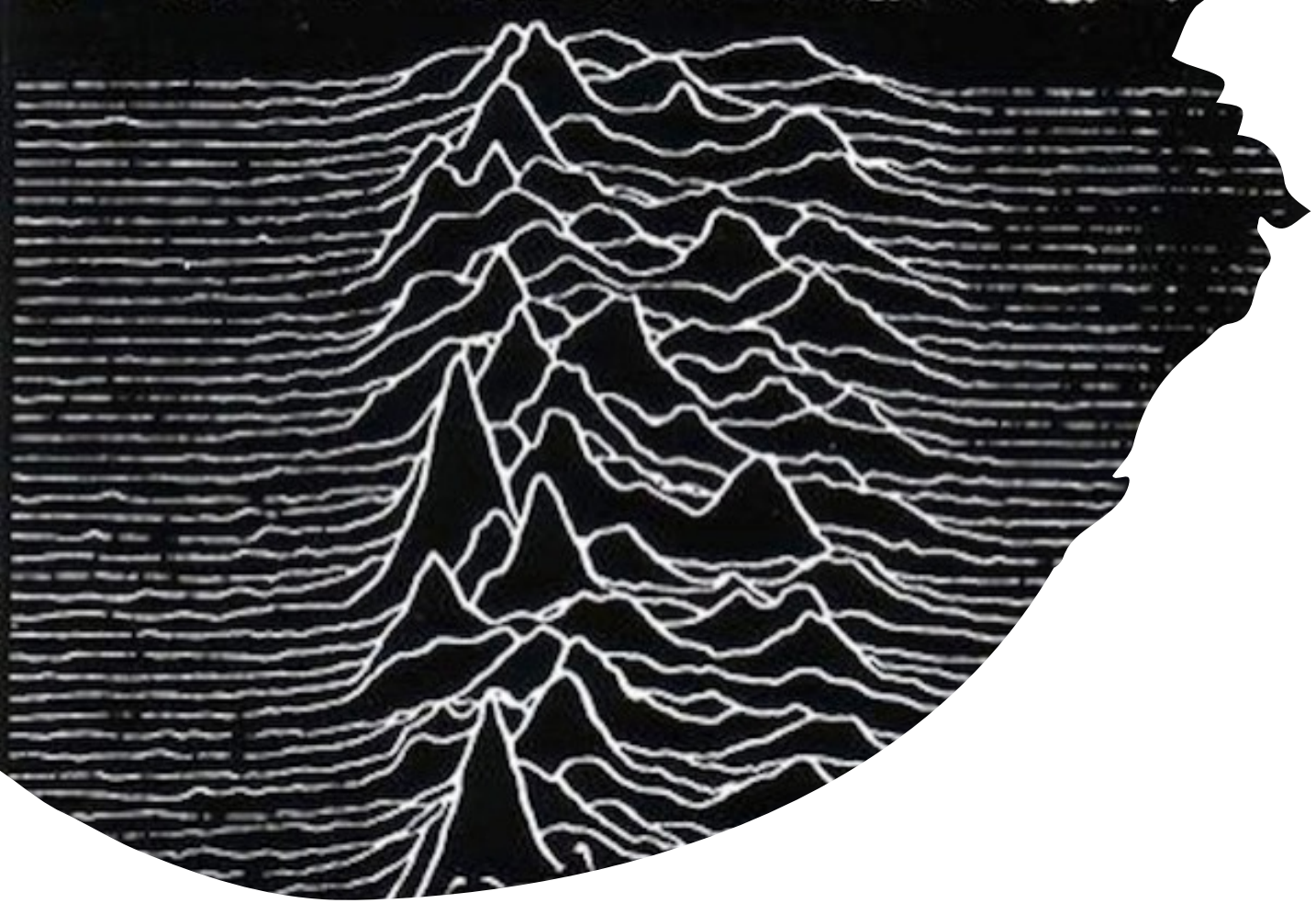


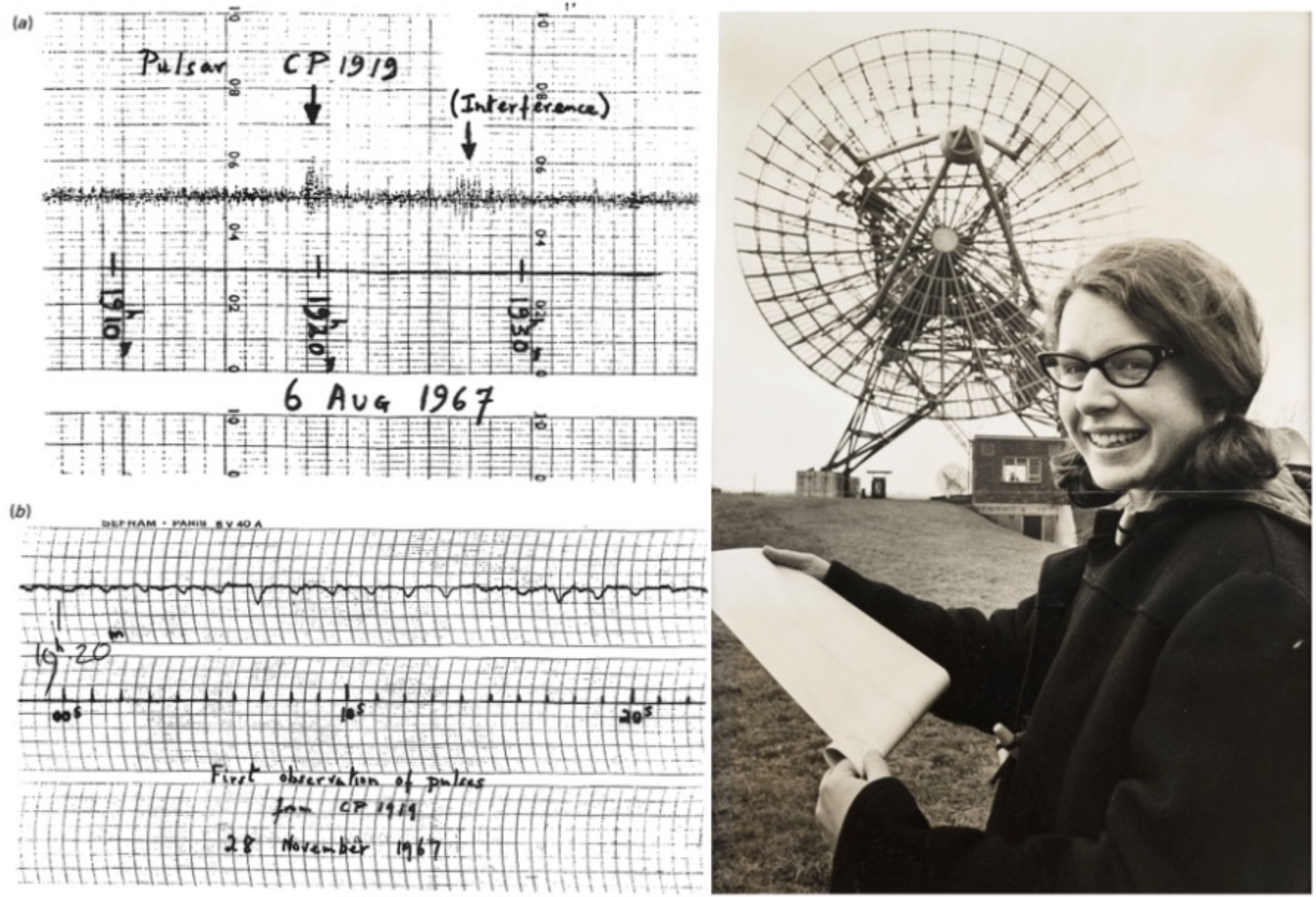
CTA-Oz meeting
22 November 2021

Pulsar TeV emission and CTA

Shi Dai
ARC DECRA Fellow
Western Sydney University

WESTERN SYDNEY UNIVERSITY

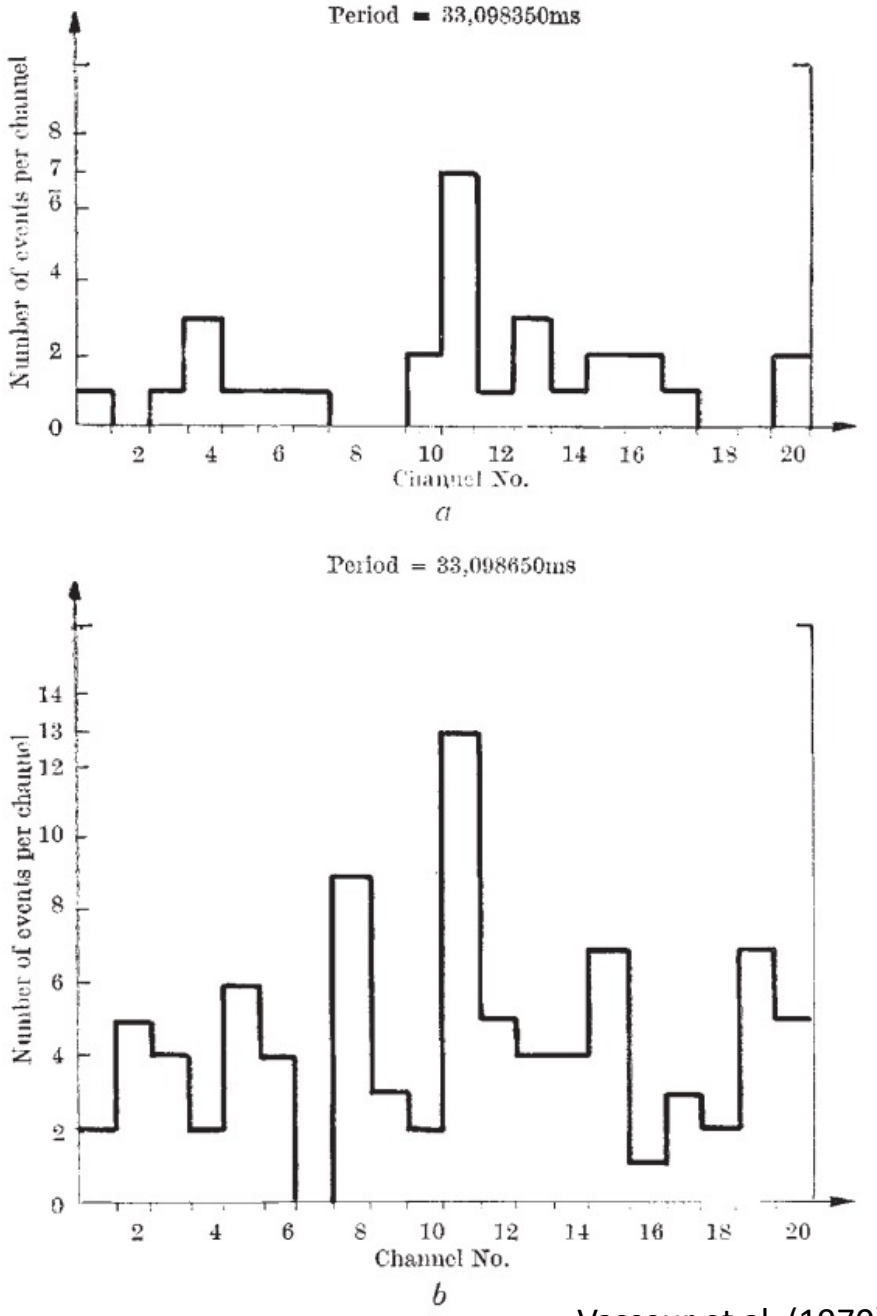
cta cherenkov telescope array



