Observational signatures of pulsars in gamma-rays

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Future Space-based Gamma-ray Observatories
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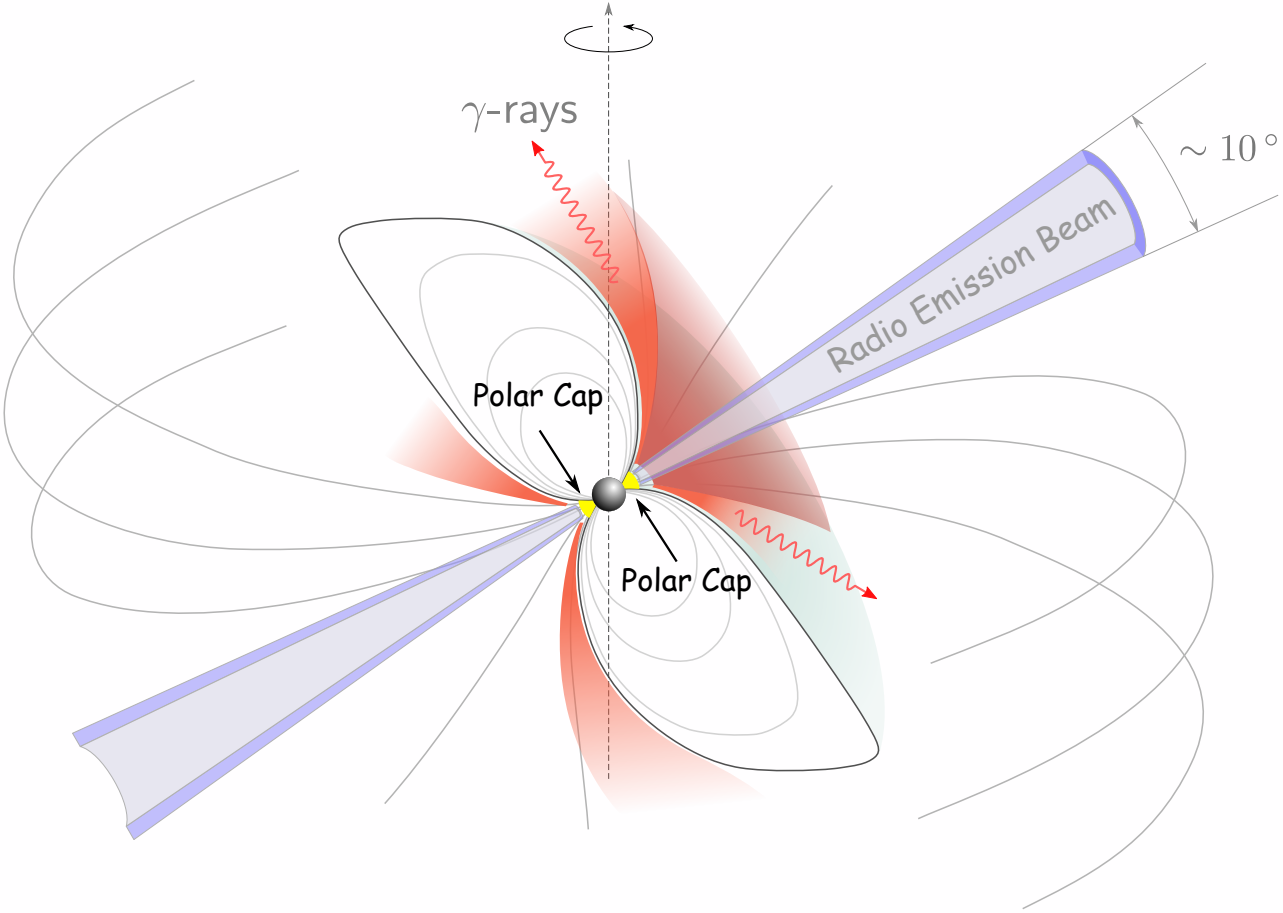
NSs are **the** most extreme objects in the Universe

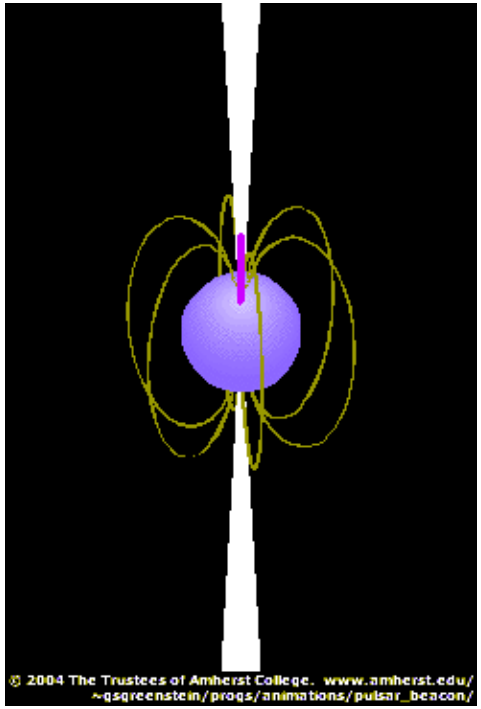
- Size: 10 km $\simeq 3r_g$ — only $\sim$ 3 times larger than a BH!
- Mean Density: $\sim 10^{15}$ g/cm^3 — Gigantic "atomic nucleus"!
- Magnetic field: $\sim 10^{12}$ G (up to -10^{15} G)
  "Density" $[(B^2/8\pi)/c^2]$: $\gtrsim 40$ g/cm^3! (cf. Pt:19.82 g/cm^3)
- Voltage: $\sim 10^{16}$ V

