Leptonic and hadronic modelling of the blazar PKS2155-304

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Introduction : Blazar Emission Models

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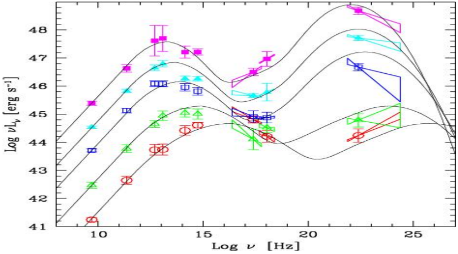
- Leptonic Models
  - Synchrotron Self-Compton (SSC)
  - External Inverse Compton (EIC)
- Hadronic Models



Fossati et al. 1998

Original Code

Code *Sblob*, written by K.Katarzynski, H.Sol and A.Kus (A&A 367,809 (2001))

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- EBL according to Kneiske et al. (2002, 2004)

Code Development

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- $\gamma - \gamma$ cross section for Pair Production modified (F.Aharonian et al., 1983)

$$\sigma_{\gamma\gamma} = \frac{3\sigma_T}{2s_0^2}[(s_0 + \frac{1}{2} ln s_0 - \frac{1}{6} + \frac{1}{2s_0}) ln(\sqrt{s_0} + \sqrt{s_0 + 1}) -$$

$$-(s_0 \frac{4}{9} - \frac{1}{9s_0}) \sqrt{1 - \frac{1}{s_0}}]$$

where $s_0 = (E_1 E_2)/(m^2 c^4)$

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- Synchrotron Emission : exact integration over pitch angles
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- Implementation of Secondary Electron distribution and Synchrotron emission

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- Synchrotron Emission : exact integration over pitch angles
- $\gamma - \gamma$ cross section for Pair Production modified (F.Aharonian et al., 1983)
- Implementation of Secondary Electron distribution and Synchrotron emission
- Proton Synchrotron emission added

Modelling PKS2155-304 emission

2003 multi-wavelength observations
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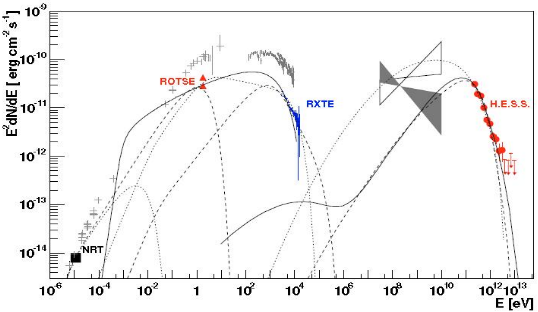

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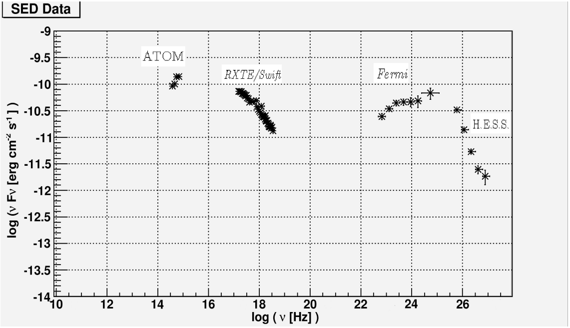

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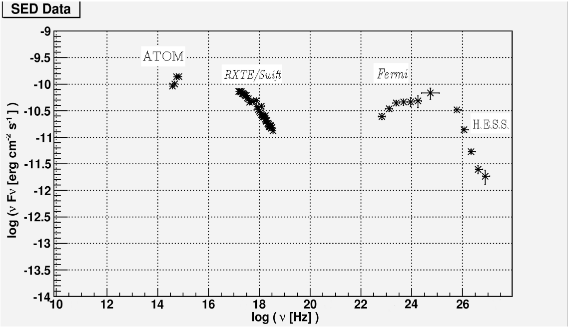

