THE NUCLEAR REGION, HOST GALAXY AND ENVIRONMENT OF ACTIVE GALAXIES:
A symposium to celebrate the 60th birthday of Deborah Dultzin-Hacyan

Kinematics and dynamics of the M51-type galaxy pair NGC3893/96

Collaborators

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Based on Fuentes-Carrera et al. (2007: In press A&A)

The interaction of galaxies as an important ingredient in their formation and evolution.

*** Morphology and Inner Structure**

*** Star Formation and Nuclear Activity**

Why is it important to study interacting galaxy pairs?

Simplest system of galaxies

Information on the DM halo structure as well as the mass-to-luminosity (M/L) ratio

Evolution of galaxies in compact groups, groups and clusters

Use kinematical and dynamical studies of isolated interacting galaxy pairs in order to:

- Determine if a pair is physical or not

- Analyse the suppression and/or formation of structure

- Determine the stage of the interacting process and the interaction parameters

- Constraint the values of the M/L of isolated interacting pairs + information on the structure of the DM halo

*Observations

2.12 m telescope at the Observatorio Astronomico Nacional in San Pedro Mártir, México

Scanning Fabry-Perot interferometer PUMA (Rosado *et al* 1995)

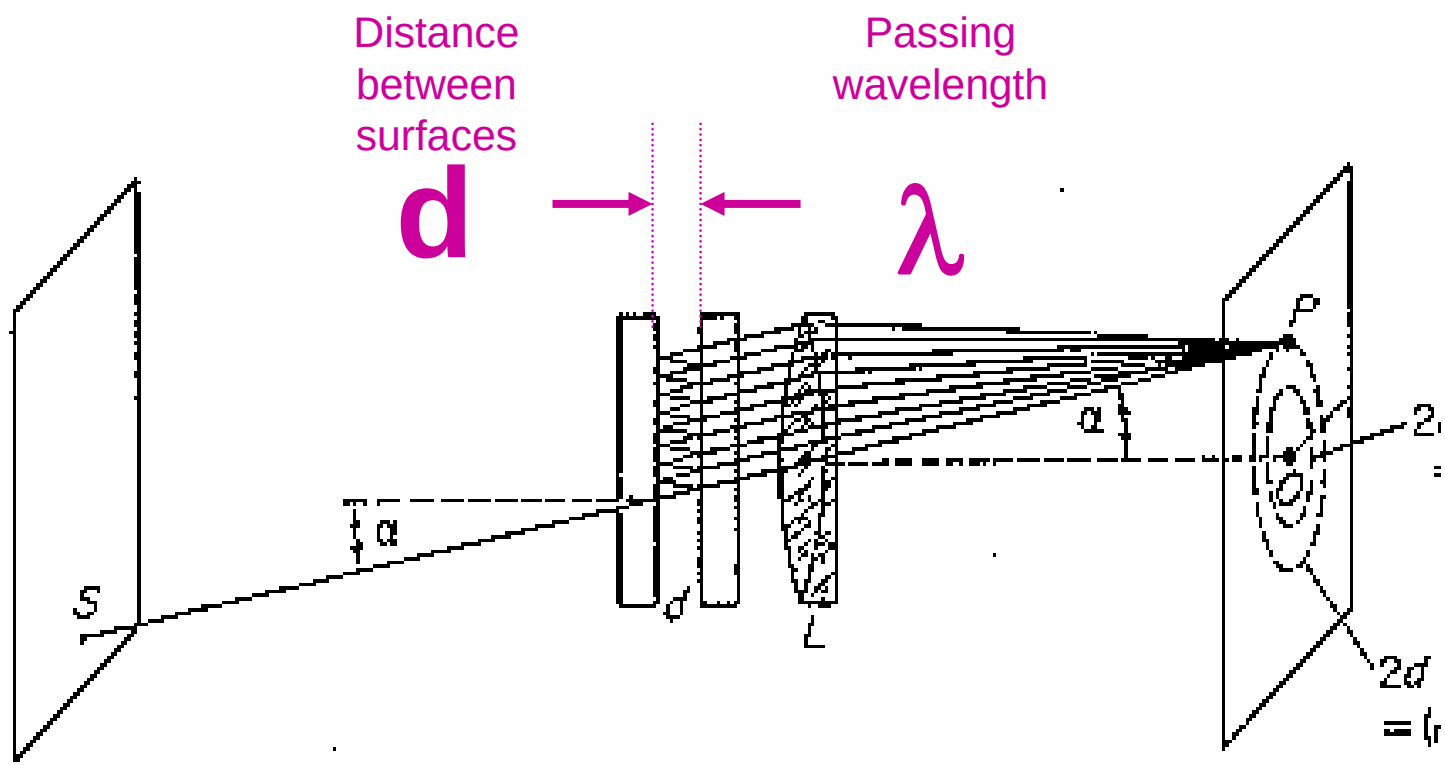
1024 x 1024 TEK CCD **bin=2** **scale= 1.18 “/pix**

Interference order = 330 at Hα
# of channels=48

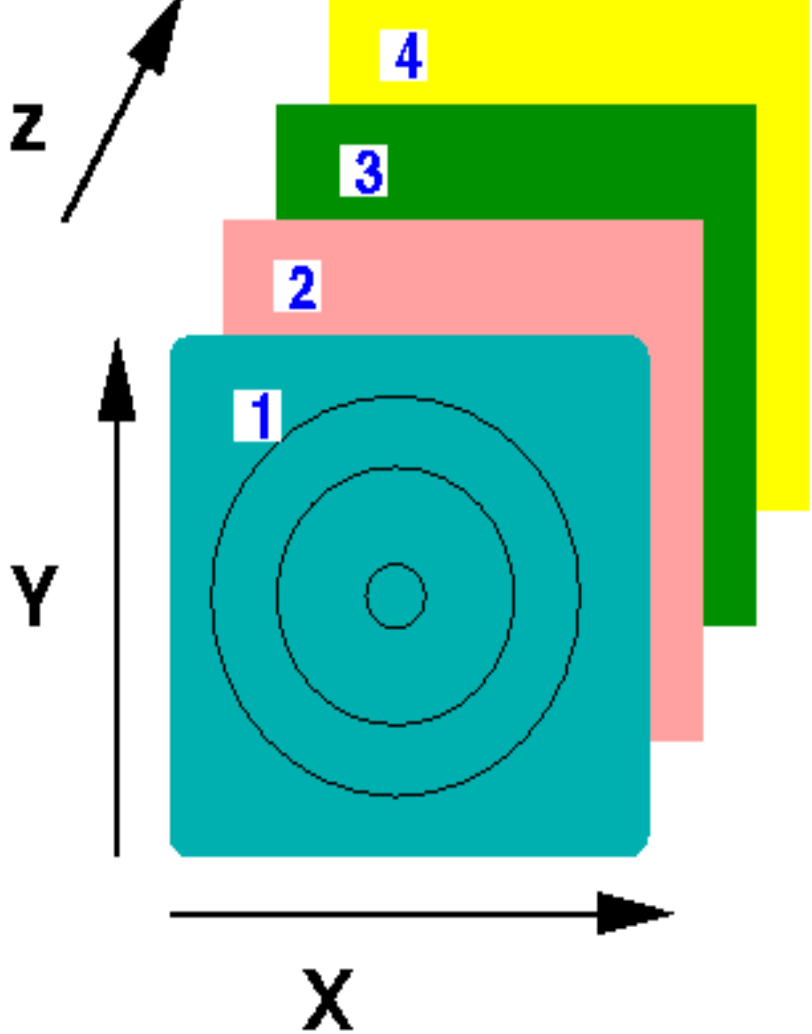
FSR=19 A (914 km/s)
t_{exp}= 120 s per channel

