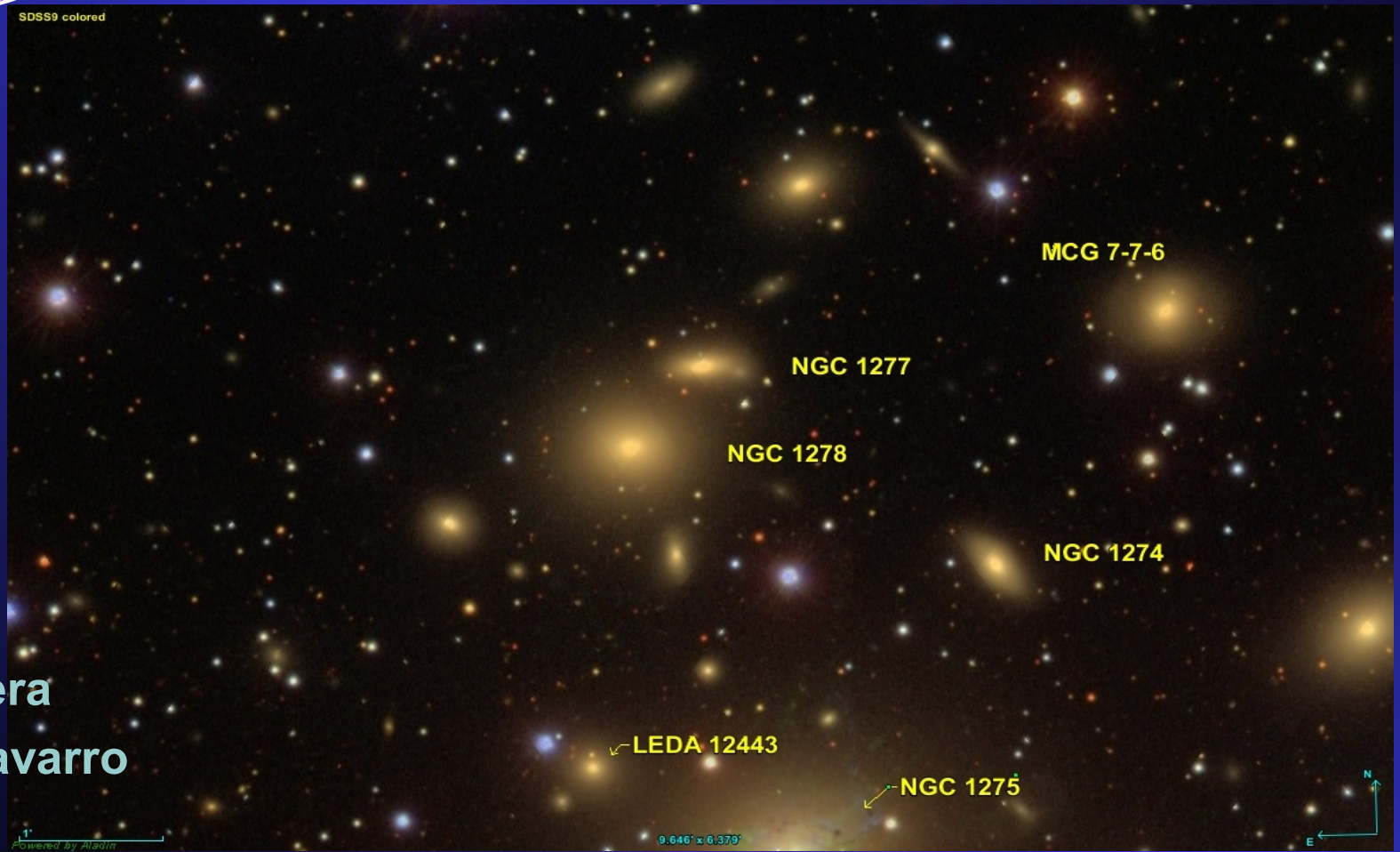
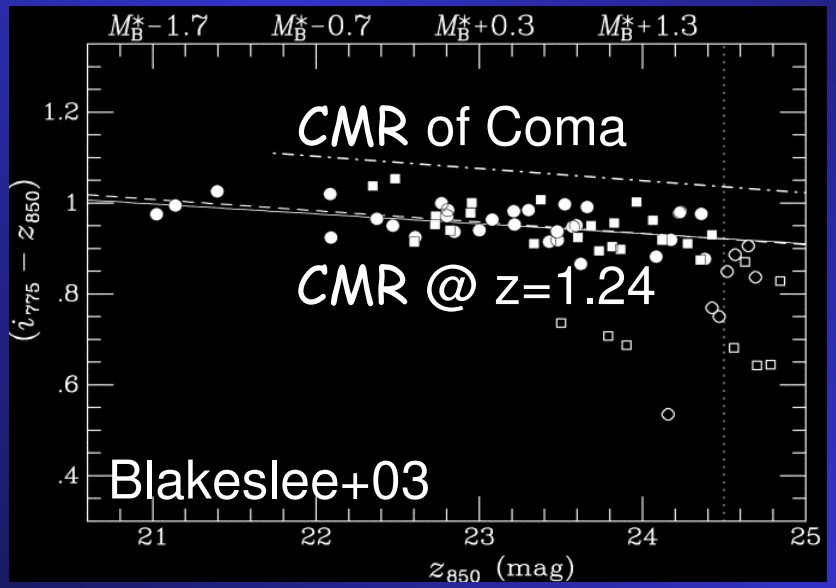
The relic galaxy NGC 1277

EMIR-RIA **Cádiz, 23-24/11/17**

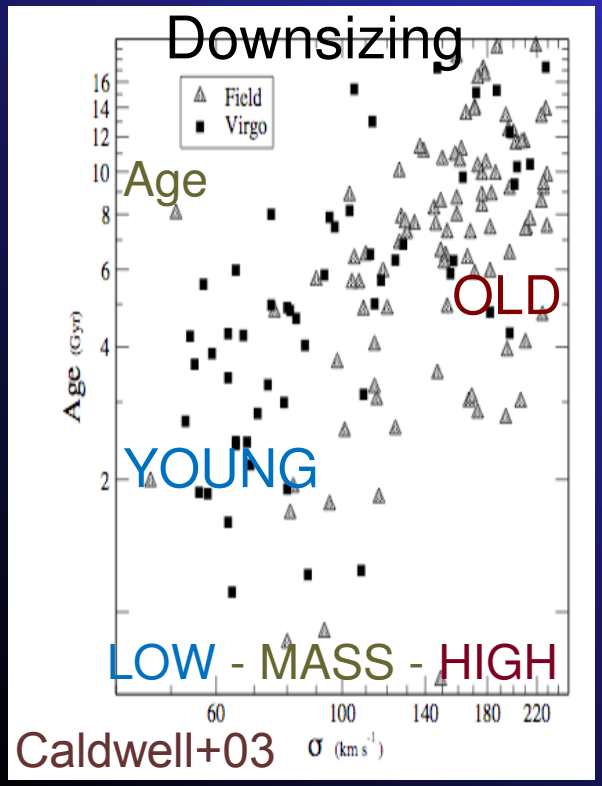
E.Eftekhari
M.Beasley
A.Vazdekis
M.Balcells
F. La Barbera
I. Martín Navarro

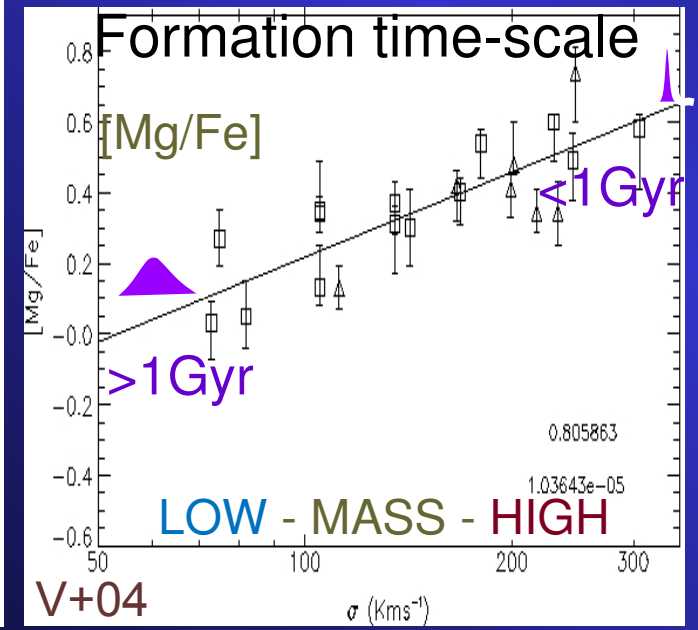


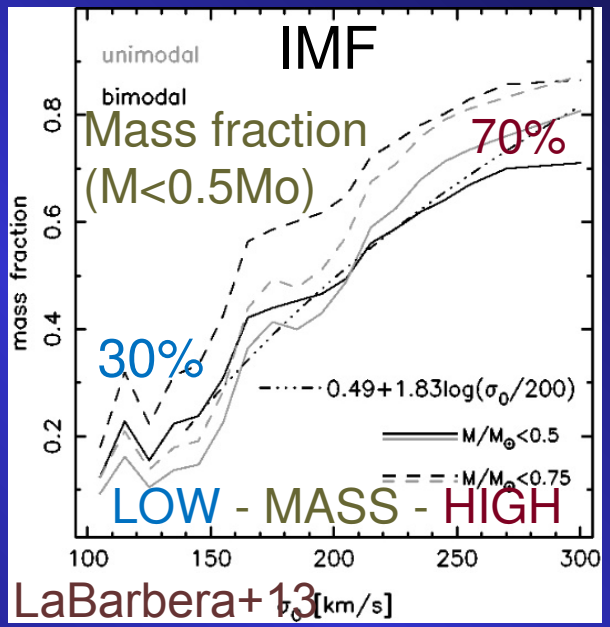


Stellar populations of ETGs as seen from the optical range:

- Tight CMR at rather high redshift.
- More massive ETGs older and more metal-rich
- Early and rapid formation of most massive ETGs ([Mg/Fe])
- Massive ETGs show a bottom-heavy IMF (fraction of stars with M<0.5 Mo): (Massive ETGs>0.6, Milky Way~0.3)



