Correlation between the γ-Ray Luminosity and the Light Cylinder Magnetic Field of Fermi-LAT Pulsars

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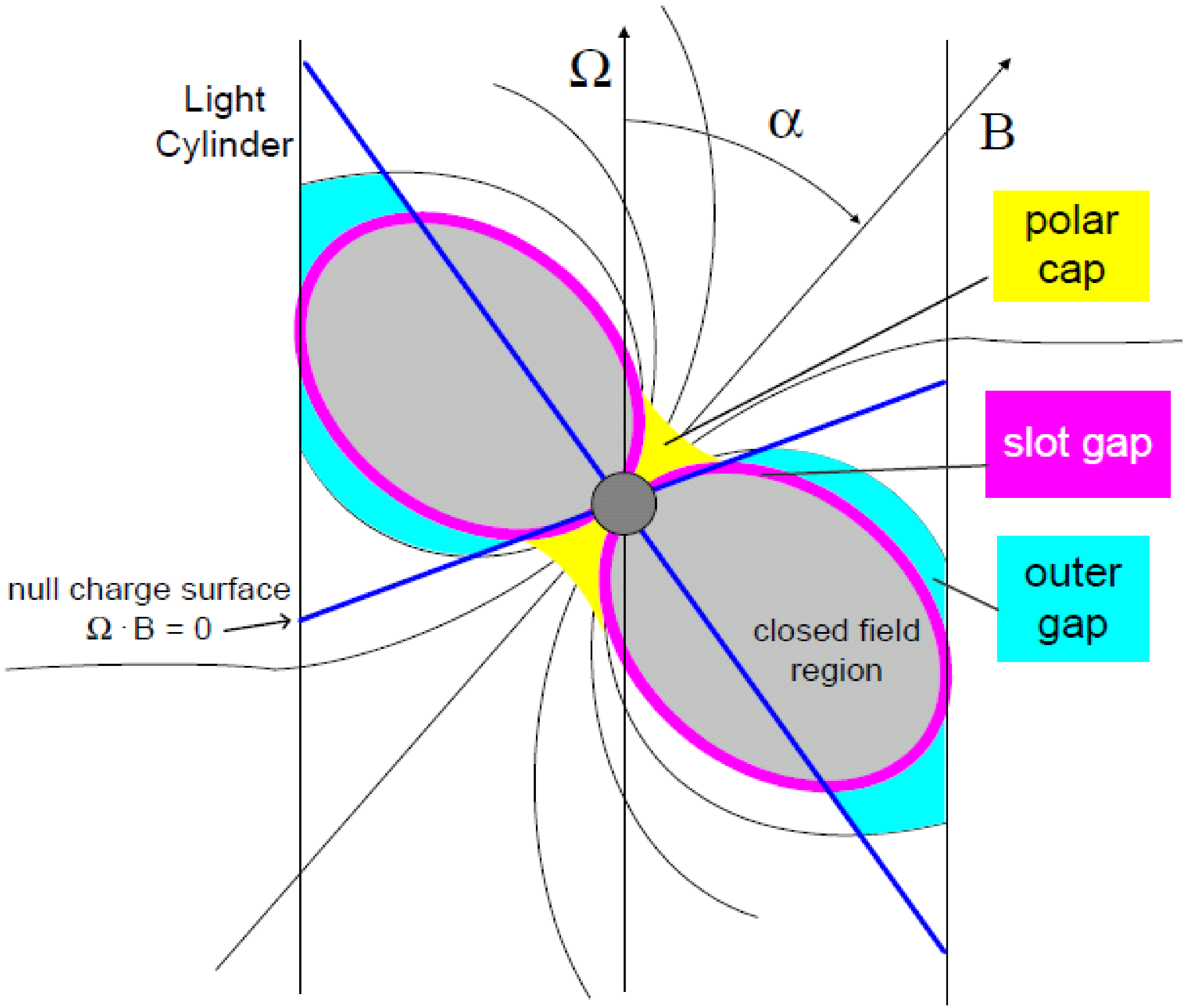
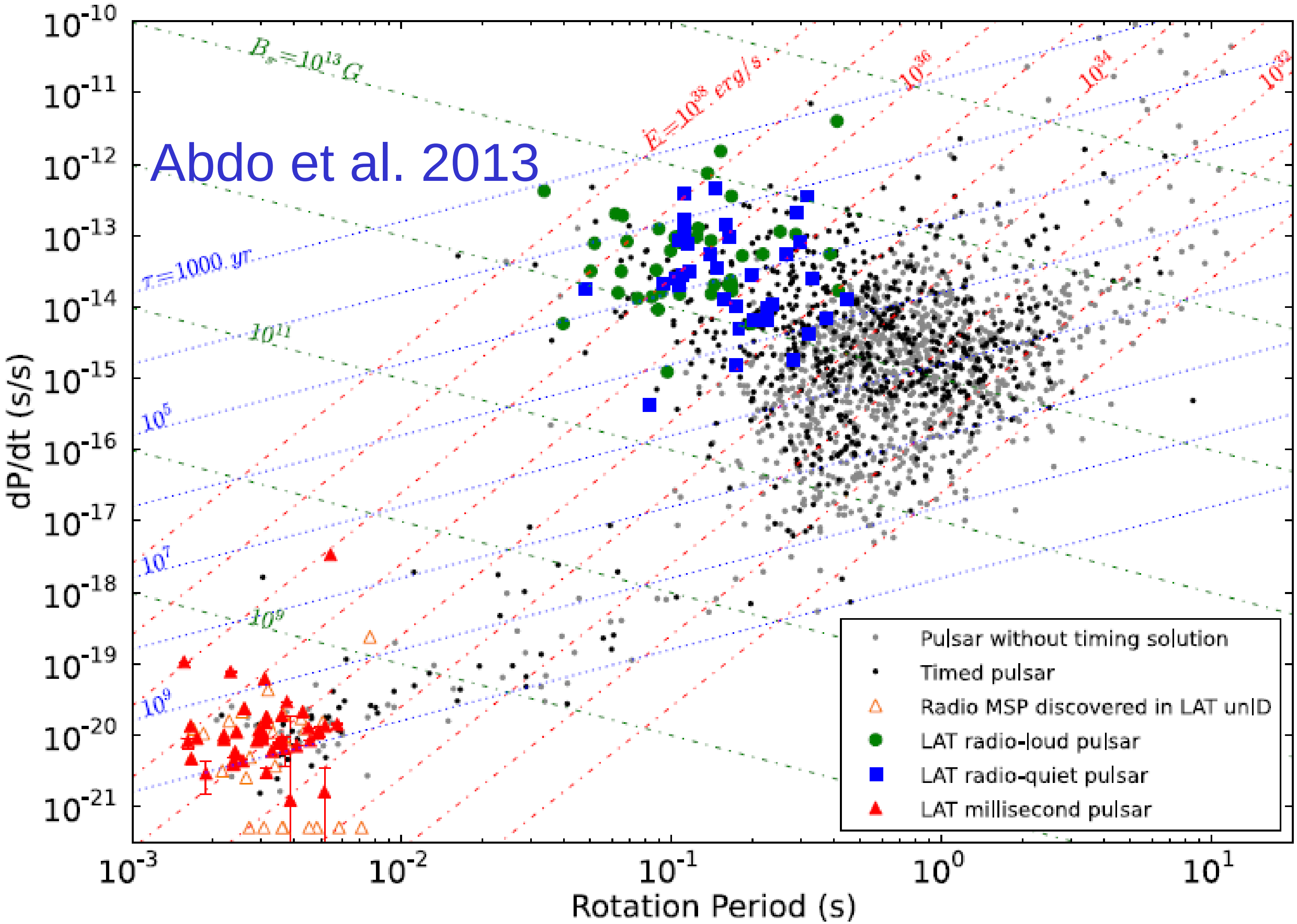
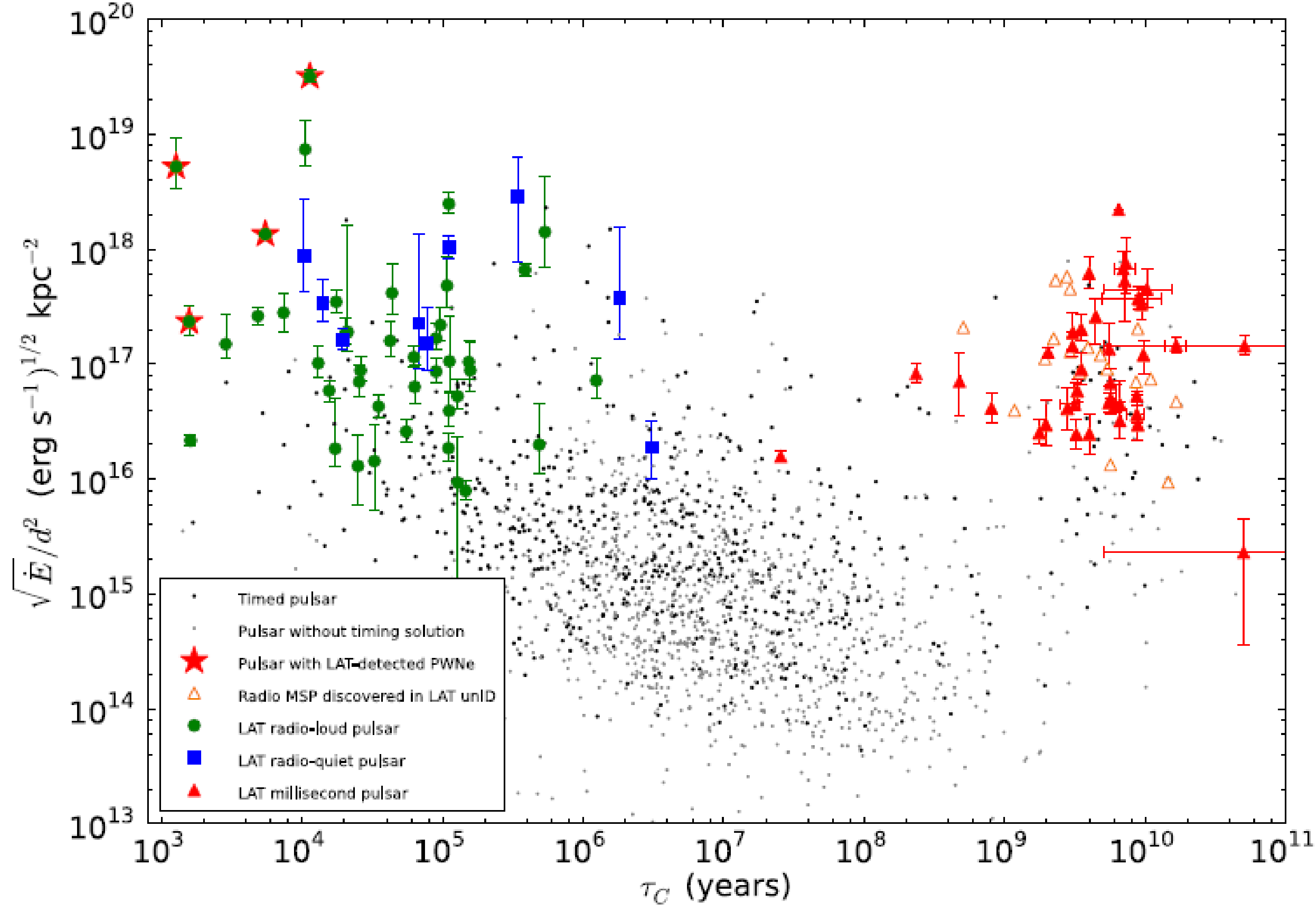
Where are gamma-rays produced?



