Resolved Stellar Populations: Chemo-dynamical models

MA2@OAS BOLOGNA
17-18 DECEMBER 2018

INAF
ISTITUTO NAZIONALE DI ASTROFISICA
OSSERVATORIO DI ASTROFISICA E SCIENZA DELLO SPAZIO DI BOLOGNA

Who we are… and what are our toys!

Francesco Calura

Chemical evolution models
Semi-analytical models
Hydrodynamic simulations

Donatella Romano

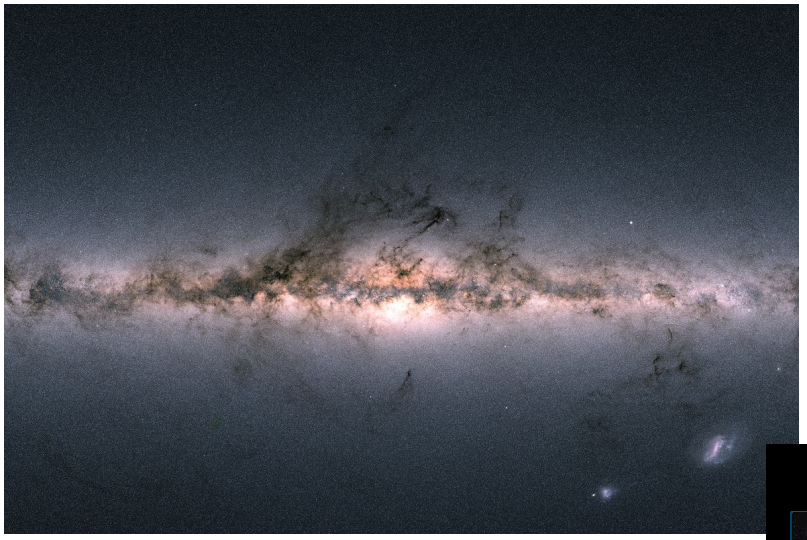
Antonio Sollima

Monte Carlo simulations
Dynamical models

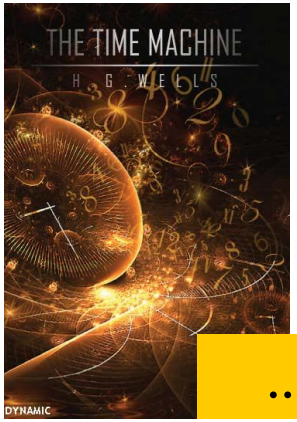
Annibale D'Ercole (ret.)

Francesco Calura
Donatella Romano
Antonio Sollima
Annibale D'Ercole (ret.)

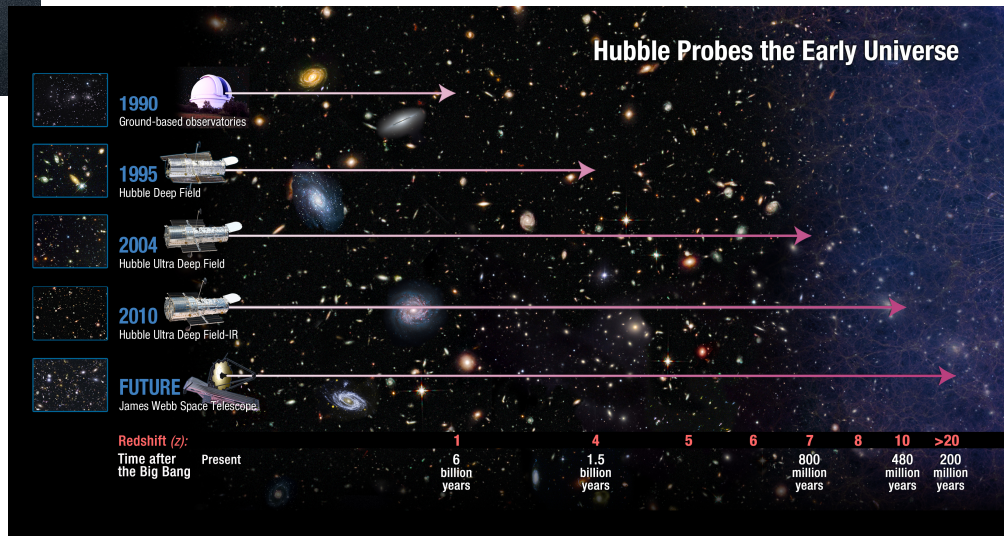
From “here and now” to “there and then” (round trip)



Galactic archaeology…

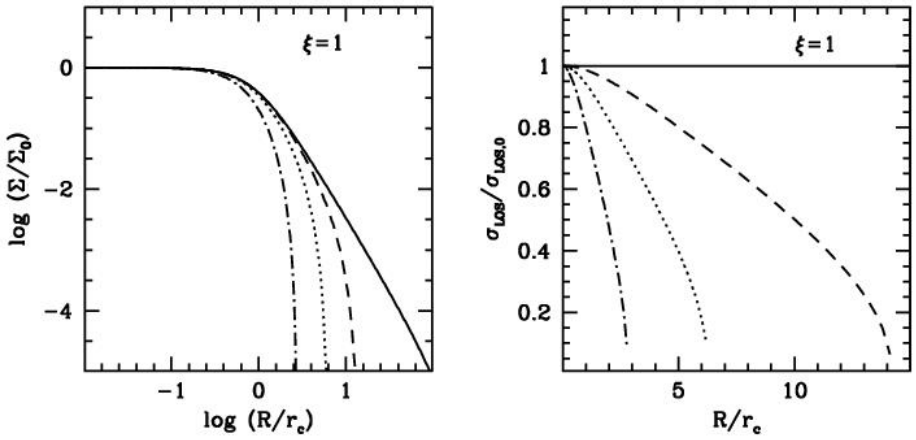


… time machine!



