Active Galaxies in GeV-TeV γ-Rays

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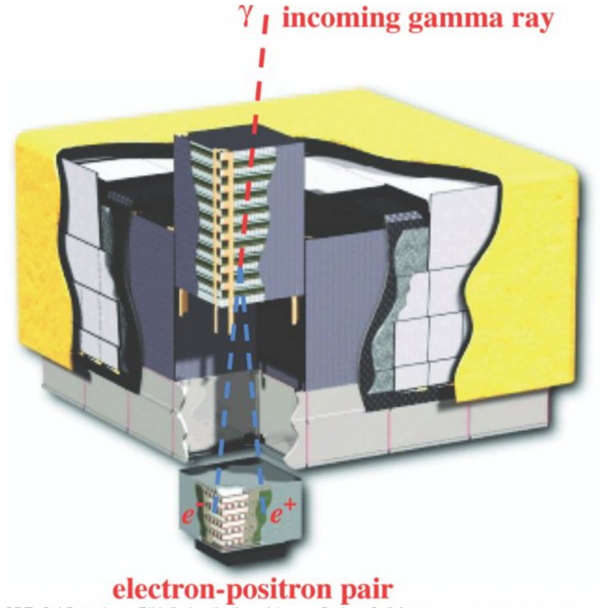
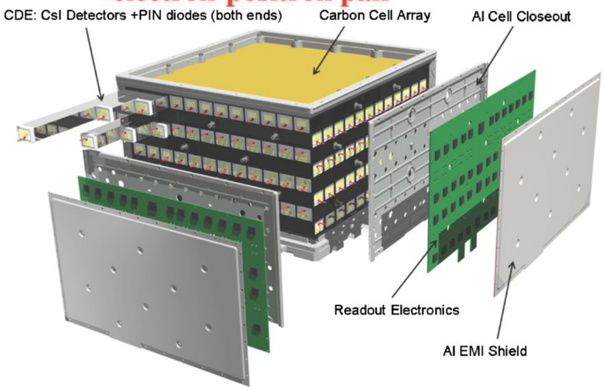
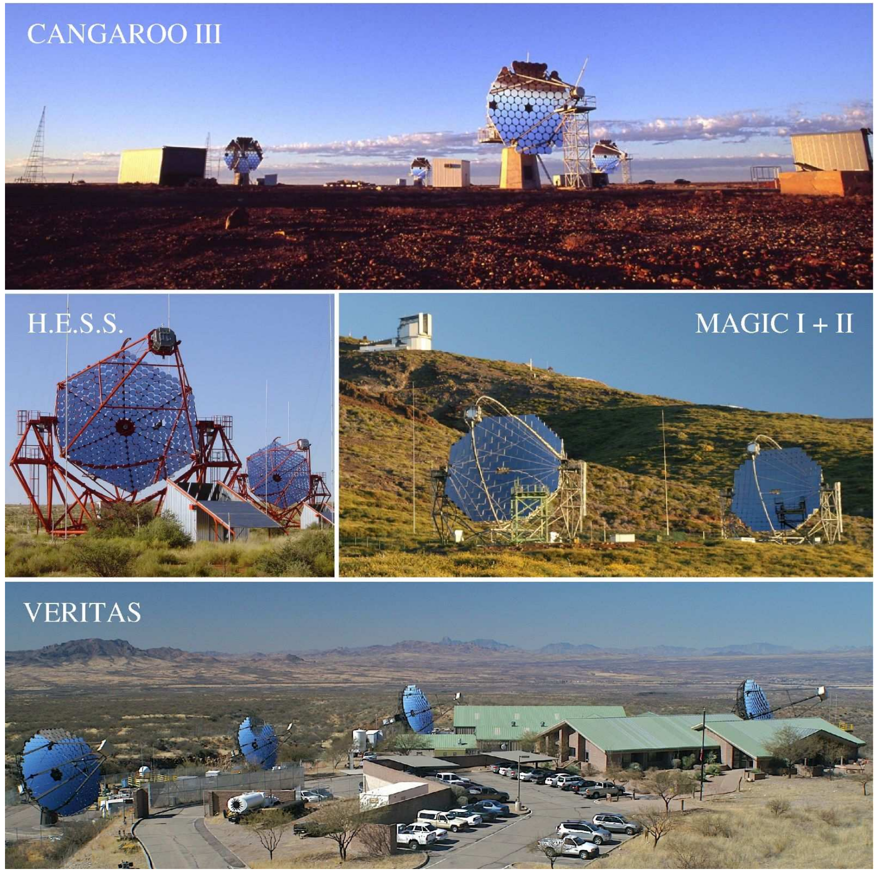
- (Progress on) Flat-spectrum Radio Quasars, GeV and TeV
- GeV-TeV observations of (Low-frequency peaked) BL Lacs
- Developments on fast VHE variability
- Perspectives

Active Galaxies in GeV-TeV γ-Rays::High/GeV and Very High/TeV



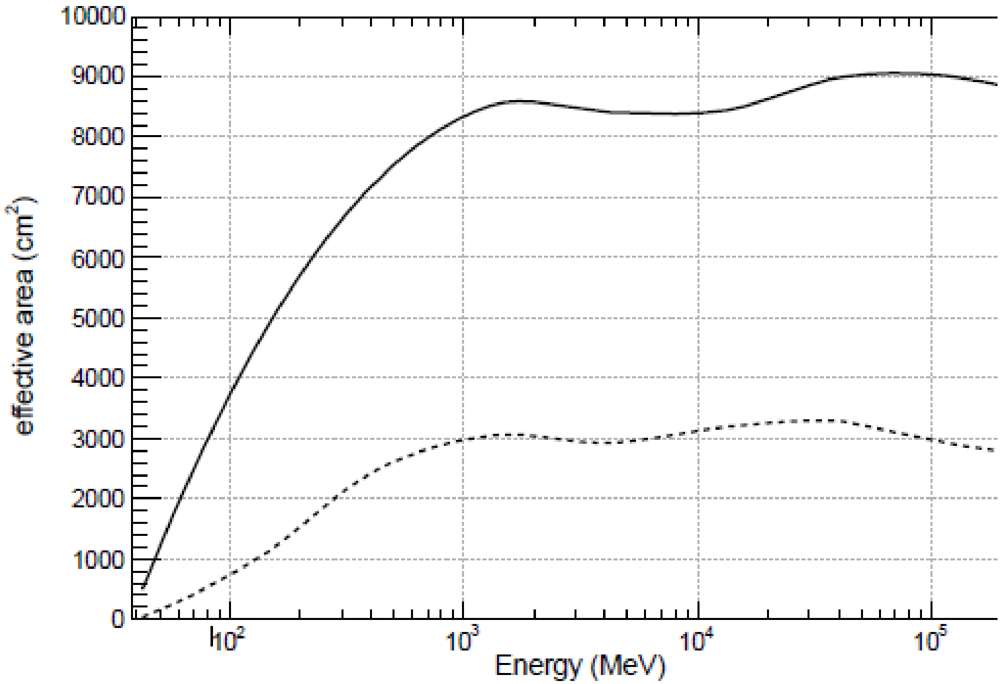


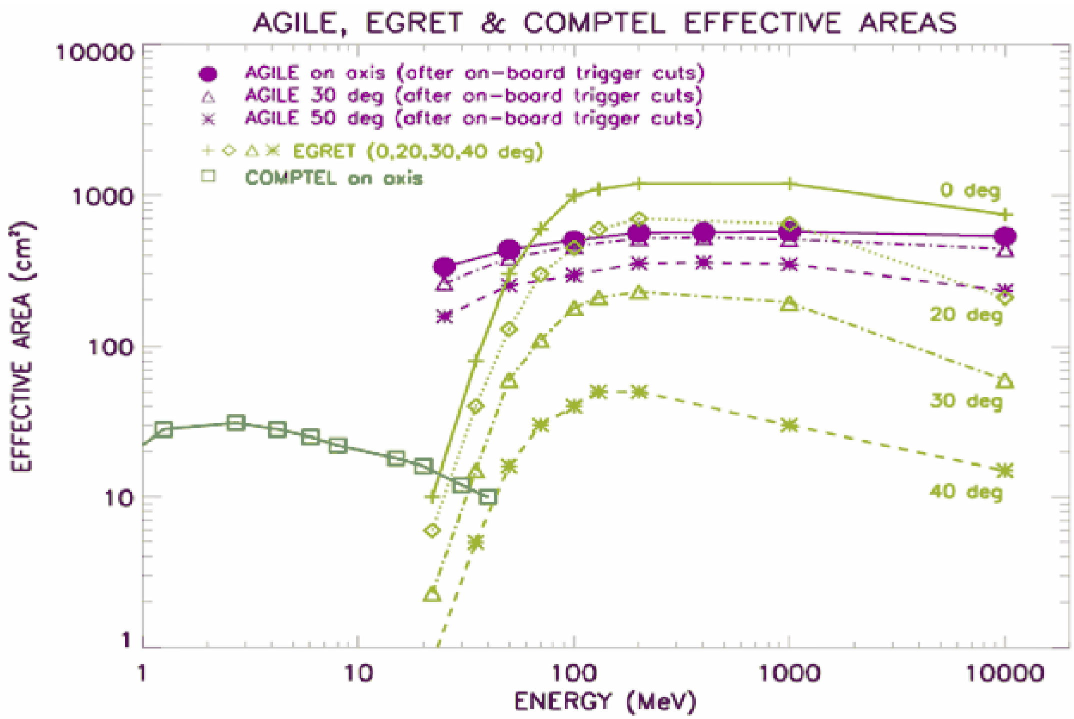


	Fermi	ACT	EAS
Effective area [m^2]	$\simeq 1$	$\simeq 10^5$	10^5@10TeV
Angular resolution	$3.5° \times \left(\frac{E}{100\,\mathrm{MeV}}\right)^{-0.7}$	$0.1°$	$0.5°$
FOV	2 sr	$5°$	2 sr
Energy resolution	$\leq 10\%$@ 10(100) GeV	20(10)% @500(10^3) GeV + syst!	
Sensitivity [erg cm^{-2} s^{-1}]	10^{-12} (1yr)	10^{-13}(50 h)	10^{-12} (1yr)
Duty cycle	$\simeq 90\%$	$\simeq 10\%$(1000 h)	$\geq 90\%$

Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky

- ACT entered astronomy era during *CGRO* operations
  $\Rightarrow$EGRET sensitivity declining at $E_\gamma > 1\,$GeV and off-axis
  $\Rightarrow$Little or no information about existing faint and "hard sources" $\Gamma \leq 2$

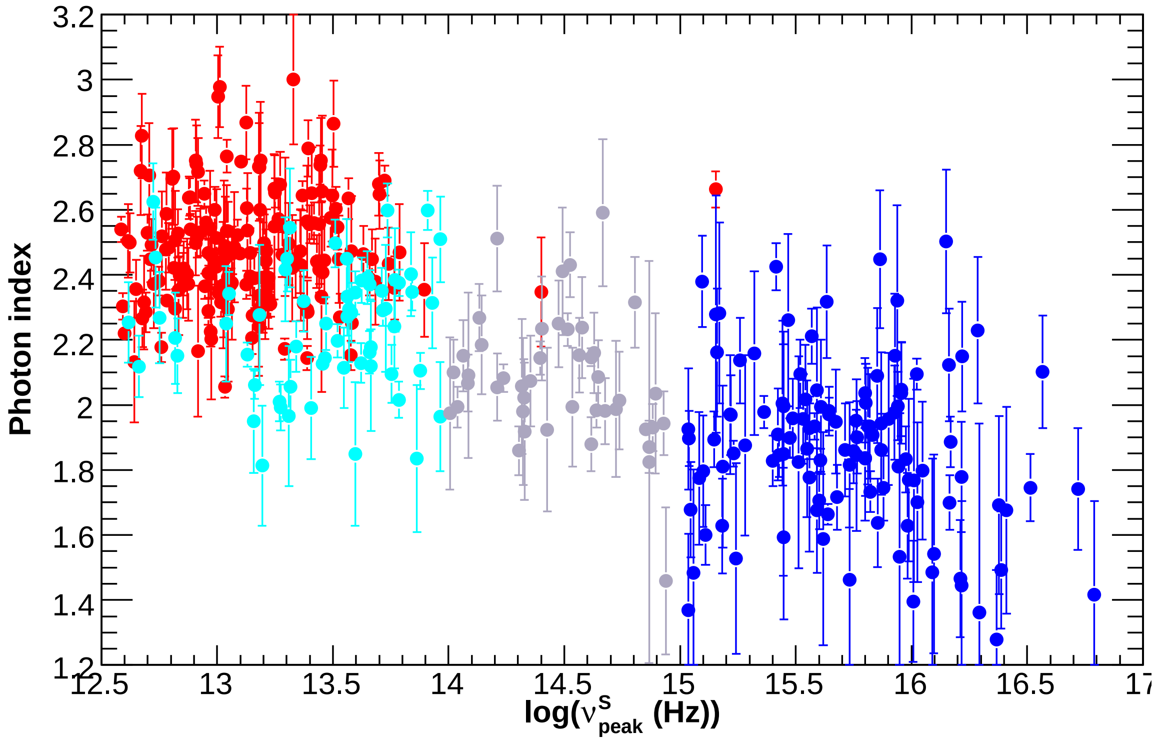


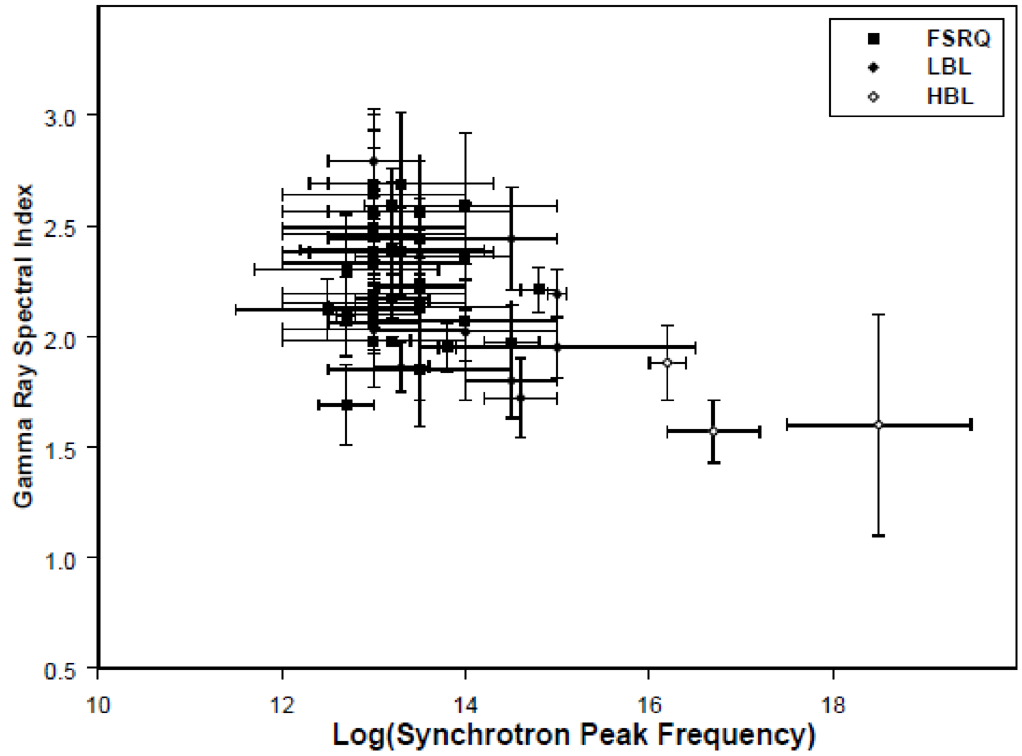


- Very limited guidance for restricted TeV observatories
  $\Rightarrow$ VHE discovery strategies rely on (mostly) archival X-ray properties

Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky

- *Fermi* improves sensitivity, field of view and range to $E_\gamma > 100\,\mathrm{GeV}$
  $\Rightarrow$ VHE target potential requires limited spectral extrapolation



