COSMOLOGICAL PARAMETERS FROM THE COMPARISON OF **PECULIAR VELOCITIES** WITH PREDICTIONS FROM THE **DENSITY FIELD** IN THE NEARBY UNIVERSE

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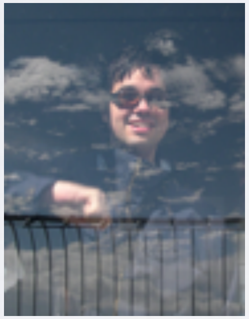

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IAP

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Quy Nhon July 5, 2016

WHY PECULIAR VELOCITIES?

- Is the problem of the LG's motion solved?
- At the 75% level

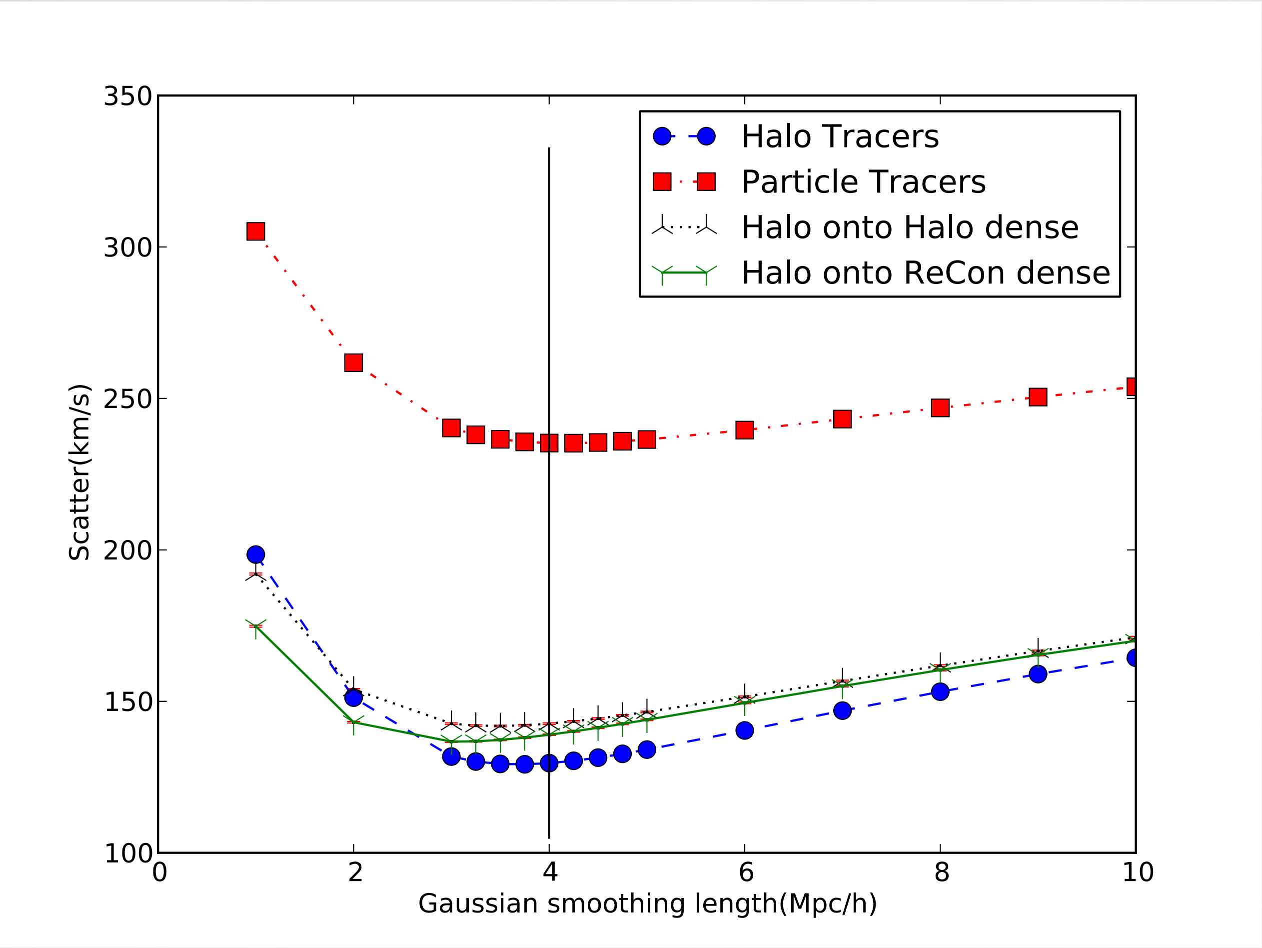
WHY PECULIAR VELOCITIES?

- Measure growth factor ***f*** and $\boldsymbol{\sigma_8}$ (also test gravity): **infall**
- Measure the *matter* power spectrum on very large (~Gpc) scales in the low z Universe : **bulk flow**

PREDICTING PECULIAR VELOCITIES FROM THE DENSITY FIELD

$$\mathbf{v}\left(\mathbf{r}\right) = \frac{fH_0}{4\pi} \int d^3\mathbf{r}' \delta_m\left(\mathbf{r}'\right) \frac{\left(\mathbf{r}' - \mathbf{r}\right)}{\left|\mathbf{r}' - \mathbf{r}\right|^3}$$

TESTS ON SIMULATIONS



Scatter around linear theory is ***~140 km/s*** for a Gaussian smoothing of 4 Mpc/h.

