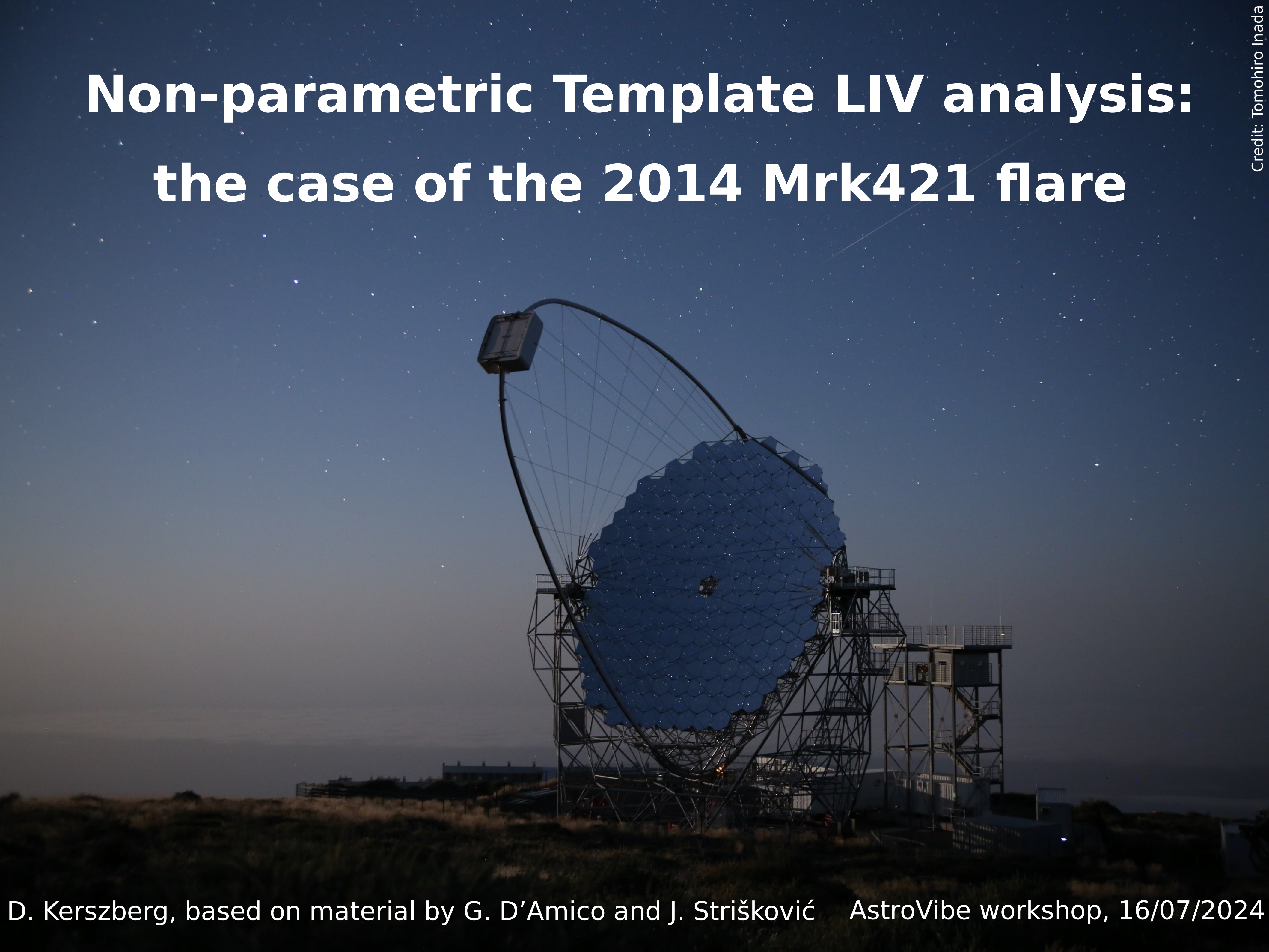
Non-parametric Template LIV analysis: the case of the 2014 Mrk421 flare



