Stellar clusters at the crossroad of massive structure formation and dynamical evolution

CROSS

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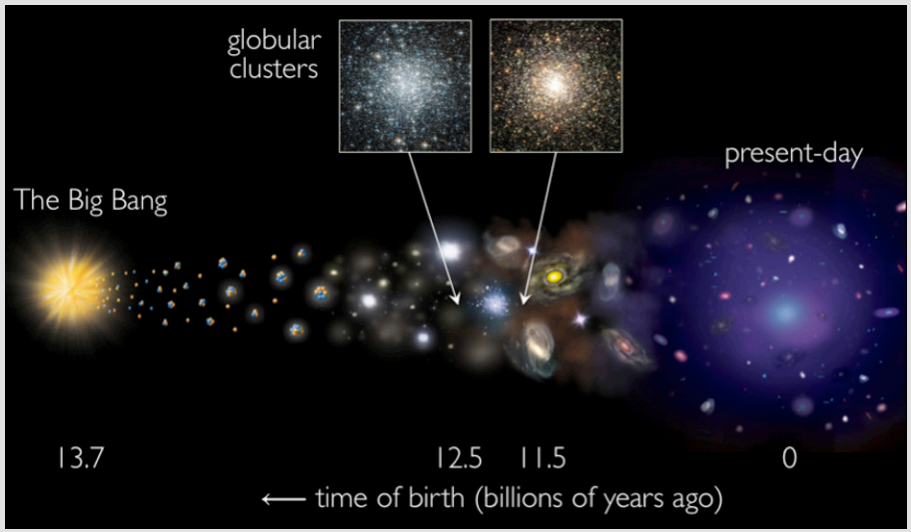
INAF ISTITUTO NAZIONALE DI ASTROFISICA NATIONAL INSTITUTE FOR ASTROPHYSICS

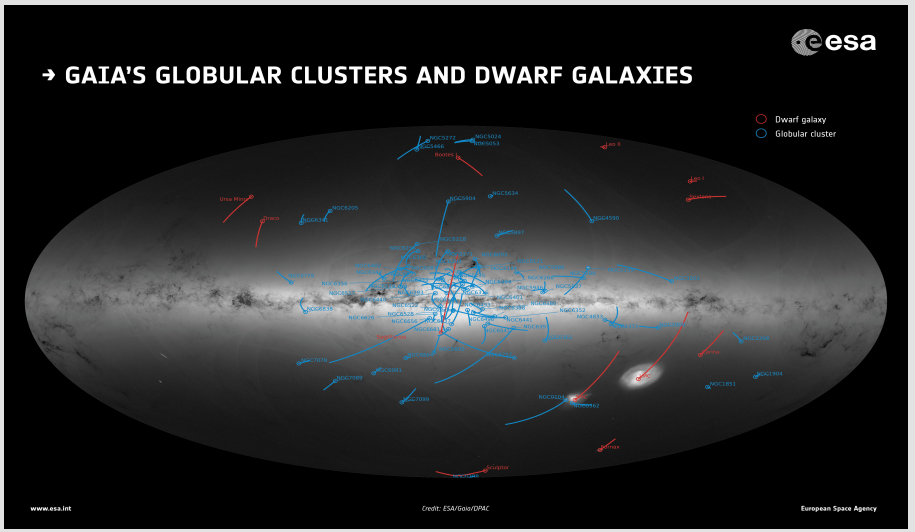
OAS

The context

GCs are ubiquitous old, massive and dense stellar systems where all the major phases of stellar evolution and stellar dynamics can be studied in great detail

GCs are valuable probes of their hosts, fossils of the epoch of galaxy formation and early evolution and tracers of their dark matter distribution





CROSS main objectives

Provide a Rosetta Stone of the entire process of cluster formation and evolution and of the use of massive clusters in near-field cosmology

1. Characterize the internal structure and kinematics of GCs

2. Trace massive cluster assembly and early evolution

- Galaxy disk formation and evolution
- Massive star physics
- Dark Universe (IMBHs, parsec scale dark matter haloes)

Team composition

CROSS involves a combination of post-docs and staff personnel mainly distributed in INAF and at the University of Bologna

- 5 Staff
- 1 Senior Post-doc
- 2 Junior Post-docs (one started last January)
- 1 PhD position for this program has been recently co-funded by INAF and will start activities by November 2021

