ZTF Collaboration Meeting, Barcelona

Growth rate of structures with ZTF peculiar velocities

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Plan

Why measure growth with peculiar velocities

ZTF DR2.5 sample

Timeline and publications

What is needed for analysis?

Blinding

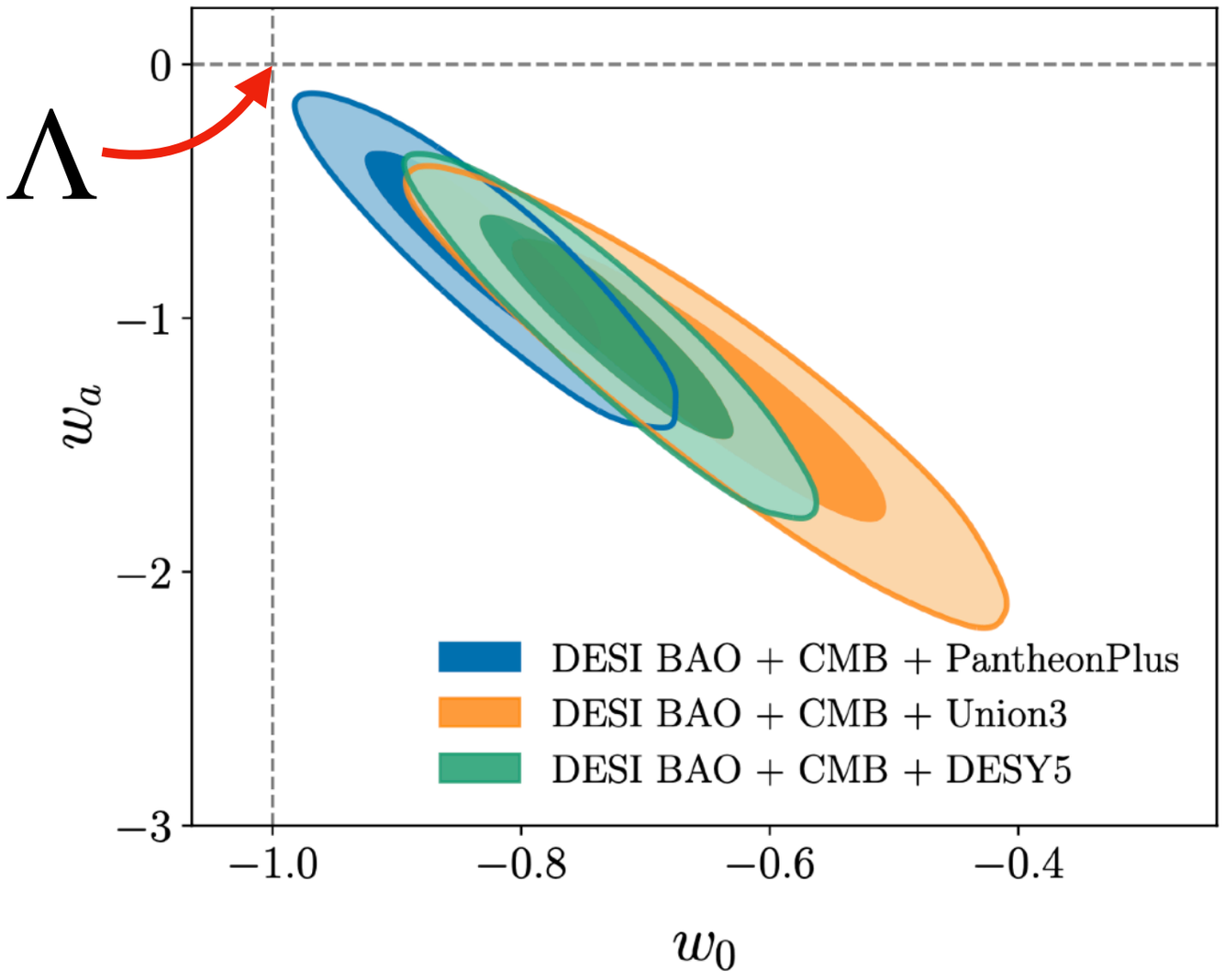
What next?

Why measure the growth rate of structures ?

Expansion rate : baryon acoustic oscillations, supernovae, cosmic microwave background

We see an accelerated expansion of the Universe!

- cosmological constant?
- evolving dark energy?
- modification of GR on large scales?



Evolving equation of state for DE

$$w(a) = w_0 + (1 - a)w_a$$

Hints of departure from a cosmological constant!

$$\text{DESI} + \text{CMB} + \text{Pantheon+} \implies 2.5\sigma$$

$$\text{DESI} + \text{CMB} + \text{Union3} \implies 3.5\sigma$$

$$\text{DESI} + \text{CMB} + \text{DES-SN5YR} \implies 3.9\sigma$$

DESI Collaboration 2024

Why measure the growth rate of structures ?

Expansion rate : baryon acoustic oscillations, supernovae, cosmic microwave background

We see an accelerated expansion of the Universe!

