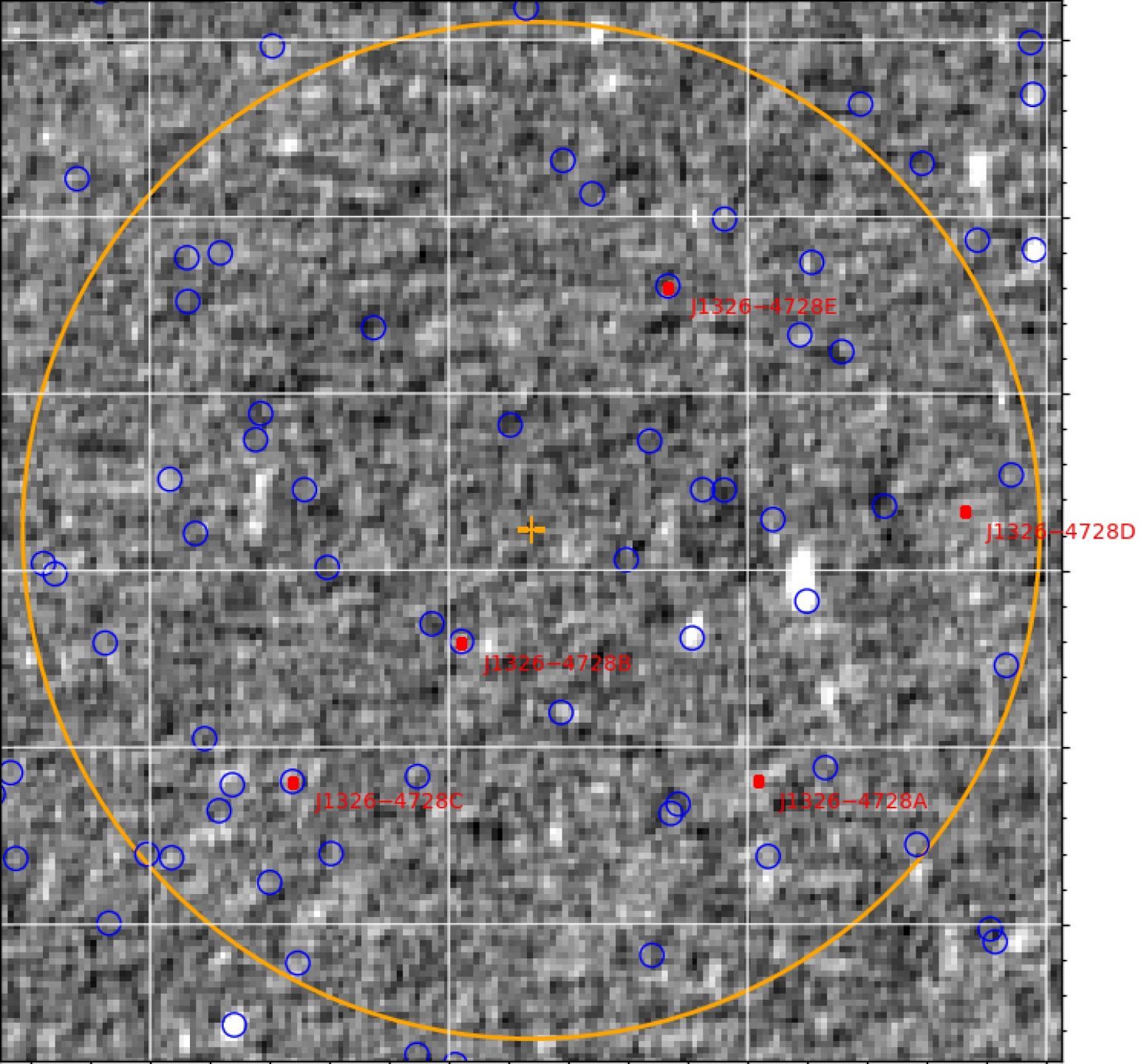


CTA-Oz Meeting #2, 2022

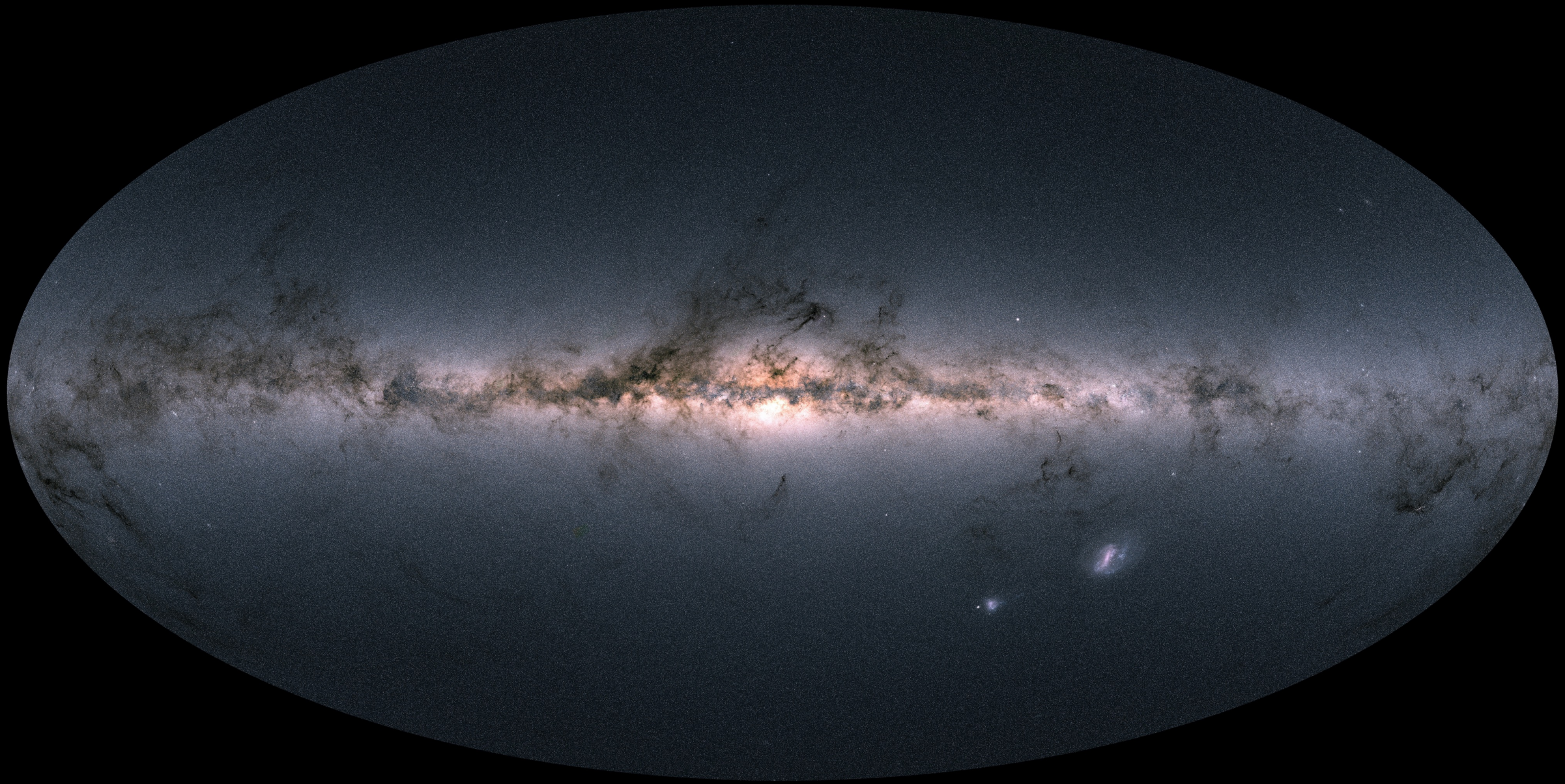
Millisecond pulsars in Omega Centauri

Shi Dai

ARC DECRA Fellow

Western Sydney University

