
Image credit: ASTRON

Redshifts in the era of thousands of FRBs

CONVINCING THE TAC TO GIVE US TELESCOPE TIME

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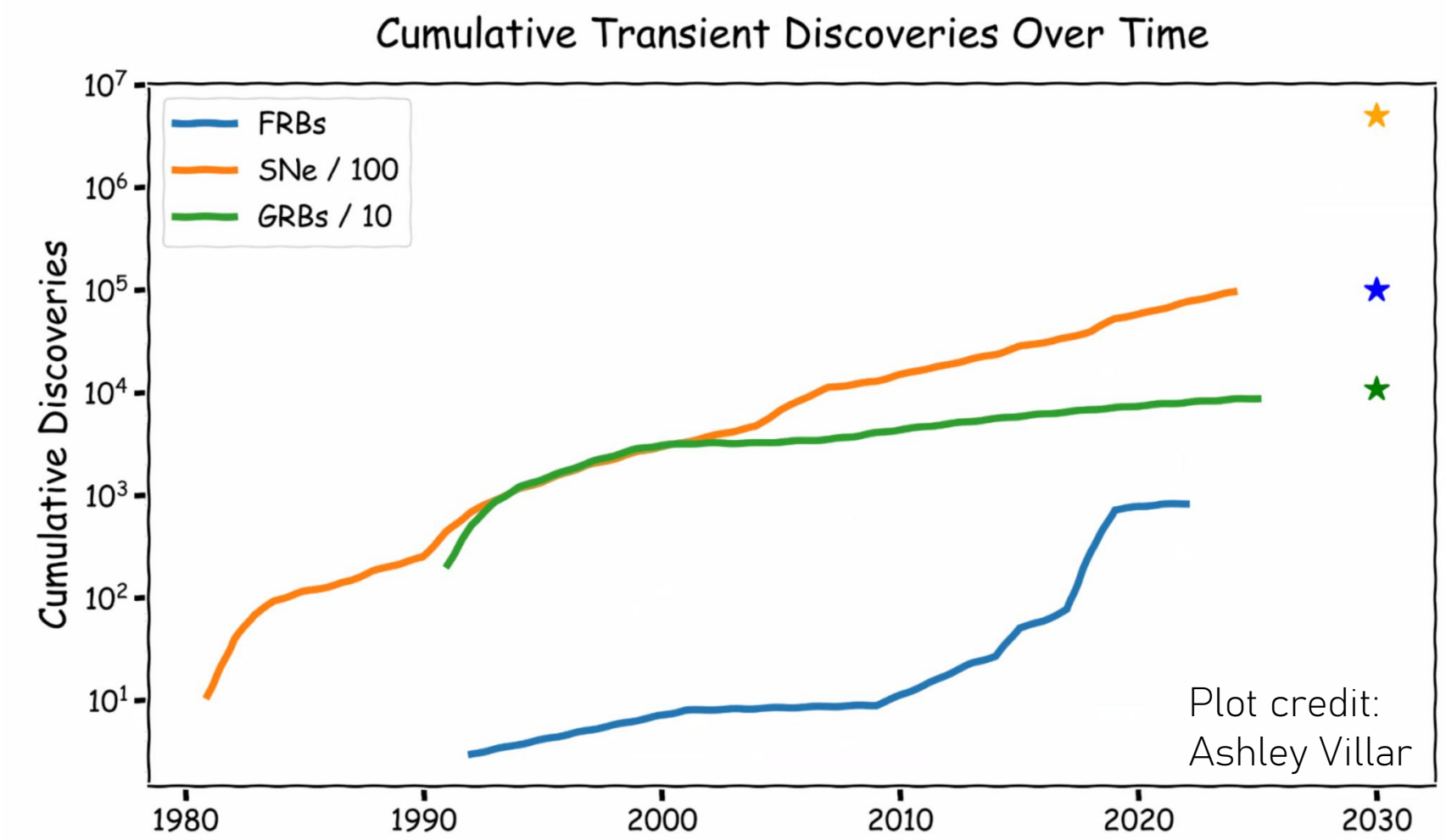
UNIVERSITY OF CHICAGO

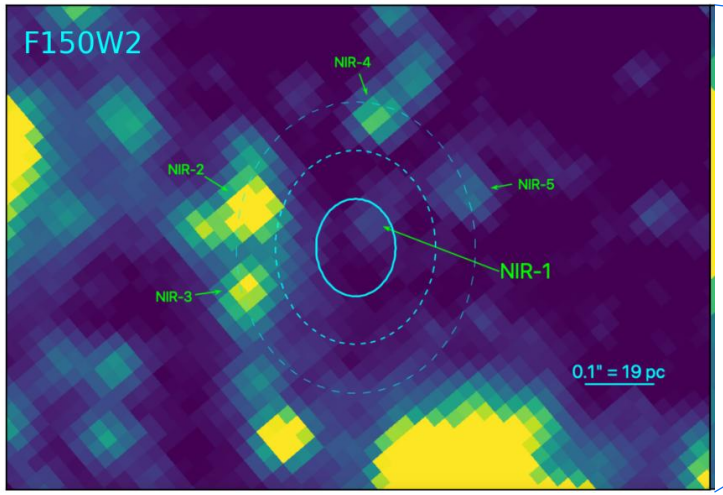
It's raining FRBs!

- FRB detection rates are growing exponentially!
- ~O(10) bursts / day expected from next generation instruments.



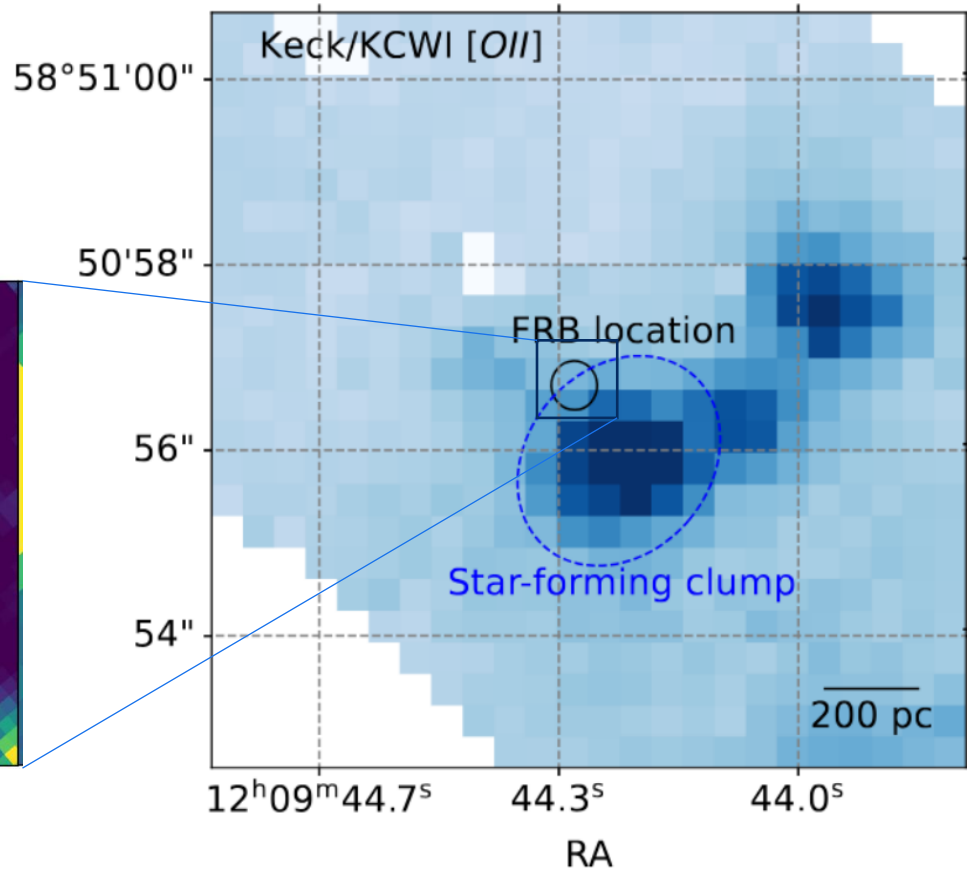
… with precise localizations!

- CHIME is already on its way to produce ~200 sub-arcsecond localizations per year!
- The majority of next gen FRB detections will have VLBI localizations.
- WE NEED SO MANY z_{Host}!



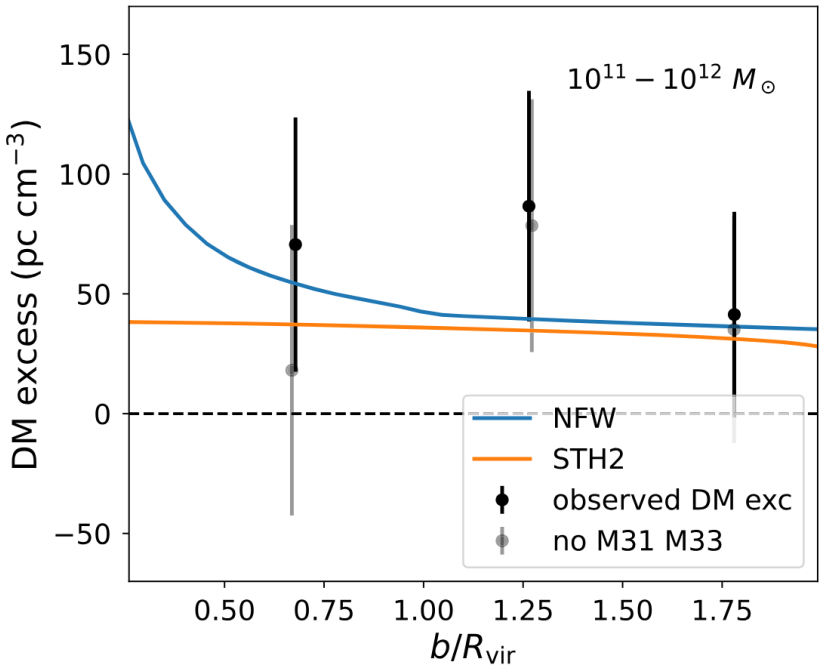
Blanchard+2025; Including the CHIME/Collaboration

FRB 20250316A

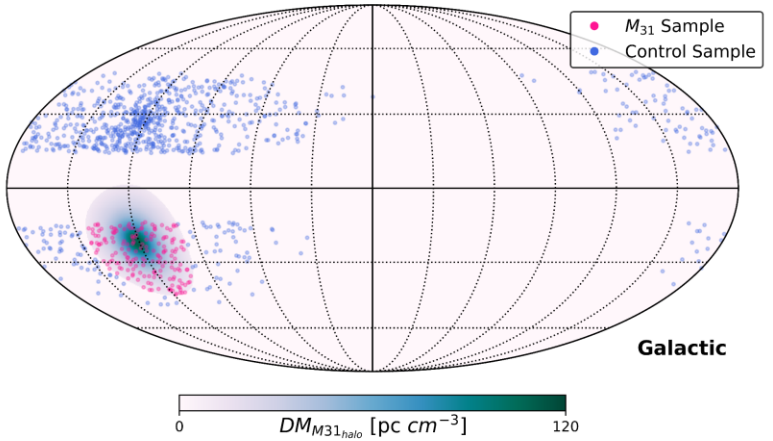


CHIME/FRB Collaboration+(2025; including Simha)

