Differences Between Radio-loud and Radio-quiet Gamma-ray pulsars as revealed by Fermi

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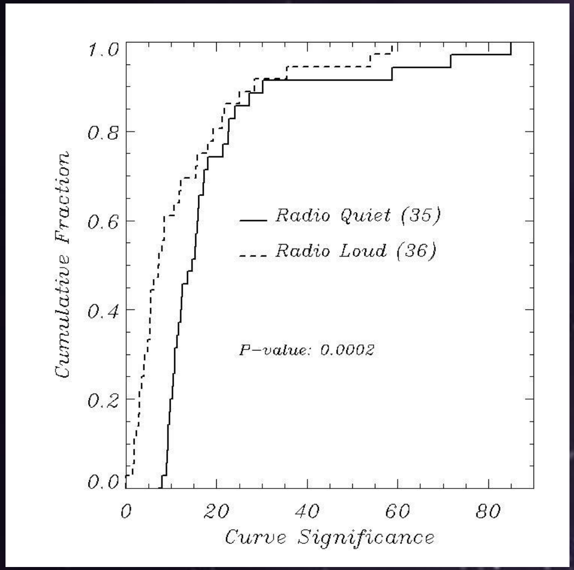
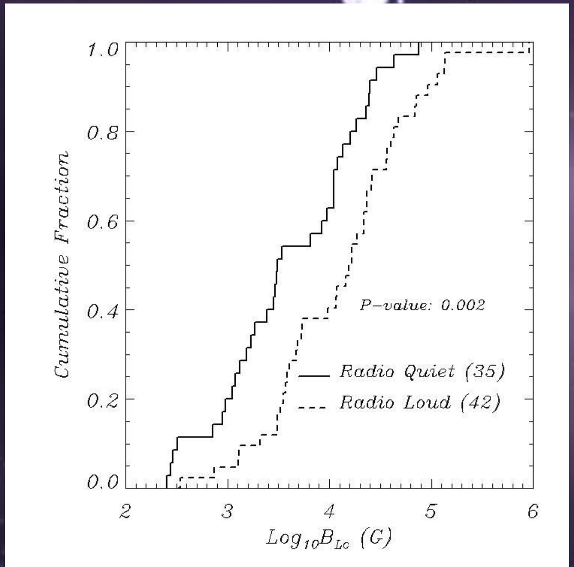
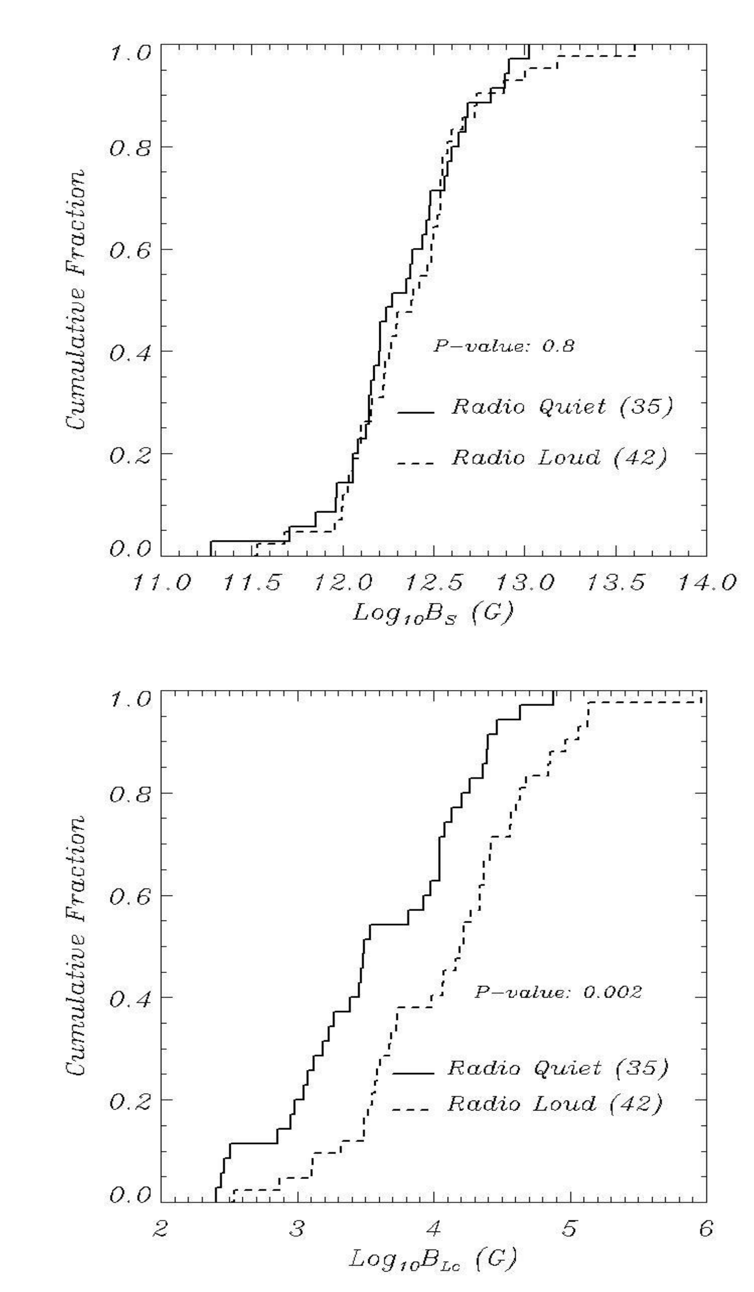
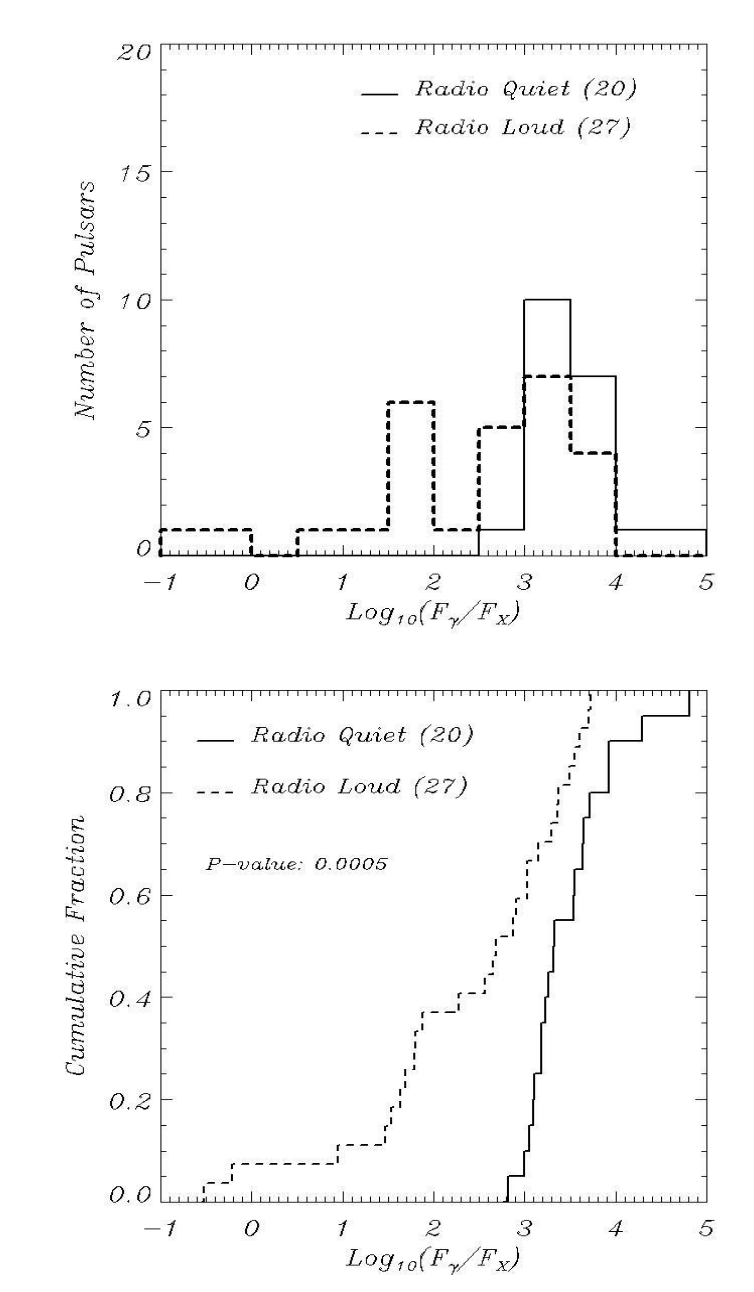




