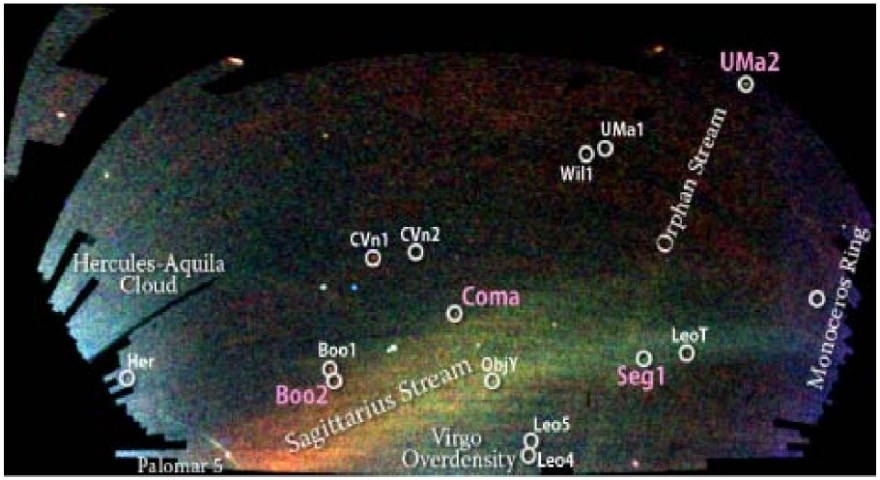
Science with 4MOST, Potsdam, November 13-15, 2012

The Milky Way Halo

Design Reference Surveys

Andreas Korn
on behalf of the
Halo Survey Coordinators
(A Helmi, N Christlieb, M Irwin)
and SWP Team

