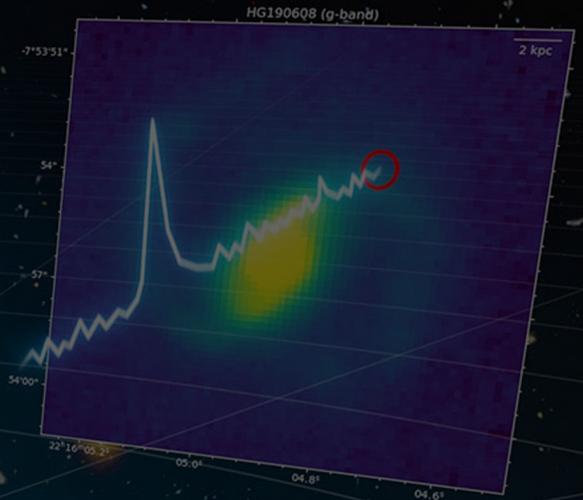
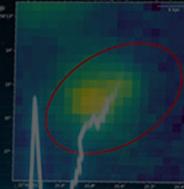
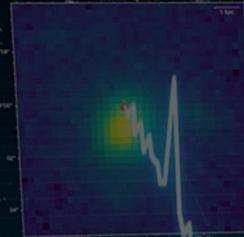
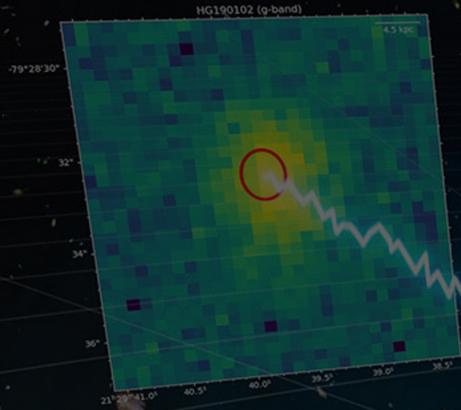


30 Jan 2026 @YITP LTWS 2026

Image Credit: S. Bhandari



The First Systematic Study of Metallicity in Fast Radio Burst Host Galaxies

Shotaro YAMASAKI (NCHU, Taiwan)

S. Y., T. Hashimoto, H. Kusakabe & T. Goto (2026), ApJL, 997, L6



Content

The background features a central globe of Earth with several satellite dishes pointing towards it. Surrounding the globe are four square panels, each displaying a different data visualization: a heatmap, a line graph with a peak, a heatmap with a red circle, and a heatmap with a line graph.

1. Introduction

2. Motivation

3. Data & Method

4. Result

5. Discussion

Content

The background features a central image of Earth from space, surrounded by several satellite dishes and four square panels displaying data plots. The plots show various patterns, including a central peak, a ring, and a complex shape, all set against a dark, starry space background.

1. Introduction

2. Motivation

3. Data & Method

4. Result

5. Discussion

Mysterious Fast Radio Bursts (FRBs)

(Lorimer+07; Thornton+12; Petroff+20)

Extragalactic
($z \gtrsim 0.1$)



Event Rate $\sim 0(10^3)/\text{day}$

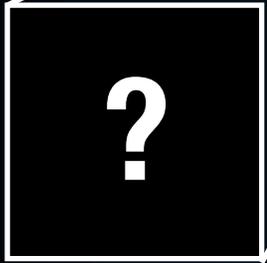
Duration $\sim \text{ms}$

Dispersion Measure:

$$DM = \int n_e dl$$

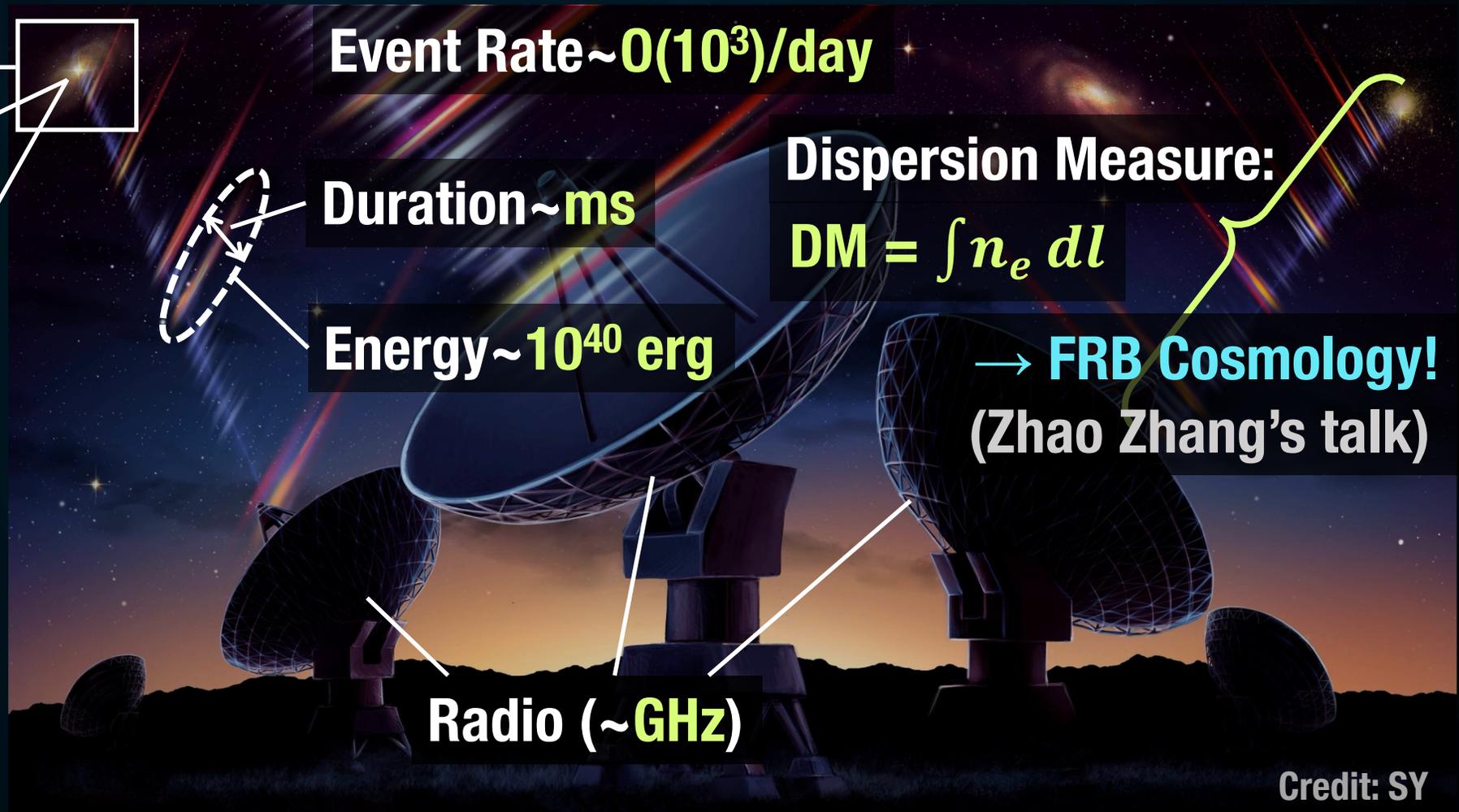
Energy $\sim 10^{40}$ erg

→ FRB Cosmology!
(Zhao Zhang's talk)



Origin(s)
unknown

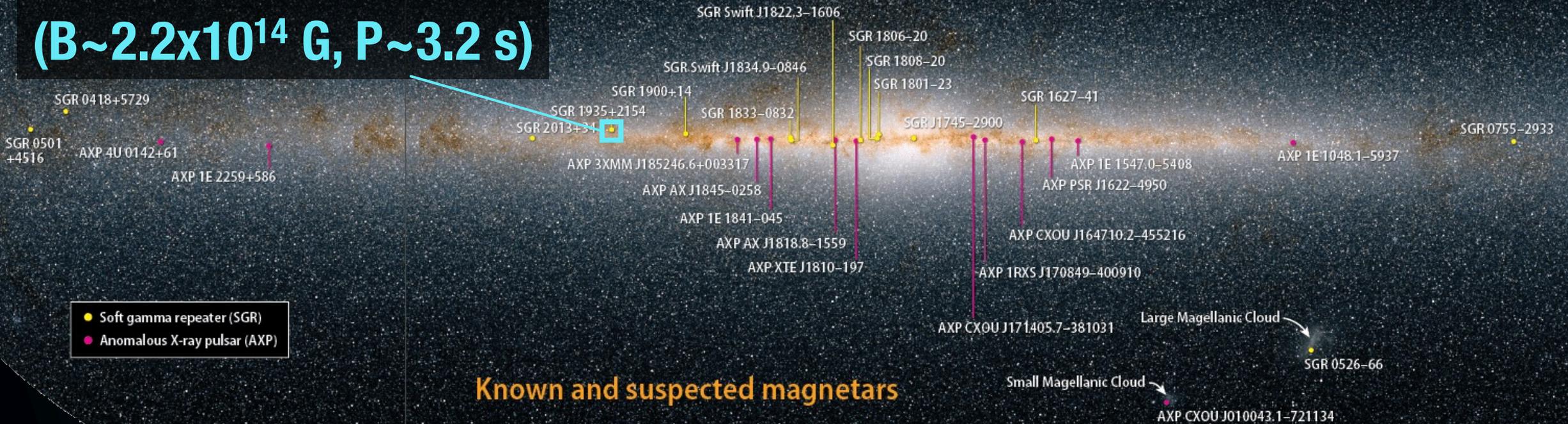
Radio ($\sim \text{GHz}$)



Origins? A Galactic FRB Event from Magnetar Bursts

(Bochenek+20, CHIME/FRB+20, Mereghetti+20, Li+20, Ridnaia+20, Tavani+20)

SGR 1935+2154
($B \sim 2.2 \times 10^{14}$ G, $P \sim 3.2$ s)



Known and suspected magnetars

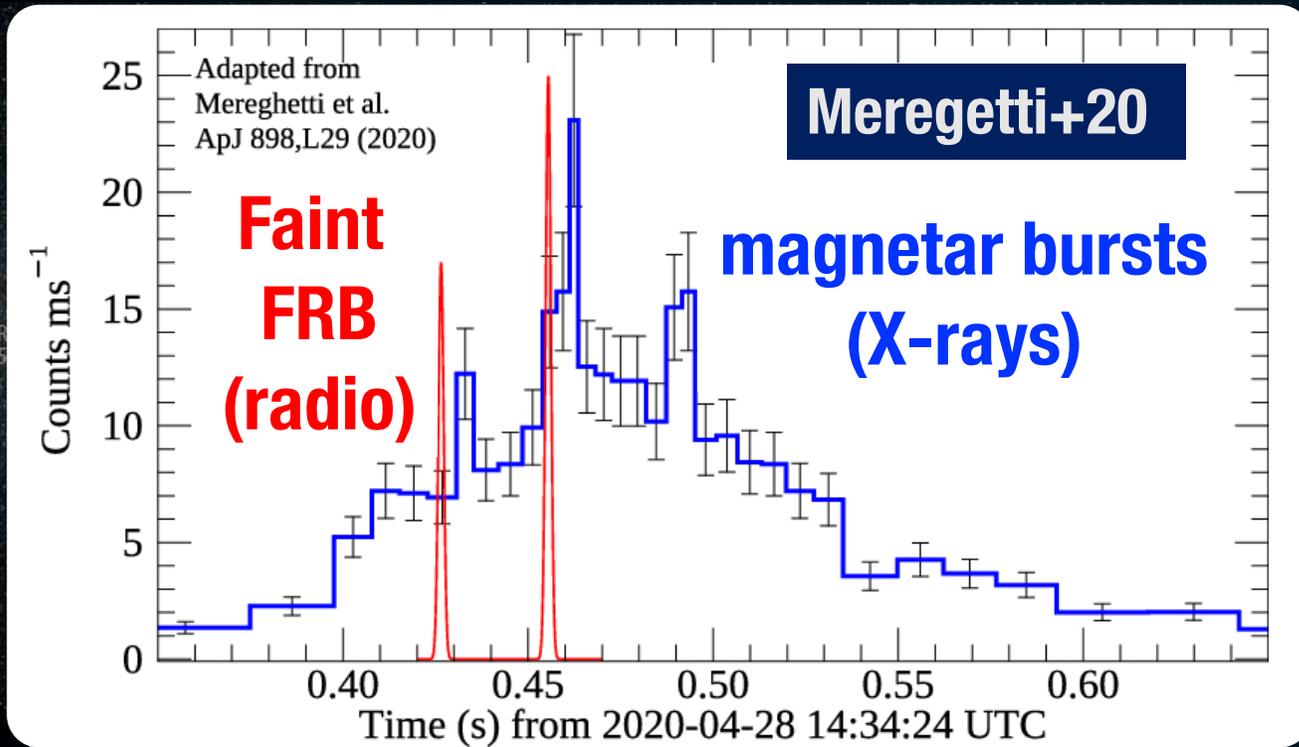
MOST MAGNETAR CANDIDATES lie in the Milky Way's disk along the galactic plane, where the most massive stars now reside. Two other known magnetars are extragalactic, with one in the Large Magellanic Cloud (LMC) and the other in the Small Magellanic Cloud (SMC).

