

Kinematic Properties and Dark Matter Halos of Dwarf Early-Type Galaxies in the Virgo Cluster

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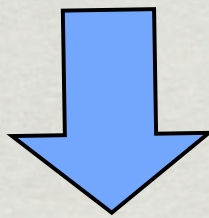
& SMAKCED collaboration

THE VIRGO CLUSTER

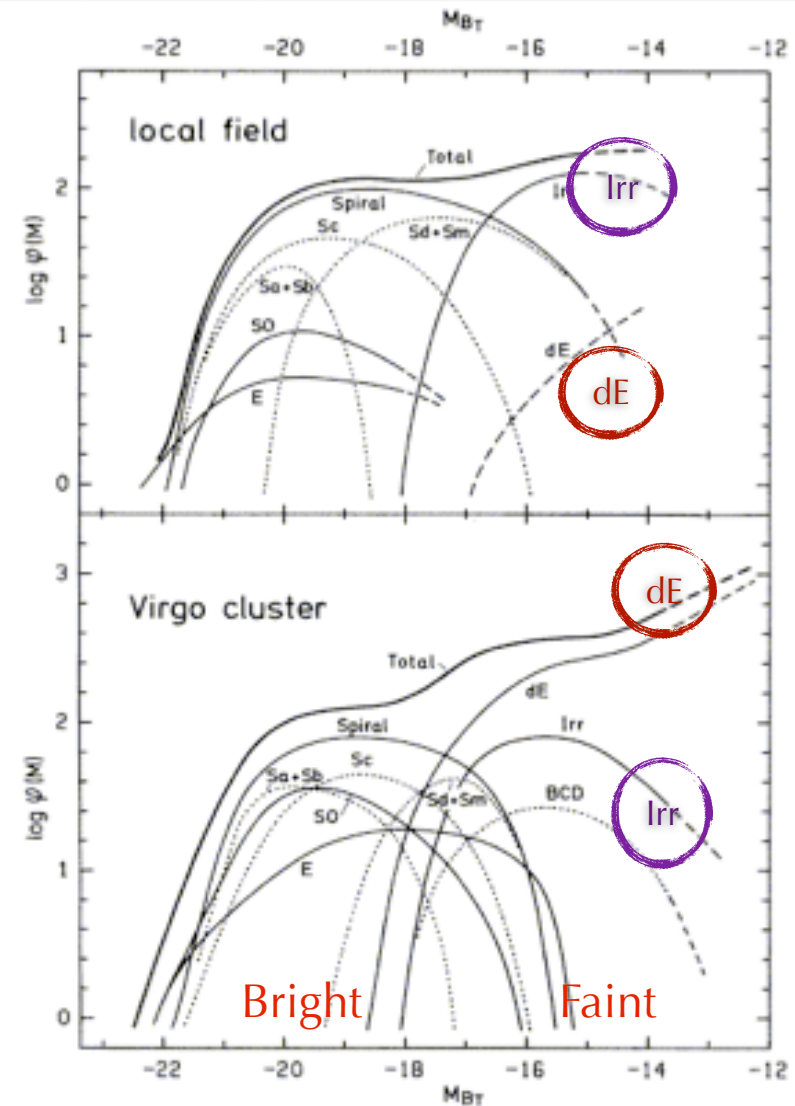
Dwarf early-types

dEs are the dominant galaxy class in the Universe

- * LF: number of objects per unit volume for a given luminosity (or abs magnitude)
- * In the field: dEs are rare
- * In clusters (Virgo): dEs are the major contributors to the LF

