WEAVE Galactic Surveys

A. Vallenari

INAF, Padova

On behalf of the Science Team

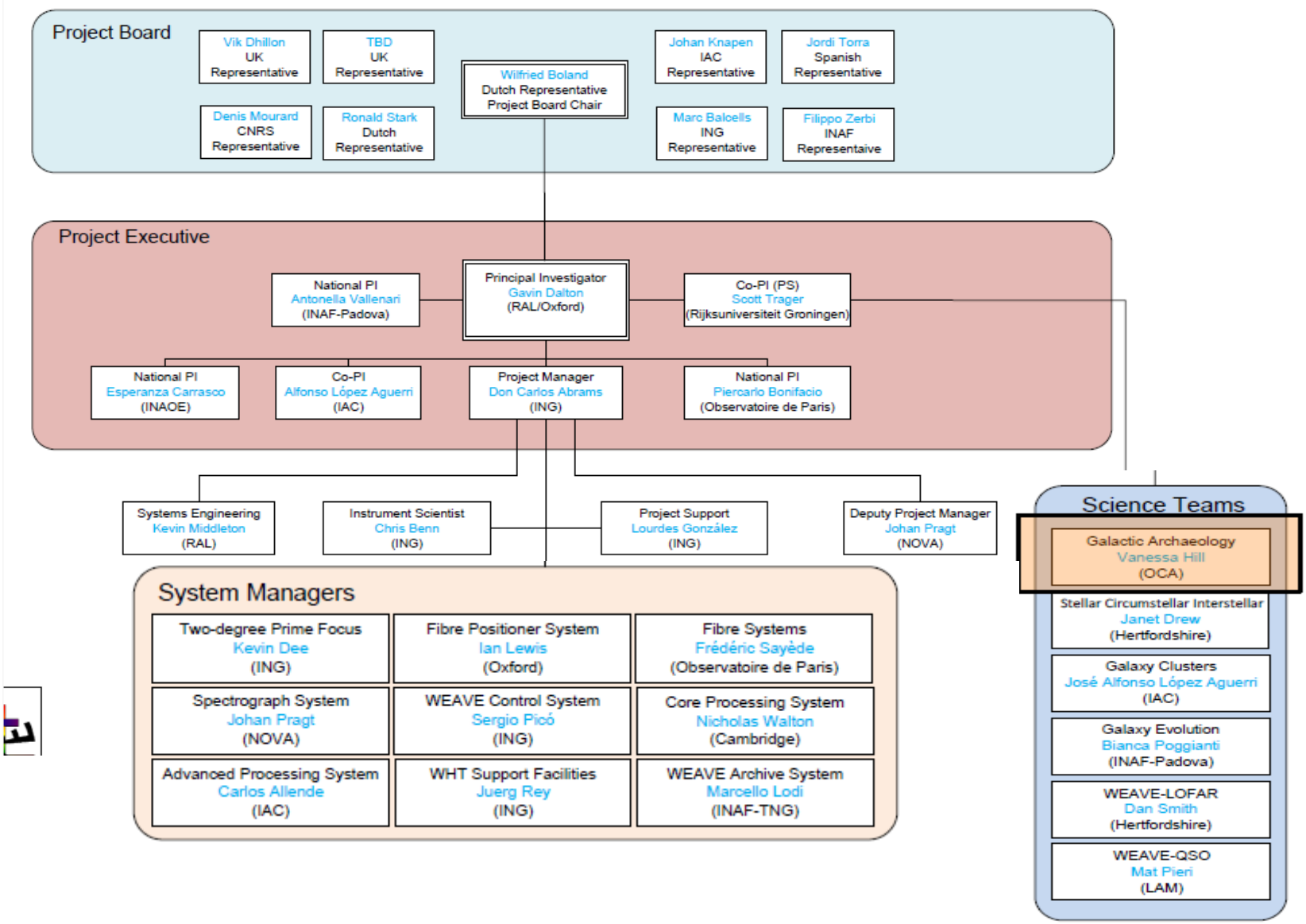
Overview

- WEAVE Surveys
- Milky Way Surveys

WEAVE Characteristics

Telescope, diameter	WHT, 4.2m
Field of view	2° ⌀
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

