Intermediate resolution spectroscopy of resolved stellar populations

in the Local Group and beyond

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Motivation:
insights on galaxy formation and evolution

- Stars, gas & dust are the visible component of galaxies
- Low mass stars can have lifetimes comparable to the age of the Universe -> record of changing galaxy properties
- By deriving ages, chemistry and kinematics of LARGE samples of individual stars we can gain insights on how galaxy properties were built up in time

With current technology this is already challenging in the outskirts of the Local Group.

Can we go out to the Virgo cluster with the E-ELT?

The NIR CaII triplet (CaT)

- Derivation of large numbers (1000) of metallicities and l.o.s. velocities from tested methods, I.e. use of the NIR CaII triplet lines
  (currently used in studies of Local Group dwarf galaxies, M31, RAVE, GAIA in the future…)

- Red Giant Branch stars as targets (usually):

  -> bright in the NIR

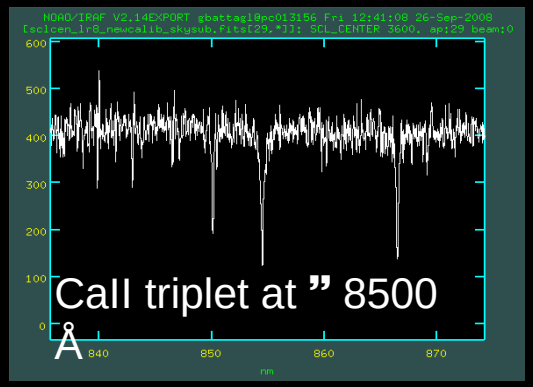
  -> cover wide age range (> 1 Gyr old)

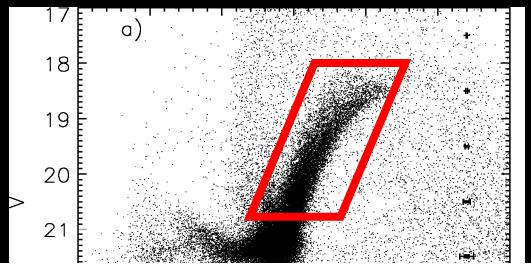
- The CaT is a strong feature in the NIR spectra o late-type stars -> need only moderate resolution (R~ 6000 to obtain accurate l.o.s. vel and EW

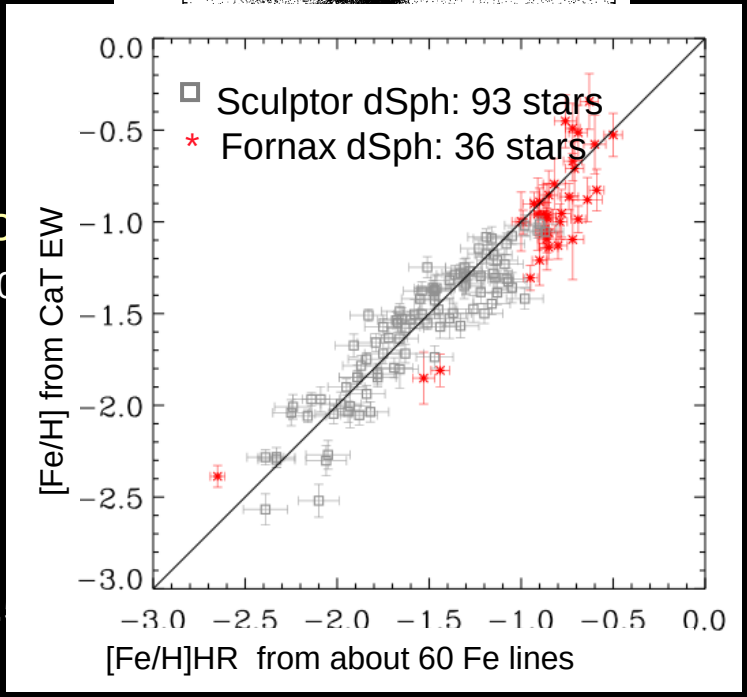
- For individual RGB stars an empirical relation holds between [Fe/H] and CaT EW

