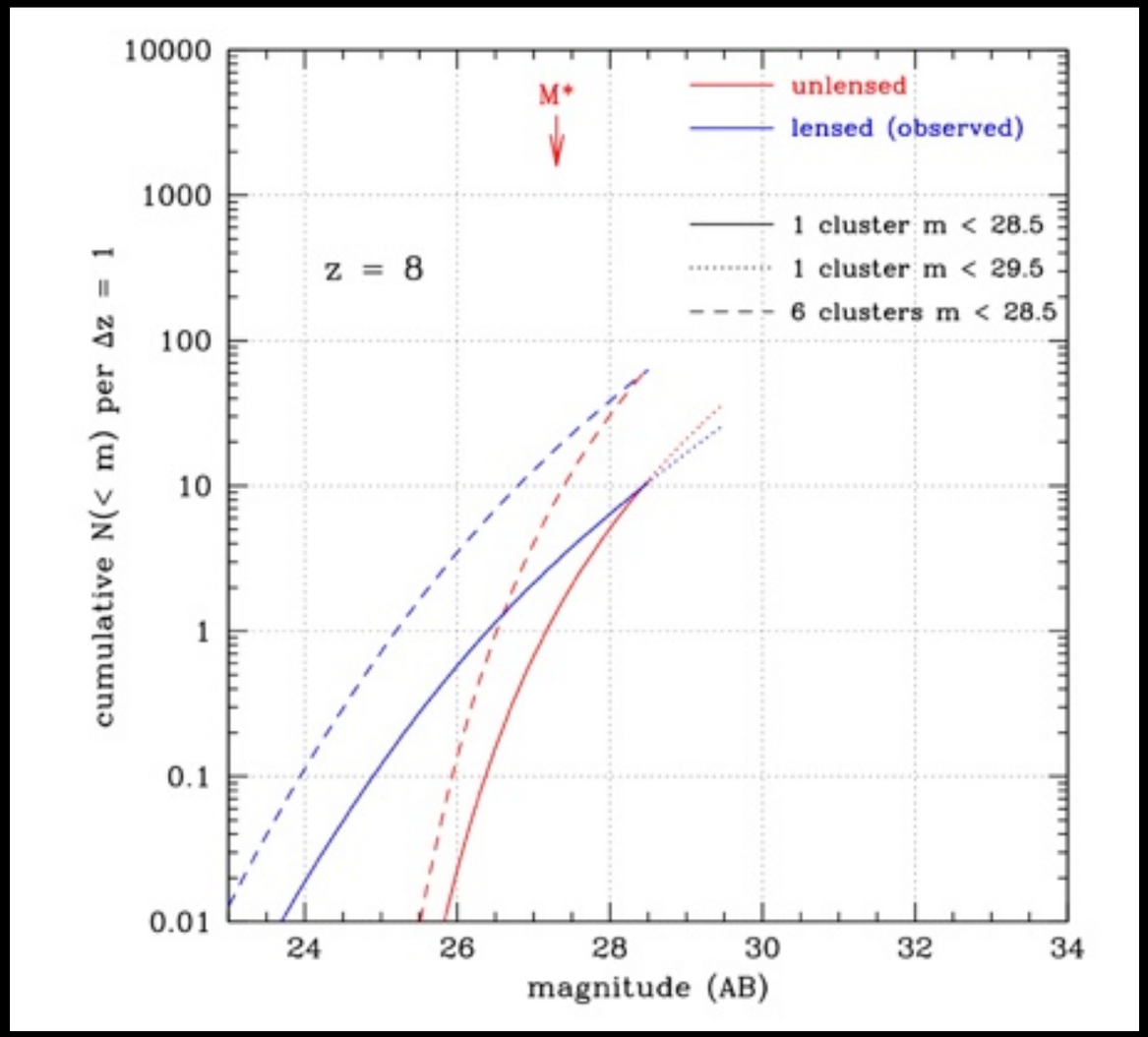
HST Frontier Fields: Science



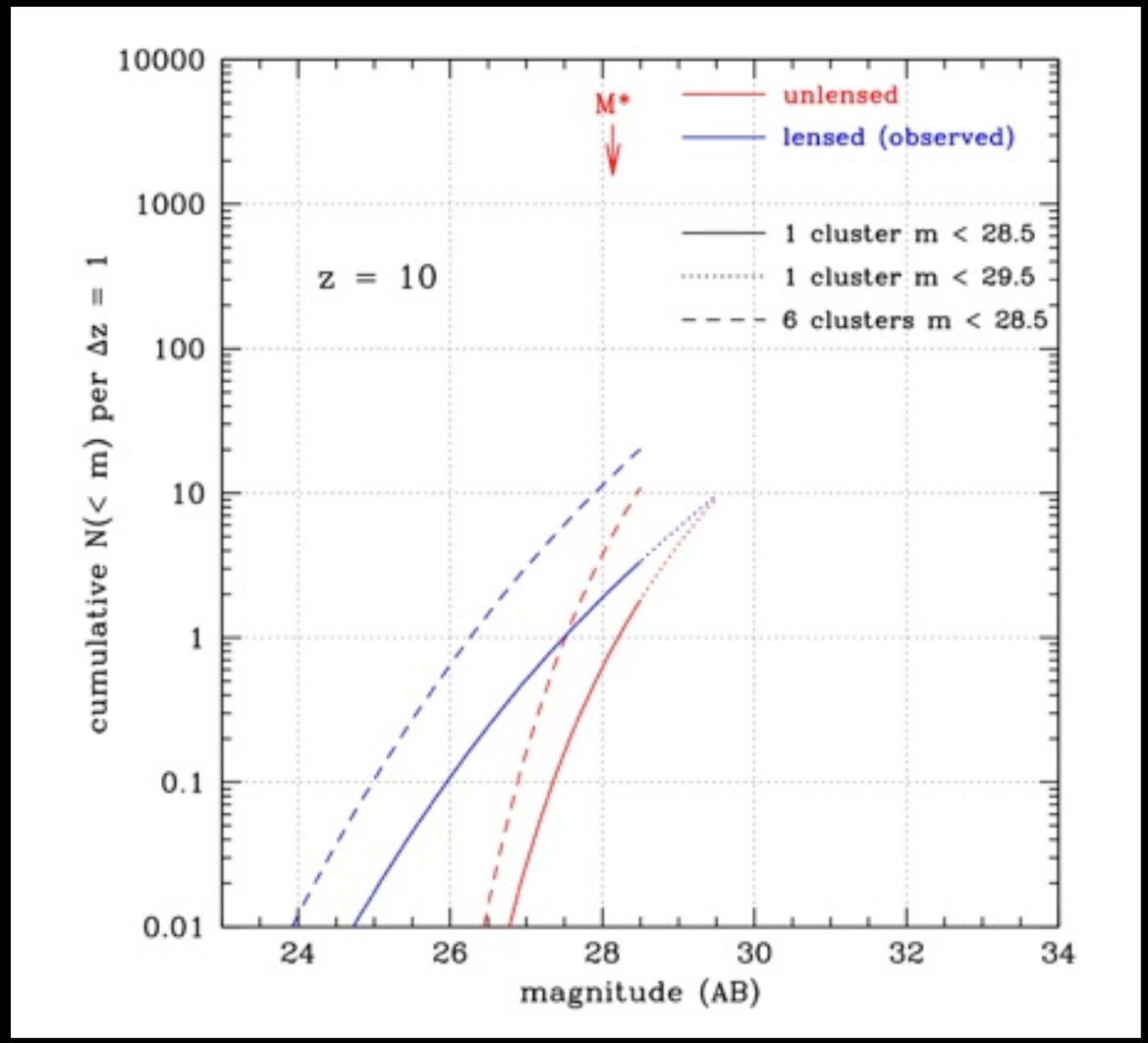
-lensed galaxies behind cluster will reach intrinsic depths ~2-3 mags deeper than HUDF2012
-parallel fields will reach intrinsic depths ~ 0.5 mag shallower than HUDF2012,
but similar to HUDF-parallels.

(HUDF2012: Y~30.0; H~29.5 AB mag 5σ 0.5" diameter ap. ; 163 orbit WFC3/IR)

HST Frontier Fields: Science



z~8 galaxies:
6 blank fields ~70 H<28.5
6 lensed fields ~70 H < 28.5 (obs)



z~10 galaxies:
6 blank fields ~15 H<28.5
6 lensed fields ~ 25 H< 28.5

assuming RXJ1347.5-1144 lens model + foreground cluster masking;
100% photometric completeness, no cosmic variance; extrapolated z~10 UVLF

HST Frontier Fields: Clusters

Initial list of ~16 clusters provided by HDFI SWG based solely on lensing properties; additional suggestions and feedback solicited from the community

Selection Criteria

- **Strongest Lensers** (# z~10 galaxies magnified to H=27 within WFC3/IR FOV)
  based on lensing models by Johan Richard, Adi Zitrin, analyzed by Dan Coe

