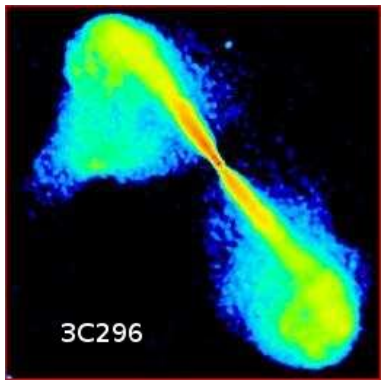
Les blazars les plus énergétiques vus par *Fermi*

David Sanchez et Berrie Giebels
pour la collaboration *Fermi* LAT.

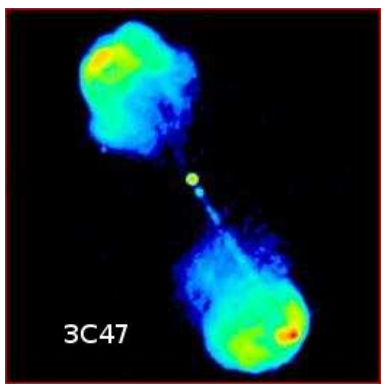
Laboratoire Leprince-Ringuet École polytechnique,
CNRS/IN2P3

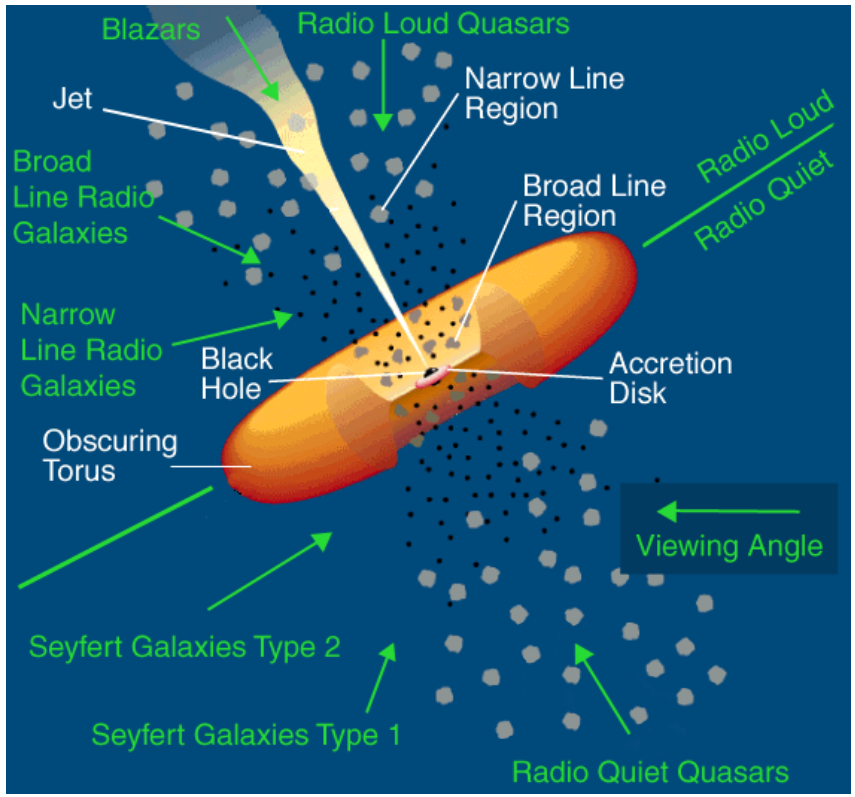
26 mars 2011

Fanaroff-Riley I $\rightarrow$ BL Lacs

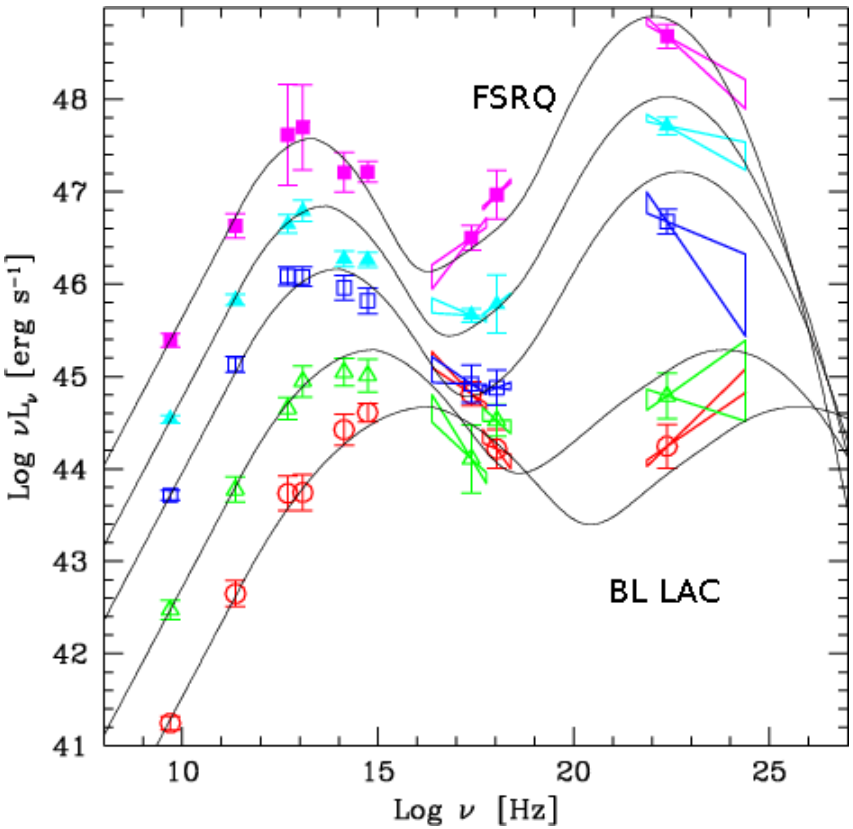


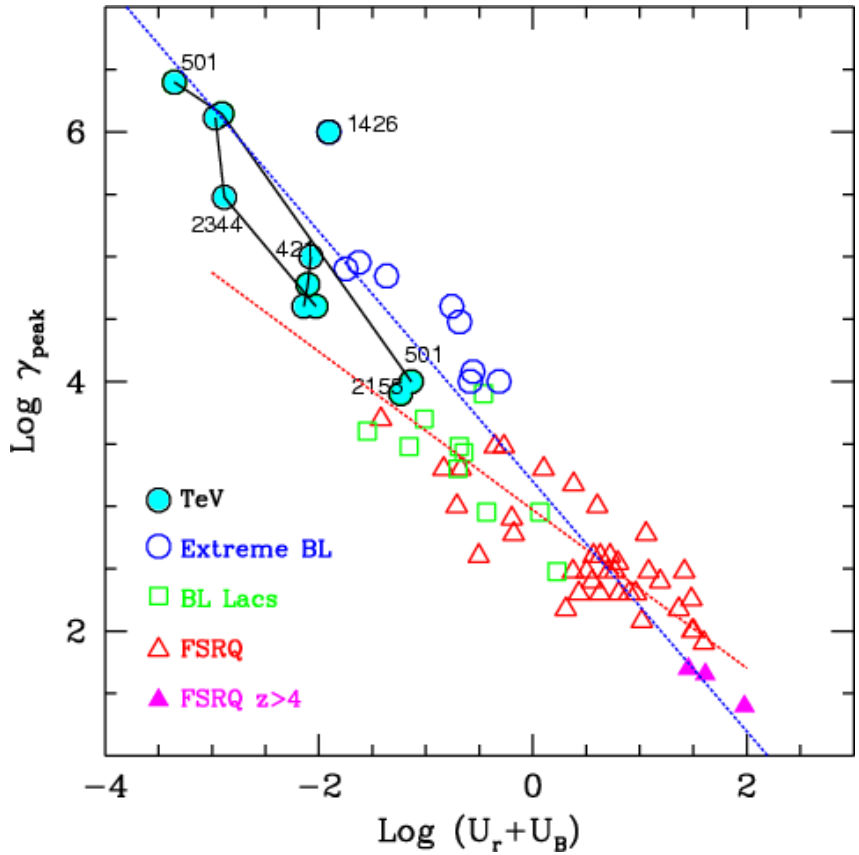
Fanaroff-Riley II $\rightarrow$ FSRQ





Sequence Blazar (Fossati et al, 1998)

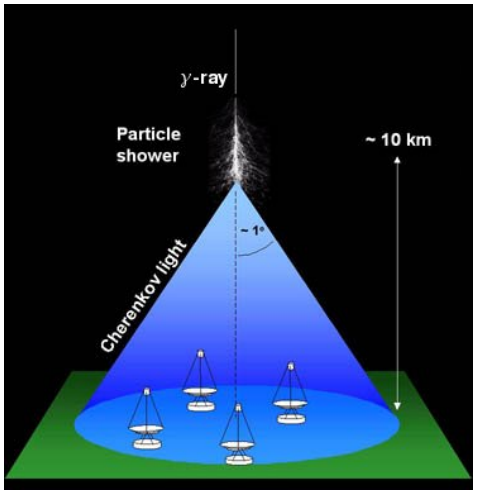




- I_{pic}^{BF} / I_{pic}^{HF} diminue quand quand L augmente
- L augmente, ν_{pic} diminue
- blazars vus au TeV : *high-frequency peaked BL LAC* (HBL)

