Towards a Local Group Factory?

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האוניברסיטה העברית בירושלים
The Hebrew University of Jerusalem

Constrained LG Simulations

Settings:

- Box 100 Mpc/h
- $256^3/512^3$ DM particles
- 100 / 24 seeds

Pipeline for C-ICs:

- CF2 (+ JS MBc)
- WF/CR/RZA3D
- IceCoreMPI (+ Ginnungagap)

Constrained LG Simulations

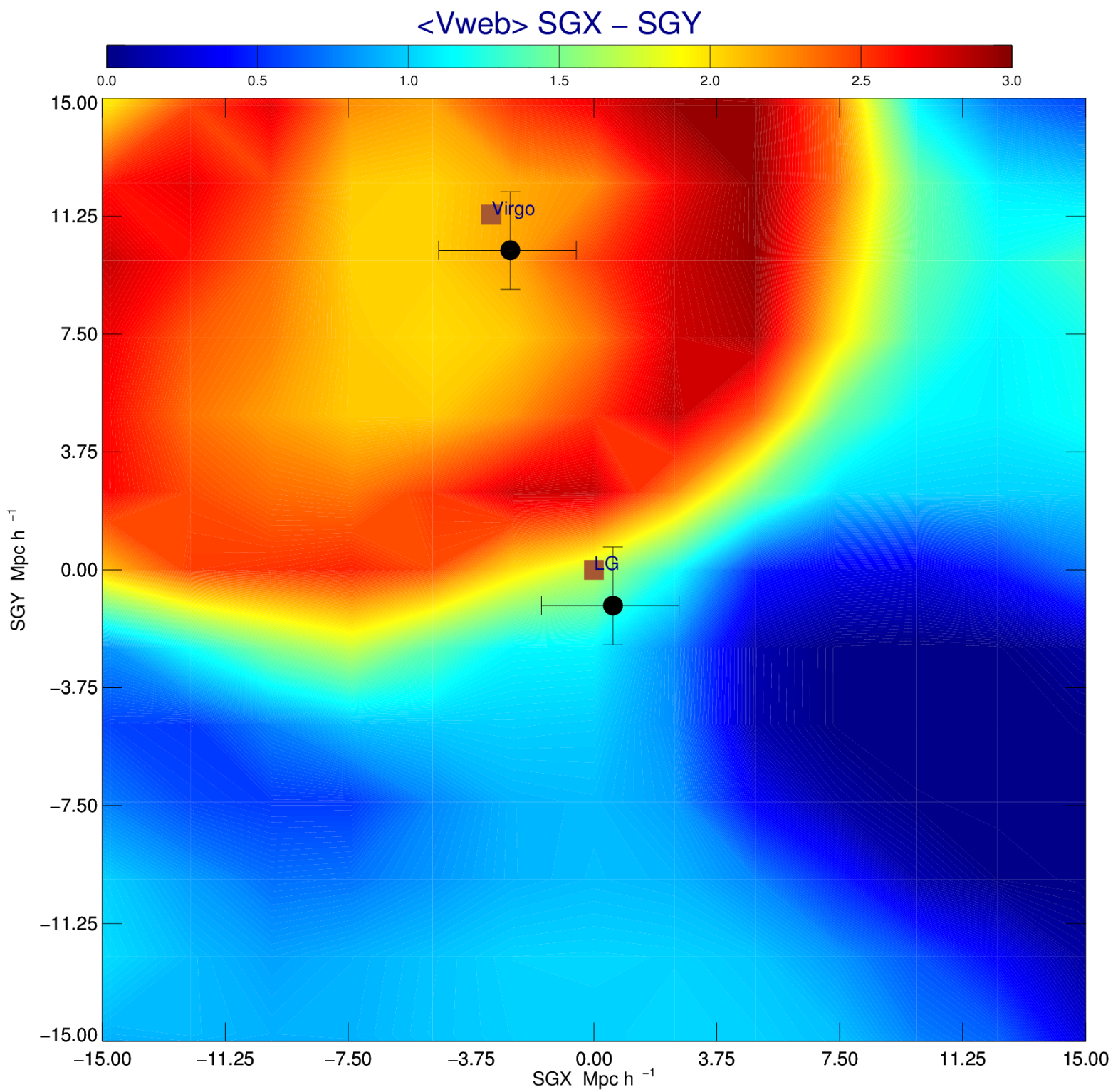
Large Scale Environment of the LG:

