Synchrotron/IC Scaling Relations in Blazar flares

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Aims:

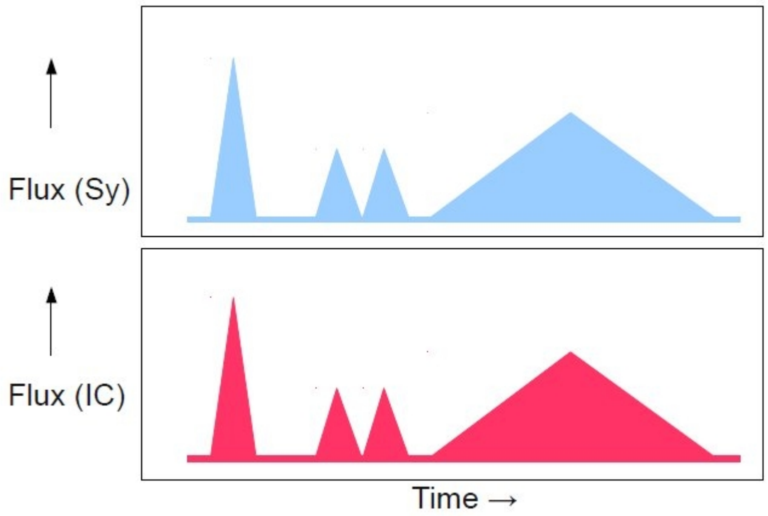
Understand the origin of gamma-ray emission;
Understand the cause of variability.

Quantify and interpret relationships between synchrotron and gamma-ray fluxes

We assume an IC origin of gamma-ray emission in our interpretations.

Naïve expectation: linear/quadratic relationships in EC/SSC cases,

Scalings and Lags



Relationship between 2 bands:

compute CCF

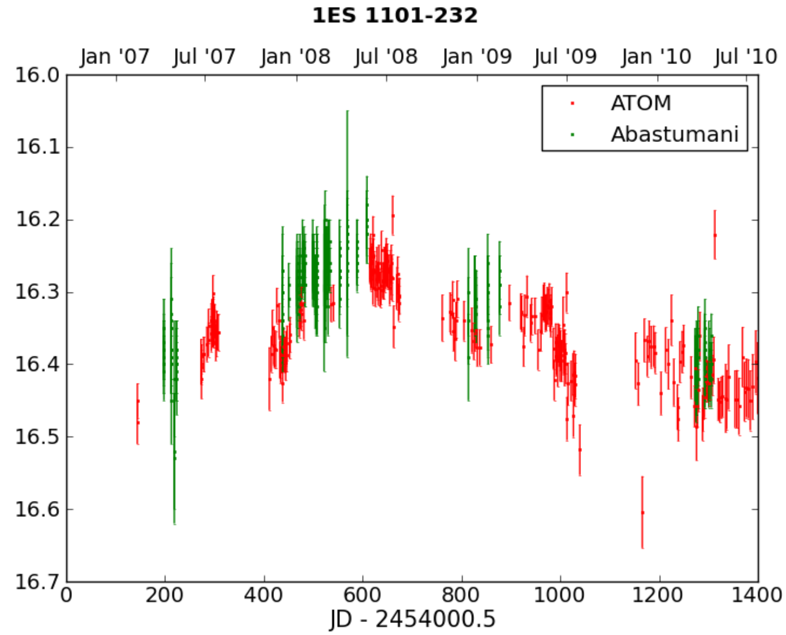
Ideal case: All flares have some amplitude scaling ≠ 1
→ CCF would be identical to ACF except for noise
Not observed in any source

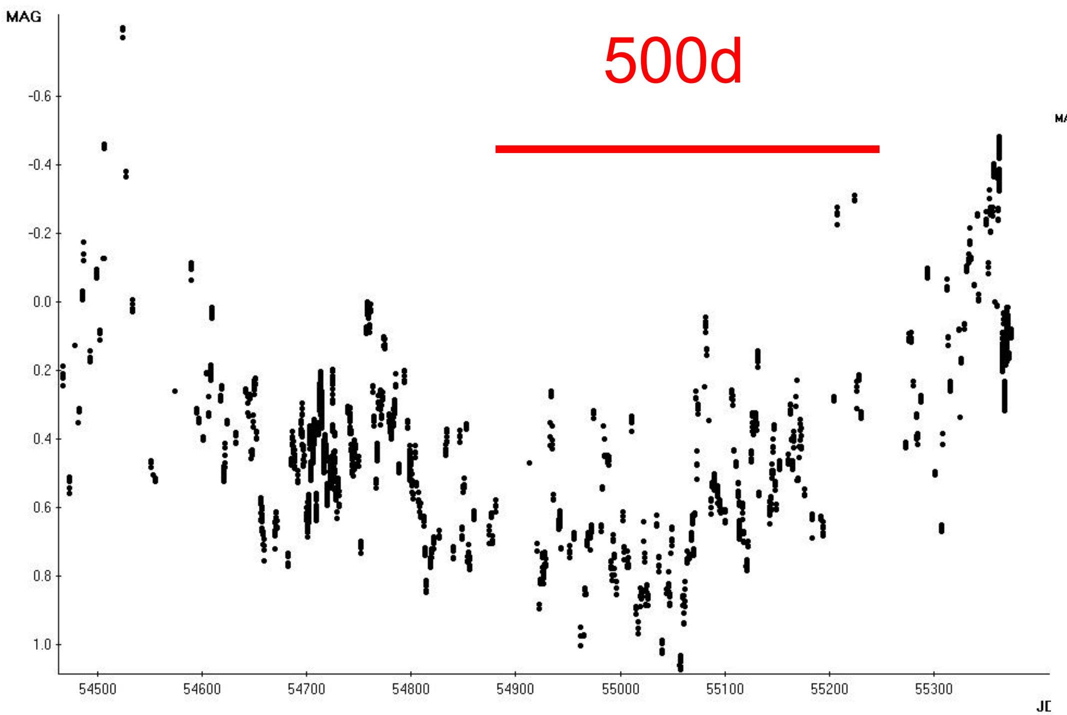
Ideal deviation: All flares shifted by the same temporal lag ≠ 0
→ as above with some non-zero lag
Not observed in any source

