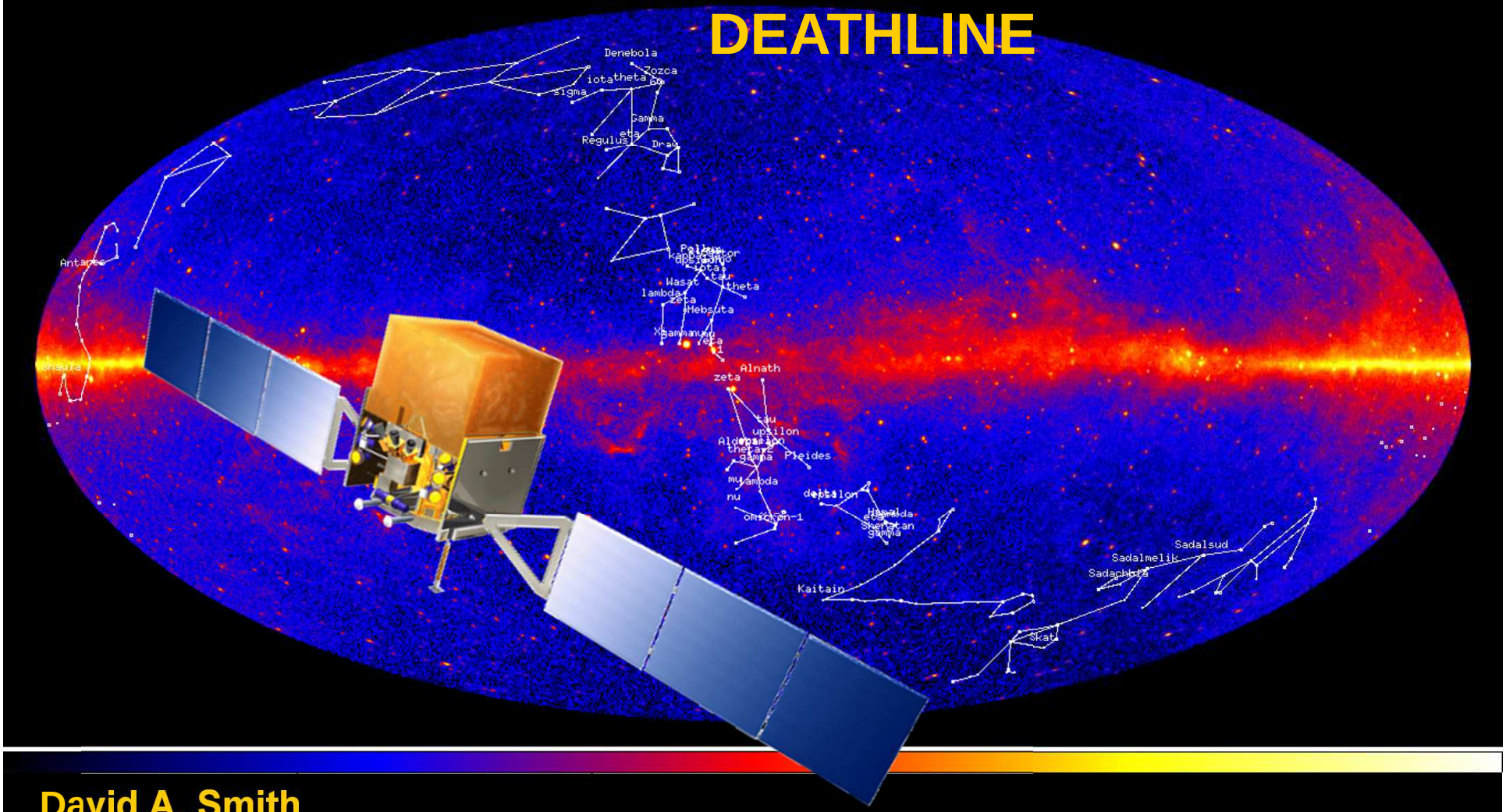
Pulsar radio polarization and gamma-ray emission

perhaps share the same

DEATHLINE



David A. Smith

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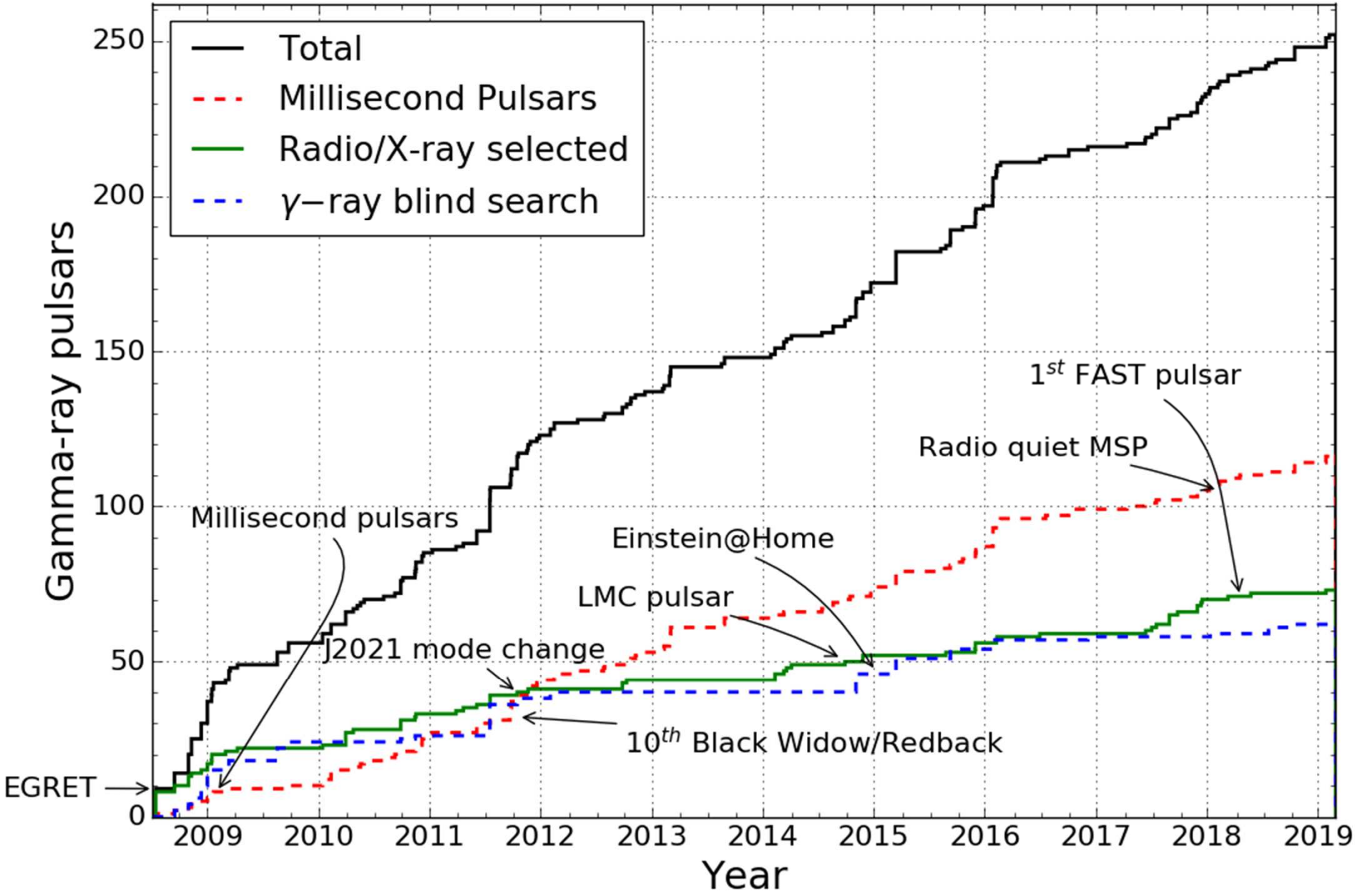
smith@cenbg.in2p3.fr

