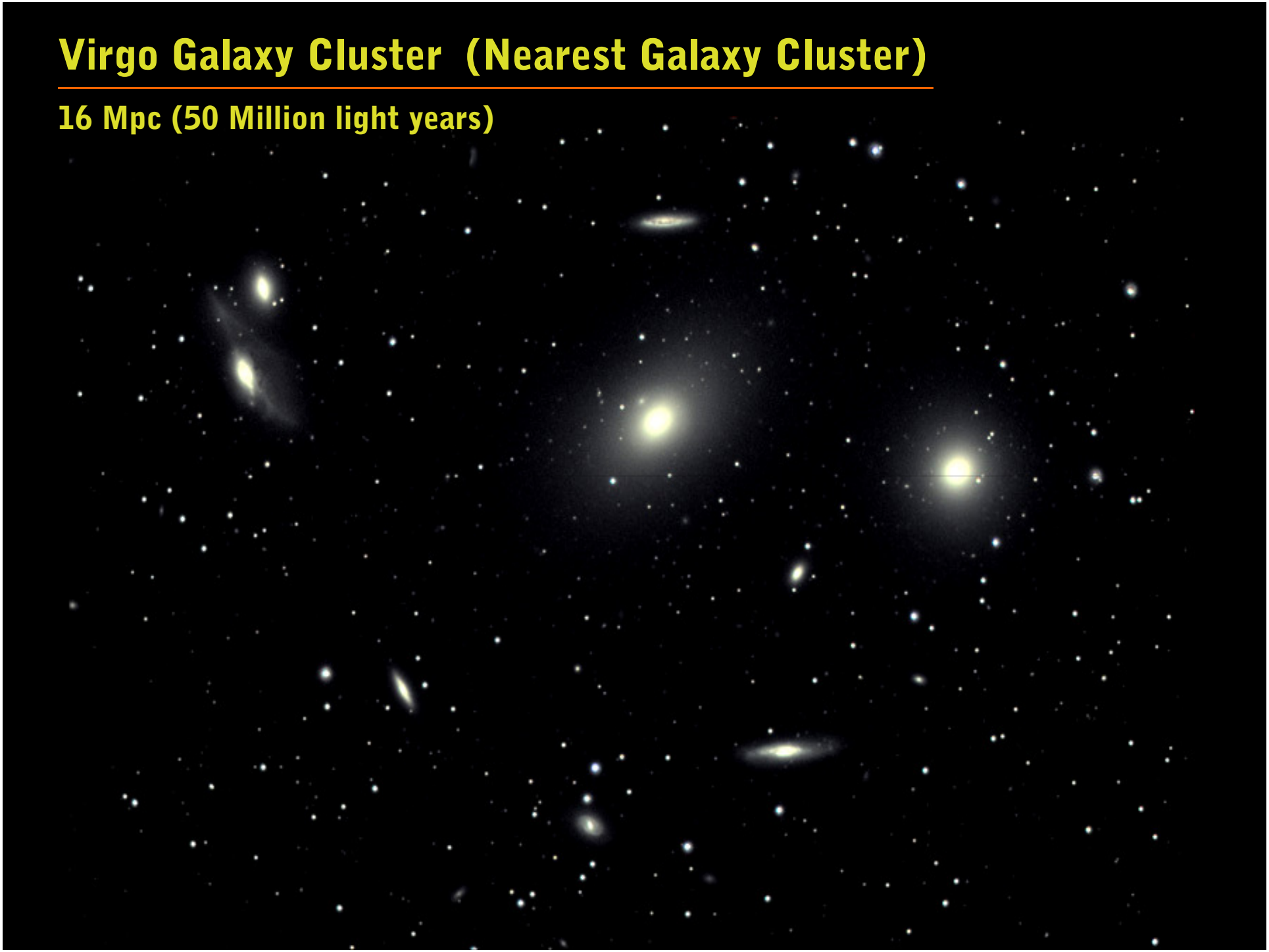
Virgo Galaxy Cluster (Nearest Galaxy Cluster)

