Acceleration Mechanism and Spectral Curvature in TeV *Blazars*

Andrea Tramacere [1]

in collaboration with Francesco Massaro [2], Alfonso Cavaliere [2]

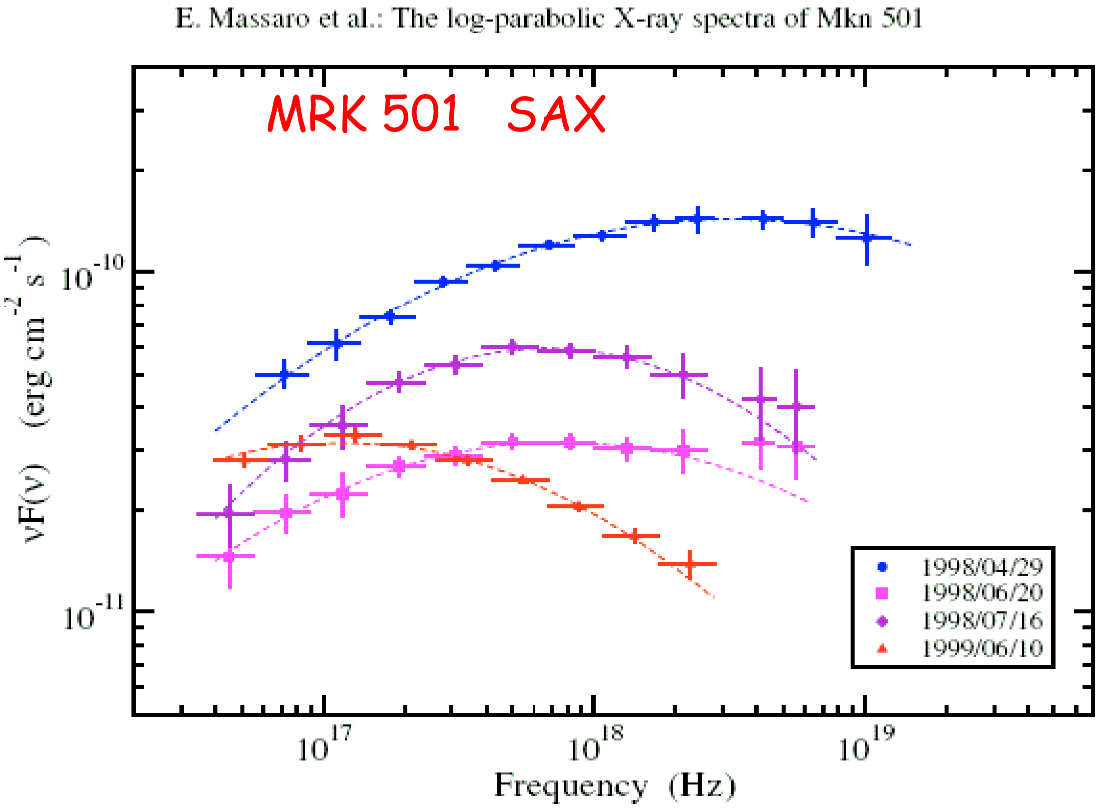
Dipartimento di Fisica Università La Sapienza Roma

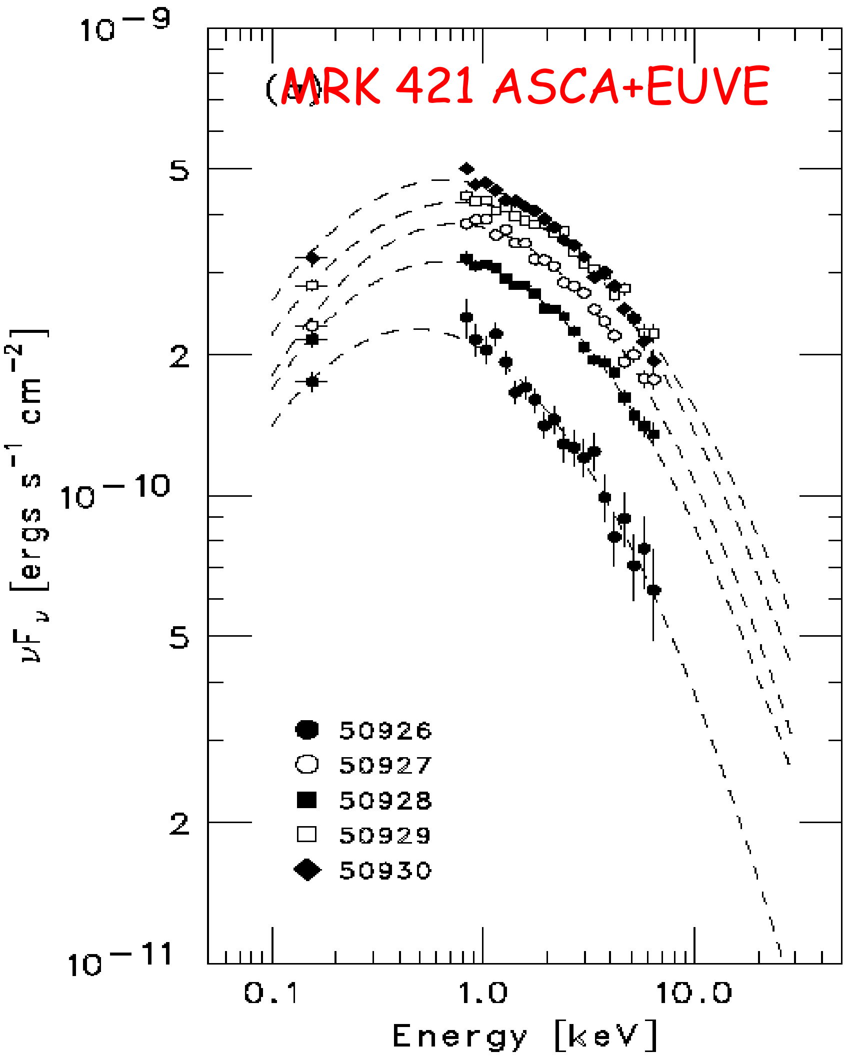
Dipartimento di Fisica Università di Tor Vergata Roma

OUTLINE

- Intrinsically Curved Spectra: observational clues
- Physical implications and acceleration processes
- Spectral relation between electron and photon distributions
- New analysis of Long-period X-rays data for Mrk421 from XMM 2000-2005
- Comparison with historical data form SAX-ASCA-EUVE data, 1997-2000
- Implications of Intrinsic curvature for IC/TeV emission and EBL determination
- Conclusions

Intrinsic spectral curvature in Synch. spectra





Spectral fit with log-par distribution

$$F(E)=K(E/E_0)^{-(a+b*Log(E/E0))}$$

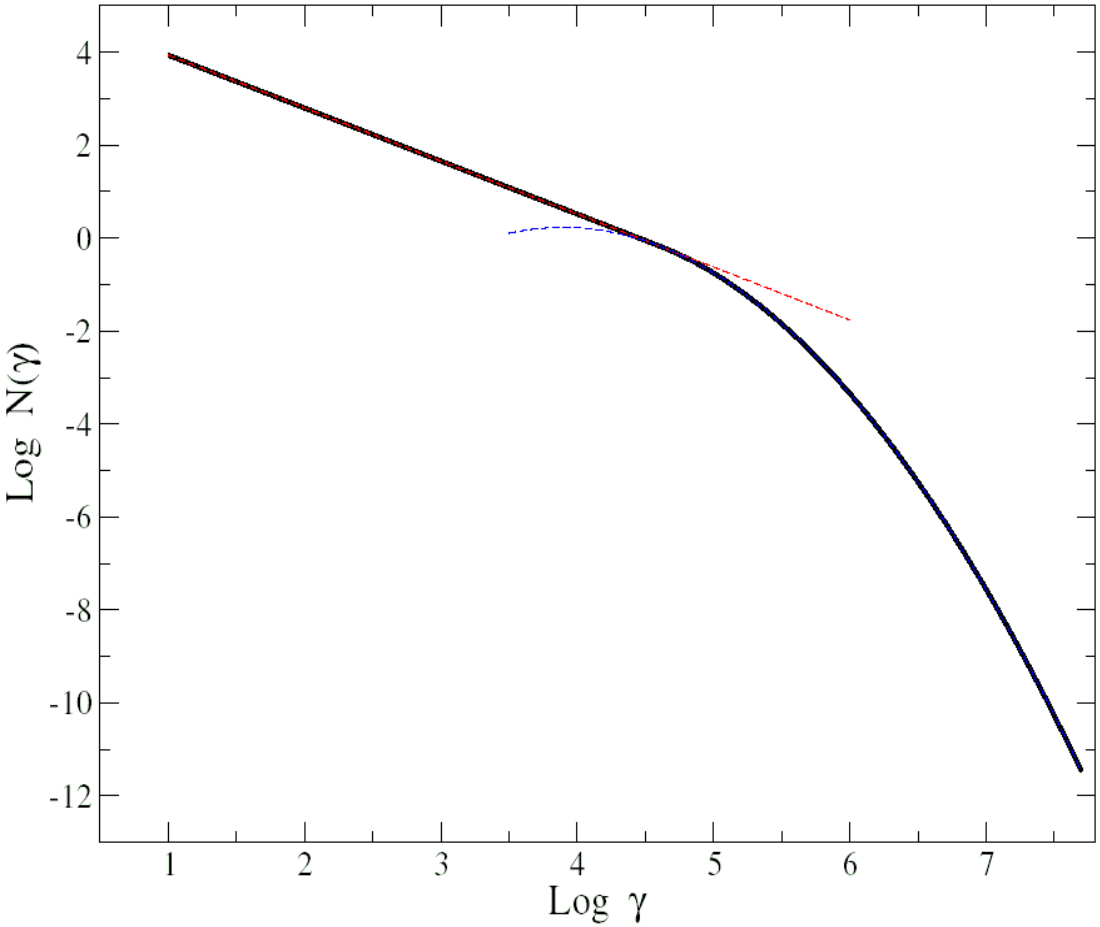
•X-rays spectral analysis for HBL gives very good description of X-rays data *(Massaro et. Al 2004a) (Massaro et. Al 2004b) (Tanihata et. Al 2004 ApJ 601)*