Large Array Telescope : LAT

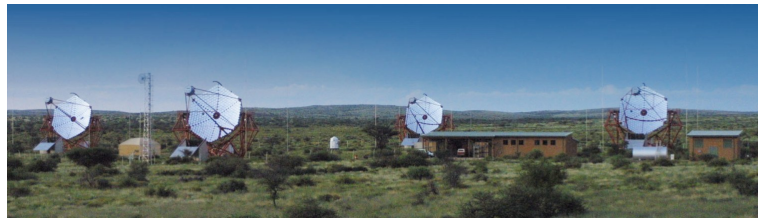
Dernière génération de télescopes



MAGIC I et II

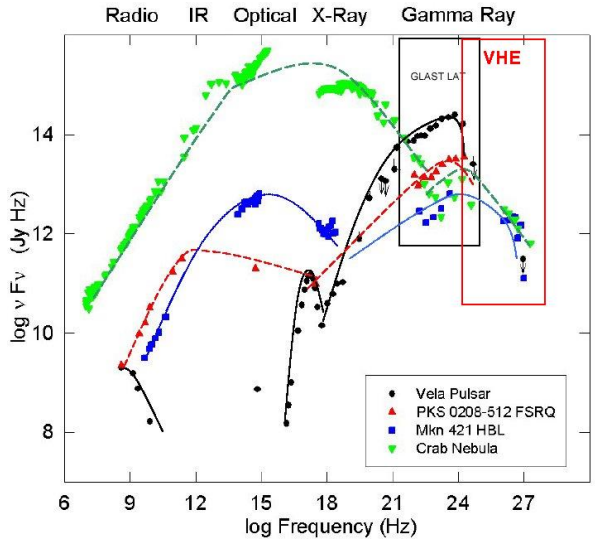
VERITAS

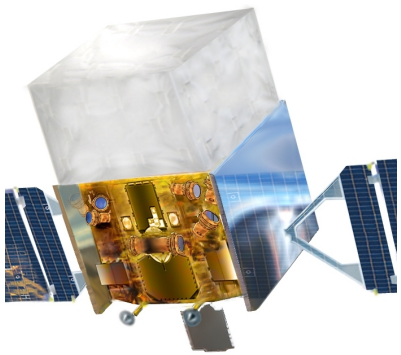
HESS

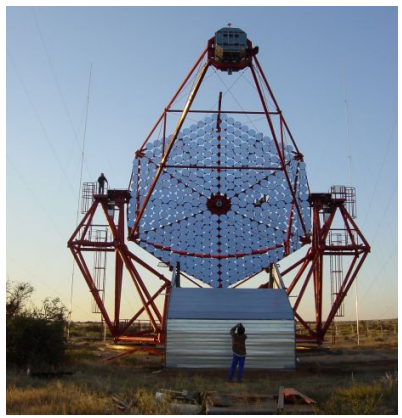


Synergie Sol/Spatial

- Recouvrement en énergie
- Bonne sensibilité : pic HE bien contraint
- Inter-calibration







LAT
100 MeV - 300 GeV
24 heures - $>$ 1 semaine

ACT
$\approx$ 100 GeV - 10 TeV
$\approx$ minutes - 1 nuit

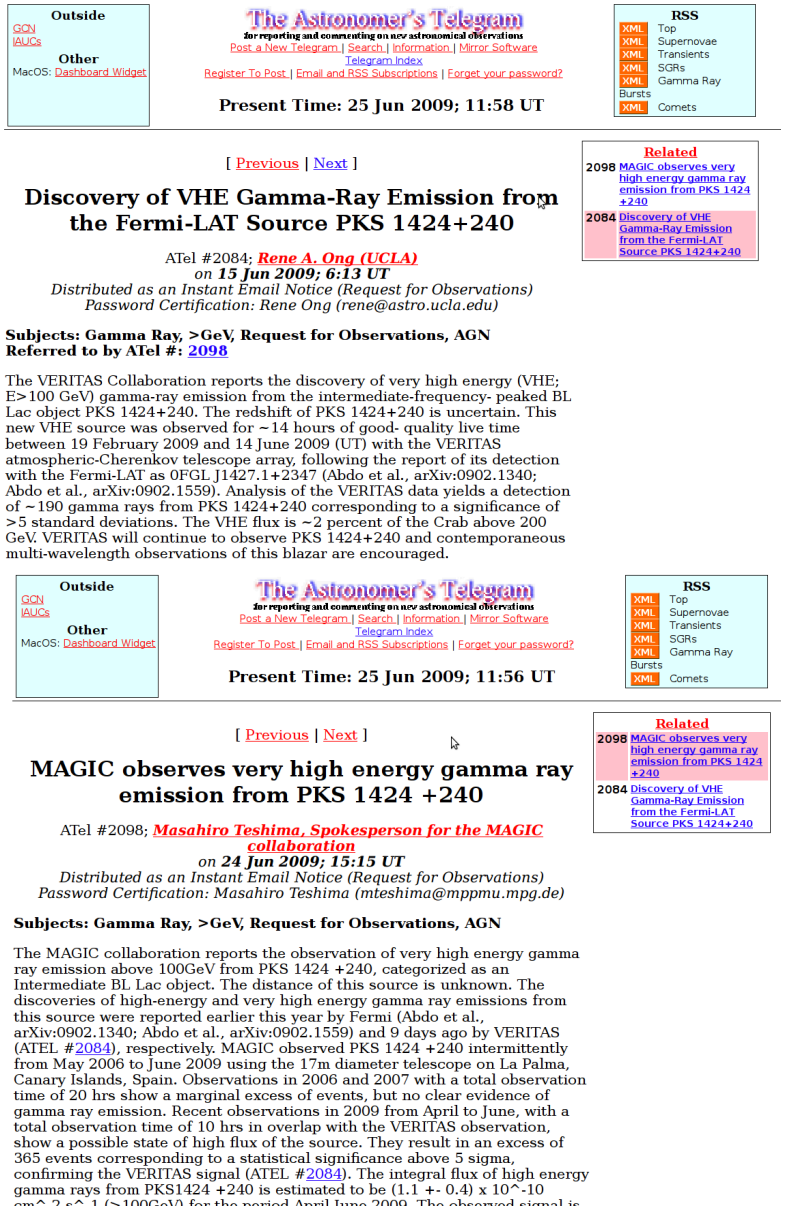
LAT comme *"all-sky monitor"*

- Champ de vue : 2.2 stéradian
- Duty Cycle 90%
- 36 ATEL

Oriente les observations TeV

Ex **PKS 1424+240**

- Source *Fermi* brillante ($> 10\sigma$)
- Détectée par VERITAS puis MAGIC



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2098 MAGIC observes very high energy gamma ray emission from PKS 1424 +240
2084 Discovery of VHE Gamma-Ray Emission from the Fermi-LAT Source PKS 1424+240

Discovery of VHE Gamma-Ray Emission from the Fermi-LAT Source PKS 1424+240

ATel #2084; ***Rene A. Ong (UCLA)***
*on **15 Jun 2009; 6:13 UT***
Distributed as an Instant Email Notice (Request for Observations)
Password Certification: Rene Ong (rene@astro.ucla.edu)

Subjects: Gamma Ray, >GeV, Request for Observations, AGN
Referred to by ATel #: 2098

The VERITAS Collaboration reports the discovery of very high energy (VHE; E>100 GeV) gamma-ray emission from the intermediate-frequency- peaked BL Lac object PKS 1424+240. The redshift of PKS 1424+240 is uncertain. This new VHE source was observed for ~14 hours of good- quality live time between 19 February 2009 and 14 June 2009 (UT) with the VERITAS atmospheric-Cherenkov telescope array, following the report of its detection with the Fermi-LAT as 0FGL J1427.1+2347 (Abdo et al., arXiv:0902.1340; Abdo et al., arXiv:0902.1559). Analysis of the VERITAS data yields a detection of ~190 gamma rays from PKS 1424+240 corresponding to a significance of >5 standard deviations. The VHE flux is ~2 percent of the Crab above 200 GeV. VERITAS will continue to observe PKS 1424+240 and contemporaneous multi-wavelength observations of this blazar are encouraged.

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2098 MAGIC observes very high energy gamma ray emission from PKS 1424 +240
2084 Discovery of VHE Gamma-Ray Emission from the Fermi-LAT Source PKS 1424+240

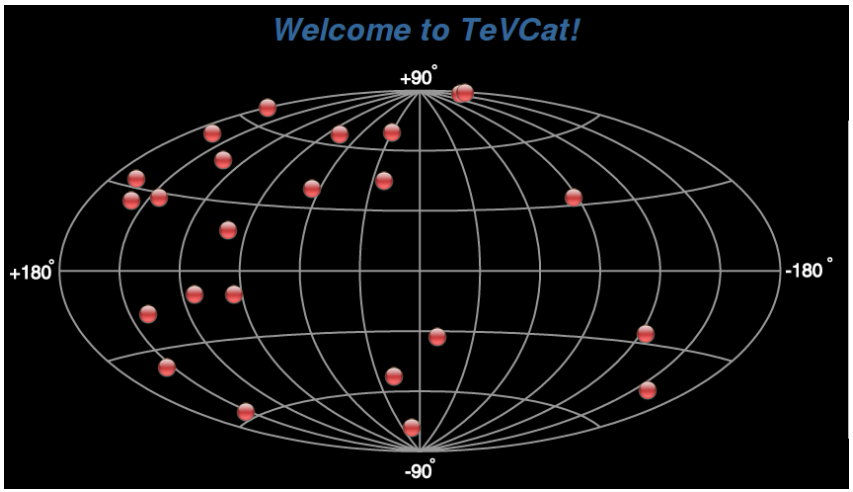
MAGIC observes very high energy gamma ray emission from PKS 1424 +240

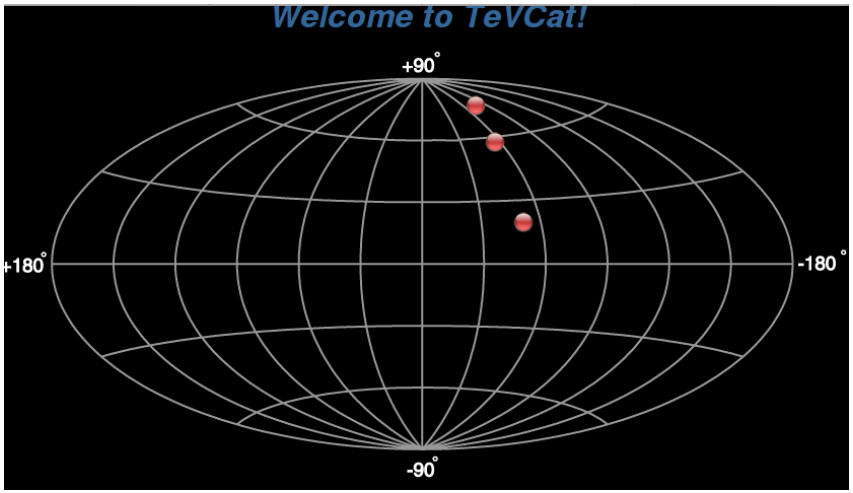
ATel #2098; ***Masahiro Teshima, Spokesperson for the MAGIC collaboration***
*on **24 Jun 2009; 15:15 UT***
Distributed as an Instant Email Notice (Request for Observations)
Password Certification: Masahiro Teshima (mteshima@mppmu.mpg.de)

