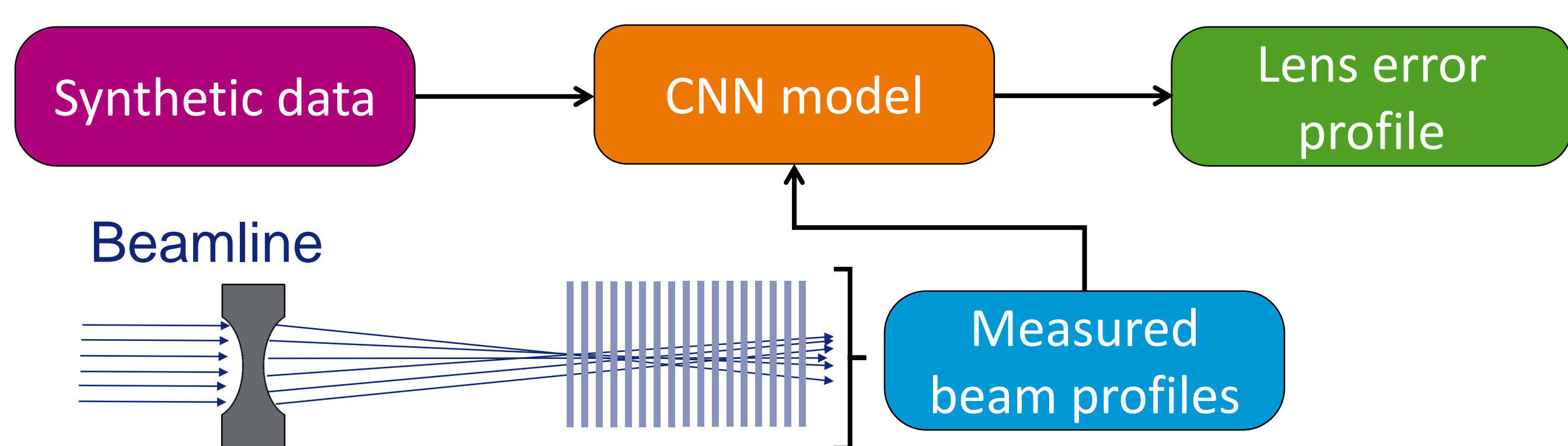


In this study, we explore the capability of a Convolutional Neural Network (CNN) trained on synthetic data to accurately estimate the profile error in an x-ray lens. The CNN is able to retrieve the profile expressed as a list of Zernike coefficients from a series of intensity distributions simulated (or measured) at several positions. This approach offers a promising method for profile error assessment in x-ray lenses without wave-front sensor measurements, potentially reducing the need for time-consuming and costly characterization techniques. The results highlight the potential of using machine learning algorithms trained on synthetic data as a valuable tool in the field of x-ray optics for efficient and accurate error analysis.

