THE RADIO COUNTERPART OF THE 2009 EXCEPTIONAL GAMMA-RAY FLARE IN 3C273

Zulema Abraham
Pedro Paulo Beaklini
USP/ Brazil

Flares in QSRs

- It is well accepted that radio-IR emission in QSRs is of synchrotron origin and X- and gamma-rays Inverse Compton

- It is also believed that flares are enhanced emission originated by particles accelerated in shocks that propagate in jets, forming the superluminal components

- The shock will be optically thick at radio frequencies and will be first detected in the IR

Flares in QSRs

- As the shock propagates, it expands and eventually becames optically thin, and it can detected at radio frequencies.
- This model was first postulated based on the observation of a radio-IR flare thar occured in 1983 (Marscher & Gear 1985)
- The study of the relation radio-IR with gamma rays only became possible FERMI observatory.

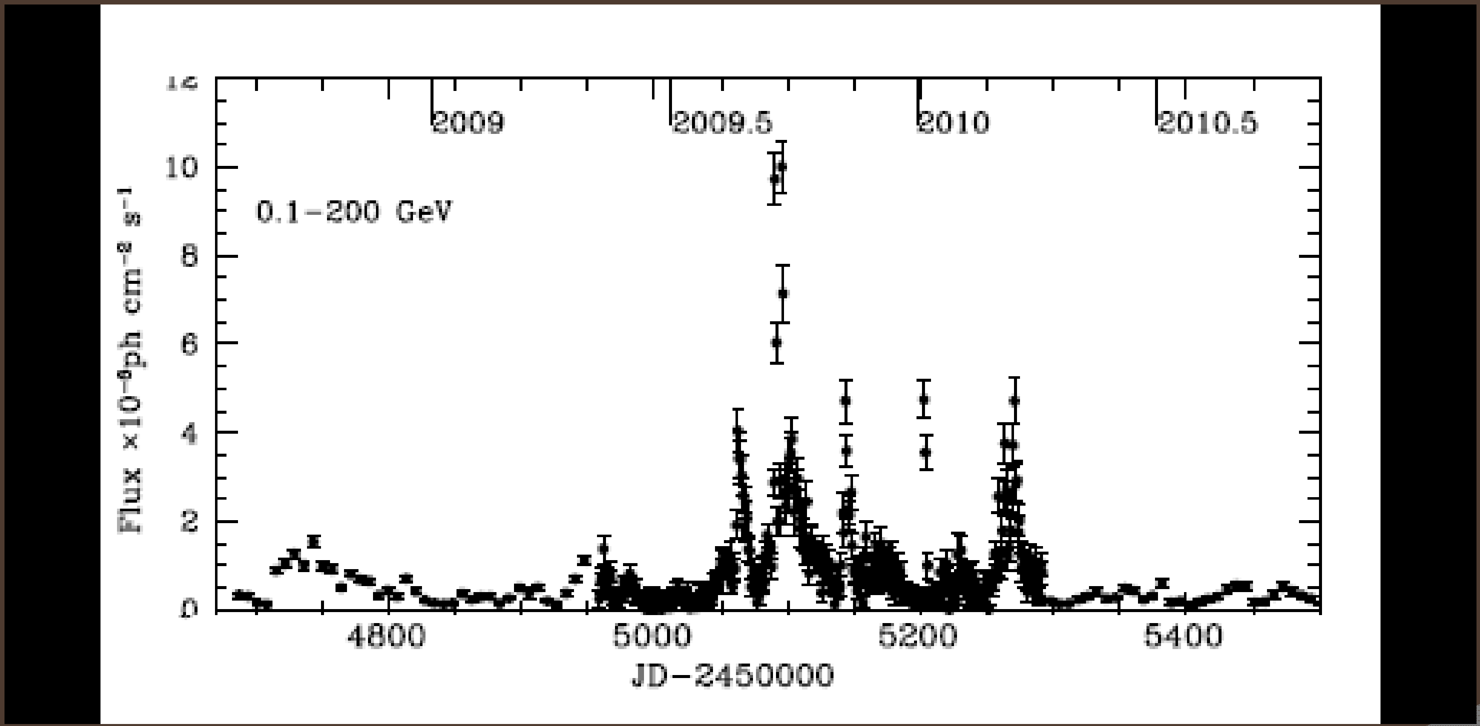
Flares in QSRs

- The result of these studies is that there is a good correlation between IR, optical and gamma variability, with almost no delays between them (Chatterjee et al. 2012)
- There is also a correlation between gamma-ray flares and the appearence of new superluminal components (Jorstad et al. 2011)
- It is difficult to measure the delay between radio and gamma-ray emission, because these delays are similar to the rate of formation of the superluminal components

