MWG and M31 Oxygen Gradients Using Planetary Nebulae as Probes

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+Support from US-NSF

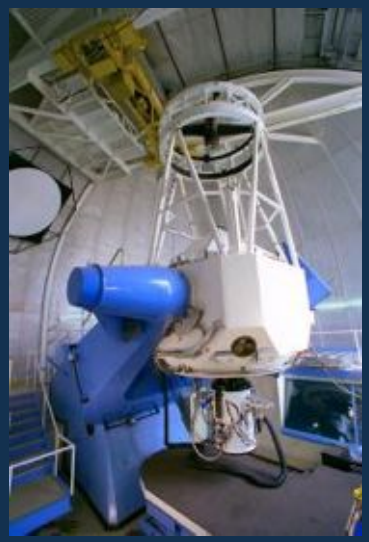
WHY DO WE CARE ABOUT ABUNDANCE GRADIENTS?

They constrain 2 important model parameters:

1. Disk formation timescale
2. Star formation efficiency

Data Acquisition/Processing

CTIO 1.5m



KPNO 2.1m

APO: 3.5m

Gemini N: 8.1m

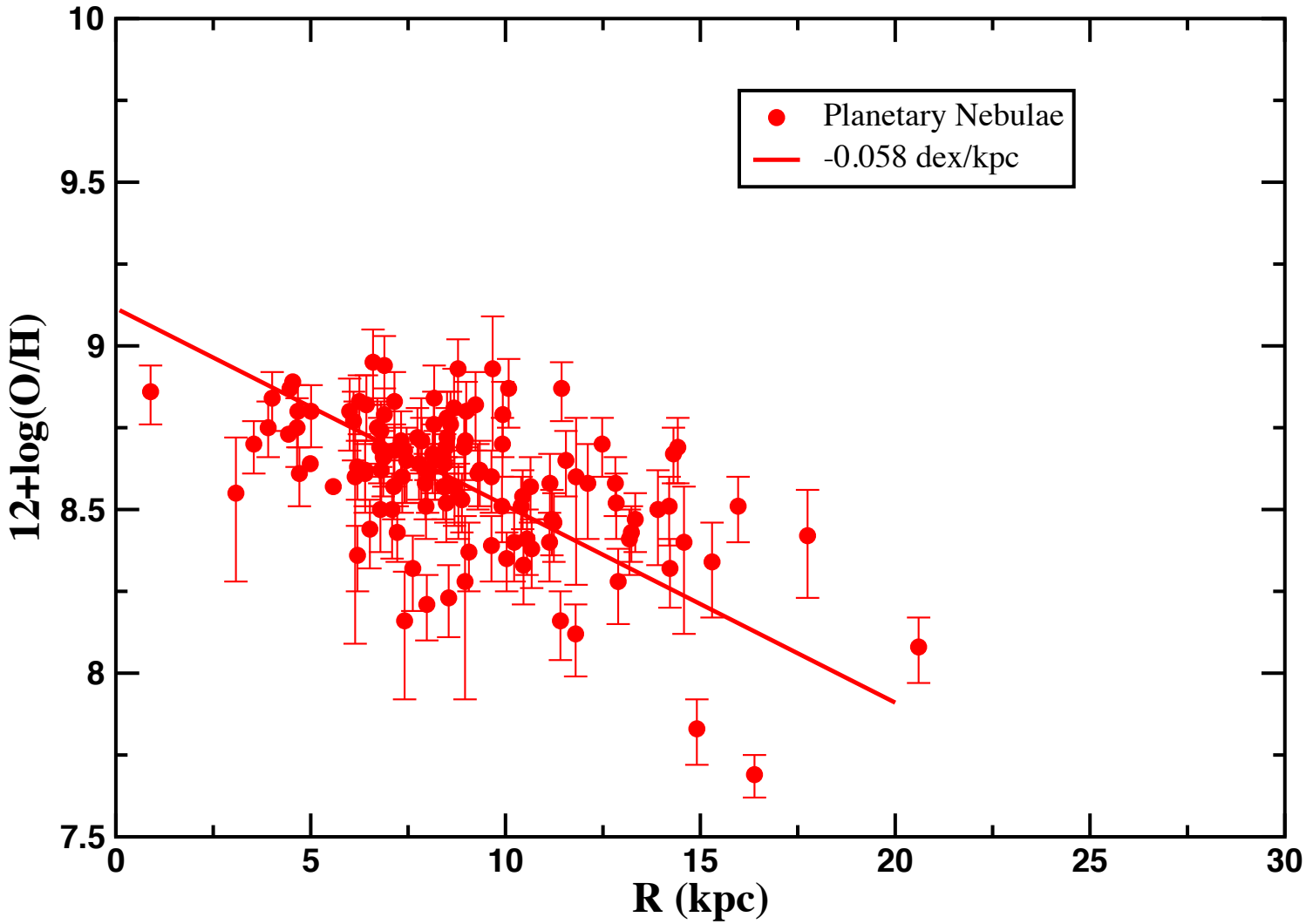
- **Spectral Range (Å)**: 3600 to 9600
- **[O III] 4363Å measured in all objects, *6 < S/N <35***
- **Homogeneous abundances of H, He, N, O, Ne, Ar, Cl, S**

