

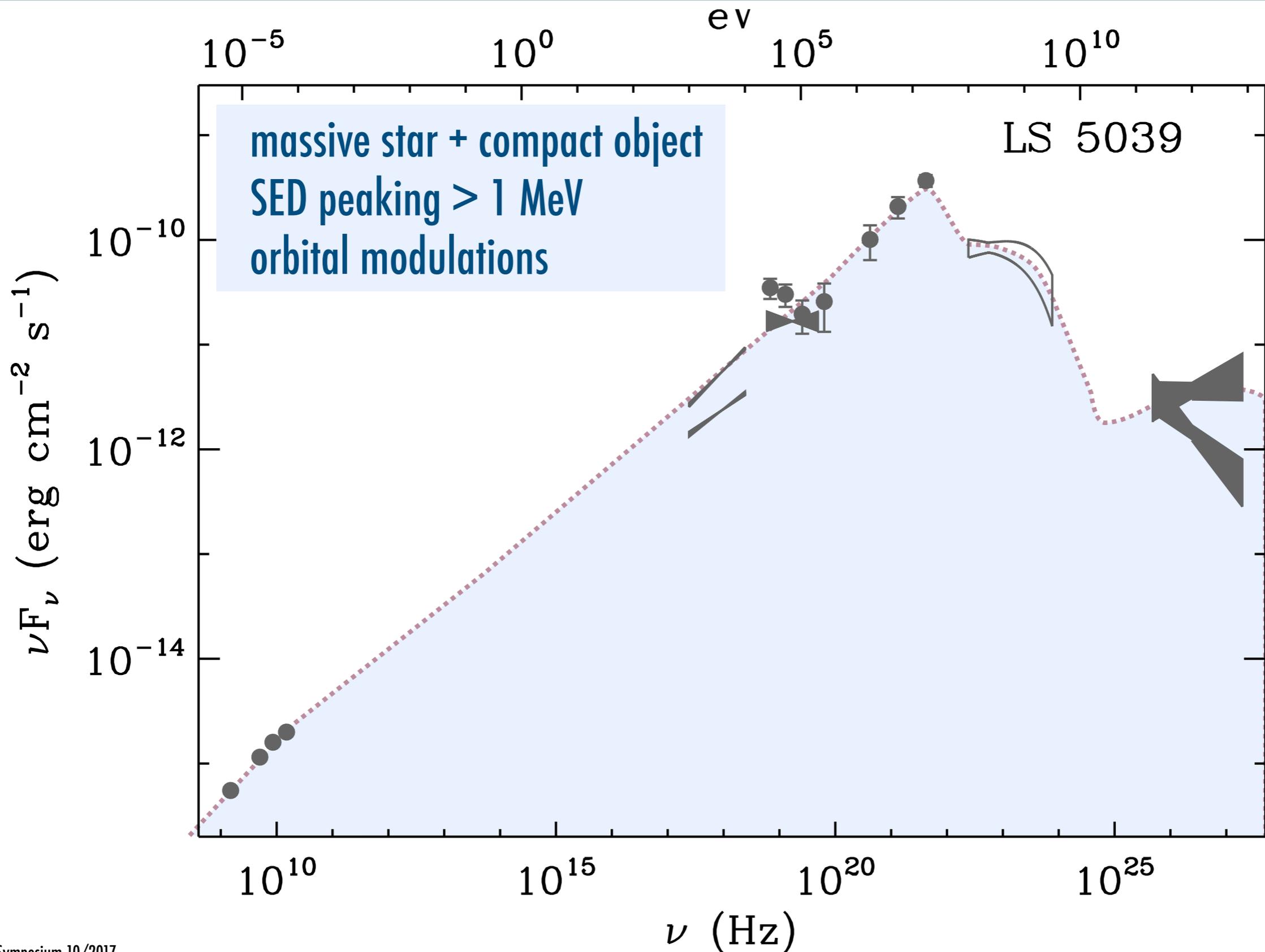
The population of gamma-ray binaries

Guillaume Dubus

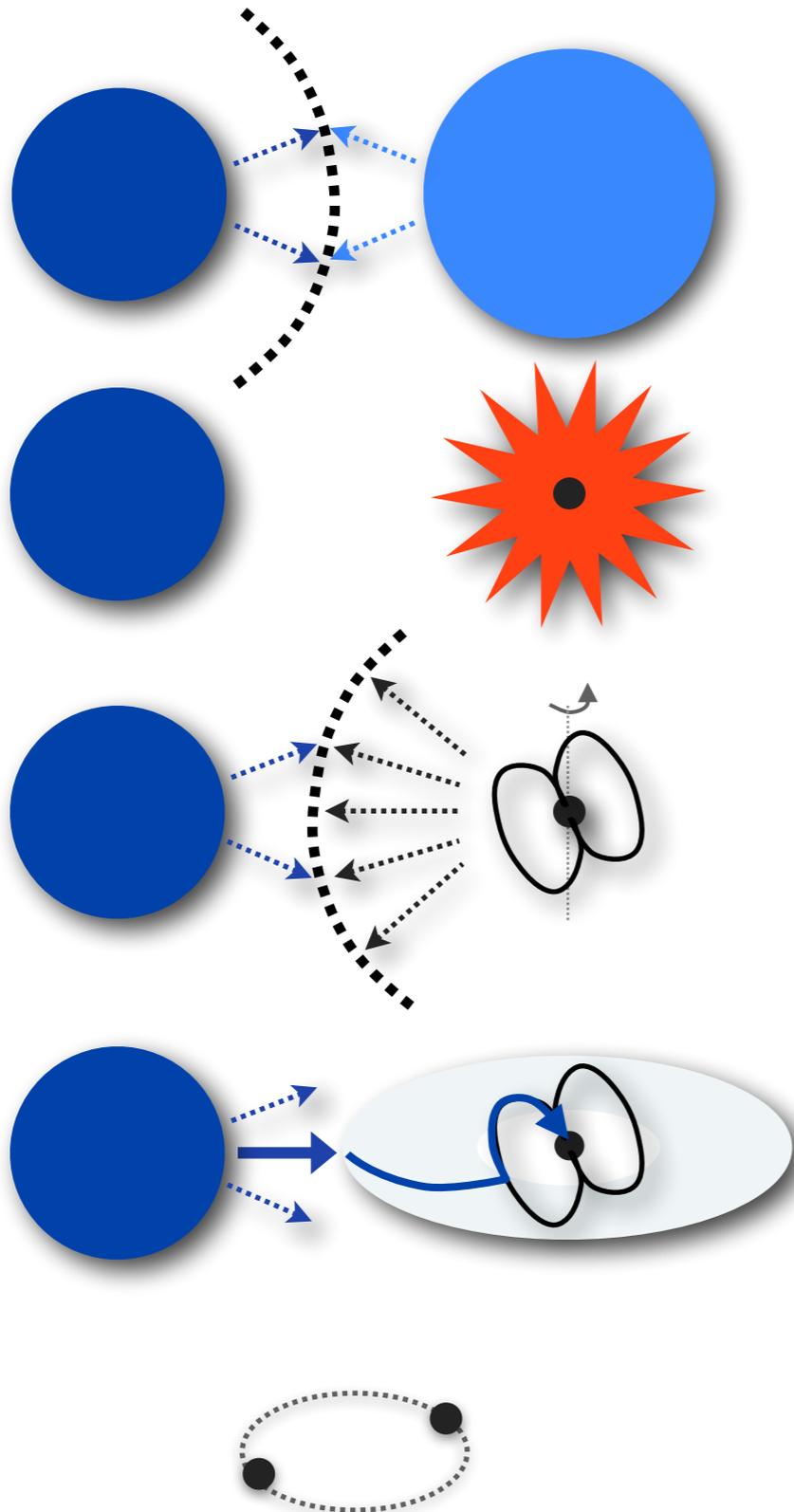
with N. Guillard, P.-O. Petrucci, P. Martin
A&A in press (ArXiv 1707.05744)

image credit
NASA / GSFC / F. Reddy

What is a gamma-ray binary?



Gamma-ray binaries in context



massive stars

colliding wind binary

supernova → neutron star

high spindown pulsar → pulsar wind

gamma-ray binaries

pulsar slows down → accretion high mass X-ray binaries

supernova → double neutron star

Known gamma-ray binaries

LMC P-3 (Corbet this afternoon)

