

Supernova feedback in the smallest Milky Way satellites

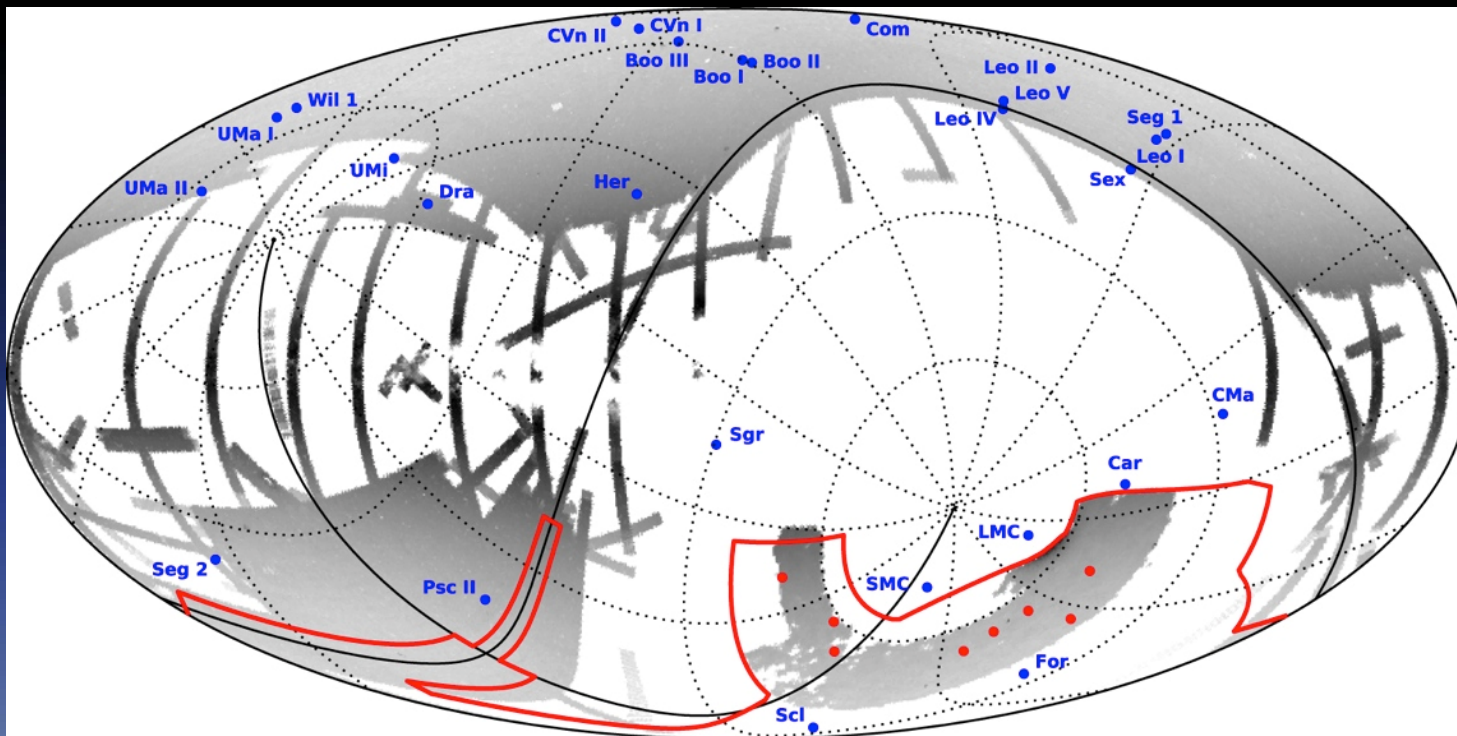
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Scientific Rationale:

Our view of the Milky Way's satellite population and halo substructures is continuously changing...



“Old” picture by Bechtol et al. (2015), reporting the discovery of eight new small satellites in the DES Survey

Our Project:

- ✓ Concentrate on Ultra Faint Dwarf galaxies (UFDs)
- ✓ Actually, concentrate on *one* UFD, Boötes I. Relatively simple system:
 - ✓ Deep CMDs reveal its stars are old and metal-poor.
 - ✓ Detailed chemical abundances are measured for a few stars → when interpreted in the framework of pure chemical evolution models, the observations suggest that this galaxy experienced extremely low-level SF and that most of the metals produced by SNe haven't entered the chemical composition of subsequent generations of stars (Vincenzo et al. 2014; Romano et al. 2015)

Our Project:

- ✓ Boötes I is devoid of gas at present, but it is not established yet whether the gas is lost by internal (galactic outflows) or external mechanisms (tidal and ram pressure stripping).
- ✓ We perform 3D hydrodynamical simulations of multiple SN explosions in a system resembling Boötes I in order to **assess whether they can trigger and sustain a large-scale outflow in this galaxy**. At the same time, we study the **distribution and mixing of metals within the galaxy**.
- ✓ The simulations are performed with **RAMSES** (Teyssier 2002), a grid-based hydro solver with adaptive mesh refinement, highly flexible, portable and stable.