Subjects: Gamma Ray, >GeV, Request for Observations, AGN

The MAGIC collaboration reports the observation of very high energy gamma ray emission above 100GeV from PKS 1424 +240, categorized as an Intermediate BL Lac object. The distance of this source is unknown. The discoveries of high-energy and very high energy gamma ray emissions from this source were reported earlier this year by Fermi (Abdo et al., arXiv:0902.1340; Abdo et al., arXiv:0902.1559) and 9 days ago by VERITAS (ATEL #2084), respectively. MAGIC observed PKS 1424 +240 intermittently from May 2006 to June 2009 using the 17m diameter telescope on La Palma, Canary Islands, Spain. Observations in 2006 and 2007 with a total observation time of 20 hrs show a marginal excess of events, but no clear evidence of gamma ray emission. Recent observations in 2009 from April to June, with a total observation time of 10 hrs in overlap with the VERITAS observation, show a possible state of high flux of the source. They result in an excess of 365 events corresponding to a statistical significance above 5 sigma, confirming the VERITAS signal (ATEL #2084). The integral flux of high energy gamma rays from PKS1424 +240 is estimated to be (1.1 +- 0.4) x 10^-10

Le ciel extragalactique à Tres Haute Energie





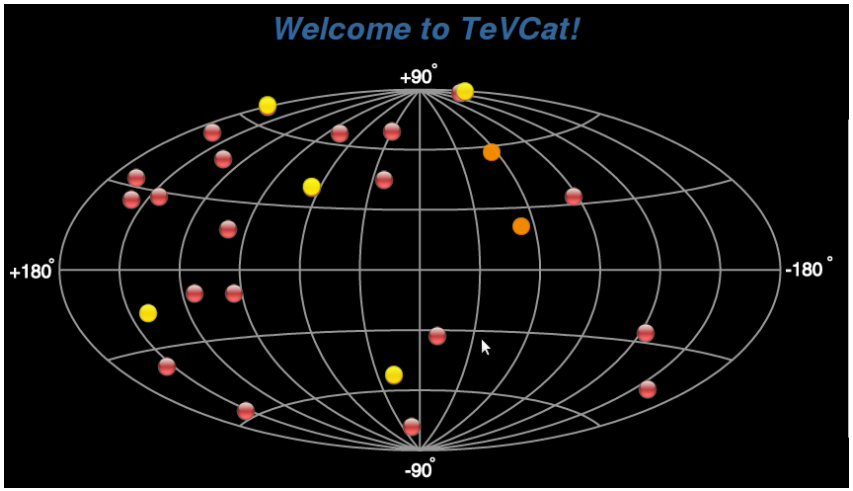
BL LAC

- Environ 25 BL Lac
- Sources 'soft' au TeV ($\Gamma > 2$)

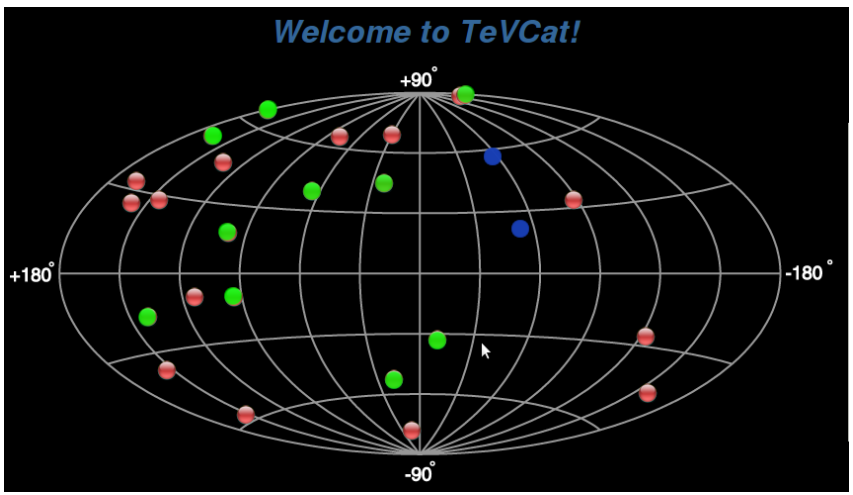
Radio-Galaxies
(M87 et Centaurus A)
FSRQ (3C 279)

`http://tevcat.uchicago.edu/`

Le ciel TeV vue par *Fermi*



Sources detectées par EGRET entre 1991 et 2000
7 sources dont Cen A et 3C 279



LAT bright AGN source (LBAS)
Abdo et al, 2009
sources brillantes détectées à 10 σ en 3 mois
12 sources en commun avec les catalogues TeV

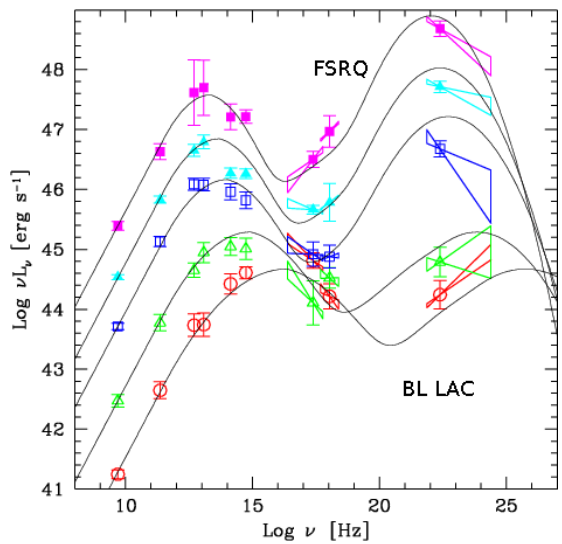
Acceptance
EGRET : qlq cm ^{2} @ 20 GeV
Fermi : $\approx$ 9000 cm^2 @ 20 GeV

Énergie maximale
$E_{max} \approx 20$ GeV
$E_{max} = 300$ GeV

$\rightarrow$ **Plus de sources dures visibles par Fermi**

Résultats LBAS

- FRSQ, $< \Gamma >= 2.33$
- BL Lac, $< \Gamma >= 1.99$
- BL Lac vus au TeV
  $< \Gamma >= 1.84$



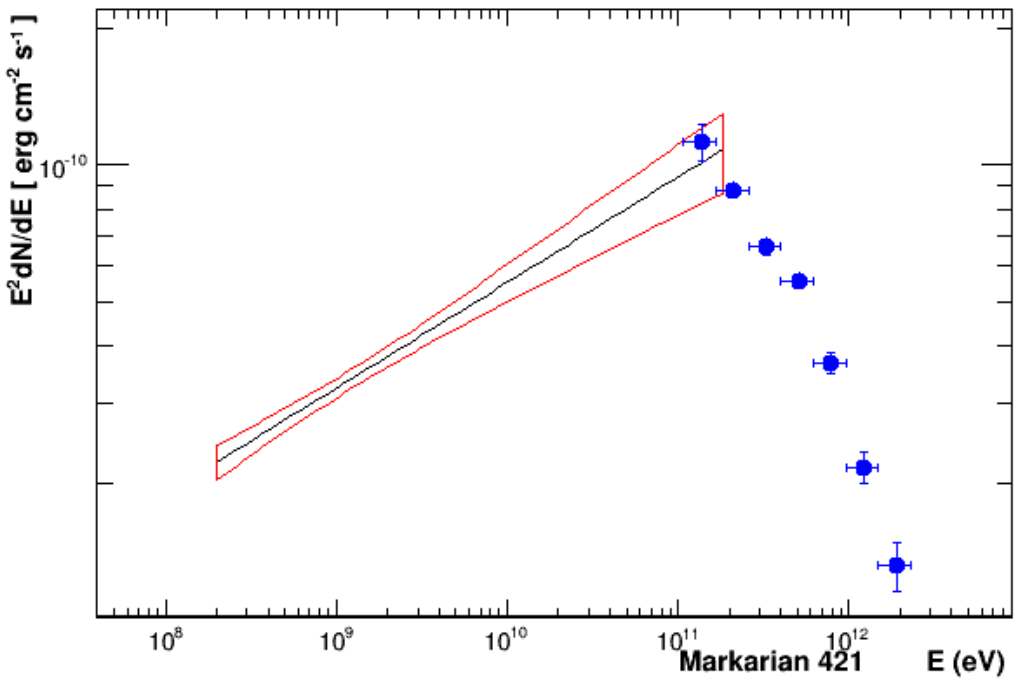
$\rightarrow$ **Séquence blazar**

Focus sur des sources particulières

Markarian 421

- Premier blazar vu au TeV
- Très variable (flux et indice) au Tev
- Pas de signe de variabilité au GeV, même si très brillante

Fermi
$\Gamma = 1.77 \pm 0.04$
Le pic HE est bien contraint



SED de **Markarian 421**
resultat a venir : Campagne Multi-λ 2009

Focus sur des sources particulières

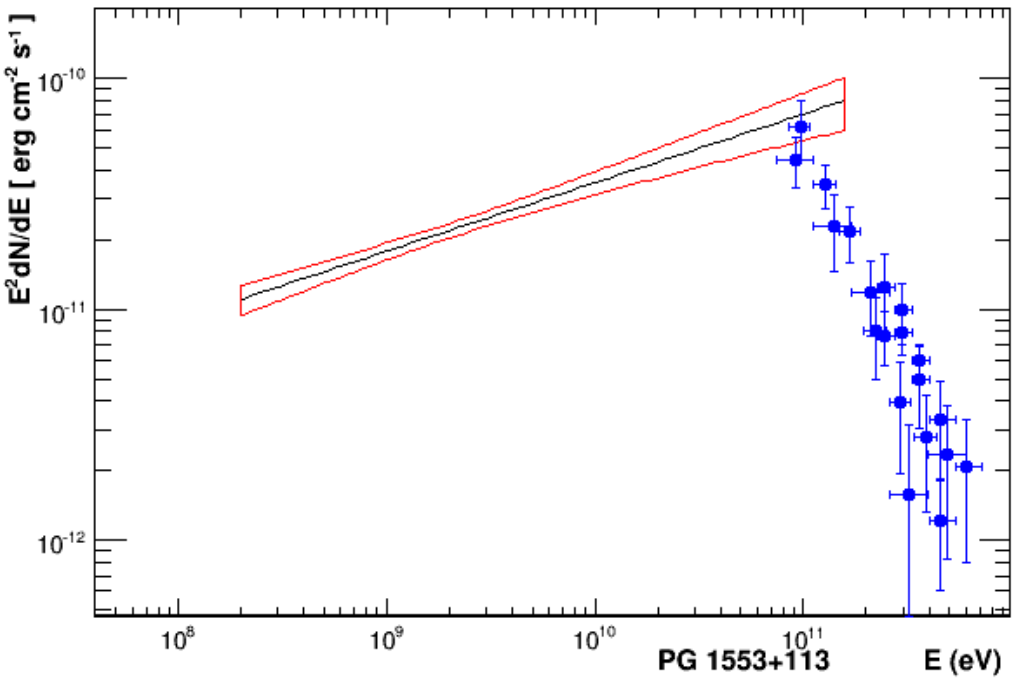
PG 1553+113

- Redshift inconnu (0.2-0.74)
- Source très 'soft' au TeV
- Pourrait être la source TeV la plus éloignée

Fermi

$\Gamma = 1.703 \pm 0.056$

$\Delta\Gamma \approx 3.5$



SED de **PG 1553+113**
Détermination de z (Abdo et al., en prep.)

