Post-doctoral Research Poster Talks, September 22nd 2017

Jet Propulsion Laboratory
California Institute of Technology

Predicting the number density of Hα-emitting galaxies

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Acknowledgements: Yun Wang (IPAC-Caltech),
Andrew Benson (Carnegie),
Andreas Faisst (IPAC-Caltech),
Daniel Masters (IPAC-Caltech),
Alina Kiessling (JPL)
& Jason Rhodes (JPL, NPP advisor)

Before we begin… what are Hα-emitting galaxies?

Light emitted when electron falls from n=3 to n=2 energy level in hydrogen atom.

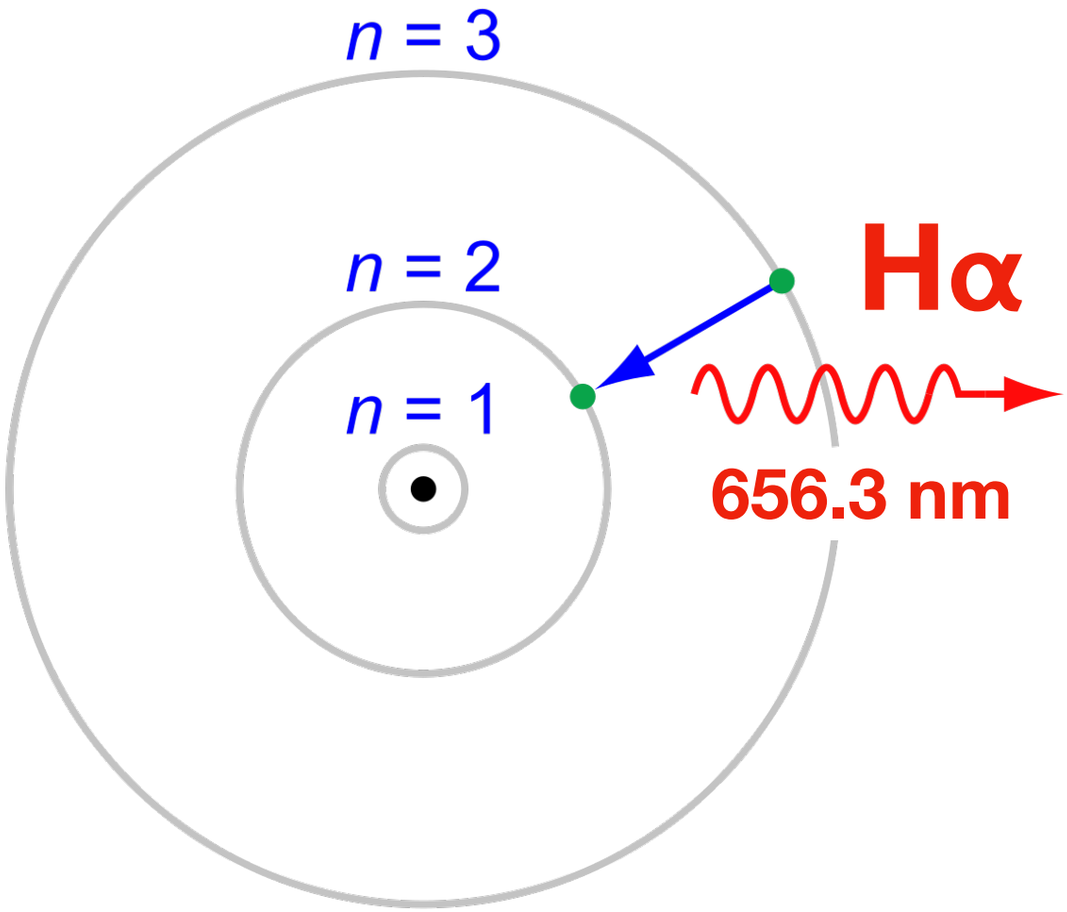


Image credit: Wikipedia

Image credit: NASA/JPL-Caltech/JHU

Star-forming galaxies typically have strong Hα emission (shown in pink).

What is our Universe made up of?