- cosmological constant?
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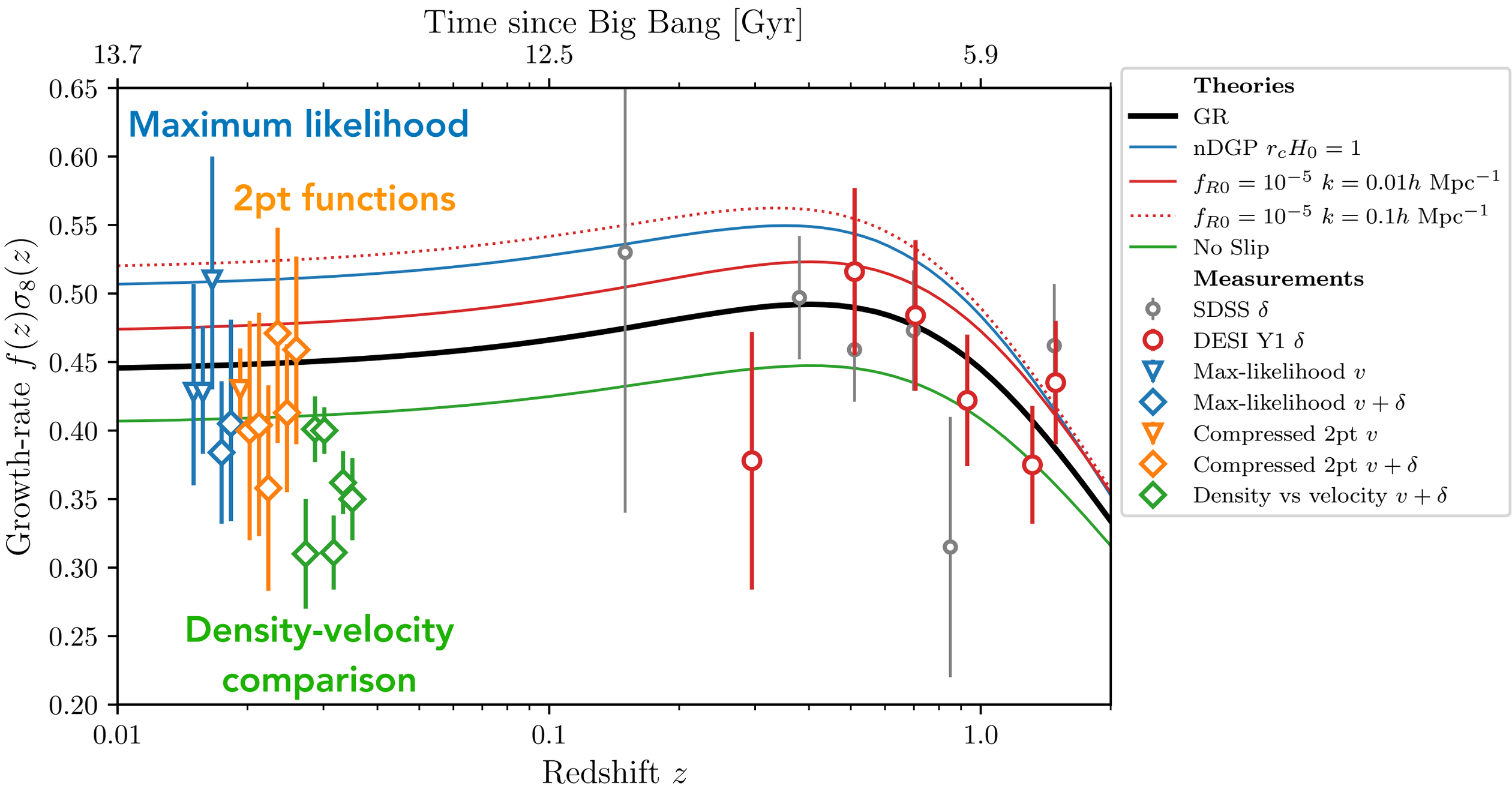
Growth rate : redshift-space distortions, peculiar velocities

We can break degeneracy between dark energy and modified gravity models !

