The 2010 M 87 VHE flare and its origin: the MWL picture

Martin Raue for the H.E.S.S., MAGIC, VERITAS, and Fermi/LAT Collaborations and the M 87 MWL Monitoring Team

“High Energy Phenomena in Relativistic Outflows III”
Barcelona, June 27 - July 1, 2011
martin.raue@desy.de
Giant radio galaxy M 87

Distance: ~16 Mpc

Central BH:
\[ M_{\text{BH}} \sim 3-6 \times 10^9 M_\odot \]

Jet angle: ~20-30°

Outer radio lobes (0.2 x 0.2 deg)

Highly structured inner jet (kpc) resolved in radio, optical, X-ray

VHE emission (HEGRA ’99)

Short-term VHE variability (H.E.S.S. 2005)

e.g. Curtis (1918), Biretta et al. (1999), Gebhardt & Thomas (2009), Aharonian et al. (2003), Aharonian et al. (2005)
Origin of the VHE emission

Dark matter annihilation
CR in M 87
Intra-cluster gas
Large scale jets
Inner/Outer-jet
   Hadronic/Leptonic
Knots? HST1?
Vicinity of black hole

E. A. Baltz et al. (2000), C. Pfrommer and T. A. Enßlin (2003),
Stawarz et al. (2005), Georganopoulos, et al. (2005), J.-P. Lenain
et al. (2008), A. Reimer et al. (2004), Neronov & Aharonian (2007),
Rieger & Aharonian (2008), Barkov et al. (2010)
Origin of the VHE emission

- Dark matter annihilation ✗
- CR in M 87 ✗
- Intra-cluster gas ✗
- Large scale jets ✗
- Inner/Outer-jet ✔
  - Hadronic/Leptonic
- Knots? HST1? (✔)
- Vicinity of black hole ✔
- ...

Short term VHE variability (~days) places strong size constraints $r < 5 \times 10^{15}$ δ cm

HST-1: flare (2005)

HST-1 = First bright feature in the jet resolved by Hubble

Underwent **major flux outburst** in 2005 (X-ray, optical, radio)

**Contemporaneous VHE activity** detected in 2005
  Time scale different

Sub-structure, super-luminal features
Core: VHE vs MWL (2008)

H.E.S.S., MAGIC, VERITAS, VLBA, & Chandra

**VHE flares** coincides with increased radio and X-ray flux in the core

Indication for **emission from vicinity of the SMBH**

Acciari et al. (2009)
2010 VHE monitoring campaign

Joint VHE monitoring campaign
MAGIC & VERITAS

ToO: H.E.S.S., Chandra (D. Harris et al.), 43 GHz VLBA (C. Walker et al.)
M 87 - 2010 VHE campaign

1. ATel - Mariotti et al. 2010
2. ATel - ToO triggered - Ong & Mariotti 2010

~80h observation time
M 87 - 2010 VHE flare

21 observations in 15 days
Well described by 2 x exponential function
Doubling time 0.6 ± 0.08 days
VHE flares from 2005 to 2010

2010 vs 2005
statistics in 2005 to low, but 2005 seems more extended

2010 vs 2008
2008 more erratic? Quantify
M 87 - MWL lightcurve

Instruments
H.E.S.S., MAGIC, VERITAS, Fermi, Chandra, HST, LT, VLBA, MOJAVE, VLA, EVN
M 87 - MWL lightcurve

Instruments
H.E.S.S., MAGIC, VERITAS, Fermi, Chandra, HST, LT, VLBA, MOJAVE, VLA, EVN

Components
Core
HST-1
VHE vs radio core
VHE vs X-ray

Poster by D. Harris et al.
VHE vs HE/O/...

Fermi
Steady source
(marginal variable?)

HST / LT
HST-1 flare 2005
LT: no strong activity in 2010

Radio HST-1
HST-1 flare 2005
Optical polarimetry

PRELIMINARY Poster by E. Perlmann et al.
Conclusions

**M 87**
Nearby (16 Mpc) VHE radio galaxy with massive SMBH
Short-term VHE variability ~1 day

**2010 campaign**
VHE monitoring by MAGIC & VERITAS (ToO: H.E.S.S., Chandra, VLBA)
VHE flare detected $t_d < 1$ day (excellent sampling)
**NO** rise in the 43 GHz radio core emission
Enhanced X-ray core emission (Chandra)

**Origin of the VHE emission?**
No unique solution?

**Full paper in preparation**
Thank you for you attention!
Backup slides
VHE flares: 2010 vs 2008

Quantify:
Calculate $\chi^2 / \text{d.o.f.}$ for 2008 flare for best fit function from 2010 (~10 days window)