

Searching a Thousand Radio Pulsars to find Faint Gamma-ray Emission

(with success) M. Kerr, on behalf of the Fermi-LAT Collaboration and the Fermi Pulsar Timing Consortium

SEARCHING A THOUSAND RADIO PULSARS FOR GAMMA-RAY EMISSION

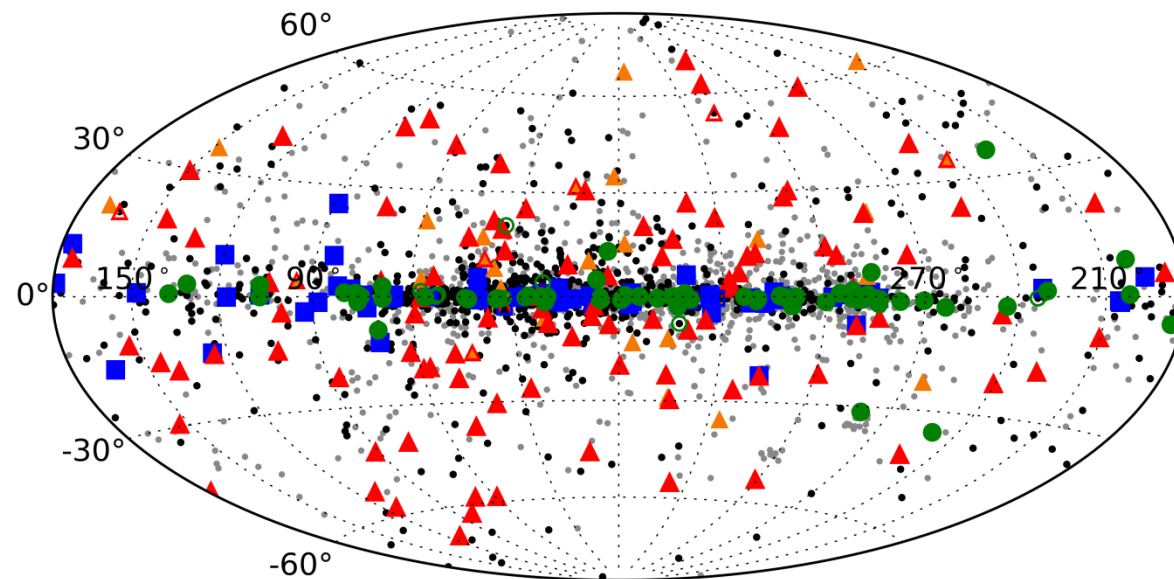
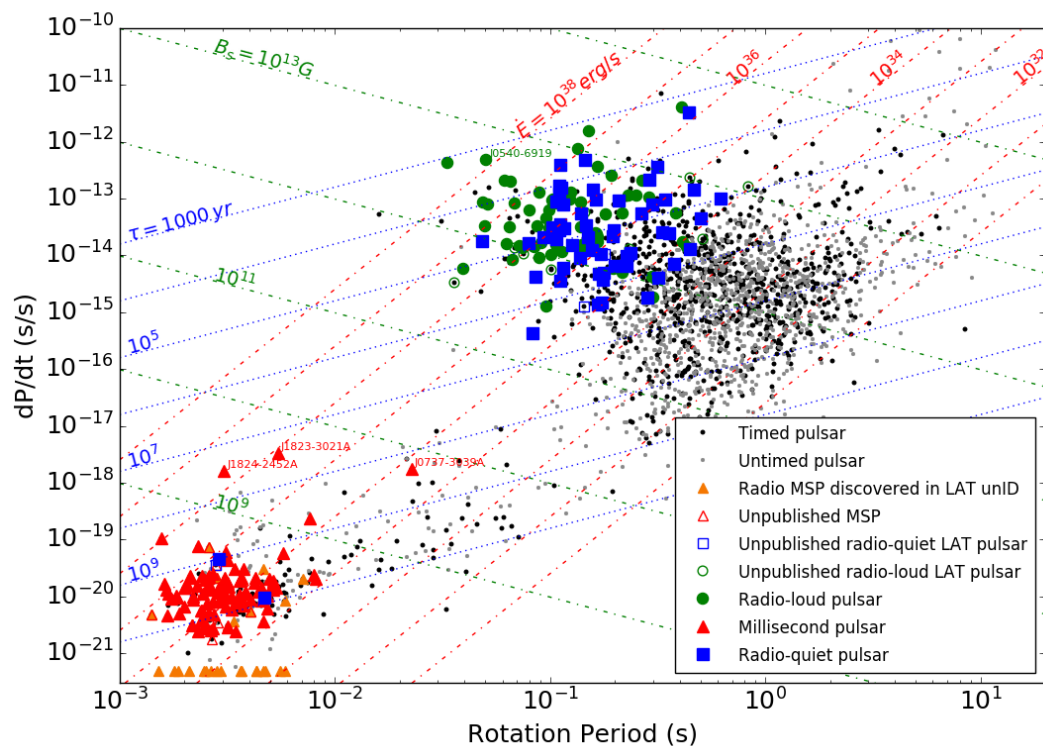
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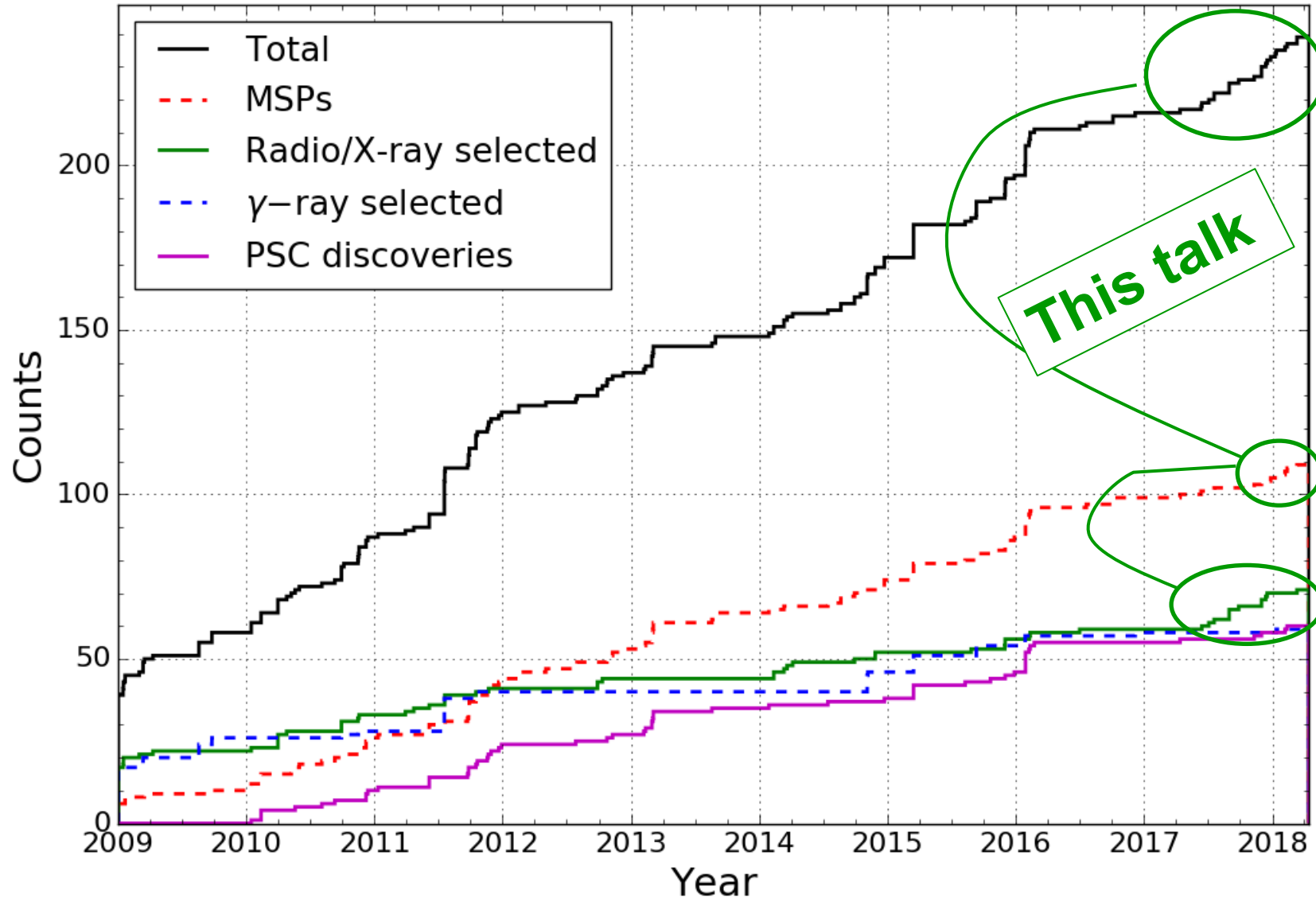