Current measurements



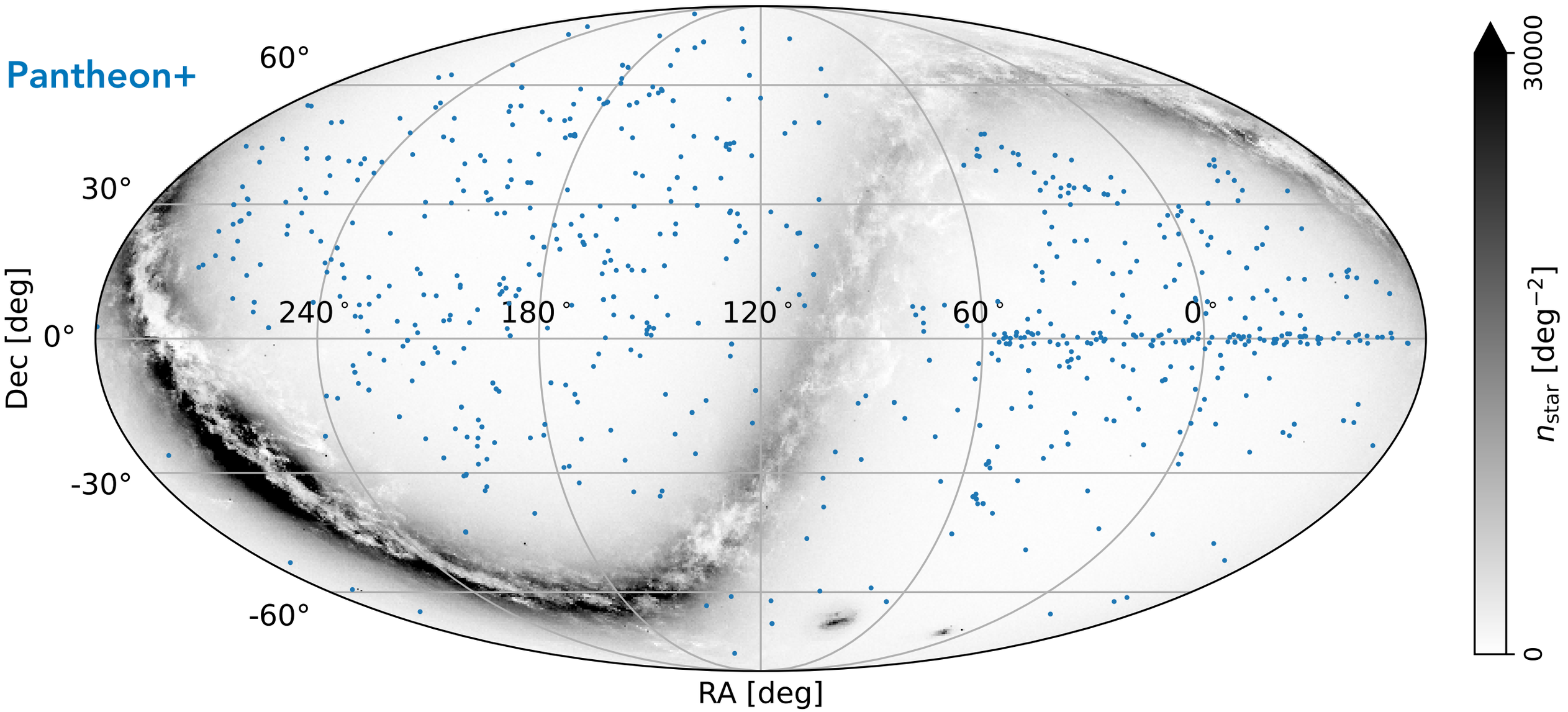
RSD + Peculiar velocities

RSD

How to measure growth rate with peculiar velocities?

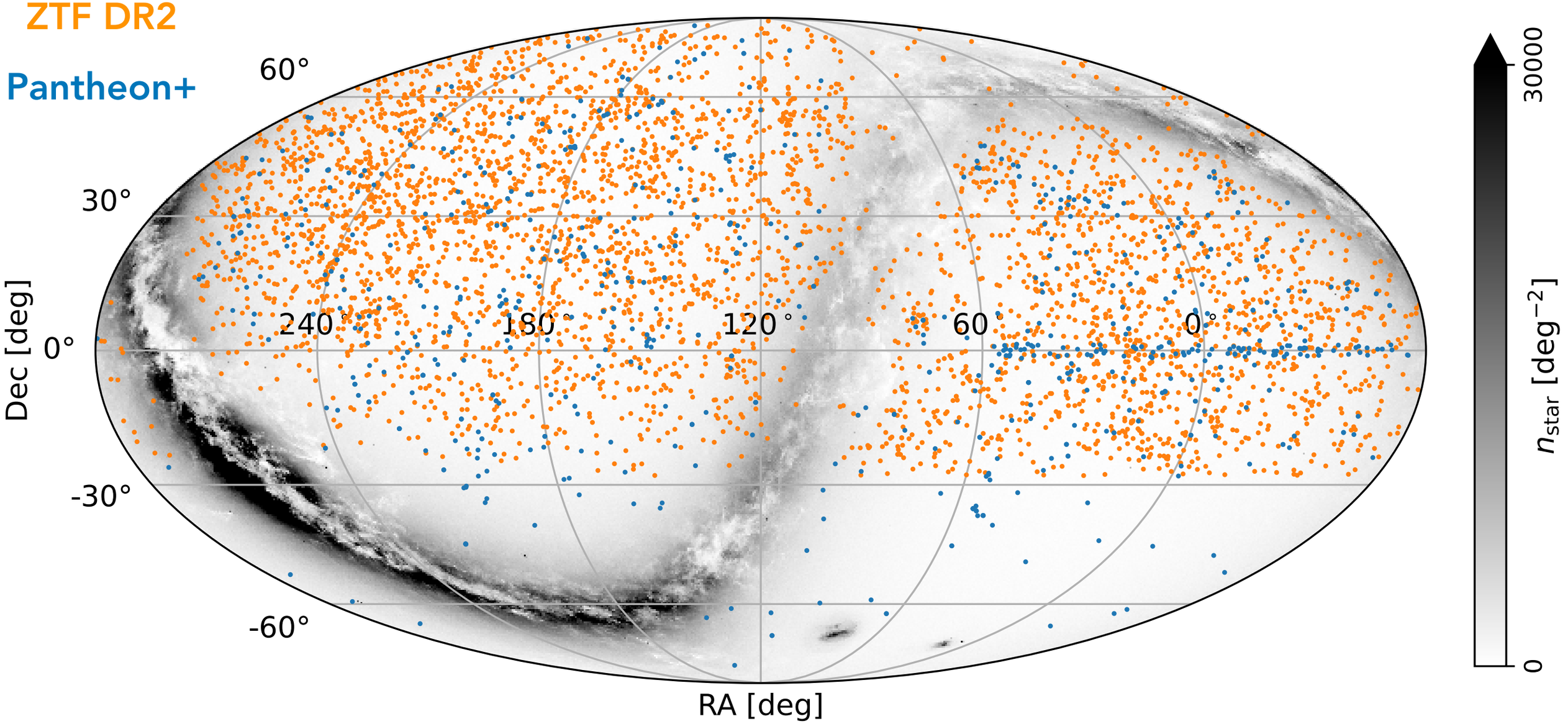
	Data vector	Model	References
Maximum likelihood	Uncompressed 2-pt statistics	2-pt statistics	Johnson++ 2014 Howlett++2017 Adams & Blake 2017/2020 Lai, Howlett, Davis 2022 Carreres++2023
2pt functions $\langle\delta_g\delta_g\rangle, \langle\delta_g p_r\rangle, \langle p_r p_r\rangle$	Compressed 2-pt statistics	2-pt statistics	Ferreira++1999 Dupuy++2019 Turner, Blake, Ruggeri 2021 Howlett++2019 Turner++2023 Qin++2020, 2024 Shi++2024
Density-velocity comparison	Velocity field $v_r(\vec{s})$	Reconstruct $v_r(\vec{s})$ from $\delta_g(\vec{s})$	Davis++2011 Springbob++2014 Carrick++2015 Boruah++2020 Said++2020 Hollinger++2024 Boubel++2024
Forward-modelling	Both fields $\delta_g(\vec{s}), v_r(\vec{s})$	Evolution from initial conditions	Graziani++2019 Boruah, Hudson, Lavaux 2020