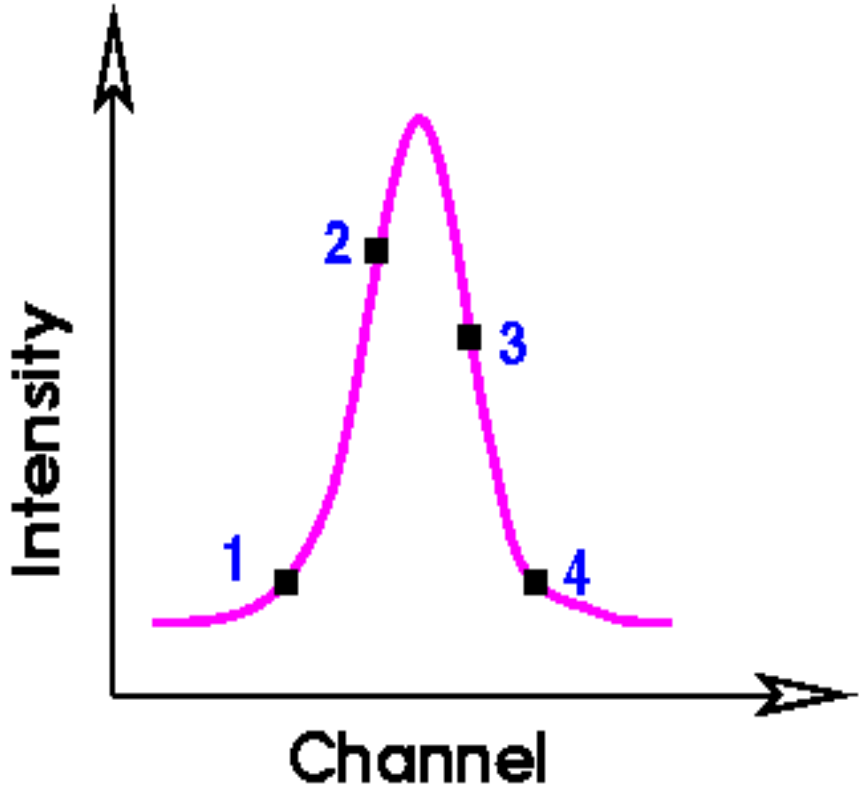
Redshifted Hα line

What does a scanning Fabry-Perot interferometer do ???



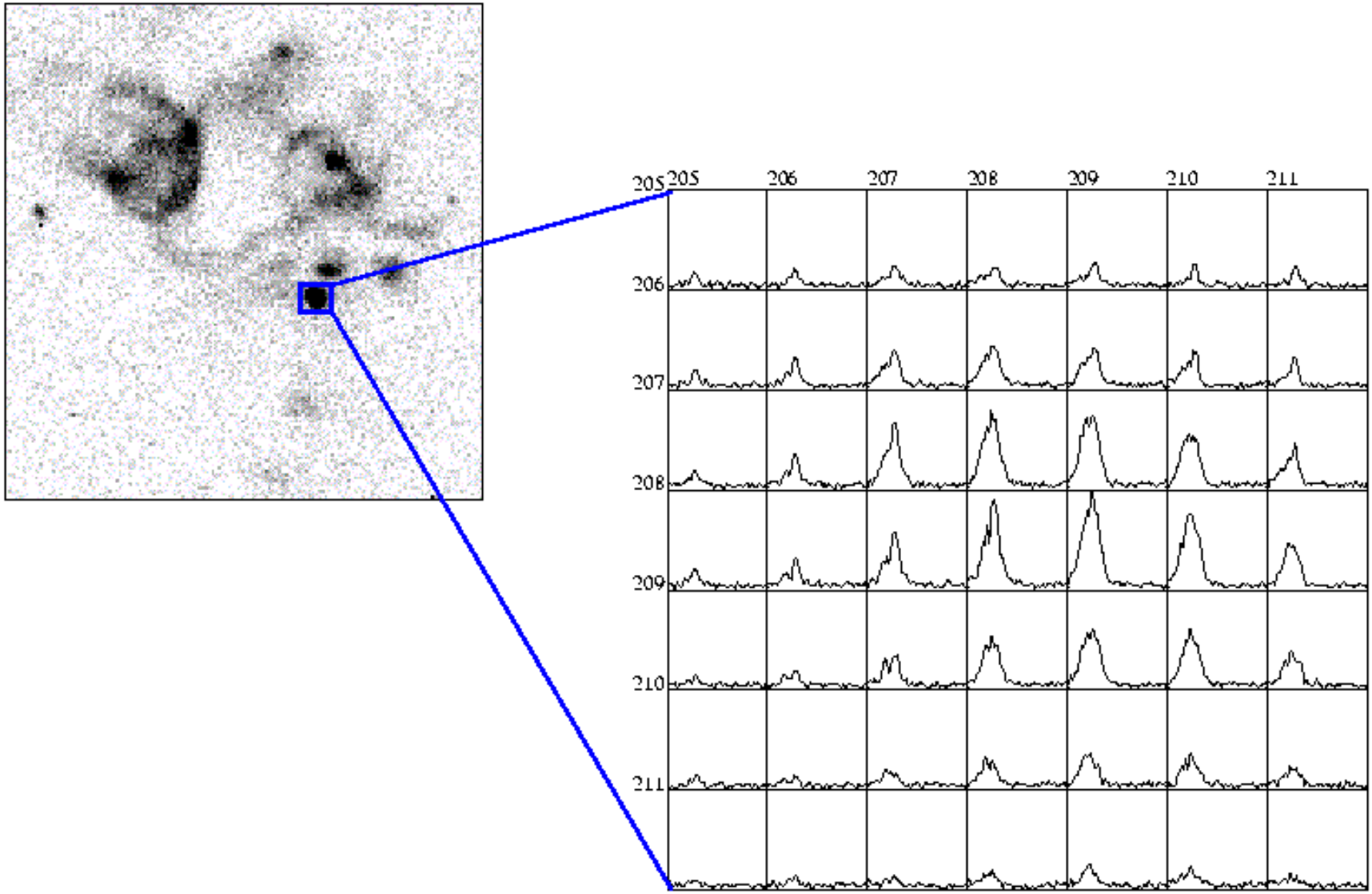
A certain radial velocity value is associated with each λ (Doppler effect).



