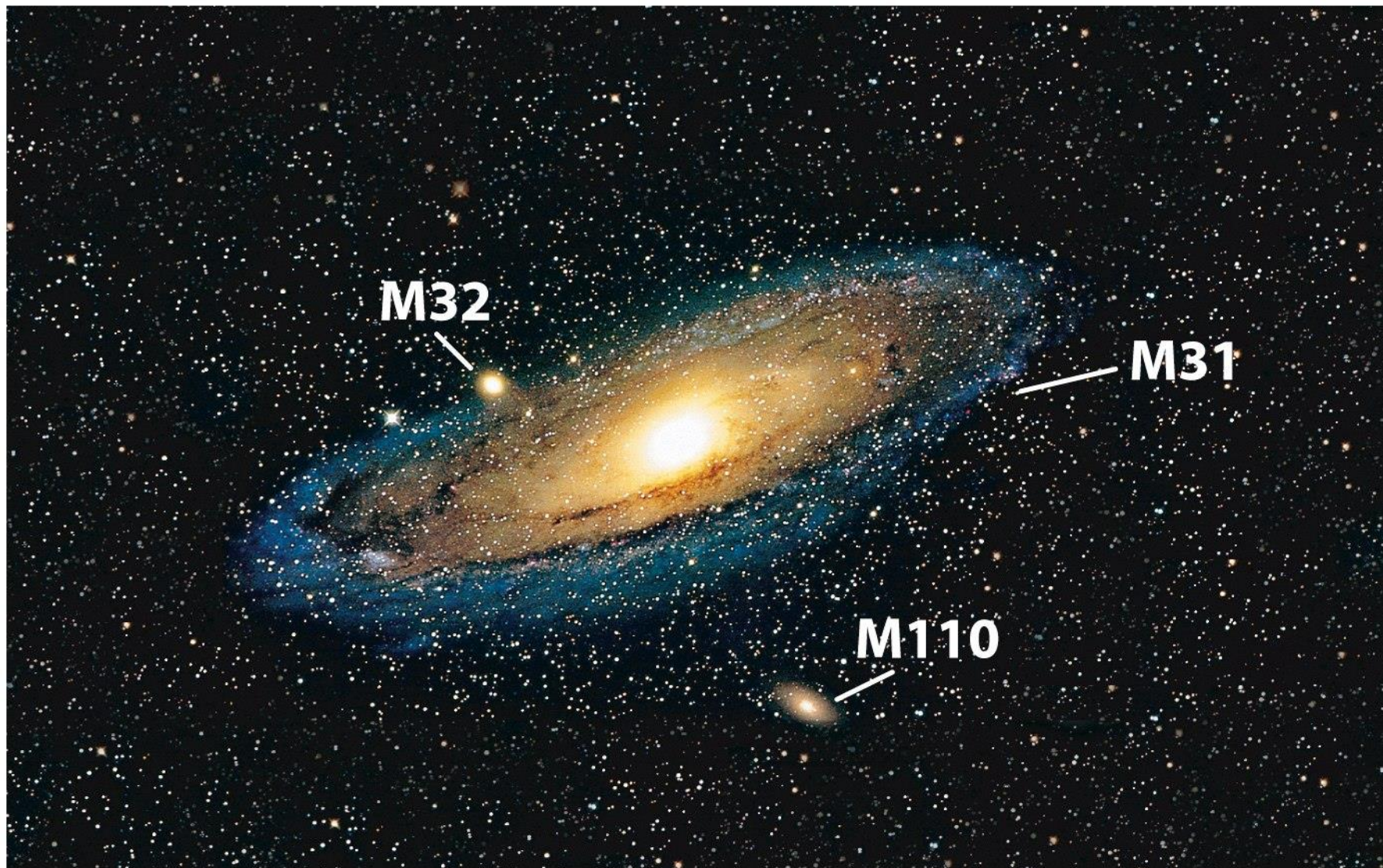


Galaxy Types

- Definition of a galaxy
- Galaxy Types
 - Spiral
 - Elliptical
 - Irregular
- Galaxy Classification
 - Hubble's Tuning Fork Diagram

