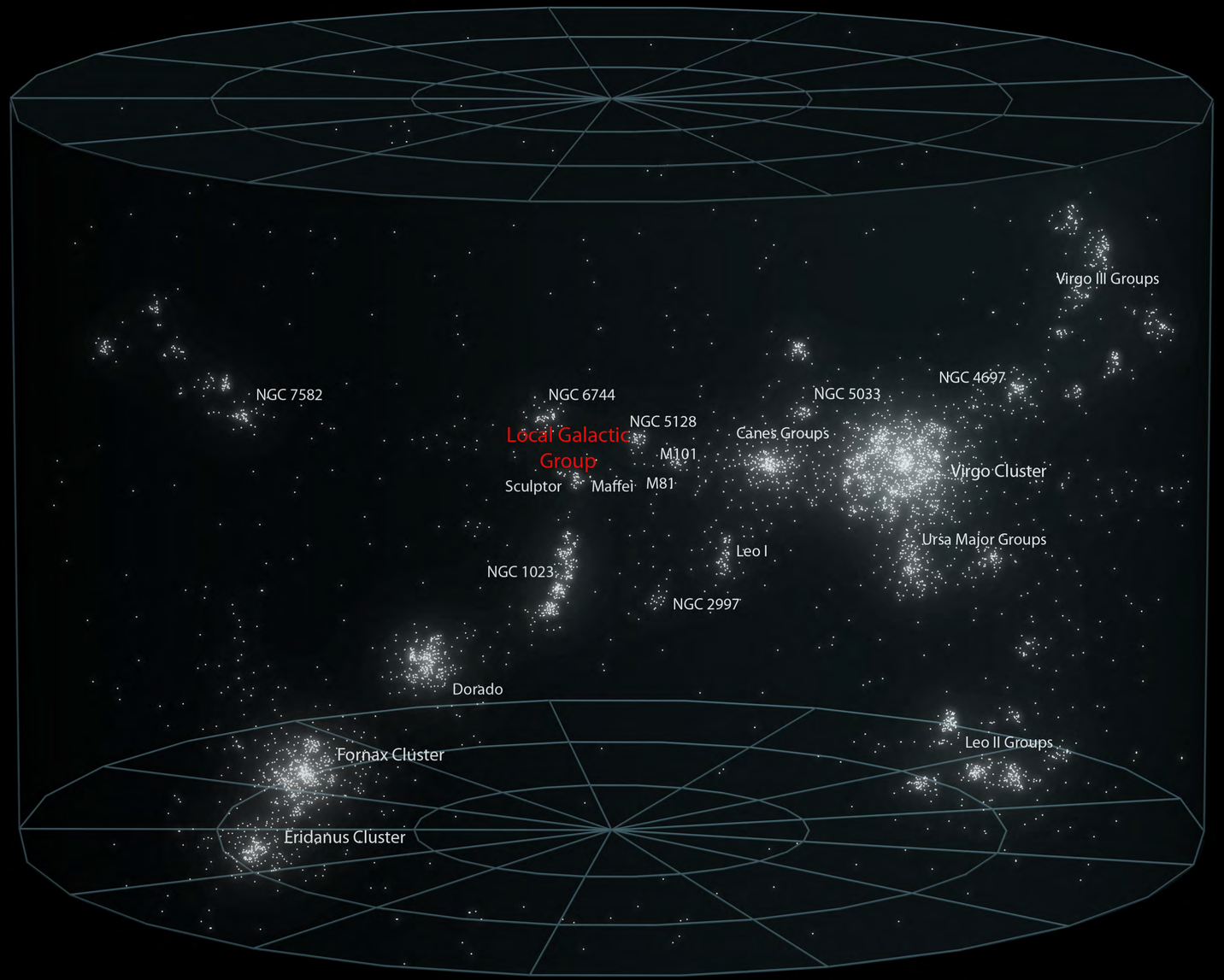
Optically Dark Clouds in Cluster of Galaxies