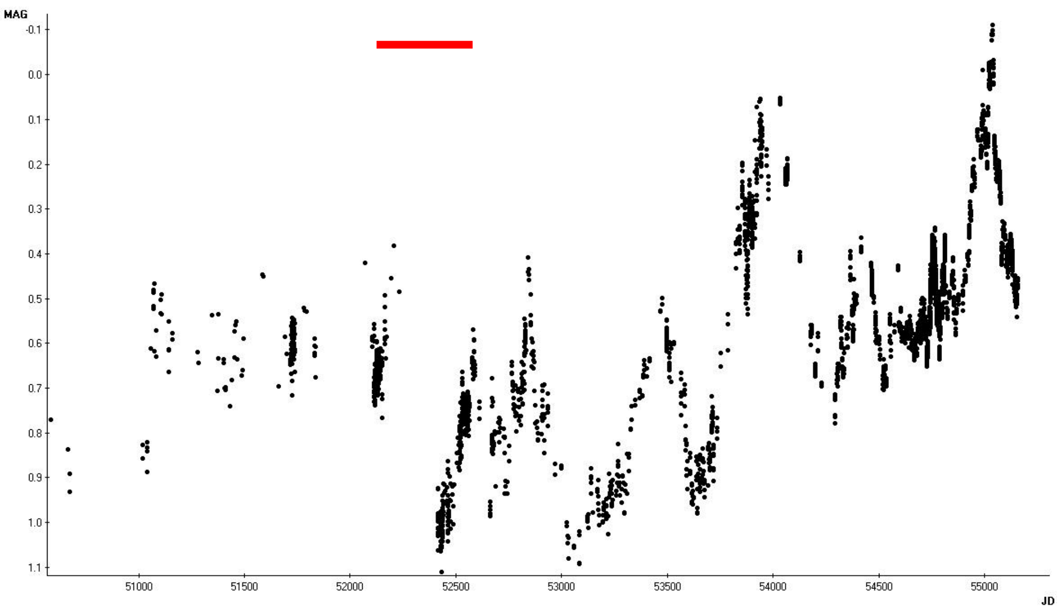
High duty cycle

Very high duty cycles
[fraction of time above 'baseline']
(→ 100 %)
(Poster AGN-100)