Dynamical models of collisional stellar systems

Analytic DF-based models of stellar systems in different gravitational frameworks



Predictions of observables (projected density, LOS velocity dispersion profile) with tunable degree of concentration, anisotropy, rotation, mass function

Sollima *& Nipoti (2010)*

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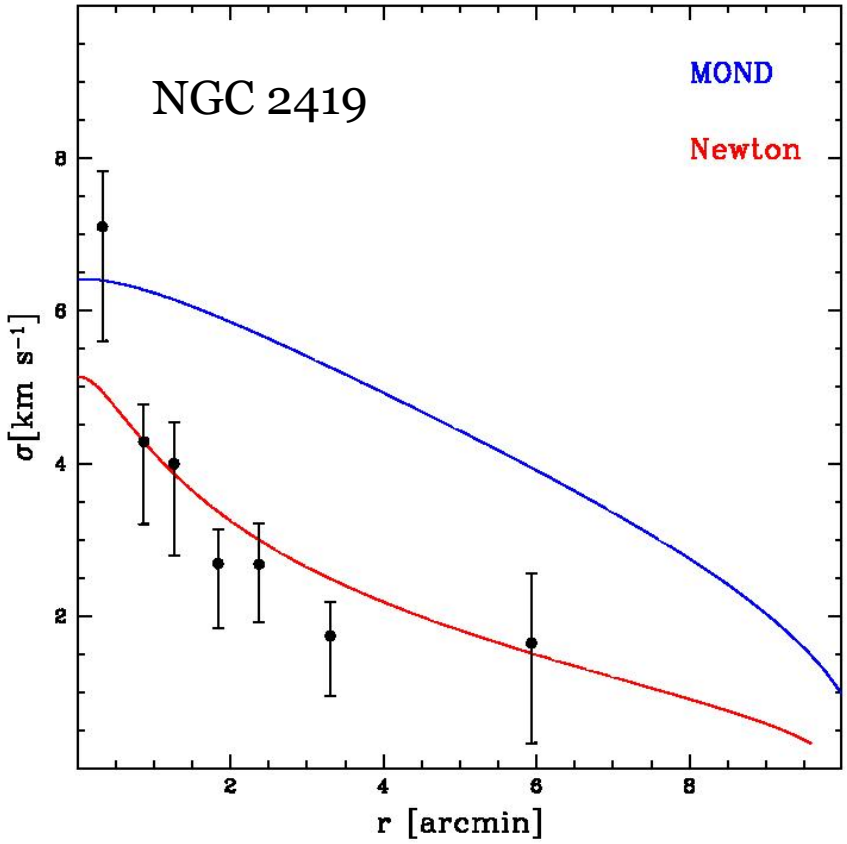

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One of the strongest evidence against MOND

Sollima *& Nipoti (2010)*

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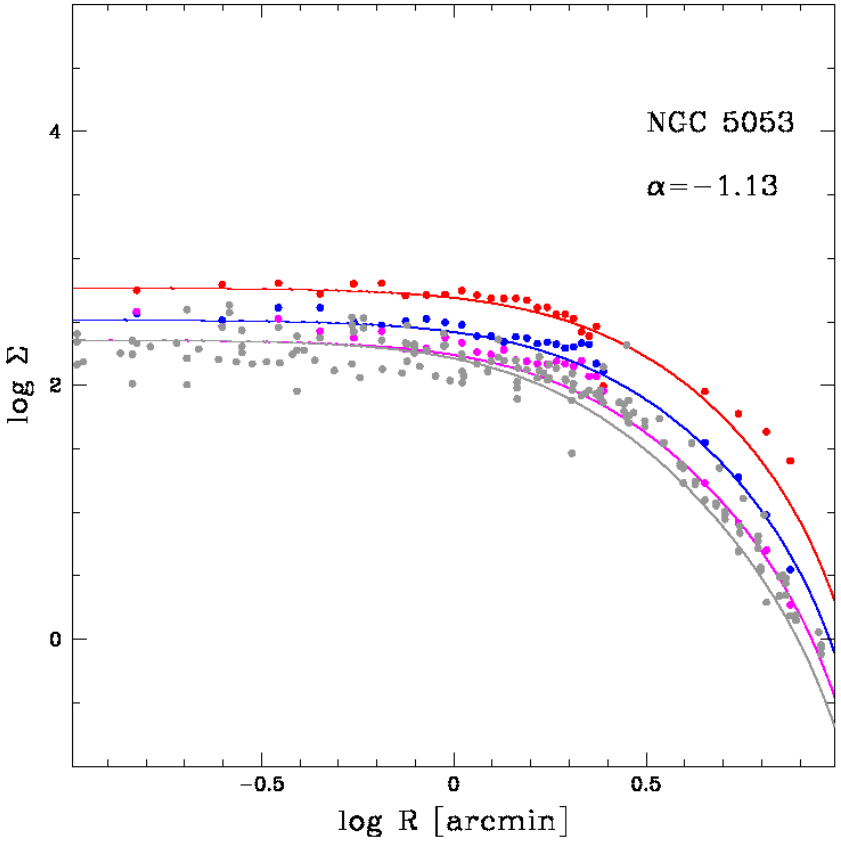

Predictions of observables (projected density, LOS velocity dispersion profile) with tunable degree of concentration, anisotropy, rotation, mass function