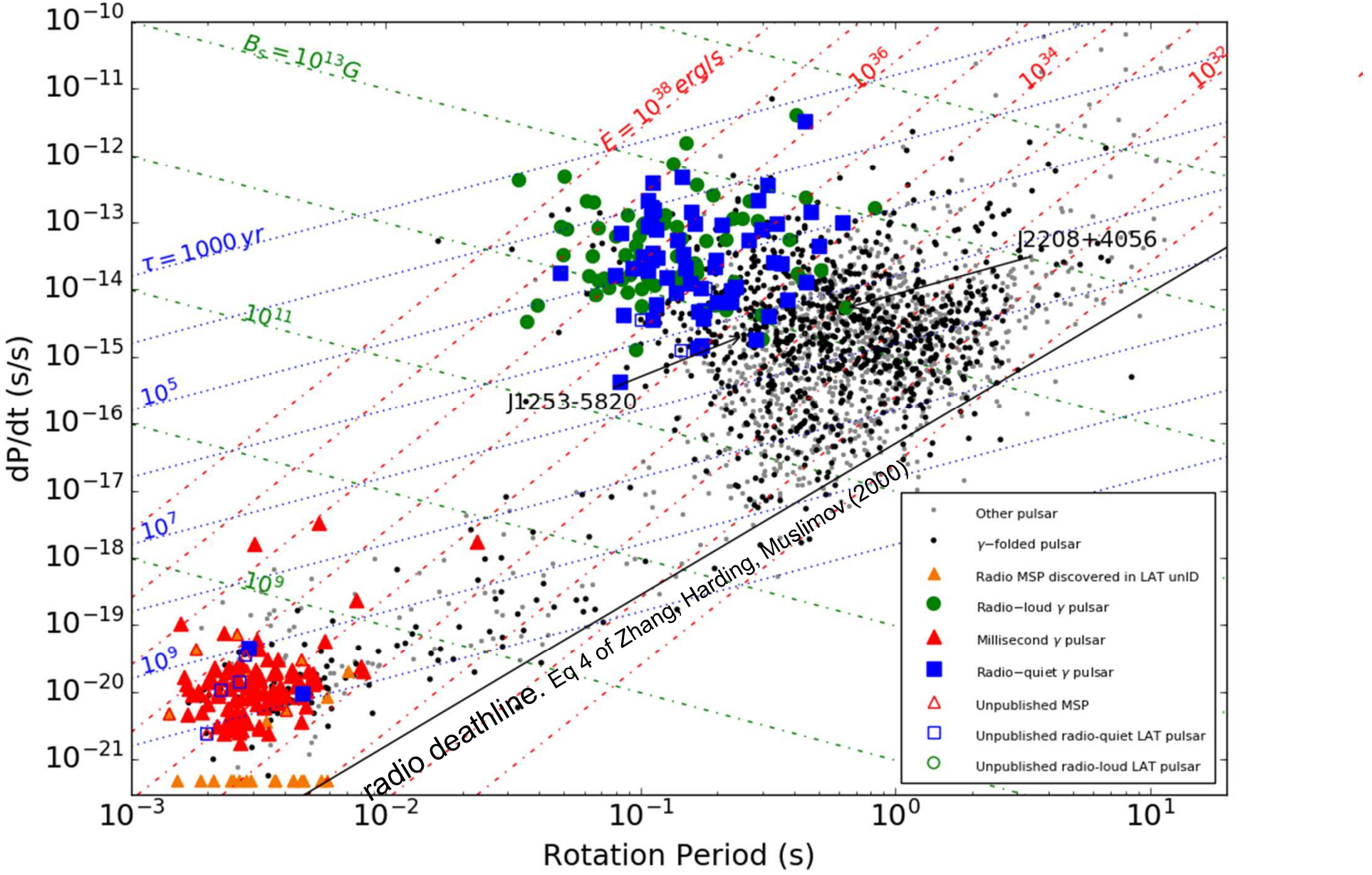
MODE
Neutron stars and their environments
Orléans, 8 April 2019

Current gamma-ray pulsar status (from NASA Senior Review)

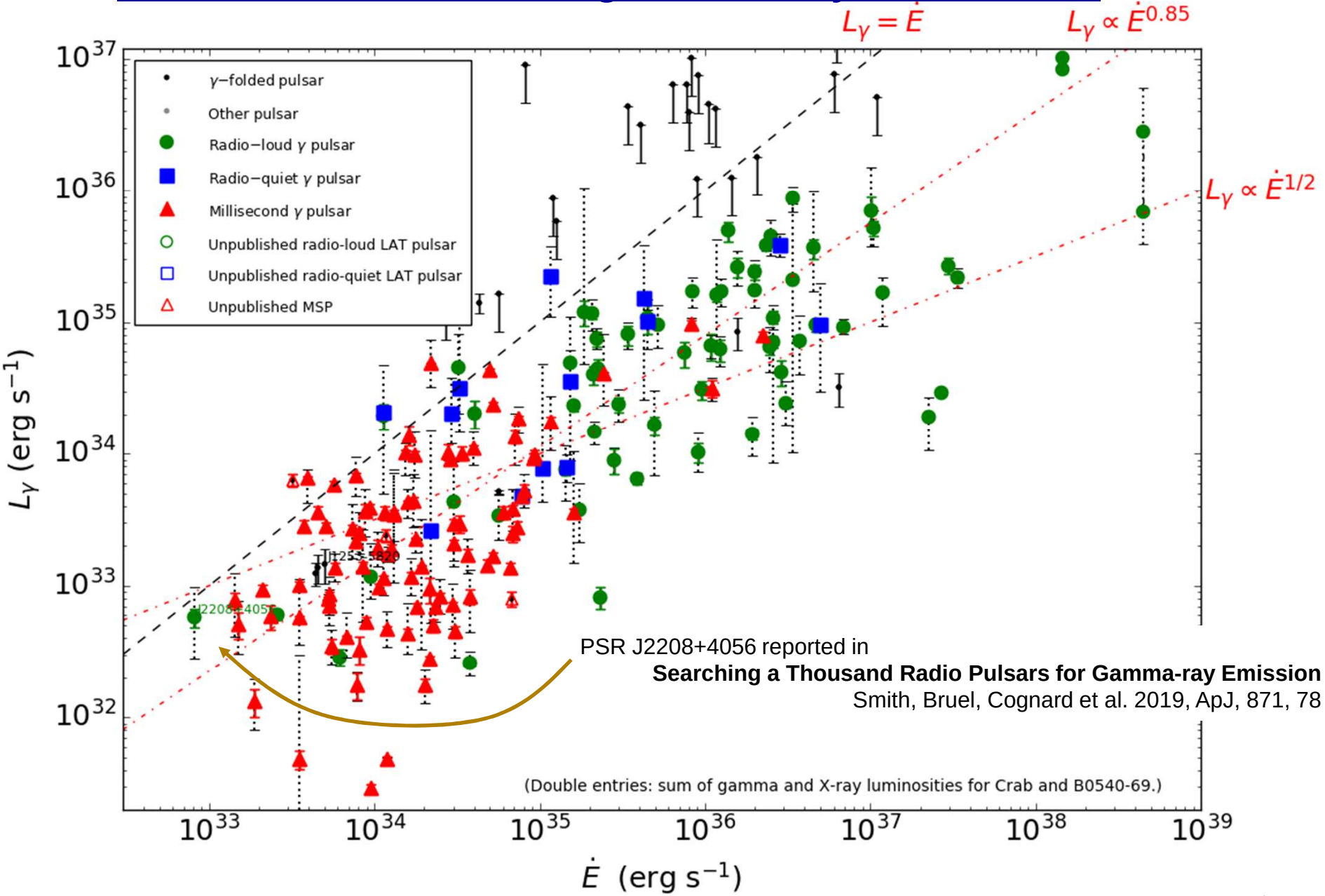
Plot by L. Guillemot + me.



