The Properties of Dense Groups in filaments with WFIRST + Searching for rare shock signatures at z = 1.5-1.9

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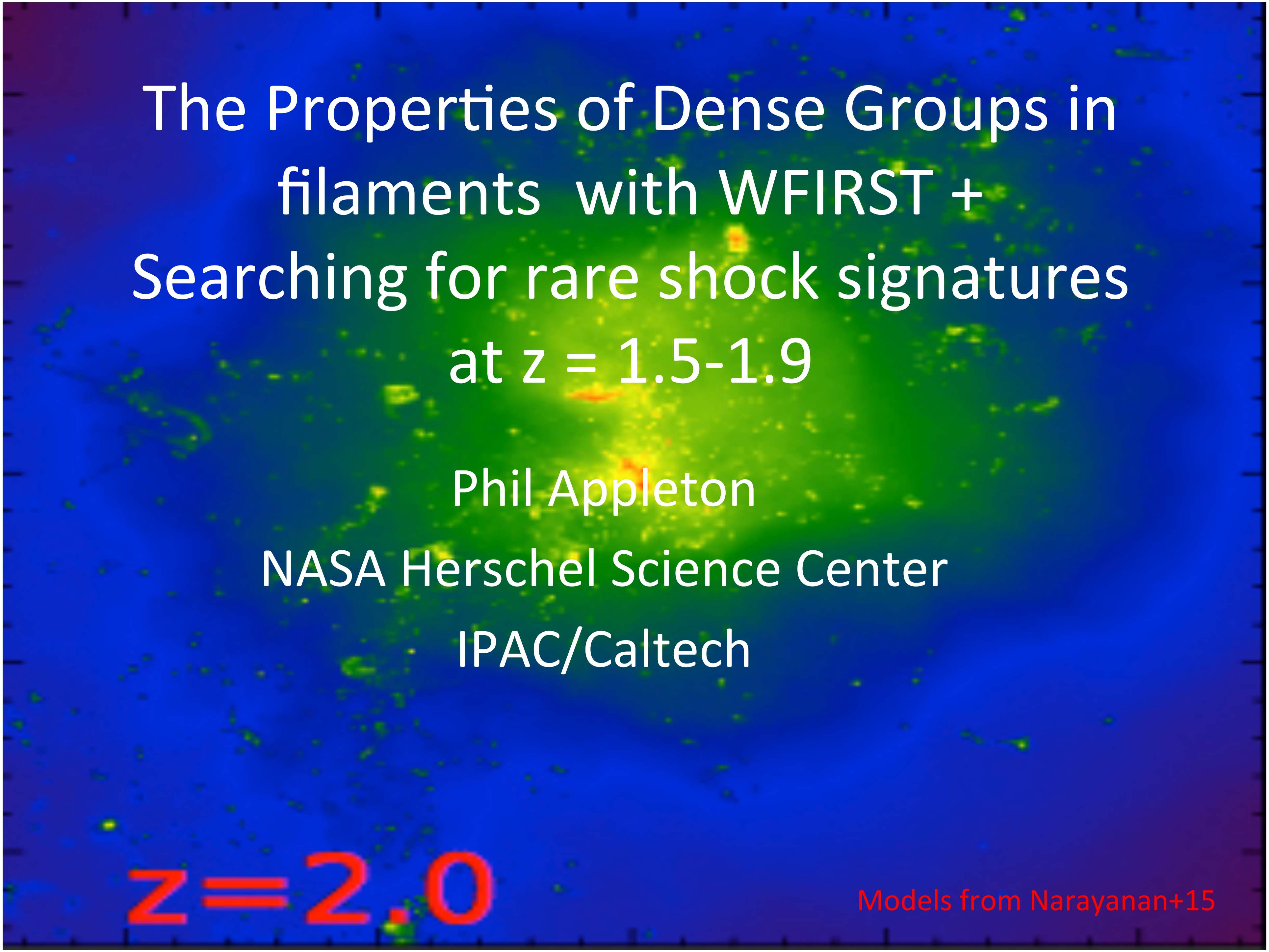
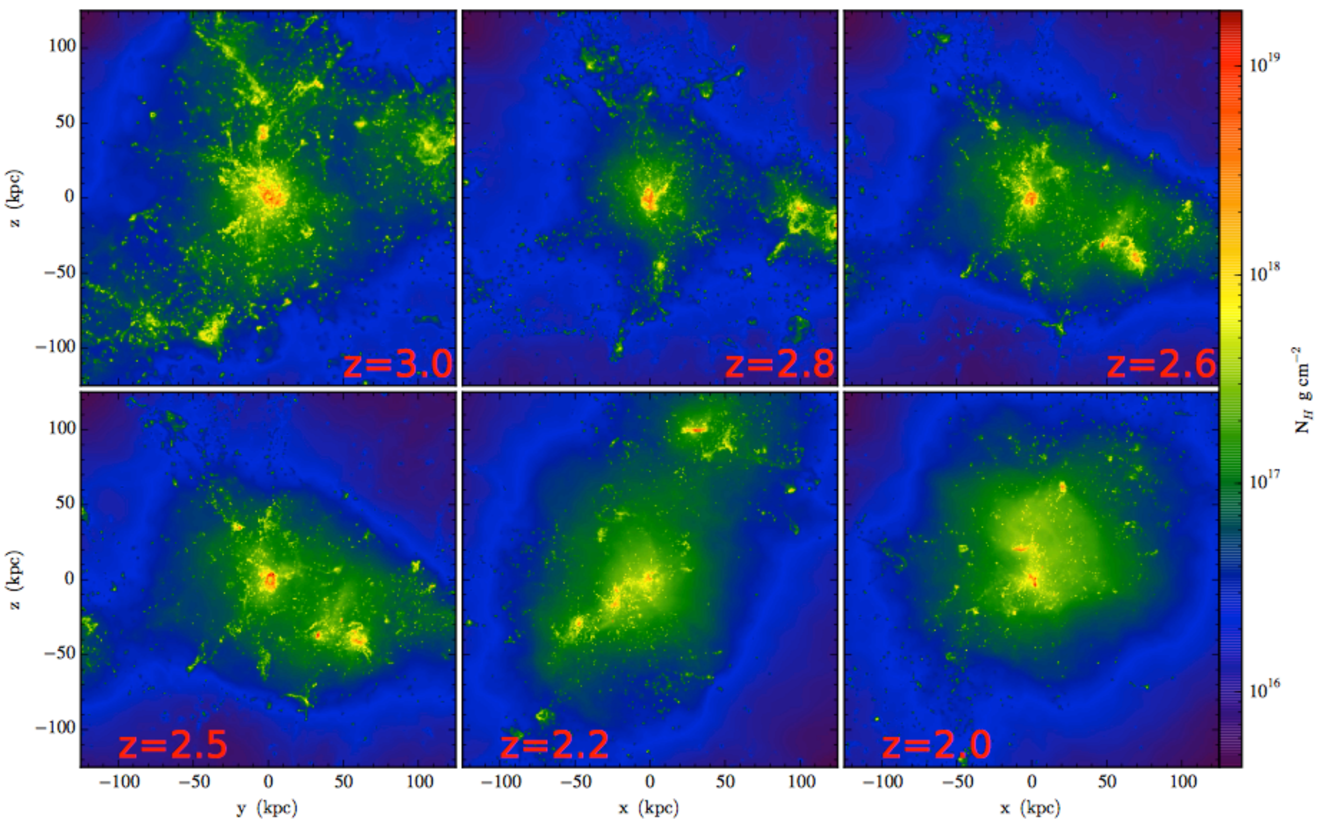