Observational evidence

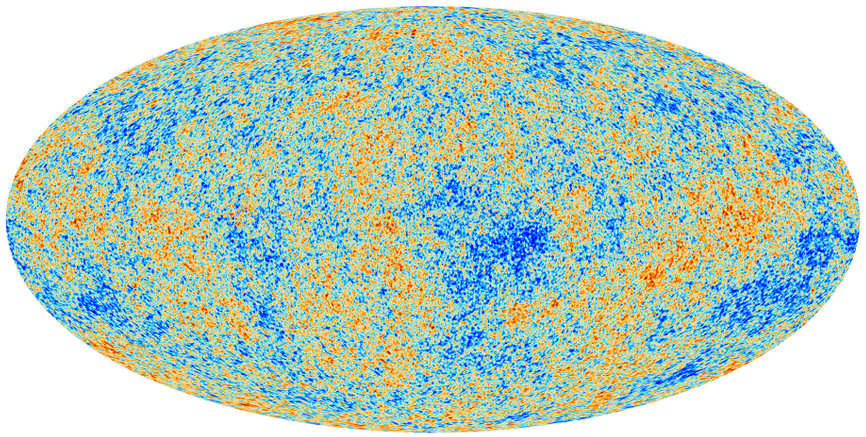


Image credit: Planck Collaboration, ESA

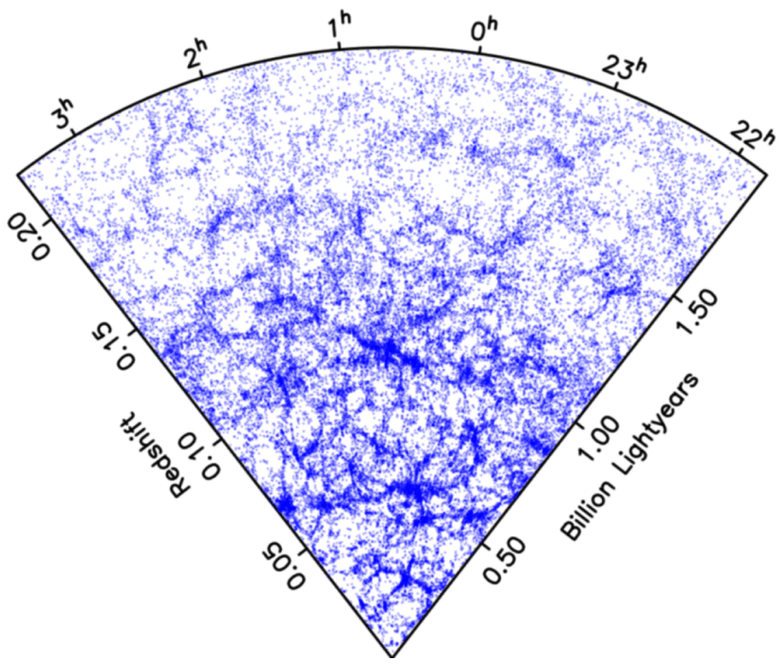


