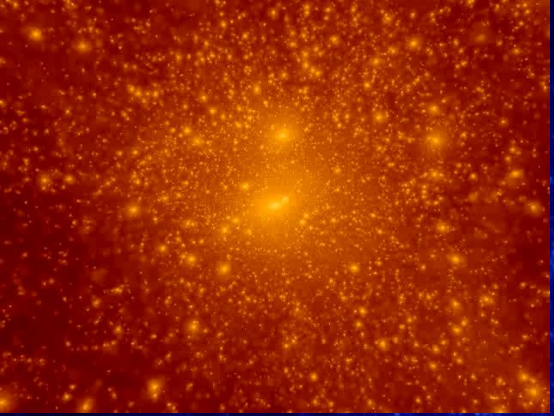
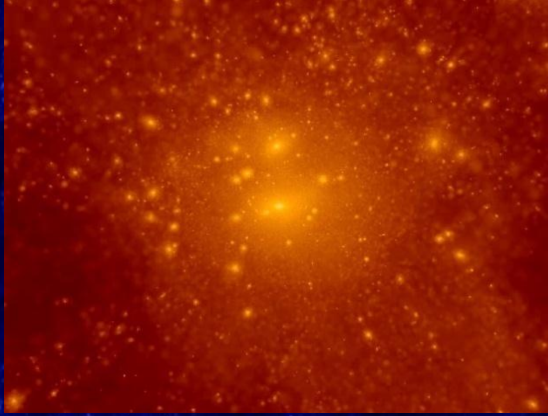
CLUES

Constrained Local UniversE Simulation Project



M31 in CDM

http://clues-project.org



M31 in WDM

How warm can dark matter be ?. Constraining the mass of dark matter particles from the Local Universe

Gustavo Yepes

Universidad Autónoma de Madrid

Ecole International Chalonge

CIAS Meudon 2010

UAM UNIVERSIDAD AUTONOMA DE MADRID

Grupo de Astrofísica Universidad Autónoma de Madrid

CLUES people

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and many more..

http://clues-project.org

The CLUES Builder…

- MareNostrum Supercomputer

  - 5th biggest supercomputer of the world (Top500 November 2006

  -1st supercomputer in Europe.

  -10,240 PPC processors and 20 TeraBytes Memory

  -280+90 Tbytes disk space.

The CLUES Builder…

- MareNostrum Supercomputer

  -h biggest supercomputer of the world (Top500 November 2006. (Now is 40th)

  -t supercomputer in Europe. (now is 10th)

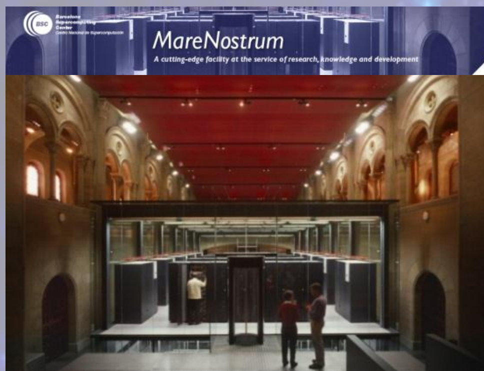
  -10,240 PPC processors and 20 TeraBytes Memory

  -280+90 Tbytes disk space.

-More than **9,000,000 CPU** hours (>1000 years) used since 2005 for the MareNostrum Numerical Cosmology Project (MNCP)

http://astro.ft.uam.es/marenostrum

CLUES
Computational Resources



Barcelona

Madrid

Jülich

LRZ Munich

DEISA

DISTRIBUTED EUROPEAN INFRAST

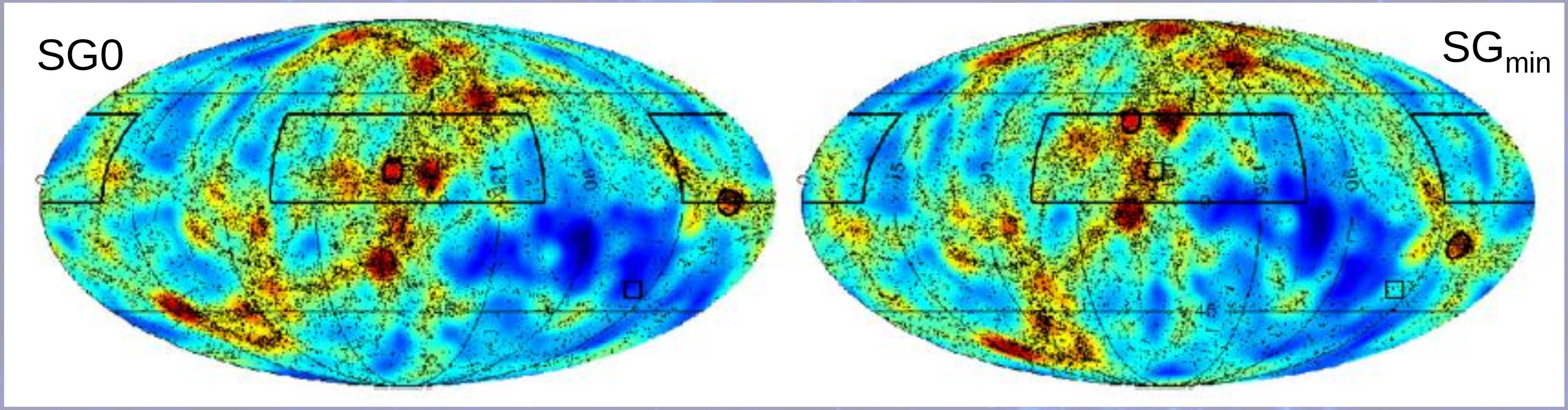
DECI PROJECTS:

SIMU-LU SIMUGAL-LU

2,000,000 cpu h

Proper projection of CLUES volume

- The significance of the study relies on proper representaton of the local environment.
- Based on the location of Virgo and LG in the simulation



Mollweiden proiection in RA-Dec system. 20/h Mpc volume projected

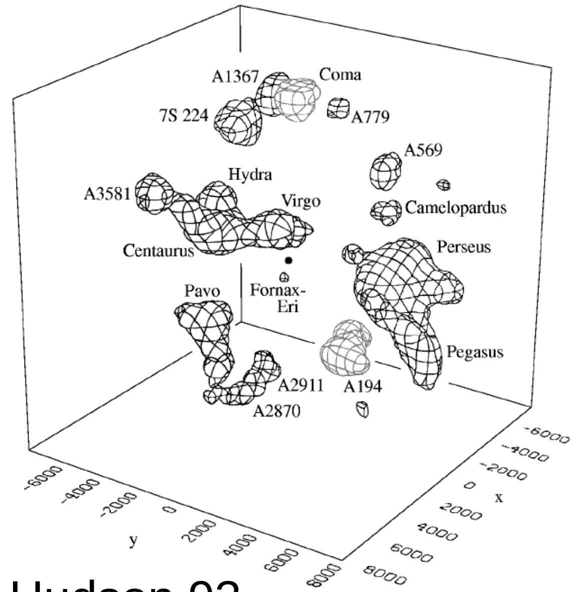
- Good agreement in the VdR, but not so good in the aVdR because of systematic shifts in the position of Fornax. Much better in the SG_{min} projection

The Local Universe

Our Local neighbourhood is the most well know piece of the universe . Thus, an ideal place to test models against observations.

But it is not a representative volume of the universe. It is dominated by large mass concentrations Virgo, Local Supercluster, Coma, G.A).

<u>Cosmic variance has to be beaten when doing Near field cosmology</u>



Hudson 93

Constrained Simulations of the Local Universe

Constrained Simulations are designed to obey a particular set of constrains, in our case the mass and velocity fields in our local neighborhood..

Why use constrained simulations?:

To *beat* the cosmic variance. We try to reproduce the observed distribution and kinematics of matter around us, from the Coma Cluster (70/h Mpc), Local Supercluster, Local Volume (5/h Mpc) to our own Local group (< 2 Mpc).

Constrained Simulations of the Local Universe

The perfect tool to study the formation of individual objects, that look like those close to us, starting from cosmological initial conditions and in a realistic environment.

- ***Eg. Virgo, Coma, the Local filament .. or the Local Group*.**

- **An excellent laboratory to investigate how dark matter is distributed and structured in a similar environment than our own galaxy group.**

Observational Constrains

Mass and velocity constrains

Masses of nearby X-ray clusters

Reiprich & Bohringer 2002

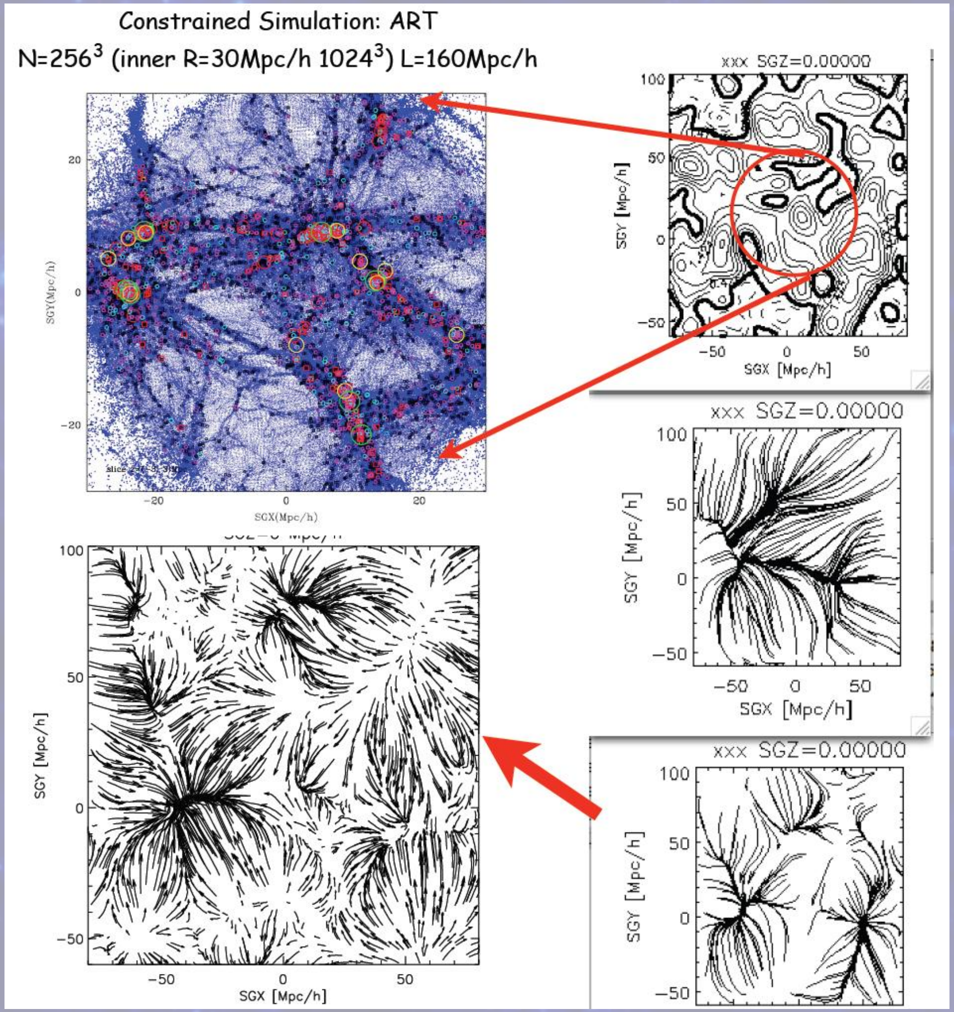
Peculiar Velocities taken from

MARK3, SBF (large scale)

(YH, Klypin,Gottlober,Kravtsov ,2002)

Cosmological Model:

WMAP3 , WMAP5 parameters



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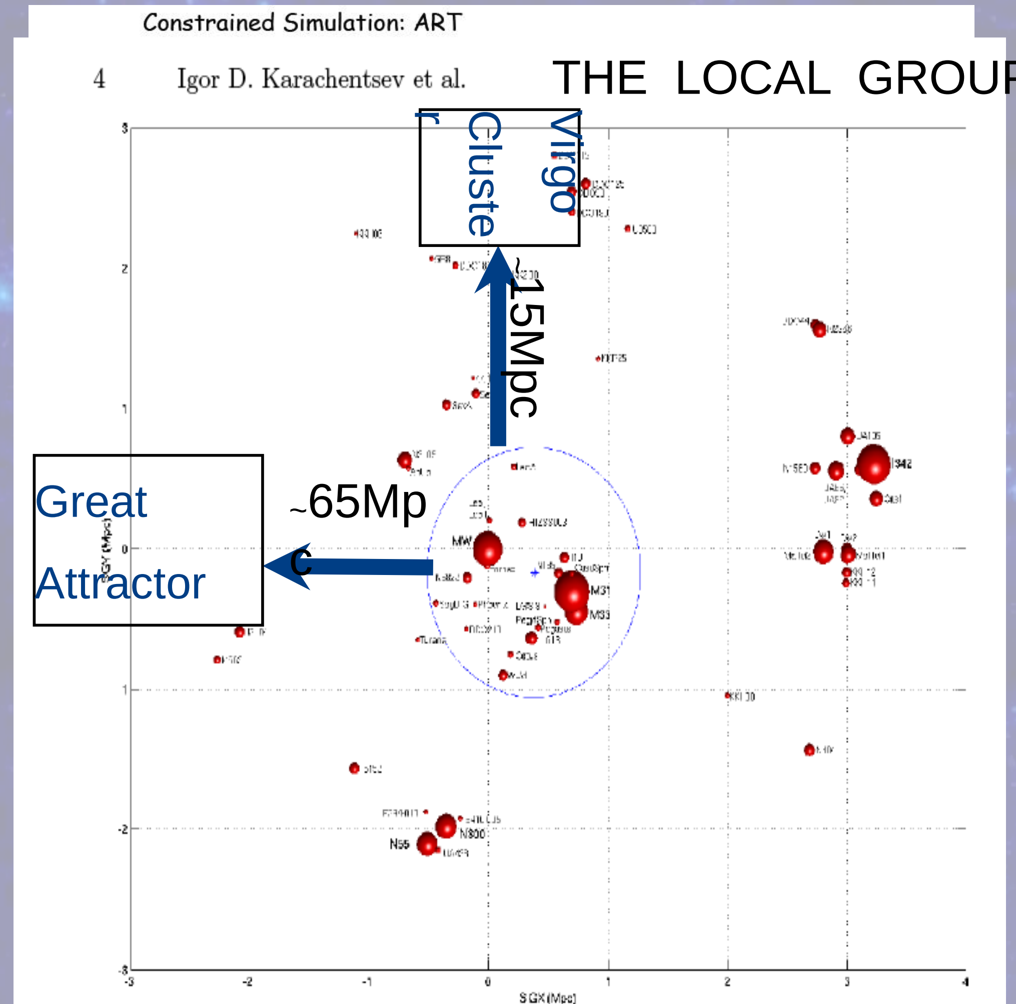
Karantchenstev et al. (LG)



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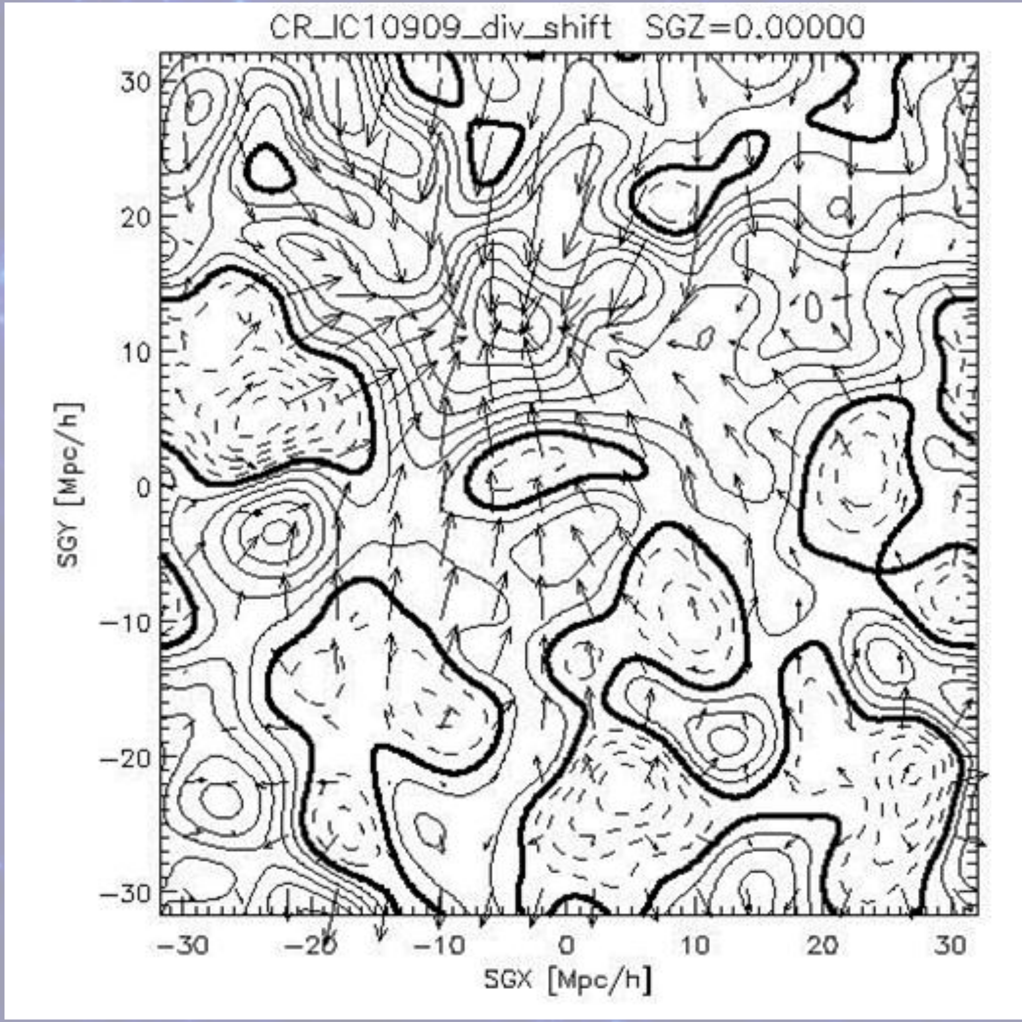

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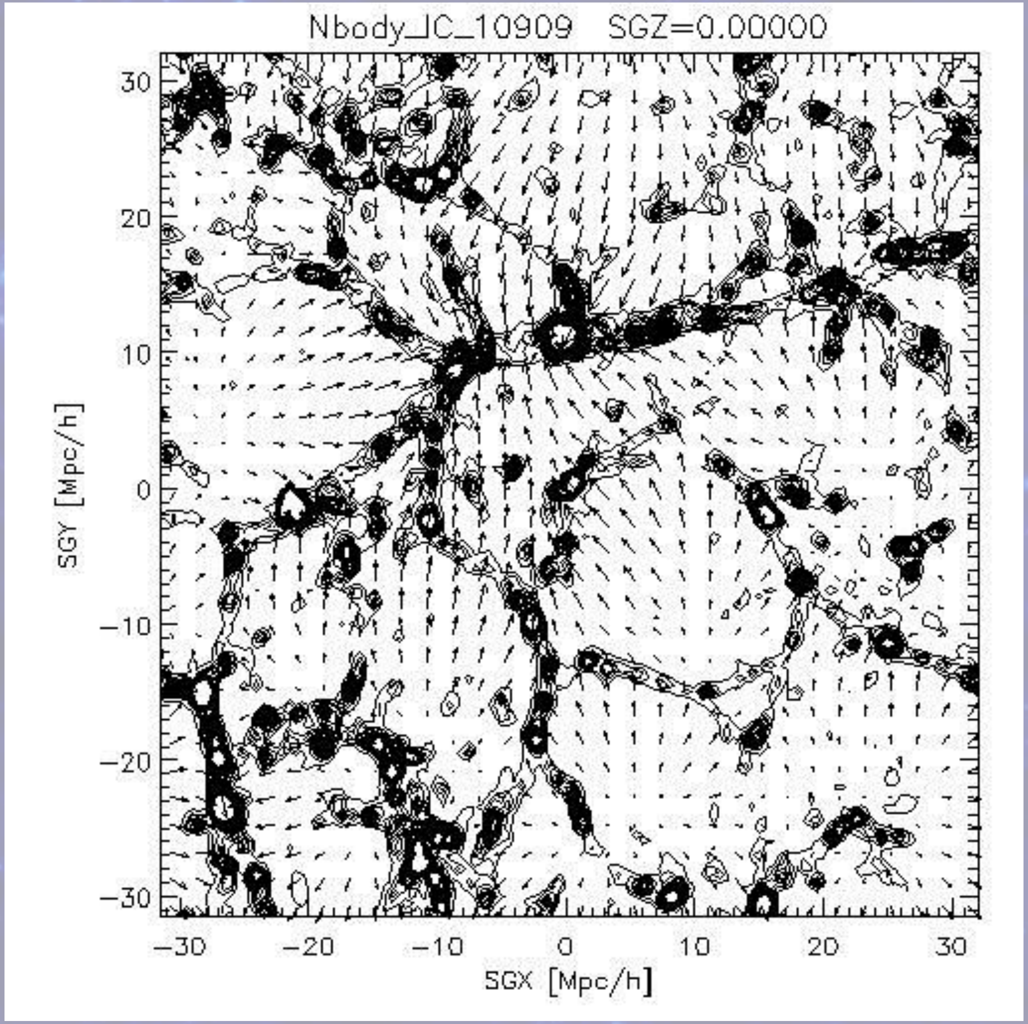


Simulated Volumes

Box 160/h Mpc:

CS: 256^3 density field

COMA, LSC, PP, GA, Virgo

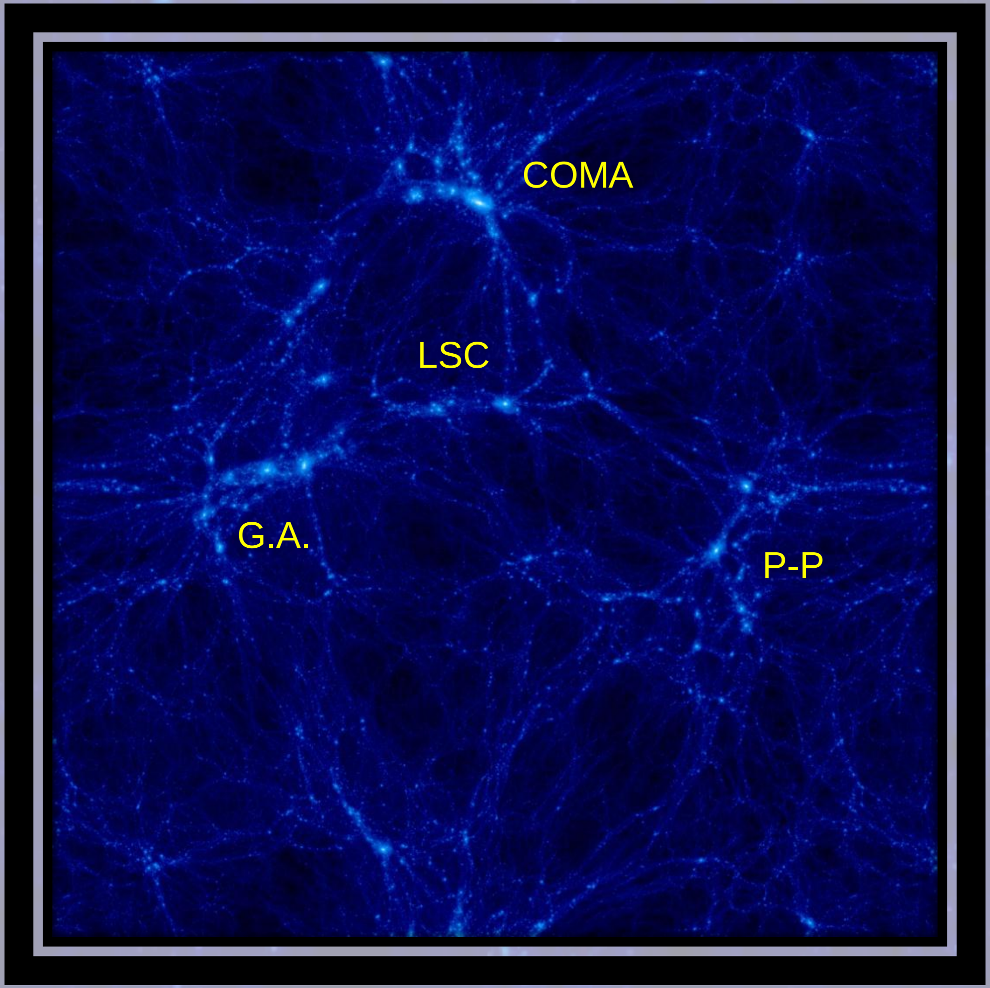
Resimulated box with much higher resolution:

Make random realization of LCDM P(K) in a 4096^3 mesh.

