LORENTZ INVARIANCE VIOLATION STUDIES AND ACTIVE GALACTIC NUCLEI

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INTRODUCTION

Lorentz Invariance Violation (LIV)

Related to some Quantum Gravity models

Impacts velocity of photon which depends on photon's energy

Implies a time-delay between photons of different energy

Two test models to research LIV :

- Linear : $t_{rec} = t_{true} + \tau E$
- Quadratic : $t_{rec} = t_{true} + \tau E^2$

Active Galactic Nuclei (AGN)

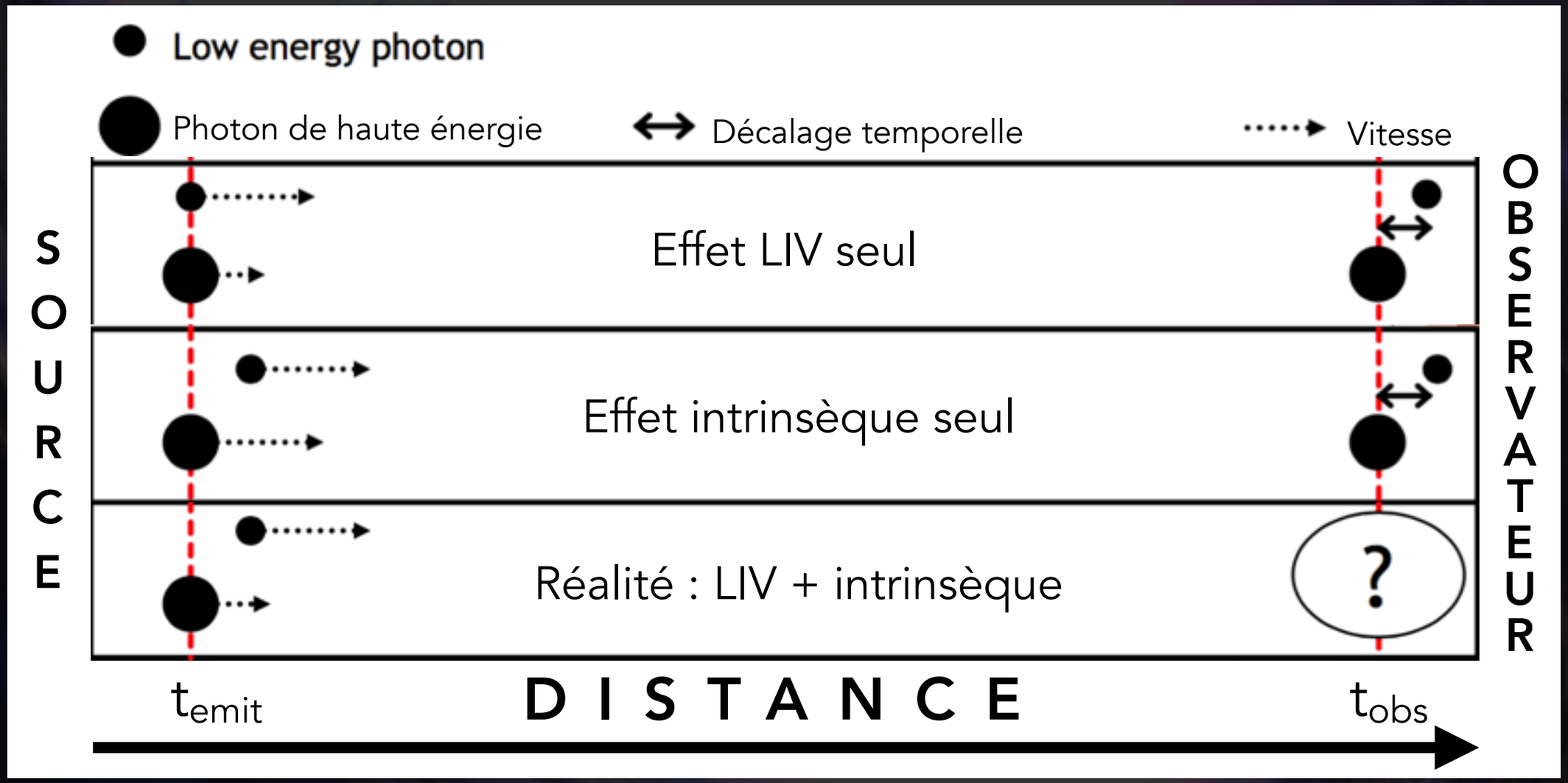
Time evolution of the particle responsible of emissions : electron