16 Mpc (50 Million light years)

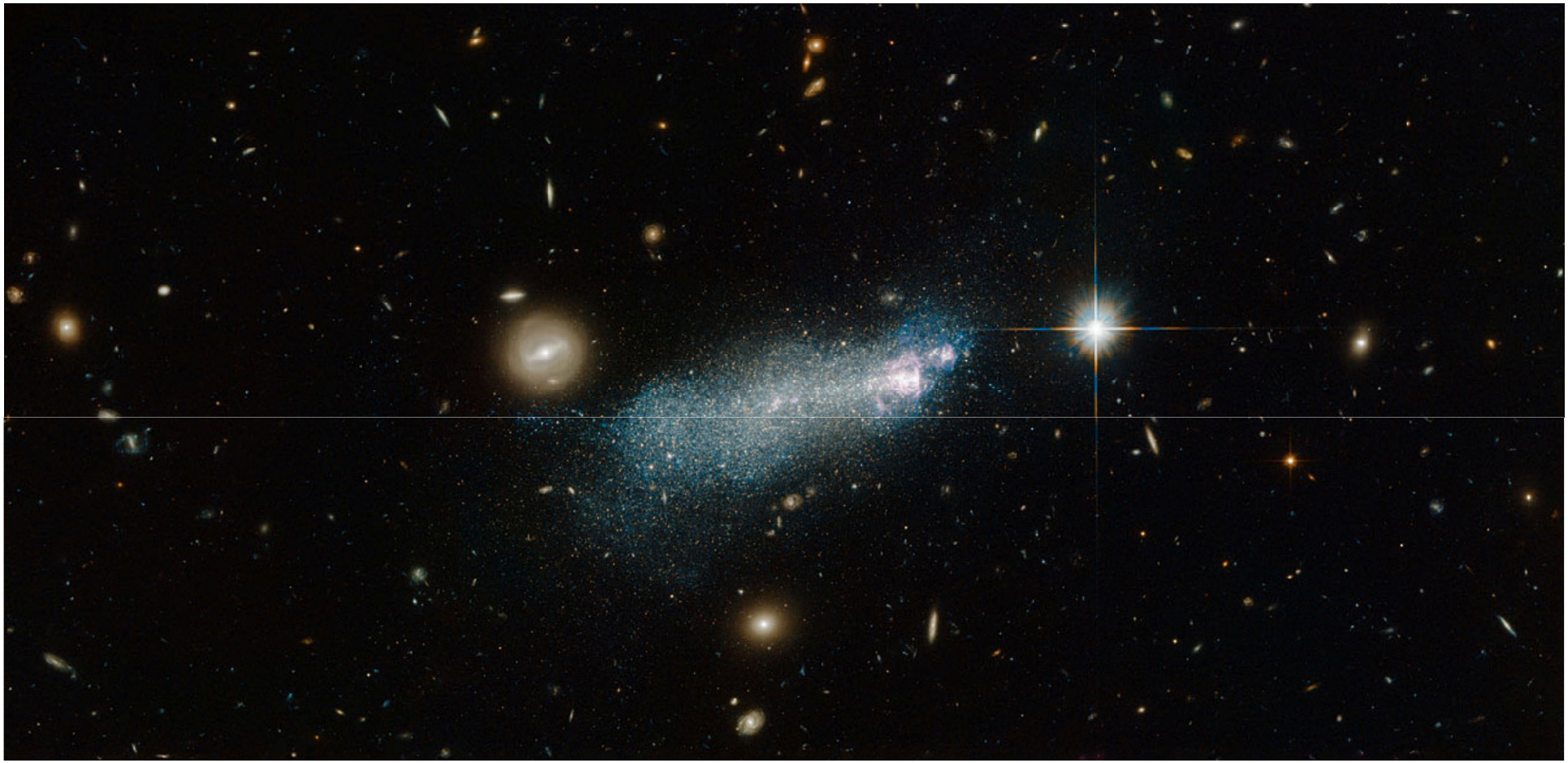


Virgo Galaxy Cluster (Nearest Galaxy Cluster)