Models from Narayanan+15

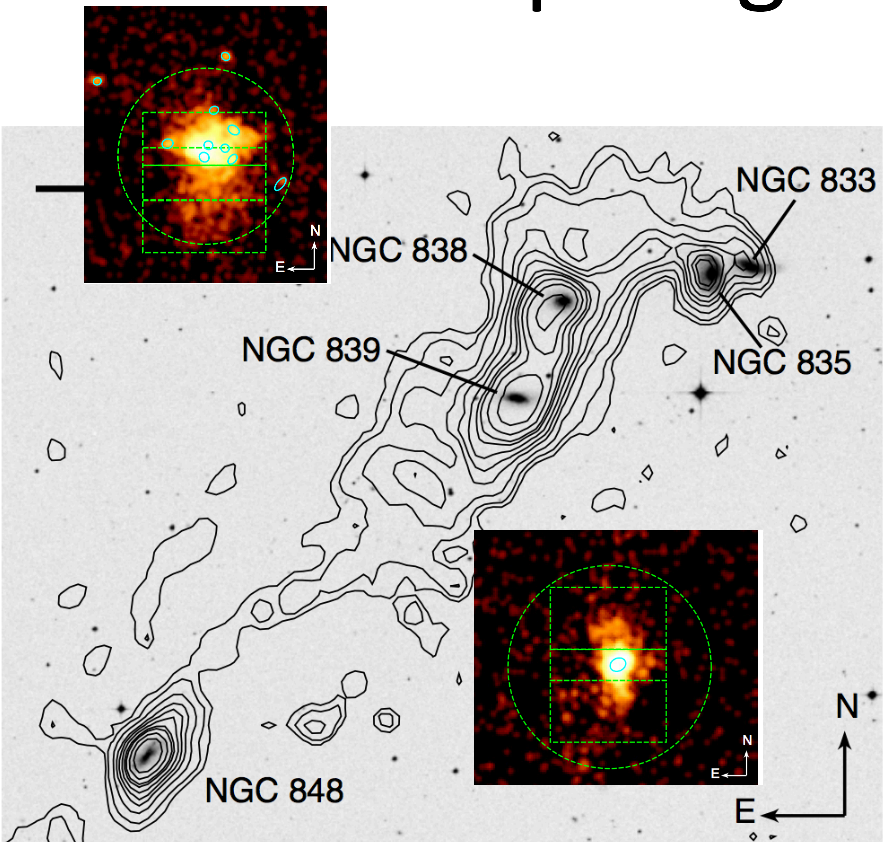
Galaxy evolution is a messy process involving many forms of feedback

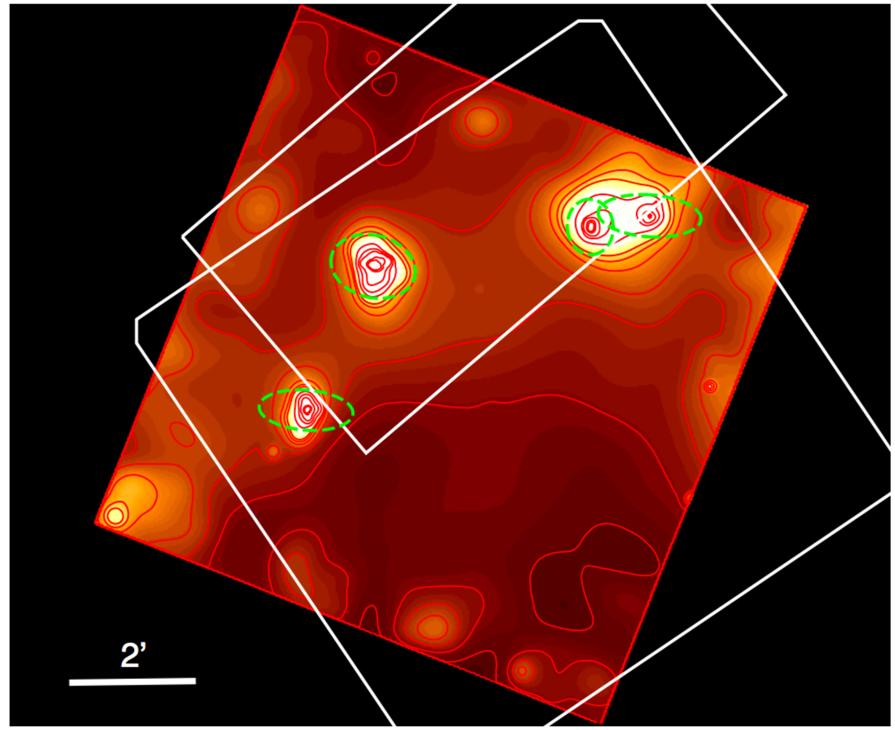
Mergers and global instability in massive halos lead to
short term variability + stellar winds outflows compete with
infalling gas from filaments (Narayanan+15)