→ decomposition difficult/impossible







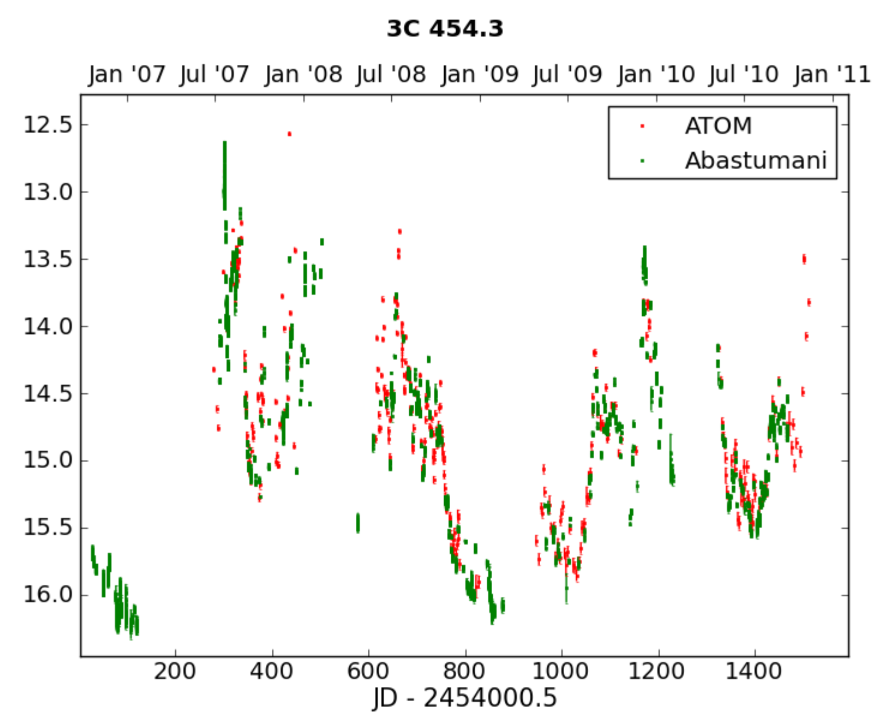
Synchrotron and IC data

Observation with ATOM (Namibia) and from Abastumani (Georgia)
In both hemispheres with large dynamic range in time and flux.

Measurements with Fermi-LAT binned in 1day (and 1 week) intervals, integrated over entire energy range (>100 MeV).

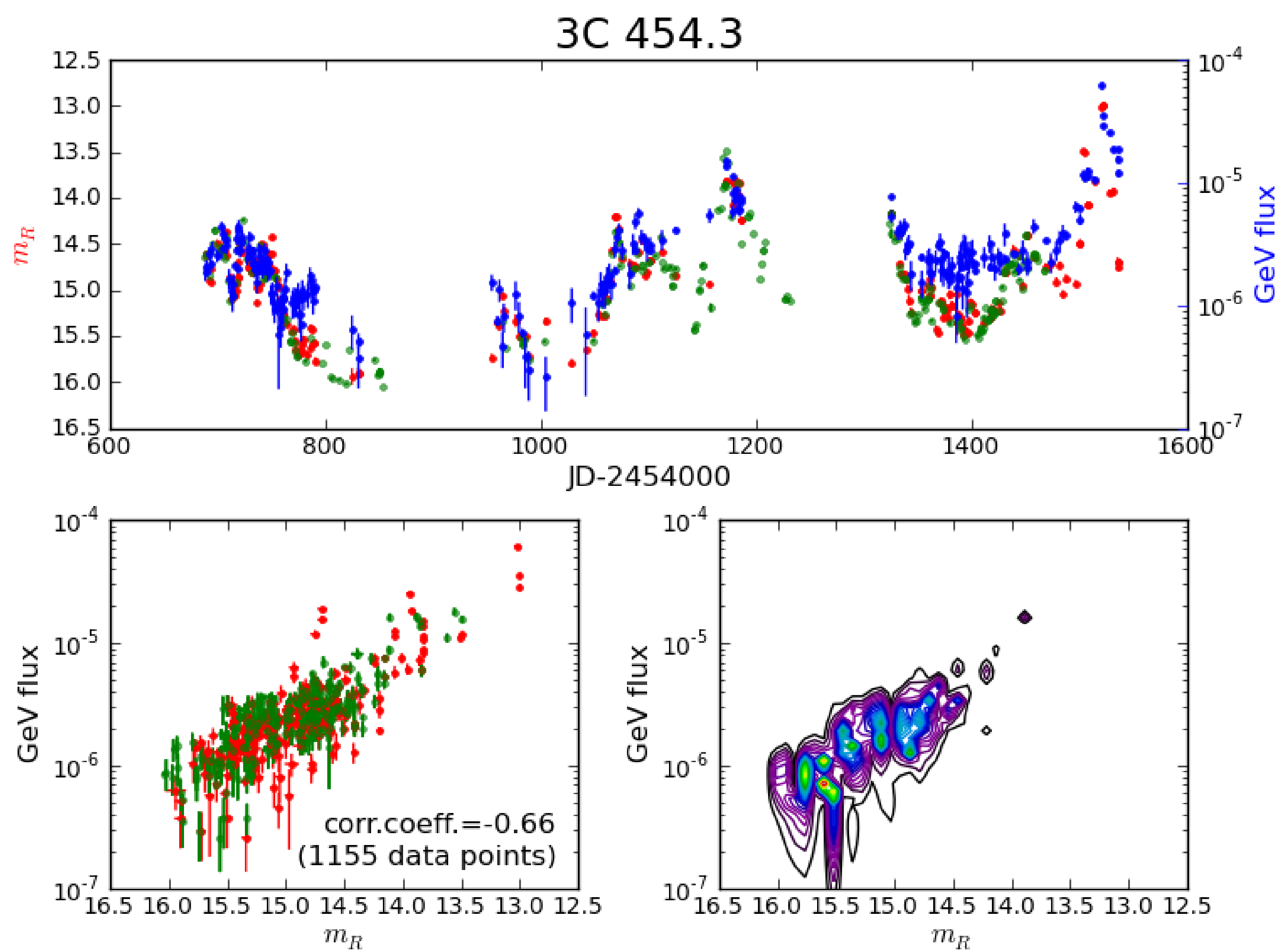
Subset used in this presentation:

Joint optical data sets,
binned to 24h averages
vs.
Identically-phased 24h
Fermi-LAT fluxes



Data matching

Correspondence of different data sets and match to Fermi



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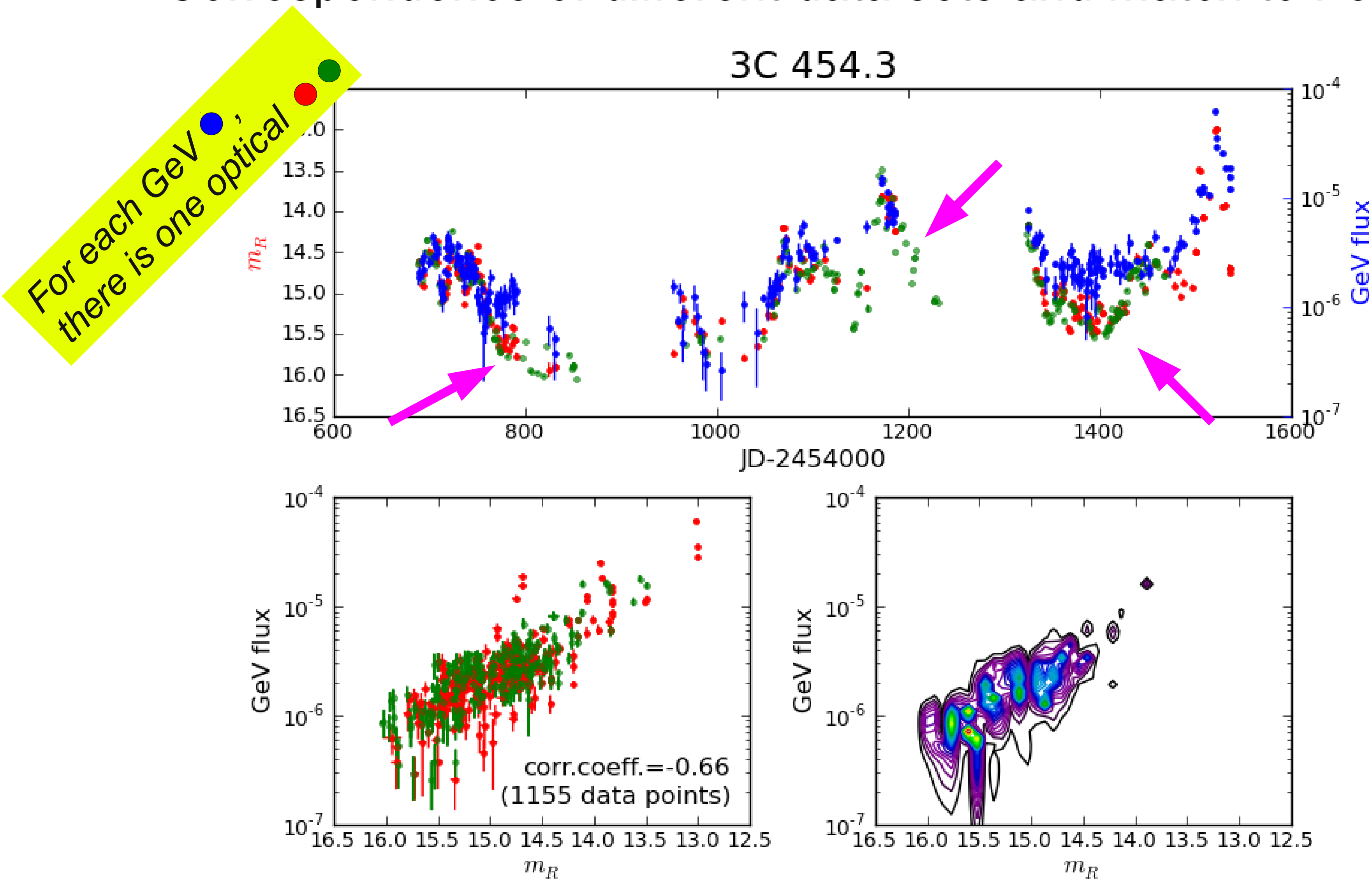
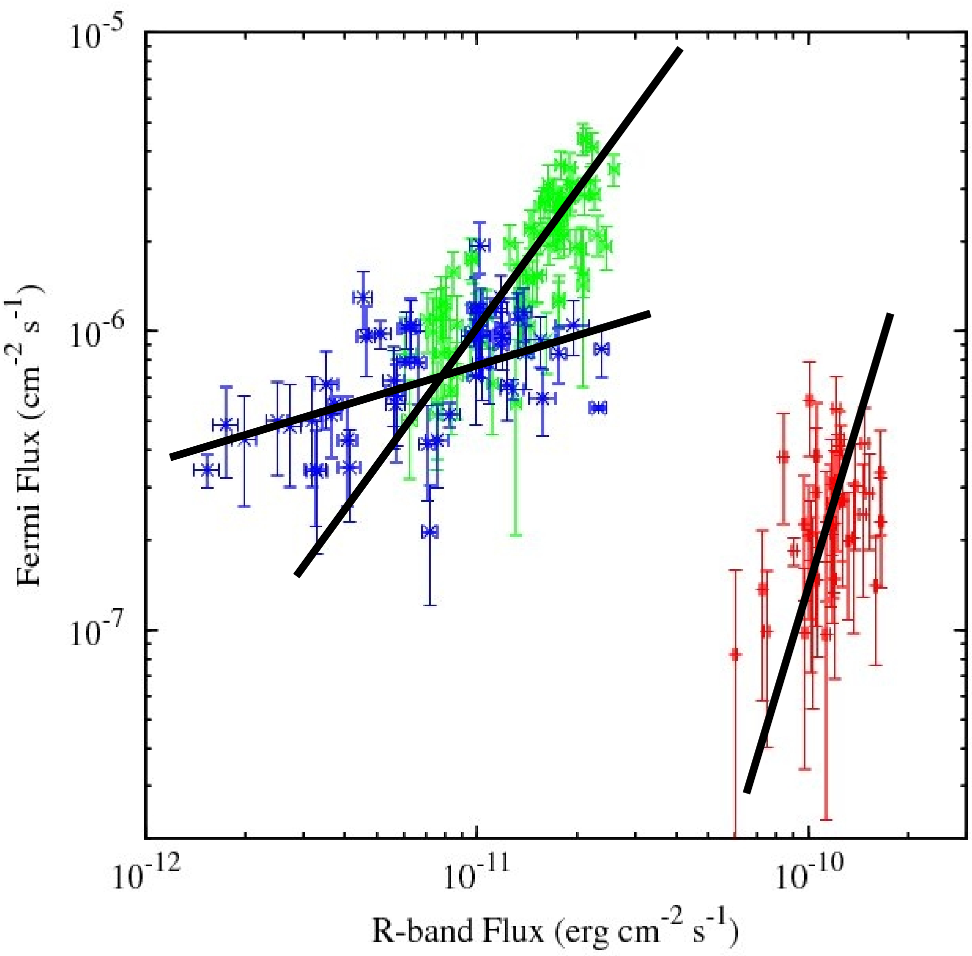