WESTERN SYDNEY UNIVERSITY



Credit: ESA/Gaia/DPAC

Credit: ESO/INAF-VST/OmegaCAM

Omega Centauri

Credit: ESA/Gaia/DPAC

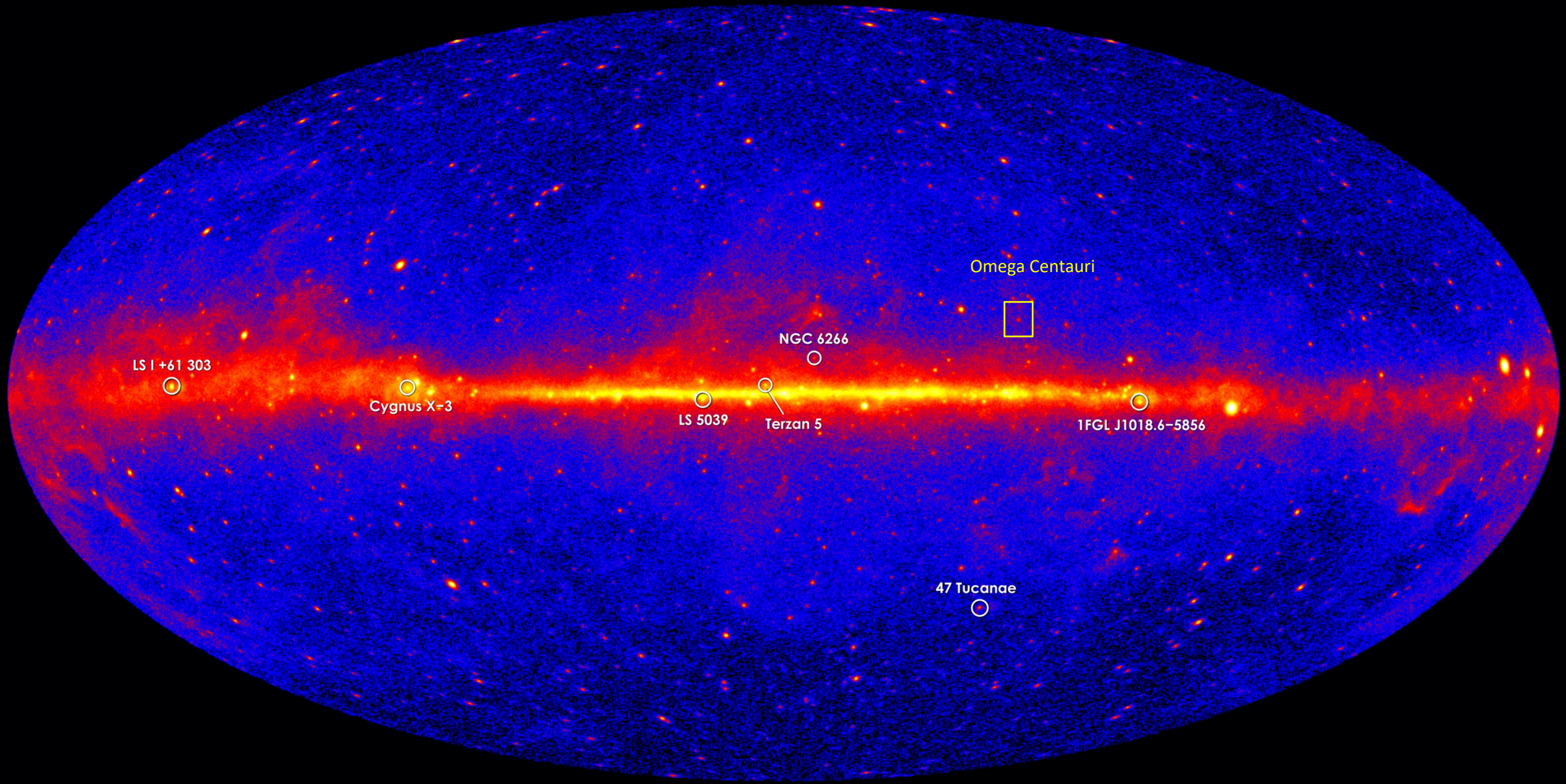
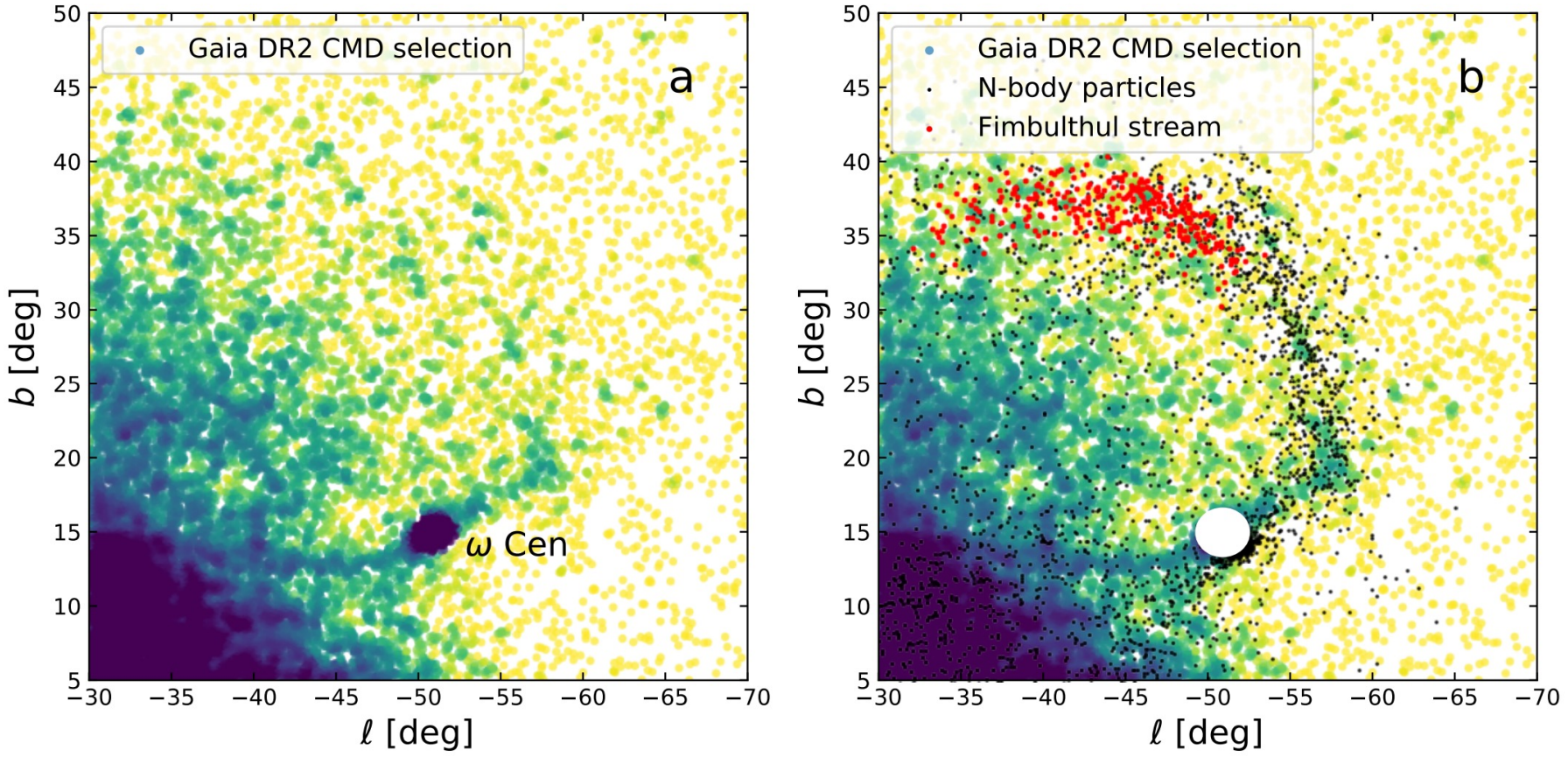


