Searching for gamma-ray binaries using Gaia DR3

The poster is based on Carretero-Castrillo et al. 2023, A&A, in press.

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ABSTRACT

Massive stars are typically formed in **binary systems**. The most massive star can explode as a supernova, and the remaining star can become a **runaway** star in a binary system or isolated. In case the binary system remains bound, it can become a **runaway gamma-ray binary**. Indeed, some gamma-ray binaries are runaways (e.g., LS 5039 or FGL J1018.6−5856). **Good-quality data** from **Gaia DR3** allows us to detect runaways. We crossmatched catalogs of massive stars with Gaia DR3 to **search for runaway massive stars and gamma-ray binaries**. Here we summarize the results obtained up to now.

MOTIVATION

Through the detection of **massive runaway stars** we can search for **gamma-ray binary candidates**

Gamma-ray binary systems are poorly understood (only 10 systems known)

- What is the real population?
- Why only O or Be stars?
- Physical parameters to produce GeV/TeV emission?
- What will CTA see?

DATA

GOSC Catalog

643 Galactic O-type stars

BeSS Catalog

2330 Be-type stars

0.5” & quality cuts

Gaia DR3

1.5” & quality cuts

GOSC - Gaia DR3 Catalog

417 stars

BeSS - Gaia DR3 Catalog

1335 stars

METHODOLOGY

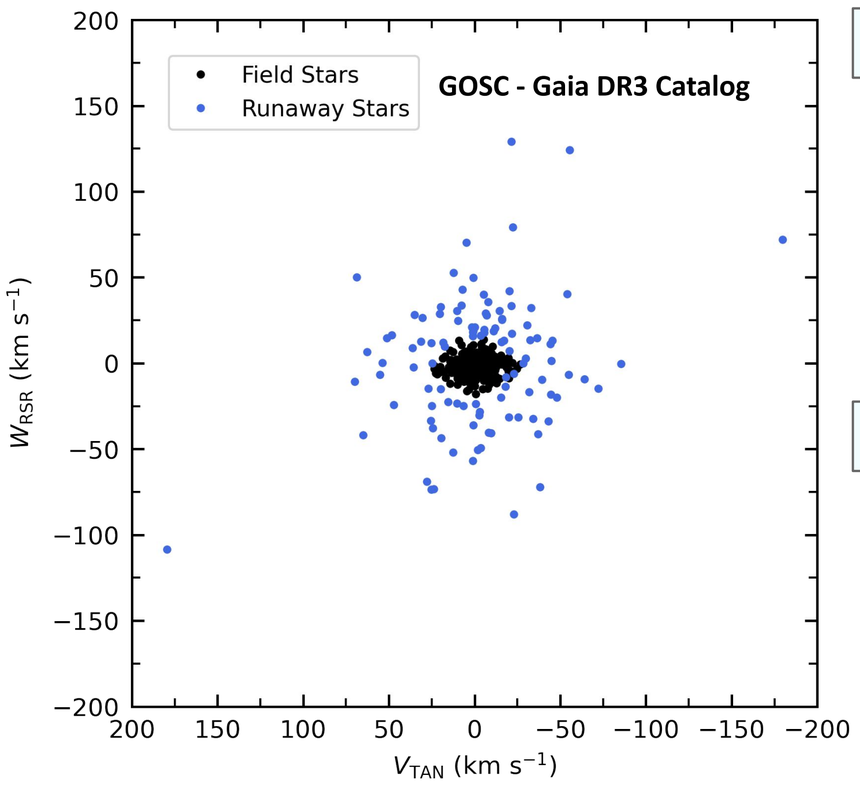
1. CROSS-MATCH
of the massive star catalogs with *Gaia* DR3

2. COMPUTE VELOCITIES
of the stars in their Regional Standard of Rest system

3. RUNAWAY CRITERION
High 2D peculiar velocity with respect to the mean Galactic rotation at 3-sigma confidence level

RESULTS

RUNAWAY STARS



GOSC - Gaia DR3 Catalog

- **106** runaway stars, 42 new
- **25.4%** of runaways
- Peculiar velocities: 16-210 km s^{-1}

BeSS - Gaia DR3 Catalog

- **69** runaway stars, 47 new
- **5.2%** of runaways
- Peculiar velocities: 16-131 km s^{-1}

MULTI-WAVELENGTH

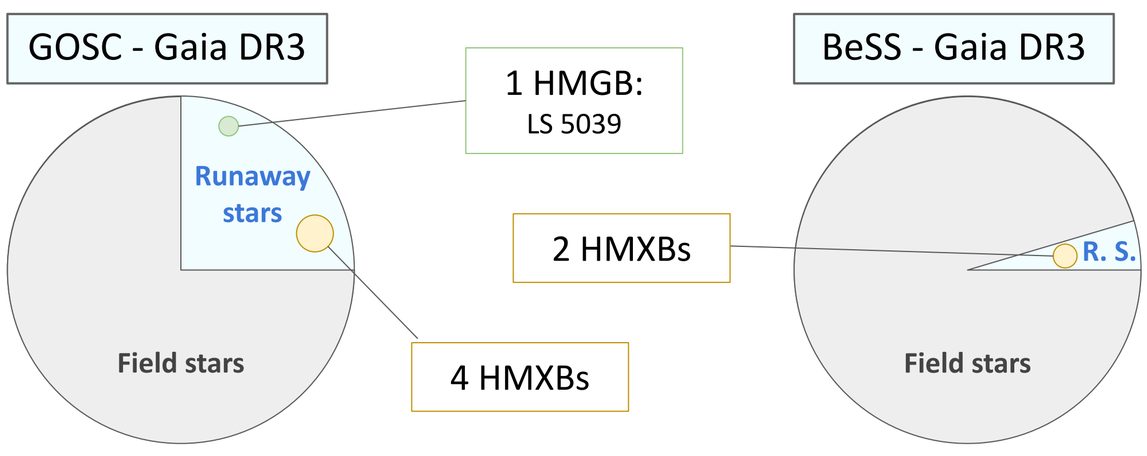
	GOSC - Gaia DR3		BeSS - Gaia DR3	
	Field stars	Runaway stars	Field stars	Runaway stars
GAMMA RAYS Fermi DR4	11	7	20	0
X-RAYS Fortin et al. 2023 & Chandra CSC 2.1	37	7	12	2
RADIO NVSS, VLASS, CGPS, FIRST, & CORNISH-N	11	3	21	2

Note: The gamma-ray counterparts represent an upper limit given the large Fermi error ellipses and the possible origin of the gamma-ray emission in other sources than the studied stars. The X-ray and radio counterparts represent a lower limit given the coverage of the used surveys.

HIGH-MASS X-RAY/GAMMA RAY BINARIES

Fortin et al. 2023

- Known high-mass X-ray /gamma-ray binaries among our runaways:



CONCLUSIONS AND FUTURE WORK

- The unprecedented accuracy of the Gaia DR3 data has allowed us to find 175 (89 new) massive runaway stars.
- We find larger velocities for O-type runaways than for Be type ones, and a factor of 5 between the percentage of runaway stars among O-type stars versus Be-type stars.
- This work opens the door to identify new high-energy systems among our runaways by conducting detailed multi-wavelength studies.

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