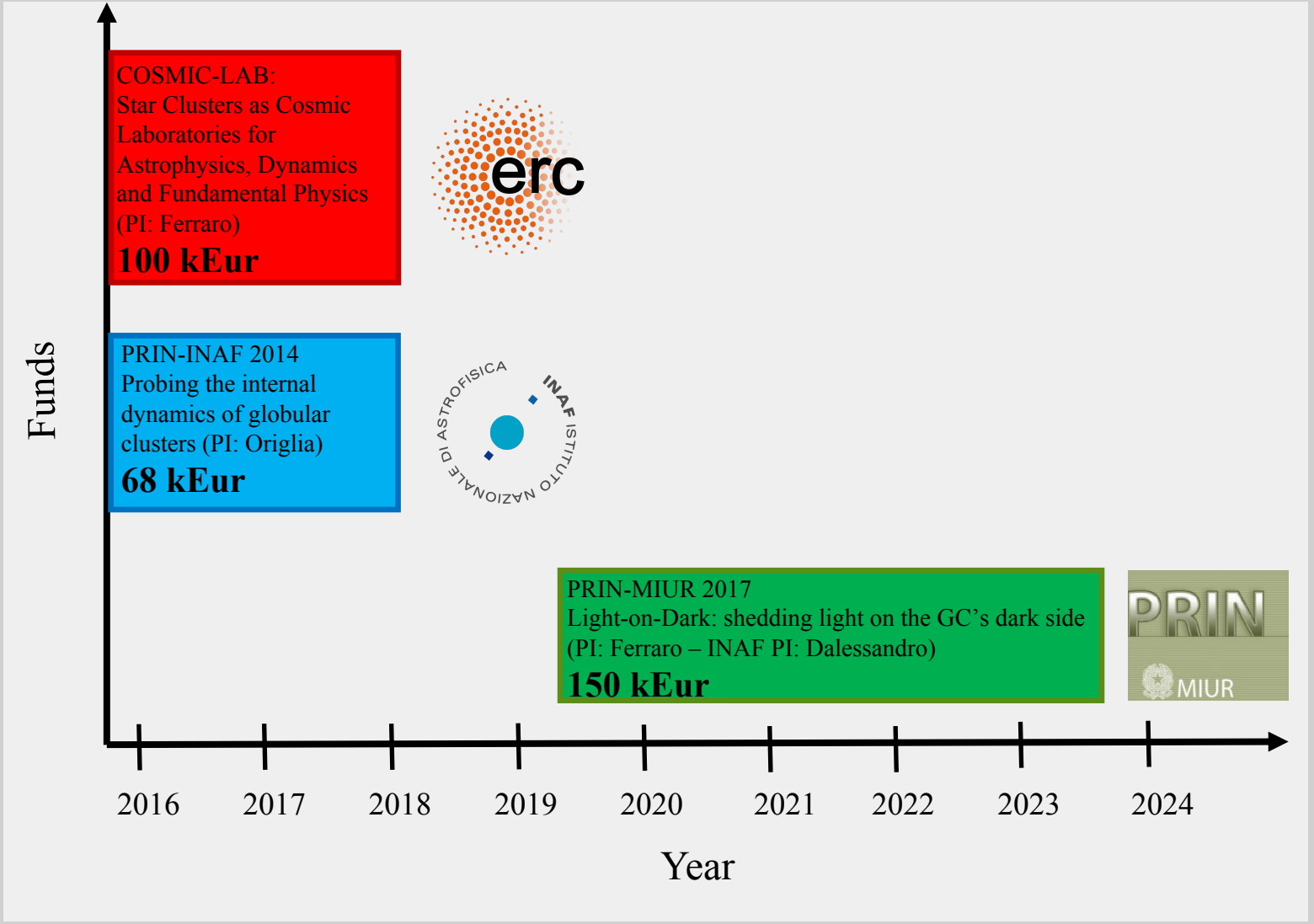
- 3 Staff
- 1 RTDa

Average effort per year = 2.4 FTE

International Collaborations:

University of Indiana *(USA)*
University of Colorado *(USA)*
University of Liverpool *(UK)*
University of Edinburgh *(UK)*
STScI, ESO, ESA
DIPC *(Spain)*
PUC, Univ. de Concepcion *(Chile)*
University of Queensland (Australia)
Obs. de Strasbourg (France)

Financial support



1. Internal structure and kinematics of globular clusters

Observational framework

The MIKiS survey: Multi Instrument Kinematic Survey of GCs

RVs of individual stars over the entire cluster extension, by using IFU spectroscopy assisted by AO in the innermost cluster core, seeing-limited IFU and multi-object spectroscopy in the outer regions

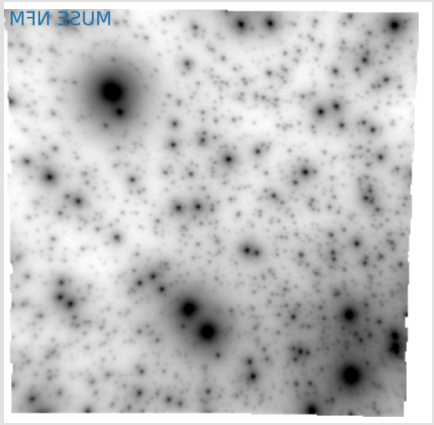
ESO Large Programme 193.D-0232 (PI: Ferraro) **194 hr** acquired with **KMOS+FLAMES**