- Virgo
- Local Void
- Filament

Shear Tensor analysis for void & filament

Virgo reconstruction in 100 Mpc/h box:

- MedianMass = $\left(2.1 \pm 0.7\right) \times 10^{14} M_{\circ} h^{-1}$
- MedianPos.Err.= $\left(2.6 \pm 0.8\right) Mpc\, h^{-1}$


<Vweb> SGX – SGY
0.0
0.5
1.0
1.5
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15.00
11.25
7.50
3.75
0.00
−3.75
−7.50
−11.25
−15.00
SGY Mpc h −1
Virgo
LG
−15.00
−11.25
−7.50
−3.75
0.00
3.75
7.50
11.25
15.00
SGX Mpc h −1

Eigenvalues at LG position

Virgo-shifted Box Center:

l_1 = 0.174 +/- 0.062

l_2 = 0.013 +/- 0.075

l_3 = -0.270 +/- 0.074

Box Center:

l_1 = 0.192 +/- 0.063

l_2 = 0.052 +/- 0.067

l_3 = -0.259 +/- 0.062

Eigenvectors at LG position

Eigenvector	mean	median	std.dev.
1_x	-0.494	-0.505	0.165
1_y	-0.425	-0.451	0.179
1_z	0.685	0.732	0.217
2_x	0.452	0.458	0.165
2_y	0.522	0.542	0.19
2_z	0.639	0.671	0.231
3_x	0.702	0.708	0.071
3_y	-0.687	-0.693	0.084
3_z	-0.12	-0.103	0.09

LG Candidates

First selection (<u>BROAD CRITERIA</u>):

- Mass: $(0.5-5)\times 10^{12} M_{\odot} h^{-1}$
- Distance: 5 Mpc/h from boxcenter, R(MW-M31) <1.5 Mpc/h
- Third largest halo: d > 3 Mpc/h

Mass	Vrad	Vtan	D Center	D Pair	D Virgo	N Sim
1.19E+012	-98.8676	32.5863	4.30484	0.609373	12.7942	4
5.63E+011						
1.25E+012	-94.0964	82.5701	3.7939	0.872125	9.68774	22
7.68E+011						
1.44E+012	-123.361	30.0712	4.99993	0.472016	12.1209	55
9.21E+011						
1.39E+012	-75.0246	30.2132	3.9487	0.831775	11.0606	59
7.63E+011						
1.63E+012	-129.219	62.2468	3.97876	0.714165	11.7207	63
7.47E+011						
1.54E+012	-80.6988	45.6205	4.28529	1.15292	13.9551	64
1.04E+012						
2.59E+012	-115.228	37.2332	4.35503	1.15014	13.776	74
1.25E+012						
8.10E+011	-112.625	6.34714	4.16644	0.901382	13.0769	89
8.05E+011						
1.49E+012	-91.1179	36.8057	4.07603	0.831184	12.5686	95
9.68E+011						
2.12E+012	-83.3594	72.8277	4.67266	0.920987	11.6375	98
8.05E+011						

