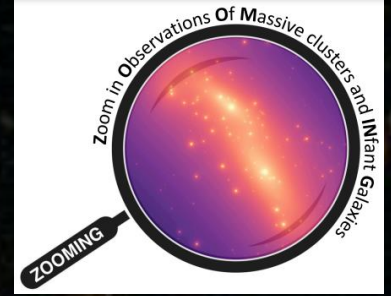




**Università  
degli Studi  
di Ferrara**



# Measuring the velocity dispersion function of red cluster galaxies with deep MUSE observations

Giovanni Granata, ICG Portsmouth

With the help of the ZOOMING collaboration

A decade of discoveries with MUSE and beyond, ESO, 19/11/2024

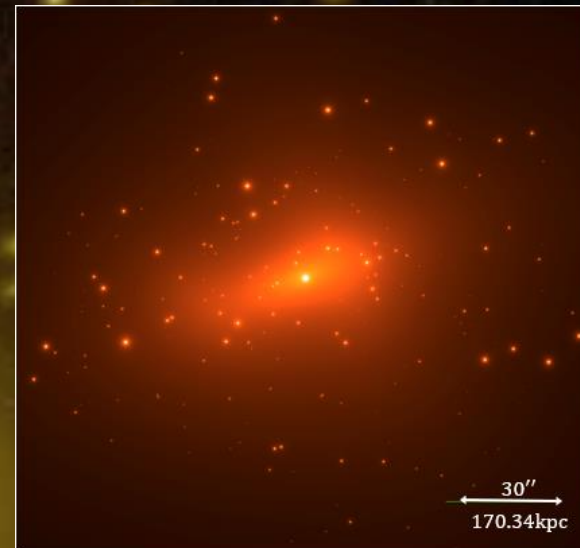
# Stellar kinematics of cluster galaxies

- Stellar kinematics of cluster galaxies enhances their description in SL models ([see previous talk by P. Bergamini](#))

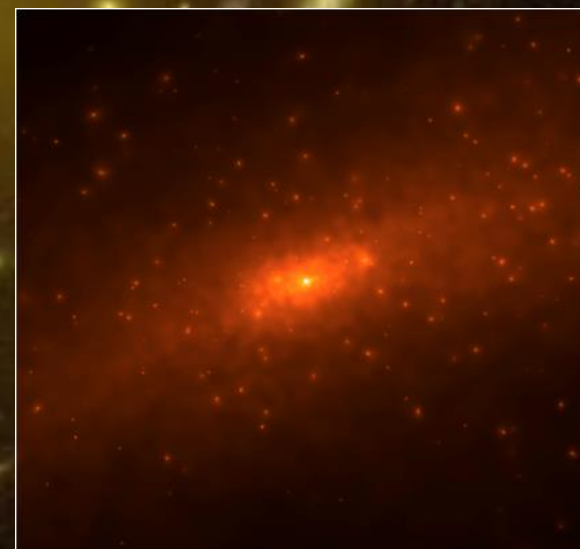


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MACS J0416  
lensing model  
(Bergamini+19)

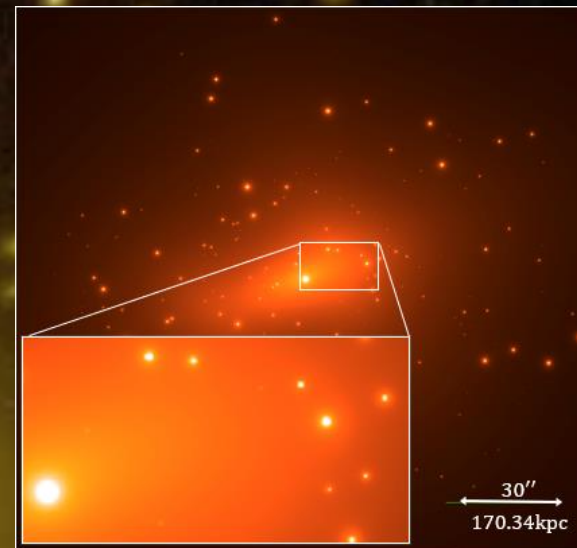


Cluster from  
Dianoga  
simulation,  
(Planelles+14,  
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Credits: P.  
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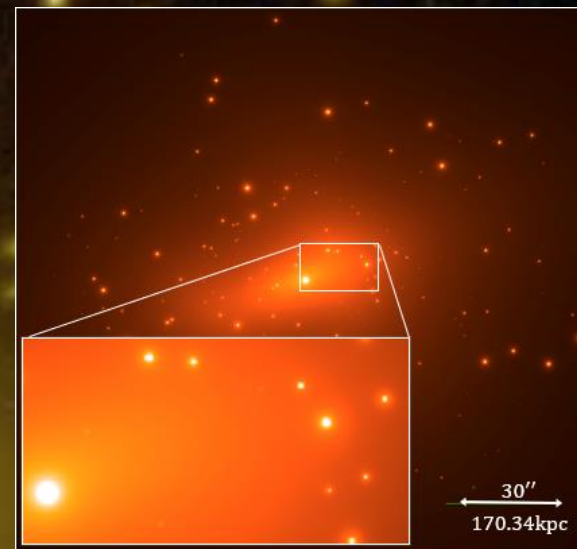
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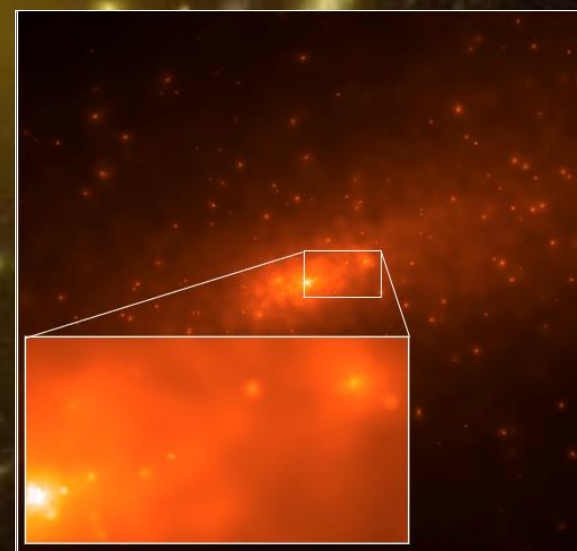


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- Stellar kinematics of cluster galaxies enhances their description in SL models (see previous talk by P. Bergamini)
- Meneghetti+20: cluster galaxies in lensing models are more compact than in the Dianoga hydro simulations
- Stellar kinematics provides us with an independent probe of the mass structure of cluster galaxies



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# Selection of the cluster sample

- Hubble Frontier Fields photometry (**HFF**, Lotz+17) and deep (5+ hrs) MUSE obs.



Abell 2744

$z=0.31$



MACS J0416.1-2403

$z=0.40$



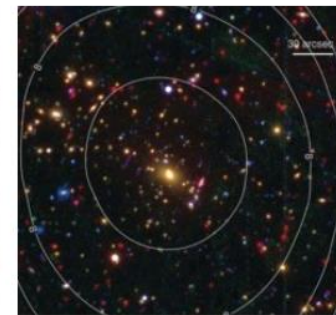
MACS J0717.5+3745

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17h MUSE

5h MUSE

5h MUSE



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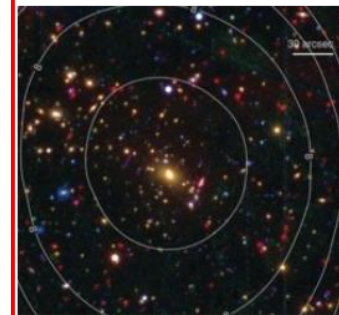
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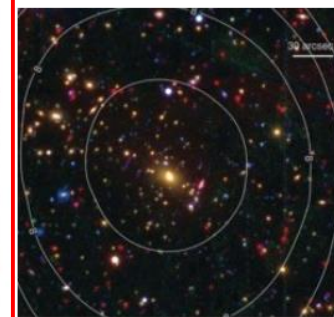
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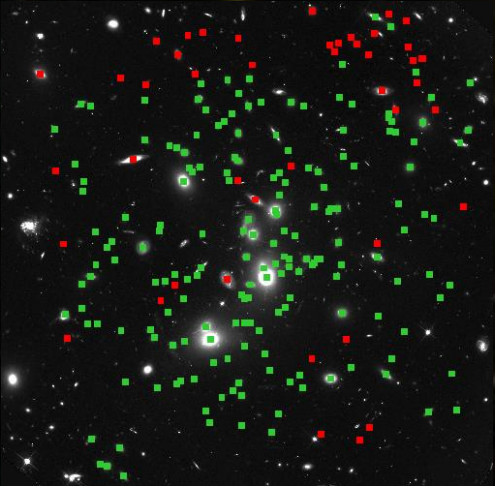
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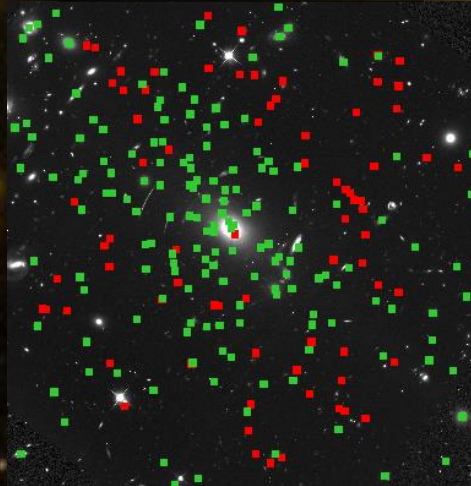
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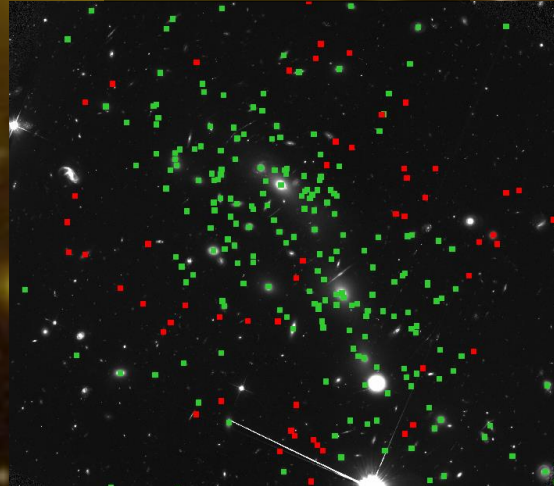
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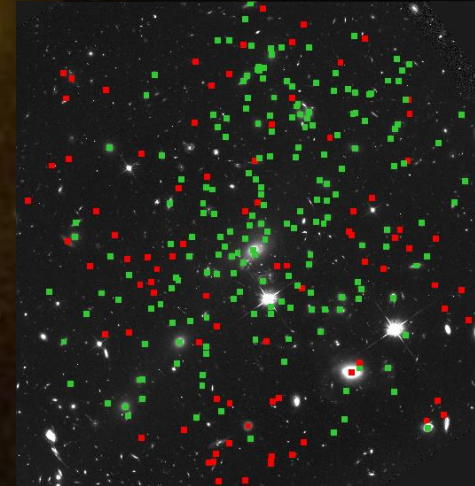
**Abell S1063**



**MACSJ0416**



**MACSJ1149**

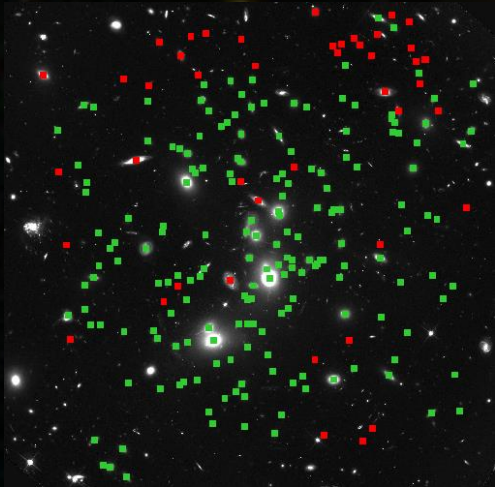




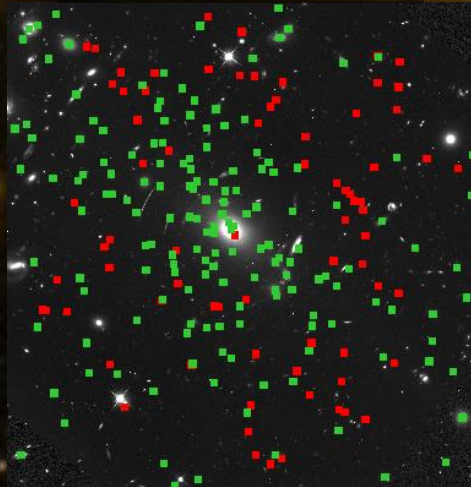
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- We measured the **structural parameters in all HFF bands for all members** with **MORPHOFIT** (Tortorelli&Mercurio23), based on Galfit

