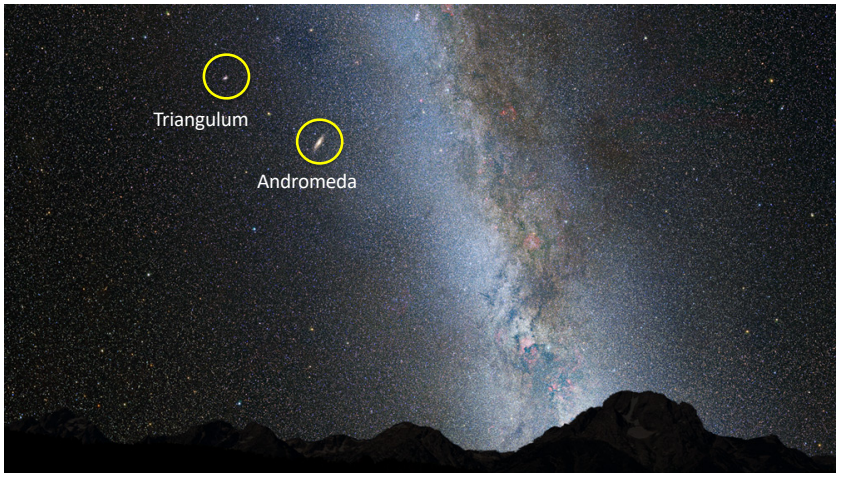
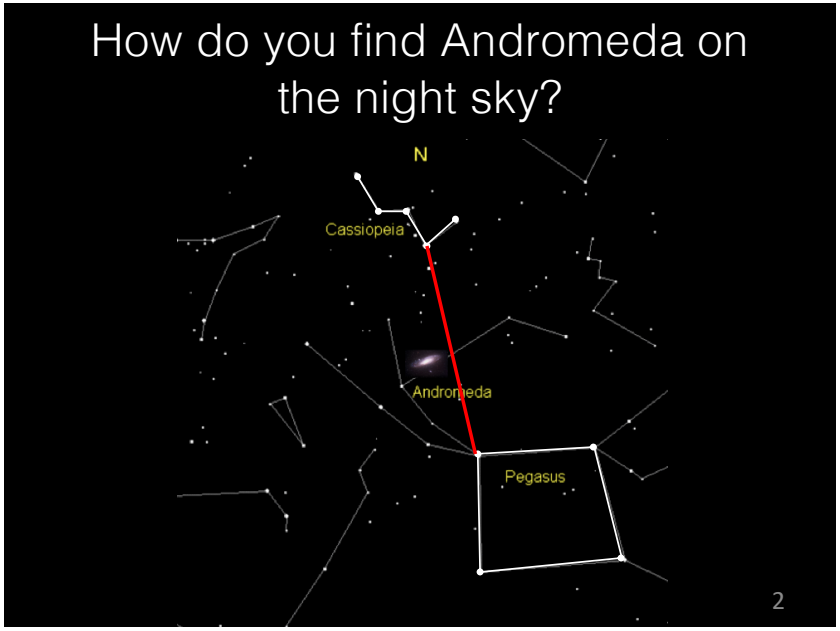
The Andromeda Galaxy (2.5 million ly away)



1

1

How do you find Andromeda on the night sky?



2

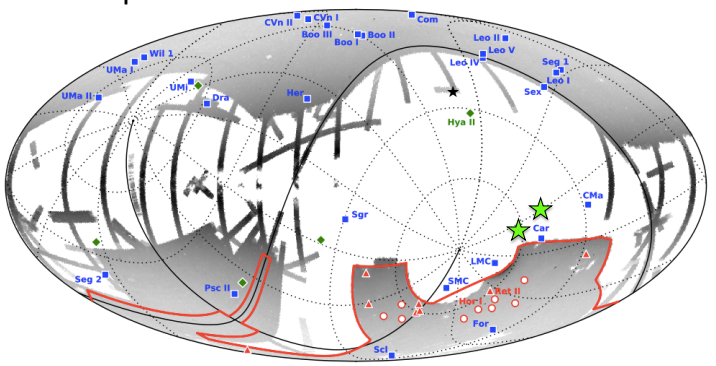
The Andromeda Galaxy

Original Photo: Stephen Rahn, Composite: tom Buckley, Andromeda in UV: NASA/JPL-Caltech

3

Possible New Dwarfs found by DES Survey
+PANSTARRS +SMASH survey = ~ 50 ?