PSR B1259-63

LS 5039

LSI+61 303

HESS J0632+057

1FGL J1018.6-5856

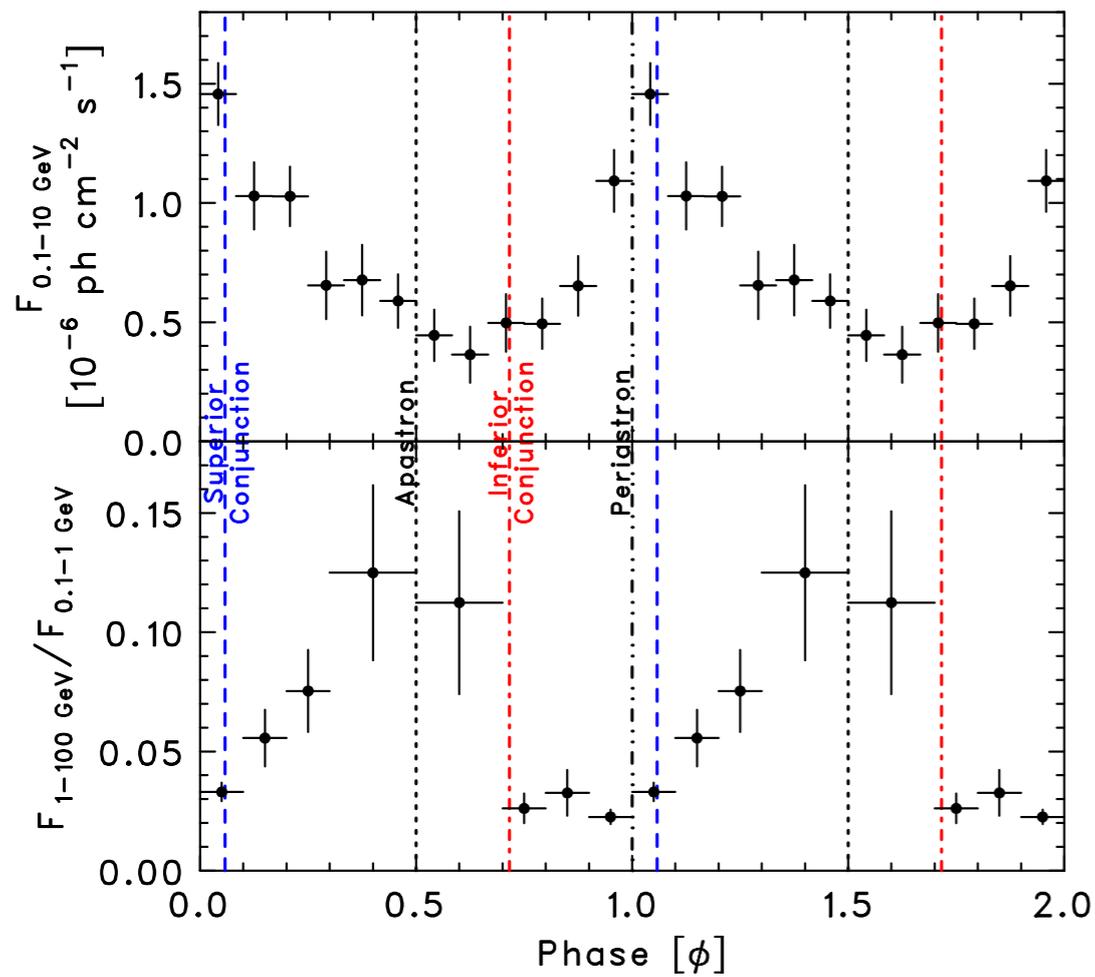
PSR J2032+4127

How many are there?

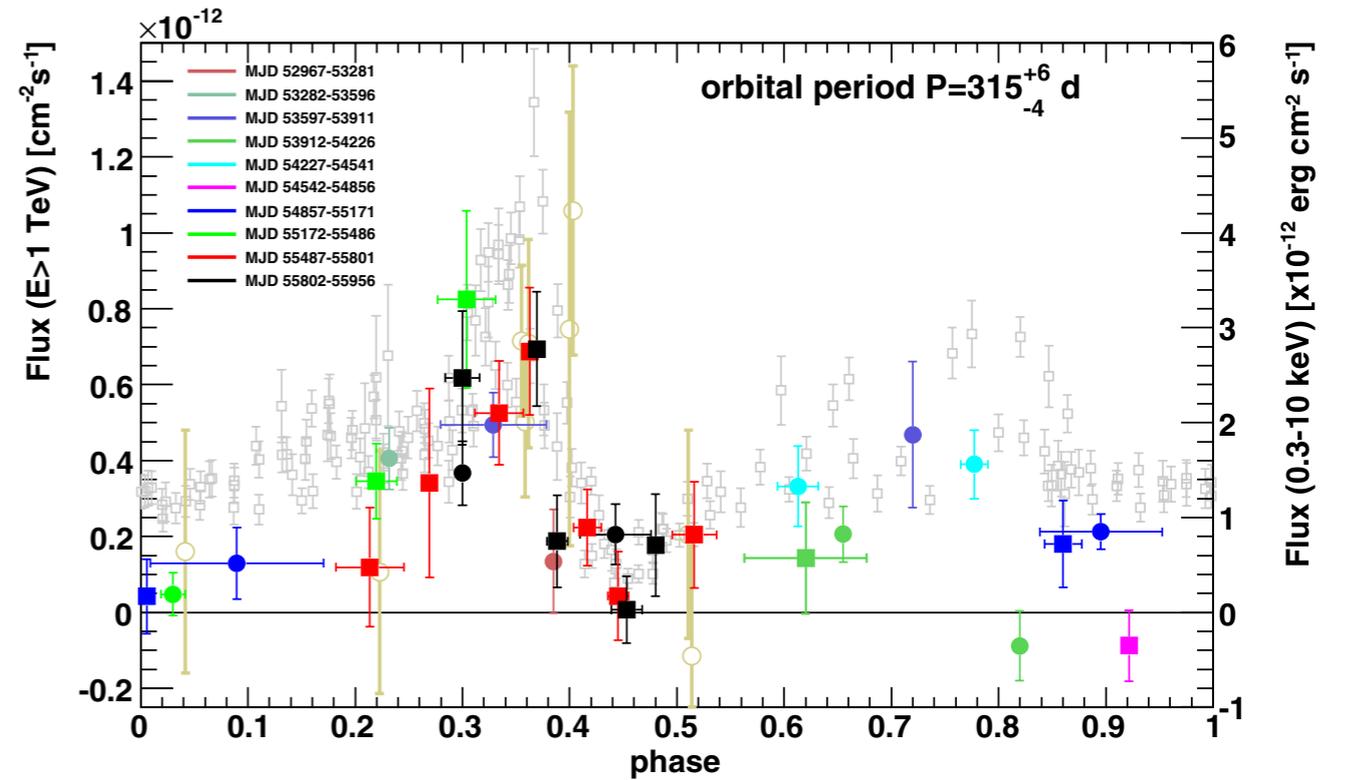
How many can we expect to see?