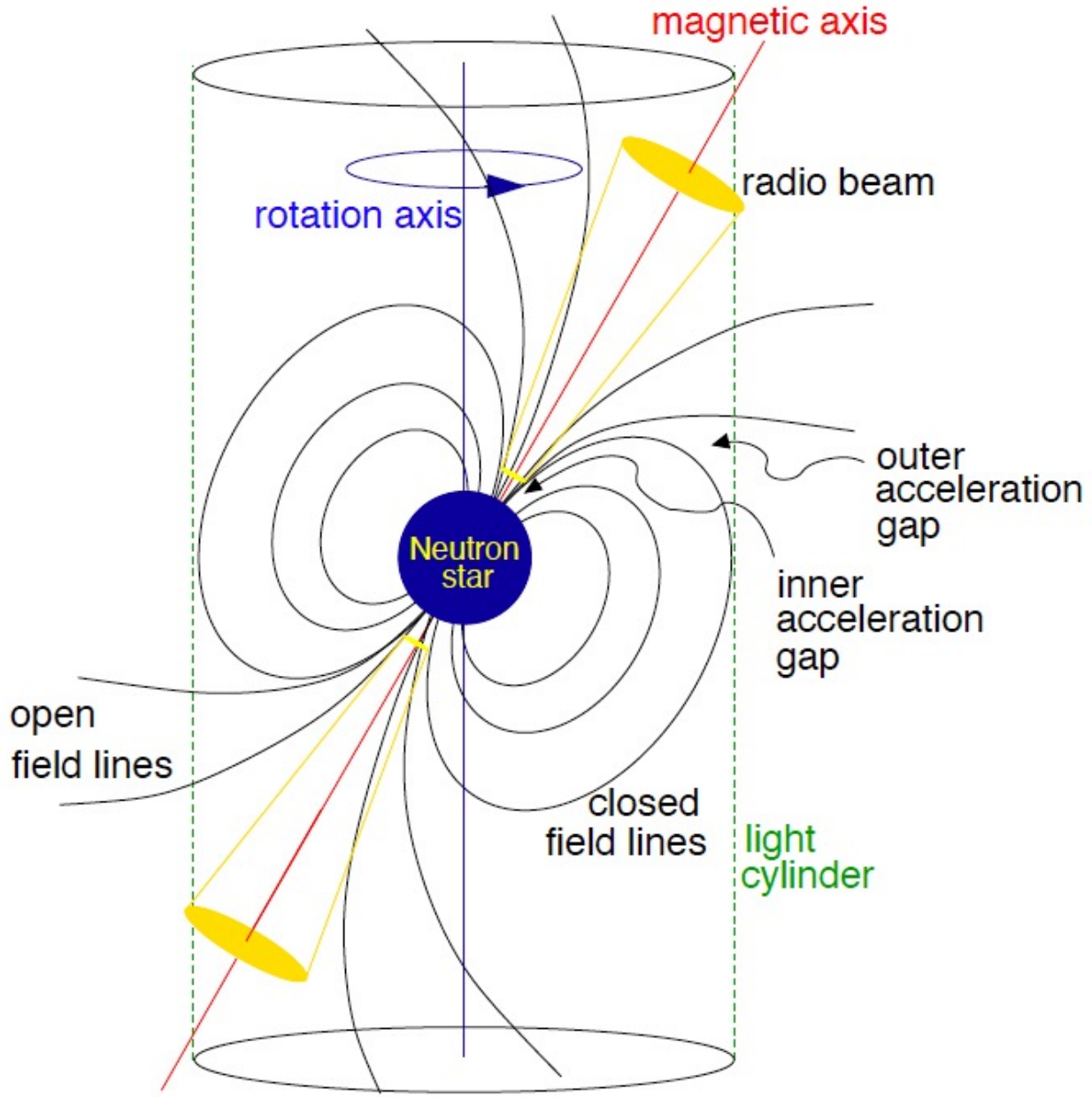
Credit: UK National Science & Media Museum

- Crab and Vela are two of the brightest Gamma-ray sources.
- Pacini (1967) first proposed that a rapidly rotating neutron star (*in a vacuum*) with a strong magnetic field emits dipole radiation.

(Pacini, 1967, Nature, 216, 567)



