A bayesian classification method applicable to the GAIA mission

How to use all *a priori* information from galactic and stellar evolution in the GAIA classification system and Science Alert ?

- Description of the galactic model
- Implementation of a bayesian classification system

Besançon model of the Galaxy

Model based on stellar and galactic evolution scheme.
starting from IMF, SFR, evolutionnary tracks, 4 populations
=> f(Mv,Teff,logg,age,mass) x ρ(x,y,z)

* age / velocity dispersion, age / [Fe/H]

* Dynamically self−consistent at the solar neighbourhood
=> age / h_z

* Produces stellar statistics, simulated catalogues of stars with observables (magnitudes UBVRIJHKL, G, colours, proper motions, radial velocity, parallaxe, spectral type)

Recent implementations

New photometric calibrations : Basel2.2 (Lejeune et al, 1997), Chabrier–Baraffe for late type dwarfs and white dwarfs

Hipparcos constraints included (Potential, luminosity function, kinematics) (Robin et al, 2003)

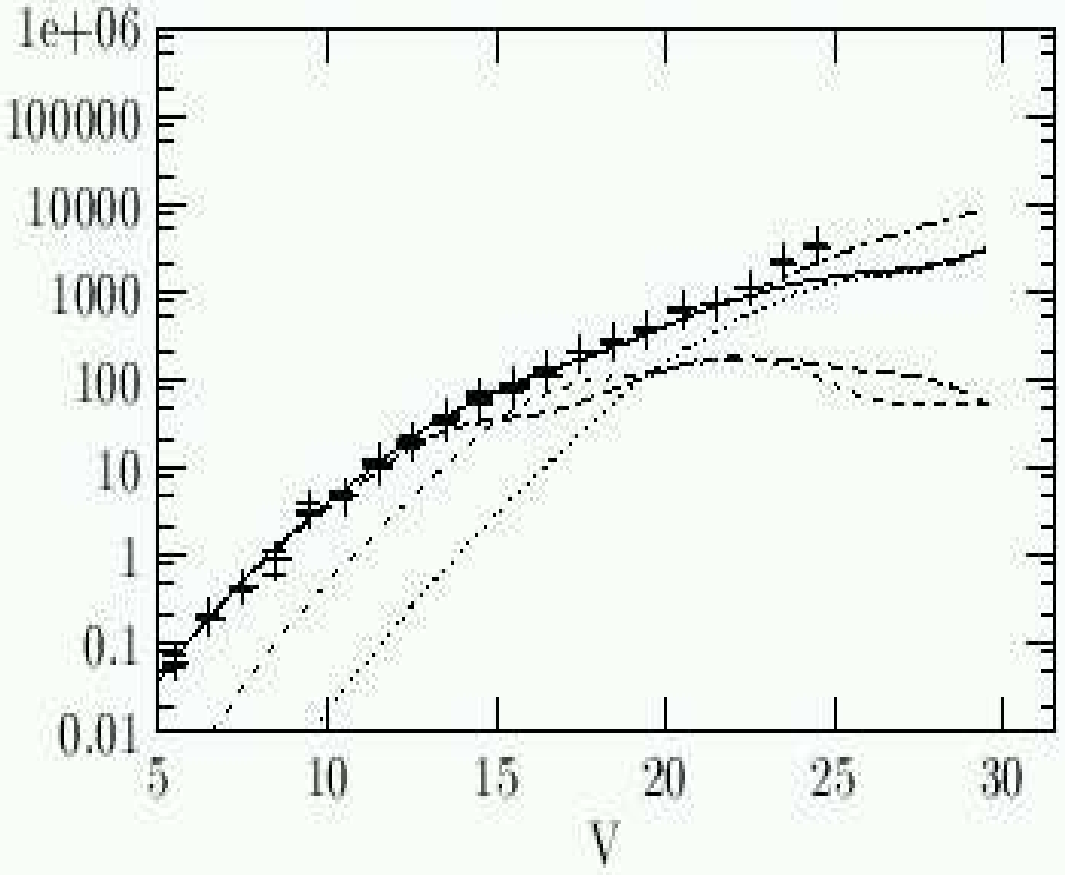
Warped disc and flare (Derrière & Robin, 1999)