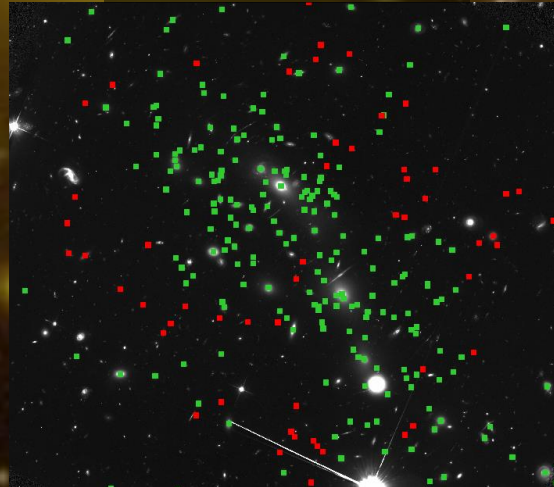
**Abell 2744**



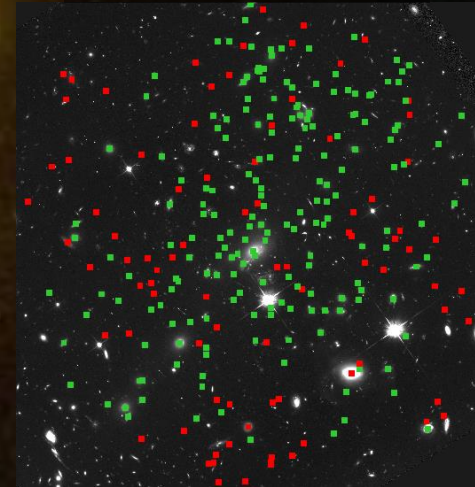
**Abell S1063**



**MACSJ0416**



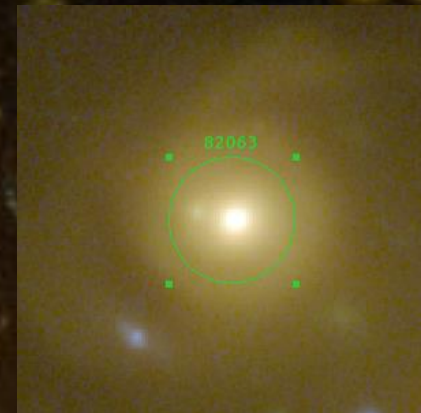
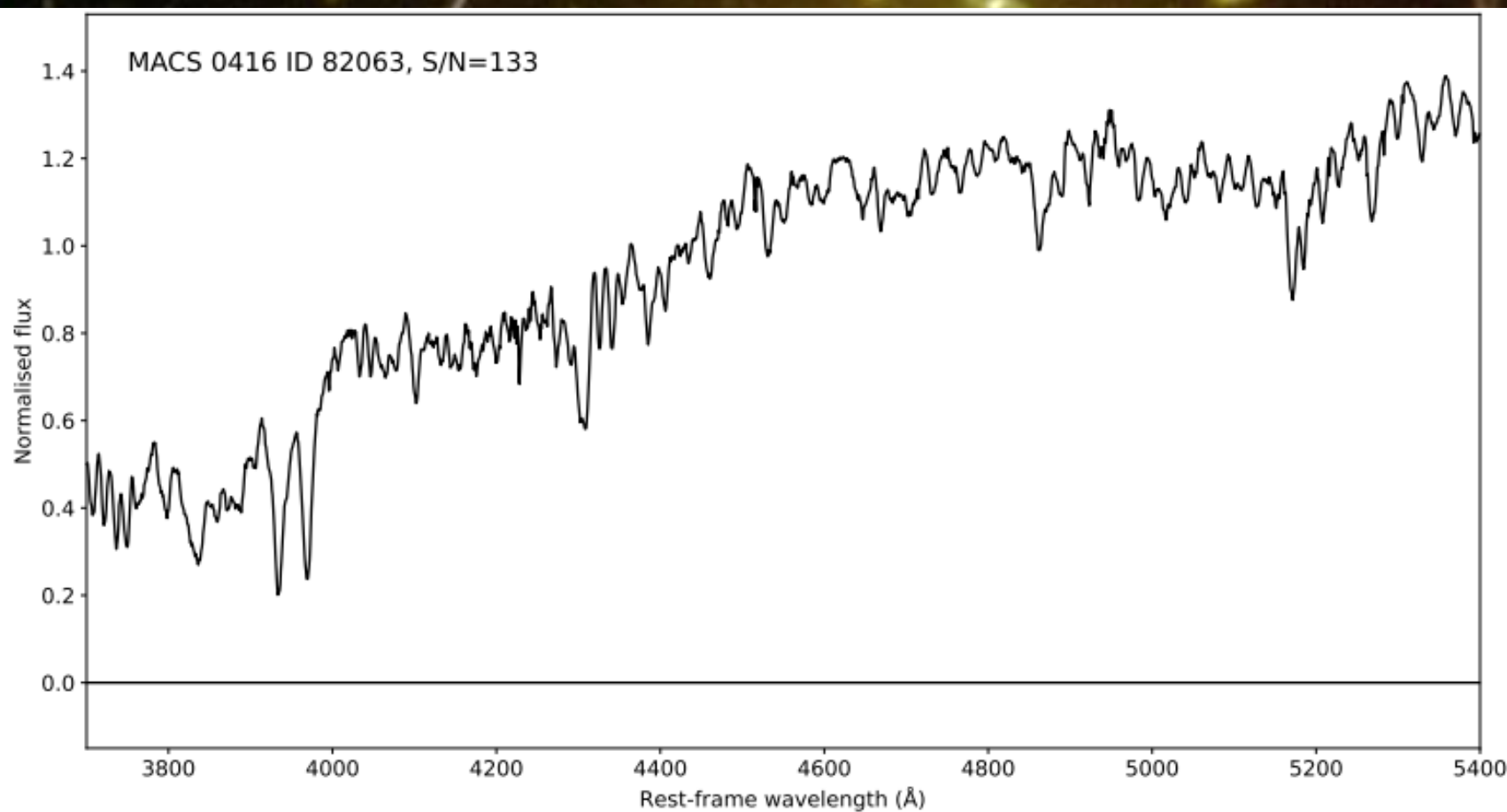
**MACSJ1149**





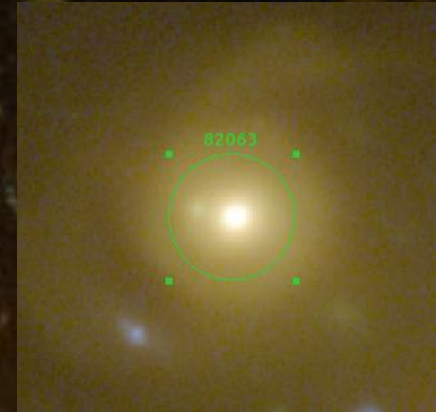
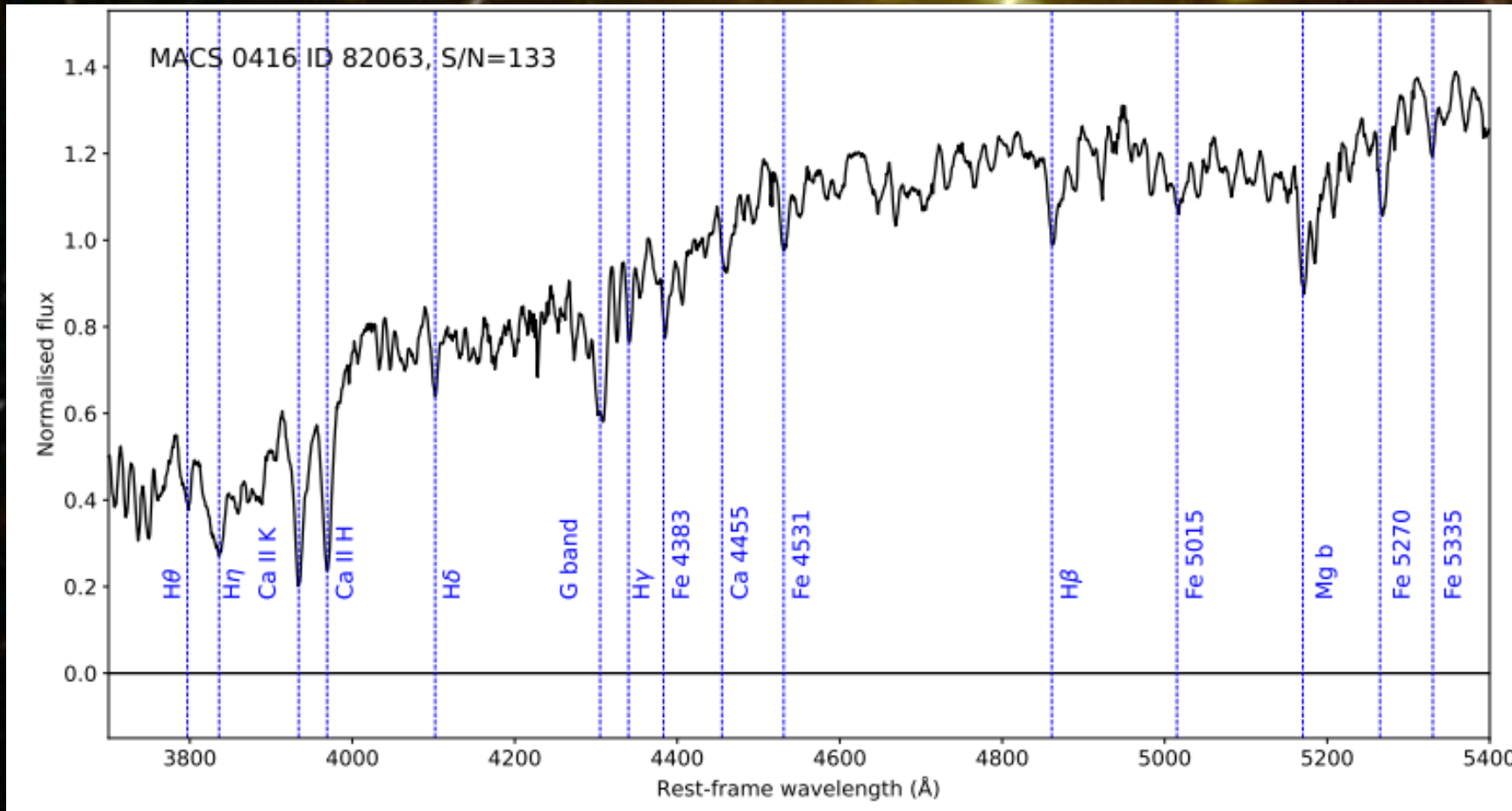
# Stellar kinematics of the members

- Given the depth of the MUSE data, we can **extract high-S/N spectra for tens of members**



# Stellar kinematics of the members

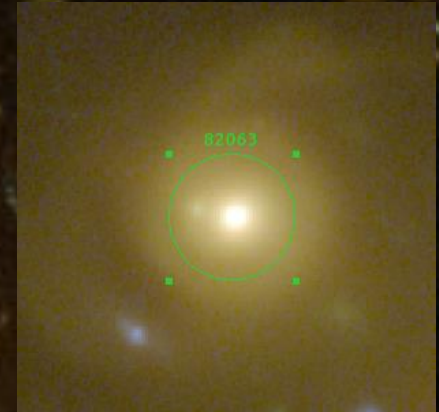
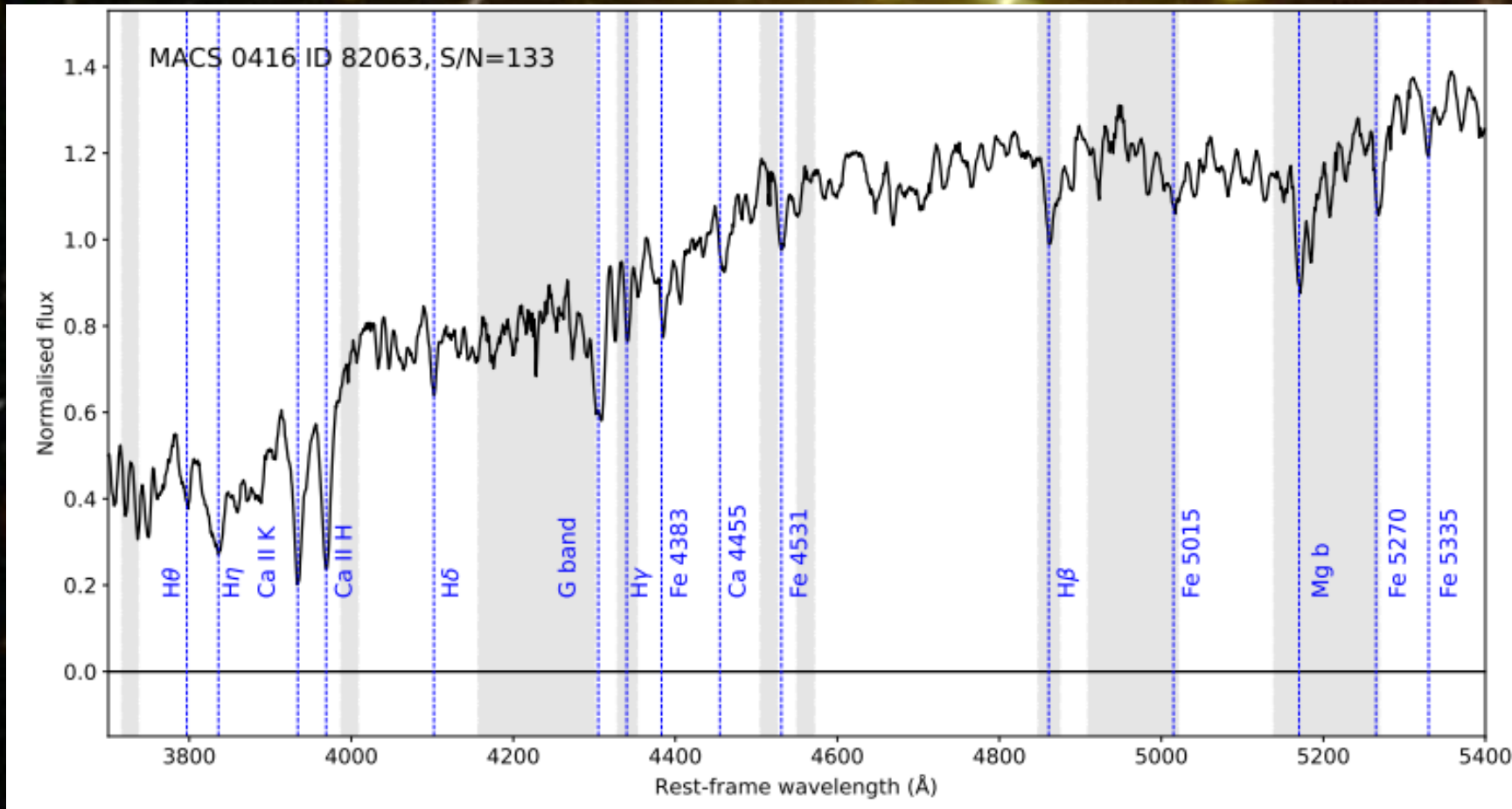
- Several absorption features are available in the MUSE wavelength range