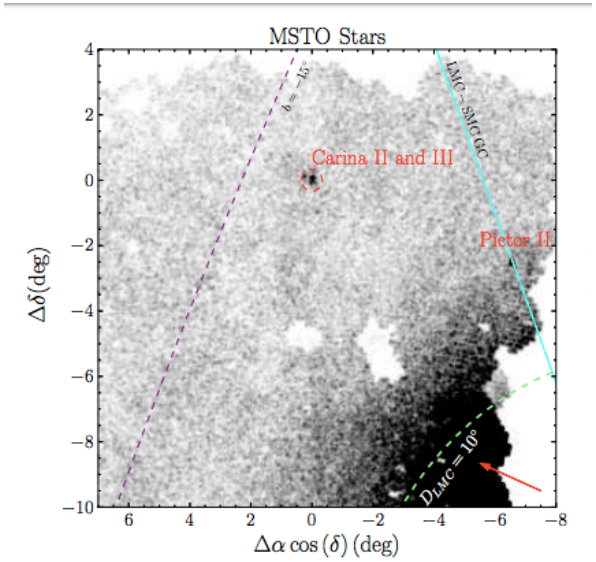
A few days ago!: ArXiv 1801.07279 MagLiteS survey
Two NEW potential satellites near Carina and the LMC



Bechtol + 2015 (DES); Koposov+2015; Laevens +2015;
Martin, Nidever, Besla+ 2015 (SMASH), Drlica-Wagner+2015
(DES), Homma+2016 … more to come with LSST!