Differential equation describing the evolution of electron resolved numerically

Compute synchrotron and inverse-Compton emissions at each time

Constrain time-delay directly from source emission

INTRODUCTION



LORENTZ INVARIANCE VIOLATION

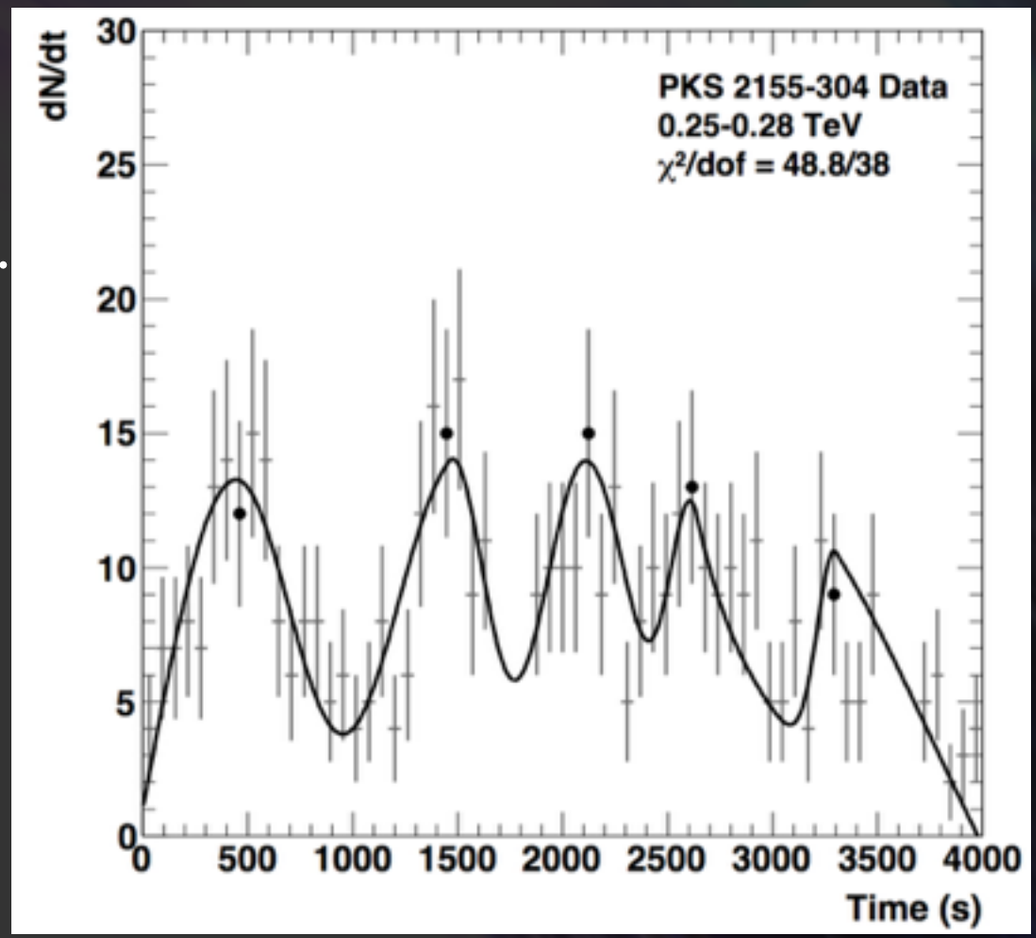
Likelihood method is used to measure time-delay

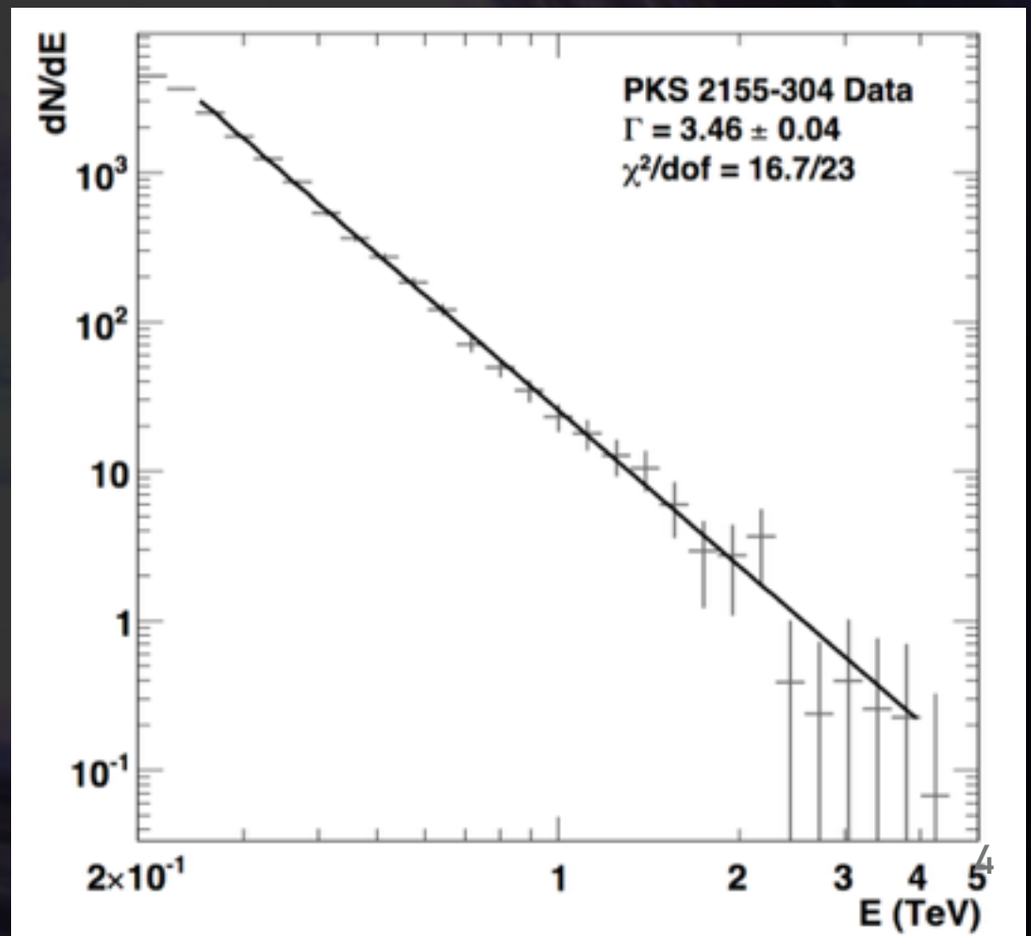
Data are split in 2 sets :

- Low energy photons as template (considered not time-delayed)

