



(Gal-Exgal survey)

– the VISTA survey of the
Magellanic System

Metallicity of stellar populations

Motion of stellar populations



**ESO Public Survey
2009-2014**

The VISTA survey of the Magellanic System

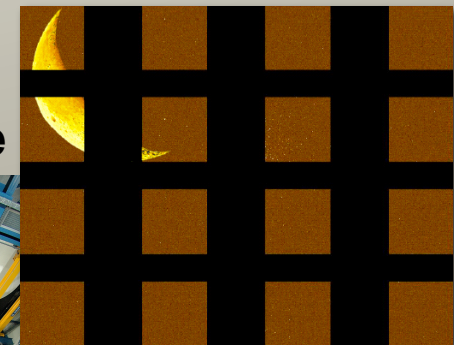
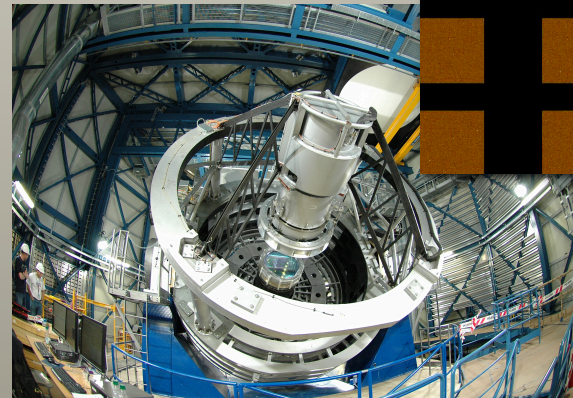
The most sensitive near-IR
survey across the LMC, SMC,
Bridge and part of the Stream

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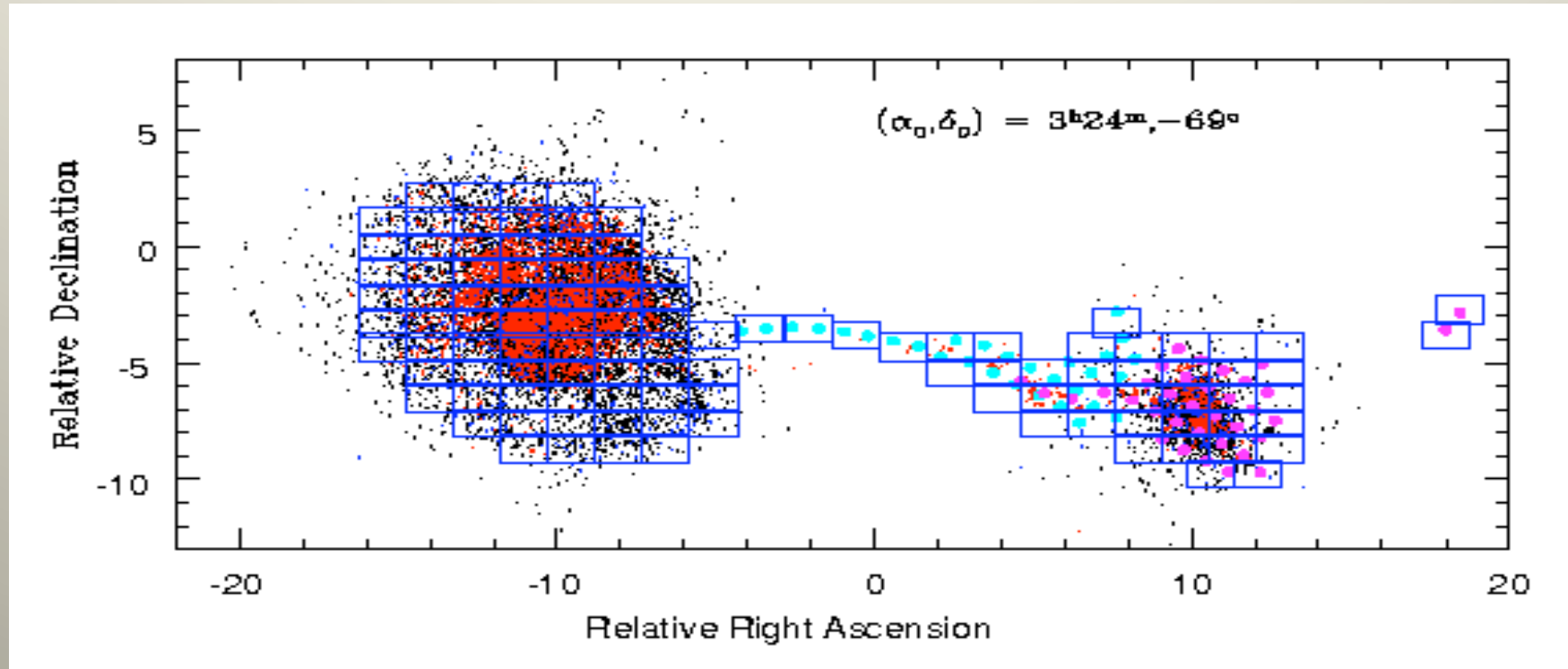
4m Telescope



