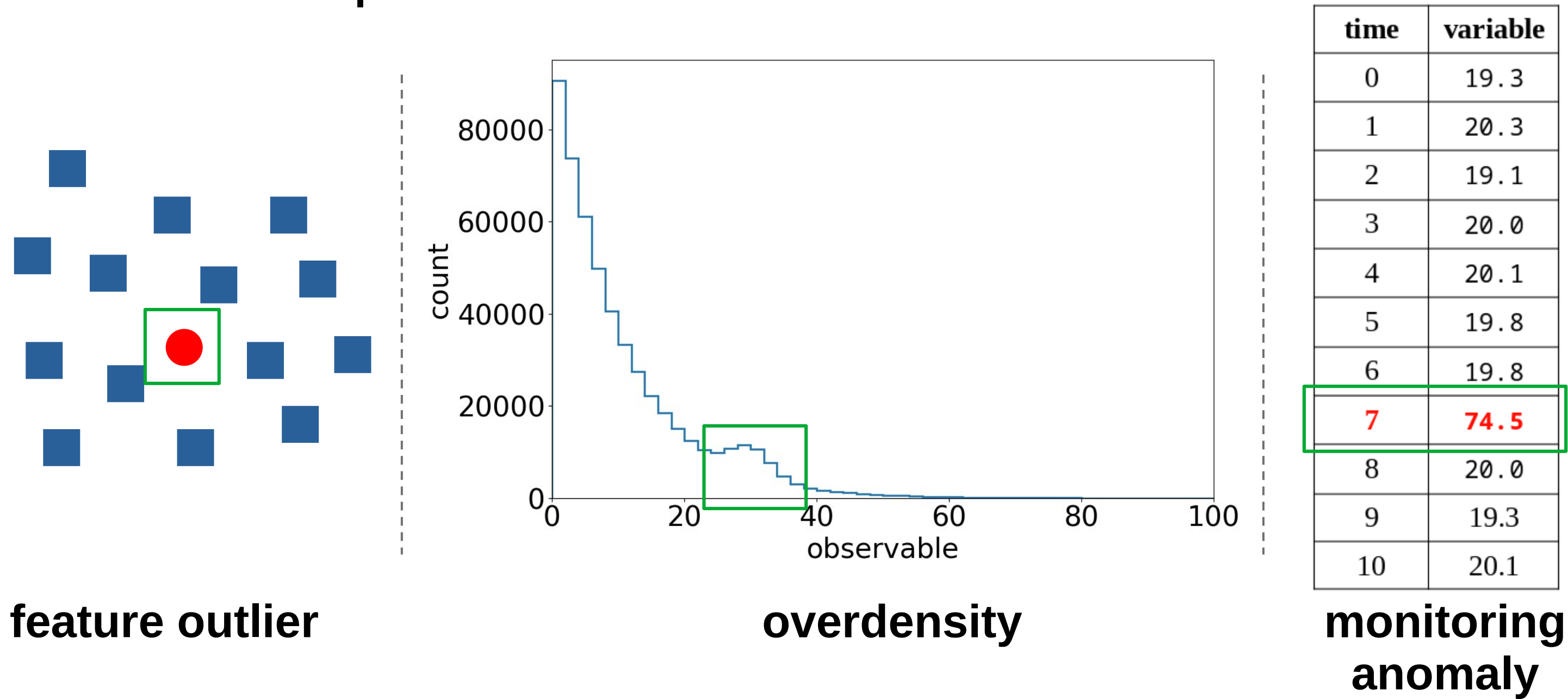


Anomaly Detection Technique applied to detector building and Quality Control

Principle of Anomaly Detection

- Active field of Data Science
Involve state of the art **Machine Learning algorithms**
Many applications in **various scientific field** as well as in everyday life
- Example of anomalies

