Gaia-LSST Synergy

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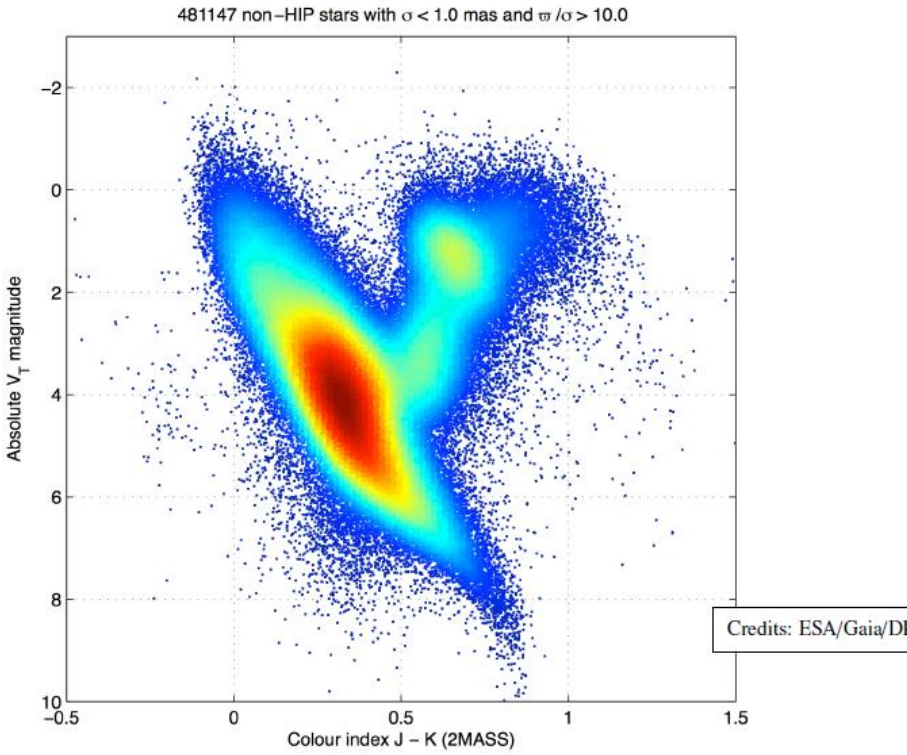
The Galaxy view

- 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→Galactic Archaelogy
- Much was learned from APOGEE, RAVE, GES, SEGUE…much still to learn
- Now Gaia will revolutionize the field
- First data release in Sept 2016 and second end 2018
- Well in the framework of LSST projects