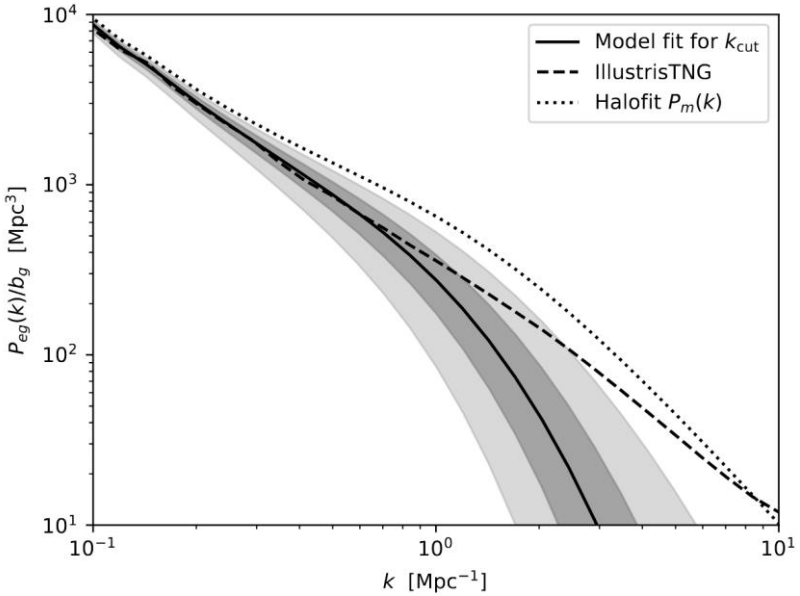
Science without z_{Host}



Wu and McQuinn 2023



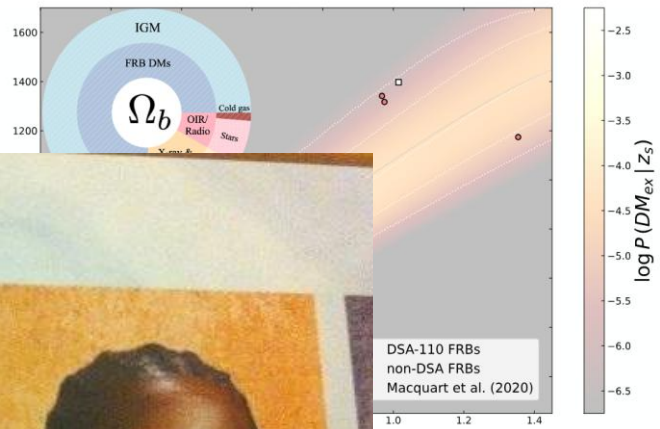
Kahinga+2025, in prep



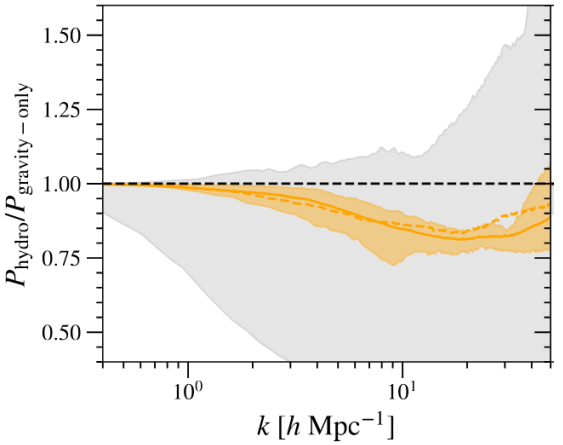
Wang+2025

Life is better with z_{Host}

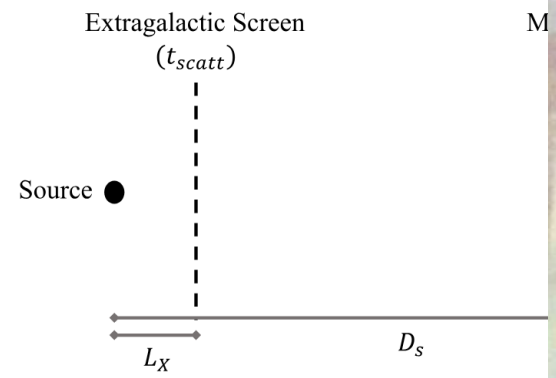
Macquart+2020,
Connor+2025



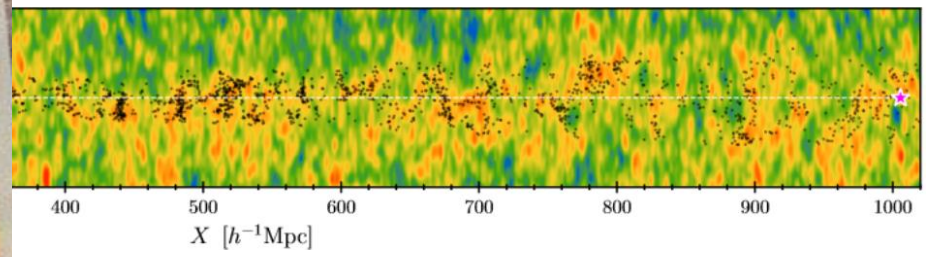
Sharma+2025



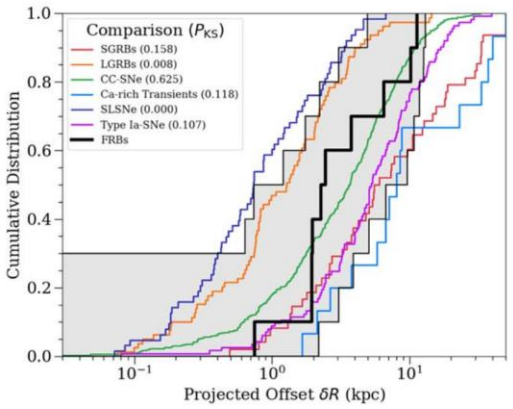
Sammon

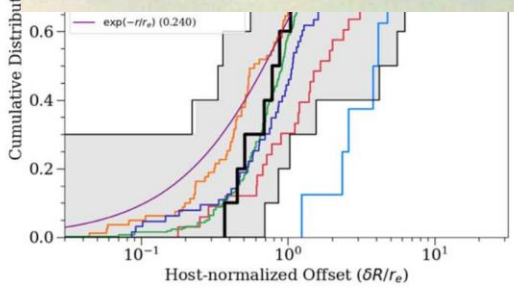


Khrykin+2024

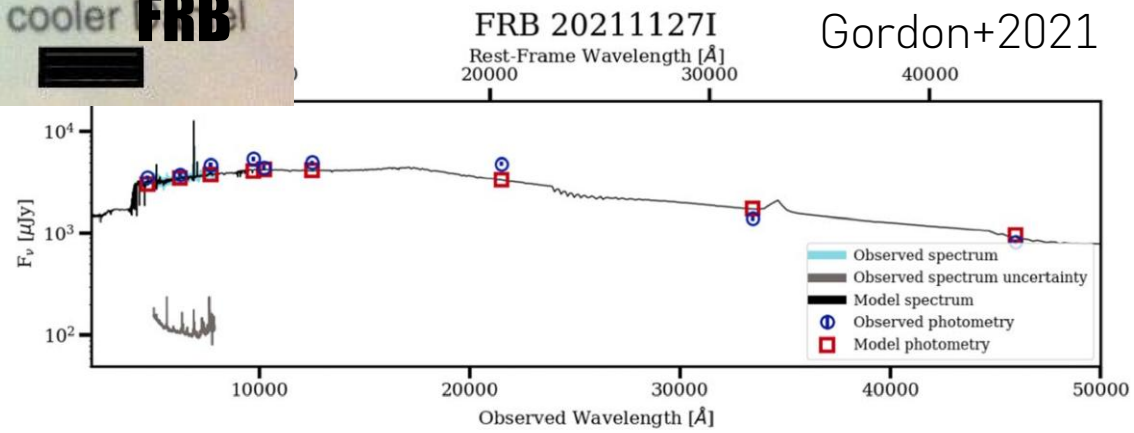


Woodland+2024; Mannings





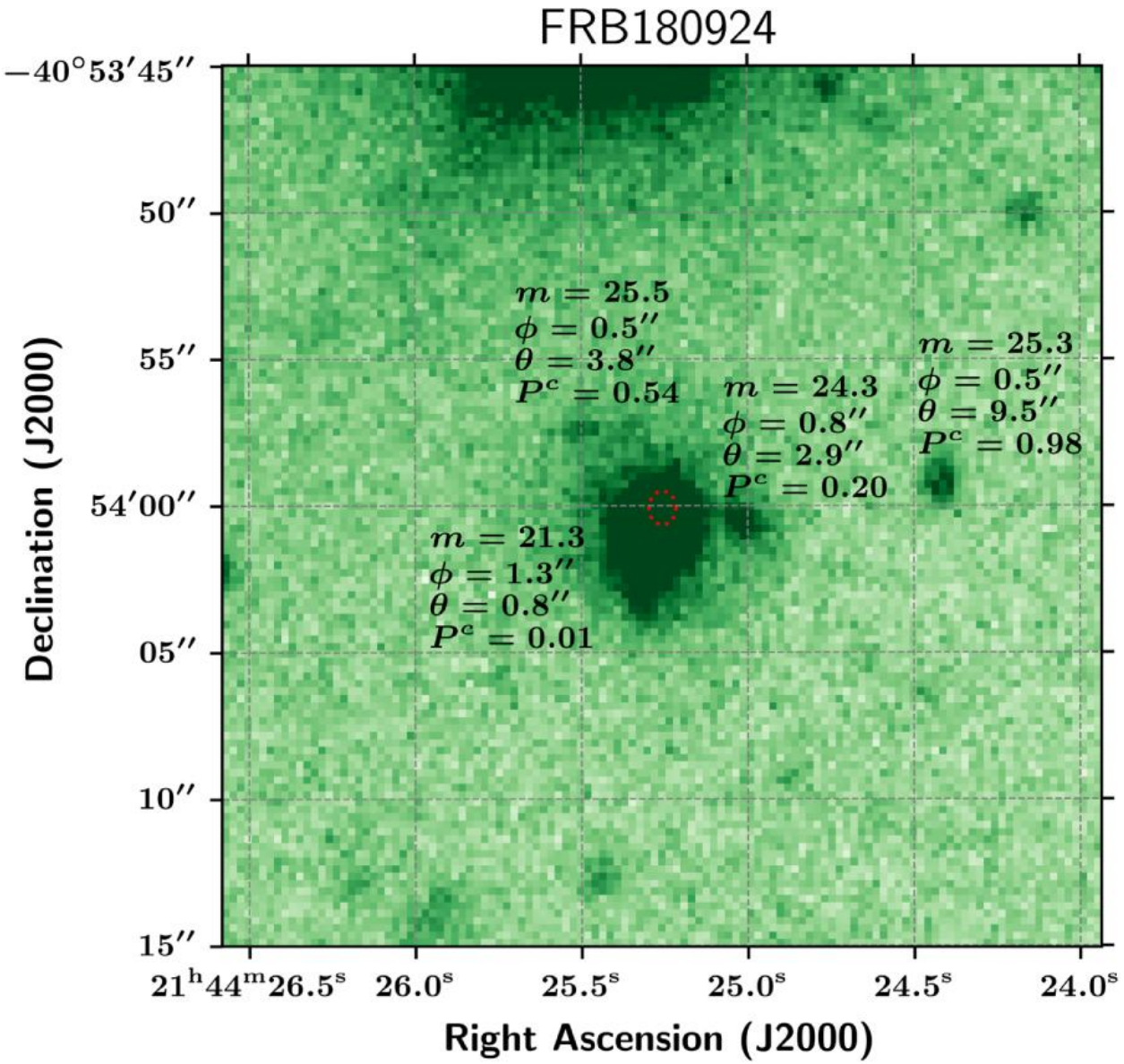
Gordon+2021



F4: Your friendly neighborhood optical folk!

What goes into measuring redshifts?

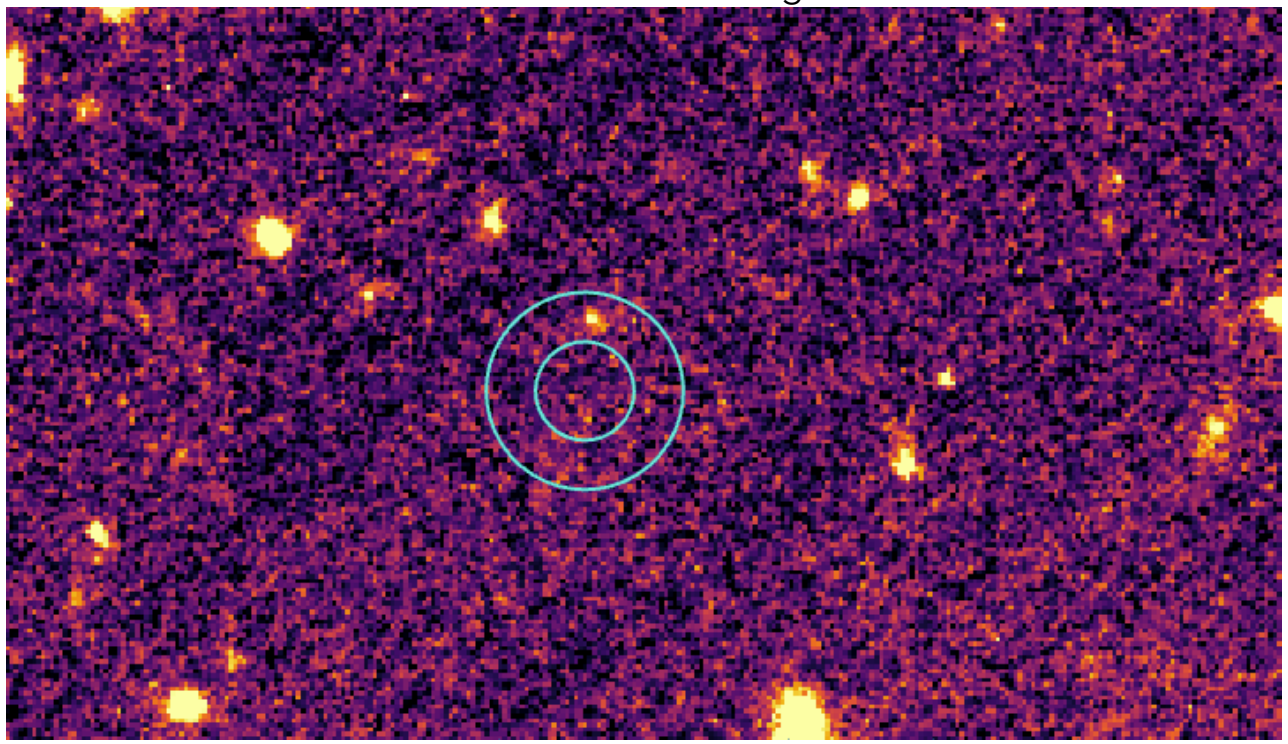
- Step 1: Host association with PATH.
- Requires *sufficiently deep* imaging.
- Mostly rely on public imaging surveys (r<23.5).
- Fainter hosts-> Deeper imaging.



Aggarwal+2021

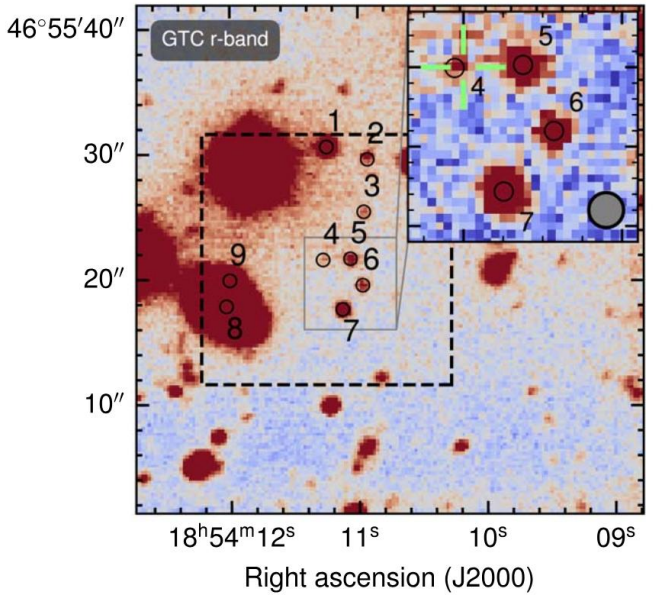
Deep imaging is expensive but often necessary

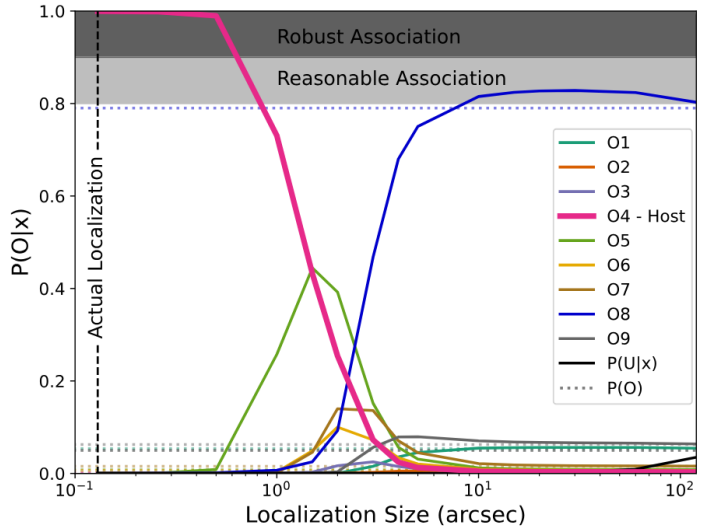
FRB 20210912A. NIRCam F150W Image credit: Adam Deller



Also see Apurba's talk!

