

References



High-Energy Emission from the Vela Pulsar

Curvature radiation with a dissipative magnetospheric electric field

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Geometry & Emission Region

The Vela pulsar's curved gamma-ray spectrum, detected up to ~100 GeV by H.E.S.S. II and the Fermi LAT, is attributed to curvature radiation from primary particles accelerated in a dissipative magnetosphere along an extended separatrix linked to the current sheet beyond the light cylinder.

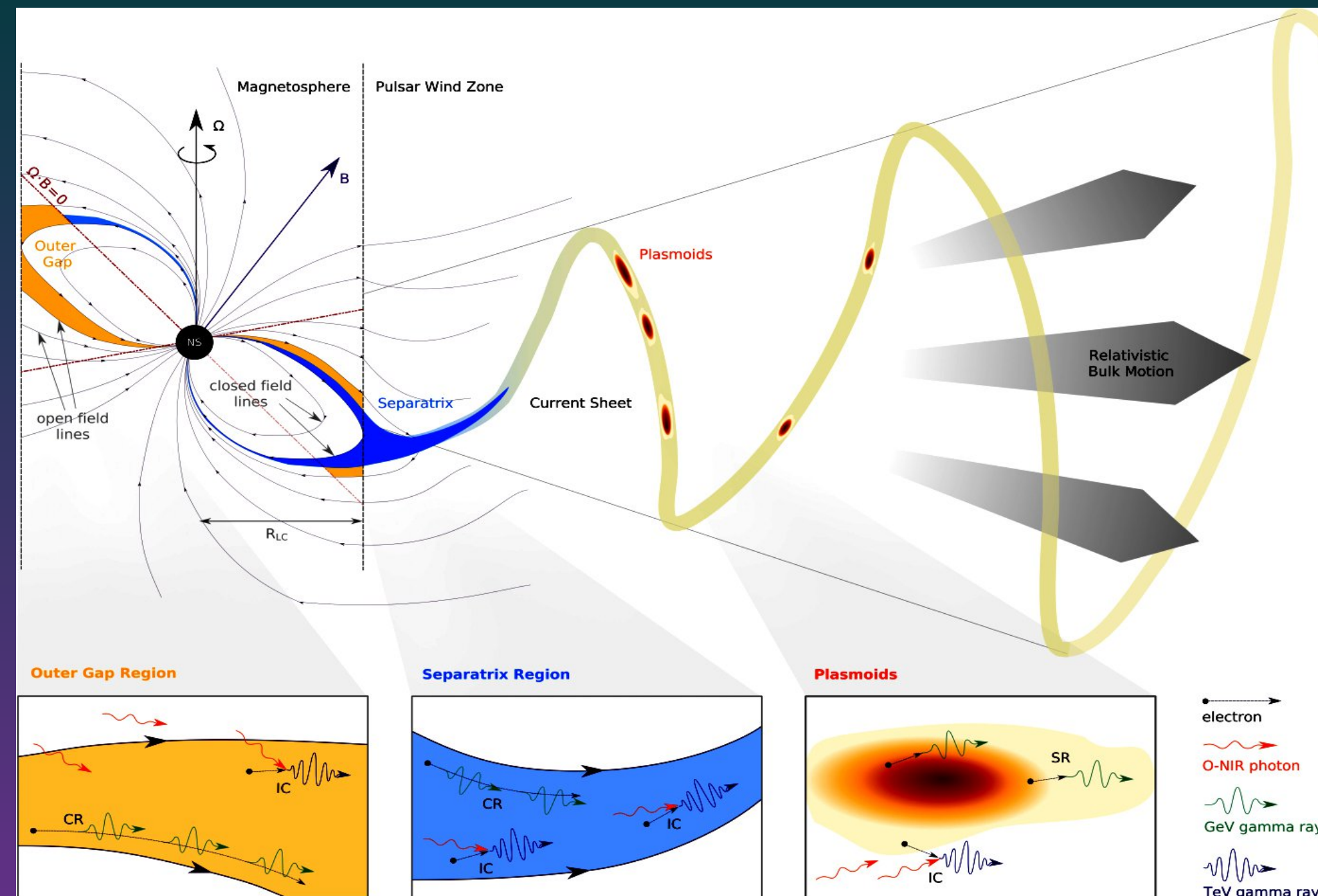


Figure 1: Schematic of pulsar magnetosphere showing **separatrix region and current sheet outside the light cylinder**, where particle acceleration occurs (H.E.S.S. collaboration, 2023)

Emission Modelling

Energy-dependent phase plots and light curves are modelled using an azimuthally dependent accelerating electric field obtained from global magnetospheric simulations, with an updated field prescription. The electric field is parameterised as proportional to the conductivity (σ), and its impact is explored via the following equations.

$$E_{\parallel} = \frac{c|(\nabla \times \mathbf{B})_{\parallel}|_{(FFE)}}{4\pi\sigma} \quad \text{Dissipative electric field (Kalapotharakos et al. 2014)}$$

$$R_{\text{acc}} \sim eE_{\parallel}/m_e c^2 \quad \text{Acceleration length (Barnard et al. 2022)}$$

$$E_{\text{CRR}} \sim E_{\parallel}^{3/4} \rho_c^{1/2} \sim \sigma^{-3/4} \rho_c^{1/2} \quad \text{Energy cutoff in the curvature radiation reaction limit (Venter & De Jager 2010)}$$

Take-home-message

Curvature radiation in a dissipative magnetosphere with an azimuthally dependent electric field reproduces key trends: peak intensity ratios, bridge emission, and energy-dependent pulse narrowing.