Image credit: 2dFGRS Team

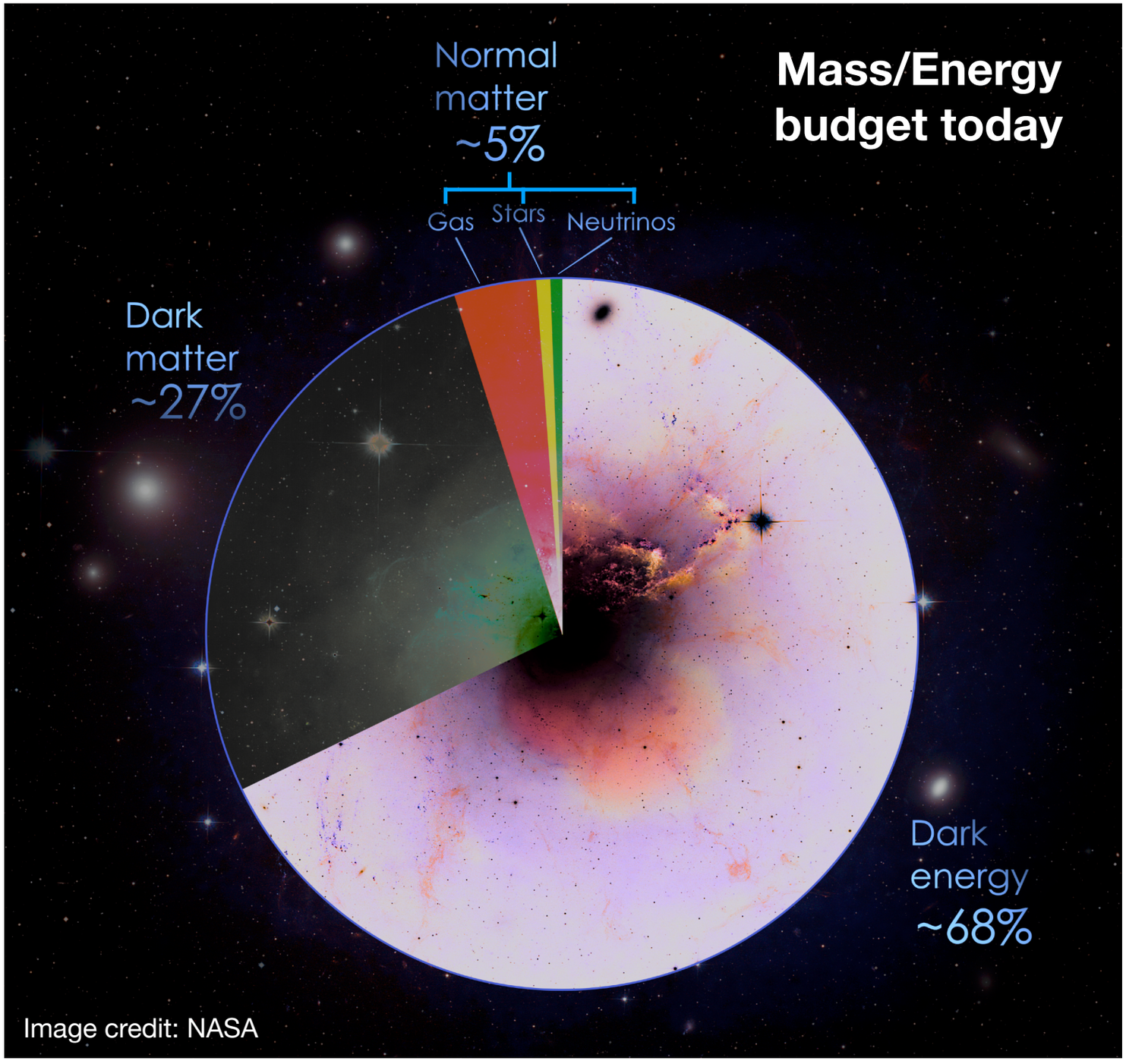
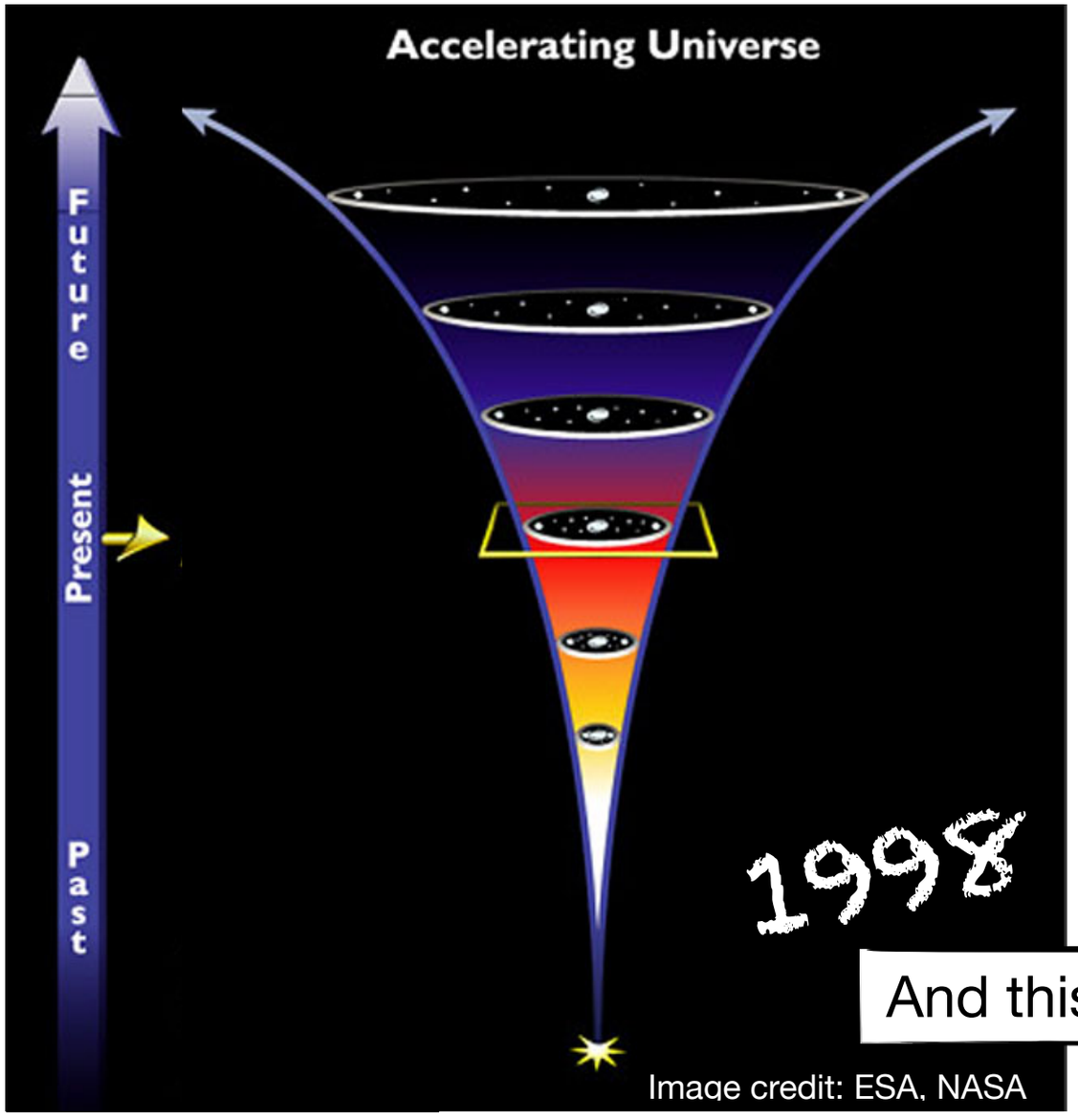