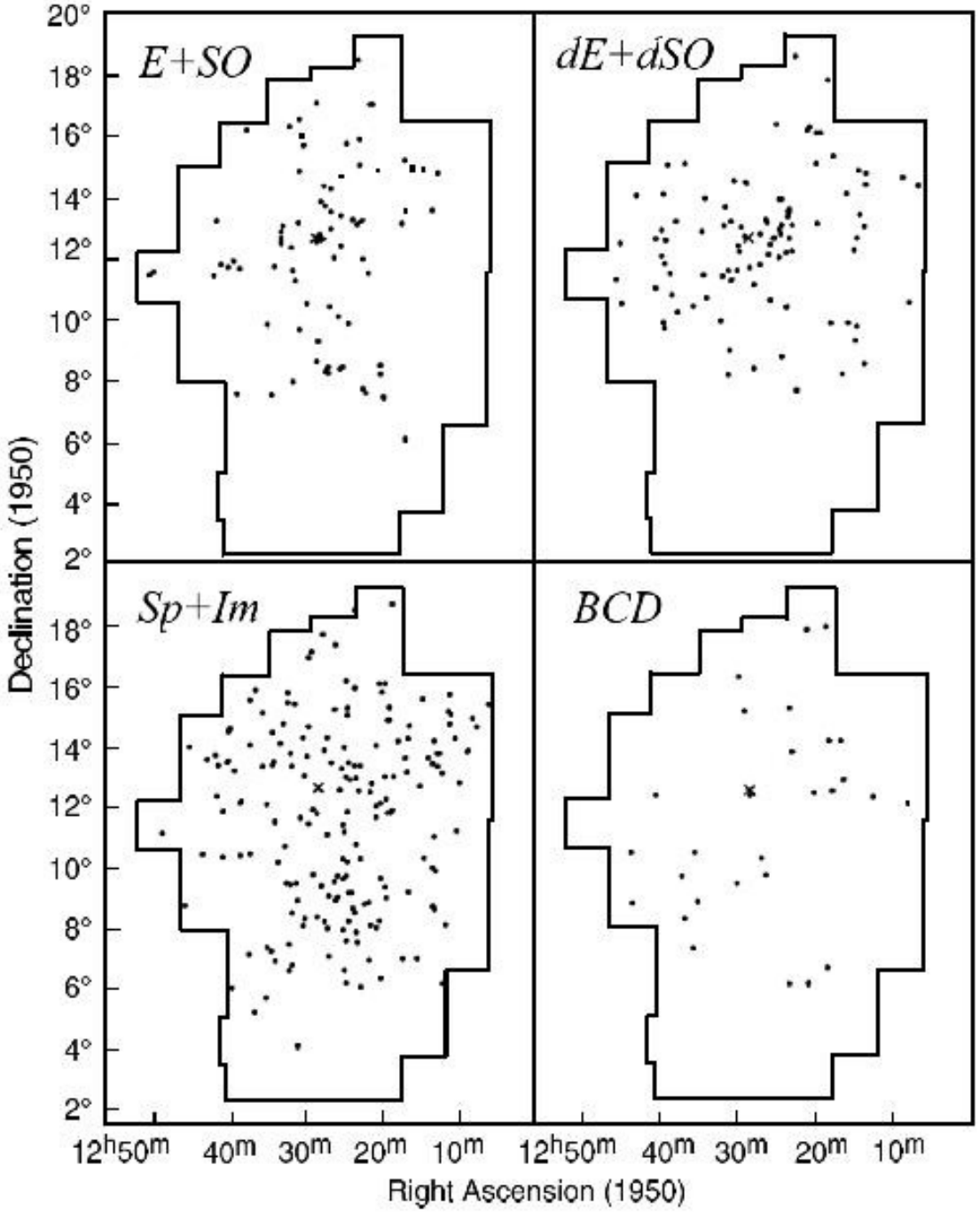
16 Mpc (50 Million light years)

In Virgo cluster, 20% of the bright galaxies are ellipticals and these occupy the central regions of the cluster. The remaining bright galaxies are spirals.