The ZTF Data Release 2.5 sample



Several telescopes, inhomogenous selection function across sky

The ZTF Data Release 2.5 sample



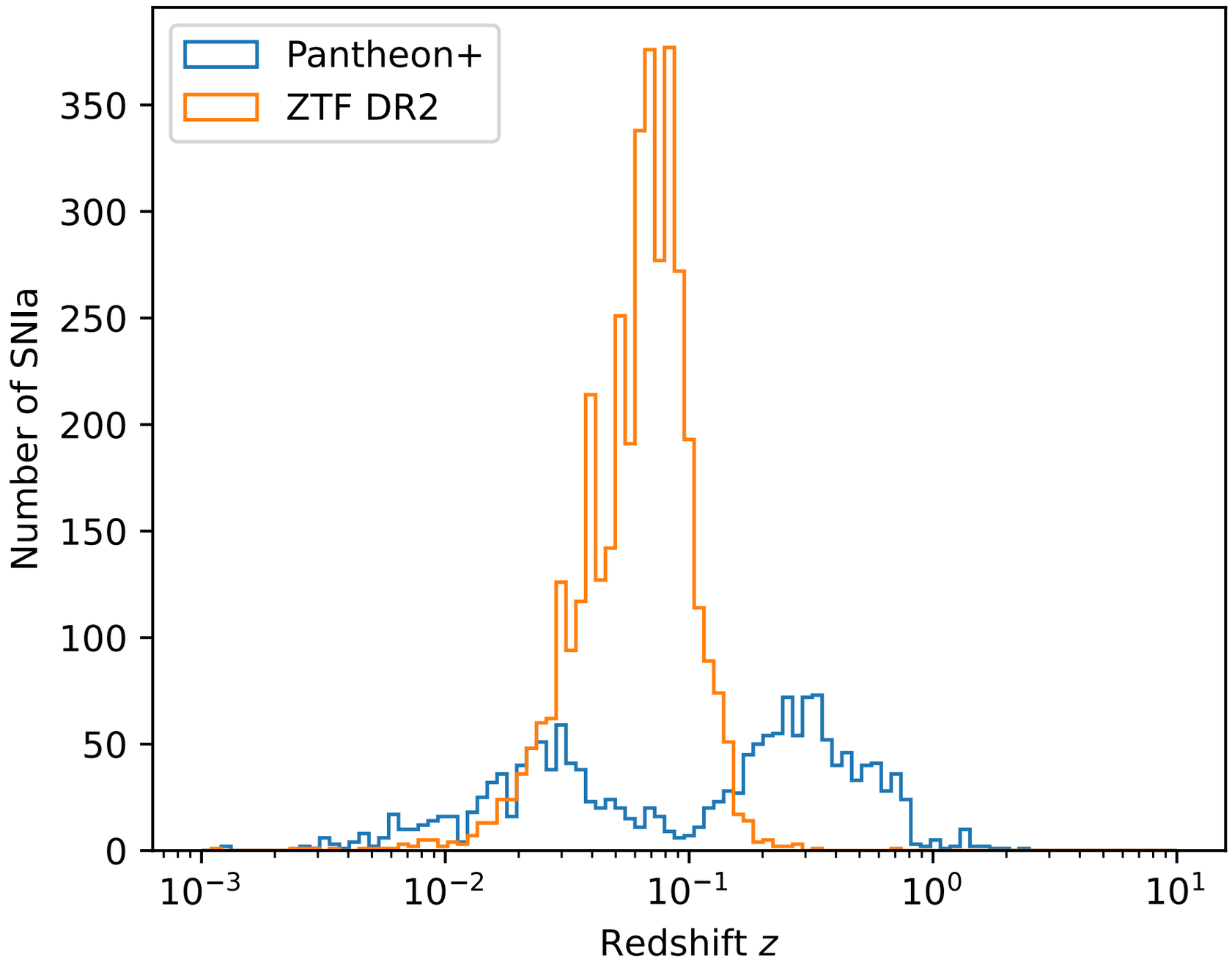
The largest and most uniform low-z SNIa survey

