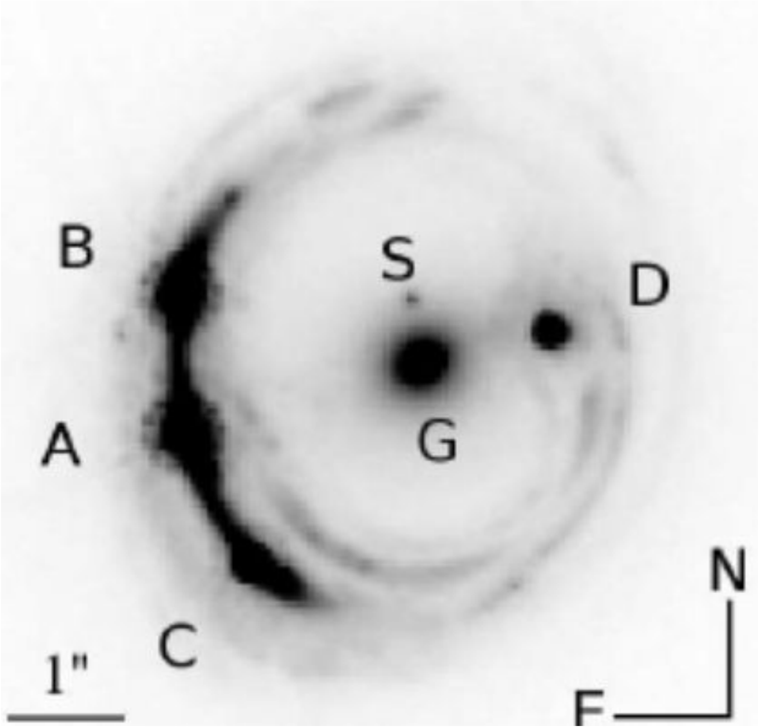
We present a method for

Time Delay Estimation in Unresolved Lensed Quasars via Convolutional Neural Networks

by: Luca Biggio, Silvano Tosi, Alba Domi, Luca Paganin, Davide Ricci*, Nino Bracco and Georgios Vernardos (*speaker)

A method to estimate the Hubble constant H0 is the measurement of the **time-delay** between multiple images of a lensed quasar via **light curves**

For example:
RXJ1131-1231
(HST image)



Large telescopes **can** resolve the lensed images, but **cannot** achieve long-term monitoring.

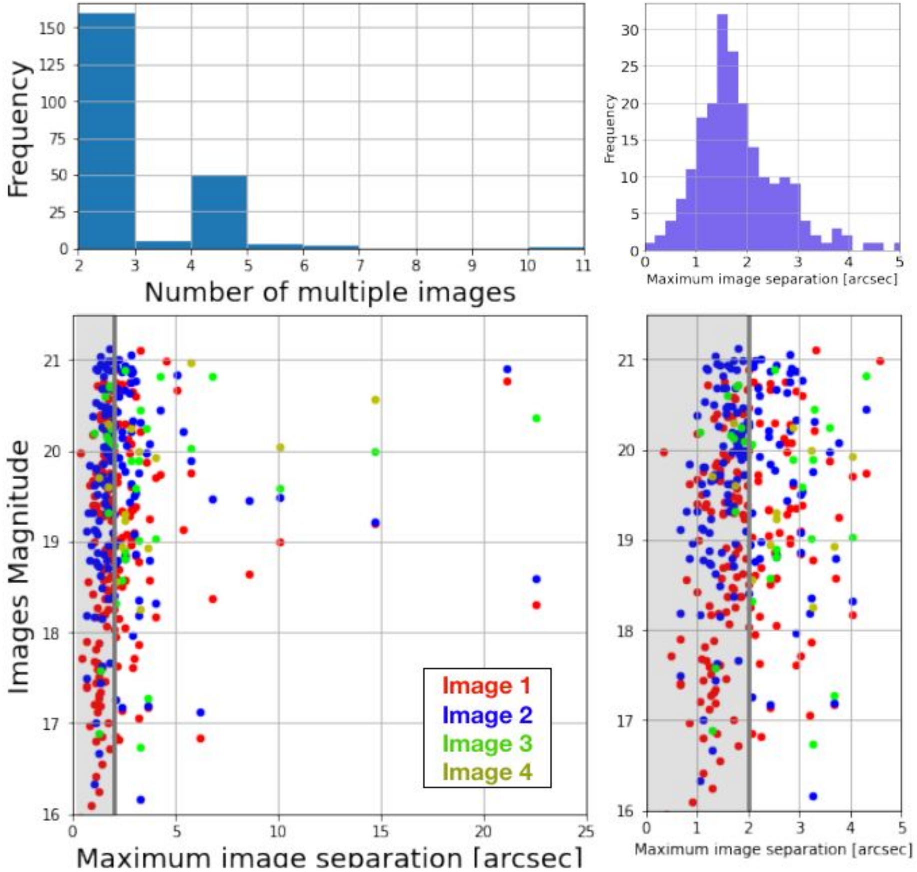
Small telescopes **cannot** resolve the lensed images, but **can** achieve long-term monitoring.