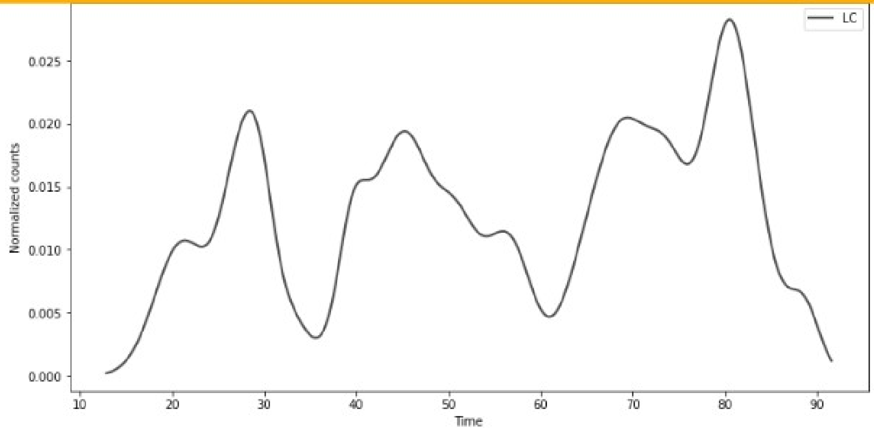
Credit: Tomohiro Inada

D. Kerszberg, based on material by G. D'Amico and J. Strišković

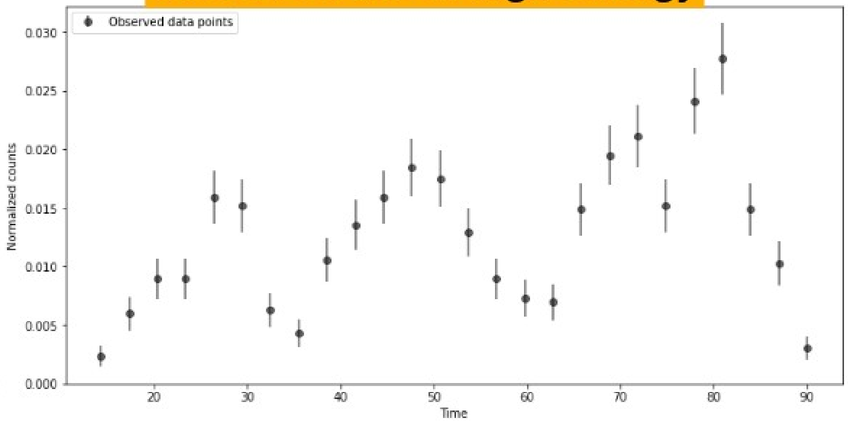
AstroVibe workshop, 16/07/2024

The “problem” with a LC template

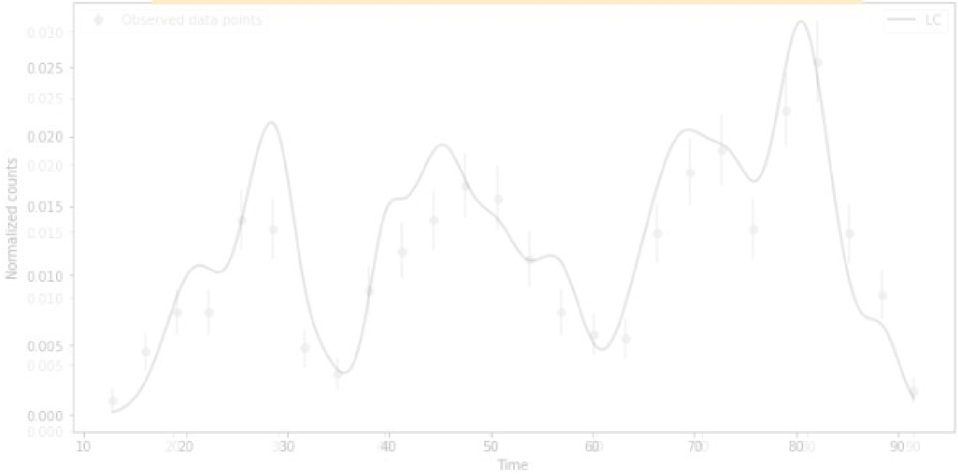
LC at low energy where LIV effects are negligible



