Extreme blazars and the VHE connection

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Very High Energy (VHE) emission above 100 GeV has been confirmed from 6 extragalactic sources (Blazars) by multiple observatories. We can now follow fluctuations in these spectra on timescales close to the shortest ones likely in these objects.

Broadband X-ray satellites (BeppoSAX, RXTE) allow to simultaneously follow all significant X-ray/γ-ray variations in blazars and make stringent tests of the synchrotron self-Compton emission and the IR EBR.

To make the field stronger as more sensitive ACTs appear (H.E.S.S., Veritas, MAGIC) there is a need for

- Large FOV monitors in X-rays with alert mechanisms
- Broadband X-ray coverage with **antisolar pointing**
- Flexible ToO programs and repoint, sensitivity, spectral capabilities

Source	z	Discovery & Confirmation
Mrk 421	0.031	Punch et al. 1992, Petry et al. 1996
Mrk 501	0.034	Quinn et al. 1996, Bradbury et al. 1997
1ES 2344+514	0.044	Catanese et al. 1998, Tluczykont et al. 2003
1ES 1959+650	0.047	Nishiyama et al. 1999, Holder et al. 2003, Aharonian et al. 2003
PKS 2155-304	0.116	Chadwick et al. 1999, Hinton et al. 2003
H 1426+428	0.129	Horan et al. 2002, Aharonian et al. 2002, Djannati et al. 2002

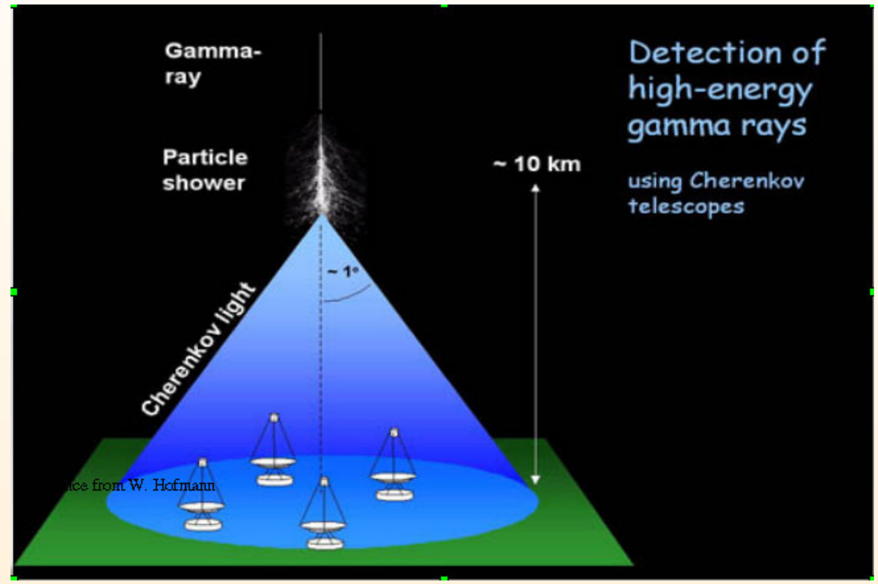
(from **H. Krawczynski - astro-ph/0309443**)

$\gamma_{\mathrm{GeV-TeV}} + hv_{\mathrm{IR-UV}} \rightarrow e^+e^-$ limit the >10 GeV horizon and therefore the highest possible emitters to our neighbourhood. The IR background itself is poorly known and its determination can shed light on galaxy formation theories.

Knowledge on the TeV spectrum is necessary to distinguish intrinsic spectra from extrinsic absorption. Extreme blazars could provide that.

- **H.E.S.S**, Phase 1, southern hemisphere
- **MAGIC**, Building, northern hemisphere
- **VERITAS**, Building prototype, northern hemisphere

Čerenkov telescopes (HESS, Namibia)



Čerenkov telescopes have huge effective areas ($10^5 m^2$), relatively good energy resolution (10%), PSF 0.1° but with a poor duty cycle (weather, moonless nights). The most constrained observatories in MWL campaigns.