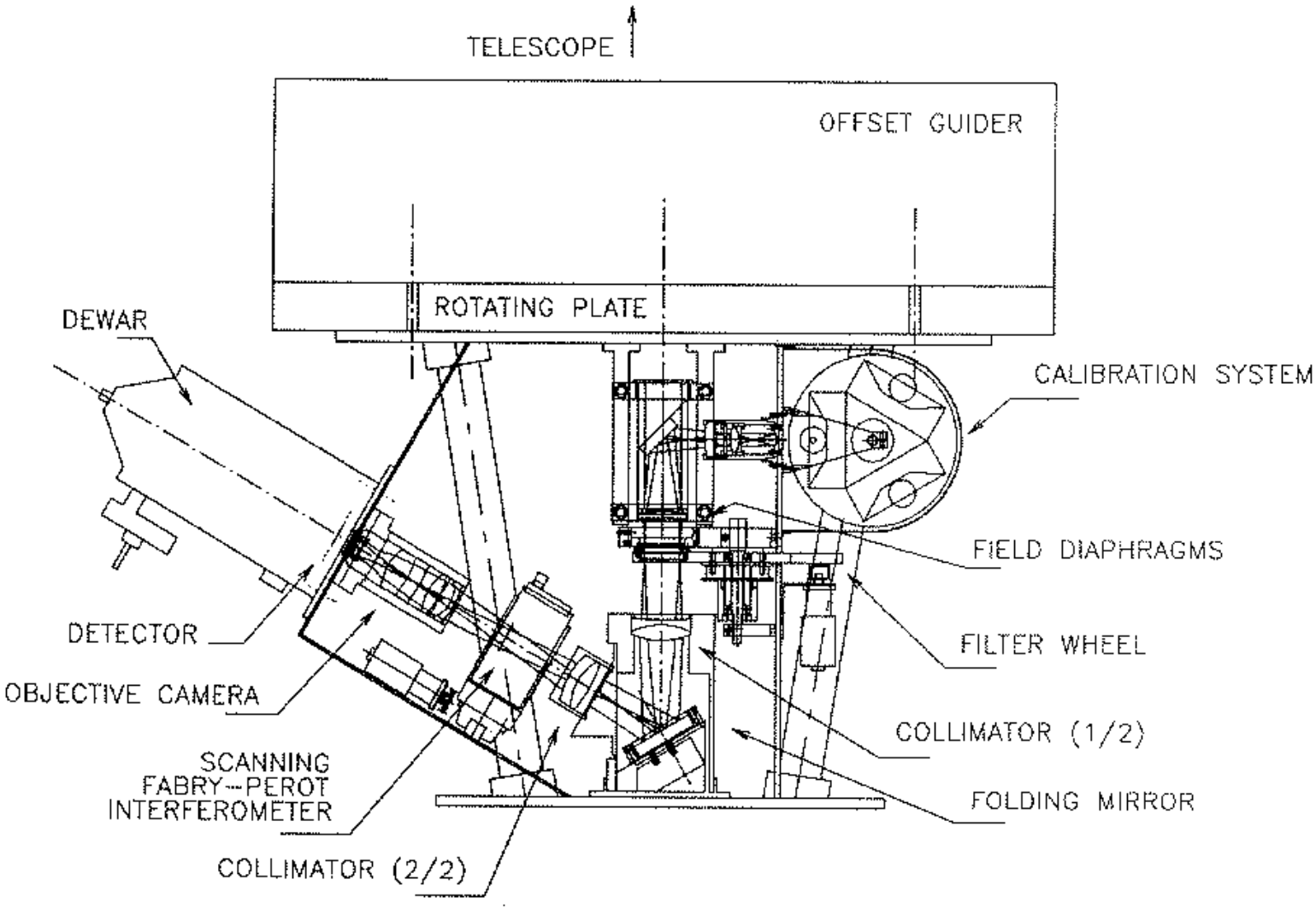


A scanning Fabry-Perot interferometer allows us to get <u>ACCURATE</u> RADIAL VELOCITIES of EXTENDED OBJECTS.

FP Spectroscopy: A High Spectral Resolution Profile for Each Pixel:



PUMA Instrument



ADHOCw software (J. Boulesteix)

http://www.observatoire.cnrs-mrs.fr

CIGALE reduction package

(Le Coarer *et al.* 1993)

* Mass Estimates

Mass within radius R, M (R)

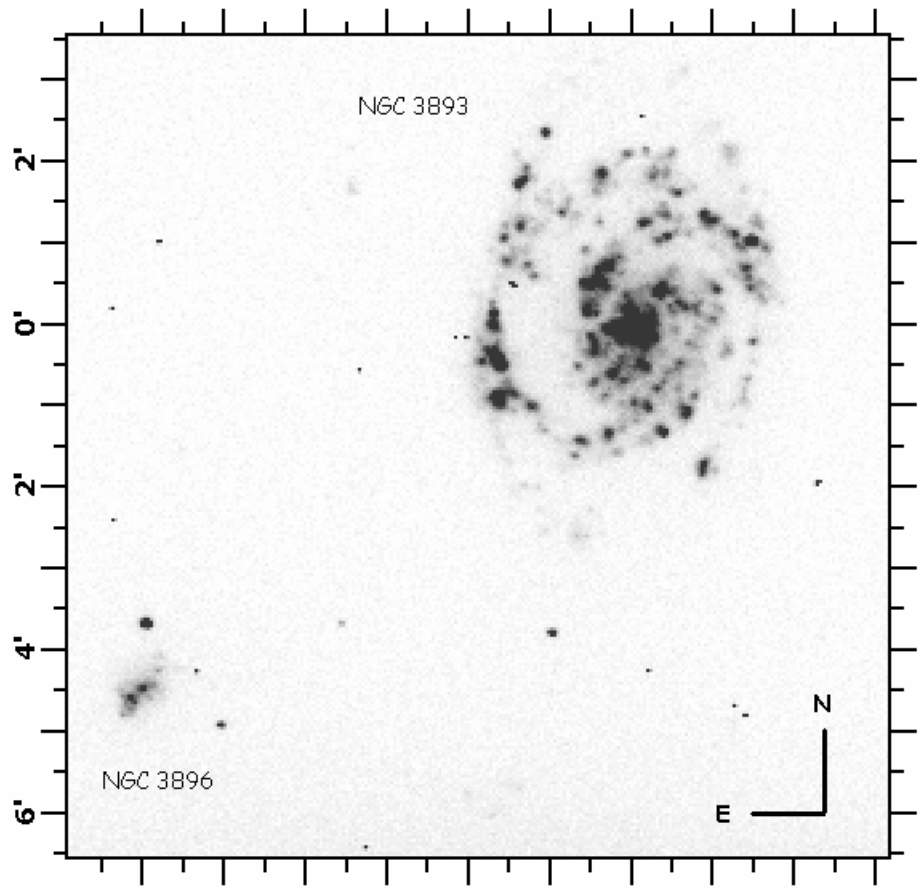
GRAVITATIONAL FORCE = CENTRIPETAL FORCE

$$M(R) = (V^2(R) / G) \times R$$

Lequeux 1983: The mass distribution in a disk galaxy lies between the mass given by a spheroid and that given by a disk distribution.

$$M(R) = (0.6 \text{ a } 1.0) \times (V^2(R) / G) \times R$$

* M/L and DM halo structure in interacting galaxy pairs: KPG 302.