  -> extensive literature for stellar clusters

  -> in composite stellar population tested in range -2.
  < [Fe/H] < -0.5







Battaglia et al. 2008, MNRAS, 383, 183

Example from VLT/FLAMES intermediate resolution (R=6500) studies of dSphs from DART team

The Sculptor dSph

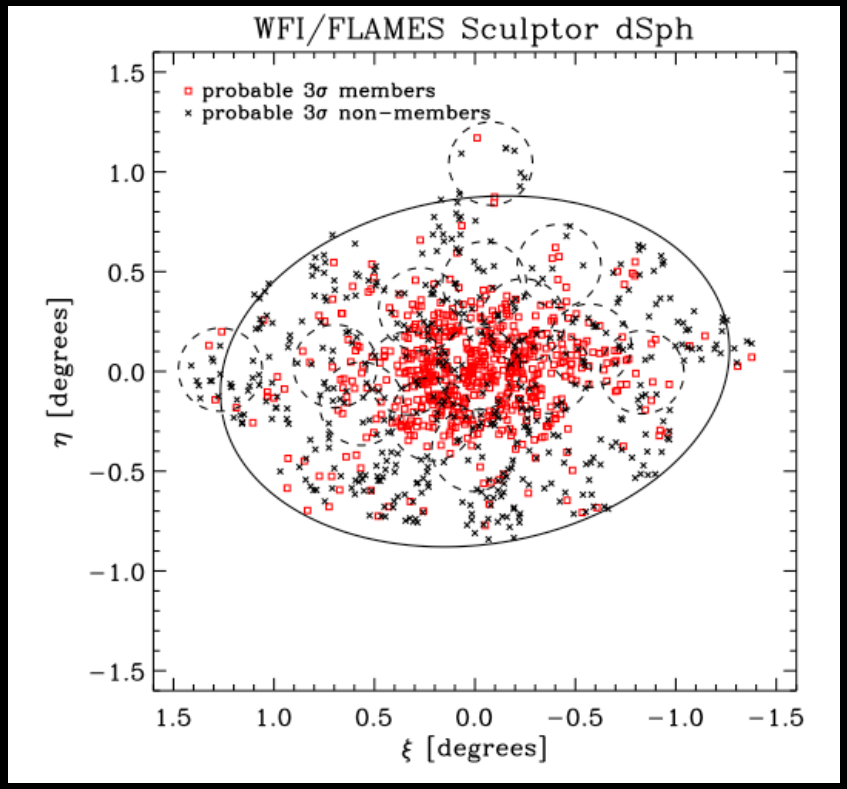
(distance = 80 kpc)

With 1h exposure time per pointing S/N=10/Å @ V=19.5. At this S/N:

-> l.o.s. velocities accurate ± 5 km/s

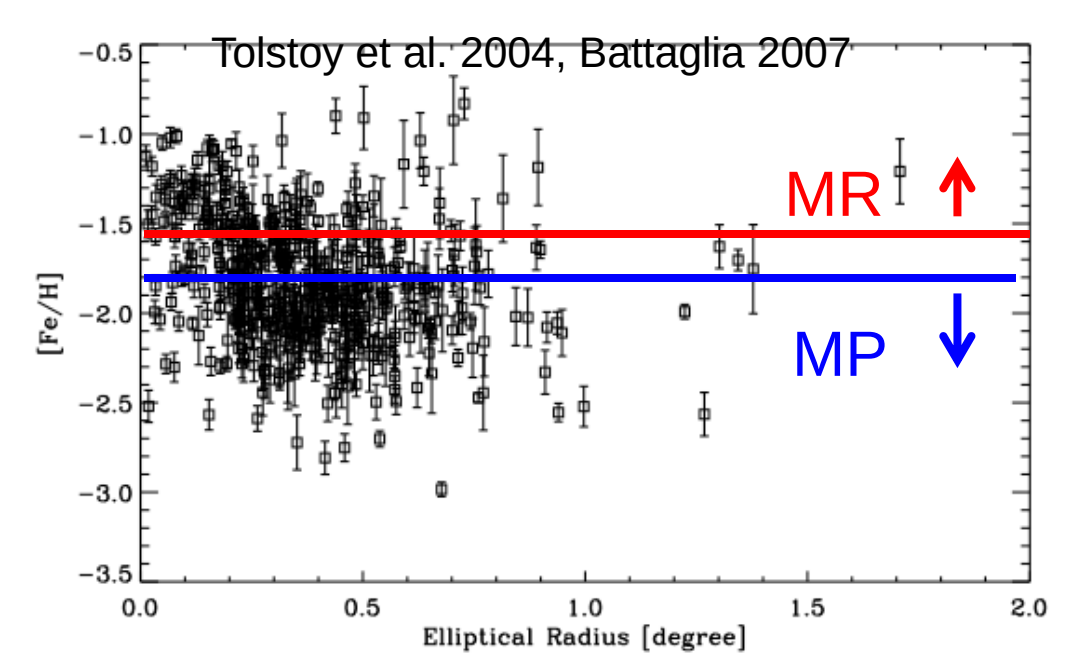
-> [Fe/H] accurate to ± 0.25 dex

20 pointings -> 670 individual members

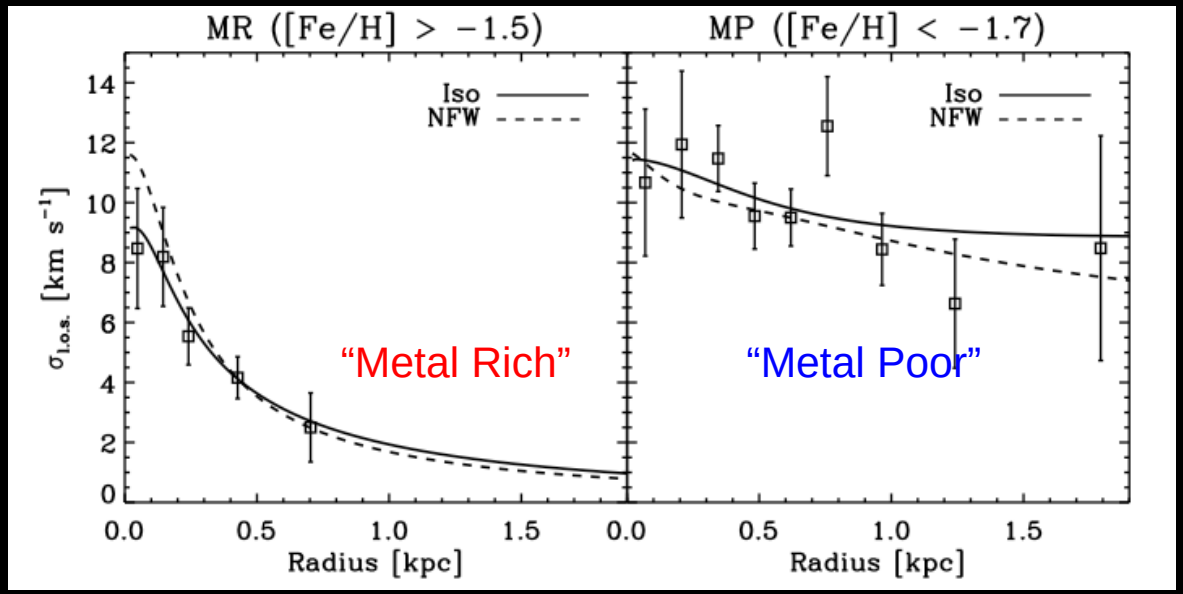


coverage of Sculptor with VLT/FLAMES GIRAFFE

