Gamma Astronomy with ARGO-YBJ

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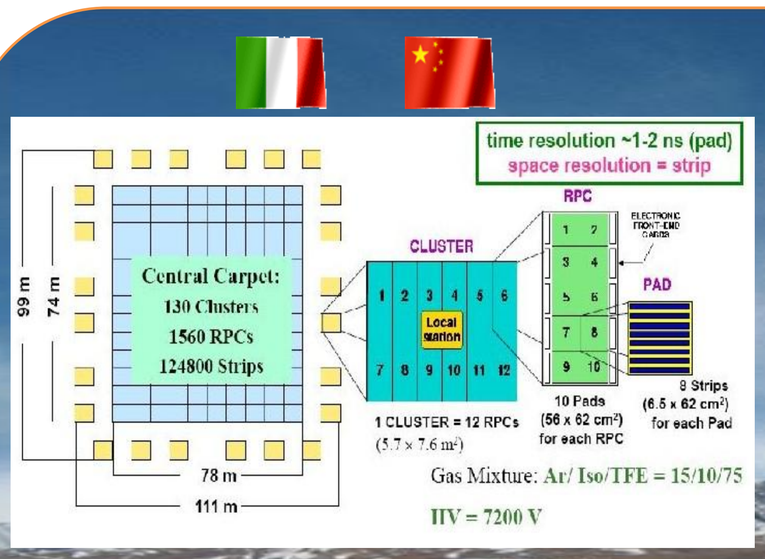
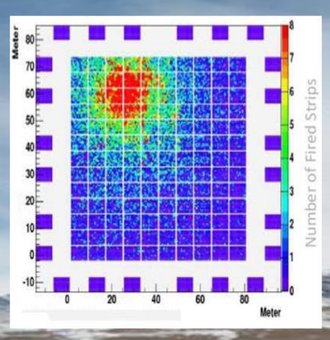


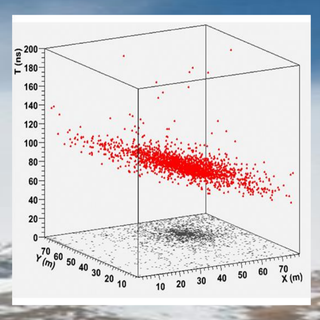
Astrophysical Radiation Ground-based Observatory @ YangBaJing

Longitude 90° 31' 50" East Latitude 30° 06' 38" North
4300 m a.s.l., Total area = 6700 m²
Full coverage (92% active surface) = 5600 m²

Shower Mode

- Cosmic-ray physics (above ~1 TeV)
- VHE γ-astronomy (above ~300 GeV)





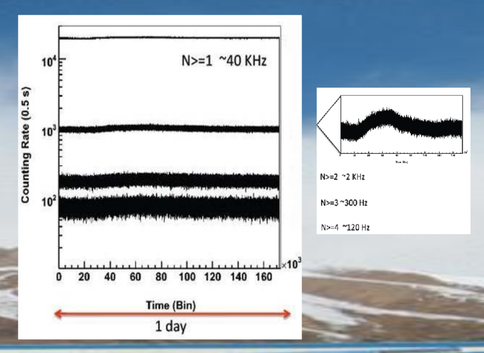
Detection of EAS (direction, size, core …)
Trigger : minimum number of fired pads within 420 ns ≥ 20 fired pads on the central carpet: rate ~3.6 kHz

Arrival direction measurement:

- Core reconstruction: Maximum Likelihood Method applied to the lateral density profile of the shower
- Fit of the shower front with a conical shape

Scaler Mode

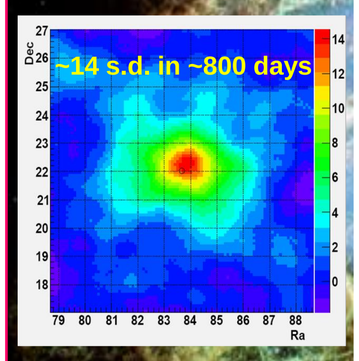
- Flaring phenomena : high energy tail of GRBs, solar flares (~1 GeV)
- Detector and environment monitor

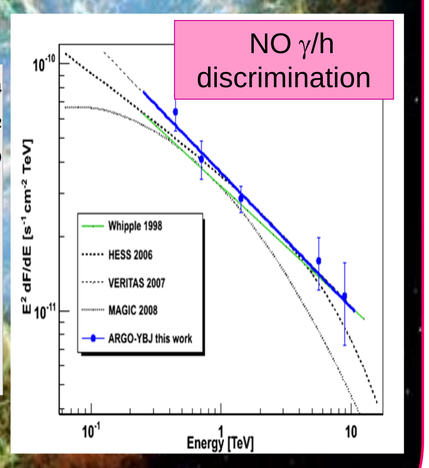


Recording the counting rates (N_{hit} ≥1, ≥2, ≥3, ≥4) for each cluster at fixed time intervals (every 0.5 s)