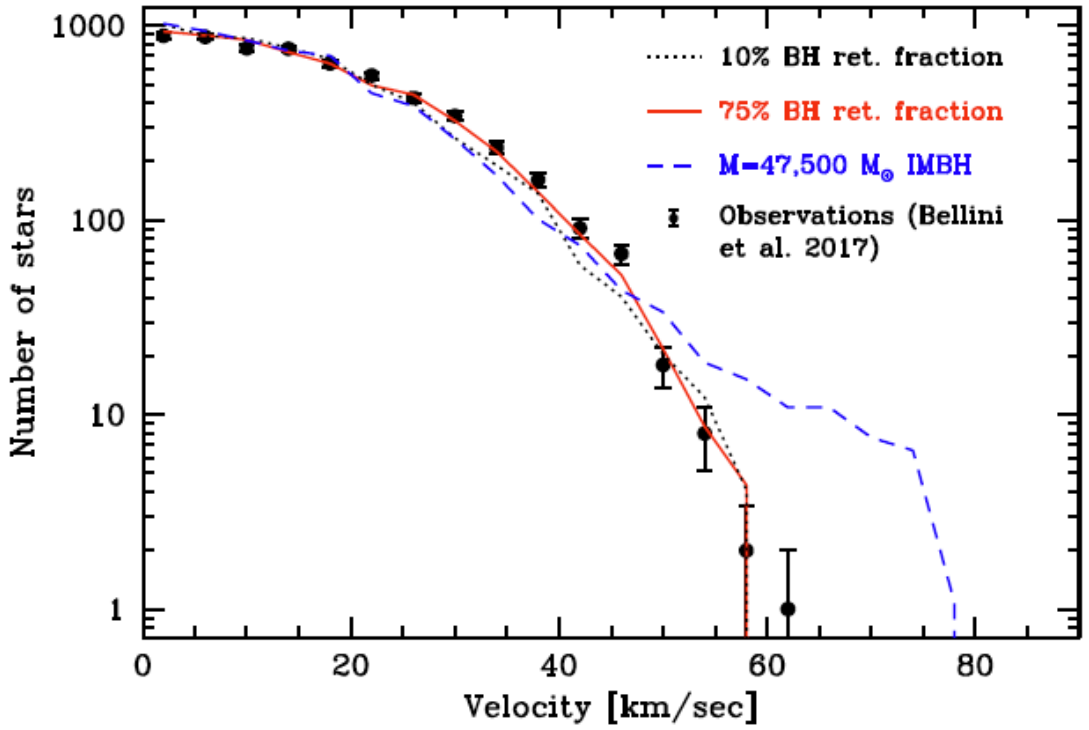
Image credit: NASA/DOE/Fermi LAT Collaboration

Omega Cen: the nuclear cluster of a tidally disrupted dwarf galaxy?



Ibata et al. (2019)

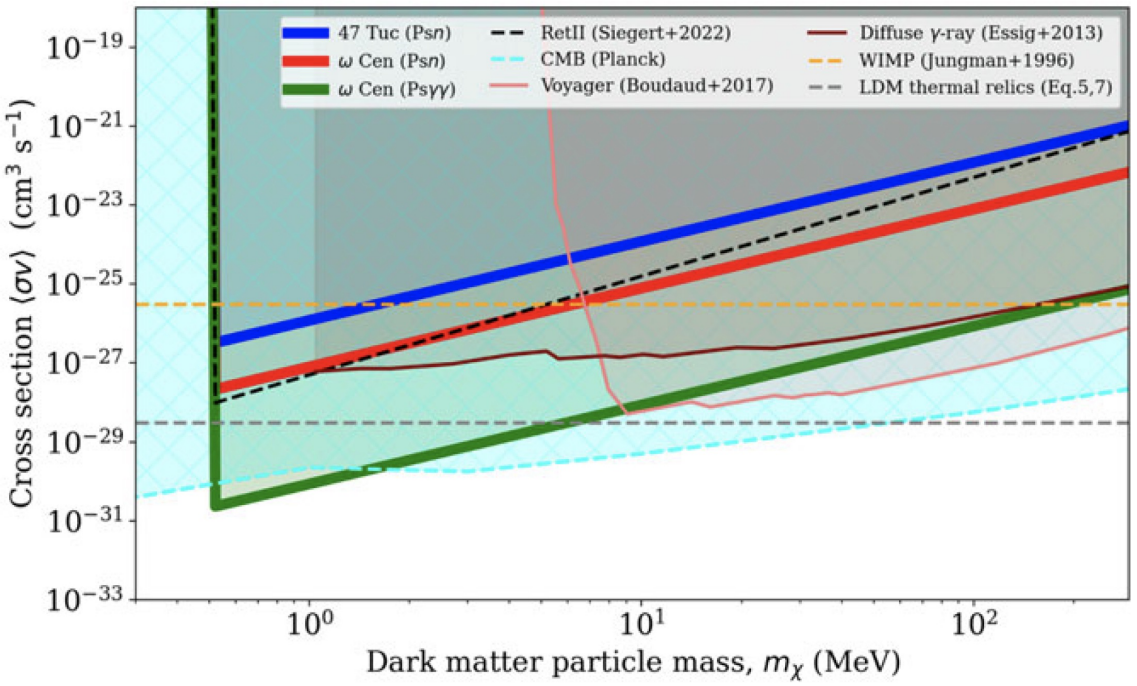
Omega Cen: the nuclear cluster of a tidally disrupted dwarf galaxy?



Baumgardt et al. (2019)

- ***Is there an intermediate-mass black hole in the centre?***
- Can we find any evidence of dark matter annihilation?