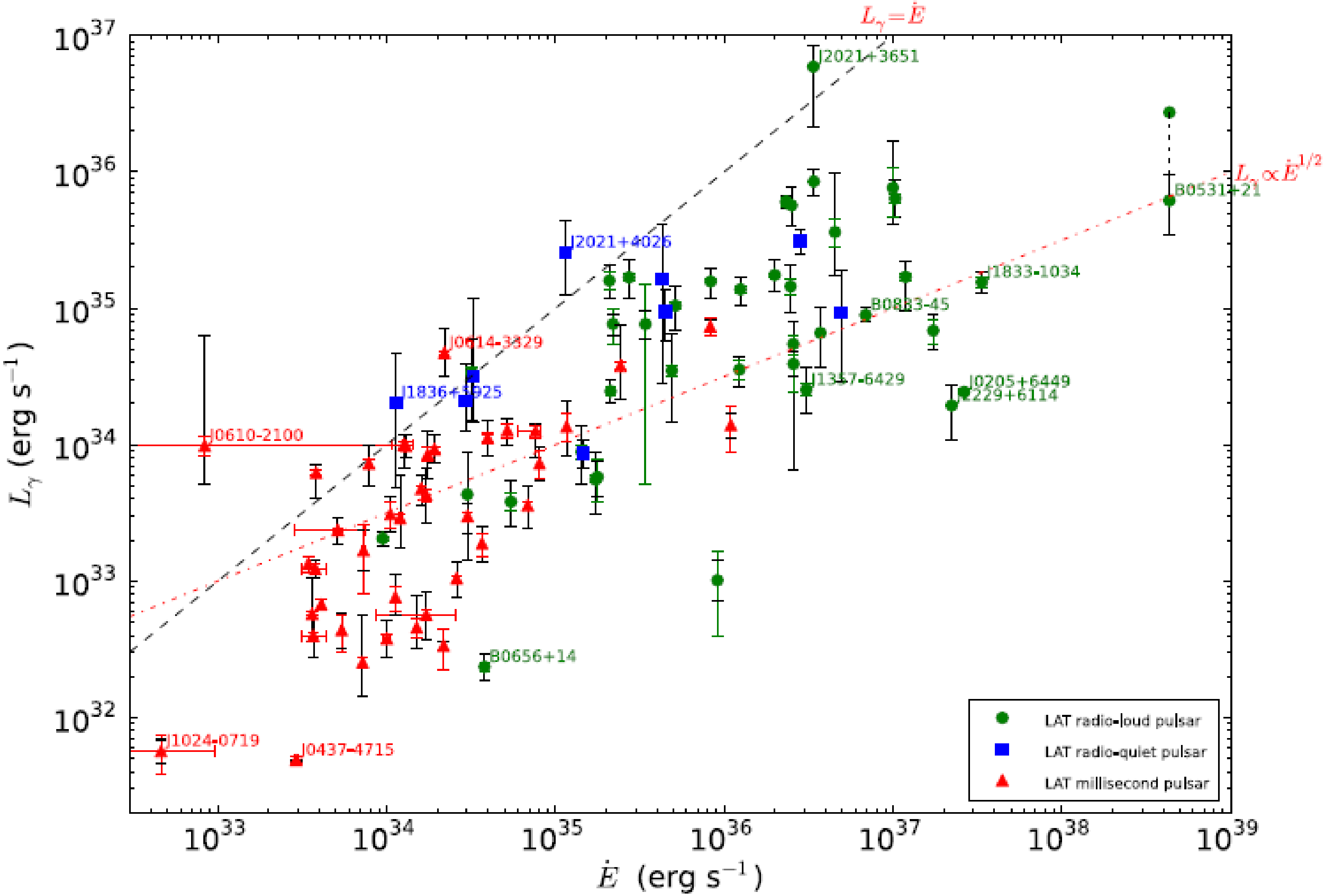
2nd Fermi pulsar catalog: higher Edot



Fermi pulsars: higher Edot



Edot controls gamma-ray



Motivations of this work

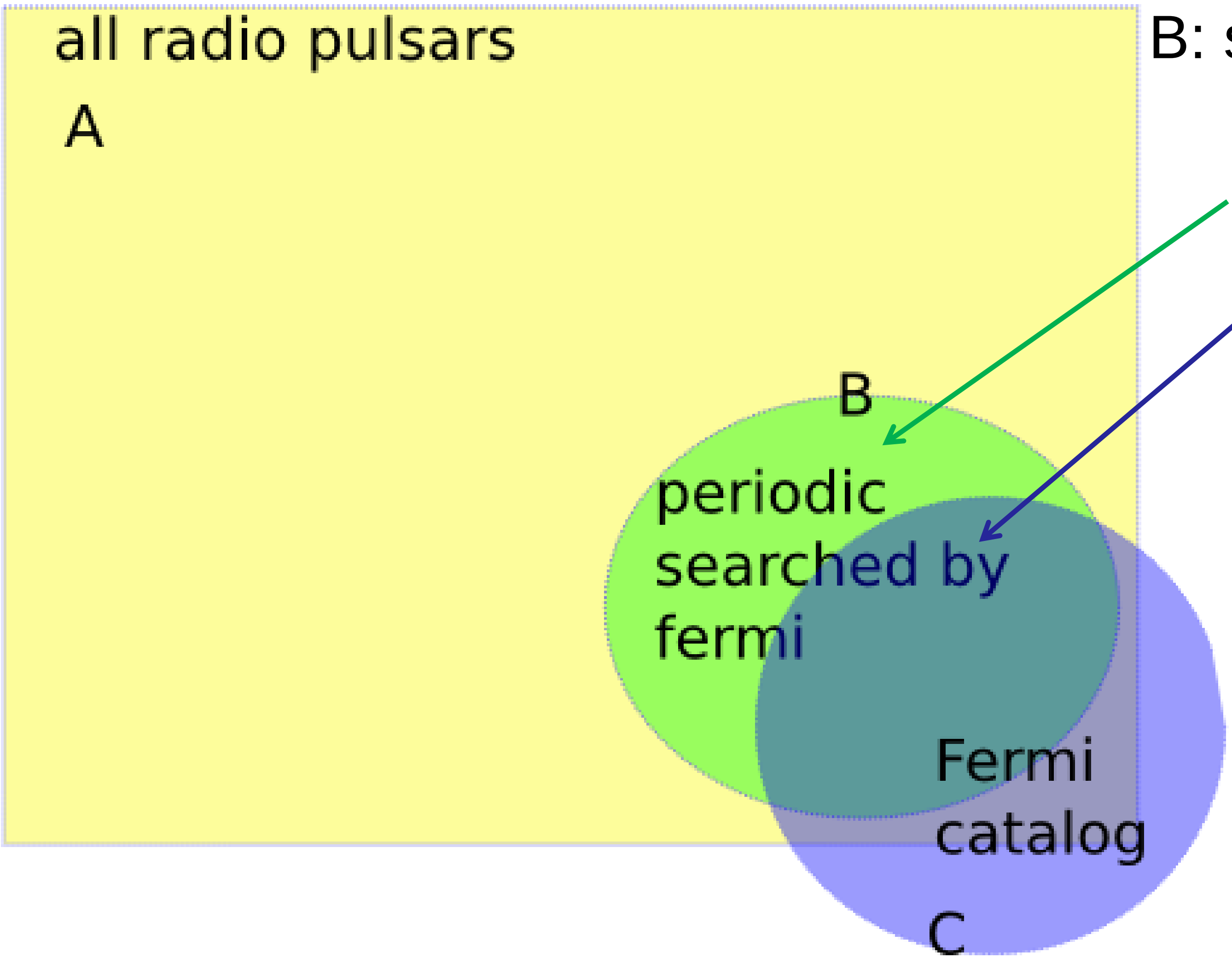
- Selection effect?
  - Fermi radio-loud gamma-ray pulsars are from a sub-sample of all radio pulsars: Edot>1x10^{34} erg/s
- Other statistical properties?
  - For the sub-sample of radio pulsars: differences between Fermi pulsars and other pulsars?

