

Zoom in Observations Of Massive clusters and INfant Galaxies (ZOOMING)

M. Nonino & **ZOOMING Team**

ZOOMING Team

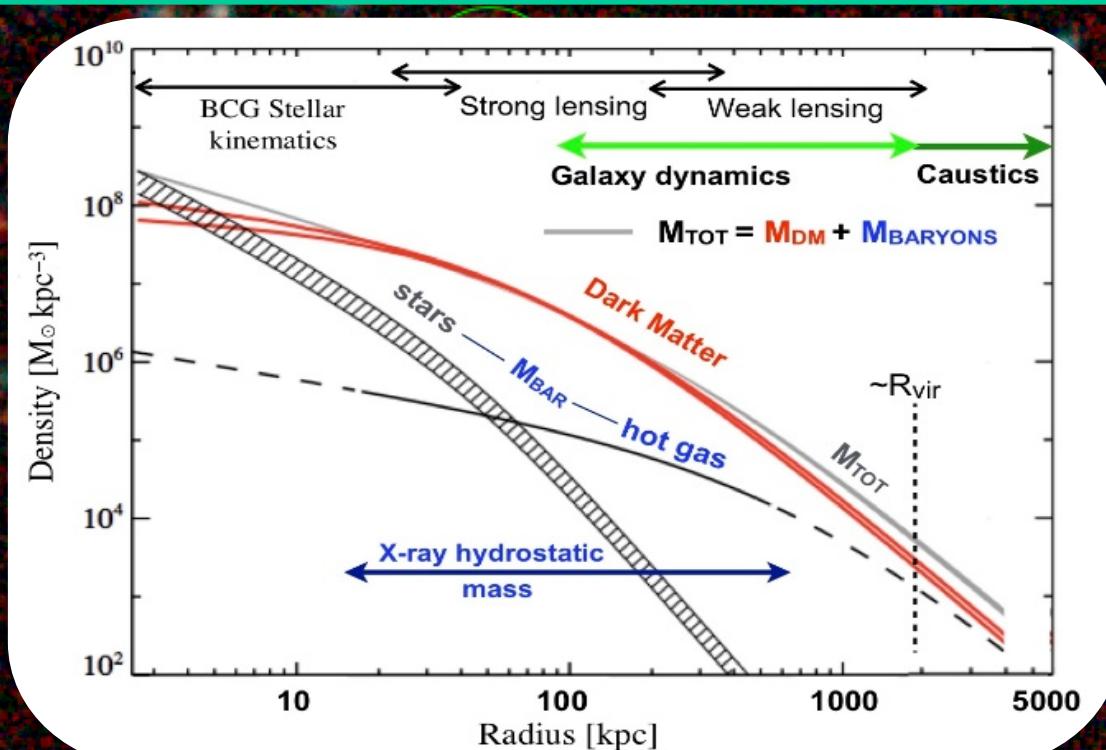


Alcuni Partners Esteri: *STScI (USA), Univ. Taiwan, MPE Munich, Univ. of Massachusetts, ESO, Univ. Yale, Madrid, Univ. Católica de Valparaíso Univ. Concepción (CL), DARK Copenhagen, JPL (USA), ETH Zurigo*

Main Scientific Objectives

Galaxy clusters
a bridge between astrophysics and cosmology

SC#1: Mass density profiles and distribution through strong and weak lensing techniques, dynamics and X-ray methods.

