

# Machine Learning Classification of Short Gamma-Ray Transients

Honours Project Proposal · 2026

Level	Honours
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## Project Description

In 2024, a **magnetar giant flare (MGF)** was detected in the nearby galaxy M82, the third such extragalactic event ever recorded. Events like this are commonly misidentified as **short gamma-ray bursts (SGRBs)**, and with the use of machine learning (ML), automated classification is increasingly becoming more important.

SGRBs originate from compact binary mergers, while MGFs arise from sudden magnetic energy release in highly magnetised neutron stars. Despite their different physical origins, both classes exhibit remarkably similar temporal and spectral features, making them difficult to distinguish, particularly when redshift information is unavailable. Misclassification directly affects merger rate estimates and population studies central to multi-messenger astronomy.

This project uses an existing *Fermi*-GBM dataset to investigate ML-based classification of SGRBs and MGFs, allowing the student to focus on ML methodology and physical interpretation.

**Project Aim.** To investigate and evaluate the effectiveness of ML techniques for distinguishing SGRBs from MGFs.

## Objectives

The student will work towards the following main objectives:

- Explore the distributions of temporal and spectral features of short gamma-ray transients through exploratory data analysis and visualisation.

- Apply dimensionality reduction (Principal Component Analysis) to understand the structure of the dimensional feature space.
- Explore ML classifiers including Random Forests and  $k$ -Nearest Neighbours and compare their performance against the baseline SVM using cross-validated metrics (accuracy, precision, recall, F1-score) to distinguish between SGRBs and MGFs.
- Evaluate classifier performance using leave-one-source-out cross-validation.
- Investigate which physical parameters contribute most strongly to the classification decision.

## Expected Outcomes

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Upon completion, the student will have produced a functioning machine learning classification framework for short gamma-ray transients. Key deliverables include:

- A comparative analysis of feature importance, identifying which observational properties best distinguish physical origins.
- Visualisation of the MGF/SGRB feature space via PCA projections.

## Student Expectations

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- Review introductory literature on gamma-ray bursts and magnetars.
- Perform exploratory data analysis and feature visualisation.
- Implement and interpret classification algorithms.
- Submit a written report and deliver an oral presentation.

## Required Skills

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Skill	Level Required
Python programming	Essential (basic level)
Statistics / data analysis	Beneficial, not required
Gamma-ray astronomy	Supervisor will provide guidance