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

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

Name	Affiliation
A. Bulgarelli	INAF-IASF Bologna
A.W. Chen	INAF-IASF Milano
I. Donnarumma	INAF-IASF Roma
P. Giommi	ASDC Roma
A. Giuliani	INAF-IASFMilano
F. Longo	INFN Trieste
C. Pittori	ASDC Roma
L. Pacciani	INAF-IASF Roma
G. Pucella	ENEA Roma
E. Striani	INAF-IASF Roma
S. Vercellone	INAF-IASF Palermo
V. Vittorini	INAF-IASF Roma & Univ. Tor Vergata

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

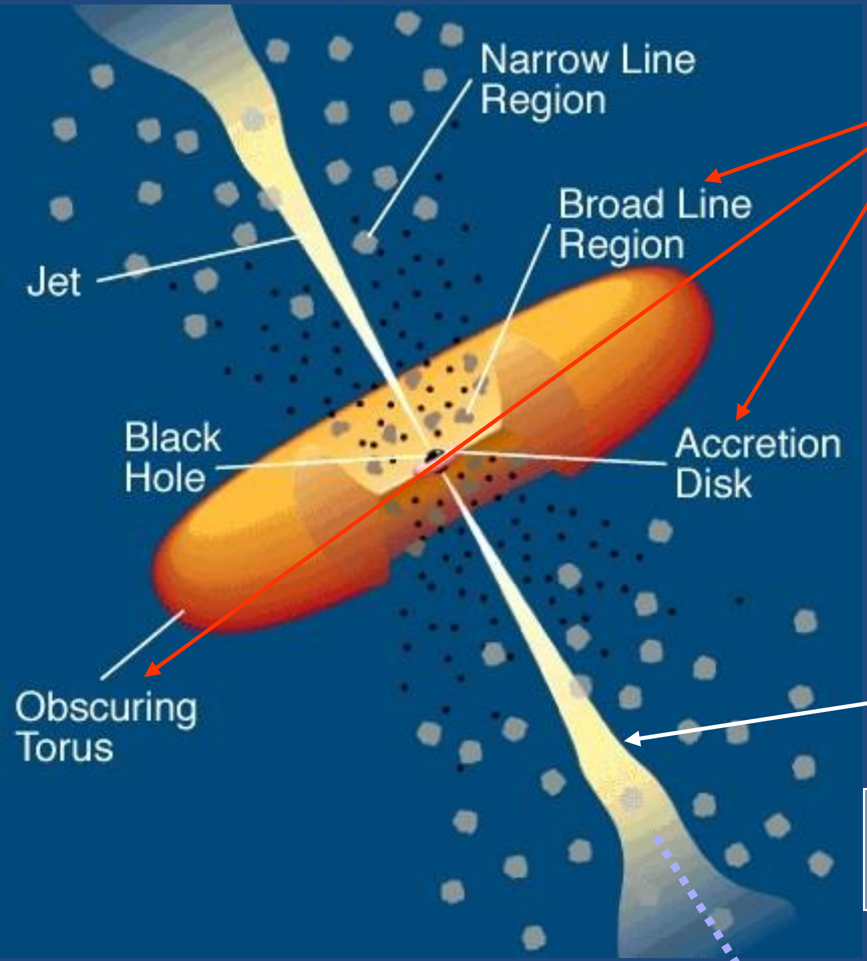
$\rho = A_{\gamma} / A_{opt} > 2$ or more.

