The age of the S0 disks and the origin of lenticular galaxies

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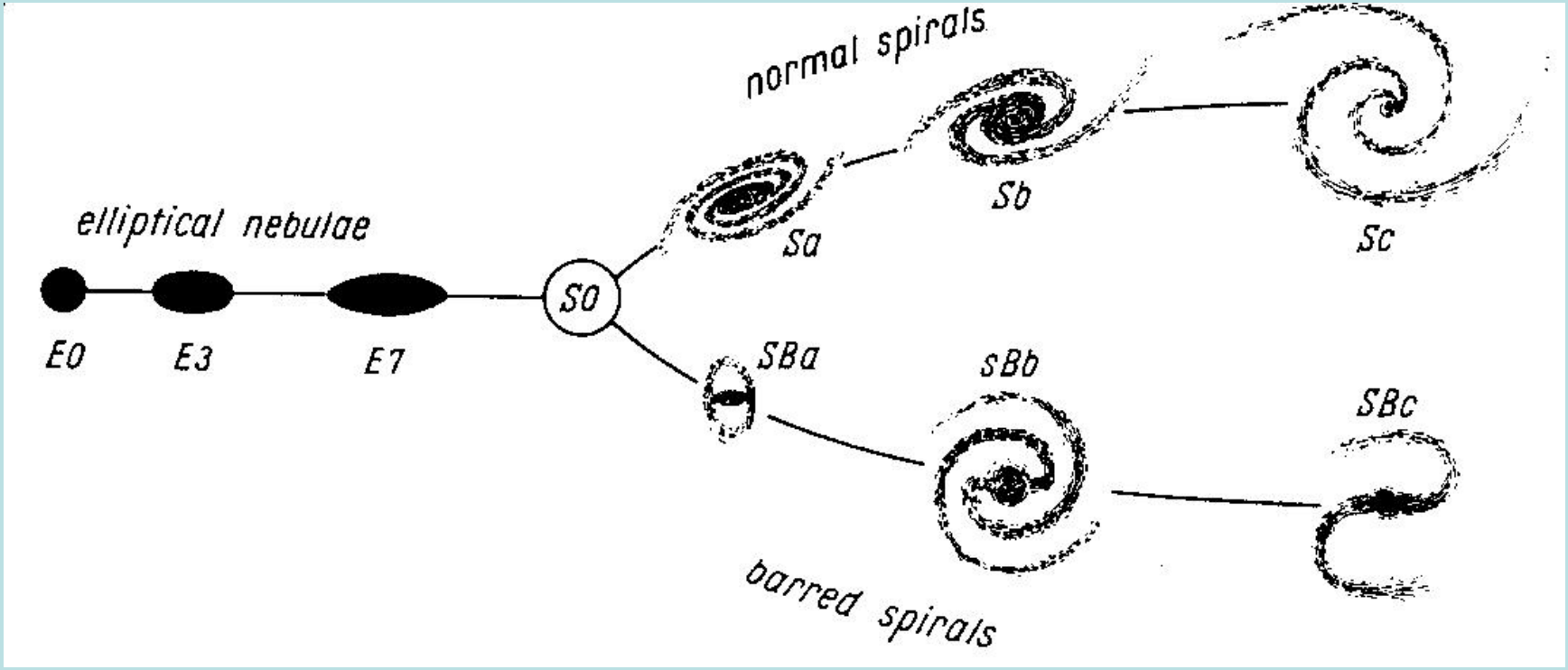
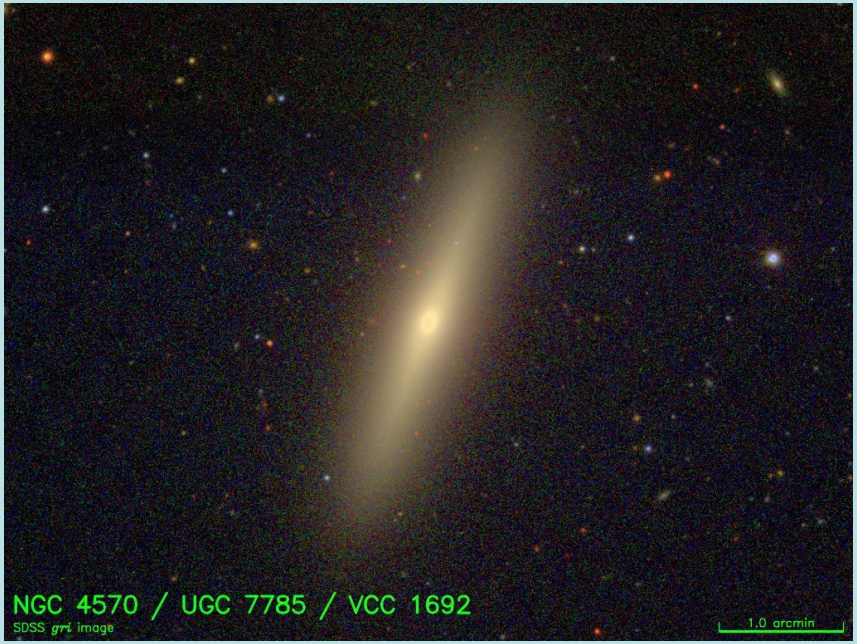
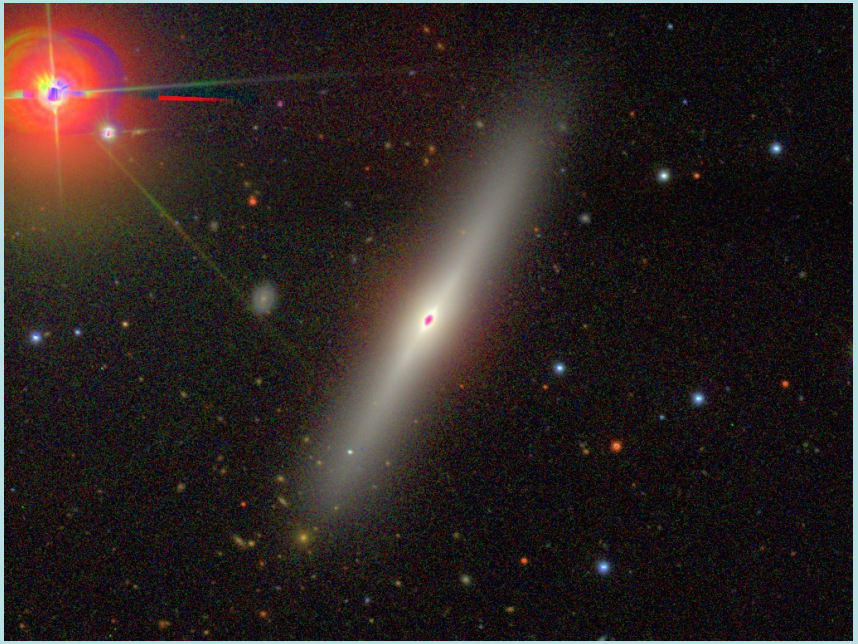
Hubble's fork (1936)



