

# Scientific Activity of the Ferrara High Energy Astrophysics Group

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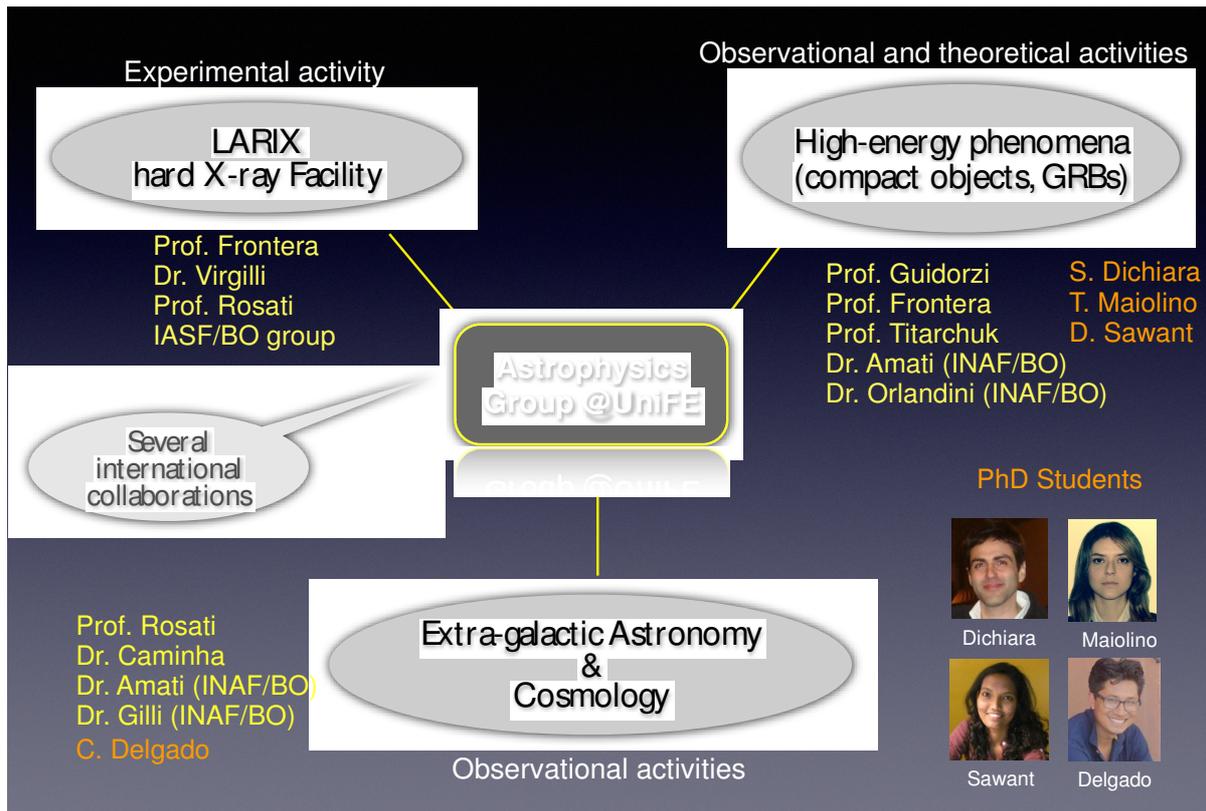
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## Research activities

*The main research activities of the Astrophysics group at University of Ferrara are summarized in the following scheme. They include:*

- *Experimental activities for the development of technologies for future high-energy missions*
- *Observational and theoretical studies of high-energy phenomena, such as compact objects in binary systems and Gamma-ray Bursts (GRBs)*
- *Observational activities in extra-galactic astronomy and Cosmology*



### ICRANet Participants

- *Filippo Frontera*
- *Piero Rosati*
- *Lev Titarchuk*
- *Gabriel Bartosch Caminha (CAPES-ICRANet postdoc)*

### Ongoing collaborations

- *From IASF/BO:*  
*Lorenzo Amati, Mauro Orlandini, Ezio Caroli, John Stephen, Claudio Labanti*

### Recent sabbatical visits

- *Maurice P.-H. M Van Putten (Sejong University, Seoul, South Korea)*
- *Shri Kulkarni (Caltech, USA)*

## Students

- *Simone Diciara (PhD)*
- *Tais Maiolino (PhD)*
- *Disha Sawant (PhD)*
- *Camilo Delgado (PhD)*
- *Erica Cavallari (Master), Sabrina Porini (Undergrad)*

## Summary of past and current research activities

The HEA Group has been operating for many years in the rich academic environment of historic University of Ferrara, with excellent results in experimental, observational and theoretical astrophysics.