Galaxies

- A galaxy is a gravitationally bound collection of stars, gas and dust
 - e.g. our Galaxy contains of order 10^{11} stars
- Usually isolated in space, although can interact with near neighbours
- The main visible component of the Universe



From Universe textbook

Galaxy Types

- Galaxies are seen in three major types
 - Spirals
 - Ellipticals
 - Irregulars

Spiral Galaxies

- Rotating *disc* dominated by spiral arms
- Spiral Arms are
 - rich in young, hot, blue stars, i.e. Population I
 - rich in gas and dust
 - where formation of new stars takes place



Credit: Gemini Observatory, GMOS Team

- An elliptical concentration of stars at the centre is called the *bulge*
- Bulge is rich in red stars – Population II and old Population I



- Also come in *barred* form where the two arms originate from the ends of a central linear feature of bulge-like stars



Credit: NASA, ESA, and The Hubble Heritage Team (STScI/AURA)

Elliptical Galaxies

- Elliptical collections of red stars – Population II and old Population I
- Smooth variation in intensity
- Very little gas & dust
- Little organized rotation
- Come in both giant and dwarf forms





Leo I
Dwarf Elliptical

From Universe textbook

Irregular Galaxies

- No regular structure
- Contain plenty of gas and dust and blue stars
- Mixture of Population I and II
- Usually relatively small



IC10: credit line: Adam Block/NOAO/AURA/NSF



Irregular galaxy NGC 4214. Credit NASA HST

Class Example

- What is the typical angular separation of stars that are about 1 pc apart in a galaxy that is at a distance of 1 Mpc?

$$q = \frac{l}{d} = \frac{1}{1 \cdot 10^6} = 1 \cdot 10^{-6} \text{ radians}$$

$$= 206265 \cdot 1 \cdot 10^{-6} = 0.206$$



<https://sci.esa.int/web/hubble/-/55194-sharpest-ever-view-of-the-andromeda-galaxy>

The Evolution of Galaxy Types

- Compare the distribution of galaxy types in two different collections of galaxies
 1. Virgo Cluster
 - Nearest rich cluster at 15 Mpc away
 2. The Hubble Extreme Deep Field
 - Deepest optical image every made
 - High resolution view of a 'blank' bit of sky

Virgo Cluster 1°



A zoom in to the XDF



2.5'

550
hours



Hubble XDF 45"



Class Exercise

- ***Estimate*** the average percentage of ellipticals, spirals and irregulars for the Virgo cluster and Hubble Extreme Deep Field images provided

