


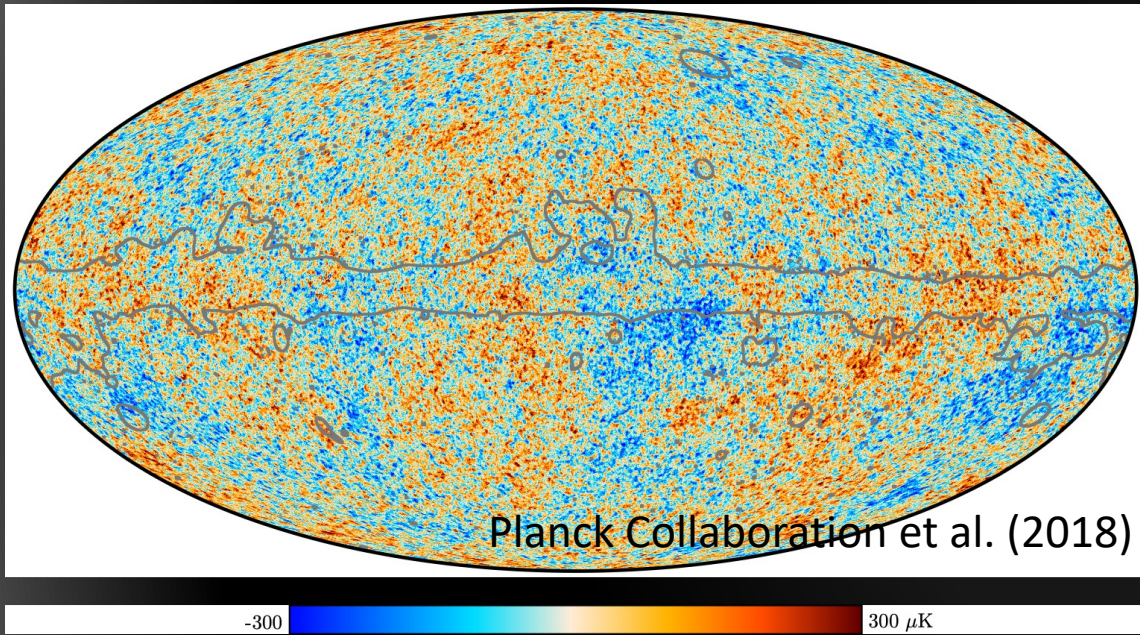
Cosmology with Current and Future Peculiar Velocity Surveys

Khaled Said

The University of Queensland

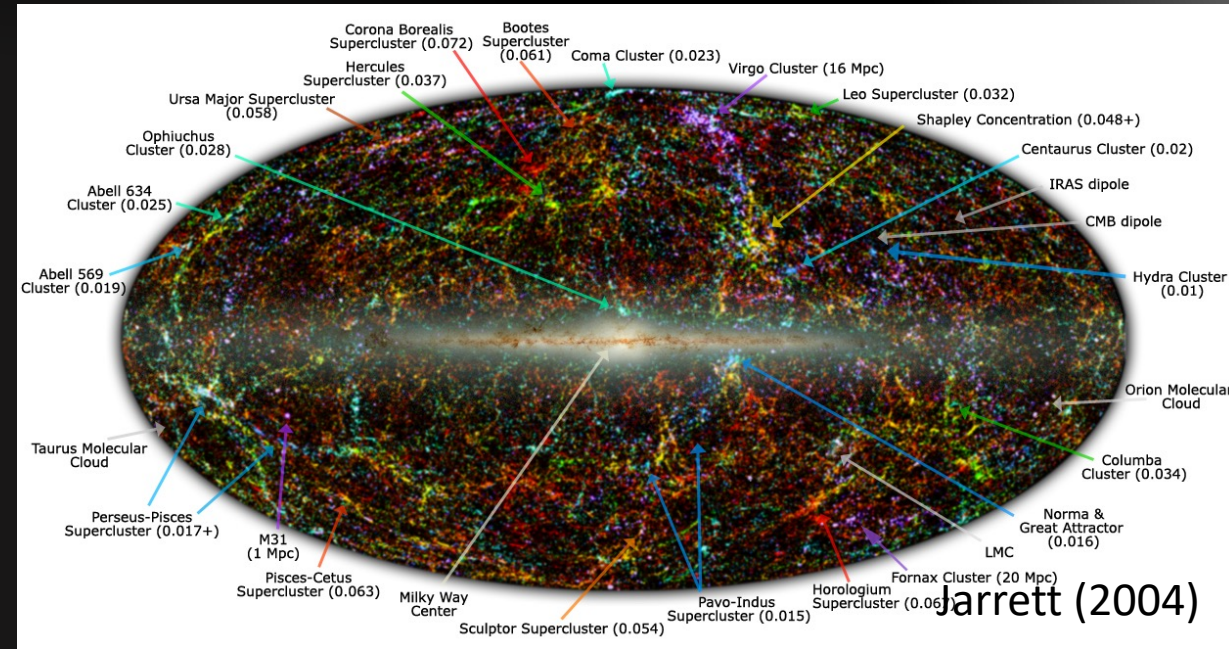


State of Cosmology



- 400,000 thousand years after the Big Bang
- Redshift $z \sim 1100$
- Fluctuations of 1 part in 100,000