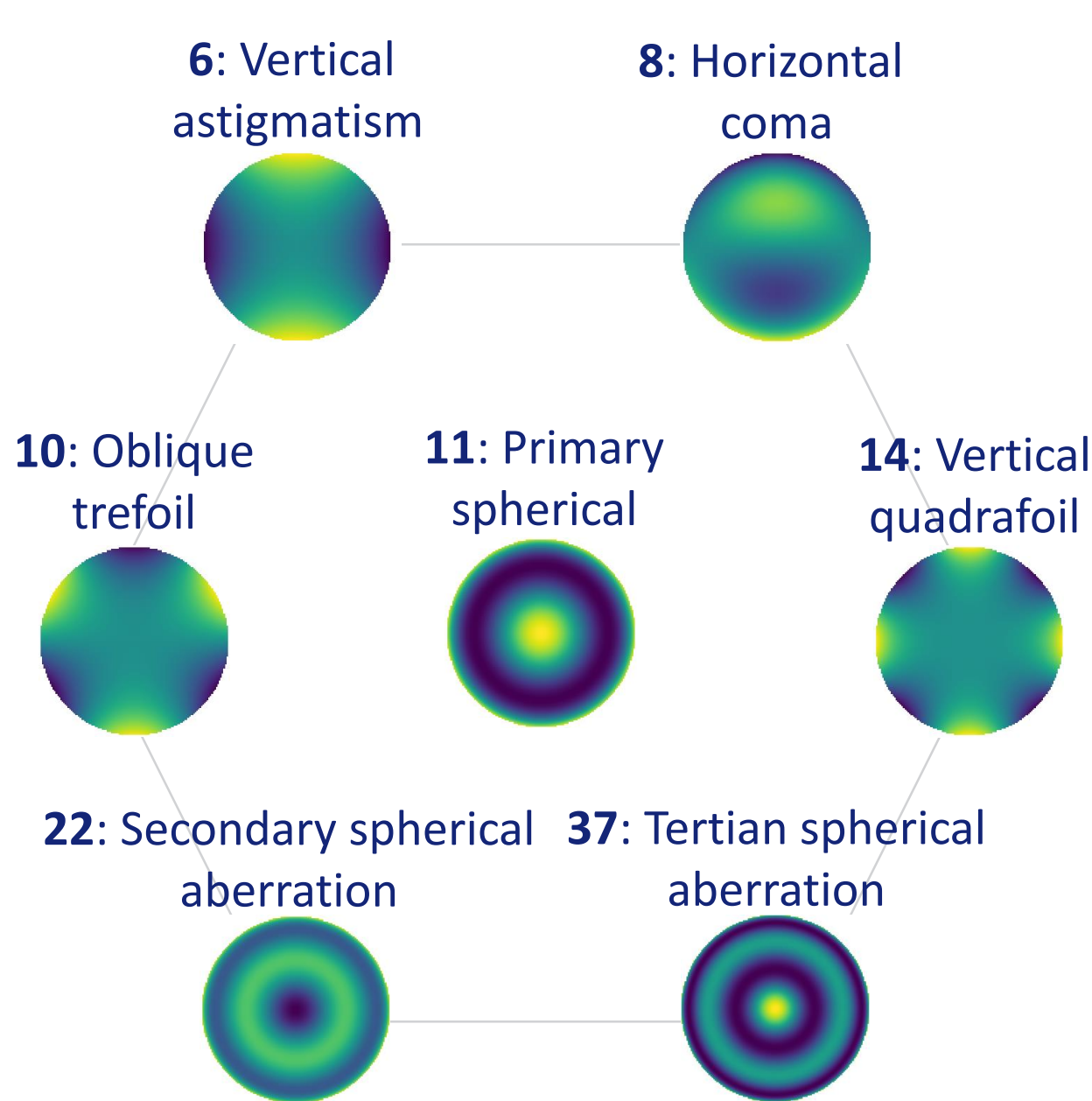
Objective

By measuring several intensity beam profiles, retrieve a lens error profile using a CNN model.



Synthetic data

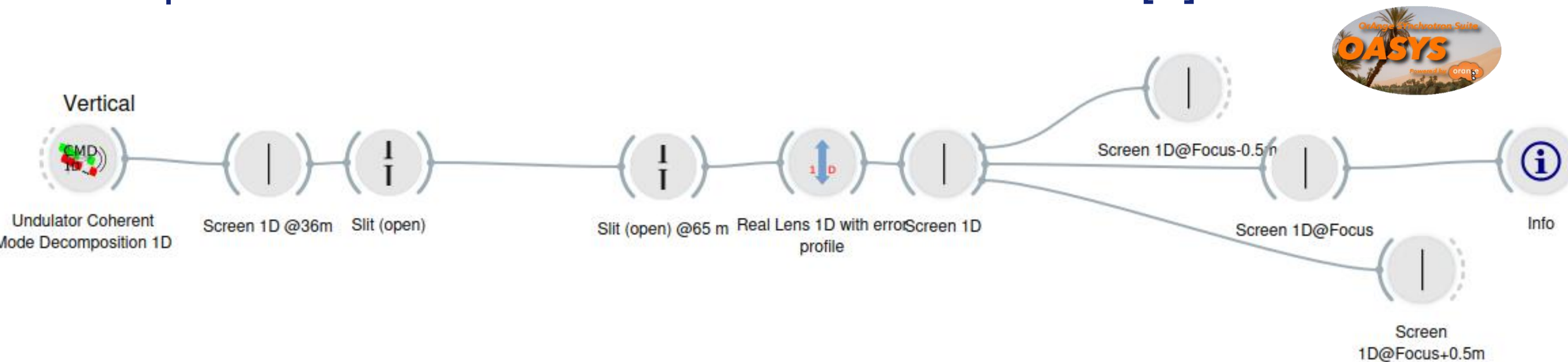
We started by creating a set of lens error profiles using random coefficients from seven picked Zernike polynomials.