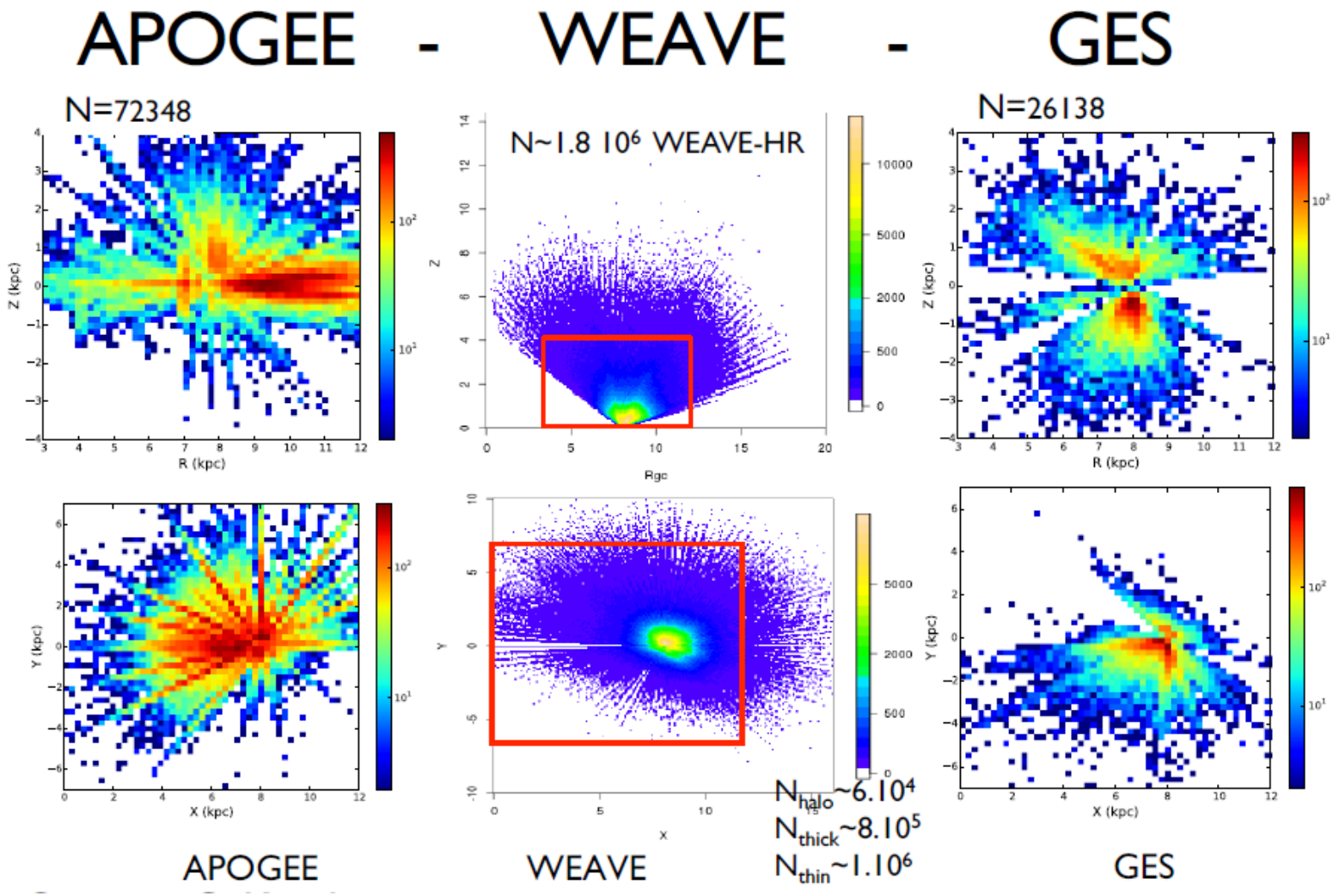


Open questions

Structure formation on sub-galactic scale

- 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)
  - How do Ocs interact with the Galactic potential?
  - What is the chemical evolution traced by the open clusters? (Magrini+ 2010, Jacobson+2016, Bragaglia+ 2006, Sestito + 2008, Cantat+2012, Donati+2012)