We aim to achieve Time Delay Estimation in Unresolved Lensed Quasars light curves

In fact, if you look at the distribution of known GLQs as a function of the number of multiple images....

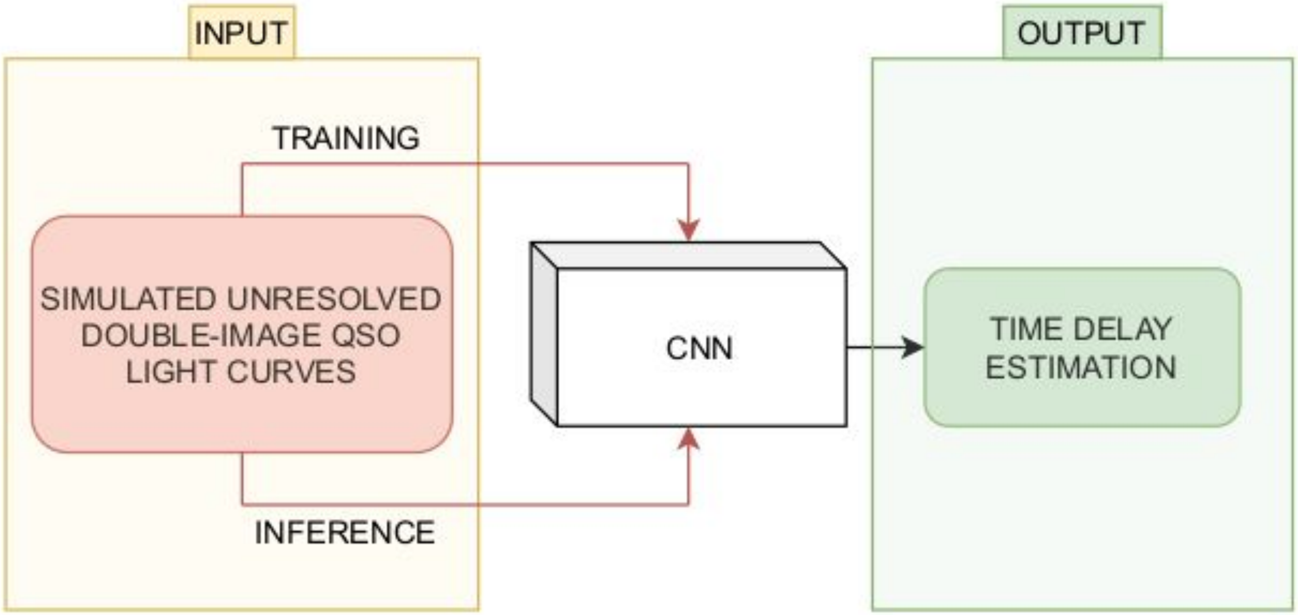
… you can see that the grey region contains 70% of the total GLQ sample: maximum separation → 2 arcsec

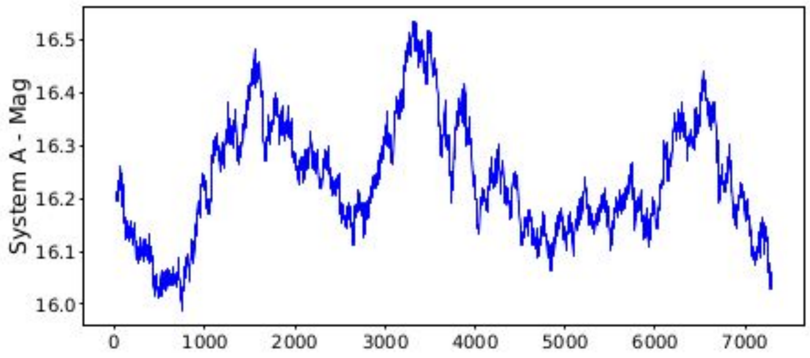
We simulate unresolved curves pairing couples of lensed images from an artificial "System A" and RXJ1131-1231