Sample definitions

B: sample 1 and sample 2

Sample 1: non-Fermi

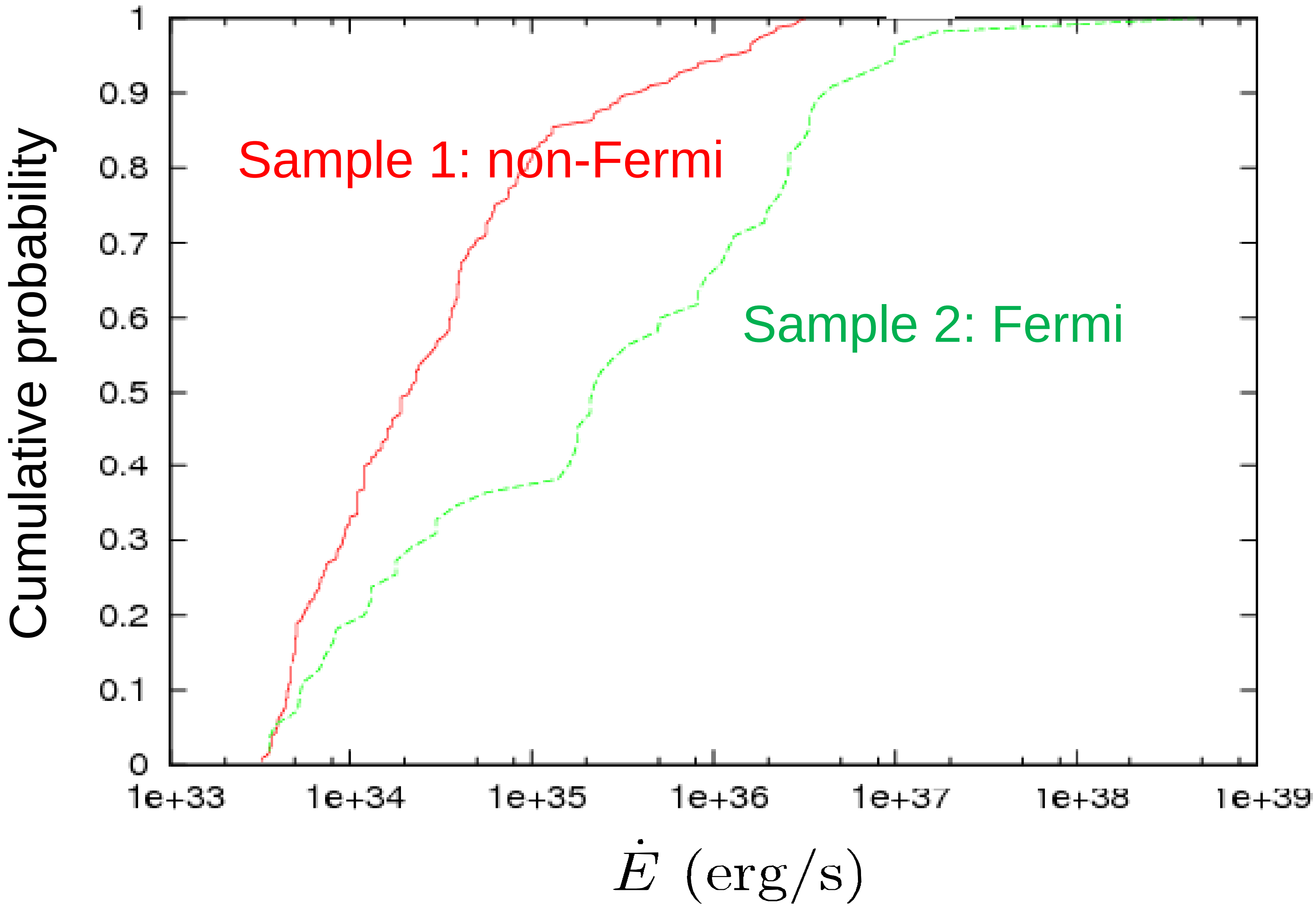
Sample 2: Fermi



Statistics of the Samples

Sample	ATNF radio pulsars with $\dot{E} > 1 \times 10^{34}$ erg/s excepting ones from *Fermi* blind search.		
		gamma-ray quiet	gamma-ray loud
Number	297	225	72