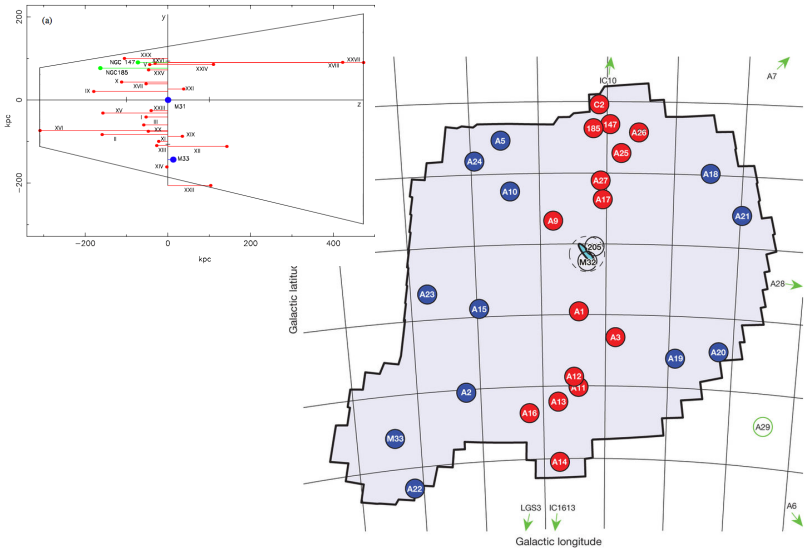
4

4



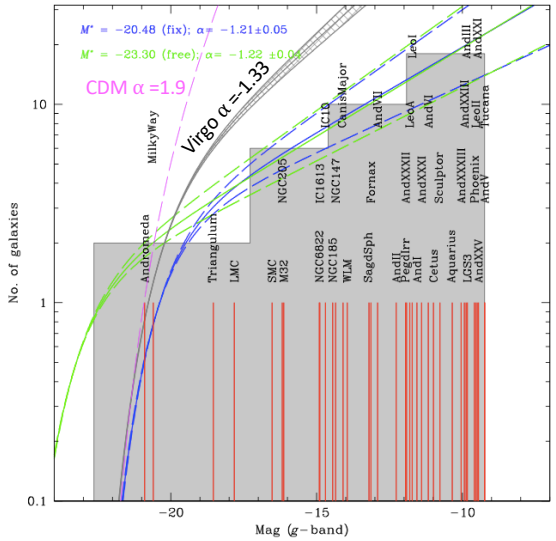
Torrealba+2018

M31 Distribution of Satellites



Luminosity Function of the Local Group

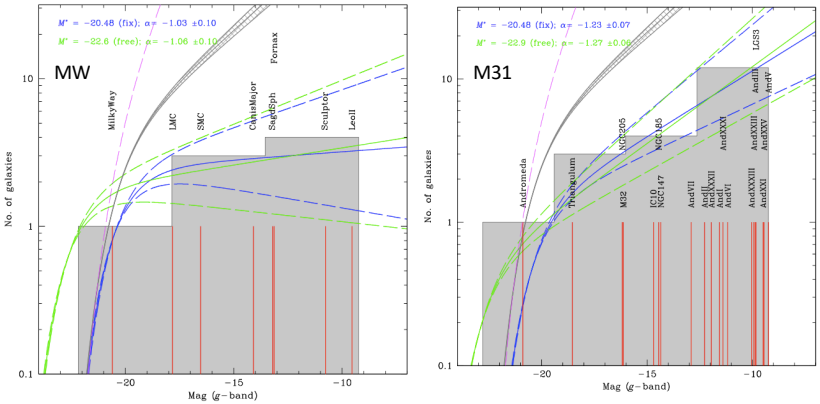
Ferrarese+2016



We're filling out the low mass end

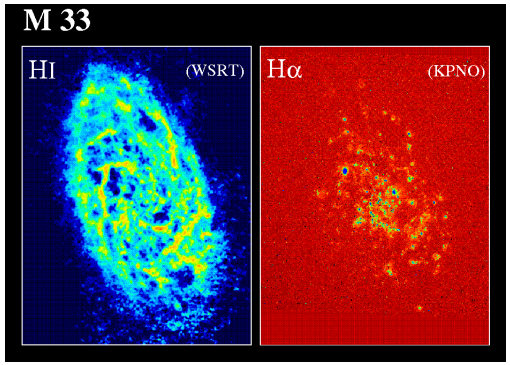
MW vs M31: Luminous Satellites

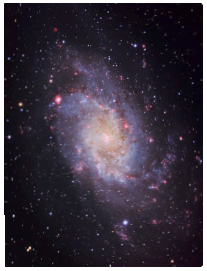
Ferrarese+2016



Higher number of luminous satellites and existence of 3 dEs around M31 favors it being a more massive system

MW vs M31: Most Massive Satellite

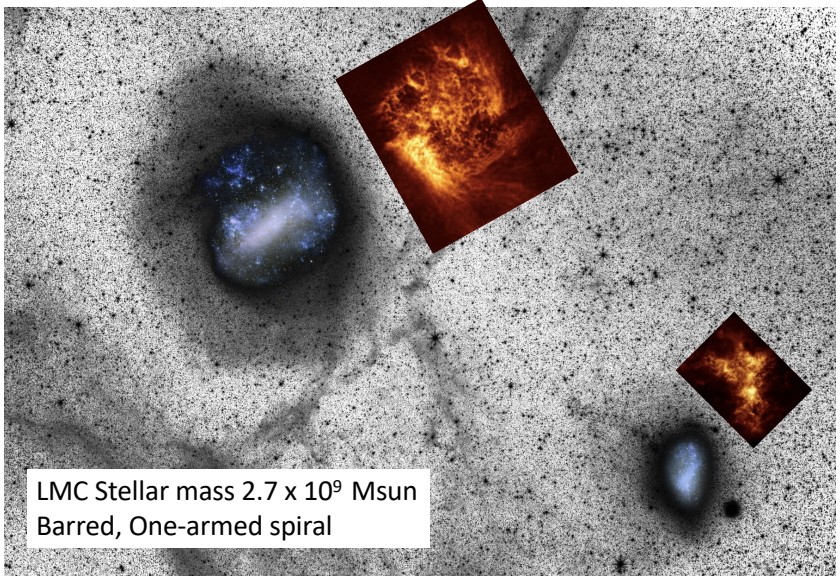




M33 Stellar mass ~ 3-5 x 10^9 Msun
Flocculent Spiral

9

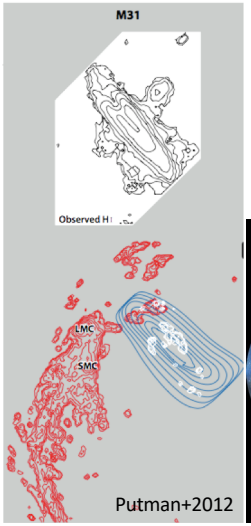
MW vs M31: Most Massive Satellite

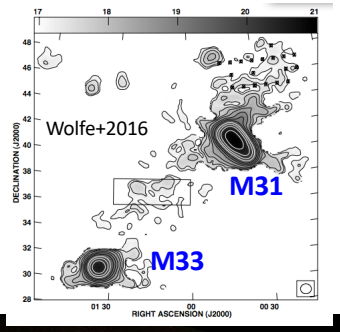


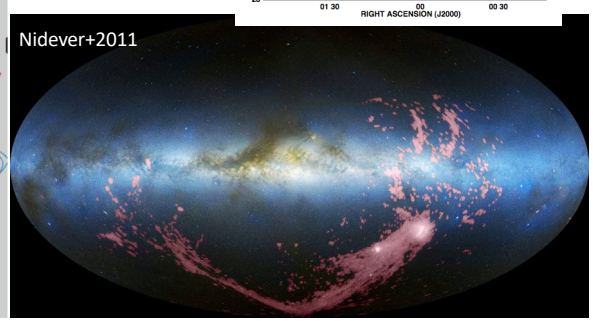
LMC Stellar mass 2.7 x 10^9 Msun
Barred, One-armed spiral