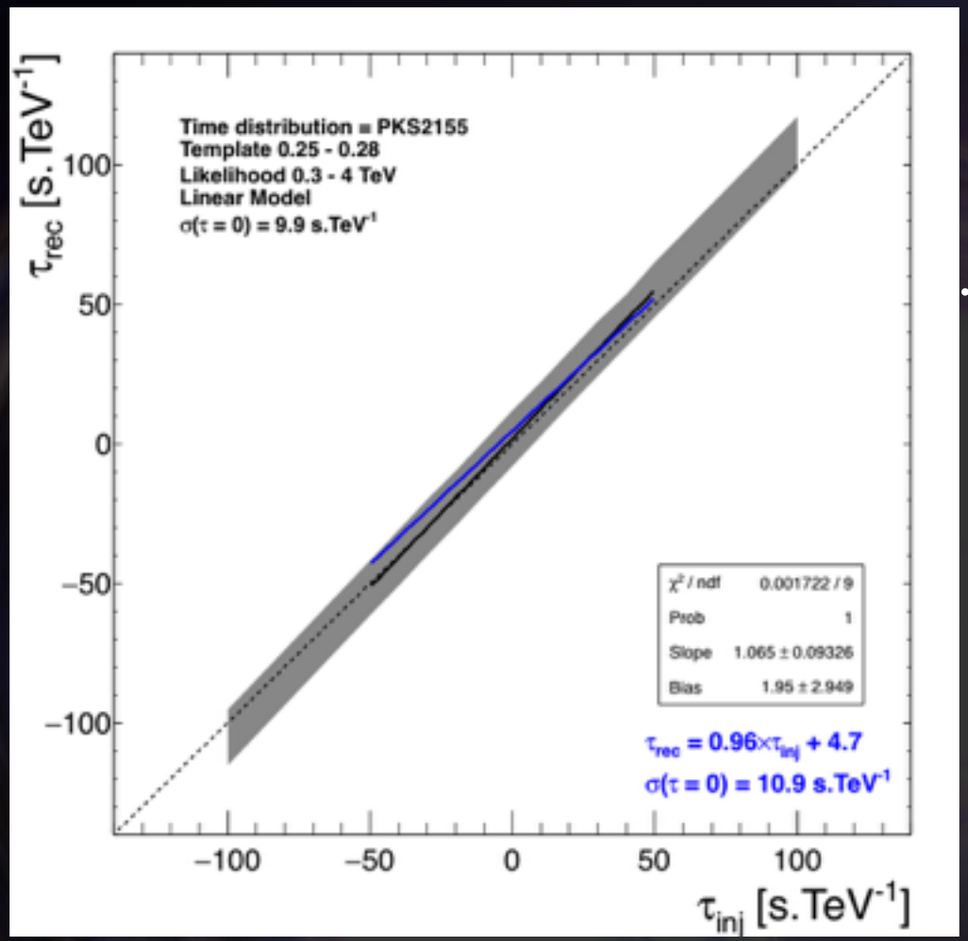
- High energy photons used in the Likelihood fit

