Old Open Clustes & the Galactic disk (LoI ESO LSS)

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The LoI (FLAMES)

PI S. Randich, about 70 co-Is

Open Star Clusters: the path from molecular clouds to the MW disc population

Towards a revolution in cluster science: Gaia + FLAMES

1. The evolution of OCs and associations: from birth to disruption
2. The evolution of stars in clusters: from birth to death
3. The population and evolution of the Milky Way thin disc

Why old Open Clusters ?

- describe the MW disk
- chemical evolution
- stellar models
- as a bridge between GCs and field

History of the disk ➔
concentrate on OLD clusters

Radial migration

Roškar et al. 2008, 2009

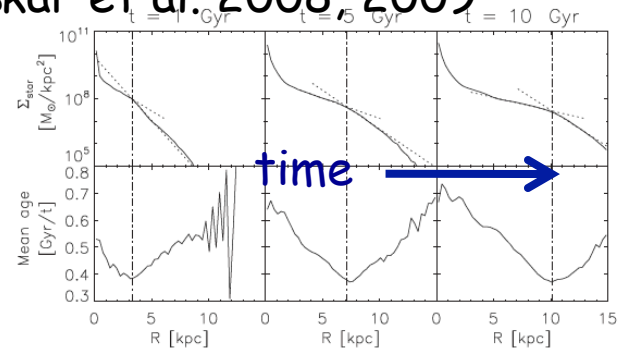
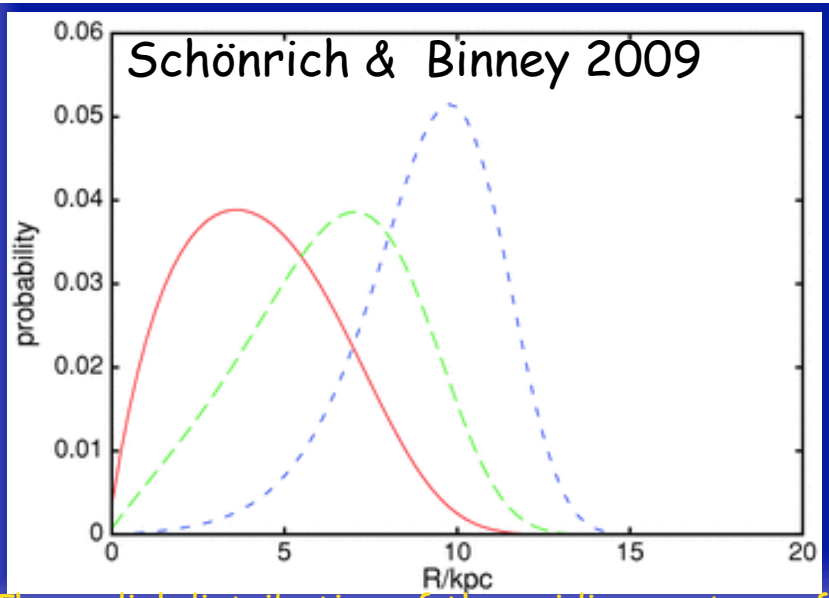
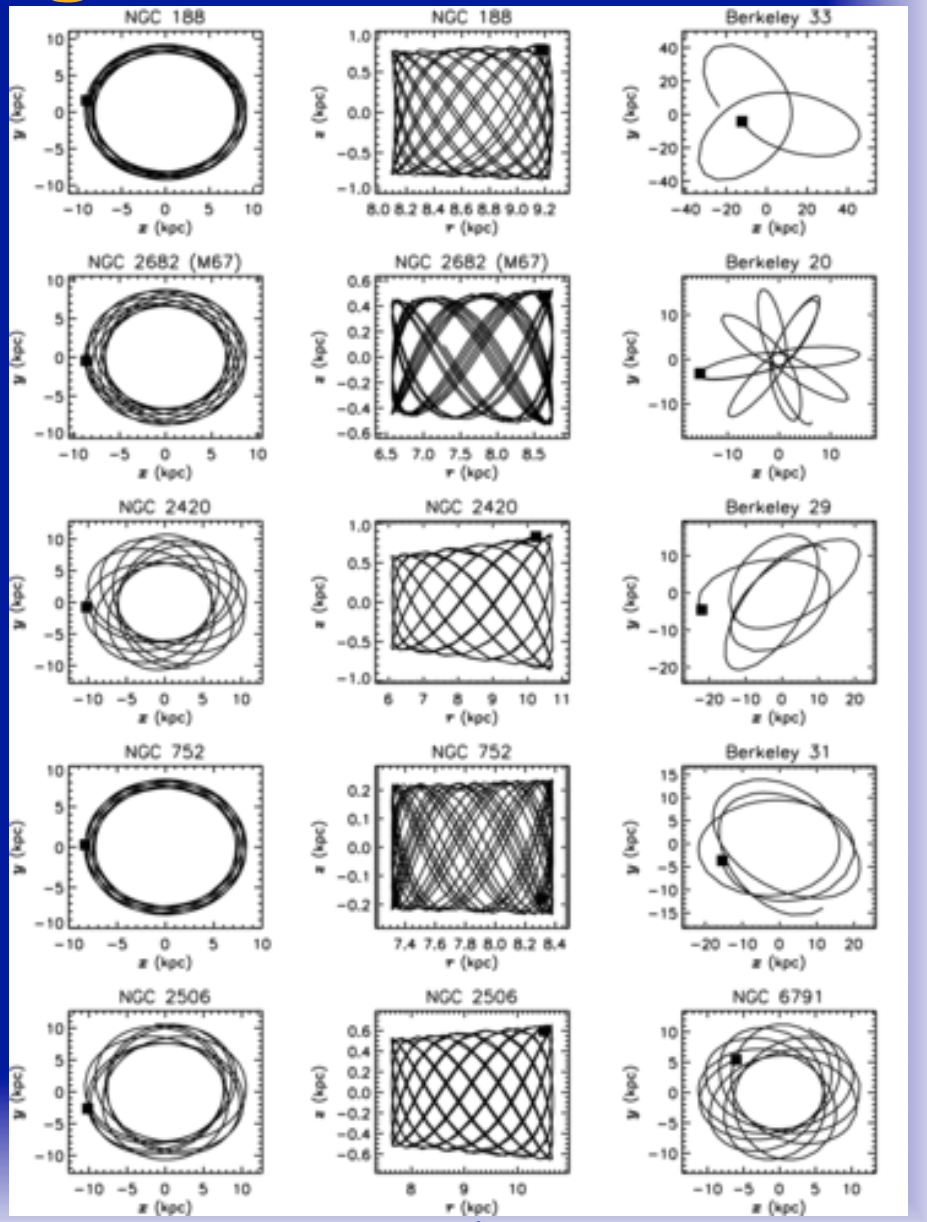


Figure 1. The stellar surface density (top panels) and mean age profiles (bottom panels) at three different times in the simulation. The dashed lines in the upper panels are double exponential fits to the surface density profile. The vertical dashed lines indicate the location of the break in all panels. At all times, the break corresponds to a minimum in the stellar mean age, which arises due to the significant radial migration of stars.

