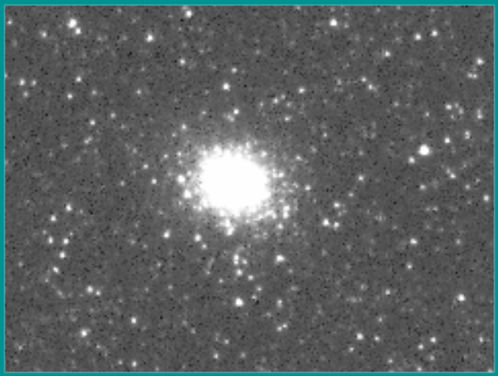
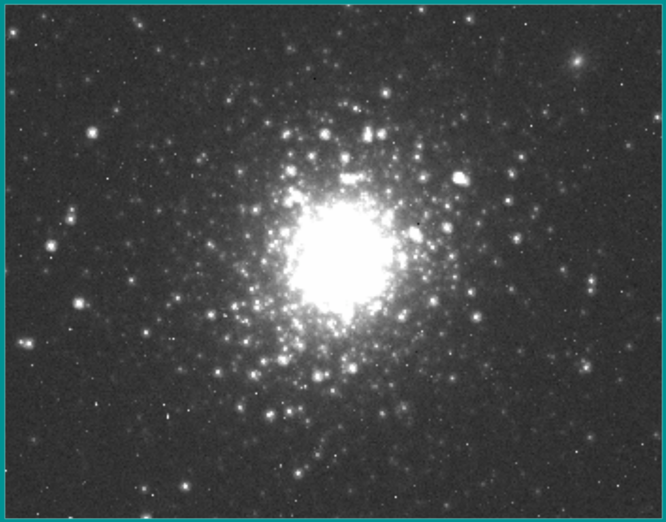
Globular Clusters in M31: Abundances from High- (and Low-) Res Spectra





Jay Strader, UCO/Lick Observatory

with R. Peterson, J. Brodie, G. Smith (UCO/Lick); S. Larsen (ESO/Utrecht)

The current situation

I think we know almost nothing about the abundances of extragalactic GCs.

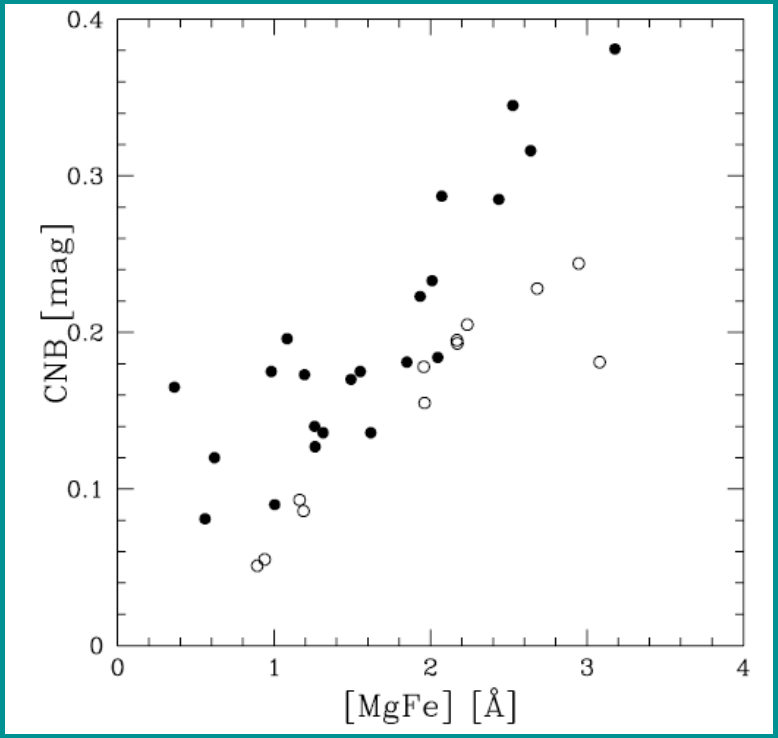
Things that are more likely than not, based on integrated spectroscopy:

- Some metal-rich GCs have [Mg/Fe] > 0
- Many M31 (and some other) GCs have [N/Fe] >> 0

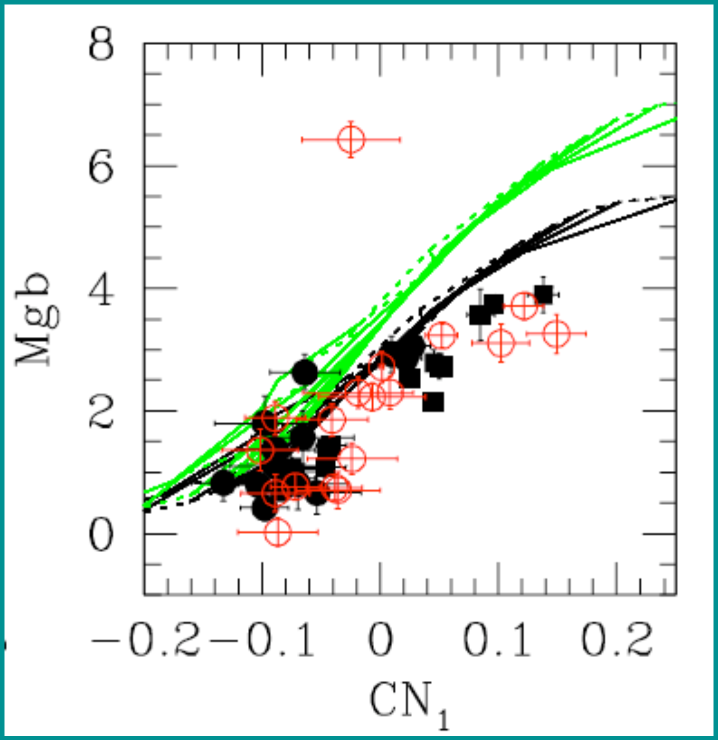
Things for which spectroscopic evidence is uncertain:

- Metal-poor GCs have [Mg/Fe] > 0
- Bimodal GC color distributions are due to metallicity

M31 vs. Milky Way: CN

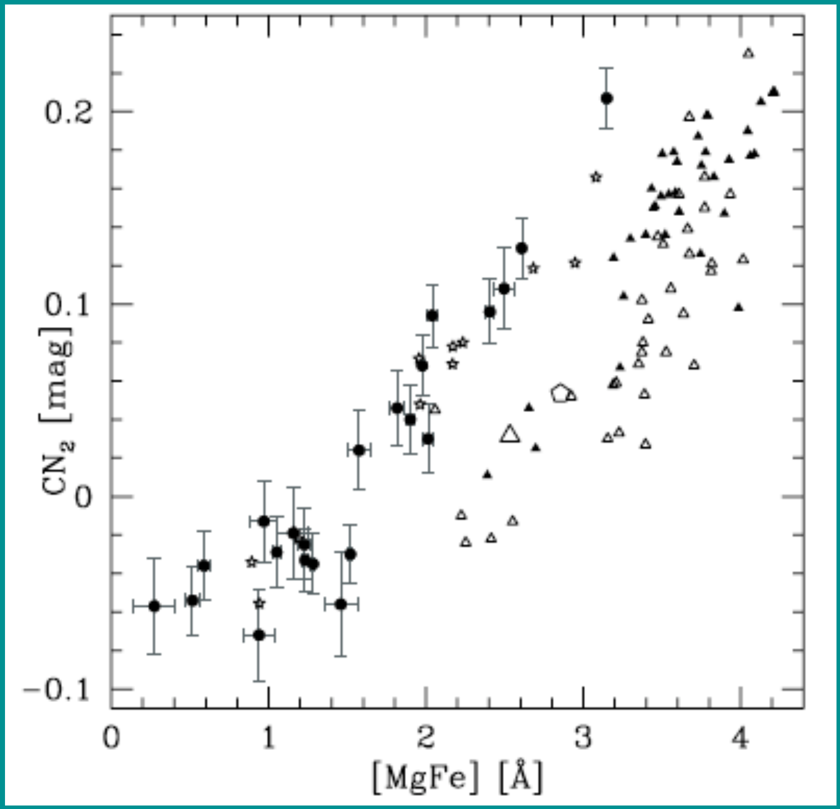


Beasley et al 2004

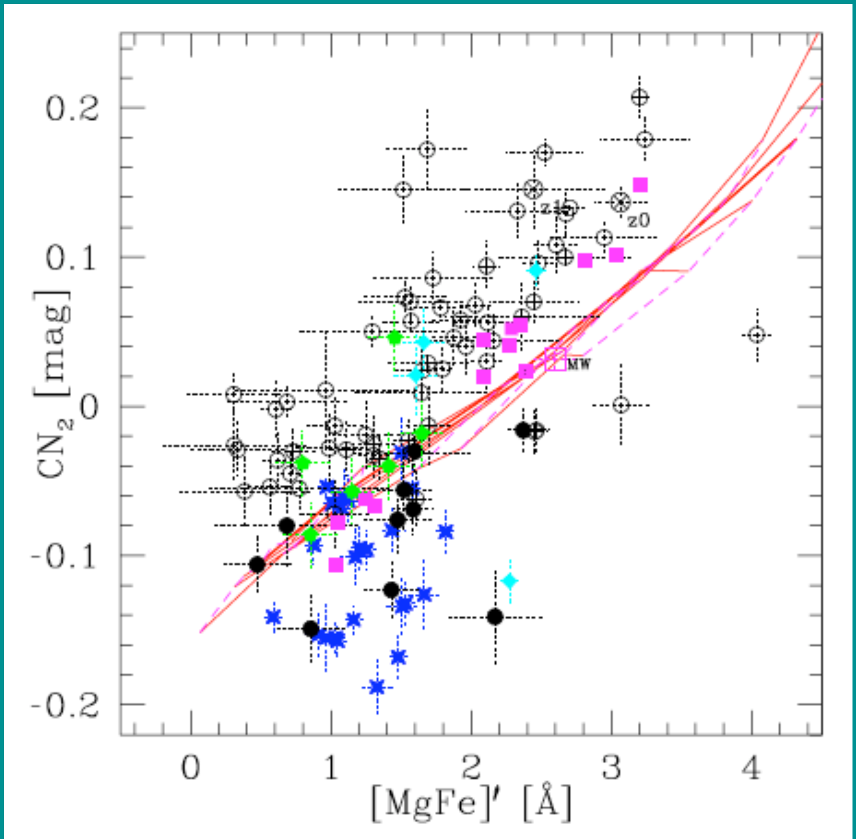


Trager 2004

M31 vs. Milky Way: CN



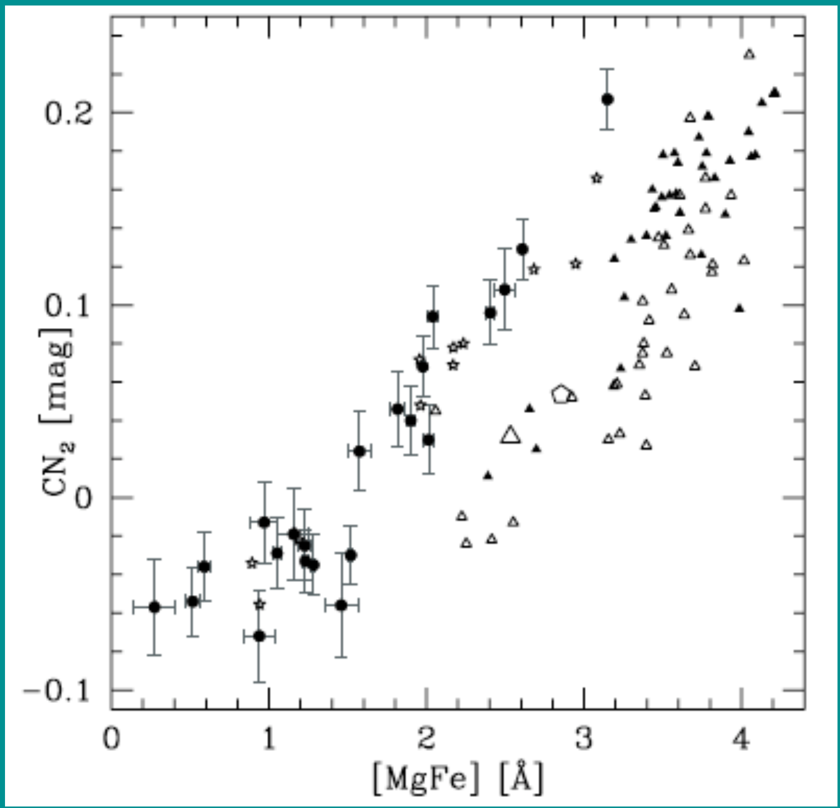
Beasley et al 2004



Puzia et al 2005

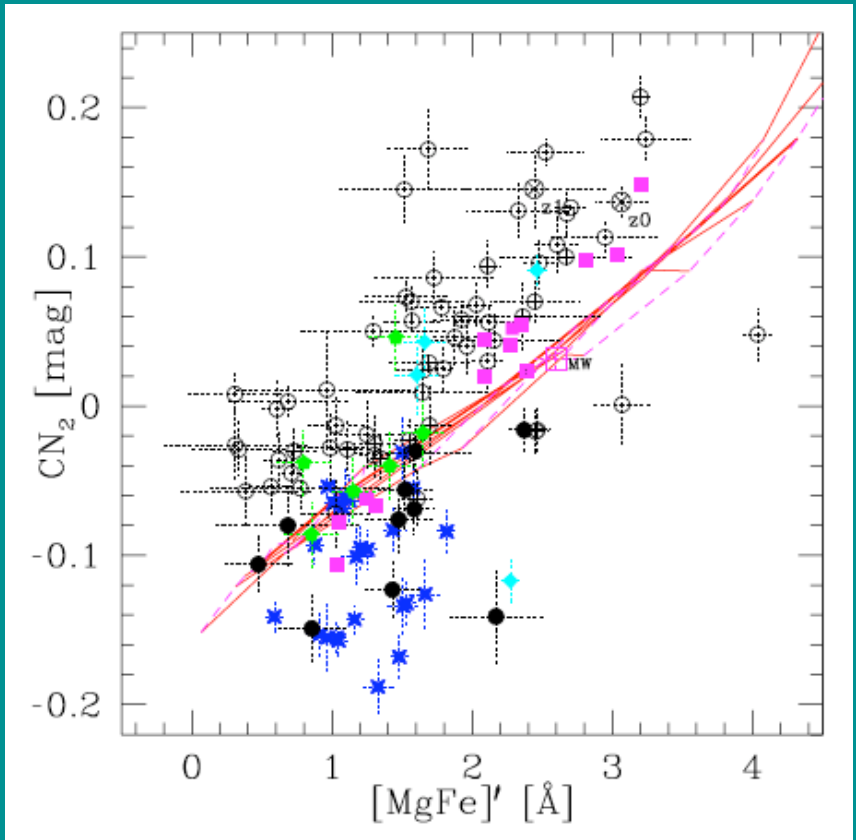
M31 vs. Milky Way: CN