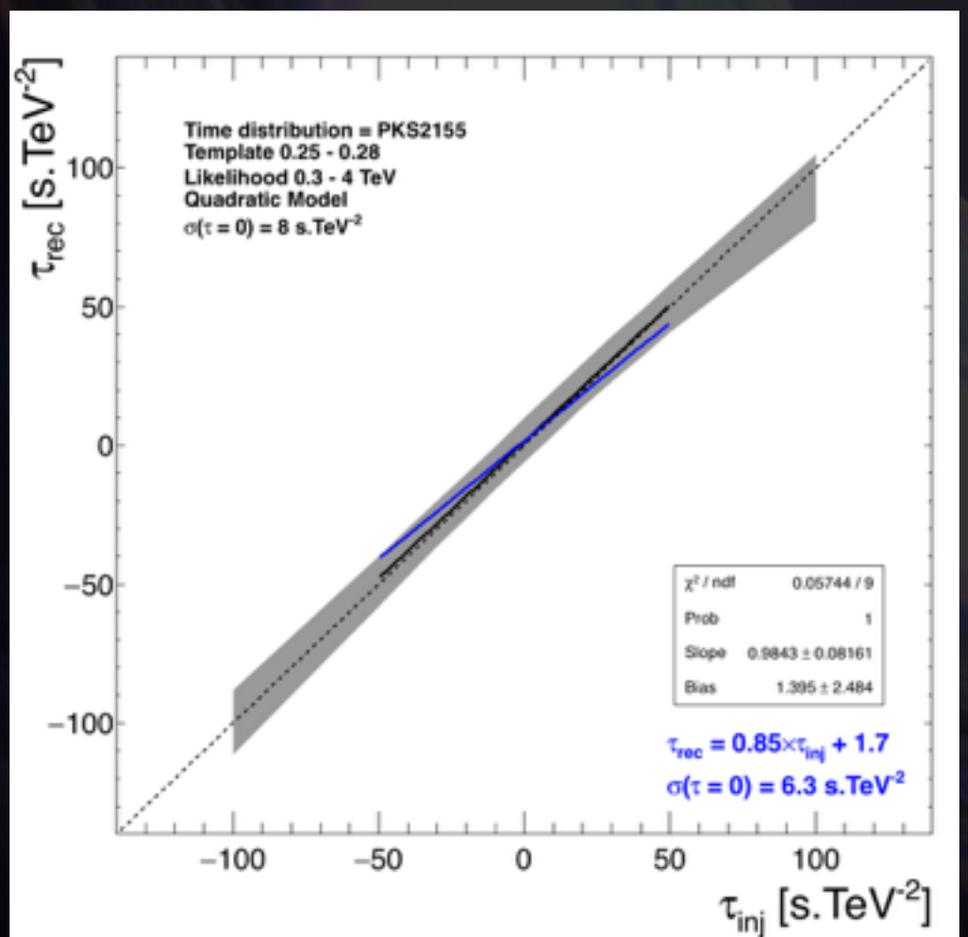
Simulations are done to test the method





LORENTZ INVARIANCE VIOLATION





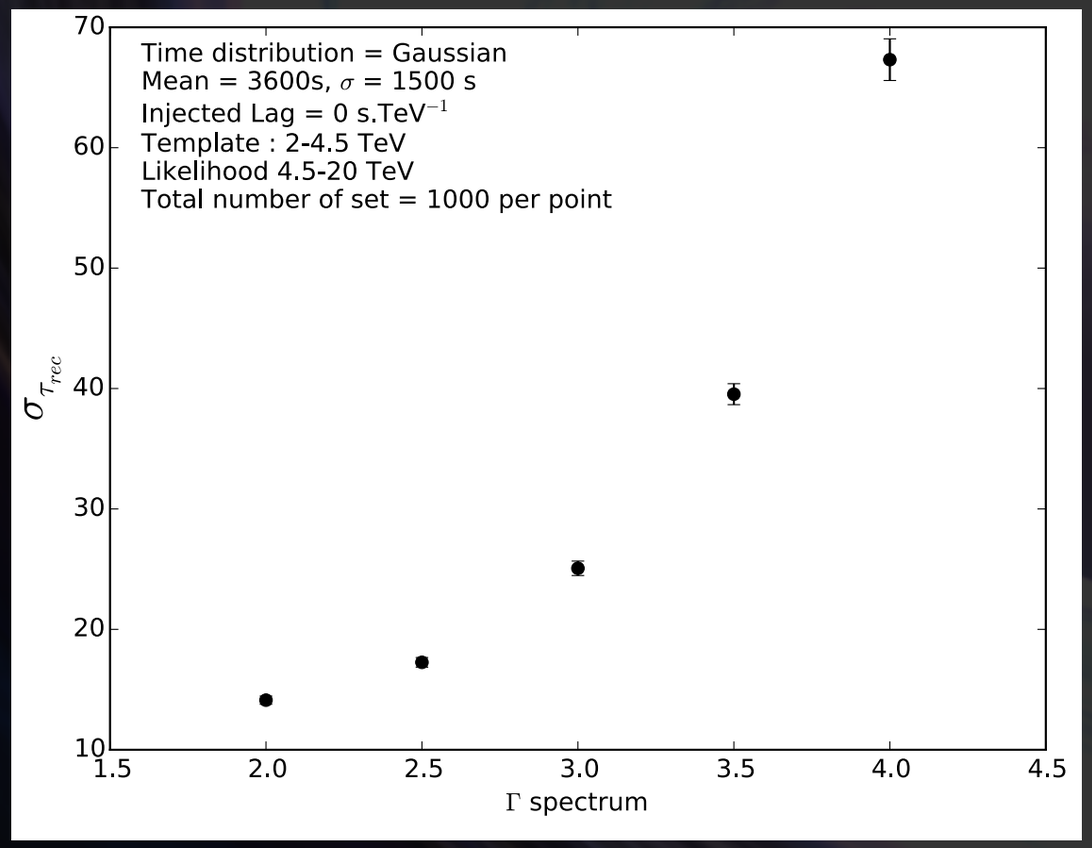
Different time-lags are injected to calibrate the method and see the response function

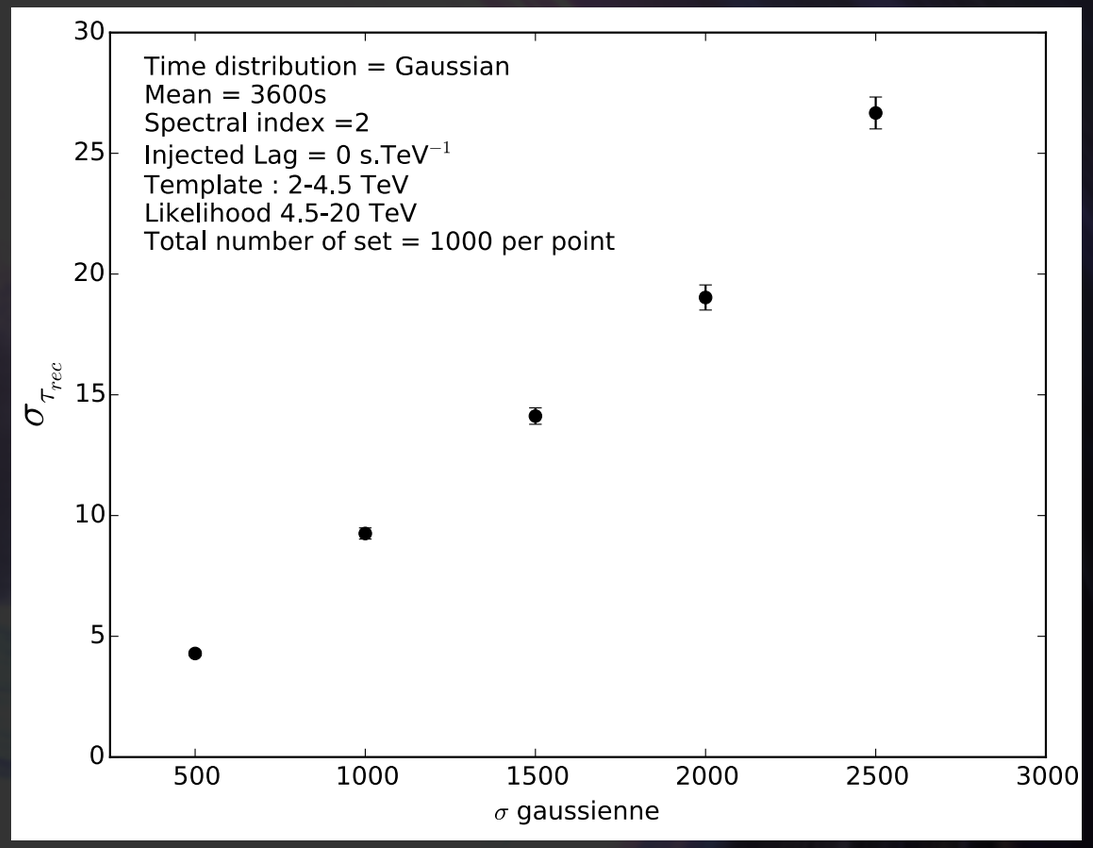
Good agreement with results from paper (H.E.S.S. Collaboration 2011) in blue