Image credit: NASA

What are the consequences of Dark Energy?



Hubble showed that the Universe is expanding!

1929

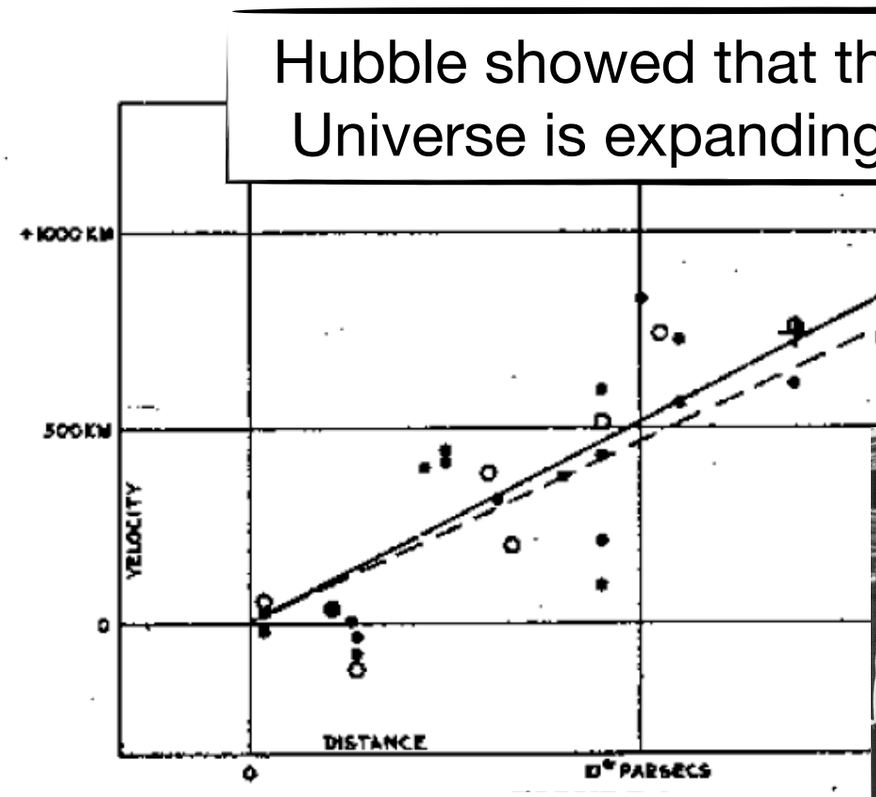


Image credits: Hubble (1929), Carnegie Observatories of Washington

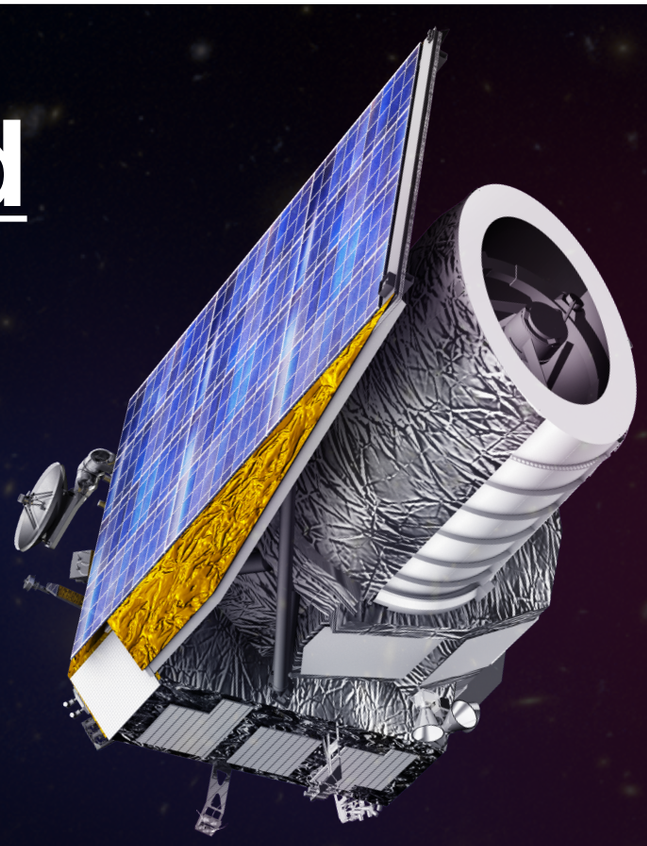
And this expansion is accelerating!

Standard cosmological model predicts Dark Energy responsible for accelerated expansion of Universe.

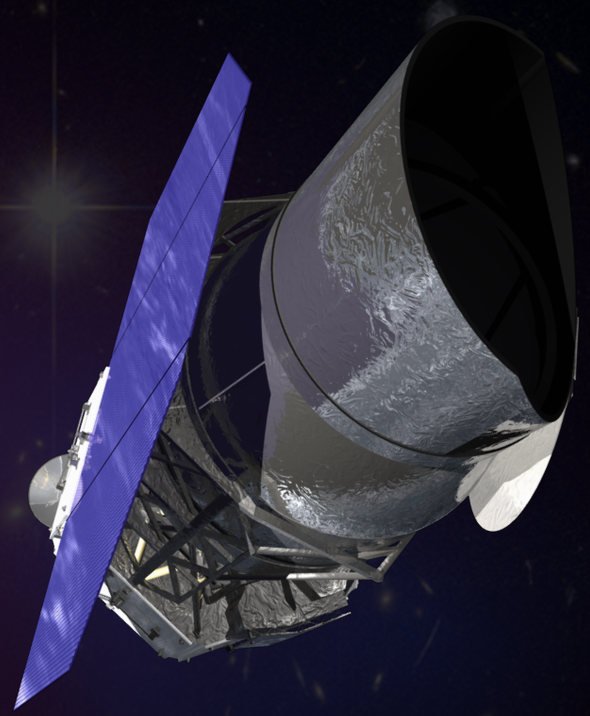
But we still do not know what Dark Energy is! We need more precise measurements to rule out competing theories…

The search for Dark Energy

Euclid



WFIRST

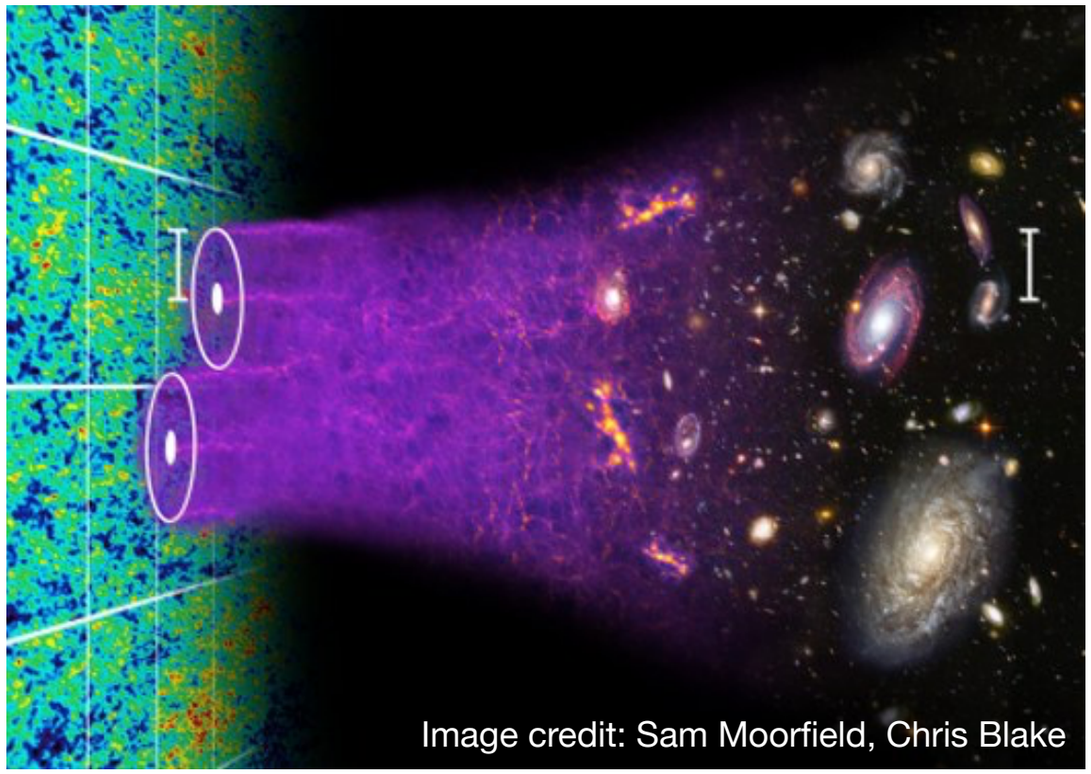


	Euclid	WFIRST
Approx. launch date	2020	2025
Observing strategy	Wide & shallow	Narrow & deep
Area (fraction of sky)	36%	6%

Will observe many millions of Hα-emitting galaxies whose light was emitted 7-10 billion years ago!

Image credits: ESA, NASA

Probing the nature of Dark Energy



Oscillations imprinted in clustering of galaxies at fixed characteristic scale that we can measure!

Universe expands ➔ characteristic scale gets physically bigger.

Measure size of acoustic scale at different times helps measure growth of Universe (and nature of Dark Energy).

Baryon Acoustic Oscillations: sound waves from interaction of matter and radiation in early Universe.