Log-Parabolic electron Spectral Distribution

Massaro, E. et. al A&A 2004

- Energy gain at each set: $E_{i+1}=\varepsilon_i * E_i$
- p_i probability to remain in acceleration region . $N_{i+1}=p_i * N_{ii}$

  if $\varepsilon_i=\varepsilon$ and $p_i=p$ at i-th step $N_{i+1}=p^i * N_0$ particelle con , $E_i=E_0 * \varepsilon^i$
- Final distribution is power law: $N(>E)=N_0 * (E_i/E_o)^{\ln p/\ln \varepsilon}$



If p_i is energy dependent :

$$p_i=\gamma/(\gamma_i)^q$$

final distribution will be

$$N(>\gamma)=N_0(\gamma/\gamma_0)^{-(s+r*Log(\gamma/\gamma_0))}$$

$$r=q/(2\ Log(\varepsilon))$$

in δ approximation

$$I_{sync}(\nu)=K^{(a+bLog(\nu/\nu 0))}$$

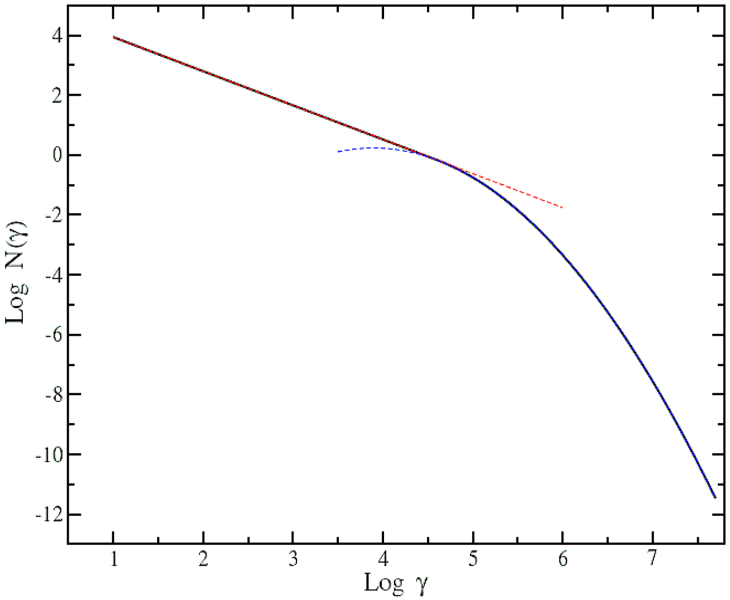
with

$$a=(s-1)/2$$

$$b=r/4$$

Intrinsic spectral curvature in S

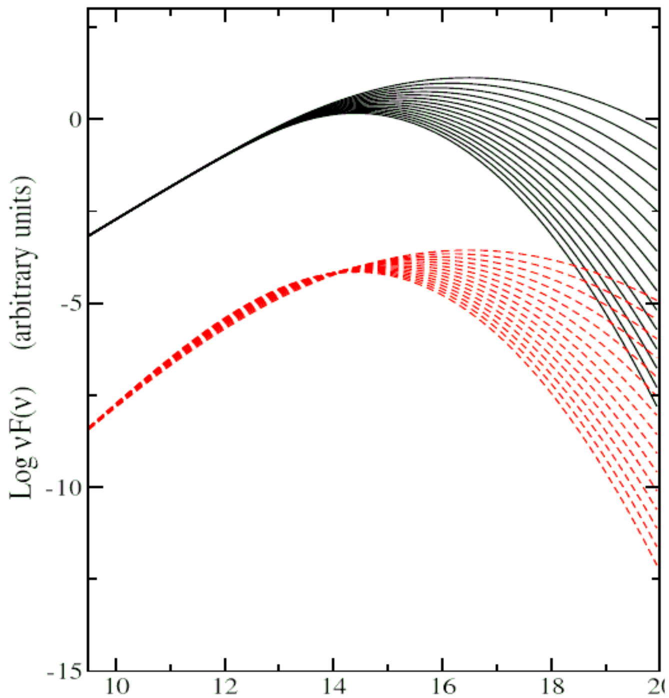
Massaro E., Tramacere A. et al. A&A 2006

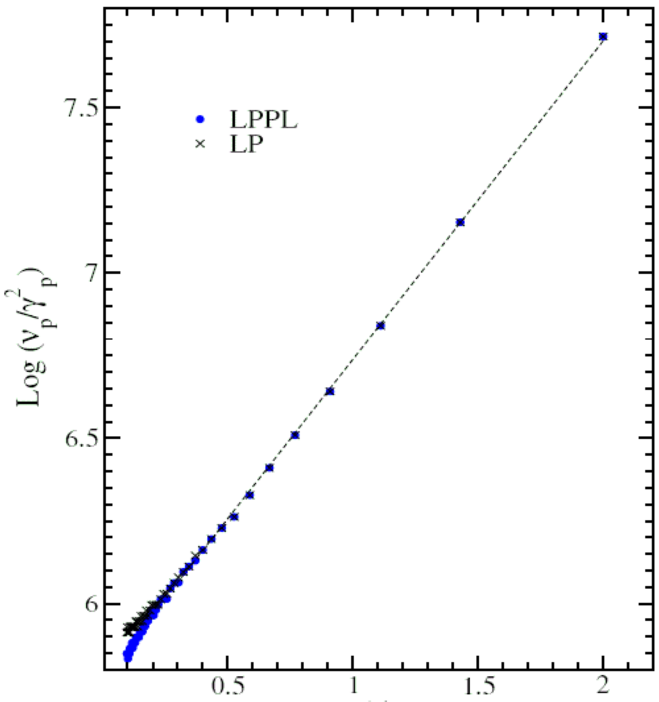


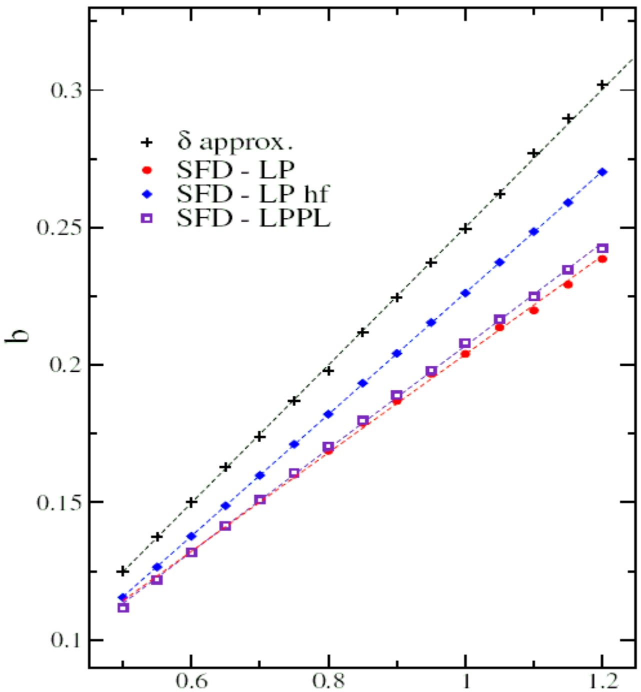
$$N(\gamma) = N_0\ (\gamma/\gamma_0)^{-s_0} \qquad \gamma \le \gamma_0$$

$$N(\gamma) = N_0\ (\gamma/\gamma_0)^{-(s_0+r\ Log(\gamma/\gamma_0))} \qquad \gamma > \gamma_0$$

- Kernel in approx delta b=r/4
- Kernel numerical b/r varia 0.18-0.19
- Kernel numerical b~r/5 @ 10 %
- The ratio $\log(\nu_{ps}/\gamma_p{}^2)$=c*(1/r) both LP and LPPL, l
- The extrapolation for 1/r=0 is consistent with theory







Test for Log-parabolic model

- $r=2q/(Log(\varepsilon))$ -> $r \sim 1/\varepsilon$
- $\gamma_p \sim \varepsilon$ -> $\gamma_p \sim 1/r$, $E_p \sim 1/b$
- SED peak$\sim N(\gamma_p)\gamma_p^3$ -> $\nu_p F(\nu_p) \sim E_p$ (δ-> $Ep \sim \delta$, SED peak$\sim \delta^4$)
- SED peak$\sim N_0$ -> $\nu_p F(\nu_p) \sim E_p$ (N_0 no link with E_p)
- $\nu_p F(\nu_p) \sim 1/b$ -> but state with high ε and low N_0 and no relation between δ and b may weaken this relation