Substitute fourier modes corresponding to those from the 256^3 CR.

Apply Zeldovich approx to find displacement fields

Fill box with arbitrary number of particles up to the 4096^3 maximum.



Simulated Volumes

Looking for the LG

Box 64/h Mpc:

CS: 256^3 density field

Virgo, Fornax, LSC

Different realizations until we found an excelent LG candidate

Resimulated area around LG

128^3-4096^3 mass refinements

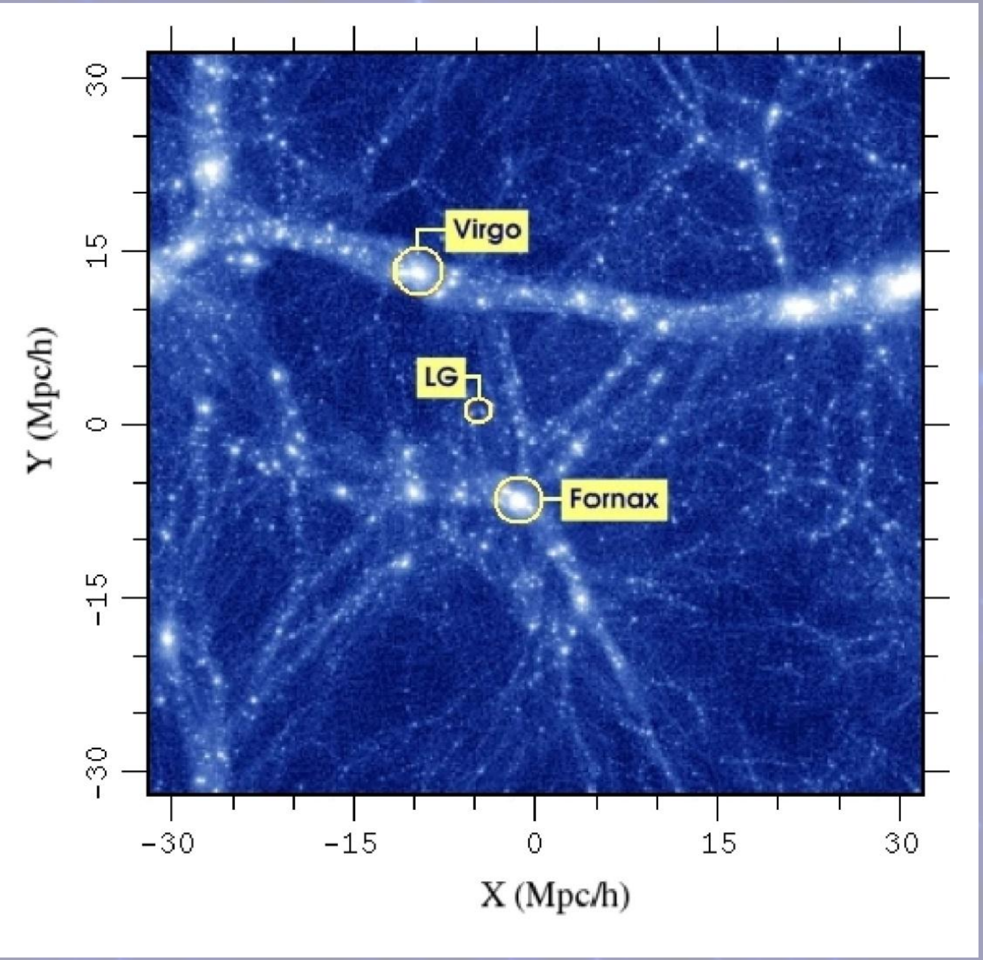
(2.5×10^5 Msun),

100 pc resolution.

60 million particles total.

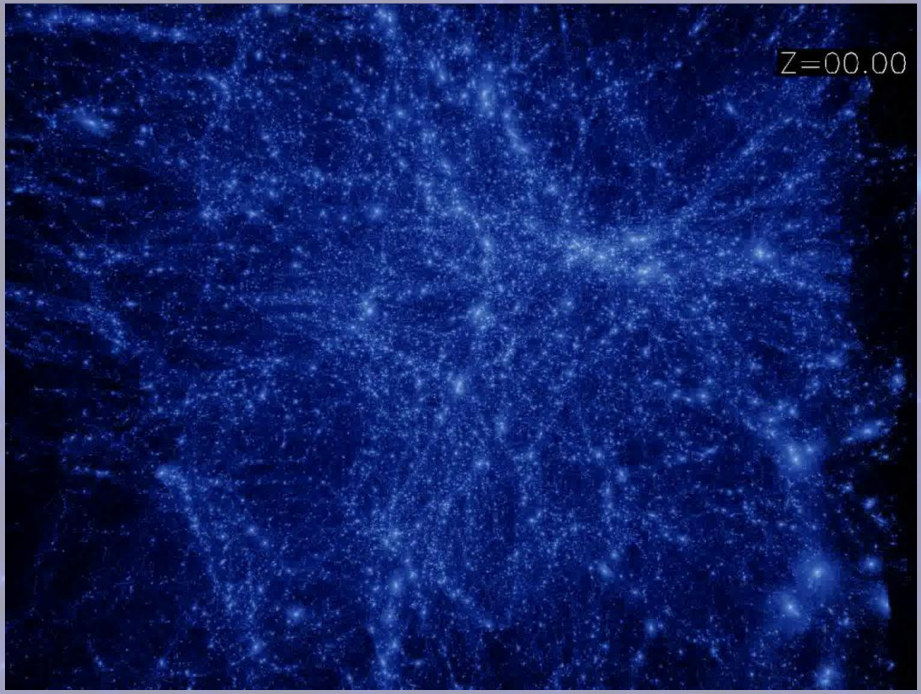
2 Mpc resolution area

Z_{init}= 100. PM-Mesh 512^3

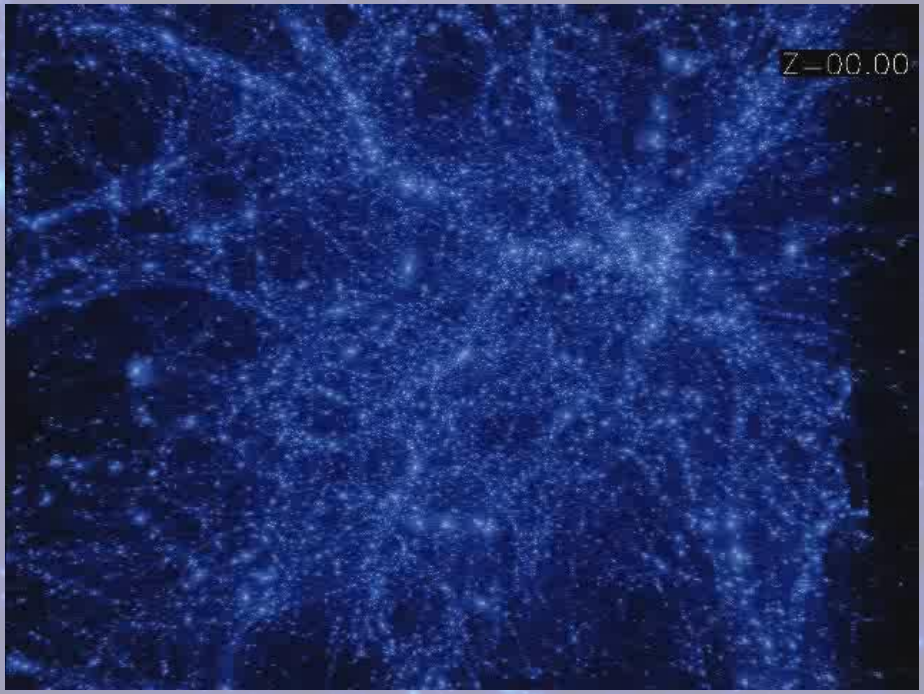


Simulating the Local Volume

WMAP3



WMAP5



64 /h Mpc box sizes

Over 200 different realizations with 256^3 particle with same constrains.

Found a handful of realistic Local Groups (4-6)

High-res simulations with 1024^3 particles total box. (in both models)

Simulated Volumes

Box 160/h Mpc:

CS: 256^3 density field

COMA, LSC, PP, GA, Virgo

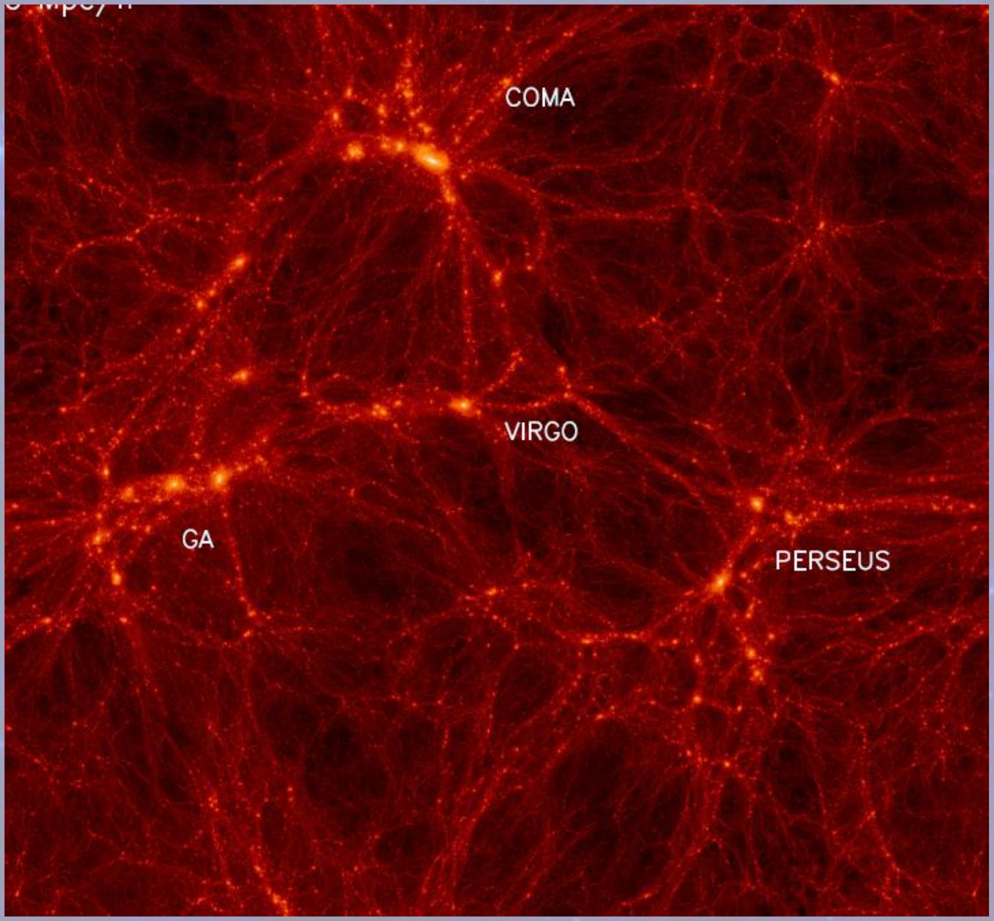
Our biggest runs:

1024^3 particles filling the box

1.2 kpc, $2.5x10^8$ Msun

.

ART N-body code.



Simulated Volumes

Box 64/h Mpc:

CS: 256^3 density field

LSC, Virgo, Local Group,

Local Volume

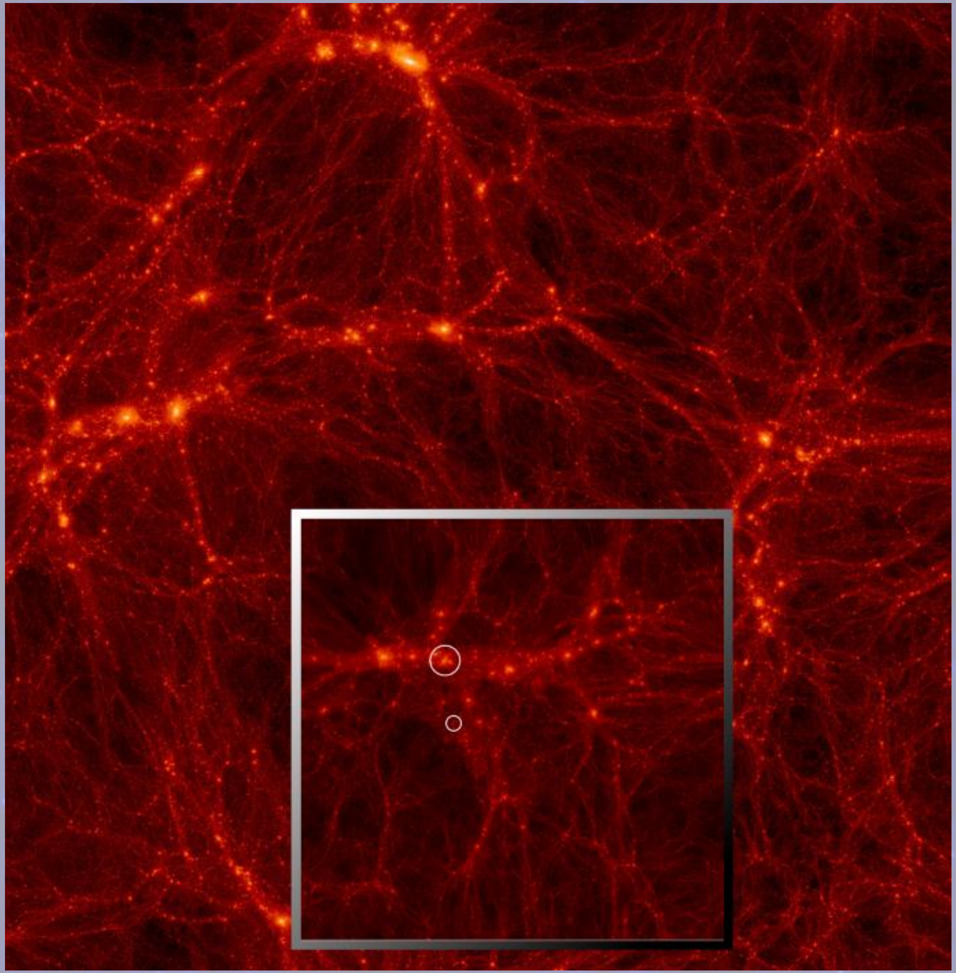
Our biggest runs:

1024^3 particles filling the box

1.2 kpc, 1.3×10^7 Msun

.

GADGET-2 code.



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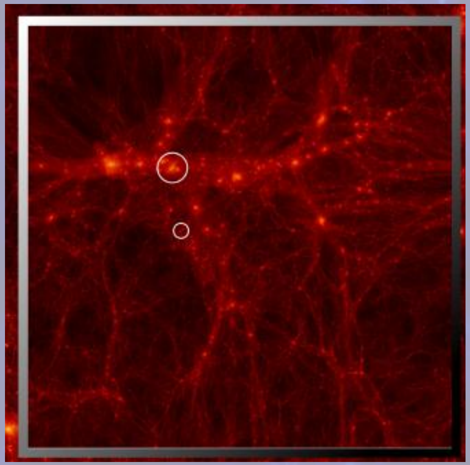

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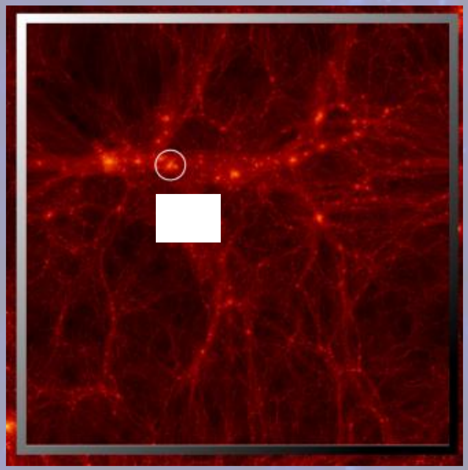
2Mpc Resimulated area around LG

4096^3 particles (2×10^5 $M_\odot$),

100 pc resolution.

150 million particles total.

GADGET-2 code.



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Box 64/h Mpc:

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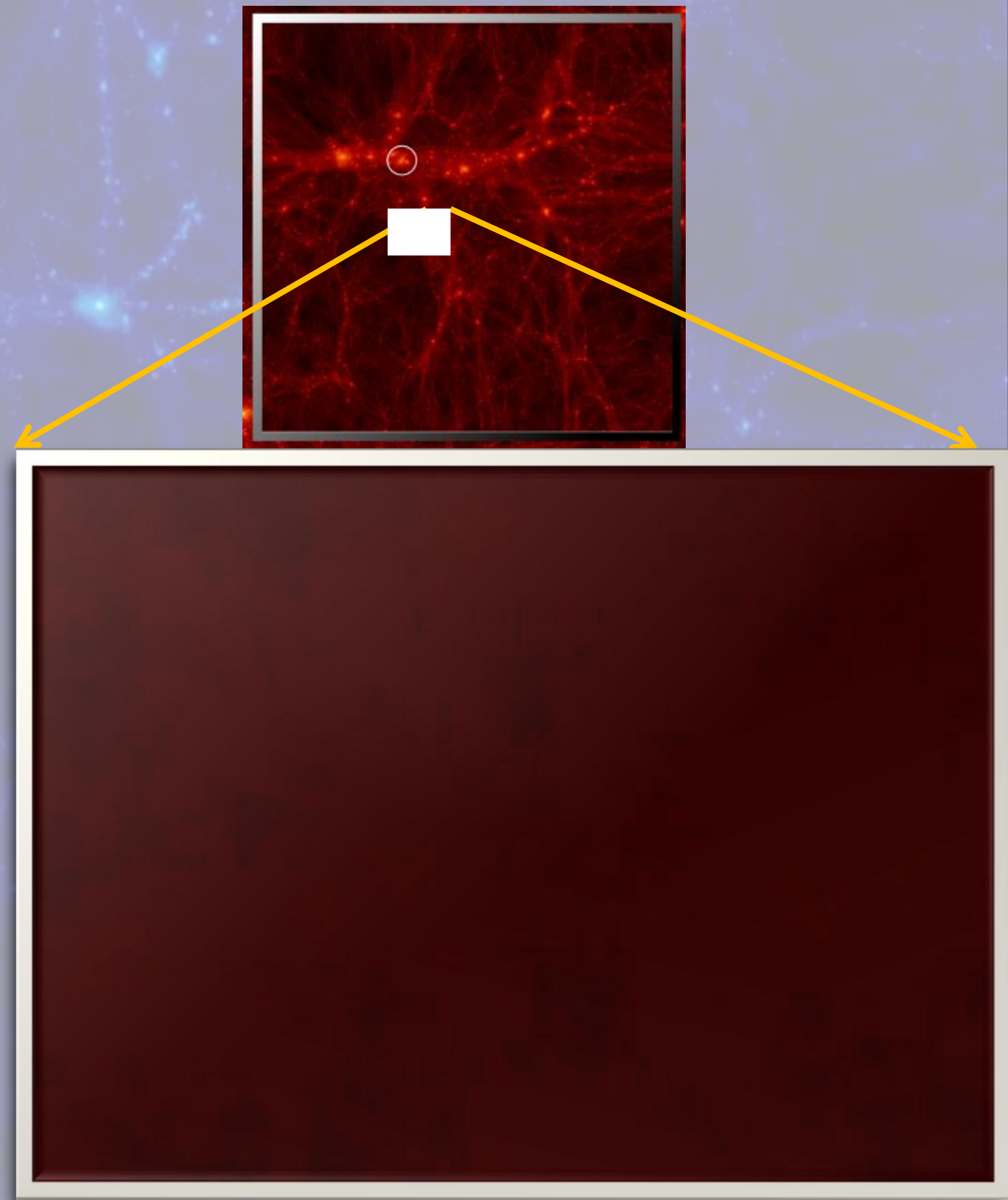

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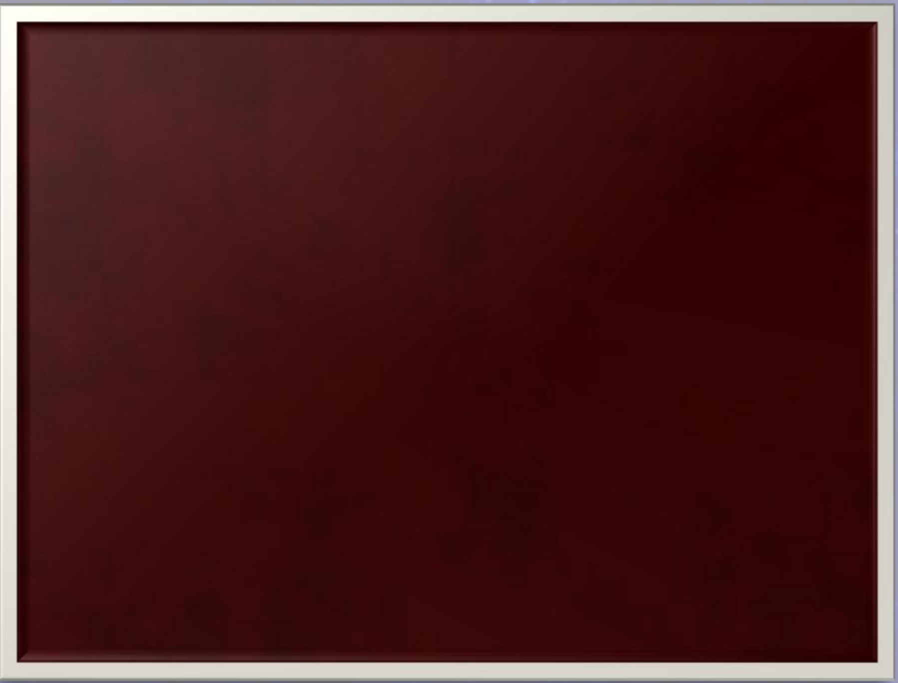
Two plausible Formation of the LG

