Parsec-Scale Jet Behavior of the Quasar 3C454.3 during the High Gamma-Ray States in 2009 and 2010.

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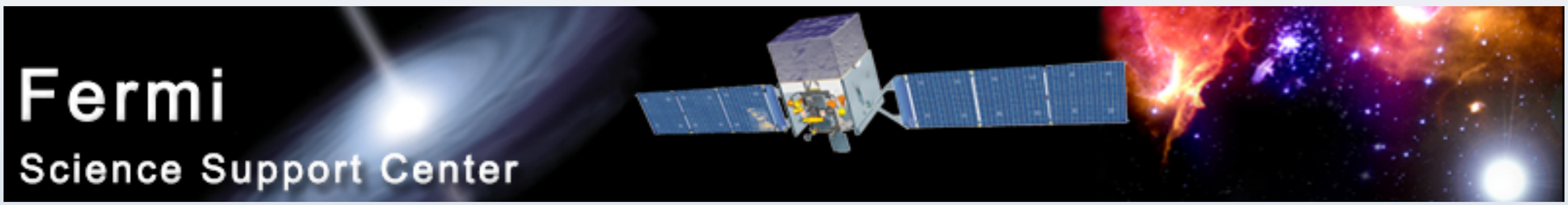

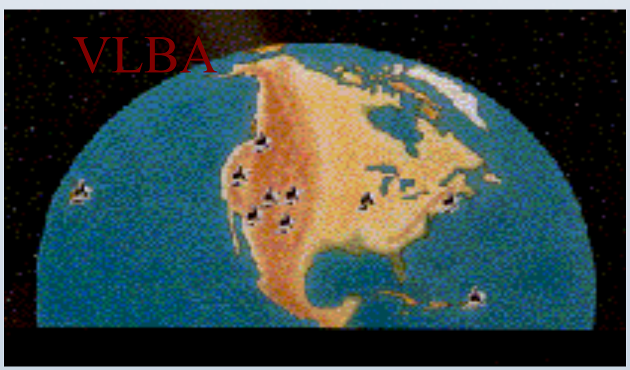

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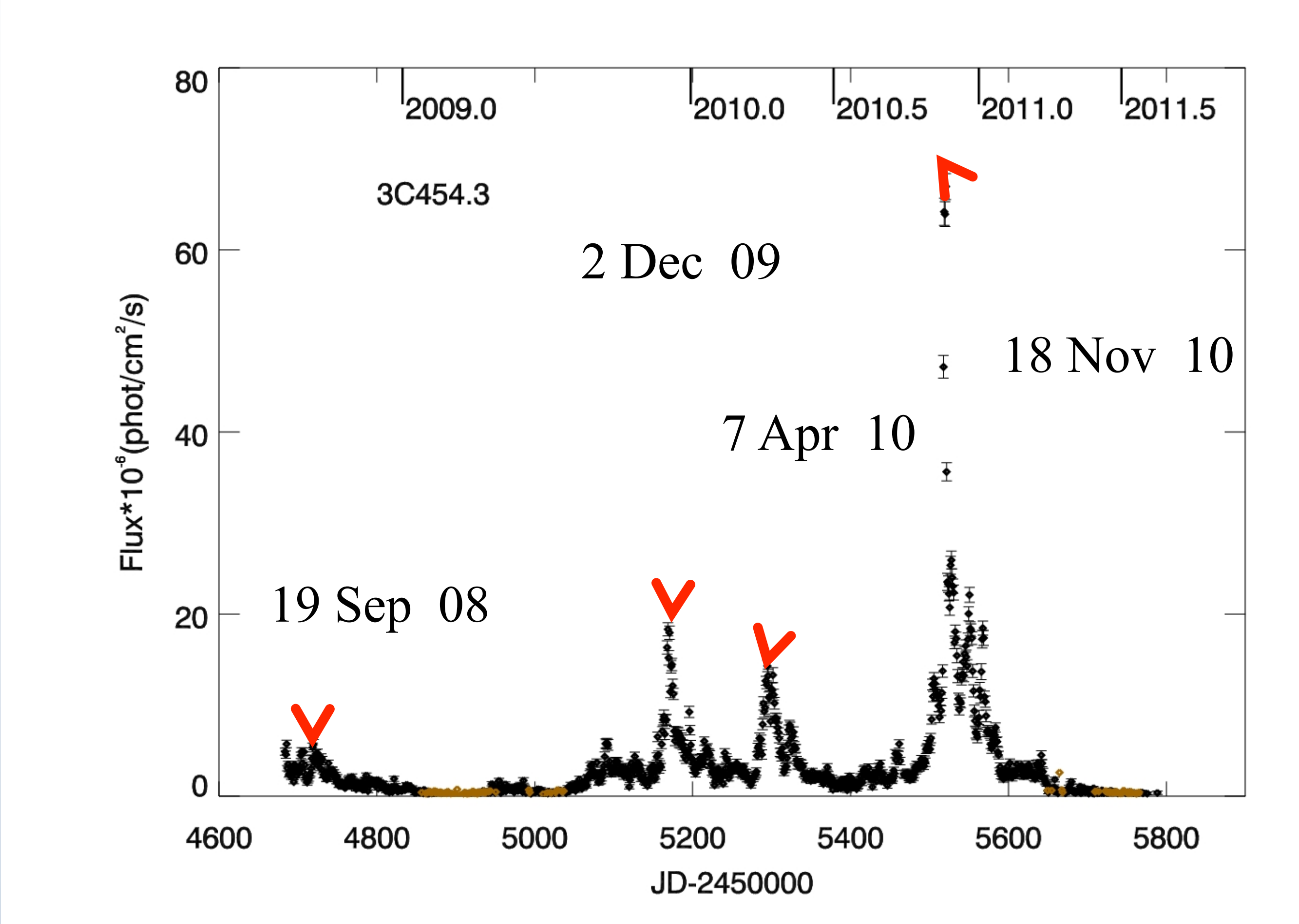
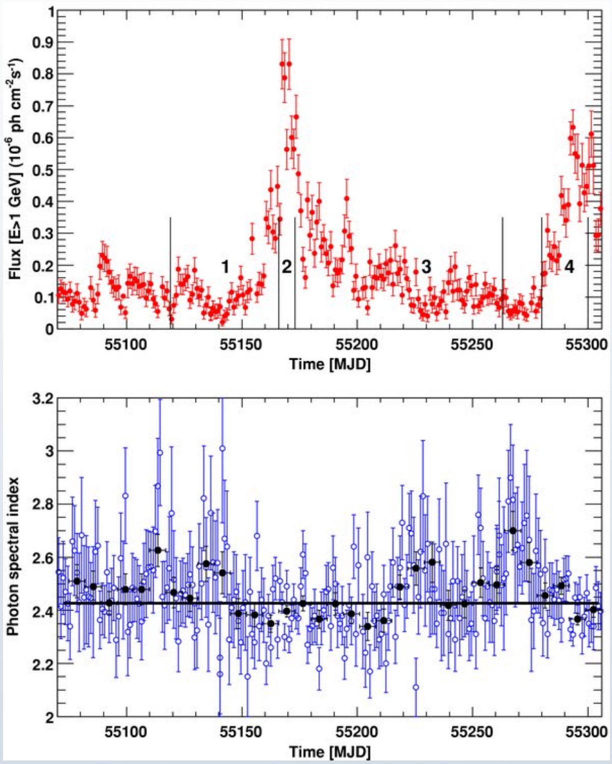
Gamma-Ray Light Curve

