Unresolved Galaxies with Gaia

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Gaia will observe millions of stars in our galaxy. Additionally, at least a few million unresolved galaxies (seen as point sources). The classification of objects will be done during the mission, so a very large effort is being done to prepare the necessary software in order to classify the various sources detected.

Our team is developing suitable libraries of synthetic galaxy spectra and is preparing the necessary software (UGC) for classification and parametrization of the observed galaxies.

For the preparation of synthetic spectral libraries we use existing code, of galaxy population synthesis, PEGASE 2. The major requirement is to obtain not just a typical set of synthetic spectra, but to enlarge the sample in order to predict all the variety of the expected galaxy spectra. (Collaboration with IAP).

A. Classification and parametrization of Unresolved galaxies

√ Libraries of galaxy spectra for classification and parametrization

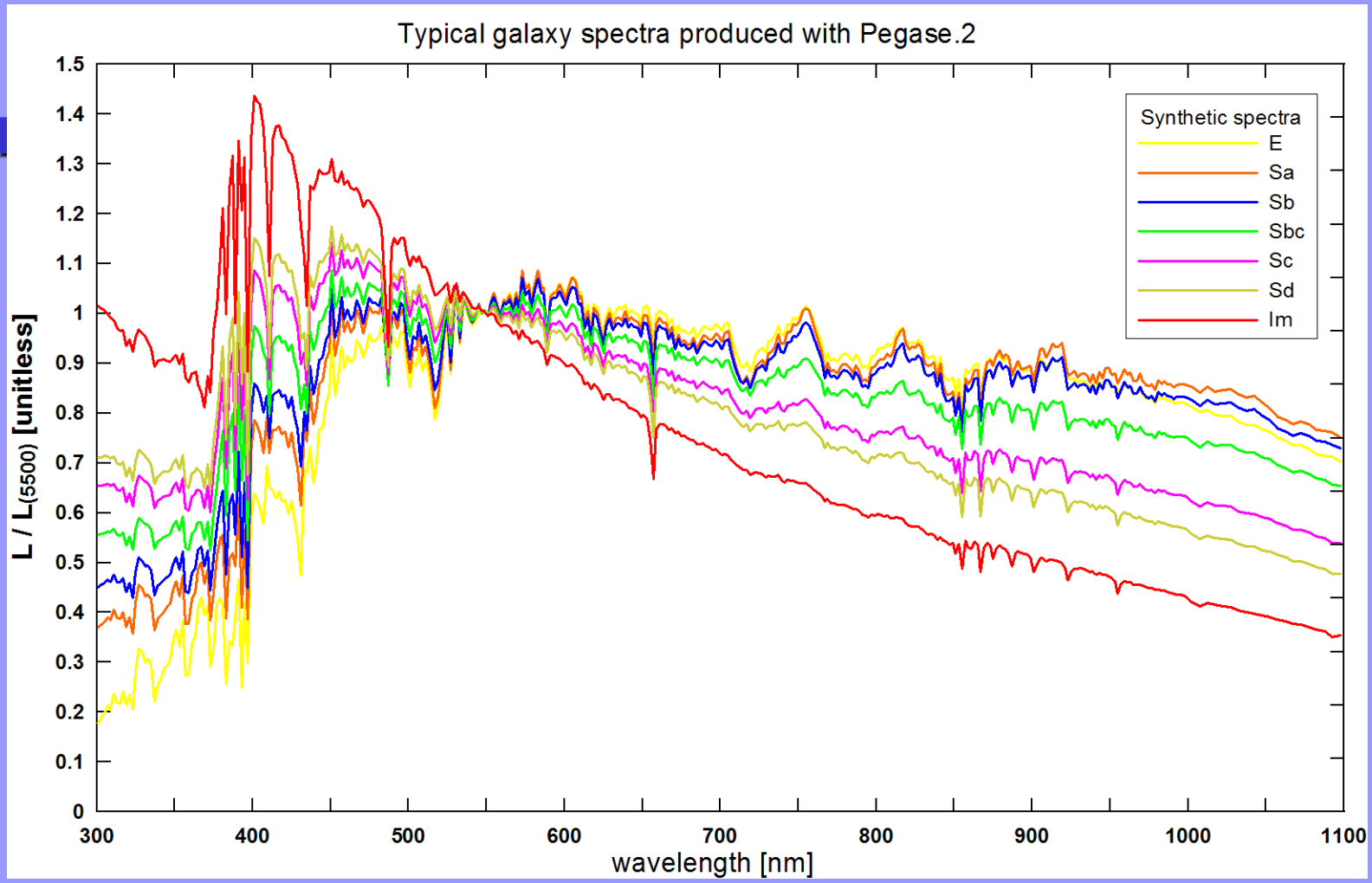
√ GWP-S-832 Unresolved Galaxy Classifier

B. Galaxies resolved by Gaia

√ Models of the galaxies resolved by Gaia for the GaiaSimu

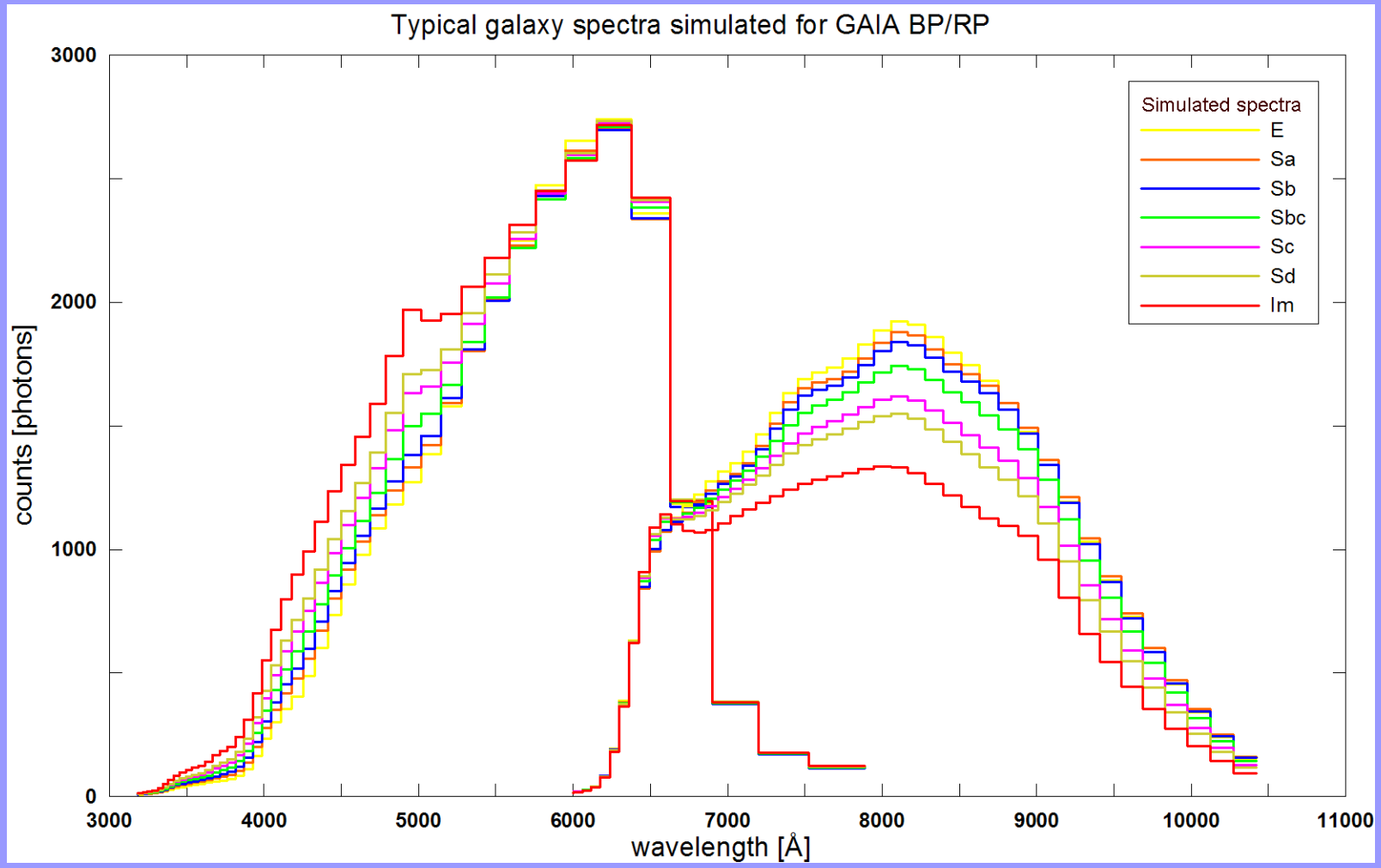
The MCs, and the nearby galaxies of the Local Group

1) A first Library of Synthetic Galaxy Spectra based on the seven types of the model (Pegase 2.) developed by Brigitte Rocca_Volmerange and collaborators.
(Tsalmantza, Kontizas et al, 2007, A&A, 470, 761)



