

Risultati e problemi aperti nelle osservazioni VHE di sorgenti extragalattiche

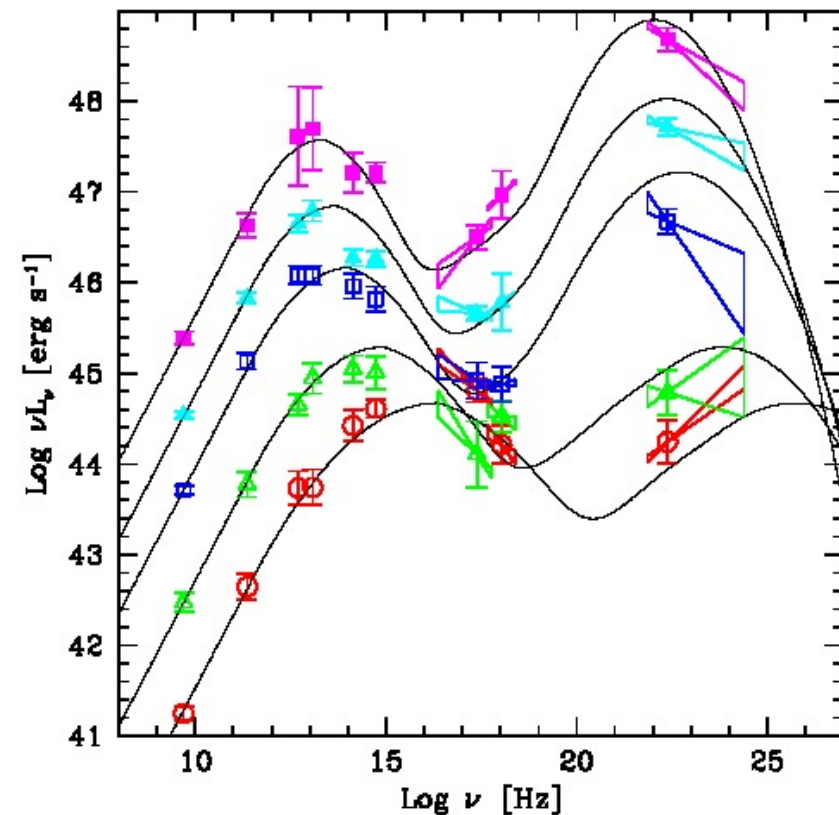
Laura Maraschi
INAF - OAB

Talk Overview

- BLAZAR SEDs: model predictions and observations
- HBL: Mkn 421 -- PKS 2155-304
- IBL: BL Lac (itself) -- W Comae
- FSRQs: 3C 279 -- 4C +21.35 (PKS 1222 +21)
- Radiogalaxies: M 87

SED: from BL Lacs to FSRQs

Very little known about
“the high energy component”
at the time, except it was
Energetically important



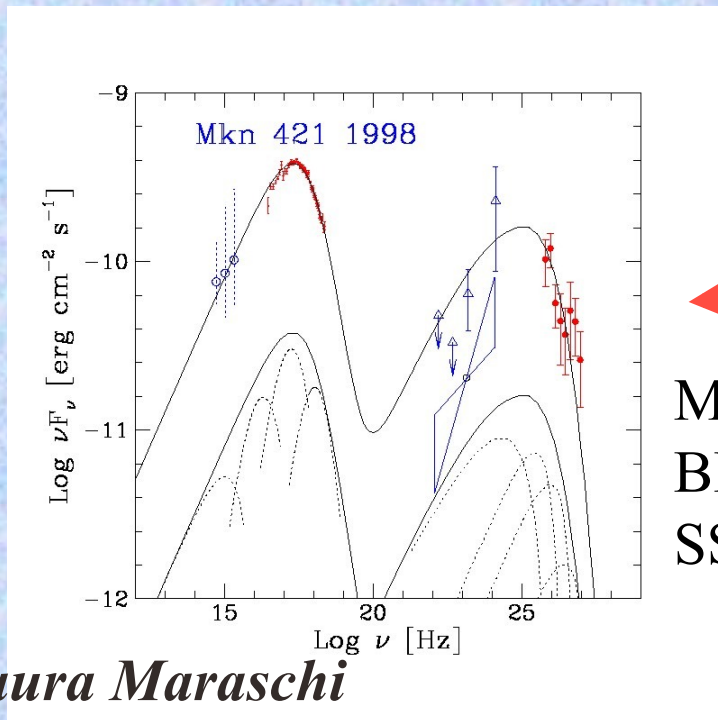
Fossati et al., *ApJ* 1998

Laura Maraschi

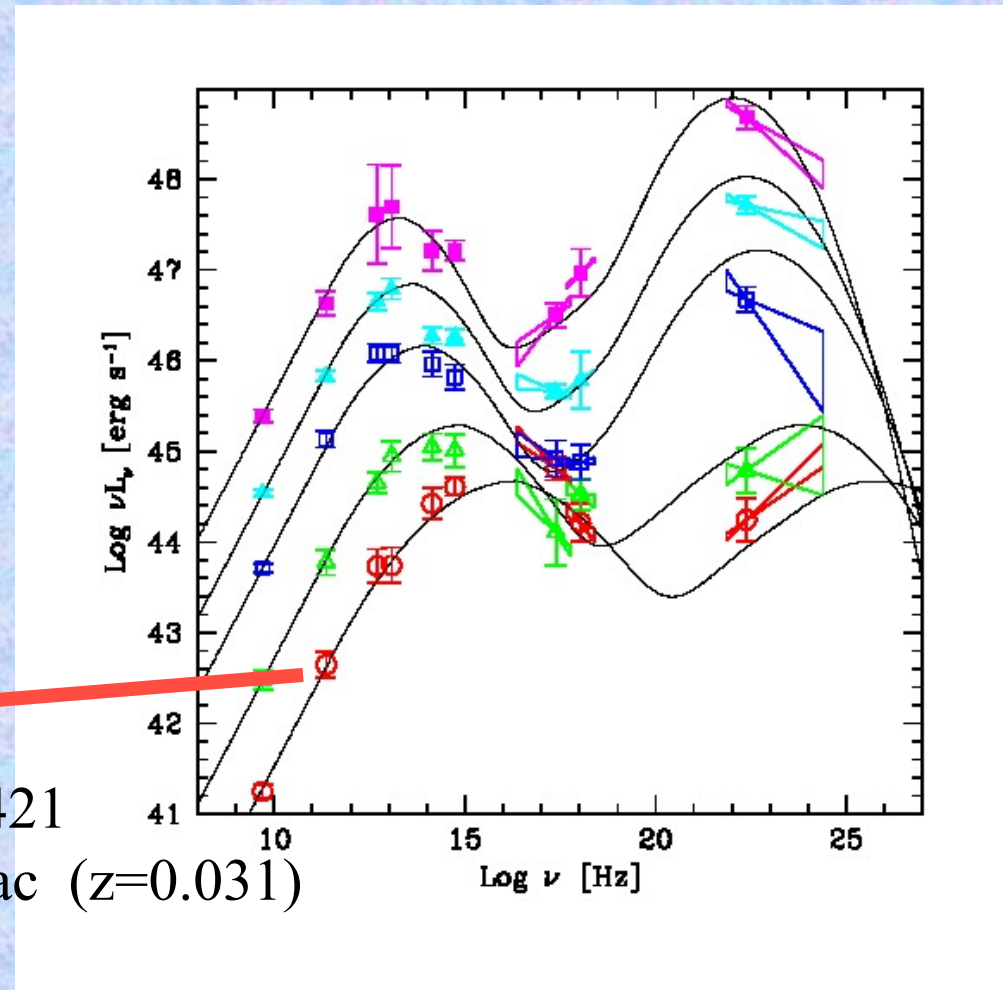
Mera-TeV

Merate. 06/10/2011

SED: from BL Lacs to FSRQs



Mrk 421
BL Lac (z=0.031)
SSC



Mera-TeV

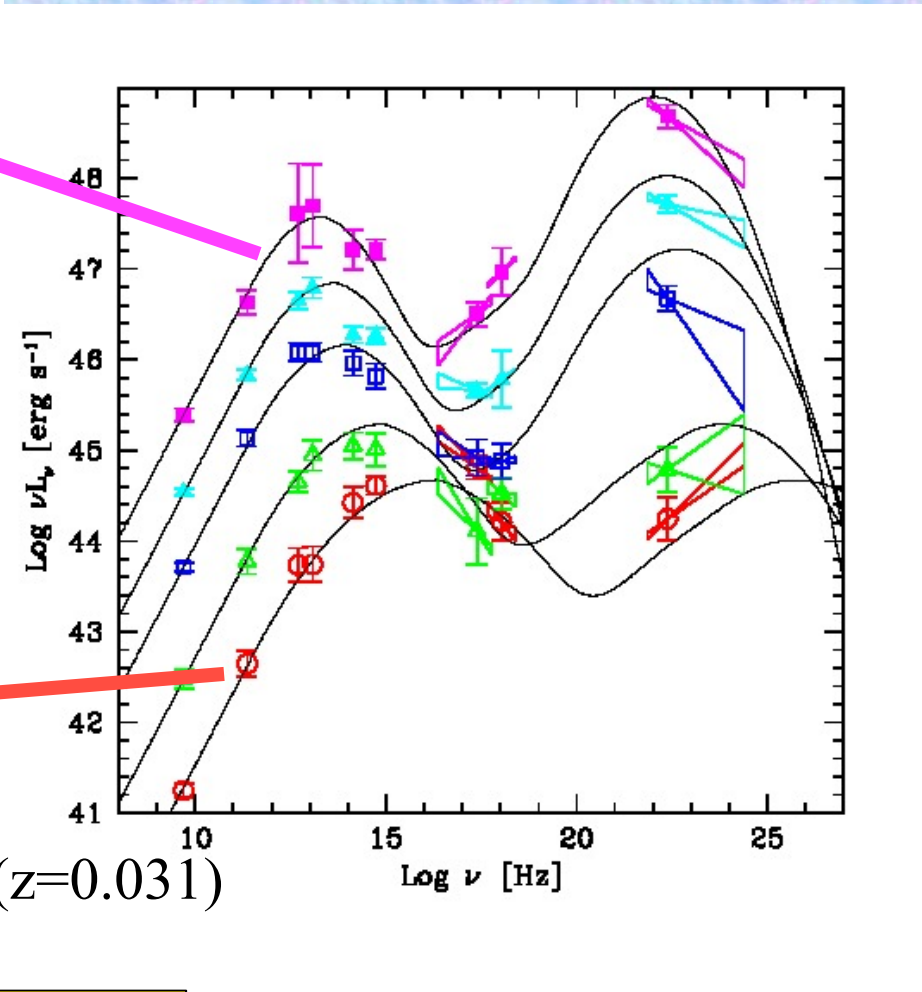
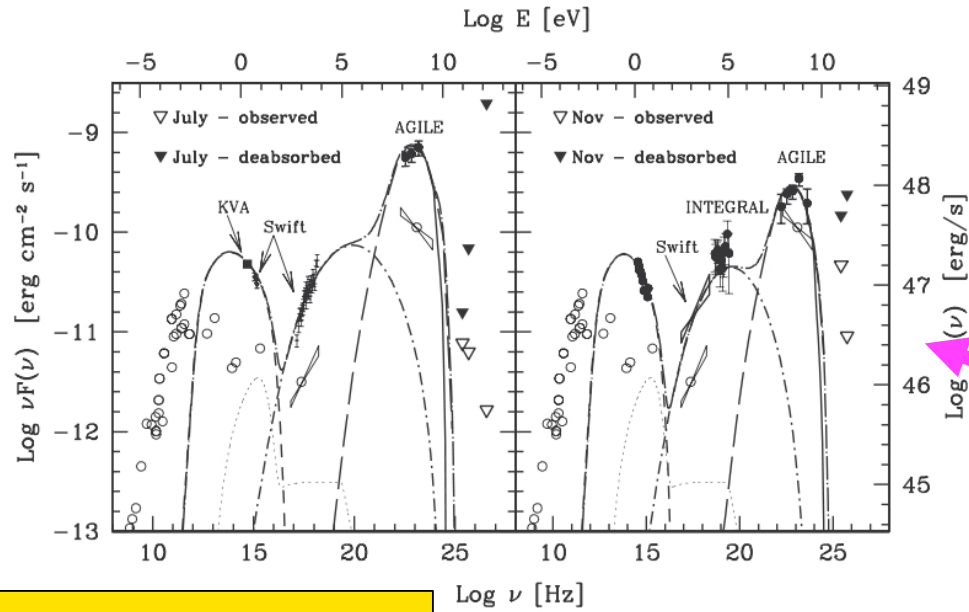
Merate. 06/10/2011

Laura Maraschi

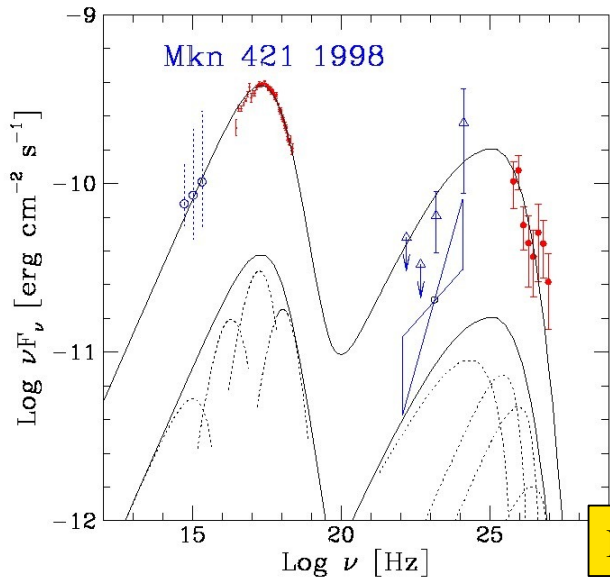
3C 454.3 FSRQ (z=0.859) EC

SED: from

BL Lacs to FSRQs



Anderhub et al., A&A 2009



Mrk 421
BL Lac (z=0.031)
SSC

Maraschi et al., ApJ, 1999

Laura Maraschi

Mera-TeV

Merate. 06/10/2011

Mrk 421

High-peaked BL Lac (HBL) at $z=0.031$

first Extragalactic TeV source

(Punch et al., *Nature* 1992)

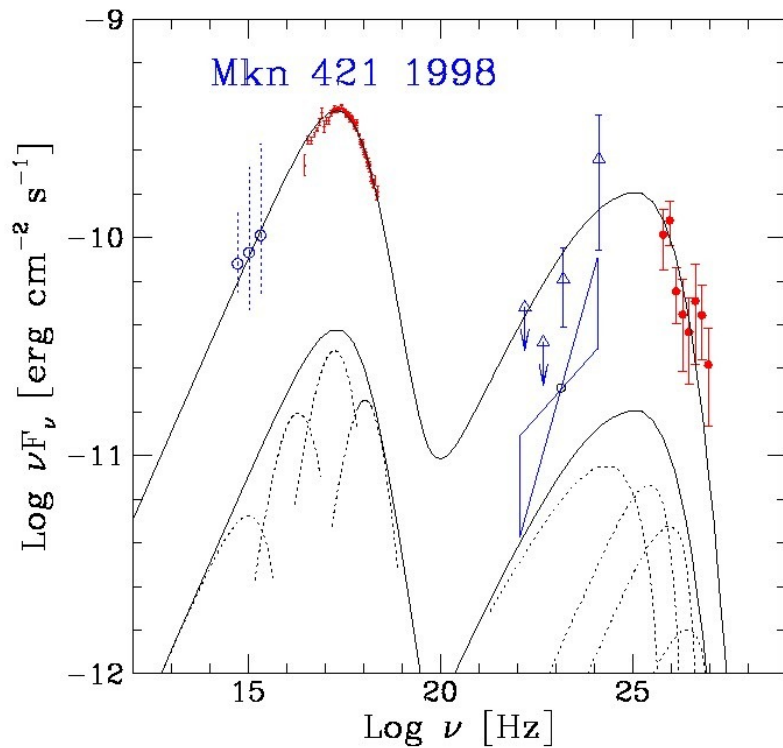
VHE rapid (15 min.) variability

(Gaidos et al., *Nature* 1996)

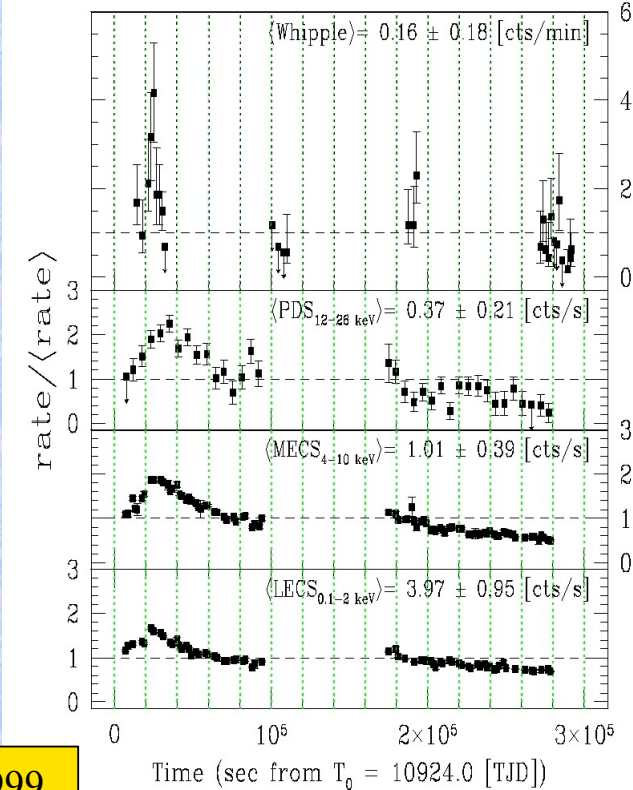
Mrk 421:

first simultaneous observations at X-ray
and TeV energies

High energy photons from SSC



● One zone emission region!