Slope is ***unbiased*** at this smoothing

Carrick et al 15, MNRAS,450, 317

$$\mathbf{v}(\mathbf{r}) = \frac{f H_0}{4\pi} \int d^3\mathbf{r}' \delta_m(\mathbf{r}') \frac{(\mathbf{r}' - \mathbf{r})}{|\mathbf{r}' - \mathbf{r}|^3}$$

β

$$\mathbf{v}(\mathbf{r}) = \frac{f}{b} \frac{H_0}{4\pi} \int_0^{R_{\max}} d^3\mathbf{r}' \delta_g(\mathbf{r}') \frac{(\mathbf{r}' - \mathbf{r})}{|\mathbf{r}' - \mathbf{r}|^3} + \mathbf{V}_{\text{ext}}$$

$$\delta_g = b\delta$$

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

$$\sigma_{8,g} = b\sigma_8$$

$$\beta = \frac{f}{b}$$

Measurable

$$f\sigma_8 = \beta\sigma_{8,g}$$

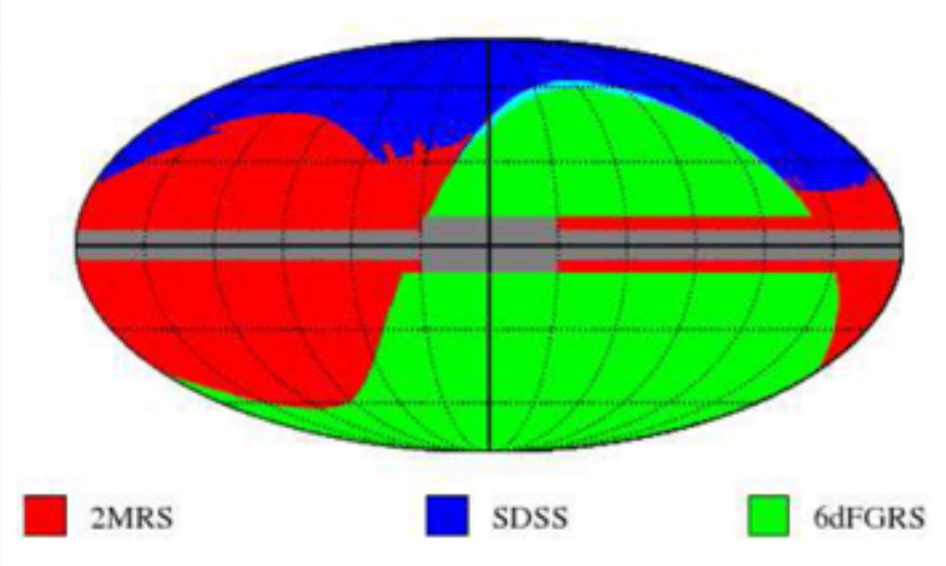
2M++

Lavaux & Hudson 2011, MNRAS, 416, 2840

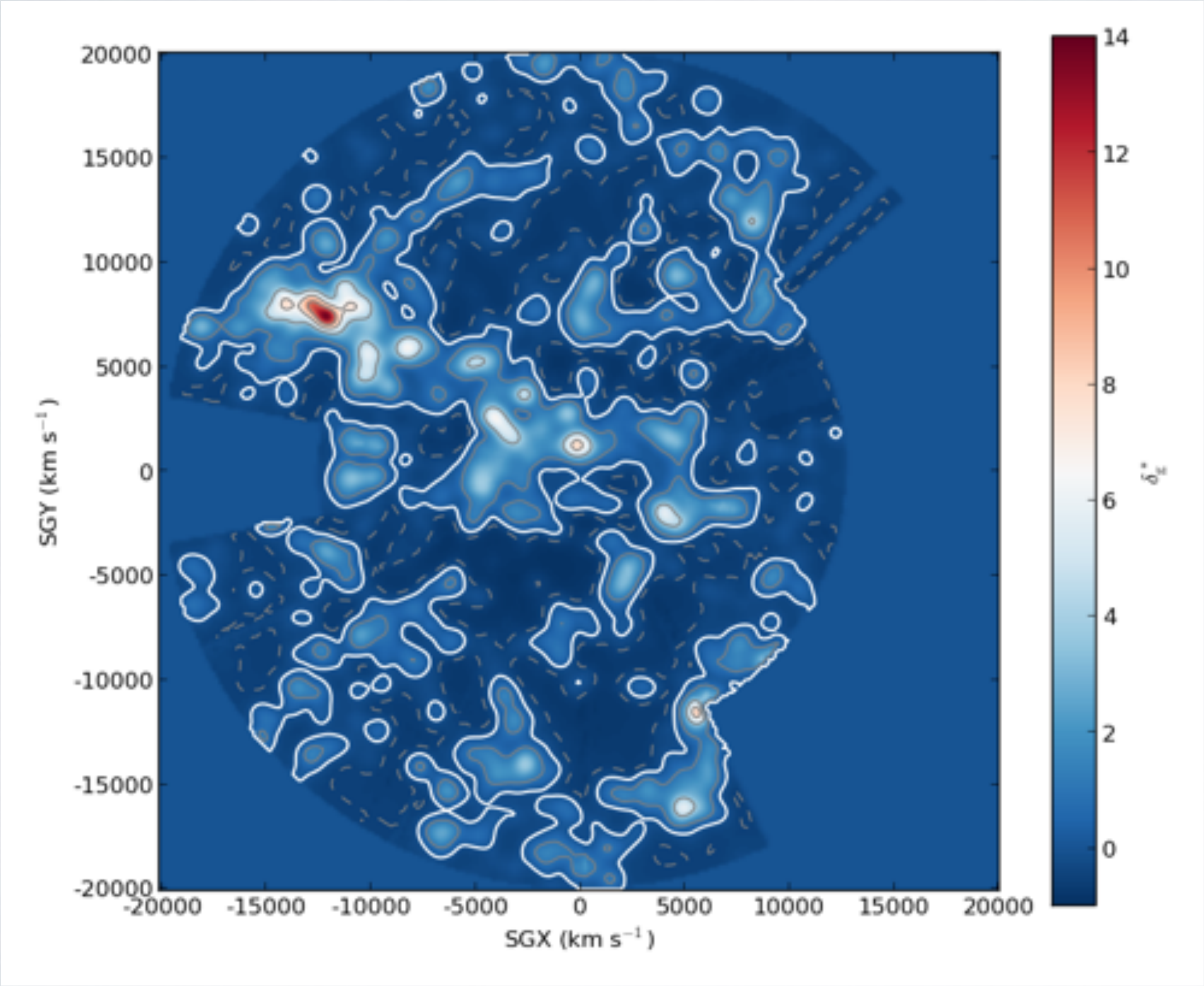
- Combine 2MRS (K<11.5), 6dF (K<12.5) and SDSS (K<12.5)