Simulation Set-up:

- ✓ The system is initially composed of a gas + DM distribution in hydrostatic equilibrium . A (coeval) stellar population is in place at $t = 0$. The initial, non-rotating gas mass distribution follows a Plummer density profile, while the DM profile follows Burkert (1995) and Mori & Burkert (2000).
- ✓ The computational box is a $(2\text{kpc})^3$ cube; the maximum resolution is ~ 0.9 pc.
- ✓ The refinement strategy is both geometry- and discontinuity-based.
- ✓ We introduce a passive tracer to follow the evolution of the total metal content in each cell, starting from $Z=0$.

Simulation Set-up:

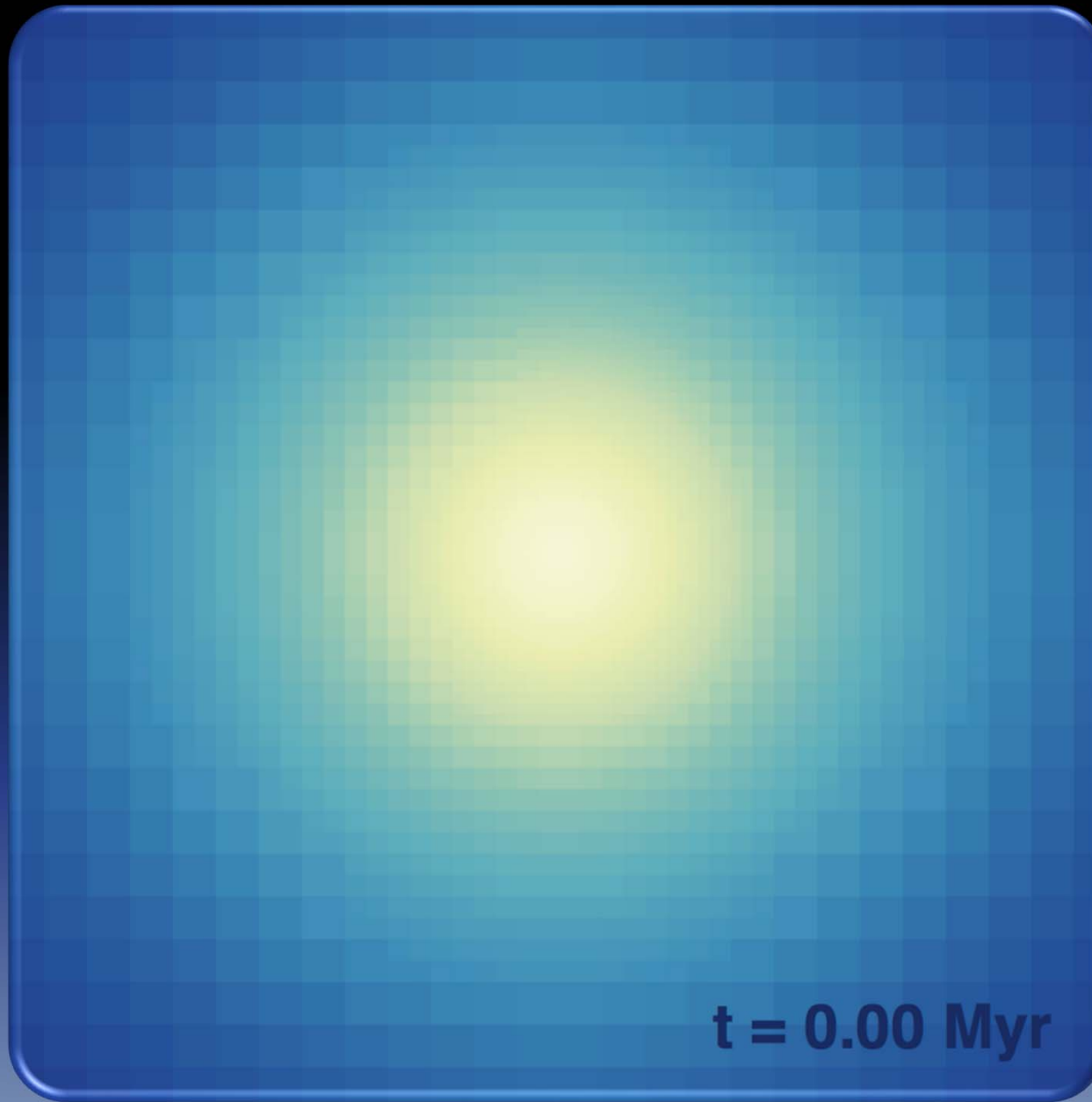
- ✓ Massive stars are grouped in associations that continuously (Mac Low & McCray 1988) inject mass and energy from $t=0$ to $t=30$ Myr.
- ✓ The mass and energy injection rates are computed following Leitherer et al. (2014).
- ✓ We use the cooling function originally implemented in RAMSES, but also analyse the extreme case of adiabatic evolution.