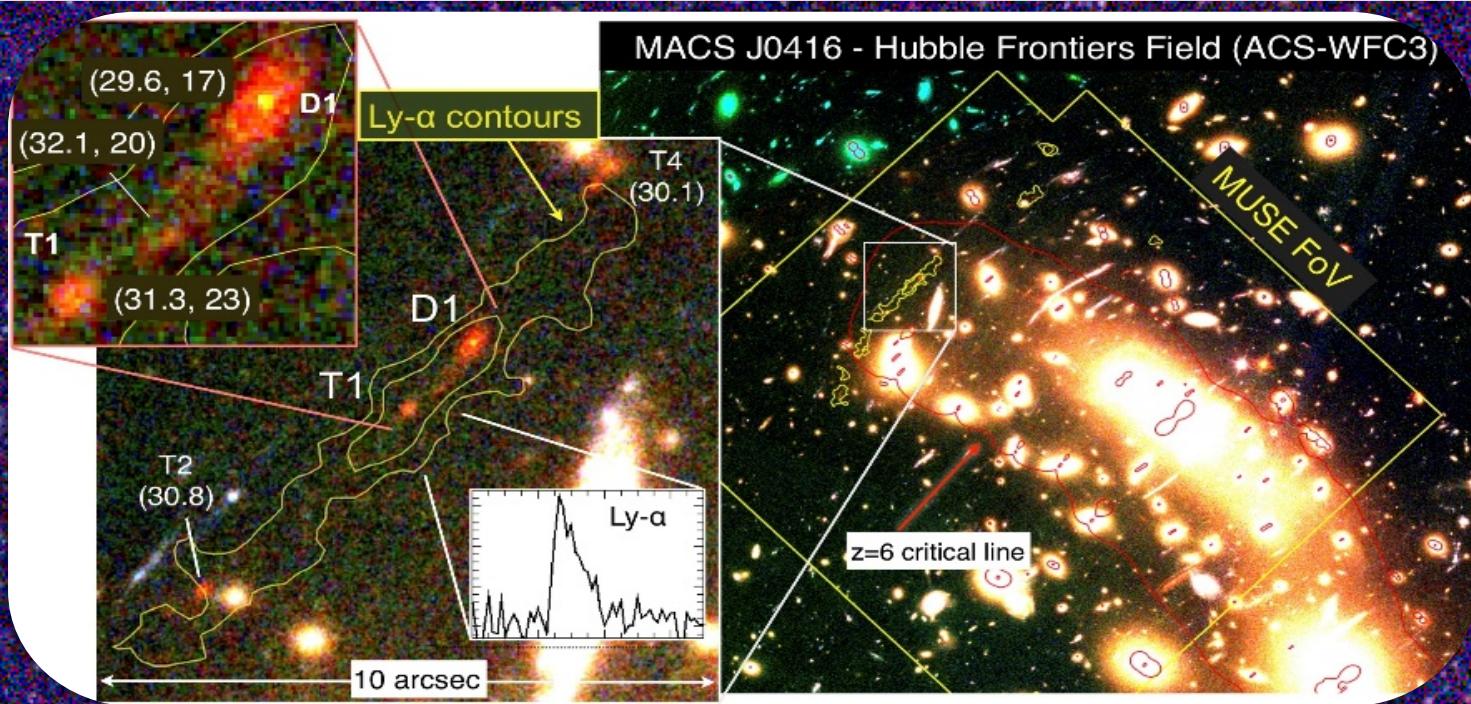


$z=0.348$

Main Scientific Objectives

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SC#2: Early star forming regions under the microscope (redshift 1-7), stellar masses (down to $\sim 10^5$), sizes (down to a few parsec). The contribution of low-luminosity high-z sources to Cosmic Reionization and Globular Cluster Precursors.