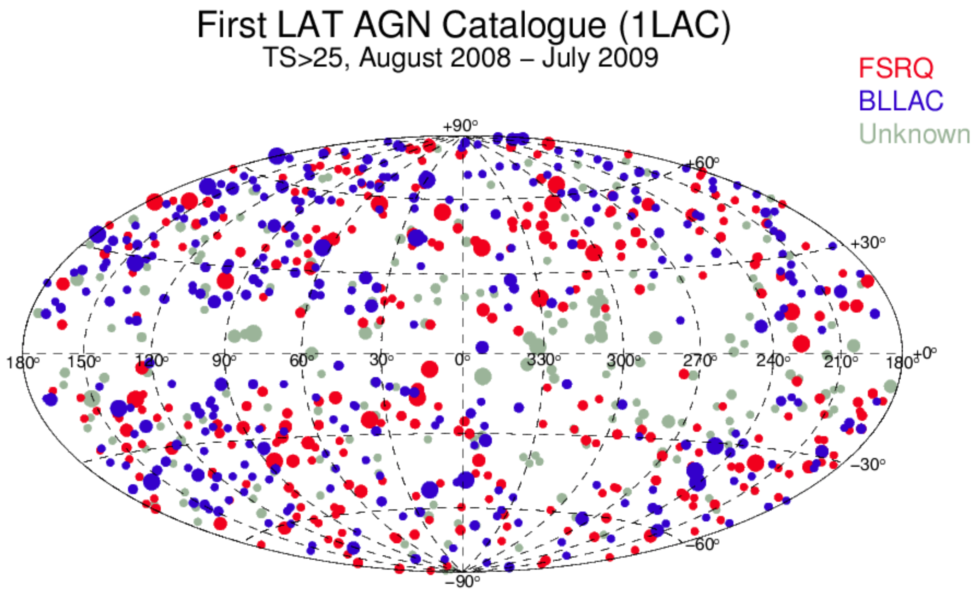


- Fermi added the ISP/HSP population to the HE sky

Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky

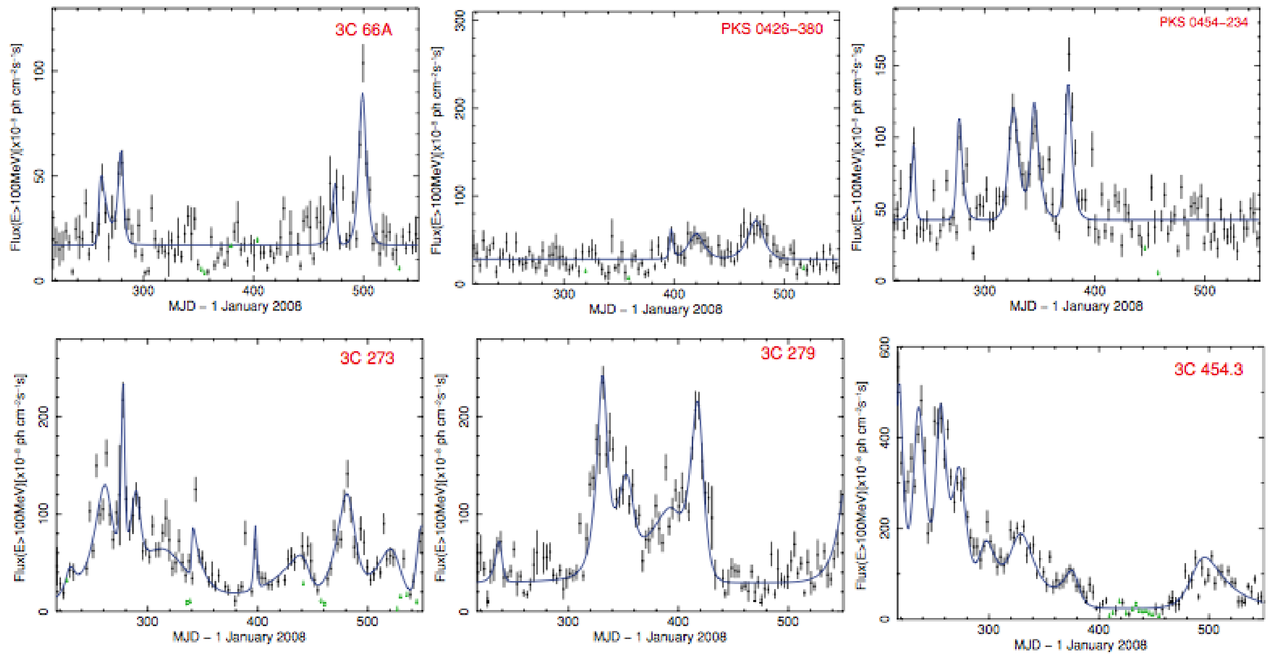
Table 4
Census of 1LAC Sources

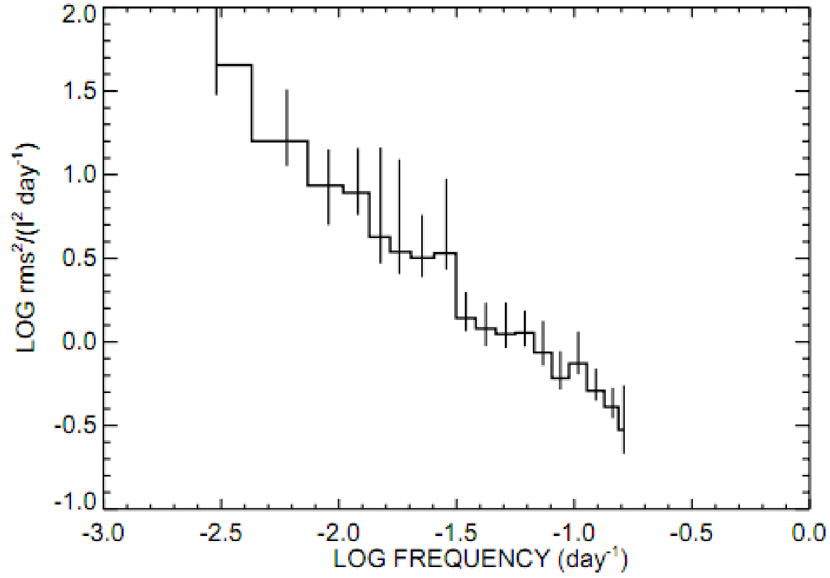
AGN Type	Number of AGNs in		
	Entire 1LAC Sample	High-confidence Sample[a]	Clean Sample[a]
All	709	663	599
FSRQ	296	281	248
. . .LSP	189	185	171
. . .ISP	3	2	1
. . .HSP	2	2	1
BL Lac	300	291	275
. . .LSP	69	67	62
. . .ISP	46	44	44
. . .HSP	118	117	113
Other AGN	41	30	26
Unknown	72	61	50



- Blazars equally divided between:
  - $\Gamma \geq 2.2$ (highly) variable FSRQs
  - $\Gamma \leq 2.2$ mostly non-variable BL Lacs
  - No redshift for $\sim 60\%$ of BL Lacs
- New subclasses of non-blazar types?
  - γ-ray emission from Seyfert galaxies $\Rightarrow$ coming from jet or starburst?
  - Radio-loud Narrow-line Sy1's $\Rightarrow$ really a new class of AGN?
- *Fermi* Symposium 2011: A wealth of new discoveries, studies, measurements $\Rightarrow$2LAC available soon

Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky





- Bright(est) blazars sampled at $\Delta t \sim 3\,\mathrm{d}$(3-6 h; Sbarrato+ 2011) and $T = 1(3)\,\mathrm{yr}$ $\Rightarrow \tau_{\gamma\gamma}(E_\gamma = 1 - 10\,\mathrm{GeV}) < 1$ constrains $\delta = \mathcal{D} = [\Gamma(1 - \beta \cdot \mathbf{n})]^{-1} \geq 2 - 7$
- $F_{>100\,\mathrm{MeV}}$ excess r.m.s.: $\sigma_{XS,LSP} \sim 0.3 > \sigma_{XS,ISP} \sim 0.2 > \sigma_{XS,HSP} \sim 0$
- $$P(\nu) \propto \begin{cases} \nu^{-1.4\pm0.1} & \text{FSRQ} \\ \nu^{-1.7\pm0.3} & \text{BL Lac} \end{cases}$$

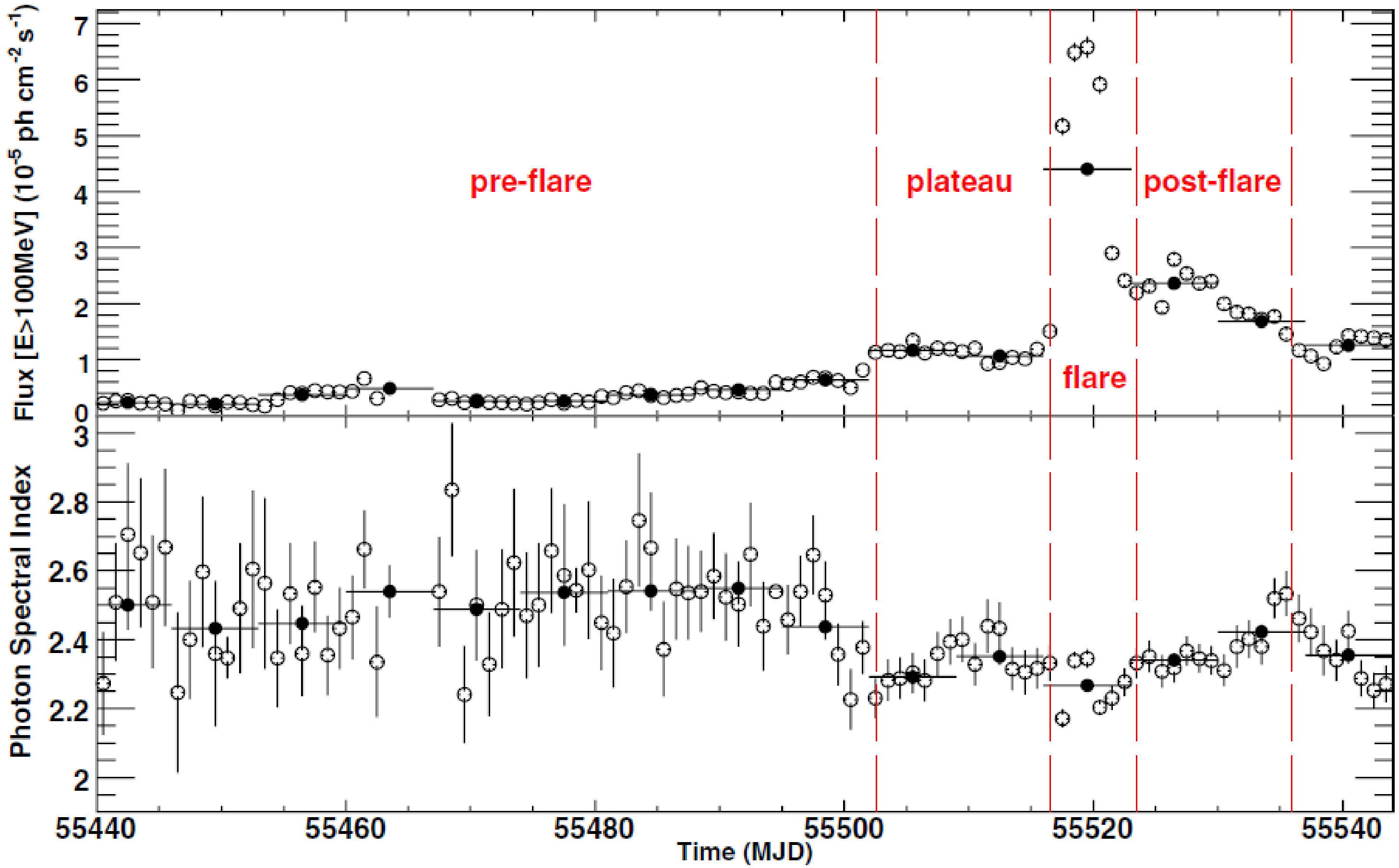
  $\Rightarrow$Low-frequency rollover $\nu_<$ exists, little noise leakage

  $\Rightarrow$High-frequency cutoff $\nu_>$(?) for AČTs, red noise leakage at low frequency

Active Galaxies in GeV-TeV γ-Rays::Variability (Gaskell & Klimek 2003)

- What is the amplitude of variability
- How are the amplitudes related to the timescales? ("Power Density Spectrum")
- What are the timescales of variability? What are the shortest timescales? What are the longest timescales? Are there preferred timescales?
- Is variability periodic?

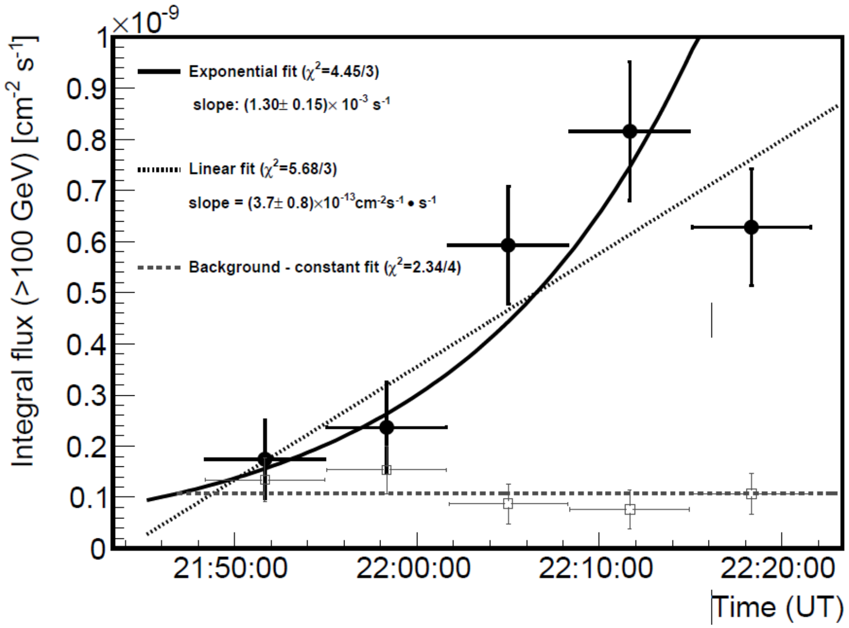
Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky

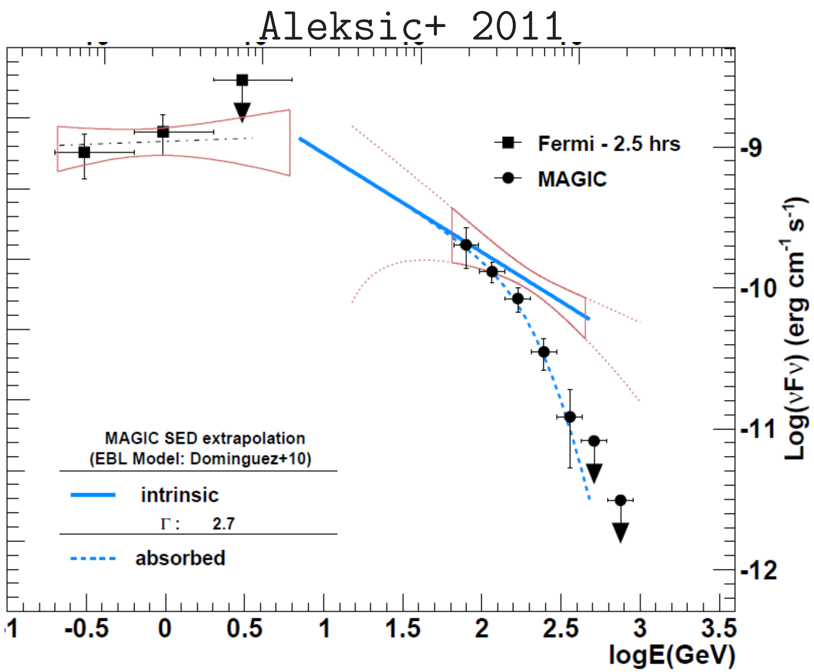


Abdo+ 2010; ApJ

- 3C454.3 in Nov 2010 $L_\gamma = 2 \times 10^{50}\,\mathrm{erg\,s^{-1}}$ brightest blazar in γ-ray history
- Largest non-GRB luminosity fluctuations $L_\gamma/\Delta t \simeq 10^{46}\,L_{50}/t_4\,\mathrm{erg\,s^{-2}}$ $\Rightarrow 3 \times 10^{44}\,\mathrm{erg\,s^{-2}}$ largest TeV fluctuations from PKS 2155-304

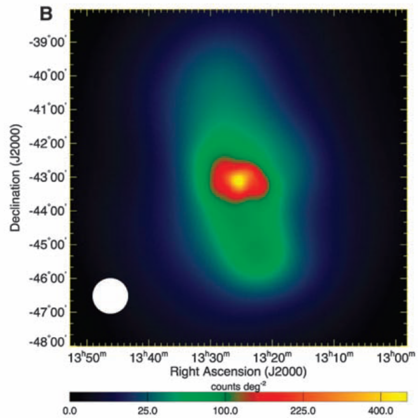
Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky

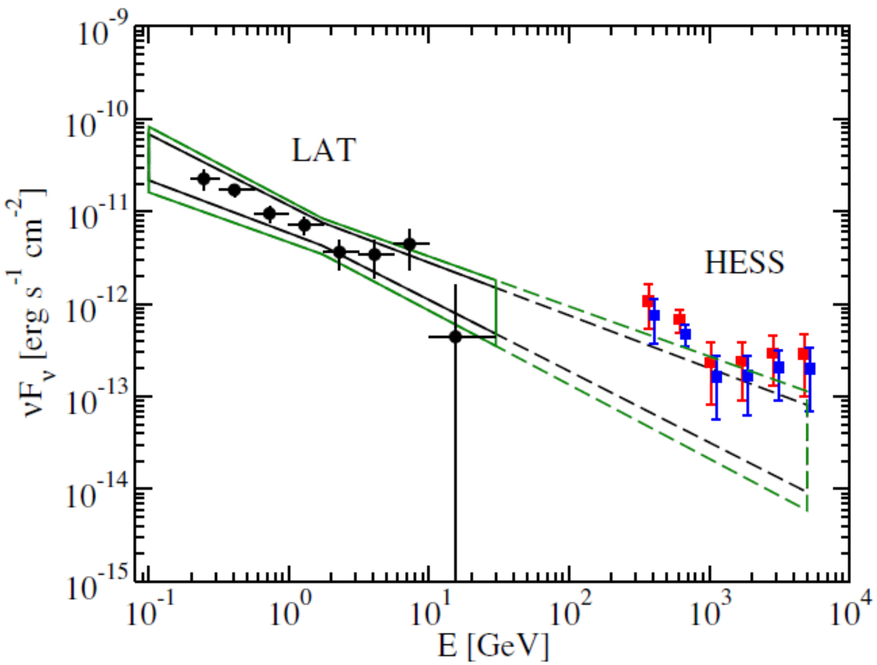


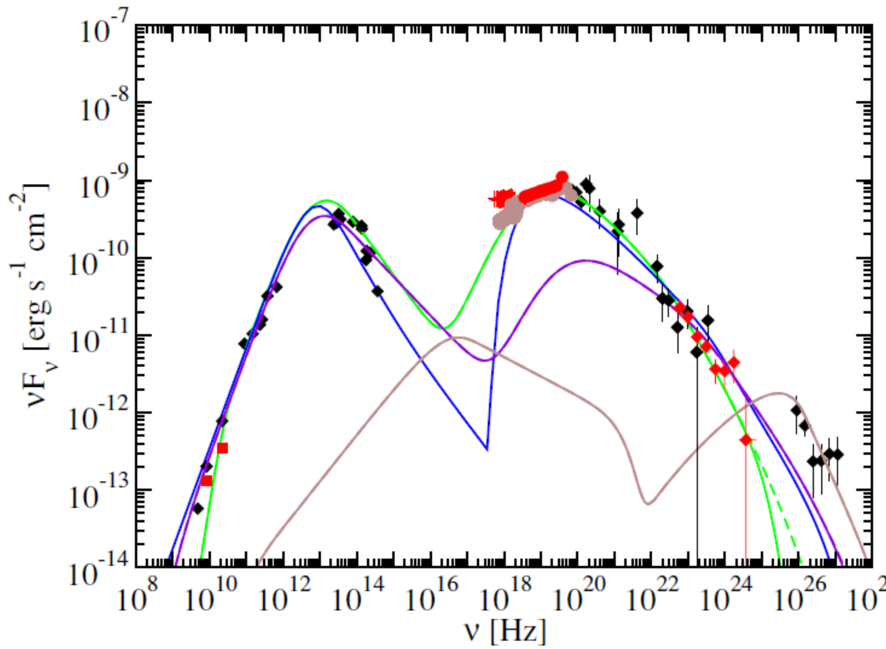


- PKS 1222+21 ($z = 0.432$) detected at "TeV" energies with $\sim$ *Crab* flux!
- Significant variability with $T_2 \sim 10'$
  $\Rightarrow$Fastest variability ever observed in FSRQ at any λ
  $\Rightarrow \tau_{\gamma\gamma} < 1$ constrains $\delta \geq 15$
  compatible with superluminal radio knots
- VHE spectrum compatible with *Fermi* extrapolated spectrum
  $\Rightarrow$no significant intrinsic BLR $\gamma\gamma$ attenuation
- 3C279 spectrum less significant *and* not contemporaneous with *Fermi*
- no details on PKS 1510-08 detection by HESS

Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky

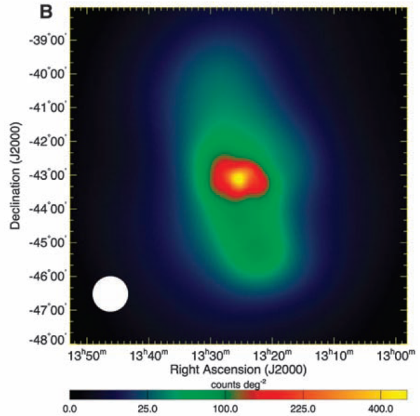


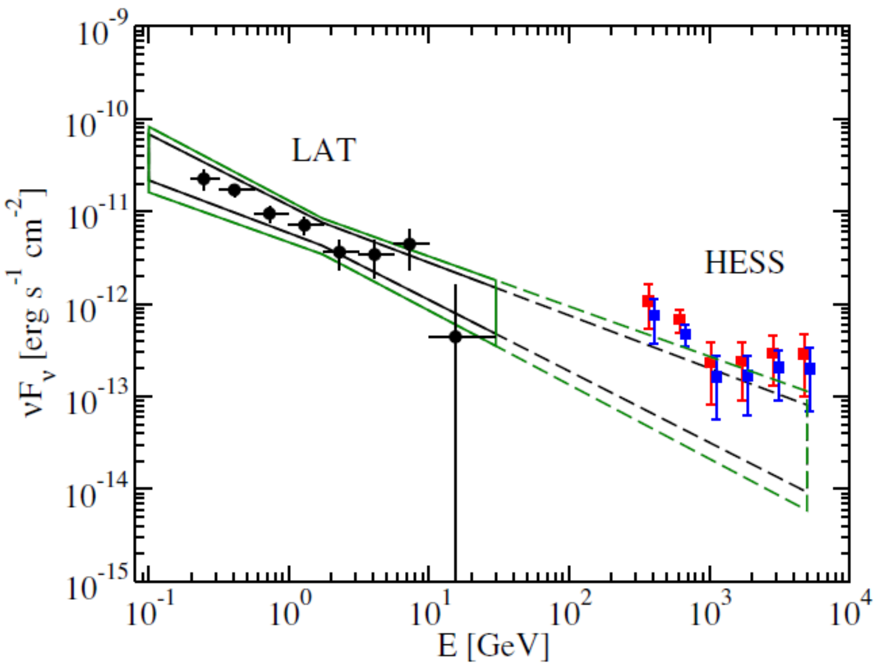


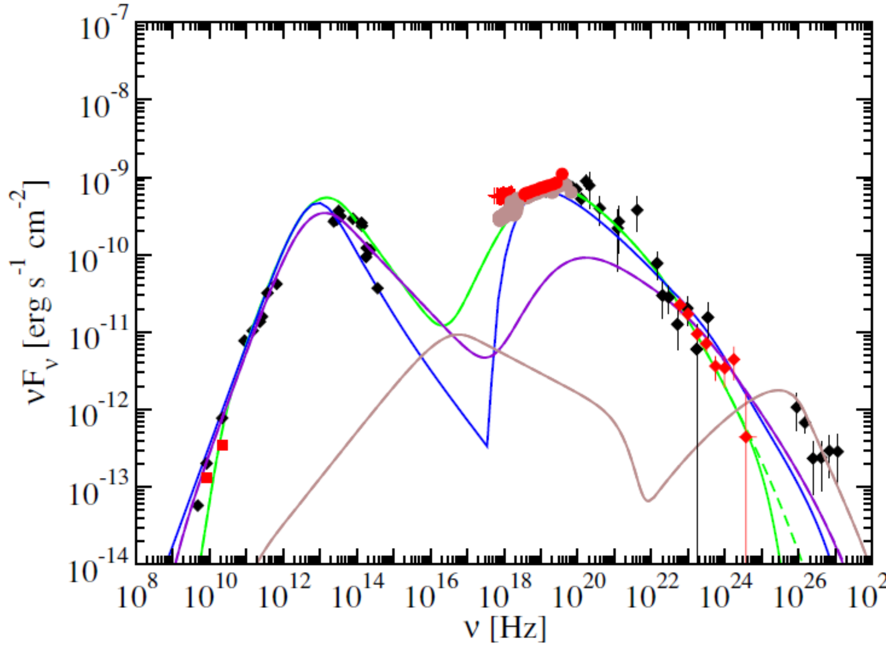


- gamma-ray resolved giant lobes in Centaurus A (Abdo+ 2010)
- once subtracted, core spectrum compatible with HESS spectrum PL over almost 5 decades
- Careful with claims of additional radiative VHE component

Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky

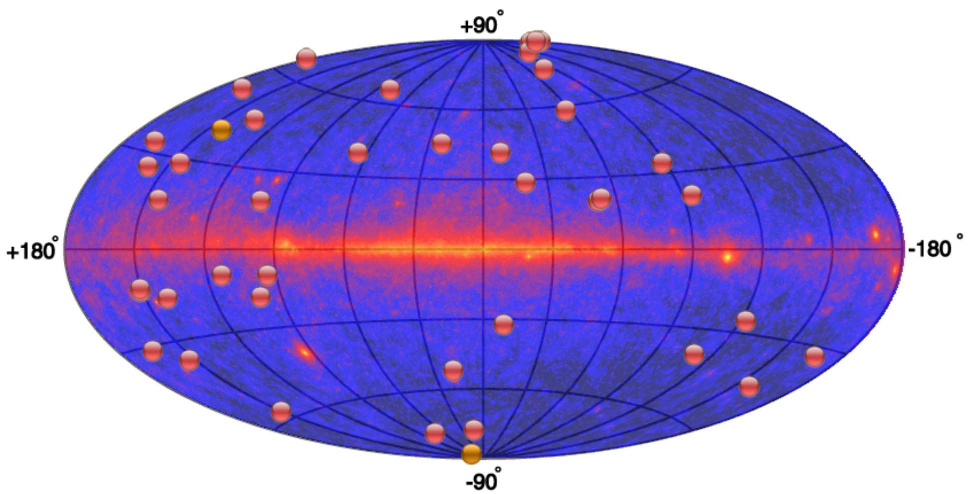




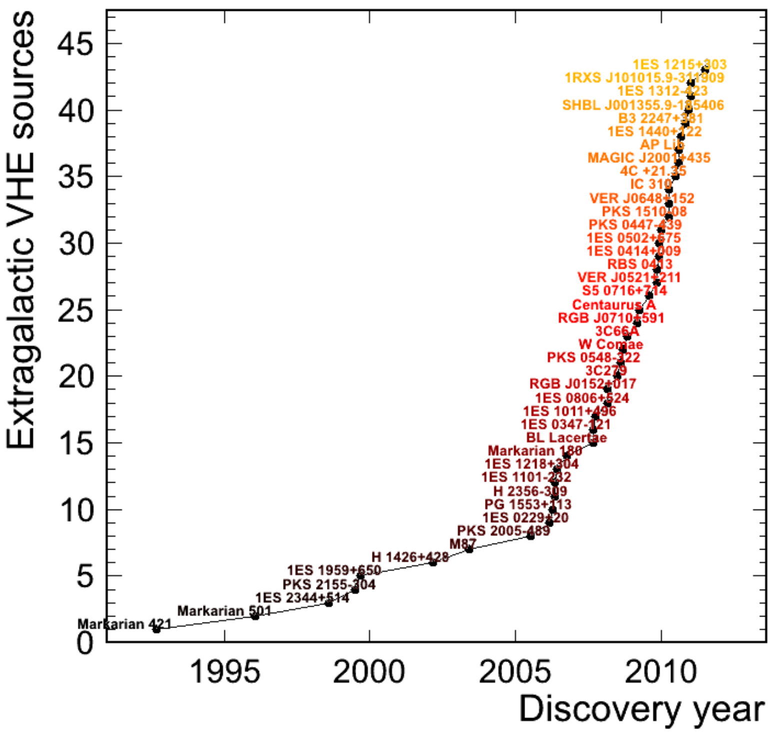


- gamma-ray resolved giant lobes in Centaurus A (Abdo+ 2010)
- once subtracted, core spectrum compatible with HESS spectrum PL over almost 5 decades
- Careful with claims of additional radiative VHE component
  "The question is not what you look at
  but what you see" (*Henry David Thoreau*)

Active Galaxies in GeV-TeV γ-Rays::VHE



http://tevcat.in2p3.fr



- "TeV" extragalactic emitters are
  - 3 unkown (See Szostek+ Poster)
  - 2 starburst galaxies
  - 3 radio galaxies/FR I
  - 3 FSRQ
  - BL Lacertae among which
    - 29 HBL
    - 4 IBL
    - 4 LBL
- Discovery rate $0.5\,\mathrm{yr}^{-1} \Rightarrow 5\,\mathrm{yr}^{-1}$
- Most *recent* VHE emitters discoveries based on *Fermi* indications

Active Galaxies in GeV-TeV γ-Rays::Finding VHE Targets

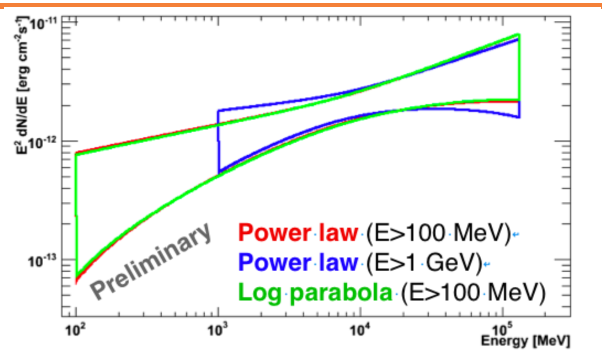


Fig. 1: SED of good TeV candidate showing no evidence for curvature.

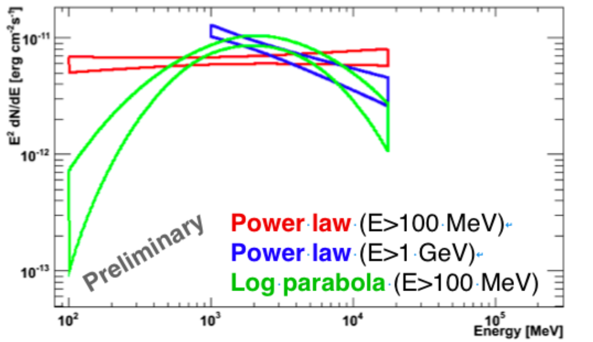
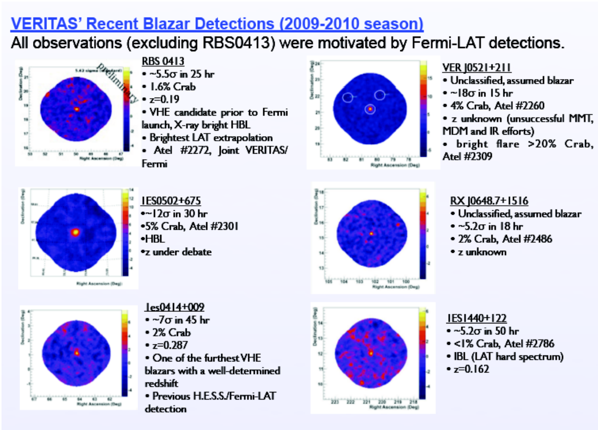


Fig. 2: SED of bad TeV candidate. Clear evidence for curvature.

Fortin, Horan & Ferrara 2009; arXiv:0912.3698



Cannon+ 2010, 8th Integral Symp.

- extract the $\gamma \leq 2$ spectra from 1LAC and test

$$F(E)dE \propto E^{-\Gamma} dE$$

at energies $E > 1\text{GeV}$ and versus

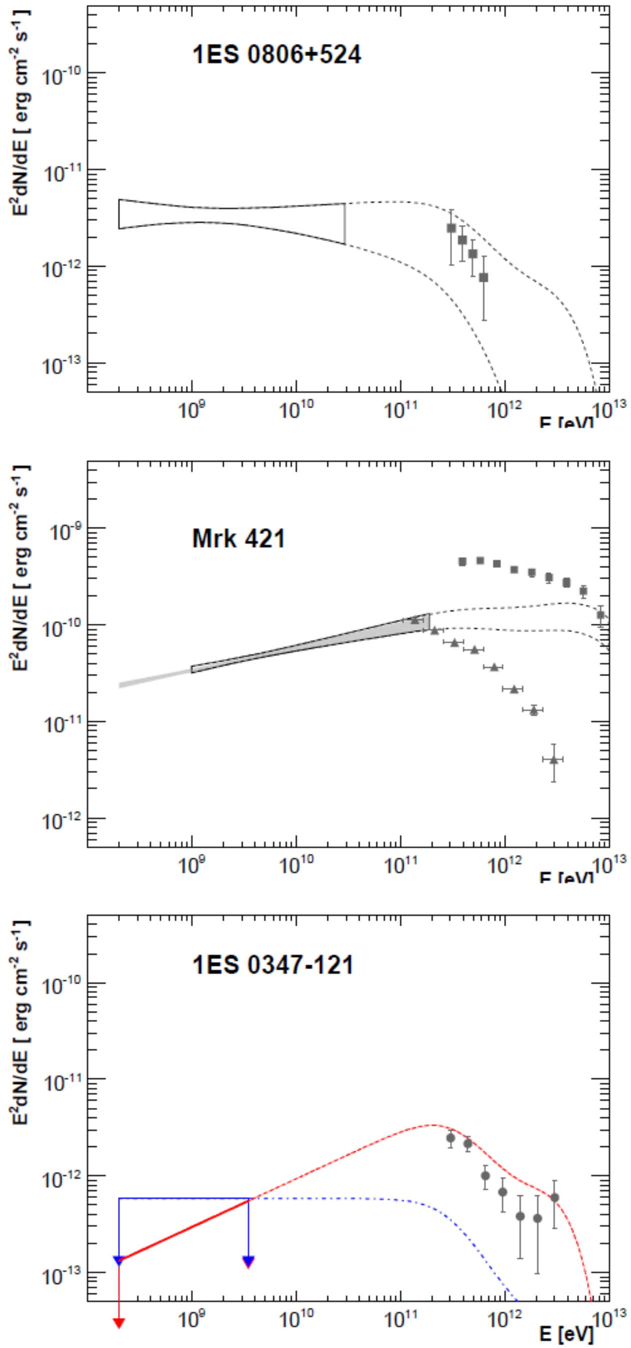
$$F(E)dE \propto E^{a+b\ln(E)} dE.$$

See Fortin, Horan+ poster

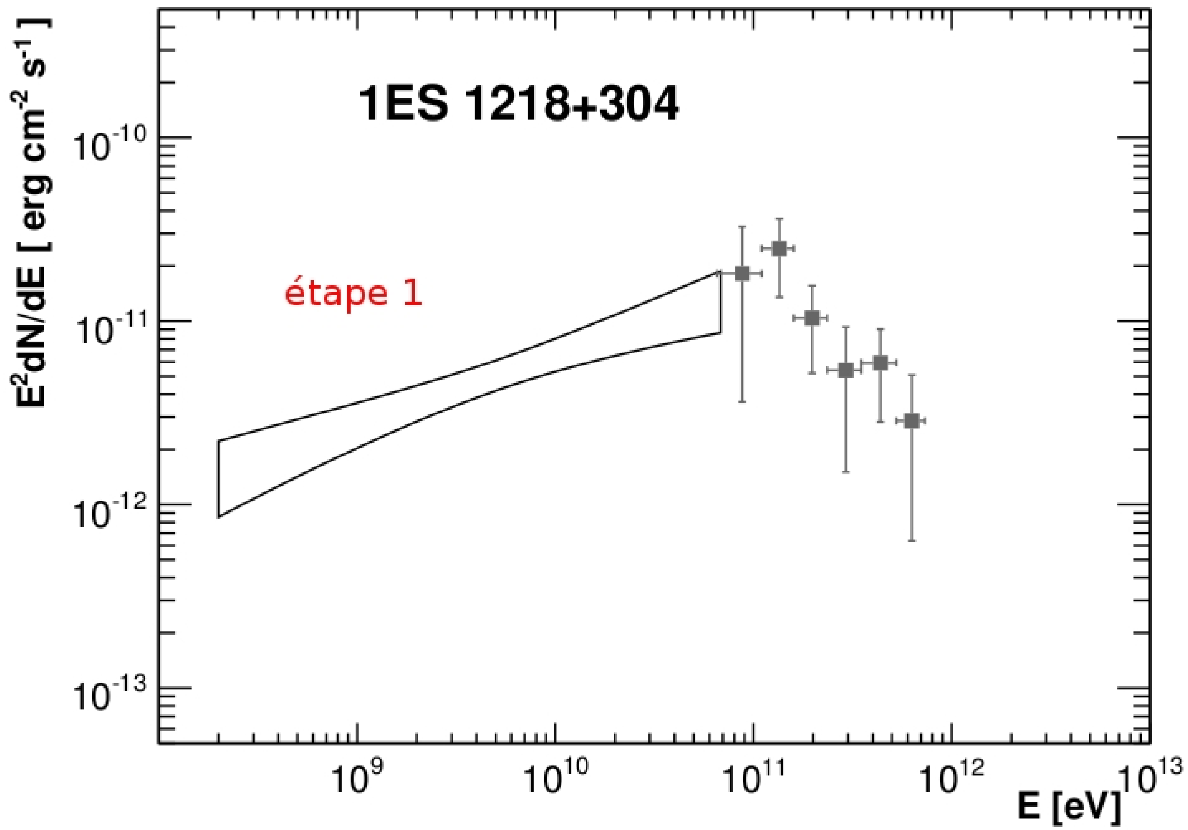
- Many new targets found for all major Čerenkov telescopes

