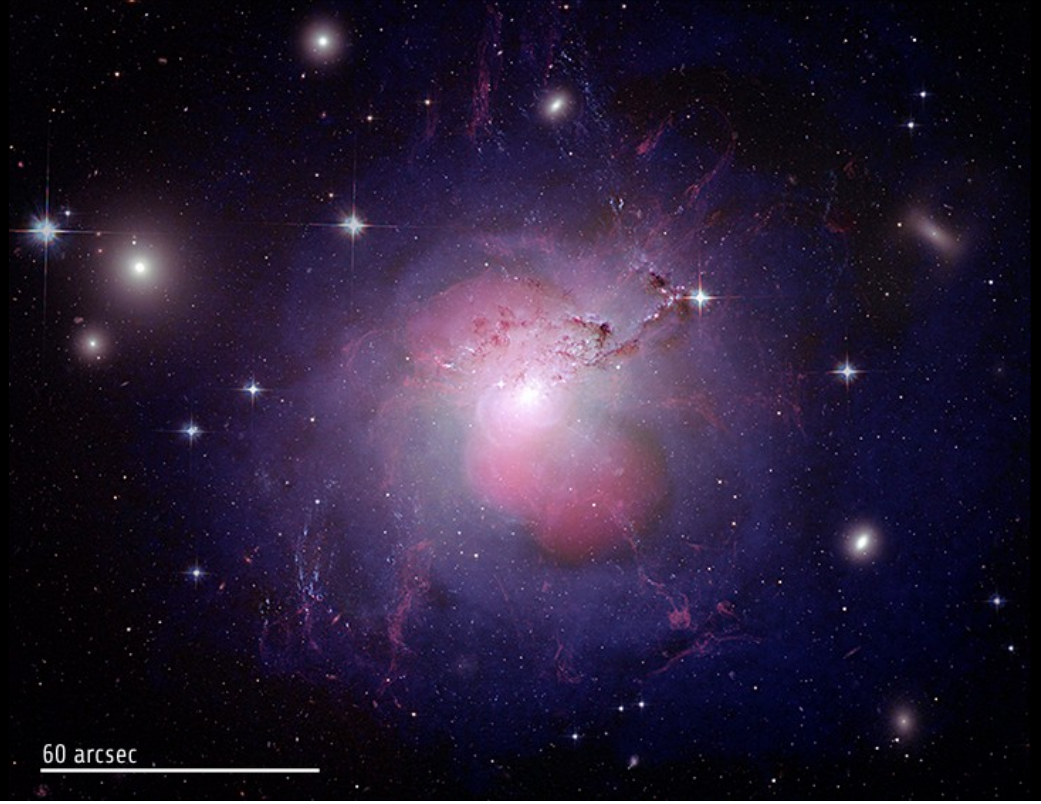


TeV flares of radio galaxies,

the case of the great flare of NGC 1275 on Jan 1st 2017

Olivier Hervet

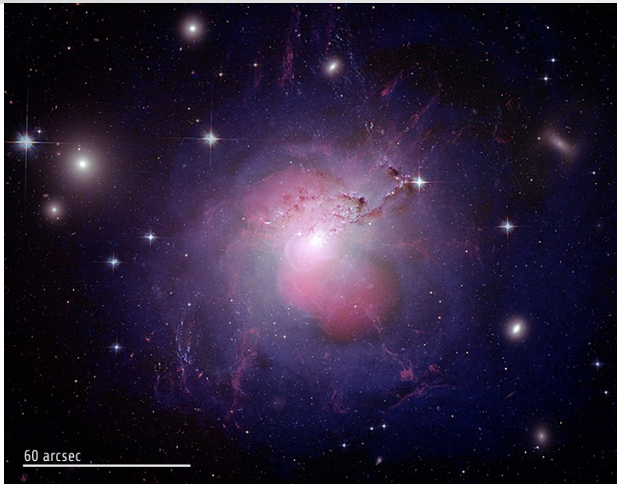
for the VERITAS Collaboration

Jets2021 Conference

June 2021, Online

NGC 1275 mugshot

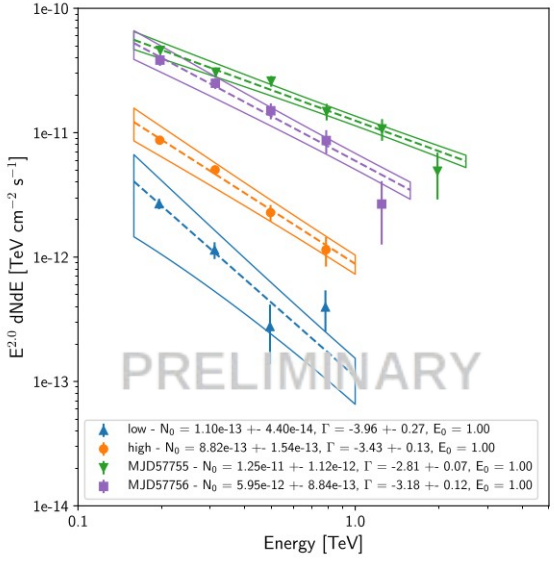
- NGC 1275 (3C 84, Perseus A), at center of the Perseus Cluster
- Radio galaxy, Giant Elliptical Galaxy, FR I, Seyfert 2 (Narrow line Seyfert),
- D=75 Mpc, 1 mas = 0.34 pc = 4500Rs, $M_{BH} = 8 \times 10^8 M_\odot$



Specific interest for the very-high-energy community:

- Historical TeV flare happened Jan 1st, 2017
- Observed by MAGIC at ~ 150% Crab (x 50 average VHE flux)
  (MAGIC Collaboration, 2018, A7A, 617, A91)
- VERITAS observed Jan 2: ~ 65% Crab
  Jan 3: ~ 60% Crab

