MAGIC
Major Atmospheric
Gamma Imaging
Cerenkov Telescope

Challenging the high energy emission zone in FSRQ

PKS1222+216 (4C 21.35) VHE detection by **MAGIC**

Antonio Stamerra

DESY & Università di Siena

and

J. Becerra-González, K. Saito, T. Terzic, L. Maraschi, D. Mazin, F. Tavecchio

on behalf of the MAGIC Collaboration

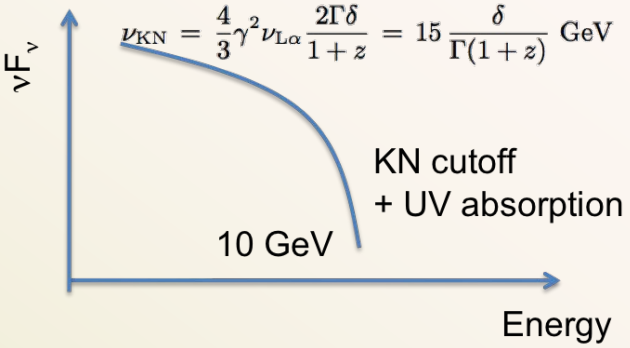
D. Wood, Y. Tanaka

on behalf of the Fermi/LAT Collaboration

Fermi Symposium
11 May 2011 - Roma

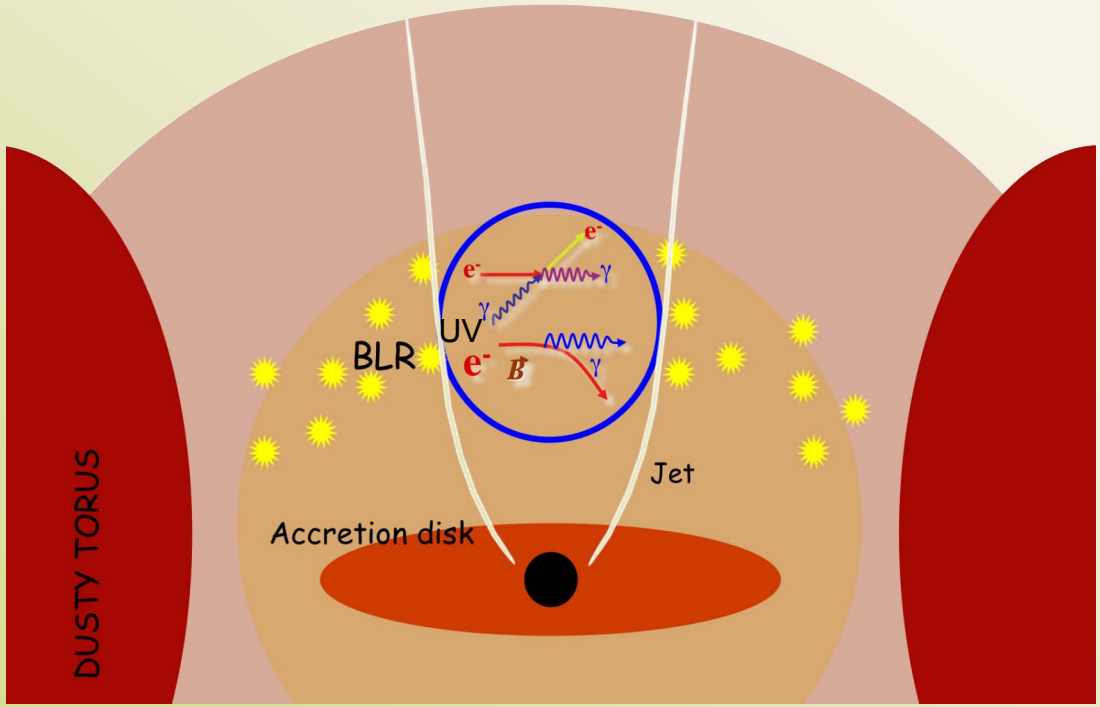
antonio.stamerra@desy.de

The "Blazar Zone" in FSRQ



The "canonical" scenario

- ¤ Emission zone <0.1pc in conical jet within BLR
- ü Short time variability
- ☹ Internal absorption
  e.g. *Liu&Bai 2006, Reimer 2007, Tavecchio&Mazin 2009*
- ☹ Reduced scattering efficiency Klein-Nishina (KN) e.g. *Albert et al. 2008, Tavecchio&Ghisellini 2008*



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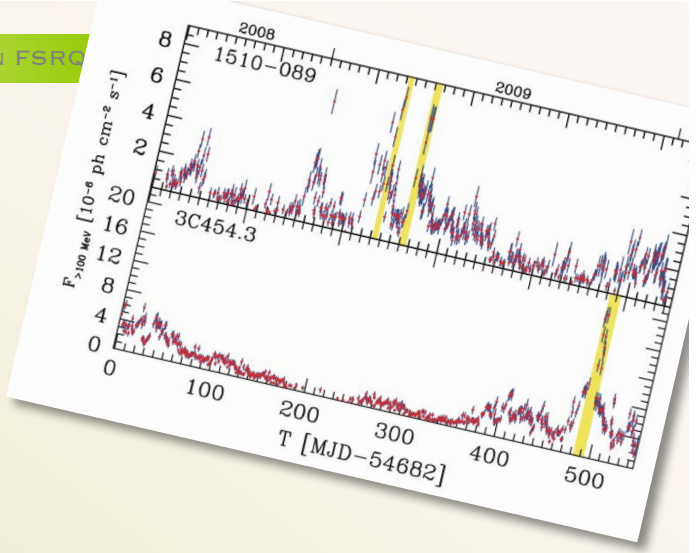
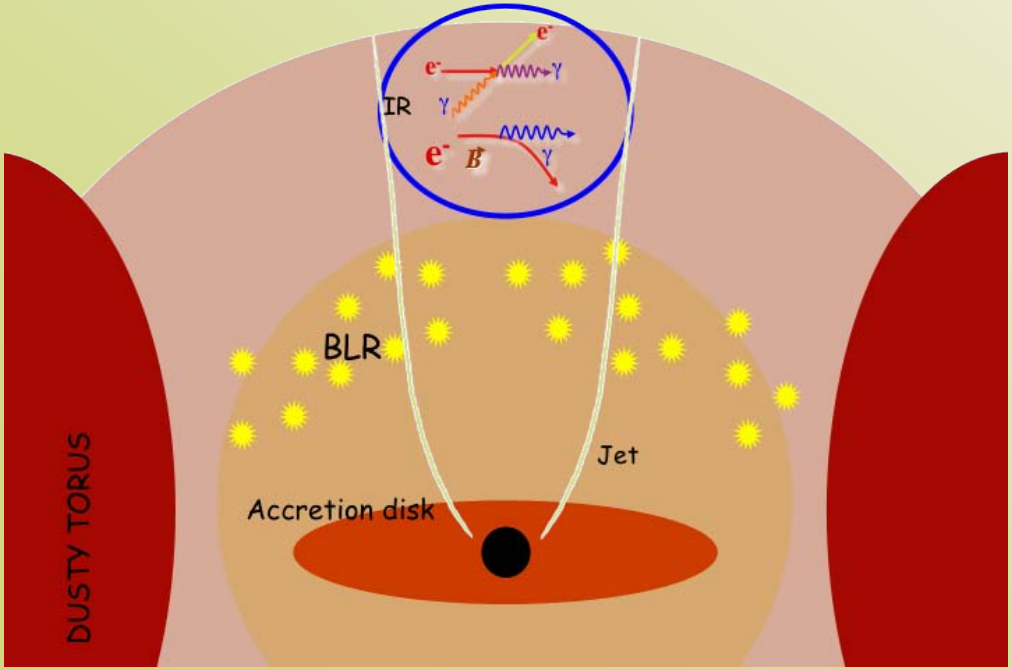


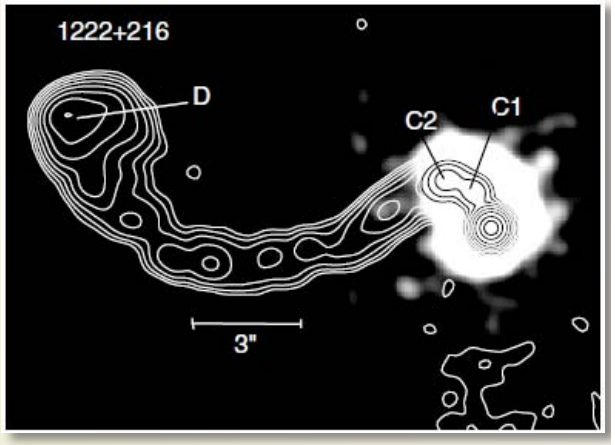
The far-dissipation scenario



- Emission zone ~1-10 pc dusty/IR torus
- Internal absorption in ~TeV
  Donea&Protheroe 2003, Ghisellini&Tavecchio 2009
- γ-ray ~ radio flares ➔ optical thin ➔ >1pc
- Fast variability ~<1 day e.g. 3C 454.3, PKS 1510-089 *Tavecchio 2010*