MILKY WAY DISK

Milky Way PN Sample

- Number of objects: 124, type II
- Location: MWG disk
- R_g range: 0.9-21 kpc (0.067-1.57 R_{25})
- R_g values: Cahn et al. (1992)
- Selection criterion: strong [O III] λ4363
- Bias against low excitation, faint PNe

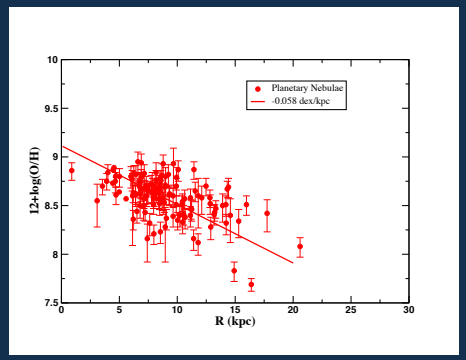
MWG gradient= -**0. 058** +/-0. 006



Evidence for Natural Scatter

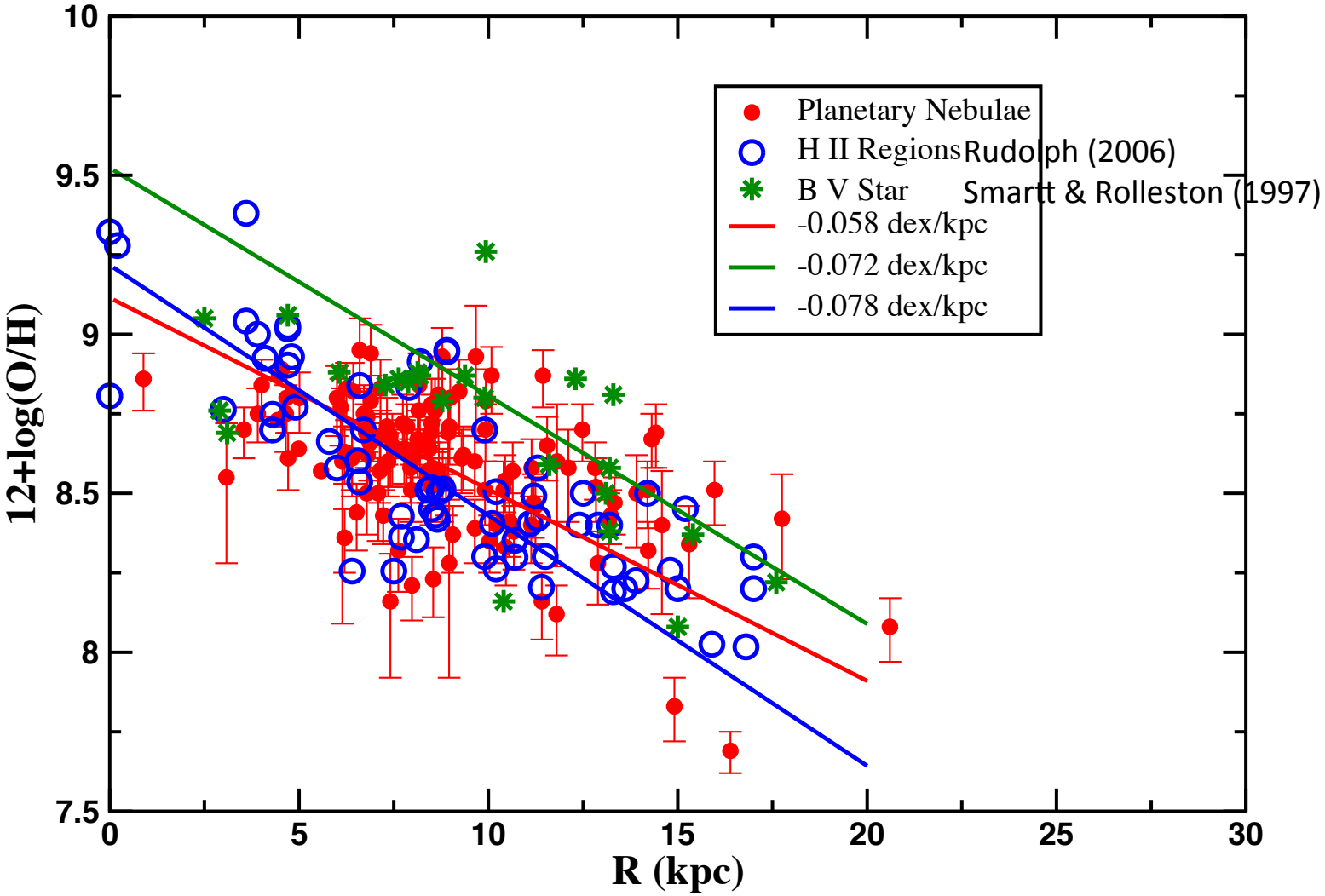
For a decent linear model (χ^2 prob > 0.05)