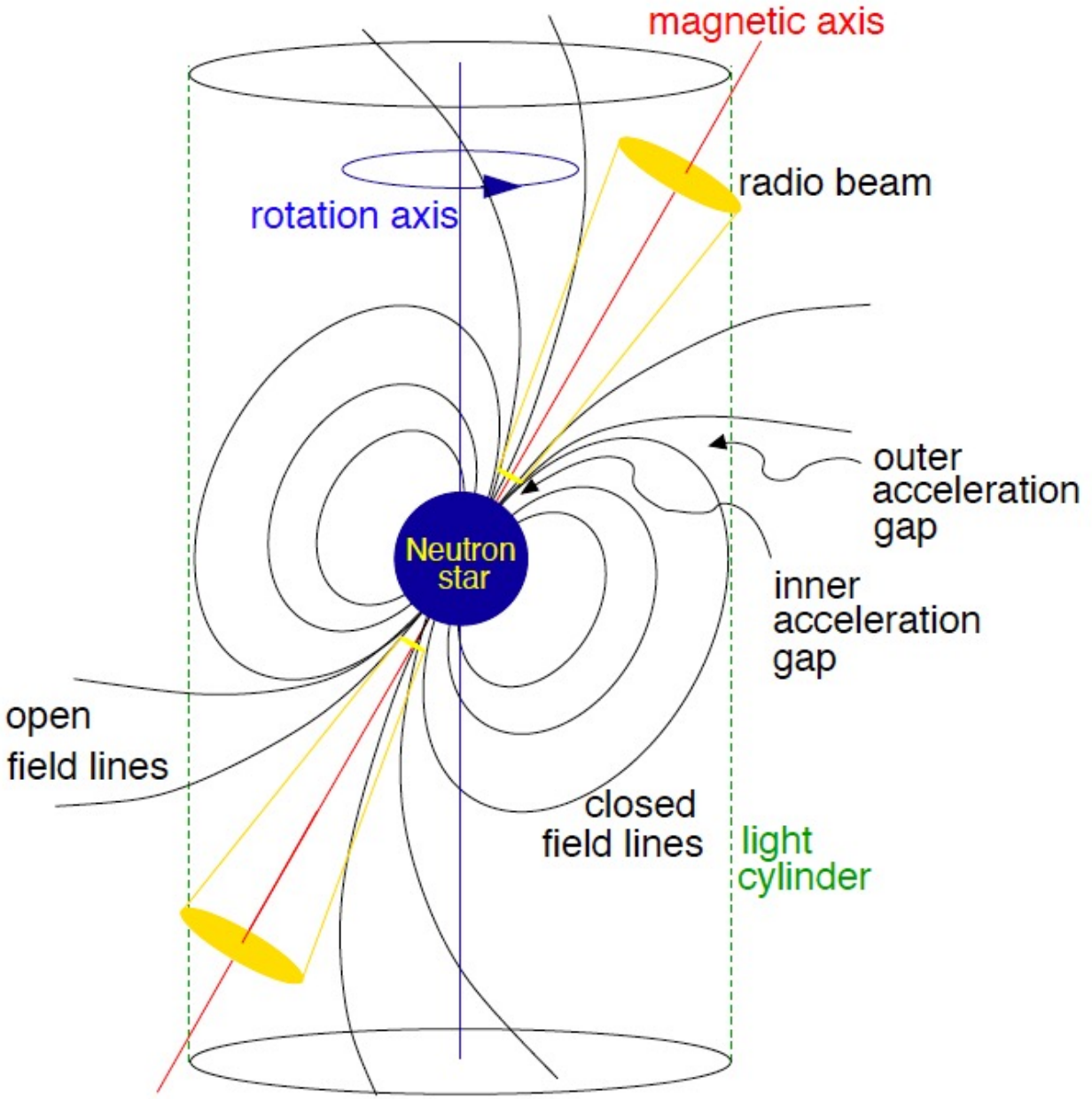
Vasseur et al. (1970)



Lorimer & Kramer (2005)

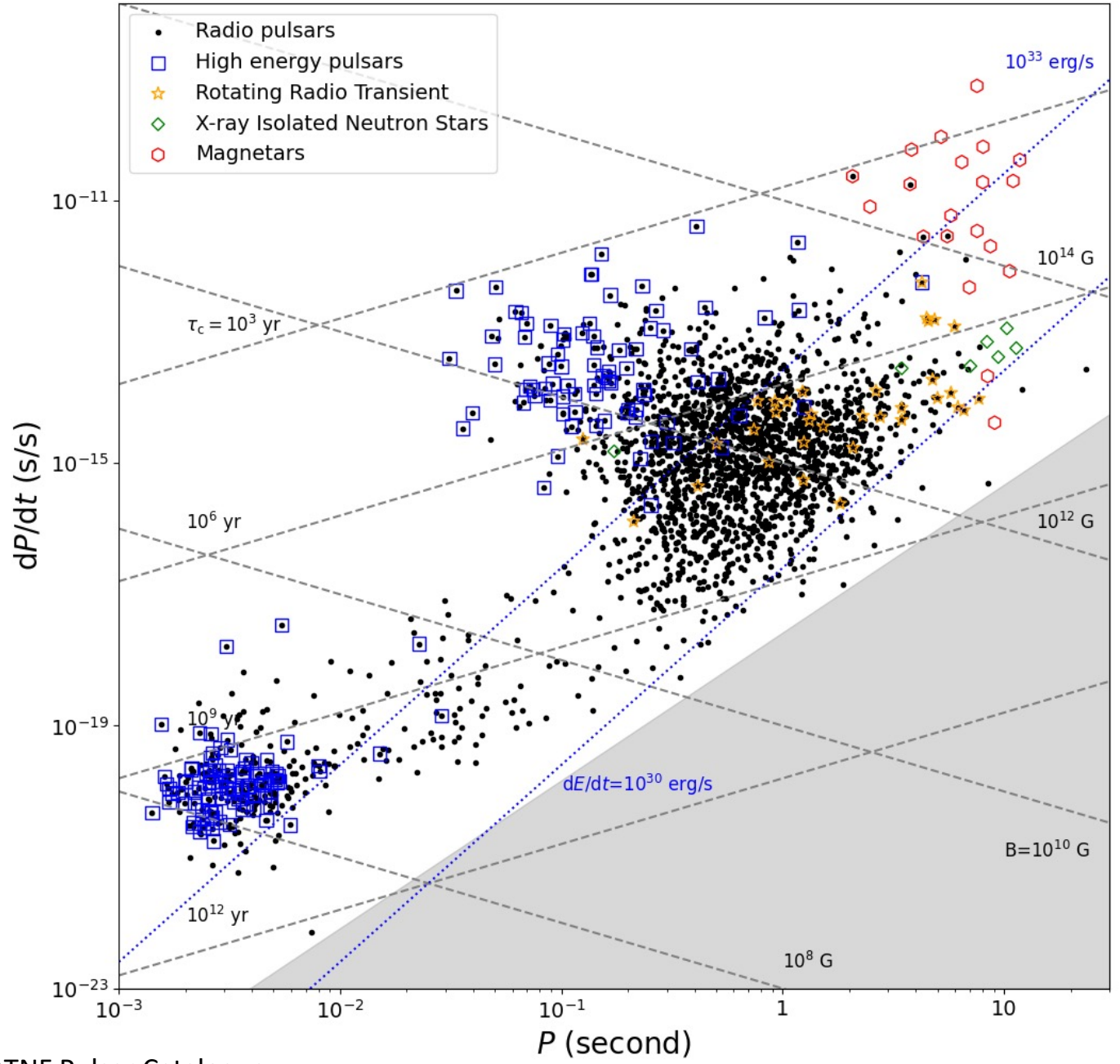
- How does the magnetosphere fill with charge?
- What is the solution of fields and currents in the magnetosphere?
- What is the energy spectrum of outflowing particles?
- What is the mechanism of the coherent radio emission?

Beskin (2016); Harding (2017)