Observed LC at high energy



Inference analysis on LIV time delays



from G. D’Amico

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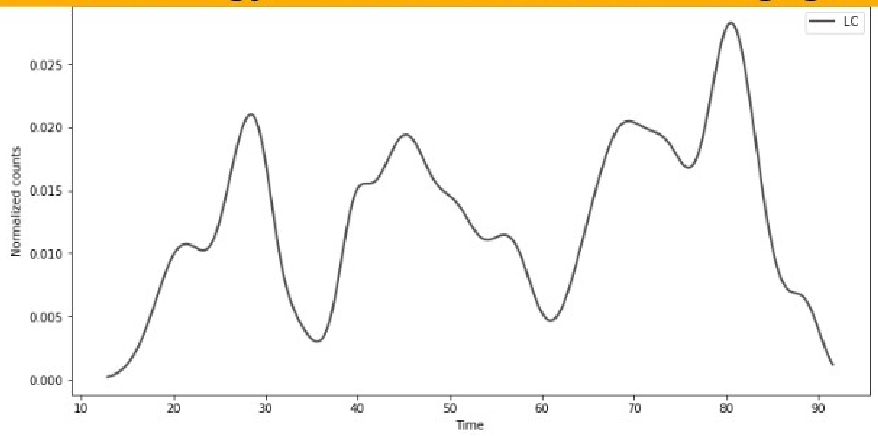

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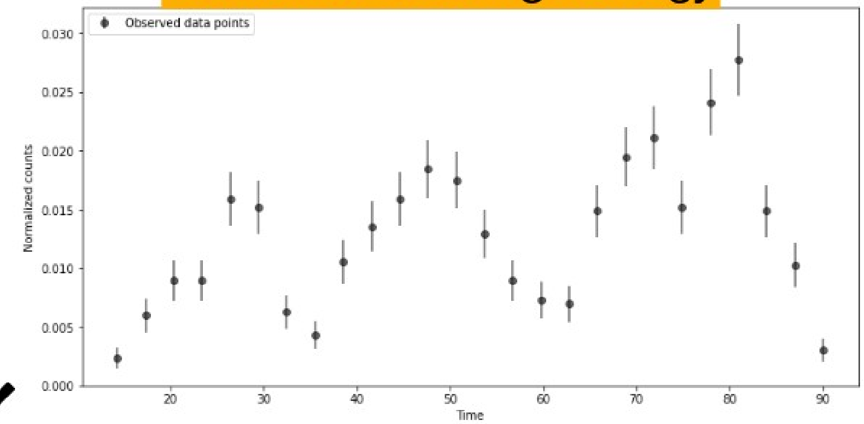