- $\sigma_{total} = \sigma_{stat} + \sigma_{natural} = 1.4\ \sigma_{stat}$



Potential sources of natural scatter:

- O destruction/production by AGB (Karakas talk)
- Poor ISM mixing
- Stellar migration
- PN progenitors age spread
- Temperature inhomogeneities
- Shock heating


Planetary Nebulae
H II Regions
B V Star
-0.058 dex/kpc
-0.072 dex/kpc
-0.078 dex/kpc
Rudolph (2006)
Smartt & Rolleston (1997)
12+log(O/H)
R (kpc)
10
9.5
9
8.5
8
7.5
0
5
10
15
20
25
30

CONFUSION LIMIT

Range in H2R/PN O/H gradients:

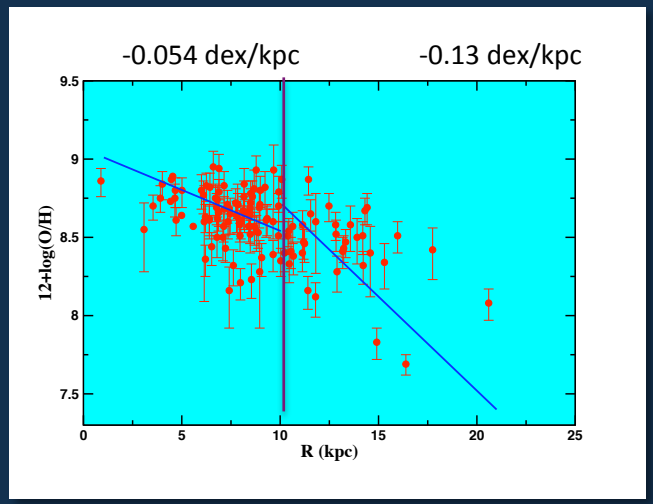
-0.02 to -0.07 dex/kpc

Can we do any better? (see Peña, next talk)

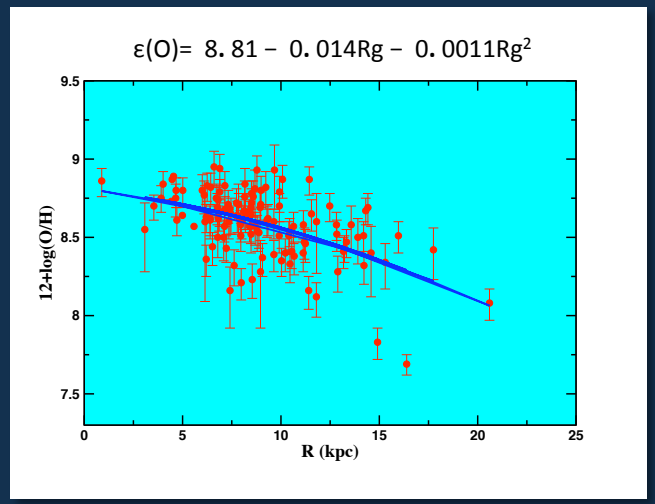
Improvement will depend upon knowing:

1. **Better galactocentric distances**
2. **Origin of natural scatter**

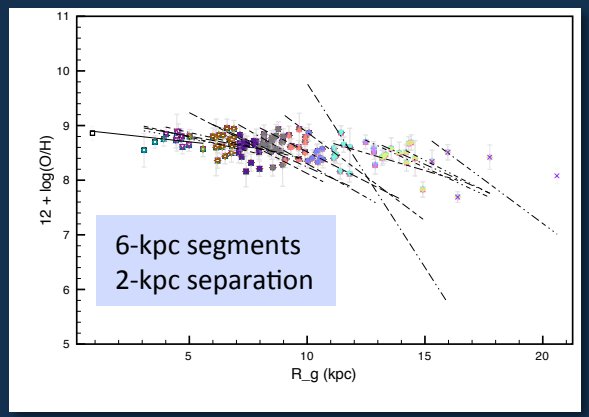
Evidence for Gradient Steepening?



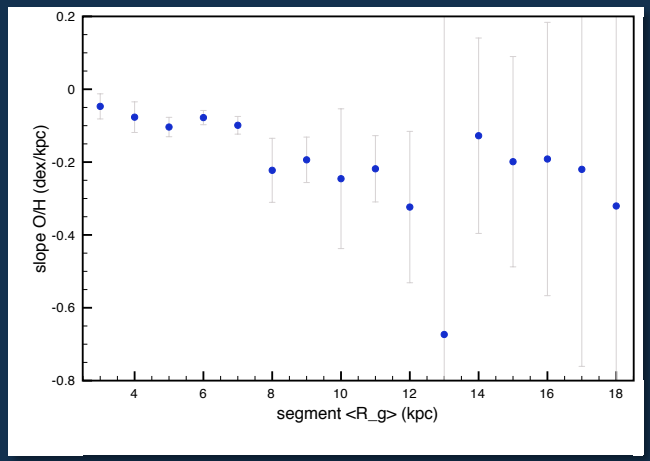
Two-part Linear Fit