The Galaxy at HR



Kordopatis+ 2016

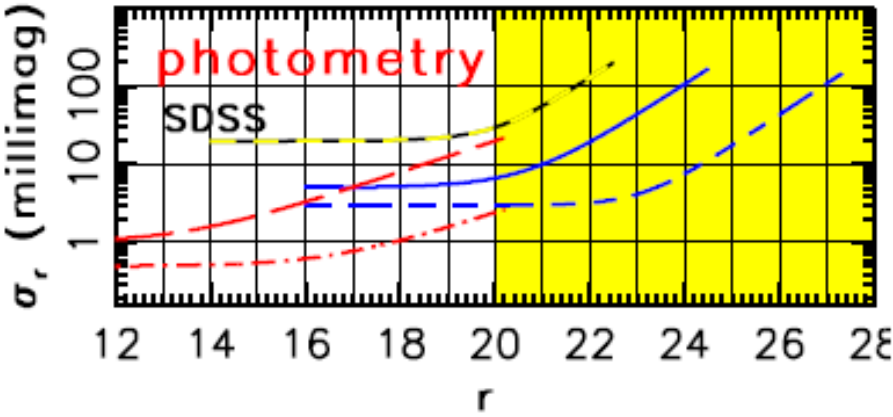
Gaia-LSST

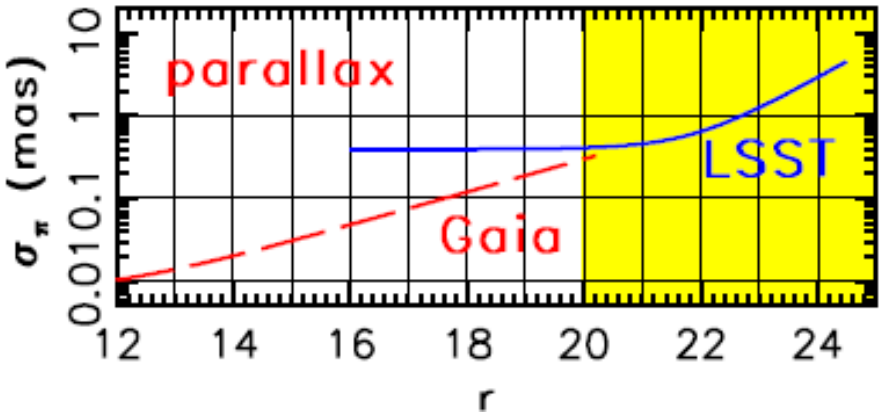
LSST Science Book: **http://ls.st/sb**

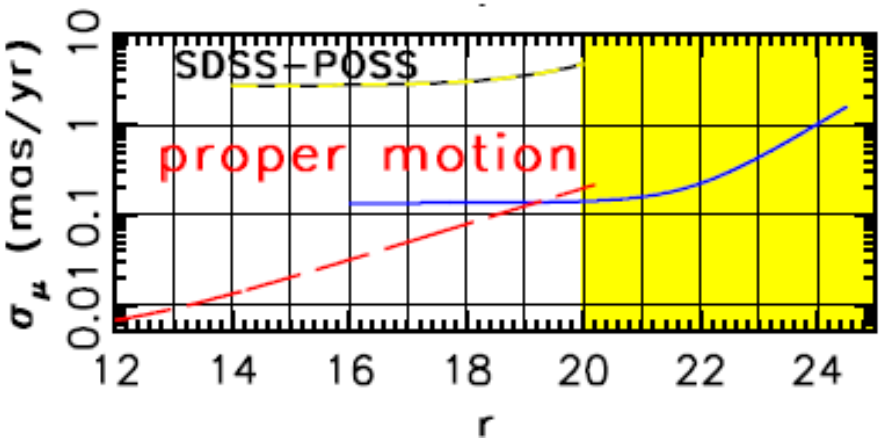
Gaia: **http://sci.esa.int/gaia**

Table 6.6: Adopted Gaia and LSST Performance

Quantity	Gaia	LSST
Sky Coverage	whole sky	half sky
Mean number of epochs	70 over 5 yrs	1000 over 10 yrs
Mean number of observations	320[a] over 5 yrs	1000[b] over 10 yrs
Wavelength Coverage	320–1050 nm	*ugrizy*
Depth per visit (5σ, r band)	20	24.5; 27.5[c]
Bright limit (r band)	6	16-17
Point Spread Function (arcsec)	0.14×0.4	0.70 FWHM
Pixel count (Gigapix)	1.0	3.2
Syst. Photometric Err. (mag)	0.001, 0.0005[d]	0.005, 0.003[e]
Syst. Parallax Err. (mas)	0.007[f]	0.40[f]
Syst. Prop. Mot. Err. (mas/yr)	0.004	0.14





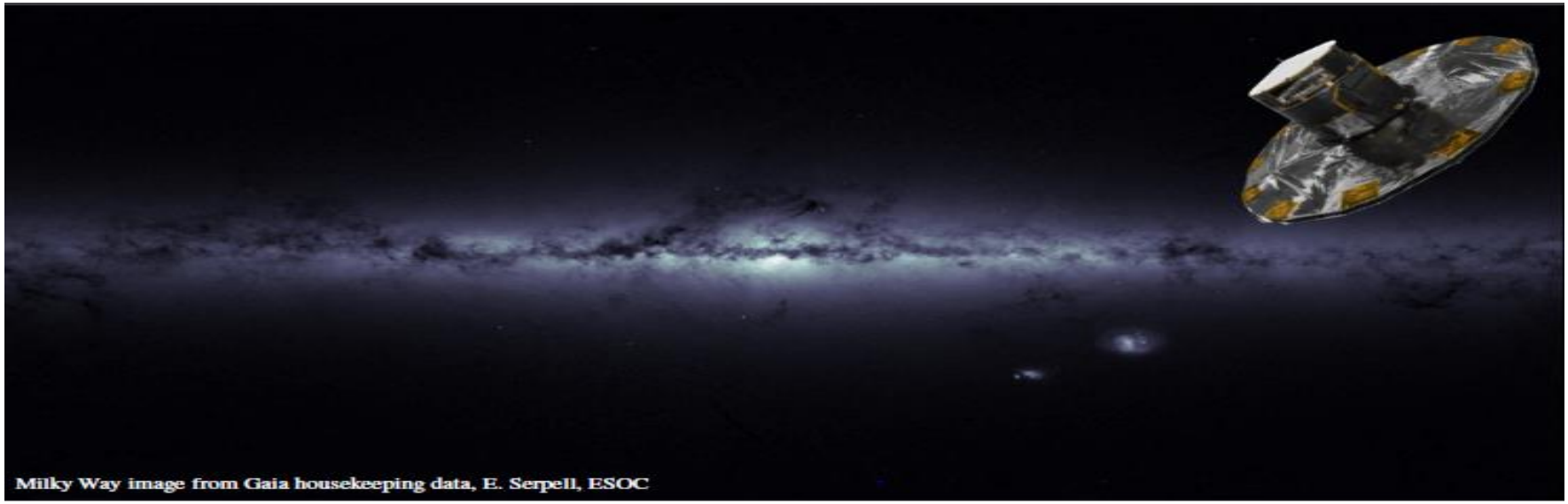


A New Galaxy View

- Gaia (r=20.7,1 Billion objects) –LSST (r=27,10 billions objects) relation
  - Catalogue of the bright sky
  - Provide first epoch positions
  - LSST reference frame based on Gaia (Lupton private comm.)
  - PM-Parallax calibration on Gaia
  - Photometry zero point calibration on Gaia
- WEAVE-LSST relation (Northern Emisphere)
  - Spectroscopic Calibration of chemical abundances from photometry
  - Chemically Peculiar objects follow-up
- GES –LSST relation
  - As WEAVE in South