- >240 gamma-ray pulsars
- ~1/2 are MSPs
- ~1/4 are radio-quiet
- ... new low \dot{E} record!

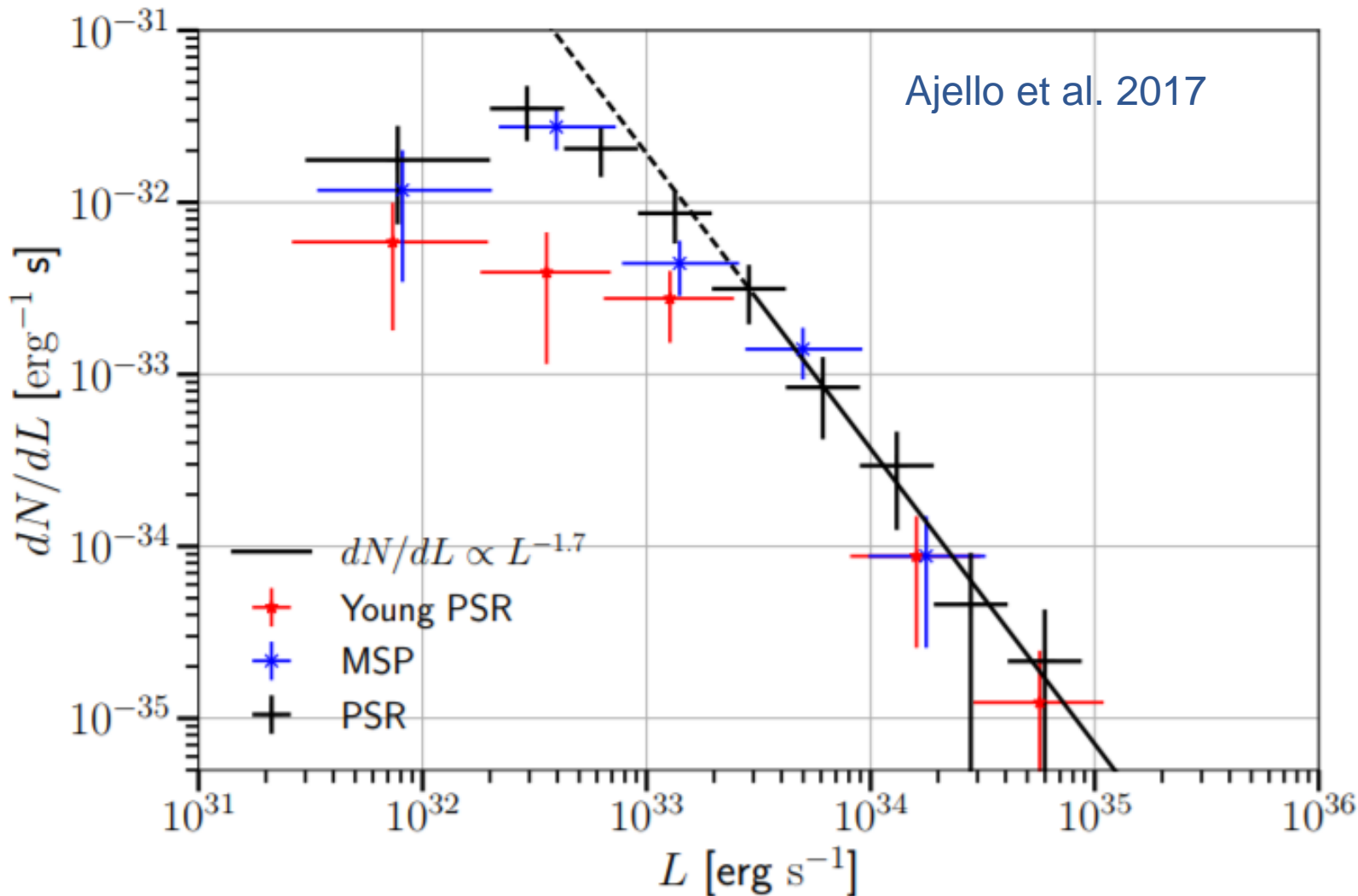
c.f. ~2700 radio pulsars

More Generally: $y=mx + b$; $m \sim 24$ pulsars/year



Low-Edot pulsars are interesting!

What is the pulsar luminosity function?



