

The Milky Way and the Local Group - Now and in the Gaia Era
Aug. 31 to Sep. 4, 2009, Heidelberg

Milky Way vs. M31 : a tale of two disks

Jinliang HOU (侯金良)

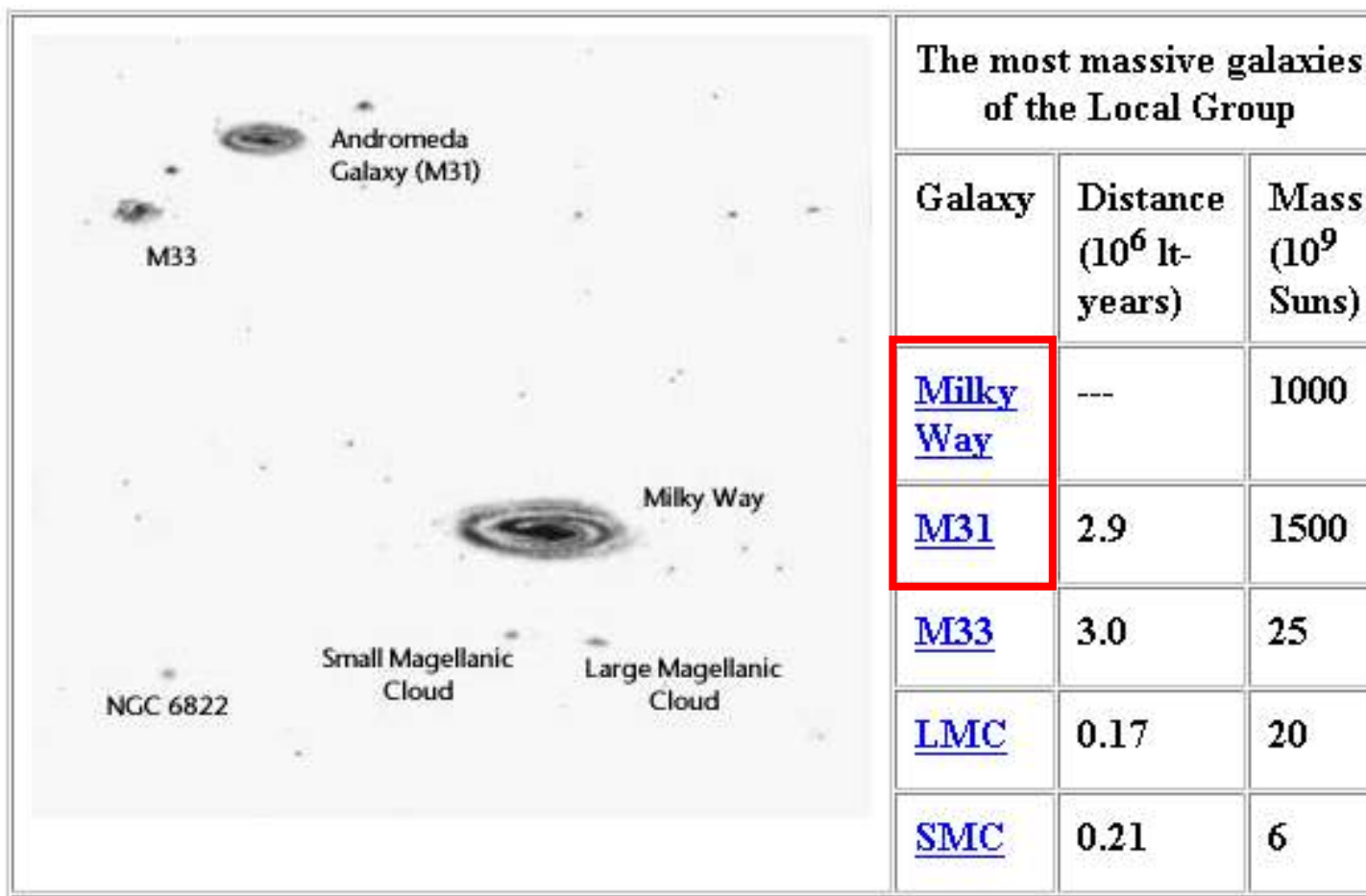
Ruixiang CHANG, Shiyin SHEN, Li CHEN, Jun YIN, Jian FU et al.

**Key Laboratory for Research in Galaxies and Cosmology
Shanghai Astronomical Observatory, CAS**

Content

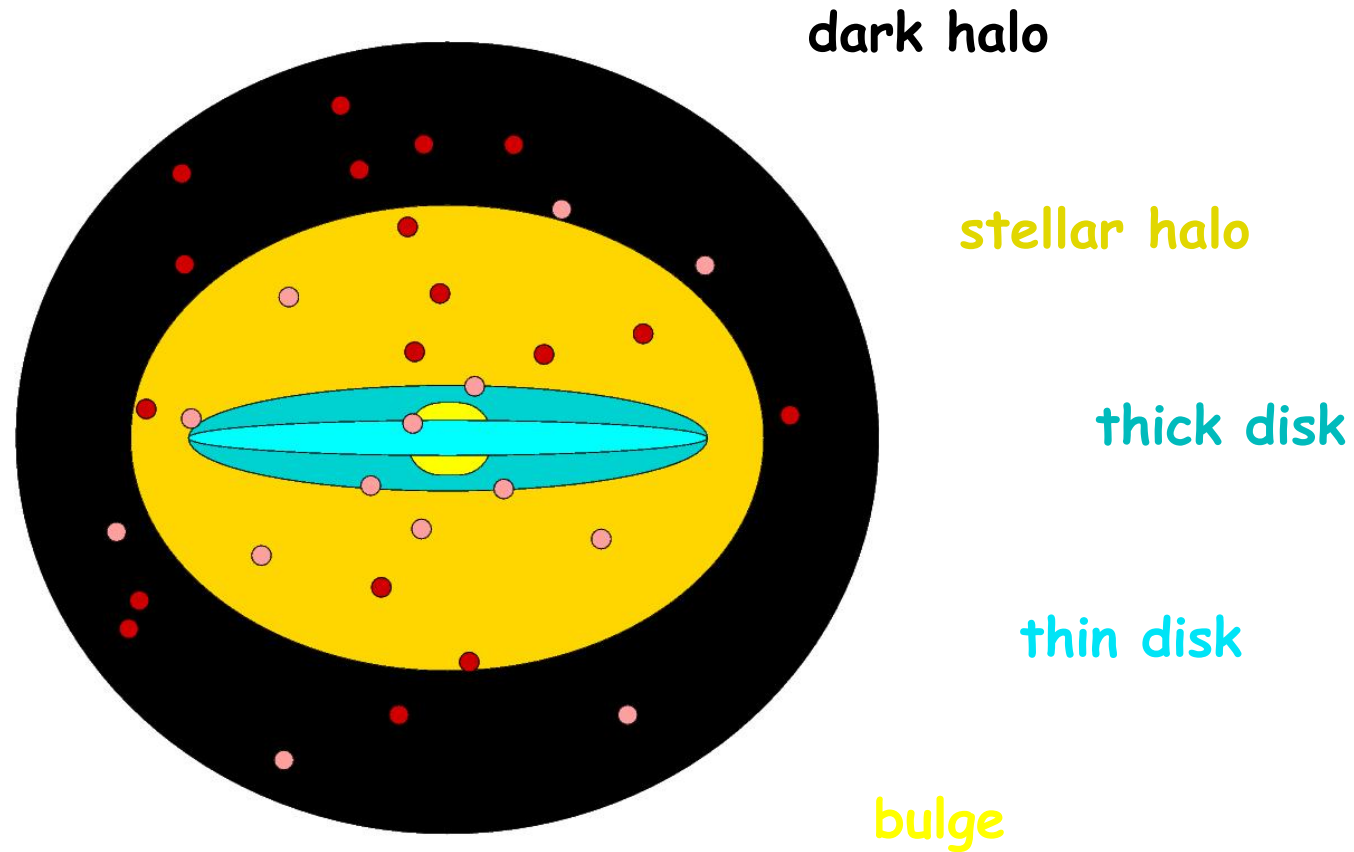
1. **MW vs. M31: observed properties**
 - ◆ **Halo**
 - ◆ **Disk**
 2. **Two disks: chemical evolution model**
 3. **Summary**
-

1. Observed properties: MW vs. M31



M31 and MWG have similar mass and morphology

Components in the Milky Way Galaxy



We would like to understand how our Galaxy came to look like this.