ESO Large Programme 195.D-0750 (PI: Ferraro) **101 hr** with **SINFONI**

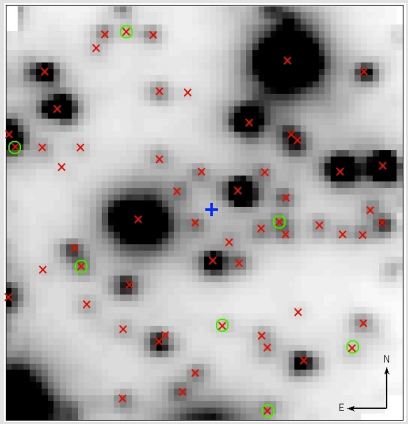
ESO Large Programme 106.D-212E.001 (PI: Ferraro) **100 hr** with **MUSE**

ESO programmes on specific targets (PI: Dalessandro) **>50 hr with MUSE and FLAMES**

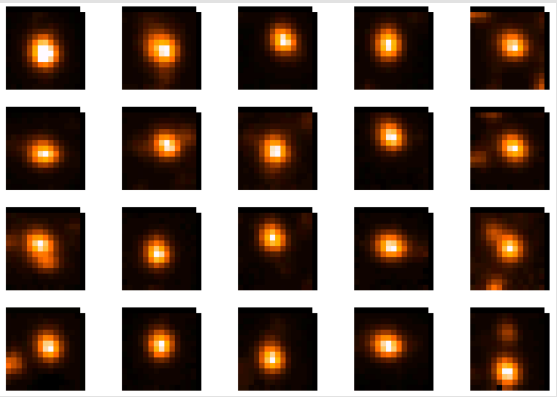
MUSE



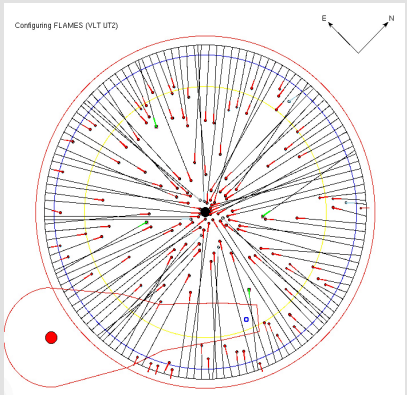
SINFONI



KMOS



FLAMES



1. Internal structure and kinematics of globular clusters

Observational framework

Multi-epoch HST and Gemini AO observations + Gaia

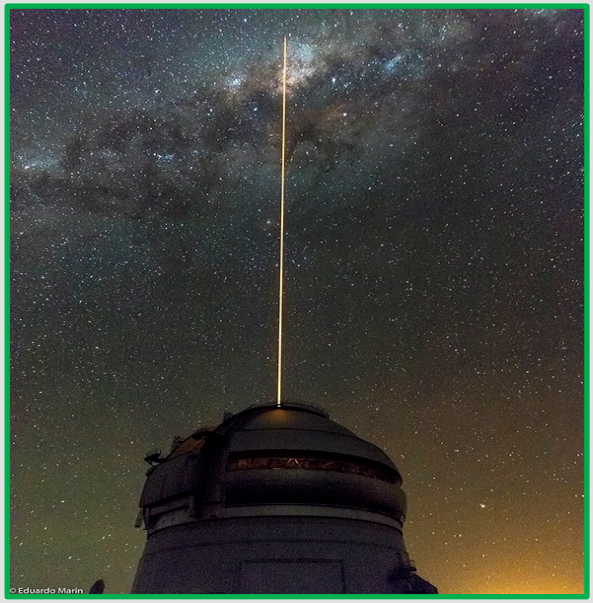
internal proper motions, stellar cluster surface brightness and density profiles

HST Medium Programme (PI: Dalessandro - Bastian) **38 orbits**

HST GO Programmes (PI: Dalessandro - Ferraro - Bastian)
100 orbits with ACS and WFC3

ESO Programmes (PI: Dalessandro)
150hr with FORS2, VIMOS and OMEGACAM

Gemini South Programmes (PI: Geisler - Cohen)
10 nights with GeMS/GSAOI



gaia

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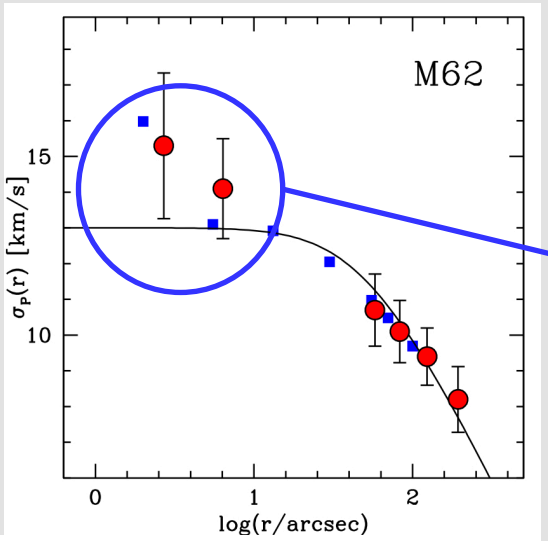
1. Internal structure and kinematics of globular clusters