Reminder about the gamma-ray deathline (1 of 4)



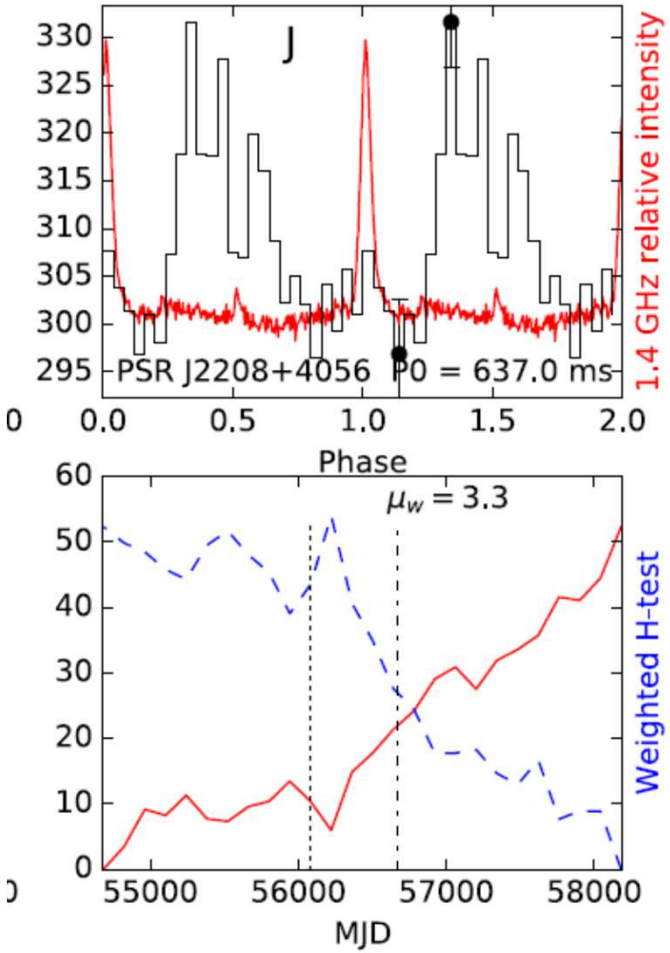
Reminder about the gamma-ray deathline (2 of 4)



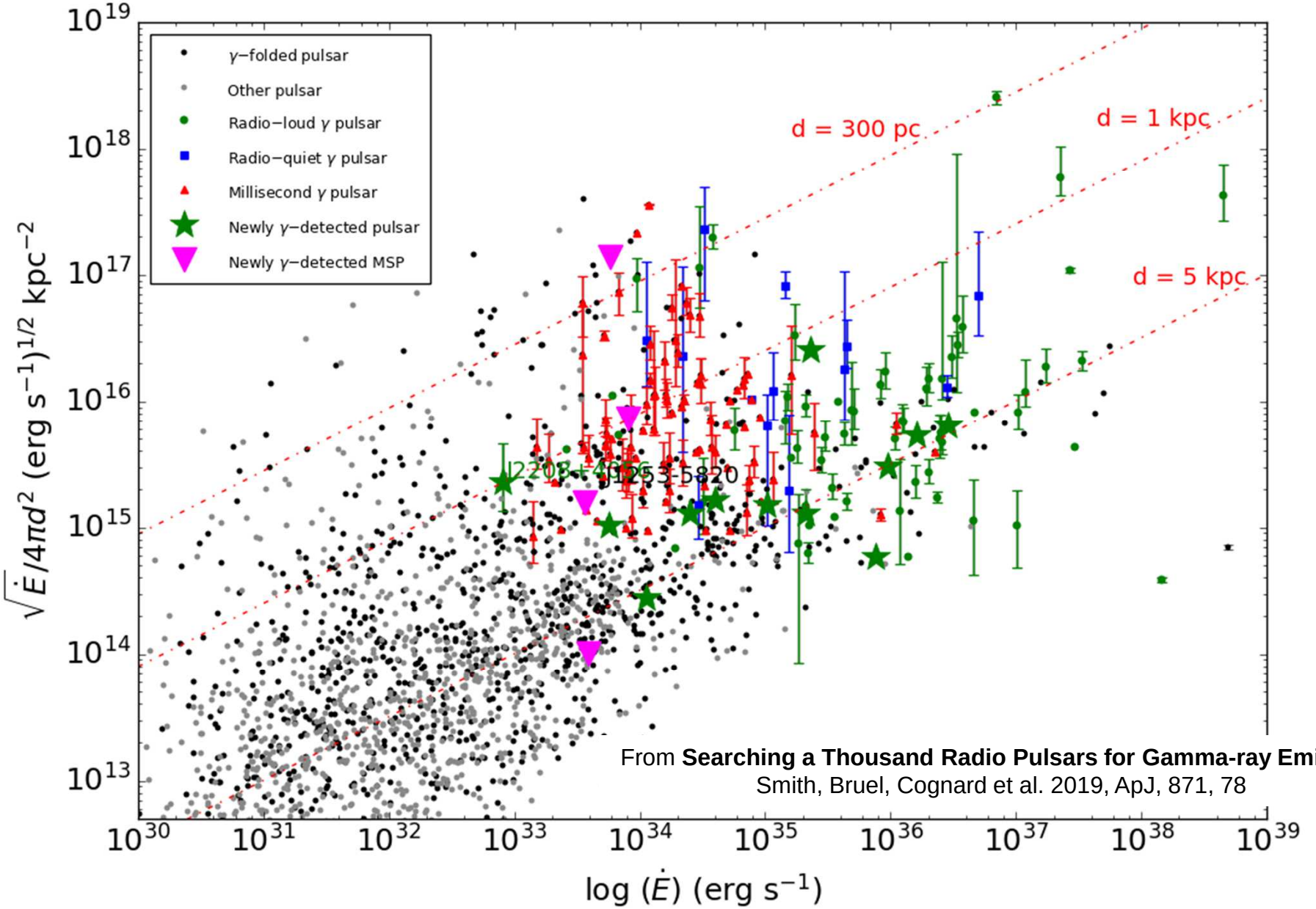
PSR J2208+4056 reported in
Searching a Thousand Radio Pulsars for Gamma-ray Emission
Smith, Bruel, Cognard et al. 2019, ApJ, 871, 78

PSR J2208+4056

Ė = 8e32 erg/s – lowest of any gamma pulsar.
Radio interpulse (orthogonal rotator)
~50% linear polarization.