Rigault et al 2024

The ZTF Data Release 2.5 sample

ZTF DR2

Pantheon+



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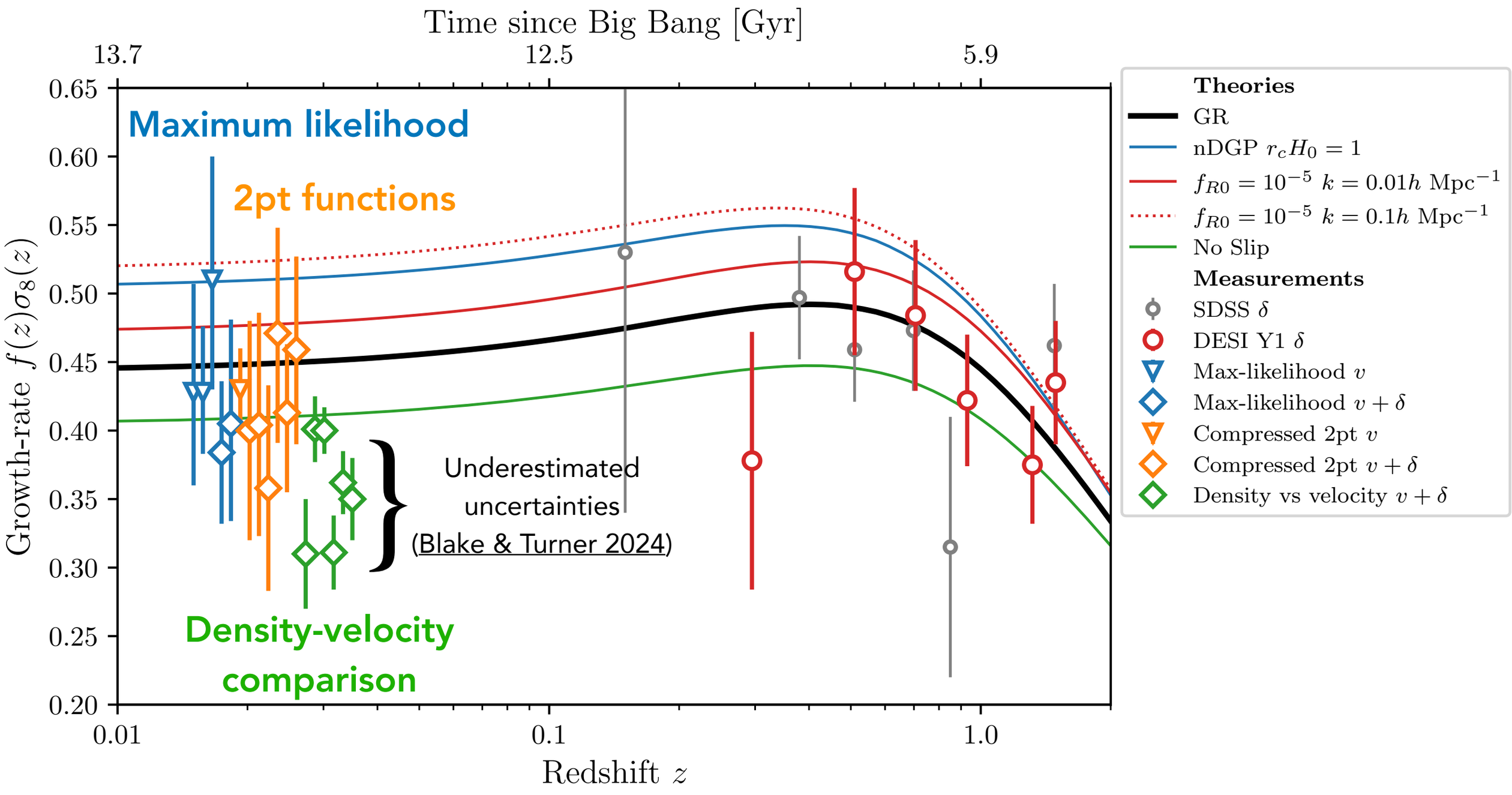
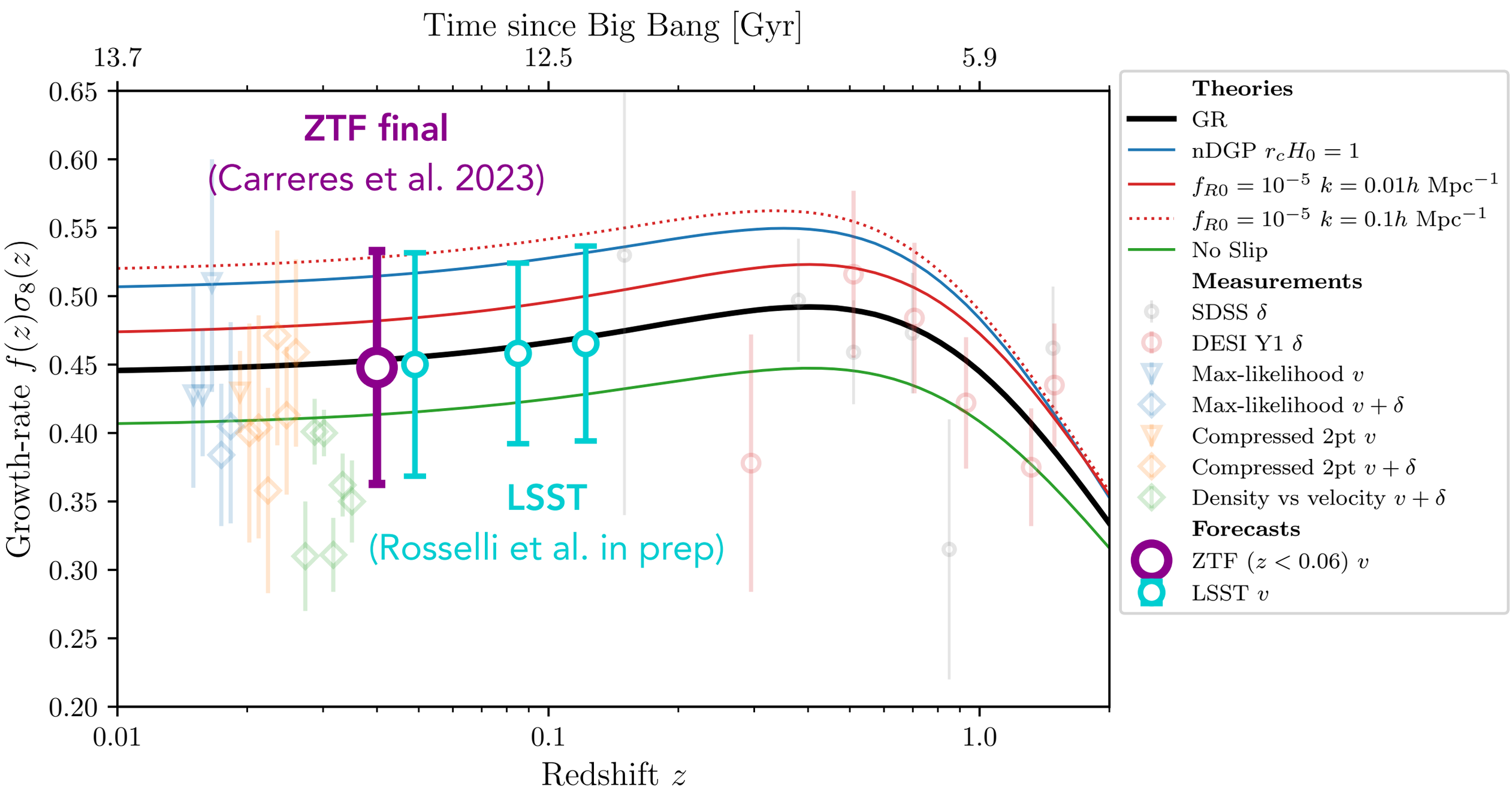