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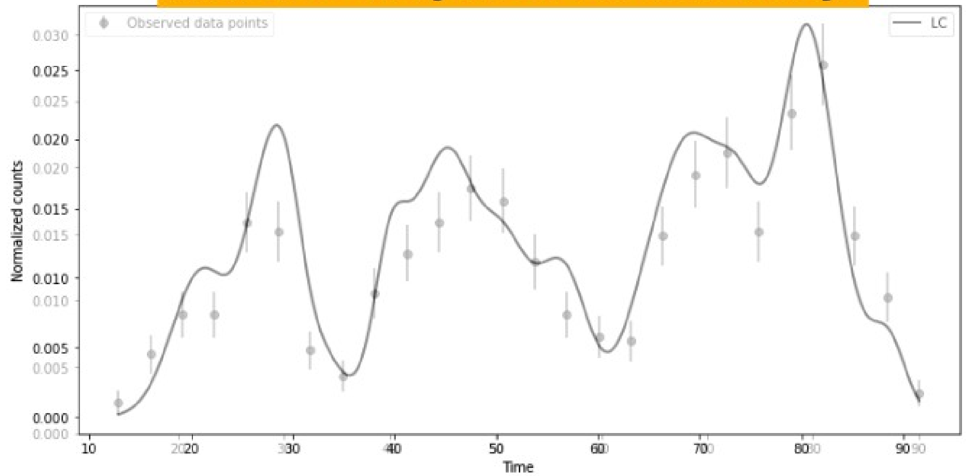

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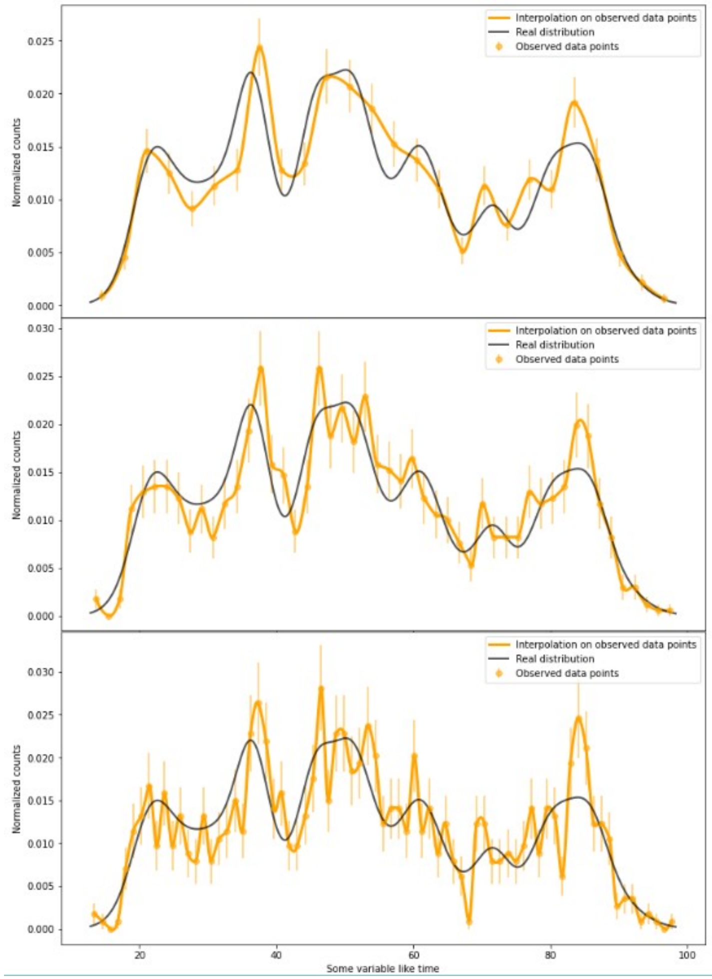


Getting the LC is not an easy job

In **black** the ‘real’ LC used for generating the events

In **orange** the observed flux and the interpolation performed to recover the LC