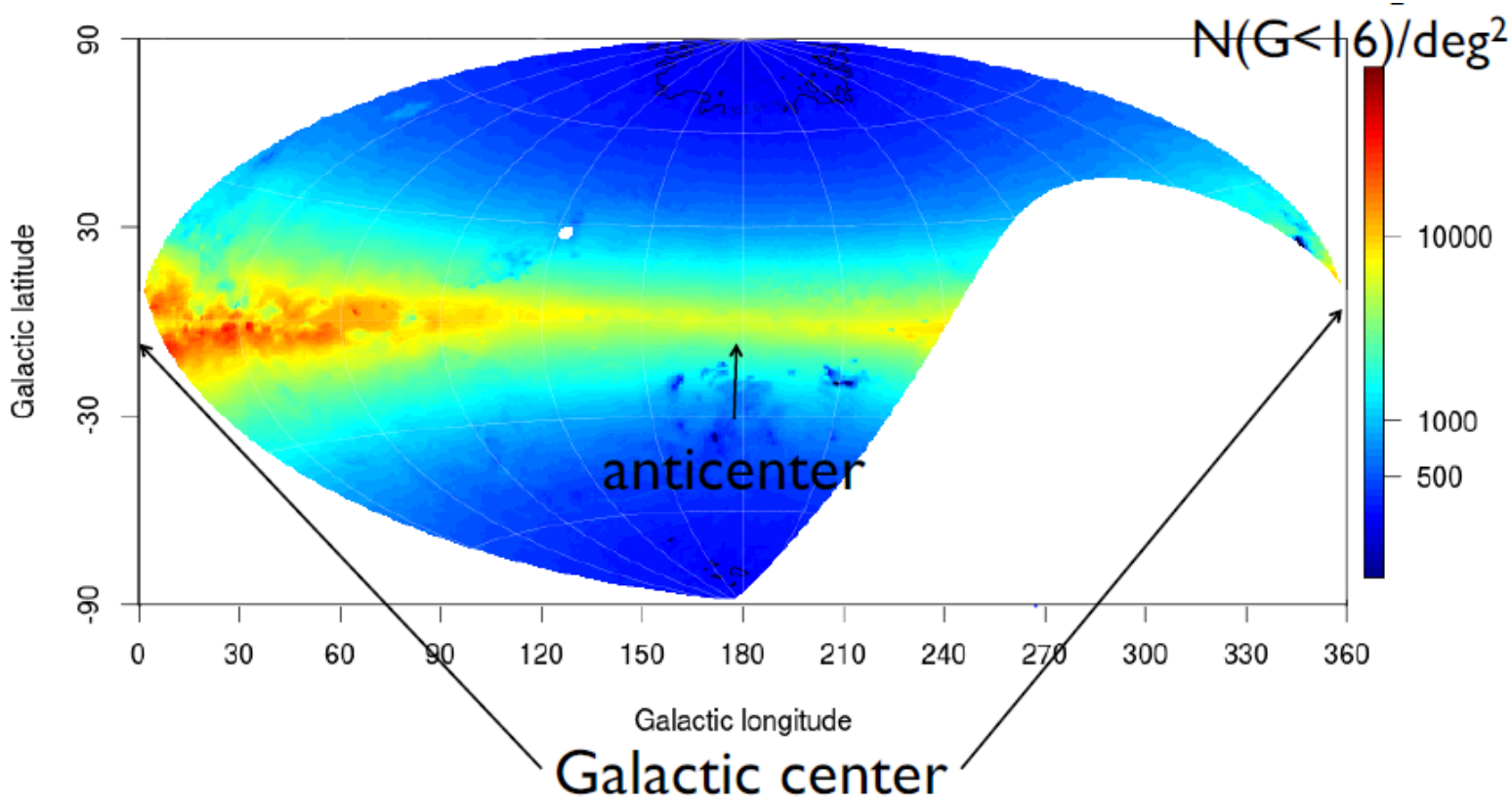
Project structure



Primary Science Surveys

- There are six primary science cases for WEAVE:
- Galactic Archaeology:
  - To complement Gaia
  - To complement 4MOST , MOONS (in the North)
  - Bridge the gaps in APOGEE footprints
- Stellar, Circumstellar, and Interstellar Physics (SCIP)
- Extragalactic S.
  - Galaxy Clusters
  - Galaxy Evolution
  - WEAVE-LOFAR
  - WEAVE-QSOs
- In the following information from WEAVE Science Book & Survey Plan

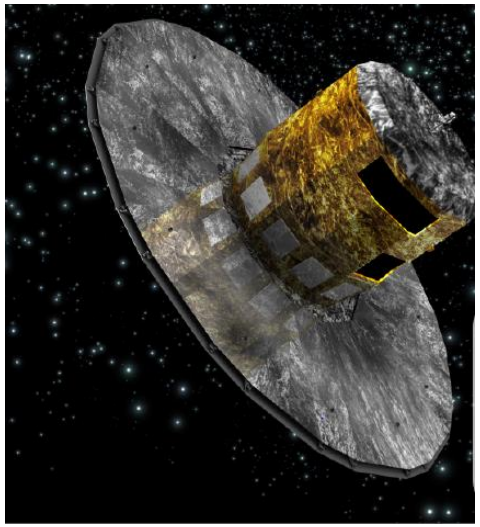
WEAVE Northern multiplex



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

Galactic Achaeology

- Kinematics + chemistry of stars enable to unravel the complex historv of the MW assembly and internal evolution
- SEGUE, RAVE, GES, APOGEE (Vrad + chemistry & photom. distances)
- Now Gaia's will revolutionize the field with geometrical D, Vt, + ages
- Gaia horizon:
  - G=20 astrometry
  - G=16 radial velocities
  - G=11 chemistry

