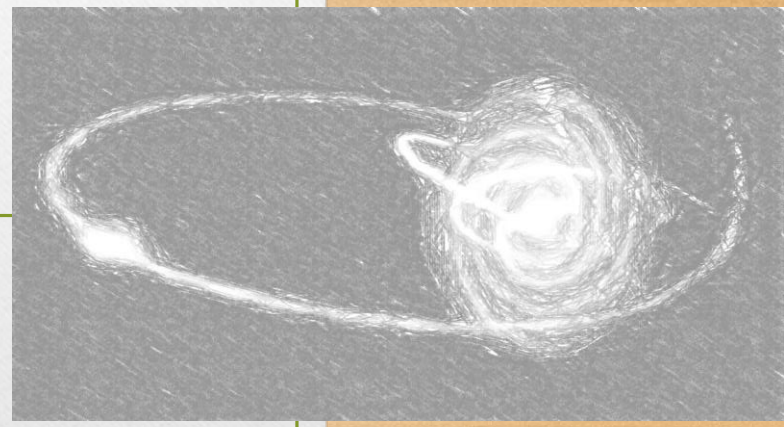
A KiDS view of the Fornax dSph



RELOADED

VST in the Era of the Large Surveys

Napoli, June 6, 2018

Massimo Dall'Ora, INAF-OACN

Near-Field Cosmology

- Observational evidence for accretion history of the Galactic halo (Searle & Zinn, 1978)
- Λ-CDM models predictions (e.g. Springel+ 2006) → assembling of the Galactic halo by accretion of small systems → ongoing
- Diagnostics:
  - Number and distribution of the satellites
  - analysis of the stellar populations (ages, chemical tagging, SFHs, etc.)

How can we test Λ-CDM predictions on our own galaxy?

- Comparison between observed and expected number of satellites → missing satellites problem → deeper and wider surveys (e.g. DES)
- Comparison between chemical content of the stars of the MW halo and of its satellites (chemical tagging)
- Analysis of suitable stellar tracers → bright and easily recognizable → RR Lyrae stars (also standard candles)
- Individual and ensemble pulsational parameters (periods, amplitudes) as functions of their structural parameters (masses, evolution, chemical composition)

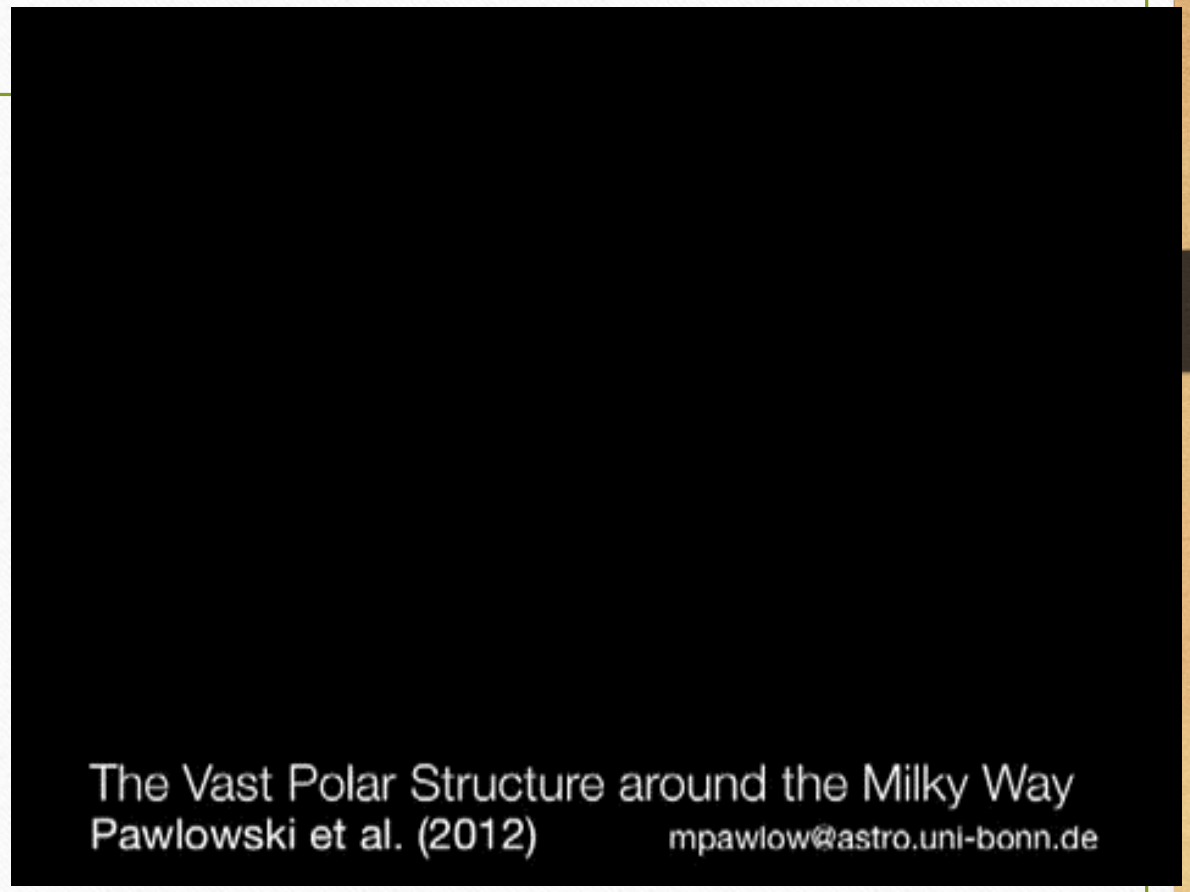
On the missing satellites problem: a real problem?

- "*There is no solution to the missing satellites problem […] since there is no problem" (→ observational bias + physics of SF)*
- At the present time, we detected satellites with luminosities of L ≈ 100 L⊙, embedded in estimated dark haloes of ≈ 10^7-10^9 M⊙ → faint systems in moderately massive haloes
- "*the missing satellites problem is perhaps better viewed as a dramatic divergence between the sub-halo mass function and the dwarf luminosity function […] with a pile-up of literally invisible objects with mass-to-light ratios of order of 10^5-10^6 M⊙/L⊙*"

Koposov et al. 2018

The Vast Polar Structure (VPOS)

- Bright andUltra-faint dwarfs
- Young globulars
- Some streams
- Aligned along a great circle (rotationally supported?)
- Tidal rather primordial origin
- Also in M31 and in other galaxies of the local universe



DATASETS

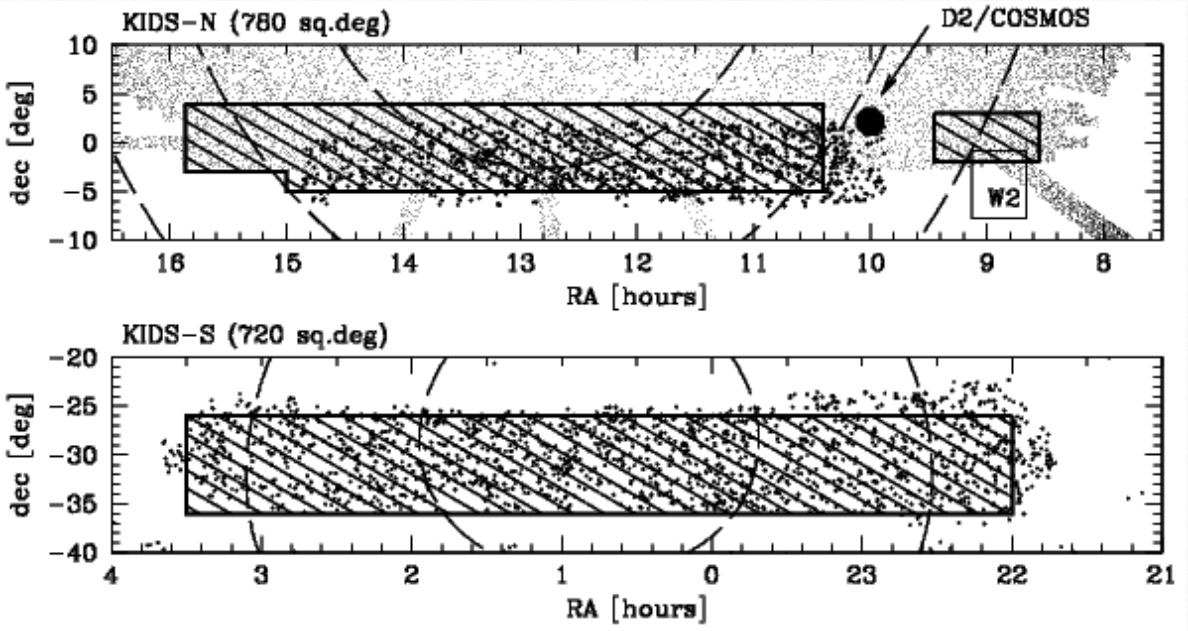
- Deep surveys for the detection
- Extended and deep surveys for the tidal tails
- Accurate multi-band photometry for the color-magnitude diagrams (ages, SFH)
- Possibly time-series, to spot and characterize RR Lyrae variable stars

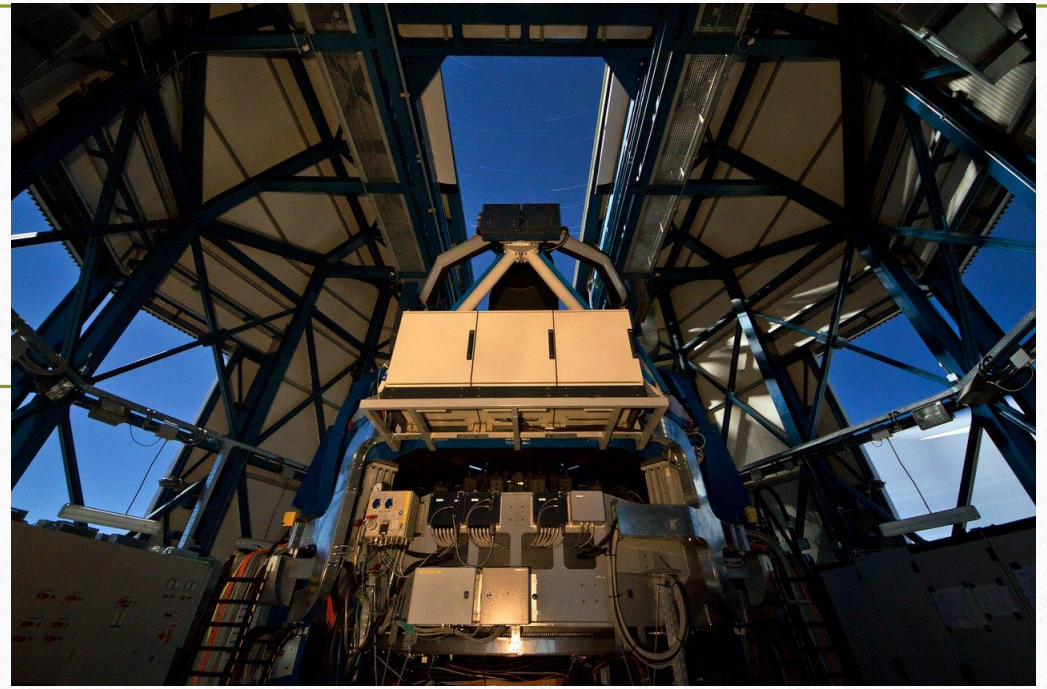
- KiDS
- KiDS+ATLAS+VIKING → ugriJHK
- PBS

Fornax dSph

- One of the brightest and massive MW satellites
- Hosts a system of globulars
- Multiple stellar populations
- Huge numer of RR Lyrae stars (> 1400, Fiorentino+ 2017)
- Reference PSF photometry by PBS, spanning > 20 years, and by De Boer+ 2012 → we can test the photometric accuracy with tw independent deep multi-band datasets

The KiloDegree Survey (KiDS)

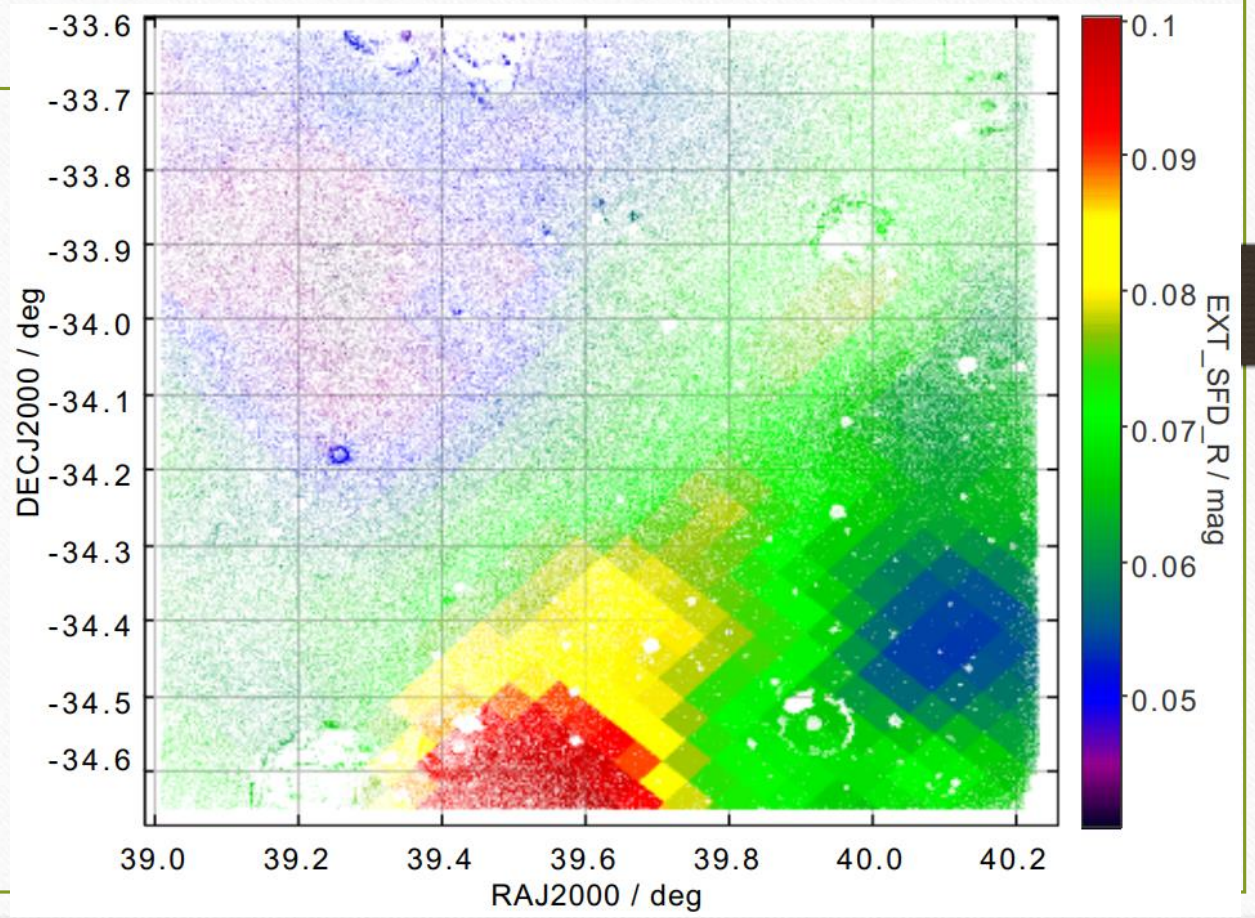




- 1500 sq degrees
- ugri photometry (r 25.2 mag AB 5 σ)
- Designed for weak lensing and photometric redshifts
- Current Data Release: DR3 (440 sq degrees) DR4 within 2018
- P.I.: K. Kuijken