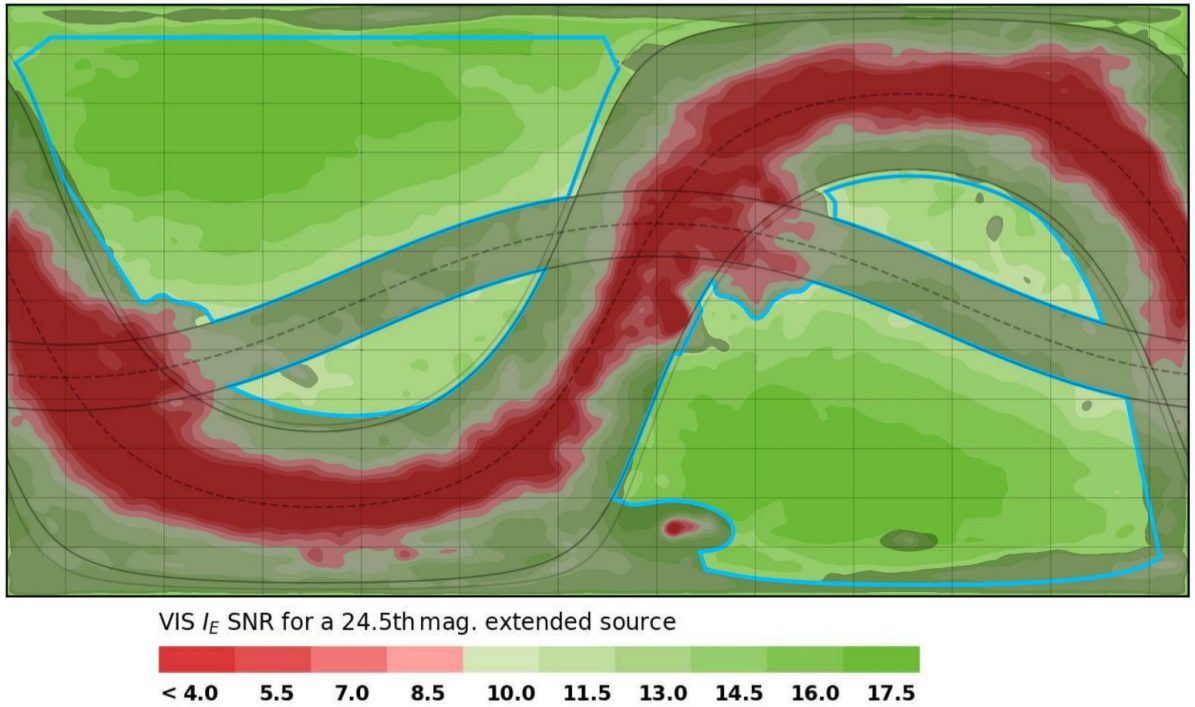
Hewitt+2024

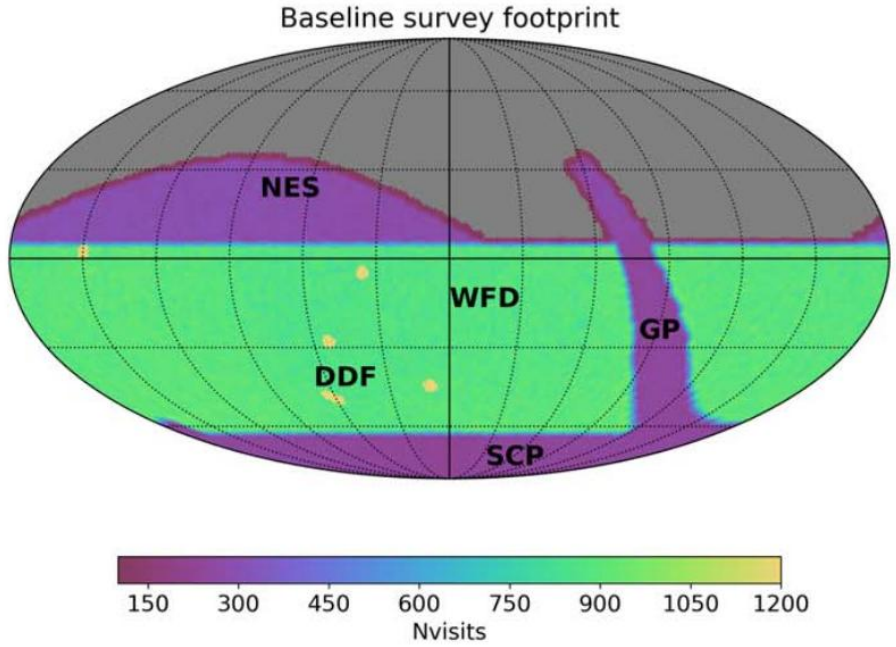




Future imaging surveys

Euclid; VIS~26 in 6 y. Scaramella+2022

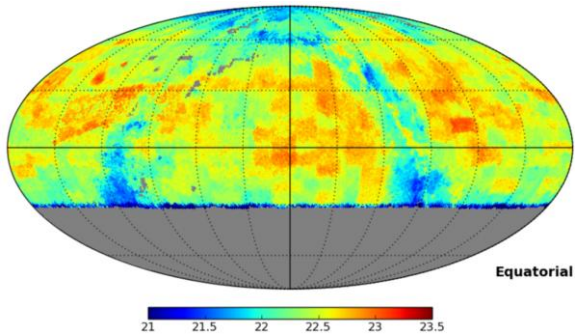




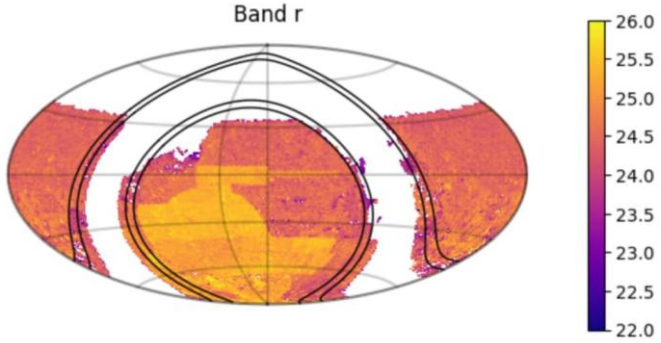
LSST; r~27 in 10 y.
Bianco+2022

Which telescopes to use for imaging

PS1 DR2; Chambers+2019

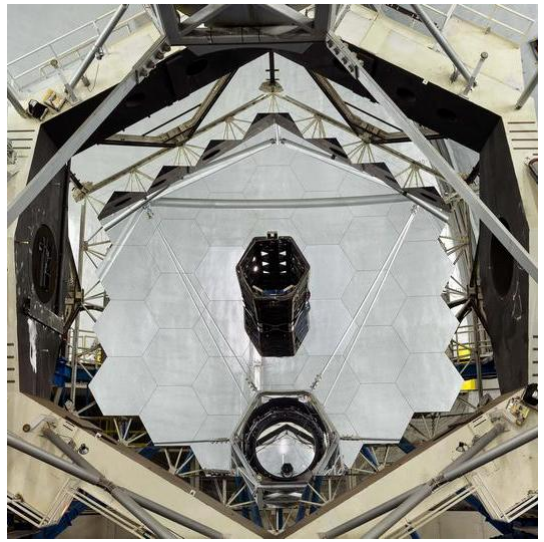


Legacy Survey; Dey+2019

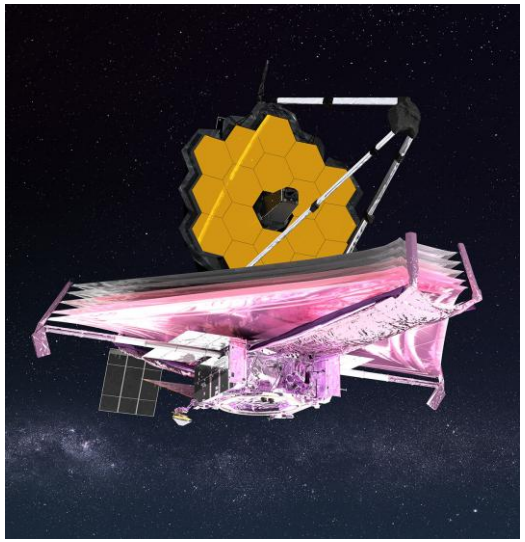


4-m class

10-m class



6-m class in space



m<23.5 → m<25 → m<27 → m<30

Is imaging enough? Can we just use photo-zs?

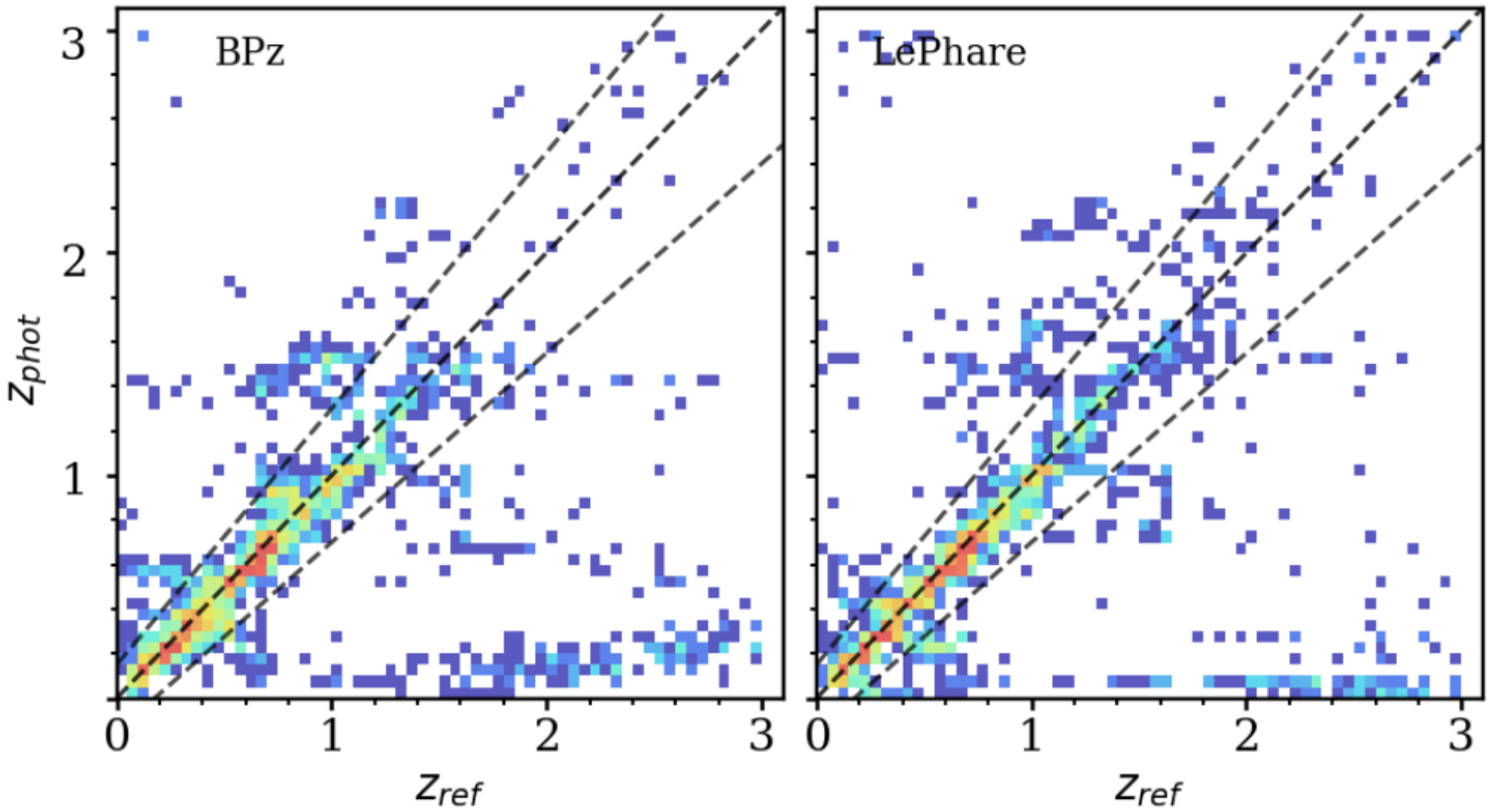
Pros:

Many more sources will have redshifts.

Cons:

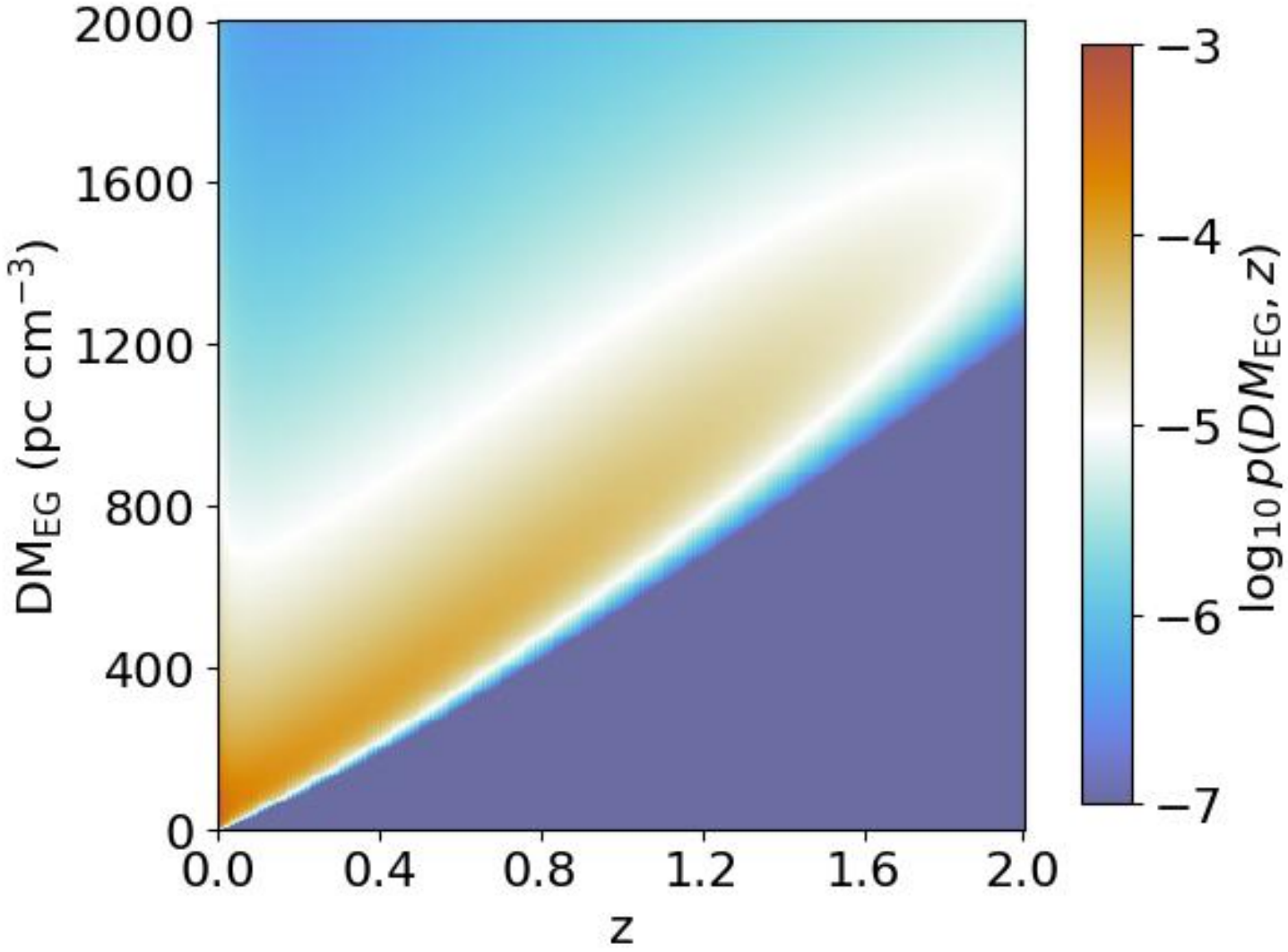
Issues with accuracy.

High-z completeness is less than desirable.



Rubin DP1 Photo-z; Zhang+2025

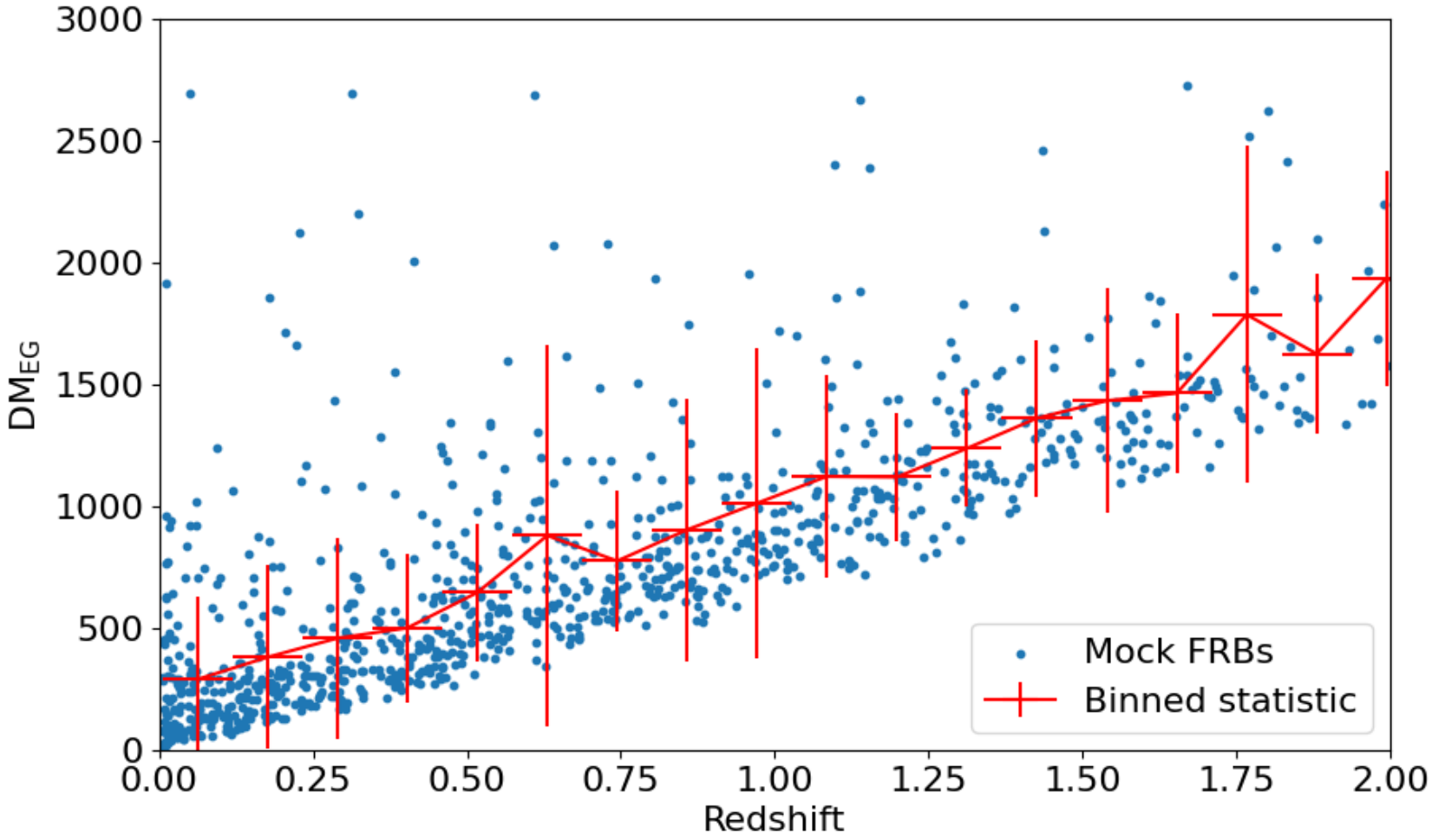
How do photo-zs affect analyses?



