High energy emission of blazars: the need for high sensitivity

G. Henri

Laboratoire d'Astrophysique de Grenoble

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Gamma-ray emitting blazars (grazars)

Dominated by NON-THERMAL processes

Most probably electromagnetic processes by highly relativistic leptons (e^- or e^+)

($\gamma \sim 10^3$ to 10^6)

-synchrotron bump at «low» energy (radio-louds)

-Inverse Compton bump at «high» energy

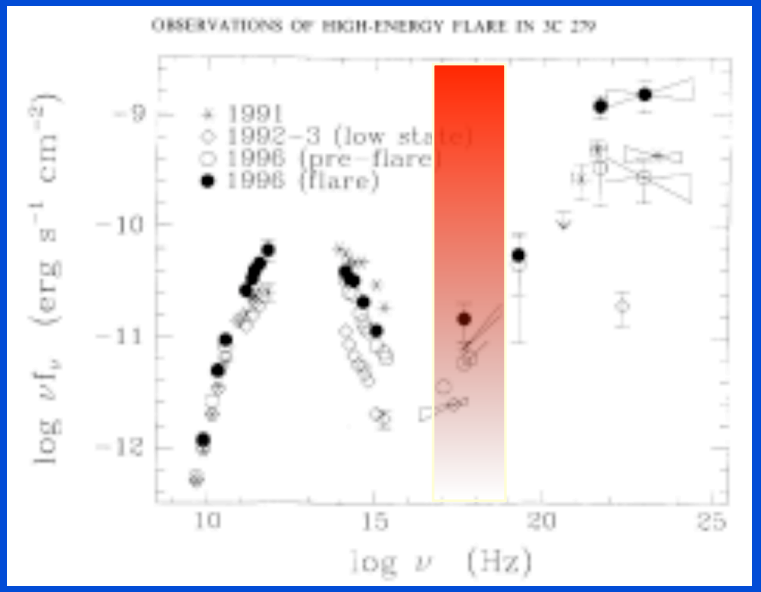
Relativistic jets with a bulk motion $\Gamma \sim 10$:

-superluminal motions $v_{app} \sim \Gamma c$

- Doppler boosting of frequencies and intensities

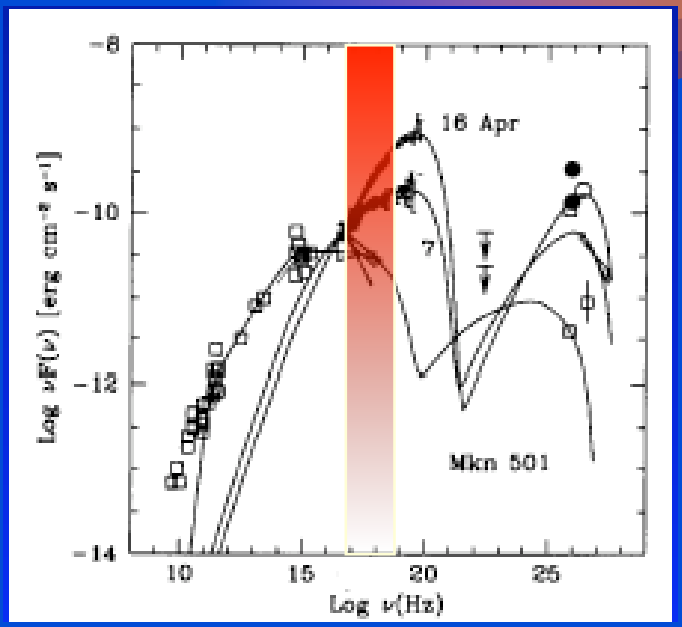
$\nu' \sim \Gamma \nu$ $\quad$ $I'_{\nu'} \sim \Gamma^3 I_\nu$ $\quad$ $L_{bol}' \sim \Gamma^4 L_{bol}$