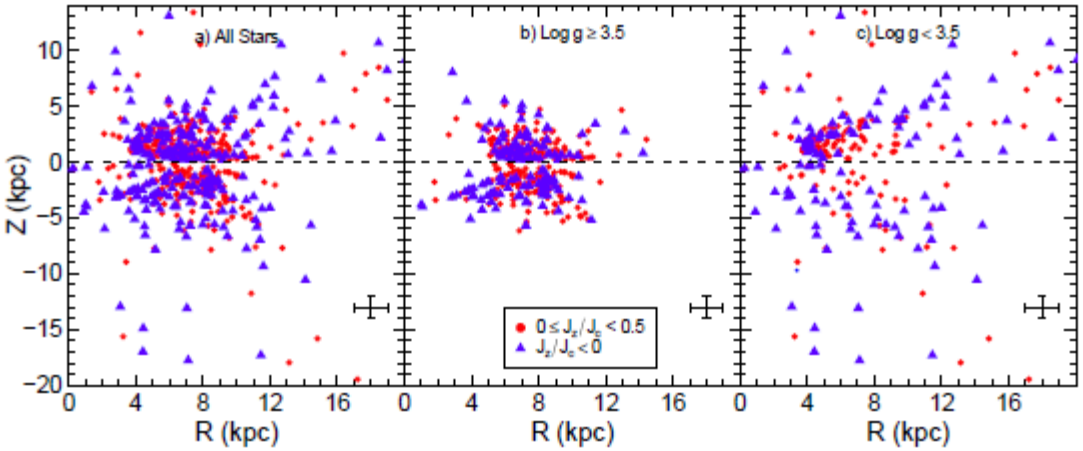
coherent view of the Galaxy from 3 to 24 mag

Local Volume



- Mdwarf Mr=12 Δvtang 1km/s at 1 Kpc (r=22)
- 12 Km/s at 2.5 Kpc (r=24)
- MS at turnoff Mr=4.5 detected by Gaia at 10 Kpc, by LSST at 100Kpc (24.5)
- Mr=15 detected at 100 pc by Gaia and 800 pc by LSST