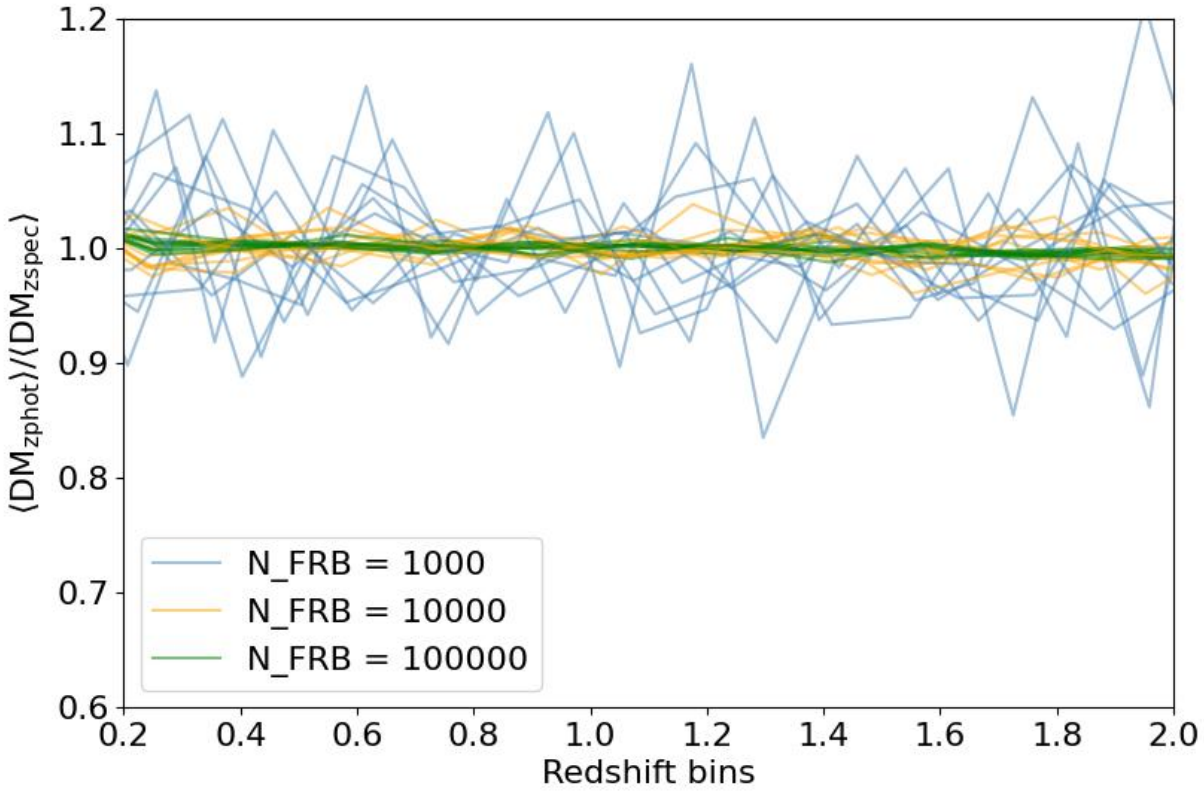
https://github.com/FRBs/zdm
James+2021

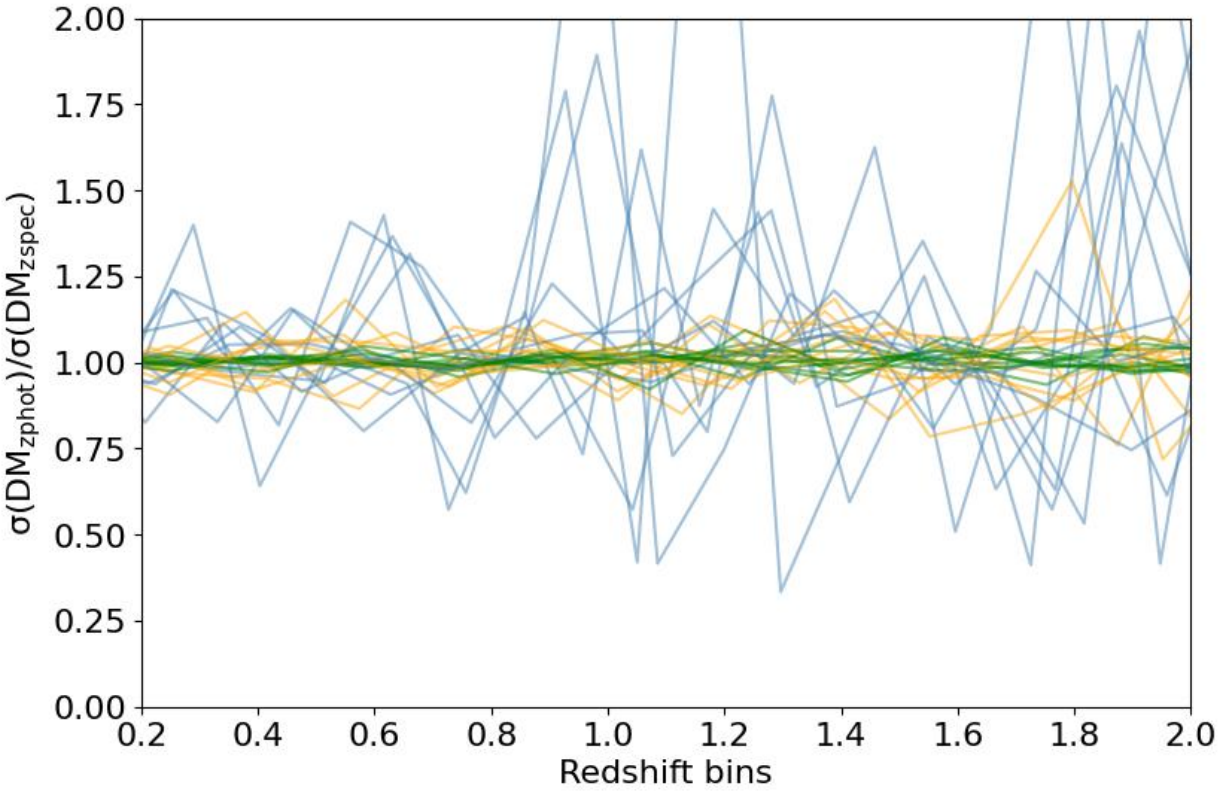
Generate a mock sample of FRBs from Clancy's code to test the effect of redshift acciracy and precision on cosmological analyses.

How do photo-zs affect analyses?



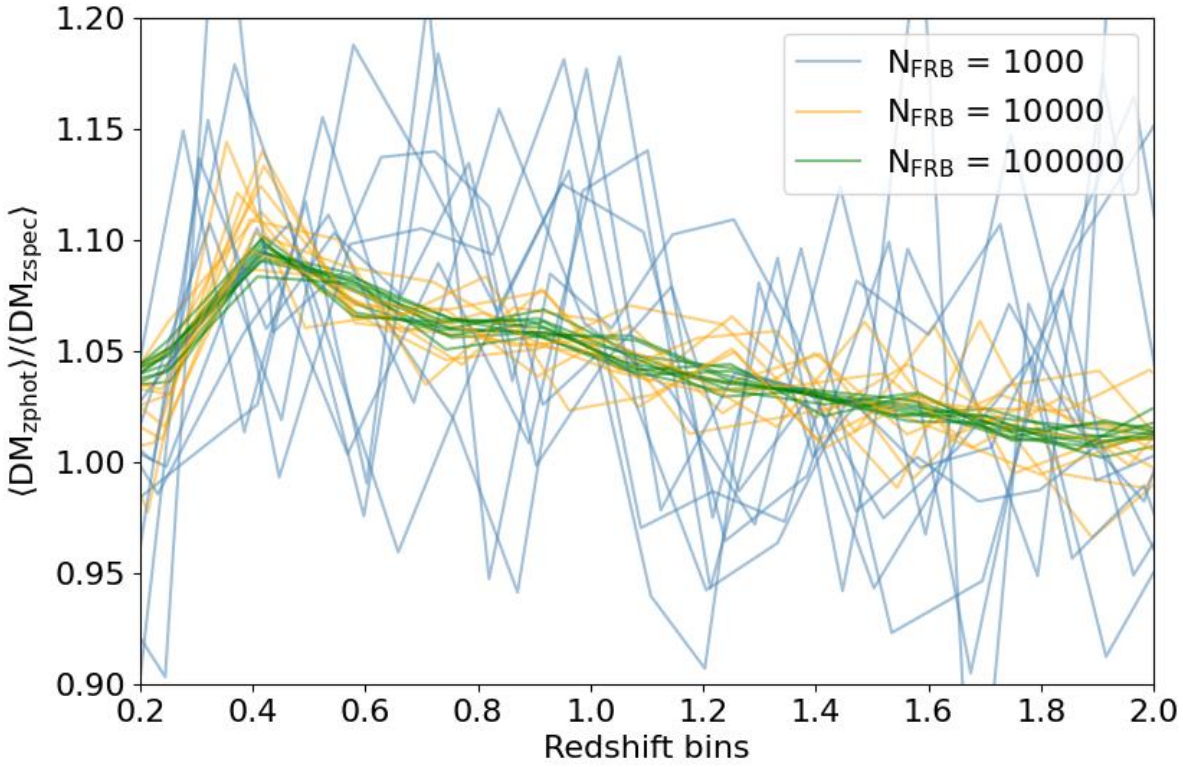
Gaussian errors in photo-z: $\Delta z \sim 0.03(1+z)$

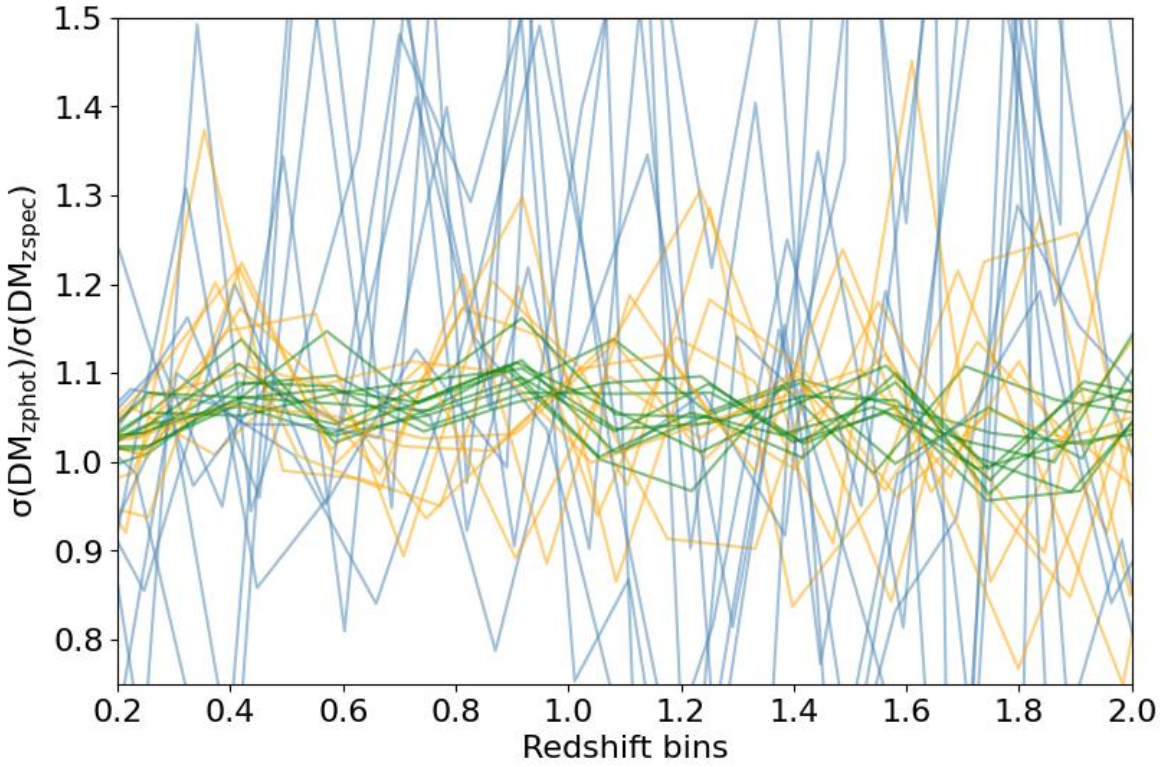




If you have large enough numbers of FRB hosts, photo-zs with gaussian errors are fine to use!

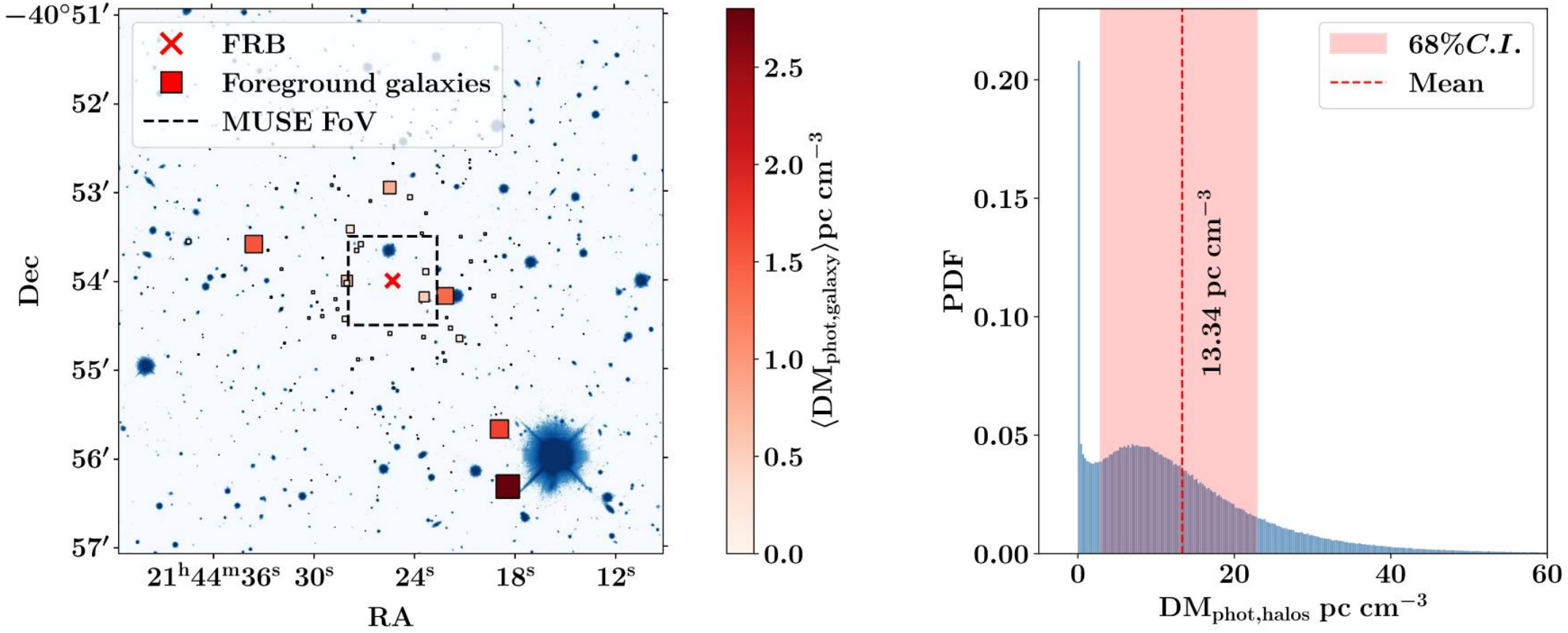
Including a catastrophic failure fraction





If 20% of high-z galaxies are incorrectly identified as low-z, mean and std.dev. of DM will be biased!