This results will take part to a collaboration with the three Cherenkov telescope experiment

LORENTZ INVARIANCE VIOLATION

Further tests were done looking at the impact of the source parameters on the error of the reconstructed time-lag





The method is working well and now waiting data.

ACTIVE GALACTIC NUCLEI

Numerical resolution of electrons' time evolution emitting synchrotron and inverse-Compton radiations

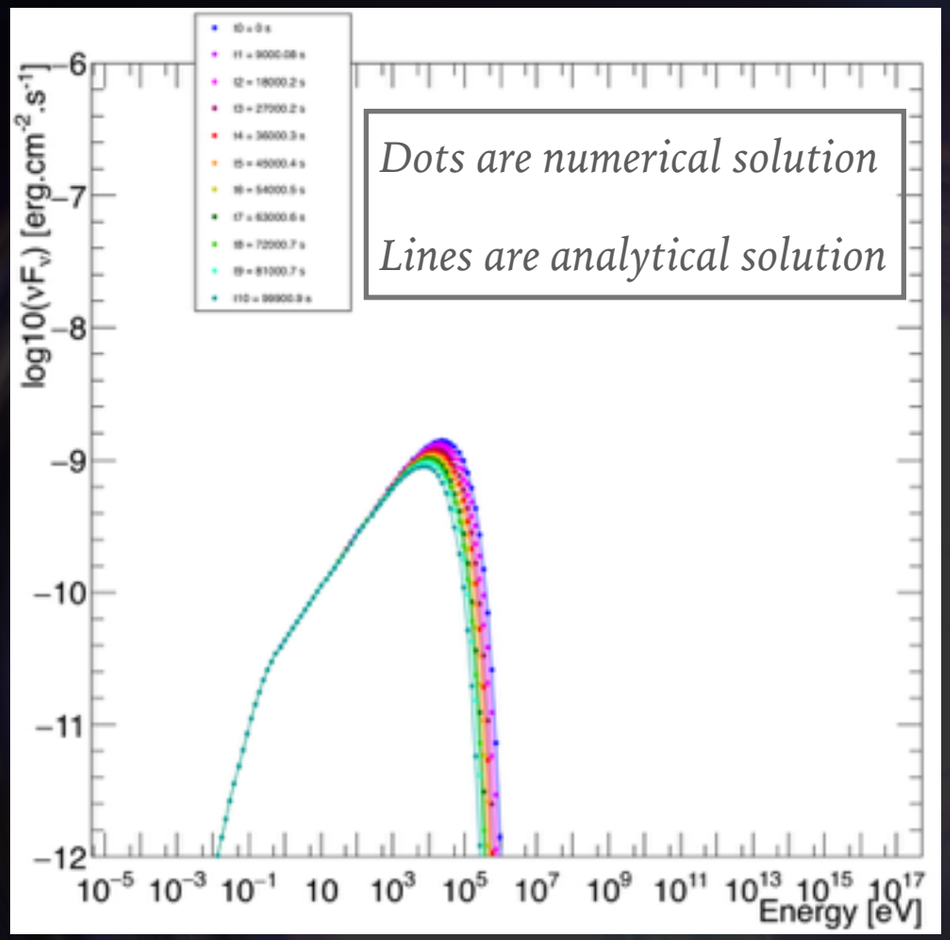
$$\frac{\partial N(E,t)}{\partial t} + \frac{\partial}{\partial E}\left(\beta E^2 N(E,t)\right) = 0$$