CRAB NEBULA

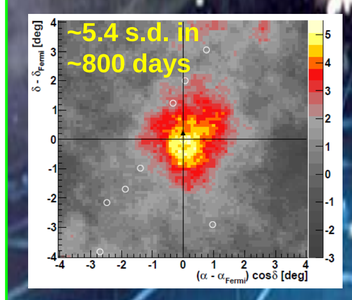
$dN/dE = (3.62\pm0.29)\cdot10^{-11}\,(E/TeV)^{-2.55\pm0.10}\ \gamma/cm^2/s/TeV$



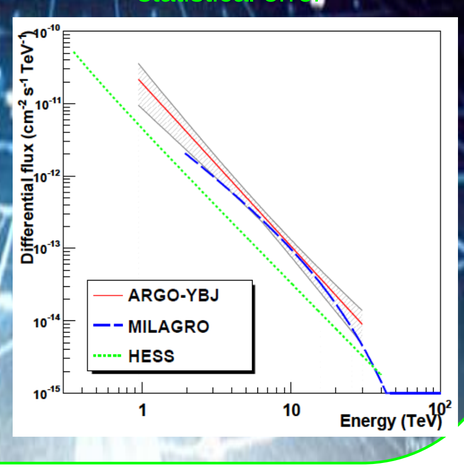


MILAGRO J1908+06

$dN/dE = (3.6\pm0.8)\cdot10^{-13}\,(E/6\ TeV)^{-2.2\pm0.3}\ \gamma/cm^2/s/TeV$

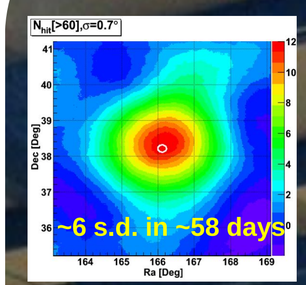


Shaded line : one standard deviation statistical error



Flux ≈ 0.8 Crab units higher than Hess one and compatible with Milagro measurements

MARKARIAN 421

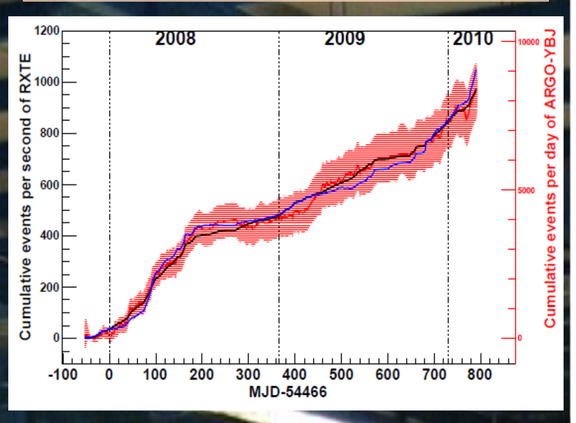


Flux ≈ 4 Crab units

- γ-ray result observed by ARGO-YBJ
- shaded red region: 1σ statistical error
- soft X-rays (2-12 keV) observed by ASM/RXTE
- hard X-rays (15-50 keV) observed by BAT/Swift: the scale has been normalized to the ASM/RXTE one.

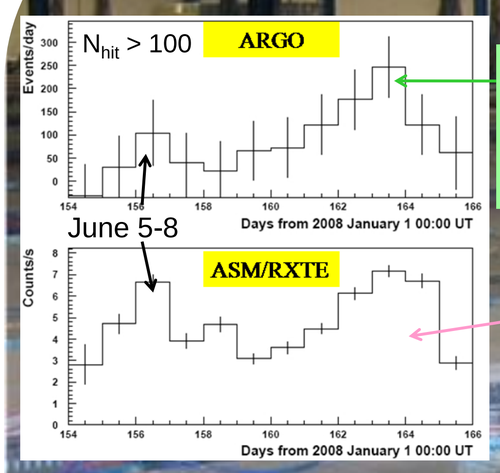
- 1st source observed by ARGO (2006 July)
- Total significance: 12 s.d. in ~800 days
- Strong flaring activity in X-rays and in TeV γ–rays.

NO Cherenkov measurements available at that time

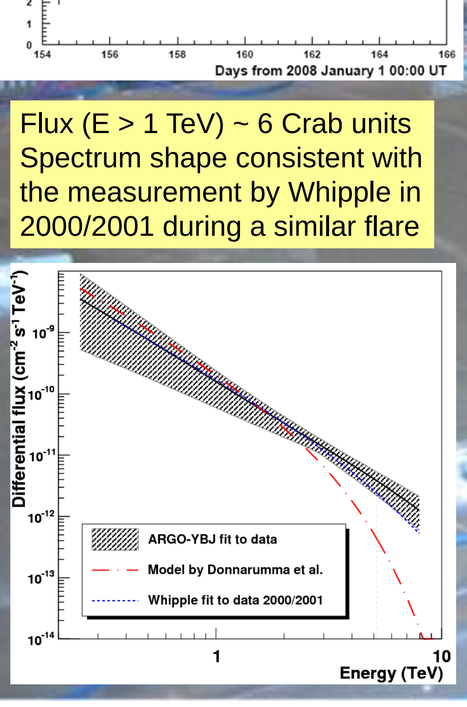


$dN/dE = (3.2\pm1.0)\cdot10^{-11}\,(E/2.5\ TeV)^{-2.1\pm0.7}\ e^{-\tau(E)}\ \gamma/cm^2/s/TeV$