Red and blue objects



Wehrle et al. 1998

A «red» object : 3C 279
Hard X-rays dominated by IC component



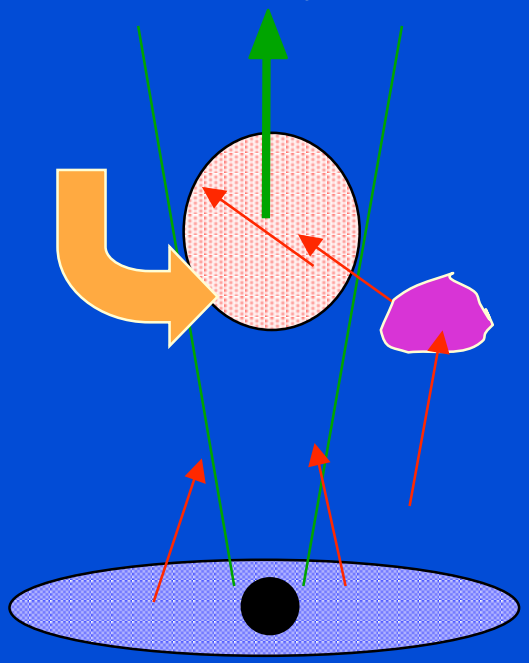
Pian et al. 1998

A «blue» object : Mrk 501
Hard X-rays dominated by synchrotron component

«Standard» model for gamma-ray emission

Physics of relativistic jets still poorly understood…

Relativistic jet $\Gamma_b = 10$



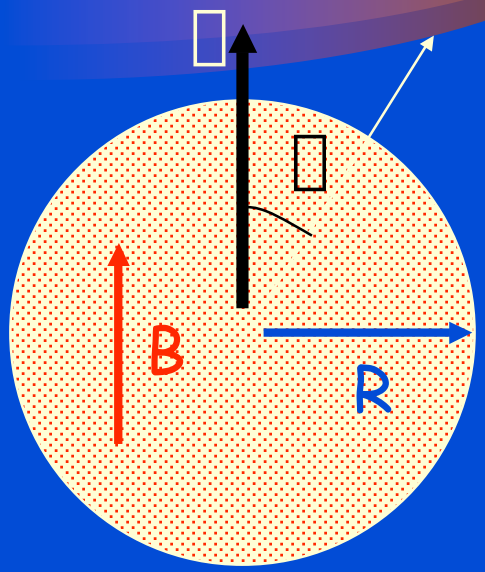
Relativistic particles
injection @ $\gamma \approx 10^3 - 10^5$
Usually power-law
Internal Shocks ?

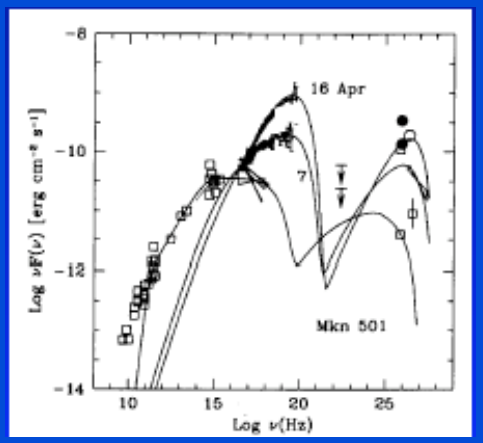
High energy photons produced by Inverse Compton scattering on soft photons

- accretion disk
- optical lines
- synchrotron (SSC)

Simplest one zone model

- Assume one-zone, spherical homogeneous blob filled with B and relativistic plasma, dominated by a characteristic energy □.
- Basically five parameters : R, B, n, □, and □=[□(1□□cos□)]□1
- And four constraints : 2 peak energies and 2 peak luminosities
- One free parameter left ! A further constraint must be found : □□□ opacity , variability time scale, … giving only upper or lower limits.





Effects of □□□ opacity

□-rays photons of energy □$m_e c^2$ mainly absorbed by low energy photons with energy □$^{-1} m_e c^2$

E'(keV) = 1/E(GeV)