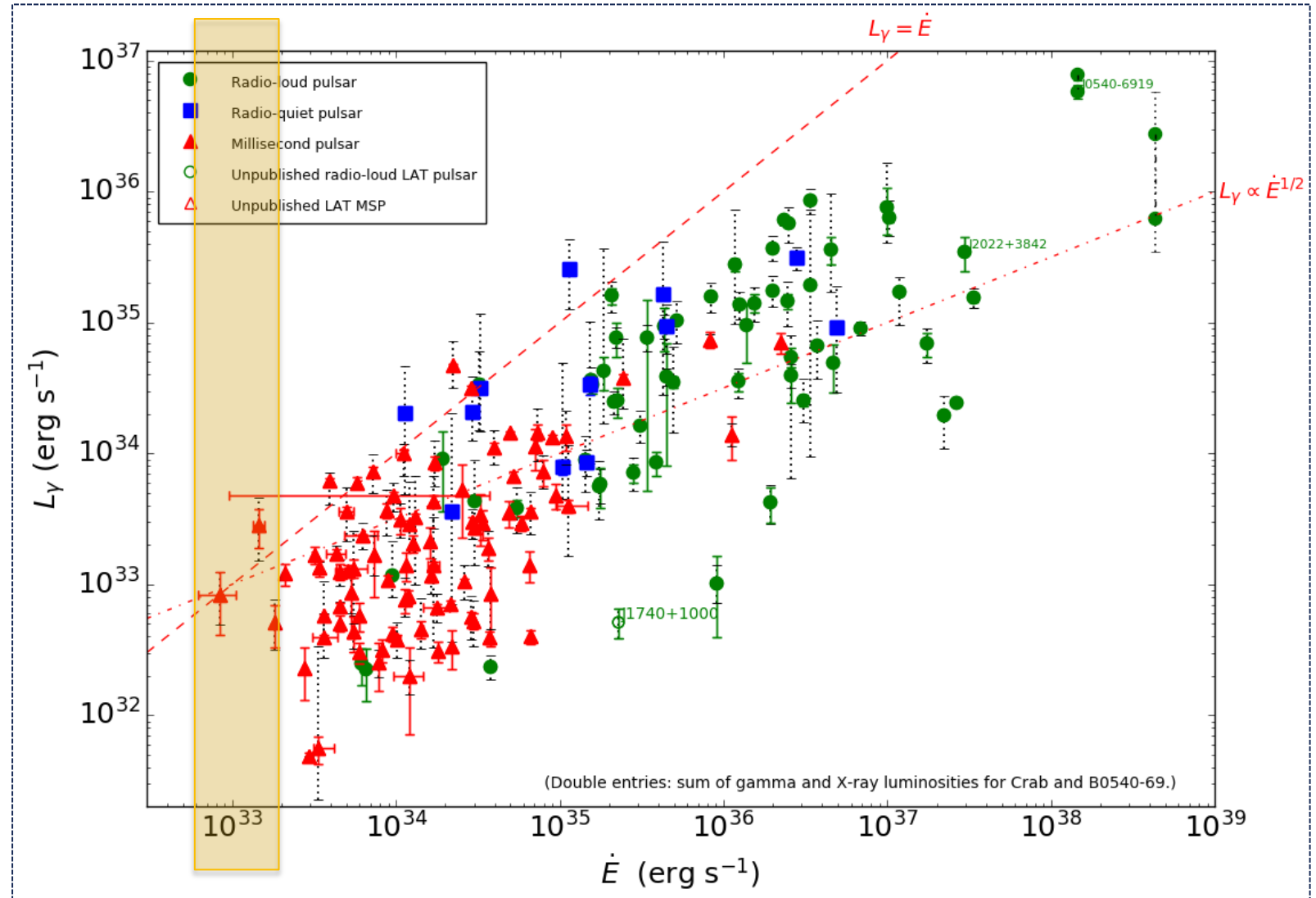
- Luminosity related to Edot.
- Low-luminosity population is critical for
 - Modelling unresolved pulsar contribution to diffuse emission (Galactic center excess?)
 - Tracking star formation

Low-Edot pulsars are interesting!

What happens to the “pulsar machine” in old age?

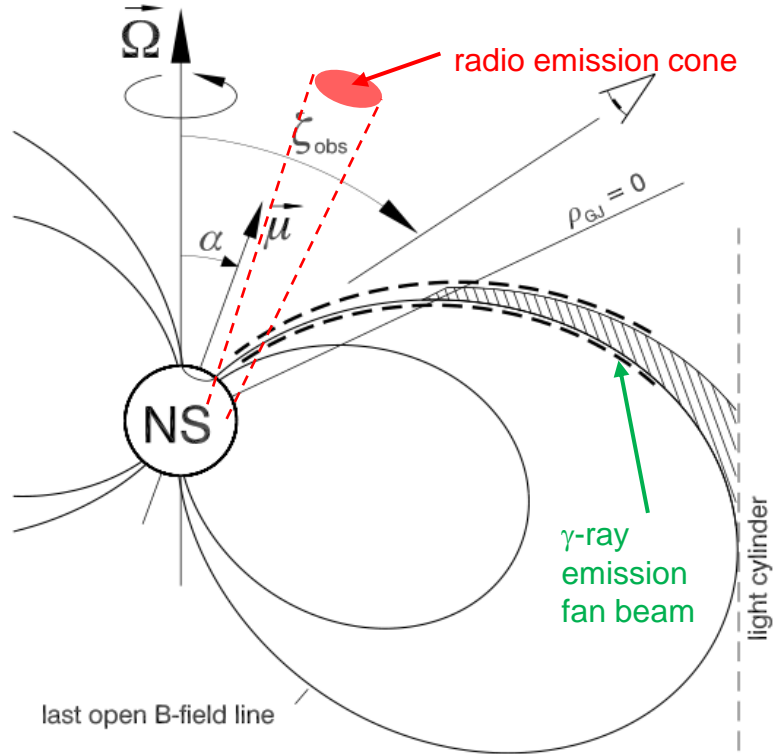
Is the $\sim 1e33$ erg/s “death line” real?

And if so, is it more of a suggestion? (How strong is the rolloff?)