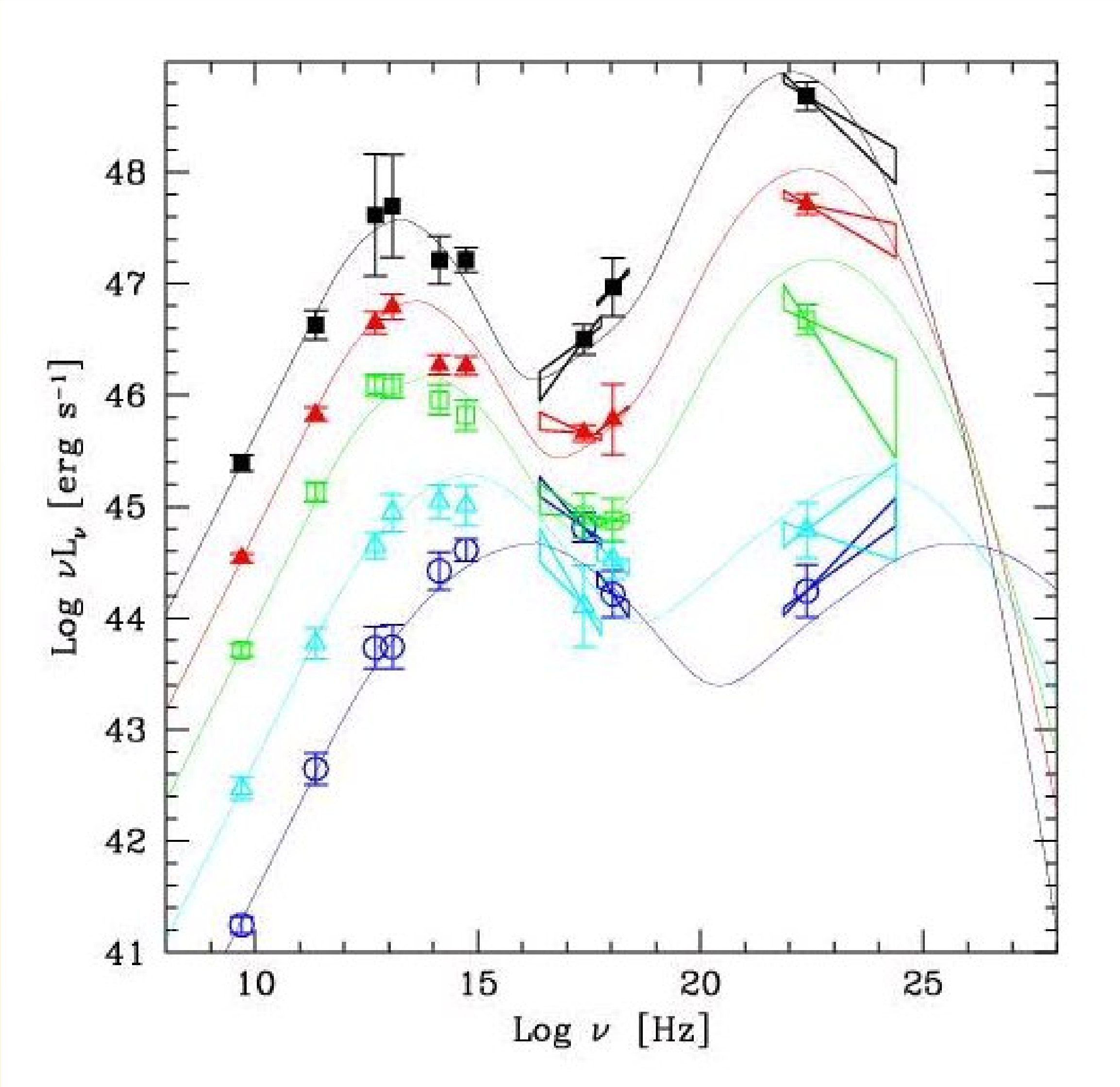
Unlikely to be challenged by space based instruments in a foreseeable future

Digression...

Subject: IAUC 8300: 2004ap; PSR 1259-63; C/2003 T5, C/2003 T6, C/2003 T7

PSR 1259-63 M. Beilicke, Universitaet Hamburg; M. Ouchrif, Laboratoire de Physiqu
Nucleaire de Haute Energie, Universite Paris VI and VII; G. Rowell, Max-Planck-Insti
fuer Kernphysik; and S. Schlenker, Humboldt-Universitaet, Berlin; on behalf of the
'High Energy Stereoscopic System Collaboration', report detection of very-high- ener
gamma-ray emission from the binary millisecond pulsar PSR 1259-63 (1236.72-day orbit
above a threshold of about 200 GeV (in the observed zenith-angle range, 40o-45o)
at the 5.9-sigma level, where previously upper limits were reported by the CANGAROO
collaboration (Kawachi et al. 2004, Ap.J., in press). The source was observed for
a total of 4.6 hr live-time between Feb. 26 and Mar. 5 with the full four-telescop
Cherenkov array. Preliminary estimates yield a flux at about 10 percent of the leve
of the Crab nebula (0.4 photons/min gamma-ray excess detected after selection cuts).
Periastron passage of the pulsar was expected on Mar. 7.43 UT. Observations at othe
wavelengths are strongly encouraged, especially on Mar. 20-25, when the neutron
star will cross the inclined Be disk for the second time. Particl acceleration asso
with the pulsar wind is predicted to result in observable GeV/TeV emission also afte
periastron (Kirk et al. 1999, Astroparticle Phys. 10, 31).

