Inverse-Compton "mirror-flash" emissions in γ-rays?

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the two remarkable cases of 3C 454.3 and PKS 1830-211 on late 2010

These challengig events show ratios between optical and γ-rays variation factors

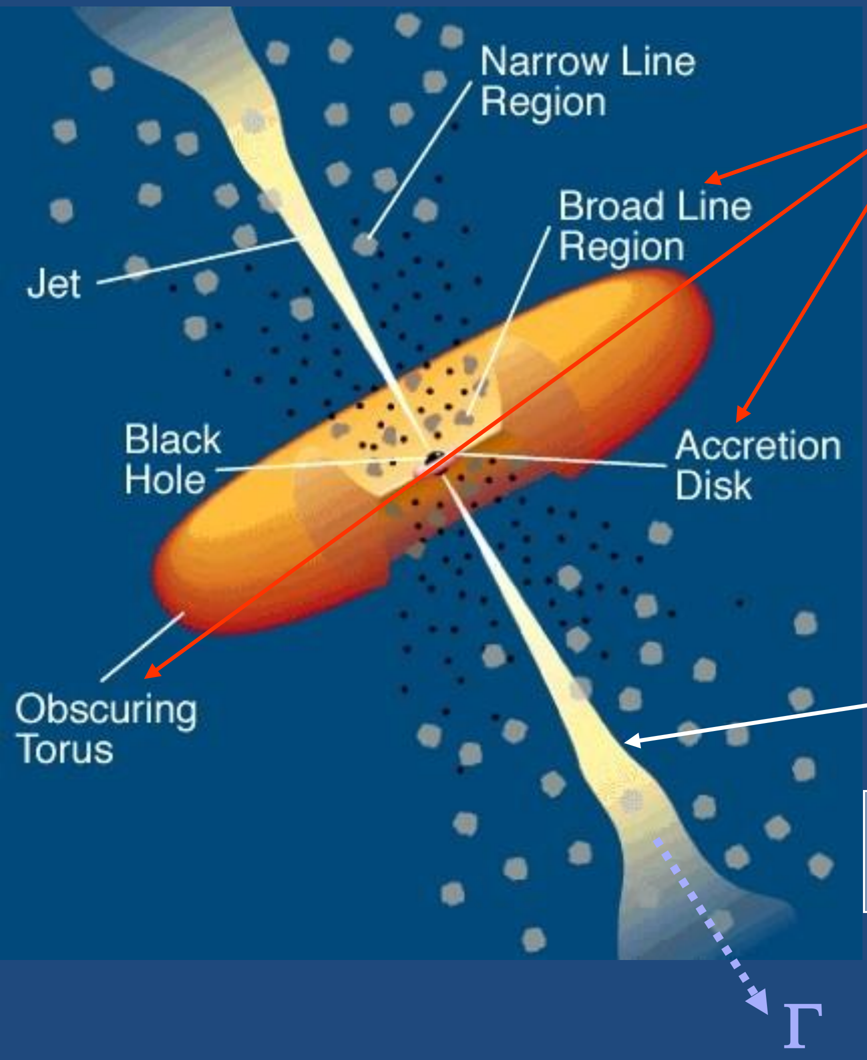
$\rho = A_{\gamma} / A_{opt} > 2$ **or more, that is, Compton dominance varies**

Standard EC predicts $\rho = 1$

Moreover γ-flux shows doubling time of few hours in these events.

V.Vittorini, E. Striani, M. Tavani, A. Cavaliere, S. Vercellone on behalf of the AGILE AGN WG