Hα image of de NGC 3893/96 taken with PUMA

M51-type galaxy pair

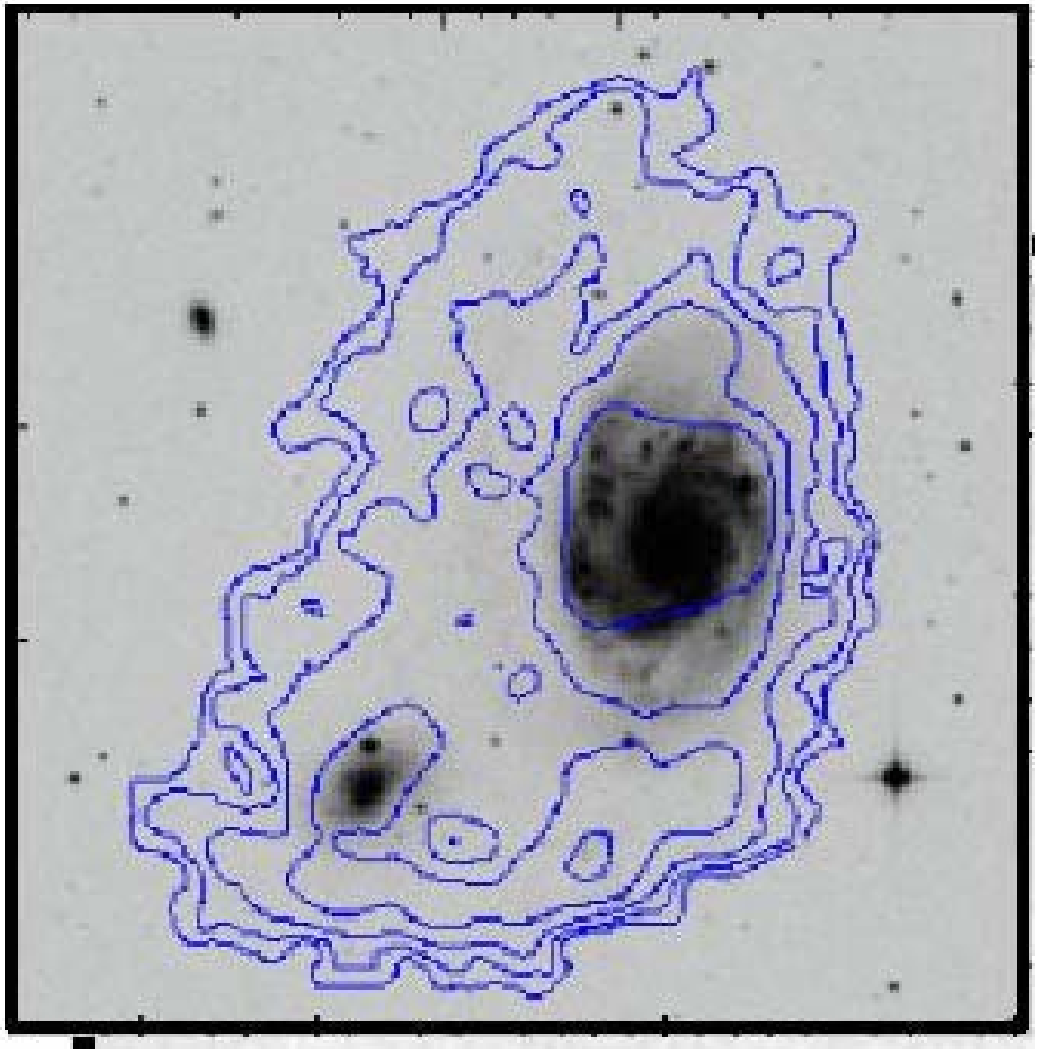
D = 18.6 kpc

NGC 3893.... Sc
NGC 3896.... Sm

B,V,R,I photometry by Hernandez-Toledo & Puerari (2001)

HI observations by Verheijen & Sancisi (2001)