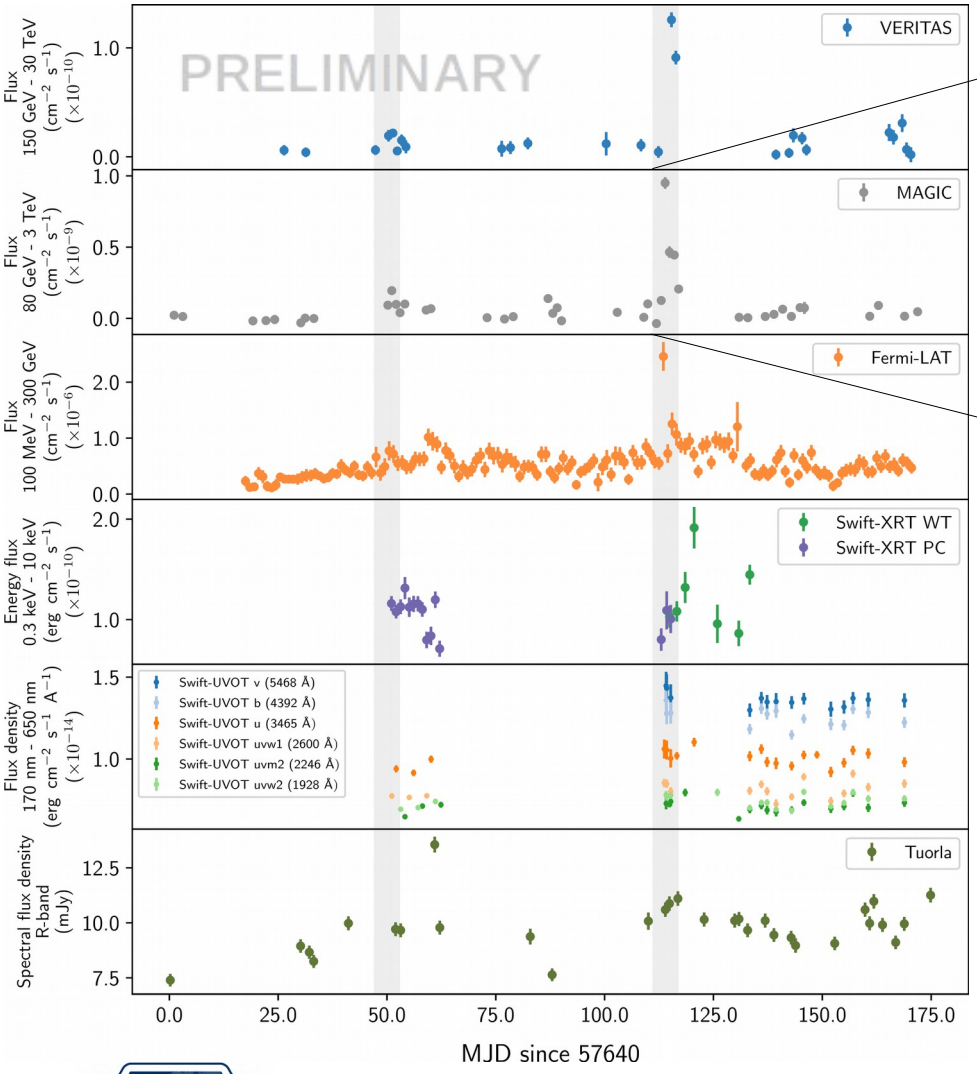
VHE 'harder when brighter' behaviour



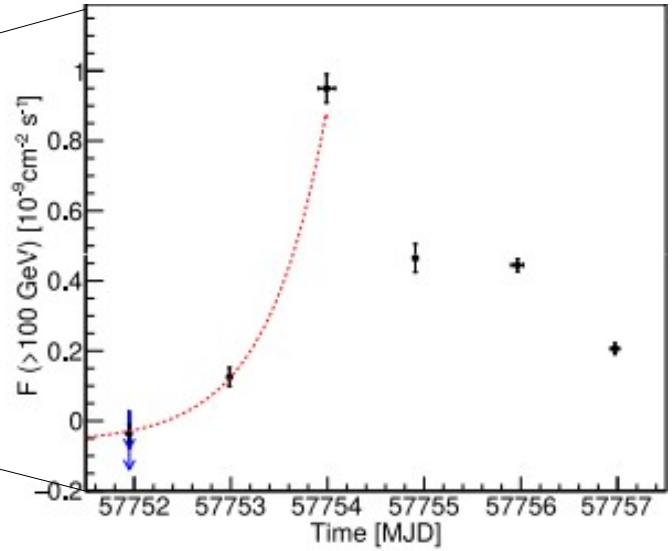
VERITAS Jan 2017 flare + 8 years of monitoring: (in prep.)

Multiwavelength lightcurve

Jan 2017 flare



Zoom on MAGIC lightcurve

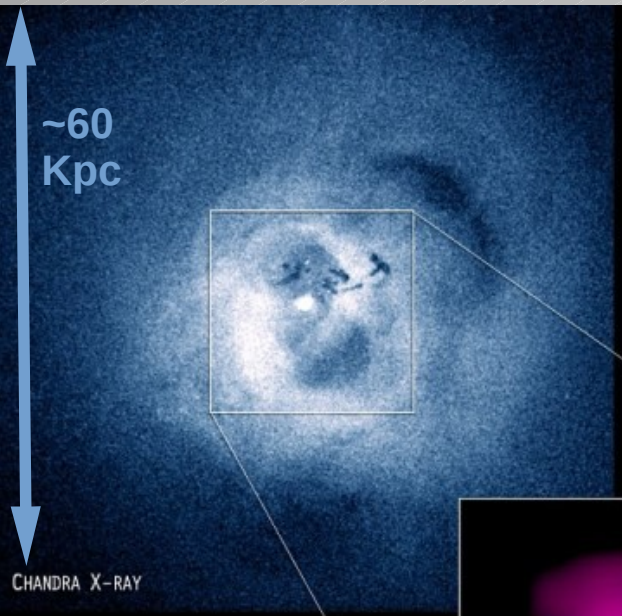