Data Products

- Full WCS and photometric calibration
- Absolute aperture-corrected fluxes
- PSF-matched magnitudes (GAaP magnitudes)
- Individual reddening



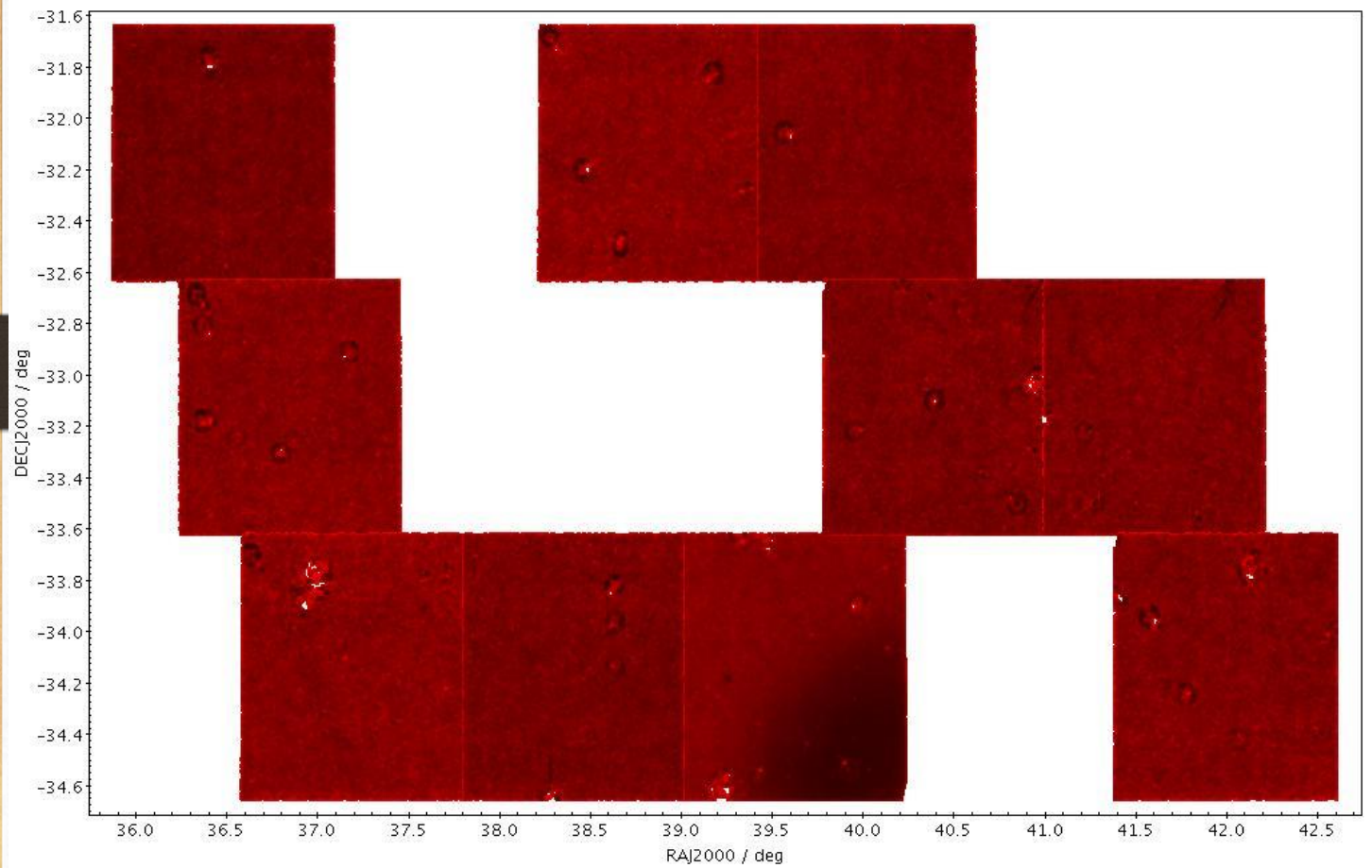
People

- KiDS members:

  J. De Jong, K. Kuijken, N.R. Napolitano, A. Grado

- Non-KiDS members:

  R. Ragusa (Univ. Naples); M. Marconi, I. Musella, V. Ripepi (OACN); M. Monelli (IAC); G. Bono (Univ. Rome 2); G. Fiorentino (OABo); P.B. Stetson (DAO)

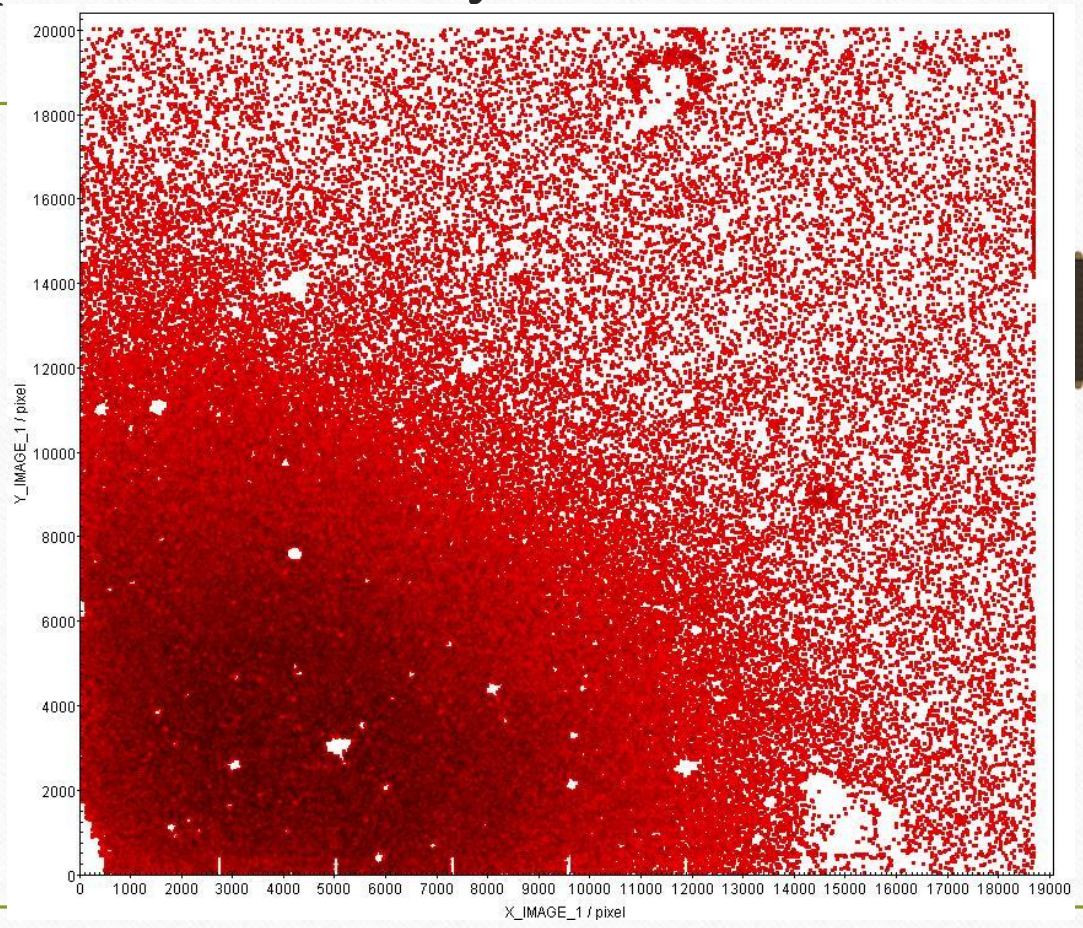


Field covered by DR3

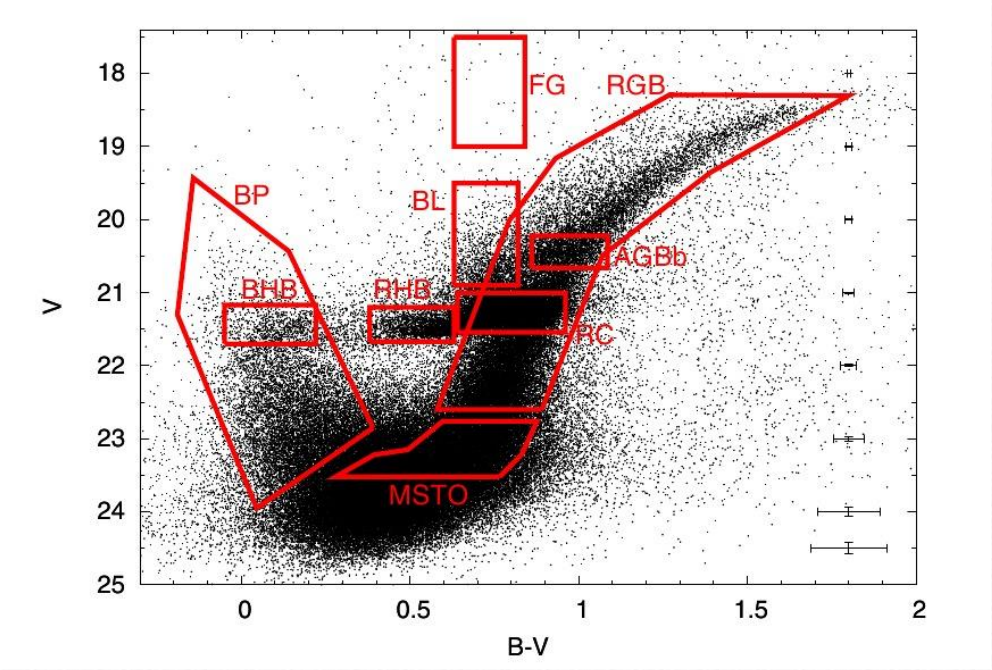
Waiting for DR4

KiDS-based photometry

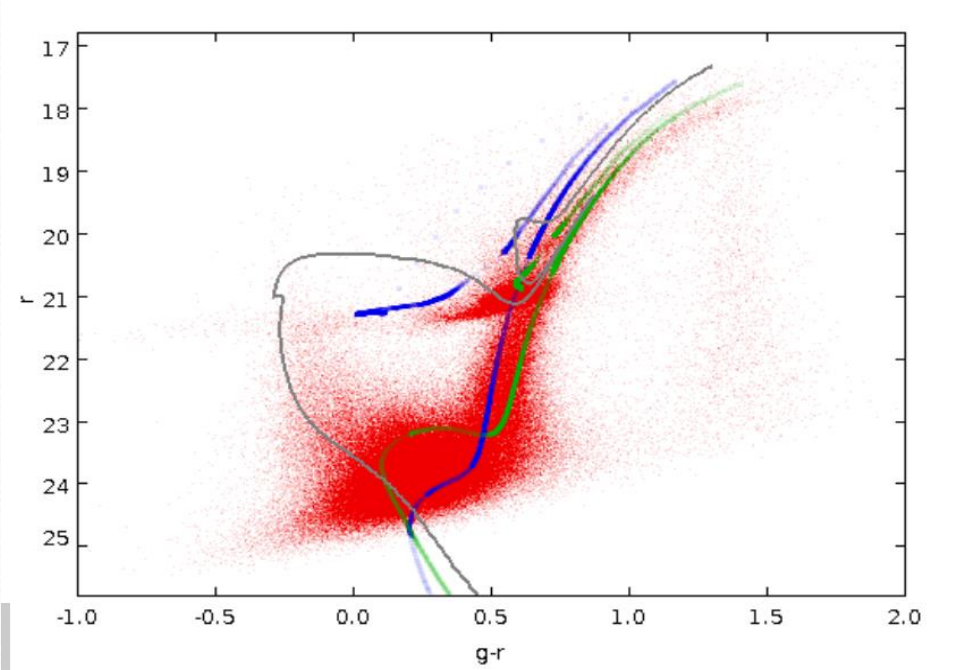
- First photometry on DR1-DR2 data (Rossella Ragusa's Bachelor degree thesis)
- Aperture photometry (6 pixels + aperture correction)
- KiDS calibration
- Match with VIKING data



Not that bad…

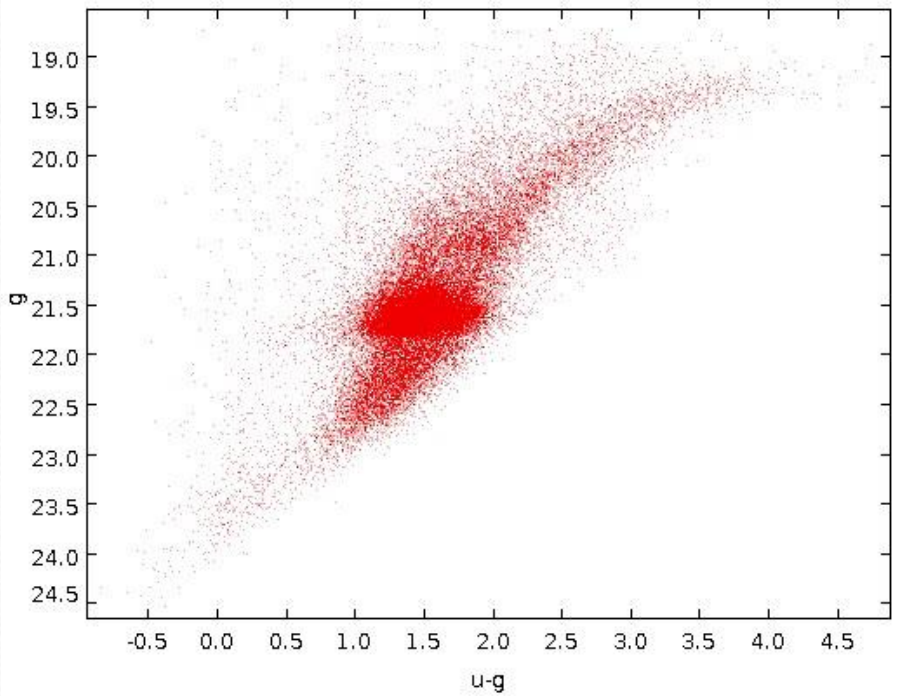


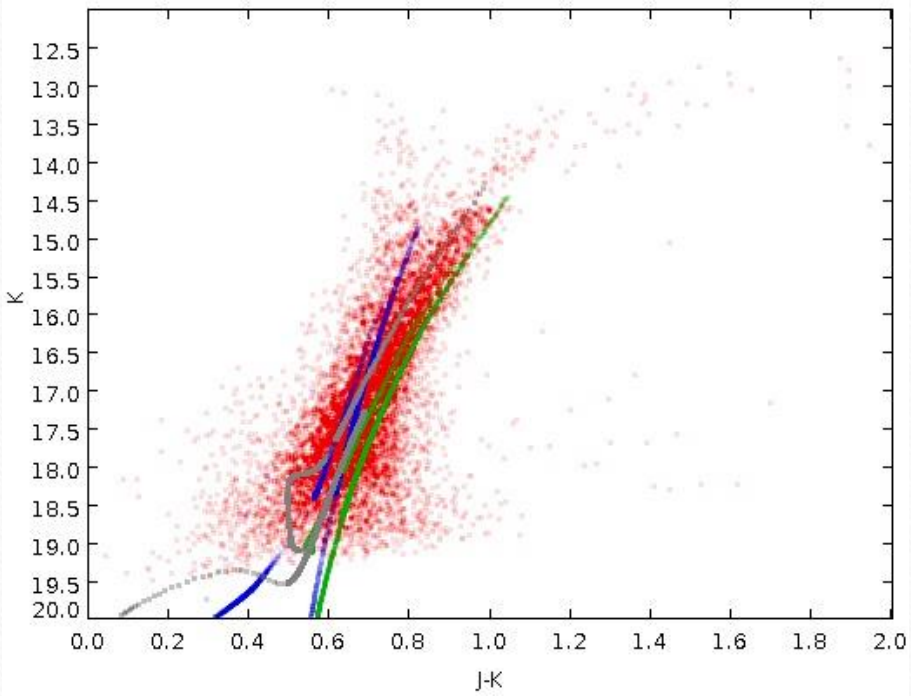
De Boer+ 2012, 270k stars in a 0.8d radius



