

Extended Virgo Cluster Catalog (EVCC) using SDSS DR7 Data

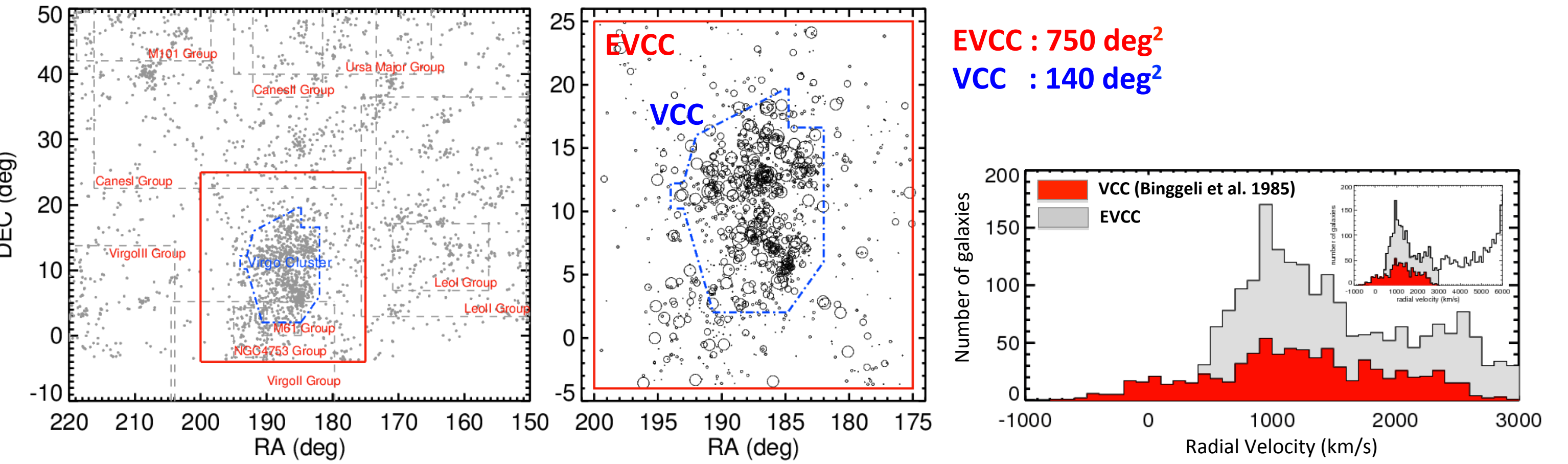
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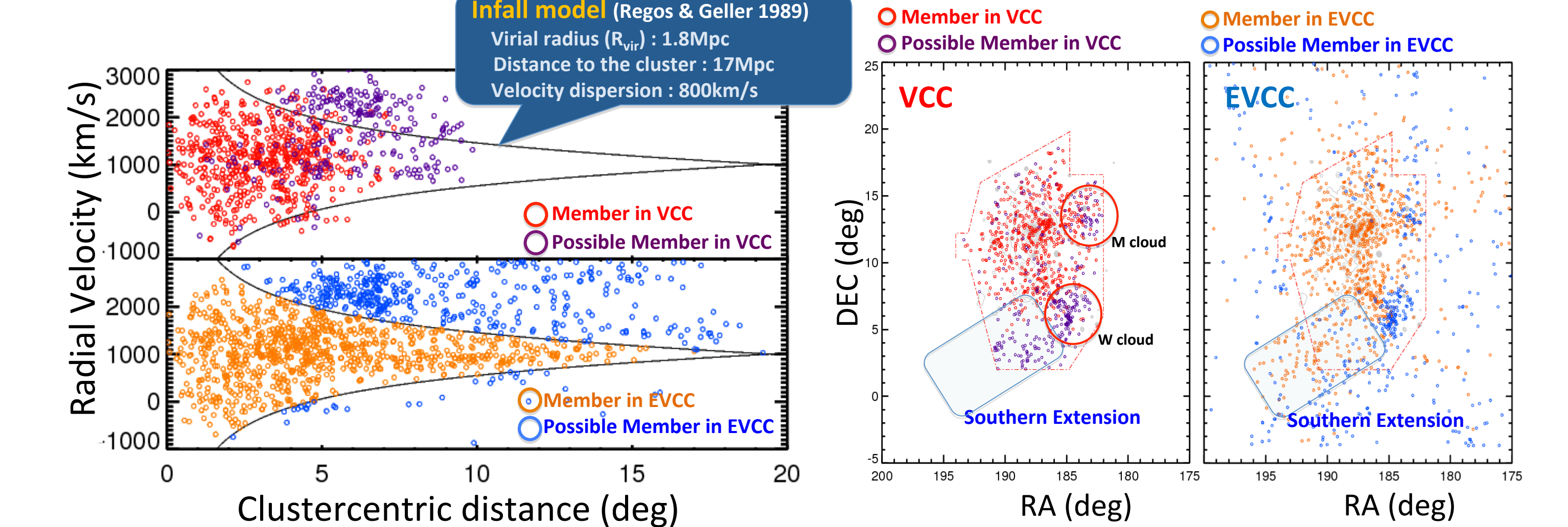
Sample Selection