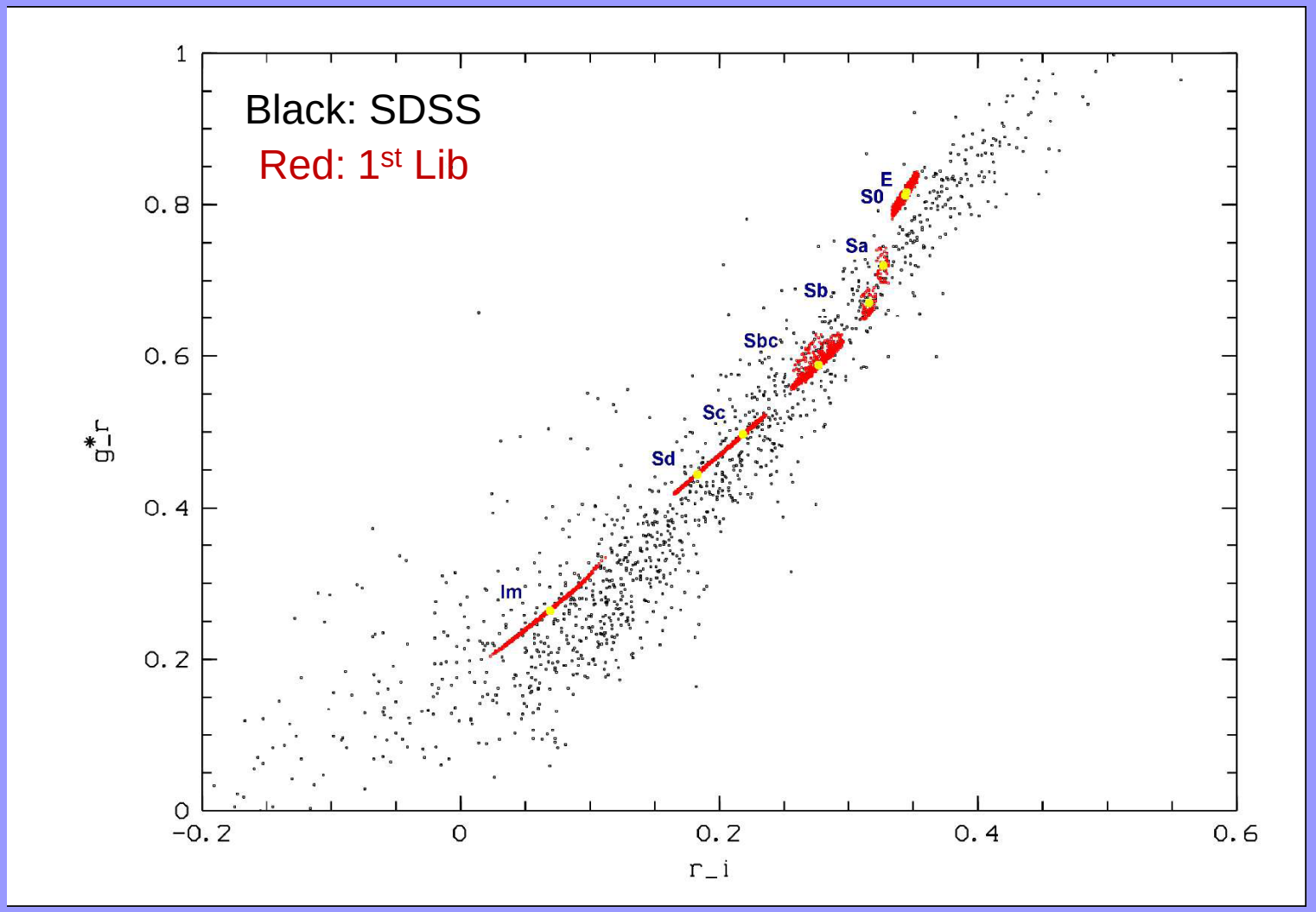
GWP-S-832 BP/RP Libraries

BP/RP Libraries: UgcLib2a GaiaGOG Simulated Spectra



The 1st library of synthetic galaxy spectra. The SDSS galaxies, the galaxies produced in the first library and the typical synthetic spectra of PEGASE.2 are presented with black, red and yellow dots respectively.

Yellow:
E
SO
Sa
Sb
Sbc
Sc
Sd
Im



2) The 2nd library to optimise the coverage of the galaxy types to be observed by Gaia (Tsalmantza, P. , Kontizas et al. , 2009, A&A ,504,1071)

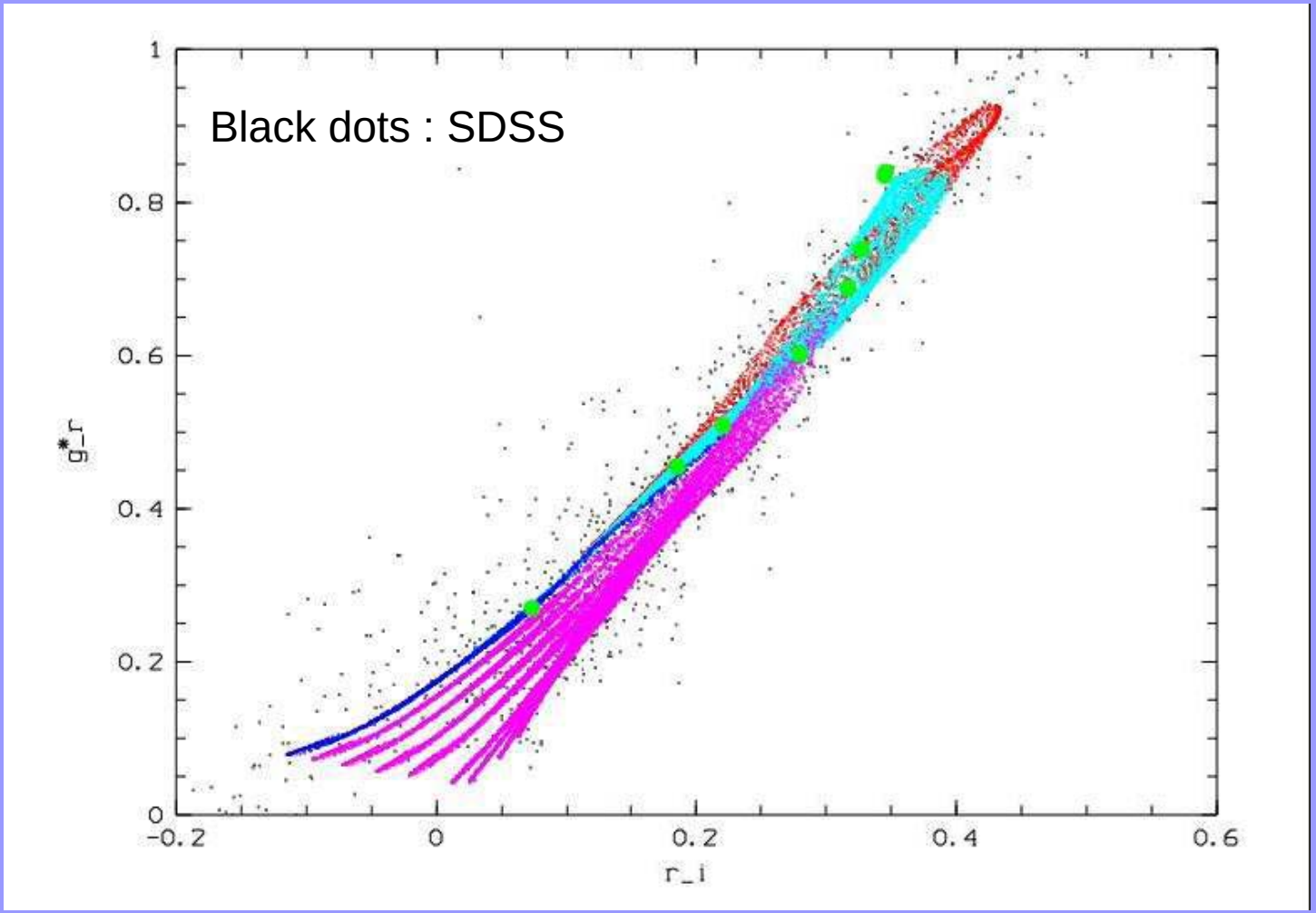
Black dots are SDSS galaxies and green dots the 8 typical synthetic spectra of Pegase 2.

Ellipticals (red).

spirals (light blue)

Irregular (blue)

QSFG (magenta)



3) A semi-empirical Library

To present a large set (about 30 000 galaxies) real spectra (observed by SDSS) extended to the spectral range of Gaia and parametrised by the same code Pegase 2.

AND WHAT is NEXT?

There are overlaps and some unrealistic spectra

Research opens new questions!!

Gaia preparations for DPAC requirements stimulated further scientific investigation.

So we are proposing an

Optimization of the Library!!!!

