



1. Introduction

Short gamma-ray bursts (SGRBs) are short-duration ($T_{90} < 2$ s), highly luminous gamma-ray bursts associated with compact binary mergers.

Magnetar giant flares (MGFs) are intense flares from magnetars.

Problem: At large distances, MGFs lose their characteristic signatures and become difficult to distinguish from SGRBs, leading to potential misclassification and biased event rates.

Solution: We apply a supervised Support Vector Machine (SVM) to temporal and spectral features from Fermi-GBM data to distinguish MGFs from SGRBs.

2. Feature Extraction

Temporal – Norris function:

$$I(t) = \begin{cases} A \exp\left[-\left(\frac{|t-t_p|}{t_{rise}}\right)^{\nu_1}\right] & t < t_p \\ A \exp\left[-\left(\frac{|t-t_p|}{t_{fall}}\right)^{\nu_2}\right] & t > t_p \end{cases}$$

Features: t_{rise} , t_{fall} , and A ,

Spectral – Comptonised model:

$$N(E) = \left(\frac{E}{100 \text{ keV}}\right)^\alpha \exp\left(-\frac{E(\alpha+2)}{E_{peak}}\right),$$

$$F = \int_{E_{min}}^{E_{max}} E N(E) dE, \quad S = F T_{90}$$

Features: α , E_{peak} , F , P , S , and E_{iso} .

Total: **9-dimensional feature vector** per sample.

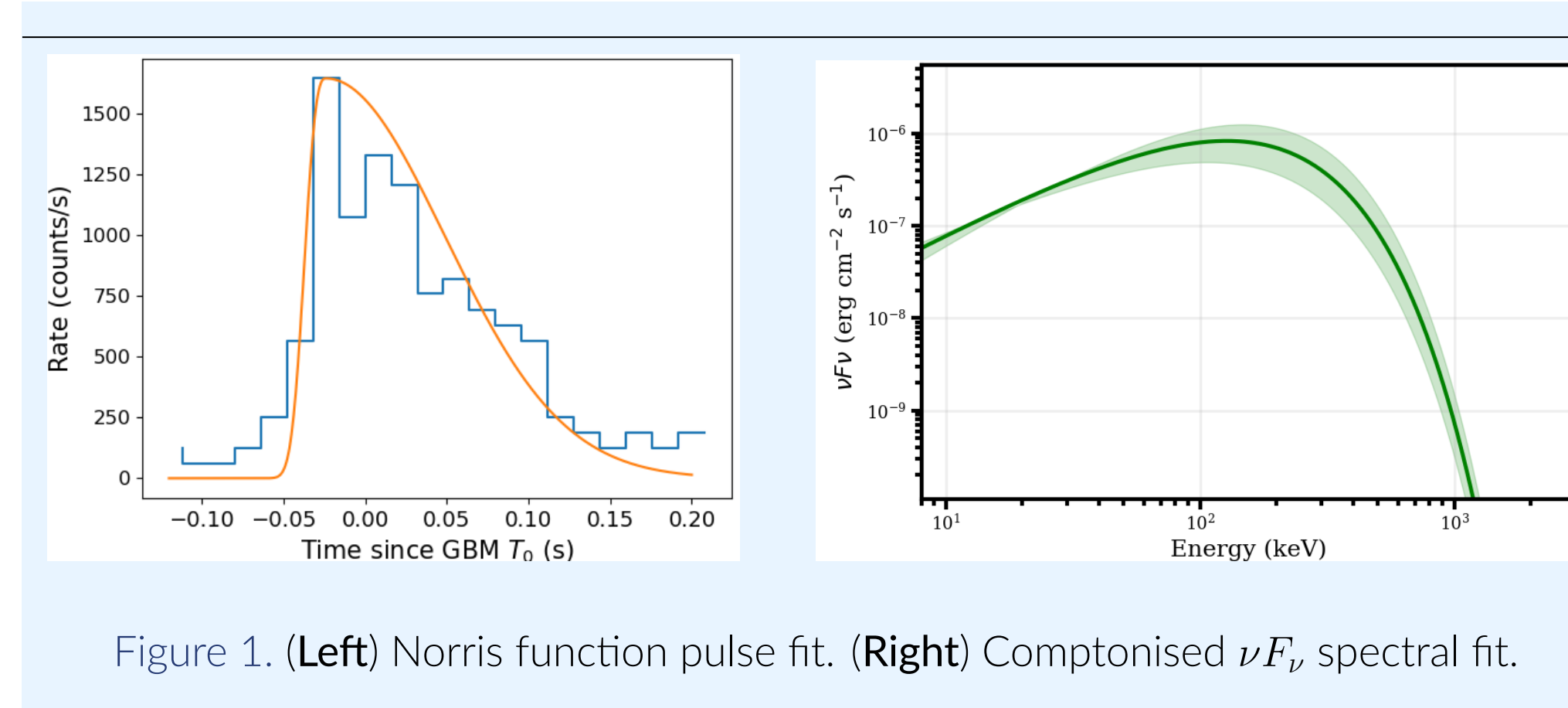


Figure 1. (Left) Norris function pulse fit. (Right) Comptonised νF_ν spectral fit.

