



HEP 2013
Stockholm
18-24 July 2013
(info@eps-hep2013.eu)



RESULTS IN ASTROPARTICLE PHYSICS FROM THE ARGO- YBJ EXPERIMENT

P. Camarri *

* University of Roma Tor Vergata and INFN
on behalf of the ARGO-YBJ Collaboration

The ARGO-YBJ experiment

Collaboration Institutes:

- ✓ Chinese Academy of Science (CAS)
- ✓ Istituto Nazionale di Fisica Nucleare (INFN)



INFN and Dpt. di Fisica Università, Lecce
INFN and Dpt. di Fisica Università', Napoli
INFN and Dpt. di Fisica Università', Pavia
INFN and Dpt di Fisica Università "Roma Tre", Roma
INFN and Dpt. di Fisica Univesità "Tor Vergata", Roma
INAF/IFSI and INFN, Torino
INAF/IASF, Palermo and INFN, Catania



IHEP, Beijing
Shandong University, Jinan
South West Jiaotong University, Chengdu
Tibet University, Lhasa
Yunnan University, Kunming
Hebei Normal University, Shijiazhuang

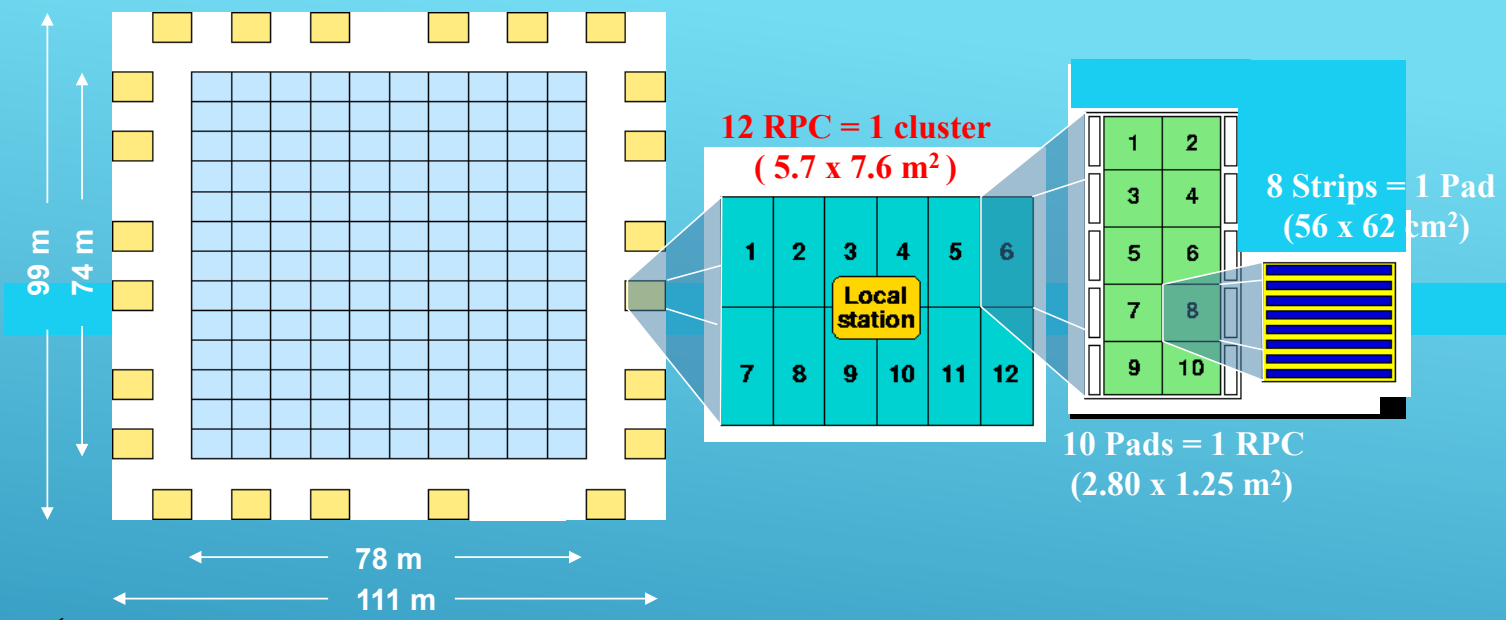


Nucl.Instrum.Meth.A562:92-96,2006
Nucl.Instrum.Meth.A608:246-250,2009

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- ▶ The ARGO-YBJ detector: performance
- ▶ γ -ray galactic sources
- ▶ AGN flares
- ▶ Cosmic Rays: spectrum and anisotropy
- ▶ Summary

