

Journées de la SF2A 2019



A spectroscopic study of the giant low surface brightness galaxy Malin 1

Junais

Main Collaborators :

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Barry Madore
Armando Gil de Paz

Philippe Amram
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Juan Carlos Munos Mateos

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Alessandro Boselli
Laurent Chemin

15 May 2019

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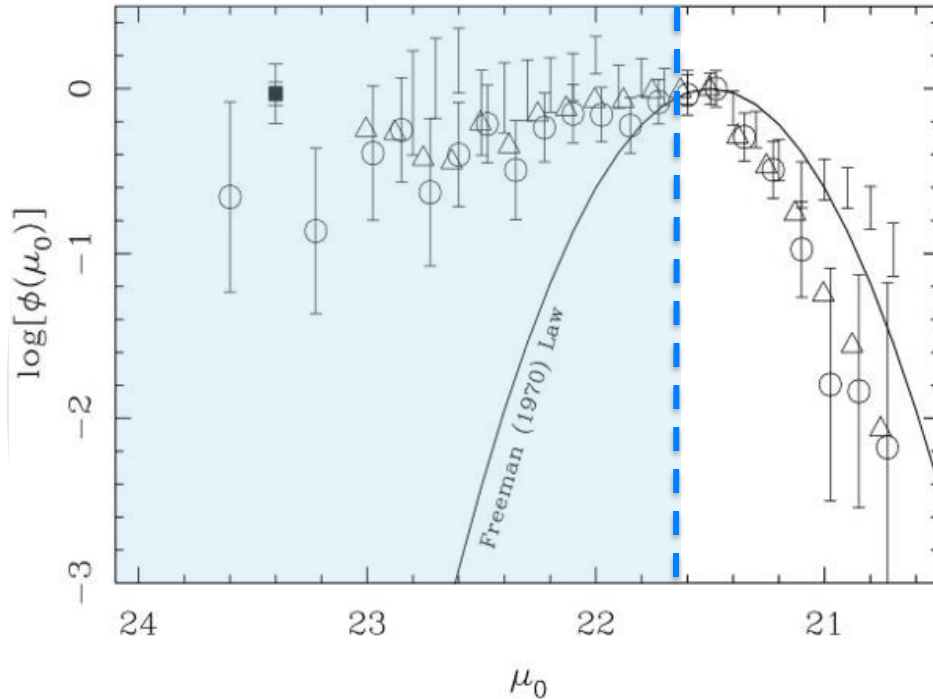
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Low Surface Brightness Galaxies (LSBs) : Definition

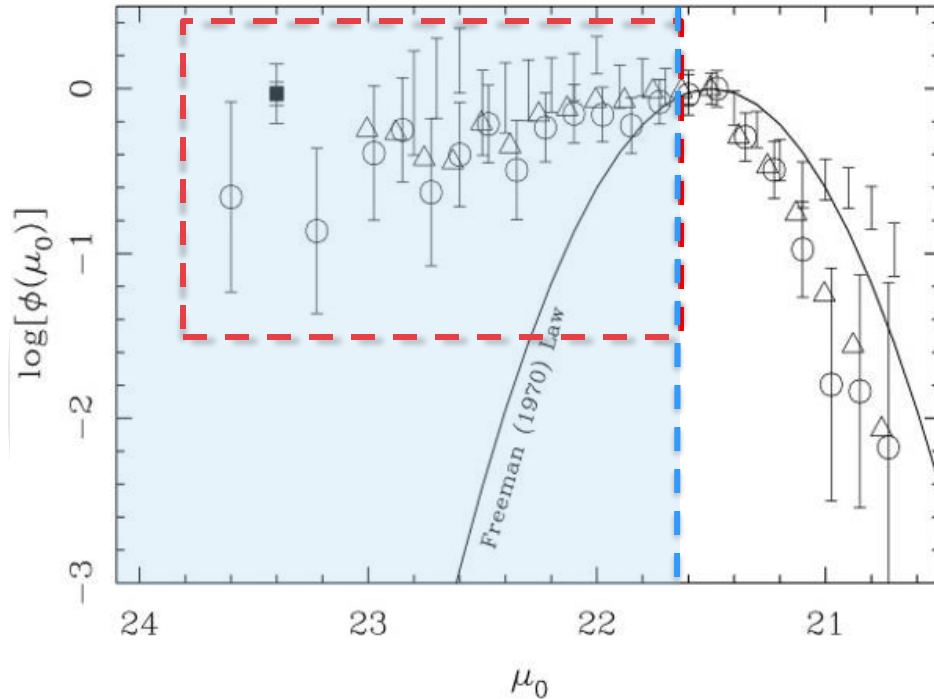


- Historical definition of LSBs based on central surface brightness (Freeman 1970):

$$\mu_{0,B} \geq 21.65 \text{ mag arcsec}^{-2}$$

De Blok (2006)

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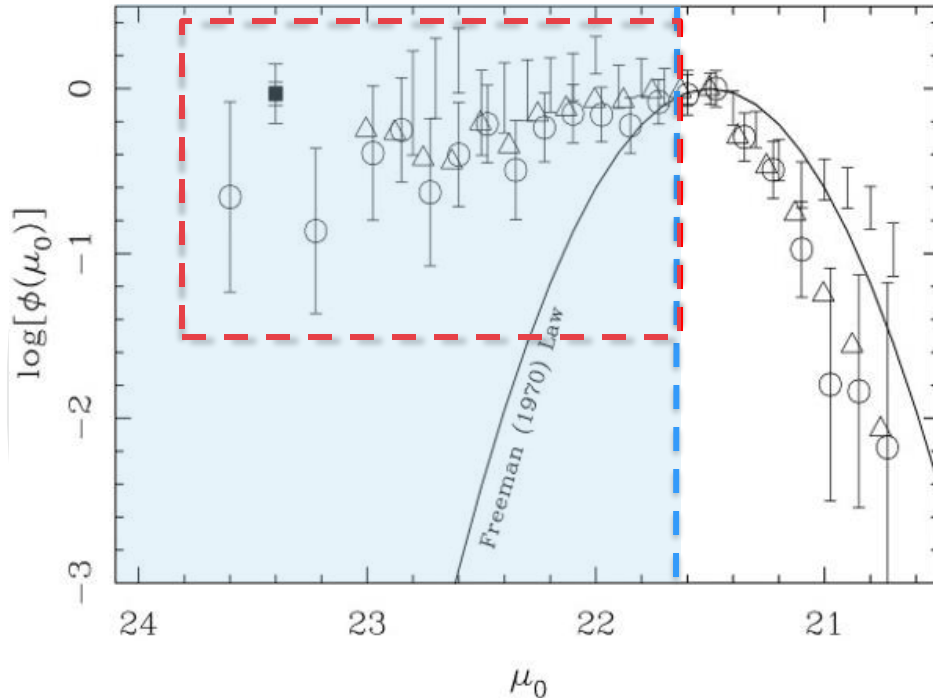
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- LSBs may account up to 50% of all the galaxies in the universe (*Impey & Bothun 1997*)

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- LSBs may account up to 50% of all the galaxies in the universe (*Impey & Bothun 1997*)

Important to study this large population of galaxies !!

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MALIN 1

7

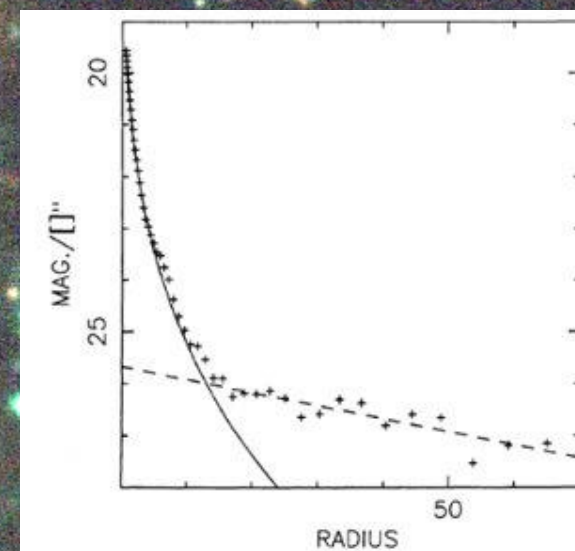
An extreme case of LSB !!

Malin 1 image credits : NGVS u, g, i

MALIN 1

8

$$\mu_{0,V} \approx 25.5 \text{ mag arcsec}^{-2}$$



Bothun et al. 1987

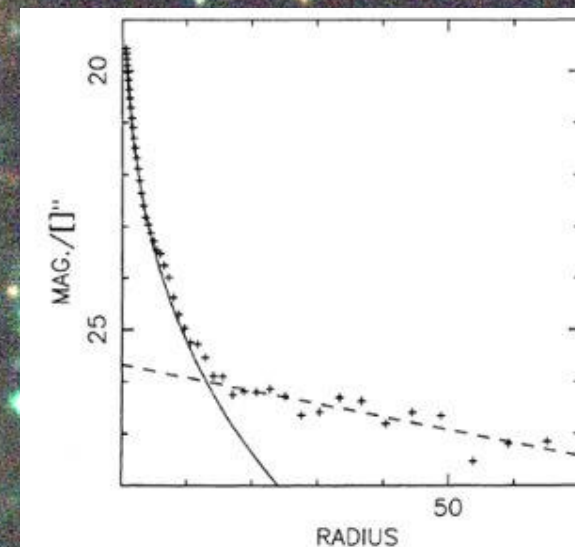
An extreme case of LSB !!