WMAP3



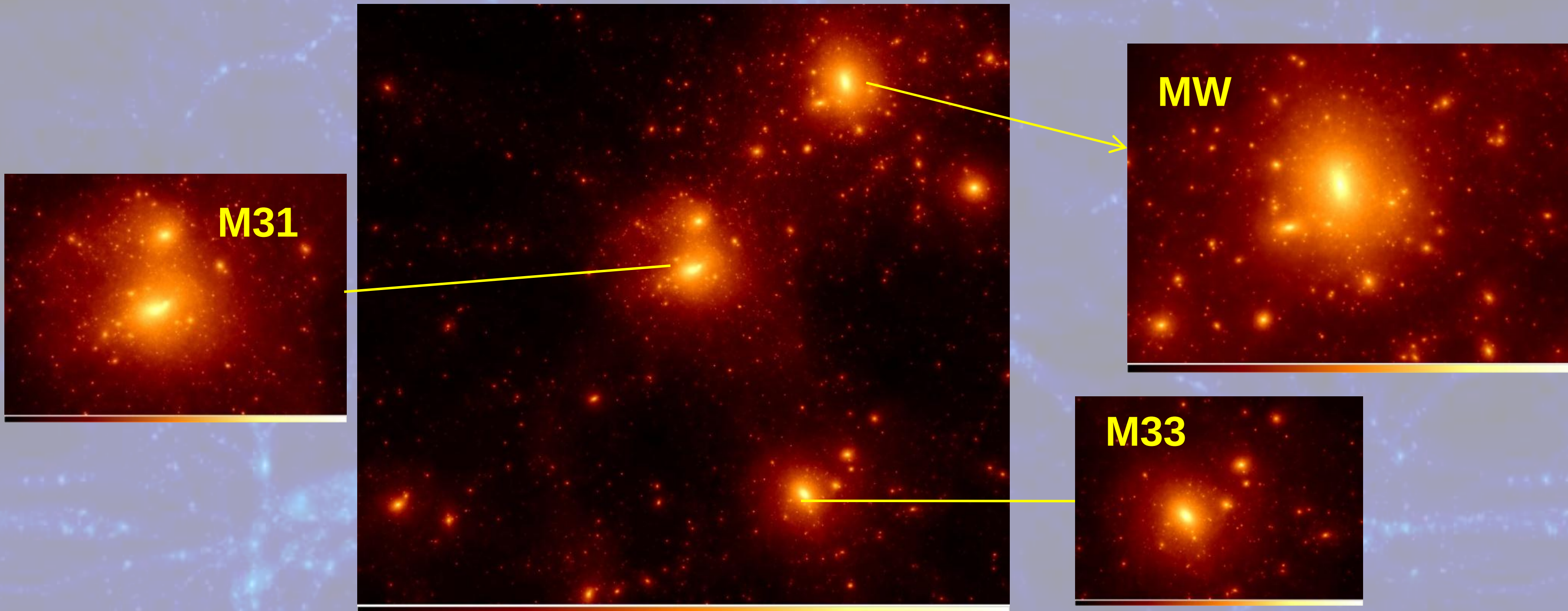
WMAP5

Two different formation processes:

WMAP3. No close contact between the two main halos

WMAP5. Formed simultaneously and with satellite exchange

THE SIMULATED LOCAL GROUP WMAP3



The simulated Local Group in numbers:

σ_H=97.1 km/s (within 2 h^1Mpc)

d_{M31-MW}=0.91 h^{-1}Mpc V_{M31-MW}= --192.6 km/s

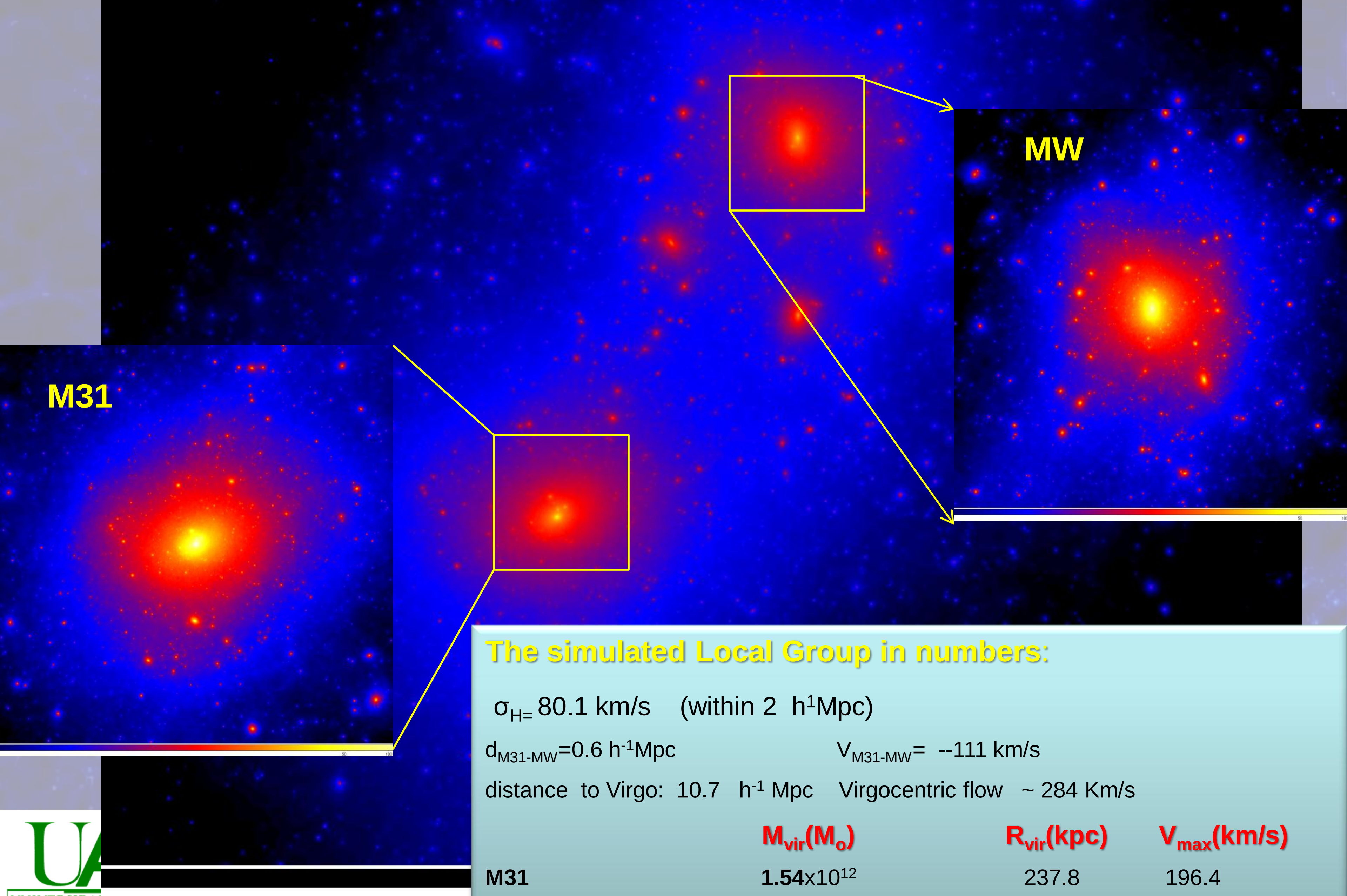
d_{M33-MW}=1.00 h^{-1}Mpc V_{M33-MW}= --185.1 km/s

$d_{M31-M33}$=0.56 h^{-1}Mpc $V_{M31-M33}$= --62.6 km/s

distance to Virgo: 9.7 h^{-1} Mpc Virgocentric flow ~ 450 Km/s

	$M_{vir}(M_o)$	R_{vir}(kpc)	V_{max}(km/s)
M31	**7.80**x10^{11}	237.6	127.9
Milky Way	**6.30**x10^{11}	221.9	130.6
M33	**3.30**x10^{11}	174.2	111.8

THE SIMULATED LOCAL GROUP WMAP5



The simulated Local Group in numbers:

$\sigma_{H=}$ 80.1 km/s (within 2 h^{1}Mpc)

d_{M31-MW}=0.6 h^{-1}Mpc V_{M31-MW}= --111 km/s

distance to Virgo: 10.7 h^{-1} Mpc   Virgocentric flow ~ 284 Km/s

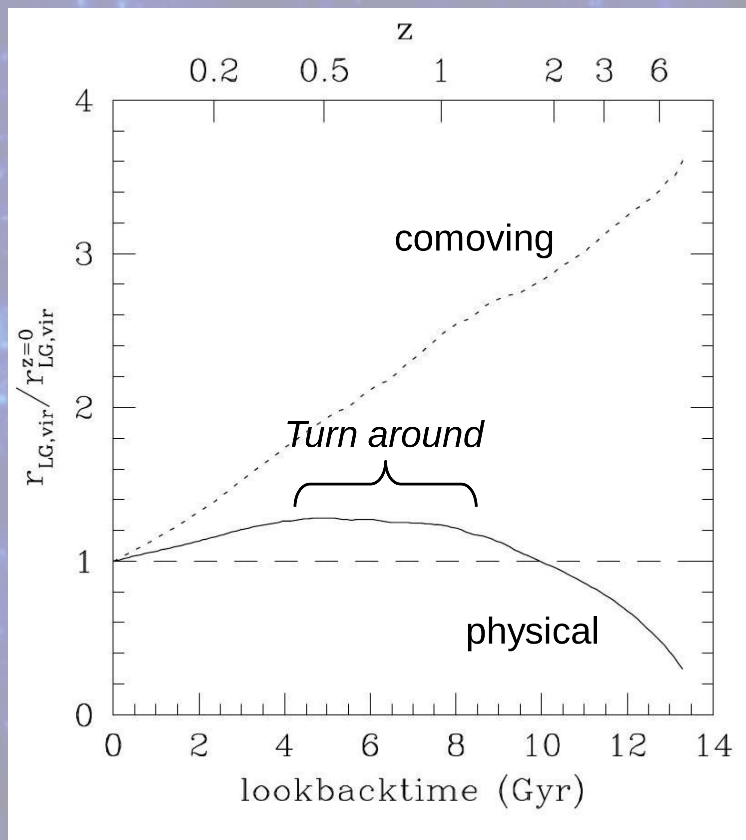
	$M_{vir}(M_o)$	R_{vir}(kpc)	V_{max}(km/s)
M31	**1.54**x10^{12}	237.8	196.4
Milky Way	**1.16**x10^{12}	216.8	178.3

RESULTS FROM CLUES SIMULATIONS

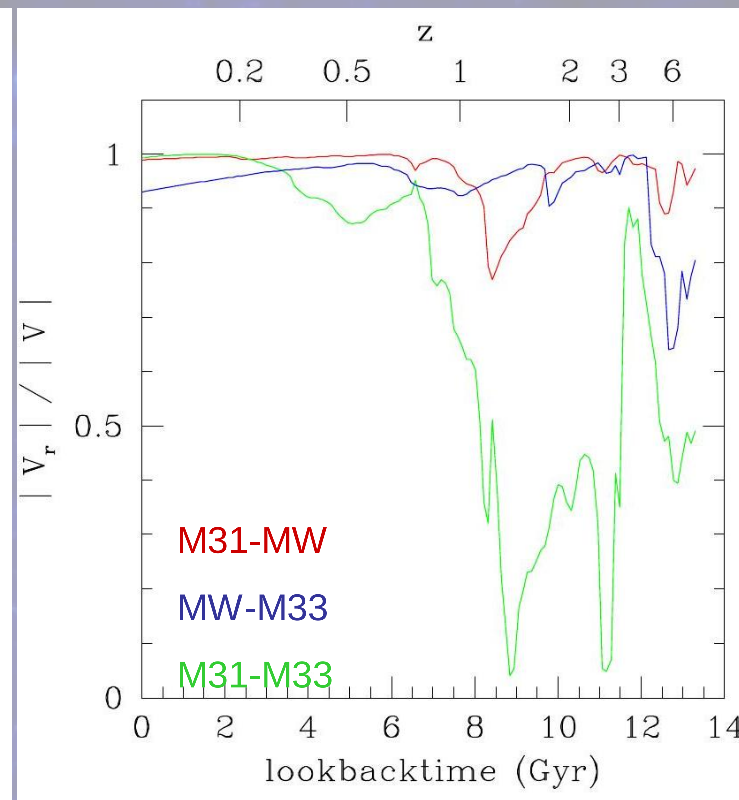
- The CR- dark matter only simulations are a wonderful database to do experiments to probe the *nature* of the dark side of the universe.
  - Study the behaviour of Dark Energy in the local universe.
    - Hoffman, Martinez-Vaquero, Yepes, Gottlober, MNRAS, 386,390 (2008)
    - Martinez-Vaquero, Yepes, Hoffman, Gottlober, Sivan, arXiv/0905.3134
  - The nature of Dark Matter: Cold versus Warm:
    - Tikhonov, Gottlöber, Yepes, Hoffman, 2009, MNRAS
    - Zavala, et al 2009, ApJ,
  - Dynamics and Environment of Local Volume
    - Klimentosky et al, 2009, MNRAS
    - Libeskind et al MNRAS, 2009, 2010
  - Galaxy formation in the Local Group
    - L. Martínez-Vaquero's PhD Thesis 2010 UAM.
  - Reionization of the Local Group
    - Iliev, Moore, Yepes, Gottloeber, Hoffman, Mellemman, 2010
  - Cold Dark Matter annihilation from extragalactic sources
    - Cuesta, **F. Zandanel, F. Prada, A. Klypin, etal**

Formation of the Local Group

Distance M31-MW



Relative velocities



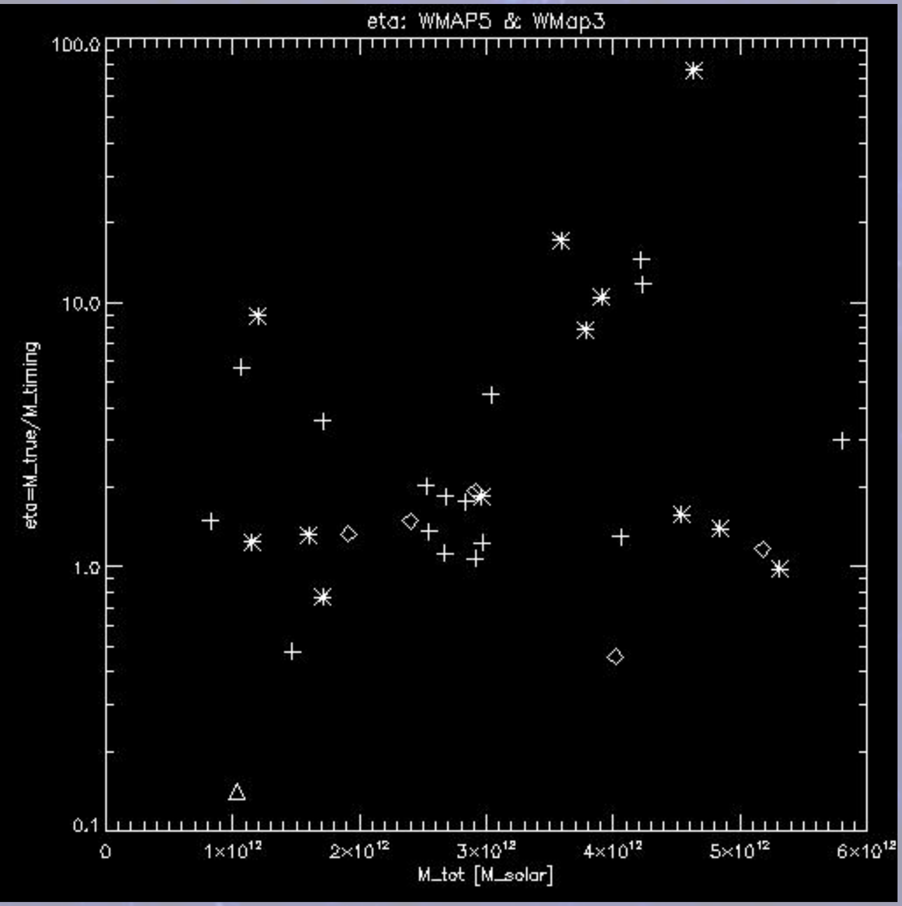
M31 and MW are approaching (radial trajectories)

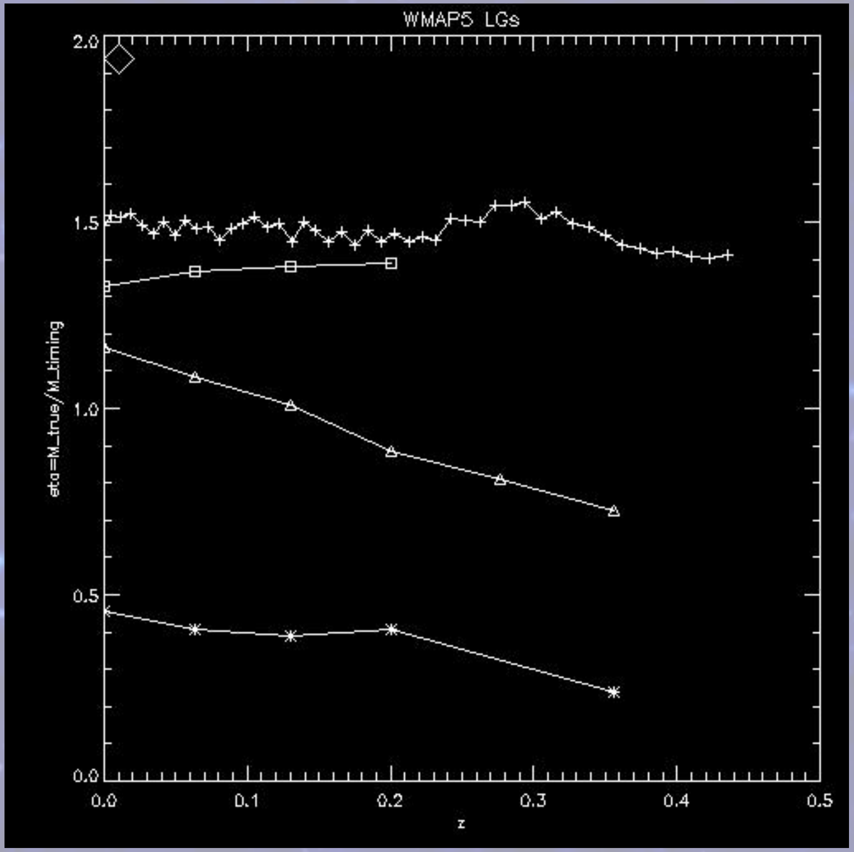
No previous interaction between them in their history

Formation of the Local Group

Mass estimates from timing argument

eta= M_{true} / M_{timing}





M31 and MW are approaching in close to radial trajectories

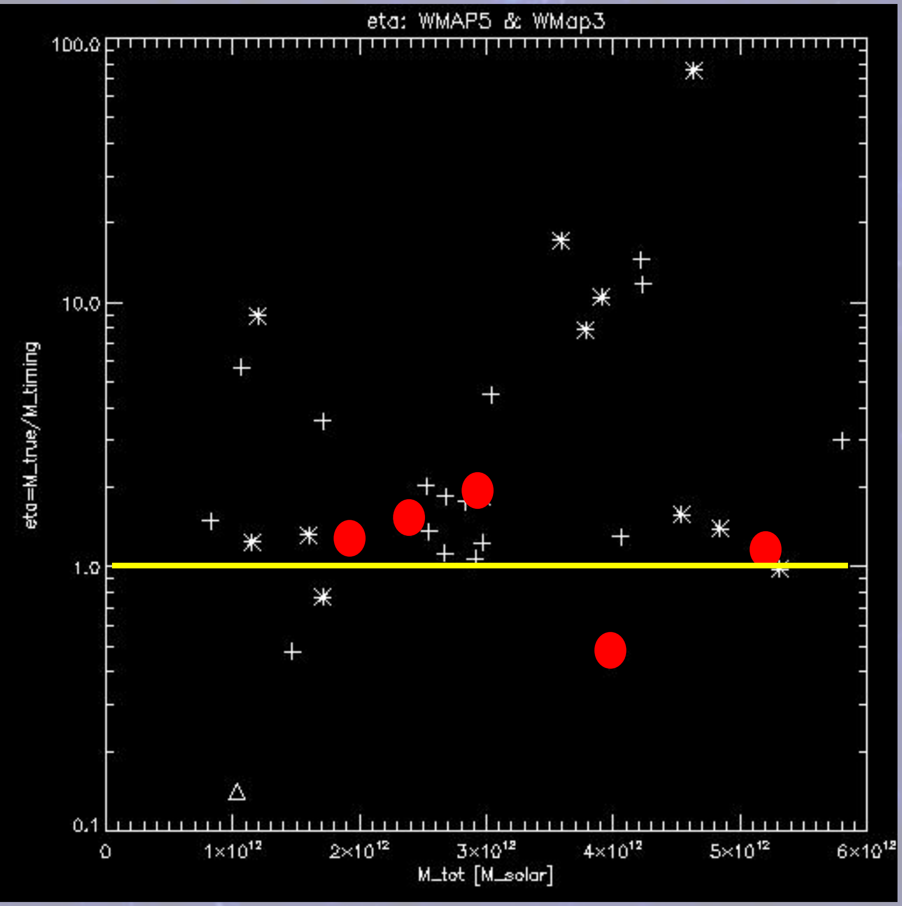
No previous interaction between them in their past history

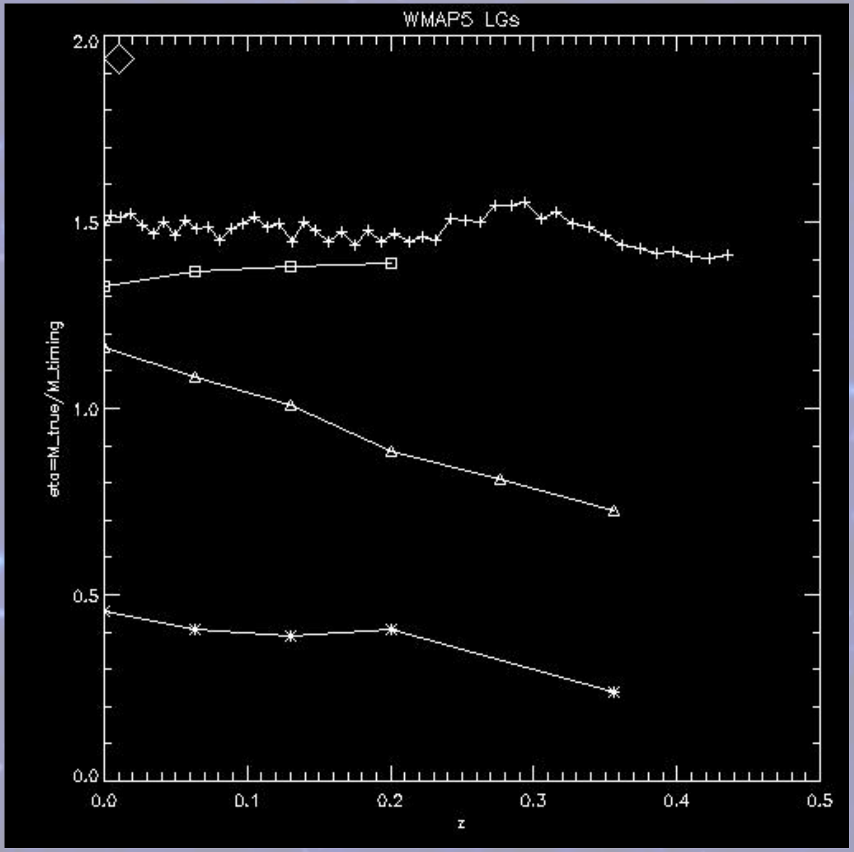
Shalhevet, Hoffmann , Yepes, Gottlober , work in progress

Formation of the Local Group

Mass estimates from timing argument

eta= M_{true} /M_{timing}





M31 and MW are approaching in close to radial trajectories)No previous interaction between them in their past history