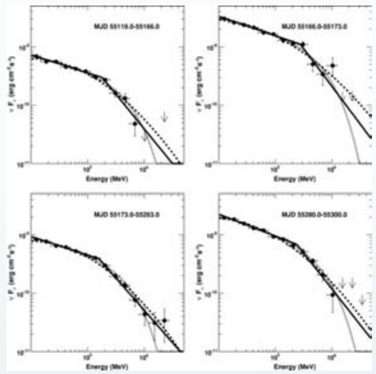


Gamma-Ray Behavior in Dec 2009

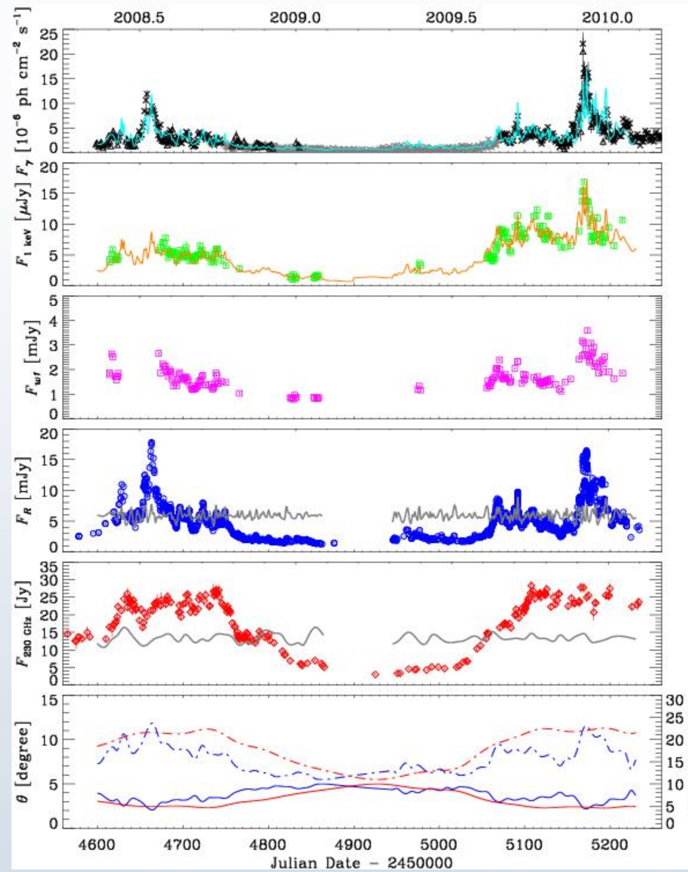
Gamma-ray peak: 2-3 Dec
$S_\gamma \approx 2.2 \pm 0.1 \times 10^{-5}$ photon cm^{-2} s^{-1}
$L_\gamma = 3.8 \pm 0.2 \times 10^{49}$ erg s^{-1}



Ackermann et al. 2010, ApJ



$t_{var} \sim 2.3$ hrs
$M_{BH} \approx 0.5\text{-}4 \times 10^9\ M_\odot$
$L_{Edd} \approx 0.6\text{-}5 \times 10^{47}$ erg s^{-1}
$\Theta_j \leq 5°$
$\delta_{\gamma\gamma} > 13\ \Theta_j \leq 4.4°$
Jorstad et al. 2005, AJ
$\Gamma_b = 15.6 \pm 2.2$
$\delta_{vlbi} = 24.6 \pm 4.5$
$\Theta_j = 1.3° \pm 1.2°$
$\theta_j = 0.8° \pm 0.2°$



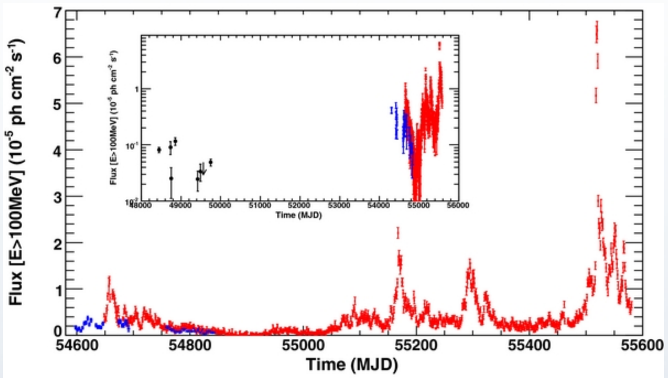
Raiteri et al. 2011, A&A

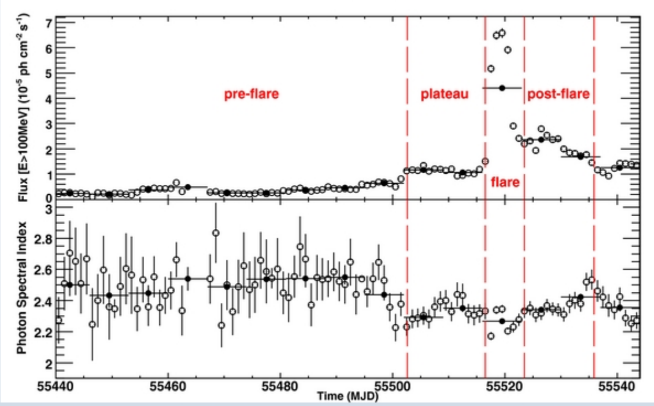
Gamma-Ray Behavior in Dec 2010

Gamma-ray peak: 18-19 Nov.

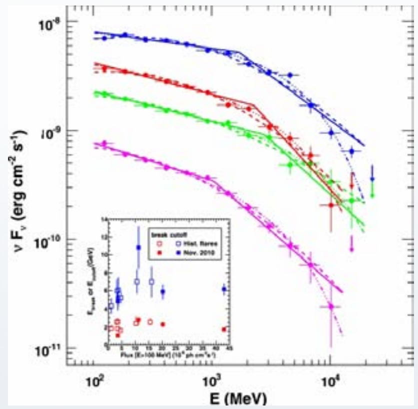
$S_\gamma \approx 6.6 \pm 0.1 \times 10^{-5}$ photon cm^{-2} s^{-1}

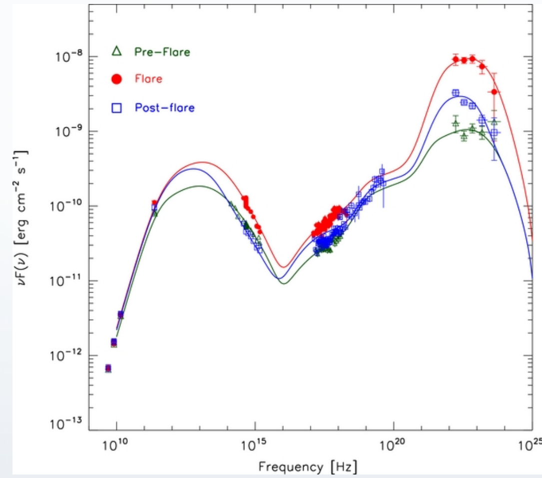
$L_\gamma = 2.1 \pm 0.2 \times 10^{50}$ $erg\ s^{-1}$





