Pulsars with Cherenkov Telescopes

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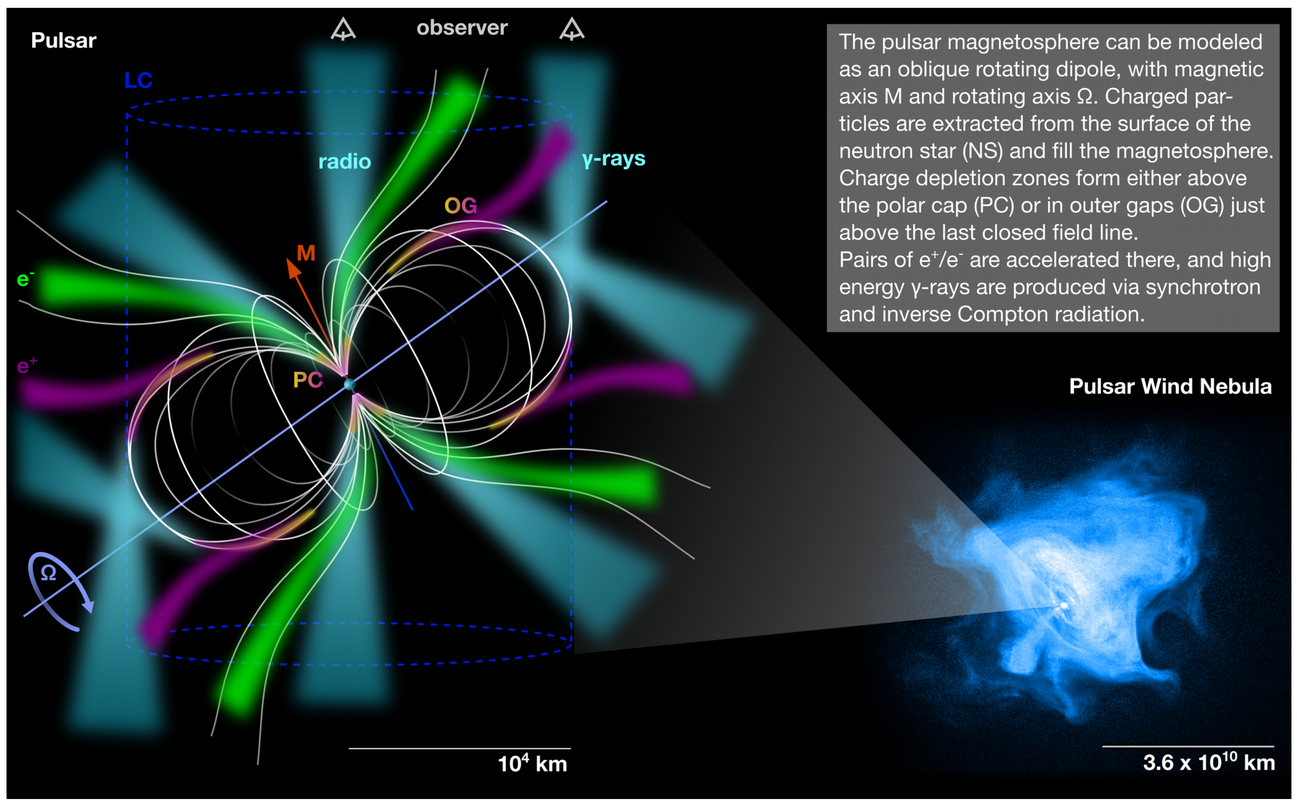
Powerful cosmic accelerators

Pulsars are compact (r ~ 10 km), rotating (P ~ 1ms – 1s), magnetized (G ~ 10^8 T) neutron stars.