- **Observable with HST, Spitzer, JWST**
  checked HST guide star availability, ~30 day position angle hold,
  Spitzer bright stars/schedule,
  checked against JWST proto-type scheduler

- **Low zodiacal background and Galactic extinction**

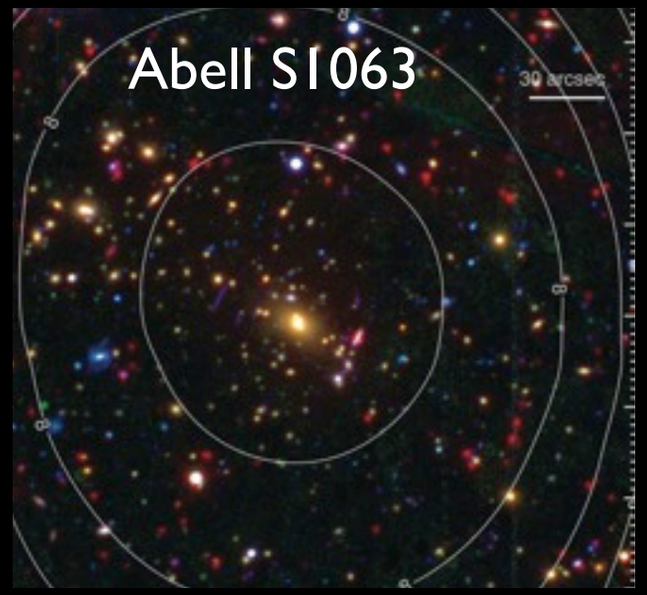
- Blank field locations selected avoid bright stars, cluster structures

- Observable with **ALMA**, Mauna Kea

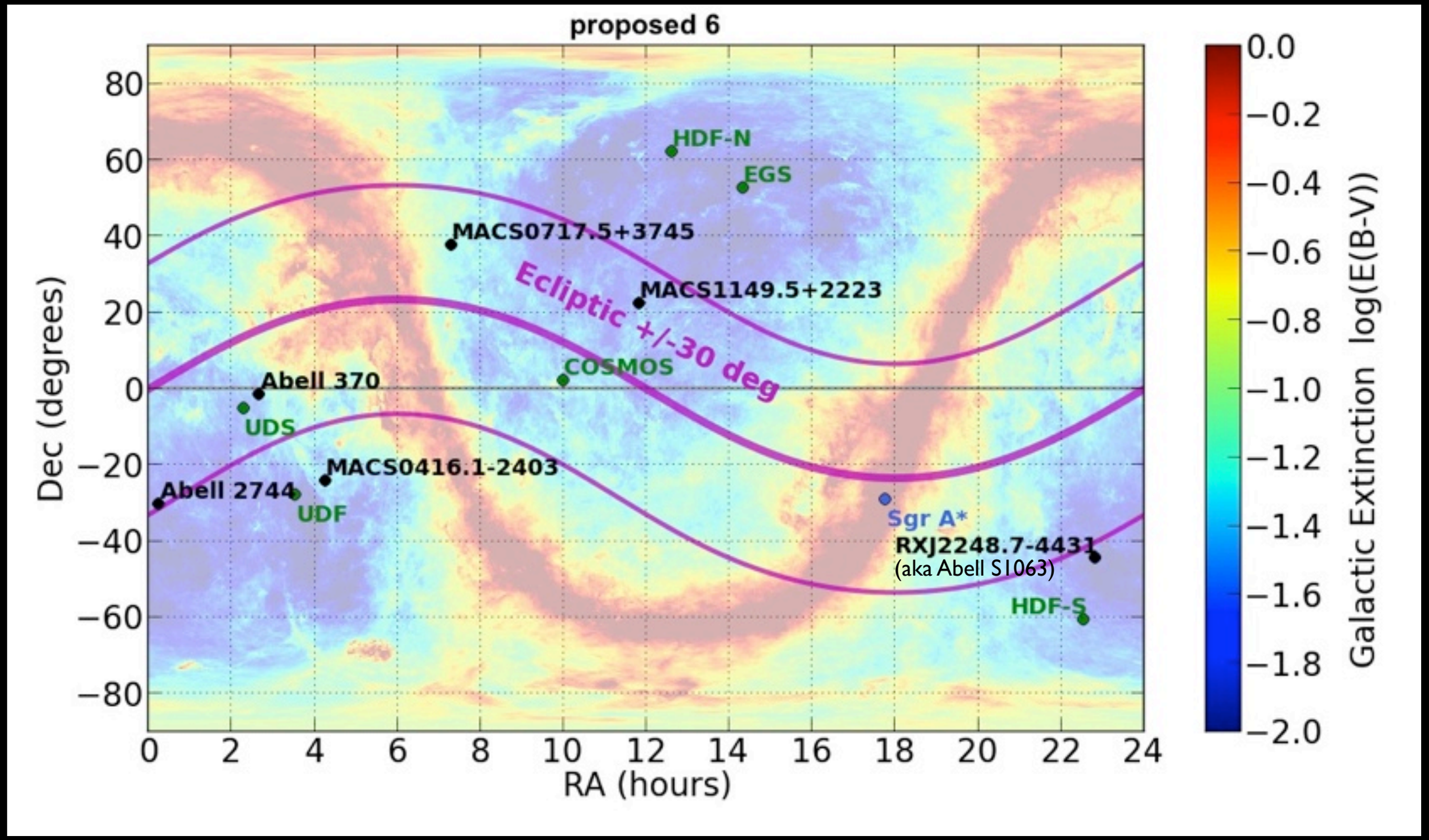
- Existing ancillary data
  (shallow HST, MIPS 24 micron, Herschel, IRAC, Chandra, SZ ..)