Optically Dark Clouds in Virgo

Observation of the clouds

Observation cluster os galaxies

Virgo Supercluster

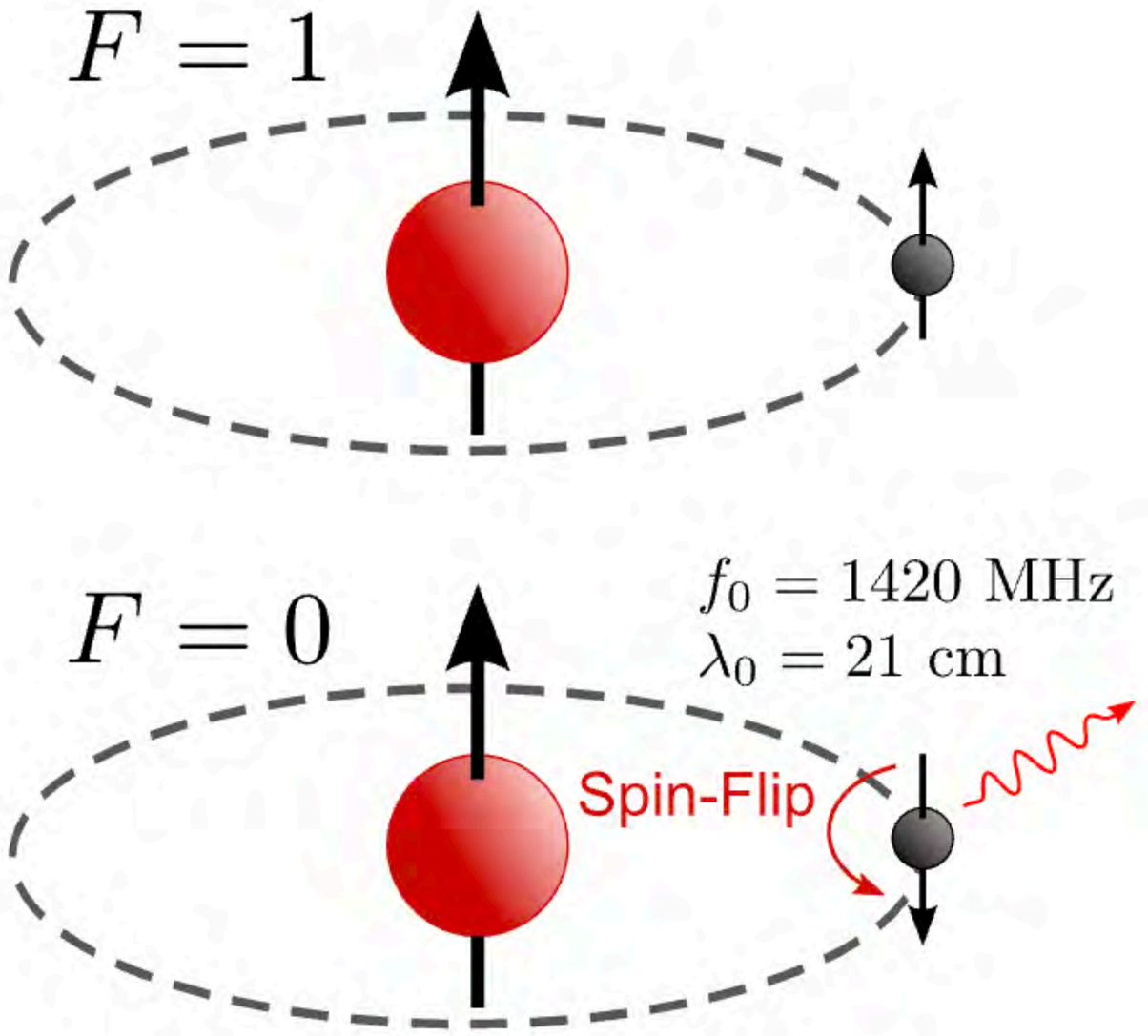


Arecibo Radio Telescope

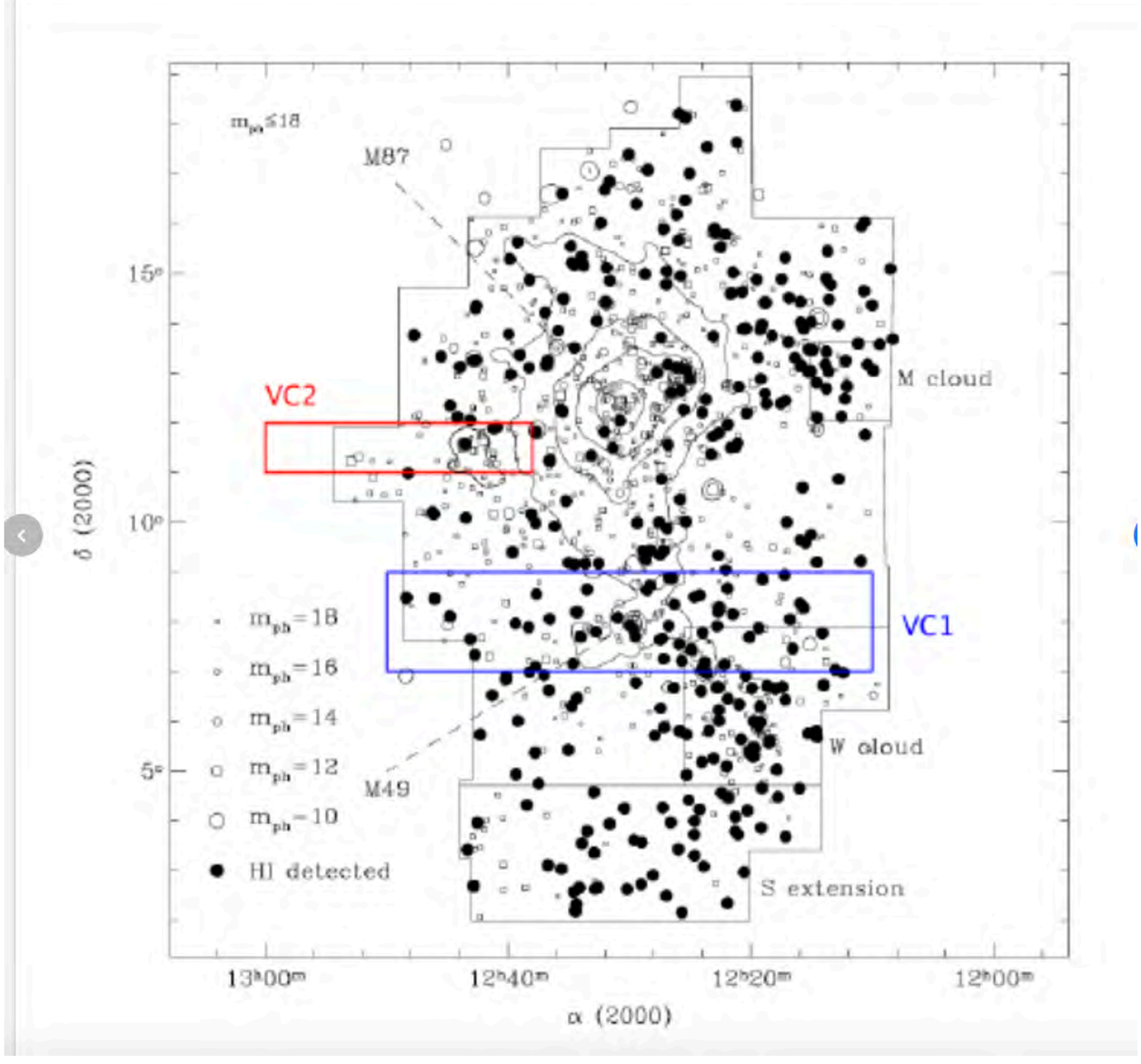
305 m

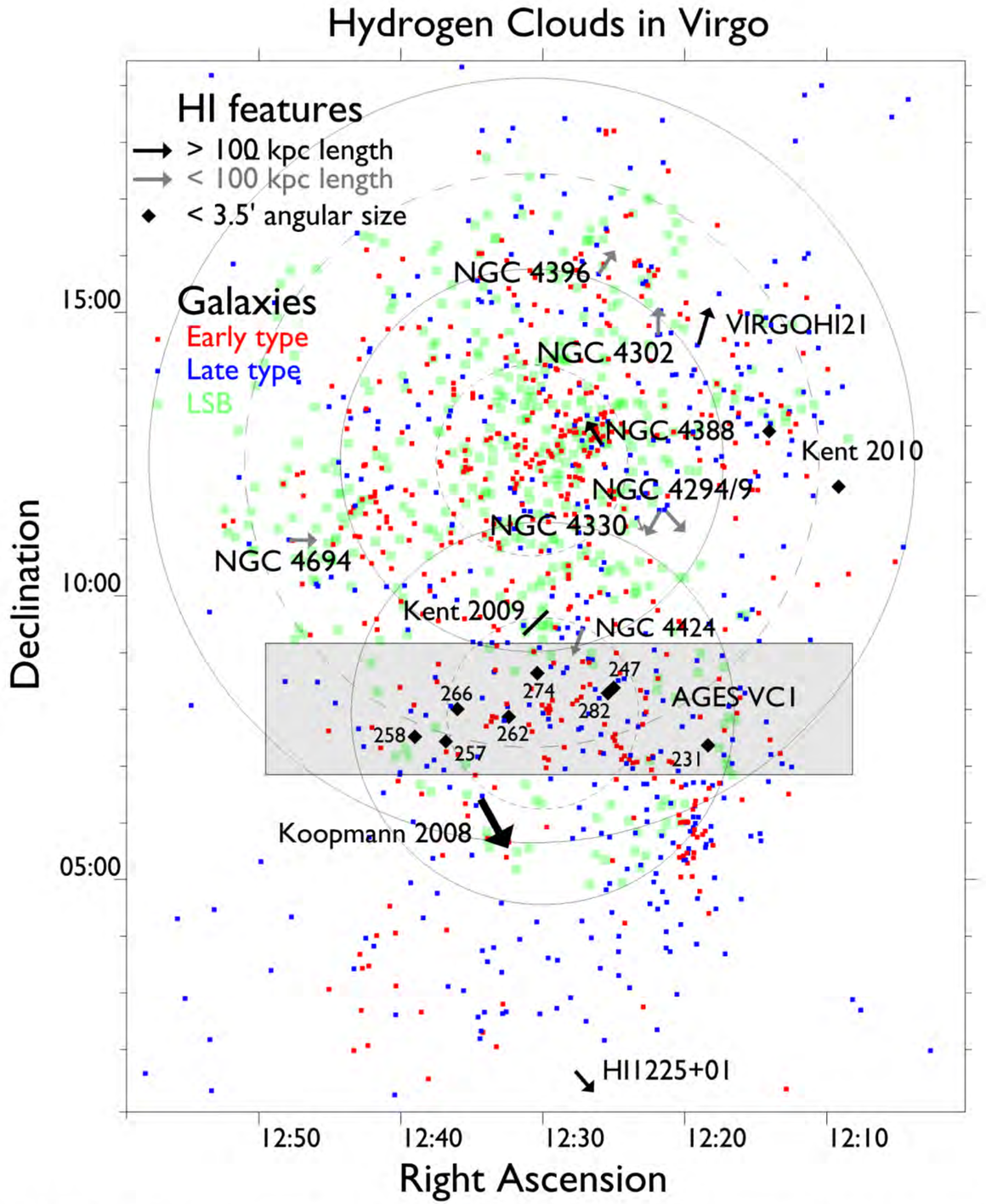
Resolution 3.5 arcmin

Images show the Arecibo Observatory telescope's collapse. NAIC Arecibo Observatory/NSF, Ricardo


$F = 1$
$F = 0$
$f_0 = 1420$ MHz
$\lambda_0 = 21$ cm