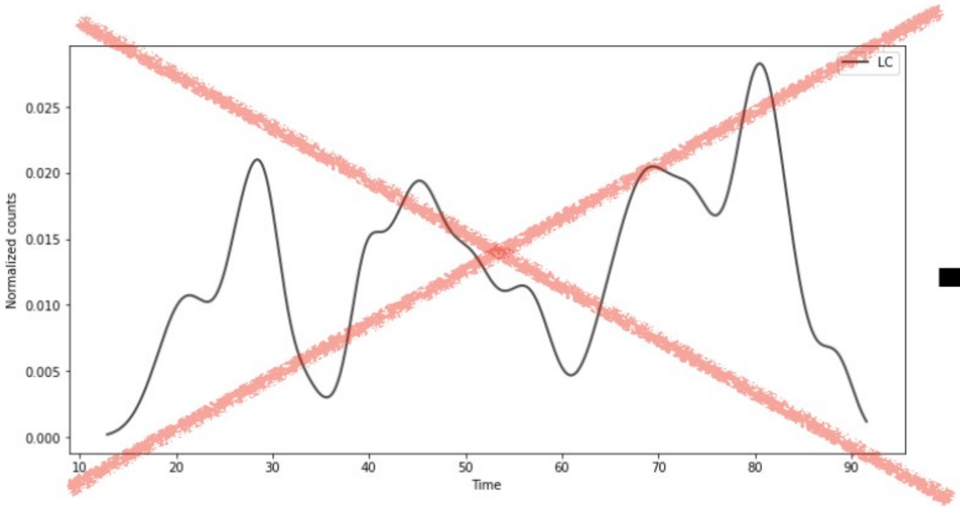
Conclusion:

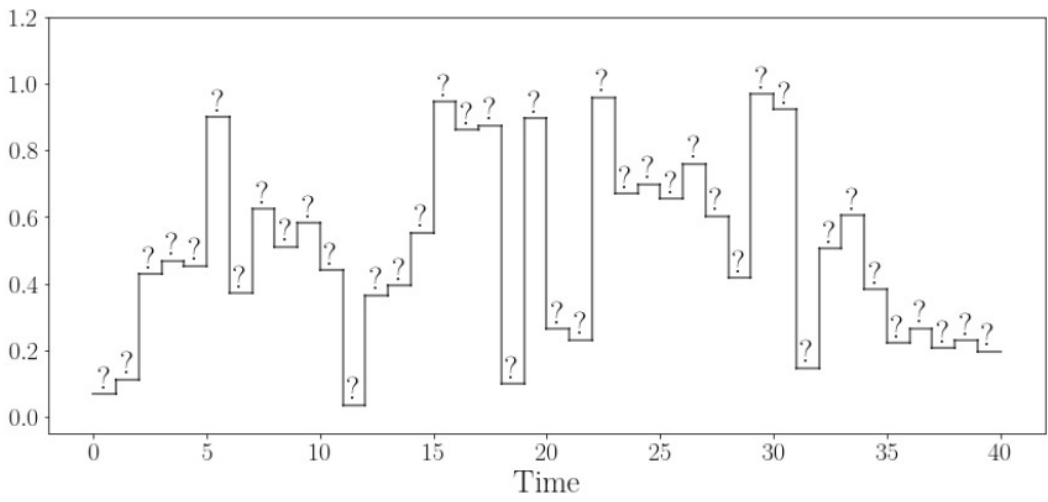
Unless you have theoretical motivations, you should always be skeptical about your fitted/interpolated LC

from G. D’Amico

A simple solution to this “problem”

Instead of ‘guessing’ the LC shape, we make the following minimal assumption:
in a given temporal bin, the flux intensity of gamma rays must have been an intensity whose value is unknown (free parameter of the likelihood)