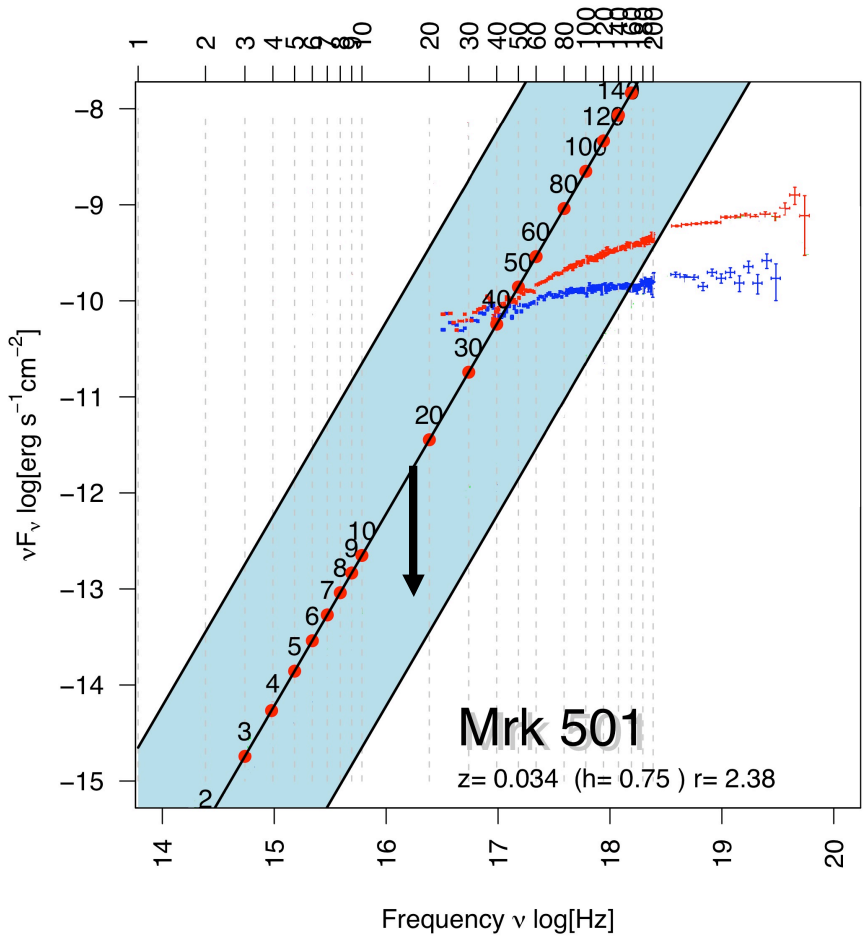
Or □(□m)=1/E(TeV)

Absorption can be extragalactic (1) and/or intrinsic (2)

* (1) raises the real gamma-ray emission level
* (2) constrains the minimal Doppler factor □ of the source

For Tev blazar Mrk 501 (1)+(2) -> □ > 50 !

Upper limits on local photon density



The case against high Lorentz factors

High Lorentz factors are problematic for several reasons :

- very hard to produce theoretically !!

- absence of superluminal motion in TeV blazars

- disagreement with both the NUMBER and the LUMINOSITY of unbeamed counterparts (FRI vs BL lacs)