Blazar SED



Highest energies are not the brightest (Fossati 1998)

What physics?

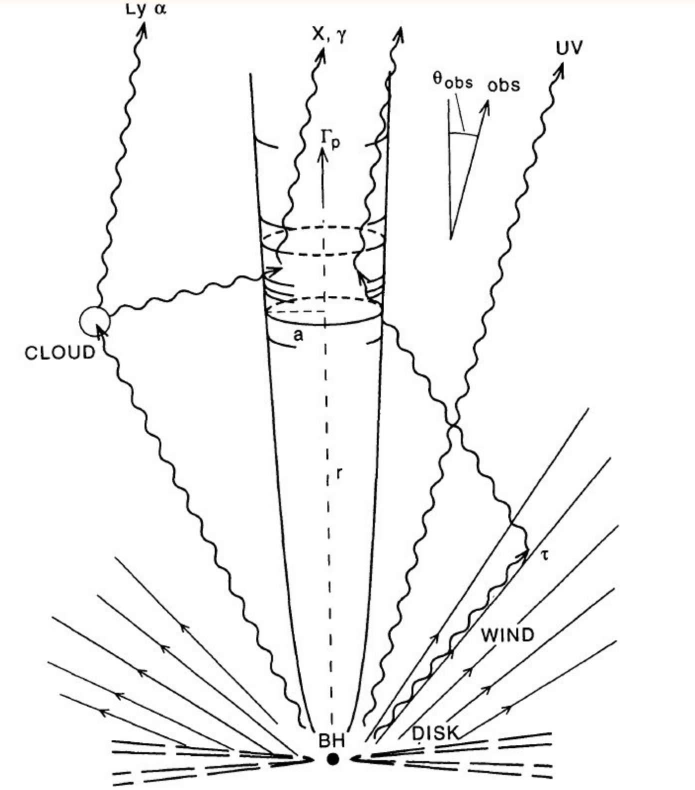
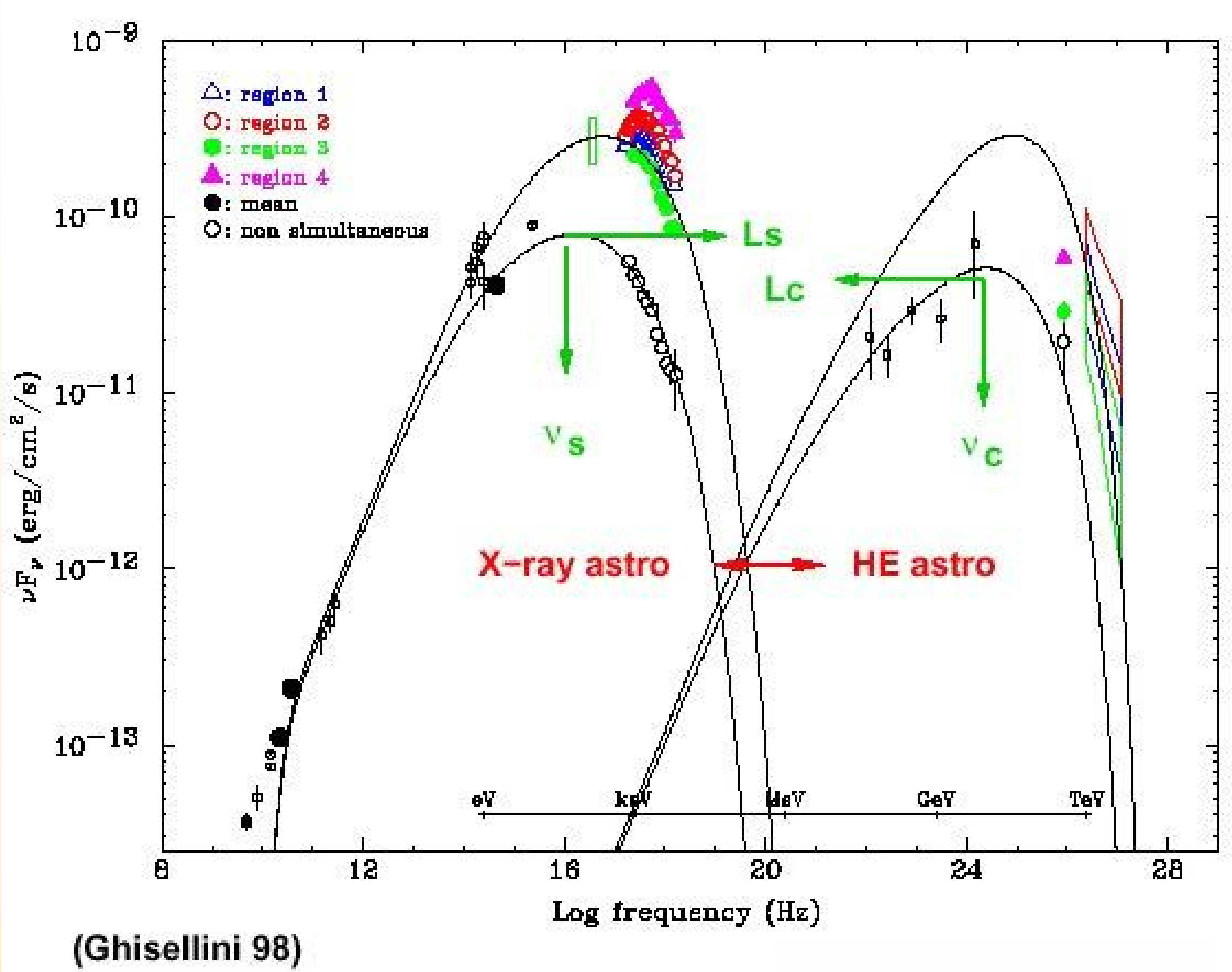