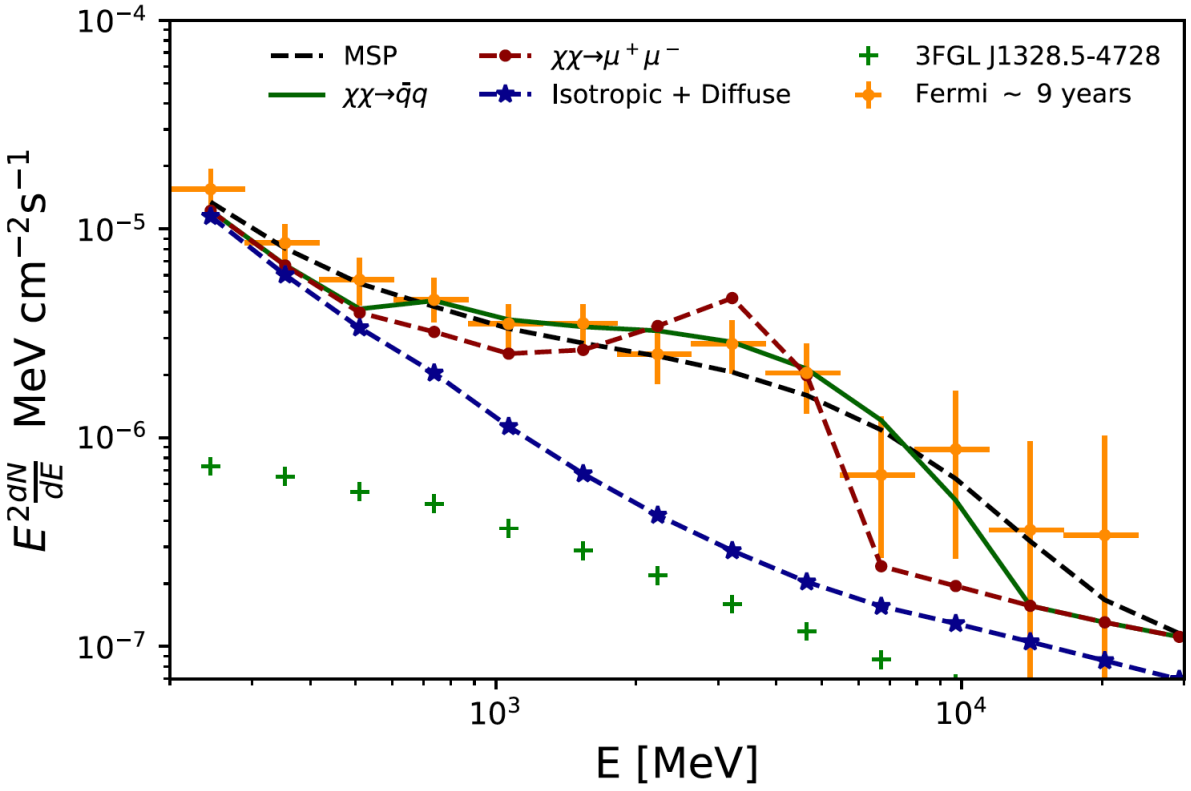
Omega Cen: the nuclear cluster of a tidally disrupted dwarf galaxy?



Staveley-Smith et al. (2022)

- Is there an intermediate-mass black hole in the centre?
- ***Can we find any evidence of dark matter annihilation?***

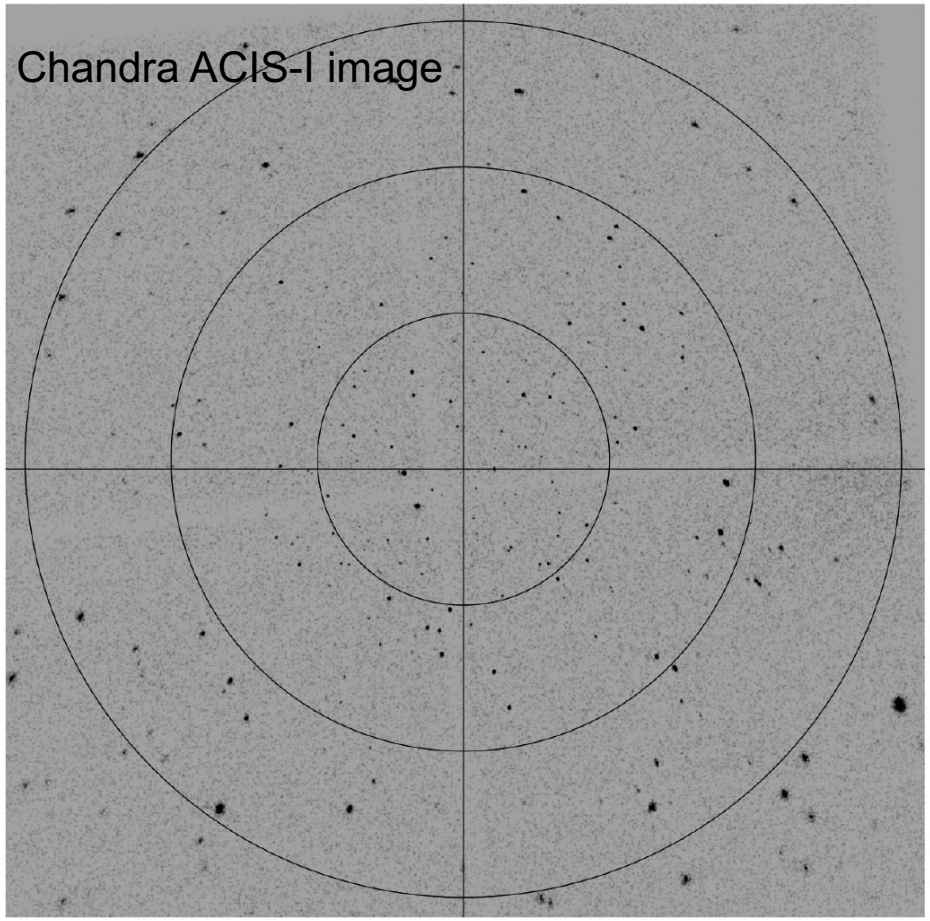
Omega Cen: the nuclear cluster of a tidally disrupted dwarf galaxy?



Reynoso-Cordova et al. (2021)

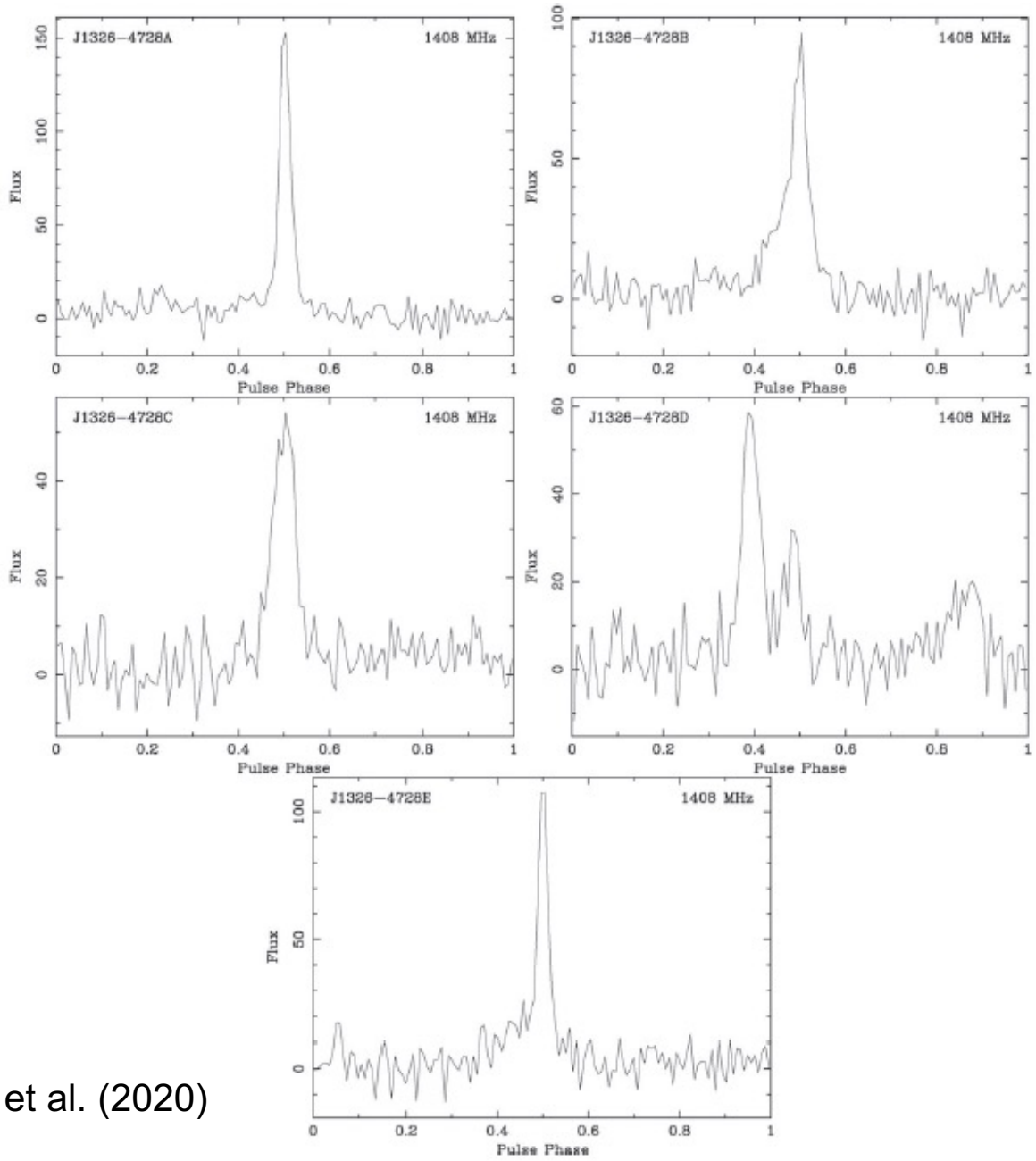
- Is there an intermediate-mass black hole in the centre?
- ***What is the origin of Gamma-ray? Dark matter annihilation?***