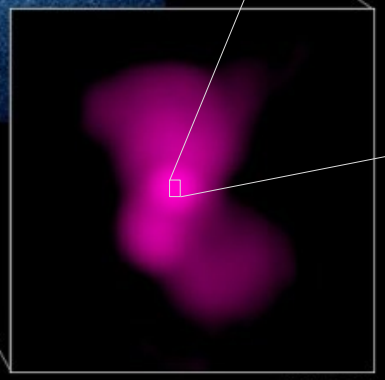
(MAGIC Collaboration, 2018, A7A, 617, A91)

Minimal variability for doubling flux:
(10.2 ± 1.7) h

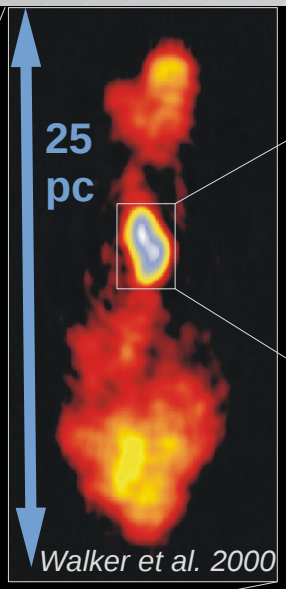
No significant variability detected in Opt-UV-X during the gamma-ray flare
→ **"Orphan flare"**