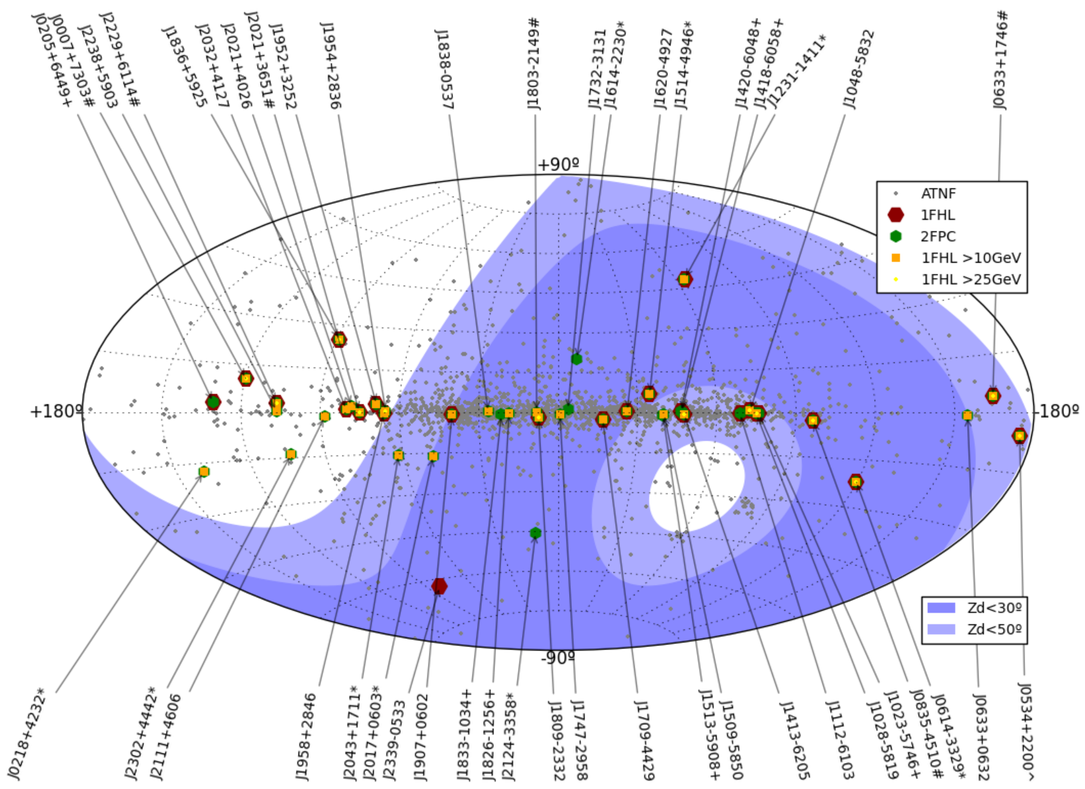
Non-thermal emission from pulsars is observed as regular pulsations across the electromagnetic spectrum, especially bright in HE (>100 MeV) γ-rays.

Pulsars accelerate electrons and positrons up to several hundreds of TeV, injecting them into the surrounding space, powering Pulsar Wind Nebulae, which are also bright, non-pulsed γ-ray sources.

Acceleration and emission mechanisms both in pulsars and PWN are not fully understood yet.



The pulsar magnetosphere can be modeled as an oblique rotating dipole, with magnetic axis M and rotating axis Ω. Charged particles are extracted from the surface of the neutron star (NS) and fill the magnetosphere. Charge depletion zones form either above the polar cap (PC) or in outer gaps (OG) just above the last closed field line.
Pairs of e^+/e^- are accelerated there, and high energy γ-rays are produced via synchrotron and inverse Compton radiation.



Pulsed γ-ray emission at VHE (>100 GeV)?

Only one pulsar so far is known to emit pulsed γ-rays above 100 GeV. This discovery prompted to reconsider the existing emission models, which were predicting a spectral cutoff at ~10 GeV. Completely new models involving different emission processes were put forward as well.

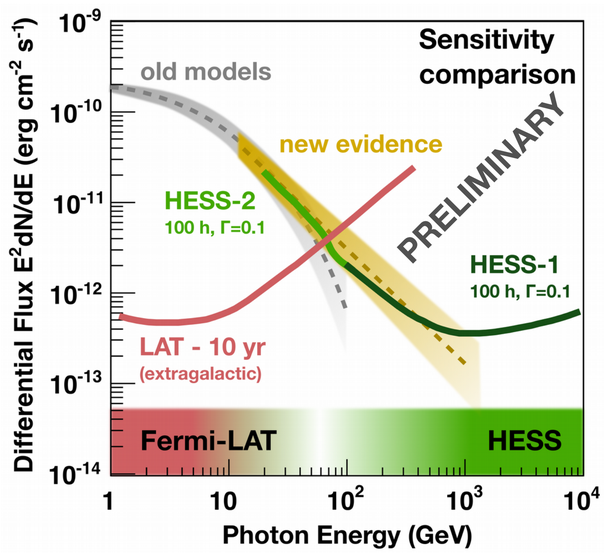
In order to test their predictions and to discriminate between them it is now crucial to search for other examples VHE pulsars.