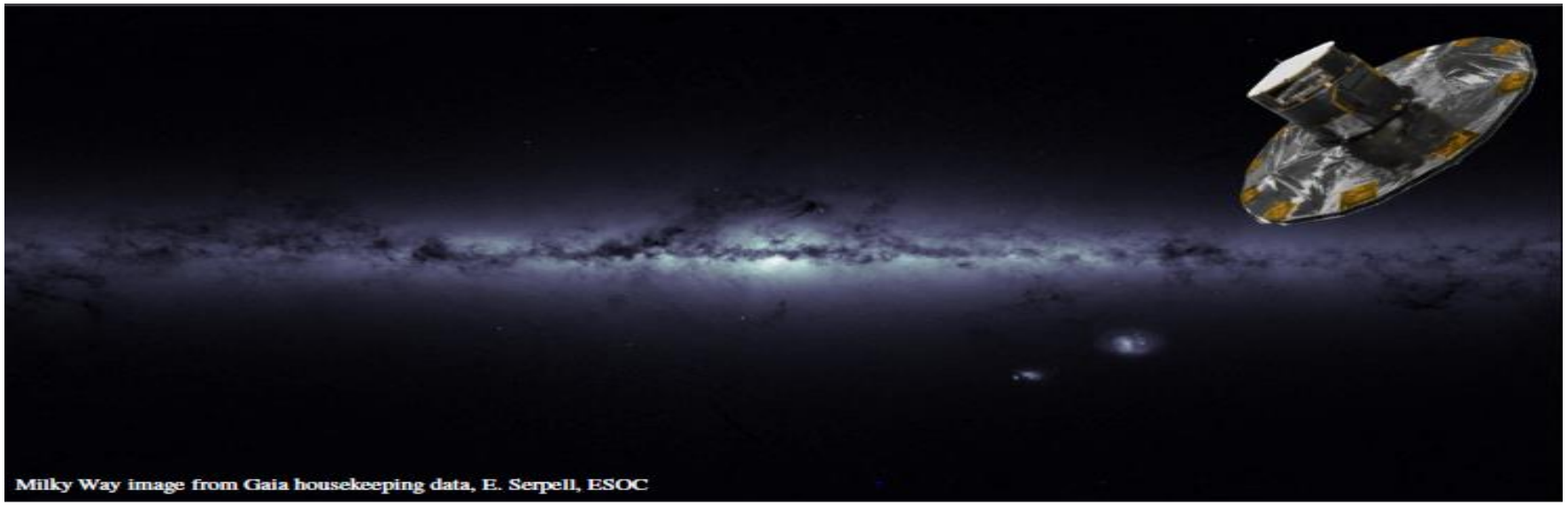


Complementing Gaia

- Surveys to acquire accurate Vr (and stellar parameters, incl. metallicity) in the range 15<G<20
  - Defined the LR mode of WEAVE:
  - R = 5,000 in a wide range [366 – 606] nm + [579 – 959] nm
- Surveys to determine accurate stellar parameters and detailed chemistry for G>11-16
  - Defined the HR mode of WEAVE:
  - R = 20,000 in two windows [404 – 465] nm or [473 – 545] nm + [595 – 685] nm
- Wide field high multiplex MOS: 950 fibers per 2° Ø field, + Dual arm spectrograph

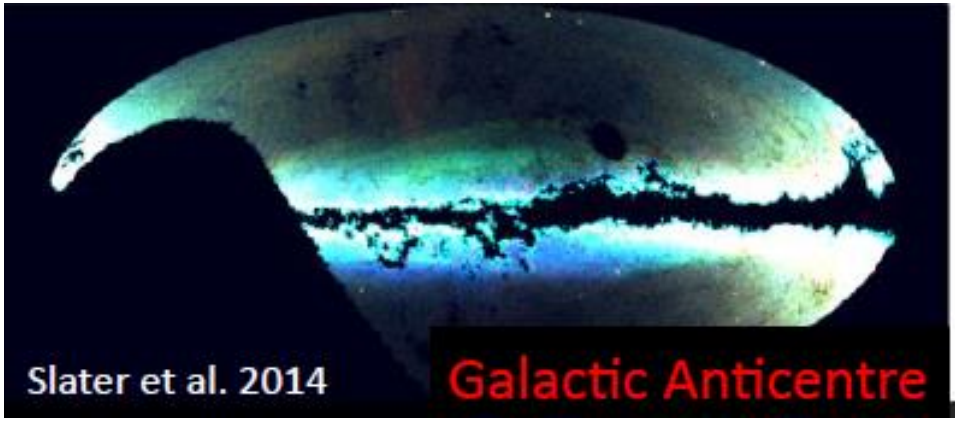
WEAVE Galactic Surveys

- LR halo
- LR disk
- HR disk + open clusters
- LR/HR Galactic plane



LR Halo: Goals

- Formation scenarios for the Galactic stellar halo: in situ or accreted?
- Outer halo survey with RGB stars: lumpiness and structure
- Total mass of the Milky Way out to 200 kpc through Jeans analysis
- The shape of the Galactic gravitational potential within 50–100 kpc from tidal streams.
- Lumpiness of the Galactic dark matter distribution within 20–50 kpc
- Chemo-dynamics of Milky Way dwarf satellite galaxies and the effect of binary stars on dark-matter estimates
- Star-formation and metal enrichment histories of disrupted dwarf satellites and of ultra-faint galaxies including binary star percentage