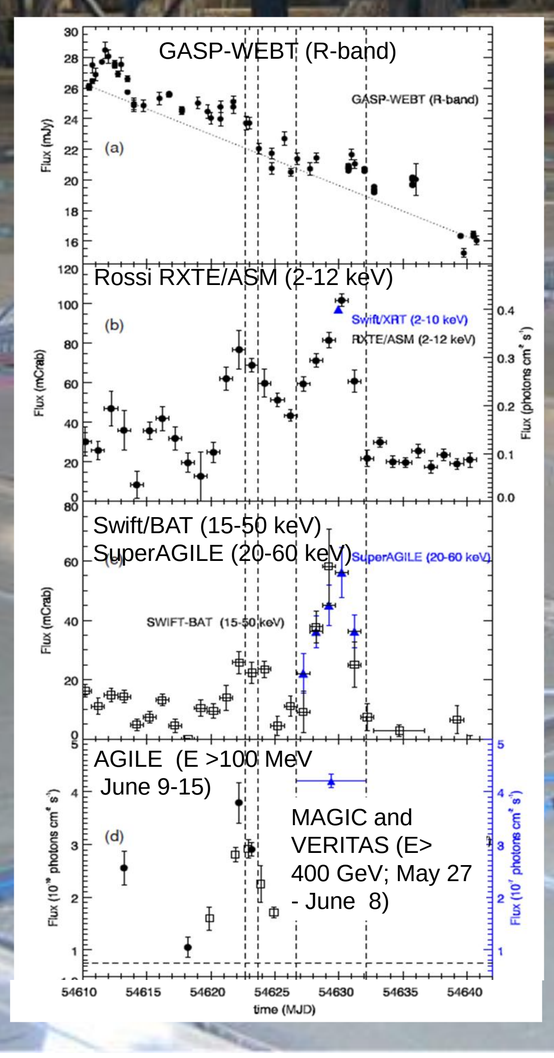
June 2008 flare



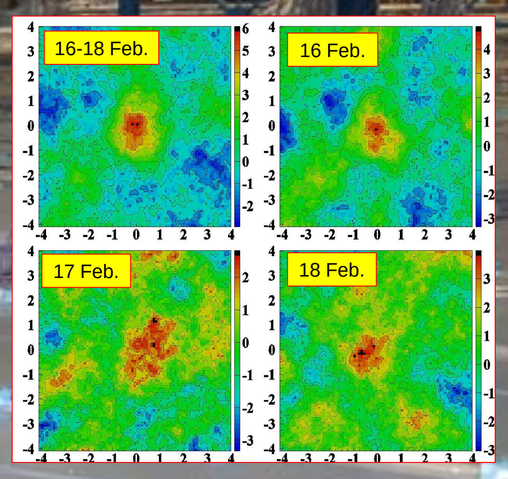
Flux (E > 1 TeV) ~ 6 Crab units
Spectrum shape consistent with the measurement by Whipple in 2000/2001 during a similar flare



NO Cherenkov data after June 8, because the moonlight hampered the Cherenkov telescopes measurements



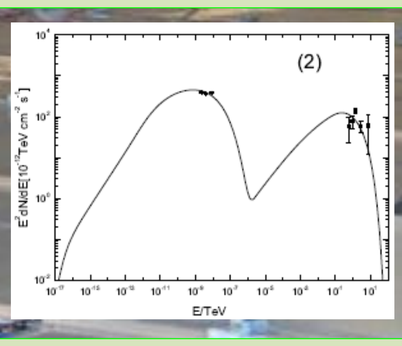
February 2010 flare



- ARGO observed a strong flare on 16-18 Feb. at 6 s.d.
- Flux > 3 Crab
- Peak flux (16 Feb) > 10 Crab
- For the first time an EAS-array observed a TeV flare at 4σ on a daily basis.
- VERITAS reported similar observation in Atel #2443.

Long-Term Monitor

- Light-curves in TeV and keV ranges are correlated.
- Time lag < 1 day
- Quadratic correlation between TeV and keV fluxes.



Construction of an homogeneous one-zone SSC model to simultaneously fit the γ-ray and X-ray emissions in different flux levels (an example in figure) by changing the electron parameters, γmax, magnetic field.

Flux variations seem to be caused by the variation of the Emax and density of the electron injection spectrum.

Evidences support the SSC model

References:

1) Vernetto, Nuclear Instruments and Methods in Physics Research A, V 630 (2011) 22-27
2) Di Sciascio, Mem. S.A.It, V 81 (2010) 326
3) Aielli et al., The Astrophysical Journal Letters, 714 (2010)
4) Donnarumma et al., proceedings of the 31st ICRC (2009)
5) Konopelko et al., The Astrophysical Journal, 679 (2008)
6) Bartoli et al., "Long-term monitor of Mrk 421 TeV emission using ARGO-YBJ experiment", The Astrophysical Journal, in press