Omega Cen: the nuclear cluster of a tidally disrupted dwarf galaxy?



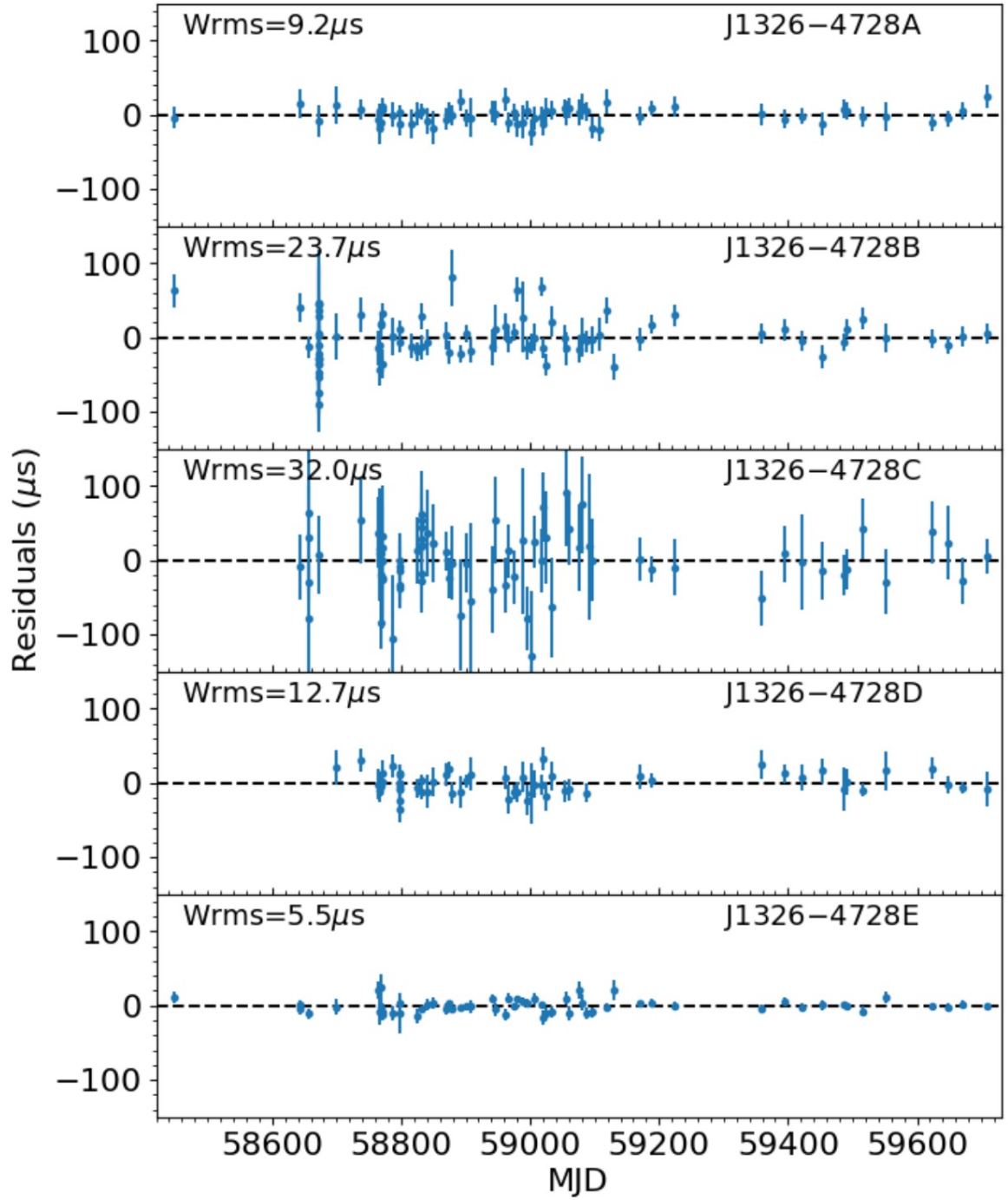
Henleywillis et al. (2018)

- Where are the pulsars???
- 260 pulsars have been found in 36 globular clusters!