Semi-Conserved Quantites

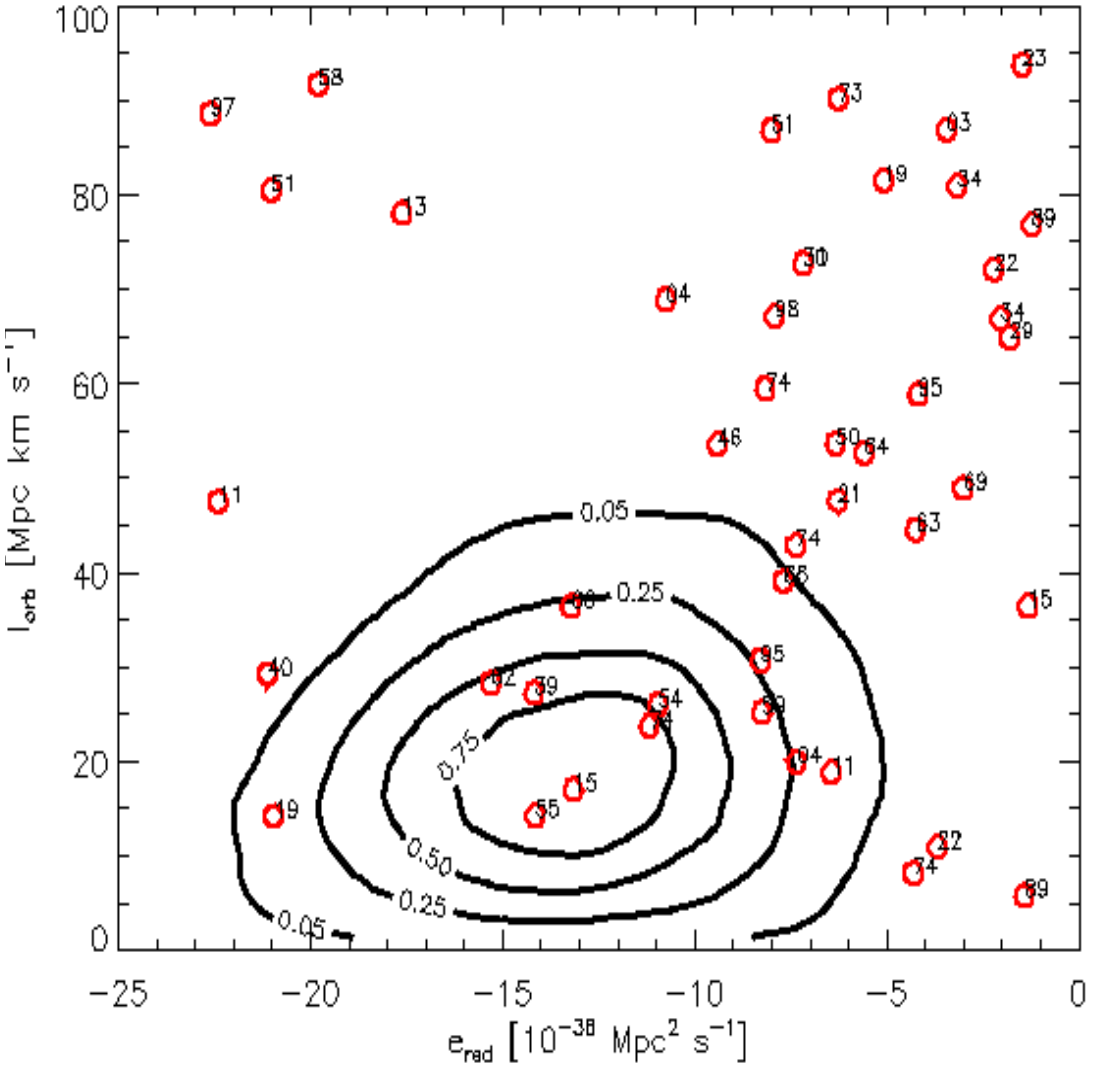
Forero-Romero, Hoffman, Bustamante, Gottloeber, Yepes 2013

TABLE 1
SUMMARY OF KINEMATIC OBSERVATIONAL CONSTRAINTS.

$v_{\rm M31,rad}$	$(\mathrm{km\ s^{-1}})$	-109.3 ± 4.4
$v_{\rm M31,tan}$	$(\mathrm{km\ s^{-1}})$	< 34.4
$r_{\rm M31}$	(kpc)	770 ± 40
$\mathbf{r}_{\rm M31}$	(kpc)	$(-378.9, 612.7, -283.1)$
$\sigma_{\mathbf{r},\rm M31}$	(kpc)	$(-18.9, 30.6, 14.5)$
$\mathbf{v}_{\rm M31}$	$(\mathrm{km\ s^{-1}})$	$(66.1, -76.3, 45.1)$
$\sigma_{\mathbf{v},\rm M31}$	$(\mathrm{km\ s^{-1}})$	$(26.7, 19.0, 26.5)$
$M_{200,\rm MW}$	$(10^{12}\mathrm{M}_\odot)$	1.6 ± 0.5
$M_{200,\rm M31}$	$(10^{12}\mathrm{M}_\odot)$	1.6 ± 0.5
$M_{200,\rm MW} + M_{200,\rm M31}$	$(10^{12}\mathrm{M}_\odot)$	3.14 ± 0.58
$\log_{10}\lambda$		-1.72 ± 0.07