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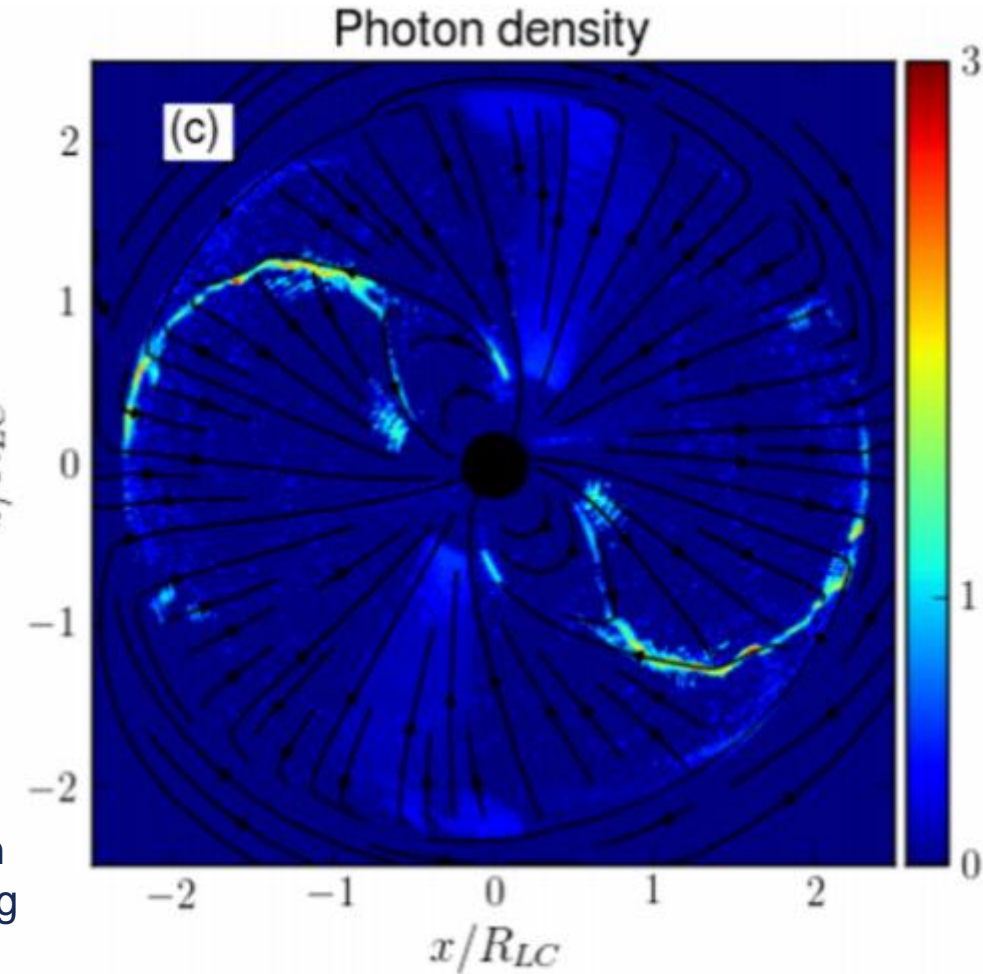
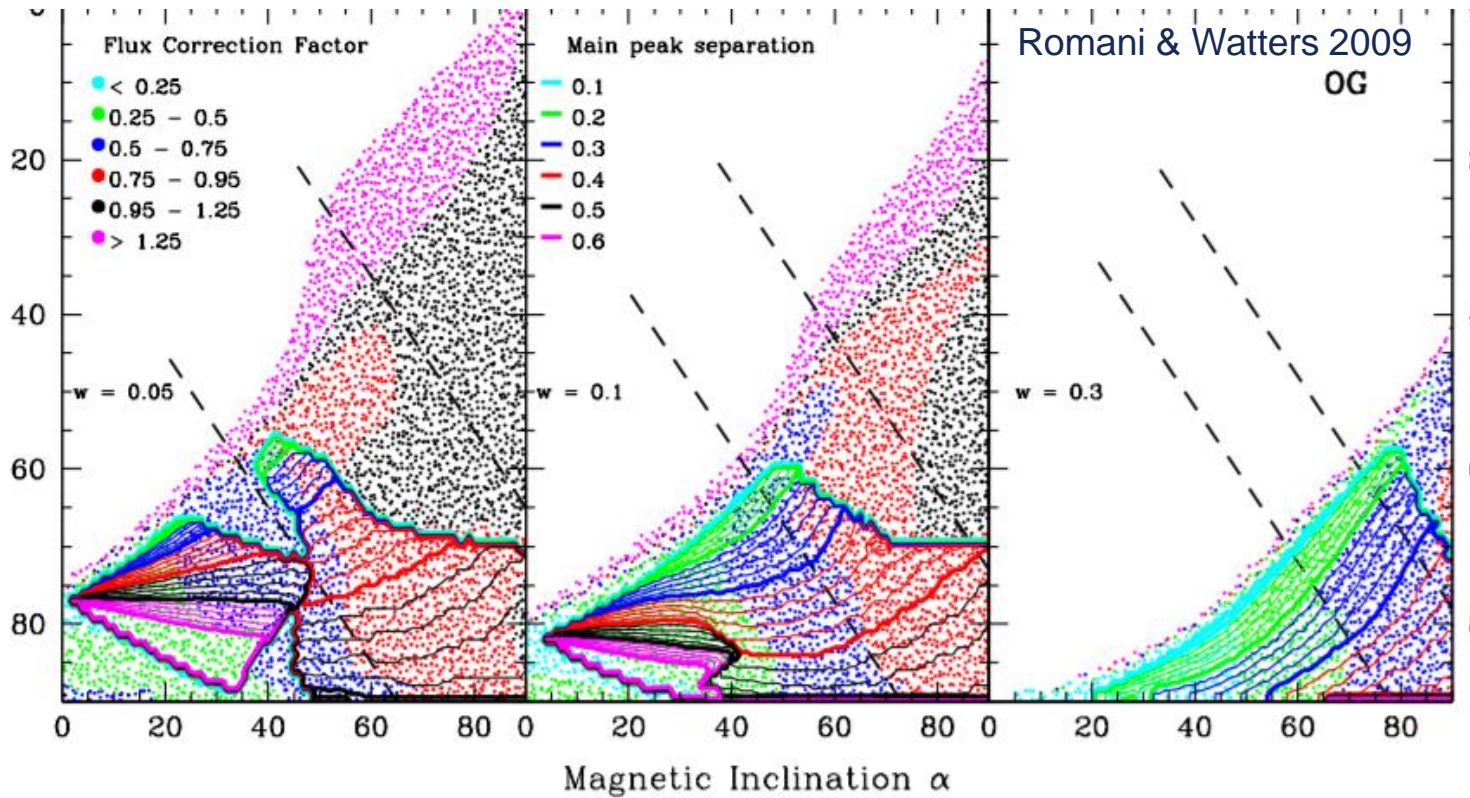


In outer gap models, gaps thicken as \dot{E} decreases, so emission happens on field lines closer to poles \rightarrow emission beamed towards spin equator, decreasing sky coverage and radio/gamma co-detection.

This is (in my opinion) largely confirmed by observations. What is interpretation with more realistic models with emission from a current sheet?