Among the experimental activities, we mention the PI-ship by one of the key persons of the Group, Prof. **Filippo Frontera**, of the High Energy Instrument PDS (Phoswich Detection System) and the GRBM (Gamma Ray Burst Monitor), both aboard the BeppoSAX Italian Satellite with Dutch participation. GRBM had a crucial role in the discovery of the Gamma Ray Burst (GRB) afterglow and thus of their extragalactic origin, a mystery lasted about 30 years. For the PI-ship of the BeppoSAX Gamma Ray Burst Monitor that had a crucial role for the 1997 discovery of the X-ray afterglow with BeppoSAX and the consequent solution of the mystery lasted about 30 years about the origin of GRBs, Filippo Frontera is a) among the winners of the Bruno Rossi Prize 1998 of the American Astronomical Society; b) among the winners of the Descartes Prize 2002 for Science of the European Committee; c) has received the Enrico Fermi Prize 2010 of the Italian Physical Society; d) has received the Marcel Grossmann Award 2012. In addition, the Group had the CoI-ship of the JEM-X mask telescope aboard the ESA gamma-ray mission INTEGRAL, still in orbit. The ground calibration of this telescope was performed at the LARIX facility of HEA Group at UNIFE. Over the last decade, after the conclusion of the BeppoSAX mission, the HEA Group has concentrated great experimental efforts in the development of Laue lenses, with the involvement, in addition to HEA scientists, of PhD students of the IRAP-PhD doctorate program. The Laue lens development for focusing high energy X-rays (60-600 keV) is an ambitious project for Space Astrophysics, with possible applications even in Medical Physics (e.g., radiotherapy). The first prototypes of Laue lenses, with 6 m focal lengths, have already been developed, while a lens petal prototype, with 20 m focal length, is being assembled. The lens assembling technique is being patented.

## **X-ray facilities**

For the Laue Lens development project and for calibration of hard X-ray detectors, two hard X-ray facilities have been developed, one 12 m long and a large gamma-ray facility, 50 m long (extendable up to 100 m). The first one is mainly used for assembling short focal length lenses and for performing crystal reflectivity tests and detector calibration, The second one is mainly used for assembling long focal length Laue lenses for astrophysical applications. The large facility has been proposed as European transnational facility.

## **Studies of new missions**

Studies of new missions are a significant part of the experimental activity. In the past, the HEA Group has participated to the study of several astrophysical missions proposed to ESA or other agencies, like GRI (Gamma Ray Imager mission) devoted to broad band X-/soft gamma-ray studies, proposed as M2 to ESA, DUAL devoted to gamma-ray surveys and observations of Supernova explosions proposed as M3 to ESA; LOFT devoted to temporal studies, proposed as M3 to ESA; Wide Field X-ray Telescope (WFXT) designed for efficient wide area soft X-ray surveys, MI-RAX of the Brazilian Space Agency devoted to GRBs, proposed as mission of opportunity to ASI (Italian Space Agency); HXMT (Hard X-ray Modulation Telescope) mission of the Chinese Space Agency, devoted to hard X-ray survey and hard X-ray spectral studies of peculiar celestial objects, proposed as mission of opportunity to ASI. The latter includes an on-going collaboration for the calibration of the High Energy Telescope detection plane. Currently it is involved in the preparation of a mission proposal to be submitted to ESA as Medium Size Mission M4. The mission proposal, THESEUS, is devoted to an unprecedented deep study of transient soft X-ray sky and to a deep survey of high z GRBs. Participants to the proposal include many Institutions from Europe (University of Leicester, CEA Saclay France, INAF Italy, University of Valencia Spain, University of Ljubljana Slovenia, Czech Technical University in Prague) and USA (NASA/MSFC, Huntsville).