FSRQ standard model



External: galaxy frame (z) ,
radiation connected with accretion

External photons N_{ext} and jet electrons $n_e(\gamma)$

produce → **External Compton (EC)**

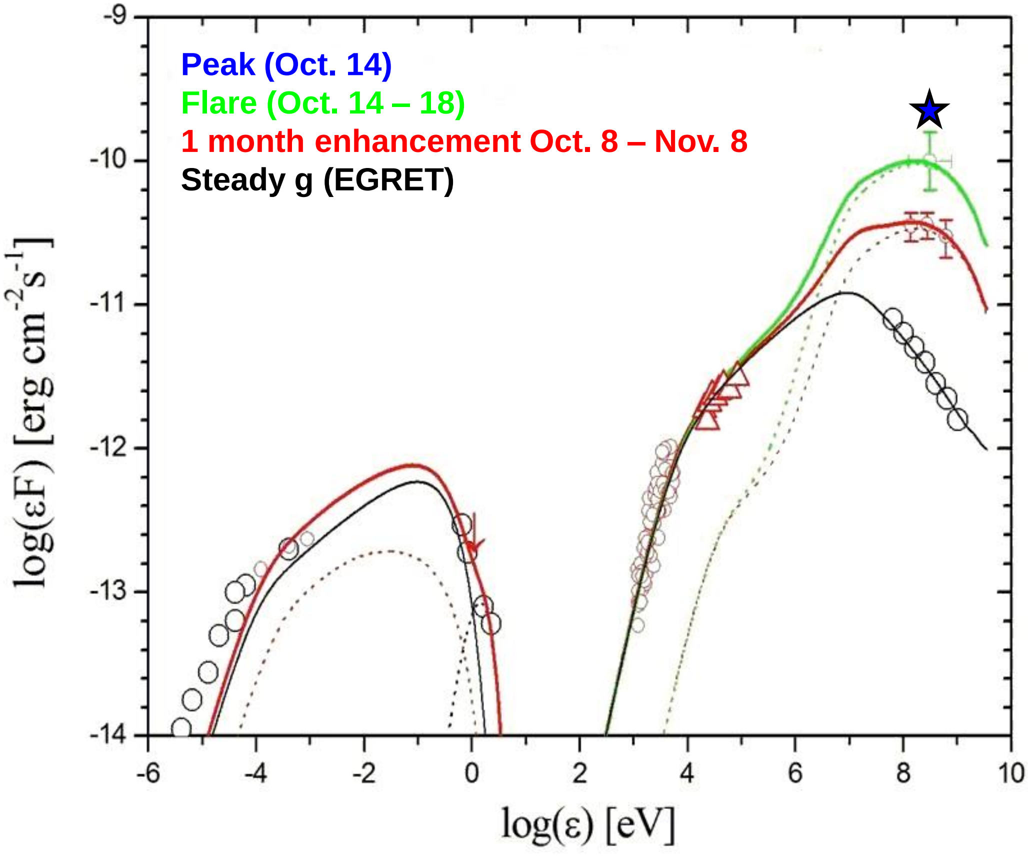
Jet: blob moving with Lorentz factor Γ,
beamed, non thermal radiation

Electron distribution $n_e(\gamma)$ and magnetic field B

produce

Synchrotron + Inverse Compton (SSC)