Impact of orbital modulation on detection?

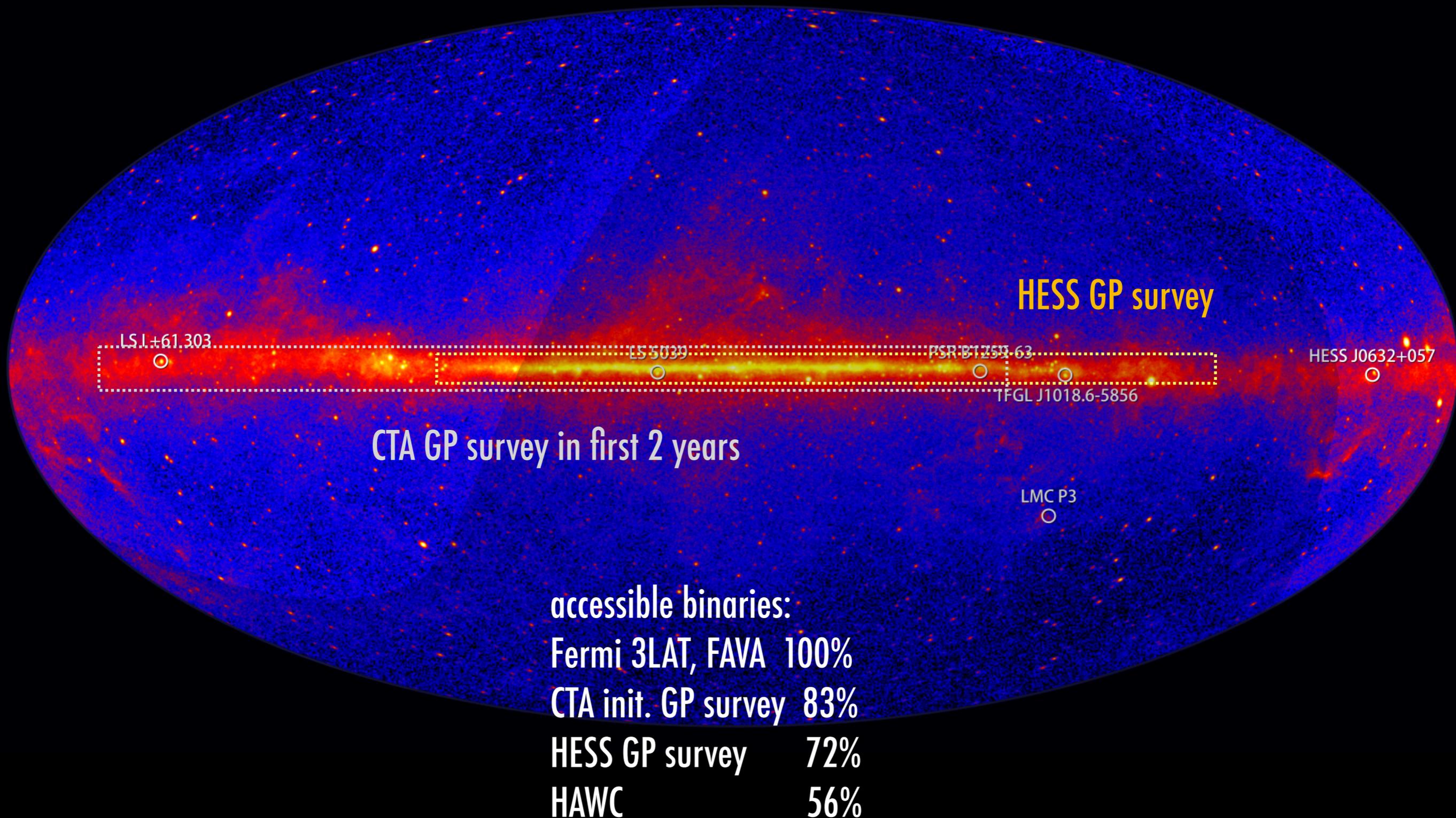
LS 5039 : 3.9 day orb. period



HESS J0632+057: 315 day orb. period



Impact of survey visibility & scheduling?