Abdo et al. 2011, ApJLetters





$t_{var} < 6$ hrs

$M_{BH} \approx 0.5\text{-}4 \times 10^9\ M_\odot$

$L_{Edd} \approx 0.6\text{-}5 \times 10^{47}$ erg s^{-1}

$\Theta_j \leq 2°$

$\delta_{\gamma\gamma} > 16$ $\Theta_j \leq 3.6°$

Flare

$L_d = 2 \times 10^{46}$ erg s^{-1}

$B = 1.1G$

$\Gamma_b = 20$

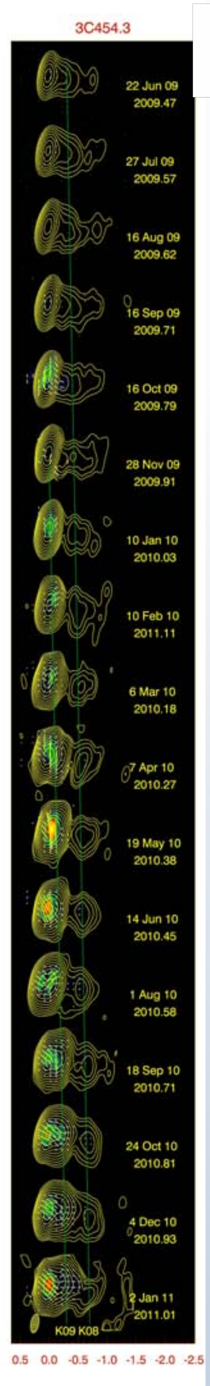
$\delta = 34.5$

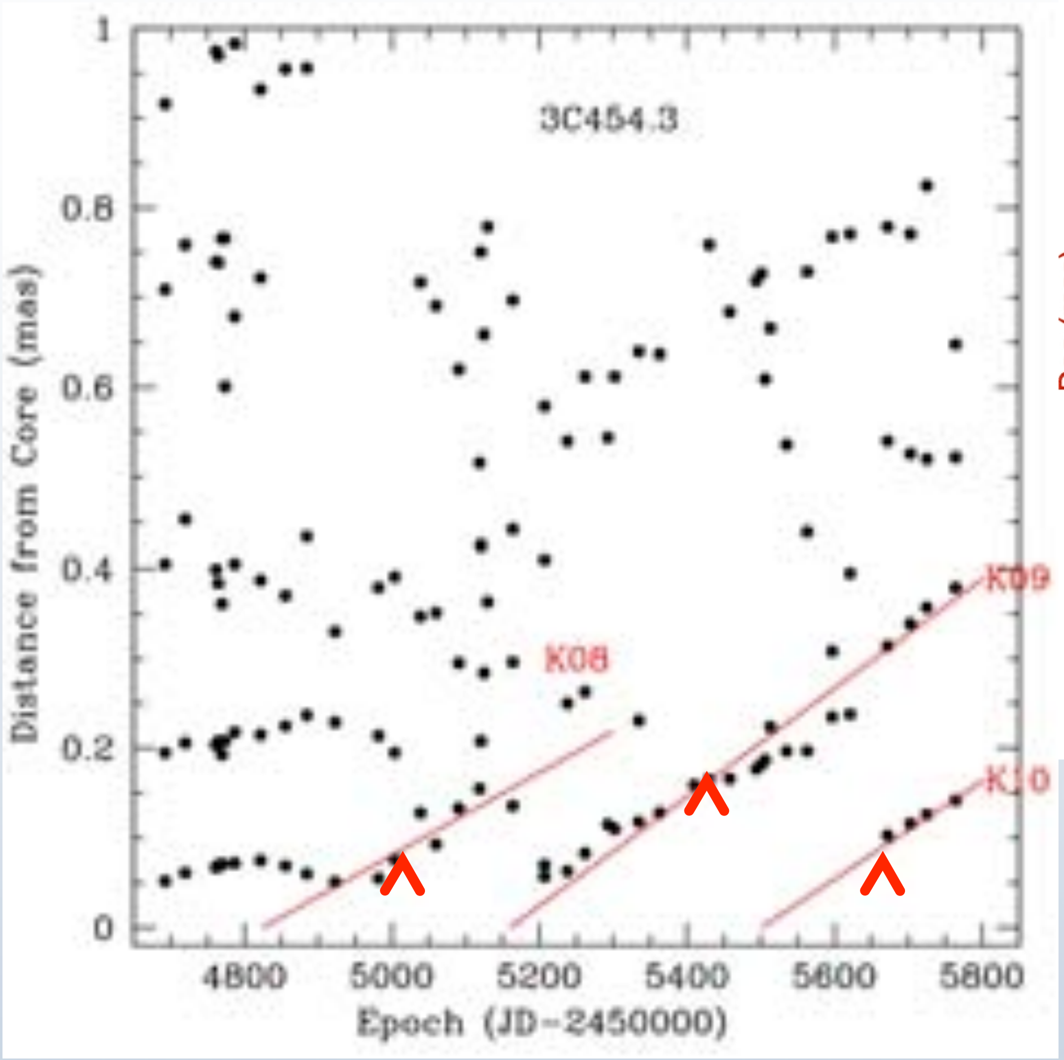
$\Theta_j = 1.15°$

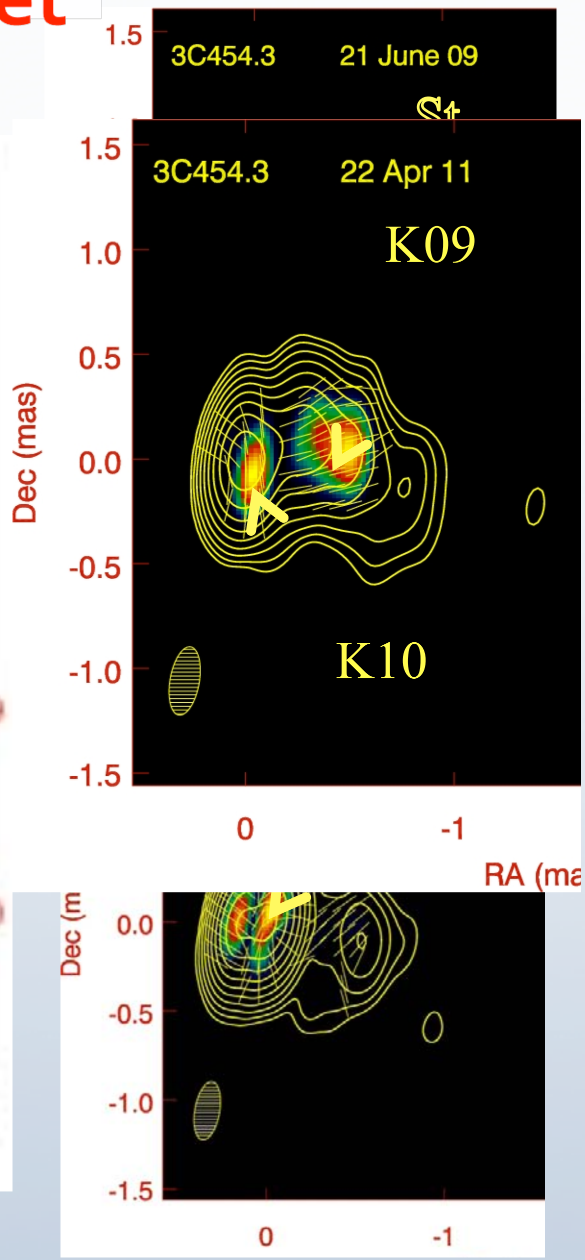
$R_b = 0.01pc$

Vercellone et al. 2011, ApJ

Kinematics of Parsec-Scale Jet

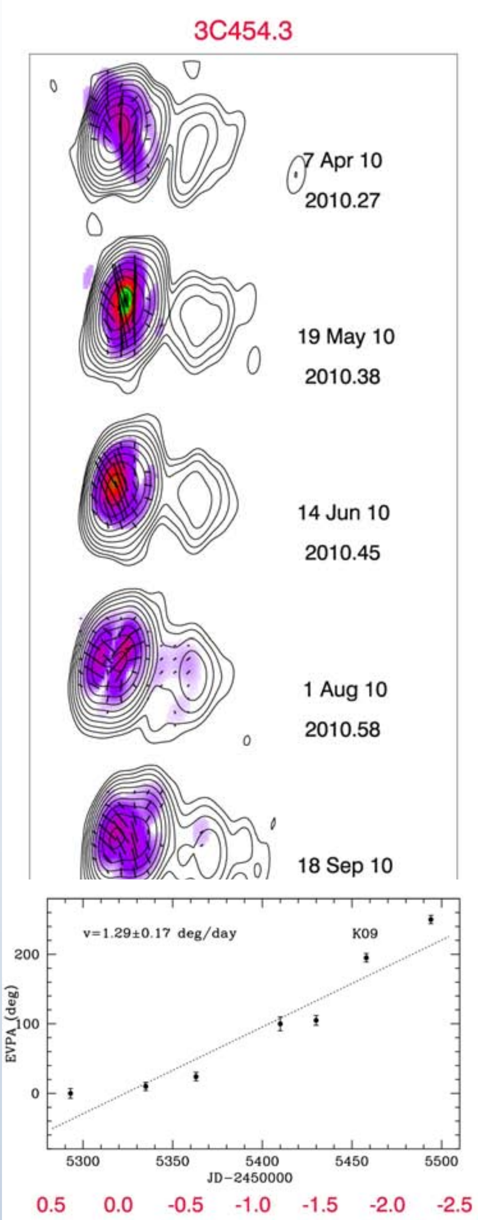




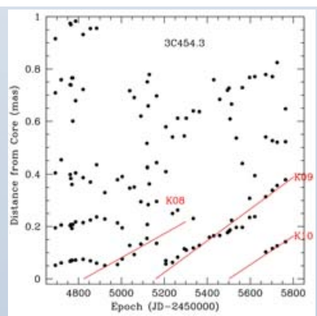


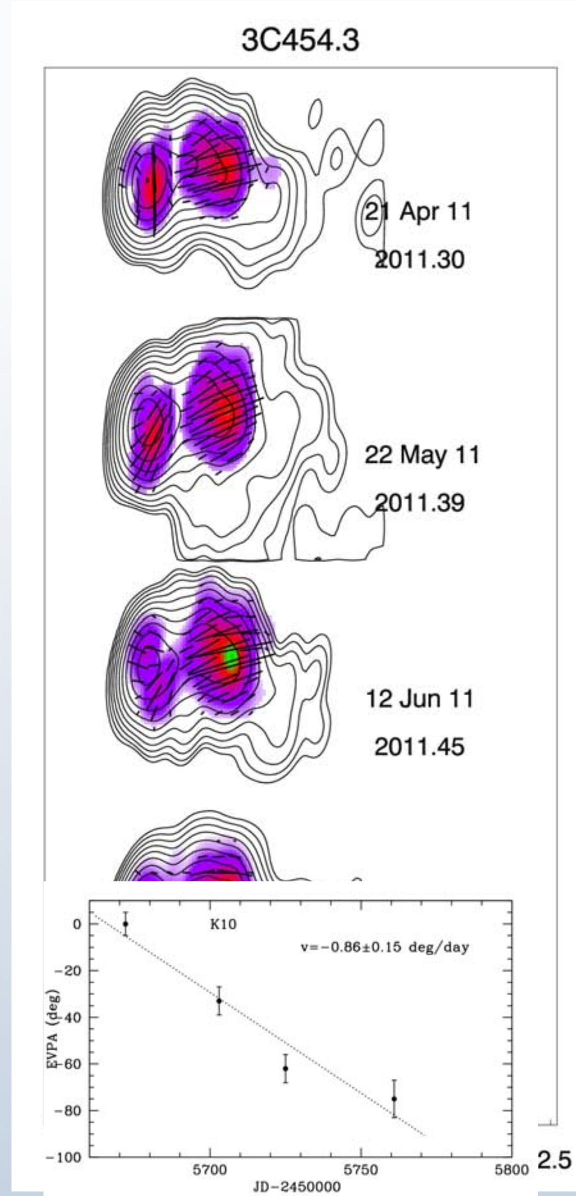
Fermi+Jansky 2011

Evolution of K09 and K10

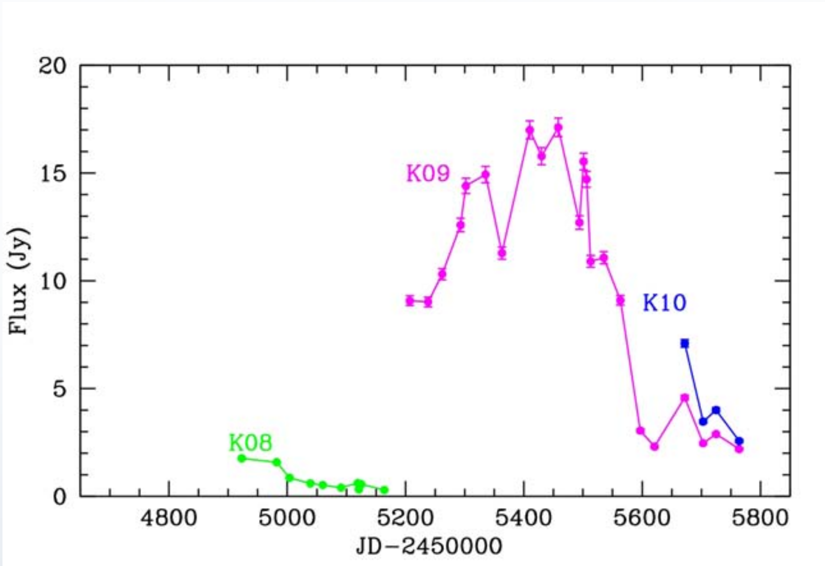