- Linear accelerators — Pevatrons
- Plasma guns — Create dense $e^{\pm}$ plasma
- Extremely stable clocks — $\delta P/P$ up to $\sim 10^{-15}$

Rapidly rotating strong magnet surrounded by self-produced plasma

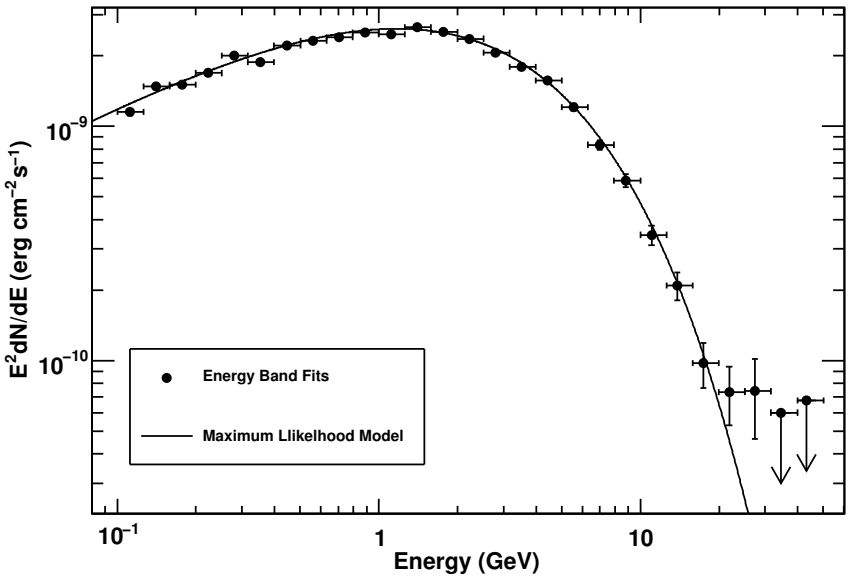
"Electric lighthouse"