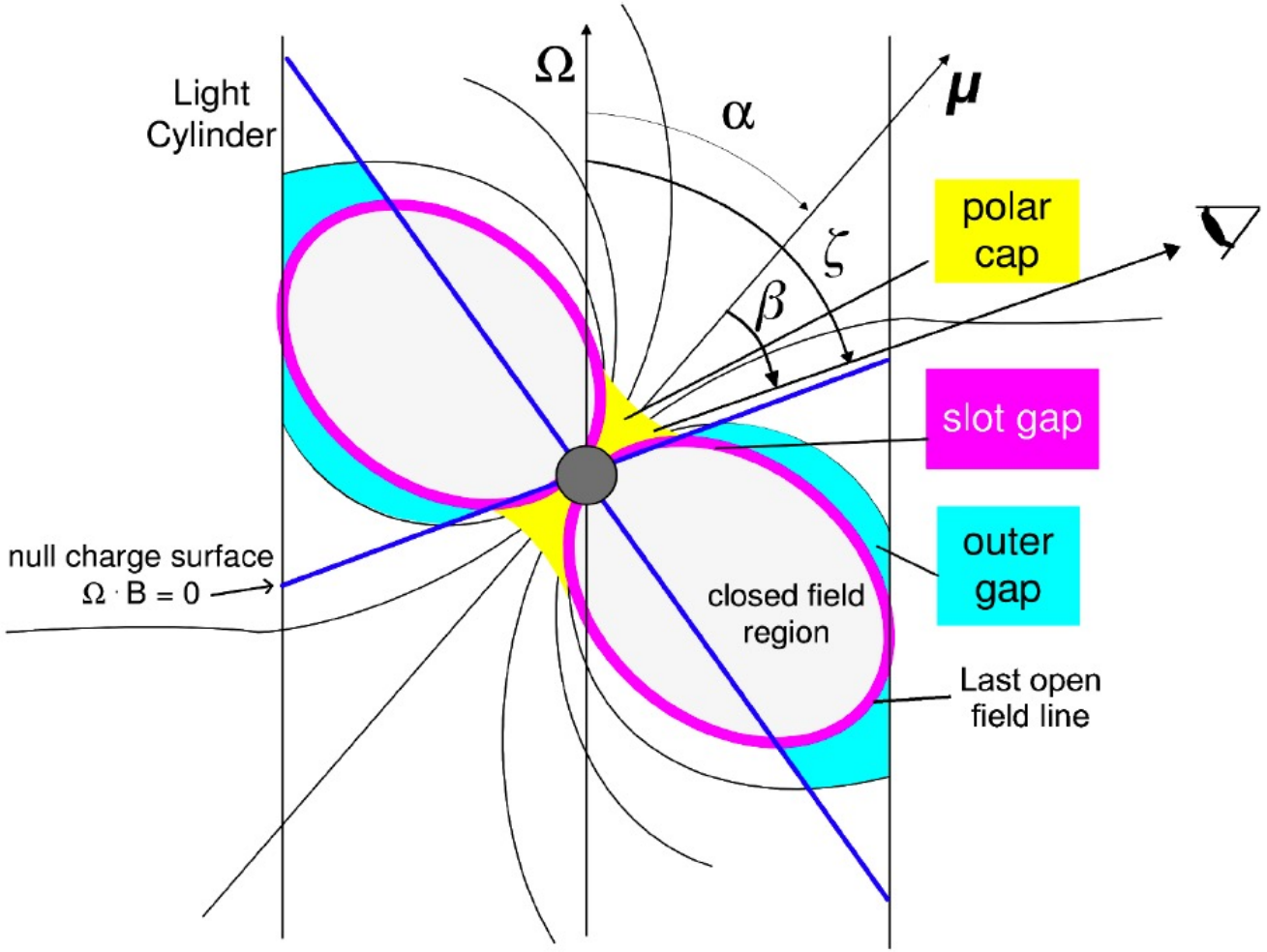


Lorimer & Kramer (2005)

- $B \propto (P \cdot \dot{P})^{1/2}$
- $Age \equiv P/2\dot{P}$



Data from the ATNF Pulsar Catalogue

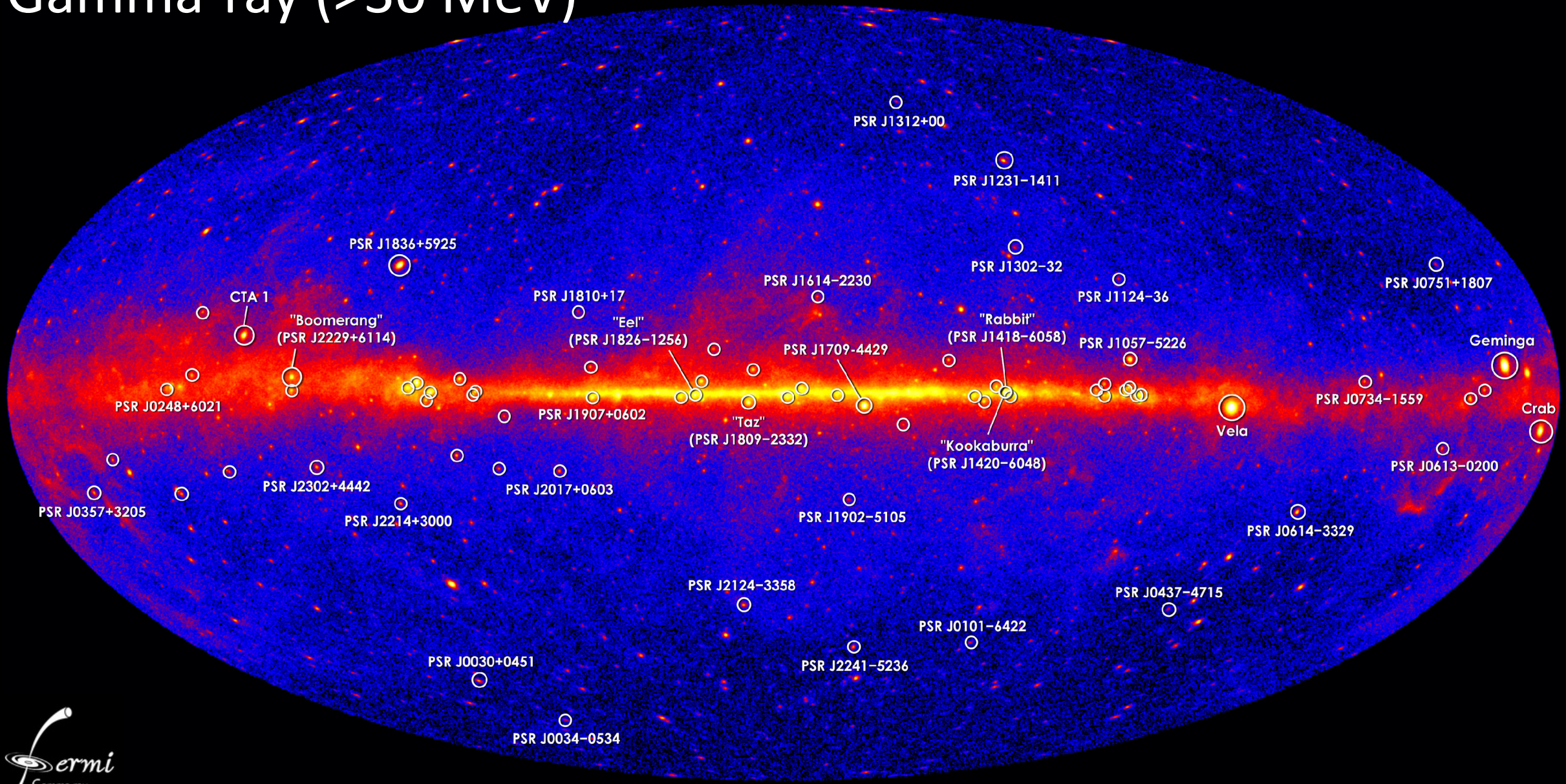


Harding (2005)

Prior to 2008

1. Acceleration region: polar cap, slot gap, outer gap?
2. Radiation mechanism: synchrotron, curvature, inverse Compton scattering?
3. Spectral cutoff: maximum electron energy, absorption?

Gamma-ray (>30 MeV)