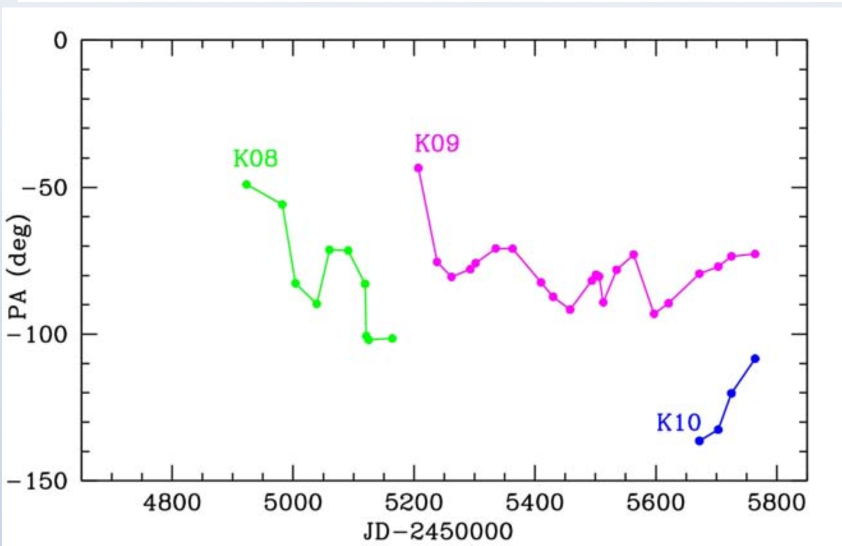
K08:
$\mu = 0.17 \pm 0.07$ mas yr^{-1}
$\beta = 7.1 \pm 2.1$ c
$T_0 = 2008.973 \pm 0.24$
(22 Dec 2008±88 days)
K09:
$\mu = 0.23 \pm 0.02$ mas yr^{-1}
$\beta = 9.7 \pm 0.9$ c
$T_0 = 2009.990 \pm 0.08$
(24 Nov 2009±29 days)
K10:
$\mu = 0.15 \pm 0.01$ mas yr^{-1}
$\beta = 6.4 \pm 0.6$ c
$T_0 = 2010.860 \pm 0.05$
(11 Nov 2010±18 days)





Jet Parameters during the Outbursts





Z=0.859 D=5.48Gpc

K08:

S_{max} = 1.8 Jy

a = 0.08 mas

t_{var} ~ 0.37 yr   δ=32.5

β = 7.1±2.1 c

Γ=17 Θ_j =0.74°

Variability Doppler Factor

$\delta_{var} = sD/[c\ \Delta t_{var}\,(1+z)]$

s=1.6a; Δt_{var} = dt/ln(S_{max}/S_{min})

a- VLBI size of component

Jorstad et al. 2005

Γ=20 Θ_j =0.73°

K10:

S_{max} = 7.1 Jy

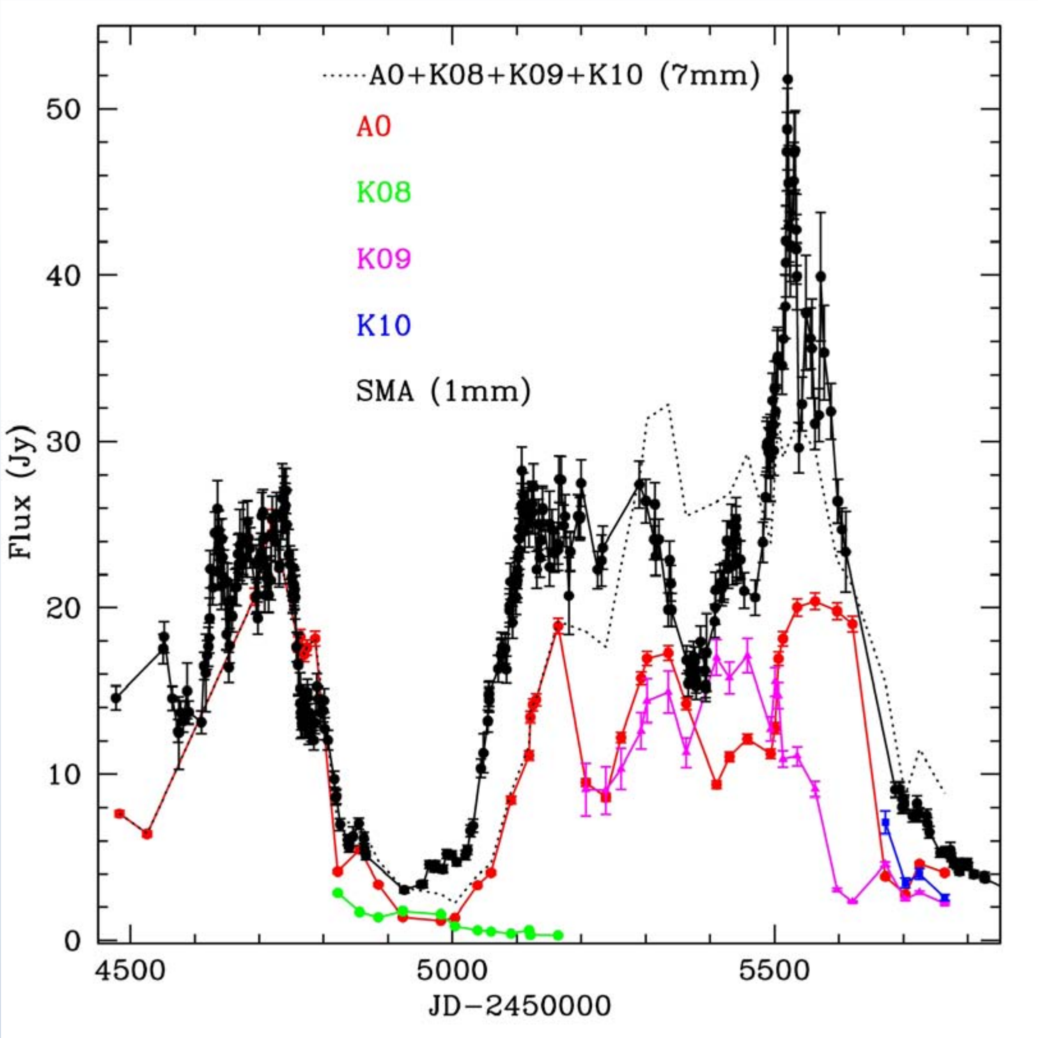
a = 0.10 mas

t_{var} ~ 0.26 yr   δ=59.0

β = 6.4±0.6 c

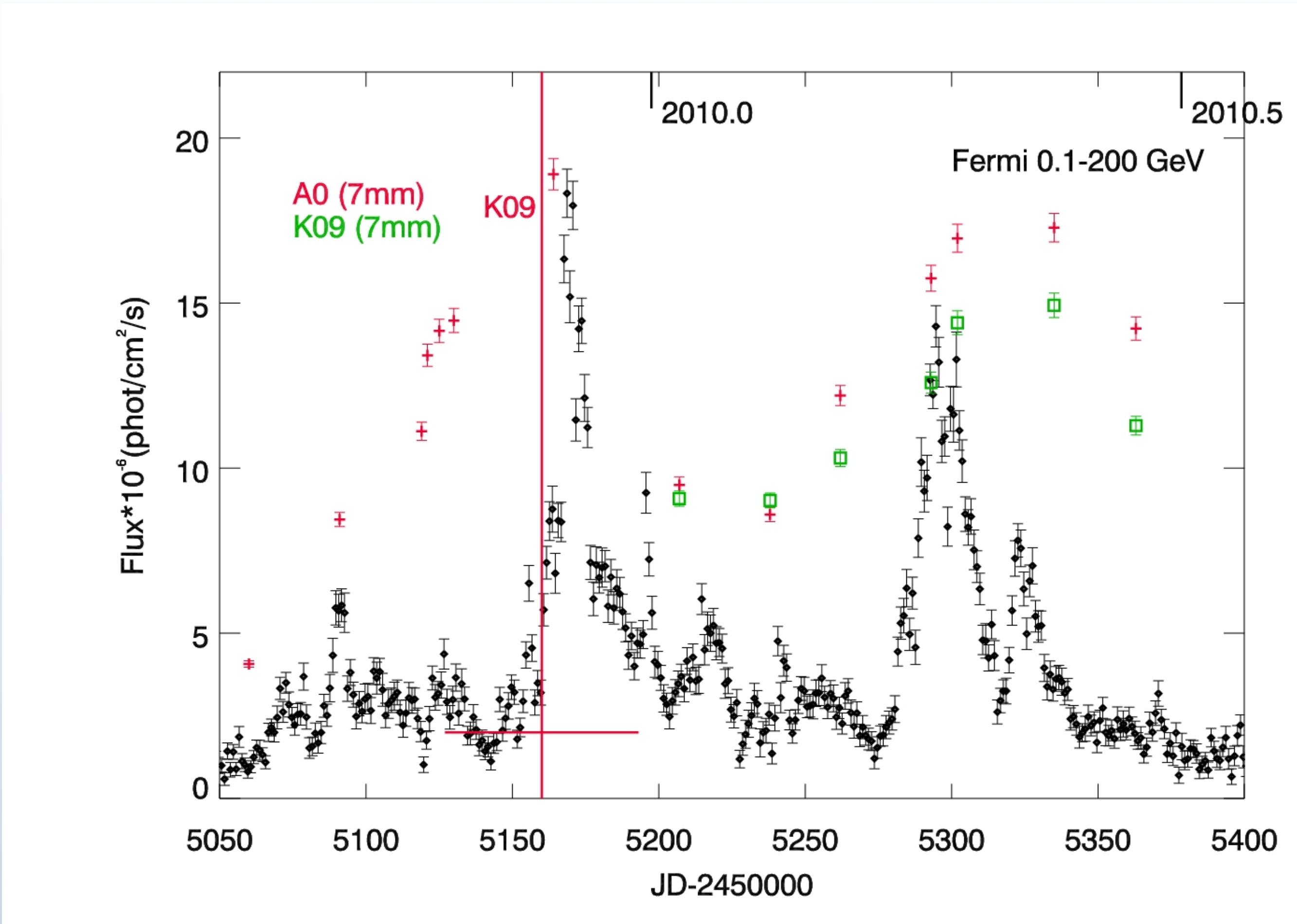
Γ=30 Θ_j =0.21°

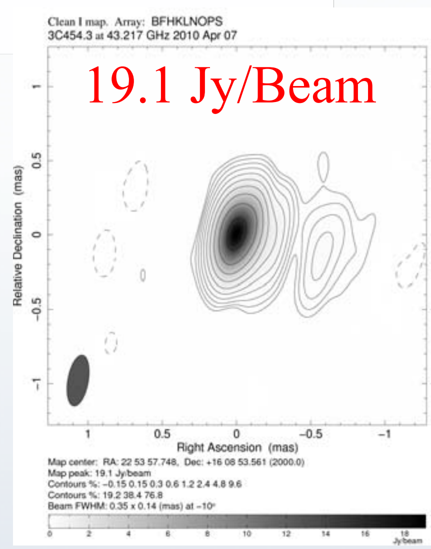
mm-wave Light Curve & Jet Structure

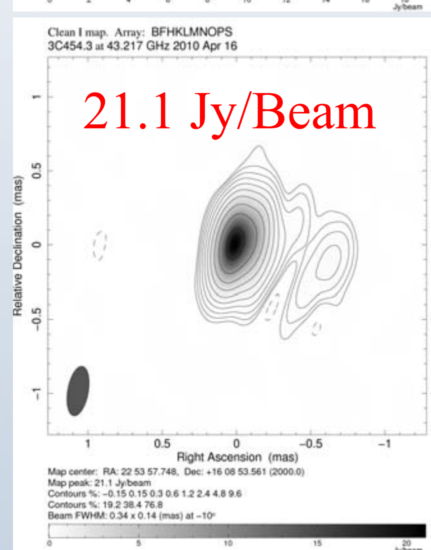


1. A good correlation between the 1mm & core light curves