gravitational instability

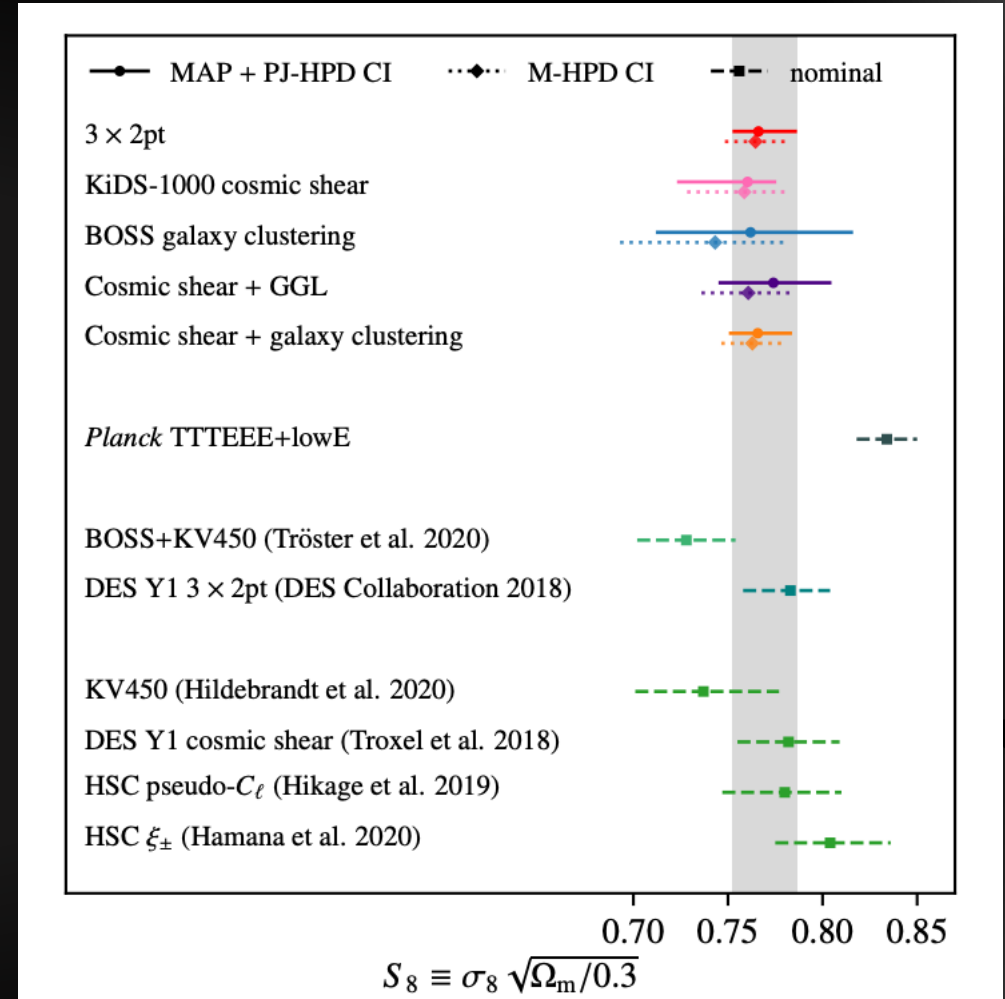


- 13.8 billion years after the Big Bang
- Redshift $z \sim 0$
- Clusters and superclusters of galaxies

State of Cosmology



Riess (2020)



Heymans et al (2020)

(2004)

How do we measure Peculiar Velocity?

$$(1 + z) = (1 + \bar{z})(1 + z_p)$$

z : Observed redshift (Measured directly from DESI spectra)

\bar{z} : The cosmological redshift corresponding to true distance -- always away from us because of the expansion of the universe

z_p : Is the peculiar redshift -- the deviation from this smooth expansion

Measuring \bar{z} directly:

- Primary distance indicators: Cepheids, TRGB, masers
- Secondary distance indicators: SN Ia, Tully-Fisher, Fundamental Plane

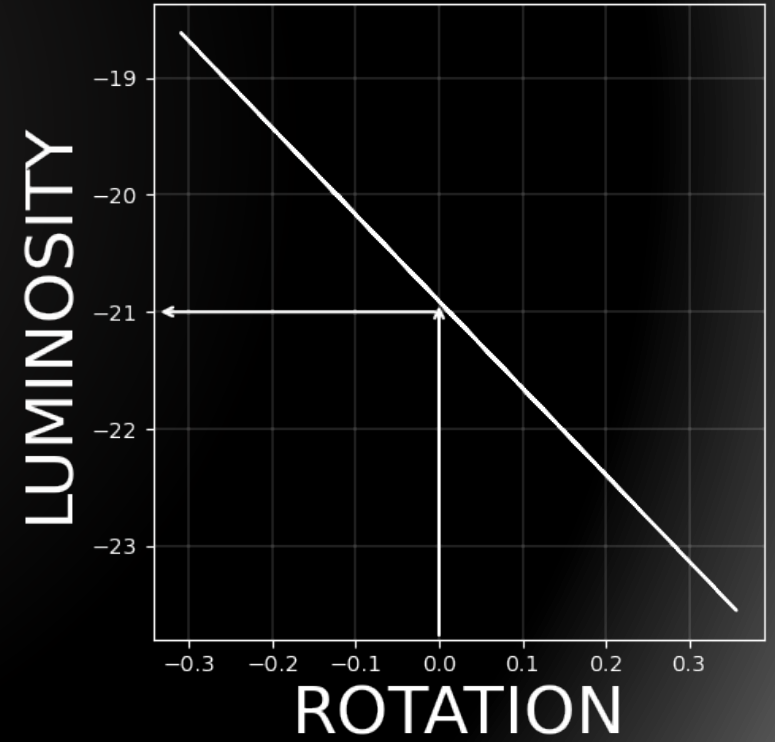
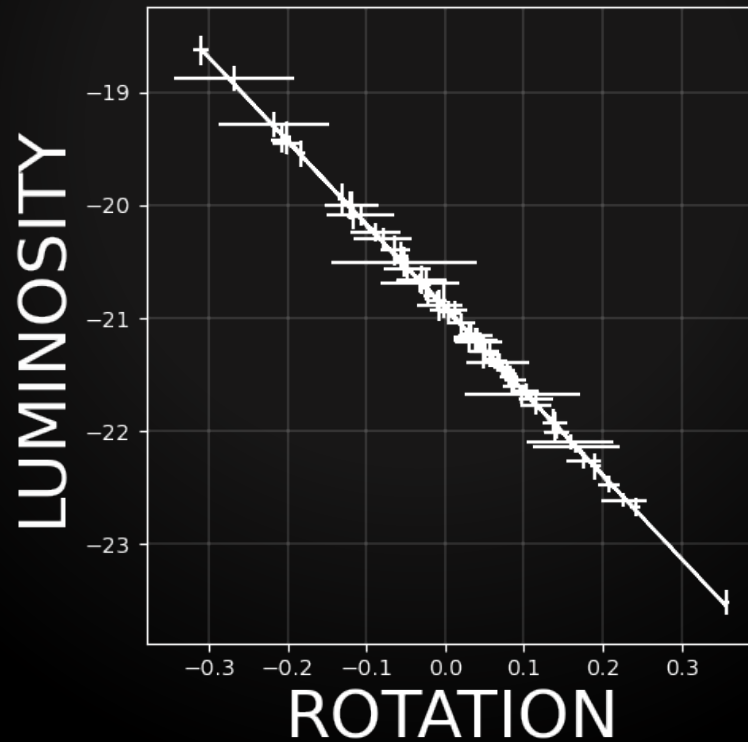
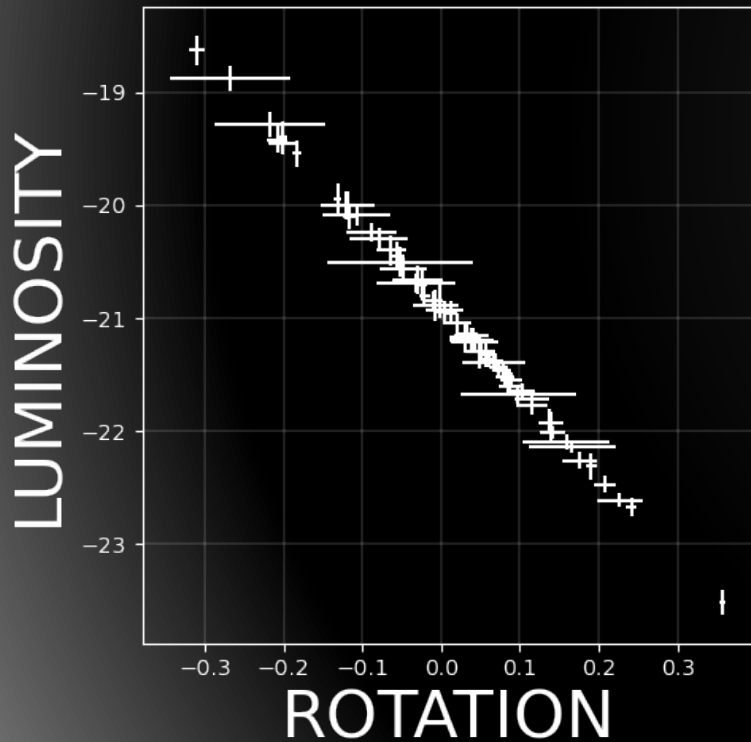
How do we measure Peculiar Velocity?