PKS 1830: an extreme instance



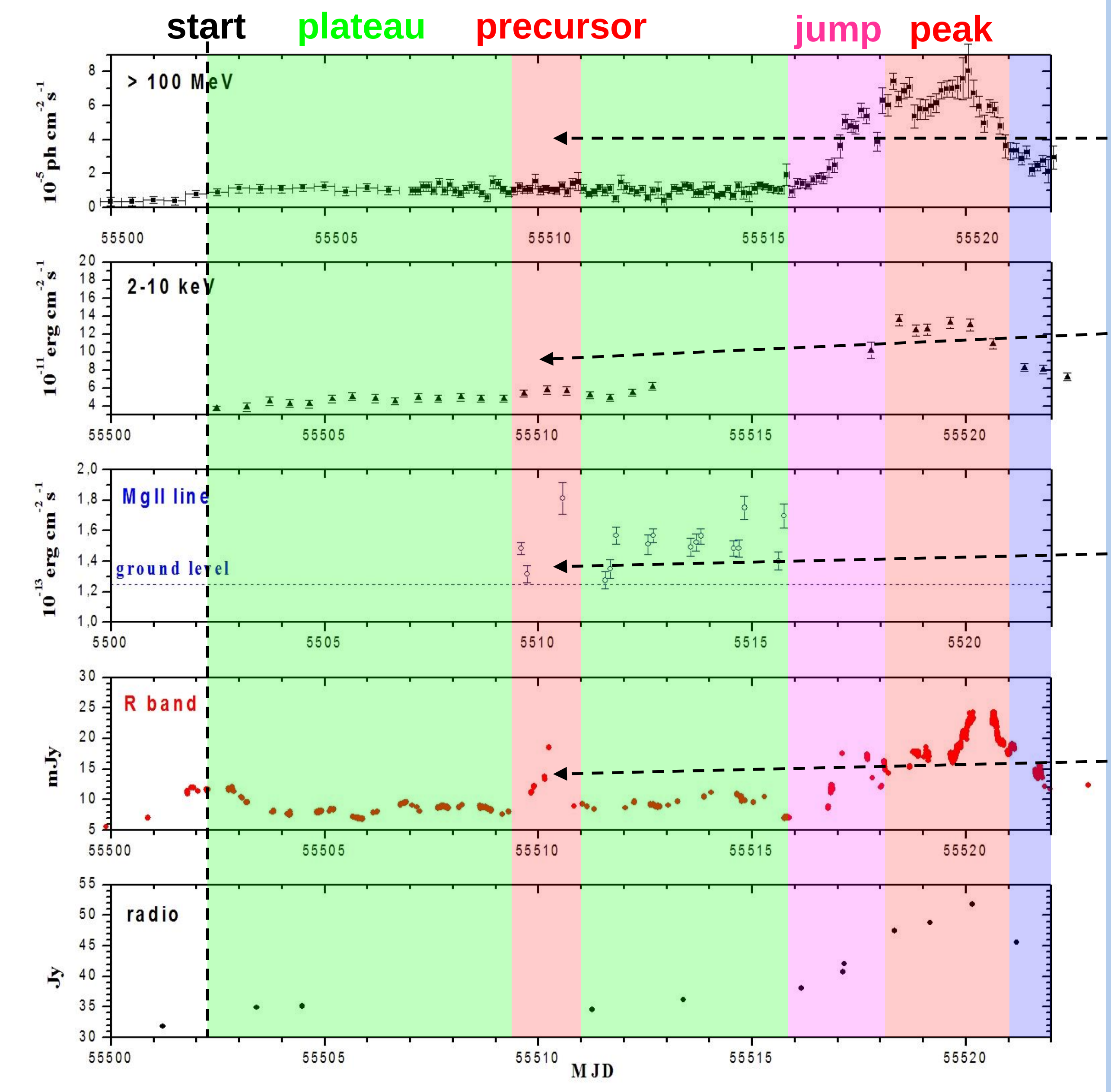
Ciprini et al. 2010; Donnarumma et al. 2011

Orphan gamma-flare during a montly activity (**A_γ=3**): Optical and X-ray remain at hystorical steady levels.

A second component of shocked particles (red dotted lines) can account for this **monthly enhancement** in gamma-rays with little or no contributions in optical and X-rays.

But the fast orphan flare (**A_γ = 5 on 6 hours**) around Oct. 14 would require some variation in the external field of seed photons !

The November 2010 super flare of 3C 454
(Vercellone et al. 2011)



No gamma-ray counterpart:
$\rho = 0$ **,** whereas at the start and during the plateau $\rho = 1$

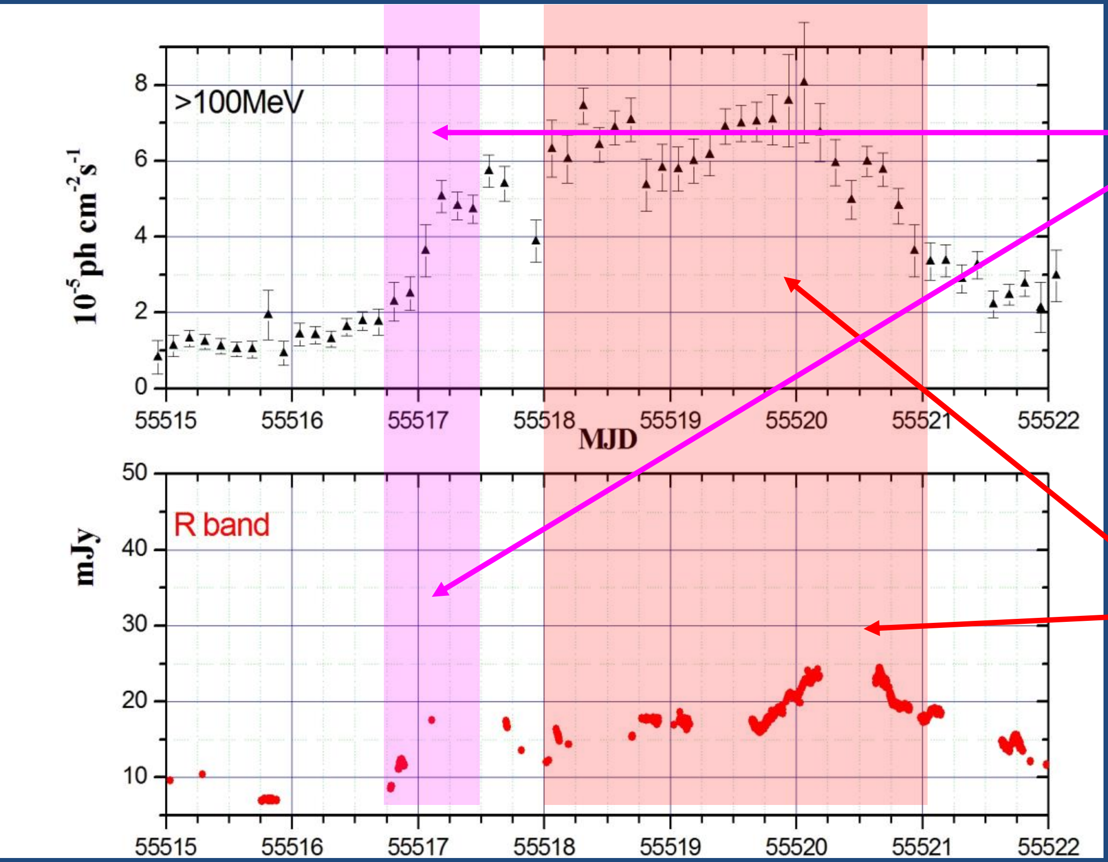
Faint soft X-ray counterpart
(SC plays a secondary role!)