2. Plato at 1mm within RJD 5100-5300 is caused by a contribution from K09
3. The core is partly optically thick when K09 and K10 passing through the core.
4. K10 undergoes significant radiative losses

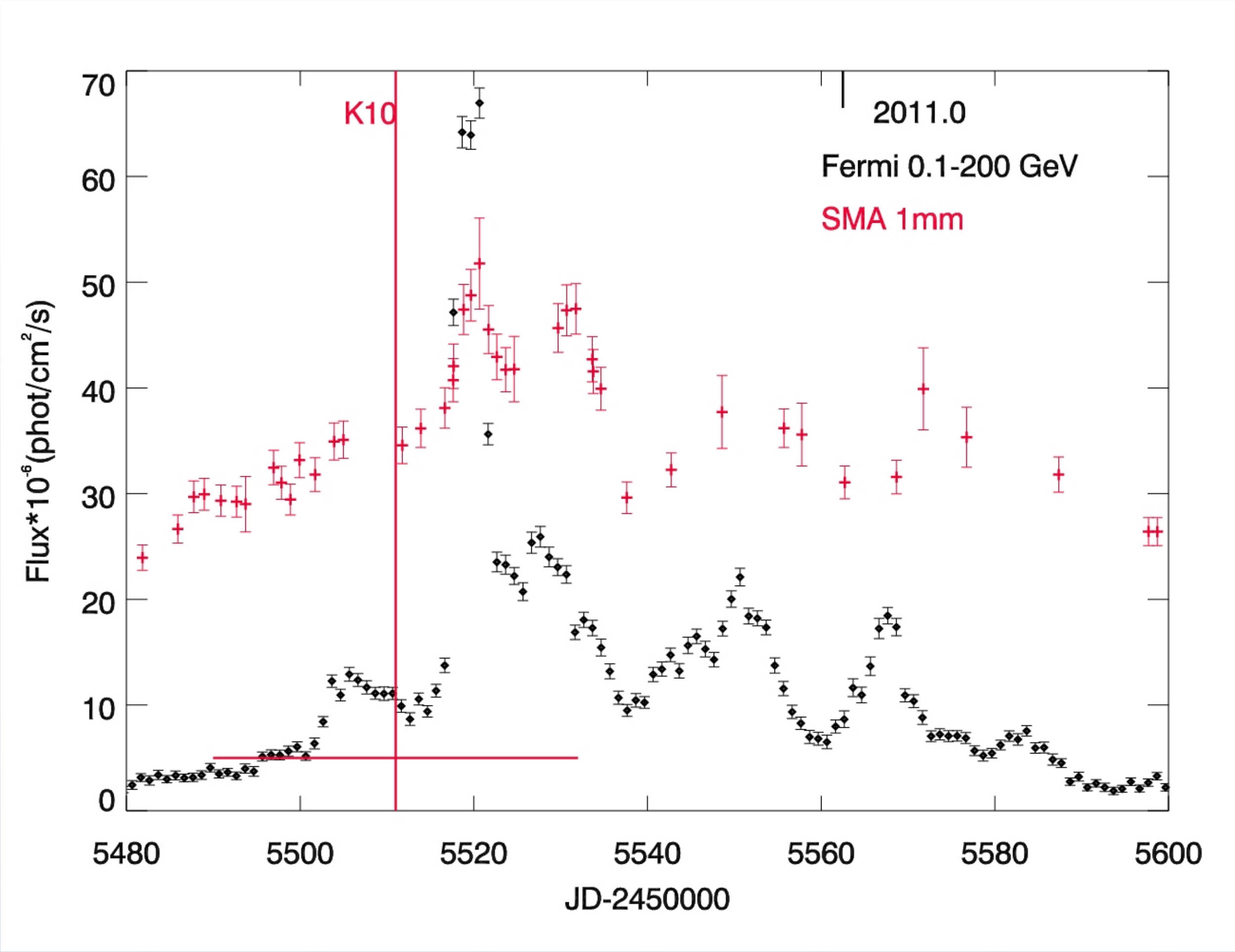
Gamma-Ray Light Curve + Jet Structure in the 2009 Outburst