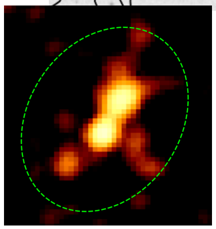


Feedback via shocks
and turbulence
will be common.
Groups evolve in
the growing DM halos

Strong Hints of feedback persist today in compact groups even at z = 0

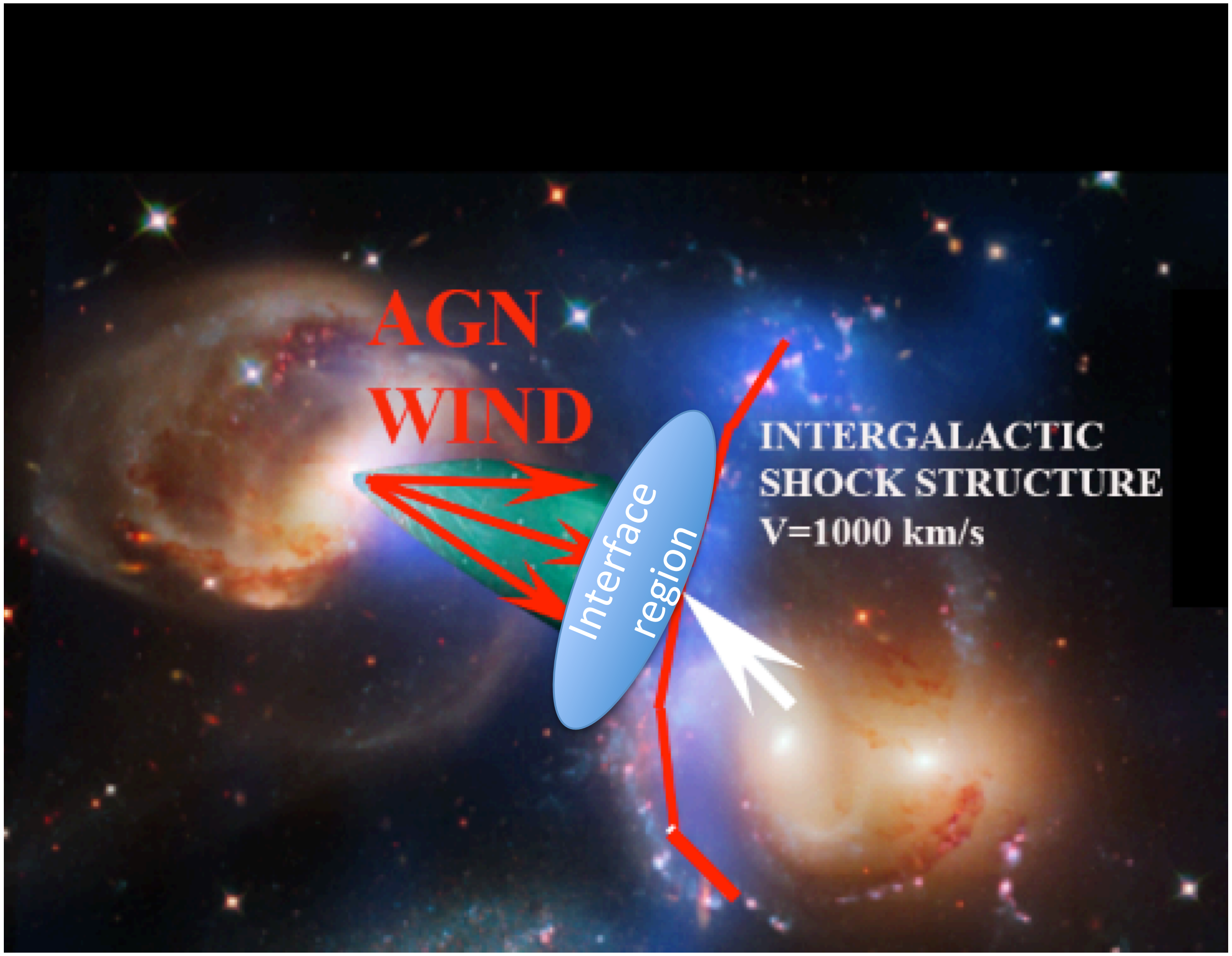






HCG16 HI and Extended X-rays (Ewan O'Sullivan+14,15)
Large mass of X-ray gas in IGM and evidence of X-ray outflows from SB winds
(Find 6 x 10^9 $M_\odot$ in IGM)

Stephan's Quintet shows GROUP-WIDE SHOCK is seen optical emission lines but most of luminosity comes out in warm H2 lines in mid-IR (Appleton+06,Cluver+10,Appleton+13)