FIG. 2.—Geometry of the source. The radiating region, denoted by short cylinder of dimension a, moves along the jet with pattern Lorentz factor Γ_p. Underlying flow moves with Lorentz factor Γ, which may be different.

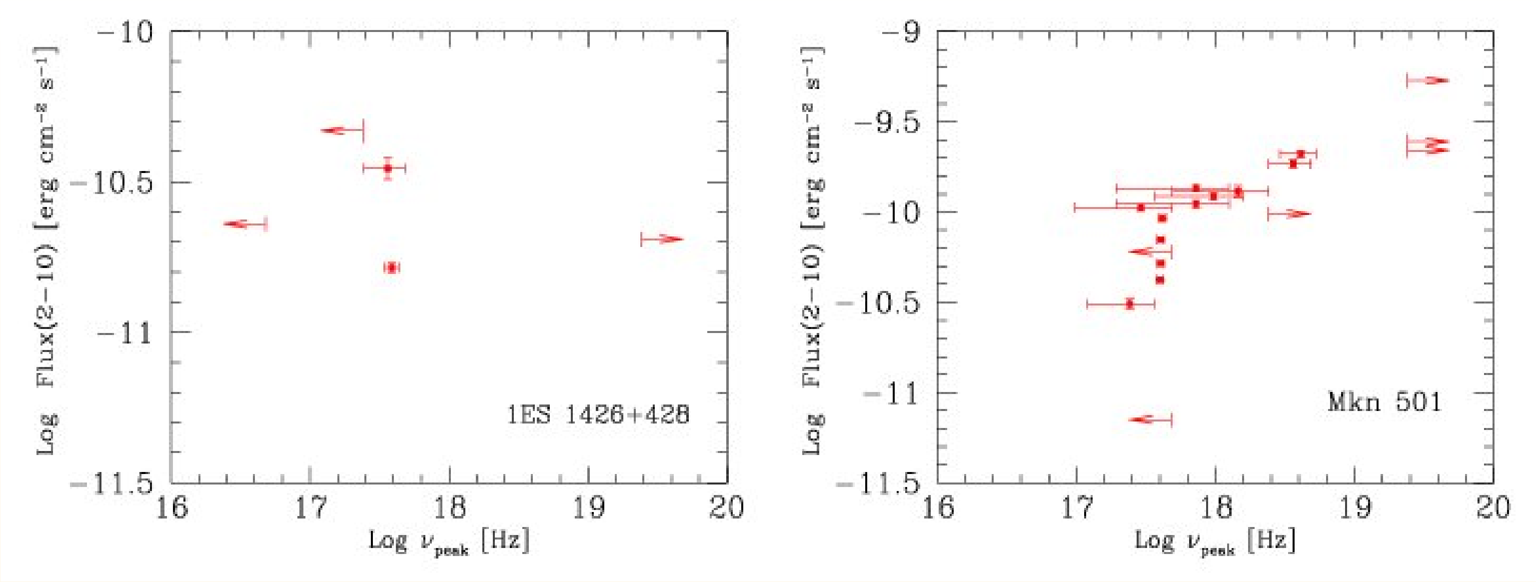
What physics are we learning from the observations? What information about the BH (mass, spin, charge...equivalent of $M - \sigma$ possible?), the disk-jet relation (σ problem), the injection, the accelerator, any GR effects, is in the gamma-rays? (**M. Sikora 1994**)

TeV blazars affected by IR absorption - SSC blazars mimic EC if absorption is not taken into account (**Coppi 2000**)! The intrinsic flux is $F(E) = F_{\rm obs}(E)\exp[\tau(E)]$ where $F_{\rm obs}$ is the observed γ-ray spectrum, $\tau(E) = d/L(E)$ the intergalactic optical depth, and d the distance to the source. For closeby objects $\tau(E) \approx 0.16(E/1{\rm TeV})$.