Complex morphology and extension

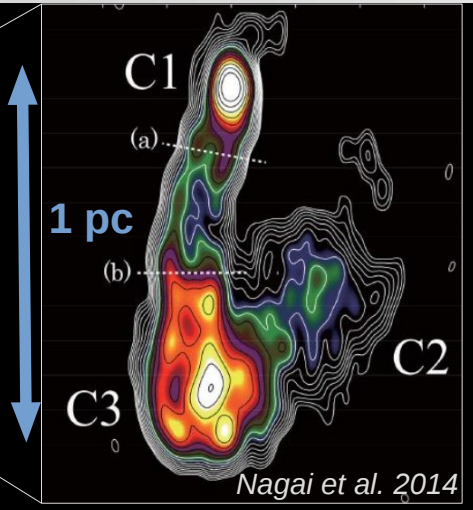




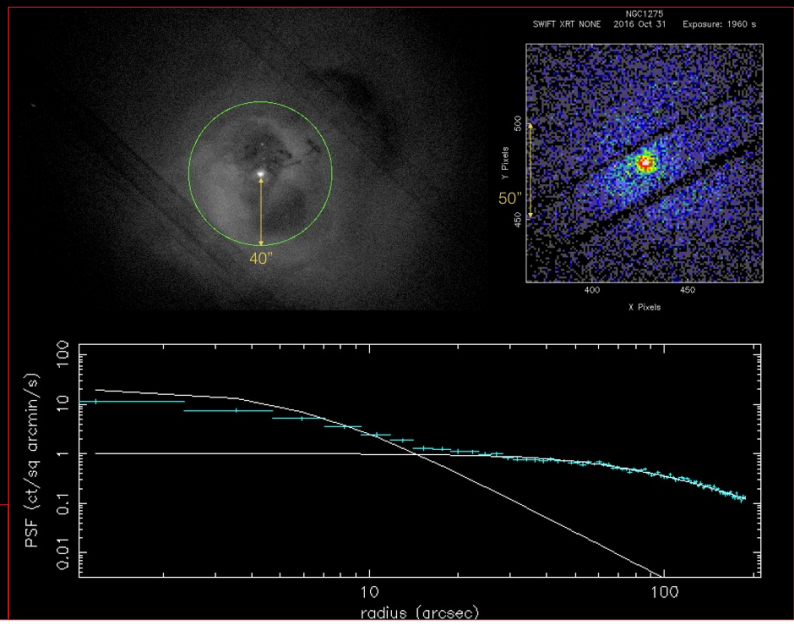
Chandra image by Fabian et al. 2006,
VLA 1.4 GHz image by G. Taylor