MgII line flux variations of 30% (Leon Tavares 2013)

Strong 1 day optical flare
(energization of a new component in the inner jet)

With courtesy of E. Striani and J. Leon Tavares

3C 454 November 2010



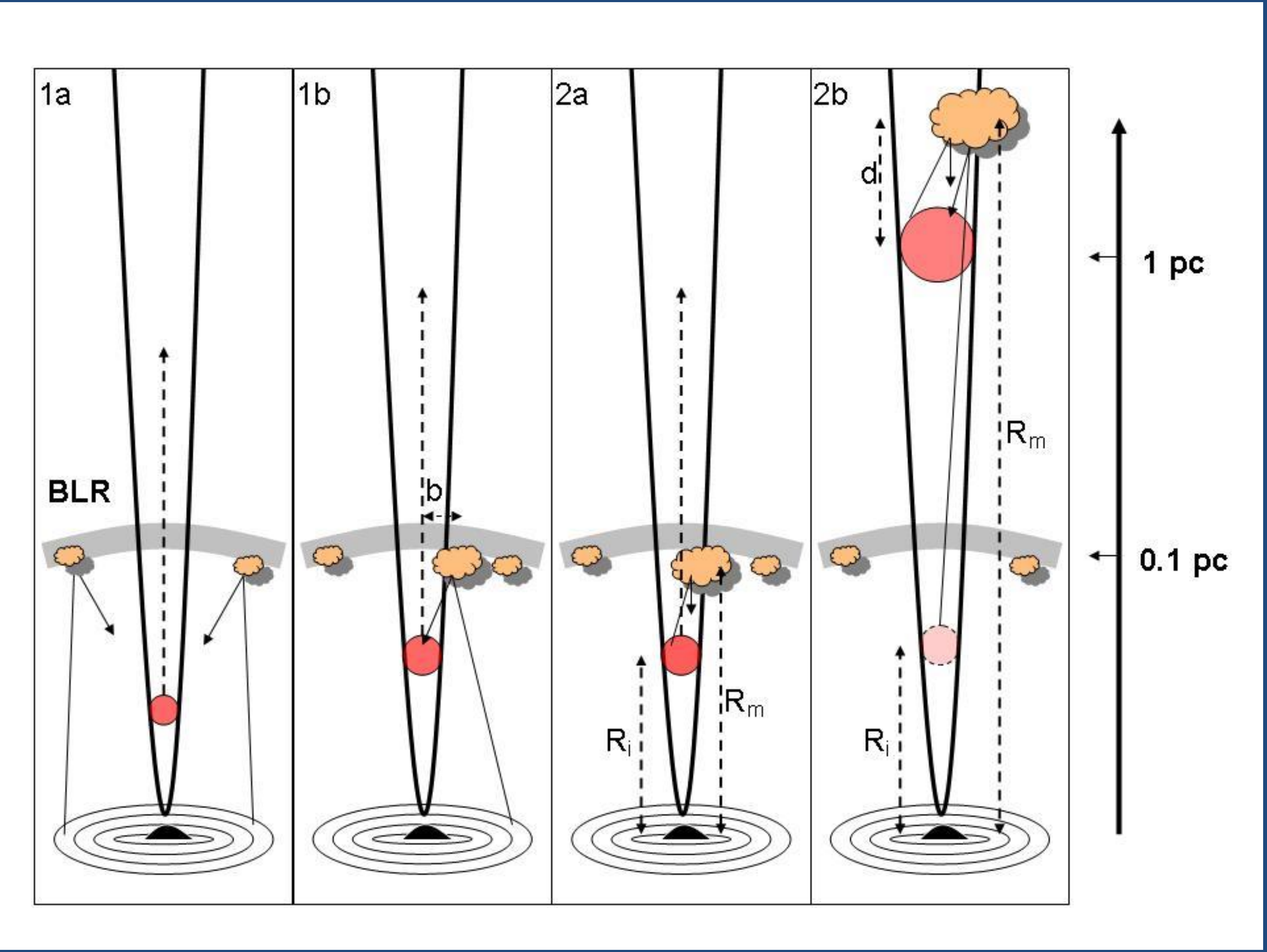
Around MJD 55517 the γ ray flux jumps by A_γ = 4 - 5
While the optical flux rises by A_{opt} = 2 only, with ρ>2!