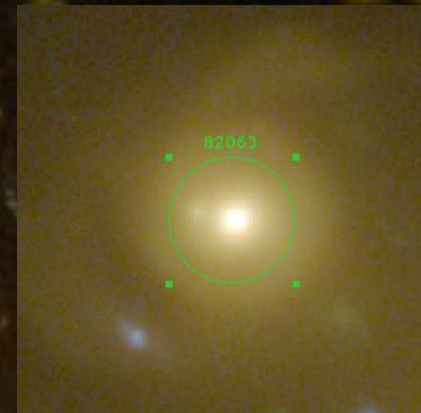
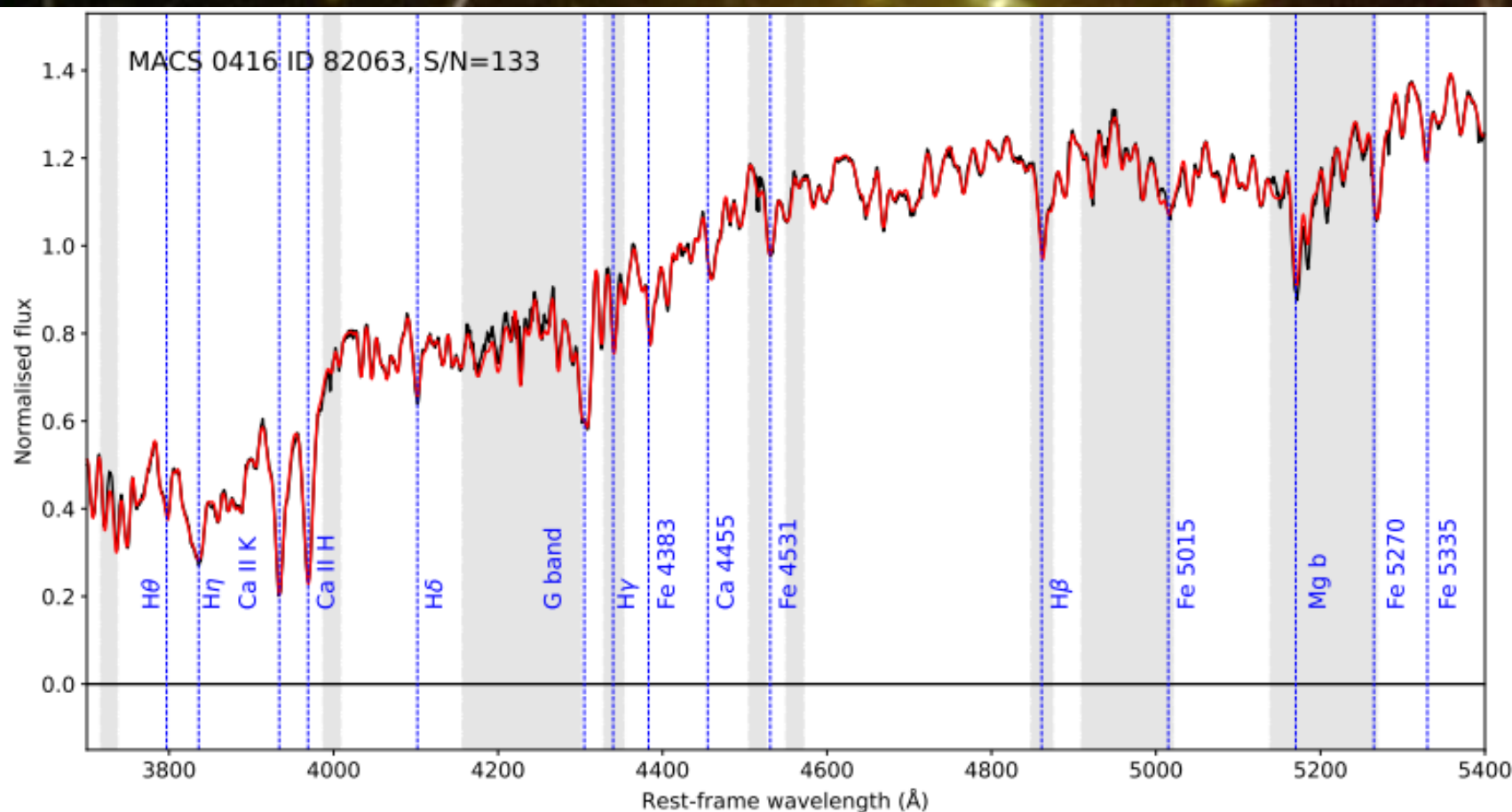
# Stellar kinematics of the members

- We mask spectral regions potentially affected by **issues with sky subtraction.**



# Stellar kinematics of the members

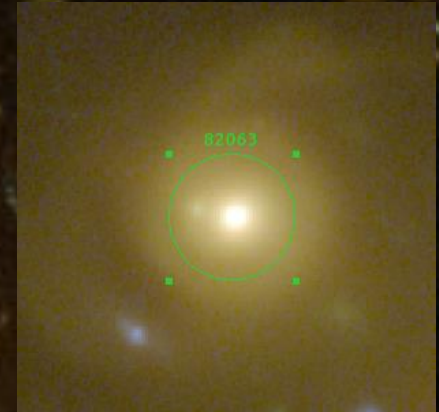
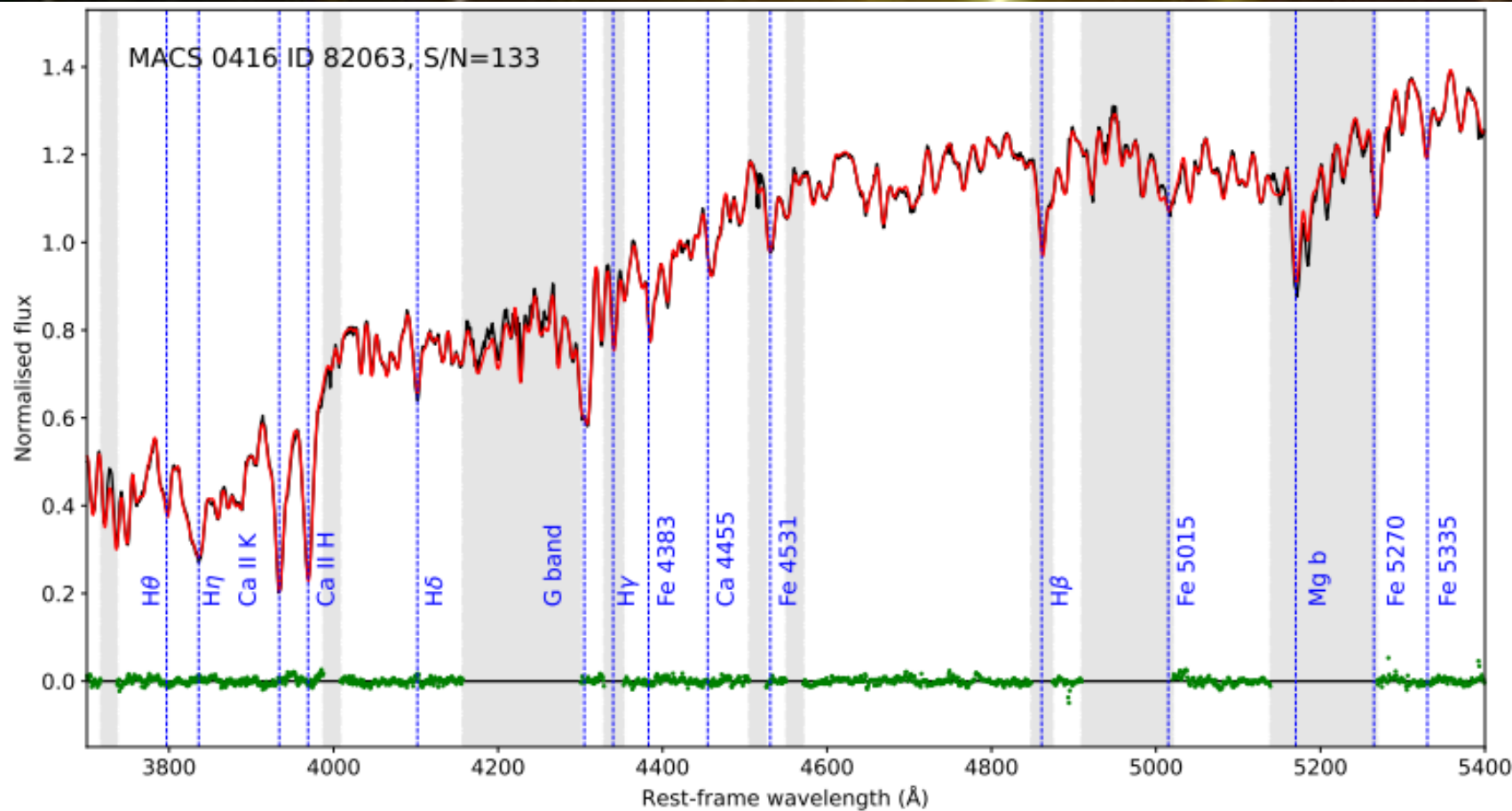
- We fit the stellar population of the member with X-Shooter library stellar templates (Gonneau+20) and the LOS velocity dispersion using pPXF. Cappellari&Emsellem04





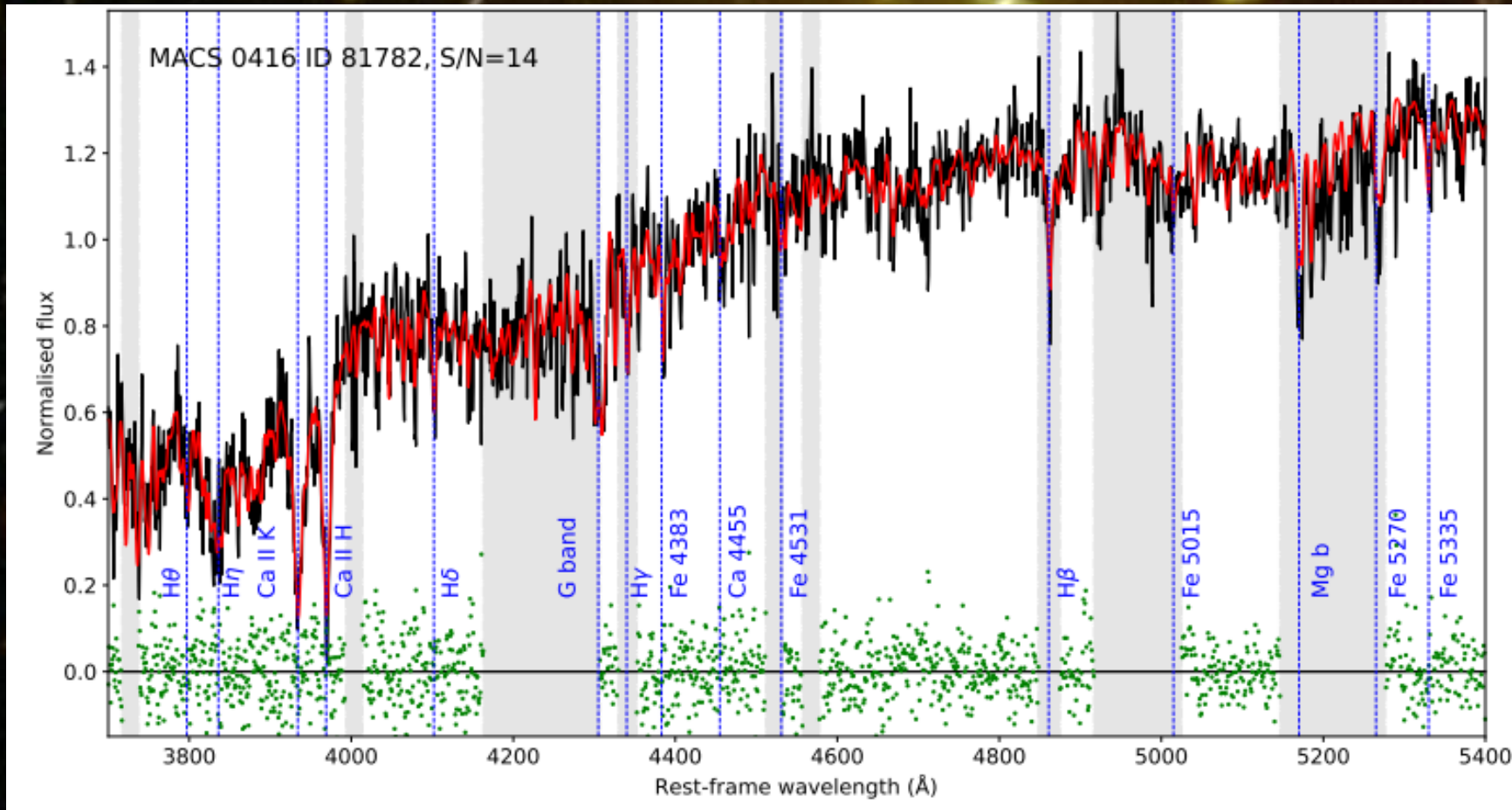
# Stellar kinematics of the members

- The residuals are very small in all the spectral regions we fit



# Stellar kinematics of the members

- How far can we push our measurements in terms of S/N?