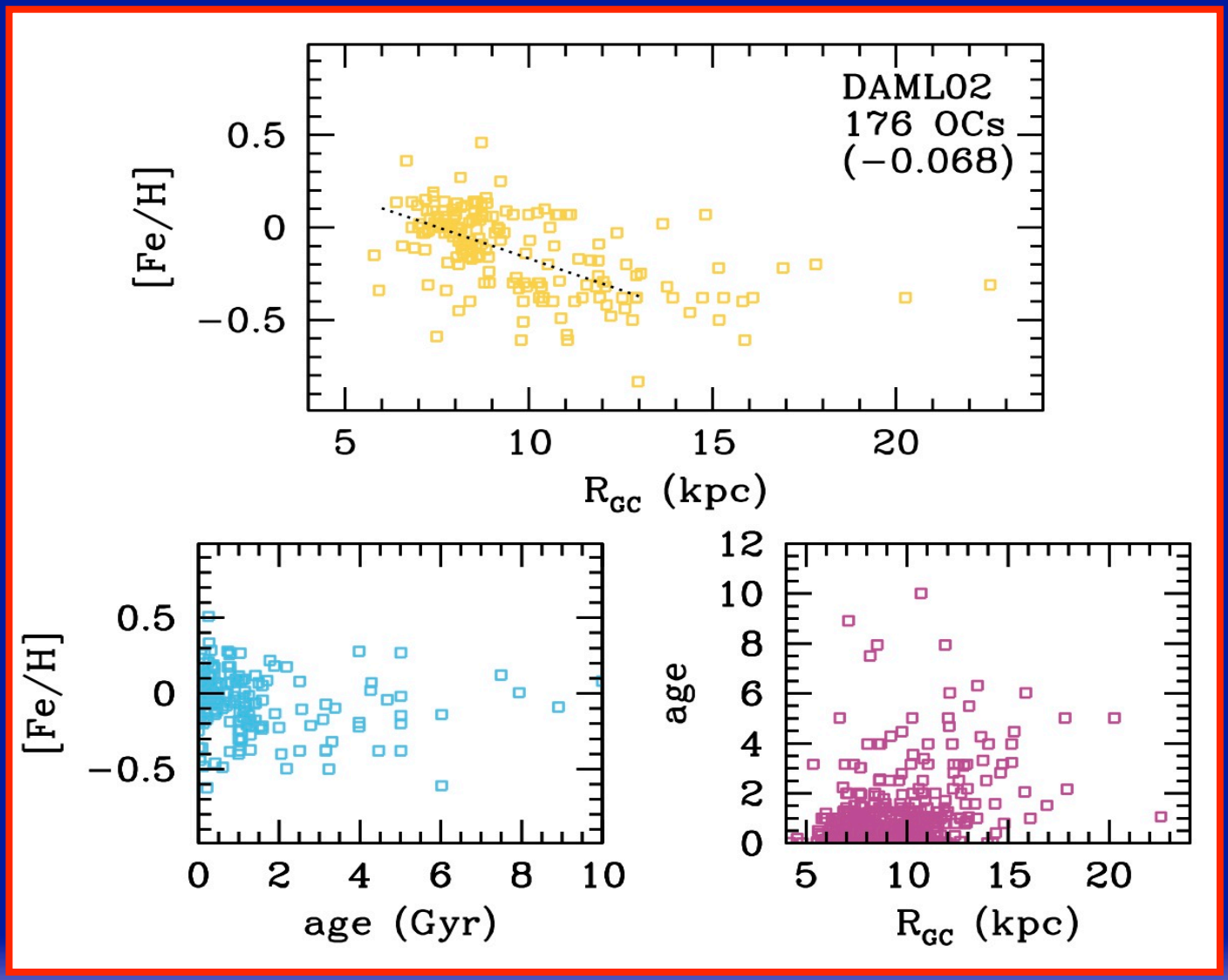


The radial distribution of the guiding centres of 12 Gyr old stars that were born at 5, 7.6 and 10 kpc when the churning fraction k_{ch}= 0.25.



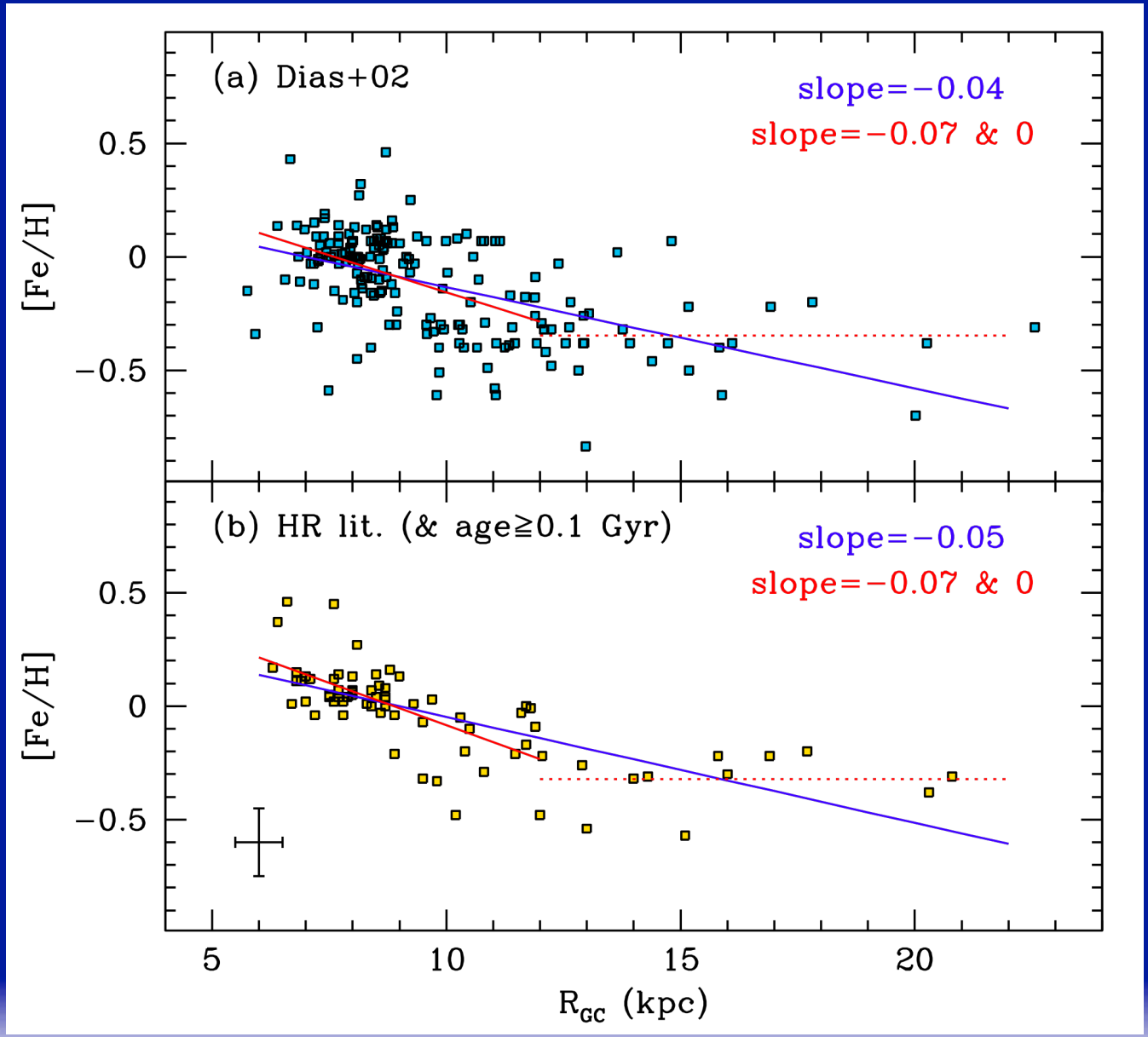
Wu et al. 2009

Present situation : Dias et al.