- Suitability for deep radio observations

HST Frontier Fields

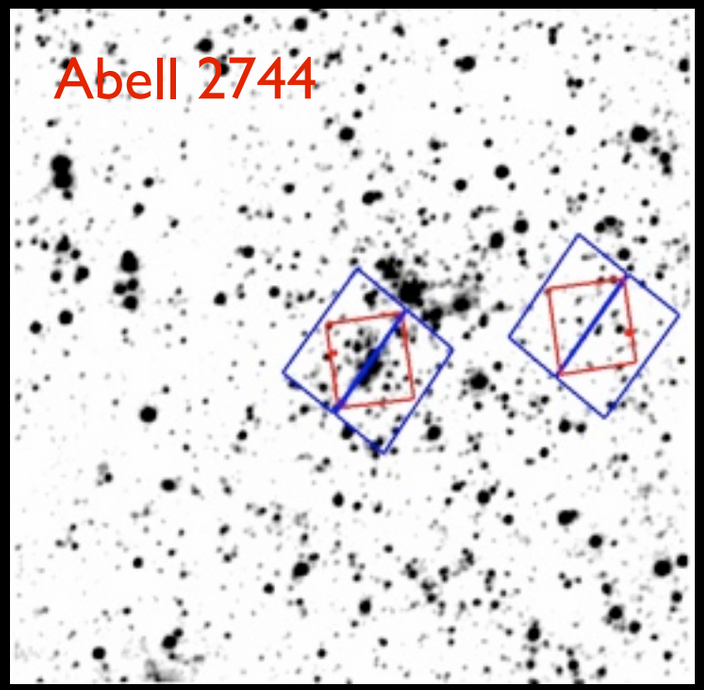


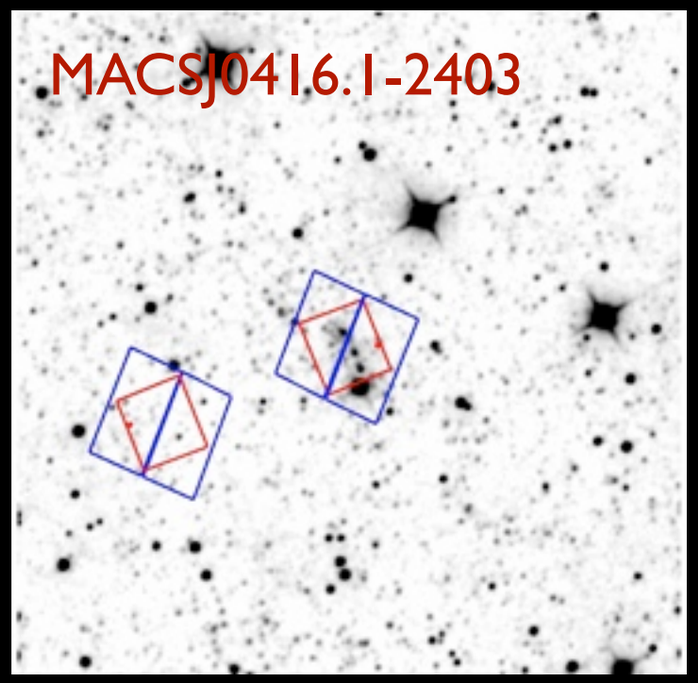
HST Frontier Fields: Clusters

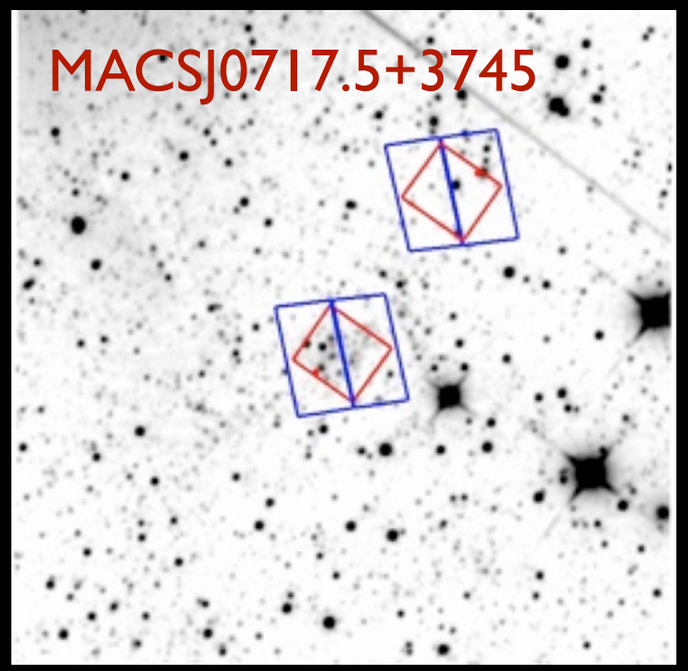


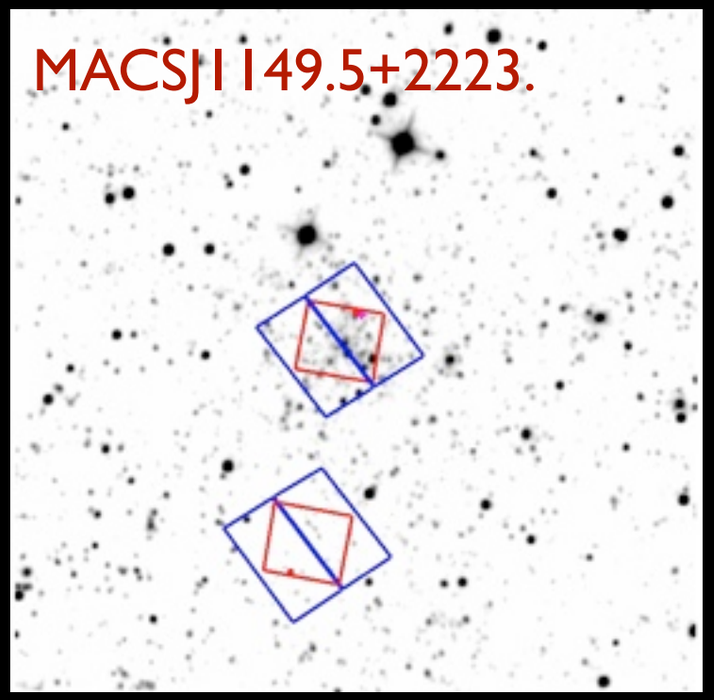
5/6 clusters observable from Mauna Kea; 5/6 cluster observable with ALMA