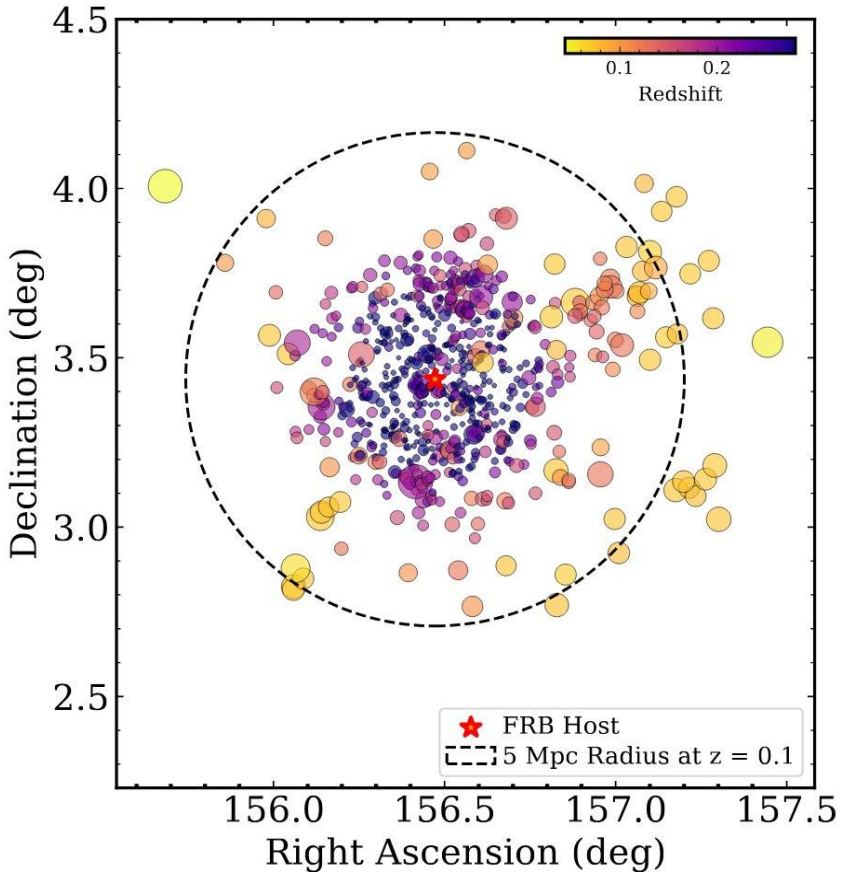
What about using photo-zs for foregrounds?

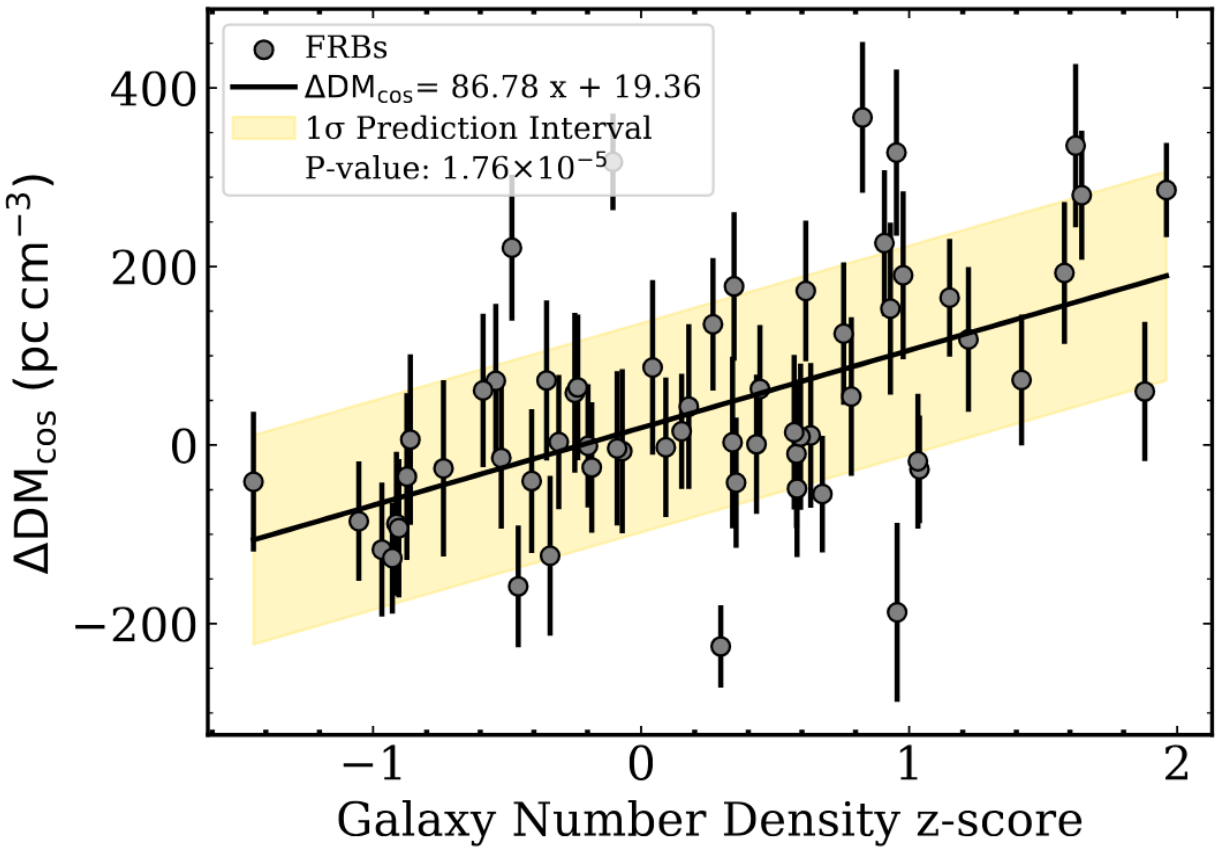


Significant uncertainties in estimating the halo contribution. IGM filaments cannot be reconstructred with typical photo-z errors.

Simha+2021

What about using photo-zs for foregrounds?

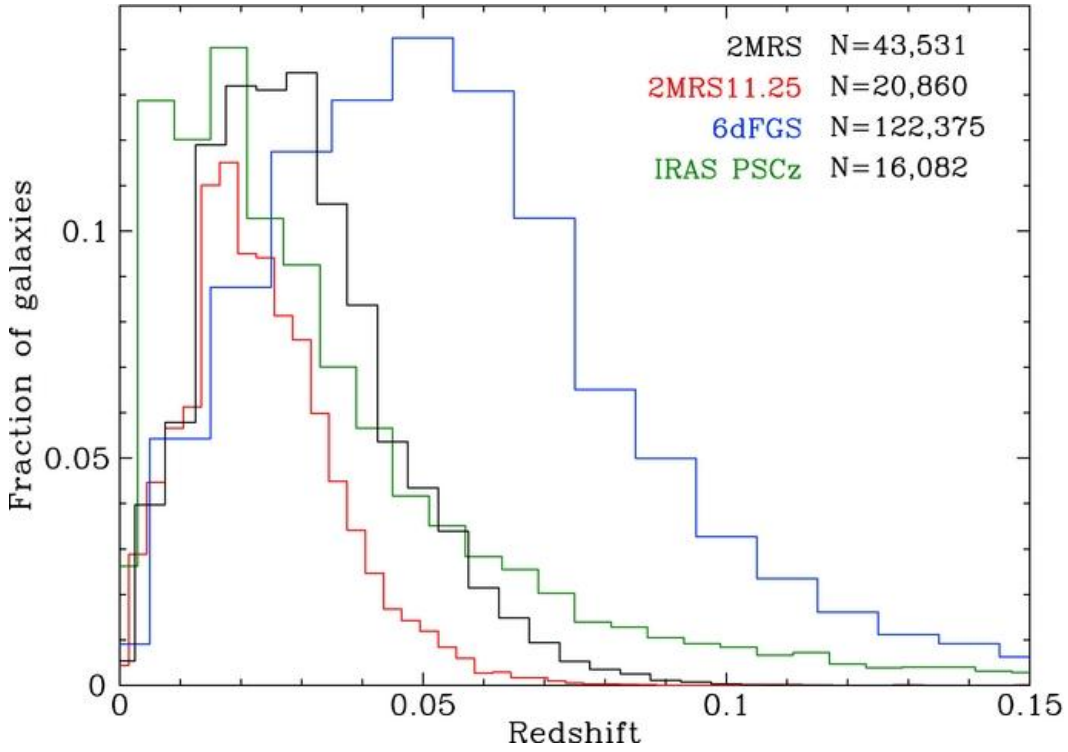


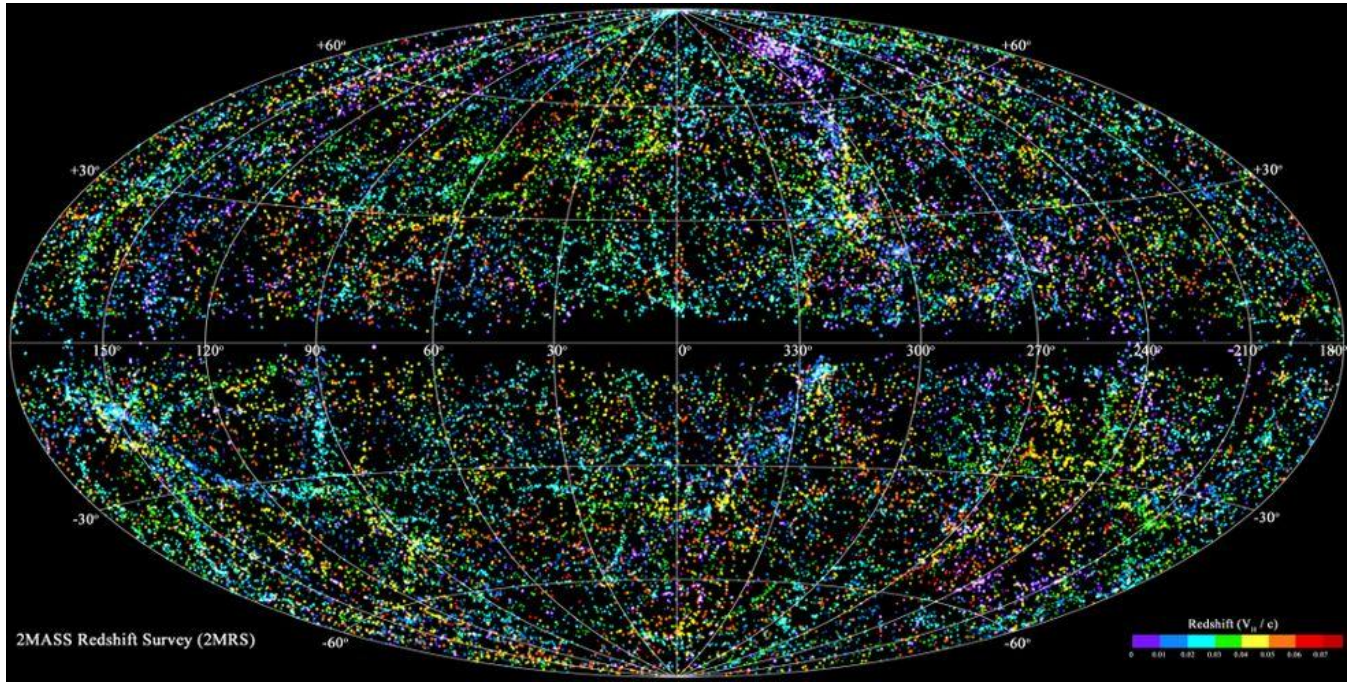


Hussaini+2025

Correlations with large-scale structure. Still need spec-zs for the FRB hosts.

