Search for VHE Emission from PSR J0218+4232

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For the MAGIC and *Fermi*-LAT Collaborations

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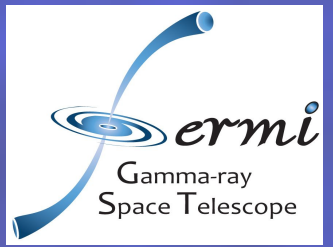
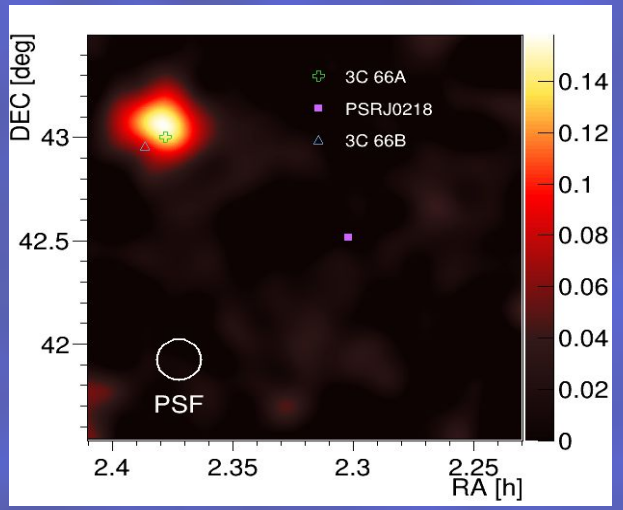


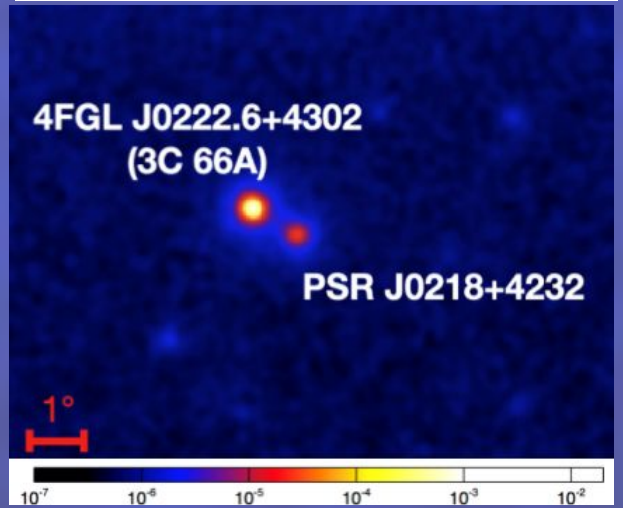
Introduction

- ★ Millisecond pulsar (MSP) with P_{spin}=2.32ms, $P_{orbital}$=2 days
- ★ **One of the youngest and most energetic MSP**
- ★ **High magnetic field strength at Light Cylinder (B_{LC}~3.2x10^5 G)**
- ★ Bright in radio and X-rays . Detected by EGRET, and Fermi-LAT
- ★ Possibly aligned rotator with ~50% unpulsed component
- ★ **Hints for pulsed emission >10 GeV**