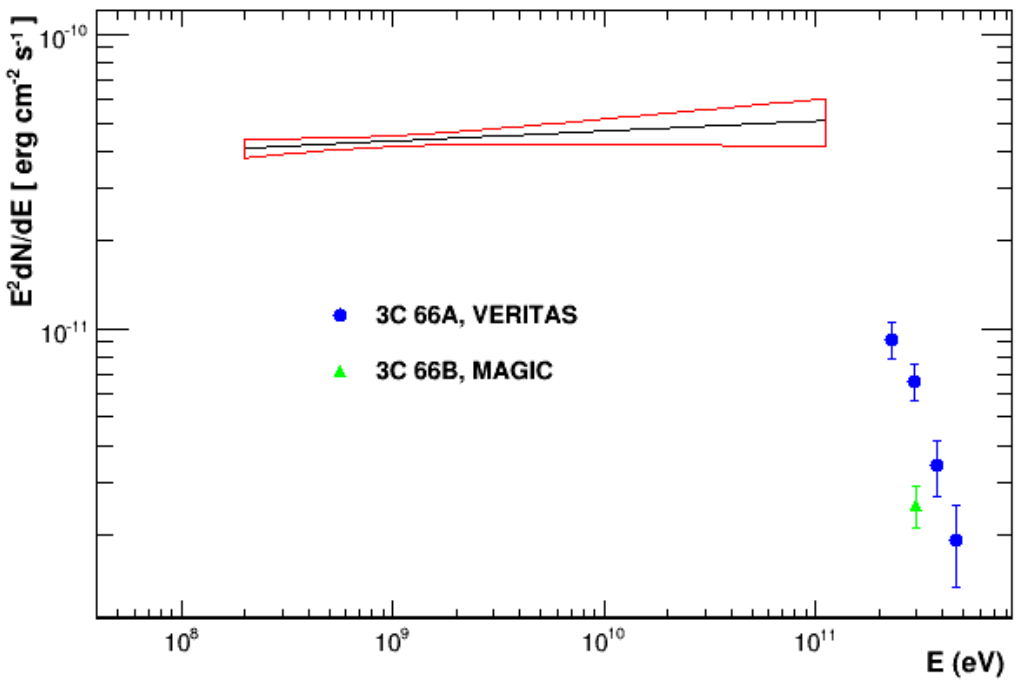
Focus sur des sources particulières

Champ de vue 3C 66A/B

- Trop proches pour être résolues
- 3C 66B radio-galaxie proche z=0.02106
- HBL, z= 0.44 (incertain)
- Émission GeV probablement dominée par 3C 66A

Fermi
$\Gamma = 1.97 \pm 0.04$

3C 66A source VERITAS
3C 66B source MAGIC



SED de **3C66A/B**

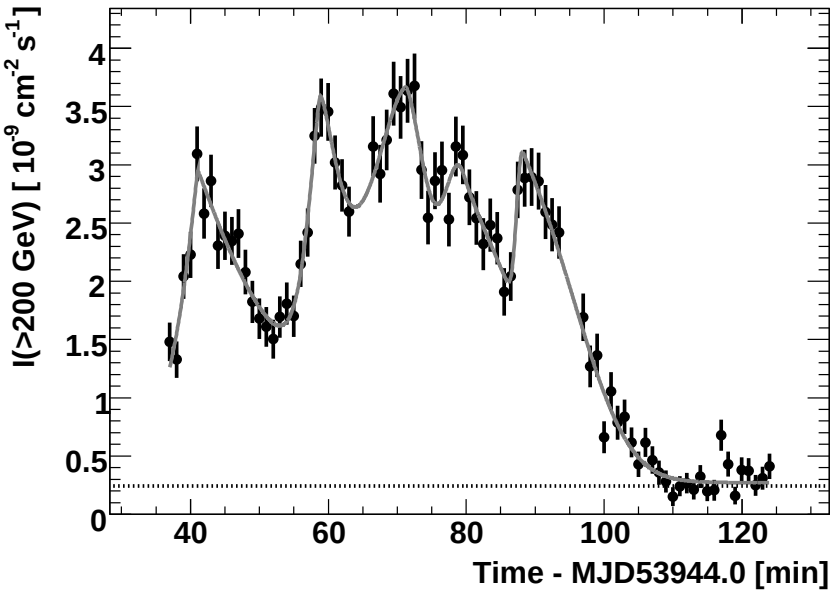
PKS 2155+304 avant *Fermi*

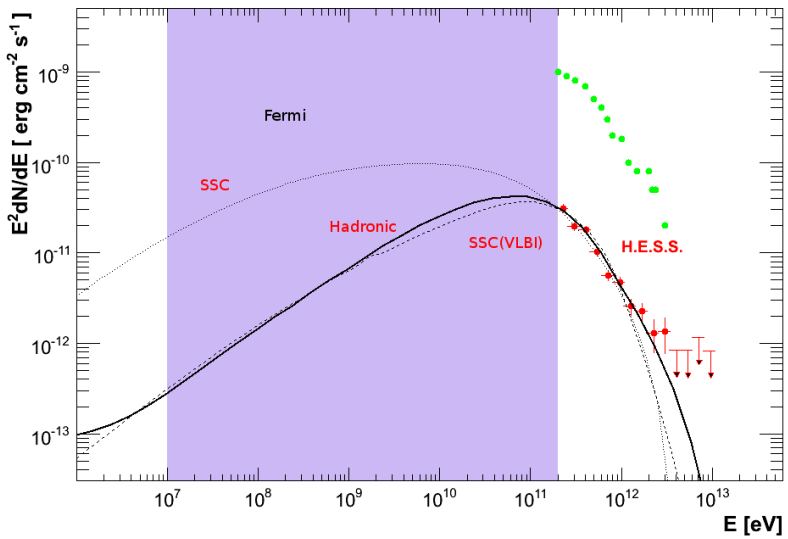
À très haute énergie :

- Source brillante
- Variabilité très rapide (< 200 sec)
- Mais état bas bien connu
- facteur 50 entre les deux états

Au GeV :

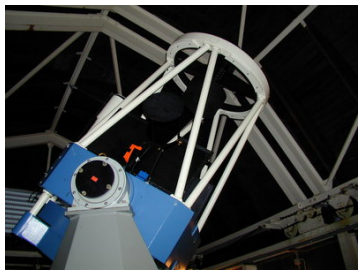
- Source faible pour EGRET
- Variable sur plusieurs années





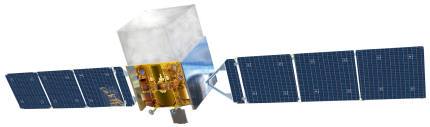
première campagne *Fermi*-H.E.S.S

4 instruments pour couvrir tout le spectre électromagnétique.
12 jours d'observation

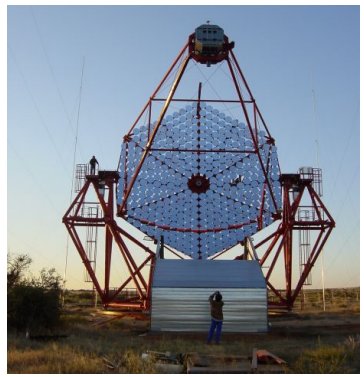


ATOM
(BRV)
106
observations
(60-200 s)