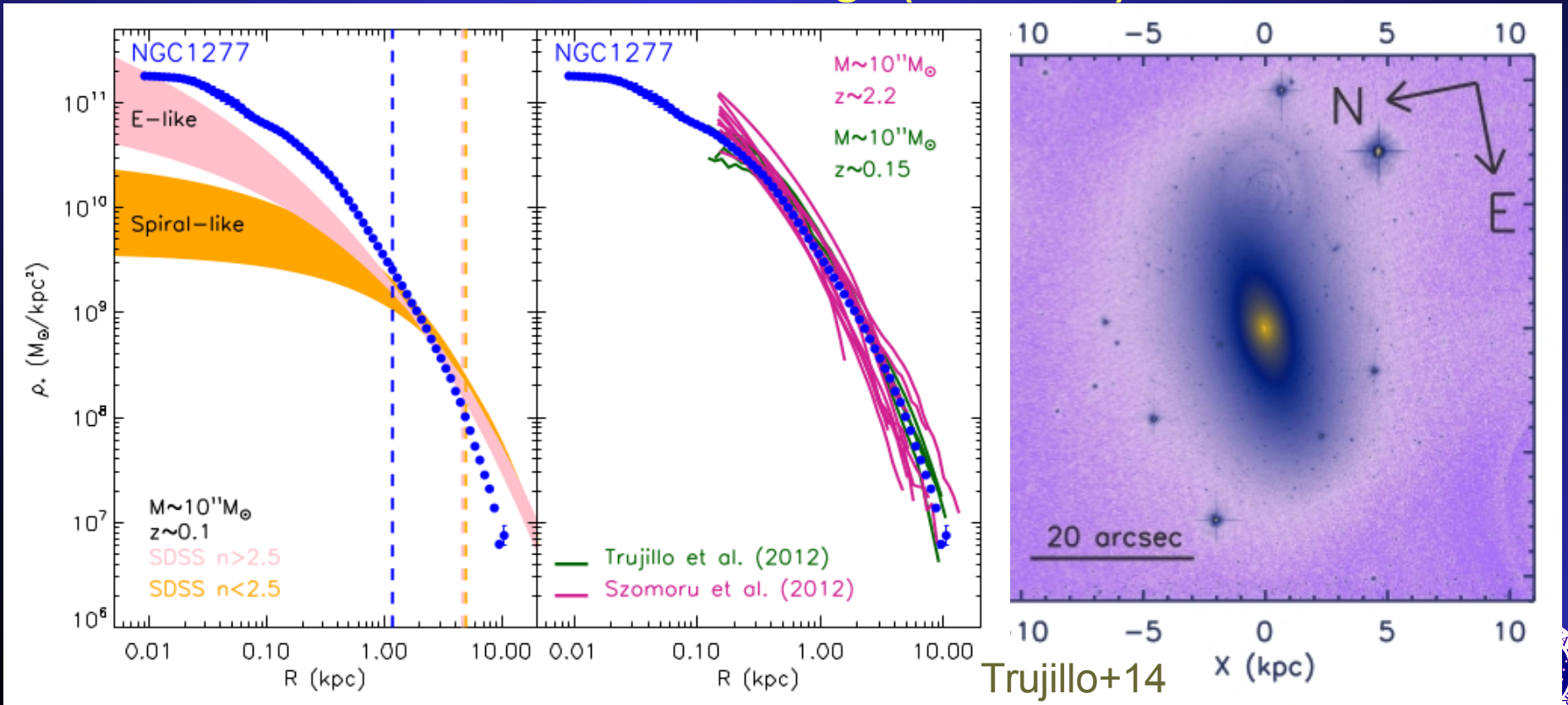




NGC 1277

- A very rare nearby very massive compact galaxy in the core of the Perseus cluster. Located very near to a massive ETG (NGC 1278)
- Similar to those found at high z, which are thought to be the progenitors of nowadays normally sized massive ETGs

Is it the result of the first stage within a two phase galaxy formation scenario with a frustrated second stage (accretion)?

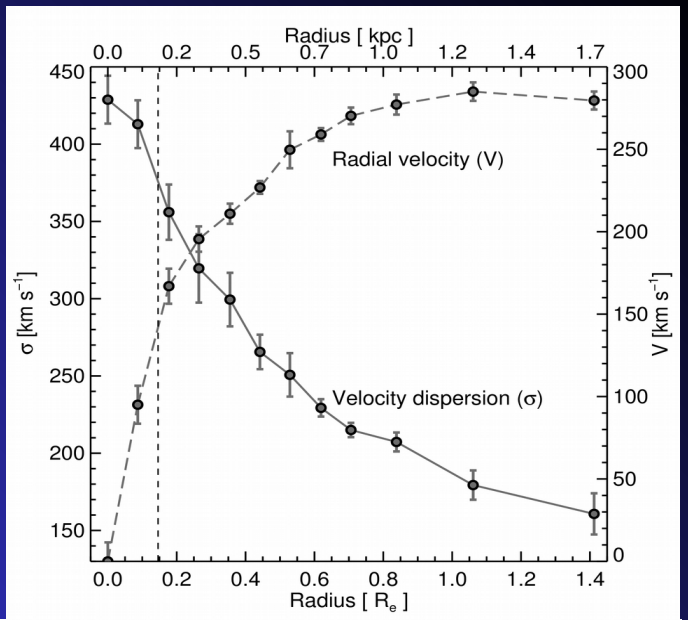


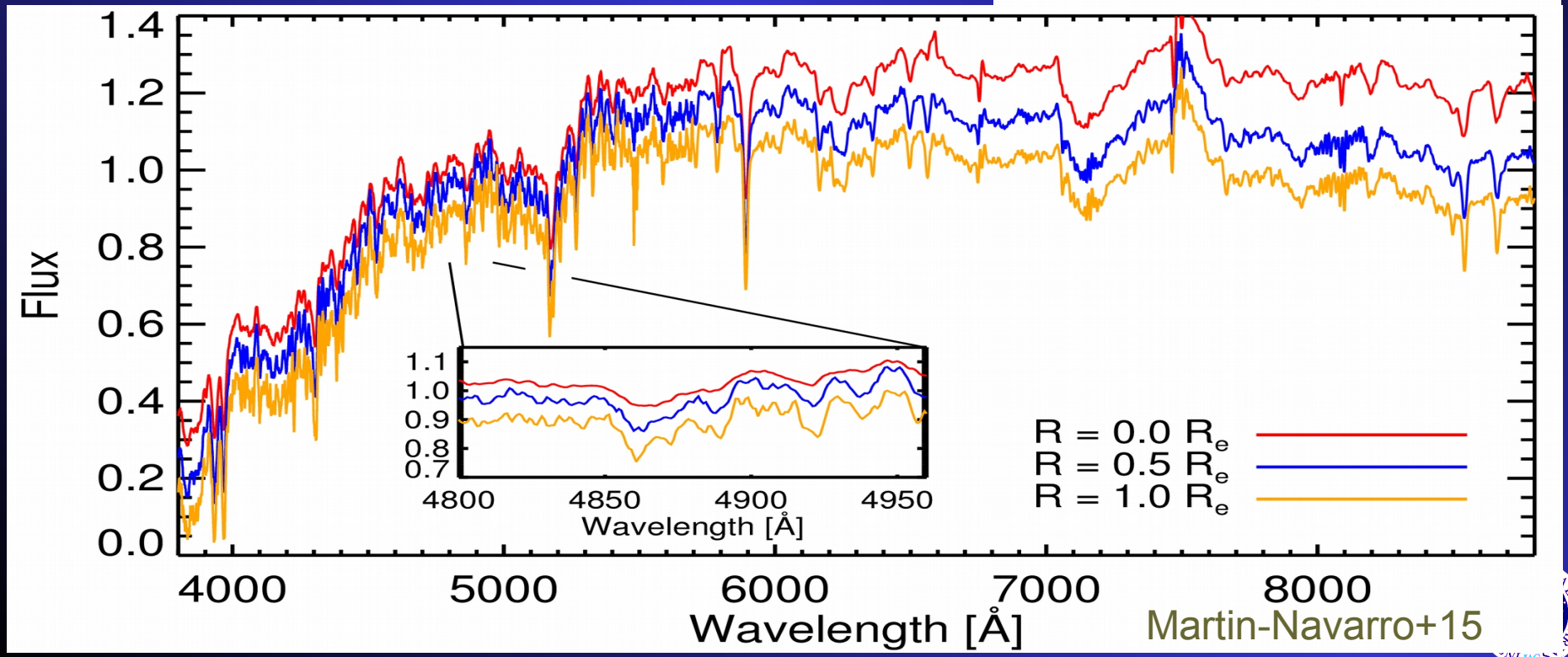
NGC 1227: GTC optical spectra

Extremely high quality optical spectra.

Kinematical properties:

- **Extremely high central velocity dispersion**
- **Fast rotator**



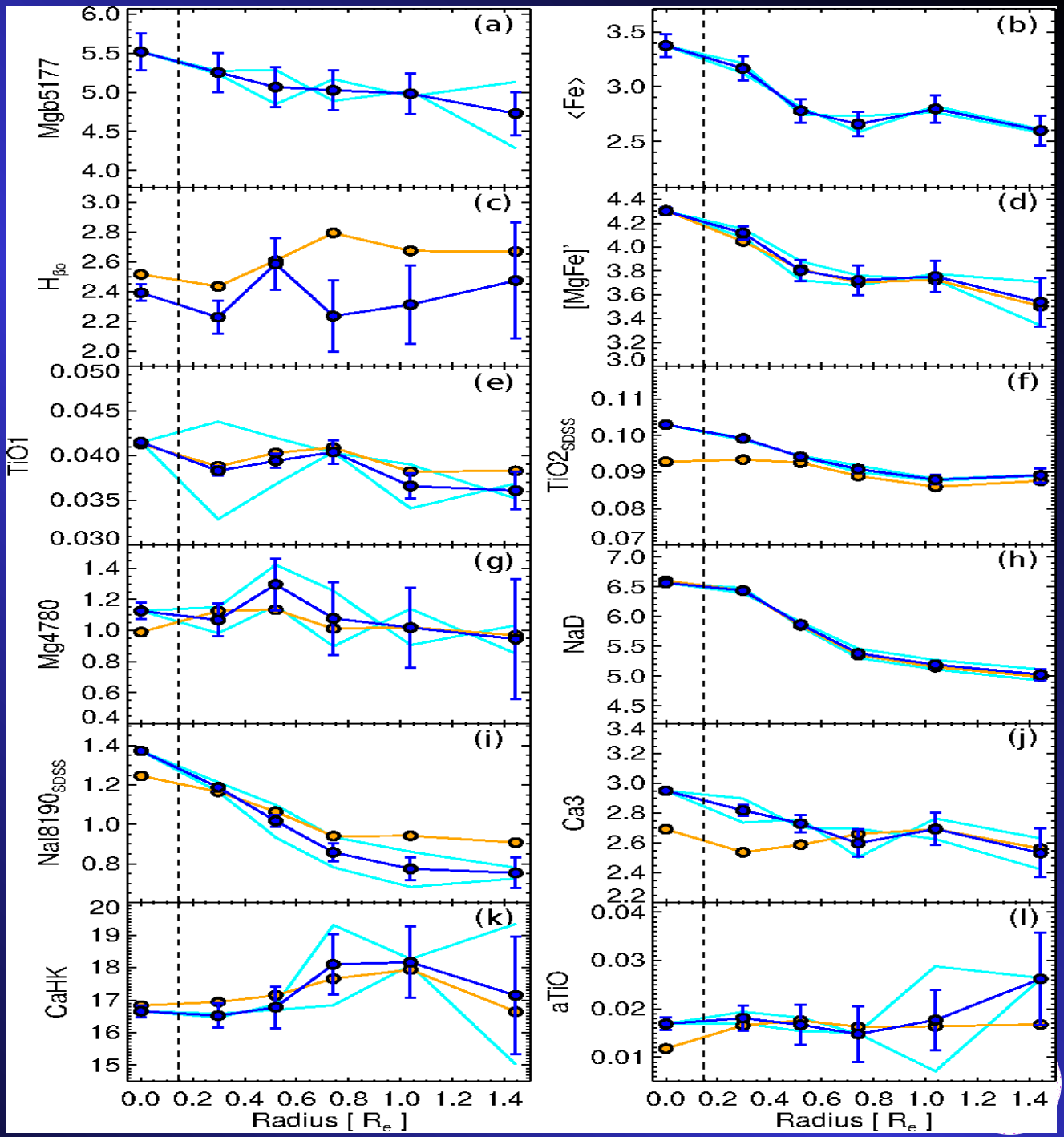


NGC 1277: stellar populations

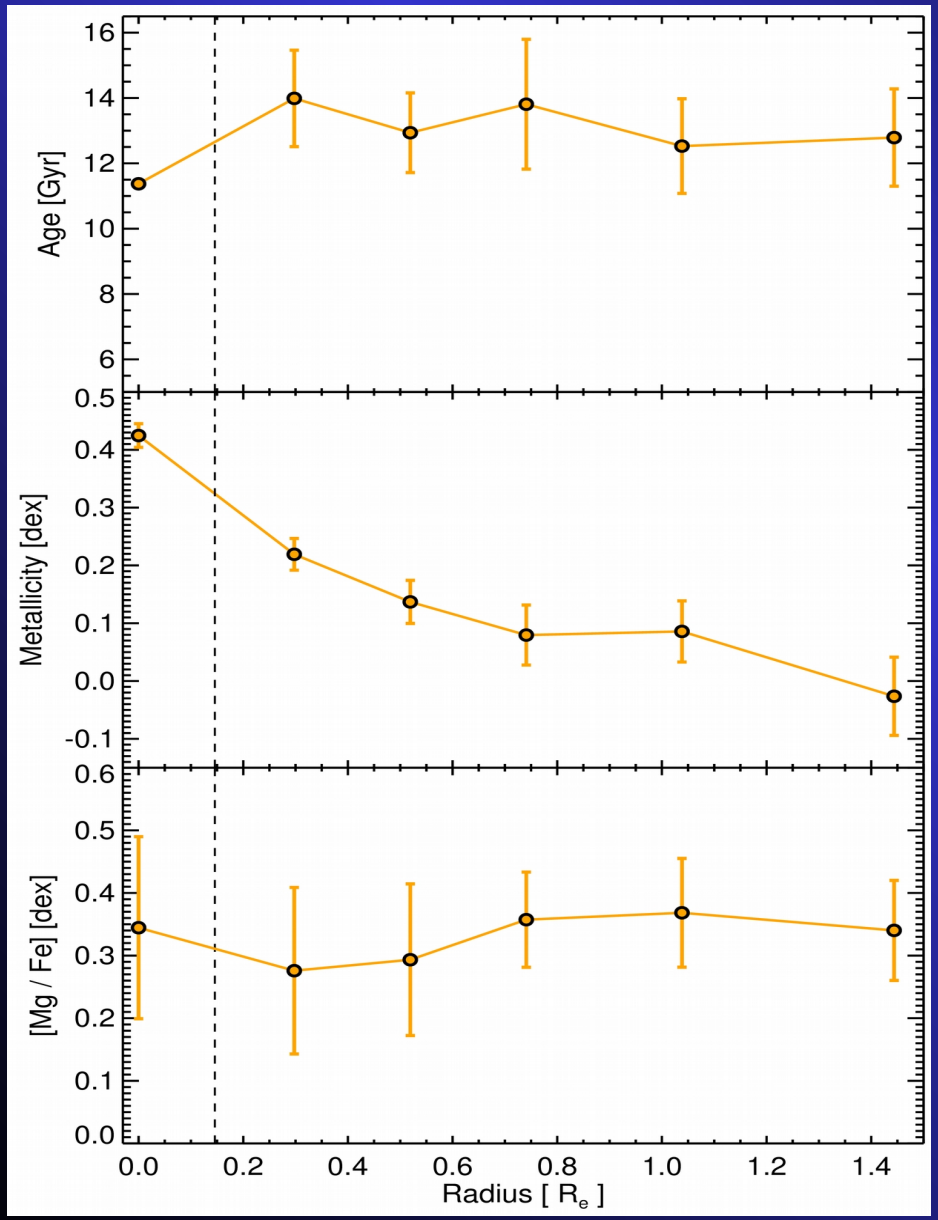
Line-strengths gradients

MILES models match the index profiles

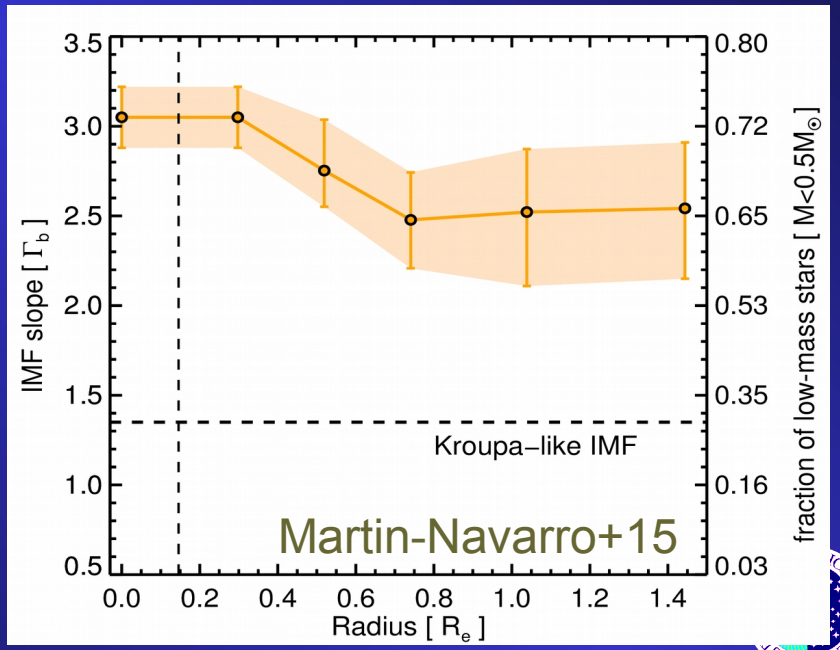
Martin-Navarro+15



NGC 1277: stellar population results

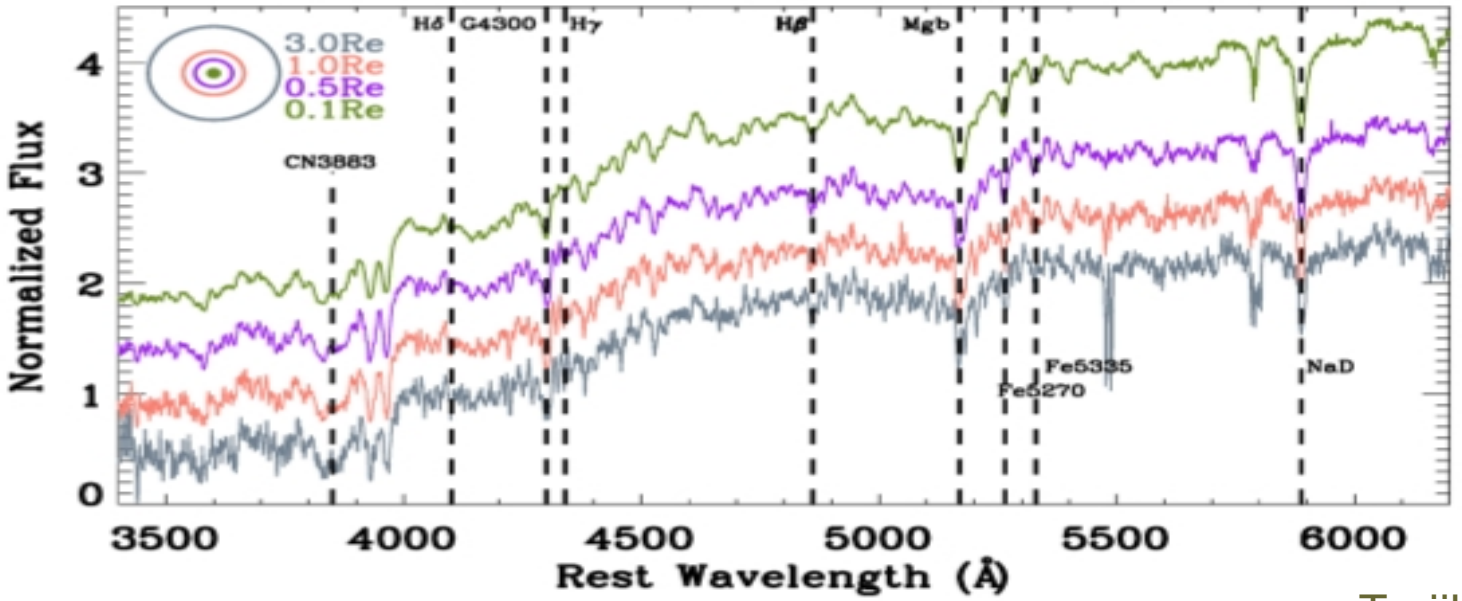


- Very old and flat radial age profile
- Very high central metallicity decaying fast with radius
- Extremely high [Mg/Fe]. Flat radial profile
- Very high IMF slope, IMF, decaying slightly with radius

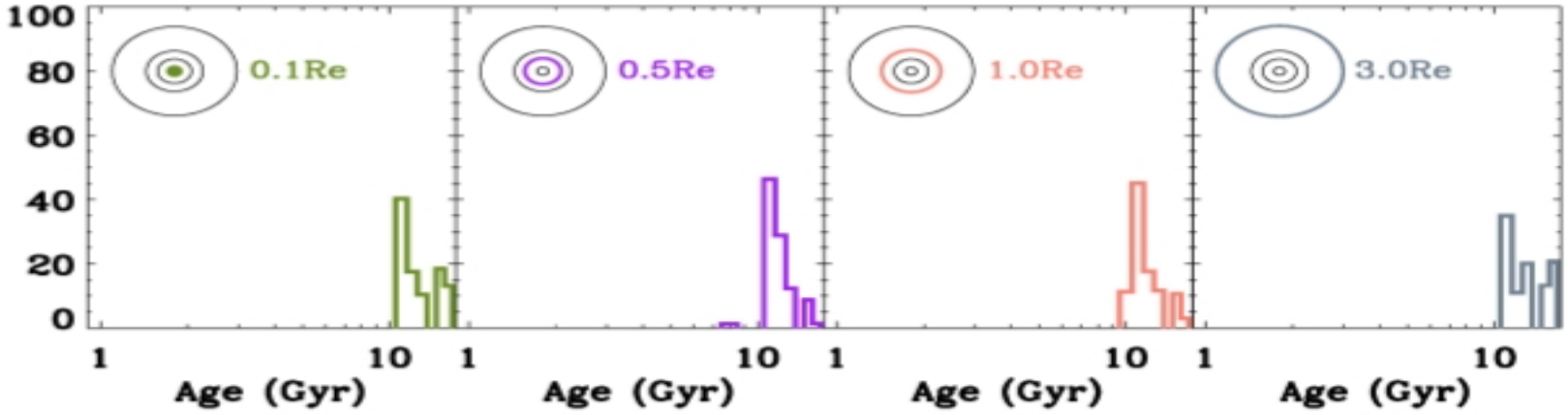


NGC 1277: Star Formation History

A truly old "relic" massive compact galaxy in the nearby Universe.