Astronomy: Roen Kelly, Background: 2MASS/J. Carpenter, M. Skrutskie, R. Hurt

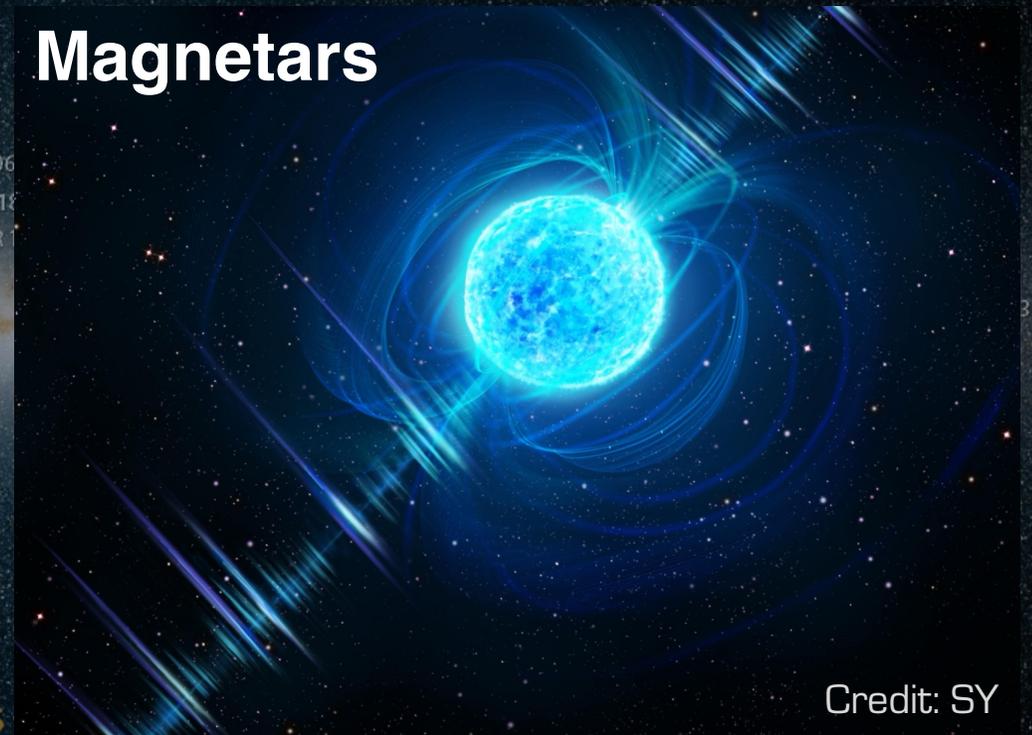
Credit: Astronomy: Roen Kelly, Background: 2MASS/J. Carpenter, M. Skrutskie, R. Hurt

Origins? A Galactic FRB Event from Magnetar Bursts

(Bochenek+20, CHIME/FRB+20, Mereghetti+20, Li+20, Ridnaia+20, Tavani+20)



Magnetars



AXP CXOU J010043.1-721134

MOST MAGNETAR CANDIDATES lie in the Milky Way's disk along the galactic plane, where the most massive stars now reside. Two other...

Magnetar-FRB connection important

Bochenek, Kelly, Background:
Li, M. Skrutskie, R. Hurt

Mysterious Fast Radio Bursts (FRBs)

(Lorimer+07; Thornton+12; Petroff+20)

Extragalactic
($z \gtrsim 0.1$)



Origin(s)
unknown
(magnetars?)

Event Rate $\sim 0(10^3)/\text{day}$

Duration $\sim \text{ms}$

Energy $\sim 10^{40}$ erg

Dispersion Measure:

$$DM = \int n_e dl$$

→ FRB Cosmology!

Radio ($\sim \text{GHz}$)

Mysterious Fast Radio Bursts (FRBs)

(Lorimer+07; Thornton+12; Petroff+20)



>100 host galaxies
(---> **Metallicity**)



**Origin(s)
unknown
(magnetars?)**



Content

The background features a central image of Earth with several satellite dishes pointing towards it. Surrounding the Earth are four square panels, each containing a different data visualization: a 2D heatmap, a 1D line plot, a 2D heatmap with a red circle, and a 2D heatmap with a white line and a red circle. The entire scene is set against a dark, starry space background.

1. Introduction

2. Motivation

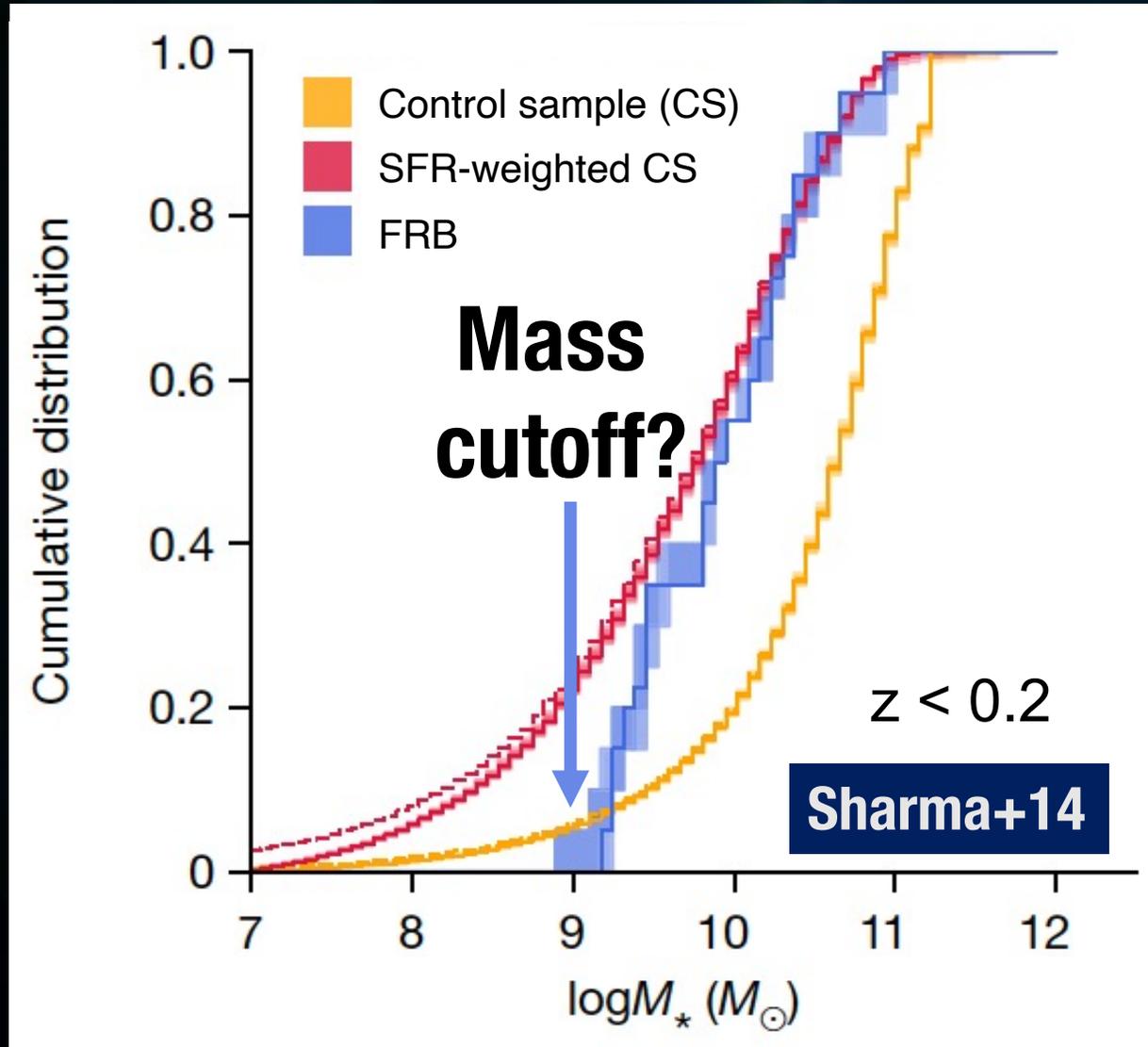
3. Data & Method

4. Result

5. Discussion

FRB Host Galaxies: Lower Cutoff Mass?

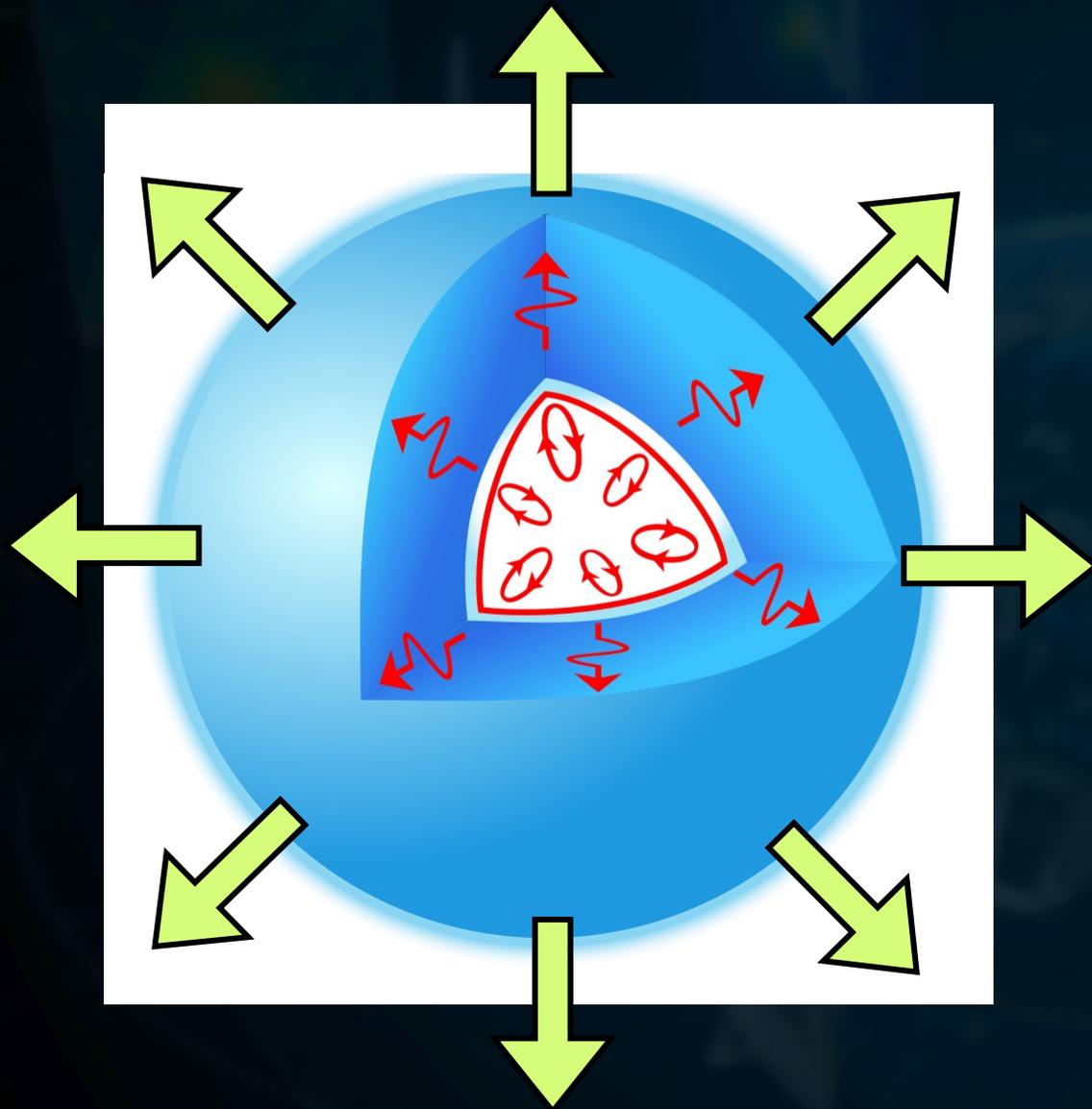
2



- Sharma+24 reported a potential **lower cutoff in stellar mass $\sim 10^9 M_{\text{sun}}$**
- However, their control sample is incomplete
- If true, **a similar lower cutoff might exist in metallicity** (= no high-z FRBs?)

Why Metallicity?