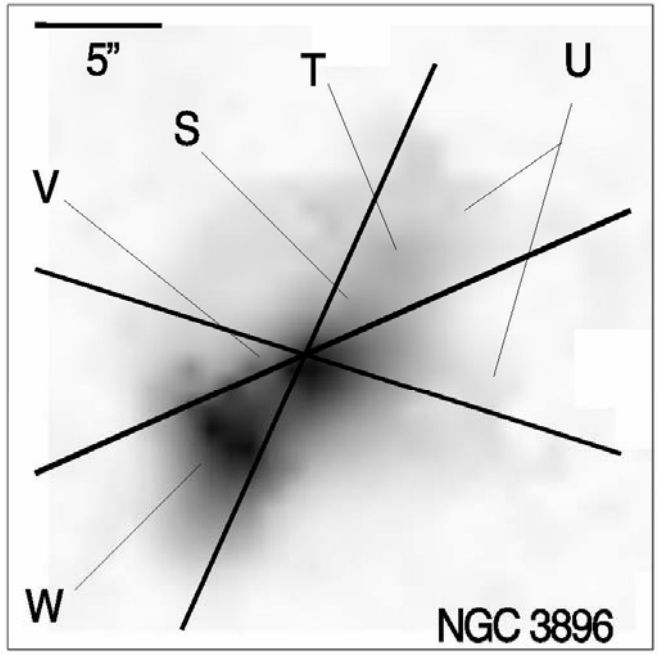
KPG 302: HI envelope

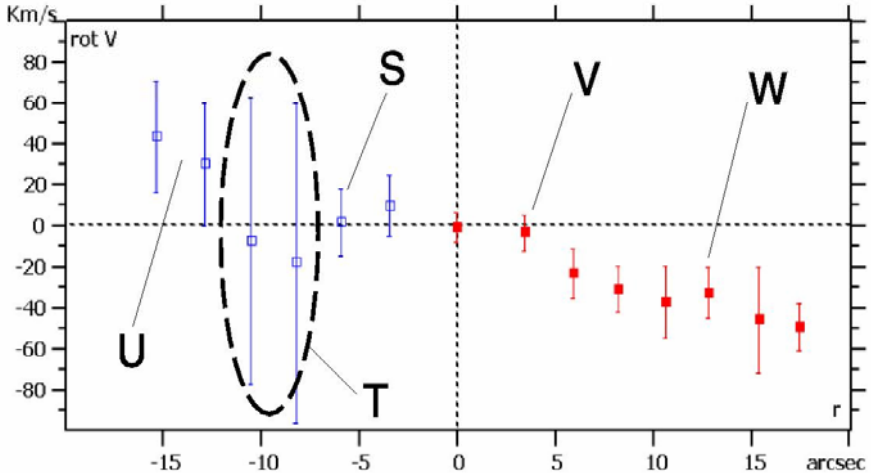


RC of NGC 3896

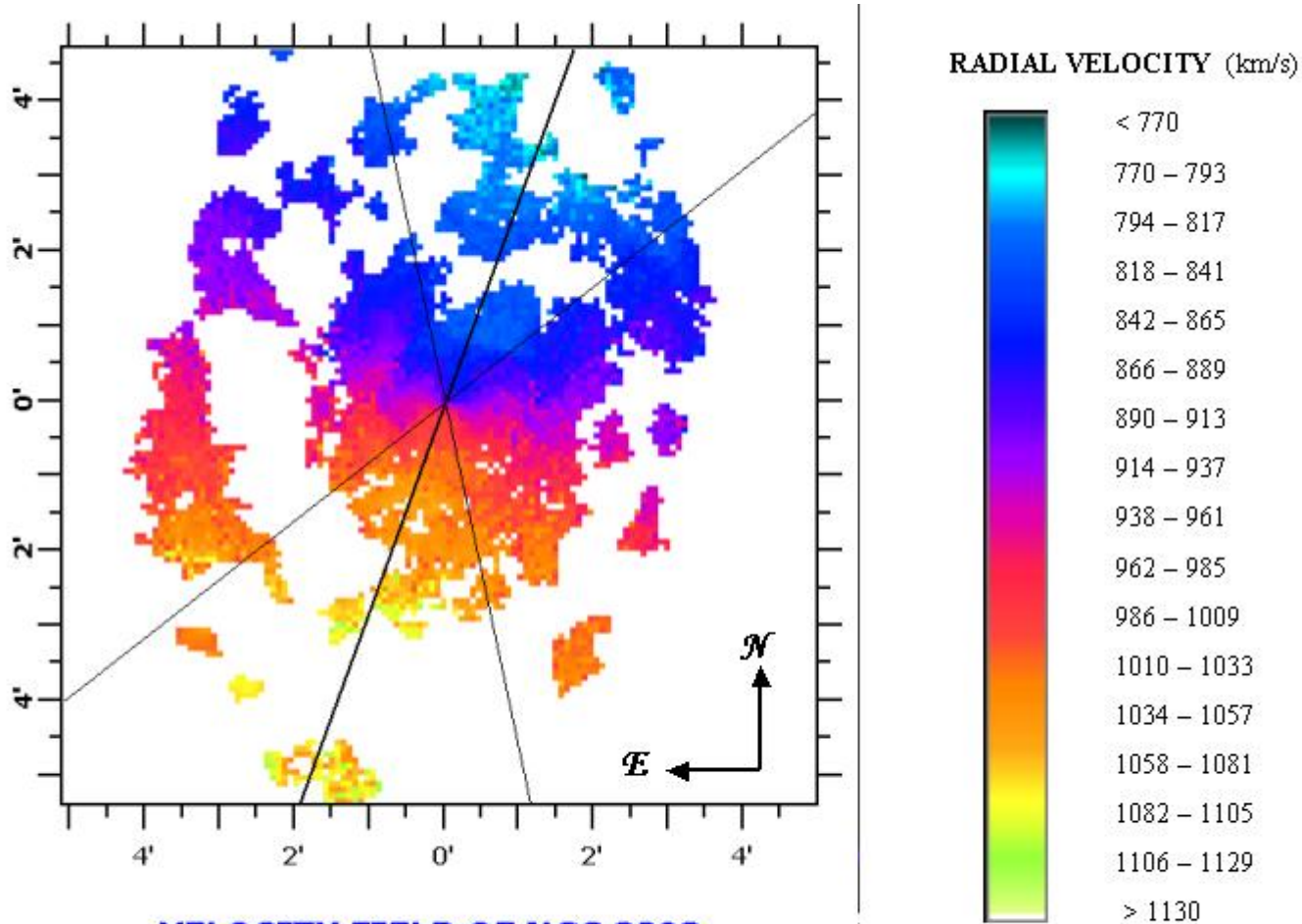
➔

M=5-8 x 10^8 M_O





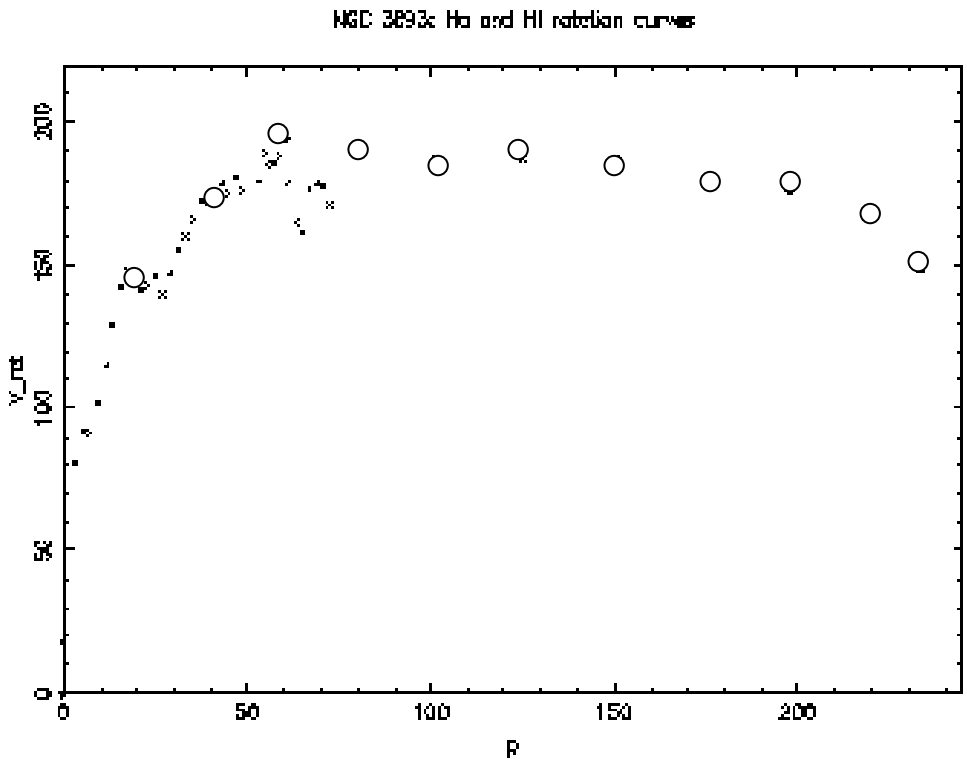
* Velocity Field of NGC 3893



VELOCITY FIELD OF NGC 3893.

Strong black line represents the galaxy's PA, thin lines show the sector angle considered for the computation of the rotation curve