- Tully-Fisher relation

$$M = a \log V_{max} + b$$

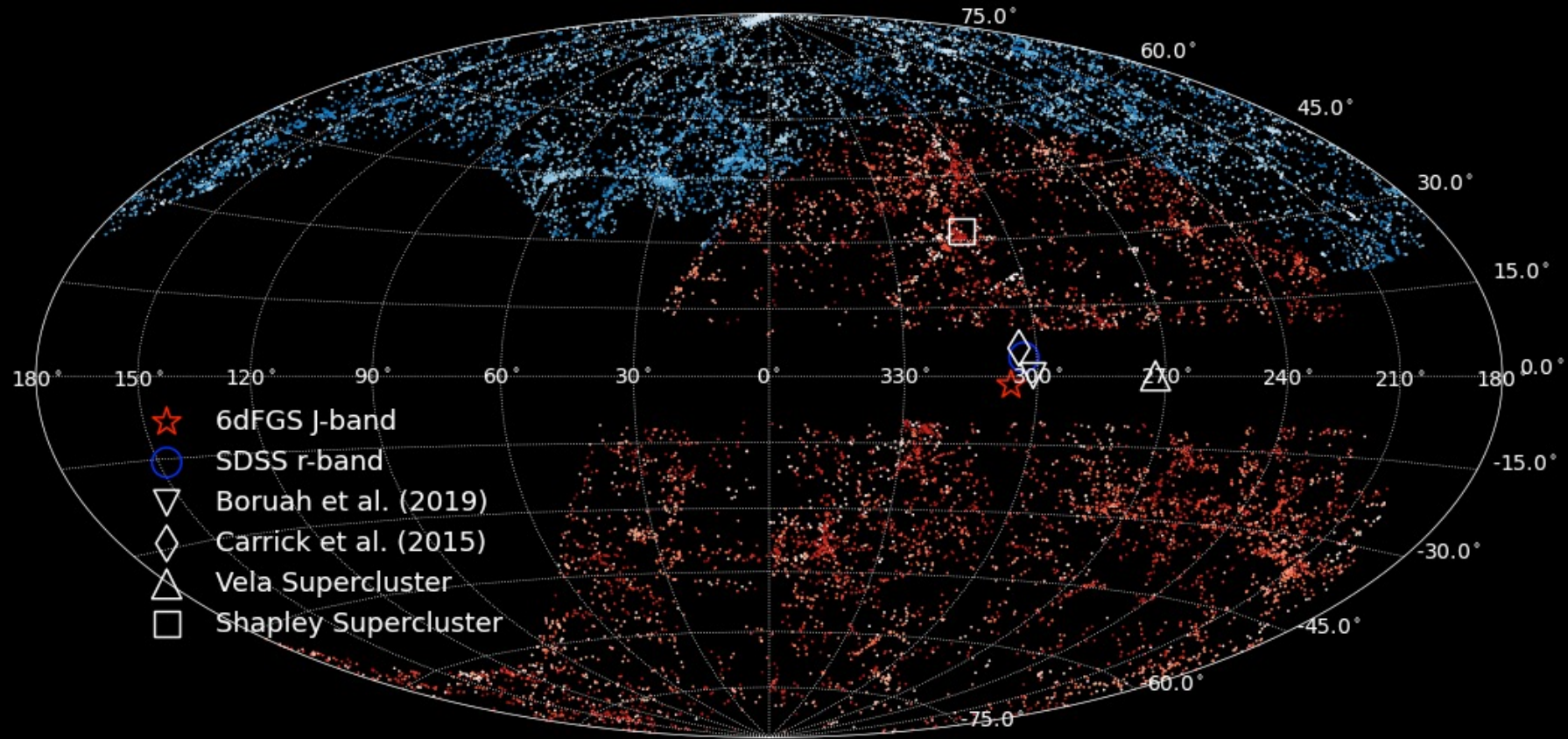
M : Absolute magnitude (distance dependent)

V_{max} : Rotational velocity (distance independent)



What can we do with peculiar velocities?

- Cosmic Cartography



Said, Colless et al. (2020)

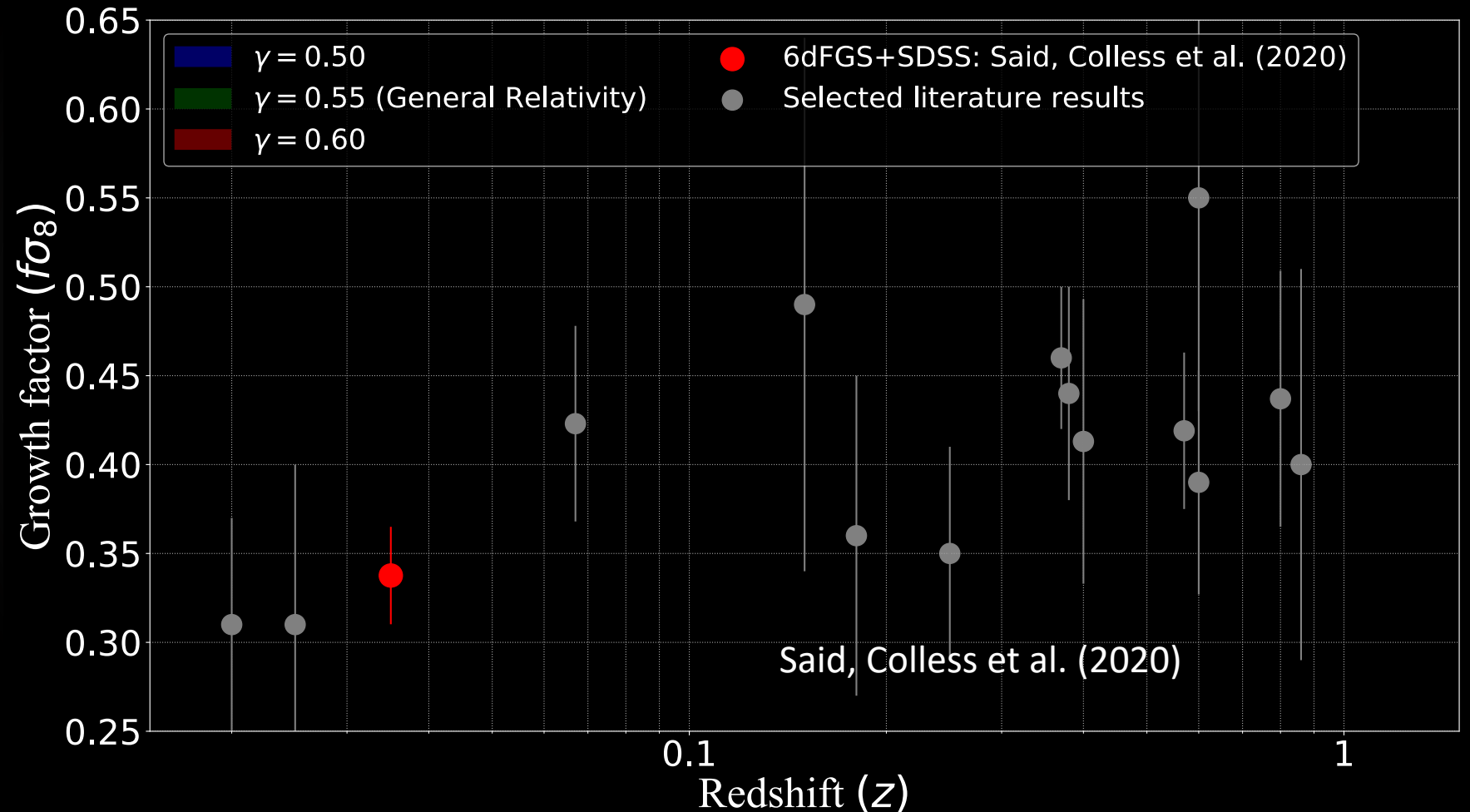
What can we do with peculiar velocities?

