

AGILE DISCOVERY OF THE FLARING CRAB NEBULA

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The Crab Nebula: a spectacular cosmic accelerator



**POWERFUL
PULSAR (rotating
30 times a second)**

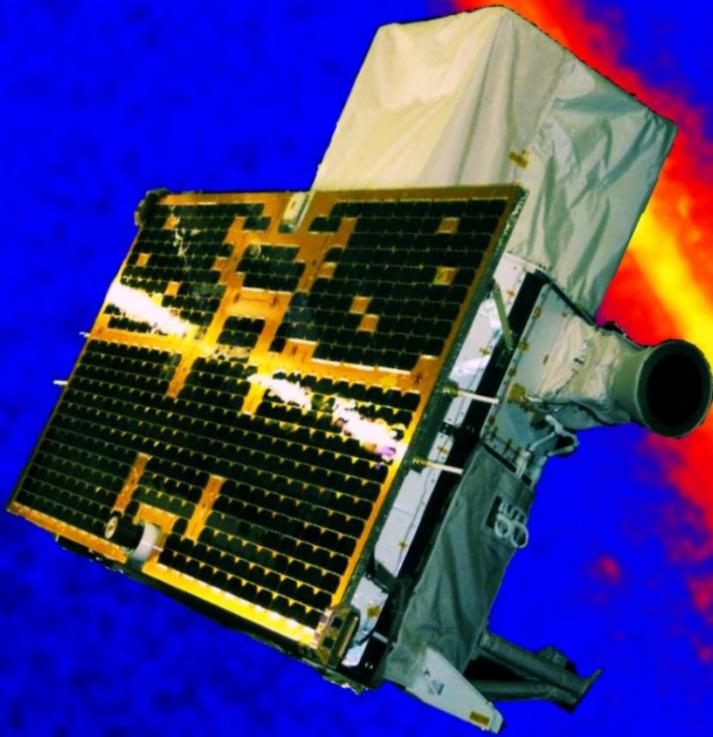
**NEBULA SHOCKED
BY THE PULSAR
WIND**

The Crab Nebula: a spectacular cosmic accelerator



**THE STANDARD
REFERENCE SOURCE
IN ASTROPHYSICS**

**IDEAL TO STUDY
SHOCK
ACCELERATION**

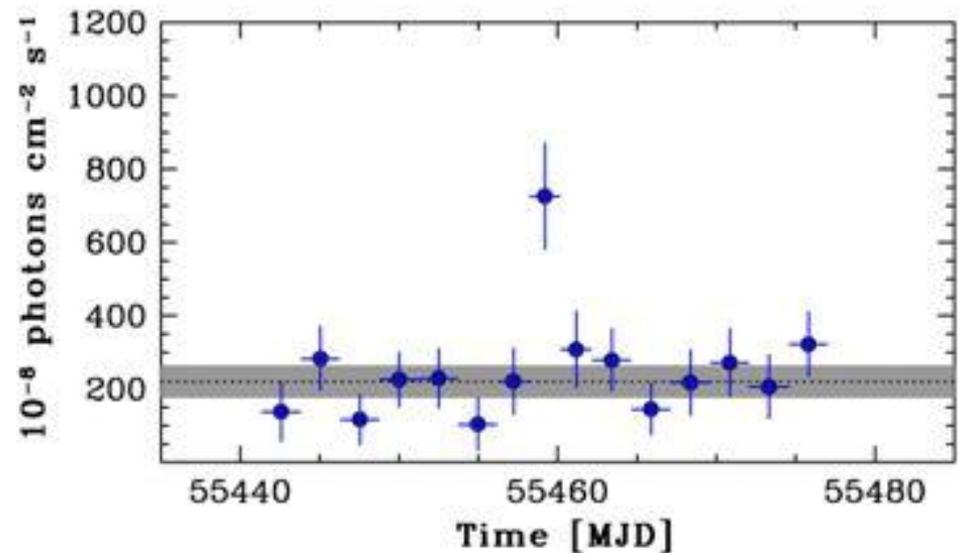


The AGILE Mission

- Gamma-rays from microquasars
(**Cygnus X-3, Cygnus X-1**)
 - *Bright blazar states*
- SNRs and **cosmic-ray acceleration**
- *Terrestrial Gamma-Ray Flashes up to 100 MeV*
- the **Crab Nebula** is variable !!!
- **optimal sensitivity at “low” energies ($E < 200$ MeV)**
- **VERY EFFICIENT ALERT SYSTEM FOR TRANSIENTS**

The Crab Nebula: a standard candle...