Project History, Current Status, and Problems:

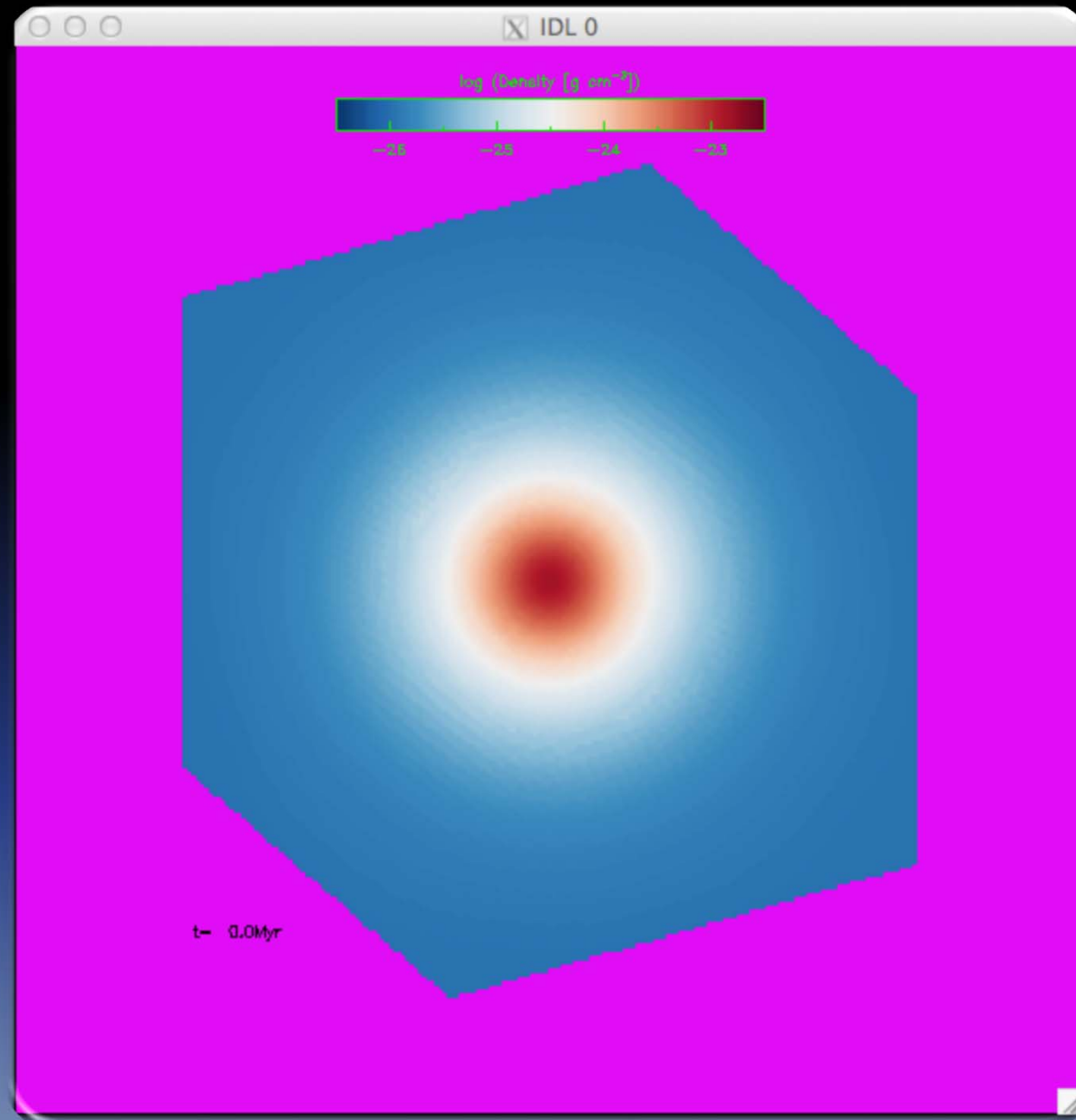
- ✓ Started February 2015, used ~400,000 core hours on the Galileo Tier-1 cluster (3 class C ISCRA proposals approved).
- ✓ First MoU INAF-CINECA call: we have been assigned other 100,000 core hours on Galileo + 200,000 core hours on the Marconi Tier-0 system to complete the project and begin a new simulation (implementation of a continuous star formation). The project expires 31 Dec 2017.
- ✓ PROBLEMS: RAMSES is very stable and portable... problems, mainly memory issues, have been solved quite quickly by interacting with the CINECA help desk.

Project History, Current Status, and Problems:

- ✓ BUT... long time delays between proposal submission and acceptance (much better now with the INAF-CINECA agreement!), long queues (much better using Marconi). System maintenance operations introduce further delays (but we understand these can not be avoided...)
- ✓ **The MoU INAF-CINECA helped us a lot to reduce the time delays!**



Plane XY, full res simulation



Full 3D simulation, resolution degraded to deal with the images on a 4 processor PC