3



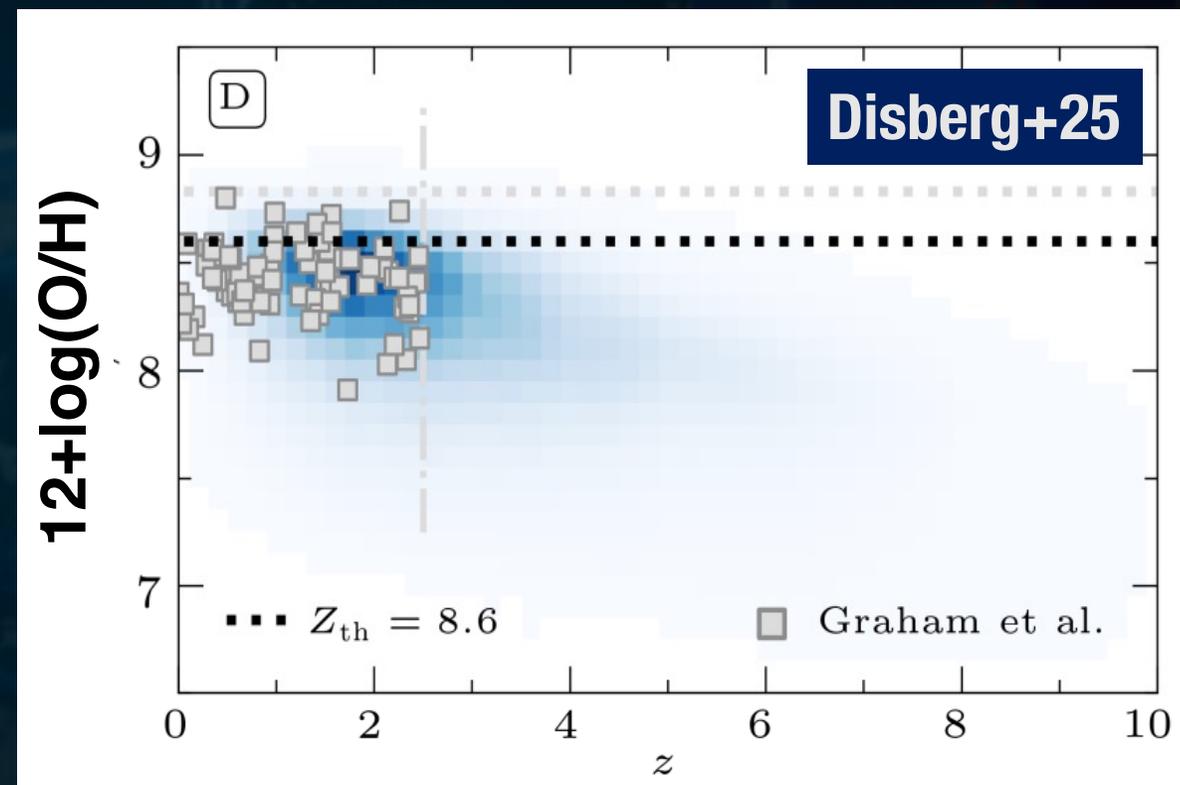
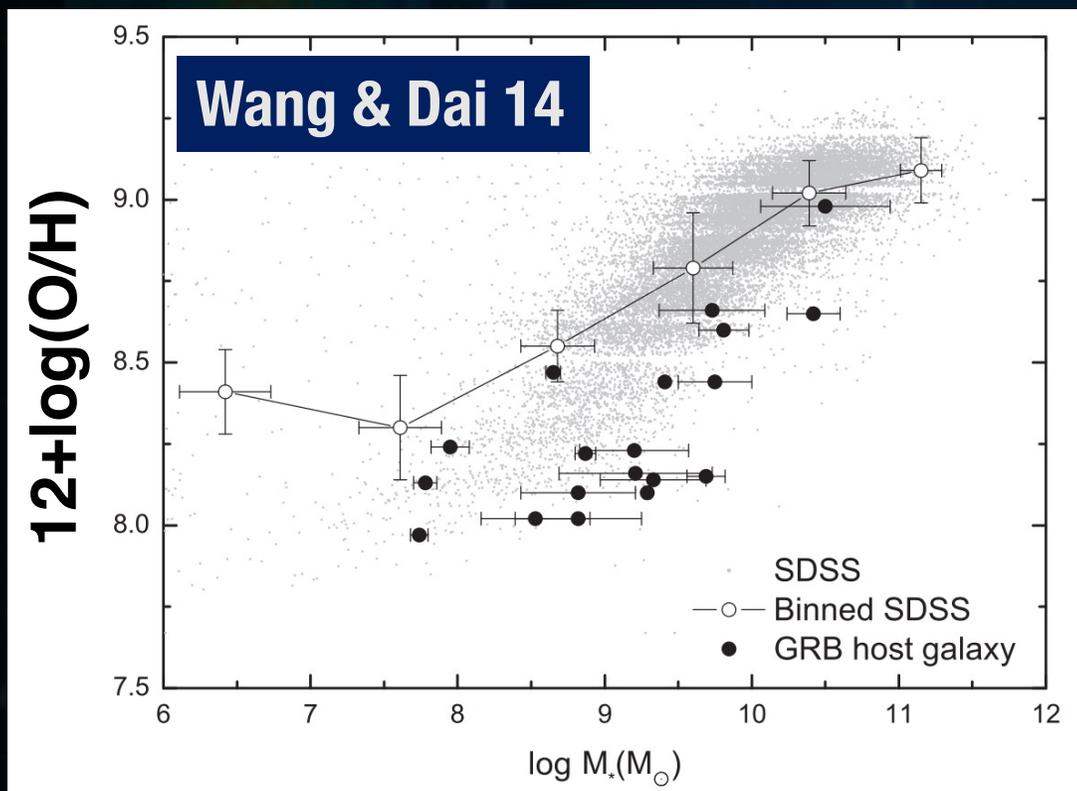
$$\dot{M}_{\text{wind}} \propto Z^{0.7} \quad (\text{Vink+01})$$

- **Metallicity (Z)** regulates stellar mass loss and compact object formation
- **FRB host metallicities**
→ **direct clues to their progenitors**

Long Gamma-Ray Burst Host Metallicity

4

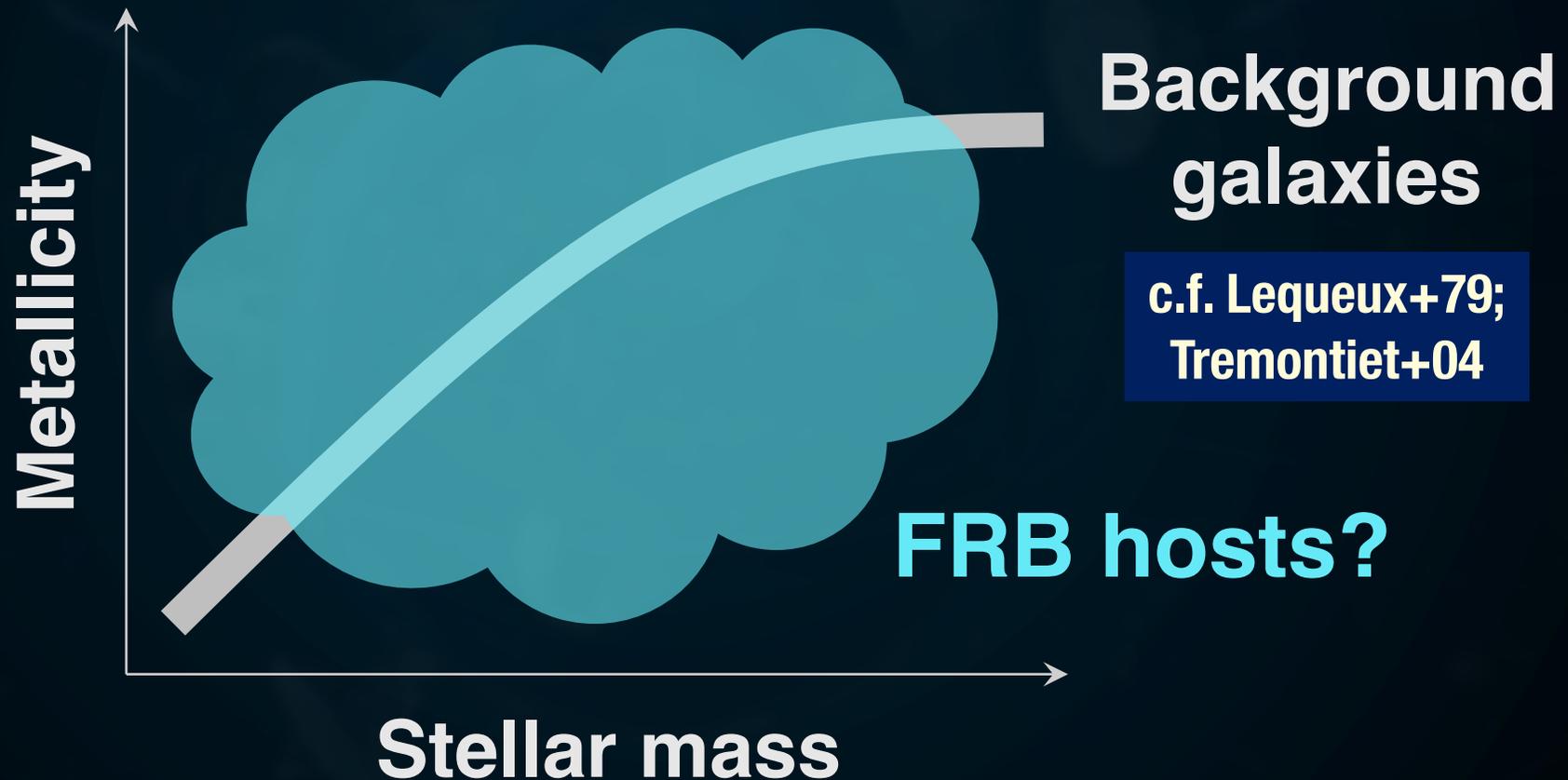
c.f. Stanek+06; Wolf & Podsiadlowski 07; Kocevski+09; Vergani+15; Perley+16; Niino+17



Lower metallicity below $12+\log(\text{O}/\text{H})_{\text{cut}} = 8.3-8.9$; broadly consistent with stellar evolution models (Yoon & Langer 05; Woosley & Heger 06)

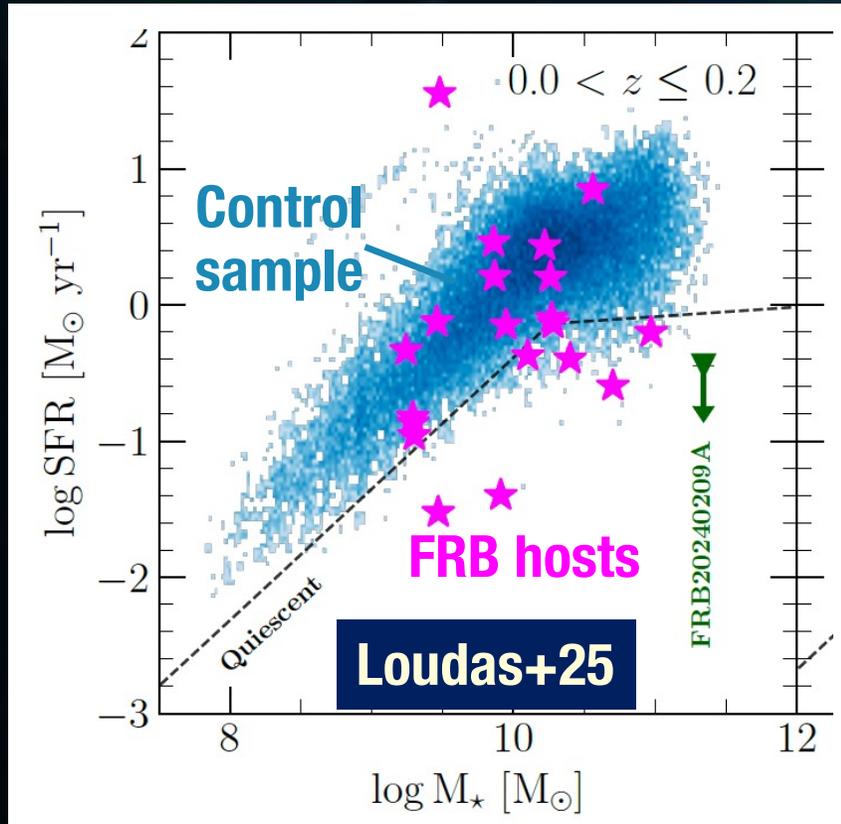
Key Question

Do FRBs prefer specific metallicity environments?



Beyond Mass & SFR: Toward Fair Comparison

6



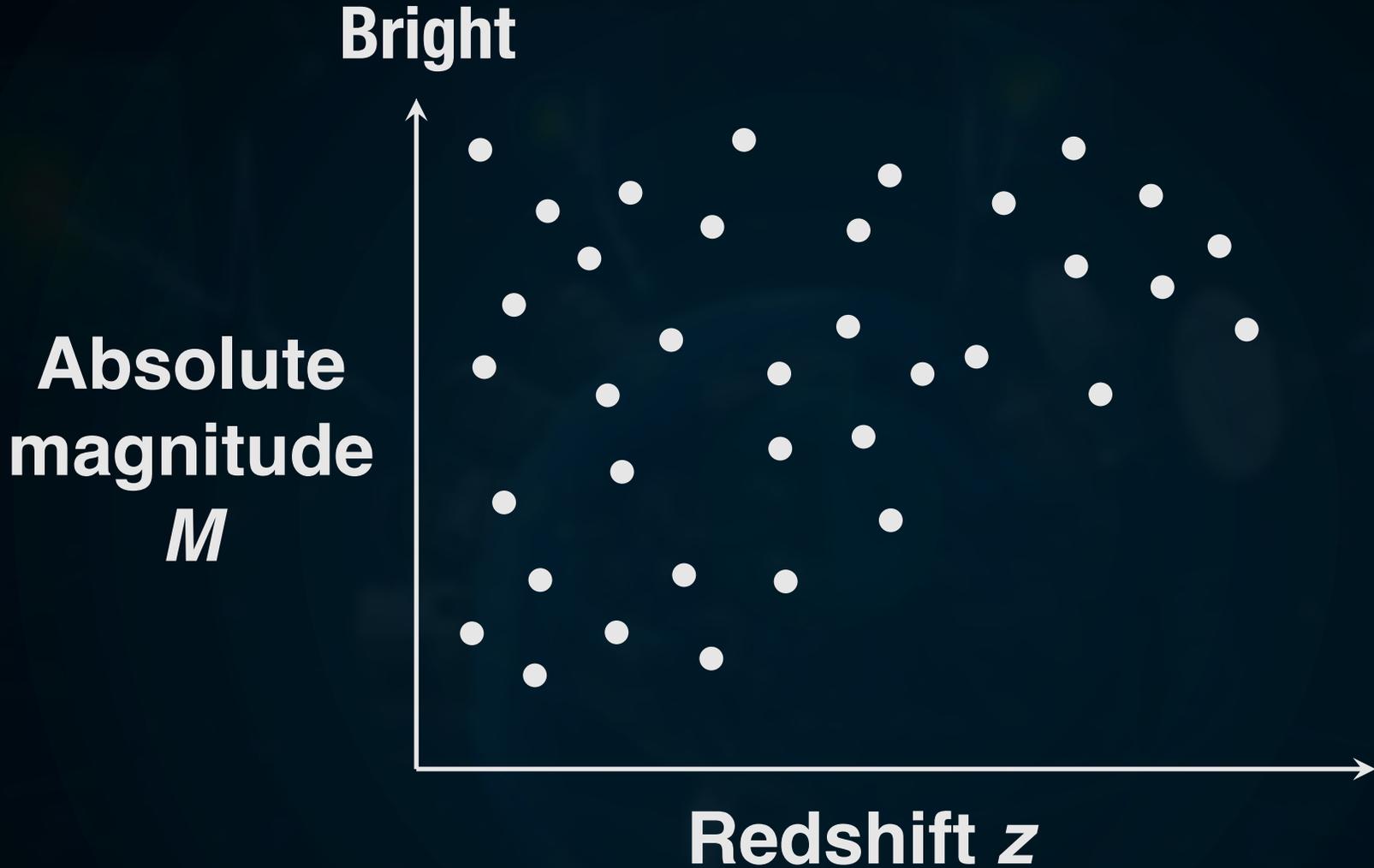
c.f. Gordon+23; Sharma+24; Horowitz & Margalit 25