Index	a	N
CN_2........................	0.0334	3



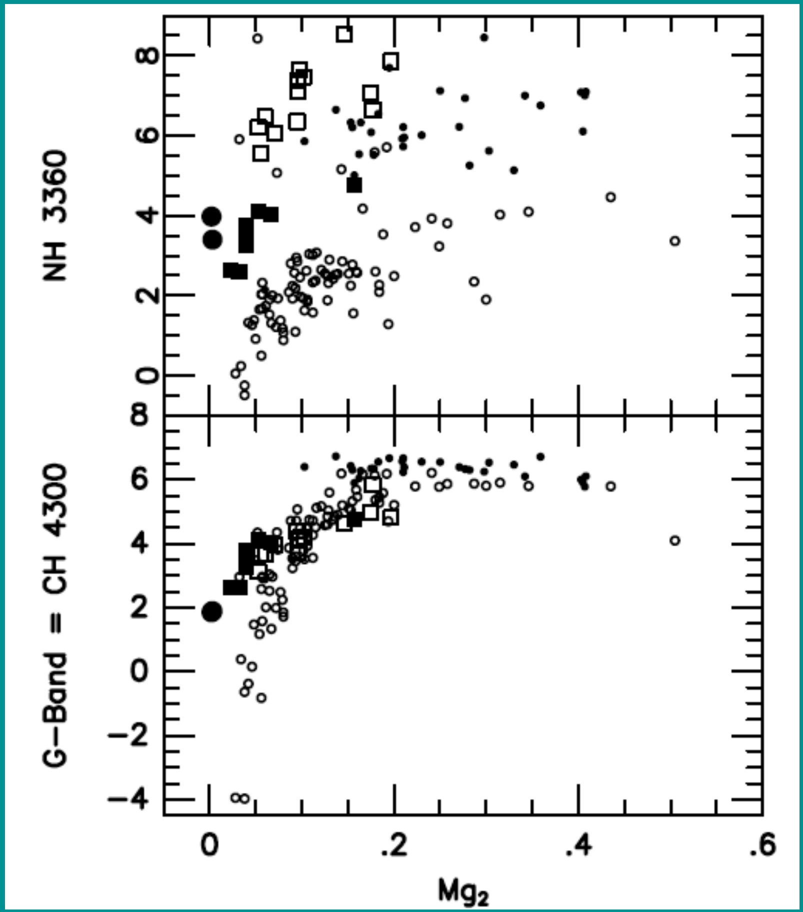
Beasley et al 2004

Index	c	rms
CN_2	0.051	0.084



Puzia et al 2005

M31 vs. Milky Way: NH



Suggest 200-500 M_{sun} hypernovae as source of N

Note comparisons at fixed Mg_2, not Fe

Burstein et al 2004

Low vs. High Resolution

Essentially, the number of elements:

Low-resolution: Fe, alphas (Mg, Ca, Ti), light (C, N)