Spin-Flip

ROSAT x-ray observation



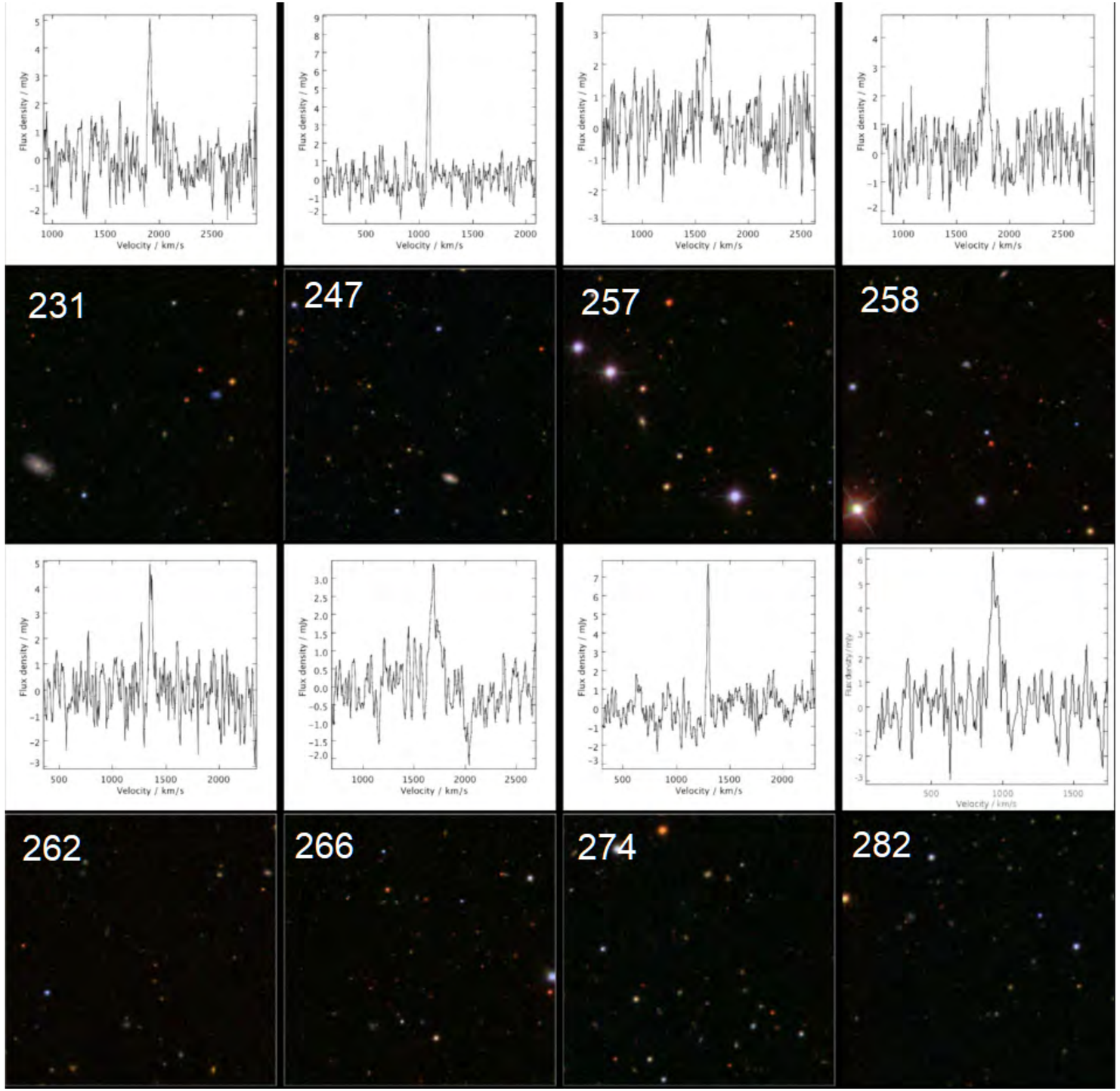

Hydrogen Clouds in Virgo
HI features
> 100 kpc length
< 100 kpc length
< 3.5' angular size
Galaxies
Early type
Late type
LSB
NGC 4396
VIRGOHI21
NGC 4302
NGC 4388
Kent 2010
NGC 4294/9
NGC 4330
NGC 4694
Kent 2009
NGC 4424
247
266
274
282
AGES VC1
258
262
257
231
Koopmann 2008
HI1225+01
15:00
10:00
05:00
Declination
12:50
12:40
12:30
12:20
12:10
Right Ascension