2) The 2nd library has to be optimised for the coverage of the galaxy types (Tsalmantza, P. , et al. , 2009, A&A ,504,1071)

Black dots are SDSS galaxies and green dots the 8 typical synthetic spectra of Pegase 2.

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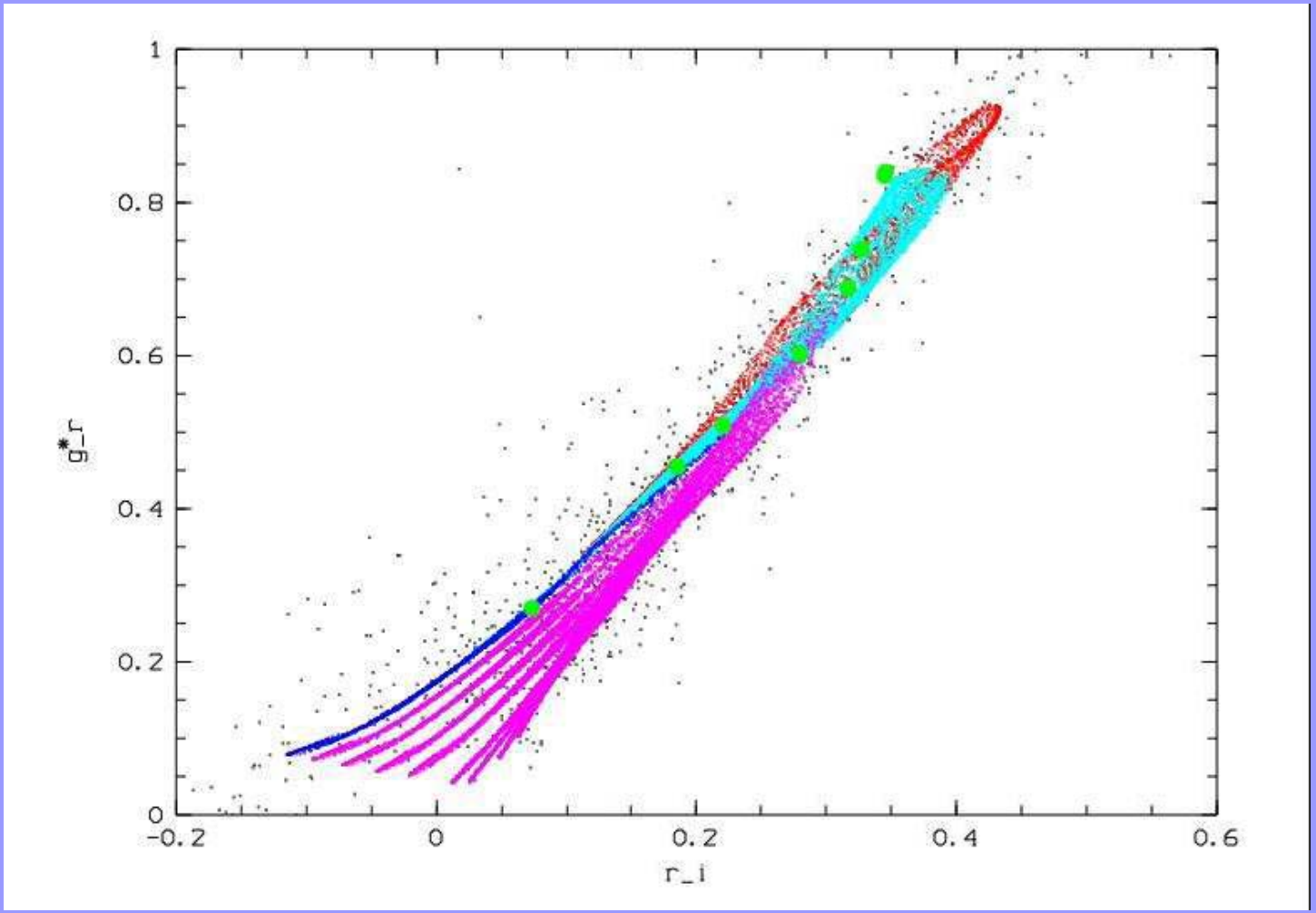
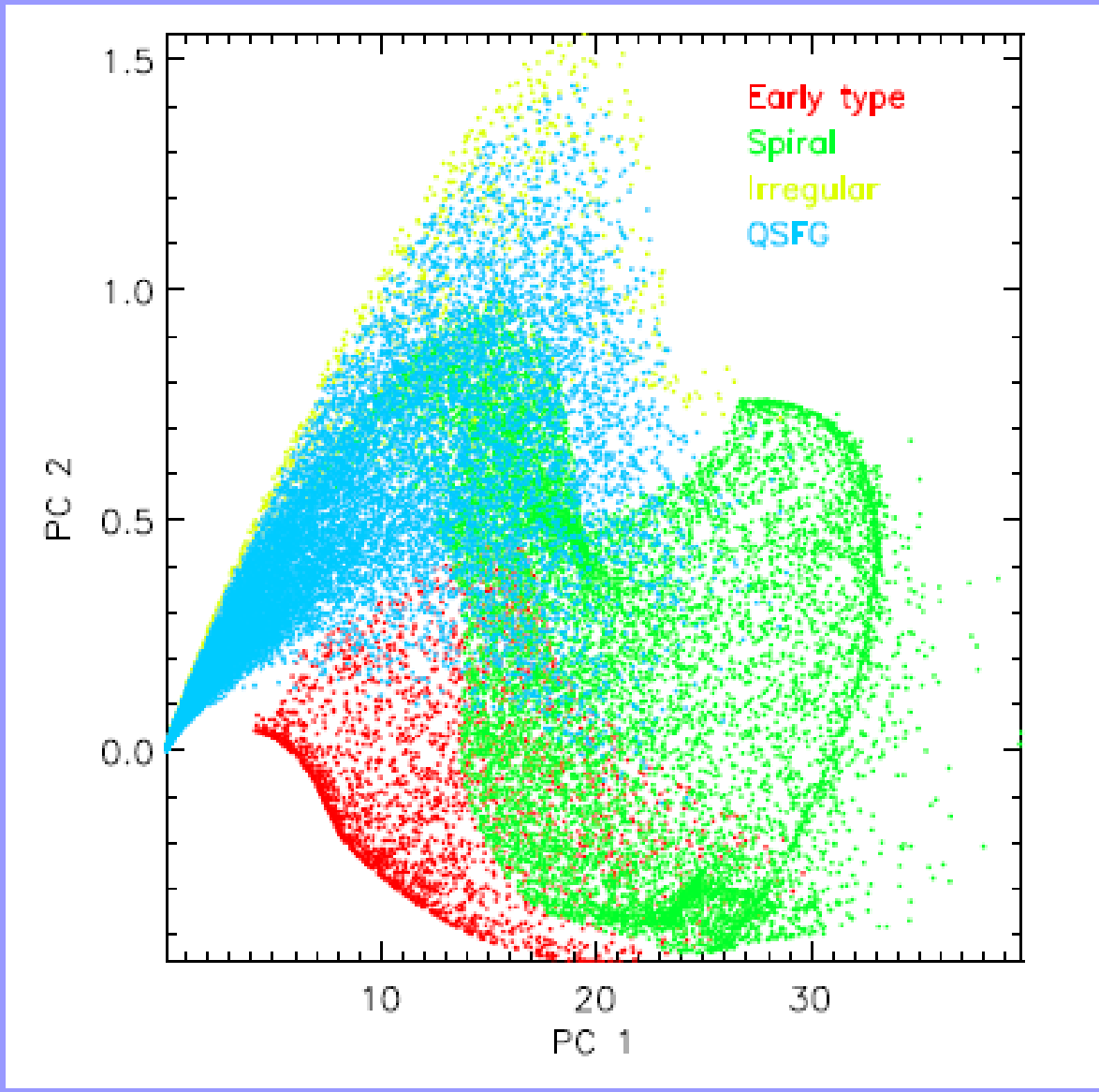


Principal Component Analysis (PCA)