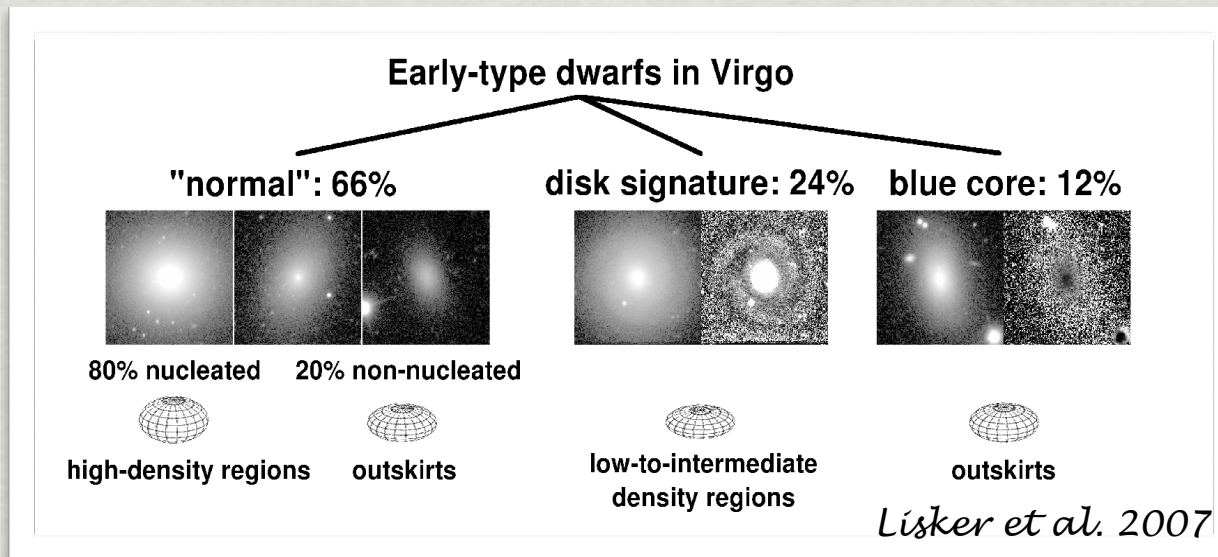


The environment must be responsible for this morphology segregation



Binggeli 1988

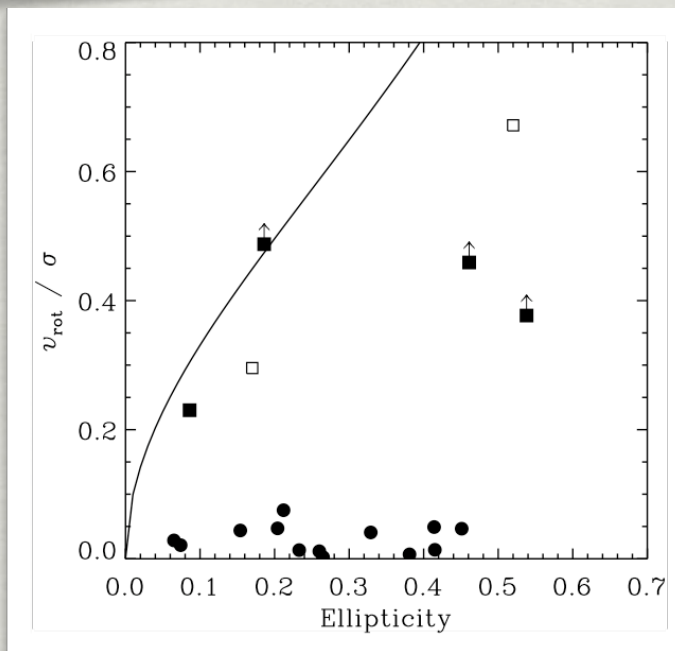
dEs are not simple systems



Lisker et al. 2006a,b,
2007, 2008 from SDSS
data



Are dEs faded dlrrs?



Geha et al. 2003

Importance of the kinematics

- * dlrr are rotating galaxies → dEs should rotate if they are faded dlrrs
- * But, not all dEs show rotation

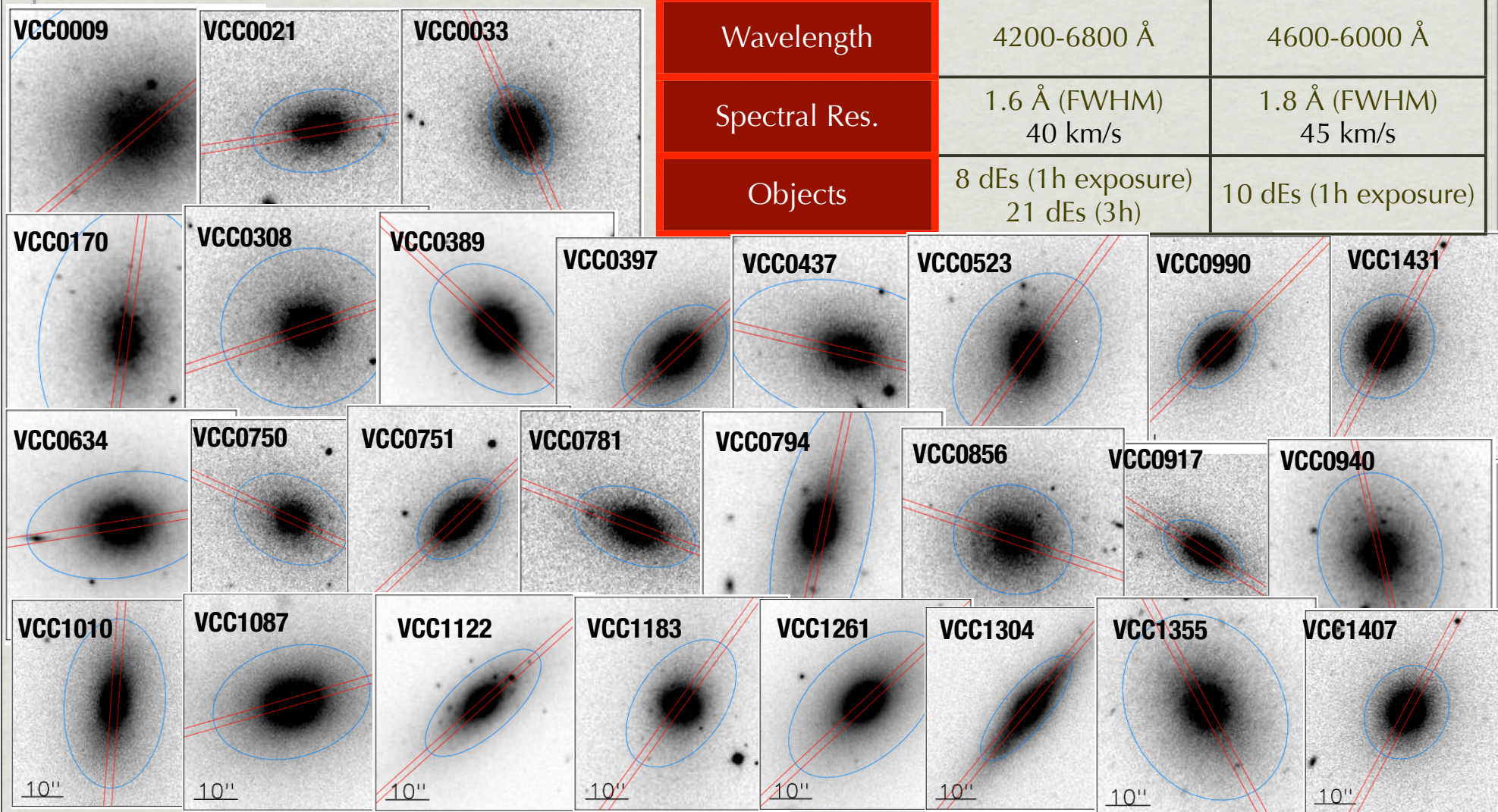
Origin of dEs?