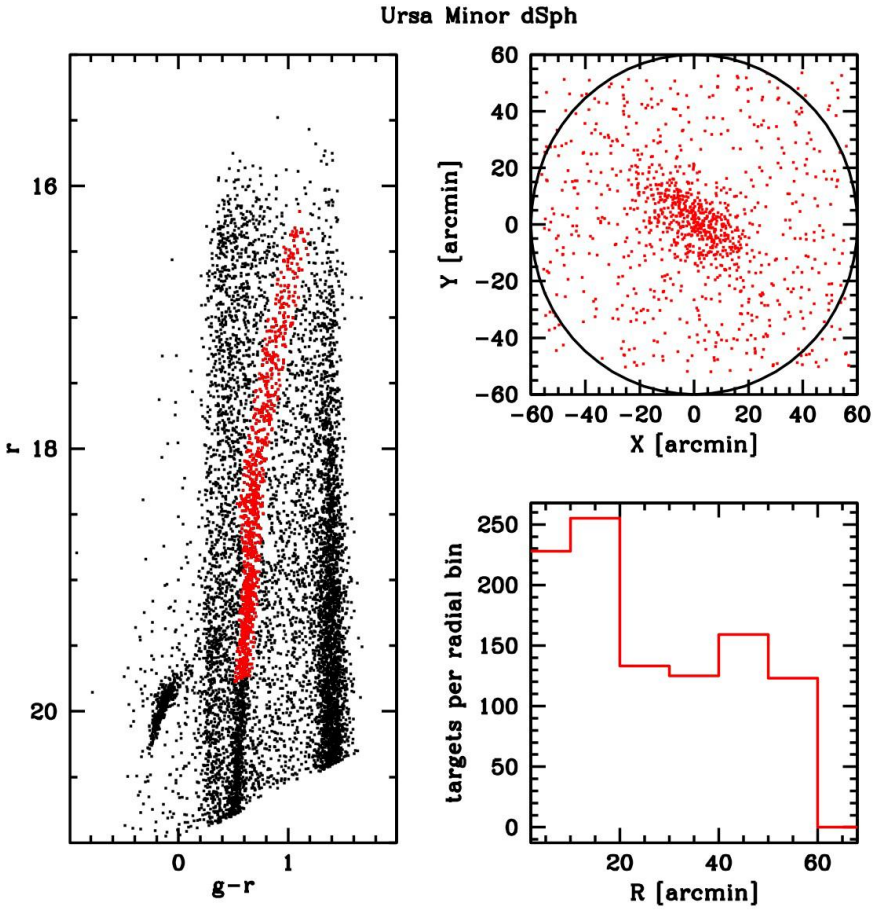


Pan-STARR1

LR Halo Pointed Survey

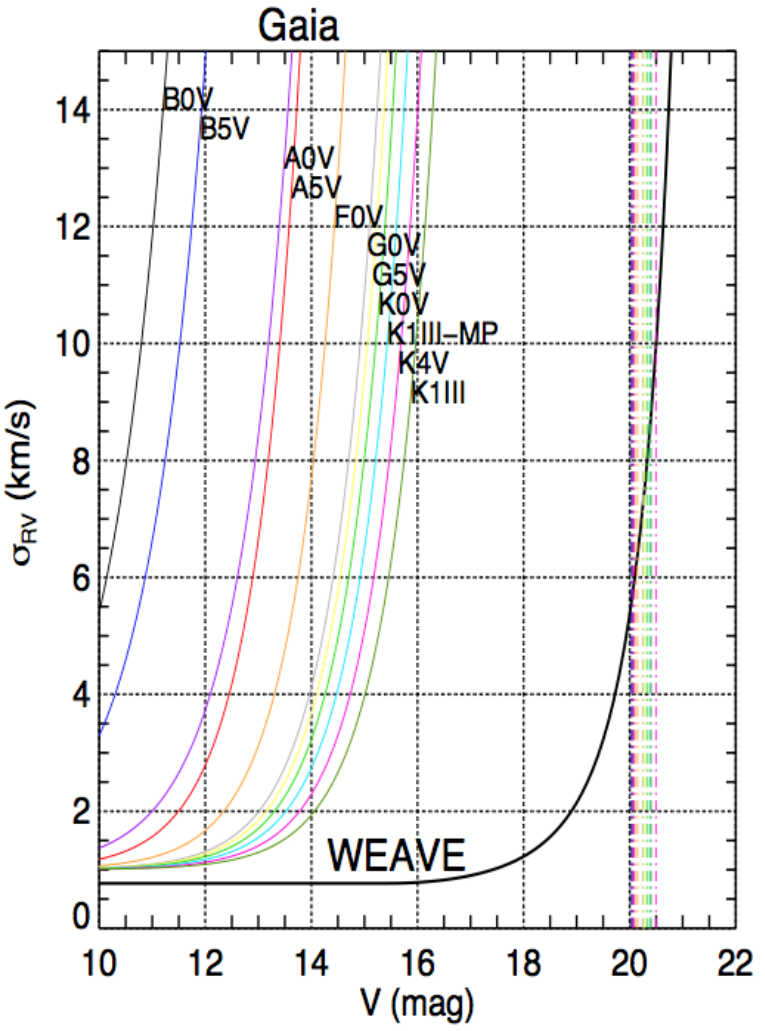
- Dwarf Galaxies and UDFs
  - Northern dSphs + large streams and clouds + UFDs
  - 300 deg^2 down to V =21 (4 exposures per pointing)
  - A few exposures over 2 years for 3 dSphs (detection of 30% of binaries with |dv| > 2 km/s;

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



WEAVE LR Disk Science

- Disk questions:
- 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?)
- Diagnostics:
- Phase-space distribution of stars of the Galactic disk (RG+MS) to Vr 1-5 Km/s
- |b|<6 to detect kinematic perturbations
- Bonus: metallicities
- WEAVE can measure Vr to sigma(vr)<5 km/s at V=20 in 1hr, i.e. closely matching the Gaia astrometric and photometric limits