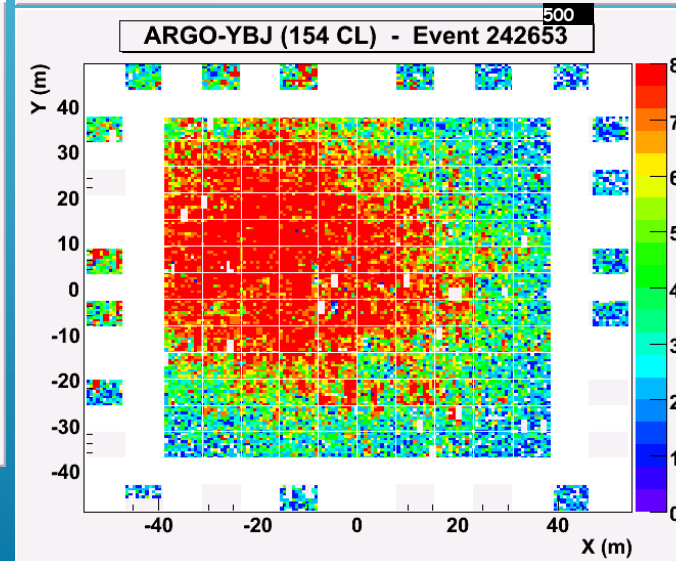
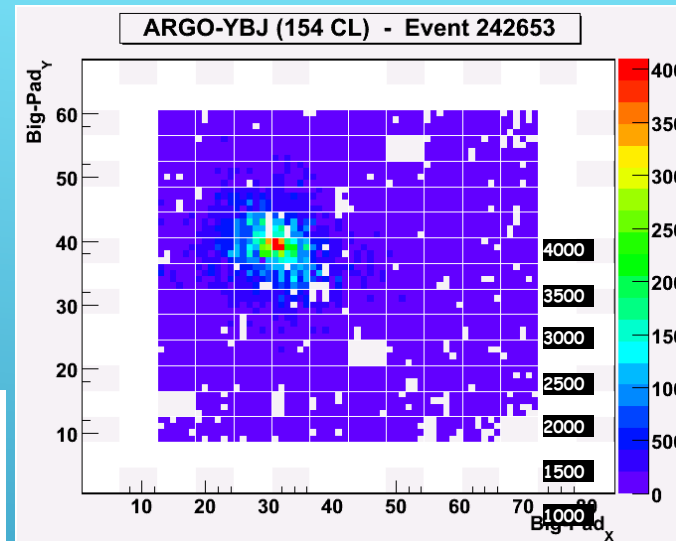
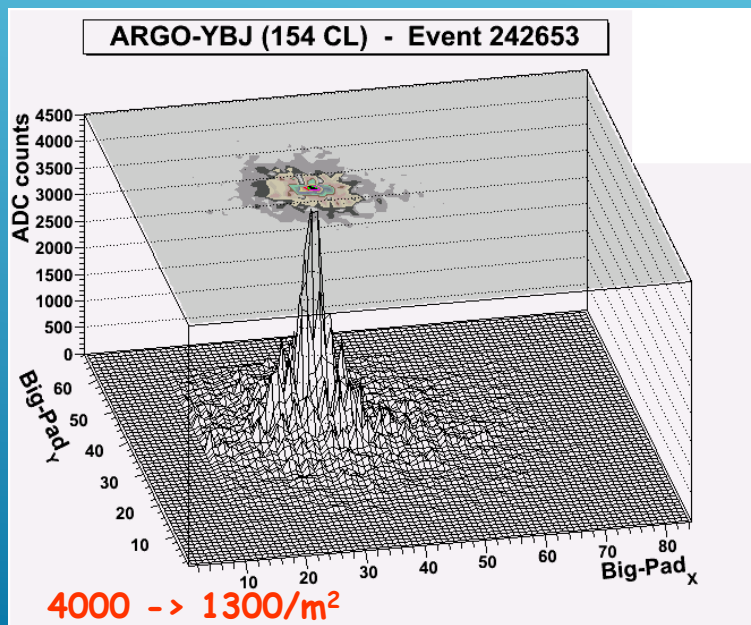
OUTLINE



Effective Area : central carpet ~ 5600 m²
 sampling guard-ring ~ 1000 m²

- ✓ Data taking: November 2007 - February 2013 (5 X 10¹¹ events)
- ✓ Trigger rate: 3.6 KHz
- ✓ Duty cycle: 86%
- ✓ Dead time: 4%
- ✓ Energy range: 300 GeV - few PeV

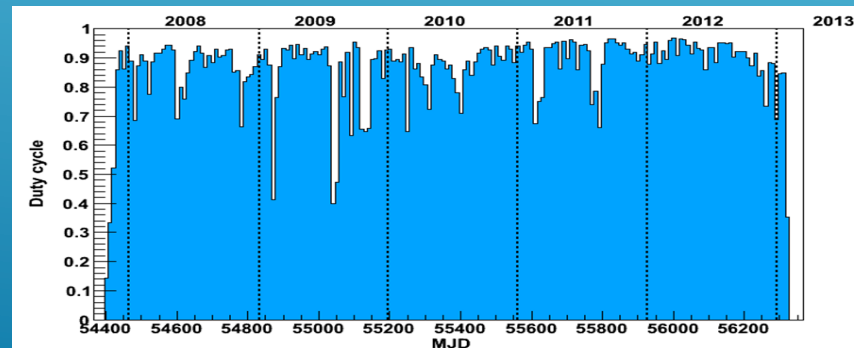
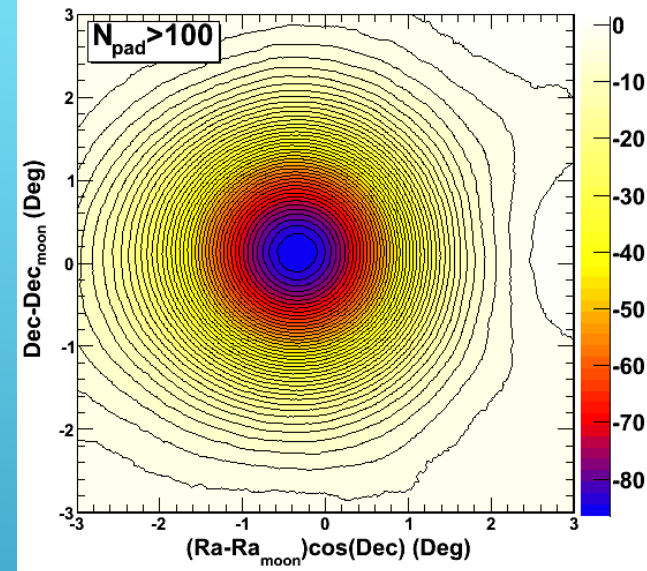
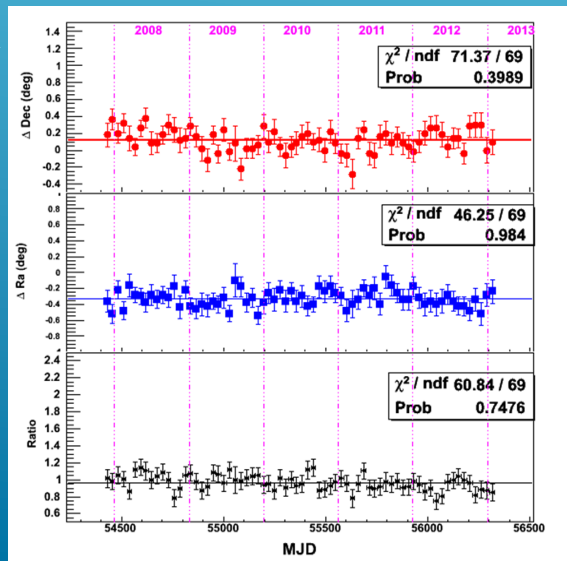
A typical event by ARGO-YBJ