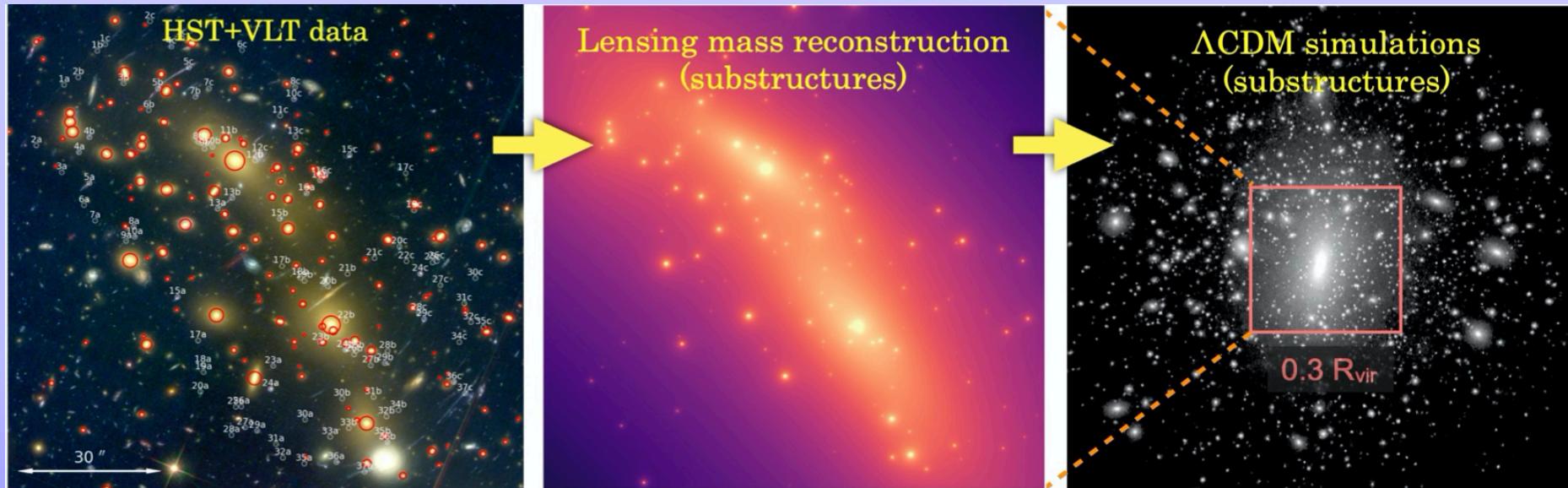


Main Scientific Objectives

Galaxy clusters
a bridge between astrophysics and cosmology

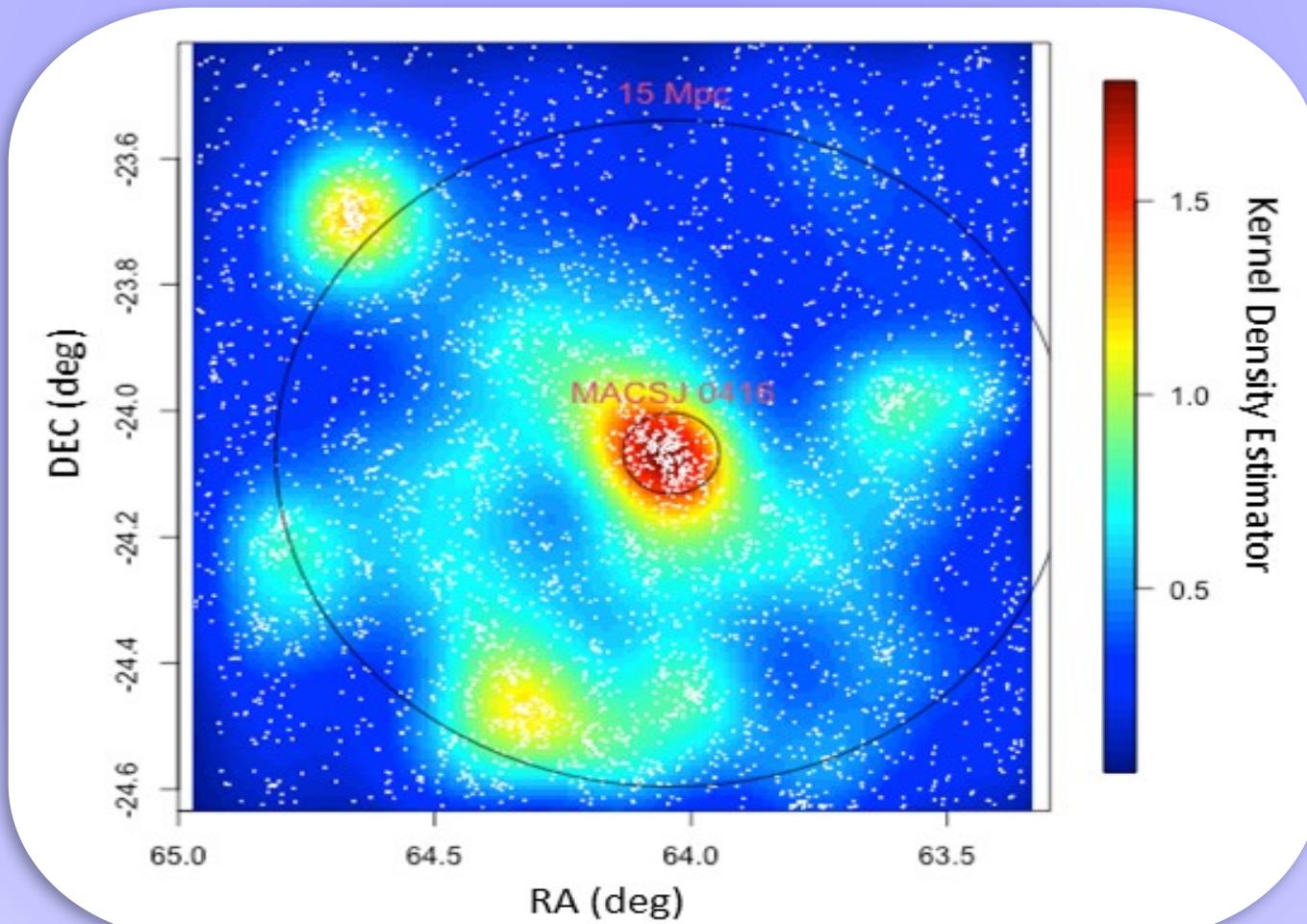
SC#3: Comparison of mass maps from state of the art cosmological simulations with observational data.