Relativistic beaming

Doppler boosting

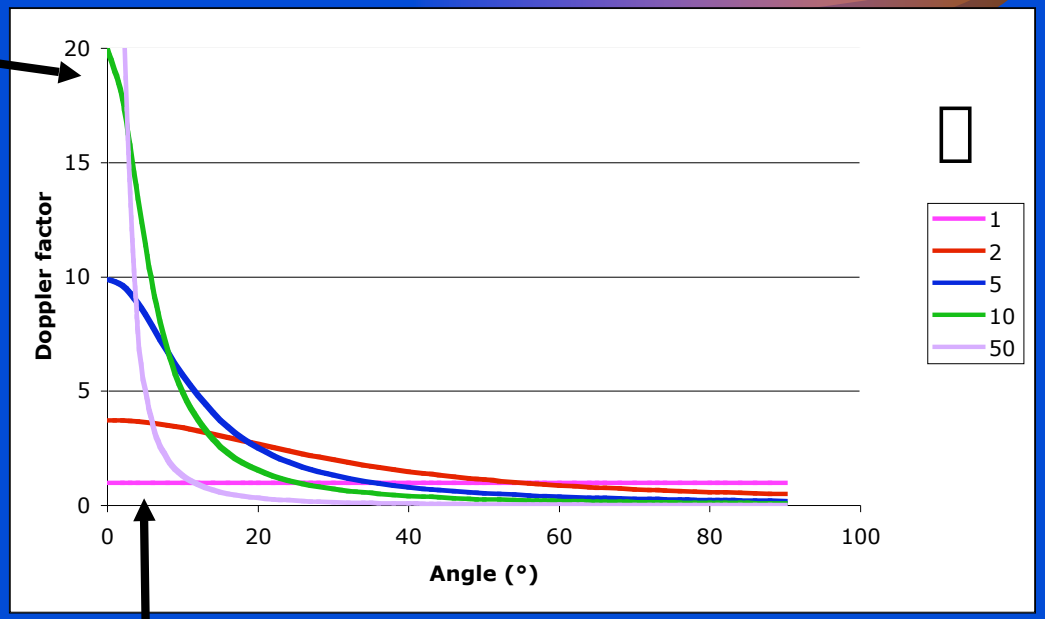
□ varies from □$^{-1}$ to 2 □

$$\frac{L_{beam}}{L_{unbeam}} \square\square^{8}$$

Predicted ~10^9

Observed ~ a few 10^4

(e.g. Trussoni et al. 2003)



Beaming angle

~ □$^{-1}$

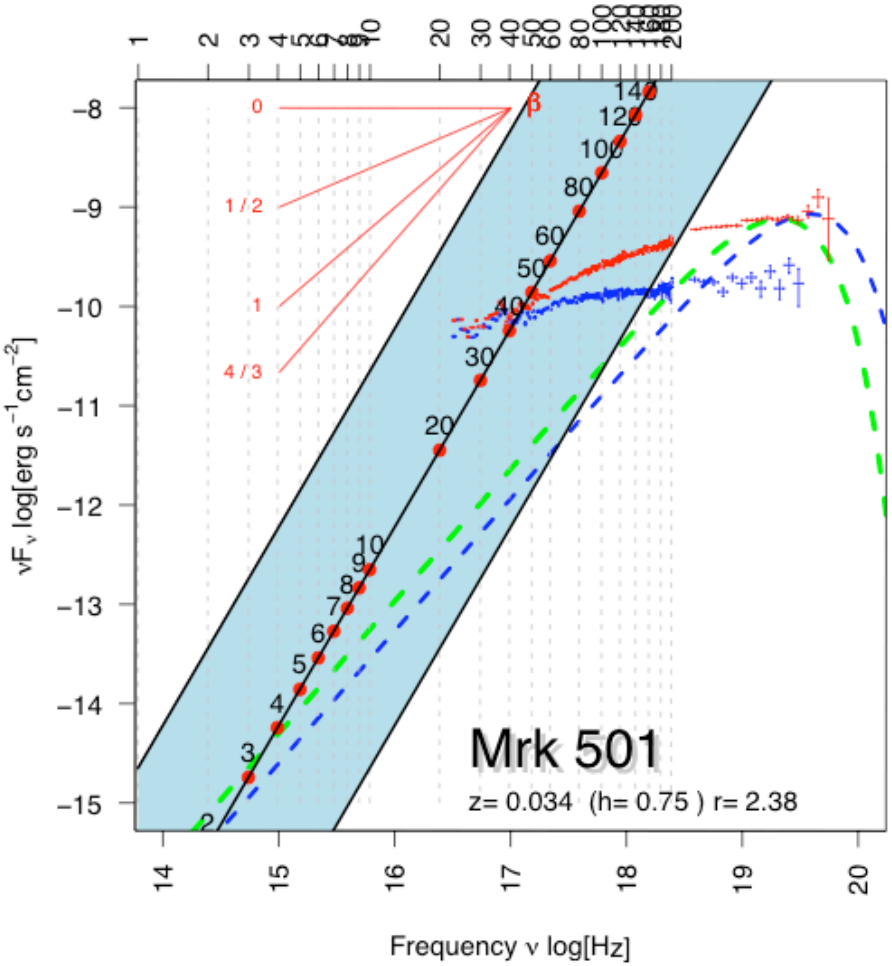
More compatible with □~3-5

$$\frac{N_{beam}}{N_{unbeam}} \square\square^{\square 2}$$

Predicted ~a few 10^{-4}

Observed ~ a few 10^{-2}

A low Lorentz factor?



Possible solution

absorption unavoidable for a homogenenous source

A clue to the issue : inhomogeneous, stratified jet with a low Lorentz factor

Steeper particle distribution function

-> pile-up

Continuous acceleration in the jet, no shock !