ARGO-YBJ

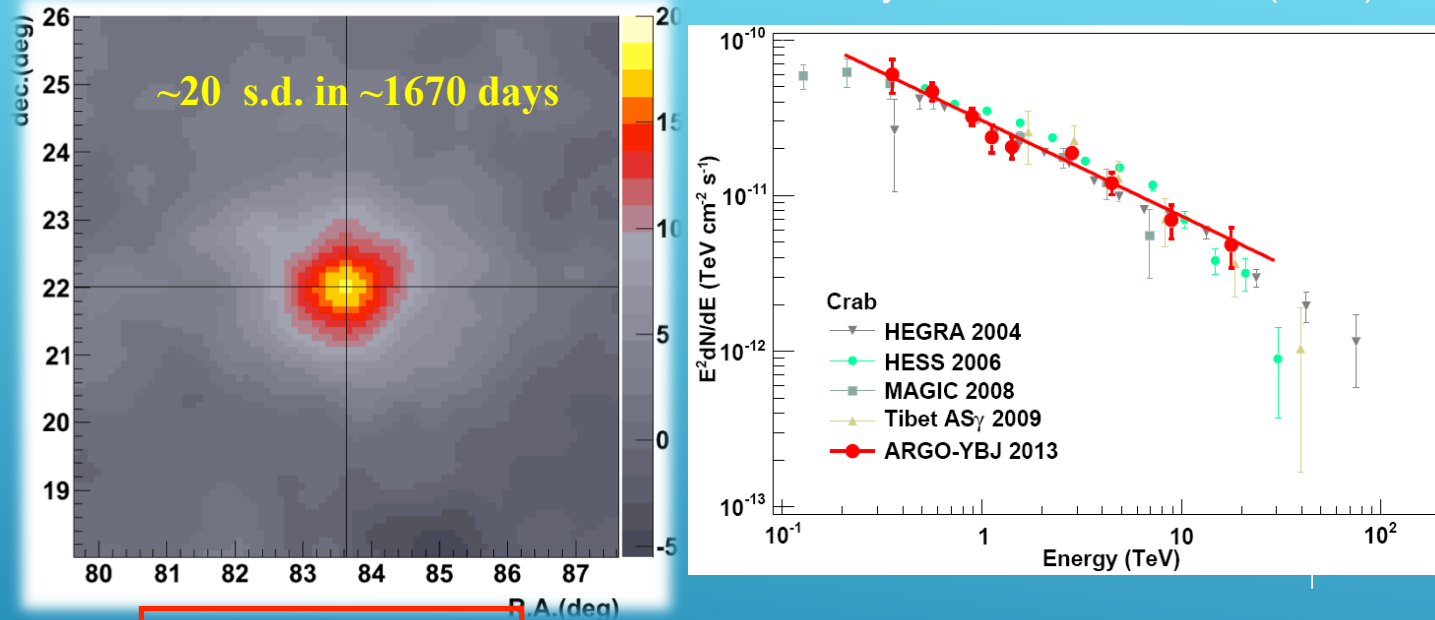
STABLE OPERATION IN 5 YRS

- ▶ duty cycle > 85%
- ▶ event rate $\pm 5\%$
- ▶ Moon shadow: 10 s.d. / month



Crab Nebula(Standard candel)

Nuclear Instruments and Methods in Physics Research A 661 (2012)



NO γ/h discrimination
 ~0.55 Crab/year

$$\frac{dN}{dE} = (3.00 \pm 0.18_{stat})(E / 1 \text{ TeV})^{(-2.62 \pm 0.06_{stat})} \times 10^{-11} \text{ cm}^{-2} \text{ s}^{-1} \text{ TeV}^{-1}$$