- Area & Membership



We define the EVCC region of the Virgo cluster (red box ; 750 deg²) as 175 deg < RA < 200 deg and -4 deg < DEC < 25 deg, which is 5.4 times larger than that of VCC (blue polygon ; 140 deg²). The region includes subgroups around the main body of the Virgo cluster such as the Virgo II group (Fouque et al. 1993), located near the south-eastern edge of the VCC region (RA ~ 192-196 deg, DEC ~ -4-5 deg). We focus on the sample galaxies with radial velocities that are available in the SDSS spectroscopic data. The selected member galaxies have heliocentric radial velocities less than 3,000 km/s.

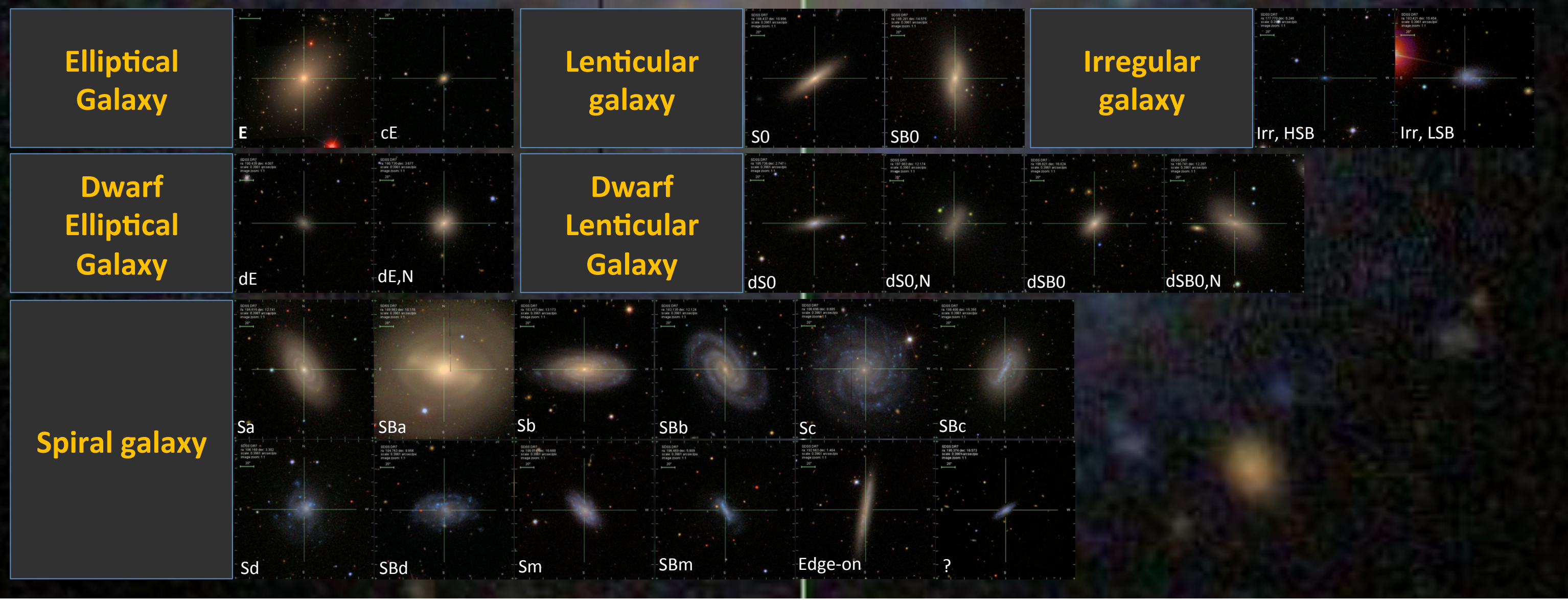
- Member & Possible member



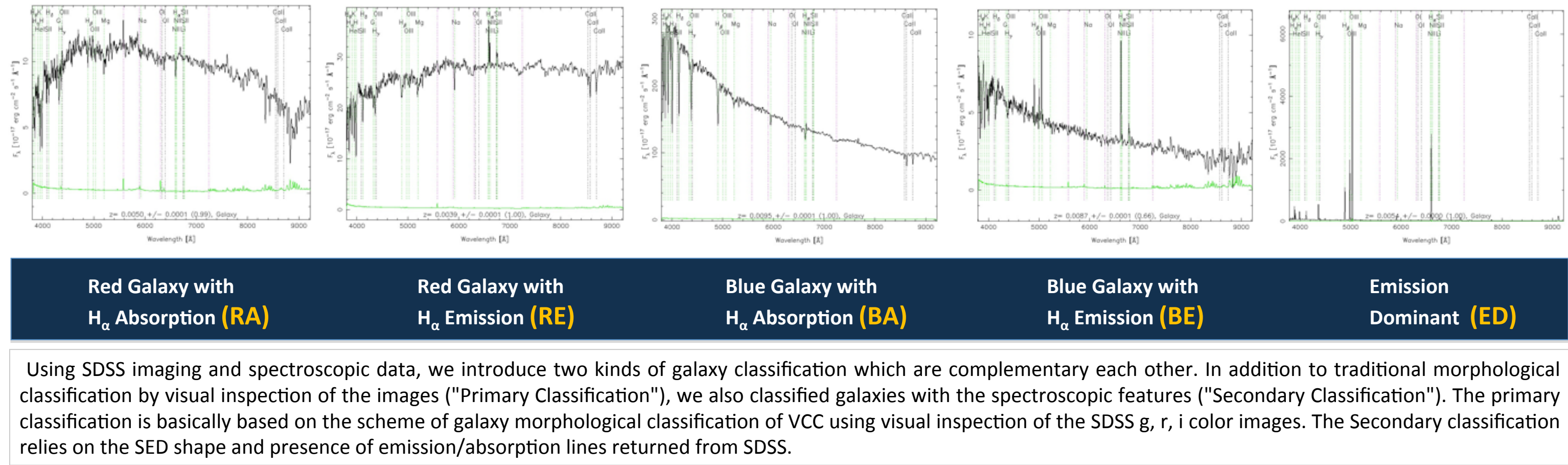
Member and possible member galaxies in the EVCC are selected from the radial velocity vs. clustercentric distance space. Member galaxies of EVCC are widely distributed beyond the region of VCC. Note that a significant fraction of the EVCC galaxies are in the region of the southern extension.