F_{GeV} – F_{eV} Relations: Slopes

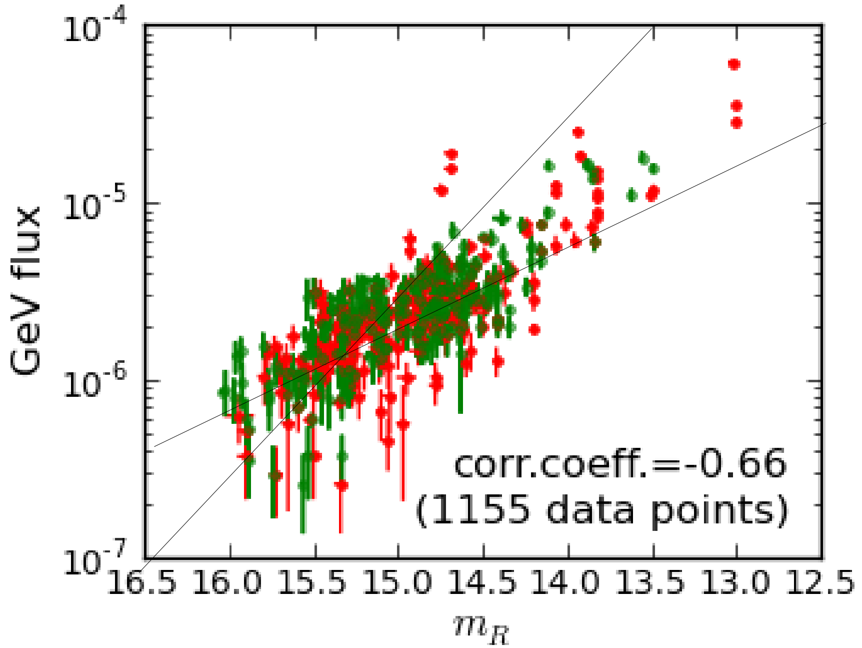


3C454.3, PKS 0235+164 and PKS 2155-304

Even for Blazars of similar type, slopes and average flux ratios are different.

With fixed observing band, slopes and ratios depend on relative locations of bands w.r.t. peaks within SED.