RXTE + Swift
(0.5 - 10 keV)
75 ks + 6.4 ks



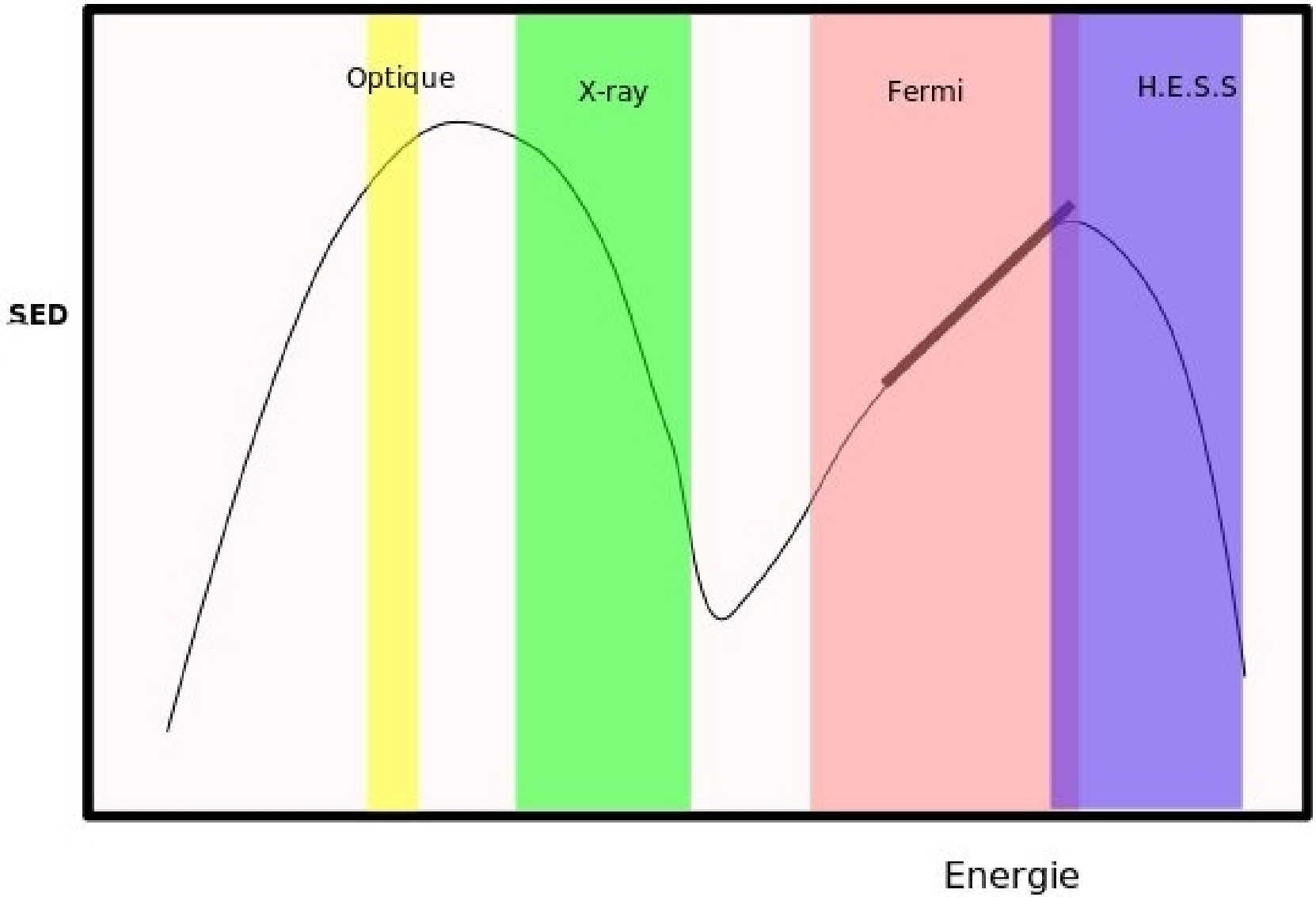
Fermi
(0.2-300 GeV)
$7.7 \times 10^8 \mathrm{cm}^2\mathrm{s}$

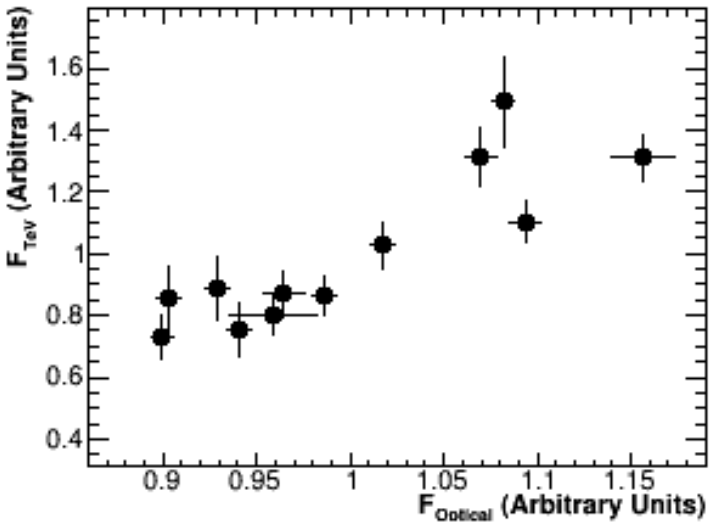


HESS
(0.2-10 TeV)
32.9 heures

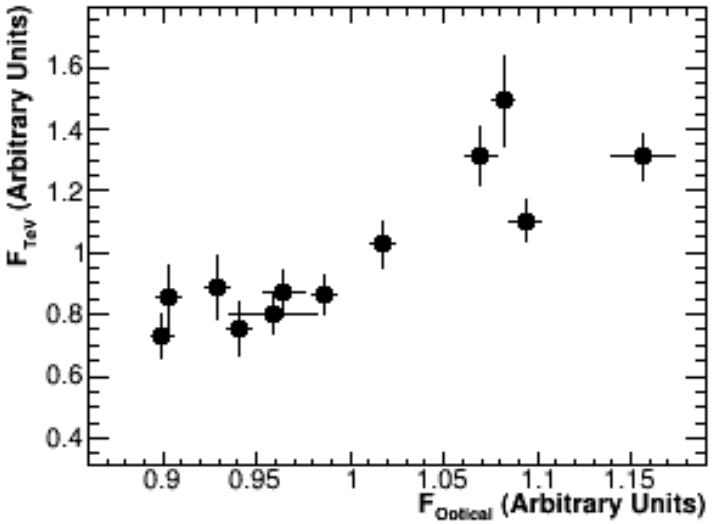
Première observation **simultanée** en optique, rayon X et rayon γ HE

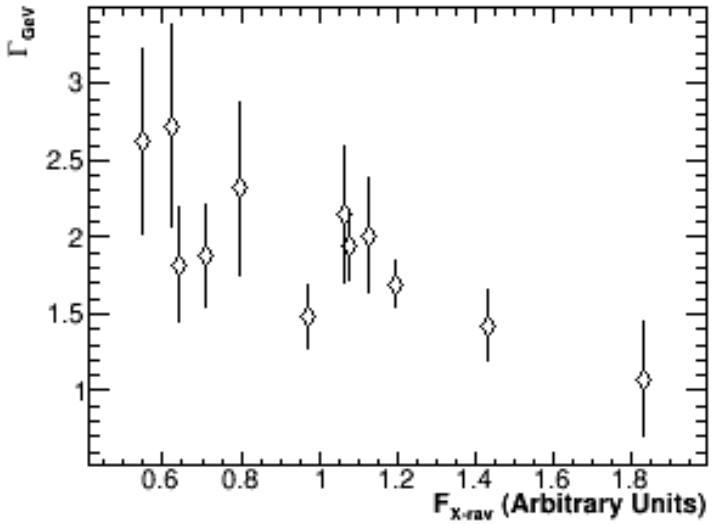
première campagne *Fermi*-H.E.S.S



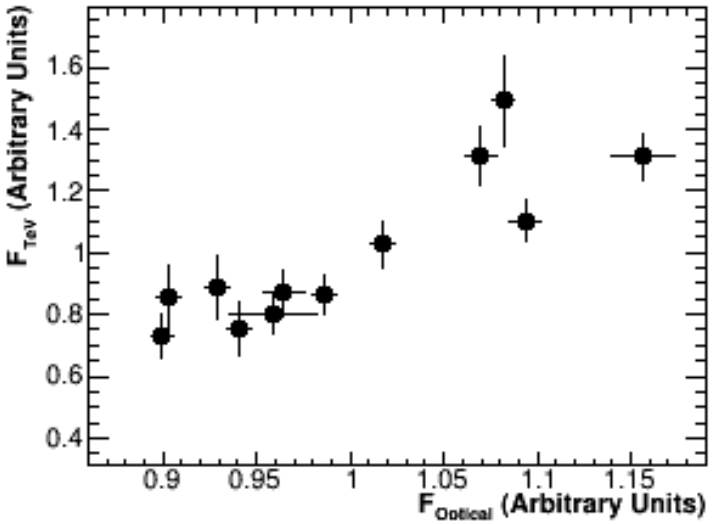


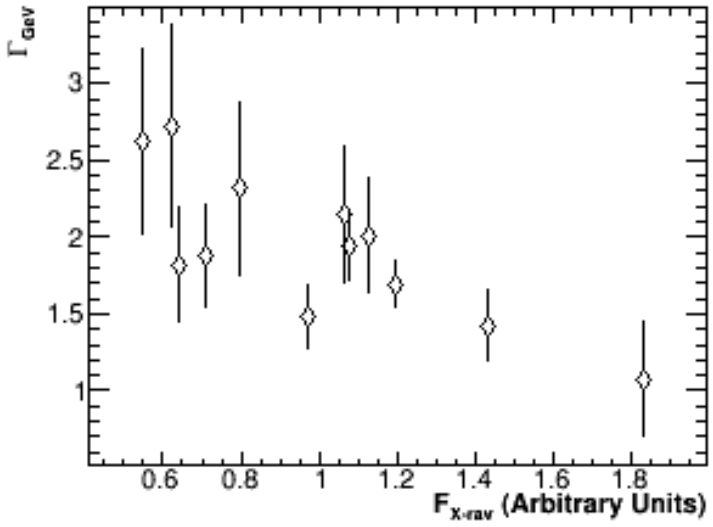
Flux optique et THE : $r = (0.77 - 0.86) \pm 0.09$

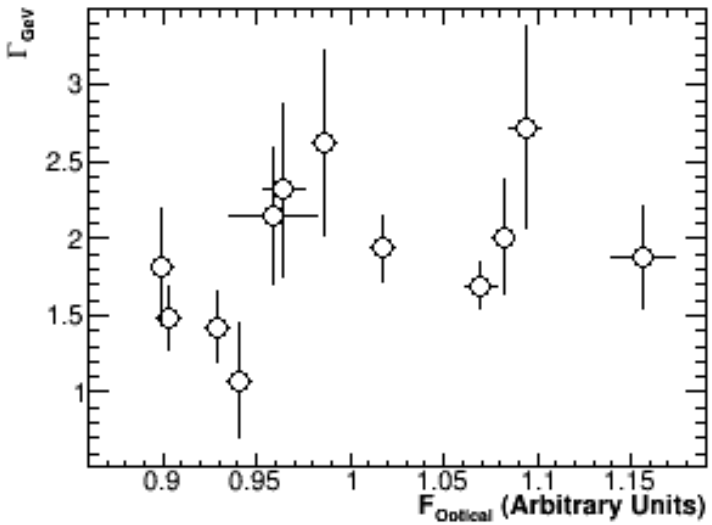




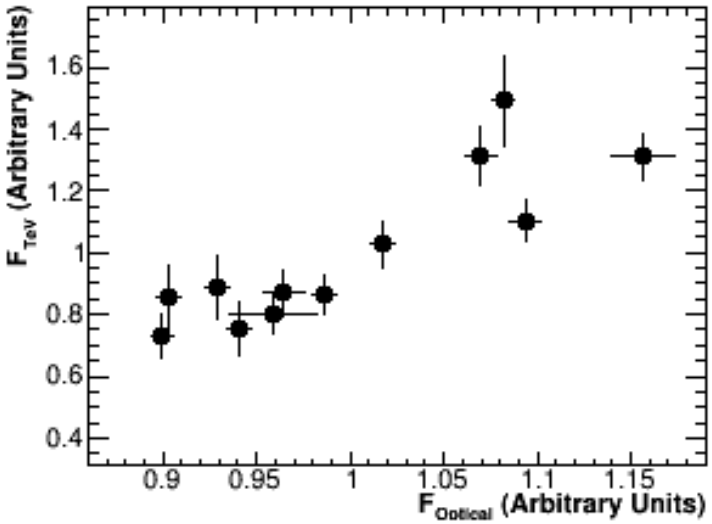
flux X et indice *Fermi* : $r = -0.80 \pm 0.15$