Observed sample of 39 Virgo dEs

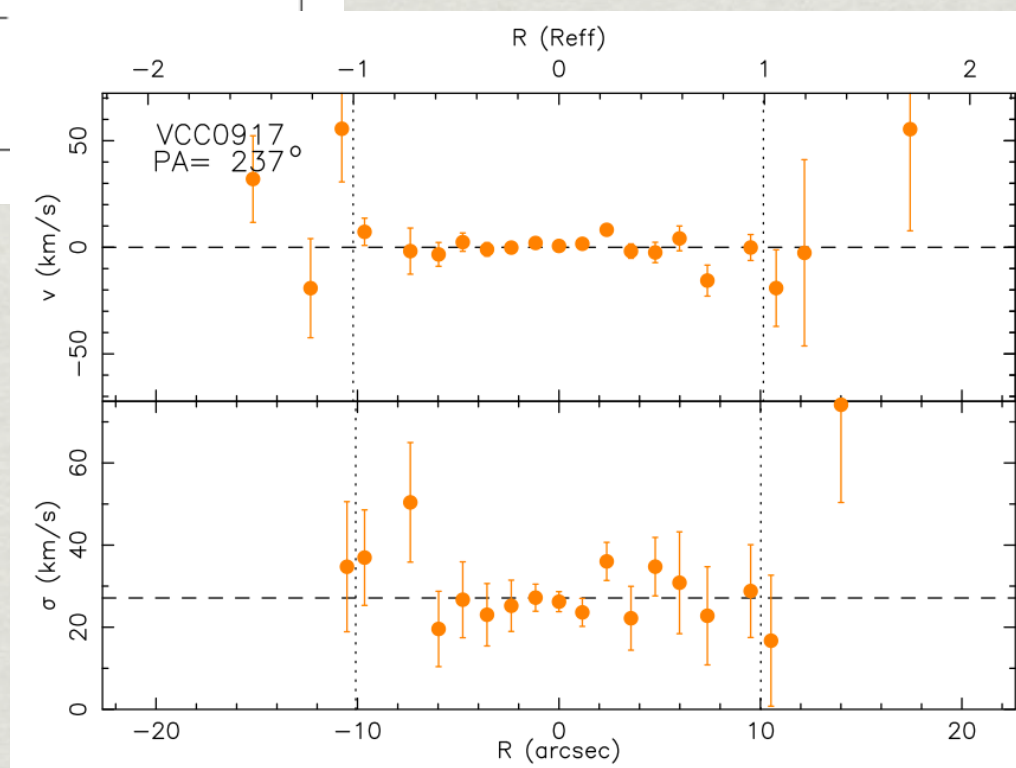
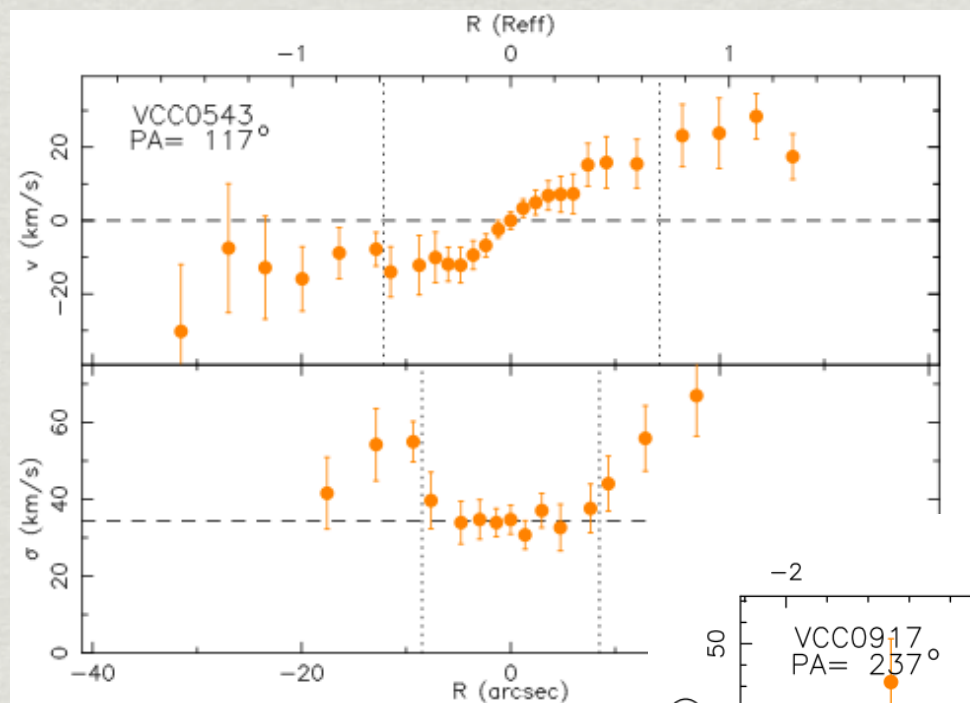
- * 18 from Toloba+2009,2011,2012
- * 21 more (Toloba+2013, in prep.)

Long-slit spectroscopy

	WHT(4.2m)	INT(2.5m)
Instrument	ISIS	IDS
Wavelength	4200-6800 Å	4600-6000 Å
Spectral Res.	1.6 Å (FWHM) 40 km/s	1.8 Å (FWHM) 45 km/s
Objects	8 dEs (1h exposure) 21 dEs (3h)	10 dEs (1h exposure)

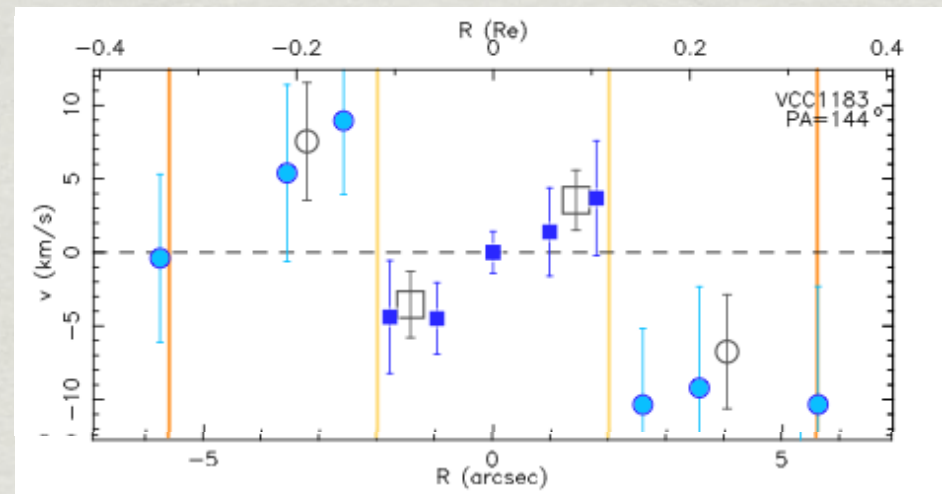
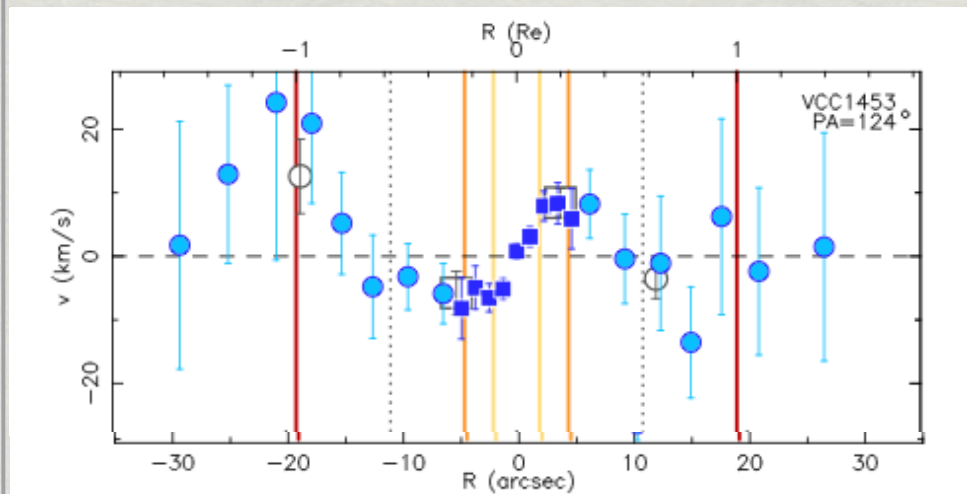