Notes:

1. The kinematic properties for M31 are reported in the galactocentric restframe (van der Marel et al. 2012).
2. Values in parenthesis correspond to vector components. $\sigma_{\mathbf{x}}$ represents the uncertainty on the components of vector $\mathbf{x}$. The uncertainties correspond to 1-σ values.
3. The values for the individual halo masses are consistent with the priors used by van der Marel et al. (2012).
4. The observational uncertainties in the position vector correspond to a 5% in each component consistent with the 1-σ uncertainties in the distance (see references in van der Marel & Guhathakurta 2008).



Problem

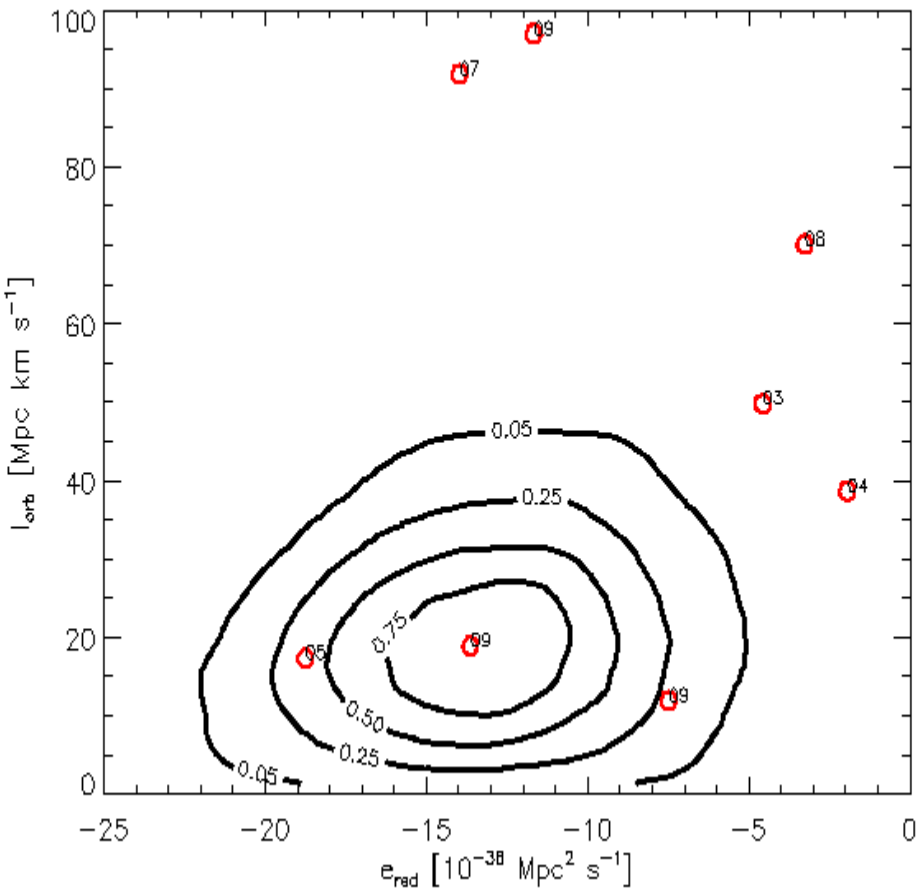
All LG-like and LG-merged objects have very high peculiar velocities > 600 km/s

Intrinsic property of the reconstruction method?
Mbc-related? Tidal fields?