Maraschi et al, *ApJ* 1999

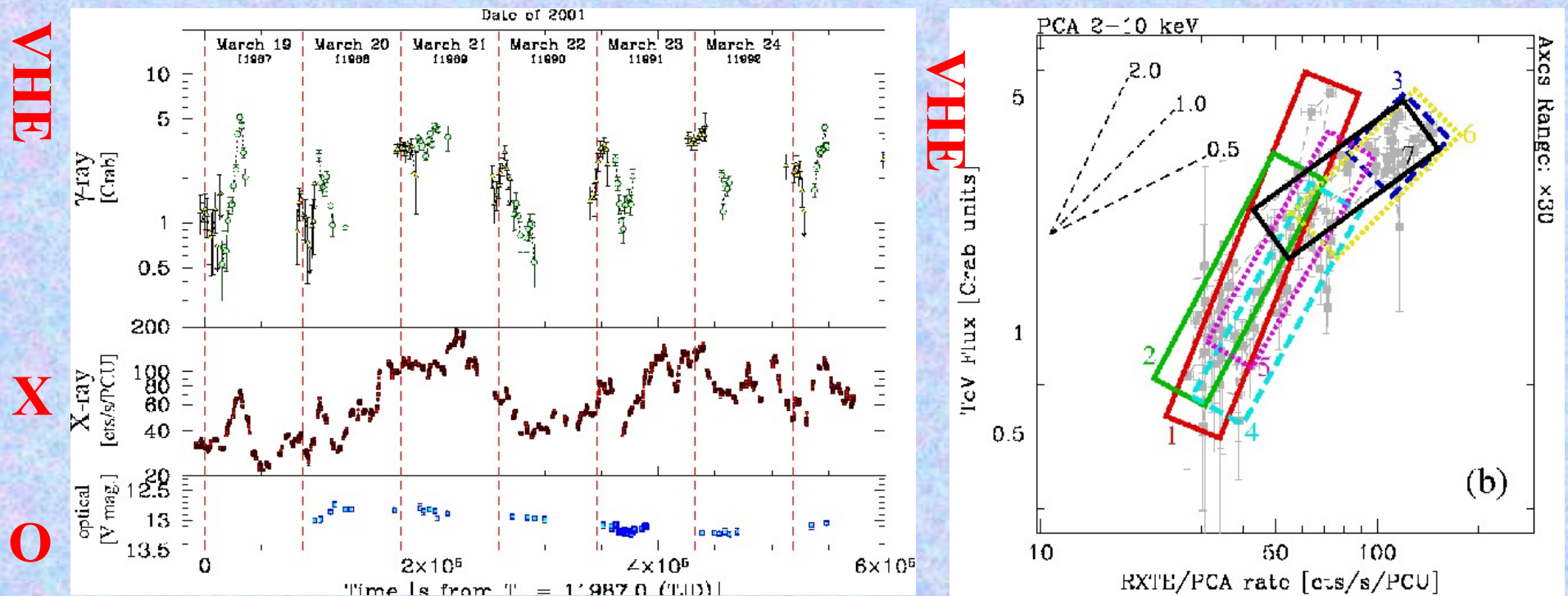
Mera-TeV

Merate. 06/10/2011

Laura Maraschi

Mrk 421: X-ray/VHE correlations

Extensive MWL observations to study the shape of the correlation (need continuous coverage)



Fossati et al, *ApJ* 2008

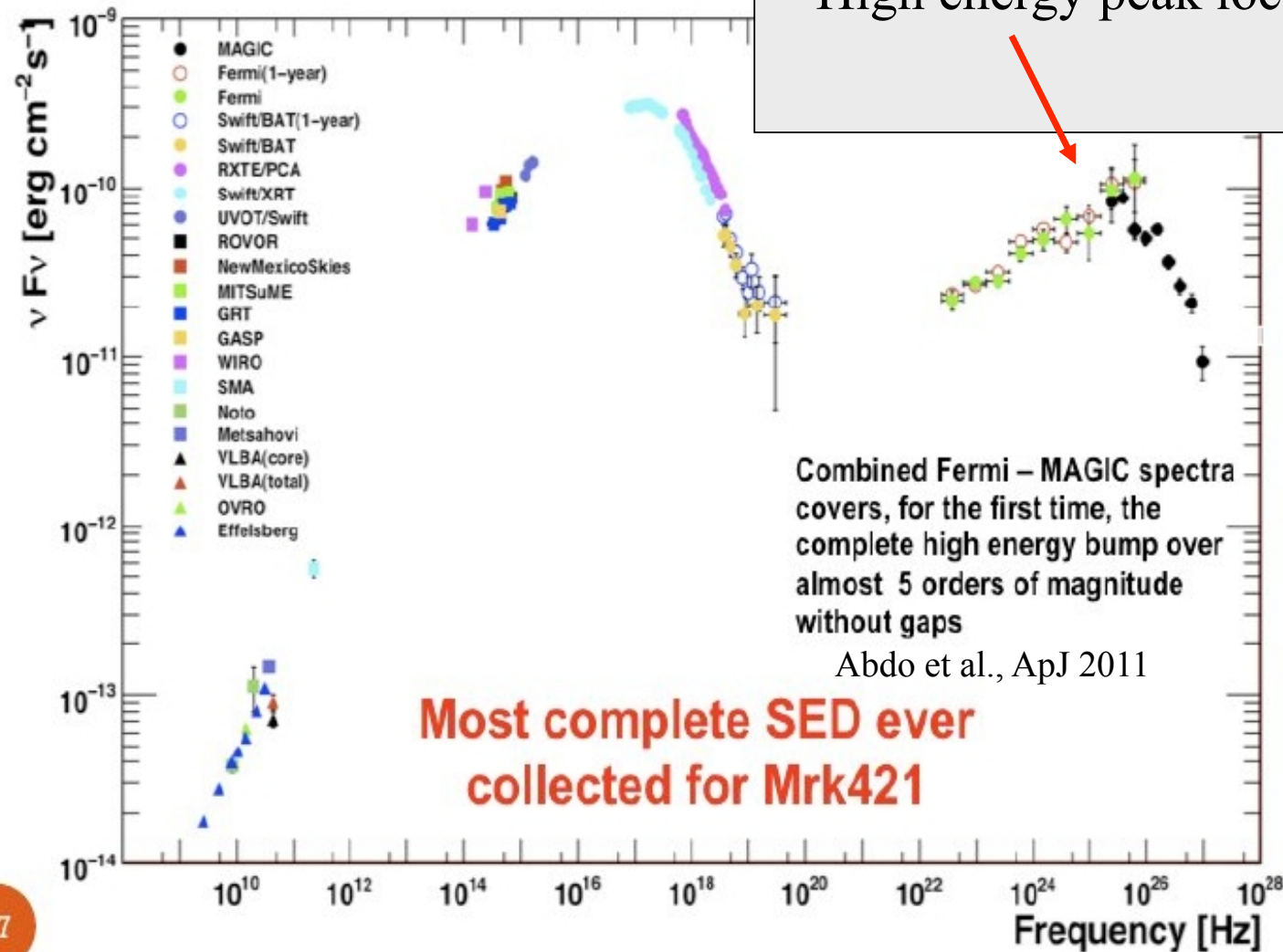
Mera-TeV

Laura Maraschi

Merate. 06/10/2011

PROGRESS : GEV + TEV after FERMI launch

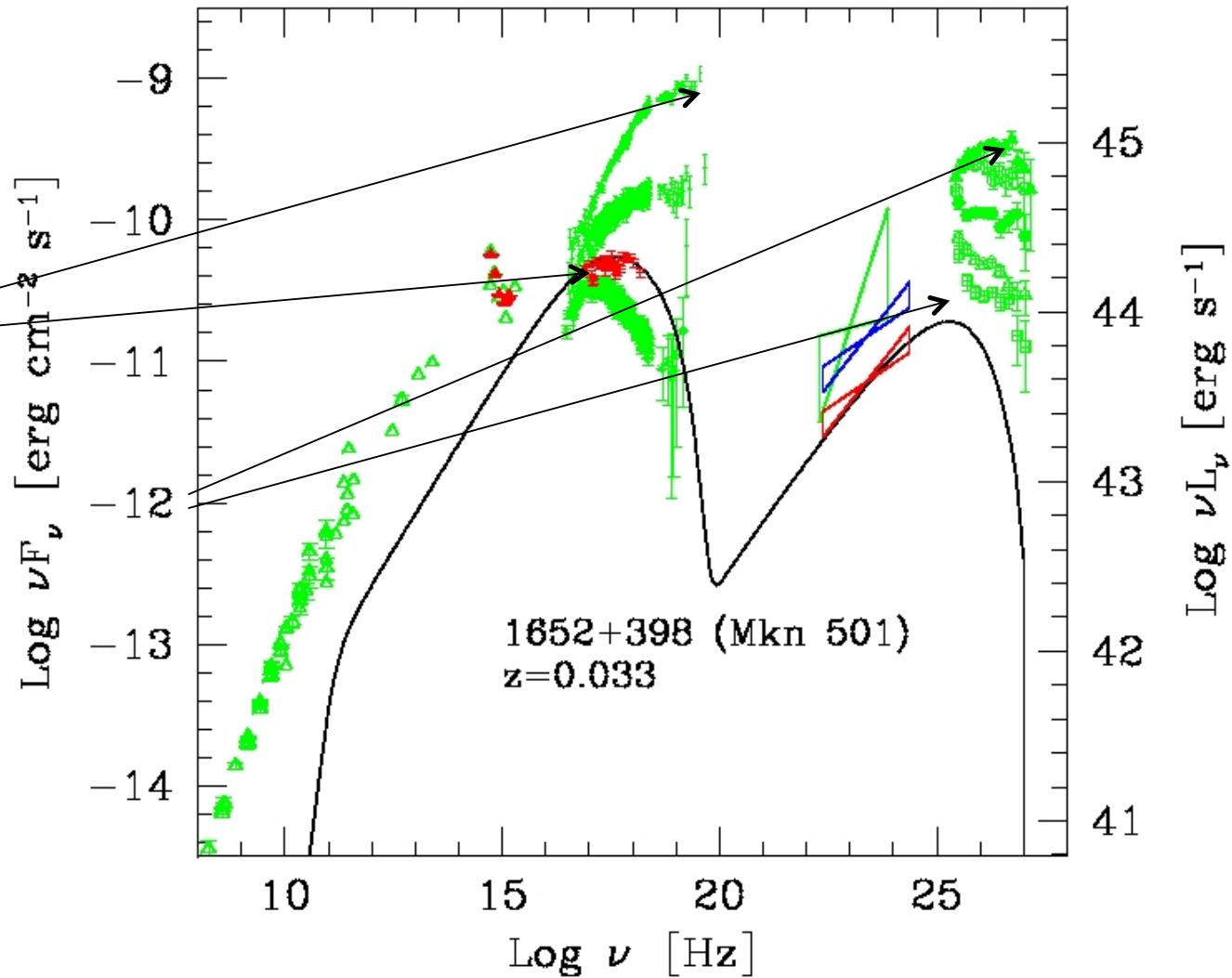
MKN 421 MWL VIEW



Mkn 501: extremely variable HBL

Peaks move
to higher
frequency
for higher
intensity

From Tavecchio
et al. 2010



Mrk 421: hour-scale snapshot MWL SED

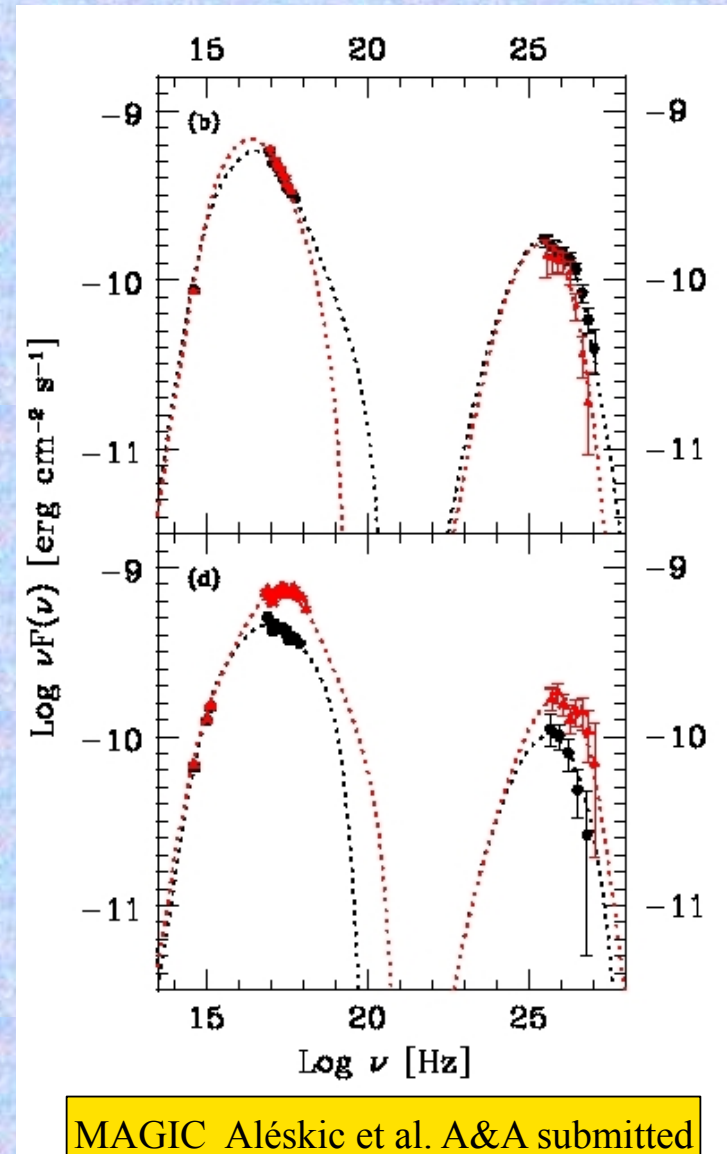
X-ray and TeV spectral *shapes* correlate

Large separation between peak frequencies
measured simultaneously
→ large Doppler factor