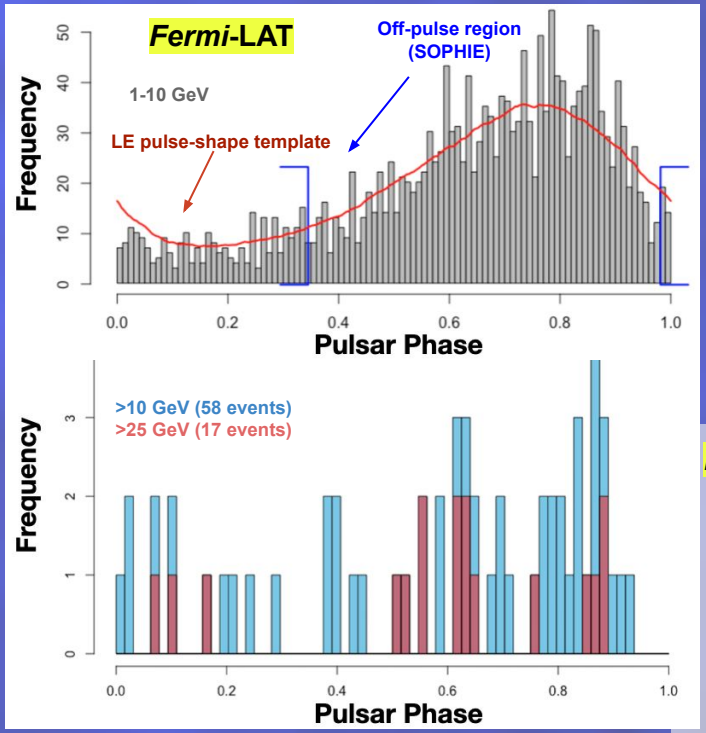
Data Analysis & Skymaps

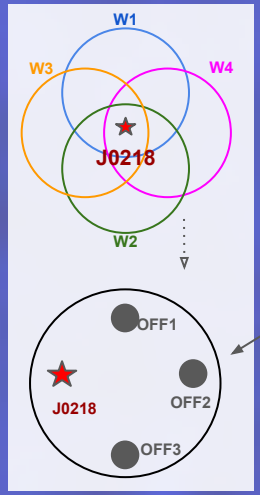
- ★ ***Fermi*-LAT**
  - **Data: 11.5 years** (2008 - 2020)
  - P8R3_SOURCE_V3
  - Energy range: 100 MeV - 870 GeV
- ★ **MAGIC**
  - **Data: 87 hours** (2018 - 2019)
  - Sum-Trigger-II system : high performance for sub-100 GeV
  - Energy Range: >20 GeV

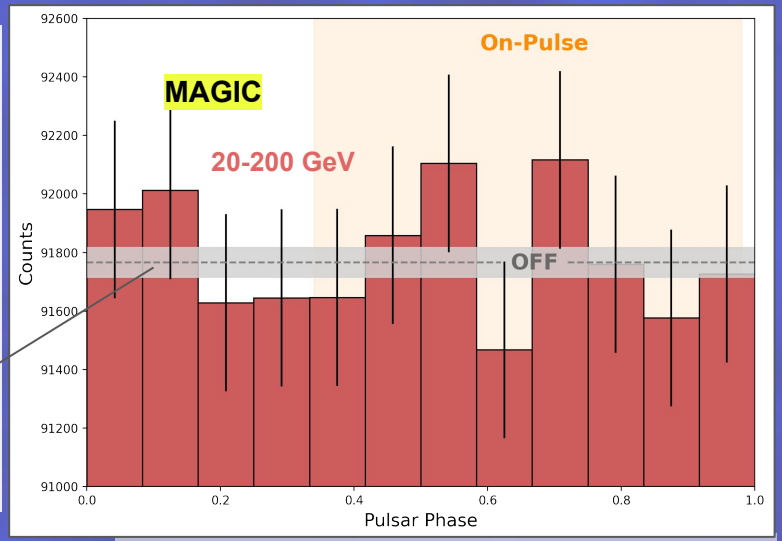




Phaseograms







Fermi-LAT : High Energy (HE) search

- ★ Likelihood ratio test (LRT) method
  - Low-Energy: 1-10 GeV (pulse-shape red template)
  - High-Energy: >10 GeV
- ★ **Results:**
  - **>10 GeV p_value: 10^{-4}**
  - **>25 GeV p_value: 10^{-2}**
  - **>30 GeV p_value > 0.05**

MAGIC : Very High Energy (VHE) search

- ★ Method 1 : LRT (Fermi-LAT LE template)
  - **p_value > 0.05**
- ★ Method 2 : Li&Ma Eqn.17
  - ON: [0.34-0.98 phase], OFF: mean 3 source-free reflected regions
  - **0.057 σ**
- ★ Method 3 : region-indep. signal tests
  - **χ^2 : 5.54/11 dof**
  - **H-test : 0.05 σ**