Estimate of the PDMF in more than 30 GCs

Sollima *& Baumgardt (2017)*

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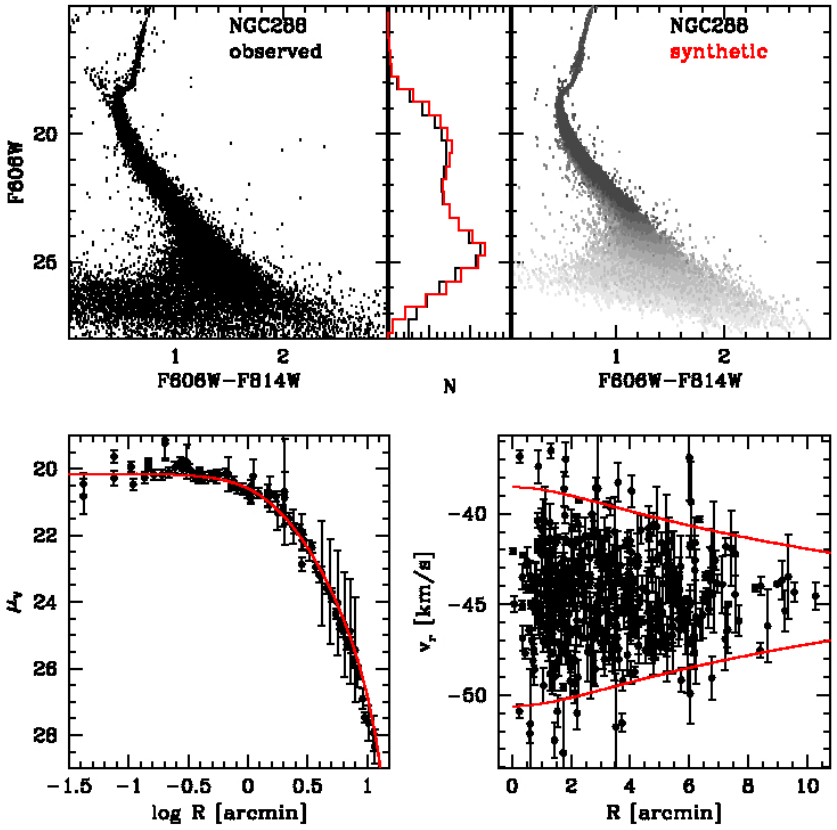

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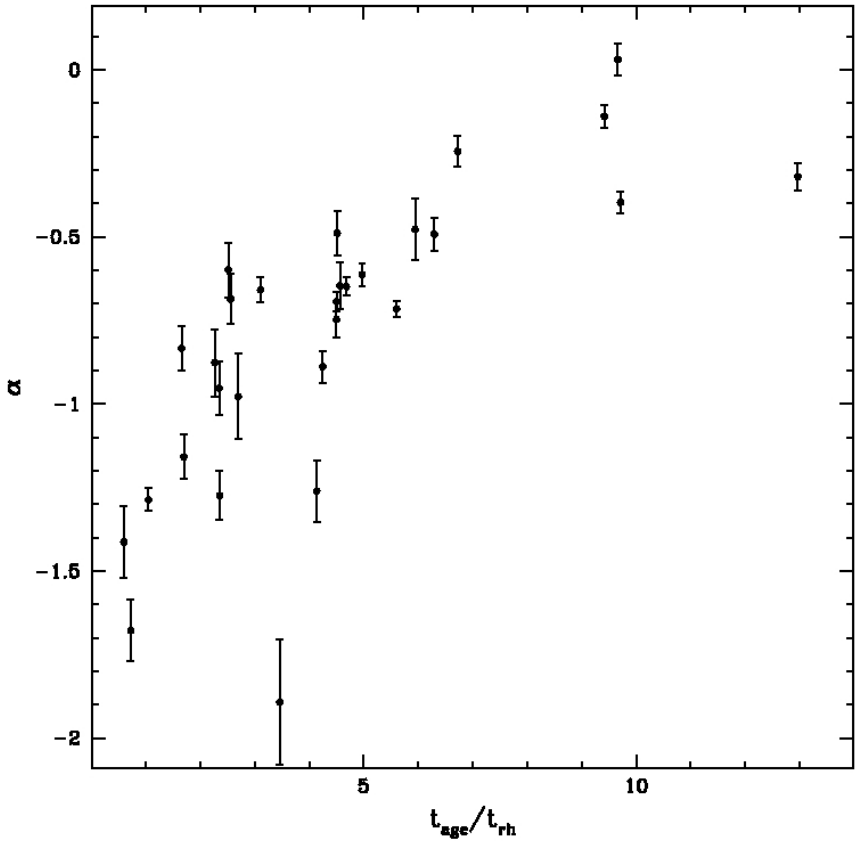

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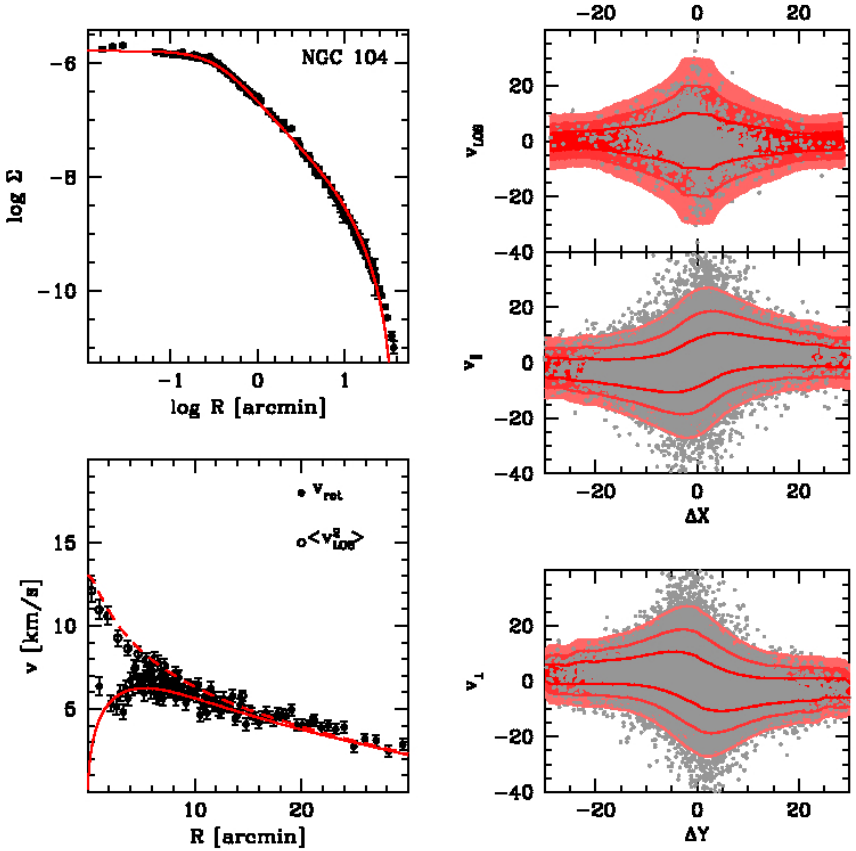