$$\delta > 40$$

MAGIC Aléskic et al., A&A submitted
VERITAS, Acciari et al. 2011 *ApJ*

Low E_{thres} → closer to the peak

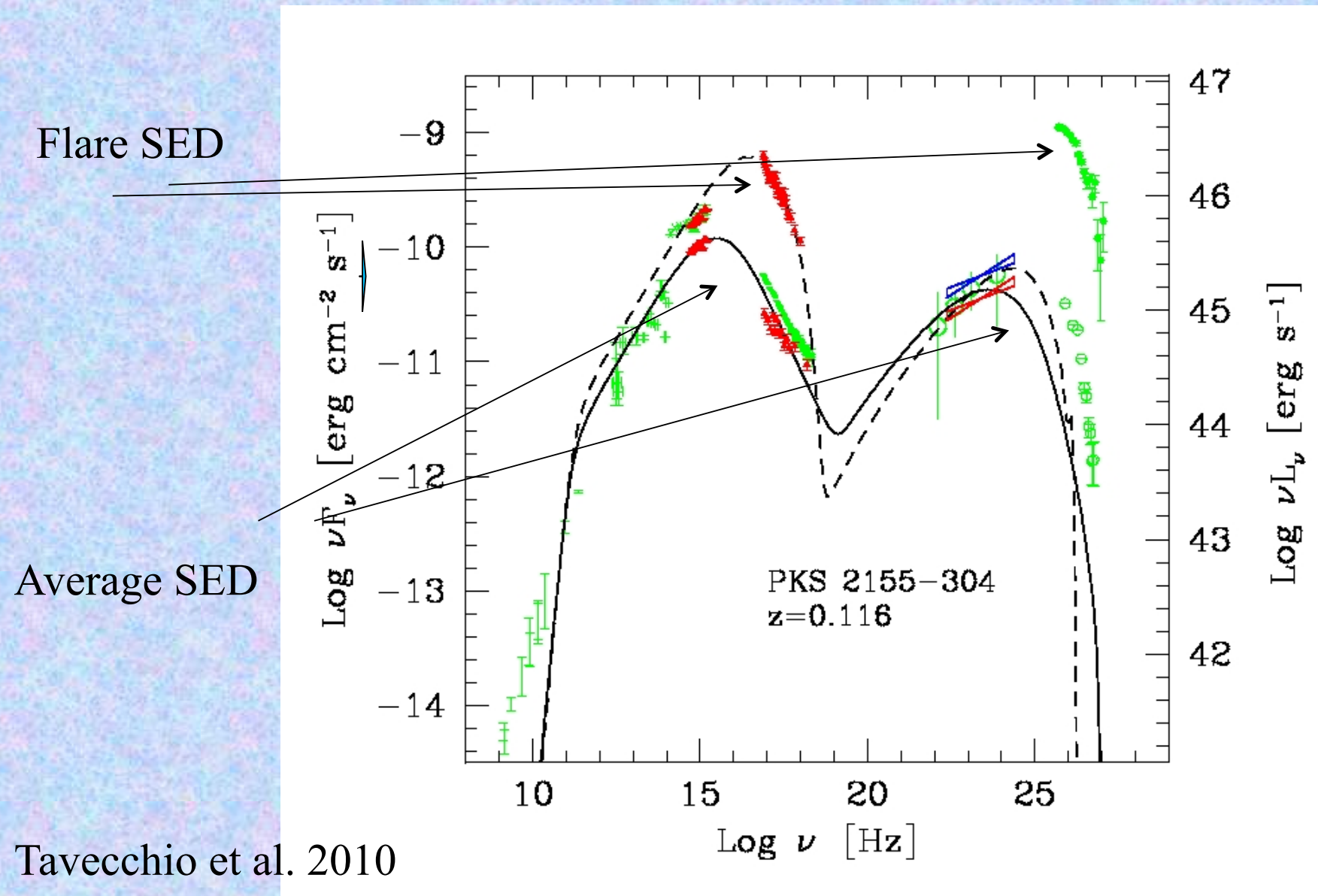


Laura Maraschi

Mera-TeV

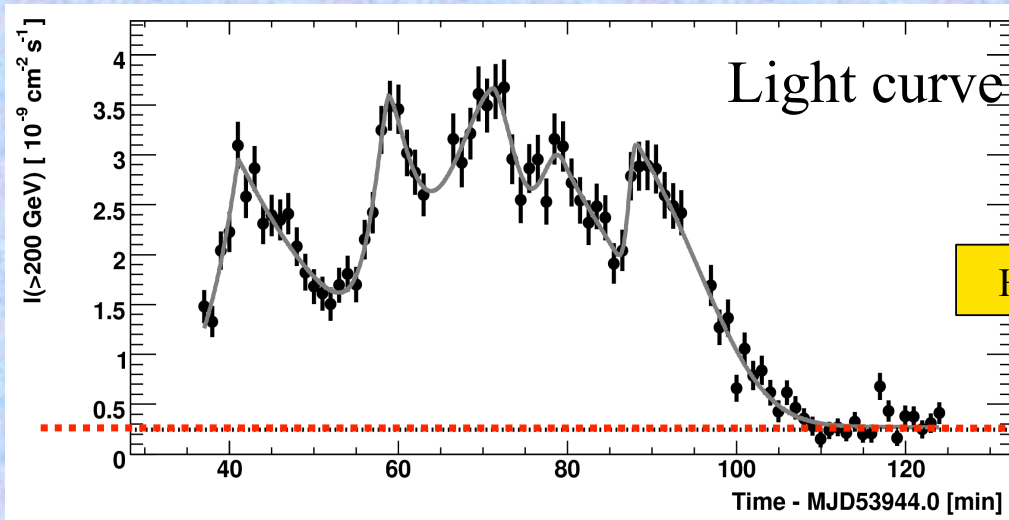
Merate. 06/10/2011

PKS 2155-304 a VERY LUMINOUS and HIGHLY VARIABLE IBL



Tavecchio et al. 2010

PKS 2155: extraordinary flare and fast variability



HBL at $z=0.116$

HESS Aharonian et al., *ApJ*. 2007

1 C.U

Time scales

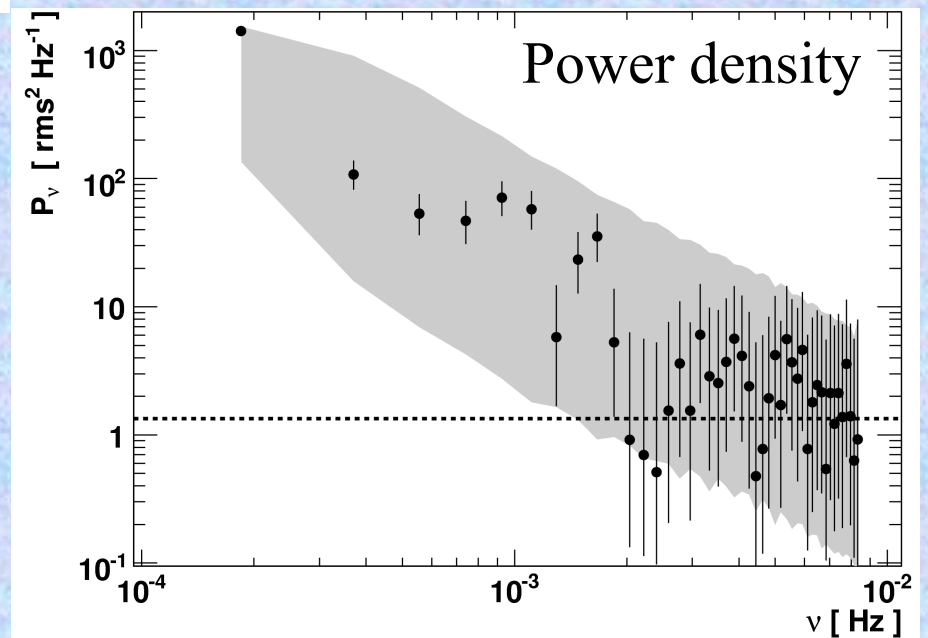
$$T_{\text{rise}} \sim 200 \text{ s} \quad T_{\text{decay}} \sim 600 \text{ s}$$

$$T_{\text{cross}} (\text{BH}) \sim 10\,000 \text{ s} (10^9 \text{ M})$$

Bulk Lorentz factor ~ 50

“Needles” within jet ?

Ghisellini & Tavecchio, *MNRAS* 2008
Neronov et al., *MNRAS* 2008



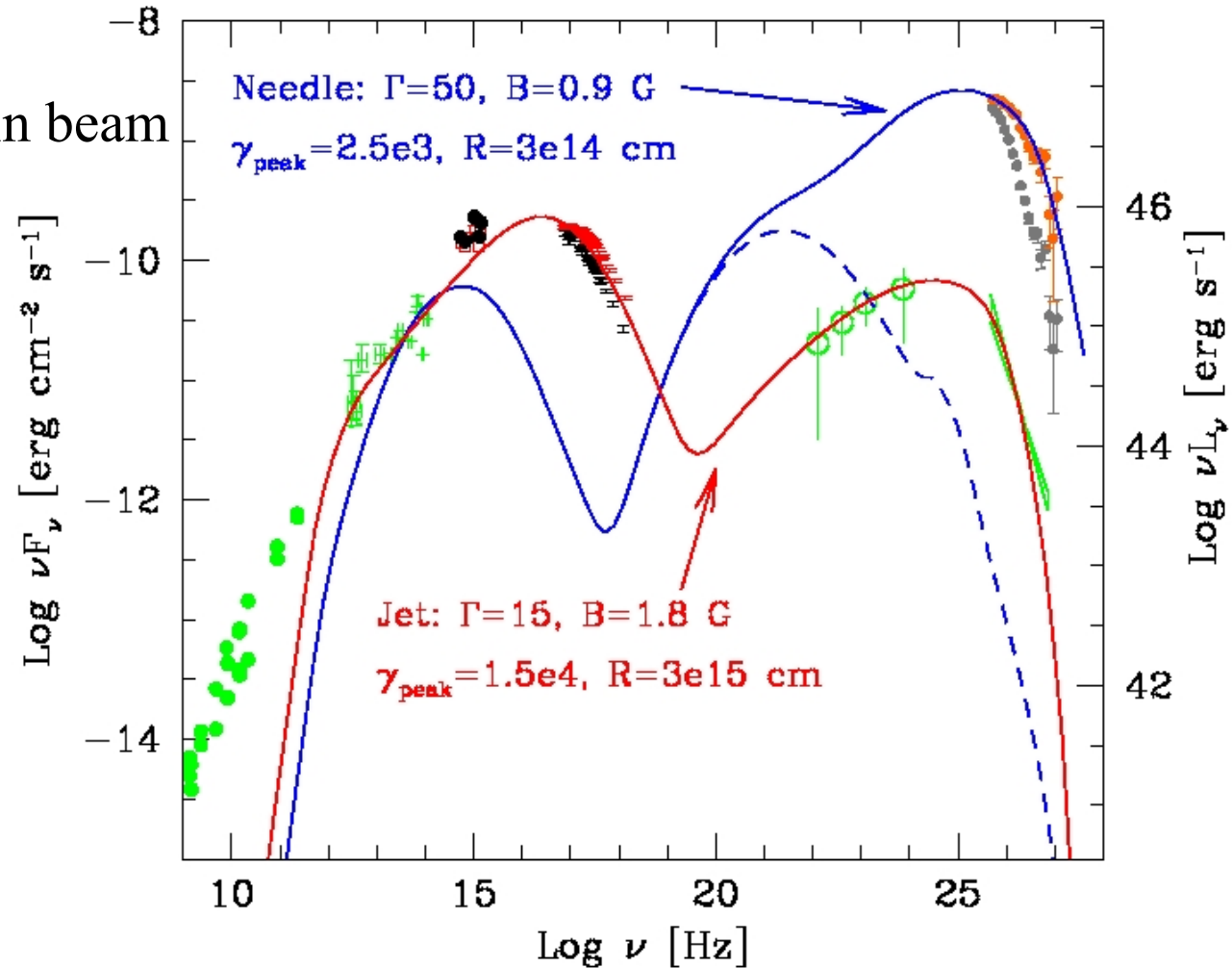
Laura Maraschi

Mera-TeV

Merate. 06/10/2011

Fast and large variability due to high Doppler factor in “thin” elongated region
Fast variation at TeV energies, slower in X-rays

Faster beam within beam



Begelman, Fabian & Rees *MNRAS* 2008

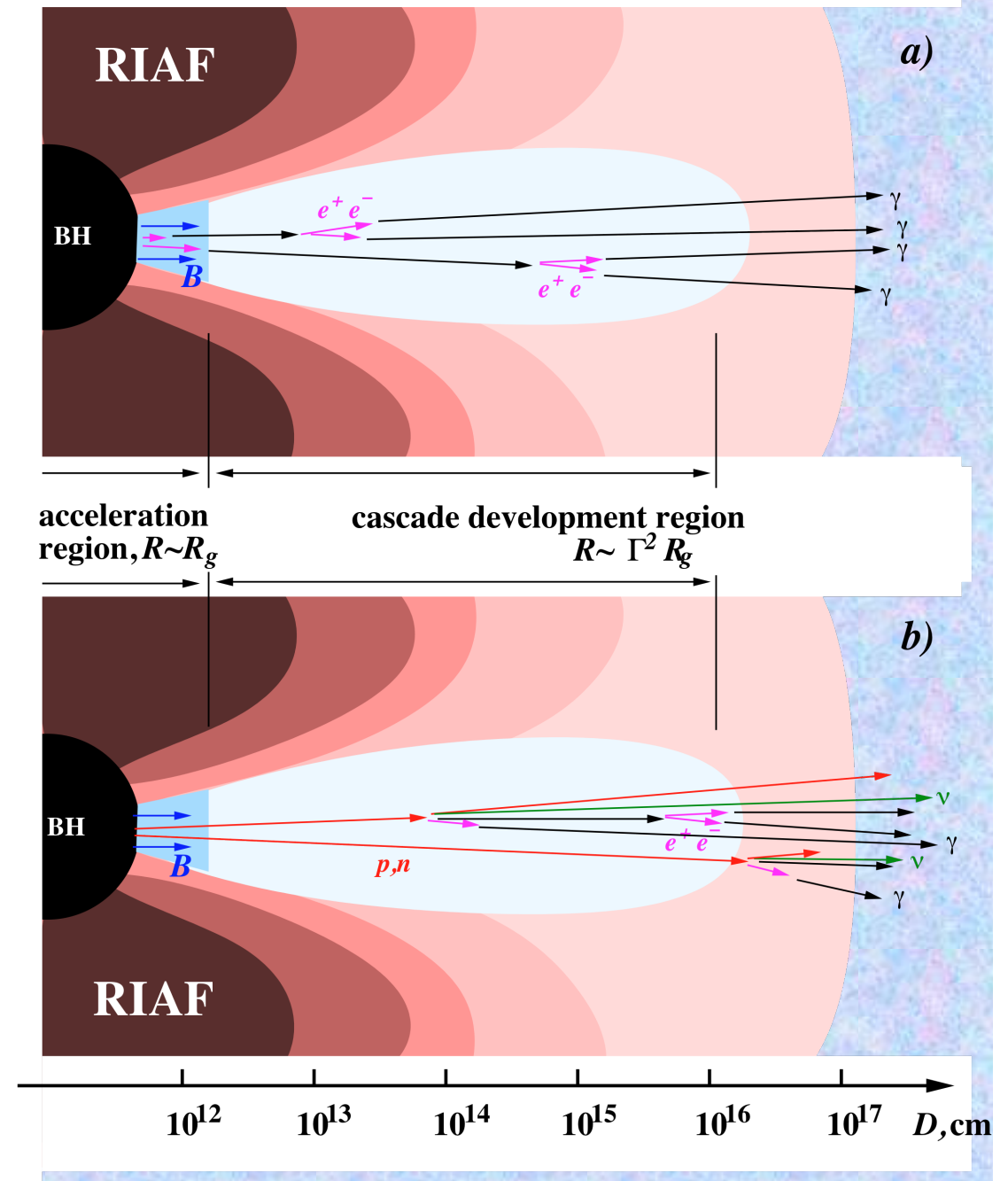
Ghisellini & Tavecchio, *MNRAS* 2008

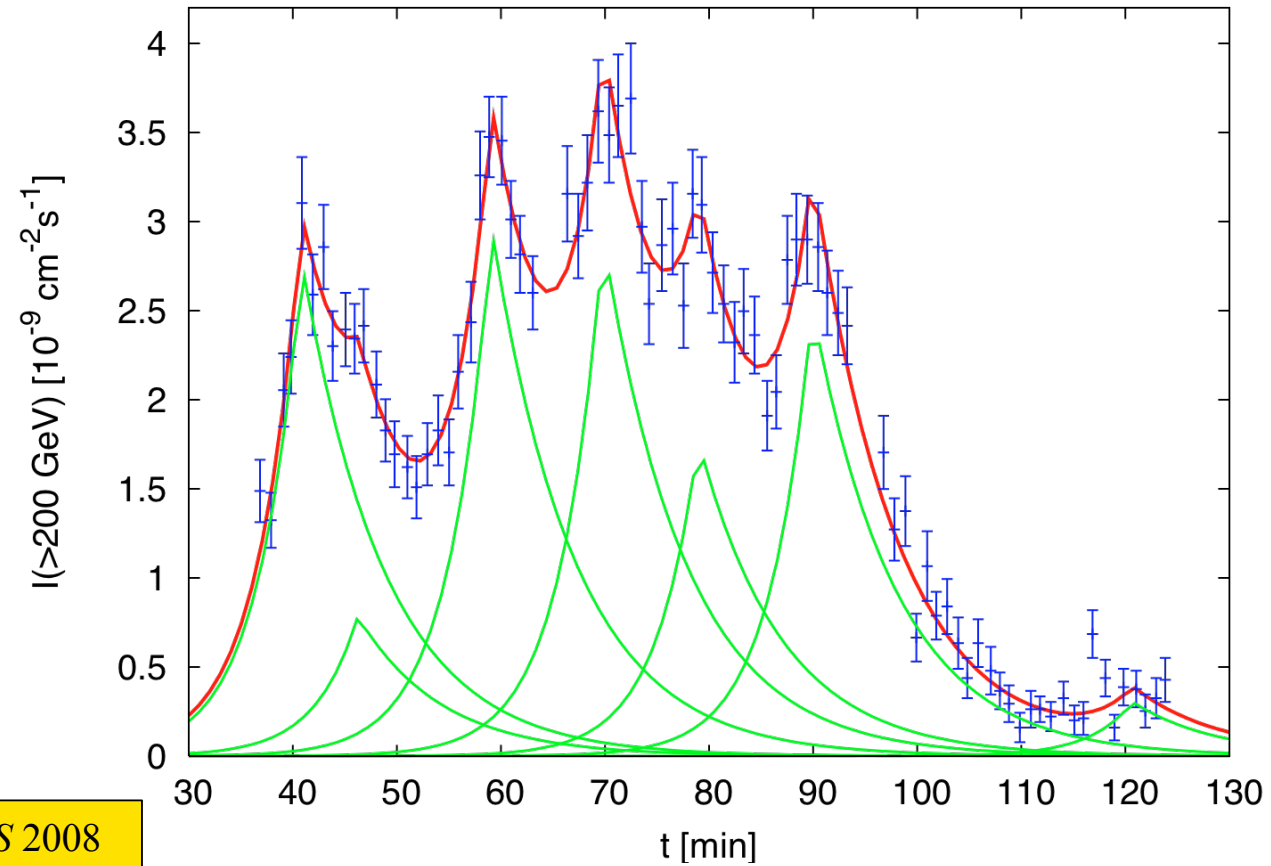
An alternative point of view

High energy particles
accelerated near BH

Pair cascades and gamma ray
production in (weak)
radiation background
from radiatively inefficient
accretion flow
(RIAF expected in largely
subEddington accretion)

Neronov et al., *MNRAS* 2008





Neronov et al., *MNRAS* 2008

Observed light curve reproduced with a number of “shots” with rise time and decay time fitted to the observed light curve
 Reminiscent of QPOs ? ➔ BH Mass $10^7 M_{\text{solar}}$?

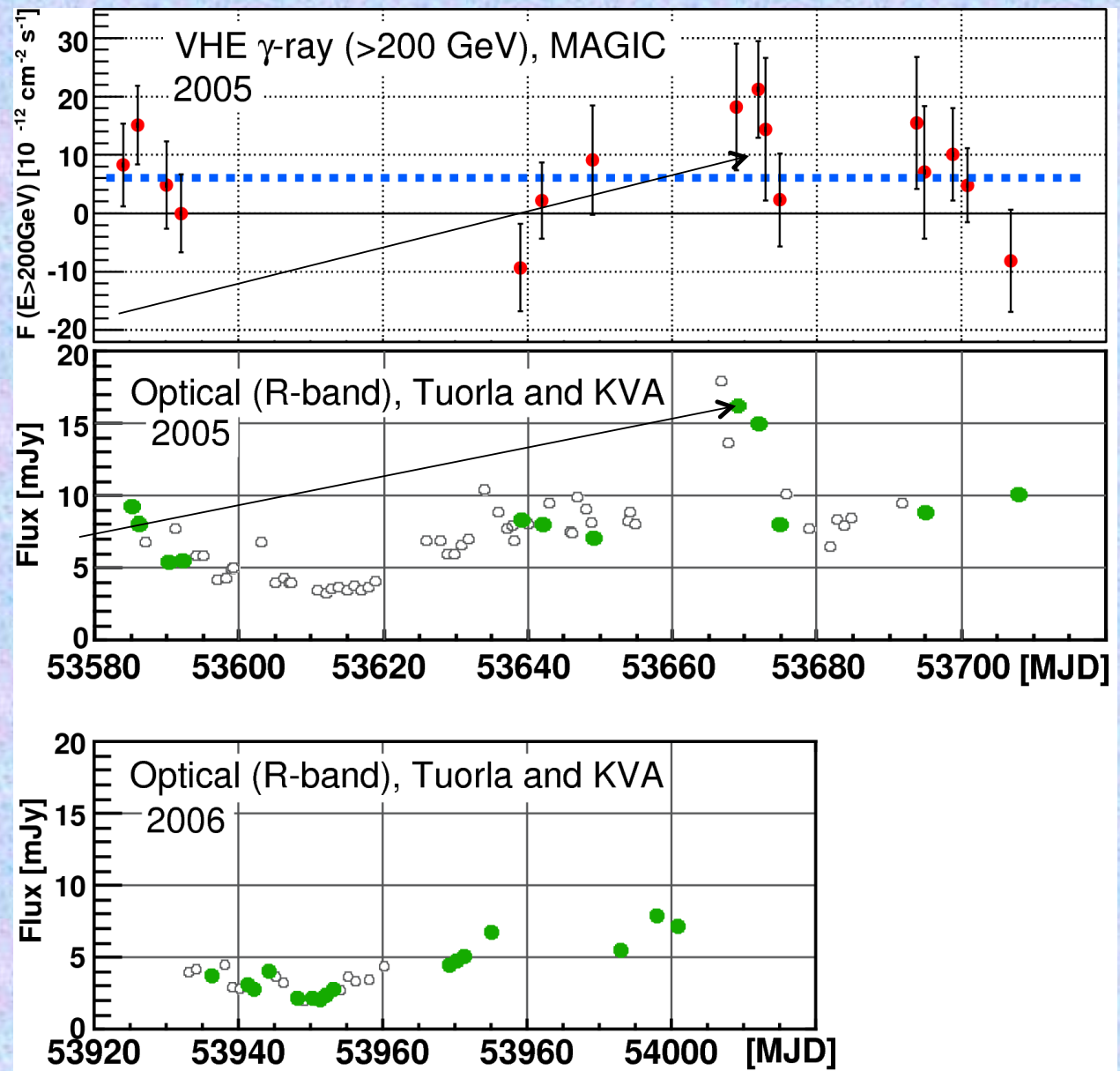
LBLs: steeper at TeV

BL Lac (itself)
LBL at $z = 0.0686$

Optical flare triggered
discovery observation!