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

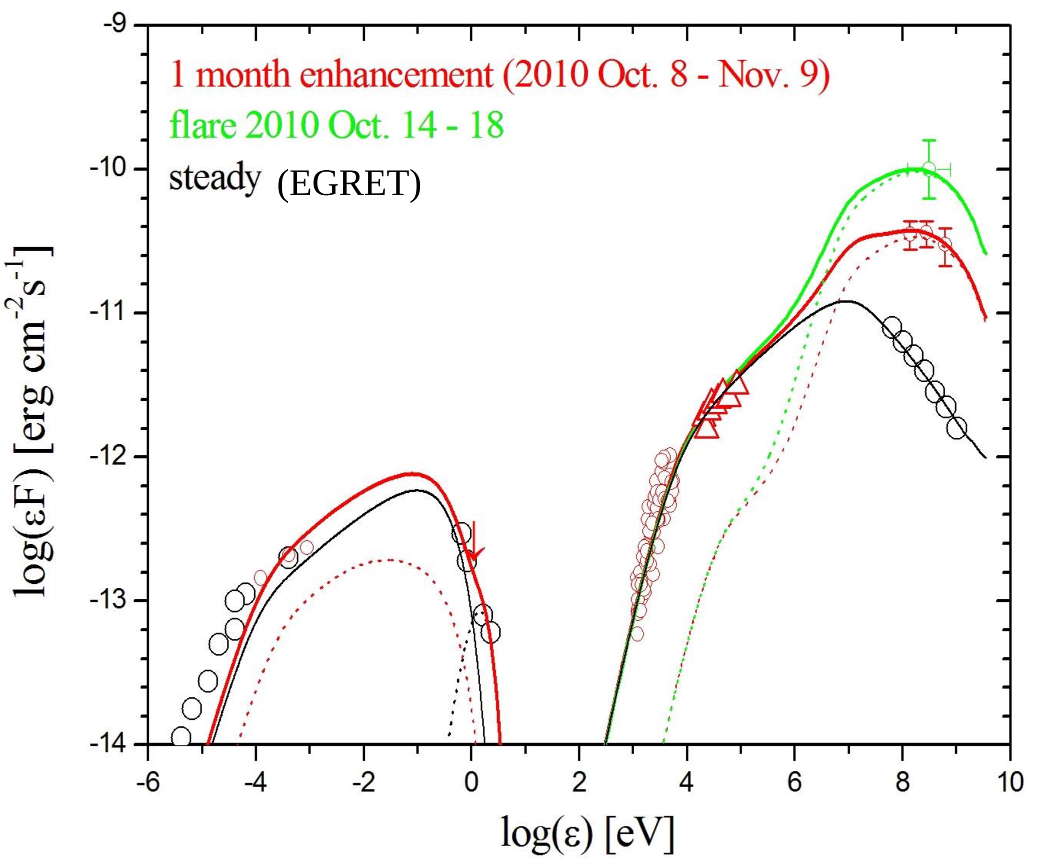
Γ

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

produce

Synchrotron + Inverse Compton (SSC)