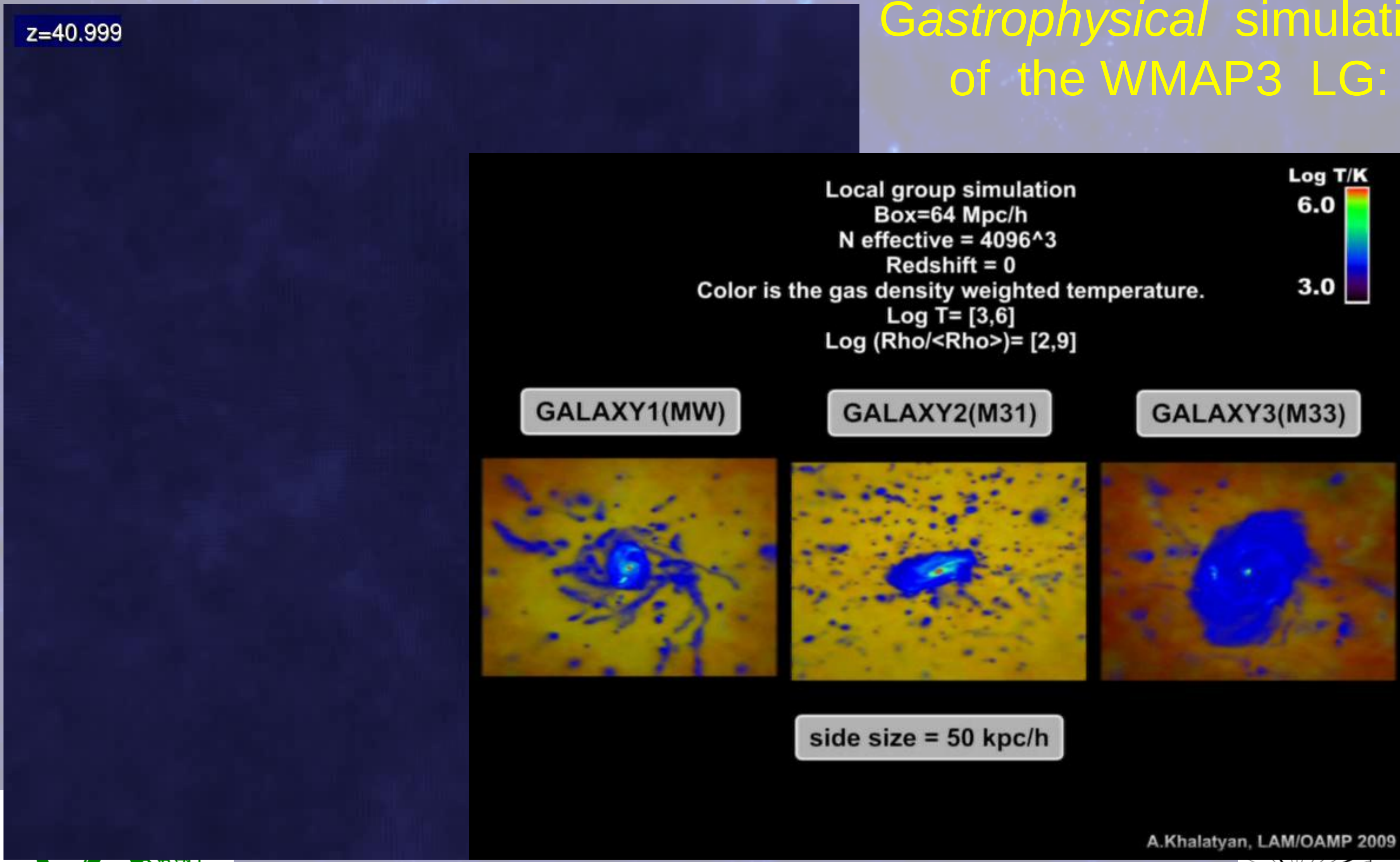
Best LG candidates found from 200 WMAP5 realizations

GASDYNAMICAL SIMULATIONS OF THE LOCAL UNIVERSE

- To have a complete view of the problem of formation of the LG and LU, we need to do galaxy formation simulations, including baryons into the CR initial conditions.
- SO far we have been able to run several zoomed high-resolution simulations of the LG found in WMAP3 cosmology in 64 Mpc box with up to 4096^3 effective particles. (m_{sph} = 30,000 Msun, $m_\star$ = 15,000 Msun)
- It can be used as a cosmological lab for galaxy formation to test different modeling of the various baryonic processes: ("gastrophysics") and compare results with observations:
  - *Disk structure, Star formation history, HI and metal distributions, Local UV sources, surviving satellites…*

GASDYNAMICAL SIMULATIONS

Gastrophysical simulation of the WMAP3 LG:



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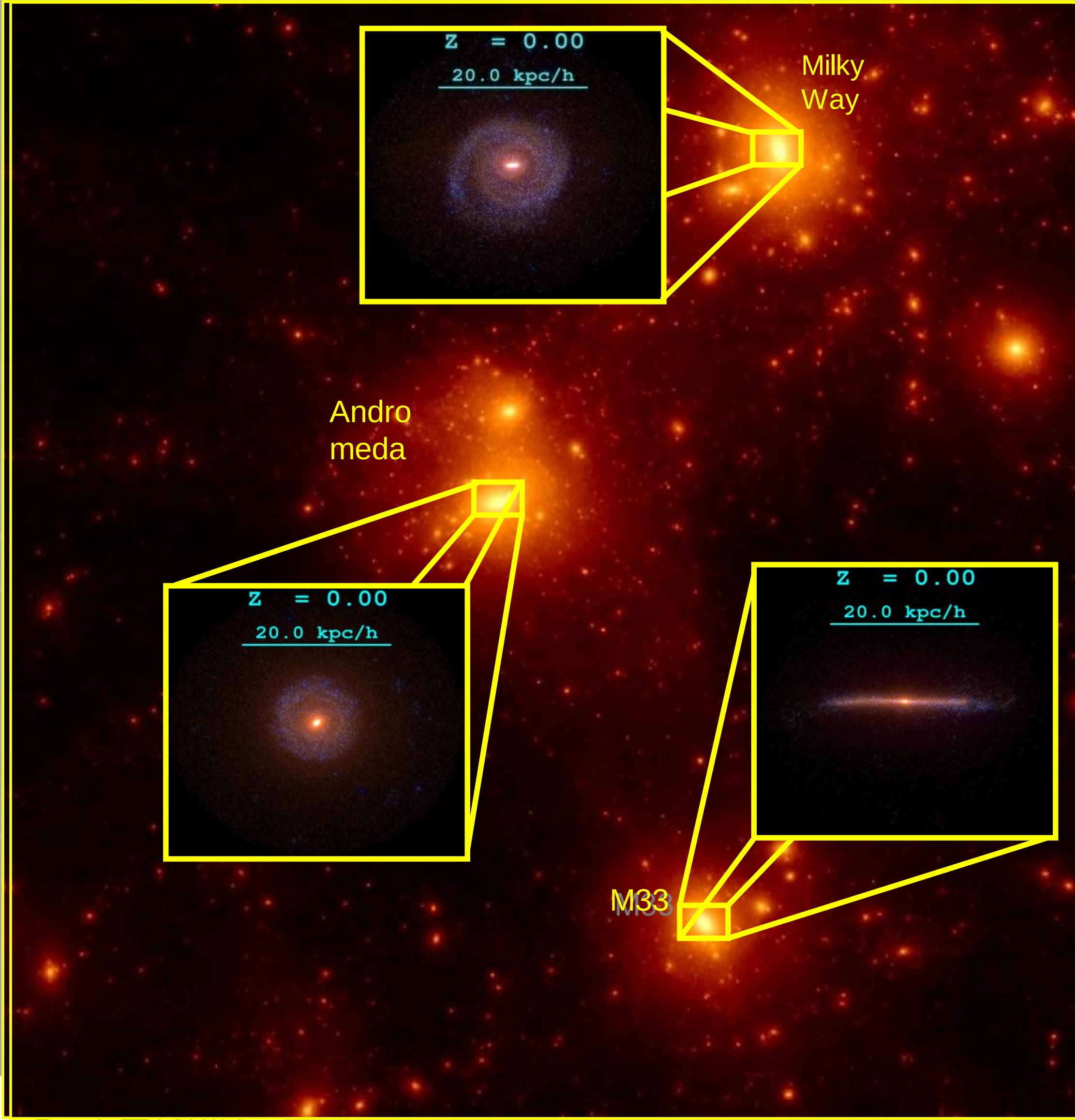
GASDYNAMICAL SIMULATIONS



Gastrophysical simulation of the WMAP3 LG:

- **High resolution run with 4096^3 mass refinement.**
  - ***100 pc smoothing,***
  - ***34,000 $M_\odot$ SPH particle.***
  - ***17,000 $M_\odot$ STAR particle***
- **SPH simulation using GADGET2**
- **UV standard photoionization scheme H&M**
- **Multiphase medium + winds S&H 2003.**
- **Bruzual & Charlot 2003 SPSM.**
- **Primordial composition cooling.**

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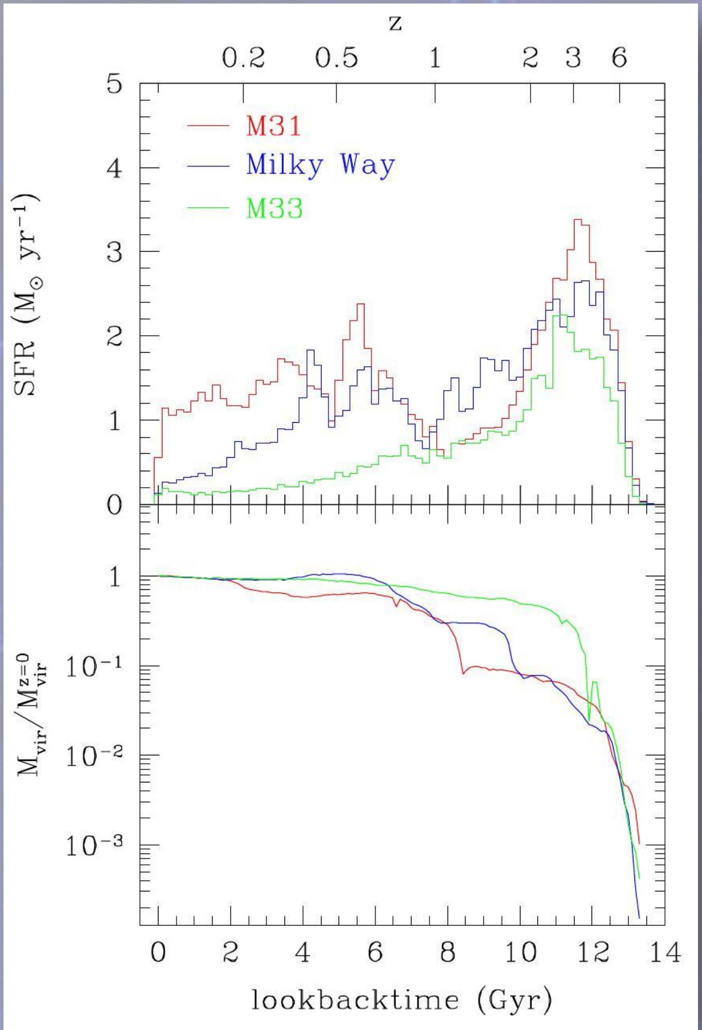
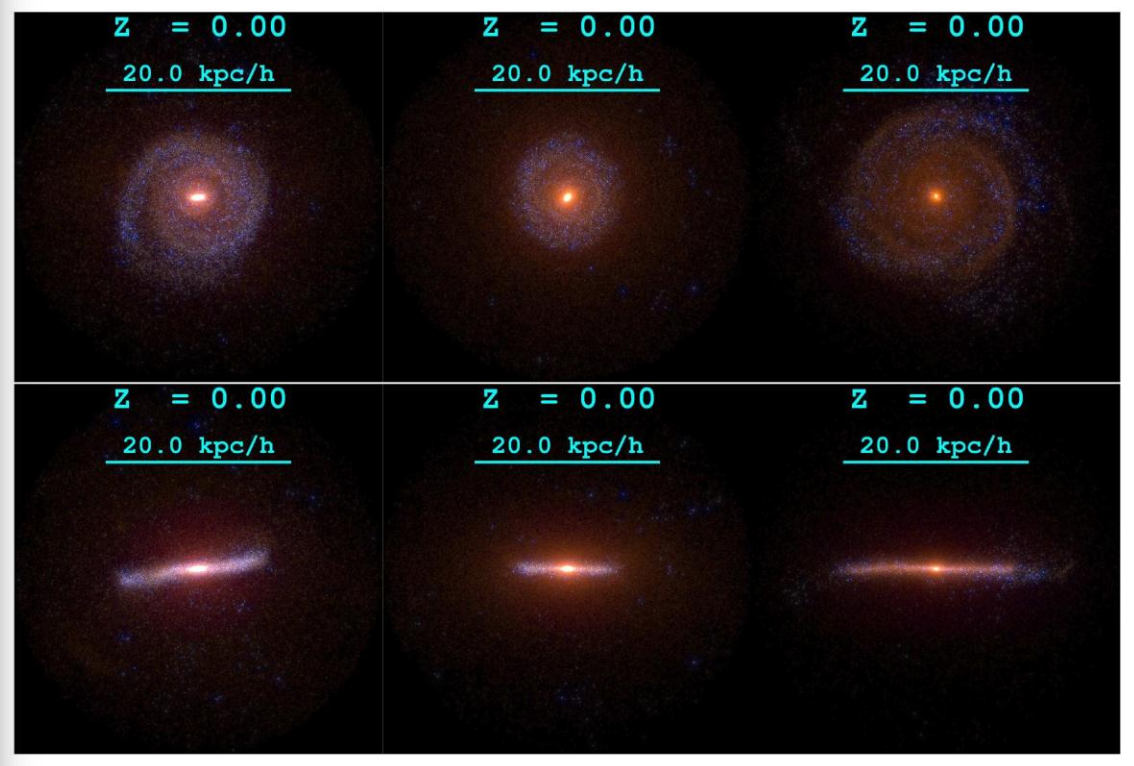
LG Galaxy properties

Composite UBV color image:

Bluer colors :> younger stars



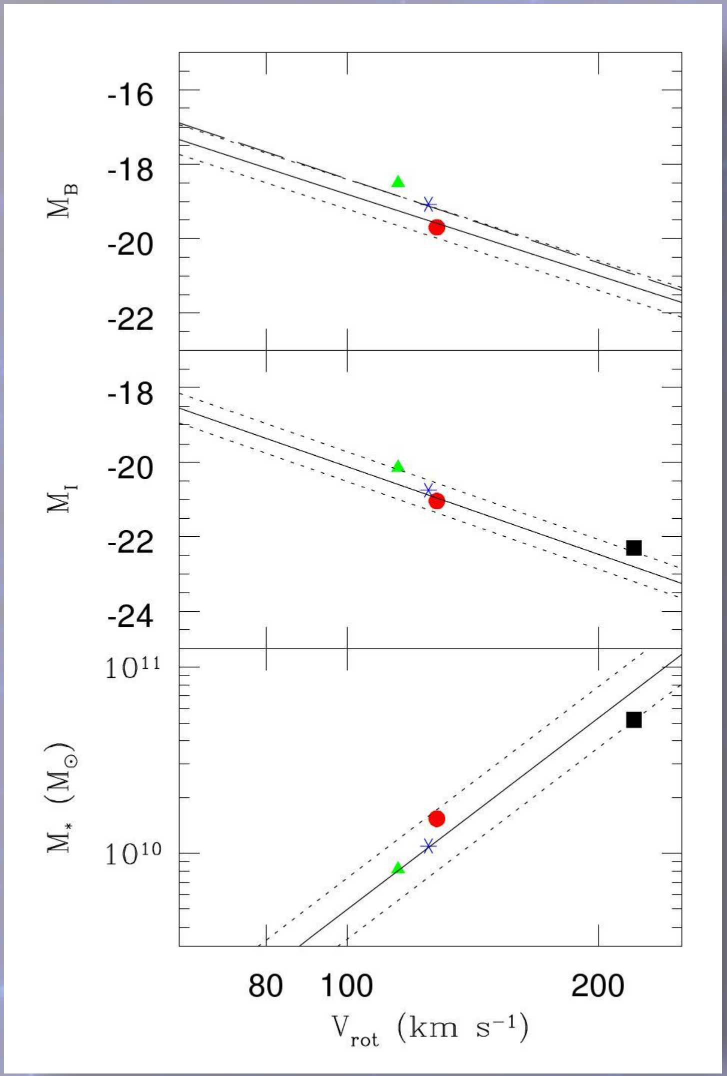
M31 MW M31



	M31	MW	M31
Mv	-20.62	-19.94	-19.15
B-V	0.35	0.65	0.60

LG Galaxy properties

Tully-Fisher Relation



Composite UBV color image:

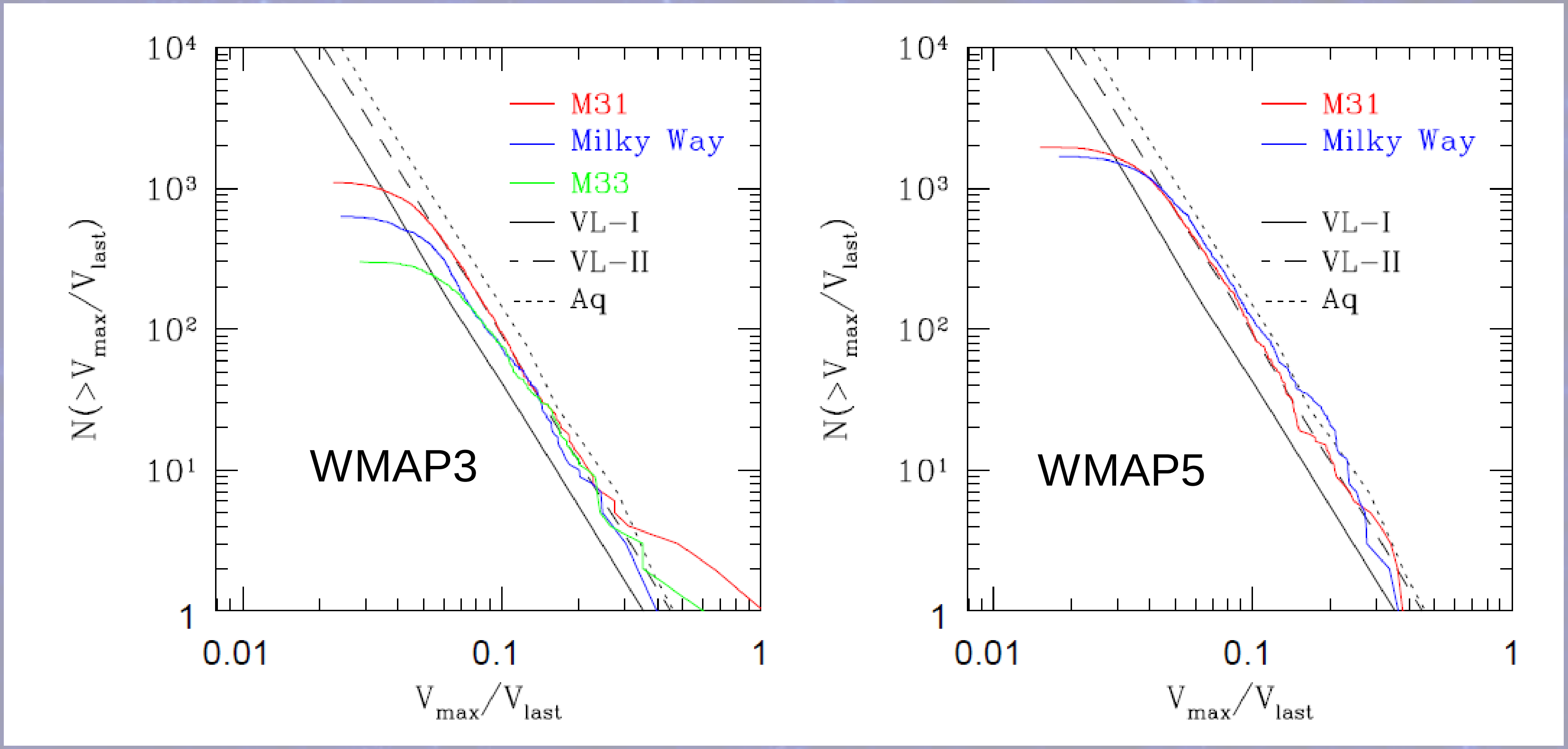
Bluer colors :> younger stars

	M31	MW	M31
Mv	-20.62	-19.94	-19.15
B-V	0.35	0.65	0.60

Substructures: dark halos vs dwarf satellites

- Substructure mass function for halos and galaxies

  Pure CDM runs velocity functions and comparison with high-res CDM halos



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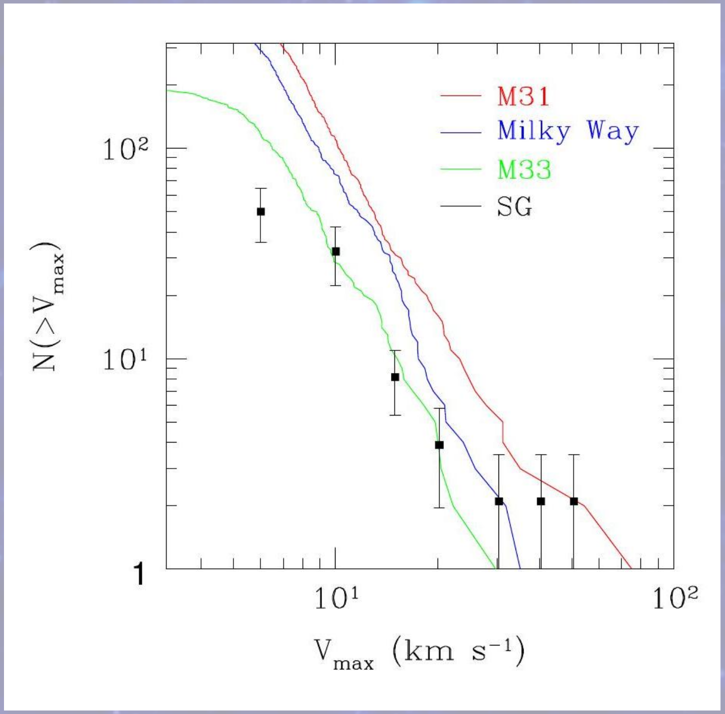
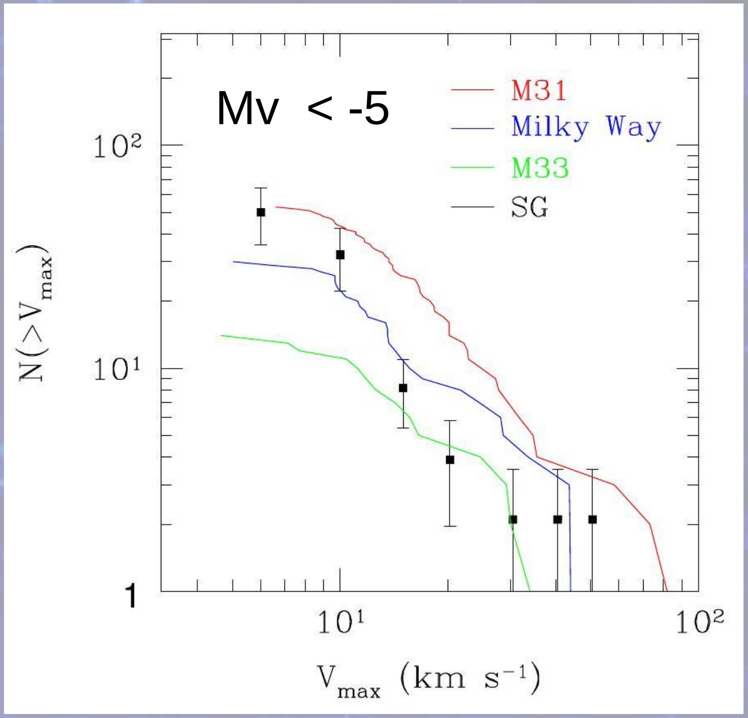
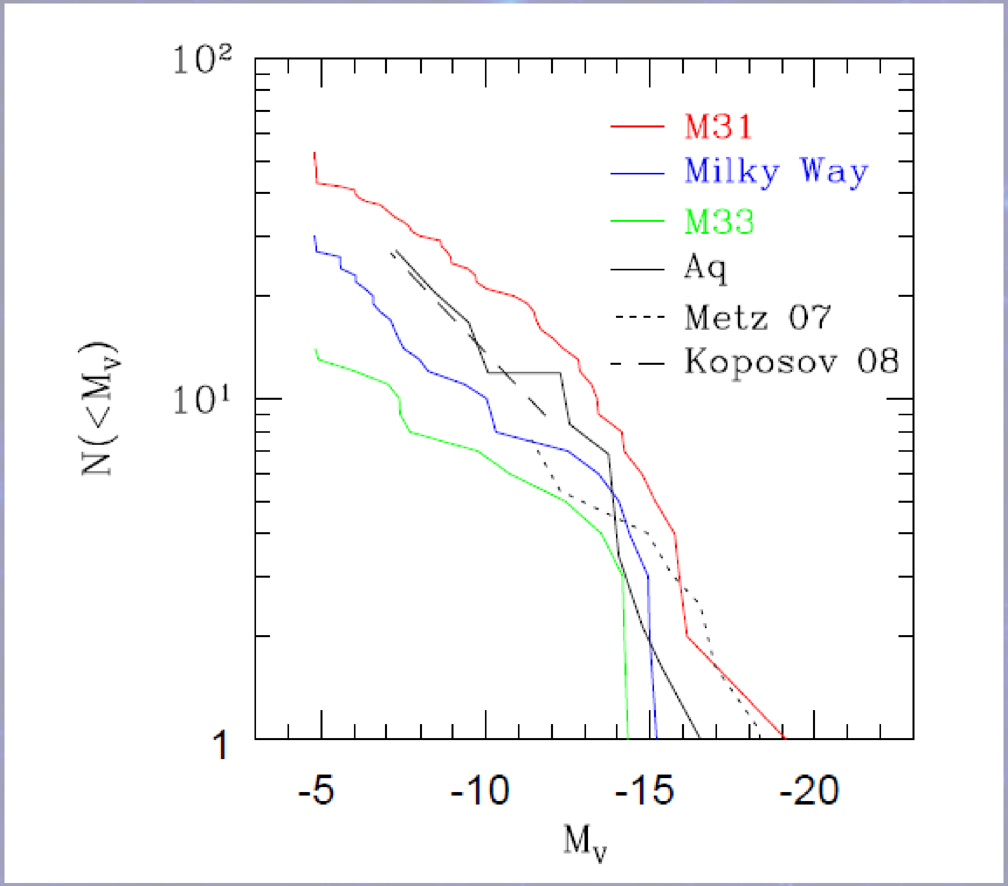




Efficient suppression of SFR due to UV photionization for

Halos with V < 10 km/s (Hoeft et al 2006)

Substructure Luminosity function



THE LOCAL UNIVERSE AND THE NATURE OF DARK MATTER .