High-resolution: odd-Z, Fe-peak, some r- and s-process possible (Ba, Eu)

Our initial work is focused on doing at high resolution what should be possible at low resolution.

Method

M31 GC 034-096
[Fe/H] ~ -0.7 (like 47 Tuc, M71)

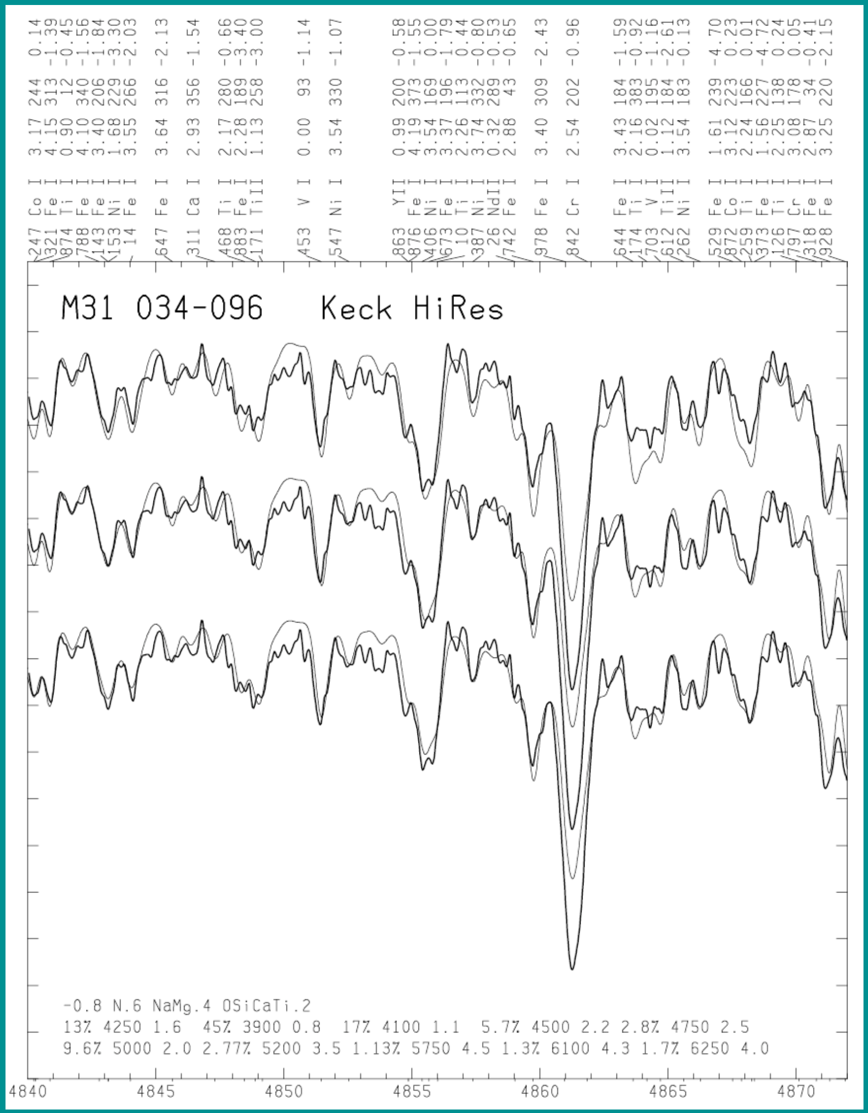
We do synthesis of theoretical spectra at high resolution.

Ten fiducial stars are used (more improves the fit little).