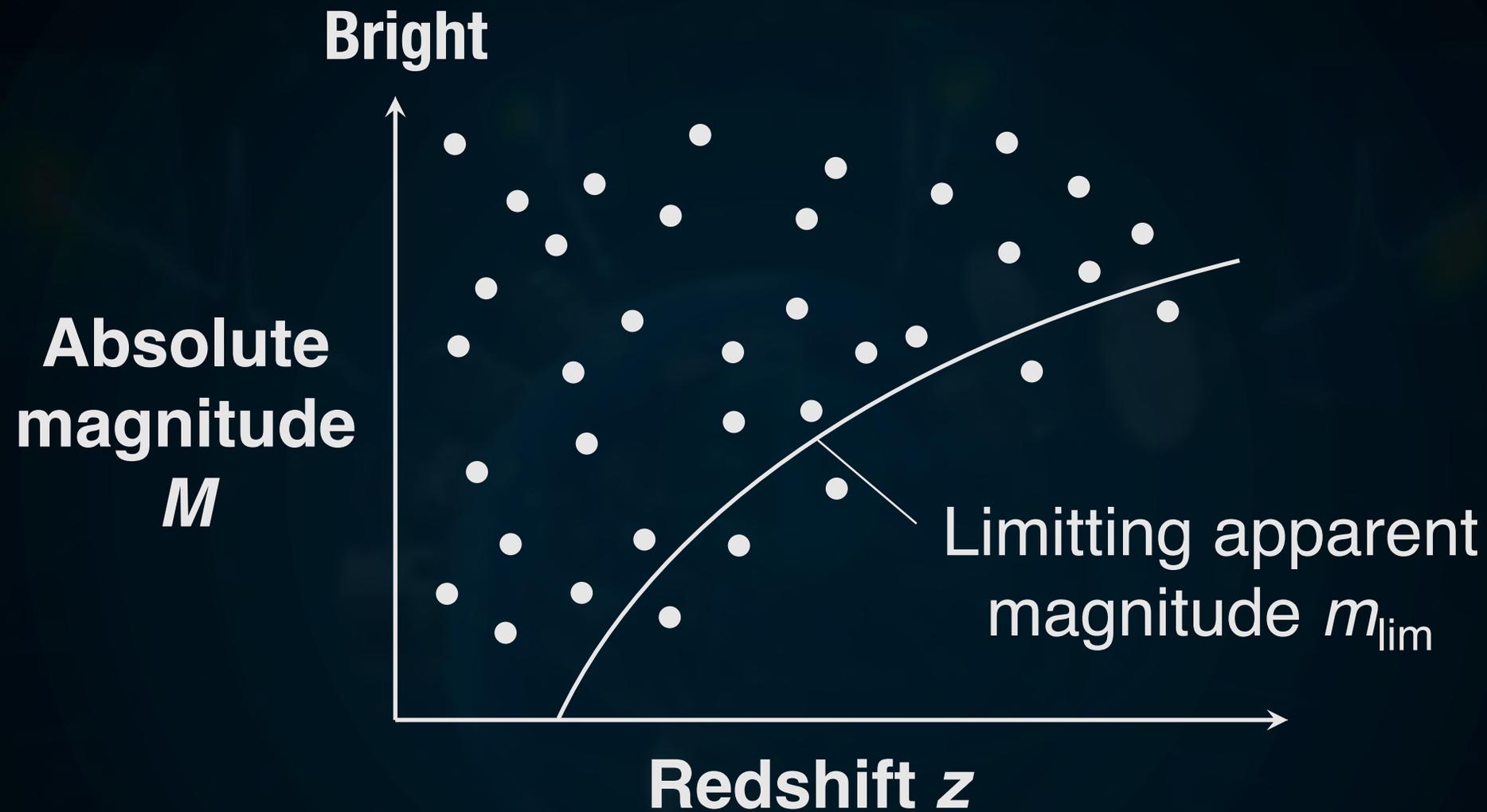
1. Missing a key physical parameter

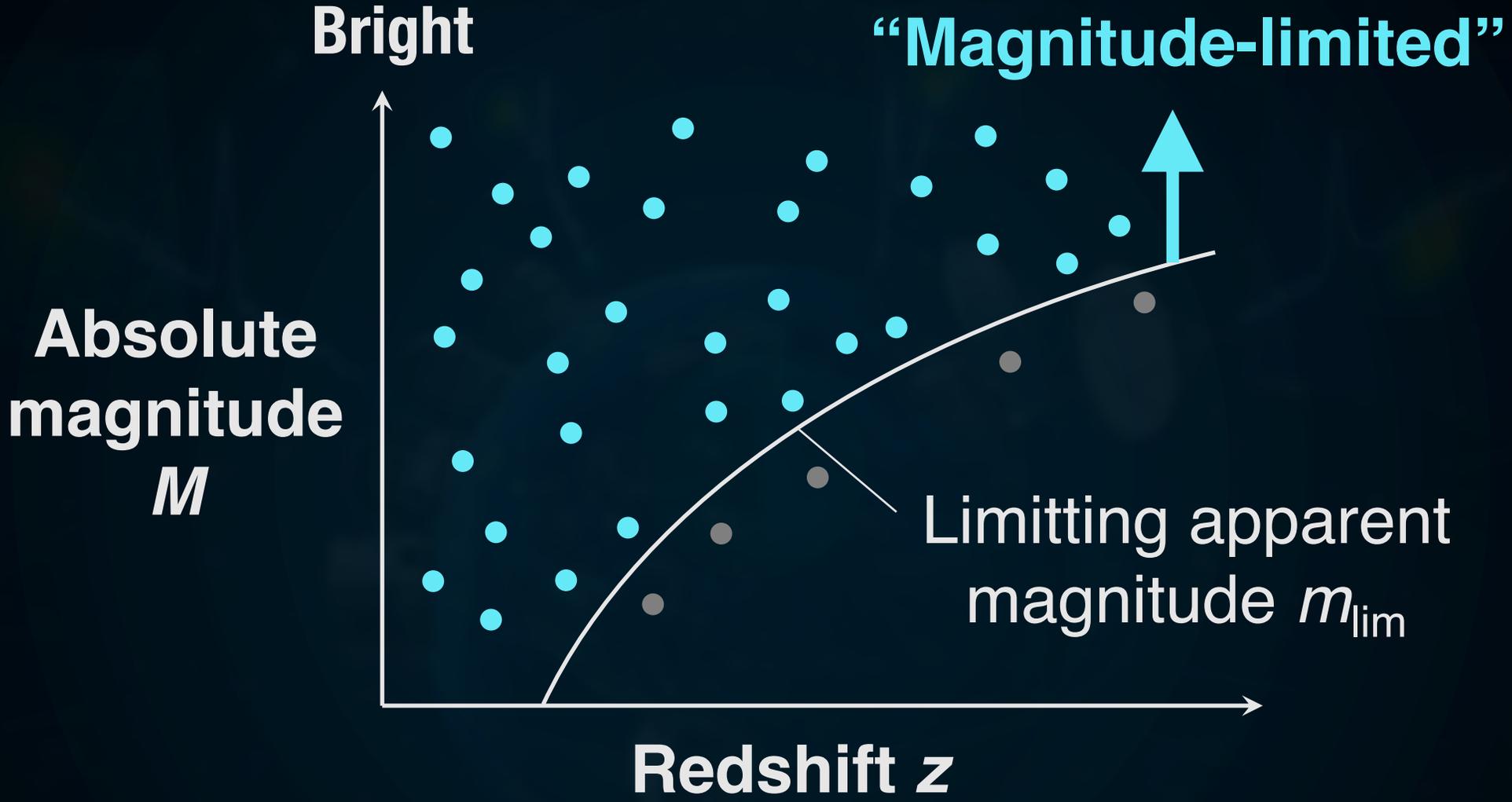
Mass/SFR are just proxies

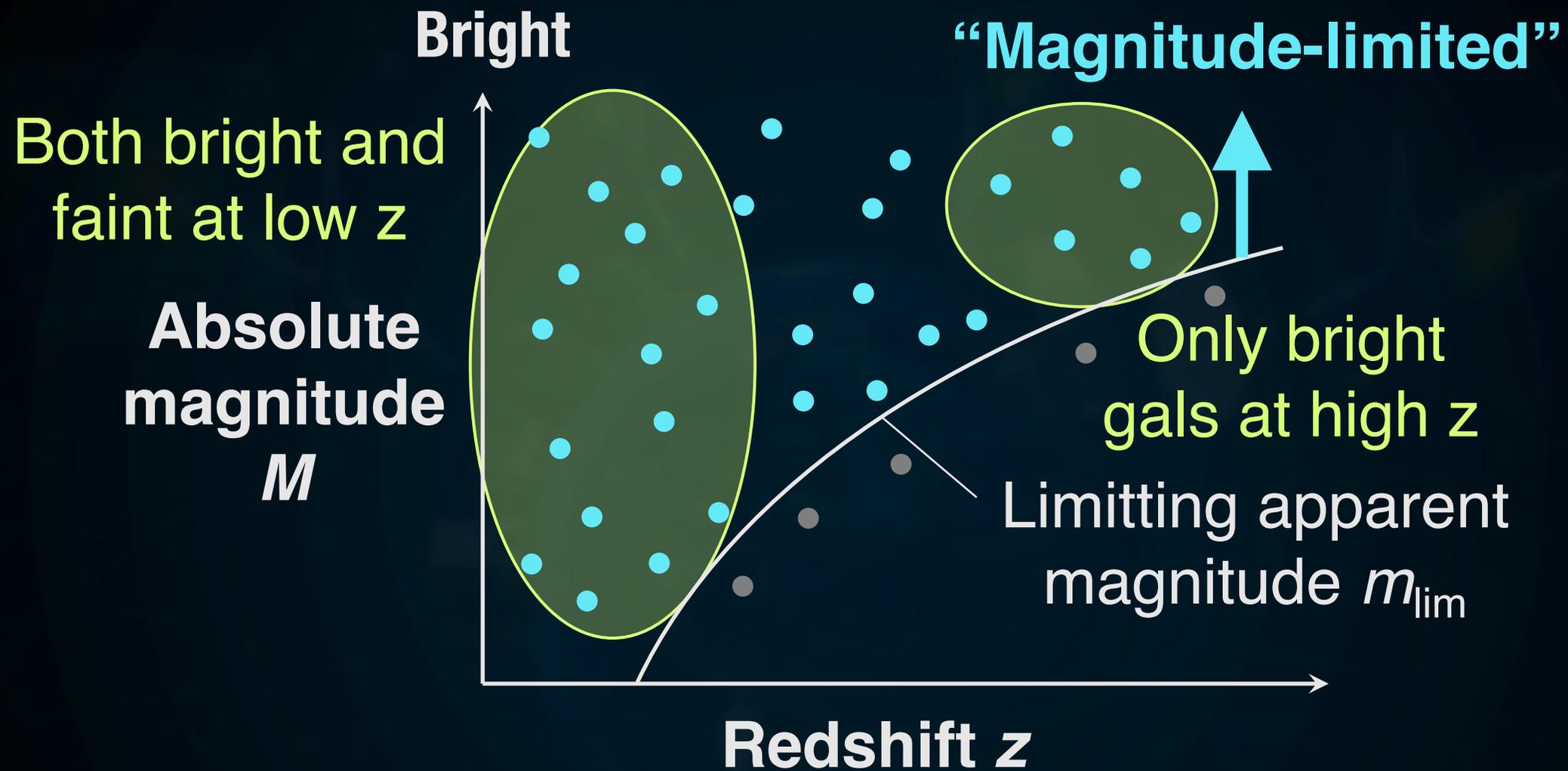
2. Incomplete control samples

Magnitude-limited samples can make comparison ambiguous





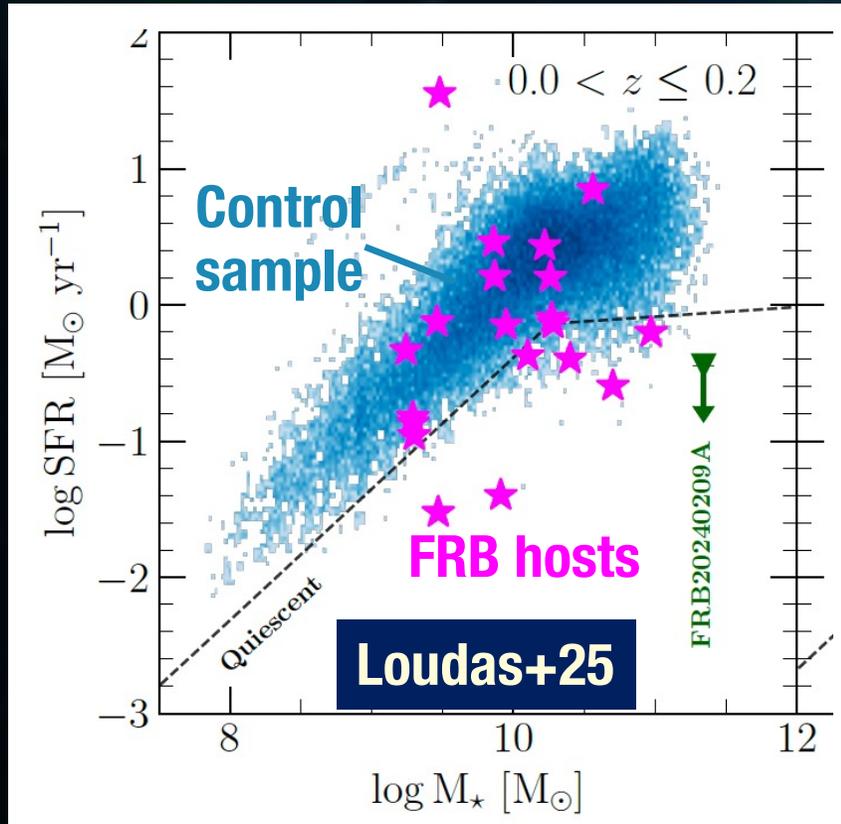




“Malmquist bias”
→ Artificial z -dependence in selected sample

Beyond Mass & SFR: Toward Fair Comparison

8



c.f. Gordon+23; Sharma+24; Horowitz & Margalit 25

1. Missing a key physical parameter

Mass/SFR are just proxies

2. Incomplete control samples

Magnitude-limited samples can make comparison ambiguous

To constrain FRB progenitors, we must move
beyond mass & SFR with a properly controlled sample

Content

The background features a central image of Earth with several satellite dishes pointing towards it. Surrounding the Earth are four square panels, each containing a different data visualization: a 2D heatmap, a 1D line plot with a peak, a 2D heatmap with a red circle, and a 1D line plot with a peak and a red circle. The entire scene is set against a dark, starry space background.