Dwarf ellipticals (dE, dSph) and BCDs are large in number



Blue Compact Dwarf (BCD) galaxy PGC 51017

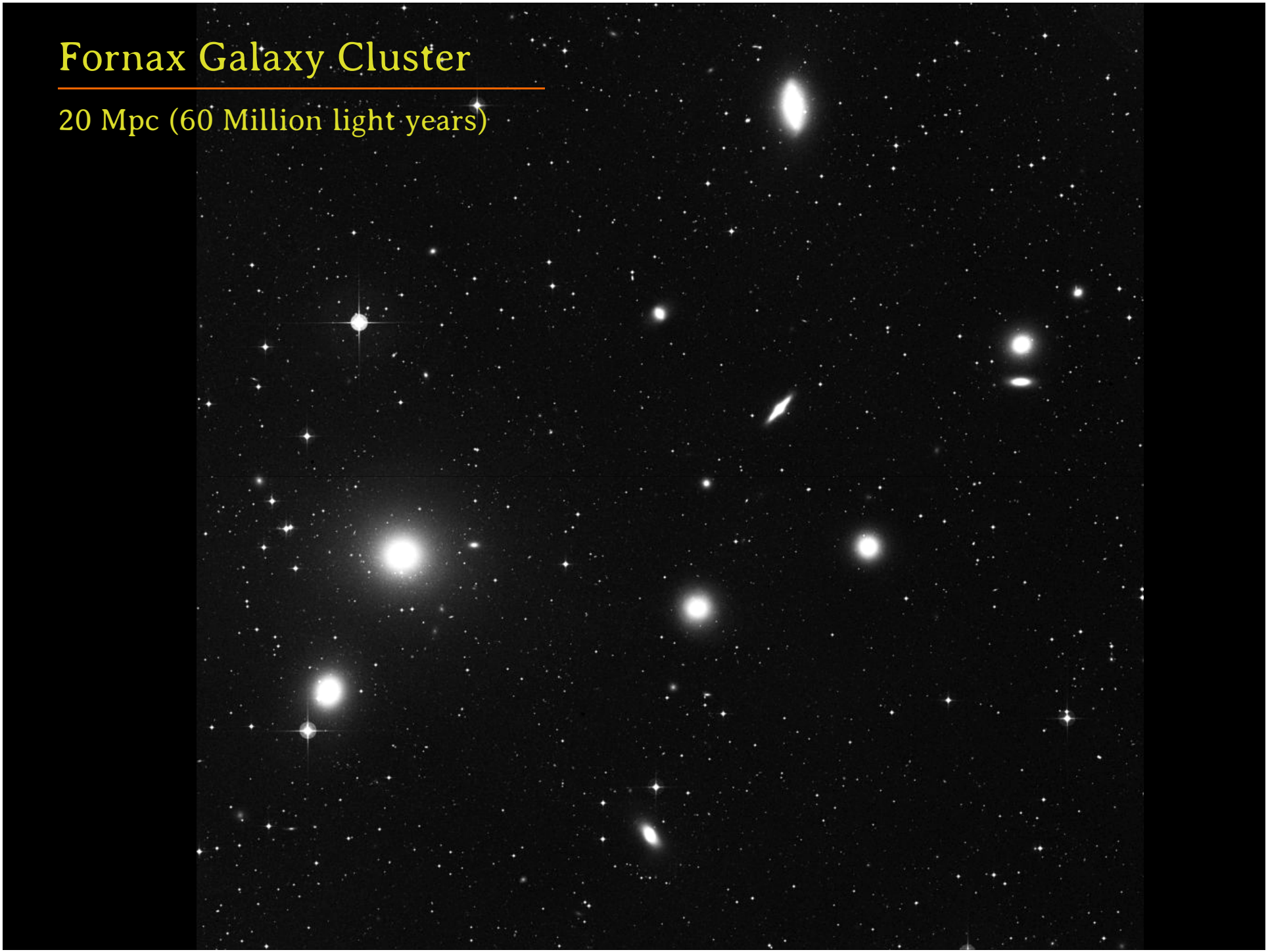


The distribution of the main morphological classes of galaxies in the Virgo cluster: E + S0, dE + dS0, spirals + magellanic irregulars, and clumpy irregulars (BCDs), shown in four panels.

Figure from Binggeli et al. (1993).

Fornax Galaxy Cluster

20 Mpc (60 Million light years)