RSD + Peculiar velocities

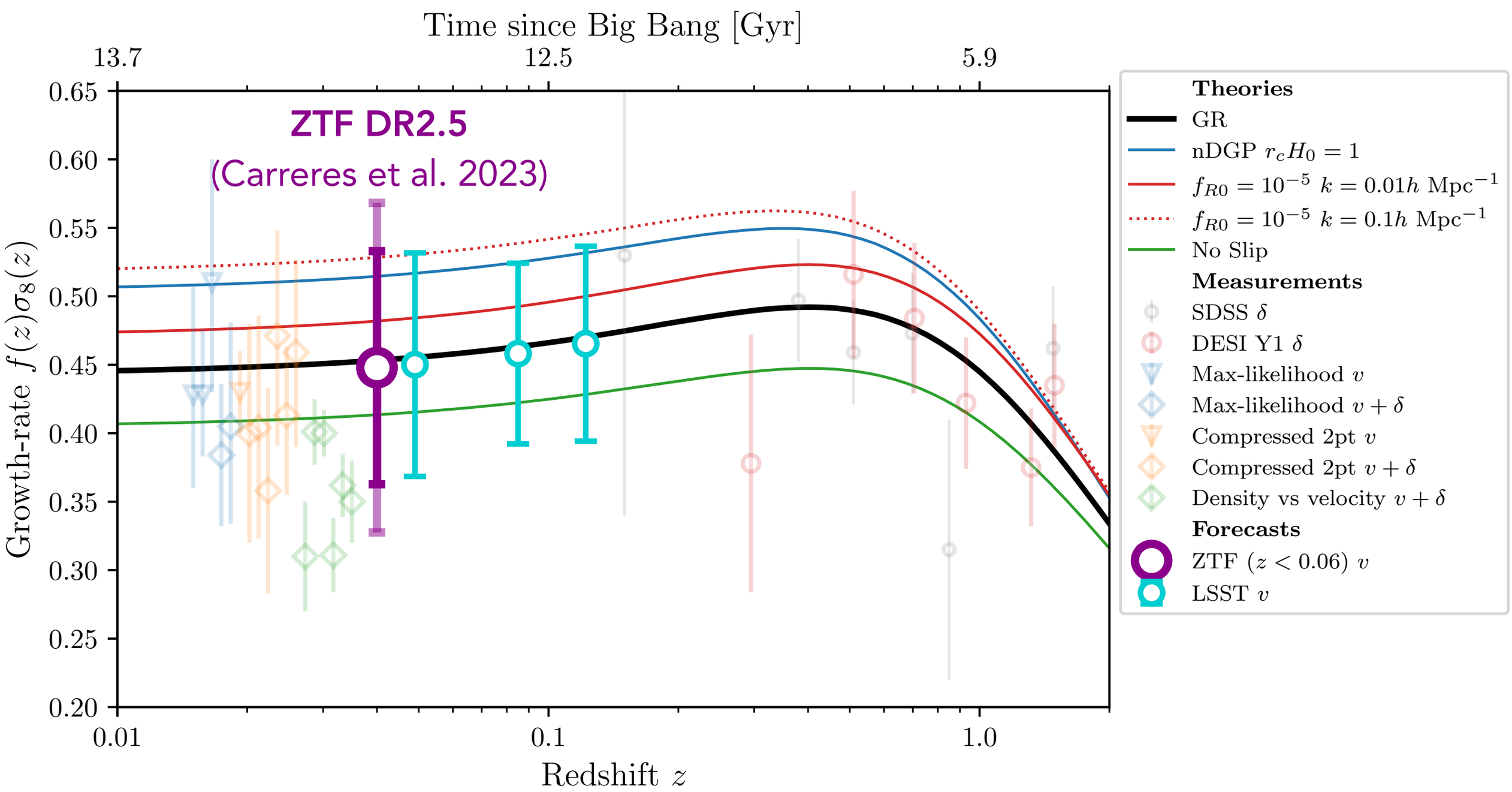
RSD

Forecasts from supernovae velocities



Forecasts based on analysis of several realistic simulations (not Fisher!)

Forecasts from supernovae velocities



Forecasts based on analysis of several realistic simulations (not Fisher!)

Publications with ZTF DR2.5

Expected completion by Summer 2025

Rafael Kebadian et al. 2025 : Measurement of the growth-rate of structures with peculiar velocities from the **complete** sample of ZTF DR2.5 with the **maximum likelihood** method

Aurélien Valade et al. 2025 : Measurement of the growth-rate of structures with peculiar velocities from the **complete** sample of ZTF DR2.5 with **forward modelling** method

Antoine Gilles-Lordet, Mahmoud Osman et al. 2025 : Measurement of the growth-rate of structures with peculiar velocities from the (complete?) sample of ZTF DR2.5 **and 2M++ galaxies** with the **density-velocity/reconstruction** method (BORG)

Dane Cross, Lluís Galbany et al. 2025 : Measurement of the growth-rate of structures with peculiar velocities from the **full sample** of ZTF DR2.5 **and 2M++ galaxies** with the **density-velocity/reconstruction** method (Theseus)

Let us know if your project is missing !

What is needed for analysis?