We look for correlation between Peak SED, E_p and b, than we use the following functional form:

$$S(E)=E_p^2 F(E_p)^{-(b*Log(E/Ep))}$$

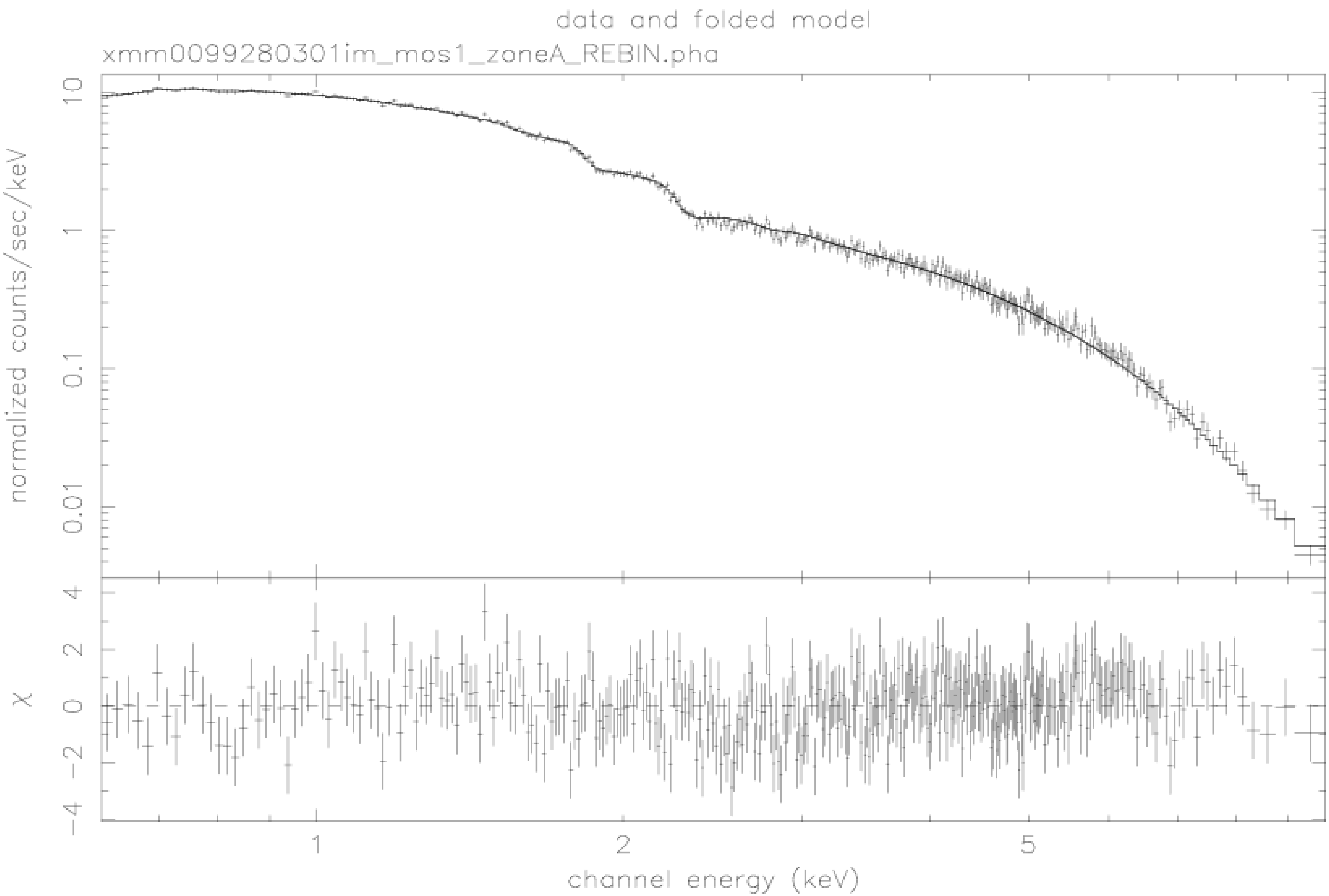
in order to minimize the contribution from the covariance matrix. <u>We remind that all these relations are affected by effects coming from cooling geometry ecc.. We need a long time sample of observations</u>

XMM data analysis for Mrk421

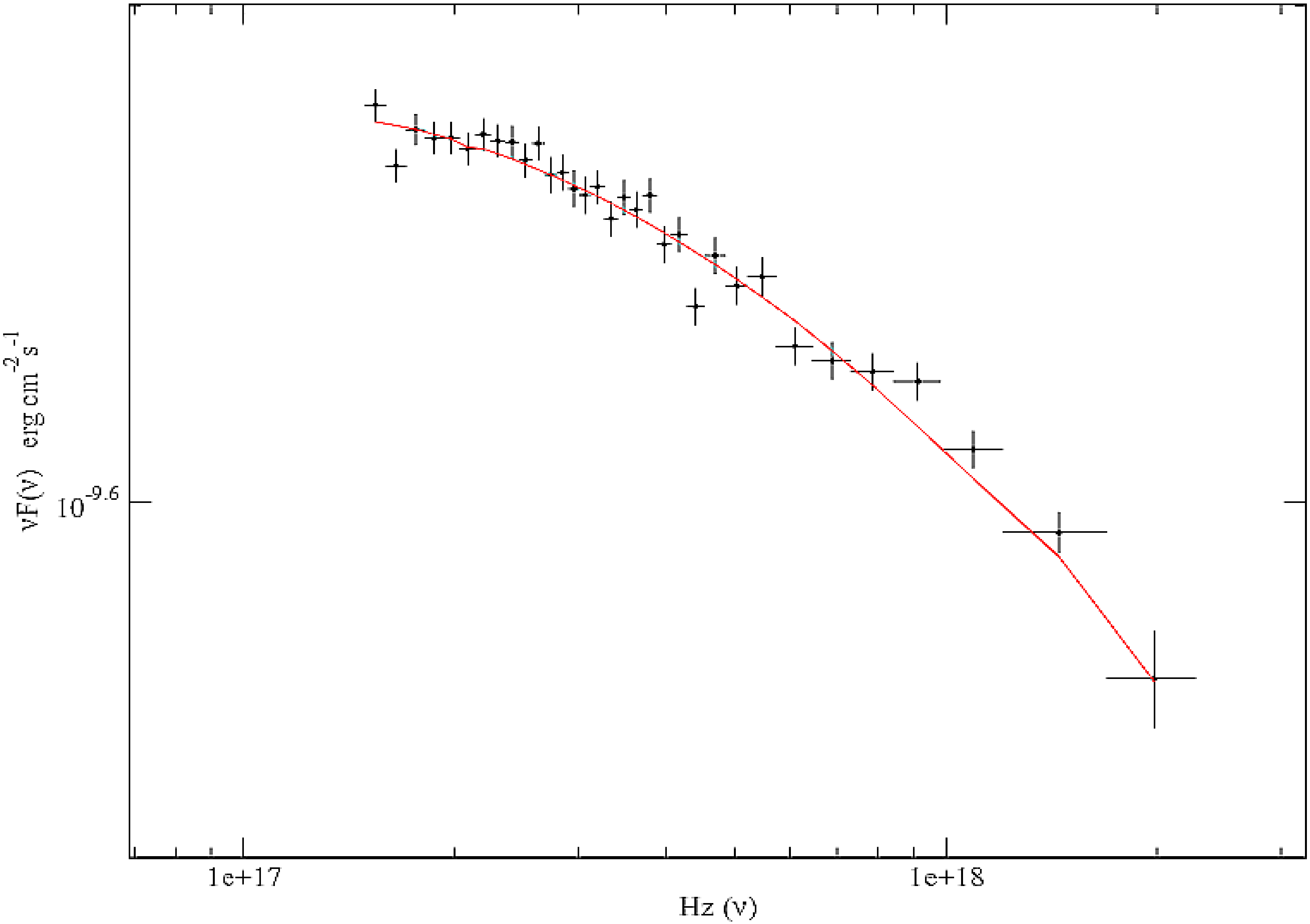
obs. ID	DATE	E_p keV	err	b	err	$\nu_p F(\nu_p)$ $10^{-12} erg\ cm^{-2} s^{-1}$	err
99280201	2000/11/01	0.22	0.08	0.25	0.05	132.80	9.60
	2000/11/01	0.22	0.04	0.23	0.02	124.80	4.80
	2000/11/01	0.31	0.06	0.28	0.03	136.00	4.80
099280301F	2000/11/13	1.09	0.04	0.27	0.02	340.64	0.96
	2000/11/13	0.92	0.03	0.40	0.02	342.88	1.12
136540101F	2001/05/08	0.74	0.05	0.35	0.02	254.40	1.60
	2001/05/08	0.82	0.04	0.27	0.02	263.52	11.20
	2001/05/08	0.85	0.04	0.37	0.02	249.44	1.12
153950601A	2002/05/04	0.39	0.07	0.49	0.06	147.20	6.40
	2002/05/04	0.38	0.06	0.46	0.05	144.00	6.40
153950701A	2002/05/05	0.23	0.04	0.44	0.04	102.40	6.40
136540801A	2002/11/14	1.43	0.04	0.39	0.03	347.20	1.60
	2002/11/14	2.0	0.1	0.32	0.05	380.80	4.80
136541001F	2002/12/01	0.87	0.05	0.41	0.03	172.64	1.12
	2002/12/01	0.72	0.07	0.38	0.04	169.60	1.60
	2002/12/01	0.77	0.06	0.40	0.04	167.68	1.44
136541101A	2002/12/02	0.64	0.05	0.34	0.03	196.80	1.60
136541201A	2002/12/02	0.83	0.08	0.35	0.04	227.20	1.60
158970201A	2003/06/02	0.36	0.08	0.45	0.06	51.20	3.20
150498701	2003/11/14	1.20	0.03	0.43	0.02	467.20	1.60
	2003/11/14	0.79	0.04	0.48	0.03	441.60	3.20
162960101	2003/12/10	0.87	0.05	0.38	0.03	209.12	1.12
	2003/12/10	0.89	0.05	0.42	0.03	207.20	1.28
158971201	2004/05/06	1.74	0.04	0.33	0.03	432.00	1.60
	2004/05/06	2.4	0.1	0.24	0.02	494.40	3.20
153951201	2005/11/07	0.9	0.1	0.38	0.06	284.80	3.20
153951301	2005/11/07	0.8	0.1	0.44	0.07	296.00	4.80
158971301	2005/11/09	0.63	0.03	0.40	0.02	420.80	3.20
	2005/11/09	0.71	0.04	0.41	0.02	430.40	3.20
	2005/11/09	0.68	0.04	0.36	0.02	460.80	3.20
	2005/11/09	0.79	0.05	0.40	0.03	505.60	3.20

- 16 pointing -> 32 time resolved analysis wiht N_H fixed at galactic value
- Proton flare are well evident in the l.c. at high energies (E >10 keV).
- To avoid contamination accurate inspection of l.c. at different energies was performed, and period with counts @E>10 keV <0.35 but near to flares were excluded.
- Pile-up can be minimized excluding the inner part of the PSF we used annular regions (int 12", ext 40"). All source extraction were tested by epatplot sas task.