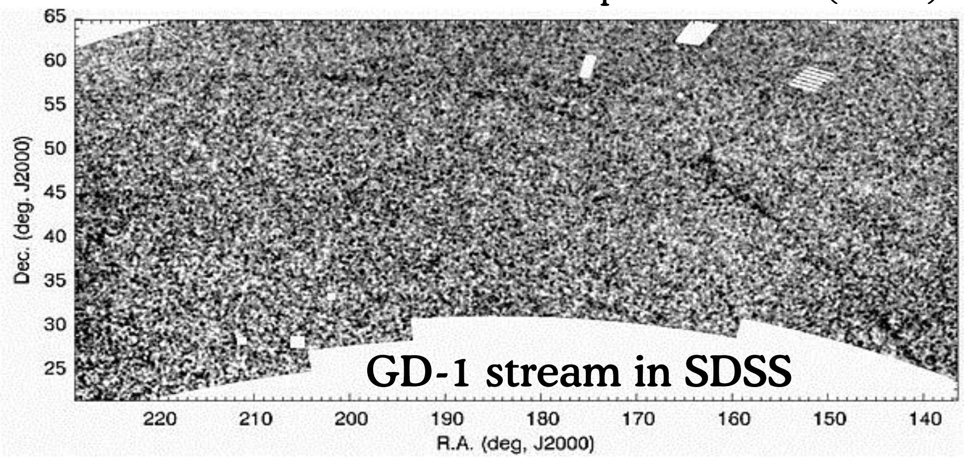
The Halo = Galactic Wild West

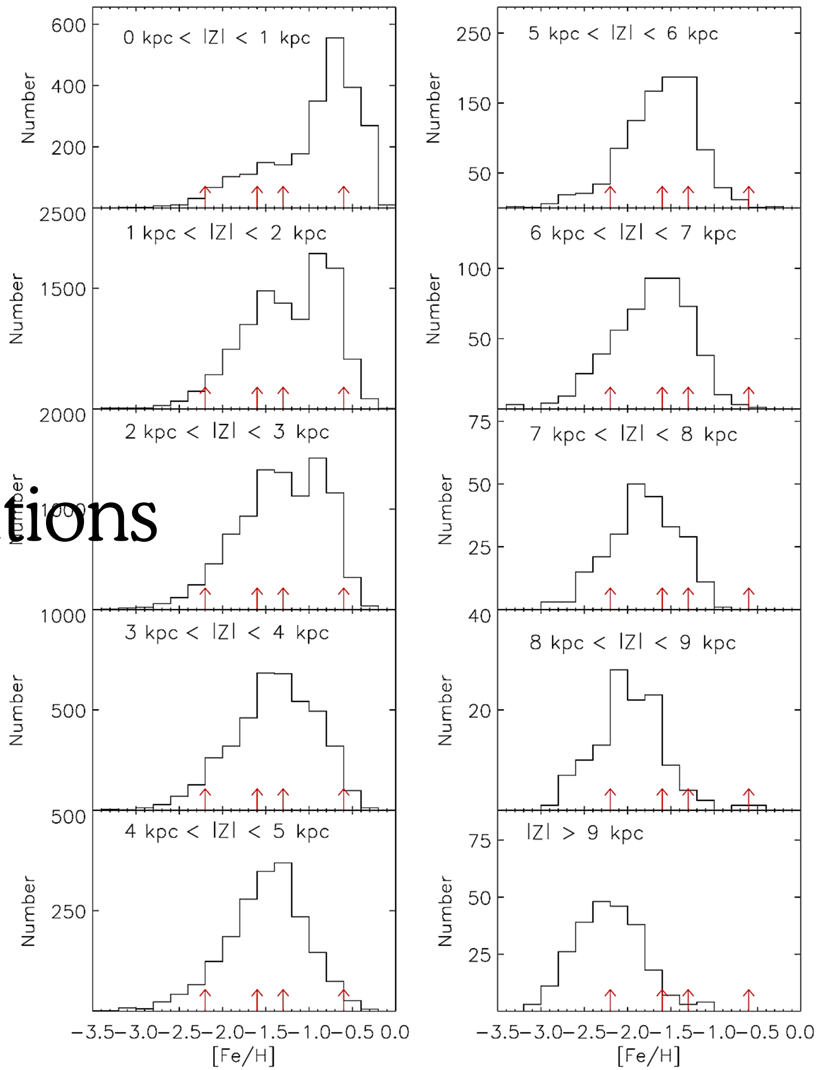


Belokurov *et al.* (2006)

Observations

Koposov *et al.* (2010)

