WEAVE Galactic Surveys

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On behalf of the Science Team

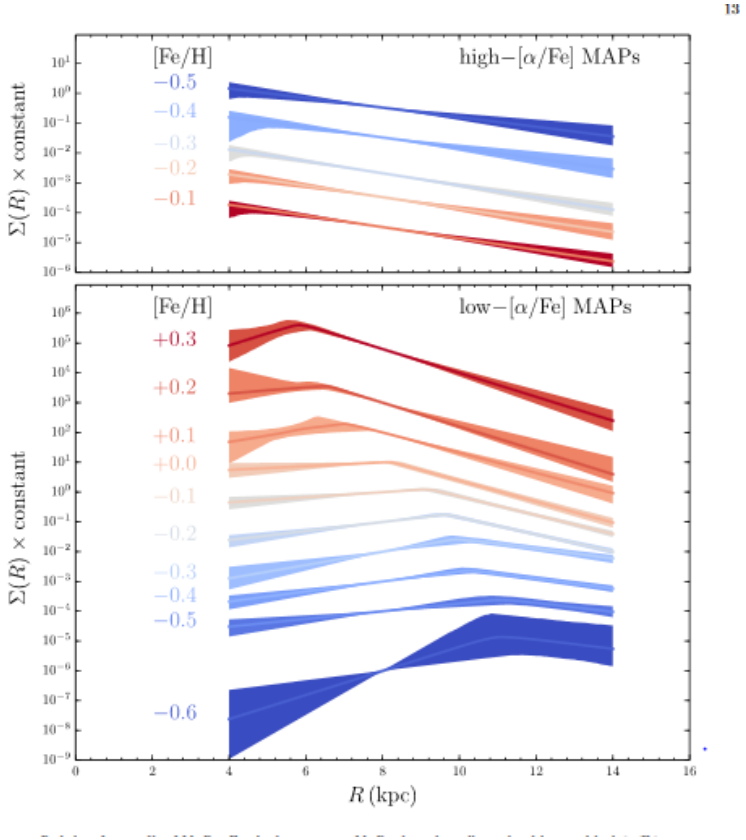
Overview

- WEAVE Goals
- How can we meet them?
- Do we need another GA survey?

The Galaxy view

- Unveiling the complex history of the MW assembly and internal evolution is still one of the main interest of astrophysics
- However the specific questions we ask have evolved substantially
- Diagnostics: Kinematics + chemistry of stars+ distance+ ages
- Metallicity from photometry
- Large amount of data requires ad-hoc modeling
- The selection function importance
- The presence of radial migration

in the disks has lead to a different way of describing stellar populations using chemical abundances as tag: → MAP



Bovy et al 2016

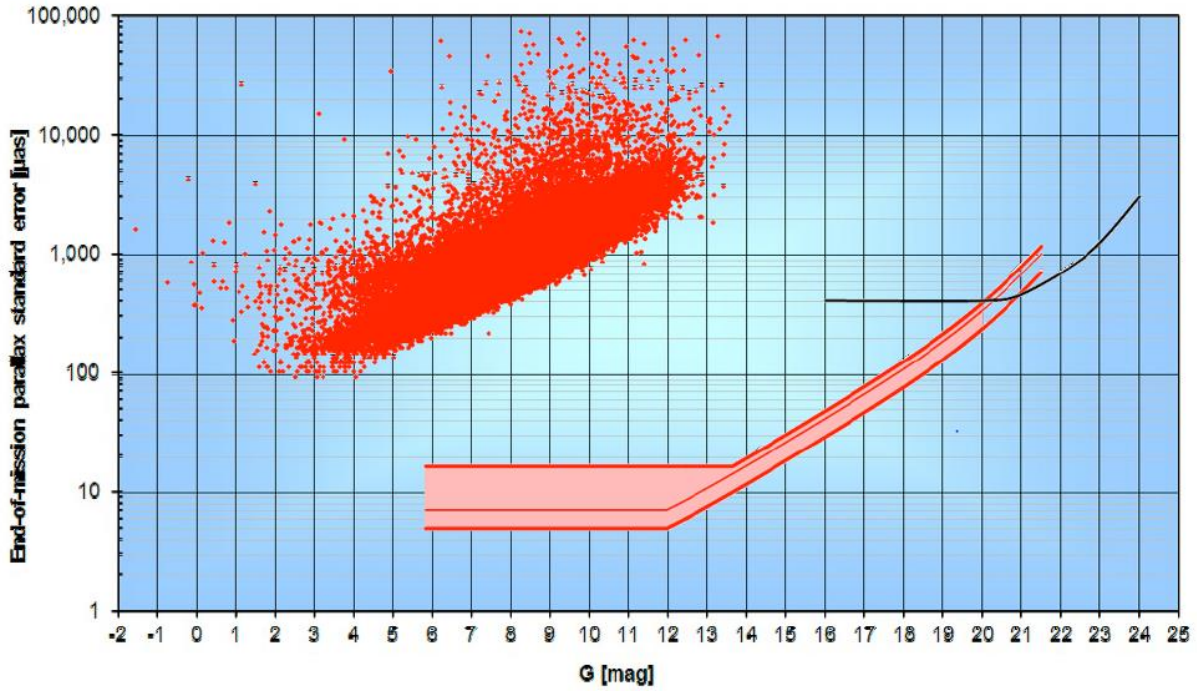
Open questions

Structure formation on sub-galactic scale

- Halo: in situ vs accreted
  - What is the total mass of the Milky Way? What is the shape of the Galactic gravitational potential? (Battaglia + 2015, Koposov+ 2009)
  - Where are the most metal-poor stars in the Milky Way, what are their properties, and what do they tell us about the physics of the early Universe? (Caffau+2011)
  - dSph and UDFs : the role of disrupted dwarfs (Fabrizzio+2015, Tolstoy+2009)
- Dark matter
  - How much substructure does the Galactic dark matter distribution have within 20–50 kpc? How do they interact with cold streams? (Yoon + 2011)
- Disks respective roles of hierarchical formation and secular evolution in shaping the Galaxy?
  - what are the roles of spirals (+ number of arms, pitch angle, pattern speed?) and the bar (length, pattern speed?) (Helmi+2006, Schoenrich & Binney 2009, Minchev+2015)
  - What is the chemical evolution traced by the open clusters? (Magrini+ 2010, Jacobson+2016, Bragaglia+ 2006, Sestito + 2008, Cantat+2012, Donati+2012)