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Philippov & Spitkovsky 2018

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Weltevrede & Johnston 2008

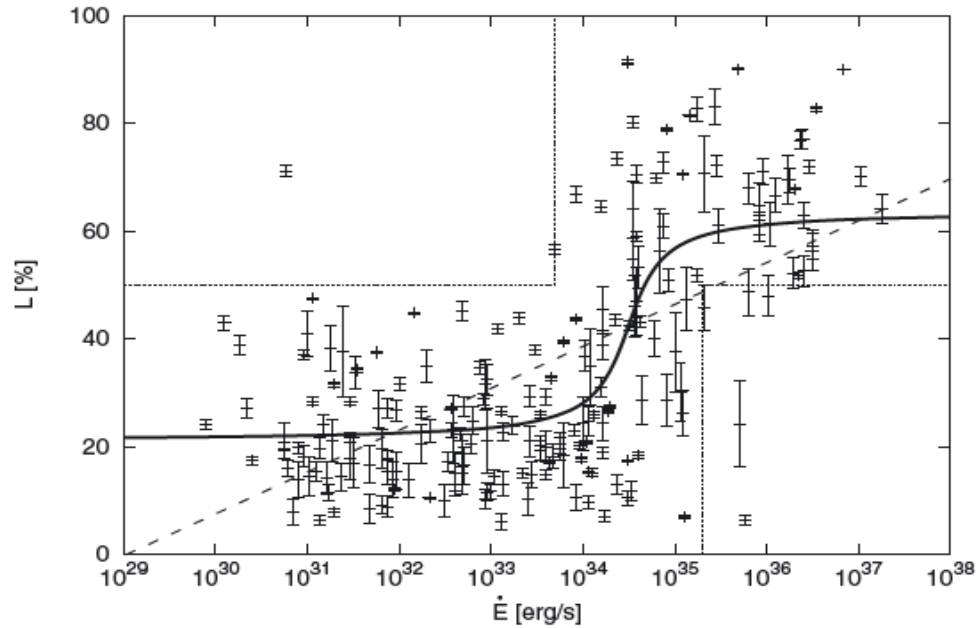
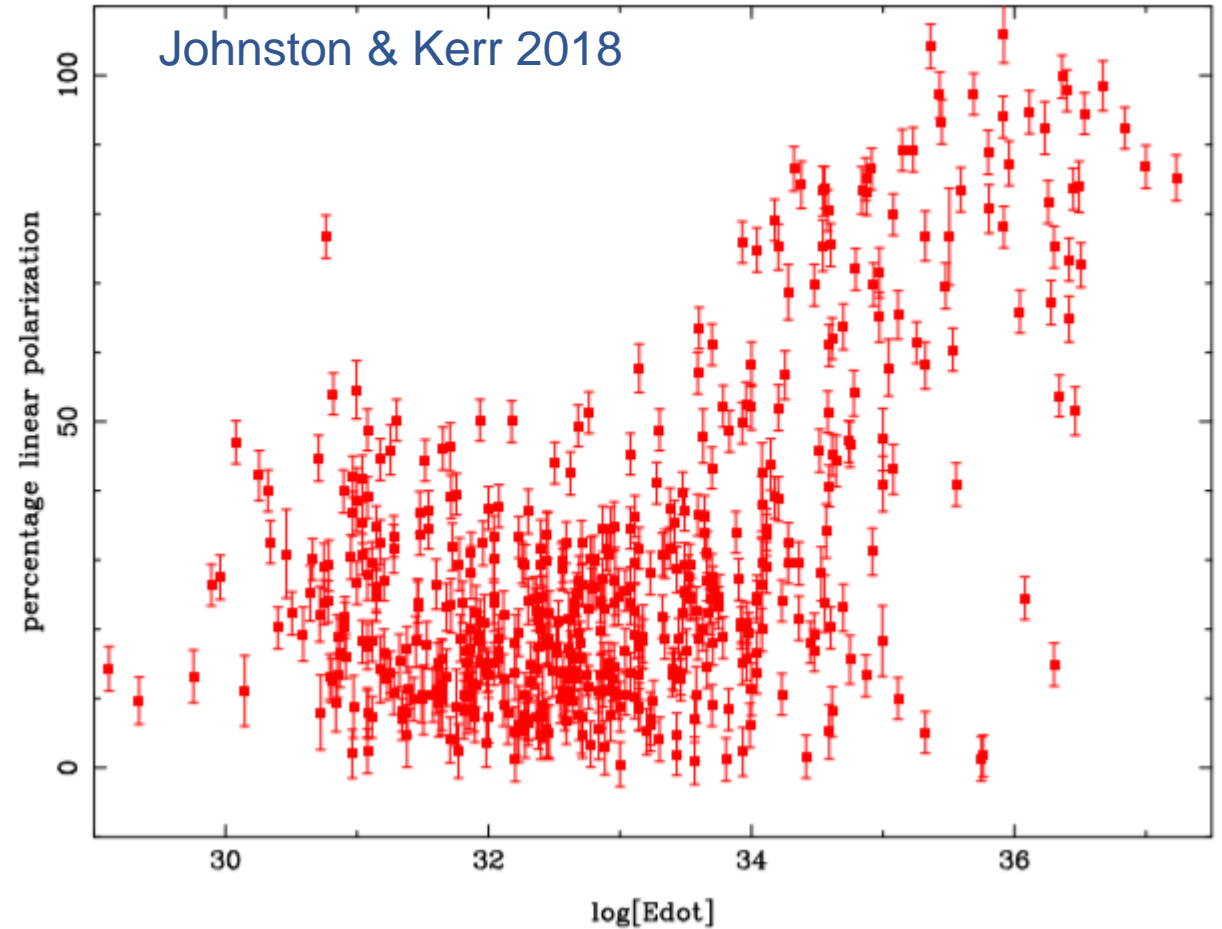
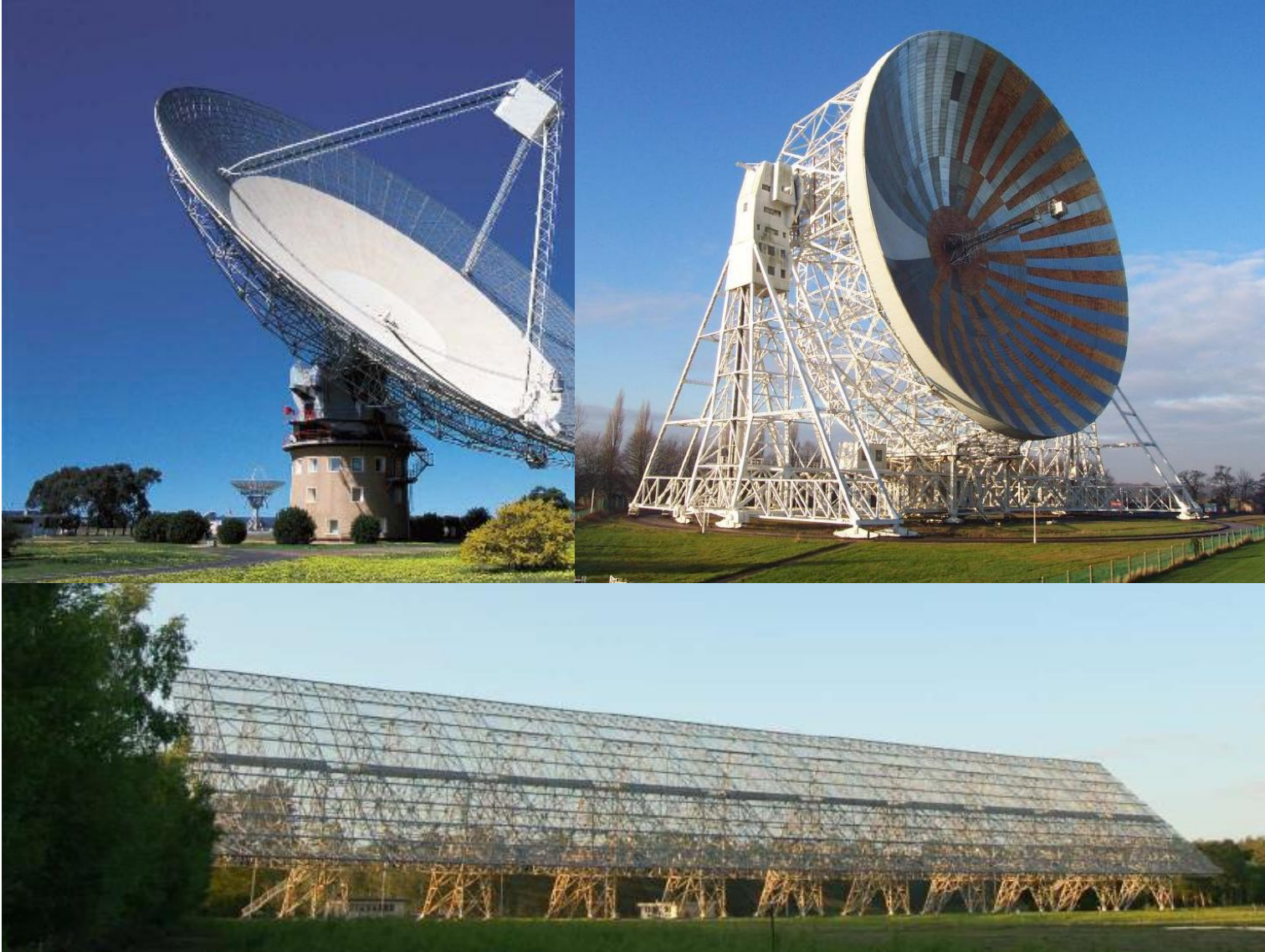