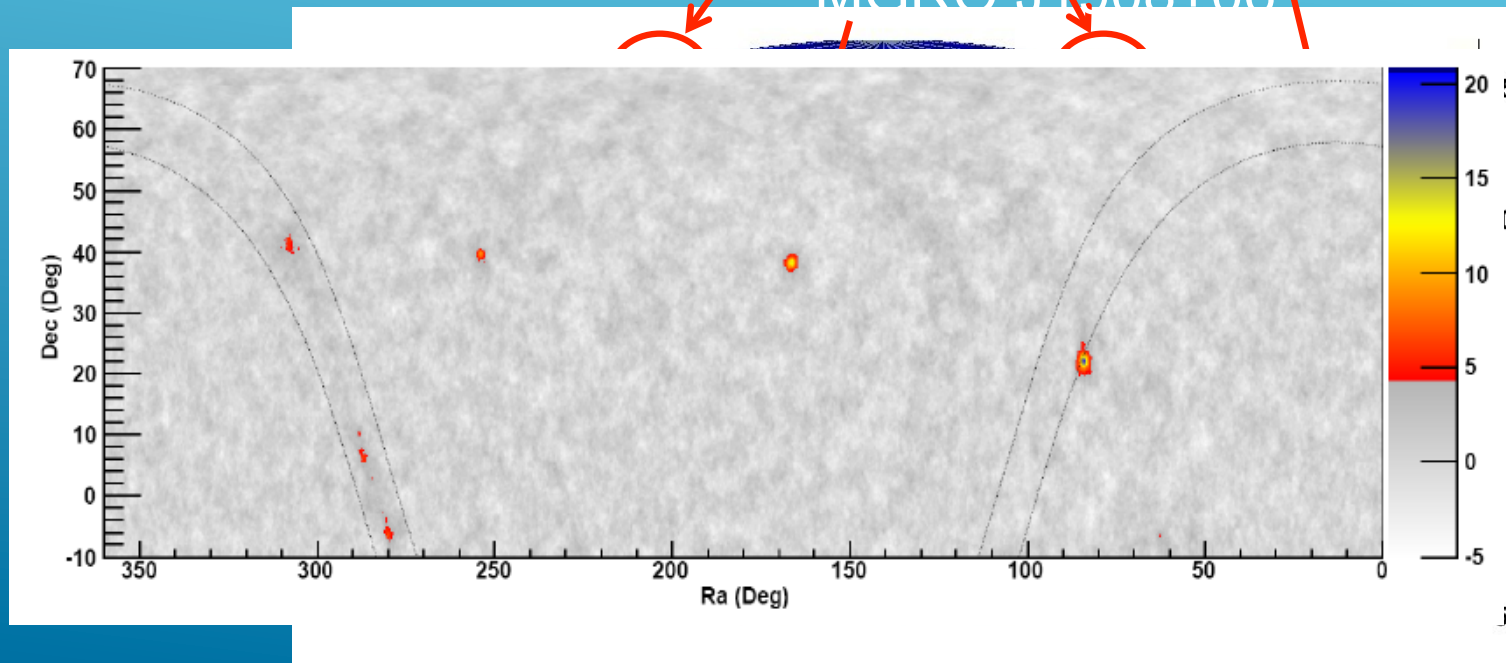
ARGO全天扫描

1670days

Mrk421

Crab

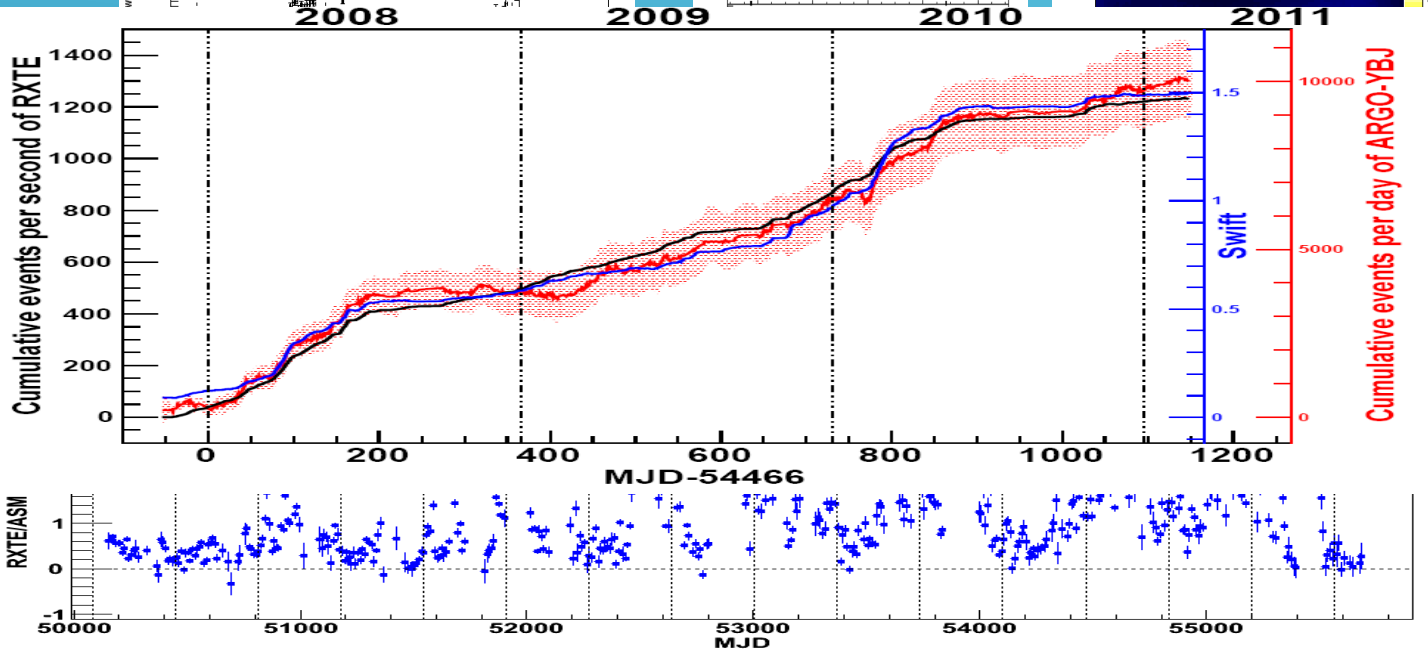
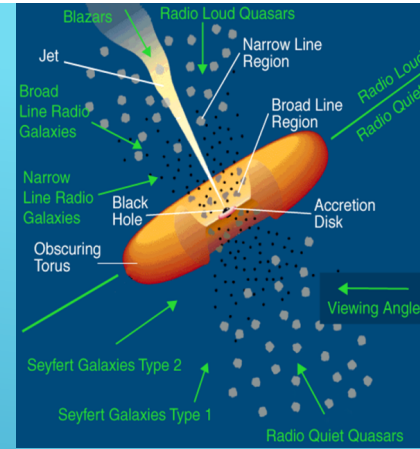
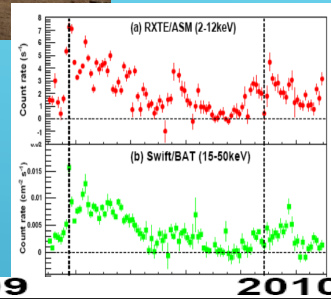
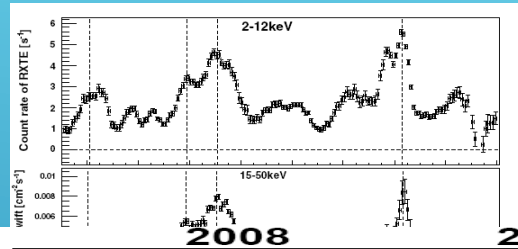
MGRO J1908+06