SC#4: Cosmography with strong lensing.



Main Scientific Objectives

SC#5: Disentangle mass and environmental effects on galaxy evolution, from filaments to cluster cores. Comparison with state-of-art theoretical models of galaxy evolution. SF and AGN activity in the BCG, feedback on ICM.



VISTA



VST



Public Survey
(575h G-CAV)

Large Programme
(275h KEDFS)
PI: M. Nonino

GTO Programme (300h,
GAME, ongoing)
PI: A. Mercurio

Subaru (+ ESO-WFI)

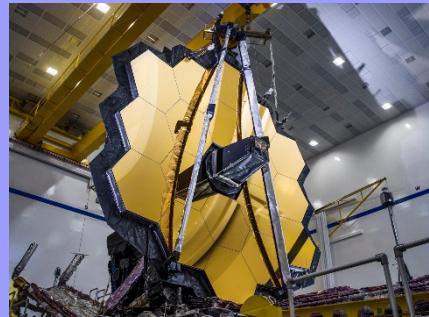


PI: K. Umetsu
M. Nonino

LBT



INAF Strategic Program:
UVCANDELS with LBT/
LBC- (just completed)
PI: M. Nonino



JWST

NIRISS, NIRCAM, NIRSPEC

Early Release Science (167 ks),
PI: T. Treu, + ZOOMING coIs
Cycle 1 GO p.1908
(24.5h, PI: E. Vanzella)



VLT

VIMOS Large Prog
(230 hr, CLASH-VLT,
completed in 2016)

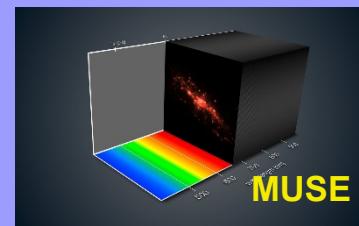
PI: P. Rosati
ORS-XSHOOTER-KMOS
PI: E. Vanzella
M. Castellano

Rubin-LSST
(Astroinformatics)



AAOmega

4 Nights (just approved)
P.I.: A. Mercurio



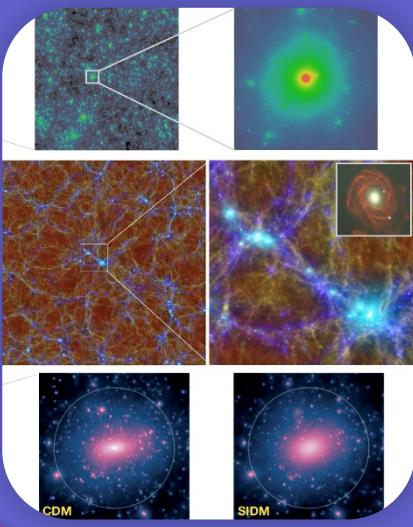
Archival and proprietary data
Many Normal progs.
P.I.s: G. Caninha
R. Gobat
C. Grillo
A. Mercurio
E. Vanzella



HST
CLASH Treasury program (Completed in 2013, PI: Postman)
Hubble Frontier Fields (HFF, Completed in 2016. Public STScI prog.)
Buffalo (Completed – PI: Steinhardt-Jauzac).



Chandra Archival +
proprietary data Submitted
Proposal (PI: P. Tozzi, 150 ks).



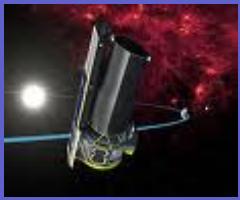
JVLA



JVLA Archival + proprietary data
(PI: P. Tozzi)

Datasets

Spitzer



Spitzer/IRAC
program (PI -
Egami, 526 hrs).

Hershel



The Herschel Lensing Survey
(PI - Egami, 272.3 hrs).