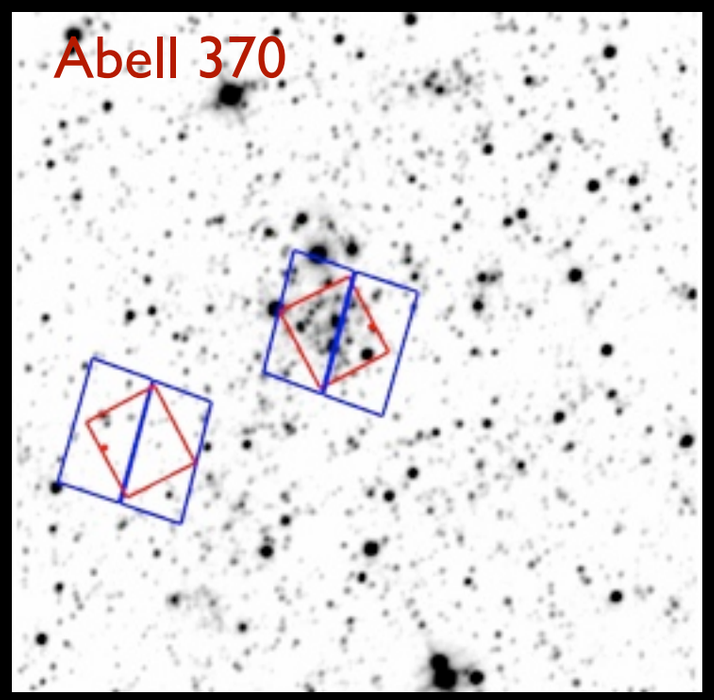
HST Frontier Fields

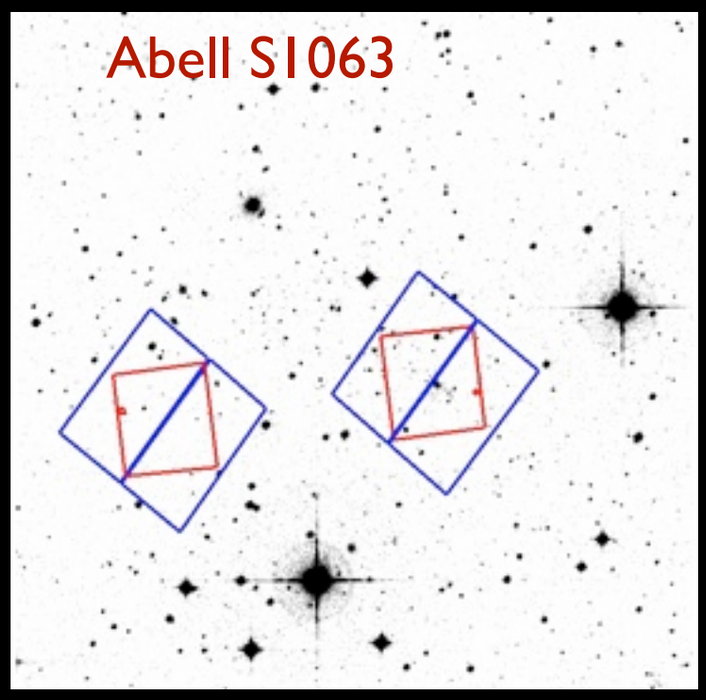