The Milky Way, typical or not?

- It is always regarded that the MWG is the **typical spiral** in the universe, especially at its mass range.
- How about **M31** galaxy, it is a spiral that is comparable with MWG in the Local Group, and now it is possible to have detailed observations.

Differences : in general

Halo:

- ◆ M31: metal-rich for field populations
- ◆ M31: more globular clusters (~ 3 times)
- ◆ M31: more substructures

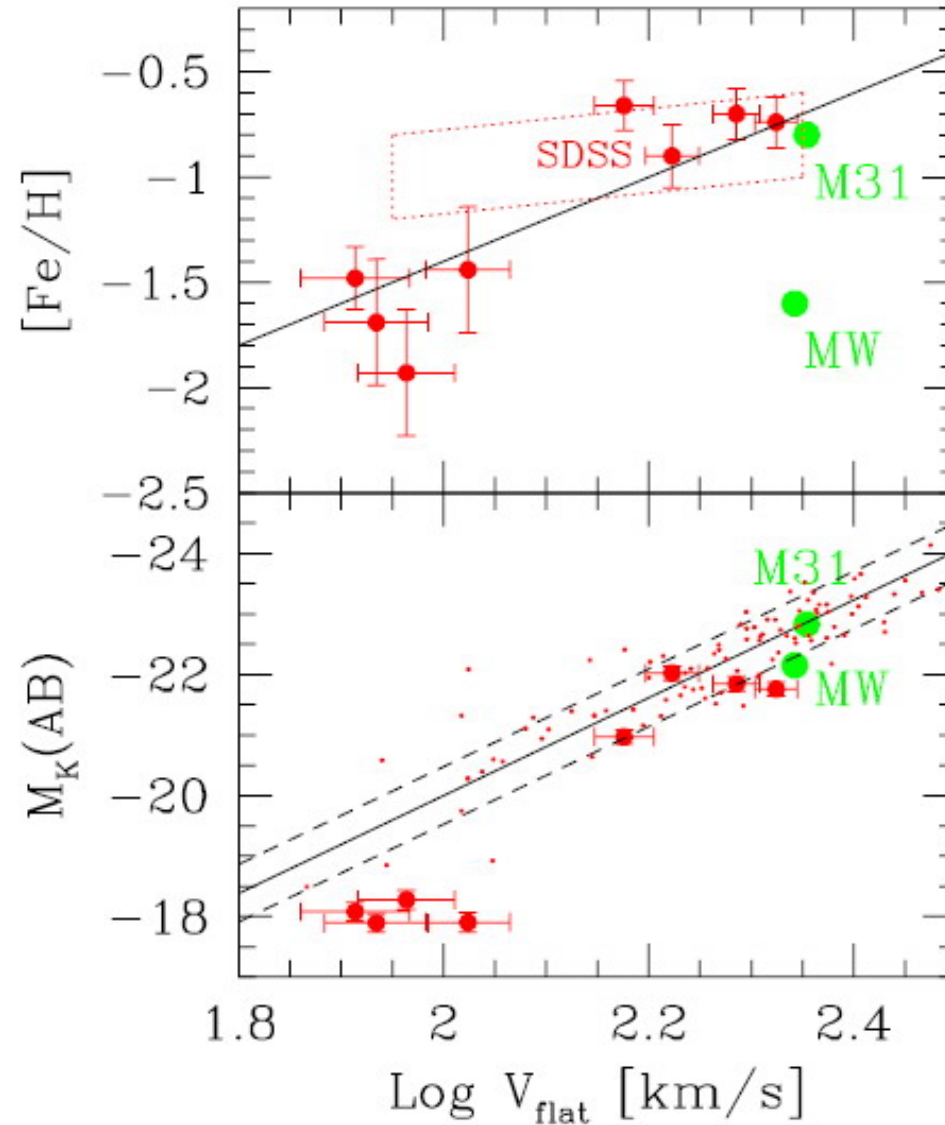
Disk:

- ◆ M31: 2 times larger than MW
- ◆ M31: present day SFR $\sim 1/10$ of MW
- ◆ M31: gas fraction $\sim 1/2$ of MW