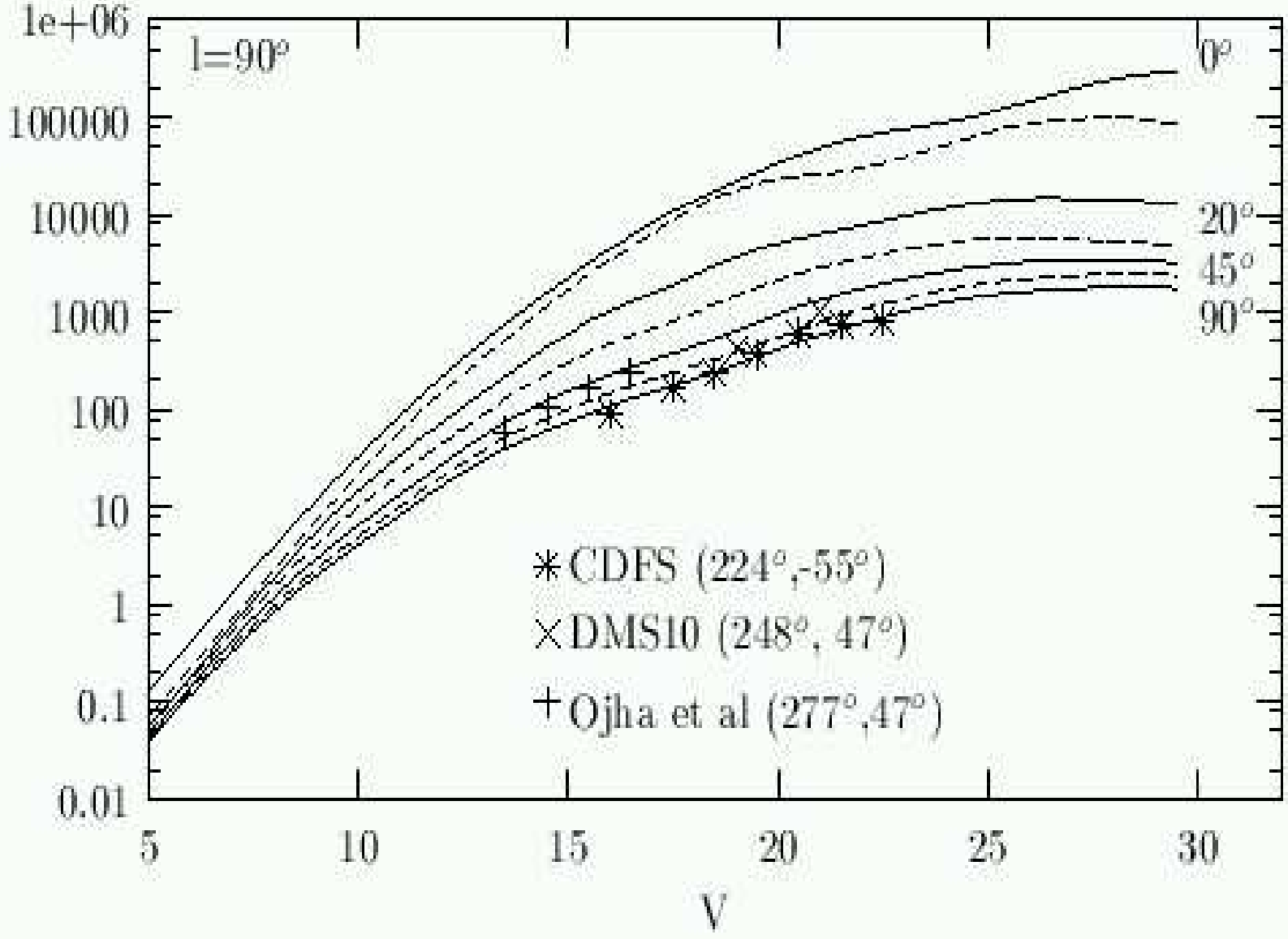
Spiral under implementation

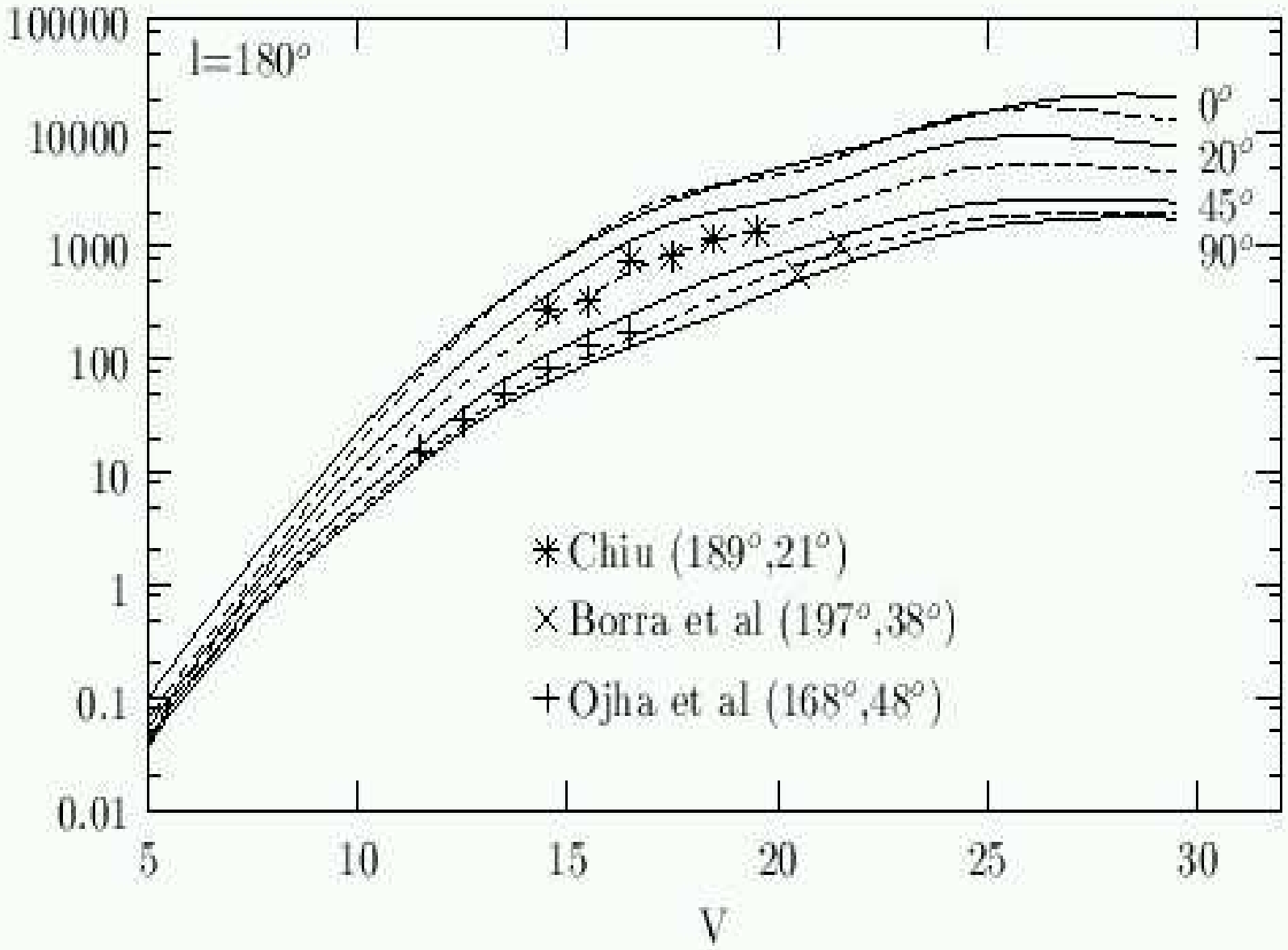
Thick disc and spheroid revised (density laws, IMF)
(Robin, Reylé & Crézé, 2000, Reylé & Robin, 2001)