MALIN 1

9

> 200 kpc diameter

$$\mu_{0,V} \approx 25.5 \text{ mag arcsec}^{-2}$$



Bothun et al. 1987

An extreme case of LSB !!

MALIN 1

10

> 200 kpc diameter

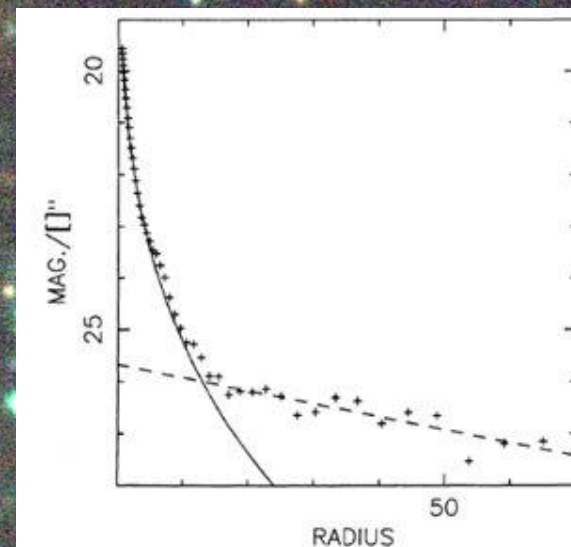
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M33



MilkyWay



Bothun et al. 1987

An extreme case of LSB !!

A new interest for Malin 1 & other giant LSBs

DEEP OPTICAL IMAGES OF MALIN 1 REVEAL NEW FEATURES*

GASPAR GALAZ¹, CARLOS MILOVIC^{2,3,4}, VINCENT SUC^{1,5}, LUIS BUSTA⁶,
GUADALUPE LIZANA¹, LEOPOLDO INFANTE^{1,7}, AND SANTIAGO ROYO⁵

2015

ON THE CLASSIFICATION OF UGC 1382 AS A GIANT LOW SURFACE BRIGHTNESS GALAXY

LEA M. Z. HAGEN^{1,2}, MARK SEIBERT³, ALEX HAGEN^{1,2}, KRISTINA NYLAND^{4,5,6}, JAMES D. NEILL⁷, MARIE TREYER⁸,
LISA M. YOUNG⁴, JEFFREY A. RICH^{3,9}, AND BARRY F. MADORE³

2016

The properties of the Malin 1 galaxy giant disk

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The origin and evolution of this galaxies is still poorly understood !!

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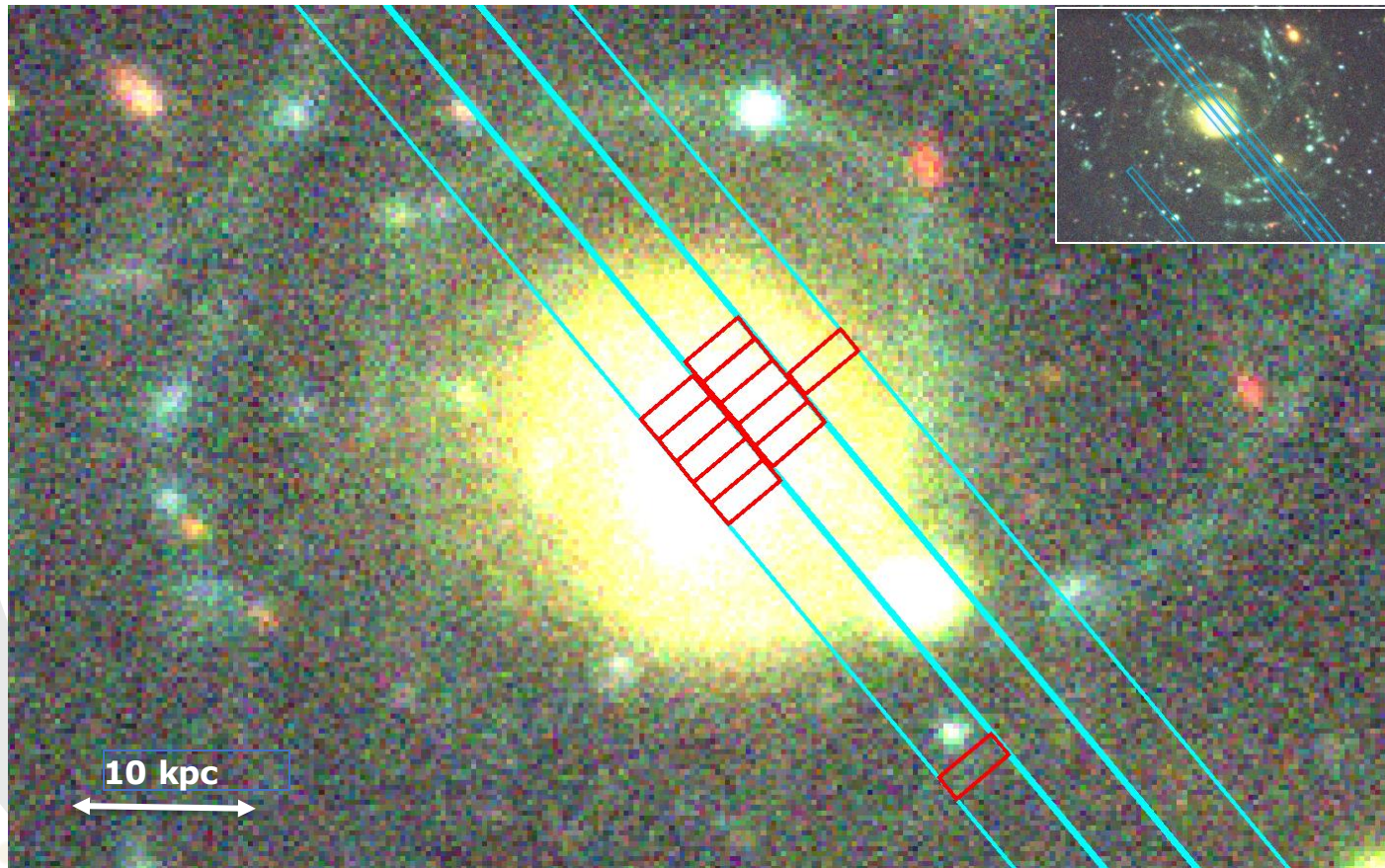
2018

We need more observations

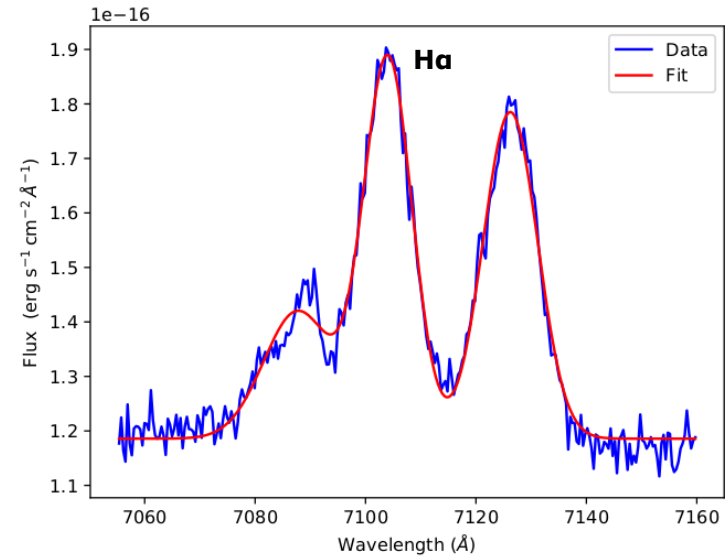
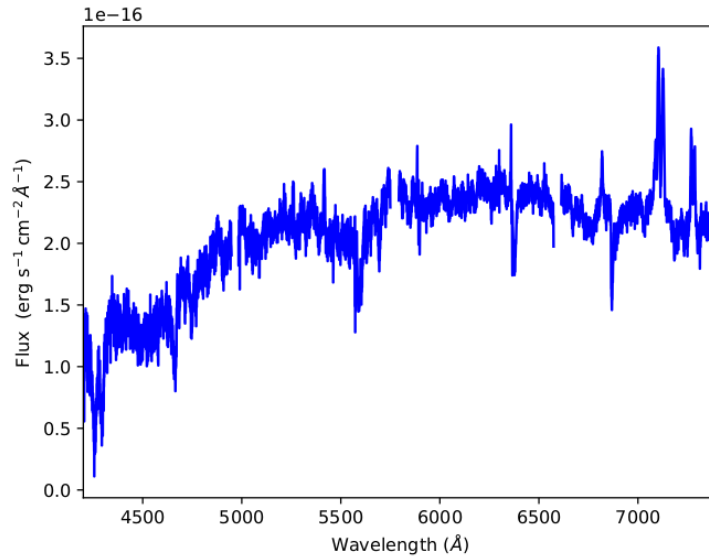
A new spectroscopic study of Malin 1

Junais et al. (In prep.)