Morphology

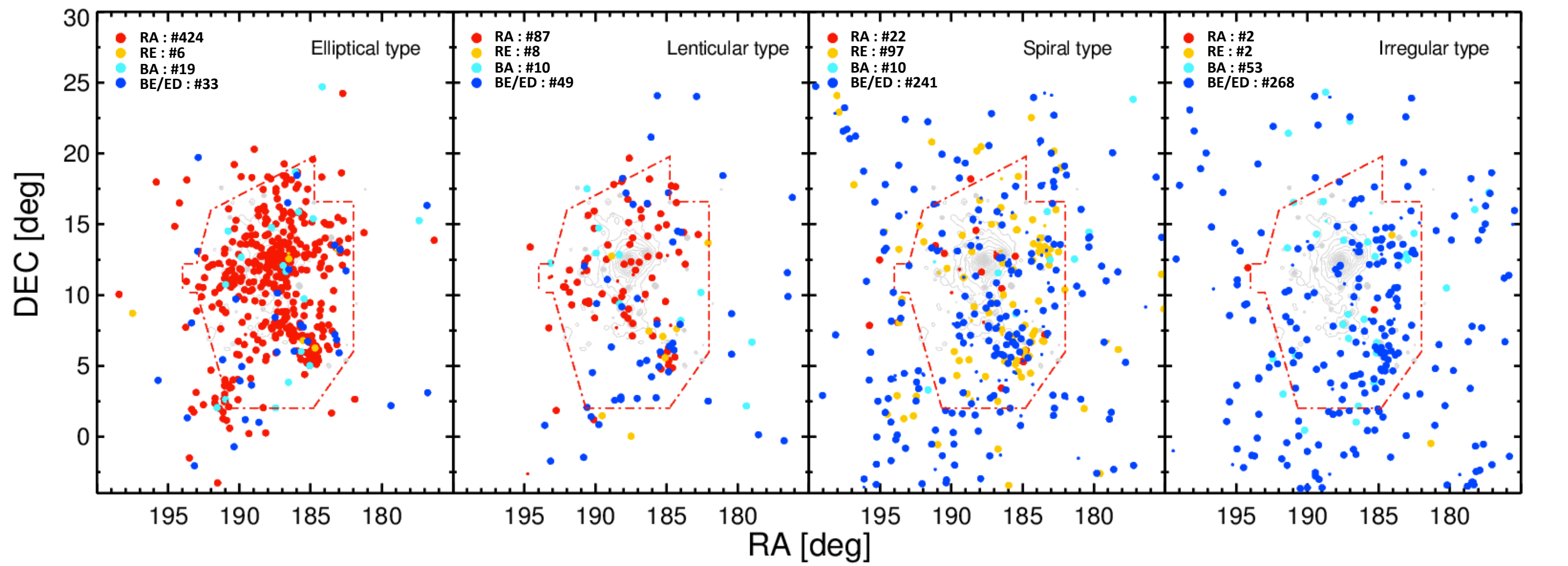
- Primary Morphology



- Secondary Morphology



Projected Spatial Distribution of EVCC Galaxies

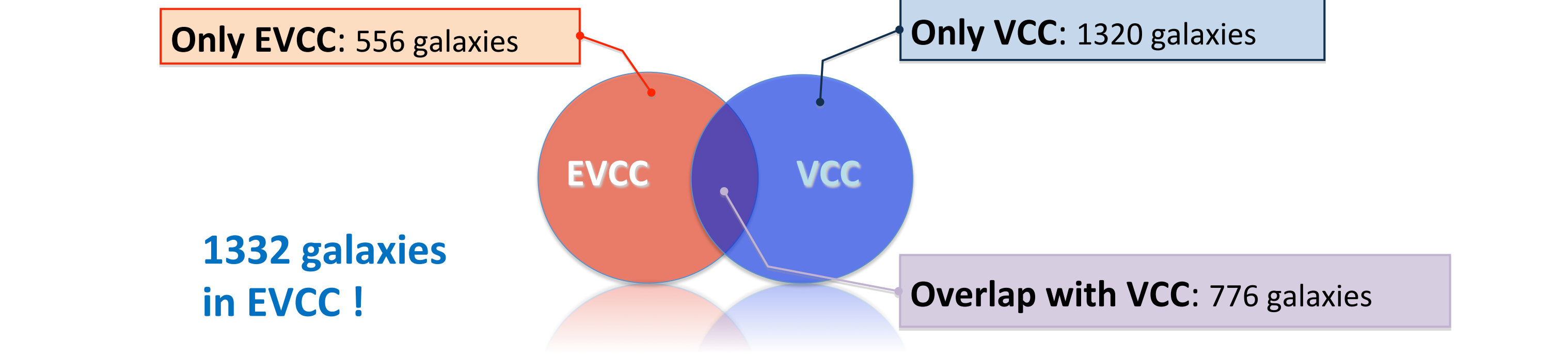


Early-type giant and dwarf galaxies (E/dE/S0/dS0) are more concentrated towards the cluster center, while the outskirts of the Virgo cluster are dominated by spiral and irregular galaxies (BE/ED type galaxies). The contour lines reflect ROSAT X-ray map and the polygon outlines the boundary of the VCC. Outside of the VCC, the EVCC covers a part of the Virgo cluster that is characterized by a relative low galaxy density and large numbers of spiral/irregular galaxies with blue emission line spectra. The prominent exception is the concentration of early-type galaxies with red spectra and H α absorption in the Southern extension.