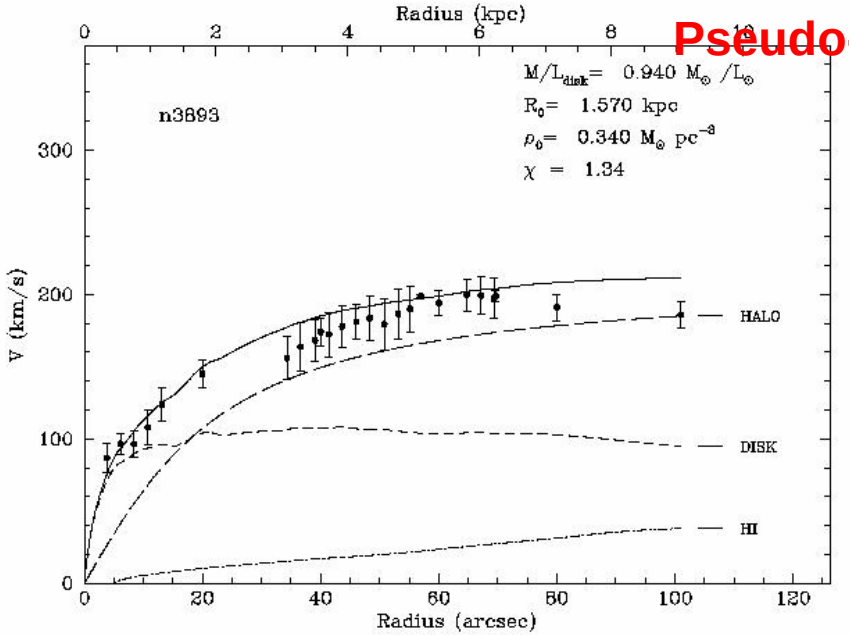
* Multi-wavelength rotation curve

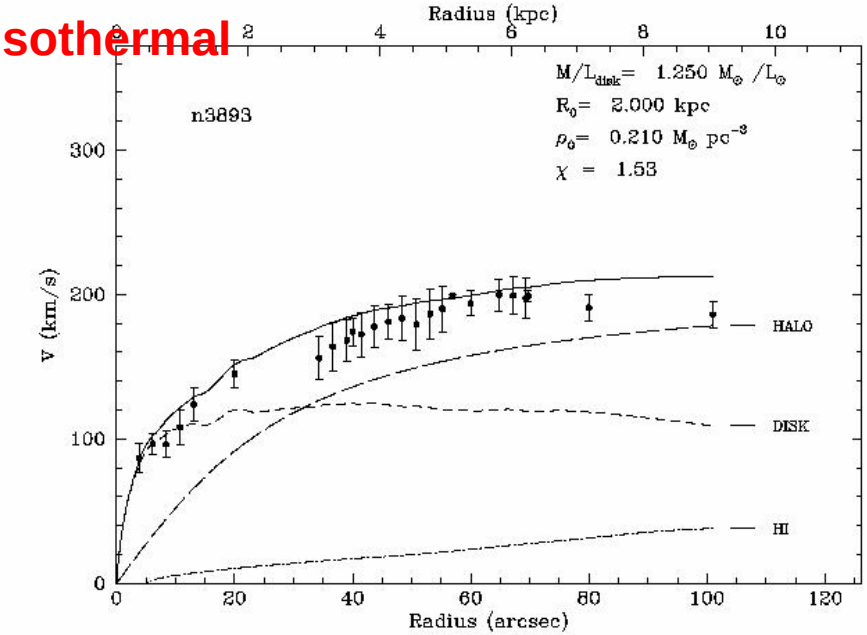


Black crosses: Hα observations with PUMA

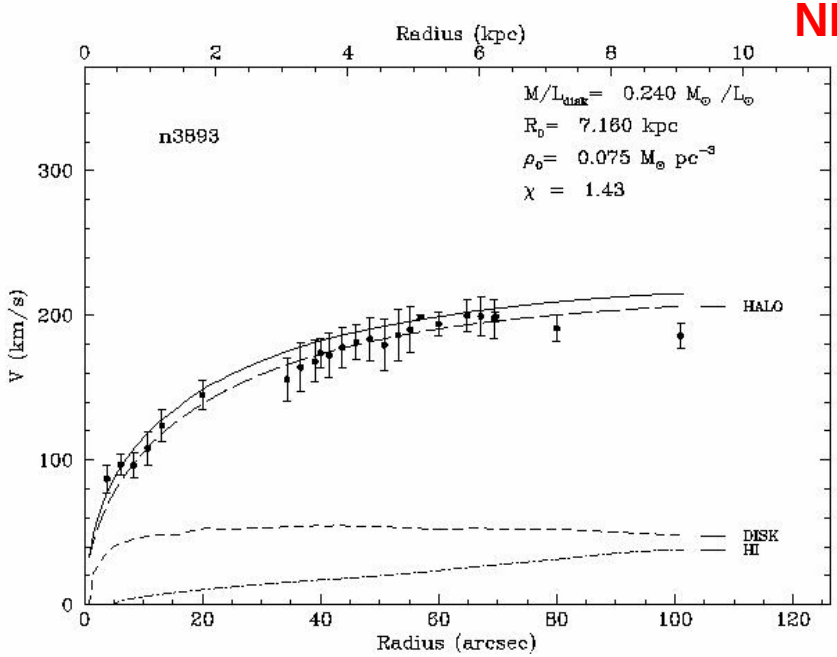
White dots: HI observations (Verheijen & Sancisi 2001)