Flares in QSRs

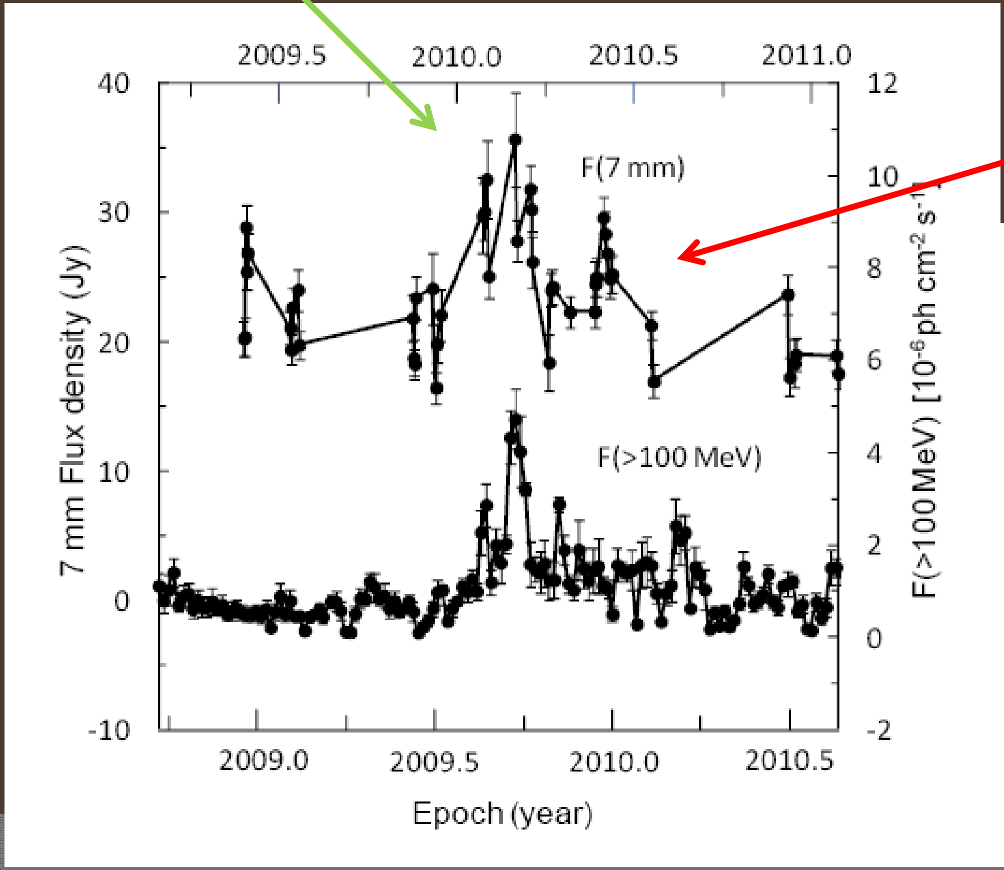
- Another question thar still open is the relation between the intensity of the emission at different frequencies.
- In particular, a very strong and complex gamma-ray flare occured in 3C273 in September 2009 (Abdo et al. 2010).
- The flare was related to the formation of a series of superluminal components at 43 GHz (Jorstad et al. 2011)
- Here we report the single dish detection of this flare at 43 GHz, with the Itapetinga radiotelescope, with a delay of 170 days.

Gamma-ray flare

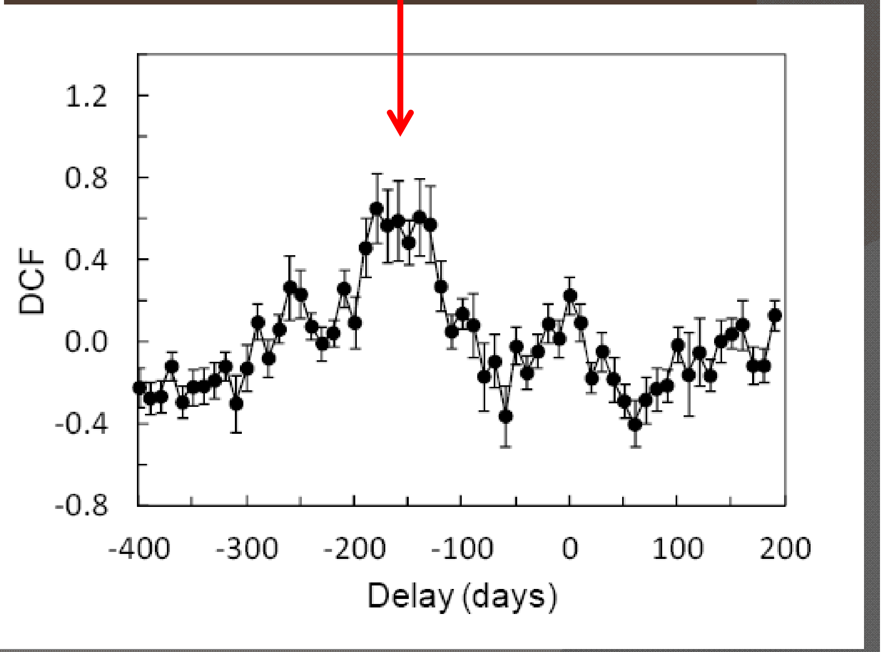


Correlation with radio

Flare observed at Itapetinga (7 mm or 43 GHz)



shifted by 170 days



Correlation with radio

- Although the intensity of the gamma-rays was the largest ever detected in 3C273 (a factor of 20), the intensity of the radio emission increase only by a factor of 2.