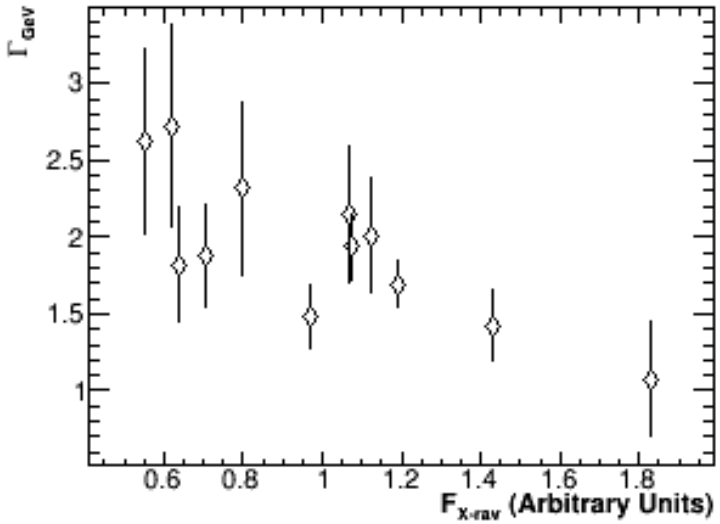


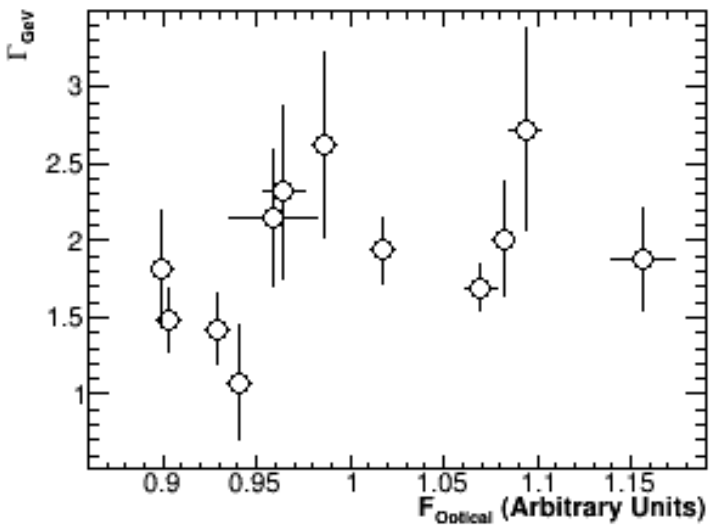


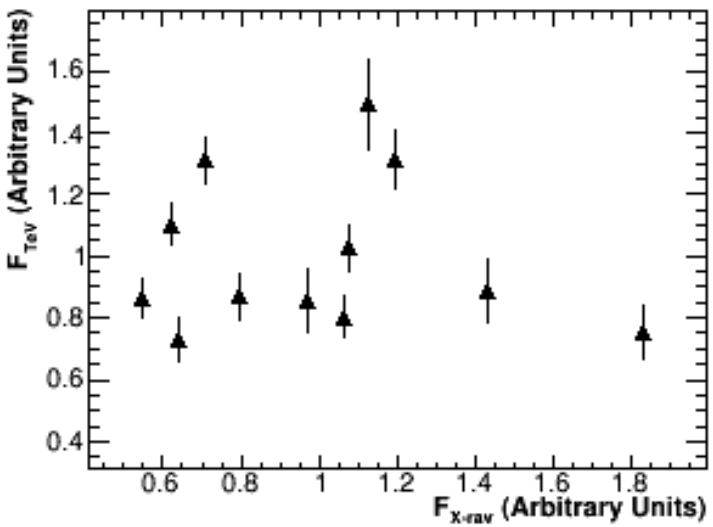


flux optique et indice *Fermi* : $r = 0.10 \pm 0.28$



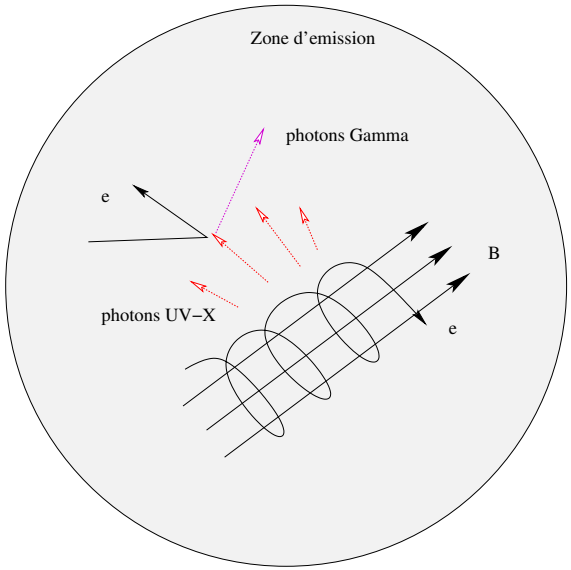




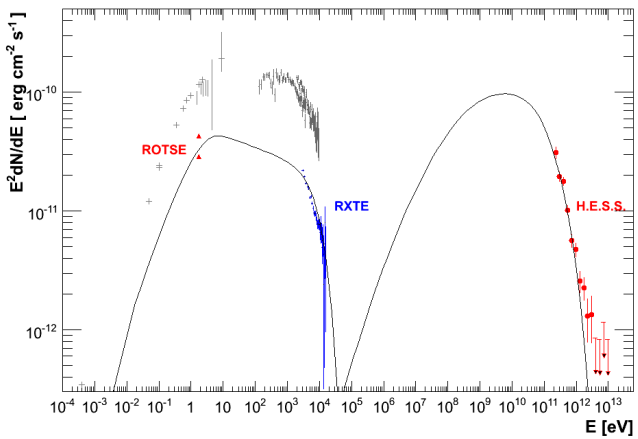


flux X et THE : $r = 0.12 \pm 0.10$

Une seule zone d'émission, sphérique, homogène (taille R)
$N_e(\gamma)$

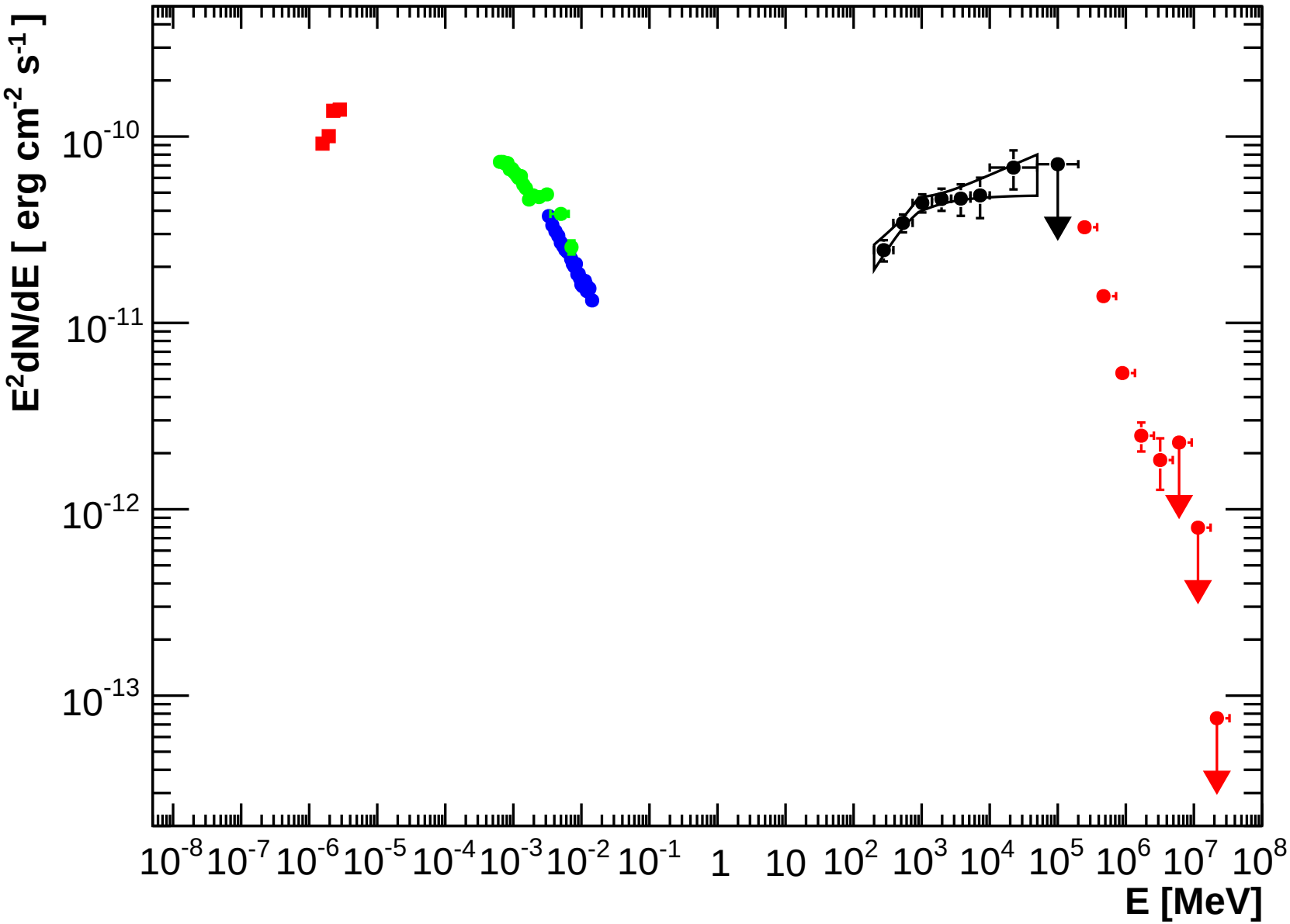


- plasma d'électron relativiste dans un champ B
- émission synchrotron
- le champ de photons synchroton : diffusé par les e^-