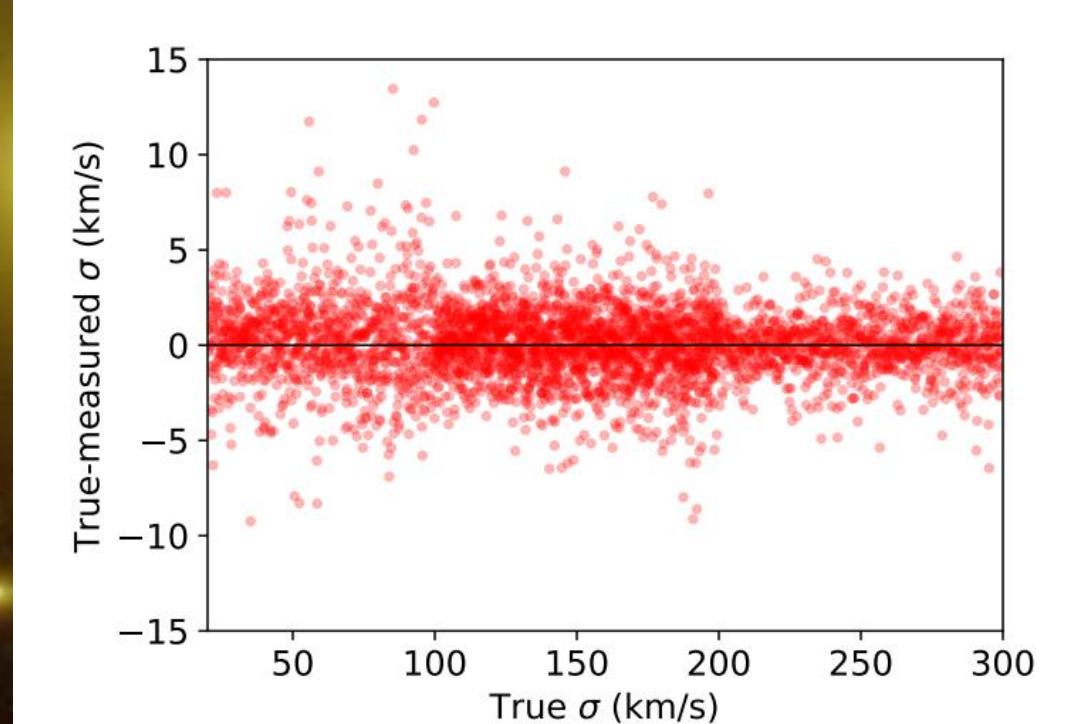
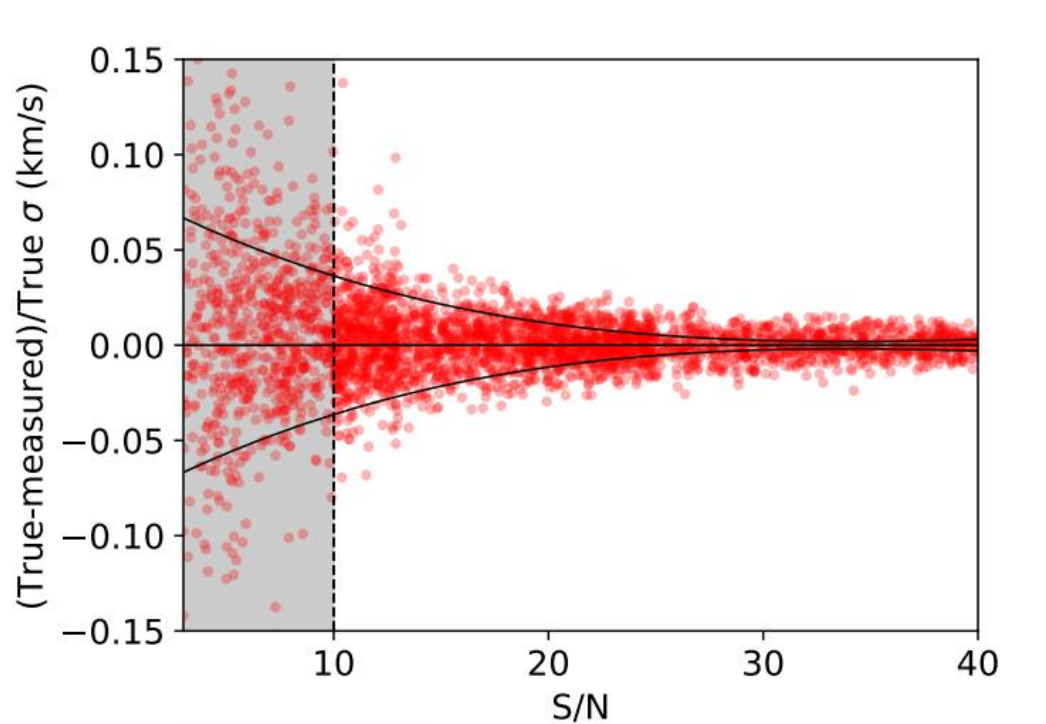


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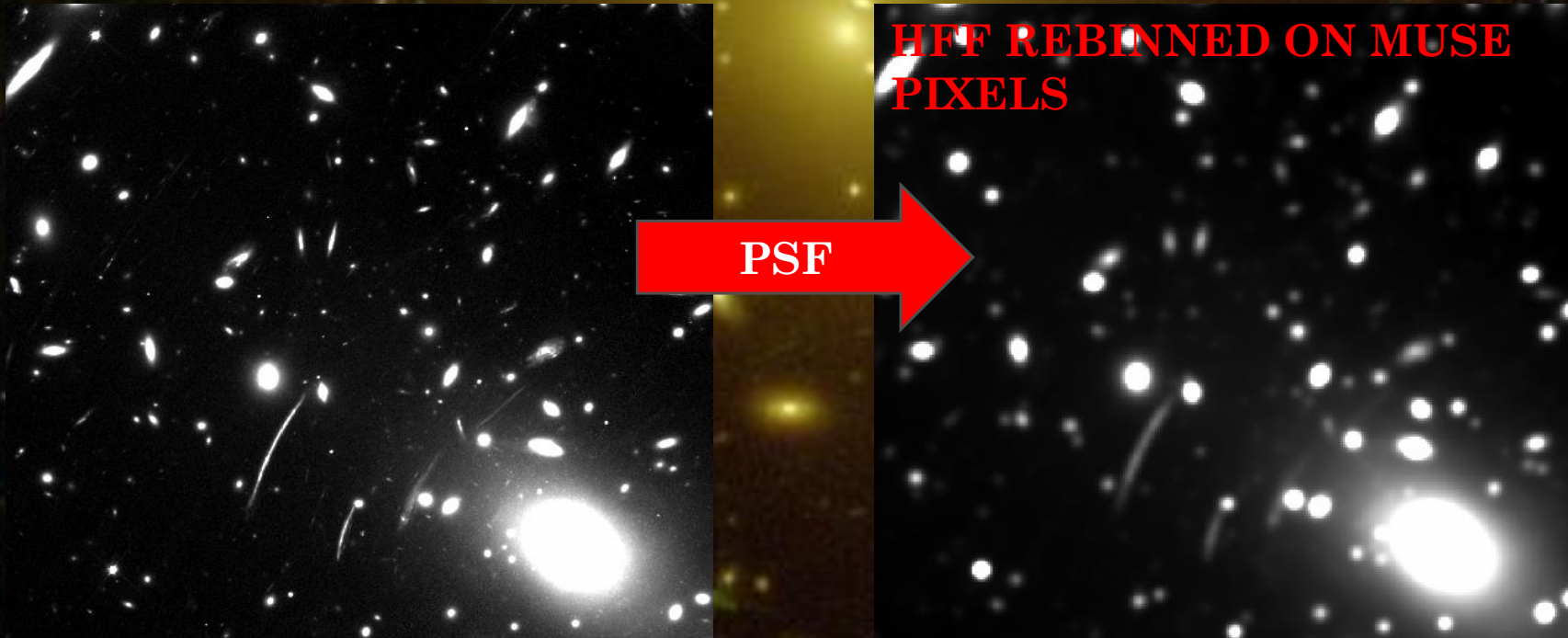
# Stellar kinematics of the members

- We use the **HST F814W light distribution** of the cluster members to **weigh the spectra** and extract from  $1.5''$  apertures.



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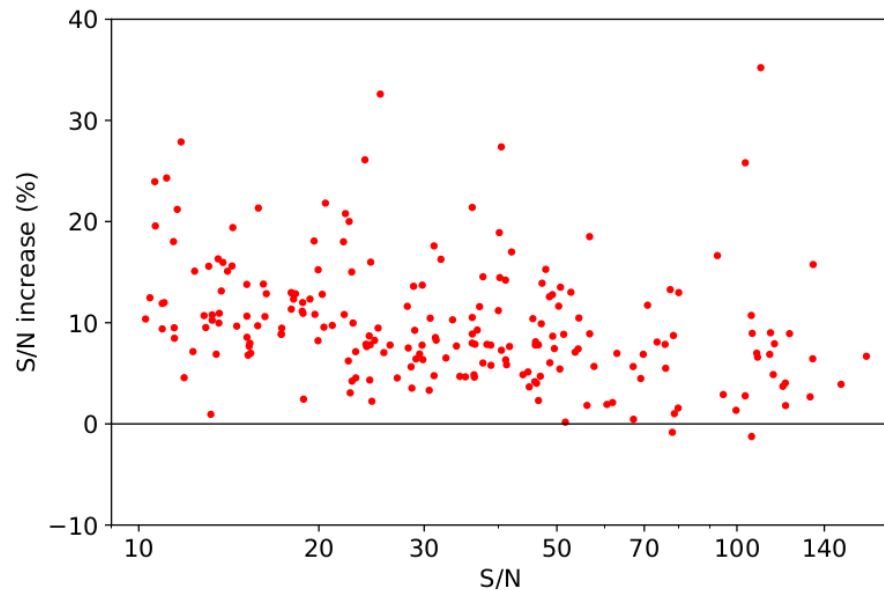