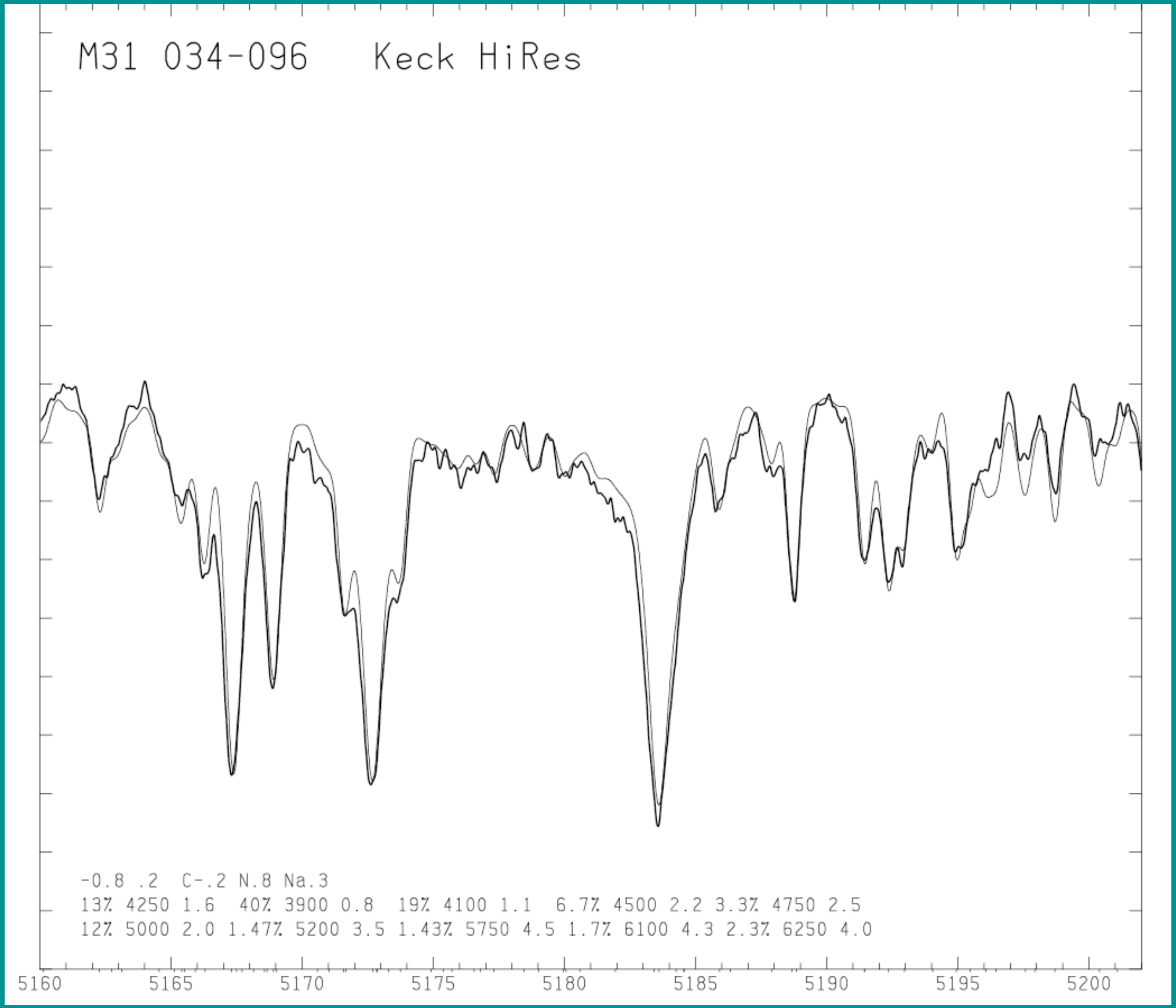
Initial parameters are taken from the properties of 47 Tuc.

Adjustments made to produce good fit across whole spectrum. By hand, at present.

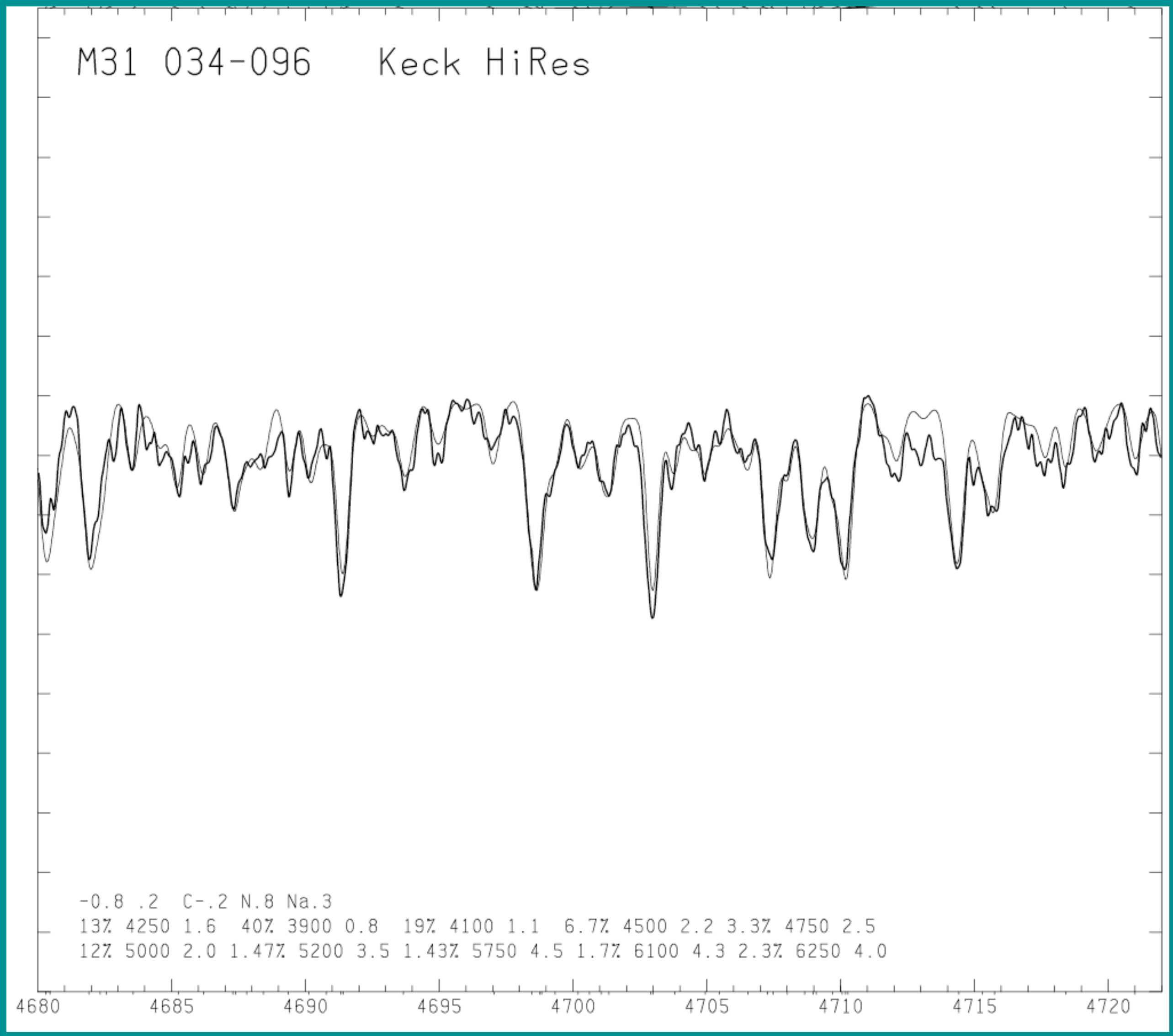
Lots more detail in Ruth's talk.