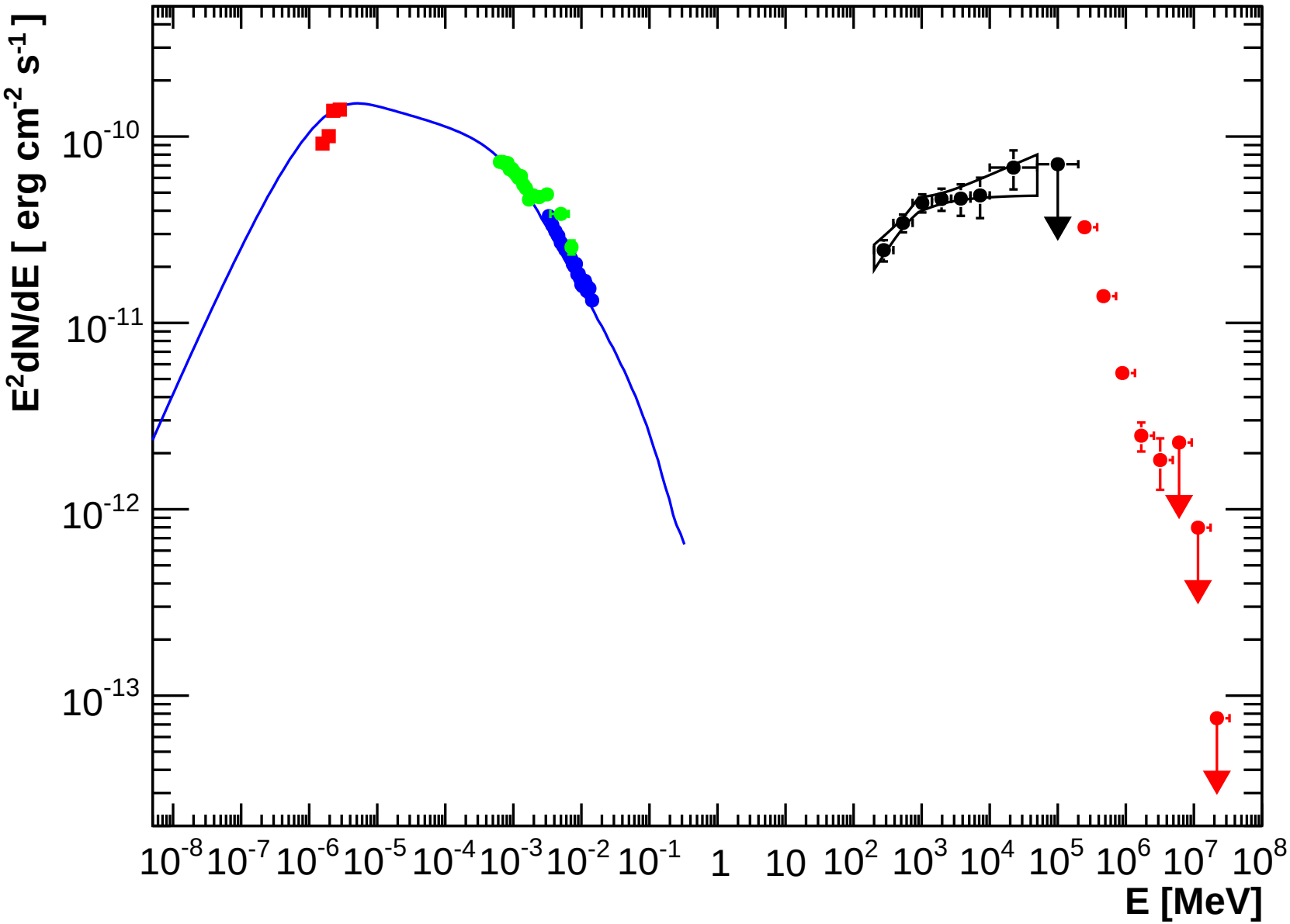


Les électrons de plus haute énergie sont responsables de l'émission au TeV.
Forte corrélation X-TeV attendue et observée

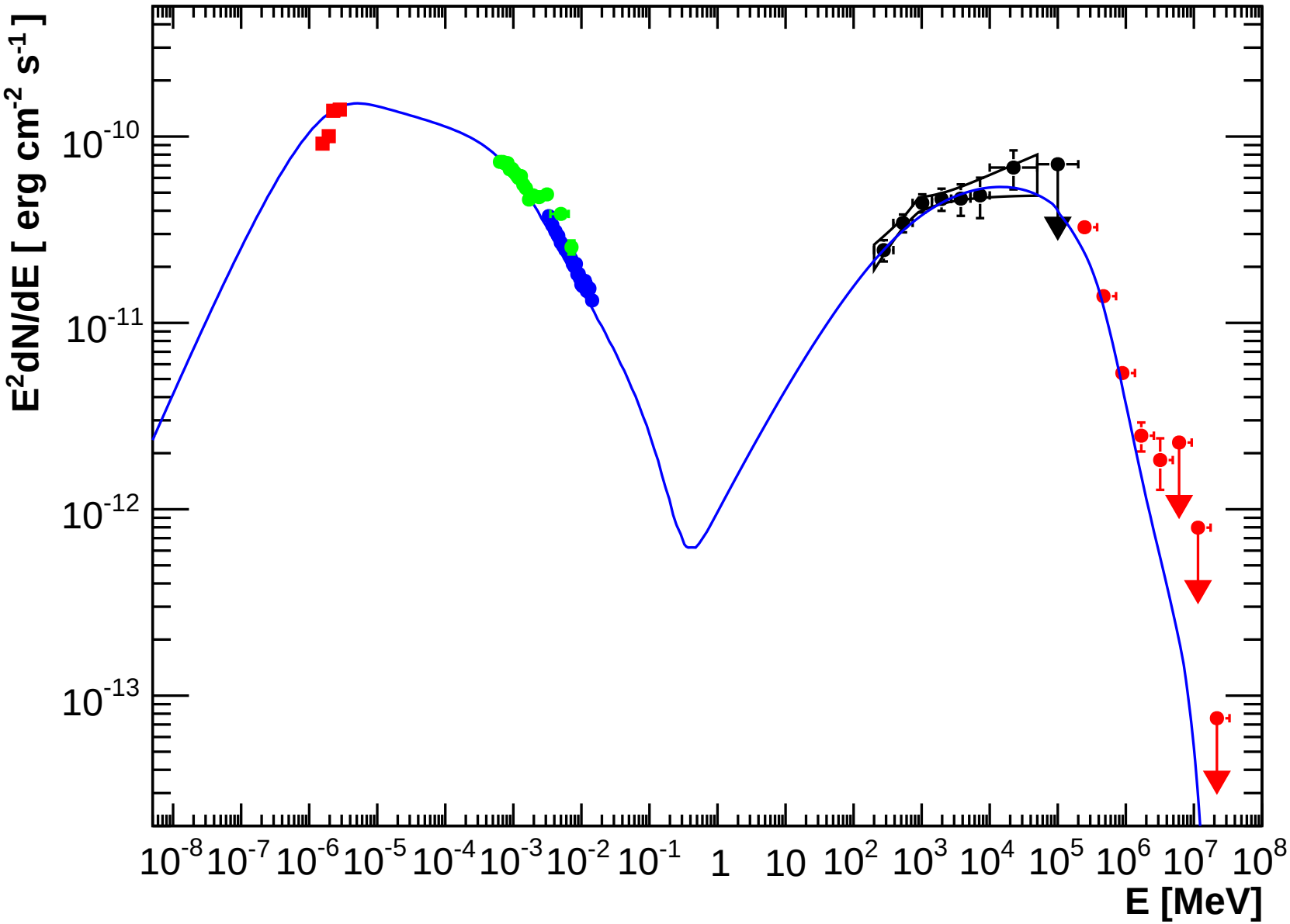
SED moyenne


E²dN/dE [erg cm⁻² s⁻¹]
10⁻¹⁰
10⁻¹¹
10⁻¹²
10⁻¹³
10⁻⁸ 10⁻⁷ 10⁻⁶ 10⁻⁵ 10⁻⁴ 10⁻³ 10⁻² 10⁻¹ 1 10 10² 10³ 10⁴ 10⁵ 10⁶ 10⁷ 10⁸
E [MeV]