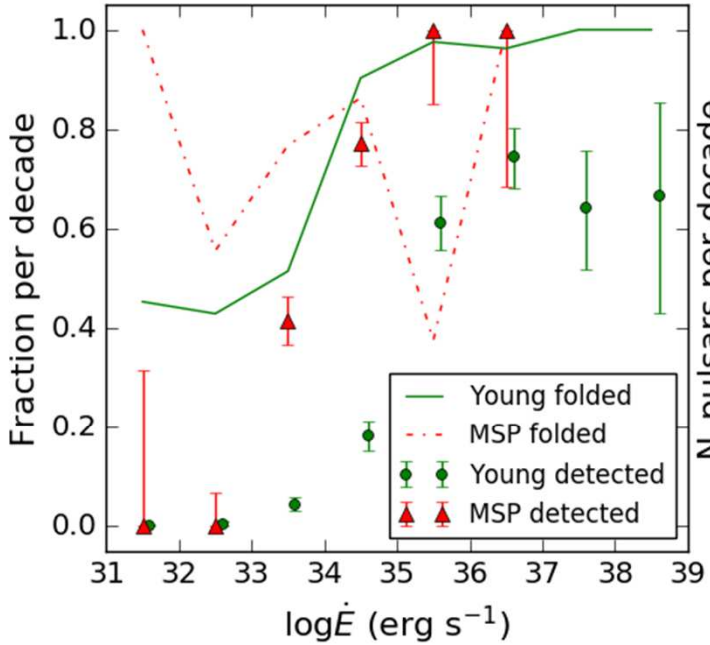


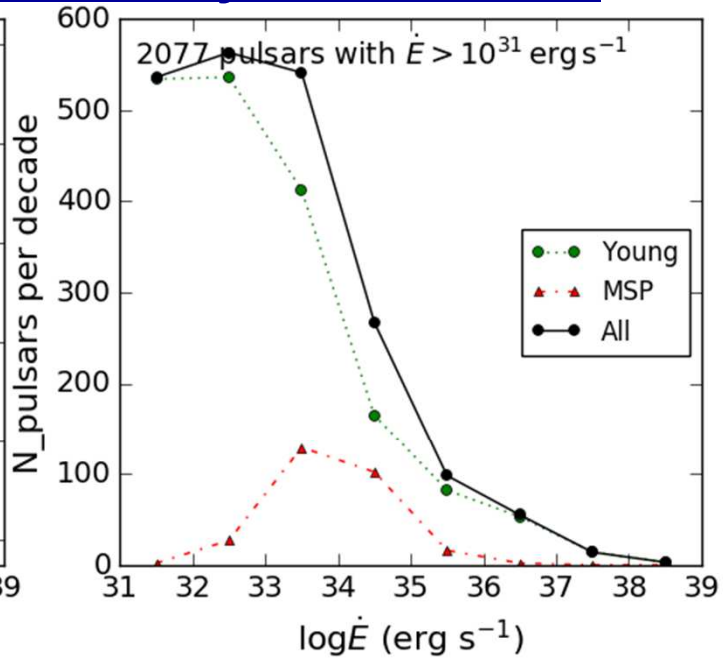
Reminder about the gamma-ray deathline (3 of 4)

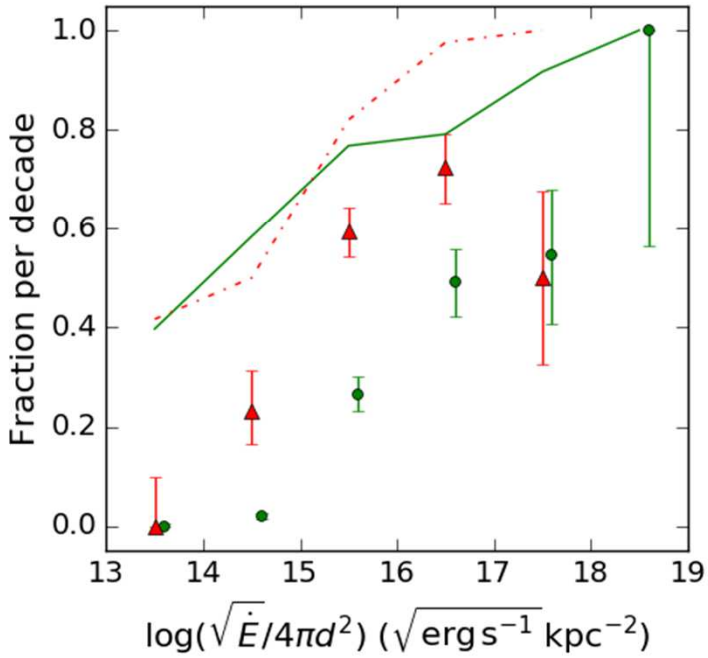


From **Searching a Thousand Radio Pulsars for Gamma-ray Emission**
Smith, Bruel, Cognard et al. 2019, ApJ, 871, 78

Reminder about the gamma-ray deathline (4 of 4)

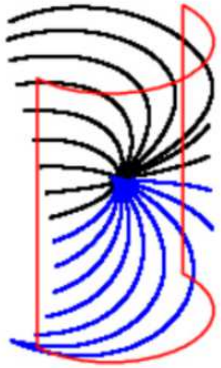




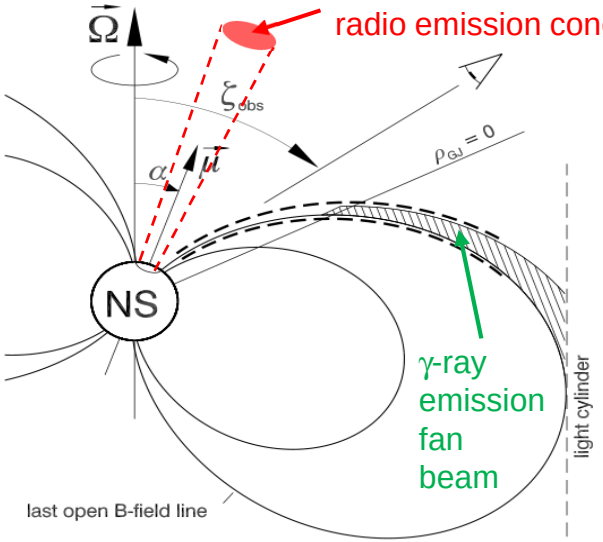


Reminder about radio polarization (1 of 2)