Outer bulge included (Picaud & Robin, 2004)

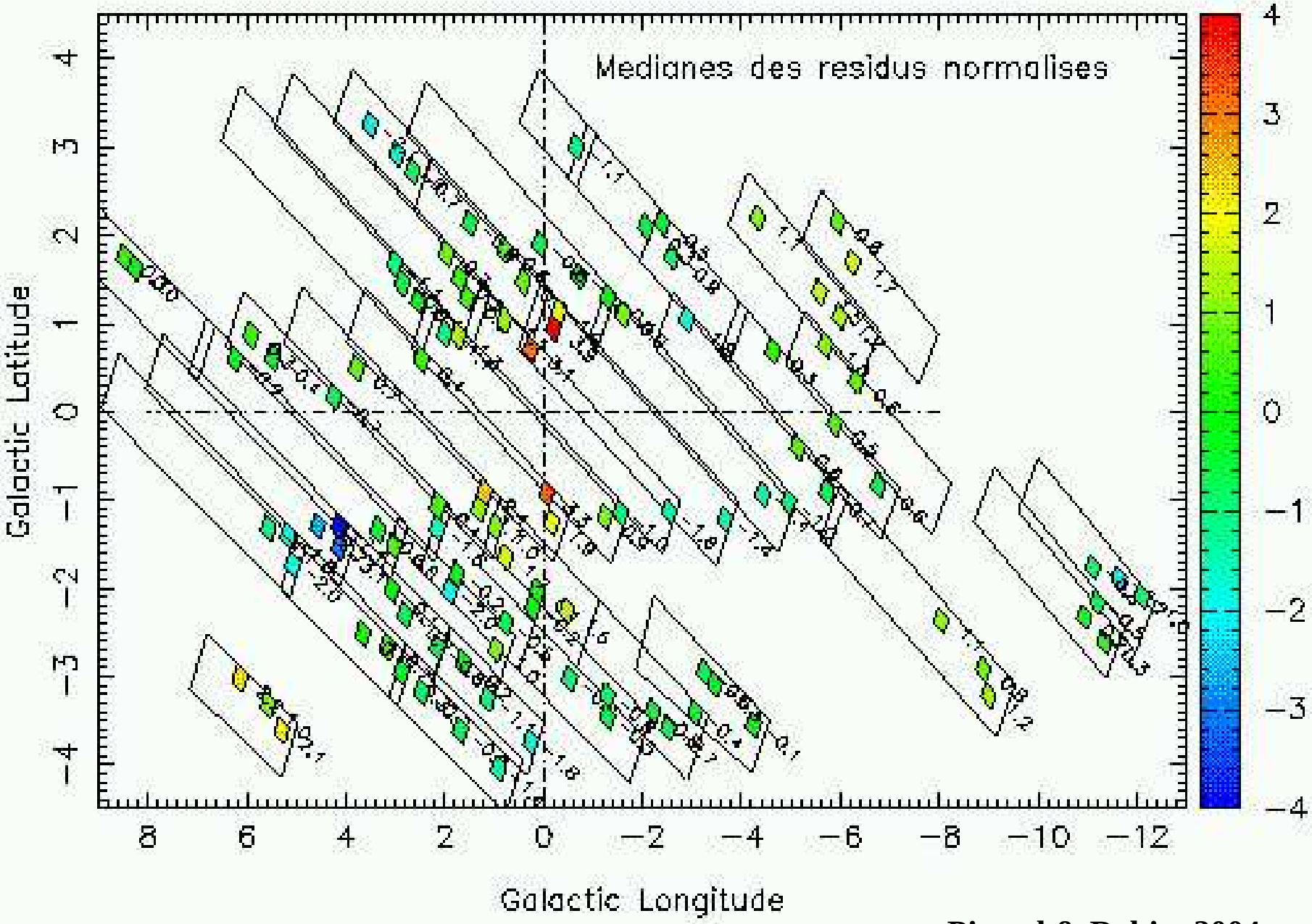
Predictions and comparisons with data sets