Results

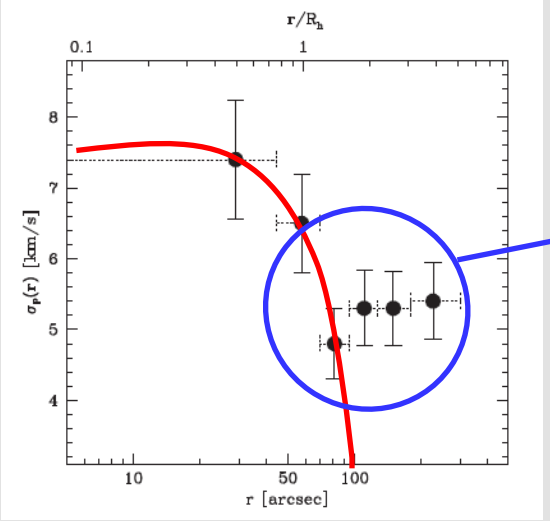
3D velocity maps, rotation and anisotropy profiles



Velocity dispersion

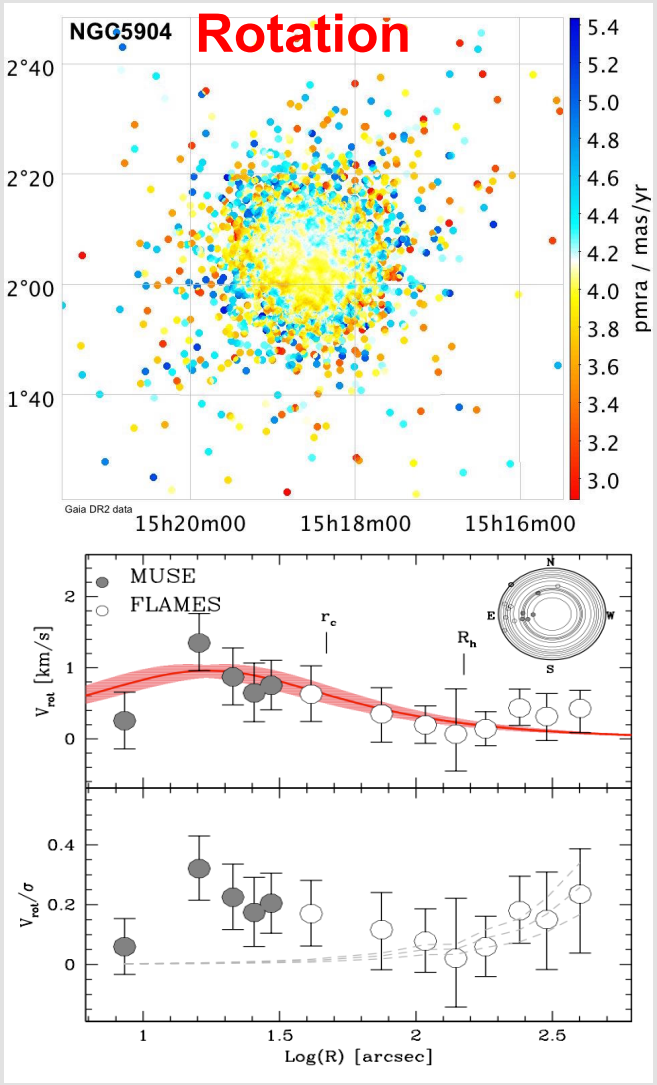
Central VD cusp

- High-velocity stars
- IMBH?



Extra-tidal tails

- Rotation
- Potential escapers
- Dark Matter?