Formation history of the disk

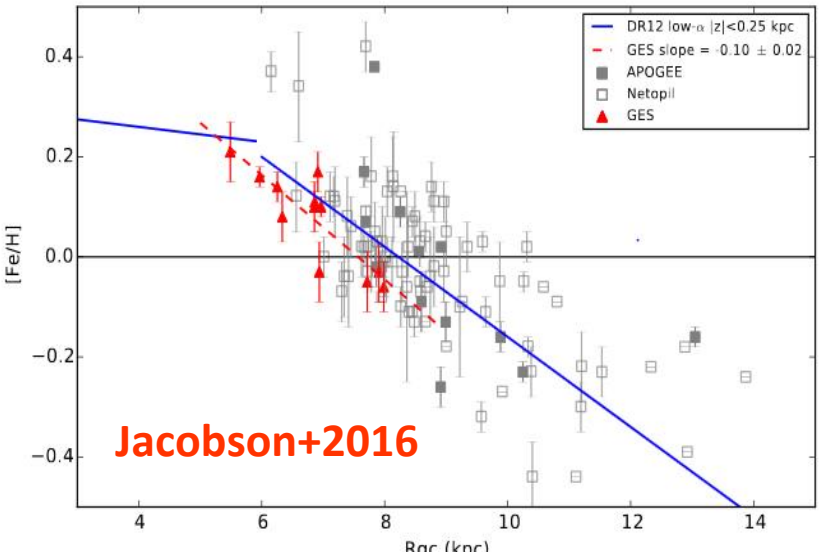


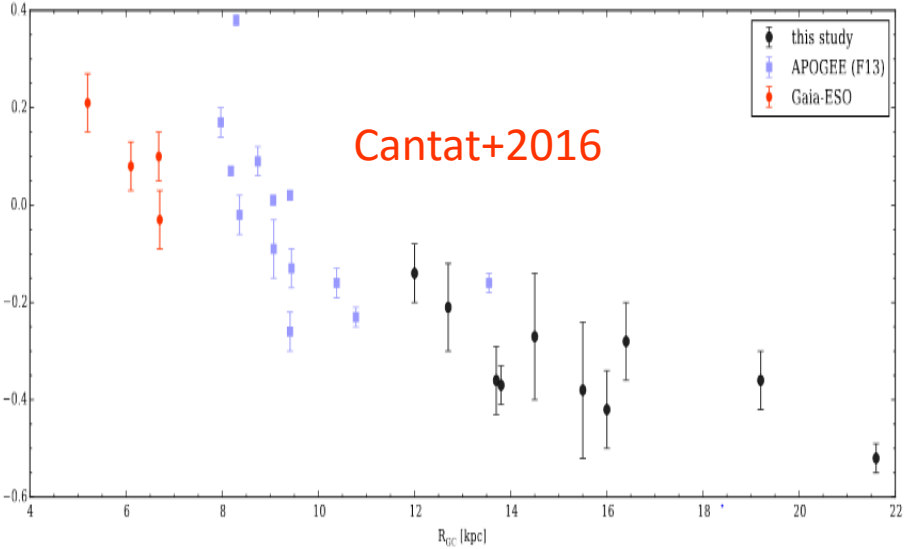
Ruchti+2015

- Metal poor end of the thin disk: accretion (Nissan & Schuster 2010)
  - Quiet disk history? (Ruchi+2015,)
- LSST contribution : metallicity measurements for about 200 million MS F/G Stars up to 100 Kpc → metallicity maps
  - Substructures at 20% density contrast in the inner disk |Z|<2 Kpc till 12 Kpc heliocentric distance → merging history of the disk

Synergie with WEAVE-GES disk surveys

GES MW radial metallicity distribution

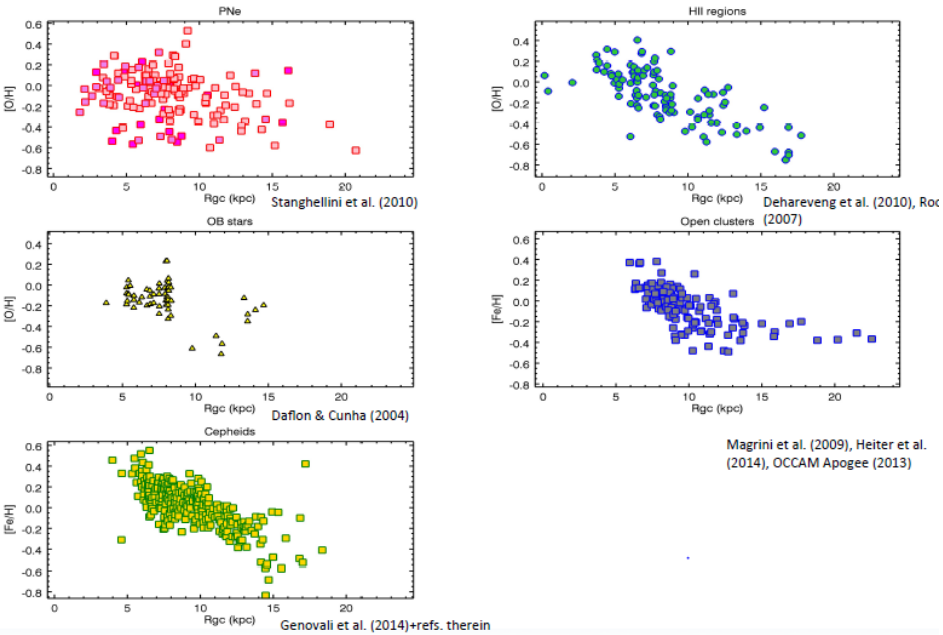




- disk <u>chemical gradient</u> disk
  → disk formation process

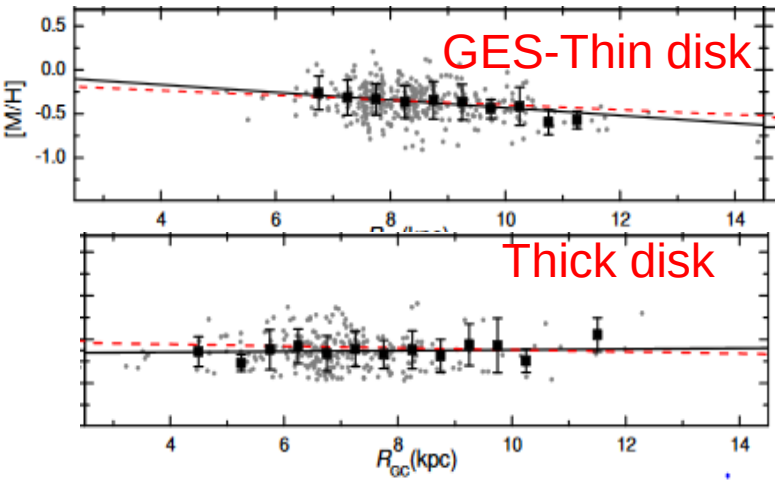
  Andriewski+ 2004, Magrini+2009, Chiappini+2001; Minchev+2015

