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UNIVERSITÀ
DEGLI STUDI
DI PADOVA

**PhD course of National Interest in Technologies for
Fundamental Research in Physics and Astrophysics**

Annual report

Name and surname: Neeraj Yadav

Cycle and a.a.: 39th, 2023-2024

Supervisor: Dr. Stefano Bagnasco

- **Research activity carried out during the year**

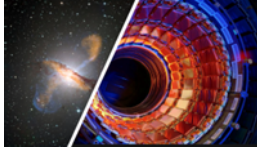
Describe the aim of the project (very briefly), discuss the research activity carried out during the year mentioning the difficulties encountered until now and the actions taken to face them. 1 page max in total.

The aim of the project is three-fold: Further development of low-latency alert generation infrastructure (LLAI) to provide alerts for multi-messenger astronomy; building infrastructure for efficient transfer and management of Gravitational wave (GW) data; developing interdisciplinary expertise bridging advanced computing and GW astronomy. They all tie with “Advanced computing systems for Gravitational wave research” which is the research topic of my PhD.

Firstly, I am currently working to set up a sandboxed version of LLAi at INFN Turin together with k8s VIRGO collaboration group. To successfully set up the LLAi infrastructure, I need to set up the 4 components it is made up of: local instance of GRAvitational-wave Candidate Event Database (GraceDB), SCiMMA Hopskotch server, Mock Event Generator (MEG) and gwelery. The way you do it is using docker containers and Kubernetes which I am learning as I go along. All the 4 components need to reside in a container to properly work and container are managed using Kubernetes. I have set up different containers sequentially following the instructions maintained by the k8s group. Setting up the LLAi was challenging because of the lack of documentation and still some work needs to be done. I have been able to set up MEG and SCiMMA Hopskotch server but still some work is needed to make these two work in conjunction with gwelery in this environment. Additionally, since the software changes quickly as the group updates these tools; because a lot of work is needed to keep up and some things does not work properly after an update. I am keeping a track of the errors (and solutions) so we can update the instructions or develop a fresh set.

Secondly, I am also working on GW Parameter estimation (PE) with Prof. Nagar and his group. I am learning about different analysis pipelines and applying them by submitting a set of jobs to the LIGO cluster at Caltech (CIT), which can take up to 2-3 weeks to complete depending upon user requests load on the cluster. I am using effective-one-body model TEOBResums (developed by a team involving Prof. Nagar) to run PE on the event GW150914. The analysis assuming circular orbit is already completed while the analysis assuming non-circular orbit is currently running. After completion, we will compare whether results from the circular or the elliptical case agrees better with the observed data.

Lastly, I am also working on VIRGO offline data transfer and management using the software RUCIO. Together with the Torino Computing Centre group, we have set up a Rucio storage element (RSE) at INFN Turin. I am in touch with my colleagues at European Gravitational Observatory (EGO) to test the raw data transfer of files. Currently, we are working to solve the problems and errors faced in the transfer. Afterwards, I will setup RSE at CNAF (INFN, Bologna) and CCIN2P3 (France).



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- **List of attended courses and passed exams**

1. “Advanced scientific computing in MATLAB” (4 CFU, exam passed)
2. “Deep networks and structured Learning” (2 CFU, exam passed)
3. “Machine learning for Physics” (3 CFU, exam remaining)

- **List of attended conferences, workshops and schools, with mention of the presented talks:**

Conference attended:

1. Einstein Telescope symposium XIV, May 6th to 10th, Maastricht, Netherlands
2. Virgo Week, 3 Jun 2024 -7 Jun 2024, EGO, Cascina, Italy

- **List of published papers/proceedings:**

None

- **Thesis title (even temporary): Development of a next-generation gravitational-wave low-latency alert generation system (provisional)**

Date: 11-09-2024

Signature:

Seen, the supervisor