- ~70k galaxies

- 200 Mpc/h in 6dF and SDSS areas

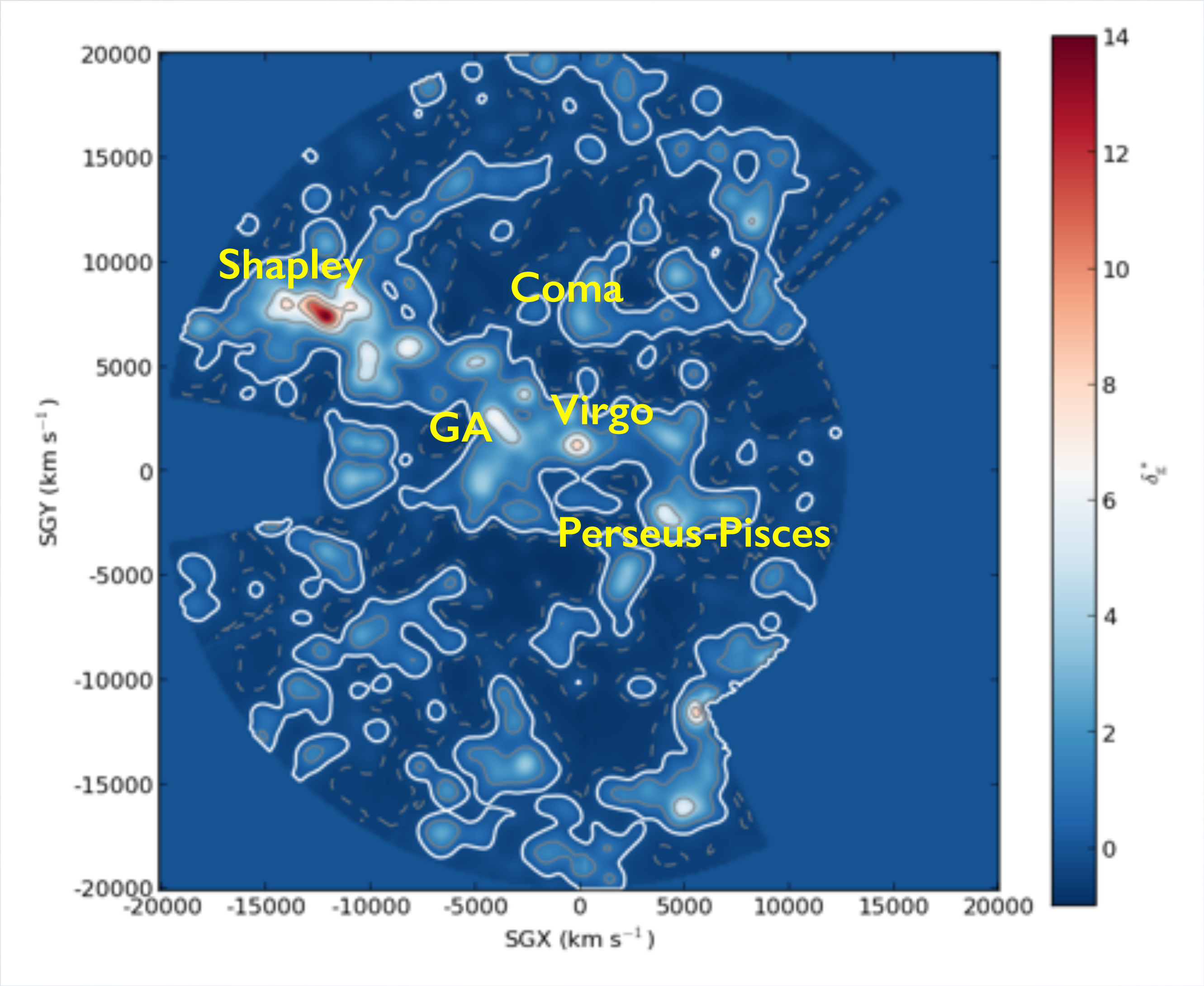


2M++ RECONSTRUCTION



Carrick et al 15, MNRAS, 450, 317

2M++ RECONSTRUCTION