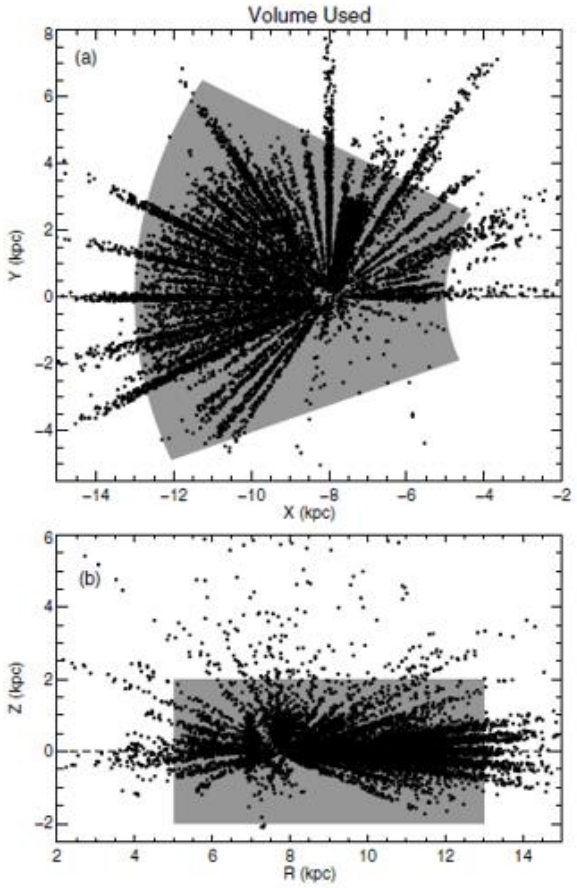
Why external disk survey

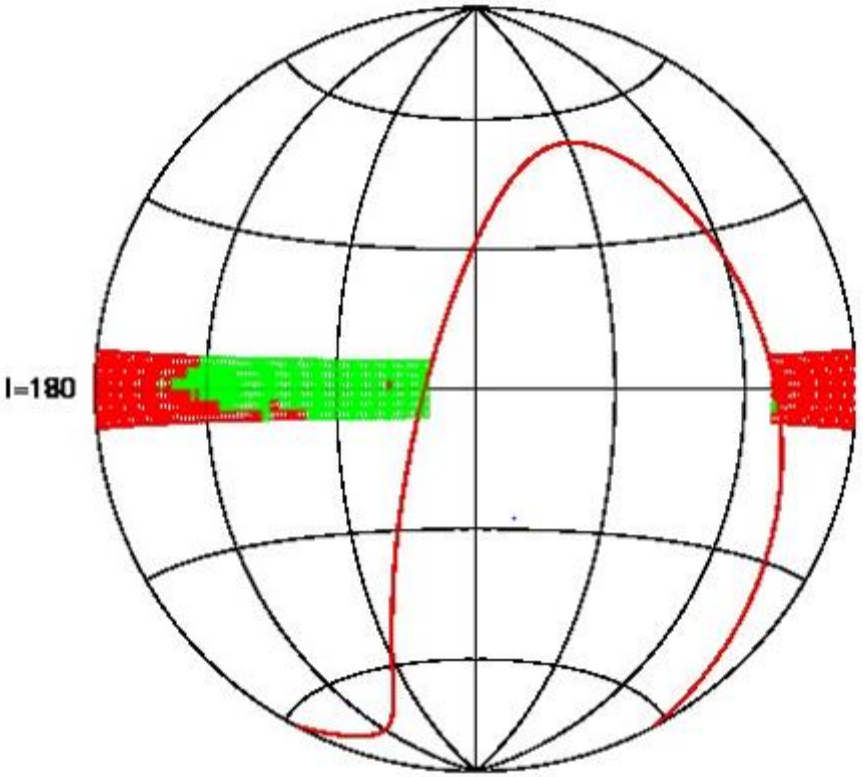
- Anticenter:Stellar density & (average) extinction lower
- Dynamical effects are the most visible
- Interactions with satellites: flaring of the stellar pops.
- Accretions: ratio of accreted vs MW stars is the largest
- Bar and spiral resonances (bar resonance at ~10 kpc)
- Radial migration: kinematics do not allow to distinguish a in situ born star from one having migrated

+ chemistry

LR disk

Green : RG
l=20 bar edge
l=90 spiral arms

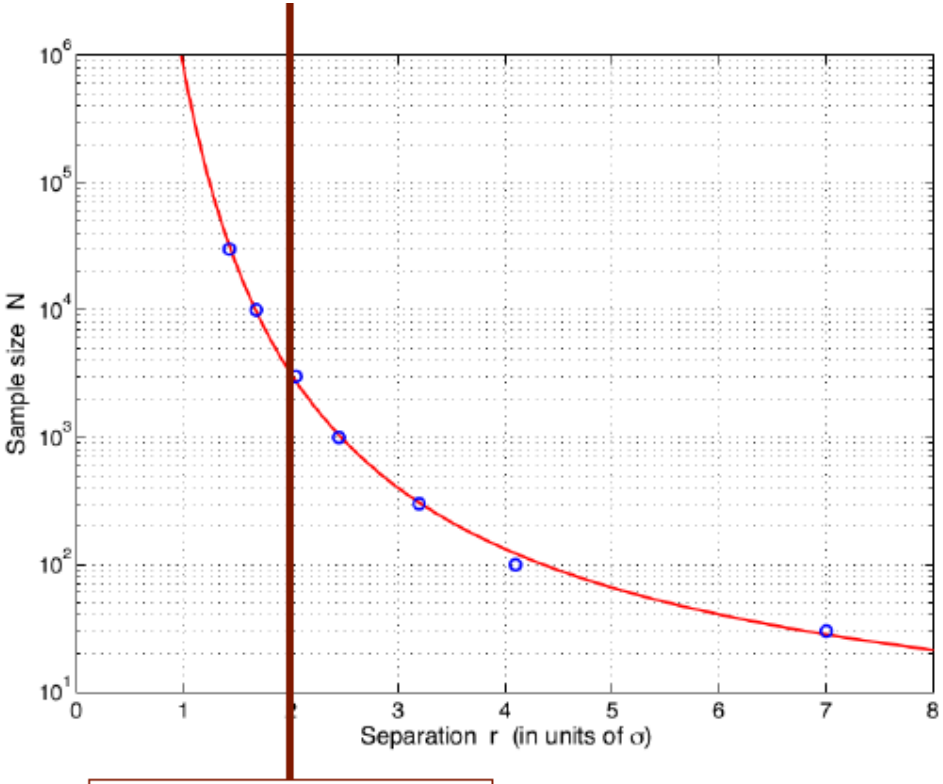




APOGEE: scarse coverage l=20 to l=90 deg
10^5 stars

WEAVE LR Disk -|b|<6- 1.5 10^6 stars
Continuos coverage to understand global phenomena

HR Goal 1: Disk assembly



→ N = 3 000

Hyp :
- Pops separated by 0.1 dex
- [α/Fe] error of 0.05 dex

Lindegren & Feltzing (2013)

- To disentangle two populations with σ [X/Fe] < 0.1 dex
- Minimum needed statistics in each (*RGC*, *Z*, [Fe/H]) box : 3 000.
- 5 *RGC* annuli, 4 *Z* slices, and 10 [Fe/H] bins requires a total absolute
- → minimum number of **targets of 6x 10 ^{6} stars for goal 1**

HR Goal 2 -3

- Goal 2: Halo assembly
- Assuming 500 streams cross the solar neighbourhood
- 100 members each needed to characterize them