- We can also use the simulations of the Local Universe to study the nature of dark matter itself.
- CDM has problems on small scales due to excess of substructure inside galactic halos as compared with observed satellites. This can also manifest on larger scales as an excess of halos that can fill the void regions we observe in the Local Universe (Tikhonov and Klypin 08).
- To alleviate this problems one can think on dark matter particles lighter than CDM: a WDM model would erase short scale fluctuations due to free streaming.

THE LOCAL UNIVERSE AND THE NATURE OF DARK MATTER .

- Limits on mass of WDM particles can be obtained from several astrophysical observations:
  - Stellar dynamics in MW satellites (Boyanovsky, de Vega, Sanchez 2008; de Vega and Sanchez 2009)
  - High-z QSO LF (e.g. Song and Lee 2009)
  - Ly-alpha forest to constrain P(k) at small scales and different z's (Most popular method: Narayanan et al 2000; Viel et al 2005;2008
  - Ly-a + SDSS results (Boyarsky et al 2009)
  - QSO lensing (Miranda & Maccio 2007)
  - Abundance of dwarf satellites of MW (Maccio & Fontanot 2010; Polysensky & Ricotti, 2010)
- Overall, all the above works seems to point out to
  - $m_{WDM} \geq$ 1-5 keV

THE LOCAL UNIVERSE AND THE NATURE OF DARK MATTER.

- We have also investigated the nature of dark matter by rerunning our ΛCDM simulations of CLUES in WDM scenarios:
  - Focused on somewhat different statistics to compare with
    - Velocity functions in the Local Environment

The Astrophysical Journal, 700:1779–1793, 2009 August 1
doi:10.1088/0004-637X/700/2/1779

THE VELOCITY FUNCTION IN THE LOCAL ENVIRONMENT FROM ΛCDM AND ΛWDM CONSTRAINED SIMULATIONS

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Received 2009 March 20; accepted 2009 June 5; published 2009 July 16

- **Voids in the Local Universe**

Mon. Not. R. Astron. Soc. **399,** 1611–1621 (2009)
doi:10.1111/j.1365-2966.2009.15381.x

The sizes of minivoids in the local Universe: an argument in favour of a warm dark matter model?

A. V. Tikhonov,[1★] S. Gottlöber,[2★] G. Yepes[3★] and Y. Hoffman[4★]

THE LOCAL UNIVERSE DARK MATTER LAB: ΛCDM vs ΛWDM

CLUES SIMULATIONS IN ΛWDM.

Same WMAP3 cosmological parameters.

Same mass and spatial resolution.

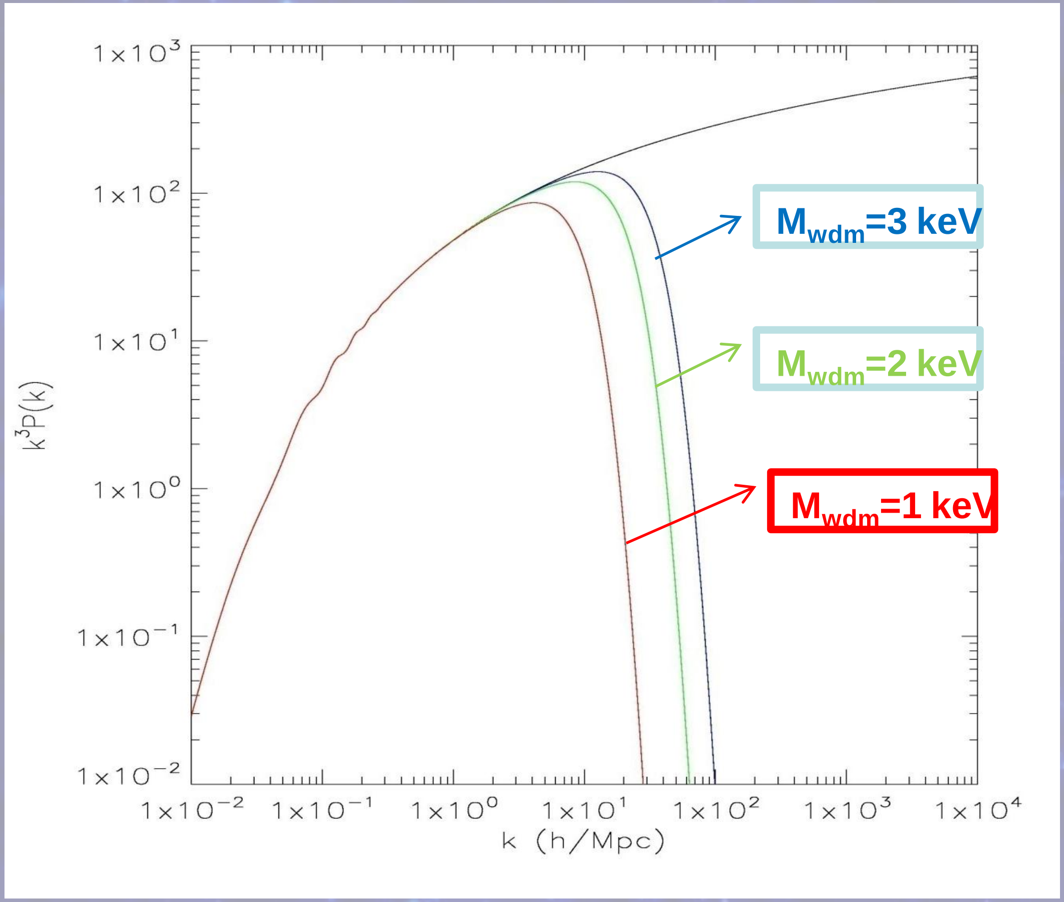
WDM particles

(thermal relics)

M_{wdm} = 3 keV –- 1 keV

Comparison with ΛCDM:

- Substructure mass and velocity functions
- Voids in L.U.
- Abundance of satellites



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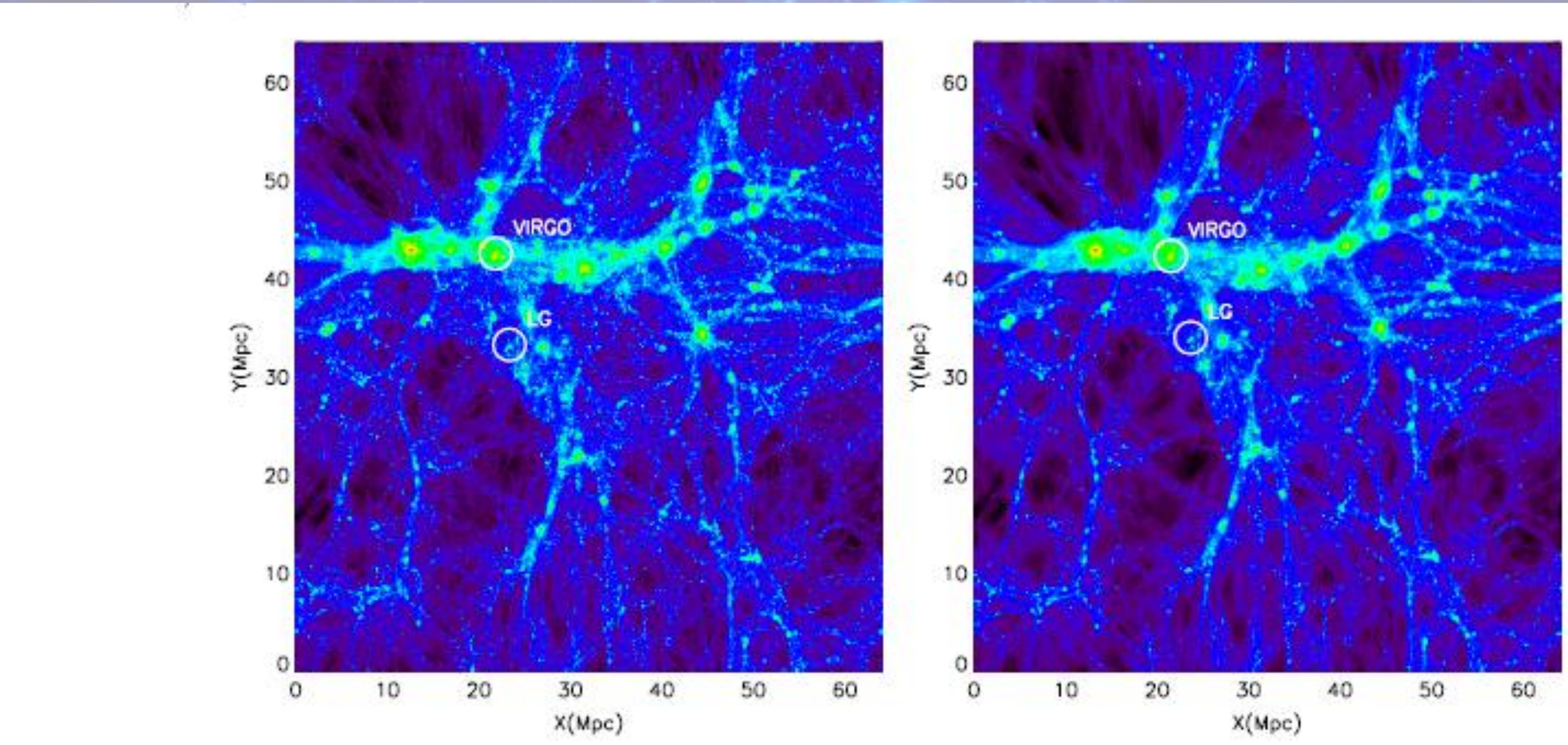


M_{wdm}

1keV

Full 64 /h Mpc box @ 1024^3 particles

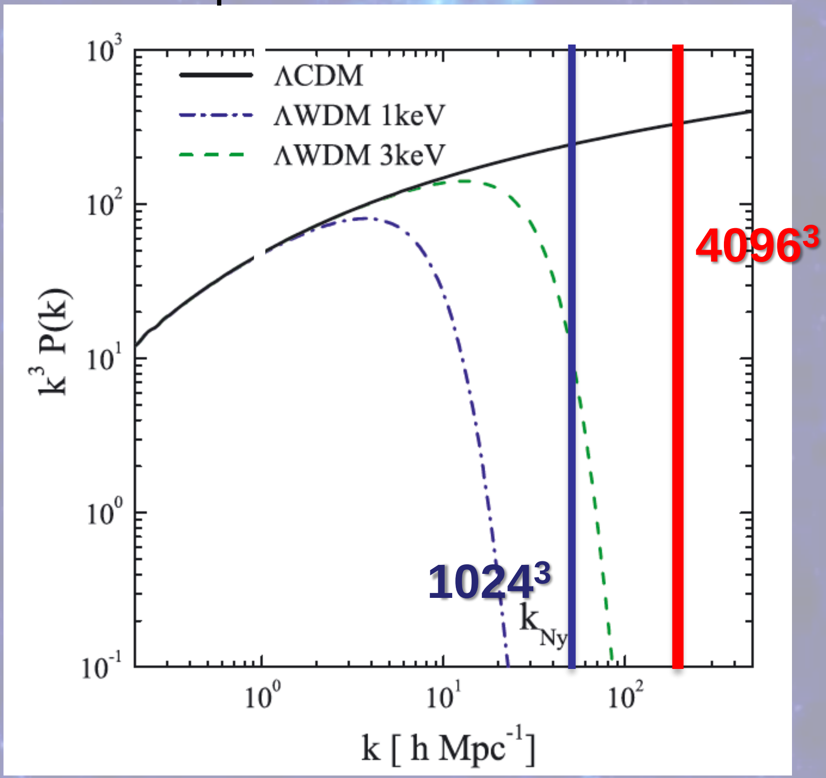
THE LOCAL UNIVERSE DARK MATTER LAB: ΛCDM vs ΛWDM

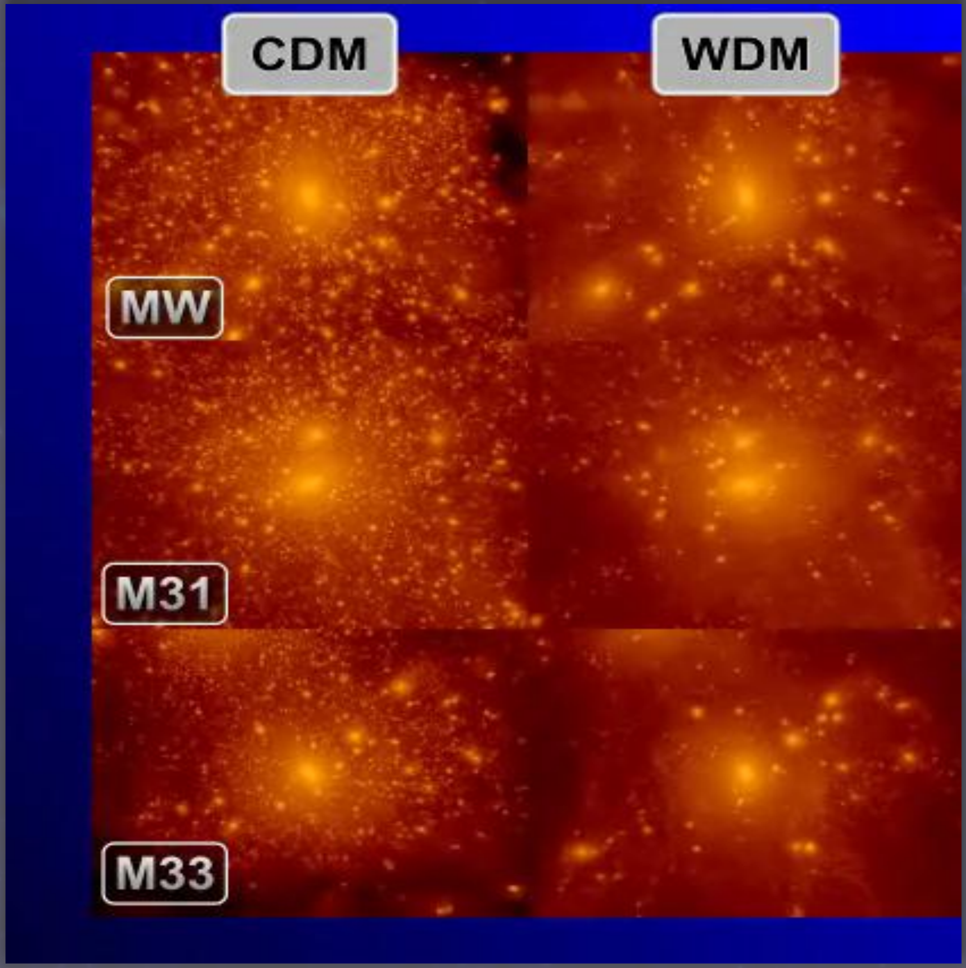
CLUES SIMULATIONS IN ΛWDM.

Same WMAP3 cosmological parameters.

Same mass and spatial resolution.

High-resolution re-simulation of the Local Group 2Mpc area @ 4096^3 effective particles





$M_{lim} \propto \rho_{mean}\, k_{Ny}^{-1}\, k_{peak}^{-2}$ (Wang & White 2007)

$M_{lim} = 3\text{-}1 \times 10^9\, M_{sun}$ (@ 1024^3-4096^3)

THE DENSITY PROFILES
ΛCDM vs ΛWDM

	c	R_S(h^{-1}kpc)	α	β	α + β	χ^2 / χ^2_{NFW}
NFW	13.64	11.88	1	2	3	1
	13.76	11.75	1	2	3	1
	6.87	23.30	1	2	3	1
JS	9.69	16.72	1.23	1.77	3	0.90
	9.69	16.68	1.24	1.76	3	0.90
	7.47	21.42	0.95	2.05	3	0.99
FREE	8.89	18.21	1.22	1.67	2.89	0.17
	8.94	18.08	1.23	1.66	2.90	0.23
	6.74	23.71	0.96	1.93	2.89	0.23
	C	R_S(h^{-1}kpc)	μ			χ^2 / χ^2_{FREE}
EINA	12.08	13.41	5.69			0.87
	12.31	13.13	5.68			0.86
	6.19	25.86	4.67			1.15

ΛCDM black

ΛWDM 3kev (red)

ΛWDM 1kev (blue)

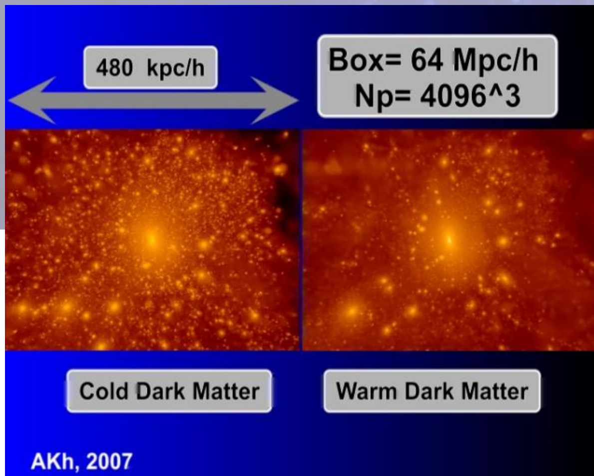
NO APPRECIABLE DIFFERENCE IN DENSITY PROFILES FROM ΛCDM AN D WDM 3keV.

Less concentration and less cuspy profiles for WMD 1keV.

Martinez-Vaquero's PhD Thesis 2010 UAM

THE MISSING SATTELITE PROBLEM

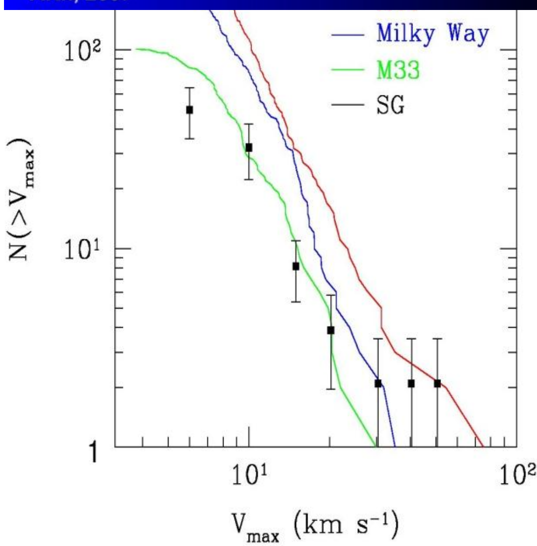
ΛCDM vs ΛWDM



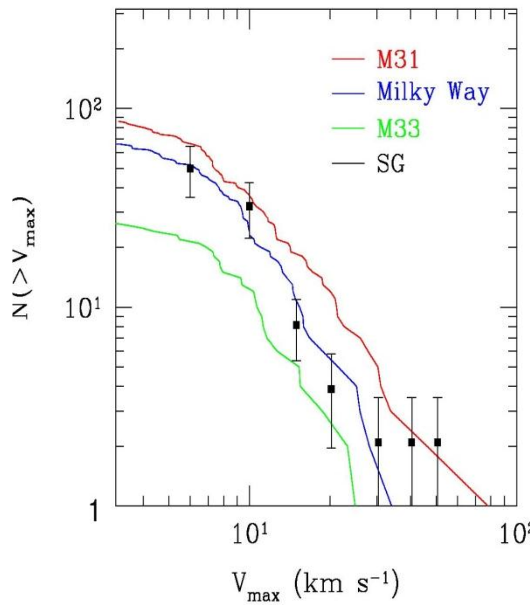
Resimulated Local Group with very high resolution:

Equivalent to 4096^3 particles in 64 Mpc box

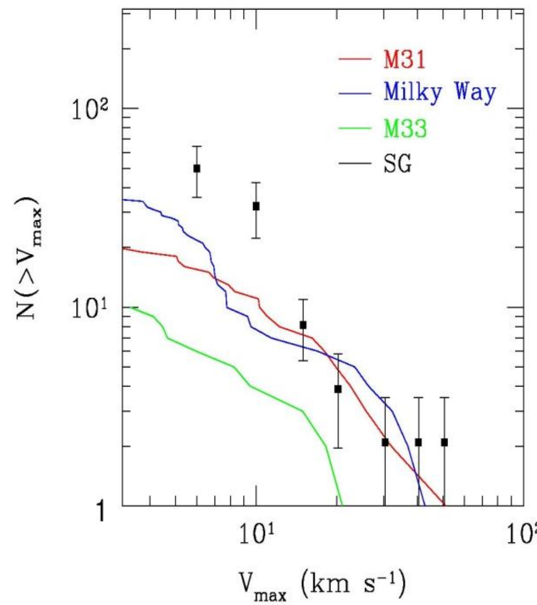
$M_{dm} = 2.5 \times 10^5 M_\odot$



ΛCDM



ΛWDM 3keV



ΛWDM 1keV

VOIDS IN THE LOCAL UNIVERSE: WDM vs CDM

- Tikhonov and Klypin (MNRAS, 2009, 395,1915) studied spectrum of mini voids in the L.U. in Karantchensev data and compared with that predicted in ΛCDM N-body simulations. They concluded that
  - **NO ΛCDM halo with V_c <35-40 km/s should contain any galaxy brighter than M_b = -12.**
  - Otherwise, the volume fraction of mini-voids would be either too big or too small compared with real L.U.
  - But.. There are galaxies in our LG with Vc < 30 km/s in the LU.
- This is another manifestation of the excess of substructure of ΛCDM at scales larger than galactic size objects

VOIDS IN THE LOCAL UNIVERSE: WDM vs CDM

- First, finding LVs in simulations:

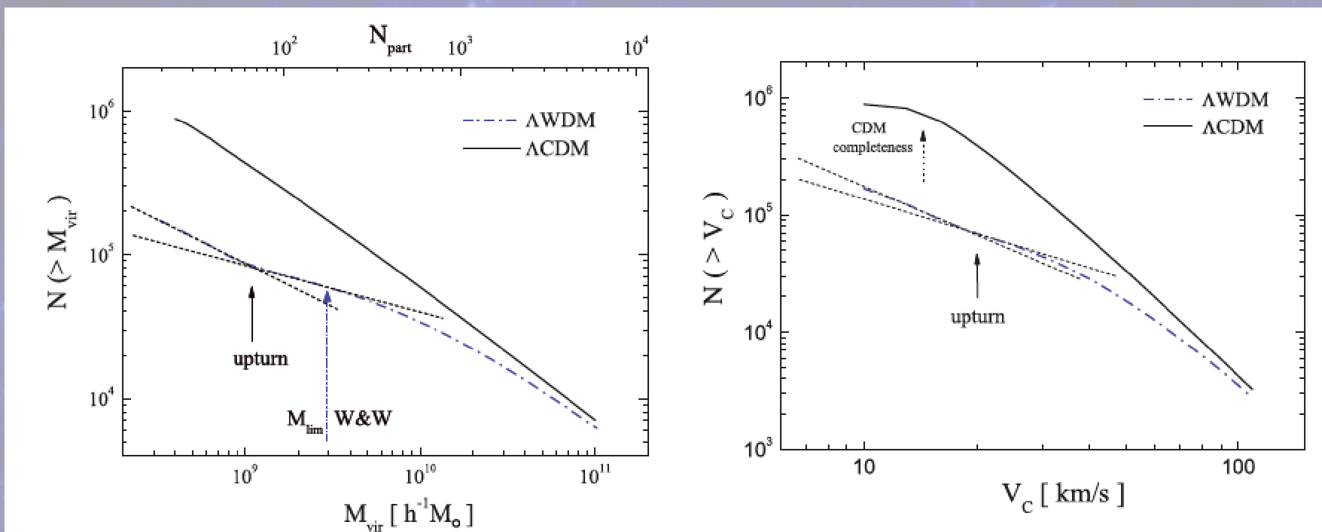
(i) We put a sphere of radius 8 Mpc on a Local Group candidate.
(ii) No haloes with $m_{\rm vir} > 2 \times 10^{13}\, \mathrm{M}_{\odot}$ are inside this sphere.
(iii) There are no haloes more massive than $5.0 \times 10^{11}\, \mathrm{M}_{\odot}$ in a distance between 1 and 3 Mpc.
(iv) The centres of the spheres (the Local Group candidates) are located at distances larger than 5 Mpc one from the other.
(v) The number density of haloes with $V_{\rm c} > 100\, \mathrm{km\, s^{-1}}$ inside this sphere exceeds the mean value in the whole box by a factor in the range 1.4–1.8.