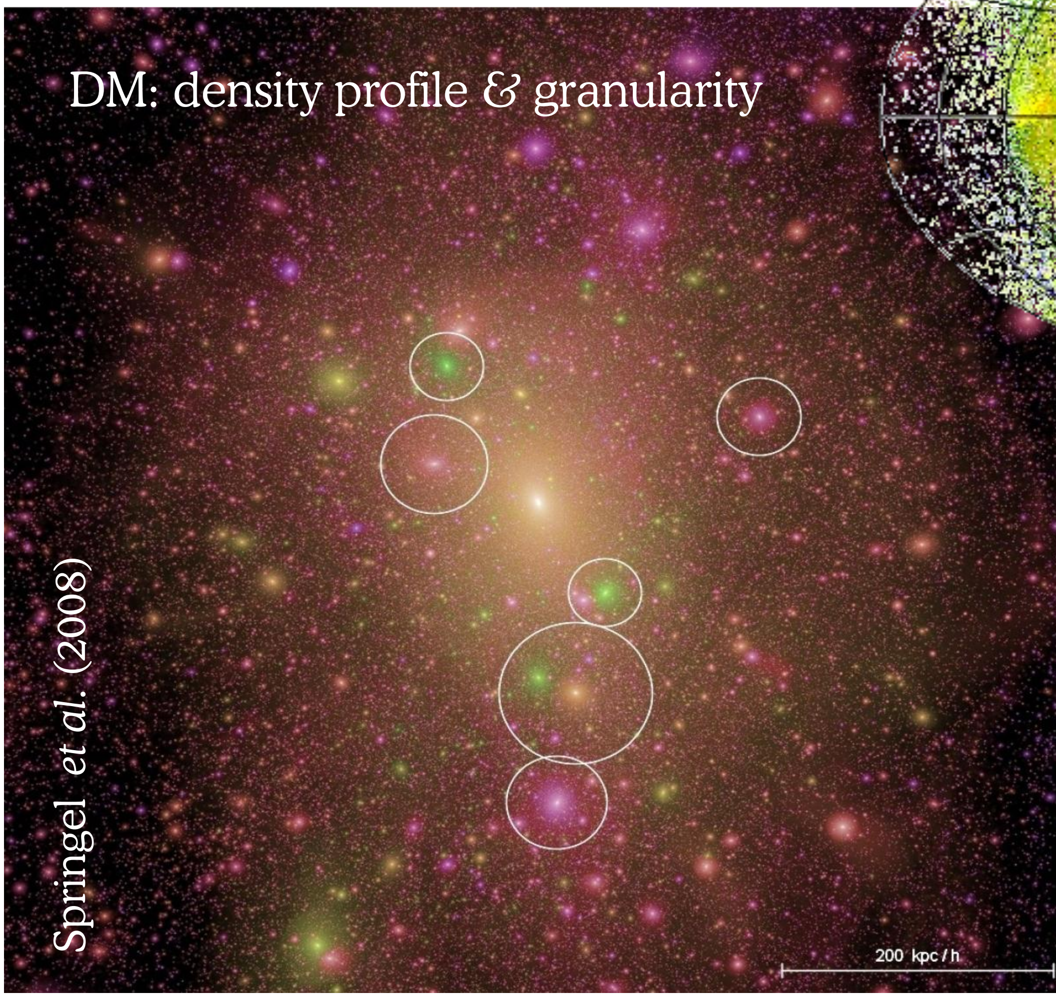


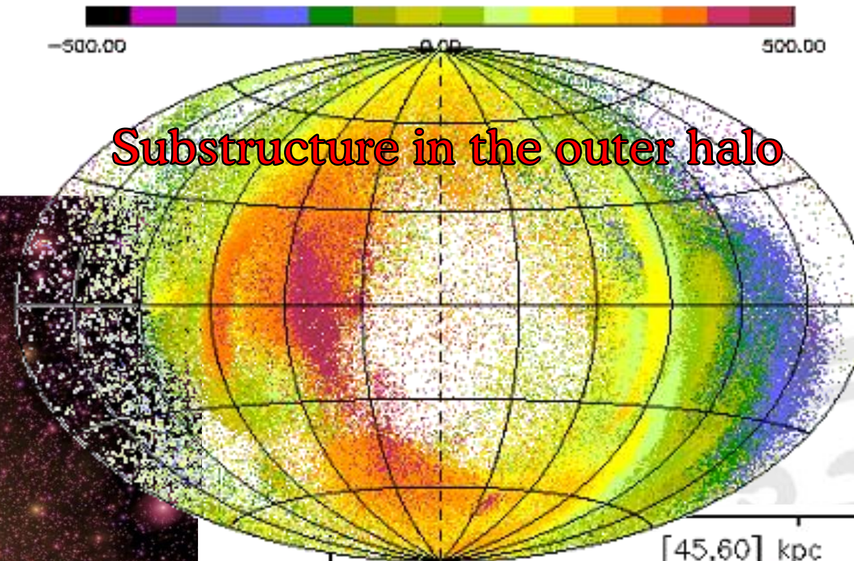


Carollo *et al.* (2010)

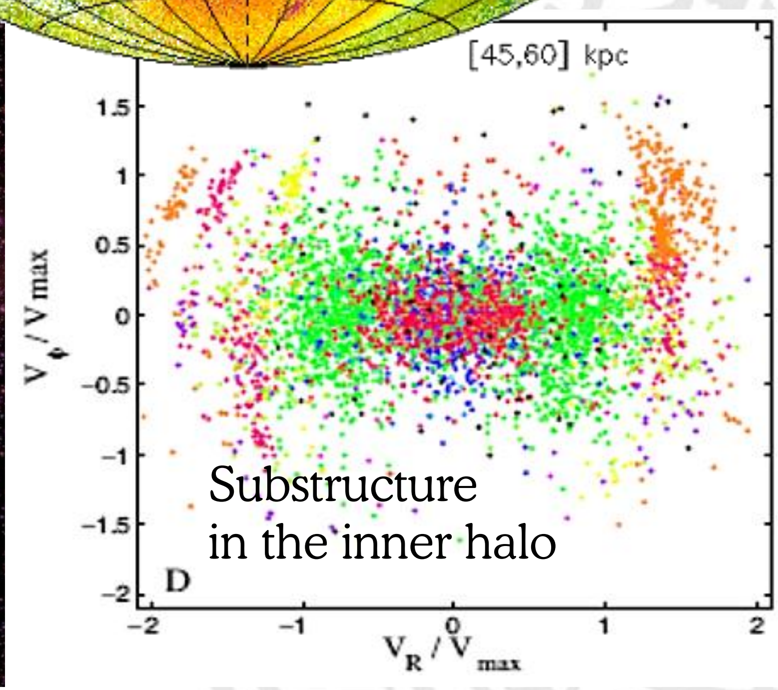
The Halo = Galactic Wild West

Theory





Cooper *et al.* (2010)



Gomez *et al.* (2010)

Key questions

- What were the properties of the First Stars?
- What is the metallicity distribution function (MDF) of the halo? What is its temporal evolution?
- How different are the chemical enrichment histories of the progenitor systems?