Hipparcos, Gaia, LSST

- Photometric surveys: broad metallicity classification, distances → ages
  - Pan-STARRS1 (Kaiser+2010, δ>-30, no u filter), Sky mapper(Keller 2012)
  - Gaia, LSST (Ivezic+ 2014, 2022, r=24.5, 30,000sq deg),
- Spectroscopic surveys for high accuracy metallicity and velocities

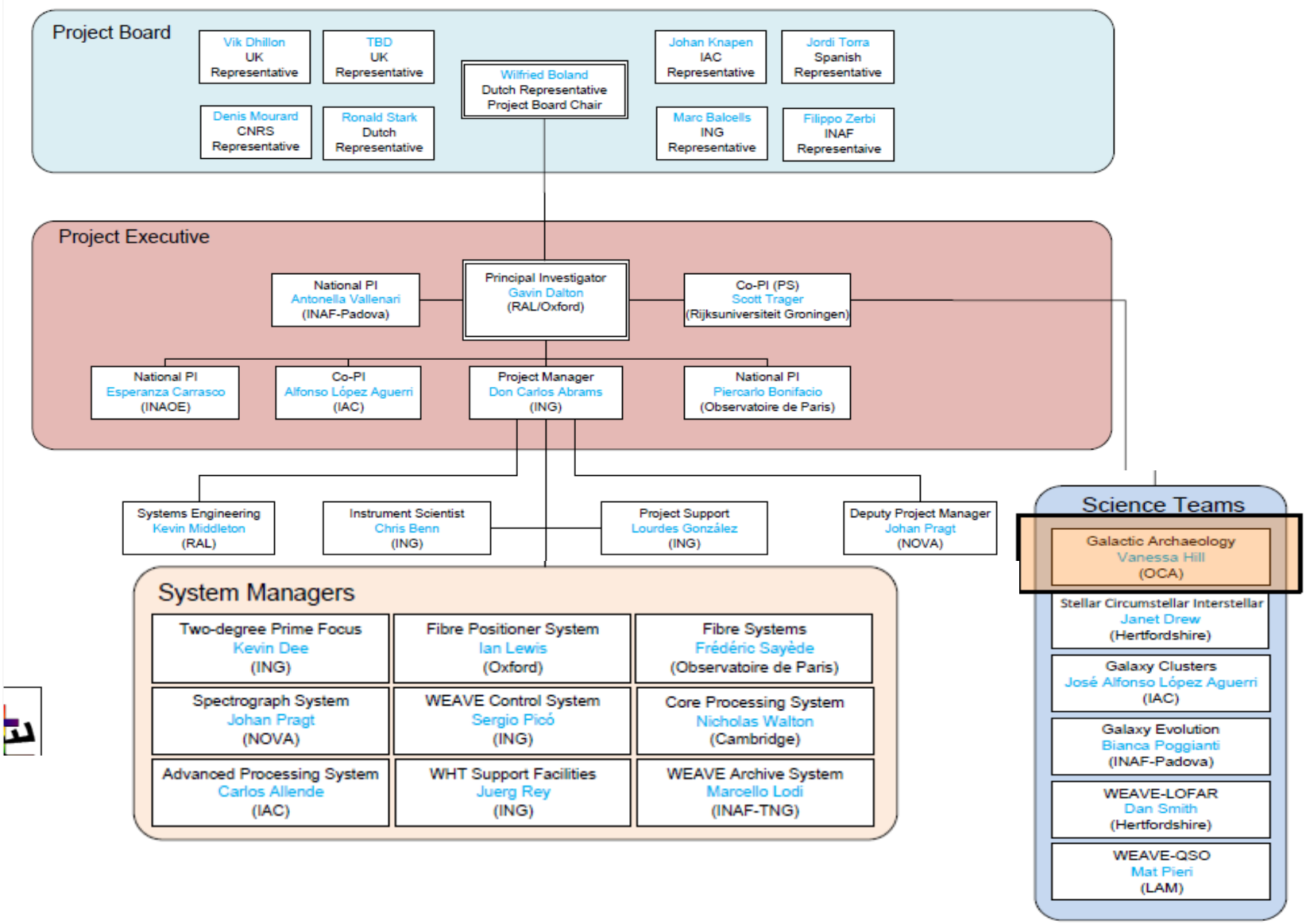


WEAVE Characteristics

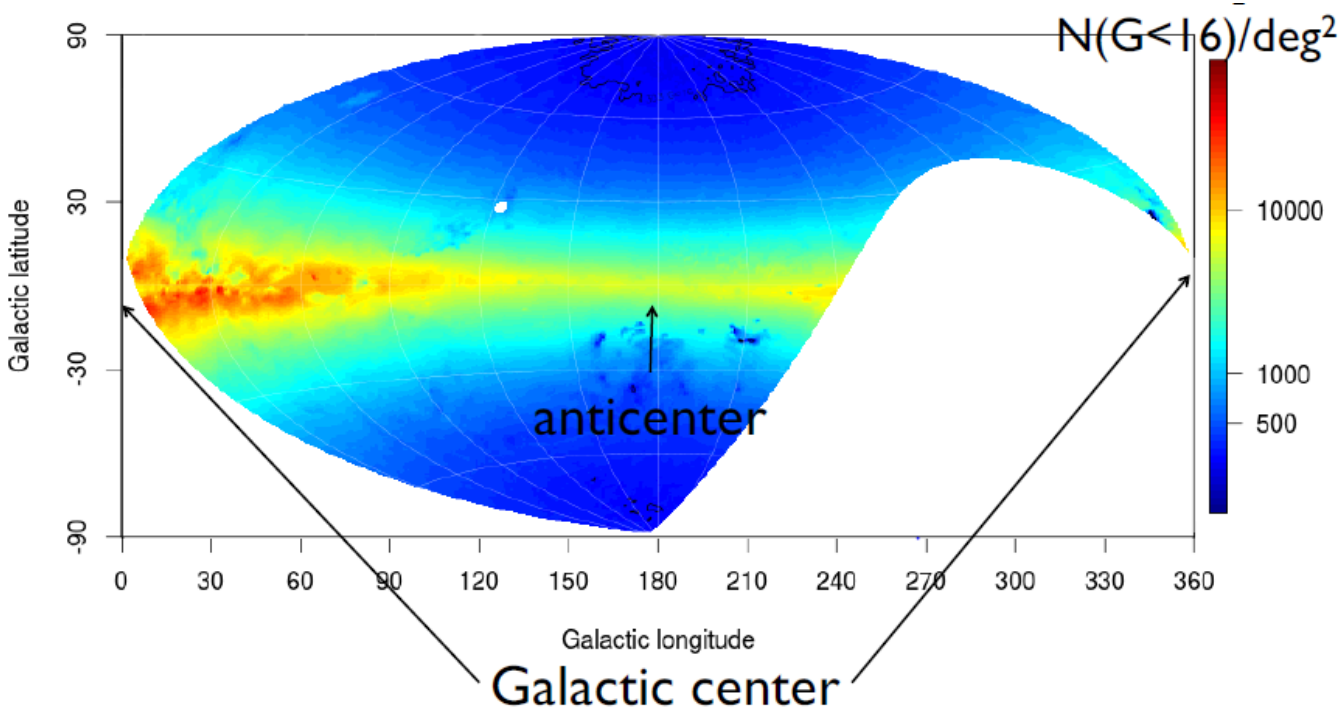
Telescope, diameter	WHT, 4.2m
Field of view	2° ø
Number of fibers	960 (plate A)/940 (plate B)
Fiber size	1.3″
Number of small IFUs, size	20 x 11″x12″ (1.3″ spaxels)
LIFU size	1.3′x1.5′ (2.6″ spaxels)
Low-resolution mode resolution	5750 (3000–7500)
Low-resolution mode wavelength coverage (Å)	3660–9590
High-resolution mode resolution	21000 (13000–25000)
High-resolution mode wavelength coverage (Å)	4040–4650, 4730–5450 5950–6850