Halo properties

Metal - Velocity

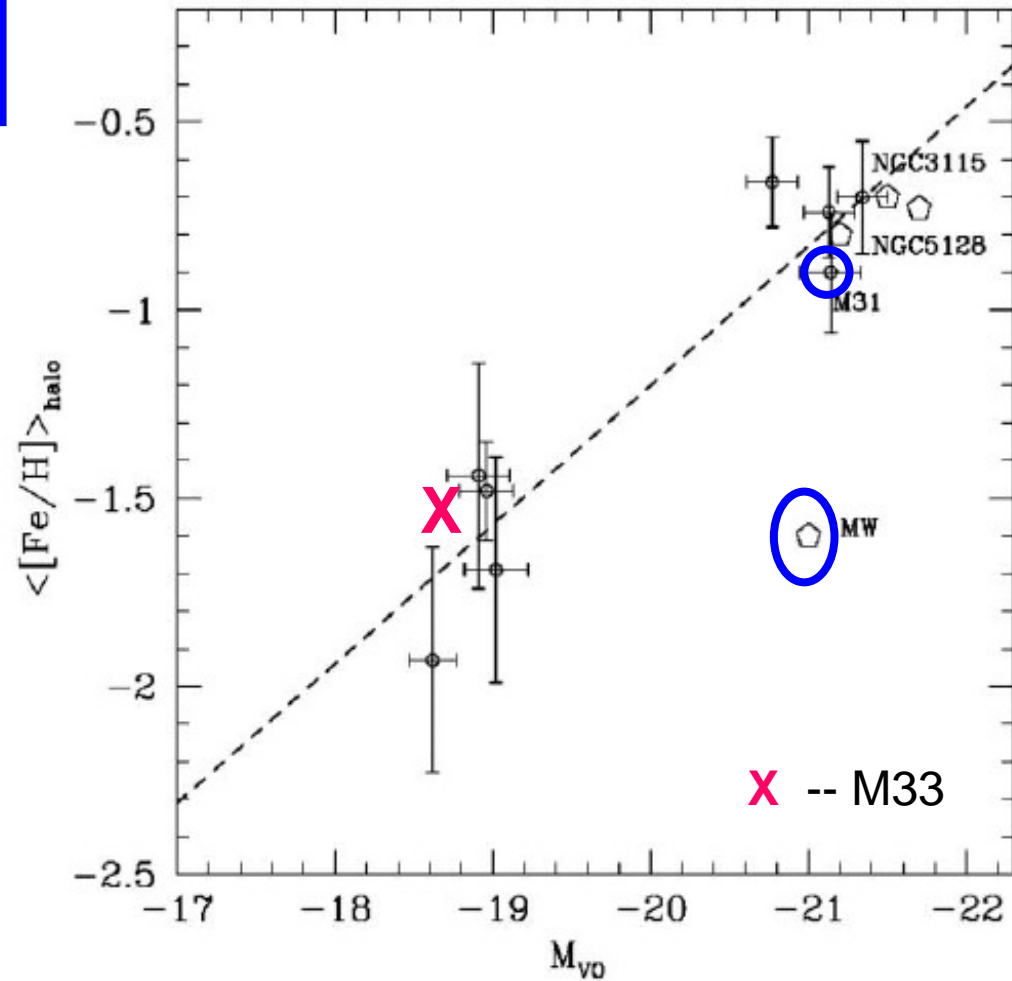
Tully-Fish Relation



SDSS: 1047 edge-on spirals

Hammer et al. 2007

Halo properties



Since M31 has a metal rich halo

Metallicity - luminosity relation

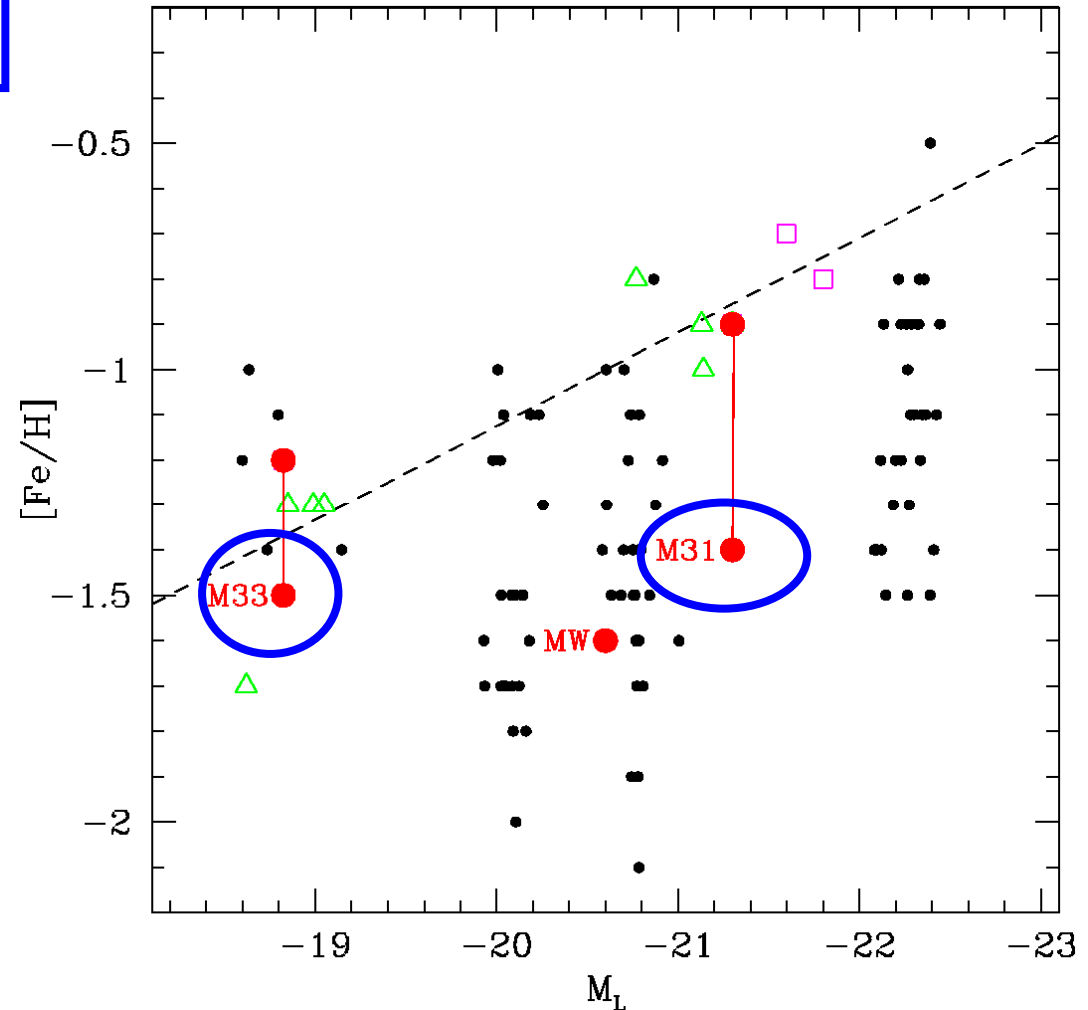
Mouhcine et al. 2005

Halo properties

Chapman et al. 2006

Stellar Halo Definition

Chapman et al (2006)
kinematically defined
stellar halo : metal-poor



Metallicity - luminosity relation ???