Example: chemo-dynamics in the Sculptor dSph

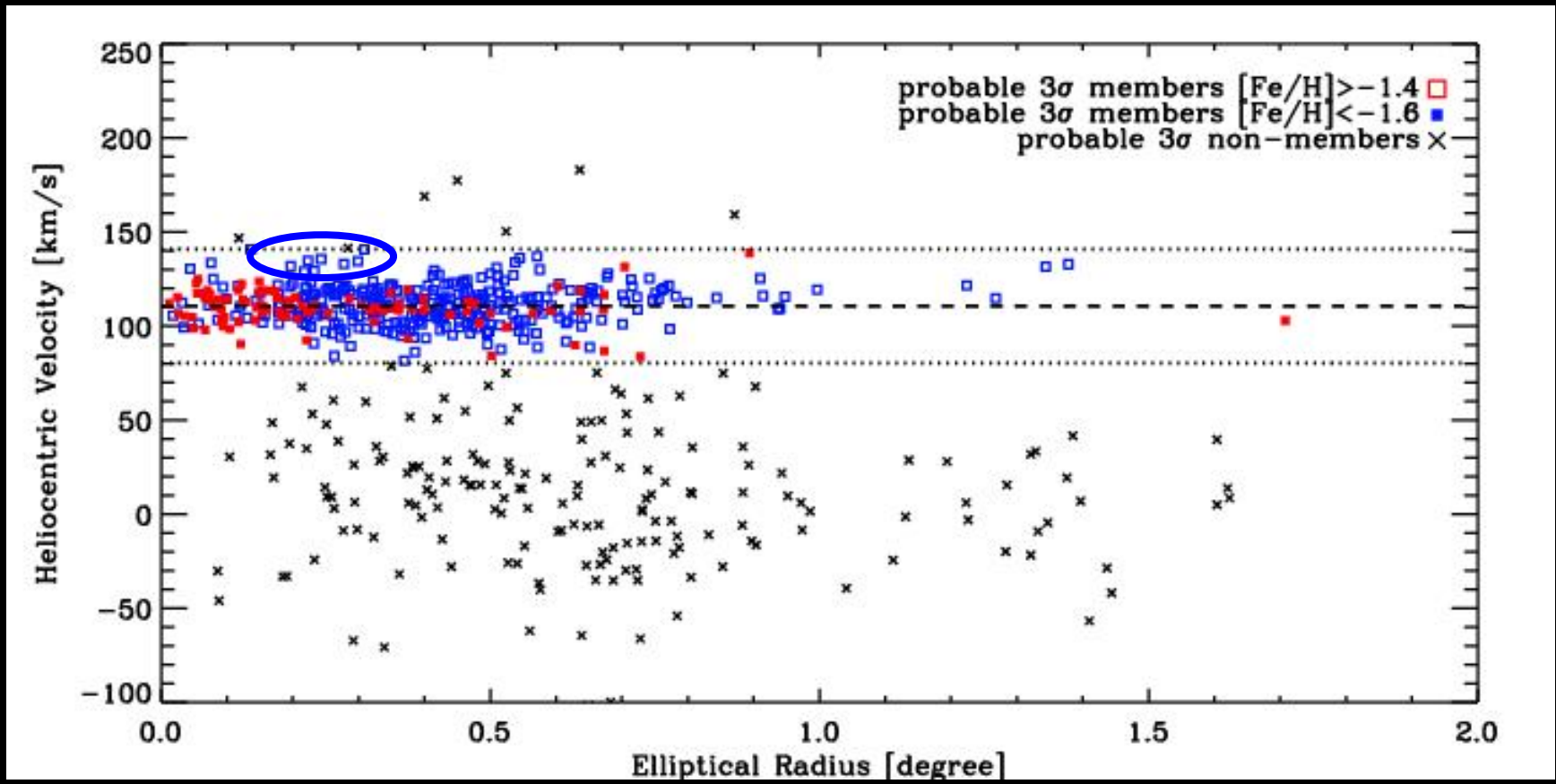


- Large scale metallicity properties
- Link between metallicity and kinematics
- Velocity dispersion profiles for mass determination