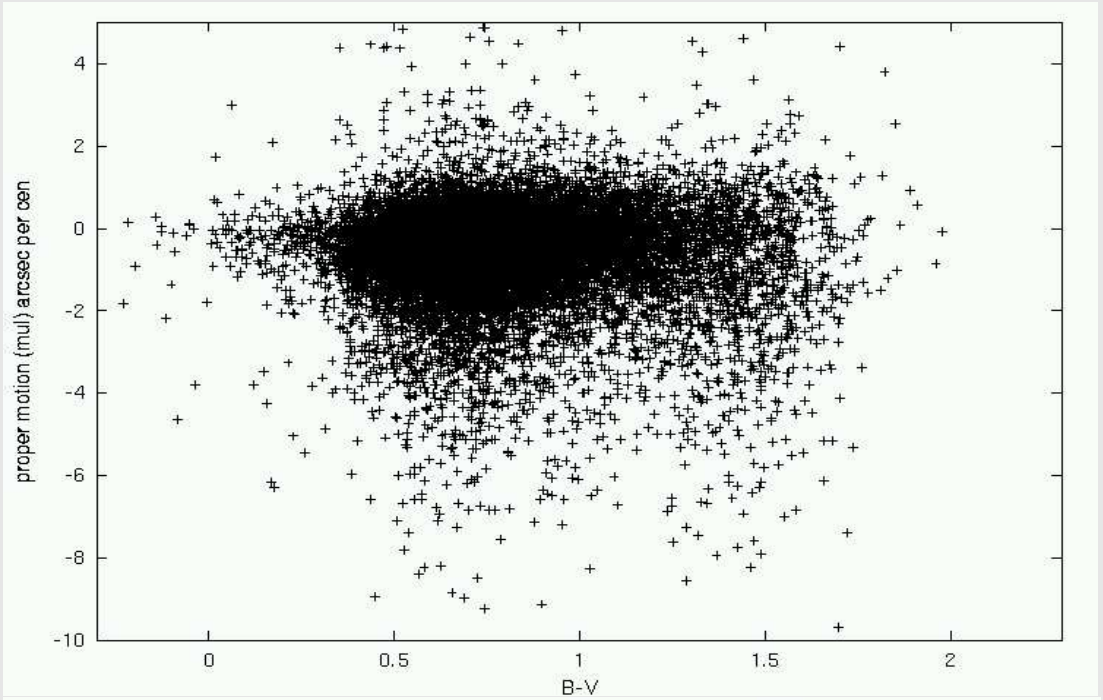

1e+06
100000
10000
1000
100
10
1
0.1
0.01
5
10
15
20
25
30
V
l=90°
0°
20°
45°
90°
*CDFS (224°,-55°)
×DMS10 (248°, 47°)
+Ojha et al (277°,47°)

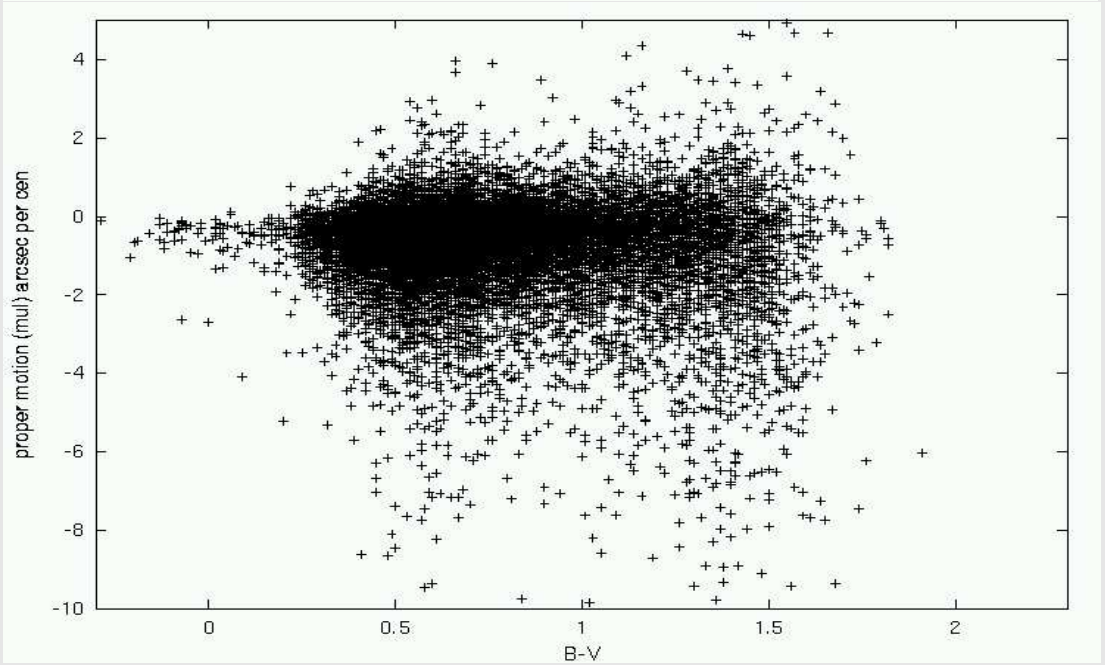

100000
10000
1000
100
10
1
0.1
0.01
l=180°
0°
20°
45°
90°
*Chiu (189°,21°)
×Borra et al (197°,38°)
+Ojha et al (168°,48°)
5
10
15
20
25
30
V

The following map shows the medians of normalized residues (red = excess of data) for the best parameters (see next page). The black boxes are the batches.



Picaud & Robin, 2004





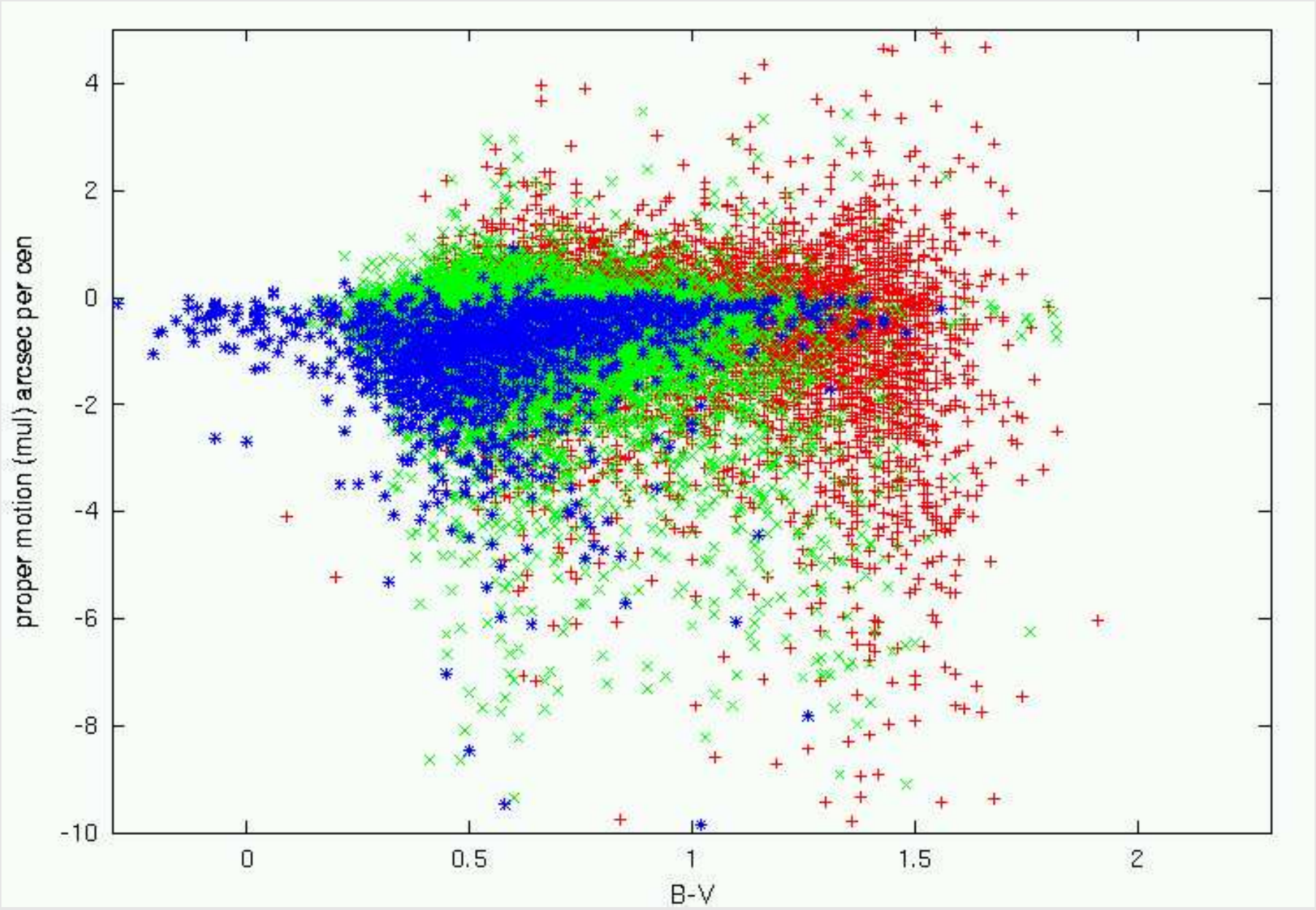
Data
Ojha et al. (1996)