γ ray flux doubles in 6 hours whereas optical flux doubles in 10 hours

Later on, variation factors appear to be comparable with ρ=1

To account for this complex correlation, some variations are required in the external photon field seen by the moving blob!

Four models for EC from clouds



1a: EC from the whole BLR that reprocess the disk radiation

1b: EC from a single cloud reprocessing the disk radiation

2a: a single cloud mirrors the approaching blob within the BLR

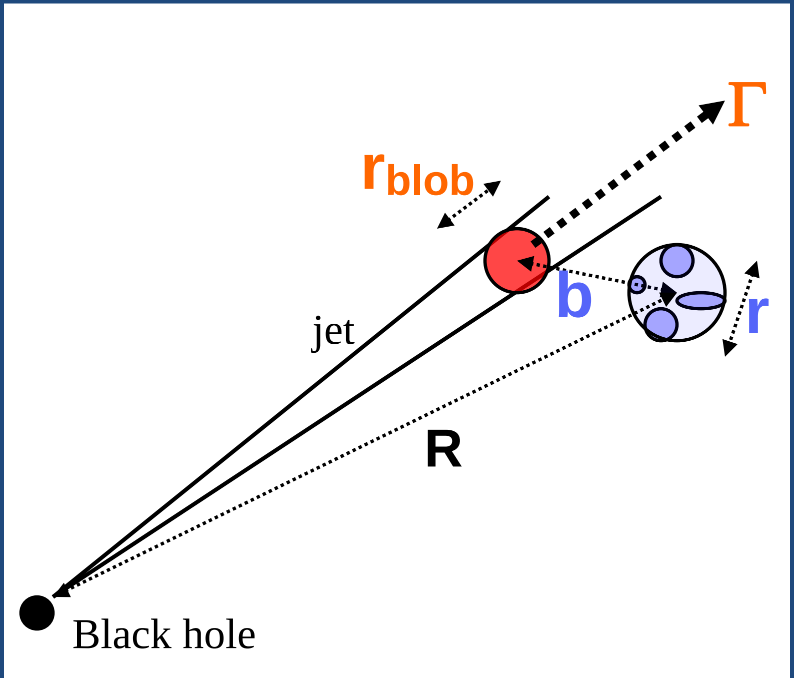
2b: same as 2a, but beyond the BLR

Vittorini et al. 2014 ApJ submitted

Wath happens when a scattering system crosses the jet trajectory at **$R<R_{BLR}$** ? (case 1b)