KN has to be taken into account - no longer a quadratic L_{IC}/L_S relationship.



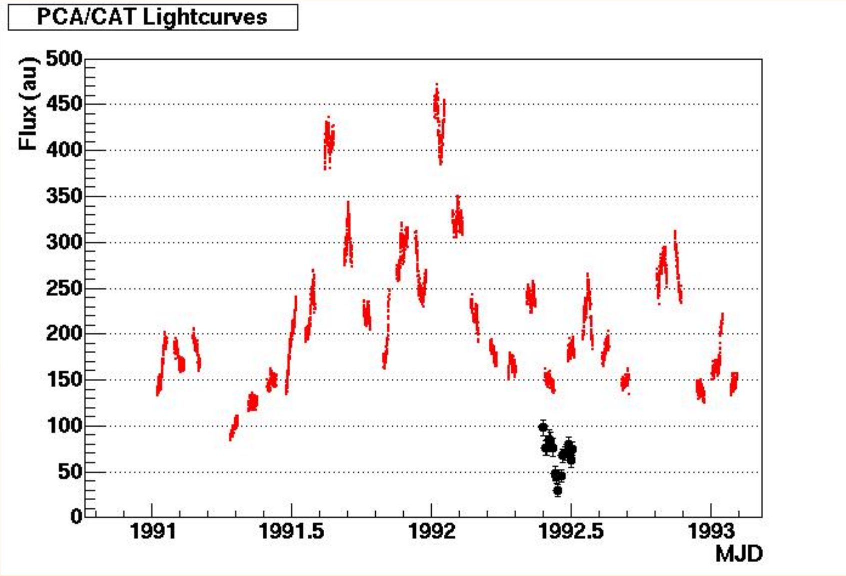
In a simple 1 zone homogeneous SSC model $\nu_c = (4/3)\gamma^2\nu_s'\delta$ Need electrons with $\gamma \approx 10^5 - 10^6$ which emit synchrotron photons of energies $h\nu = 1.5B\gamma_5^2\delta_1$ keV. KN scatters higher-than-O/IR photons (Costamante 2002 *extreme BL Lacs*).



- Synchrotron peak frequencies vary in the 1-100 keV range!
- Mkn 501, 1ES2344+514, 1ES1426+428, 1ES1101-232
- The "higher when brighter" behavior doesn't always apply!

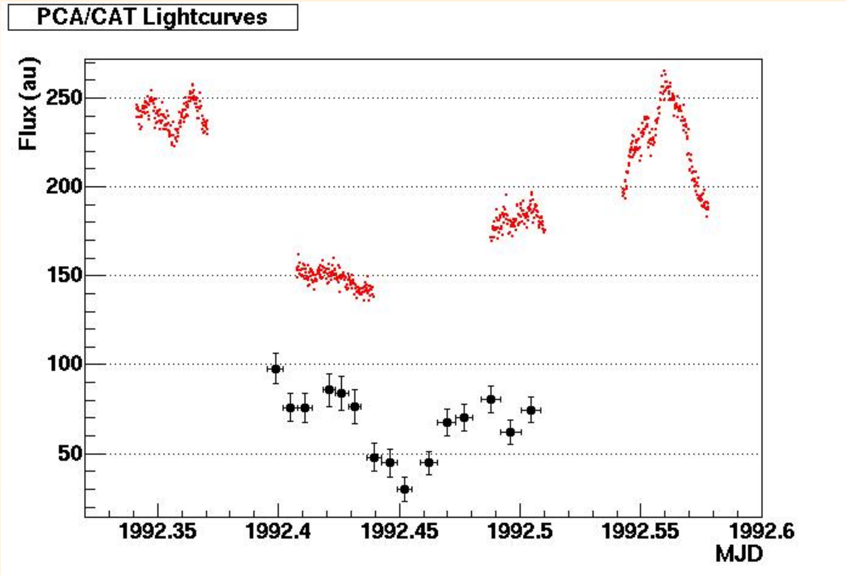
simultaneous monitoring of active and quiet states in a broad keV range is crucial in the understanding of these extreme accelerators

Simultaneous MWL results - Coordination



- RXTE/Whipple/CAT Mkn 421 Campaign, 1998. Coordination within fractions of an hour is necessary!