SED & Theoretical Modelling

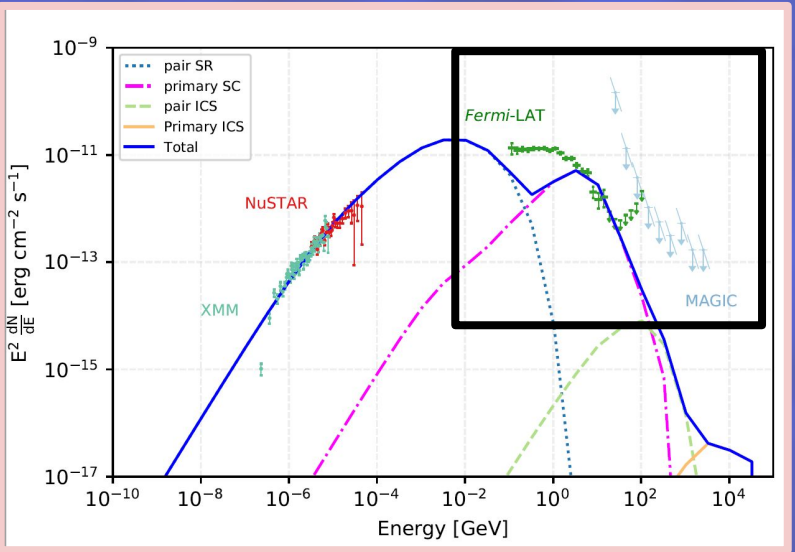
★ ***Fermi*-LAT**
- Power-law with exponential cut-off, steep > 10 GeV
- **Significant emission up to 20 GeV**

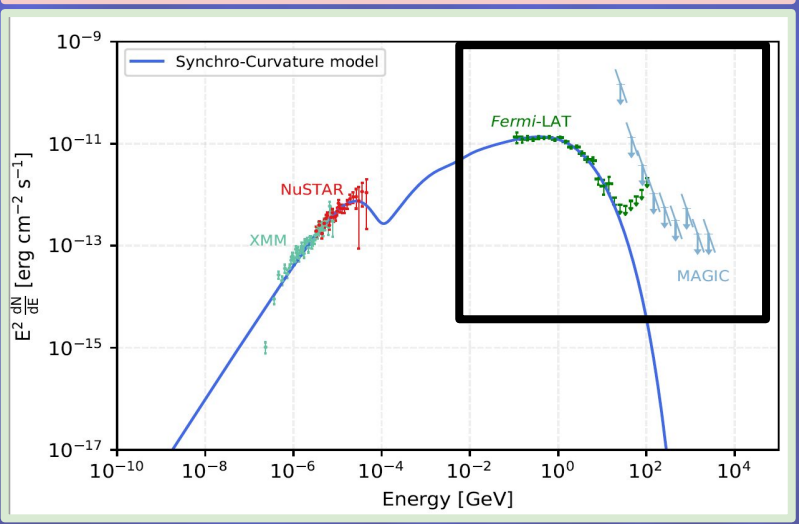
★ **MAGIC**
- Power-law with Γ=4.5 (from Fermi-LAT data)
- ON: [0.34-0.98 phase]
- **No significant detection, only upper limits**

Theoretical Models

★ **Force-free Magnetosphere Model (Harding et al., 2015)**
- Two populations of particles injected **at neutron star surface**
  - Primary e-/e+: accelerated by $E_{||}$
  - Secondary e-/e+: from polar cap pair cascade
- **Emission: Synchro-Curvature and Inverse Compton**

★ **Synchro-Curvature Model (Torres et al., 2019)**
- Particles accelerated by $E_{//}$ **around Light Cylinder radius**
- **Emission: Synchro-Curvature radiation**





Discussion

- ★ ***Fermi*-LAT**
  - Pulsed emission significant > 10 GeV , marginal >25 GeV, no evidence > 30 GeV
- ★ **MAGIC**
  - No significant emission > 20 GeV (neither pulsed nor unpulsed)
- ★ **Theory**
  - Data is in better agreement with Synchro-curvature Model
  - No VHE emission is predicted, agreement with MAGIC results
- ★ **For more details, please have a look at the poster**
- ★ **Stay tuned for the publication**

THANK YOU FOR LISTENING!