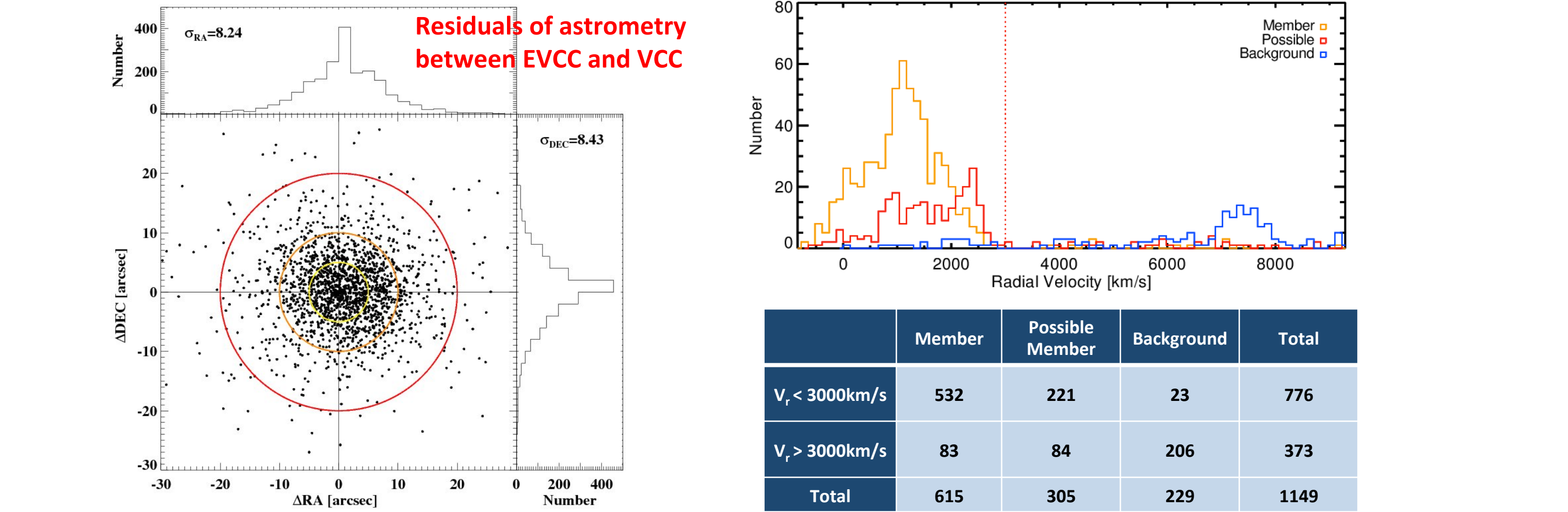
ABSTRACT

We established a new photometric and spectroscopic catalog of galaxies in the extended Virgo cluster environment using the SDSS DR7 data, the extended Virgo cluster catalog (EVCC). The EVCC covers an area 5.4 times larger (750 deg²) than the footprint of the classical Virgo cluster catalog by Binggeli and collaborators. We focused on galaxies with available SDSS spectra and heliocentric radial velocities less than 3,000 km/sec. Our selection process secured a total of 1,332 galaxies of which 556 are not included in the VCC. Based on SDSS imaging and spectroscopic data, we introduced two complementary galaxy classification schemes. In addition to the traditional morphological classification based on optical images ("Primary Classification"), we also characterized galaxies from their spectroscopic features ("Secondary Classification"). For each EVCC galaxy we measured u, g, r, i, z photometric and structural parameters using a sophisticated data reduction pipeline within SExtractor. The EVCC represents a wide range in galaxy densities that is quite different from the inner cluster region. This allows to study the morphological evolution/transformation and the associated star formation activities of galaxies on their first infall into the Virgo cluster, thereby complementing ongoing or planned Virgo cluster surveys at various wavelengths.