The Samples

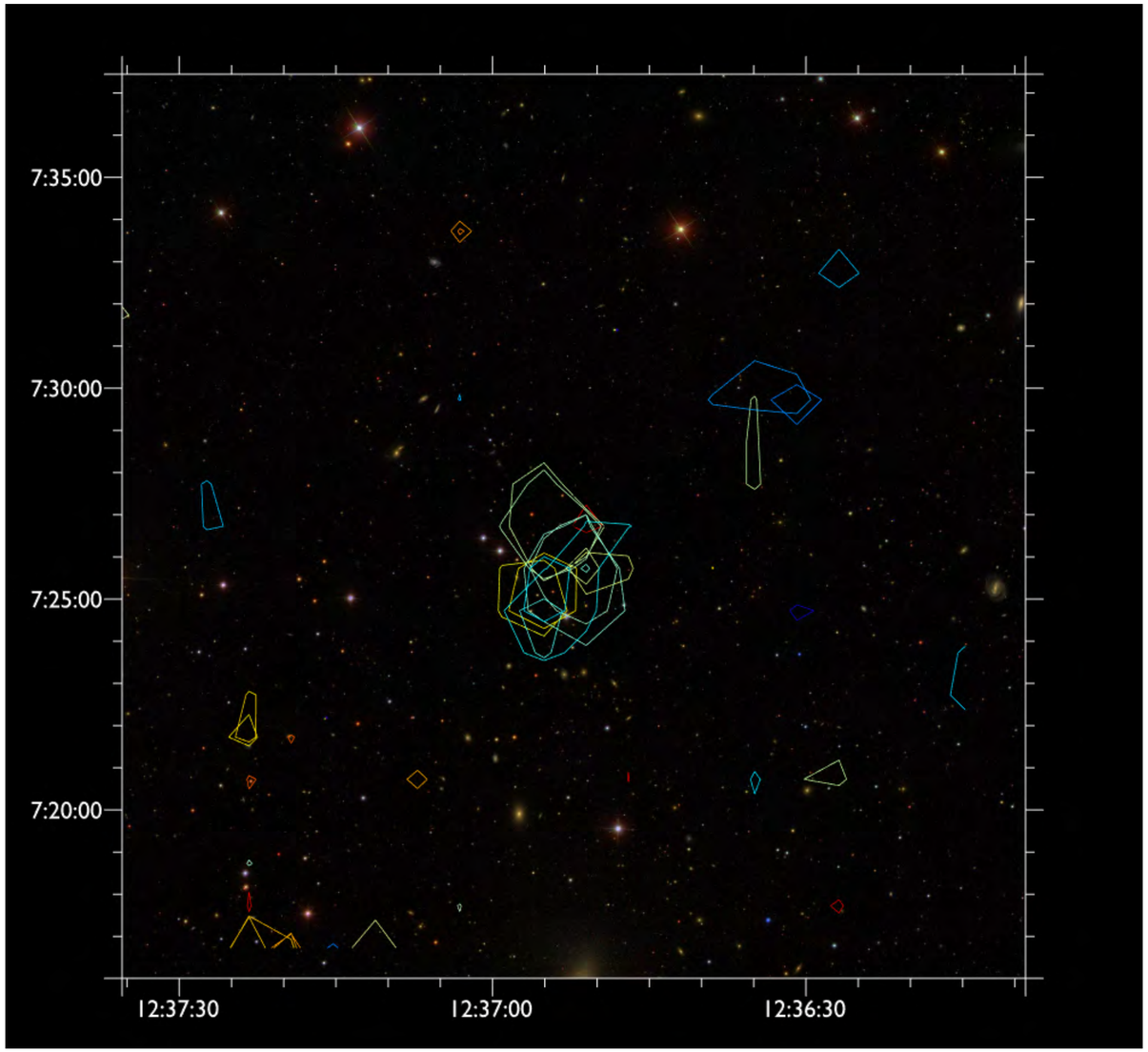
Table 5. Derived properties of the dark H I clouds detected in the Virgo Cluster by AGES. The columns are as follows: (1) name in AGES V; (2) assumed distance as described in AGES V; (3) H I mass in solar units; (4) velocity width in km s^{-1}; (5) peak S/N; (6) radius at which the H I would be in stable, self-bound rotation; (7) radius (in kpc) at which the H I would have a column density of 9.4×10^{20} cm^{-2} – typical for dwarf galaxies as described in Leroy et al. (2008); (8) maximum radius of the H I (since they are unresolved by the Arecibo beam) in kpc; (9) time in Myr to expand to the Arecibo beam size assuming their velocity width corresponds to the expansion velocity; (10) distance (kpc) and (11) angular distance (arcmin) travelled across the cluster assuming a velocity of 590 km s^{-1}.