**1.5 deg²
FOV**

<http://star.herts.ac.uk/~mcioni/vmc/>

0. Observe the Magellanic System



- ◆ $\approx 180 \text{ deg}^2$
- ◆ 3 filters - YJK_s
- ◆ 15 epochs (12 in K_s and 3 in YJ; once simultaneous colours)
- ◆ S/N=10 at: Y=21.9, J=21.4, K_s=20.3 (K_s \approx 19 single epoch)
- ◆ Seeing 0.8 arcsec – average
- ◆ Spatial resolution 0.34 pix/arcsec (0.51 arcsec instrument PSF)
- ◆ Service mode observing
- ◆ 1840 hours / 240 nights

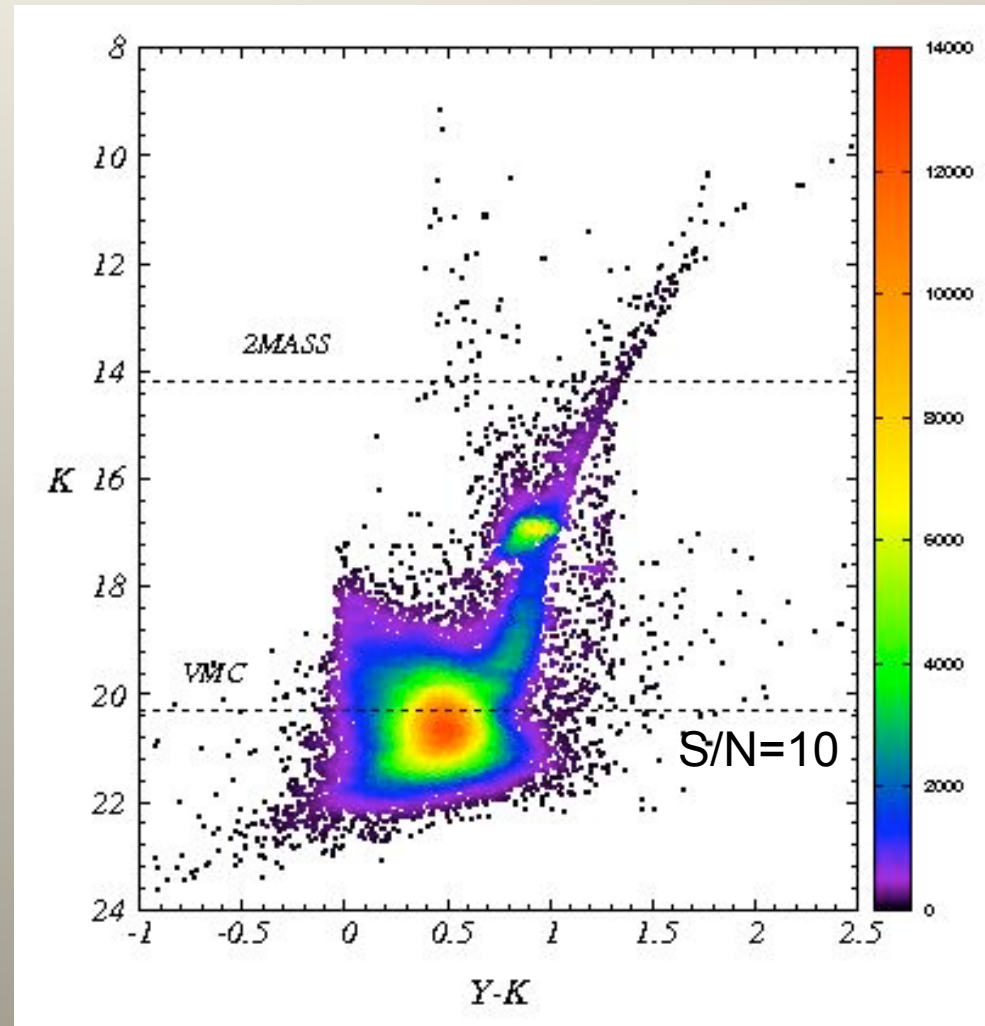
I. Derive the spatially resolved SFH

Synthetic diagram of a typical LMC stellar field as expected from VMC data.

This field covers 1 VISTA detector!

Accuracy: metallicity 0.1 dex and age 20% in 0.1 deg²

Kerber et al 2009

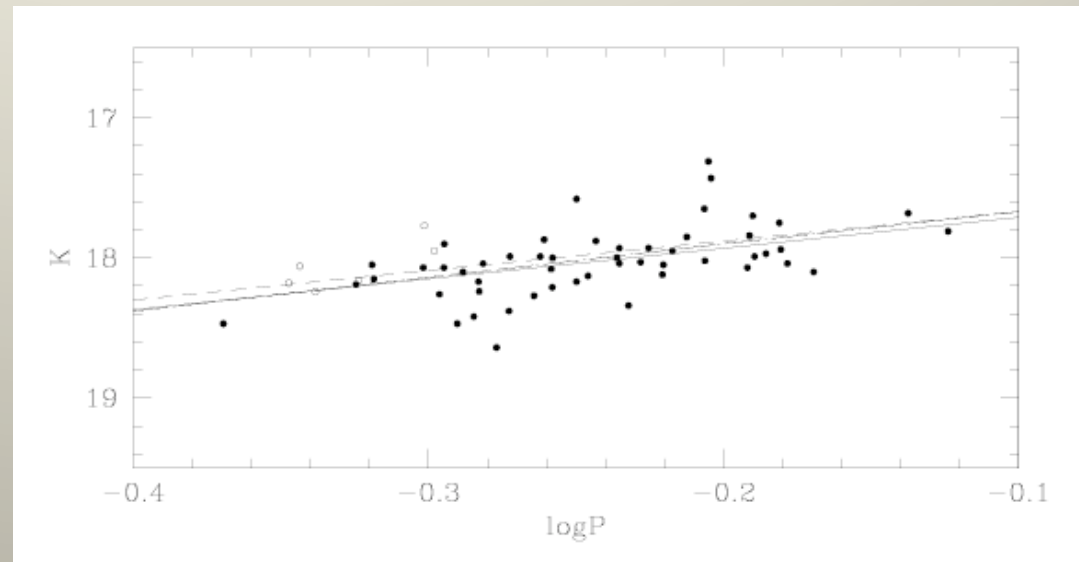


II. Trace the 3D structure as a function of time

The LMC is a few kpc thick and the SMC up to 20 kpc

RR Lyrae stars are
excellent distance
indicators in the near-IR

First application to the
LMC bar to derive the
LMC distance (Szewczyk
et al 2008) – 0.2 kpc
accuracy



The structure of the Magellanic System will be measured using Cepheid variables, the red clump luminosity, the tip of the red giant branch, etc.

III. IV. V. VI. VII. VIII....

Stellar Clusters and other sub-structures

Planetary Nebula and other emission line objects

Obscured massive stars and pre-MS stars of a few M_{Sun}

The differential proper motion

The distance of the Large Magellanic Cloud

Simulations of the Magellanic System

Etc.