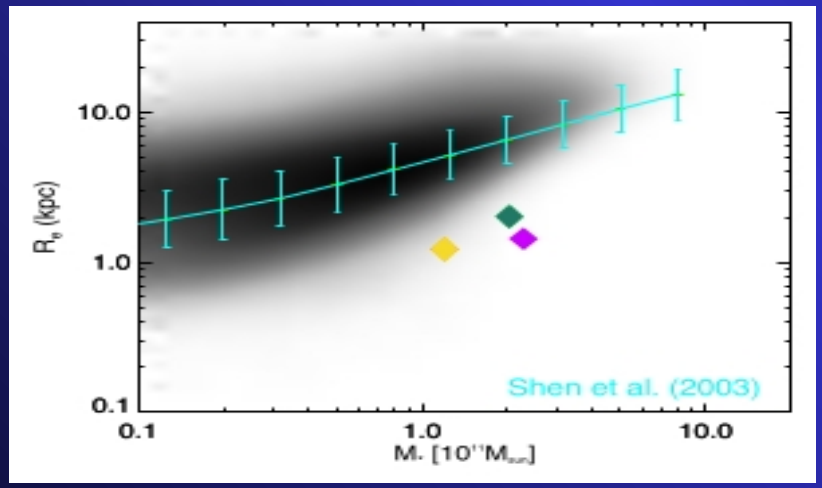


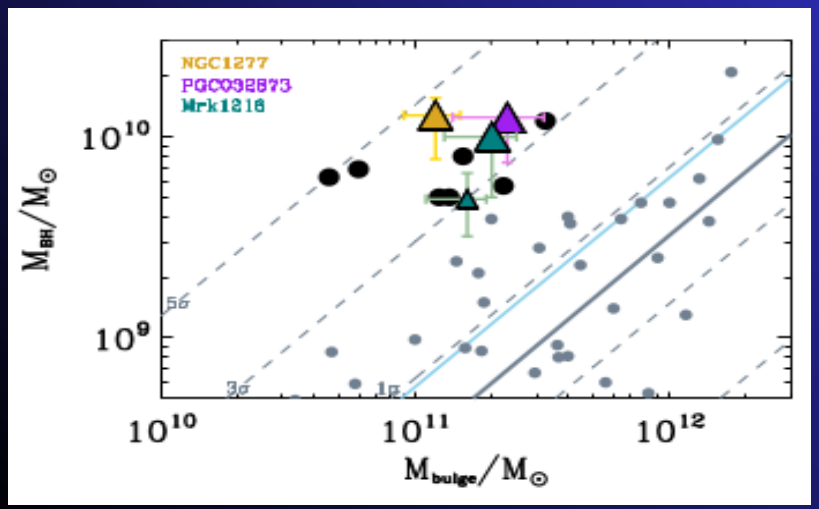
Trujillo+14

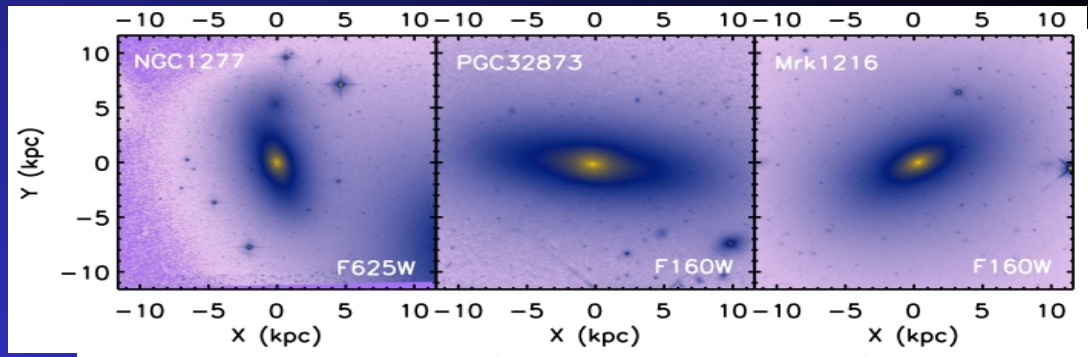


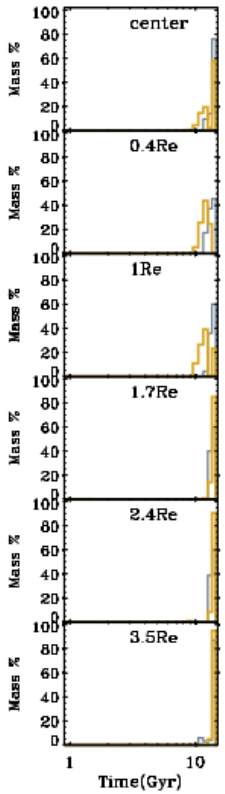
Is NGC1277 peculiar?

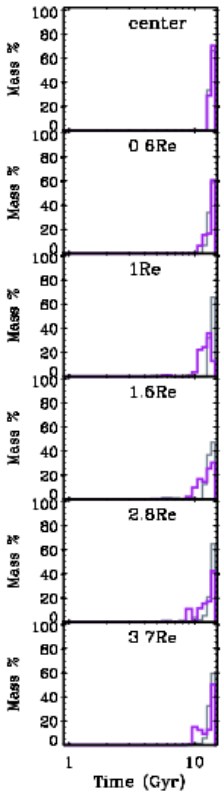
With respect to their normally-sized counterparts: YES

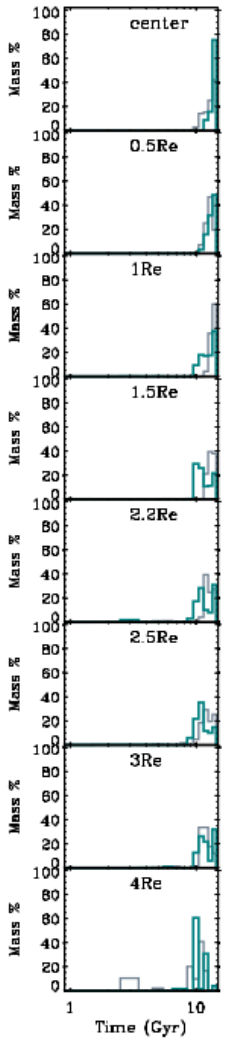










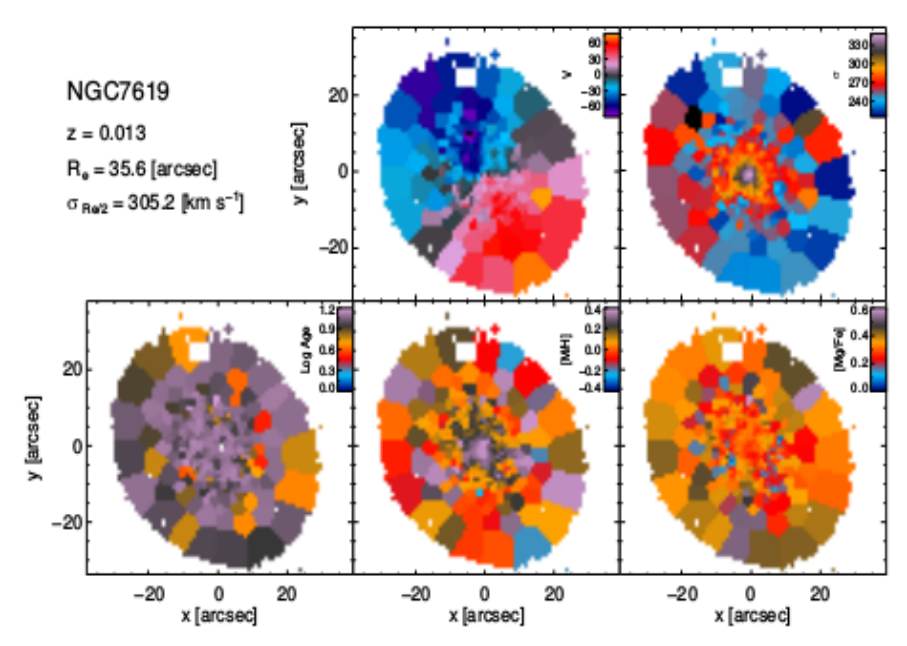


Compared to other (few) compact galaxies: NO

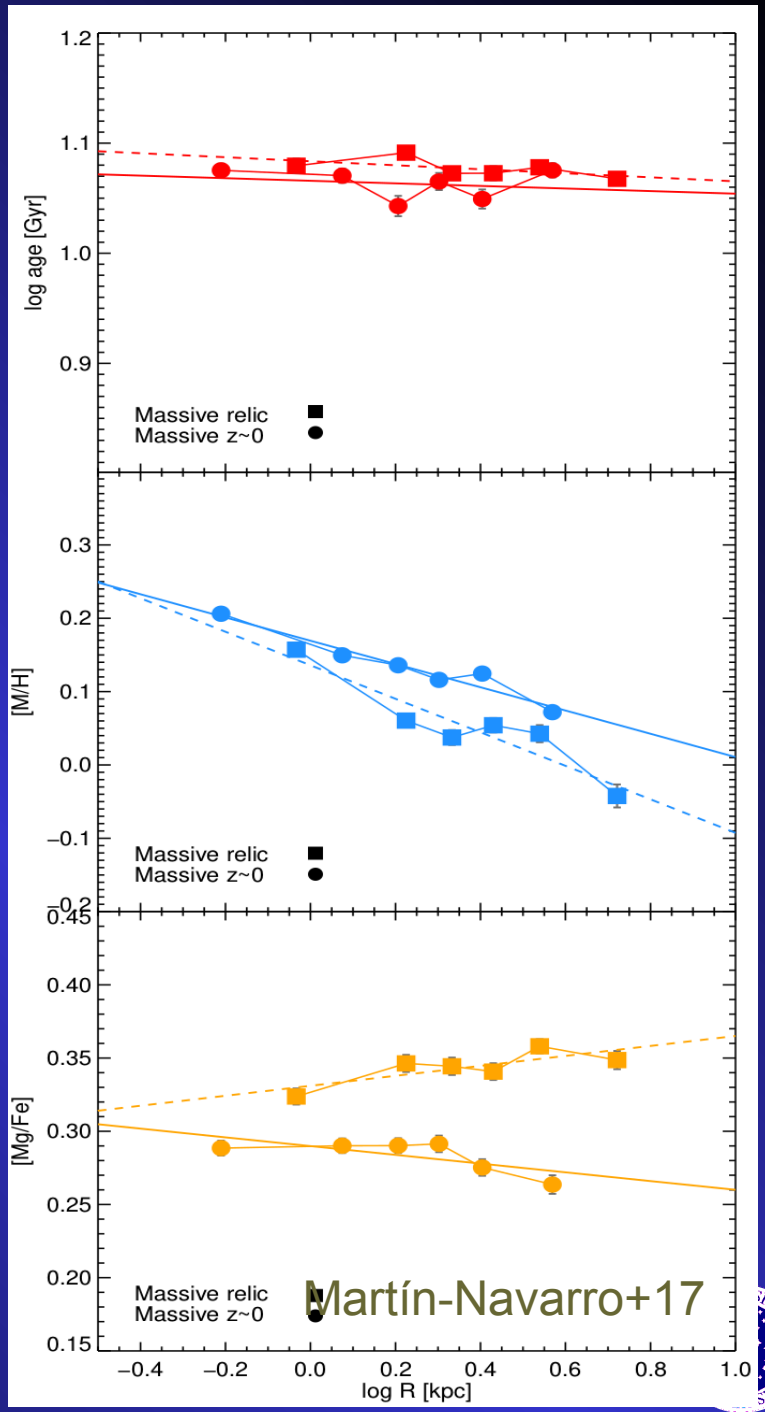
Ferré-Mateu+17

Stellar population gradients

Compact relics vs. Massive Es from the CALIFA survey.