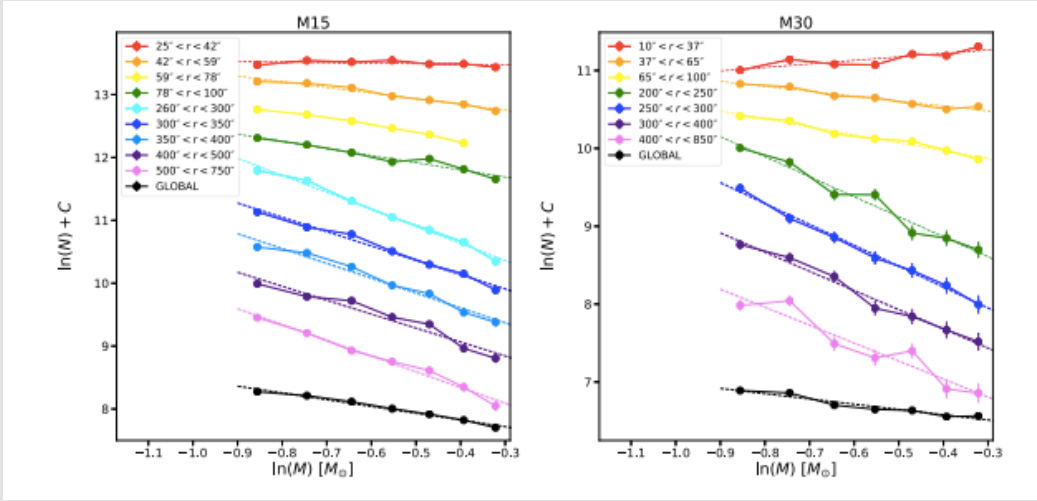


1. Internal structure and kinematics of globular clusters

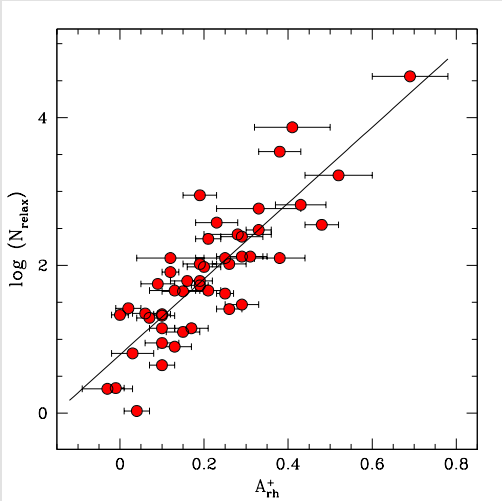
Results

mass functions, initial conditions and dynamical age

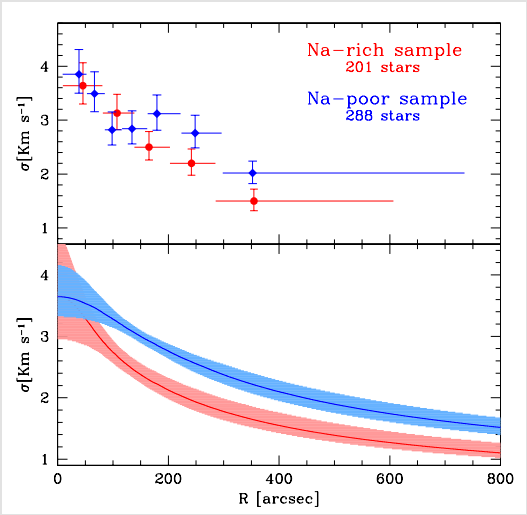
GC IMF and possible variations



Dynamical clocks



Crucial constraints on cluster initial conditions



2. Proto-GC assembly and early evolution

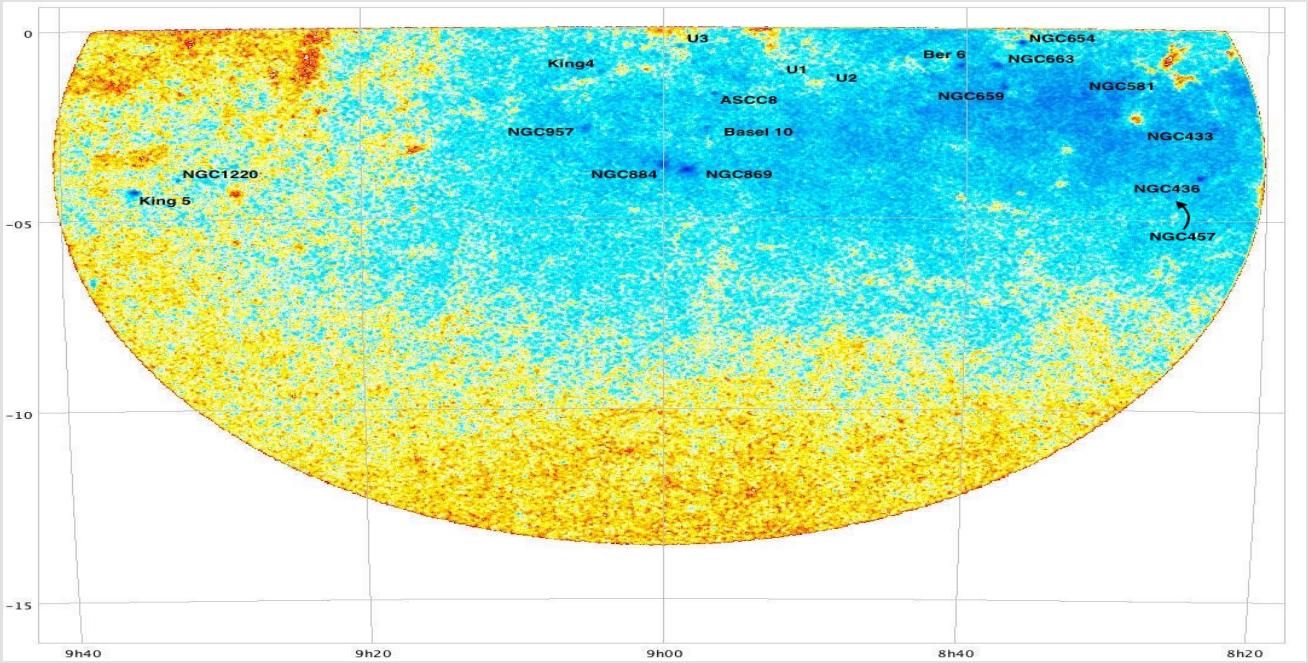
Observational framework

Spectro-photometric and kinematic study of young massive clusters in the Milky Way and Magellanic Clouds

TNG Large Programme SPA – Stellar Population Astrophysics. The detailed age-resolved chemistry of the MW disk (PI: Origlia), **68 nights** with **HARPS-N+GIANO-B**

ESO HAWK-I/GRAAL Science Verification (PI: Dalessandro)

ESO/VLT FORS2 Programmes (PI: Dalessandro)