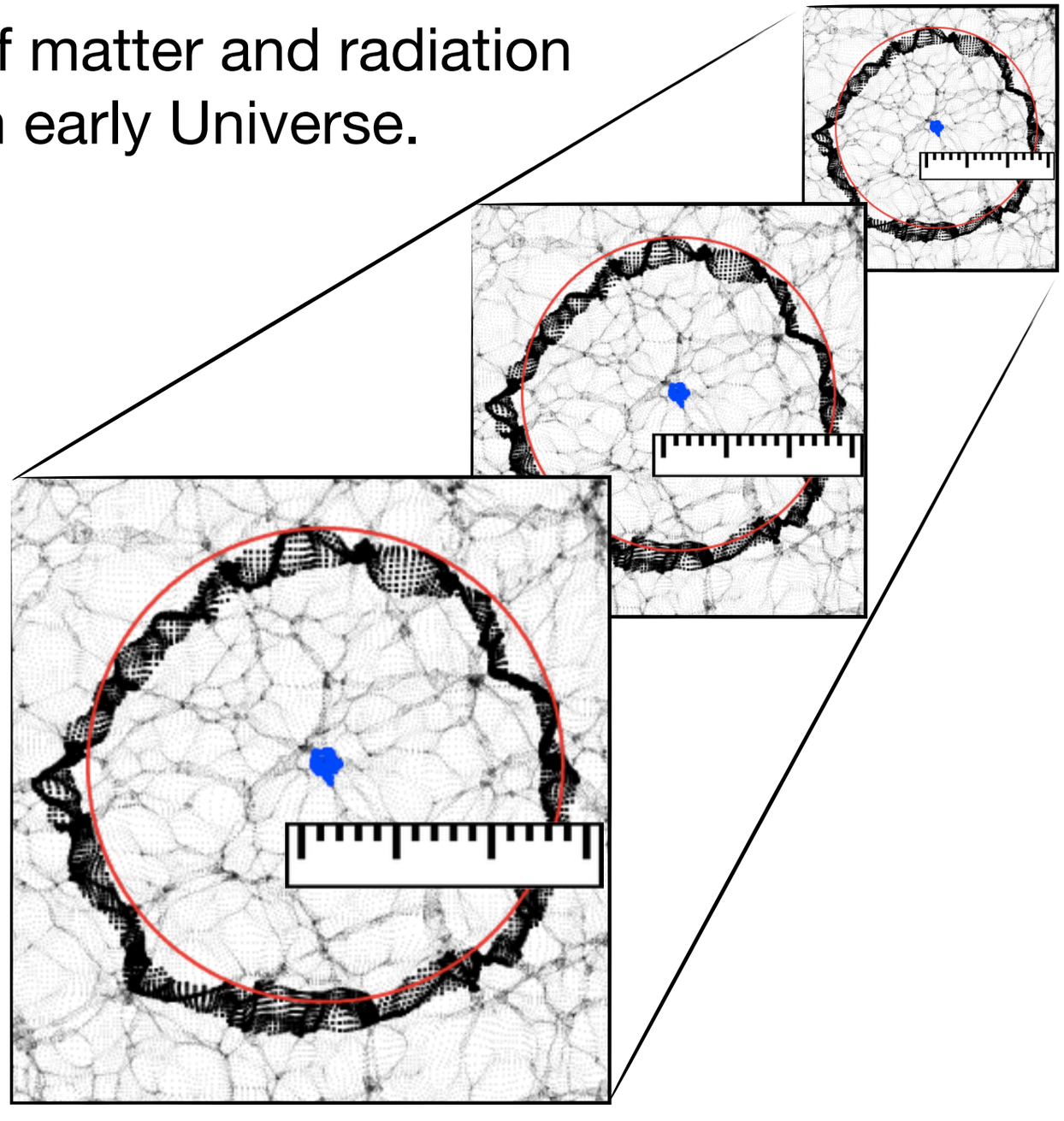


Image credit: Padmanabhan et al. (2012), SDSS Collaboration

How many Hα-emitting galaxies?

Oscillations imprinted as excess of galaxies at preferred separation.

The more galaxies we can see…

… the more precisely we can measure their clustering pattern, and so…

… the more precise our measurement of the imprinted oscillations.

Large uncertainty in how many Hα-emitting galaxies expect to see due to limited-size of existing datasets and influence of contaminants (e.g. dust).