10

MW vs M31: CGM



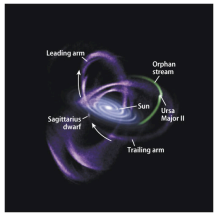




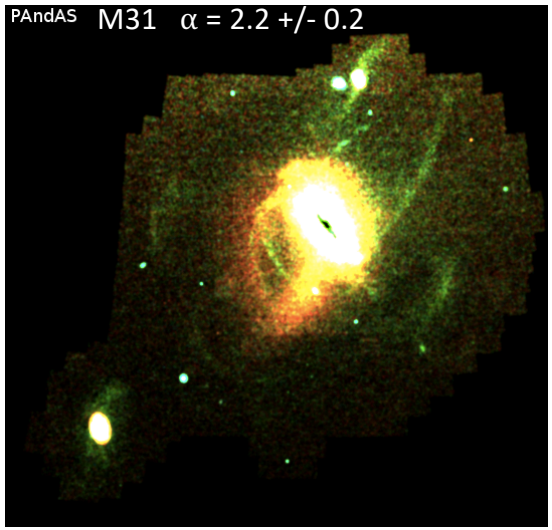
11

MW vs M31: Stellar Halo

$I \propto r^{-\alpha}$

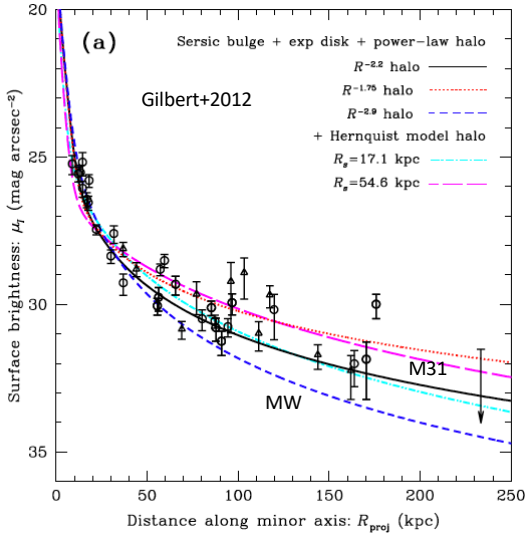


MW
α = 1.7-2.5

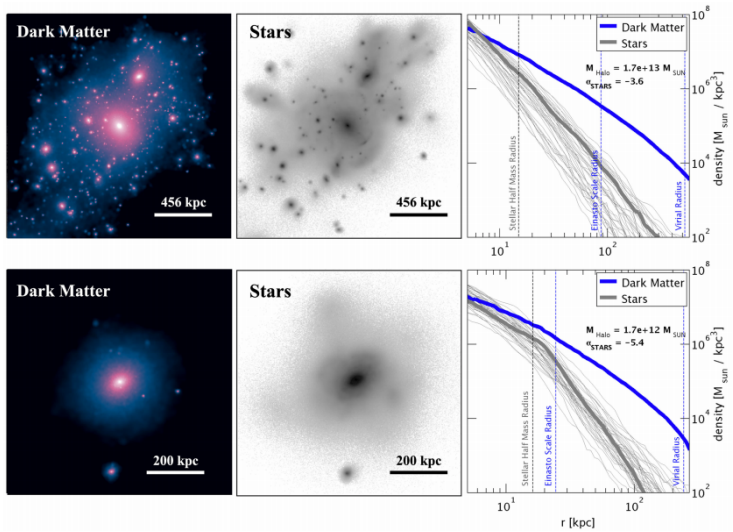


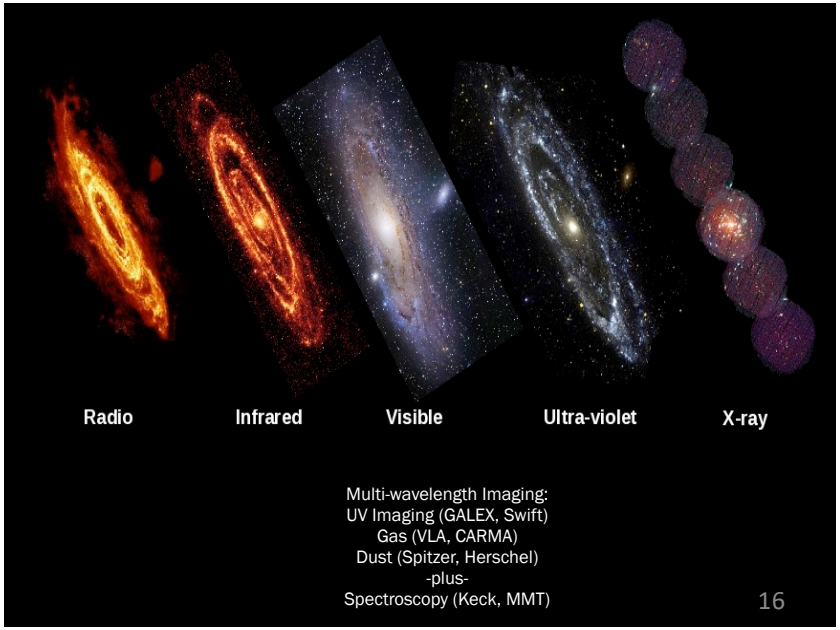
12

Stellar Halo: Surface Brightness Profiles

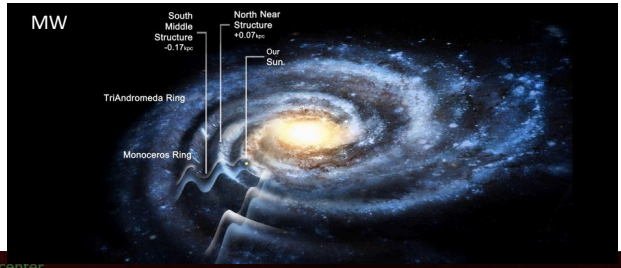


Stellar Halo: Surface Brightness Profiles

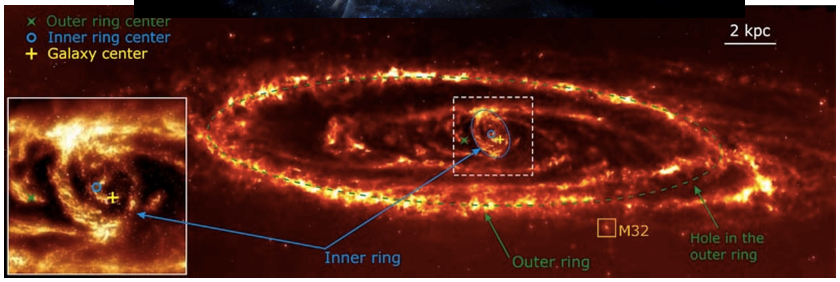


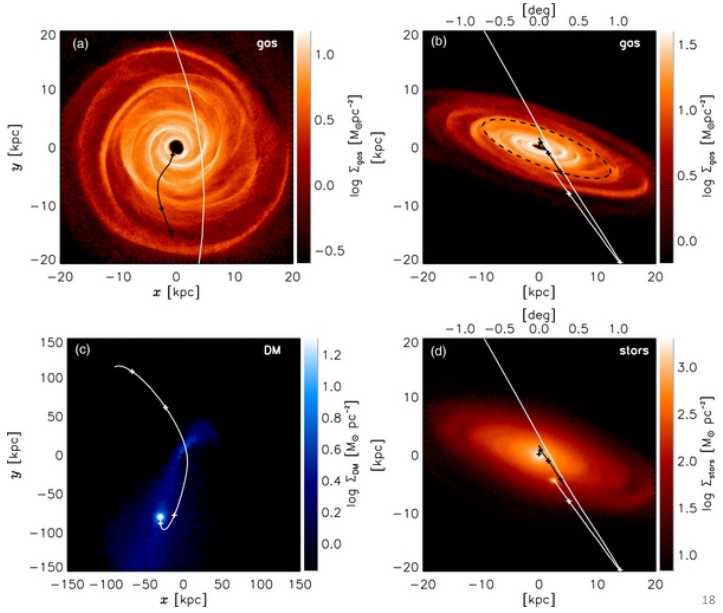