Longslit spectra from Magellan – IMACS



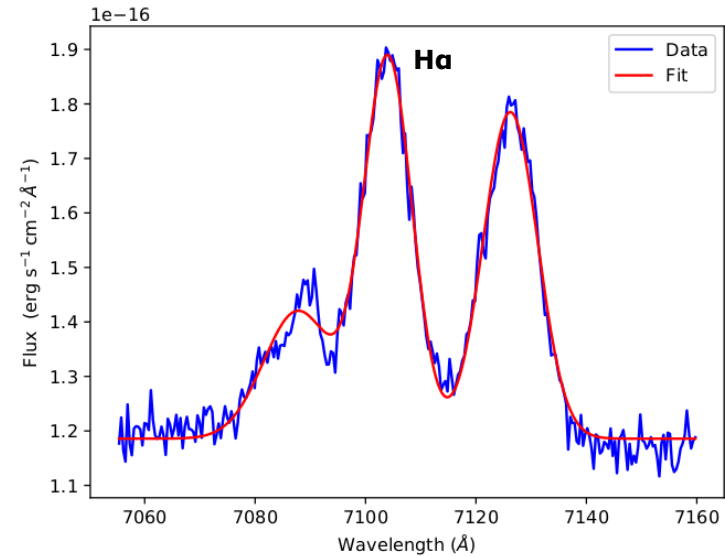
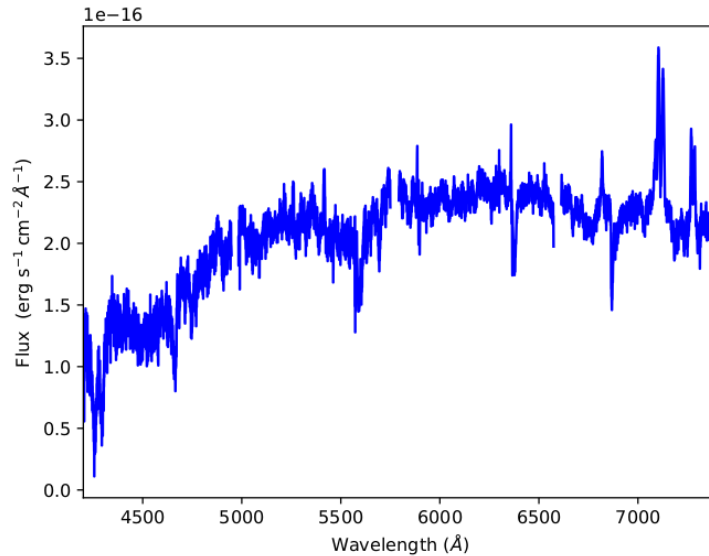
Extracted Spectra



- Similar kind of spectrum extracted for 12 different regions of Malin 1
- Focussed on the **H α** emission line => strongest of all
- Measured quantities :

- Wavelength shift
- Line Flux

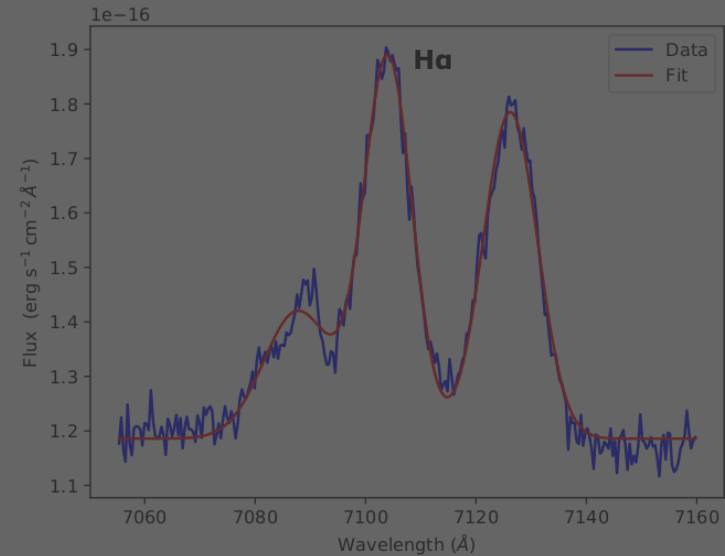
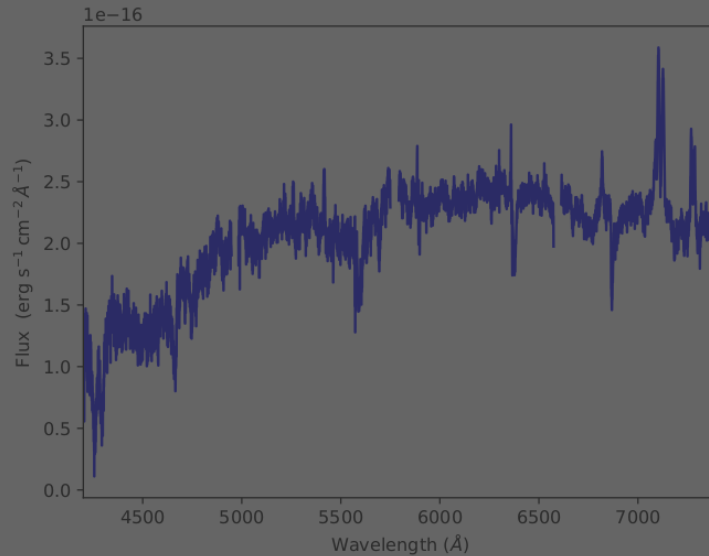
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- Wavelength shift \longrightarrow *Rotational Velocity*
- Line Flux \longrightarrow *SFR*

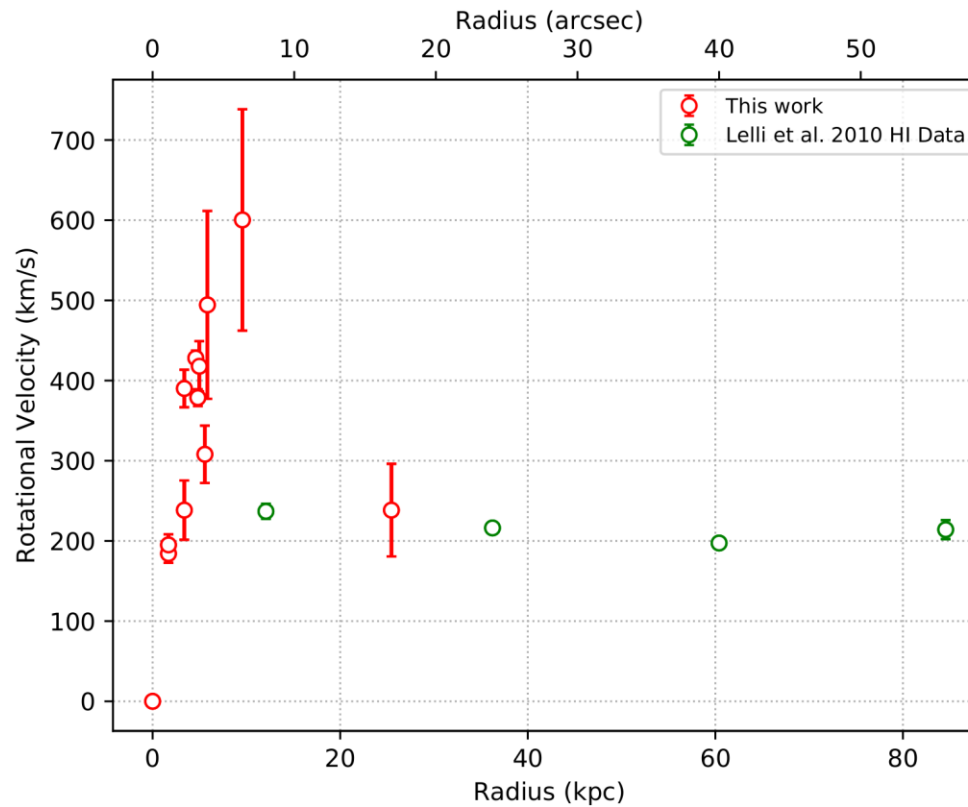
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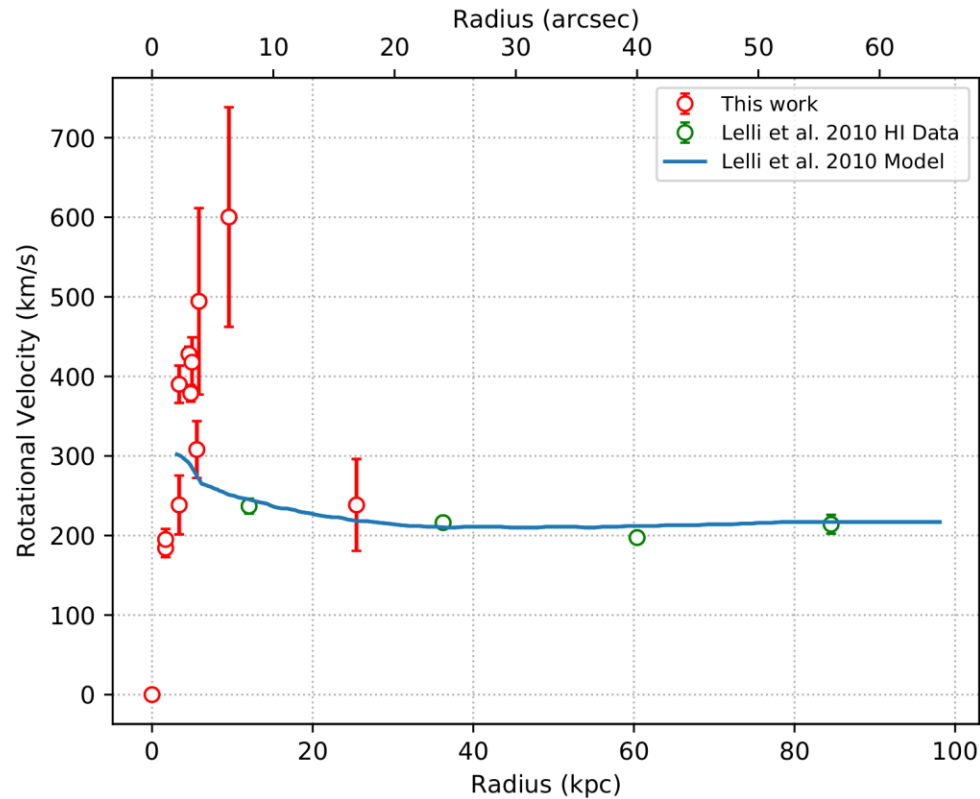
- Wavelength shift \longrightarrow **Rotational Velocity**
- Line Flux \longrightarrow **SFR**