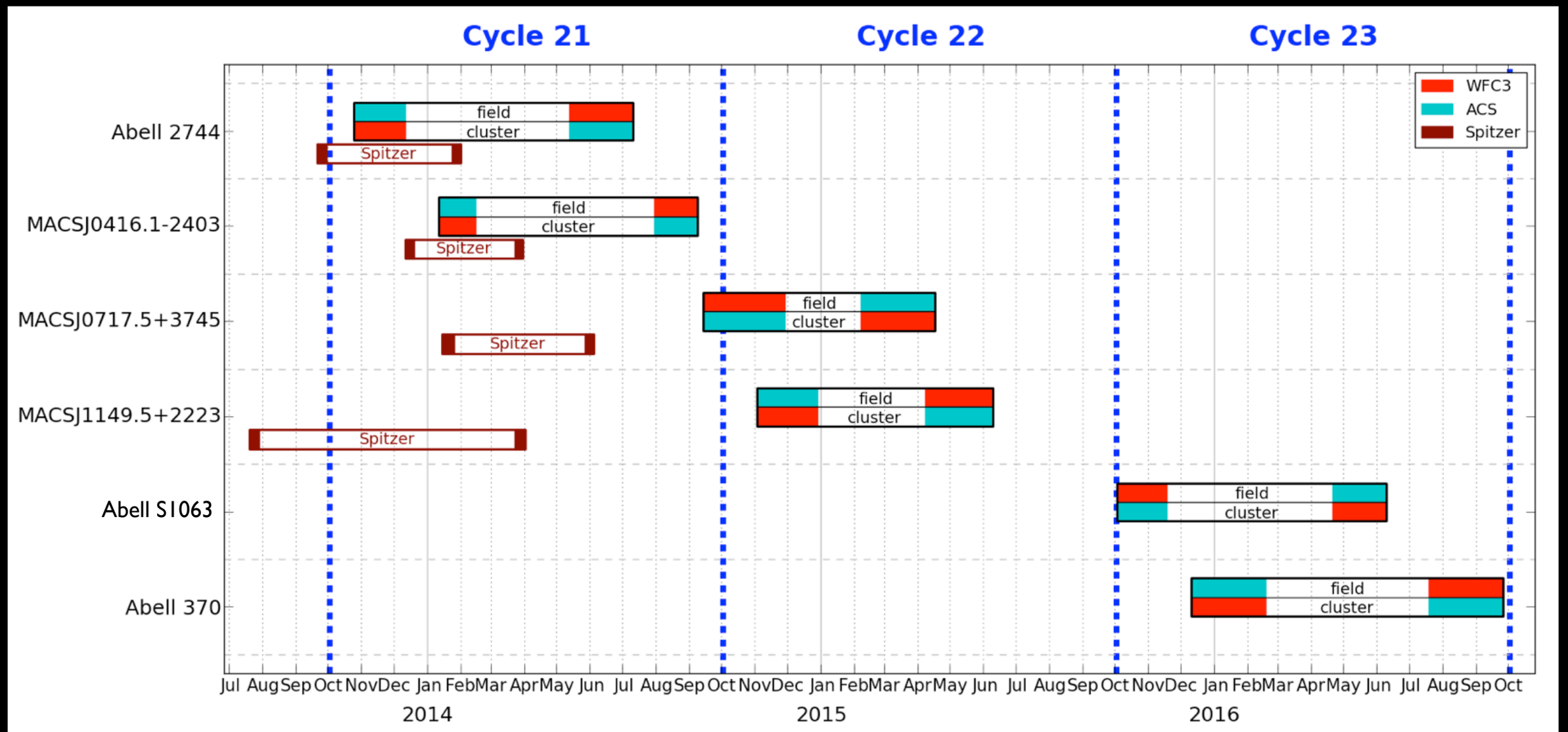




many fields have bright stars