MW vs M31: Spiral Arms/Rings/Ripples
MW Sbc CW rot. M31 Sb CCW rot



M31
IR imaging





Dierickx+2014

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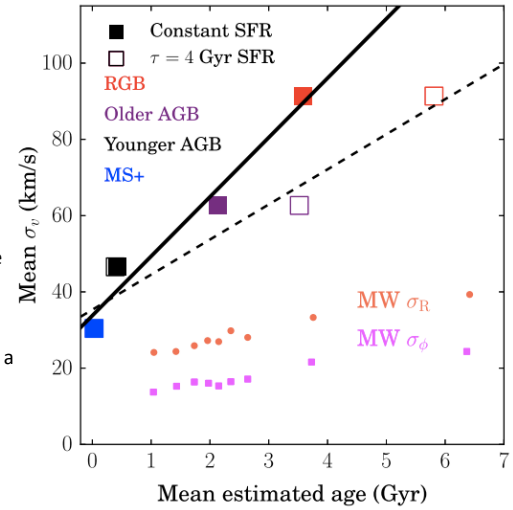
MW vs M31: Disk Velocity Dispersion

First time the age velocity dispersion relation has been measured in an external galaxy

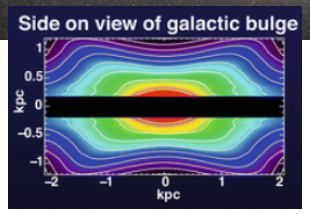
Implies: M31 has had a more violent recent past - this is more in line with LCDM expectations. MW may be atypical in that it has a quiet history.