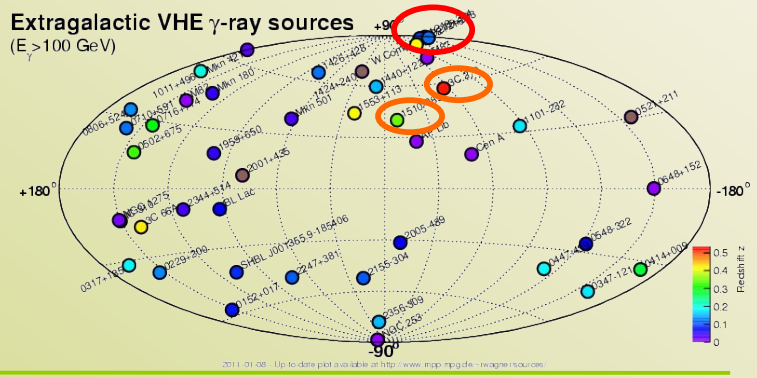
PKS1222+21

Z=0.432 Lum. dist. 2.3 Gpc



- Distorted quasar (bended jet) *Saikia 1993*
- Jet aligned to our line of sight ~5-10°
- Superluminal motion 17-21c *Homan 2001, Lister 2009*
- X-ray emission *Jorstad&Marscher 2006*
- Gamma-ray blazar
  - 3EG J1224+2118, 1FGL J1224.7+2121,
  - 3 FSRQ in VHE; MAGIC VHE detection: Atel #2684

M_{BH}~1.5x10^8 $M_\odot$
L_{BLR} ~10^{45} erg/s
L_{disk}~10^{46} erg/s
R_{BLR}~10^{17}cm



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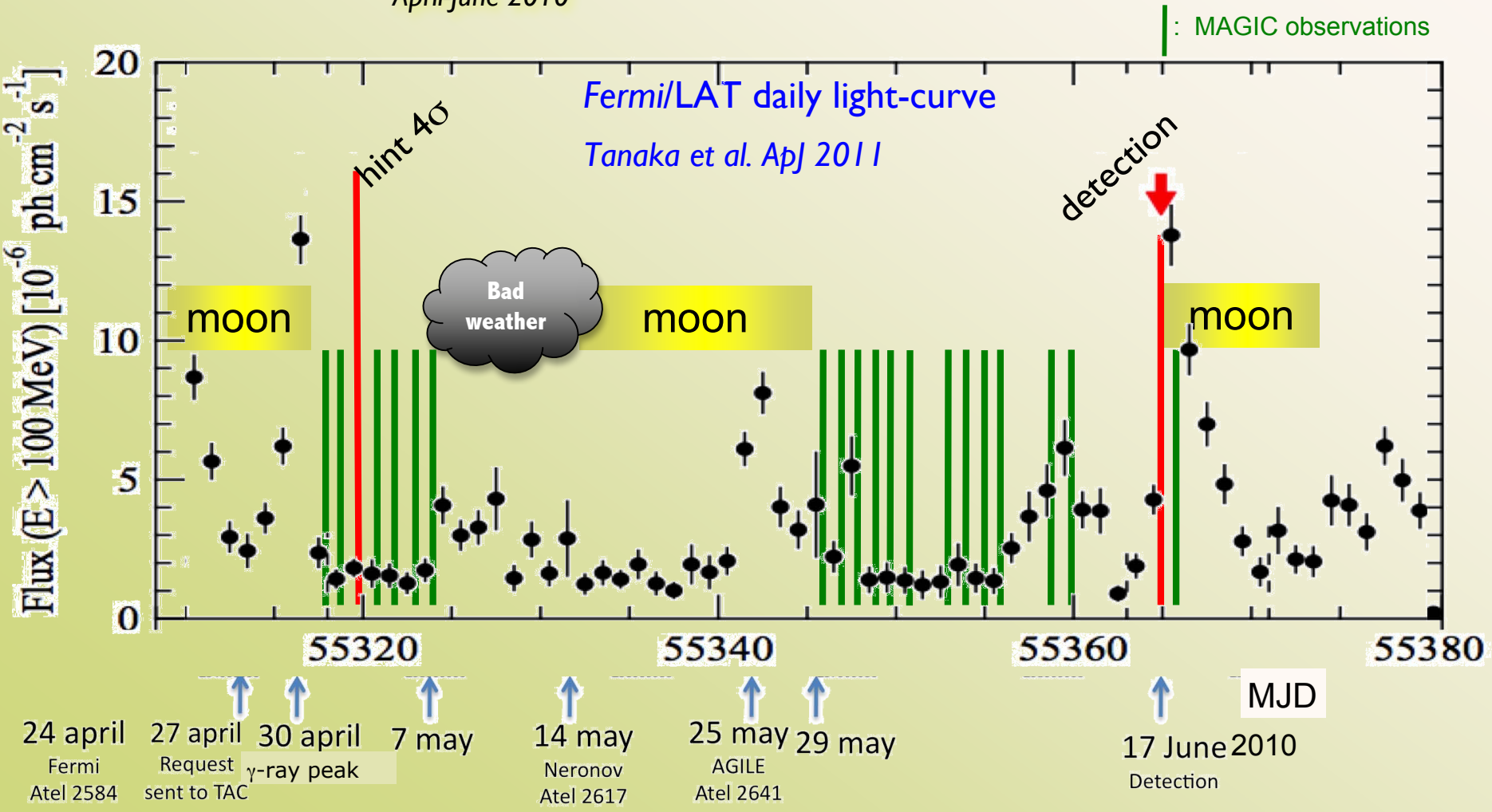
MAGIC campaign

April-June 2010



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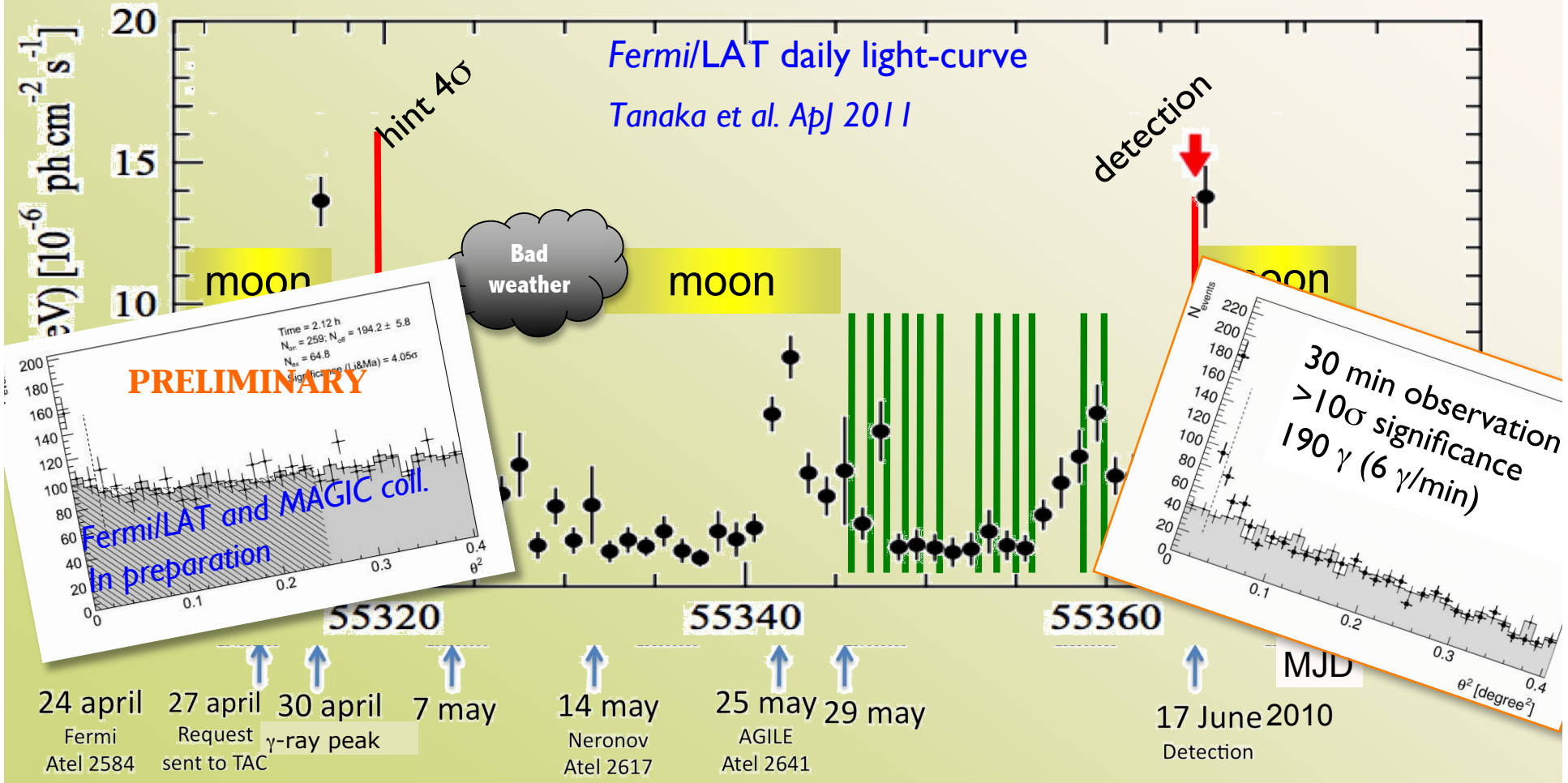