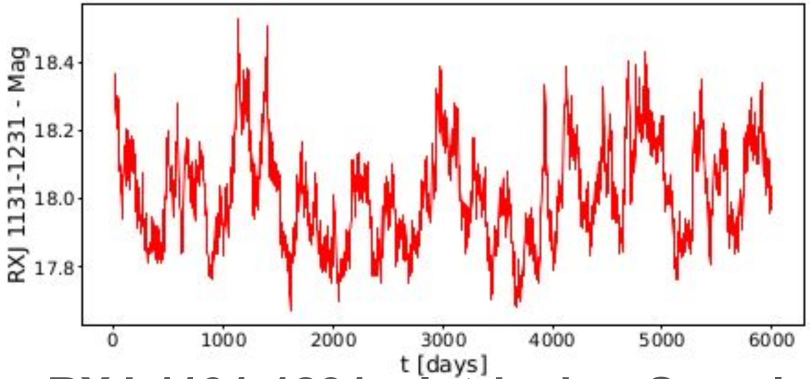


We use a Convolutional Neural Network (CNN) to retrieve time delay from light curves of unresolved quasars.

Artificial data are used to train the CNN model. Inference is then performed on the original non-resolved light curves using the trained model.



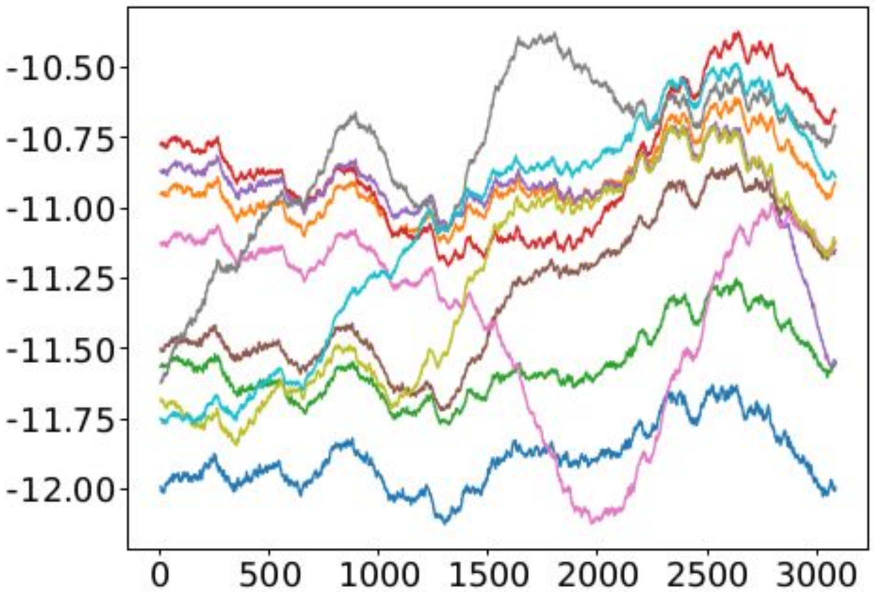


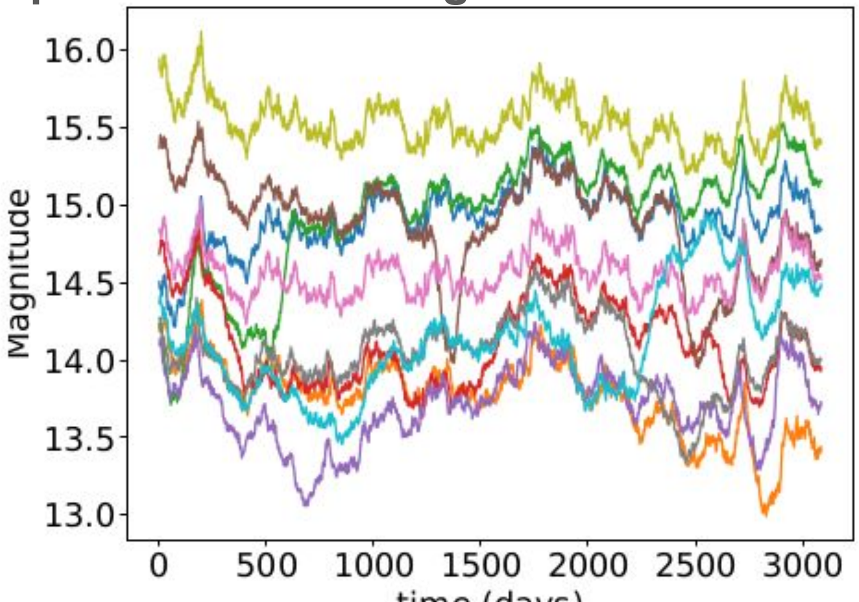


“System A” ↑ Intrinsic ↓ Samples

RXJ-1131-1231 ↑ Intrinsic ↓ Samples

Samples are paired in couple of 2 lensed images



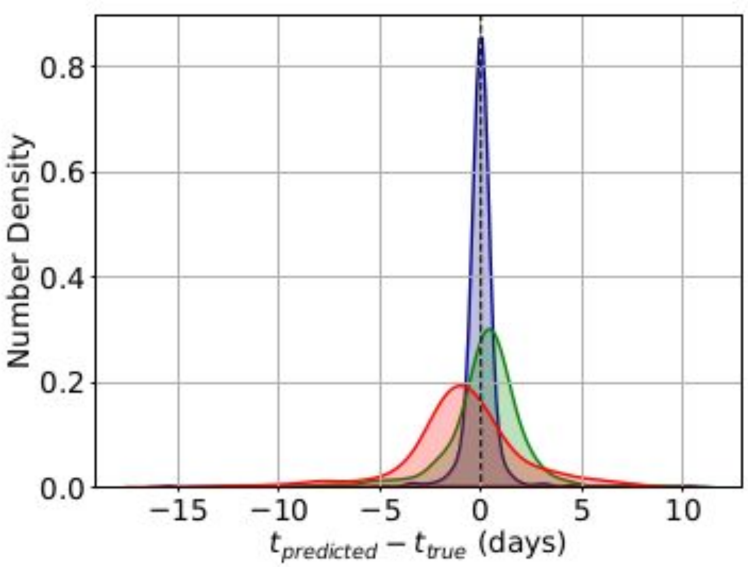


Results

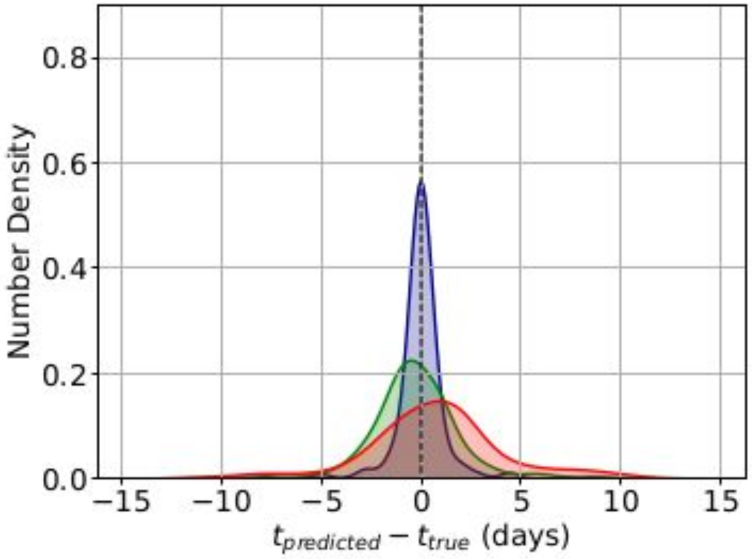
Simulations show that the CNN model performs better with respect to other NN methods. We are ready to apply this method to real data.

Kernel Density Estimation CNN model (blue), InceptionTime (red) and ResNet (green)

“System A”



RXJ-1131-1231



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Time delay estimation in unresolved lensed quasars

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The fractional uncertainty on the H_0 measurement, performed with time-delay cosmography, linearly decreases with the number of analysed systems and it is directly related to the uncertainty on relative time delays measurements between multiple images of gravitationally-lensed sources. Analysing more lensed systems, and collecting data in regular and long-term monitoring campaigns contributes to mitigating such uncertainties. The ideal instruments would clearly be big telescopes thanks to their high angular resolution, but, because of the very large amount of observational requests they have to fulfill, they are hardly suitable for the purpose. On the other hand, small/medium-sized telescopes are much more accessible and are often characterized by more versatile observational programs. However, their limited resolution capabilities and their often not privileged geographical locations may prevent them from providing well-separated images of lensed sources. Future campaigns plan to discover a huge number of lensed quasar systems which small/medium-sized telescopes will not be able to properly resolve. This work presents a deep learning-based approach, which exploits the capabilities of convolutional neural networks to estimate the time-delay in unresolved lensed quasar systems. Experiments on simulated unresolved light curves show the potential of the proposed method and pave the way for future applications in time-delay cosmography.

Thank you very much for your attention! :-)