Towards l=4, b=45

at V<18

B−V versus
proper motion
μl in arcsec
per century

Model



Model towards l=4, b=45 at V<18, disc (red), thick disc (green), spheroid (blue)

A Bayesian classification tool

An "agap" model of the Galaxy :

=> Frequencies of different types of stars as a function of position in the Galaxy

=

Probability to find a star of a certain type in a certain place, with certain properties

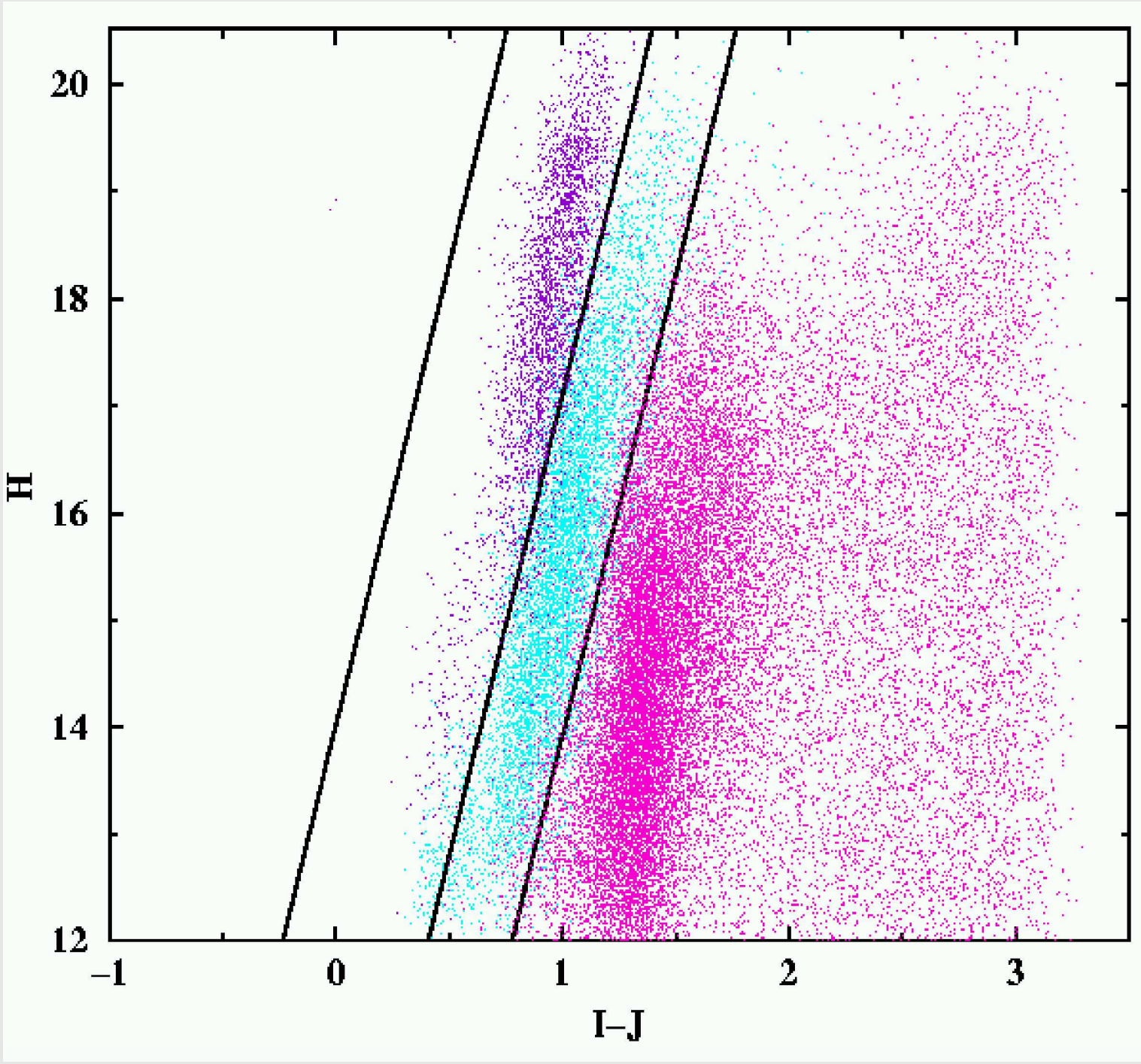
Apparent magnitude
colours
proper motions
parallaxes
radial velocities
coordinates