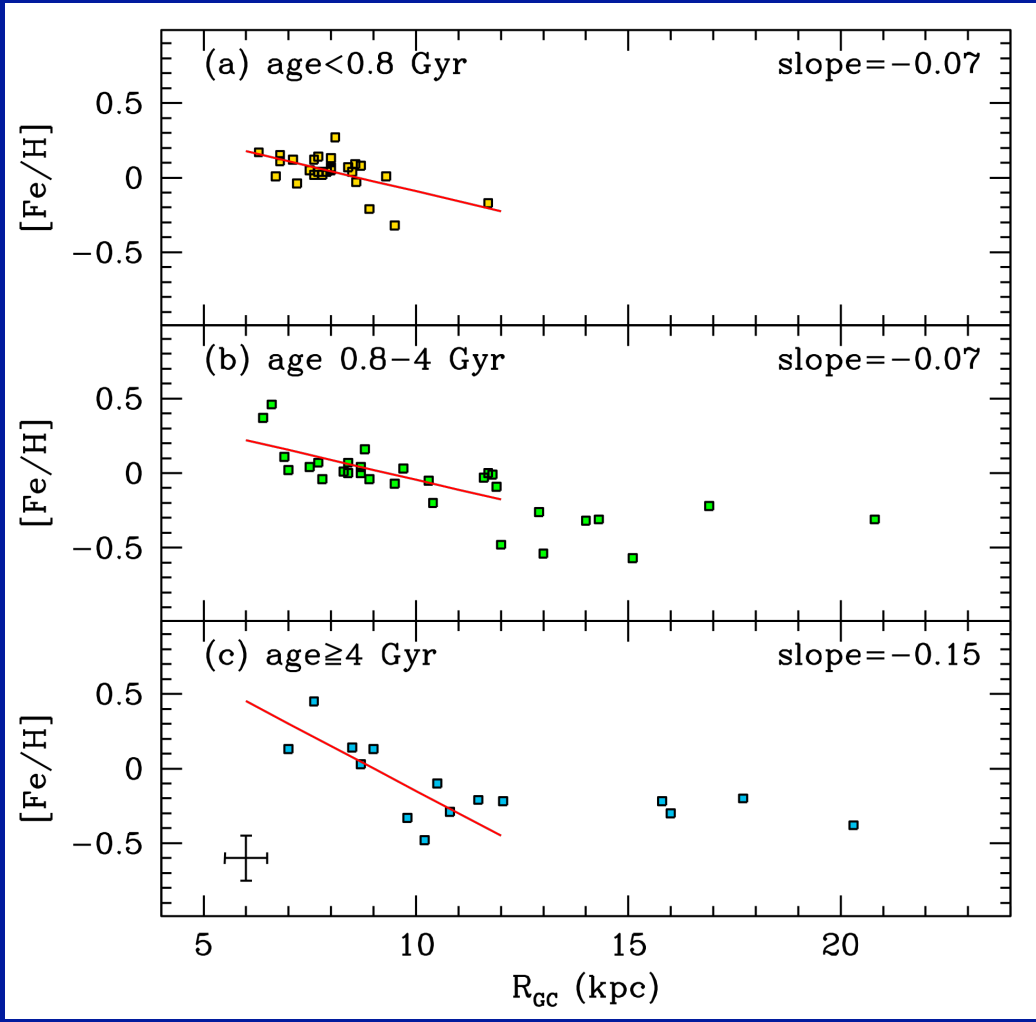


Non homogeneous age/distance/metallicity

Present situation : gradient



Present situation : gradient

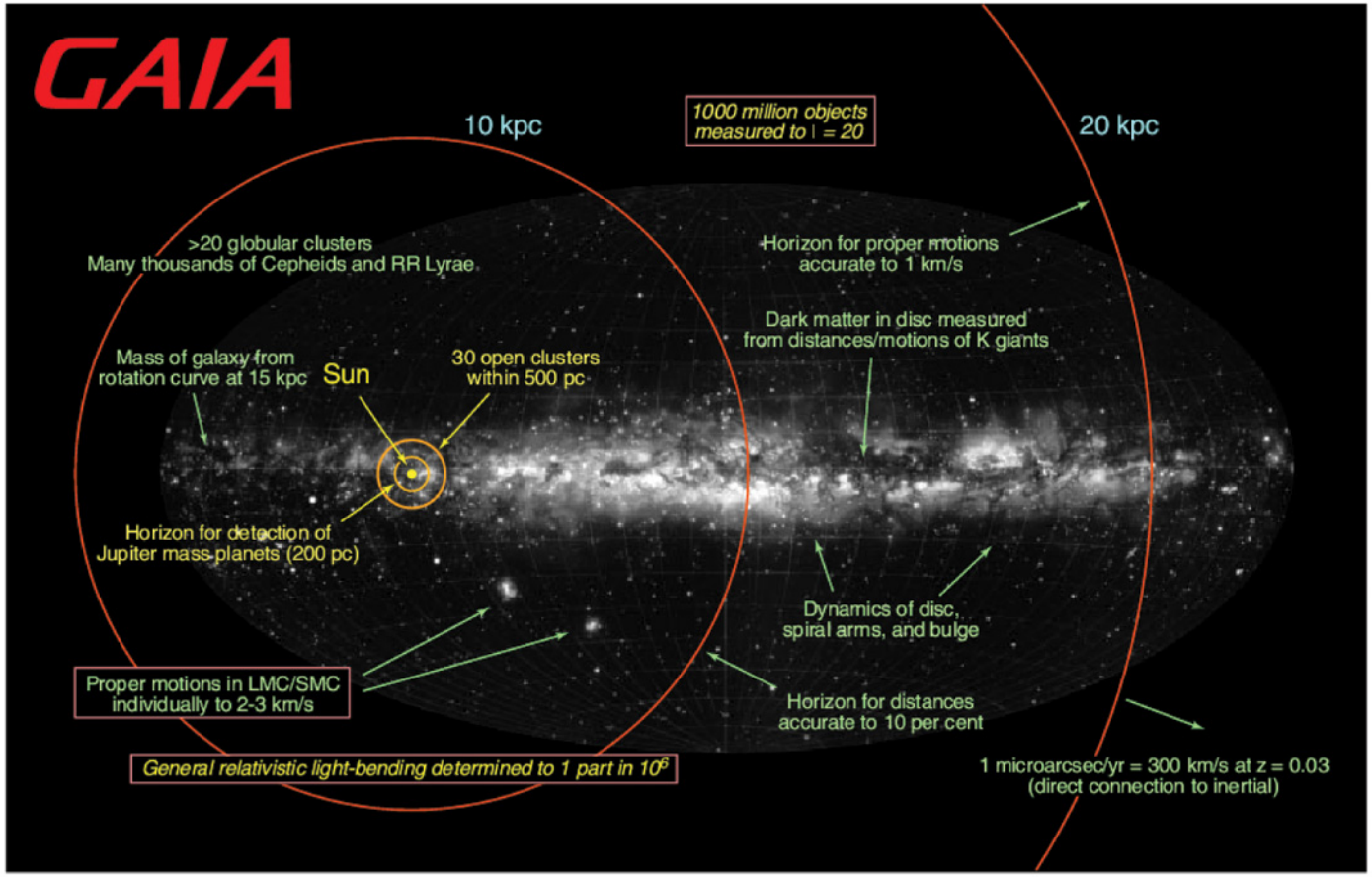


We need …

To fulfill the promise of open clusters we need:

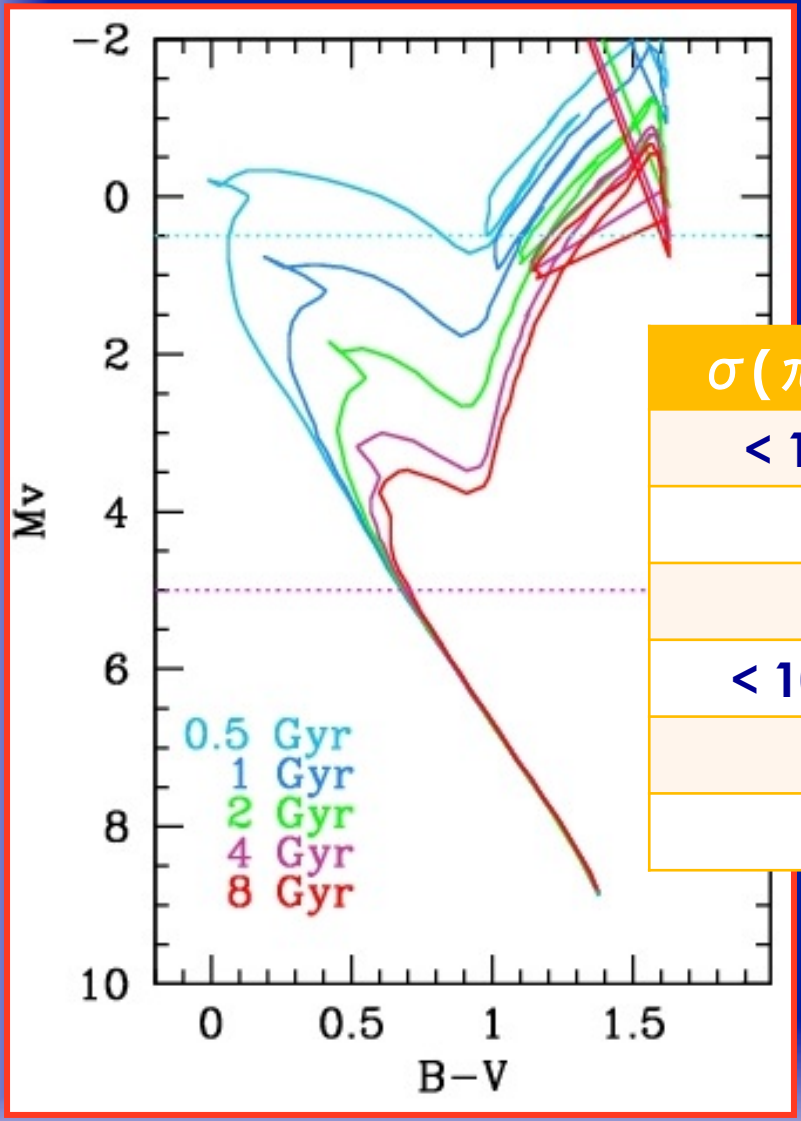
- Large samples, full MW coverage (position, age & metallicity)
- Add undiscovered/unstudied clusters
- Precise, deep photometry (wide/narrow band/IR) on wide fields
- Membership (p.m., RV, statistics?)
- Binaries
- Spectroscopy (R~5000 to R~50000) of many/"all" stars, i.e. MOS
- Stellar models (theo models, conversion theo-obs)
- Stellar parameters (Teff,logg)
- Maximum homogeneity

Waiting for Gaia



Credit Lund Obs & ESA http://www.rssd.esa.int

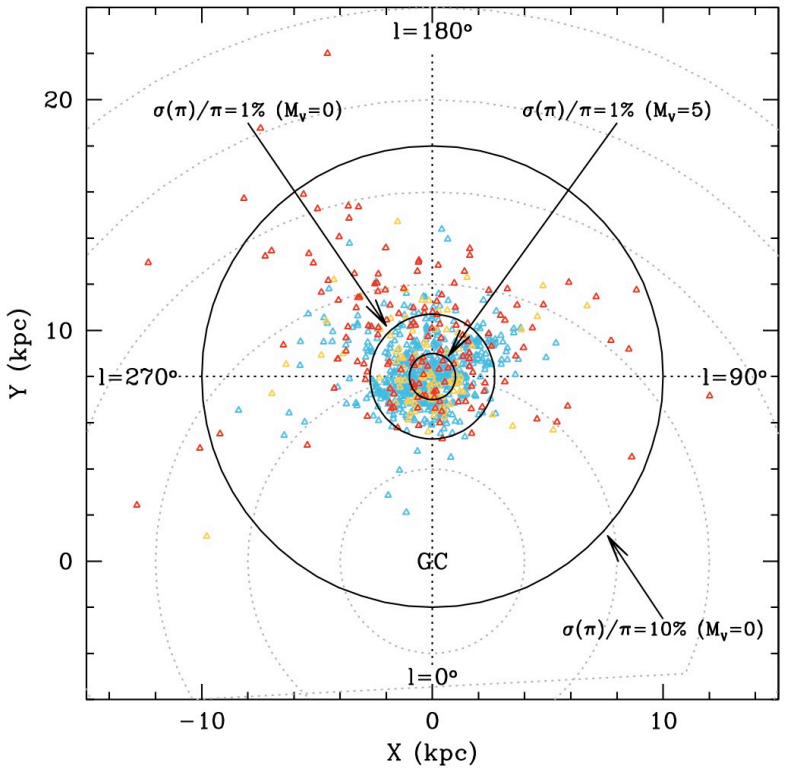
Waiting for Gaia

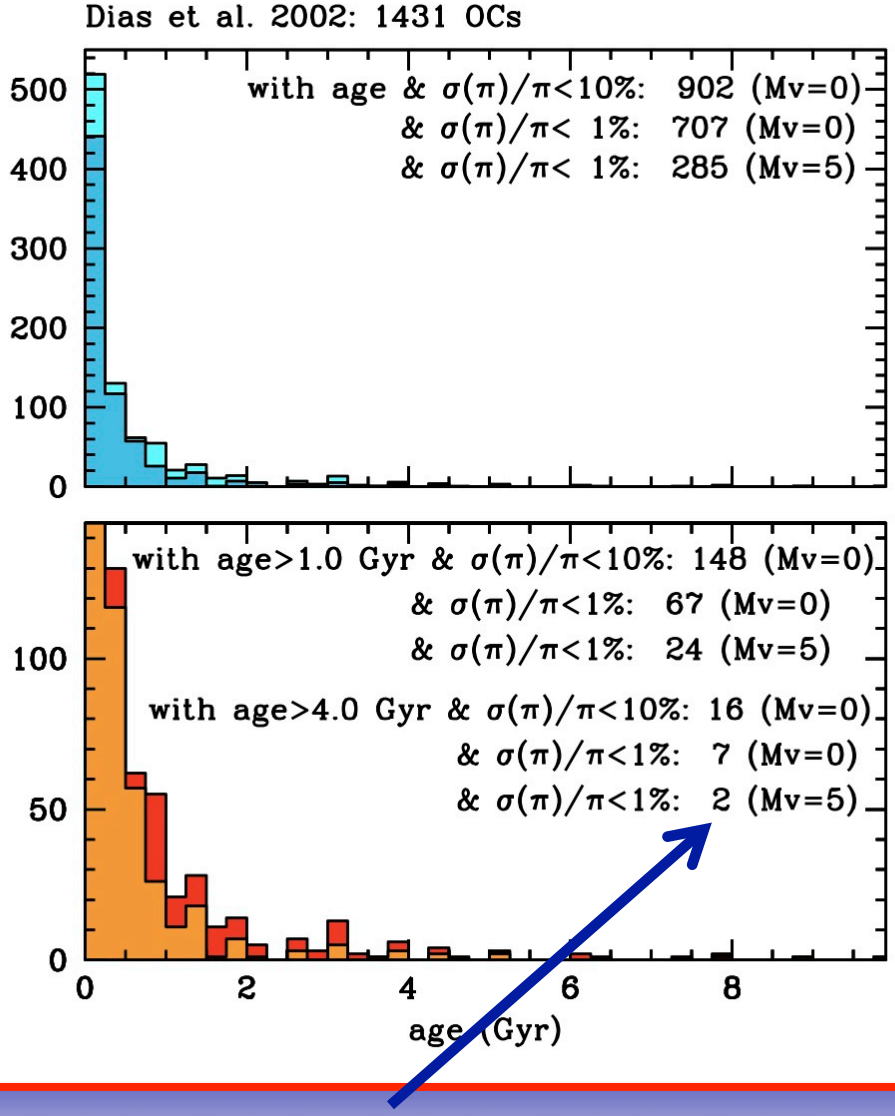


σ(π)/π	Mv	V	Dist (pc)
< 1%	-5	7	2700
	0	12	2700
	+5	15	1000
< 10%	0	15	10000
	+5	17	2700
	+10	20	1000

Waiting for Gaia

Dias, Alessi, Moitinho, Lepine (DAML), 2002, A&A, 389, 781):





Note: one of the 2 is NGC 2509 (age=1.2 Gyr in Carraro & Costa 2007 ...)