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- What is the metallicity distribution function (MDF) of the halo? What is its temporal evolution?
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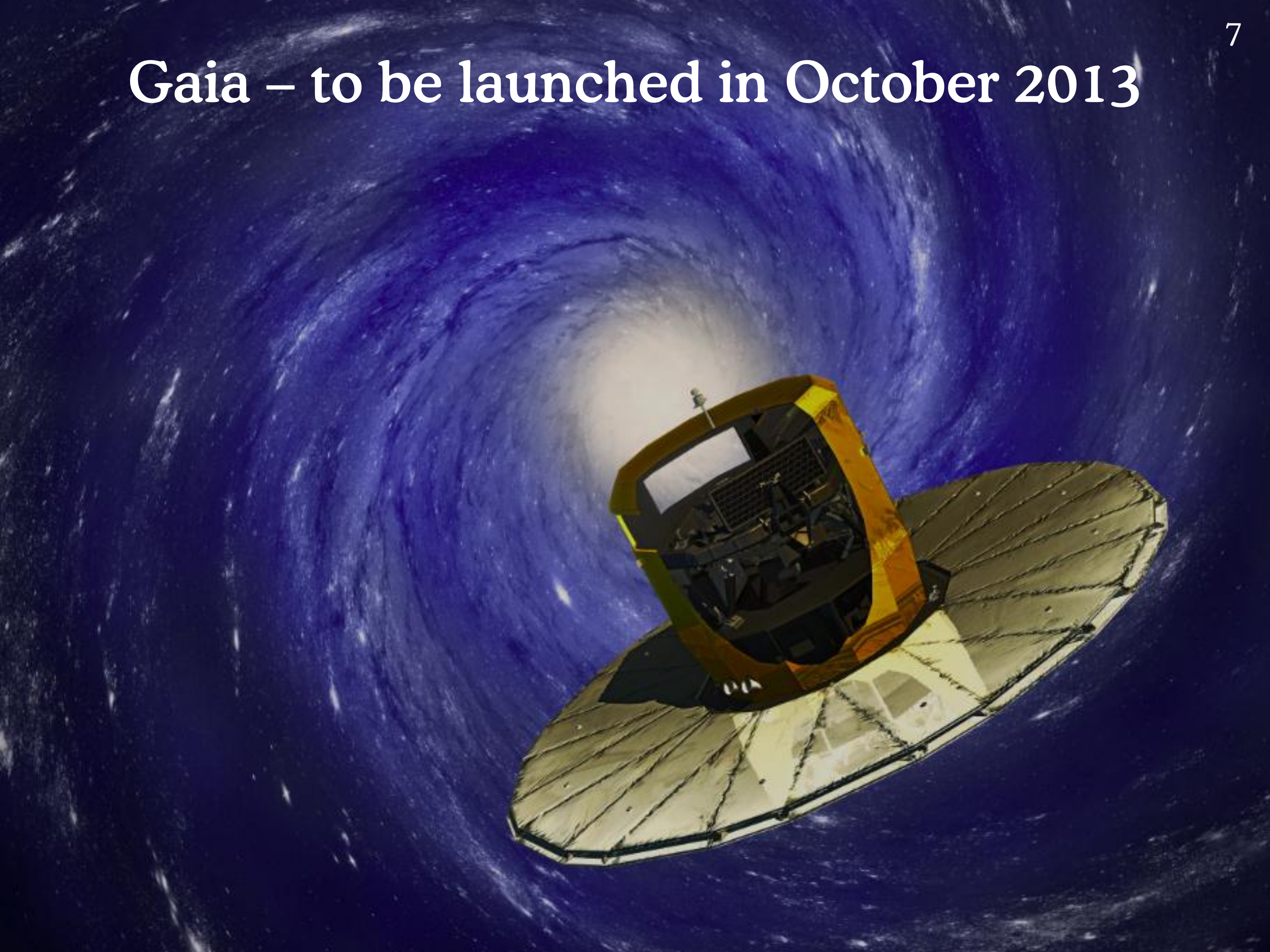
- What is the shape of the DM halo: spherical, oblate, prolate, triaxial? Can we trace its temporal evolution?
- How many building blocks, dark and luminous-but-faint, are there: enough to explain the satellite crisis?
- How was the Milky Way assembled? Bulge, bar, thick disk...

Gaia – to be launched in October 2013



Gaia in a nutshell (2013 – 2018)