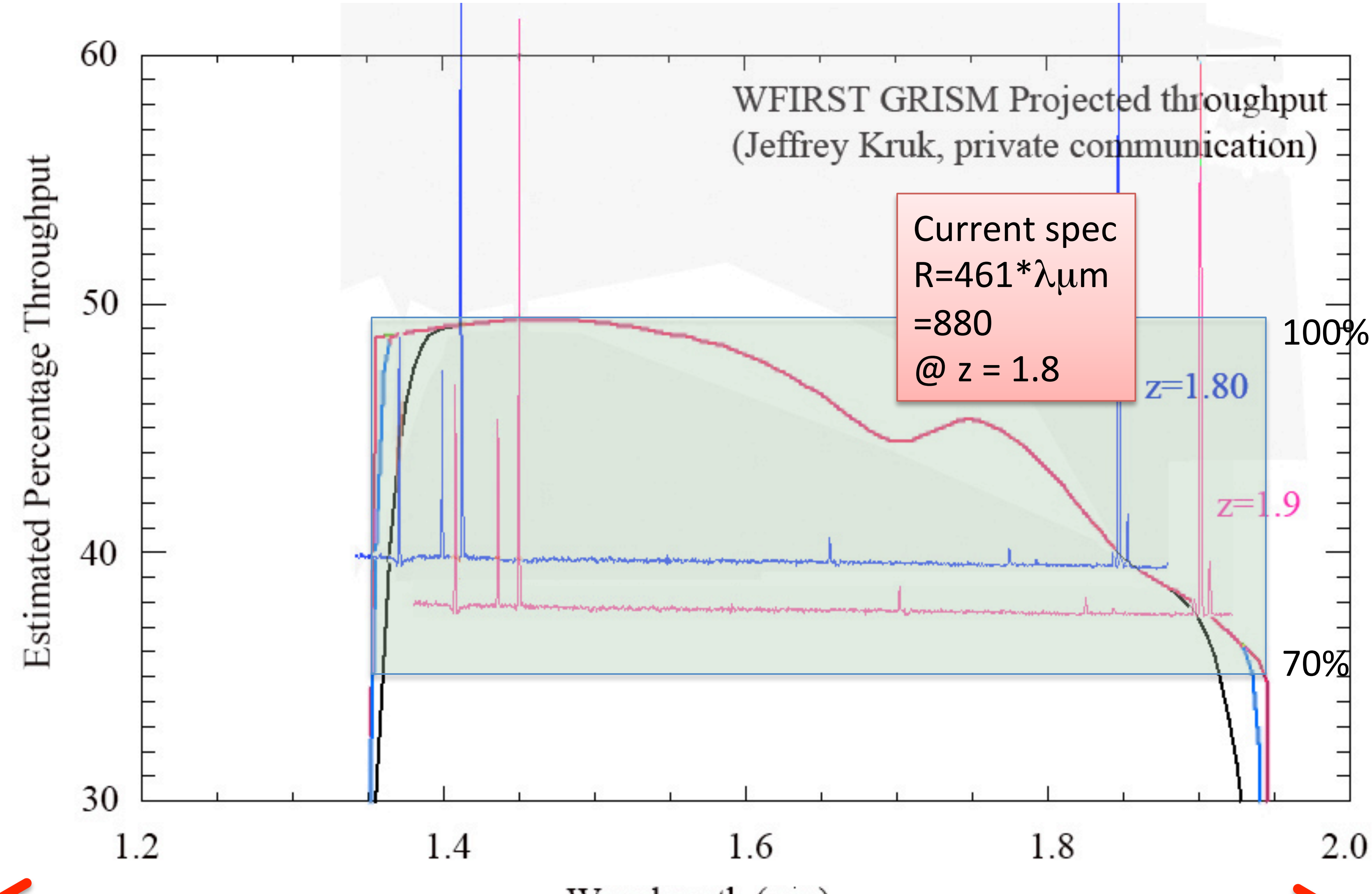
Appleton+06, Guillard+09, Cluver+10, Appleton+13

At the previous WFIRST meeting two years ago I suggested:

- The WFIRST GRISM has a “sweet spot” providing the potential for emission-line excitation studies between 1.8 (1.2)* < z < 1.95 because H-Beta/[OIII] and H-alpha/[NII] or [OI]6300 fall simultaneously on GRISM. Even this narrow range when multiplied up over the large surveys would involve HUGE volume of universe. **(CAVEAT—R = 461*λ/1μm does not decrease)**
- I discussed how “Rare” galaxies, such as shock-dominated galaxies (< 0.5% of local SDSS galaxies) would be potentially discoverable in large numbers if they exist at higher-z
- I presented evidence that shock-dominated group galaxies may be symptomatic of star formation quenching in compact groups (See Alatalo & Appleton+15). The mechanism: either powerful outflows from SF or AGN winds, or multiple collisions in these dense environments.

* If GRISM EXTENDS DOWN TO 1.1μm

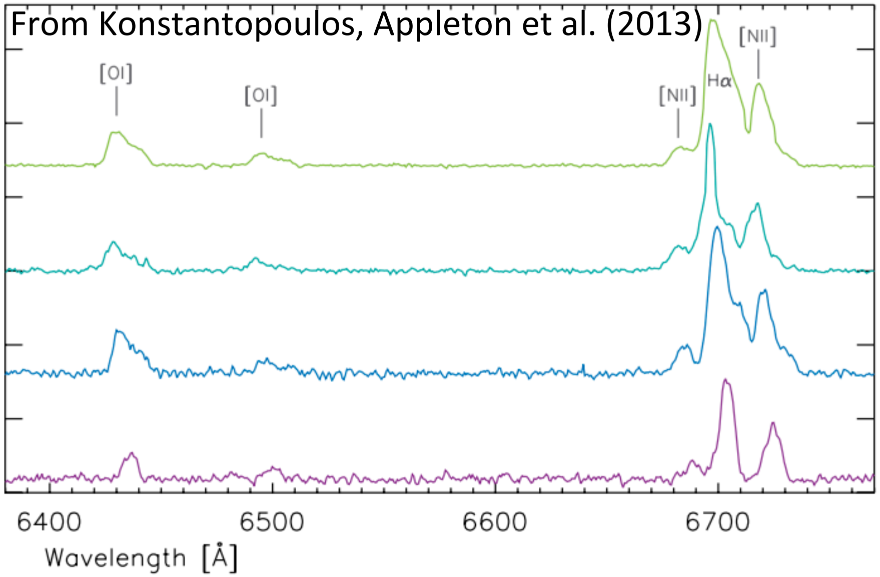
WFIRST GRISM Sweet-spot
Lowish-R but huge surveys possible



Under investigation TO EXTEND COVERAGE to 1 < λ < 2 μm (1.1 < z < 1.9)

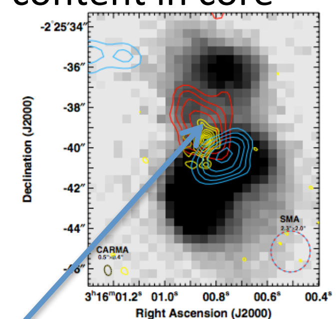
Galaxies with known shocked gas have low [OIII]/Hbeta and high [OI]/Halpha and are quite RARE