In standard EC from BLR, clouds cover **a = 10%** at distance **R_{BLR}= 5 10^{17}cm**, and reprocess **f = 20%** of the disk luminosity **L_D**.
The energy density of photons seen by a plasmoid moving with bulk Lorentz factor Γ is

$$U'_{BLR} \approx a\, f \frac{L_D \Gamma^2}{4\pi c R^2_{BLR}}$$

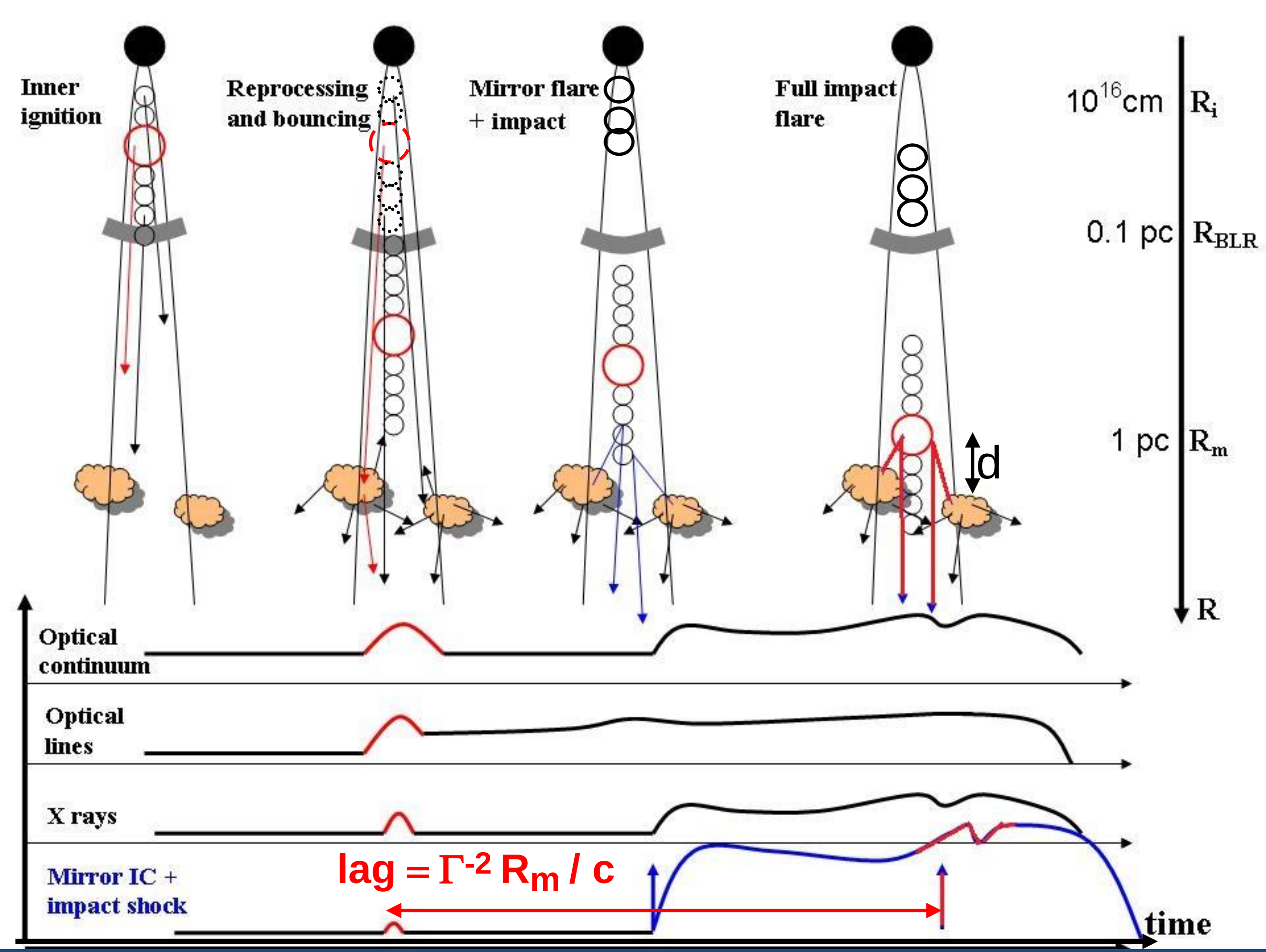


When the plasmoid approaches at distance b << R_{BLR} a scattering system of size r, a gain

$$g \equiv 1 + a^{-1}\left(\frac{r}{2b}\right)^2 \lesssim 5$$

can be obtained with
U'_{loc} = g U'_{BLR} on time-scale
Γ^{-2} (r + r_{blob}) / c

Vittorini et al. 2014 ApJ submitted



…And beyond the BLR? (case 2b)