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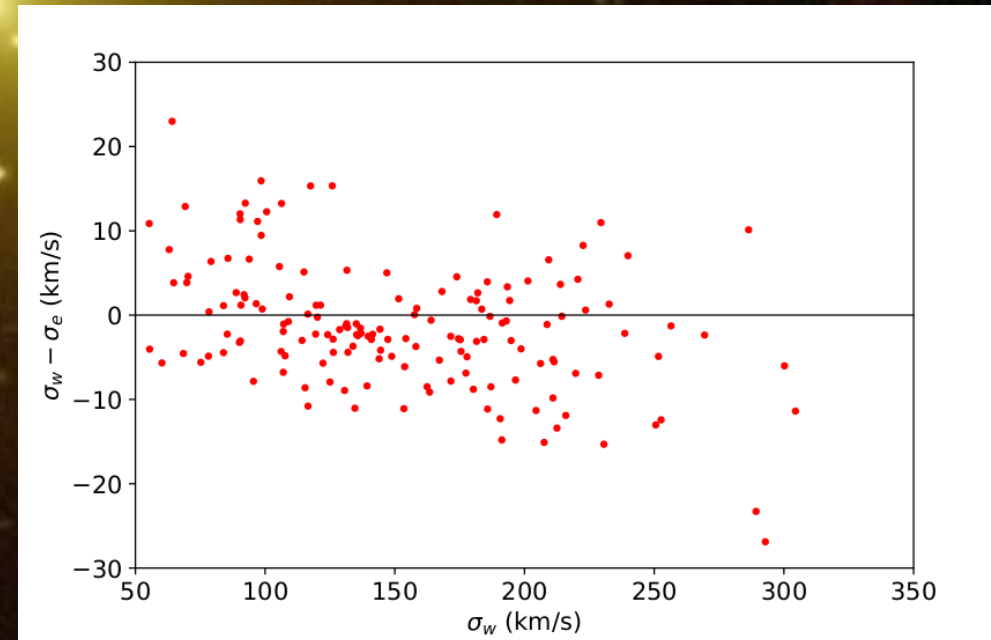
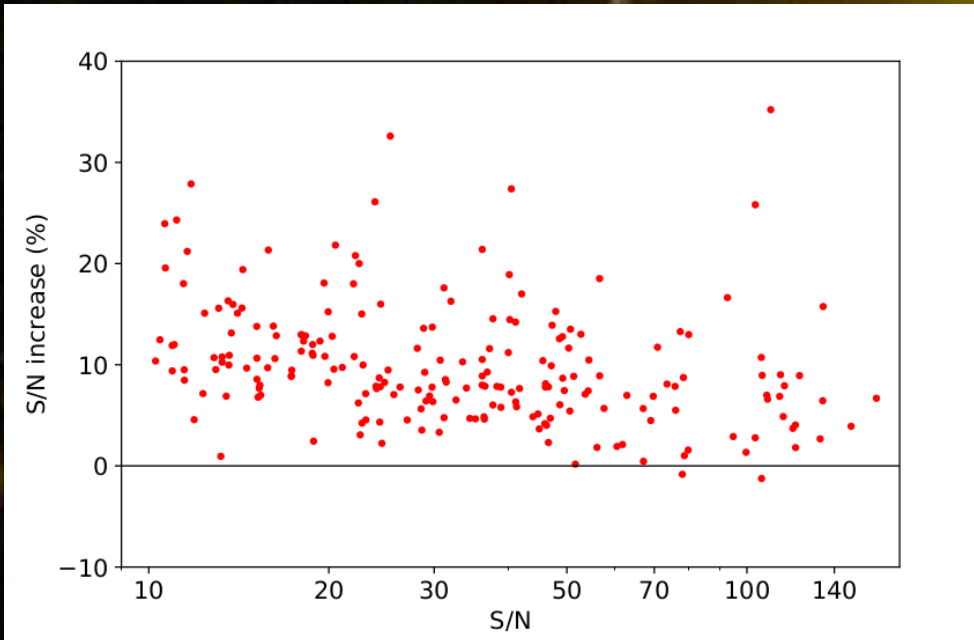
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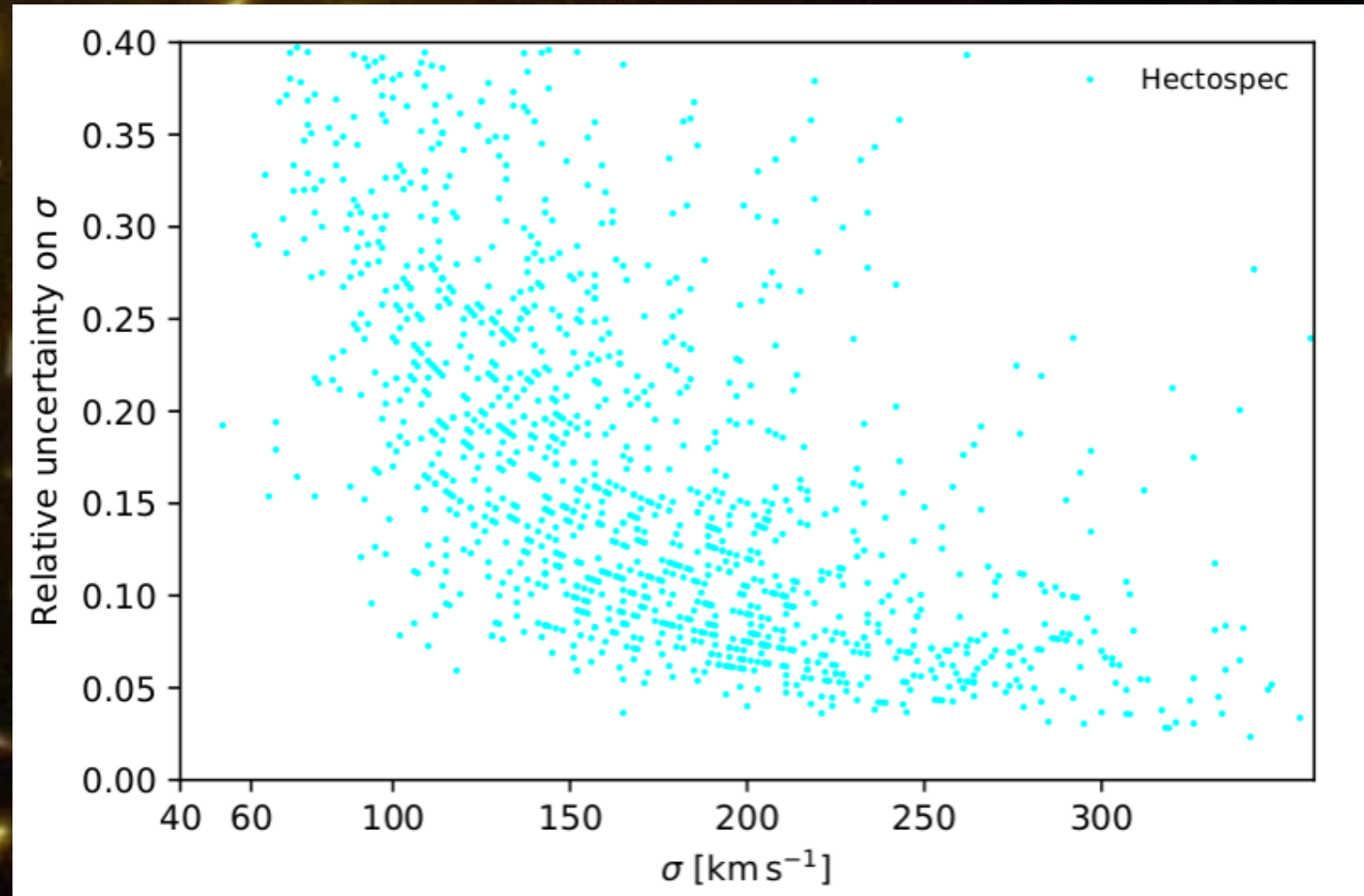
# Measured LOSVD of cluster galaxies

- Comparison with Hectospec obs. of nine SL clusters at  $z = 0.18 - 0.29$  (Sohn+20)



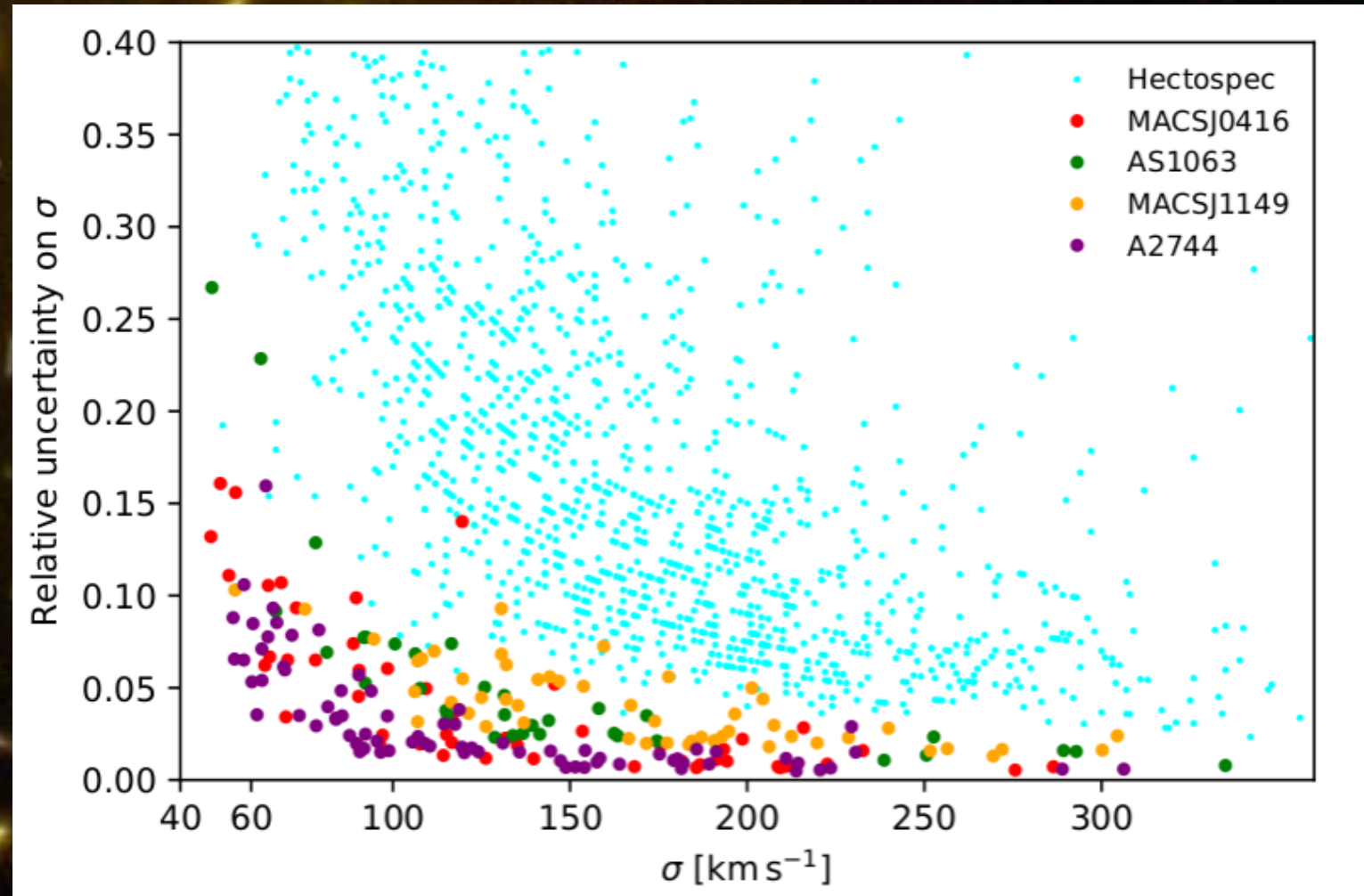
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- We can push to  $\sigma$  values below  $100 \text{ km s}^{-1}$  with  $<5\%$  uncertainty.



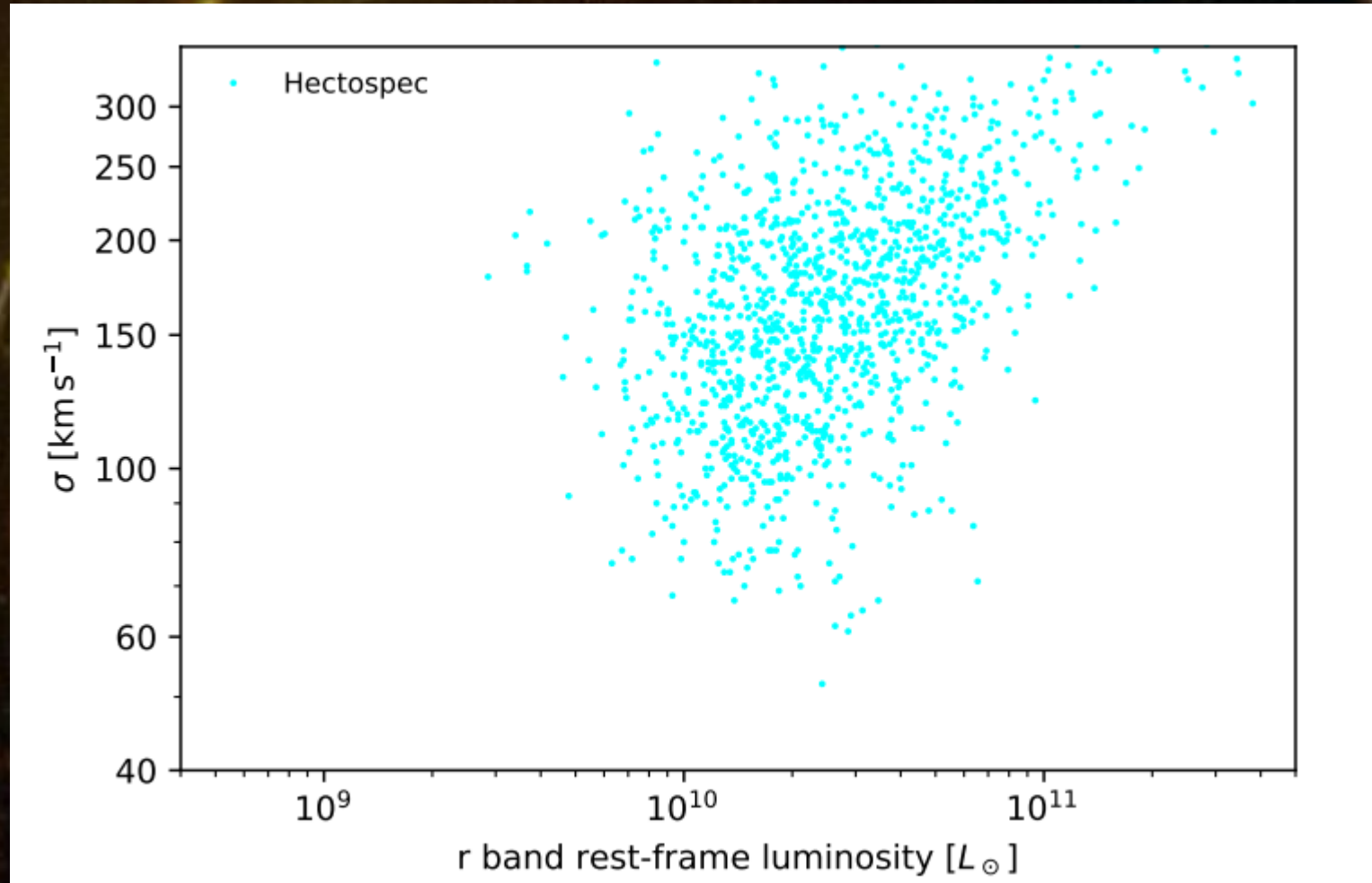


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- We can push one order of magnitude towards fainter luminosity/stellar mass.