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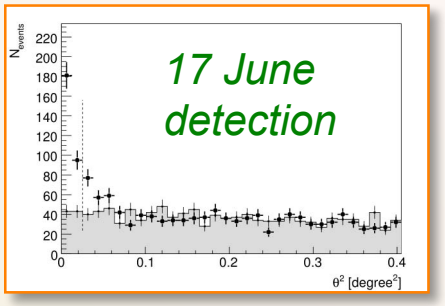
VHE spectrum



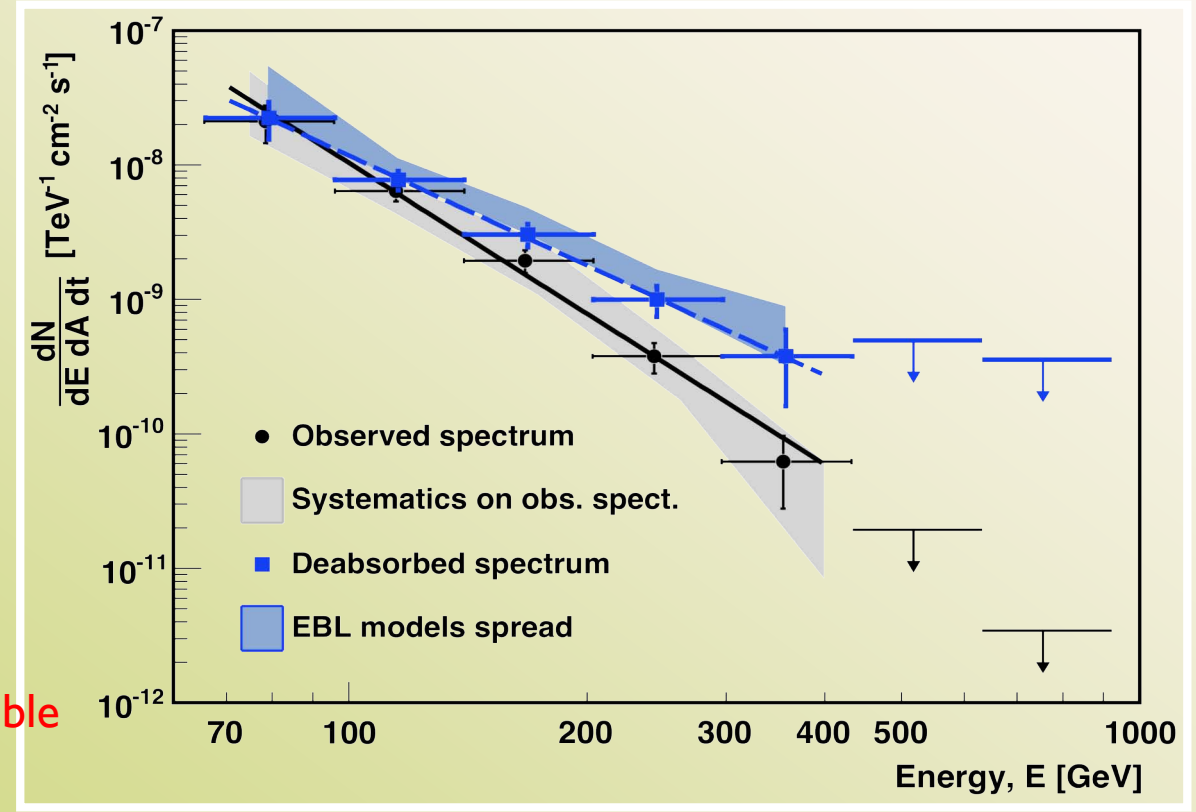
Aleksić et al. ApJL 730 (2011)

- Measured spectrum:

$\alpha = 3.75 \pm 0.29$

- De-absorbed Spectrum (*Dominguez+10*):

$\alpha = 2.72 \pm 0.34$



De-absorbed spectrum compatible with a simple power law

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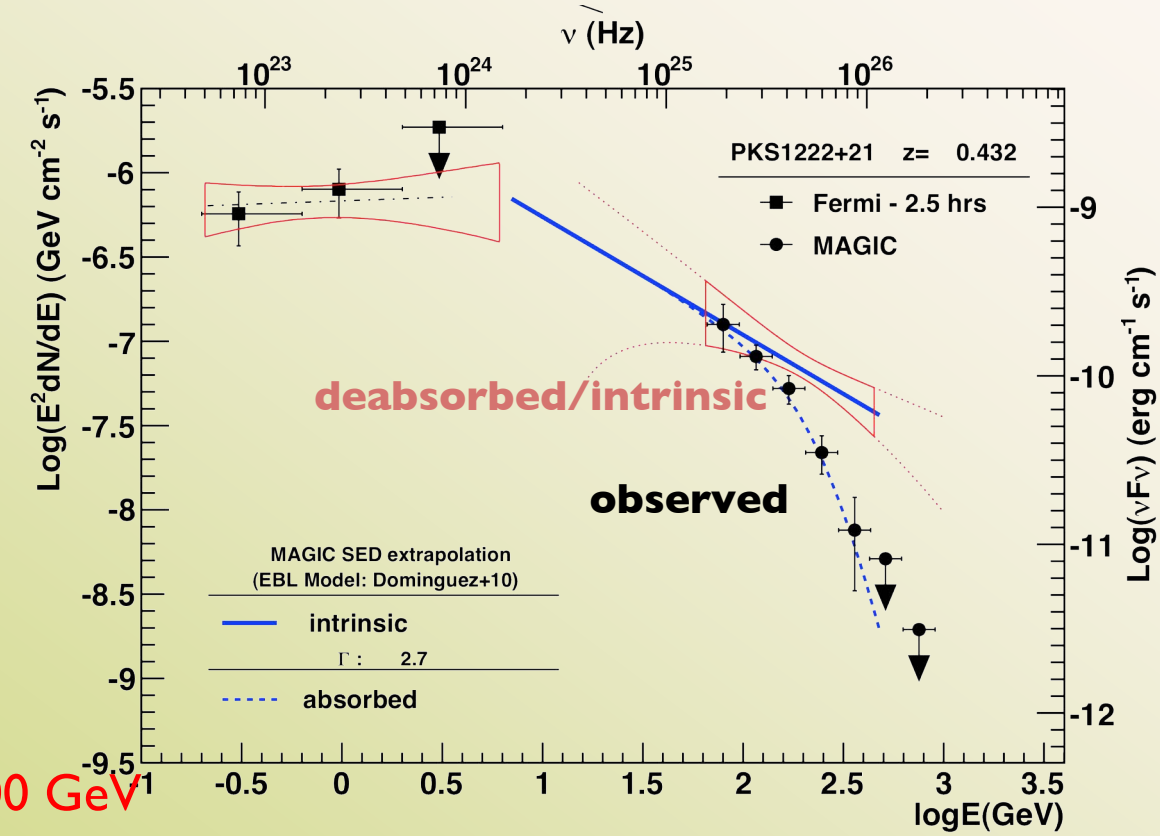
High energy SED

Aleksić et al. ApJL 730 (2011)

- Simultaneous *Fermi*/LAT 2.5 hrs encompassing MAGIC obs.