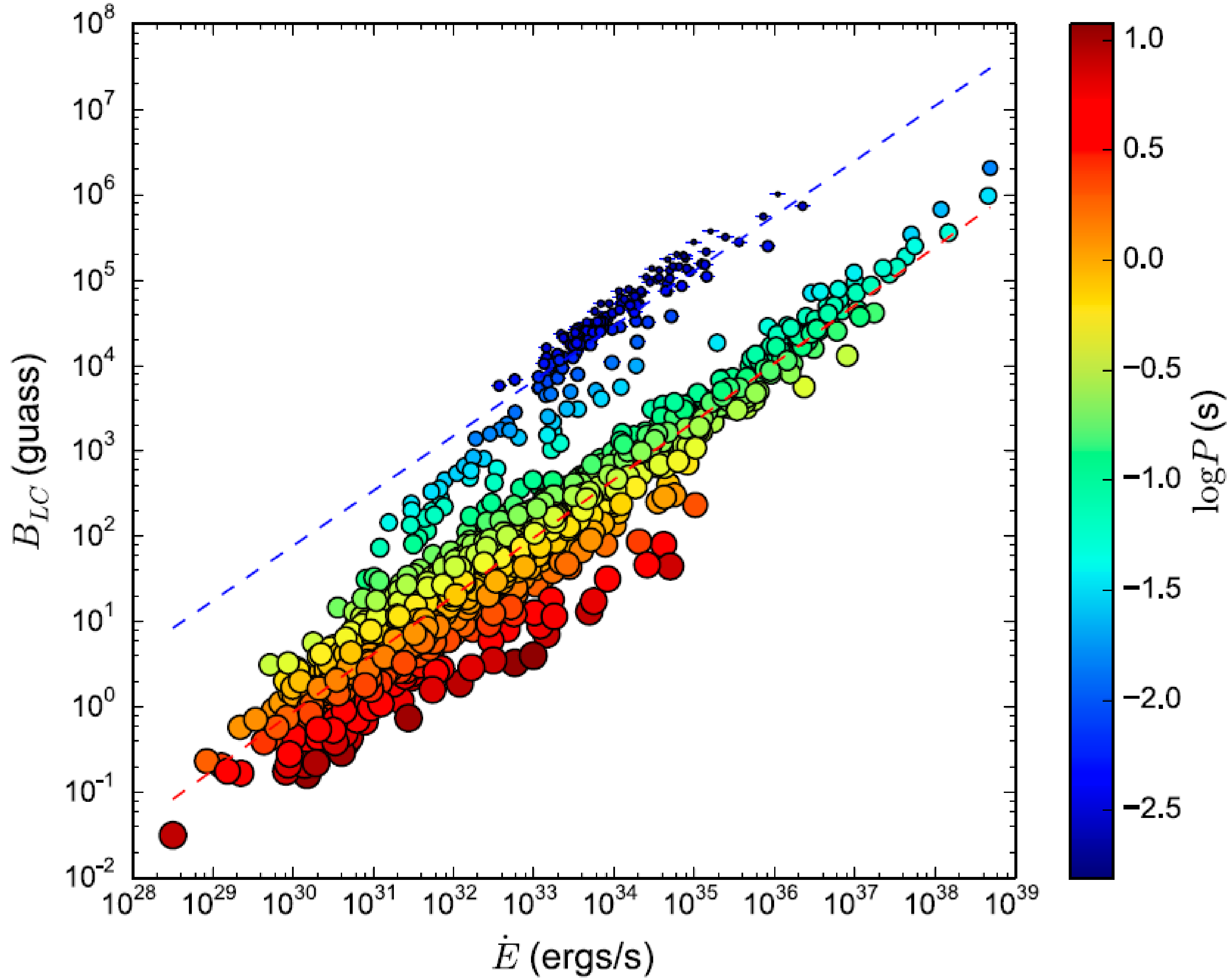
Fermi pulsars tend to have higher Edot



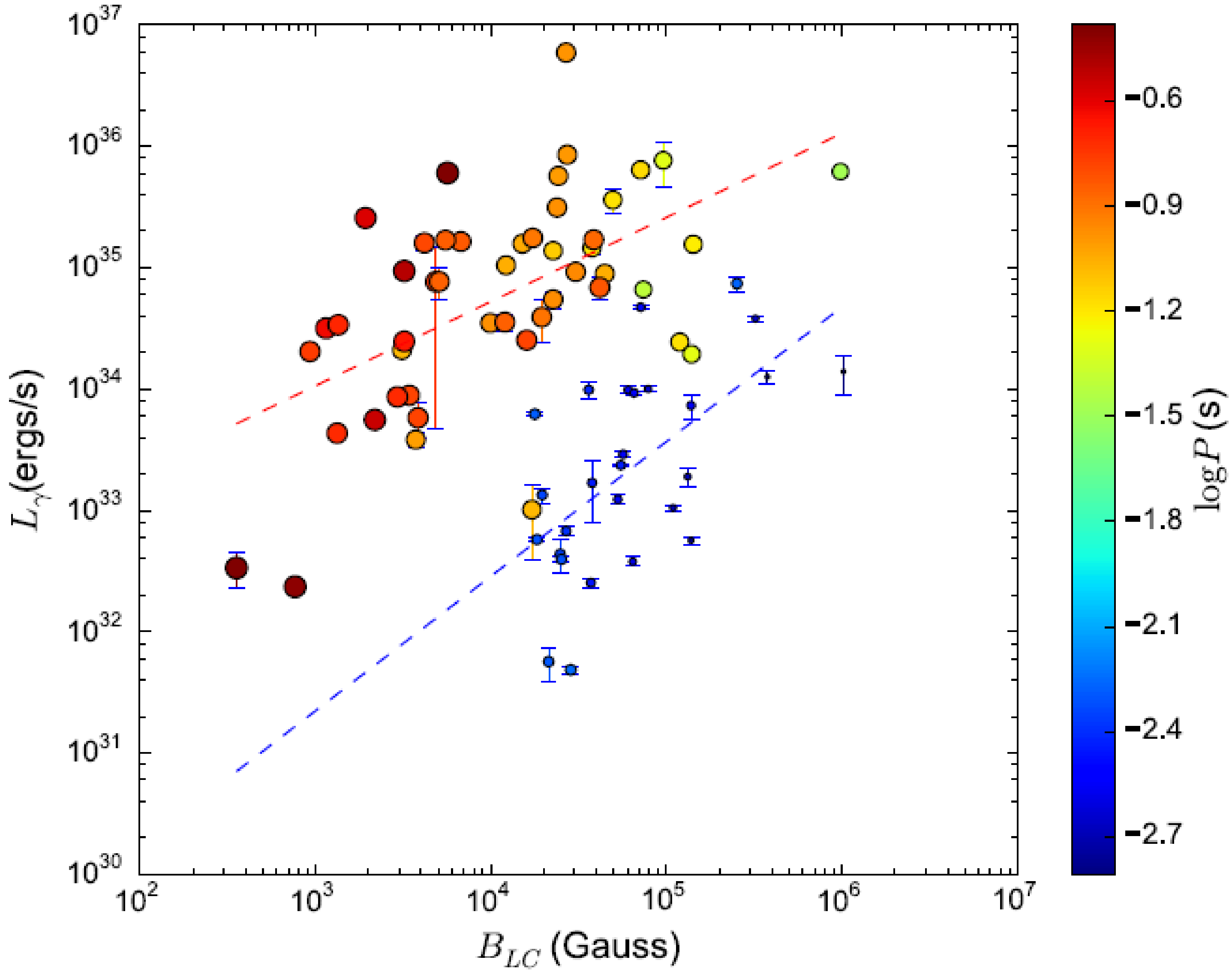
KS tests between the two samples

Parameter	p-value
SI414	0.79
$B_{\rm surf}$	9.7×10^{-4}
$\ddot{\nu}$	5.6×10^{-4}
τ	4.8×10^{-4}
$\dot{\nu}$	6.0×10^{-6}
$\dot{E}$	3.9×10^{-10}
P	7.9×10^{-15}
$B_{\rm LC}$	2.2×10^{-18}