Figure 8. The degree of linear polarization versus \dot{E} of all pulsars observed at 20 cm for which a significant degree of linear polarization was measured. Pulsars which show evidence for scatter broadening were excluded. There are two relatively well-defined regions which are almost empty in this diagram. The dashed line shows the linear fit and the solid curve the fit of an arctan function illustrating the step in the degree of linear polarization.



How Do We Find Low-Edot Pulsars?

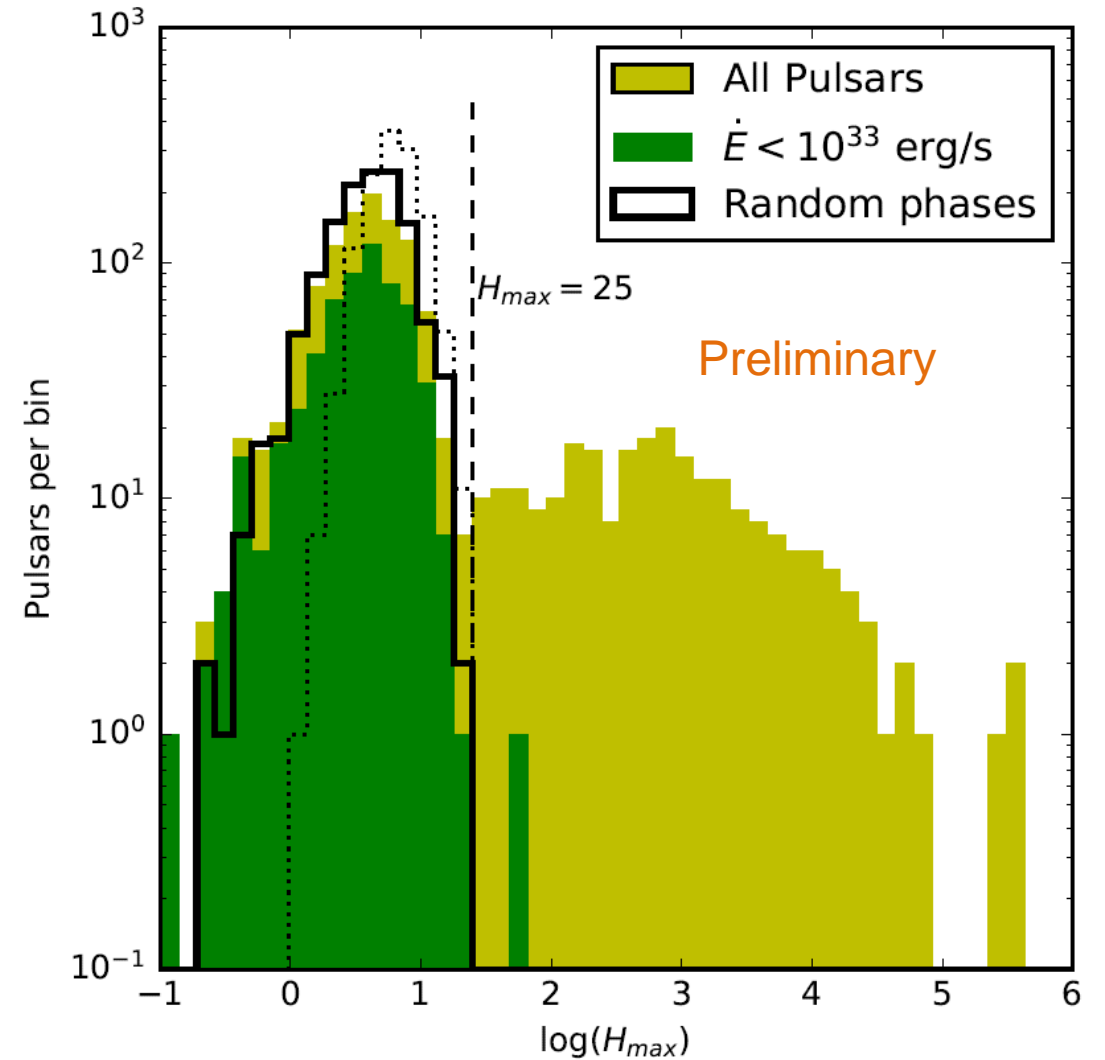


- Folding with an ephemeris requires no trials penalty
- Photon weights help (previous talk by P. Bruel)
- Need to revisit our assumptions about false positives to set as low of a threshold as possible.
- Make friends with radio astronomers.