Dorman+2015

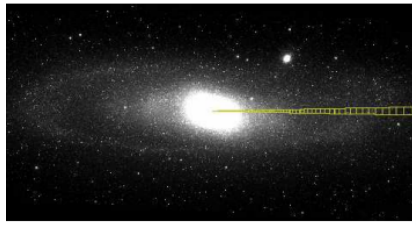


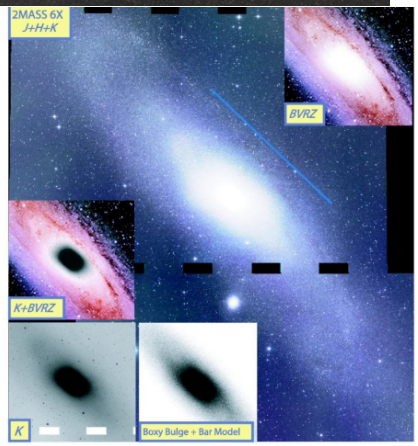
19

MW vs M31: Bulge



M31 IRAC 3.6 micron (old stars)

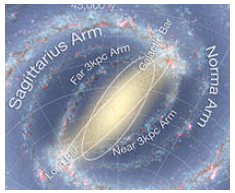


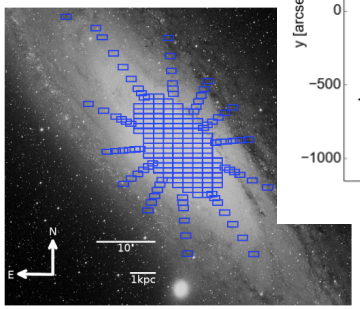


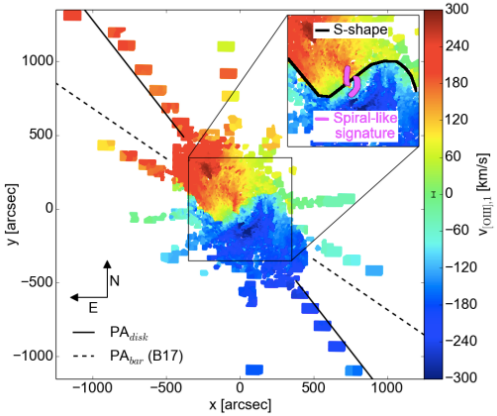
20

MW vs M31: Bar

MW







Opitsch+2017
IFU: OIII

21

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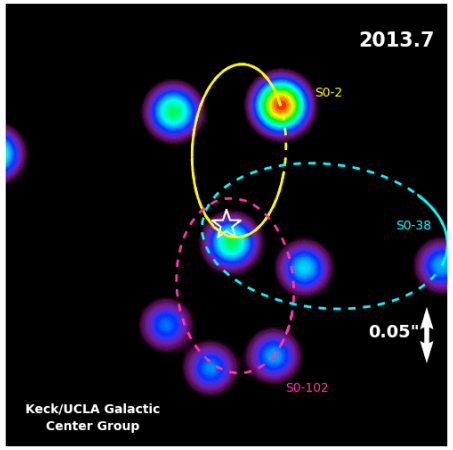
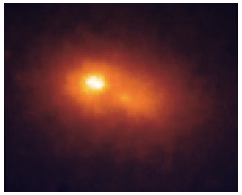
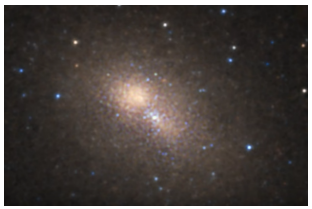
MW vs M31: Black Hole/Nucleus



HST Imaging of M31 shows 2 complexes. One hosts a SMBH. The other might be Nuclear stellar cluster





https://www.youtube.com/watch?v=jojrHPITg-I

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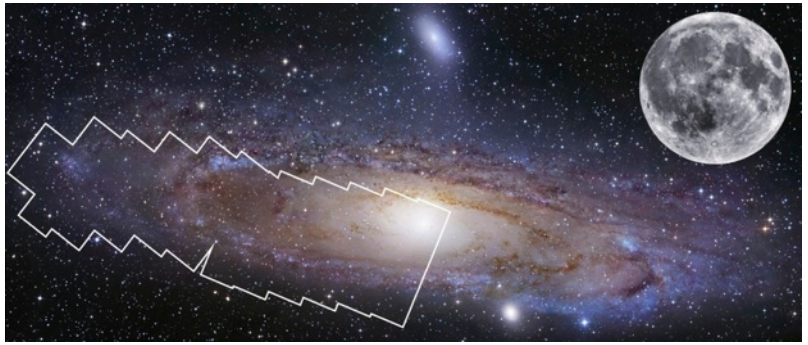
PHAT

Dalcanton+2012 ; Williams + 2014



The Panchromatic Hubble Andromeda Treasury is a Hubble Space Telescope Multi-cycle program to map roughly a third of M31's star forming disk, using 6 filters covering from the ultraviolet through the near infrared. With HST's resolution and sensitivity, the disk of M31 is resolved into more than 100 million stars, enabling a wide range of scientific endeavors.