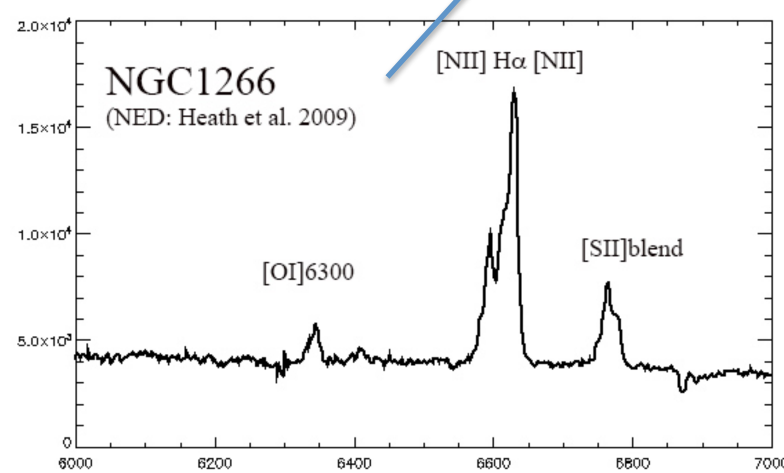
Stephan's quintet is a GROUP-WIDE shock



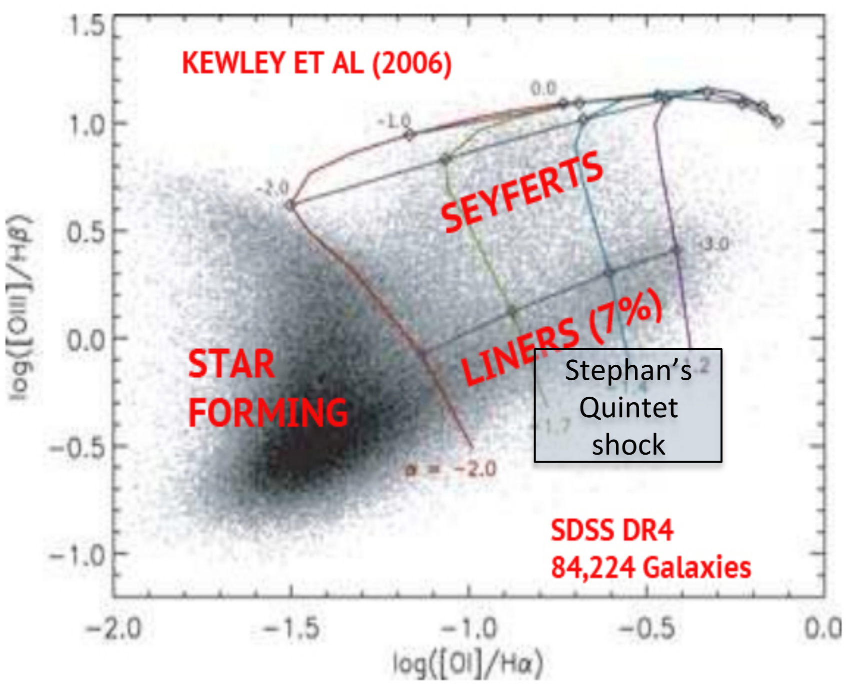
Optical Shock Signature:
High [OI]6300/Hα ratio
Very broad lines often asymmetric

Alatalo+11,+12,+14
Bipolar outflow
Strongly Suppressed
SF, Huge molecular
content in core

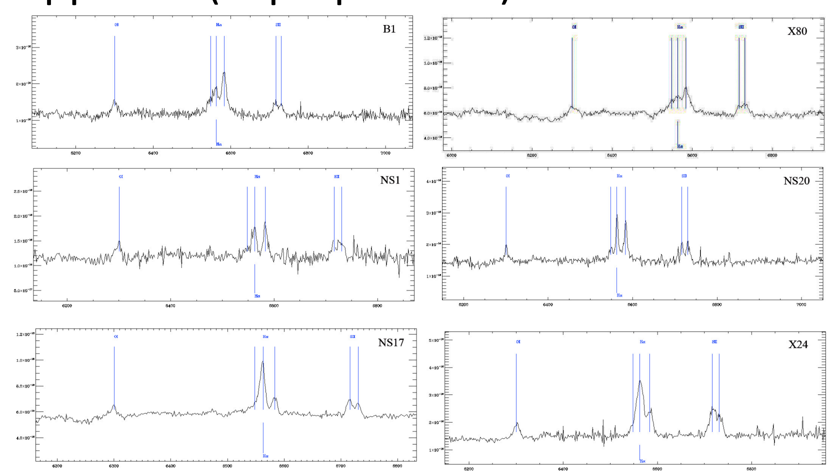




At low redshift shock-dominated galaxies seem very rare: They represent on 0.5% of galaxies derived from a large sample of well studied SDSS galaxies for z < 0.1