commissioning 2018, 5 years at 70% time

Project structure



WEAVE Northern multiplex



WEAVE is the only HR Xwide field Xmultiplex optical facility in the north !

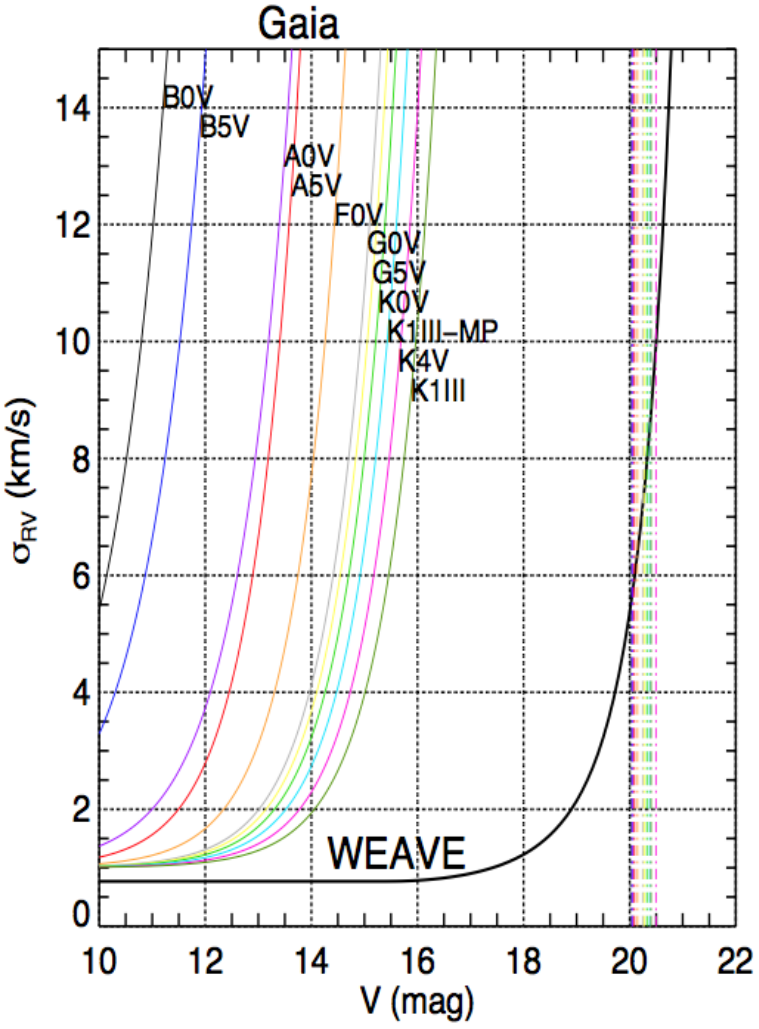
- Lamost: R=1800, r=19 mag (Tian+2016)
- Disk structure, 5 million spectra at the anti-center
- [Fe/H] uncertainty of 0.3
- No chemical tagging

Primary Science Surveys

- WEAVE GA Goals:
  - To complement Gaia
  - To complement 4MOST , MOONS (in the North)
  - Bridge the gaps in APOGEE footprints
- GA Surveys:
  - LR Halo /LR disk
  - HR halo/HR disk/OC
- Stellar, Circumstellar, and Interstellar Physics (SCIP)
- Extragalactic S.
- Characteristics:
  - Continuous sky coverage to sample global phenomena
  - High statistics