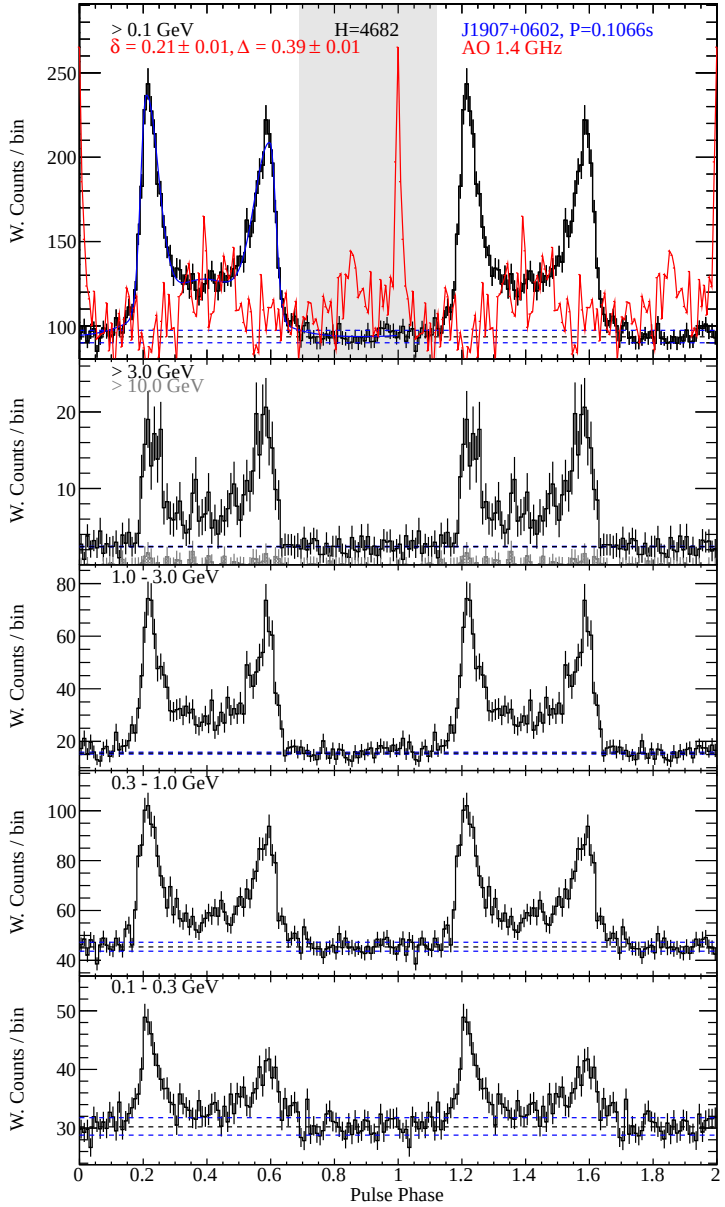




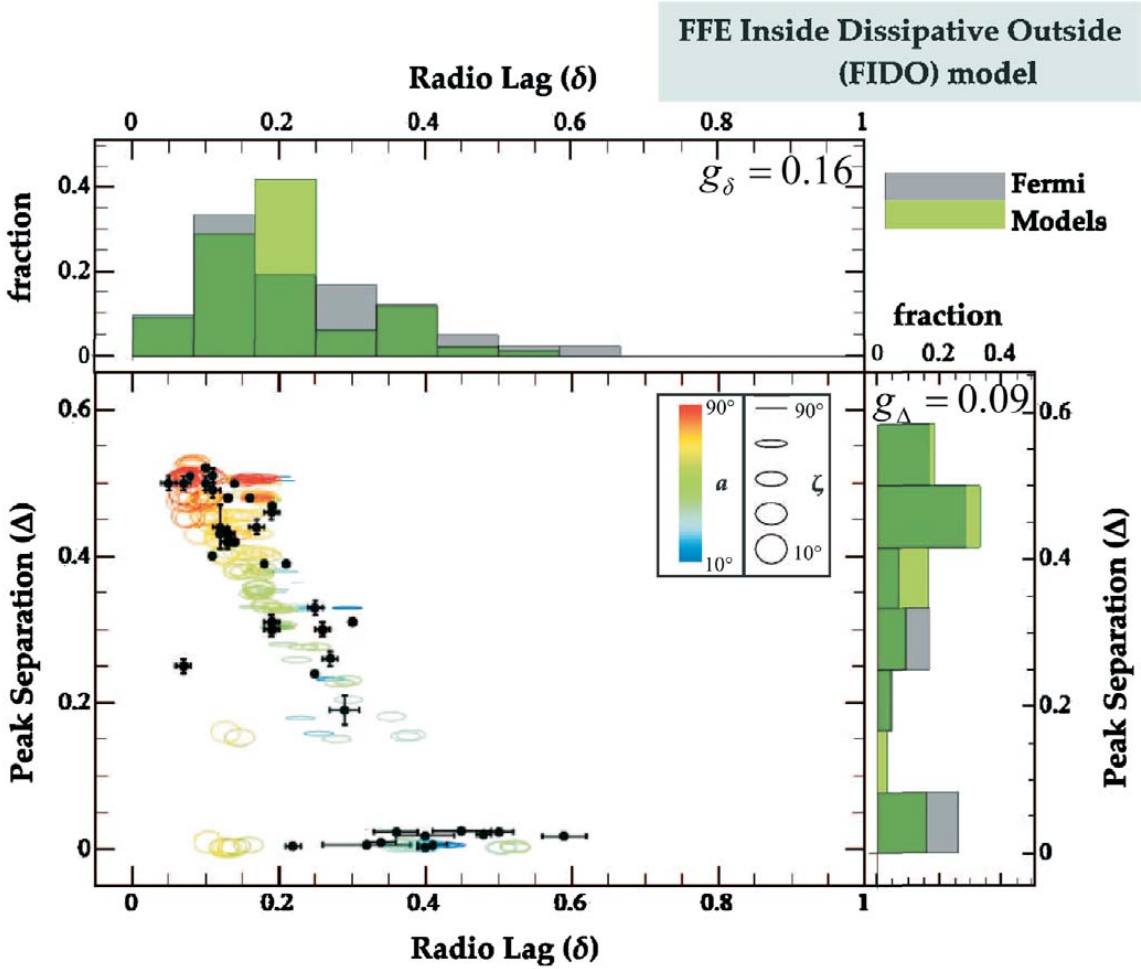
Pulsars seen by Fermi

Emission from the outer magnetosphere