Single component from 2 to 400 GeV

Cutoff excluded at E < ~130 GeV (95% CL)

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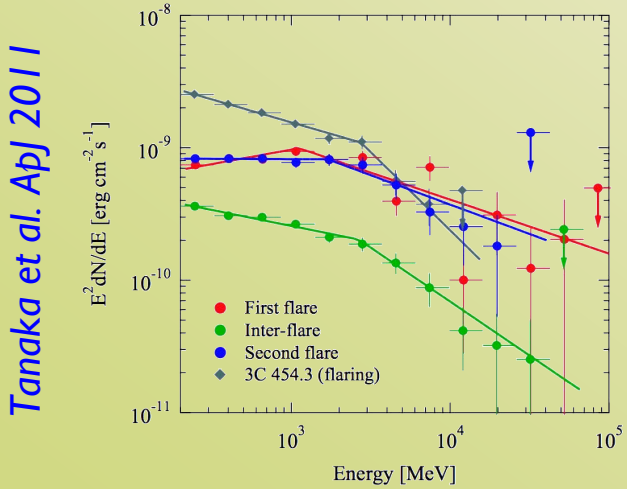

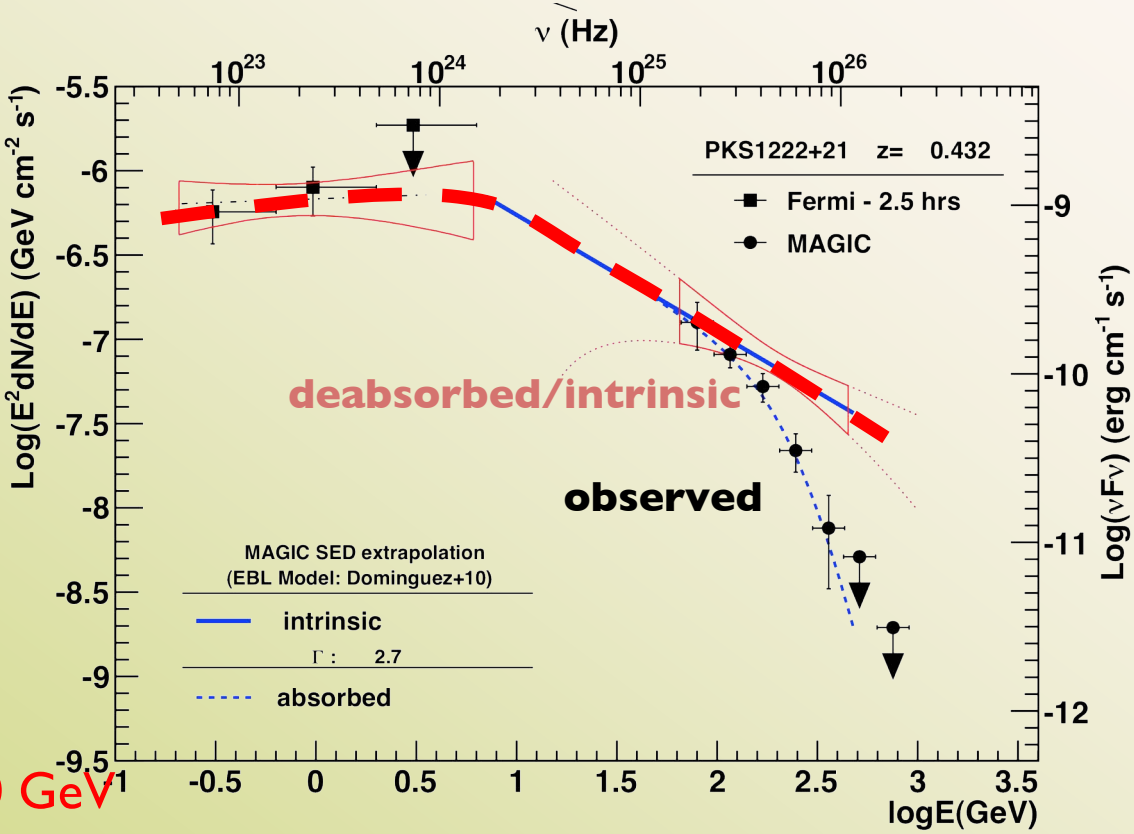

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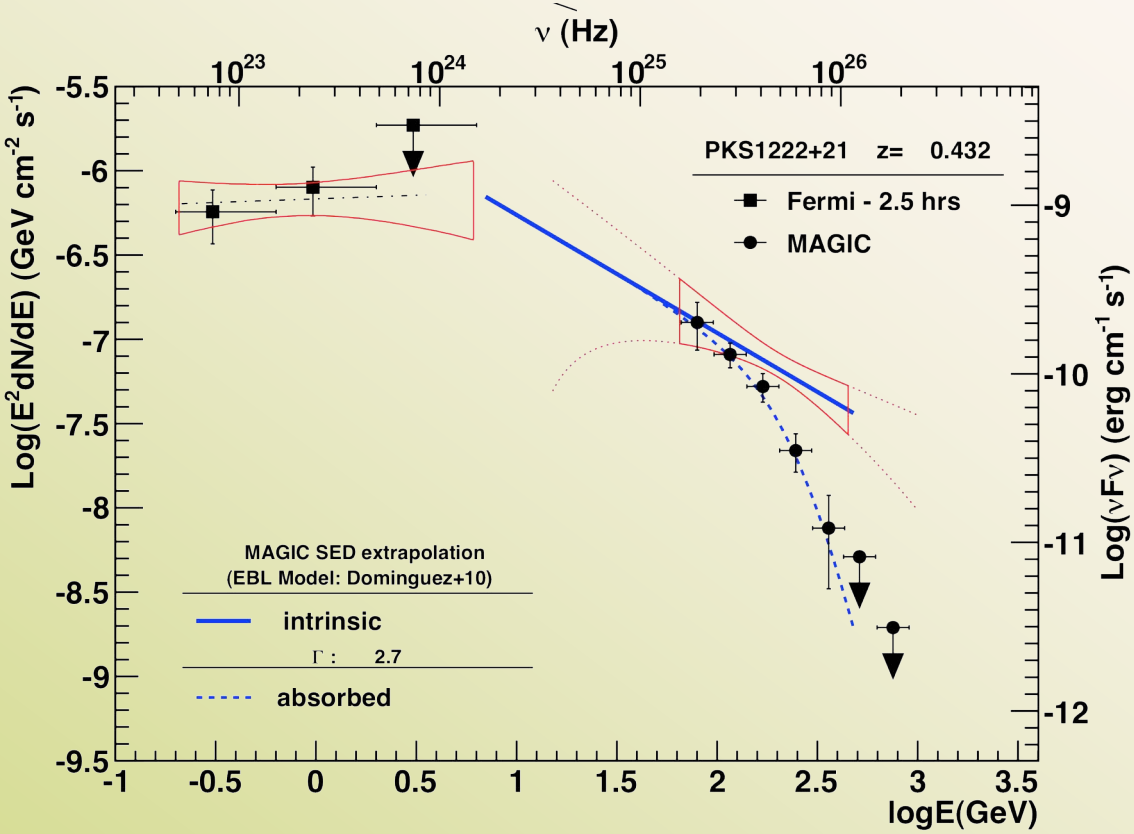
High energy SED

Aleksić et al. ApJL 730 (2011)

- If 1-10 GeV breaks due to photon-photon interaction in the BLR
- γ-ray production should be in the BLR region!

Poutanen&Stern 2010



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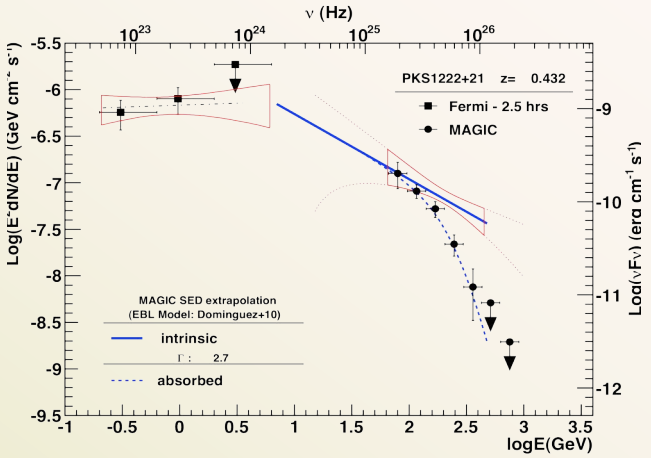