n-body simulations

Uchuu + UniverseMachine
2 Gpc/h box
27 realisations z < 0.10

AbacusSummit + "DESI" HOD
25 x 2 Gpc/h boxes
675 realisations z < 0.10

Fast LPT or PMWD
matter fields
Under dev by Aurélien

ZTF simulators

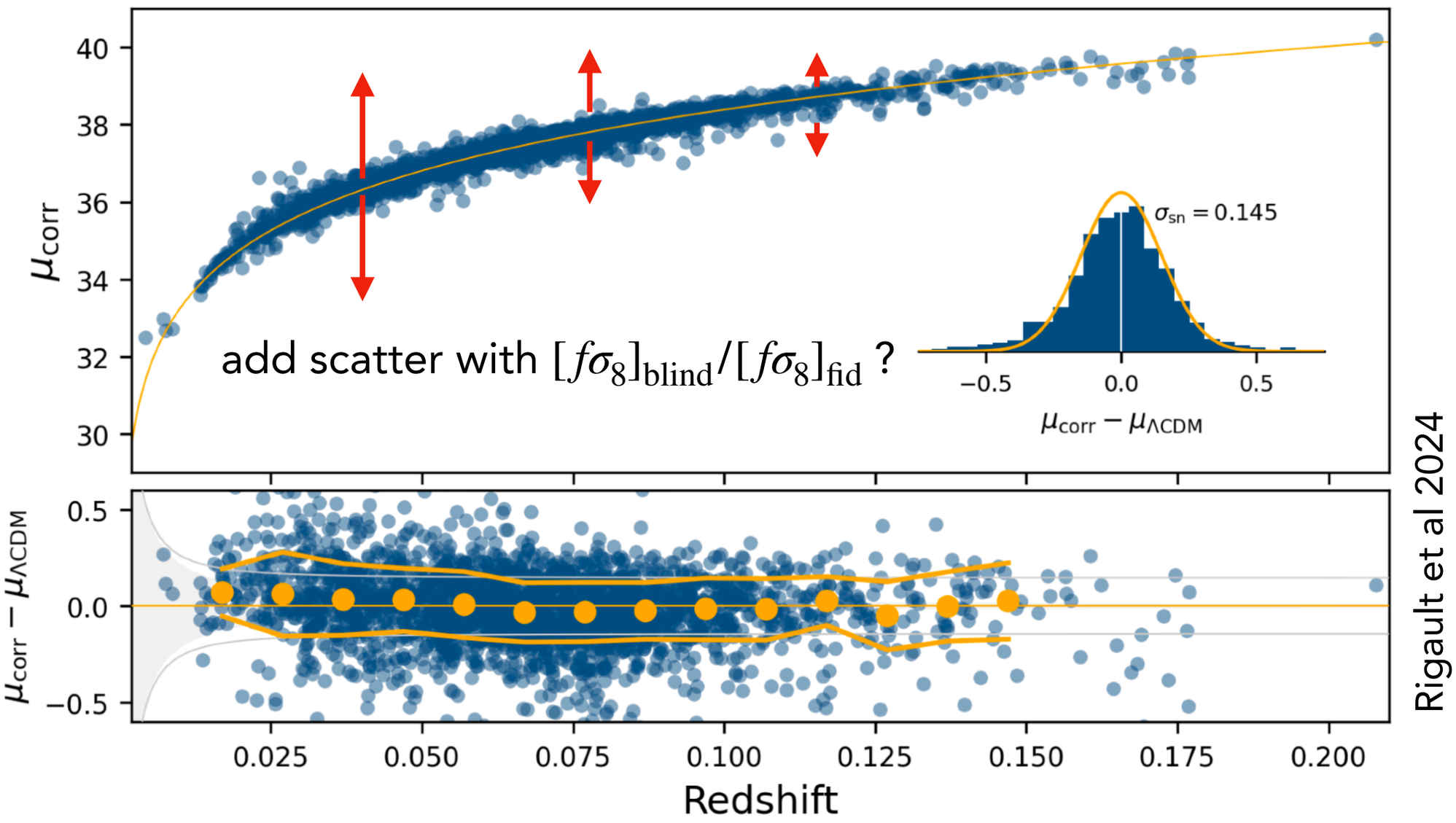
snsim

skysurvey

- Make sure ZTF simulators agree
- Plug these mocks into the Data Challenges
- Integrate analysis in Lemaitre framework
- Start systematic tests that potentially impact $f\sigma_8$!

Blinding