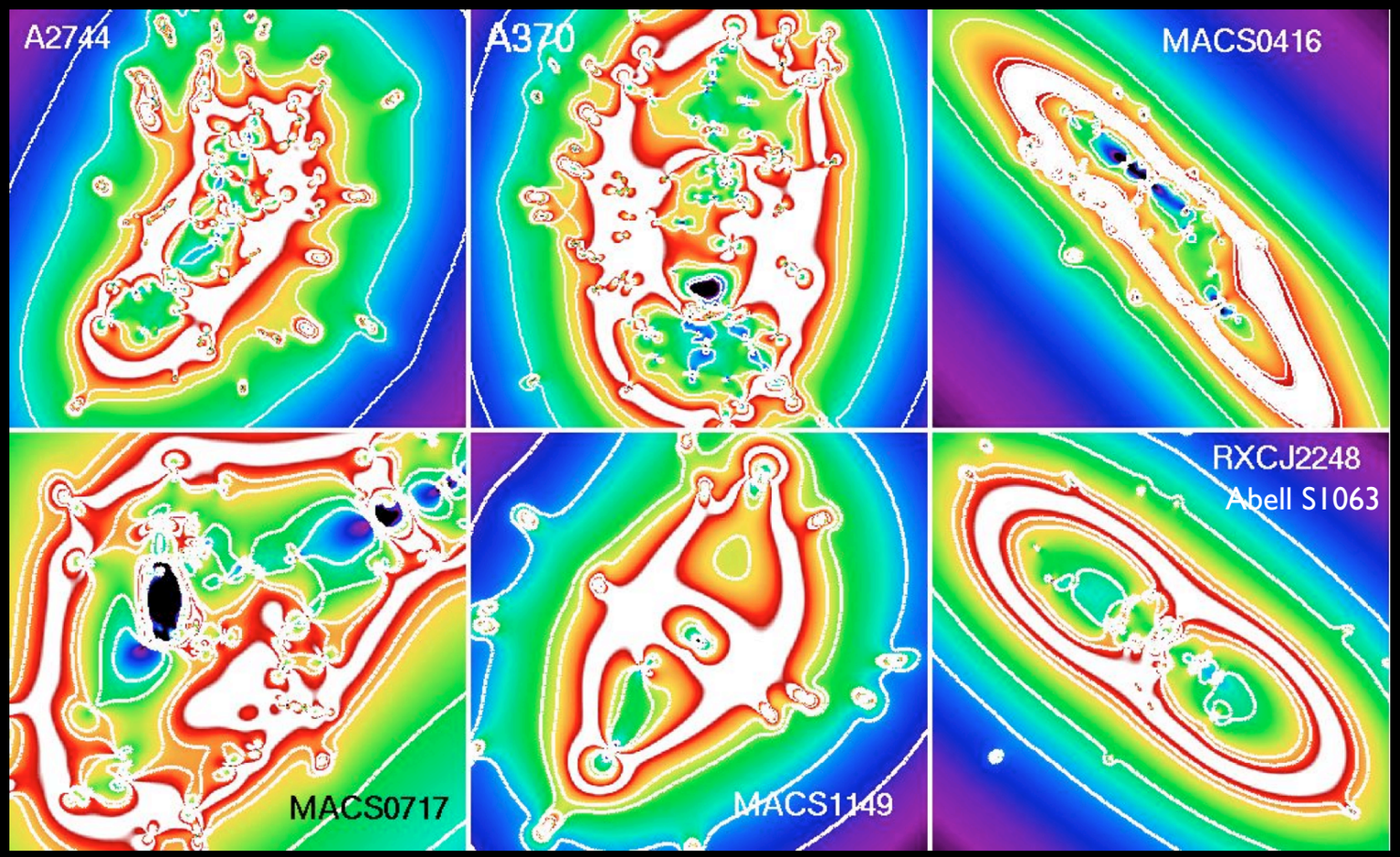
Gemini GEMS observations of MACS0416.1-2403 planned