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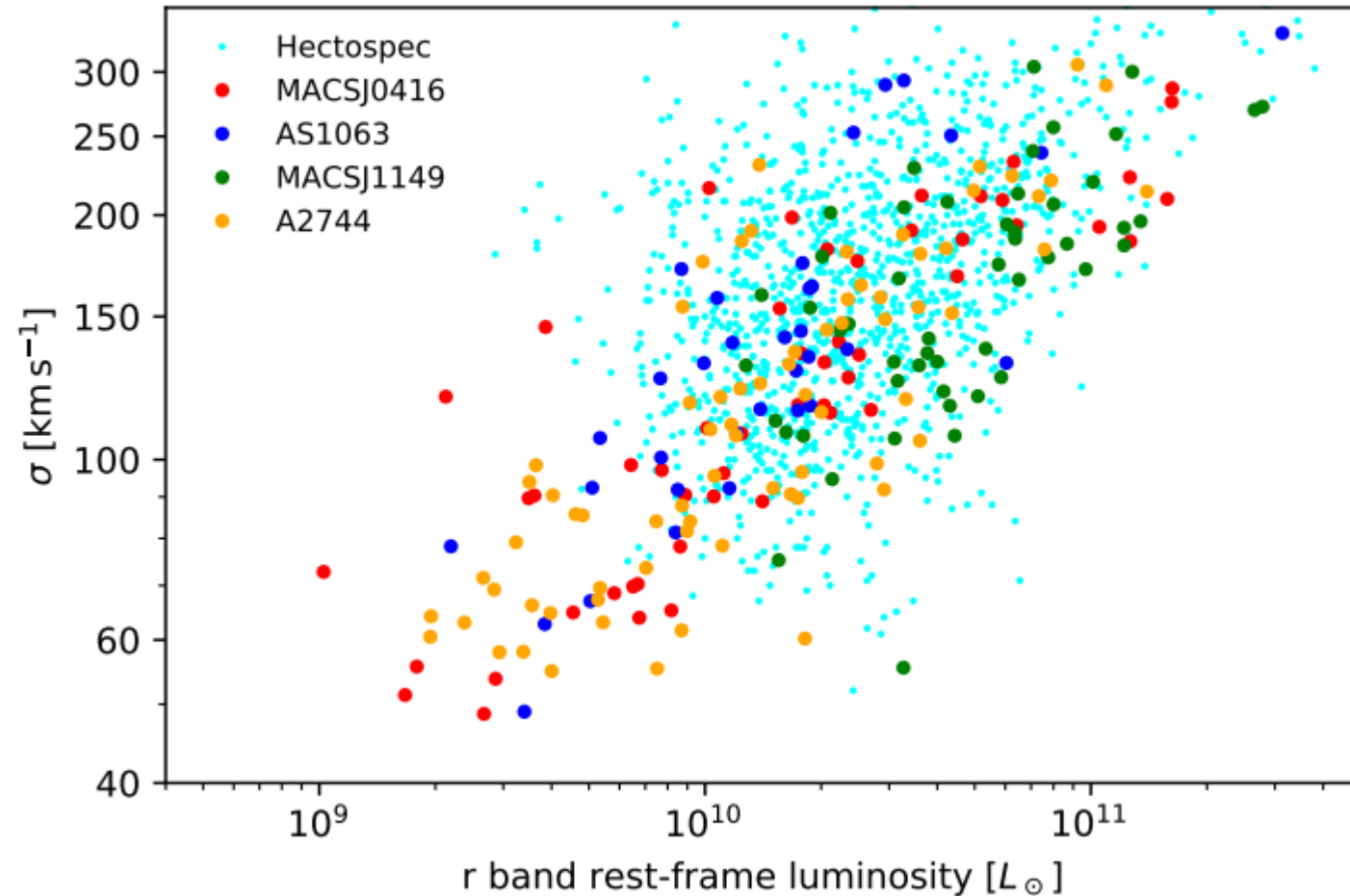
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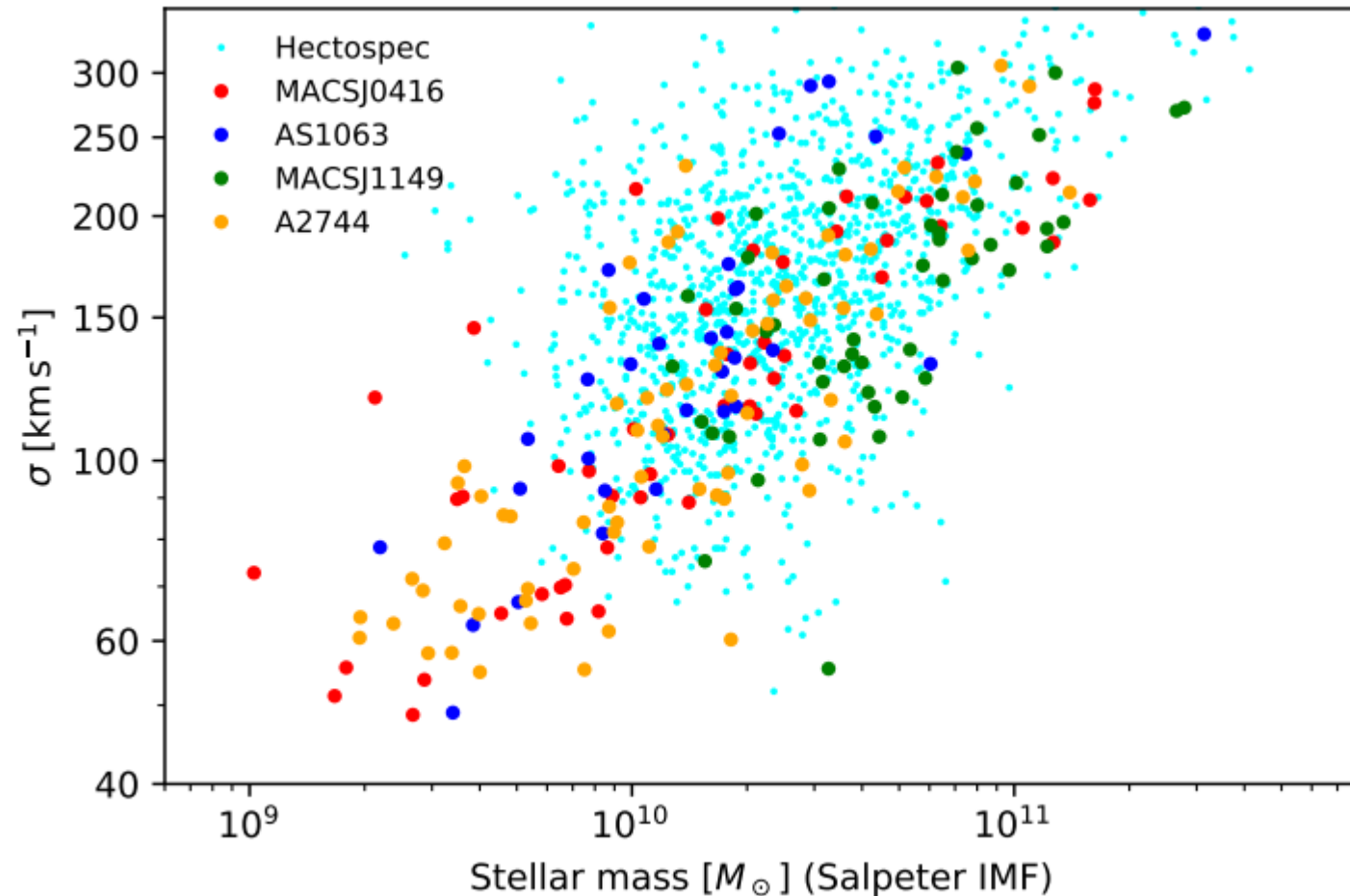
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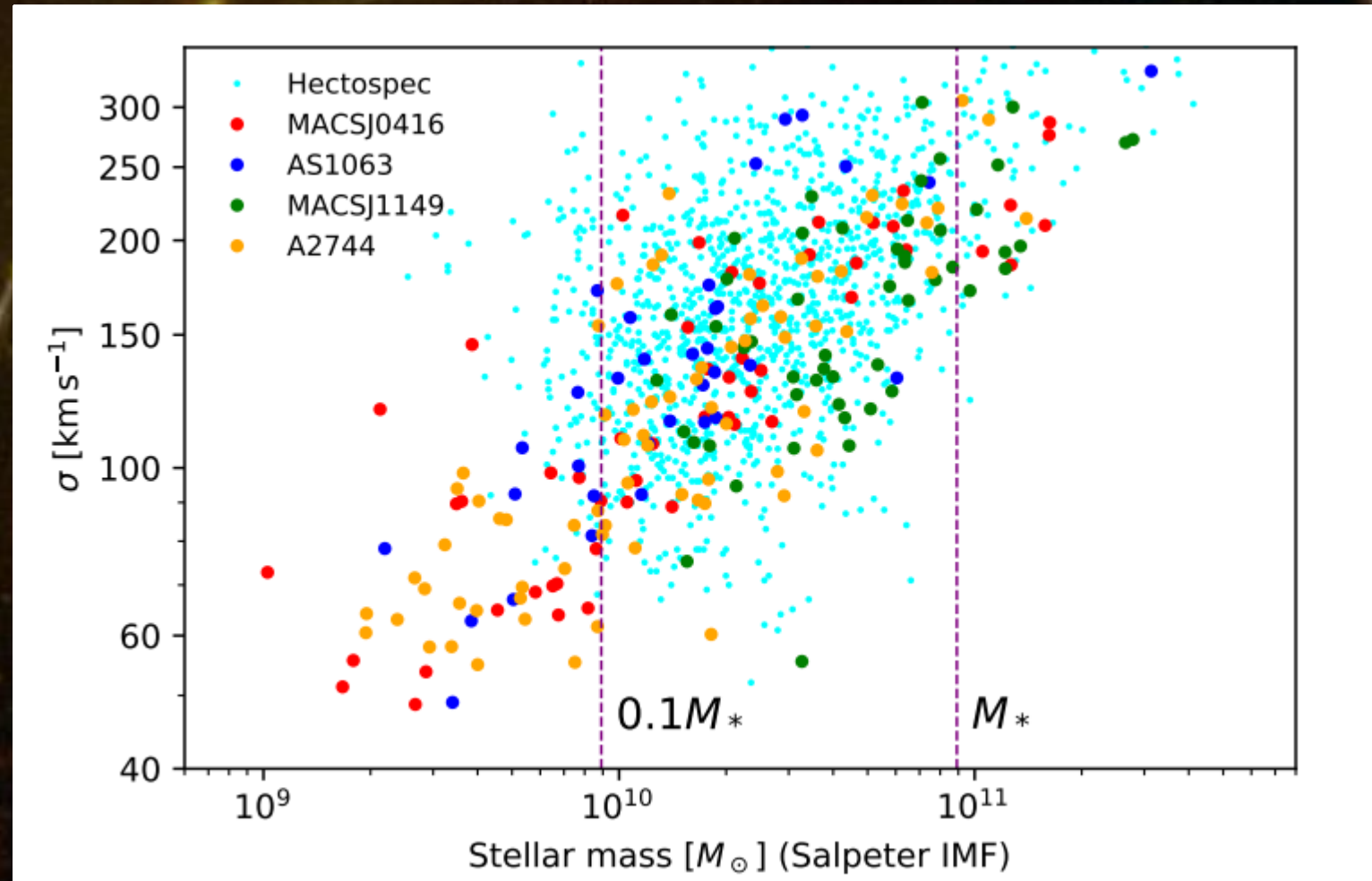
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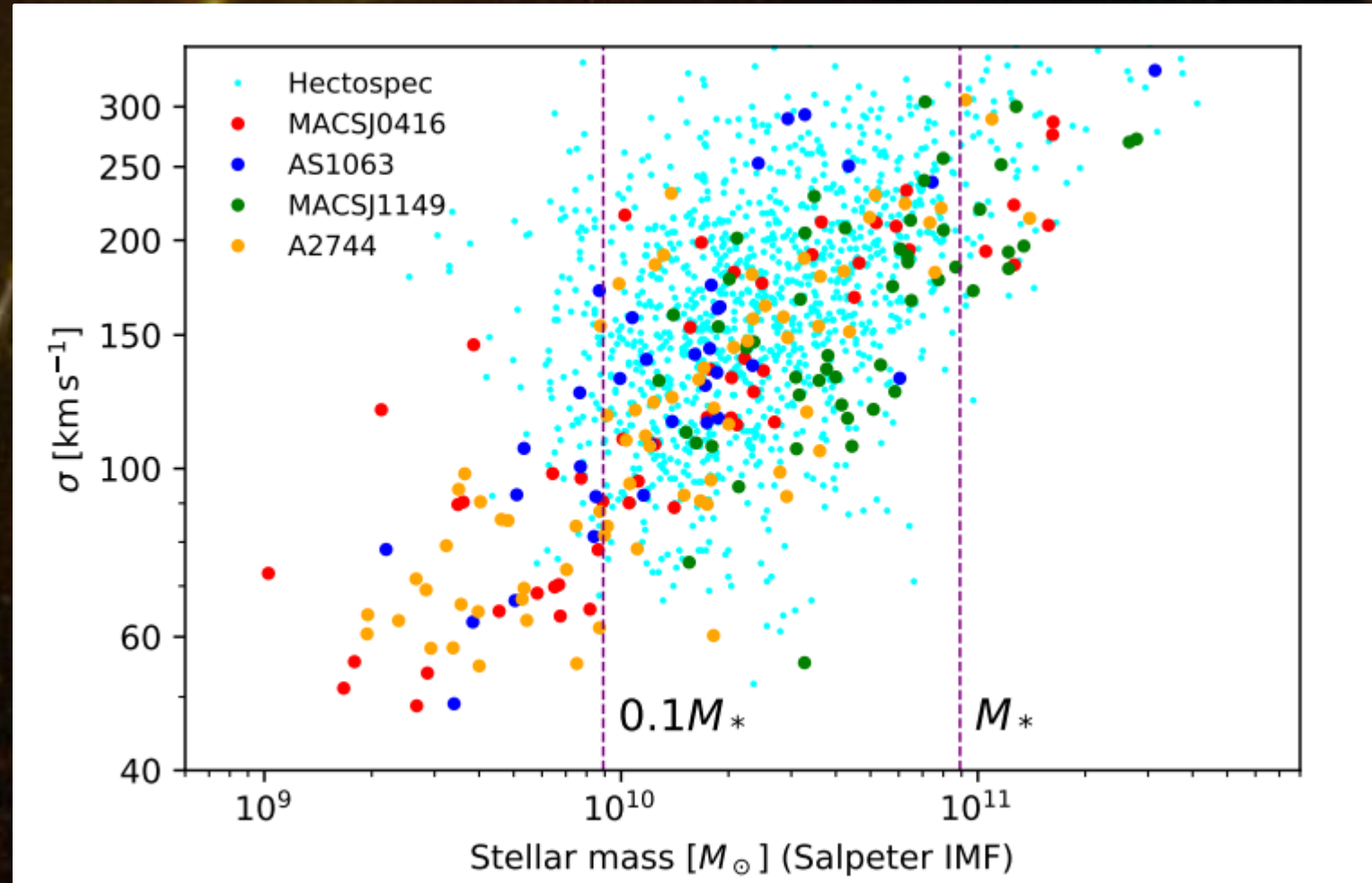
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# Measured LOSVD of cluster galaxies