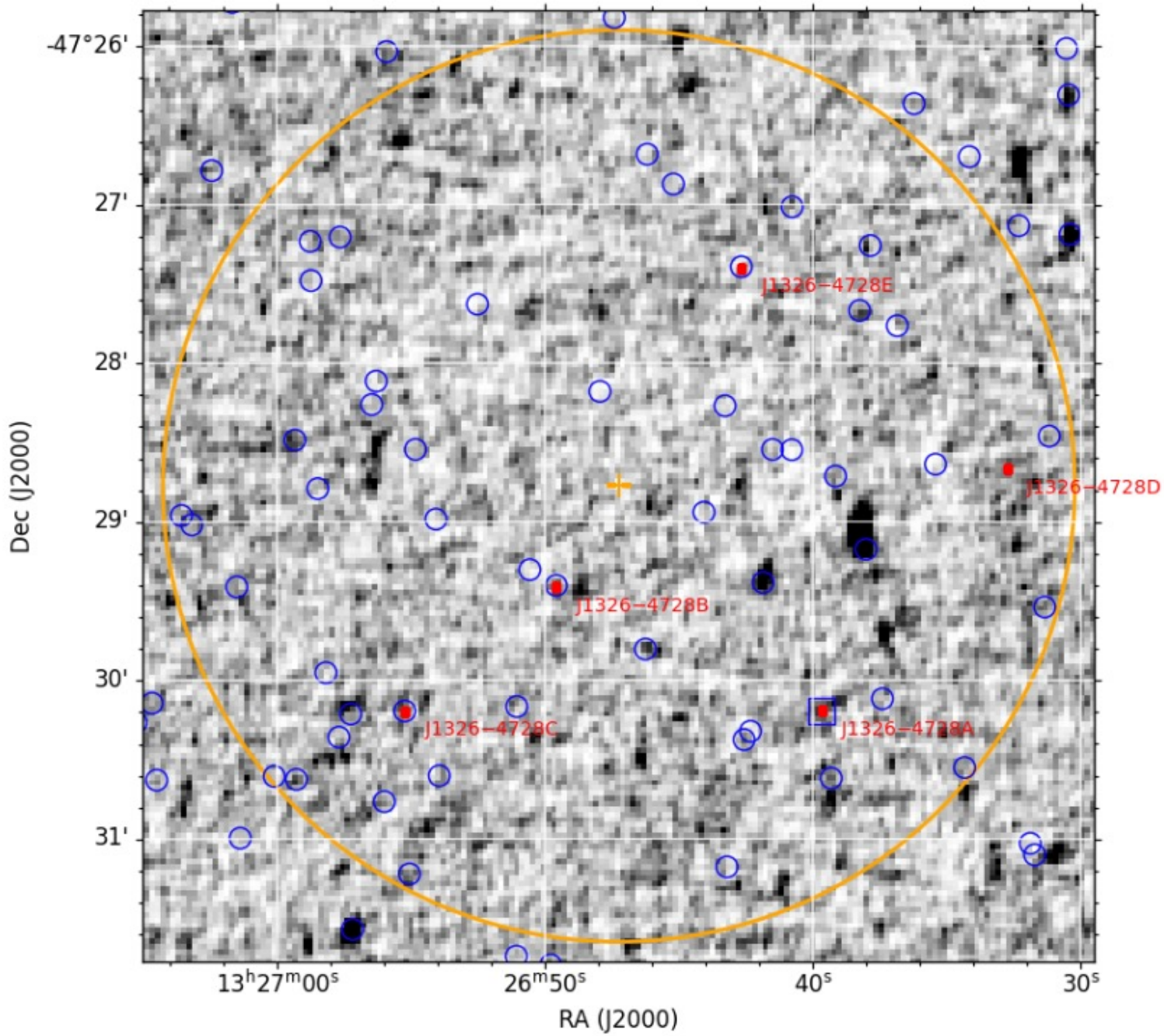


Dai et al. (2020)

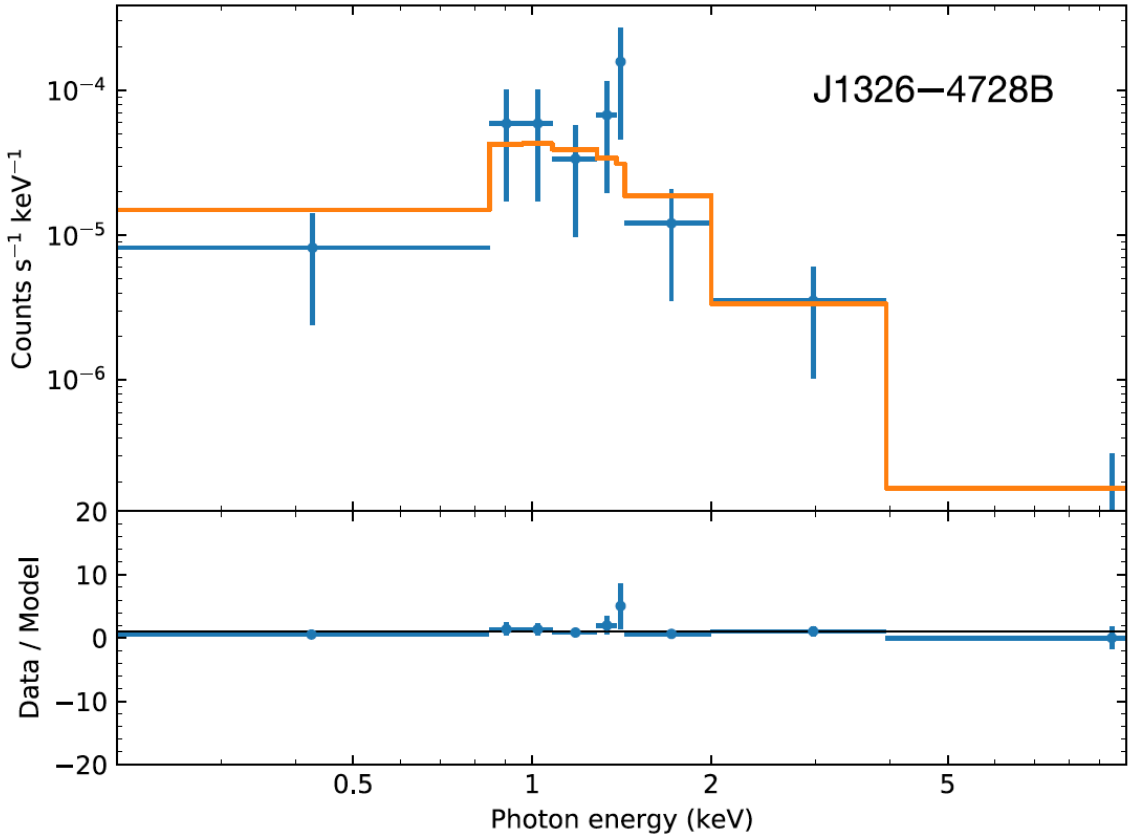
- Five millisecond pulsars (MSPs) discovered (Dai et al. 2020).
- Four isolated, one in a 2hr binary with a low-mass star.
- All five MSPs located within in the core of Omega Cen.


Wrms=9.2μs
J1326−4728A
Wrms=23.7μs
J1326−4728B
Wrms=32.0μs
J1326−4728C
Wrms=12.7μs
J1326−4728D
Wrms=5.5μs
J1326−4728E
Residuals (μs)
100
0
−100
58600
58800
59000
59200
59400
59600
MJD

	J1326−4728A	J1326−4728B	J1326−4728C	J1326−4728D	J1326−4728E
RAJ (J2000)	13:26:39.6700(2)	13:26:49.5686(3)	13:26:55.2213(7)	13:26:32.7130(2)	13:26:42.67835(7)
DECJ (J2000)	−47:30:11.639(3)	−47:29:24.886(4)	−47:30:11.75(1)	−47:28:40.050(3)	−47:27:23.999(1)
ν (Hz)	243.38088019776(7)	208.68683313296(8)	145.6057701814(2)	218.3962371417(1)	237.65856646670(2)
$\dot{\nu}$ (Hz/s)	$-1.621(7)\times10^{-15}$	$2.369(2)\times10^{-15}$	$-2.06(2)\times10^{-16}$	$1.965(3)\times10^{-15}$	$-9.190(6)\times10^{-16}$
PMRA (mas/yr)	-5(1)	-2(3)	-1(4)	-2(2)	-4.5(7)
PMDEC (mas/yr)	-8(2)	-10(4)	-7(5)	-9(3)	-7.4(9)
PEPOCH (MJD)	58447.77	58768.0	58447.77	58797.01	58796.79
Time span (MJD)	58444.95−59709.54	58444.95−59709.54	58643.33−59709.54	58700.27−59709.54	58447.79−59709.54
DM ($\mathrm{cm^{-3}\,pc}$)	100.313(3)	100.273(3)	100.648(4)	96.542(3)	94.3841(9)
RM ($\mathrm{rad\,m^{-2}}$)	-18(8)				
Binary parameters (ELL1 model, Hobbs et al. 2006)					
P_b (days)		0.089611204(1)			
χ (ls)		0.021452(4)			
T_asc (MJD)		58768.037248(4)			
η (10^{-3})		-0.1(4)			
κ (10^{-3})		-0.4(4)			
Association with X-ray sources (Henleywillis et al. 2018; Zhao & Heinke 2022)					
RAJ (J2000)	13:26:39.670	13:26:49.574	13:26:55.231		13:26:42.670
DECJ (J2000)	−47:30:11.64	−47:29:24.18	−47:30:11.63		−47:27:23.56
Flux ($10^{-16}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$)	6.1	20.3	9.2		6.3