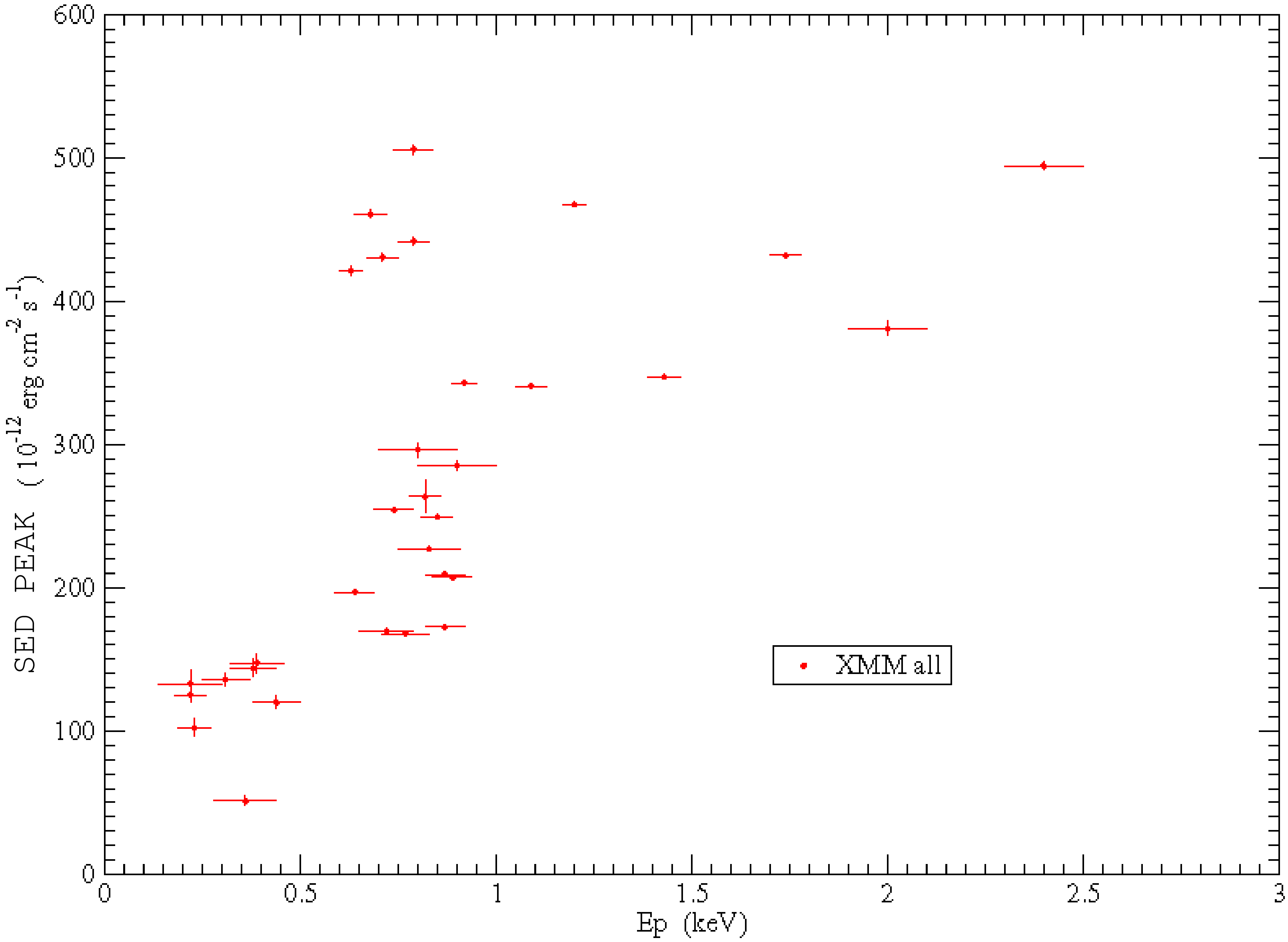
XMM SAMPLE OF SPECTRA AND TABLE



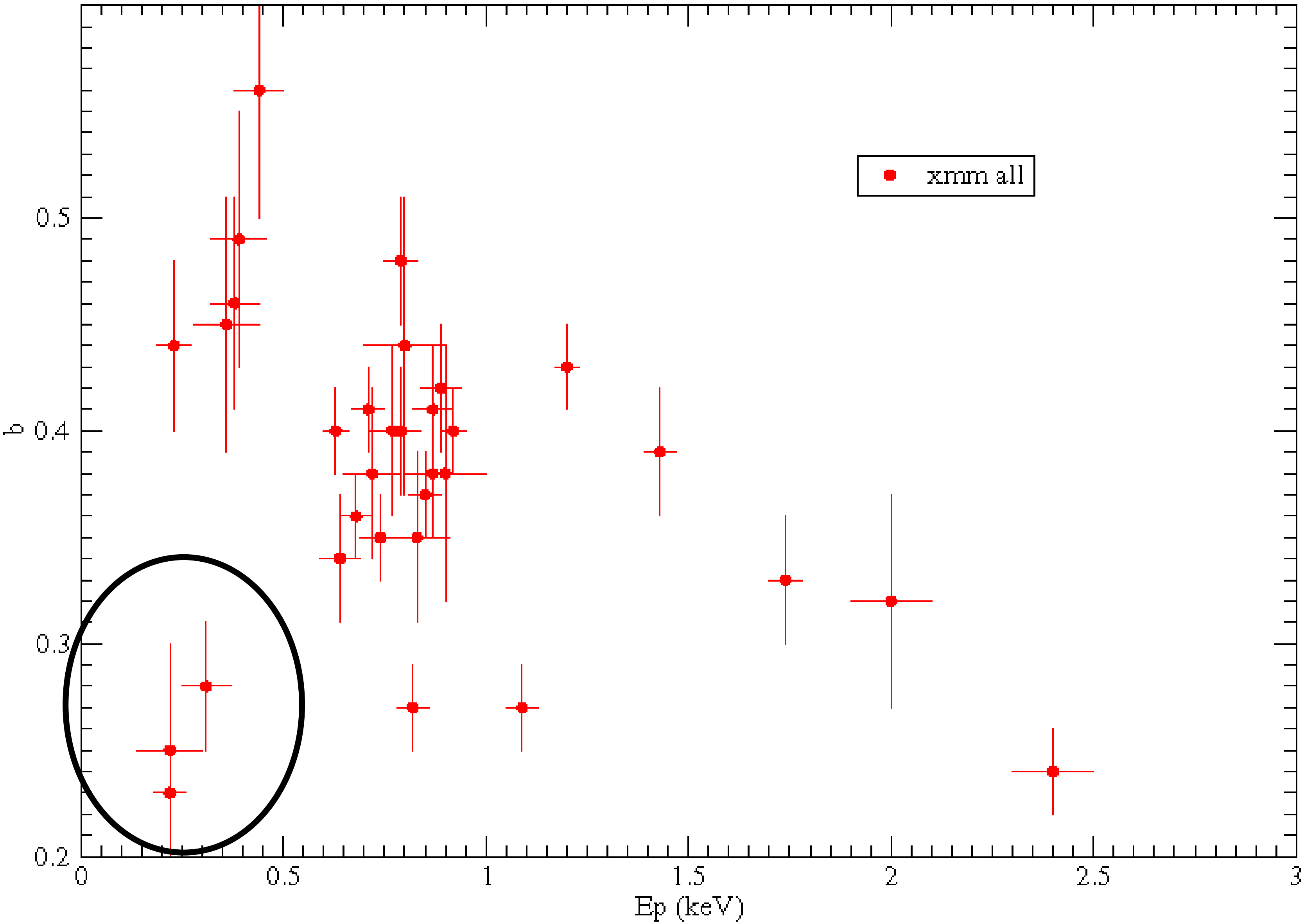
XMM SAMPLE OF SPECTRA AND TABLE



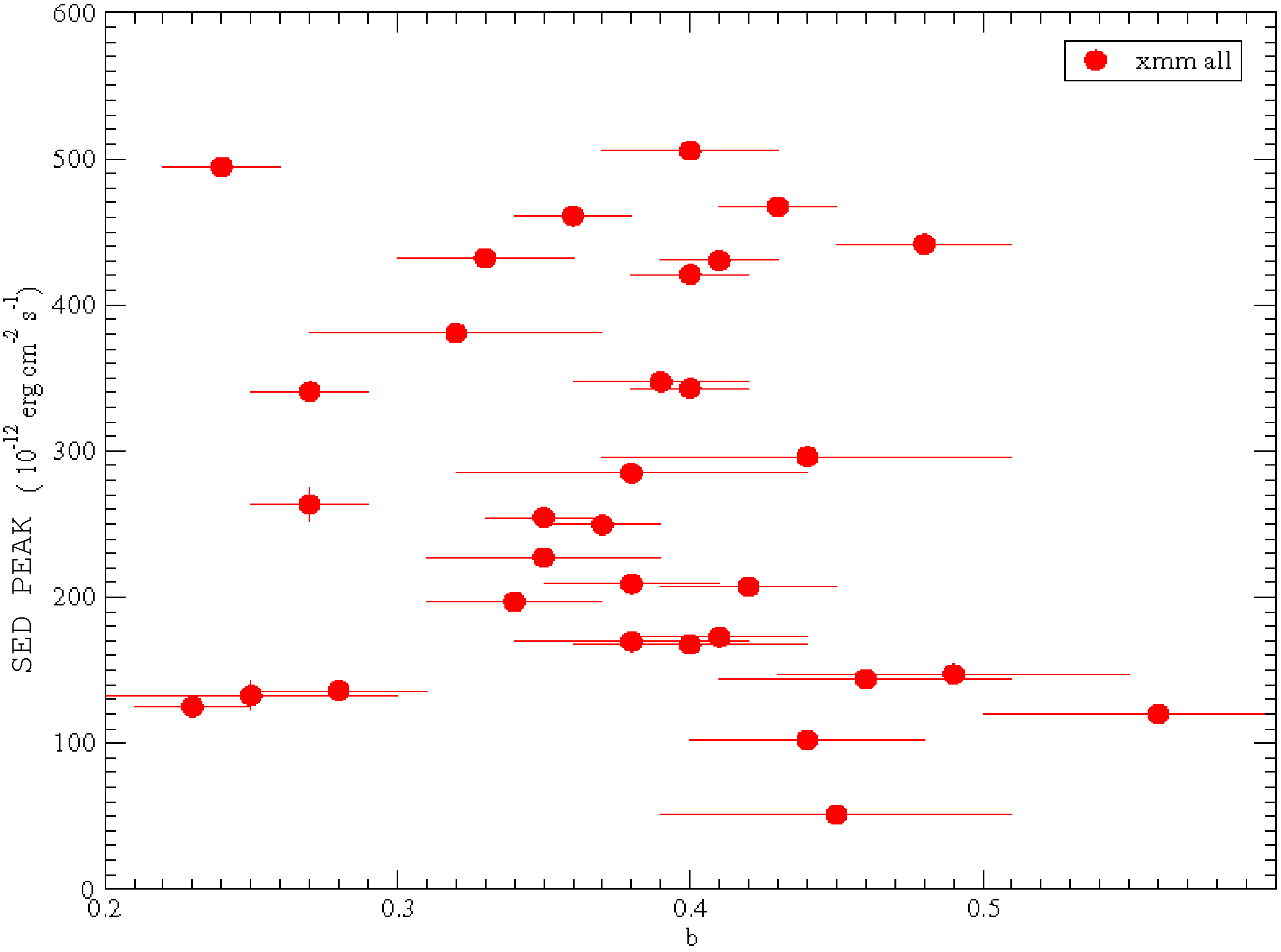
Results from *XMM* E_p-$\nu_p F(\nu_p)$



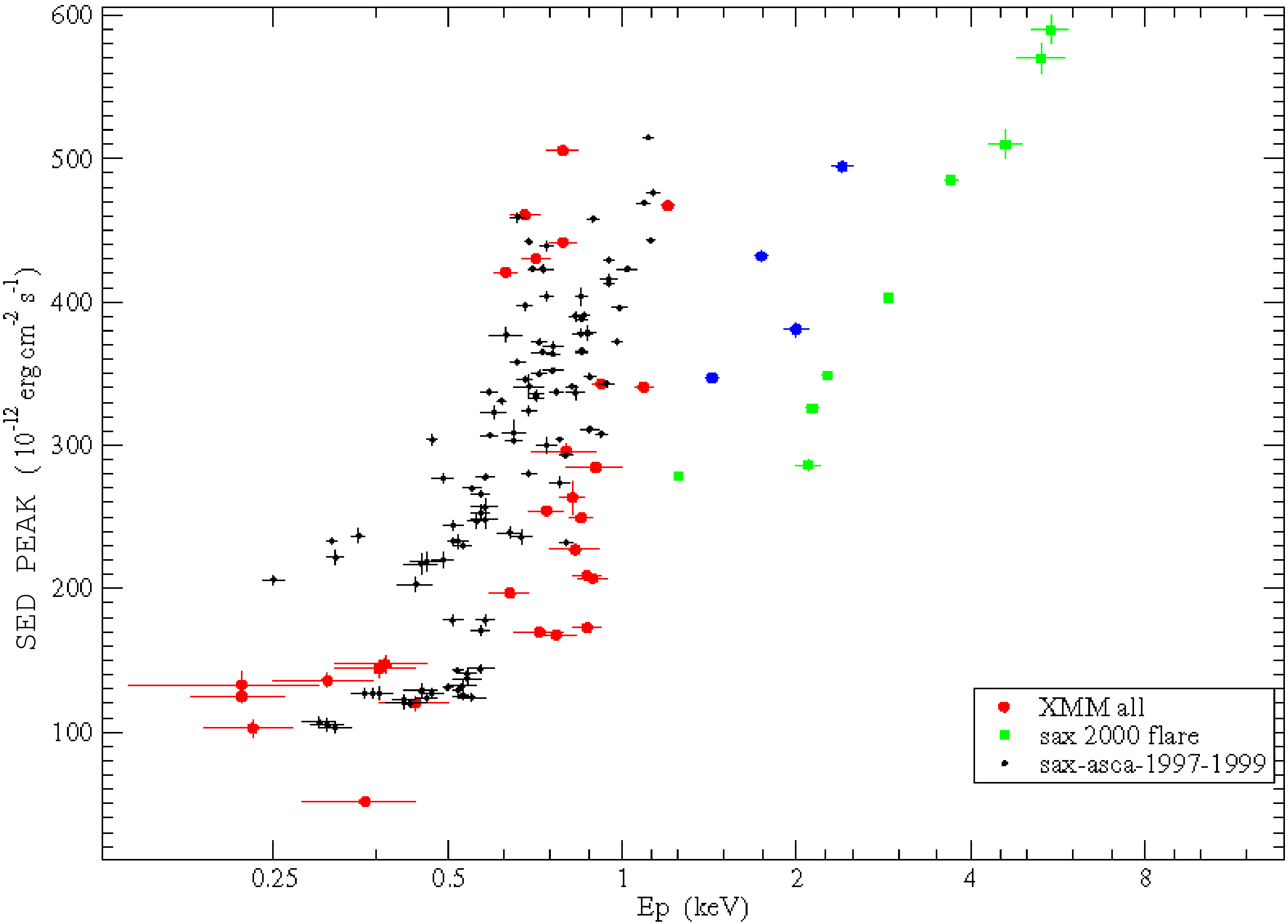
Results from *XMM* E_p-*b*