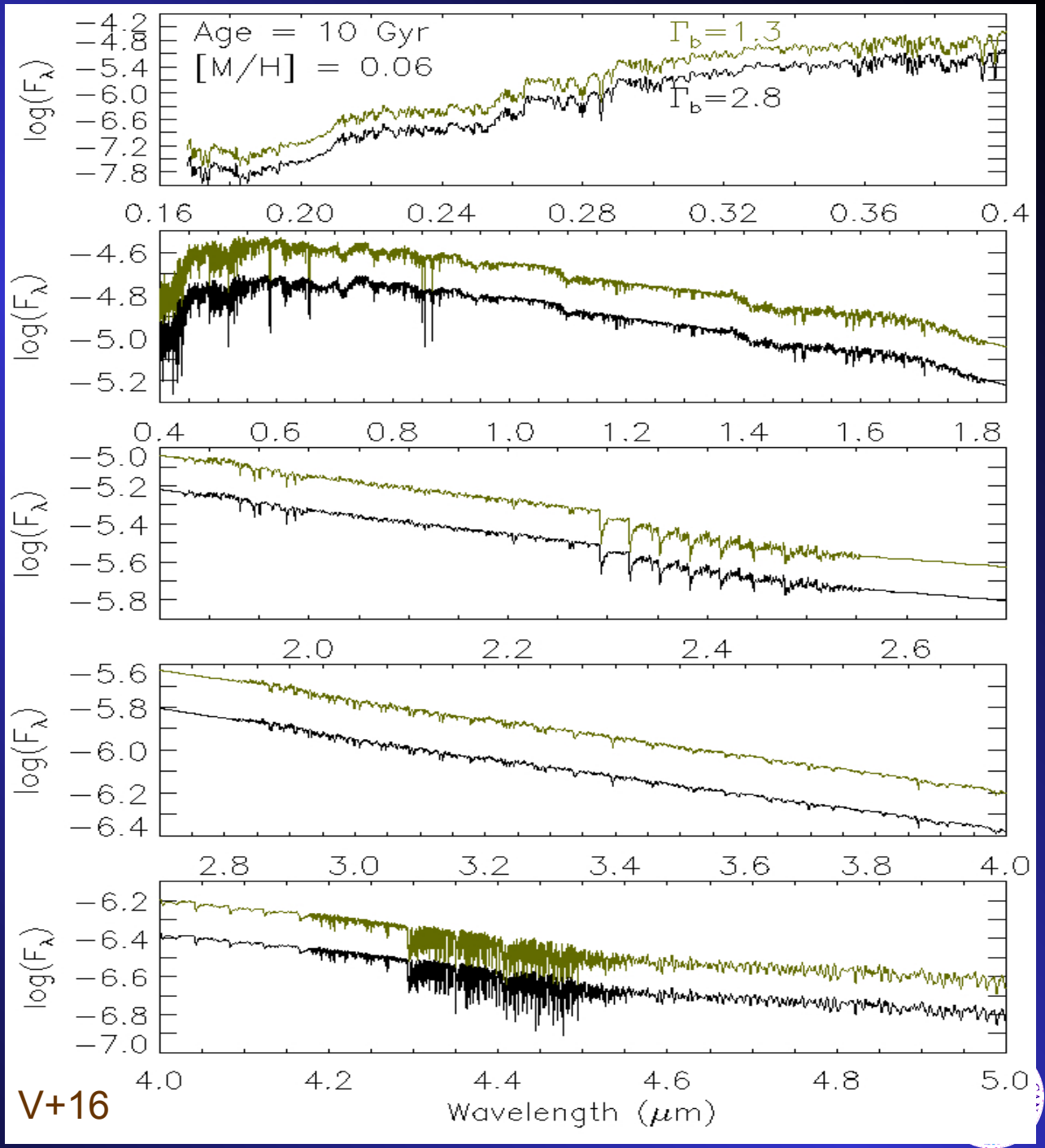
- **Age:** Older but similarly flat age gradients.
- **[M/H]:** Steeper gradients.
- **[Mg/Fe]:** Higher values and possitive gradients.



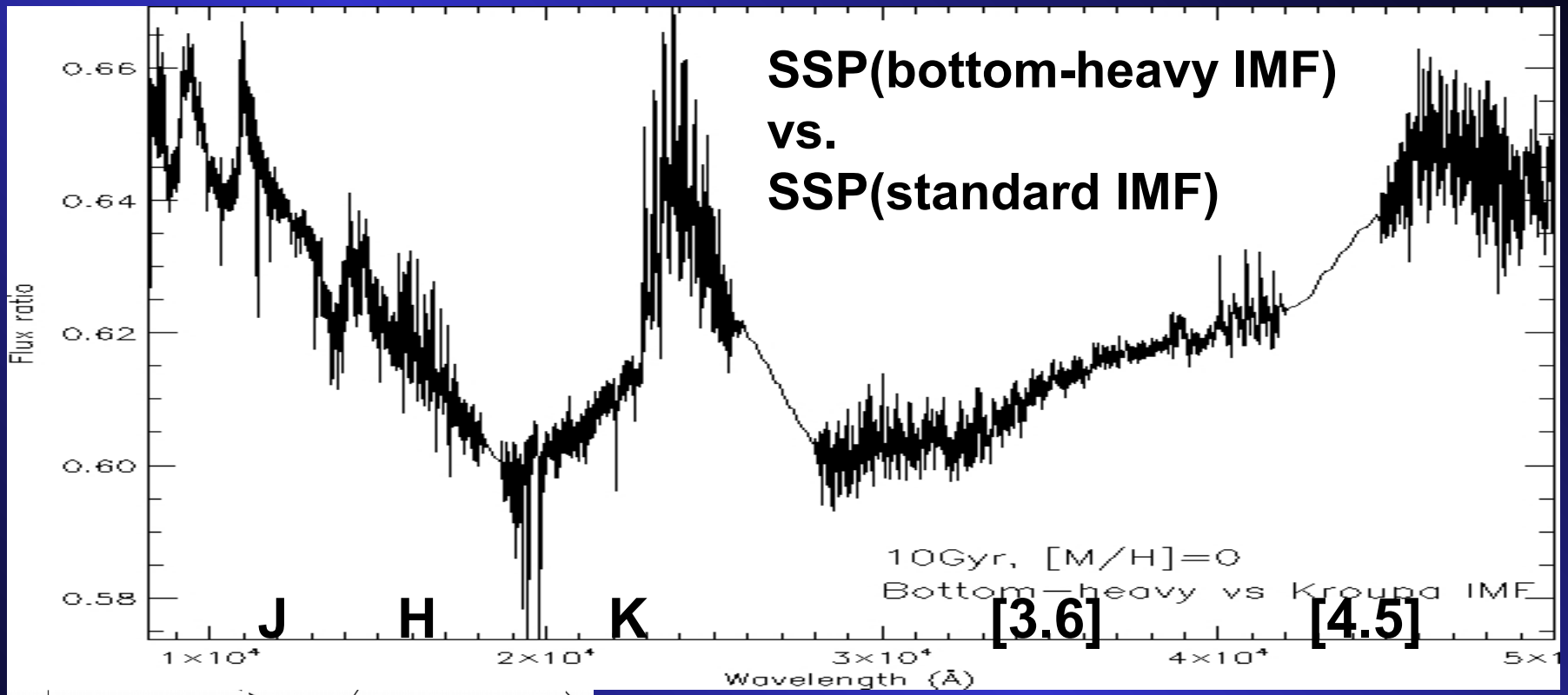
The Near-IR spectral range

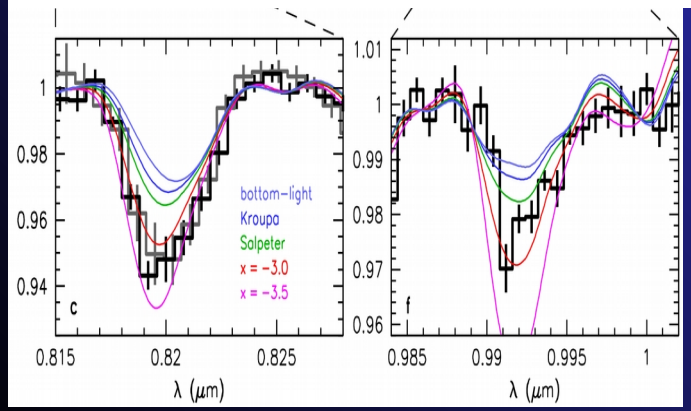
Extended E-MILES stellar population models

- **Based on empirical stellar spectral libraries (NGSL, MILES, Indo-US, CaT, IRTF)**
- **(α,Na) abundance ratios incorporated with the aid of theoretical stellar spectra (ODFNEW4 ATLAS9 + ASSεT)**
- **Coverage (0.17-5μ) & resolution:**
  λ<0.9μ: ~2.5Å (FWHM)
  λ>0.9μ: σ~60 kms^{-1}