Quadratic Fit

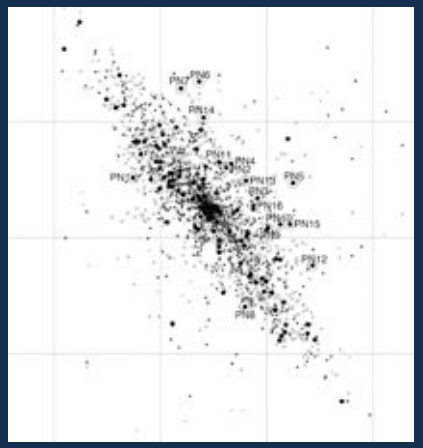


Multi-Segment Fit



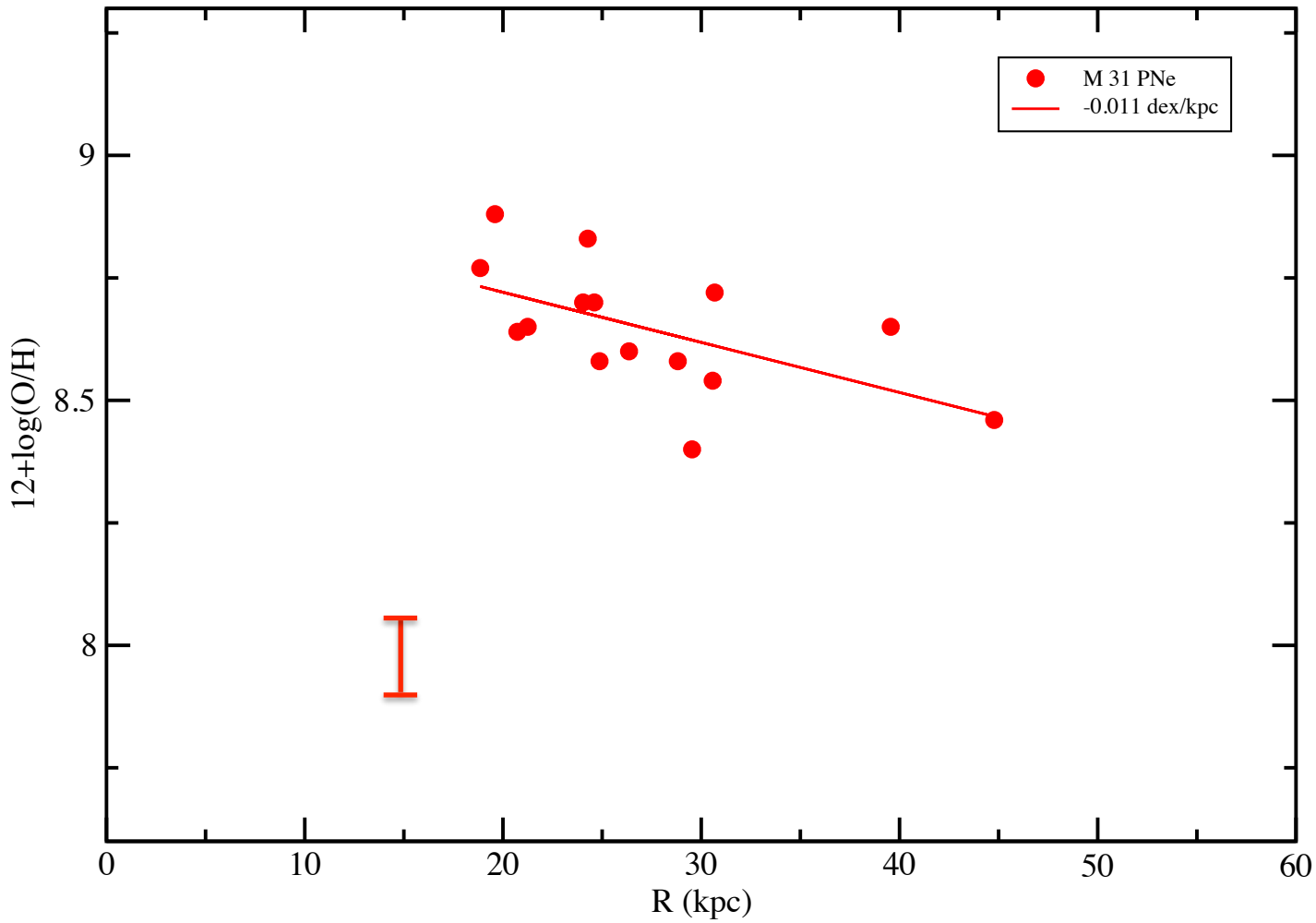
M31 DISK

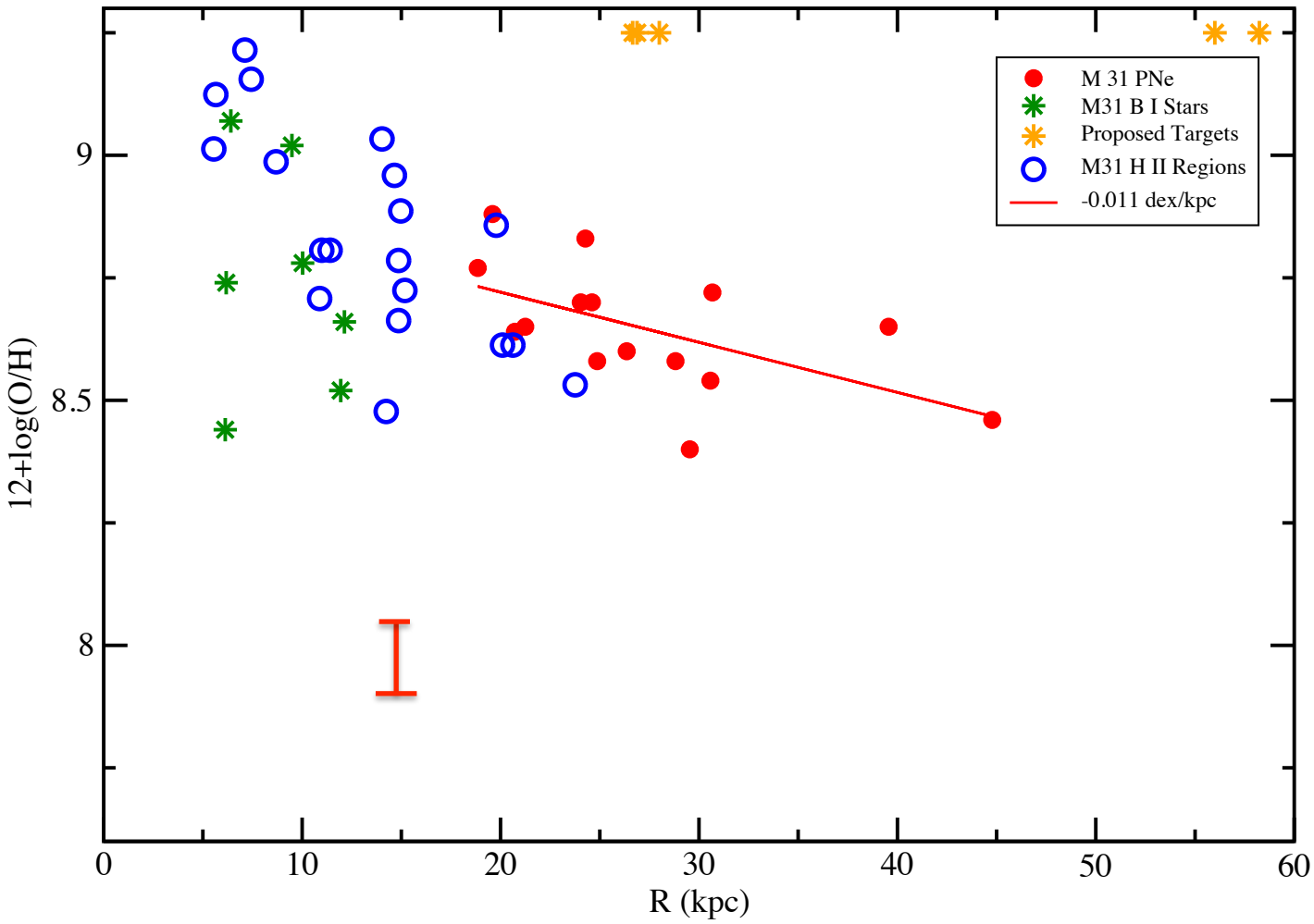
M31 PN Sample



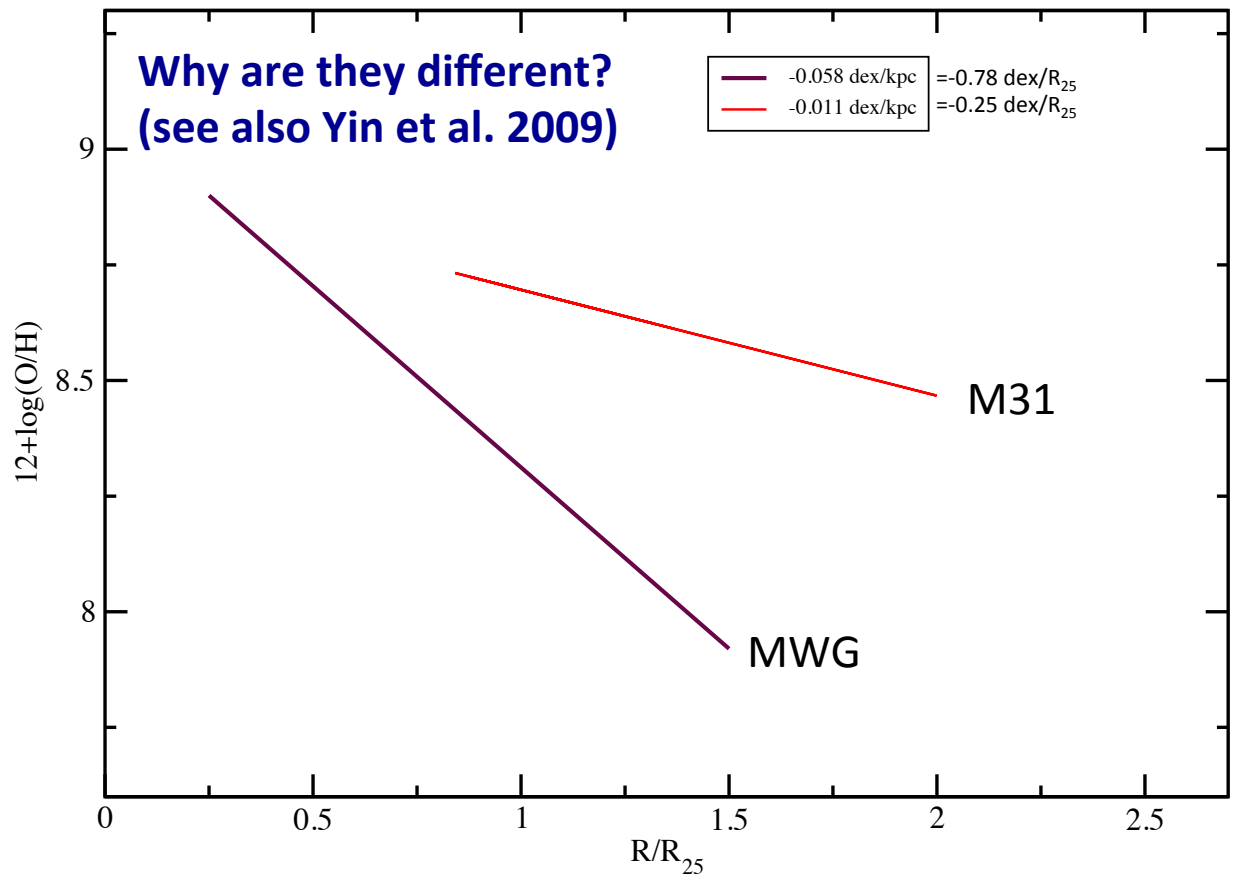
- Number of objects: 15, types I & II
- Location: M31 disk
- R_g range: 19-45 kpc (0.8-2.0 R_{25})
- Source: Merrett et al. (2006)
- Selection criterion: strong [O III] λ4363
- Bias against low excitation, faint PNe