Optical /TeV
correlation

Albert et al., *ApJ* 2007

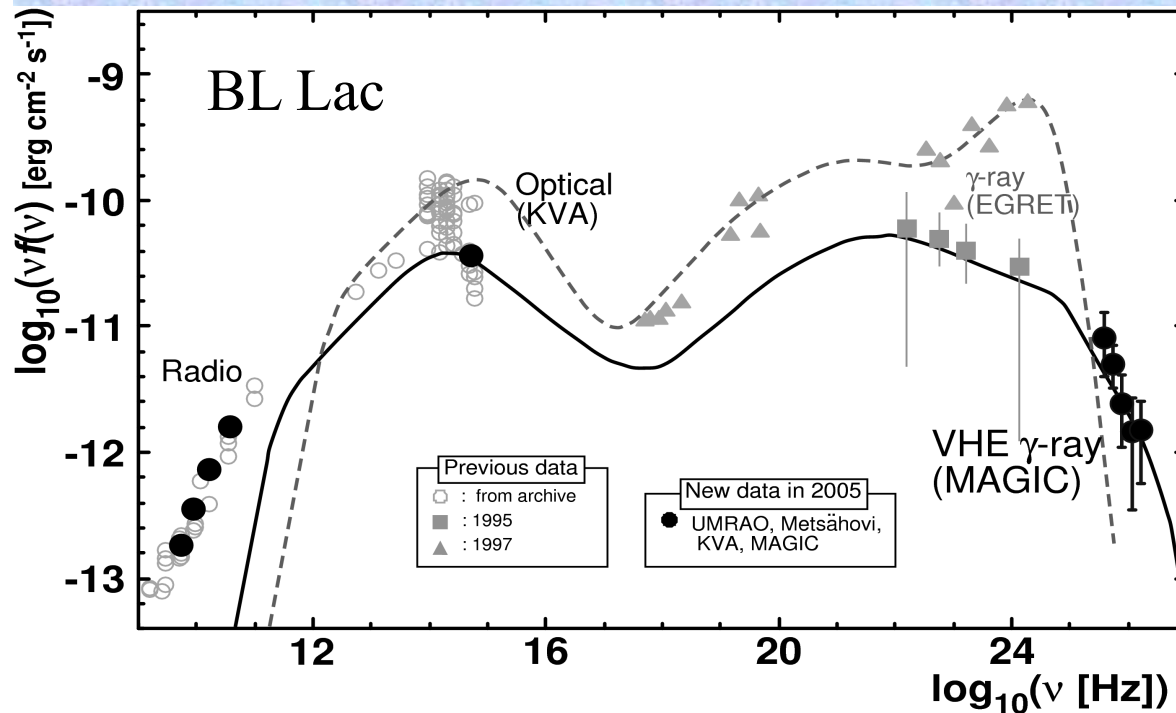


Laura Maraschi

meru-TeV

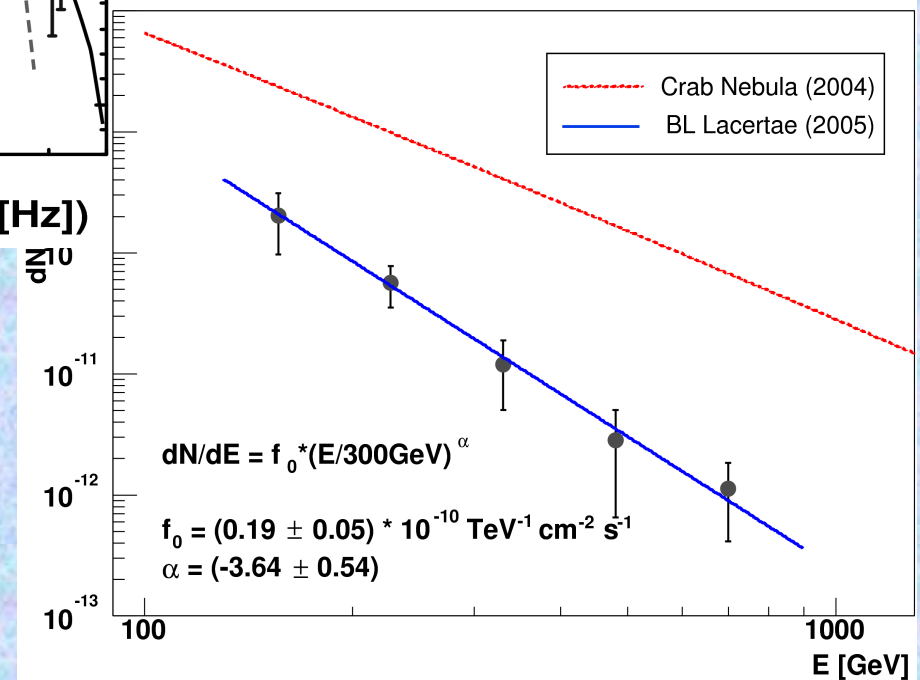
MAGIC: 00/10/2011

BL Lac: where is the high energy peak ?



LBL at $z = 0.0686$

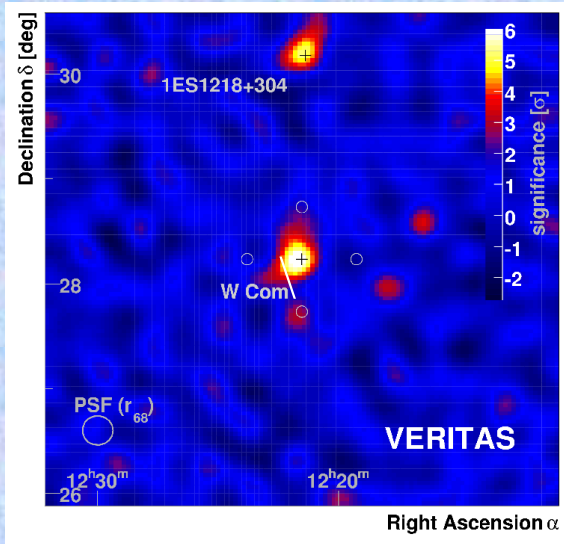
$$\alpha_{TeV} = 3.5 \pm 0.5$$



Importance of low $E_{\text{thres}} \rightarrow$
CTA will be less biased towards HBLs

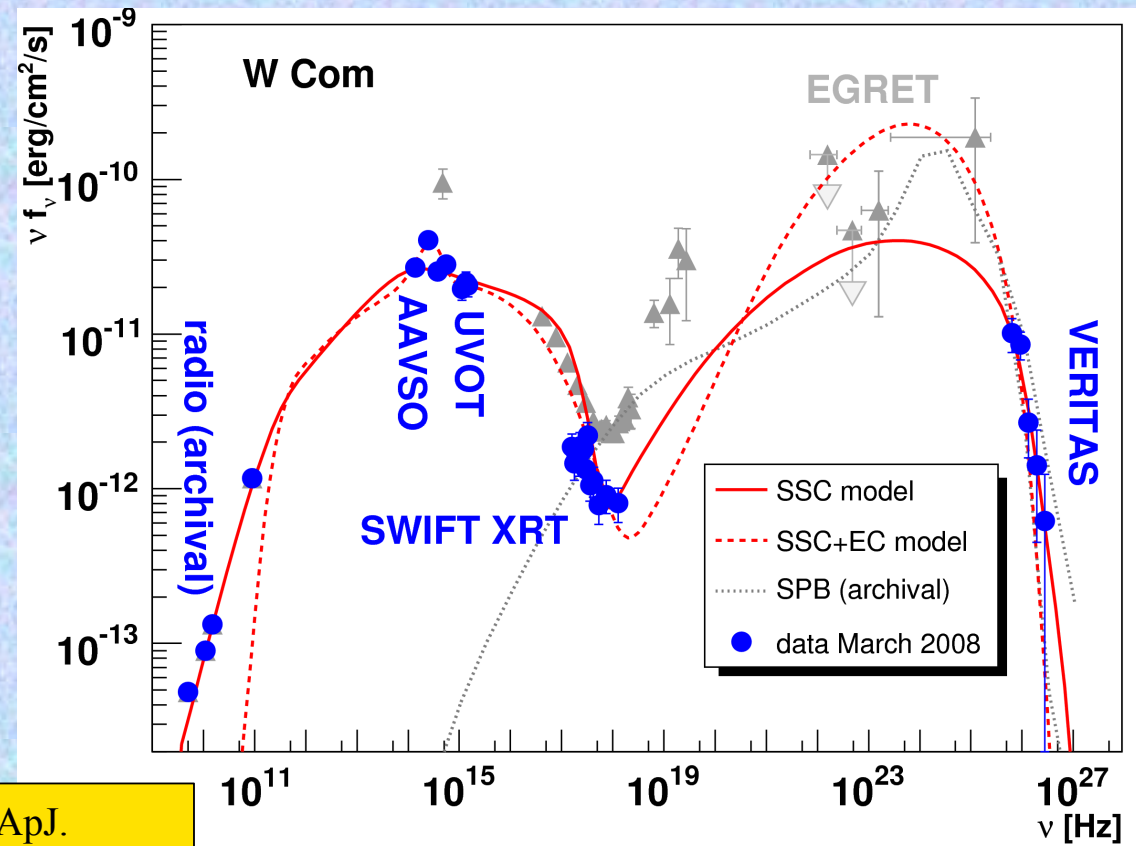
W Comae

Discovered at VHE energies at the time of an optical flare



IBL at $z=0.102$

$$\alpha_{TeV} = 3.8 \pm 0.4$$



VERITAS Acciari et al. 2008 ApJ.

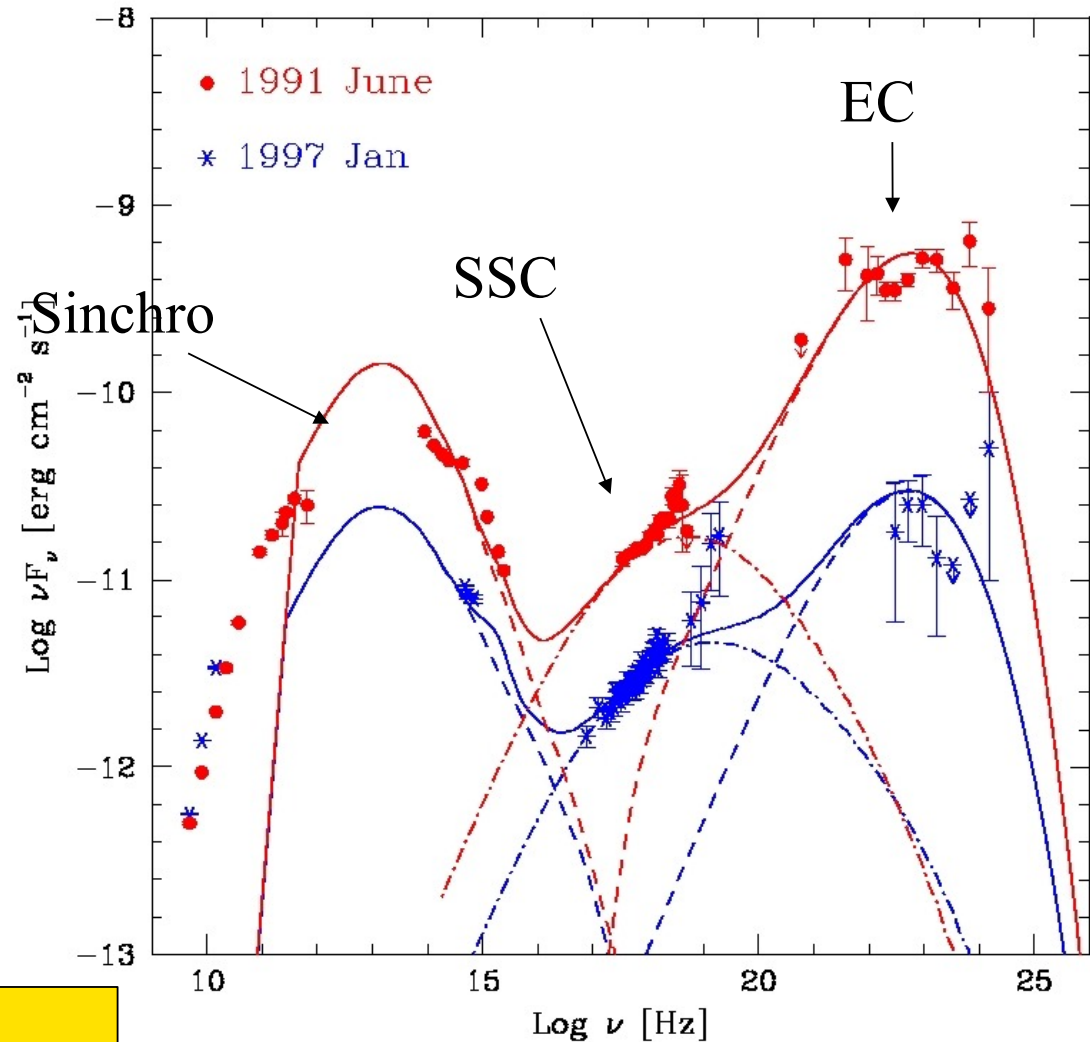
FSRQs : 3C 279 in the EGRET era

MWL correlation in
FSRQ

SSC and EC emission
vary together with
Synchro but with
increasing amplitude

Little variability in
radio due to self-
absorption

Ballo et al. 2002 *ApJ*.