Kinematic profiles



Toloba et al. 2011, A&A 526 114
Toloba et al. 2013, in prep.

Counter-rotating Kinematically Decoupled Cores: cannibalism?



Toloba et al. 2013, in prep.

- ▶ Counter-rotating KDCs known so far:
 - ▶ 2% in ATLAS3D (IFU 260 Es, Emsellem+2011)
 - ▶ 1 low luminosity E (spectra+photometry, Geha+2005)
 - ▶ 1 Virgo dE (spectra, Thomas+2006)
- ▶ Cannibalism in dwarf galaxies: very rare
(e.g. NGC4449: Martínez-Delgado+2012)
- ▶ Not possible in clusters -> possible evidence of infalling groups in Virgo

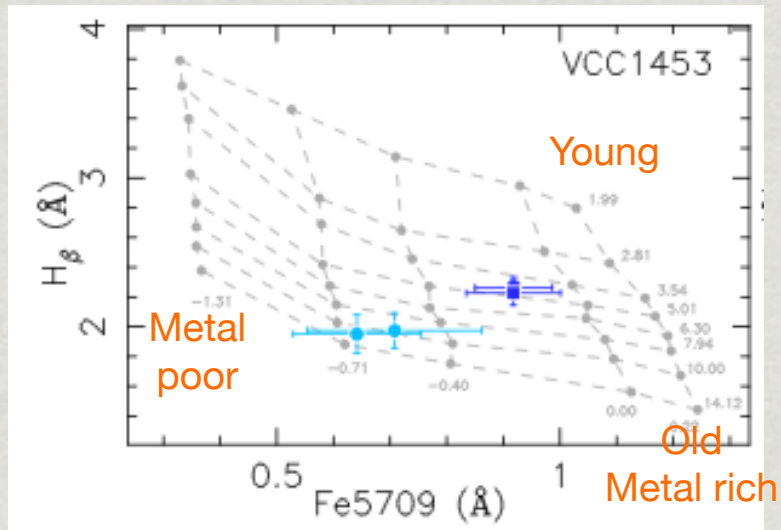
VCC1453

Yellow line: rotation

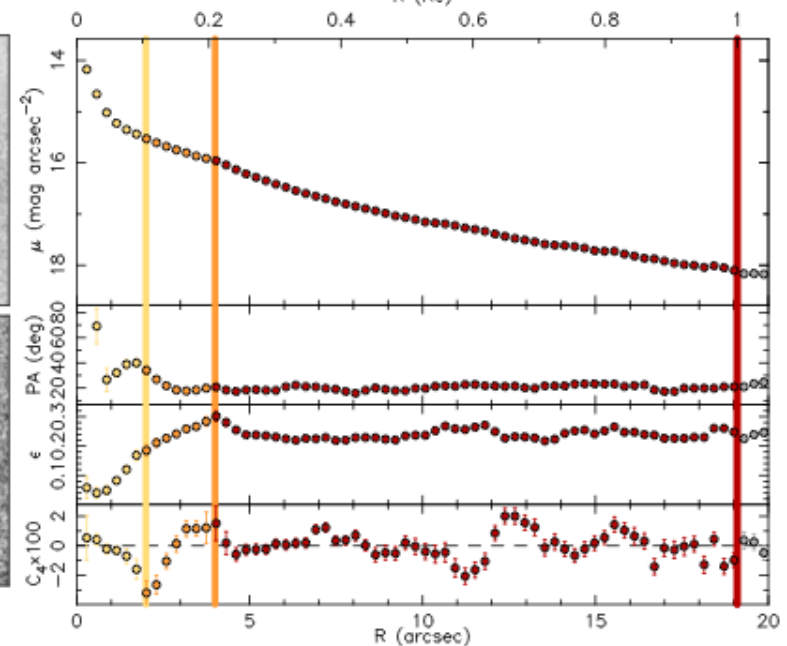
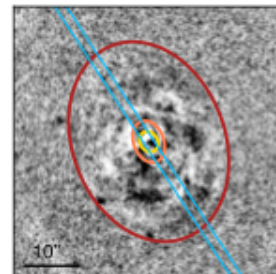
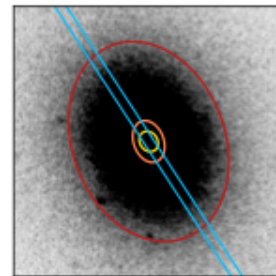
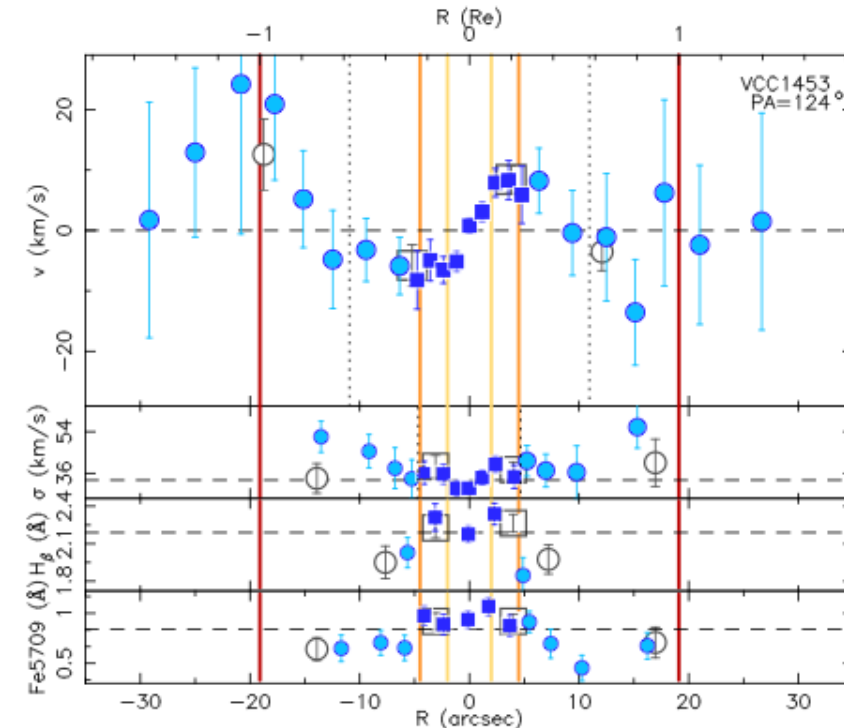
Orange line: photometry