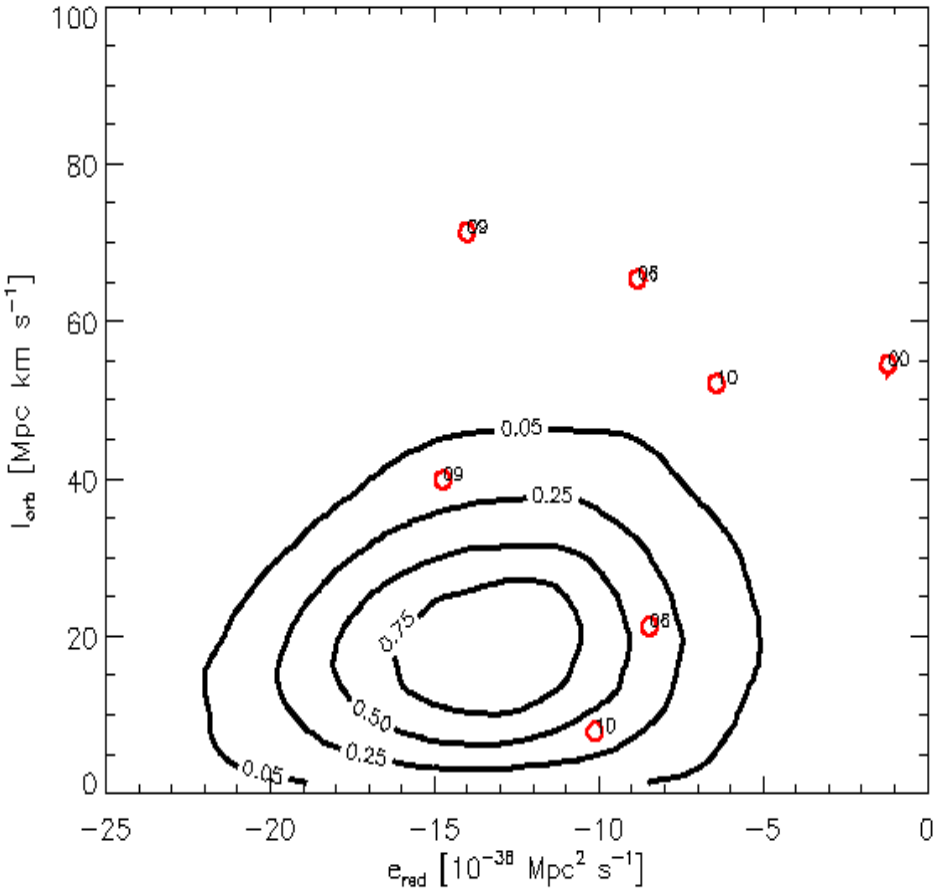
Increasing Resolution

- Use GINNUNGAGAP to increase the resolution to 512^3 DM particles and add short-wave modes
- Environment stable, but substantial changes of LG-like selected objects
- Use the same base 256^3 WN field adding different random seeds for GINNUNGAGAP
- 12 base low-res sims with compatible LG-like objects

Comparing 2 HR Runs



Ginnungagap seed 00



Ginnungagap seed 01

Comparing 2 HR Runs

Mass	Vrad	Vtan	D Pair	N Sim
9.33E+011	-100.104	90.1776	0.551358	3
7.87E+011				
8.69E+011	-136.08	85.7245	0.449781	4
6.75E+011				
2.43E+012	-113.851	146.32	0.626859	7
2.01E+012				
1.18E+012	-89.5448	17.5121	0.674328	9
5.87E+011				

Mass	Vrad	Vtan	D Pair	N Sim
1.66E+012	-140.362	61.0298	0.89173	0
1.00E+012				
1.81E+012	-135.547	27.3187	0.773904	6
1.35E+012				
2.43E+012	-80.2425	89.6376	0.794584	9
1.36E+012				
1.43E+012	-113.529	78.117	0.666056	10
9.86E+011				