Zernike Number	Sampling distribution	Interval
6	Normal	$\sigma=0.5$
8	Normal	$\sigma=0.5$
10	Normal	$\sigma=0.5$
11	Uniform	± 0.5
14	Normal	$\sigma=0.5$
22	Uniform	± 0.5
37	Uniform	± 0.5

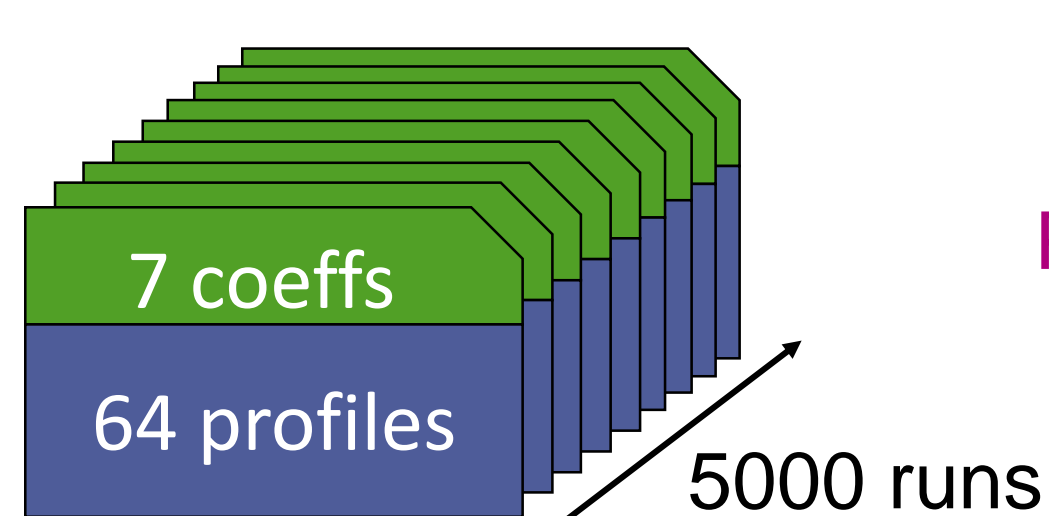
*All coefficients were multiply by a factor of $5 \mu\text{m}$

Vertical axis sections of the error profiles were used in 1D full and partial coherence simulations with WOFRY [1].



For each error profile, we obtained intensity profiles for 64 propagation planes around the focusing plane, with a total of 5000 error profiles.