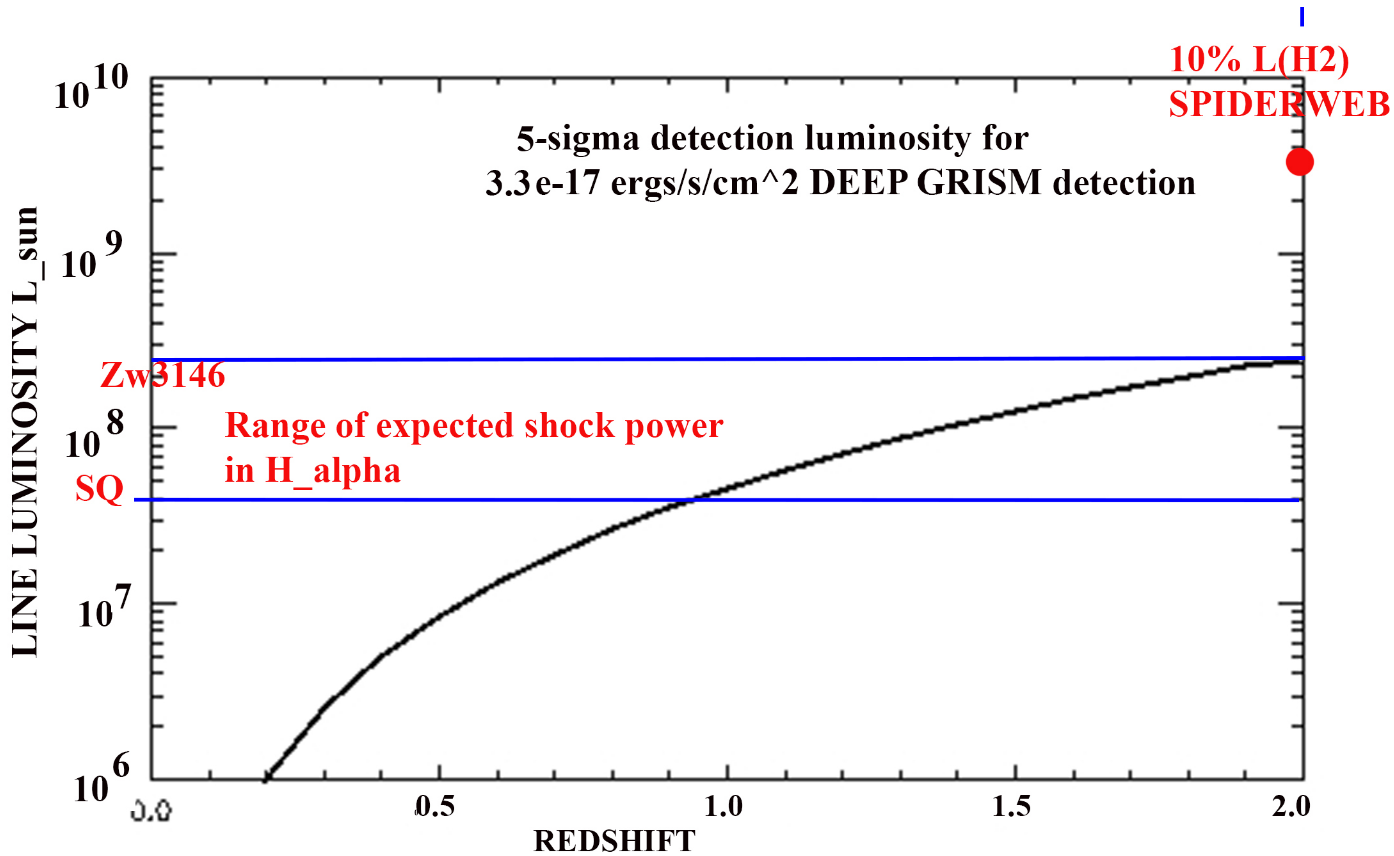
Appleton (in preparation)



They may represent a short phase
In galaxy evolution?

Do we find them at higher-z

Detection at higher z assuming 3 x deeper than HLS



Would need modestly scaled-up versions of local systems to reach z = 2

Why might we care about galaxies with shock-dominated ISM/IGMs?

- They allow study of turbulent and shock processes in galaxies and environs
- Shocks may INHIBIT (at low z) SF in some cases tracking quenching, but at high z this trend may reverse? Where? How?
- They may represent an important but short-lived phase in galaxy evolution (hence rarity)

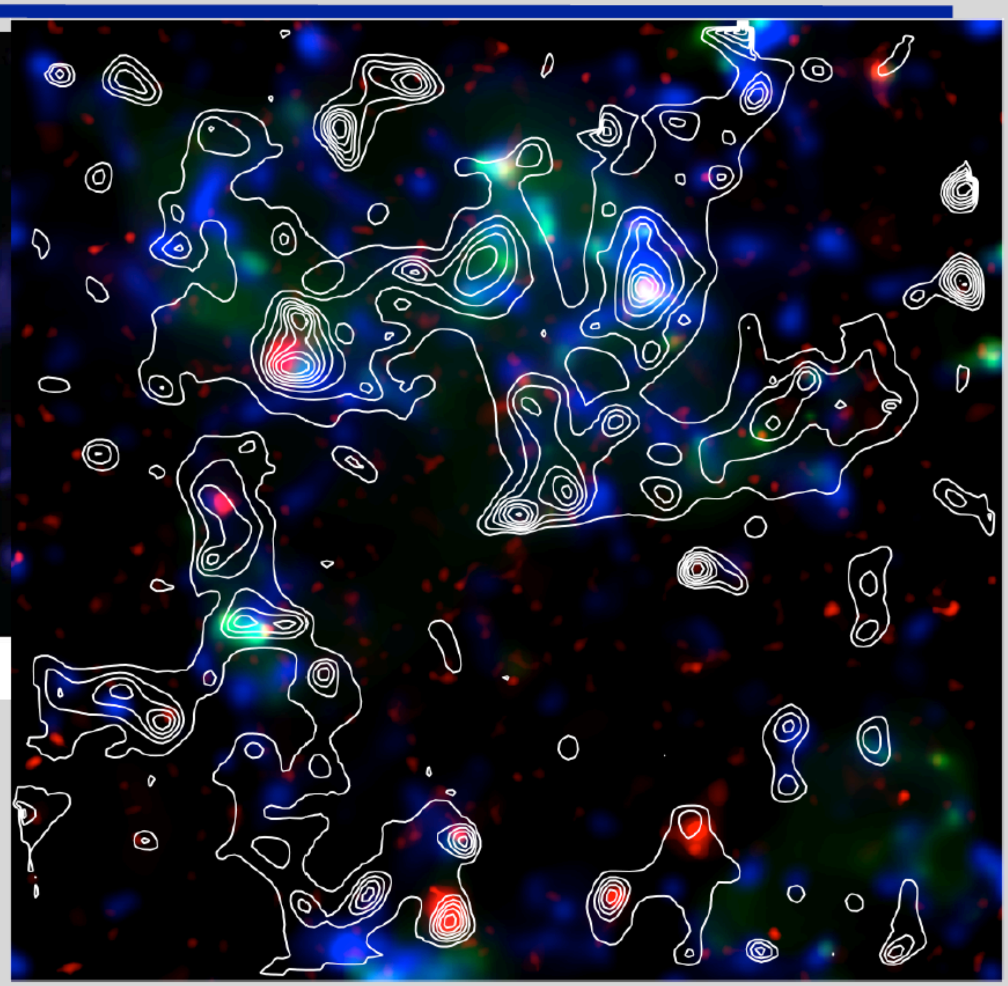
With WFIRST we can

1) Archival: Use High Latitude (large area) Survey (HLS) with imaging and GRISM in combination with deep all-sky radio (SKA) surveys to identify diversity of filaments and embedded groups between $z = 1$ and 2. Cherry pick filaments and groups at different z's. Brightes galaxies only.