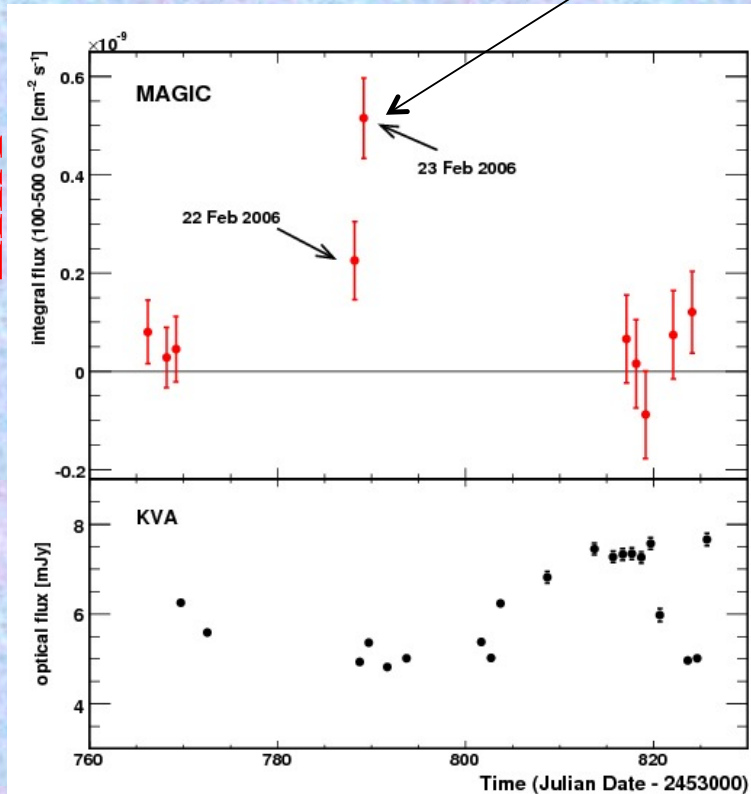
3C 279 discovery at VHE

Note the comparison of the dereddened points with the model

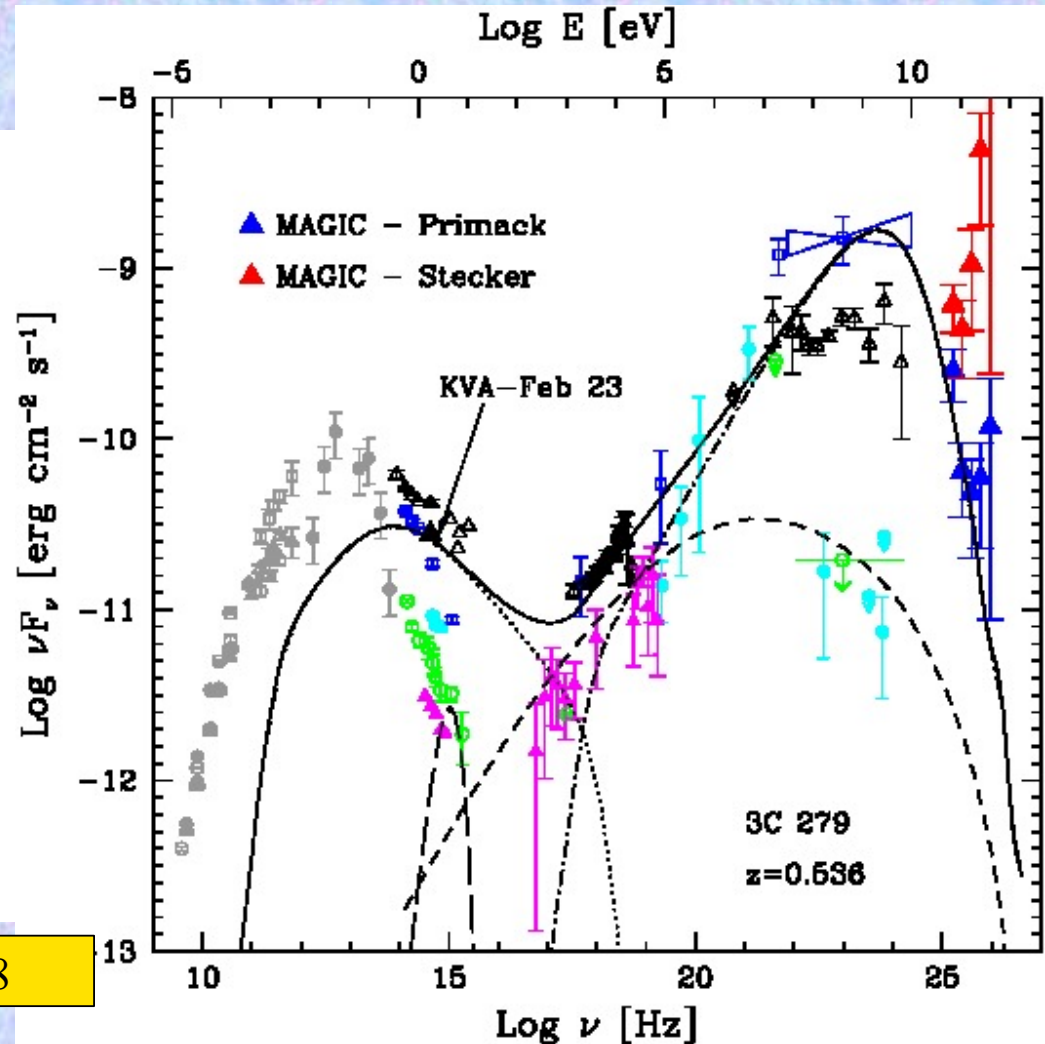
Again guided by optical flare

VHE

O

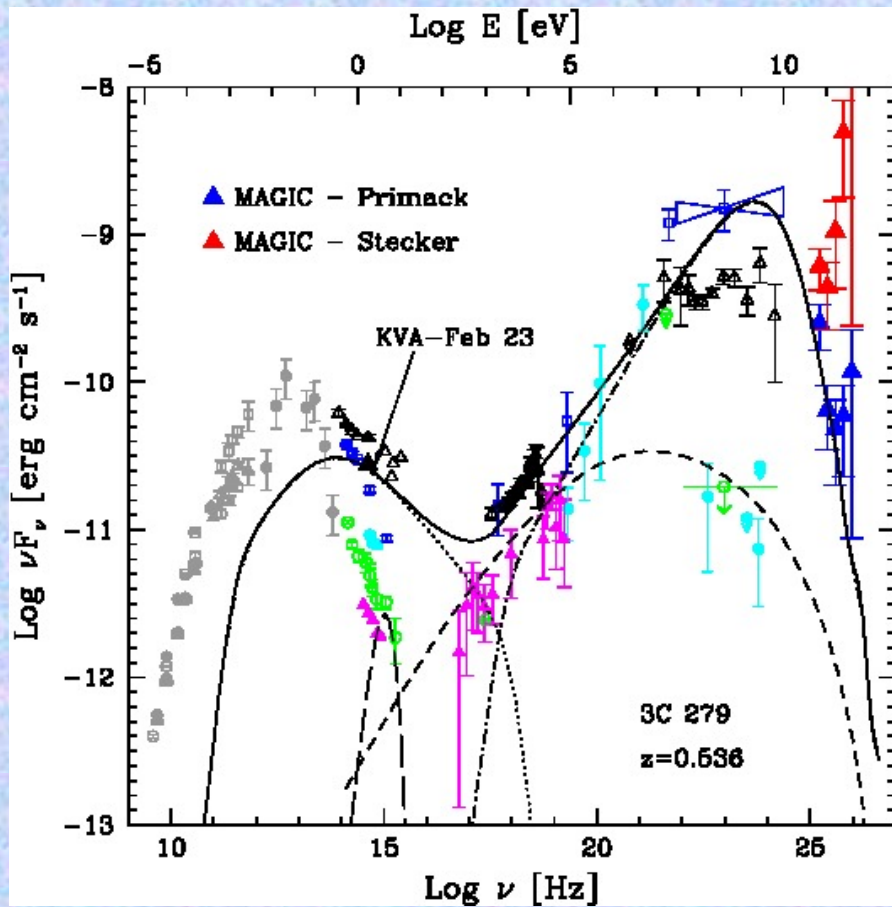


MAGIC Collaboration, *Science*, 2008

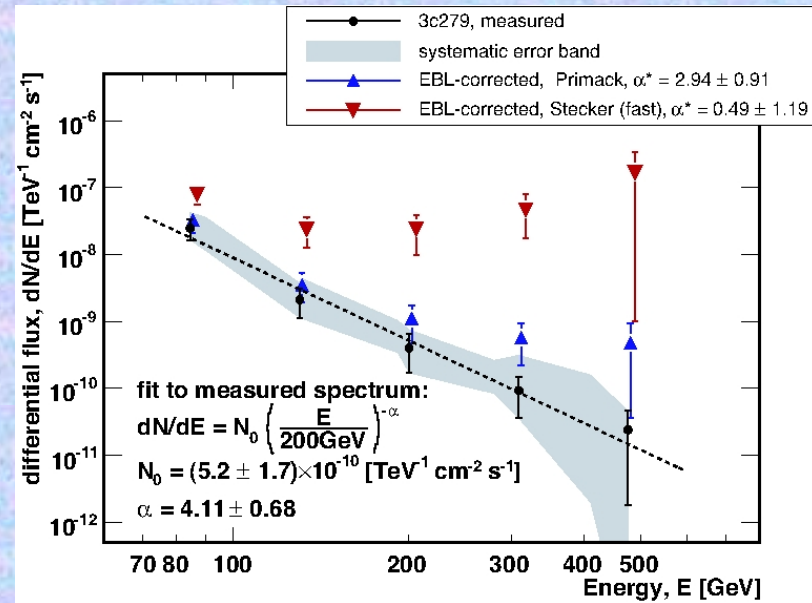


3C 279 (z= 0.536) and the EBL

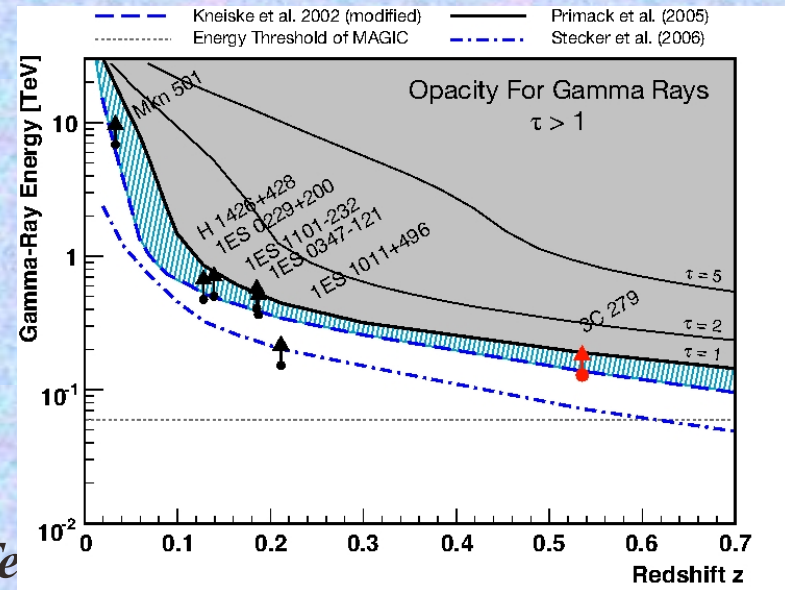
MAGIC Collaboration, *Science*, 2008



Laura Maraschi



Mera-Te



3C 279: MWL monitoring in 2007

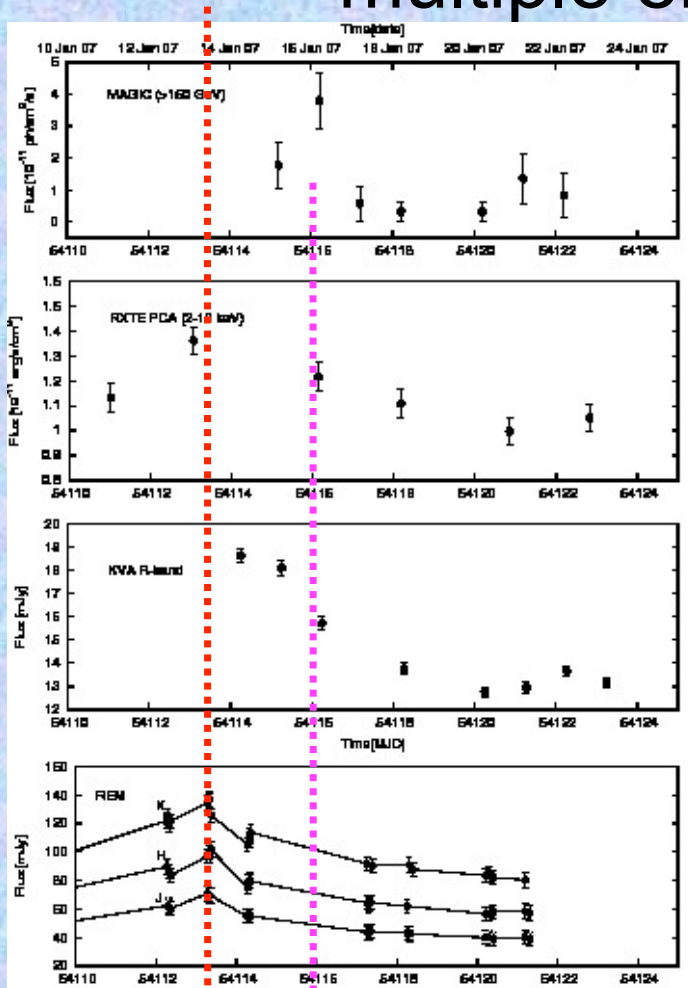
multiple emission regions?

VHE

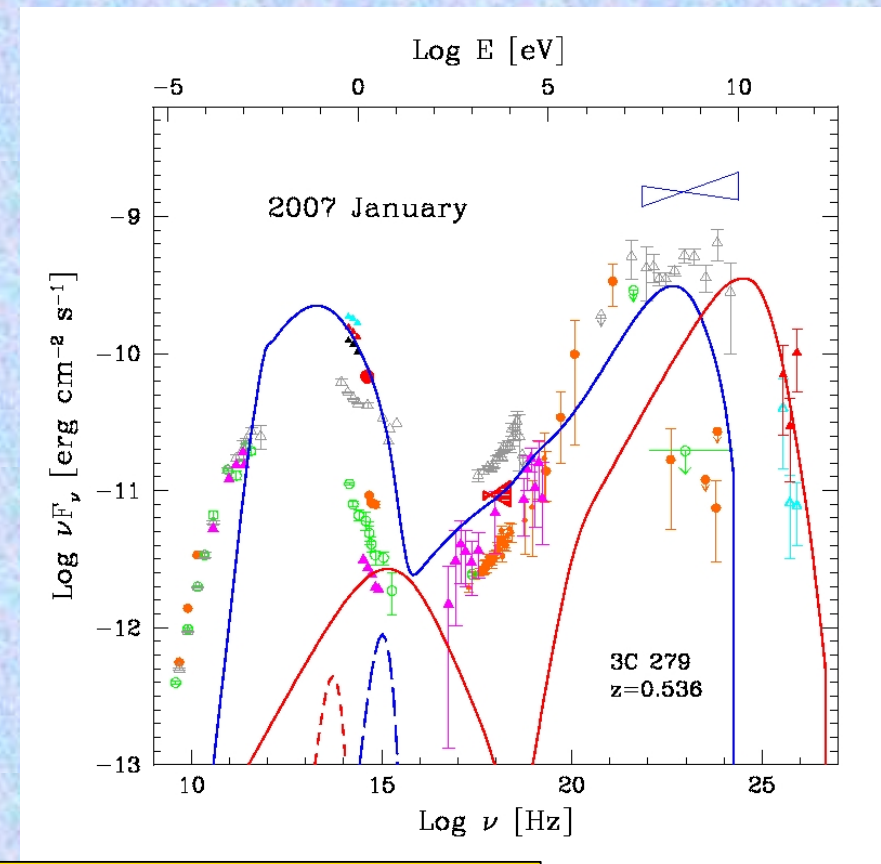
X

R

IR



TeV emission outside the BLR



VHE delayed w.r. to optical

Laura Maraschi

Aleksic et al. 2011 A&A.

Mera-TeV

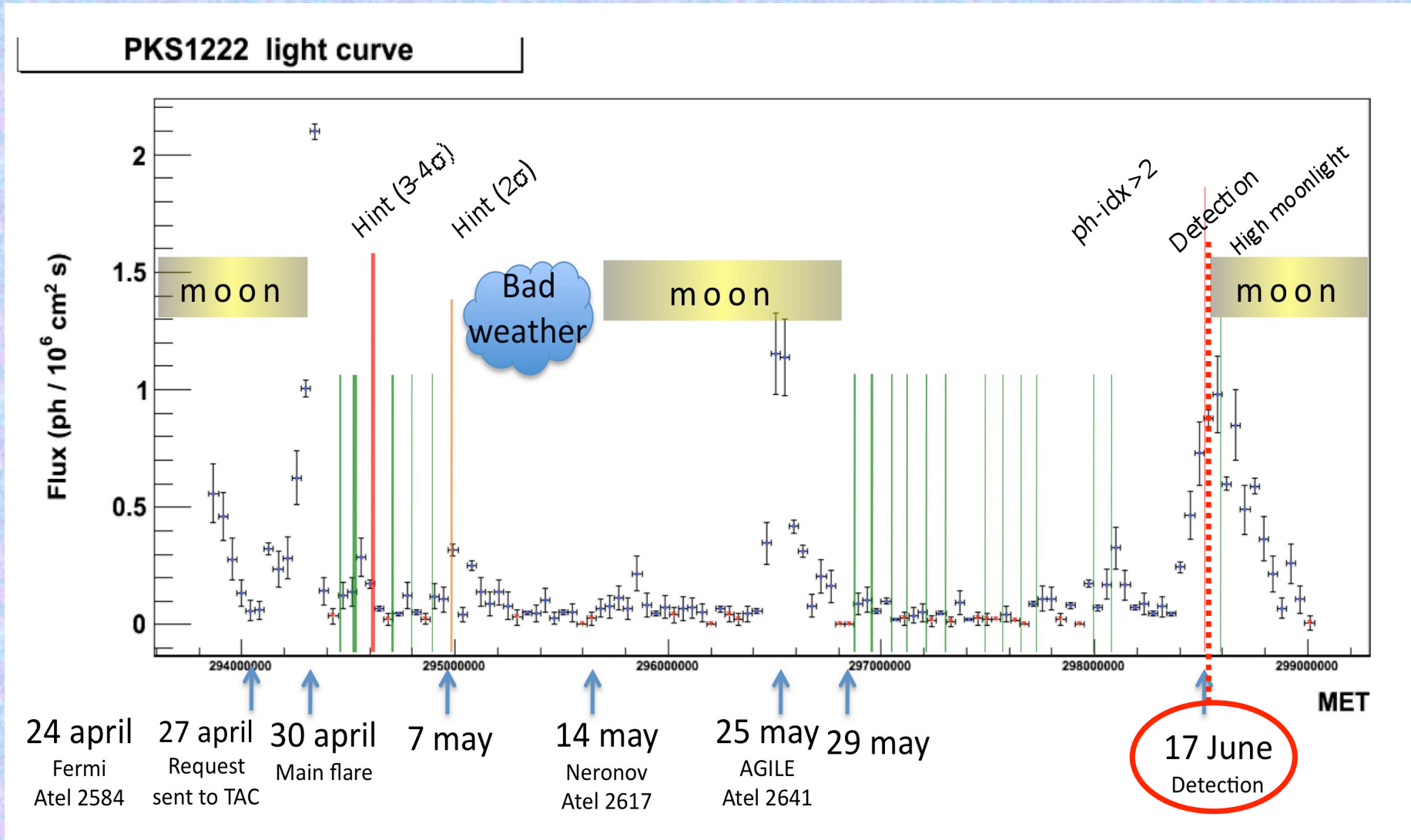
Merate. 06/10/2011

PKS 1222+21, a γ -ray flaring FSRQ
observed by Fermi and MAGIC

Second most distant TeV emitter
($z=0.432$)

Challenging blazar emission models?

PKS 1222 MAGIC observations: lucky or unlucky ?