A unique counterpart for existing and planned (e.g. VST) optical surveys & mid-infrared Spitzer observations

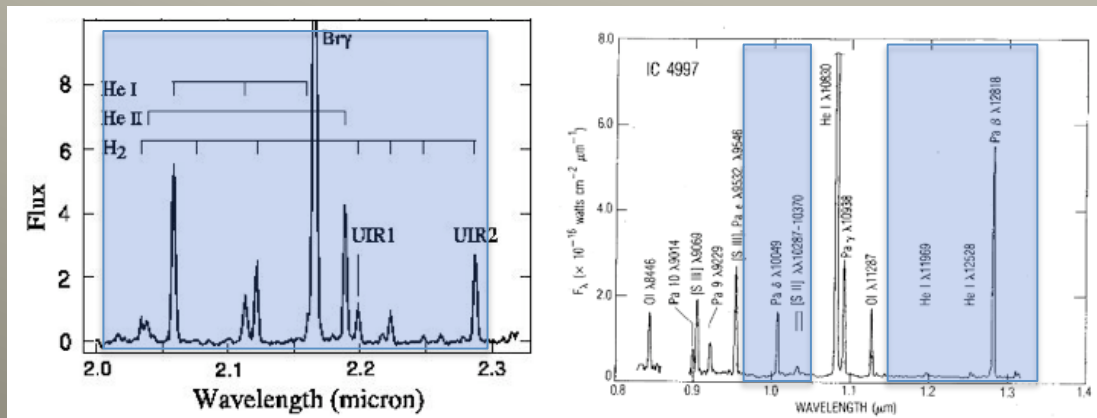
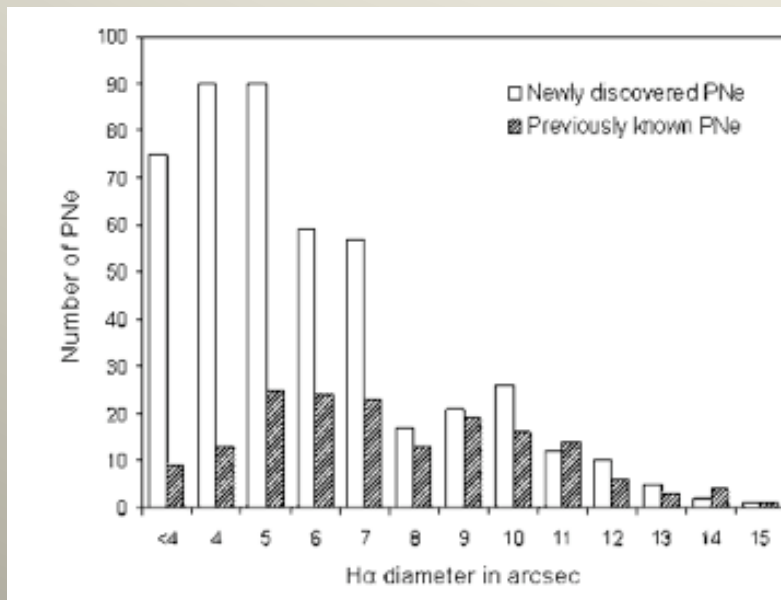
Complementary to a survey of the outer region (8-20 kpc); the VISTA-VHS will cover this area ($K_s \approx 18$)

PNe detection

The sample of PNe across the Magellanic Clouds is very incomplete

Current samples are biased to bright (young and asymmetric) PNe

Reid & Parker (2006) have doubled the number of PNe in the central 25 deg²



VMC will detect PNe from their colours; VMC spatial resolution - good

Ks includes Bry with very little contamination by He

Bry traces nebulae as H α

Spectroscopic follow-up is required for confirmation

The metallicity (iron+) as a tracer of history and structure

- ✧ Primordial gas is metal-poor.
- ✧ Enrichment is due to subsequent star formation, accretion or merging.
- ✧ The distribution of gas is influenced by the structure and dynamics of the host galaxy.

What is the chemical history of the Magellanic System?