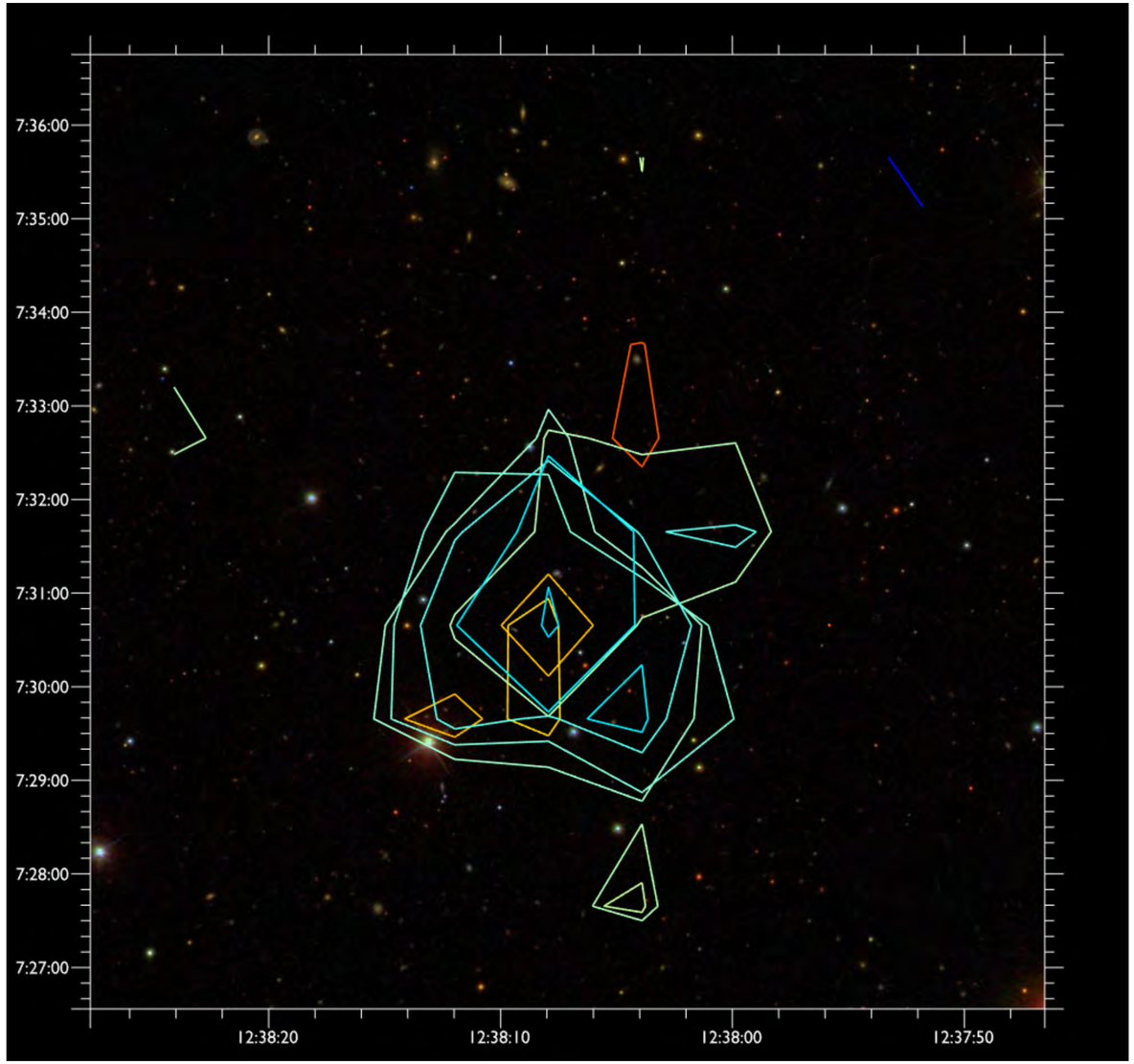
(1) Name	(2) Distance Mpc	(3) MH I $M_\odot$	(4) W20 km s^{-1}	(5) SN	(6) Size to be self-bound; kpc	(7) Size at dwarf galaxy NH I; kpc	(8) Arecibo beam size; kpc	(9) Lifespan Myr	(10) Travelled kpc	(11) Travelled arcmin
AGESVC1_231	32	4.2E7	152	7.8	0.031	1.3	16.3	192	116	12
AGESVC1_247	23	2.3E7	33	15.9	0.363	1.0	11.7	635	383	57
AGESVC1_257	17	1.4E7	157	5.4	0.010	0.8	8.7	98	59	11
AGESVC1_258	17	1.4E7	120	7.6	0.017	0.8	8.7	128	78	16
AGESVC1_262	23	2.0E7	146	7.2	0.016	0.9	11.7	144	87	13
AGESVC1_266	17	3.2E7	173	6.4	0.018	1.2	8.7	85	51	10
AGESVC1_274	17	7.3E6	35	14.2	0.103	0.6	8.7	452	273	55
AGESVC1_282	23	4.4E7	164	11.4	0.028	1.4	11.7	123	74	11