Black dot:
simulation from
Renda et al. 2005

Disk Profiles

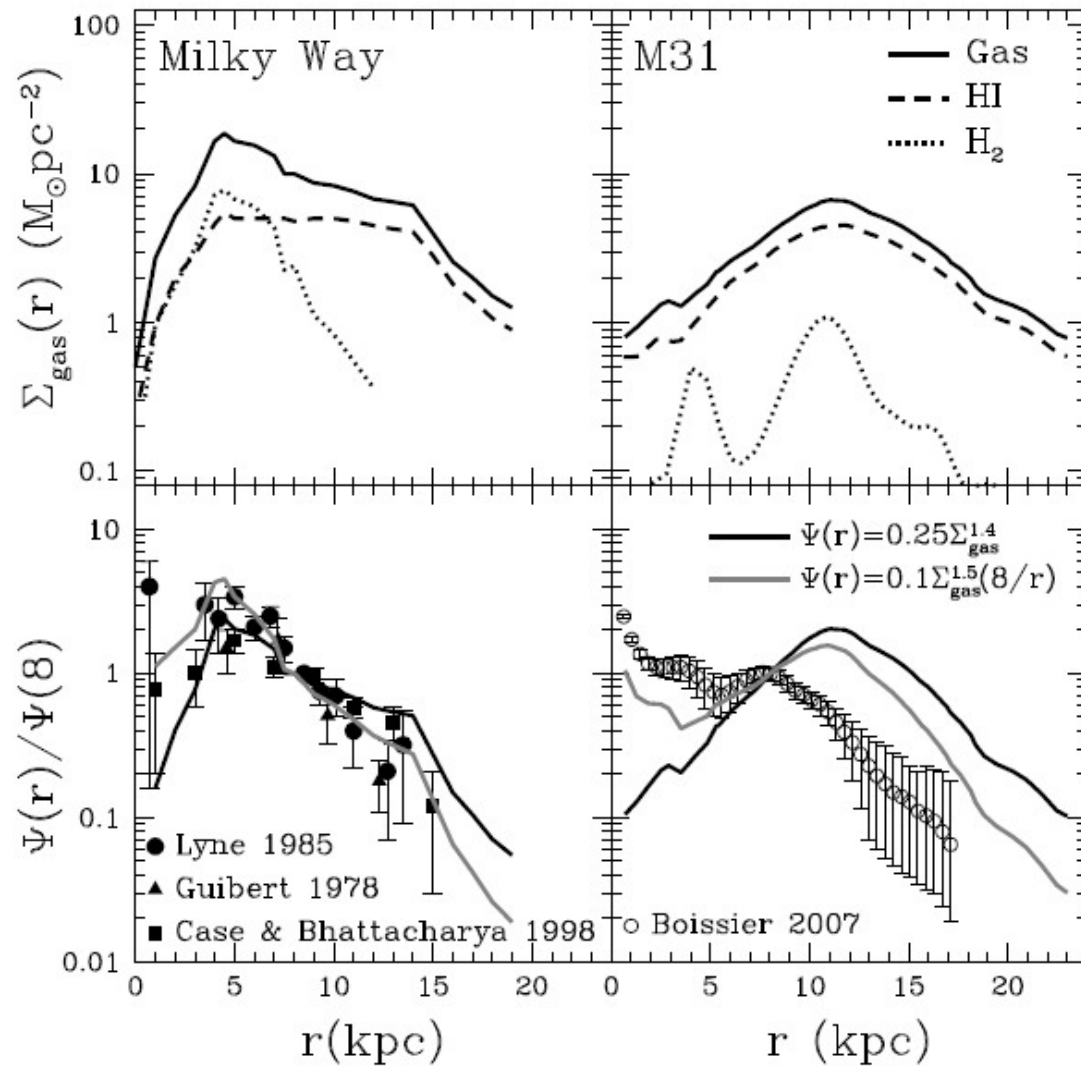
Total gas fraction

M31: 1/2 of MW

Total disk SFR

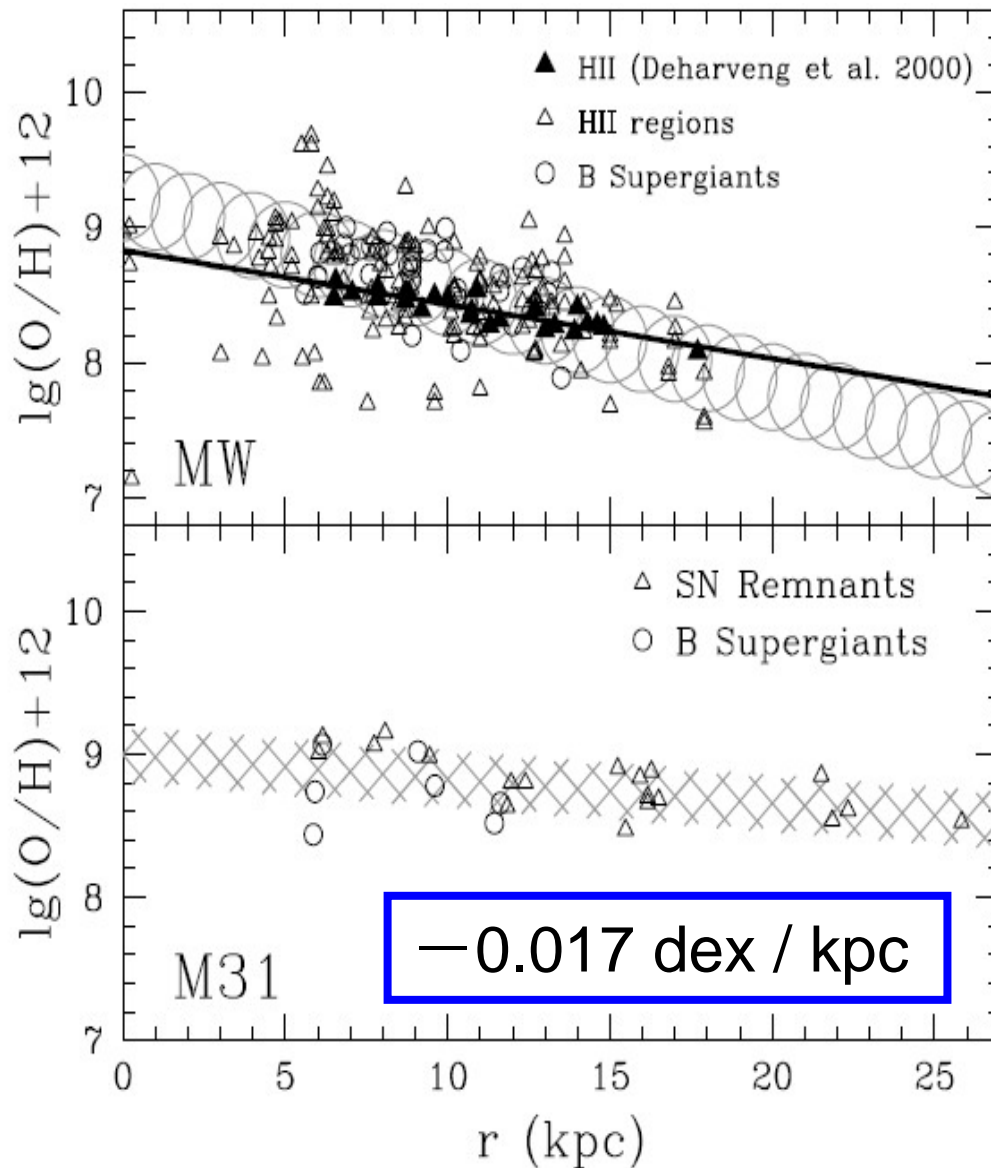
MW $\sim 2 M_{\odot} \text{ yr}^{-1}$

M31 $0.4 \sim 1 M_{\odot} \text{ yr}^{-1}$



Yin et al. 2009

[O/H] gradient from young objects



Two gradients reported:

Steep: -0.07 dex / kpc
(Rudolph et al. 2006)

Flat: -0.04 dex/kpc
(Deharveng et al. 2000
Dalfon and Cunha 2004)