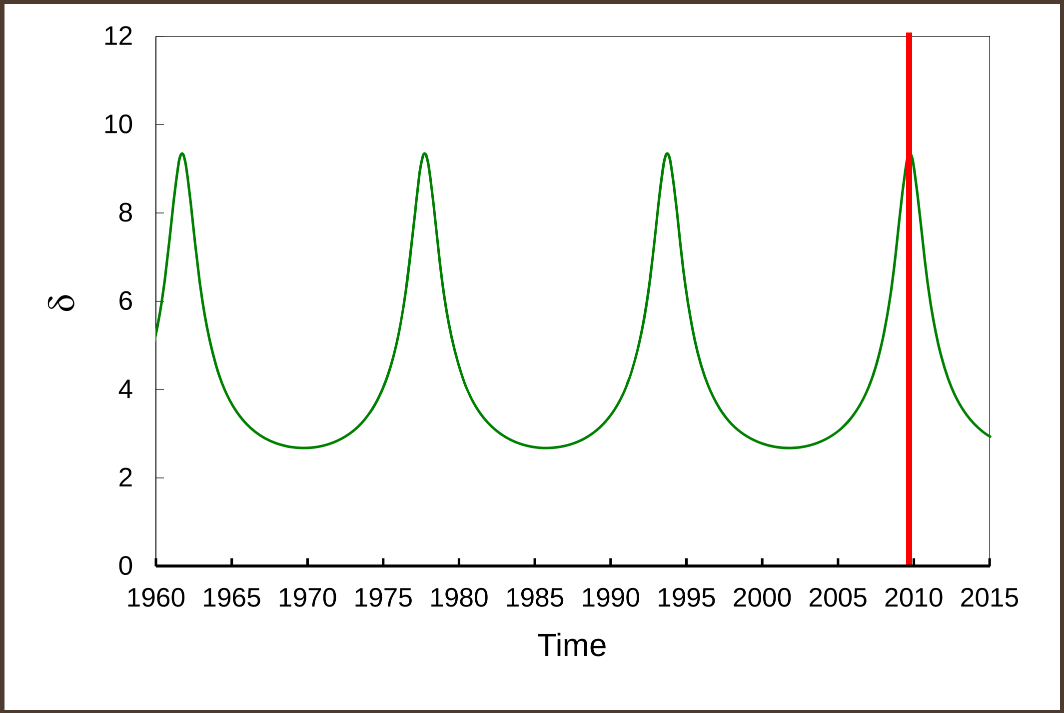
- We explain this fact as a consequence of a change of the Doppler factor, due to a change of the angle between the jet and the line of sight

- This fact, including the epoch of enhanced X-ray emission was already predicted by the precession model of Abraham & Romero (1999)

The precessing model

- This model was based in the detection of a curvature in the parsec scale jet projected in the plane of the sky, and in the differences in velocities of the superluminal components, which reflect the angle with the line of sight
- Assuming a constant Lorentz factor, we found the observations compatible with a period of 16 years
- Precession will produce a change in the Doppler factor, which will be larger when the angle between the jet and the line of sight becomes smaller.

Intensity of radio and gamma-rays



$$S_{\text{app}}(\nu) = S_{\text{source}}(\nu)\delta^{p+\alpha}$$

$$\delta = \frac{1}{\gamma}\frac{1}{1-\beta\cos\theta}$$

$$\gamma = \frac{1}{\sqrt{1-\beta^2}}$$

p =2 α = -2 (radio) α = 1 (gamma-rays)

Consequences of variation in δ

Delay radio-gamma $$\tau(\delta_2) = \frac{\delta_1}{\delta_2}\tau(\delta_1)$$

$$\tau(\delta_2) = 170 \text{ days} \Longrightarrow \tau(\delta_1) = 340 - 510 \text{ days}$$

However, the frequency of observation corresponds to:

$$\nu(\delta_2) = \frac{\delta_2}{\delta_1}\nu(\delta_1)$$

or:

$$\nu(\delta_2) = 43 \text{ GHz} \Longrightarrow \nu(\delta_1) = 21 - 14 \text{ GHz}$$

However: $\tau(\nu) \propto \nu^{-\beta}$ with $\beta \sim 1$

Therefore, the increase of the delay (in the jet reference) is a consequence of the decrease in the frequency (also in the jet reference system)

Conclusions

- We detected the radio counterpart of the strong gamma-ray flare of August 2009
- We were able to explain the high gamma-ray flux density as the result of an increase in the beaming factor
- This increase was predicted by the precession model of Abraham & Romero (1999) and occurred at the predicted epoch
- The observed time delay is in agreement with what is expected, because the observed frequency (43 GHz) corresponds to a lower frequency in the jet reference system.