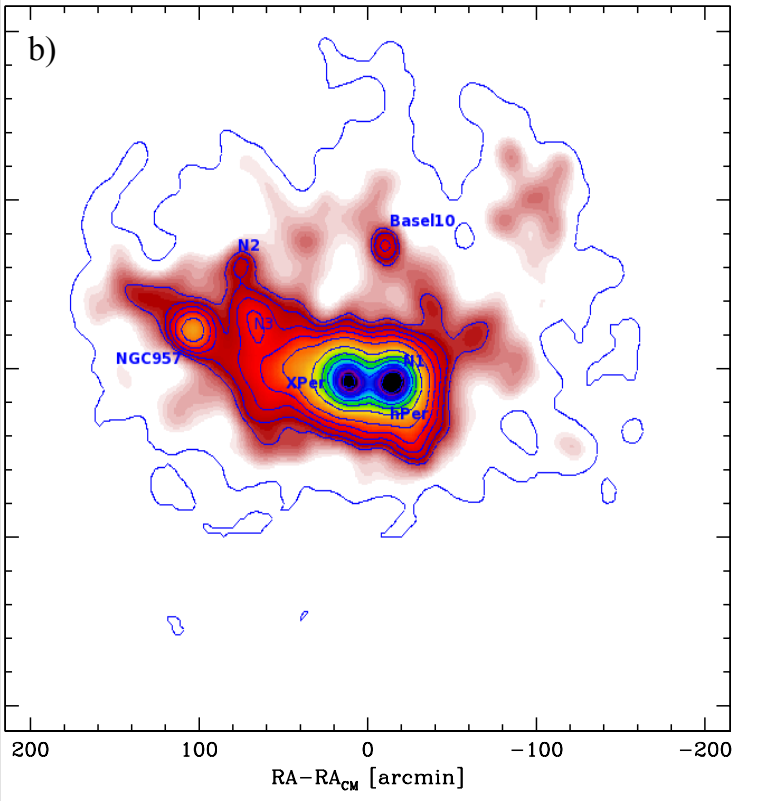


2. Proto-GC assembly and early evolution

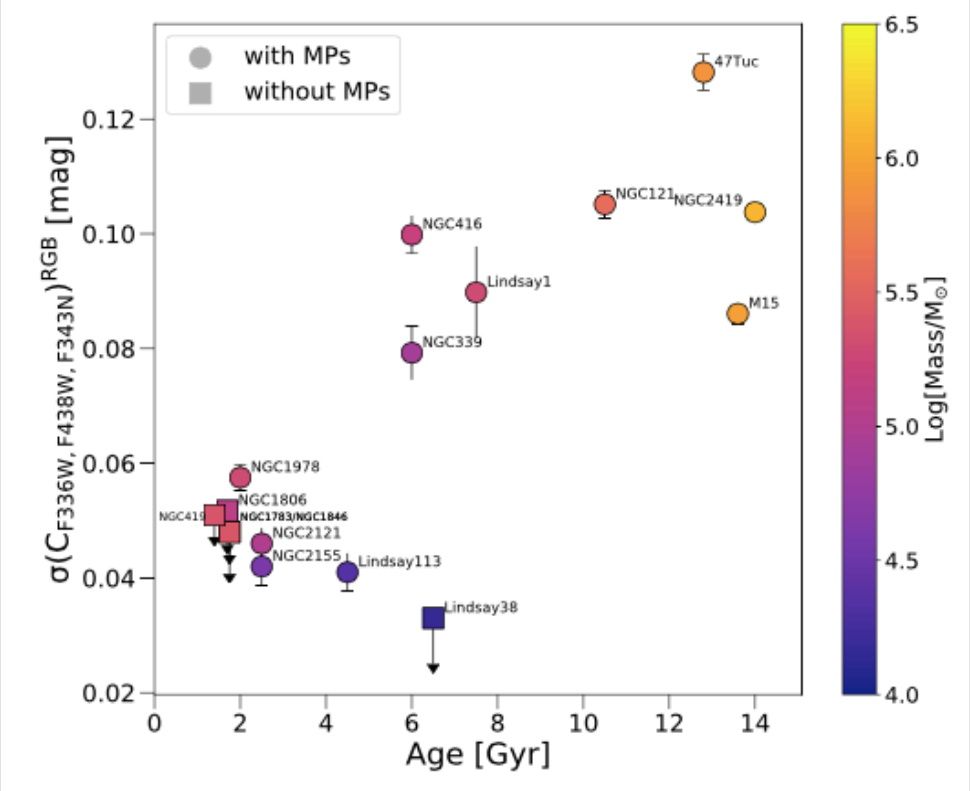
Results

The study of YMCs can open a new window on cluster formation and evolution over cosmic time