Fits to Orders



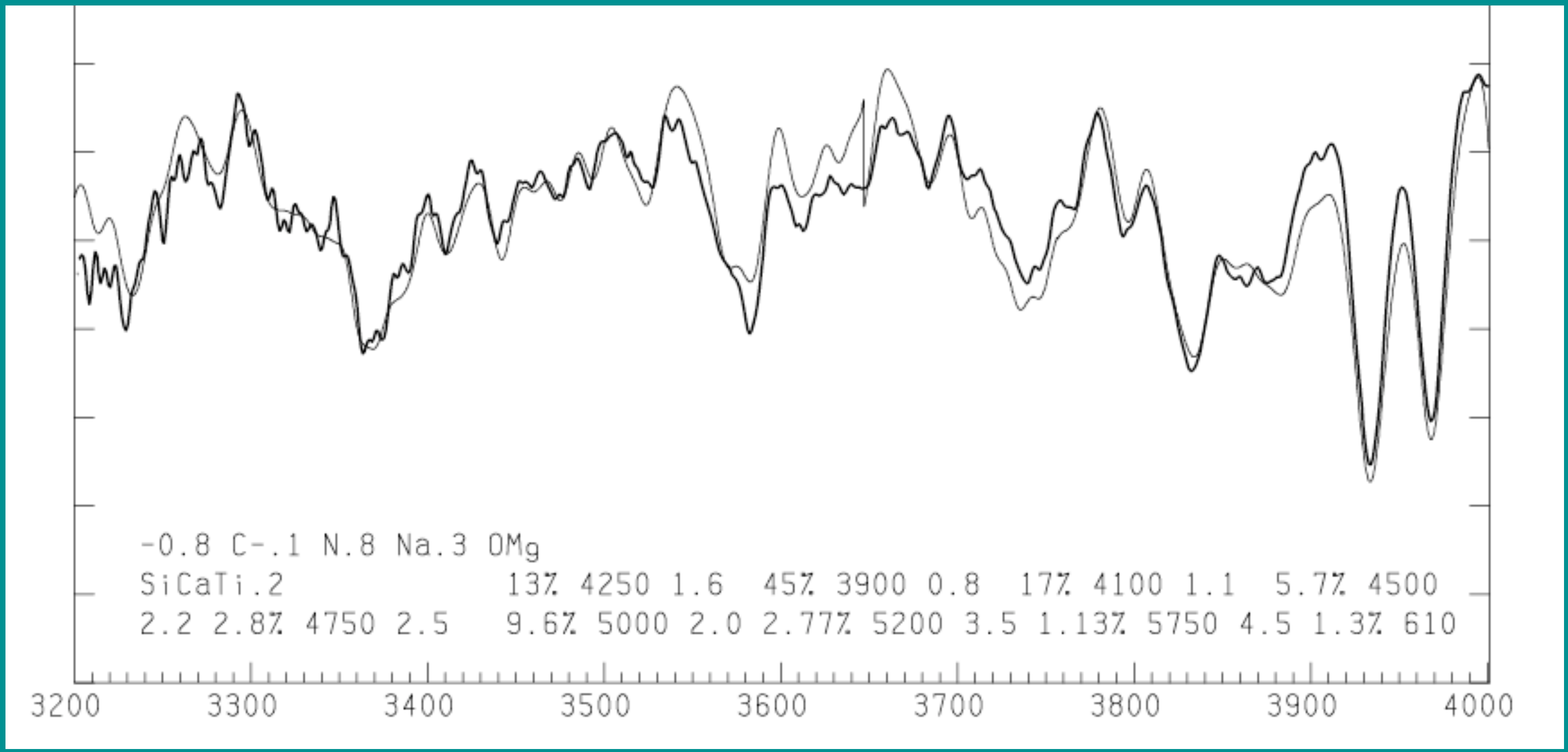
Fits to Orders



Results

[Fe/H] ~ -0.8, [Na/Fe] ~ 0.3-0.4, [Mg,Ti/Fe] ~ 0-0.2

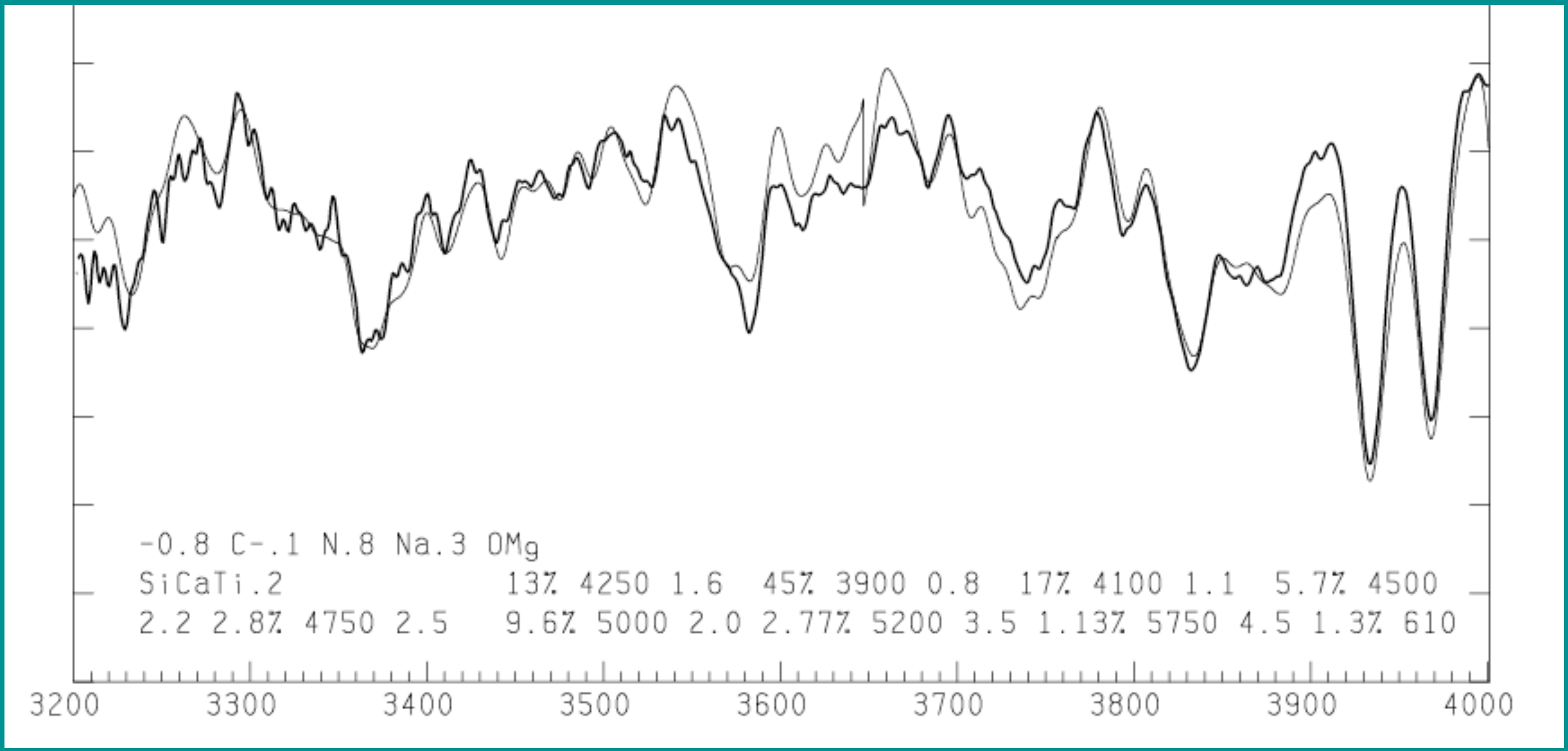
[Ca/Fe] ~ 0, [N/Fe] ~ 0.6-0.8, [C/Fe] ~ -0.2-0



Results

[Fe/H] ~ -0.8, [Na/Fe] ~ 0.3-0.4, [Mg,Ti/Fe] ~ 0-0.2

[Ca/Fe] ~ 0 [N/Fe] ~ 0.6-0.8, [C/Fe] ~ -0.2-0



Comparing to MW

In 47 Tuc/M71:

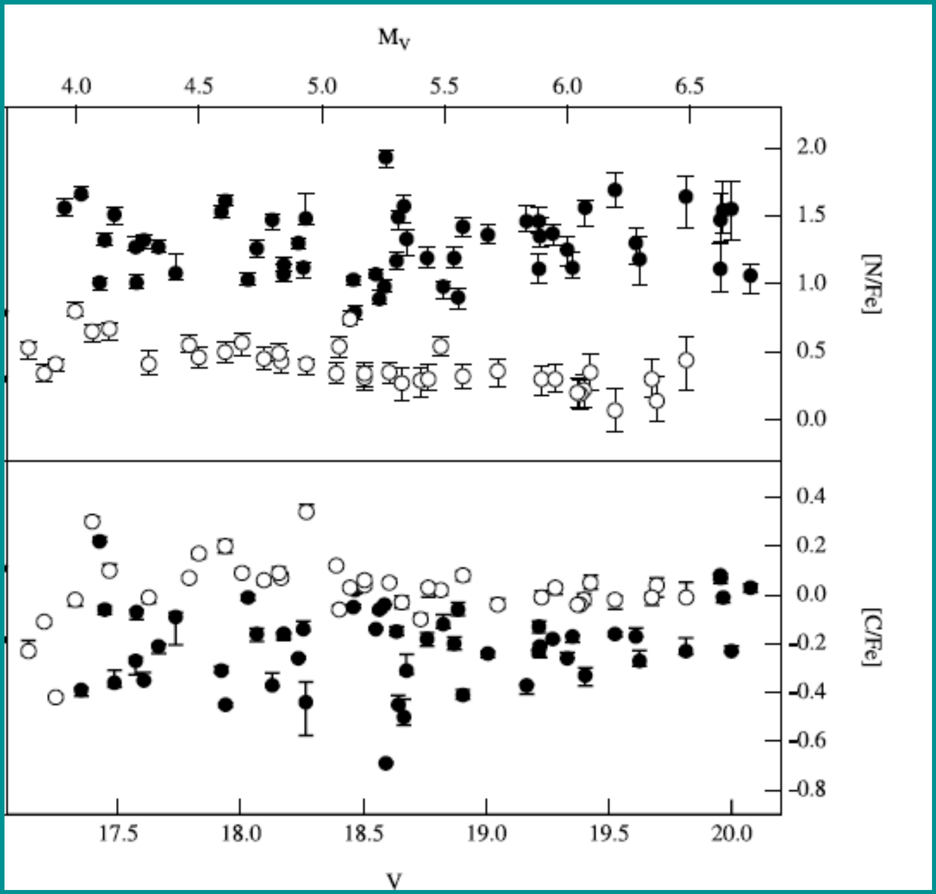
CN strong: [N/Fe] ~ 1.3-1.4
[C/Fe] ~ -0.3

CN weak: [N/Fe] ~ 0.4
[C/Fe] ~ 0

Schiavon (2006) fit to Lick indices for 47 Tuc gives:

[N/Fe] = 0.8, [C/Fe] =-0.05

Briley et al. 2004



Note...this fit takes mass segregation into account, which is good.

Comparing to MW

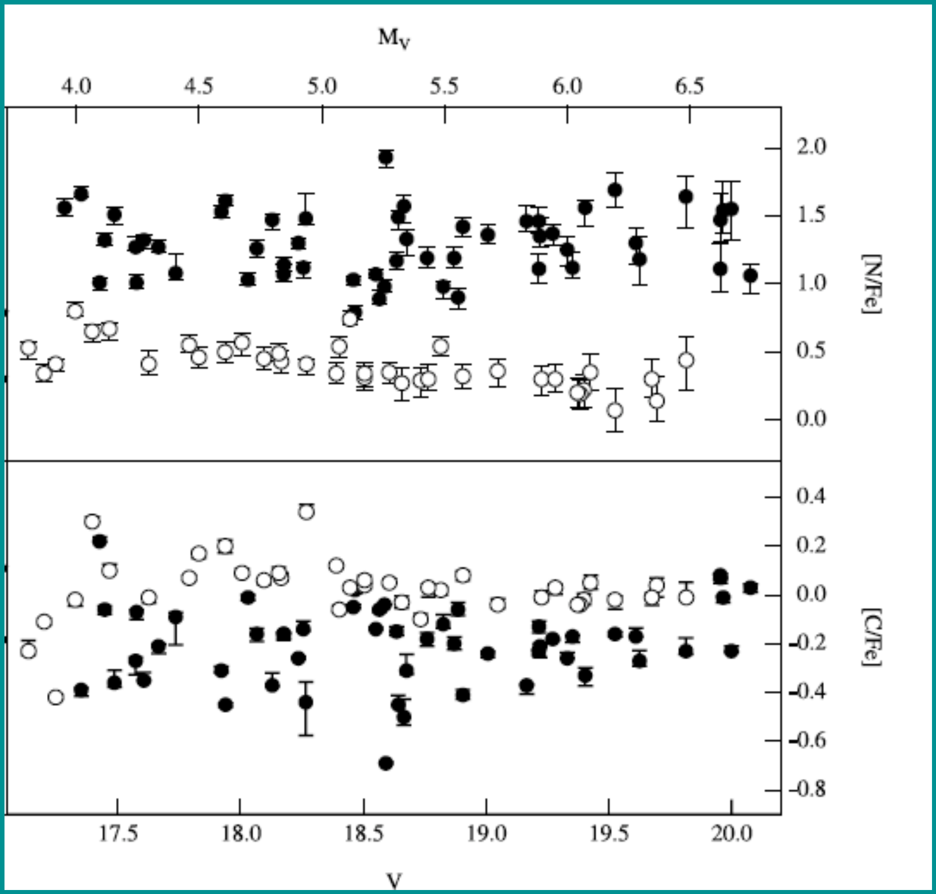
In 47 Tuc/M71:

CN strong: [N/Fe] ~ 1.3-1.4
[C/Fe] ~ -0.3

CN weak: [N/Fe] ~ 0.4
[C/Fe] ~ 0

M31 034-096:
[N/Fe] ~ 0.7
[C/Fe] ~ -0.1

Briley et al. 2004



No "abnormal" enrichment needed!

Final Points

- Encouraging agreement between low and high-resolution results, and lots of potential for improvement in the latter
- No clear need for “extra” N in at least one M31 metal-rich GC...but we may be left with same hard problem as in MW
- I’m agnostic as to whether there is a general CN issue between M31 and MW

Lots of new data --- 300 Hectospec GCs; upcoming HIRES run