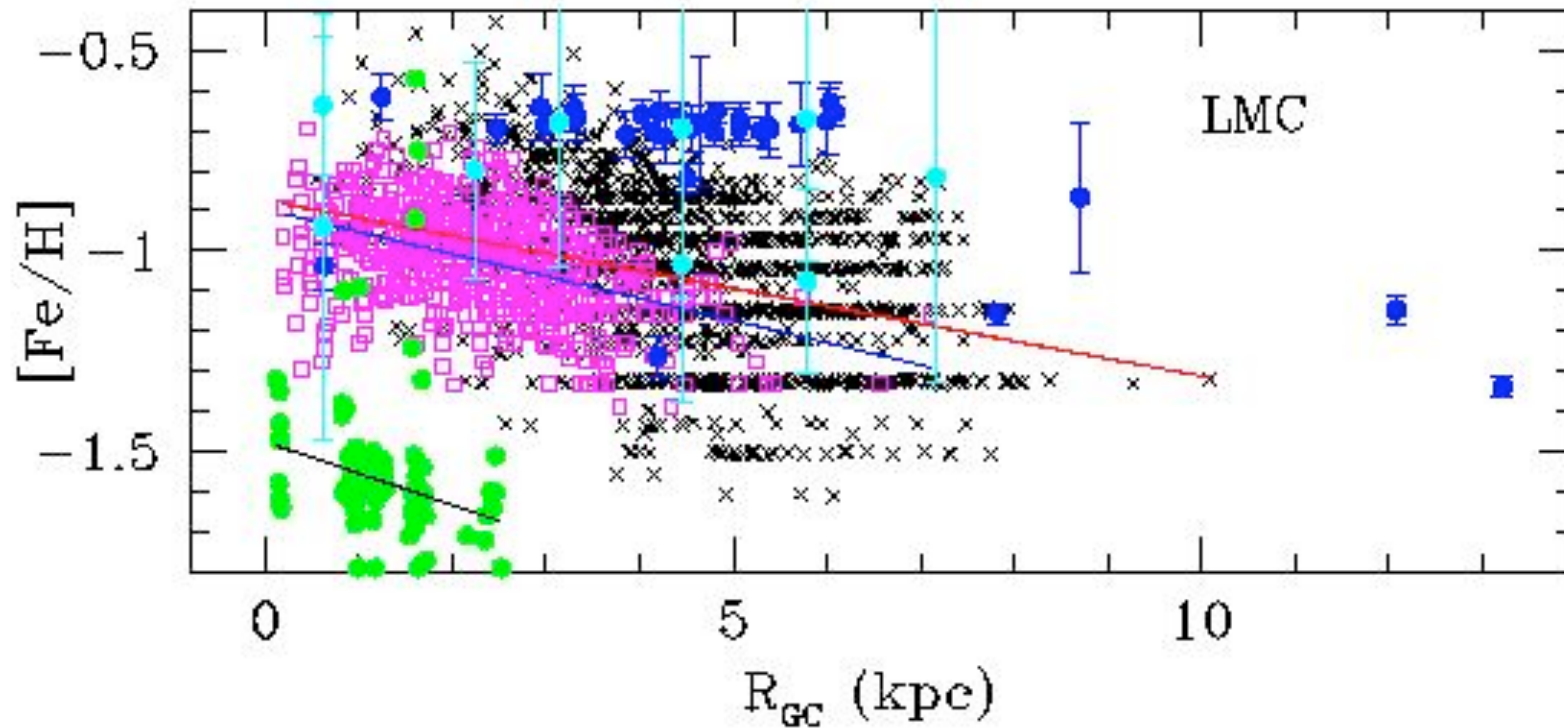
How and when the Bridge and Stream formed?

What is the depth of the Magellanic Clouds?

Are they disc galaxies with a spheroidal halo?

How and when these structures formed?