Lenticulars edge-on

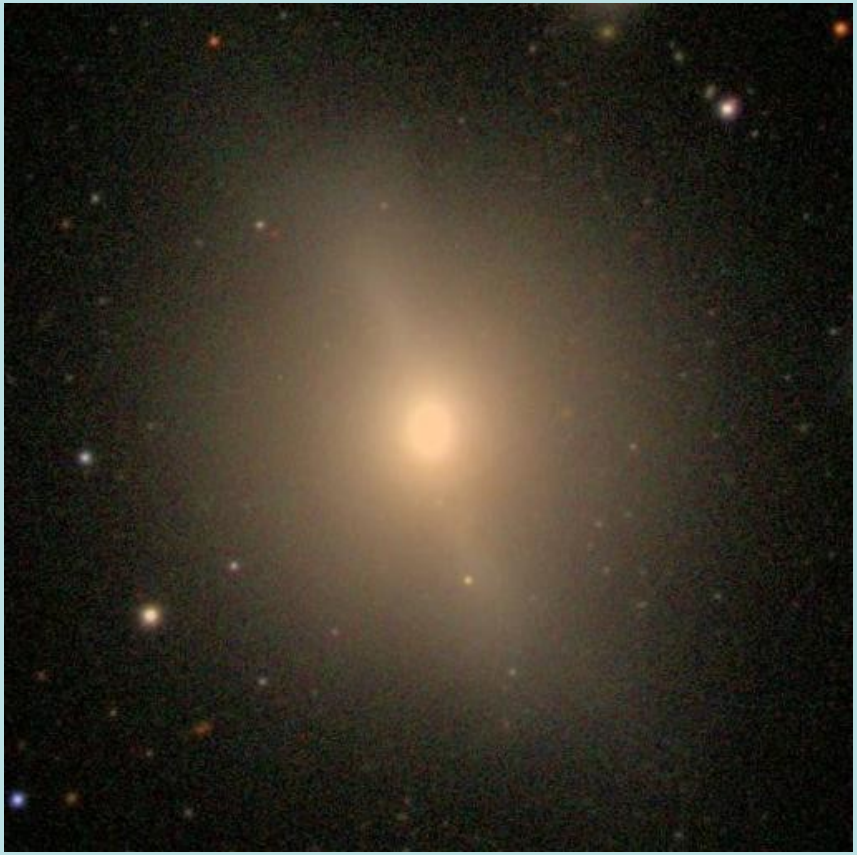


NGC 4570

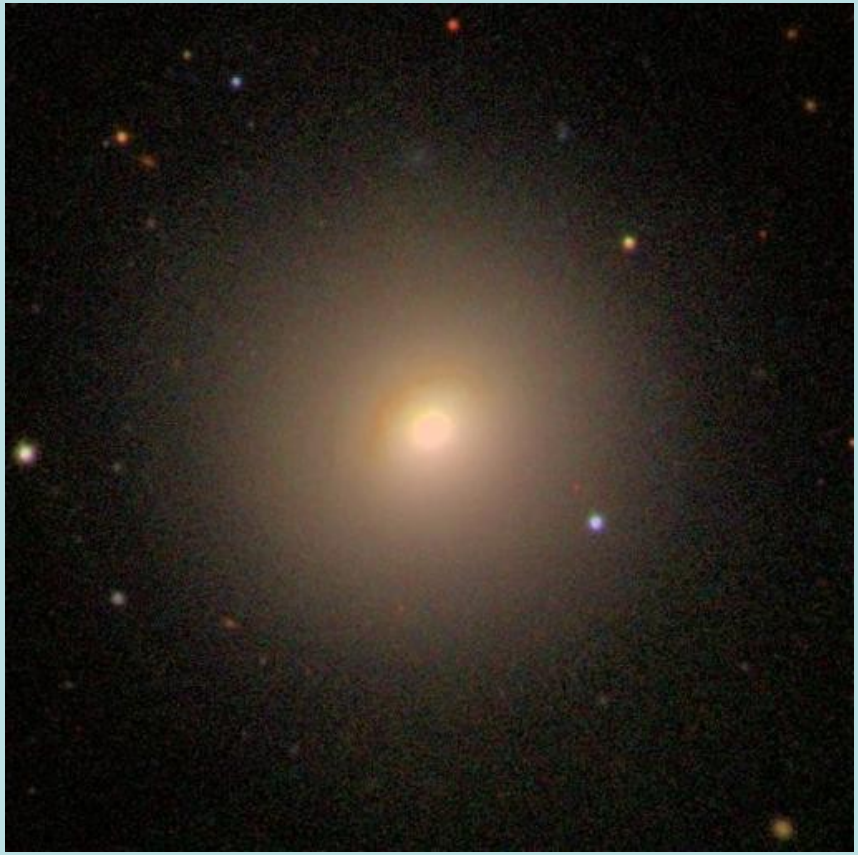


NGC 4111

Lenticulars face-on



NGC 3414, SDSS-DR7



NGC 5631,SDSS-DR7

What is the difference between spirals and lenticulars?

Lenticulars:

- are redder (due to older age or higher metallicity?)
- lack significant gas amount and star formation
- lack spiral arms in their disks

- Larson, Tinsley, Caldwell (1981): lenticulars are (trans-)formed from spirals in dense environments (in clusters) about 4-5 Gyr ago.

The mechanisms to transform spirals into lenticulars

All what is needed – to remove gas from the large-scale disk and to heat the stellar disk to stabilize it against spiral wave perturbations.

It may be done by:

1) Minor mergers (many, many fans);

2) Tidal interaction between the galaxies (Byrd & Valtonen 1990)