Scatter in Scaling Relations



e.g. 3C454.3

Neither linear nor quadratic

There is highly significant scatter around the average slope

The scatter increases with numbers of flares (not data-points)

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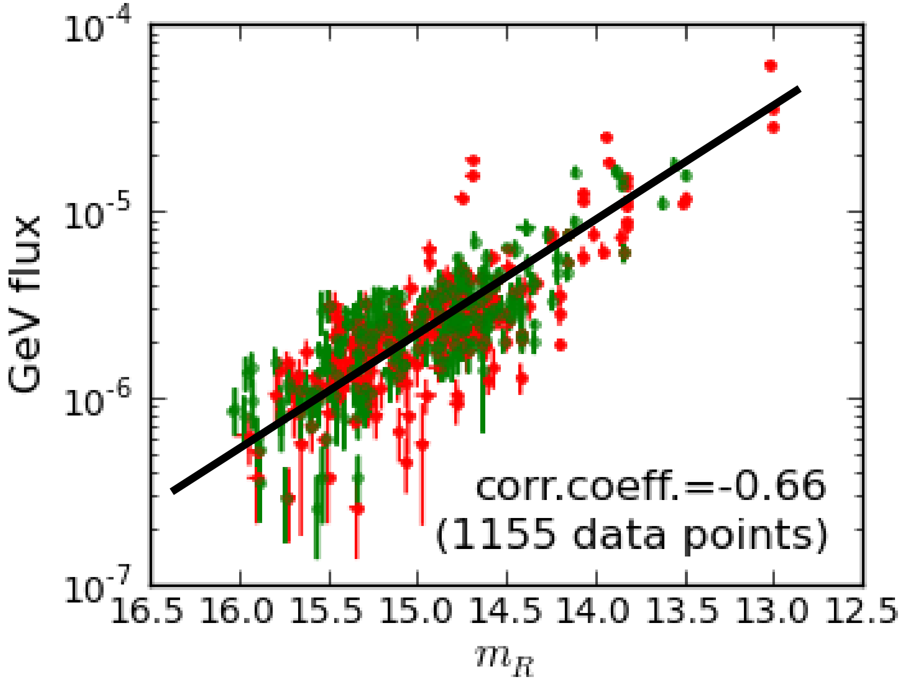