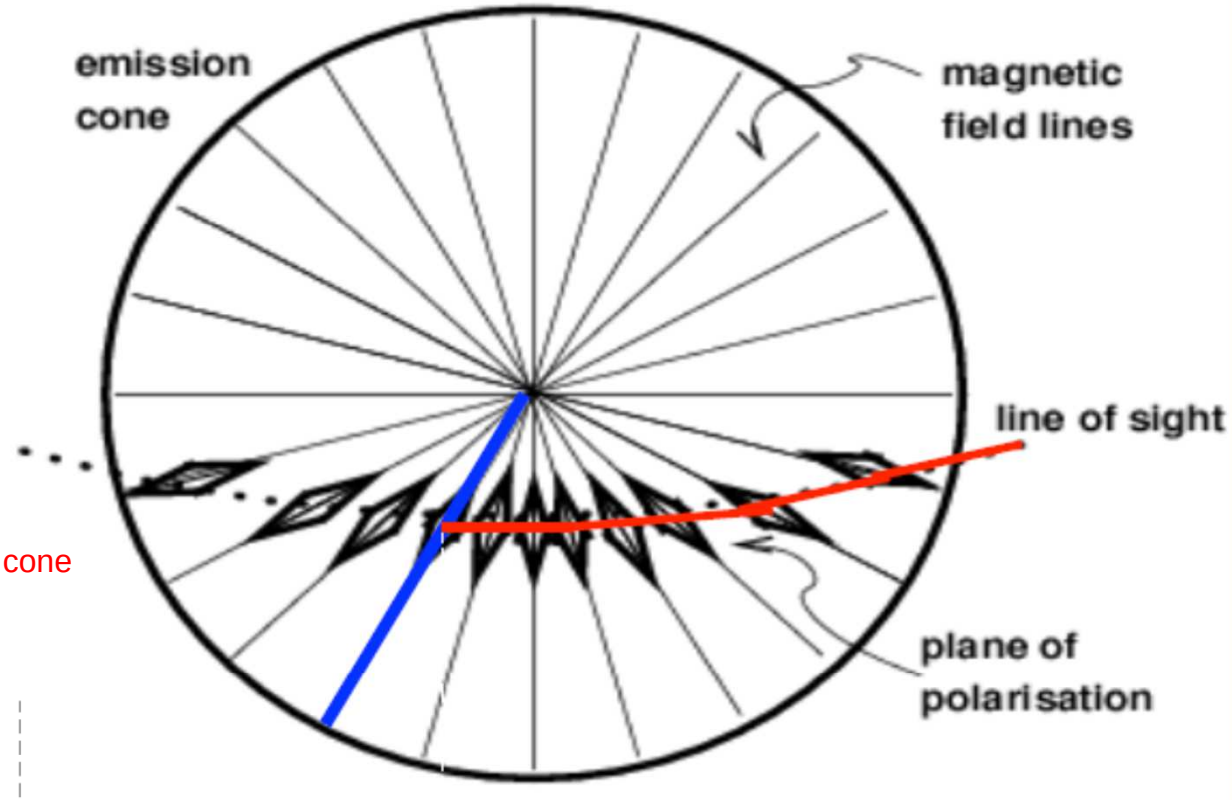
The Rotating Vector Model (RVM) for polarization



Looking into the radio beam is like looking down a 3-D dipole "trumpet horn".



Radhakrishnan & Cooke. 1969



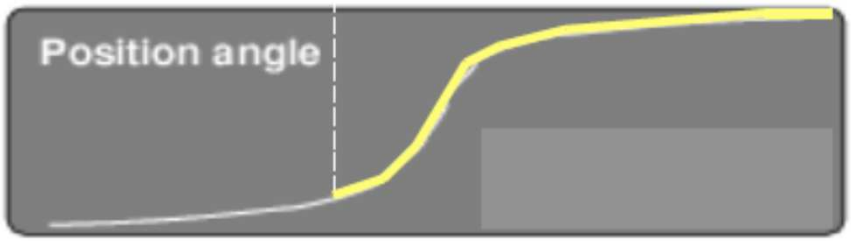
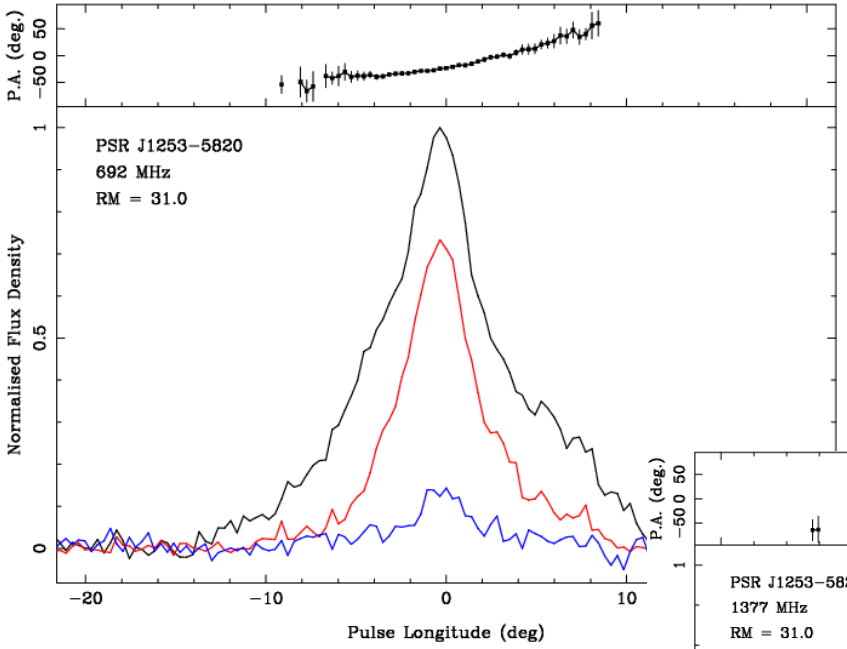


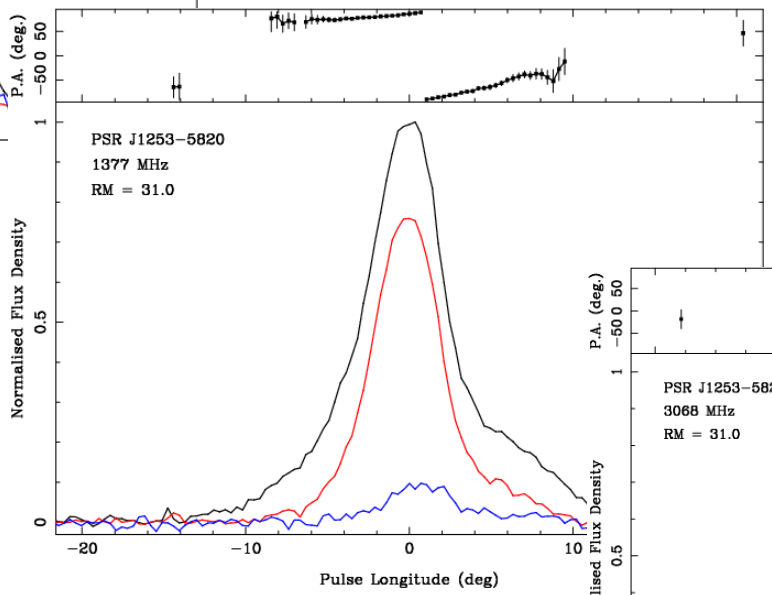
Illustration by A. Karastergiou via S. Johnston

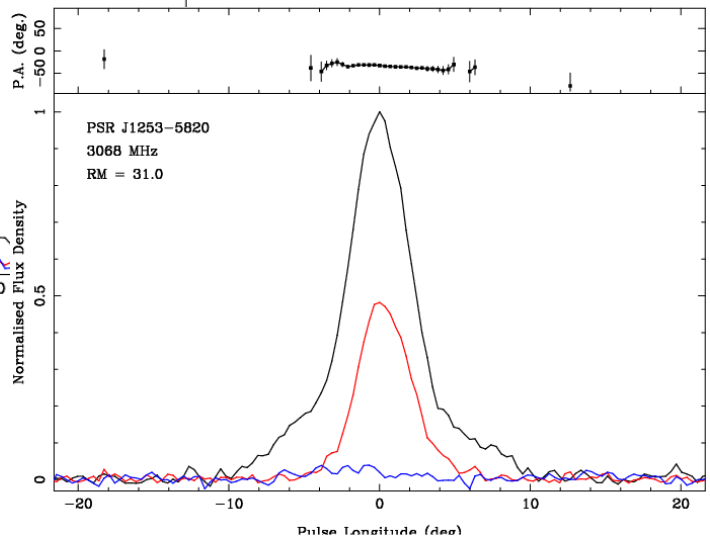
Reminder about radio polarization (2 of 2)