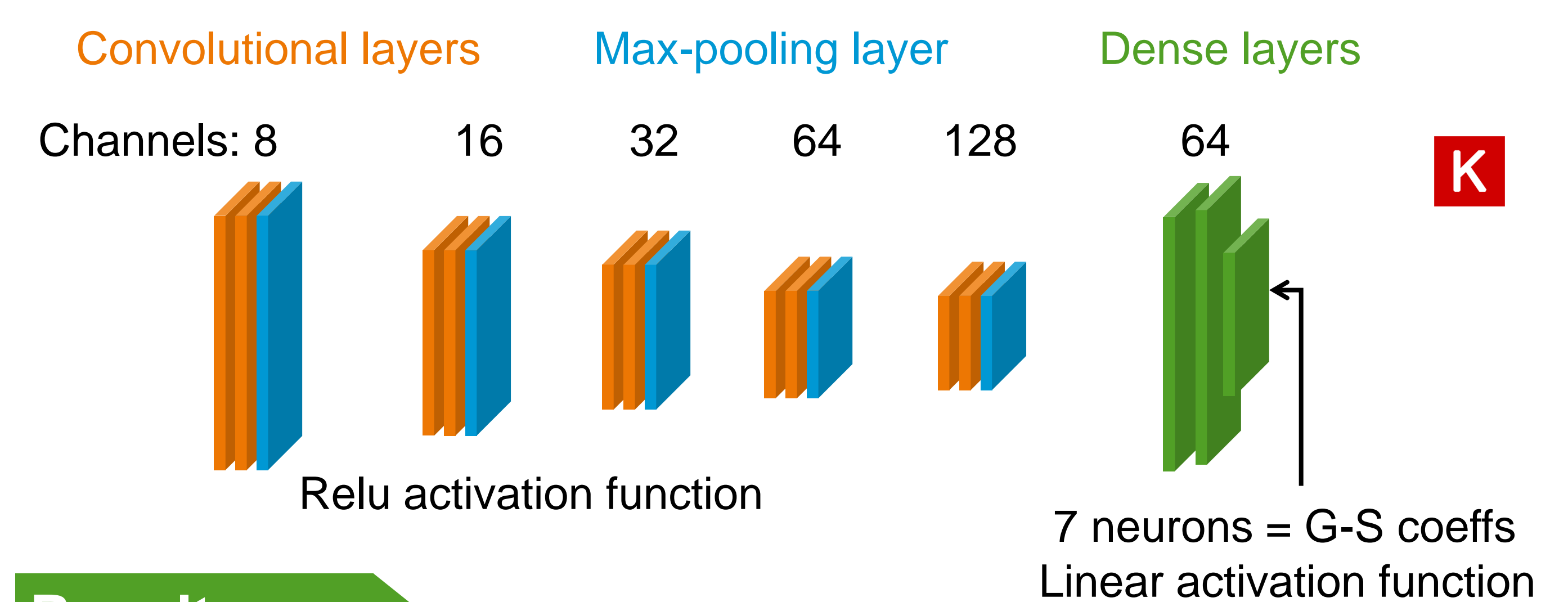
Coeffs were transformed to an orthonormal base by the Gram-Schmidt (G-S) method