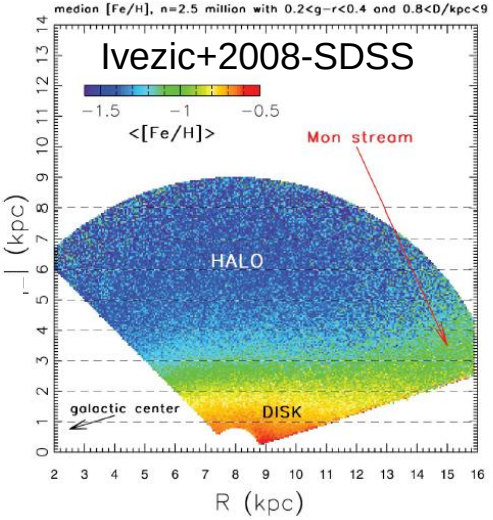
- Tracing radial migration ?
  (Wu+2007, vandePutte+ 2011, DeBattista+2015)

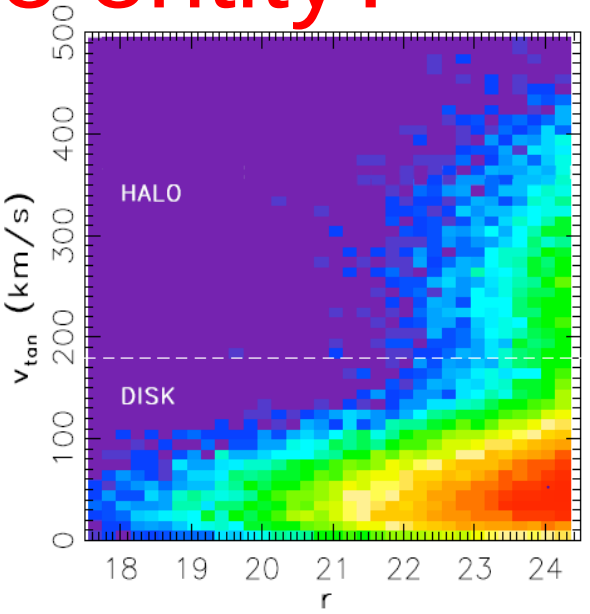


Thin vs Thick disk:unique entity?