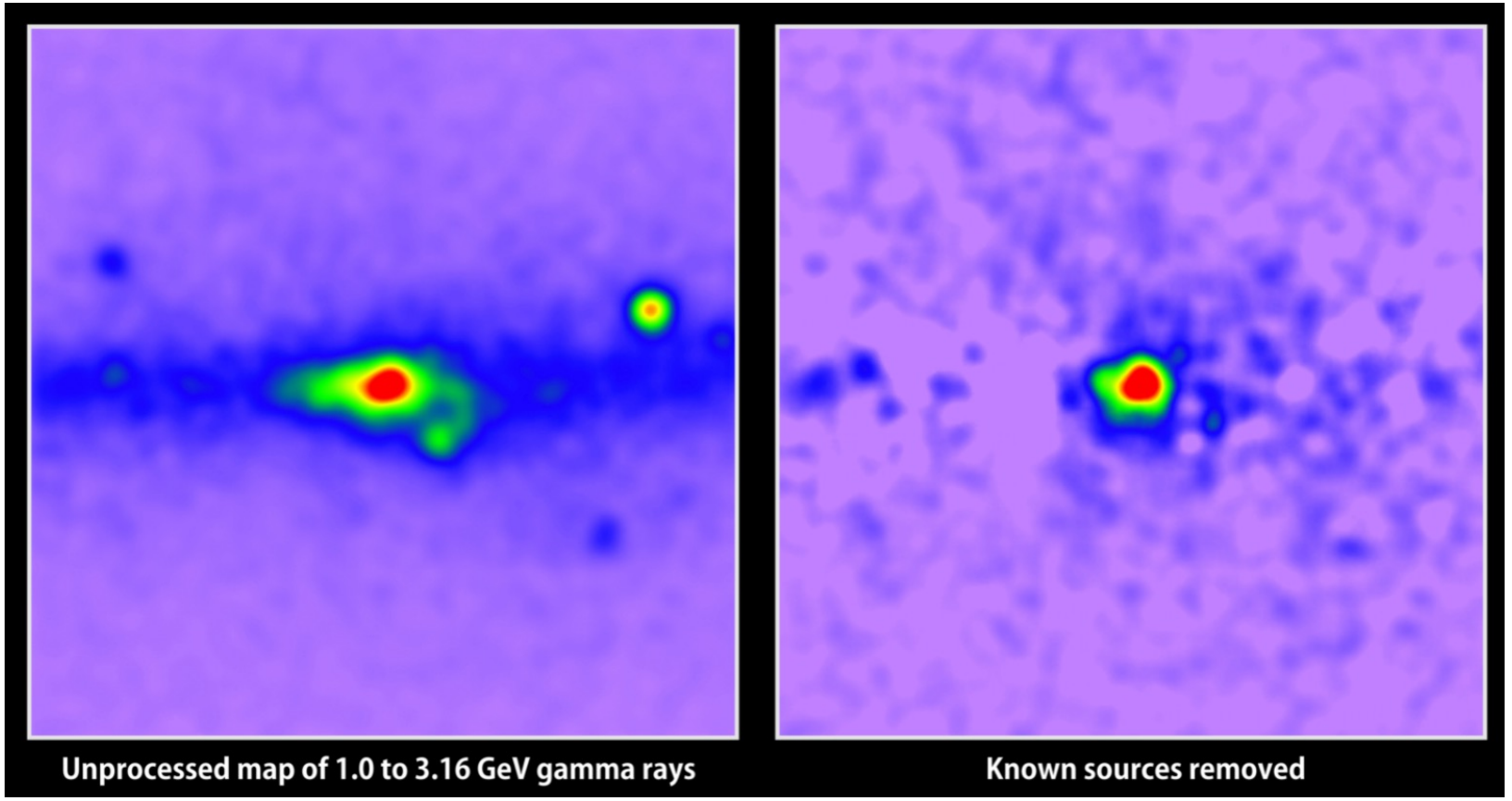


Fermi Gamma-ray Space Telescope

Credit: NASA/DOE/Fermi LAT Collaboration

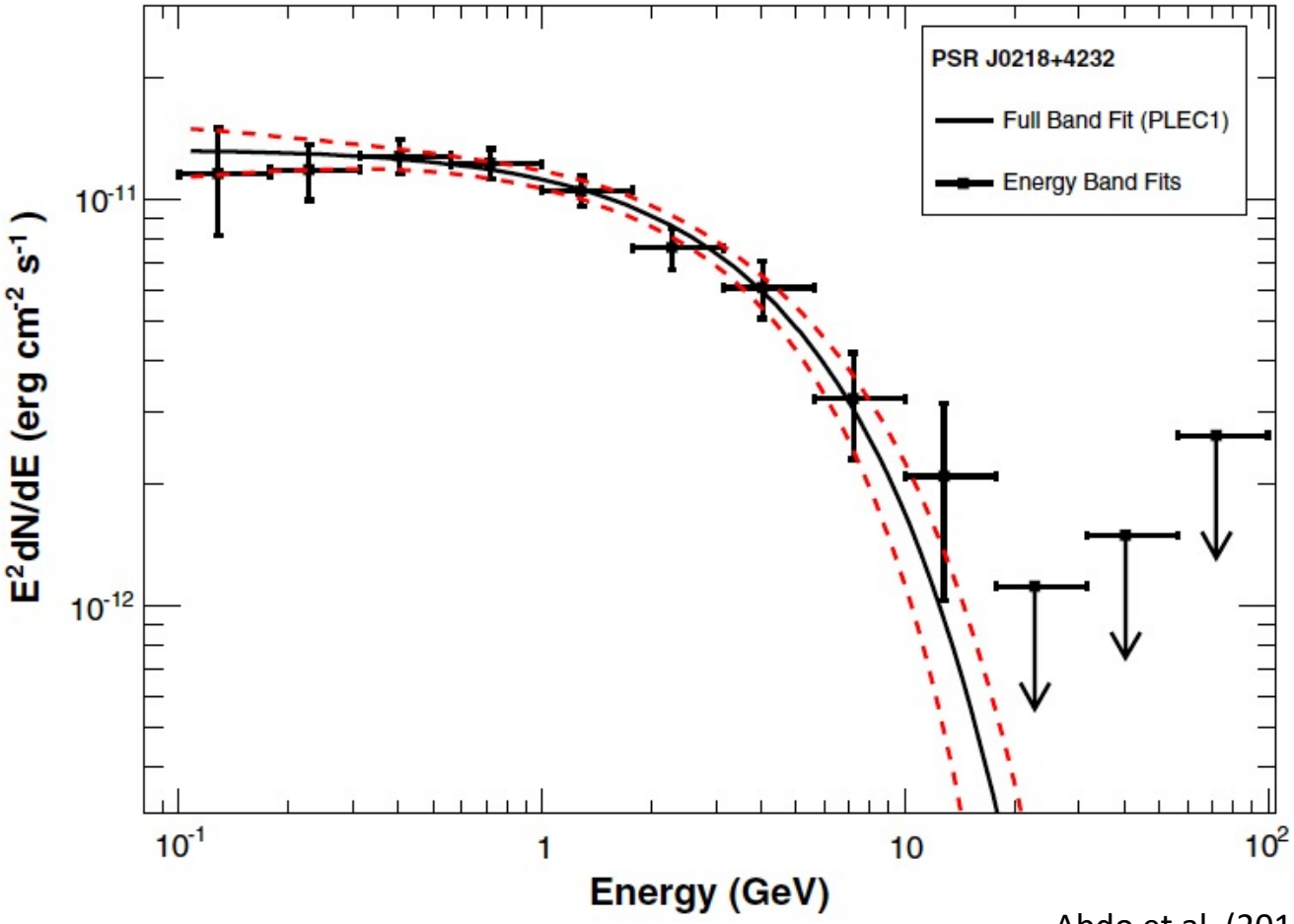
- Discovery of a population of new millisecond pulsars.
- What's the origin of gamma-ray in the Galactic Centra and globular clusters?

Galactic Centre



Credits: T. Linden

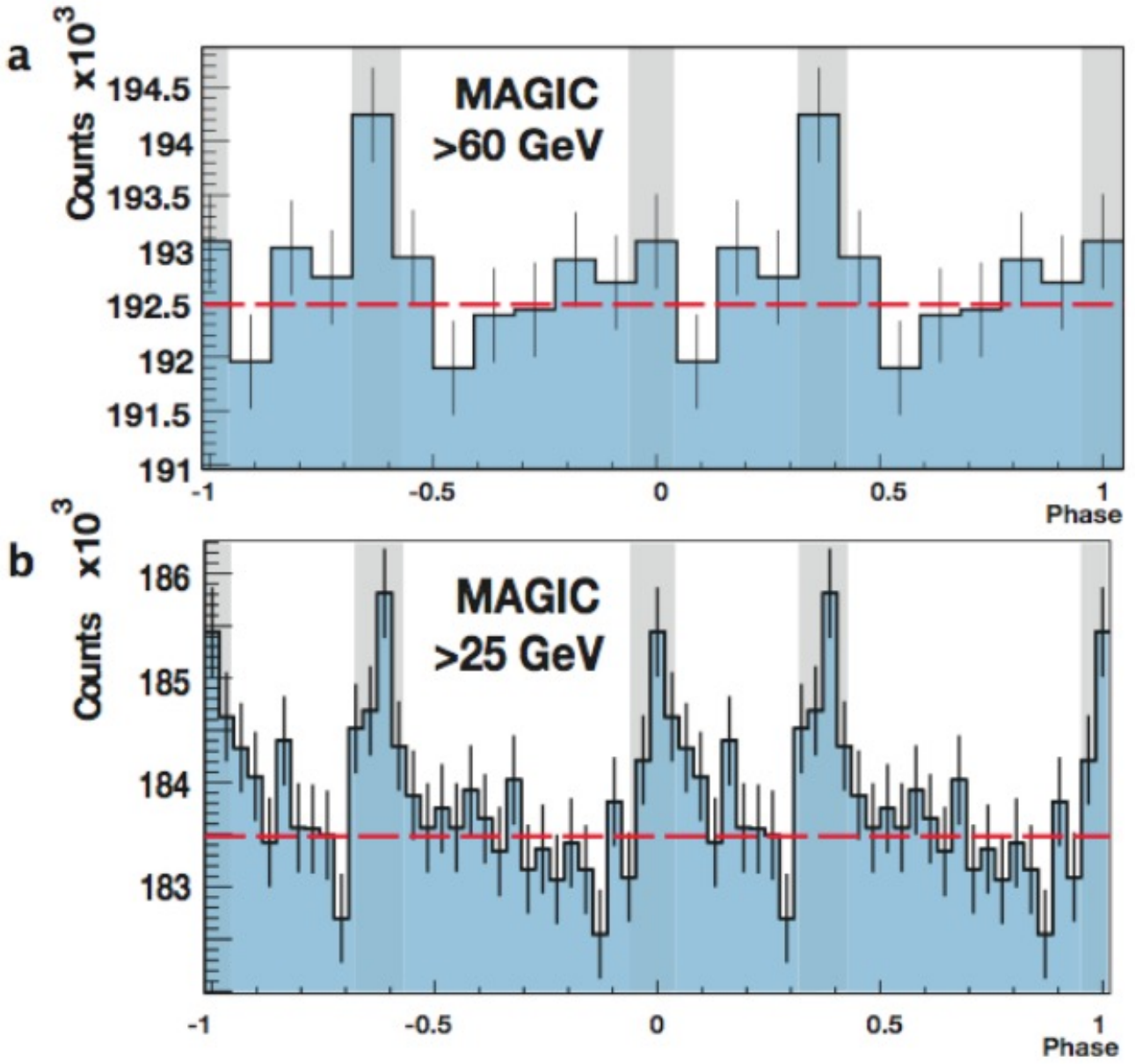
- The gamma-ray emission is from high-altitude emission zones (e.g., outer gap).