Finite difference is used to resolved the equation with a Lax-Wendroff scheme

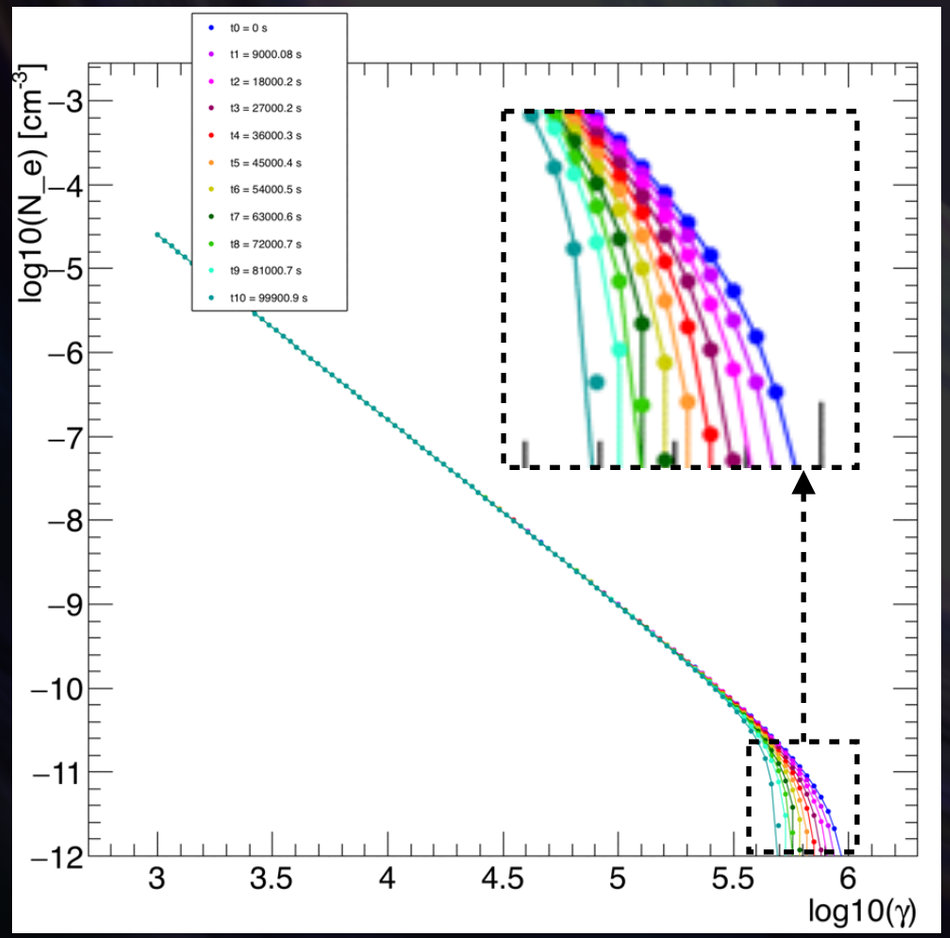
The simplest 2D scheme : $u_i^{n+1} = u_i^n - \frac{\Delta t}{\Delta x}(F_{i+1}^n - F_i^n)$

Lax-Wendroff scheme : $u_i^{n+1} = u_i^n - \frac{\Delta t}{\Delta x}\left(F_{i+\frac{1}{2}}^{n+\frac{1}{2}} - F_{i-\frac{1}{2}}^{n+\frac{1}{2}}\right)$

ACTIVE GALACTIC NUCLEI



Only synchrotron was considered first because it's the only case with simple analytic solution



Initial electron spectrum :

$$N(E, t=0) = KE^{-\Gamma}\left(1 - \left(\frac{E}{E_{cut}}\right)^2\right)$$

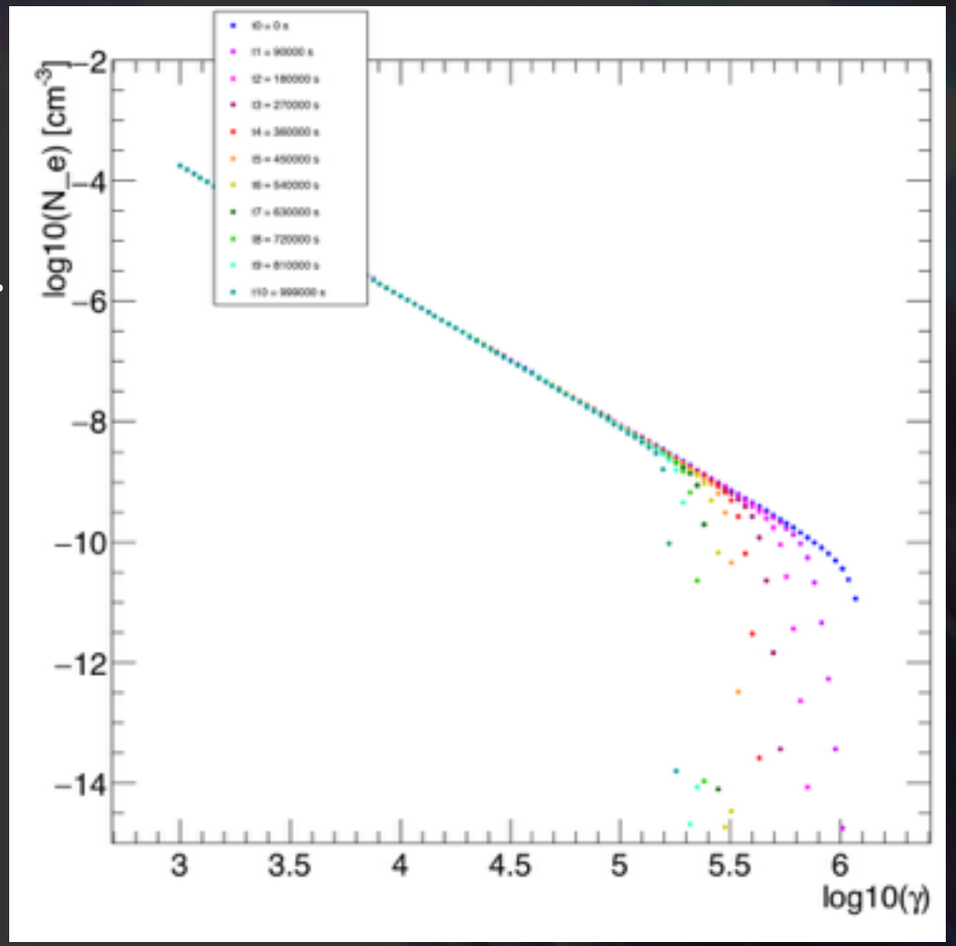
These results don't rely on real physical parameters