The Velocity dispersion of the clouds

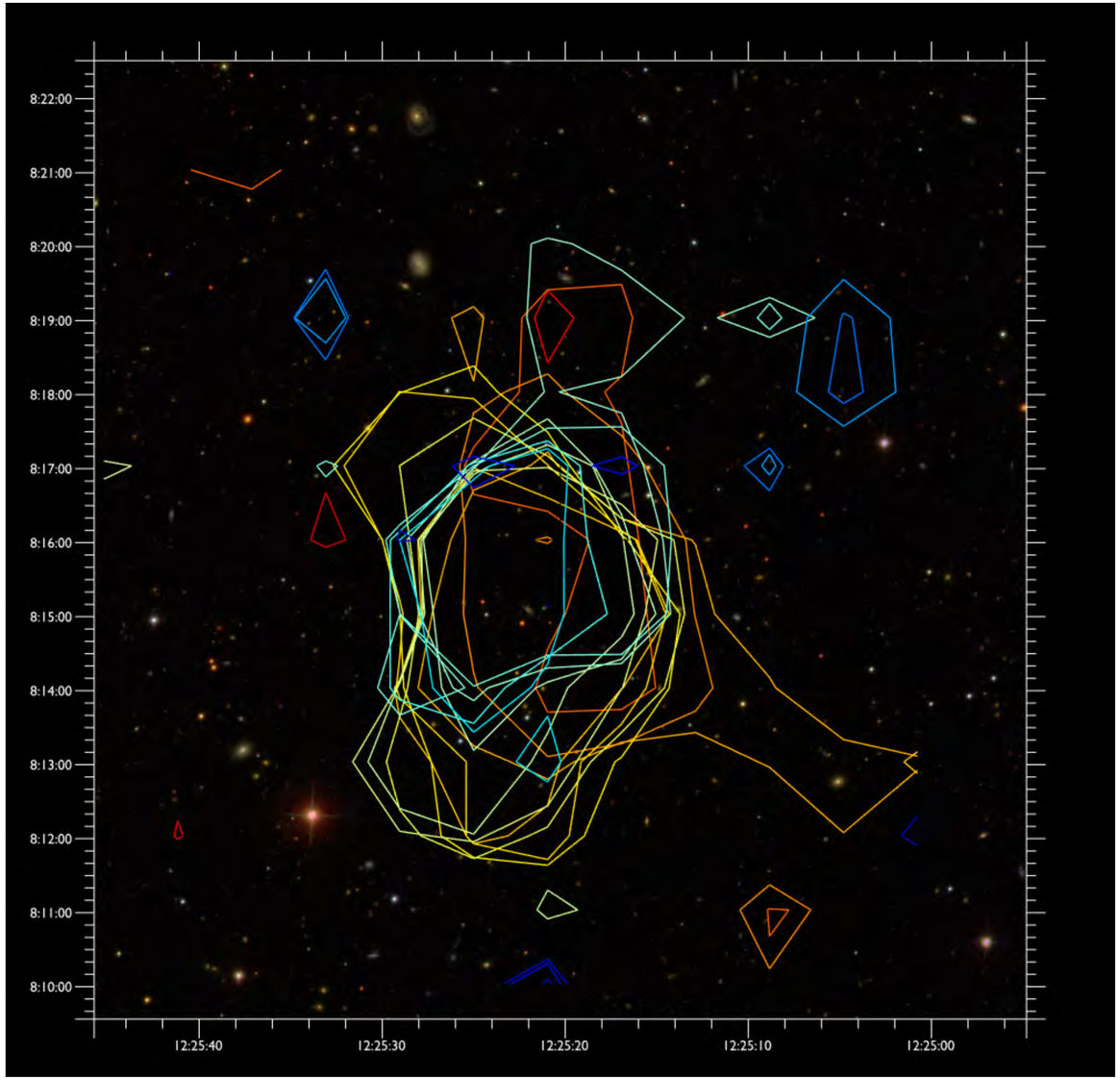


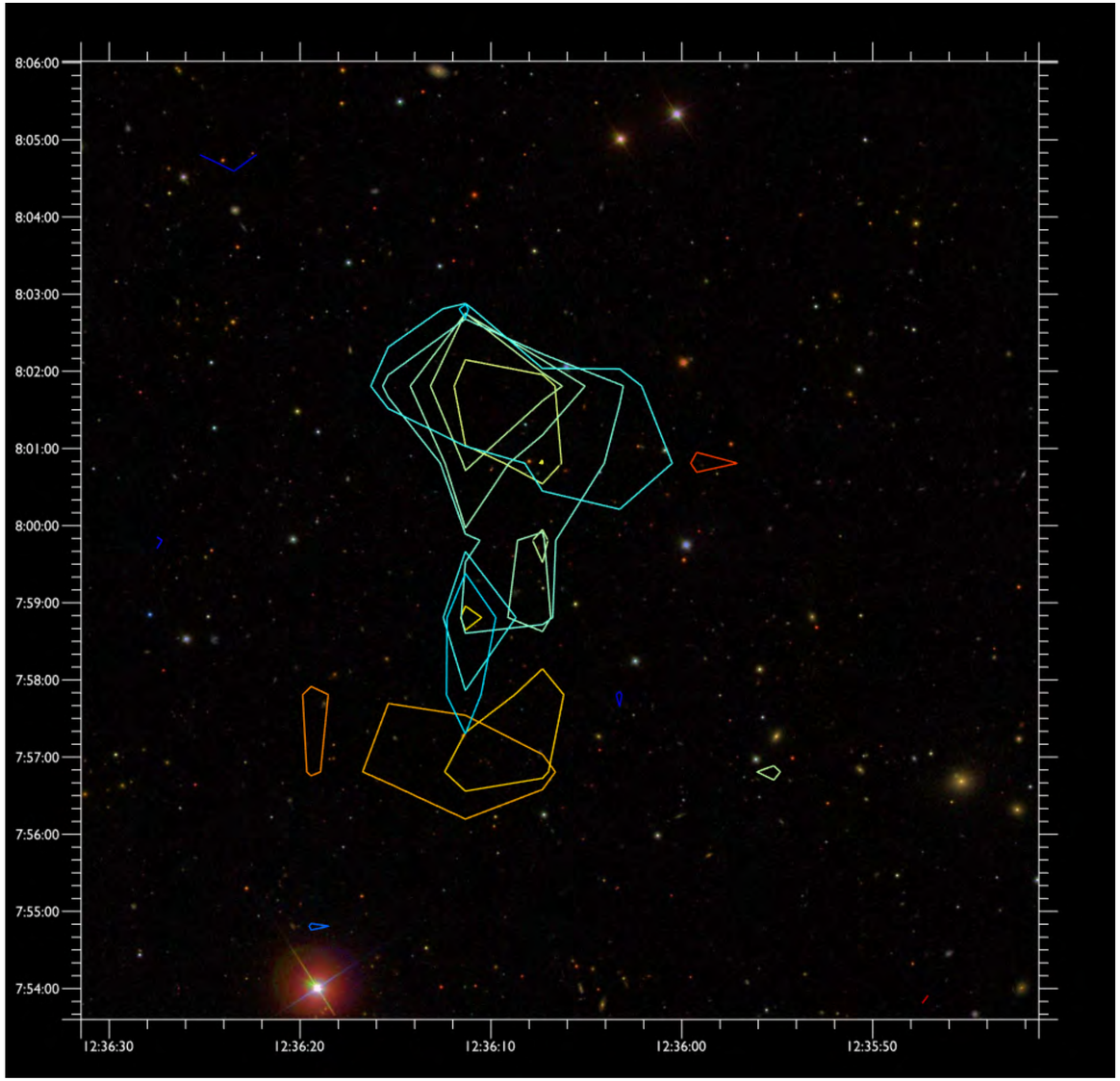
HI contours at different velocity





HI contours at different velocity





Brightness Mass

$$M_{\mathrm{HI}} = 2.36 \times 10^5 \times d^2 \times F_{\mathrm{HI}}$$

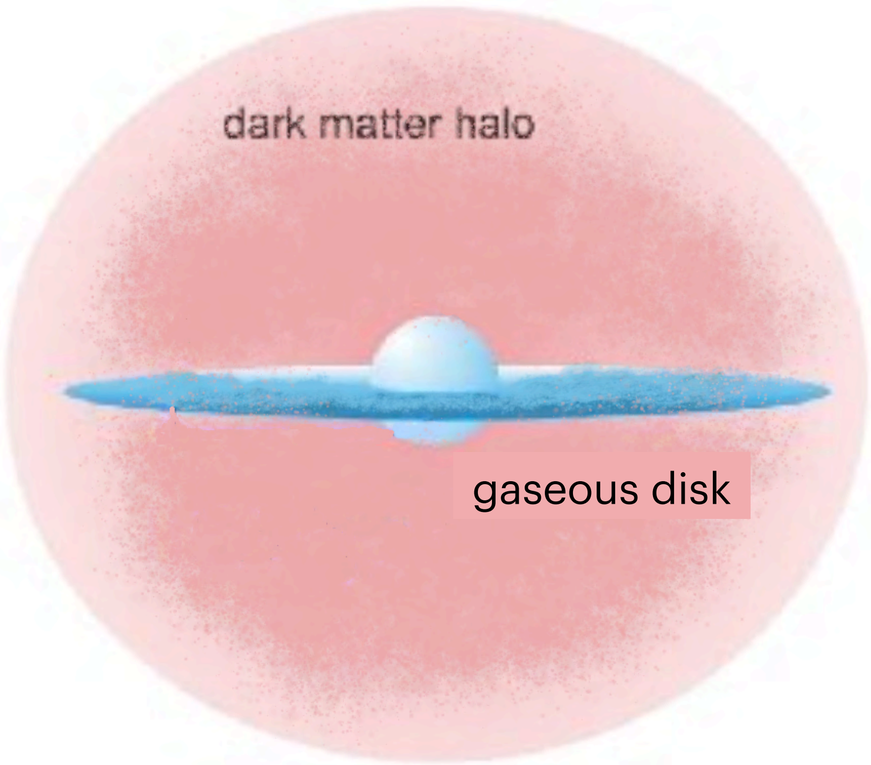
Dynamic Mass

$$M_{\mathrm{dyn}} = \frac{r\, v_c^2}{G}$$

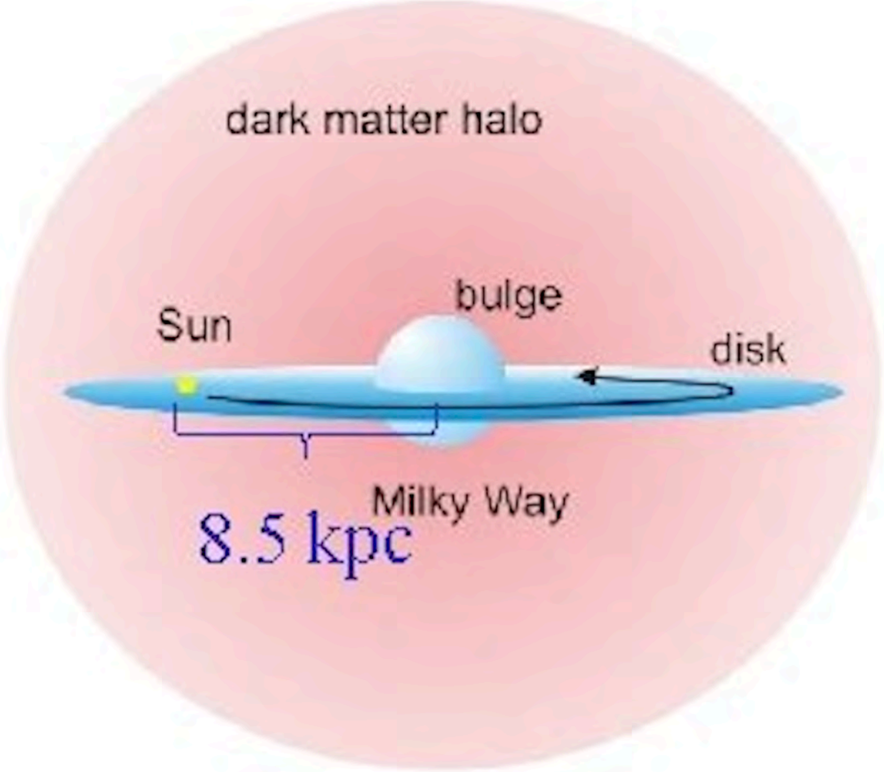
Model

Simulation

The model
Dark galaxy in the dark matter halo



Milky Way
in the dark matter halo



Simulation

The hydrodynamic equations

$$\frac{D\rho}{Dt} + \rho\nabla\cdot\boldsymbol{v} = 0 \,,$$

$$\frac{D\boldsymbol{v}}{\mathrm{Dt}} = -\nabla p - \rho\nabla\Phi \,,$$

$$\frac{D}{Dt}\left(\frac{e}{\rho}\right) = -p\nabla\cdot\boldsymbol{v} \,.$$