What Gaia will do best

Ages : theo models (uncertain, different)

Distances : π (Hipparcos*, 10^5 stars to V=13, 1-3 mas;
GCTSP, 10^4 stars, mag >13, 4-10mas) ;
CMD + theo models

p.m. : Tycho2, 2.5M stars to V=11.5, 2.5 mas/yr;
UCAC2, 48M stars to R=16, 1-7 mas/yr

Radial velocities : a few-a hundred stars (membership, binarity, internal dynamics?)

Metallicity : photometry (wide/narrow band) ;
low-res spec ; high-res spec

Detailed chemistry : high-res spec (R>30000)

…

*see van Leeuwen 2009, A&A 497, 209:
20 OCs ($D_\odot$<500pc), π's & p.m, CMDs & models

What FLAMES can do best

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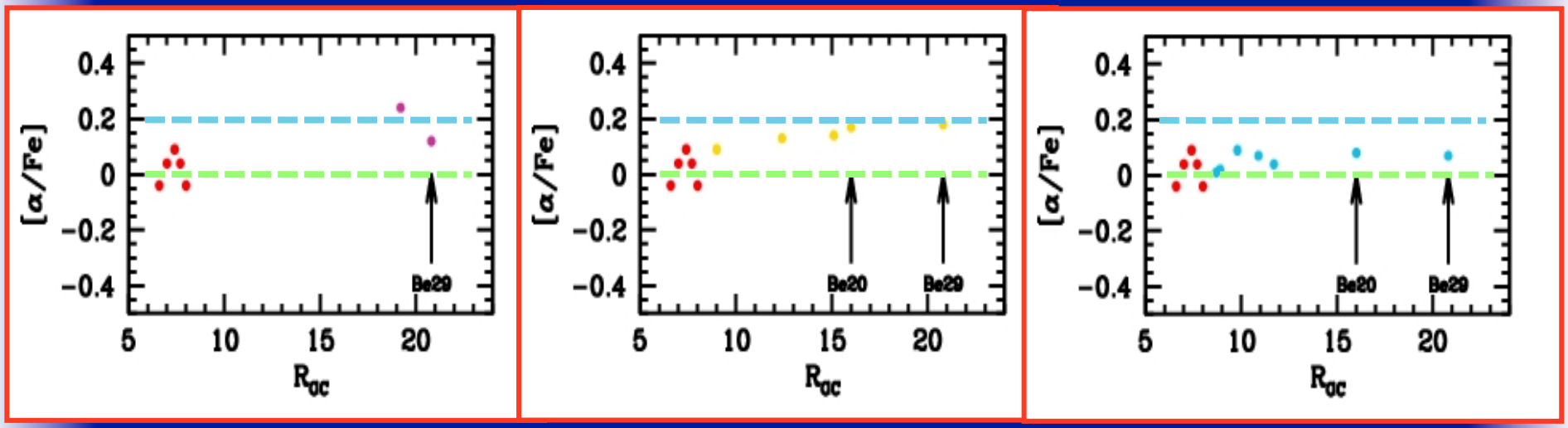
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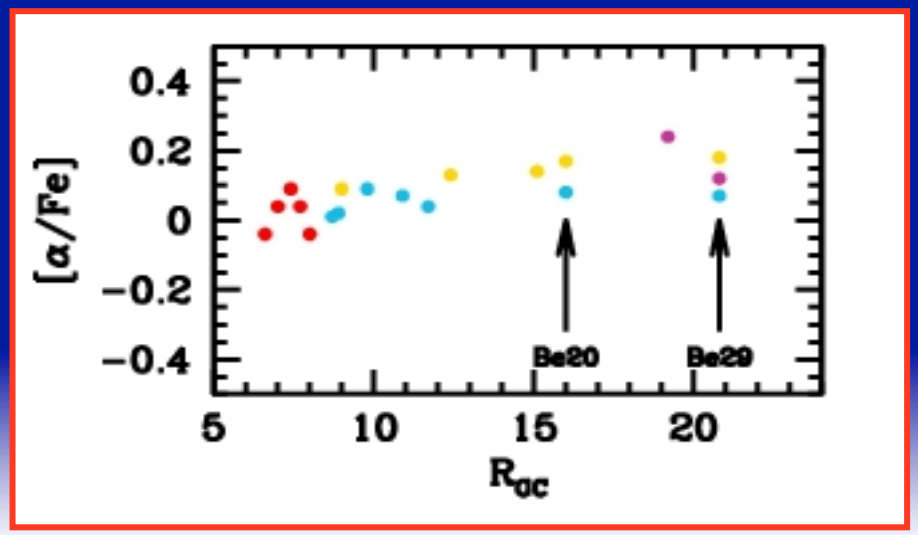
…

*see van Leeuwen 2009, A&A 497, 209:
20 OCs ($D_\odot$<500pc), π's & p.m, CMDs & models

Trend of [α/Fe] with R_{GC}

[α/Fe] vs R_{GC} : increase for outer disk ?





systematics

FLAMES LoI

Goal :

50 old OCs (age>0.5 Gyr) + 20 age 100-500 Myr

Targets :

G-K giants <16.5 (UVES 580) +

A-K dwarfs/giants < 19 (GIRAFFE HR15N, HR21)

Exposures :

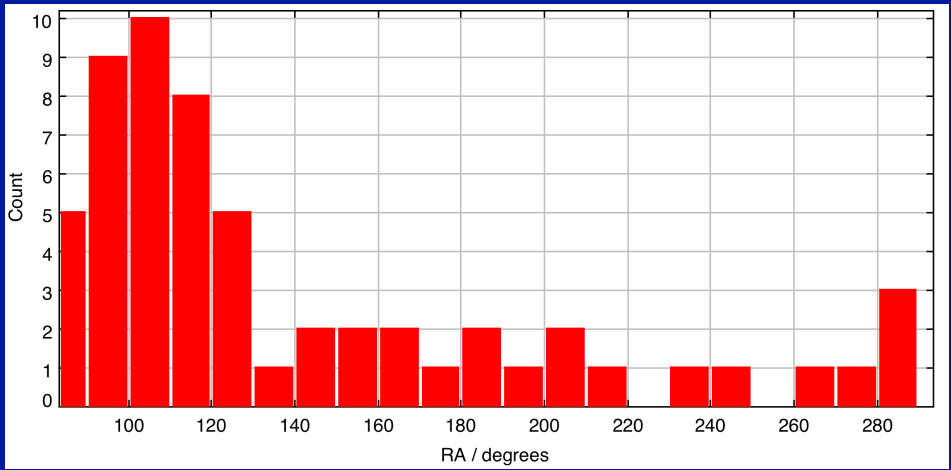
~12 1-hr OBs (different pointings & 2 epochs)