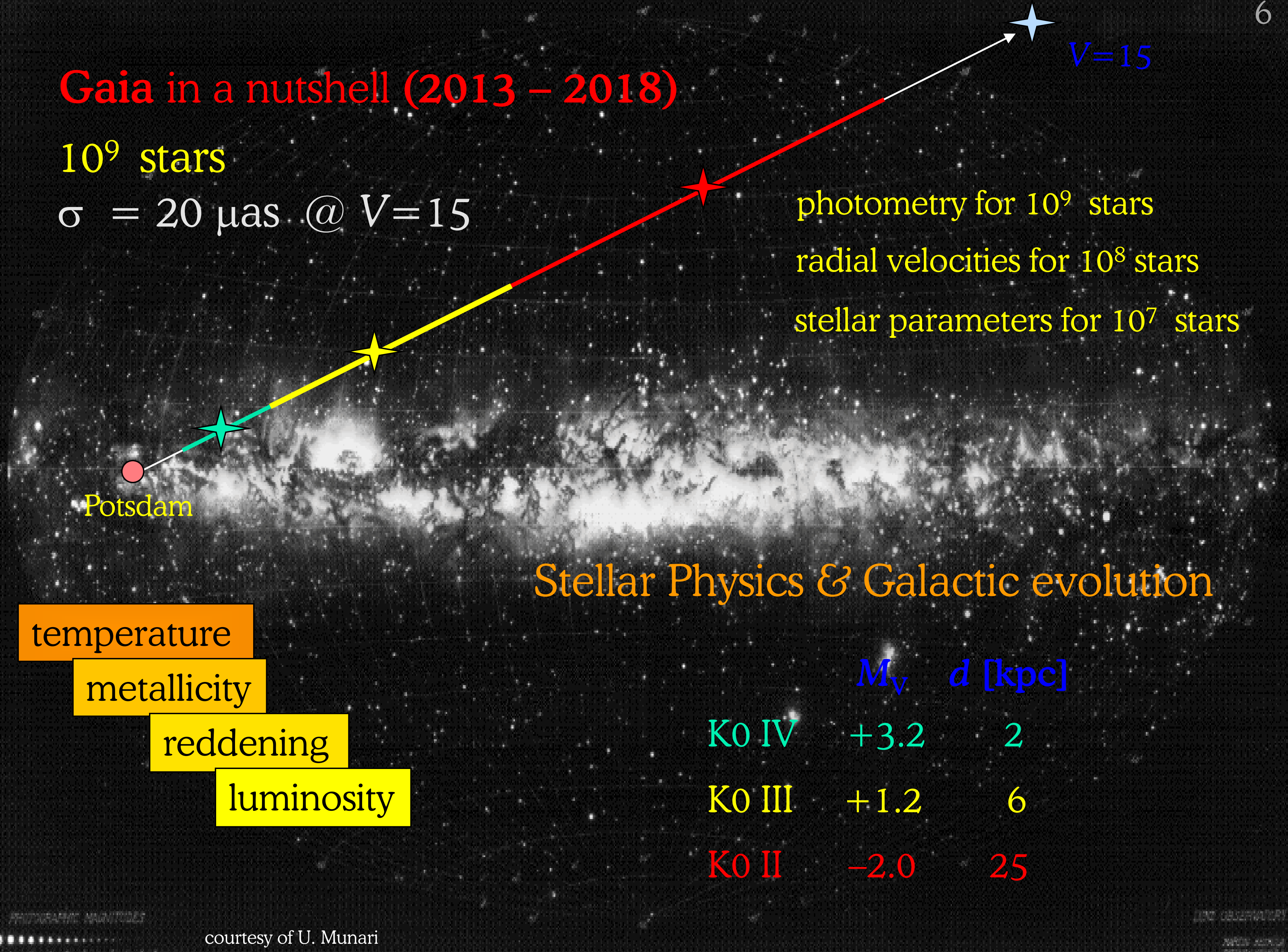
10^9 stars

$\sigma = 20\ \mu as$ @ $V=15$

photometry for 10^9 stars

radial velocities for 10^8 stars

stellar parameters for 10^7 stars



Stellar Physics & Galactic evolution

temperature

metallicity

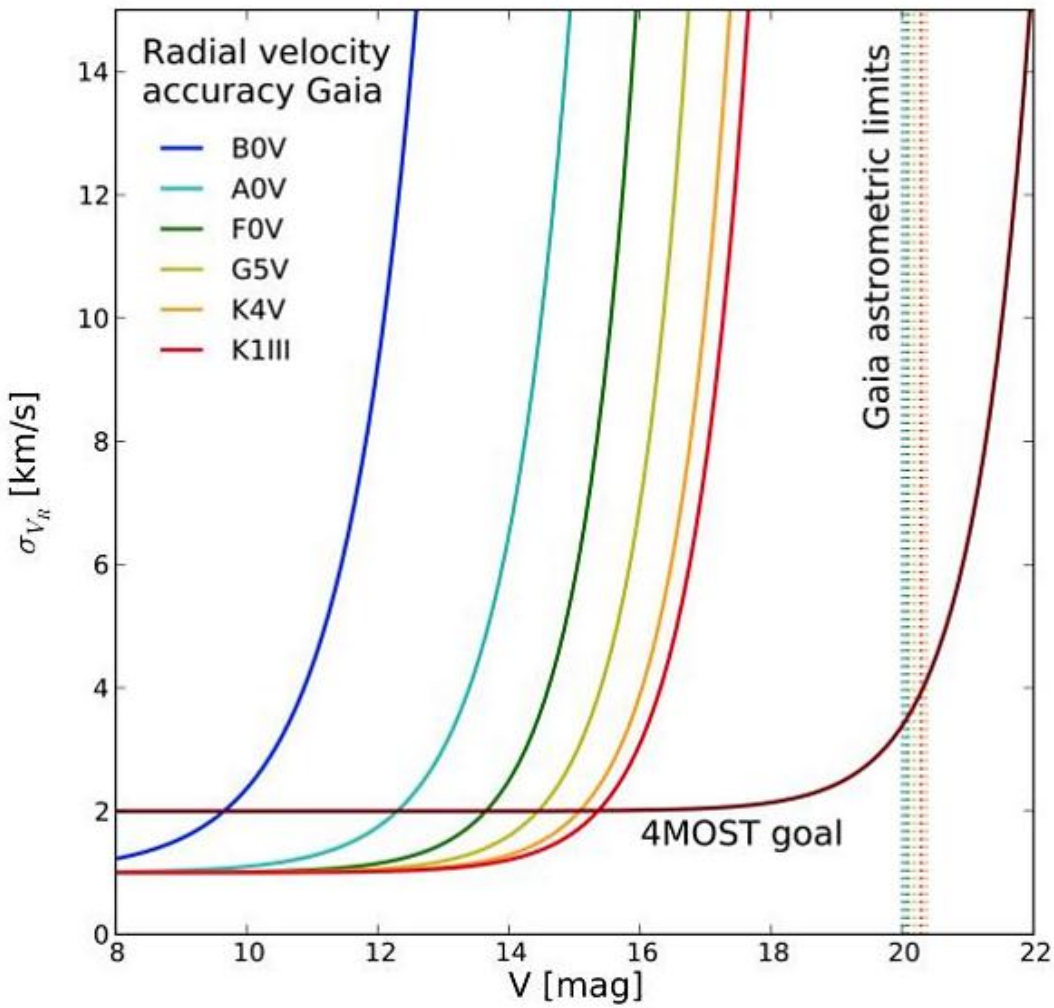
reddening

luminosity

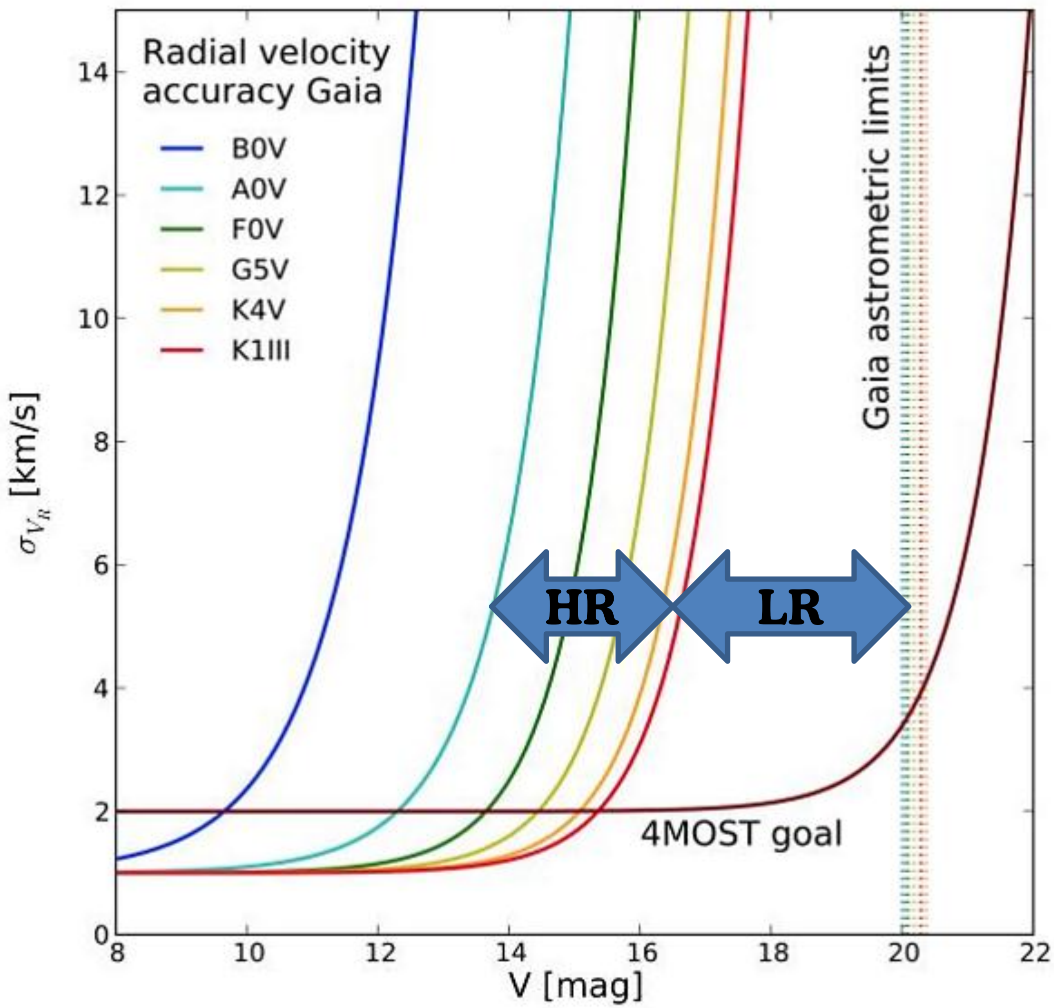
	M_V	d [kpc]
K0 IV	+3.2	2
K0 III	+1.2	6
K0 II	–2.0	25

courtesy of U. Munari

Limitations of Gaia I: υ_{rad}



Limitations of Gaia I: υ_{rad}



Limitations of Gaia II: A_i

2-D	→	3-D	→	5-D	→	6-D	→	12+ D
Position		Parallax		Proper motions		Spectrum		Astrophysical parameters
Ultra-precision, over years		Distance		Transverse velocities		Radial velocity + chemistry		Ages, histories, astrophysics

Gilmore *et al.* (2012), The Messenger

Constraints:

V, M_V: go deep into the halo ⇒ K giants (TOP stars) as tracers
FOV/sky coverage: needs to be large, as target density is fairly low
R: 5,000 (LR) / 20,000 (HR) is a good compromise given the lower line density in spectra of metal-deficient stars
λ: covering key elements, for the spectroscopic analysis ($\upsilon_{\rm rad}$, $T_{\rm eff}$, log g) and probing the major nucleosynthetic channels (up to 20 species)