## Observational and theoretical activities in the field of high-energy astrophysics

They involve data analysis and related interpretation of X-/gamma-ray observations of celestial objects, in particular compact sources (White Dwarfs, Neutron Stars and Black holes) in binary systems, GRBs, Active Galactic Nuclei and Galaxy Clusters. Data are obtained from Public Data Archives and from approved Guest Observer programs from the missions INTEGRAL, XMM-Newton, and Chandra, in addition to BeppoSAX, In the GRB field, observations of optical counterparts are also carried out with a number of ground-based telescopes. Several students have prepared their Master and/or PhD thesis with the HEA Group on these subjects. Theoretical activities are mainly led by one of the senior professors of the Group, **Lev Titarchuk**, well known in the international community. They focus on the development of spectral models of emission from Galactic Black Holes (GBH) and low magnetic field Neutron Stars (NS) in binary systems. Recently, a spectral emission model of GRBs has been proposed (Titarchuk et al. 2013) and successfully tested (Frontera et al. 2013) with broad band data (2 keV - 2 MeV) obtained with BeppoSAX WFCs and BATSE contemporaneous observations of GRBs. Several PhD theses have been developed thanks to this activity.

## Observational activities in the area of extra-galactic surveys and cosmology

A wide range of observational activities in the area of extra-galactic surveys and cosmology is led by Prof. **Piero Rosati**, who has recently joined UNIFE as full professor, after many years at the European Southern Observatory, extending and strengthening the activities of the HEA group. Such activities build on a number of forefront multi-wavelength observational studies carried out over the last 15 years on X-ray selected surveys of distant galaxy clusters and active galactic nuclei with all major ground-based and space observatories. These programs, led or co-led by Piero Rosati, which include the ROSAT Deep Cluster Survey, the Chandra Deep Field South, the Great Observatory Deep Survey (GOODS), have not only produced a large number of high-impact publications but also trained a generation of young students in the field of cluster cosmology, distribution of baryons and dark matter in the Universe, galaxy formation and evolution, accretion history of supermassive black holes. Prof. Rosati has also brought to UNIFE the project CLASH (Cluster Lensing and Supernova survey with Hubble), a recent systematic study of 25 massive lensing clusters to study the dark matter distribution on kilo-mega-parsec scales with unprecedented detail. Specifically, he is leading an on-going comprehensive spectroscopic campaign with an ESO VLT Large Programme, which, in combination with HST and Chandra data, will provide stringent tests of the currently favored  $\Lambda$ CDM paradigm (Cold Dark Matter with cosmological constant) and shed light on the nature of the dark matter (e.g. Sartoris et al. 2014). Such research activity on dark matter with astrophysical probes will greatly benefit from the interdisciplinary environment at the UNIFE Physics department, which is home to leading theoretical and experimental scientists in the field of particle and astro-particle physics. In addition, the CLASH-VLT project pursues the search for primordial galaxies and first star formation in the Universe, using the magnification power of gravitational lensing which has recently allowed the identification of young galaxies just 400 million years after the Big Bang (e.g. Coe et al. 2013).

### 2014 List of Publication

- Seifina, Elena; Titarchuk, Lev; Frontera, Filippo, *The unique stability of the photon indices in "dipping" Z-source GX 340+0 throughout spectral states*, 40th COSPAR Scientific Assembly. Held 2-10 August 2014, in Moscow, Russia, Abstract E1.1-40-14.
- Virgili, E.; Frontera, F.; Valsan, V.; Liccardo, V.; Carassiti, V.; Squerzanti, S.; Statera, M.; Parise, M.; Chiozzi, S.; Evangelisti, F.; Caroli, E.; Stephen, J.; Auricchio, N.; Silvestri, S.; Basili, A.; Cassese, F.; Recanatesi, L.; Guidi, V.; Bellucci, V.; Camattari, R.; Ferrari, C.; Zappettini, A.; Buffagni, E.; Bonnini, E.; Pecora, M.; Mottini, S.; Negri, B, *The LAUE project and its main results*, Proceedings of the SPIE, Volume 8861 (2013); eprint arXiv:1401.4948 (2014)
- van Putten, Maurice H. P. M.; Guidorzi, Cristiano; Frontera, Filippo, *Broadband Turbulent Spectra in Gamma-Ray Burst Light Curves*, The Astrophysical Journal, Volume 786, Issue 2, article id. 146, 8 pp. (2014).
- Amati, Lorenzo; Campana, Riccardo; Evangelista, Yuri; Feroci, Marco; Fuschino,