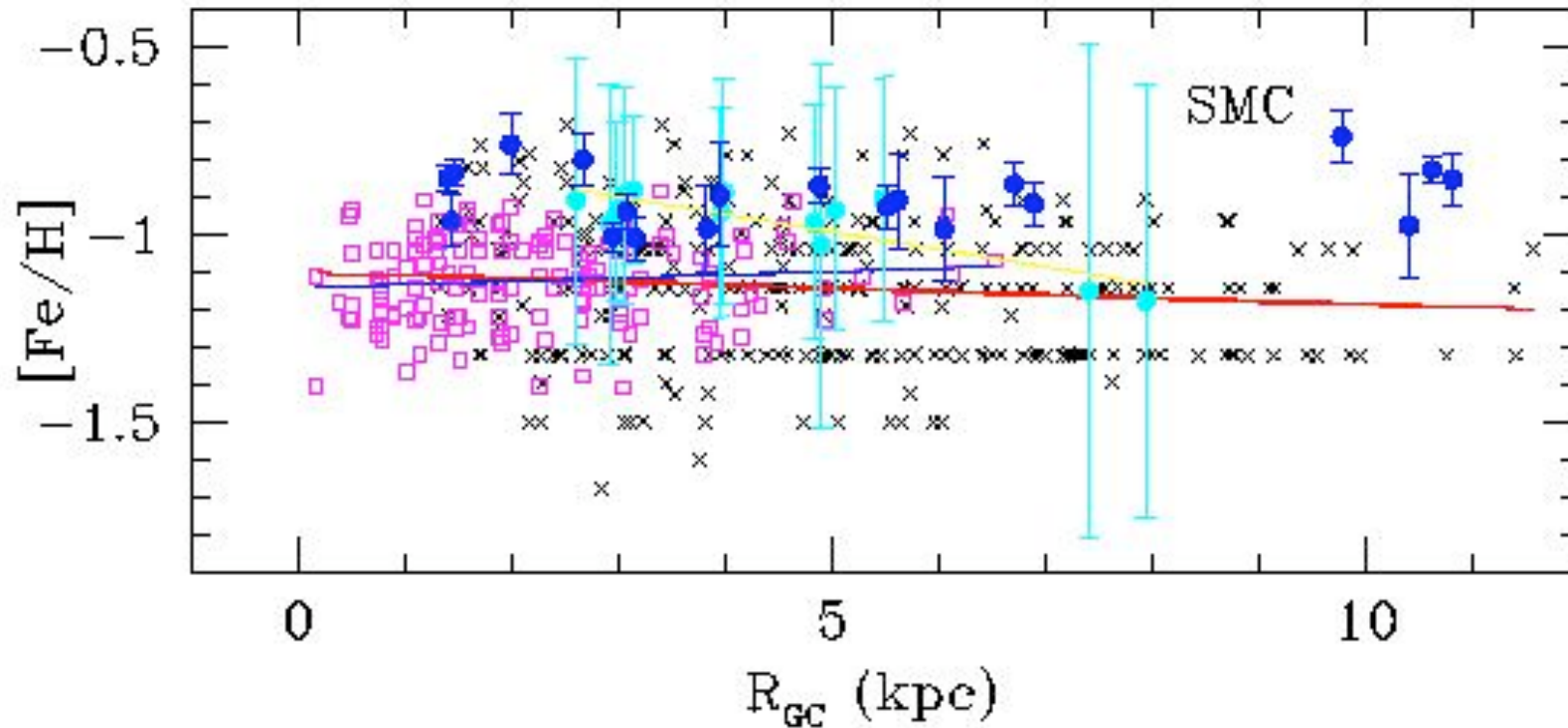
Etc...



Metallicity gradient across the LMC

(Cioni 2009, tbs)

- ◆ The metallicity decreases linearly; a flat outer gradient? ◆ **RR Lyrae stars**, metal poor **RGB stars** and old **stellar clusters** trace the same gradient as **AGB stars** (outer disc/halo?) ◆ Young RGB stars and young stellar clusters show no gradient (bar effect?)



Metallicity gradient across the SMC

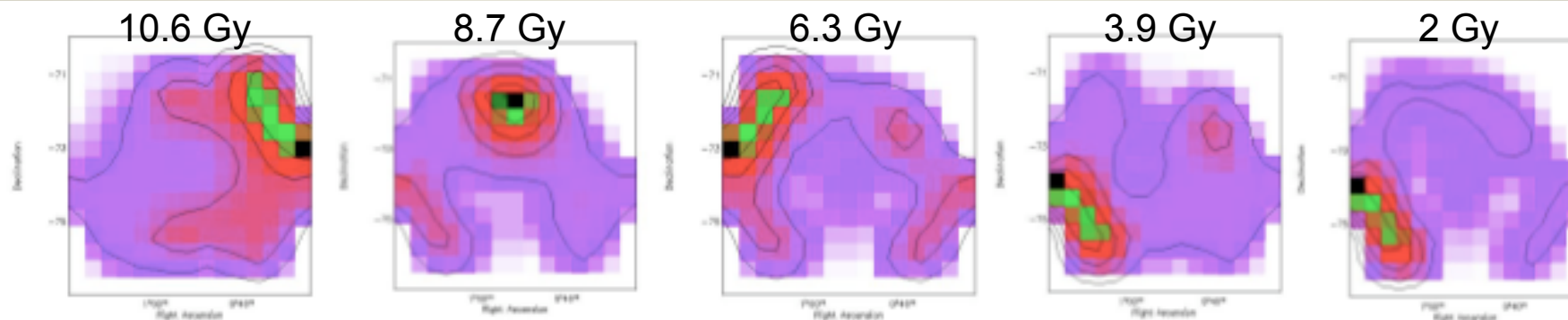
(Cioni 2009, tbs)