WEAVE performances

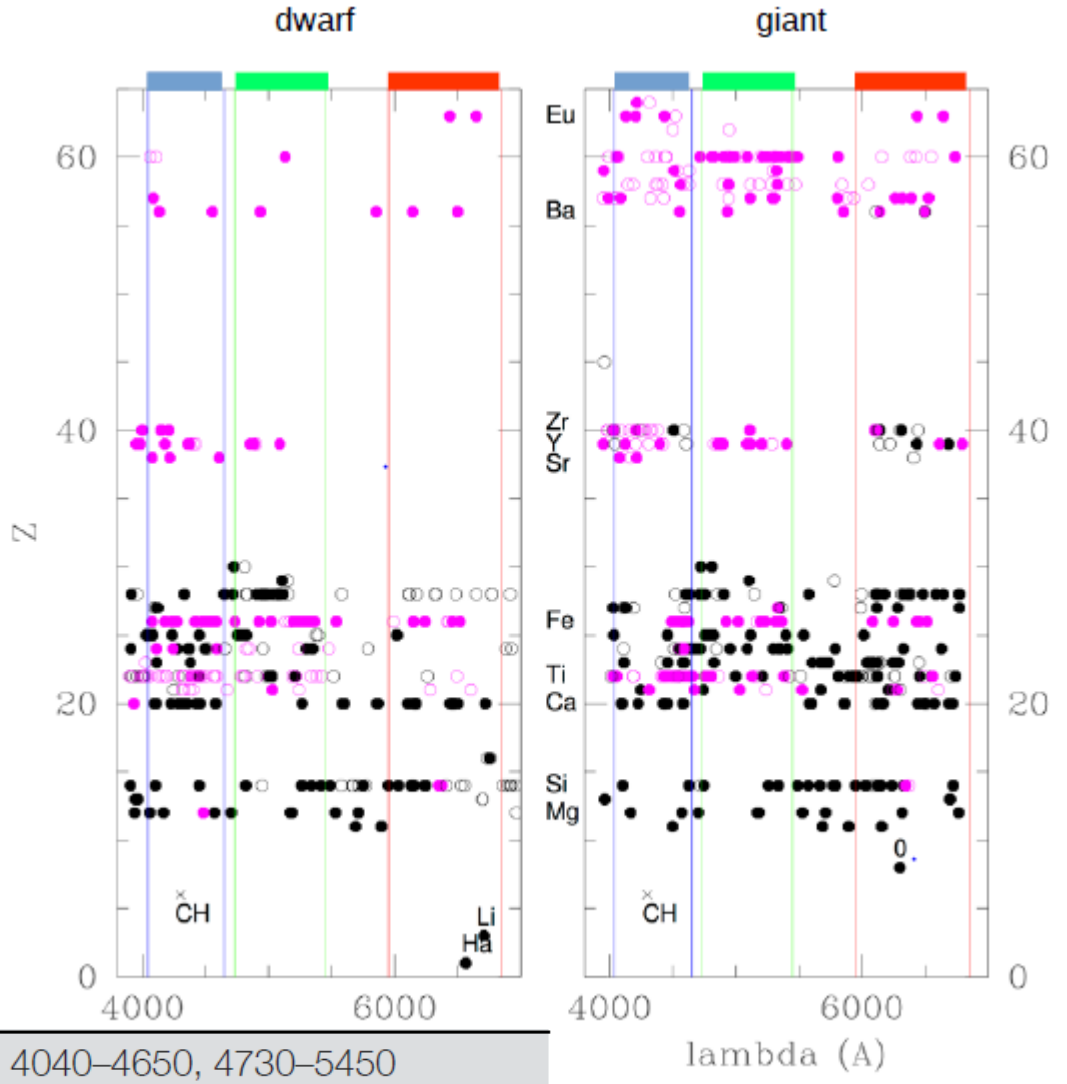
- Surveys to acquire accurate Vr (and stellar parameters, incl. metallicity) in the range 15<G<20 (bonus chemical abundances)
  - Defined the LR mode of WEAVE:
  - R = 5,000 in a wide range [366 – 606] nm + [579 – 959] nm
  - Surveys. LR halo & LR disk & GP
- Surveys to determine accurate stellar parameters and detailed chemistry for G>11-18
  - Defined the HR mode of WEAVE:
  - R = 20,000 in two windows [404 – 465] nm or [473 – 545] nm + [595 – 685] nm
  - Surveys: HR halo & disk +OCs



R=5000

WEAVE HR products

- WEAVE can measure stellar parameters and individual abundances in all main nucleosynthetic channels to V=16, i.e. closely matching the Gaia's most precise sphere (distances, ages)
- Teff, log(g), Vrad, Vsini
- Nucleosynthetic chanels :
  - Lithium → young objects
  - iron peak (Fe, Ni, Cr, Co, Zn),
  - alpha elements (C, Mg, Si, Ca, [OI]…),
  - neutron-capture slow and rapid elements (Zr, Y, Sr, Ba, La, Nd,Eu),
  - odd elements (Na, Al, Sc)



High-resolution mode wavelength coverage (Å)	4040–4650, 4730–5450 5950–6850

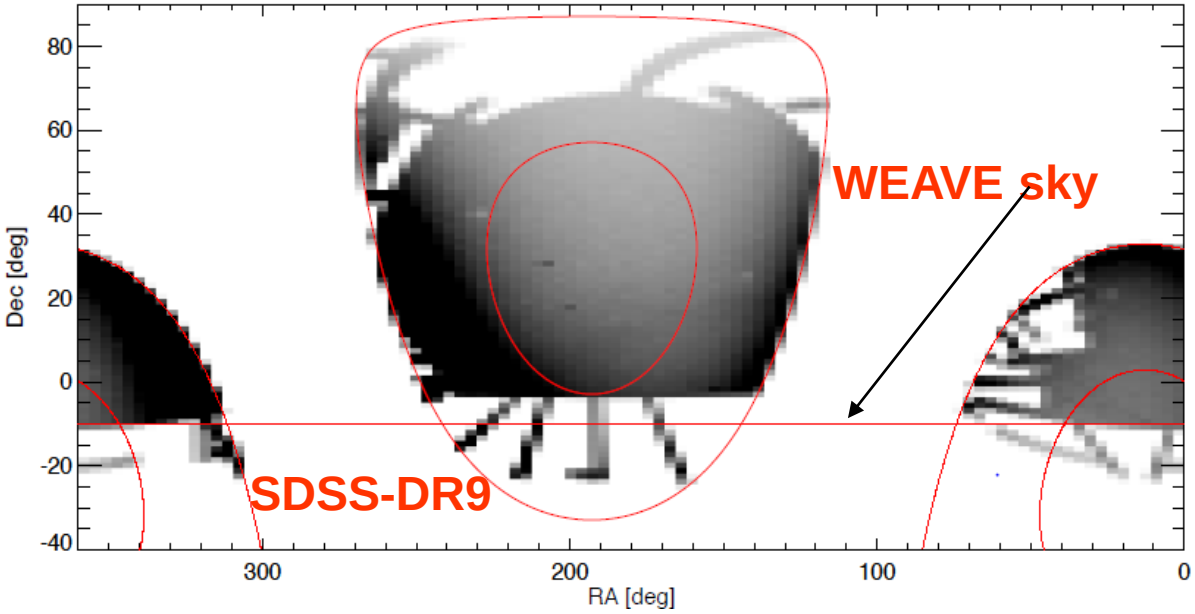
LR Halo wide survey: 10,000 deg ^{2}

- Constraining mass and scale radius of dark halo
- High galactic latitude survey (|b|>30°)
- Total number ~1–2×10^6 stars (nstream > 30 to break degeneracy, Helmi 2011)
- Tracers : MS (30Kpc)+RG (100 kpc)
- Selection on SDSS