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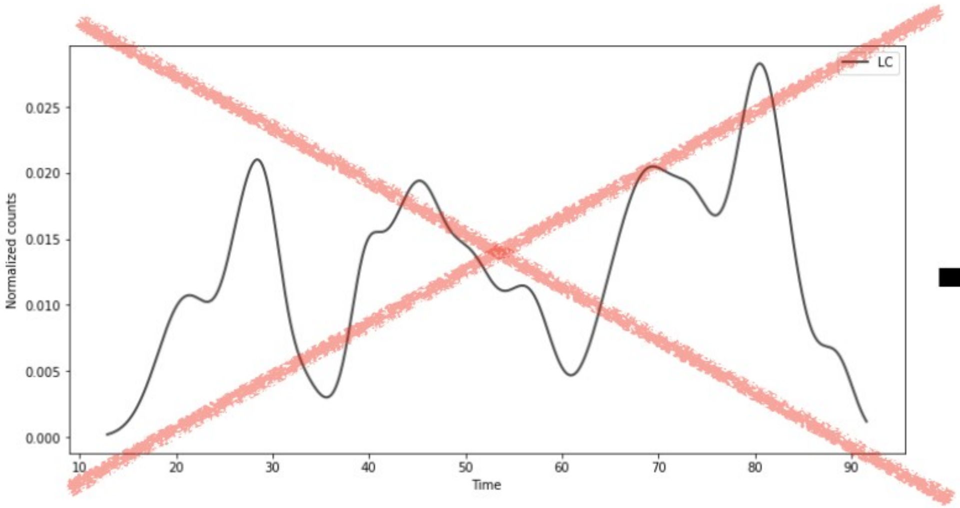
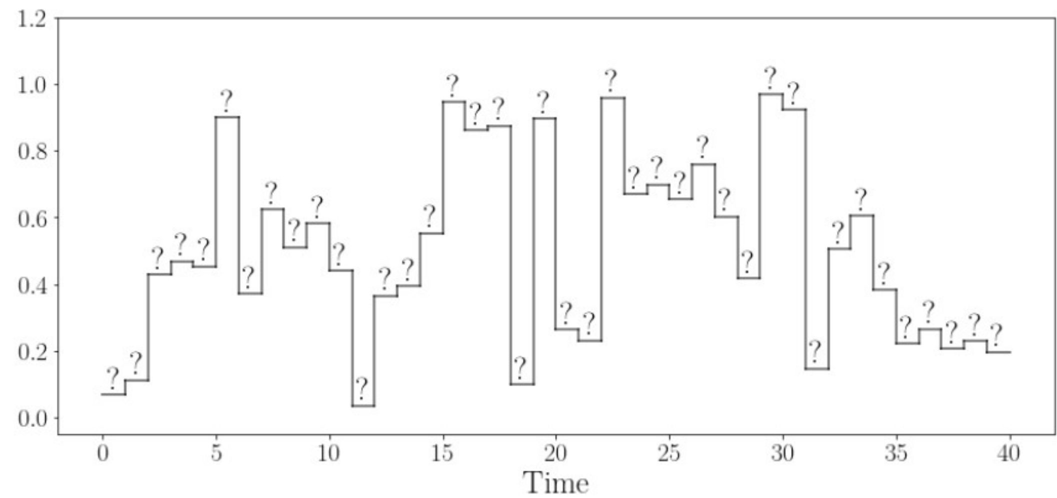