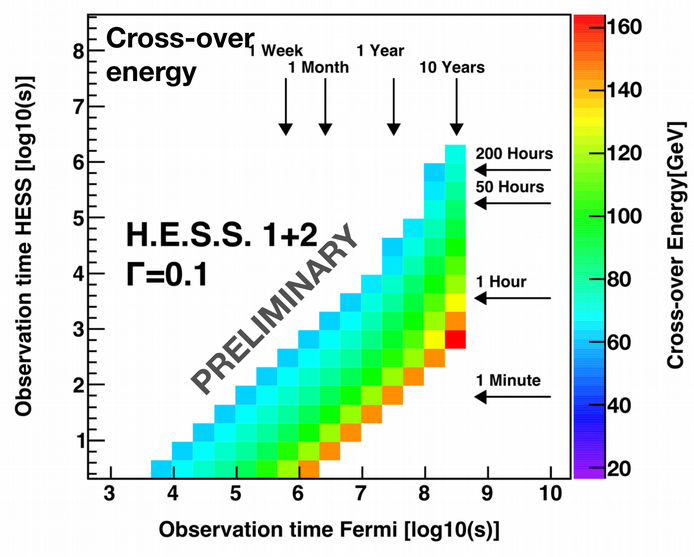
Fermi-LAT data already gives some hints: dozens of pulsars already detected above 25 GeV represent good candidates.

A question of threshold: size matters

Imaging Atmospheric Cherenkov Telescopes (IACT) are the only instruments able to detect γ-rays in the ~100 GeV energy range with enough sensitivity, since the *Fermi*-LAT lacks statistics. However, 100 GeV is the lowest energy threshold achievable 12-m class arrays, such as VERITAS and HESS-1. Bigger mirror areas are the most straightforward way to explore lower energies.

HESS-2, a 28-m class single telescope commissioned in 2012, enhances the capabilities of the HESS array in that direction, giving the best chances to detect another VHE pulsar before CTA becomes operative.





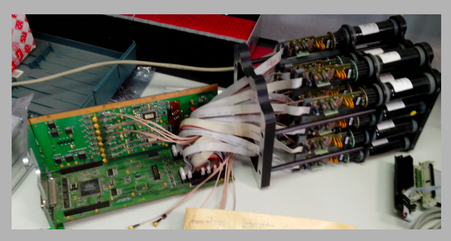
Mixed-size HESS array: the need to upgrade

The only IACT array with telescope of different sizes is HESS. “Hybrid” operation is desirable since it would heavily suppress background noise, however it presents unique challenges.

The most serious one is the hardware of the legacy HESS-1 telescopes: its dead-time limits severely the sensitivity of the array.

An upgrade of the electronics of the HESS-1 cameras is ongoing, lead by the HESS group in DESY–Zeuthen. Most of the components will be replaced or refurbished. The upgrade will allow for hybrid operation and reliable performance of the HESS array for the next >5 years.

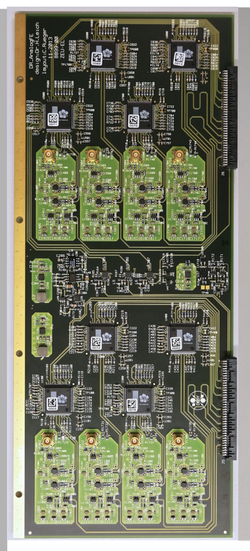
Modular camera unit: PMT drawer



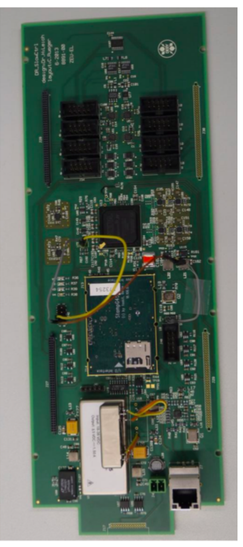
The upgraded components are:

- Electronics (readout & SC)
- Power Supply
- Trigger interface
- Infrastructure, cooling & mechanics

NECTAR analog ring sampler



analog board



slow control board

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