Public spectroscopic databases

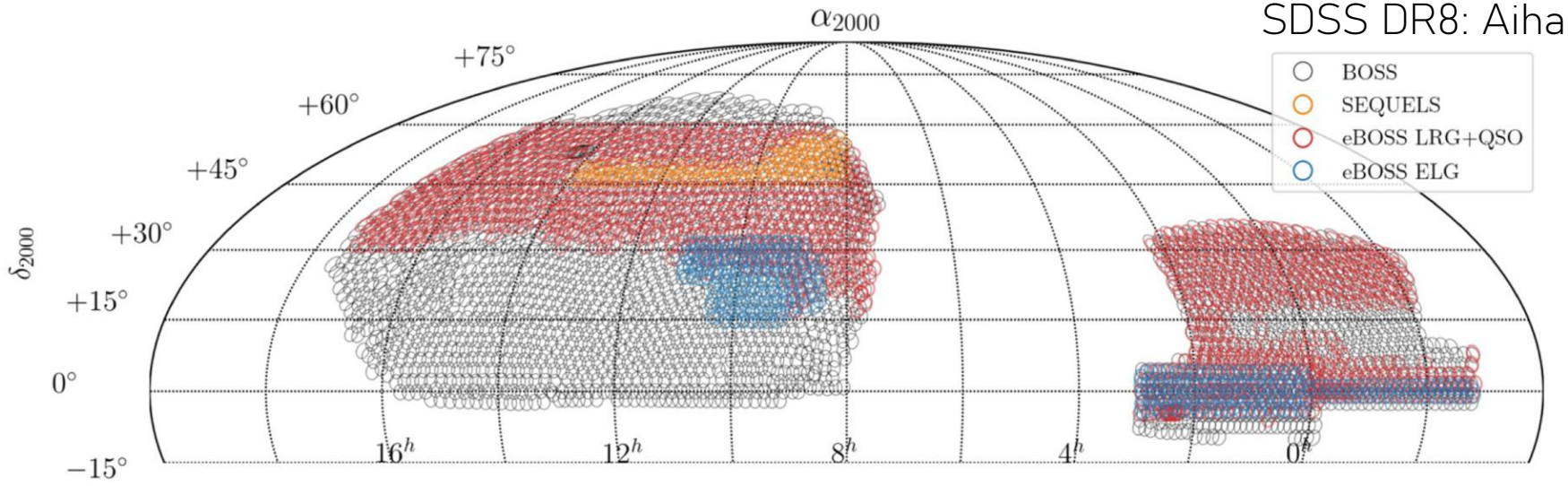


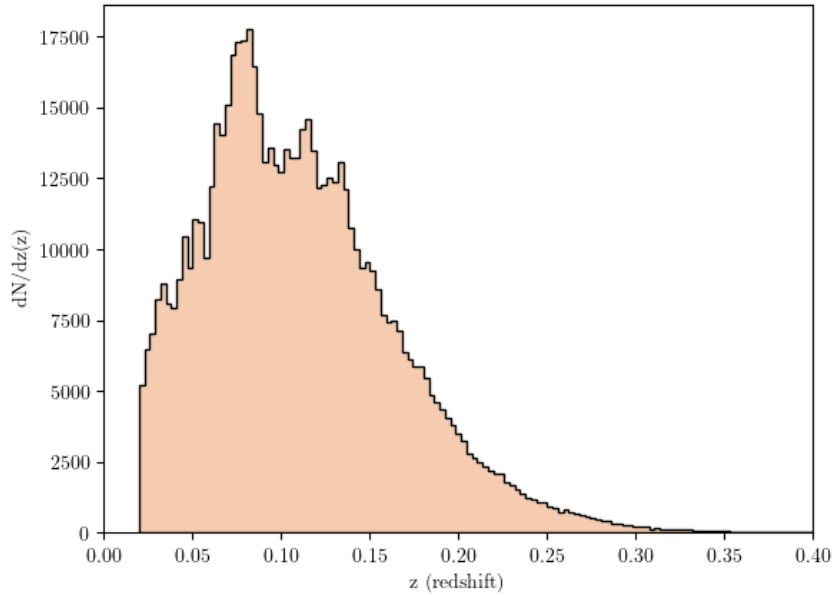


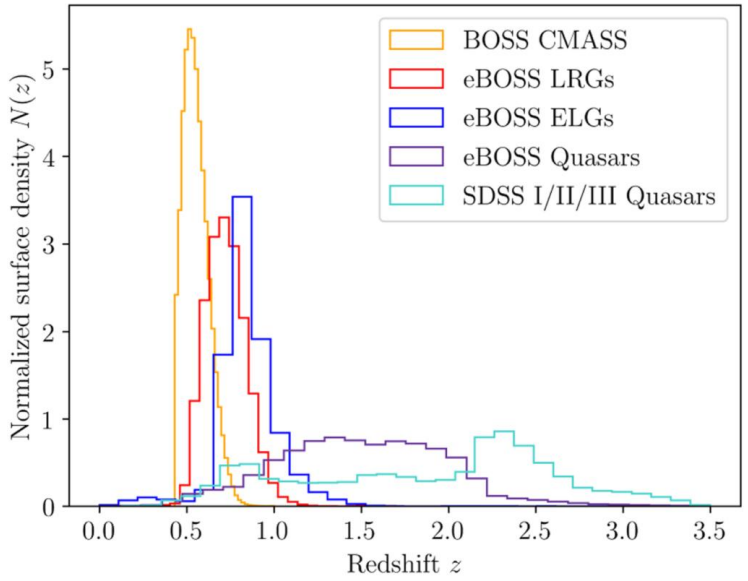
2MRS:Huchra+2012;
6dFGS: Jones+2009

Public spectroscopic databases

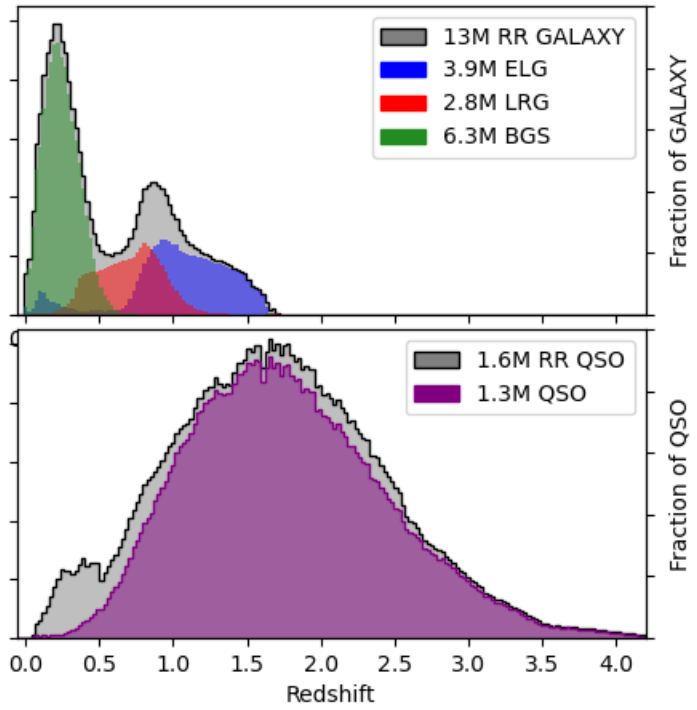
SDSS DR17: Abdurro'uf+2021;
SDSS DR8: Aihara+2011

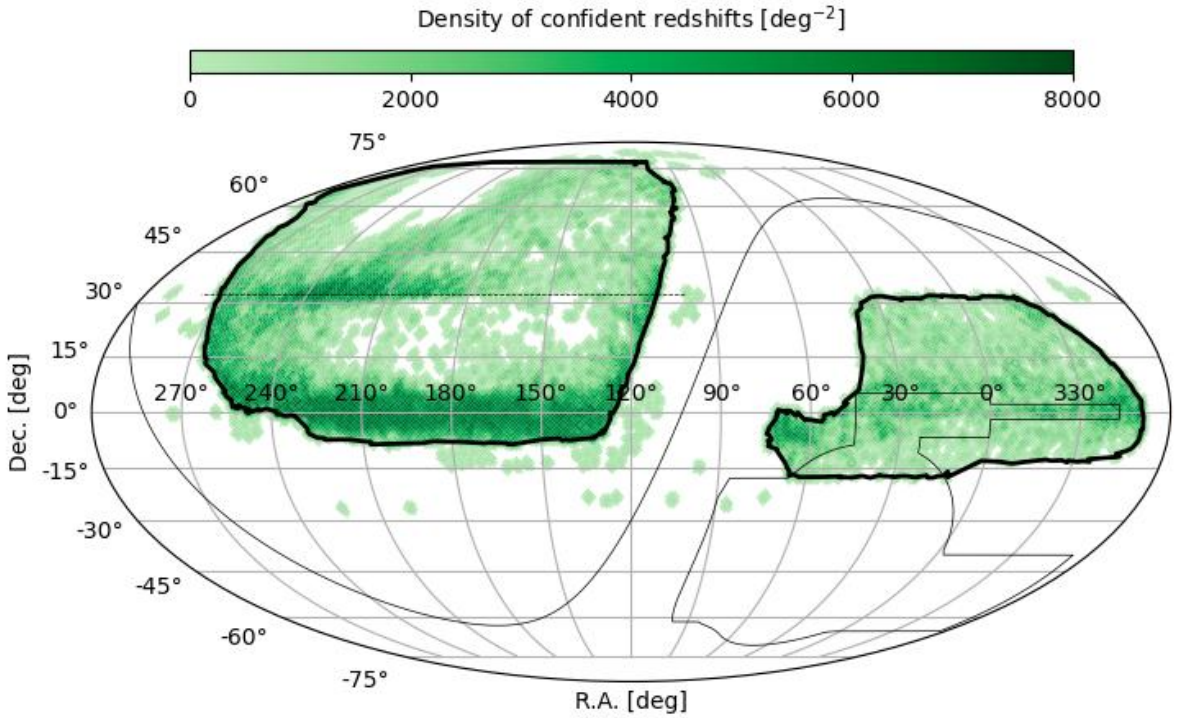






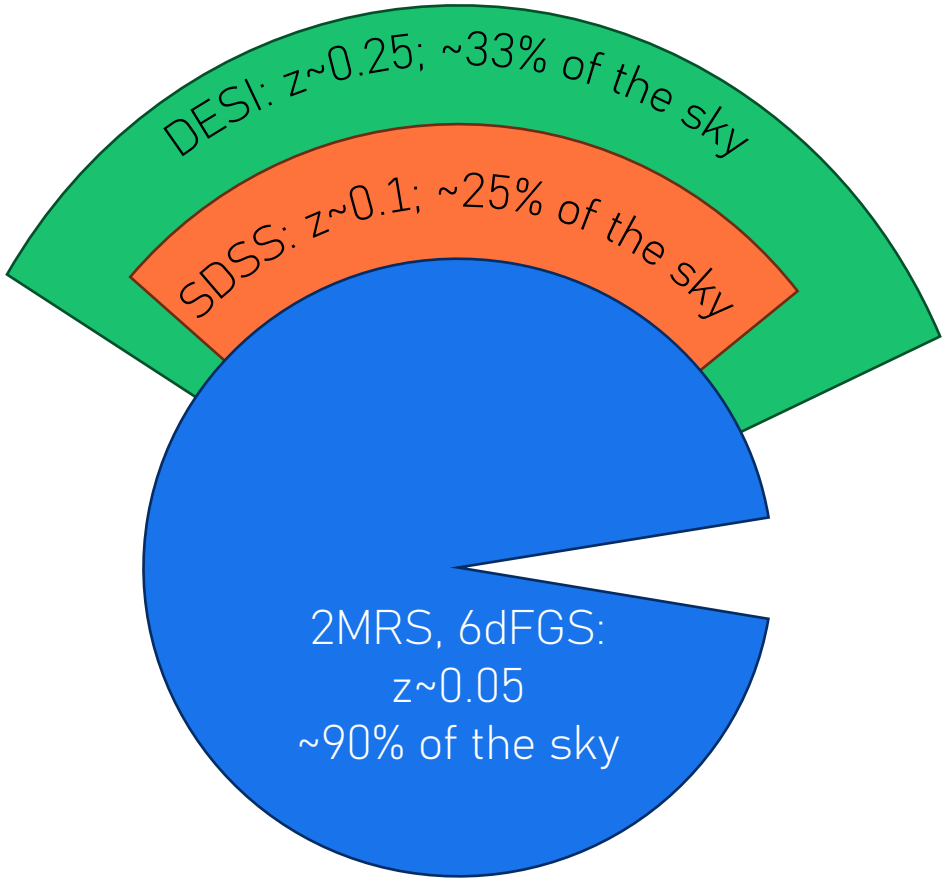
Public spectroscopic databases



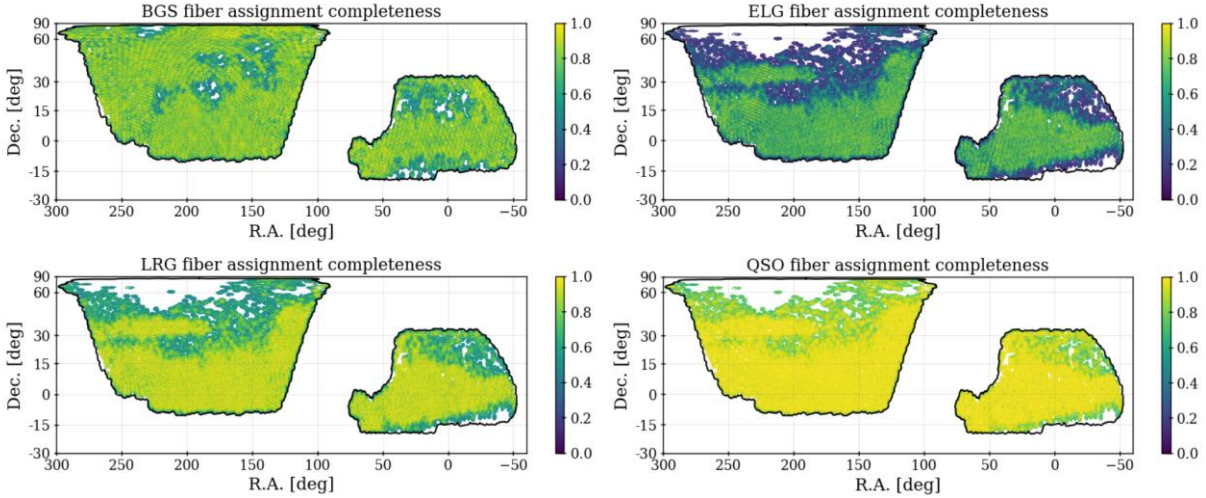


DESI DR1: DESI Collaboration+2025

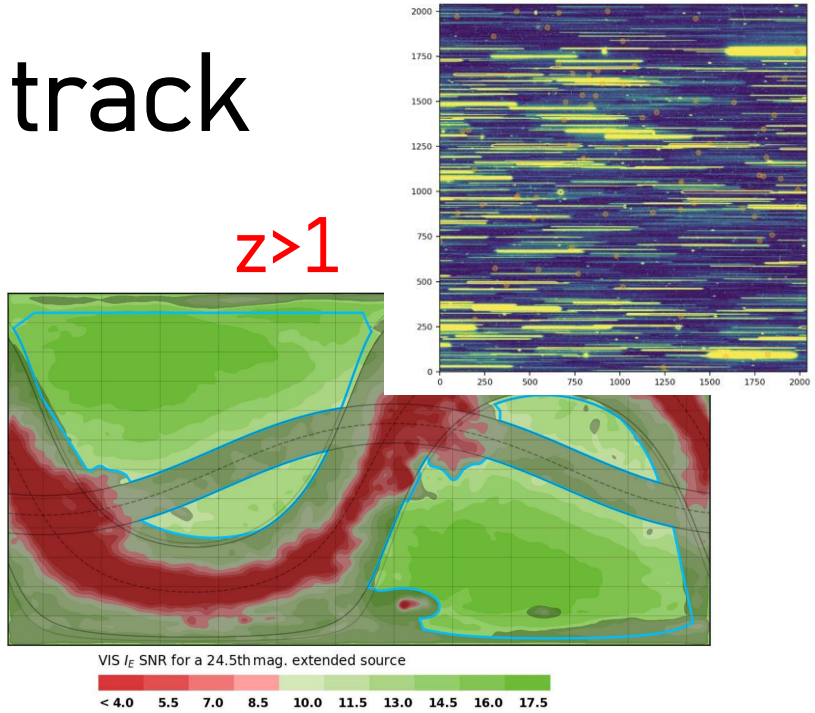
Summary of spec-z databases



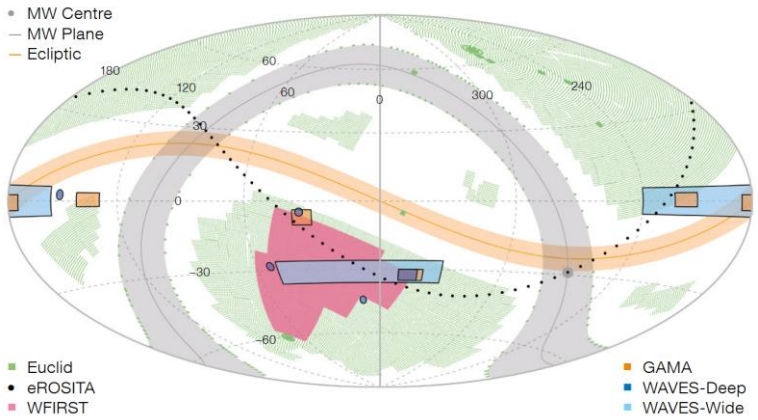
Future surveys/data releases to track



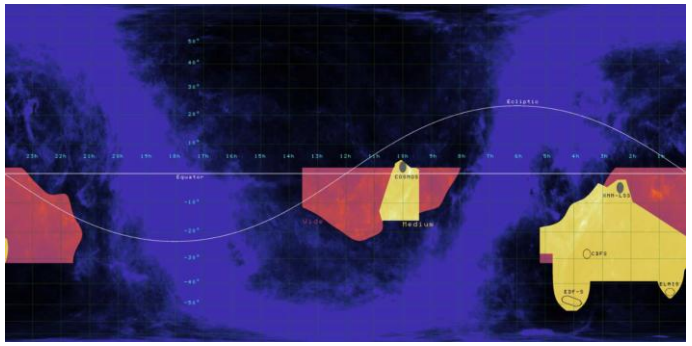
DESI DR2: DESI Collaboration+202X



Euclid and Roman slitless spectroscopy



WAVES (4MOST): Driver+2019

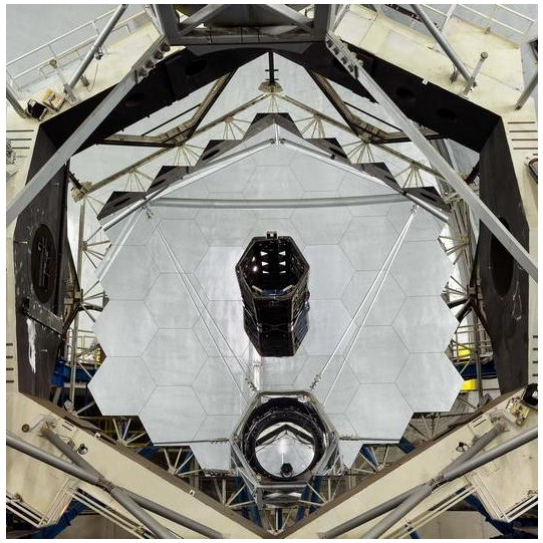


What if I need to get my own spec-zs?