-47°26'
27'
28'
29'
30'
31'
Dec (J2000)
J1326−4728E
J1326−4728D
J1326−4728B
J1326−4728C
J1326−4728A
13h27m00s
26m50s
40s
30s
RA (J2000)

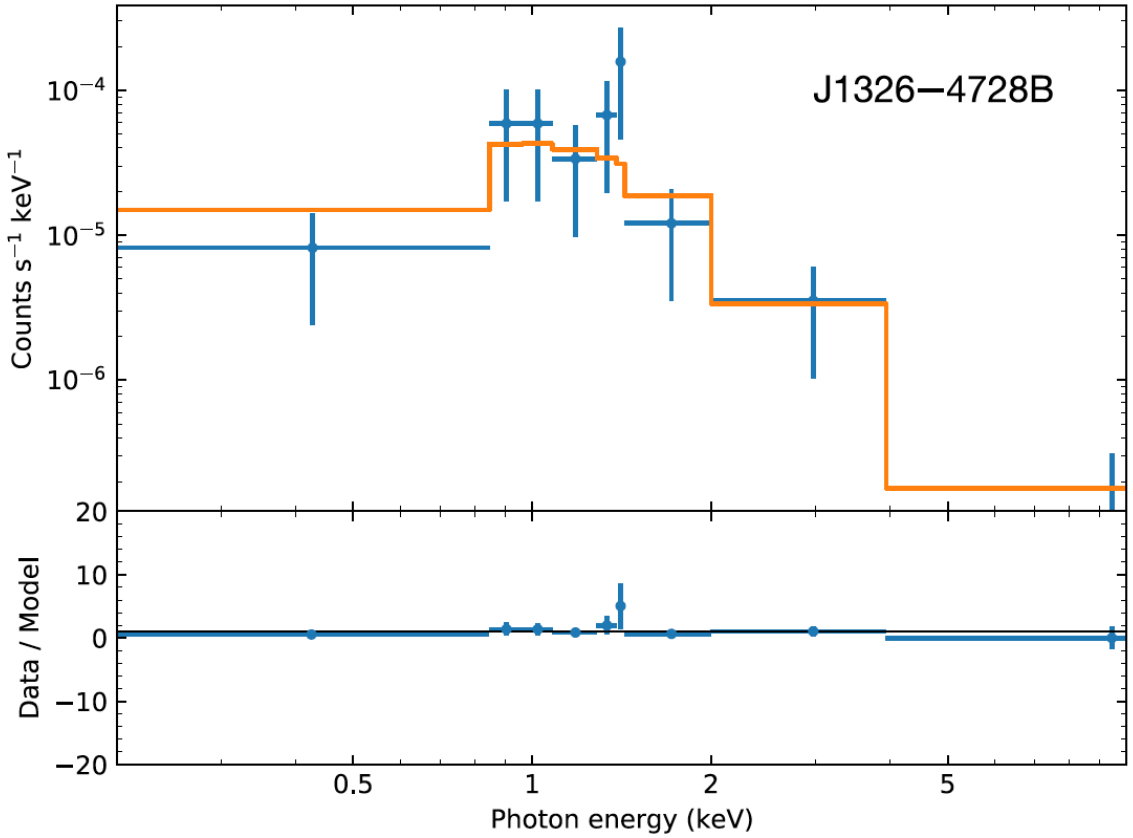
What is the origin of Gamma-ray?



Zhao & Heinke (2022)

- To search for pulsed Gamma-ray signals, we used Pass 8 data from the Fermi L AT selected with energies 0.1–30 GeV within 3 deg of the cluster centre and with a time range MJD 54682-59900 (14.3 yr)
- ***No pulsed Gamma-ray has been detected so far.***

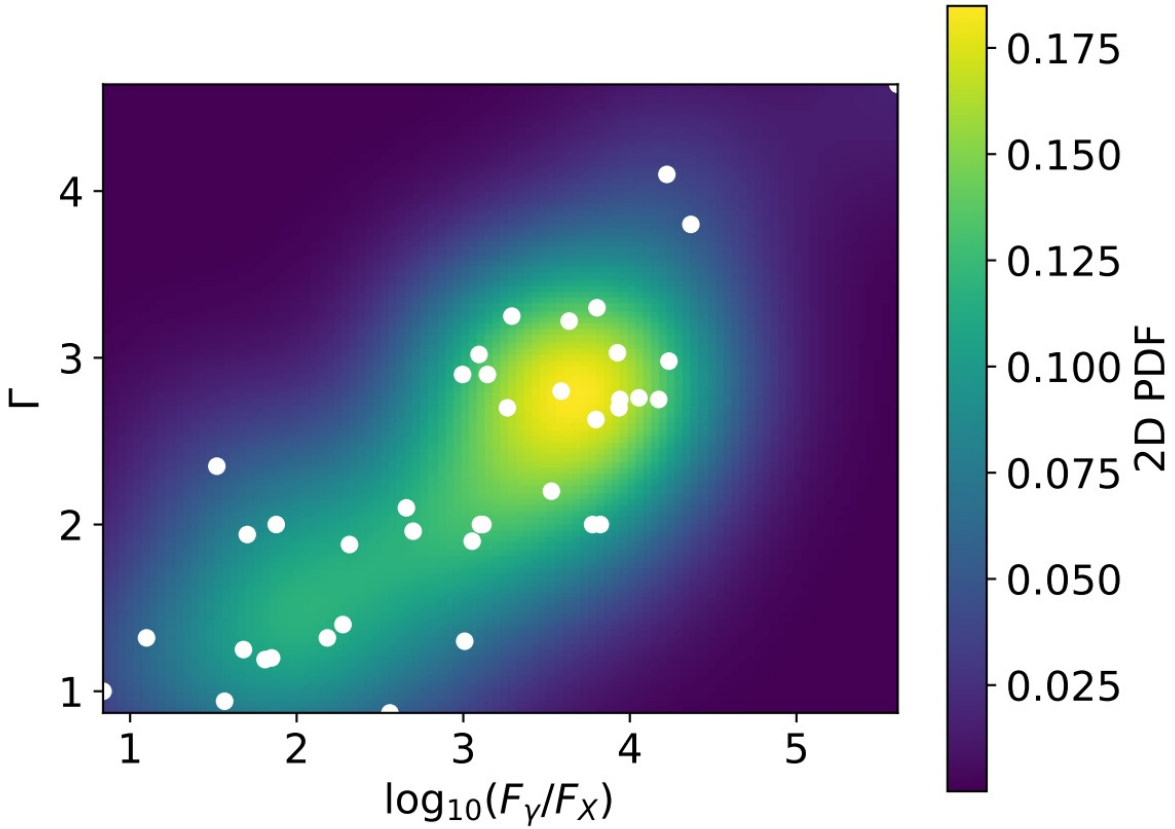
What is the origin of Gamma-ray?



Zhao & Heinke (2022)

- **Four pulsars are associated with X-ray sources.**
- With the spectral index of X-ray, we can estimate the Gamma-ray photon flux.
- Pulsar B could contribute up to 30% of the observed Gamma-ray.