- Northern dSphs

+ large streams + UFDs

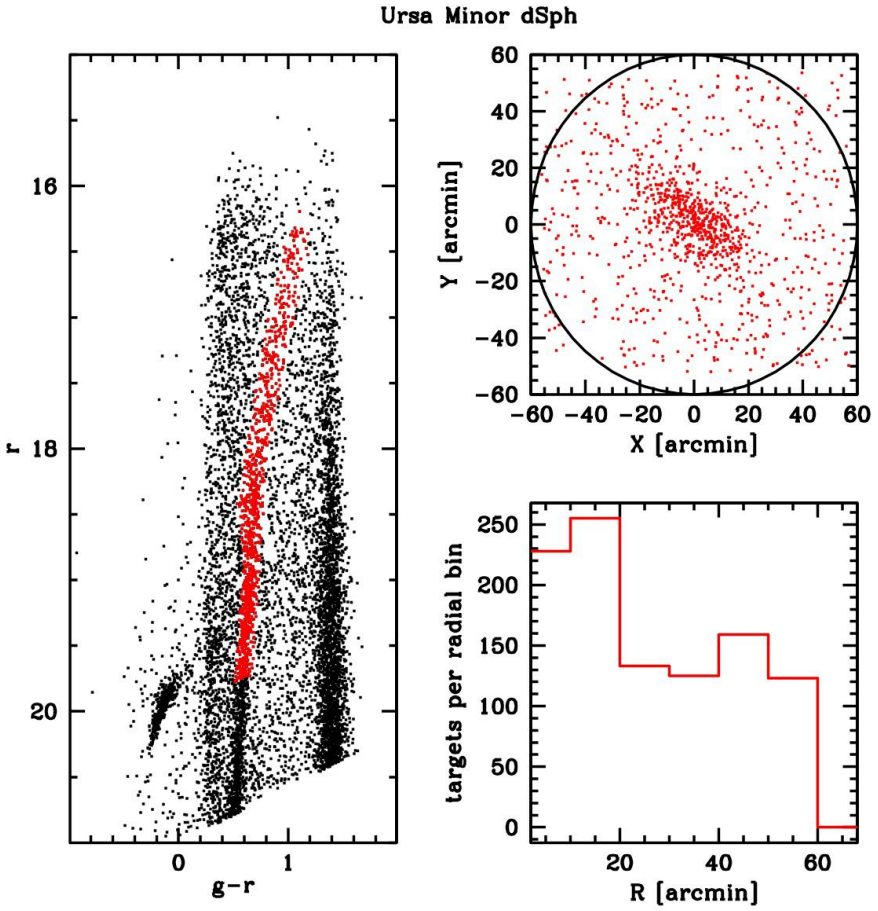
- 300 deg2
- V =21 (4 exposures pe



LR Halo Pointed Survey

- Dwarf Galaxies and UDFs
  - Northern dSphs + large streams and clouds + UFDs
  - 300 deg^2 down to V =21 (4 exposures per pointing)
  - A few exposures over 2 years for 3 dSphs (detection of 30% of binaries with |dv| > 2 km/s;

Catalogues: e.g. SDSS/PanSTARRS photometry or proprietary data



LR disk survey

- A galactic plane experiment to constrain the disc potential, including departures from axisymetry (spiral arms, bar, …), moving groups
- Needs: Vr to 2Km/s to discriminate streams with 5-10 km/s
- Tracers: red clumps
- Science on outer disk
  - How resilient to perturbations are disks? (Bovy et al 2011)
  - Anticenter:Stellar density & (average) extinction lower
  - Dynamical effects are the most visible (Kordopatis+2016)
  - Interactions with satellites: flaring of the stellar pops.
  - Accretions: ratio of accreted vs MW stars is the largest
  - Bar and spiral resonances (bar resonance at ~10 kpc, Bovy+2015)
  - Radial migration: kinematics do not allow to distinguish a in situ born star from one having migrated+ chemistry(DeBattista 2014)

WEAVE HR Surveys

- **Goal: Chemical tagging : 5000deg ^{2}**
- High latitude Halo: searching for streams + first stars
- Assuming 500 streams cross the solar neighbourhood
- 100 members each needed to characterize them

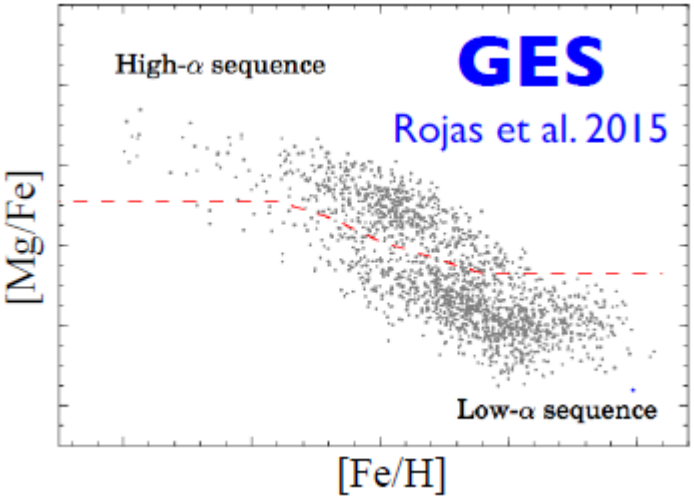
  → 5 x10 ^{4} halo star– target 5 x10 ^{5} stars
- Given the density of halo stars at magnitudes 12<V<16 (~10 / deg^2)