Abdo et al. (2013)

Gamma-ray (>10 GeV)

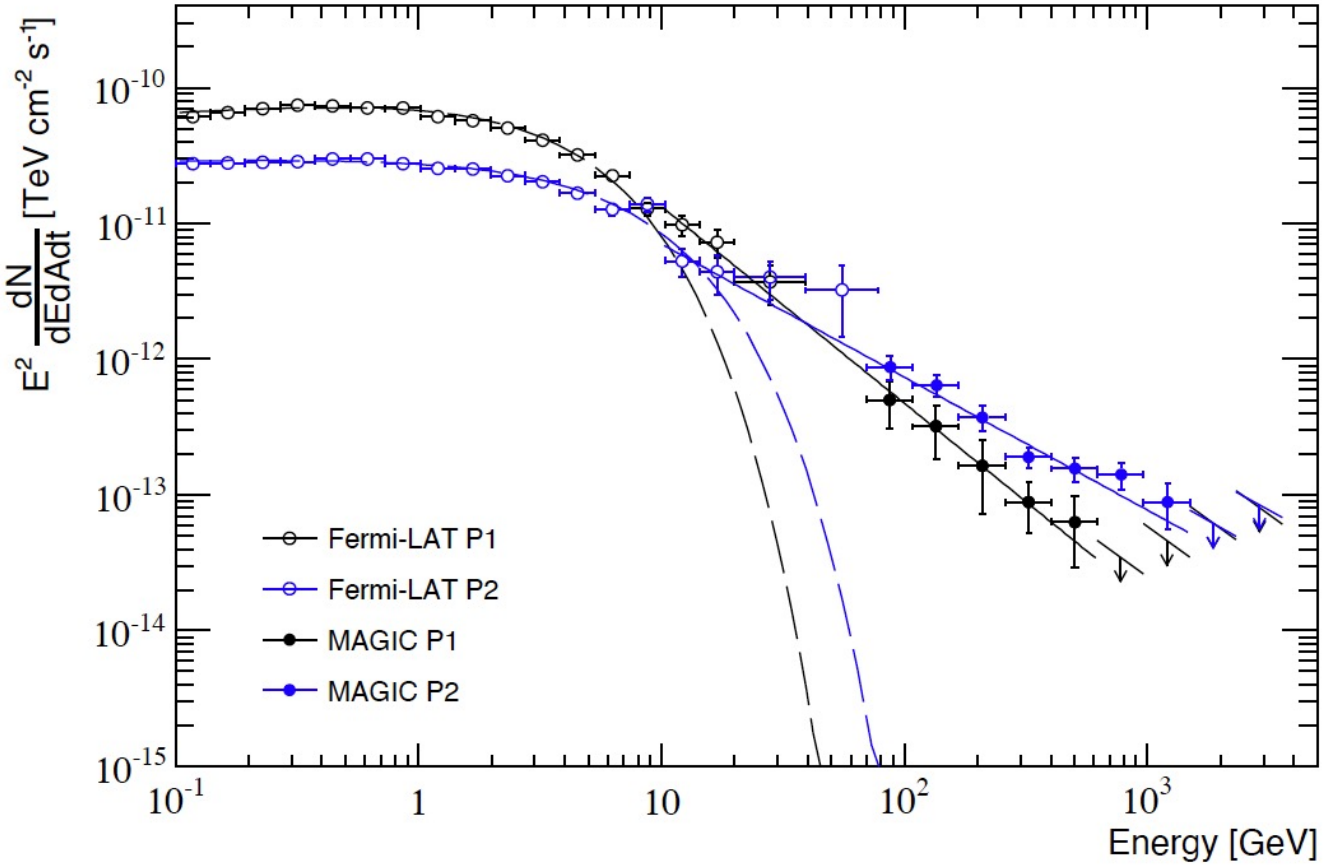
- Pulsed gamma-ray above 25GeV from Crab detected by **MAGIC** (Aliu et al. 2007).
- The detection strongly suggests that high energy emission is not from polar-cap region.



Aliu et al. (2007)

Gamma-ray (>10 GeV)

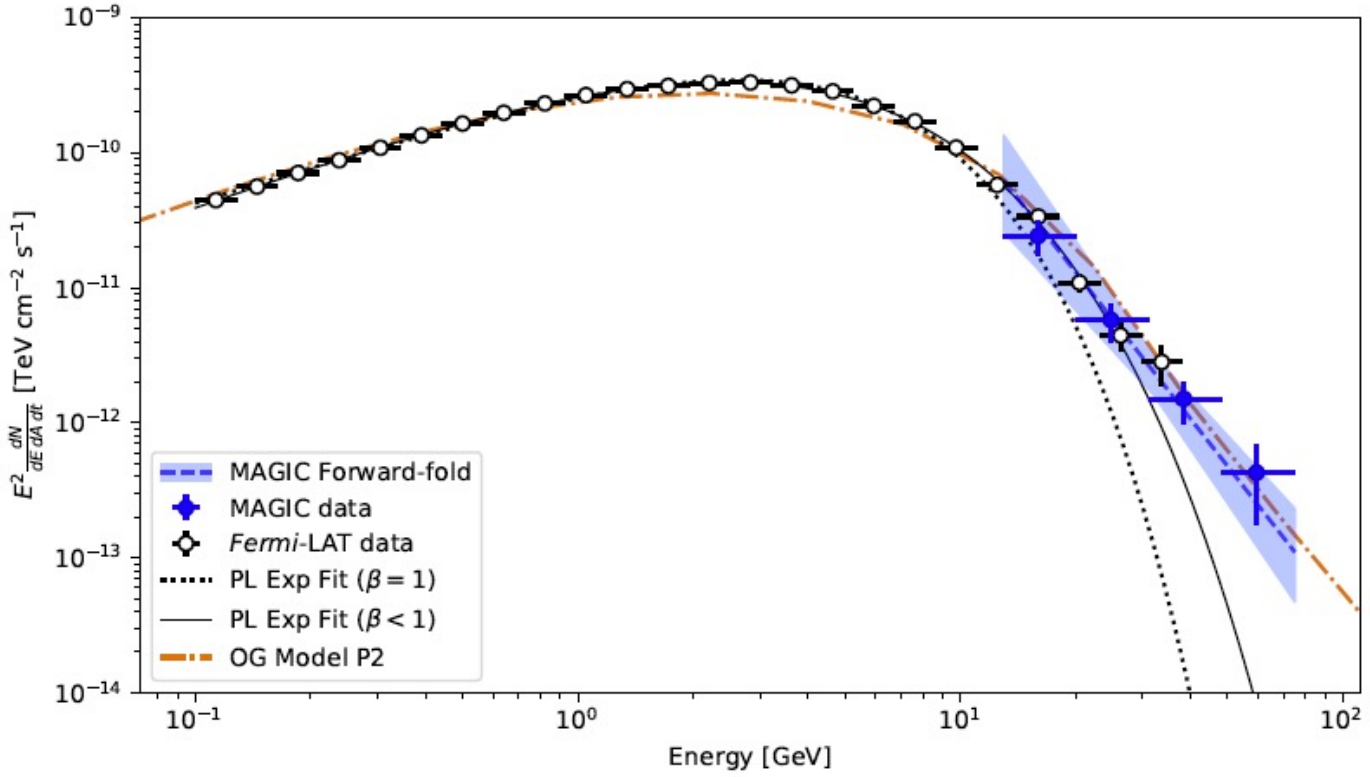
- Pulsed gamma-ray at TeV was first detected from Crab by **MAGIC** (Ansoldi et al. 2016).