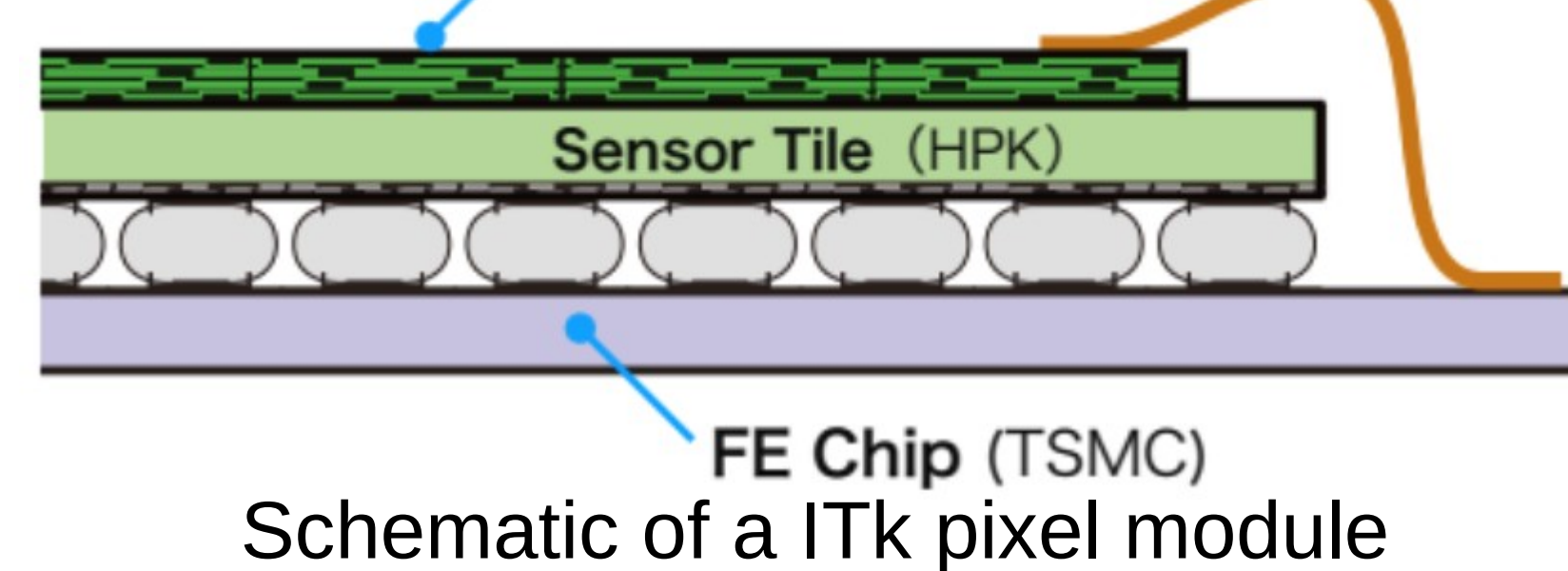


New silicon central detector for ATLAS (ITk)

- Upgrade toward HL-LHC
More luminosity => more challenges
New silicon central detector : ITk
High precision particle tracking and high radiation hardness
- Pixel module production in Japan
2800 pixel modules produced in Japan for ITk
Each component must be carefully **assembled and checked**

Mass production starts in 2024

Flexible PCB (Yamashita Mat.)