Battaglia et al. 2008, ApJL

Example: substructures in the Sculptor dSph

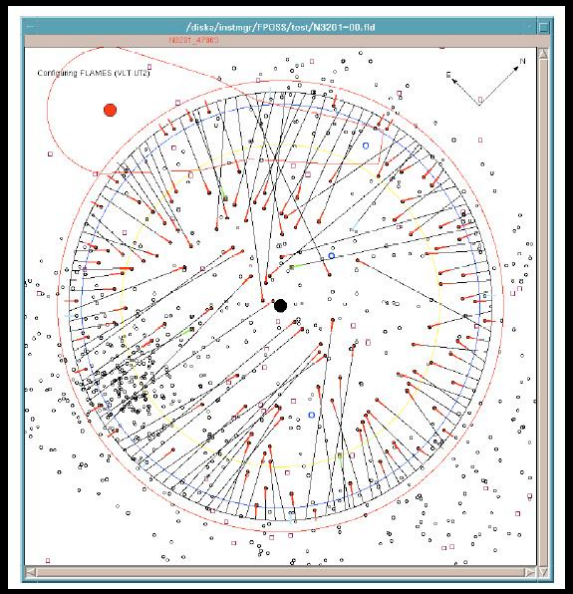


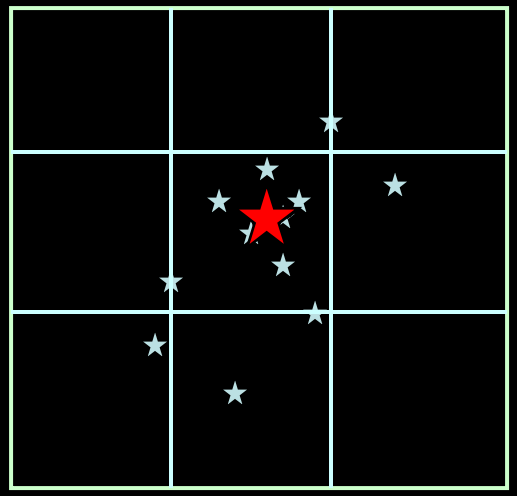
- Consistent with a disrupted stellar cluster
- Indications of kinematic substructures have been found in several dSphs (Sextans: Walker et al. 2006, UrsaMinor: Kleyna et al. 2003; Fornax: Battaglia et al. 2006)

Looking farther out

- Local Group is not representative of all environments
- Local Group contains mainly dwarf galaxies

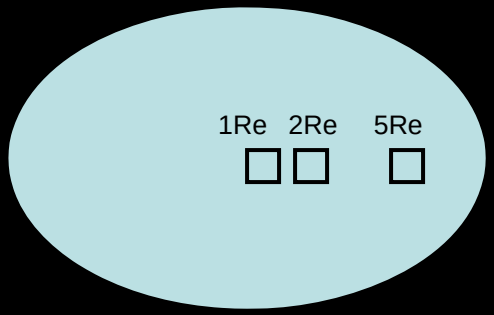
- Larger distances (1- 17 Mpc)
- Effect of stellar background in the spatial resolution element (spaxel) on the properties of target RGB star