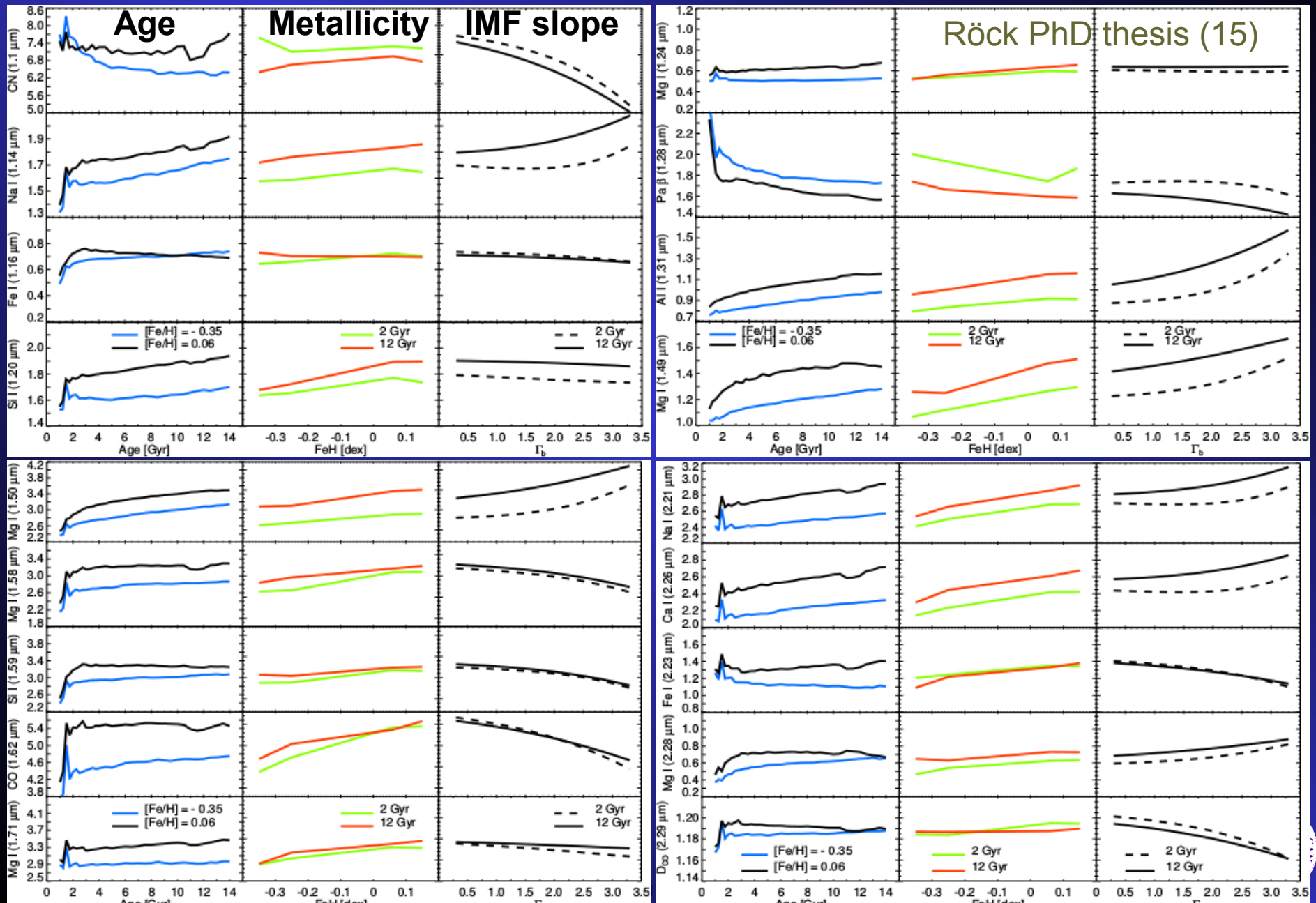
New means to constrain the IMF





Great sensitivity to the IMF with optimal indices to separate the effets of the IMF from those of the abundance ratios.

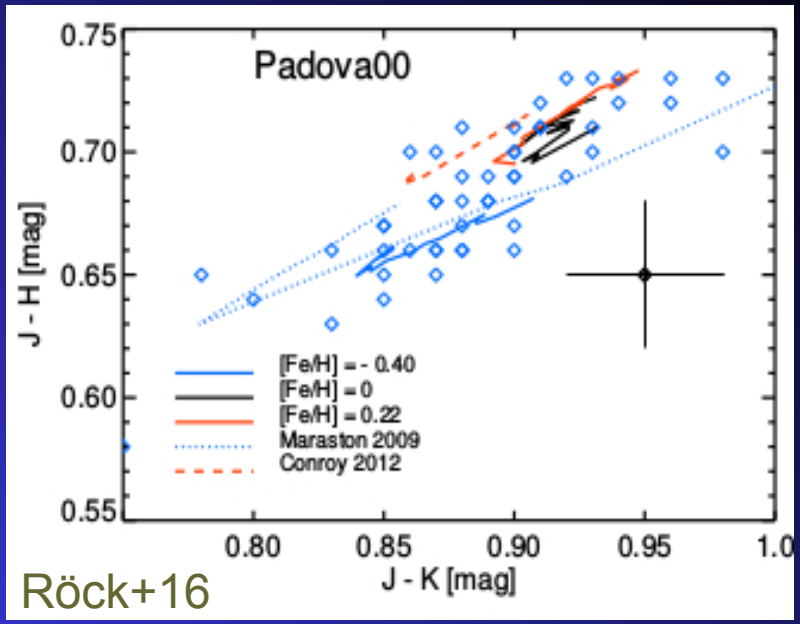
Line-strength indices in the J,H,K bands:



The Near-IR

Are there intermediate-age (AGB-dominated) stellar populations that go unnoticed in the optical range?

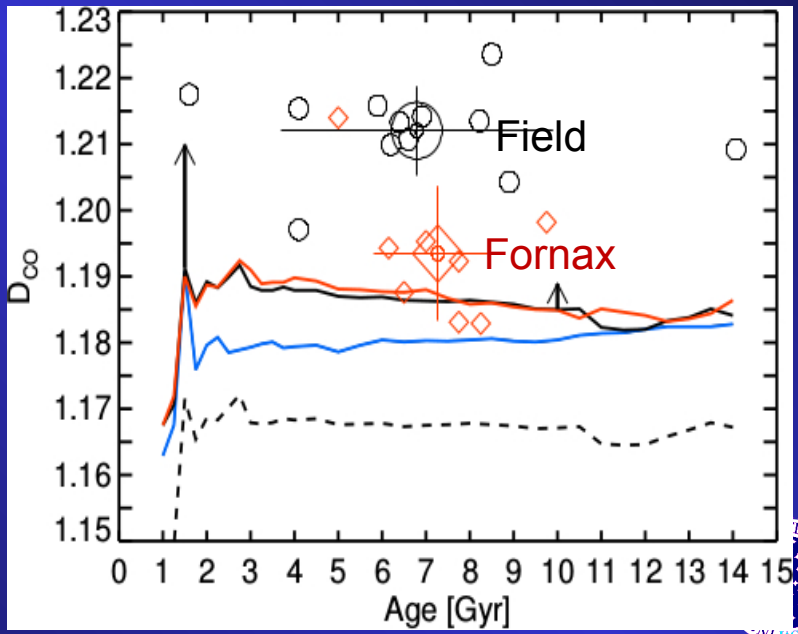
→ as claimed from Near-IR colours:
Good fits with single-burst like old stellar populations



→ as claimed from near-IR indices:

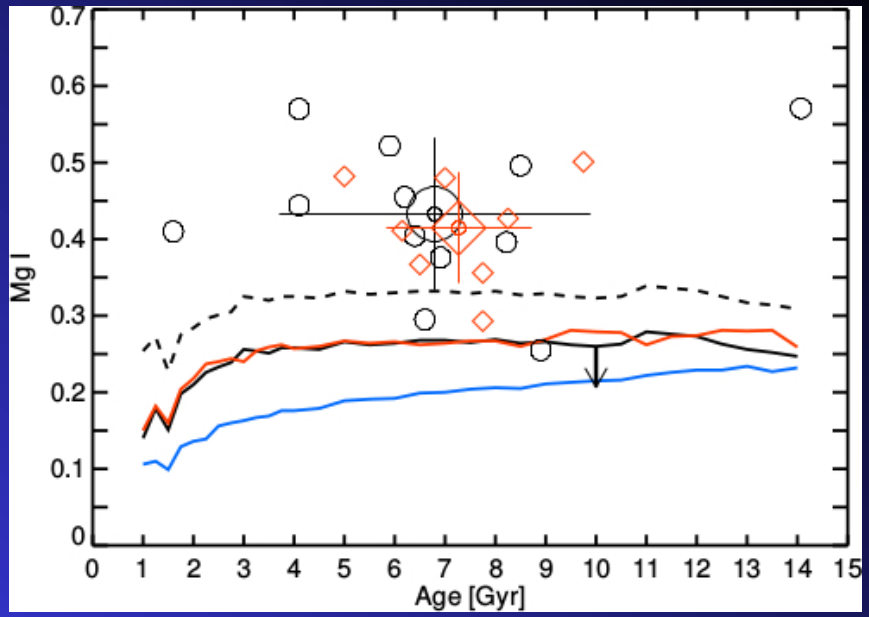
OLD + 3%(1Gyr + AGB-enhanced to 70% contribution) doesn't fit.

Field ETGs could only be fit with 100% 1Gyr (in strong disagreement with optical indicators, e.g. Hβ)

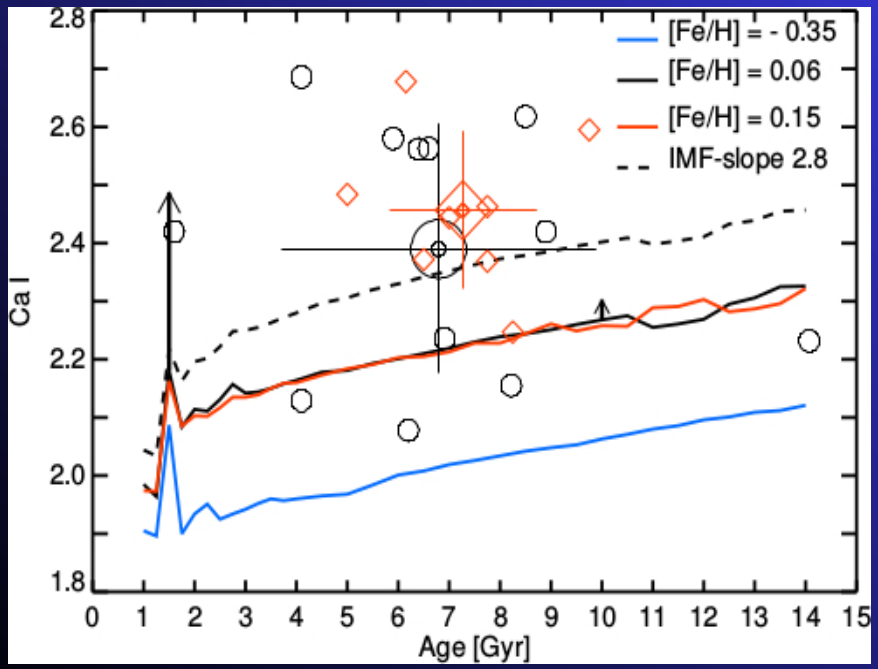


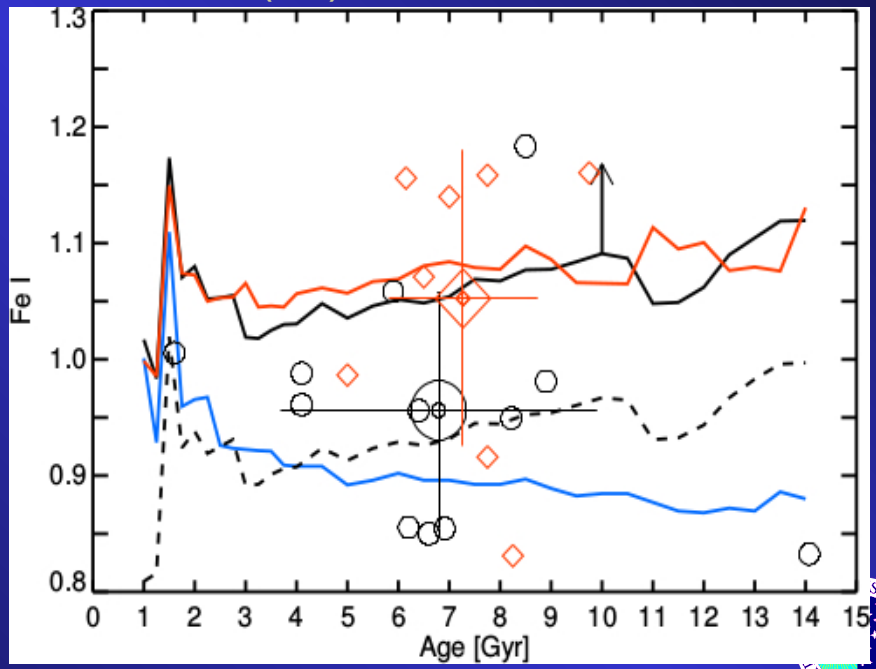
How about other line-strength indices in the K band?