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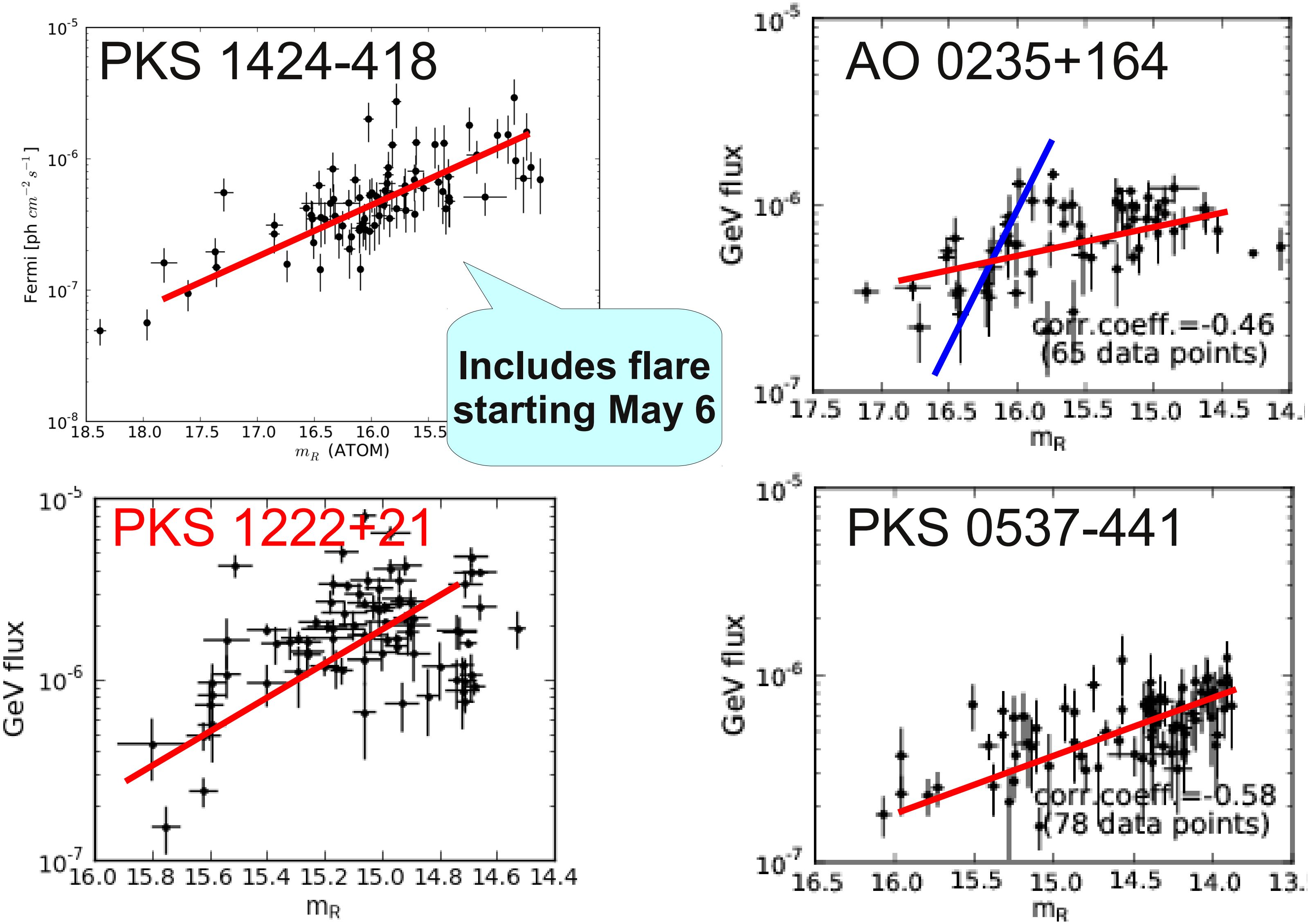
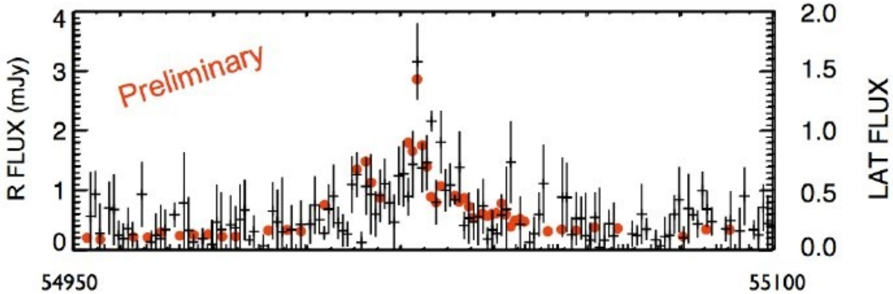
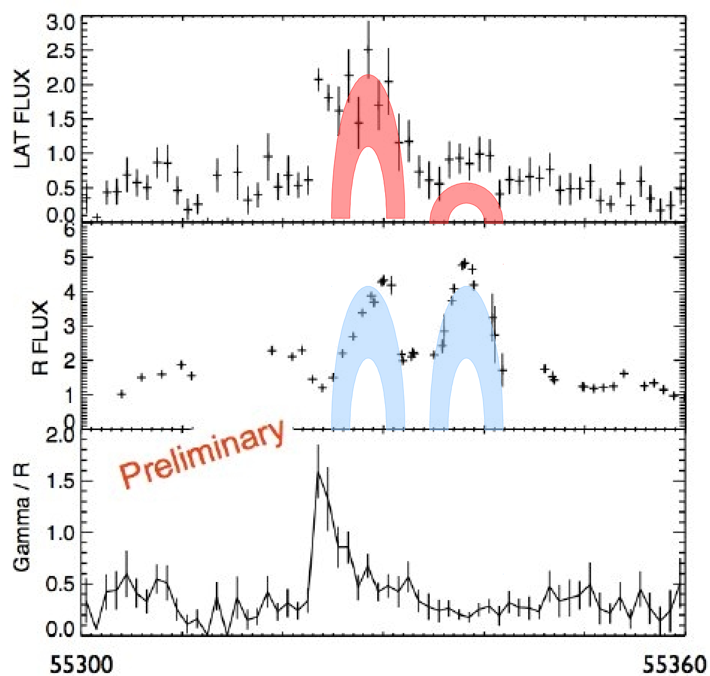
Examples (statistics)