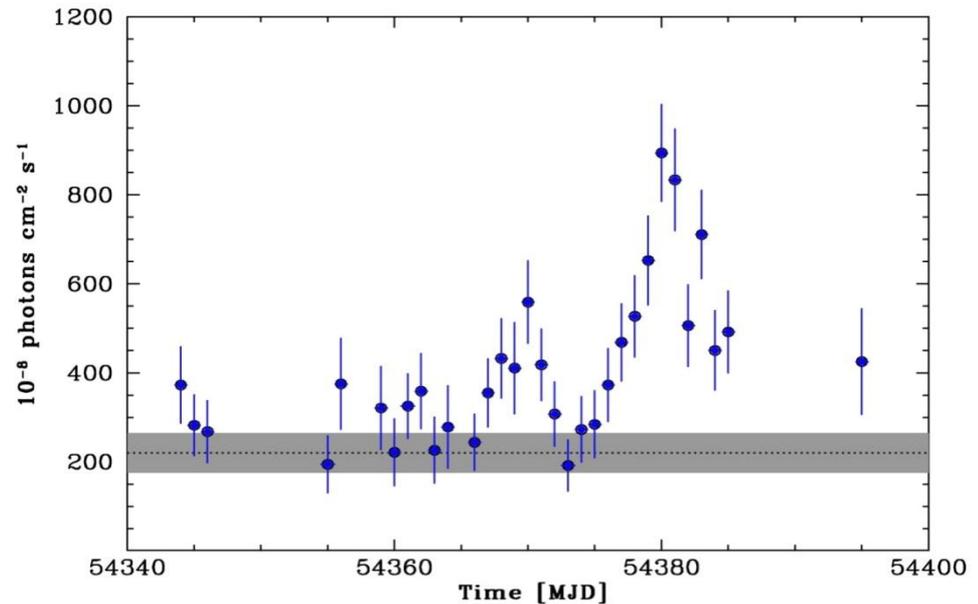
FIRST PUBLIC ANNOUNCEMENT
Sept. 22, 2010: AGILE issues the
Astronomer's Telegram n. 2855



***Science Express* (6 January 2011)**

The variable Crab Nebula !

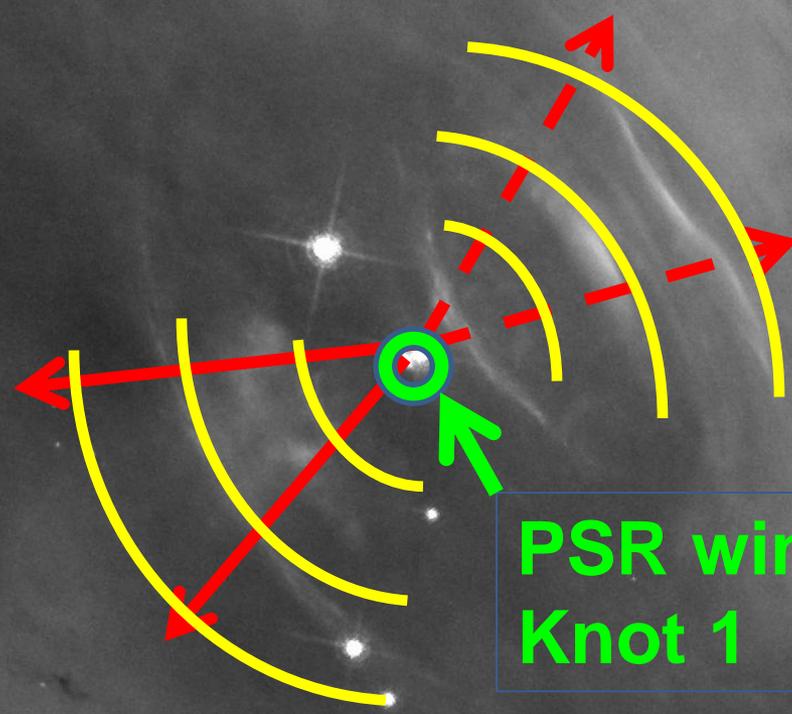
AGILE first detection of a strong gamma-ray flare in Oct. 2007