Simulating surveys

1. get orbital lightcurve
known or modelled

2. place binary in spiral arms

3. run through mock survey
taking into account #visits, total
exposure, seasonal observability, etc

Fermi 3FGL

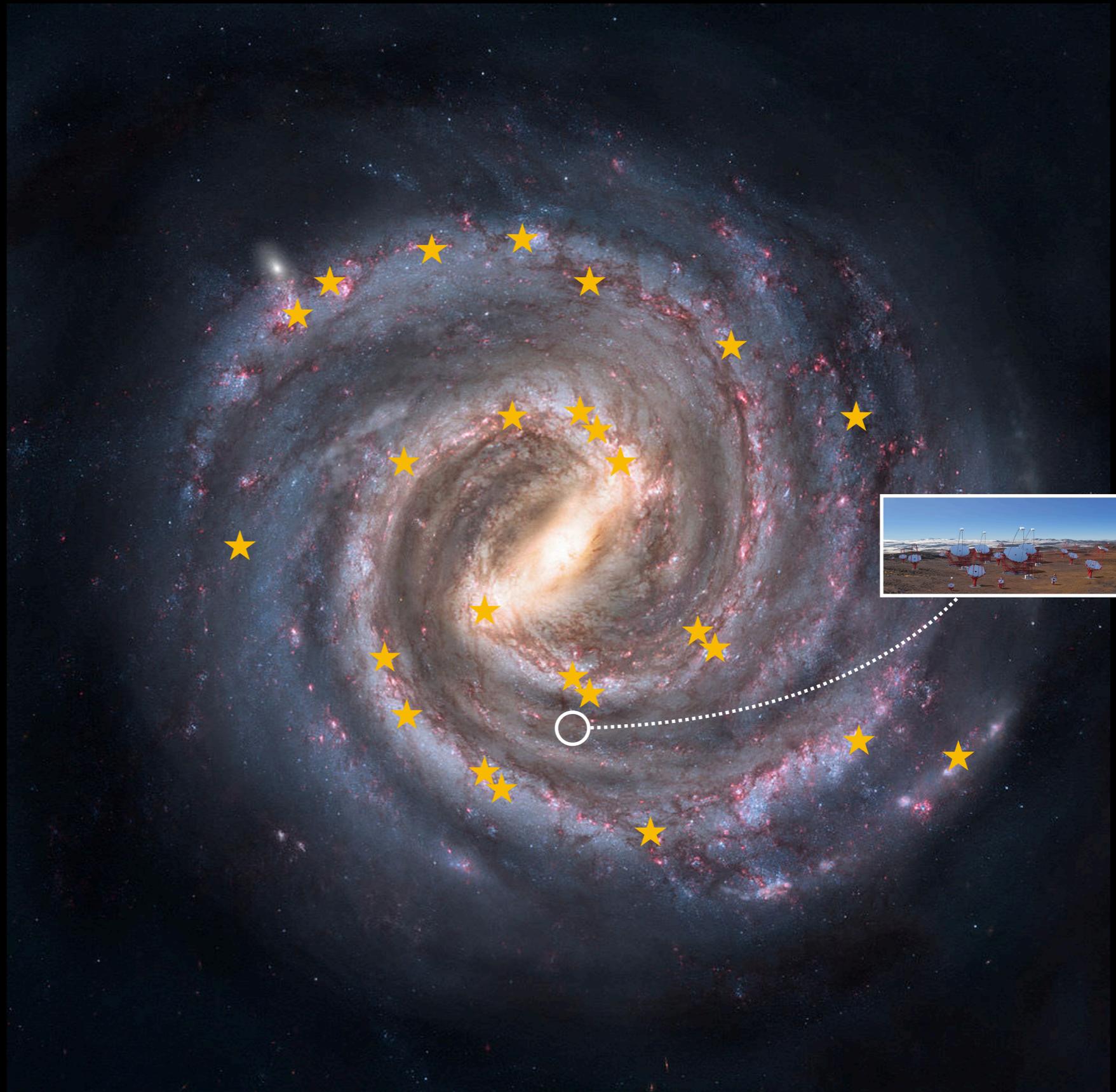
Fermi FAVA

HESS GP

CTA GP

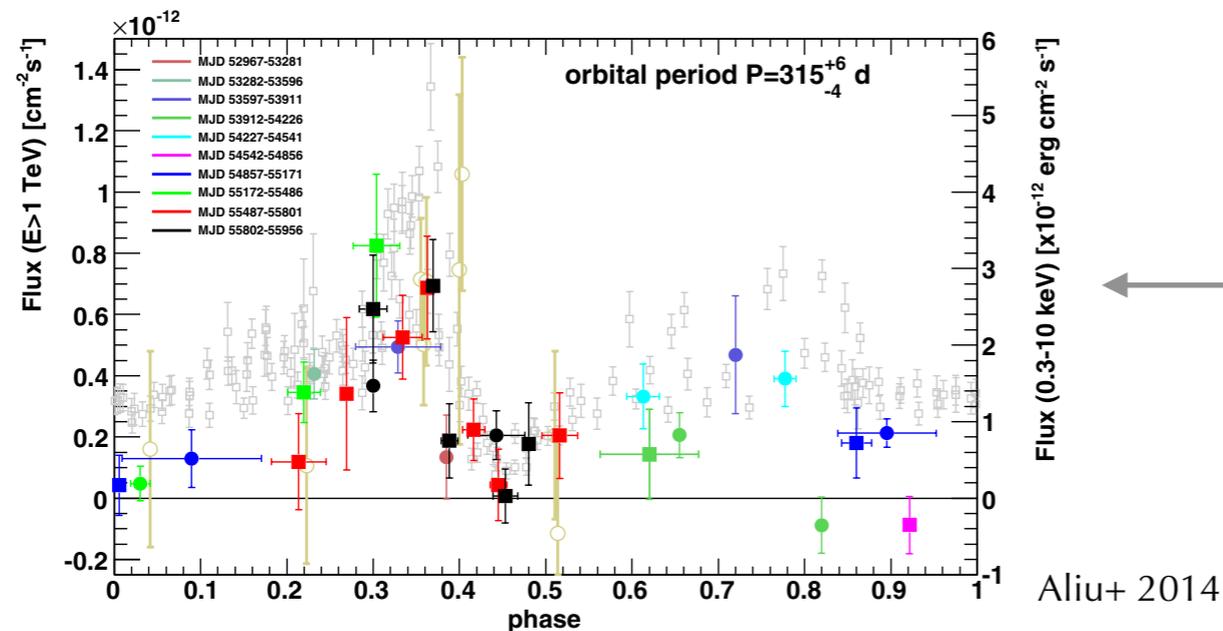
HAWC

4. infer population size
from detection rates



Extrapolating from known systems

Assume same lightcurve as known system, place randomly in Galaxy, get detection rate



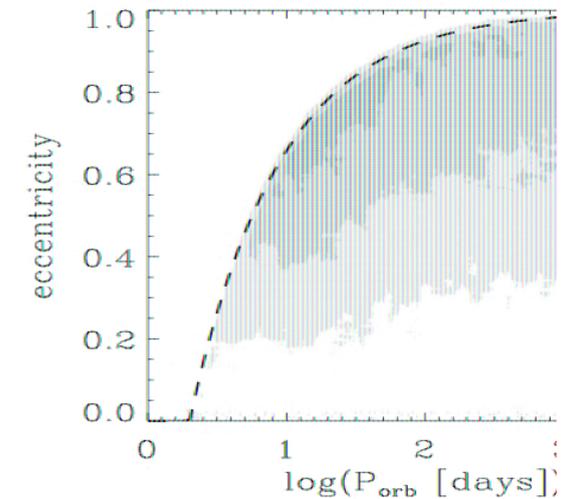