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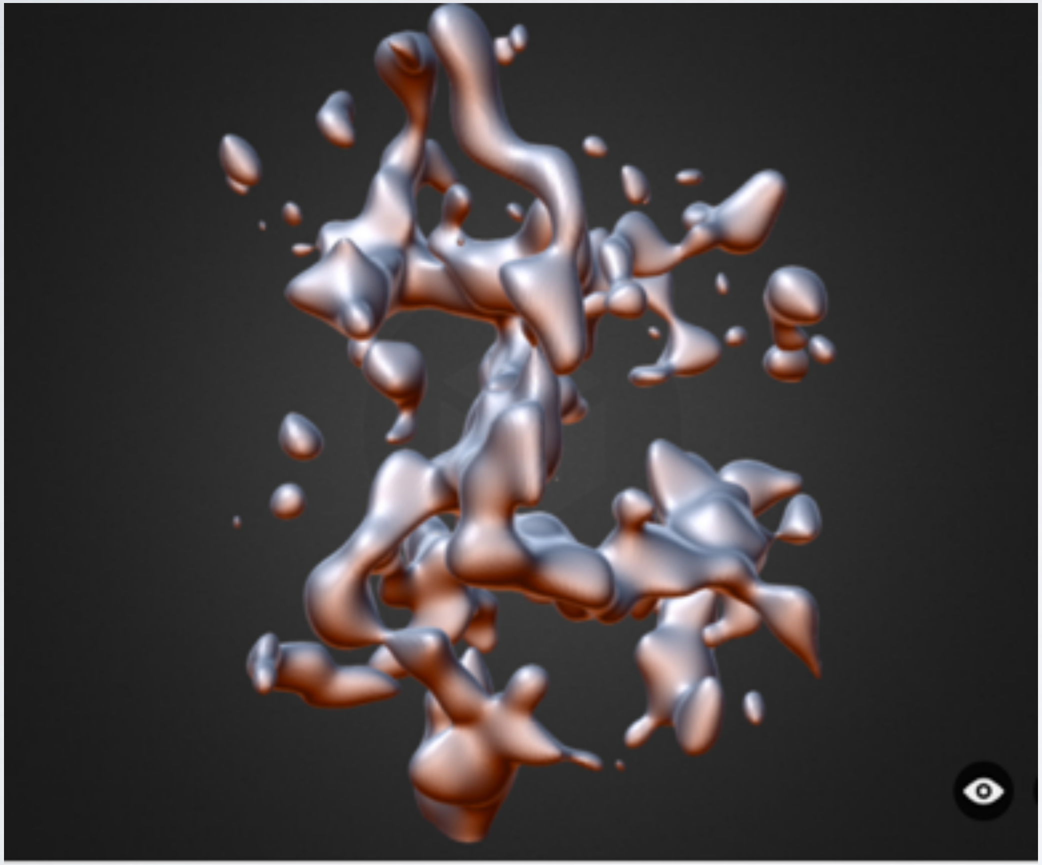
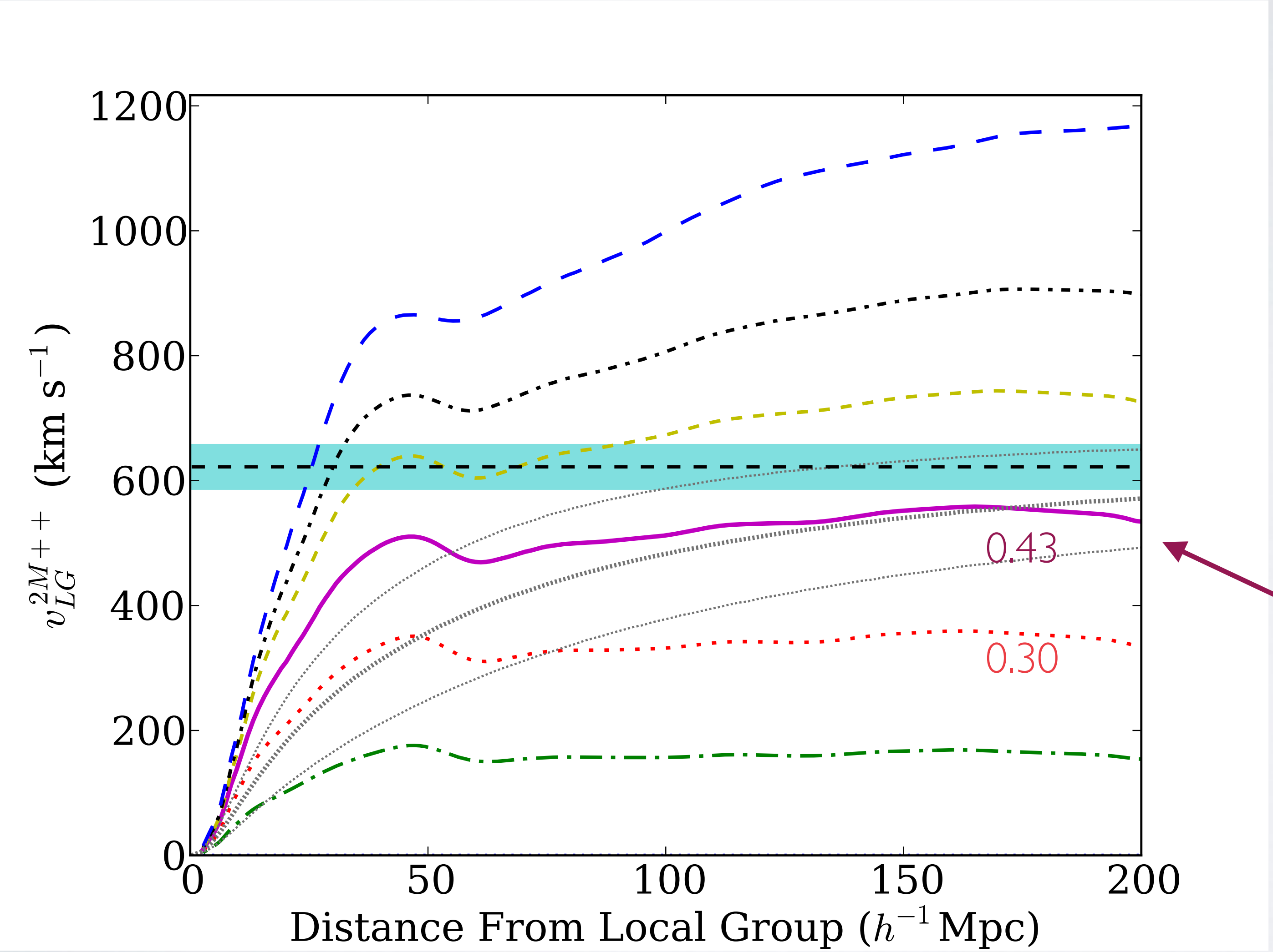
NOW IN 3D!



https://skfb.ly/Iy7R

2M++ GRAVITY DIPOLE



Excellent alignment ~ 10 degrees.