AGILE Discovery of Crab Nebula Variability: a Chronology

- April 2007: AGILE launch.
- October 2007: AGILE detects the first “anomalous” gamma-ray flare from the Crab.
- Oct. 23, 2007: AGILE team meeting and first discussion of the Crab event (STAG n. 39 Minutes of Meeting).
- Sept. 2009: Pittori et al. *Astron. & Astrophys.*, 509, 1563, 2009: “the anomalous flux from the Crab in Oct. 2007 is under investigation.”
- Sept. 19-21, 2010: detection of the second Crab γ -ray flare by the AGILE Alert System: **evidence for a repetitive phenomenon.**
- **Sept. 22, 2010: AGILE stuns the scientific community by issuing Astronomer’s Telegram 2855 announcing the discovery of a γ -ray flare from the Crab.**
- **Sept. 23, 2010: *Fermi* issues the ATel 2861 confirming the flare.**
- Sept. 28, 2010: first post-flare *Chandra* pointing.
- Oct. 2, 2010: *Hubble* points at the Crab; several pointings by *Swift*.

toroidal shocks “jet” shocks



PSR wind inner region,
Knot 1

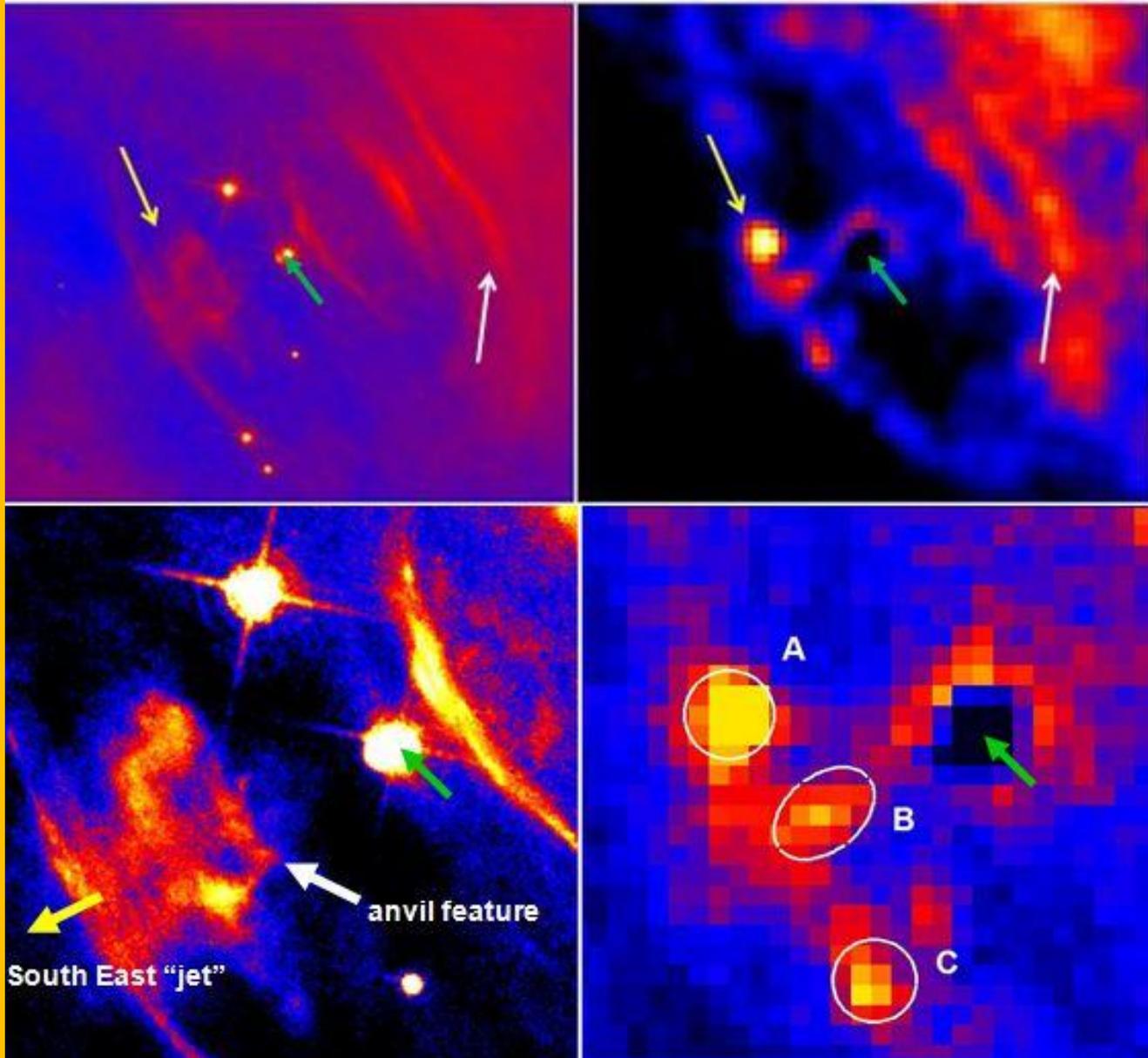
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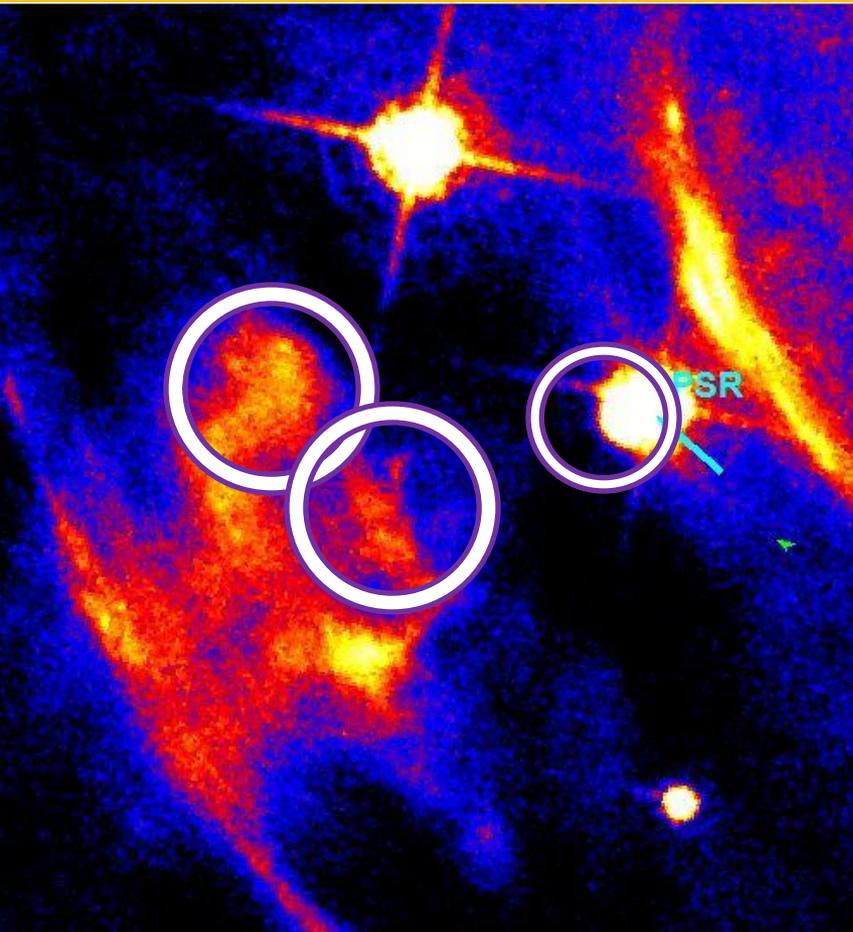