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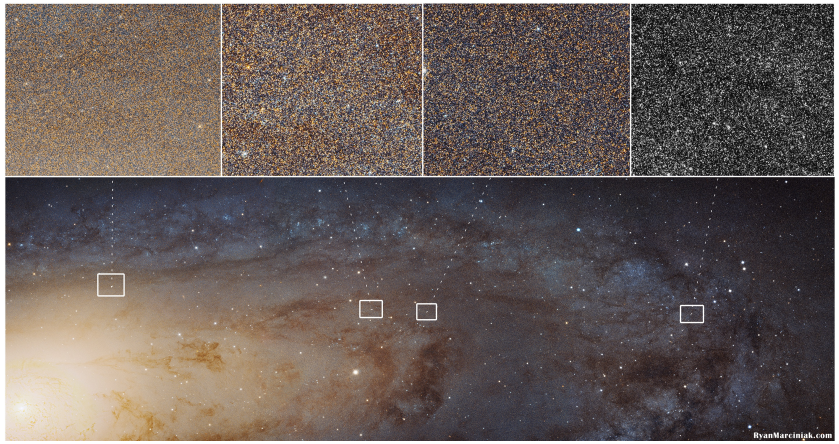
PHAT



http://hubblesite.org/gallery/album/entire/pr2015002a/warn/

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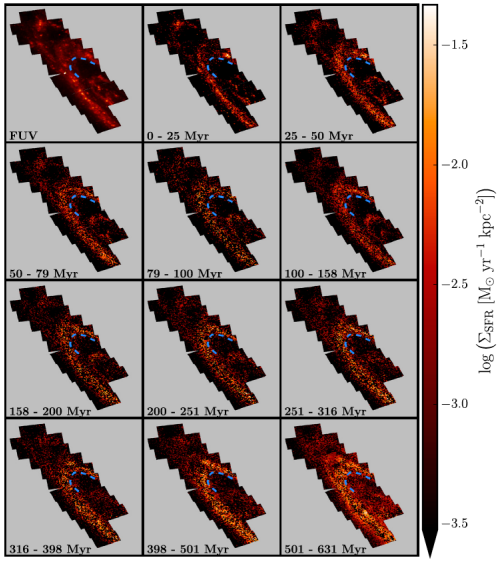
MW vs M31: Star Formation Rate



MW SFR ~ 1 Msun/yr

M31 ~ Constant over past 500 Myr with mild upturn 50 Myr ago.

Over past 100 Myr, average SFR 0.28 +/- 0.03 Msun/yr in PHAT
Extrapolating to full disk = 0.7 Msun/yr

Lewis+2015
PHAT survey

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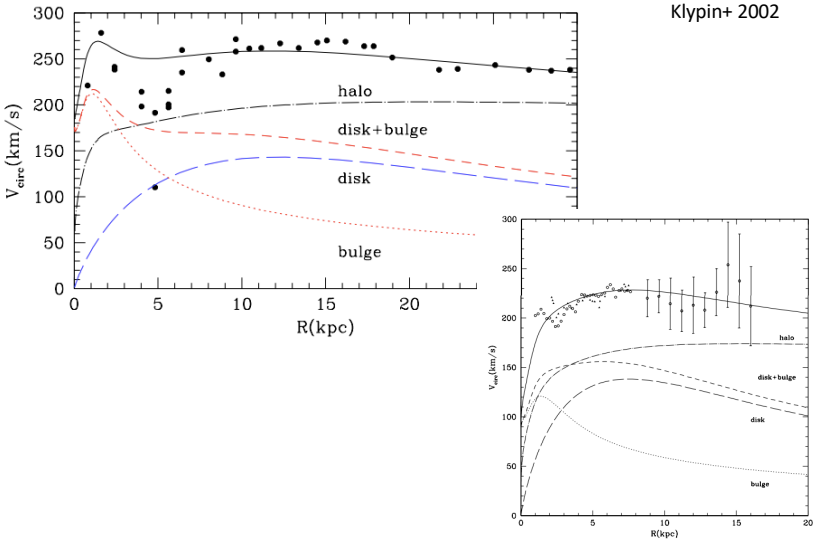
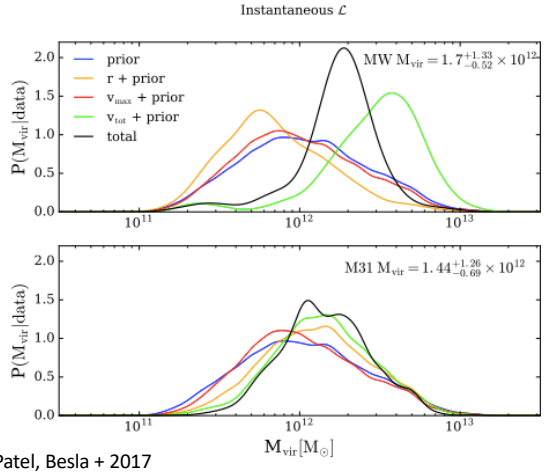
MW vs M31: Halo Mass