First evidence of an ongoing hierarchical cluster formation process

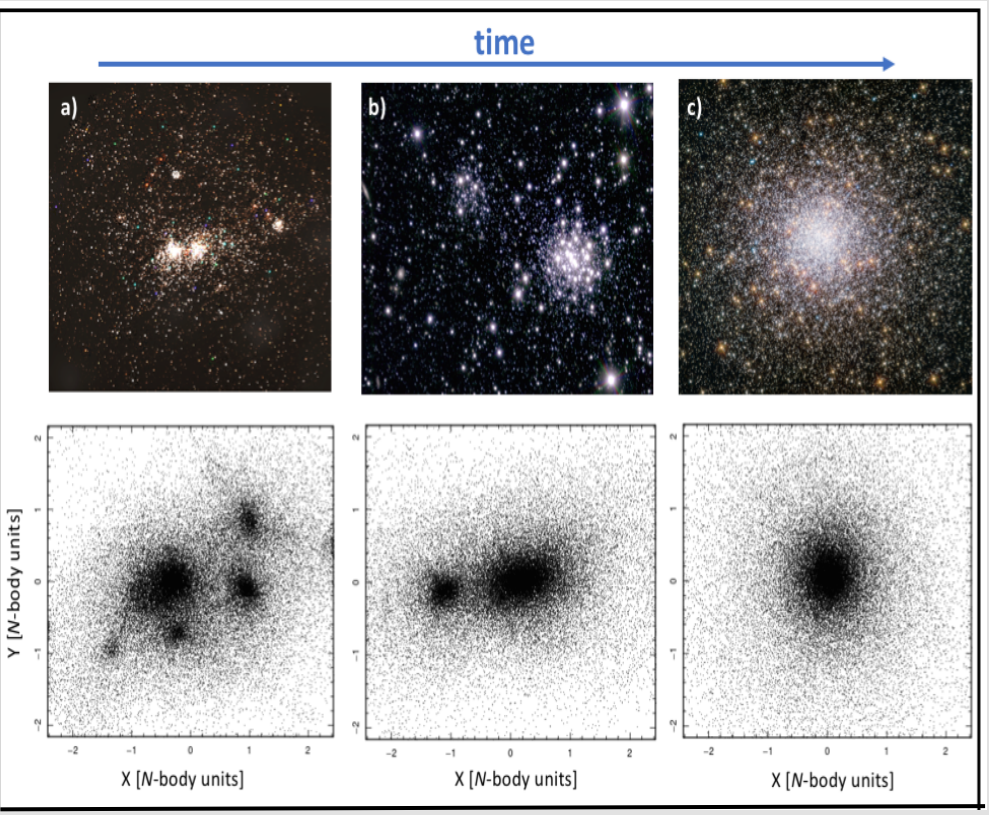


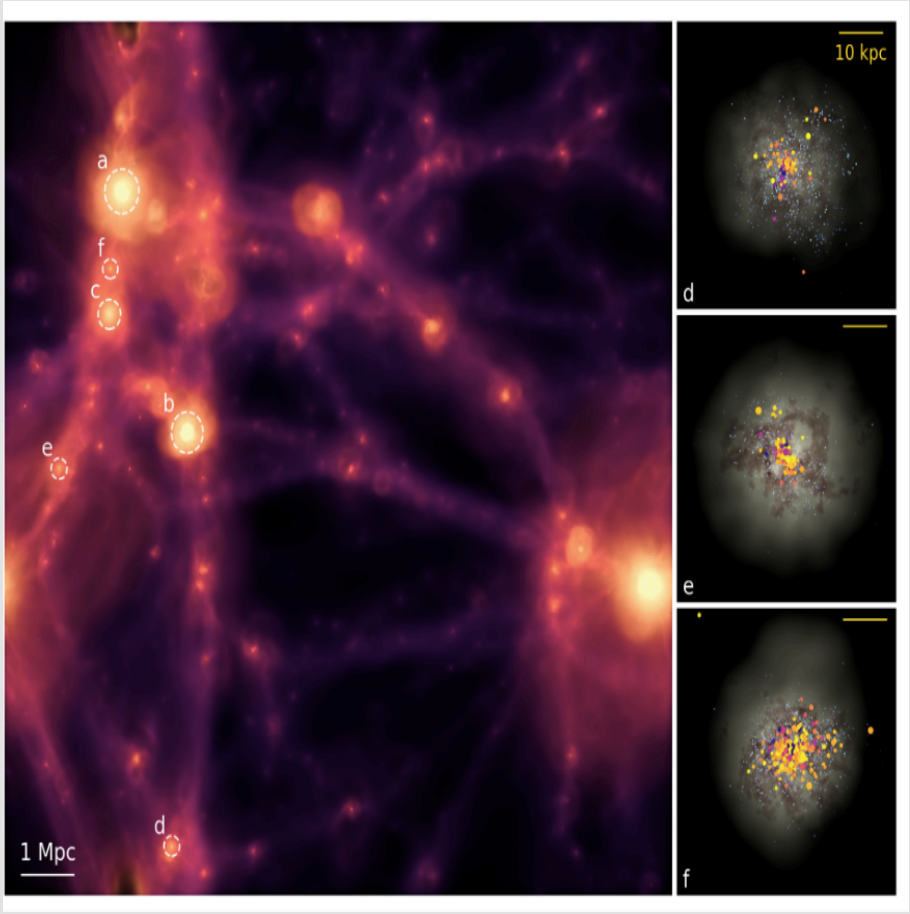
First reading of the link between YMCs with old globulars



2. Proto-GC assembly and early evolution

***N*-body and Monte Carlo simulations of star cluster formation and evolution**





Provide an unprecedented test-bench for models of cluster formation and evolution in high-resolution cosmological simulations

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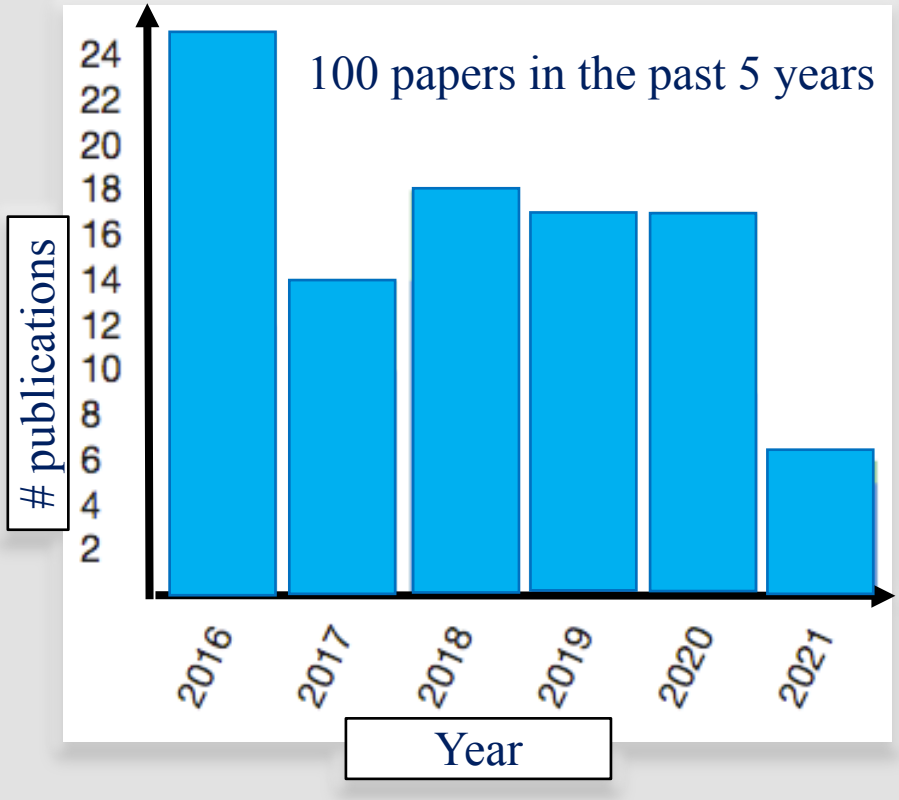
CROSS perspectives and criticalities

CROSS is addressing crucial open questions on star cluster formation and evolution, by exploring new methodologies, both from the observational and theoretical points of view



CROSS has a rewarding record of publications of new and original results

CROSS has been investing resources for training students and involving young researchers in its activities, dealing with various aspects of stellar, dynamic and chemical evolution

CROSS is maintaining an important network of international collaborations to maximise the scientific output and visibility of its projects.

These objectives require some regular financial support. In particular, in a 2-year timeframe, it is urgent a financial contribution for a 2yr Junior Post-Doc working on the *N*-body and hydro-dynamical simulations.