✓ By comparing the properties of non-recycled radio-loud γ-ray pulsars and radio-quiet γ-ray pulsars, we have searched for the differences between these two populations. We found that the γ-ray spectral curvature of radio-quiet pulsars can be larger than that of radio-loud pulsars. Based on the full sample of non-recycled γ-ray pulsars, their distributions of the magnetic field strength at the light cylinder are also found to be difference.



- ✓Another interesting result is the comparison for magnetic field between two populations. The distribution and statistical test was not shown the difference in $B_{Surface}$, while we can show the definitely difference in $B_{Light\ Cylinder}$.
- ✓B_{LC} is function of P and $\dot{P}$. To investigate if the difference in B_{LC} is caused by the distributions of their rotational parameters, we have also applied the A-D test separately on P (p-value~0.006) and $\dot{P}$ (p-value~0.2).
- ✓Since $B_{LC} \sim B_S P^{-3}$, the differences between radio-loud and radio-quiet populations should stem from the rotational period P. We noted that P of radio-loud pulsars are generally smaller than radio-quiet pulsars.
- ✓Therefore, shorter period pulsars will have wider radio cone and hence more favorable to be radio-loud. And thence the radio-quietness in the pulsar population might be a result of their narrower radio cones.



- ✓In re-examining the distributions of nominal values of $\frac{F_\gamma}{F_X}$, we confirmed the difference between the radio-loud and radio-quiet pulsars as claimed by Marelli et al. (2015).
- ✓Concerning the difference in $\frac{F_\gamma}{F_X}$, we consider a geometric effect together with assumption that the X-ray are coming from the regions near the polar cap.
- ✓In this case its intensity F_X^{PC} should depend on the angle between the magnetic axis and the viewing angle θ, namely $F_X^{PC} \propto \theta$.
- ✓Then radio-loud pulsars should have smaller θ than those radio-quiet pulsars.
- ✓This implies the mean F_X of radio-loud pulsars is larger than that of the radio-quiet pulsars

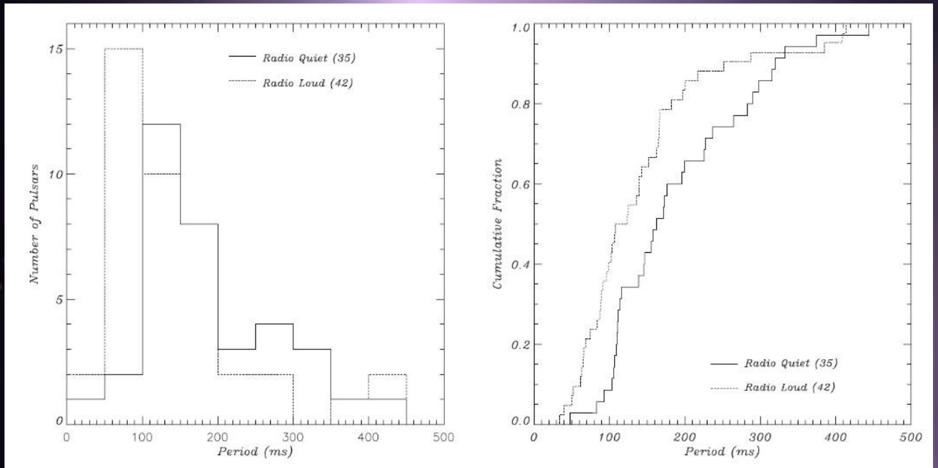


Fig. 3.— Comparing the rotational period distributions from the radio-loud and radio-quiet $\gamma-$ray pulsars in histograms (*left panel*) and cumulative distributions (*right panel*).

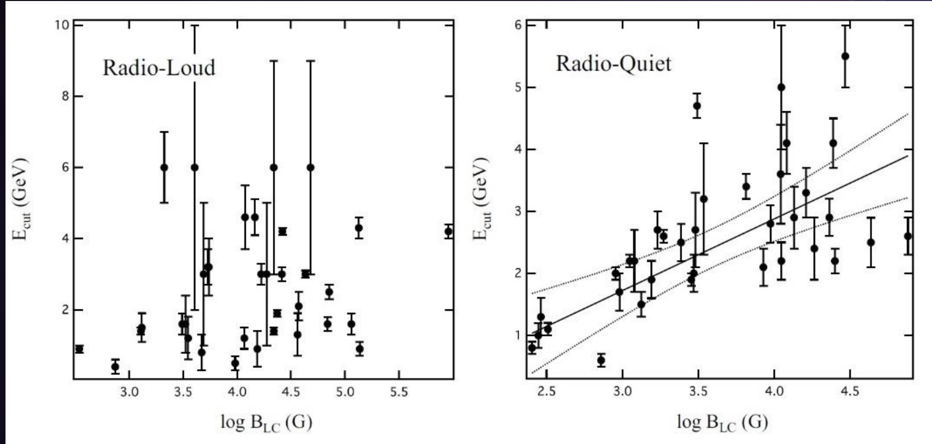


Fig. 4.— The cut-off energies E_{cut} vs. B_{LC} in radio-loud (*left panel*) and radio-quiet (*right panel*) $\gamma-$ray pulsar populations. The solid line in the right panel represent the best-fit from the regression analysis. The dotted lines represent the upper and lower 95% confidence bands.

- ✓ Whether PL or PLE model best fit depends on the photon statistics. Since radio-loud γ-ray pulsars can be more easily detected, their detection significances are generally lower than that of radio-quiet γ-ray pulsars.
- ✓ To account for the difference of γ-ray spectral curvature, we speculate that inverse Compton (IC) process may play a role in high energy photon production. And this might result in more curved spectra of radio-quiet pulsars.
- ✓ E_{cut} of radio-quiet pulsars are found to be strongly correlated with B_{Lc}. E_{cut} might be determined by IC scattering between the radio emission and the primary electrons/positrons in the outer gap.
- ✓ Such effect can be enhanced if the open angle of the radio cone is larger. And hence E_{cut} should be proportional to 1/P and this result in the positive correlation between E_{cut} and B_{LC}
- ✓ The best-fit model for radio-quiet pulsar population is :

$$E_{Cut} = (-1.74 \pm 0.36) + (1.15 \pm 0.11) log B_{LC} GeV.$$

Relation	Spearman	Probability
Radio-loud pulsar population		
$E_{cut} vs\ B_{LC}$	0.3	0.1
Radio-quiet pulsar population		
$E_{cut} vs\ B_{LC}$	0.7	2×10^{-6}