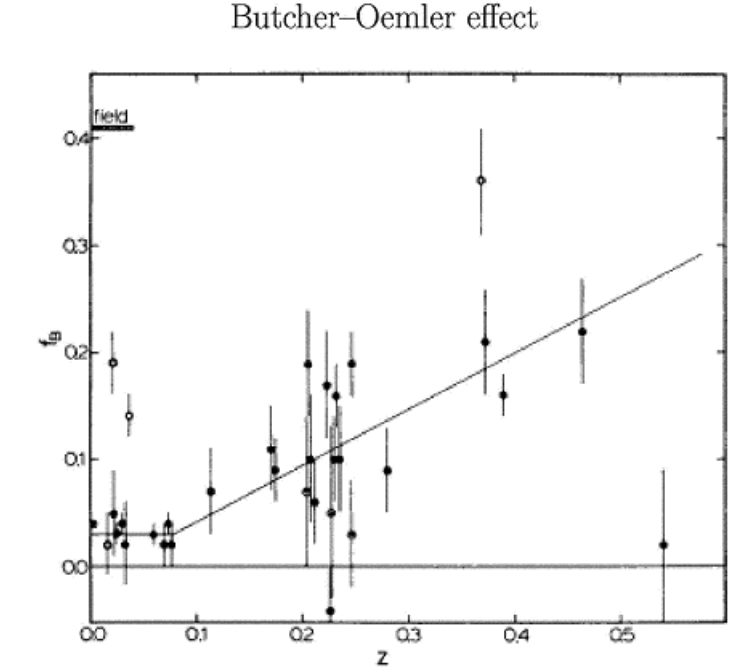
3) Ram pressure by intergalactic hot medium (Quilis et al. 2000)

4) Harrasment by cluster potential (Moore et al. 1996)

5) “Starvation”of star formation by removing the outer gas reservoir (Larson, Tinsley, Caldwell 1981)

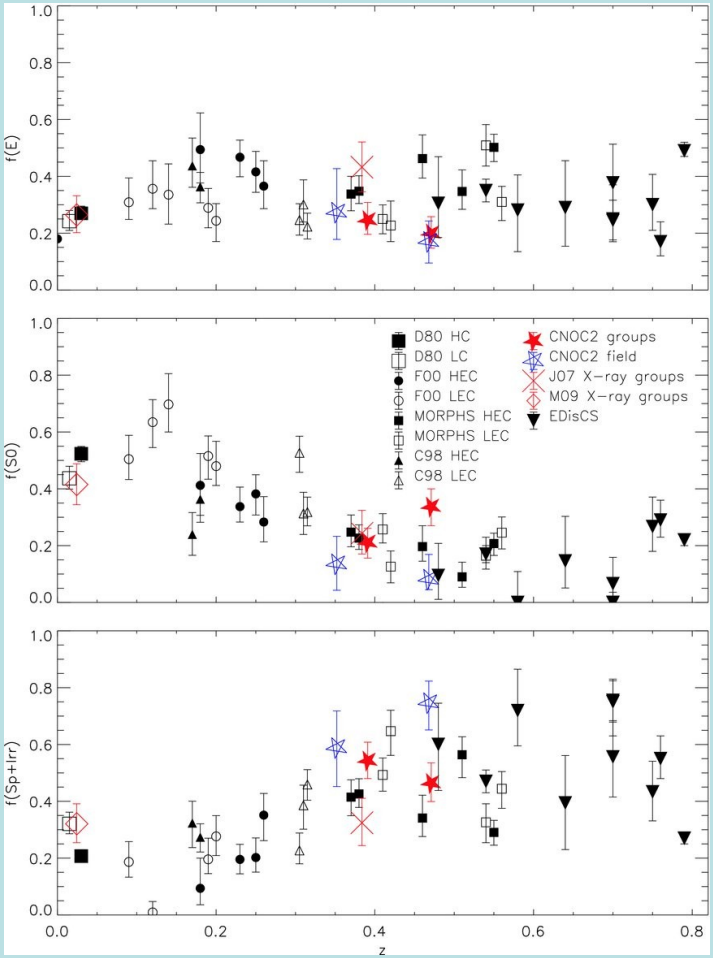
etc

The reason for the Larson's et al. model:



Butcher & Oemler 1984

Morphological mix evolution in clusters at z=0-0.8

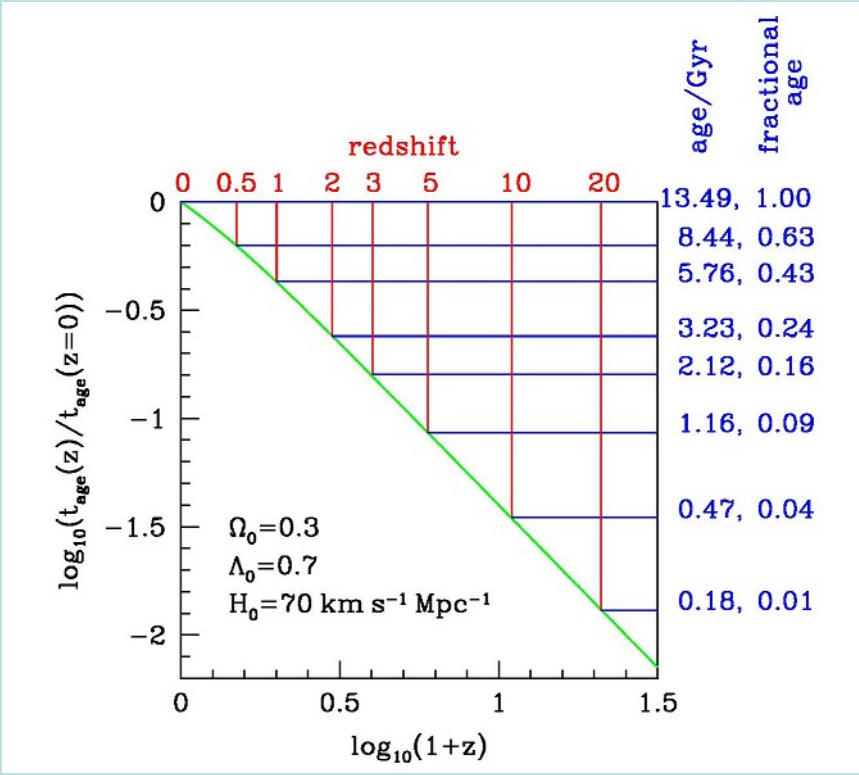


- S0 galaxies appear in clusters at z after 0.4; they “replace” spirals which dominate in clusters at z=0.4-1.0

Wilman et al. 2009

High-redshift galaxies are in fact the galaxies in the past…

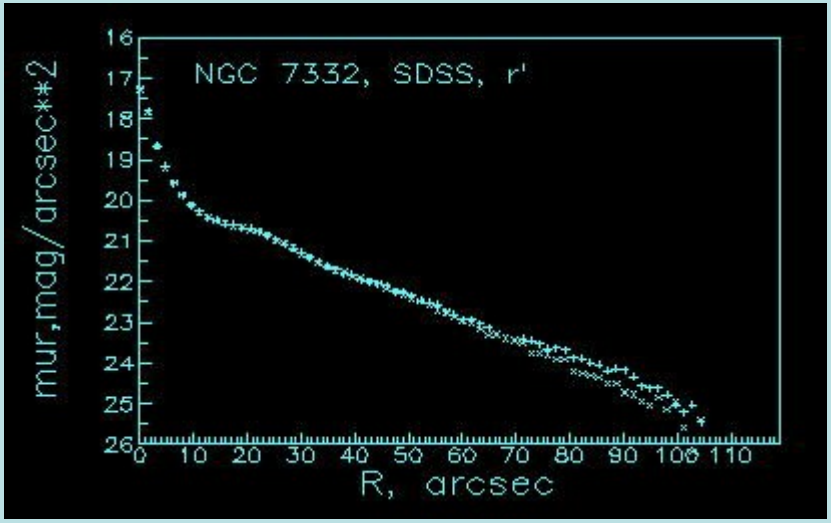
- But a key problem is to connect any high-redshift galaxy population with the present ones…

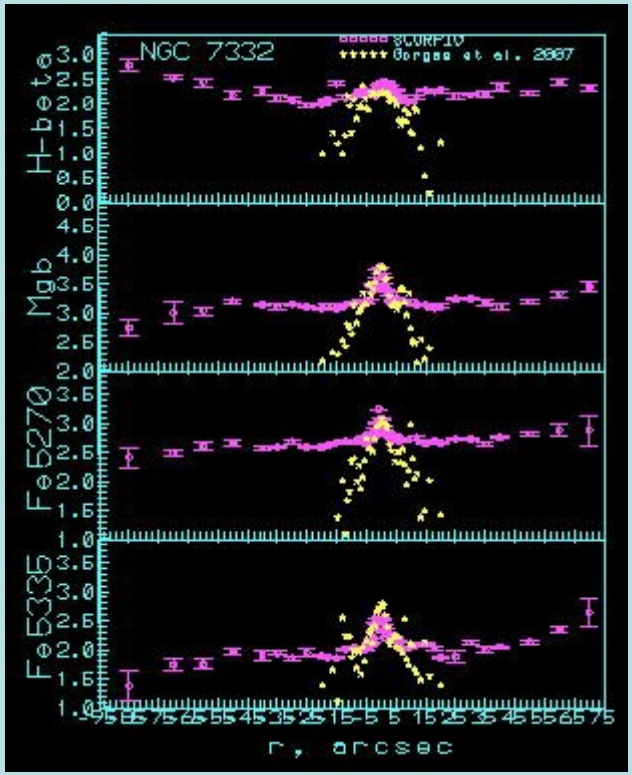


Our approach is to study **nearby** galaxies: very deep long-slit spectroscopy of the S0 disks, mostly edge-on