PKS 1830: an extreme instance



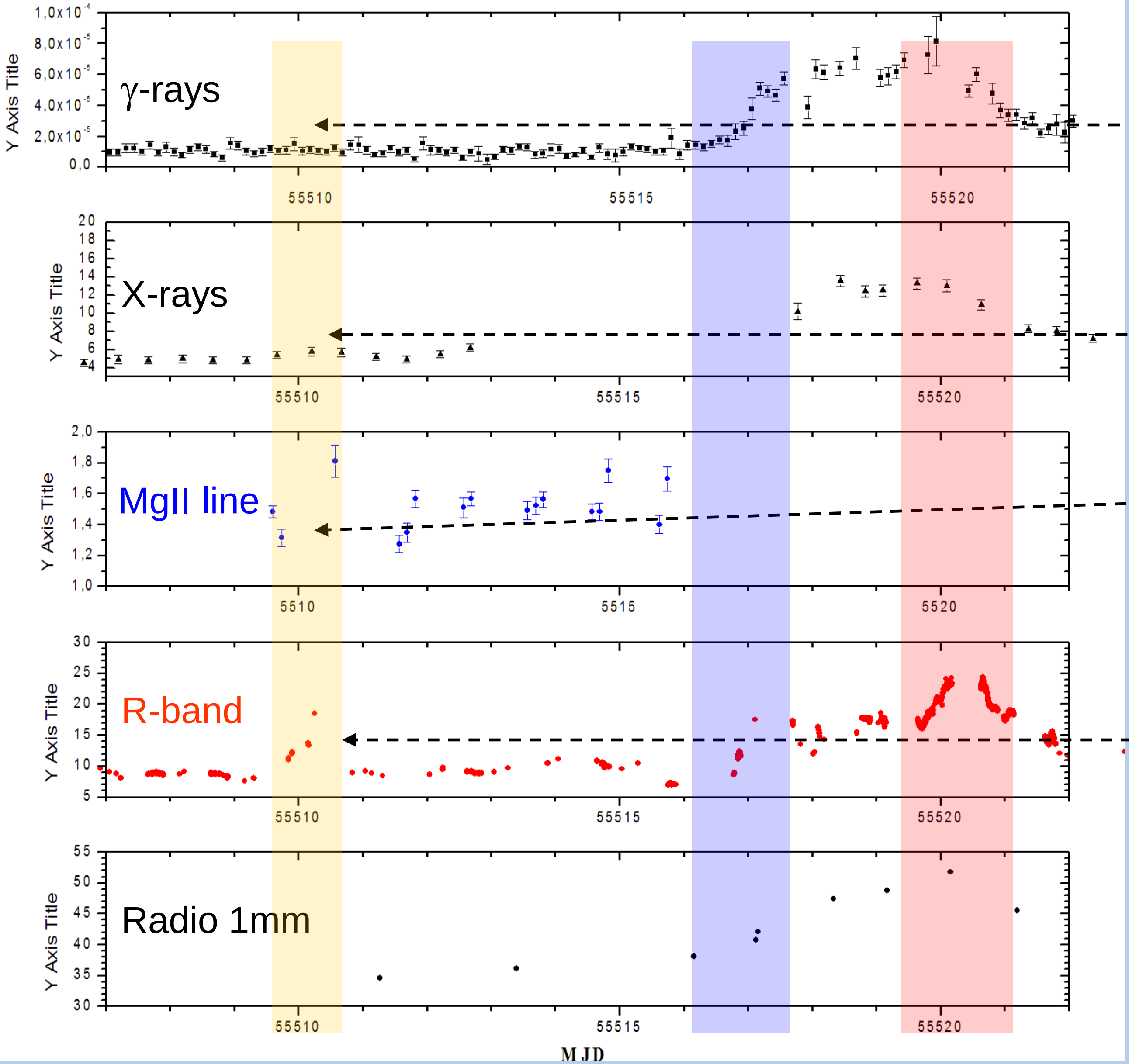
Orphan gamma-flare during a montly activity: Optical and X-ray remain at hystorical steady levels, and **ρ=3**

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

But the **fast orphan** flare (**A_γ = 3 on 6 hours**) around Oct. 14 would require some variation in the external field of seed photons !