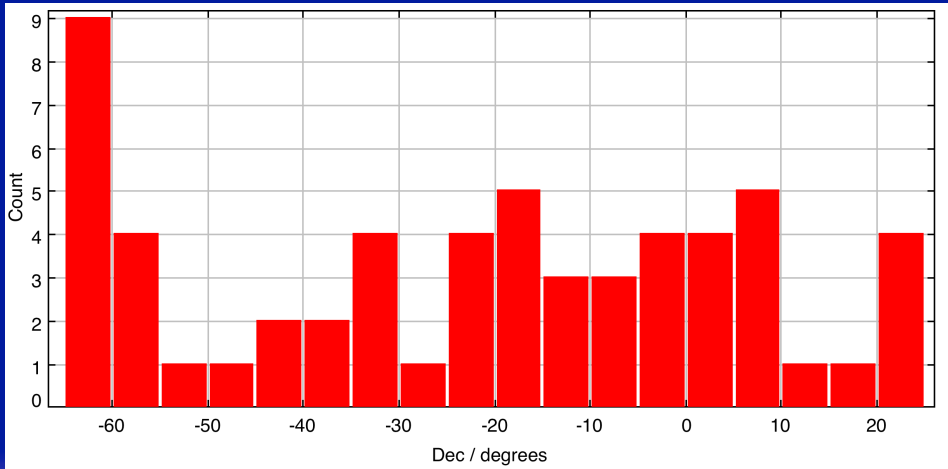
58 OCs selected (preliminar) from www.univie.ac.at/webda

- $\delta < +25^{o}$
- photometry available (astrometry…)
- not in ESO archive (7 partial data)

Many have [Fe/H] high-res, but only for a few stars & non homogeneous

FLAMES LoI



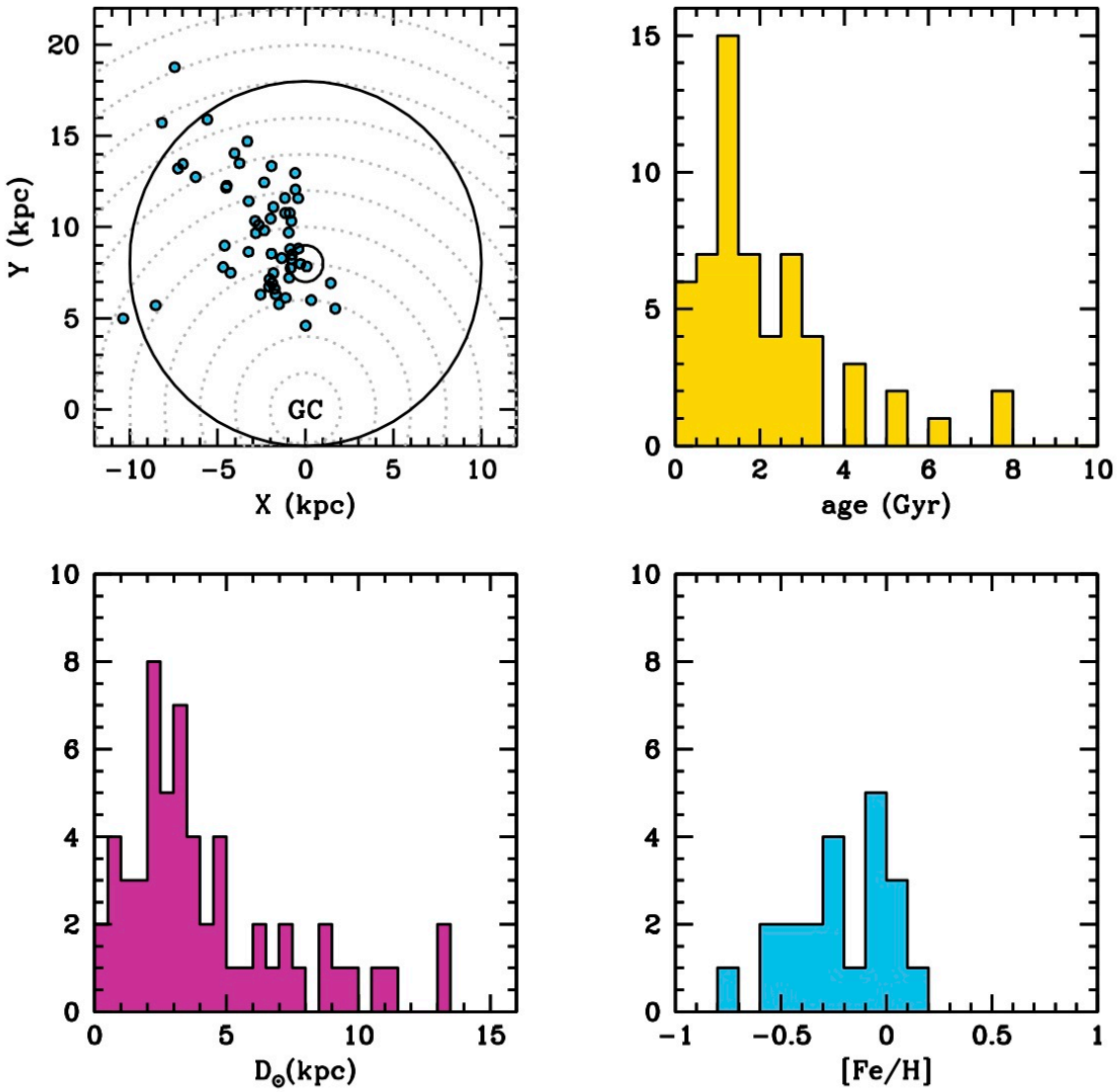


RA: ~ 5^h-20^h (peak ~7^h)

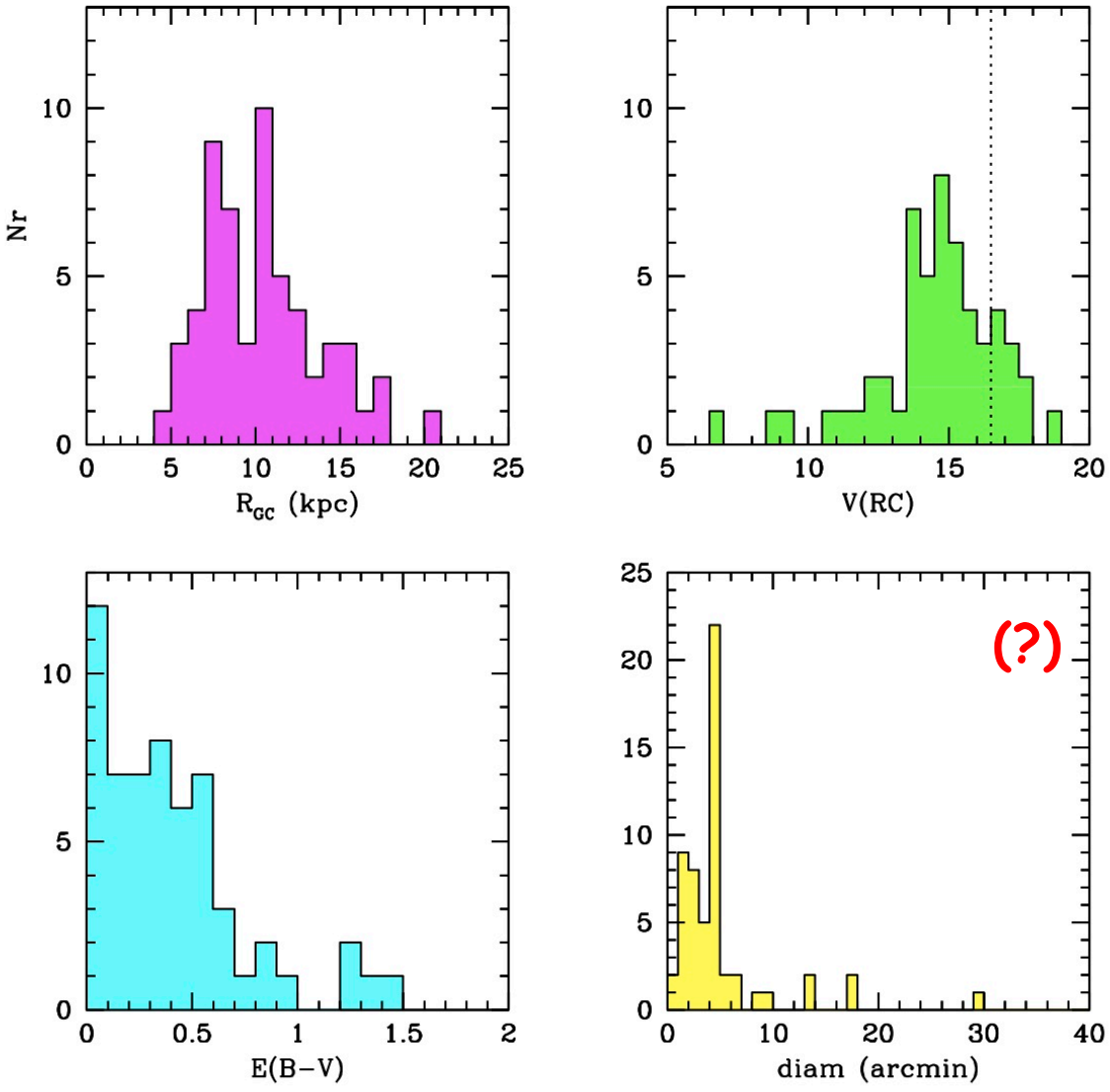
➔ concentrated in (Southern emisphere) spring/ summer/ fall