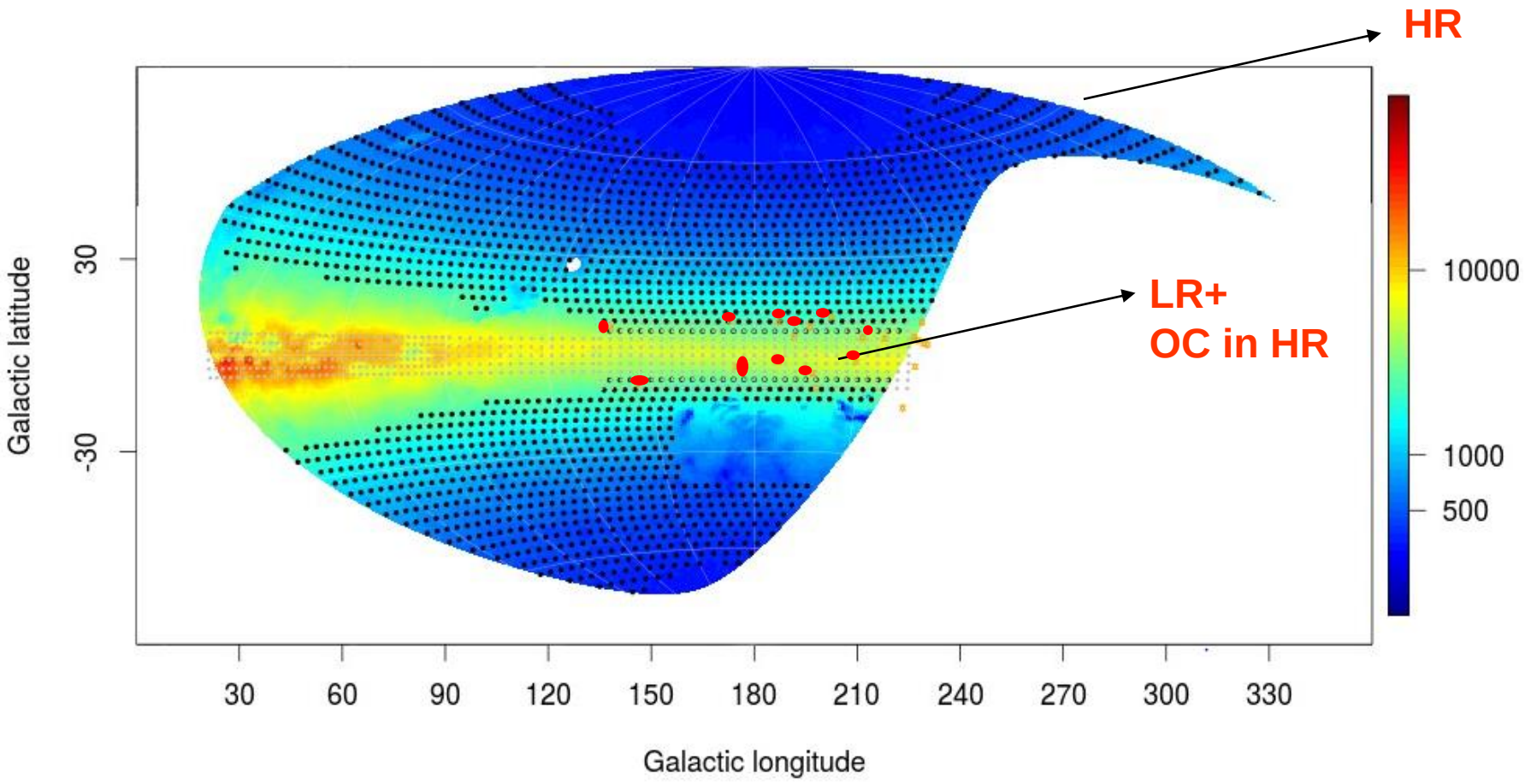
  → 5 x10 ^{4} halo star– target 5 x10 ^{5} stars
- Given the density of halo stars at magnitudes 12<V<16 (~10 / deg2)

  → demands a high-latitude survey of 5000 deg2 (at |b|>30-40)

- Goal 3: low metallicity and first stars
- targeting [Fe/H] < -3
- → < 1 candidates per WEAVE FoV

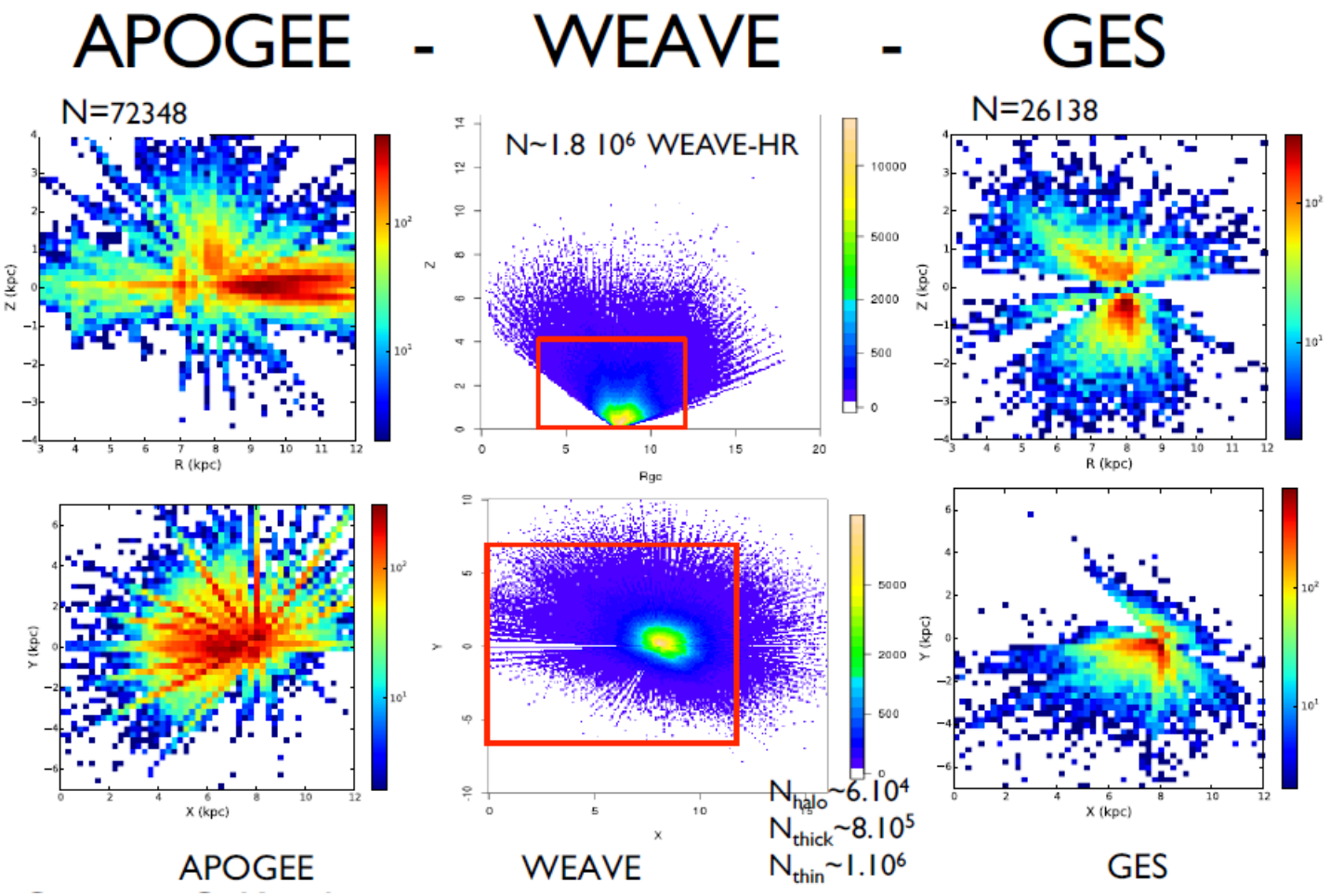
- Selection on MS(age sphere) +RG (distant halo) made on Gaia