Coma Galaxy Cluster
90 Mpc (320 Million light years)

Galaxy Groups & Clusters

inside a sphere of diameter 1.5 Mpc

- Galaxy over-density regions
  - N < 50 : ***group***
  - N > 50 : ***clusters***

- Clusters and groups of galaxies are *bound, virialized, high overdensity systems of galaxies*, held together by gravity

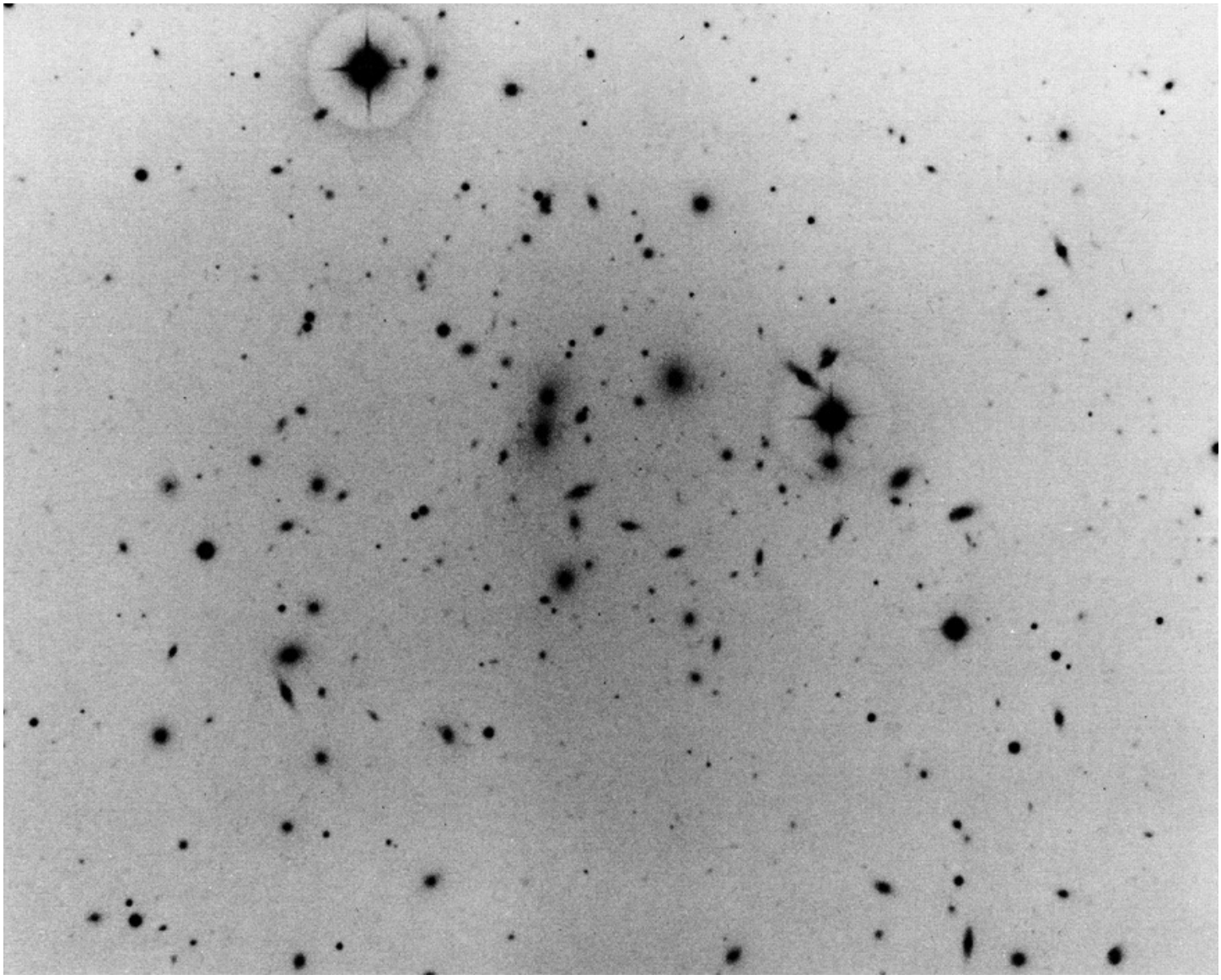
- Galaxies isolated in space are called ***field galaxies***