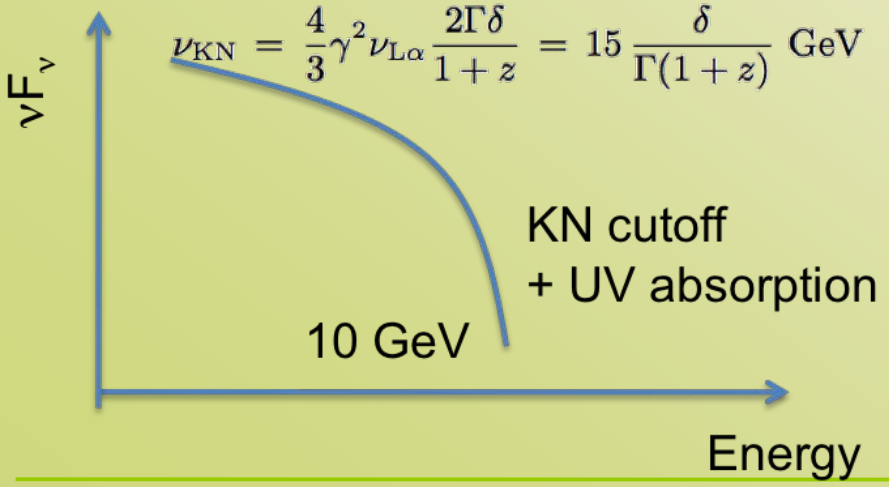
- Internal absorption + Klein-Nishina break

Ghisellini&Tavecchio 2009

Liu&Bai 2006

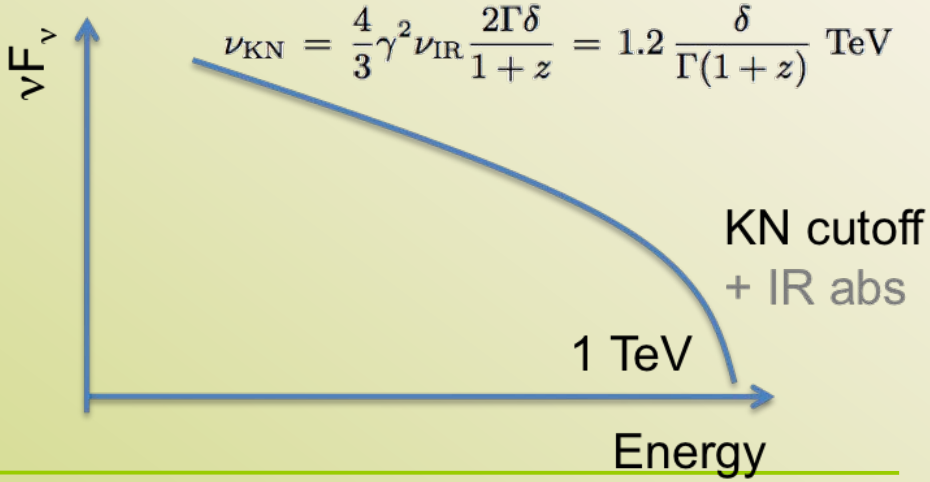
Inside BLR

$$\nu_{KN} = \frac{4}{3}\gamma^2 \nu_{L\alpha} \frac{2\Gamma\delta}{1+z} = 15 \frac{\delta}{\Gamma(1+z)} \text{ GeV}$$

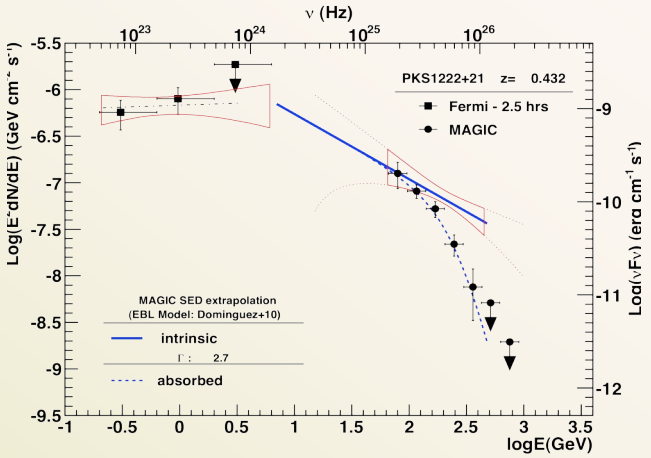


Outside BLR

$$\nu_{KN} = \frac{4}{3}\gamma^2 \nu_{IR} \frac{2\Gamma\delta}{1+z} = 1.2 \frac{\delta}{\Gamma(1+z)} \text{ TeV}$$



High energy SED



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~~Inside BLR~~

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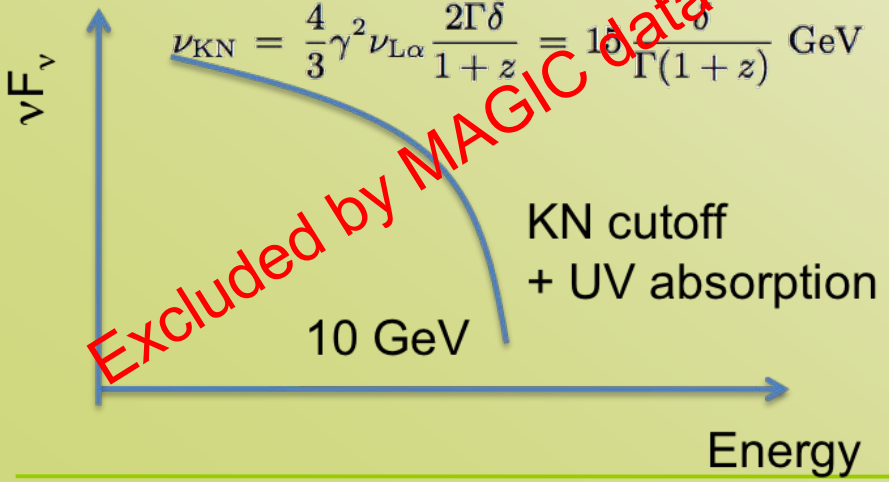