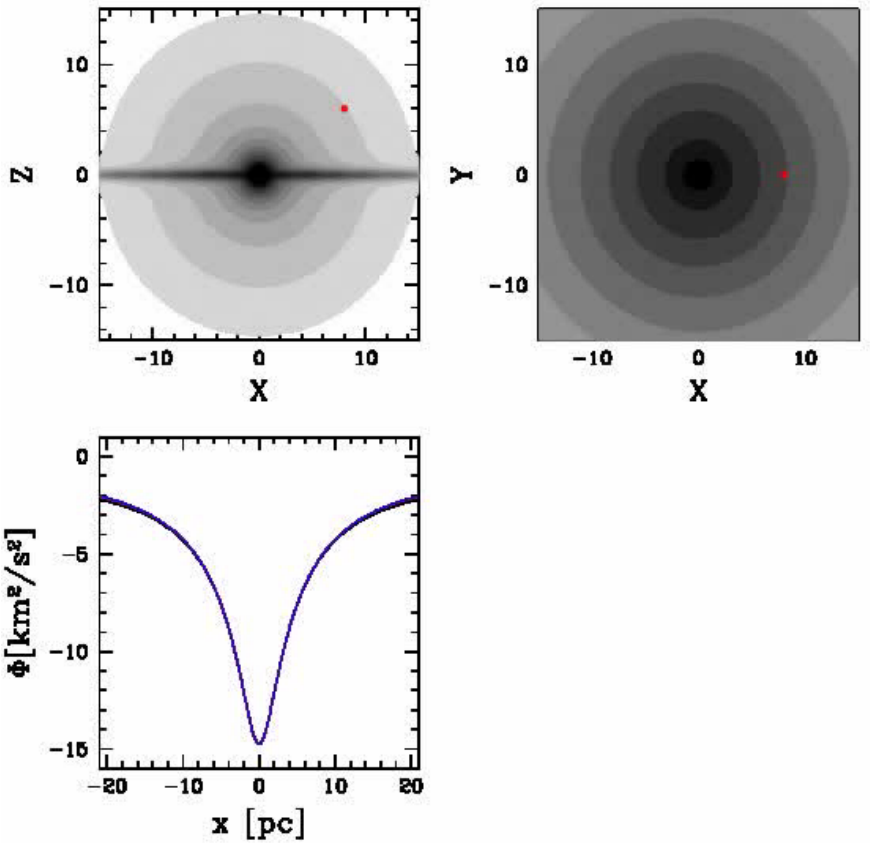
Predictions of observables (projected density, LOS velocity dispersion profile) with tunable degree of concentration, anisotropy, rotation, mass function

Estimate of the rotation pattern in 15 GCs

***Sollima** et al. (in preparation)*

Dynamical models of collisional stellar systems

First Monte Carlo code including a realistic tidal field



Able to follow the evolution of any spherical stellar system taking into account for both internal (2-body relaxation) and external (tides) dynamical processes

Sollima *& Mastrobuono Battisti (2014)*

Dynamical models of collisional stellar systems

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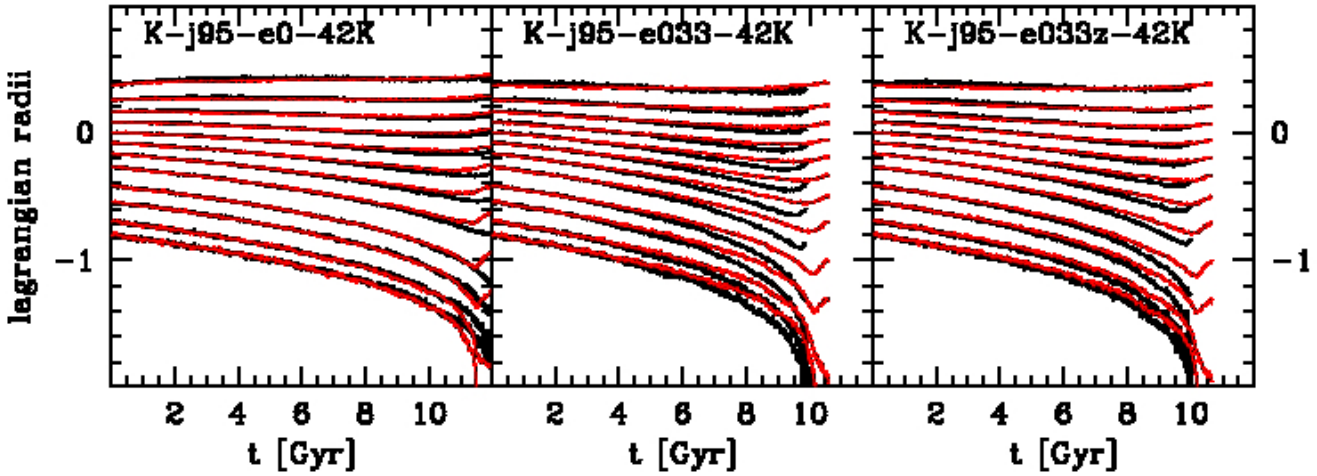
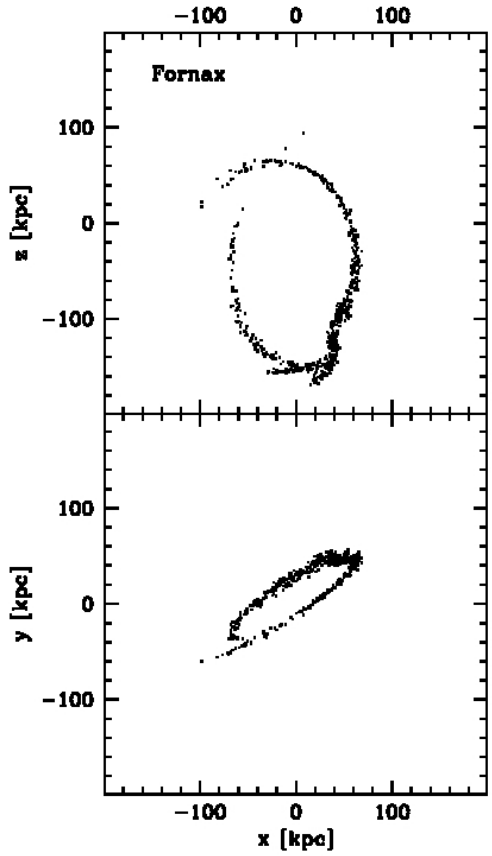