Dec < +25°

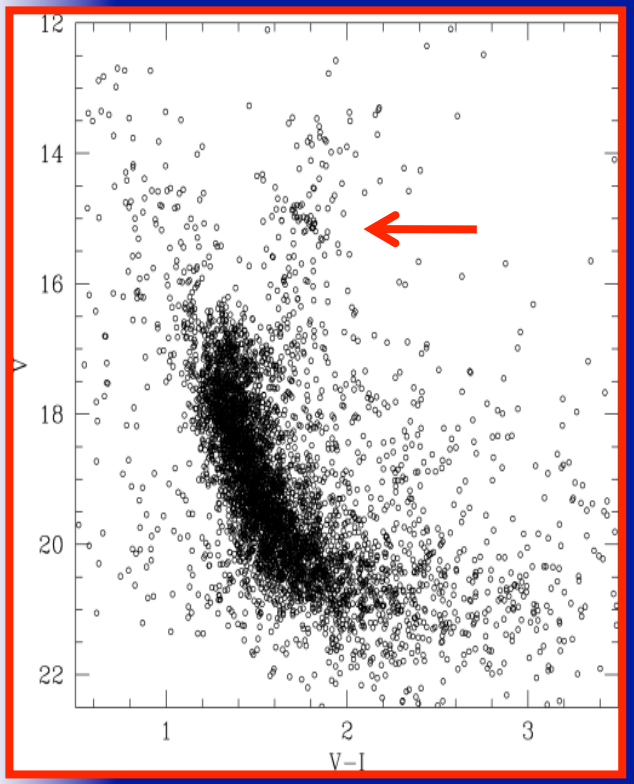
LoI: actively waiting for Gaia



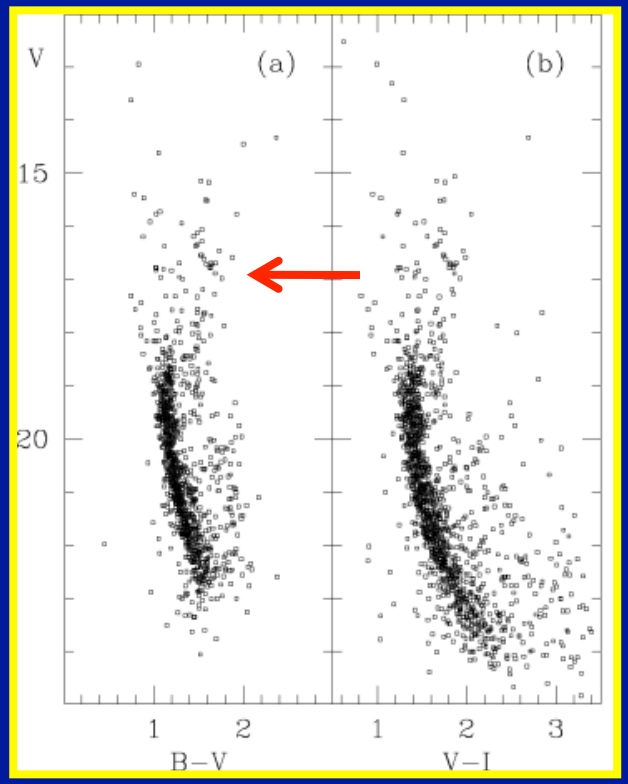
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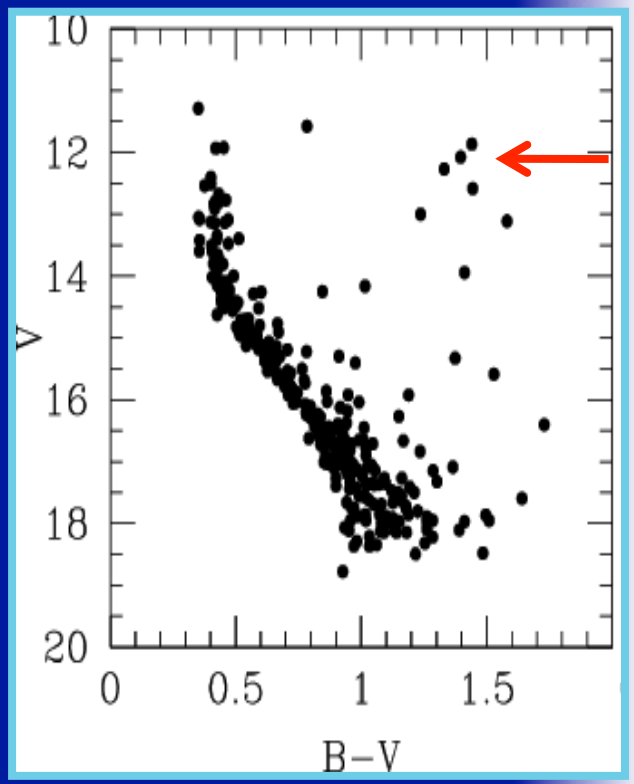
LoI: a few examples