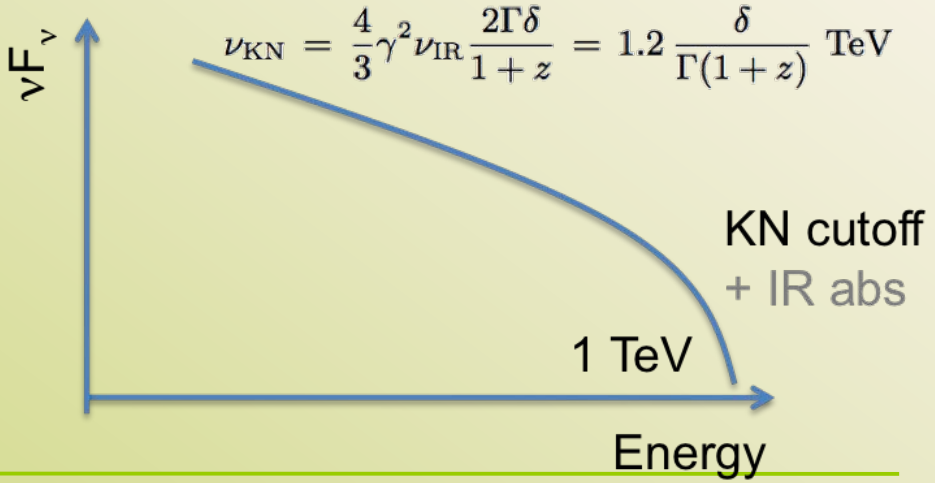

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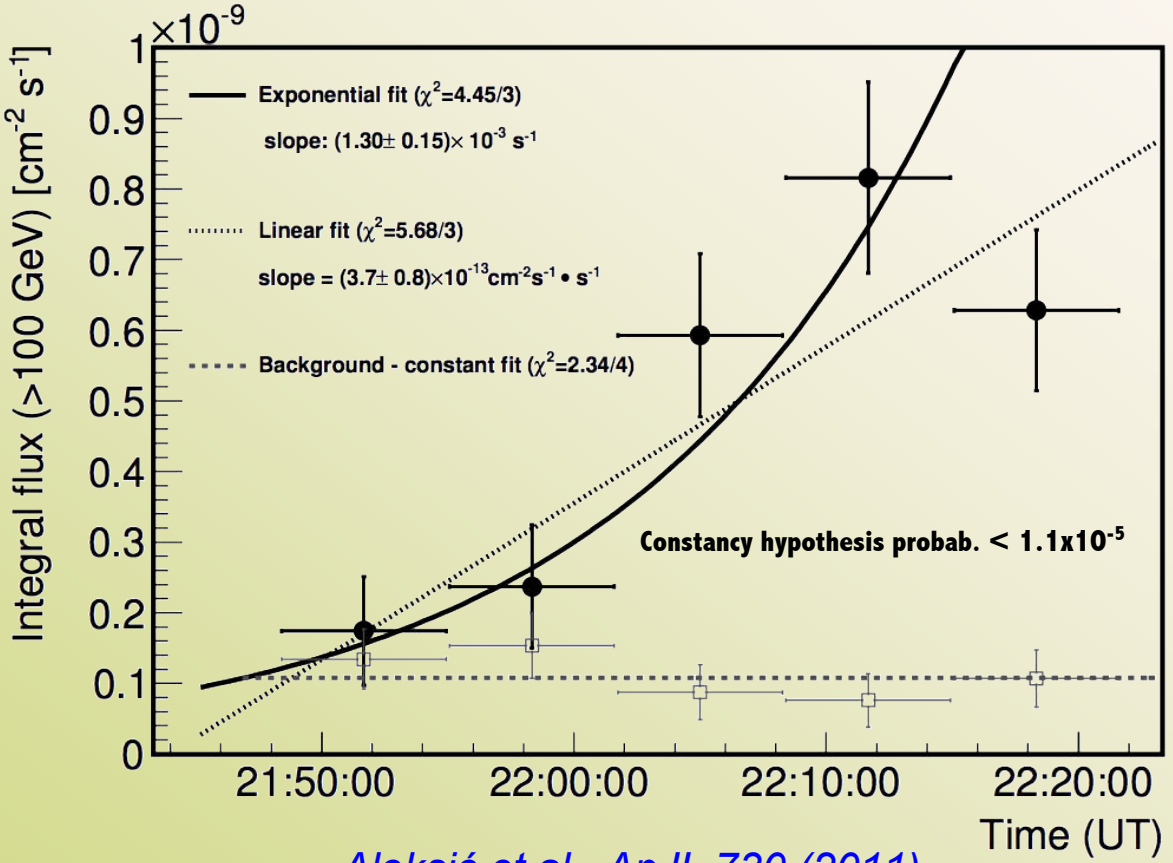
Light curve

- Very fast variability
- Doubling time: ~ 10 minutes
- Size emission region:
- R ~ 10^{14} cm

$$R < ct_{\rm var}\frac{\delta}{(1+z)} \approx$$

$$1.3\times10^{14}\left(\frac{\delta}{10}\right)\left(\frac{t_{\rm var}}{10\,{\rm min}}\right)\ {\rm cm}$$



Aleksić et al. ApJL 730 (2011)

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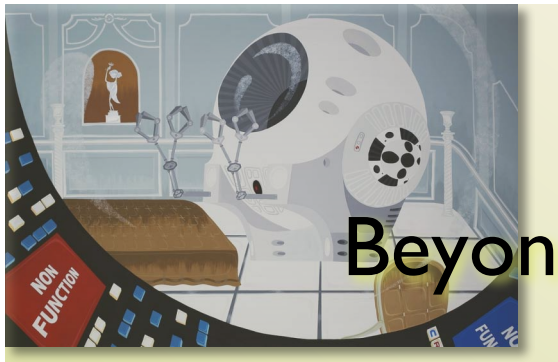
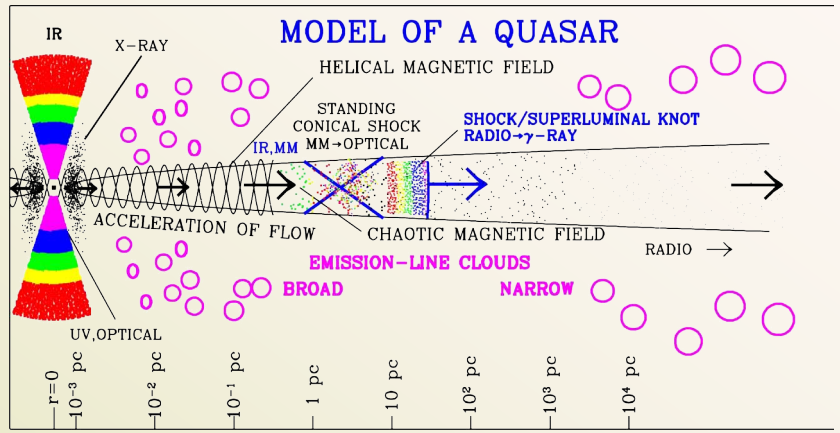
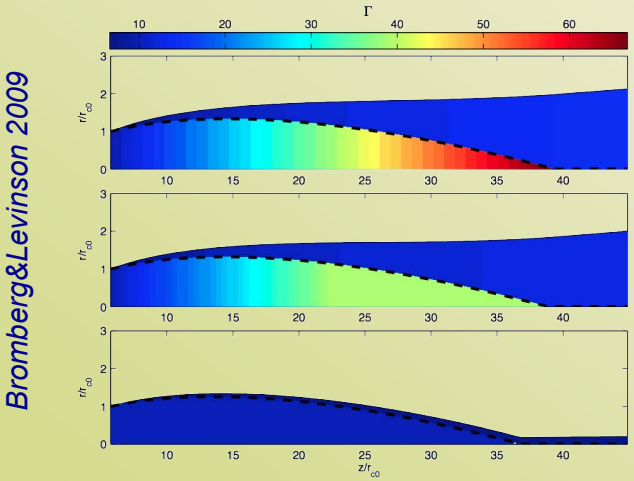


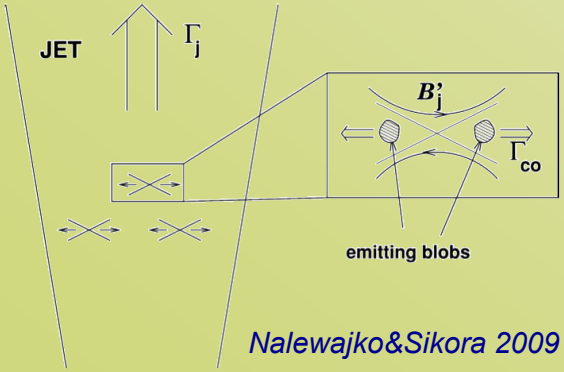
Beyond the BLR



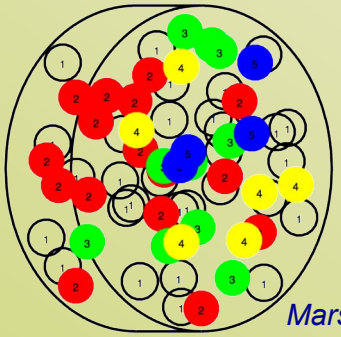


Bromberg&Levinson 2009

- **Recollimation**
  Marscher 1980, Bromberg&Levinson 2009
- **Reconfinement shocks**
  Nalewajko&Sikora 2009, Stawarz 2006
- **Compact region embedded**
  Giannios 2009, Marscher&Jorstad2010, Ghisellini&Tavecchio 2008