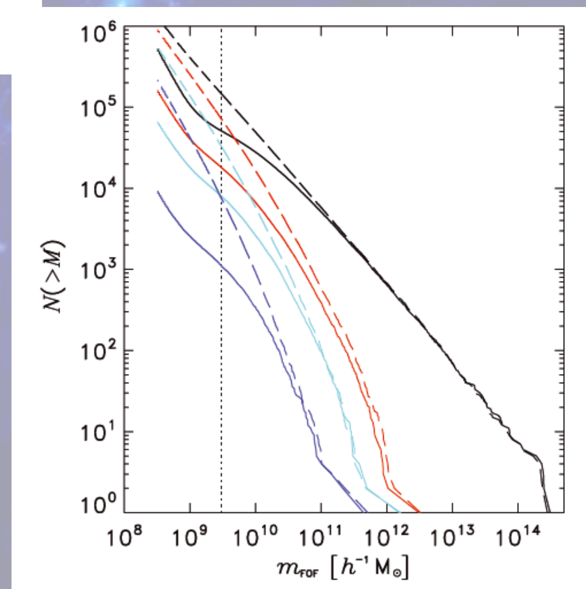
- FoF or AHF (Knollmann& Knebe 2009) halo finders
- Void Finder: (Tikhonov & Karachentsev 2006), using overlapping spheres with no galaxies brighter than a limiting magnitude.

VOIDS IN THE LOCAL UNIVERSE: ΛWDM vs ΛCDM

Tikhonov, Gottlöber, Yepes, Hoffman, MNRAS 399,1611, 2009 , astro-ph/0904.0175

Influence of fake dark matter halos



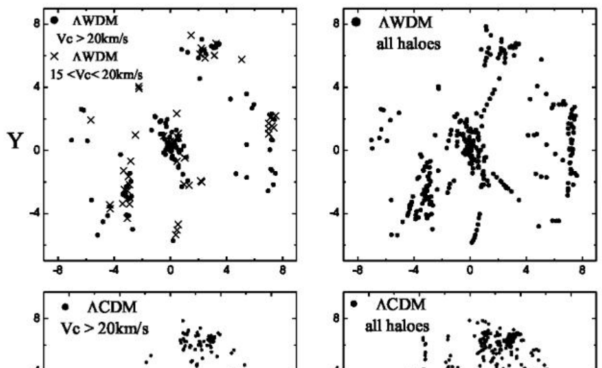


Fake halos are formed at all epochs (z=8—0). Clearly shows a complex behavior that needs to be explored in detail numerically. SO, we consider M_{lim} from W&W as good as any other characterization of the mass function of halos.

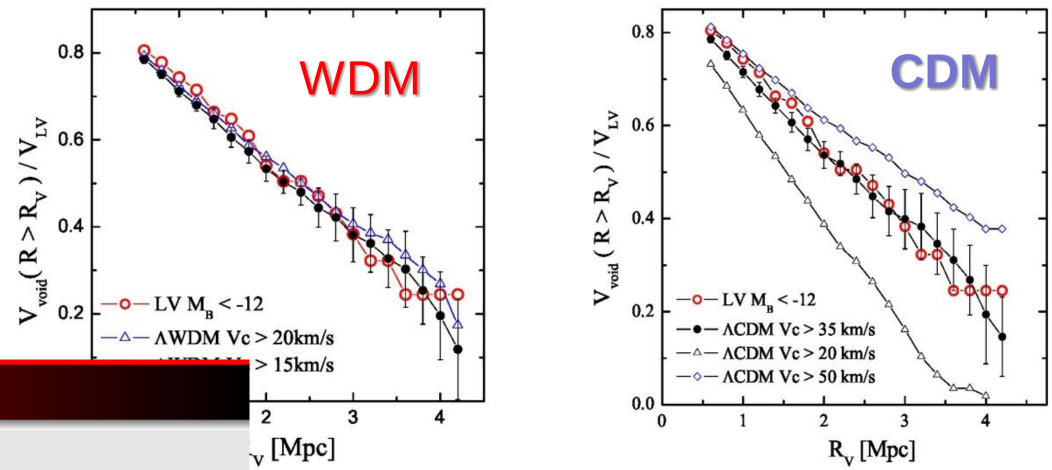
We have taken the upturn of the mass function as a limit to distinguish fake from real halos in our WDM runs

VOIDS IN THE LOCAL UNIVERSE: ΛWDM vs ΛCDM

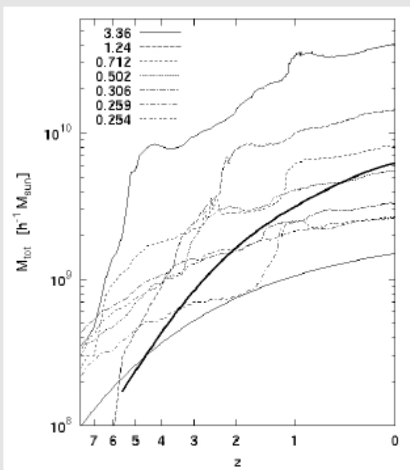
Tikhonov, Gottlöber, Yepes, Hoffman, MNRAS 399,1611, 2009 , astro-ph/0904.0175



Volume filling fraction of voids



Critical mass M_c of star formation



Hoeft et al. (2006)

- uniform UV-background (Haardt, Madau 1996)
- critical mass $M_c(z)$ for halos with low gas fraction (thick solid line)
- mass accretion history of seven halos (mass in $10^{10} h^{-1} M_\odot$)
- mean mass accretion history of a $1.4 \times 10^9 h^{-1} M_\odot$ halo

no star formation right of the thick solid line

Conclusions: For WDM, only halos with Vc < 20 km/s would not have to host galaxies.

Better in agreement with data: there are galaxies as low as V_c=20 km/s observed. Need to do galaxy formation simulations for a self consistent picture.

HI Velocity Function in CDM vs WDM

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- **Compare Velocity functions (VF) instead of Mass functions.**
  - **Advantage** of a more direct comparison with observations. Avoids the complex problem of relating Dark halo mass vs galaxy Luminosity.
  - Need to provide a model for baryon infall to estimate V_{max} of disk+halo from V_{max} of halos.
- HI Observations of nearby galaxies can estimate the VF down to the lowest luminous rotationally supported objects.

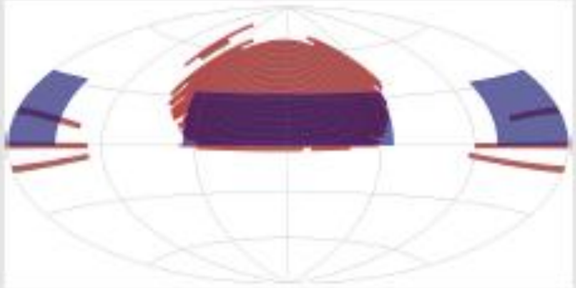
HI Velocity Function in CDM vs WDM

Arecibo Legacy Fast ALFA (ALFALFA) survey

Giovanelli et al 2007; Kent et al 2008 (Vdr)

Saintonge et al 2008; (aVdr)

~6% final volume



- blind HI survey, started February 4, 2005 (6-7 years expected)
- detection of 20,000 galaxies expected within 200 Mpc
- gas rich galaxies with only a few or no stars ("dark")
- two arrays (Virgo and anti-Virgo)

Subsample of ALFALFA objects:

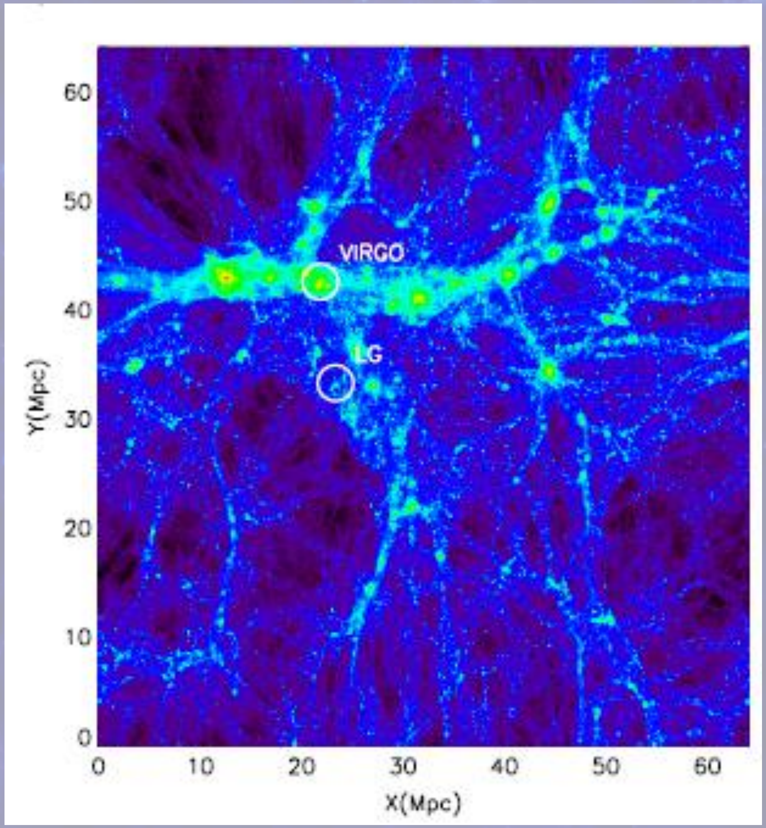
D<20/h Mpc

No HVC or no measured HI masses

Measured inclination and i>30º

Proper projection of CLUES volume

- The significance of the study relies on proper representaton of the local environment.
- Based on the location of Virgo and LG in the simulation volume we define the Supergalactic coordinate system



Two reference systems:

- SG0: Equatorial plane defined by the position of the LG and the Local Super Cluster. Need Virgo and another cluster in the LSC to define the plane. Take Virgo to the right position in SG coords by rotations of the orthogonal axes
- SG_{min}: Minimize the quadratic distance from LG to Virgo and Fornax clusters.

Proper projection of CLUES volume

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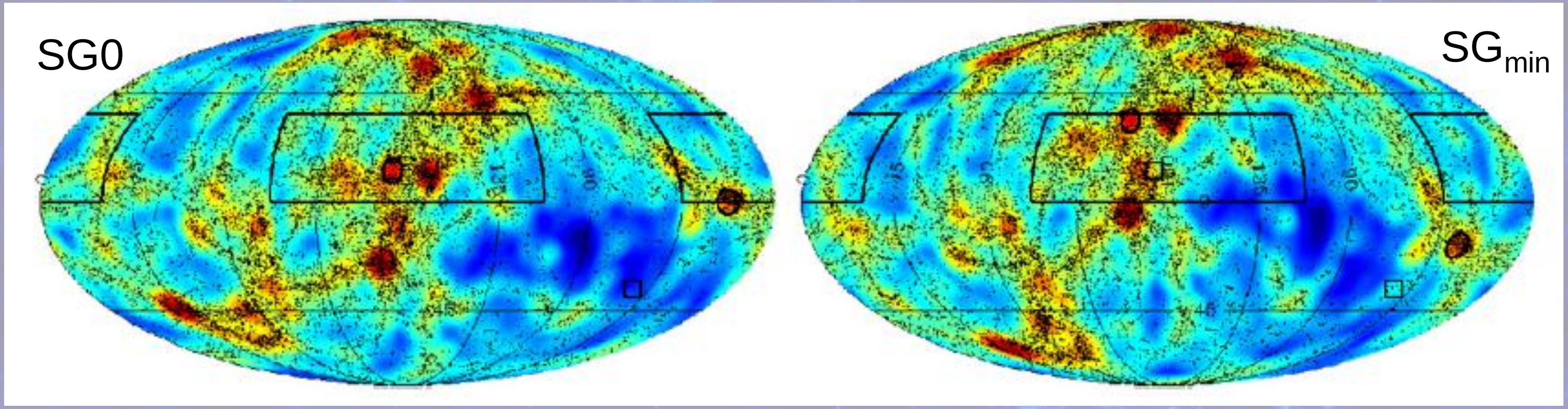
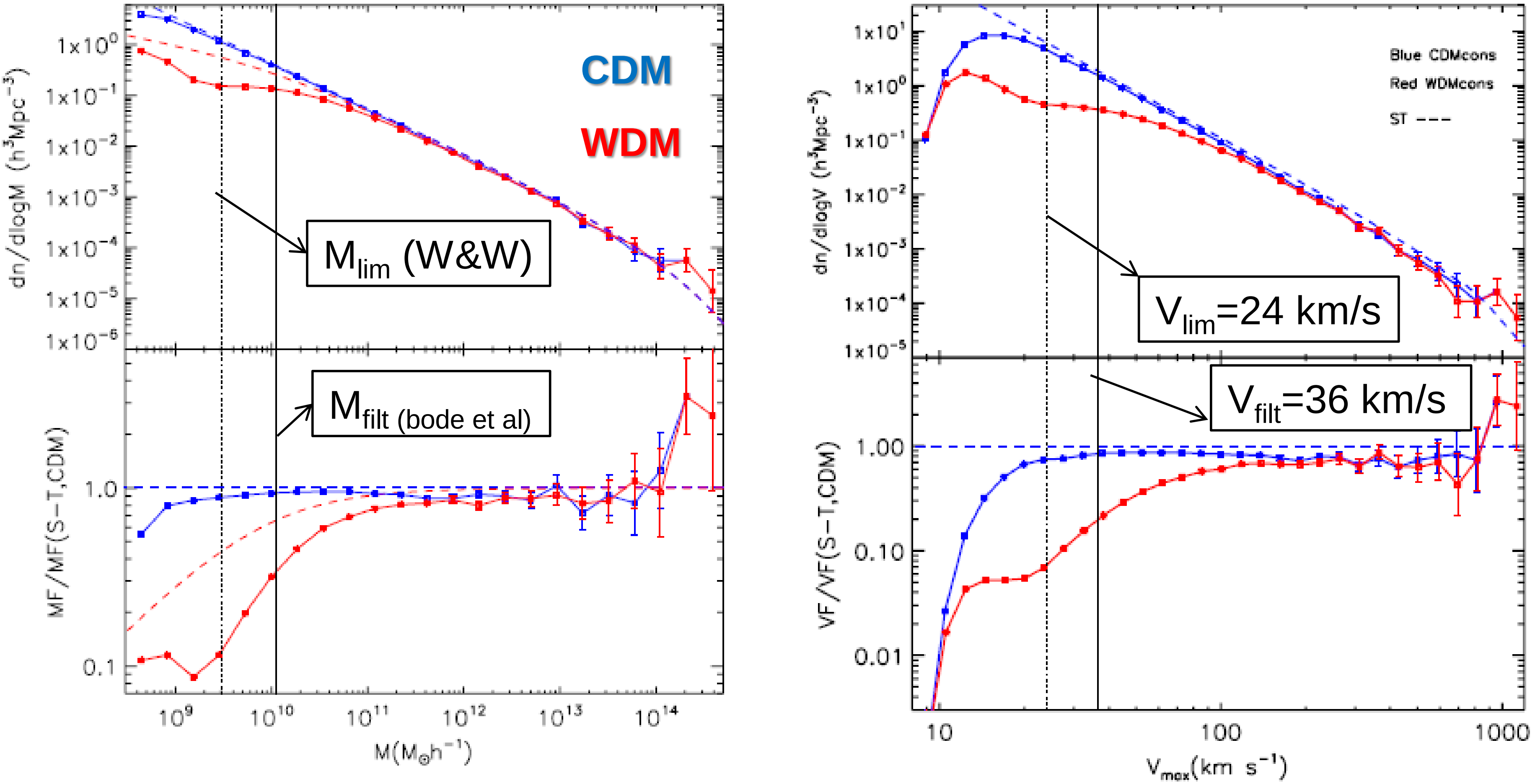


Mollweiden proiection in RA-Dec system. 20/h Mpc volume projected

- Good agreement in the VdR, but not so good in the aVdR because of systematic shifts in the position of Fornax. Much better in the SG_{min} projection

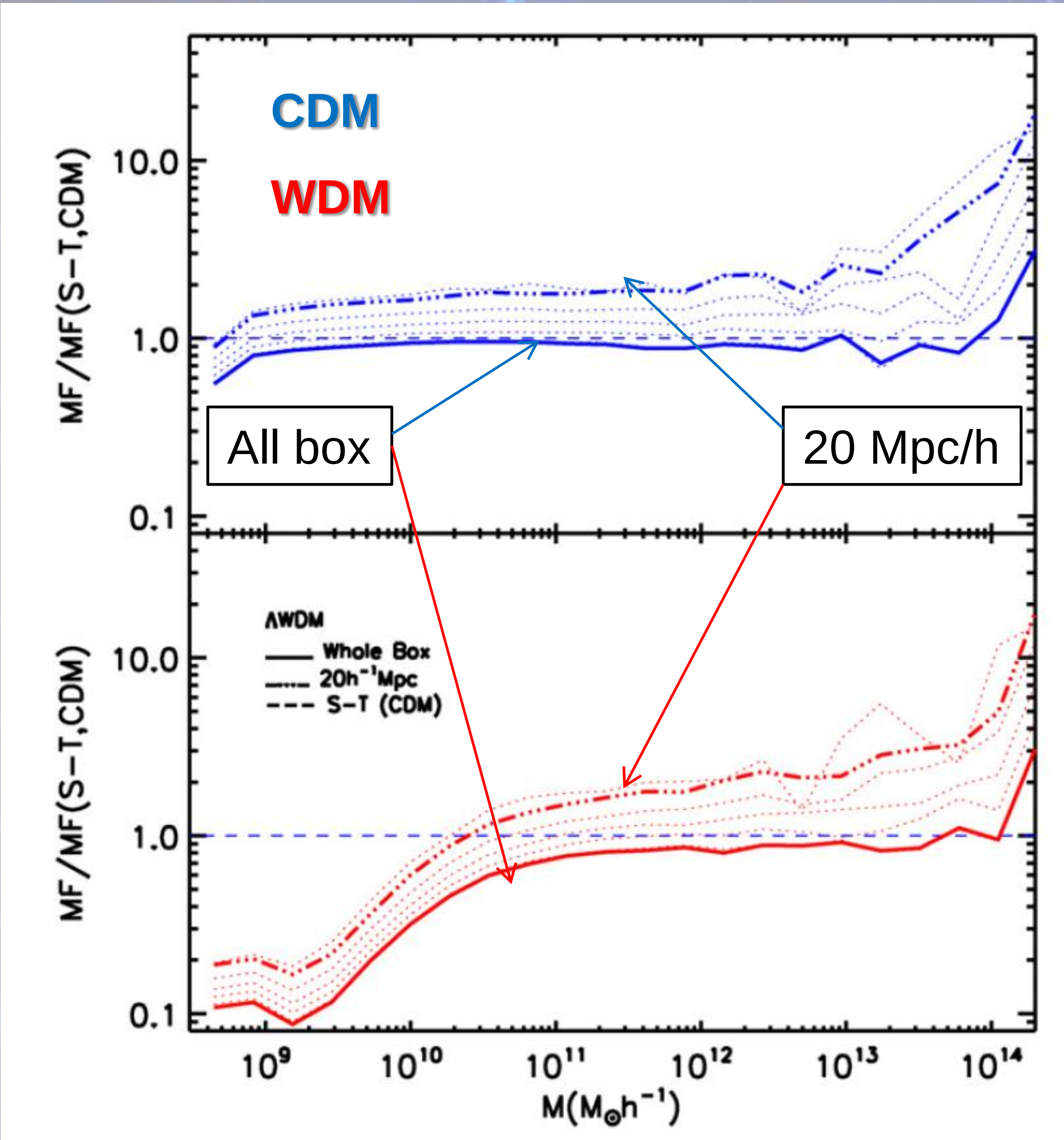
Mass and Velocity functions

- Global Mass and Velocity functions from the whole simulate box 64 /h Mpc.
  - Analytical velocity estimate from S-T + c-M relation+NFW (Sigad et al 2000)



Local Mass and Velocity functions

- Mass functions in Local Neighborhood.