Red line: 1Re

- Dip in velocity dispersion
- KDC: younger
- KDC: more metal poor



- Change in PA
- Change in ellipticity
- Change in boxiness (C4)



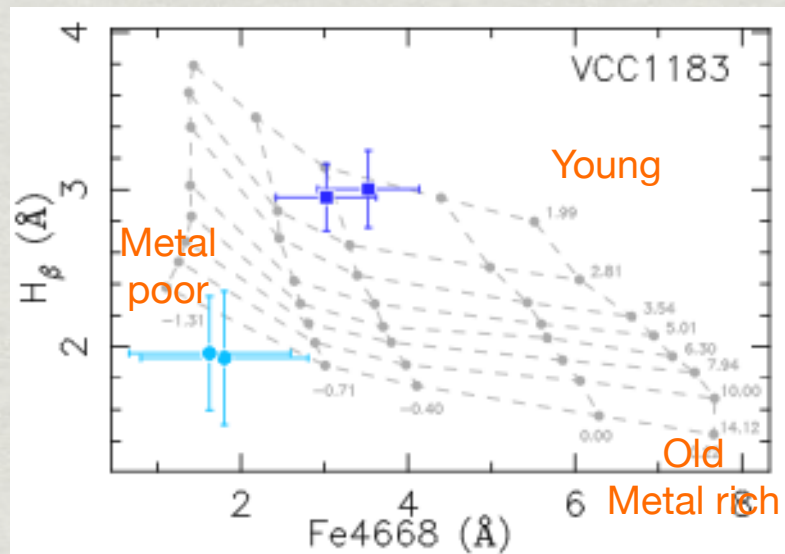
VCC1183

Yellow line: rotation

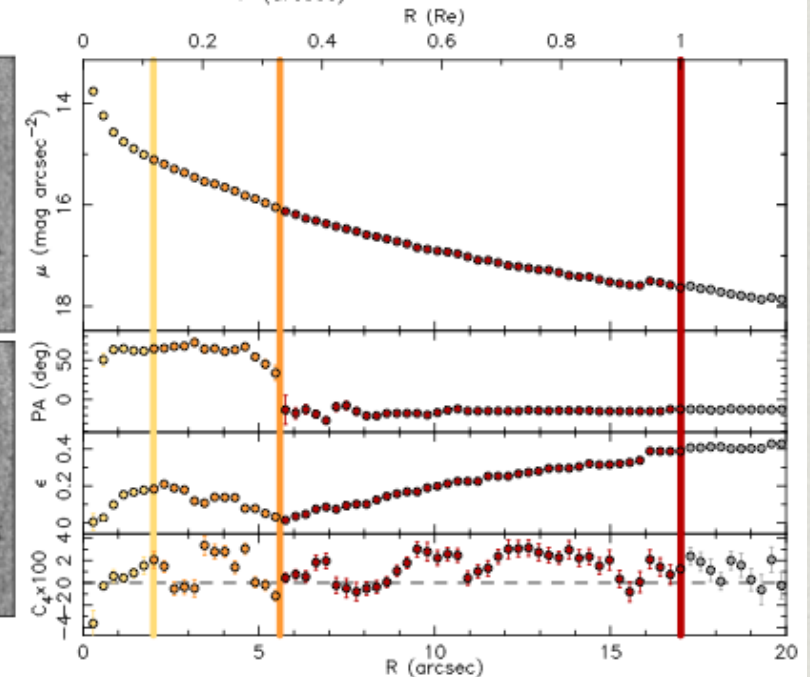
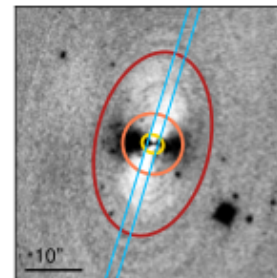
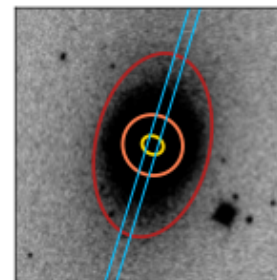
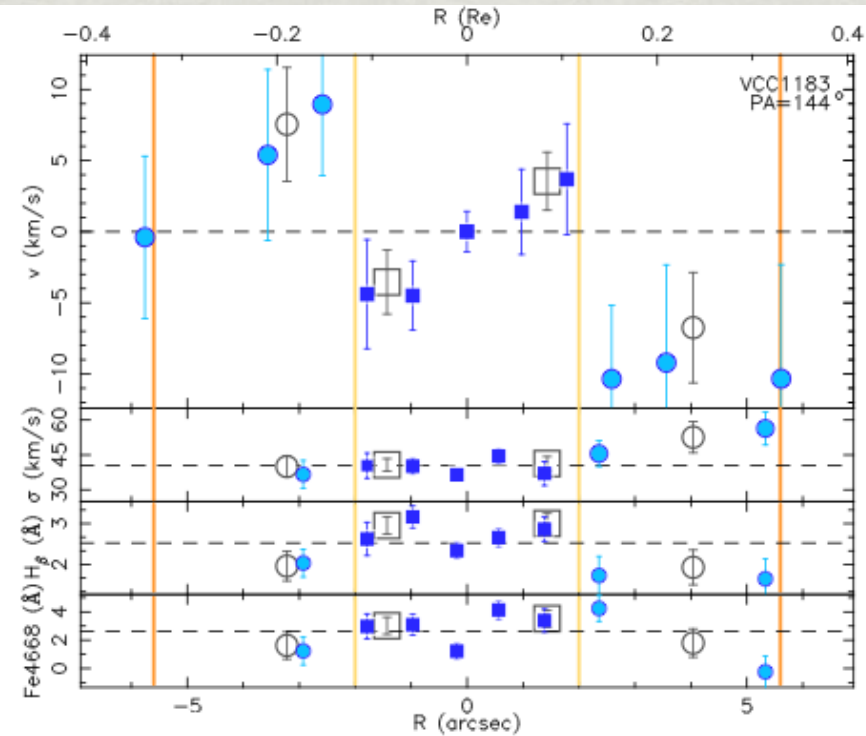
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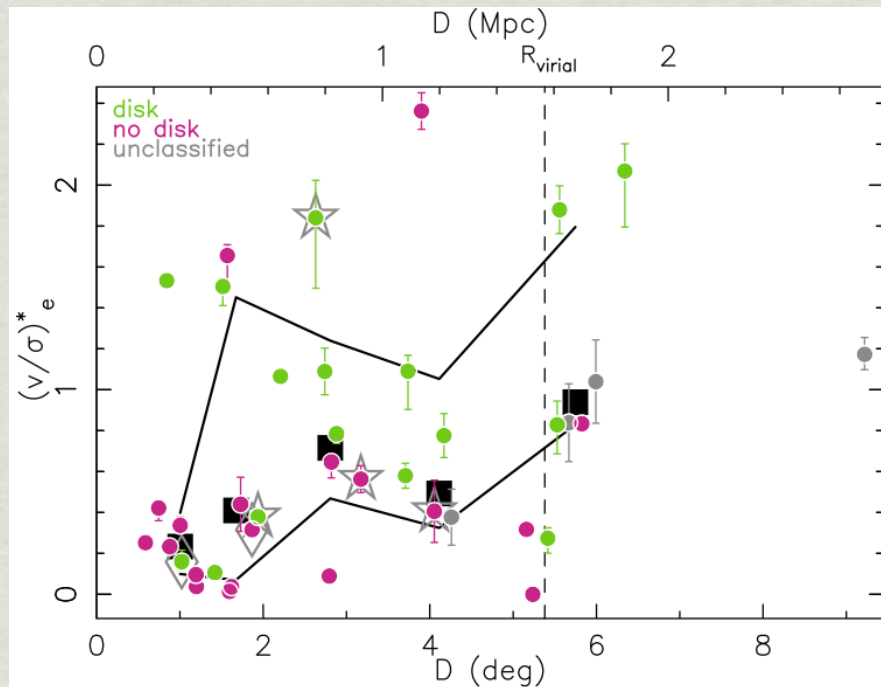