- Low redshift growth rate

$$f(z) = \Omega_{m(z)}^\gamma$$

$$\gamma = \frac{6}{11} \text{ for GR } \& \frac{11}{16} \text{ for DGP}$$

- the growth index $\gamma > \frac{6}{11}$
- Hubble constant $H_0 > 70$
- a fluctuation amplitude $\sigma_8 < 0.8$
- some combination of the above

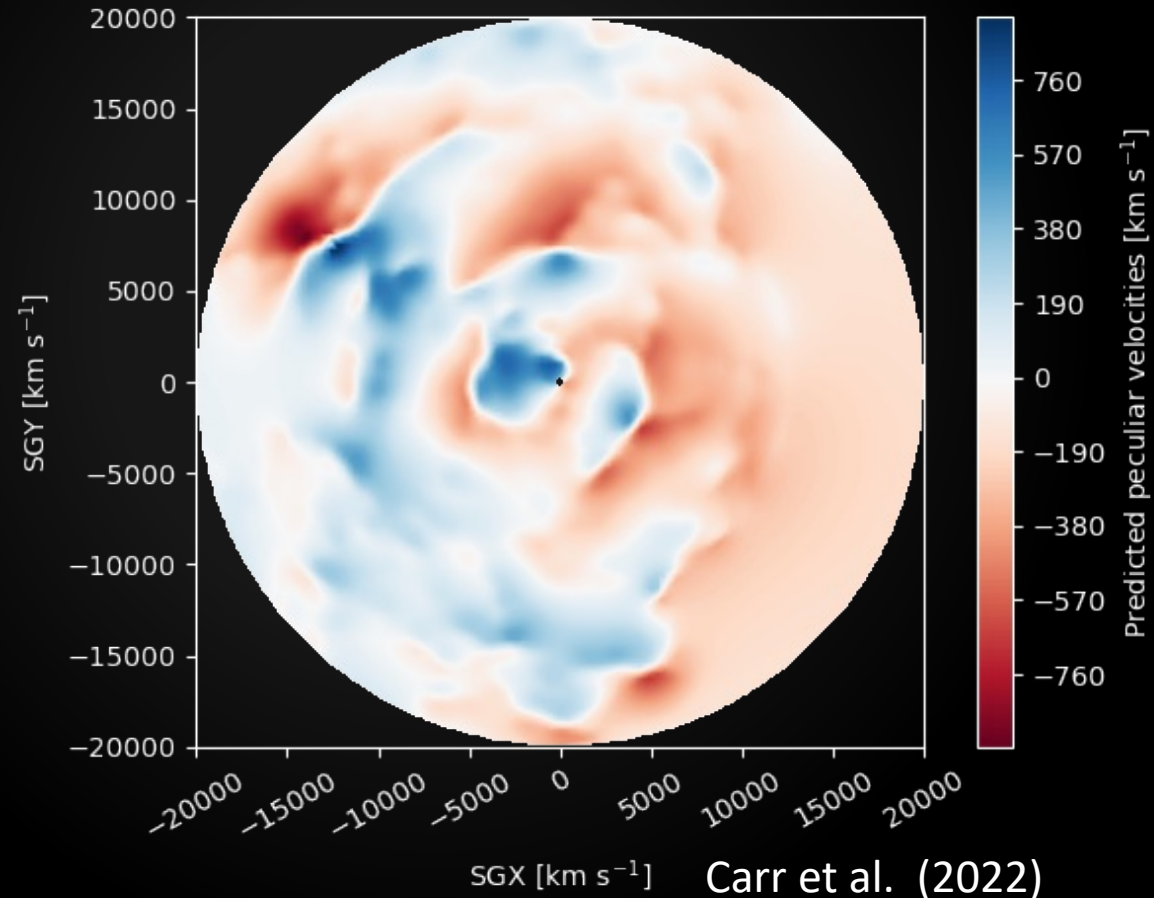


What can we do with peculiar velocities?

- Necessary velocity correction for H_0 measurements

Pantheon+:

- Peterson et al (2022)
- Carr et al. (2022)
- Brout et al. (2022)



Future peculiar velocity surveys:

The Dark Energy Spectroscopic Instrument (DESI) Survey



DARK ENERGY
SPECTROSCOPIC
INSTRUMENT

U.S. Department of Energy Office of Science

- Located on 4m Mayall Telescope @ Kitt Peak, Arizona
- 5,000 fibre multi-object spectrograph.
- Collaboration of over 800 astronomers, technicians and engineers.

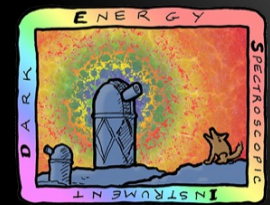
Aims:

- Measuring Distances with Baryon Acoustic Oscillations
- Measuring Growth of Structure with Redshift Space Distortions
- Cosmology Beyond Dark Energy
 1. First 3σ measurement of the sum of neutrino masses
 2. Help pin down the properties of cosmic inflation.