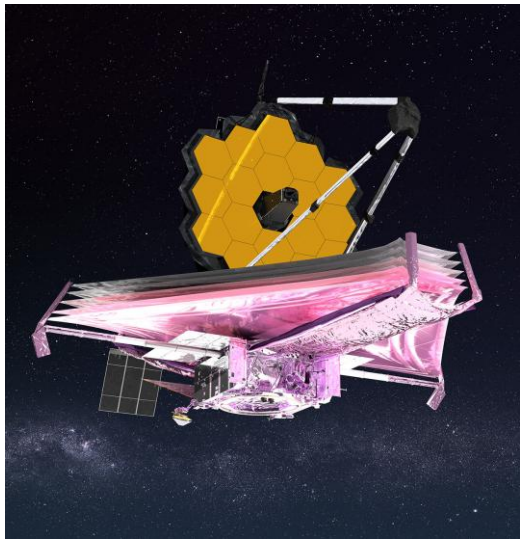
2-3 mag fainter limits for spectroscopic follow-up than imaging!

4-m class

10-m class



6-m class in space



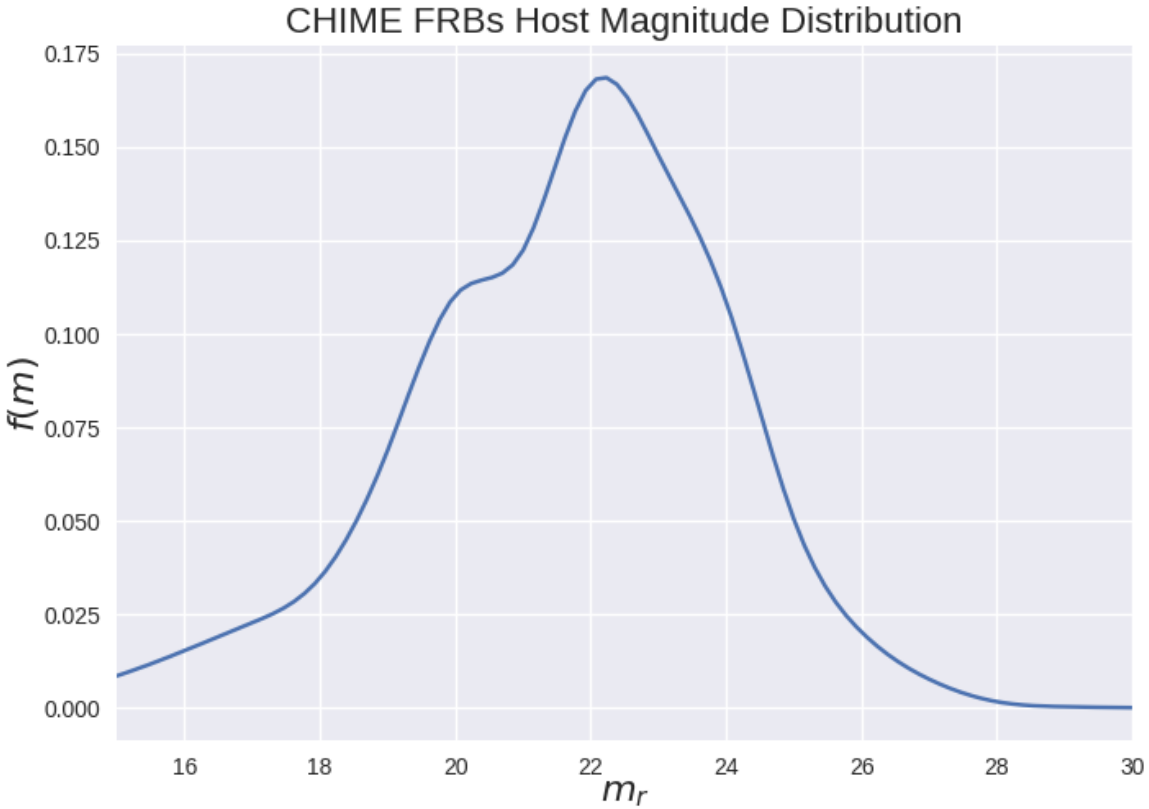
m<21

m<24

m<27

Challenges in obtaining z

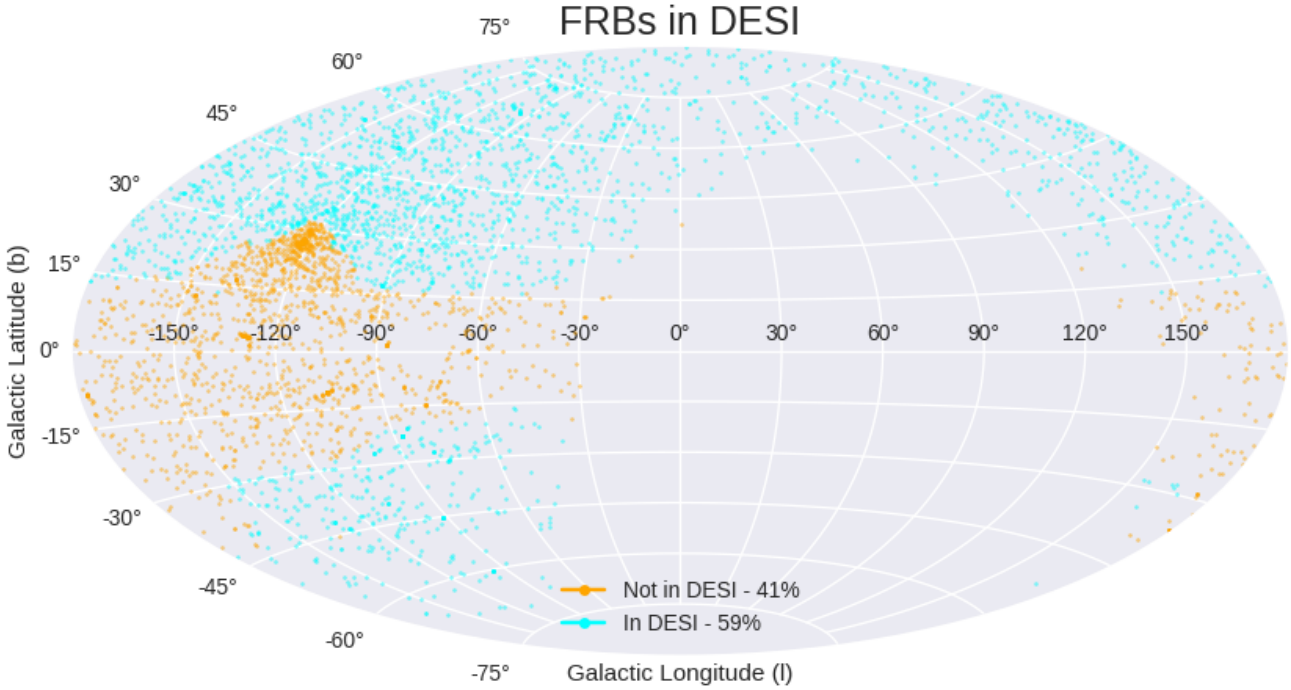
- O(1,000) FRBs per year implies large scale follow-up required.
- FRB hosts at higher z will be fainter. i.e. Bigger or space telescopes preferred/essential.
- Most hosts will not be in public catalogs.

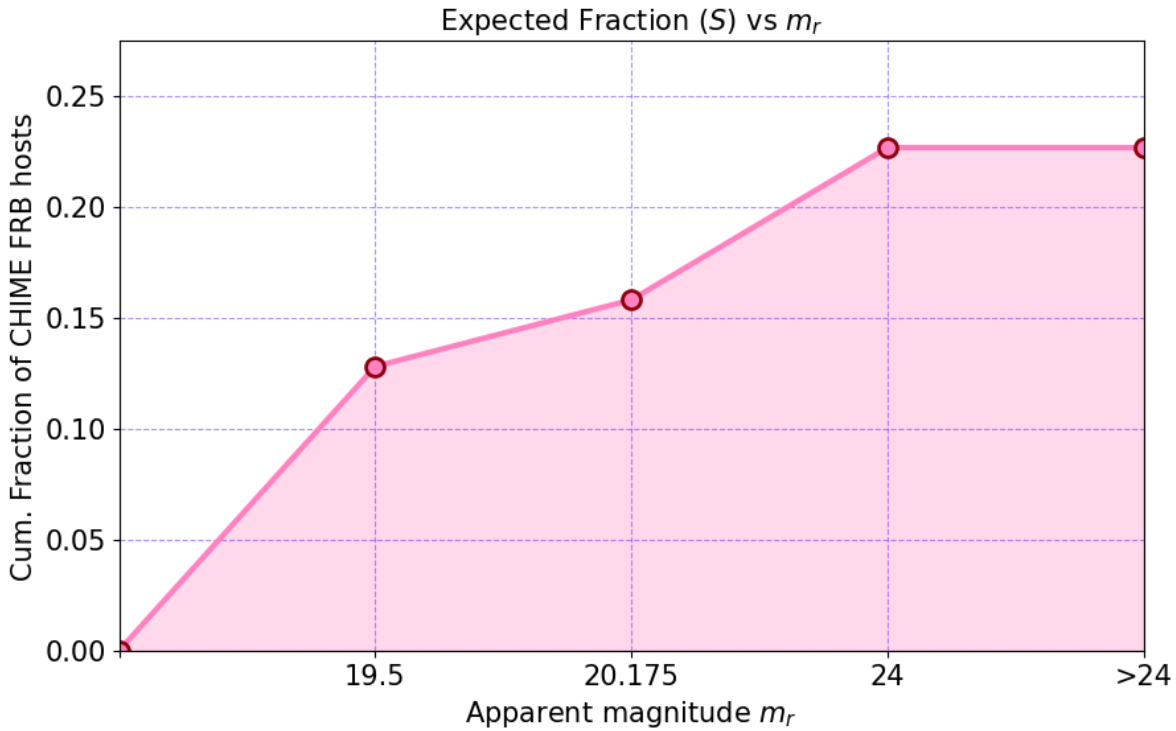


Plot credit: Lordrick Kahinga

Follow-up still needed for the majority of redshifts

- ≤ 25 % of CHIME/FRB redshifts can be directly obtained from DESI.

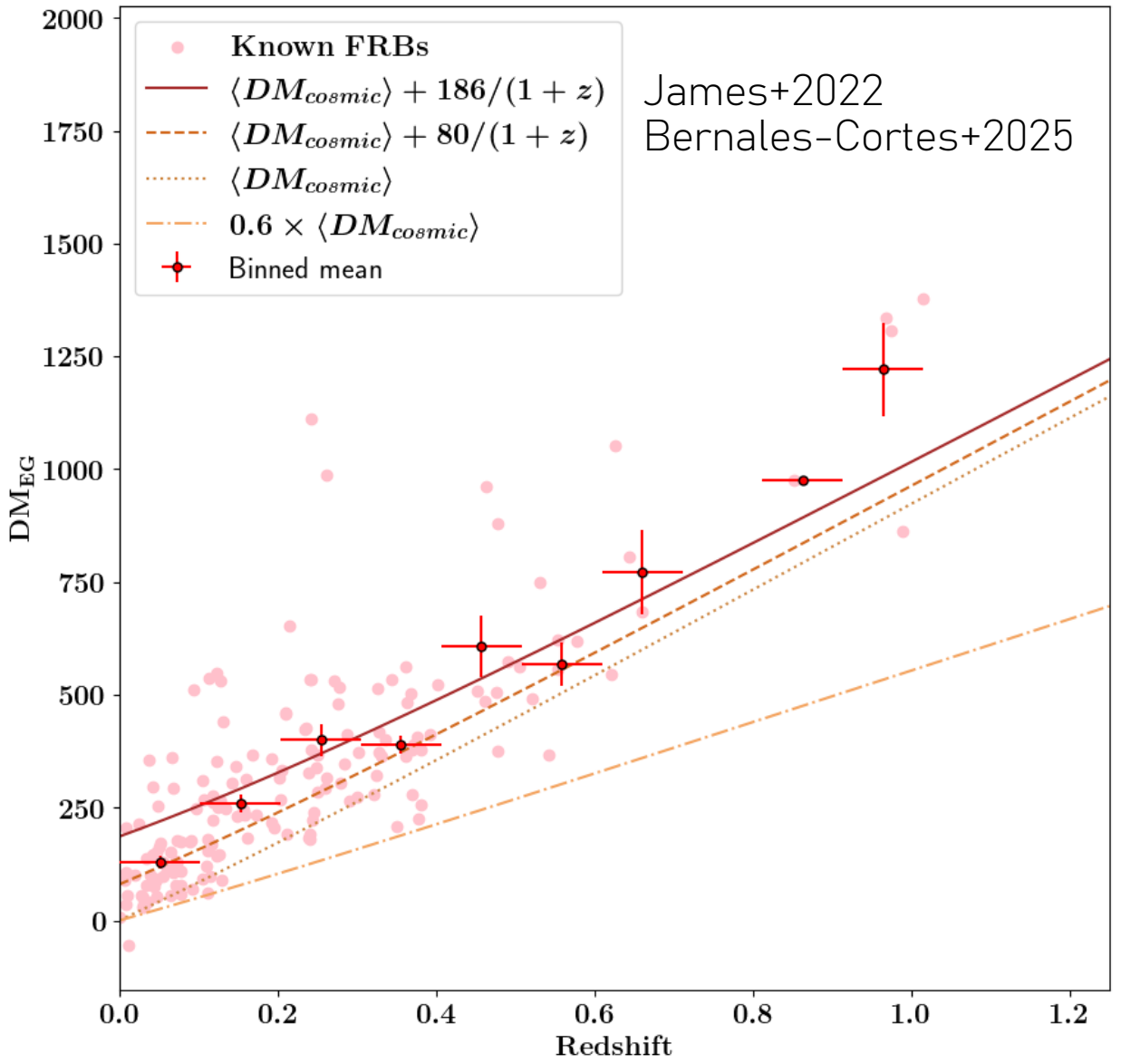




Plot credit: Lordrick Kahinga

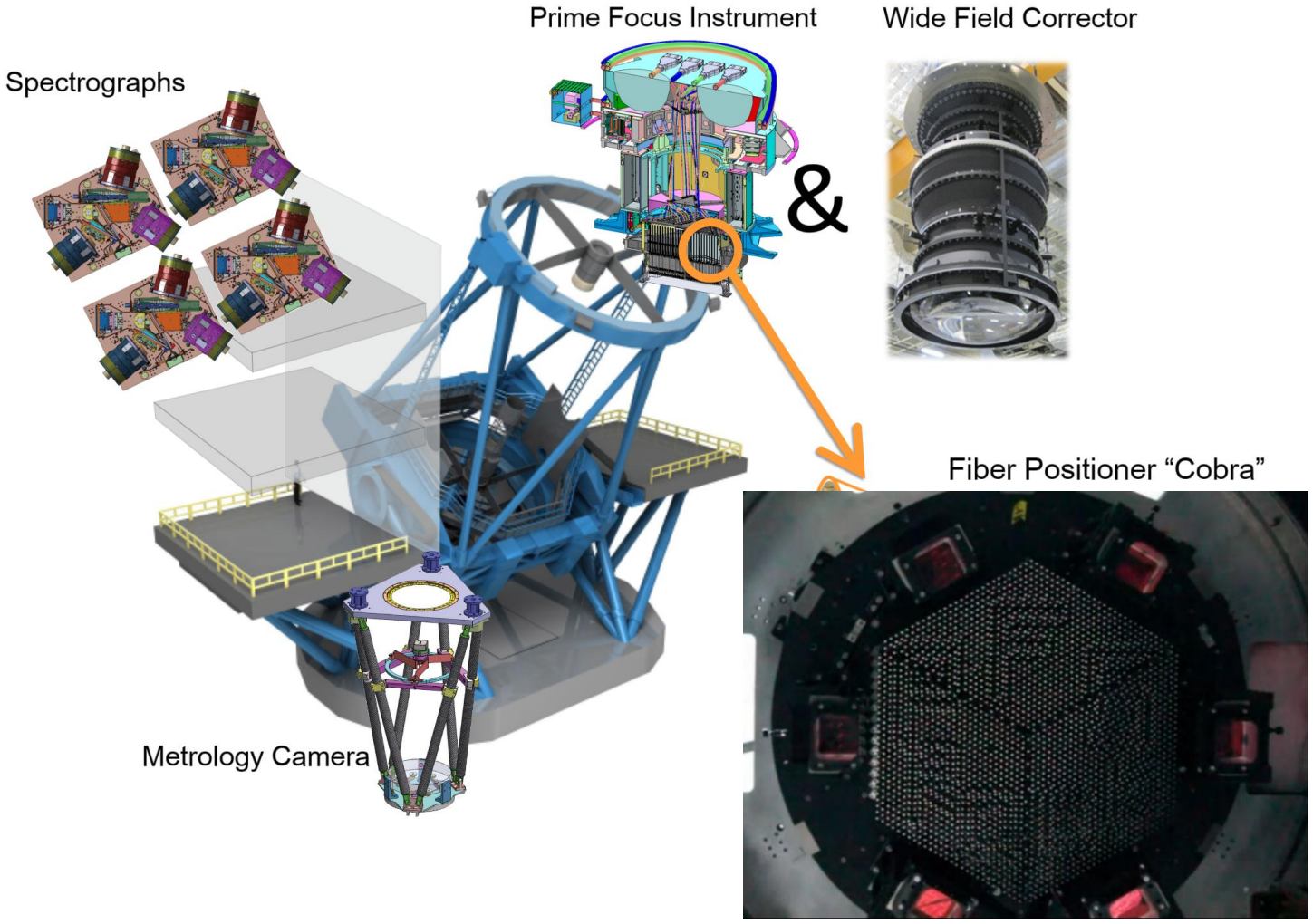
Convincing the TAC

- "What will XX more host redshifts yield?"
- We need efficient/science-oriented strategies for obtaining redshifts.