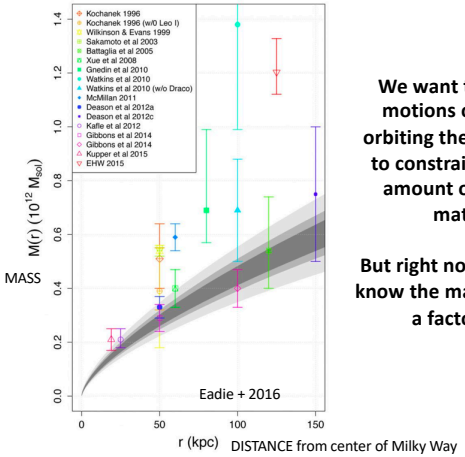


Klypin+ 2002

MW vs M31 Halo Mass: Cosmological Simulations



Patel, Besla + 2017

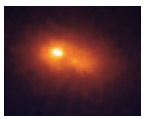


MASS

DISTANCE from center of Milky Way

We want to use the motions of objects orbiting the Milky Way to constrain the total amount of its dark matter.

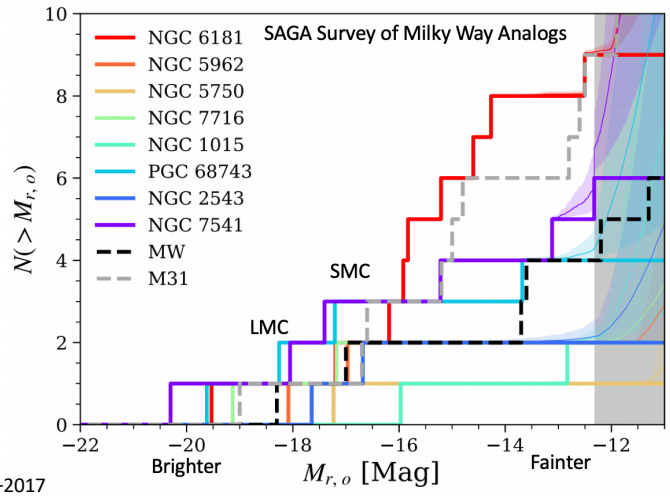
But right now, we don't know the mass to within a factor of 2



MW vs M31

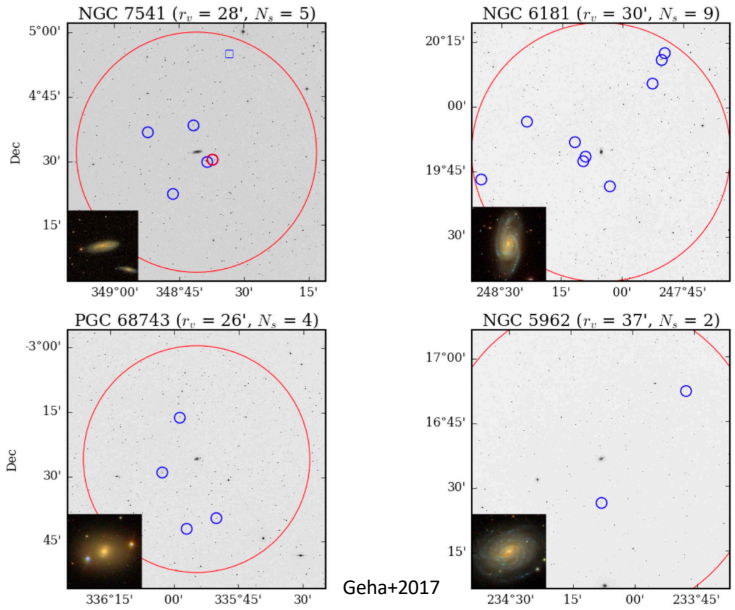
	MW	M31
Stellar Mass/Luminosity	Lv = 1.5x 10^{10} $L_\odot$ < 2.7 x 10^{10} $L_\odot$ M* = 8 x 10^{10} $M_\odot$ < 10^{11} $M_\odot$	
Bulge Properties	pseudo ~ 10^{10} < classical (ish) 2.5e10 $M_\odot$	
SMBH	~4 x 10^6 $M_\odot$ (Ghez+2016)	< 5–23 x 10^7 $M_\odot$ (Bender+2005, Lauer+2012)
Bar?	yes	yes
Halo Mass	1-1.5 e12 $M_\odot$	< 1.5-2.5e12 $M_\odot$
Satellites	Total >~50 ~> 1e9 LMC dE 0	>~30 M33 3
	~1 $M_\odot$/yr	~ 1 $M_\odot$/yr ??
	YSOs (Robitalle & Whitney2010)	Williams+2003
	< 40 km/s	????

SAGA Survey



Geha+2017

30



Geha+2017

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