Walker et al. 2000

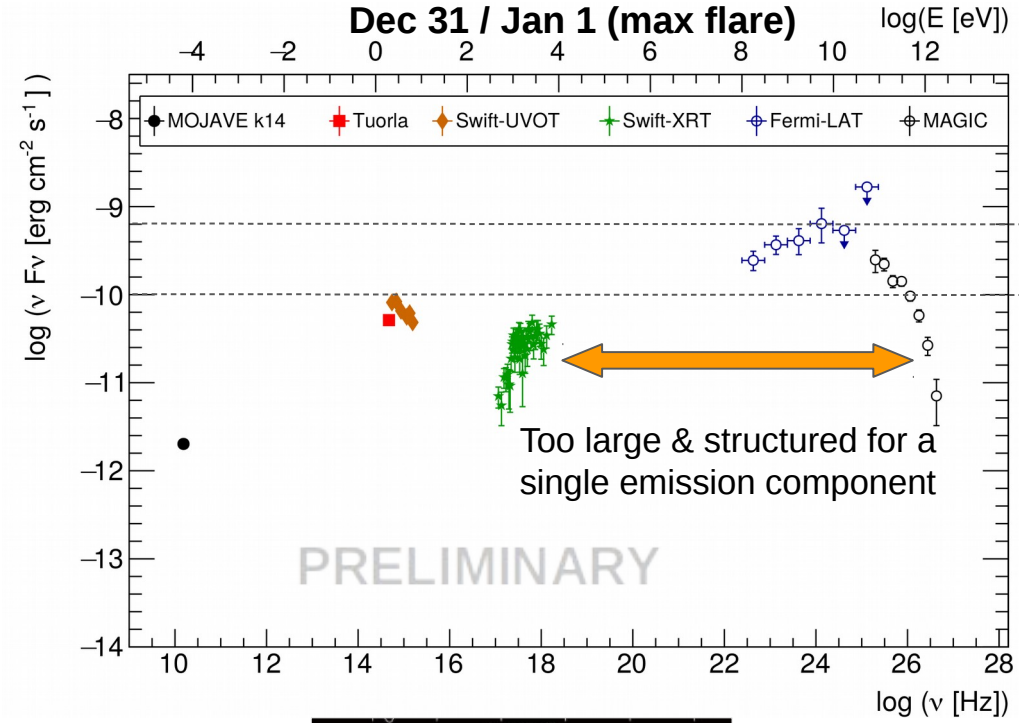


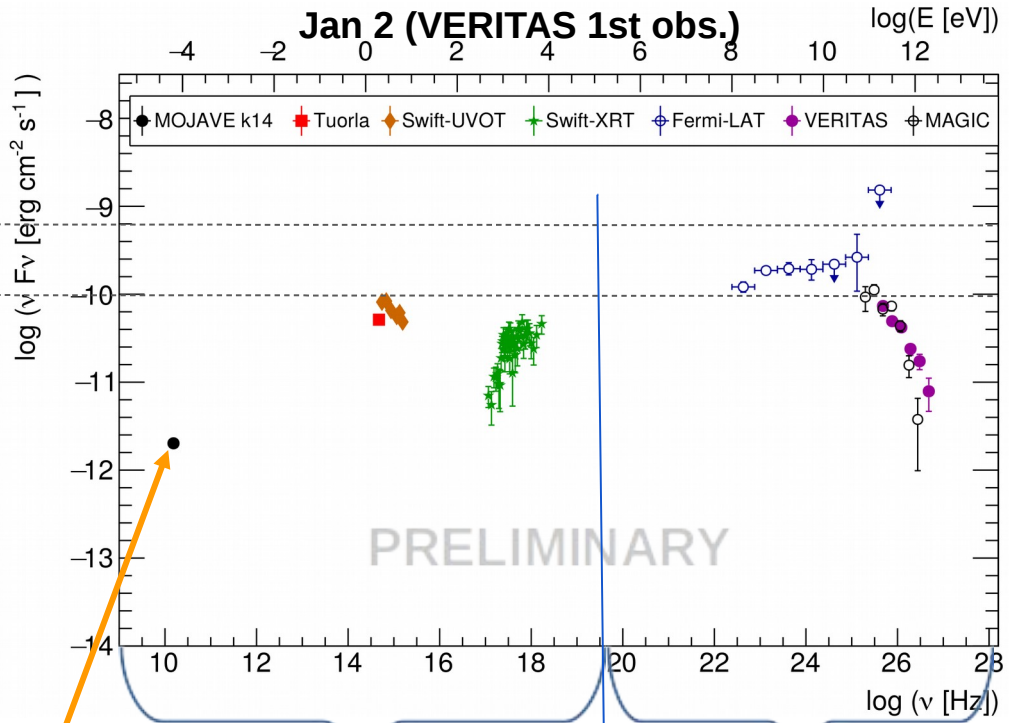
Nagai et al. 2014

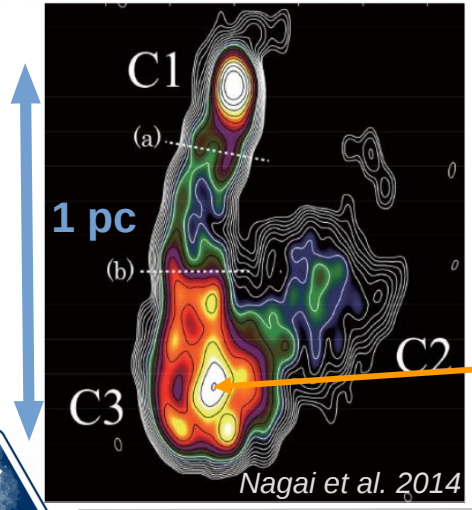


- X-ray extension and strong background
- Swift-XRT emission extracted in a radius of 5”