Redshifts at scale

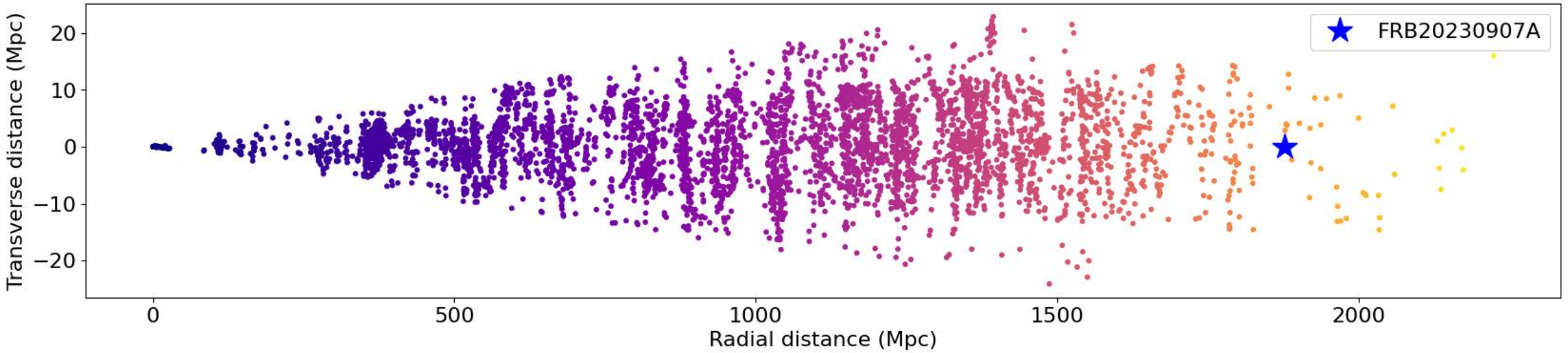
- Multi-Object spectroscopy could prove to be the preferred mode of operation in the future.
- Subaru PFS:
  - Most powerful multi-object spectrograph in the world.
  - Simultaneously observe ~2000 targets over 1.25 deg^2 footprint
  - R~3000, wavelength coverage 380nm-1.25micron.
  - Began operation spring 2025.



The power of the PFS

~6000 redshifts in ~4 h.

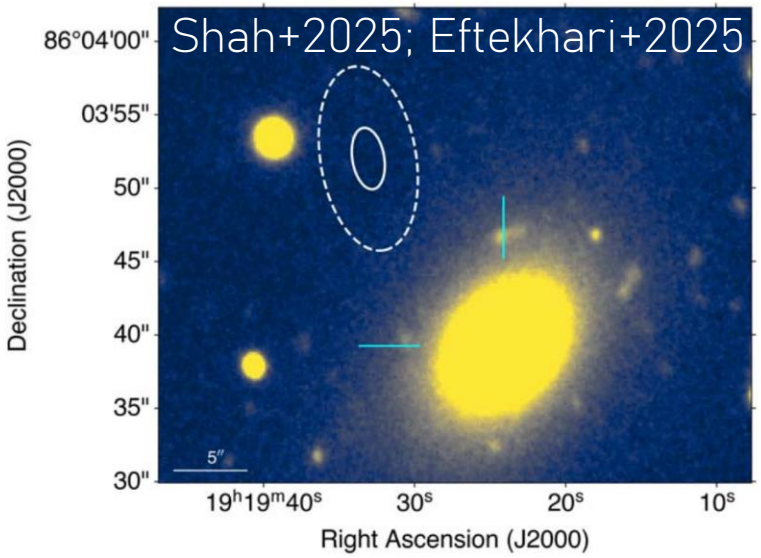
As opposed to >40 h on AAT+Keck

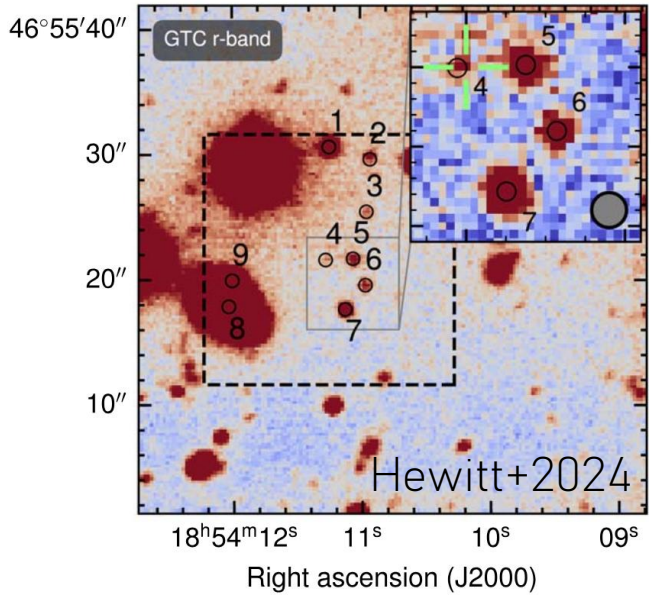


Queue mode observing is the default. Further gains in efficiency.

Targeted follow-up of subsamples

- Define target criteria for accomplishing a science goal.
- Select 10-100 sources at a time for spectroscopic follow-up.
- Examples:
  - **“Unseen” dwarf population**: Must be in the Rubin/Euclid footprint without well-associated host. DM < 500 to select dwarfs?

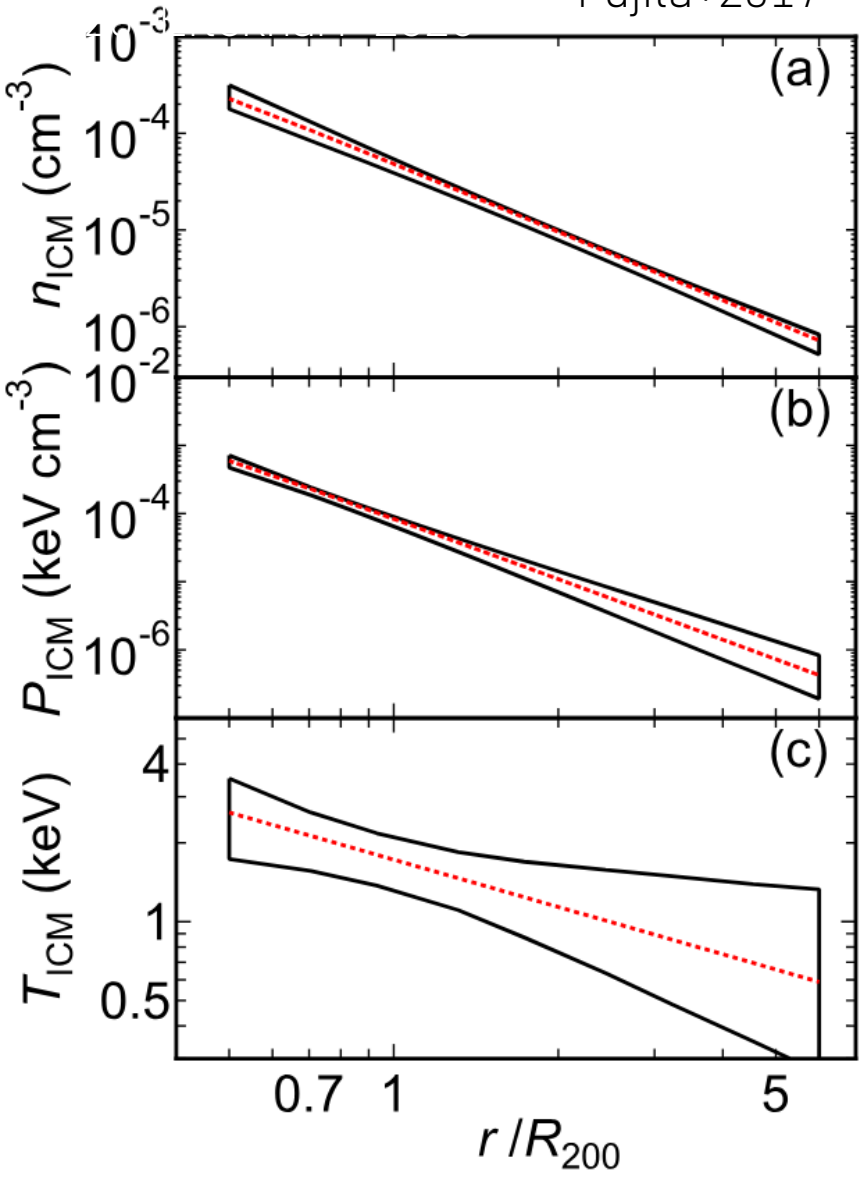




Targeted follow-up of subsamples

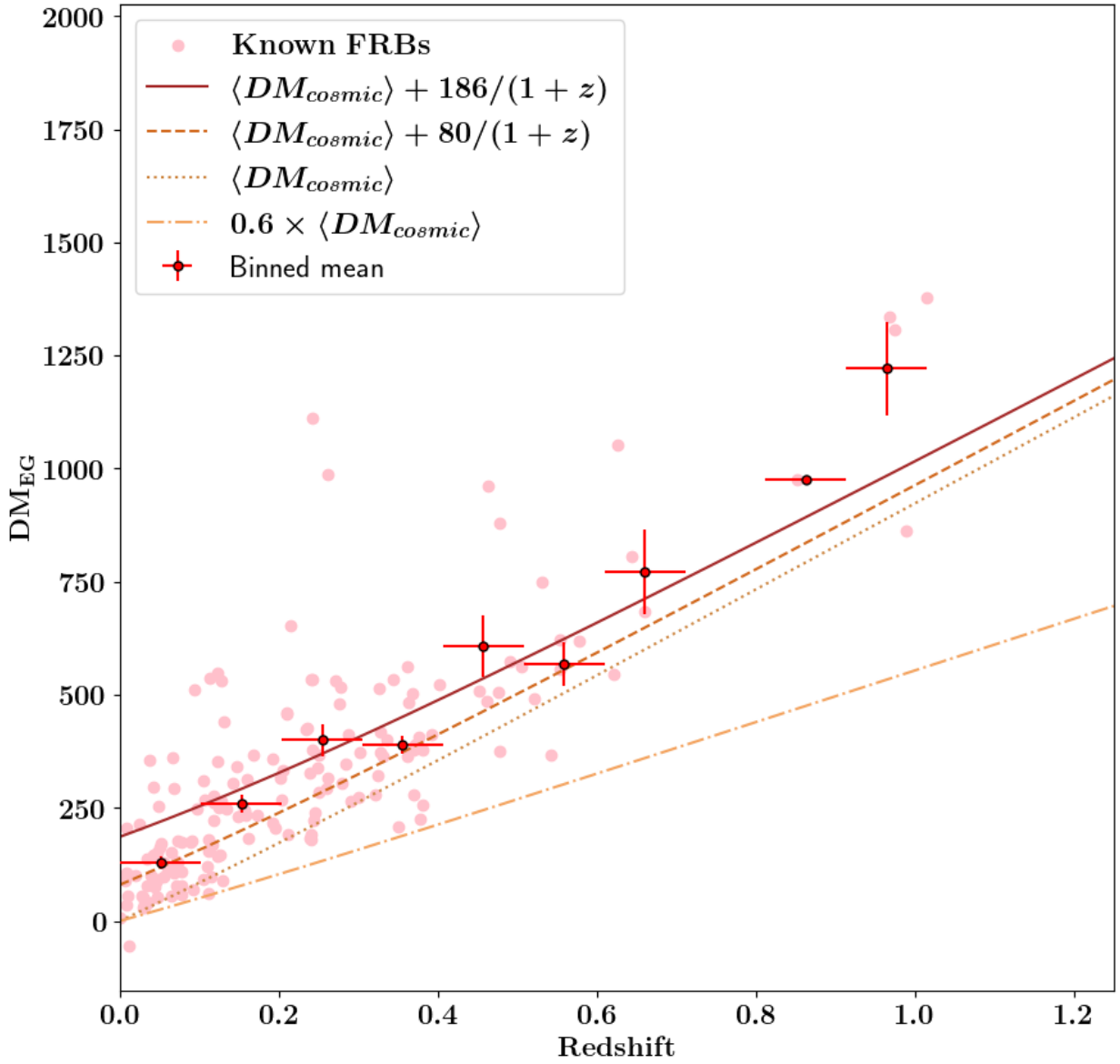
- Define target criteria for accomplishing a science goal.
- Select 10-100 sources at a time for spectroscopic follow-up.
- Examples:
  - **Map cluster gas with FRB DM**: Within 1 r_{vir} of the same cluster (say, Virgo). Well-associated host with photo-z < 0.2.

Fujita+2017



Targeted follow-up of subsamples

- Define target criteria for accomplishing a science goal.
- Select 10-100 sources at a time for spectroscopic follow-up.
- Examples:
  - **Polar unbiased sample:** Utilize the higher density of targets in circumpolar regions to request dedicated PFS pointings. E.g. Get $DM_{host}(z)$ distribution.



For the community's consideration

- Crowd-sourcing FRB zs: Report a significant fraction of detected FRBs for optical follow-up.
  - DSA-2000 is planning on making all their FRBs public.
  - Could just be a sample of "typical/boring" FRBs. Report precise RA/Dec, DM. (other properties?)
- Collaboration with teams that have massive multiplexing capabilities
  - The DESI 2 upgrade will have 10k fibers to target high z sources.
  - Subaru PFS is already observing with 2k fibers to z ~ 0.6 easily.
  - ToO/Spare fiber program?
- Create infrastructure to share FRBs and optical follow-up data.
  - FRB-hosts.org

Summary

- FRB host redshifts are challenging to obtain on a large scale but they enable interesting science.
- Photo-zs will be available for a large number of hosts but care must be taken in using them for analysis.
- Public surveys might yield redshifts for $z < 0.3$ hosts in the near future but only for a small fraction of hosts.
  - Rely on public surveys alone? Potential biases.
- Multiplexed fiber-fed spectrographs might help with efficient follow up of large host samples.
  - DESI II, 4MOST, PFS
- Targeted science strategies can create manageable subsamples for follow-up.
  - Only follow-up sources that fit your science goal.