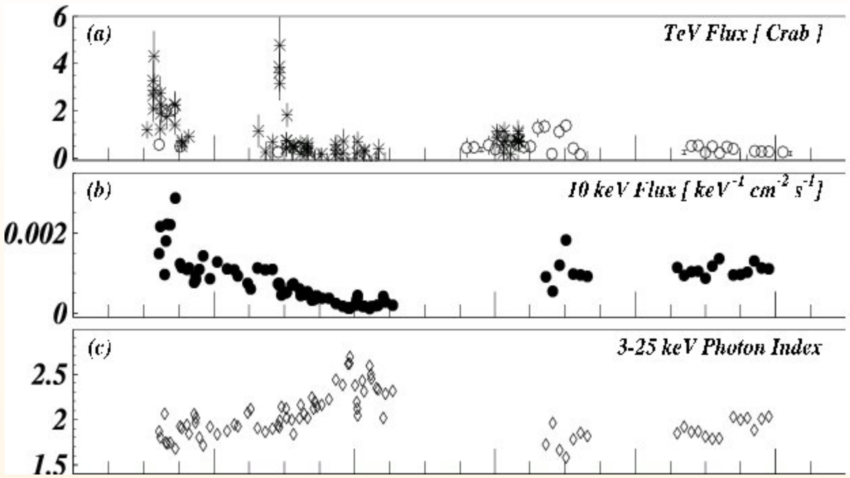
- Higher orbits (ASCA, XMM, INTEGRAL) mean a better chance to catch the "golden flare".

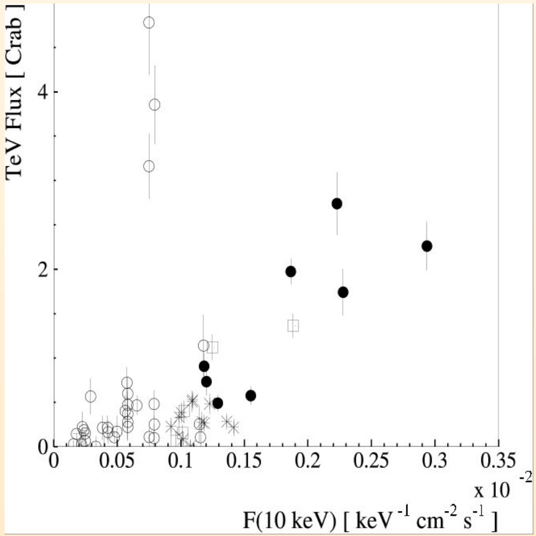


- RXTE/VERITAS (Whipple) 1Es1959+650 campaign, 2003. An "orphan flare" has been observed (**Krawczynski 2003**)! No significant simultaneous X-ray variability.

- Population of e with a very hard spectrum: synchrotron emission too hard for XTE's bandpass.

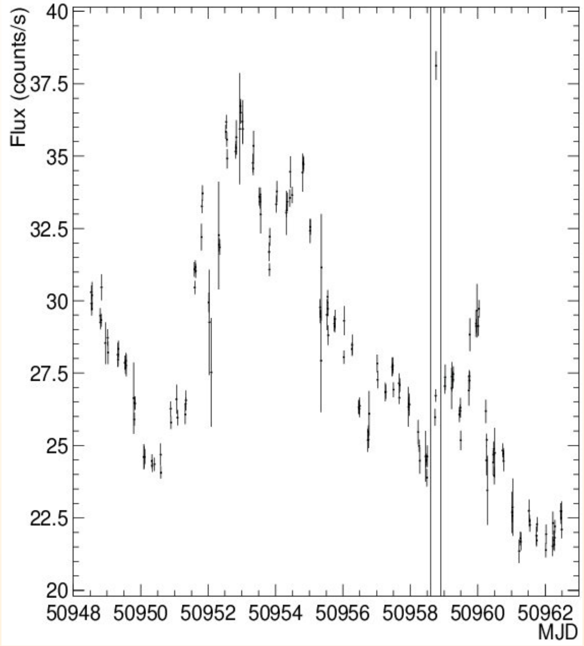
- A very dense and small emission region within the jet: $L_S/L_{IC} << 1$

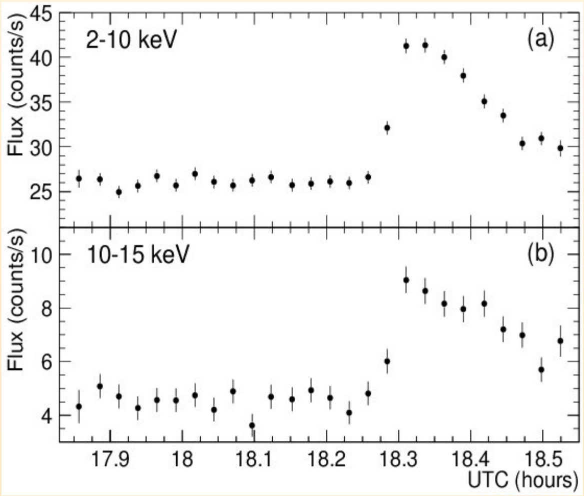




Fast variability

- Mkn 501 observations in 1998 provided the fastest X-ray variability seen so far (**Catanese 2000**). A very rapid flare in the middle of an active state where the 2-10 keV flux increases by 60% in $<$200 seconds and drops by 40% in $<$ 600 seconds.
- Flares usually are loops in a Flux-index plane with clockwise or counterclockwise patterns. ASCA observations of a series of 5 consecutive flares show both patterns. Probably related to varying timescales of $_{var}$, t_{cool} and t_{acc} (**Kirk 1999**).