Mikolaitis + 2014





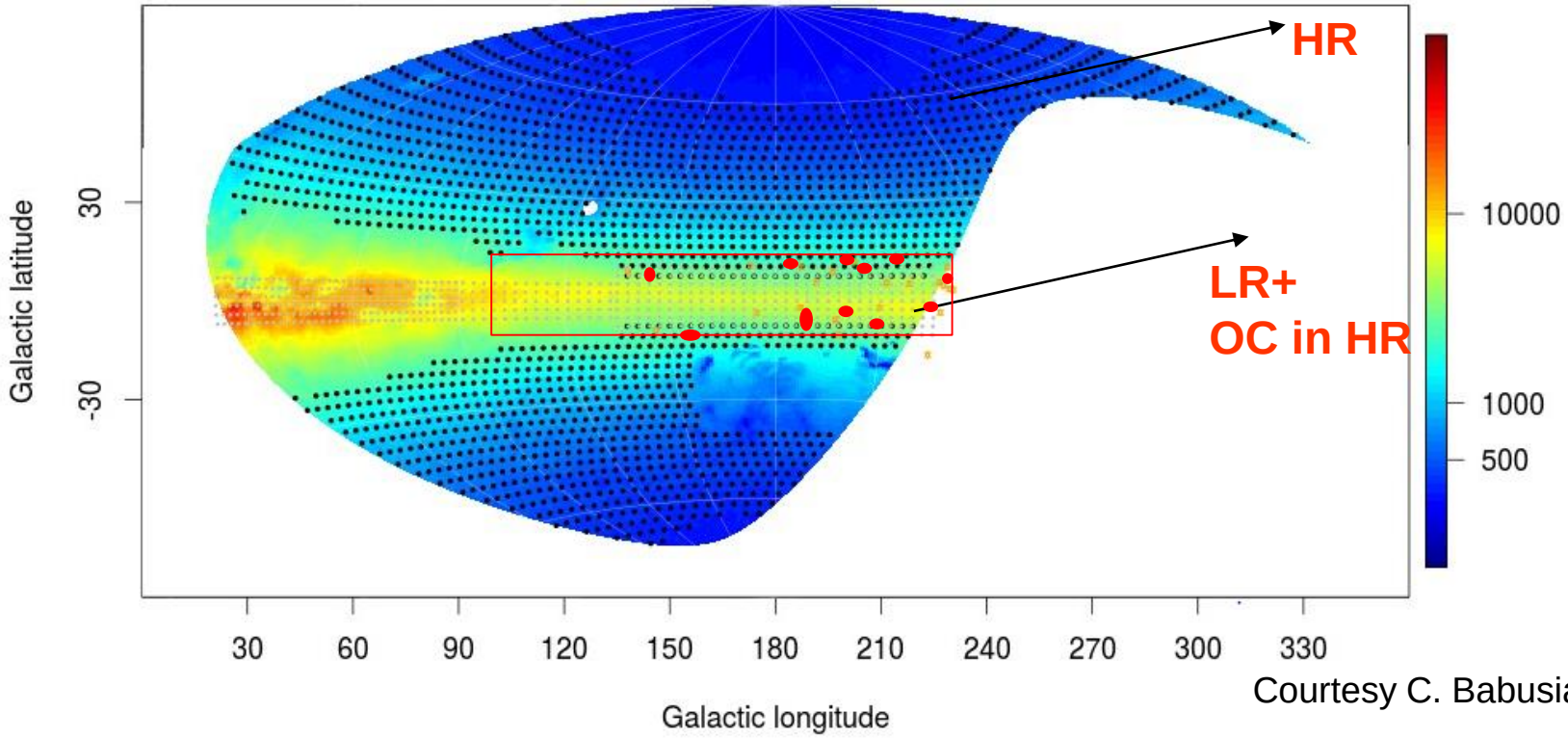


- The thin disc reaches metallicities as low as -0.8
- The thick disk can be supersolar (Kordopatis+2015, GES data)
- Are they two different entities? (Bovy+ 2010, Mikolaitis+2014, Bensby+2014)
- Metal rich tail of the thin disk(supersolar): migration?
- Inner halo- metal poor thick disk: no differences using APOGEE/RAVE (Hawkins +2015)→ thick disk formed in situ?
- LSST: Vtang at 10 km/s at 10 Kpc: disentangling halo/thick disk

WEAVE Galactic Surveys

LR halo: |b|>30
1.x10^6 stars – 10,000 deg2

HR halo: |b|>30
1.x10^4 stars – 5,000 deg2



Courtesy C. Babusiaux

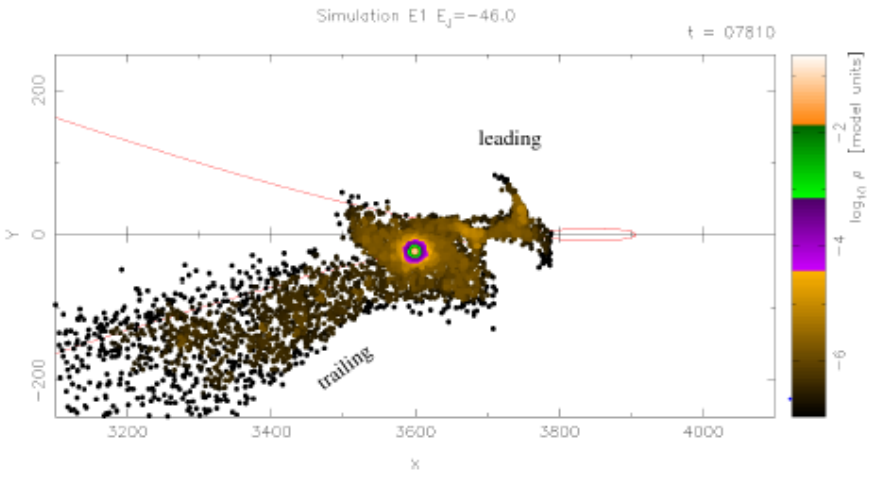
LR disk: |b|<6
1.5x10^6 stars – on 210+405 LoS

