

# SamBa TimeS - São Paulo meets Bavaria: A Time Series Workshop

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Although the underlying physics may be very different, similar challenges arise in time series analysis in various areas of astrophysics. This proposal aims to facilitate the exchange of algorithmic tools as used and developed for radio, multi-wavelength and radio neutrino astronomy, in order to help tackle outstanding issues in each field.

This exchange would culminate in the **organization of two one-day workshops on time series analysis** at the University of Würzburg and at the National Instituto of Space Research São Paulo (INPE). Through this series of gatherings, we aim to facilitate an intensive and dynamic exchange of diverse data analysis tools. We plan to have one person from Brazil contribute his expertise to the Würzburg workshop and three people from ECAP/JMU Würzburg contributing to the Brazil workshop. The workshops will be organized by a joint team from ECAP, JMU Würzburg and INPE and will be targeted to master and PhD students. We will organize a one-day program consisting of talks on basic principles of time series analysis (i.e. Basics Time Series Features Extractions, Data denoising, Forecast Time series, Machine Learning classical tools, Deep learning classifications, Bayesian block analysis) and provide hands-on sessions to share our knowledge and software tools within the participating institutions.

In advance to the workshop, the members of the proposing team will start collaborating on individual projects revolving around time series analysis. Throughout the week of the workshop, the proposed team will intensively discuss these projects and the applied methods together. Our collaboration intends to use this opportunity to solve several problems in high-energy astrophysics in the multi-messenger era:

- **Fast Radio Burst (FRB) detection methods and RFI classification** (L. Baraúna & F. Eppel): The detection and processing of transient radio data is a major challenge in radio astronomy and both sides of the collaboration will profit from joint analysis tools that can be deployed for the BINGO and Effelsberg telescopes to perform searches for new Fast Radio Bursts. We will improve existing tools and expand them using Machine Learning (ML) methods which will contribute to the on-going search for the progenitor of FRBs.
- **Multi-wavelength light curve analysis** (L. Baraúna, F. Eppel & S. Wagner): Our team has immediate access to radio (F. Eppel: TELAMON/Effelsberg<sup>1</sup>), X-ray (F. Eppel, S. Wagner) and  $\gamma$ -ray data (S. Wagner: *Fermi-LAT*, JMU Würzburg: FACT/MAGIC) of variable AGN sources. We are aiming to study variability properties (modulation index, periodicity) of these sources and perform multi-wavelength cross-correlation studies to constrain emission models in AGN.
- **Pulse identification of radio neutrino signals** (L. Baraúna & S. Bouma): The identification of neutrino signals for in-ice radio neutrino observatories (RNO-G, IceCube-Gen2) in noisy data is a major challenge for both reconstruction and background rejection. We will attempt to use deep-learning methods to improve on existing approaches to this problem.

On the one hand we aim to advance existing software packages used and developed within our team (e.g., lightcurves python package<sup>2</sup>, Fast Radio Burst analysis pipelines) and on the other hand we want to share data analysis tools in a series of hands-on sessions. At the workshop we will also present these projects to students and offer potential thesis projects.

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<sup>1</sup><https://telamon.astro.uni-wuerzburg.de>

<sup>2</sup><https://pypi.org/project/lightcurves/>