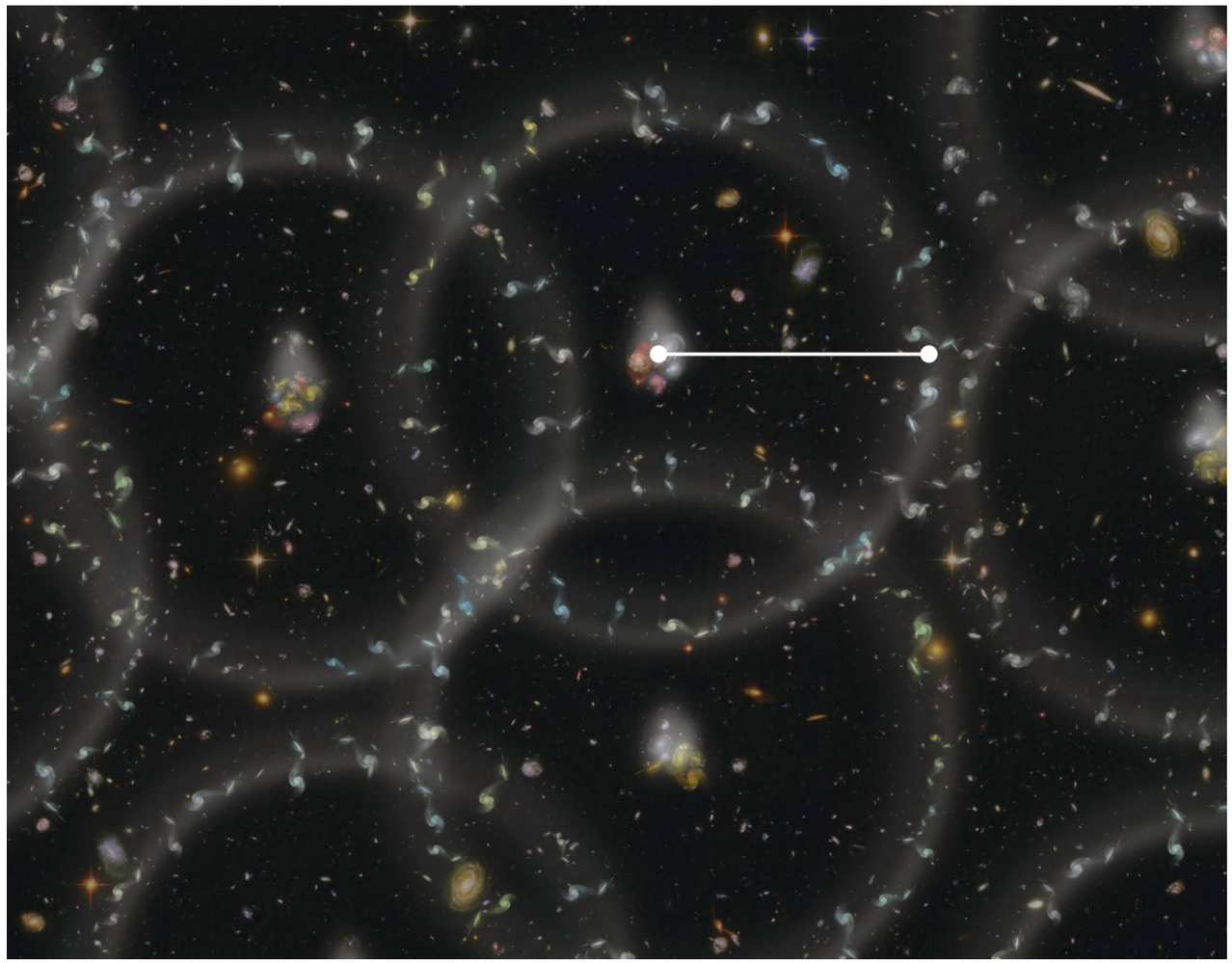


Image credit: Zosia Rostomian, Lawrence Berkeley National Laboratory

Use physically motivated galaxy formation model to predict how many Hα-emitting galaxies will observe with Euclid and WFIRST.

Building a galaxy catalogue in a computer

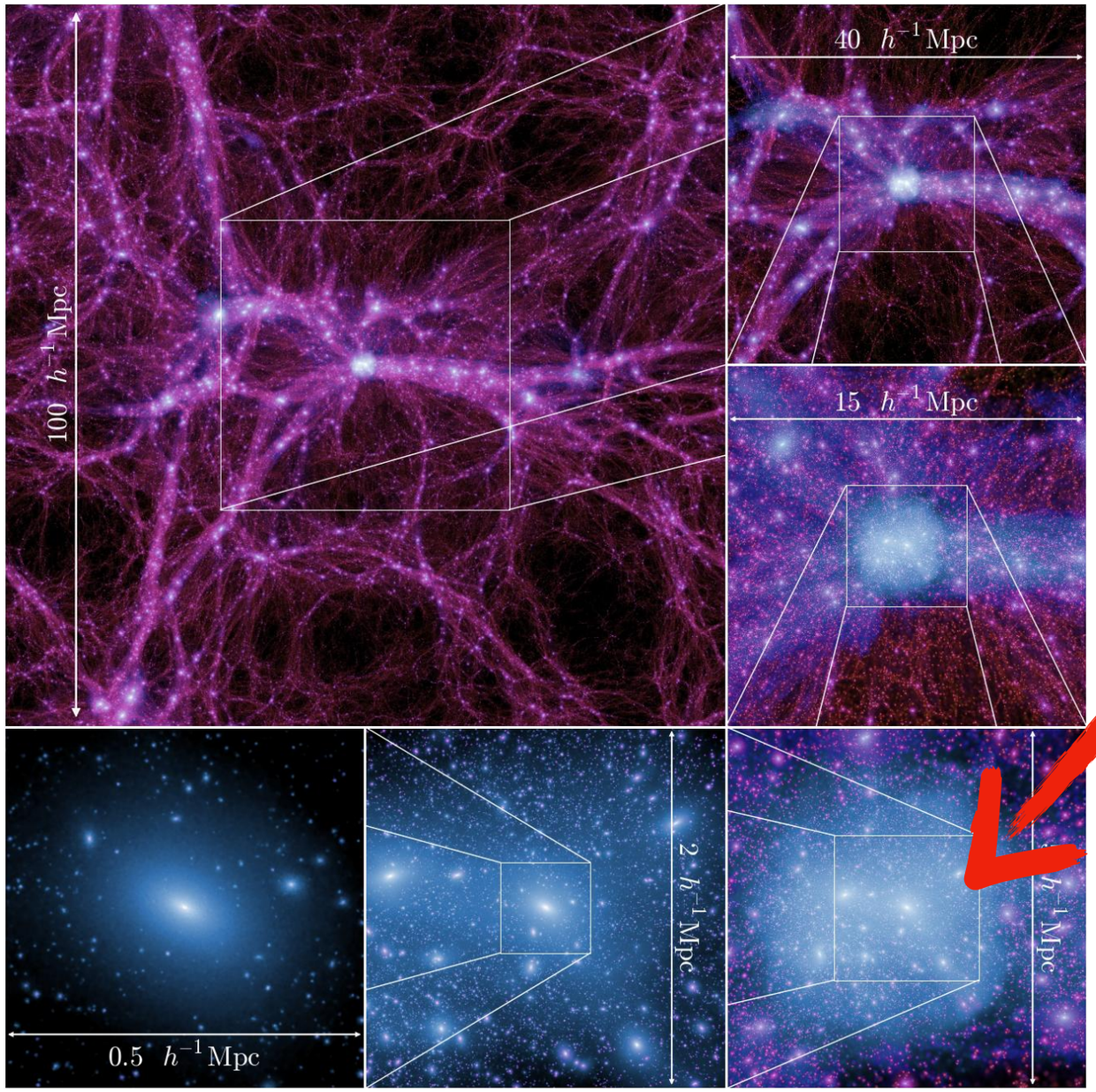
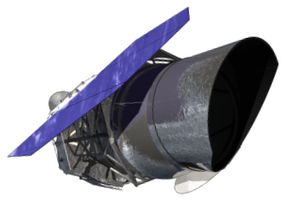


