# DEEP NEURAL NETWORK FOR BEAM PROFILE CLASSIFICATION IN SYNCHROTRON

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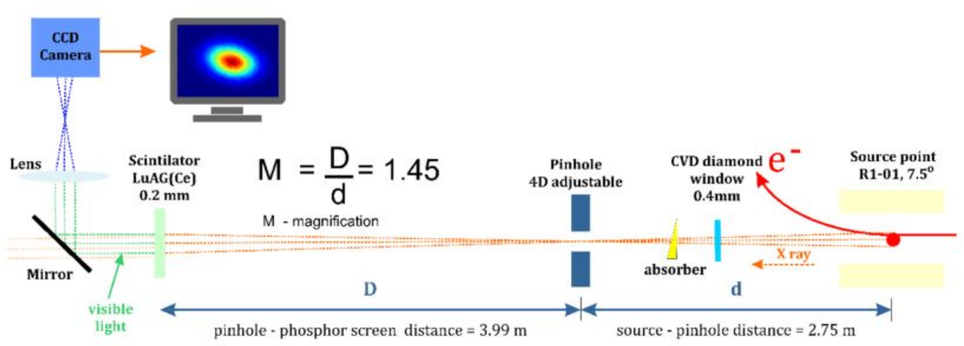
## IN A FEW WORDS

In this poster a deep neural network for transverse beam profile classification is proposed. Main task of the system is to automatically assess and classify transverse beam profiles based solely on the evaluation of the beam image from the Pinhole diagnostic beamline at Solaris. At the present stage, a binary assignment of each profile is performed: stable beam operation or unstable beam operation / no beam. Base model architecture consists of a pre-trained convolutional neural network (CNN) followed by a densely-connected classifier and the system reaches accuracy at the level of 94.10%.

## SOLARIS SYNCHROTRON

SOLARIS synchrotron is a third generation light source operating at the Jagiellonian University in Krakow, Poland. This advanced and complex scientific infrastructure offers new highly innovative research opportunities for areas including physics, medicine and nanotechnology. Currently facility offers five experimental beamlines with various techniques and is also a National Cryo-EM Centre, with two latest generation cryo-electron microscopes enabling life science researchers to unravel life at the molecular level.

## PINHOLE BEAMLINE




For the emittance and beam size monitoring and measurements Pinhole diagnostic beamline has been setup in SOLARIS. It is based on X-ray radiation extracted from the dipole through a diamond window, a pinhole cross down to the scintillator crystal where is converted to the visible light, then imaged by a CCD camera.

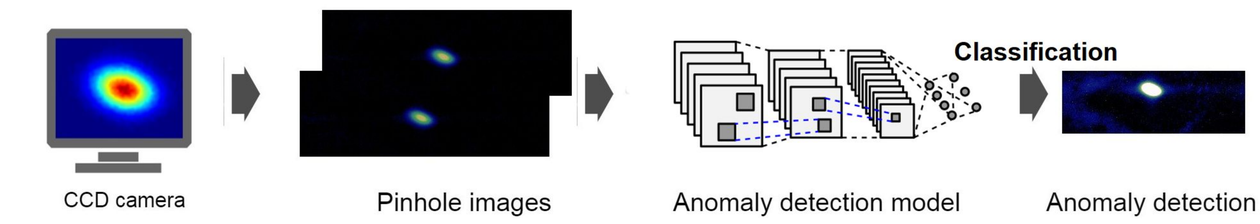
Example of data extracted from this diagnostic beamlie at Solaris has been shown in Figures on the right.

## PROPOSED SYSTEM

Architecture for Pinhole diagnostic images evaluation:

- created using deep neural networks
- soft fine-tuning strategy used (form of transfer learning)
- InceptionV3 as a base model
- classifier has been created specifically for the problem of recognizing two classes: correct and not correct beam shape (anomaly)
- consists of: Fully-Connected layer with ReLU activation function, Dropout layer and finally the Fully-Connected output layer with two outputs and the Softmax activation function

**Flow-chart of the proposed anomaly detection system**




- trained at almost 137 000 images
- dataset labelled using emmitances thresholds
- accuracy of the proposed system reached 95.20% and 94.10% for training and validation datasets respectively
- confusion matrix of validation dataset is presented below

| Actual class | Predicted class | |
|---|---|---|
| | **positive** | **negative** |
| **positive** | 62037 | 3559 |
| **negative** | 6574 | 100592 |

## CONCLUSIONS

- it has been proved that using deep neural network based systems can achieve high accuracy in electron beam quality assessment,
- **novelty:** assessment can be done directly from the raw Pinhole image without having to calculate any physical beam parameters,
- such systems could certainly serve as a support for the Operators giving valuable information on the current machine performance,
- next stage will be real time Pinhole image capturing and their classification as well as extending the number of classes

## ACKNOWLEDGEMENTS

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## REFERENCES

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2. *Pinhole beamline overview graphics: Kisiel, Arkadiusz., Marendziak, A Ptaszkiewicz, M Wawrzyniak, Adriana. (2019). X-RAY PINHOLE CAMERA FOR EMITTANCE MEASUREMENT IN SOLARIS STORAGE RING, 10.18429/JACoW-IPAC2019-WEPRB116.*