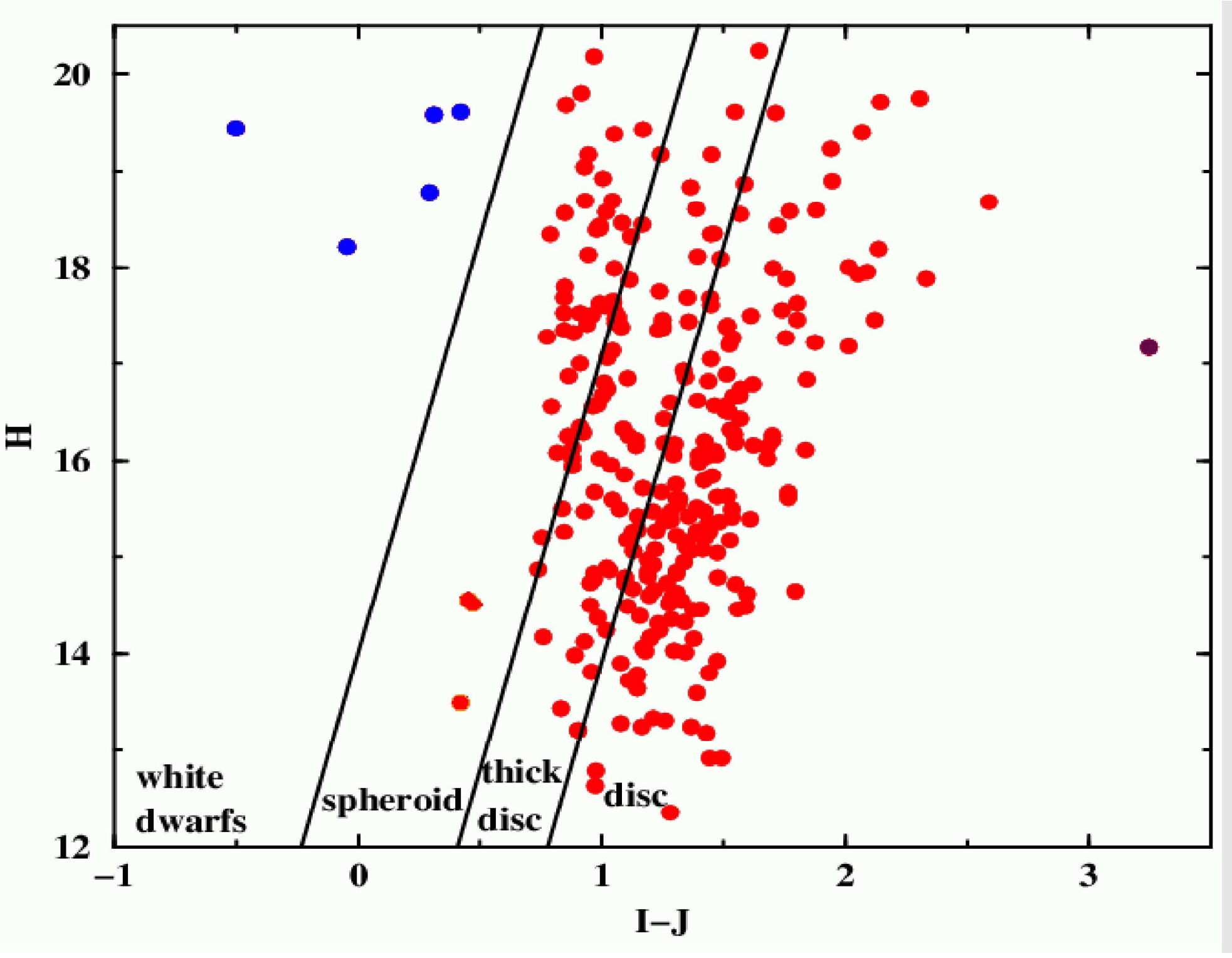
Observables

Teff
log g
spectral type
distance
absolute magnitude
metallicity
velocities

Classification

Age, population


20
18
16
14
12
H
–1
0
1
2
3
I–J

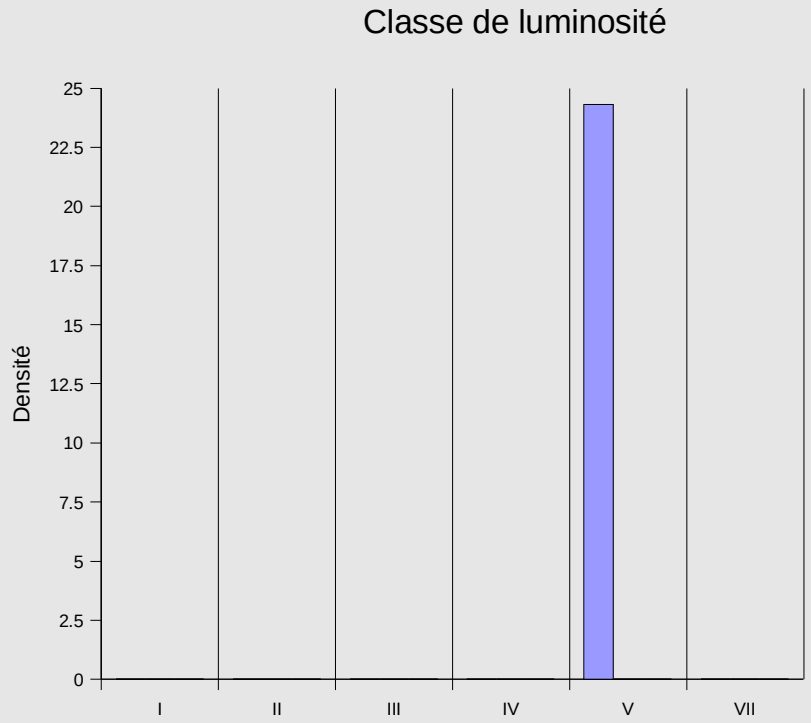

20
18
16
14
12
H
−1
0
1
2