- Compton peak constrained

Modelling PKS2155-304 emission

Modelling 2008 data in three different scenarios:

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Modelling PKS2155-304 emission

Modelling 2008 data in three different scenarios:

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- Lepto-Hadronic Model

SSC Model

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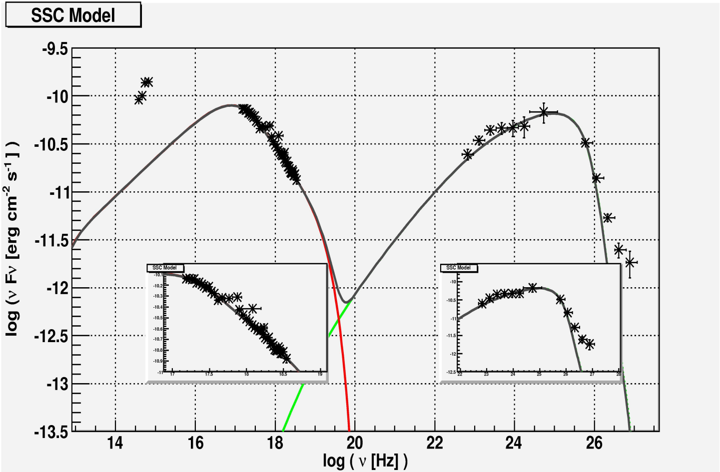

SSC Model
log (ν Fν [erg cm^-2 s^-1])
log (ν [Hz])
-9.5
-10
-10.5
-11
-11.5
-12
-12.5
-13
-13.5
14
16
18
20
22
24
26

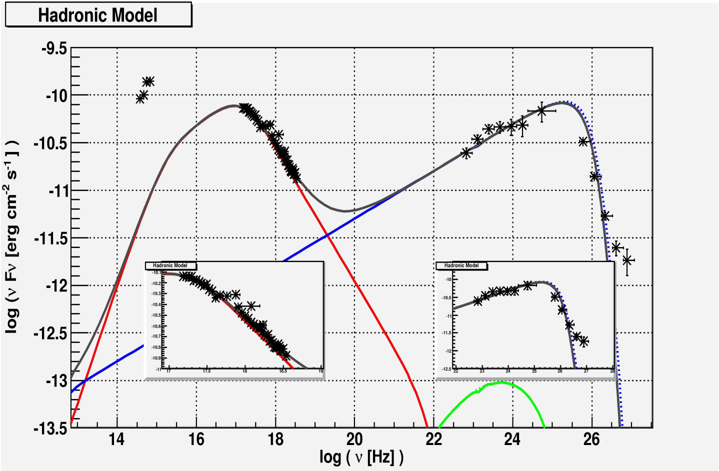
SSC Model : parameters

Our results (compared to 2005 paper)

$\underline{\delta = 25}$	$(\underline{25})$
$K = 5.2 \cdot 10^4\ \mathrm{cm}^{-3}$	$(2.0 \cdot 10^3\ \mathrm{cm}^{-3})$
$\gamma_{min} = 500$	(500)
$\gamma_{max} = 5 \cdot 10^5$	$(9 \cdot 10^5)$
$\gamma_{break} = 6.7 \cdot 10^4$	$(1 \cdot 10^5)$
$n_1 = 2.2$	(1.7)
$n_2 = 4.2$	(4.65)
$\underline{B = 0.25\ \mathrm{G}}$	$(\underline{0.25\ \mathrm{G}})$
$r = 5.6 \cdot 10^{15}\ \mathrm{cm}$	$(1.5 \cdot 10^{15}\ \mathrm{cm})$