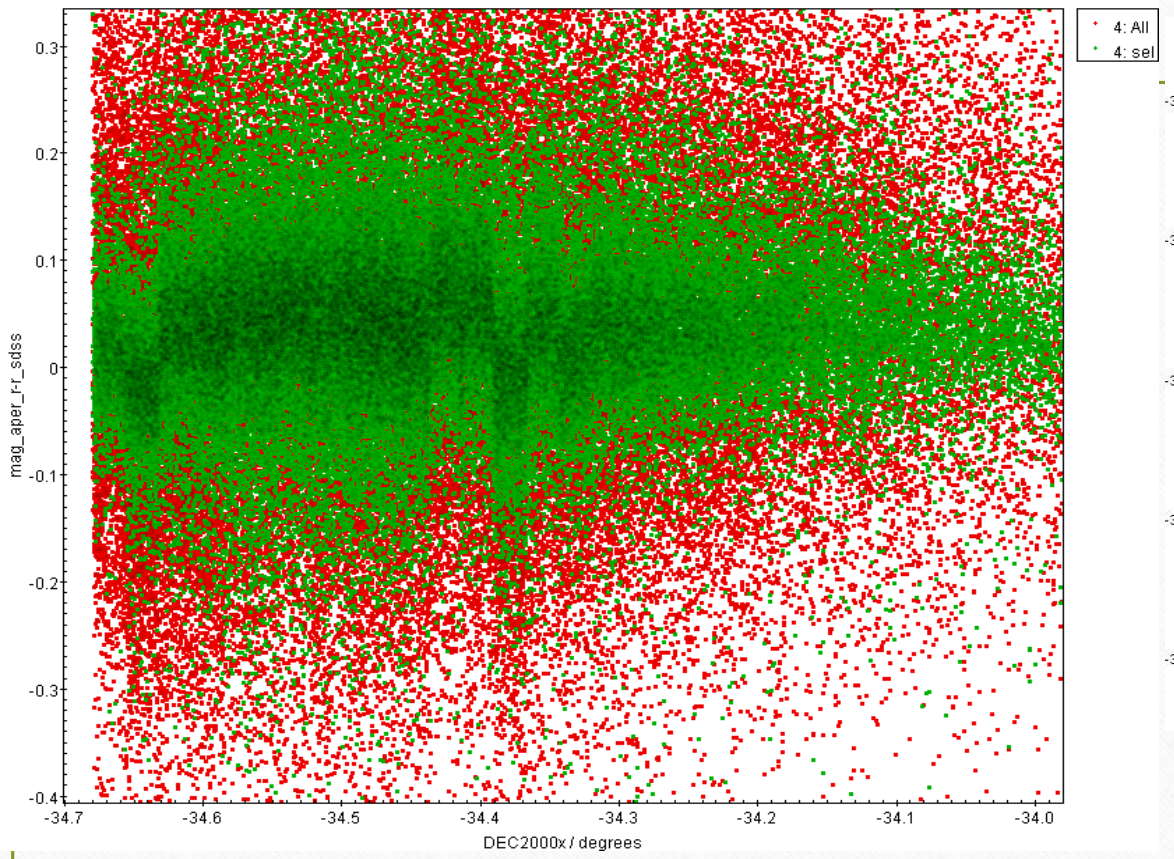
KiDS, 220k stars, Rossella Ragusa's thesis