Setting up the simulations

- Explore different surface brightness, e.g. at 1Re, 2Re, 5Re…
- Produce stellar catalogue for the chosen stellar population (SFH, [Fe/H], [alpha/Fe]), in a (50mas -> HARMONI) spaxel
- For each star (log g, Teff, [M/H], [alpha/Fe]) find the appropriate synthetic spectrum in the Munari et al. (2005) library (R=20˙000)
- Redshift individual spectra according to stellar velocities
- Produce the integrated spectrum (R=20000)
- take into account effect of atmosphere, telescope, instrument, PSF
- Convolve to desired resolution (R=6000) and add noise
- Measure line-of-sight velocities and CaT EWs



Stellar population code developed by J.Liske & E.Tolstoy

Simulations performed as part of the DRM for E-ELT

Results at CenA distance: velocity

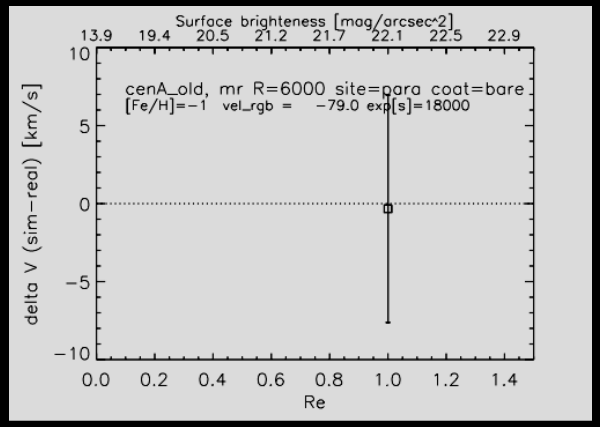
- Galaxy = CenA; Distance modulus = 27.92
- About 1 star per spaxel (+ target RGB star)
- Error-bars from standard deviation of 10000 simulations

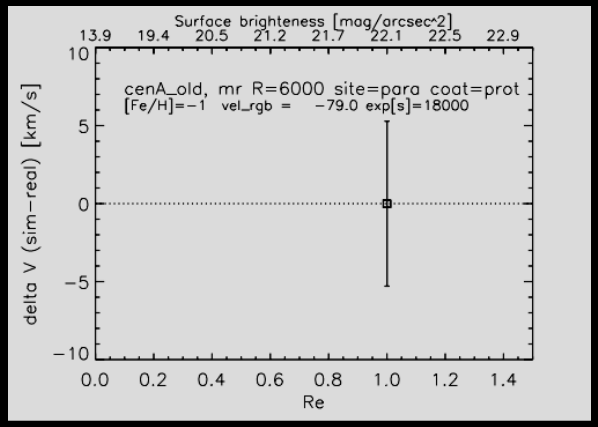
- Effect of coating is not dramatic
- 5h exposure time x pointing => accuracy: ± 5-10 km/s