Malin 1 H α Rotation Curve



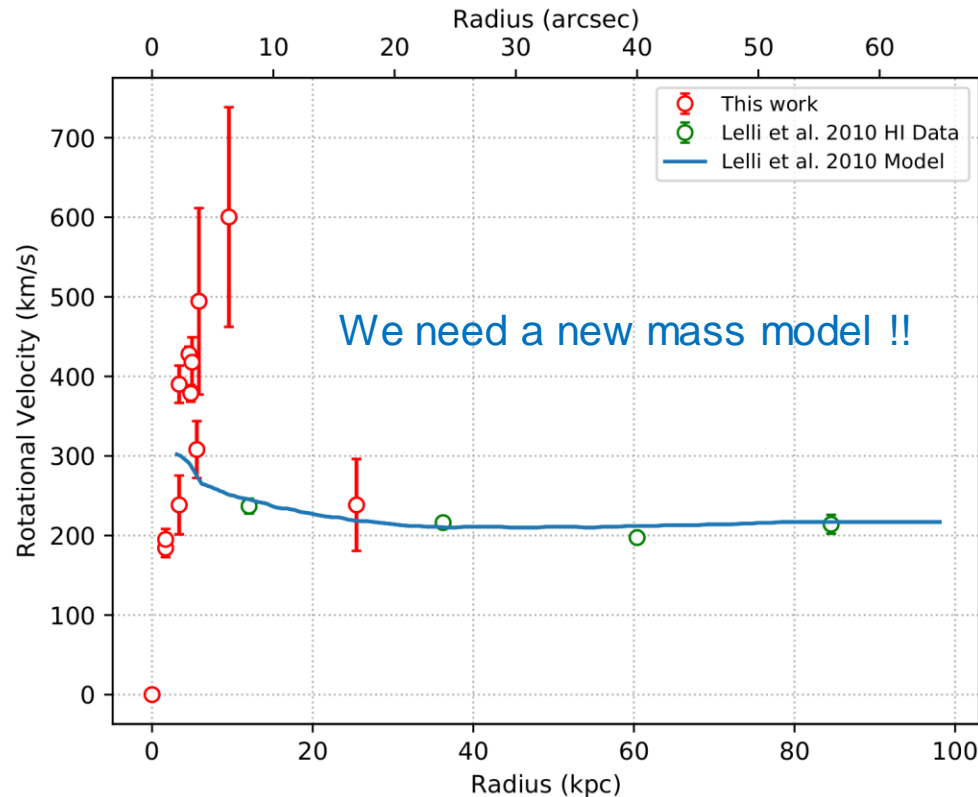
- First time to observe a steep rise in the rotation curve for Malin 1 (inside ~10 kpc)

Malin 1 H α Rotation Curve



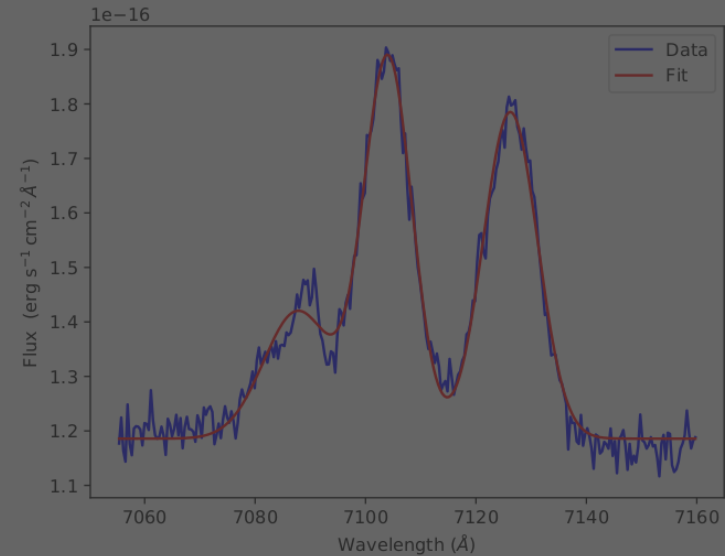
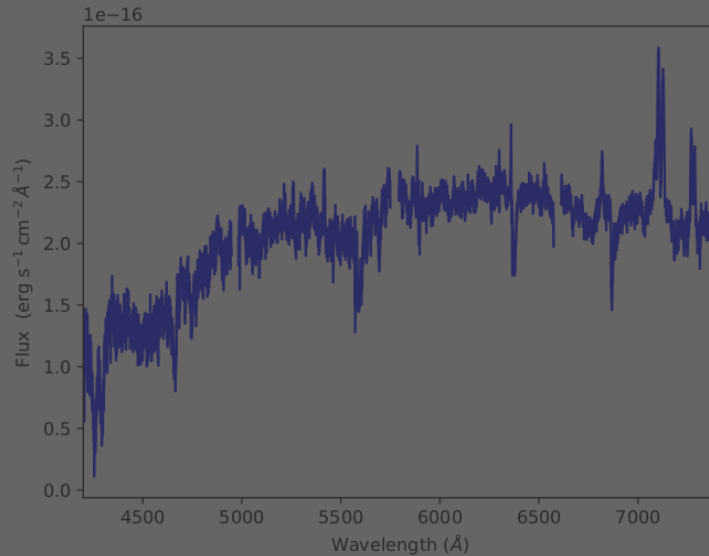
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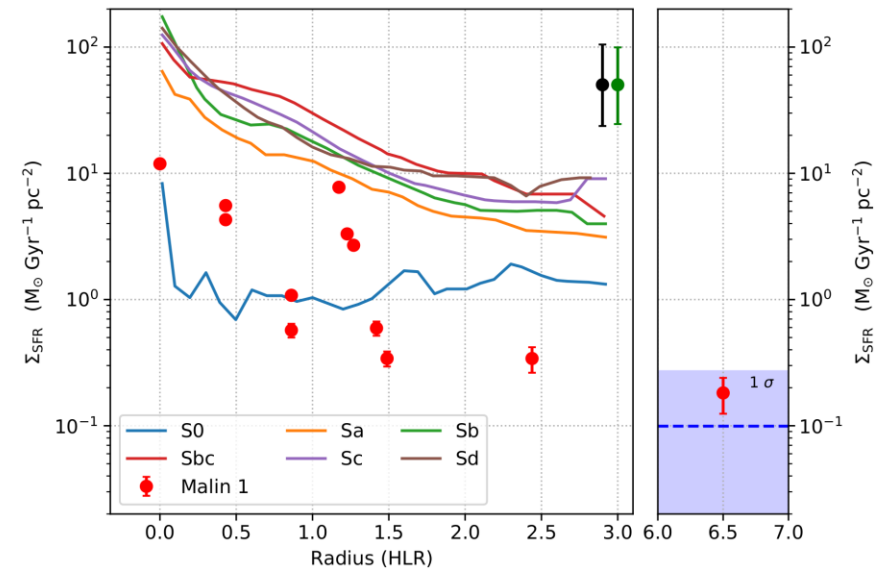
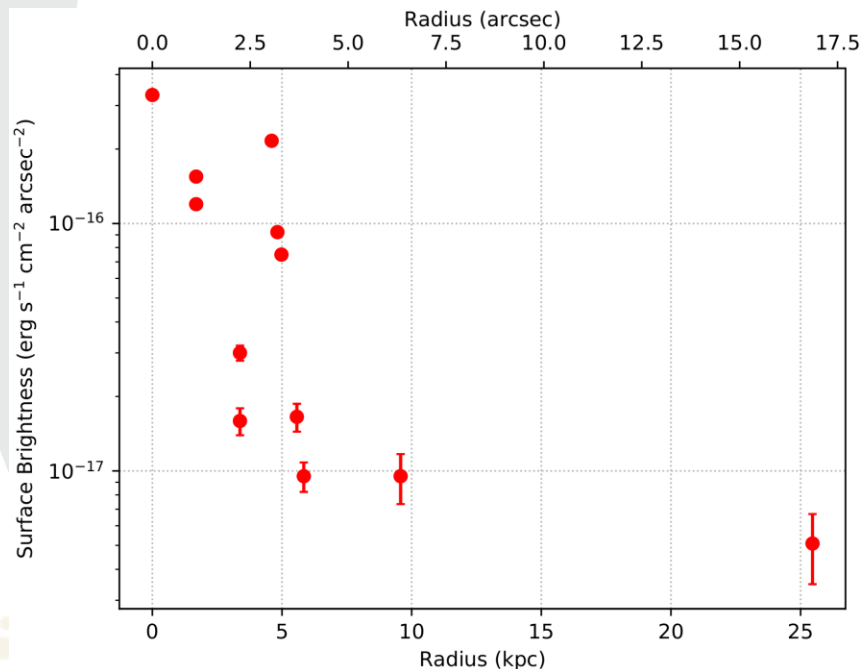