Scaled gradient

MWD: -0.161

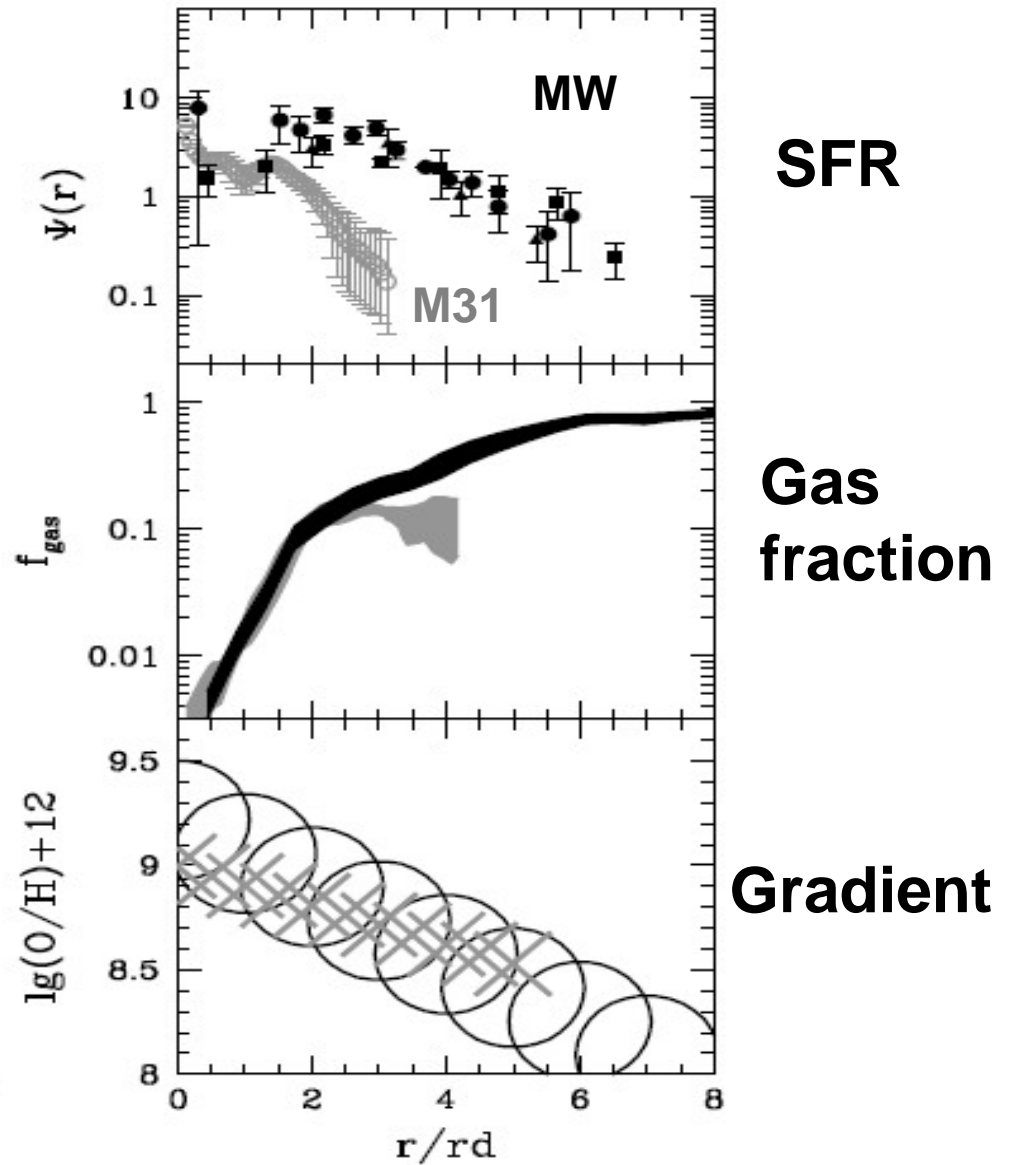
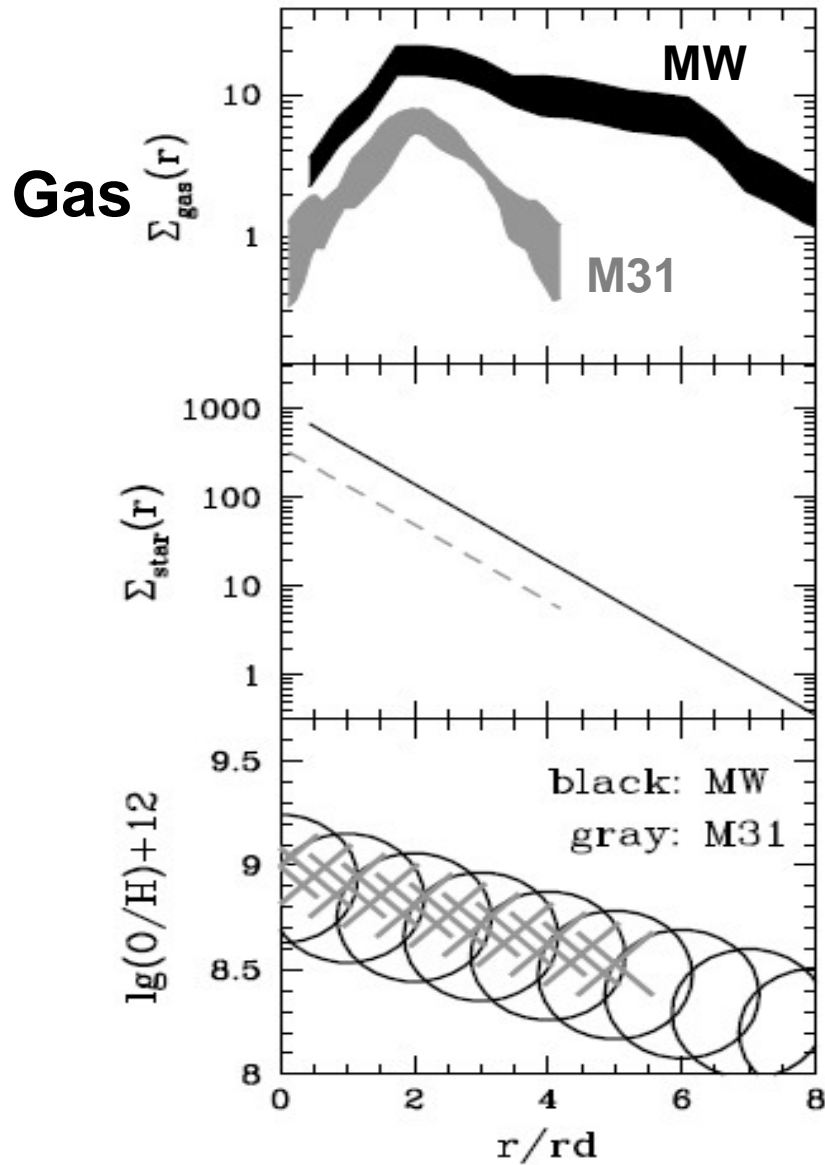
-0.093

M31 : -0.094

Observed disk properties: summary

	MWD	M31 / MWD
Rd (kpc)	~ 2.3	2.4
Mass($10^{10}M_{\odot}$)	~ 3.7	2.0
V_{flat} (km/s)	220	1.0
[X/H] (scaled)	~ - 0.16 / - 0.09	~ 0.5 / 1.0
Total f_{Gas}	0.19	1/2
SFR (M_{\odot}/yr)	~ 1-2	1/10

Scaled profiles



2. Two disks: chemical evolution comparison

Using the same model

- Find common features
- Find which properties are galaxy dependent
- M31 and MWG, which one is typical ?