  → demands a high-latitude survey of 5000 deg2 (at |b|>30-40)
- Intermediate latitude survey mapping the thick disk
- MSTO stars selected from Gaia
- **1,800 deg^2 with 15<|b|<30°**

  to insure Rgc,Z coverage

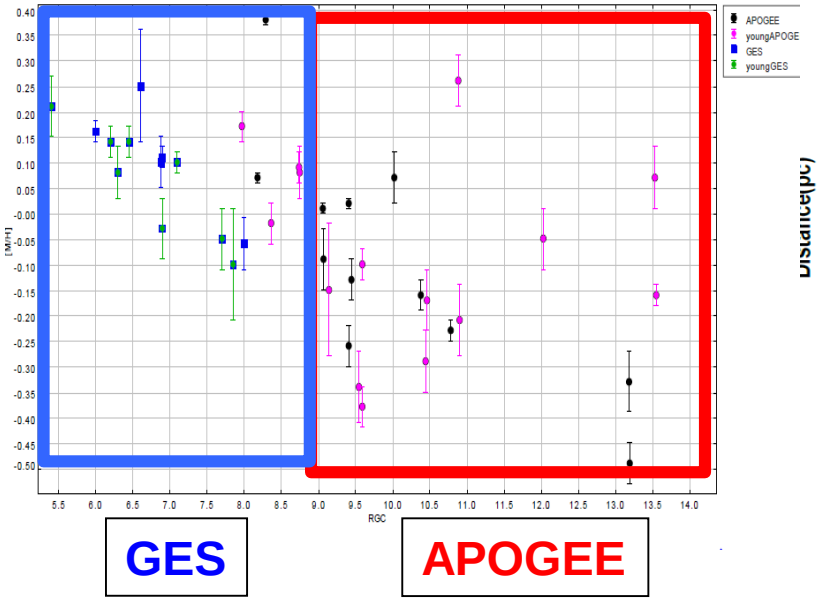
→ minimum number of targets of 6x 10 ^{6} HR disk

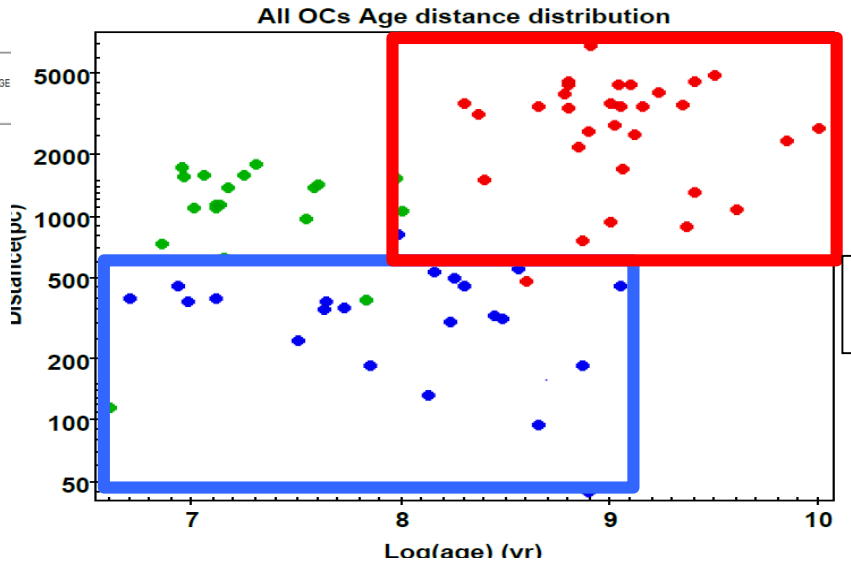
- HR Open clusters



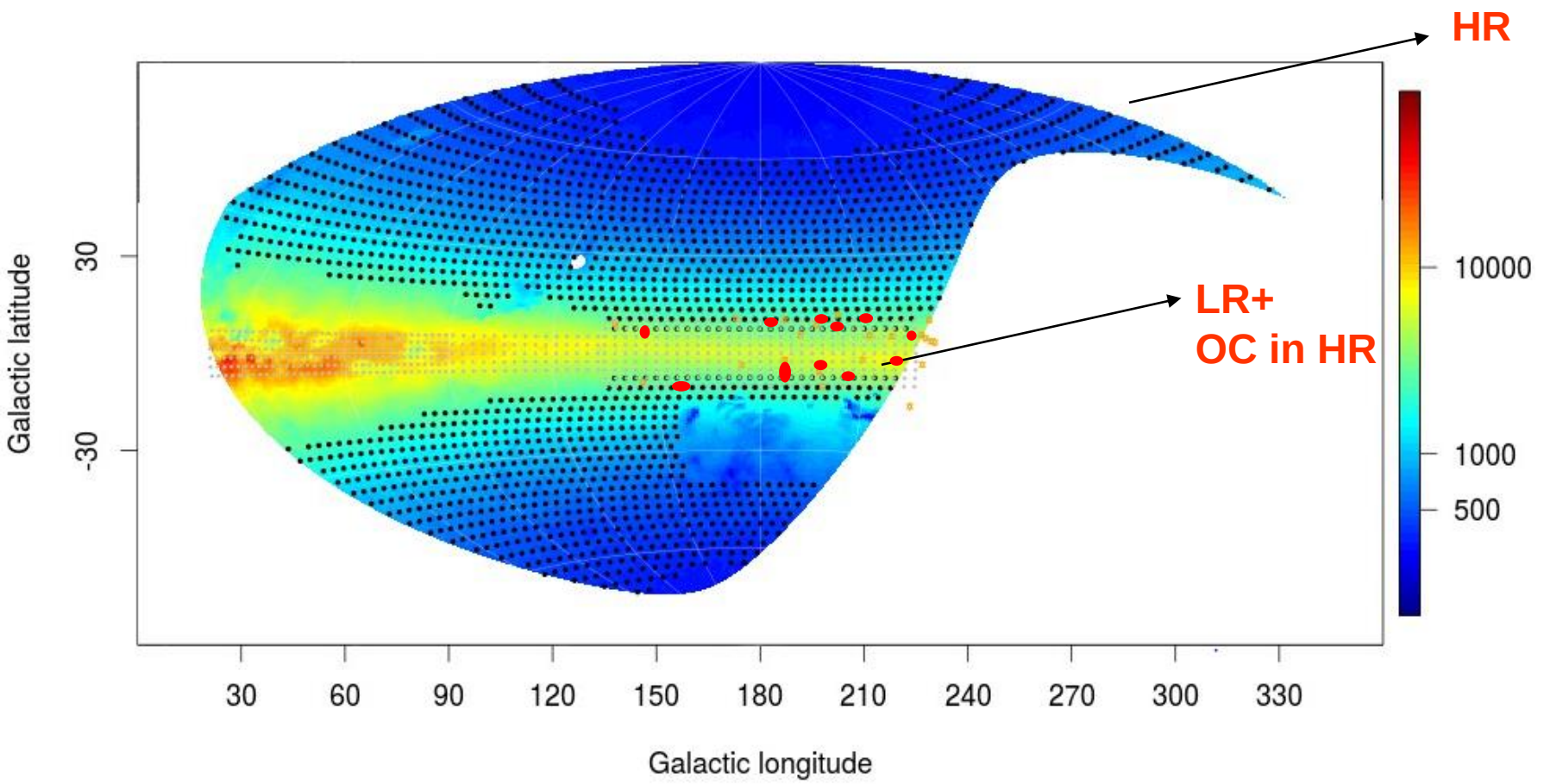
OC Survey

- Are all stars formed in clusters? How do clusters dissolve into the disc field? (Baumgardt& Kroupa 2007, Bressert+2010)
- What is the spatial distribution of the chemical elements in the Galactic disc? What is the effect of environment on star formation and the early stages of stellar evolution? (Mapelli+2014, Spina+2014)
- What is the impact of internal mixing, stellar rotation, and magnetic fields on stellar evolution?