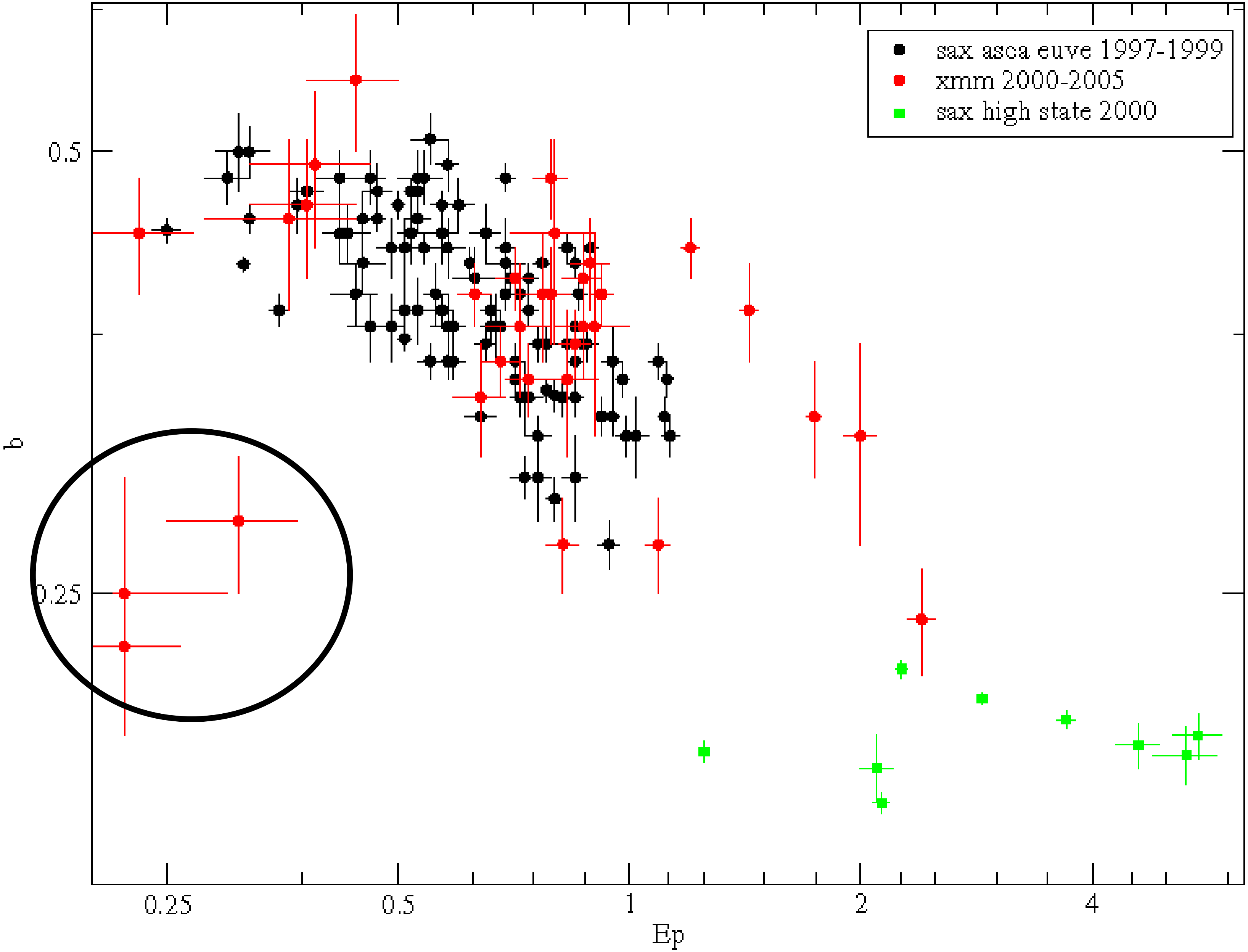
Results from *XMM* $\nu_p F(\nu_p)$-b



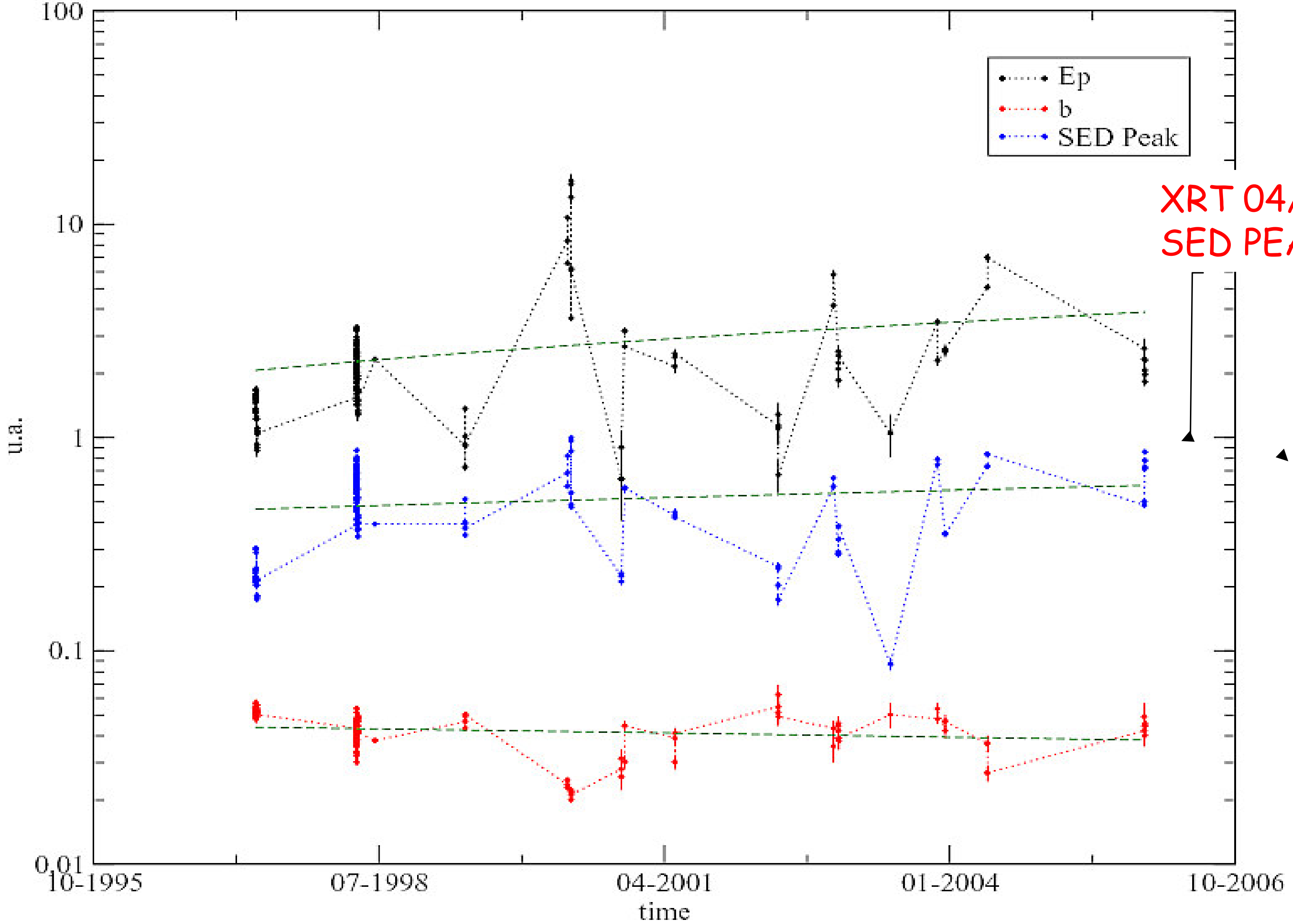
Results *XMM+SAX+ASCA*



Results *XMM+SAX+ASCA*



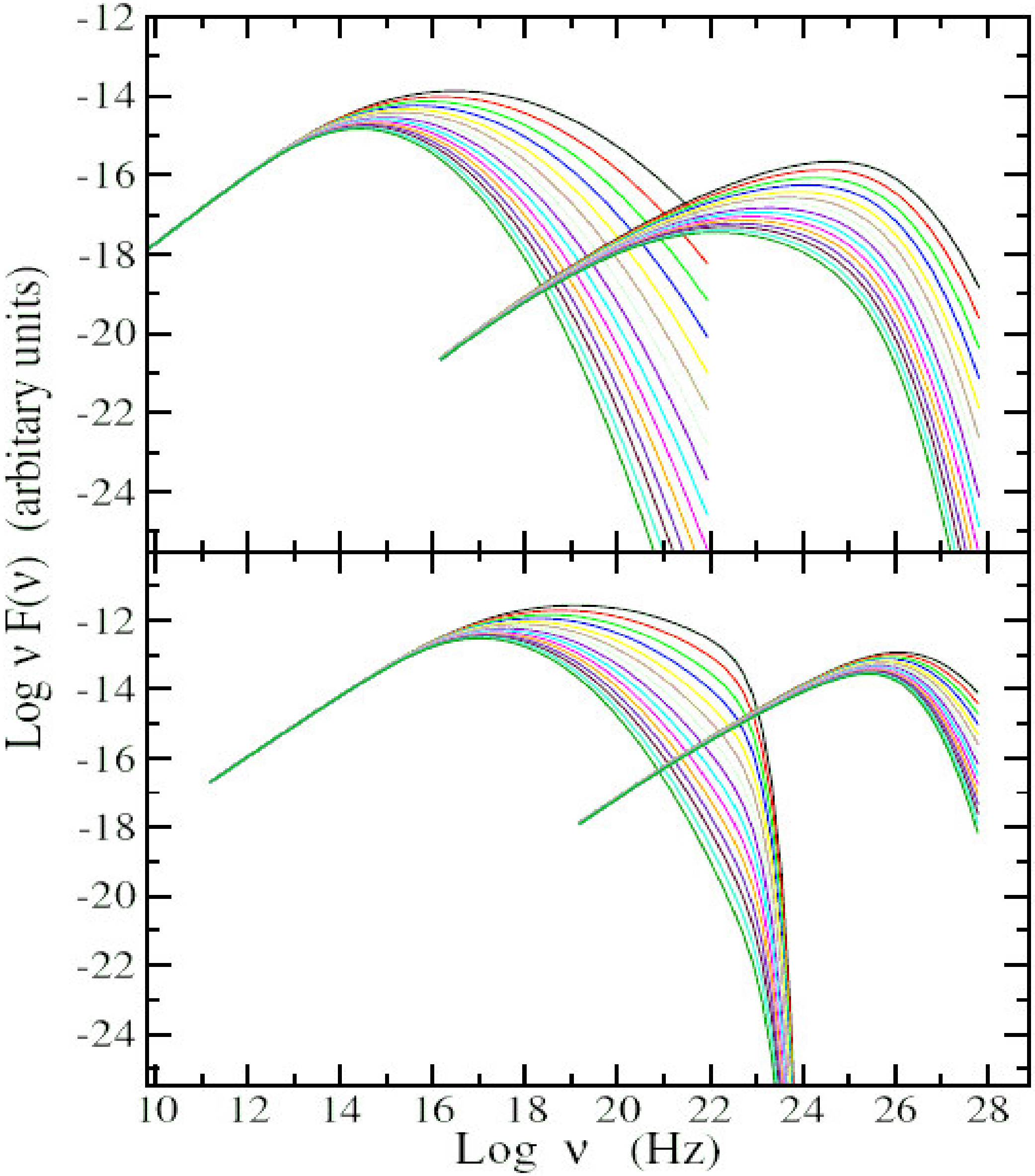
Results *XMM+SAX+ASCA*



XRT 04/2006
SED PEAK~10^{-9}

IC intrinsic curvature and TeV emission

Massaro E., Tramacere A. et al. A&A 2006