Schematic of a ITk pixel module

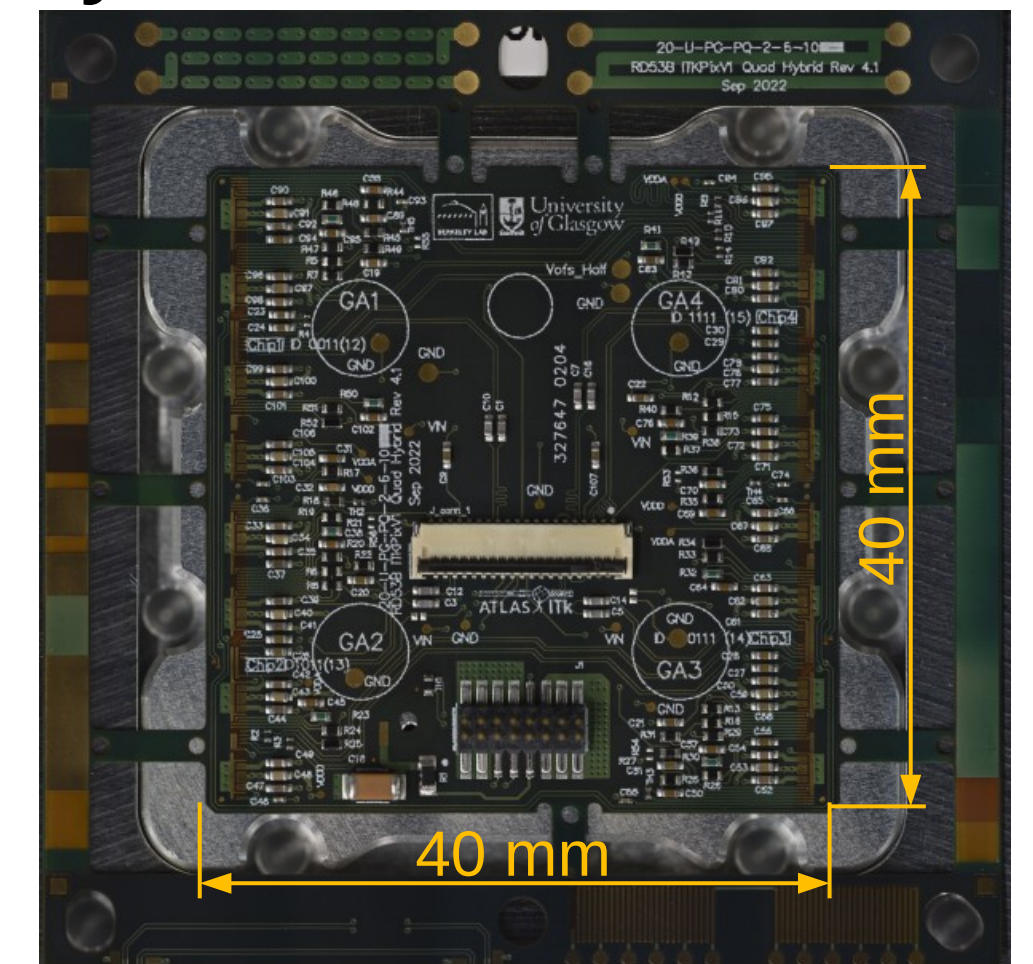


Photo of a populated Flex PCB

Anomaly Detection and Quality Control

- Important part of the production chain
Make sure that every components of the detector is in **perfect working condition**
Must accommodate a rate of **8 modules per day** during mass production
- Visual Inspection at every step
Search for visible defect on **each component** at **each step of production**