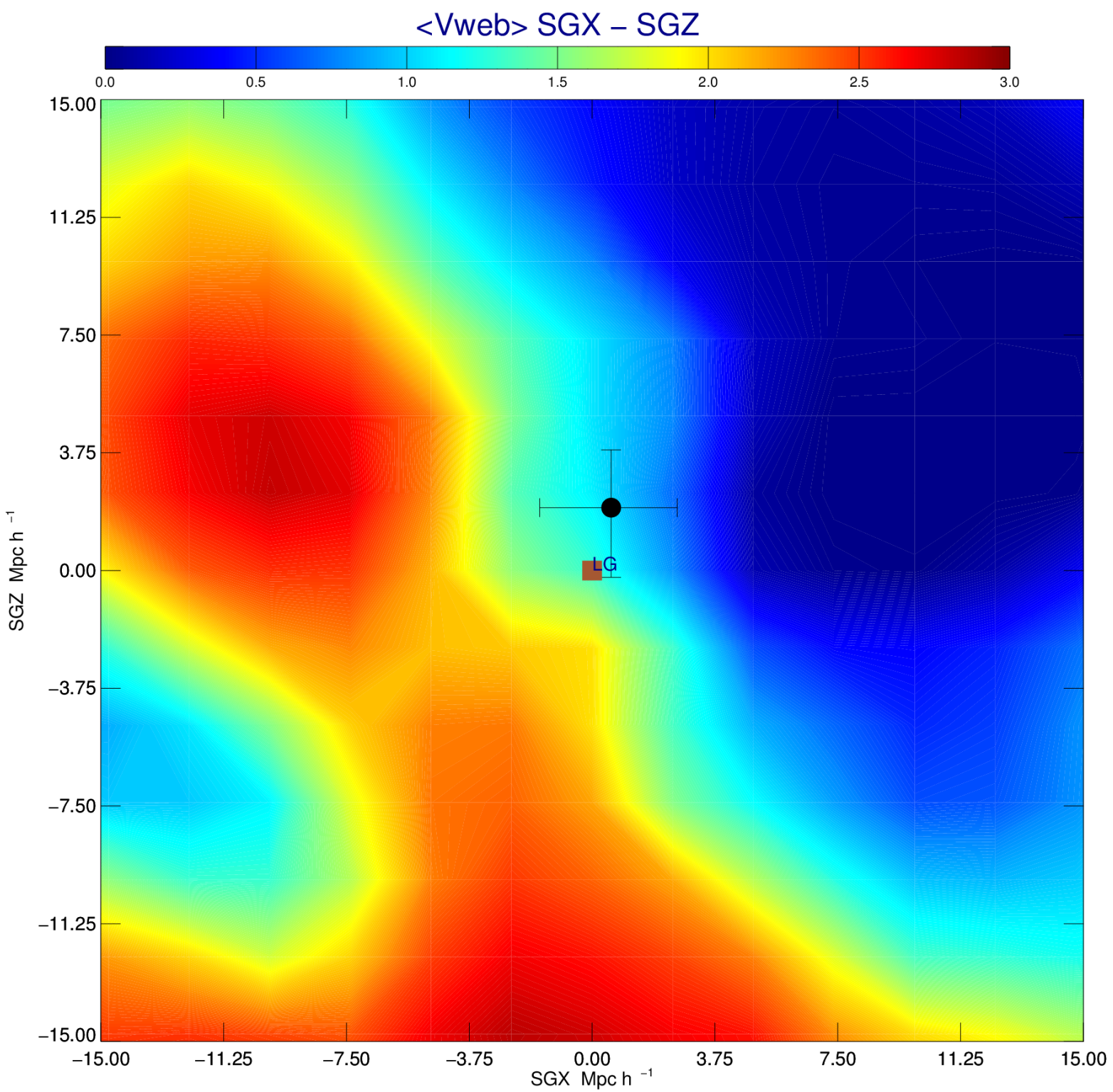
Conclusions

- **Result**: new generation of CS of LG feature a very stable LG environment, substantial number of LG-like objects (isolated halo pairs) at the right position

- **Problems**: very high peculiar velocities (600 km/s), Virgo mass below observational one, increasing resolution.

WATCH YOUR HEAD!