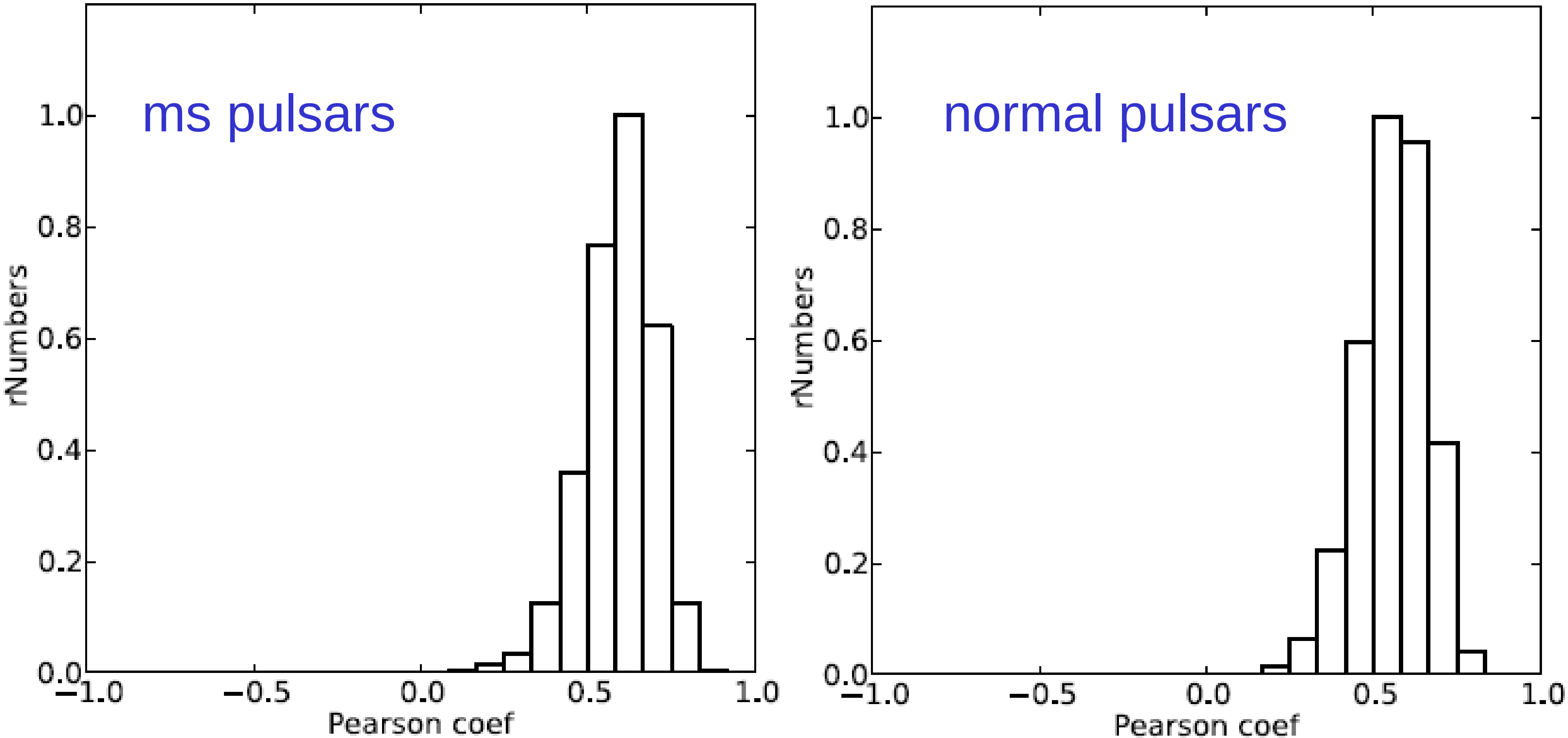
Correlation between Edot and B_{LC}



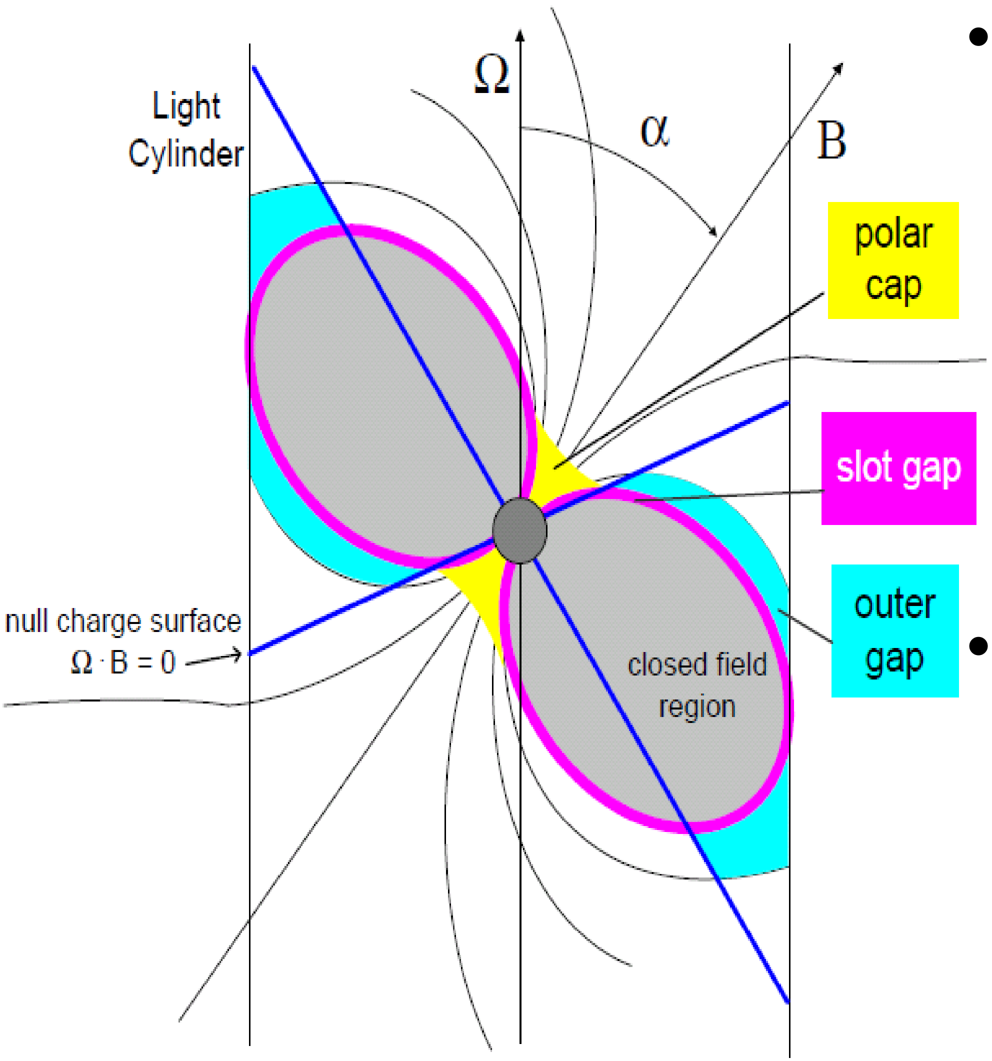
Correlation between B_{LC} and Lγ