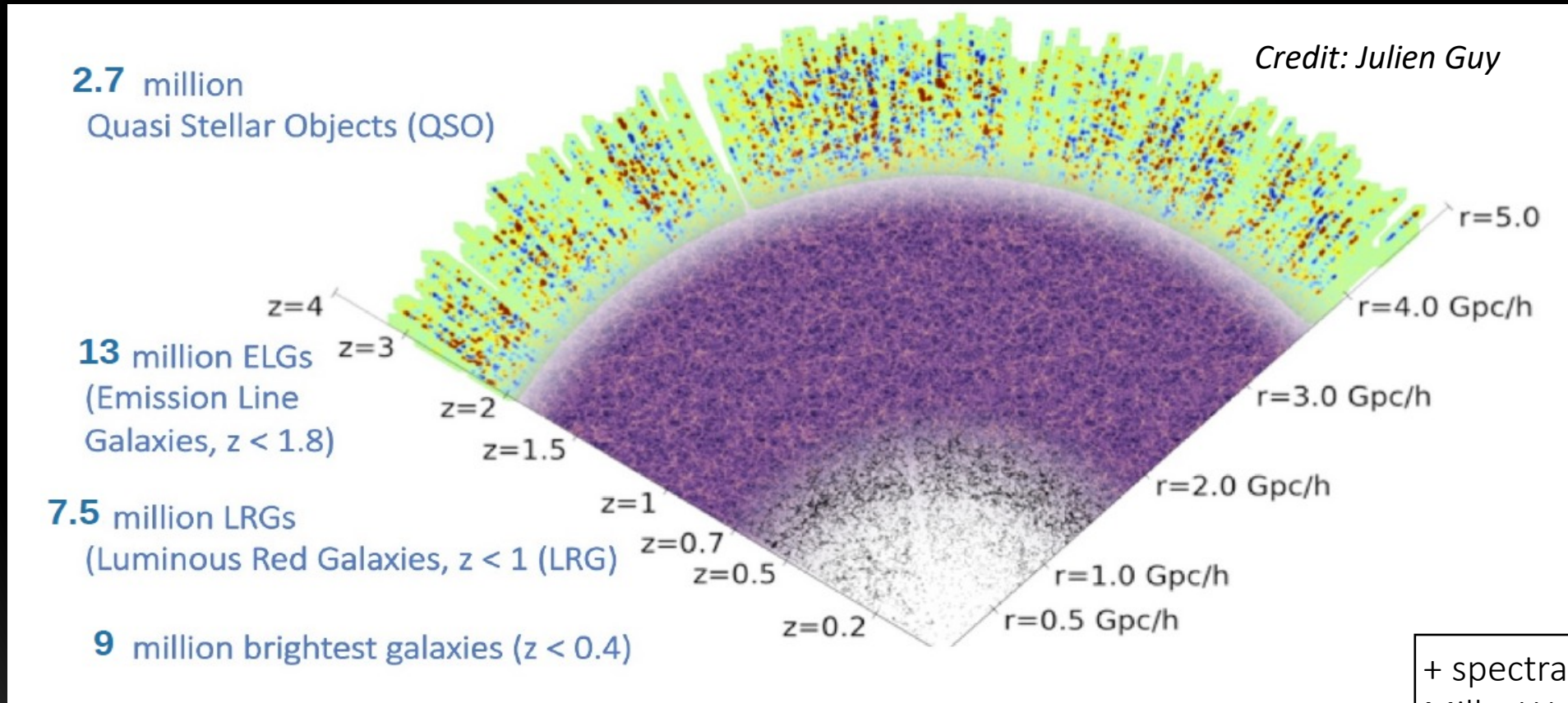
Future peculiar velocity surveys:

The Dark Energy Spectroscopic Instrument (DESI) Survey



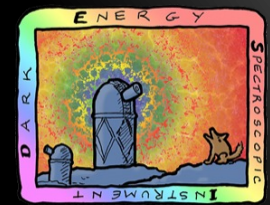
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Future peculiar velocity surveys:

The Dark Energy Spectroscopic Instrument (DESI) Survey



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The DESI peculiar velocity survey is a secondary target program that will become the largest collection of distance measurements to nearby galaxies ever assembled and enable a range of science

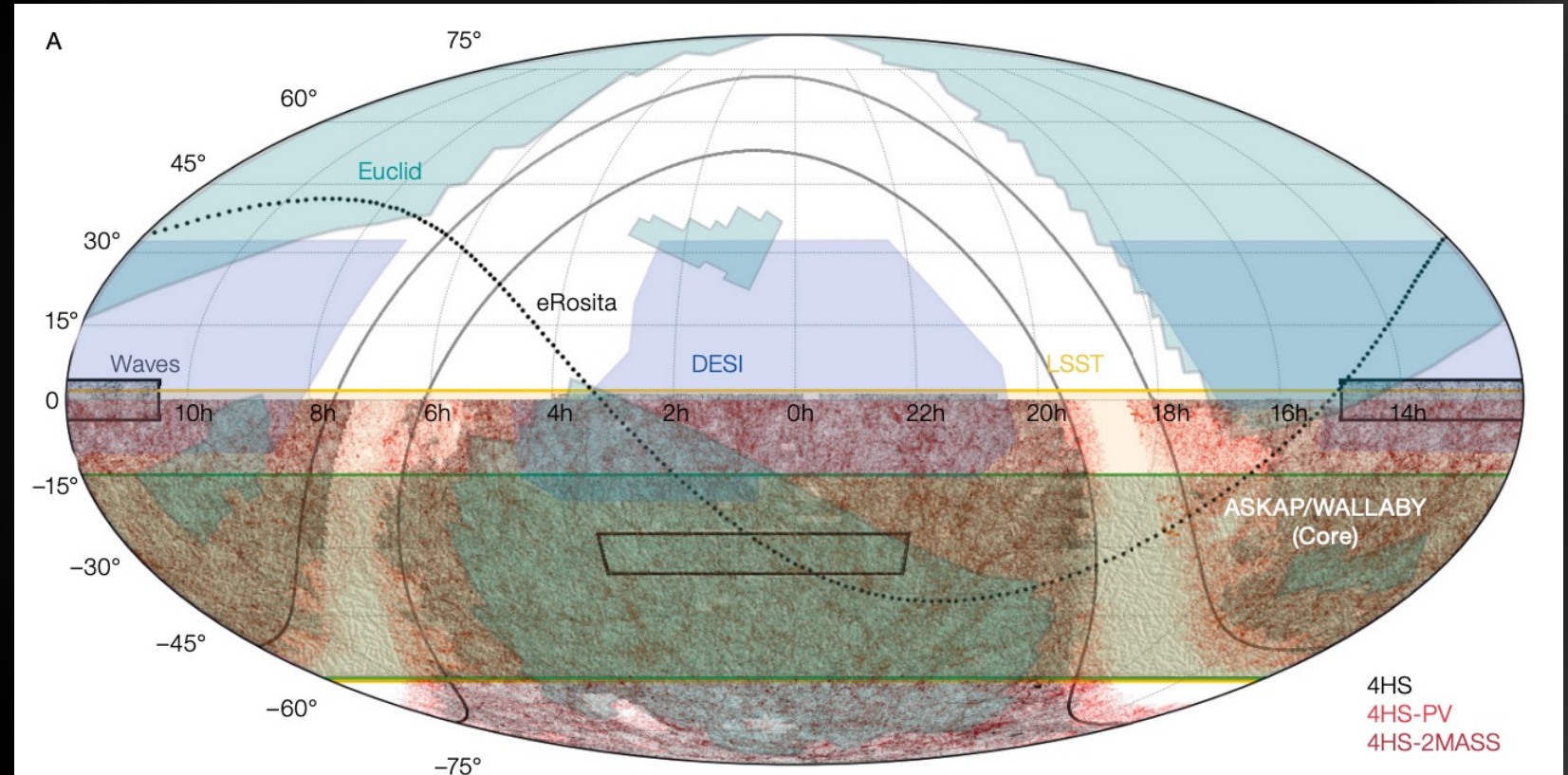
Some excellent preliminary results have been obtained using SV