- ◆ **Stellar clusters** (young and old), **AGB stars** and **RGB stars** do not show a significant gradient. Bar effect?
- ◆ The metallicity is consistent with that in the Bridge
- ◆ The metallicity of the SMC is the same as that of the LMC at 4 kpc (inner disc/outer disc or halo transition?)

An SMC metal-rich ring?

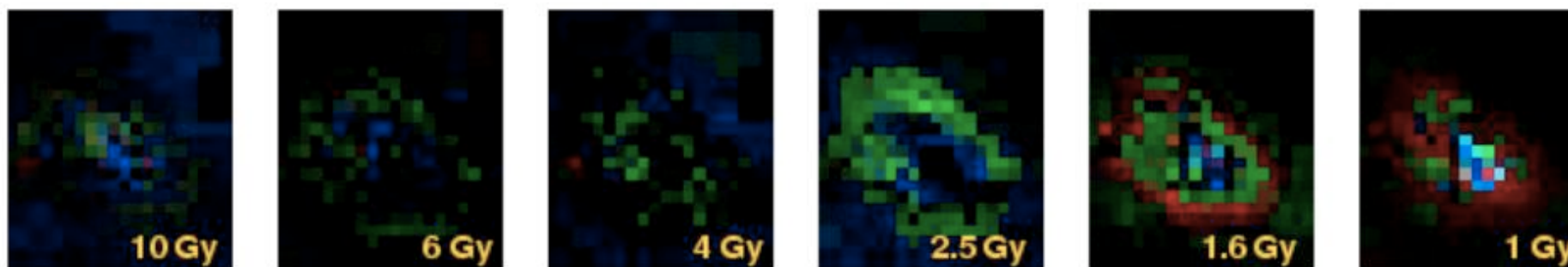
via magnitude distributions of AGB stars

Cioni et al 2006



via optical colour-magnitude diagrams

Harris & Zaritsky 2004



- ◆ Propagation of star formation?
- ◆ Accretion of satellite?
- ◆ Star forming episode induced by LMC interaction?
- ◆ Effect of bar?
- ◆ α elements or oxygen enhancement?

A viable picture (agreement/disagreement/large errors/models?):

The Magellanic Clouds experienced two major episodes of star formation: one many Gyr ago and one 2-4 Gyr ago

The old episode formed the LMC outer disc/halo and the SMC bar. The recent episode formed the inner LMC disc, the LMC bar and induced star formation in the SMC ring.

The Magellanic Stream formed out of LMC gas in the recent episode: $[Fe/H] = -0.6$ dex (Nidever et al 2008).

The Magellanic Bridge formed out of SMC gas.

The SMC may have a bulge (Subramanian & Subramanian 2009).