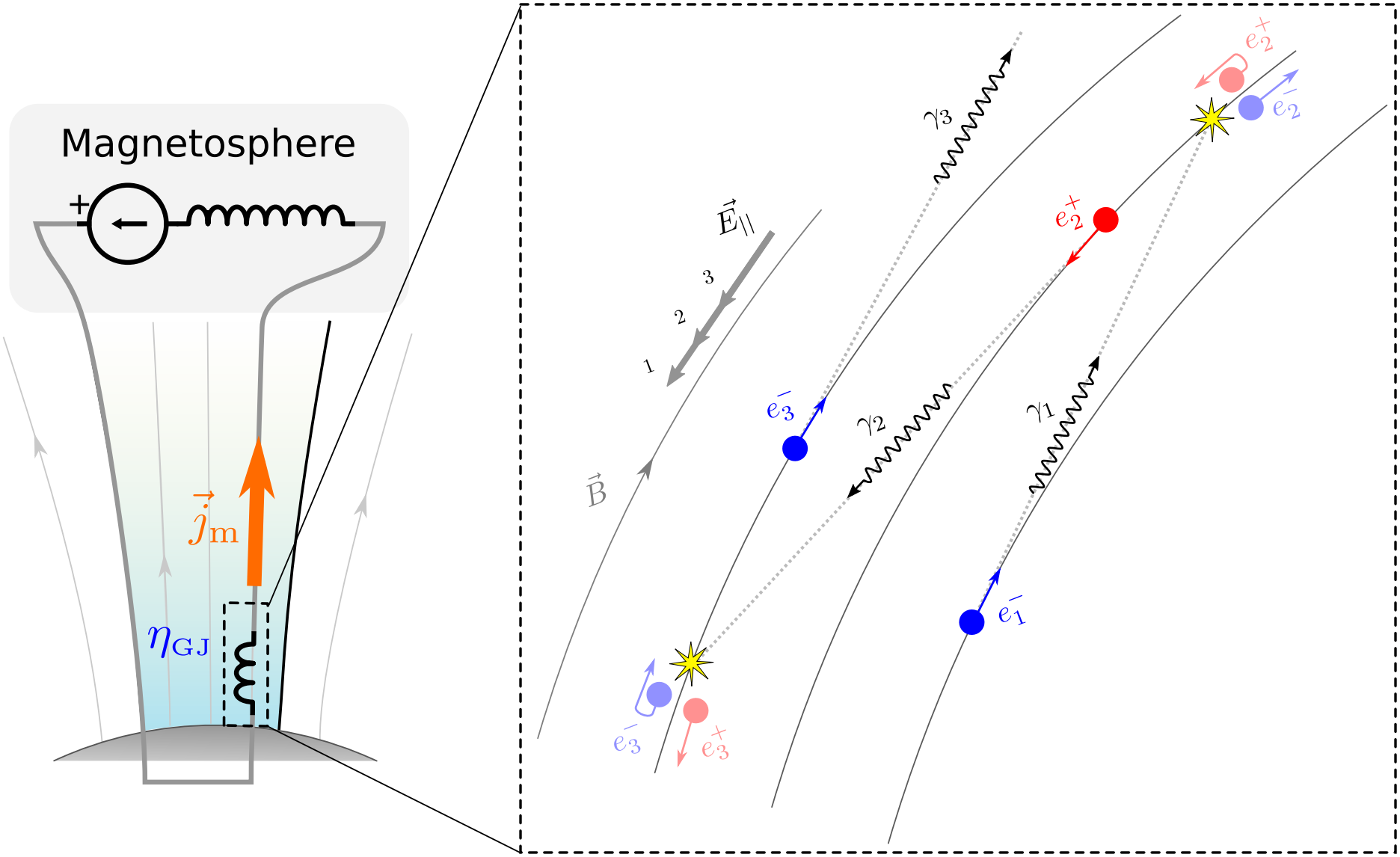
Peak Separation(Δ) vs Radio Lag (δ): good agreement with Fermi data



(Kalapotharakos et al. 2014)