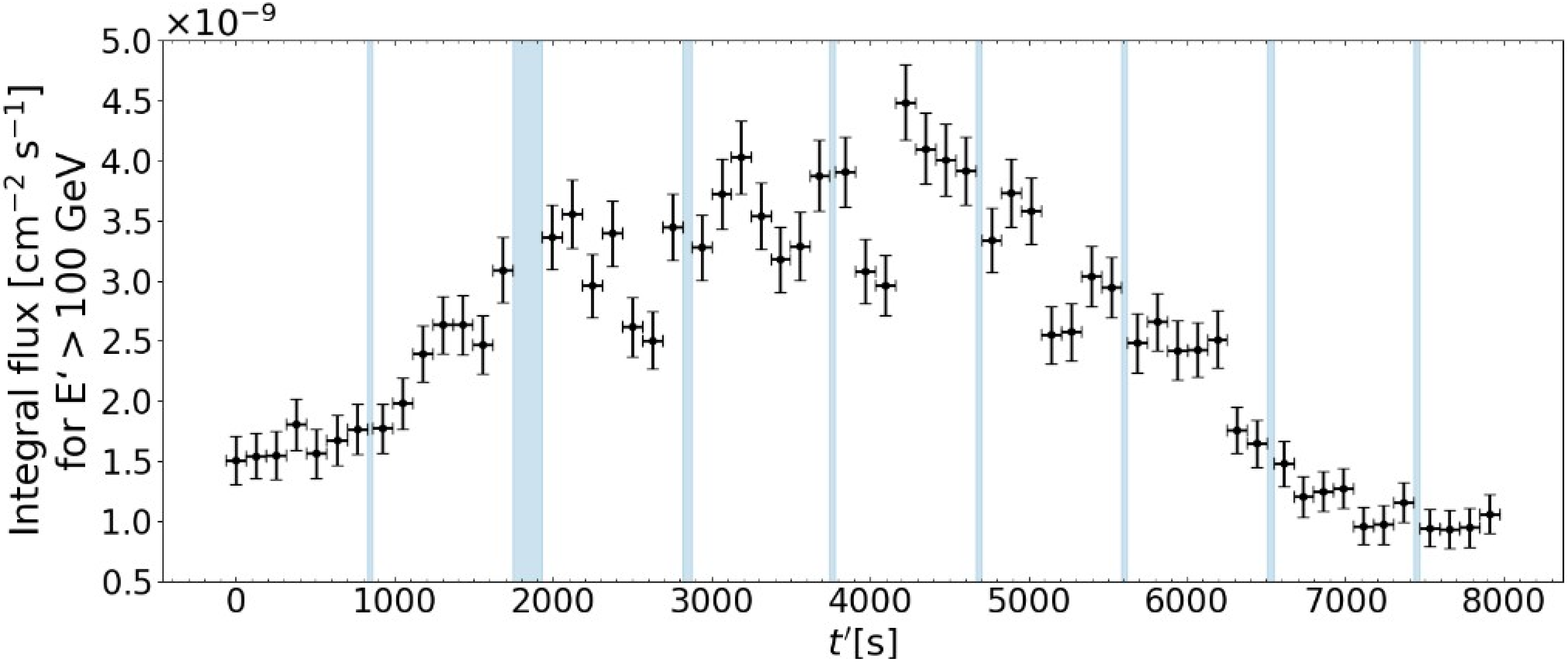


$$\mathcal{L}(\eta_n) = \prod_{i=1}^{N} P(E'_i, t'_i | \eta_n)$$

$$\mathcal{L} = \prod_{i=1}^{N_t} \prod_{j=1}^{N_E} \mathcal{P}(s_{i,j}, b_{i,j} | N_{\mathrm{on},i,j}, N_{\mathrm{off},i,j})$$

from G. D'Amico

The 2014 Mrk421 flare seen by MAGIC



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https://arxiv.org/pdf/2406.07140

Results

Obtained limits		
Case	**No systematic uncertainties**	**Including systematic uncertainties**
Linear scenario: $E_{\mathrm{QG},1}/\mathrm{GeV}$		
superluminal	3.5×10^{17}	2.7×10^{17}
subluminal	4.8×10^{17}	3.6×10^{17}
Quadratic scenario: $E_{\mathrm{QG},2}/\mathrm{GeV}$		
superluminal	3.6×10^{10}	2.6×10^{10}
subluminal	3.5×10^{10}	2.5×10^{10}

https://arxiv.org/pdf/2406.07140

Conclusion

- Today:
  - For complex light curves we already spend a significant amount of time fitting the light curve
  - By doing so we make unphysical assumption on these light curves, and introduce (small) biases in the analysis

  → we don't need to do so!
- In the future, we want to combine multiple (many) sources:
  - We will simply not have the time to do such a "fitting procedure" of the light curve for each source
- One solution to this problem is to go for binned likelihood analysis, or non-parametric template analysis as Sami like to call it :-)
- This is what MAGIC (Giacomo, Jelena) did for this Mrk421 2014 flare, demonstrating that the method works
- A technical paper is in preparation showing with simulations the advantage of this method