Hubble (optical) Oct. 2, 2010

Chandra (X-rays) Sept. 28, 2010



Marco Tavani, "AGILE Discovery of Gamma-Ray flares from the Crab Nebula"



PUZZLING ACCELERATION:

- fast flares imply VERY EFFICIENT particle acceleration at shocks, and “small” emission sites
 - **FAST ACCELERATION** *inconsistent with “slow” diffusion processes, a challenge to shock acceleration theory !*
- acceleration up to 10^{15} eV, 1000 times larger than Tevatron or LHC
- shock structures might be the sites of transient gamma-rays, HST and Chandra candidates

Conclusions

- **very exciting: the Crab Nebula is not a standard candle in gamma-rays**

Flare date	Duration	Peak γ -ray flux	Instruments
October 2007	~ 15 days	~ $6 \cdot 10^{-6}$ ph cm ⁻² s ⁻¹	AGILE
February 2009	~ 15 days	~ $4 \cdot 10^{-6}$ ph cm ⁻² s ⁻¹	<i>Fermi</i>
September 2010	~ 4 days	~ $5 \cdot 10^{-6}$ ph cm ⁻² s ⁻¹	AGILE, <i>Fermi</i>

- **we “lost” the stability of an ideal reference source, but gained tremendous information about the fundamental process of particle acceleration**
- **a big theoretical challenge**
- **the ultimate source of particle enhancements in the pulsar wind needs to be established: future surprises**