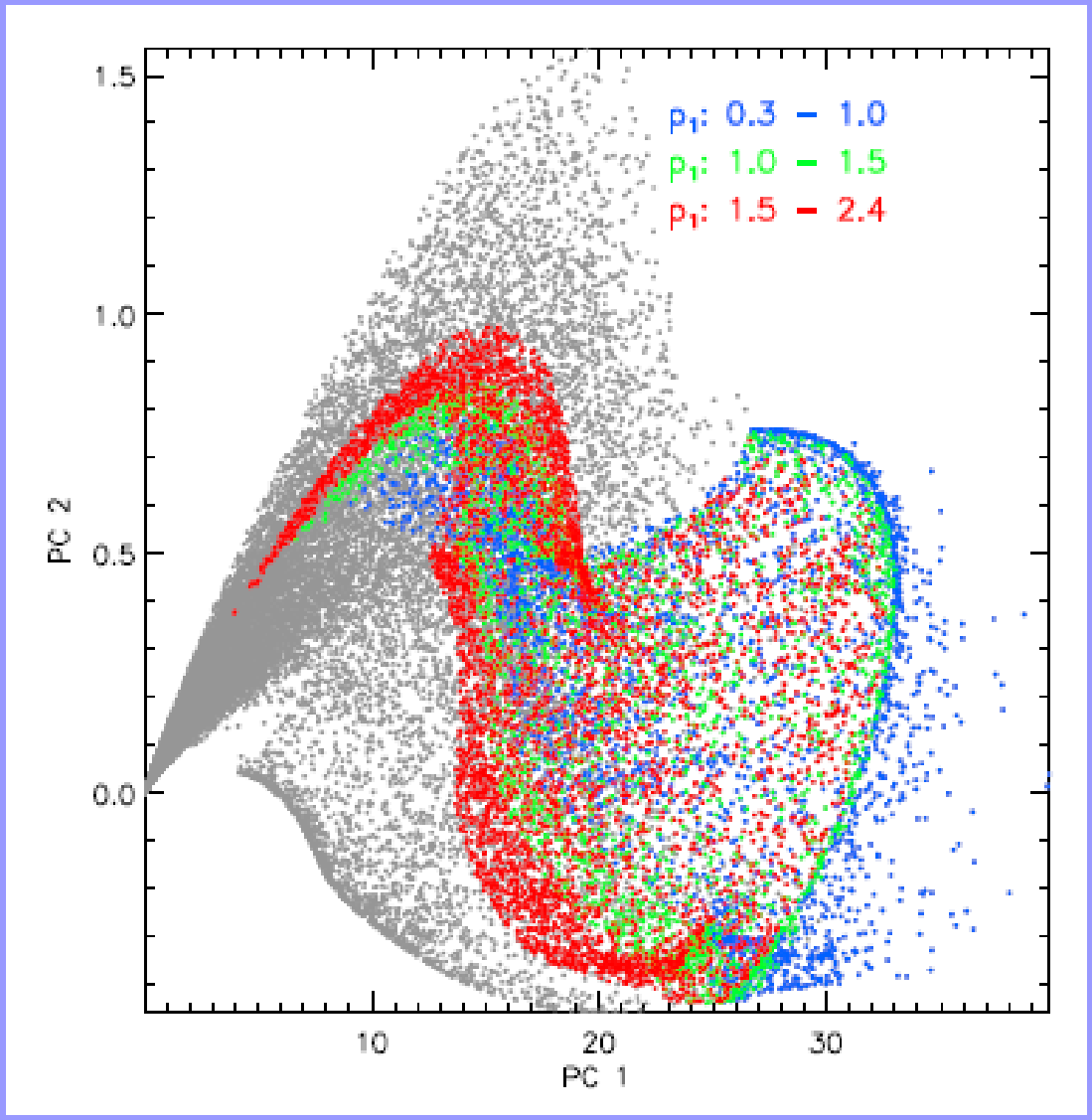
is a technique used to analyse multidimentional datasets.
It is an efficient method to extract information from a large set of data allowing us to identify patterns and correlations in the data that otherwise would hardly be noticed.

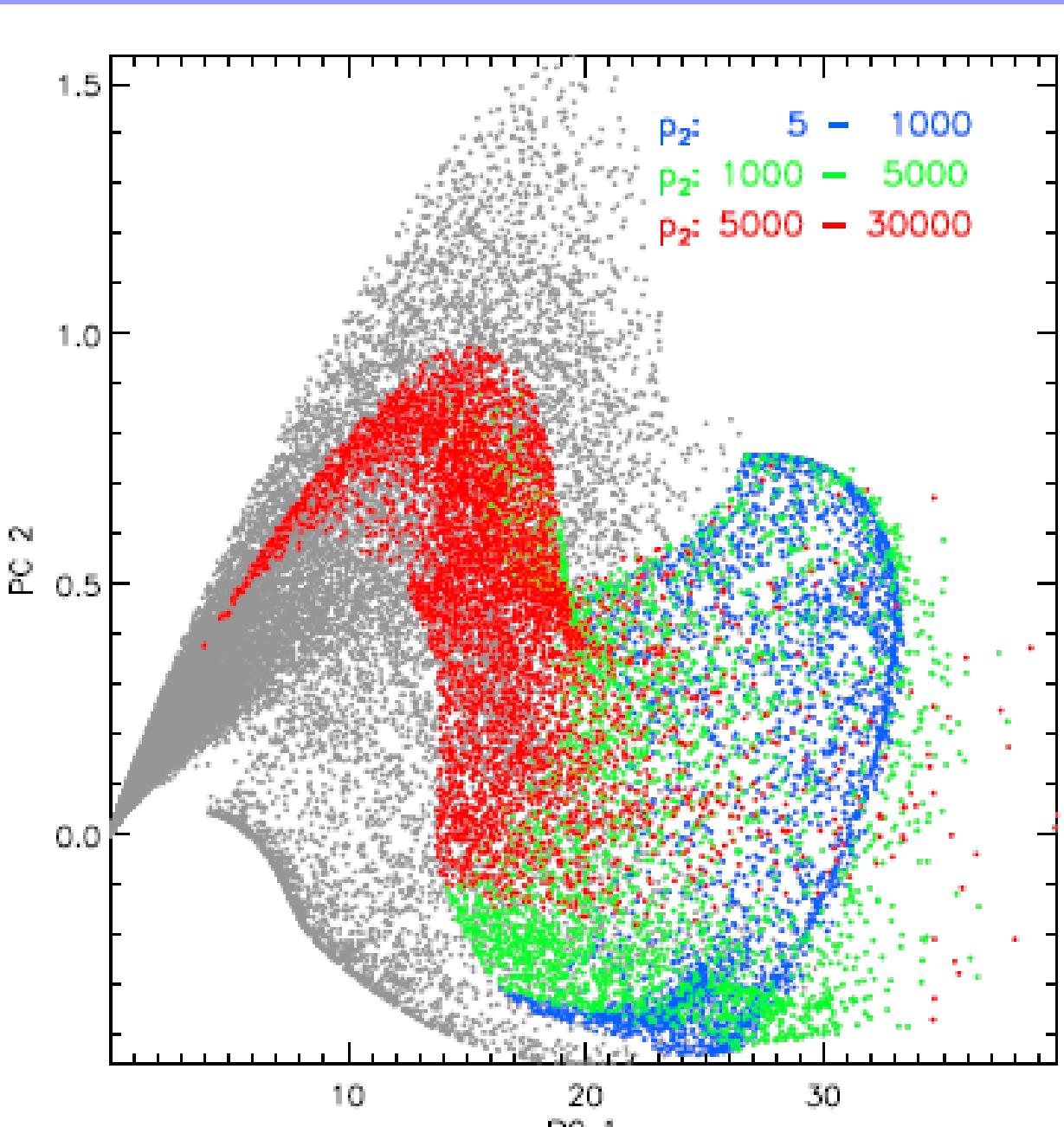
Mathematically it is defined as a linear orthogonal transformation that expresses the data in a new coordinates system such that the first of these new coordinates, E_1 **(Eigenvector1)** contains the largest variance fraction, the second E_2 contains the second largest variance and so on.