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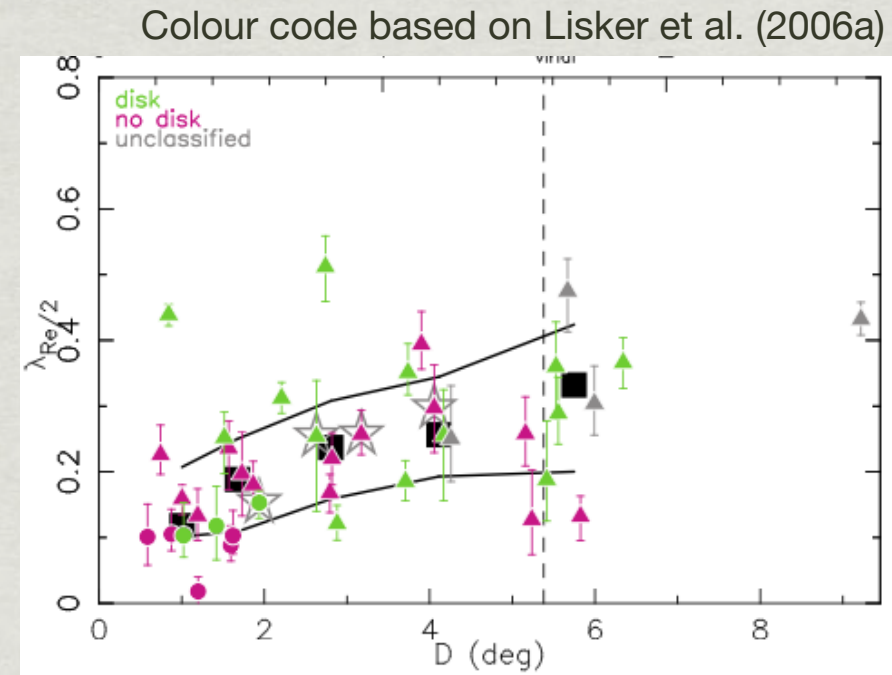
- Twist in the isophotes: inner disk
- Change in ellipticity
- Change in boxiness (C4)



Rotational support: virgocentric distance dependence



$$(v/\sigma)^* = \frac{(v/\sigma)_e}{\sqrt{\epsilon/(1-\epsilon)}}$$



$$\lambda_R = \frac{\sum_{i=1}^N F_i R_i |v_i|}{\sum_{i=1}^N F_i R_i \sqrt{v_i^2 + \sigma_i^2}}$$