ΛCDM we expect ~40 km/s per component from material beyond 20000 km/s.

If β ~ 0.43 for this sample, then we have recovered much of LG dipole.*

Carrick et al. 2015

PECULIAR VELOCITY DATA

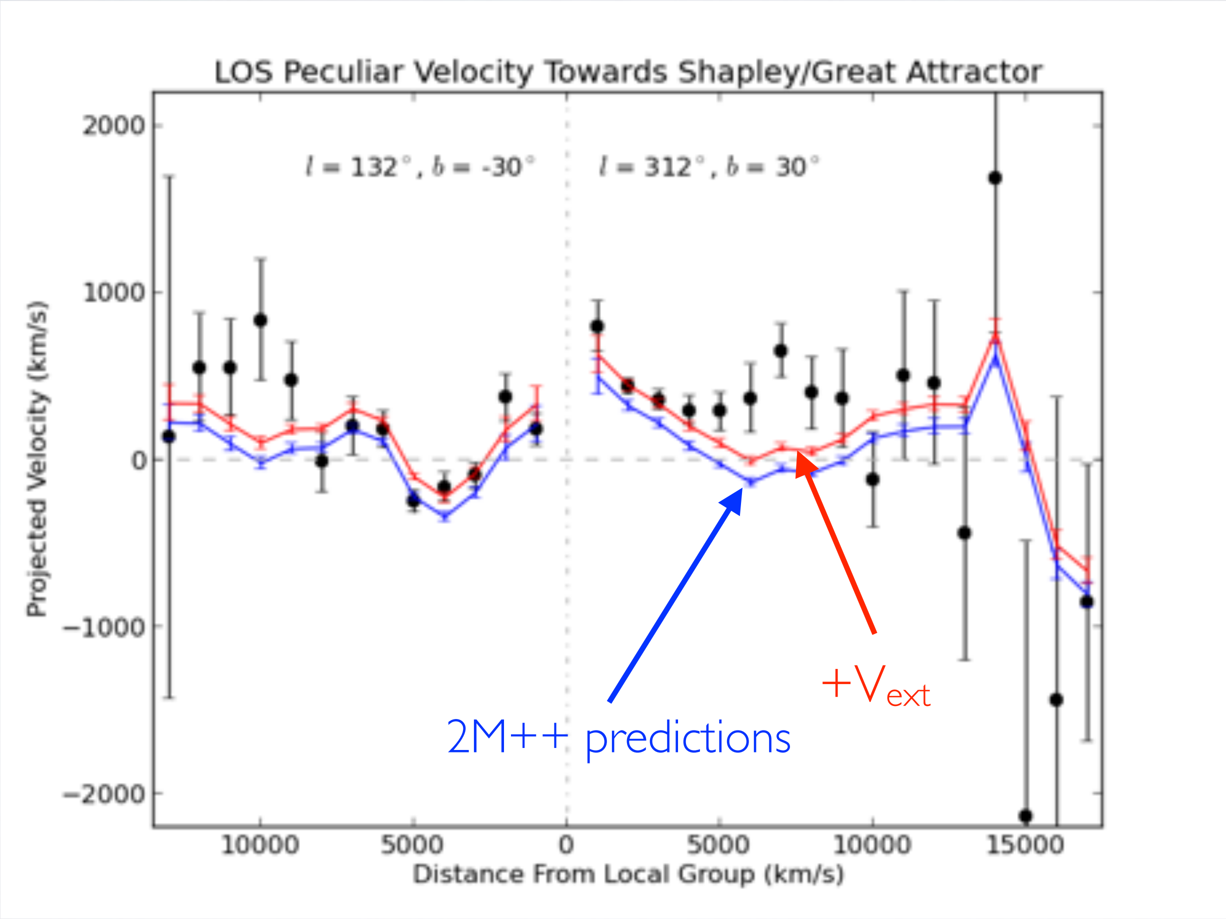
- **SFI++** (Spiral TF Field I-band)
    - Masters et al 2006, Springob et al 2007
    - Cut to exclude faint, low linewidth galaxies (similar to Davis et al)
- **“First Amendment” SNe** (245)
    - Compiled by Turnbull et al 2012

Table 1. Summary of best-fitting values of β^* using different weighting schemes, methods of analysis and peculiar velocity data sets. Results obtained using luminosity weighting are indicated by (LW), whereas those obtained using number weighting are indicated by (NW). Unless explicitly indicated, all data sets were used for the method mentioned with the exception of Inverse VELMOD which used all individual galaxies from SFI++.