Pair production probably important

(Saugé & H. in prep)

The two flow model

(Sol, Pelletier, Asséo 1985, Marcowith et al. 1995)

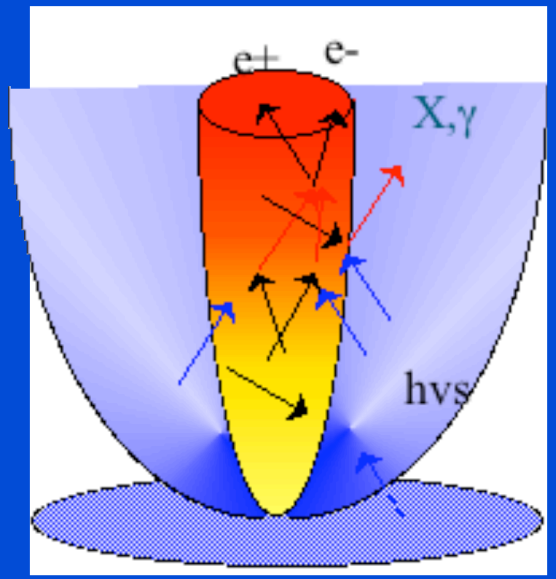
Jet emitted from an accretion disk

only mildly relativistic (v~0,5 c)

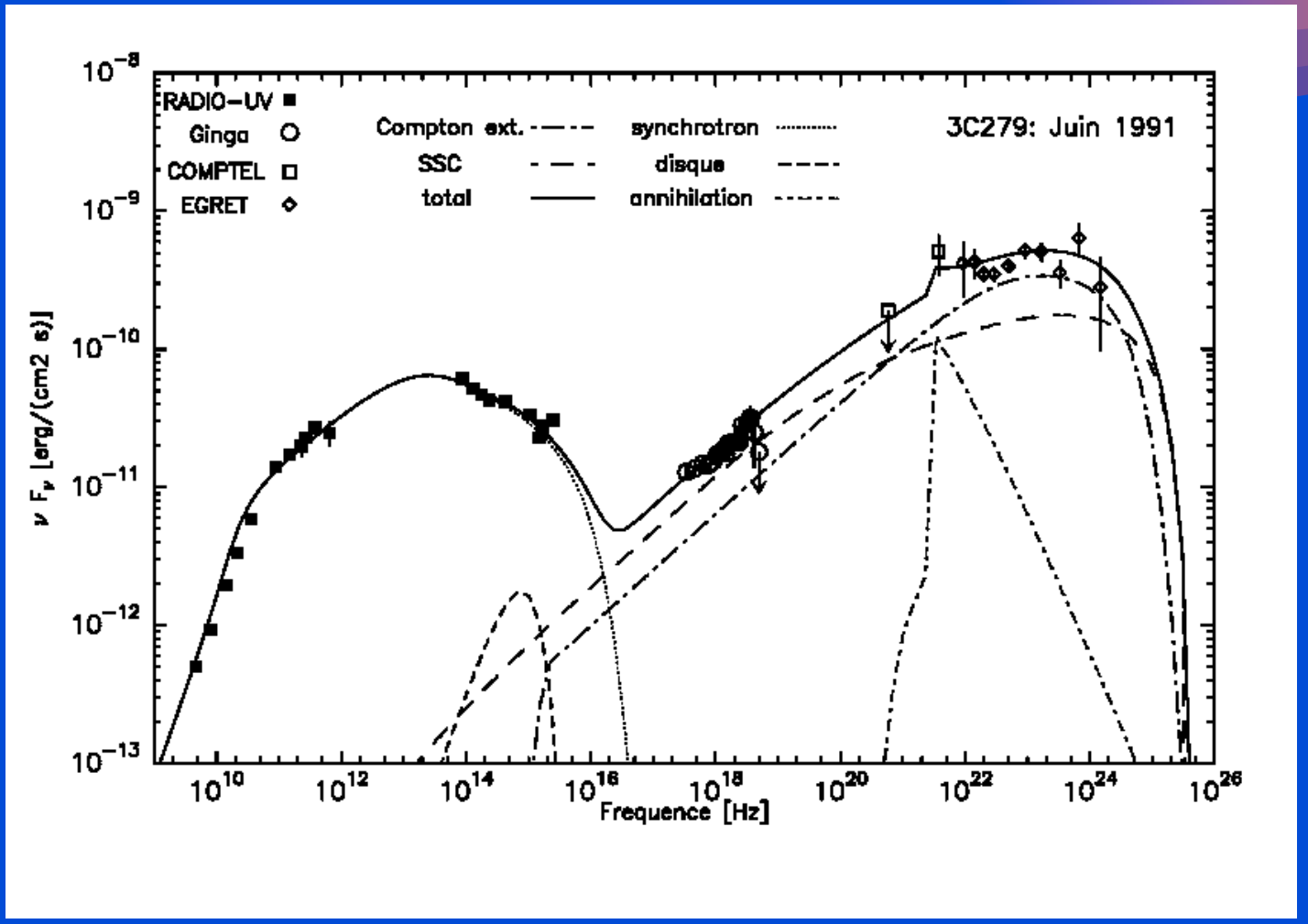
+ In situ generation of relativistic pair plasma