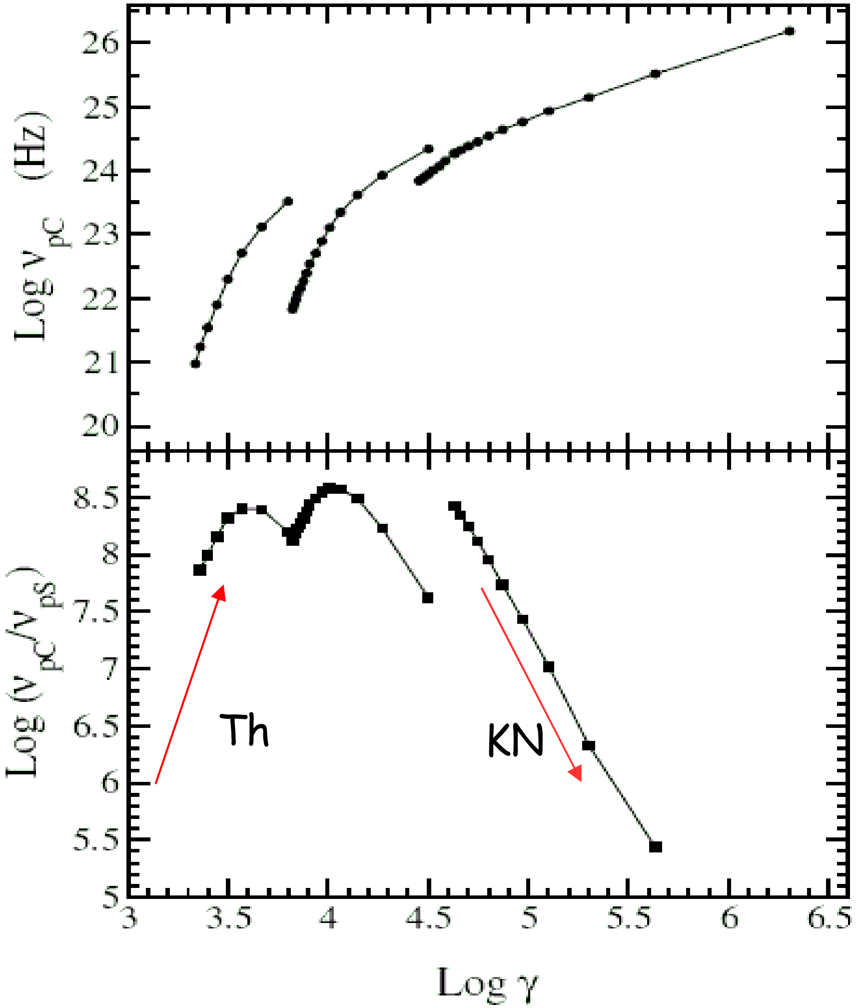


- We want to investigate how the curvature of electron and S spectra can determine the curvature of the IC spectra.
- This topic is crucial for TeV observed object because an intrinsic curvature require lower EBL densities to reproduce the observed spectra.