Excellent agreement with N-body codes in 1/100 of computation time

Sollima *& Mastrobuono Battisti (2014)*

Dynamical models of collisional stellar systems

Collisionless N-body simulations

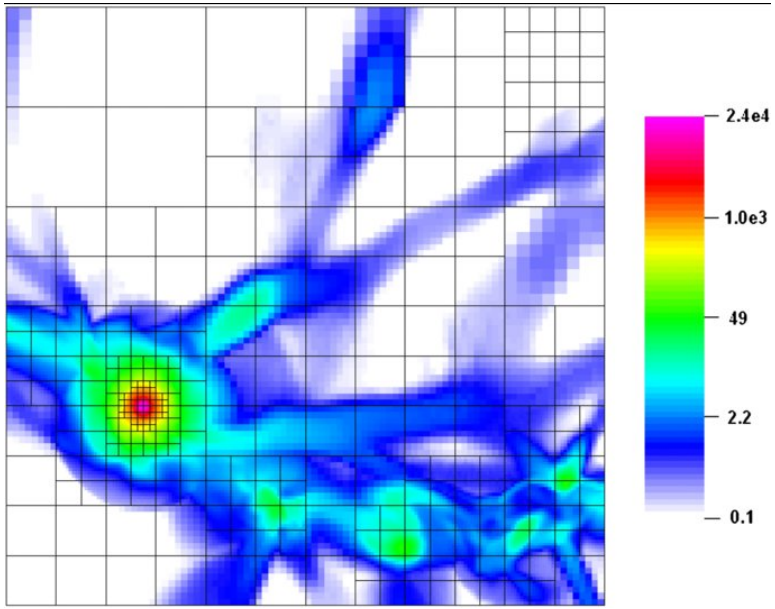


Contraint to the orbit of Galactic satellites and appearence of debris of ancient accretion events

*Battaglia, **Sollima** & Nipoti (2015)*

3D Hydrodynamic simulations

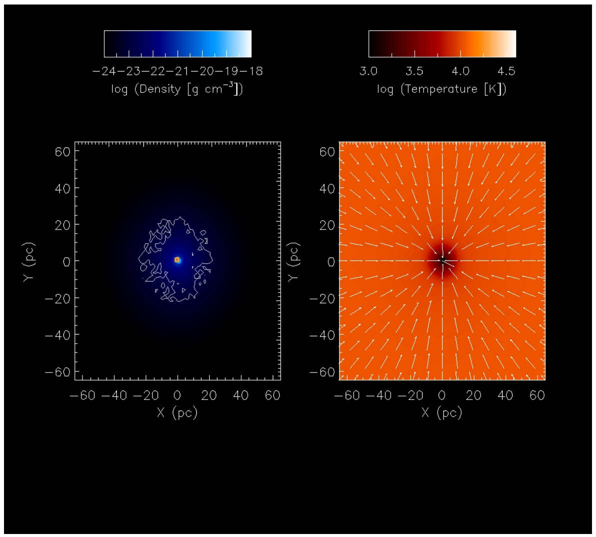
The Adaptive Mesh Refinement code RAMSES (Teyssier 2002)

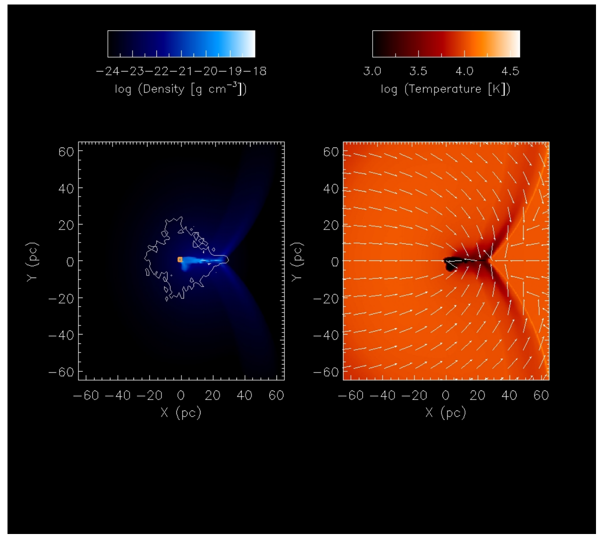


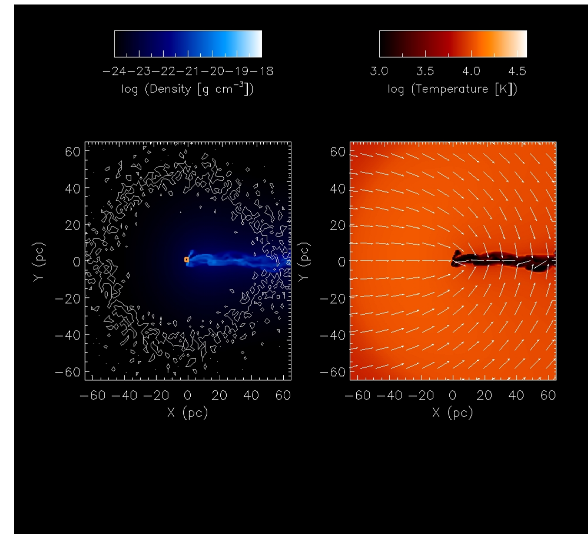
- Eulerian (better for resolving shocks)
- Highly portable, very easy to install and run on several platforms
- High scalability on parallel HPC systems
- Include AMR