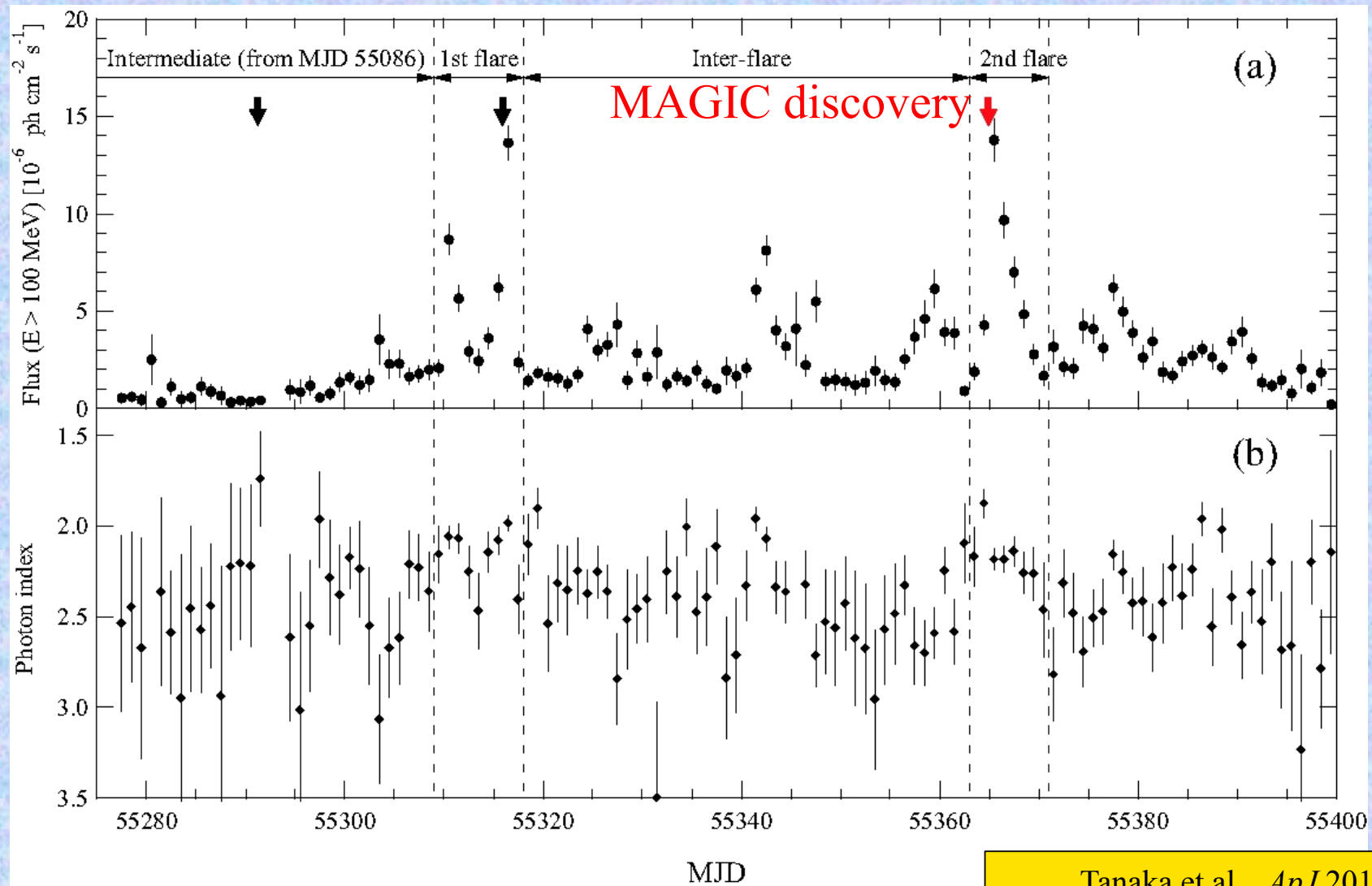


Laura Maraschi

Mera-TeV

Merate. 06/10/2011

PKS 1222 Fermi/LAT monitoring



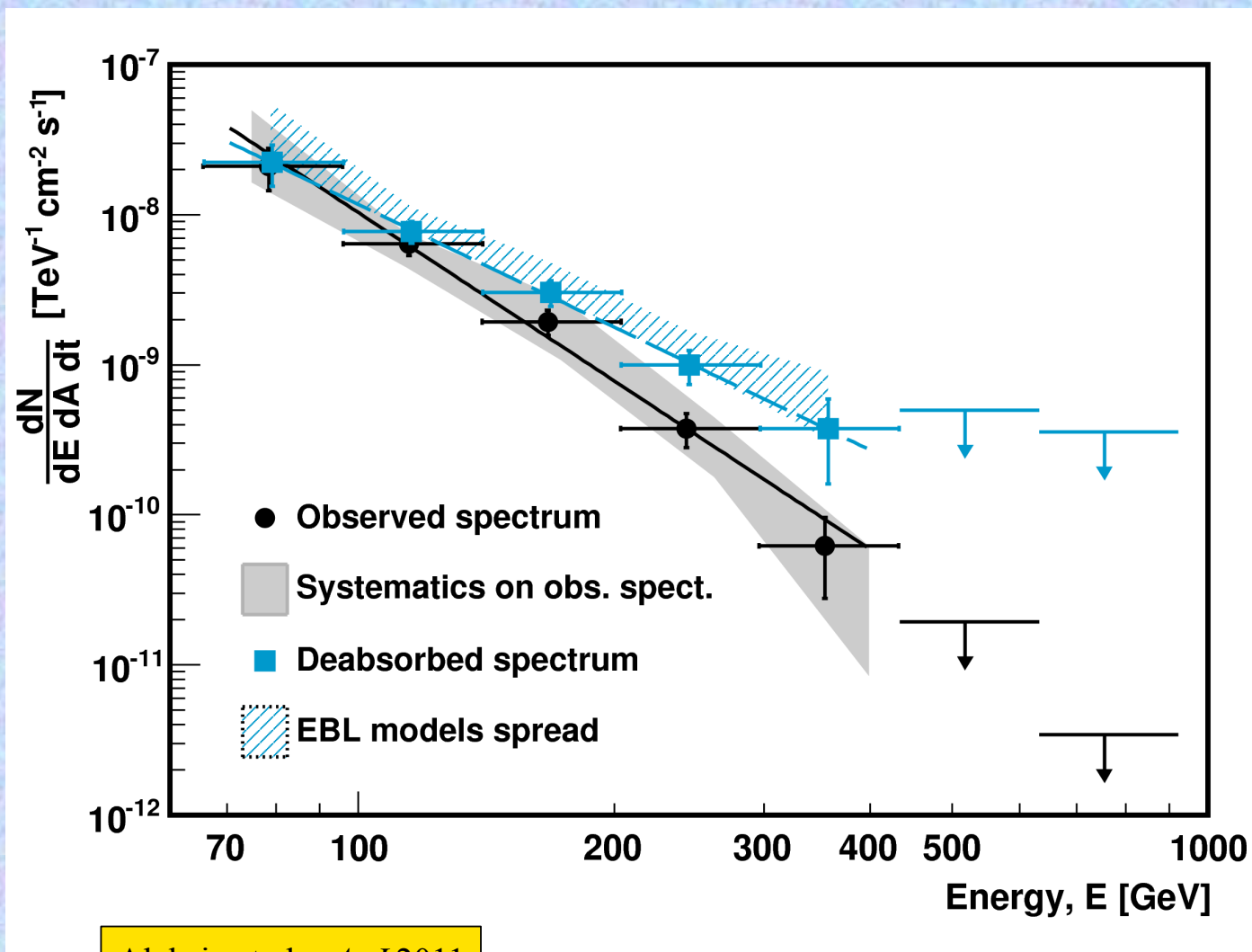
Tanaka et al., *ApJ* 2011

Laura Maraschi

Mera-TeV

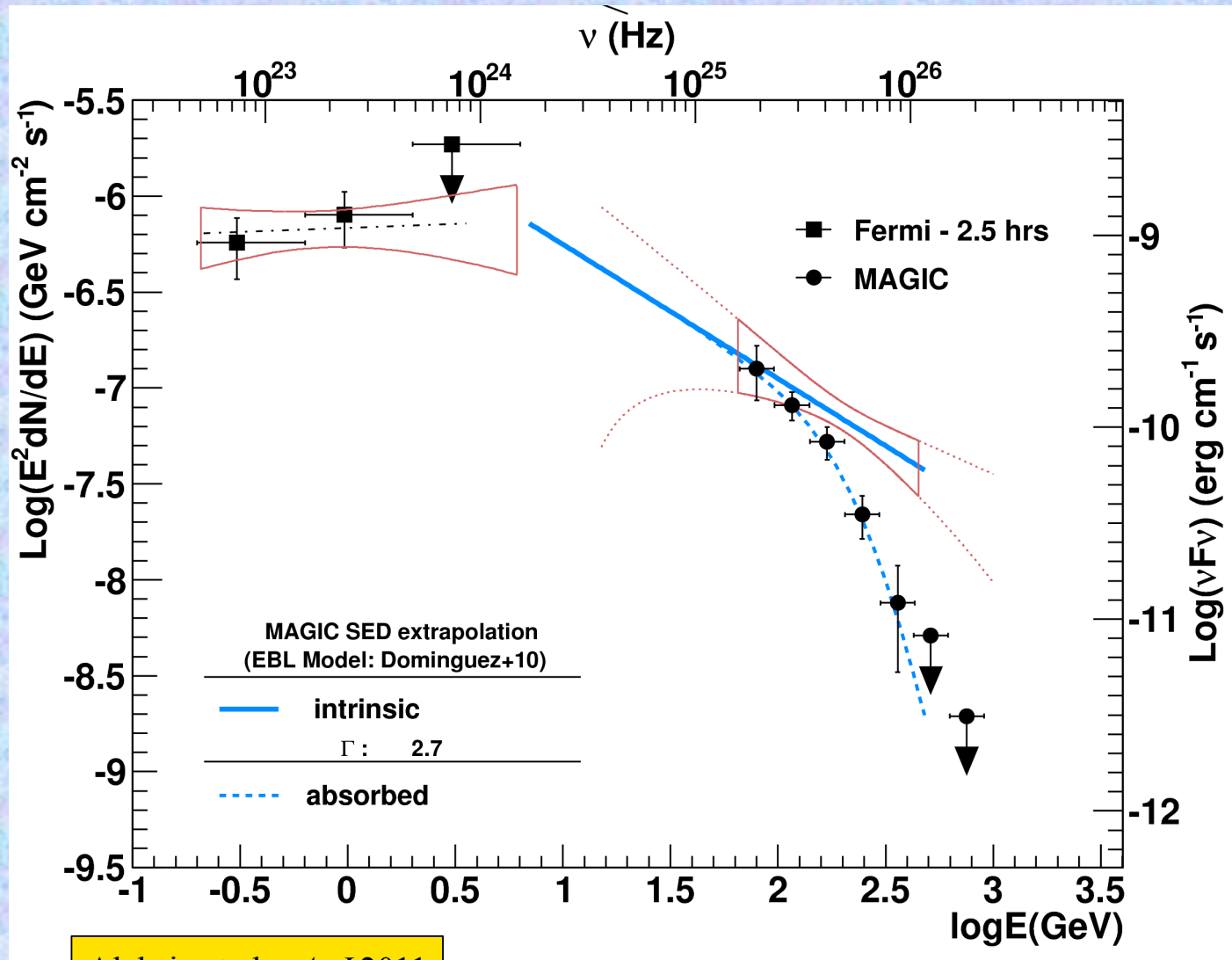
Merate. 06/10/2011

PKS 1222 VHE spectrum and EBL correction



Aleksic et al., *ApJ* 2011

PKS 1222 MWL SED



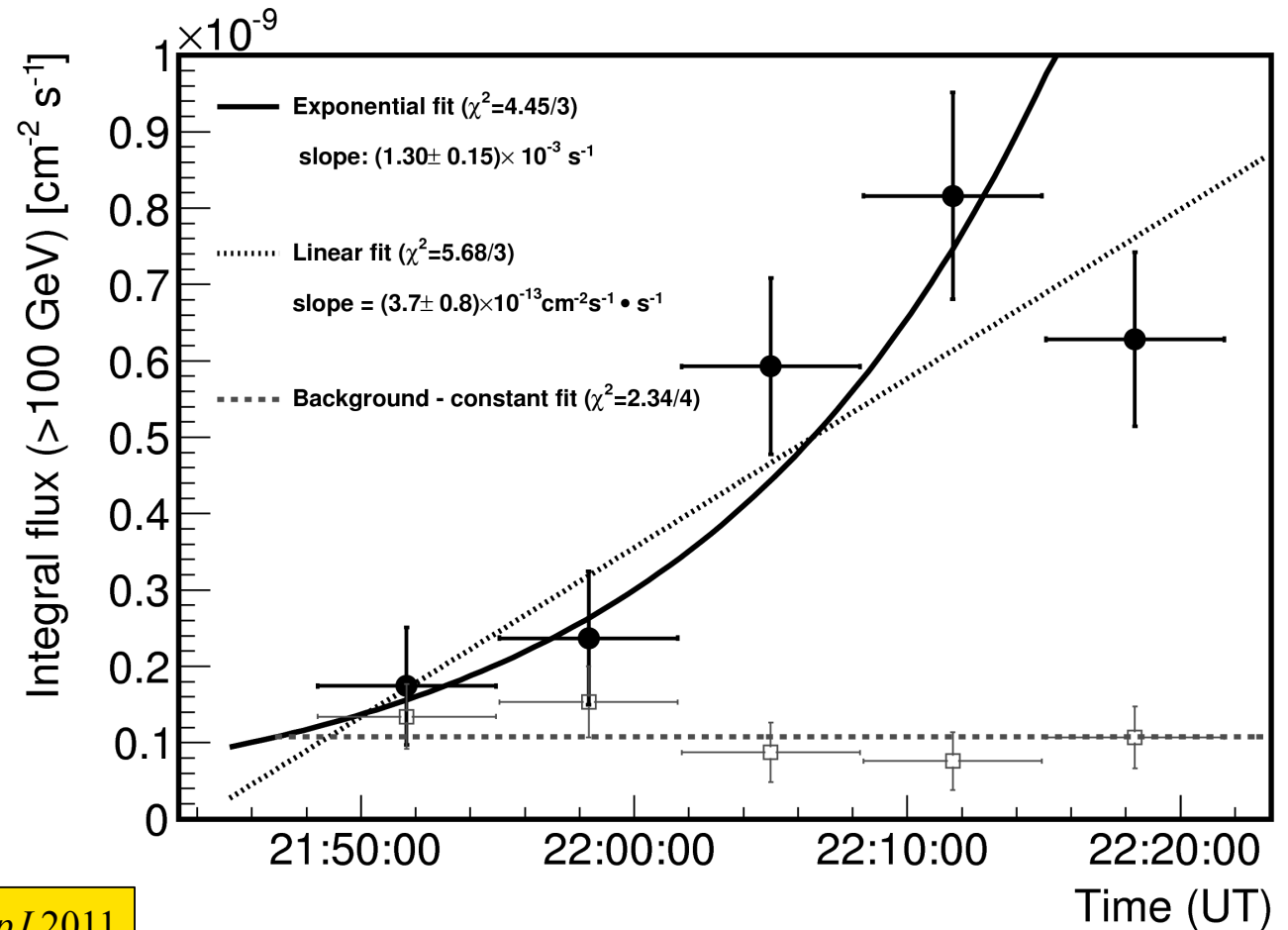
Aleksic et al., *ApJ* 2011

PKS 1222+21, a γ -ray flaring FSRQ observed by Fermi and MAGIC: challenging blazar emission models

$$T_{\text{var}} \sim 10 \text{ min}$$

Fast variability \rightarrow small region

TeV emission \rightarrow low photon
density \rightarrow outside BLR



Aleksic et al., *ApJ* 2011

Laura Maraschi

Mera-TeV

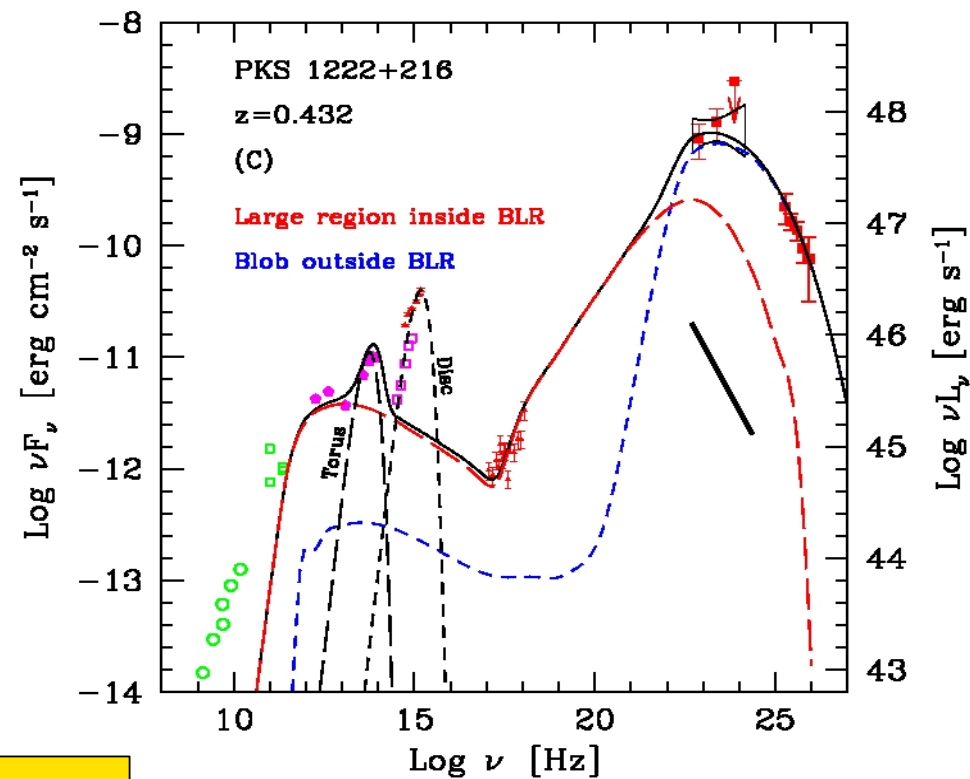
Merate. 06/10/2011

PKS 1222+21, a γ -ray flaring FSRQ observed by Fermi and MAGIC: challenging blazar emission models

$$T_{\text{var}} \sim 10 \text{ min}$$

Fast variability \rightarrow small region

TeV emission \rightarrow low photon
density \rightarrow outside BLR



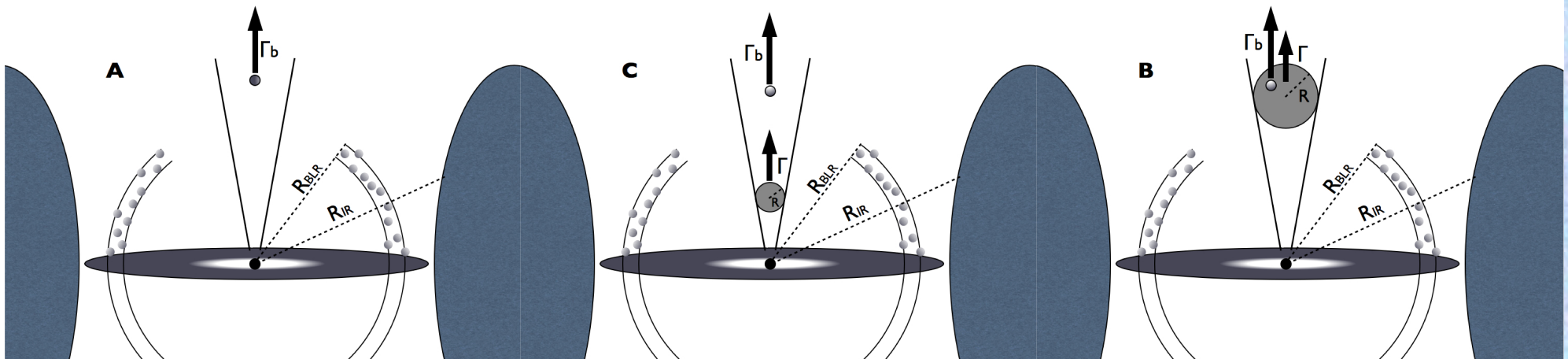
Tavecchio et al., *A&A* 2011

PKS 1222+21

Fast variability \rightarrow small region

$$T_{\text{var}} \sim 10 \text{ min}$$

TeV emission \rightarrow low photon density \rightarrow outside BLR



Blob only

Jet in

Jet out

This object has a peculiar jet radio morphology

Tavecchio et al., *A&A* 2011

Laura Maraschi

Mera-TeV

Merate. 06/10/2011

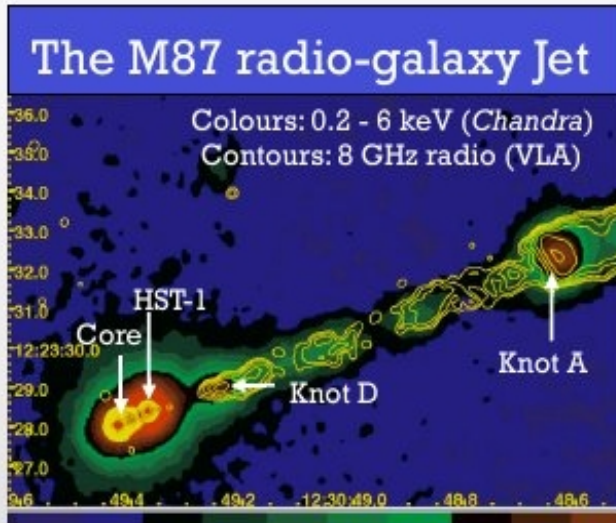
Radiogalaxies: a surprise?