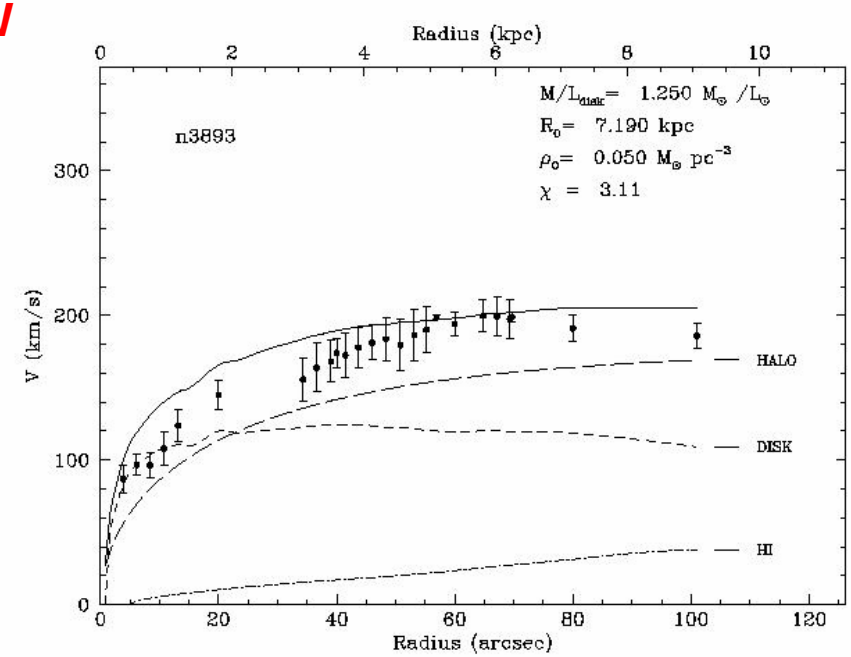
Pseudo-isothermal





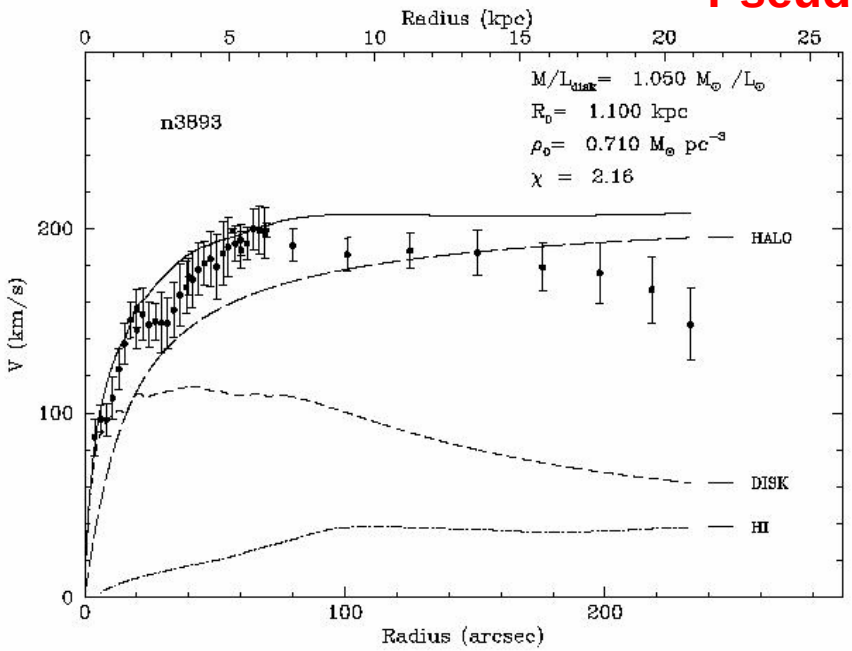
NFW

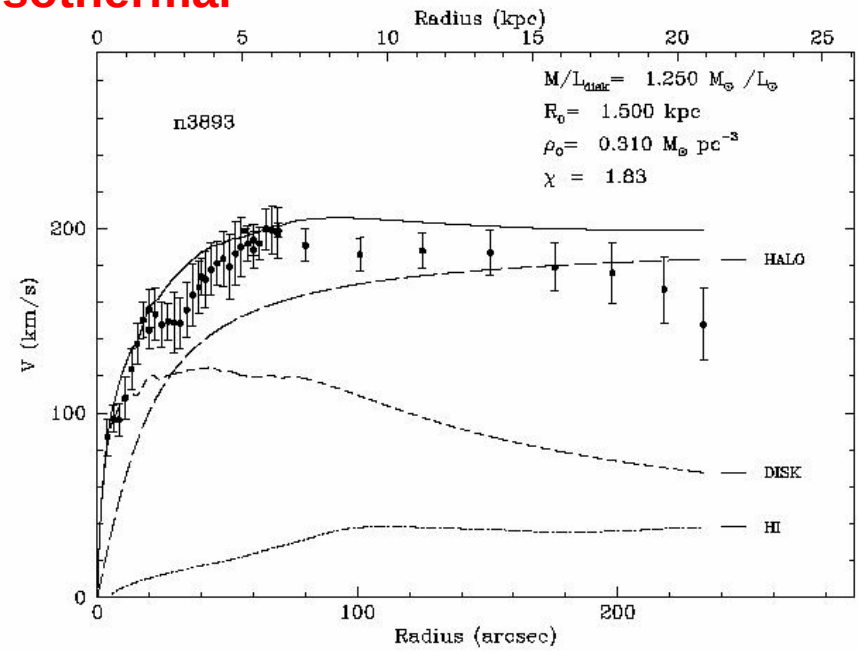




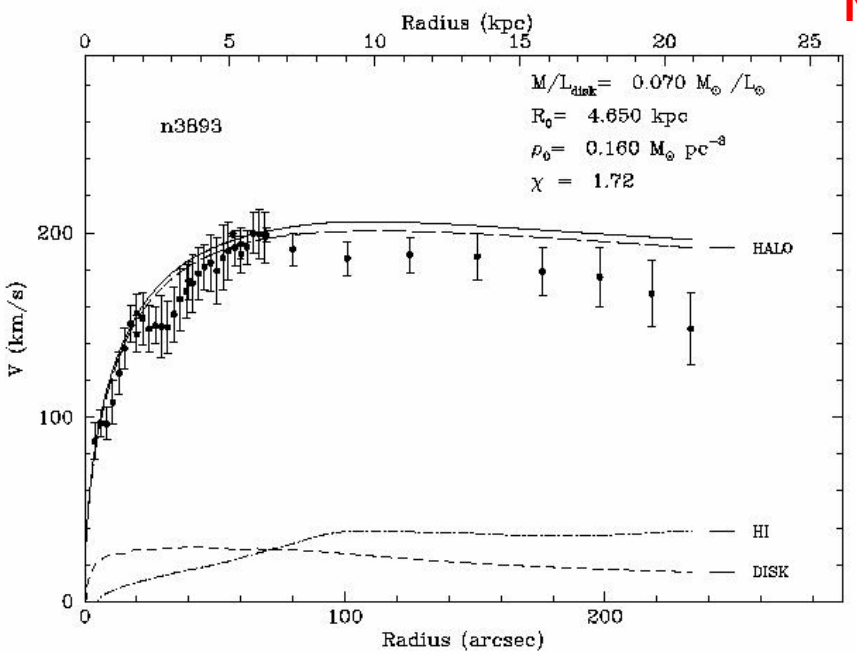
Only points with circular motions

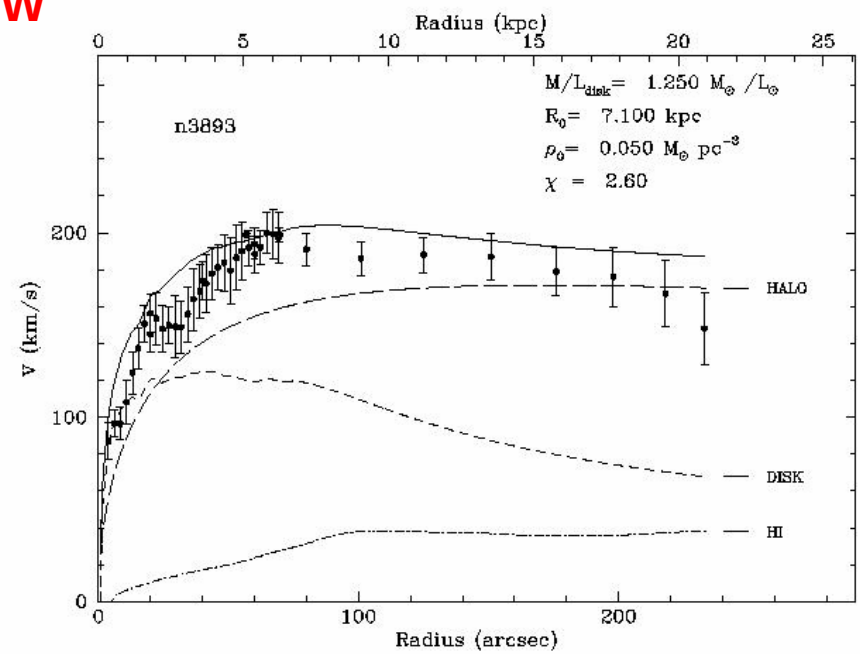
Pseudo-isothermal





NFW

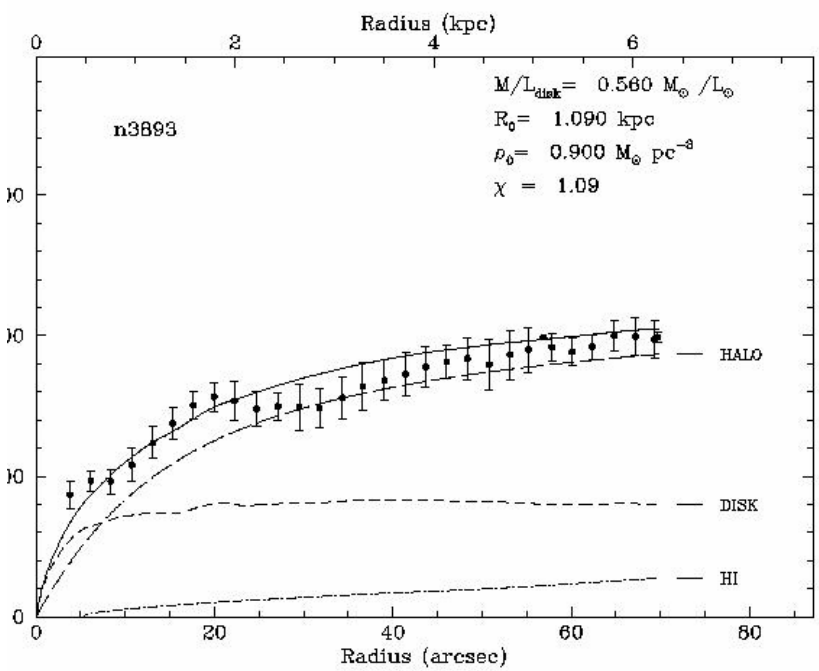




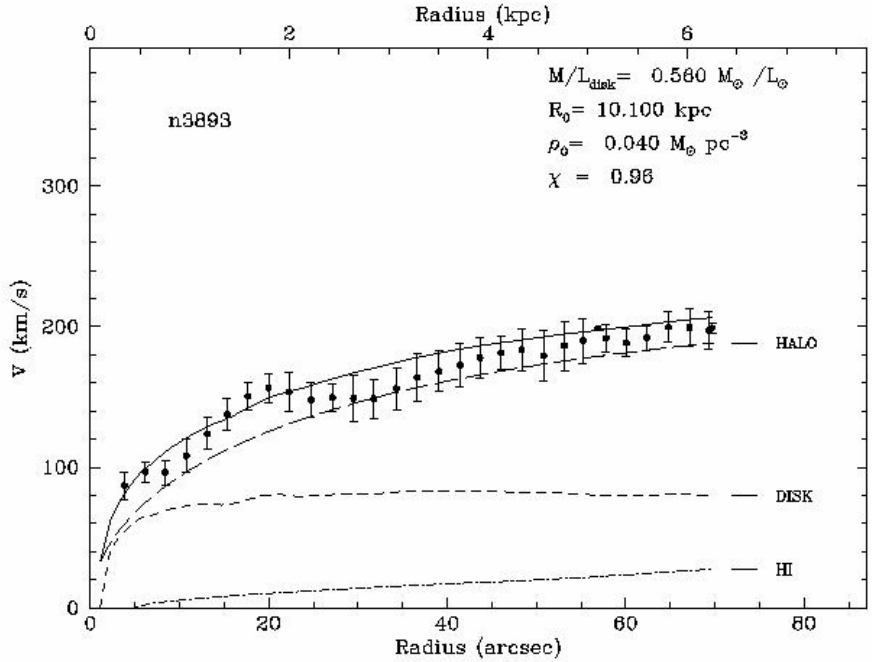
All points

Fits with realistic M/L

Pseudo-isothermal



NFW



Only optical points

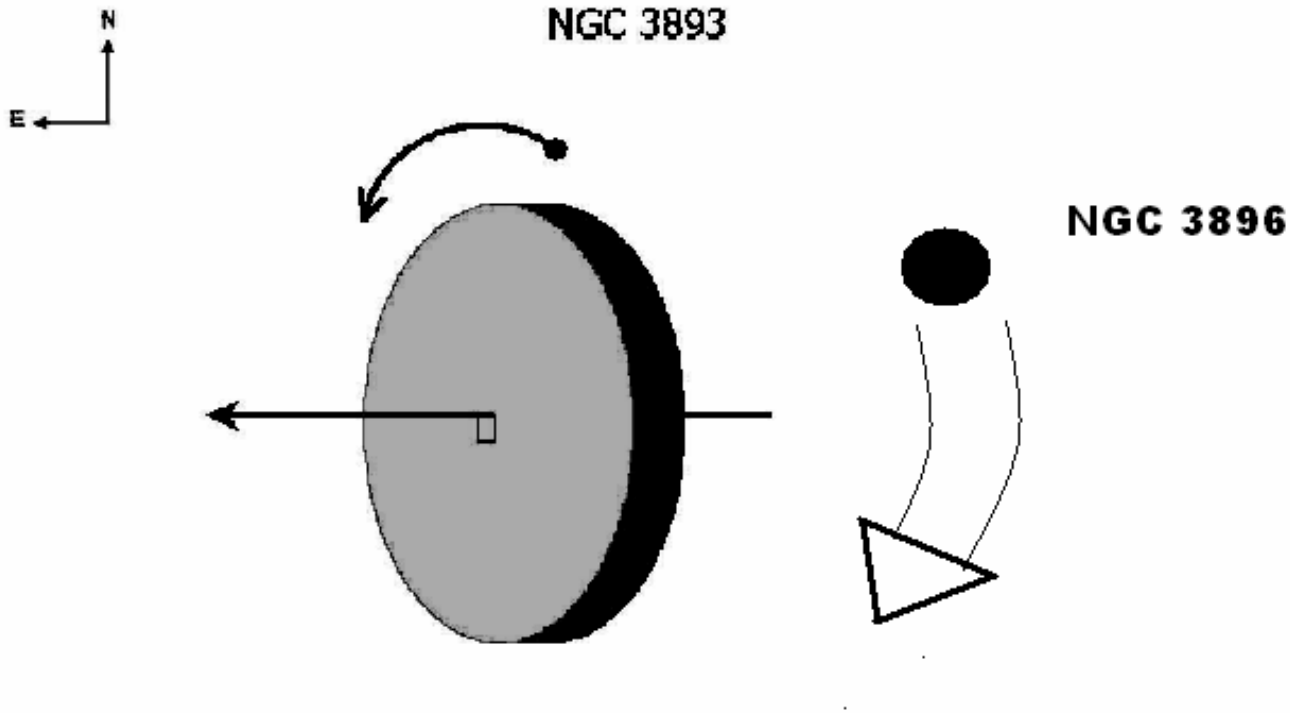
Table 3. Mass models parameters for NGC 3893 from best fits of the multi-wavelength rotation curve considering only points associated to circular motions

Type of halo	Maximal disc	$(M/L)_{disc}$ (I band)	R_0 (kpc)	ρ_0 $(M_\odot/pc^{-3})$	χ^2
Multi-wavelength curve, non-circular motions excluded					
p-ISO	no	0.940	1.570	0.340	1.34
p-ISO	yes	1.250	2.000	0.210	1.53
NFW	no	0.240	7.160	0.075	1.43
NFW	yes	1.250	7.100	0.050	2.60
Multi-wavelength curve, non-circular motions included					
p-ISO	no	1.050	1.100	0.710	2.16
p-ISO	yes	1.250	1.500	0.310	1.83
NFW	no	0.070	4.650	0.160	1.72
NFW	yes	1.250	7.100	0.050	2.60
Hα curve, non-circular motions included					
p-ISO	no	0.560	1.090	0.900	1.09
NFW	no	0.560	10.100	0.040	0.96
HI curve, non-circular motions excluded					
p-ISO	yes	1.750	2.600	0.079	1.32
NFW	yes	1.745	7.000	0.030	3.17

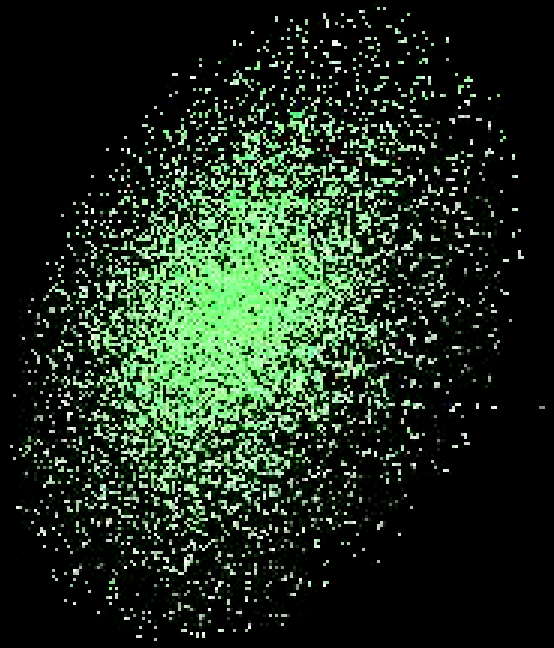
Table 4. Mass estimates for NGC 3893 and NGC 3896

Galaxy	R_{mass} (kpc)	R_{mass} ($D_{25}/2$)	$M(R_{mass})$ ($10^{10} M_{\odot}$)	Mass ratio from RC within 0.4 $D_{25}/2$	Mass ratio from NIR
NGC 3893	10.8	0.99	5.00 to 8.40		
				0.025 to 0.026	0.0314