Active Galaxies in GeV-TeV γ-Rays

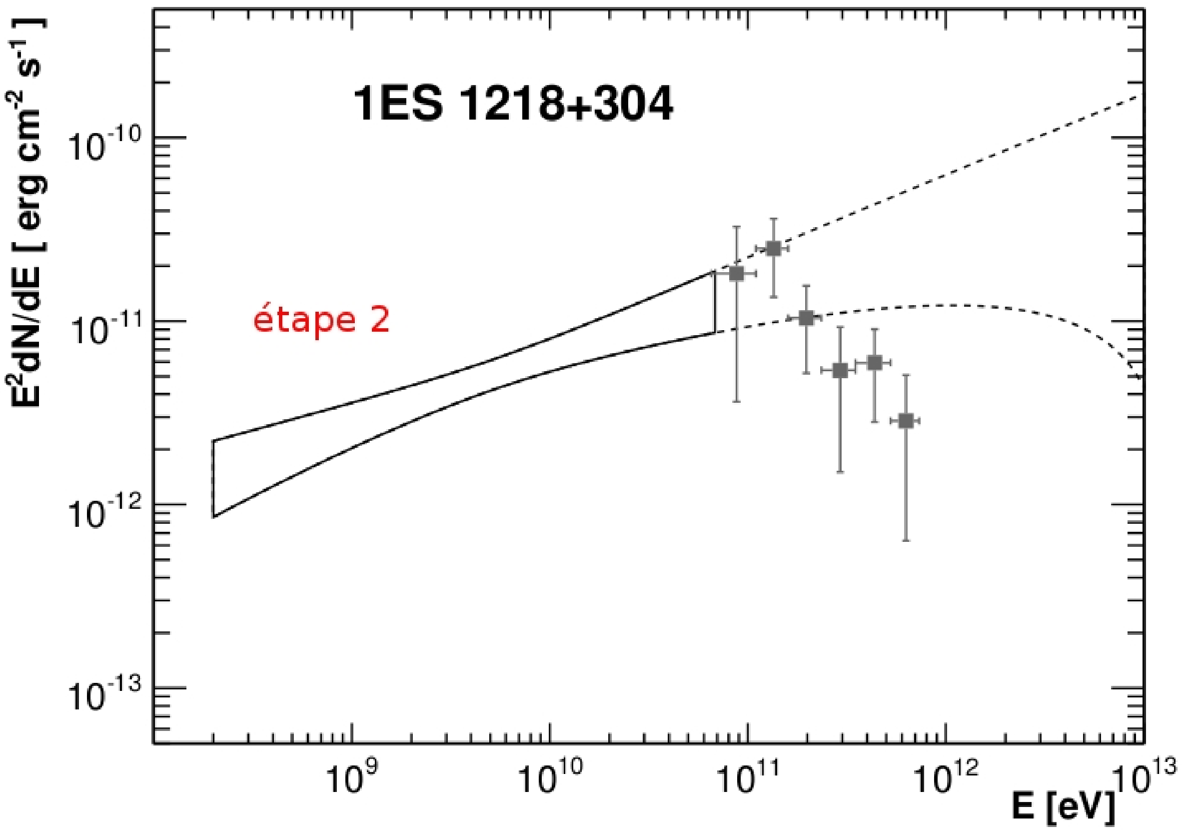
- *Fermi*-LAT counterparts of *known* extragalactic VHE emitters:
  Mostly power law spectra $F(E) = N_0(\frac{E}{E_0})^{-\Gamma}$
  $\Rightarrow 1.5 \lesssim \Gamma_{HE} \leq 2$ while $\Gamma_{VHE} > 2$
  Fermi observations constrain observed SED peak
  TeV emitters have the *hardest Fermi* spectra
- Normalizations generally in good agreement
  $\Rightarrow$HE counterparts mostly non-variable
- unseen HE sources still compatible with $\Gamma_{HE} \simeq 1.5$



Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky

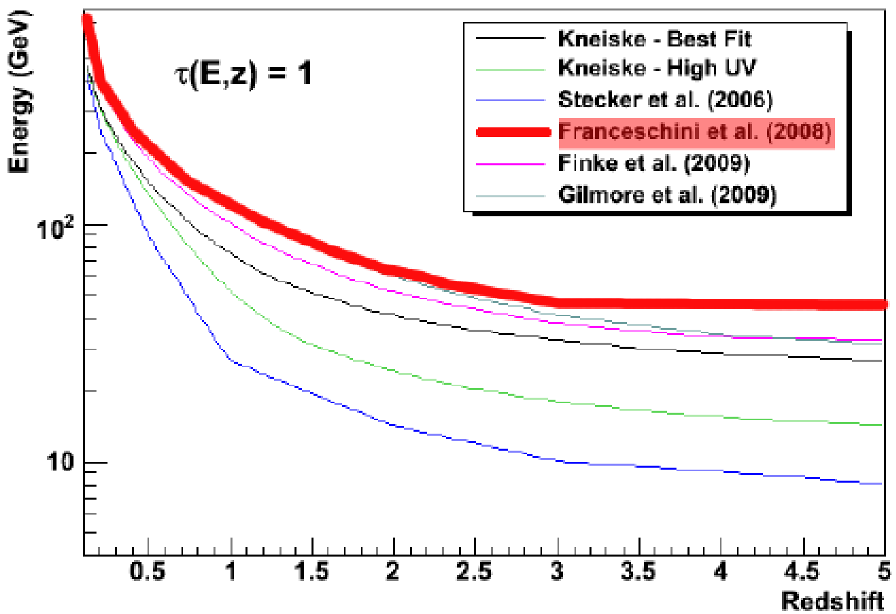


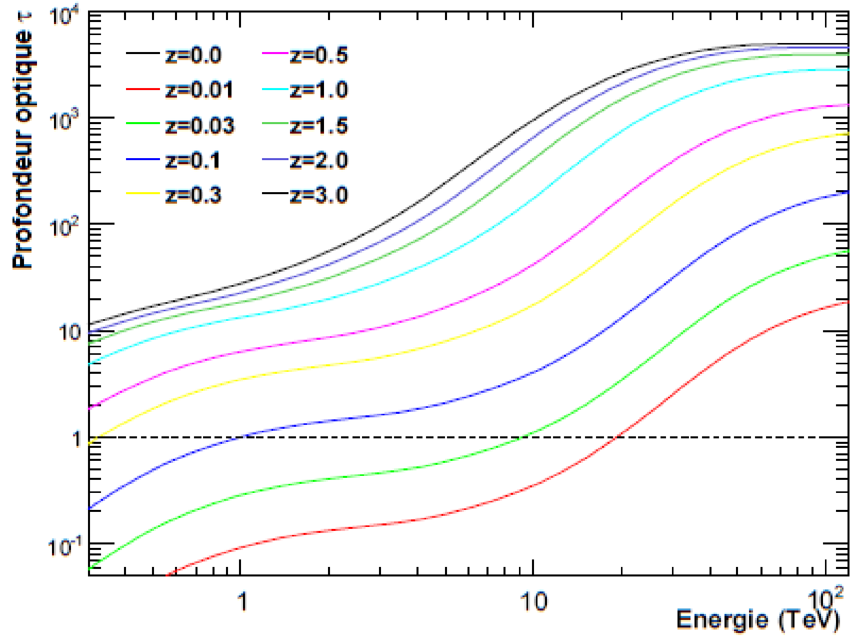
- GeV-TeV spectrum of 1ES 1218+304 (Albert+ 2006)



- GeV-TeV spectrum of 1ES 1218+304 with $\Delta\Gamma = 1.17 \begin{cases} \Gamma_{HE} = 1.91 \\ \Gamma_{VHE} = 3.08 \end{cases}$
- Power law confidence region extrapolation without EBL

Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky



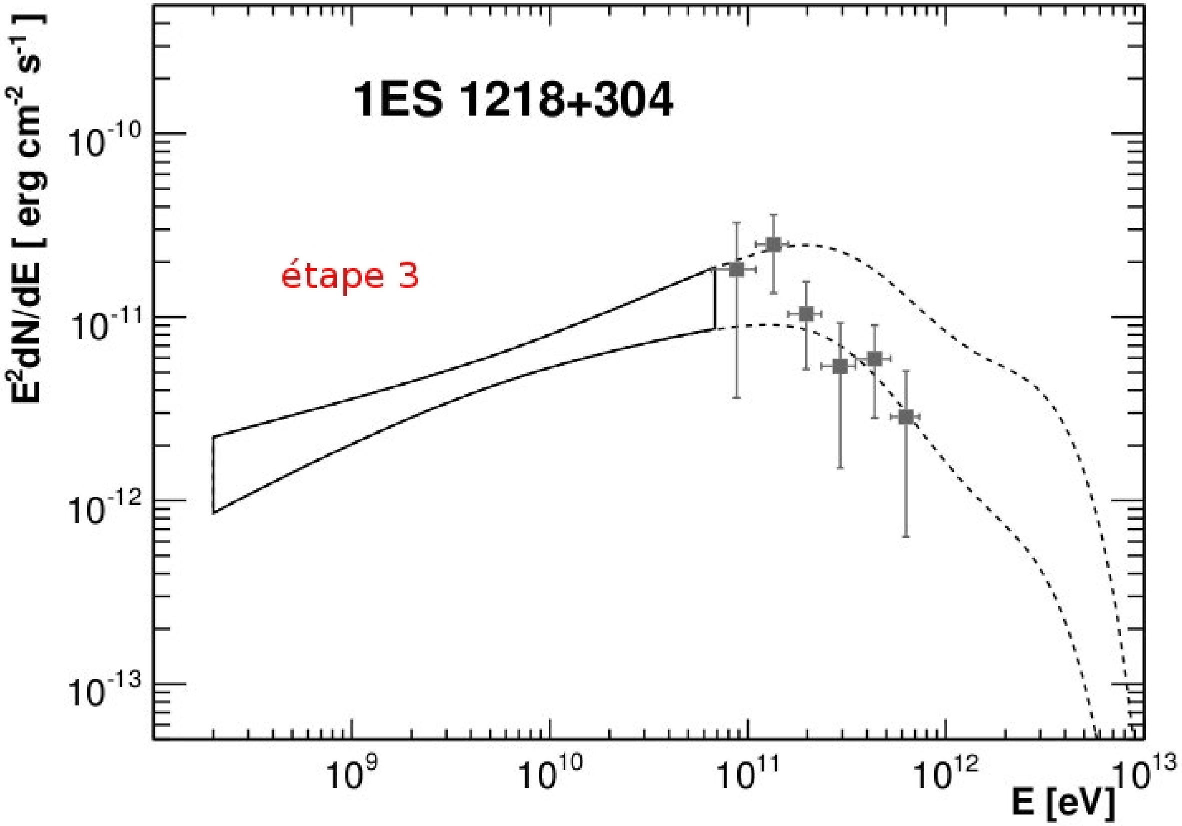


- γ-rays can interact with cosmological backgrounds $E_\gamma E_t \geq 2m_e^2c^4$
  $\Rightarrow$Observed spectrum $F_{\mathrm{VHE}}(E_\gamma) = e^{-\tau(E_\gamma, z)} \times F_{\mathrm{VHE,int}}(E_\gamma)$

$$\tau_\gamma(E_\gamma,\ z) = \int_0^z \mathrm{d}\ell(\mathrm{z}) \int_{-1}^{+1} \mathrm{d}\mu\, \frac{1-\mu}{2} \int_{\epsilon'_{th}}^{\infty} \mathrm{d}\epsilon'\ n_\epsilon(\epsilon', z)\ \sigma_{\gamma\gamma}(E'_\gamma,\ \epsilon',\ \mu)$$

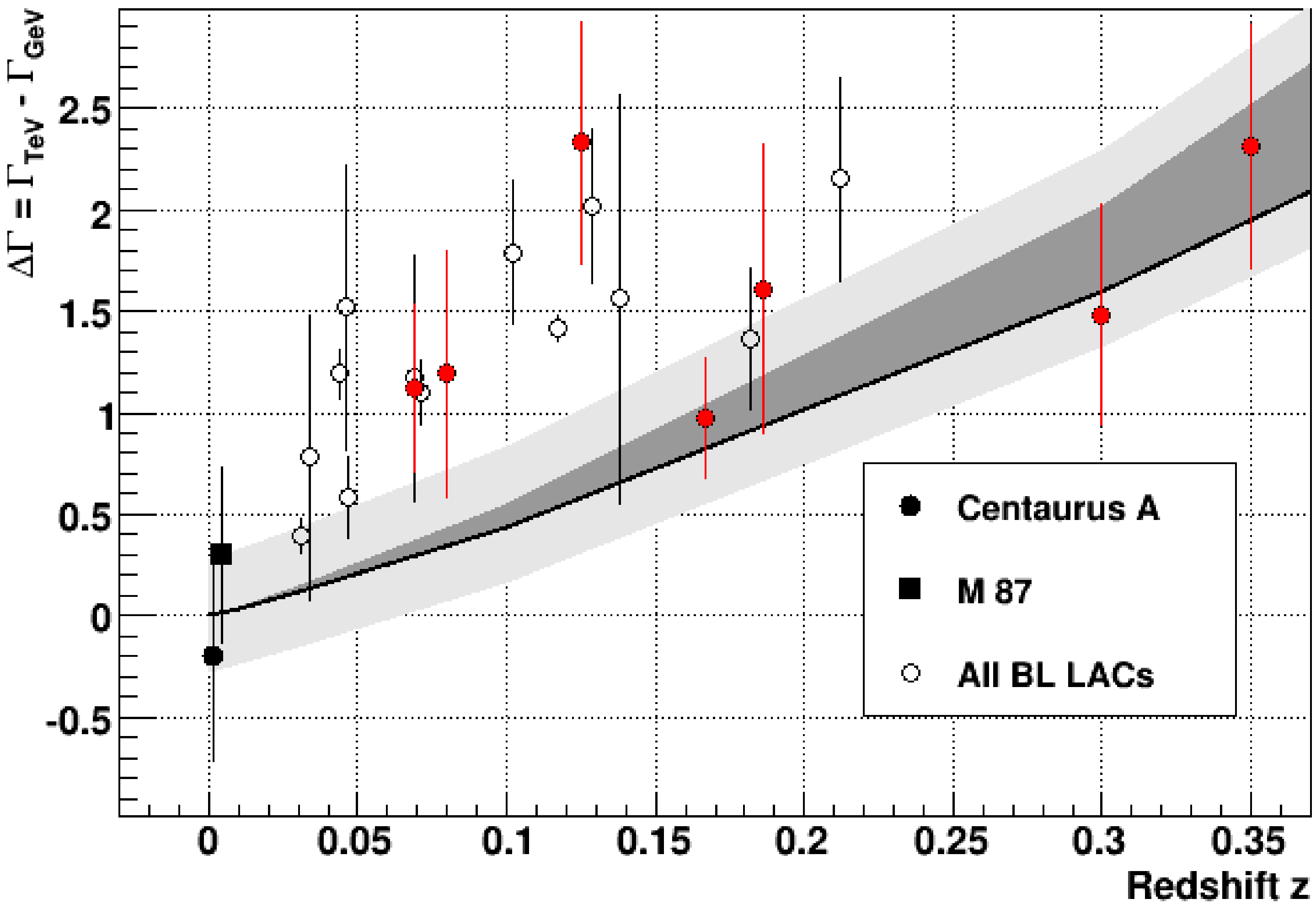
- Minimal EBL used to derive minimal $\Delta\Gamma(z) = \Gamma_{VHE} - \Gamma_{HE}$
  $\Rightarrow$ if $\Gamma_{\mathrm{VHE}} = \Gamma_{\mathrm{HE}} + \Delta\Gamma(z)$ then spectral break not intrinsic

Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky



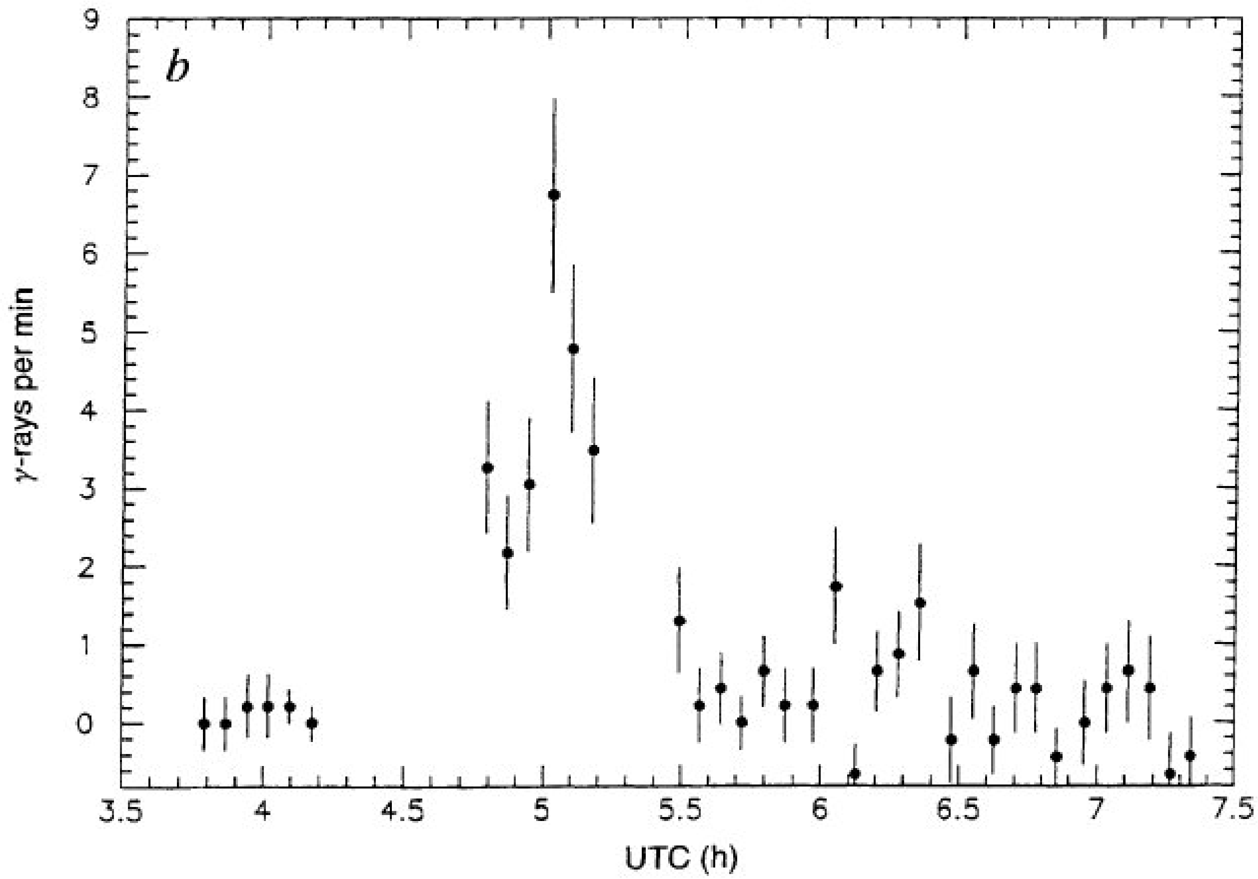
- GeV-TeV spectrum of 1ES 1218+304 with $\Delta\Gamma = 1.17 \begin{cases} \Gamma_{\mathrm{HE}} = 1.91 \\ \Gamma_{\mathrm{VHE}} = 3.08 \end{cases}$
- Power law confidence region extrapolation without EBL
- Power law confidence region $\times e^{-\tau(E,z=0.182)}$
  $\Rightarrow$spectral rollover compatible with extended and attenuated Fermi spectrum

Active Galaxies in GeV-TeV γ-Rays::*Fermi*'s Sky



- Distribution compatible with extrinsic attenuations + intrinsic curvature
- Possibly first direct evidence for a cosmological absorption *à la GZK* on AGN
- *Intrinsic* IC peak undefined when $\Gamma_{HE} < 2$ *and* $\Gamma_{VHE} = \Gamma_{HE} + \Delta\Gamma(z)$

Active Galaxies in GeV-TeV γ-Rays::VHE variability



GAMMA-RAY ASTRONOMY

Catching photons from hell

Francis Halzen

THE most energetic γ-rays yet discovered from beyond our Galaxy are described by Punch *et al.* on page 477 of this issue[1]. The source, Markarian 421, is a giant elliptical galaxy harbouring an active nucleus. That a distant source like this can be seen at all in teraelectronvolt (TeV = 10^{12} eV) γ-rays implies that its intrinsic luminosity may exceed by 10 orders of magnitude that of sources in our Galaxy such as the Crab supernova remnant.