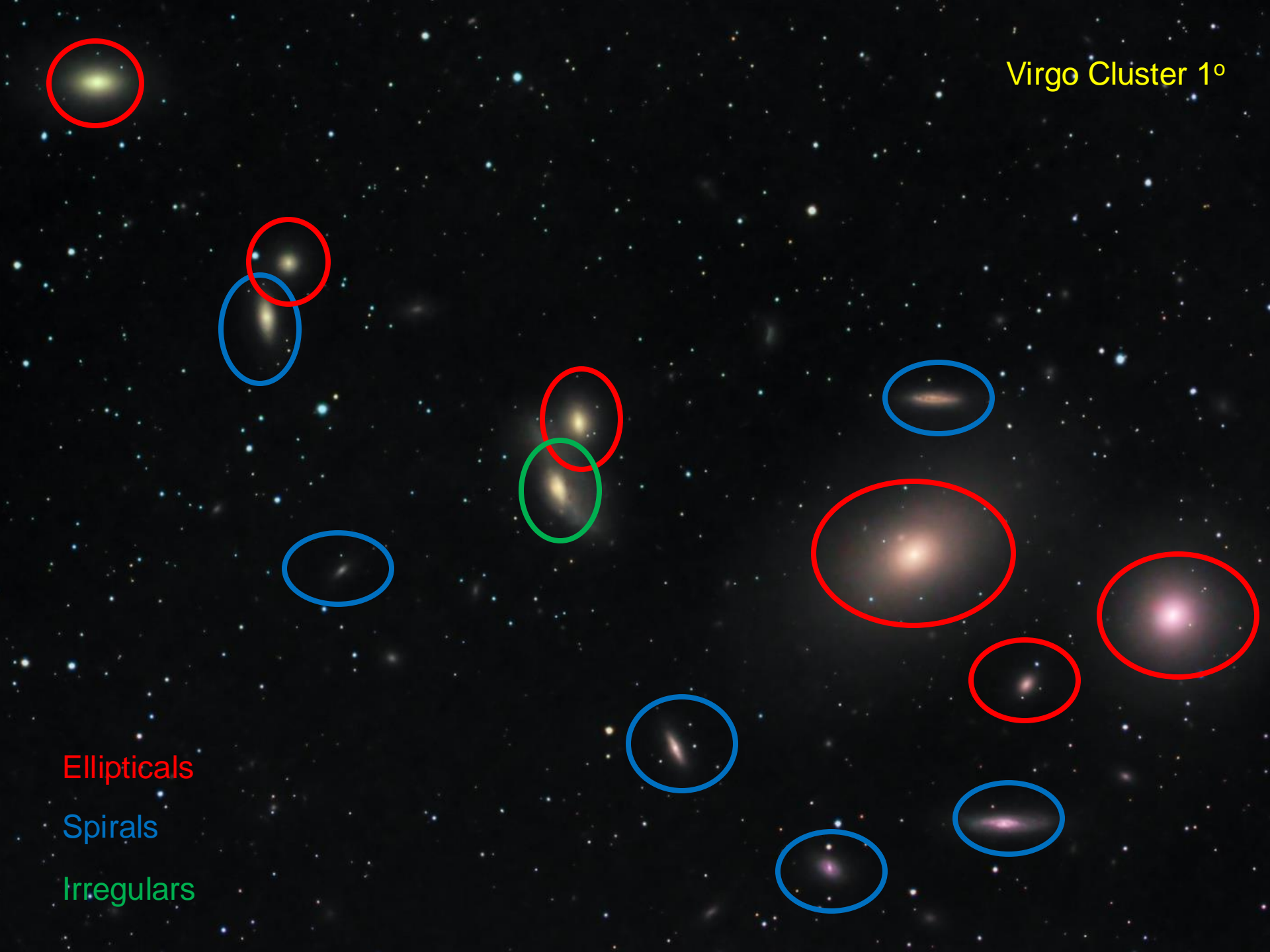
	E	S	Irr
Virgo			
XDF			

Virgo Cluster 1°

Ellipticals

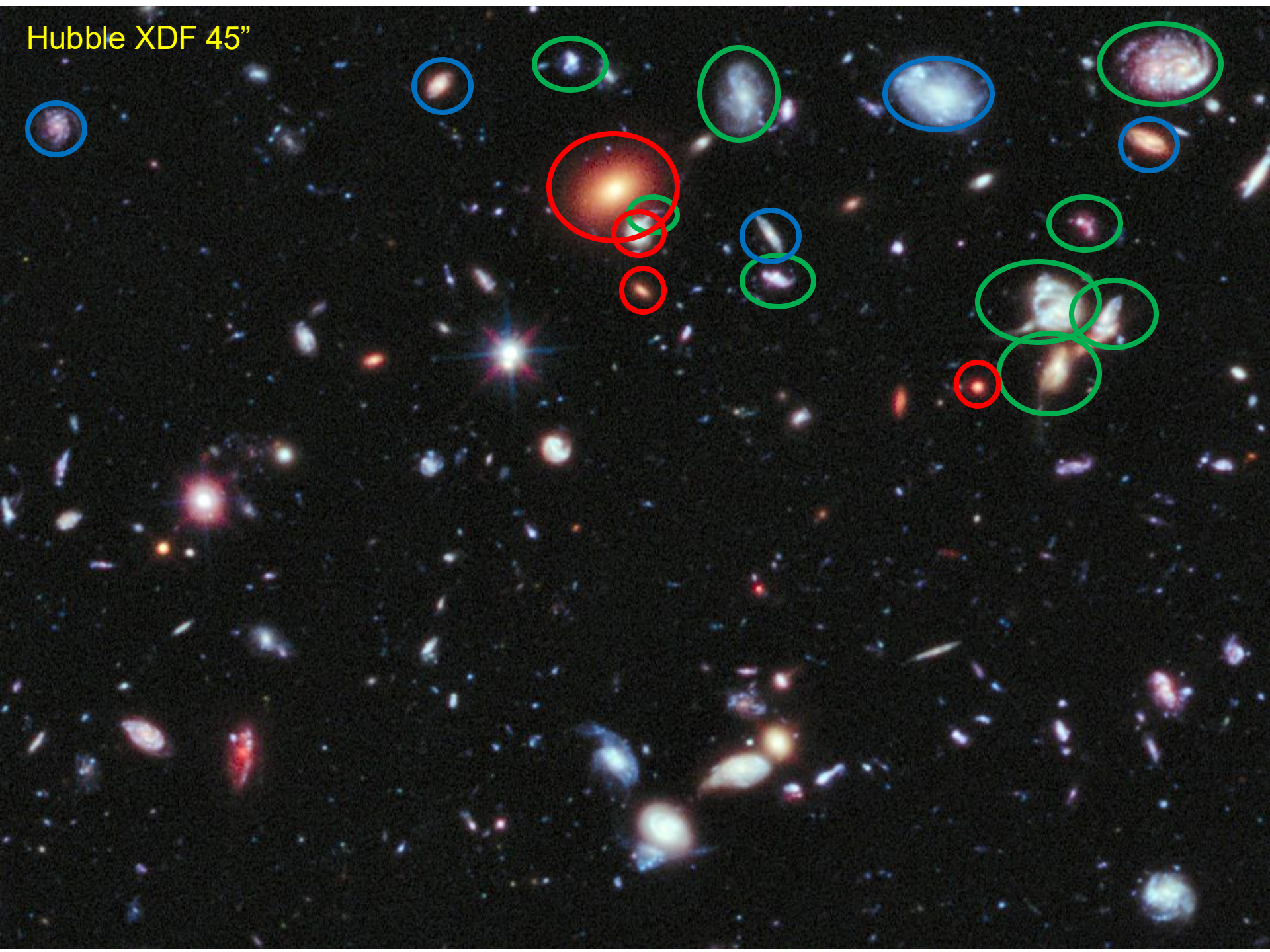
Spirals

Irregulars



	E	S	Irr
Virgo			
XDF			

Hubble XDF 45"

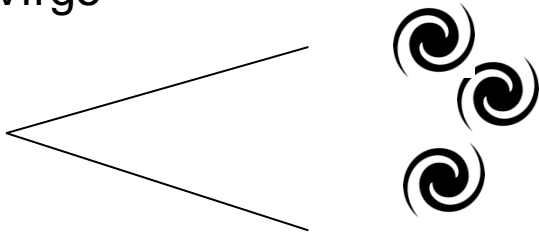


	E	S	Irr
Virgo			
XDF			

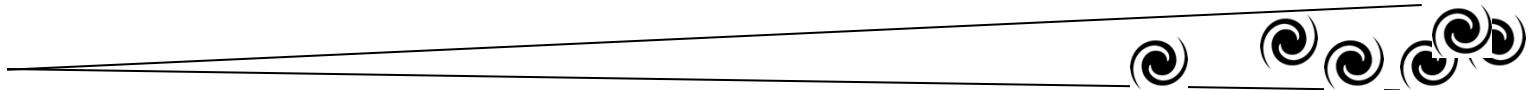
	E	S	Irr
Virgo	46%	46%	8%
XDF	22%	28%	50%

Two Views of a Population of Galaxies

Virgo



XDF



Spirals galaxies merge to form ellipticals



Summary

- Galaxies can be classified as either spirals, ellipticals or irregulars
- Spirals and irregulars contain gas, dust and blue stars whilst ellipticals contain only red stars
- The population of galaxies has evolved over cosmic time driven mainly by mergers of gas-rich galaxies merge to form ellipticals