NGC 3896	1.5	0.4	0.05 to 0.08		

Geometry of the encounter considered for the simulations



0.0000000E+00

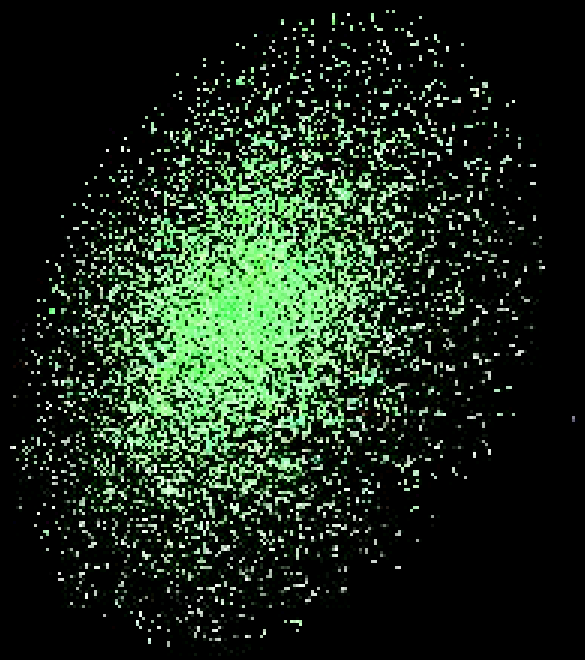


2007 R.G.

Simulation 1

- N-body: 10000 in disk and 60000 in halo
- Host: disk+NFW halo, without gas
- Satellite: point mass $M_S/M_H = 1/50$
- Elliptic orbit (e=0.79)
- Time unit = 250 Myr
- ➔ No grand design spiral pattern is produced after one revolution

0.0000000E+00



2007 R.G.

Simulation 2

- N-body : 10000 in disk and 60000 in halo
- Host: disk+NFW halo, without gas
- Satellite: point mass $M_S/M_H = 1/10$
- Elliptic orbit (e=0.79)
- Time unit = 250 Myr
- ➔ The system develops grand design spiral arms
- ➔ But: it merges too fast (within 500 Myr)

* Conclusions

Extended kinematical (**3D**) and photometric information essential to study the interacting process between galaxies

Importance of detailed information on the inner kpc of the rotation curve of interacting galaxies: Hα scanning F-P observations

Information on the outer parts of interacting galaxies in order to study their mass distribution and (faint) interacting features

* Conclusions

In the case of KPG 302, we cannot distinguish between NFW and pseudo-isothermal DM haloes.

It is possible that the DM halo differs from that of a single galaxy and that NGC 3893 and NGC 3896 share a common halo

* Conclusions

Preliminary numerical simulations of this encounter show that the mass of the satellite cannot be too high

We expect that the inclusion of gas in the simulation helps to produce HI envelope and grand design spiral pattern of the host

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DEBORITA !