M31 gradient= -**0. 011** +/-0. 004 dex/kpc




M 31 PNe
M31 B I Stars
Proposed Targets
M31 H II Regions
-0.011 dex/kpc
12+log(O/H)
9
8.5
8
0
10
20
30
40
50
60
R (kpc)

MWG & M31 Gradient Comparison



Model Characteristics

General

- accounts for finite stellar lifetimes
- infall rate function of R_g
- instantaneous mixing

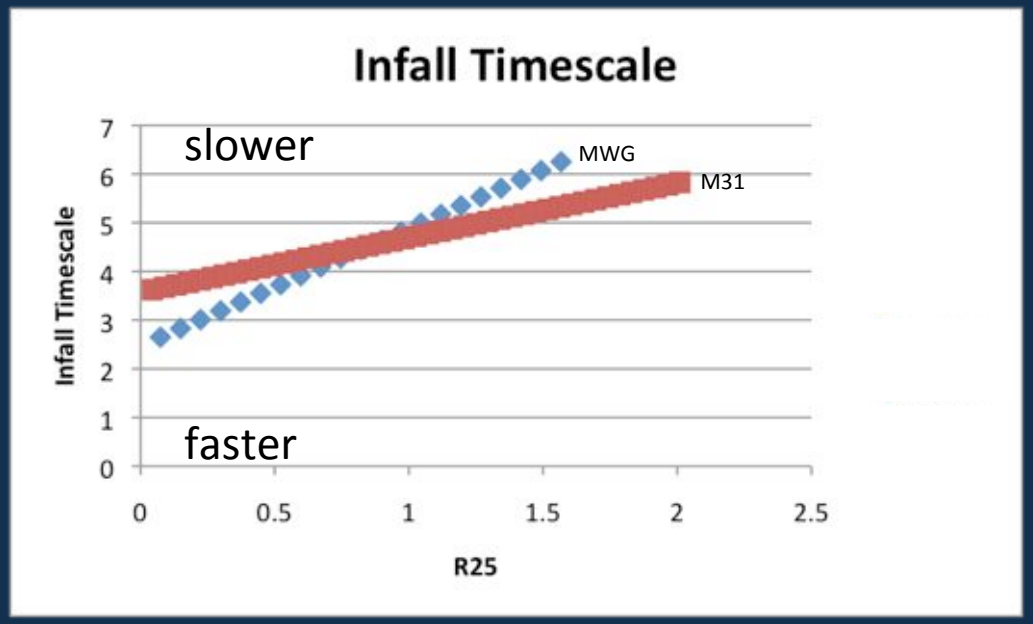
Non-varying parameters:

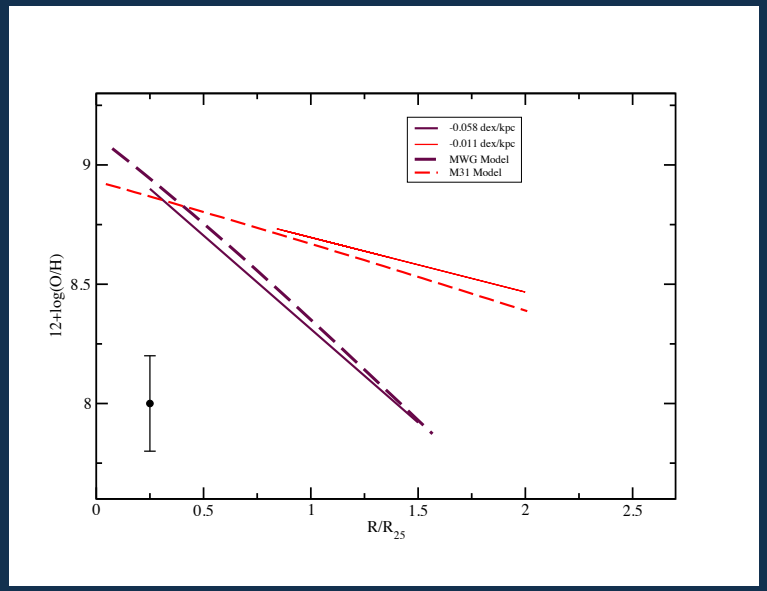
- stellar yields (Portinari & Marigo)
- Salpeter IMF
- current disk age=13 Gyr

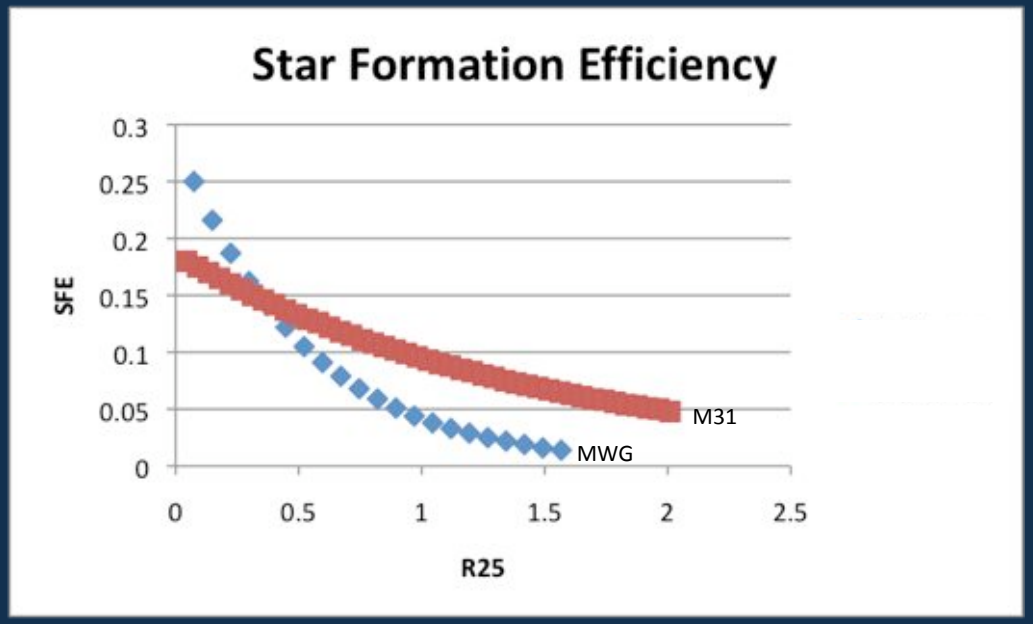
Varying parameters:

- star formation efficiency
- radially-varying disk formation timescale

MWG: **steeper increase of infall timescale** across the disk.







MWG: **steeper decrease of SF efficiency** across the disk.

Conclusions

1. MWG's gradient = *-0.058 +/-.006 dex/kpc* .
2. M31's gradient = *-0.011 +/-.004 dex/kpc*.
3. Models→ MWG has *steeper decline* in SFE and *steeper increase* in infall timescale across its disk than M31.

MWG: Henry et al., ApJ, 724, 761 (2010)

M31: Kwitter et al., ApJ, in press (2012), arXiv1202.4933