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H α Surface Brightness

- Calculated from the H α line flux
- Decrease in surface brightness with radius
- Estimate of the local SFR



Gonzalez et al. 2016

Inner regions of Malin 1 :
intermediate between **S0** and **Sa** type

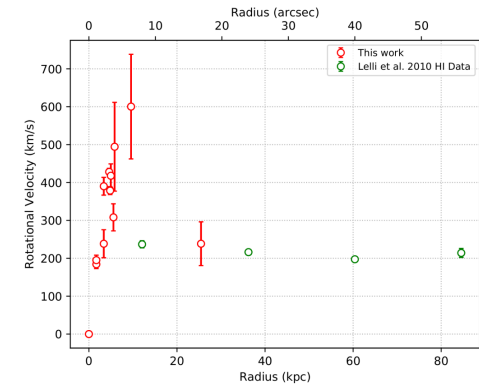
Barth (2007) : Inner part of Malin 1 is an early-type barred spiral

Summary

- **Major result** : *Inner rise of Malin 1 rotation curve*
- Surface Brightness --> first SFR order of magnitude estimate for Malin 1 using H α

Future Prospects :

- Similar study could be extended to other LSBs & XUVs in a broader context with Malin 1 as a prototype.
- Obviously, we need more data
- Submitted a target list of more giant LSBs for Magellan-IMACS observation
- UVIT proposal for Malin 1
- Obtained a LAM grant to buy a new narrow-band H α filter at the redshift of Malin 1
- Ongoing study of LSBs in Virgo --> See Samuel's talk



Rotation curve for Malin 1

Name	RA (deg)	DEC (deg)	Distance (Mpc)	D ₂₅ (kpc)	Last UV Radius GALEX		Observability at Las Campanas		
					(arcsec)	(kpc)	Top Altitude	Airmass	Month
UGC 00568	13.787	-1.046	182.96	46.34	5.00	4.435	60°	1.15	September
UGC 1382	28.671	-0.143	75.23	24.00	200.0	73	60°	1.15	October
UGC 02936	60.701	1.966	50.71	34.59	57.10	14.04	60°	1.15	November
PGC 135754	159.365	2.089	304.59	48.69	24.50	36.18	60°	1.15	March
UGC 6614	174.811	17.143	91.62	35.11	125.0	55.5	45°	1.41	March
Malin 1	189.247	14.330	343.44	25.09	48.00	79.92	45°	1.41	March
PGC 45080	195.817	1.469	172.44	45.74	48.10	40.21	60°	1.15	March
NGC 7589	349.565	0.261	117.39	32.59	38.30	21.79	60°	1.15	September
PGC 71626	352.635	-2.463	132.29	53.08	84.40	54.10	60°	1.15	September

New GLSB target list for IMACS-Magellan

THANK YOU

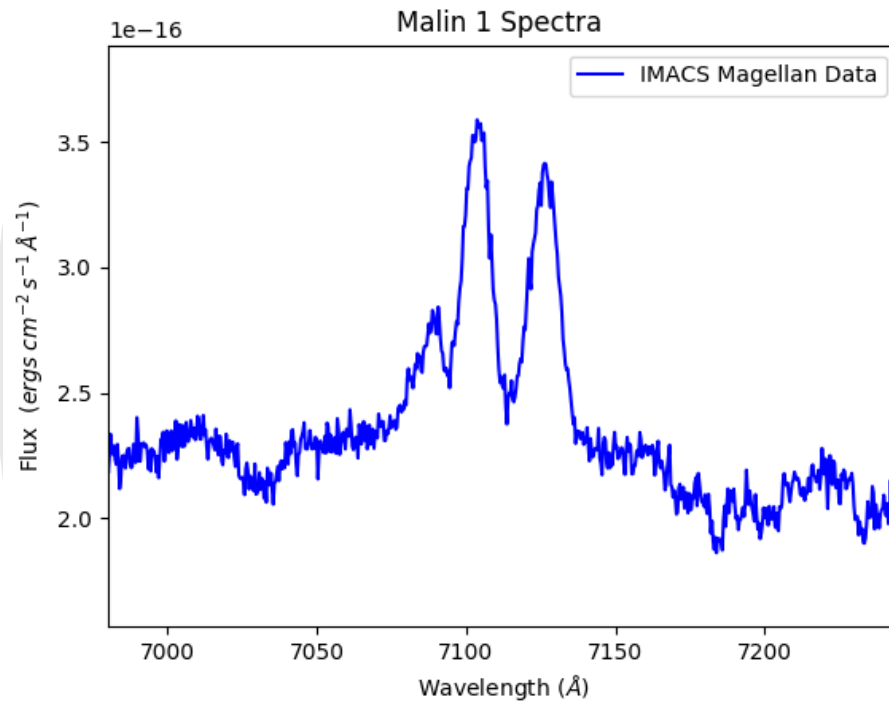
Extra slides

IMACS Specifications

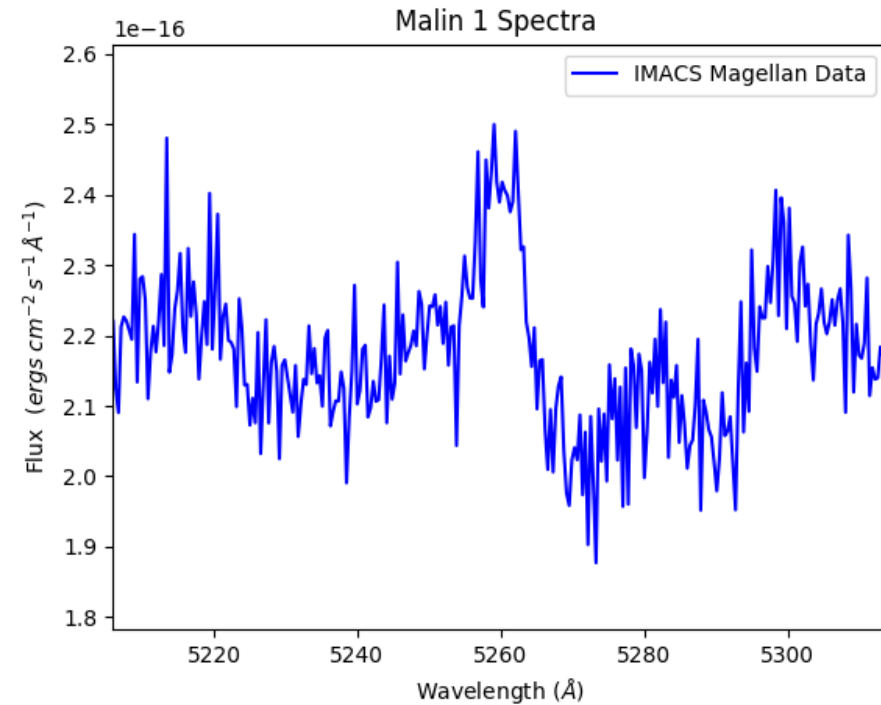
IMACS Characteristics of our Observations

Imaging	:	f/4 Camera
Field of View	:	15.4×15.4 arcmin
CCD	:	8K \times 8K pixels (8 chips of 2K \times 4K)
CCD Pixel Scale	:	0.111''/pixel
Slit width	:	2.5''
Grating	:	600 lines/mm
Central Wavelength	:	5790 Å
Wavelength Range	:	4180 - 7400 Å
Dispersion	:	0.378 Å/pixel
FWHM Spectral Resolution	:	8.5 Å