Galaxy Groups & Clusters

One dimensional velocity dispersion :	200 km s^{-1} (groups)	1000 km s^{-1} (clusters)
Dynamical Mass :	10^{13} M (groups)	10^{15} M (clusters)

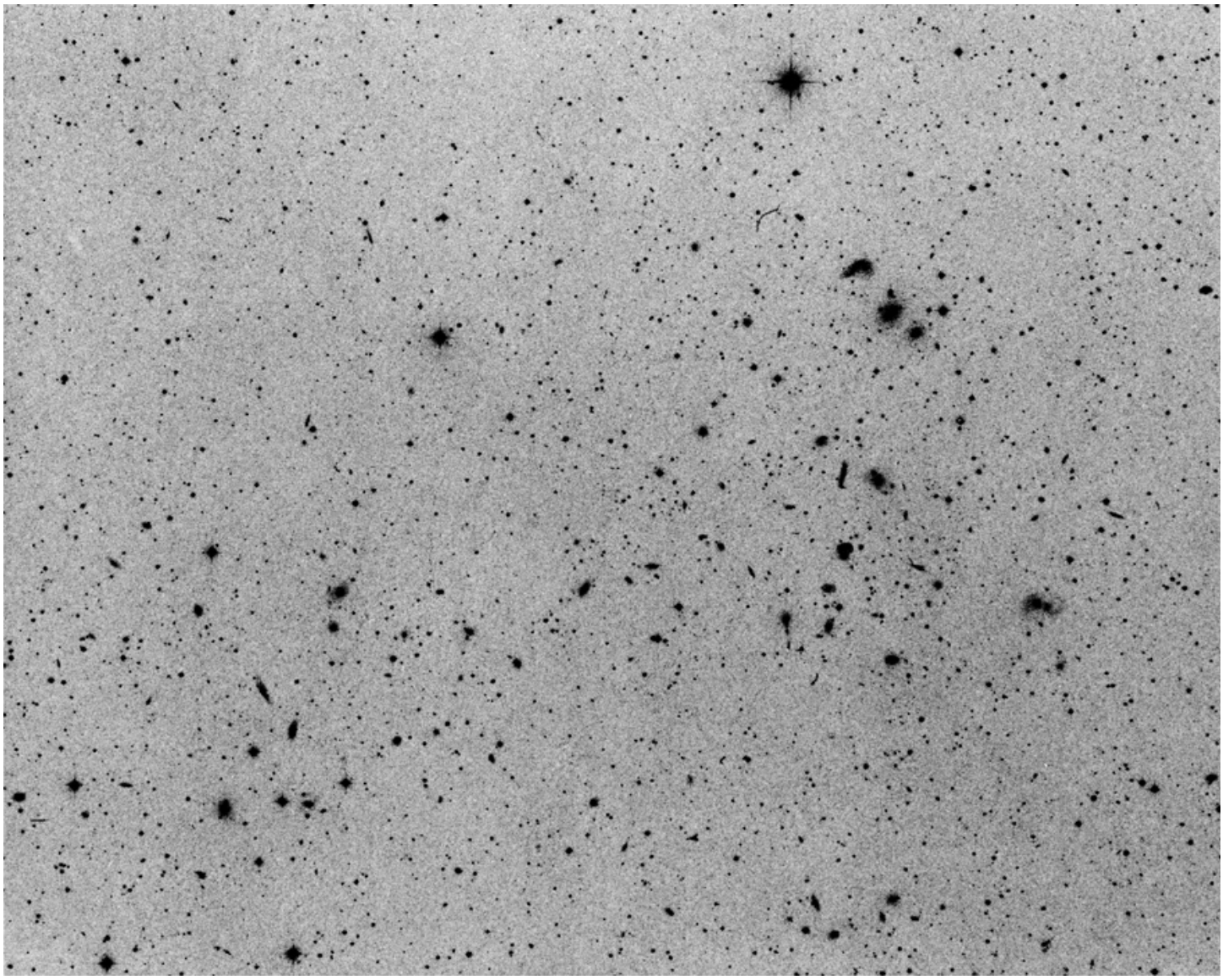
Galaxy cluster ABELL 2065

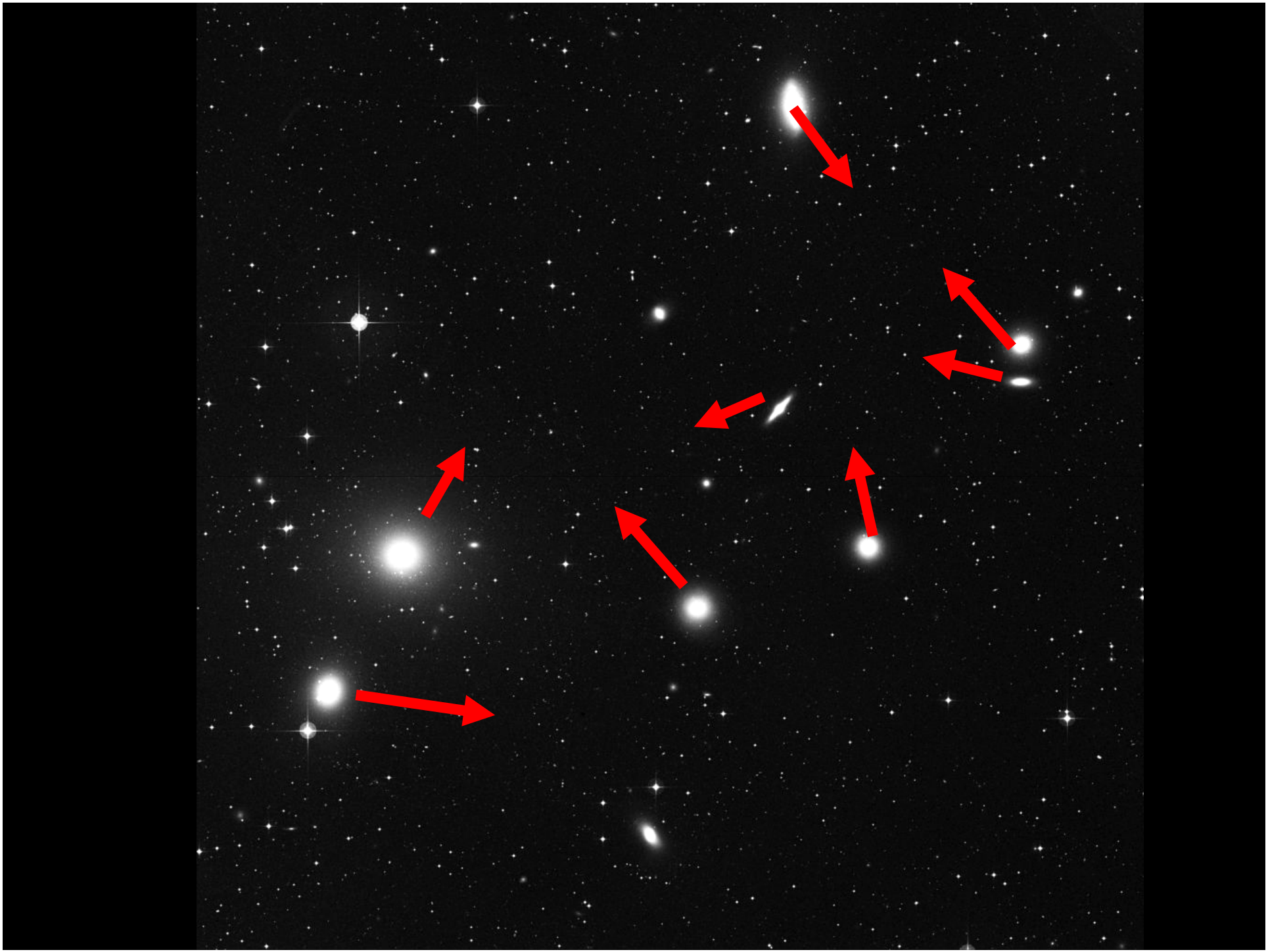
(in the direction of the constellation Corona Borealis), photographed with the 200-inch telescope. Scale: 1 mm = 3.9".