1. Introduction

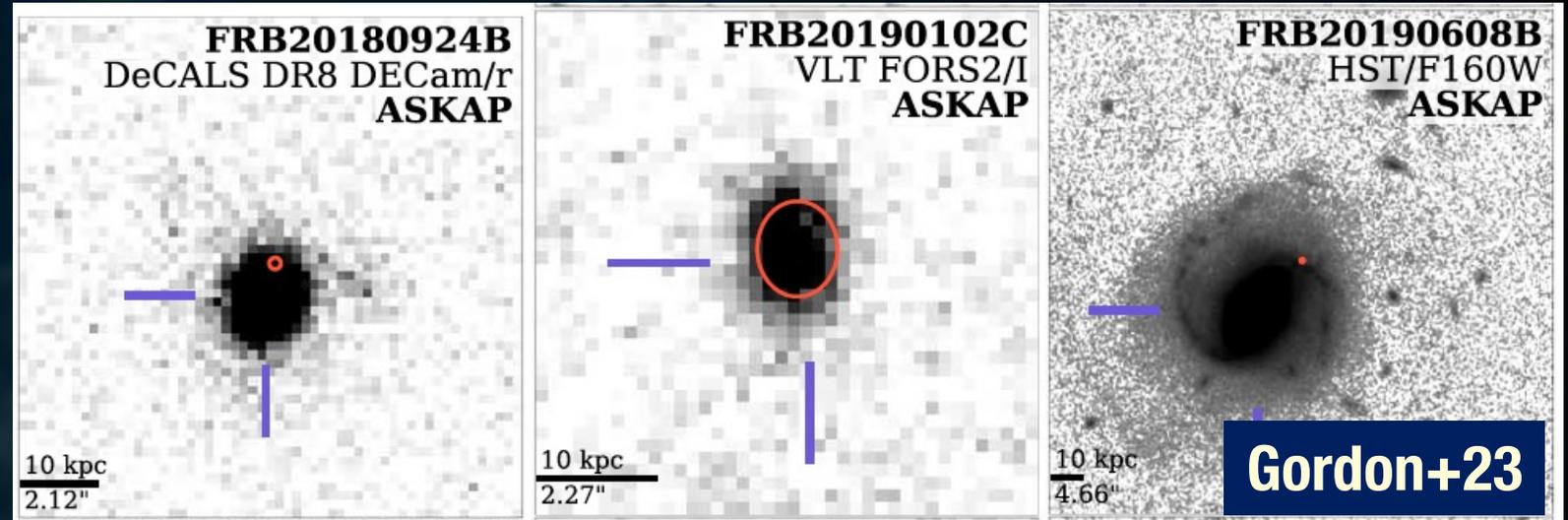
2. Motivation

3. Data & Method

4. Result

5. Discussion

FRB Host Sample



- **49 localized FRB hosts @ $z = 0.04-0.98$** from ASKAP (Gordon+23; Eftekhari+23) & DSA-110 (Sharma+24), with 4-8 m optical spectroscopy
- Nebular emission lines ($H\alpha$, $H\beta$, [OIII], [NII]) **for uniform metallicity measurements**

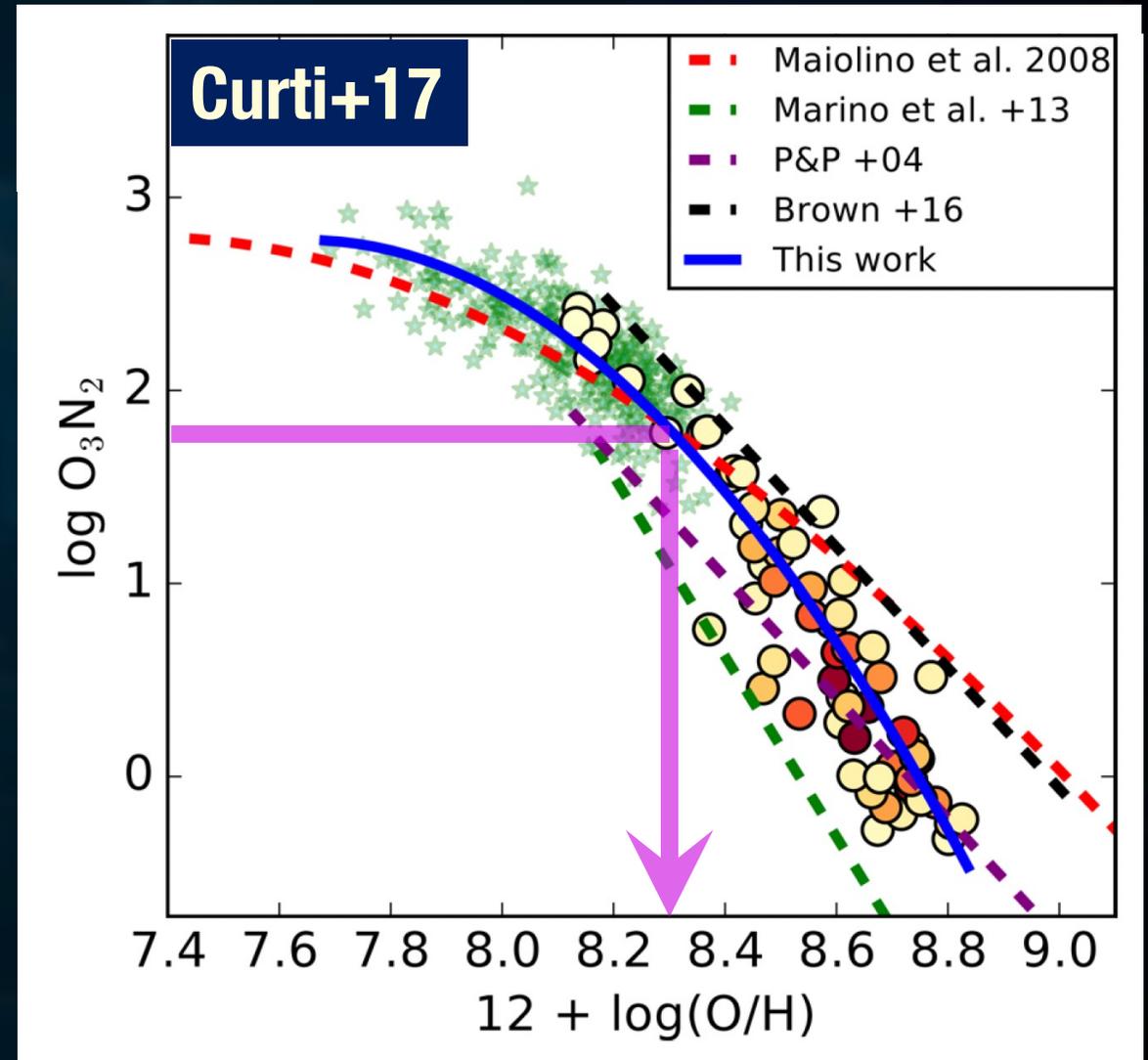
Method: Metallicity Measurements

10

- A strong optical line diagnostics with **O3N2 index** (Pettini & Pagel 2004)

$$\text{O3N2} = \frac{[\text{OIII}]\lambda 5007 / \text{H}\beta}{[\text{NII}]\lambda 6584 / \text{H}\alpha}$$

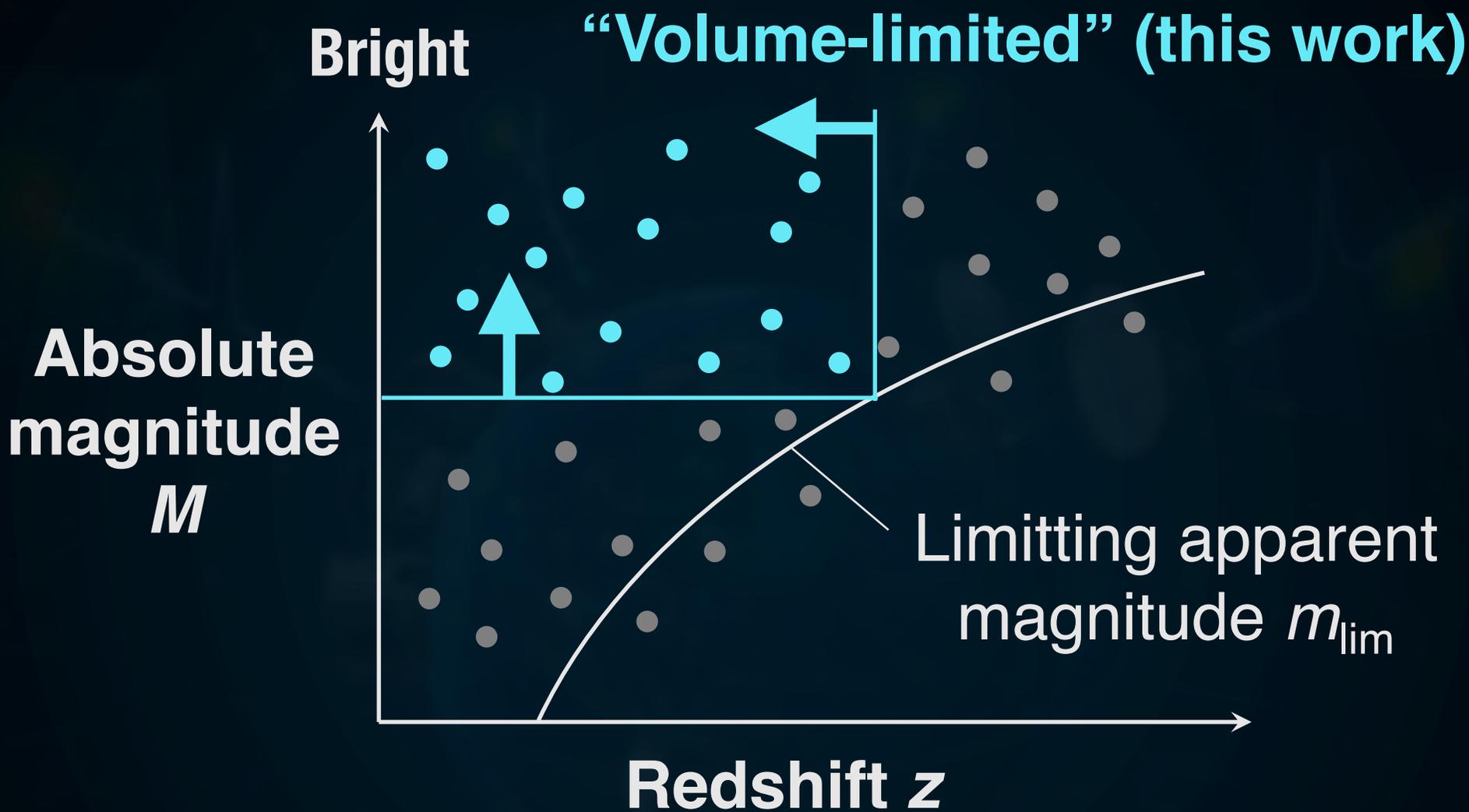
- Calibration by Curti+17 applicable at $12 + \log(\text{O}/\text{H}) = 7.76 - 8.85$ (intrinsic scatter 0.09 dex)