Halo LoRes DRS

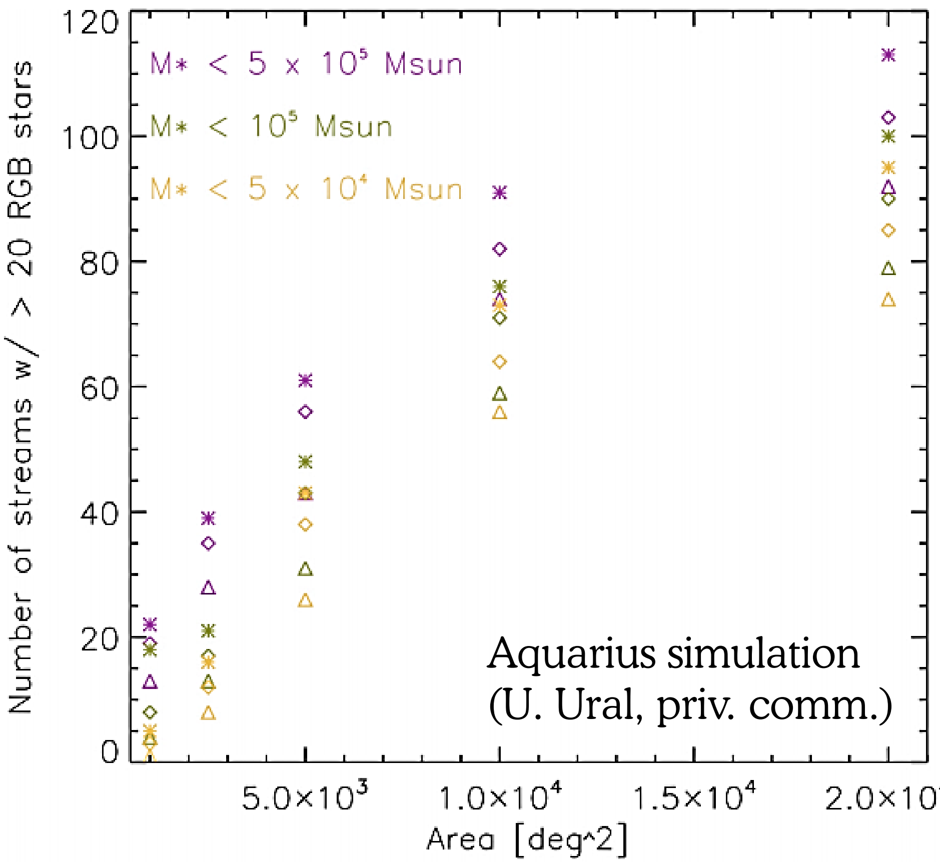
Target density: 100-200 K giants deg^{-2} down to V=20

To constrain the **mass distribution of the MW and the DM granularity** imprinted on the velocities of stream stars, we need to

- survey 5,000 deg^2,
- get υ_{rad} to 1-2 km/s

To achieve this, spectra of SNR=10 per Å at Mg b and Ca T are needed. Such spectra can be used to get rough metallicities. UMP targets!!!

Harvest: 1.5 million halo giants across the virial volume of the MW



Halo HiRes DRS

Substructure survey strategy

Assuming that there are as many as 500 streams in the halo, we need 500 * 100 = 50,000 stars minimum to characterize the substructures chemically.