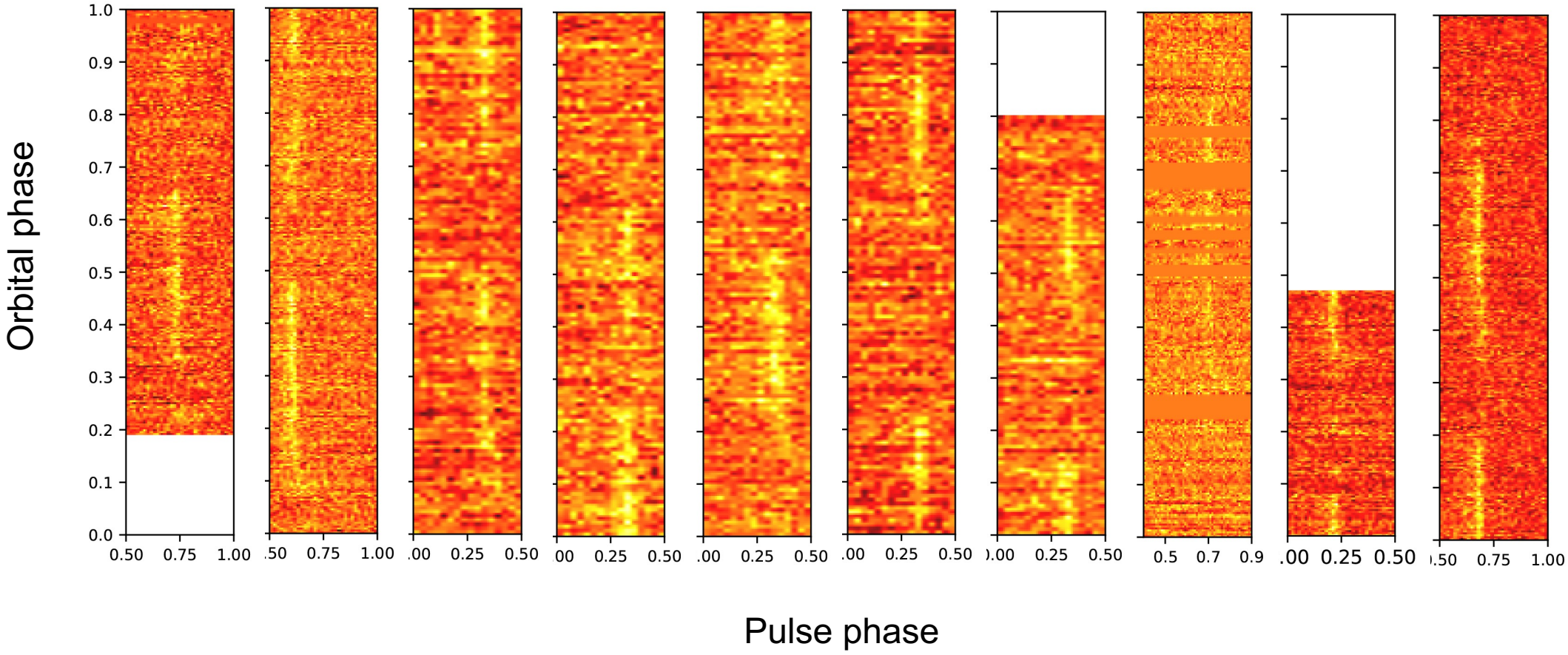
What is the origin of Gamma-ray?

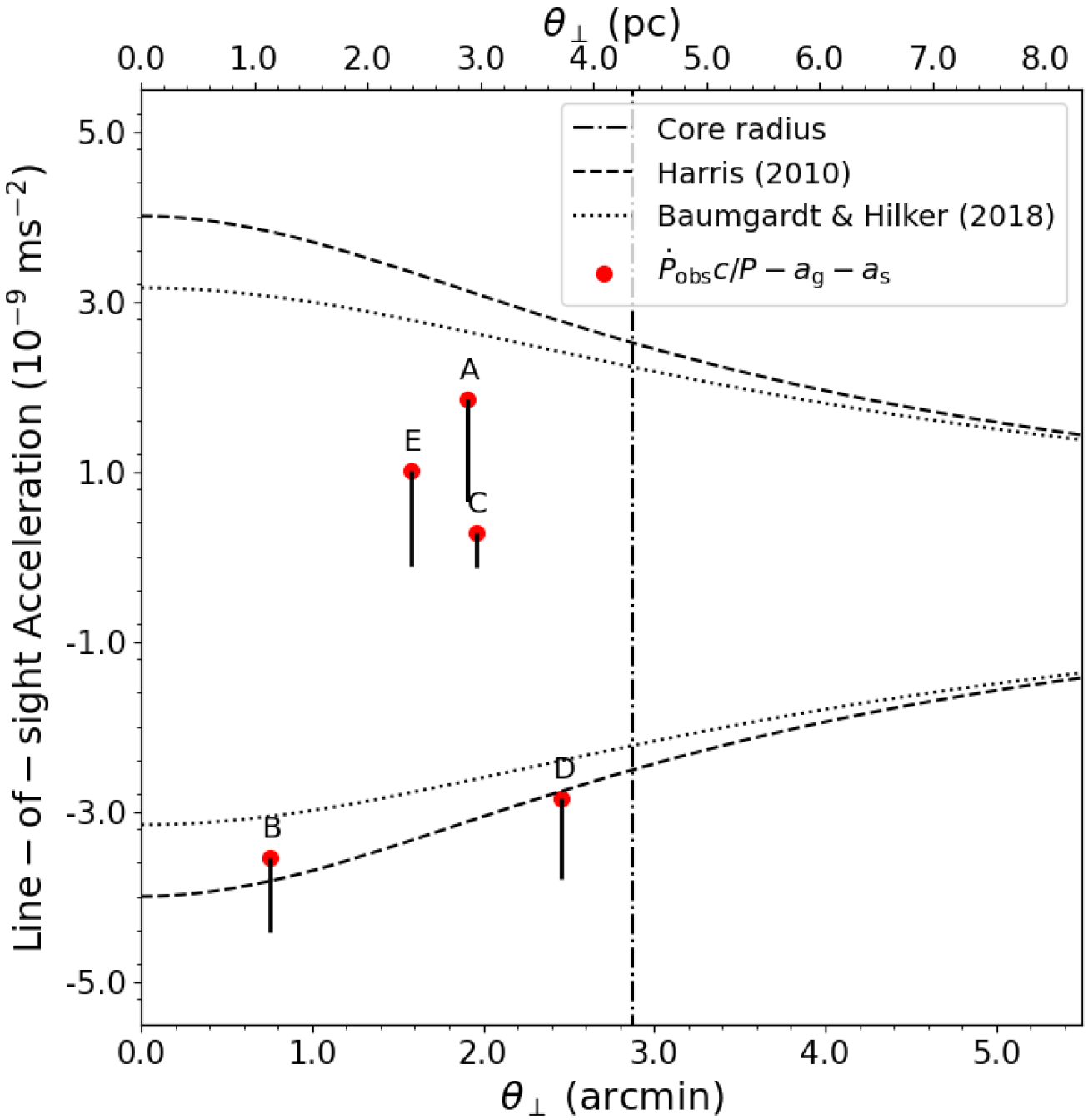


Berteaud et al. (2021)

- **Four pulsars are associated with X-ray sources.**
- With the spectral index of X-ray, we can estimate the Gamma-ray photon flux.
- Pulsar B could contribute up to 30% of the observed Gamma-ray.

PSR J1326-4728B: the first irregularly eclipsing black widow pulsar





- The observed spin-down of pulsars in GCs is dominated by the dynamical effect caused by the gravitational potential of GC.
- Observed pulsar spin-down can be translated into pulsar line-of-sight acceleration, which allows us to probe the dynamics in the core region.
- ***IMBH v.s. a population of stellar-mass BHs?***

- Omega Cen hosts a population of MSPs.
- No Gamma-ray pulsation has been detected so far.
- Omega Cen could be a CTA target?
- Timing and discovery of more MSPs will allow us to answer several key questions about Omega Cen.