ARGO-YBJ GAMMA RAY SOURCES

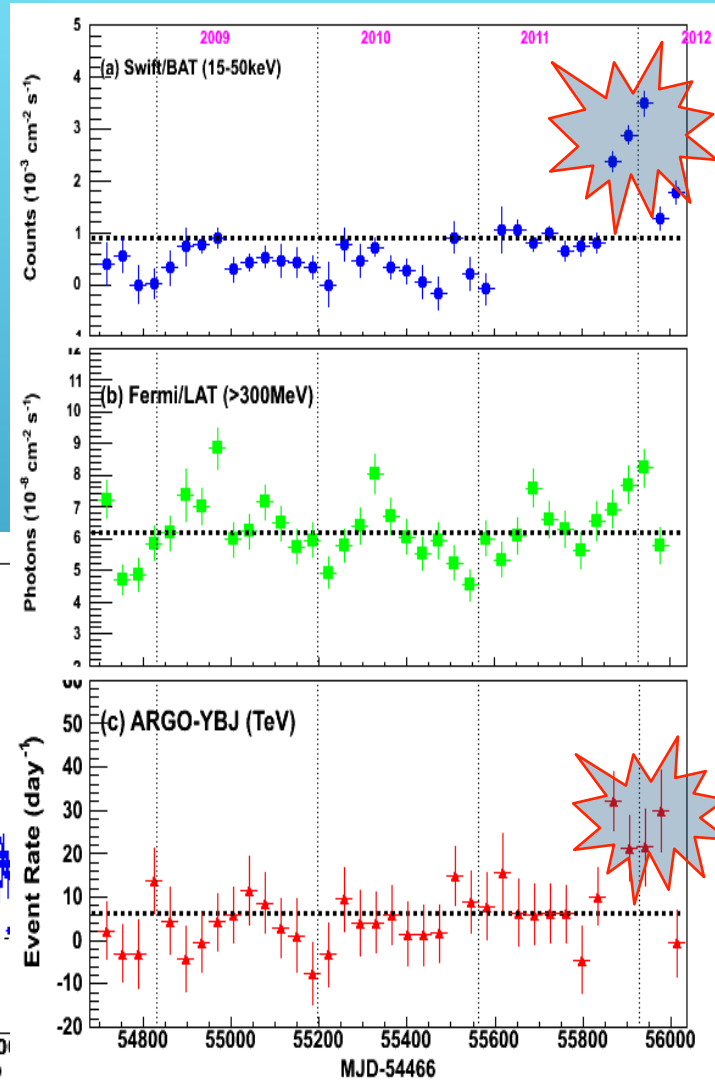
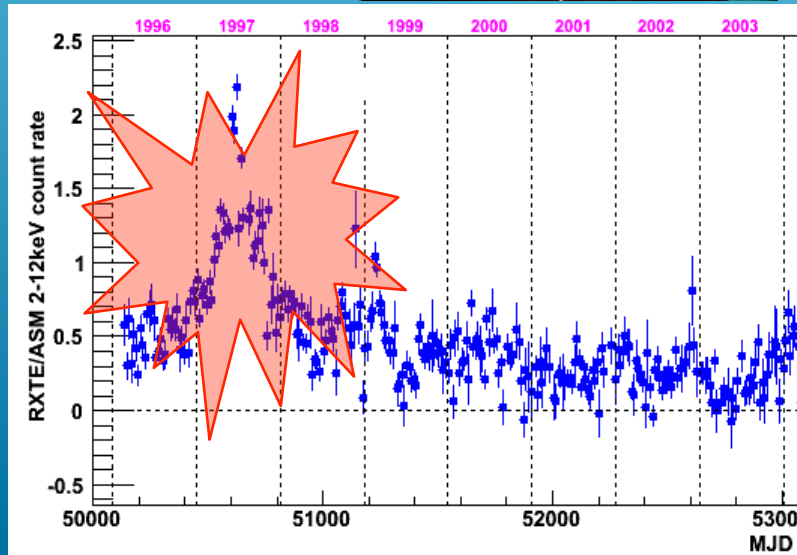
ARGO-YBJ Name	Ra (deg)	Dec (deg)	l (deg)	b (deg)	S (S.D.)	Associated TeV Source
ARGO J0409-0627	62.35	-6.45	198.51	-38.73	4.8	
ARGO J0535+2203	83.75	22.05	184.59	-5.67	20.8	Crab Nebula
ARGO J1105+3821	166.25	38.35	179.43	65.09	14.1	Mrk 421
ARGO J1654+3945	253.55	39.75	63.59	38.80	9.4	Mrk 501
ARGO J1839-0627	279.95	-6.45	25.87	-0.36	6.0	HESS J1841-055
ARGO J1907+0627	286.95	6.45	40.53	-0.68	5.3	HESS J1908+063
ARGO J1910+0720	287.65	7.35	41.65	-0.88	4.3	
ARGO J1912+1026	288.05	10.45	44.59	0.20	4.2	HESS J1912+101
ARGO J2021+4038	305.25	40.65	78.34	2.28	4.3	VER J2019+407
ARGO J2031+4157	307.95	41.95	80.58	1.38	6.1	MGRO J2031+41 TeV J2032+4130
ARGO J1841-0332	280.25	-3.55	28.58	0.70	4.2	