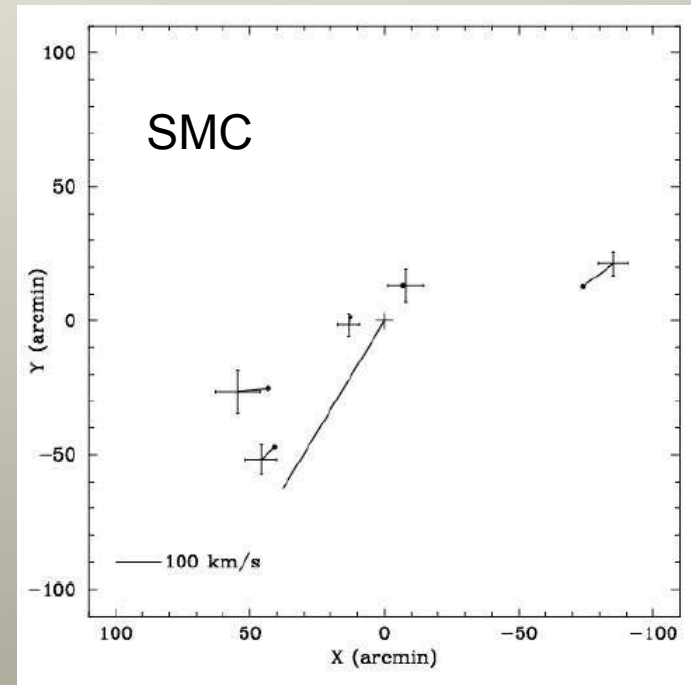
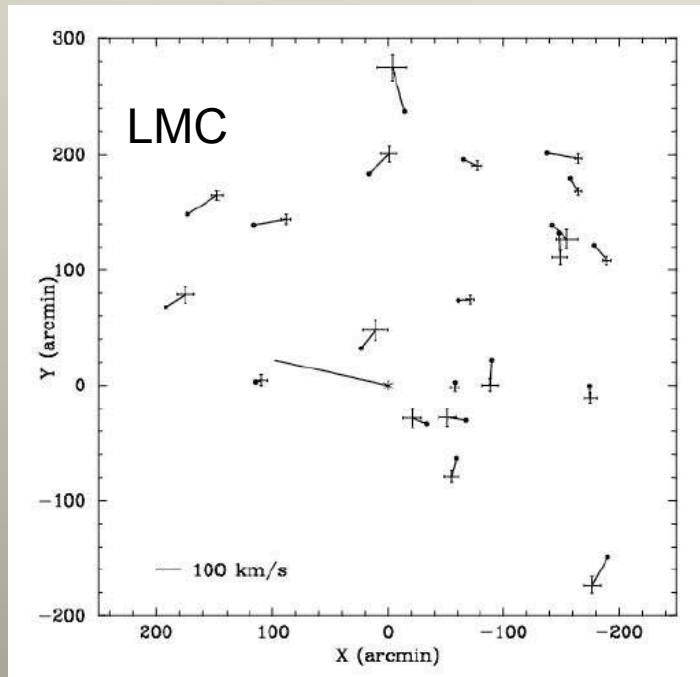
The Motion of stellar populations

- ✧ The age and chemistry of groups of stars are not sufficient to describe the formation and evolution of the host galaxy
- ✧ The dynamical state is needed to recognize substructures that shaped the Magellanic System (bulge, halo, clusters vs field stars)
- ✧ The space motion requires both the radial velocity and the tangential velocity
- ✧ Radial velocity observations exist only for subsets of stars limited in type or location

Differential Proper motion

PM in different fields (HST 2 yr) indicates rotation in the LMC and radial expansion in the SMC

Piatek et al 2008



What is the PM in space and time?

$\Delta PM = 0.8 - 1$ mas/yr among different fields

VMC can reach PM accuracy of 0.05 mas/yr comparable with HST from many stars and reference objects per resolution element (TBD)

Extract from shopping list

VMC will naturally lead to spectroscopic follow-up studies

MCs are the closest example of interacting galaxies

MCs are a laboratory for stellar evolution

VMC survey (2009-2014)

- ✧ total metallicity - error < 0.1 dex
- ✧ age - error 20% in 0.1 deg^2
- ✧ depth - error 0.2 kpc
- ✧ proper motion of different populations - error 0.05 mas/yr

Photometry & Spectra:

- ✧ structure vs time
- ✧ chemistry vs time and structure
- ✧ global evolution/simulation of the system

Spectroscopic survey

- ✧ [Fe/H] with small errors
- ✧ Measure α and other elements abundances
- ✧ Confirm/select targets
- ✧ Measure radial velocity

GAIA (2011-)

Metallicity, radial velocity and proper motion of bright giants

- ✧ Short-term: low-res/molecules; high-res/limited FoV/samples
- ✧ Long-term: wide-field/faint populations