- **The ~1Gyr model with enhanced AGB contribution doesn´t match other near-IR indices too.**
- **A bottom-heavy IMF improves the fits although it is not enough to fully match the data.**



Röck PhD Thesis (15)



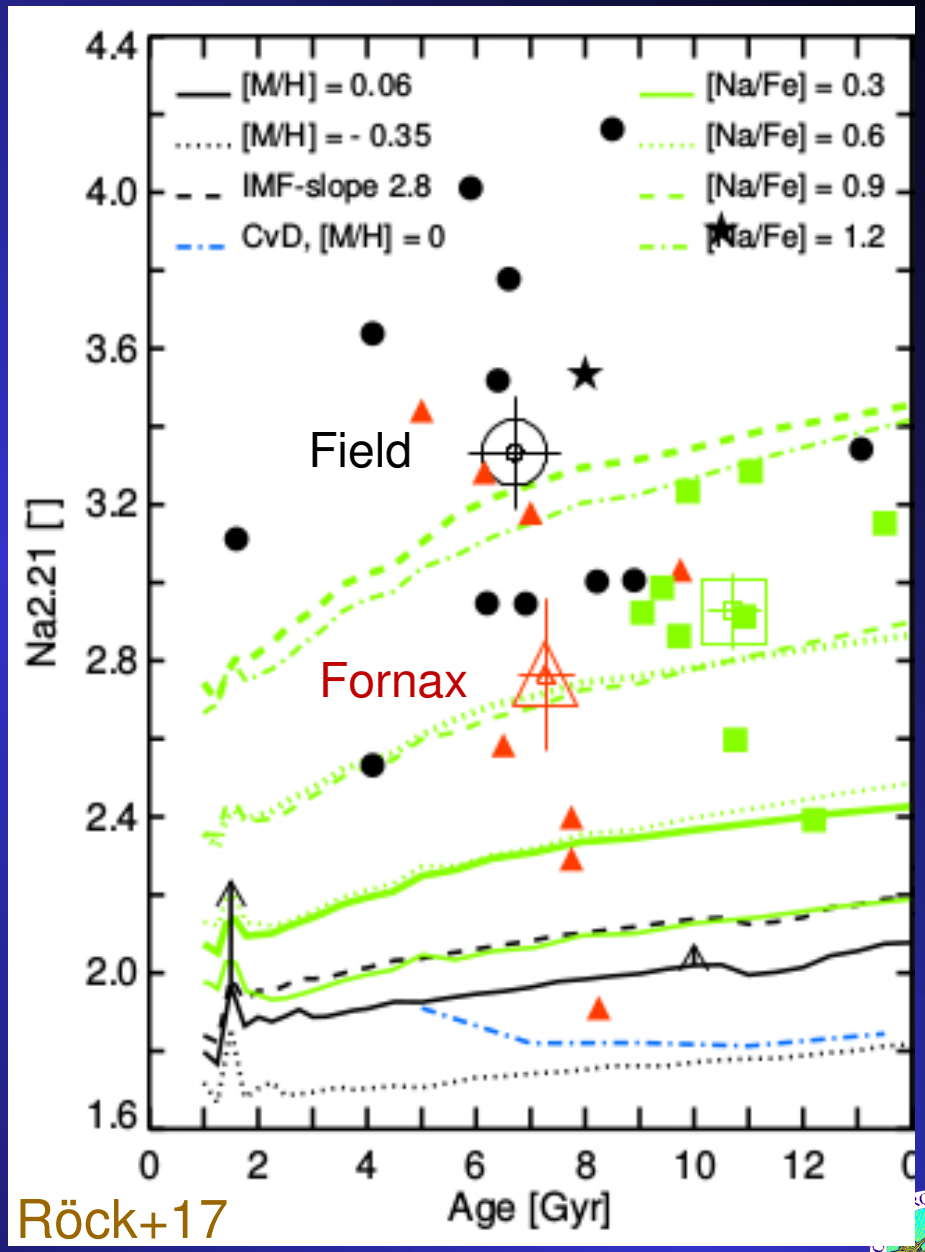


IMF – [Na/Fe] degeneracy:

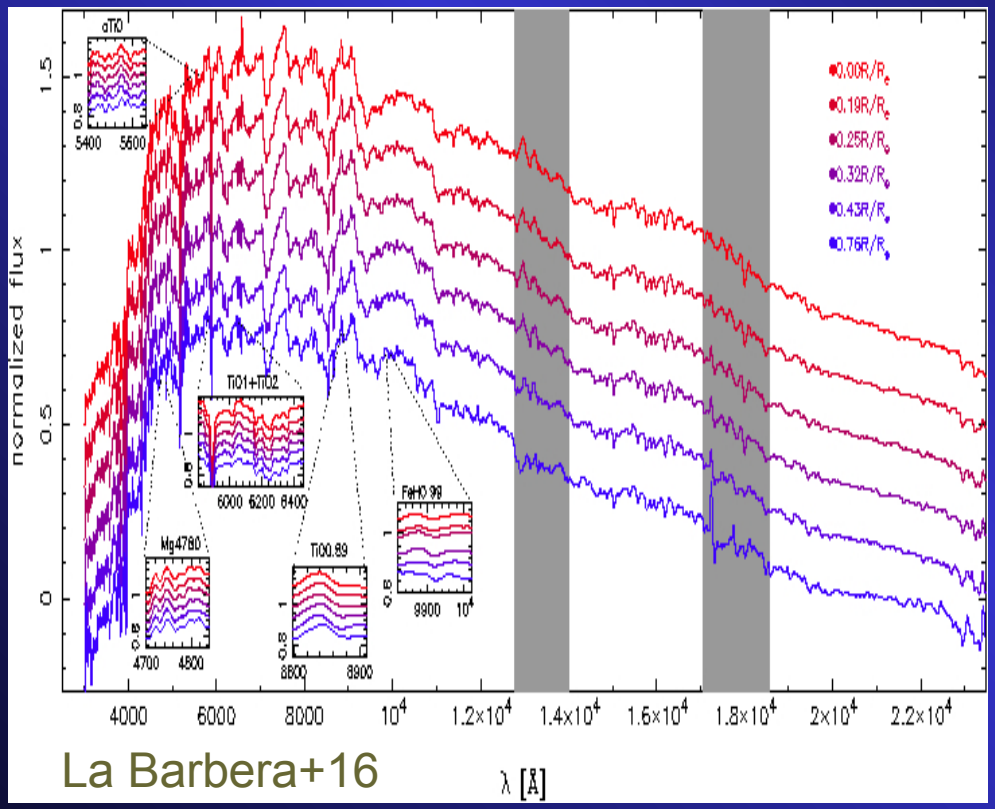
The fits obtained with steeper IMF slopes require lower [Na/Fe] abundance ratio enhancement.

And the difference between Fornax and Field can be attributed to [C/Fe]

Such environment-sensitive potential is unequaled in the optical spectral range!

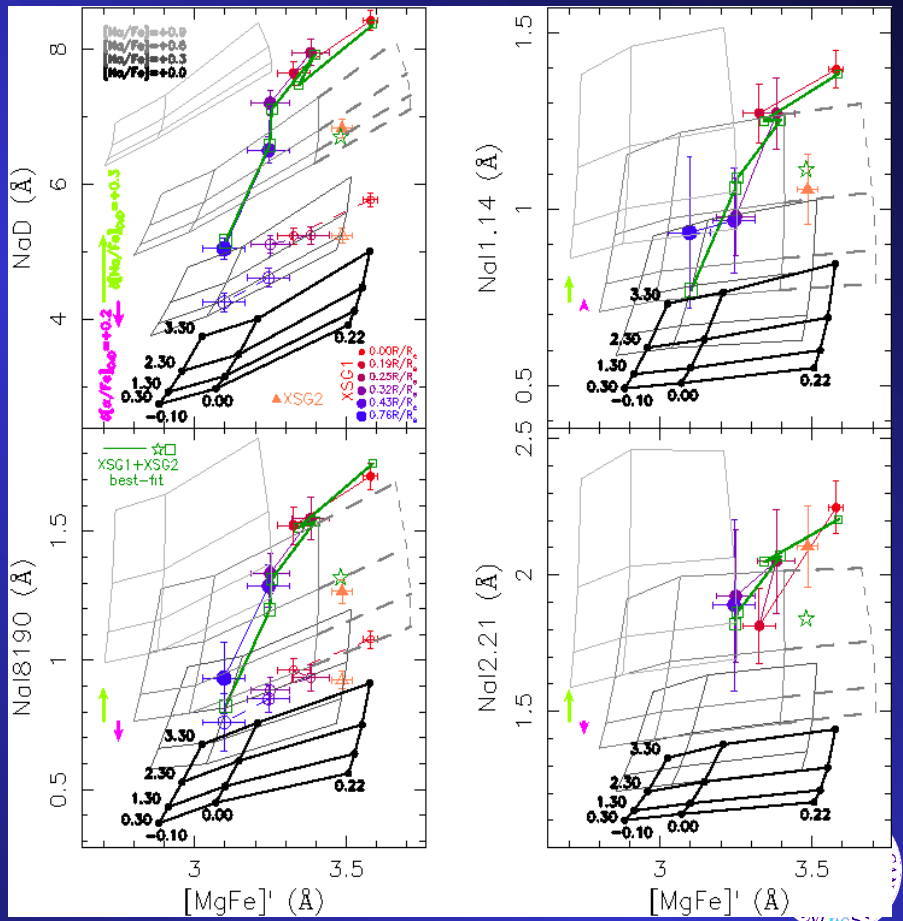


IMF gradients in massive ETGs from their Na lines



La Barbera+16

- Extremely high S/N (>400) X-shooter@VLT spectra.
- Extreme galaxy in the Mass-Size and M/L – σ planes