A few nearby radio-loud *non-blazar* AGN are recognized TeV emitters:

M 87 - Cen A - IC 310 - NGC 1275

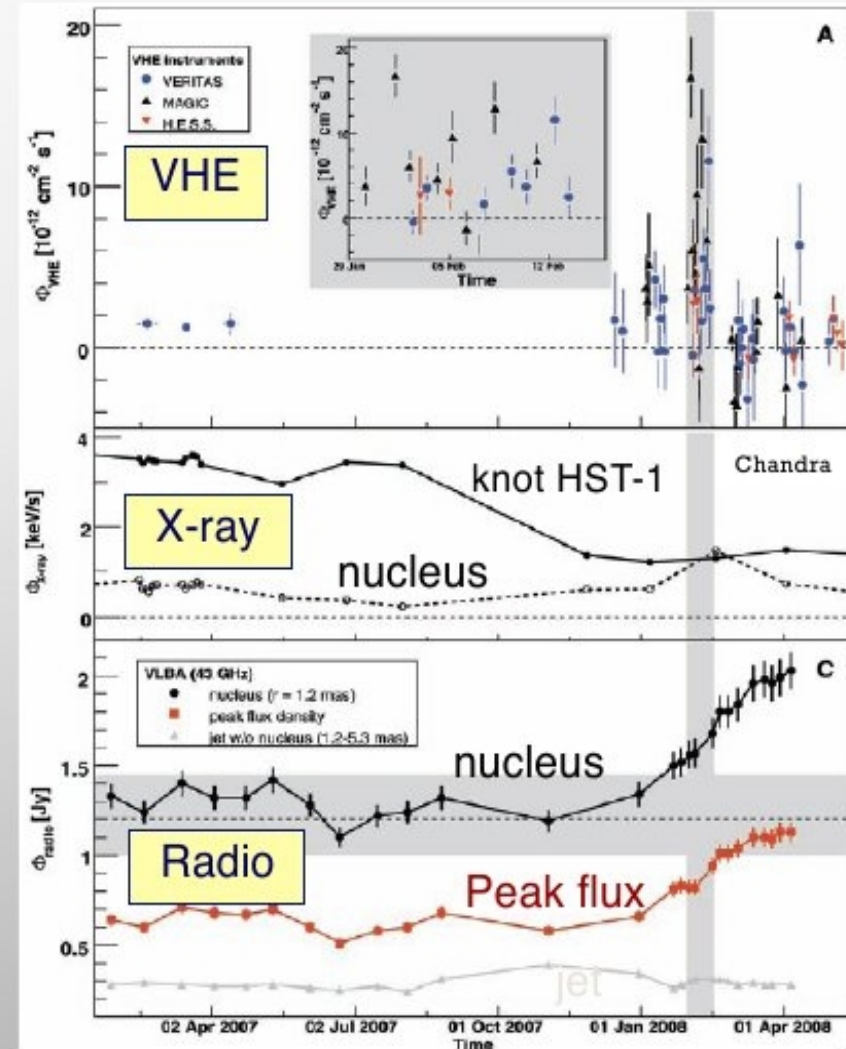
- Resolved radio morphology suggests a spine-layer structure for the jet
- M 87 best studied, and TeV emission region can be localized

JOINT HESS-MAGIC-VERITAS CAMPAIGN OF M87 (SCIENCE 2009)

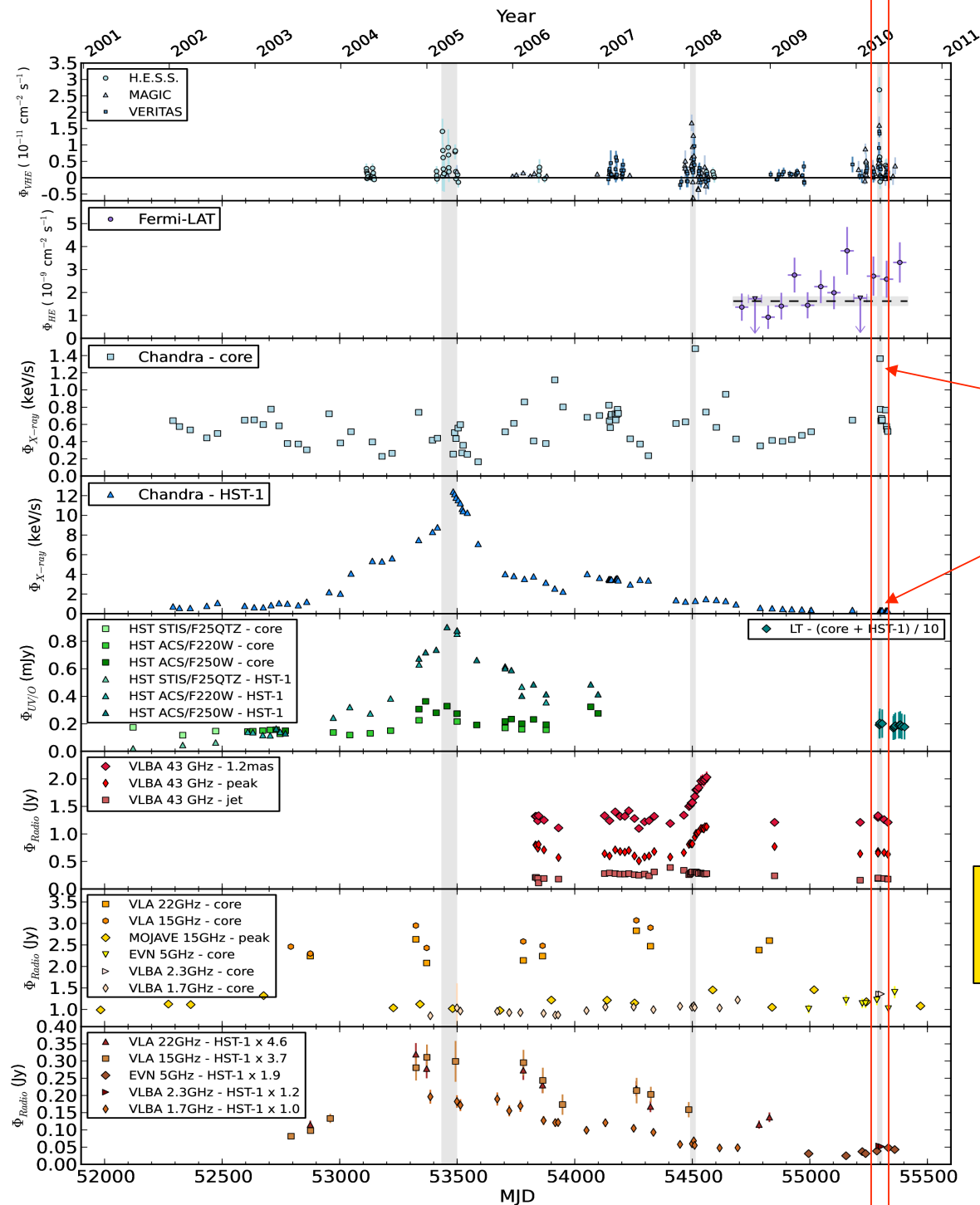


- Shared monitoring HESS, MAGIC, VERITAS
- Confirmation of day-scale variability at VHE
- Evidence of central origin of the VHE emission (60 Rs to the BH)

17



M87 2010 VHE flare



X-ray core

X-ray HST-1

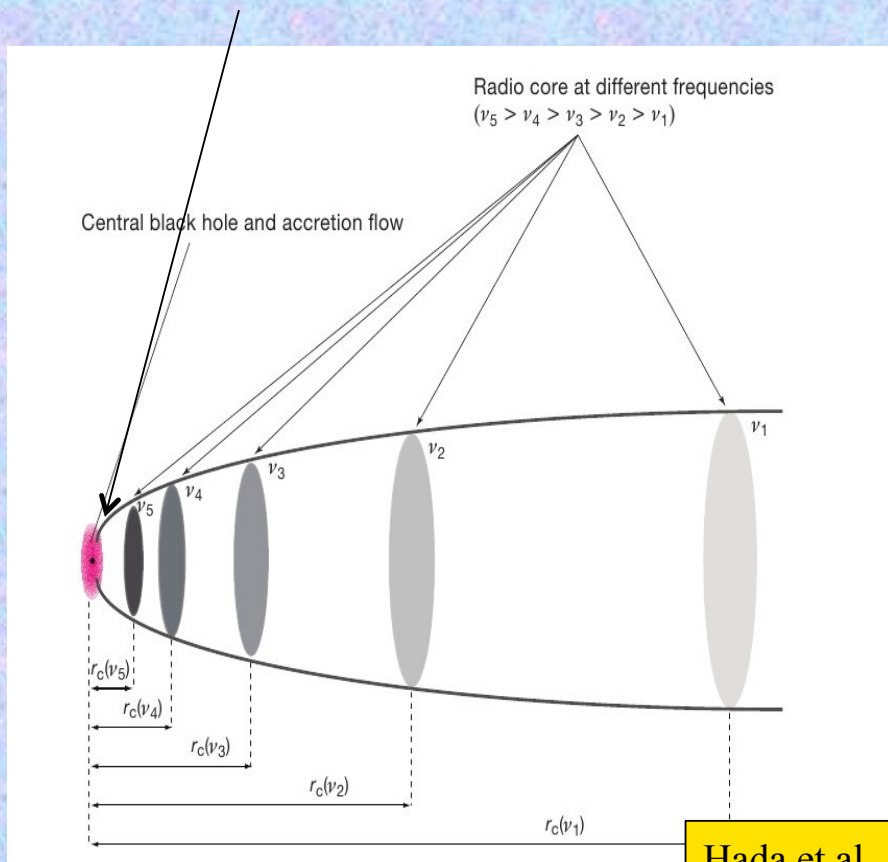
H.E.S.S. MAGIC VERITAS et al,
submitted to *ApJ*

Merate. 06/10/2011

Radio core position at different frequencies

Positional accuracy ~ 0.02 mas @ 43GHz

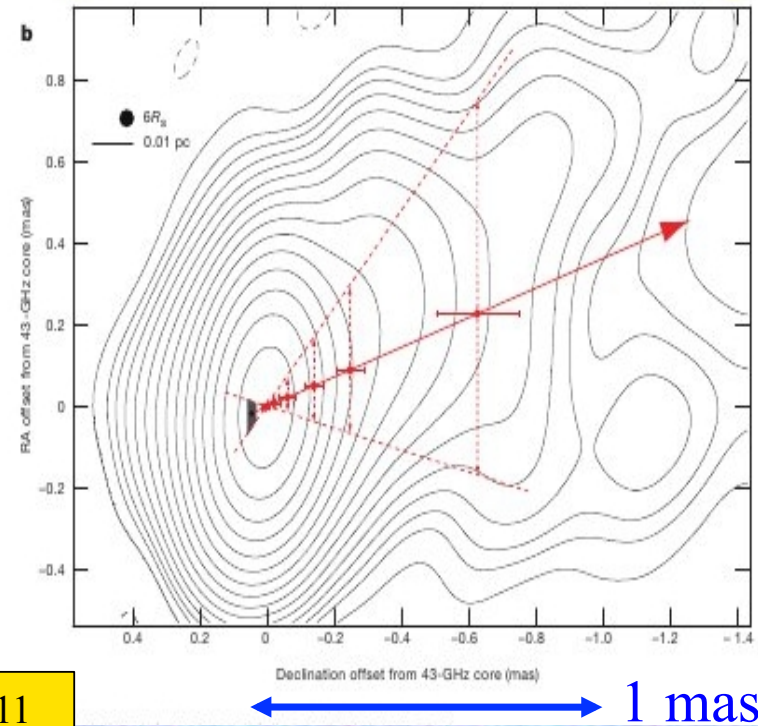
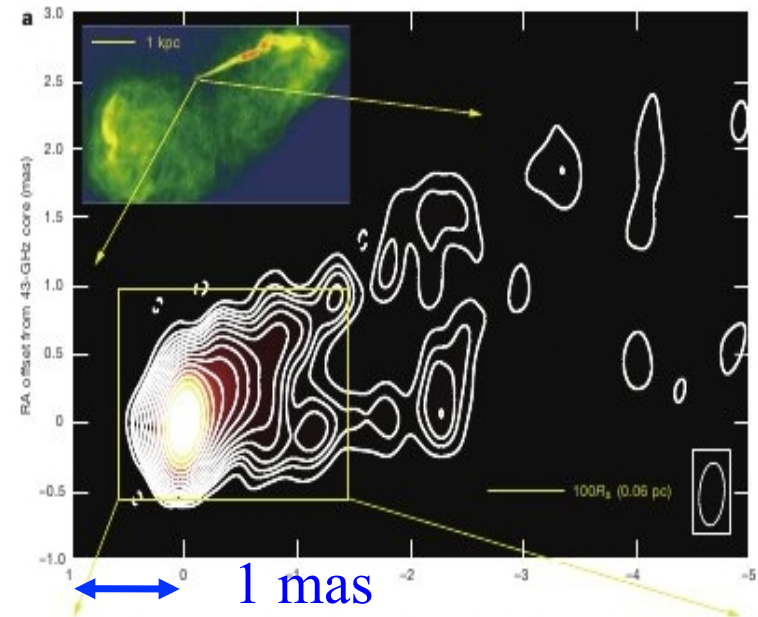
Size and location of BH and acc.disk



Hada et al, *Nature*, 2011

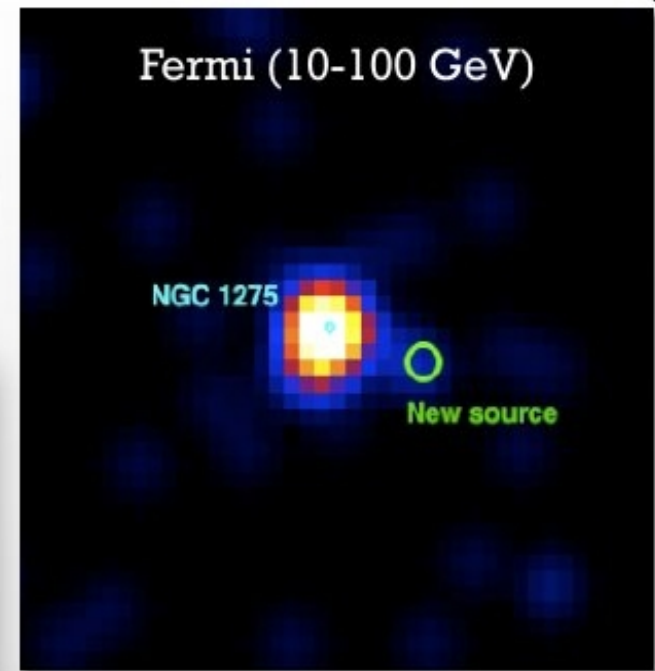
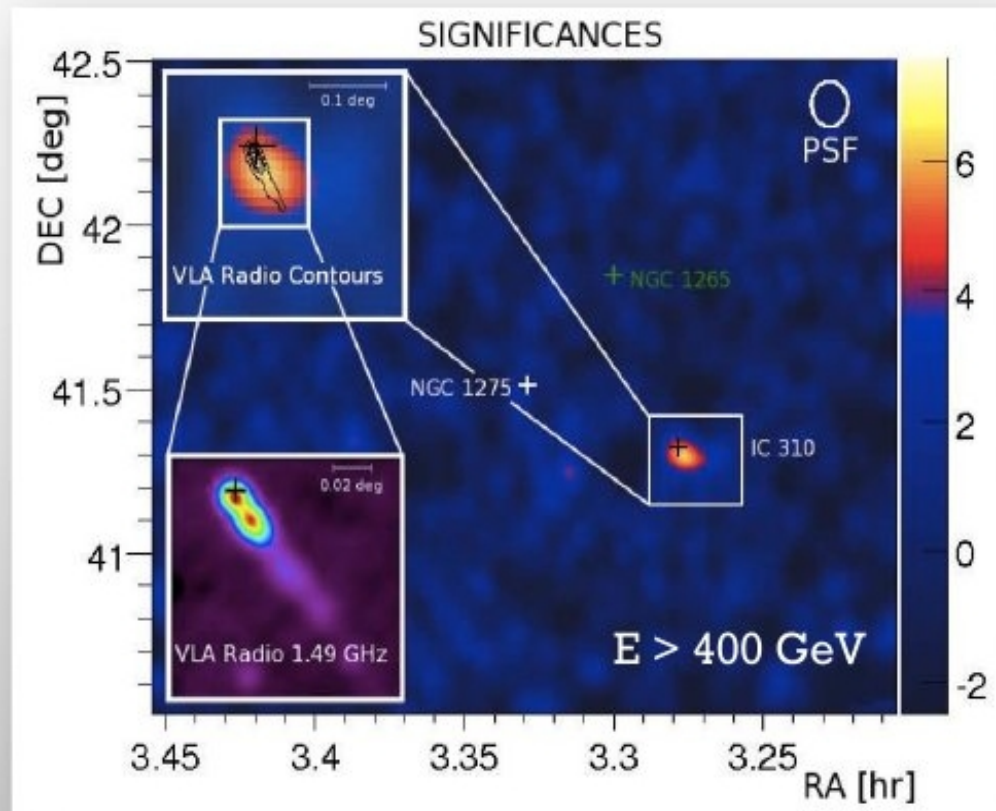
Laura Maraschi