Emission Lines

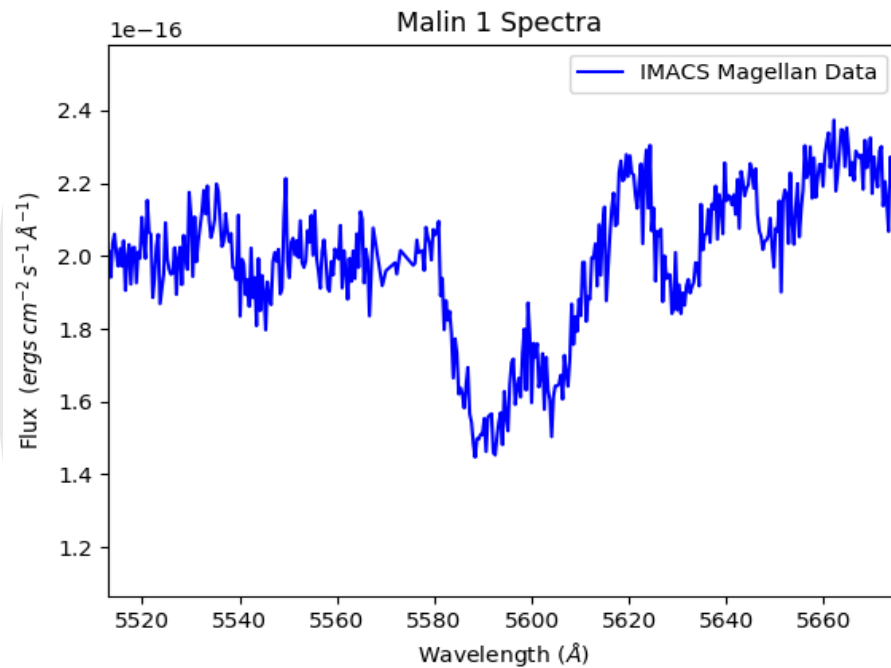


H α

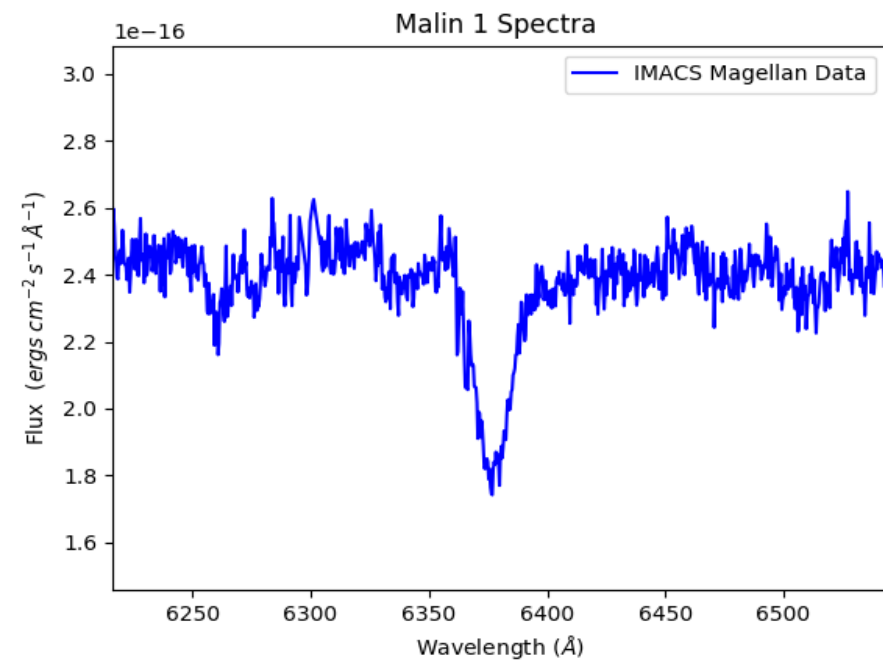


H β

Absorption Lines



Mg I (5175)



Na I

Geometry

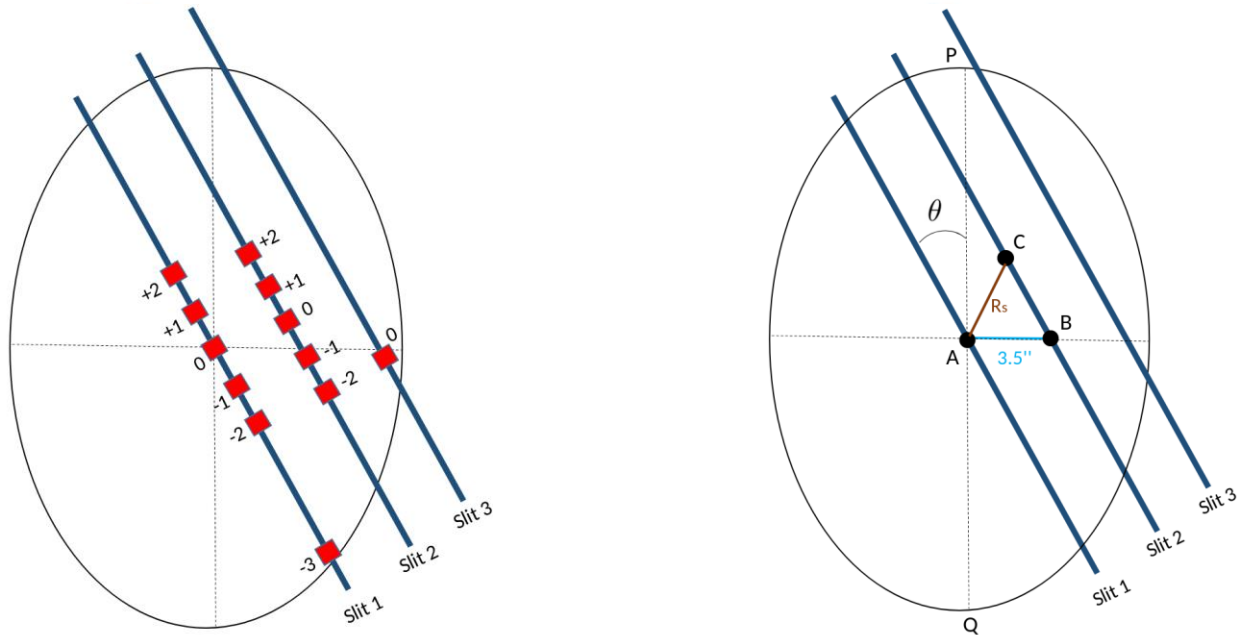
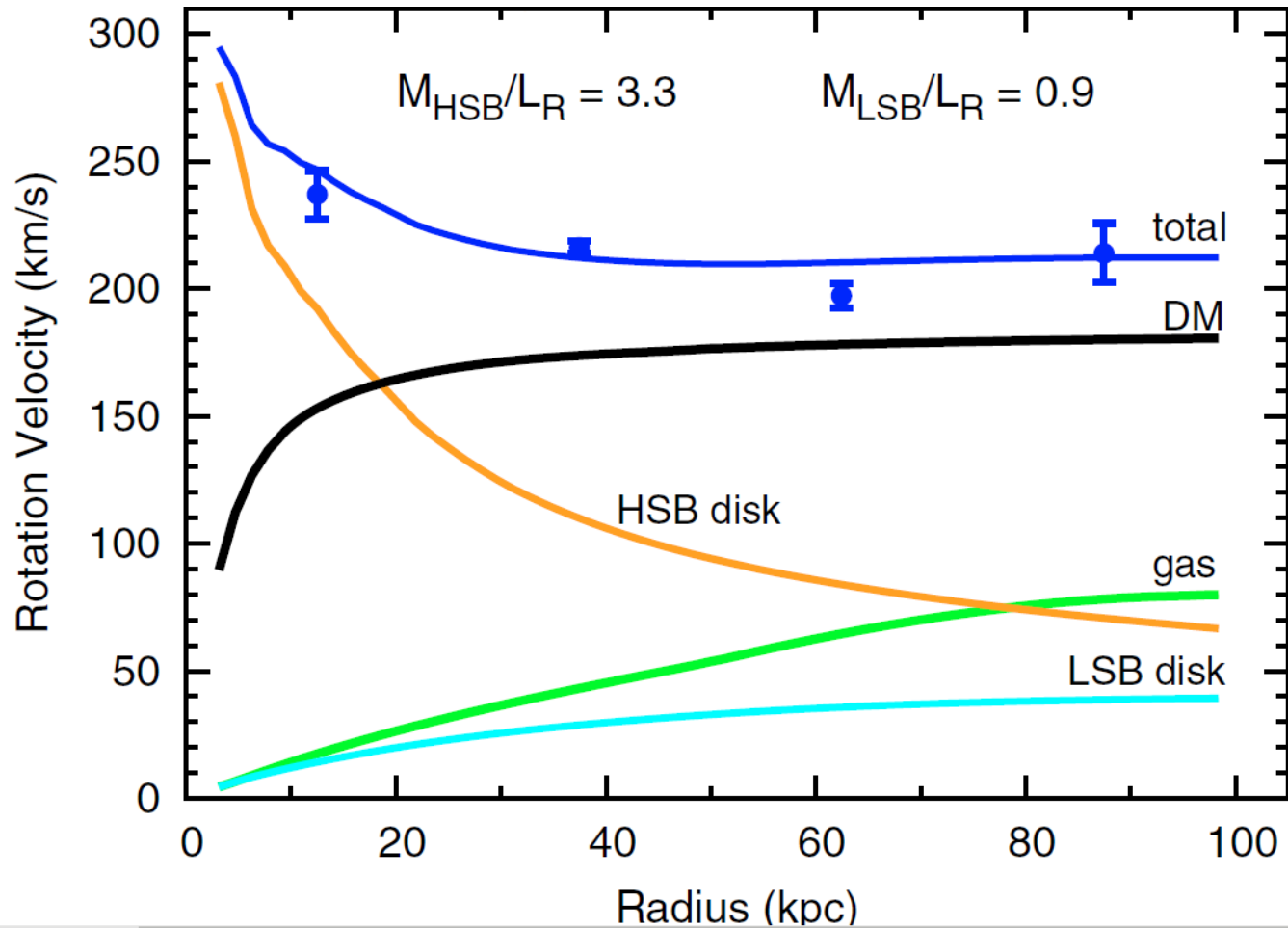
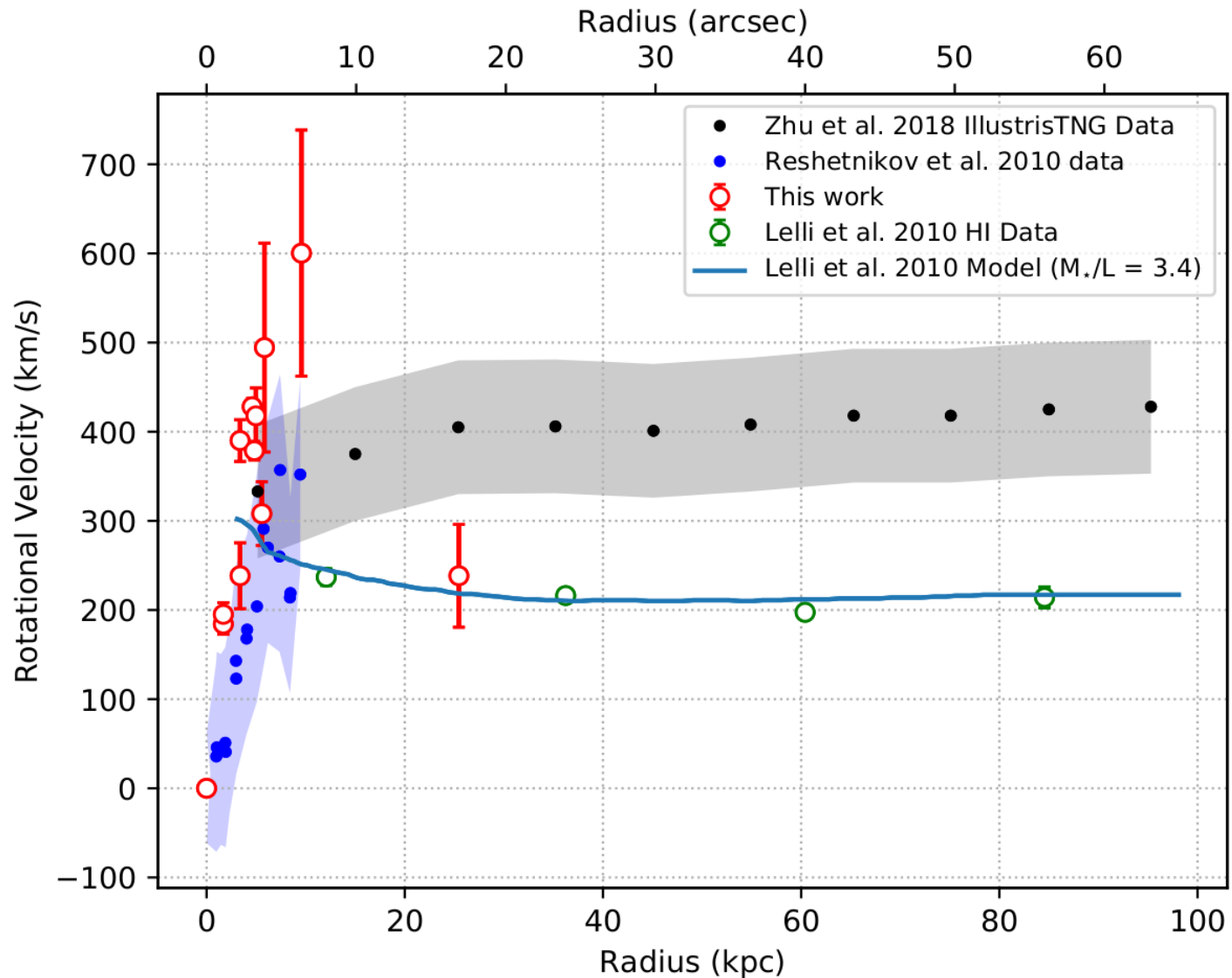