Ciprini et al. 2010; Donnarumma et al. 2011

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



No gamma-ray counterpart

Faint soft X-ray counterpart

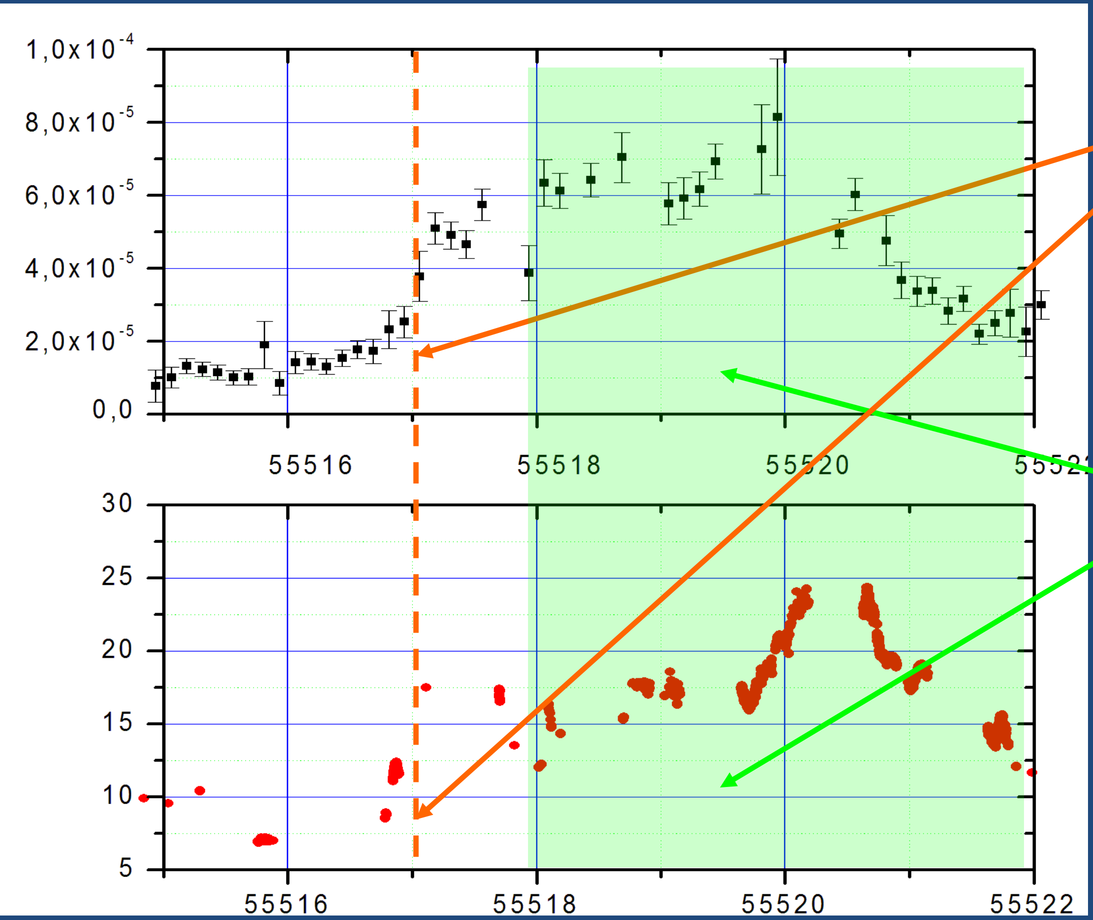
(SC plays a secondary role!)

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 factor $A_\gamma = 4 - 5$ while the optical flux rises by a factor $A_{opt} = 2$ only!

γ ray flux varies of 100% in 6 hours

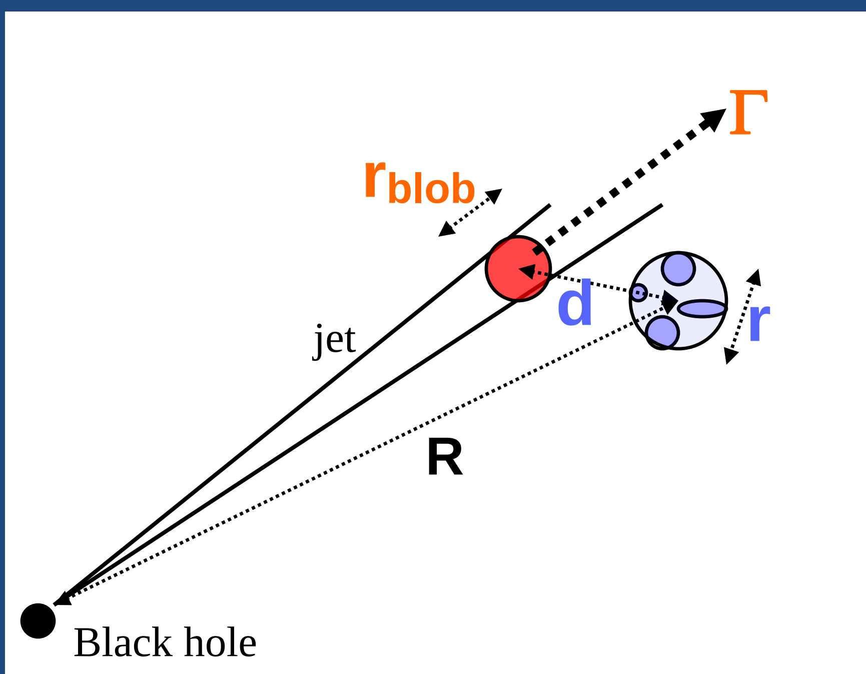
Later on, variation factors appear to be comparable with ρ=1