Trumpler 5
(Piatti et al. 2004)
D=3 kpc, age=4 Gyr,
diam=14′
V(RC)=15

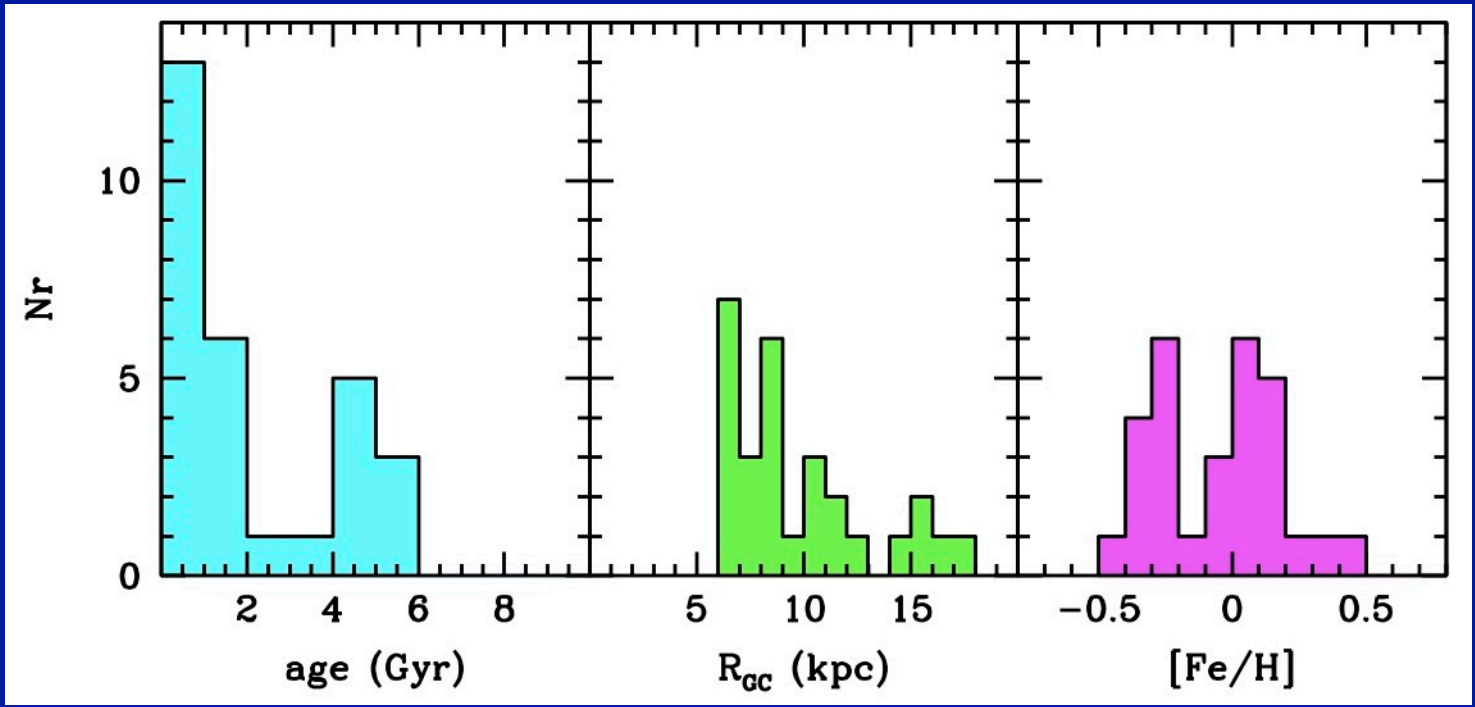


Berkeley 22
(Di Fabrizio et al. 2005)
D=5.8 kpc, age=2.4,
diam=1′, [Fe/H]=-0.3
V(RC)=16.5



Melotte 105
(Piatti & Costa 2001)
D=2.2 kpc, age=0.2 Gyr,
diam=5′
V(RC)=12

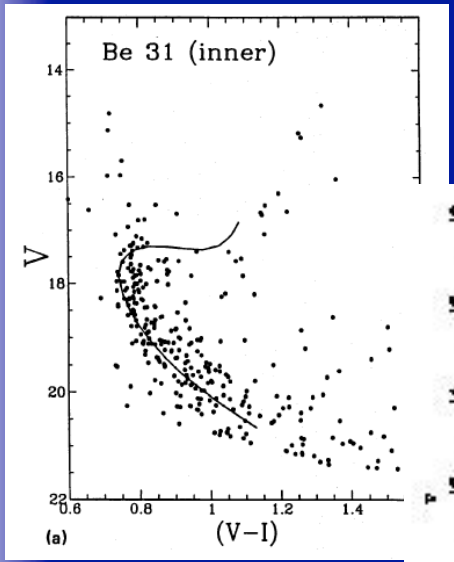
… in the ESO archive



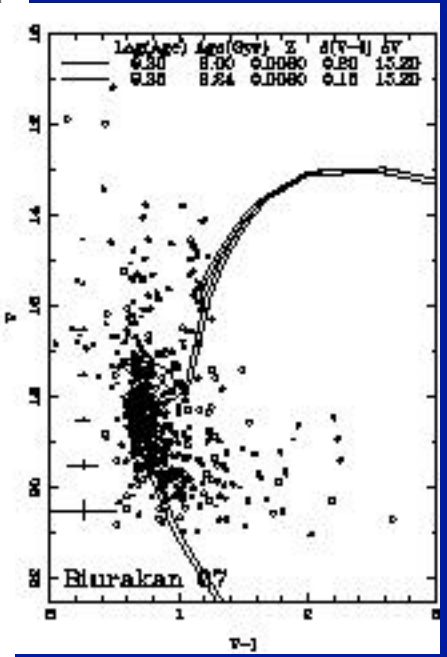
About 30 OCs observed with FLAMES

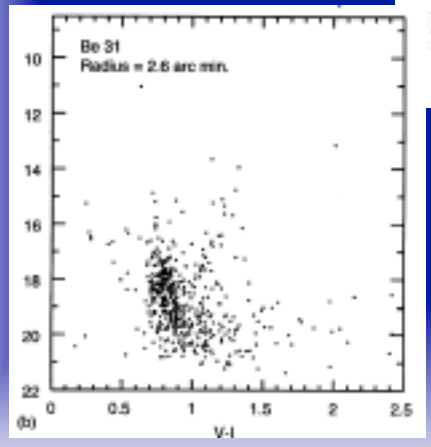
...and do not forget photometry

Gutter 1993



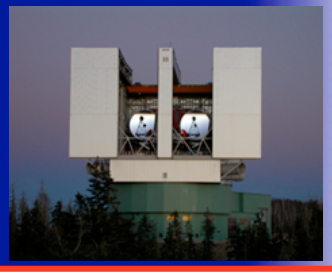
Hasegawa et al. 2004



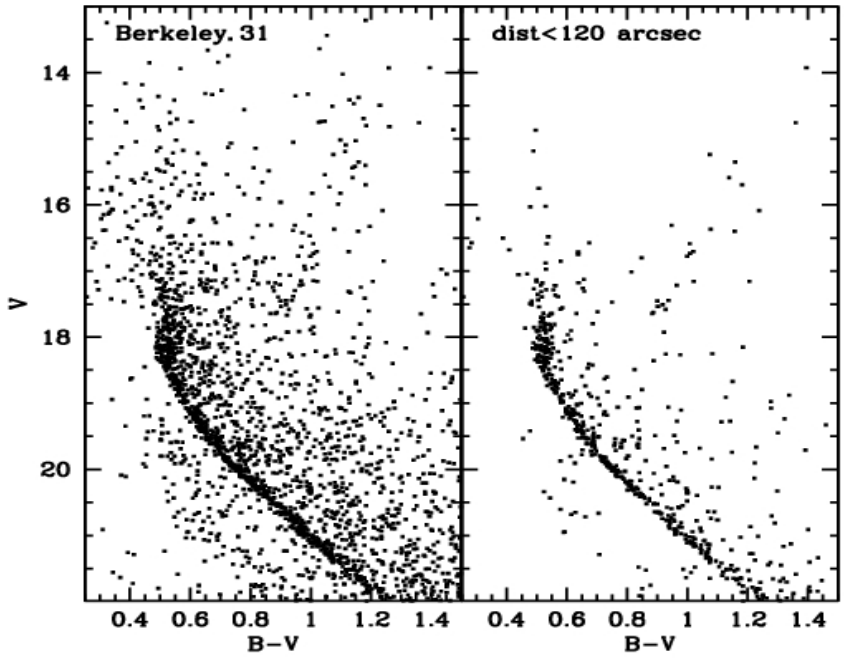


PJM 1994

Berkeley 31:
age=2-8 Gyr
Rgc=11.5-16.5 kpc



LBC@LBT: 23'x23'



➔ **Present/future (all-sky) surveys or dedicated obs.**

Thank you