Simulations

| Type | Brief description |
|-------------------|---|
| LCDM Cosmol. Box | Illustris-TNG100: Cosmological volume of $\sim 111^3 \text{ Mpc}^3$; Full-hydro. |
| LCDM Zoom-in | Dianoga: 29 massive clusters ($M > 5 \cdot 10^{14} \text{ M}_\odot / h$); re-simulations; Several snapshots ($z=0-1$). |
| | The 300 Project: 324 massive clusters, ($M > 8 \cdot 10^{14} \text{ M}_\odot / h$); Several snapshots ($z=0-1$). |
| SIDM/ FDM Zoom-in | Dianoga Self Interacting (SIDM) and Fuzzy Dark Matter (FDM) simulations: 29 Dianoga clusters re-simulated with SIDM and FDM starting from the same initial conditions. SIDM: |

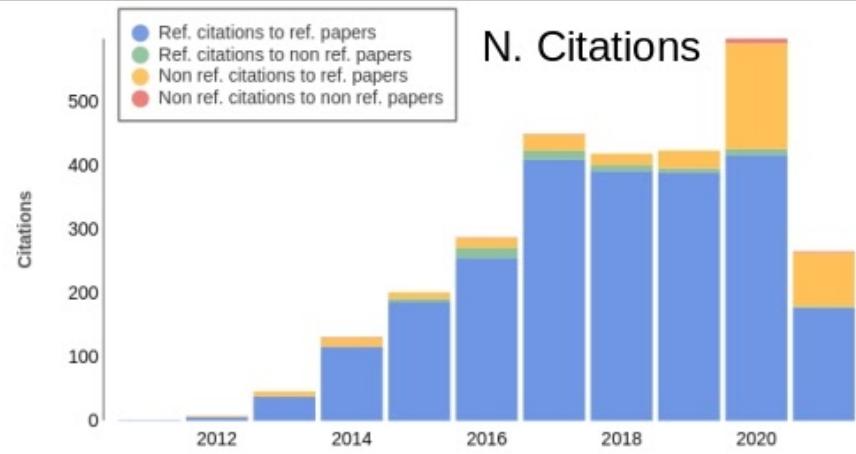
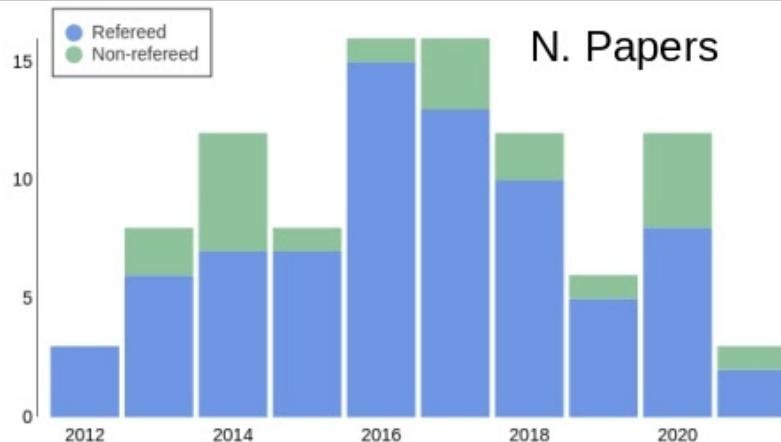
GAEA
(de Lucia)



INCC
(Borgani)

Results

The results obtained within the ZOOMING program have been published in about 100 papers, starting from 2012, with more than 2800 citations and 53000 reads.



Leadership

- ◆ PIs of many observational proposals in international facilities.
- ◆ International reputation on cosmological simulations and theoretical aspects of gravitational lensing and dynamics and galaxy evolution, ad well as machine learning.
- ◆ M. Meneghetti led the *Science* paper (2020) on the discrepancy between observations and Λ CDM predictions (NASA, ESA, HST, INAF PRs, and many interviews e.g., CNN, BBC).
- ◆ Leading role also in training young researchers. In 2016 received financial support for an INAF PhD fellow. The Thesis work also was the observational base, when compared with simulations, for the *Science* paper.
- ◆ Organization of International Meetings (e.g., "Tracing cosmic evolution with clusters of galaxies - In Memory of Riccardo Giacconi", 8-12/07/2019, ~250 participants) and Schools ("Hands-on multi-probe mass measurements in galaxy clusters", 18-21/06/2018), financial support received by INAF.