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

Open Clusters

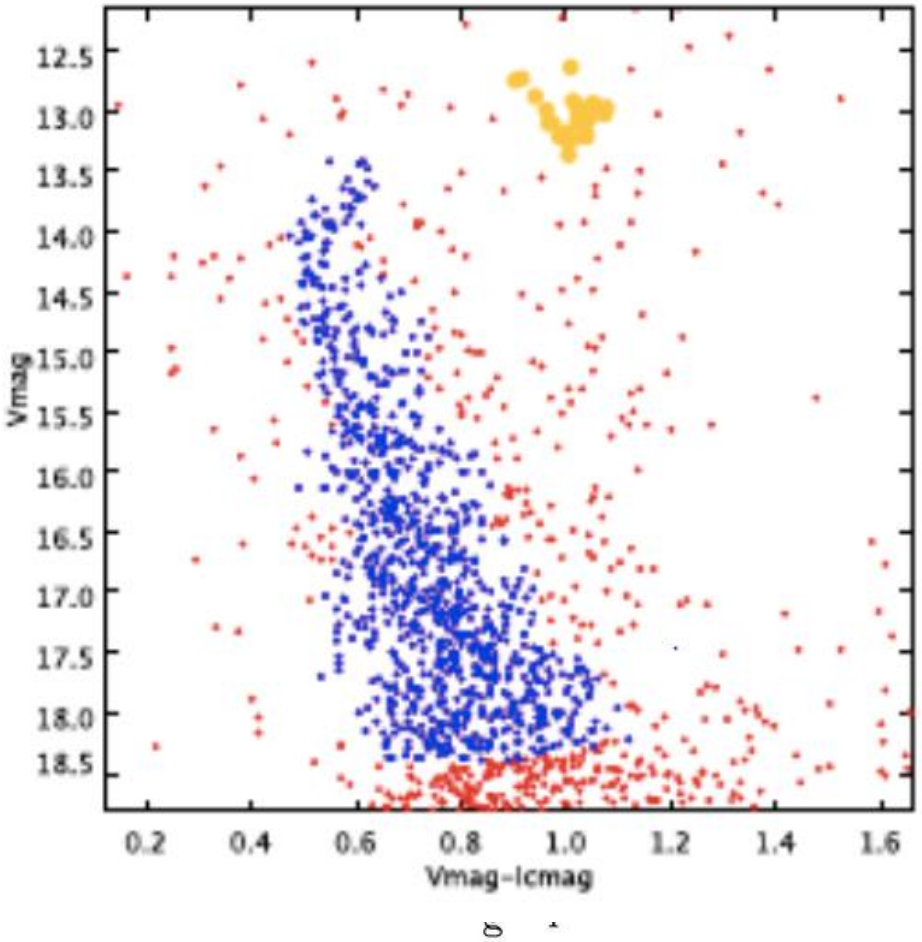
- Their birth, internal kinematics/ dynamical evolution, evaporation, disruption, self-pollution (if any) trace the Galactic environment
  → Tidal field (Berentzen & Athanassoula 2011, Kupper et al 2010)
  → interaction with giant molecular clouds & spiral arms
  (Gieles et al 2006, Kujissen+2011) + stellar evolution effects (infant mortality)

- 400 known Ocs in LSST
- 50-60 Ocs in WEAVE
- 70-80 Ocs in GES
- **LSST contribution:**
- Improving the census of faint Ocs
- Stellar halos and tidal streams from photometry
- Understand the interplay between Ocs and field stars
- Dynamical tracers of MW potential

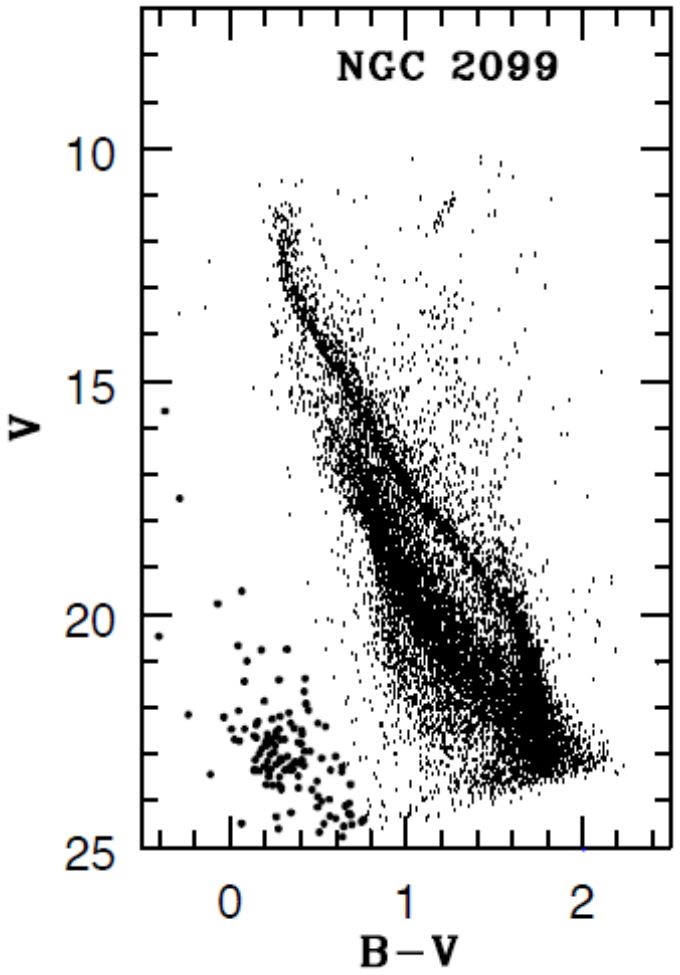


HR Open Clusters

NGC 2509- d=900pc



Kalirai 2001 ,0.5 Gyr, 1.5 Kpc-N



Direct age from WD cooling sequence up to 8Kpc (1Gyr) or 1Kpc (10Gyr)

Conclusions

- Continuum of properties between Gaia and LSST data
- New view of the disk formation and evolution combining Gaia+LSST+ spectroscopic surveys