e.g. 11.2% of HESS J0632-like system detected in full CTA survey

- *Fermi* is much more constraining than VHE surveys except full (10yr) CTA GP.
- 3FGL is generally better than FAVA at detecting systems.
- We have seen nearly all bright binaries but
 - a handful of PSR B1259-like systems could have escaped detection,
 - could have ≈ 200 HESS J0632-like “GeV-faint” systems: strong constrains from CTA.

A synthetic population

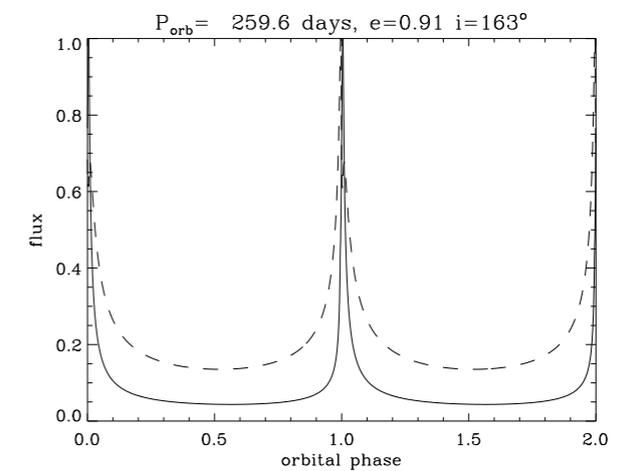
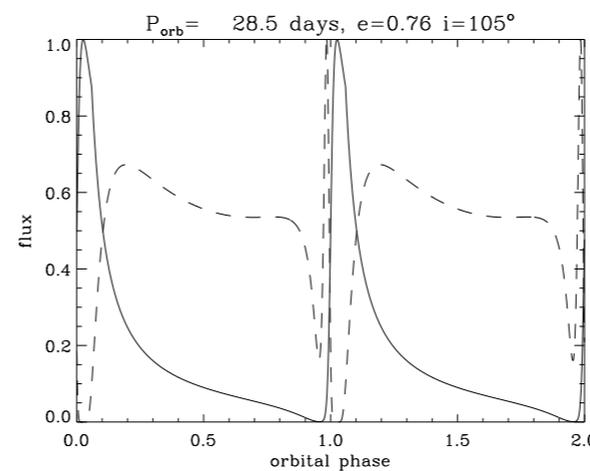
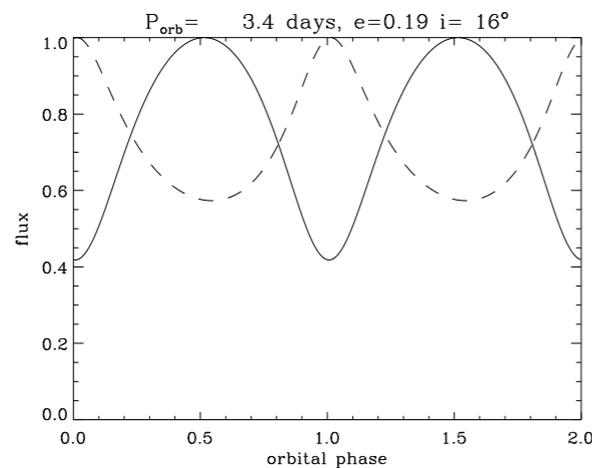
system parameters