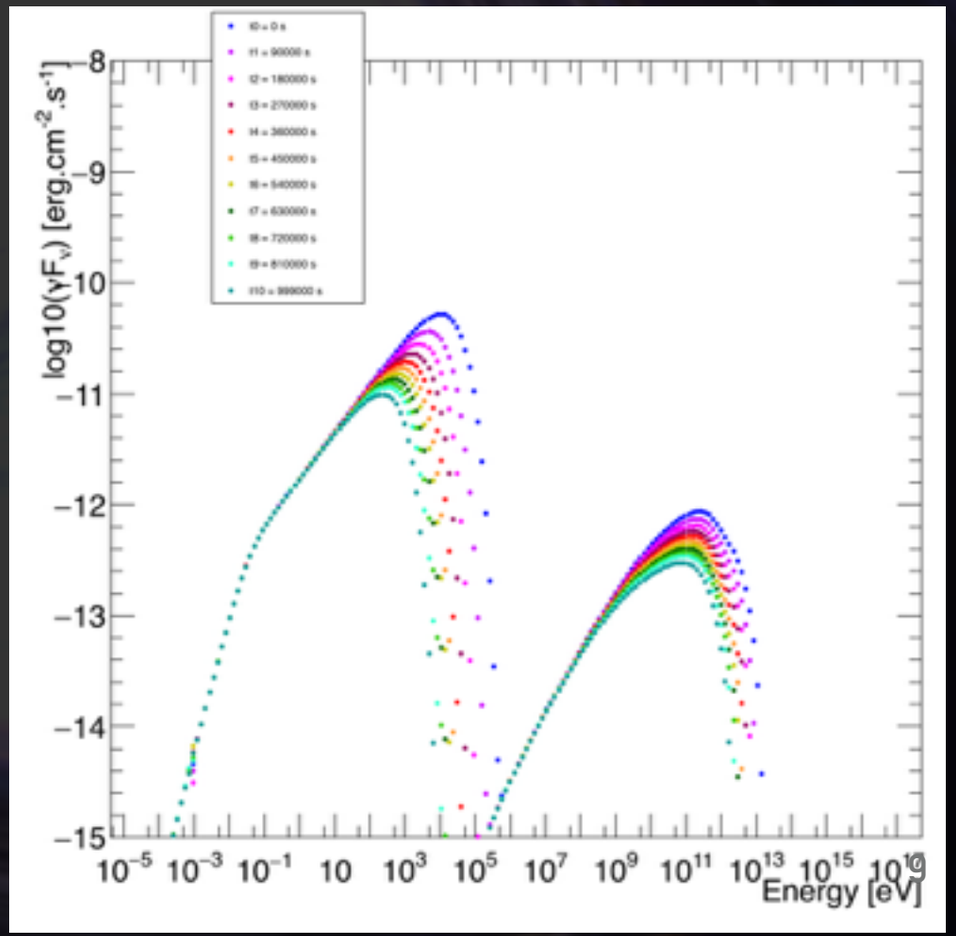
ACTIVE GALACTIC NUCLEI

Then inverse-Compton process was added, which emits more energetic photons

Inverse-Compton relies directly on synchrotron emission

No analytical solution for this scenario





CONCLUSION

Lorentz Invariance Violation (LIV)

Analysis program to reconstruct time-lag is ready and validated

Waiting new data from H.E.S.S. to analyse data and calibrate with simulation

Collaboration with MAGIC and VERITAS for combination of sources on-going

Active Galactic Nuclei (AGN)

Numerical resolution working on simple case

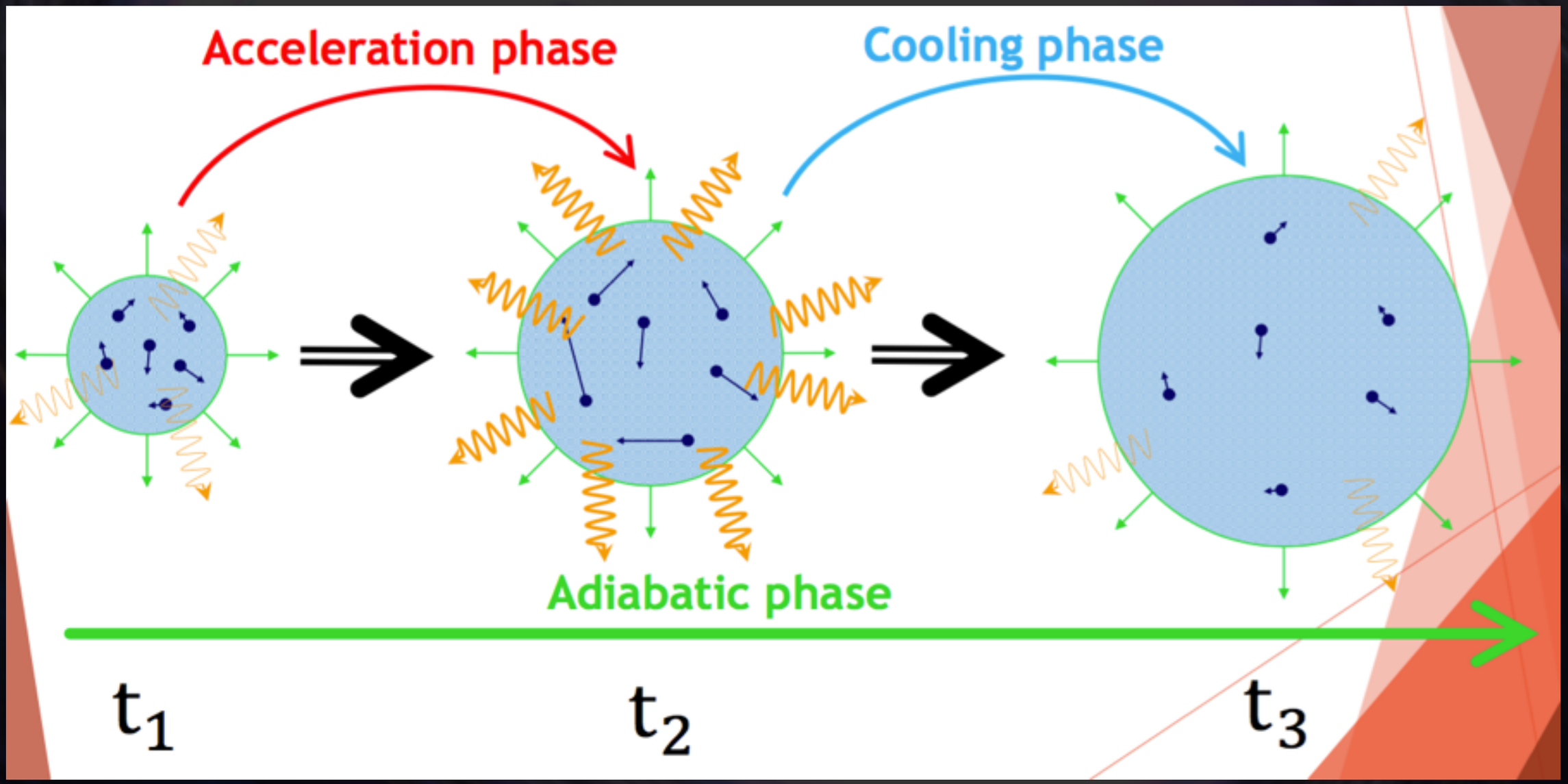
Inverse-Compton added but need to be compared with other models in literature