Multiwavelength SEDs of Jan 2017 flare





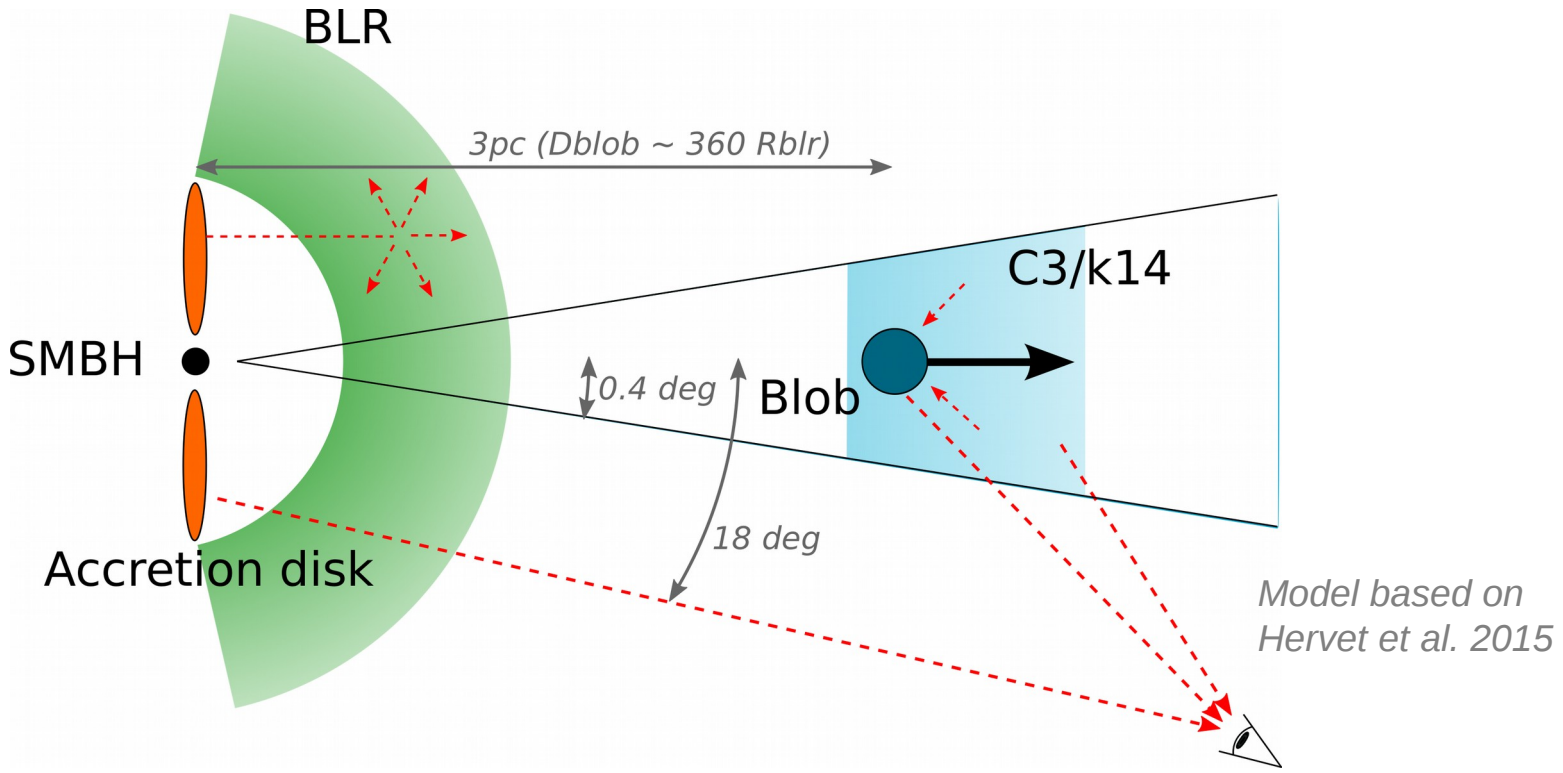


Quasi-steady component
→ large/slow zone

Flaring component
→ compact/fast zone

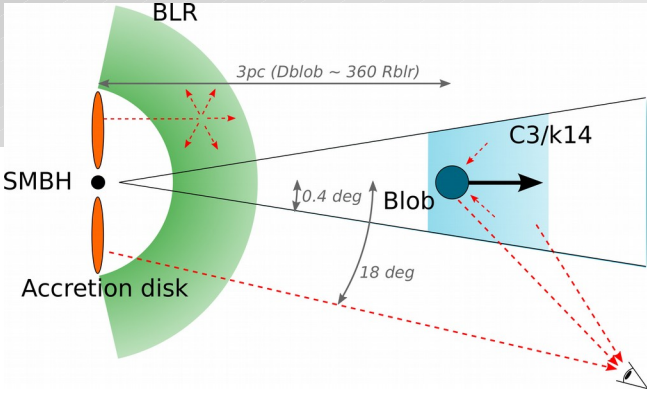
C3 is the brightest component observed by MOJAVE (k14)
~3.5 core flux at 15 GHz Dec 26th 2016

Multizone model: “Blob-in-C3”



- Consider blob within C3 at ~ 3pc from the core for an angle of 18deg *(Tavecchio et al. 2014, Giovannini et al. 2018)*
- Blob well outside the BLR, thermal external inverse Compton (EIC) not favored
- ...but possible strong EIC blob/C3
- Weak Doppler boosting $\delta_{blob} = 3$, $\delta_{C3} = 2$