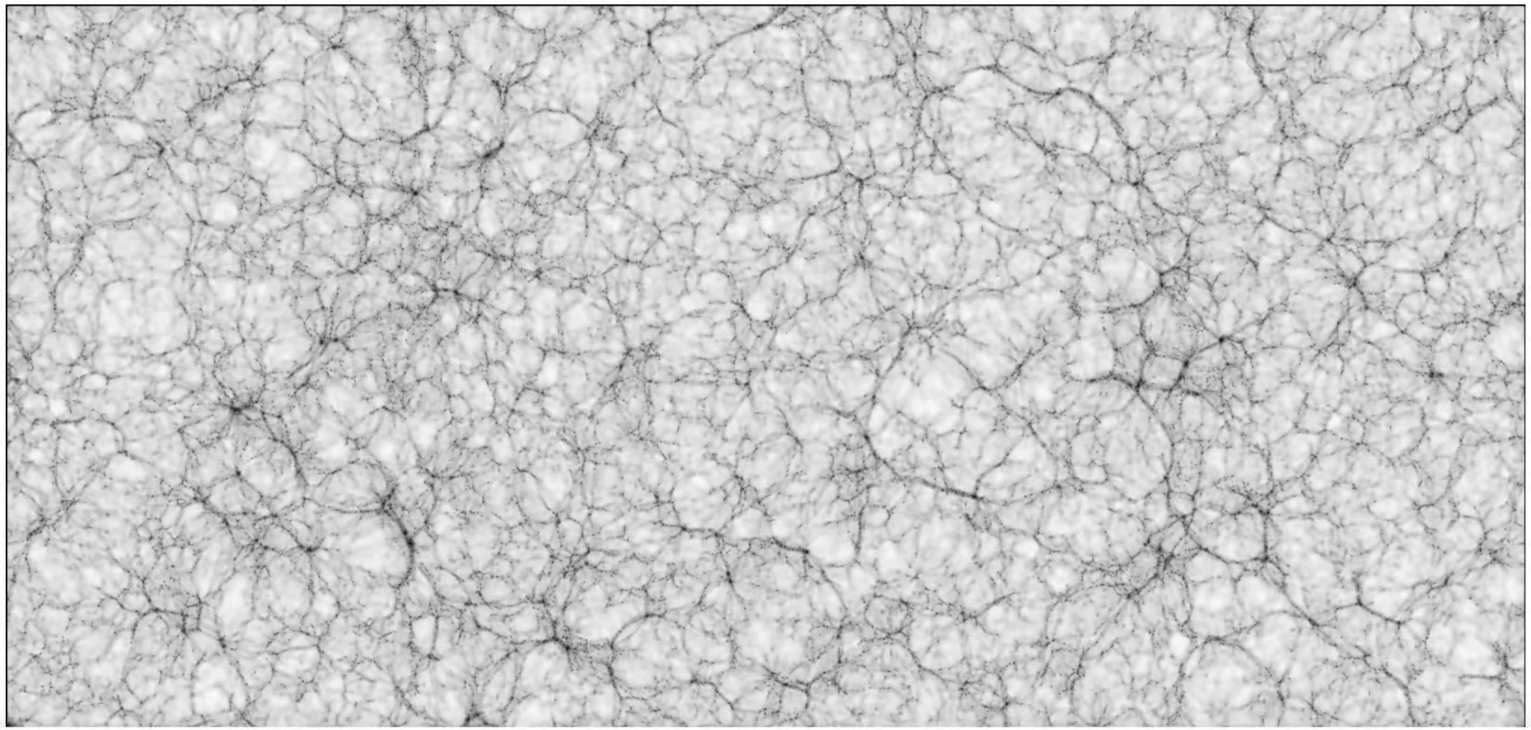
Arepo code

moving mesh hydrodynamics

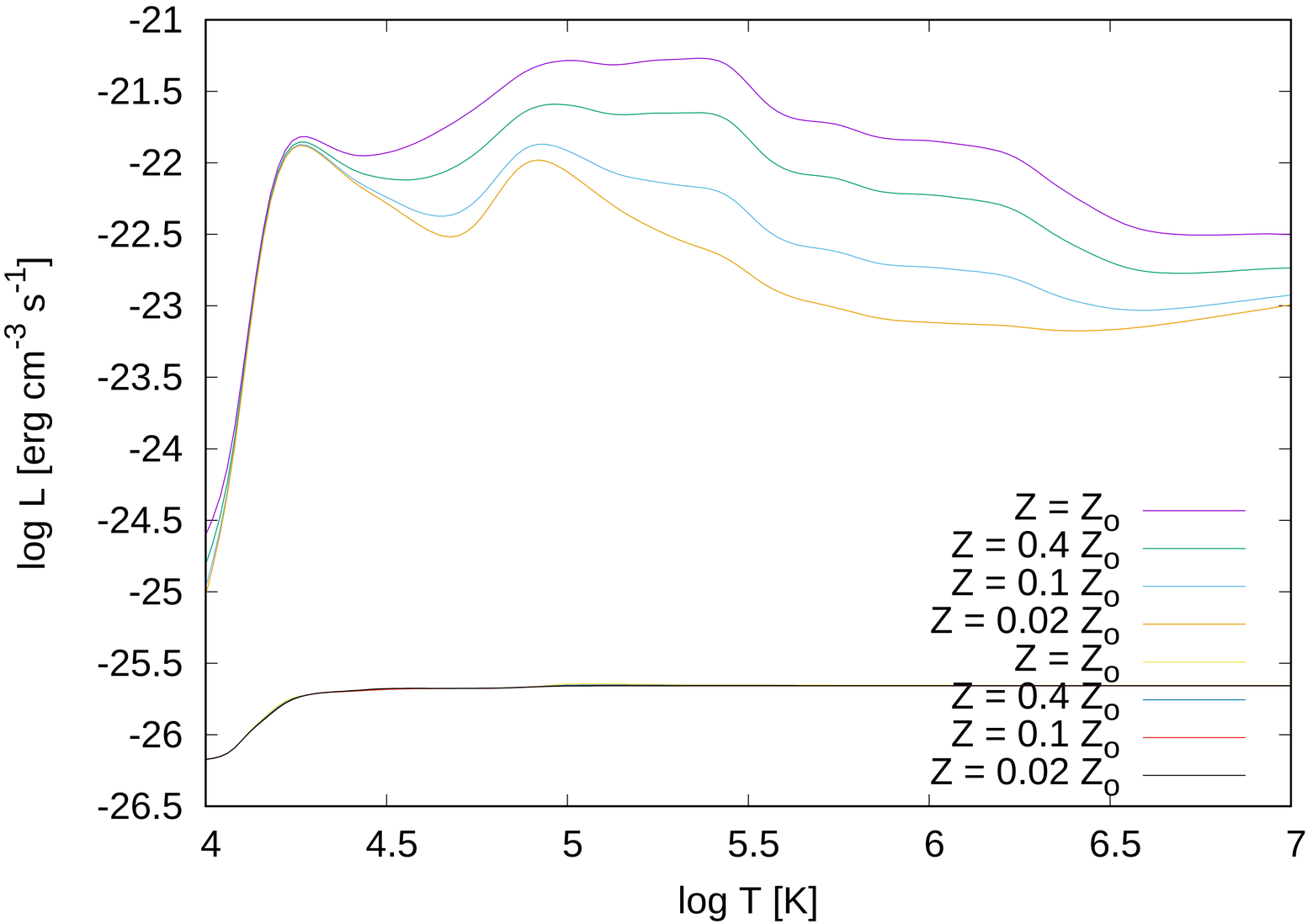
Home Abou

Large Scale Structure

Large scale structure of the Universe calculated with Arepo in a gravity-only simulation (1.5 Gpc side length, 1,073,741,824 simulation particles).



Cooling and heating for different metallically



Very Large Array

INO Lens Array

Among the three intended telescopes on the summit of Mount Gargash, INO Lens Array was the first one to become operational in 2018. It is an innovative multi-lens array designed for low surface brightness astronomy at visible wavelengths. The array is designed and built by INO's Technology Development Division (TDD). It is initially made up of three Canon 400mm lenses with fantastic nano-fabricated coatings and with sub-wavelength structure on optical glasses. The particular design of this telescope enables it to reveal faint structures by greatly reducing scattered light and internal reflections within its optics. It also has the capability of being used as a wide field array to observe multiple objects.

INO Lens Array on tp of Mount Gargash. Credit: INO

Project Plan

we plan to explore under which conditions the dark galaxies can survive in the ICM of the cluster; and under which conditions they remain optically dark, i.e. do not form stars

Star Formation

Thanks for your attention

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Painting by Mahmoud Frachian