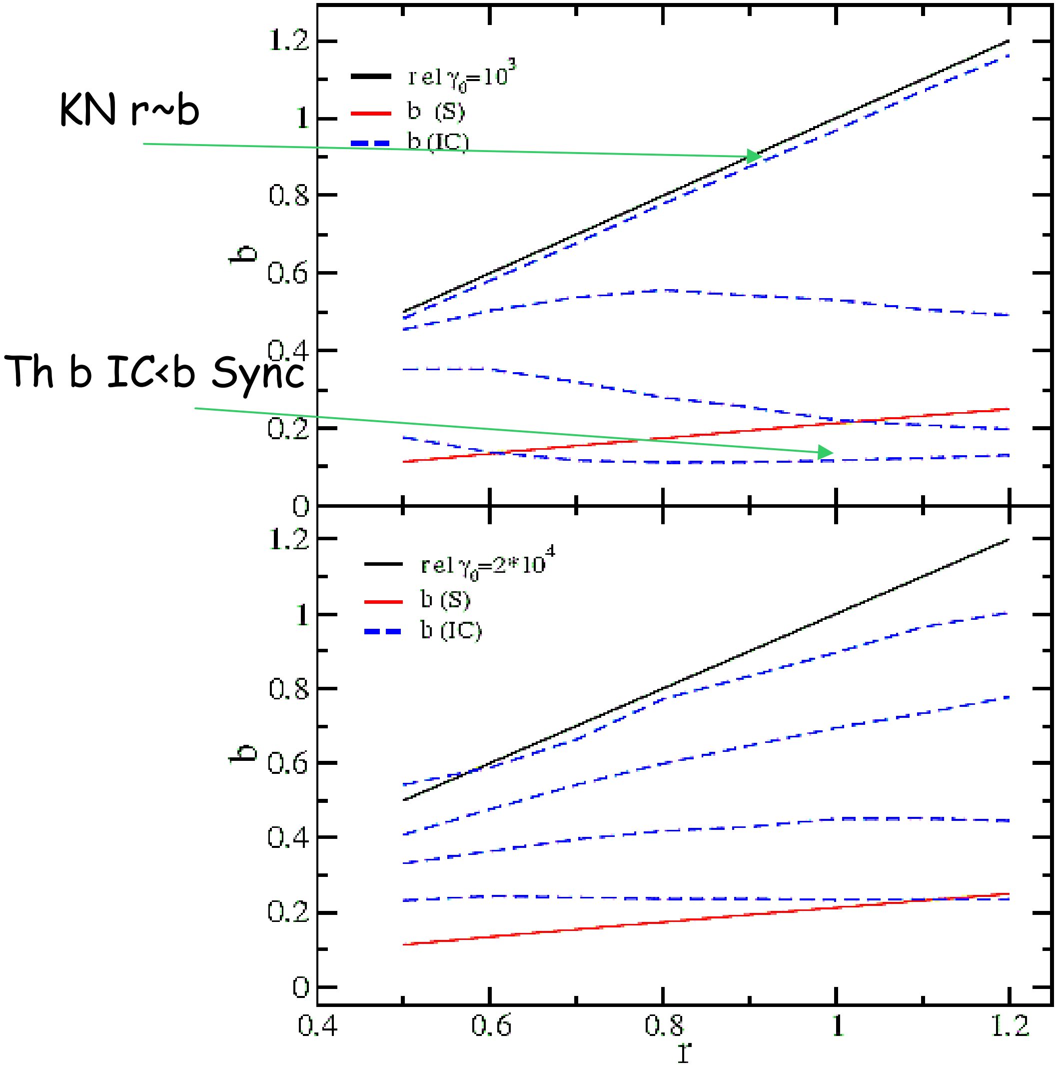
IC em.: transition between Th and KN regime

Massaro E., Tramacere A.,et al.
A&A 2006

fixed $\gamma_0=10^3,5*10^3,10^4$
change r



fixed $\gamma_0=10^3,2*10^4$
change r and move the center of the range over which measure IC curvature



Interaction of EBL with TeV photons

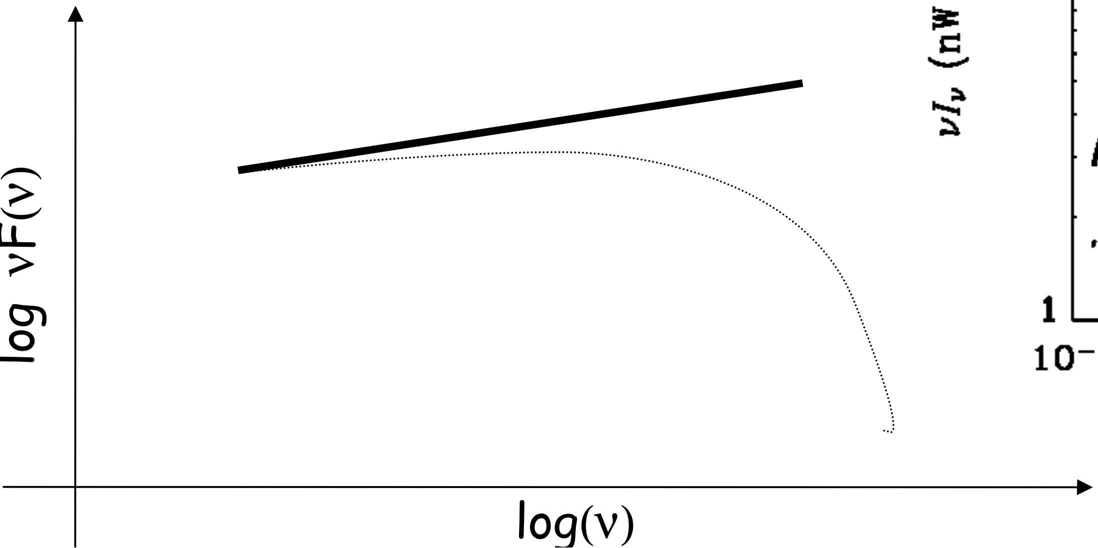
DWEK & KRENNRICH 2005

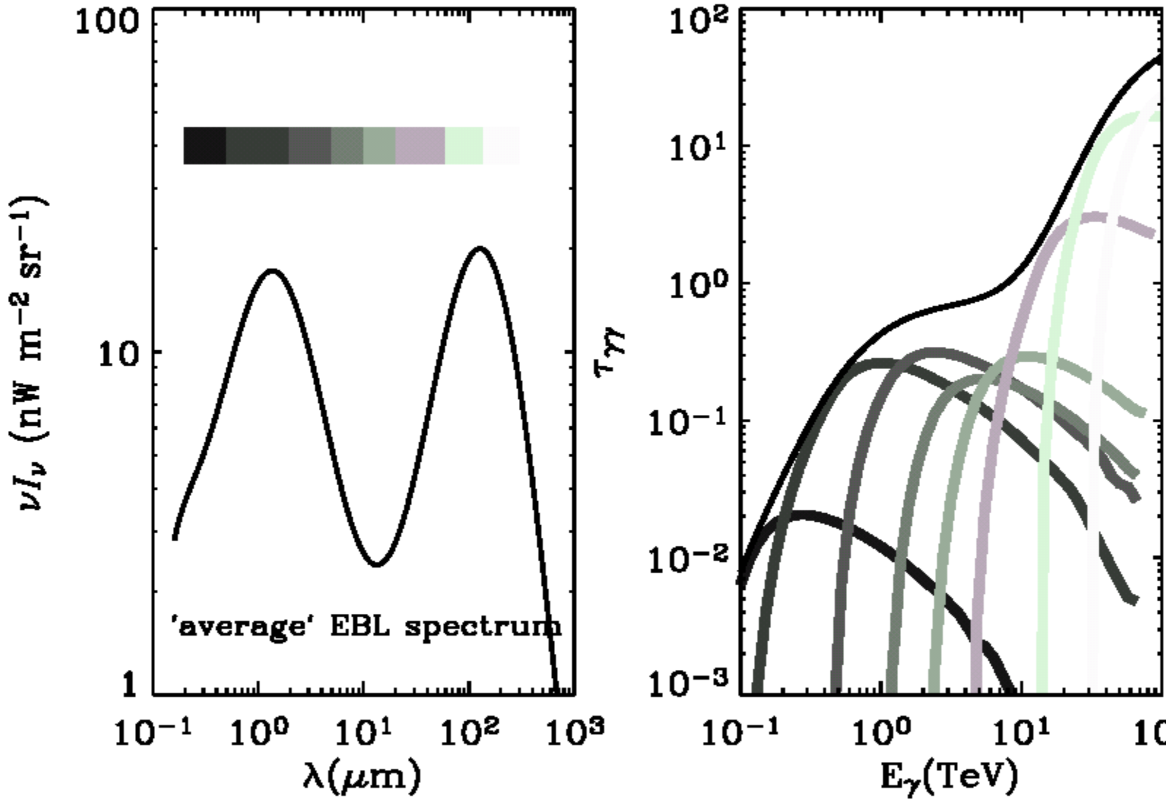
$$\tau_\gamma(E_\gamma,\ z) = \int_0^z \left(\frac{dl}{dz'}\right) dz' \int_{-1}^{+1} d\mu \frac{1-\mu}{2} \int_{\epsilon'_{\rm th}}^{\infty} d\epsilon' n_\epsilon(\epsilon',\ z')\sigma_{\gamma\gamma}(E'_\gamma,\ \epsilon',\ \mu),$$

$$\left(\frac{dl}{dz}\right) = c\left(\frac{dt}{dz}\right) = \frac{R_H}{(1+z)E(z)}$$