ExtraSlides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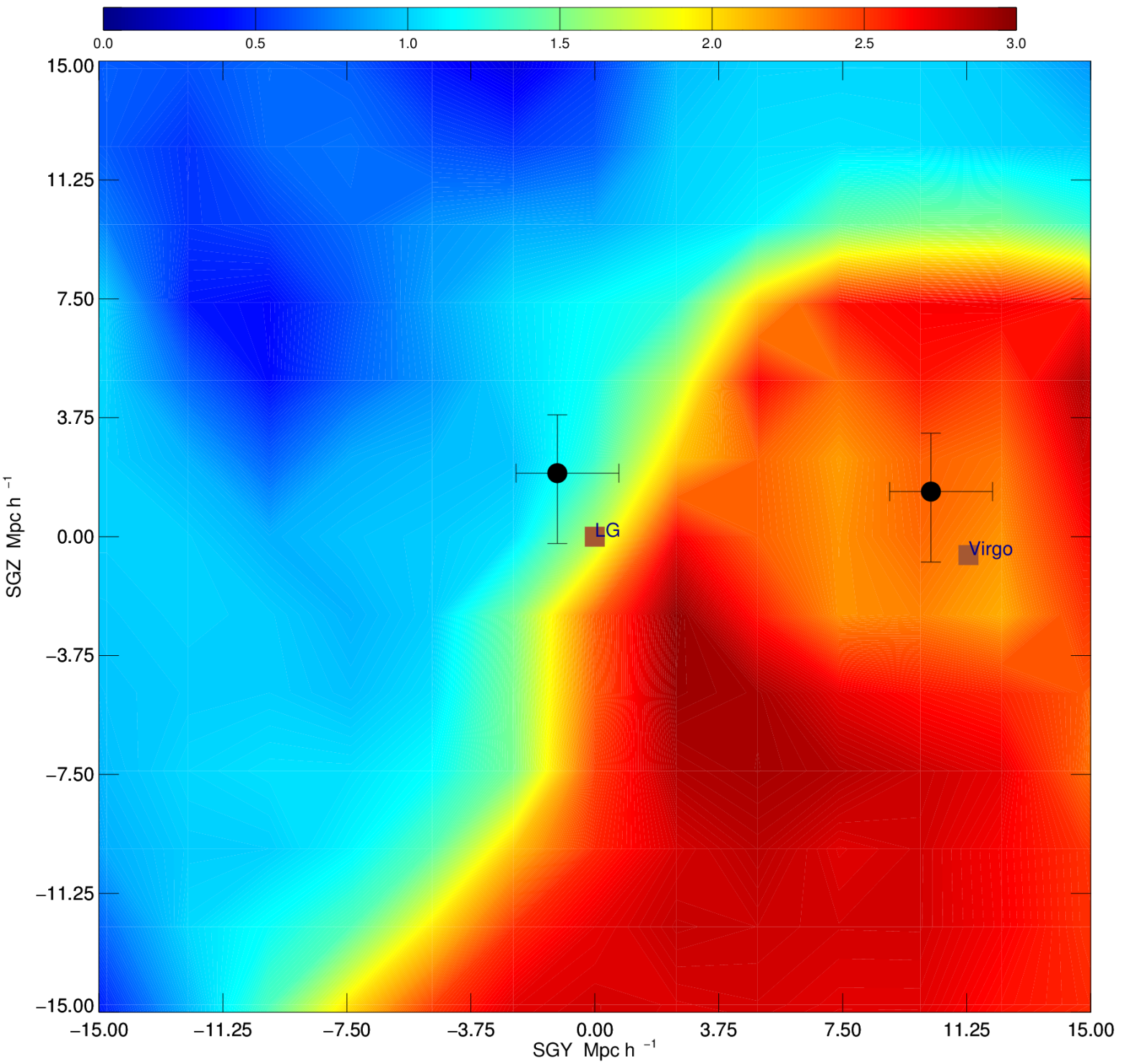
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−11.25
−7.50
−3.75
0.00
3.75
7.50
11.25
15.00
SGY Mpc h −1

Mass	D Center	D Virgo	e1	e2	e3	N Sim
3.15E+012	4.07385	8.29846	0.22505	0.0828073	-0.188772	9
3.70E+012	3.58515	12.3368	0.0821983	0.0530676	-0.175994	37
3.14E+012	4.00546	7.98458	0.233687	0.0846719	-0.187323	40
3.31E+012	3.51553	11.8905	0.17583	0.13816	-0.197253	43
2.09E+012	3.87753	8.71008	0.758351	0.23748	-0.271944	55
2.86E+012	3.45293	10.479	0.168829	0.042033	-0.182629	61
2.20E+012	3.75827	13.7083	0.112137	0.0388597	-0.293784	68
3.18E+012	3.935	9.48649	0.28785	0.134261	-0.232824	78
2.40E+012	3.35905	10.0613	0.185183	0.162081	-0.273945	85
2.91E+012	4.19547	8.54099	0.970199	0.171416	-0.0935953	88

LSE: Cosmic Web

Velocity Shear Tensor on grid (cell=1.56 Mpc/h), compute the number of positive eigenvalues ***I*** at each node.

Define: $l_1 > l_2 > l_3$

VST web classification:

- Voids (type=0)
- Sheets (type=1)
- Filaments (type=2)
- Knots (type=3)