Nalewajko&Sikora 2009



Marscher&Jorstad 2010

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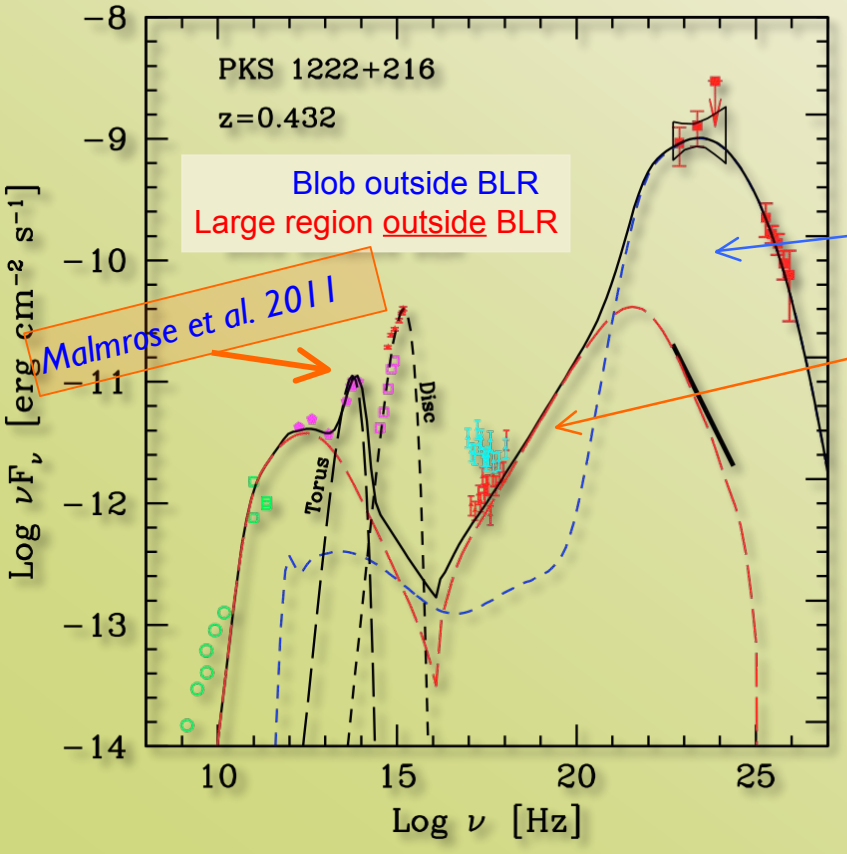
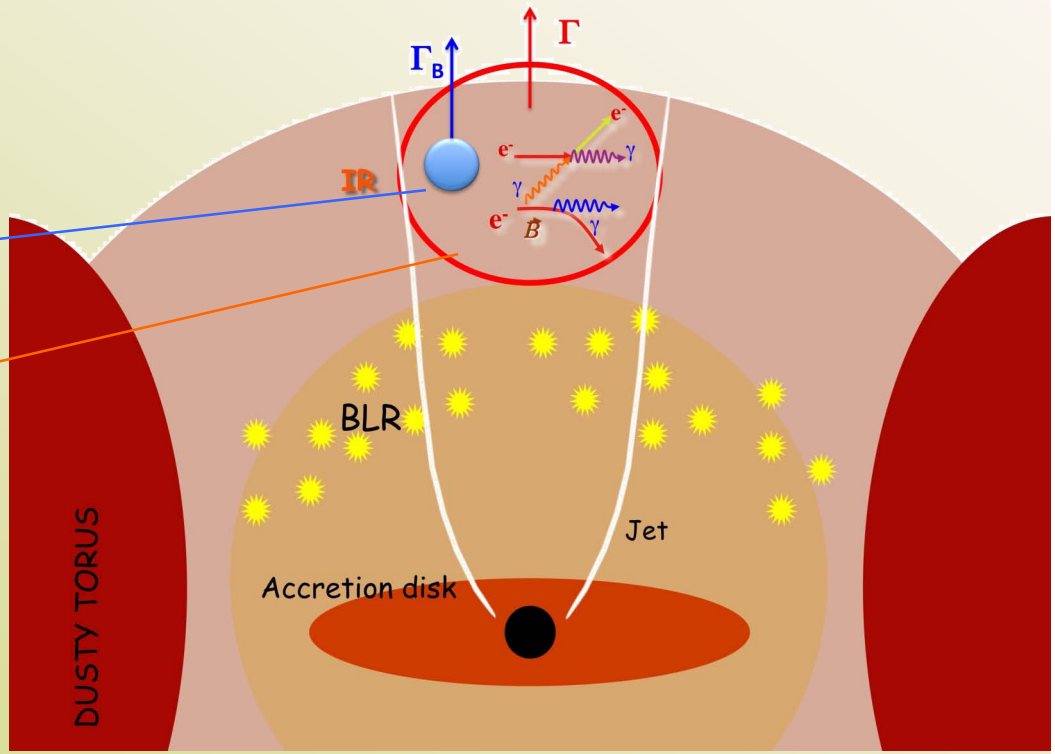
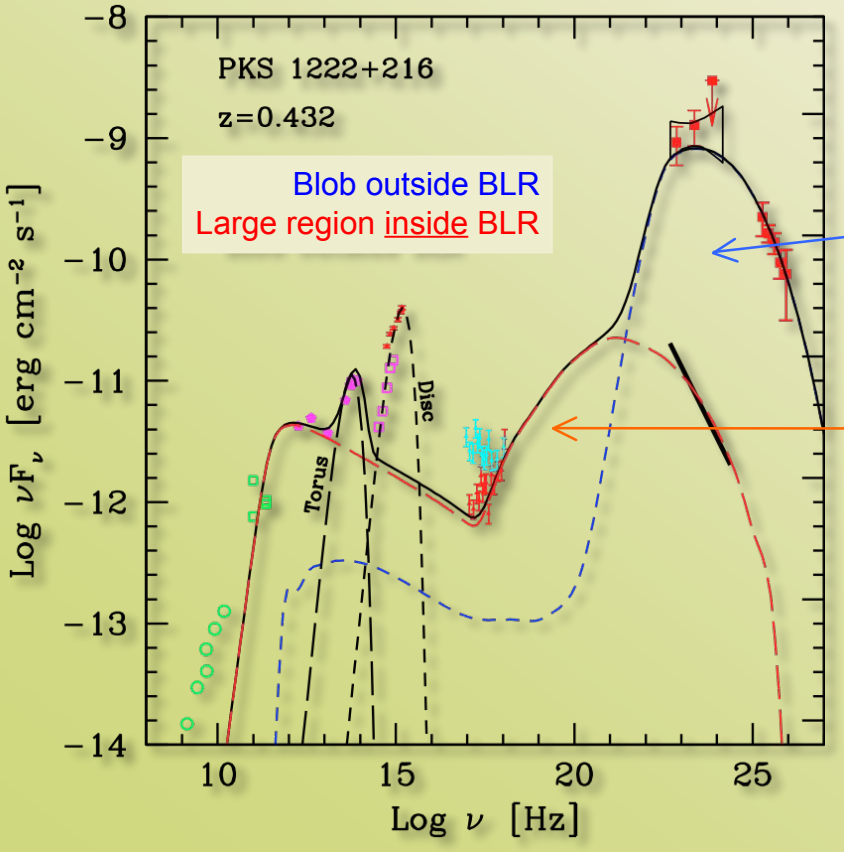
Two zones EC

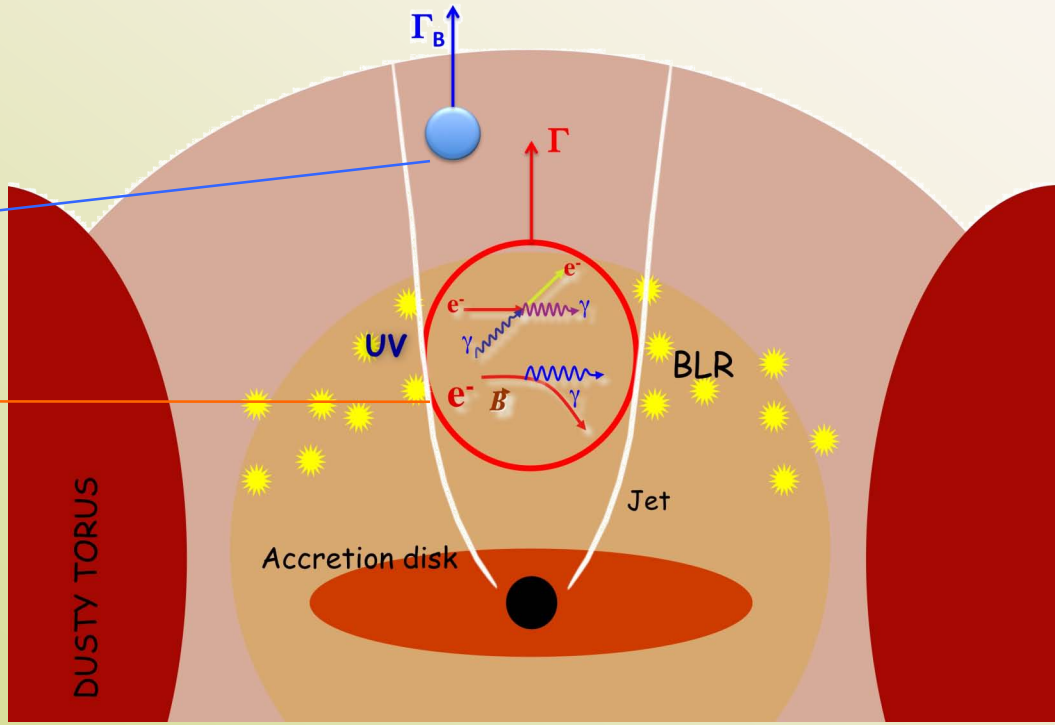




Tavecchio et al. submitted

Two zones EC





Tavecchio et al. submitted

Conclusions

More details on:
Aleksić et al. ApJL 730 (2011)
MAGIC Discovery of Very-High Energy Emission from the FSRQ PKS 1222+21

- ¤ MAGIC detection of FSRQ PKS1222+21 during high gamma-ray activity observed by *Fermi*/LAT
- ü No VHE cutoff detectable
- ü Fast variability ~10 min
- Ø Severe constraints to FSRQ emission models
- Ø Challenge to "canonical" and "far-dissipation" scenarios
- ☺ Promise of substantial progress from simultaneous MAGIC-Fermi observations