Fluxes of astronomical high-energy photons are so small that even the latest satellite experiments, such as the EGRET detector on the Compton γ-ray Observatory, cannot extend their observations beyond energies of 10 GeV (10^{10} eV). The key to TeV astronomy and beyond is the use of the Earth's atmosphere as the active detector volume. A mirror with 2° aperture views photon-induced particle showers in the atmosphere over an effective area of 10^5 m^2. A 0.5 TeV photon will produce several hundred electrons at an altitude of 10 km. Although the shower is absorbed in the air, the Cerenkov radiation produced by the shower particles can be detected with mirrors viewing the sky from mountains during clear, moonless nights.

This Cerenkov method conveniently becomes operative at a threshold not far above the energy at which satellites become insensitive. The real experimental problem is that γ-ray signals are drowned in a background of showers produced by cosmic ray nuclei. Background showers fortunately differ in two essential ways. Most of them will not originate from the direction of the γ-ray source, and they produce hadronic (nuclear) rather than purely electromagnetic showers.

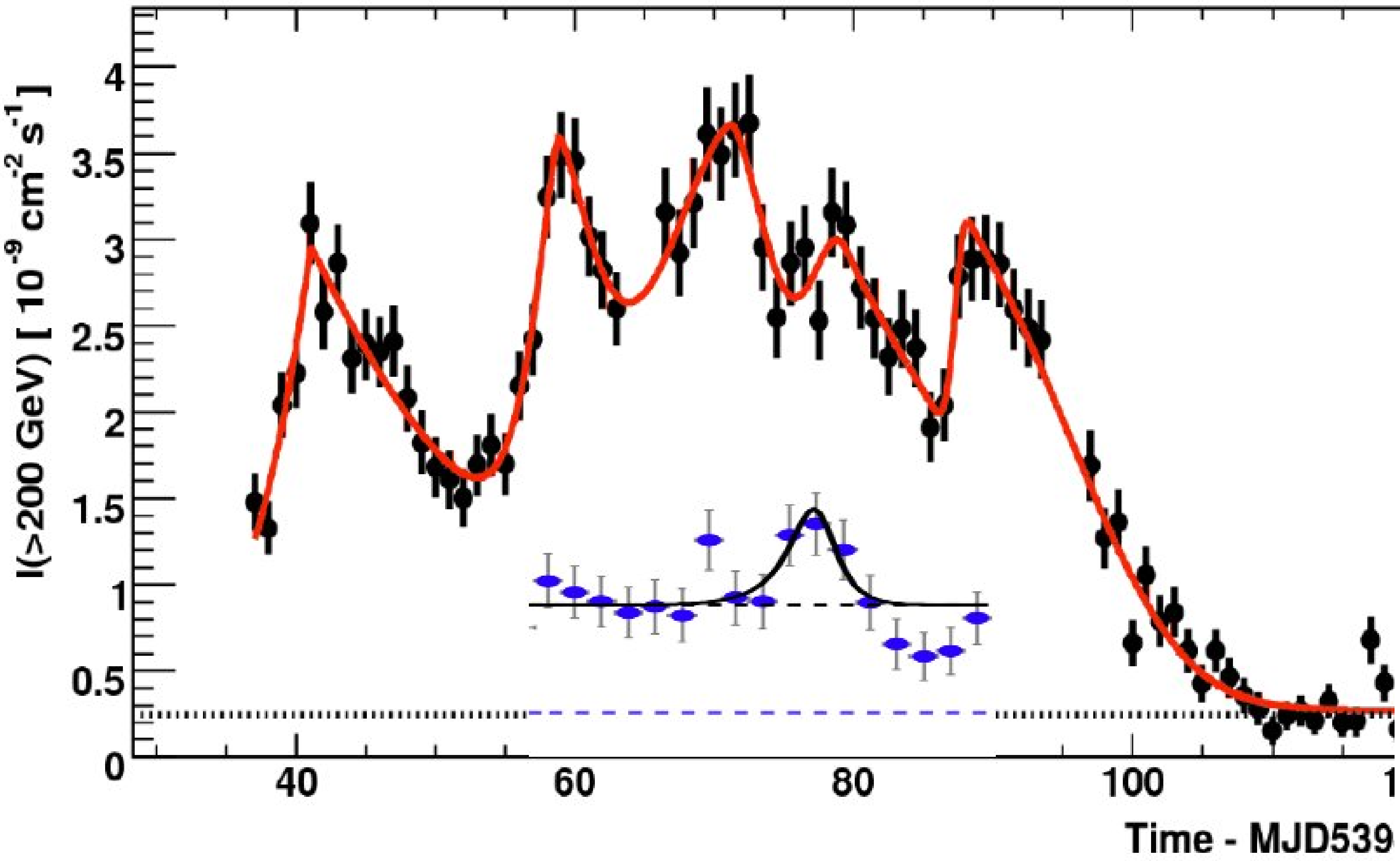
The Whipple Observatory, on Mount Hopkins in Arizona, has over 100 fast photomultipliers to map the image painted by the showers on its 10-m aperture[2]. Pattern recognition techniques are applied to the shower images to reject hadron-initiated events with a minimal depletion of the photon signal. This technique has been fine-tuned in observations of the Crab Nebula. The measured flux (10^{34} erg s^{-1}) has since been confirmed by two French experiments in the Pyrenees, and the Crab is the 'standard candle' for TeV astronomy.

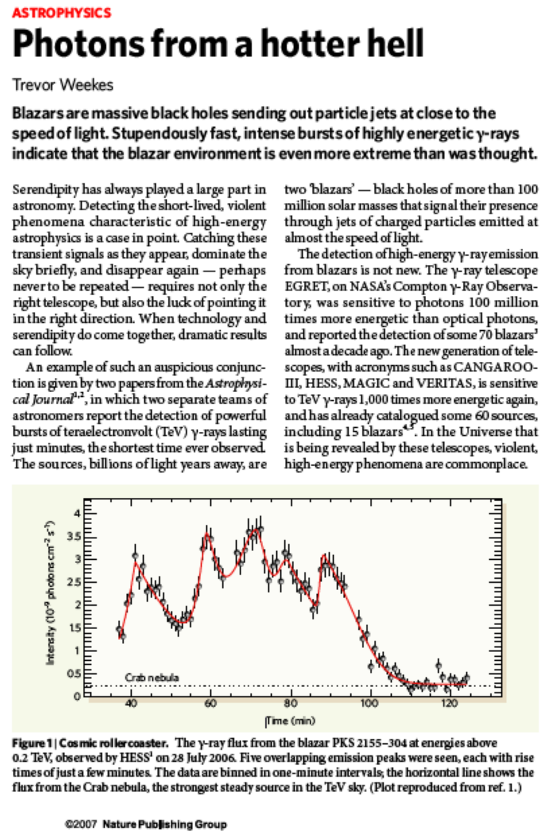
The Whipple telescope was trained on Mk421 from March to June of this year. Although the galaxy is 10^5 times further from us than is the Crab, the count rate

452

- TeV γ-ray flares from Mkn421 seen by the Whipple observatory (Gaidos 1992)
- Variability on timescales $\lesssim 15'$ ($T_2 \sim 3\Delta t$)
  $\Rightarrow$Doppler factor $\delta \geq 10$ if $\tau_{\gamma\gamma} < 1$ (Celotti, Fabian & Rees 1998)

Active Galaxies in GeV-TeV γ-Rays::VHE variability





ASTROPHYSICS

Photons from a hotter hell

Trevor Weekes

Blazars are massive black holes sending out particle jets at close to the speed of light. Stupendously fast, intense bursts of highly energetic γ-rays indicate that the blazar environment is even more extreme than was thought.

Serendipity has always played a large part in astronomy. Detecting the short-lived, violent phenomena characteristic of high-energy astrophysics is a case in point. Catching these transient signals as they appear, dominate the sky briefly, and disappear again — perhaps never to be repeated — requires not only the right telescope, but also the luck of pointing it in the right direction. When technology and serendipity do come together, dramatic results can follow.

An example of such an auspicious conjunction is given by two papers from the *Astrophysical Journal*[1,2], in which two separate teams of astronomers report the detection of powerful bursts of teraelectronvolt (TeV) γ-rays lasting just minutes, the shortest time ever observed. The sources, billions of light years away, are two 'blazars' — black holes of more than 100 million solar masses that signal their presence through jets of charged particles emitted at almost the speed of light.

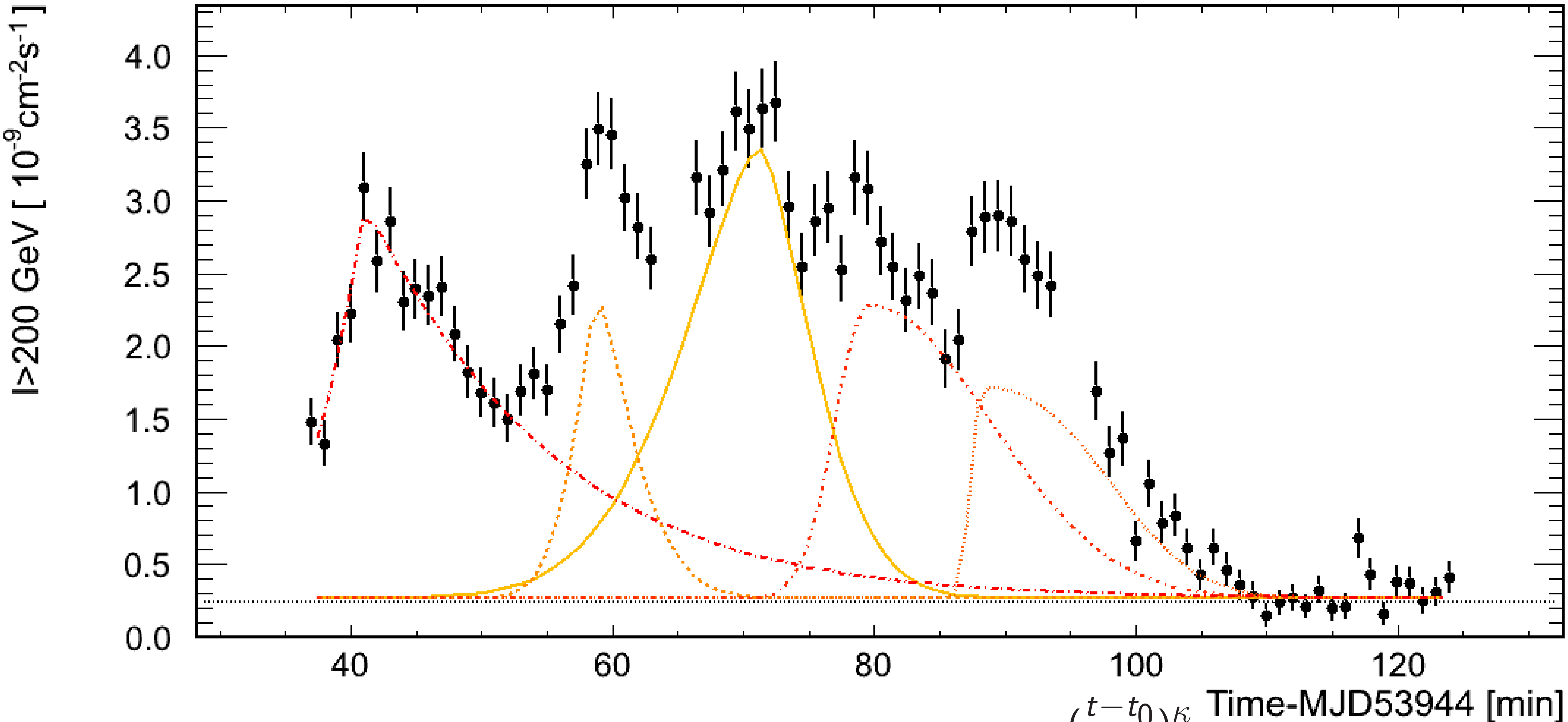
The detection of high-energy γ-ray emission from blazars is not new. The γ-ray telescope EGRET, on NASA's Compton γ-Ray Observatory, was sensitive to photons 100 million times more energetic than optical photons, and reported the detection of some 70 blazars[3] almost a decade ago. The new generation of telescopes, with acronyms such as CANGAROO-III, HESS, MAGIC and VERITAS, is sensitive to TeV γ-rays 1,000 times more energetic again, and has already catalogued some 60 sources, including 15 blazars[4,5]. In the Universe that is being revealed by these telescopes, violent, high-energy phenomena are commonplace.

Figure 1 | Cosmic rollercoaster. The γ-ray flux from the blazar PKS 2155–304 at energies above 0.2 TeV, observed by HESS[1] on 28 July 2006. Five overlapping emission peaks were seen, each with rise times of just a few minutes. The data are binned in one-minute intervals; the horizontal line shows the flux from the Crab nebula, the strongest steady source in the TeV sky. (Plot reproduced from ref. 1.)

Hinton 2008, ICRC review

- HESS $\Delta t = 1'$ fastest doubling time scale $T_2 = |\frac{t_j - t_i}{\Phi_j - \Phi_i}|\frac{\Phi_i + \Phi_j}{2} = 224 \pm 60\,\mathrm{s}$
- MAGIC $\Delta t = 2'$ and $T_2 \sim 2'$
- Caveat: T_2 meaningless if variability scale invariant (McHardy & Czerny 1987)

Active Galaxies in GeV-TeV γ-Rays::VHE variability



- GRB-like generalized Gaussian shapes $I(t) = I_0 e^{-(\frac{t-t_0}{\sigma_{r,d}})^{\kappa}}$
- Fastest significant rise/fall time is

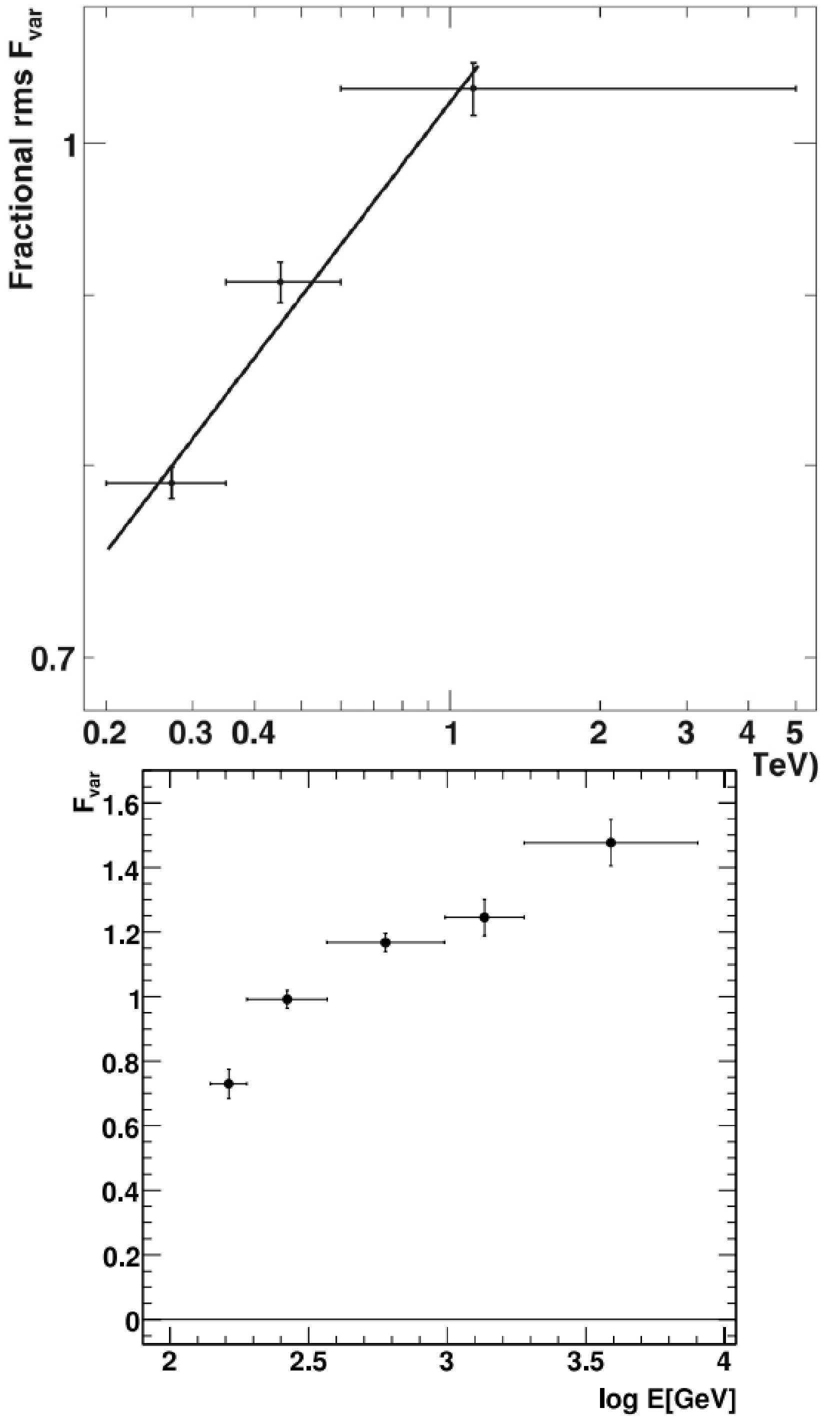
$$\tau_r = (\ln 2)^{1/\kappa}\sigma_r = \begin{cases} 173 \pm 28\,\text{s for PKS } 2155-304 \\ \sim 180\,\text{s for Mkn } 501 \end{cases} \qquad \tau_{\gamma\gamma} \begin{cases} > 1 & E_\gamma = 1\text{TeV} \\ \simeq 1 & \text{if } \delta \geq 50 \end{cases}$$