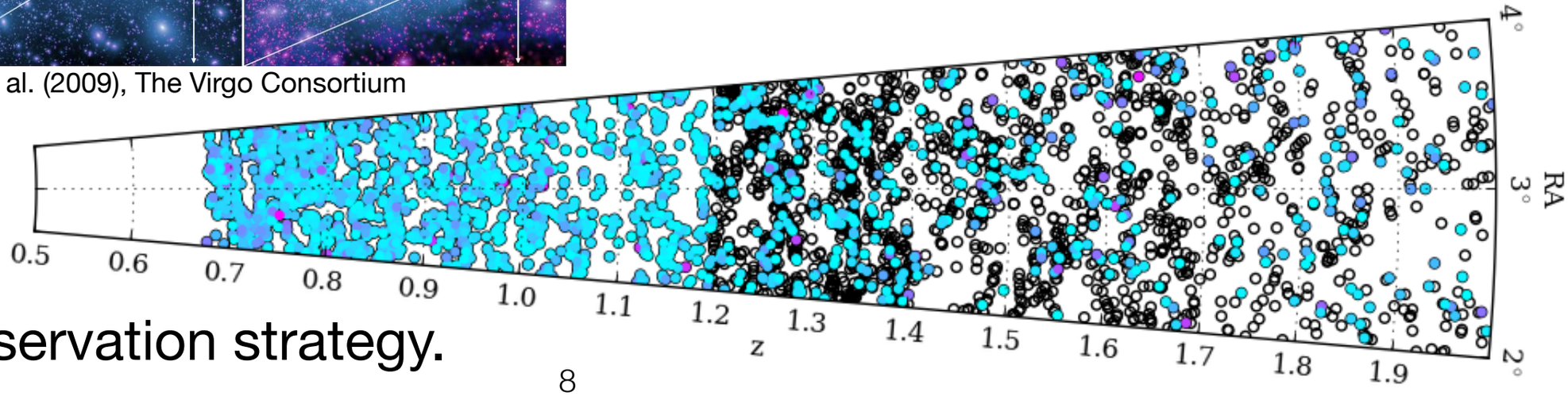
Image credit: Boylan-Kolchin et al. (2009), The Virgo Consortium

(1) Build cosmic structure (dark matter) in computer simulation.

Image credits: NASA, Hubble Heritage Team

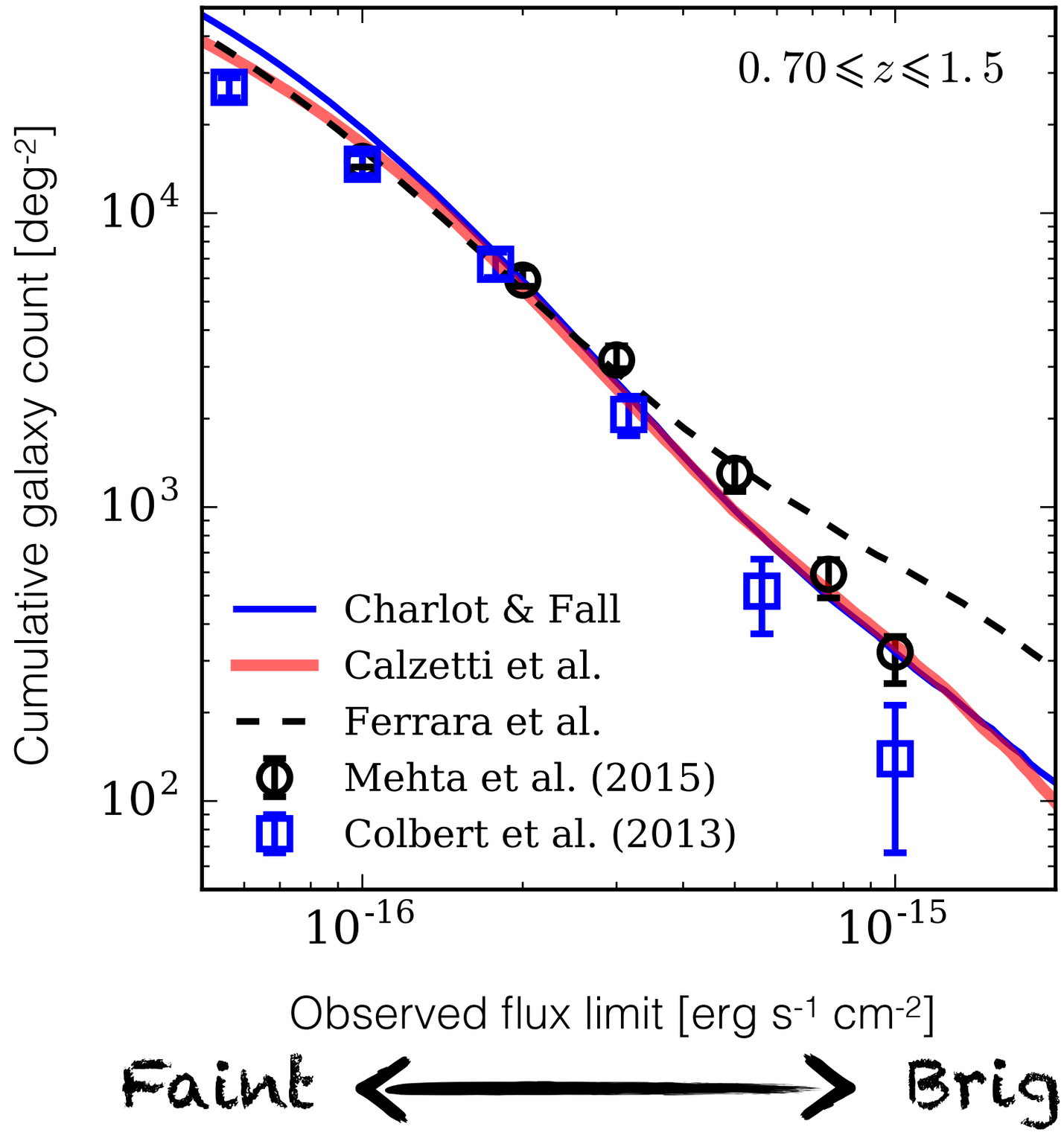
(2) Assign galaxies using galaxy formation model ‘Galacticus’ (Benson 2012).