HST Frontier Fields
Schedule

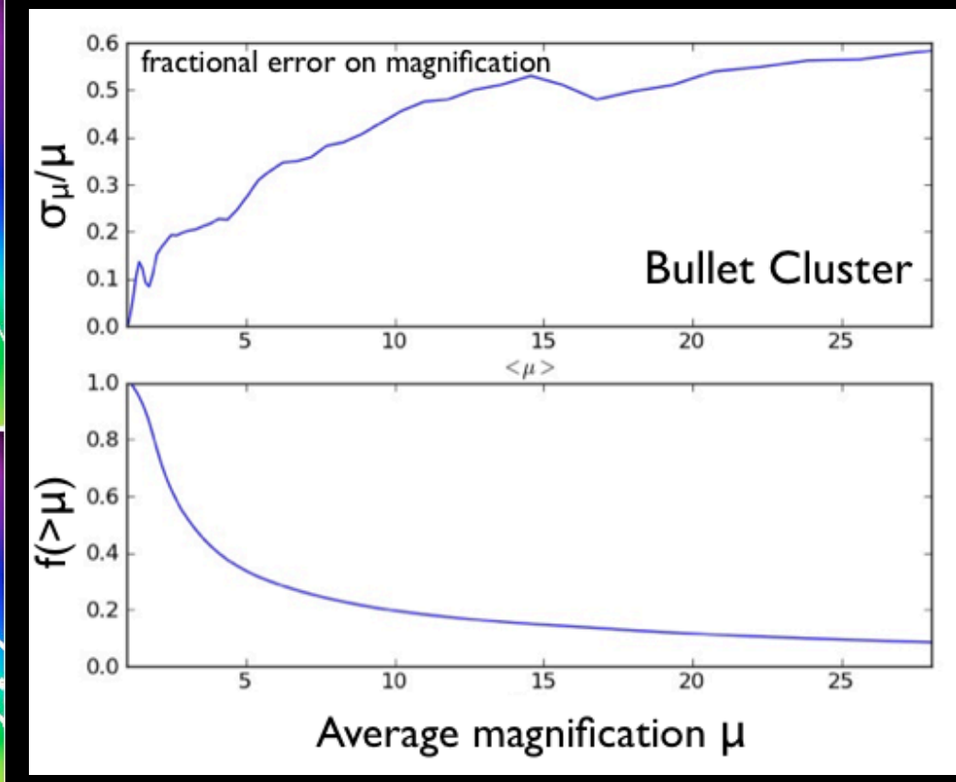


first HST Frontier Fields DD observations this fall
first Spitzer Frontier Fields DD observations now
decision on Cycle 23 observation expected in Dec. 2014

HST Frontier Fields
Lensing Maps



J. Richards 2013



Natarajan+ 2012

lensing models are key to interpreting luminosities of background galaxies

5 groups will produce preliminary magnification maps for FF before 1st observations

100s of arcs expected in FF data ⇒ tighter constraints on lensing models

HST Frontier Fields:
a legacy for the community

All cluster and parallel fields have been selected and Phase II have been submitted.

10 programs related to FF selected in HST Cycle 21 TAC
Rodney: SN followup; Siana: WFC3/UV; Treu: WFC3 grism
+ 7 archival programs (theory, lensing, asteroids ...)

All raw HST DD data will be public as soon as possible. STScI will provide high-quality data products, including calibrated + drizzled images, as quickly as possible.

existing (shallow) HST + Spitzer data are available at
www.stsci.edu/hst/campaigns/frontier-fields

~1000 hrs of Spitzer DD time for IRAC 3.6, 4.5 micron (key recommendation of SWG).
SSC will provide calibrated, reduced IRAC images.

deep Chandra observations approved (~200+ ks per field, Murray/Jones PIs)

5/6 fields observable with ALMA, **5/6 observable with Mauna Kea**,
4/6 have MIPS 24micron, 4/6 suitable for deep radio, all are observable with JWST