Comparison between EVCC and VCC

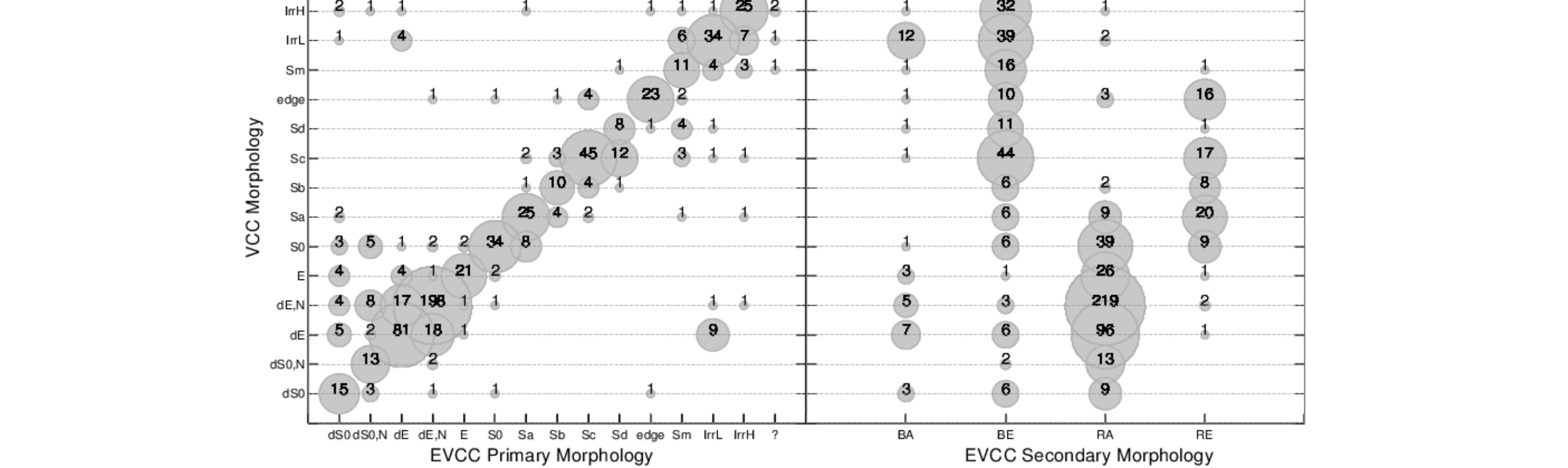


- Issues on the VCC : Astrometry and Membership



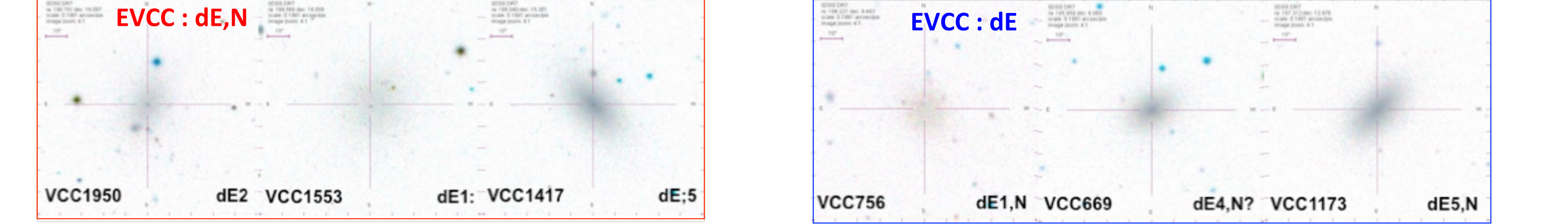
Coordinates of many galaxies listed in the VCC deviate significantly from the true center of the galaxies. Among the 2,096 galaxies in the VCC, 586 galaxies (or 28%) have center coordinate offsets between EVCC and VCC larger than 10 arcsec. Some galaxies defined as cluster members and possible members in the VCC are found to have larger (> 3000km/s) radial velocities (about 13% and 28% for members and possible members, respectively). On the other hand, about 10% of background objects in the VCC are within the the radial velocity limit of 3000 km/s

- Morphology



we present a two-dimensional histogram comparing morphologies of 776 common object in the EVCC and the VCC. A symbol size is proportional to the number of galaxies. Our primary morphologies of the EVCC are well correlated with those of the VCC, although morphologies of a few galaxies are slightly different from the VCC. The main findings are as follows:

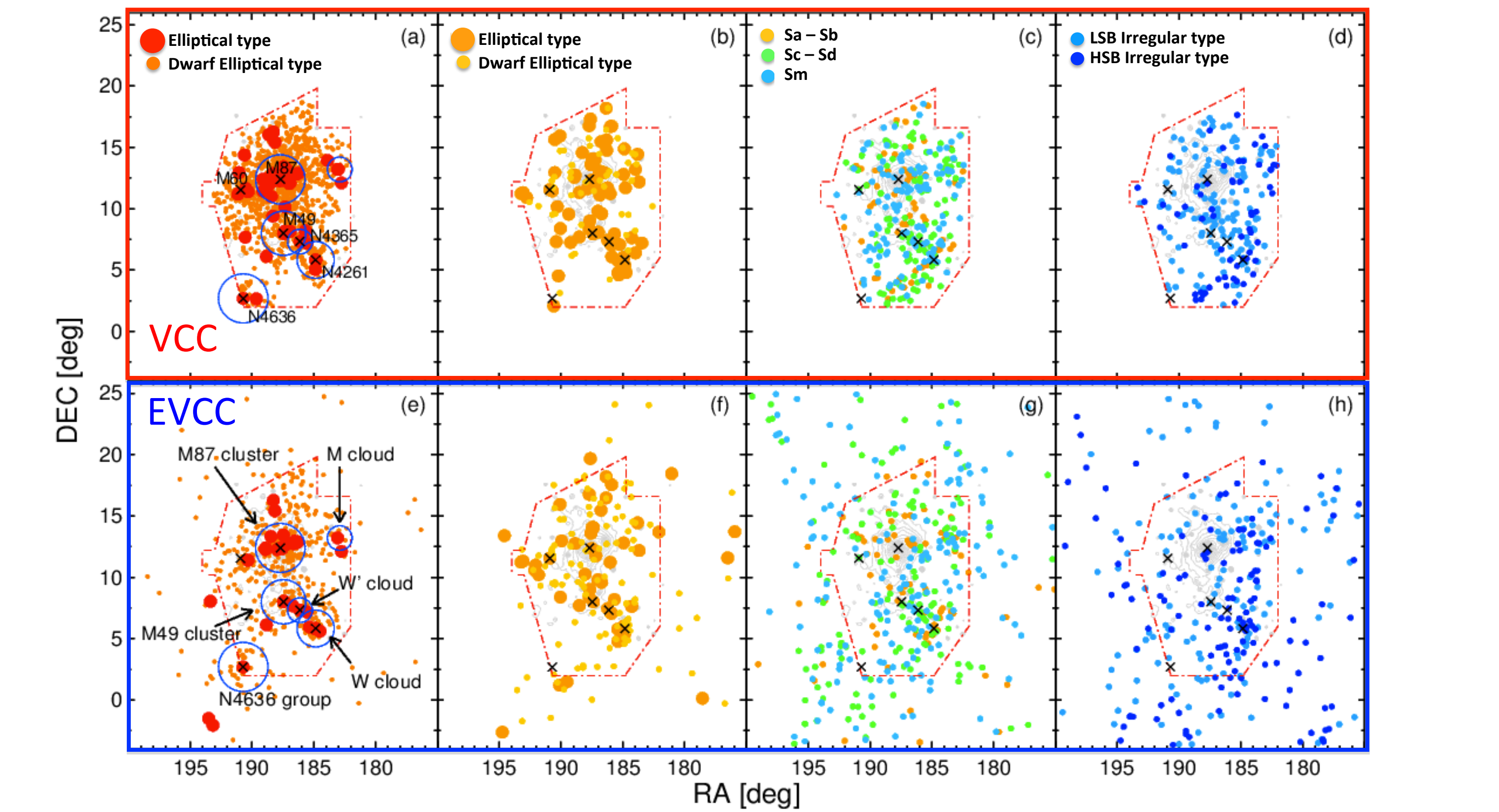
- 1) dS0 and dS0,N galaxies in the EVCC show wide range of morphologies in the VCC (e.g., dE, dE,N, E, S0, Sa). However, large numbers of them were defined by ambiguous morphology in the VCC.
- 2) The VCC and EVCC show small difference to classify dE,N. We classify 17 dE,Ns in the VCC as dEs in the EVCC. 17 dE,Ns in the VCC do not show nuclear in SDSS images. And 18 dEs in VCC are changed to be dE,Ns in EVCC.



- 3) 12 galaxies of the 21 dS galaxies in EVCC are Sc type in the VCC (~57%). Among them, 50% (6/12) galaxies show ambiguous morphology (Scd, SBcd) in the VCC.

At a given secondary morphology, red galaxies with H α absorption (RA) and emission (RE) in the EVCC are well correlated with early type galaxies and spiral galaxies, respectively. Early (Sa,Sb) and late(Sc, Sd) spiral galaxies are matched with RE and BE, respectively. IrrL and IrrH galaxies are mostly BE. Many IrrL galaxies are also correlated with BA. Some early type dwarf galaxies in the BE and BA are assumed to be dE with the blue center (Lisker et al. 2006b).

- Projected Spatial Distribution



- E and S0 galaxies in the VCC and EVCC are strongly concentrated not only near the M87 but also in sub-groups (M49 cluster, W' group, W, and M cloud).
- dE galaxies are distributed surrounding giant elliptical galaxies in the EVCC and VCC.
- Late-type (spiral, irregular) galaxies are relatively more scattered and randomly distributed than the early-type galaxies in the VCC and EVCC. And most galaxies outside the VCC are late-type galaxies.
- Late-type galaxies are located in outer region of M87 cluster and NGC4636 group. However in M and W cloud, spiral and irregular galaxies are strongly concentrated.