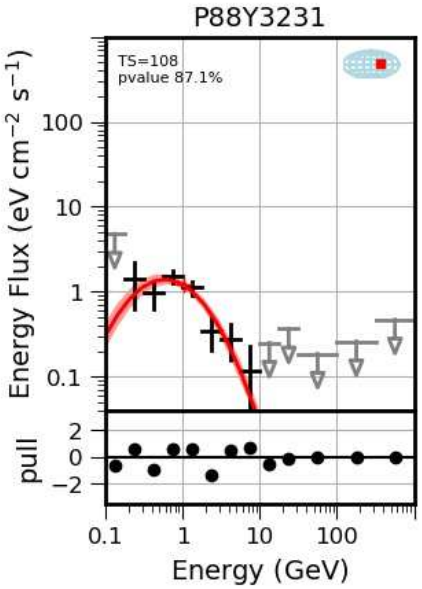
Example: https://confluence.slac.stanford.edu/display/SCIGRPS/PSUE+J1253-5820

Ė= 5e33 erg/s P0 = 255 ms Not 4σ γ pulsations yet… Assc. w. 4FGL J1253.3-5816









A radio polarization Deathline

Mon. Not. R. Astron. Soc. **391,** 1210–1226 (2008) doi:10.11

Profile and polarization characteristics of energetic pulsars

Patrick Weltevrede★ and Simon Johnston
Australia Telescope National Facility, CSIRO, PO Box 76 Epping, NSW 1710, Australia

Occurs around $\dot{E}$ ~ 1.E34 erg/s, as for gamma emission.

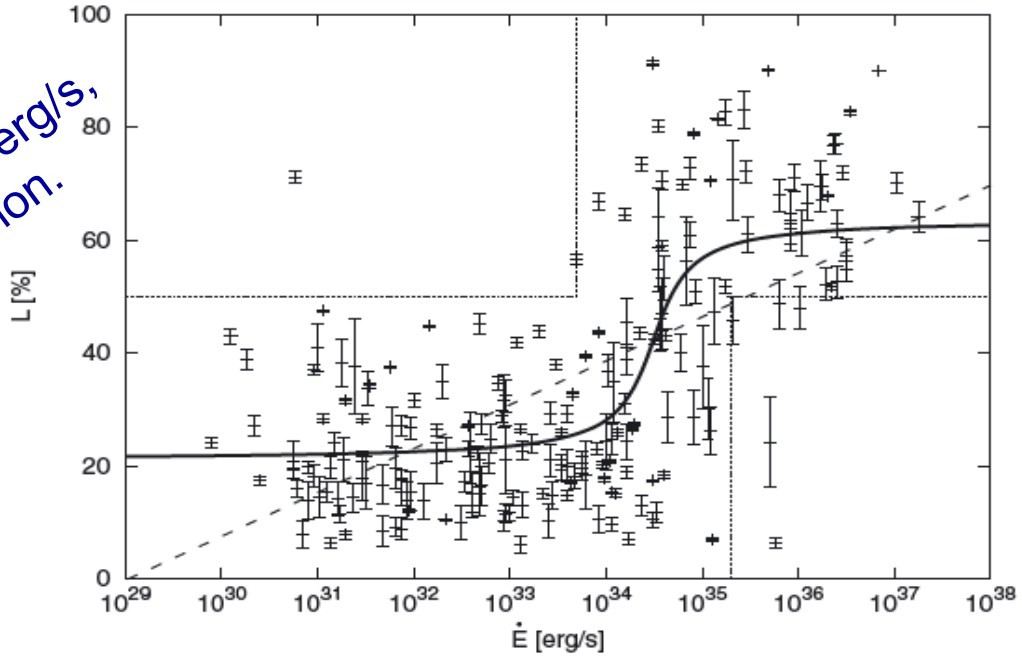
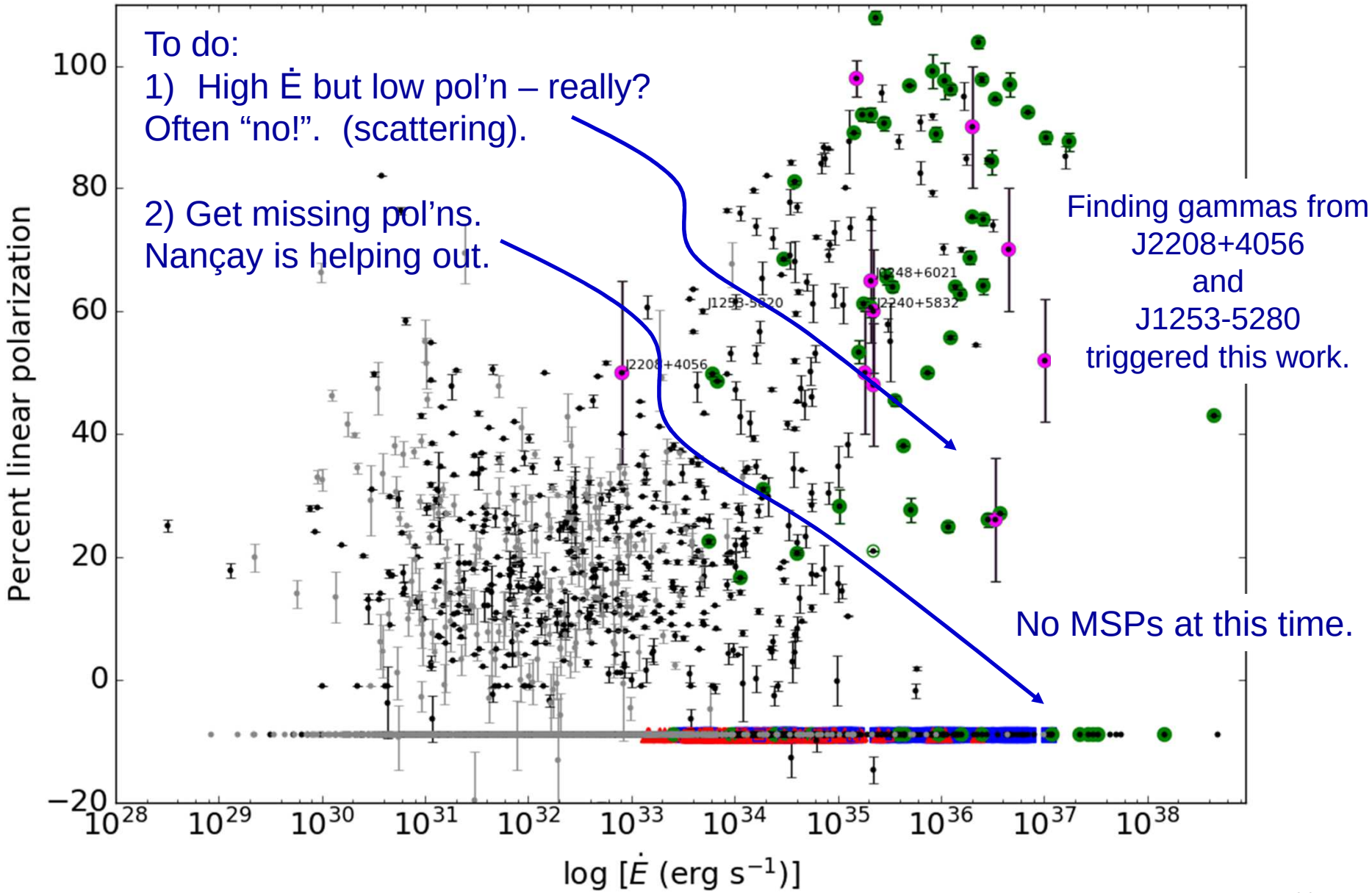


Figure 8. The degree of linear polarization versus $\dot{E}$ of all pulsars observed at 20 cm for which a significant degree of linear polarization was measured. Pulsars which show evidence for scatter broadening were excluded. There are two relatively well-defined regions which are almost empty in this 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.