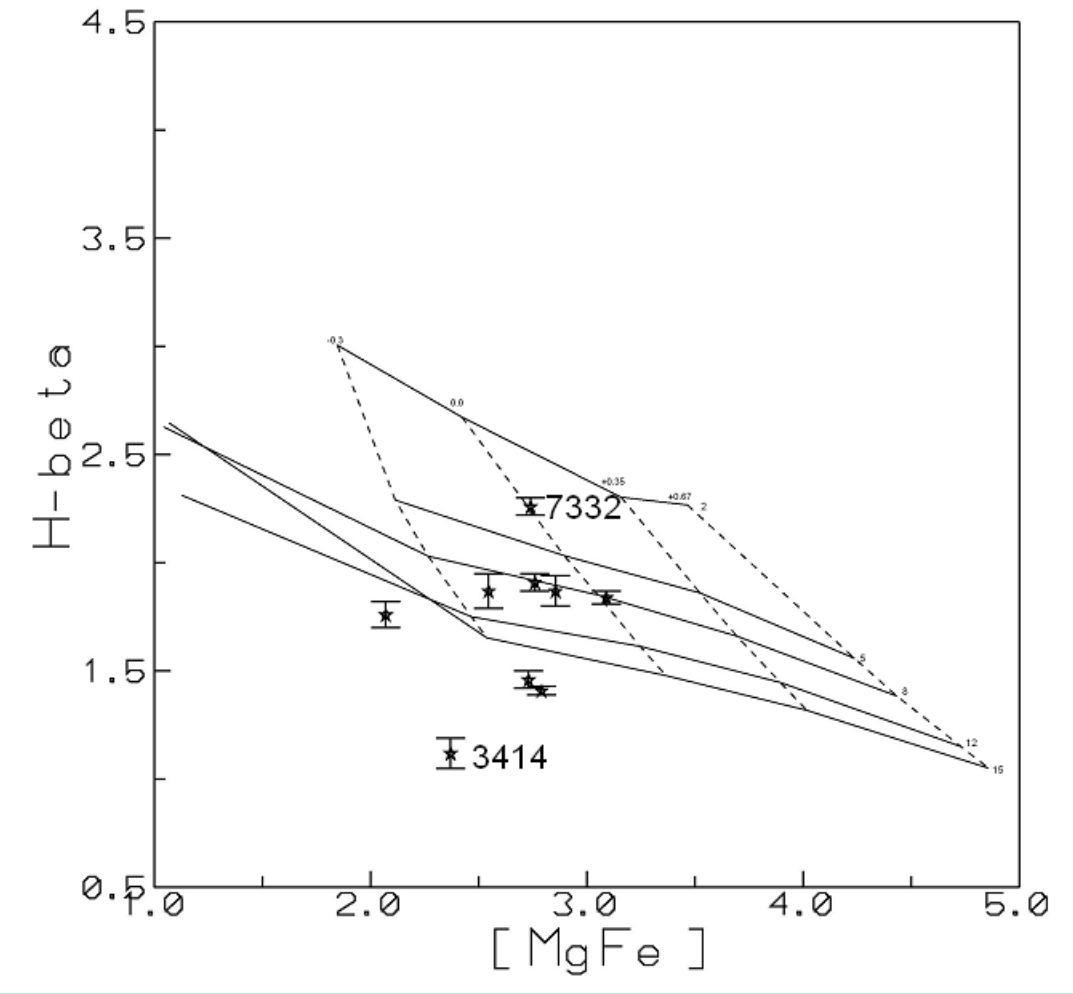
- Observations at the Russian 6-meter telescope (Special Astrophysical Observatory), with the focal reducer SCORPIO; the slit of 6', the spectral resolution is 2 A;
- The observational program has been formulated by Natalia Sotnikova to study the stellar **kinematics**;
- However, the data have appeared to be extremely good for Lick index derivation and to study the stellar population properties.