- We can push one order of magnitude towards fainter luminosity/stellar mass.
- Final sample:
  - MACS J0416: 57
  - Abell 2744: 77
  - MACS J1149: 51
  - Abell S1063: 34
  - Total: 219



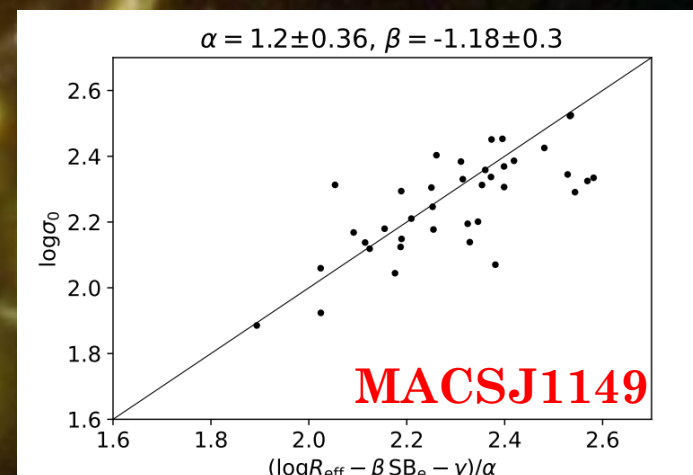
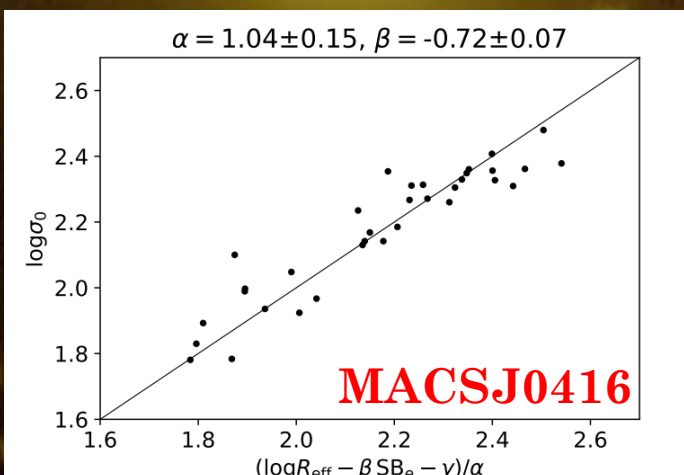
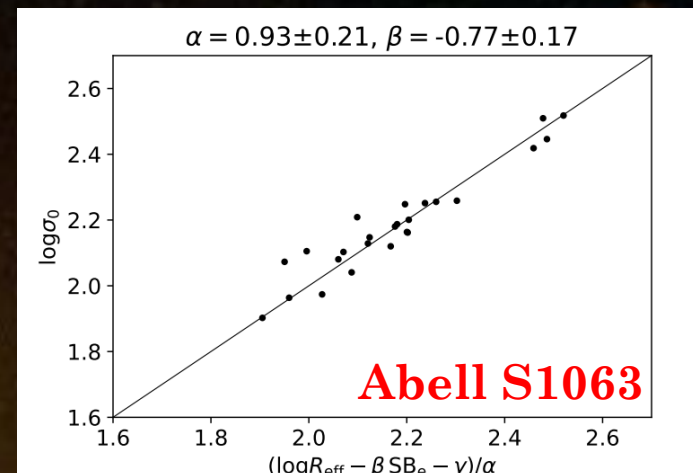
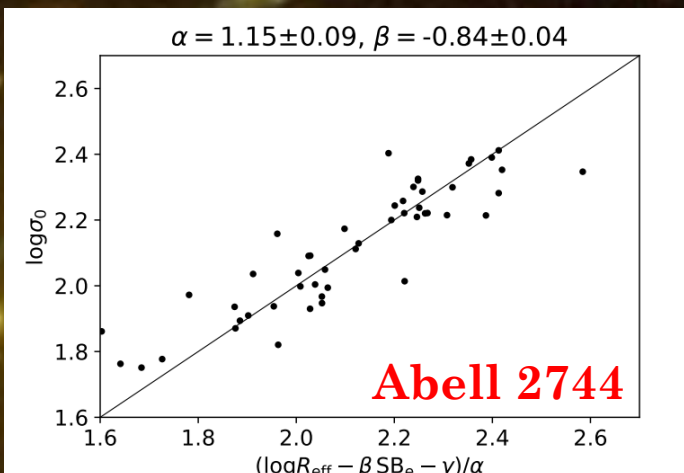


# Calibrating the Fundamental Plane

- With the **MORPHOFIT** structural parameters we can calibrate the **Fundamental Plane (FP)** relation in the rest-frame  $r$  band:
- $\log R_e = \alpha \log \sigma_0 + \beta SB_e + \gamma$

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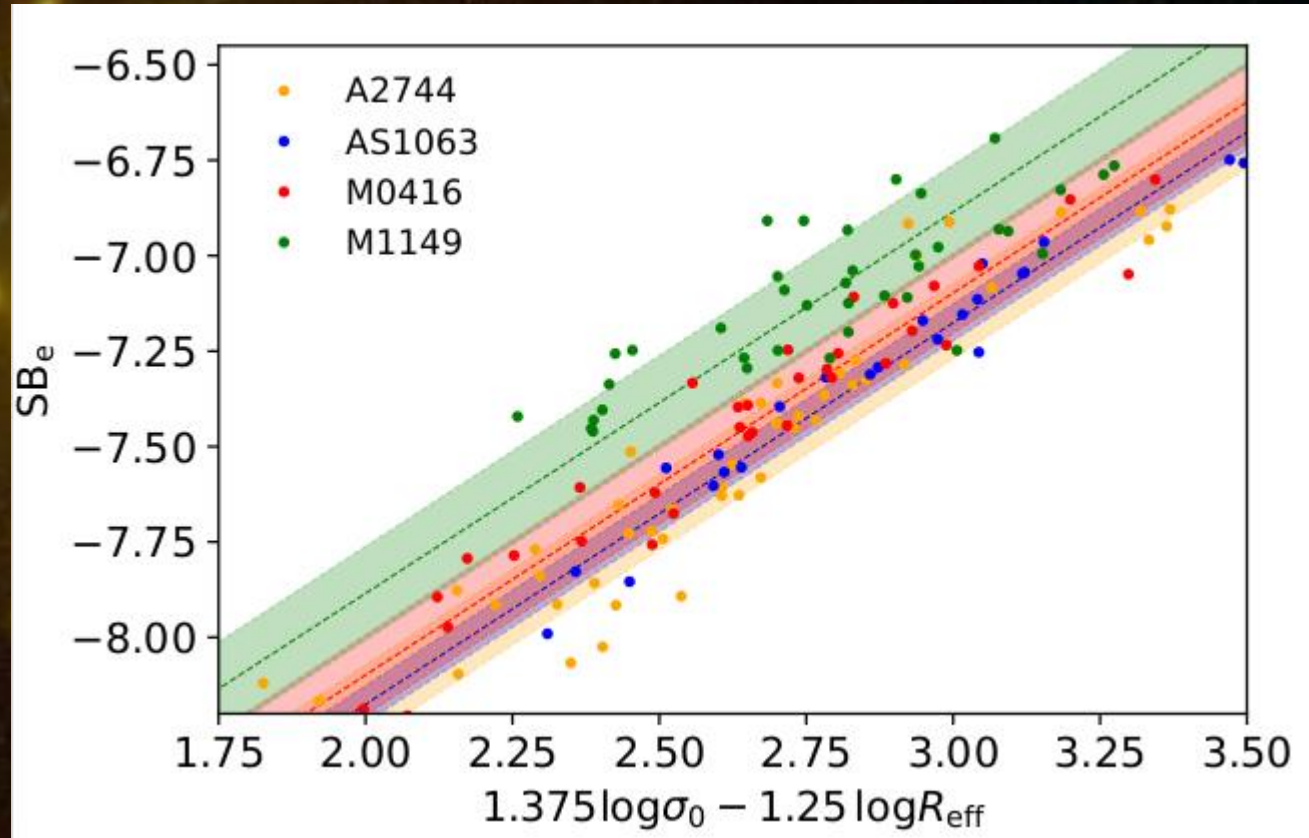
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- Hints of evolution of  $M/L$  from  $z = 0.31$  to  $z = 0.54$



# The $\sigma$ function of red cluster galaxies

- Our highly complete structural parameters catalogue contains  $\sim 200$  red members per each cluster core.