- Black hole mass in PKS 2155-304 estimated at $M_{\rm PKS} = 1 - 2 \times 10^9 M_\odot$
  $\Rightarrow$Light crossing time

$$t_{\rm LCT} = 2GM_{\rm PKS}/c^3 = R_{\rm S}/c = 3 - 6\,{\rm h}$$

  $\Rightarrow t_{\rm LCT}/t_{\rm var} = 60 - 120$ when $t_{\rm LCT}/t_{\rm var} < 1$ in GRB
  - "[..] we would not expect to see large amplitude variability on much shorter timescales" (Sikora+ 1994)
  - "[..] the jet becomes radiative on scales much larger than the central source dimension" (Spada+ 2001)
- Assume $R \geq R_{\rm S} \rightarrow t'_{var} = \delta^{-1} t_{\rm var} \geq t_{\rm LCT}$
  $\Rightarrow$ large Doppler boost $\delta \geq 60 - 120 \times R/R_{\rm S}$
  "[..]observed variability imprinted either by a small fraction of the BH horizon" (Begelman+ 2008)$\Rightarrow$"jets in a jet" (Giannos, Uzdensky & Begelman)
  δ no longer indicative of jet properties $\mathcal{D}$? (Ghisellini+ 2010)
  $\Rightarrow$Needle/jet structured model (Tavecchio & Ghisellini 2009)

Active Galaxies in GeV-TeV γ-Rays::VHE variability



- What is the amplitude of variability in the dynamic range?
- energy-binned light curve on 4 nights $\Rightarrow F_{\mathrm{var}}(E) \propto E^{0.19}$
  similar behaviour in synchrotron radiation
- Possibly related to energy-dependent cooling time scales
- Also found in Mkn 501 data (MAGIC collaboration 2007)

- Variance of a light curve $\Phi(t)$ expressed as

$$\sigma_V = \int_0^T (\Phi(t) - \overline{\Phi})^2 dt = \int_{1/T}^{1/\Delta t} P(\nu) d\nu$$

with $P(\nu) = \frac{2T}{\overline{\Phi}^2 N^2} |\hat{F}(\nu)|^2$ the Power Density Spectrum
and usually $P(\nu) \propto \nu^{-\alpha}$ over a broad range for X-ray observations of AGN

- However $\Phi(t)$ affected by discontinuities and gaps inherent to ACTs
$\Rightarrow \Phi(n) = \phi(n) \cdot \omega(n) \cdot \eta(n)$
$\Rightarrow \phi(n)$ is just one *realization* of the stationary random process
$\Rightarrow$ Misleading artefacts in frequency space for all transforms

- Derive $\alpha \pm \sigma_\alpha$ from likelihood comparison of $N \gg 1$ stochastic process simulations with experimental conditions (sampling, flux uncertainties, run resets, daily observation length) assuming signal is red noise (using Timmer & König 1995 light curve method).

- First VHE PDS (ever) on "Big Flare" light curve
  $\Rightarrow$ Red noise fluctuations with

$$P(\nu) \propto \nu^{-\alpha},\ \alpha \leq 2$$

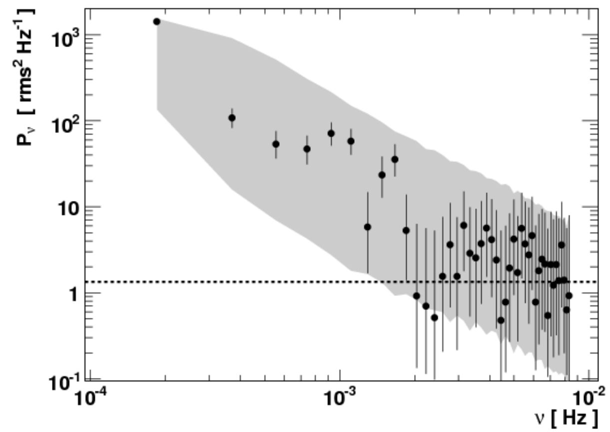
- Maximum likelihood method using *simulated structure functions* extended to 4 consecutive high-state nights converges to

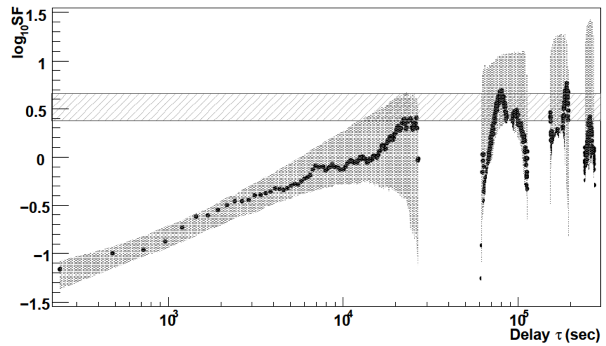
$$\alpha = 2.32 \pm 0.12$$

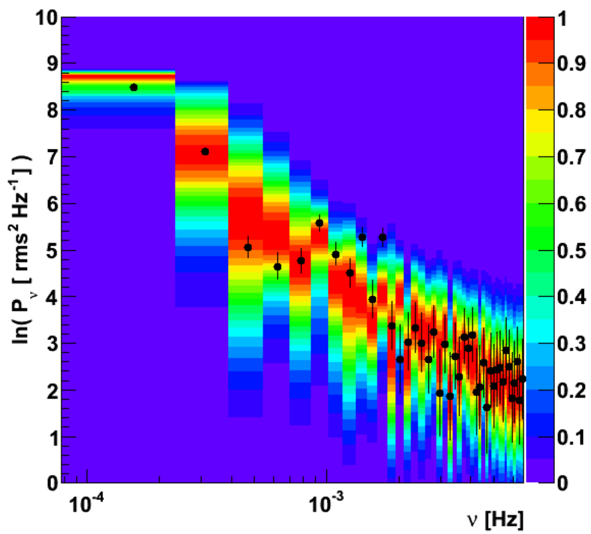
- Maximum likelihood method using *simulated Fourier transforms* to 4 consecutive high-state nights converges to

$$\alpha = 1.76^{+0.22}_{-0.21}$$

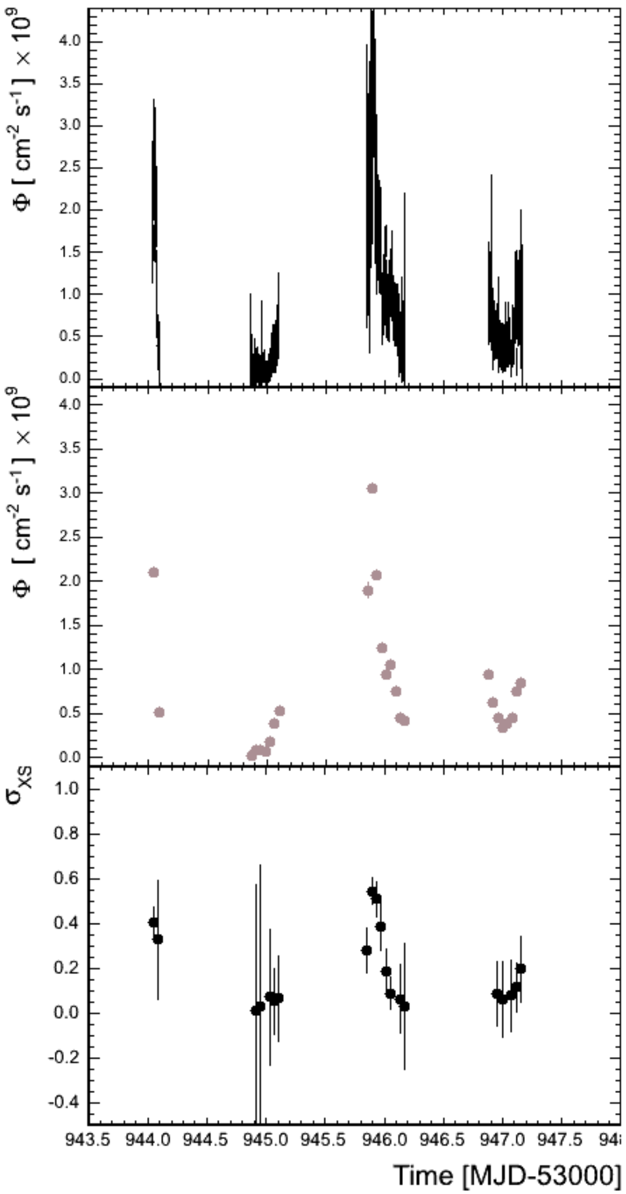
- Compatible with archival X-ray PDS
  no indication of low/high-frequency cutoff







Active Galaxies in GeV-TeV γ-Rays::VHE variability

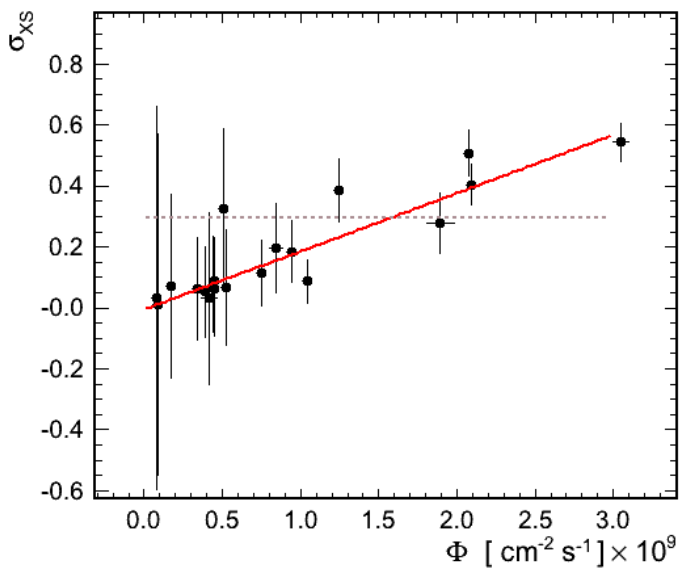


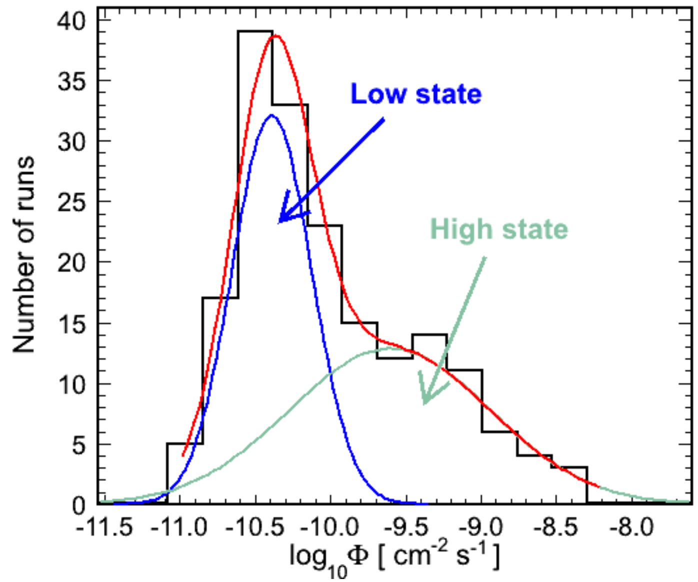
- $\Delta t = 1'$ time series averaged over $\sim 60'$
  $\Rightarrow$ Excess rms

$$\sigma^2_{XS} = \frac{1}{N}\sum_{i=1}^{i=N}[(\phi_i - \Phi)^2 - \sigma_i^2]$$

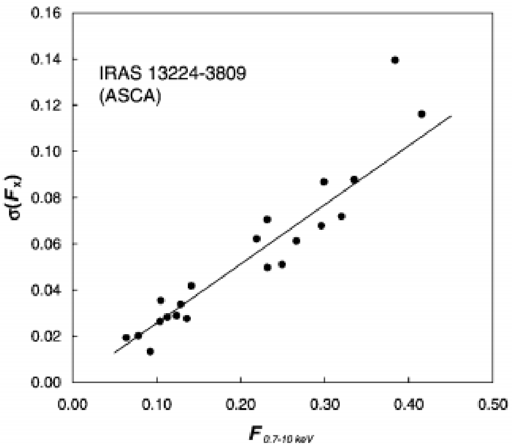
is proportional to average flux Φ

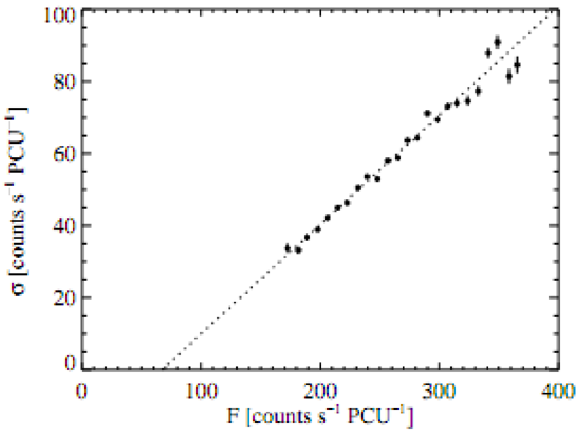
$\Rightarrow \sigma_{XS} \propto (0.19 \pm 0.03) \times \Phi$

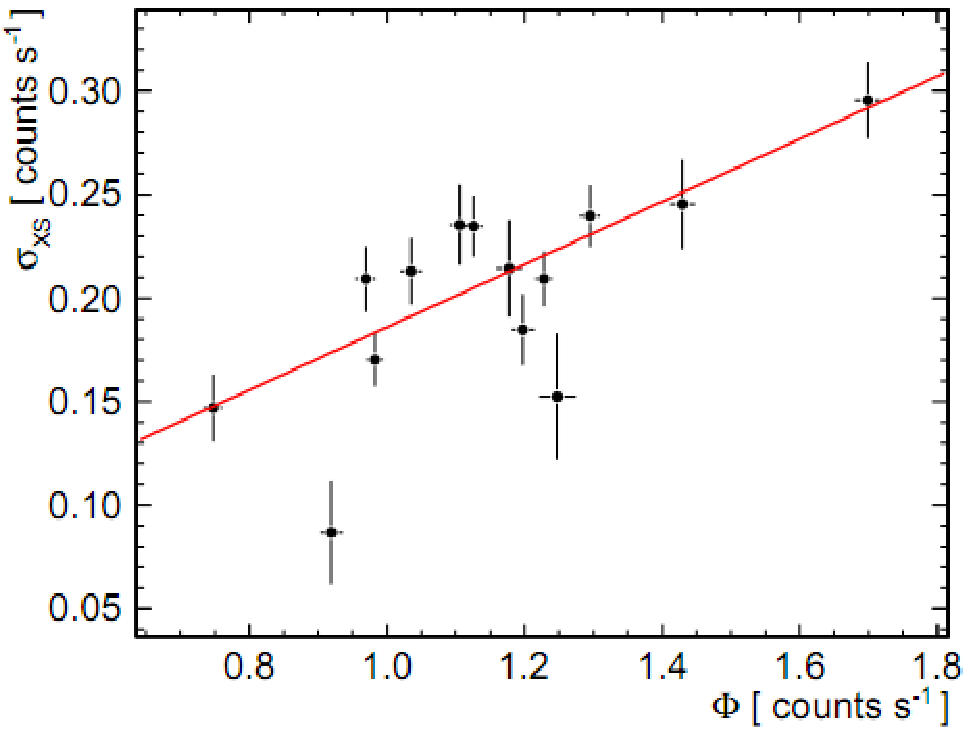




Active Galaxies in GeV-TeV γ-Rays::VHE variability



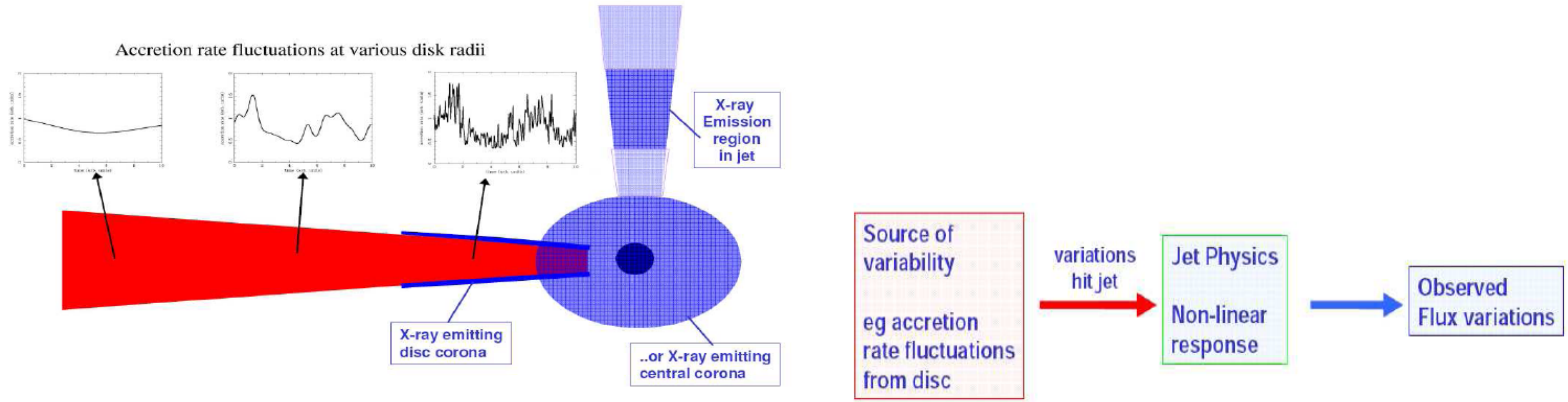




- linear rms-flux relation and gaussian distribution of log flux
  $\Rightarrow$variations are lognormal
- X-ray Lognormal fluctuations unrelated to jet except one BL Lac:
  SAX J1808 (Uttley & McHardy 2001)
  Mrk 766 (Vaughan+ 2003)
  IRAS 13244-3809 (Gaskell 2004)
  Cygnus X-1 (Uttley+ 2005)
  BL Lac (Giebels & Degrange 2009)
  $\Rightarrow \sigma_{XS} \propto (0.15 - 0.3)\Phi$
- LC result of many independent stochastic processes?