Jan 2017 flare and post-flare

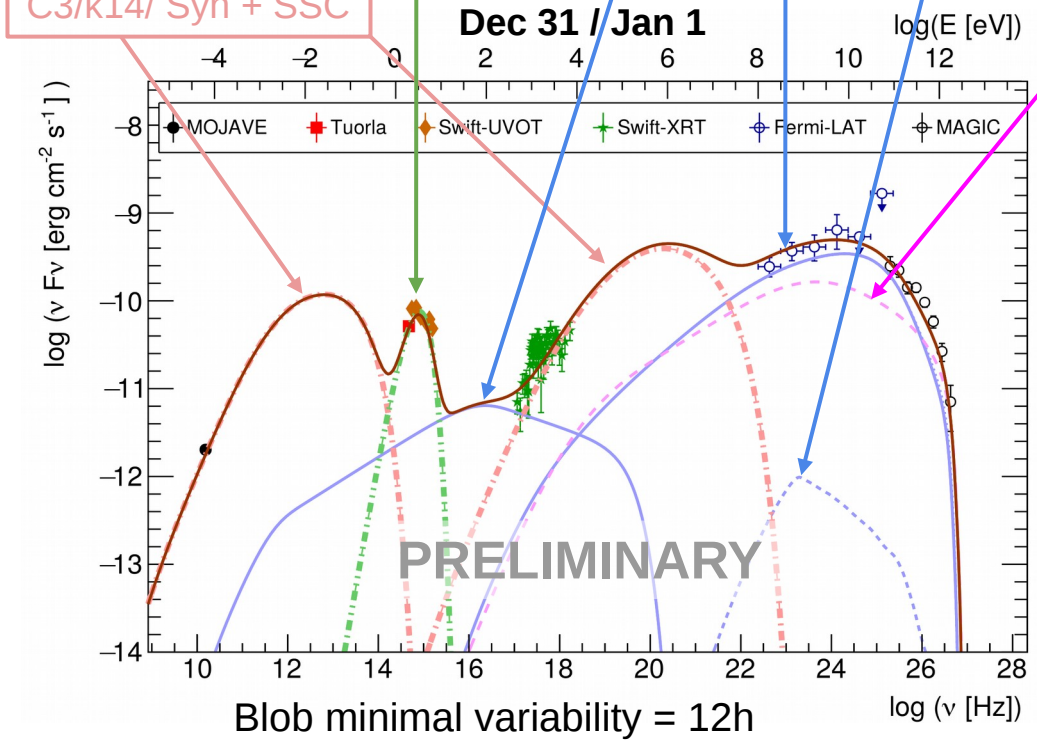


Blob Syn + SSC + 2nd order SSC

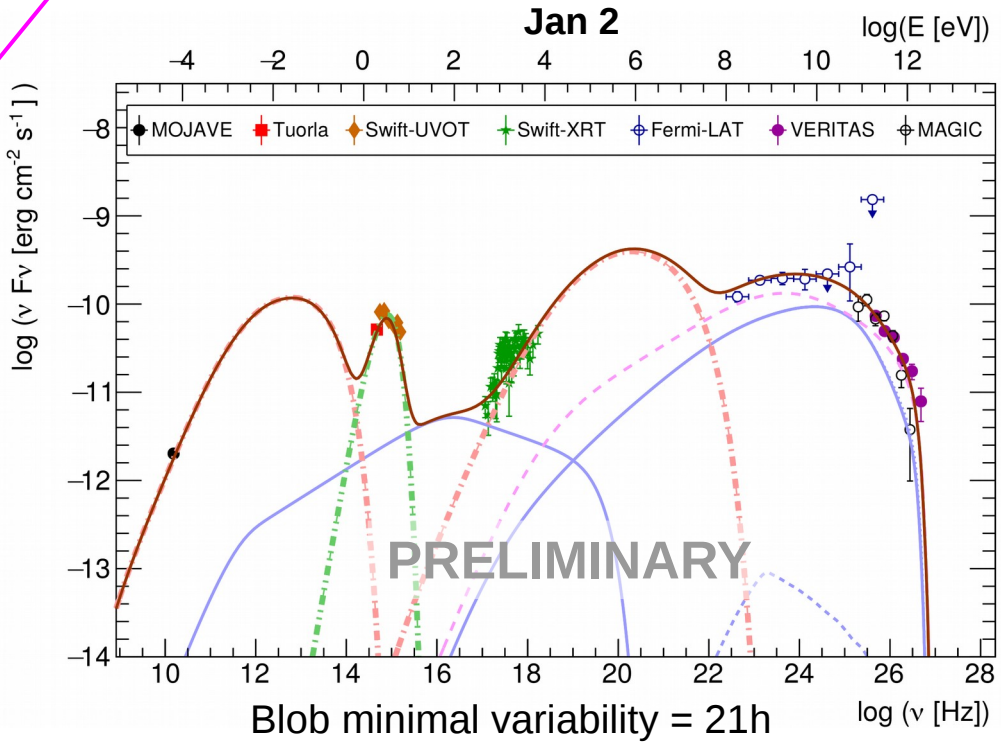
Disk BBB

EIC C3 Syn on blob

C3/k14/ Syn + SSC



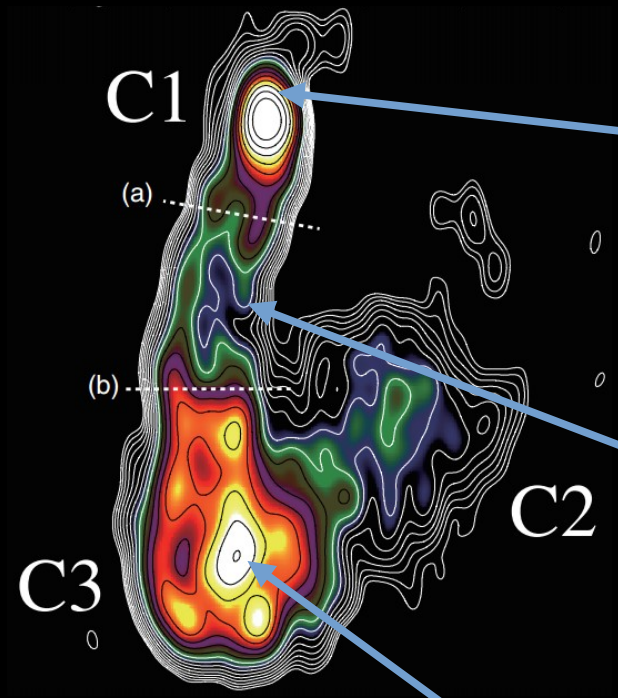
Blob minimal variability = 12h
C3 minimal variability = 12 days



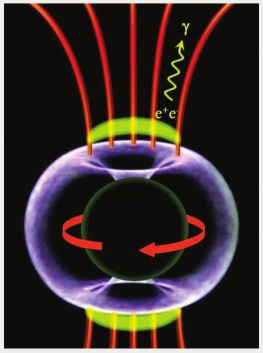
Blob minimal variability = 21h
C3 minimal variability = 12 days

Simple blob adiabatic expansion: $\rho \times V = \mathrm{cst}$

On the gamma-ray origin of NGC 1275



MAGIC Coll. 2018: "black hole lightning"

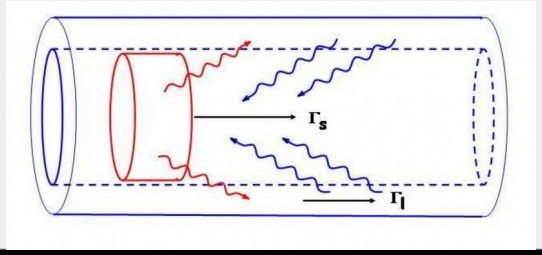


"The only possibility to fit the enormous luminosity […] would be an enhancement of the magnetic field threading the BH horizon"

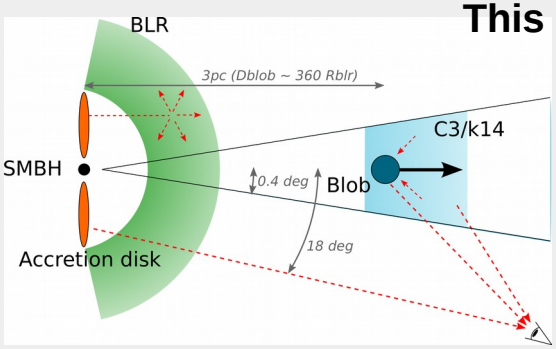
But need a gamma transparent BLR…
No modelling performed

Tavecchio et al. 2014: "spine-layer"

Produces good SED fit but requires low variability (>1week for previous NGC1275 study)



This model



- Good SED fit and fast variability with a relatively low power budget
- Geometrically constrained
- Would quickly reach its limits for a larger angle

Discussion & Outlook