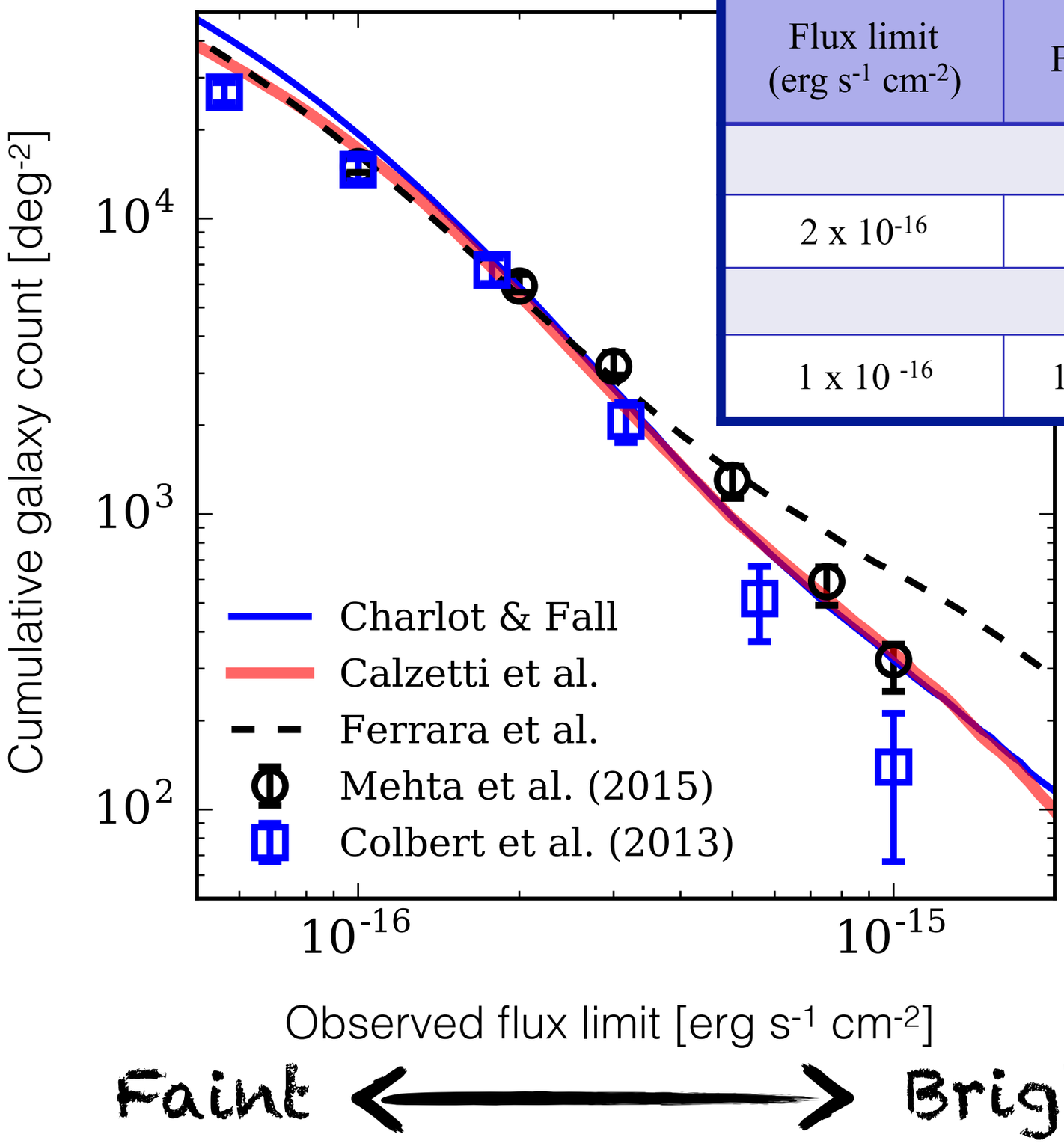
(3) Emulate observation strategy.

Hα number densities from Galacticus



- Galacticus can reproduce current observed Hα galaxy counts (different methods for dust modeling give consistent results)
- Can now produce predictions for Hα galaxy counts with reduced scatter compared to previous work.
- These vital numbers are required by Euclid and WFIRST missions to forecast the precision with which galaxy clustering can be measured.

Hα number densities from Galacticus



Flux limit (erg s^{-1} cm^{-2})	Ferrara et al.	Calzetti et al.	Charlot & Fall
Euclid ($0.9 < z < 1.8$)			
2×10^{-16}	4036 ± 62	4849 ± 192	3884 ± 252
WFIRST ($1 < z < 2$)			
1×10^{-16}	10403 ± 141	15176 ± 528	12195 ± 987

- Can now produce predictions for Hα galaxy counts with reduced scatter compared to previous work.
- These vital numbers are required by Euclid and WFIRST missions to forecast the precision with which galaxy clustering can be measured.

Summary & Future Work

- What is the Dark Energy driving the accelerated expansion of the Universe?

- Euclid and WFIRST will help probe the nature of Dark Energy by precisely measuring the clustering of Hα-emitting galaxies.

- Need to know how many Hα-emitting galaxies will see (impacts scientific success of these missions). Currently large uncertainty.

- Used a galaxy formation model to make new predictions for number of Hα-emitting galaxies, which will be vital for providing accurate forecasts.

- Future work: assess how galaxy formation physics impacts observed number of Hα-emitting galaxies, examine how Hα-emitting galaxies trace the large-scale structure, …