Radial Profiles as constraints

- Gas profile
- SFR profile
- Abundance gradient
- MDFs in different positions

Basic gradients in the chemical evolution model

- Gas Infall (time scale radial dependent)
- Stellar yields
- IMF
- SFR

Adoption of **SFR Law** for the chemical evolution model of spiral galaxies

$$\Sigma_{SFR} = \alpha(r) \Sigma_{gas}^n$$

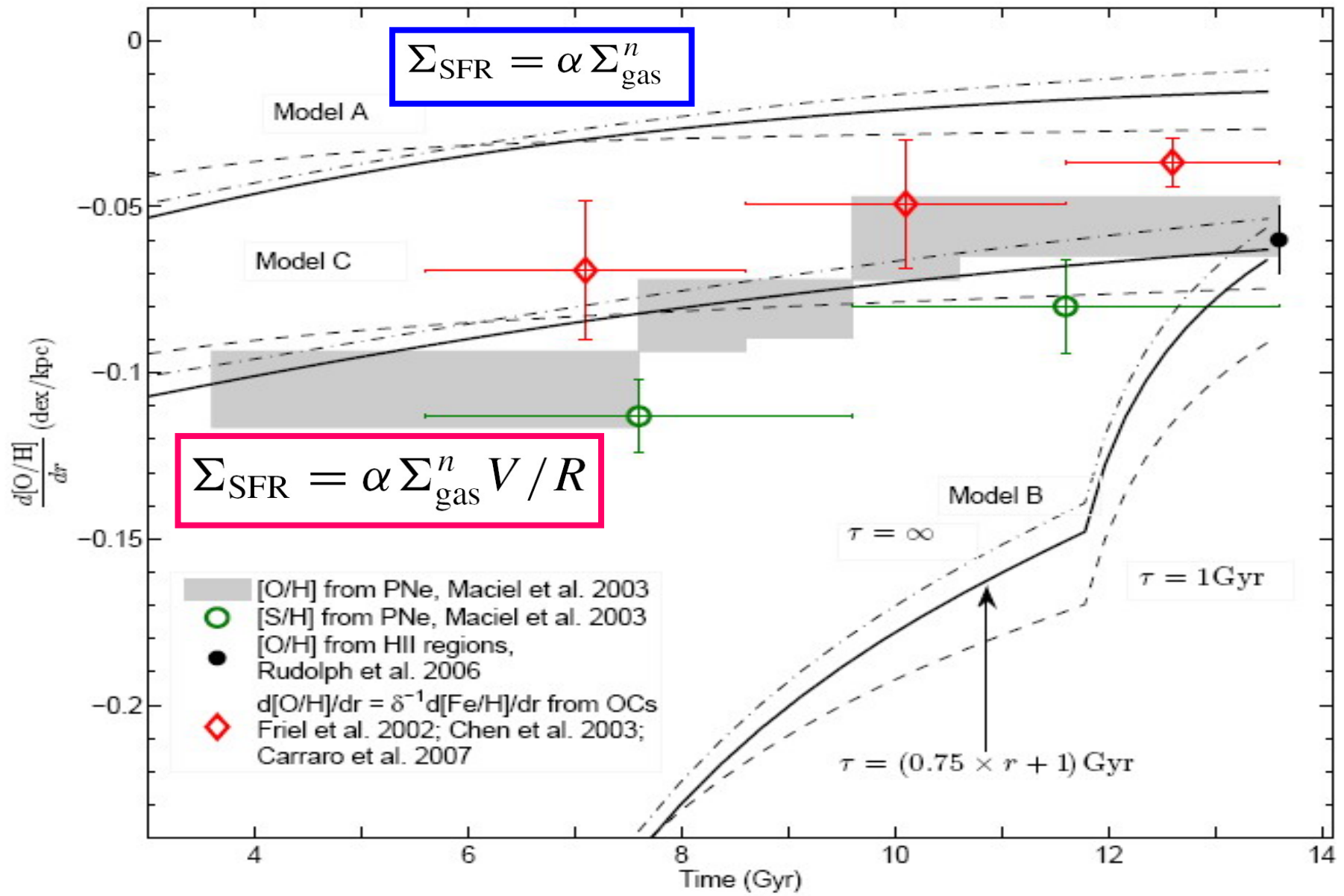
M-KS law

- For the average properties of a galaxies, KS law is OK and $\alpha(r) = 0.25$
- For **local properties**, SFR could be local dependent, that is, $\alpha(r)$ is radial dependent, **M-KS law is preferred**

M-KS law

$$\Psi(r, t) = \alpha \Sigma_{\text{gas}}^n \left[\frac{V(r)}{220} \right] \left[\frac{r}{r_{\odot}} \right]^{-1}$$

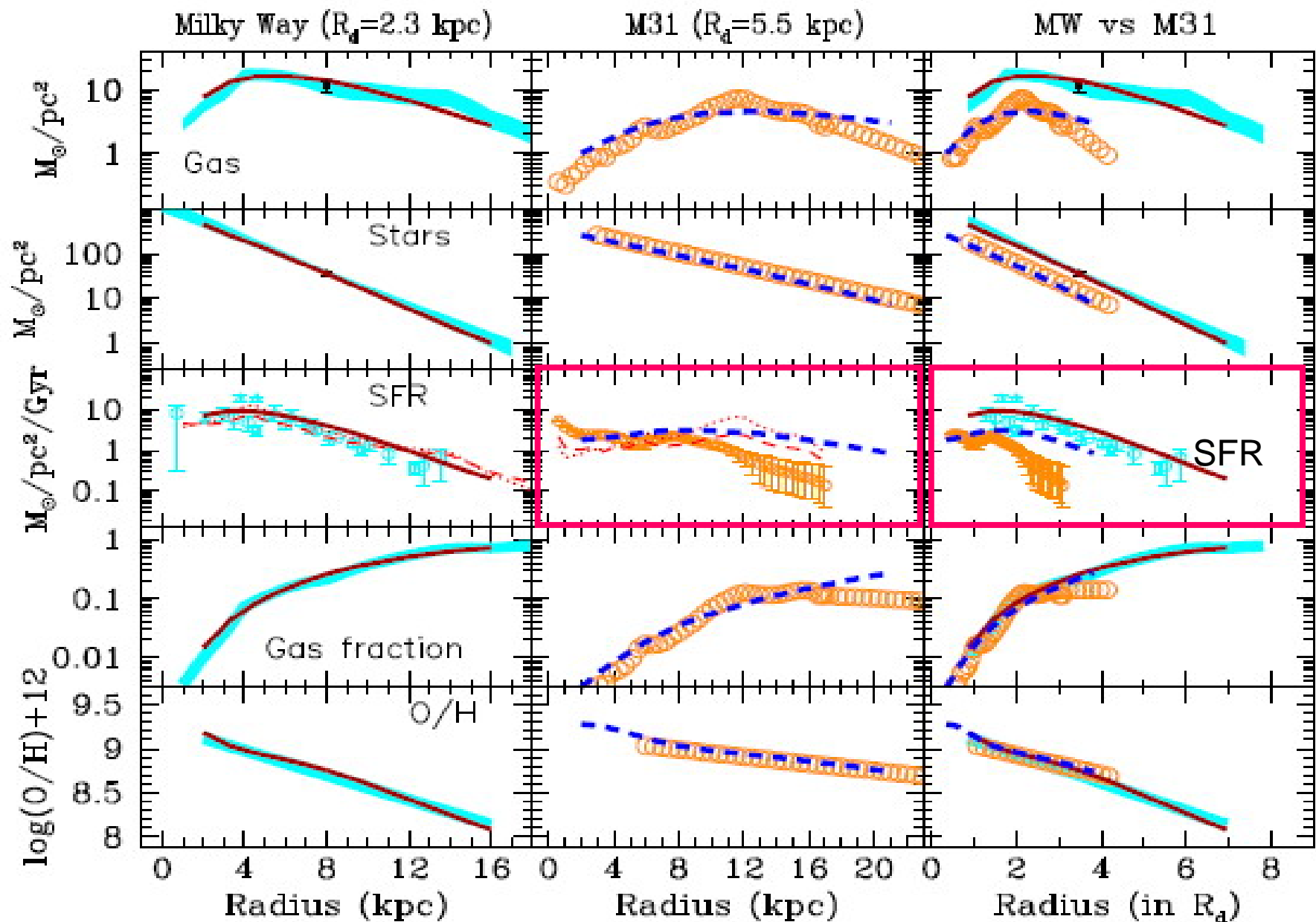
- ◆ This modified KS law is very successful in predicting the **current** properties of disk
- ◆ Not much **TESTED** for the disk history
– less constrains available
- ◆ Recently, observed abundance gradient from Open Clusters and Planetary Nebulae have made this possible