The origin of VHE emission from radio galaxies is still not clearly understood, contradictory observations:
→ Large angle with the line of sight = weak (no) Doppler boosting
→ VHE production & fast variability = significant Doppler boosting

Are we sure that pc-scale jets of VHE radio galaxies are strongly misaligned?
(we can still have enough Doppler boosting up to ~20deg for sub-daily variabilty)

- Pc-scale blazar jets have been proposed for IC 310 *(Kadler et al, 2012)* & PKS 0625-354 *(H.E.S.S. Coll. 2018)*
- 3C 264 & M87 < 20deg *(VERITAS Coll. 2020)*
- Is Cen A the only truly misaligned TeV radio galaxy ?

NGC 1275, what really is the jet direction?

- **30-55 deg** consistent with VLBI data (counter-jet + Bapp ~0.4 c) *(Walker et al. 1994)*
- **11 deg** from apparent speeds *(MOJAVE Coll. 2009)*
- **~18 deg** from MWL SED and spine-layer model *(Tavecchio et al. 2014)*
- **65 +- 15 deg** (same approach as Walker 94, with Bapp ~0.23 c) *(Fujita & Nagai 2017)*
- **~4 deg** from jet opening, but admit this source suffers from a Doppler factor crisis *(Jorstad et al. 2017)*

Precise estimation of radio galaxies pc-scale jet directions is critical for understanding the origin of gamma-rays