- Target Selection paper (Saulder et al. 2023)
- Tully-Fisher relation (Douglass et al. in prep)
- Fundamental Plane (Said et al. in prep)

Future peculiar velocity surveys:

The 4MOST Hemisphere Survey of the Nearby Universe (4HS)

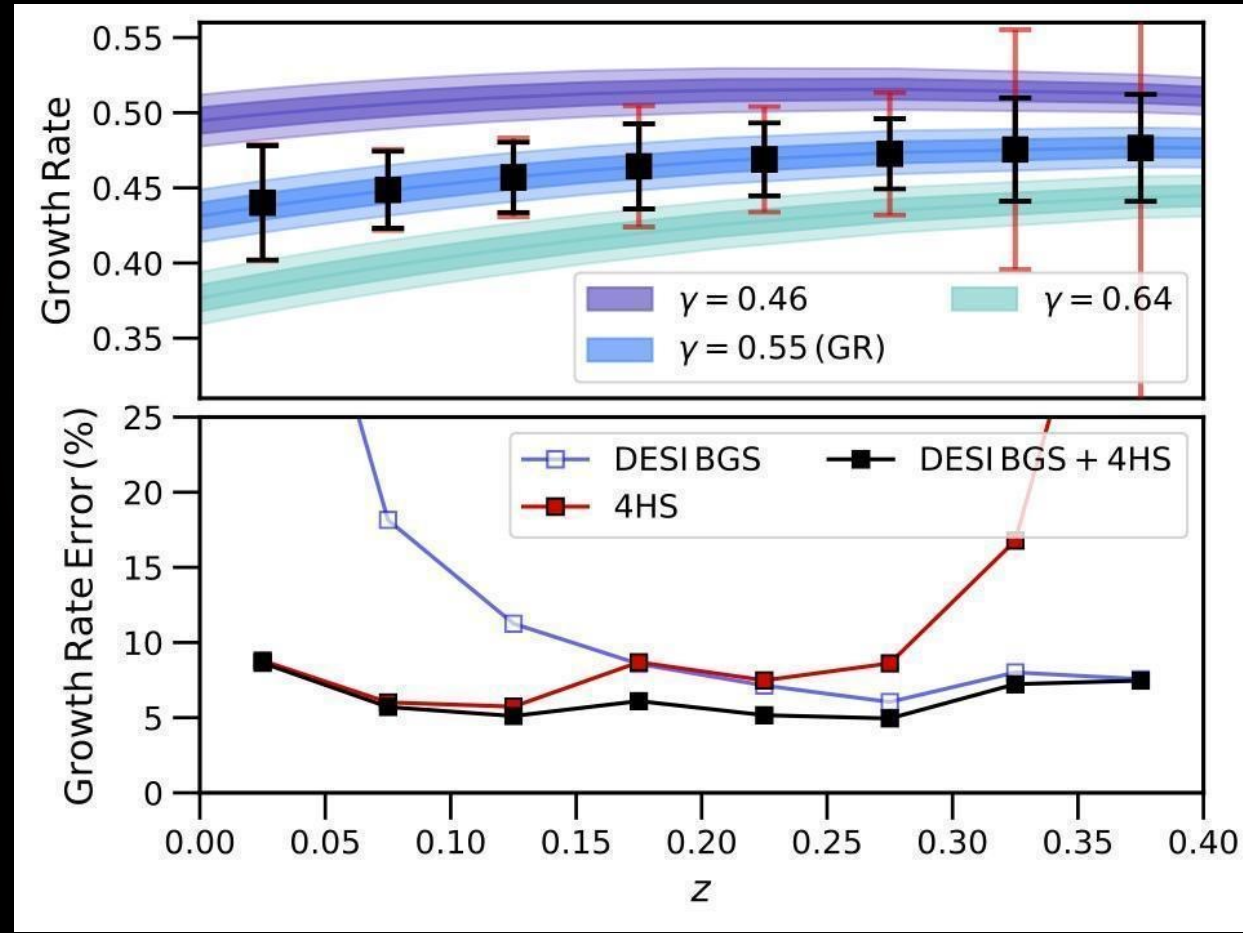
- A spectroscopic redshift survey of ~ 6 M galaxies spanning $17\,000\text{ deg}^2$
- Complete the map of mass and motion in the Local Volume



Taylor, Cluver et al.2023

Future peculiar velocity surveys:

The 4MOST Hemisphere Survey of the Nearby Universe (4HS)