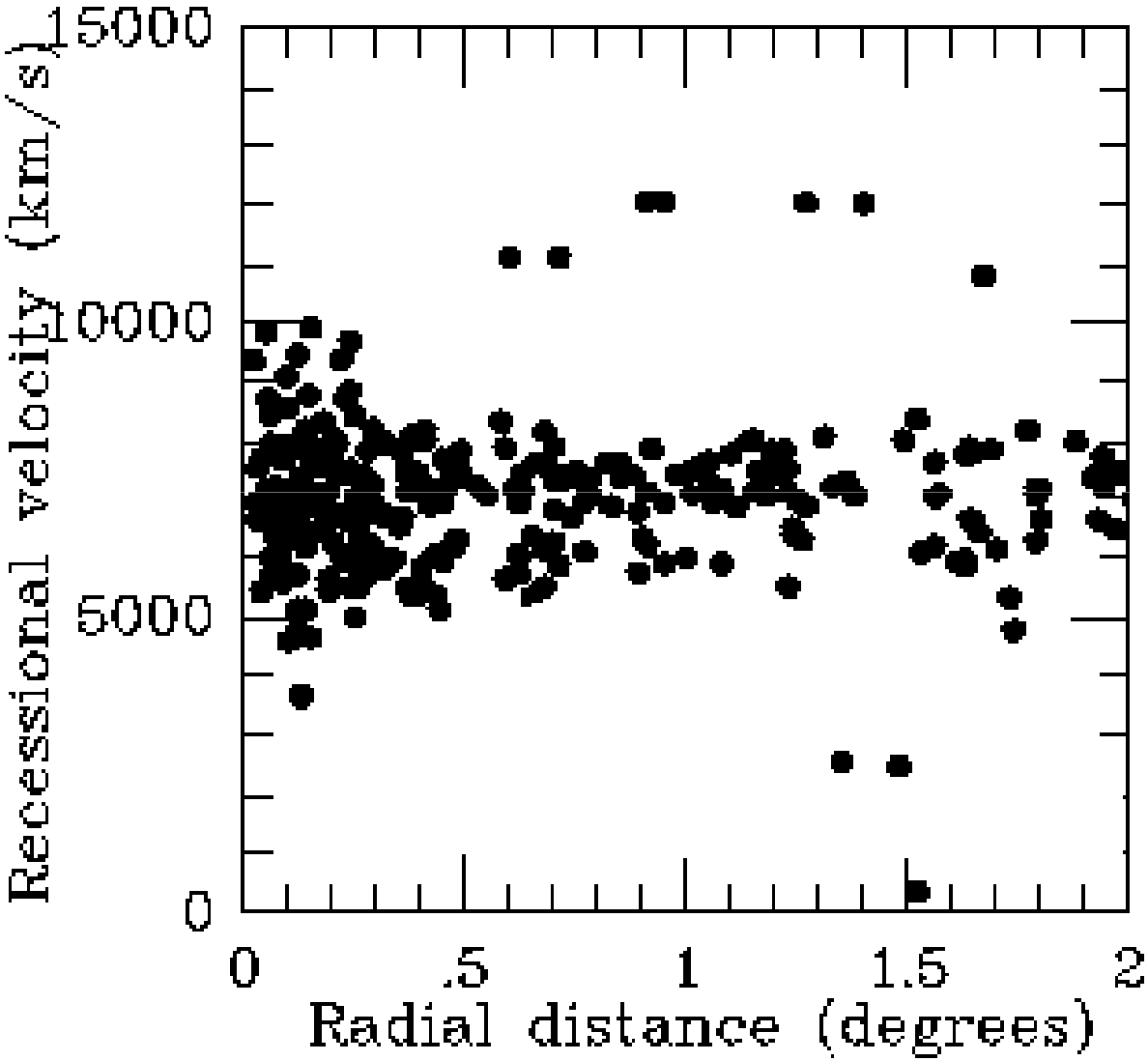
Galaxy Cluster ABELL 2151

(in the direction of the constellation Hercules), photographed with the 48-inch Schmidt telescope. Scale: 1 mm = 22.3".