Fu et al. 2009

- **Main results (1) : Radial profiles**

A problem in SFR profile for M31
disk



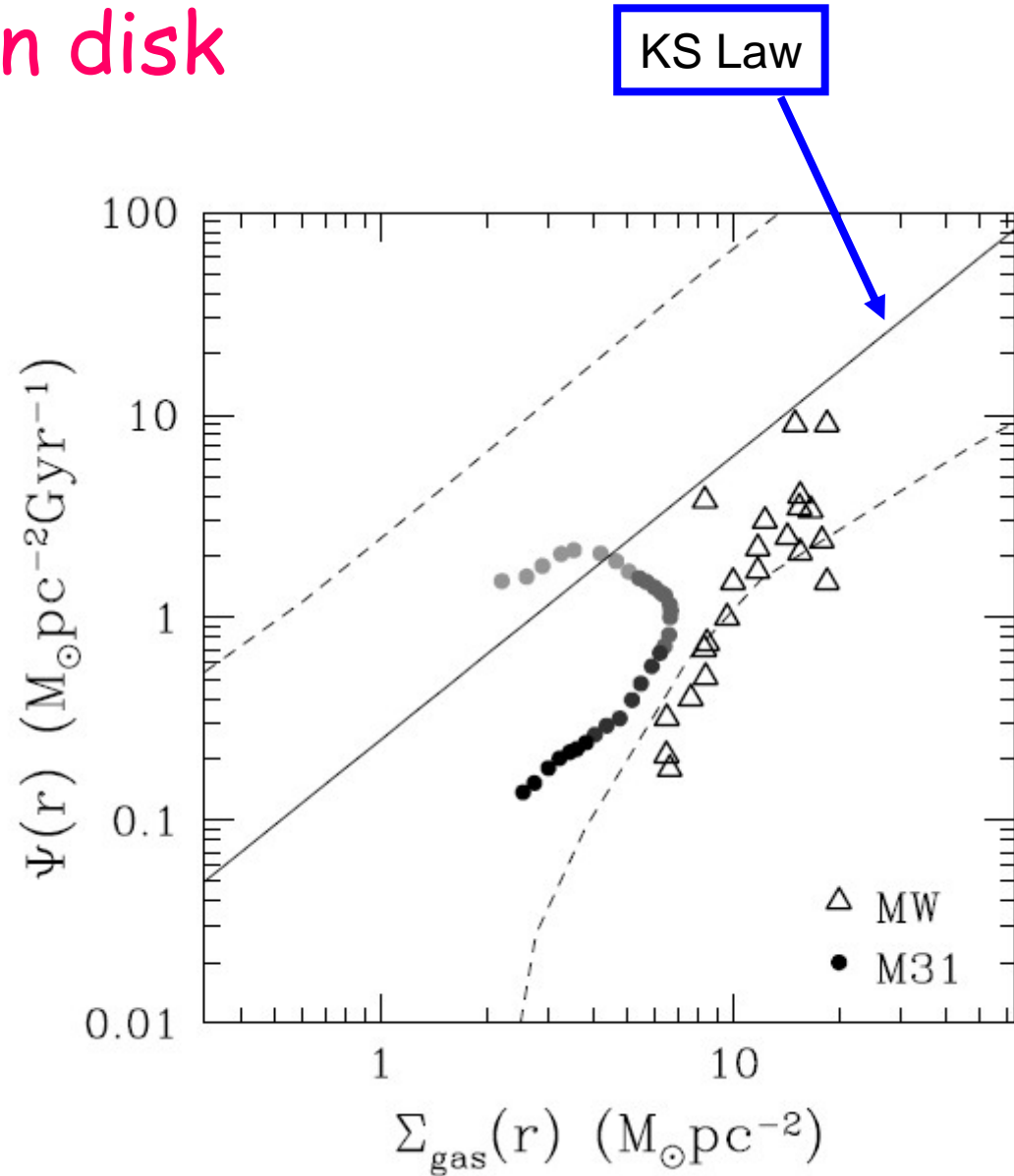
$$\alpha_{MW} = 0.1$$

$$\alpha_{M31} = 0.2$$

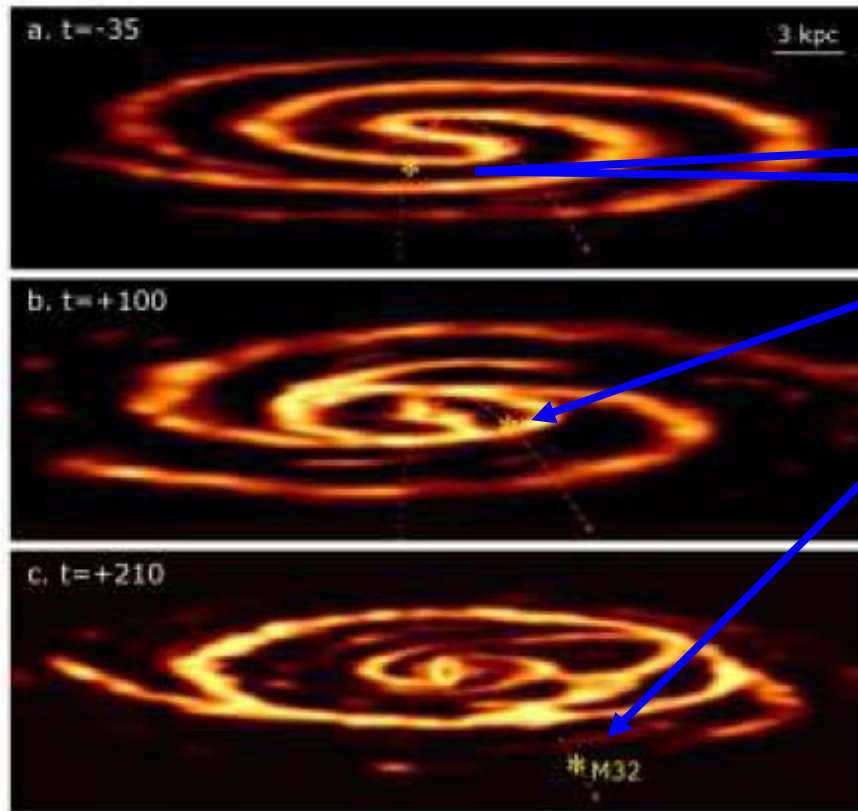
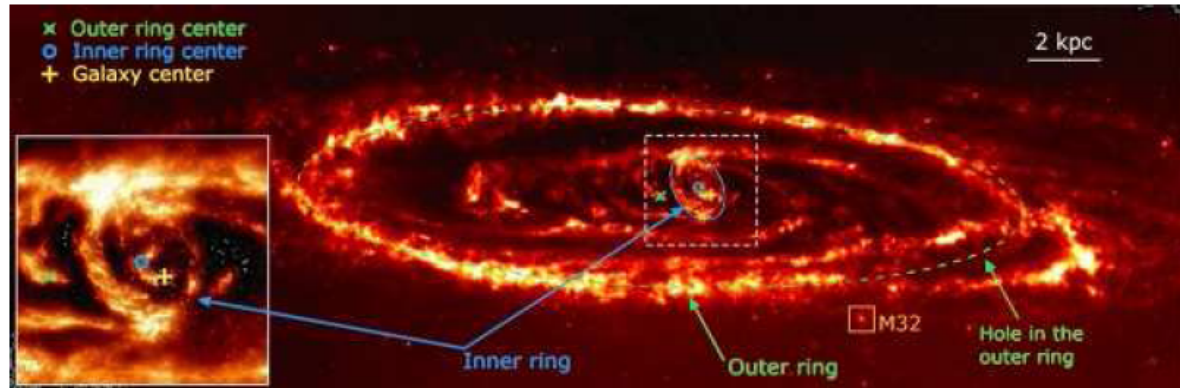
Yin et al. 2009

M31 gas and SFR in disk

- Observed of gas and SFR profiles are abnormal when compared with Kennicutt law.
- Gas and SFR must be modified by some **interaction**



Simulation



Observed

Two rings
structure

Evidence of M31
disk interaction

Block et al. (Nature 2006)