2) GI: Perform DEEP IMAGING of selected large fields to push weak lensing to $z = 1.5$ (May use statistical methods to get average properties) (If lucky may be able to use leverage from large SN fields). MAP GRAVITATIONAL POTENTIALS

3) GI: Perform DEEP GRISM spectroscopy of same large fields to explore SFRs (from $0.5 < z < 1.9$) and excitation properties and search for rare galaxies over Largest redshift range possible. (potentially $1.25 < z < 1.9$ if GRISM is extended down to λ=1.1μm) Use stacking techniques to push to deeper levels.

COSMOS: Mapping the Dark Matter



Weak lensing mass contours(HST)

Extended *x*-ray emission (XMM-Newton)

Galaxy number density (Subaru & CFHT)

Galaxy stellar mass (Subaru/CFHT)

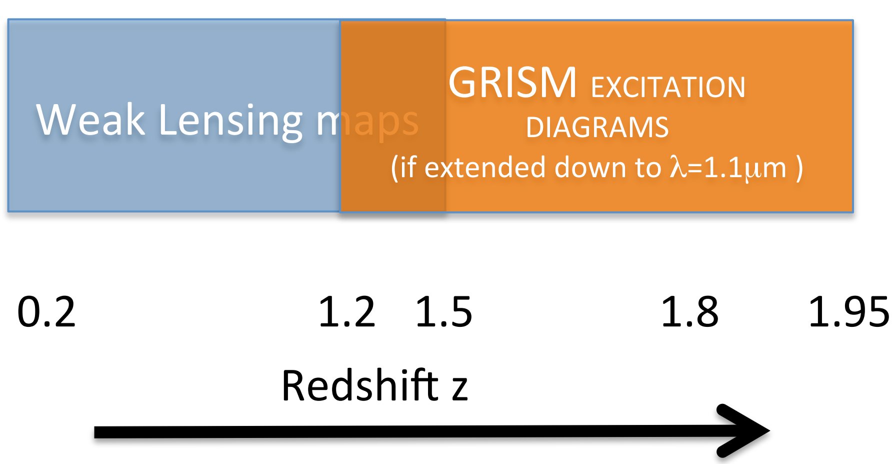
Massey, Rhodes et al 2007

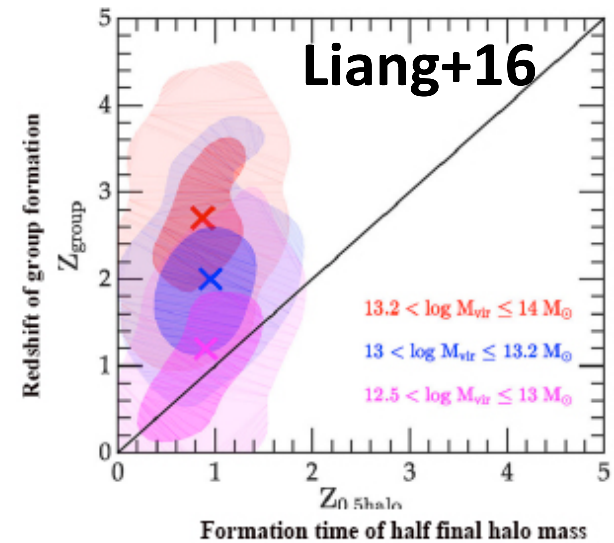
Weak-lensing part is similar to that proposed at low-z for DECaLS (using SDSS spectra) and the work of Massey/Rhodes+07-general COSMOS result
Alexie Leauthaud+10… for COSMOS group structures

Under the right circumstances we can get an interesting confluence of techniques!

Use confluence of Weak Lensing and GRISM excitation to attempt to explore emission line properties of compact groups

This is the formation epoch of massive halos ranging from 10^{12} -10^{13} which eventually become groups.





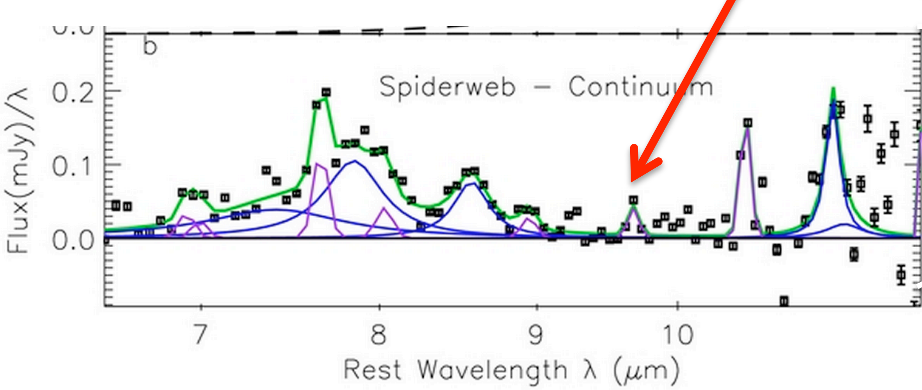
Half of halo mass of groups in place by z = 1