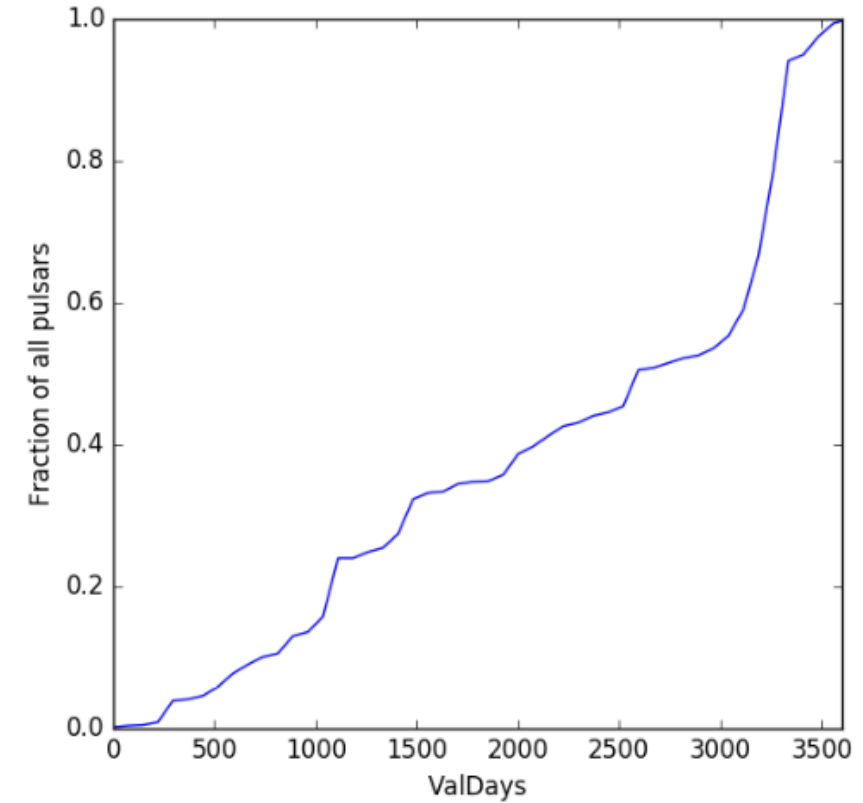
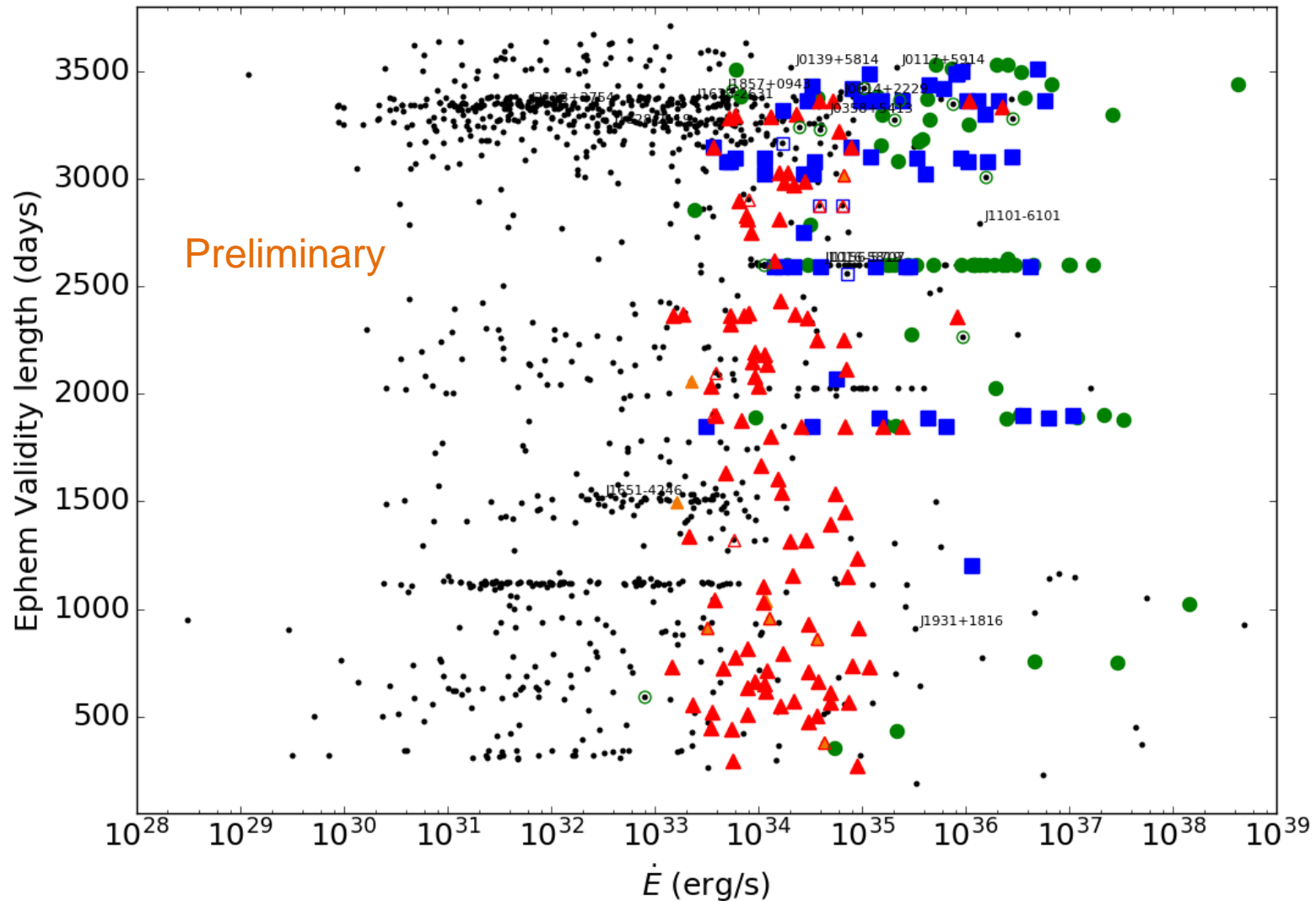
Tuning our Threshold

Simulations of null case for each of the ~ 1000 positions (and photon weights) we have a radio ephemeris for.

False probability rate is negligible for $H > 25$ (including trials from “simple” weighting scheme). This is about a 4-sigma threshold.



