Title: HPC enhanced LOFAR VLBI Observations of the Euclid Deep Field North

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Summary:

The PhD project addresses the effective exploitation of the next generation of LOFAR observations to produce large VLBI images at a resolution of about 0.3 arcsec at 144 MHz in the Euclid Deep Field North (EDFN). The EDFN is part of the LoTSS Deep Field project, and it was observed with LOFAR at 144 MHz for around 400 hours. An image obtained from the first 72 hours with an angular resolution of 6 arcsec centered on the EDFN has been recently published (Bondi et al 2024), and the analysis of the remaining observations will provide an image with a rms sensitivity of around 10 microJy/beam at 6 arcsec resolution.

The scientific objective of the project is to obtain deep LOFAR images with sub-arcsecond angular resolutions (0.3-1.0 arcsec, the so-called widefield LOFAR-VLBI) using the data from the LOFAR International Stations on a subset of the available observations and reaching a sensitivity of around 20 microJy/beam at 144 MHz to fully exploit the synergy with the Euclid mission. The images and catalogs of radio sources that will be obtained will be cross-matched with the data from the Euclid mission and the optical/near-infrared ancillary observations. The final scientific goal is to investigate the linear radio size cosmic evolution of radio selected AGNs and star-forming galaxies, comparing them with the optical/near-infrared sizes that will be measured by the Euclid mission, both for the radio-selected sample and for a mass-selected control sample.

The VLBI data have large size and high complexity, requiring the adoption of highly computational demanding algorithms for their processing and the analysis, as well as the usage of High-Performance Computing (HPC) resources. In modern HPC systems, performance is achieved through many-core and accelerated computing (based, for instance, on GPUs), combined to the exploitation of sophisticated high-speed interconnects, for data exchange, and storage subsystems, for effective and efficient I/O. Data reduction and imaging software tools must be adapted, if not completely re-designed, to exploit such systems. The Ph.D. candidate will also contribute to the development of the RICK (Radio Imaging Code Kernels) library, focusing on the enabling and optimization on GPUs of selected algorithms, necessary to accelerate the generation of VLBI images and on the optimization of the I/O, exploiting advanced parallel or in-memory I/O solutions to minimize the impact of data read/write processes. During the PhD work, the candidate will have the opportunity to extensively work on the most advanced supercomputing systems available at INAF and at CINECA (the Italian National Supercomputing Centre).