		β^*	χ^2/(DOF)
	Forward likelihood (LW)		
SNe	A1	0.440 ± 0.023	–
TF	SFI++ Galaxy Groups	0.429 ± 0.022	–
	SFI++ Field Galaxies	0.423 ± 0.045	–
	All	$\mathbf{0.431 \pm 0.021}$	–
	Forward likelihood (NW)	0.439 ± 0.020	–
TF	Inverse VELMOD (LW)	0.387 ± 0.048	–
	χ^2 (LW)	0.444 ± 0.026	2194/2899
	χ^2 (NW)	0.442 ± 0.028	2200/2899

Reduced Chi^2 ~ 1

PREDICTIONS VS. OBSERVATIONS



- Overall patches reduced Chi^2 ~ 1

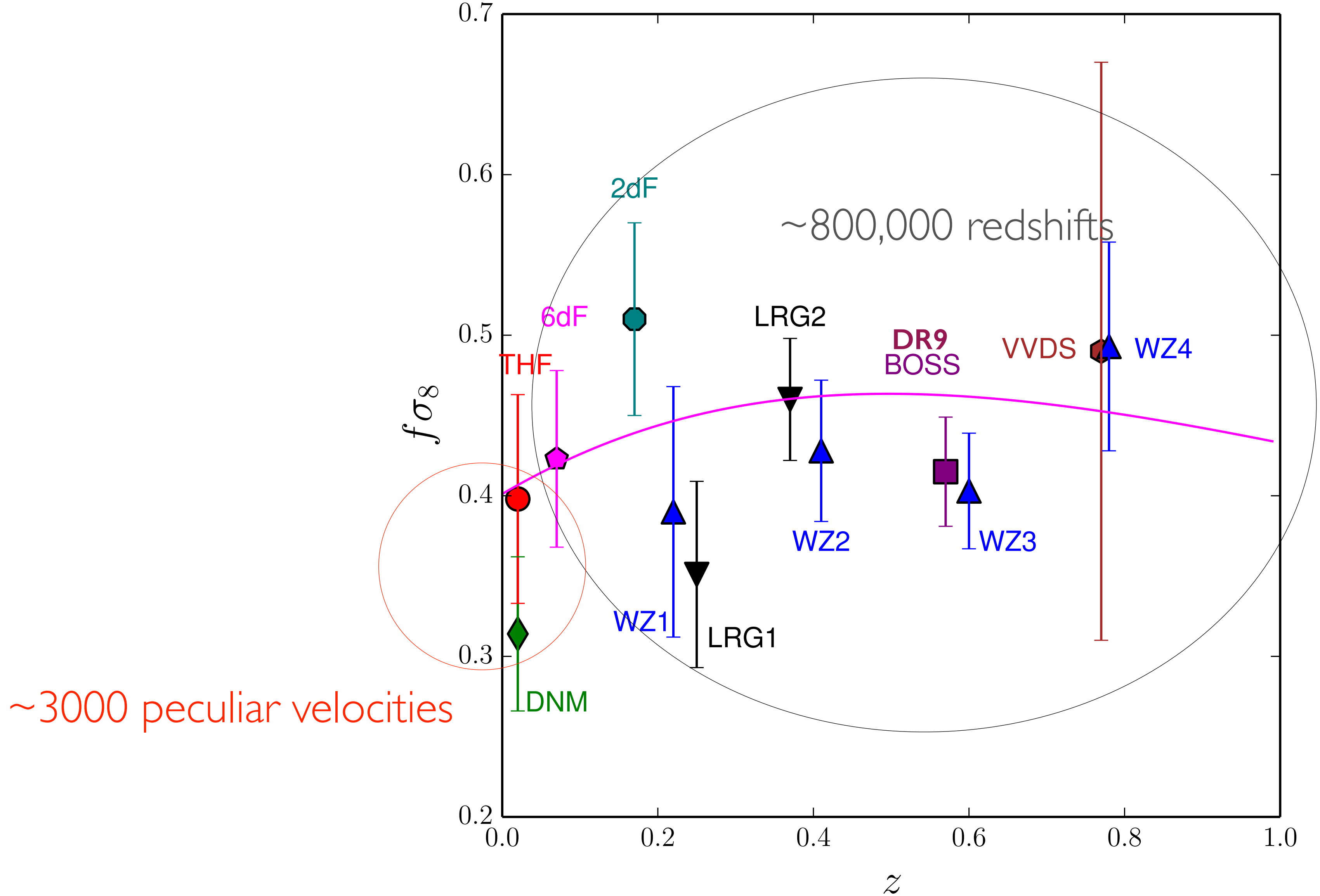
Carrick et al 15

COSMOLOGICAL PARAMETERS

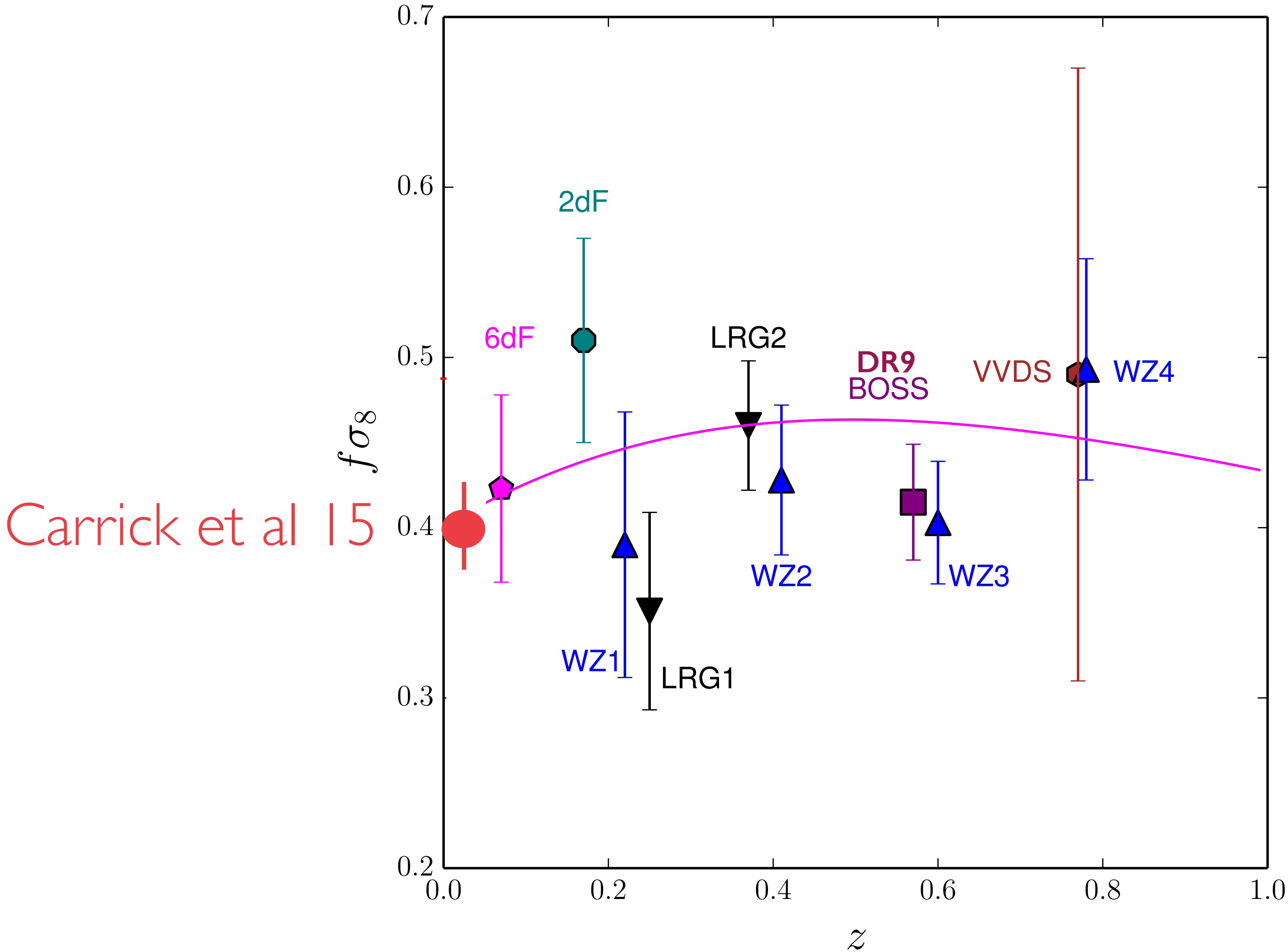
Combined with galaxy clustering measurements, peculiar velocities yield:

$$f\,\sigma_8 = 0.401 \pm 0.024$$

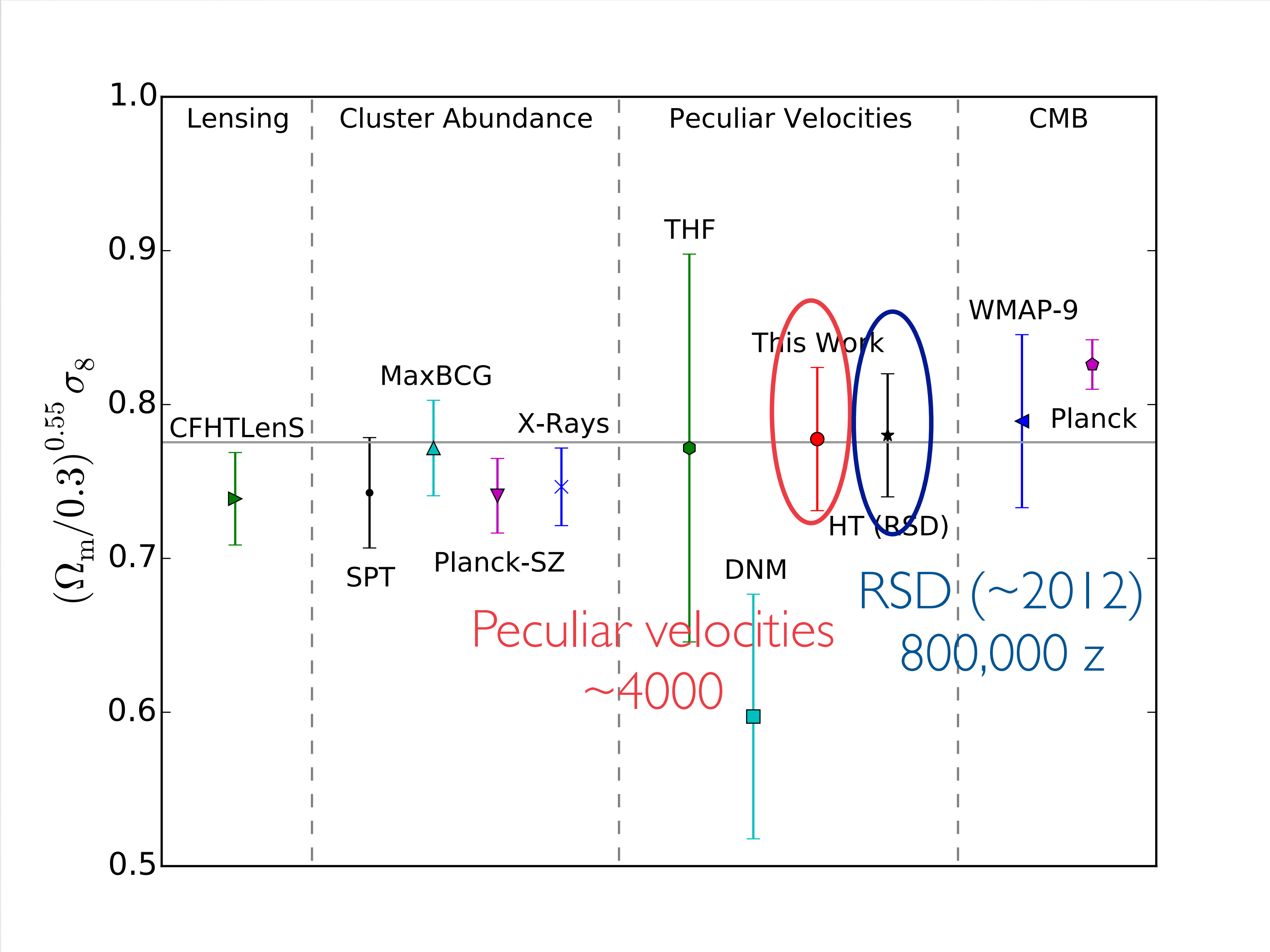
Peculiar velocities are consistent with other cosmological probes on small (~20 Mpc/h) scales.