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

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

In standard EC from BLR, clouds cover a=10% at distance R_{BLR}=3 10^{17}cm, and reflect the disk luminosity L_D. The energy density of photons seen by a far blob moving with bulk Lorentz factor Γ is

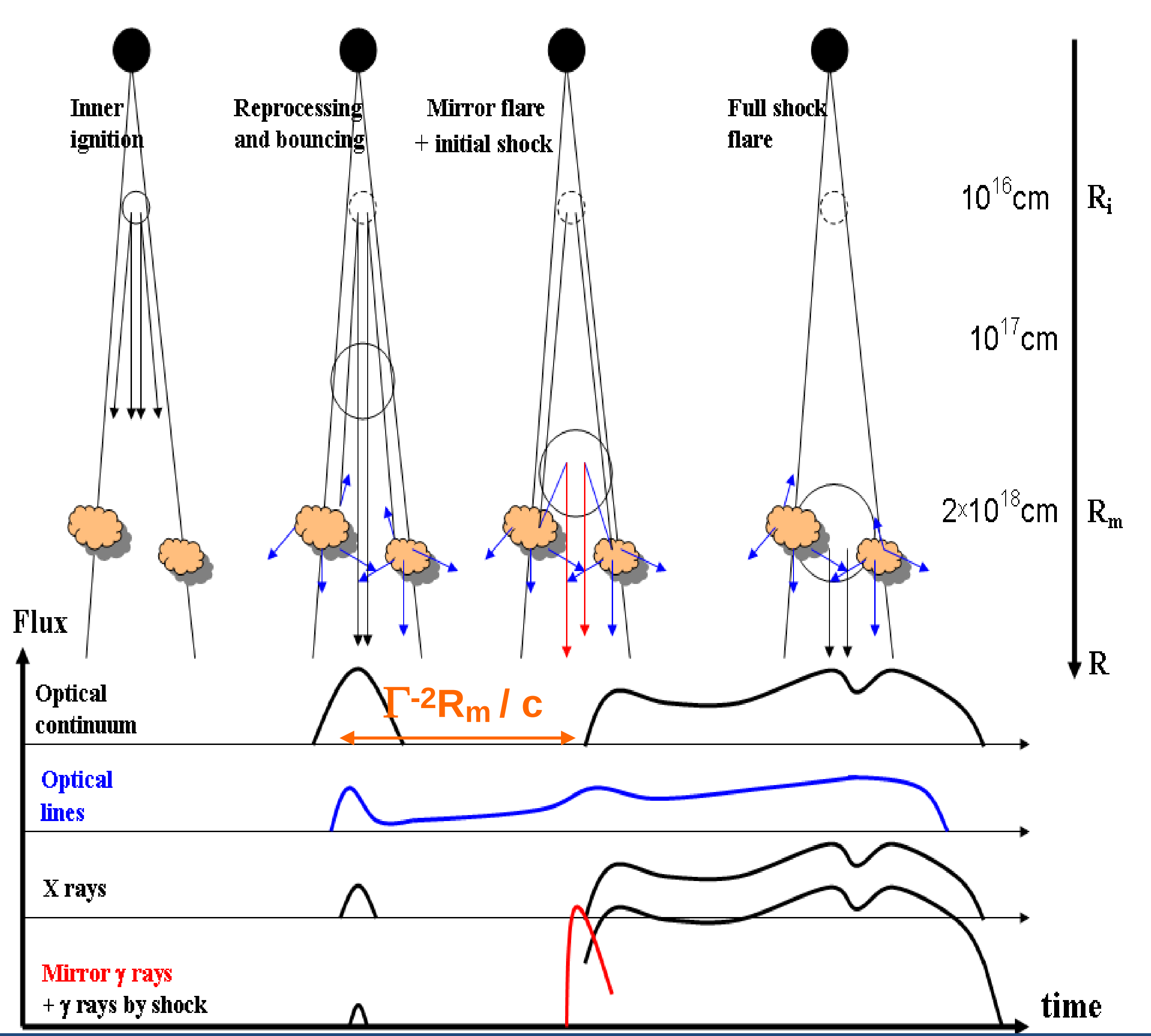
$$U'_{\rm BLR} \sim \frac{17}{12}\,\frac{a L_{\rm D}\Gamma^2}{4\pi R^2_{\rm BLR} c}$$