$U'_{MIR} = f\, L'_{syn}\, \Gamma^4 / (cd^2) = U'_{BLR}\, (L_S/L_D)\, (R_{BLR}/\Gamma d)^2$

But causality constrain $d < R_m / (4\Gamma^2)$, then $U'_M > U'_{BLR}$ results for a crossing time

$\Delta t_{obs} = (d+r)/(c\Gamma^2)$
Is the observed duration

$t_{del} = d/(c\Gamma^2)$= half hour
Blob impact delay

Adequate γ amplification

Rise-time of few hours

Shock delay of half hour

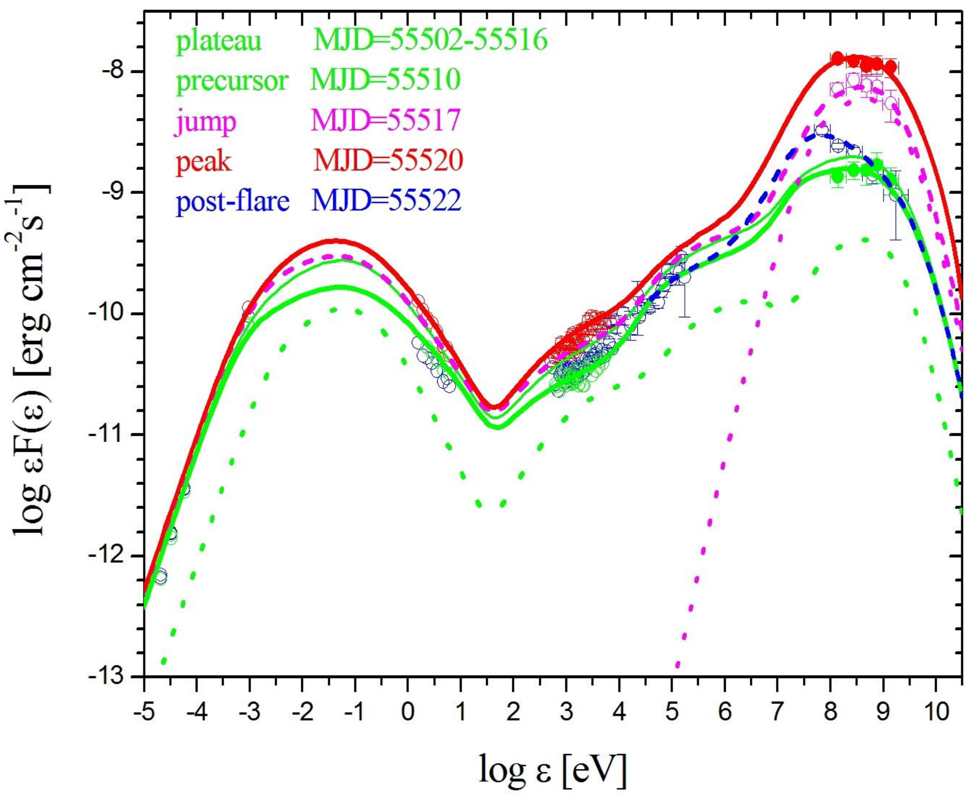
γ-ray emitted at pc scale

Optical precursor with 30% line enhancement

Vittorini et al. 2014 ApJ submitted

3C 454 in Nov. 2010

Vittorini et al. 2014
ApJ submitted



This idea explains the SED during the entire period of activity, by **a plasmoid train:**

Plasmoids are continuosly ejected emitting the **plateau** and the **opt. precursor** within the BLR.

When the edge of the train attains the **mirror** located at distance **R_m = few pc**, strong mirror-EC is produced causing the **jump** in **γ rays** with **ρ > 2** !