How to properly blind the true value of $f\sigma_8$?



Need to decide on methodology

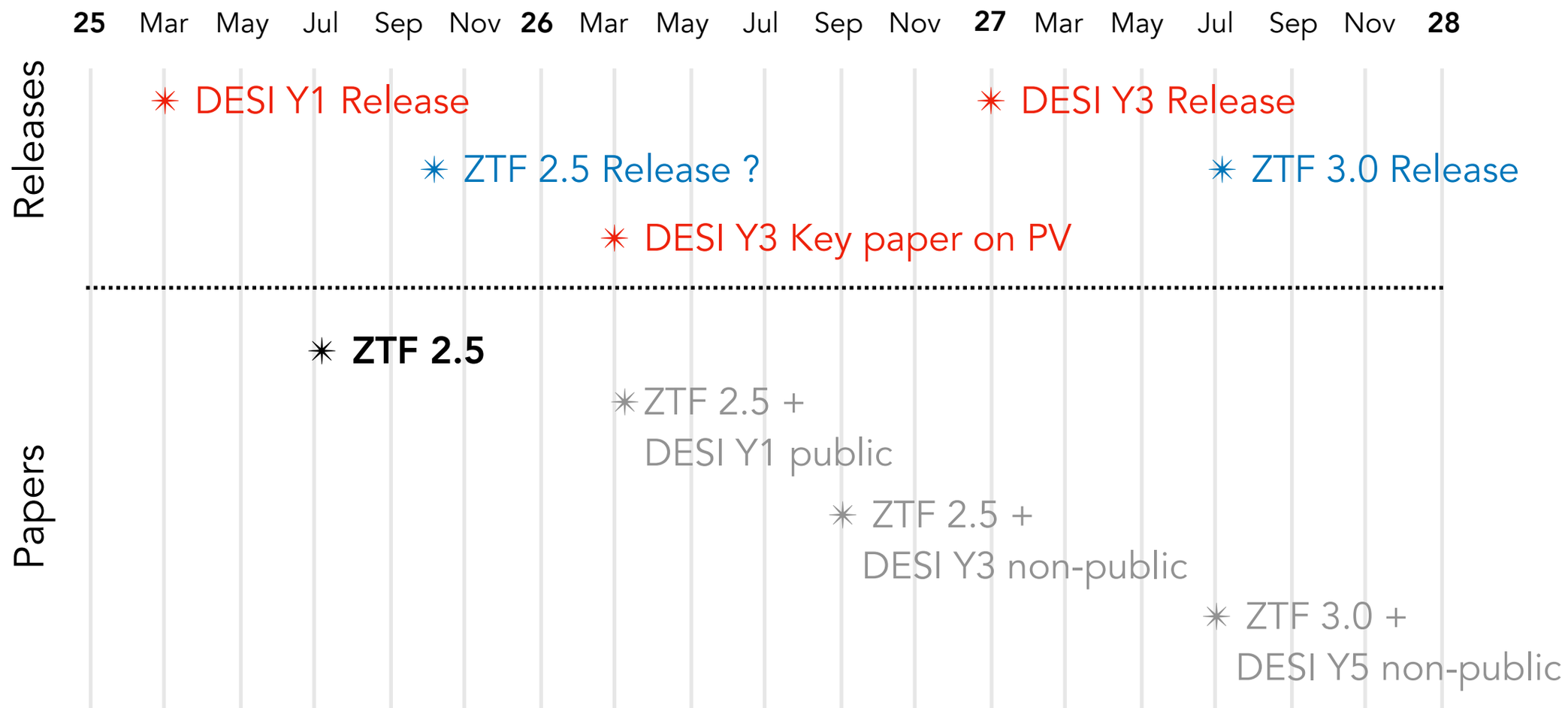
Test it on mocks

Write a nice paper about it !

What next ?

Combination of ZTF with galaxy density field from DESI

Factor of 2 improvement expected on $f\sigma_8$!



Conclusion

ZTF is one of the best peculiar velocity surveys

Nice opportunity for a single-survey measurement of growth rate

Many methods, many simulations : robust measurement

Exciting times ahead