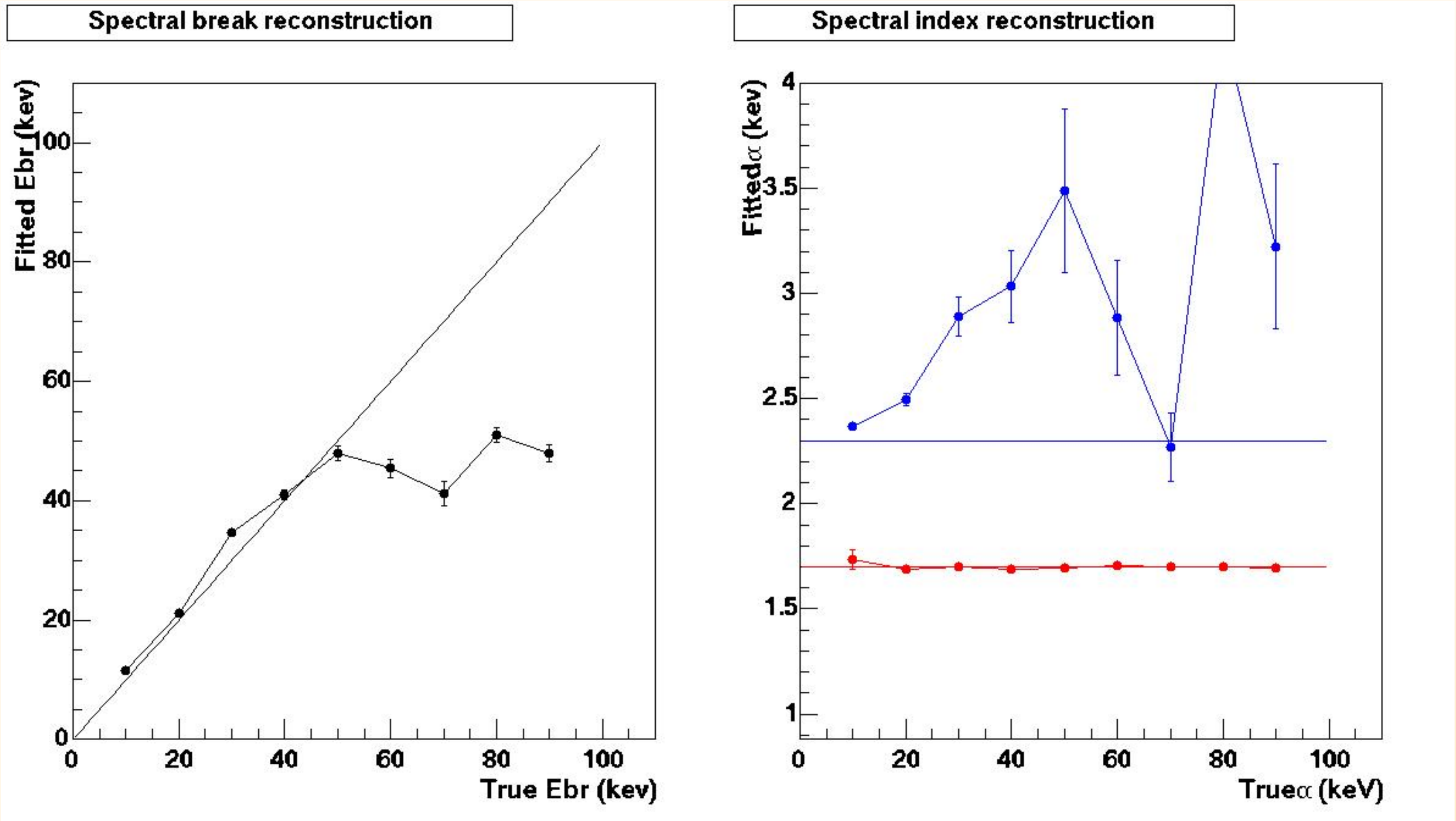
Time lags

- Lags between observations of different components in the synchrotron radiation (millimeter thru X-rays) sample the energy dependent finite radiative lifetime of freshly accelerated electrons
- Inverse compton component peaks only after the new synchrotron seed photons had time to propagate through the source. In SSC models one expects a time-lag of the order of $Rc^{-1}\delta^{-1}$ (Coppi 1999).
- No such time lag has yet been observed with high statistical confidence.