Hadronic Model

Hadronic Model

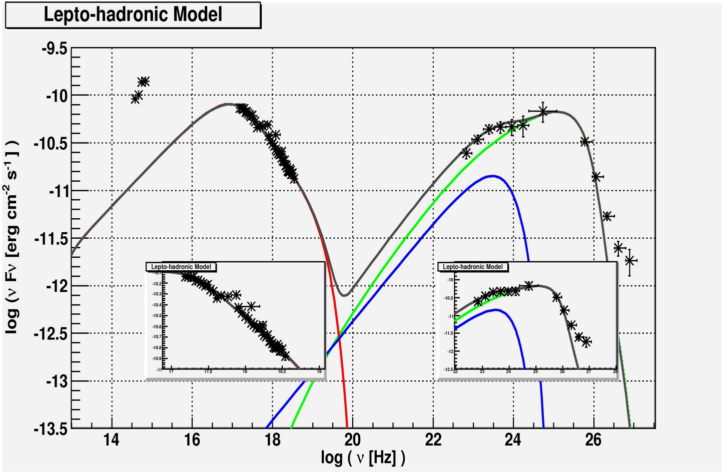


Hadronic model : parameters

Our results	(compared to 2005 paper)
$\underline{\delta = 20}$	$(\underline{20})$
$K = 2.23 \cdot 10^3 \mathrm{cm}^{-3}$	$(? \mathrm{cm}^{-3})$
$\gamma_{min} = 500$	
$\gamma_{max} = 5 \cdot 10^5$	
$\gamma_{break} = 6.7 \cdot 10^4$	
$n_1 = 2.2$	(1.6)
$n_2 = 4.4$	(1.6)
$\gamma_{p,min} = 1000$	
$\gamma_{p,max} = 6 \cdot 10^9$	$(8 \cdot 10^9)$
$n_p = 2.5$	(1.6)
$\eta = 5 \cdot 10^4$	(≈ 1)
$B = 70 \mathrm{G}$	$(80\ \mathrm{G})$
$\underline{r = 1 \cdot 10^{15} \mathrm{cm}}$	$(\underline{1 \cdot 10^{15}\ \mathrm{cm}})$

Lepto-Hadronic Model

Lepto-Hadronic Model



Lepto-Hadronic model : parameters

Our results (and comparison to SSC model)

$\underline{\delta = 25}$	$(\underline{25})$
$K = 2.2 \cdot 10^4\ \mathrm{cm}^{-3}$	$(5.2 \cdot 10^4\ \mathrm{cm}^{-3})$
$\gamma_{min} = 500$	(500)
$\gamma_{max} = 7.5 \cdot 10^5$	$(5 \cdot 10^5)$
$\gamma_{break} = 6.7 \cdot 10^4$	$(6.7 \cdot 10^4)$
$n_1 = 2.1$	(2.2)
$n_2 = 4.2$	(4.2)
$\gamma_{p,min} = 1000$	
$\gamma_{p,max} = 8 \cdot 10^9$	
$n_p = 1.96$	
$\underline{B = 0.25\ \mathrm{G}}$	$(\underline{0.25\ \mathrm{G}})$
$r = 5.2 \cdot 10^{15}\ \mathrm{cm}$	$(5.6 \cdot 10^{15}\ \mathrm{cm})$

Conclusions

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- Development of *SBLOB* code : from a leptonic SSC model to a lepto-hadronic one
  - correction of the approximations used in order to properly add the proton synchrotron emission
  - implementation of first generation pair spectrum and synchrotron emission
  - implementation of EIC already done by J.P.Lenain
  - !! TO DO !! : $p - \gamma$ and $p - p$ interactions and emission by secondary particles (!! WORK IN PROGRESS !!)

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- Very preliminary results : in a stationary approach PKS2155-304 can be equally well described by a SSC model or a Proton Synchrotron one (caveat : without p-p and p$-\gamma$ interactions).

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- A mixed model, dominated by the SSC but with a non negligible Proton Synchrotron emission fit the data as well.
- Fermi and CTA era : towards more complicated models and detection of different components?

Thanks to...

Thanks to Catherine Boisson, Andreas Zech, Etienne Ferrière, Clementina Medina