Ansoldi et al. (2016)

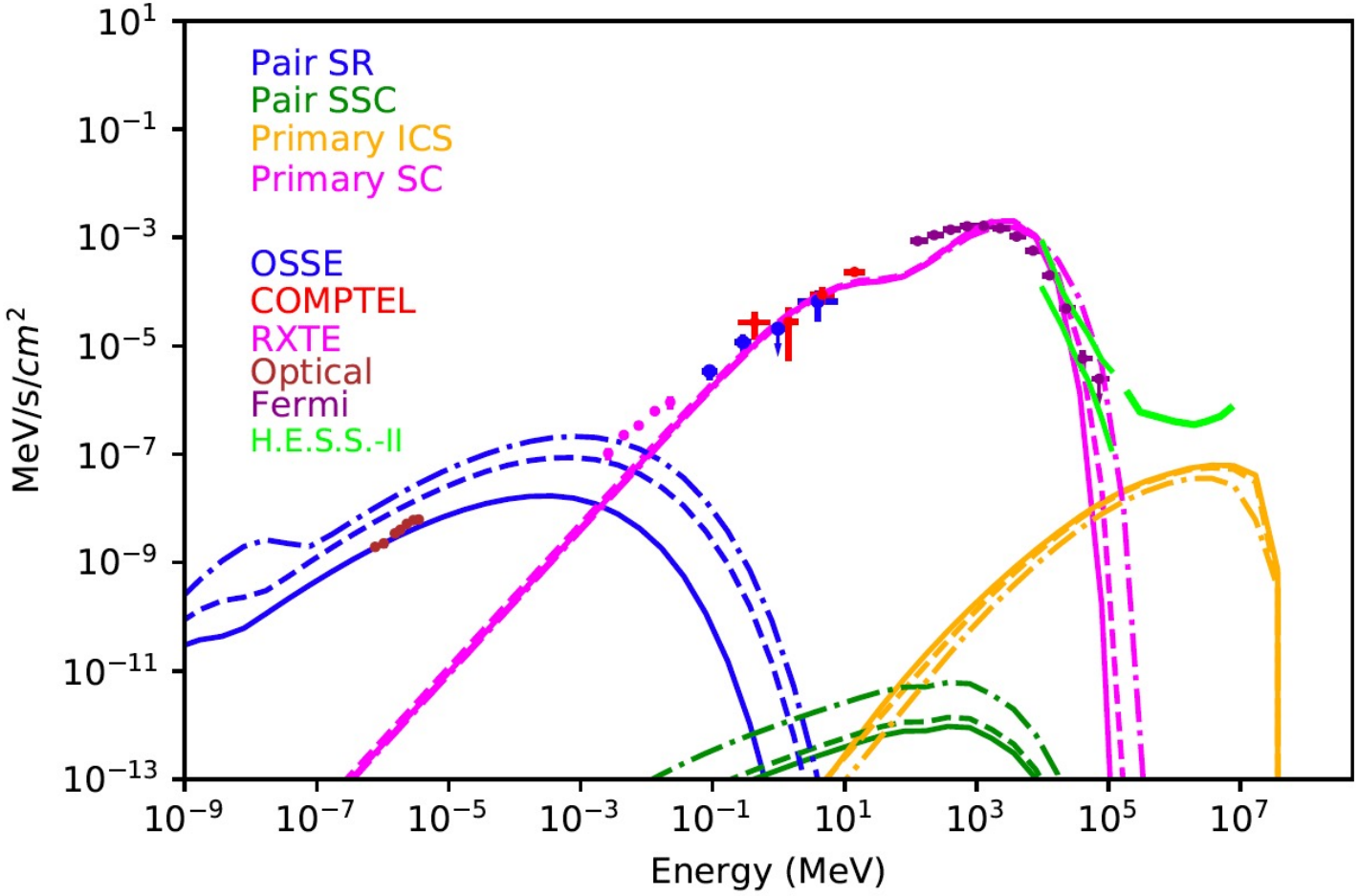
Towards TeV Gammas…

- Vela up to TeV (H.E.S.S in prep.)
- PSR B1706−44: sub-100GeV (Spir-Jacob et al. 2019)
- Geminga: up to 75GeV (Acciari et al 2020)



Acciari et al. (2020)

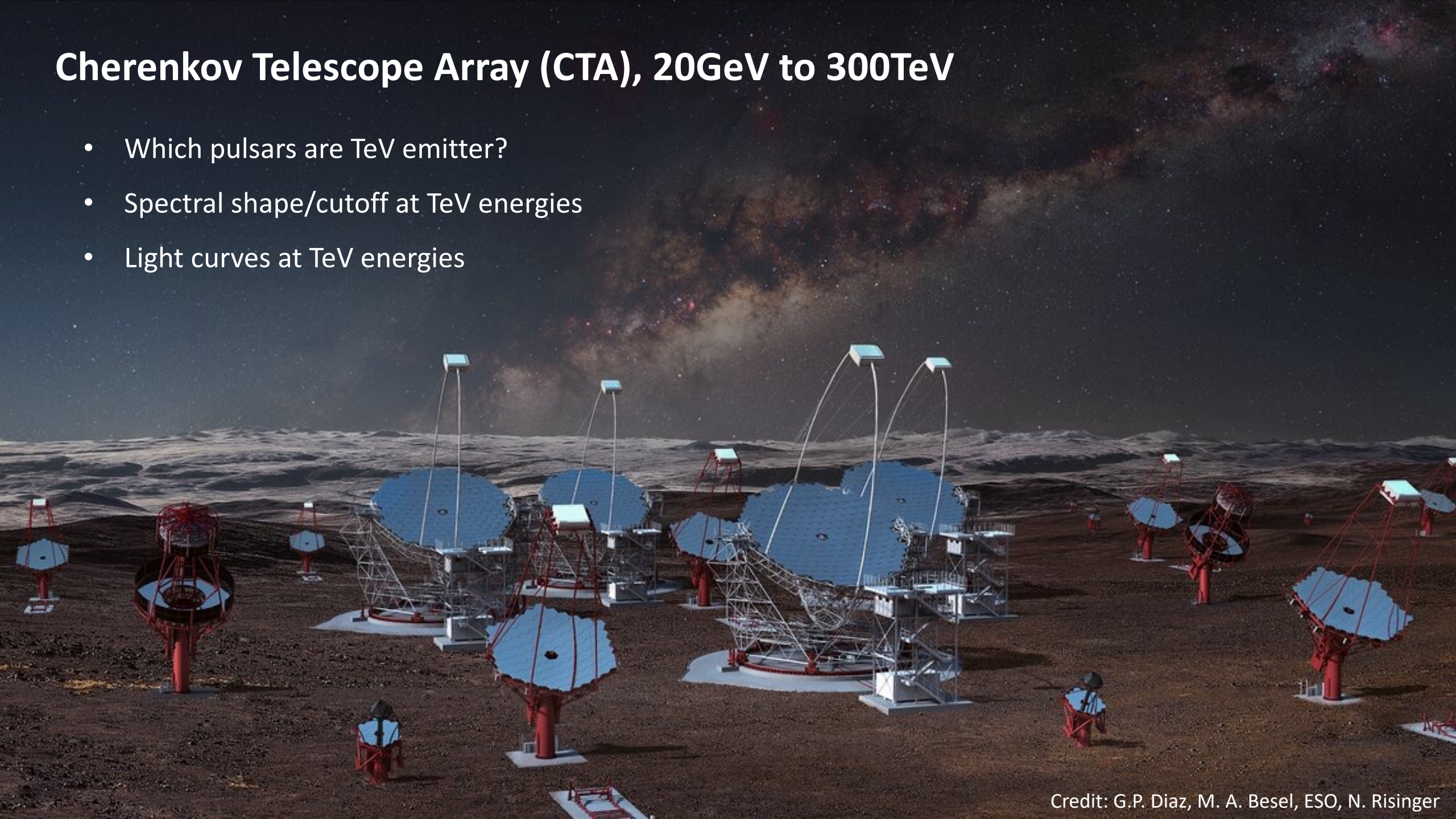
- The TeV window may play an important role in constraining particle energetics and break degeneracies that exist when only considering lower-energy data.