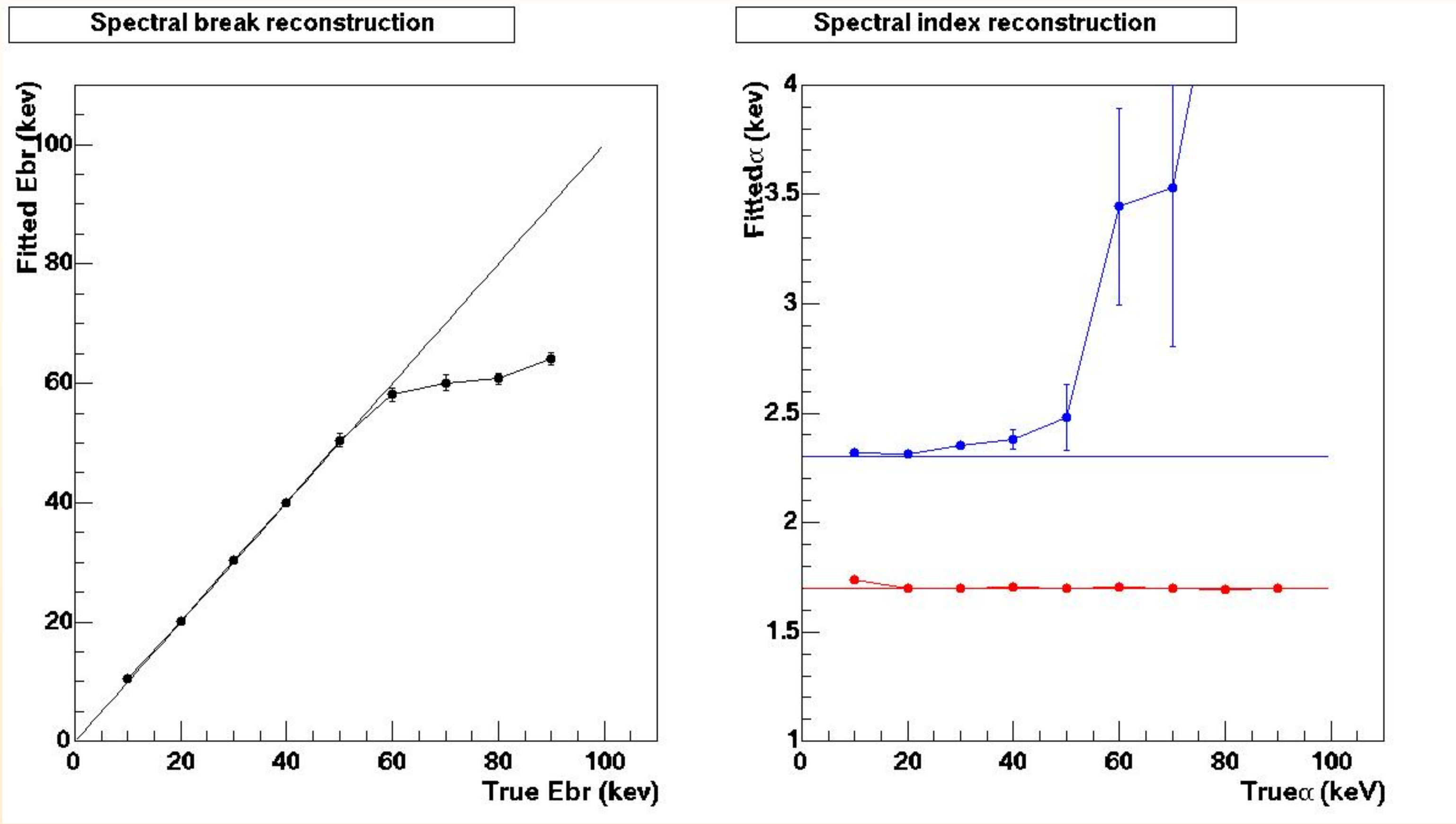
- Stratified models (Marscher 1998) predict hard lags
- Local re-acceleration models (Maraschi 1992) also predict hard lags
- Precursors (Sikora 2001) predict soft peak before shells collide

Tentative spectra measurement with SX

Using a moving simple `phabs(bknpow)` and comparing RXTE/(PCA-HEXTE) with SIMBOL-X. Trying to retrieve $\alpha_1 = 1.7$, $\alpha_2 = 2.3$ and $10\mathrm{keV} < E_b < 90\mathrm{keV}$ keeping the 2-10 keV flux at 3.10^{-11} erg cm^{-2} s^{-1} (1ES1426 Low) and using `bkg2_total_czt-filsdd.fak`. Thanks Philippe and Jean :o)



Same source, flux $\times$ 10 (medium or high).



Capabilities are good for extending the knowledge in the extreme blazar field!