Significant correlation between B_{LC} and $L\gamma$

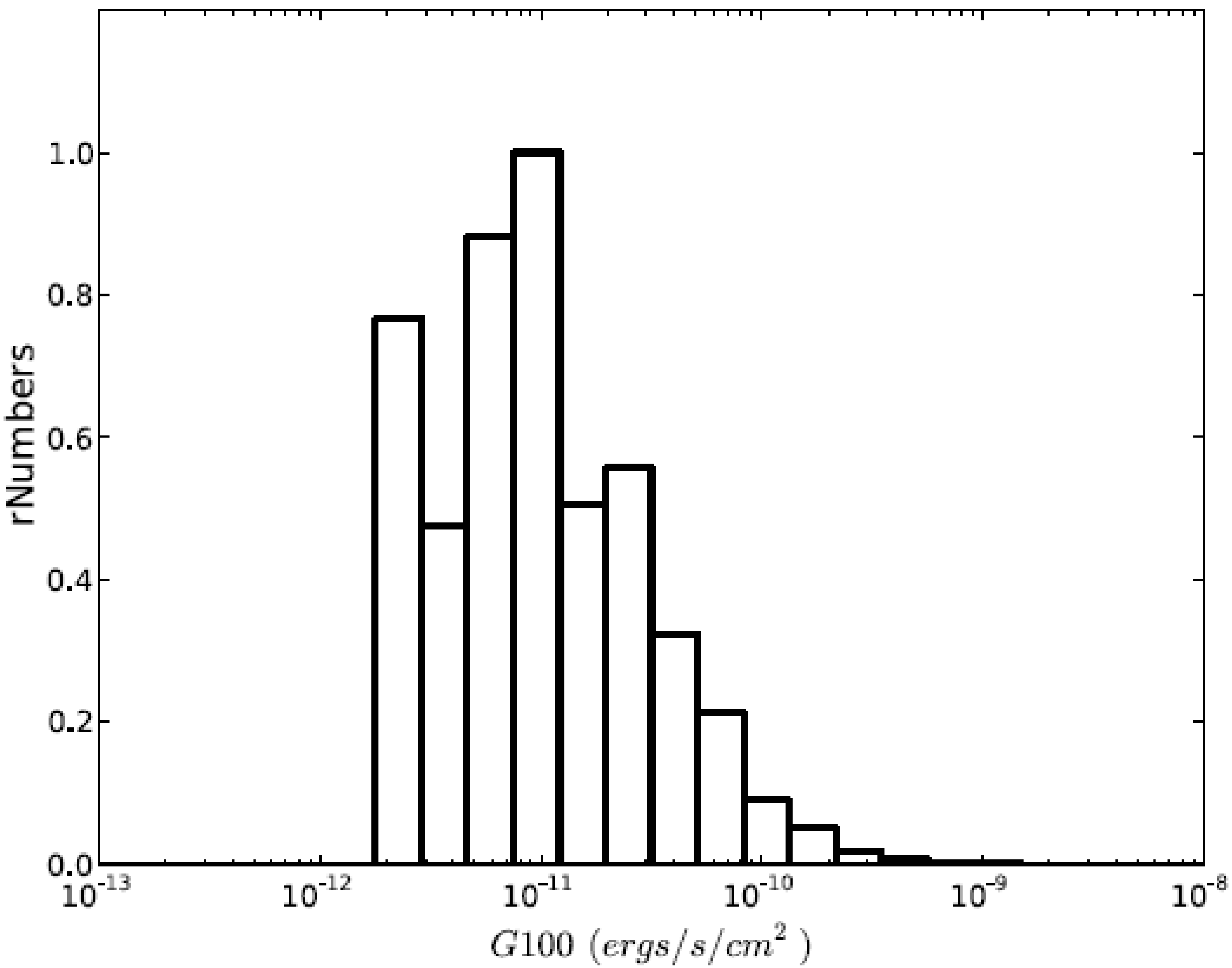


Implications for gamma-ray model?