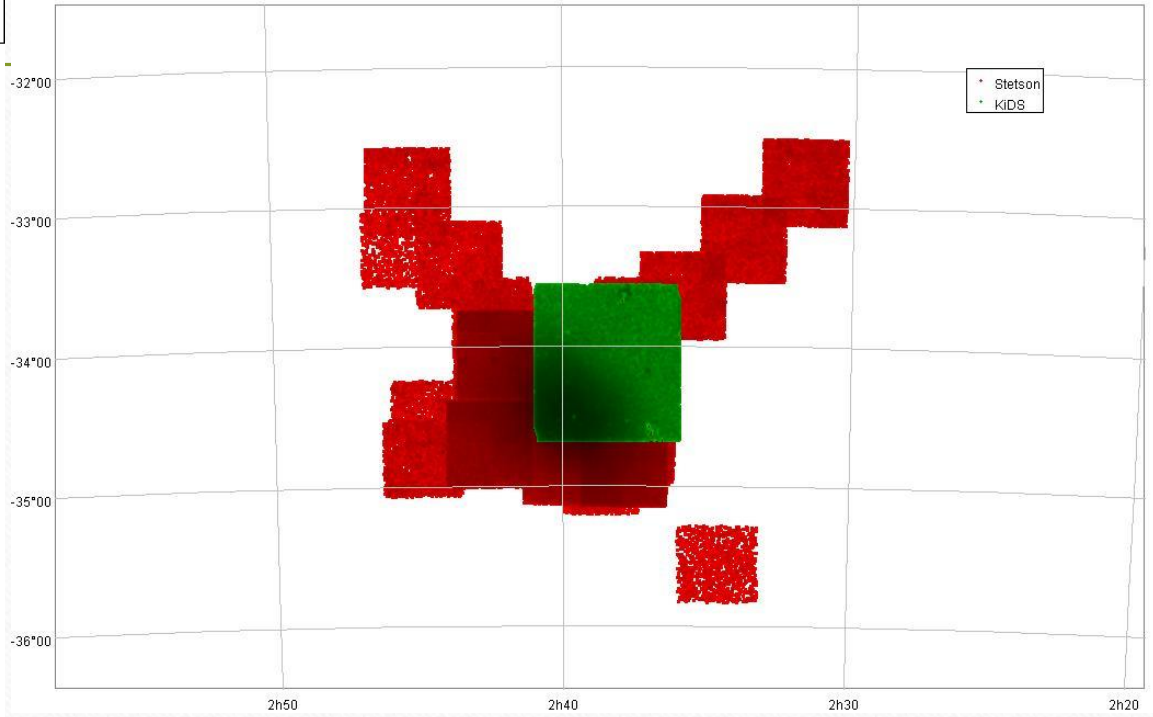
From u to K band



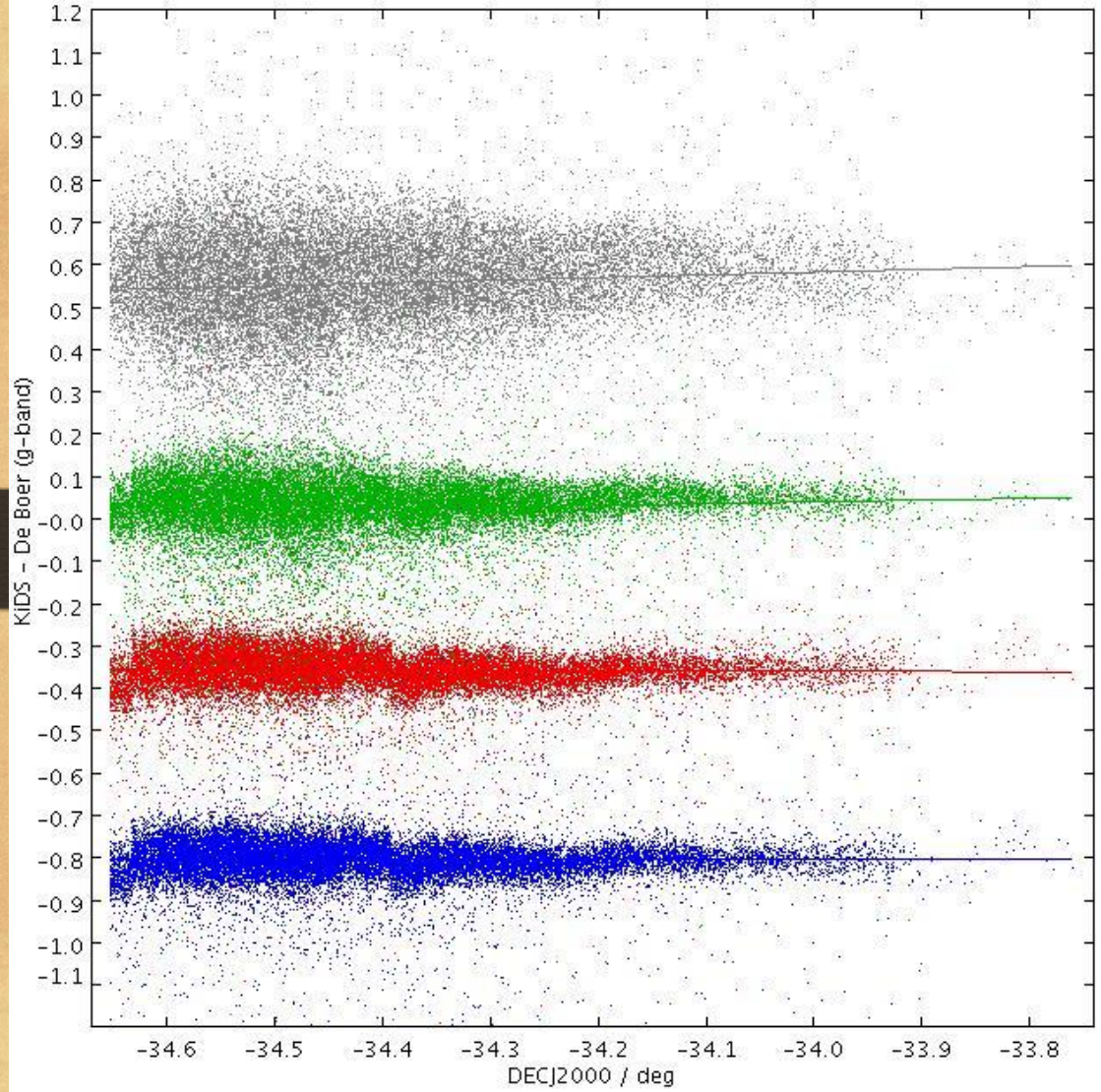


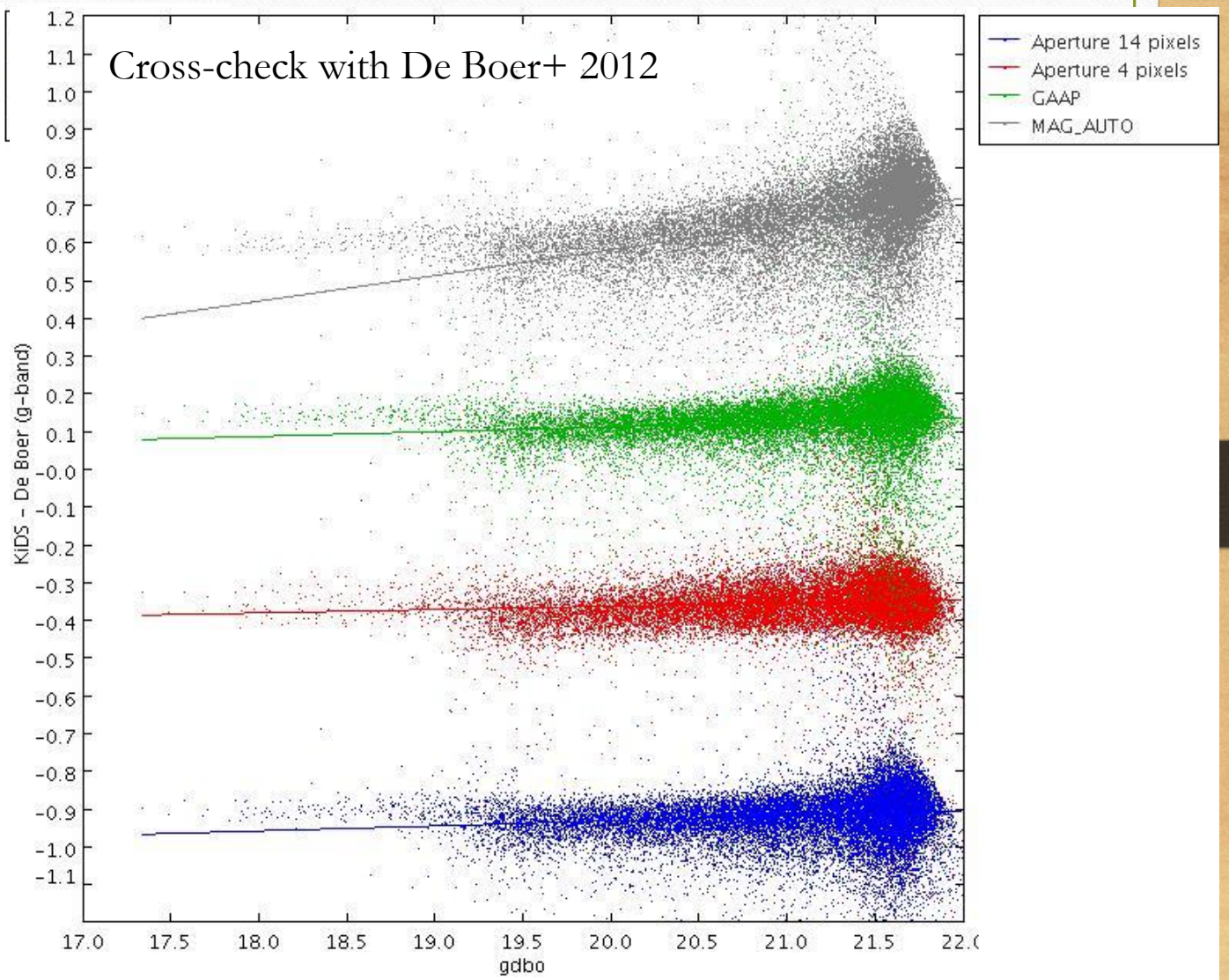
Zero Point



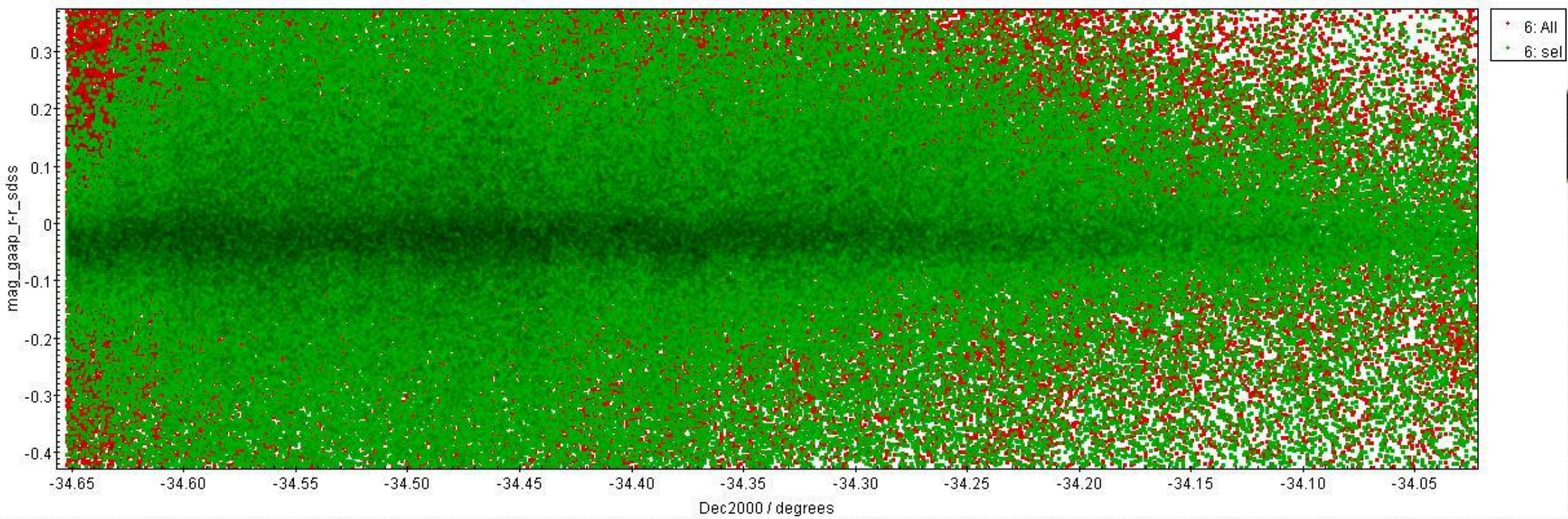


PBS photometry, 195kstars in common
from a catalogue of 759k. Green dots, selected74k stars


KiDS – De Boer (g-band)
DECJ2000 / deg

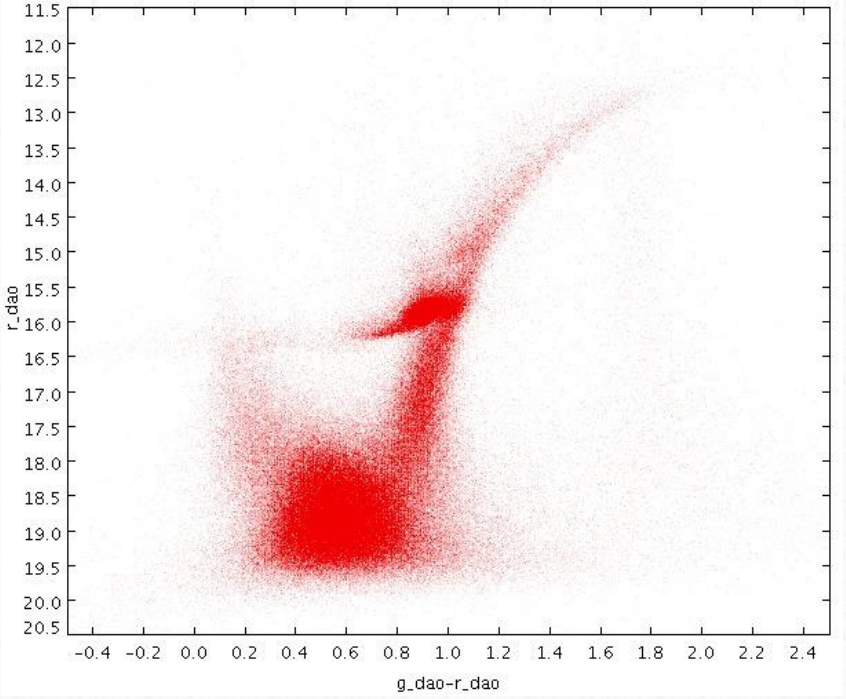

Cross-check with De Boer+ 2012
Aperture 14 pixels
Aperture 4 pixels
GAAP
MAG_AUTO
KiDS – De Boer (g-band)
gdbo

GAaP magnitudes

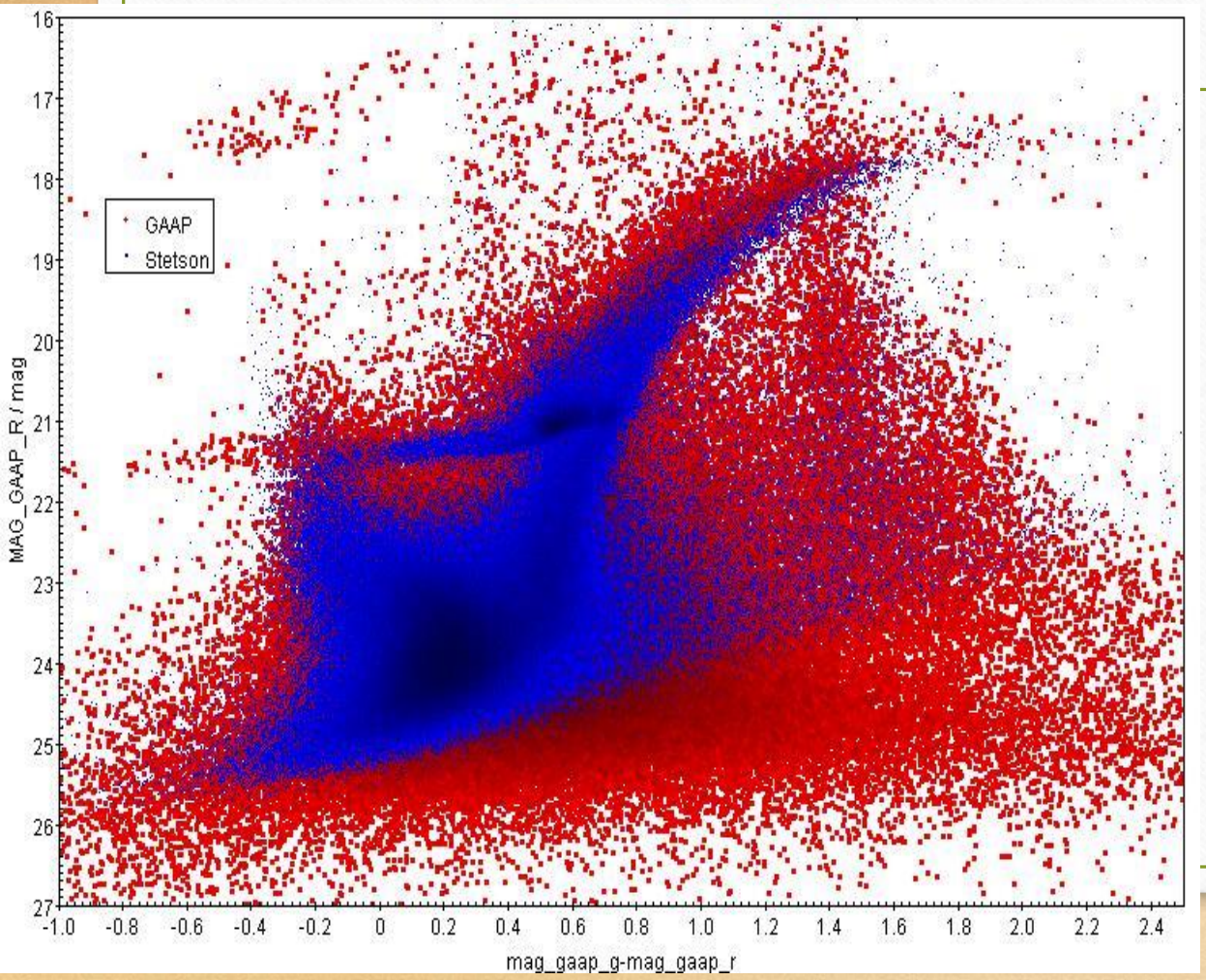


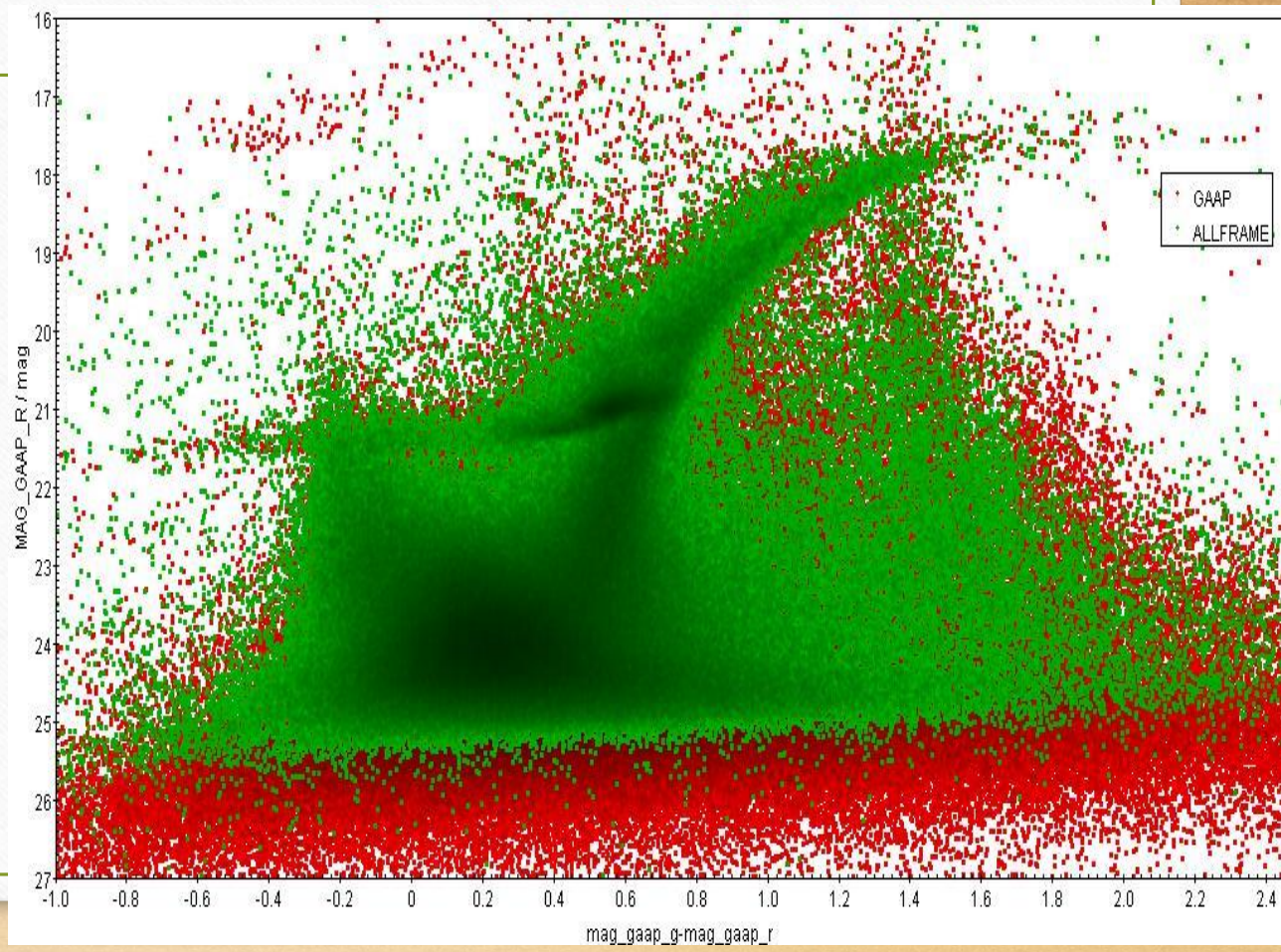
ALLFRAME Photometry

- ALLFRAME (Stetson 1994) measures *simultaneously* ALL the stars in ALL the available images
- Accurate PSF photometry (202k stars)
- Master list built on the STACK of all the available images