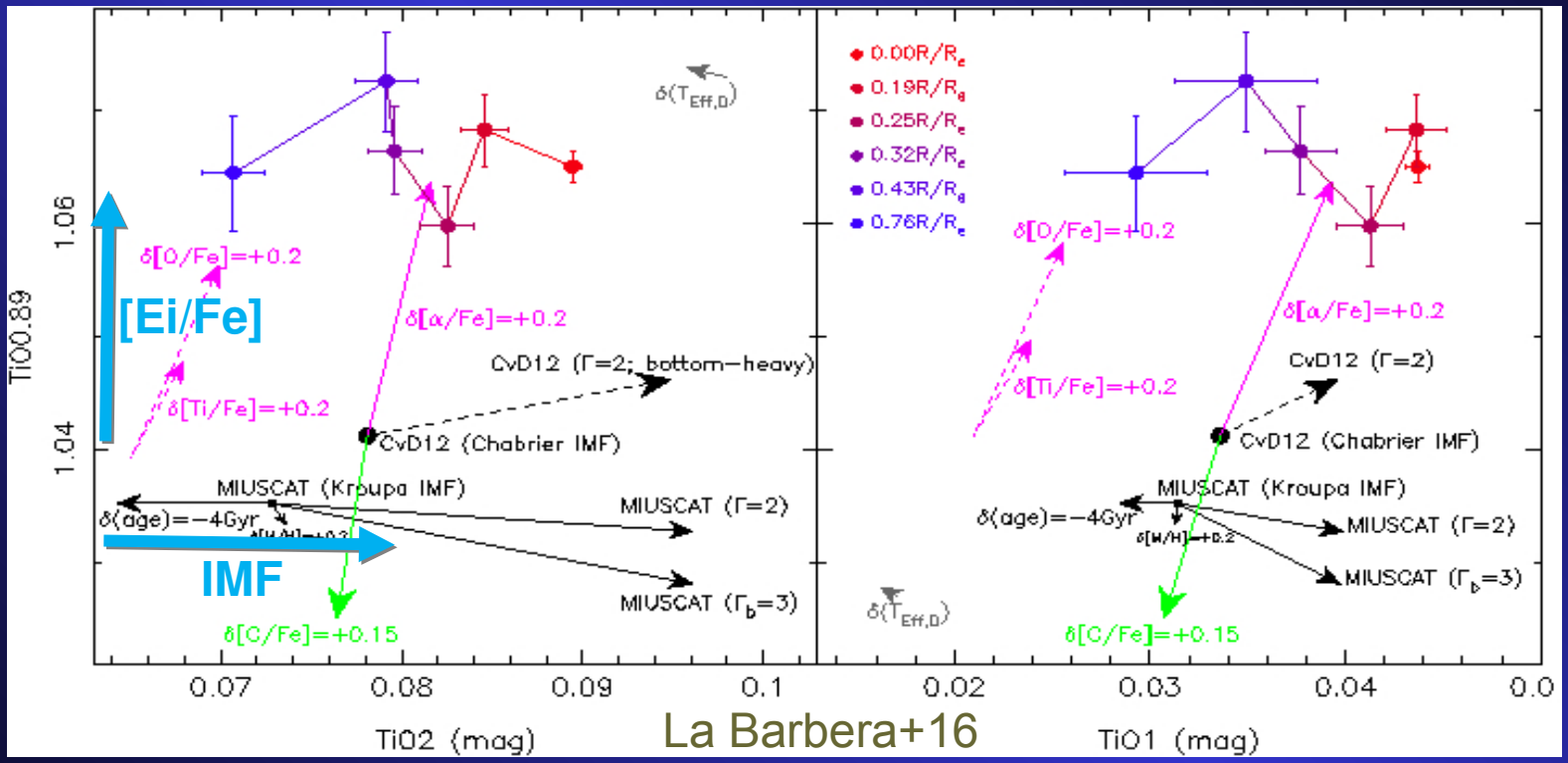


- The four Na line indices in the R, I, J and K bands can be matched with a bottom-heavy IMF and [Na/Fe]~0.6.
- The results are consistent with other IMF indicators

La Barbera+17

Separating IMF and abundance ratio effects

Combining near-IR & optical IMF-sensitive indices we orthogonalize the IMF and abundance ratios effects:



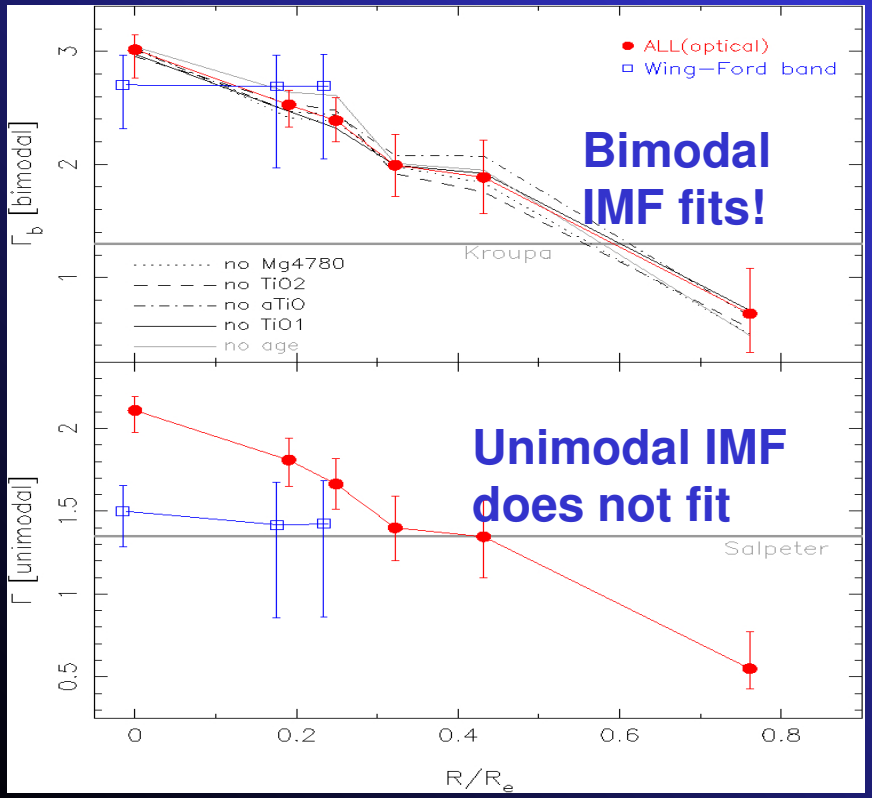
IMF varies with radius in massive ETGs: it is a local property!. Bottom-heavy in the center & MW-like at >0.5Re (Martín-Navarro+15a; La Barbera+16) , which suggests different formation scenarios for inner/outer parts

Constraining the lower mass end of the IMF shape

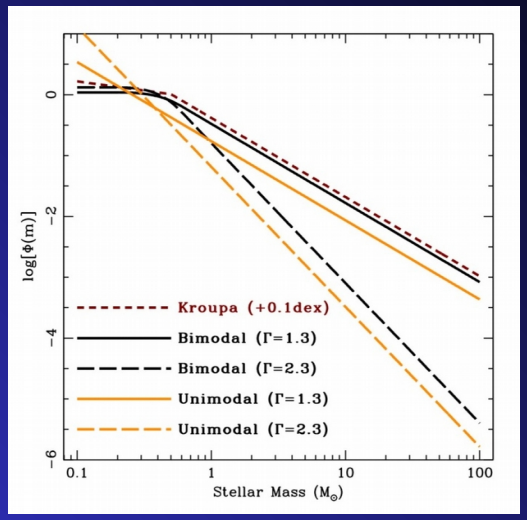
From the optical range we constrain the fraction of stars with M<0.5Mo

- **Bottom-heavy, single power-law "unimodal" IMFs lead too high M/L**
- **Low-mass tappered "bimodal" IMFs provide galaxy masses that agree with dynamical masses**

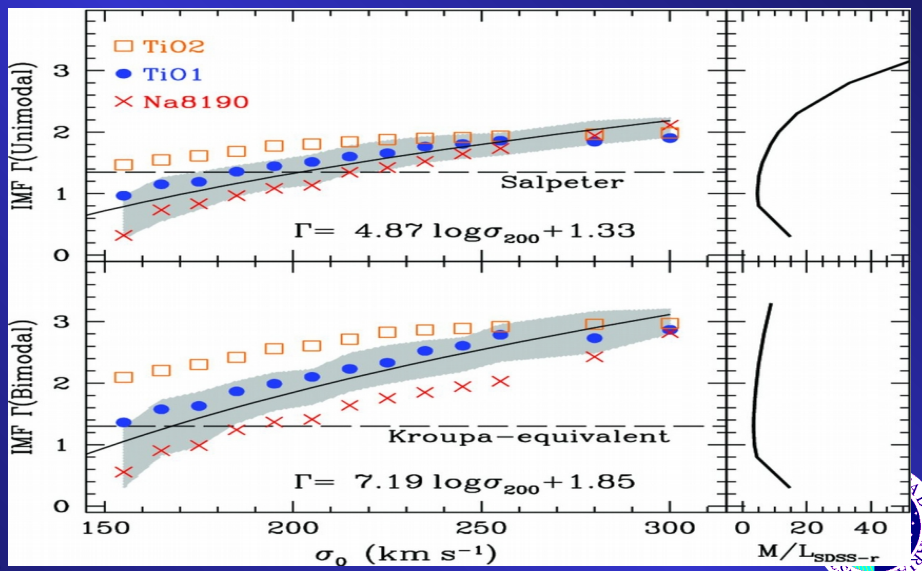
With near-IR IMF-sensitive indices we can also constrain the low-mass end IMF shape.



La Barbera+16



Ferreras+13



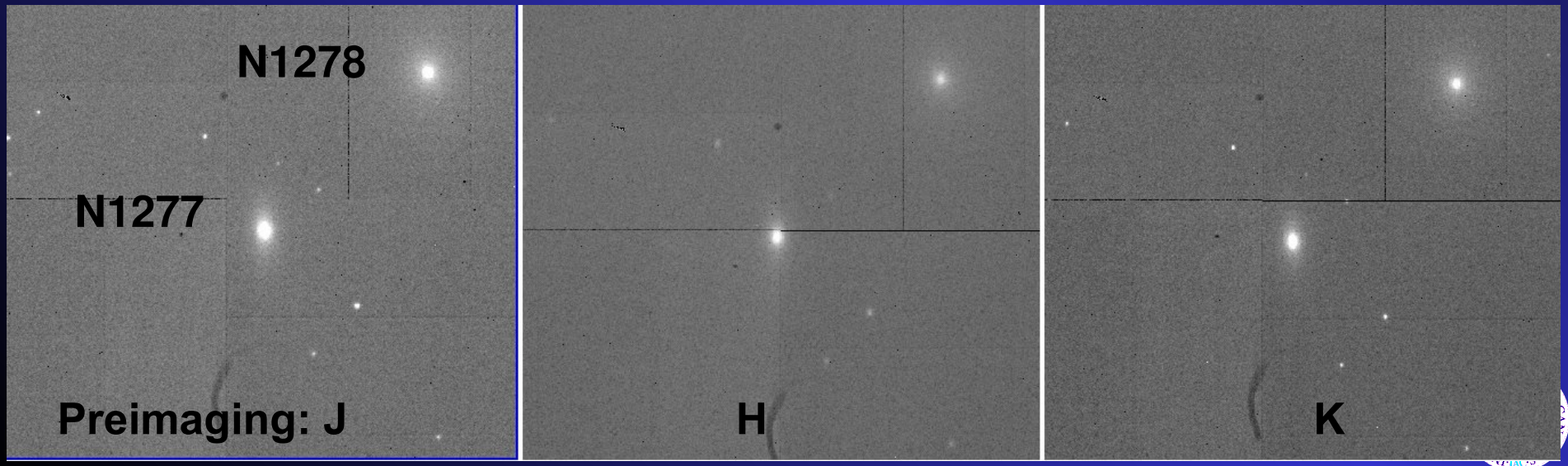
EMIR data of NGC1277

Mean surface brightness in 1 Re: J=14.8 mag arcsec^{-2}, H=14.1,K=13.7

- Total exposure time: 5760s in J, 4320s in H and 3840s in K
- Slit = 0.6 ", Seeing ~ 0.7-0.8", bright time, airmass~1.3. Nodded:ABBA
- Resolution: J~5200, H~4300, K~4000

Preliminary reduction (only to show it here by Mike Beasley):

- Extraction 30pix ~1Re (0.19 "/pix =5.7 " = 2kpc at Perseus).
- Sky subtracted, but NOT telluric corrected and NOT Flux-calibrated.



EMIR spectra of NGC1277

Top panels: counts. Bottom panels: SNR (counts / variance, 30 pix ~1Re, 120s). Measured SNR/pix > ETC expectation in all the bands!