MRK421 MONITORING



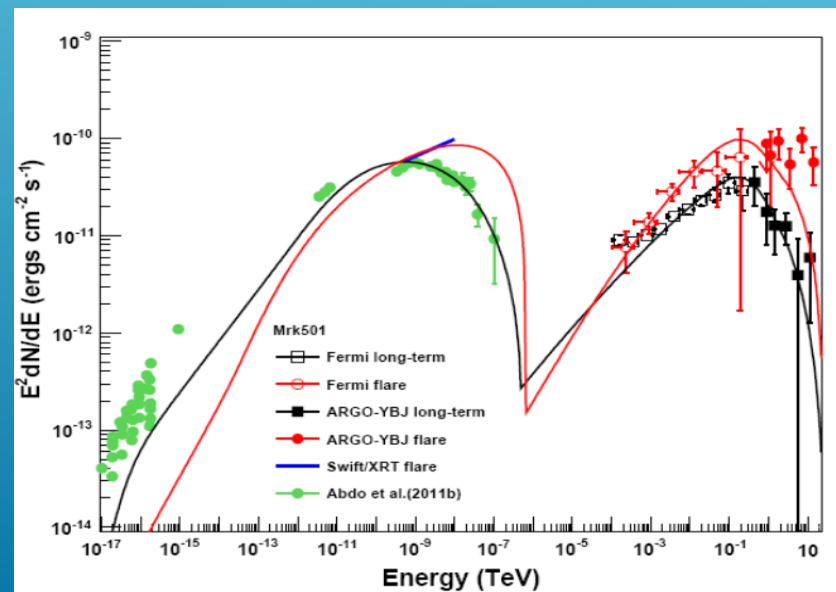
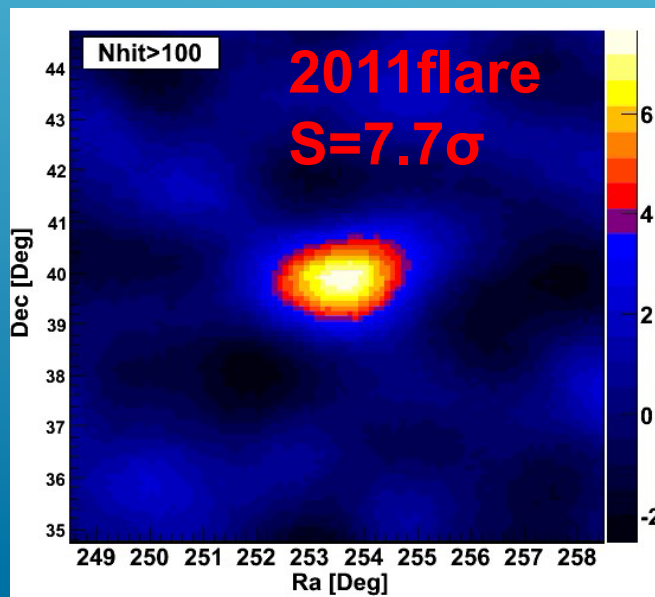
AGN : TRANSIENTS

MRK501



SED ANALYSIS FOR RADIATION MECHANISM

- ▶ For steady states, the SSC model is favored.
- ▶ **During flares, the spectrum is hardened.**
Simple SSC model is not favored
- ▶ Evolution is well observed