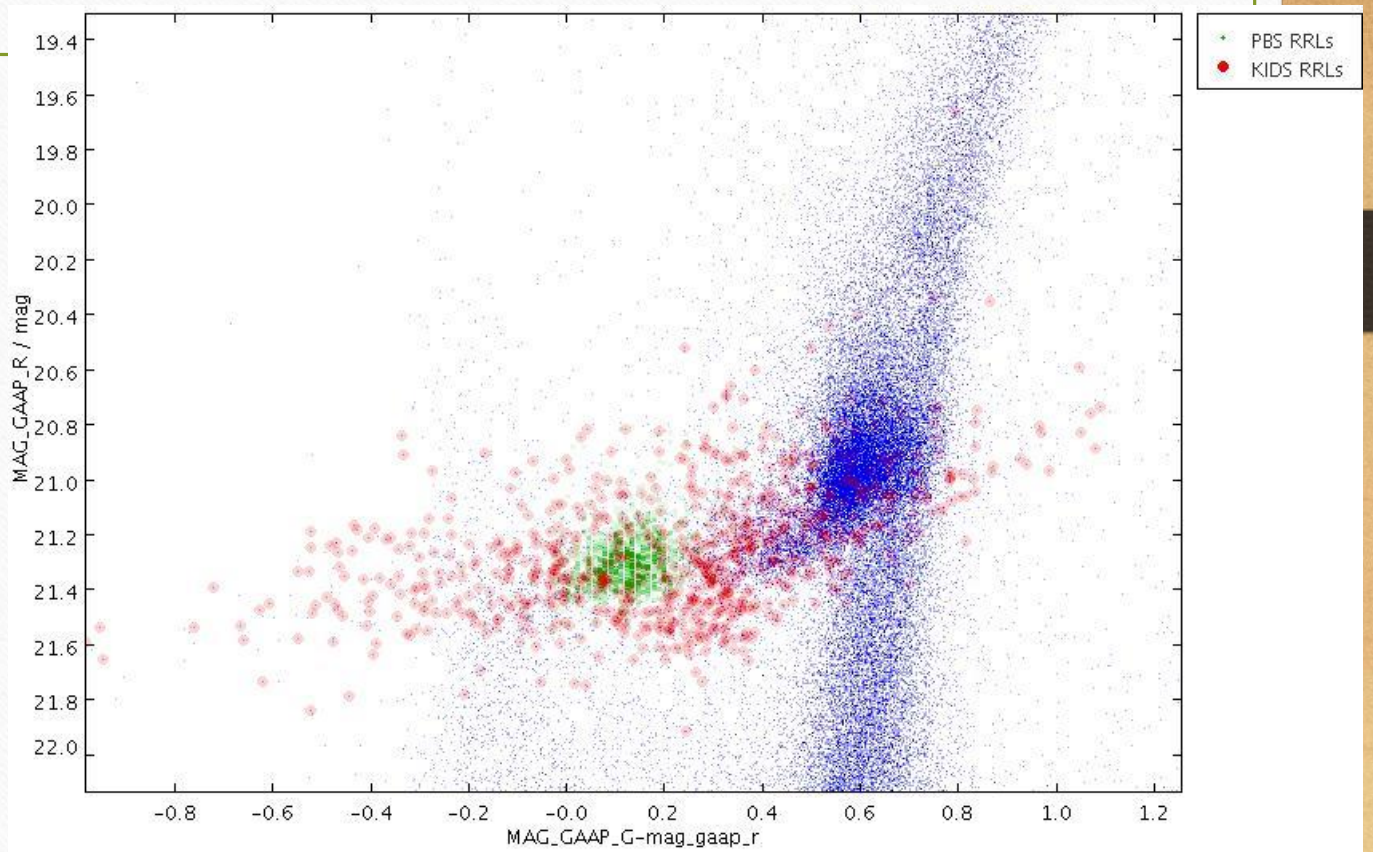
GAaP Magnitudes



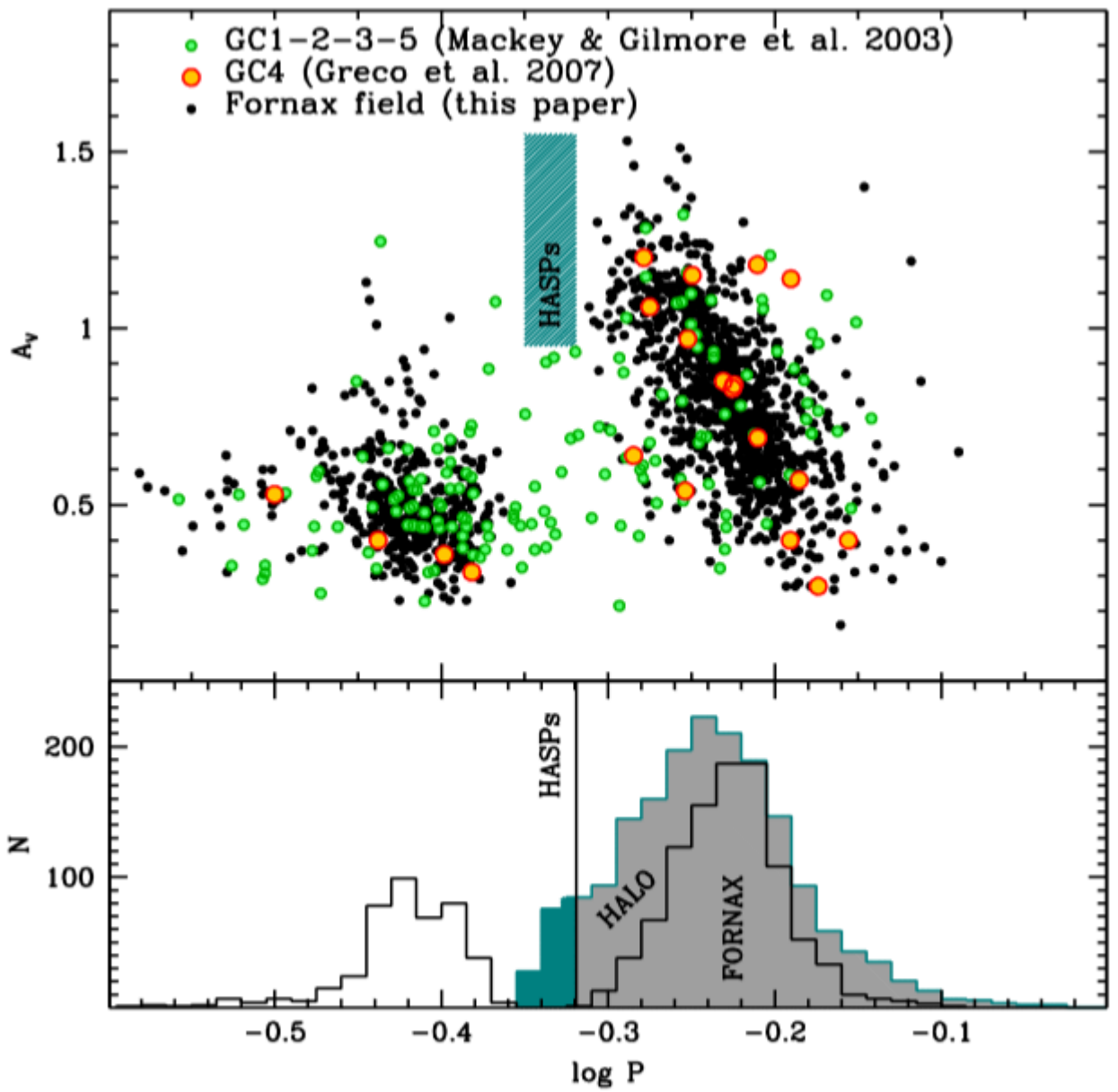


RR Lyrae stars

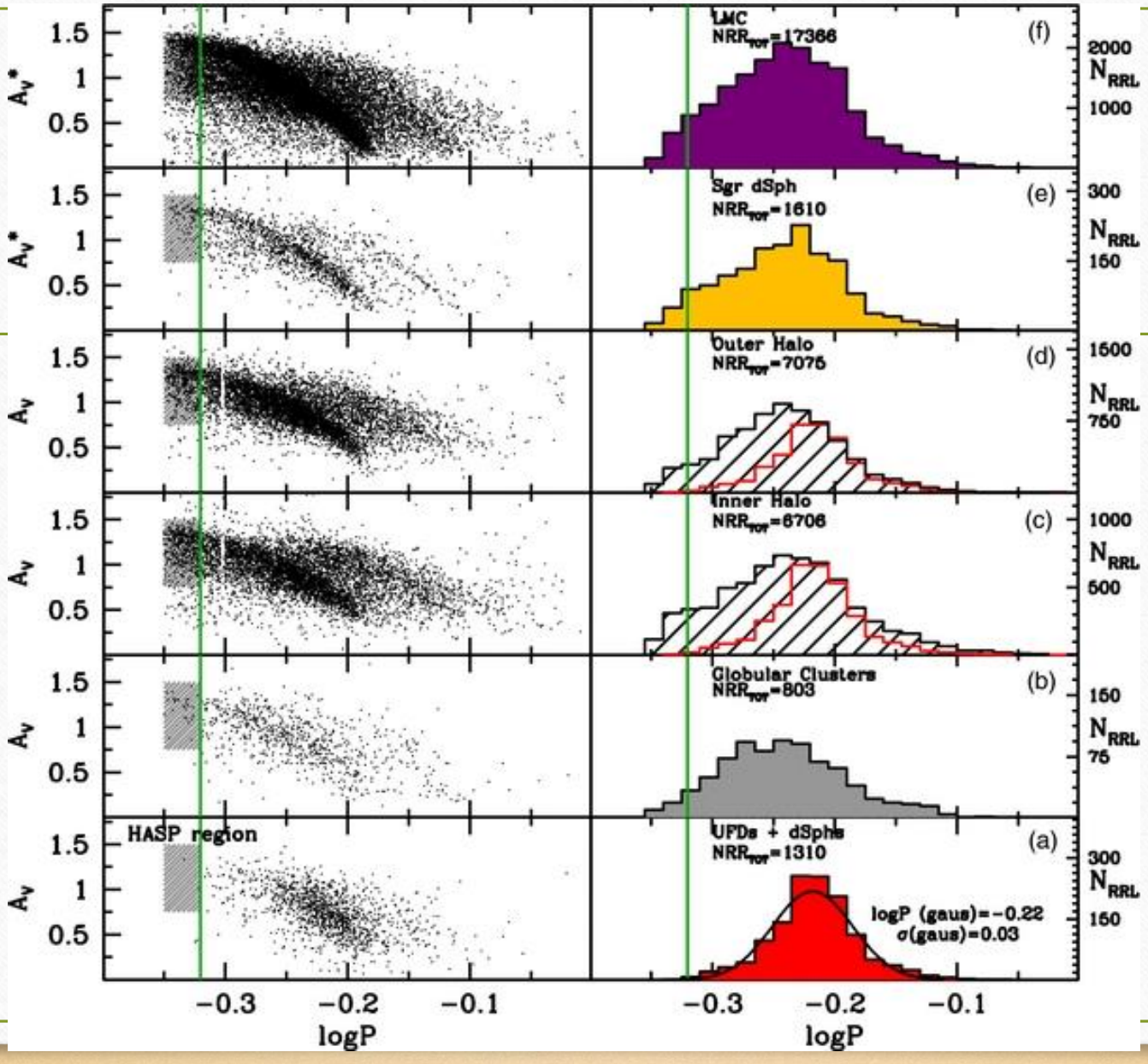
- Can we recover RRL stars from "single-epoch" colors? (WARNING)
- Basis: known RRL (Fiorentino et al. 2017)



Lack of HASP variables, both in the main body and in the clusters

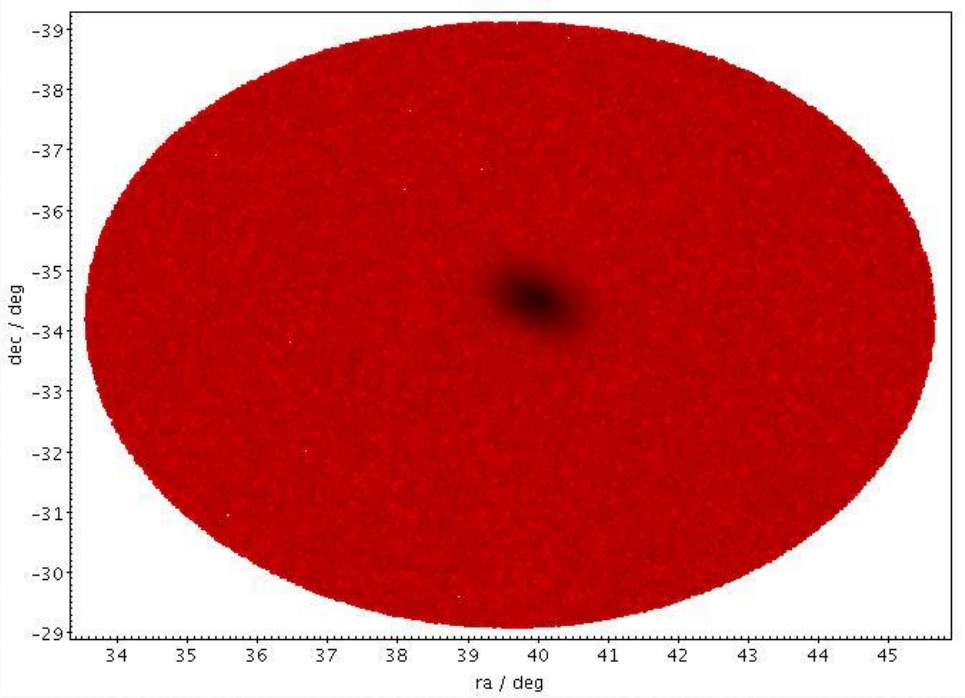


Fiorentino et al. 2017

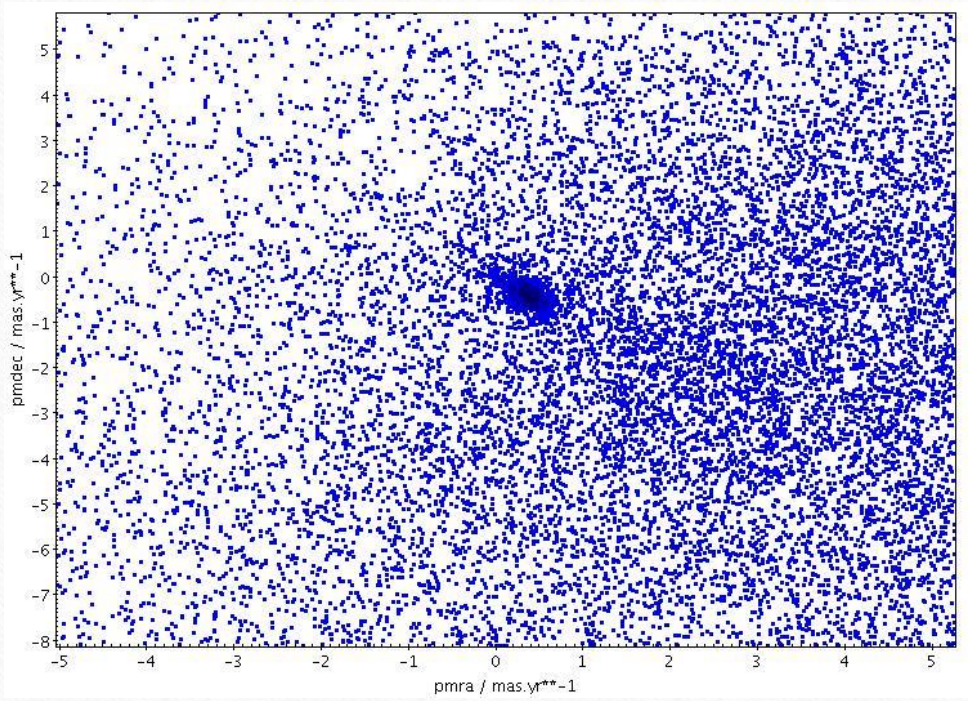


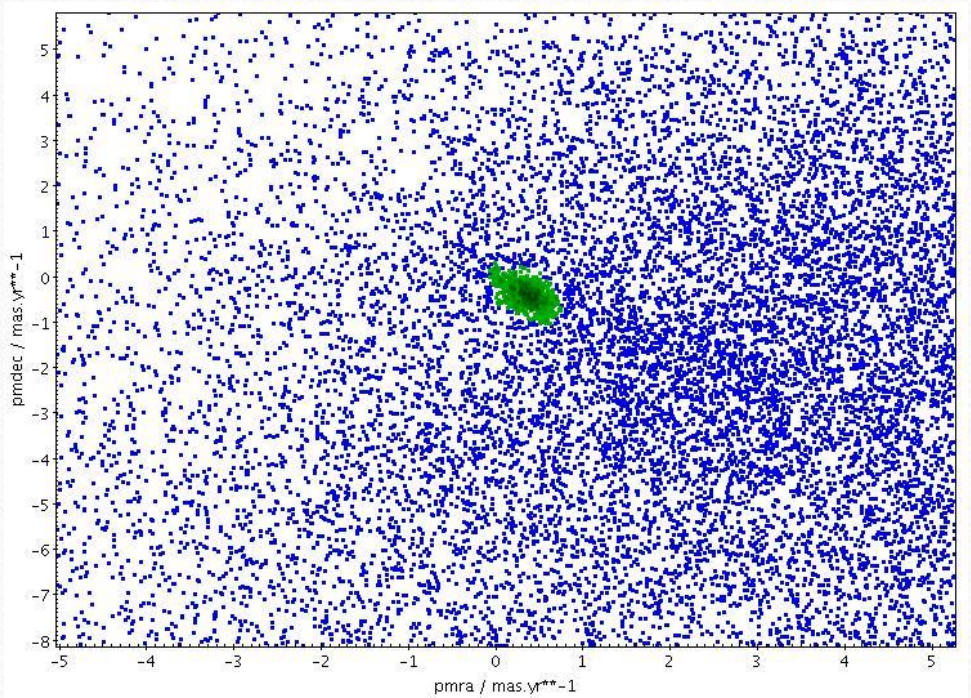
Fiorentino+ 2015

KiDS and GAIA DR2

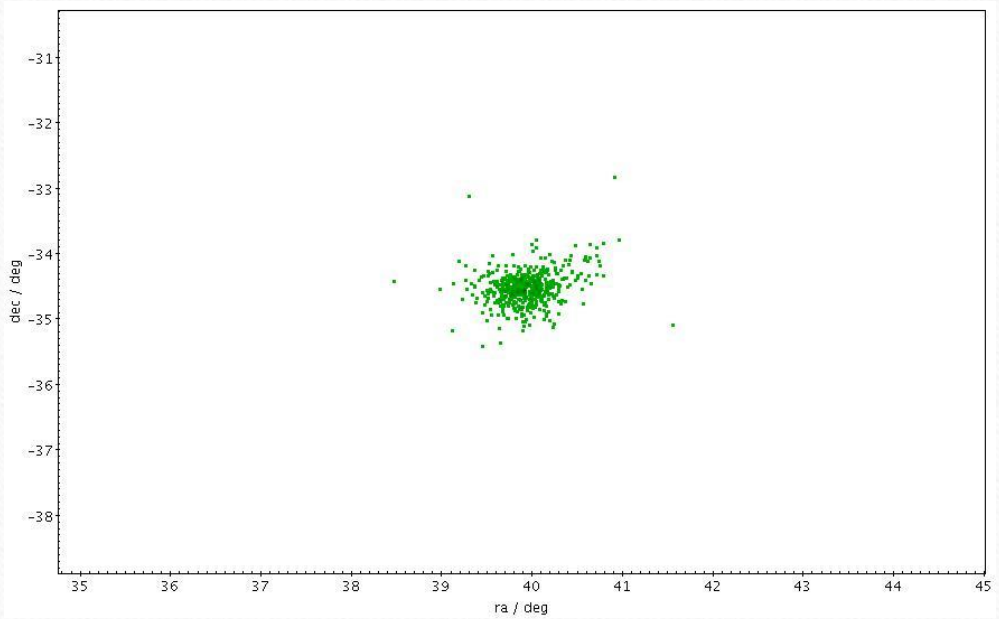


Proper motions selection





Proper motions selection



- We selected by hand the overdensity in the PM plane, and get:

PM_RA = 0.36 ± 0.16 mas/yr

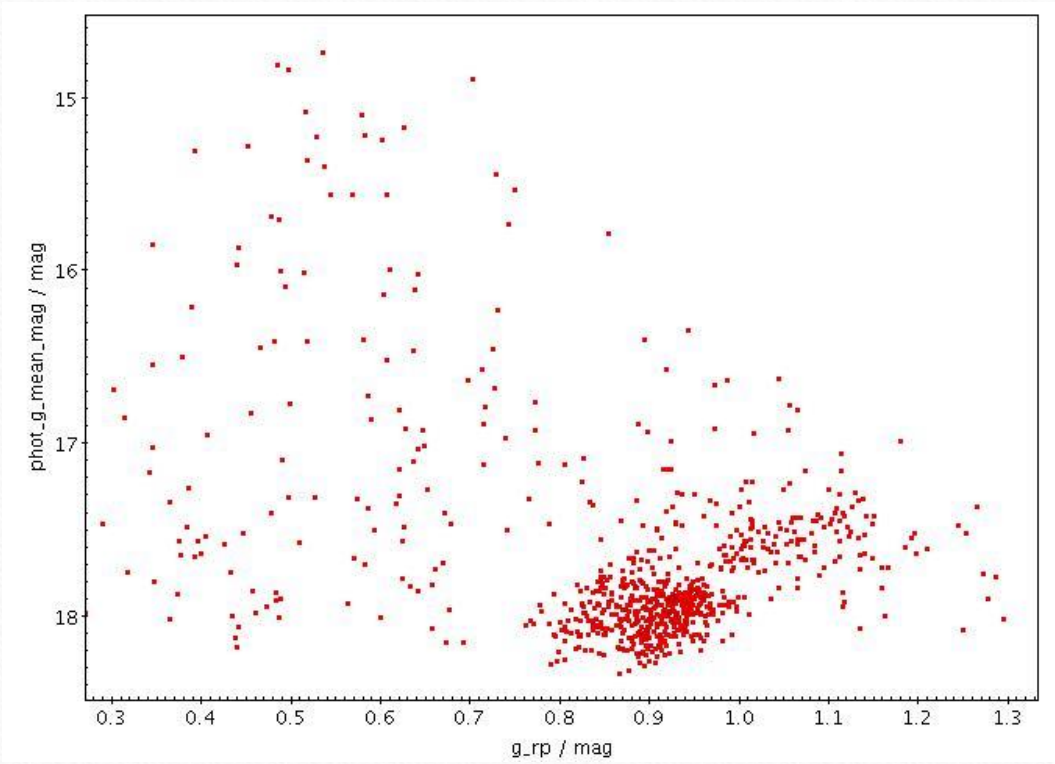
PM_DEC = -0.40 ± 0.23 mas/yr

- In excellent agreement with Fritz+ 2018

PM_RA = 0.375 ± 0.004 mas/yr (± 0.22 rms)

PM_DEC = - 0.401 ± 0.005 mas/yr (± 0.27 rms)

Proper motions selection



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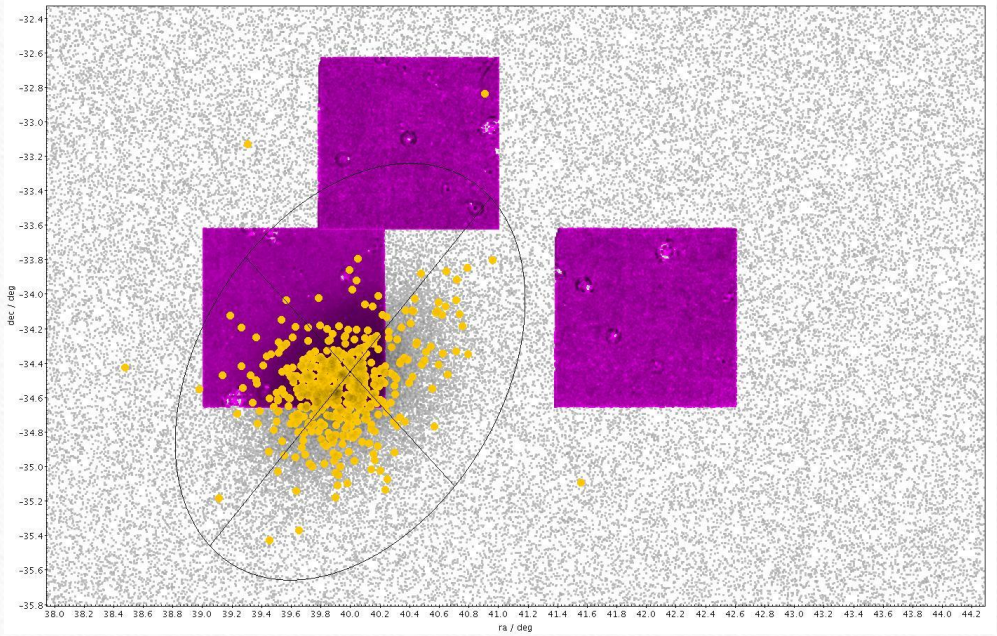
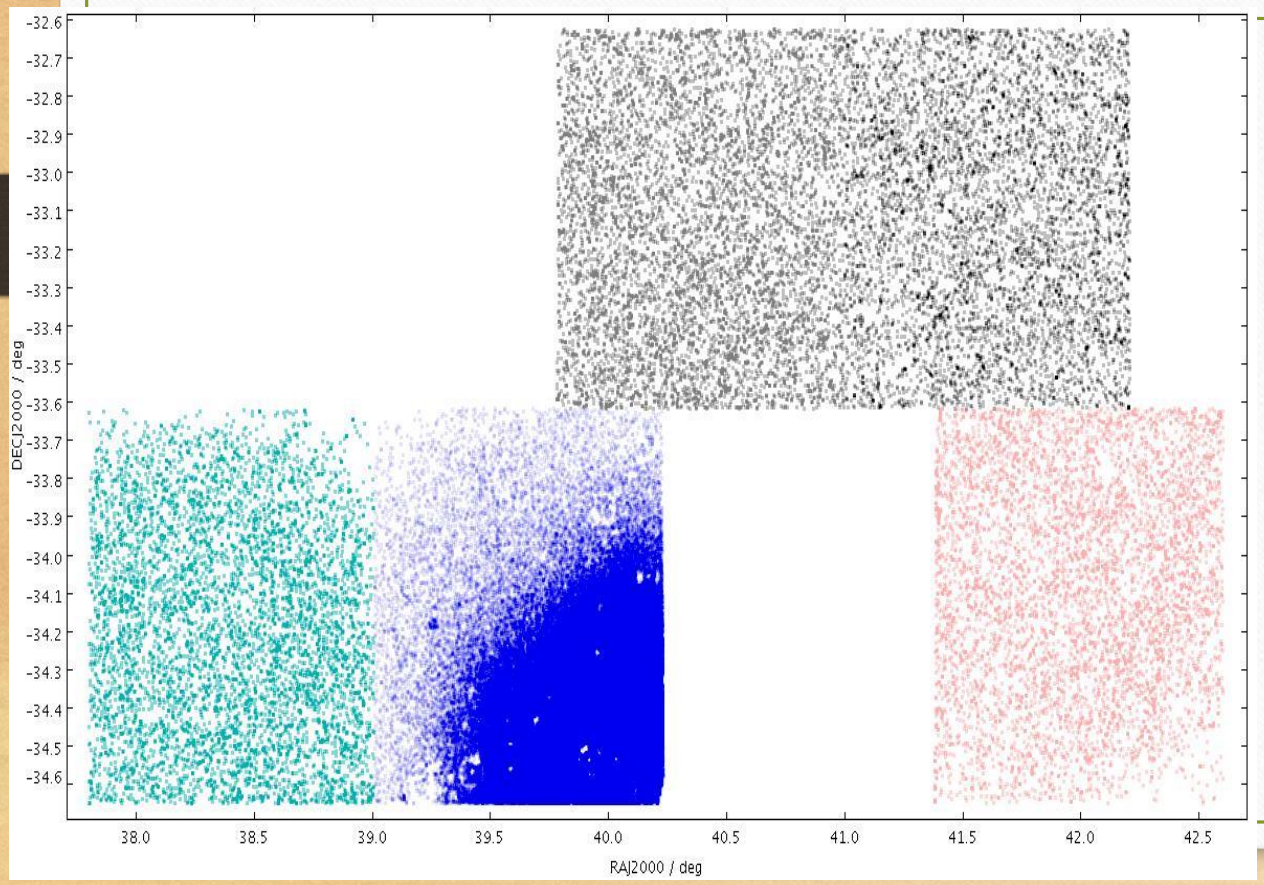
PM_DEC = - 0.401 ± 0.005 mas/yr (± 0.27 rms)