Mera-TeV



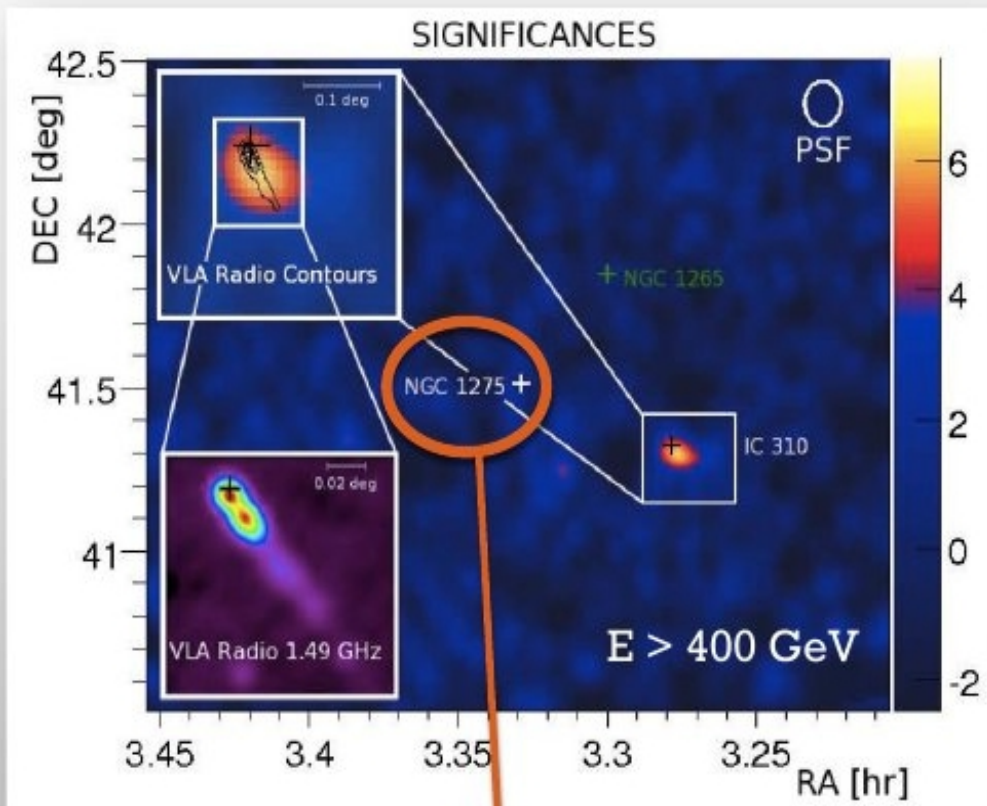
Merate. 06/10/2011

A RECENT DISCOVERY: IC 310 (MONO & STEREO)



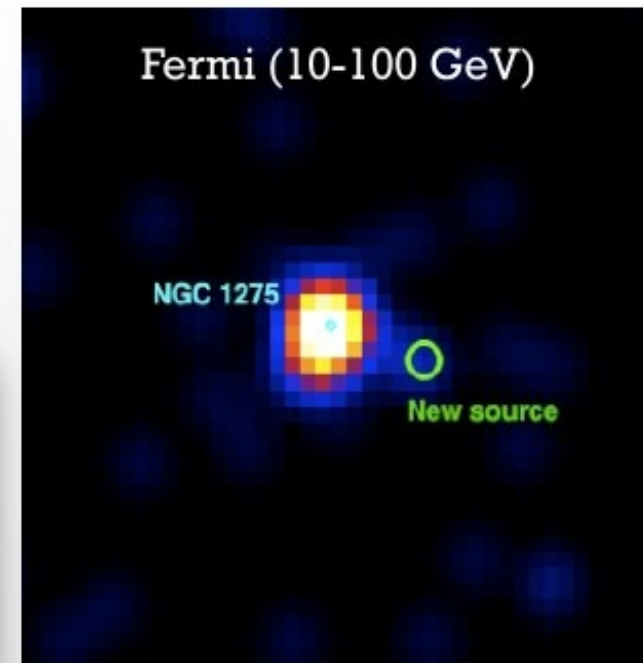
- Head tail radio galaxy
- Observation triggered by *Fermi* (hard spectra)
- Complex FoV
- Variable emission (since 2008)
- Inner jet emission location favored

A RECENT DISCOVERY: IC 310 (MONO & STEREO)



29

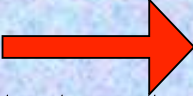
MAGIC discovery!!
ATel January 2011



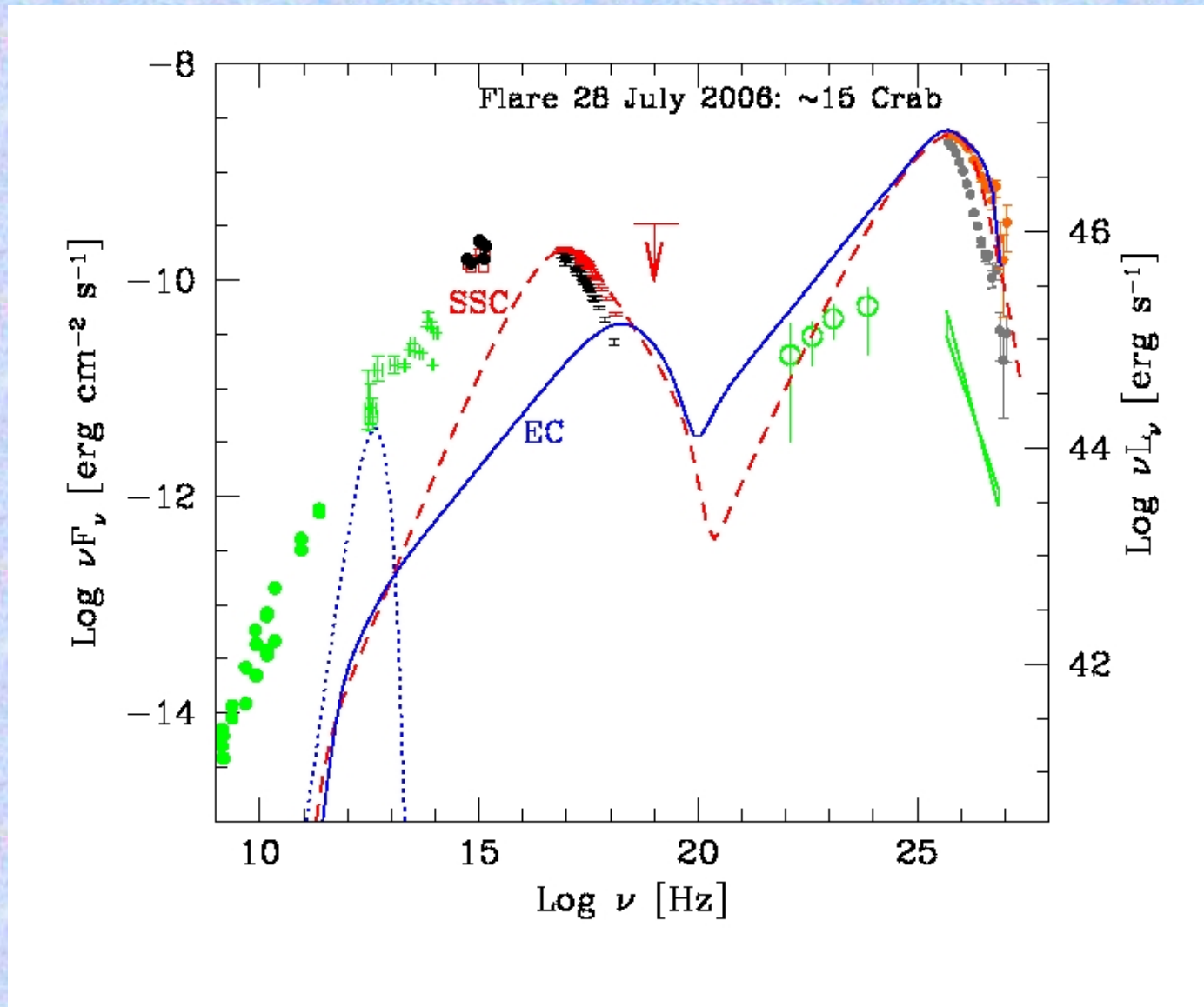
- Head tail radio galaxy
- Observation triggered by *Fermi* (hard spectra)
- Complex FoV
- Variable emission (since 2008)
- Inner jet emission location favored

MAGIC Coll., *ApJ Lett.*
723 (2010) L207-212

Talk Summary

- BLAZAR SEDsare predictive !
- HBL: Mkn 421 -- PKS 2155-304
- X-ray (synchro) – TeV (synchro-self Compton)  correlation
- Fast variability : close to the core or in compact structures within jet?
- IBL: BL Lac (itself) -- W Comae
- Optical (synchro) – TeV (synchro-self Compton tail, steep spectrum)
- FSRQs: 3C 279 -- 4C +21.35 (PKS 1222 +21) most complex!
- Synchro in IR – X-rays from SSC – TeV from EC within or outside the BLR ????? Fast Variability a difficult challenge
- Radiogalaxies: M 87 – a direct view of the BH vicinity
- More puzzles: IC 310 who knows this guy?
- NGC 1275 likely medium angle view of a blazar

PKS 2155 -304 exceptional flare – model 1



Thanks!

Laura Maraschi

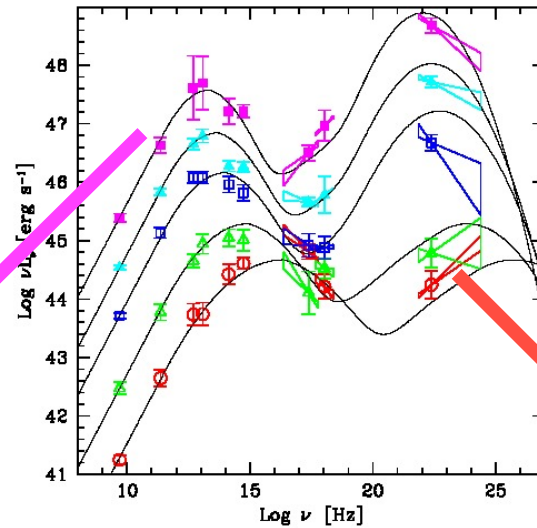
Mera-TeV

Merate. 06/10/2011

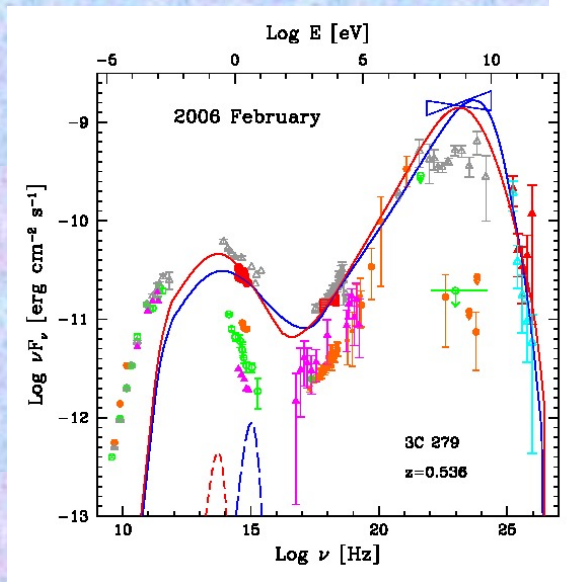
Backup

BL Lacs and FSRQs

3C 279
FSRQ ($z=0.536$)
EC



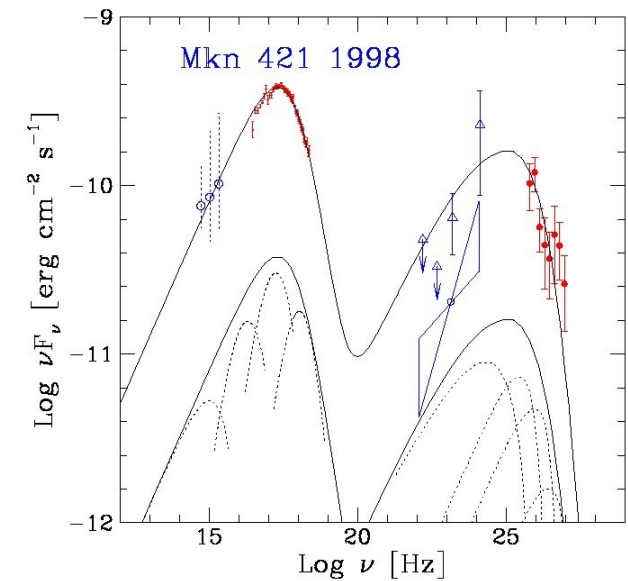
Mrk 421
BL Lac ($z=0.031$)
SSC



Laura Maraschi

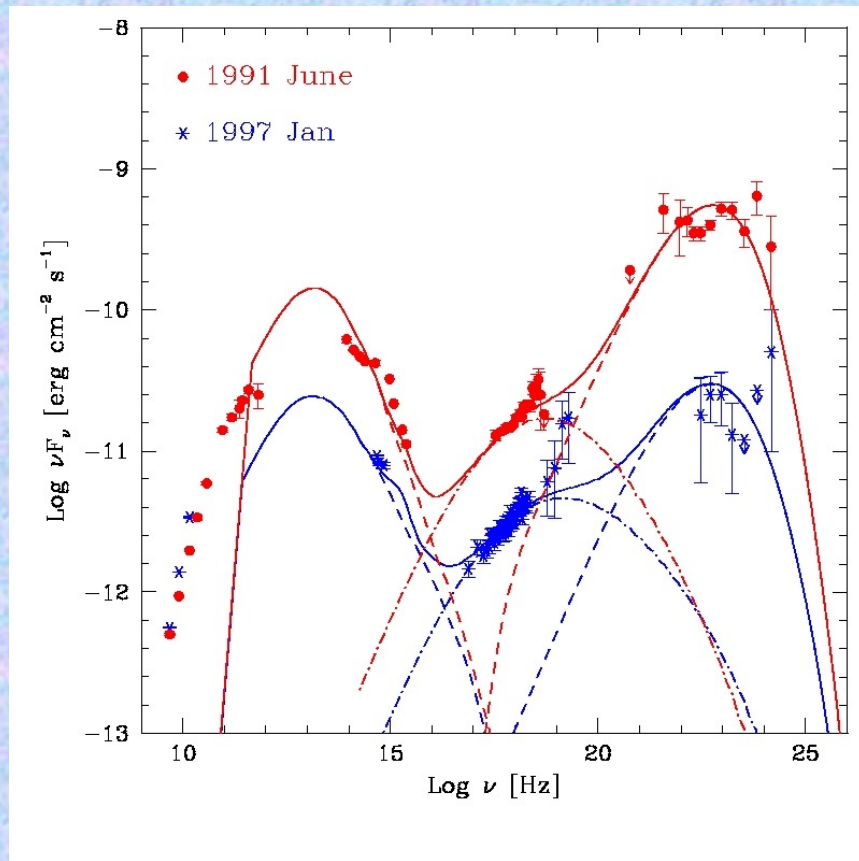


Mera-TeV

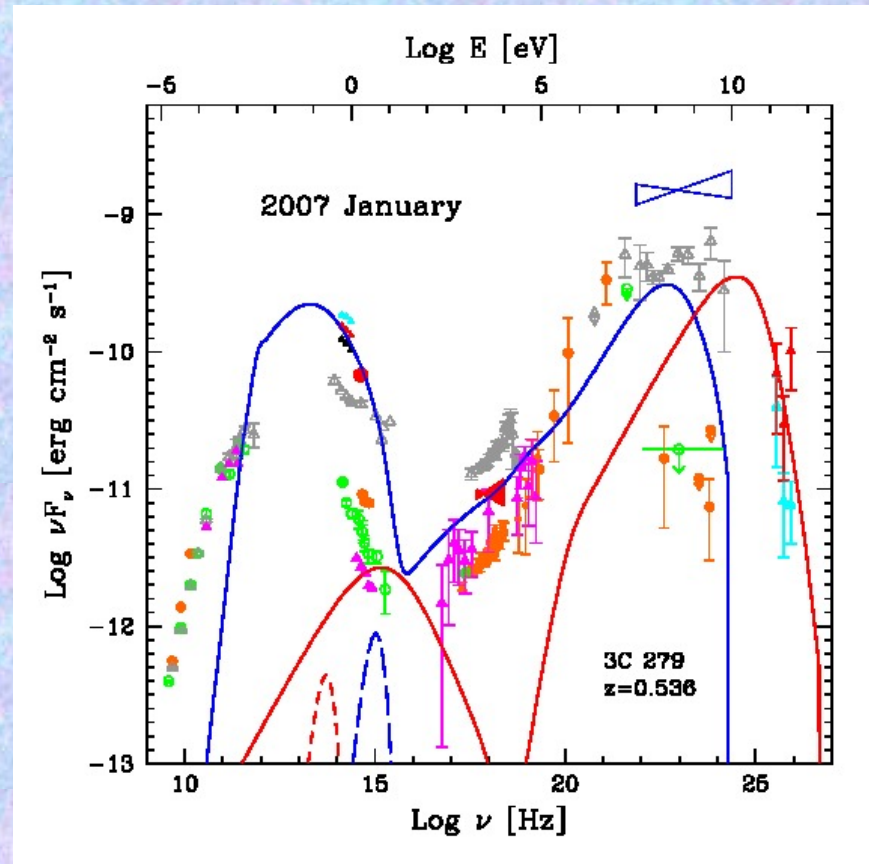


Merate. 06/10/2011

3C 279: from EGRET to MAGIC



Laura Maraschi



Mera-TeV

Merate. 06/10/2011