# The $\sigma$ function of red cluster galaxies

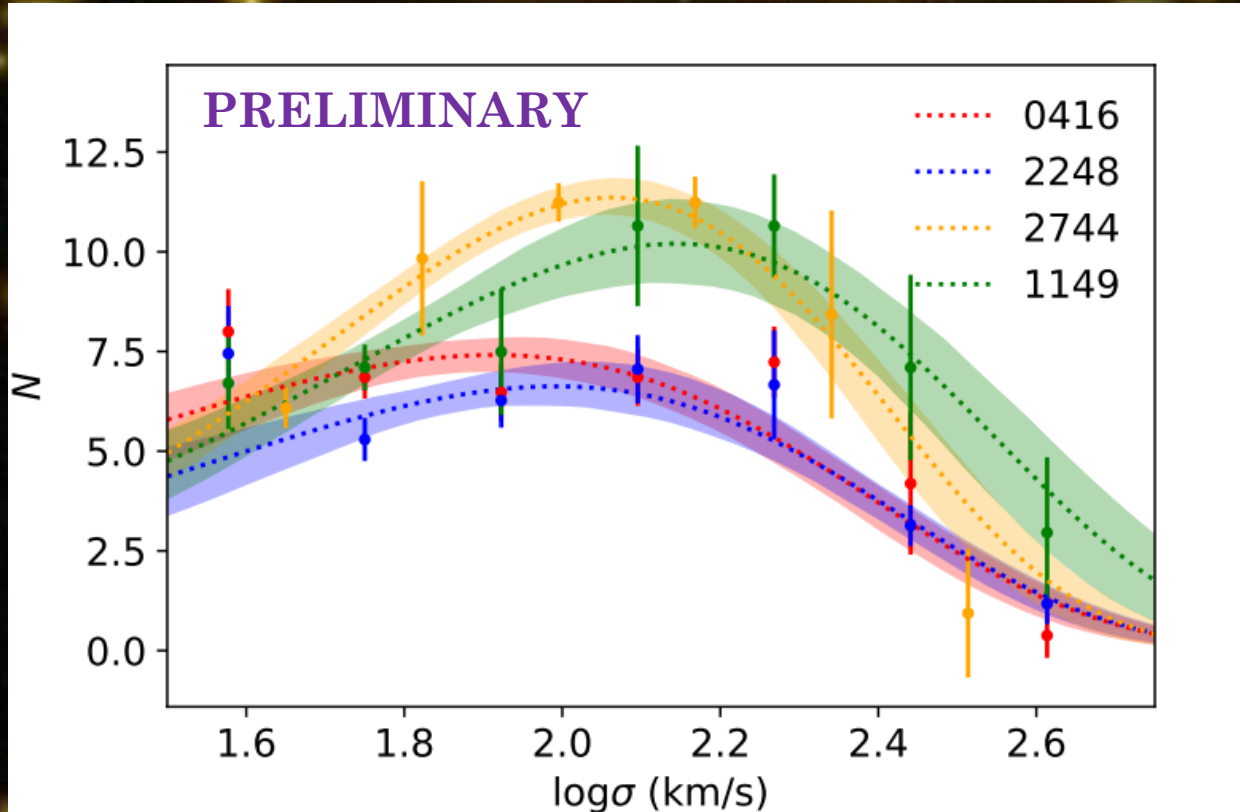
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- We build a  $\sigma$  function, an unbiased probe of their total mass.



# The $\sigma$ function of red cluster galaxies

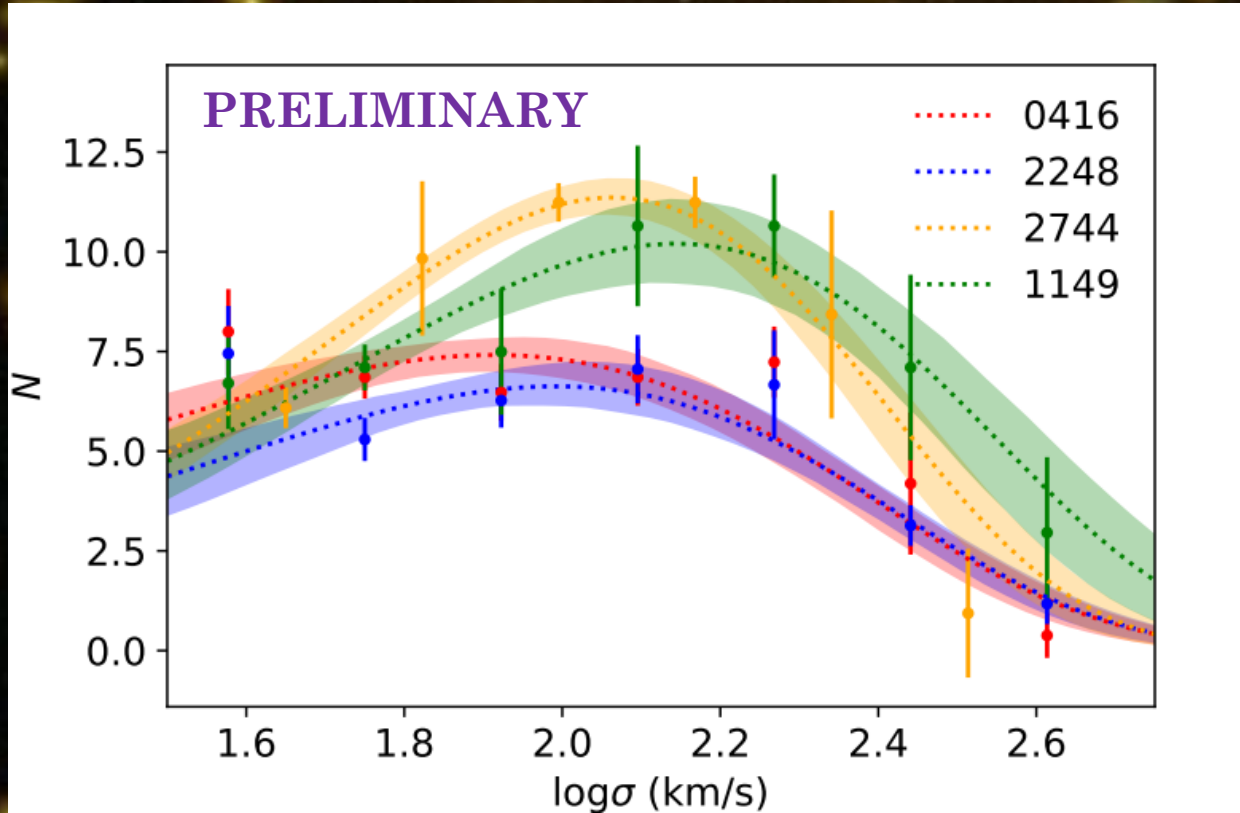


$$\alpha = 0.80 - 1.48$$

$$\log \sigma^* \text{ [km/s]} \\ = 2.25 - 2.45$$

- We fit a **Press-Schechter function**
- $$N(\sigma) = N^* \cdot \left(\frac{\sigma}{\sigma^*}\right)^\alpha \cdot \exp\left(-\frac{\sigma}{\sigma^*}\right)$$

# The $\sigma$ function of red cluster galaxies

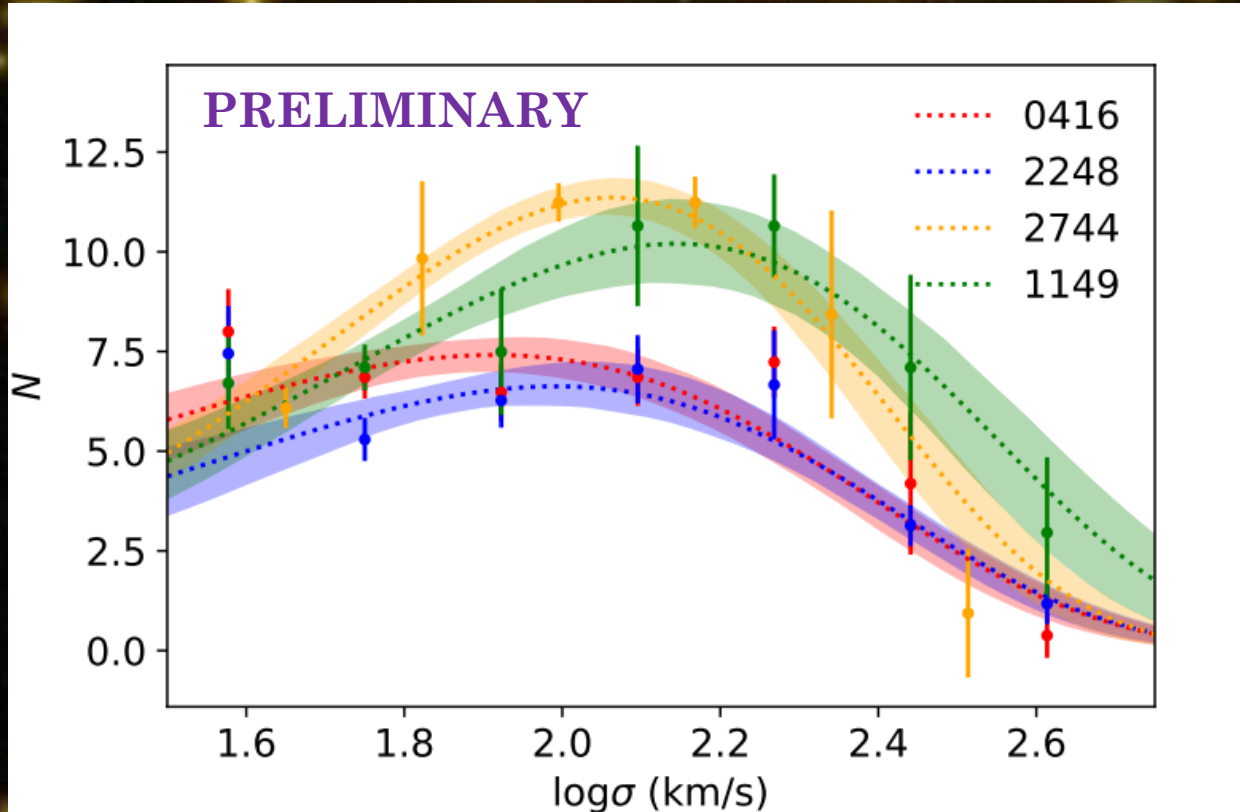


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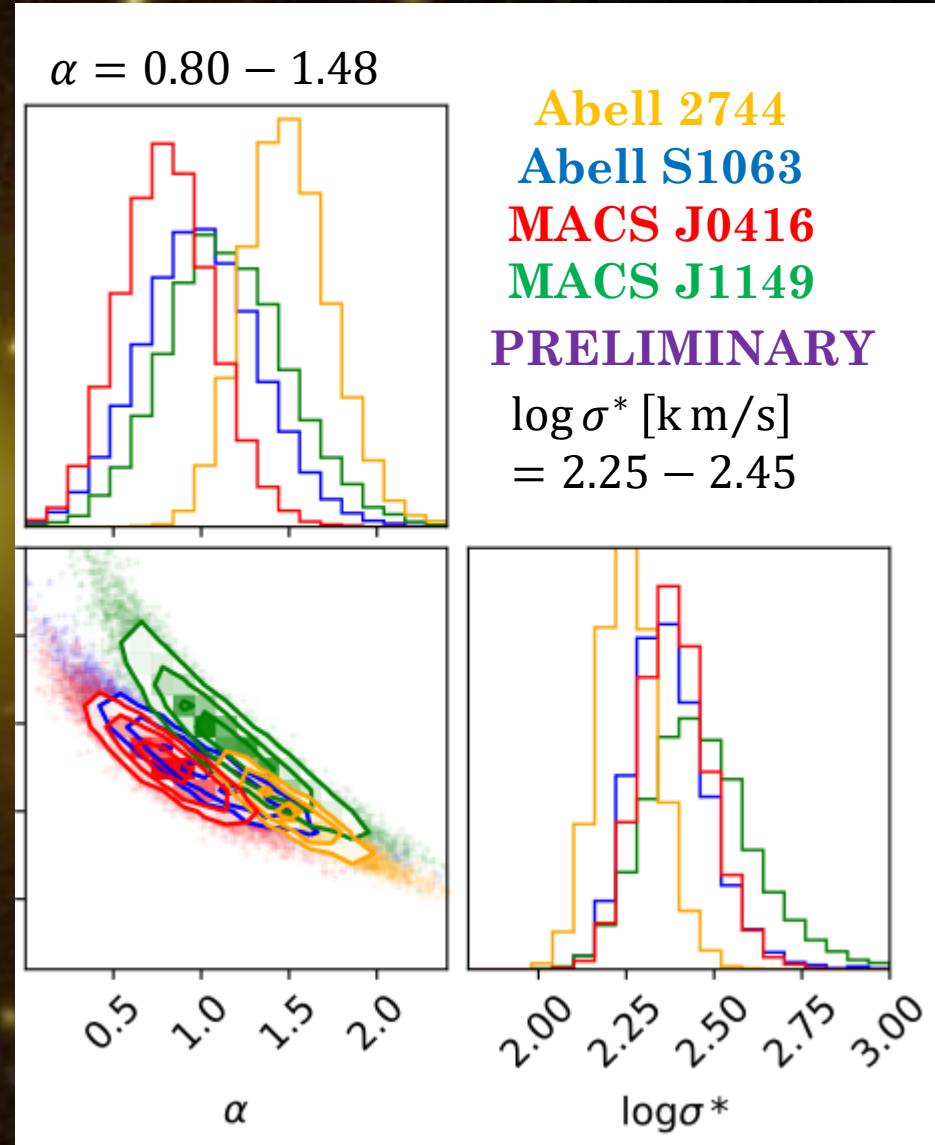


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# Conclustions and perspectives

- We have performed the deepest morpho-kinematic study of cluster galaxies at  $z = 0.31 - 0.54$ 
  - We have measured the structural parameters for  $\sim 200$  galaxies per cluster
  - And studied their stellar kinematics down to  $\sigma \gtrsim 50 \text{ km s}^{-1}$
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- I presented preliminary results on the calibration of their  $\sigma$  functions.
- The sample of clusters can be extended towards higher redshifts
  - 7h MUSE observations of SPT-CLJ2011-5228,  $z=1.06$  (PI: Granata, Period 113)

The background of the slide is a deep space image featuring a dense field of galaxies. A prominent, bright yellow-white glow emanates from the center, creating a radial gradient of light. Numerous galaxies of various shapes and sizes are visible, some appearing as distinct spirals or ellipticals, while others are more diffuse. The overall color palette is dominated by the dark blues and blacks of space, punctuated by the golden-yellow light of the central source and the varied colors of the distant galaxies.

**Thank you for your attention**