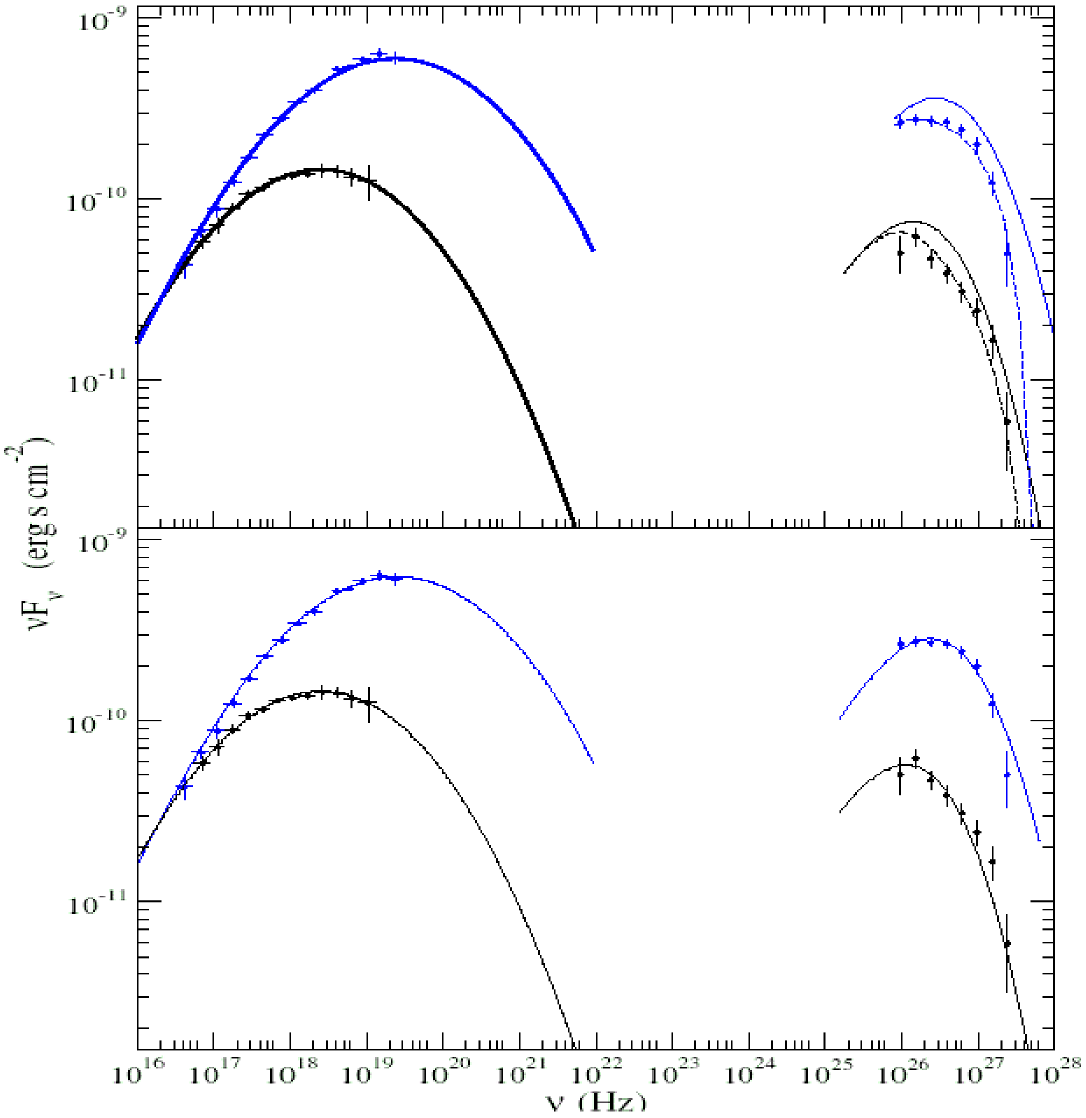
$$E(z) \equiv \{(1+z)^2(\Omega_m z + 1) + z(2+z)[(1+z)^2\Omega_r - $$

EBL spectrum is characterized by polynomial, for various realizations





HBL Mrk 501 1997 large Flare



- We used the lowest EBL realization from Dwek and Krennrich 2005, to evaluate EBL attenuation for Mrk 501
- If EBL is high why we do not see hard intrinsic TeV spectra in nearby Blazars?
- The discovery at at TeV energies of new Blazars with higher z should be in contrast with high EBL densities

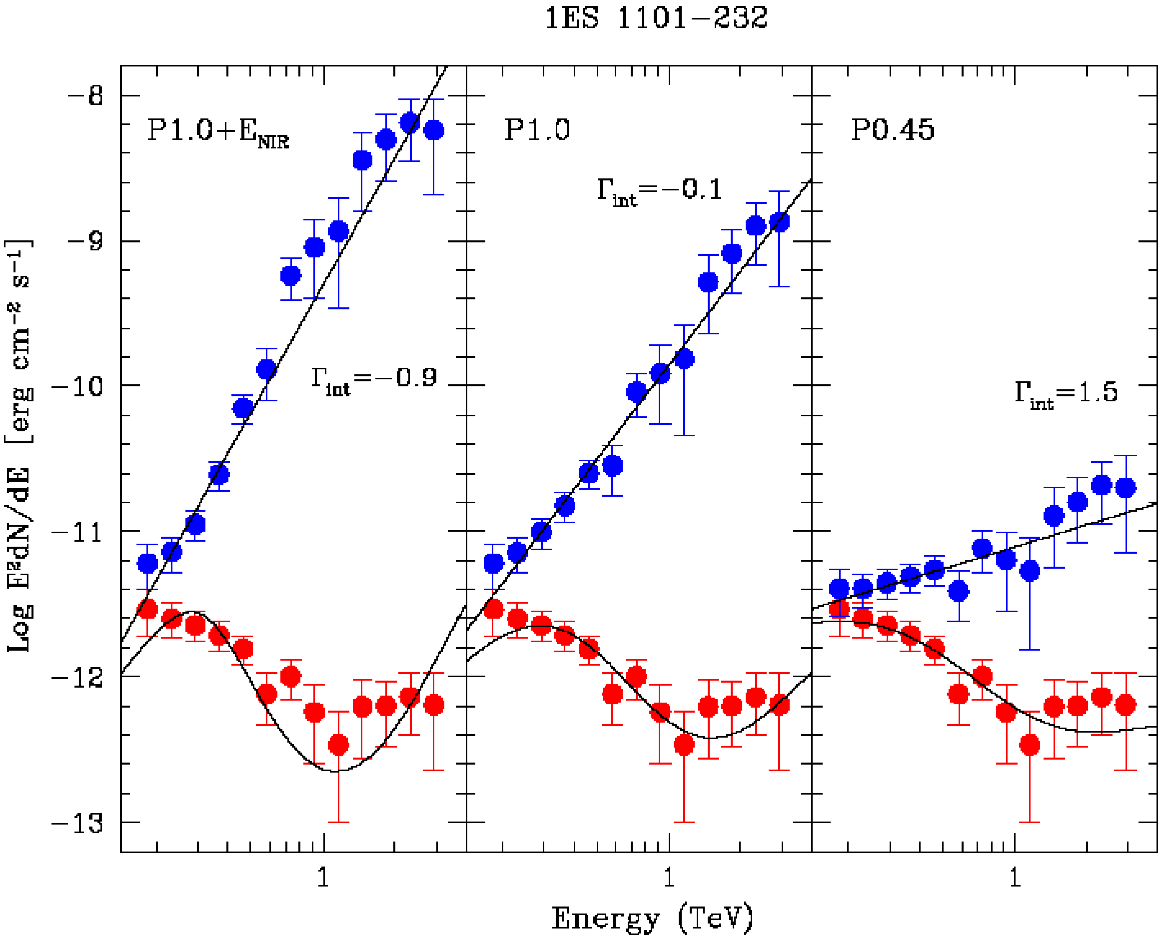
Massaro E., Tramacere A.,et al. A&A 2006

Date	s	r	n cm^{-3}	γ_0 10^4	γ_p 10^5	V cm^3	N_e 10^{45}	E_e 10^{44} erg	$\nu L_\nu(S)$ 10^{39}erg/s	$\nu L_\nu(IC)$ 10^{39}erg/s	B G	δ
SSC - 1 zone												
Apr. 07	1.12	0.81	4.25	4.80	1.67	1.57×10^{47}	669	91.0	8.70	4.47	0.10	15
Apr. 16	1.18	0.70	30.0	8.70	3.36	1.72×10^{46}	515	90.6	34.60	21.4	0.14	15
SSC - 2 zones												
Apr. 07 (Z1)	1.14	0.81	4.6	4.0	1.35	1.2×10^{47}	552	57.9	8.71	3.42	0.14	15
Apr. 11 (Z2)	1.2	1.00	1050	14	3.52	9.2×10^{40}	0.096	0.156	6.92	1.44	1.5	15

MAGIC & H.E.S.S. HIGH z *BLAZARS*

1ES1101-232 z=0.186, 1H2356-309 z=0.165

Aharonian et al. 2006



Conclusions & Future

- Our analysis shows that intrinsic curvature is an observable parameter linked to the acceleration process.
- Measurement of intrinsic curvature is a possible interpretative scheme to understand how much efficient is the electron acceleration in the jet.
- This model predicts a lower EBL density to explain observed spectra and is in agreement with recent discovery at TeV energies of Blazar with z>0.16 .
- We are studying the whole sample of TeV Blazar observed by XMM/SWIFT to test this model on other objects of the same category **(Tramacere A. et al. 2006 in prep, Massaro F., Tramacere A., 2006 in preparation).**
- We are investigating an alternative physical model to obtain log-parabolic electron distribution, and preliminary results are in agreement with those presented **(Tramacere A. Massaro E., et al 2006 in preparation).**
- Broad band X-ray telescope and X-rays/TeV simultaneous observation are necessary.