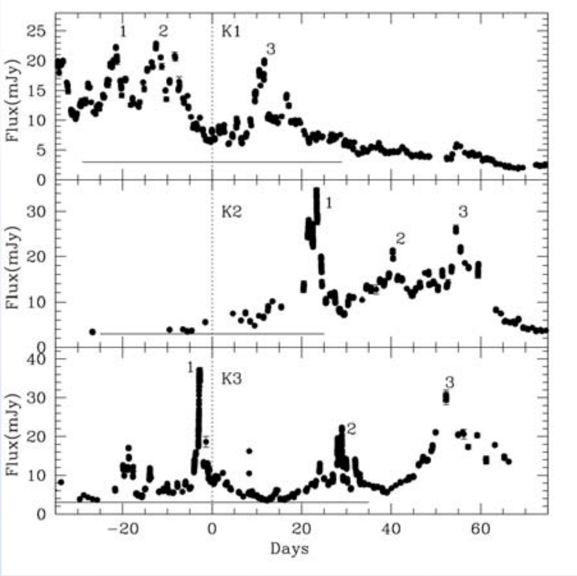






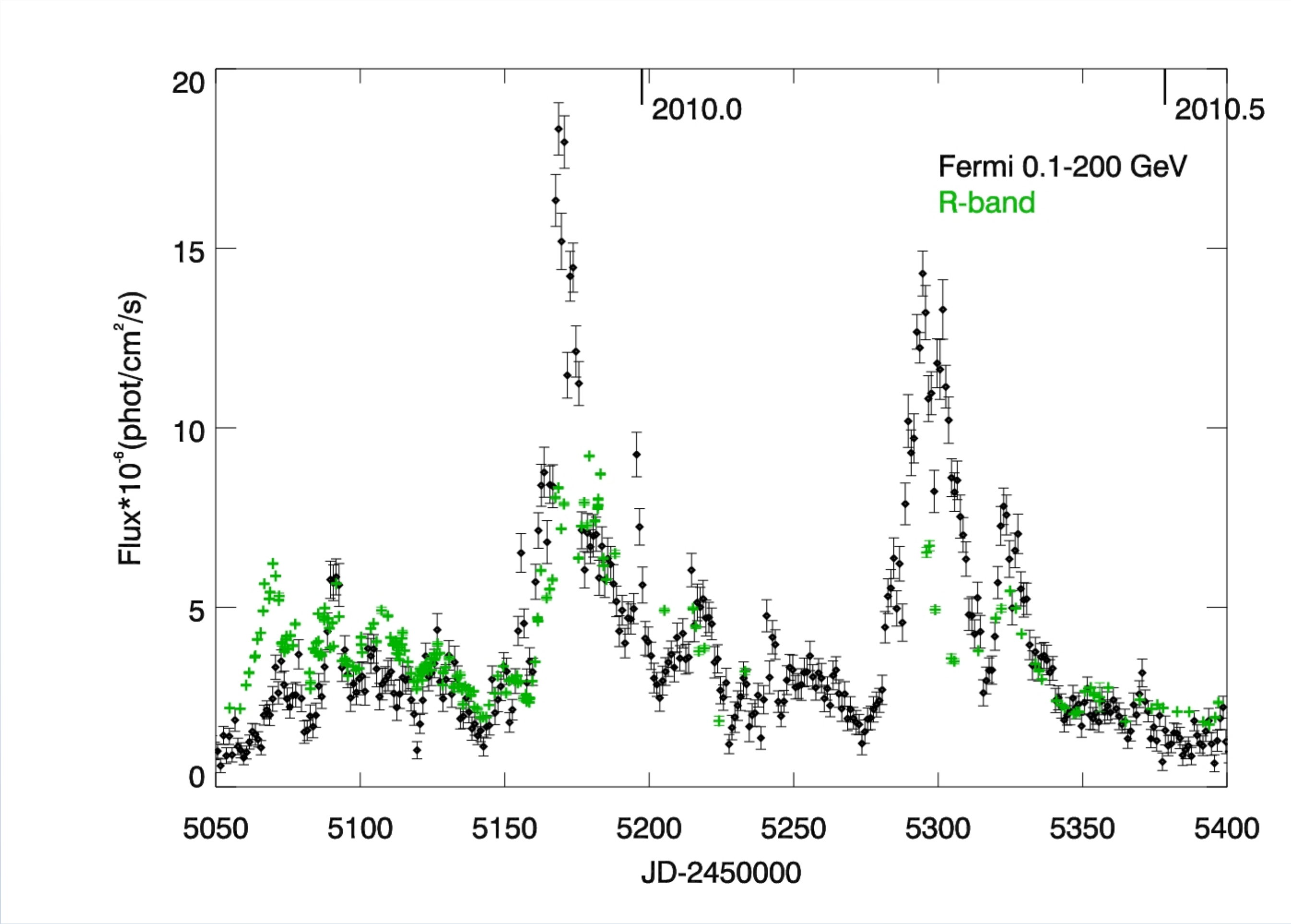
Gamma-Ray/mm Light Curves + Jet Structure in the 2010 Outburst