Bare Al

Ag/Al

RGB tip



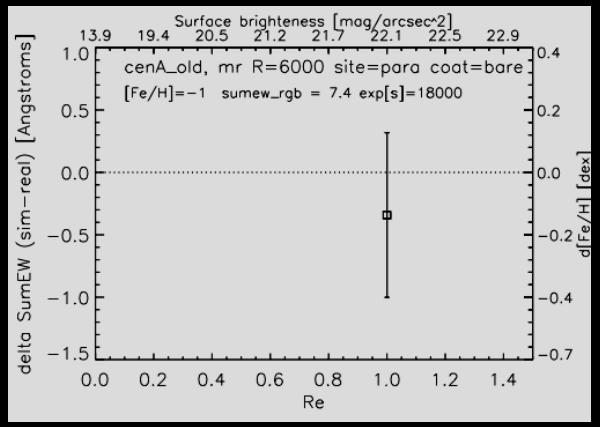


Results at CenA distance: CaT EW

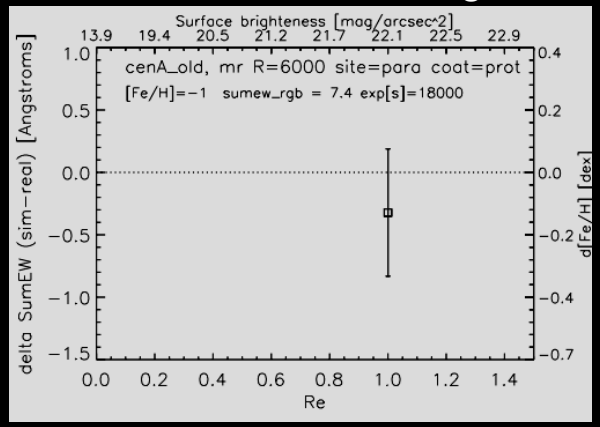
- Galaxy = CenA; Distance modulus = 27.92
- About 1 star per spaxel (+ target RGB star)
- 5h exposure time x pointing => accuracy: ± 0.2-0.4 dex

RGB tip

Bare Al

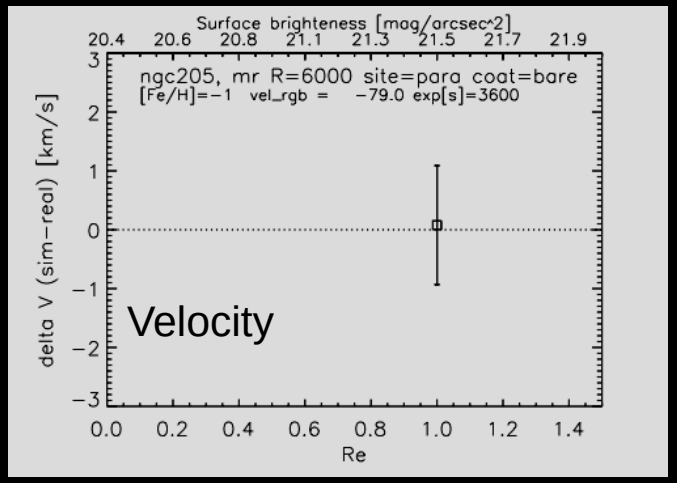


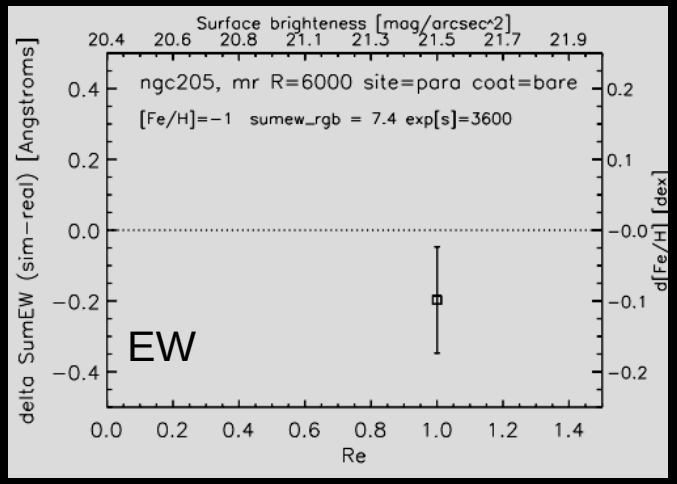
Ag/Al



Results at the outskirts of LG

- NGC205 = dwarf elliptical
- Distance modulus = 24.58
- Always < 1 star per 50 mas spaxel (only target RGB star)
- 1 h exposure time x pointing =>
  accuracy: ± 1 km/s
  accuracy: ± 0.1-0.2 dex





Summary

- For a 50 mas spaxel size, stars resolved (LG & CenA)
- An exposure time of 5h x pointing allows l.o.s. velocity and CaT EW measurements accurate to 5-10km/s and 0.2-0.4dex for CenA
- Improvement with different mirror coating is not dramatic
- To acquire about 1000 targets in CenA (R<20 kpc), we estimate an exposure time on source of about 130h (for targets within 0.5 mag from the RGB tip)
- And Virgo? DRM workshop in May!!!