3
I−J
white
dwarfs
spheroid
thick
disc
disc

Probability estimates

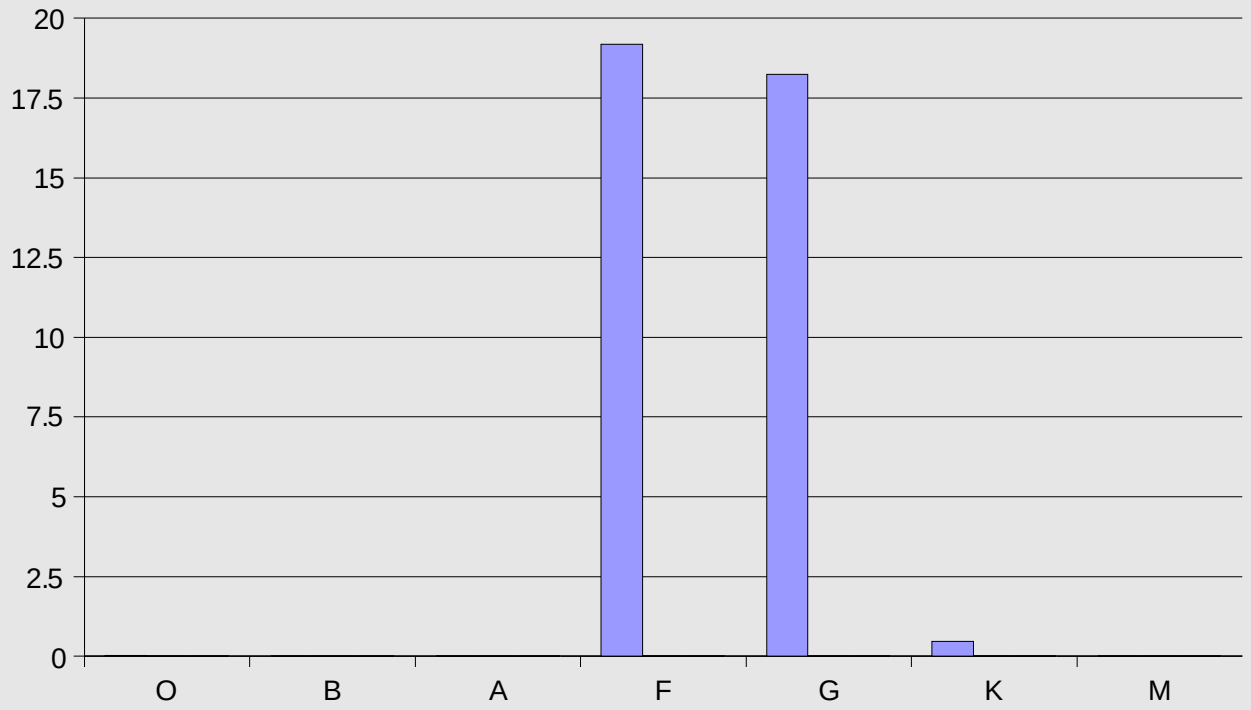
Example : a star of magnitude V=18+−1.0
and B−V=0.6+−0.15

Towards l=200, b=59

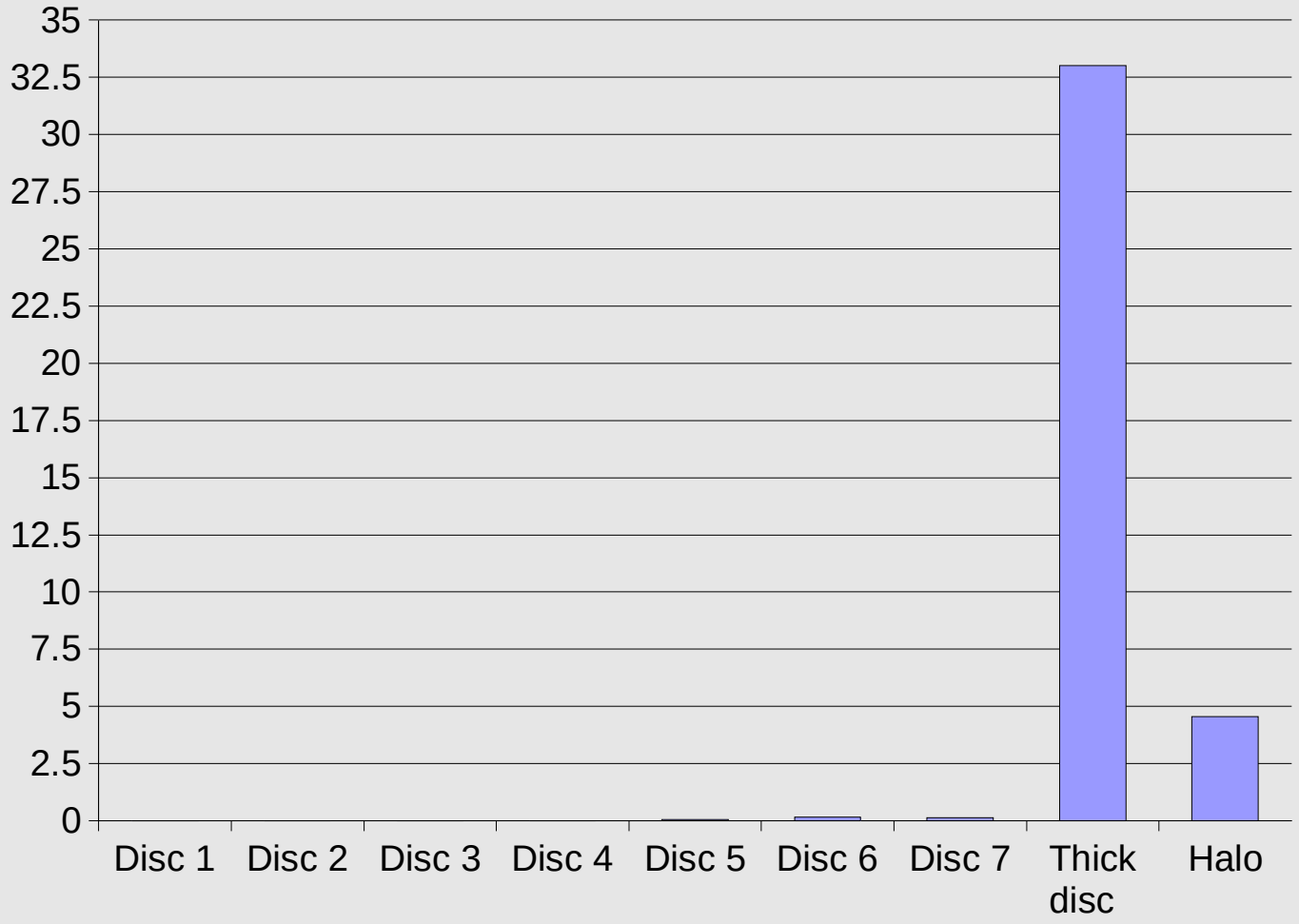
Luminosity class distribution :