- Fabio; Labanti, Claudio; Salvaterra, Ruben; Stratta, Giulia; Tagliaferri, Gianpiero; Frontera, Filippo; Guidorzi, Cristiano; Rosati, Piero; Titarchuk, Lev; Braga, Joo; Penacchioni, Ana; Ruffini, Remo; Izzo, Luca; Zampa, Nicola; Vacchi, Andrea; Santangelo, Andrea; Hudec, Rene; Gomboc, Andreja; Rodic, Tomaz, *GAME: GRB and All-sky Monitor Experiment*, International Journal of Modern Physics D, Volume 23, Issue 6, id. 1430010 (2014).
- Campana, Riccardo; Orlandini, Mauro; Del Monte, Ettore; Feroci, Marco; Frontera, Filippo, *The radiation environment in a low earth orbit: the case of BeppoSAX*, Experimental Astronomy, Volume 37, Issue 3, pp.599-613 (2014)
  - Dichiara, S.; Guidorzi, C.; Amati, L.; Frontera, F., *VizieR Online Data Catalog: BeppoSAX/GRBM and Fermi/GBM long GRBs*, VizieR On-line Data Catalog: J/MNRAS/431/3608. Originally published in: 2013MNRAS.431.3608D (2014)
  - Khalil, Mohamad; Frontera, Filippo; Caroli, Ezio; Virgilli, Enrico; Vlasan; Vineeth, *A simulation Study on the Focal Plane Detector of the LAUE Project*, Nuclear Instruments and Methods A, to be published (2014).
  - Ursi, Alessandro; Guidorzi, Cristiano; Marisaldi, Martino; Frontera, Filippo, *A search for Terrestrial Gamma-ray Flashes in the BeppoSAX Gamma-Ray Burst Monitor data archive*, EGU General Assembly 2014, held 27 April - 2 May, 2014 in Vienna, Austria, id.7381
  - Liccardo, Vincenzo; Virgilli, Enrico; Frontera, Filippo; Valsan, Vineeth; *Study and characterization of bent crystals for Laue*, Experimental Astronomy, on line (2014).
  - Grillo, C., Suyu, S.H., Rosati, P., Mercurio, A., Balestra, I. et al. (23 other coauthors) 2014 *CLASH-VLT: Insights on the mass substructures in the Frontier Fields Cluster MACS J0416.1-2403 through accurate strong lens modeling*, ApJ, submitted (2014) (arXiv1407.7866)
  - R. Bouwens et al. (37 coauthors including P. Rosati) *A Census of Star-forming Galaxies in the  $Z \sim 9-10$  Universe based on HST+Spitzer Observations over 19 Clash Clusters: Three Candidate  $Z \sim 9-10$  Galaxies and Improved Constraints on the Star Formation Rate Density at  $z \sim 9.2$*  (2014), ApJ, 795, 126 (2014)
  - M. Donahue et al. (38 coauthors including P. Rosati); *CLASH-X: A Comparison of Lensing and X-ray Techniques for Measuring the Mass Profiles of Galaxy Clusters*, ApJ, 794, 136, (2014) (arXiv1405.7876)
  - K. Umetsu et al. (41 coauthors including P. Rosati); *CLASH: Weak-Lensing Shear-and-Magnification Analysis of 20 Galaxy Clusters*, ApJ, 795, 163 (2014) (arXiv1404.1376)
  - J. Merten et al. (41 coauthors including P. Rosati) 2014• ; *CLASH: The Concentration-Mass Relation of Galaxy Clusters*, ApJ, in press (2014) (arXiv1405.7876)
  - M. Meneghetti et al. (45 coauthors including P. Rosati) 2014• ; *The MUSIC of CLASH: predictions on the concentration-mass relation*, ApJ, in press (2014) (arXiv1404.1384)