- Growing spheres of radius 15/h to 40 /h Mpc
- **The Local Environment represented in the simulation shows an overabundance of halos of a factor of ~2 compared with the mean in the whole volume.**
- Tikhonov and Klypin 2009 found similar behaviour for LV galaxies (8 Mpc /h sphere). Luminosity function is larger by 1.4 than universal LF…

Simulating the ALFALFA Field of View

- Extracted the two separate regions: Virgo (VdR) and Anti-Virgo (aVdR)

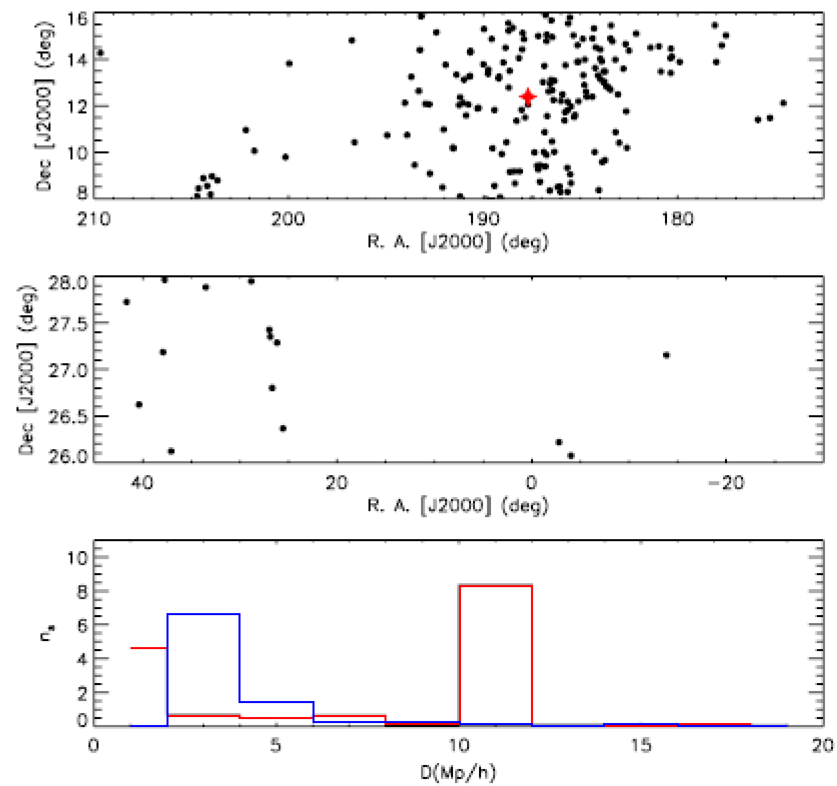
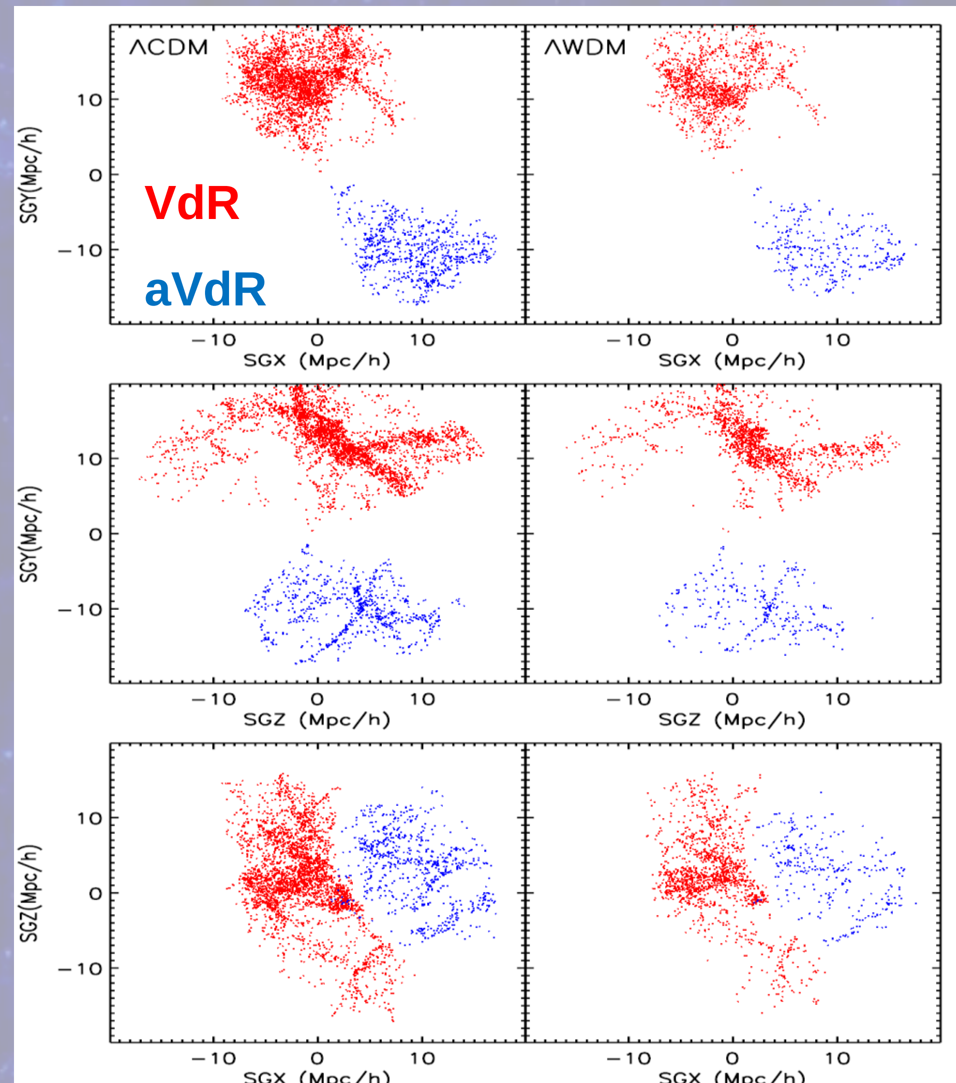


Figure 12. Upper panel: distribution in equatorial coordinates of the sample of H I sources taken from the ALFALFA public catalogs released so far in the VdR. The position of M87 in the Virgo cluster is marked as a red star. Middle panel: sample of sources in the aVdR. Lower panel: the number density of sources as a function of their distance to the MW (red and blue for the VdR and aVdR, respectively).



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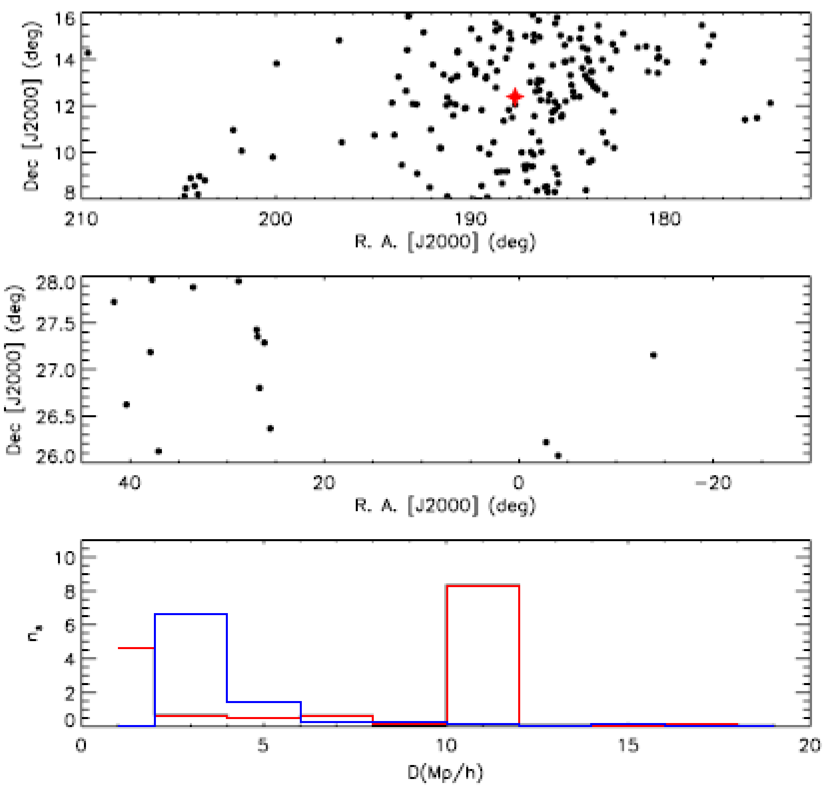

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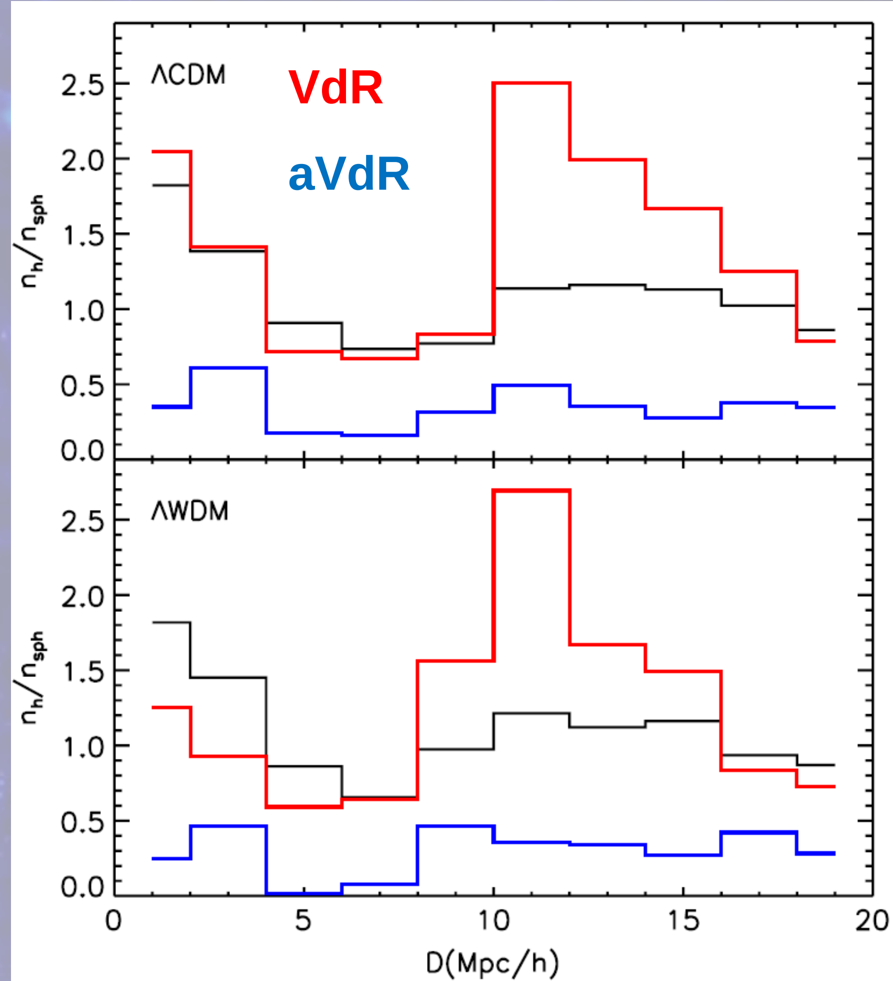
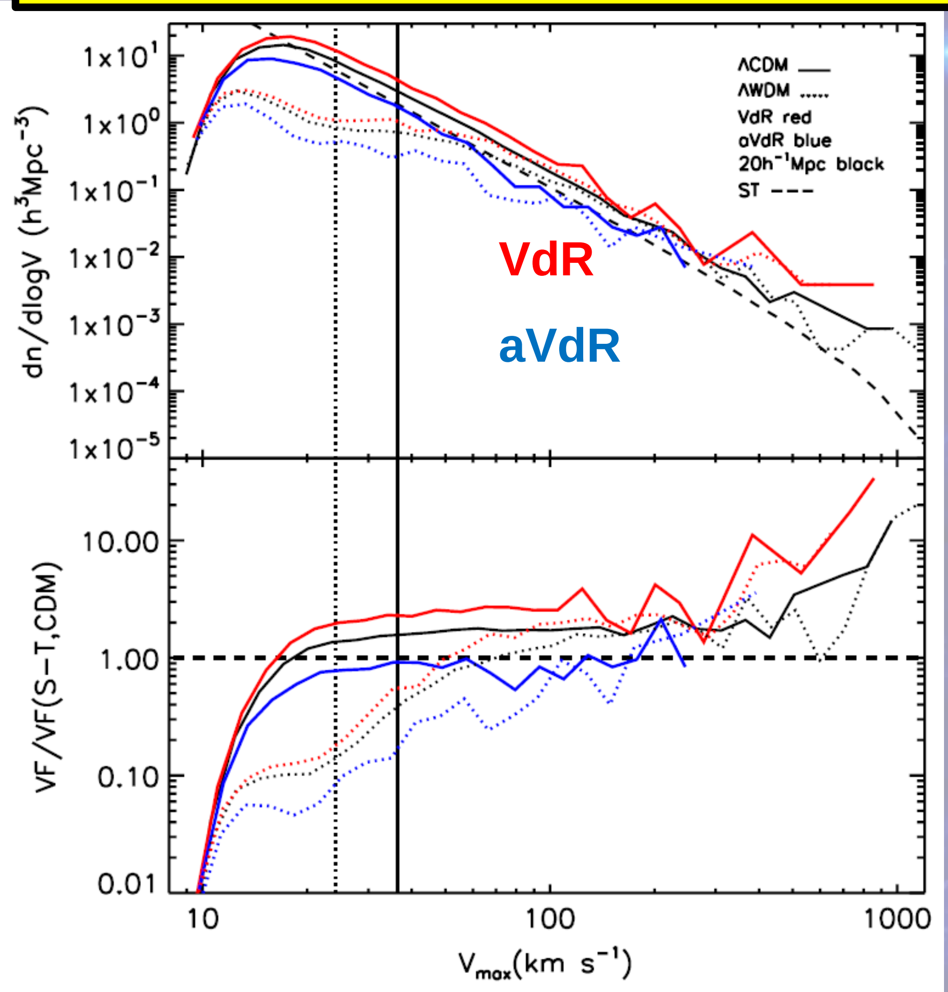


Simulating the ALFALFA Field of View

- Extracted the two separate regions: Virgo (VdR) and Anti-Virgo (aVdR)

Differential VF for ALFALFA FoVs in the CLUES CDM and WDM



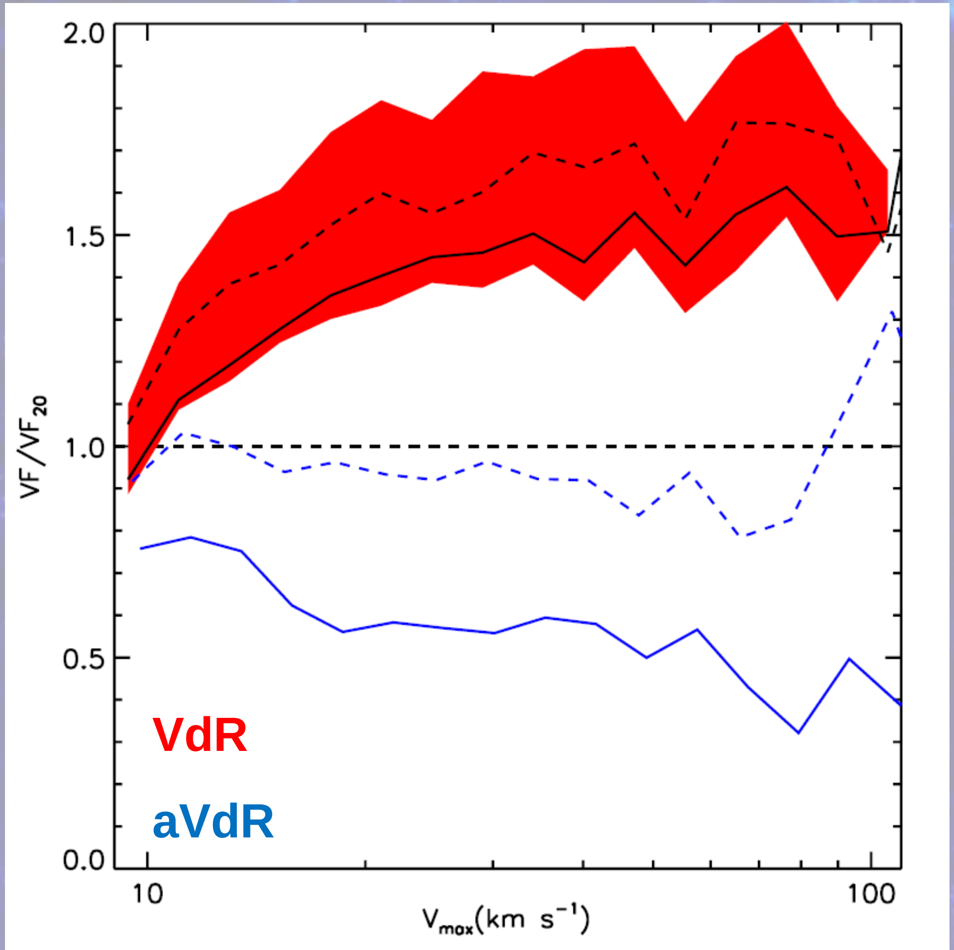
For V_{lim}=24km/s < V_{ma}x < 100 Km/s

VF's differ by factor of 3 between VdrR and aVdR in both cosmologies.

Simulating the ALFALFA Field of View

- ❑ Extracted the two separate regions: Virgo (VdR) and Anti-Virgo (aVdR)

Dependence of the selection of System of reference:



For Vlim=24km/s < Vmax < 100 Km/s

VF's differ by factor of 3 between VdrR and aVdR in both cosmologies.

Ratio of differential VF for two FoV

- Solid lines are for SG_{min}
- Dashed for SG0

Results vary from 15-20% (VdR) and by 40-50% (aVdR)

Red area represents rotations of the SG0 up to 20º in both directions for VdR: changes of order 20-30%

Modeling Velocity function for disk galaxies

- To direct comparison with ALFALFA data we need to populate our halos with disk galaxies:
  - Need to establish a relationship between measured circular velocity of disk galaxies with Vmax of halos.
- Since we are dealing with rather low mass isolated galaxies, we assume no halos > 10^{13} Msun and no satellites, just the central galaxy of each halo.
  - Satellites are roughly 10-40% (Zheng et al 2007) and are not likely to be detected by ALFALFA (most of them are likely to have lost HI gas
  - HI studies of nearby groups show that half of satellites will not have enough gas to be detected by ALFALFA (Kilborn et al 2005
- Our results may underestimate the abundance of HI sources by 5-20% at most.

Modeling Velocity function for disk galaxies

- Use Mo et al 1998 model to compute circular velocity of disk lying in the center of dark halos.
  - Conservation of specific angular momentum of both gas and dark matter.
  - $J_{disk}/M_{disk} = J_h/M_h$ during disk formation.
  - V_{max} (disk+halo) = $G(\lambda, f_{disk})\, V_{max,halo}$

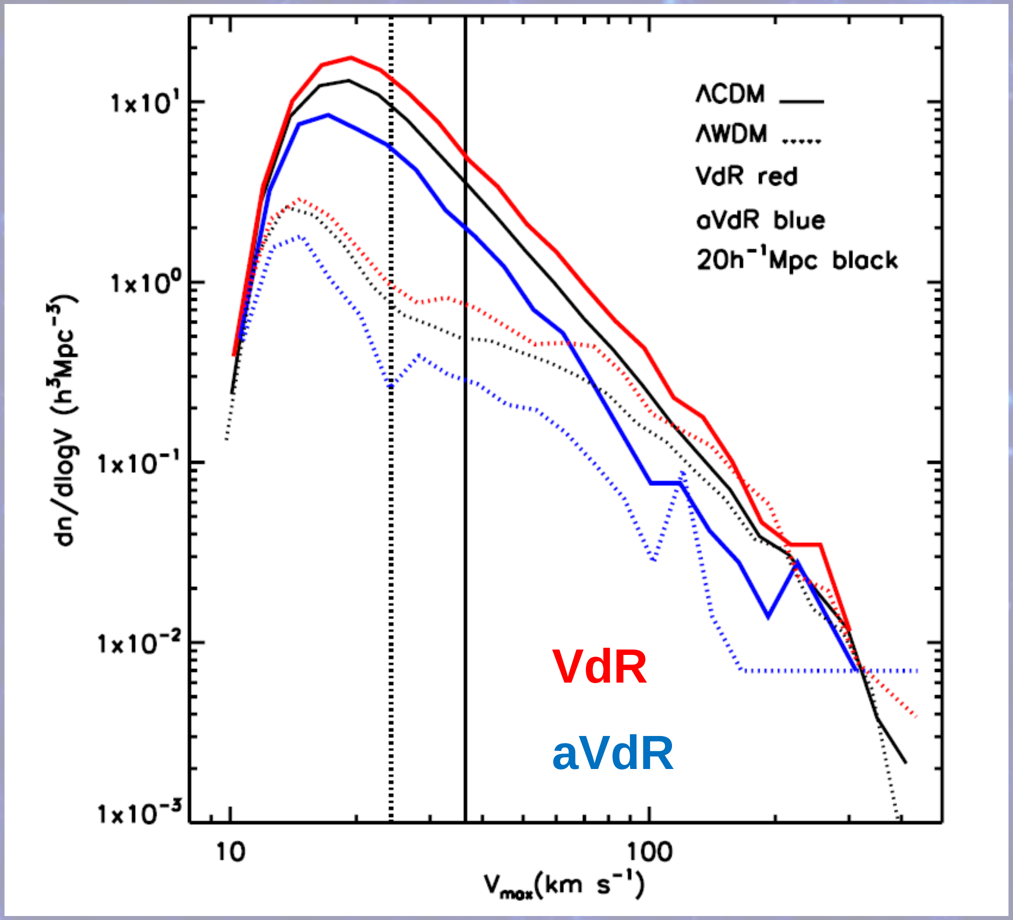
$$G(\lambda,\, f_{\rm disk}) = 1.04\left(1 - \frac{0.11\, f_{\rm disk} + 5\times 10^{-4}}{\lambda}\right)^{-1}$$

Zavala (2003)

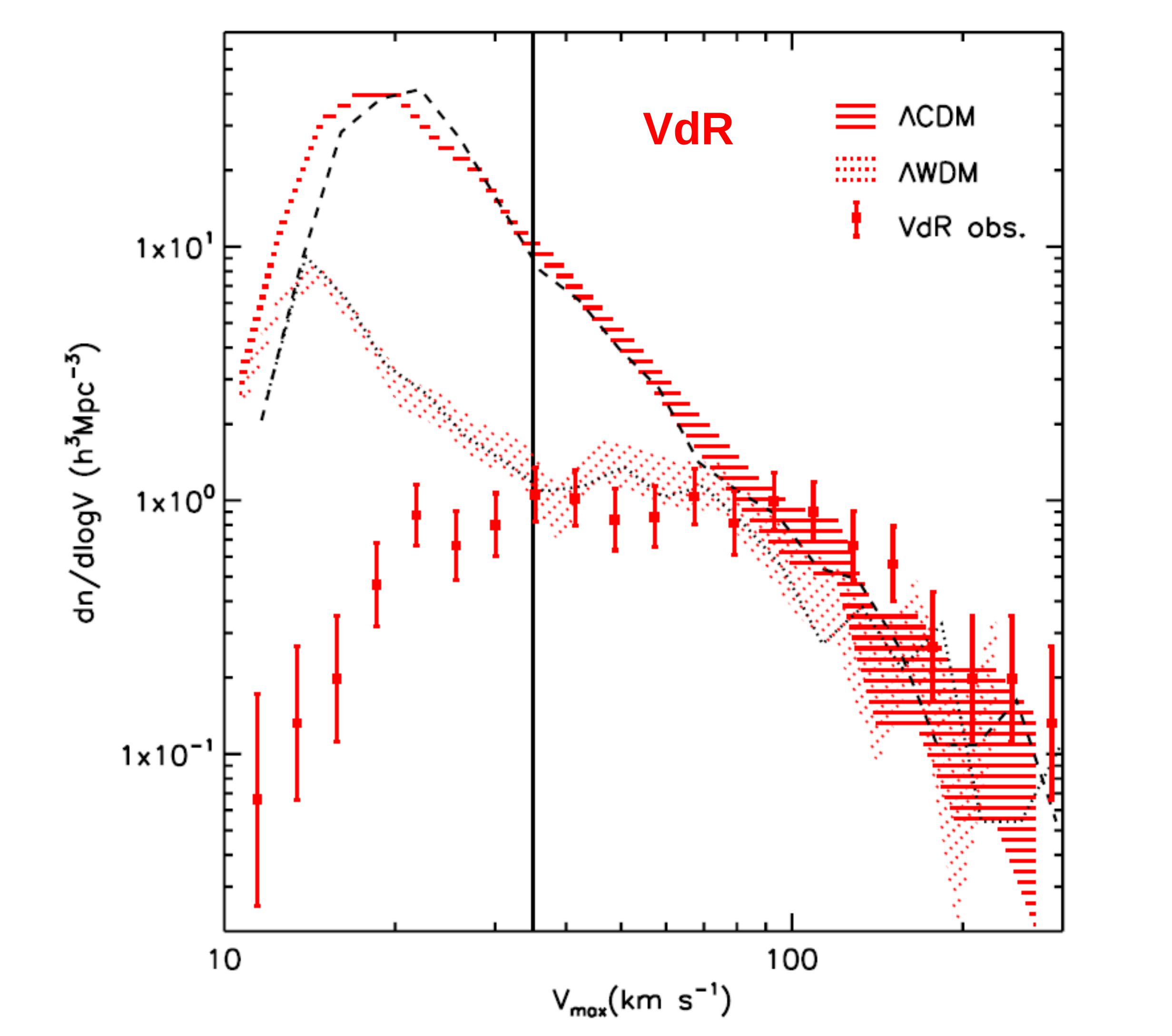
  - $f_{disk} = M_{disk}/M_{vir}$ (depends on disk assembly, take constant 0.03)
  - λ_{lim}= 0.02 (for lower spin parameters no stable disk (Mo etal 08)

Modeling Velocity function for disk galaxies

- Differential Velocity function of modeled galaxies (disk+halo). Fixed value for f_{disk} has been used.