- P_{orb} : flat from 1 to 10^4 days
- e : thermal with circularisation
- **Injected power**: young radio pulsars with radiative eff. calibrated on PSR B1259



model lightcurve

- electrons at location of compact object
- **anisotropic IC scattering** of star photons
- **VHE absorption** from pair production

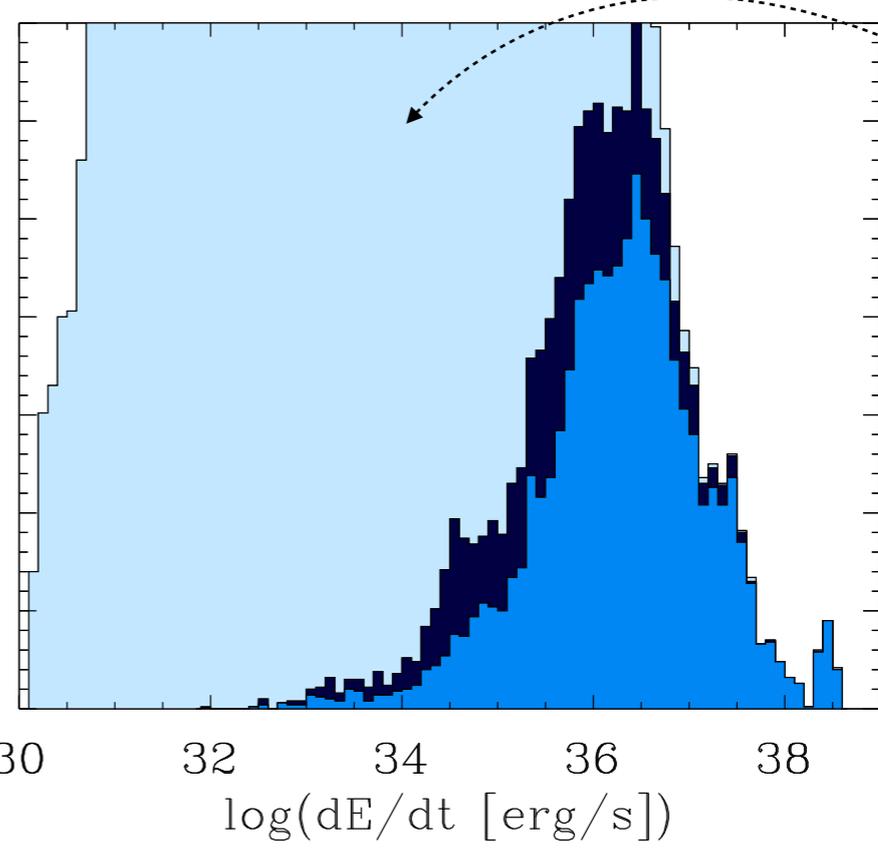
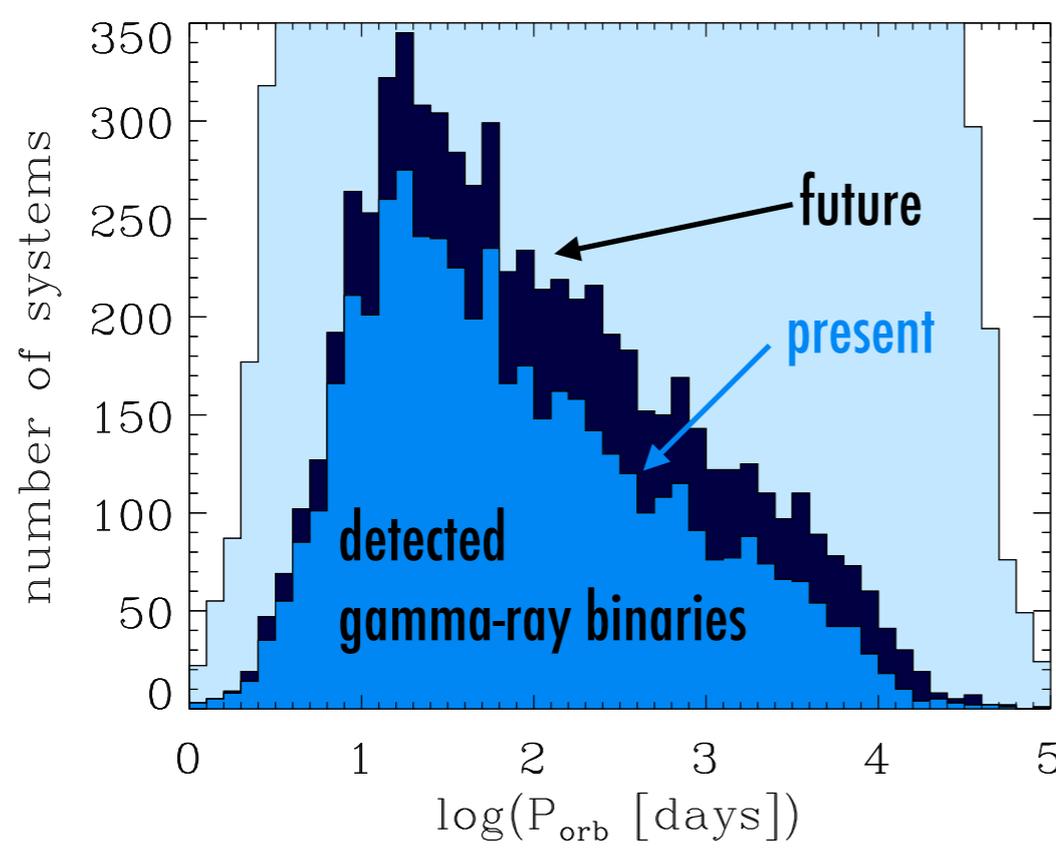
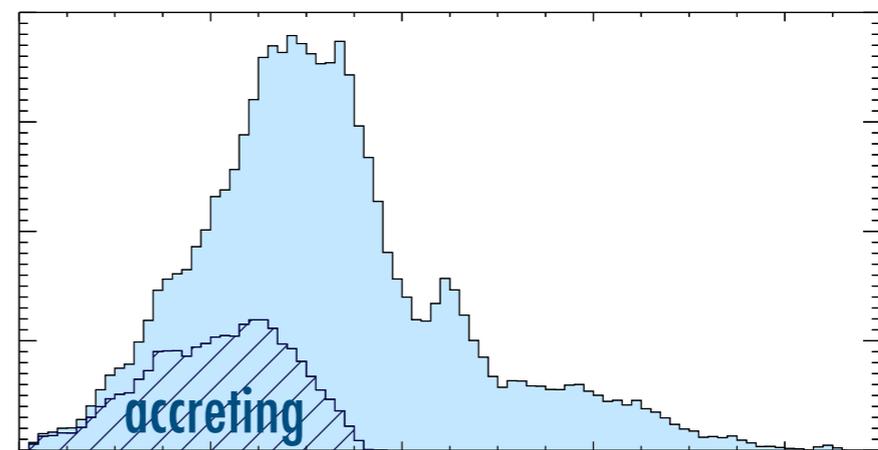
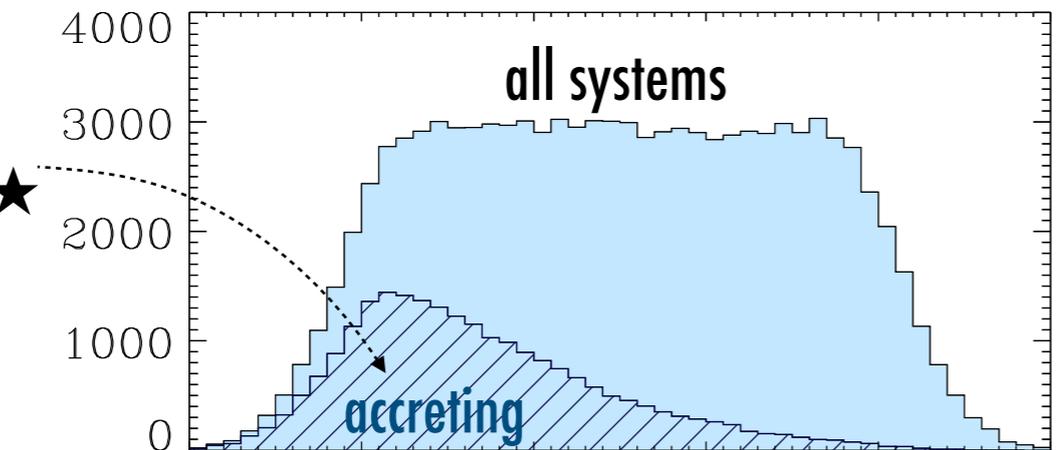


Detection rate

distribution of orbital periods

distribution of spindown power

X-ray pulsars
with massive ★
A0538-66
SAX J0635+0533



radio pulsars
with massive ★
PSR J0045-7319
PSR J1638-4725
PSR J1740-3052

about 6% of the systems are detected, at short P_{orb} and high power

Conclusions

- **Pulsar + massive star population estimated at 101^{+89}_{-52} systems**
 - orbital modulation not important for detectability (but important for identification)
 - future: up to 8 new detections in 16 years of Fermi, 6 detections in full CTA survey
- **Gamma-rays, X-rays, radio access different aspects of same population**
 - combine with detection rates in radio (SKA) and X-ray (eROSITA) surveys.

see Dubus, Guillard, Petrucci, Martin 2017, A&A in press (ArXiv:1707.05744)