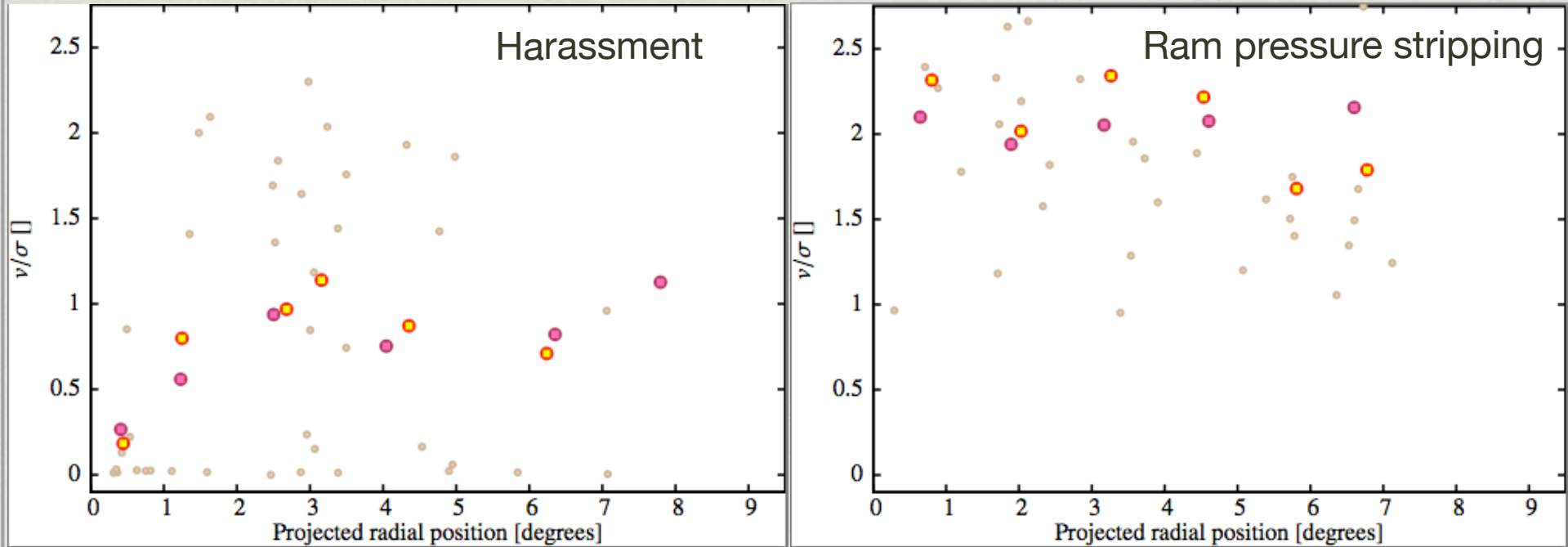
dEs in the center of the cluster do not rotate or do so very slowly

Rapid rotators are found in the outskirts of the cluster

Previously found in
Toloba et al. 2009, ApJ 707 L17

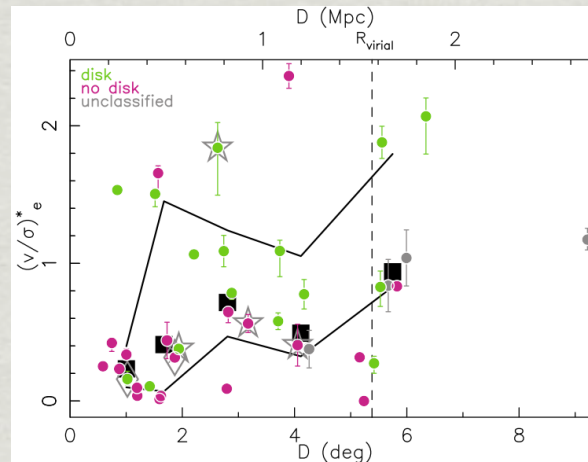
Possible formation mechanisms

Semi-analytic models by A. Benson



Benson, Toloba et al. 2013, in prep.

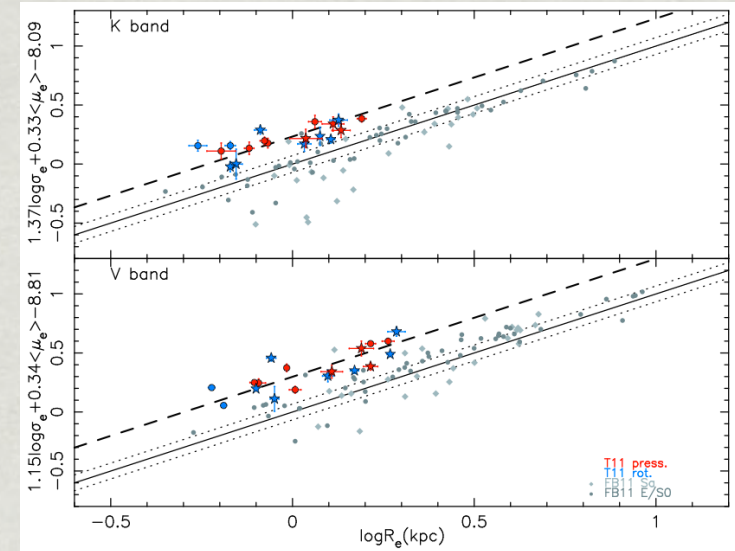
-  Median of 39 random dEs in the simulation
-  Median of all dEs in the simulation
-  Some random dEs in the simulation



Dark Matter Content

Are dEs dark matter dominated systems?