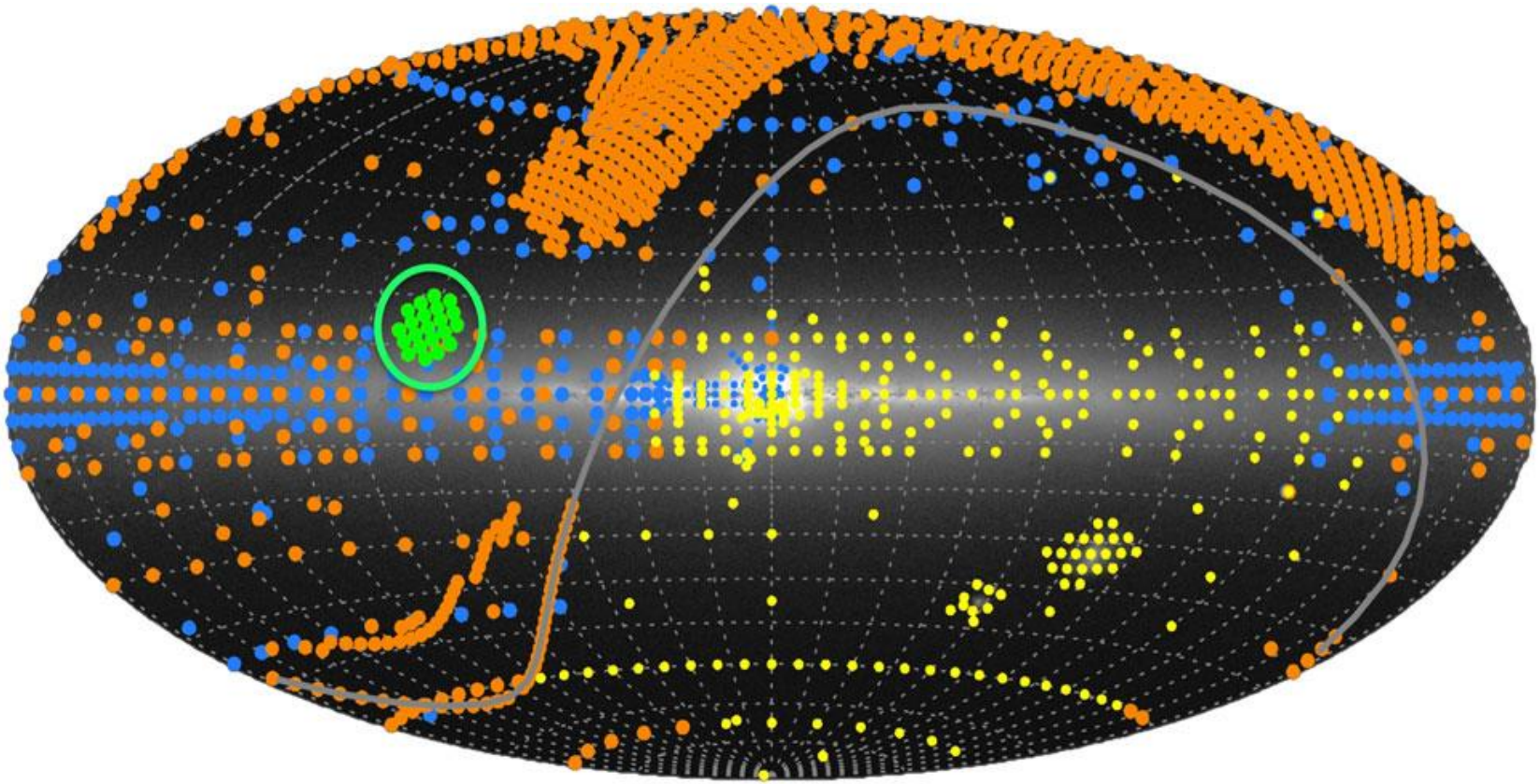
Survey Baseline



LR disk: |b|<6
1.5x10^6 stars – on 210+405 LoS

HR disk: 1,800 deg2 with 15<|b|<30° to insure coverage of discs

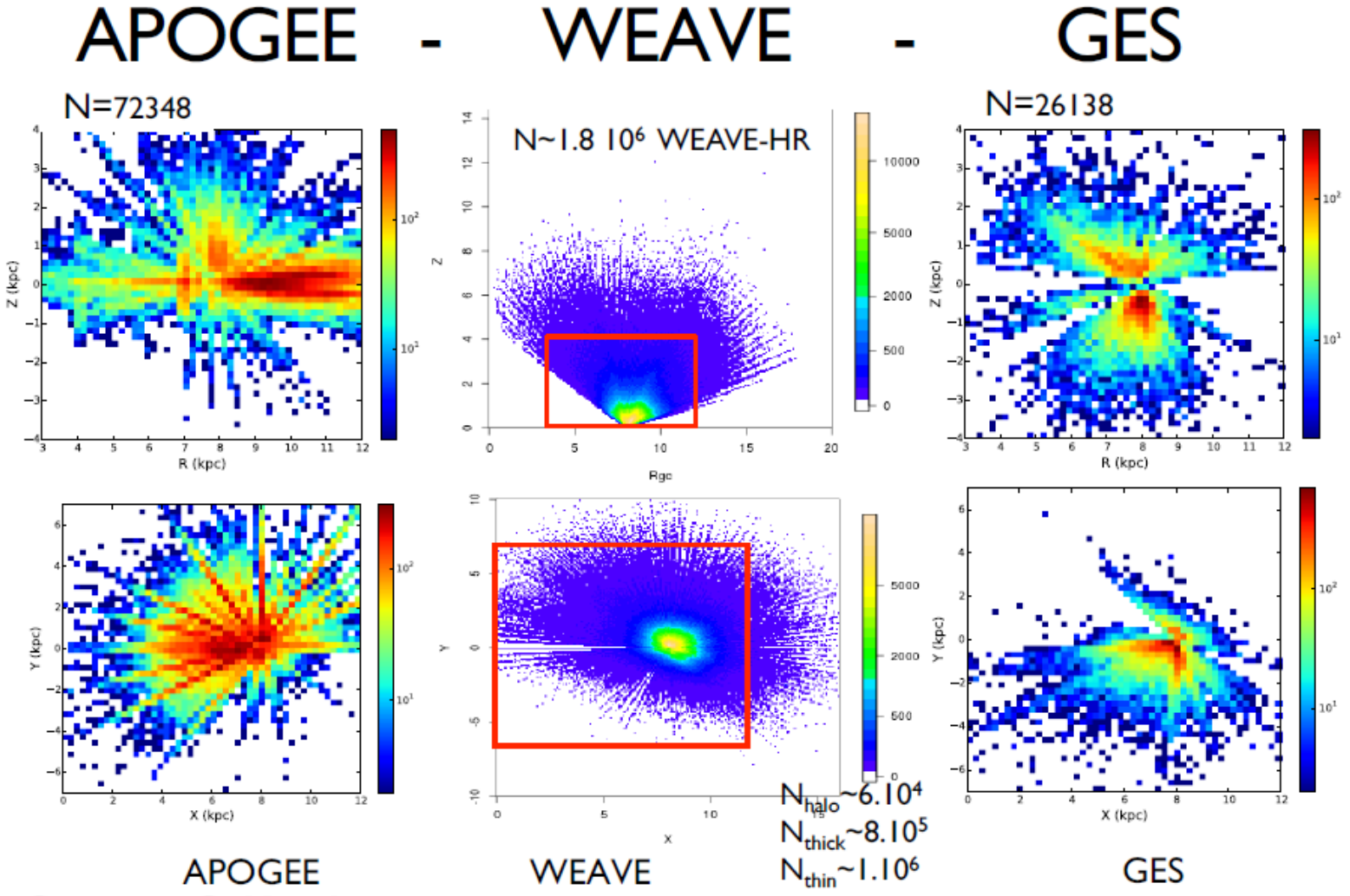
APOGEE-2 sky coverage



anticenter

300000 targets, R=22000 H=12.2

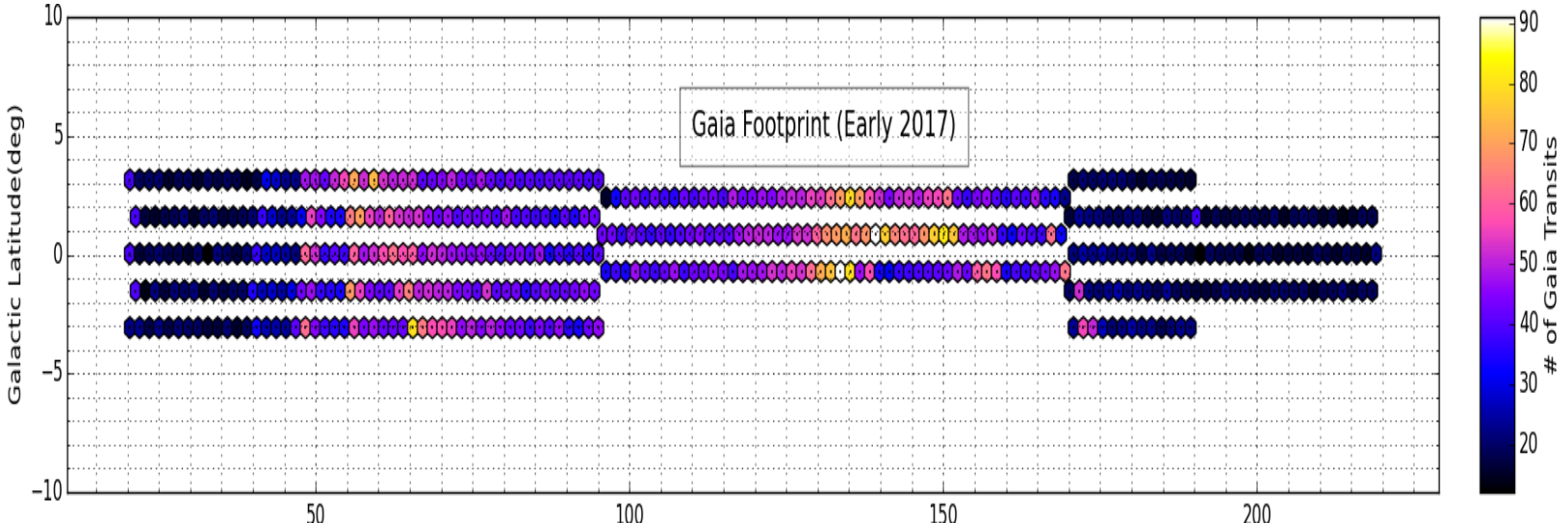
WEAVE HR in contest



Kordopatis+ 2016

Galactic Plane Stellar, Circumstellar and Interstellar Physics (SCIP)

- LR Surveys on GP selected from EGAPS over 1380 sq.deg
- Synergie with EGAPS: GP surveys
  - b<3 deg, ugri, Halpha , 20th mag VPHAS+ (u,g,r,i,Ha) ESO, UVEX (u,g,r, some HeI) North
  - IPHAS (r,i,Halpha) North
- Targets: *Young massive stars:* Comprehensive samples for improved modelling of massive-star evolution & Unbiased demographics: e.g. unclustered as well as clustered OB stars included
  - Targets: early B star with Av ~ 3, 10kpc away would have apparent mags B ~ 18.5, R ~ 17.5, I ~ 17 (S/N >30)



Conclusions

- WEAVE Galactic surveys will complement present and upcoming Galactic surveys
- Italian scientific community should organize itself to ensure the maximum scientific return
- For more information see: www.ict.inaf.it/indico/event/428

  or *www.ing.iac.es/**weave**/*