Looking for tails

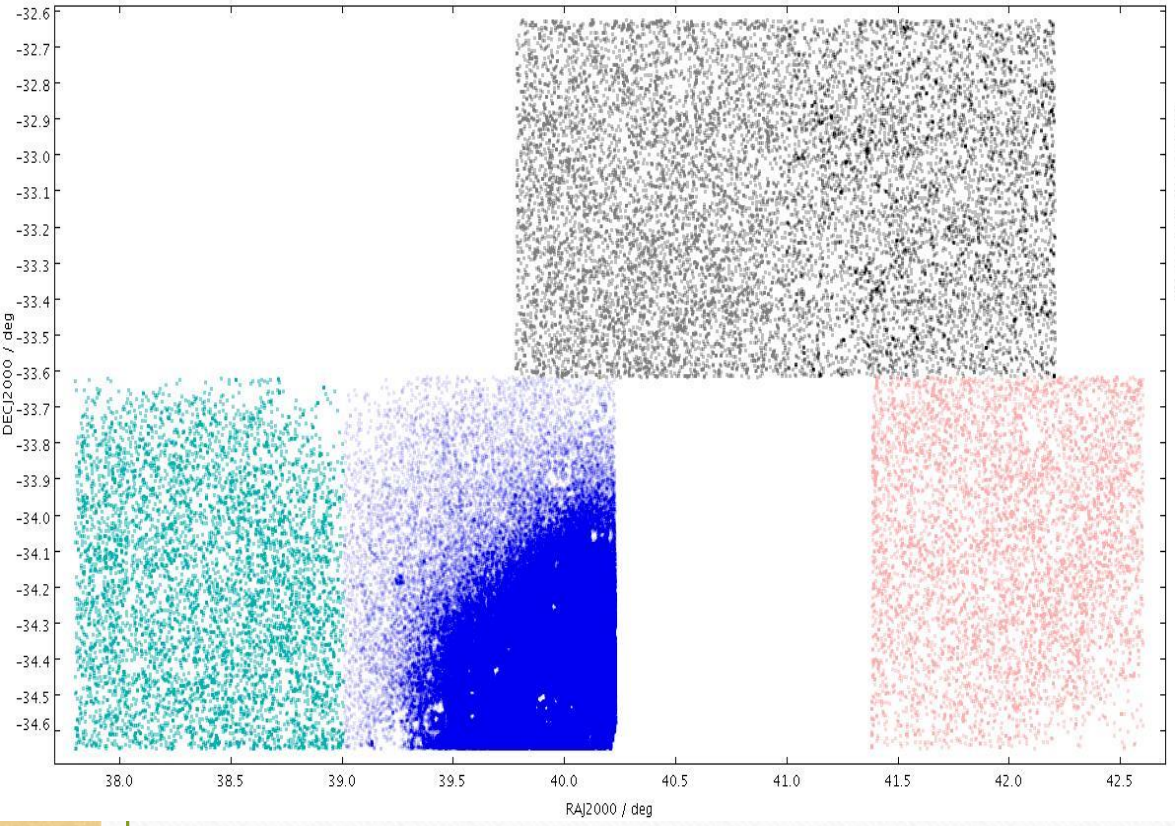


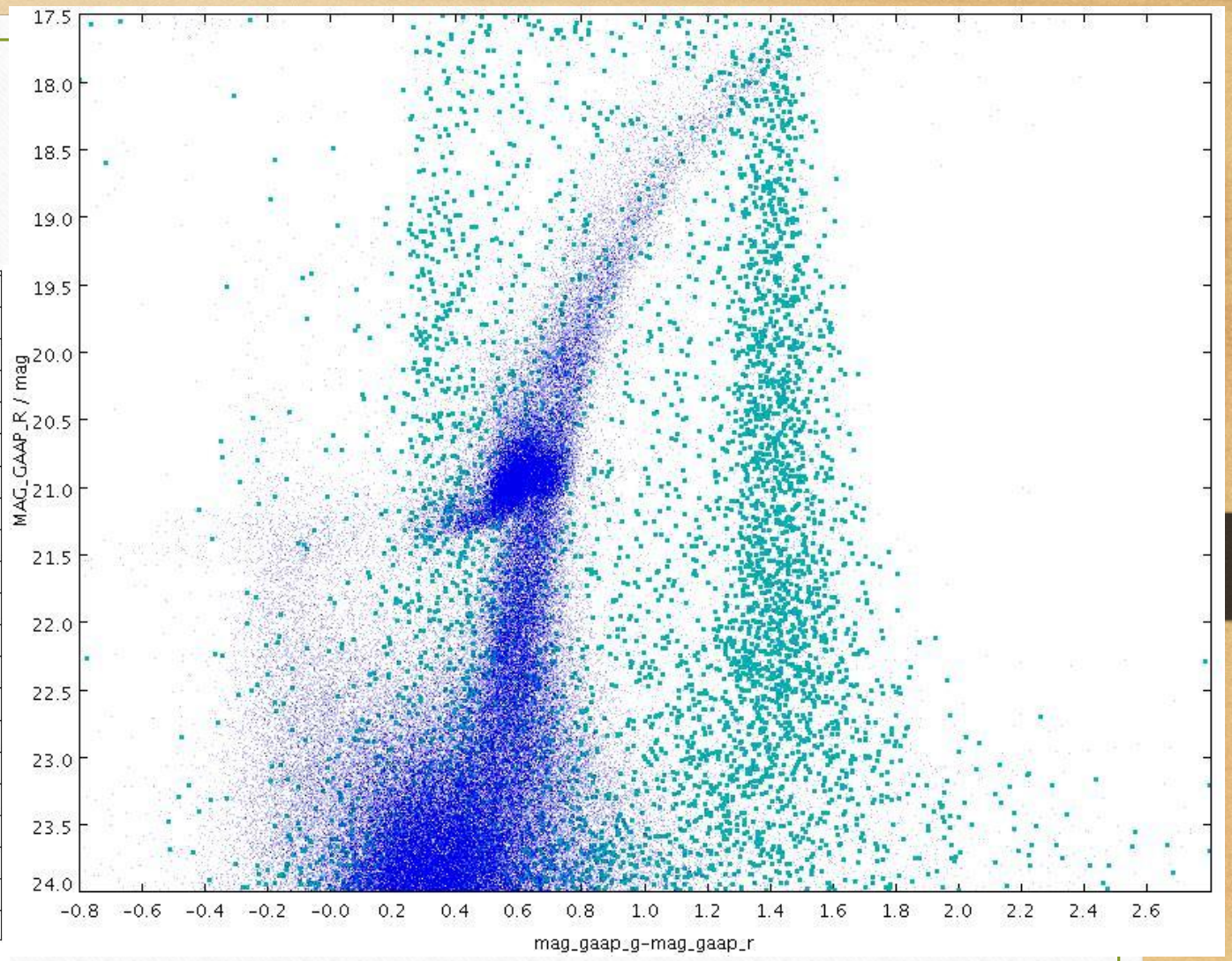
- Marginal evidence for an asymmetric distribution of the bright stars (but look out for population effects)
- Still, the “tail” is within the estimated tidal radius
- We miss a KiDS tile to cross-check the CMD

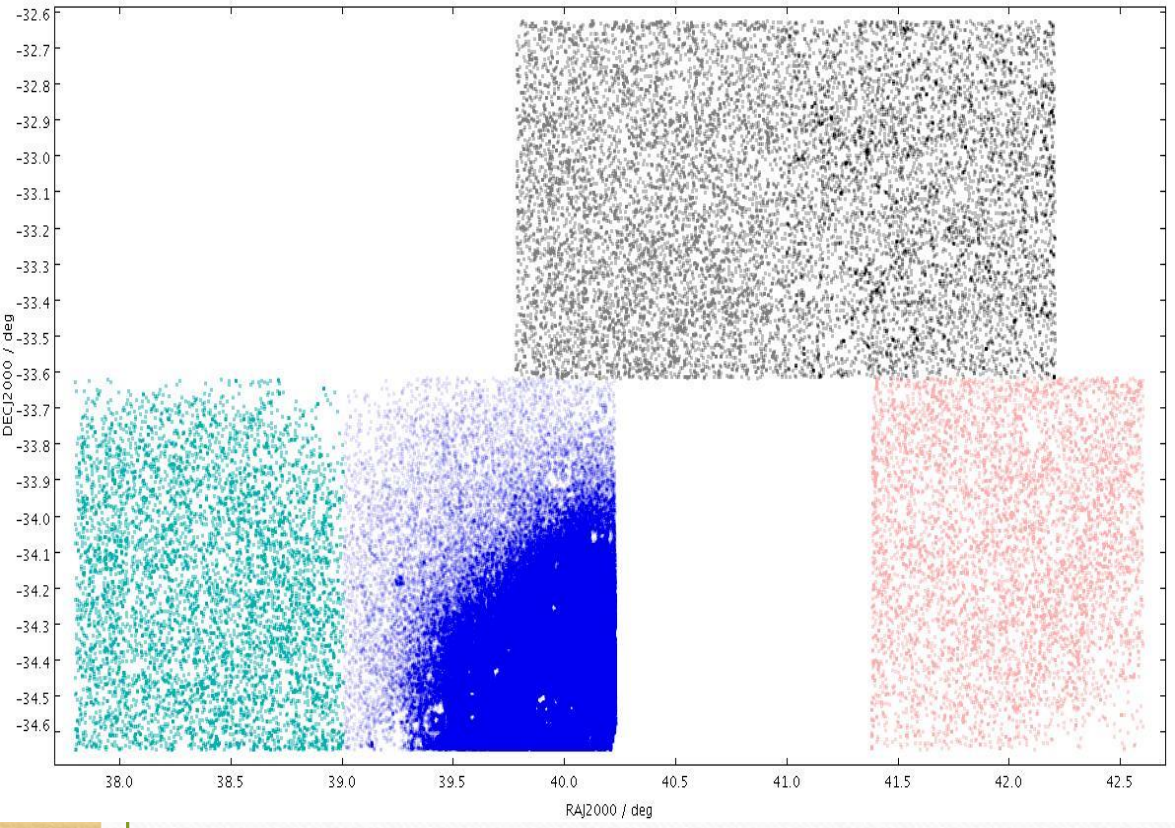
Looking for extra-tidal population

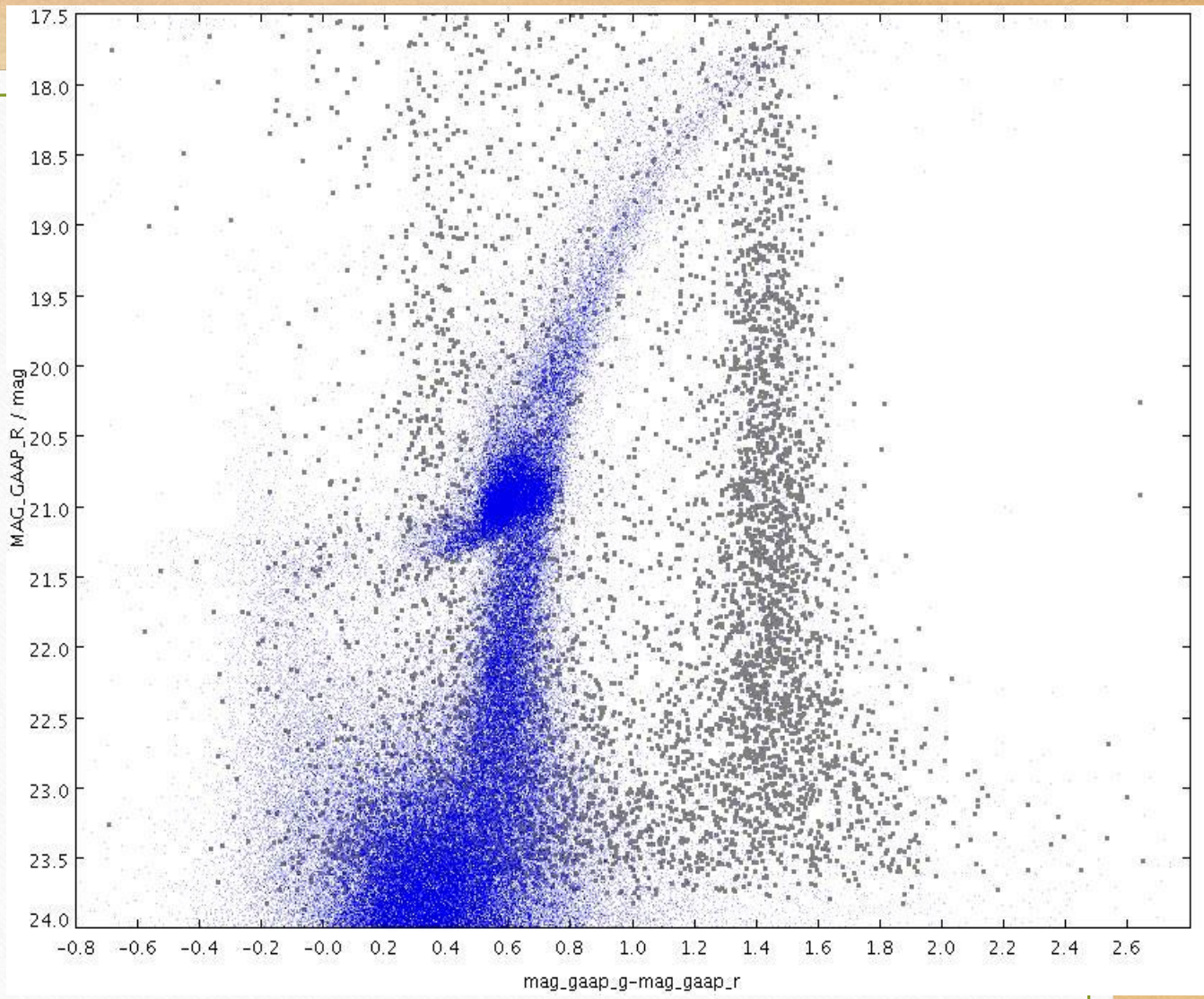


- We built the CMDs of the available regions, and compared with the CMD of the central region

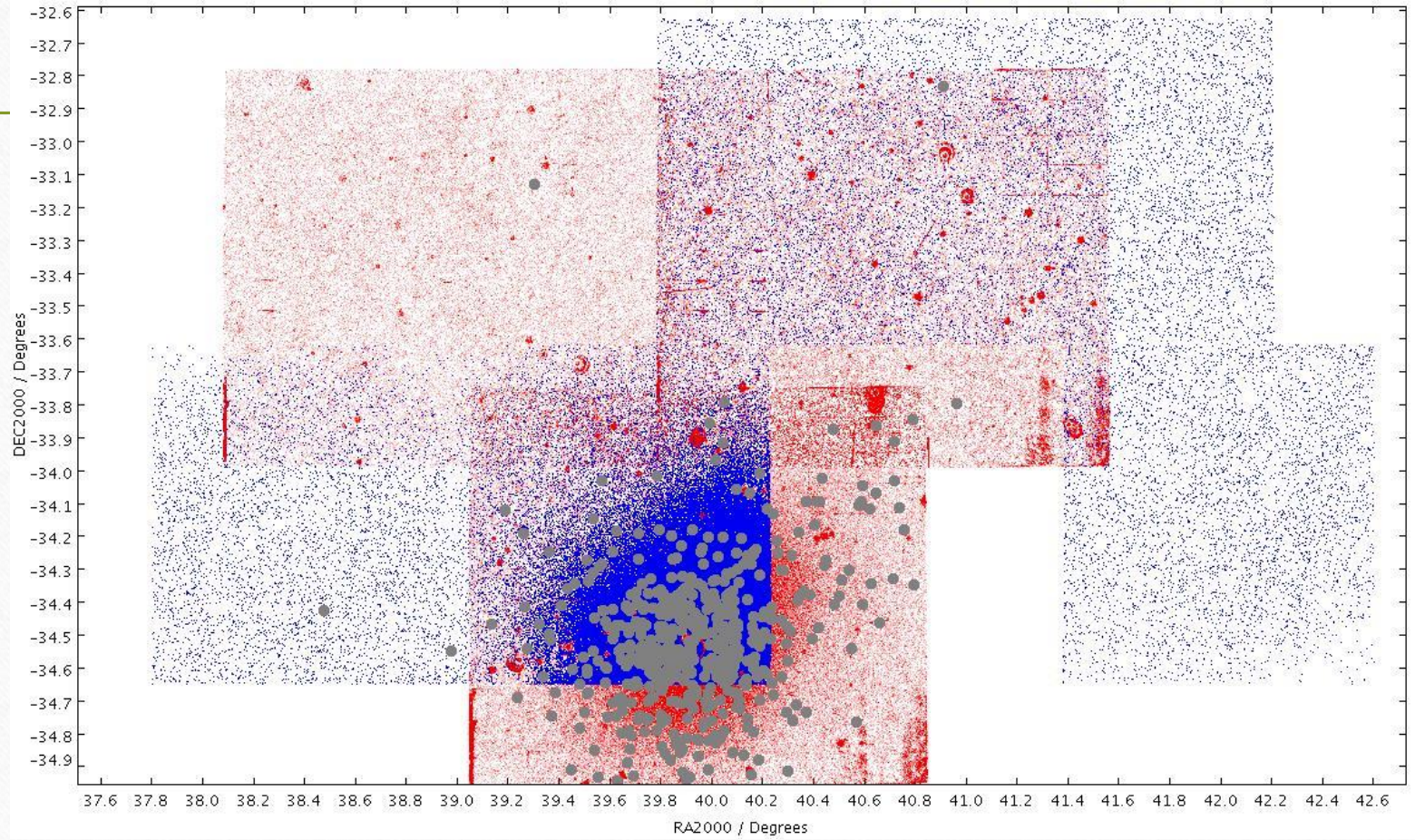

DECJ2000 / deg
RAJ2000 / deg


MAG_GAAP_R / mag
mag_gaap_g-mag_gaap_r


DECJ2000 / deg
RAJ2000 / deg


MAG_GAAP_R / mag
mag_gaap_g-mag_gaap_r

KiDS, VIKING, GAIA



Final remarks (1)

Fornax dSph

- Detailed investigation about the GAaP magnitudes → robust
- We need the other half of the galaxy (next ESO proposal?)
- RR Lyrae stars → no chance to have a clean sample from a color selection
- Comparison with GAIA → proper motions → asymmetrid distribution of the 4 Gyr population?
- Need to fully compare with VIKING (and don't forget ATLAS!)
- No clear evidence of extra-tidal components

Final remarks (2)