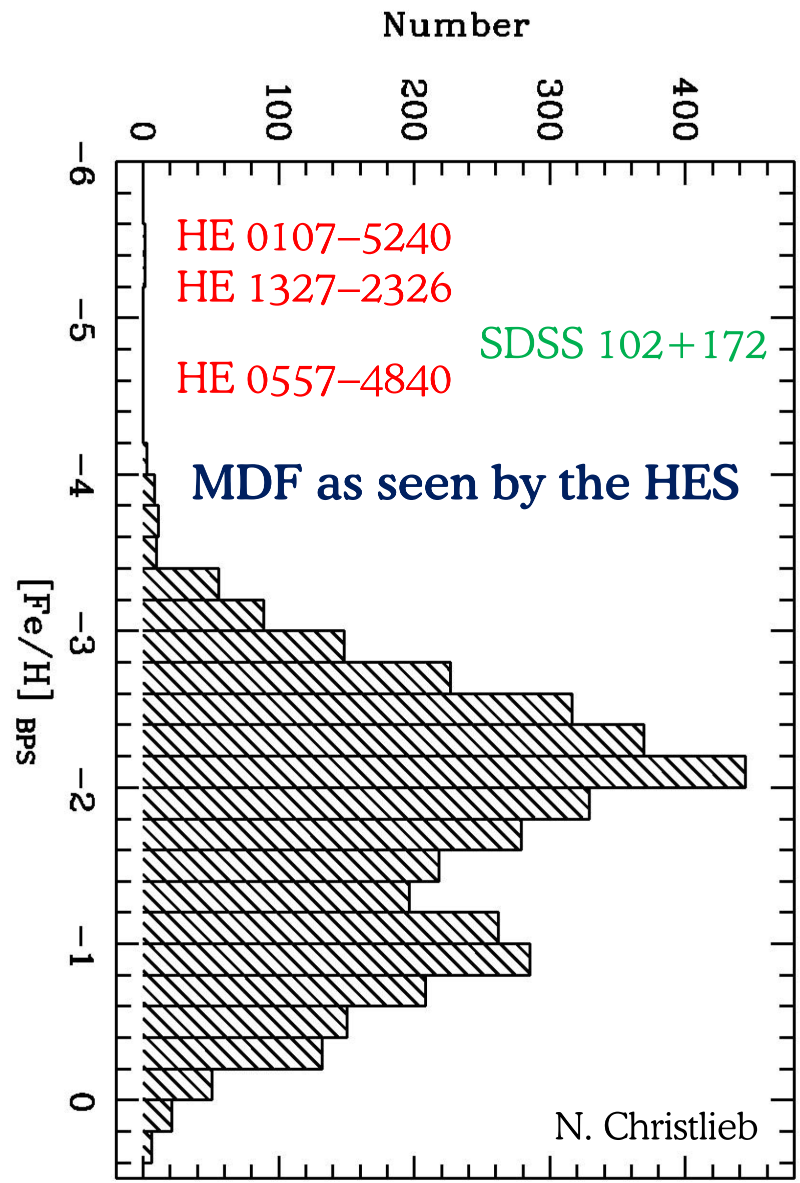
MDF survey strategy

Preselect stars to be metal-deficient ([Fe/H]<–1) using Skymapper or Gaia.

Observe ***all*** giant stars acccessible to 4MOST with *V*<16.

SNR requirement: 50 pixel^{-1} (150 Å^{-1})
(2 h exposures at the faint end)

Harvest: 100,000 metal-deficient giants with detailed chemical passports (× 100), below ([Fe/H]=–2.5 × 10, new UMP stars.

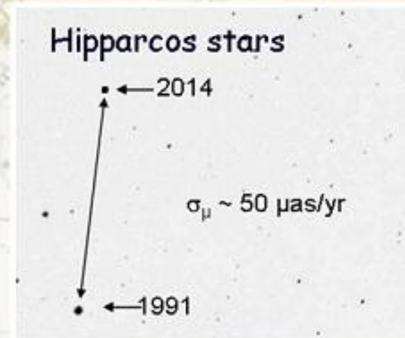


Gaia Data Releases

Release

L + 22m

α deg 8	δ deg 9
4.18700521	41.06905721
57.84982093	−25.93298679
87.24506095	63.69702032
	50422



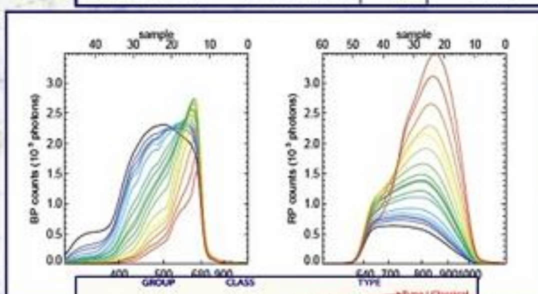
L + 28m

α deg 8	δ deg 9	π mas 11	μ_{α^*} mas/yr 12	μ_δ mas/yr 13
4.18700521	41.06905721	18.92	190.14	27.75
57.84982093	−25.93298679	21.42	273.72	167.93
87.24506095	63.69702032	4.12	5.07	−98.19
97.98452970	−27.72950422	17.95	21.31	217.87
106.43757563	26.14031575	21.74	18.58	−10.54
109.41026120	−29.01434479	7.92	−4.53	−7.01

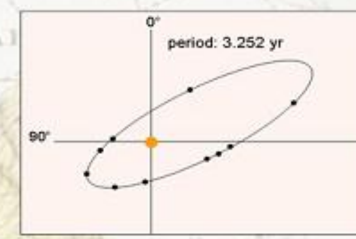
G G_{BP} G_{RP}

L + 40m

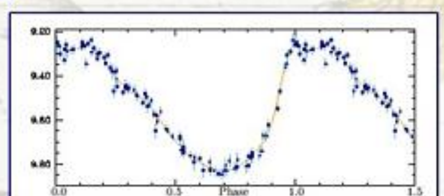
=2017.3

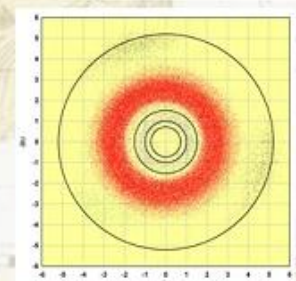


<Vr>



L + 65m





F. Mignard

Conclusions

The 4MOST Galactic (halo) DRSs can make very significant contributions to our understanding of the assembly and chemo-dynamical evolution of the Milky Way.
In conjunction with Gaia astrometry, this field of science will be truly and lastingly transformed.

In 2022, we will know a great deal more about the DM distribution, the nature of the first stars and why the Milky Way looks the way it does.

On top of that…

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Expect the unexpected!