Model Predictions

Modelling the curvature emission over a range of σ -values reproduces key observational trends: decreasing peak 1/peak 2 (=P1/P2) flux ratio, evolving bridge emission, stable peak phases, and pulse narrowing with energy.

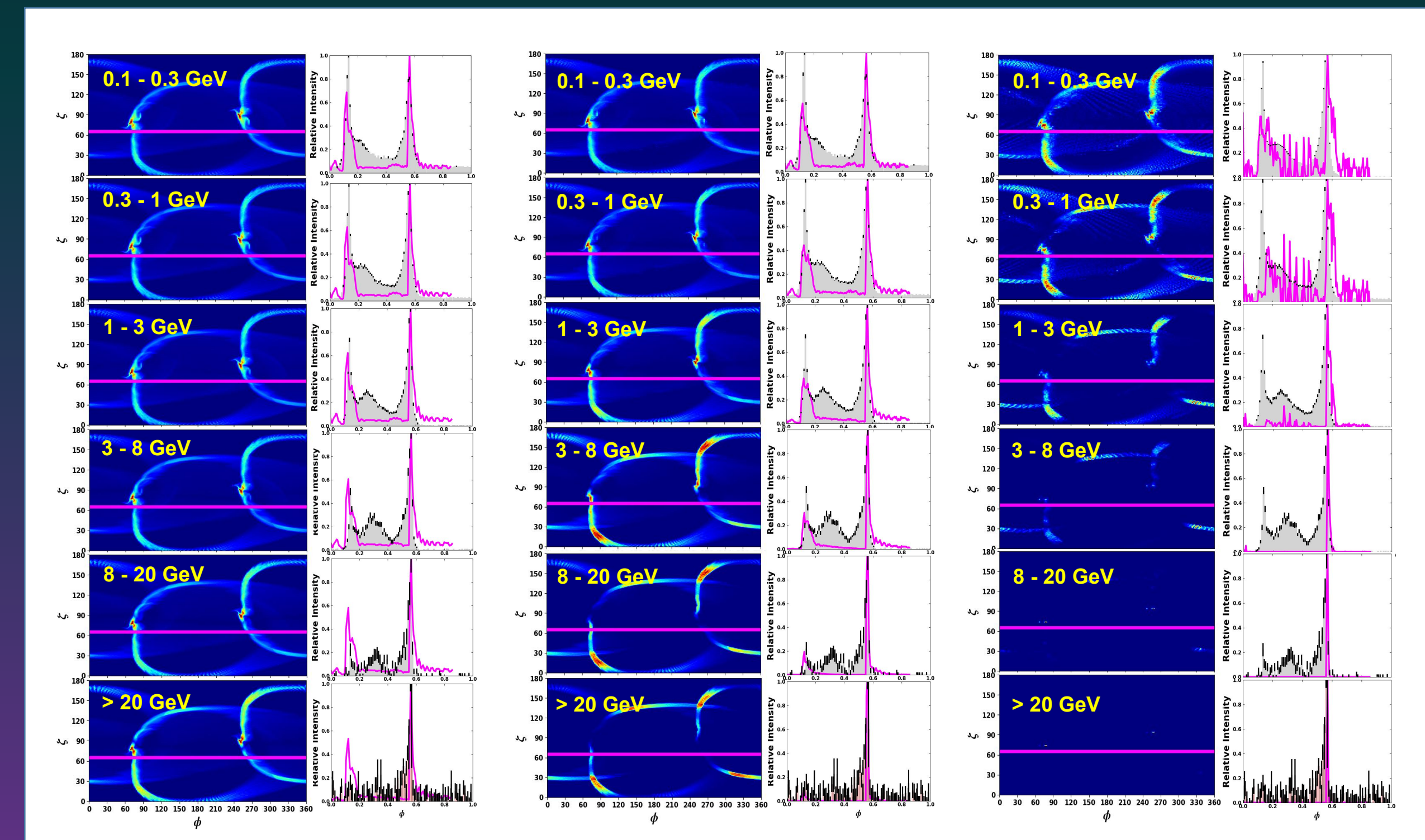


Figure 2: Energy-dependent phase plots and light curves for $\alpha=75^\circ$ and (a) $\sigma=0.02\Omega$, (b) $\sigma=1\Omega$, and (c) $\sigma=30\Omega$, respectively. The energy ranges (in GeV) are indicated in yellow.