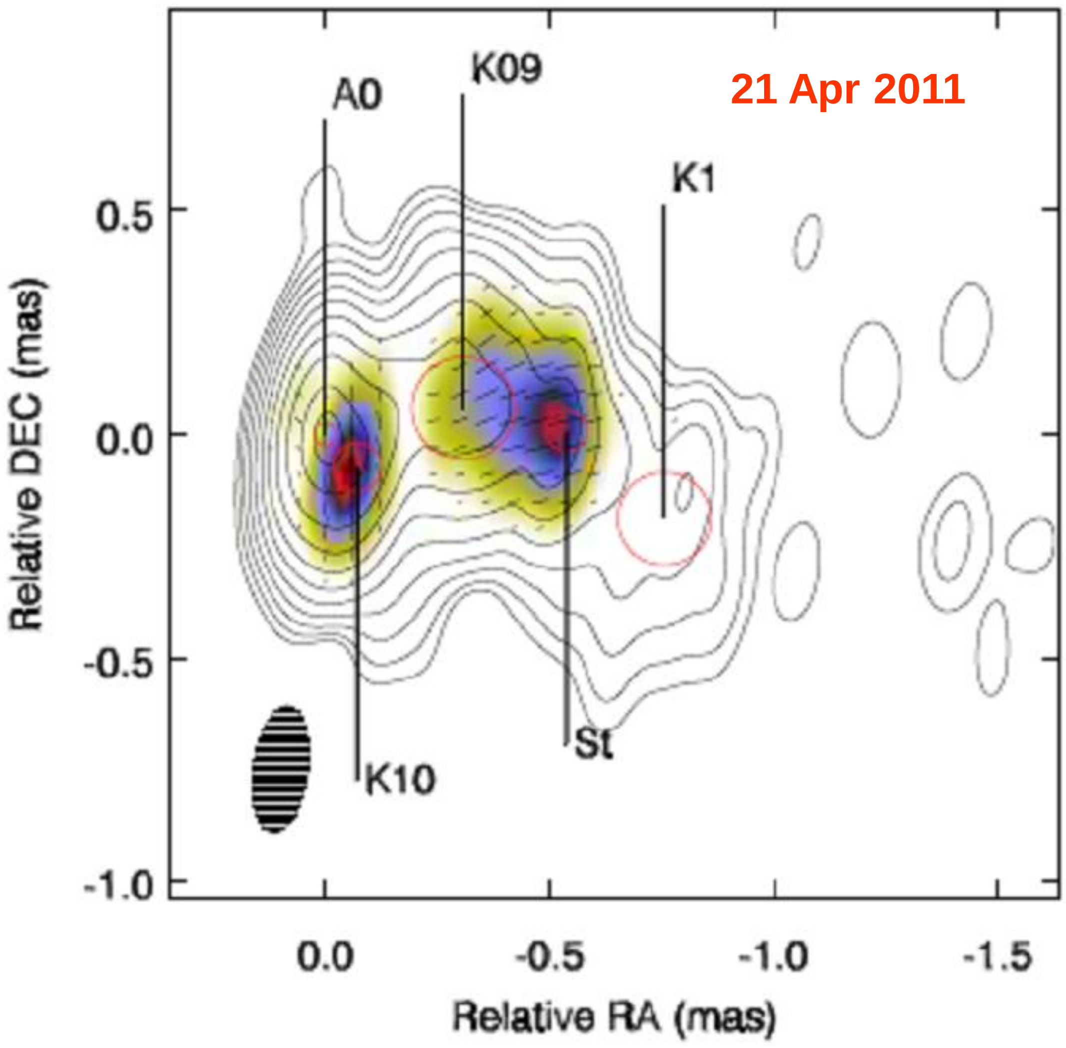
The **peak** in **γ rays** is emitted when the dominant plasmoid (responsible of the opt. precursor) attains the **mirror.** The lag between the **opt. precursor** and the related **peak** is **$\Gamma^{-2} R_m$ / c = 7 days** with **Γ=10**

Data concerning PKS 1830 and 3C 454 suggest:

Ejection of several plasmoids seem unavoidable in order to account for the complex **optical vs. γ-ray** correlations and for the **2-week plateau**.

Standard EC models are challenged!
In fact, variations in the external photon field seen by the blob are required to understand the **strong variations observed in Compton dominance** with **very fast γ-ray variations** (100% in few hours).

Mirroring of the blob photons by scattering material beyond the BLR ensures **fast optical events within the BLR and fast γ-ray emission at pc-scales** correlated with **lag of weeks.**
Moreover, **enhancements in the line-emission** are predicted.



The knot K10 emerges from the core **T=160** days after the flare (Jorstad et al. 2012).

With a jet opening angle 1.6° K10 traveled **R_c=16** pc before being resolved.

For **Γ = 10** and **$\theta = \Gamma^{-1}$** the predicted lag is

$T=(1-\beta\cos\theta)\, R_c / c$

$T=\Gamma^{-2} R_c / c$ = 0.5 years