The Weltevrede & Johnston plot, with gamma rays (work in progress).

600 polarizations from Johnston & Kerr (2018), 300 from Gould & Lyne (1998).



Radio scattering in the ISM* blurs pol'n,

but there's less at higher frequencies.

Example: Theureau et al (2011).

** Interstellar Medium*

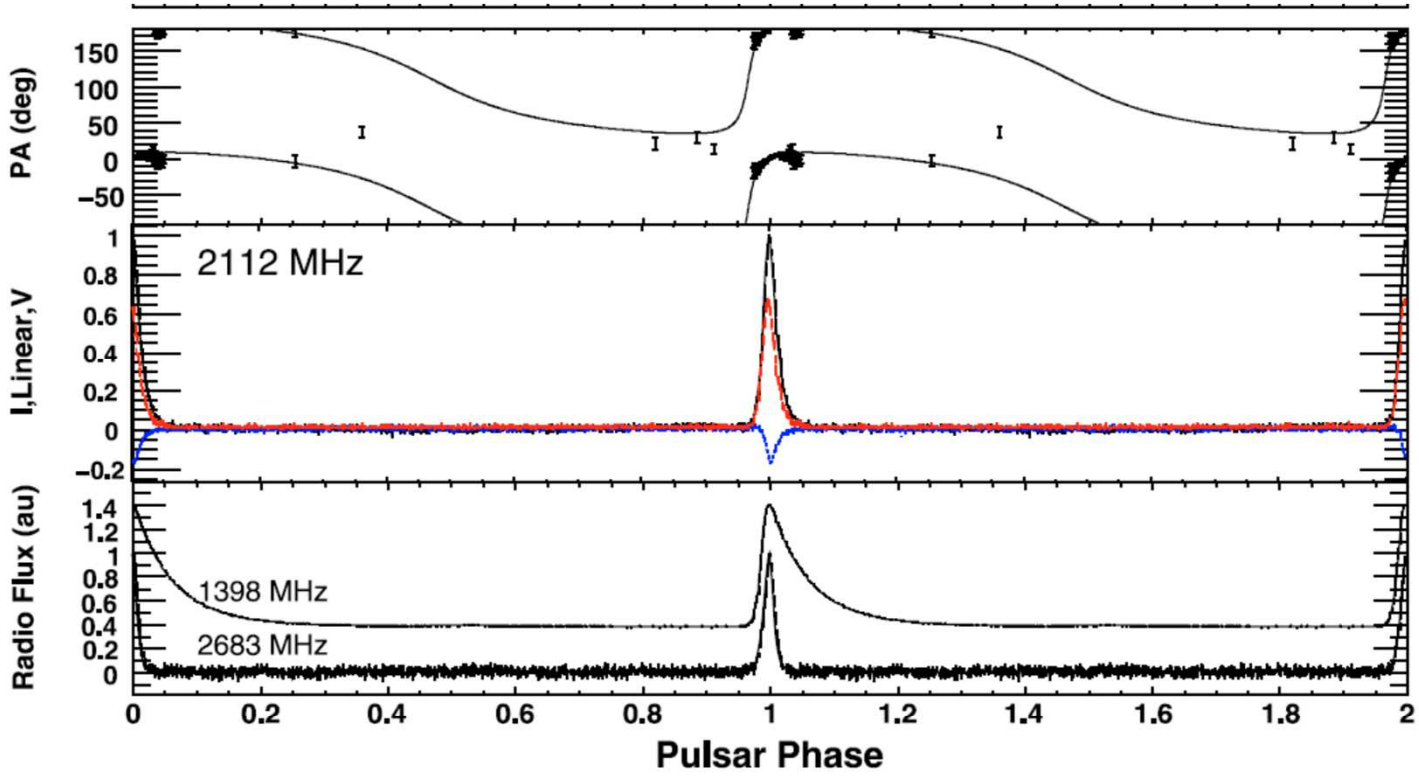
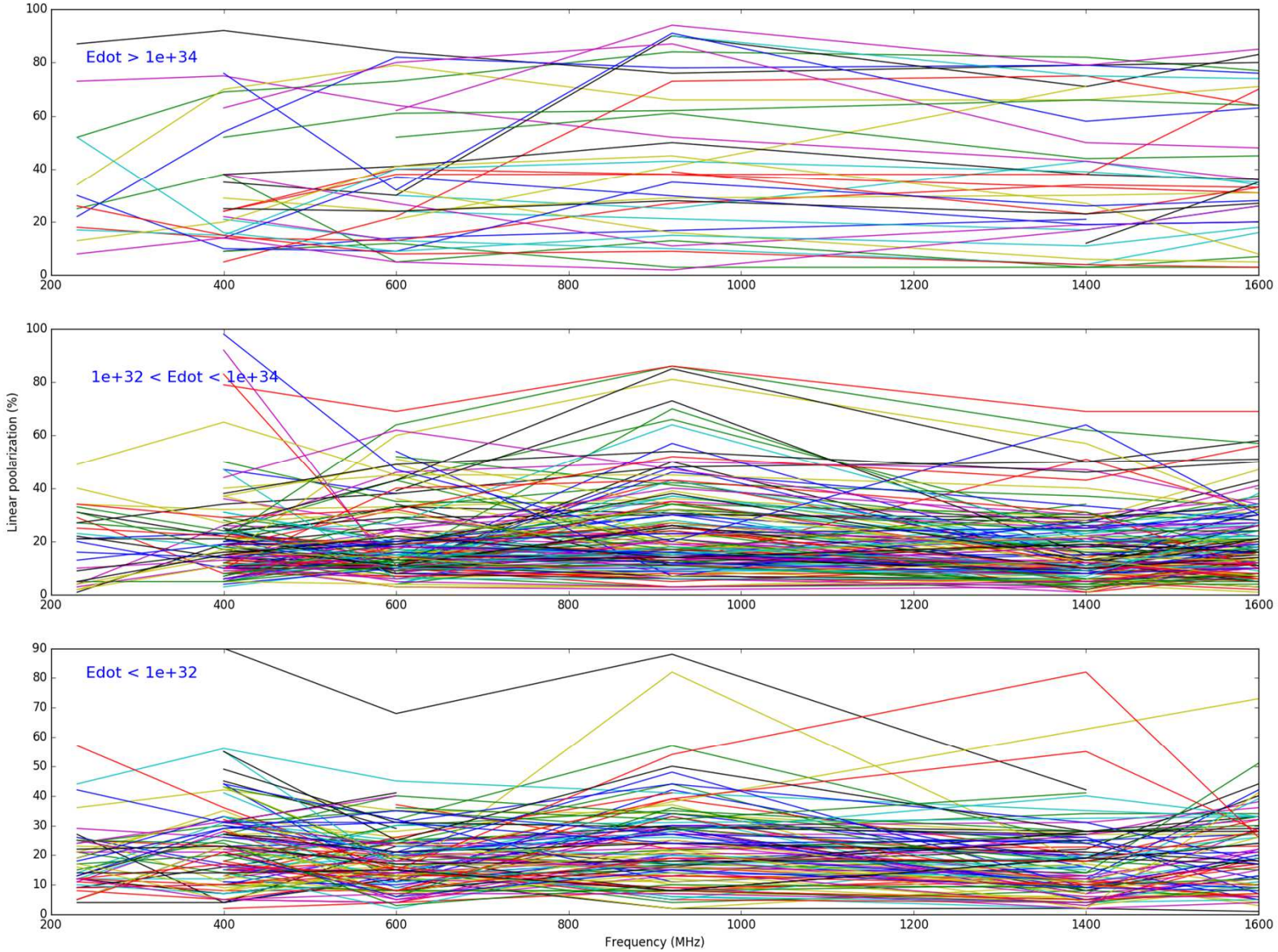


Fig. 1. Phase-aligned γ-ray and radio light curves for PSR J0248+6021 obtained with the *Fermi* Large Area Telescope and the Nançay Radio Telescope. *The bottom panels* show the radio profiles at three frequencies used to build the ephemeris. The second panel from the bottom

Can you mix frequencies? Apples w apples?