Sample Selection for Fair Comparison

11

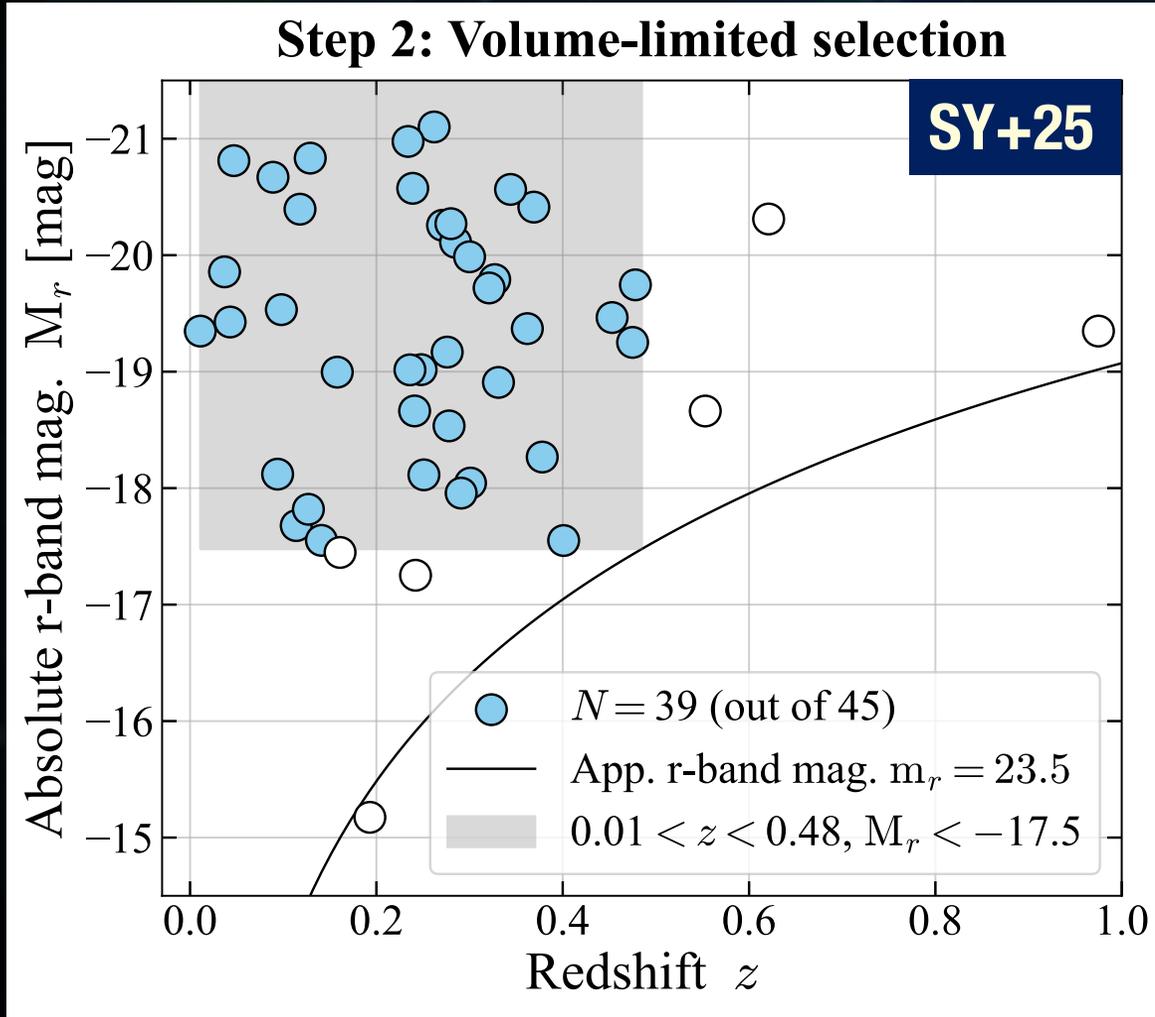
- Define a volume-limited FRB host sample



Uniform comparison across different z

Sample Selection for Fair Comparison

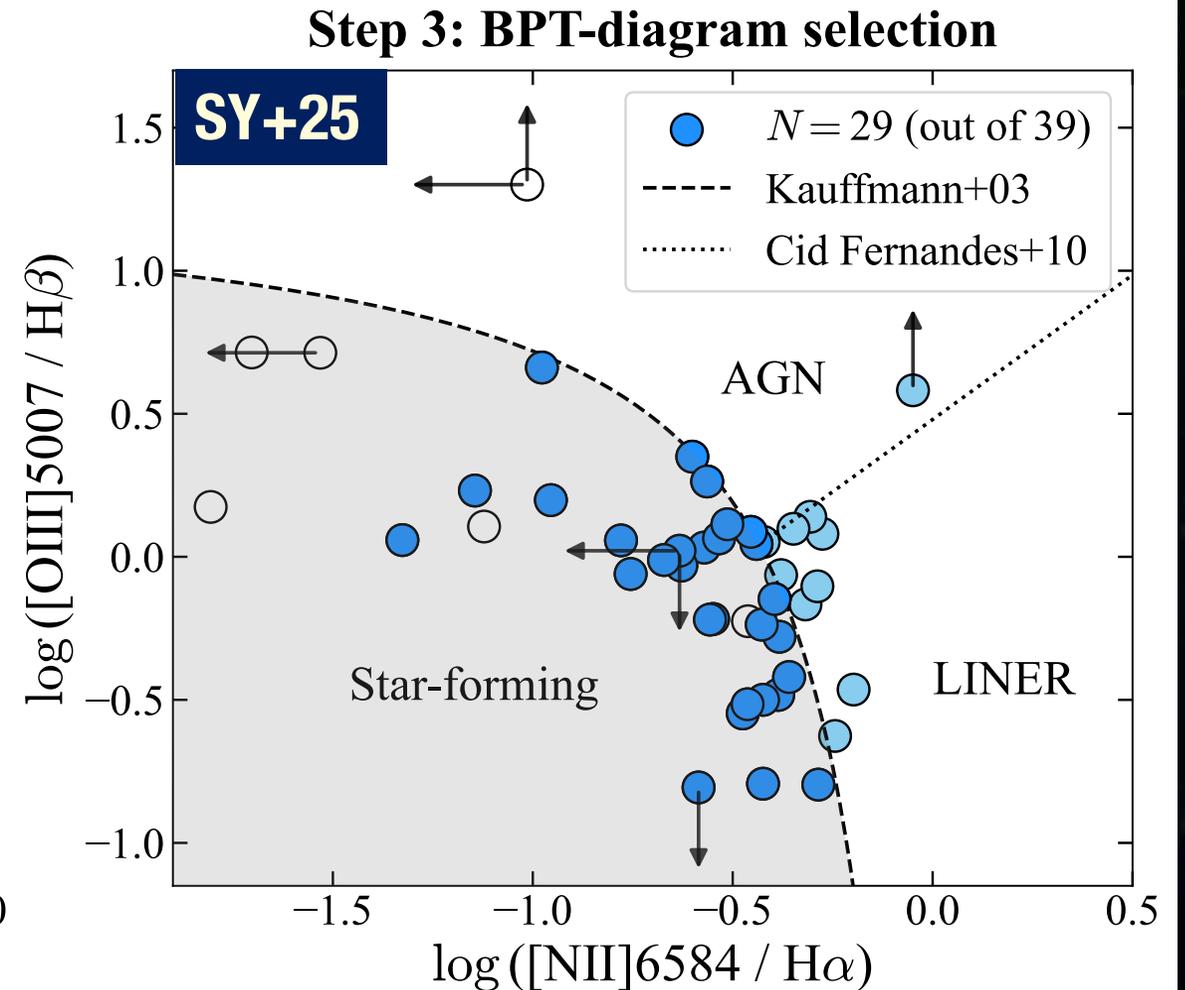
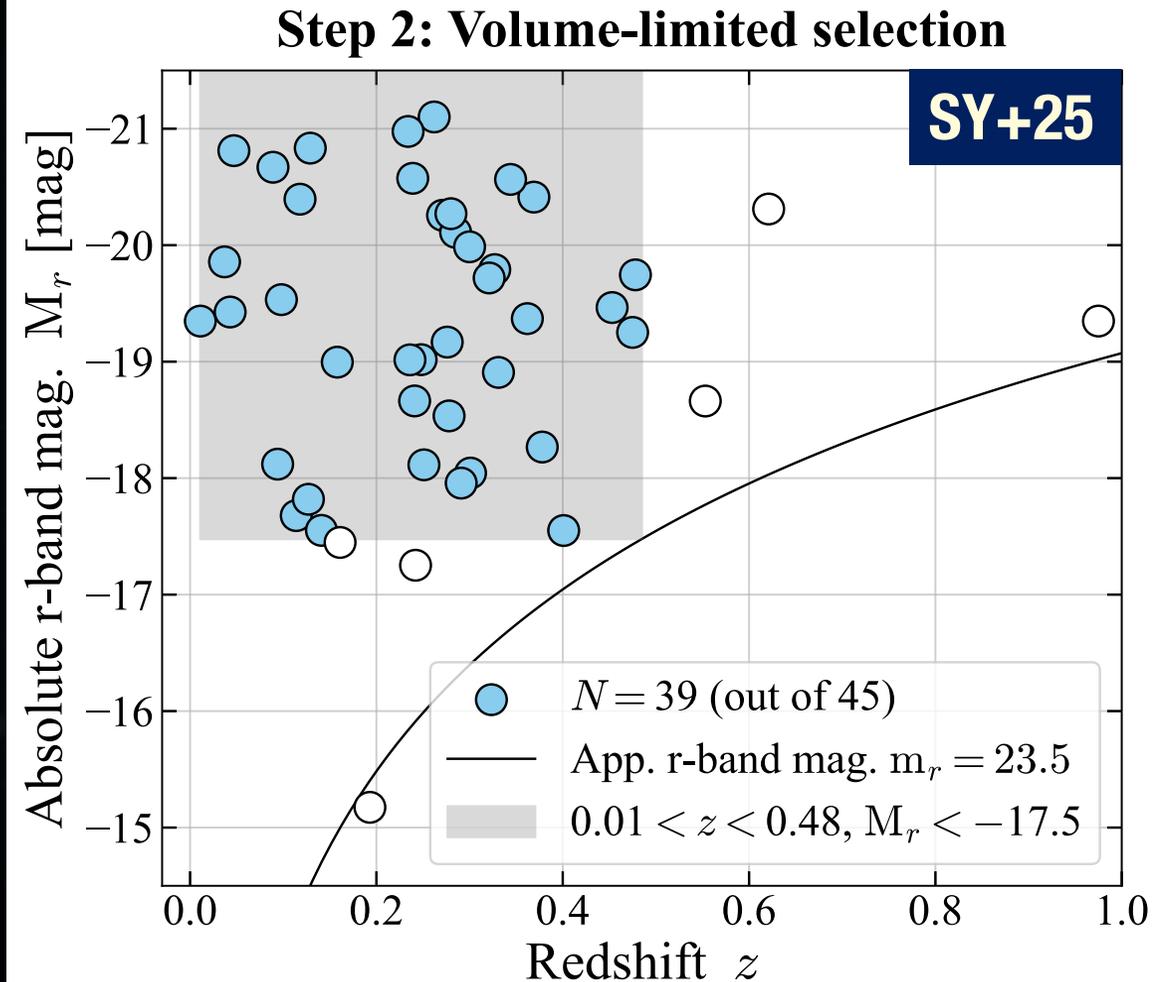
11



- Define a volume-limited FRB host sample
- Build a **control galaxy sample** w/ GALFRB code (Loudas+25) under the same volume-limit criteria
- Compare stellar mass (M_*), star formation rate (**SFR**) & metallicity: **$12+\log(\text{O}/\text{H})$**

Sample Selection for Fair Comparison

11



Content

The background features a central image of Earth with several satellite dishes pointing towards it. Surrounding the Earth are four square panels, each containing a different data visualization: a heatmap with a white line, a heatmap with a red circle, a heatmap with a white line, and a heatmap with a white line and a red circle. The entire scene is set against a dark, starry space background.