Disk/Halo Baseline



About 6800 sqdeg in HR, |b|=15-60 deg

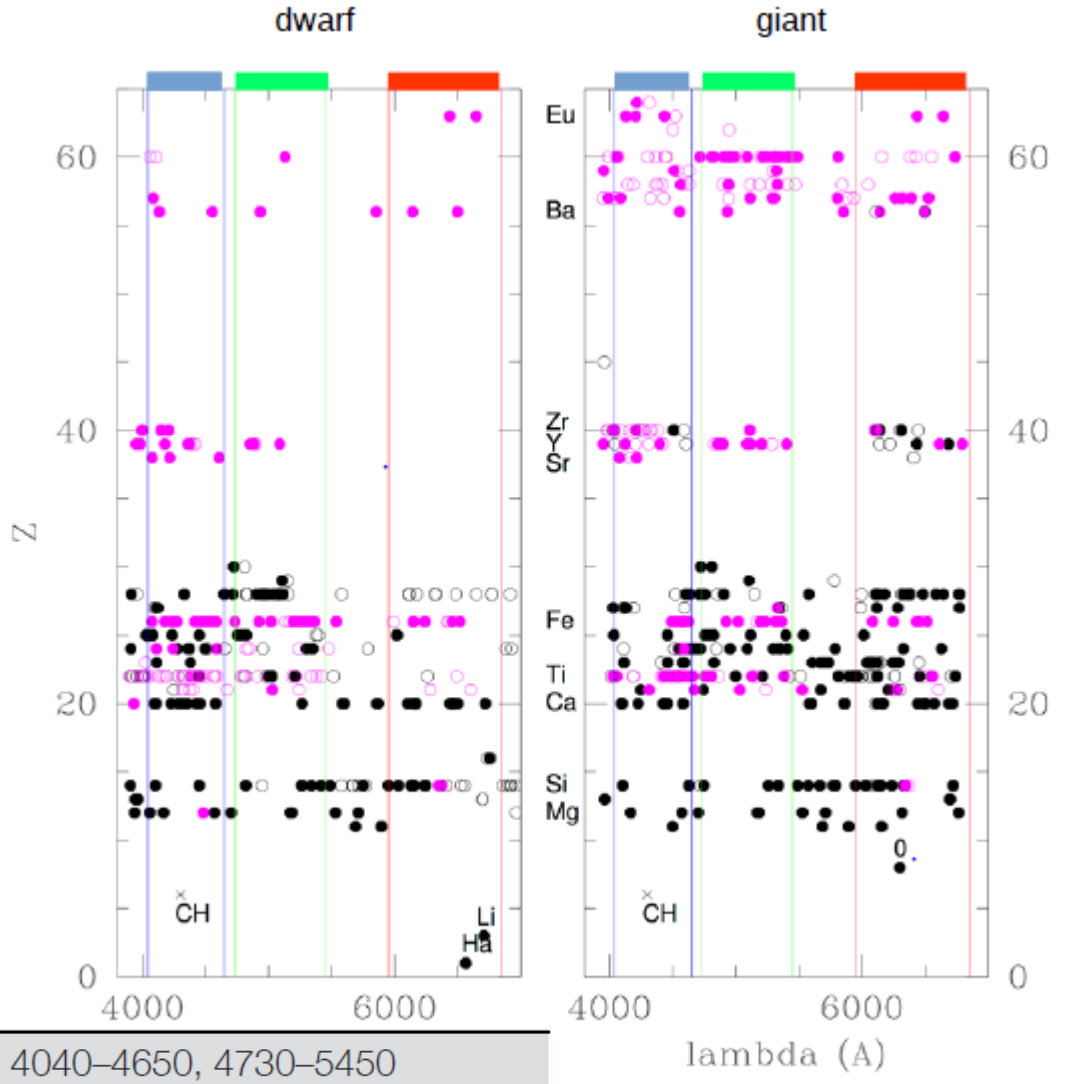
WEAVE HR in contest



Kordopatis+ 2016

WEAVE HR products

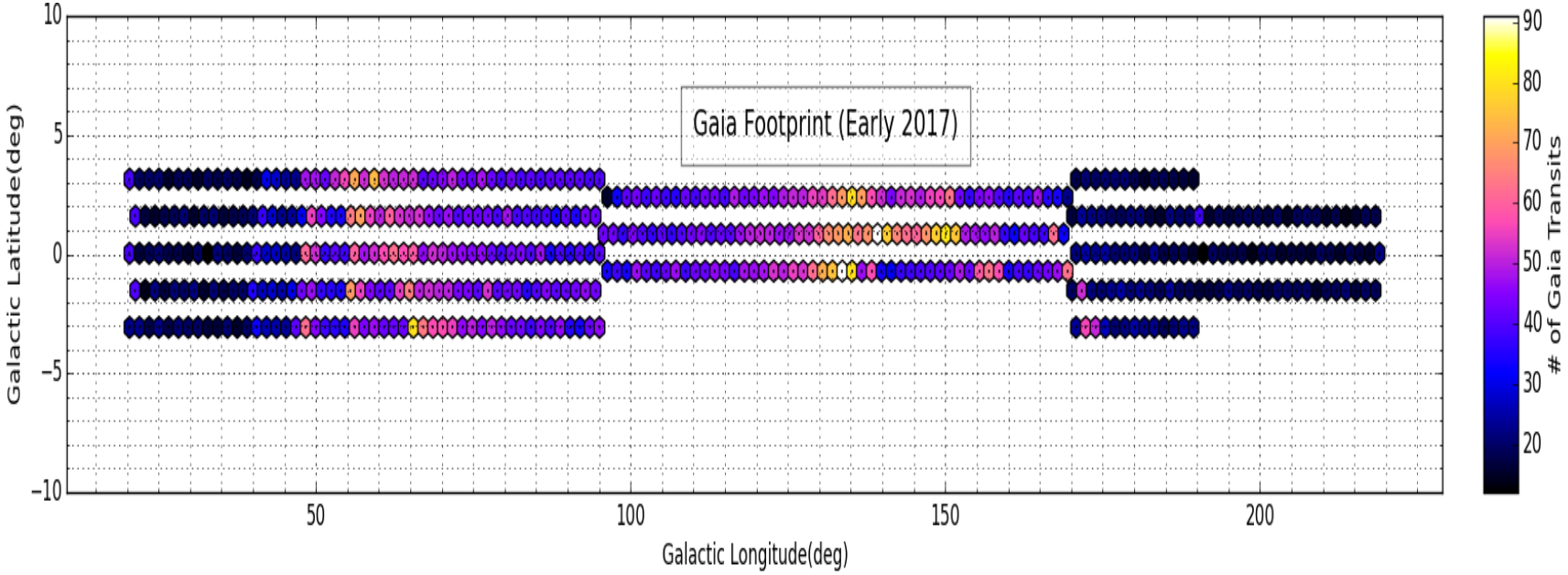
- WEAVE can measure stellar parameters and individual abundances in all main nucleosynthetic channels to V=16, i.e. closely matching the Gaia's most precise sphere (distances, ages)
- Teff, log(g), Vrad, Vsini
- Nucleosynthetic chanels :
  - Lithium → young objects
  - iron peak (Fe, Ni, Cr, Co, Zn),
  - 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

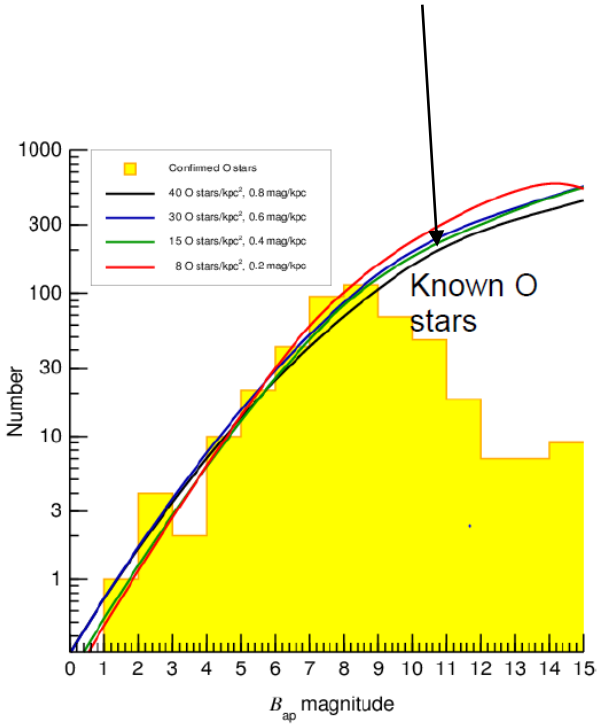
Galactic Plane Stellar, Circumstellar and Interstellar Physics (SCIP)

- LR Surveys on GP selected from EGAPS
- 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
- pointings do overlap: sky areas involved are 1380 sq.deg
- *SCIP LR footprint, coloured according to expected coverage in first Gaia release*



HR/LR SCIP

- LR Surveys : massive and young stars
- OBA/massive stars: 500+ fibres
  - 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)
  - Faint stars selected from EGAPS colors
- The diffuse ISM, PNe and SNR: 200-300 fibres
- Minority elements (sparse object classes):
  - Evolved lower mass stars
  - Young stars and the creation of the stellar field
- HR: Cygn OB association:
  - targeting OB and FG stars



(Figure – courtesy of J Maiz-Apellaniz)

Interstellar medium

- WEAVE @ R=5000, with 3700—9500 A spectral coverage, can deliver:
- Full set of nebular diagnostics: extinction, temperatures, densities, abundances...
- Good-enough RVs (3-5 km/s) to permit placing within the context of the Galactic disc velocity field. The LR ISM programme can take a big step towards linking the sources of ionization with the ionized ISM – never tried before on this scale.
- Approach:
  - Single fibres for sampling diffuse ISM/large HII complexes
  - IFUs to be deployed for new/catalogued PNe/SNR and smaller HII regions.

Conclusions

- WEAVE Galactic surveys will complement present and upcoming Galactic surveys
- Italian scientific community should organize itself to ensure the maximum scientific return
- Web site with presentations