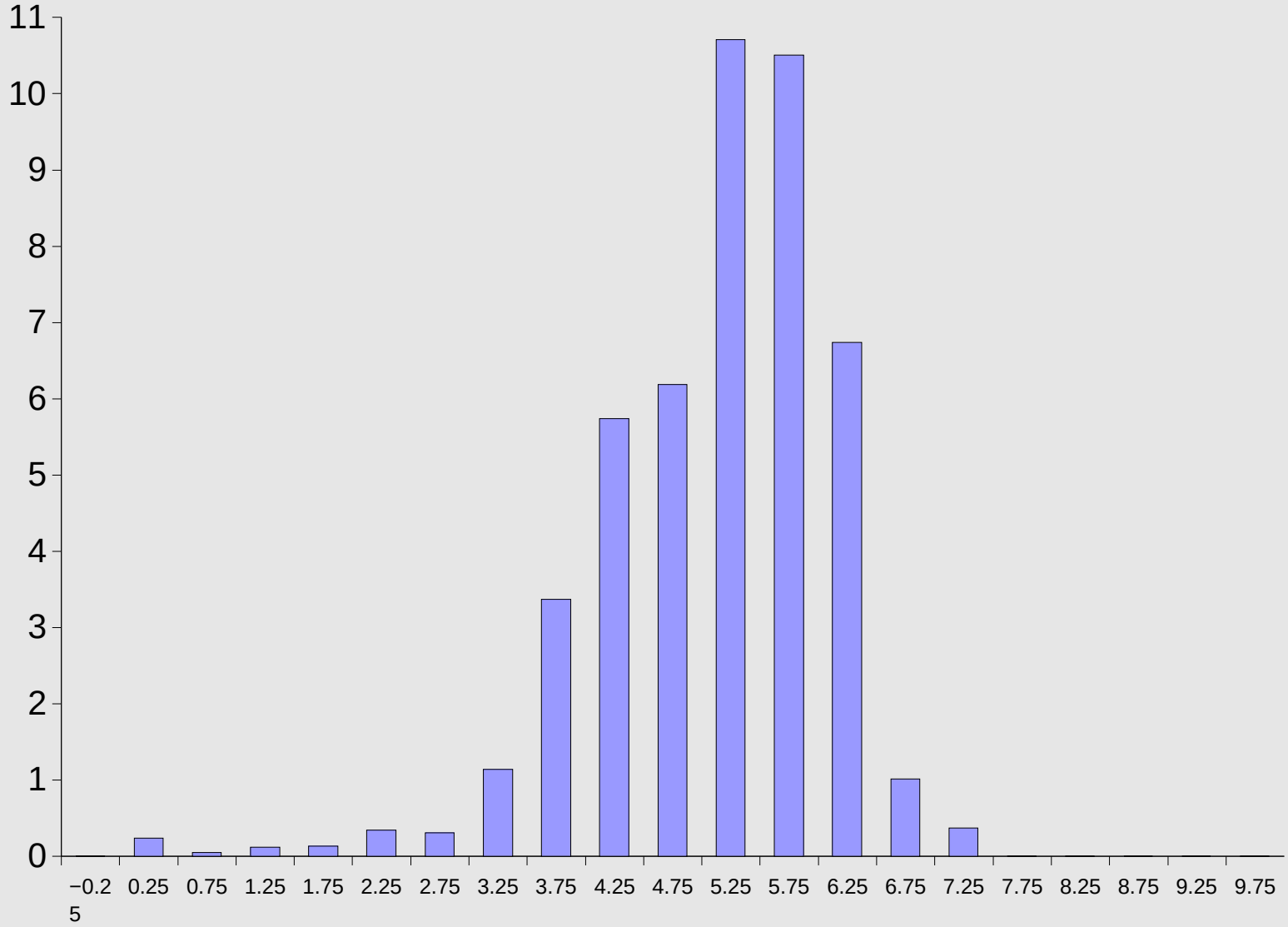
Spectral type distribution



Population


35
32.5
30
27.5
25
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
Disc 1
Disc 2
Disc 3
Disc 4
Disc 5
Disc 6
Disc 7
Thick disc
Halo

Absolute magnitude



Future implementations

– A 3D extinction model

– Padoue isochrones and adjustable SFR (coll. Haywood)

– GAIA photometric system (Photometric WG)

Science Alert

Classification for most stars.
When the classification fails (an object in an improbable region)

=> Science Alert

Possibility of exploring multivariate space of observables, more than in a normal classification.

Classification may evolve during the mission.

Work in progress at Heidelberg (ARI) by Sébastien Picaud

Conclusions

- CLASSIFICATION:

Complementary to standard classifications (age estimate,
account for galactic structure knowledge)

Useful when standard classifications fail (degeneracies)
and at low signal/noise

Necessity to make verification tests during the mission
statistical tests on the database on distributions of observables
model learning ?

- SCIENCE ALERT: Detection of unusual/new types of objects