Profiles with 256 points

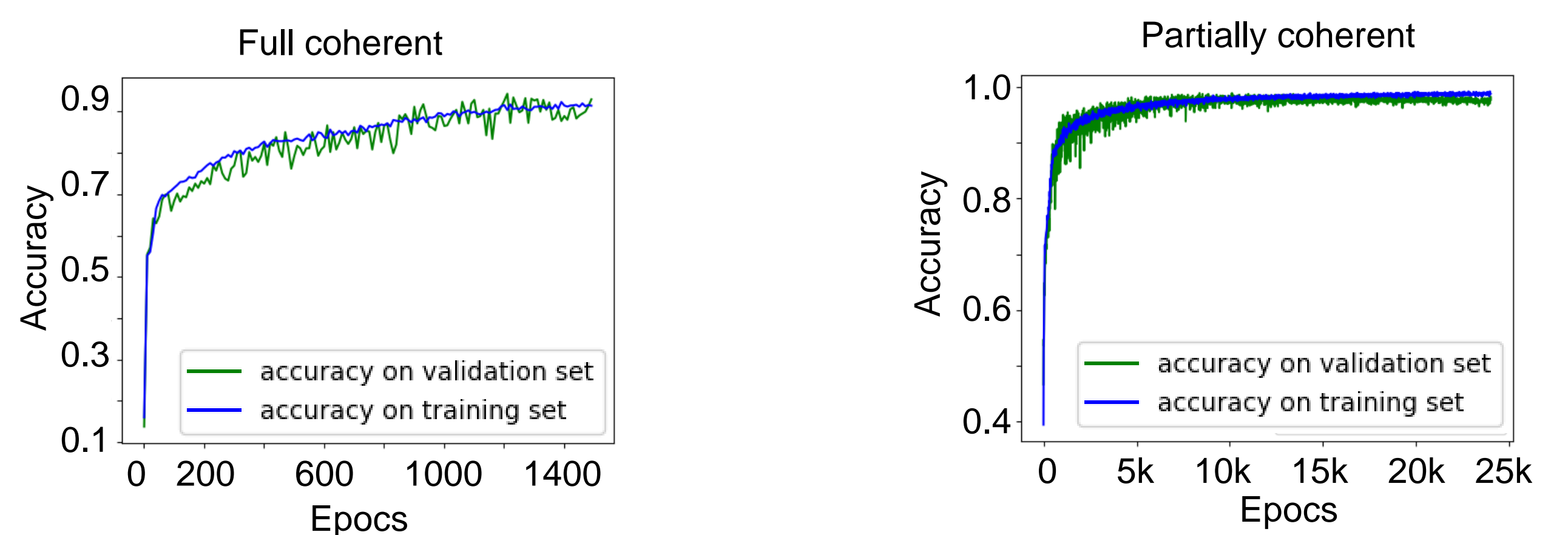
CNN model

Our approach is strongly inspired by Saha et al. in the visual microscopy field [2], we used Keras to build a CNN

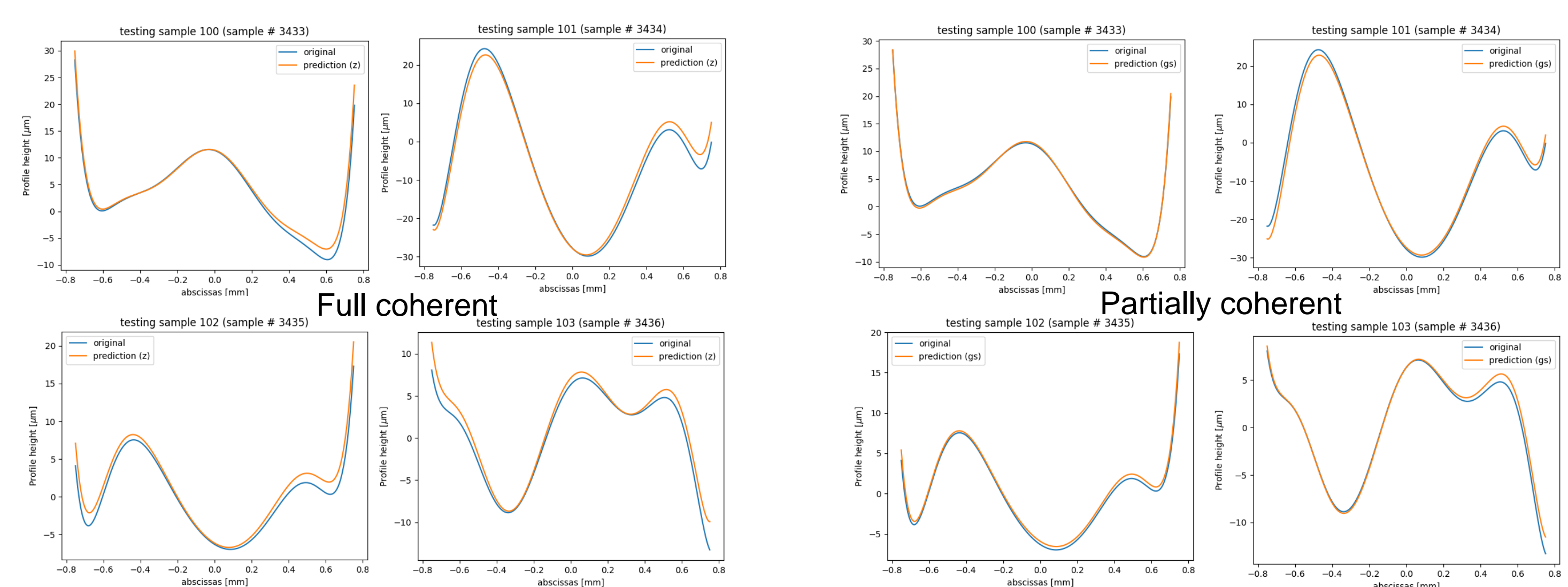


Results

CNN accuracies:



Retrieved error profiles vs originals:



Remarks

- A CNN trained with synthetic data is able to retrieve the profile error in an x-ray lens giving as input a set of intensity distributions measured or calculated at different positions.

TODO:

- Try fine tuning to reduce number of images planes.
- Test with experimental data.
- Implement procedure to 2D simulations.