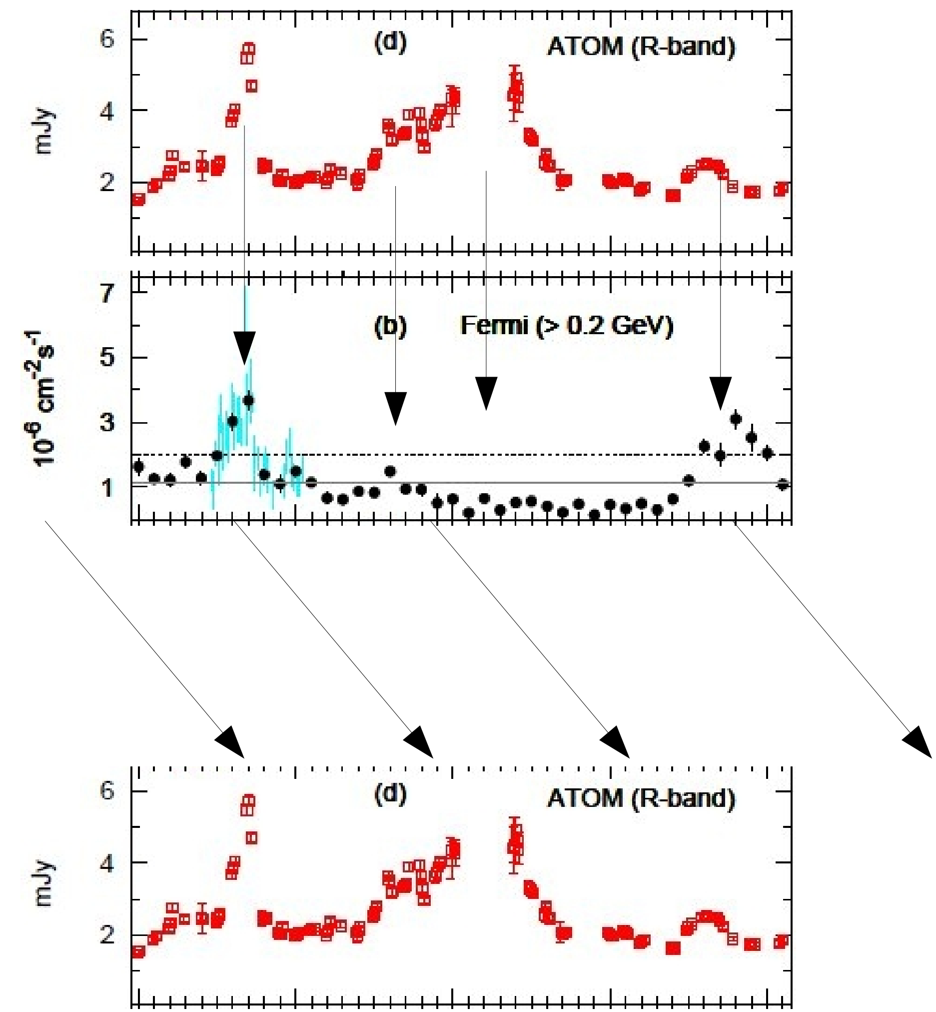
Examples (most extreme cases)

PKS 1424-418
(Poster # 59, Longo et al.)





PKS 1510-089



Conclusions

Optical and GeV gamma-ray flares match in almost all sources with sufficiently complete data sets.

There is no significant indication for > 50h lags in sets with multiple flares.

Optical/GeV fluxes follow power-law relations with 0.2 < <slope> < 3.1.

Frequency bands are fixed but peak frequencies of synchrotron and IC components vary throughout the sample, affecting the slopes.

All cases exhibit statistically significant scatter beyond power-law relationship, resulting from different tracks in different flares.

Different flares (which often superpose) are likely to exhibit different specific SEDs, implying different physical states in emission volumes.

Simultaneous SEDs characterize events - but not necessarily sources.

Caveats and Warnings

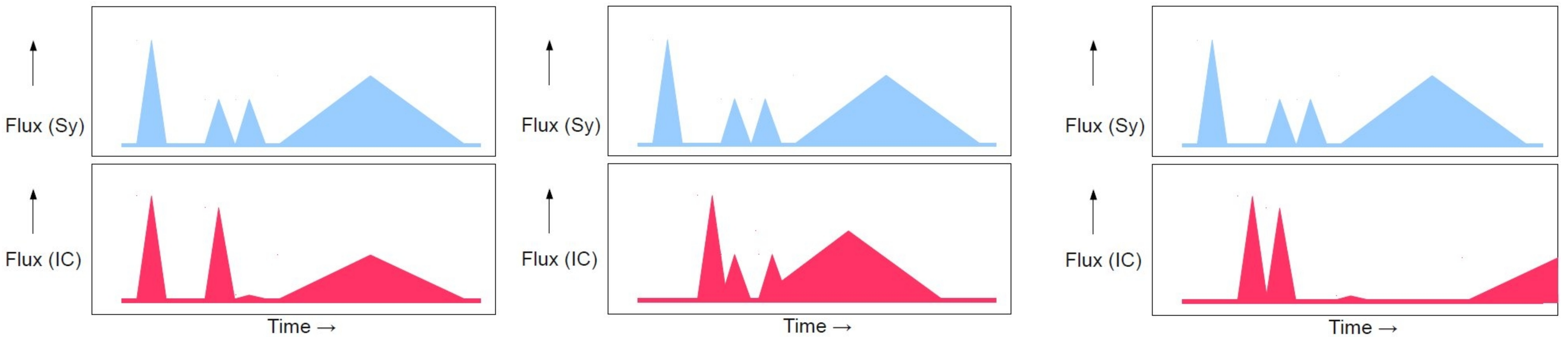
Power-law PDS and high-frequency end (IDV):
How characteristic are one-day averages?
(Extension to dynamic binning of GeV data possible?)

Could there be small lags? - Possibly, check with colours

Individual sources: Both effects contribute marginally to scatter.

In FSRQs one may want to worry about variable thermal emission
(e.g. 3C454.3, but see, e.g. Poster # 39, Isler)

Scalings and Lags



Blending makes distinctions difficult.
Well-sampled, high S/N data-trains suggest duty cycles → 100%
(Poster # AGN-100)

Best-sampled sources rule out constant-scaling/individual-lags;
Individual-scaling/individual-lag scenario unconstrained in statistical study

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PKS 1424-418
(Poster # , Longo et al.)