- **Main results (2) : MDFs**

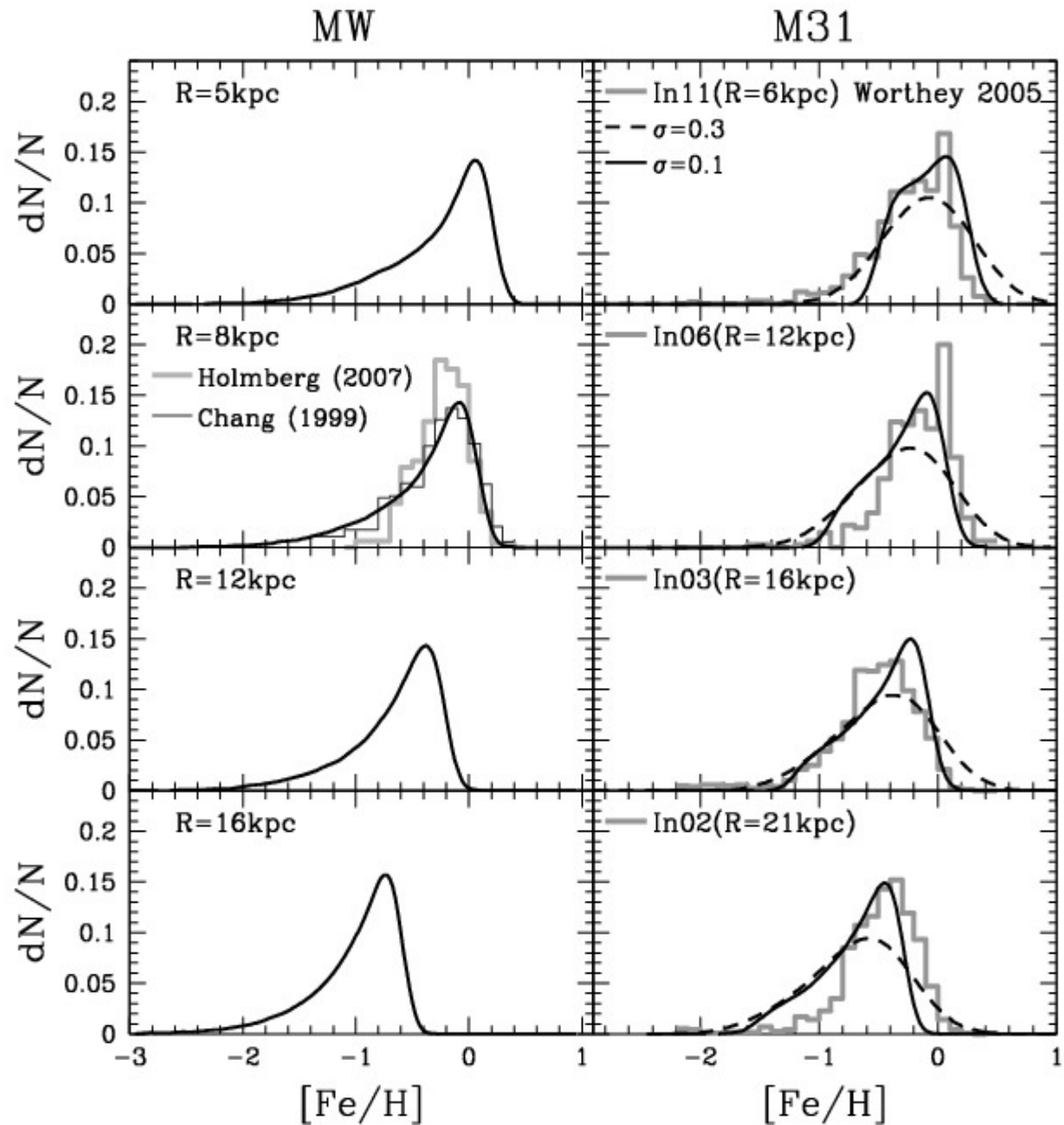
A need for MDFs in different locations
in the MWD

MDFs

At different
locations of the
disks

Test the
successfulness
of the model

Yin et al. 2009

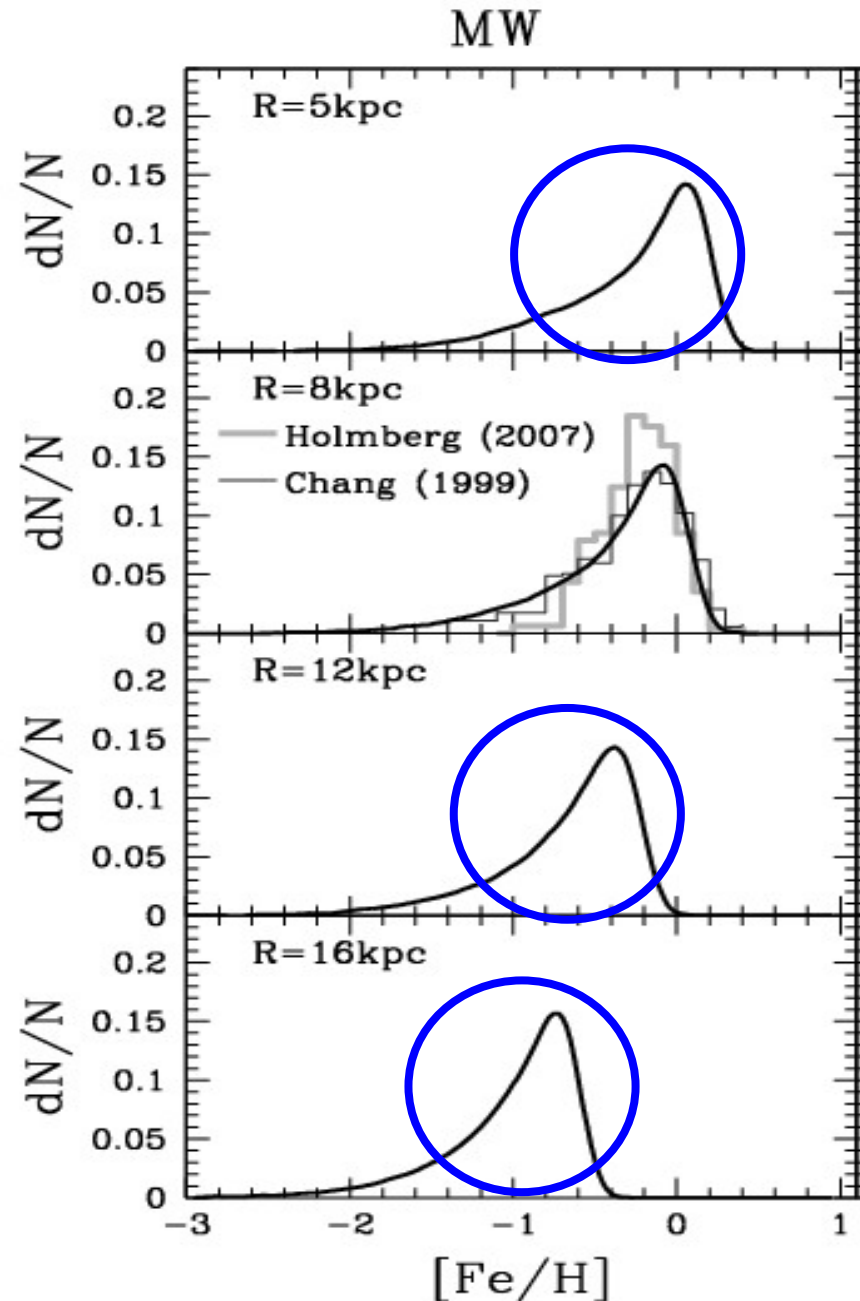


MDFs

We need MDFs at different locations of the **Milky Way** disk

GAIA, LAMOST ?

By MDFs, we are able to test the infall history, SFH at different location of disk.



3. Summary (I) : M31 disk properties

- Current star formation properties are atypical in the M31 disk.
- ◆ **M31 disk evolution could be affected by events**
- Has low current SFR in M31 disk
- ◆ **Shorter time scale for the infall in disk**

3. Summary (II) : Problems in two disks

➤ Models:

- ◆ Traditional chemical evolution model can only be applied to Milky Way type disk (more quiescent), not applicable to M31 (merger or interaction occurs)

➤ Observations:

- ◆ We need **MDFs** in other locations of the **Milky Way disk**, test SFH of disk. **(GAIA, LAMOST)**
- ◆ The evolution of gradients is very important. Need more observations from **PN** (Maciel et al.), and **Open Clusters** (Chen et al; **LAMOST**)