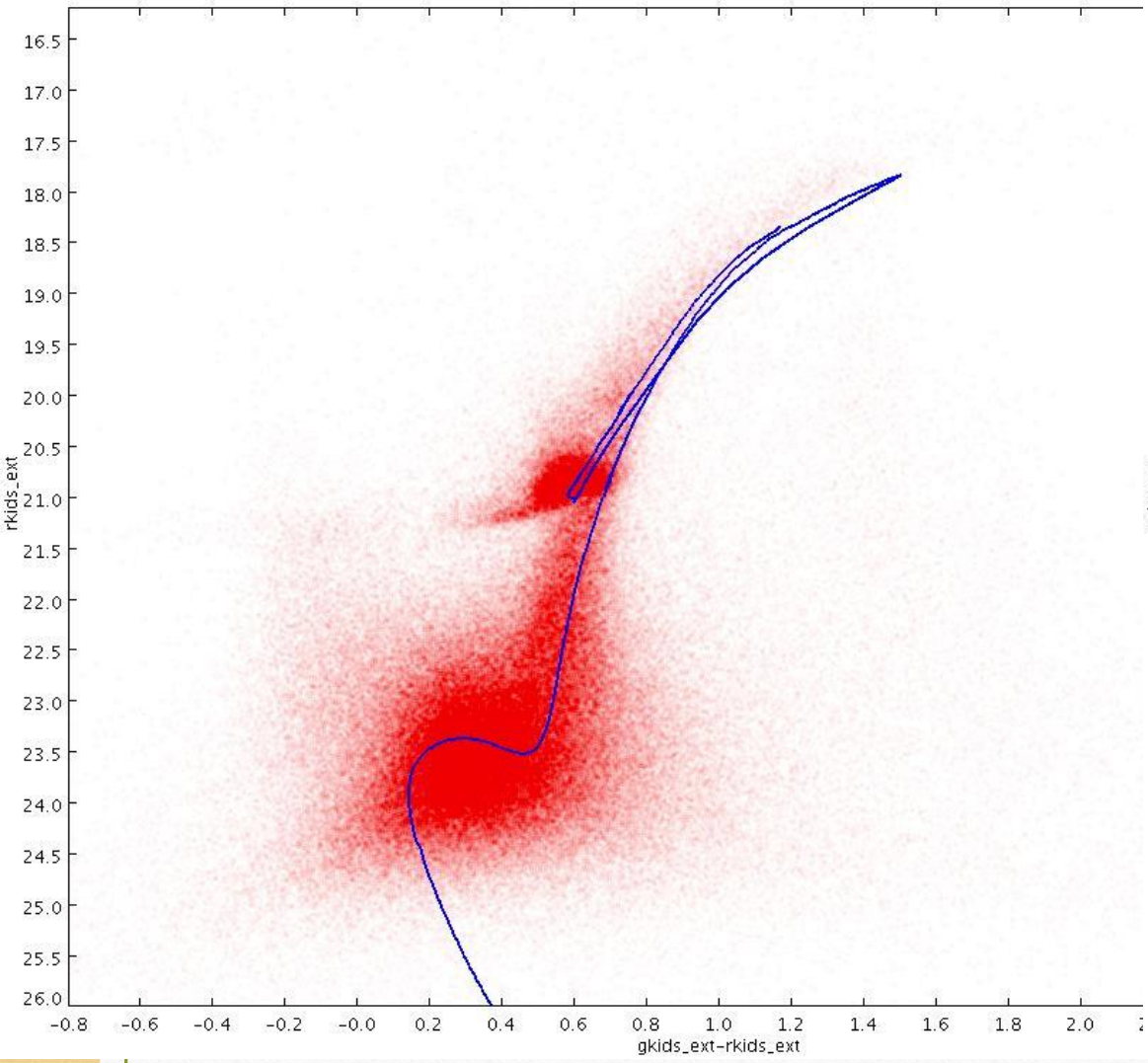
The VLT survey telescope

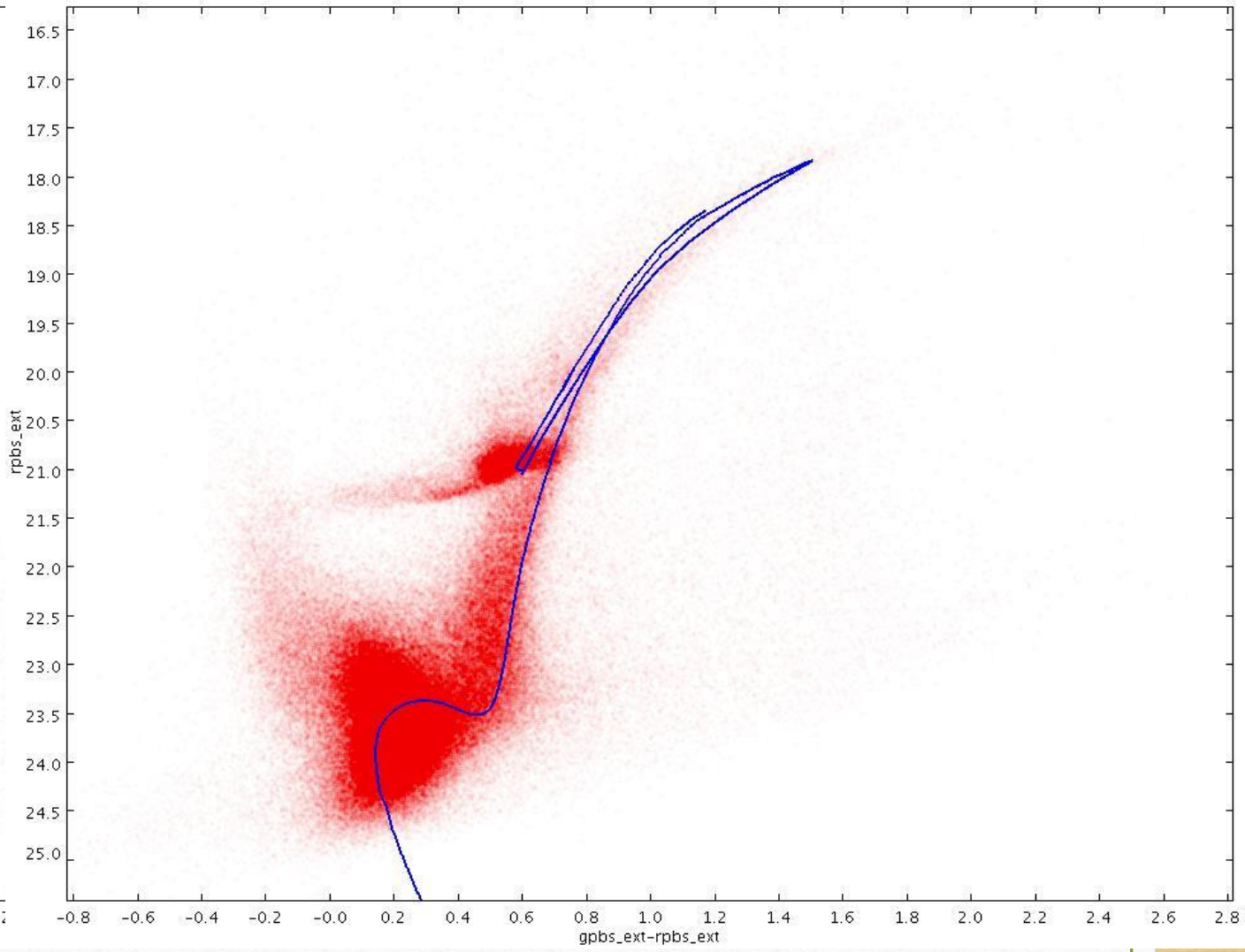
- Provides deep data with excellent PSF
- Some issues with the ZP (background, illumination correction): deep expertise needed to treat the data
- Could be an excellent complimentary machine to LSST (cadence, pointings, etc.)

Final Remarks (3)

Massive datasets: the good and the evil

- Massive dataset provide
  - Homogenous deep data, possibly all-aky (homogeneous comparisons)
  - Reference catalogs → multi-band, multi-epoch, multi-position studies
- Massive data require fully automatic procedures, both for reduction and analysis
  - Photometric zero-points can be not accurate
  - Completeness and classification issues (e.g. RR Lyrae with GAIA, see Clementini+2018, Molnar+2018, Holl+2018, LSST Crowded Field Photometry Task Force, *priv. comm.*)
- Are we moving toward a wider knowledge, but maybe not deeper?


rkids_ext
gkids_ext-rkids_ext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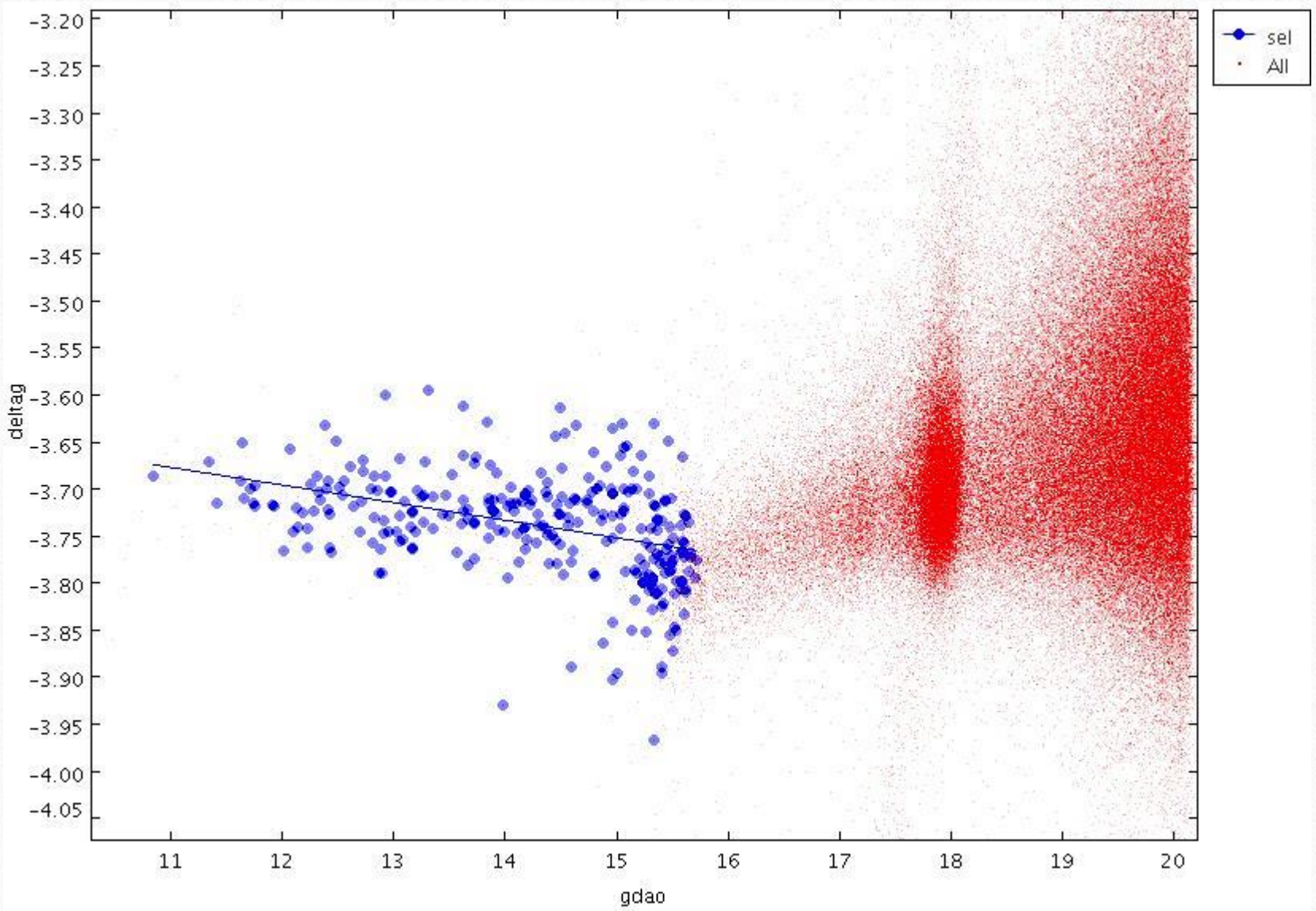
-3.20
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-3.70
-3.75
-3.80
-3.85
-3.90
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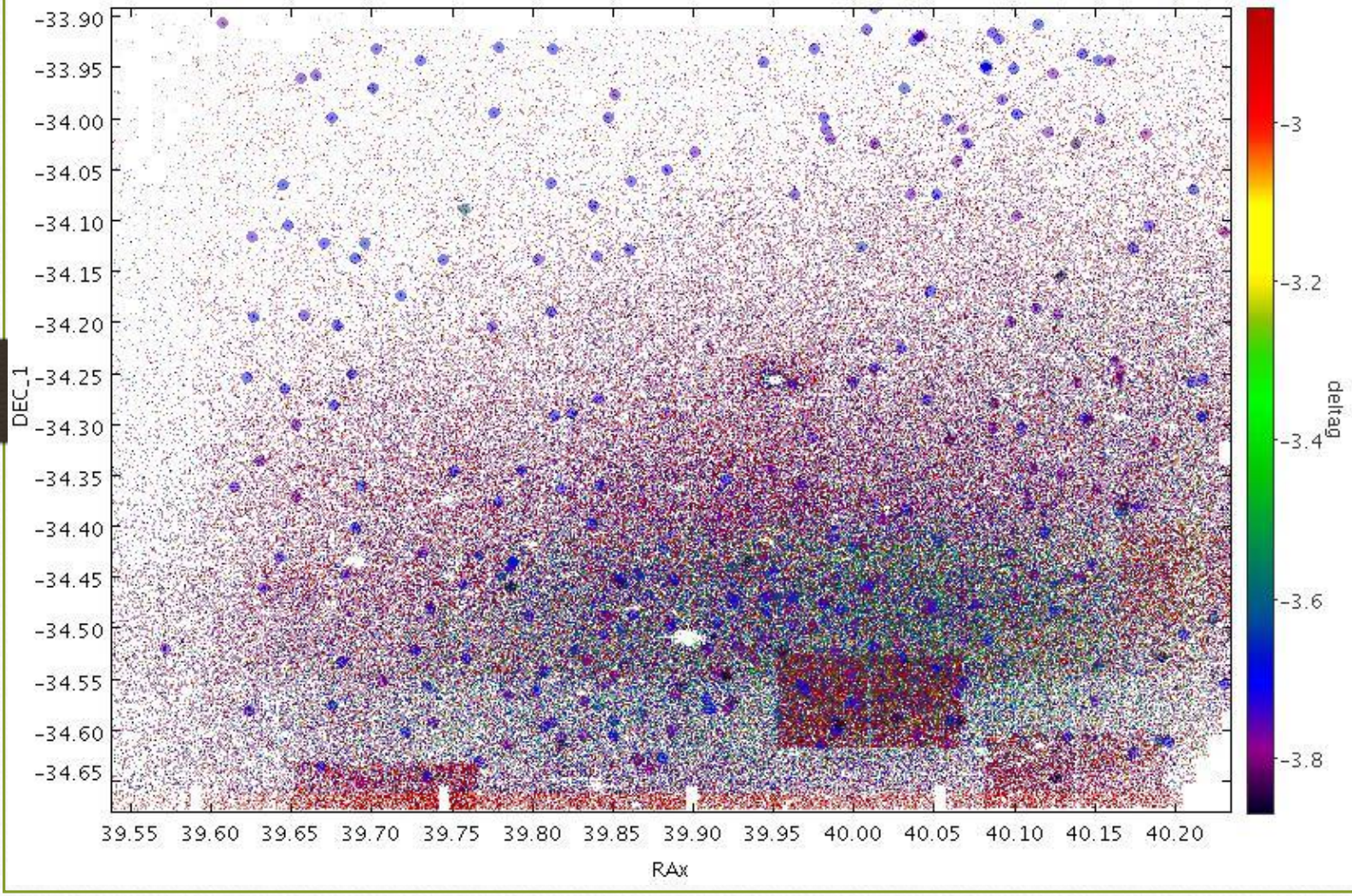
All



- Jumps and trends in the ZP