When the blob approaches at distance $d \ll R_{BLR}$ a system of size r, a gain **$g=a^{-1}(r/2d)^2$** < 3 can be obtained, with time-scale $\Gamma^{-2}(r+r_{blob})/c$ and

$$U'_{loc} = U'_{BLR}\,(1+g)$$

…and beyond the BLR?



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

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

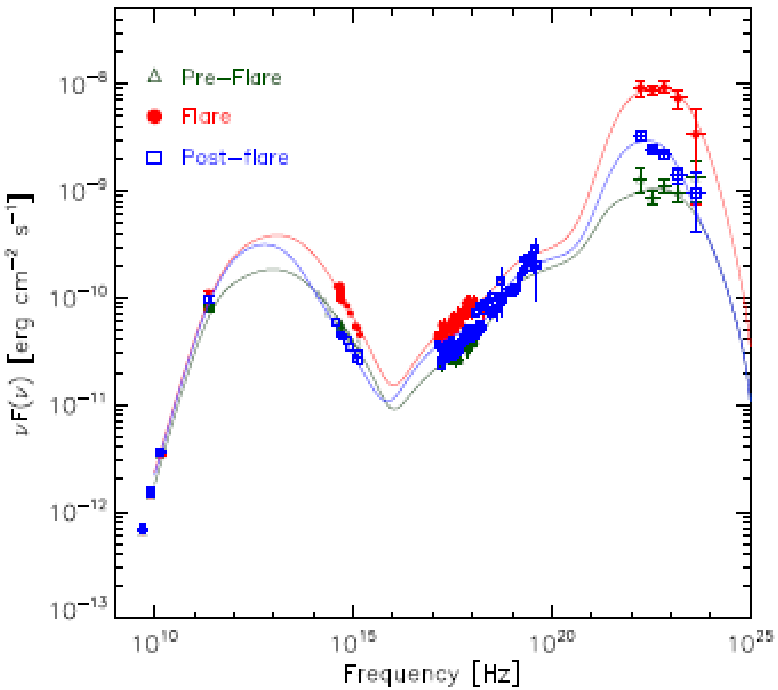
Shock delay of half hour

γ-ray emitted at pc scale

Optical precursor with 30% line enhancement

3C 454 in Nov. 2010

Vercellone et al. 2011



This idea explains the SED during the entire period of activity, by **two** electron populations in the jet