The Search



Timing for ~1300 pulsars 😊
No timing for ~1500 pulsars ☹️

The Results

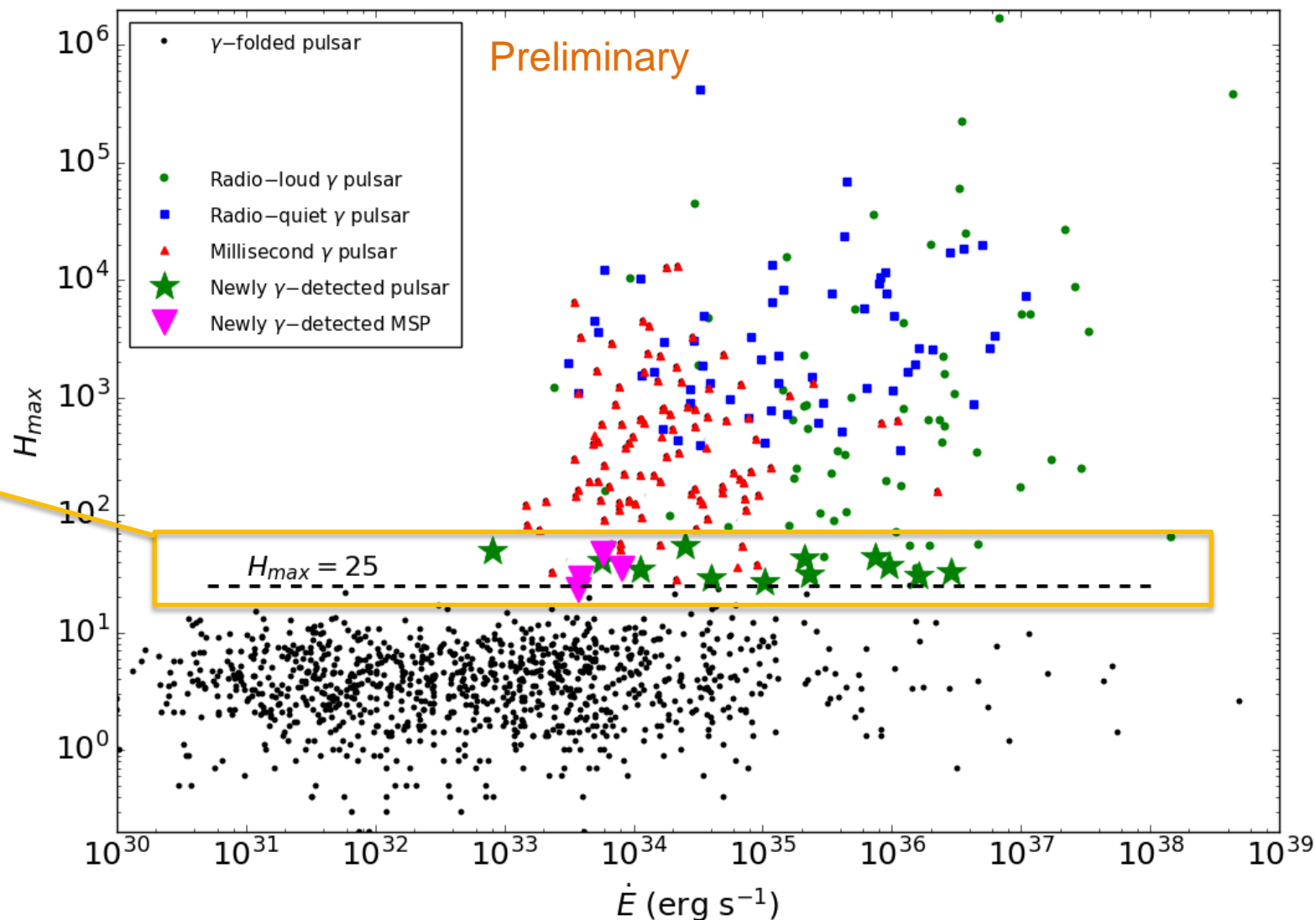
12 new young pulsars and 4 new millisecond pulsars!

The radio pulsars with new gamma-ray pulsations cover a wide range of \dot{E} dots, just over threshold.

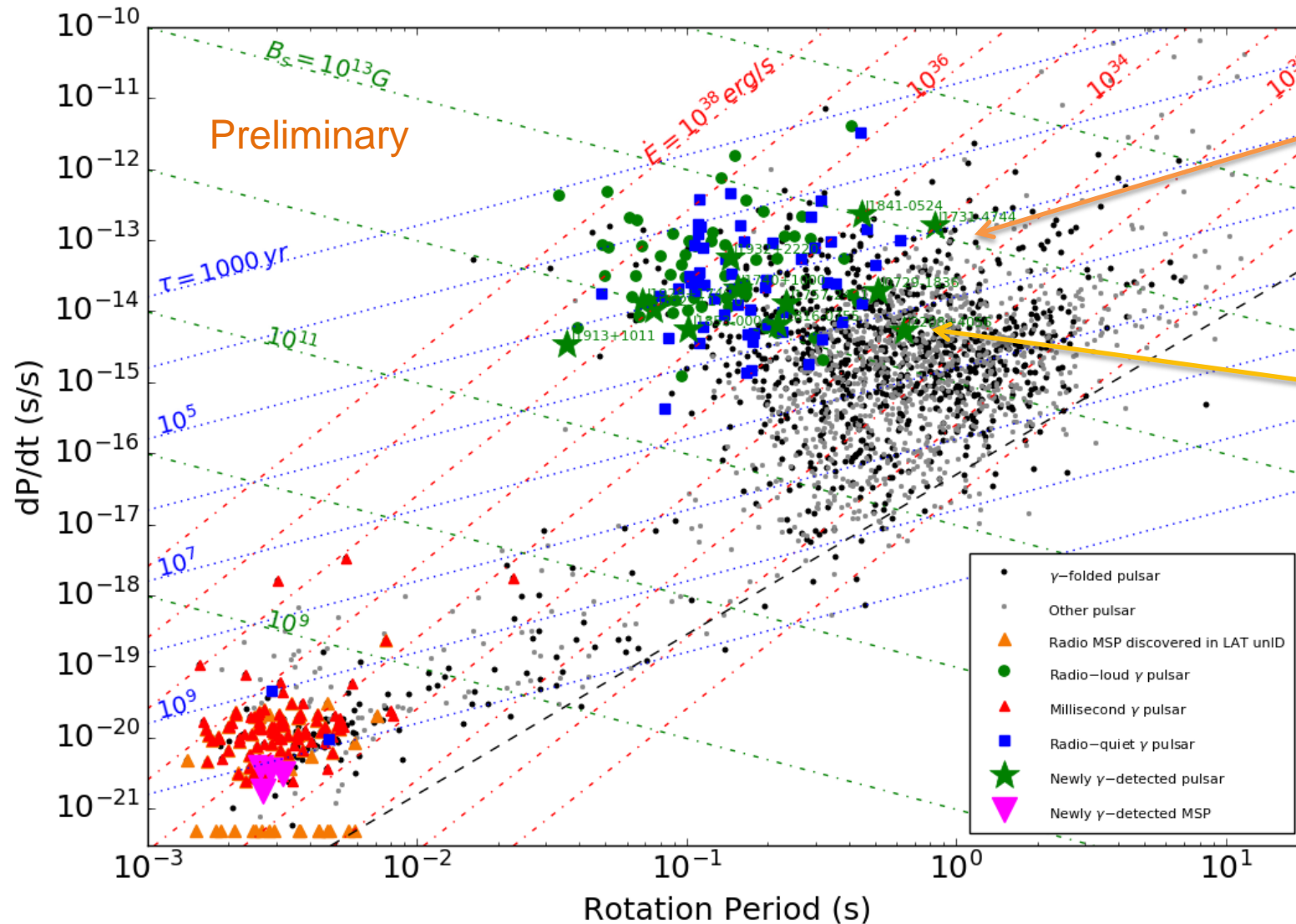
These pulsars could *not* have been found in the traditional way:

8/16 have $TS < 25$

11/16 have $TS < 30$



More Results



J1731-4744 is the slowest-spinning gamma-ray pulsar.

J2208+4056 has the lowest \dot{E} of any gamma-ray pulsar.

- $8e32 \text{ erg/s}$ is below the “death line”!
- An interpulsar, so likely viewed along spin equator.
- Preliminary measurement of 50% polarization.

Heroic effort by radio astronomers and David Smith, and some new techniques, netted 16 new pulsars.

With >1000 non-detections, death line is largely confirmed, but with some intrigue. Is J2208+4056 special (high polarization, orthogonal rotator)?

More complete picture of gamma-ray pulsar life cycle.

New constraints on luminosity function. Selection function is messy – good luck, population synthesizers.

Improved version of weighting method already netting some new pulsars (P. Bruel's talk).

New, widefield radio telescopes like CHIME and MeerKAT will make it possible to time many more pulsars – let's keep Fermi going and the pulsars coming!