grey : all 2nd library blue – green – red: Spirals

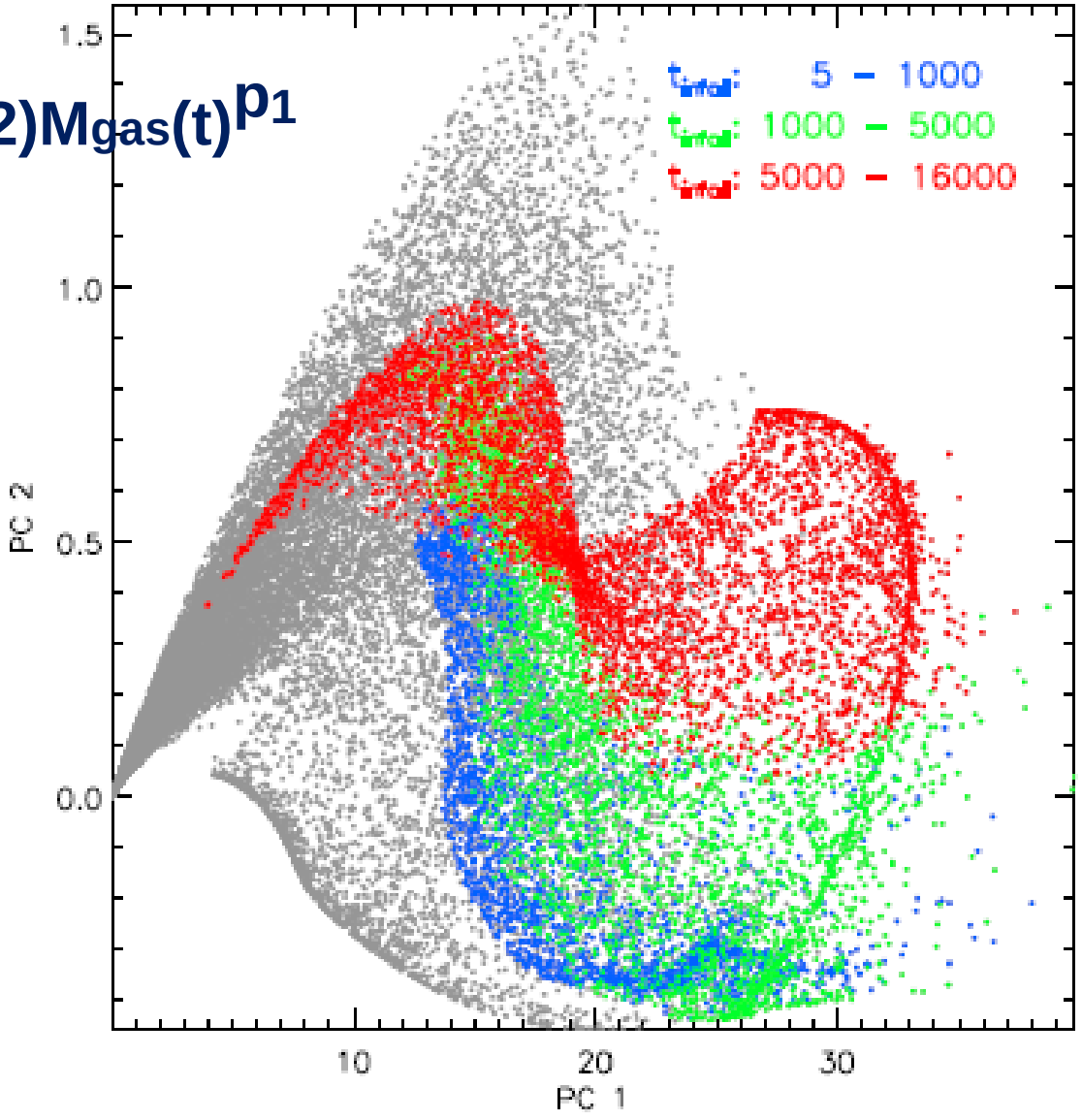
SFR(t) = (1/p2)Mgas(t)^{p_1}




p2: 5 – 1000
p2: 1000 – 5000
p2: 5000 – 30000
PC 2
1.5
1.0
0.5
0.0
10
20
30

Grey: all 2nd library blue – green – red: Spirals

SFR(t) = (1/p2)$M_{gas}(t)^{p_1}$



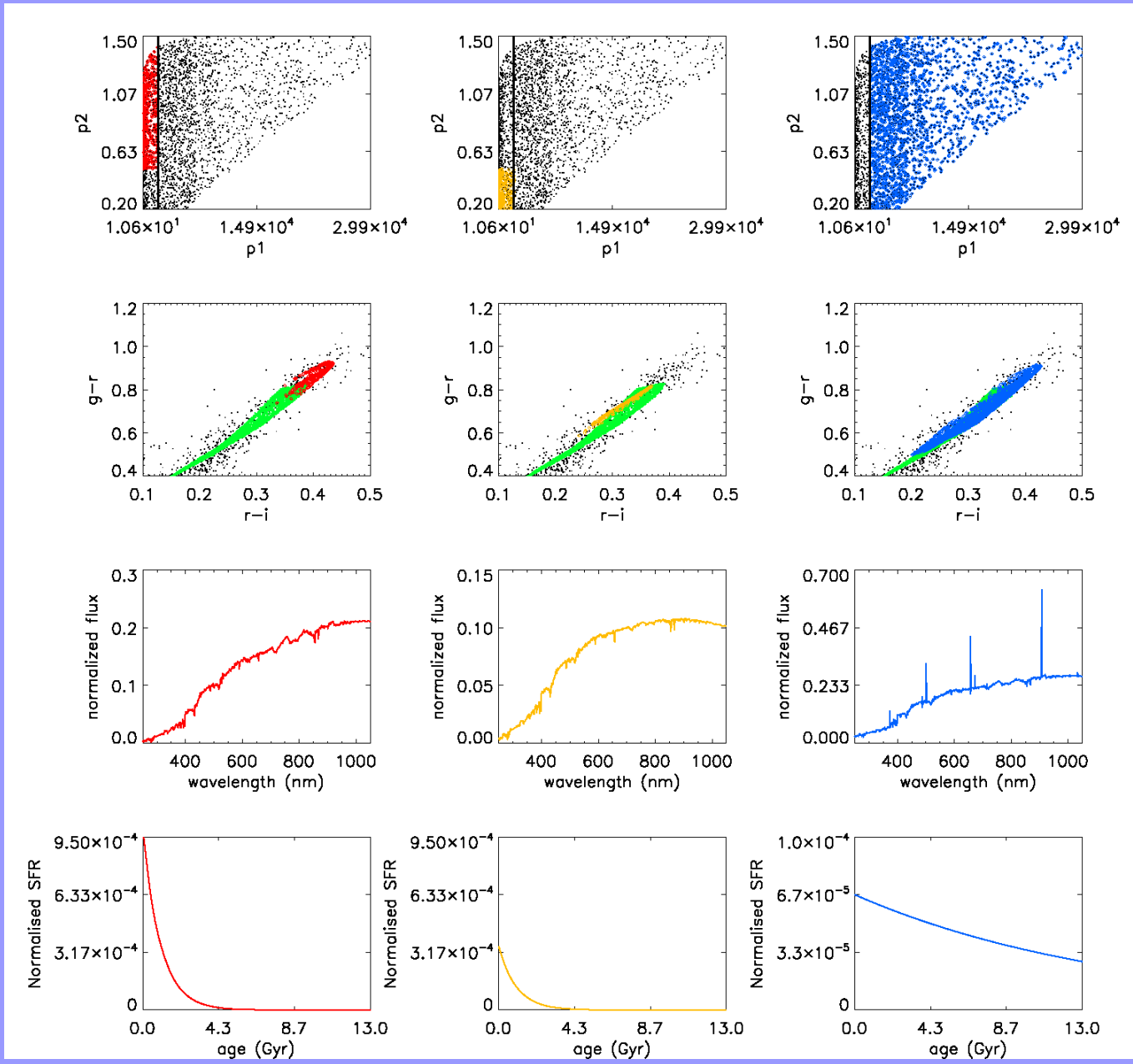
Ellipticals

blue: With emission lines

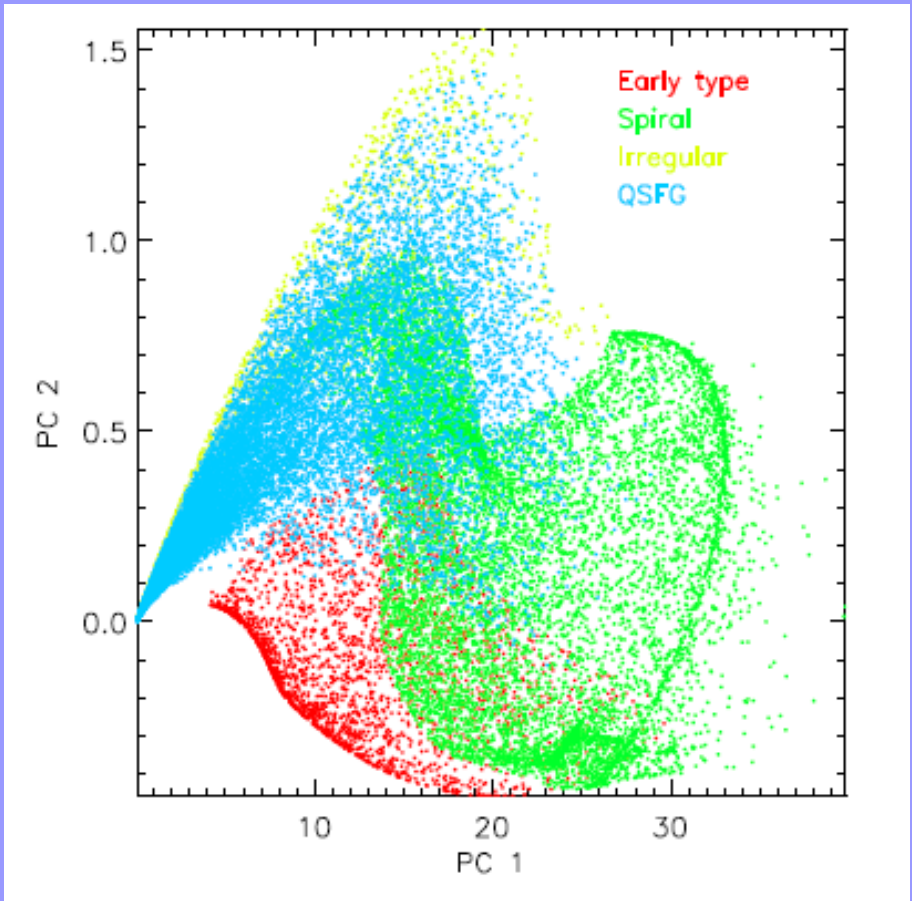
green: Low SFR

red: High SFR

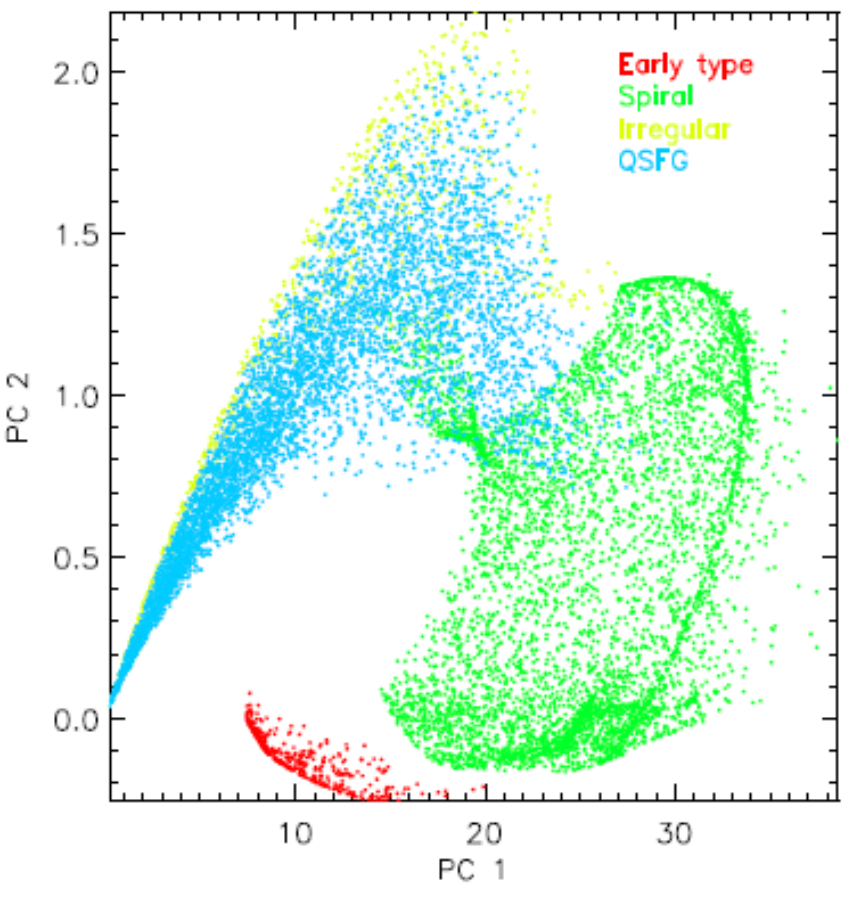
SFR(t) = (p2/p1)*e(-t/p1)



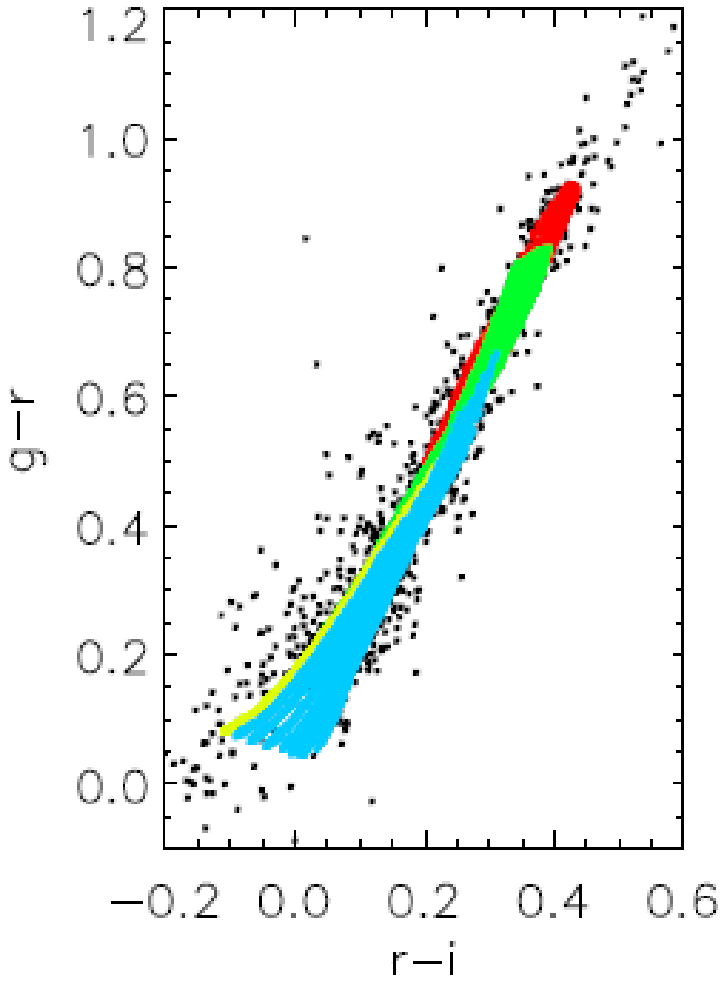
Before optimazation



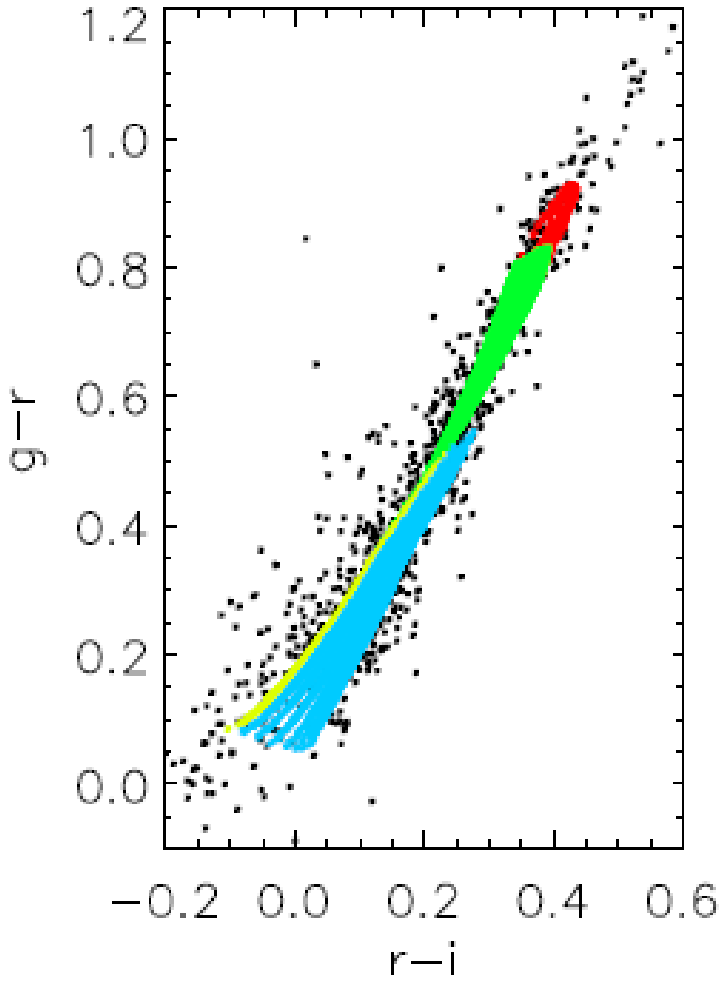
After optimazation



Before optimization



After optimization



GWP-S-832 UGC Software Unit

Software Requirements Specification(I. Bellas-Velidis)

Function: Classifies unresolved galaxy spectra and estimates key astrophysical parameters (AP)	*Implemented in UGCv7, passed H1 science chain tests (UGCv8 with highly extended functionality currently under development)*
Control: CU8 Discrete Source Classifier marks the spectra as unresolved galaxy class	*CU8 DSC ⇒ UGC linkage based on object class probability matrix provided by DSC*
Input data: Combined GAIA BP/RP spectrophotometry	*GAIA BP/RP simulated spectra library: UgcLib5 (G=15, Av=0, z=0, SE, noiseless), based on Pegase2 synthetic spectra Lib3.*
Method: Supervised training based algorithm	*Support Vector Machines (SVM) algorithm in "classifier" and in "regression" mode.*
Output: Class probability and values prediction for APs to be included in the GAIA database	*Class probability galType (E,S,I,B), SF galAPs (SfrP1,SfrP2,SfrP3,Infall) and redshift and TGE parameters estimate*

CU2/DU3 Universe model

a) Unresolved galaxies

b) Resolved Galaxies (see Belcheva)

2.1. ***Spiral galaxies***

For the production of the spiral galaxy spectra **(Sa, Sb, Sbc, Sc and Sd)** we have used the scenarios described by Le Borgne & Rocca-Volmerange (2002) and Fioc & Rocca-Volmerange (1997).