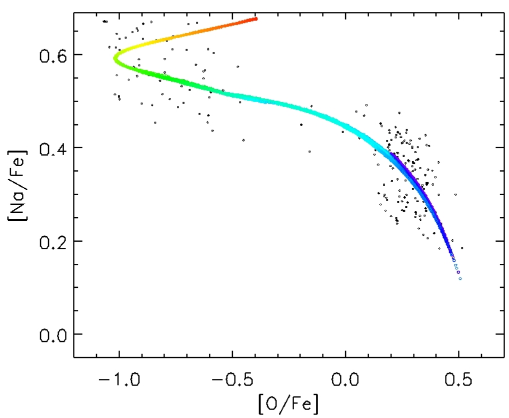
3D Hydrodynamic simulations

Multiple populations in GCs









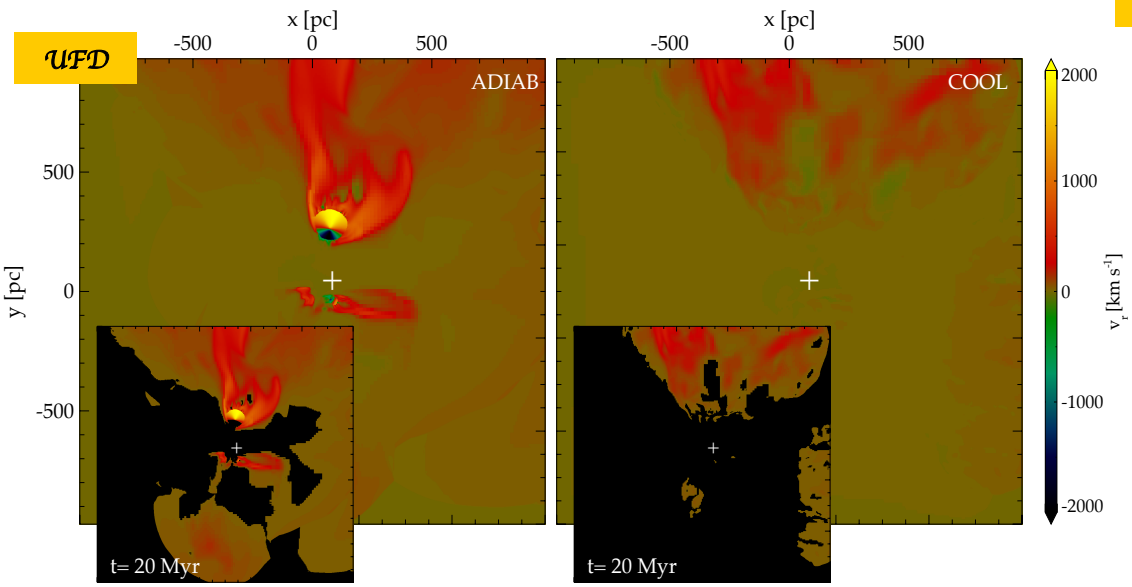
Aim: reproduce the main physical properties (stellar mass, chemical composition, magnitudes of high-*z* stellar clusters [Vanzella et al. 2017, 2018])

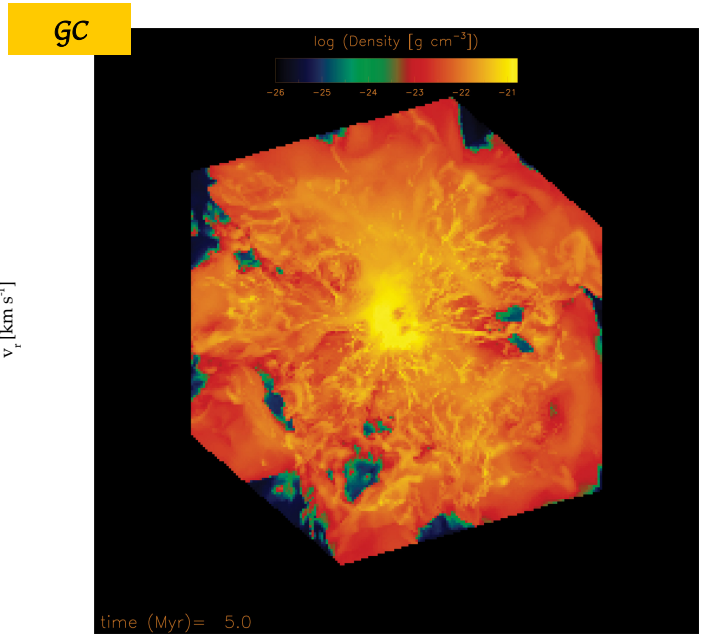
Calura *et al. (in preparation; with* ***E. Vanzella, A. Sollima****)*

3D Hydrodynamic simulations

Stellar feedback in young star clusters and in the smallest MW satellites

Does internal feedback get rid of cold gas in these systems (quenching of star formation on short timescales)?