COSMIC RAY PHYSICS

- ▶ Light component (p+He) energy spectrum
- ▶ CR anisotropy in the few TeV region
- ▶ Compton Getting effect
- ▶ Mass composition studies
- ▶ Antiproton to proton ratio
- ▶ Hadronic interaction studies
- ▶ Horizontal air showers
- ▶ Geomagnetic effects
- ▶ Atmospheric effects
- ▶ Sun shadow and solar activity

ENERGY SCALE: MOON SHADOW DISPLACEMENT

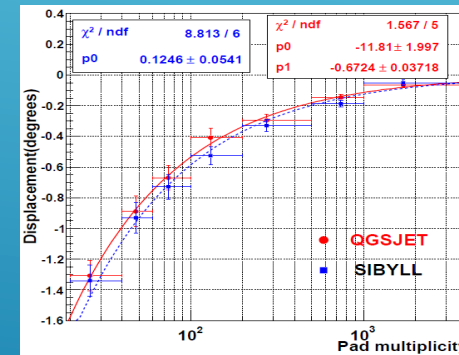
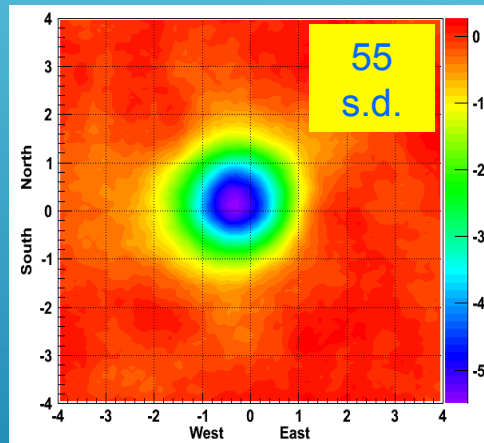
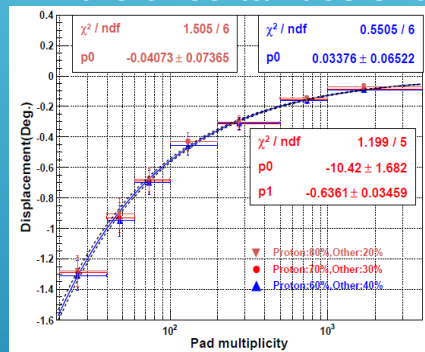


$$N \approx 21 \cdot (E_{\text{TeV}}/Z)^{1.5}$$

1 – 30 (TeV/Z)

Two systematic uncertainties may affect the Multiplicity-Energy relation:

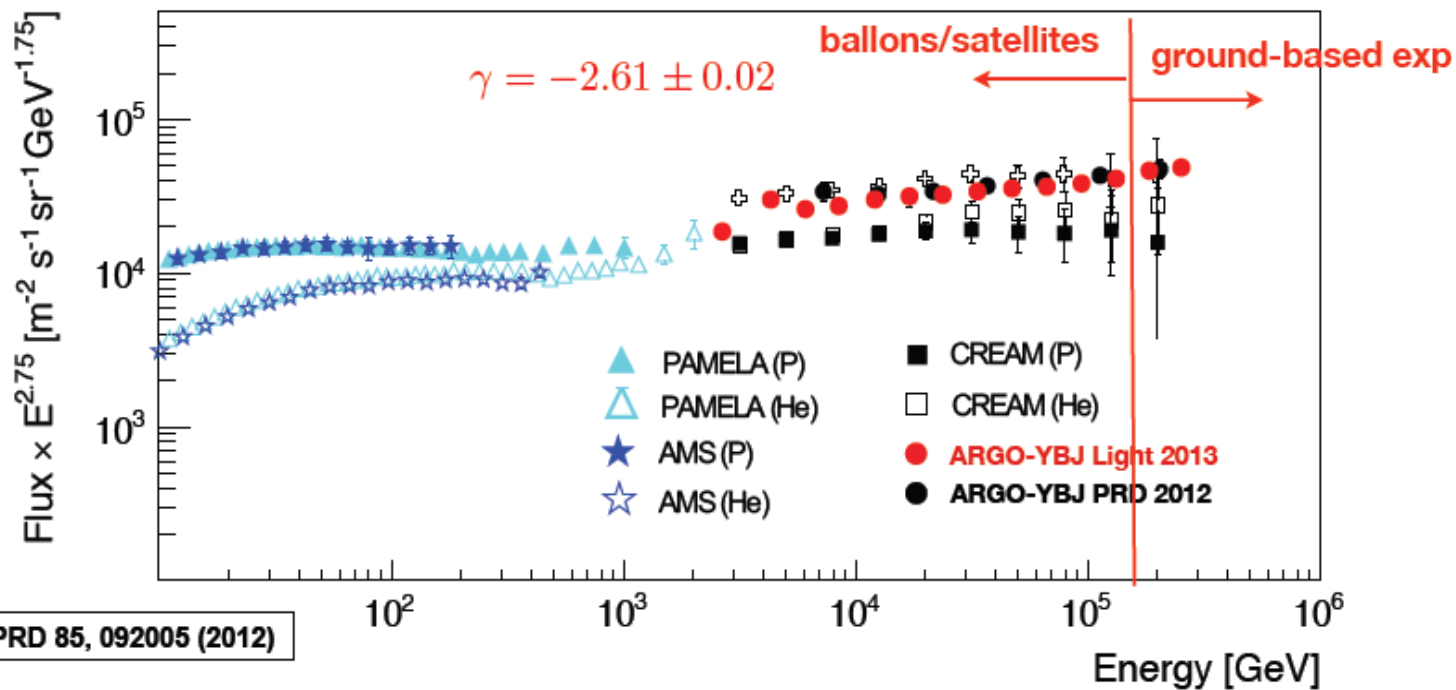
- the assumed primary CR chemical composition (7%)
- the uncertainties of different hadronic models (6%)



The energy scale error is estimated to be less than 13% in the energy range 1 – 30 (TeV/Z).