Feed-back on gamma-ray emission

- Some relativistic particles
- X-ray and gamma-ray emission by IC and/or SSC
- □□□annihilation forms new pairs
- Continuous reacceleration by MHD turbulence
- Gradual acceleration of the pair plasma due to anisotropic IC effect -> only modest values of □~2- 3 in the emission zone



Spectral fits



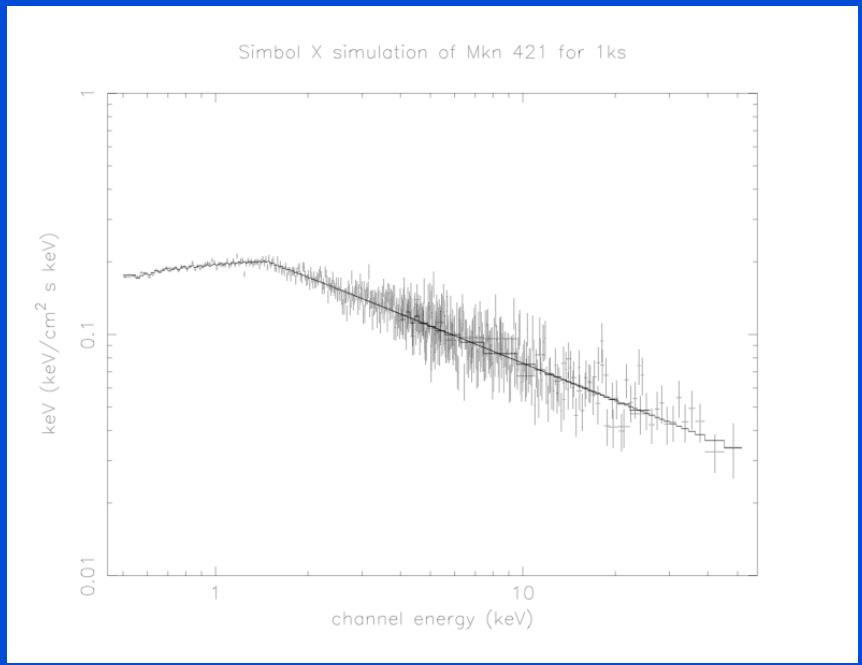
Need for fast variability studies

TeV observations by ACT showfast (<30') variability
Critical to distinguish between models
Not testable by current hard X-rays instruments
Need for much higher sensitivity !-> SIMBOL-X !!

Simulated 1ks observation of Mrk 421

Broken power law
- gamma1=1.973
- Ebreak=1.473
- gamma2=2.5

Spectral fit
- gamma1= 2.02+/-0.05
- Ebreak=1.59+/-0.06
- gamma2=2.61+/-0.02



Other interesting targets

* Faint unbeamed radio-galaxies : improvement of statistical samples

* Far, TeV-absorbed sources : search for hard X-rays flares.

* «Red» Quasars, measurement of the IC component, complementary with GLAST

Conclusions

* High energy emission of blazars related to the physics of relativistic jets, which is still poorly understood

High sensitivity, fast multiwavelength observations needed.

- SIMBOL-X would be an ideal instrument in the hard X-ray range
- Hope that the French research will still be living in 2010 !