Add more processes like acceleration of particle or adiabatic expansion of the emitting zone

More details on my work the 28th October for my Friday seminar

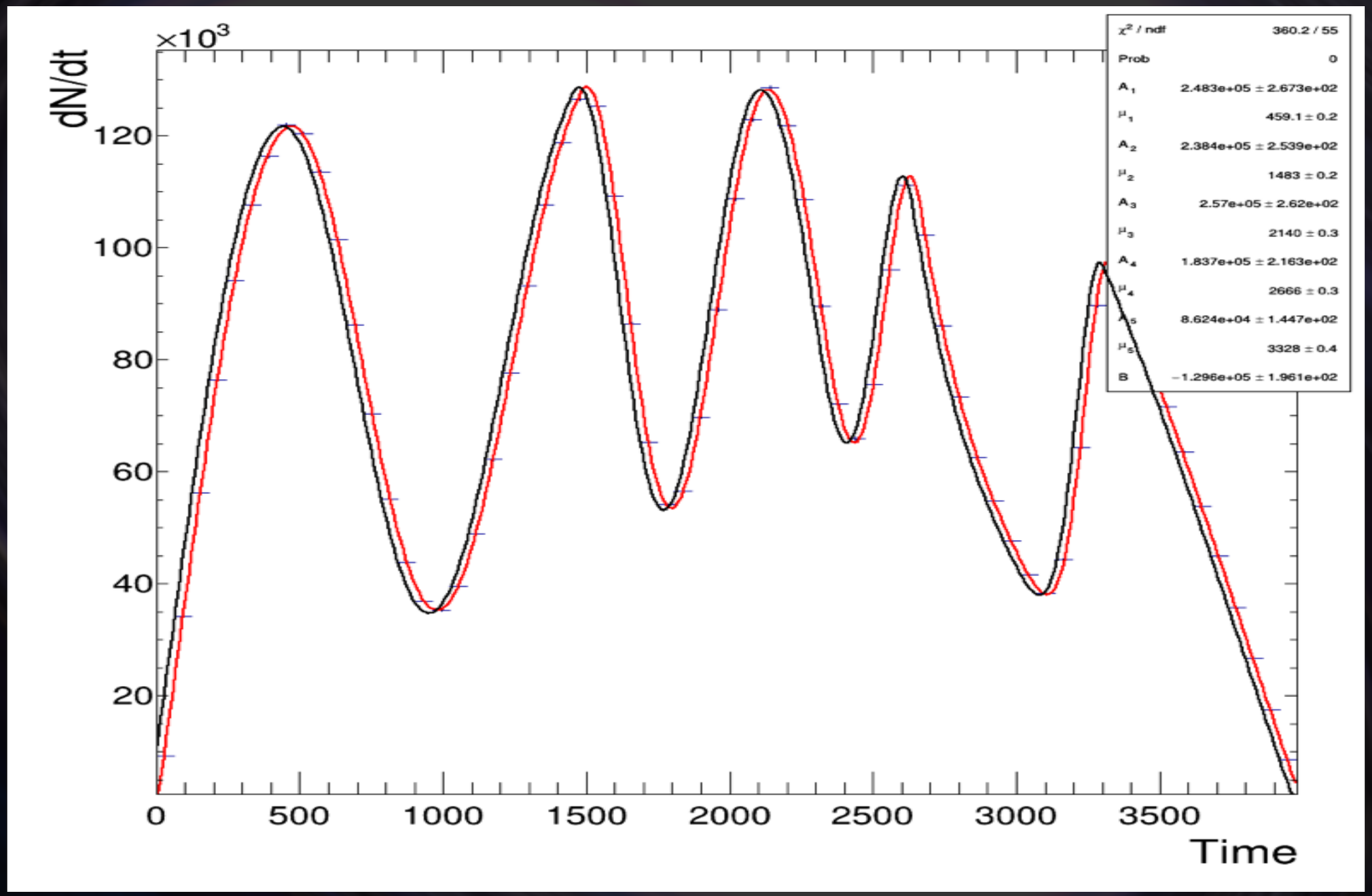
(Maybe with update :))

BACK-UP



Evolution of the emission zone of the "final" model

BACK-UP



Effect of linear model time-lag with $\tau = 100\ s.TeV^{-1}$