$$\Phi_N = \prod_{n=1}^{N} \phi_n \rightarrow \ln \Phi_N = \sum_{n=1}^{N} \ln \phi_n$$

Active Galaxies in GeV-TeV γ-Rays::VHE variability



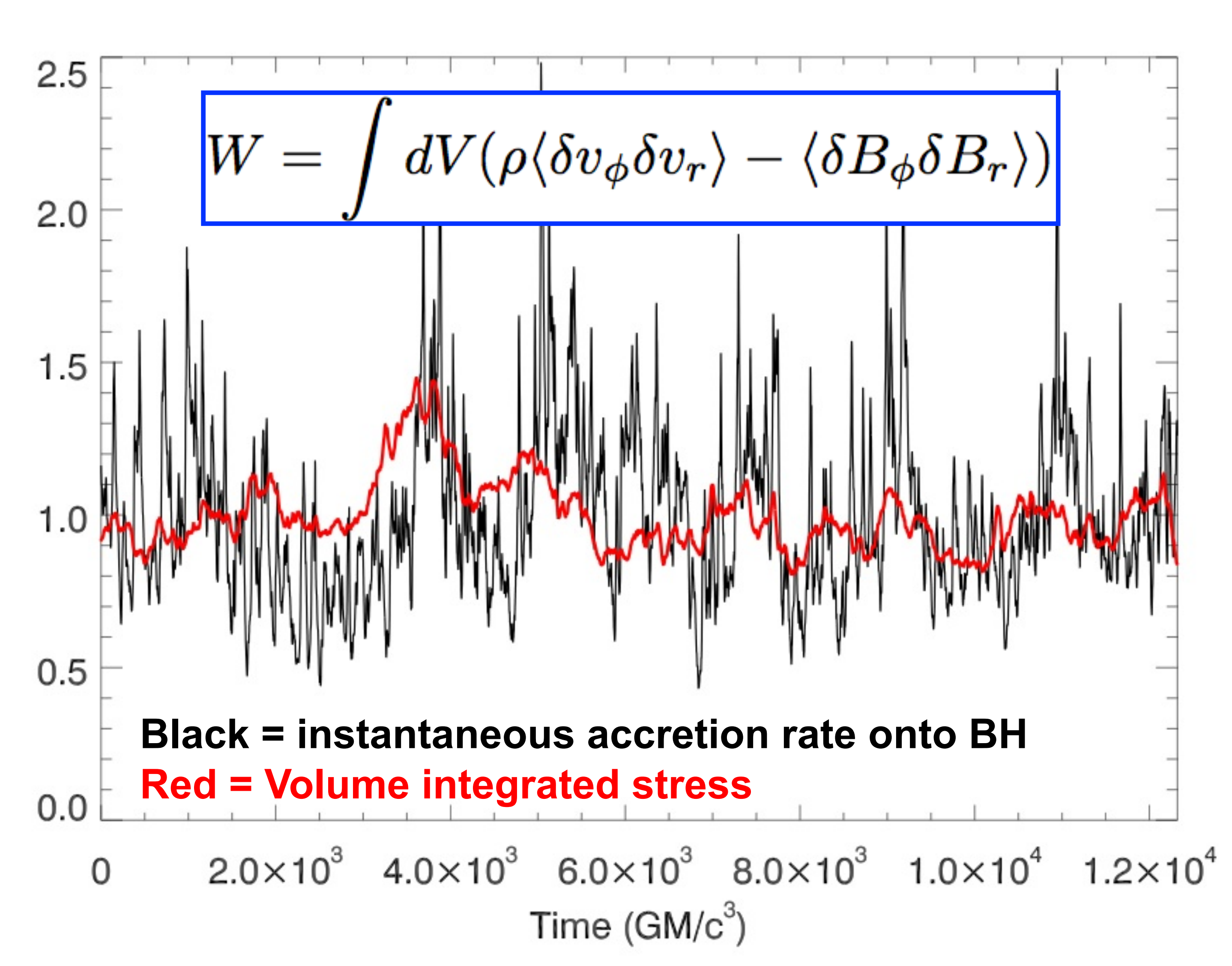
McHardy 2008; PoS

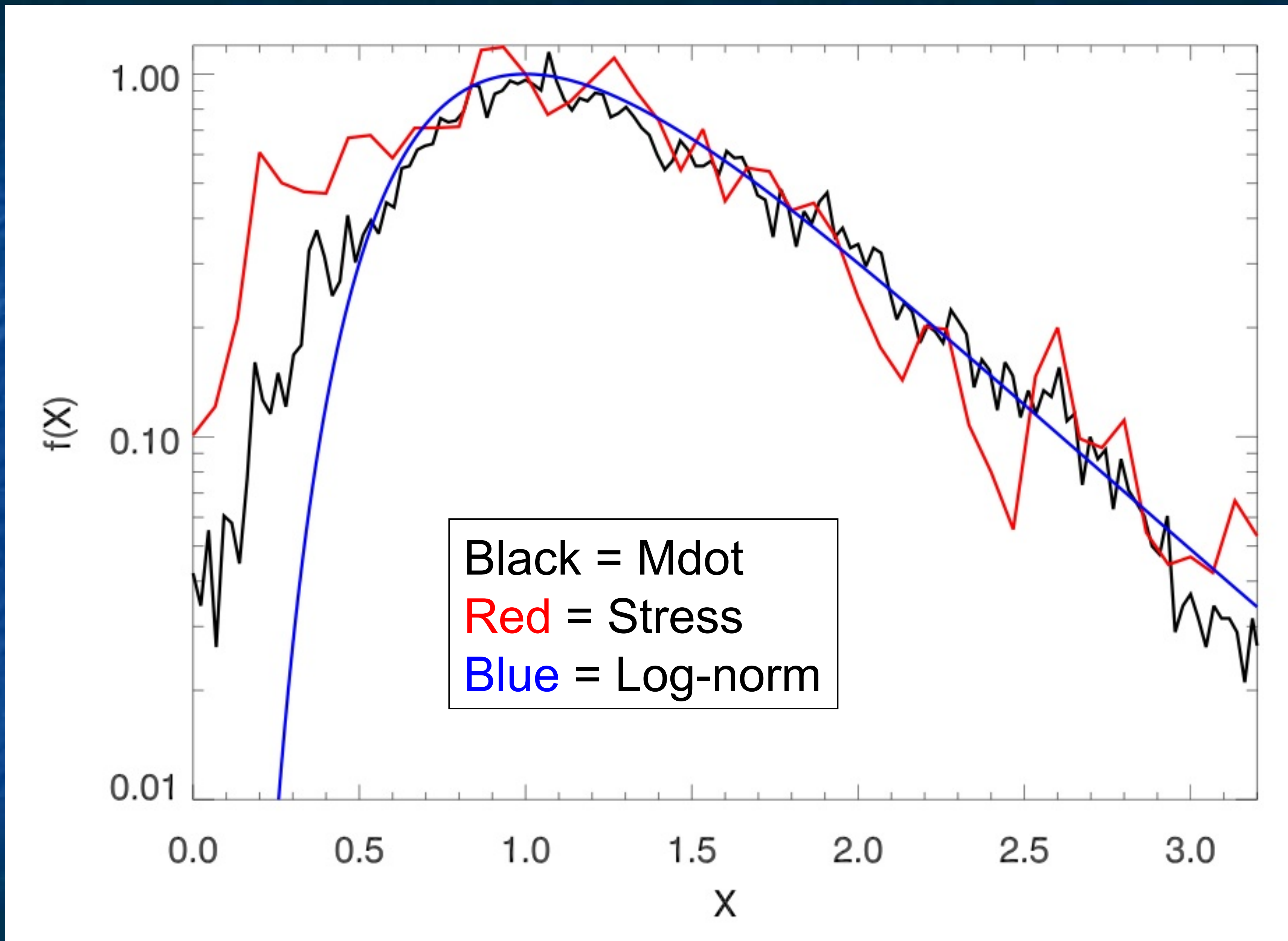
- Uttley & McHardy (2001): "Subdivision of magnetic reconnection energy release as an avalanche occuring on large scales in the corona" or "radius-dependent fluctuations in the mass accretion rate as modelled in Lyubarskii+ (1997)"
- Photon breeding mechanism (Stern & Poutanen 2006)

⇒ Link lognormal distribution to underlying physics

⇒*Difficult measurement but lognormality needs to be searched for*

Proxy light curves…




1.00
0.10
0.01
f(X)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
X
Black = Mdot
Red = Stress
Blue = Log-norm

Active Galaxies in GeV-TeV γ-Rays::Variability

- What is the amplitude of variability in the dynamic range/at various wavebands?
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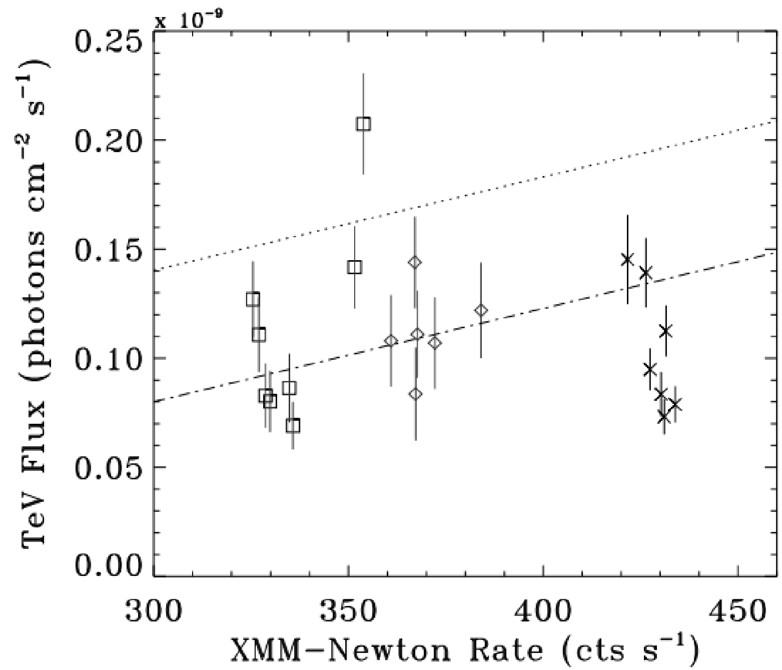
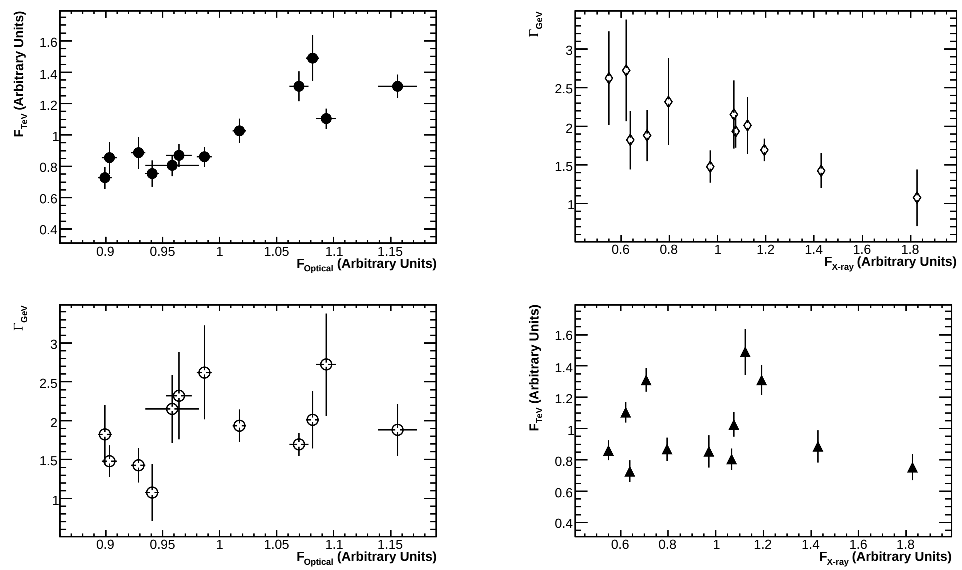
- Is there evidence for non-linear behavior?
- How does the variability vary with luminosity in the d. r./at various wavebands?
- Can the variability properties of an AGN change with time?
  $\Rightarrow$ "are AGNs moody?"

Active Galaxies in GeV-TeV γ-Rays::VHE/X-ray correlations?

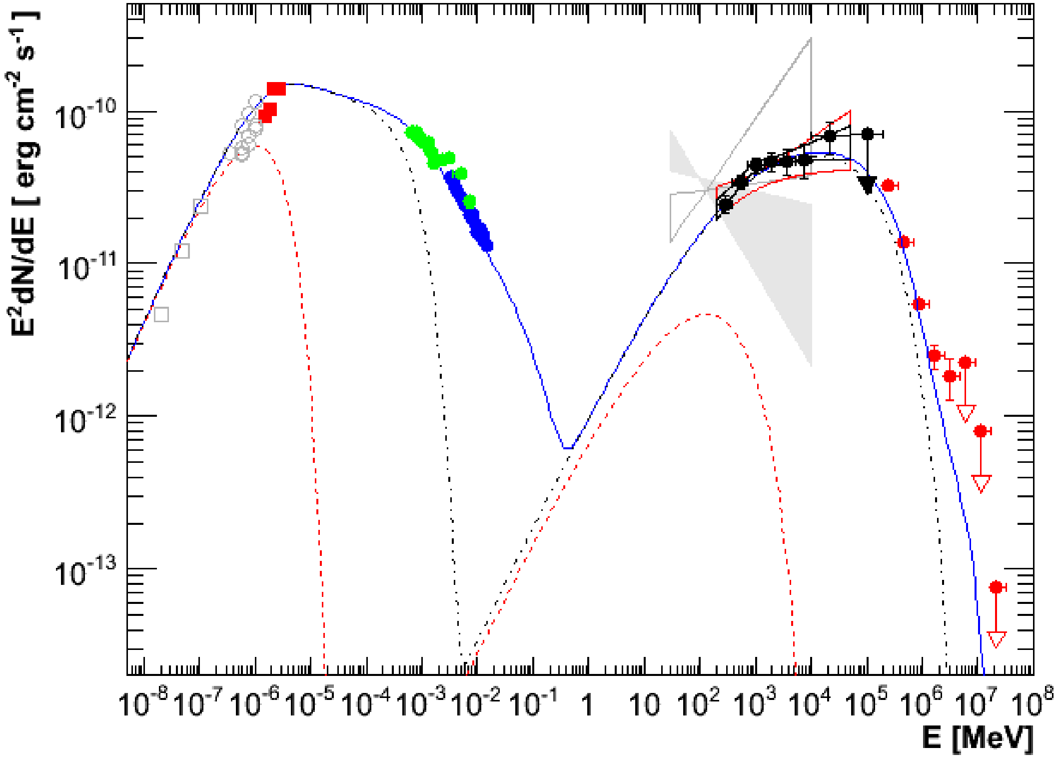
- VHE γ-ray and X-ray flux correlated
  $\Rightarrow$ growing literature on $F_\gamma \propto F_X^{\eta(F_\gamma)}$
- Instances of *no* correlated variability challenging for simple SSC (one zone homogenous) models
  - in Mkn 421 (Acciari+ 2009)
  - in PKS 2155-304 (Abdo & Aharonian+ 2010, Aharonian+ 2004)

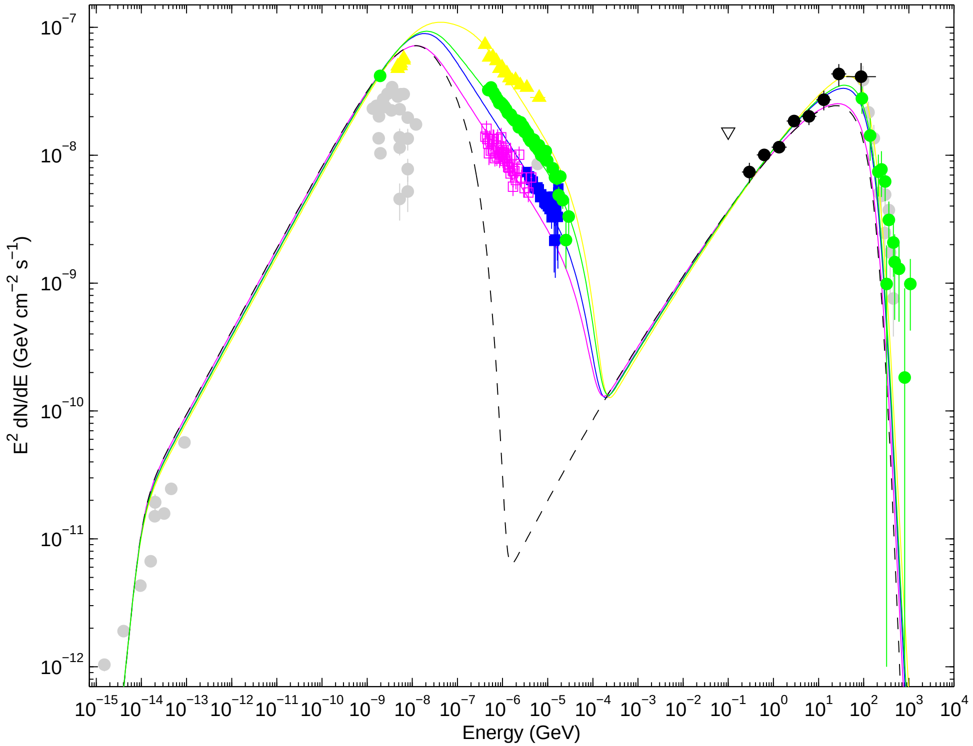
  $\Rightarrow$claimed as evidence for *hadronic* emission (see also Poster Cerruti)
- "[..] protons, despite being efficiently accelerated [..] are more likely to remain radiatively passive in AGN jets." (Sikora 2011)





Active Galaxies in GeV-TeV γ-Rays::VHE/X-ray correlations?