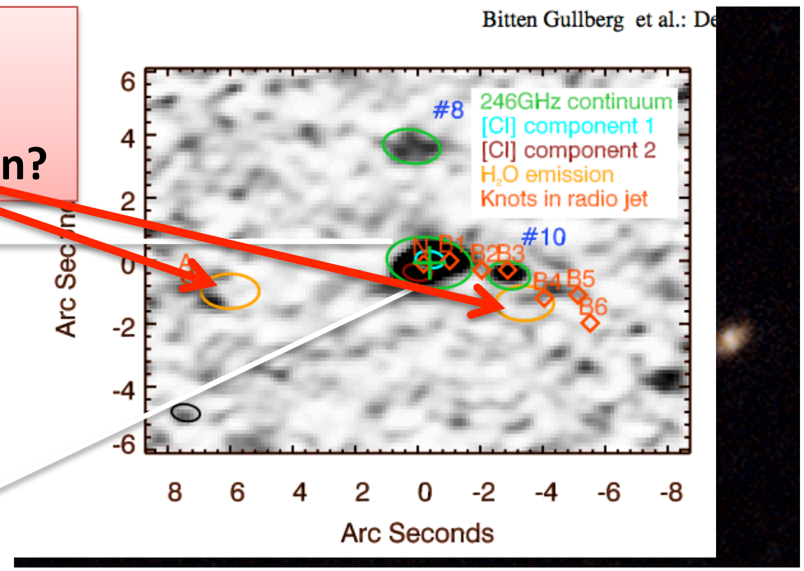
Simulation show that higher mass groups appear first as group halos grow

Do we expect shocked systems at high-z?

Extreme example is the Spiderweb galaxy at z = 2.15

ALMA> Strong CI from nucleus and H_2O from extended shocked regions along radio jet. Role of radio jet in excitation?





IMPORTANT CAVEATS

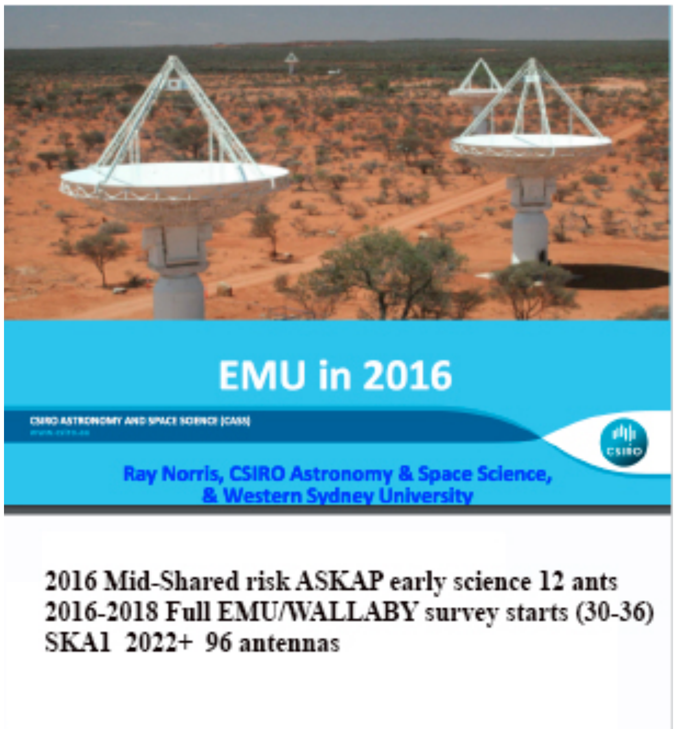
- Feasibility depends on details of GRISM (sensitivity and R) that require simulation
  - STRONG ADVOCATE FOR R~600 and BW 1-1.9μm
  - Potential issues for faint extended sources
- Are there systematics that could reduce the impact?
  - DETAILS ARE IMPORTANT—Simulations will help clarify feasibilty
- SIZE (Areas) of Deep component will depend on diversity of structures—Admit that this is vague yet—will be firmed up with simulations of instrument plus cosmological simulations including gas—formulation teams and early science

Summary

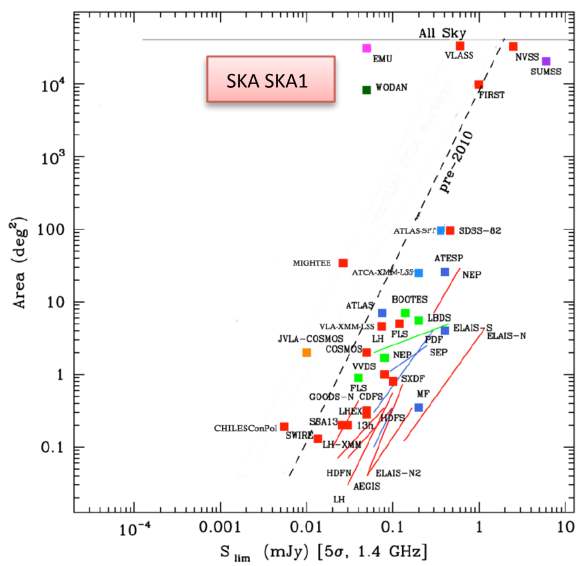
- Emission-line diagnostics may be doable with current GRISM R-specs* over z=1.8-1.9 (covering Hβ to Hα) with the current GRISM bandwidth
- Extending bandwidth down to λ = 1.1μm may ALLOW CONFLUENCE of weak lensing and spectral excitation for DEEP SPECTRAL AND IMAGING SURVEYS of FILAMENTS and Embedded groups in formation.
- Allow for discovery of potentially important rare galaxies or groups containing shock/turbulence dominated ISM/IGMs
- Modestly scaled-up versions of local shocked systems may be detectable. If we go 3x deeper than baseline GRISM large surveys
- WFIRST will be the era of pre-cursor SKA (e. g. EMU/ASKAP) and early SKA1 and deep JVLA surveys (microJy level all-sky surveys) which will complement spectroscopy for obtaining important information on SFR and other properties to correlate with group evolution over cosmic time

*Assuming modest resolution is maintained (R~600-800)

Exploit deep large-area radio surveys and large number of spectroscopic z's from Euclid and WFIRST GRISMs



EMU
(Evolutionary Map
of the Universe)
Square Kilometer Array
precursor



Extras