Romano, Calura, *D'Ercole, Few (to be subm.)*

Calura, *Few,* ***Romano****, D'Ercole (2015)*

3D Hydrodynamic simulations

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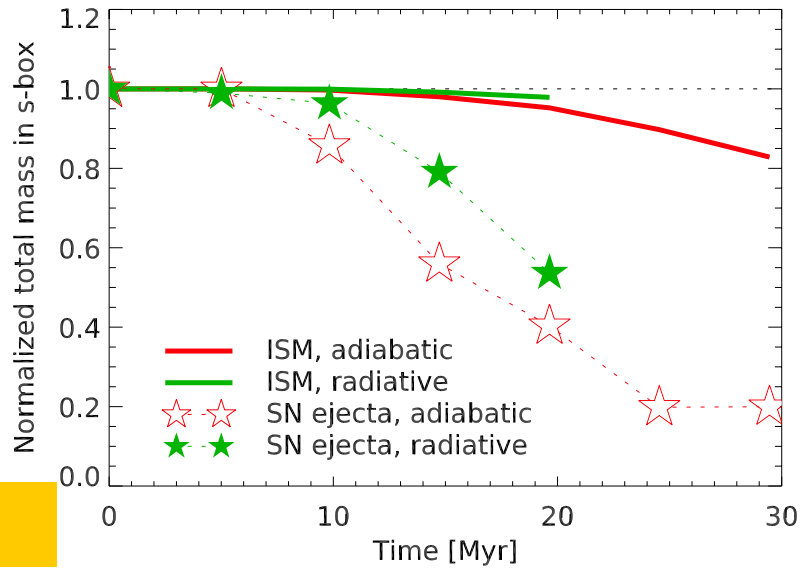
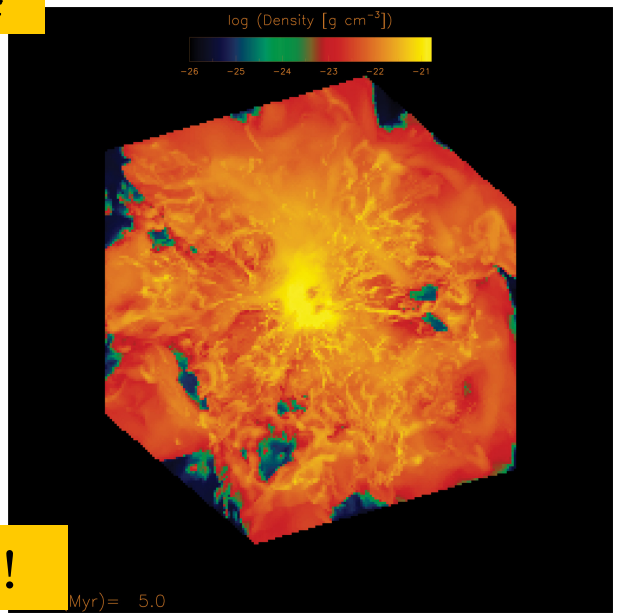
UFD



NO!

Romano, Calura, *D'Ercole, Few (to be subm.)*

GC



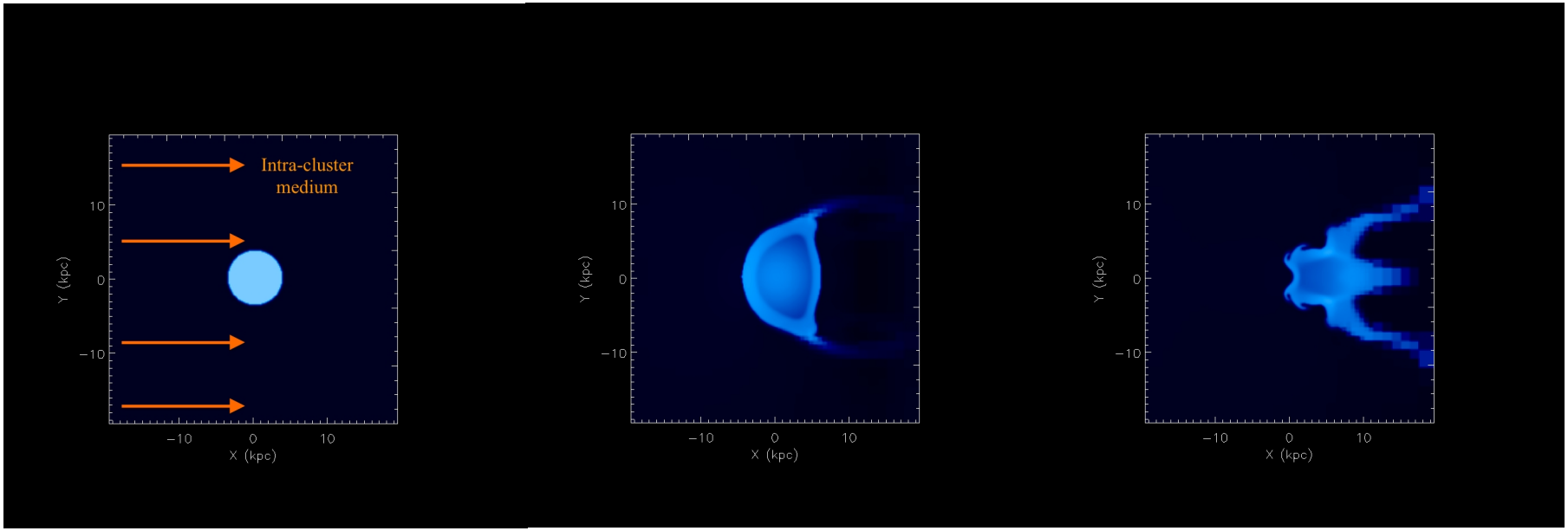
YES!

Calura, *Few,* ***Romano****, D'Ercole (2015)*

3D Hydrodynamic simulations

Pressure-confined galaxies

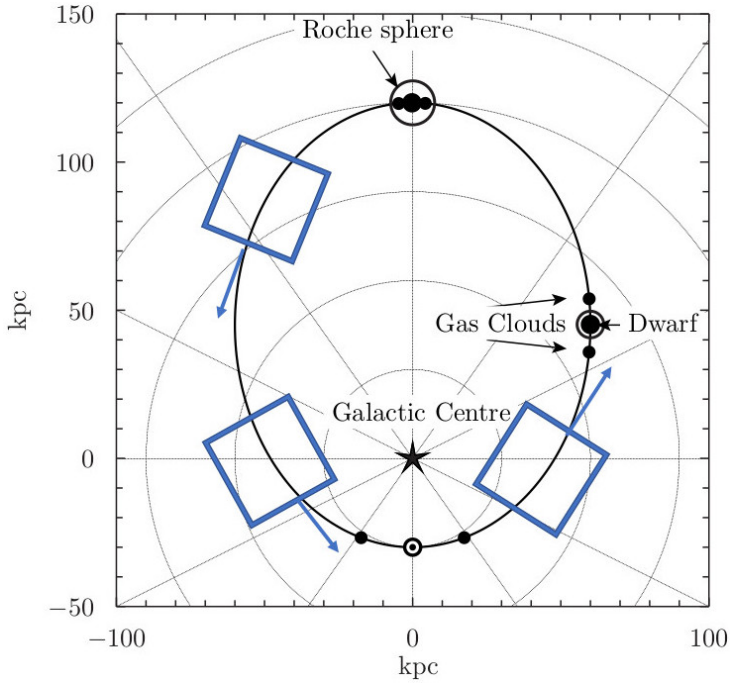
Survivability of a cloud of cold gas in motion in the Virgo cluster
Main physical processes involved: ram pressure, radiative cooling, star formation, stellar feedback