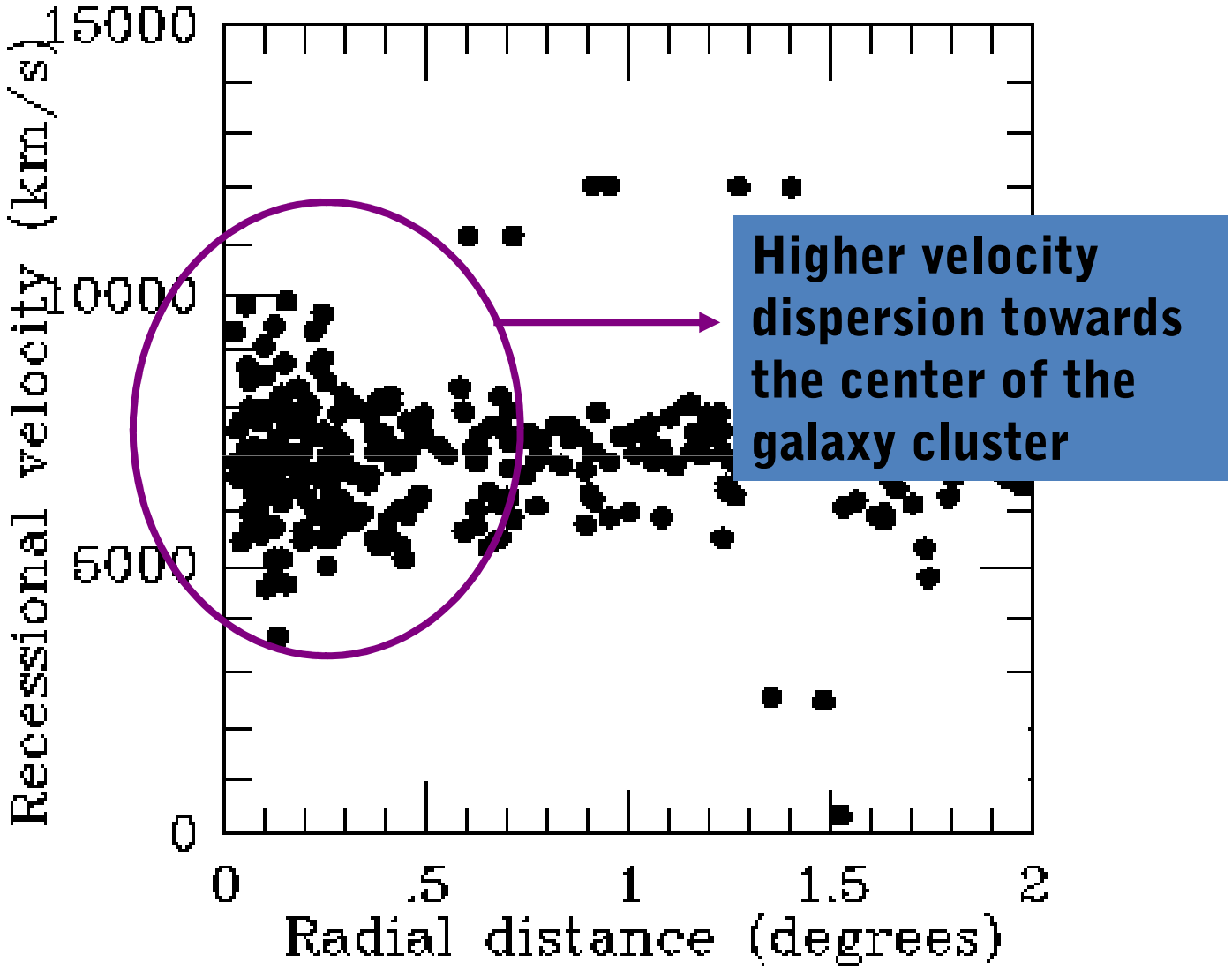




Identifying Cluster Members



Identifying Cluster Members



Galaxy Clusters Are Gravitationally Bound ?

- Are galaxy clusters gravitational bound structures or transient structures? – answering this is fundamental to estimating cluster dynamical mass.

- How to answer : Estimate the crossing time of galaxies in a cluster. How does that compare with the age of the cluster?

Crossing time : the time it takes for a galaxy to cross the cluster from end-to-end

$$t_{cross} \sim \frac{R}{\sigma_v} \sim \frac{1\ \mathrm{Mpc}}{1000\ \mathrm{km/s}} \sim 10^9\ \mathrm{yrs}$$

[enough time clusters had to dissipate off when compared to the age of the universe]

Clusters of galaxies in the nearby universe are ***relaxed*** systems

Application of virial theorem to galaxy clusters is valid