The HI Velocity Function



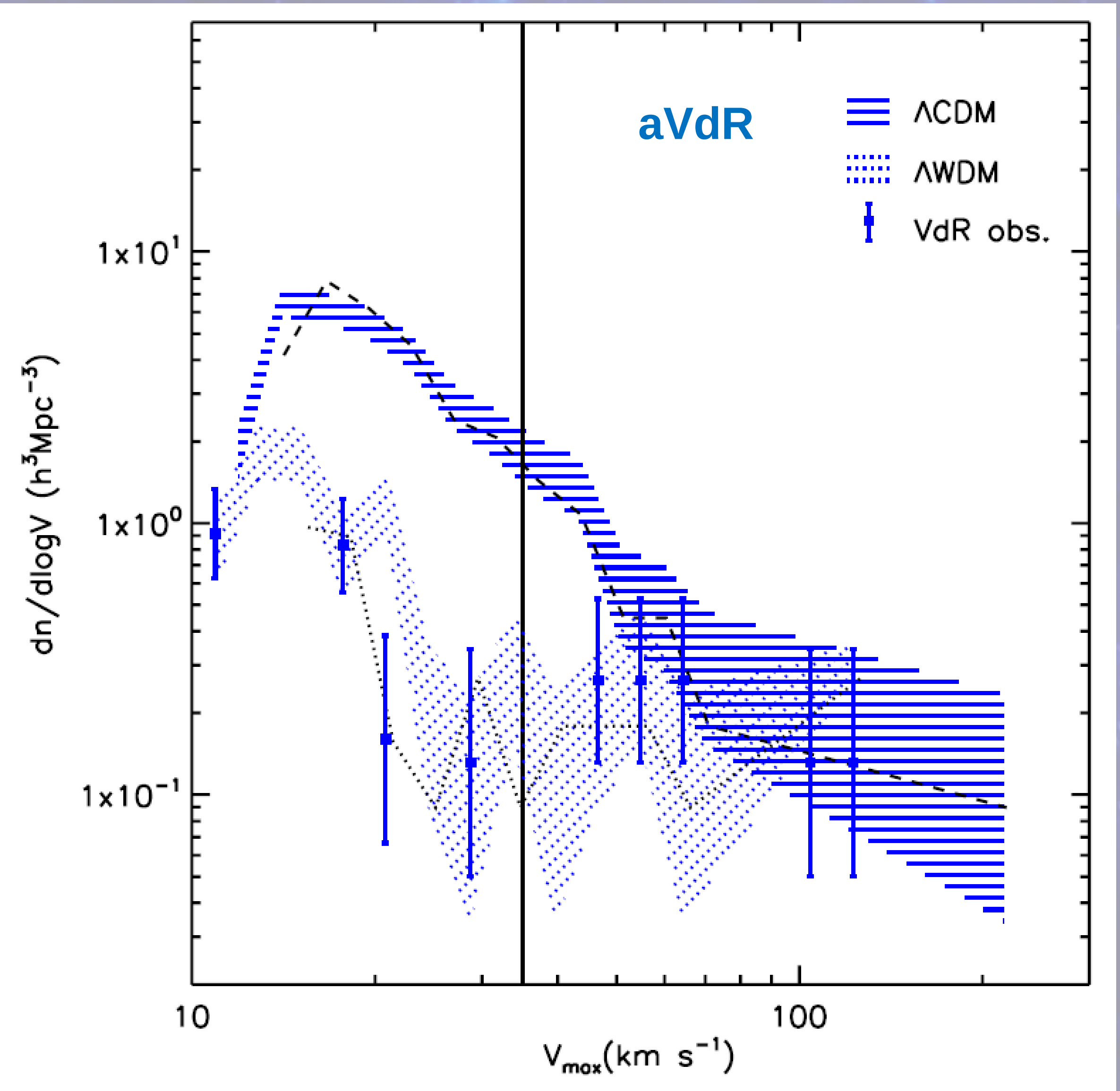
Comparison of WDM and CDM predictions to the VF with ALFALFA results for the Virgo region.

For V > 80 km/s both simulations agree well with the data.

But CDM is predicting too many HI galaxies for lower Vcir as compared with ALFALFA and WDM.

No significant effect of (simple) feedback to reduce abundance in CDM. Need almost a factor 10 suppresion at completion limit.

The HI Velocity Function



Comparison of WDM and CDM predictions to the VF with ALFALFA results for the Virgo region.

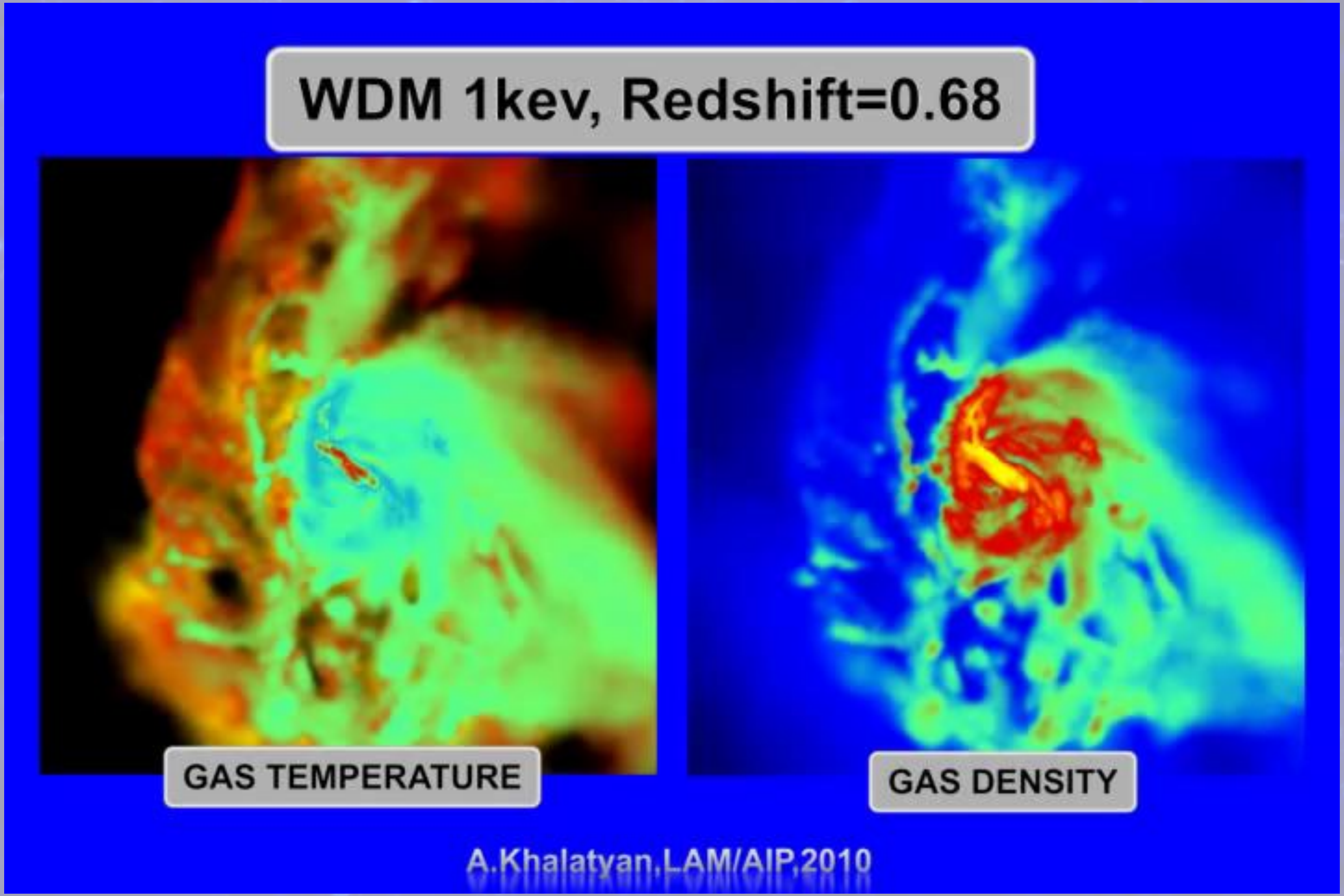
For V > 80 km/s both simulations agree well with the data.

But CDM is predicting too many HI galaxies for lower Vcir as compared with ALFALFA and WDM.

For aVdR statistical significance of the observed sample is much smaller, only 15 sources.

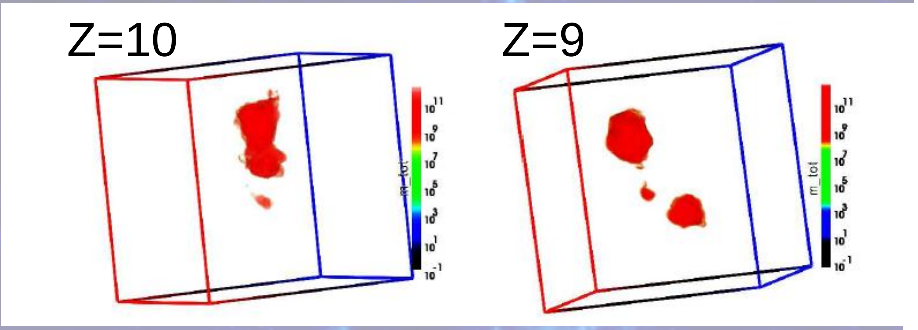
WDM Gasdynamics

- Effect of baryons in WDM halos is not yet studied in detail. Need to run gasdynamical simulations to see whether the effects are similar to CDM halos:
- Resimulation of the LG WMAP3 in WDM with Gastrophysics



Reionization of the Local Group

Total mass of progenitors



Neutral mass of progenitors

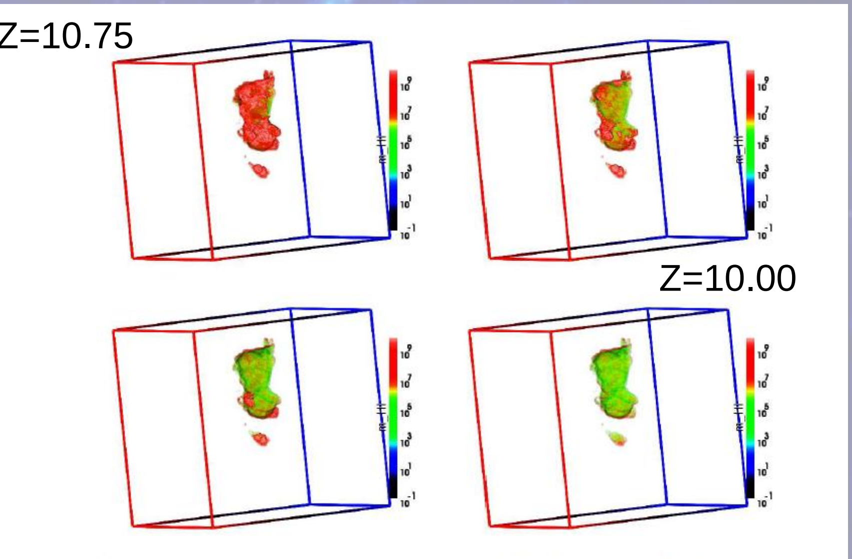


Figure 5. Evolution of the neutral mass at (top to bottom and left to right) redshifts $z = 10.75, 10.5, 10.25$ and 10 for Model 1. Red is neutral, green is ionized.

Reionization of the Local Group of Galaxies

Ilian T. Iliev[1,2⋆], Ben Moore[2], Stefan Gottlöber[3], Gustavo Yepes[4], Yehuda Hoffman[5] and Garrelt Mellema[6]
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[2] Universität Zürich, Institut für Theoretische Physik, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland
[3] Astrophysical Institute Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany
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[6] Stockholm University, SE-106 91 Stockholm, Sweden

astroph/1005.3139

Ve present the first detailed structure formation and radiative transfer simulations of the reionzation history of our cosmic neighbourhood. To this end, we follow the formation of the Loal Group of galaxies and nearby clusters by means of constrained simulations, which use he available observational constraints to construct a representation of those structures which reproduces their actual positions and properties at the present time. We find that the reionization history of the Local Group is strongly dependent on the assumed photon production efficiencies of the ionizing sources, which are still poorly constrained. If sources are relatively efficient, i.e. the process is 'photon-rich', the Local Group is primarily ionized externally by the nearby clusters. Alternatively, if the sources are inefficient, i.e. reionization is 'photon-poor' the Local Group evolves largely isolated and reionizes itself. The mode of reionization, external vs. internal, has important implications for the evolution of our neighbourhood, in terms of e.g. its satellite galaxy populations and primordial stellar populations. This therefore provides an important avenue for understanding the yound universe by detailed studies of our nearby structures.

Depending on the efficiency of the sources of UV:

Photo-rich: LG is reionized externally from Virgo and Fornax

Photo-poor: The LG reionizes itself.

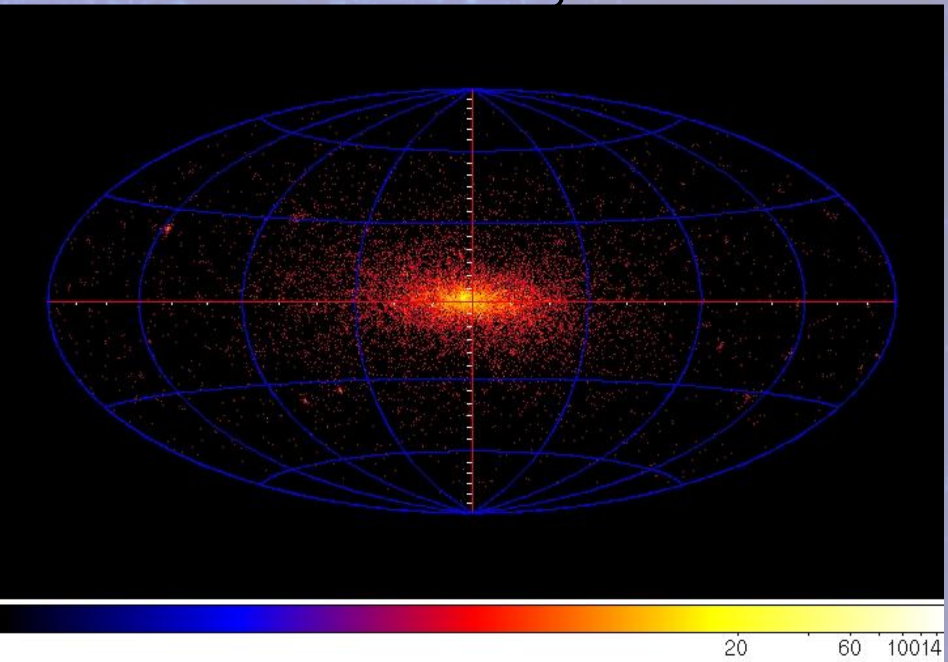
CLUES and Dark Matter Detection

Make simulated maps of γ-ray detection by FERMI

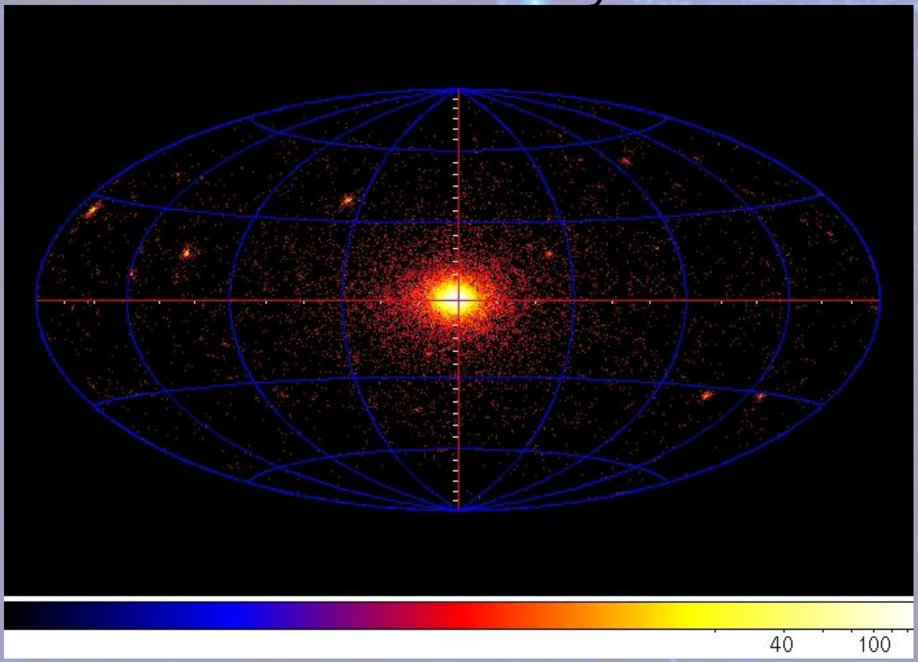
Study emission in substructures .

Compare between dark matter only and baryons.

MW dark matter only



MW dark+baryons



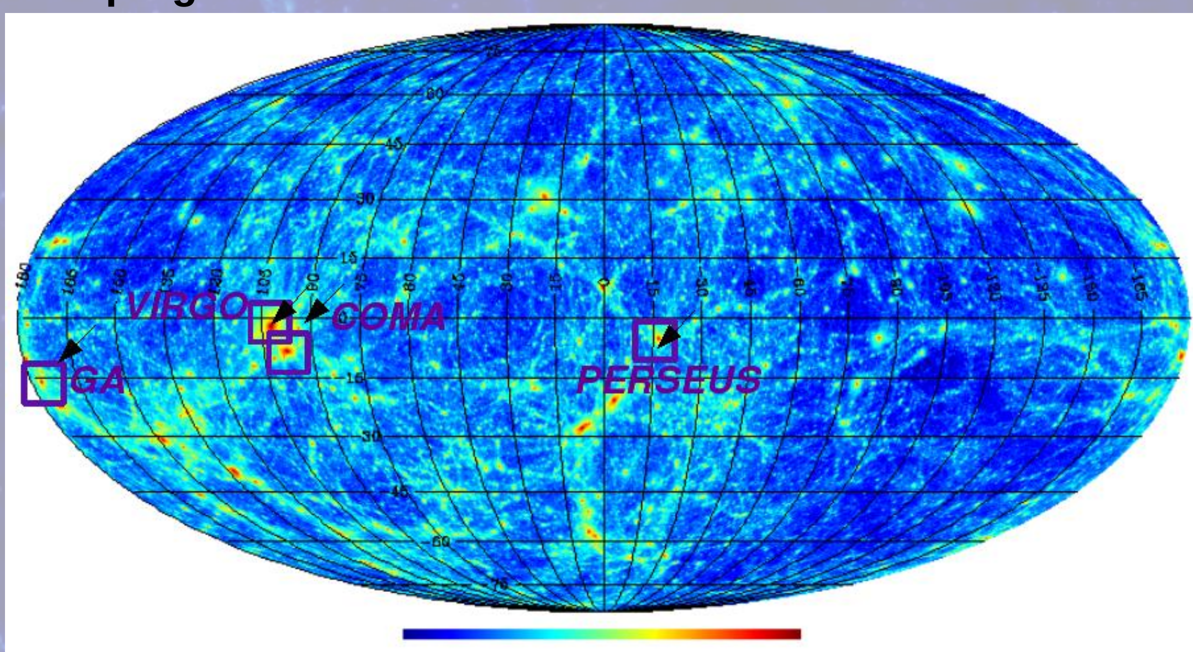
CLUES and Dark Matter Detection

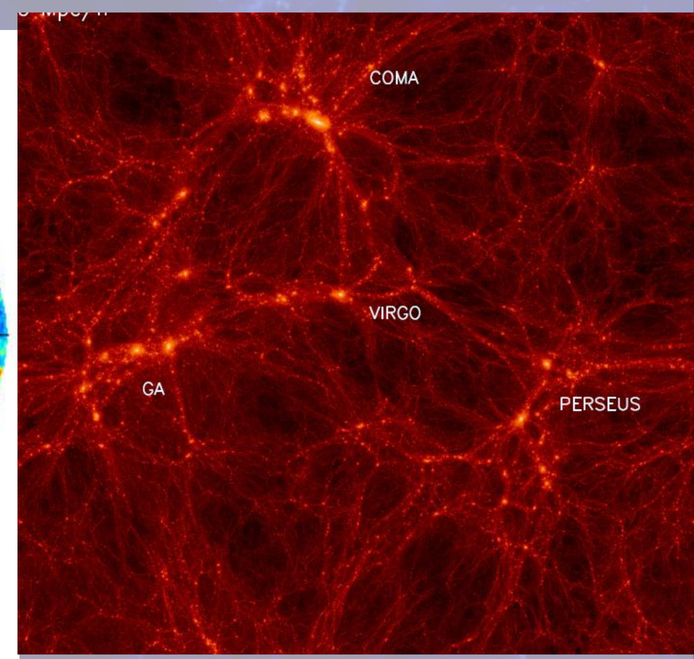
Make simulated maps of γ-ray detection by FERMI

Signal from extragalactic nearby structures to the LG.

Box 160 Mpc density projection

in supergalactic coordinates





CONCLUSIONS AND FUTURE PROJECTS

- Constrained Simulations of Local Universe are a very interesting tool to do Near Field Cosmology.
- The CLUES project is aimed at producing a set of initial conditions which mimics better than any other simulation before the mass distributions around us, up to 80 Mpc away.
  - *Solve the controversy about the influence of D.E in the dynamics of LG*
- **We have resimulated the formation of LG-like objects with high resolution in different dark matter models (CDM and WDM)**
  - To reconcile the number of MW satellites with dark matter substructures one can resort to photoionization of gas in CDM model or to WDM with m=3keV particles. For less massive WDM particles, we **under predict** number of substructures.
  - To reconcile with abundance of voids in L.U. and HI velocity function, a smaller mass for WDM would be required (m_{WDM} 1 keV)
  - SIMUGAL-LU DEISA has made possible to produce high-resolution gasdynamical simulations of Local Group. Useful to study the effects of baryons on the dark matter and direct comparison with observations. One of the highest resolution simulations of a LG object which include baryons.
- New simulation with baryons are under way. WMAP5 LG and the Local Volume. Also improving set of observational constrains and generation of ICS .

CLUES

Constrained Local UniversE Simulations

GRACIAS POR SU ATENCIÓN

THANKS FOR YOUR ATTENTION

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