| | WG#0 | WG#1 | WG#2 | WG#3 | WG#4 | WG#5 |
|-------------------------------|---|--|--|---|--|---|
| | <i>Data sets</i> | <i>Cluster mass distribution</i> | <i>High-z lensed galaxies</i> | <i>Theory & Simulations</i> | <i>Testing ΛCDM</i> | <i>Galaxy evolution</i> |
| INAF | M.Nonino, A. Mercurio, P. Tozzi, E. Vanzella | P. Bergamini, A. Biviano, M. Brescia, D. Carollo, S. Ettori, M. Meneghetti, A. Mercurio , B. Sartoris, P. Tozzi | E. Vanzella, F.Calura, D.Carollo, M. Castellano, S. Cristiani, G.Cupani, V. D'Odorico, R. Gilli, M. Meneghetti, A.Mercurio ,U.Mest ric, M. Mignoli, M.Nonino, L. Pentericci, P. Tozzi, A. Zanella | M. Meneghetti, D. Carollo, G. De Lucia, F. Fontanot, C. Giocoli, E. Rasia | A.Biviano, M. Meneghetti, A. Mercurio , B. Sartoris | A. Mercurio, A. Biviano, M. Brescia, G. De Lucia, A. Gargiulo, M.Gullieuszik, C. Mancini, E. Merlin, A. Moretti, M. Nonino , V. Strazzullo, P. Tozzi, B. Vulcani |
| Associati | C. Grillo , R. Gobat, P. Rosati | C. Grillo , M. Girardi, R. Gobat, P. Rosati | G. Angora , C.Grillo , P. Rosati | S. Borgani, B. Metcalf, L. Moscardini | P. Rosati , S. Borgani, C. Grillo | N. Estrada , R. Gobat, M. Girardi, G. Rodighiero |
| External collaborators | L. Ang, G.B. Caminha (Munich), D. Coe (STScI), M. Postman(STScI), | A. Acebron (Milano), M. Annunziatella (Madrid), G.B. Caminha (Munich), G. Granata (Milano) , M. Lombardi (Milano), S. Suyu (Munich), K. Umetsu (Taiwan) | G.B. Caminha (Munich), M. Giavalisco, M. Gronke (Oslo), M. Lombardi, E. Sani (ESO) | K. Dolag (Munich) | P. Natarajan (Yale), A. Acebron (Milano) | M. Annunziatella (Madrid), R. Demarco (Conception, Cile), D. Gruen (Stanford), M. Hirschmann (Dark Cosmology Centre), A. Rettura (JPL, USA), L. Tortorelli (Zurig) |

The coordinator of each WG is reported in **bold**, core team members in **blue**, and PhD students in **red**.

Financial support (2010-2020)

- **PRIN-INAF 2010 (120 K€, PI. Nonino).**
- **PRIN-INAF 2014 (190 K€ PI. Nonino).**
- **3yr - PhD fellow (60 K€ Rosati/Mercurio) + 1 Astrofit**
- **Support for School and Meetings Organization (20 K€ A. Mercurio).**
- **MAECI 120 (45 K€ M. Meneghetti).**
- **PRIN-MIUR 2017(P.Rosati, 477K€)**
- **2 MainStream (M. Nonino, 26.5K€, E. Vanzella,37 K€).**

Stima fondi acquisiti da INAF fino al 2020 (k€):

456

Tabella fondi:

| # | Provenienza | Certi 2021 (k€) | Certi 22 (k€) | Certi 23 (k€) | Presun. 2021 (k€) | Presun. 22 (k€) | Presun. 23 (k€) | Totale Certi (k€) | Totale Presunti (k€) |
|---|------------------------------------|--------------------|------------------|------------------|----------------------|--------------------|--------------------|----------------------|-------------------------|
| 1 | PRIN MIUR 2017 | 166.5 | 166.5 | 83.5 | 0 | 0 | 0 | 415 | 0 |
| 2 | INAF MainStream (P.I. Nonino) | 15.5 | 8 | 0 | 0 | 0 | 0 | 23 | 0 |
| 3 | INAF MainStream (P.I. Vanzella) | 14 | 6.5 | 0 | 0 | 0 | 0 | 20 | 0 |
| 4 | PRIN MIUR 2020 | 0 | 0 | 0 | 118.5 | 236.5 | 236.5 | 0 | 590 |

Conclusions and Criticalities

- *  Relatively **small** team, yet excellent in training young researches, some of the now in industry: e.g. Fincantieri, and companies focused on data science (Munich) and modelling of financial investments (London).
- *  Attracted ~500KE in 10 yrs, with more than 100 papers related to ZOOMING
- *  **Astroinformatician** for databases integrated with tools for data visualization and catalogue manipulation. Stimulate young computer engineers or astroinformatician for new algorithms and advanced software on high-performance computers.
- *  **Lack of continuous financial support** to guarantee a salary adequate to European standards for more than two years. **Annual contracts**  are not attractive for competitive researchers in the international job market 
- *  hint: *price list* e.g. for competitive observing time on major facilities.