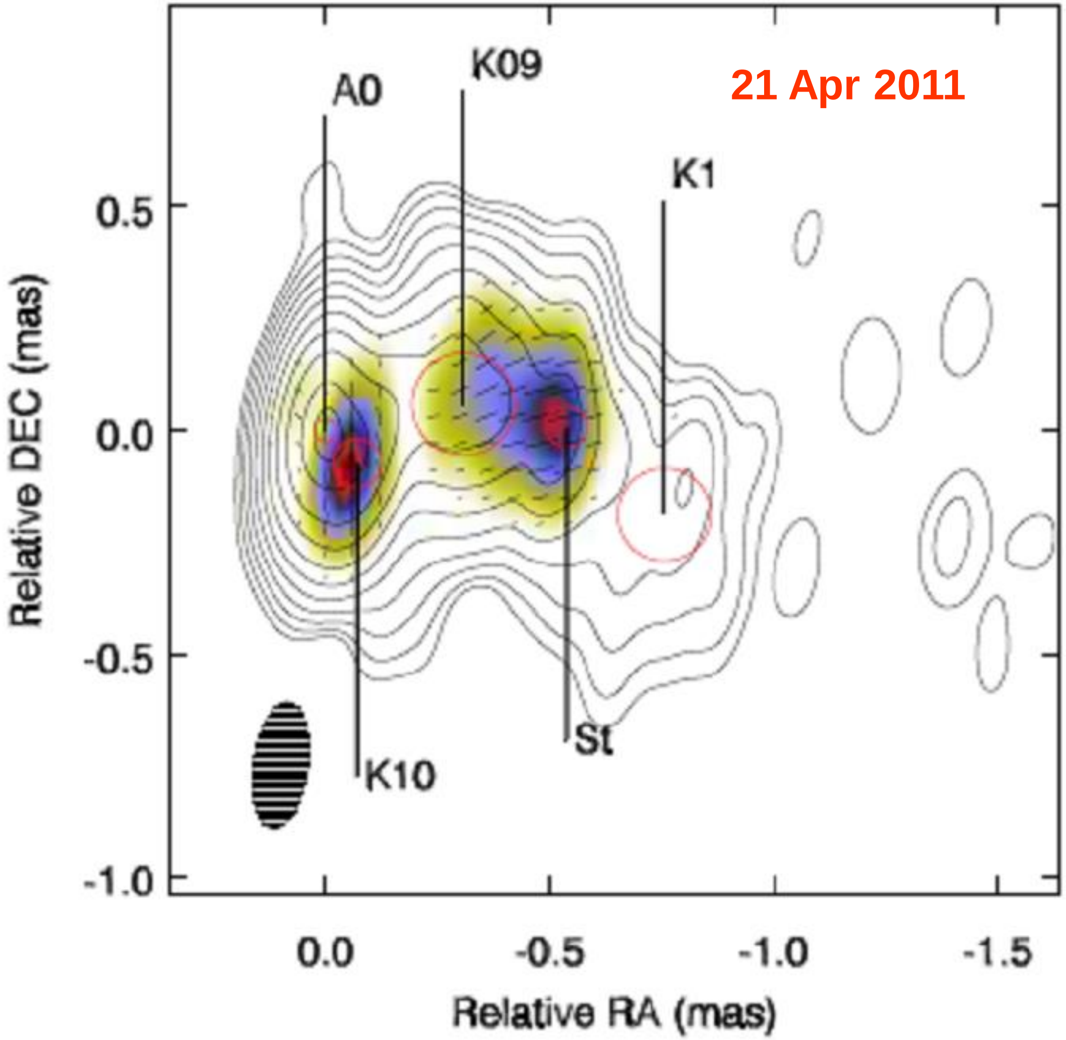
Parameter	Pre-flare	Flare	
		SEDs model parameters	
α_l	2.35	2.35	
α_h	4.2	4.8	
γ_{min}	50	80	
γ_b	650	700	
K	300	700	cm^{-3}
R_{blob}	7.0	3.6	10^{16} cm
B	0.65	1.1	G
δ	34.5	34.5	
L_d	2	2	10^{46} erg s^{-1}
T_d	10^4	10^4	$^\circ K$
r_d	0.05	0.05	pc
Θ_0	1.15	1.15	degrees
Γ	20	20	

Data concerning PKS 1830 and 3C 454 suggest:

Two populations of electrons seem unavoidable.

Standard EC models are challenged!
In fact, variations in the external photon field seen by the blob are required to understand the observed complex γ-ray vs. Opt. behavior. This also accounts for very fast γ variations of 100% in few hours.

Mirroring of the blob photons by scattering material accounts for γ-ray emission at pc scales: far from the BLR



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** the predicted lag is

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