The Lick index profiles are traced up to the 3-4 disk exponential scalelengths with a very high accuracy



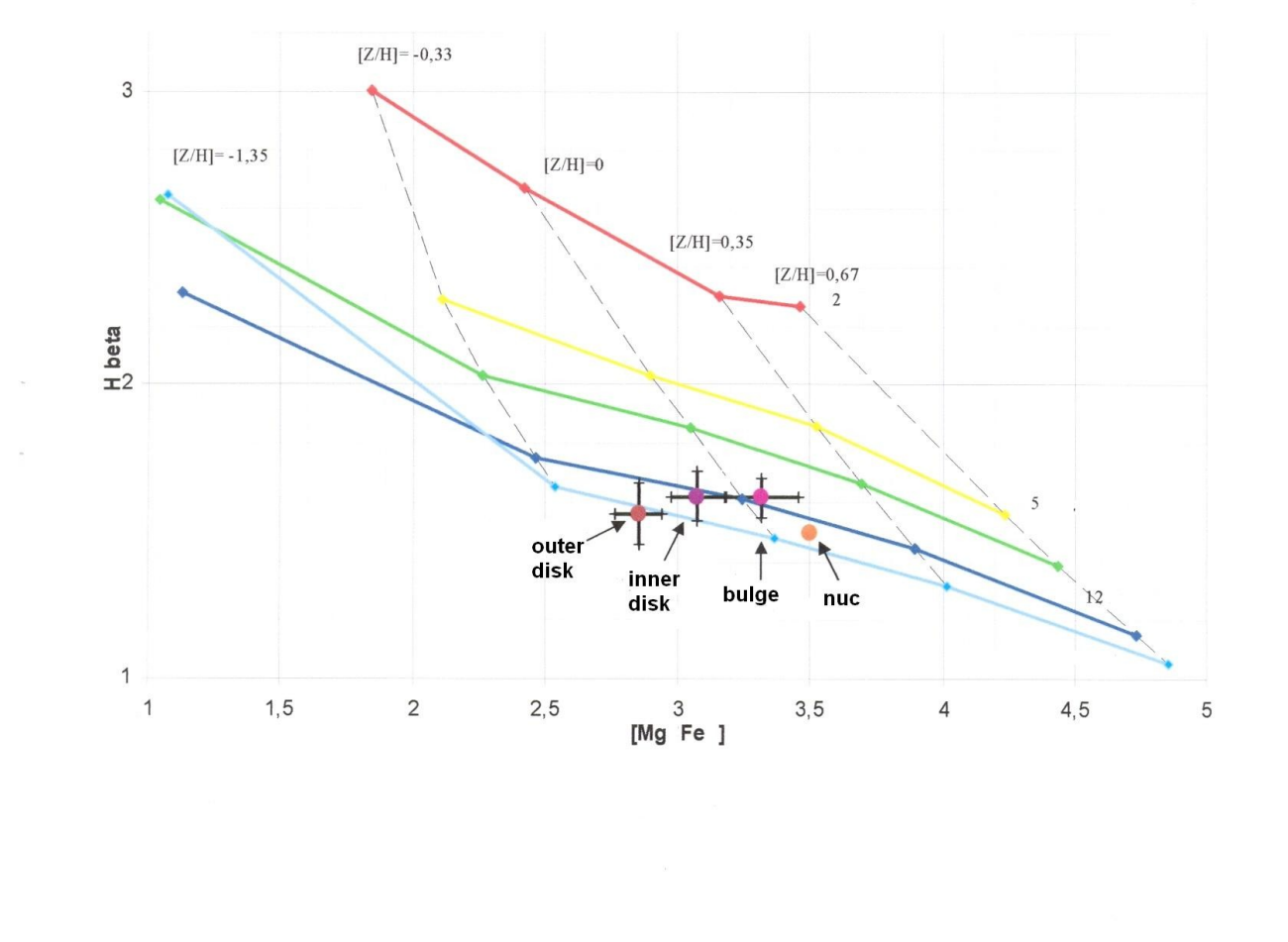


The large-scale stellar disks of the nearby lenticulars are mostly OLD



If to compare to the models by Thomas et al. (2003): T=8-15 Gyr

NGC 524 – a giant face-on S0 in the center of a rich group



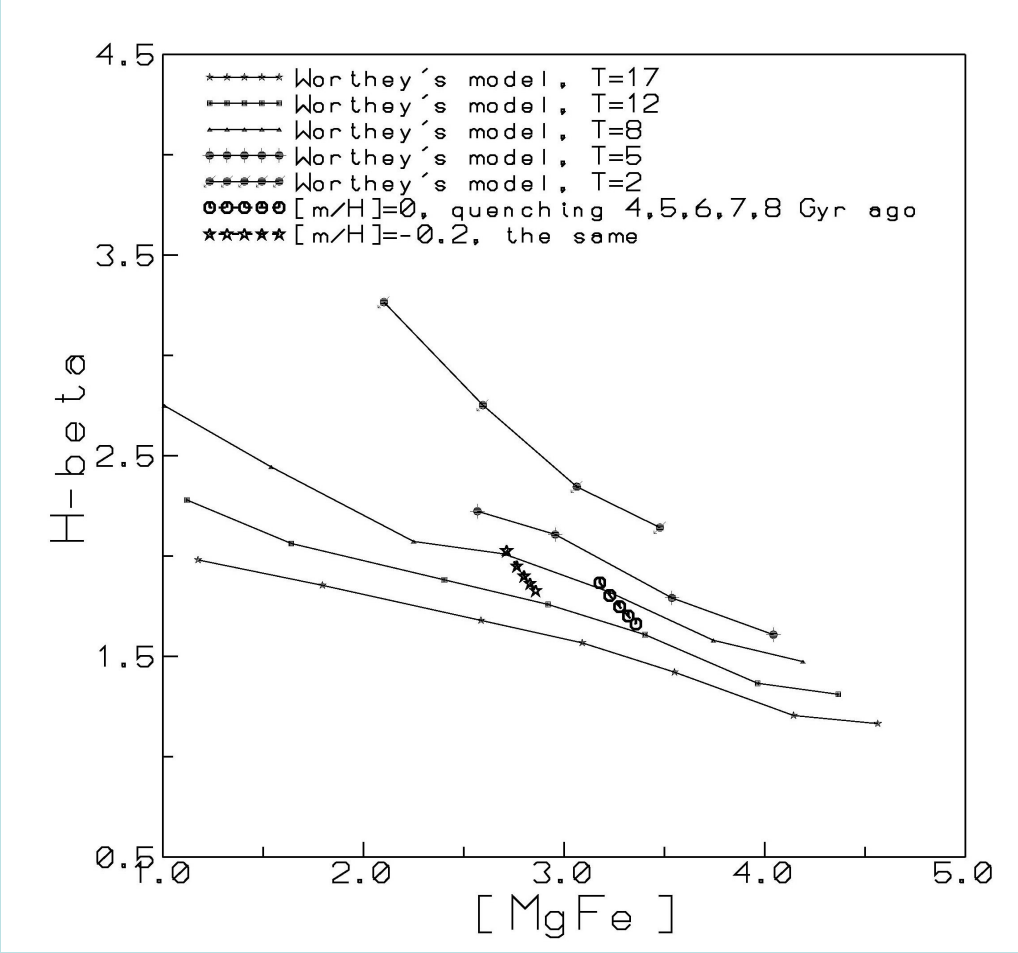
Proshina I.S., Master's Thesis, 2009

Do we see a trend of disks' stellar population properties with environment?

NGC	Environment	Disks': [Z/H]	Age, Gyr
4570	Virgo cluster	-0.3	>12
4111	UMa cluster	<-0.5	>12
3414	The center of a rich group	-0.4	>12
5353	The center of a rich group	-0.3	10+/-2
524	The center of a rich group	-0.2	>12
5308	A member of a rich group	-0.2	>12
1032	Loose group	-0.1	8+/-2
2732	Loose group	-0.1	8+/-1
7332	Close pair with an Sbc	0.0	3+/-0.5
1184	Isolated	0.0	8+/-1

Fall direction

Stellar population synthesis experiment with star formation quenching



Conclusion

- The S0 galaxies in dense environments (in clusters, first of all) have not transformed from spirals after z=0.4 when they become the dominant population in clusters, otherwise we should see in their disks the SSP-equivalent age of the stellar population less than 8 Gyr which is now *sometimes* observed only in SPARSE-environment galaxies.
- To provide the SSP-equivalent age of the disks >12 Gyr, the star formation in the disks of lenticulars had to stop more than 8 Gyr ago – or at z>1.
- The hot intracluster medium and ram pressure are not probably the agents of S0 (trans-)formation…