Figure 6. *Left* : Geometrical sketch of our galaxy and the slit positions, with the 12 regions of extraction and their aperture IDs (marked in red). The dotted lines denotes the major axis and minor axis of the galaxy (here the inclination is exaggerated for demonstration purpose). *Right* : Geometry to measure the radius and projection angle of an aperture marked C. All the angles here are defined in a counter-clockwise direction with respect to the upper major axis of the galaxy.

Lelli Mass Model

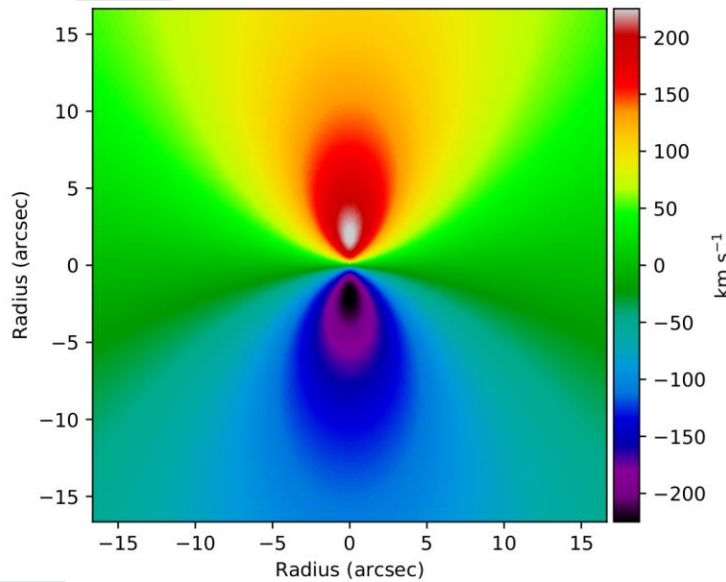


Existing Models

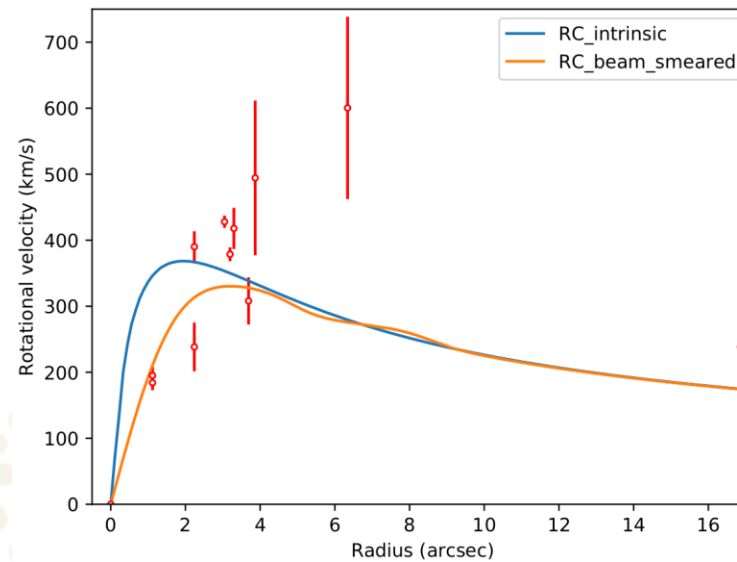
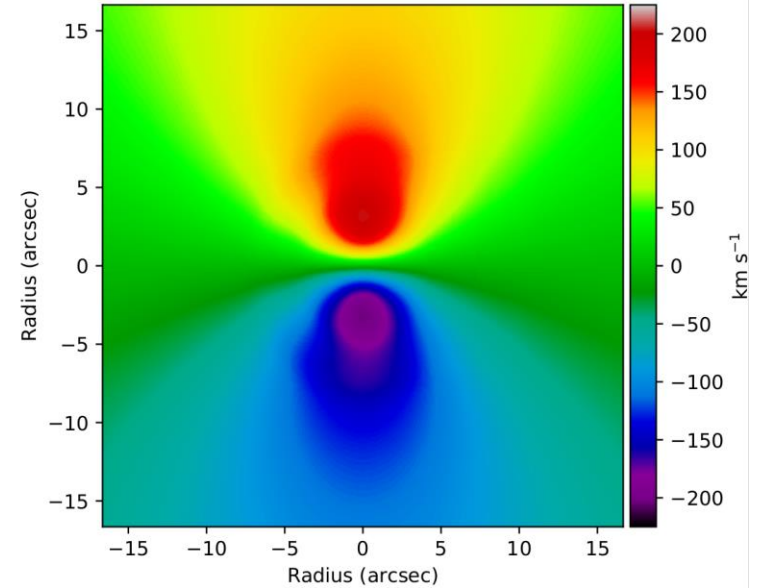