- Favors outer gap model
  - $L\gamma$ (normal) > $L\gamma$ (ms)
  - Normal pulsars (Zhang & Cheng 1997) $L_\gamma \propto B_{\rm LC}^{2/7}$
  - ms pulsars (Zhang & Cheng 2003) $L_\gamma \propto B_{\rm LC}^{11/28}$
- Disfavors polar cap model
  - Gamma-ray loud and quite samples have similar radio properties

Fermi threshold for pulsars: 2×10^{-12} ergs/s/cm^2



(B_{LC} ,-Lγ)→Gamma-ray pulsar candidates

Name	G100 (erg/s/cm^2)	$\dot{E}$ (erg/s)	Name	G100 (erg/s/cm^2)	$\dot{E}$ (erg/s)
J1745-3040	5.8×10^{-10}	8.49×10^{33}	*J1603-7202	3.7×10^{-11}	1.89×10^{32}
J0745-5353	5.5×10^{-10}	1.09×10^{34}	*J1643-1224	3.7×10^{-11}	7.38×10^{33}
*J0900-3144	3.8×10^{-10}	1.41×10^{33}	J0108-1431	3.7×10^{-11}	5.77×10^{30}
J2222-0137	2.9×10^{-10}	5.29×10^{31}	J0749-4247	3.5×10^{-11}	2.93×10^{31}
J1752-2806	2.8×10^{-10}	1.80×10^{33}	J0835-3707	3.5×10^{-11}	2.43×10^{33}
J1932+1059	2.5×10^{-10}	3.93×10^{33}	J0834-4159	3.4×10^{-11}	9.86×10^{34}
J0843-5022	2.3×10^{-10}	7.46×10^{32}	J2053-7200	3.4×10^{-11}	1.94×10^{32}
*J1022+1001	2.2×10^{-10}	3.84×10^{32}	J1518+4904	3.3×10^{-11}	1.56×10^{31}
J1740-3015	2.1×10^{-10}	8.23×10^{34}	J0630-2834	3.2×10^{-11}	1.46×10^{32}
*J1017-7156	1.9×10^{-10}	6.85×10^{33}	*J1045-4509	3.2×10^{-11}	1.67×10^{33}
J0953+0755	1.9×10^{-10}	5.6×10^{32}	J1946+1805	3.1×10^{-11}	1.11×10^{31}
*J2145-0750	1.7×10^{-10}	2.84×10^{32}	J1705-1906	3.1×10^{-11}	6.11×10^{33}
J1825-0935	1.3×10^{-10}	4.56×10^{33}	J0820-4114	2.8×10^{-11}	4.6×10^{30}
J0942-5552	1.3×10^{-10}	3.08×10^{33}	J0907-5157	2.8×10^{-11}	4.43×10^{33}
J0842-4851	1.3×10^{-10}	1.4×10^{33}	J0117+5914	2.7×10^{-11}	2.21×10^{35}
J0809-4753	1.2×10^{-10}	7.43×10^{32}	*J1525-5545	2.5×10^{-11}	3.54×10^{34}
J1820-0427	1.0×10^{-10}	1.17×10^{33}	J1908+0734	2.4×10^{-11}	3.4×10^{33}
*J1439-5501	1.0×10^{-10}	2.38×10^{32}	J1136+1551	2.4×10^{-11}	8.79×10^{31}
*J0737-3039A	9.2×10^{-11}	5.94×10^{33}	J1913+1011	2.4×10^{-11}	2.87×10^{36}
*J1723-2837	9.0×10^{-11}	4.66×10^{34}	J1809-1917	2.2×10^{-11}	1.78×10^{36}
*J2129-5721	7.9×10^{-11}	1.59×10^{34}	*J1300+1240	2.1×10^{-11}	1.88×10^{34}
J0826+2637	7.6×10^{-11}	4.52×10^{32}	J1528-3146	2.1×10^{-11}	4.37×10^{31}
J0134-2937	7.5×10^{-11}	1.20×10^{33}	*J1038+0032	2.1×10^{-11}	1.10×10^{32}
J0807-5421	7.4×10^{-11}	1.02×10^{32}	*J2022+3842	2.1×10^{-11}	1.19×10^{38}
J0831-4406	7.2×10^{-11}	1.67×10^{33}	*J1933-6211	2.0×10^{-11}	3.28×10^{33}
J1740+1000	6.9×10^{-11}	2.32×10^{35}	*J0407+1607	2.0×10^{-11}	1.84×10^{32}
J0840-5332	6.7×10^{-11}	1.73×10^{32}	J0746-4529	2.0×10^{-11}	3.03×10^{31}
J0452-1759	6.8×10^{-11}	1.37×10^{33}	J1921+2153	2.0×10^{-11}	2.23×10^{31}
J0358+5413	6.4×10^{-11}	4.54×10^{34}	*J1843-1113	1.9×10^{-11}	6.02×10^{34}
J1302-6350	5.9×10^{-11}	8.26×10^{35}	J1826-1334	1.8×10^{-11}	2.84×10^{36}
J0821-4221	5.7×10^{-11}	2.2×10^{33}	J0855-4644	1.8×10^{-11}	1.06×10^{36}
J1537+1155	5.6×10^{-11}	1.76×10^{33}	J1530-5327	1.8×10^{-11}	8.52×10^{33}
J1001-5507	5.4×10^{-11}	6.84×10^{32}	*J1311-3430	1.7×10^{-11}	4.93×10^{34}
J1456-6843	5.1×10^{-11}	2.12×10^{32}	*J1745-0952	1.7×10^{-11}	5.02×10^{32}
*J1623-2631	5.0×10^{-11}	1.95×10^{34}	J1831-0952	1.6×10^{-11}	1.08×10^{36}
J1524-5625	4.5×10^{-11}	3.21×10^{36}	J0922+0638	1.6×10^{-11}	6.79×10^{33}
*J1203+0038	4.4×10^{-11}	9.85×10^{34}	J1739-3023	1.6×10^{-11}	3.01×10^{35}
J0538+2817	4.1×10^{-11}	4.94×10^{34}	J0206-4028	1.6×10^{-11}	1.89×10^{32}

Statistics of the new candidates

- 76 with Lγ > 1.6×10^{-11} ergs/s/cm^2 >> 2×10^{-12} ergs/s/cm^2
  - only 24 with Edot>1×10^{34} erg/s
    - 5 already listed as gamma-ray pulsars
  - 18 with Lγ > 10^{-10} ergs/s/cm^2
    - Only two with Edot>1×10^{34} erg/s
  - We expect a large number of pulsars to be detectable if systematic period-folding is done.
    - Radio monitoring of these pulsars are required!

Summary

- Higher $\dot{E}$ → easier gamma-ray detection
  - But is $\dot{E}$ the best gamma-ray indicator?
- Higher B_{LC} → even easier gamma-ray detection?
  - KS test → B_{LC} discriminates gamma-ray loud and quiet pulsars better than $\dot{E}$
- $B_{\mathrm{LC}} \sim L_{\gamma}$ consistent with outer gap model
- New candidates of gamma-ray pulsars are predicted

Thanks for your attention!