Harding et al. (2021)

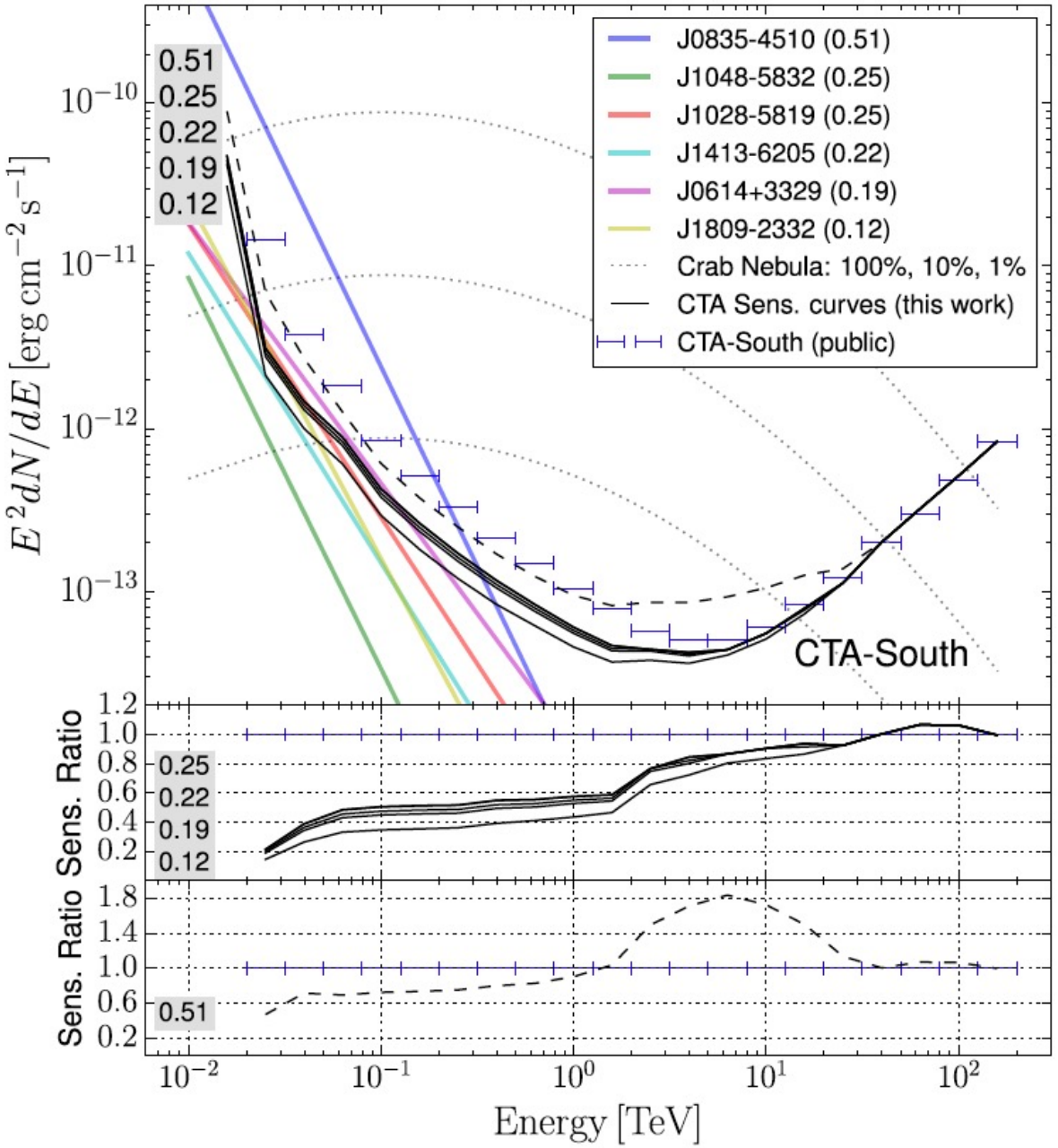
Cherenkov Telescope Array (CTA), 20GeV to 300TeV

- Which pulsars are TeV emitter?
- Spectral shape/cutoff at TeV energies
- Light curves at TeV energies



Credit: G.P. Diaz, M. A. Besel, ESO, N. Risinger

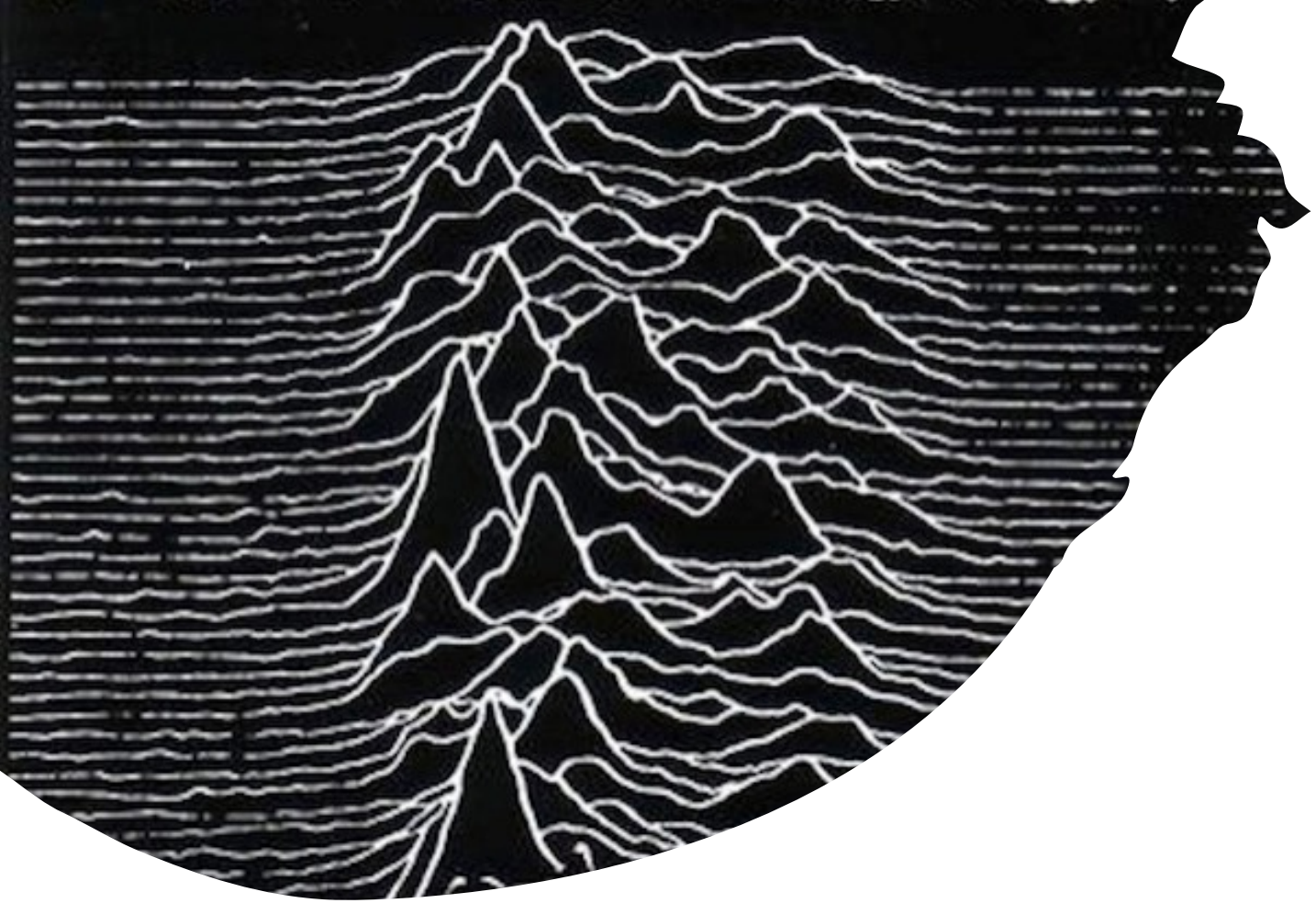
- Simulations based on Fermi data show that up to eight pulsars can be detected at >0.1 TeV in 50hr with CTA.
- The Galactic Plane Survey has limited sensitivity and will not cover many MSPs.
- Targeted observation of a sample of pulsars (in collaboration with radio).



Burtovoi et al. (2017)

- The Parkes young pulsar timing project, where we observe 300 pulsars monthly.
- Providing the most up-to-date pulsar ephemeris (i.e. parameters) for the search of Gamma-ray emission.

Credit: CSIRO



- CTA will shed new light on the origin of very high energy (VHE) emission from pulsars.
- VHE emission reveals key information about the outer part of pulsar magnetosphere (close to the light cylinder), where radio giant pulses and fast radio bursts (possibly) originate.
- Understanding the VHE spectrum of pulsars (MSPs) is important for a range of astrophysics (e.g., dark matter, globular clusters, Galactic Centre).

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cta cherenkov telescope array