***Calura** et al. (in preparation; with **M. Bellazzini**)*

3D Hydrodynamic simulations

Ram pressure stripping & host-satellite interaction effects on the evolution of the smallest MW satellites (including cooling, stellar feedback)

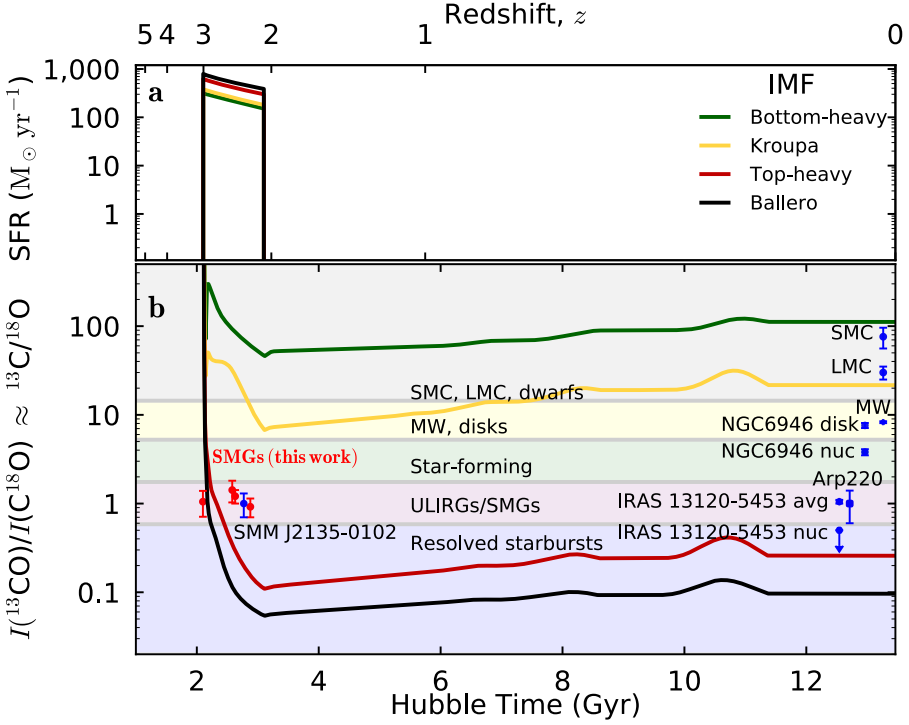


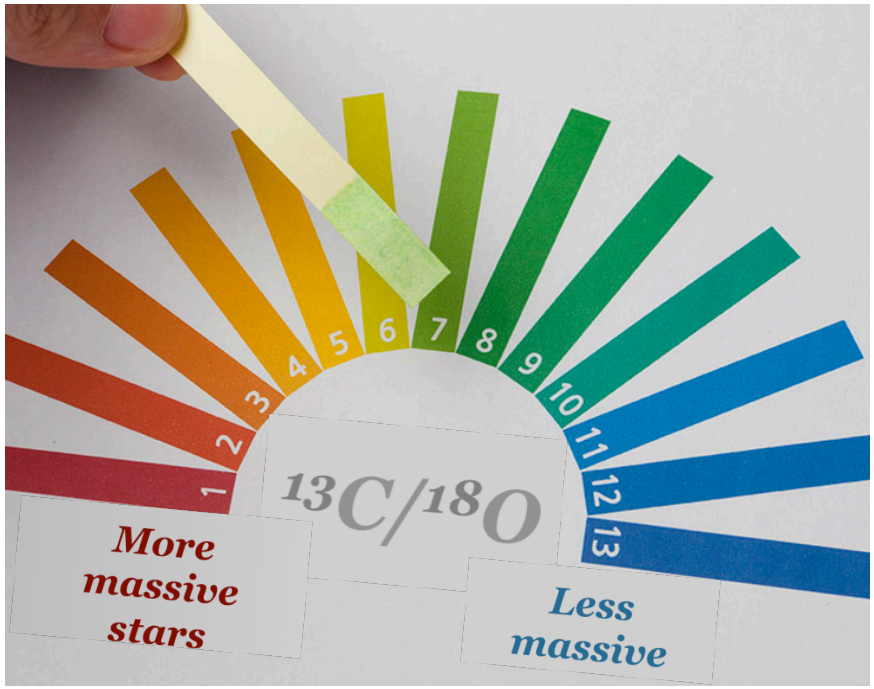
- Highly demanding in terms of computational time because of the high resolution required
- MoU INAF-CINECA Class A proposal submitted (Marconi@CINECA, 3.000.000 CPU/hr)

Romano, Calura, D'Ercole *(in preparation)*

Chemical evolution models

13C/18O as a litmus test of stellar IMF in dust-obscured starbursts at high *z*





***Romano** et al. (2017); Zhang, **Romano** et al. (2018, Nature)*

Chemical evolution and semi-analytical models

- Evolution models of interstellar dust in galaxies (**F. Calura**, with F. Pozzi et al.)
- Chemical evolution of AGN hosts (**F. Calura**, with **M. Mignoli, R. Gilli**)
- Use of semi-analytical models of galaxy formation for chemical evolution studies (**F. Calura** et al., **D. Romano** et al.)
- Implementation of full IGIMF theory in chemical evolution models for elliptical galaxies (**D. Romano** et al., PhD Thesis of C. M. De Masi@UniTS)
- Implementation of up-to-date stellar yields from rotating massive stars (more physics!) in chemical evolution models to study the high N/O ratios measured in DDO 68 (**D. Romano**, with **F. Annibali**, **M. Tosi**; see Francesca's talk) and CNO isotope ratios in SMGs (**D. Romano** et al.)

Critical issues

- Intel (Fortran) compilers
- Software developer (code parallelization and optimization, CPU→GPU [see recent talk by C. Gheller], etc.)
- We are too few…