- Toloba et al. 2011, A&A 526 114
 - I band: $M_{\text{dyn}}/M^* = 1.6 \pm 1.2$
- Toloba et al. 2012, A&A 548 78
 - V band: $M_{\text{dyn}}/M^* \geq 1.7 \pm 0.6$
 - K band: $M_{\text{dyn}}/M^* \geq 1.7 \pm 0.5$



Their dark matter fraction within 1Re is $M_{\text{DM}}/M^* \geq 42\%$
No DM dominated within 1Re

- Work in progress: DM halo of dEs up to $>8R_e$

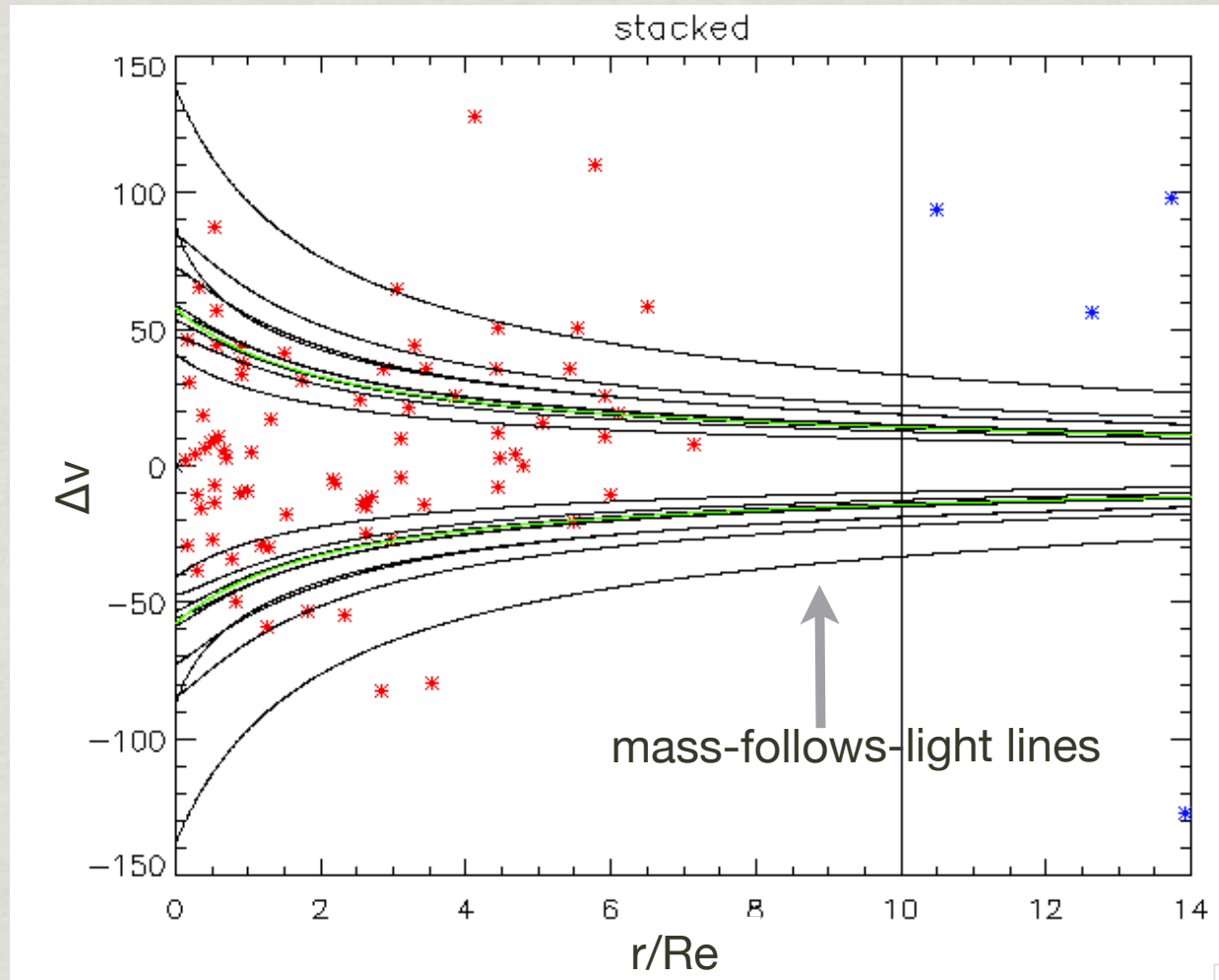
People: Toloba, Guhathakurta, Peng, Ferrarese, Cote, Jordan

Observations completed: Keck/DEIMOS

GCs used as tracers of the potential well

300 GC candidates observed (124 ACSVCS catalog, 176 NGVS) on **21 Virgo dEs**

Dark Matter Content



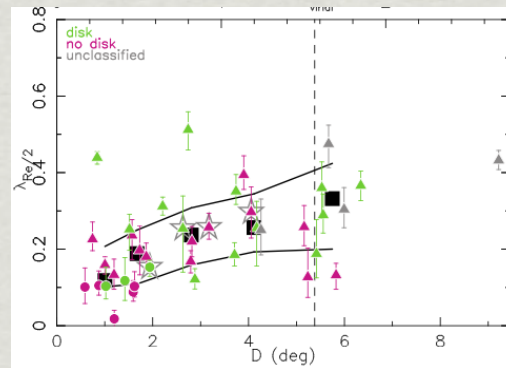
- Different lines: escape velocity for the dEs
- Green line: average of all the curves
- Some of the GCs are outside the curves

Preliminary result:
Some DM but
not DM dominated

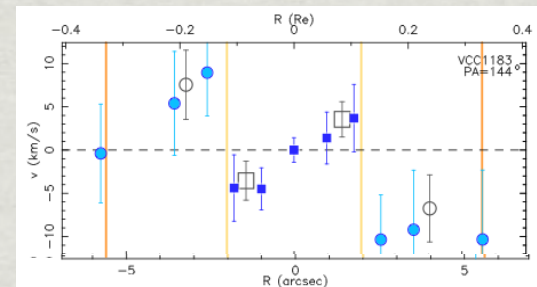
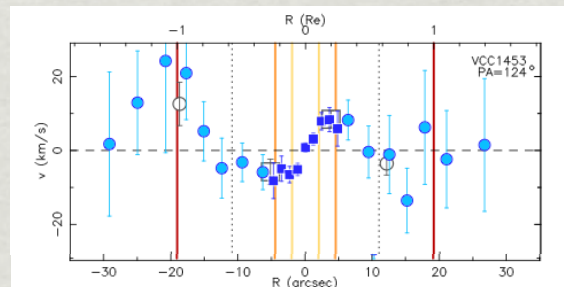
In collaboration with Stephanie Chen, Jingjing Cheng,
Raja Guhathakurta, Eric Peng

Summary

- Infall of spirals in Virgo + ram pressure stripping/harassment = dEs



- counter-rotating KDCs: infalling groups in Virgo



- dEs have DM (42% more than Es within the R_e) but not DM-dominated