1. Introduction

2. Motivation

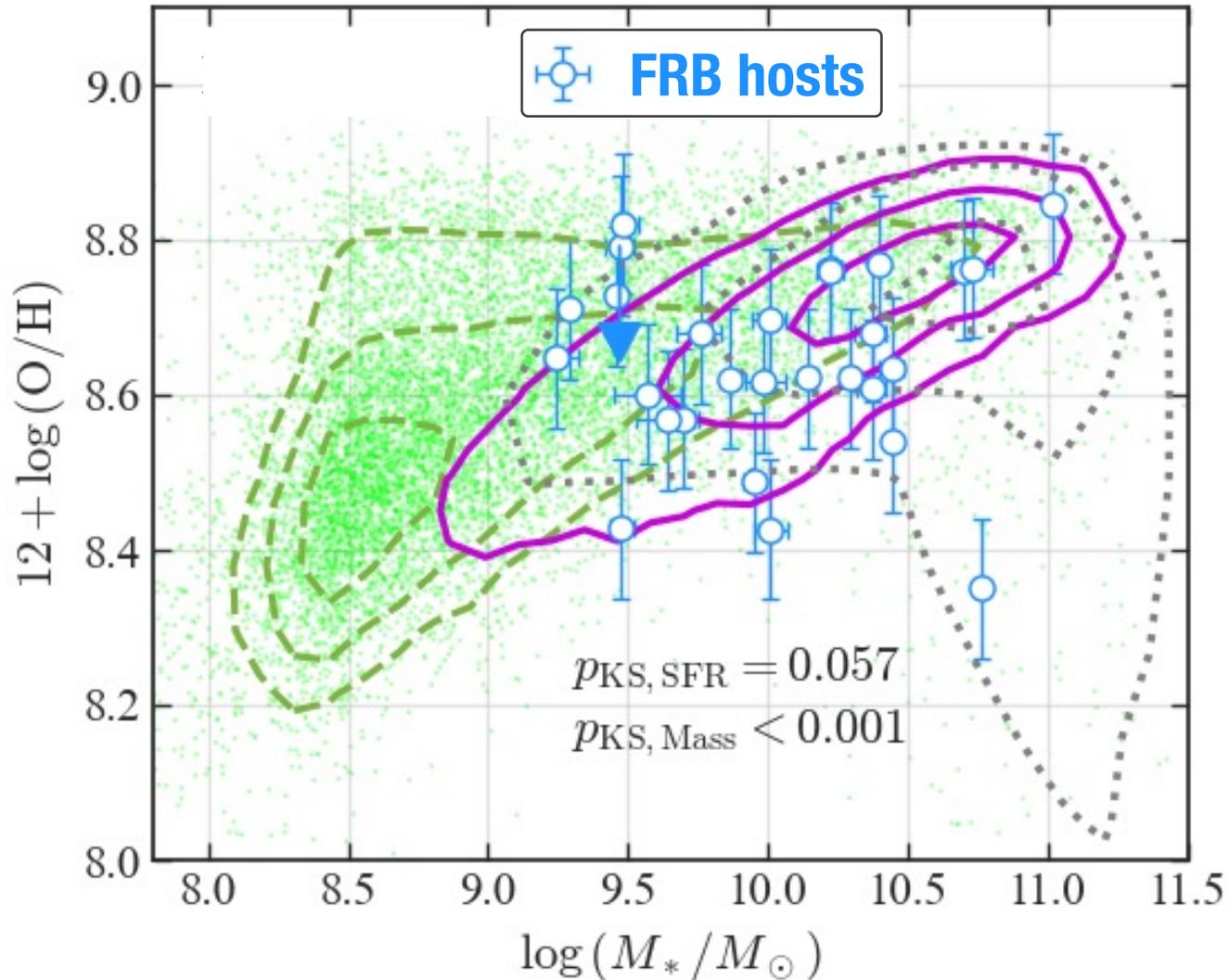
3. Data & Method

4. Result

5. Discussion

2D: Mass-Metallicity Relation

12



Modeled
galaxies

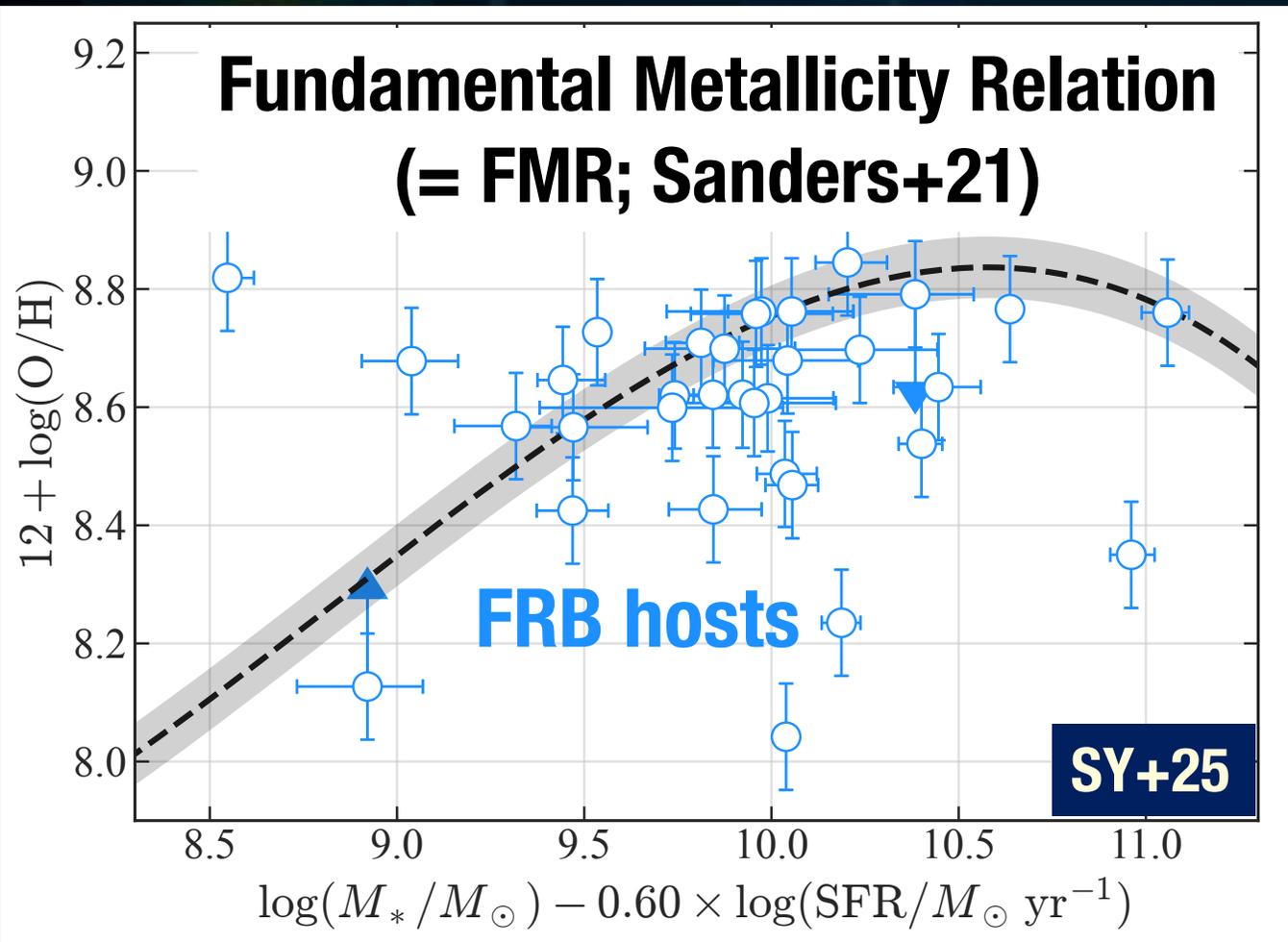
--- Unweighted
— SFR-weighted
..... Mass-weighted

**FRB hosts: consistent
with SFR-weighted
background galaxies**
(2D KS test, $p \approx 0.06$)

**No strong metallicity
preference!**

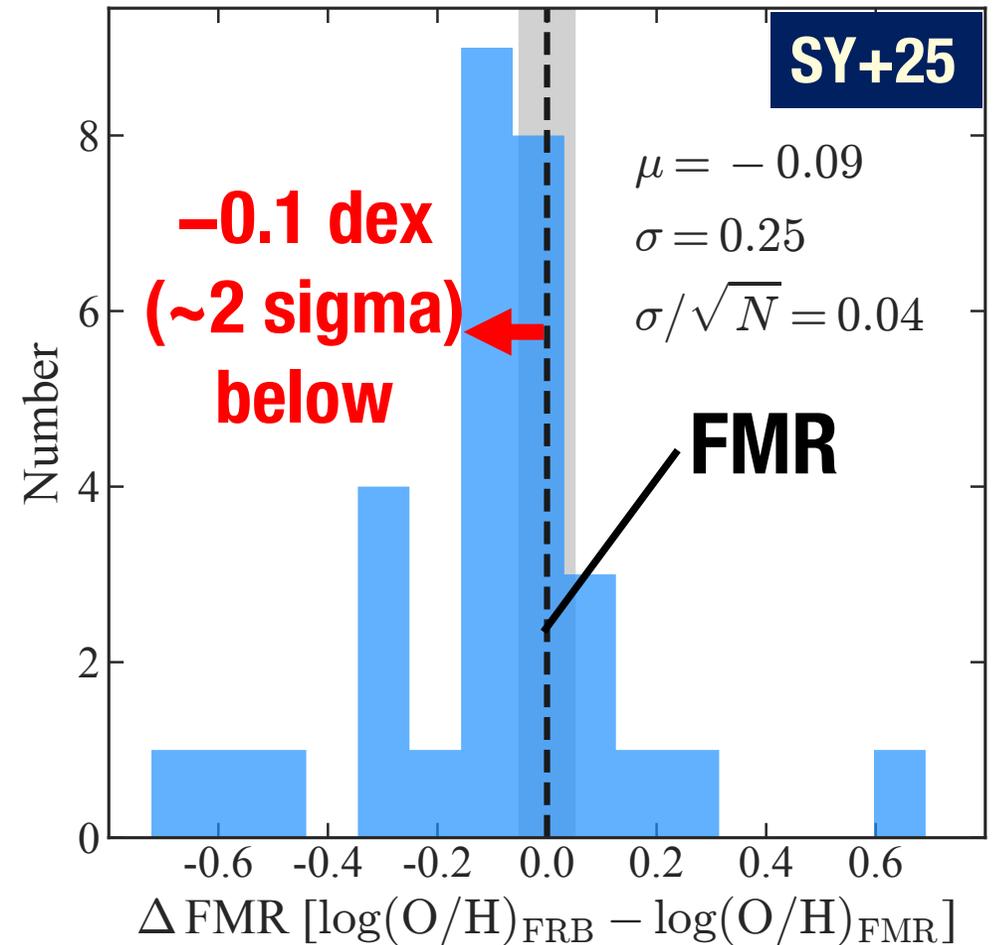
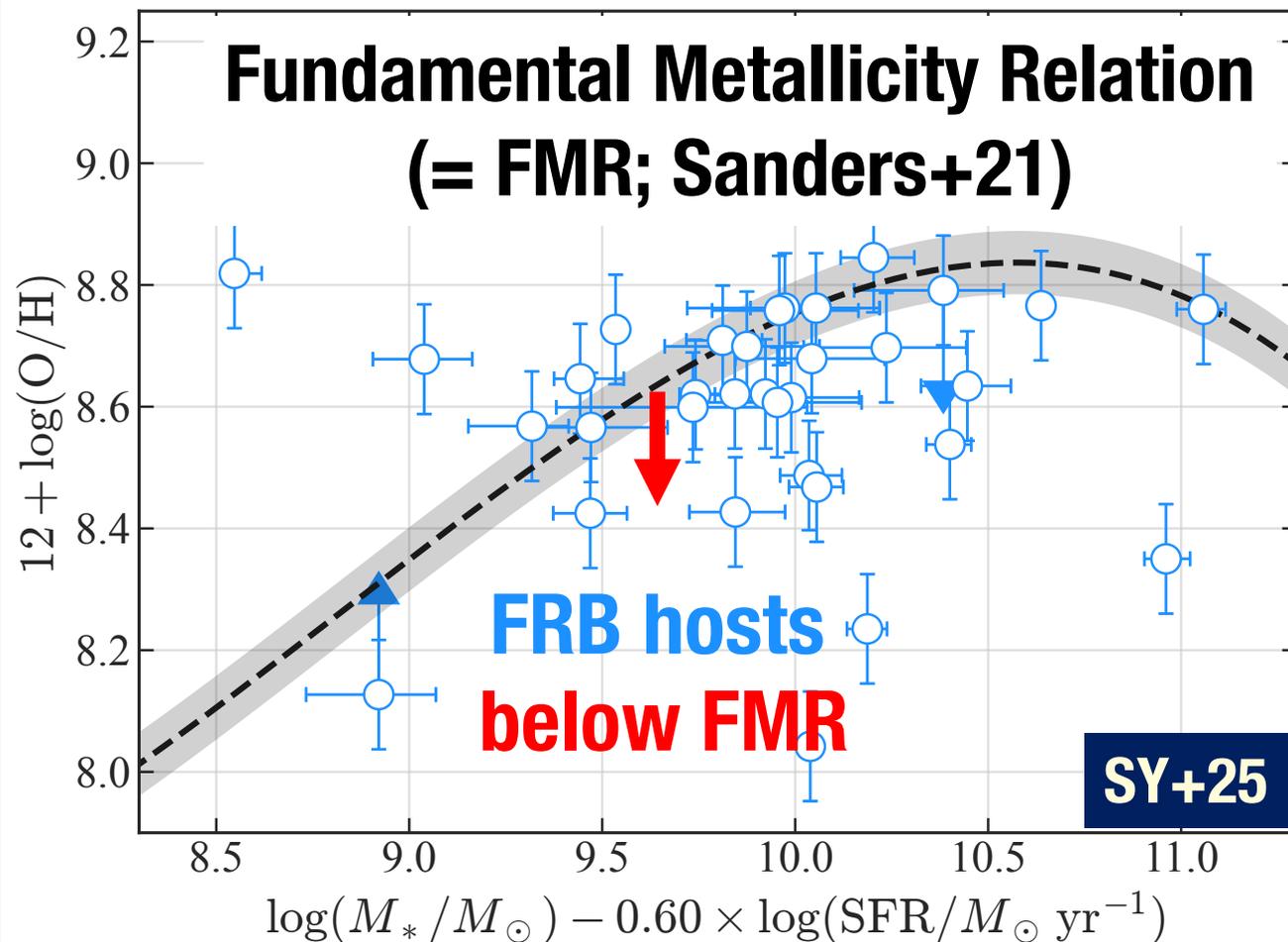
3D: Mass-SFR-Metallicity Relation

13



3D: Mass-SFR-Metallicity Relation

13



Content

The background features a central image of Earth with several satellite dishes pointing towards it. Surrounding the Earth are four square panels, each containing a different data visualization: a heatmap with a white line, a heatmap with a red circle, a heatmap with a white line, and a heatmap with a white line and a red circle. The entire scene is set against a dark, starry space background.