New Mass Model : Preliminary plots

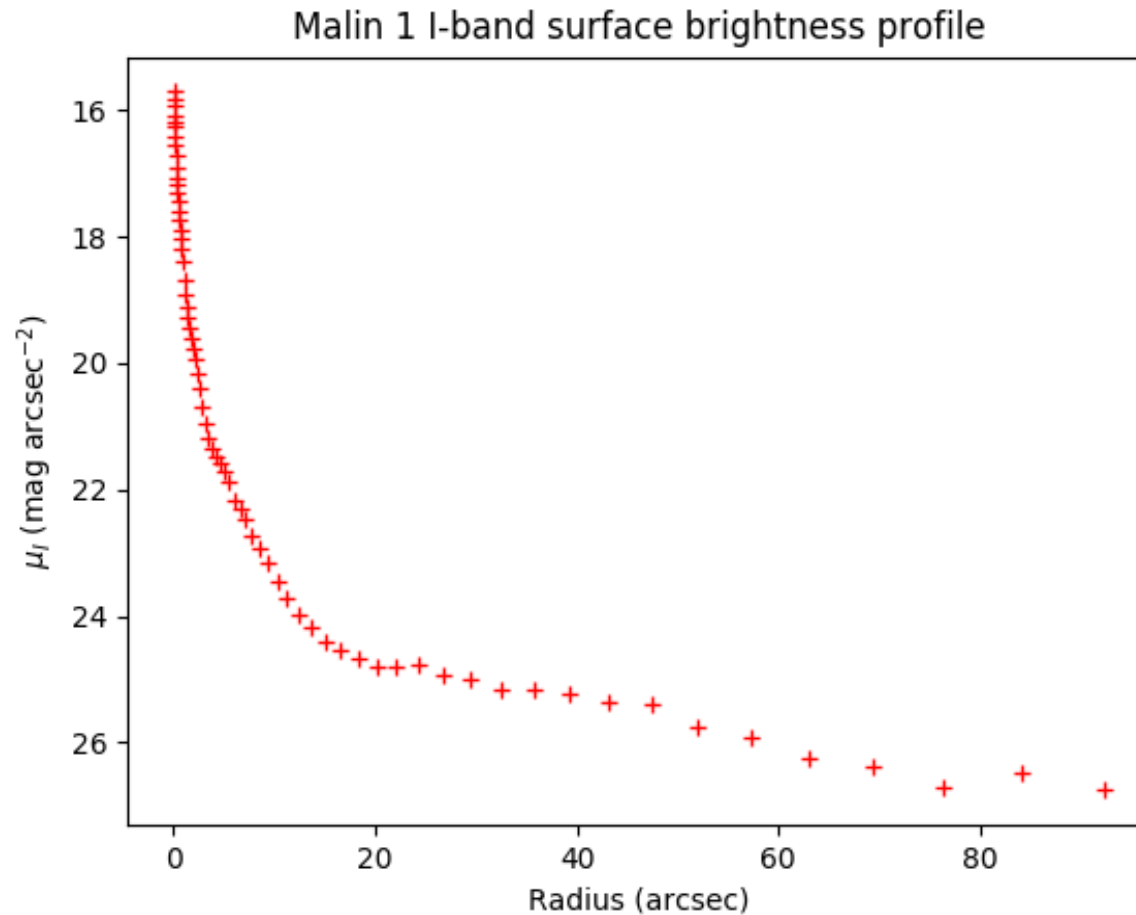
Bulge Velocity map



Bulge Velocity map : with beam smearing

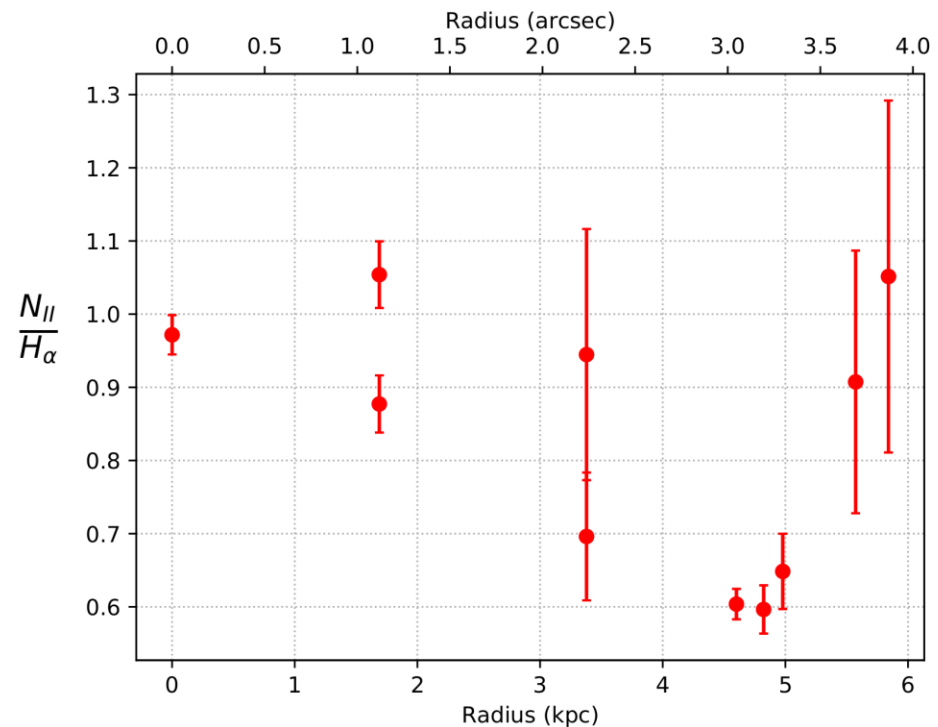


Malin 1 surface brightness profile



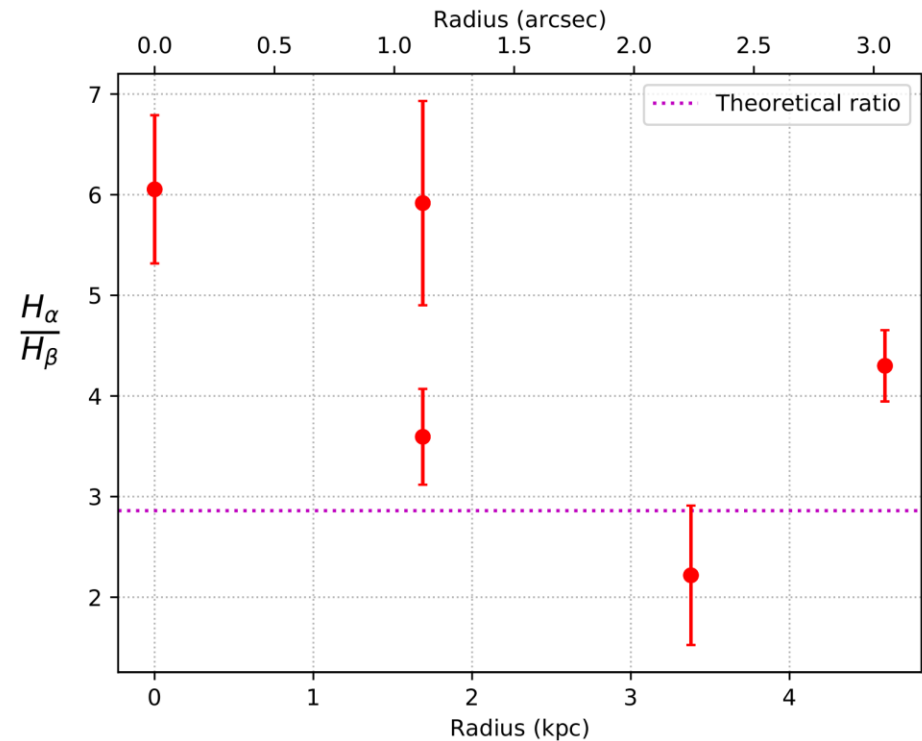
Abundance Ratio

- $[N II]_{6584}/H\alpha$ ratio --> Abundance estimator (*Denicolo et al. 2002*)
- Observed high abundance at inner regions of Malin 1
- Could also be due to AGN activity
- *Boissier '16 model* for Malin 1 predicts low abundance – only for outer disk
- Need to make model for inner regions



Dust Attenuation

- **H α /H β** ratio --> Highly sensible to dust attenuation
- Observed high H α /H β ratio at inner regions of Malin 1
- Could indicate high dust content
- Only few data points – cannot conclude much
- Possible errors – calibration, underlying absorption



SB – SFR Corrected using Balmer Ratio