3. Support Vector Machine

The **SVM** finds the optimal boundary separating MGFs and SGRBs in a 9D feature space. **LOOCV** validates generalisation to unseen sources, but with only **2 confirmed MGF sources**, limited training diversity remains the key challenge despite balanced class weights

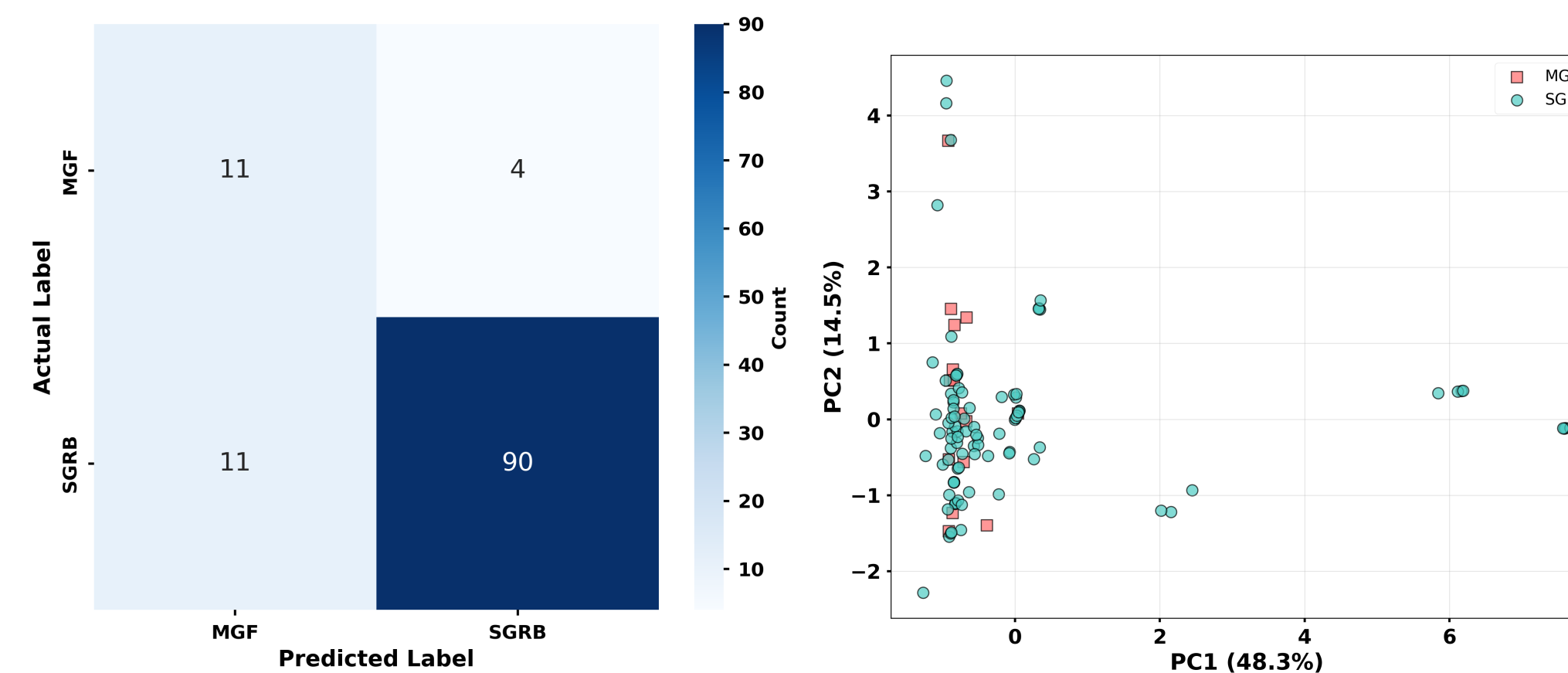


Figure 2. (Left) Confusion matrix (LOOCV): 90/101 SGRBs and 4/15 MGFs correctly classified. (Right) PCA 2D projection.

4. Results

PC	Feature	Load.	Contrib.
PC1 (48.3%)	Flux	+0.999	25.6%
	E_{iso}	+0.995	25.4%
	Fluence	+0.969	24.1%
PC2 (14.5%)	E_{peak}	+0.815	56.6%
	α	-0.678	39.2%
	t_{fall}	-0.211	3.8%

Spectral features dominate; α anti-correlation with PC2 reflects hardness differences between MGFs and SGRBs.

GRB	Pred.	P(MGF)	P(SGRB)
GRB070201	SGRB	34.3%	65.7%
GRB051103	SGRB	37.3%	62.7%
GRB070222	SGRB	37.3%	62.7%
GRB200415A	SGRB	37.2%	62.8%
GRB041227	SGRB	37.6%	62.4%
GRB980827	SGRB	37.2%	62.8%
GRB790305B	SGRB	37.5%	62.5%

All MGF candidates misclassified as SGRBs (62–66% confidence), reflecting the classifier's majority-class bias.

5. Discussion & Conclusions

The SVM correctly classifies **90/101 SGRBs** but only **4/15 MGFs**, with feature overlap consistent with magnetar central-engine models. **MGF scarcity and class imbalance bias the model toward SGRBs**. Future work will expand the MGF sample, and explore deep learning approaches.

6. References

- [1] E. Nakar, *Phys. Rep.* **442**, 166 (2007).
- [2] B.P. Abbott et al., *ApJL* **848**, L13 (2017).
- [3] K. Hurley et al., *Nature* **434**, 1098 (2005).
- [4] E. Burns et al., *ApJL* **907**, L28 (2021).