Seems that "yes: weak pol'n dependence". 300 pulsars, Gould & Lyne (1998).

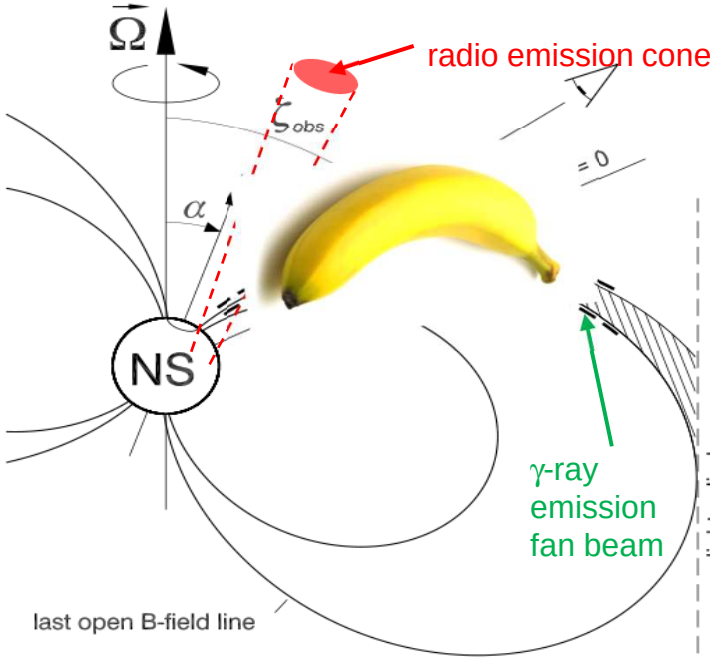


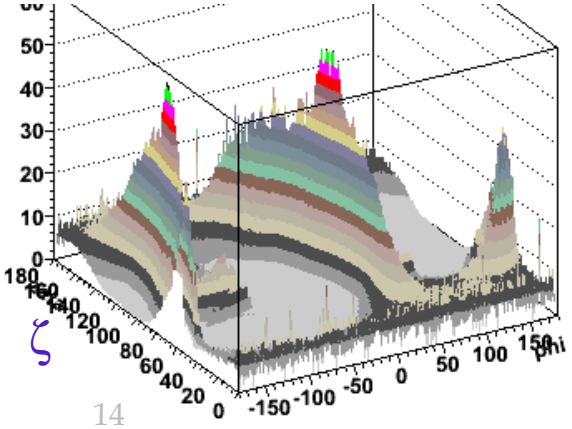
Puzzle:

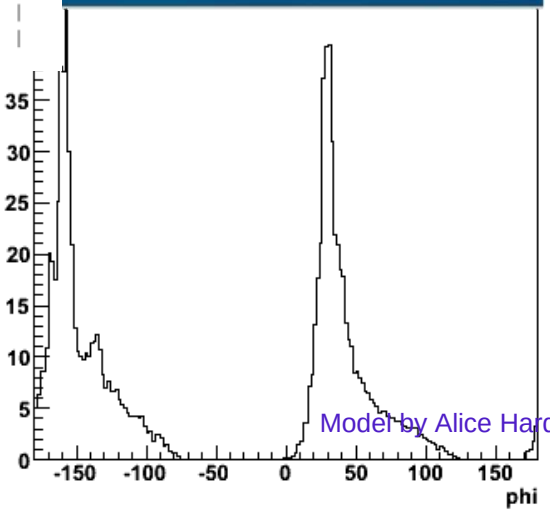
Radio from electrons near polar caps.

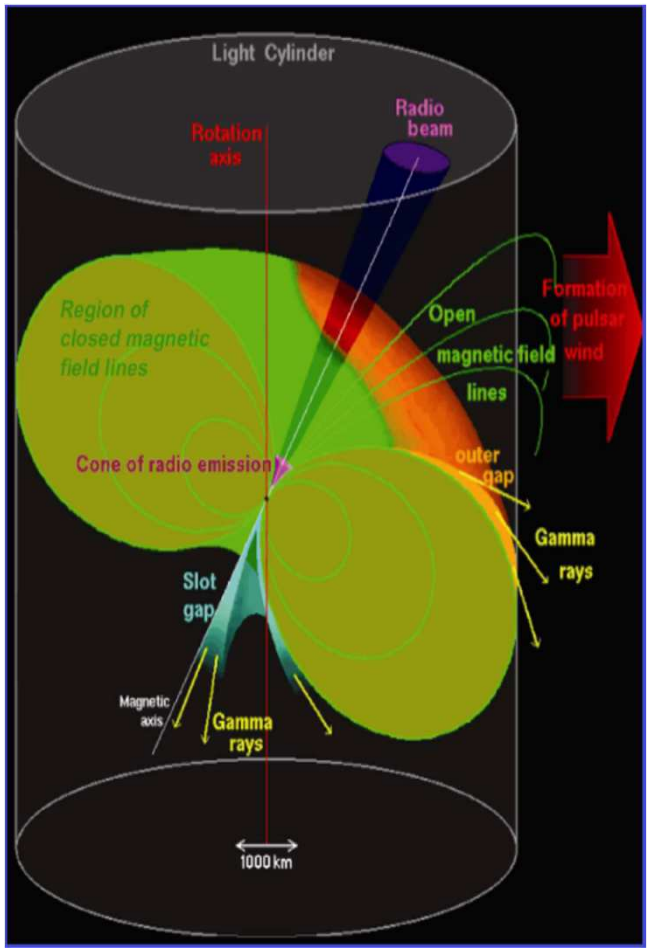
Gammas from electrons far away.

Why would separate populations jointly stop emission?









LOBs = Luminous Orbiting Bananas

Model by Alice Harding

Work-in-progress:

1. Improve the Pol'n vs Ė plot: obtain missing gamma pulsars, investigate outliers.

   See how strong the correlation (coincidence) is or isn't.

2. Study the sample, e.g. for "obvious" geometry info:
   - Interpulse pulsars
   - When α, ζ are available
   - Rookyard, Weltevrede, Johnston et al, 2015 to 2017:
     Study of e.g. radio pulse width vs gamma yes/no.
   - Remove the X-ray loud, radio faint pulsars.

3. Towards a physical model: if pol'n and gammas both shut down below the same Ė, does it mean
   - Same population of emitting electrons?
   - Different populations, similar Ė-related mechanism?
   - Else?

   Hope to provide model constraints.