Plasma creation in the polar cap

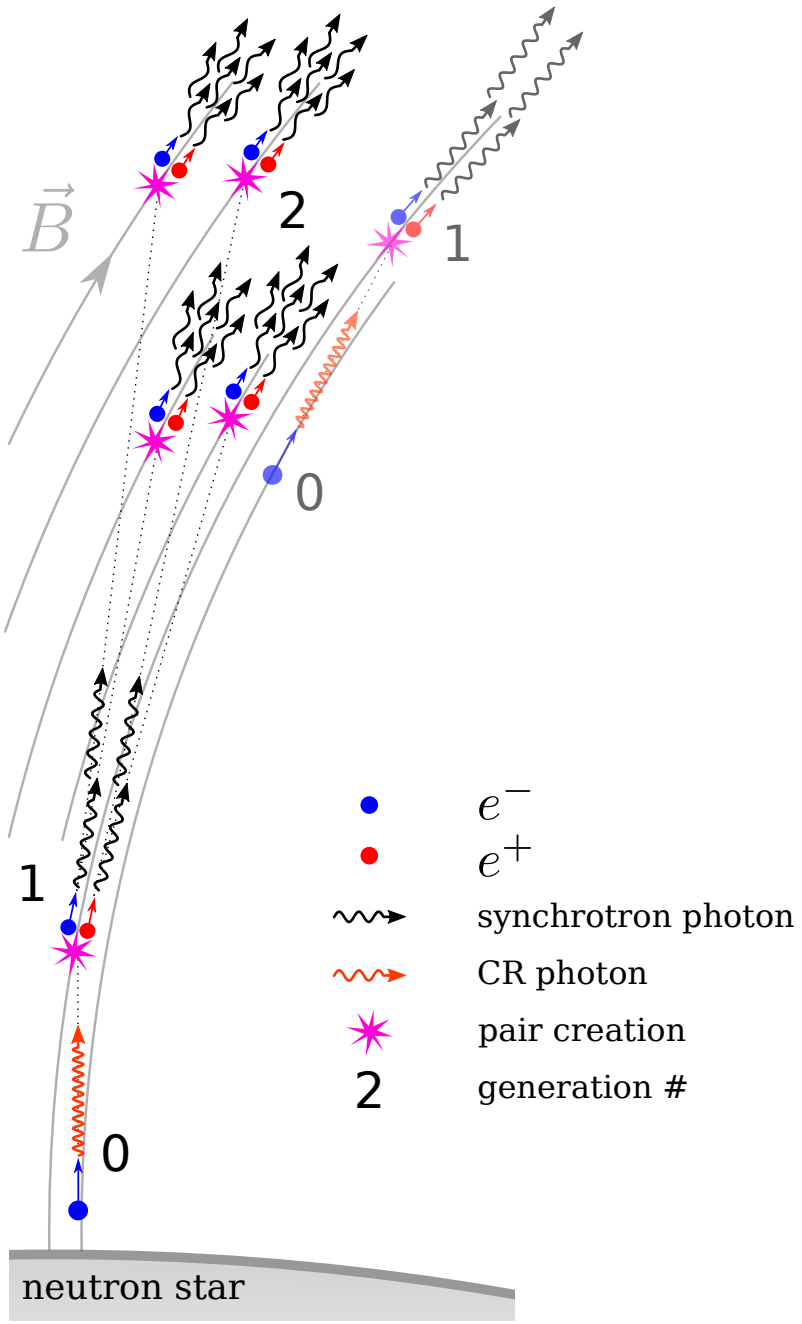
Cascades are electromagnetically driven



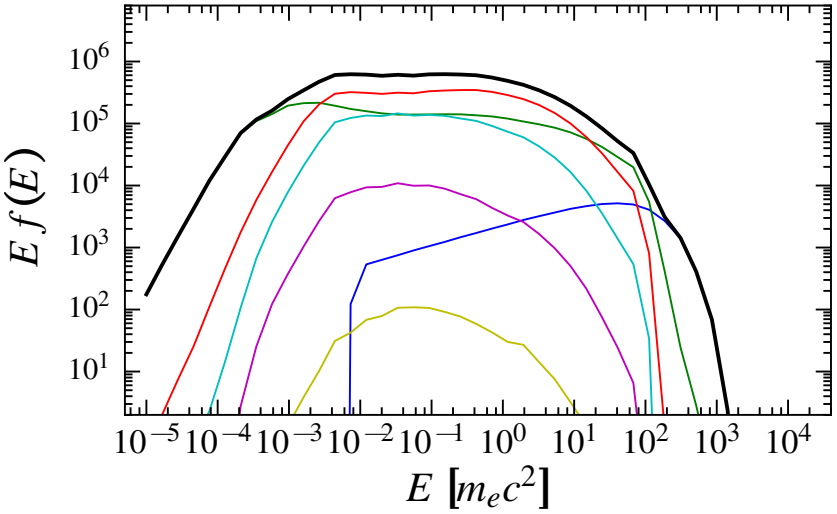
Full cascade

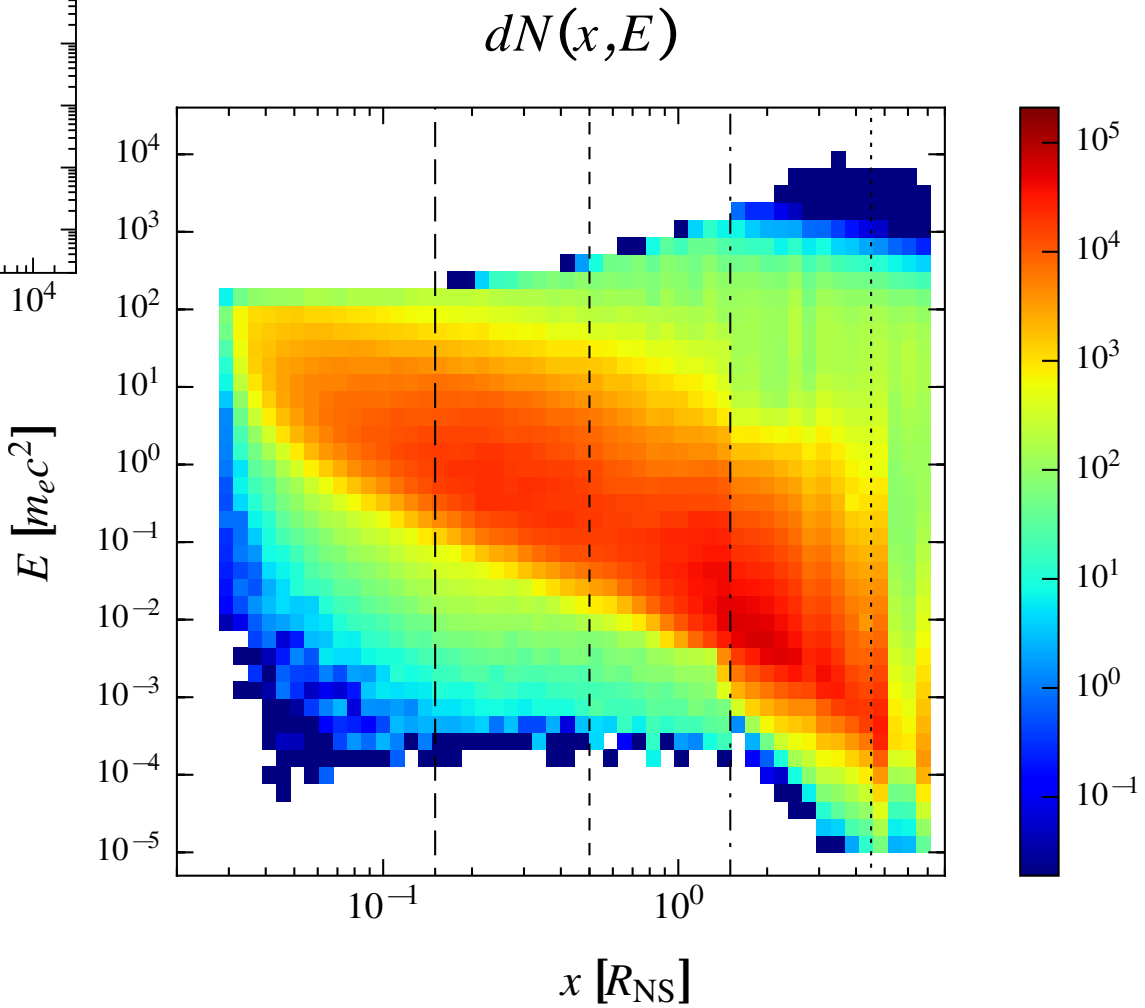
Synctrotron cascade

Curvature Radiation