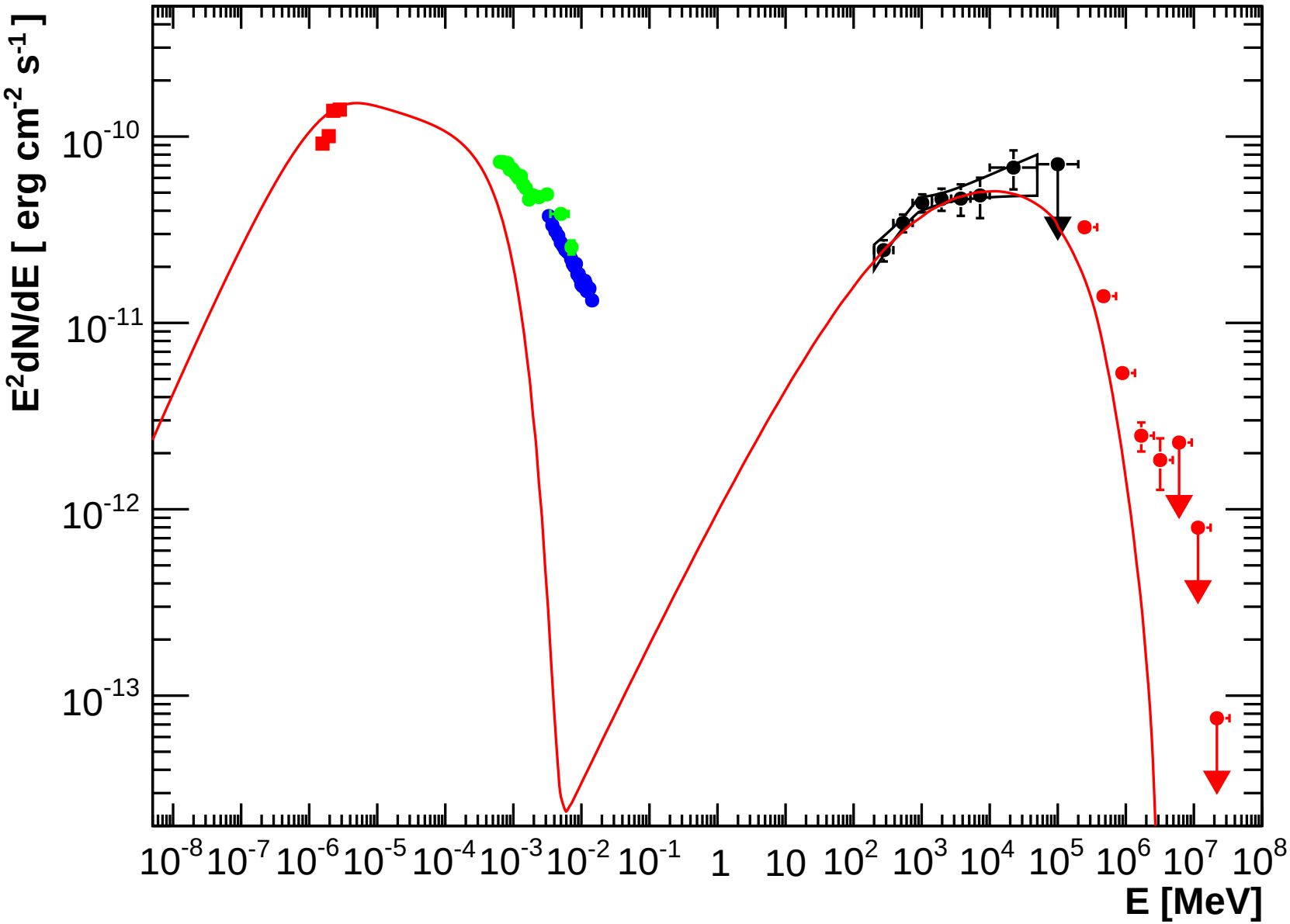
Détermination de $N_e(\gamma)$



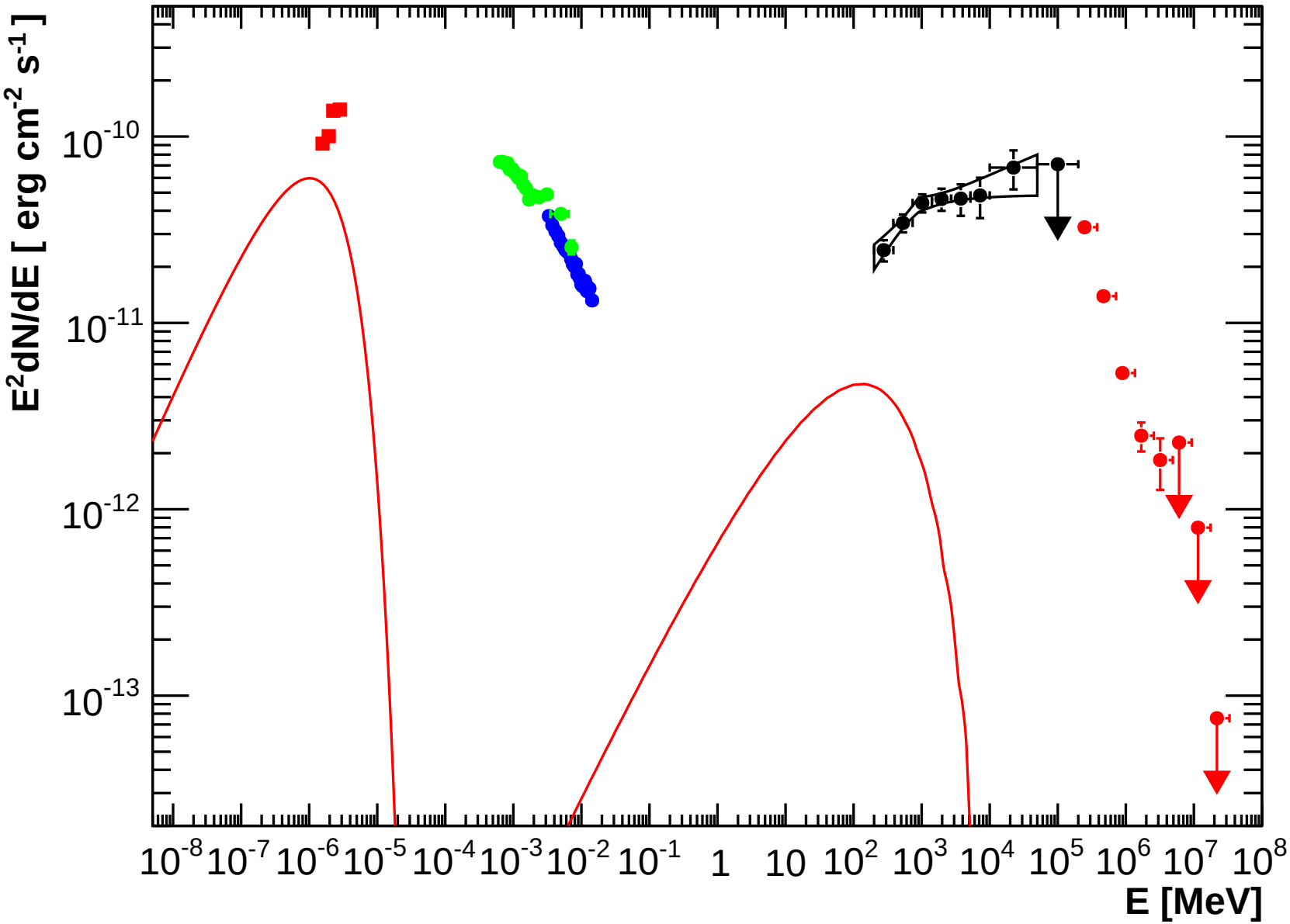
Détermination de B,R,δ



Sans les électrons émettant des rayons X



Sans les électrons émettant des UV



Conclusions

Les nouvelles du ciel γ : http://fermisky.blogspot.com/

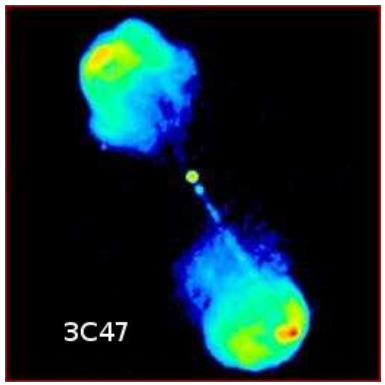
Données + outils d'analyse public début Août 2010
http://heasarc.gsfc.nasa.gov/

Fermi Symposium 2009
http://fermi.gsfc.nasa.gov/science/symposium/2009/

HESS phase II :
20 GeV en monotéléscope
$\approx$ 50 GeV en stéréoscopie avec HESS I

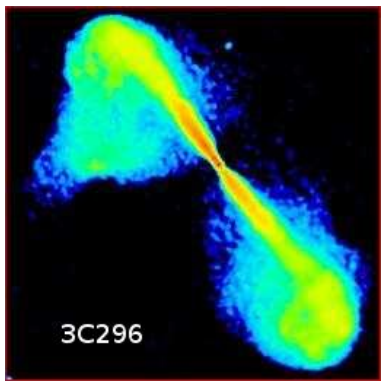
Backup slides

Fanaroff-Riley II $\rightarrow$ FSRQ



Bright outer edges, hot spots
well–collimated jets, still relativistic in lobes,
high power : $L_{radio} > 10^{42}$ erg/s
emission lines 10 times brighter than FRI

Fanaroff-Riley I $\rightarrow$ BL Lacs



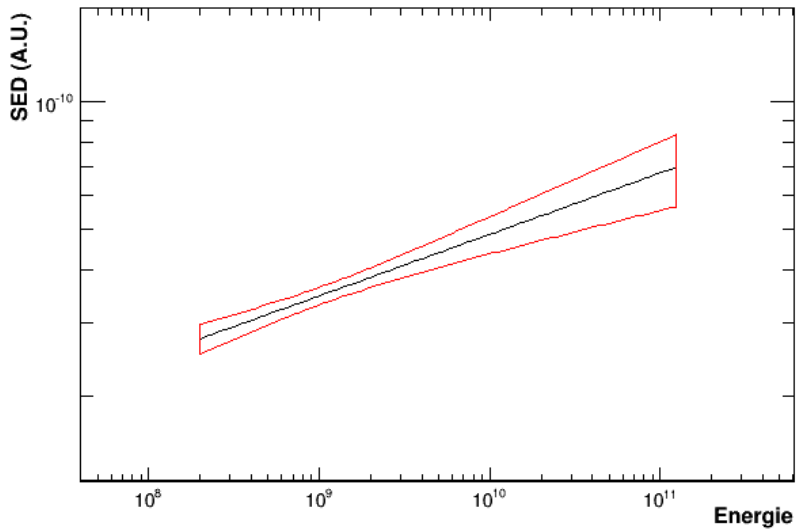
Emission peaks near the center
less–collimated jets, no hot spot
lower power ($L_{radio} < 10^{42}$ erg/s)

Butterfly

Numerical results of the fit

$$F(E) = N_0 \left(\frac{E}{E_0}\right)^{-\Gamma}$$

- Prefactor $N_0 \pm \Delta N_0$
- Photon index $\Gamma \pm \Delta\Gamma$
- Covariance $\mathrm{cov}(N_0, \Gamma)$



$$\Delta F^2 = \left(\frac{F}{N_0}\right)^2 \Delta^2 N_0 + F^2 \log^2(E/E_0)\Delta\Gamma^2 - 2\mathrm{cov}(N_0, \Gamma)\frac{F}{N_0} F \log(E/E_0)$$