2.2. ***Irregular Magellanic Galaxies (Im)***

2.3. ***The early type galaxies***

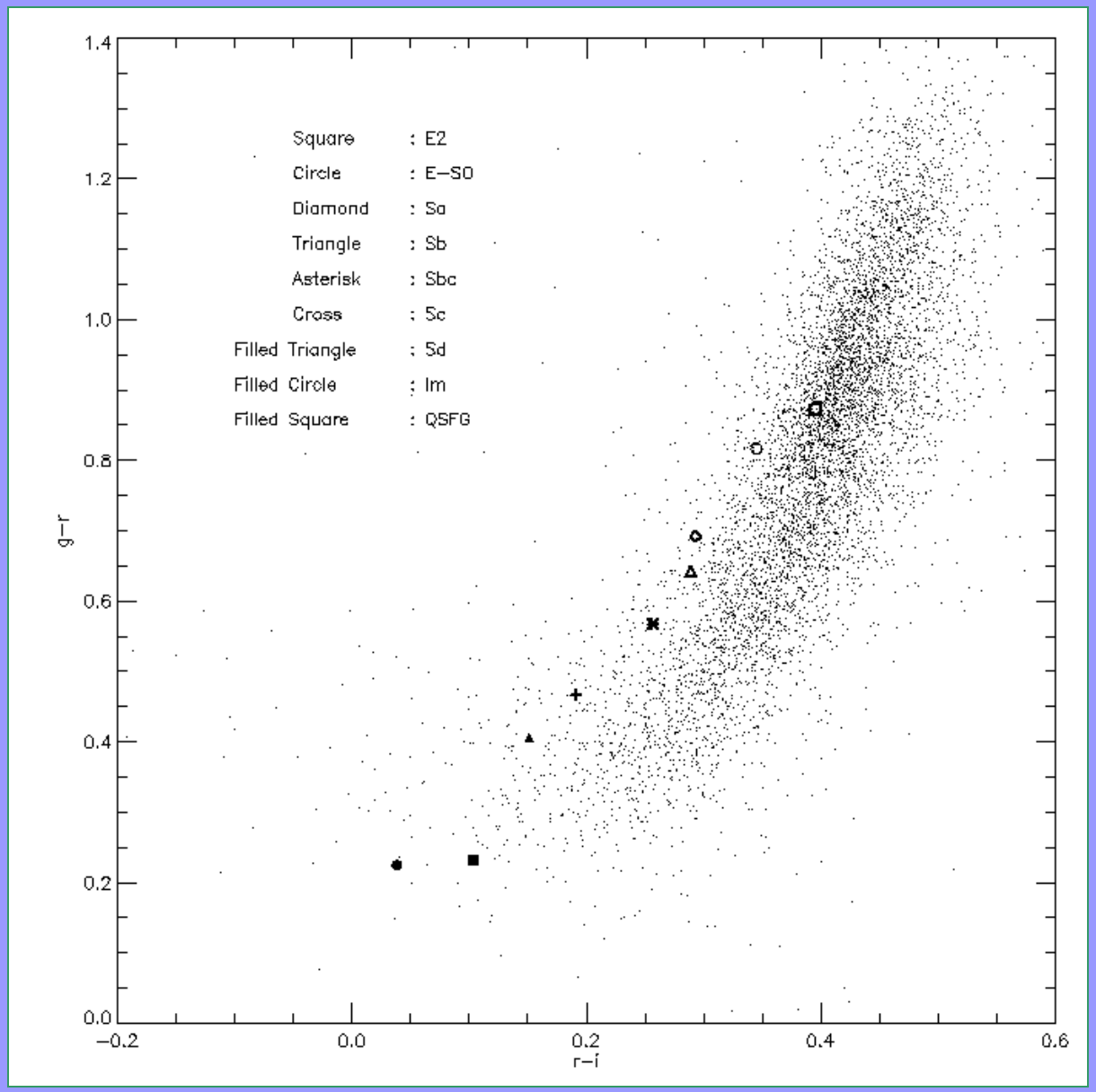
Normal Elliptical or **SO (E-SO):**

Red Elliptical**: E2**:

2.4. ***The Quenched Star Forming Galaxies (QSFG)***

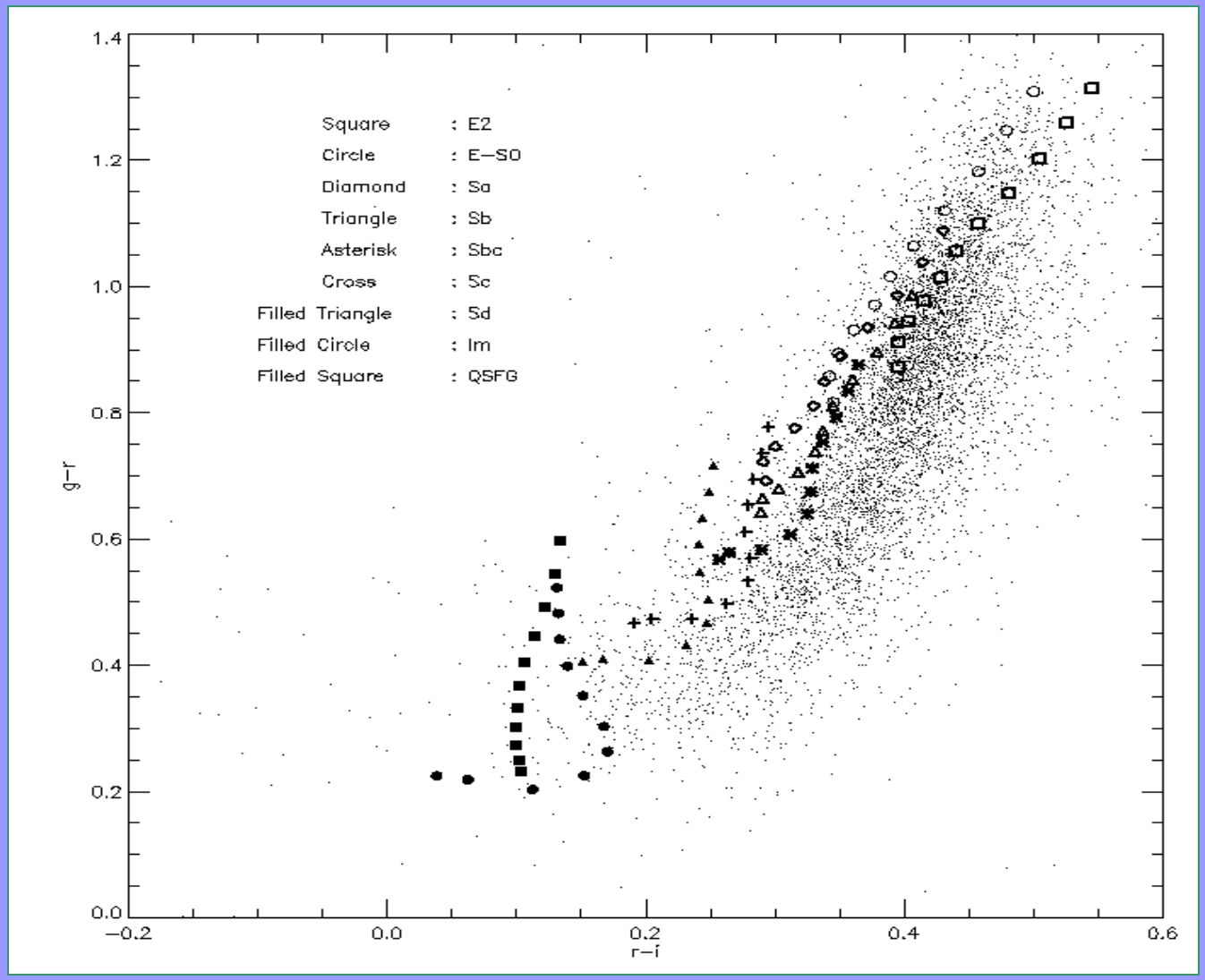
The scenario of a Quenched Star Forming Galaxy from the 2nd library (Tsalmantza et al. 2009), is also used to simulate the bluest populations of the color-color diagram of galaxies from the SDSS observational photometry and therefore was chosen to represent this galaxy type

Colour-colour diagram from synthetic typical galaxy types from Pegase.2 for z=0.0 and for inclination=45.0 degrees plotted over SDSS galaxies with z≤0.20.



Colour-colour diagram from synthetic typical galaxy types from Pegase.2 for the different z values between 0.00 and 0.20 plotted over SDSS galaxies selected to cover the same z range. Inclination is set to 45.0 deg again.