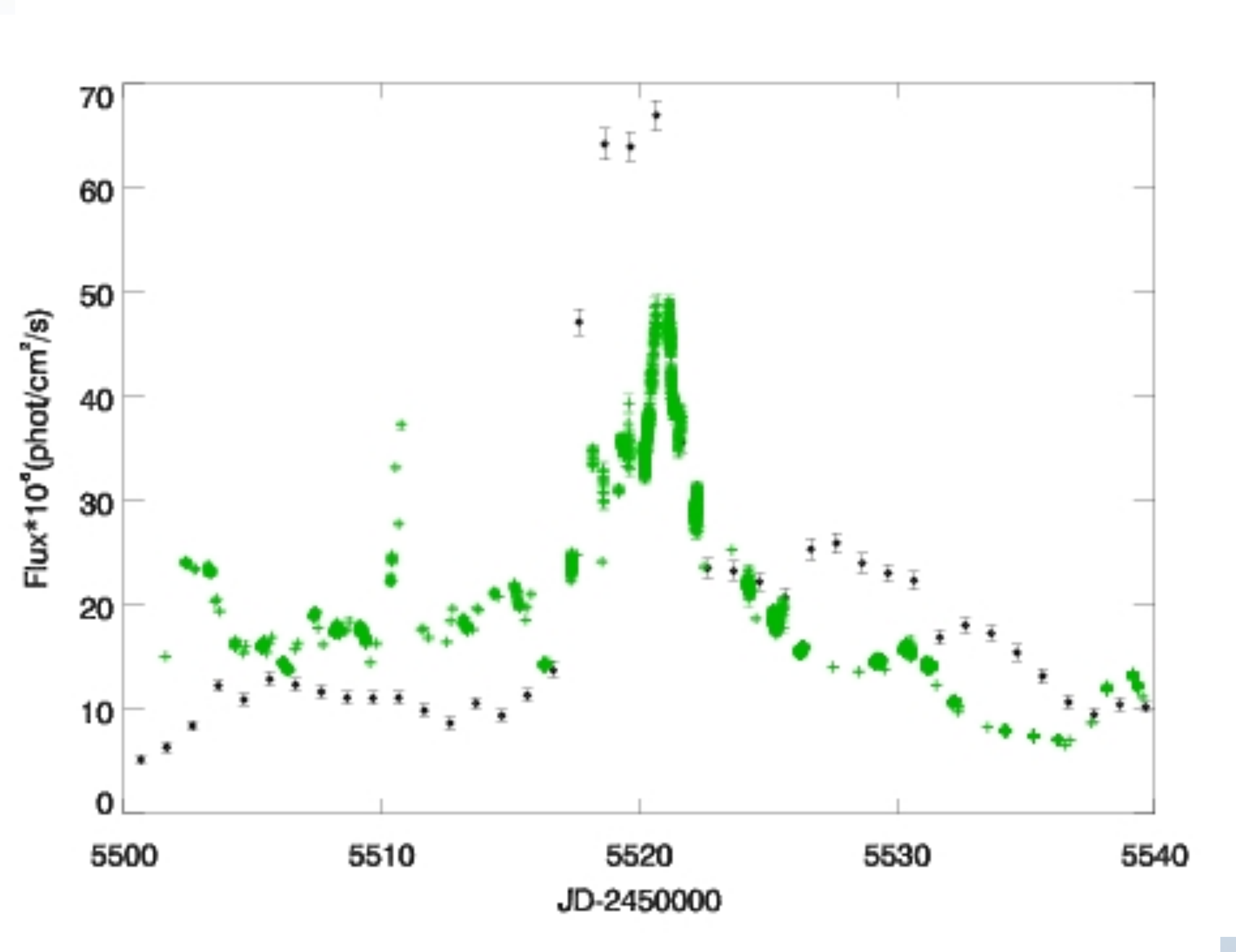


Jorstad et al. 2010, ApJ

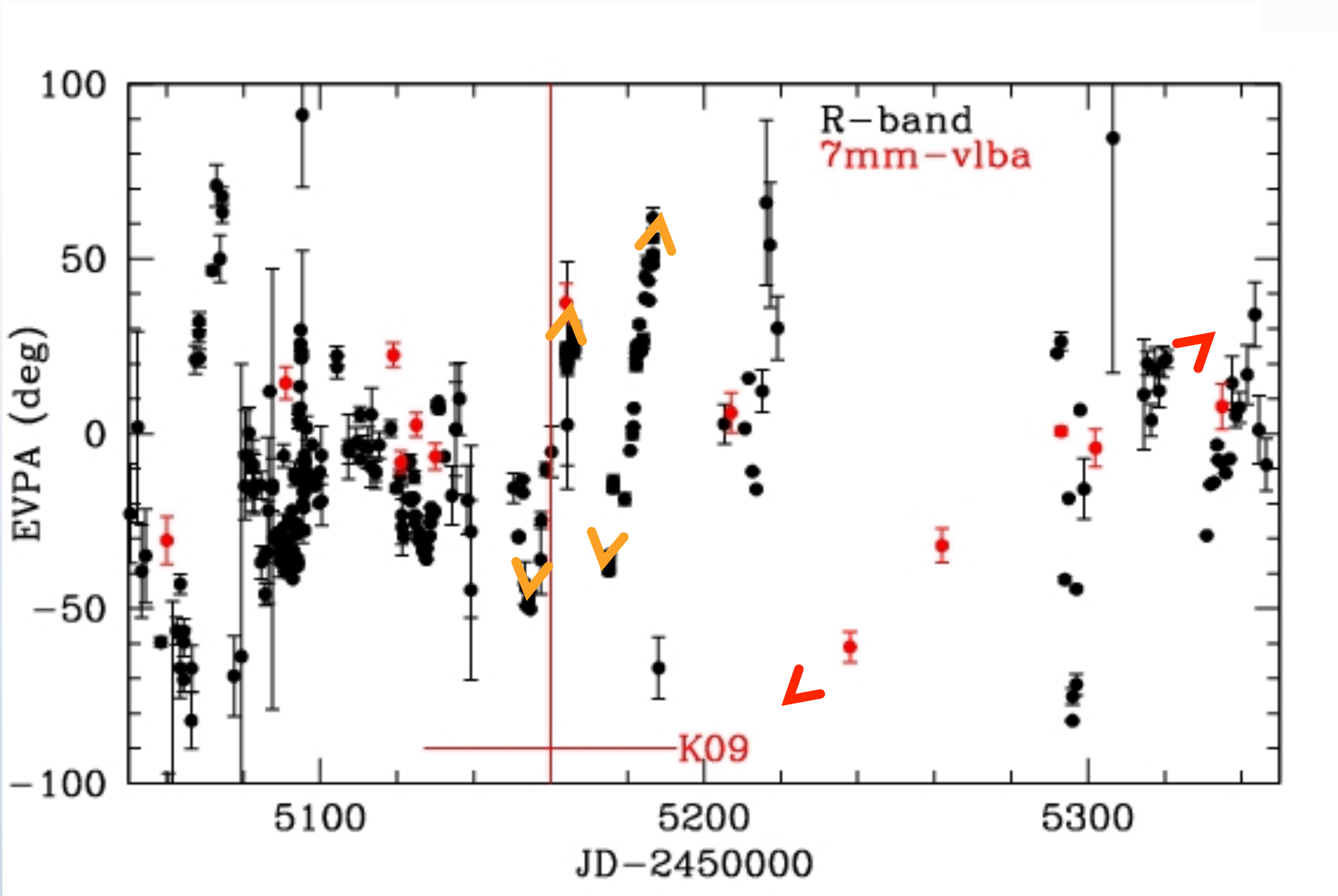
Gamma-Ray + Optical Light Curves in the 2009 Outburst



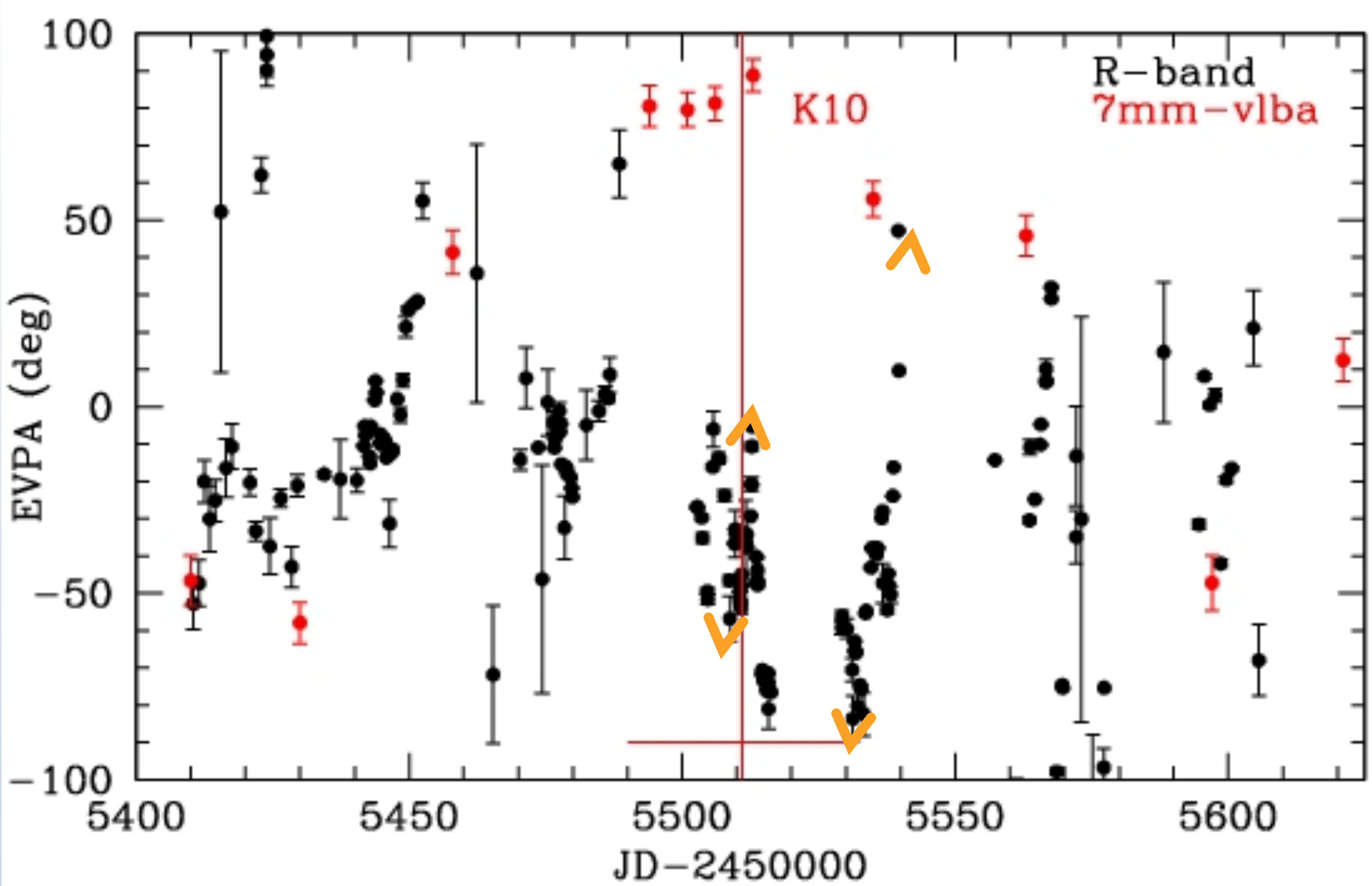
Gamma-Ray + Optical Light Curves in the 2010 Outburst



Polarization behavior during the 2009 Outburst



Polarization Behavior during the 2010 Outburst



Conclusions

1. The mm-wave light curves of the quasar 3C454.3 - the 7 mm VLBI core and 1mm from the whole source - show a strong correlation with γ-ray variations without any delay ≥ 1 day; this is impossible to explain if the γ-ray emission originates within the broad line regions.
2. Although optical variations show a strong correlation with γ-rays, any connection between variations on short time scales (days) is weak or absent; this requires either inhomogeneous field of external seed photons or second-order scattering of synchrotron optical photons for γ-ray production.
3. In both γ-ray outbursts of 2009 and 2010, a superluminal knot emerges from the core at a time close to the peak of the γ-ray event.
4. Analysis of jet kinematics reveals a connection between parameters of the knot and properties of the corresponding γ-ray event. During the most luminous γ-ray outburst, with $L\gamma \sim 2 \times 10^{50}$ erg s^{-1}, the VLBI data suggest an extreme Doppler factor of the jet, $\delta \sim 60$.

Conclusions

5. A clear pattern emerging from multi-frequency observations of blazars is that a strong γ-ray event, > 10^{-6} ph cm^{-2} s^{-1}, (BLLac, 1510-089, 3C273, 1633+382, and 3C454.3, see also A.Marscher's talk) coincides with

i) an optical through mm-wave outburst,

ii) an increase of the flux and polarization in the mm-wave VLBI core,

iii) the appearance of a superluminal feature in the jet,

vi) rising of the degree of optical polarization,

v) rotation of position angle of optical polarization during the peak of γ-ray flux.