- Annunziatella, M., Biviano, A., Mercurio, A., Nonino, A., Rosati, P. et al. (22 other coauthors) 2014; *CLASH-VLT: The stellar mass function and stellar mass density profile of the  $z = 0.44$  cluster of galaxies MACS J1206.2-0847*, A&A, in press (2014)
- R. Fassbender et al. (23 coauthors including P. Rosati); • *Galaxy population properties of the massive X-ray luminous galaxy cluster XDCEP J0044.0- 2033 at  $z = 1.58$ : red-sequence formation, massive galaxy assembly, and central star formation activity*, A&A, 568, A5 (2014)
- Tozzi, P., Moretti, A., Tundo, E., Liu, T., Rosati, P. et al. (5 other coauthors) *The Swift X-ray Telescope Cluster Survey. II. X-ray spectral analysis*, A&A, 567, 89A (2014)
- Grillo, C., Gobat, R., Presotto, V., Balestra, I., Mercurio, A., Rosati, P. et al. (32 other coauthors), *CLASH: Extending Galaxy Strong Lensing to Small Physical Scales with Distant Sources Highly Magnified by Galaxy Cluster Members*, ApJ, 786, 11 (2014)
- P. Brandon et al. (45 coauthors including P. Rosati); *Three Gravitationally Lensed Supernovae behind CLASH Galaxy Clusters*, ApJ, 786, 9 (2014)
- Presotto, V., Girardi, M., Nonino, M., Mercurio, A., Grillo, C., Rosati, P. et al. (33 other coauthors); *Intracluster light properties in the CLASH-VLT cluster MACS J1206.2-0847*, A&A, 565, 126A (2014)
- De Grandi, S., Santos, J.S., Nonino, M., Molendi, S., Tozzi, P., Rossetti, M., Fritz, A., Rosati, P. ; *On the Fe abundance peak formation in cool-core clusters of galaxies: hints from cluster WARPJ1415.1+3612 at  $z = 1.03$* , A&A, 567, 102A (2014)
- A. Nastasi et al. (14 coauthors including P. Rosati) *Kinematic analysis of a sample of X-ray luminous distant galaxy clusters. The LX –  $\sigma$  relation in the  $z > 0.6$  universe*, A&A, 562, 17A (2014)
- R. Smit et al. (33 coauthors including P. Rosati) • *Evidence for Ubiquitous High-equivalent-width Nebular Emission in  $z \sim 7$  Galaxies: Toward a Clean Measurement of the Specific Star-formation Rate Using a Sample of Bright, Magnified Galaxies*, ApJ, 784, 58 (2014)
- E. Vanzella et al. (21 coauthors including P. Rosati) • *Characterizing faint galaxies in the reionization epoch: LBT confirms two  $L < 0.2L^*$  sources at  $z = 6.4$  behind the CLASH/Frontier Fields cluster MACS0717.5+3745*, ApJ, 783, L12 (2014)
- Sartoris, B., Biviano, A., Rosati, P., Borgani, S., Umetsu, K. et al. (37 other coauthors); *CLASH-VLT: Constraints on the Dark Matter Equation of State from Accurate Measurements of Galaxy Cluster Mass Profiles*, ApJ, 783, L11 (2014)
- O. Graur et al. (41 coauthors including P. Rosati); • *Type-Ia Supernova Rates to Redshift 2.4 from CLASH: The Cluster Lensing And Supernova Survey with Hubble*, ApJ, 783, 28 (2014)
- S. Jouvel et al. (38 coauthors including P. Rosati); *CLASH: Photometric redshifts with*

*16 HST bands in galaxy cluster fields, A&A, 562, 86A (2014)*

- A. Monna et al. (30 coauthors including P. Rosati); • *CLASH:  $z \sim 6$  young galaxy candidate quintuply lensed by the frontier field cluster RXC J2248.7-4431, MNRAS, 438, 1417 (2014)*