E. Livanou et al, Livelink



THE INTRINSIC PROPERTIES OF SDSS GALAXIES

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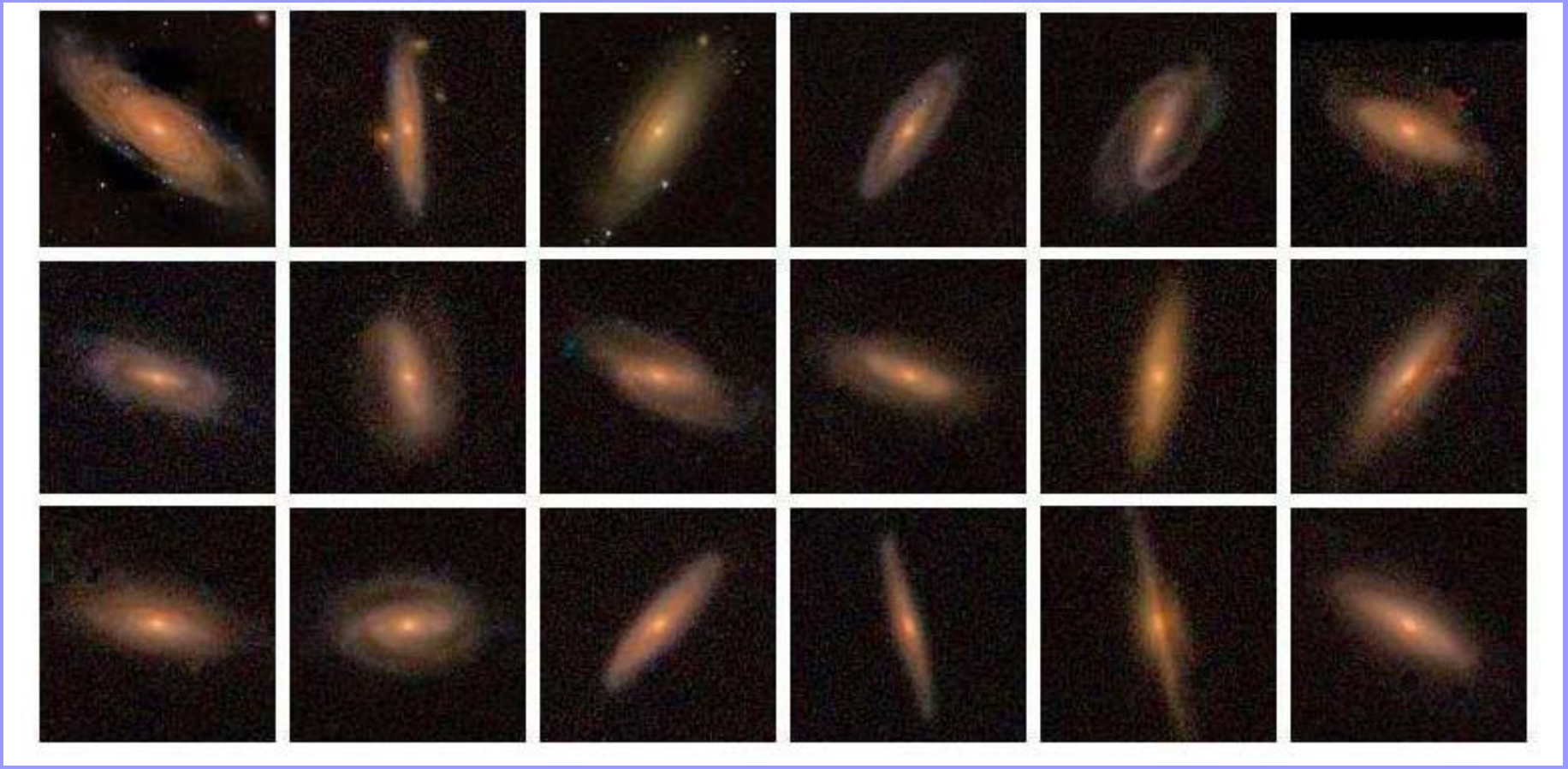
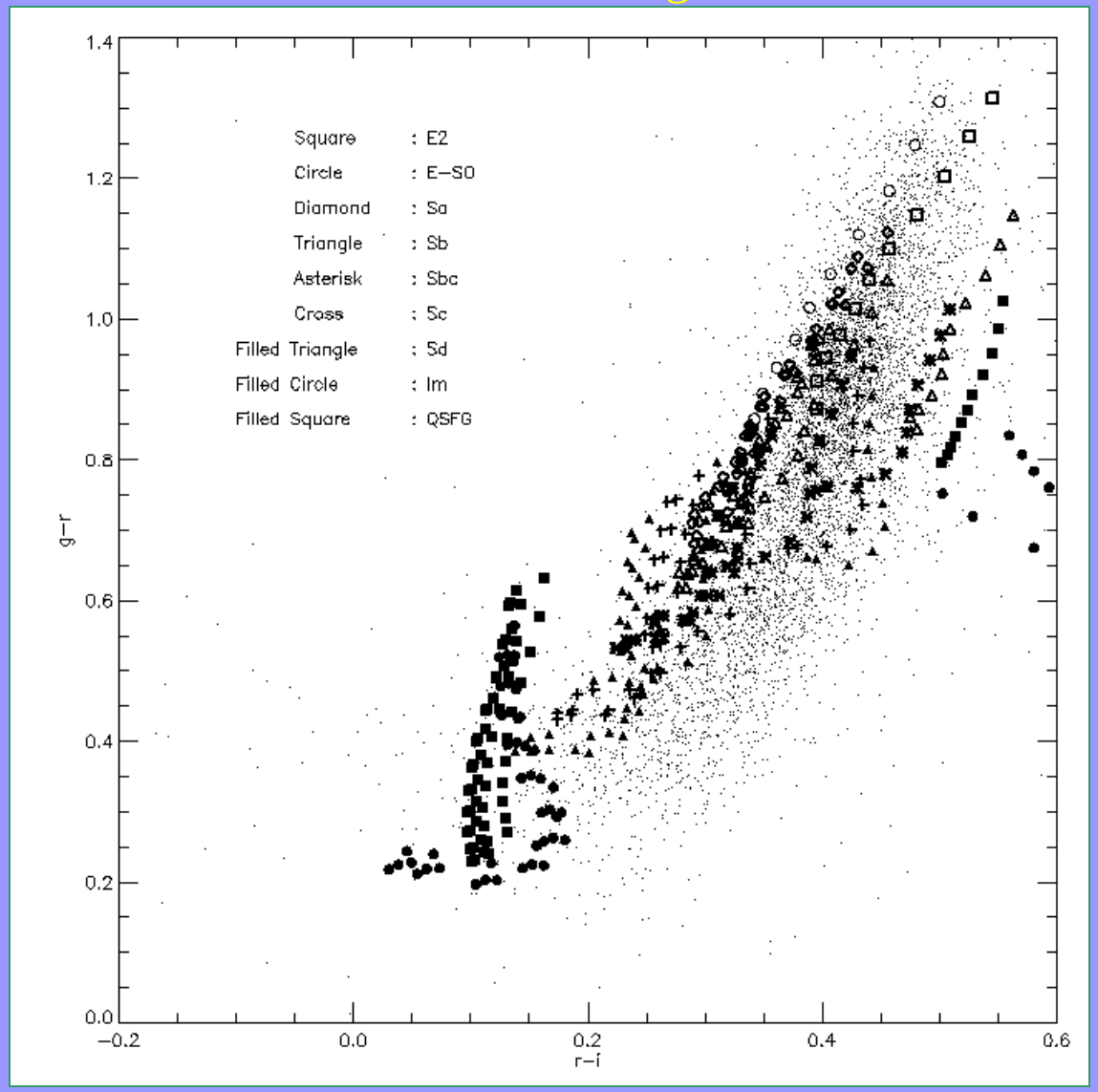


Fig. 2.— Images of red ($g - r > 0.75$) and concentrated ($n_s > 4.0$) and inclined ($b/a < 0.5$) galaxies from our sample. Clearly these red, concentrated galaxies are disk galaxies. Besides the cuts stated the only selection in these images is that the galaxy has a large angular size so that it makes a nice image. Axis ratio is an important diagnostic of galaxy type.

Colour-colour diagram from synthetic typical galaxy types from Pegase.2 for the different z and inclination values plotted over the SDSS galaxies selected to cover the same z range.



How many unresolved galaxies will be observed by Gaia Photometry BP/RP?

Those observed like point sources are expected to be about (1-5)x10^6

The galaxies will be observed for 5 years!

This is a unique survey of this kind.

What Gaia will offer to galaxies' s research?

1) A very large homogeneous sample (1-5)x10^6 of spectra of galaxies up to z=0.4 from all the sky.

2) A low resolution sample of spectra very useful to test galaxy evolution models.

3) Detect unknown variabilities.

4) Search for colour indices, important towards the understanding of the physics of galaxies particularly in connection with other surveys such as SDSS etc.

THANK YOU CATHERINE AND ALL LOC MEMBERS

An excellent meeting!!

THANK YOU LENNART

We appreciated your way of coordinating the RTN!!

Thank you all members of the RTN for your collaboration all these years. It has been an unforgettable experience!!