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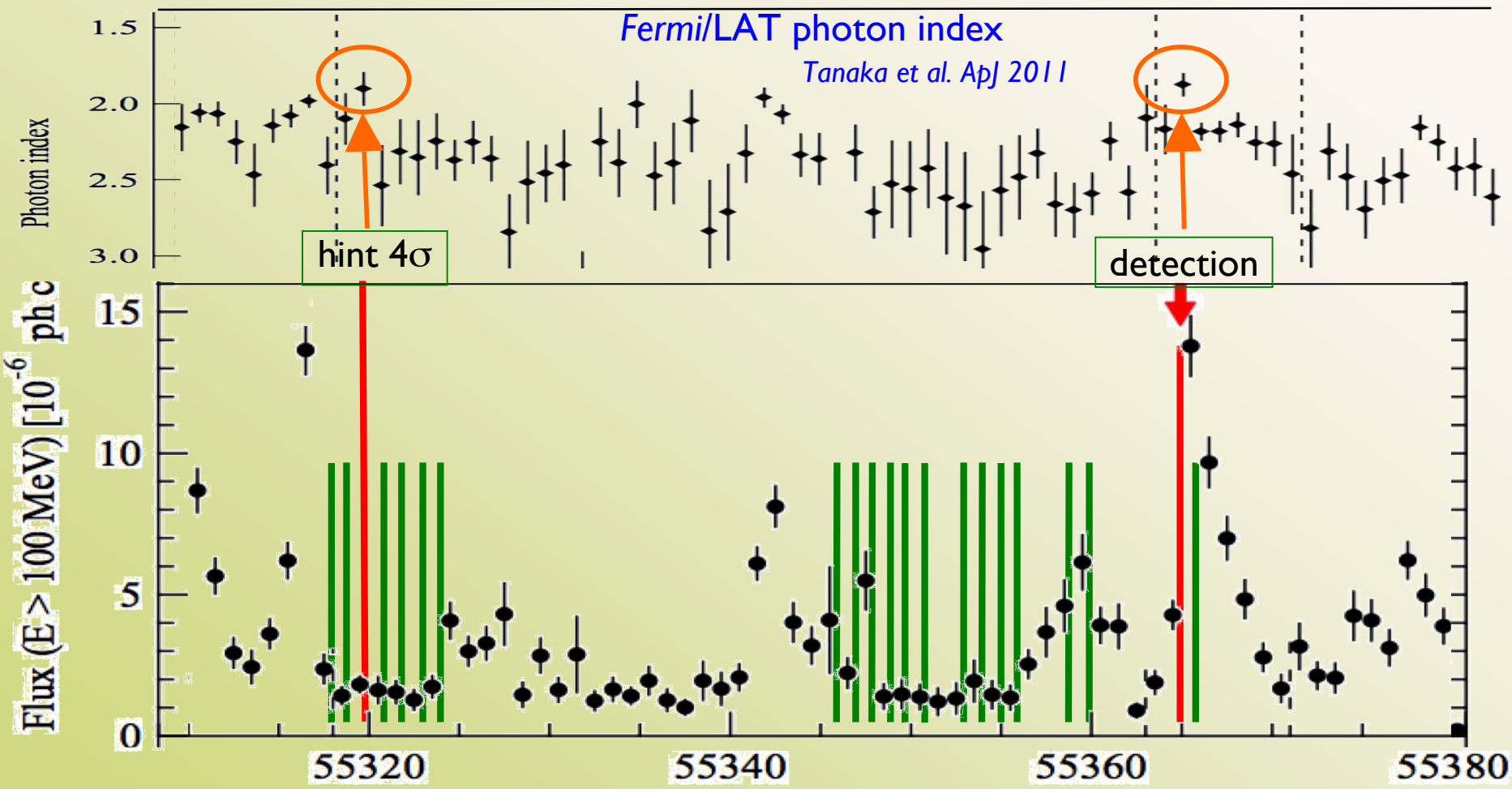

high VHE flux ➔ flat GeV photon index

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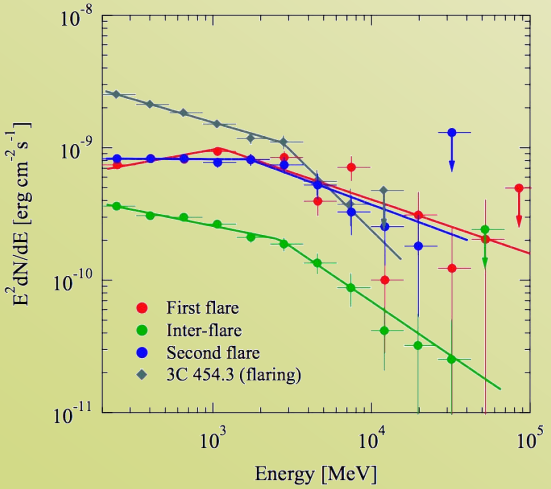
High energy SED

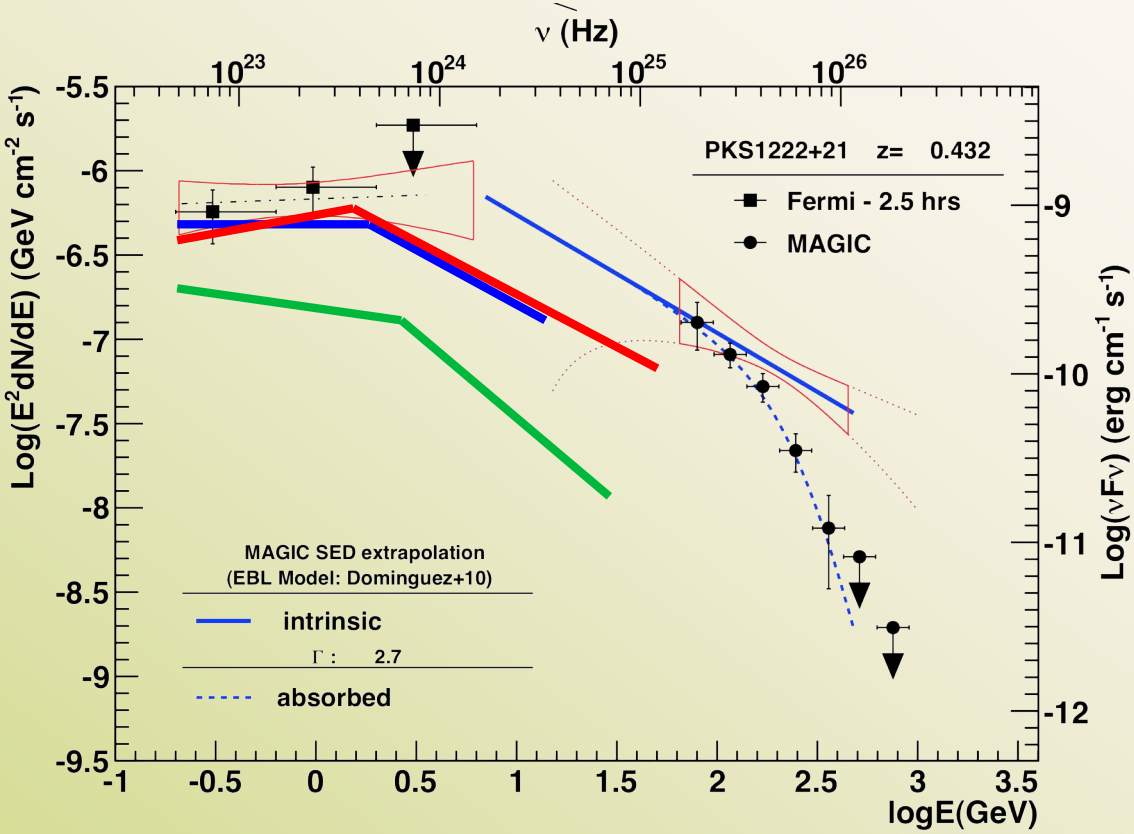
MAGIC Coll. ApJL 730 (2011)

- Simultaneous *Fermi*/LAT 2.5 hrs encompassing MAGIC obs.

Tanaka et al. ApJ 2011



State	Γ_{LE}	Γ_{HE}	E_{br} [GeV]	ΔL
Intermediate+Active	2.18±0.02	2.64±0.06	$2.4^{+0.2}_{-0.2}$	-27.2
Intermediate	2.30±0.05	2.69±0.40	$2.5^{+1.1}_{-0.4}$	-6.6
First flare	1.80±0.06	2.40±0.07	$1.1^{+0.3}_{-0.2}$	-17.9
Inter-flare	2.24±0.03	2.81±0.14	$2.7^{+0.6}_{-0.6}$	-8.4
Second flare	2.00±0.05	2.44±0.10	$1.7^{+1.1}_{-0.4}$	-6.3



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