Hudson and Turnbull 2012, ApJL, 751, L30, arXiv:1203.4814



Carrick et al 15
2dF
6dF
LRG2
DR9
BOSS
VVDS
WZ4
WZ2
WZ3
WZ1
LRG1
$f\sigma_8$
z
0.2
0.3
0.4
0.5
0.6
0.7
0.0
0.2
0.4
0.6
0.8
1.0



$f\sigma_8$ from different probes

Carrick et al 15

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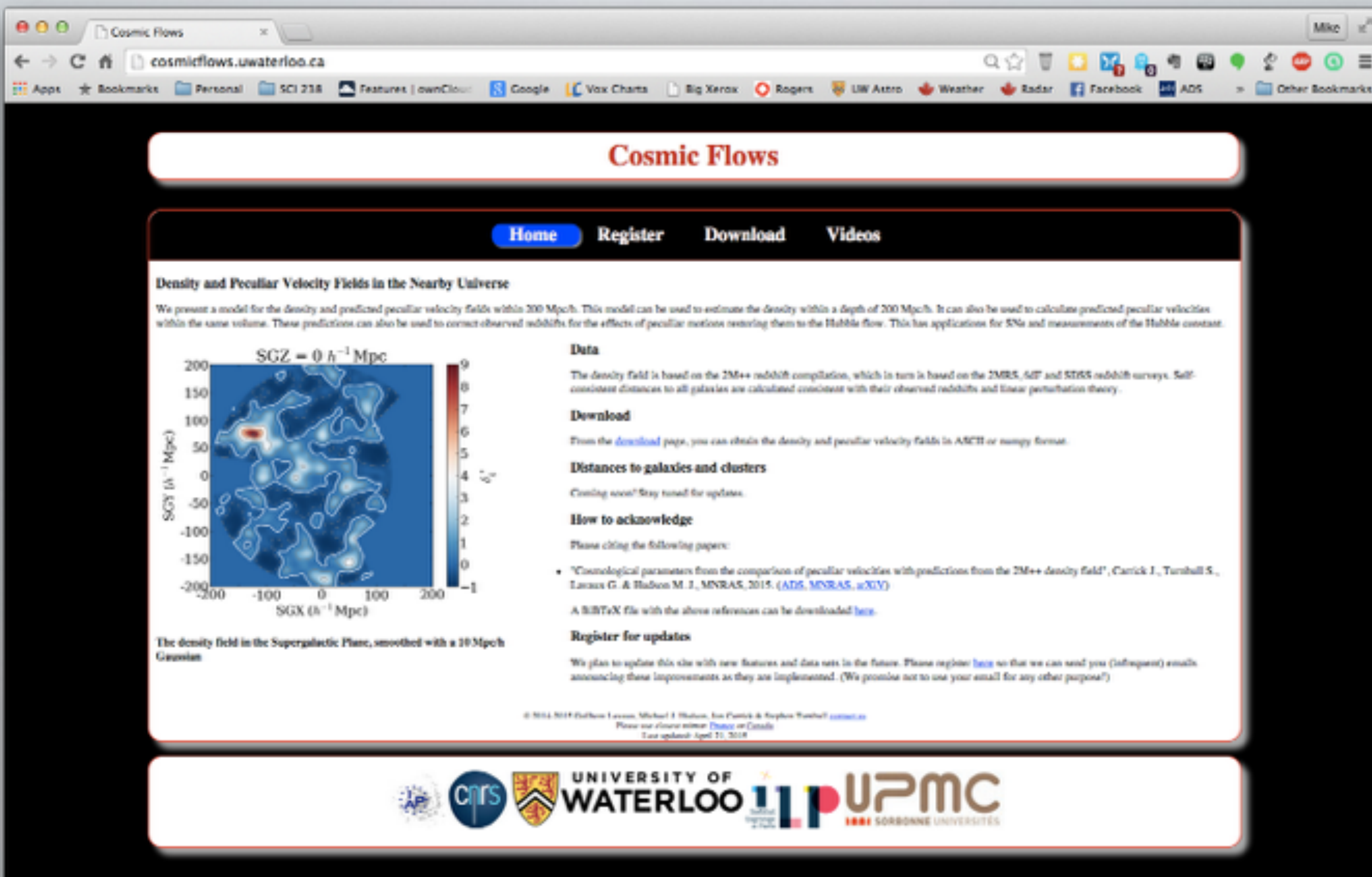
- The residual bulk flow suggests that 2M++ does not account for all of the local motion:

  V_{ext} = *159 ± 23 km/s towards l=304, b=6*

- Is the missing contribution:
  - Beyond 200 Mpc/h?

    LCDM predicts ~40 km/s per component from R>200 Mpc/h
  - In the ZoA
  - Or within the volume spanned by the 2M++ data?

    linear biasing not adequate?



cosmicflows.uwaterloo.ca or cosmicflows.iap.fr

COSMIC FLOWS SUMMARY

- Only ~3000 peculiar velocities give competitive constraints on $\boldsymbol{f\sigma_8}$.
- 2M++ recovers most of the LG motion *wrt* CMB, but there remains a significant "external" contribution.

Cosmic flows estimated from direct peculiar velocity estimates have great potential : need systematic SDSS-like surveys such as TAIPAN, DESI …