CR ENERGY SPECTRUM BY ARGO-YBJ:

Measurement of the **light-component (p+He)** CR spectrum in the energy region (2.5 – 300) TeV via a Bayesian unfolding procedure



PRD 85, 092005 (2012)

PRD.85,092005 (2012)

Medium Scale Anisotropy

Data: November 8, 2007 - May 20, 2012

$\approx 3.70 \times 10^{11}$ events

dec. region $\delta \sim -20^\circ \div 80^\circ$

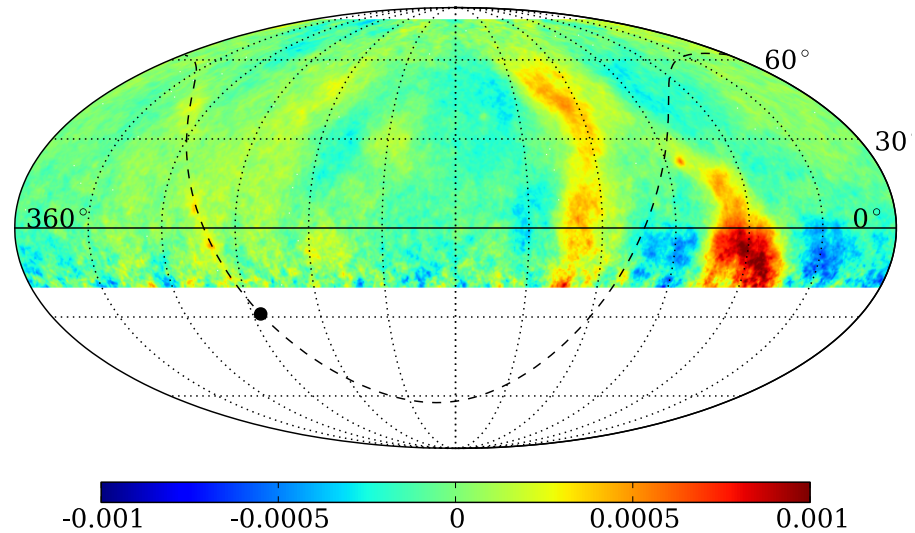
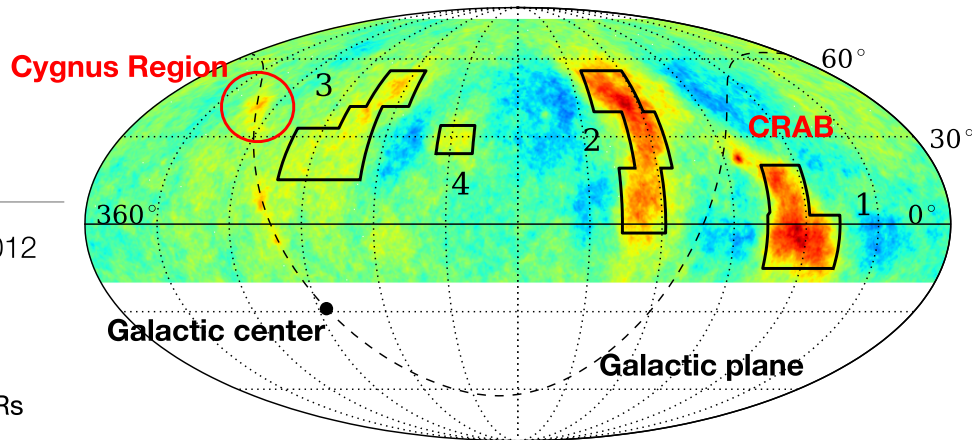
Map smoothed with the detected PSF for CRs

Proton median energy ≈ 1 TeV

**CRs excess $\approx 0.1\%$
with significance up to 15 s.d.**

Strip-multiplicity interval	number of events	E_p^{50} [TeV]
25 – 40	1.1409×10^{11} (38%)	0.66
40 – 100	1.4317×10^{11} (48%)	1.4
100 – 250	3.088×10^{10} (10%)	3.5
250 – 630	8.86×10^9 (3%)	7.3
more than 630	3.52×10^9 (1%)	20

TABLE I: Multiplicity intervals used in the analysis. The central columns report the number of events collected. The right column shows the corresponding isotropic CR proton median energy.



SUMMARY

- ▶ ARGO-YBJ has operated very stably for over 5 years, until February 2013, the overall significance on the standard candle Crab-Nebula having reached 20 s.d.
- ▶ 6 VHE gamma-ray sources were observed in the all-sky survey at a level of 0.25 crab unit. Both spatially extended and temporally flaring sources were investigated in very significant ways that deepen the knowledge about the radiation mechanism of the sources.
- ▶ The energy spectrum of CR proton and Helium were well measured at energies above 10 TeV up to 0.8 PeV with all the systematic issues under control.
- ▶ The anisotropy of CR arrival directions was investigated at both large and medium spatial scales.
- ▶ An effort to restart the ARGO-YBJ data taking is being done presently, and a major step to upgrade VHE gamma-ray and cosmic-ray observation at high altitudes (>4300m) has been proposed to the Chinese major funding agency. The same issue is under consideration by the INFN.