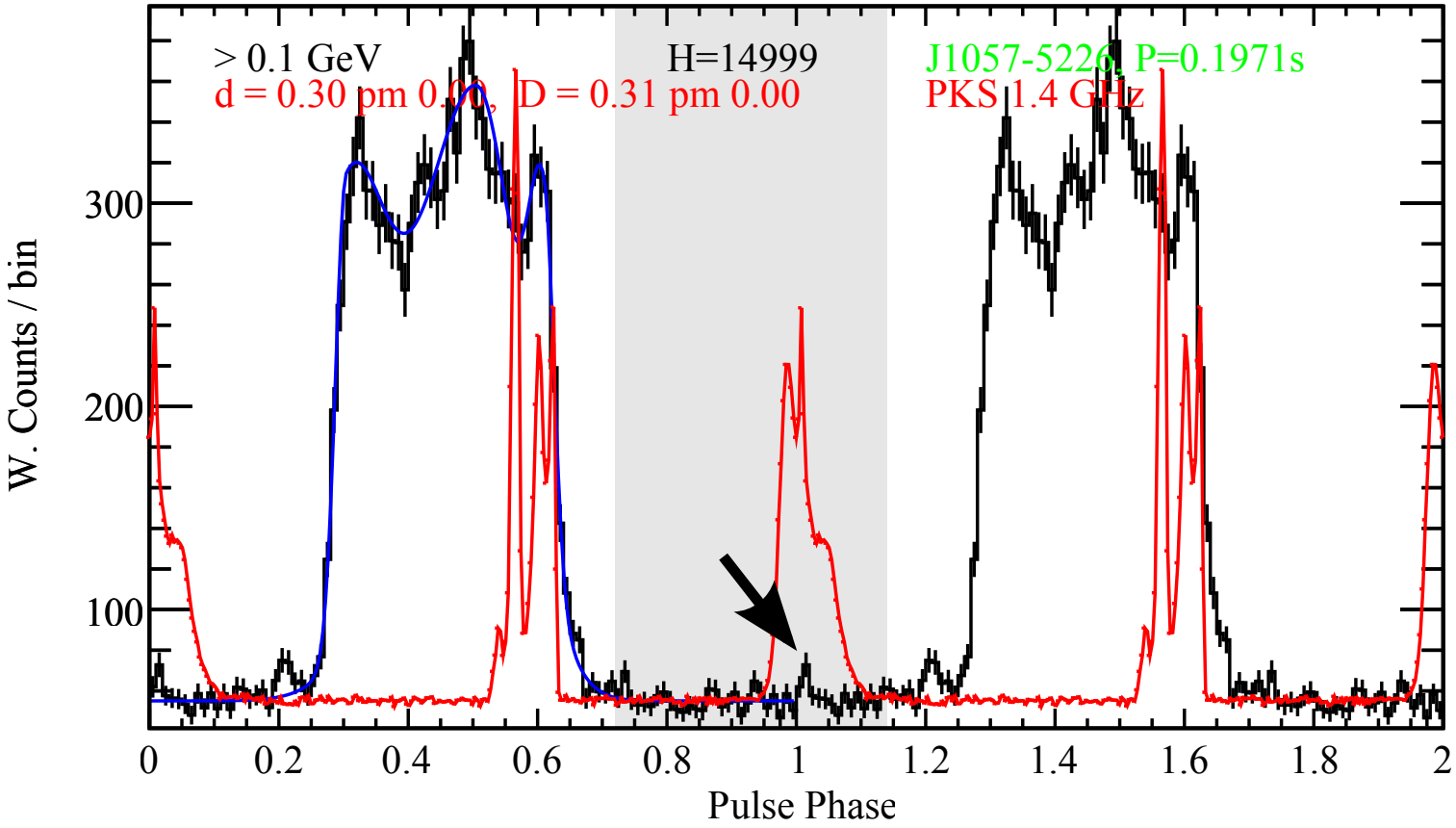


γ-rays from polar cap cascades

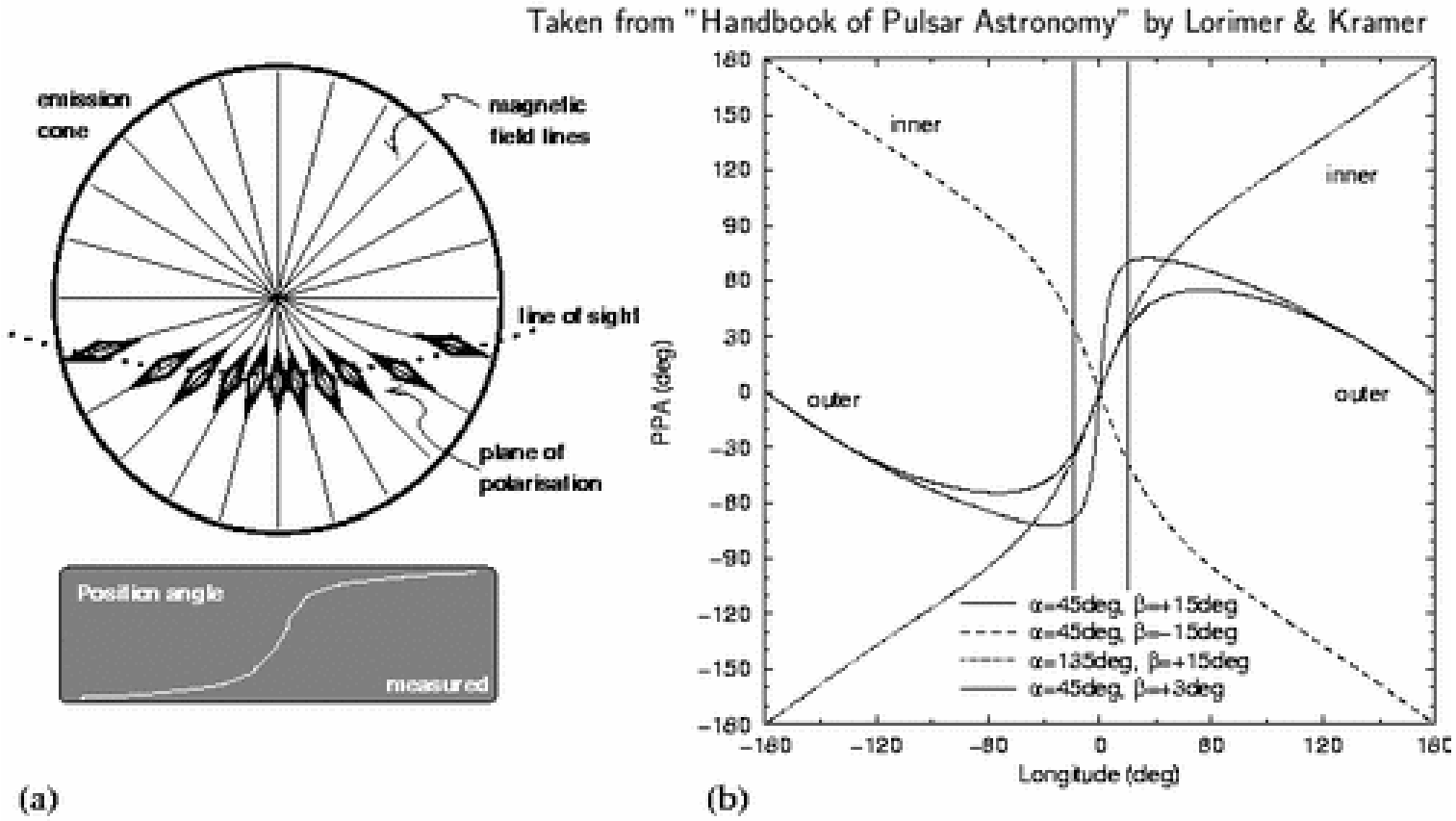




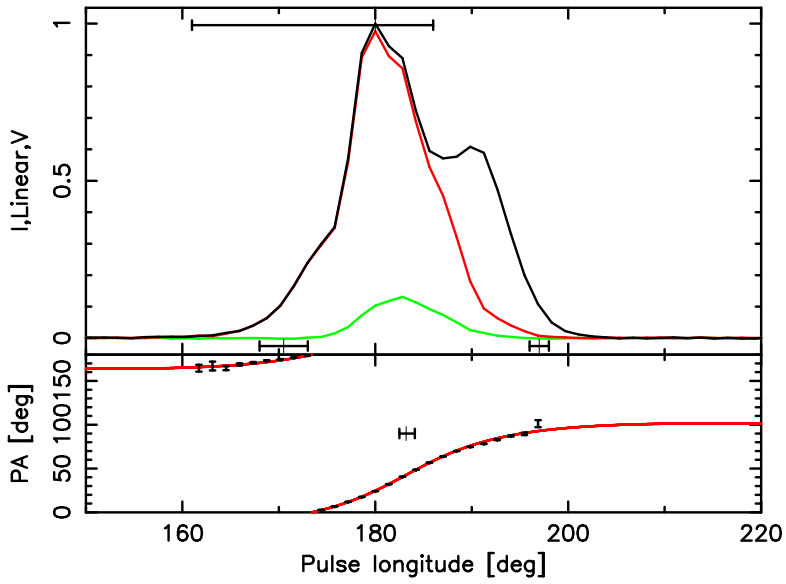
PSR J1057-5226: Polar cap emission?

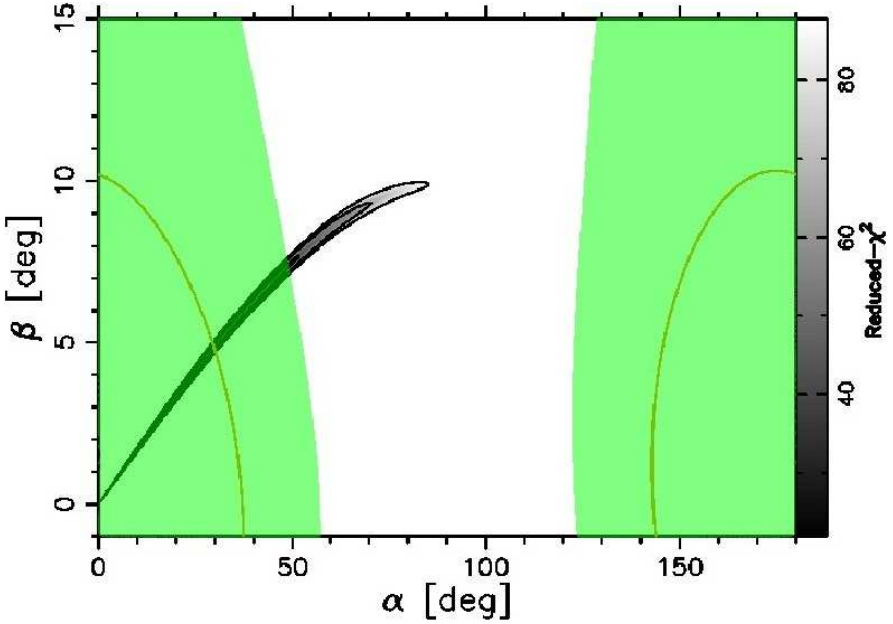


Inferring geometry through linear polarization: Rotating Vector Model (RVM)



Inferring geometry through linear polarization: PSR J1048-5832 in Radio





(Rookyard, Weltevrede, Johnston 2015)

Why do we need an MeV telescope/polarimeter?

- Why should we go to MeV range?
  Want to see the cut-off due to pair production!
  γ-ray emission from polar caps should be at $\sim 10 - 100$ MeV
- Why do we need polarization?
  Polarization is the ultimate mapping tool
  - polar caps
  - outer magnetosphere
- There might be surprises (?)