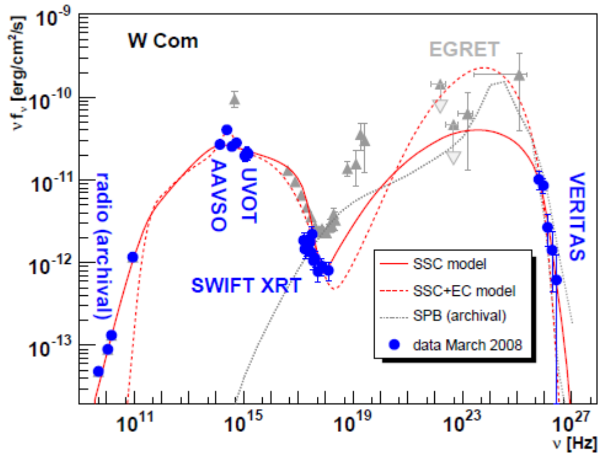


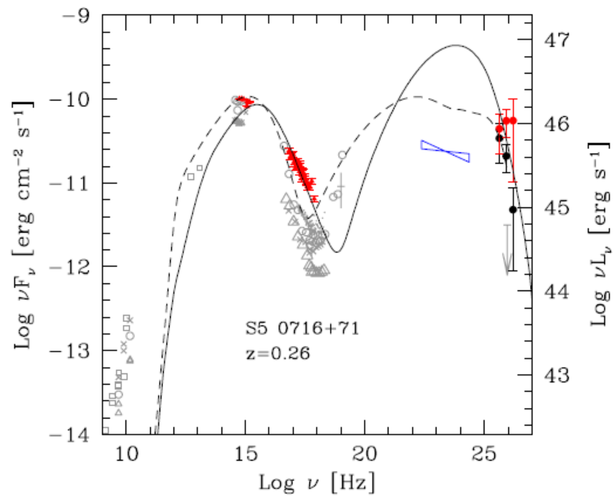


- Stationary SSC models usually adjust well to HBL
  - PKS 2155-304 MWL "quiescent state" and PG 1553+113 SED
- 100% variation in X-ray emitting $\gamma_e > 10^5$ for PKS 2155 and PG 1553
  $\Rightarrow < 50\%$ variability at $E_\gamma < 1\,\mathrm{TeV}$
  $\Rightarrow$ Current ACTs not sensitive to quiescent-state energetic electron fluctuations

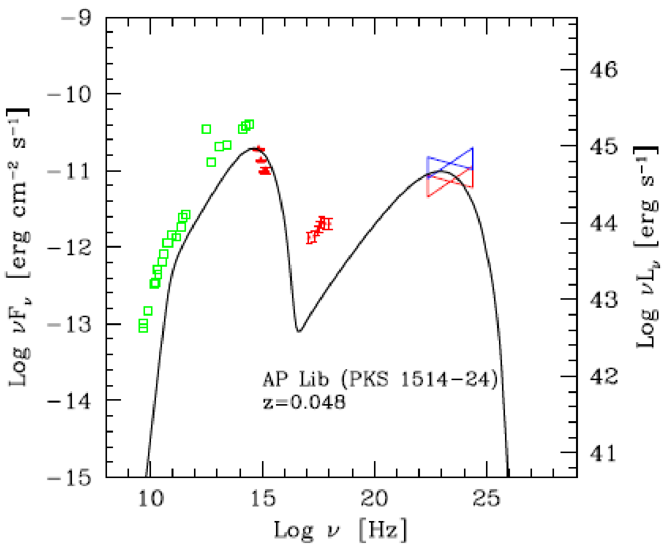
Active Galaxies in GeV-TeV γ-Rays::LBL

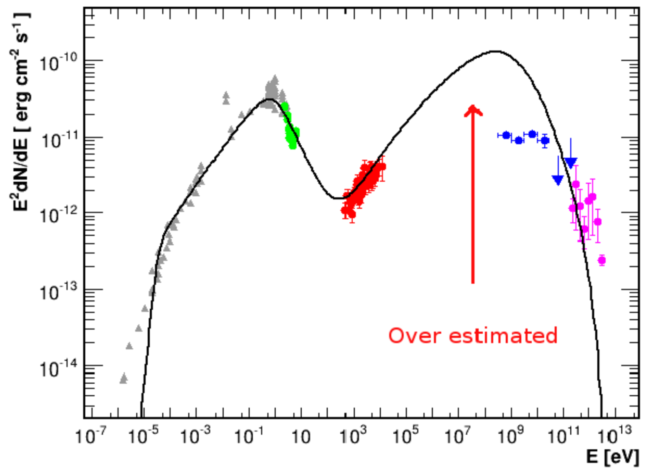
- Emerging source class for AČT
- All have issues with *overpredicting* the simultaneous our contemporaneous HE flux as measured by *Fermi* with SSC models
  $\Rightarrow$adding EC contributions not helping





Tavecchio+ 2010





Active Galaxies in GeV-TeV γ-Rays::Variability

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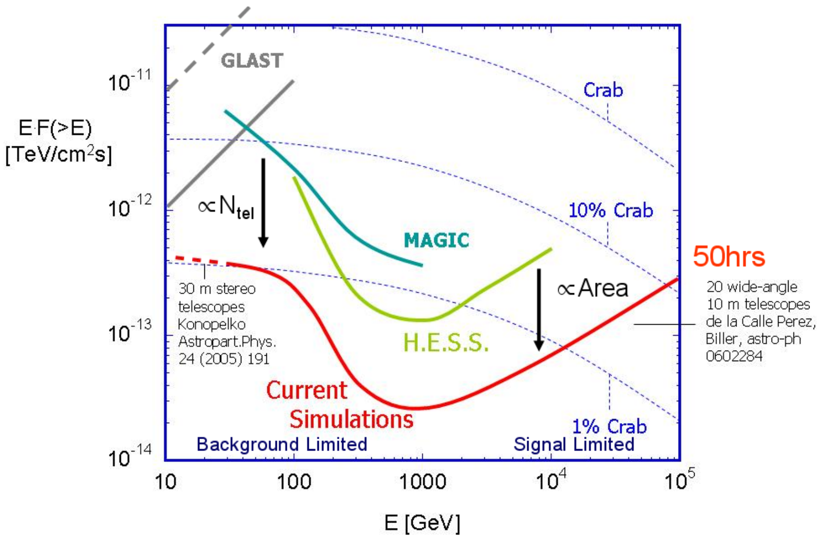
- Can the variability properties of an AGN change with time?
  $\Rightarrow$ "are AGNs moody?"
- How is variability of the various continua related?

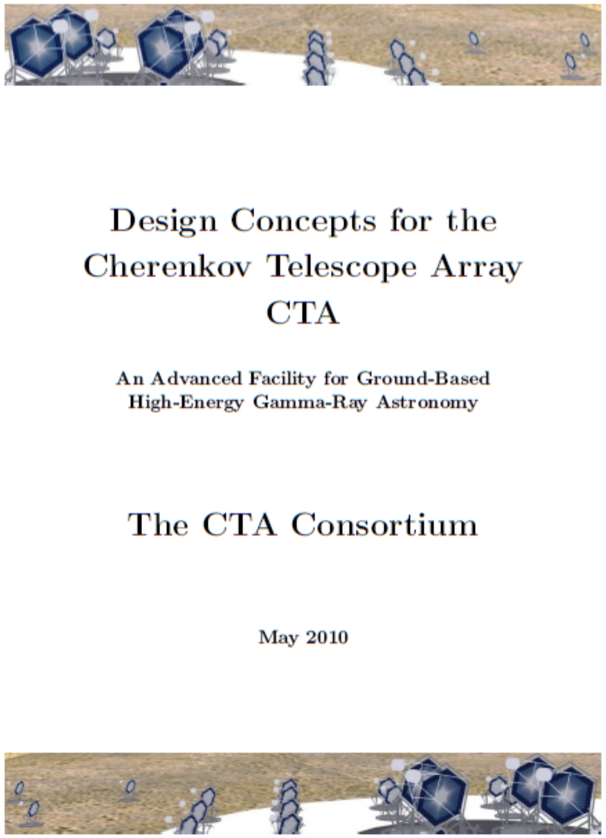
Active Galaxies in GeV-TeV γ-Rays::Perspectives::Short Term

Upcoming 28-m class HESS2 telescope

- Statistical nature of the quiescent γ-ray emission of PKS 2155-304
- Quiescent level of less bright AGN (PKS 2005-489, AP Librae, ..)
- Spectrally resolved burst analyses of flaring AGN
- Light curve/variability of LBL/FSRQ AGN
- improve $\Delta\Gamma = f(z)$ at $z > 0.2$ with better σ_Γ
  $\Rightarrow$ joint/intercalibrated analyses to fit EBL shapes beyond $\Delta\Gamma$?

Active Galaxies in GeV-TeV γ-Rays::Perspectives::Long Term





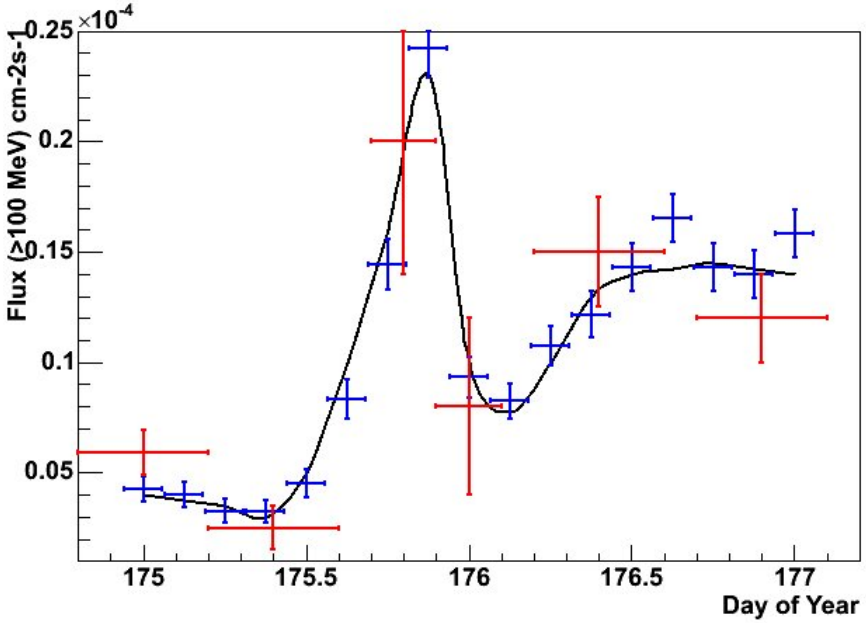
Design Concepts for the
Cherenkov Telescope Array
CTA

An Advanced Facility for Ground-Based
High-Energy Gamma-Ray Astronomy

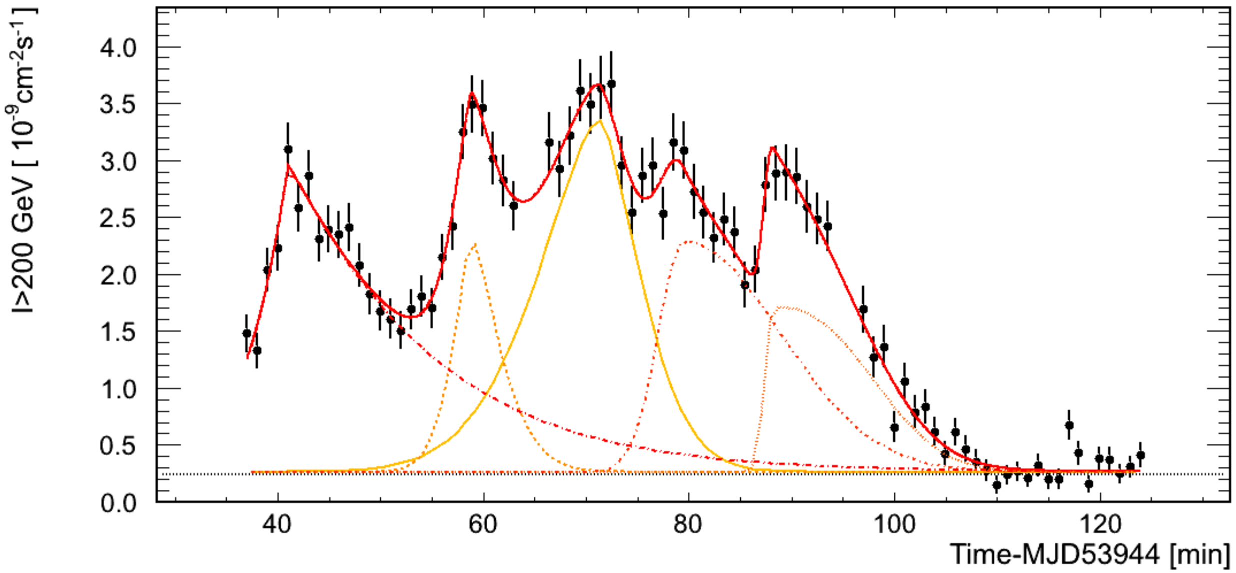
The CTA Consortium

May 2010

- CTA: 5-10 improvement in sensitivity in 100 GeV – 10 TeV
  extensions $\ll$ 100 GeV and $\geq$ 100 TeV.
- observatory to a wide astrophysics community
- AGN science case mainly:
  - MWL observations to distinguish emission models
  - improved spectra and lower threshold for EBL/EMF studies
  - probing variability down to the shortest time scales



- "Advertisement" for GLAST/Fermi performance based on EGRET "iconic" observation of 1633+382 variability (Mattox 1993)
- Probably first computation of δ based on pair production absorption at the source
- How to "improve" the "iconic" PKS 2155-304 flaring observations?



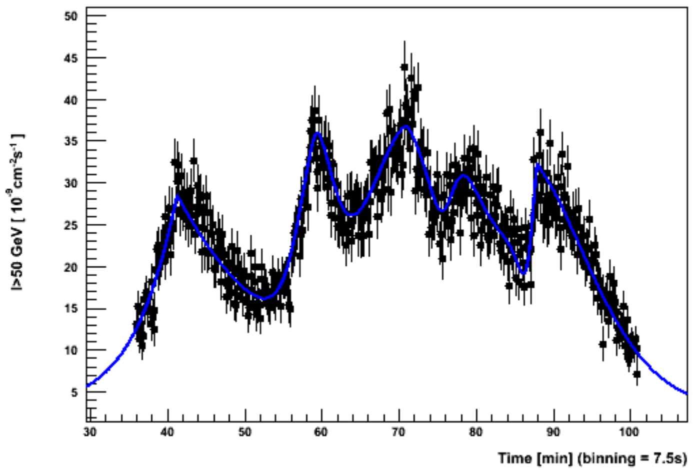
Active Galaxies in GeV-TeV γ-Rays::Perspectives

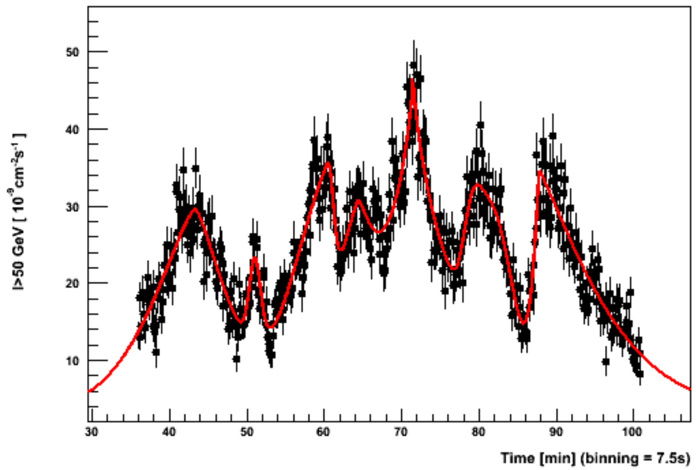
- Use generalized Gaussian shape $I(t)$ and improve statistics by

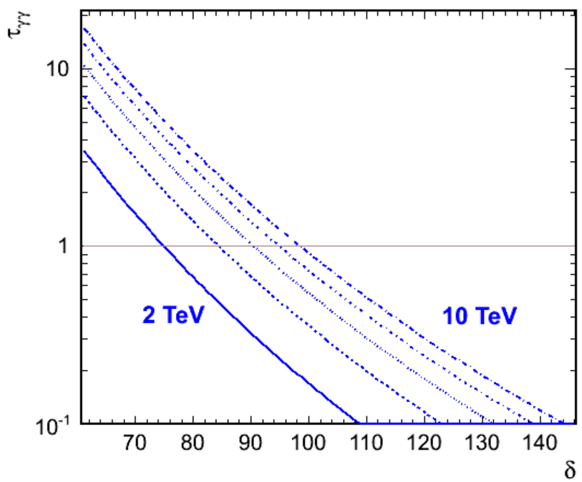
$$\Phi_{\text{CTA}}(t) = \Phi_{\text{HESS}}(t) \times \frac{\int_{E_{\text{min CTA}}}^{E_{\text{max CTA}}} F(E)\text{d}E}{\int_{E_{\text{min HESS}}}^{E_{\text{max HESS}}} F(E)\text{d}E}$$

$\Rightarrow$ "Boring", but evidence for high-frequency cutoff in PSD

- Additional red noise $\propto P(\nu)^{-2}$ for $\nu < 1.3 \times 10^{-3}$ Hz
$\Rightarrow \Phi'_{\text{CTA}}(t) = \Phi_{\text{CTA}}(t) + \Psi(t)$
"Exciting" new and faster features:
$t_{\text{var}} = 25 \pm 4\,\text{s} \longrightarrow \delta \geq 80-100$







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- Can the variability properties of an AGN change with time?
  $\Rightarrow$ "are AGNs moody?"
- How is variability of the various continua related?
- Are mean variability properties the same for different classes of AGN?
  $\Rightarrow$ e.g., LBL-IBL-HBL, FSRQs, Radio Galaxies
- Do AGNs of the same class have the same variability properties?
  $\Rightarrow$ "do AGN have different personalities?"