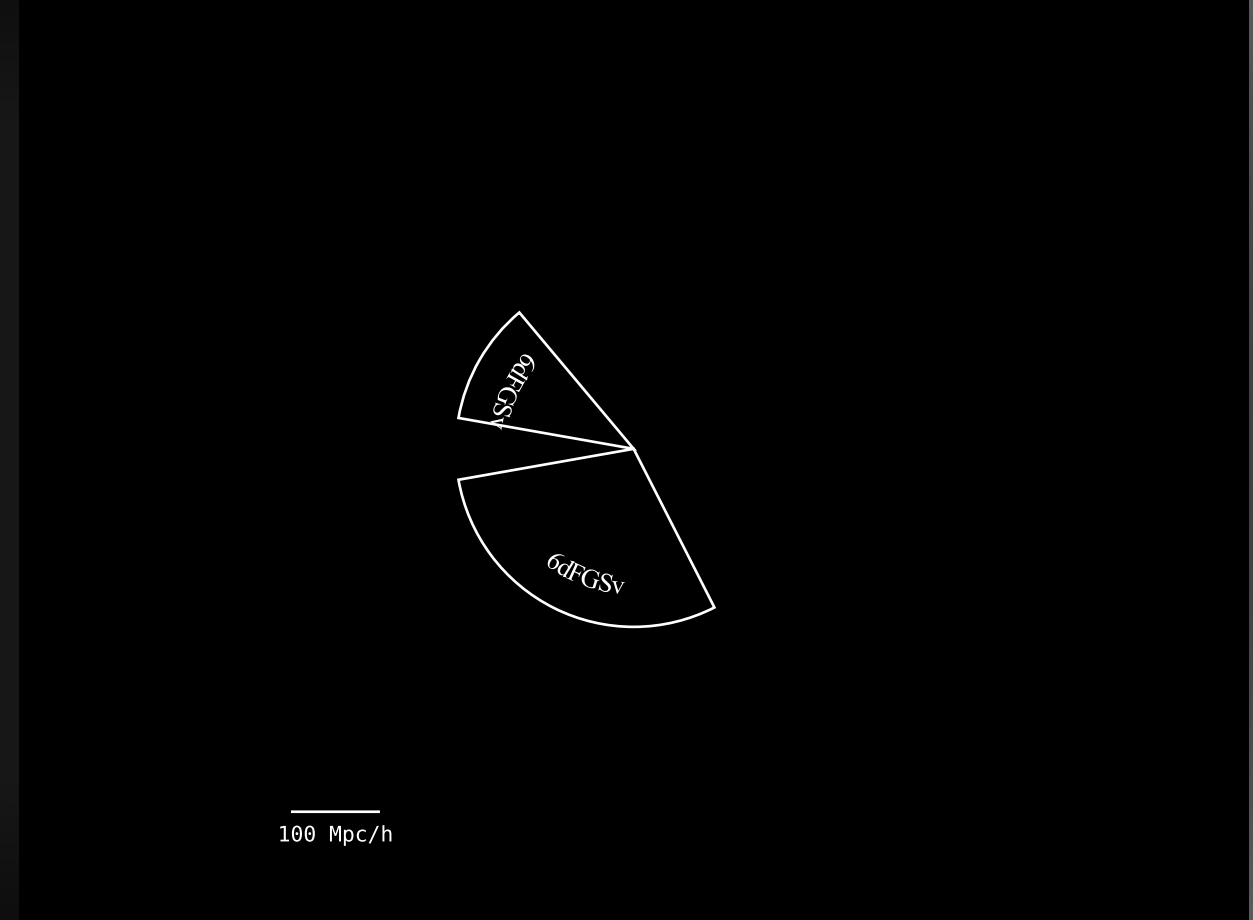


Taylor, Cluver et al. 2023

Future peculiar velocity surveys:

Summary of current and future PV surveys

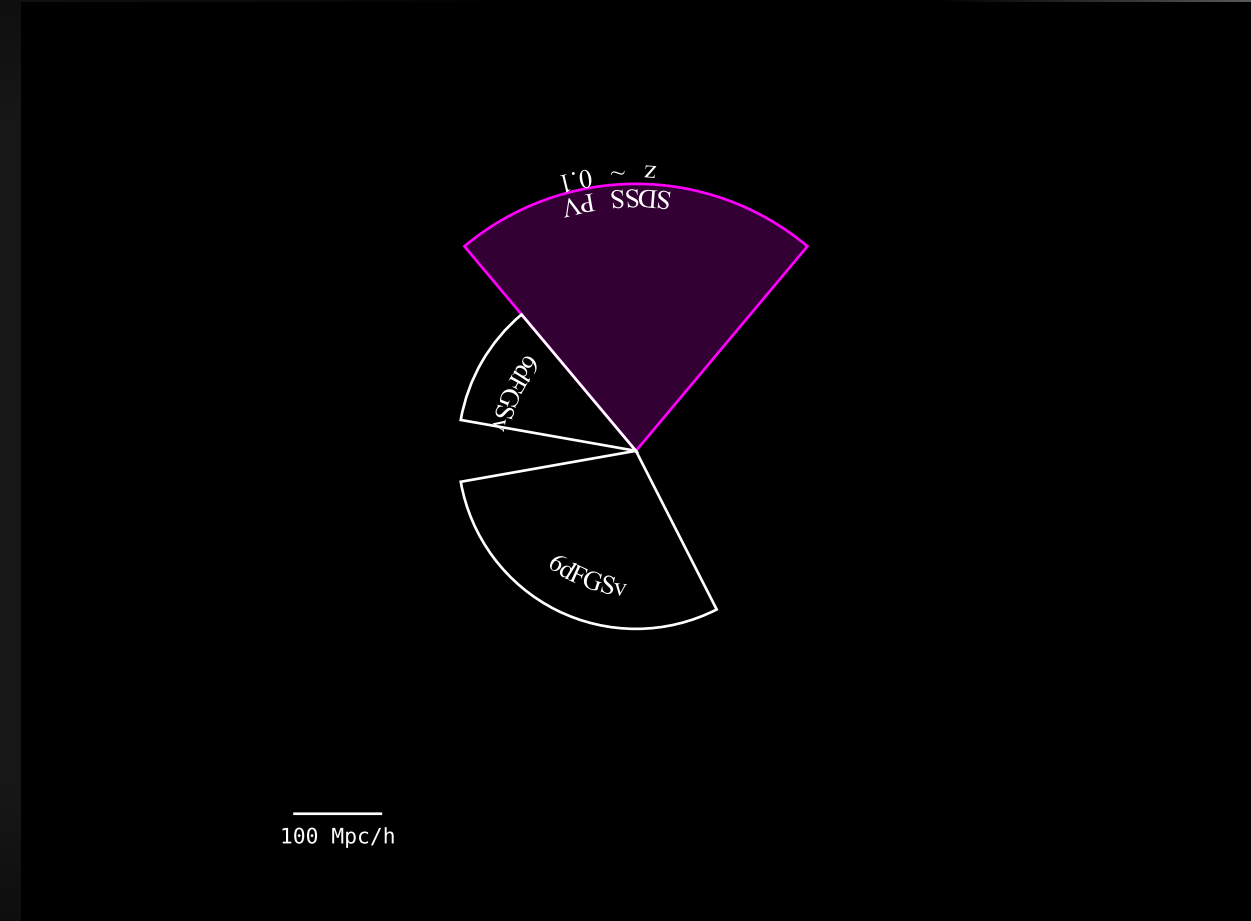
Survey	6dFGSv
Redshift	$z < 0.06$
Distance indicator	FP
Distances	8k
Timeline/ reference	Published /Springob +2014



Future peculiar velocity surveys:

Summary of current and future PV surveys

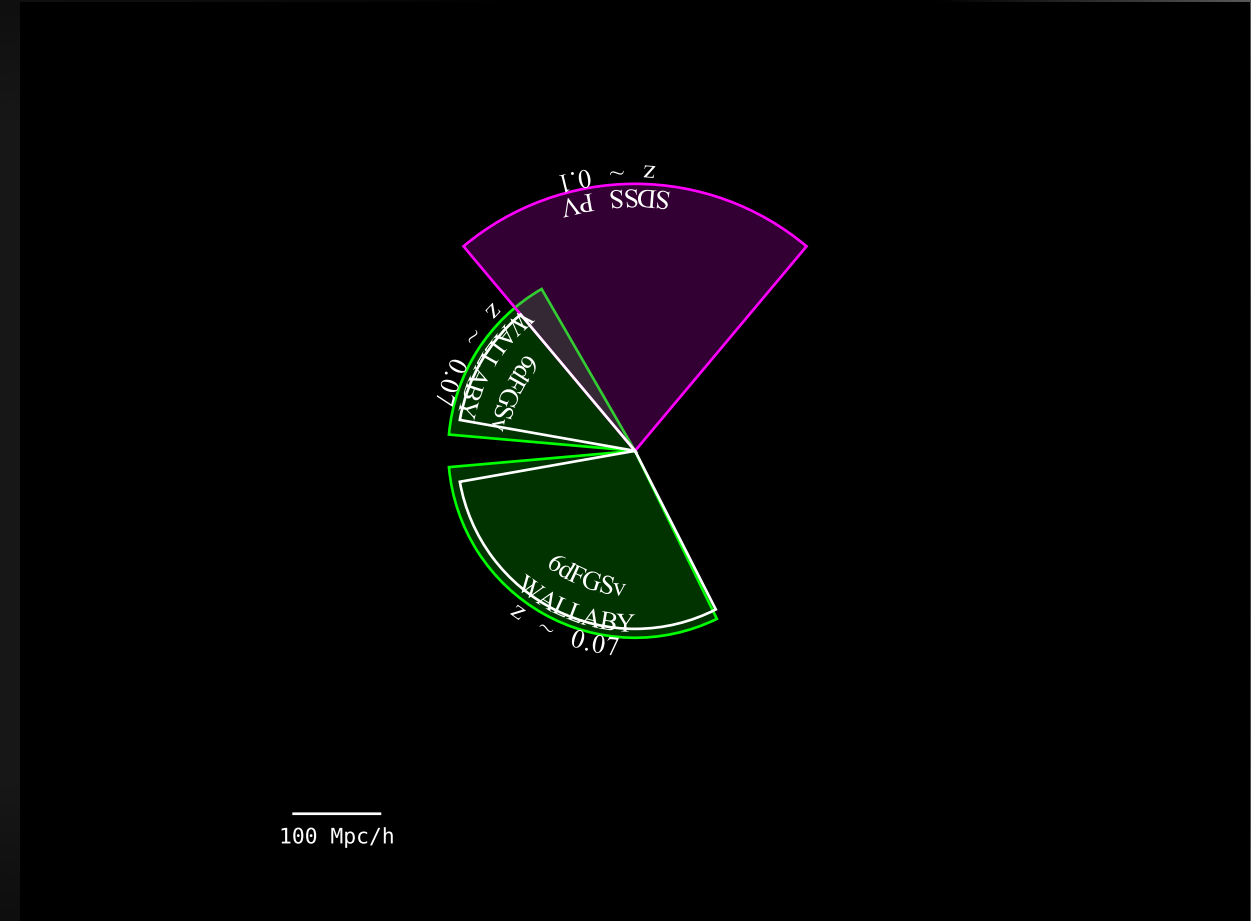
Survey	6dFGSv	SDSS
Redshift	$z < 0.06$	$z < 0.1$
Distance indicator	FP	FP
Distances	8k	34k
Timeline/reference	Published /Springob +2014	Published /Howlett +2022



Future peculiar velocity surveys:

Summary of current and future PV surveys

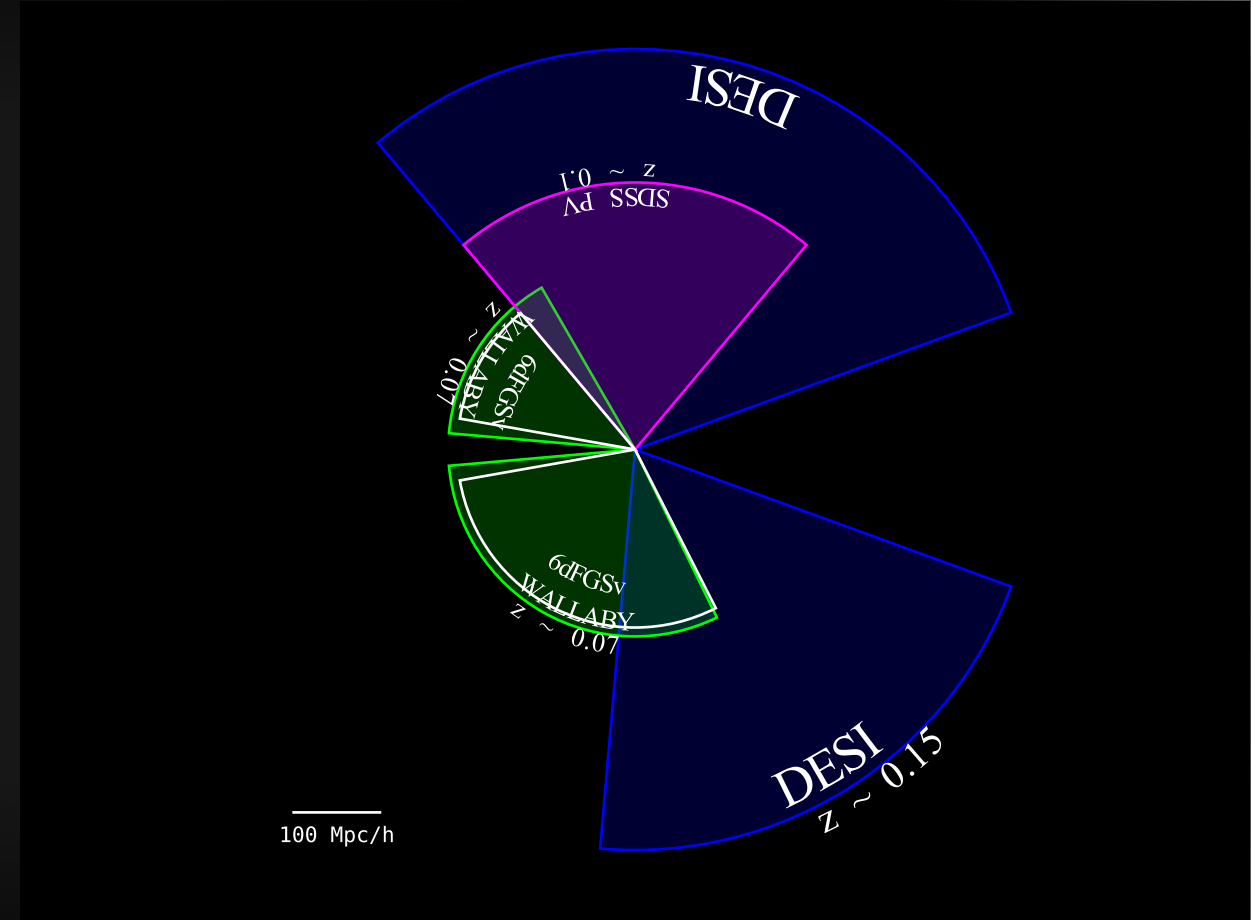
Survey	6dFGSv	SDSS	WALLABY
Redshift	$z < 0.06$	$z < 0.1$	$z < 0.07$
Distance indicator	FP	FP	TF
Distances	8k	34k	200k
Timeline/reference	Published /Springob +2014	Published /Howlett +2022	Pilot survey published /Courtois +2023



Future peculiar velocity surveys:

Summary of current and future PV surveys

Survey	6dFGSv	SDSS	WALLABY	DESI
Redshift	$z < 0.06$	$z < 0.1$	$z < 0.07$	$z < 0.15$
Distance indicator	FP	FP	TF	FP & TF
Distances	8k	34k	200k	186k
Timeline/reference	Published /Springob +2014	Published /Howlett +2022	Pilot survey published /Courtois +2023	Target selection published /Saulder+ 2023



Future peculiar velocity surveys:

Summary of current and future PV surveys

Survey	6dFGSv	SDSS	WALLABY	DESI	4HS
Redshift	$z < 0.06$	$z < 0.1$	$z < 0.07$	$z < 0.15$	$z < 0.15$
Distance indicator	FP	FP	TF	FP & TF	FP
Distances	8k	34k	200k	186k	450k
Timeline/reference	Published /Springob +2014	Published /Howlett +2022	Pilot survey published /Courtois +2023	Target selection published /Saulder+ 2023	2024-2029/ Taylor+ 2023