1. Introduction

2. Motivation

3. Data & Method

4. Result

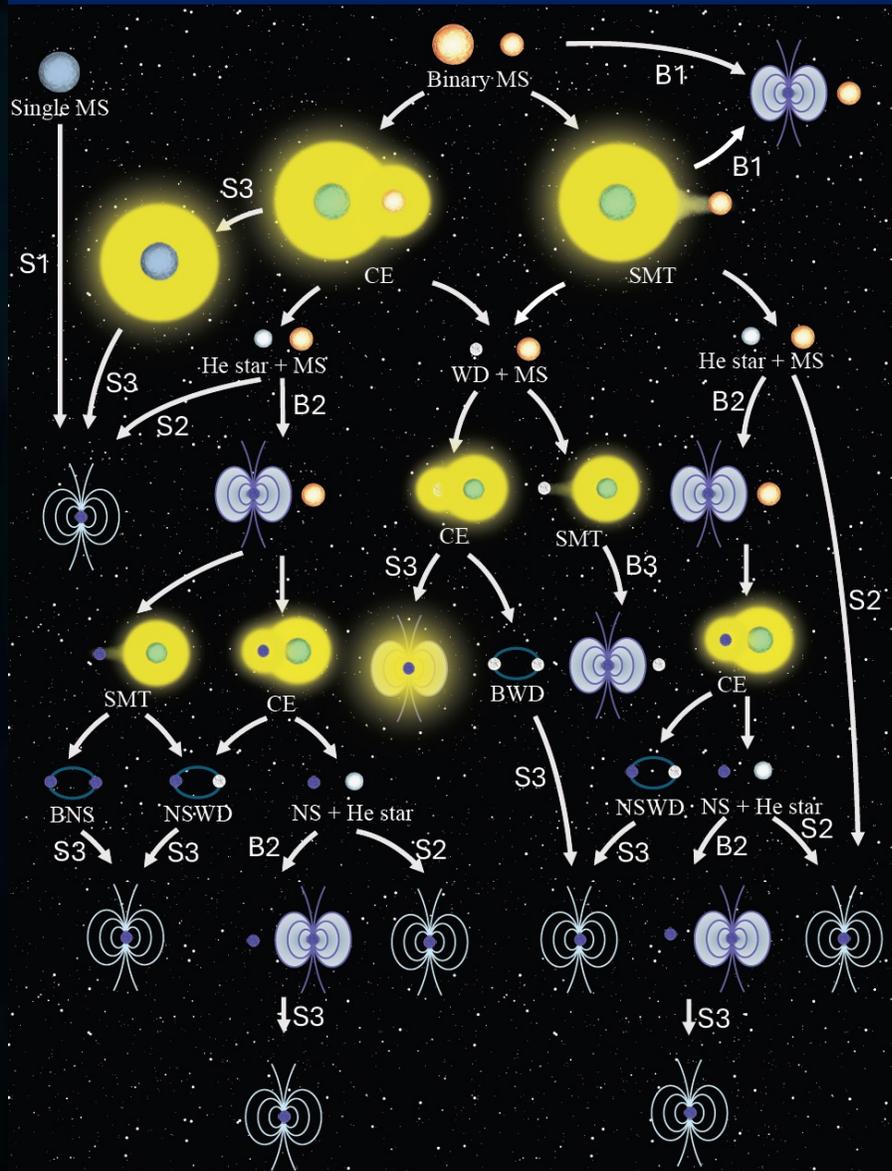
5. Discussion

No Metallicity Restriction: Implications?

14

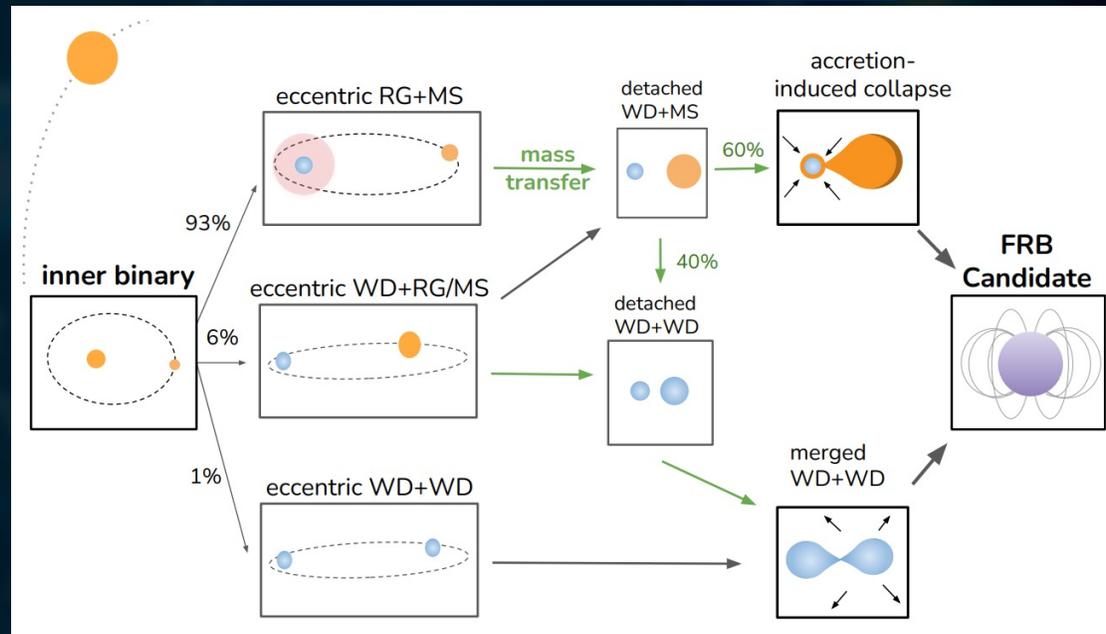
- **Metal-independent** formation paths of magnetars favored (e.g. Hu & Zhang 25; Shariat+25)

Hu & Zhang 25 (1- & 2-star evol.)



Magnetar Formation?

Shariat+25 (3-star evol.)

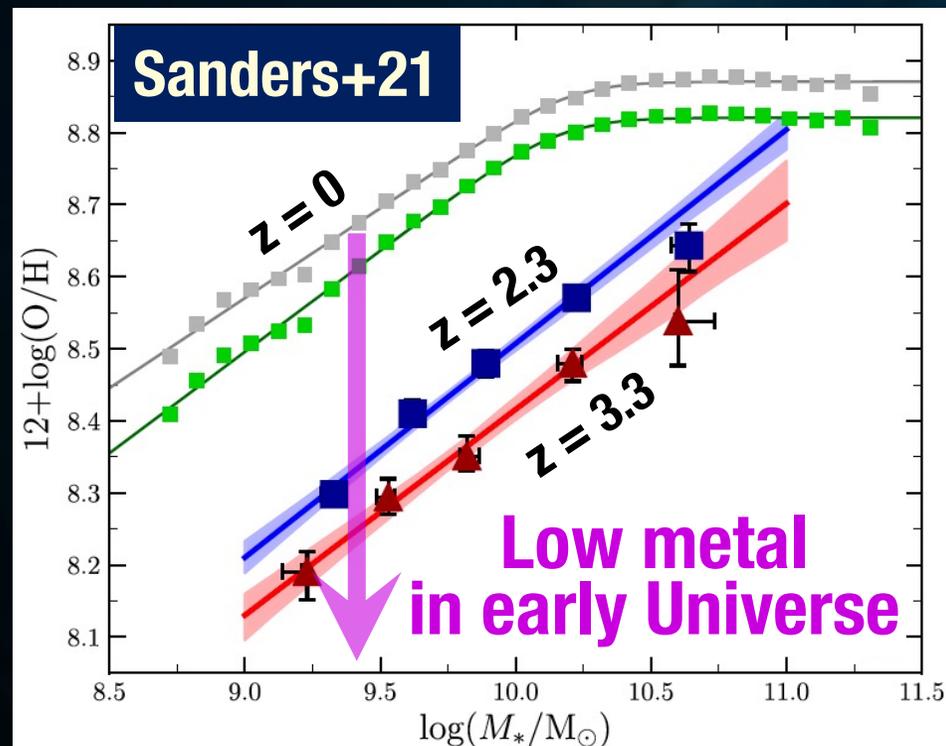


Merger channels WD-WD & WD-MS: metal insensitive

No Metallicity Restriction: Implications?

16

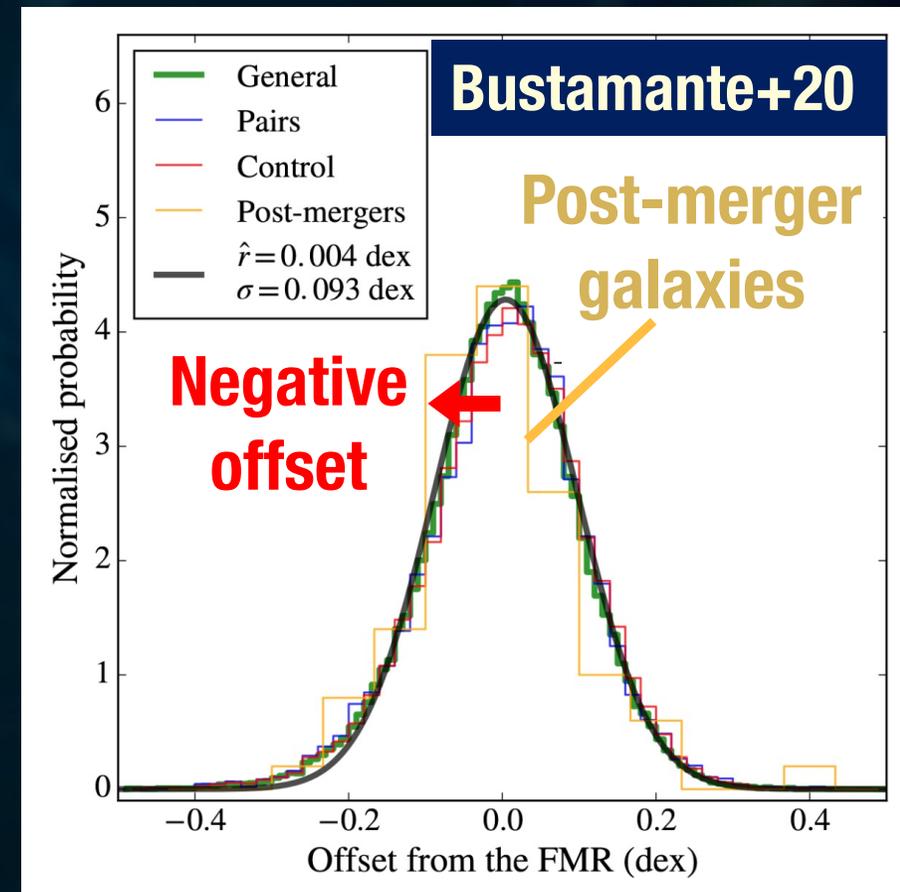
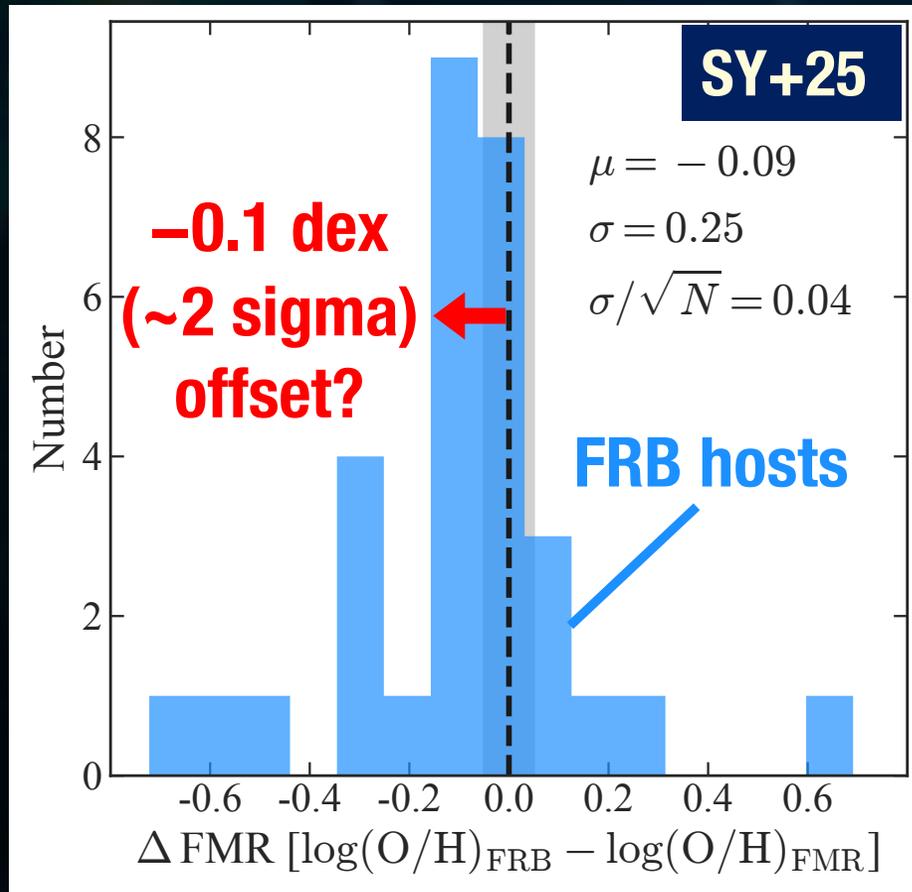
- **Metal-independent** formation paths of magnetars favored (e.g. Hu & Zhang 25; Shariat+25)
- FRBs can occur **even in low-metal environments at high-z**



He/H reionization probed by high-z FRBs (e.g. Caleb+19; Hashimoto+21)

FMR Offsets: Implications?

Post-merger galaxies show similar FMR offsets to FRB hosts



Merger-driven star formation \rightarrow FRBs after $\lesssim 500 \text{ Myr}$?

Summary

19

- We **pioneered a study of FRB host metallicities** (largest, uniform & fair comparison)
- FRB hosts show **no strong metallicity preference** and follow the SFR-weighted metallicity distribution of star-forming galaxies
- **Metal-insensitive progenitor formation** pathway(s) favored
- **Marginal (2σ) FMR offsets similar to post-merger systems** hint at an origin of FRBs in stars formed during galaxy interactions, emerging after $\sim 100\text{--}500$ Myr