Manual Visual inspection by human operators

=> **Time consuming** (8~10 min)
=> **Unreliable**

Computer Visual Inspection

=> **Fast** (<1 min)
=> **Reliable**

Anomaly Detection using Computer Vision algorithms

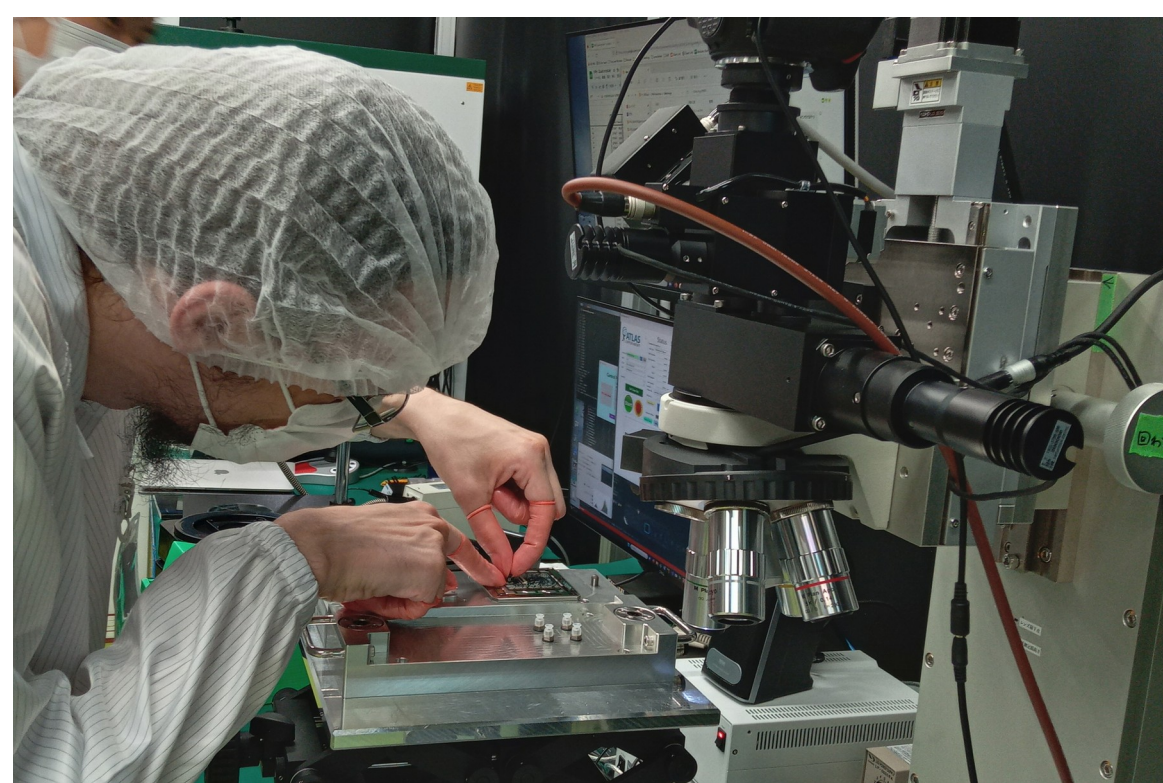


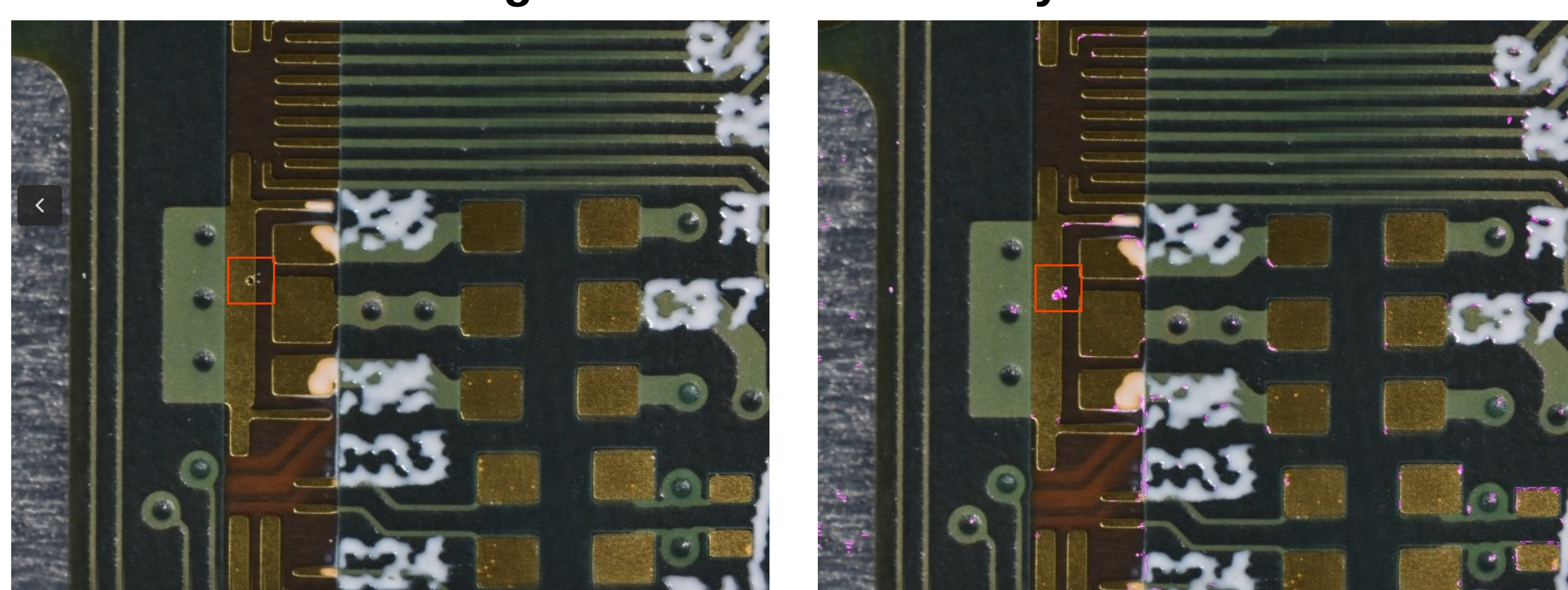
Photo of the imaging setup

Algorithms

- Unsupervised learning
Objective: identify rare and new types of defects
Unsupervised deep Neural Network (Auto-Encoder)
=> Identify anomalous area within a image
Filtering algorithm based on DBSCAN clustering
=> Isolate and highlight major defect candidates
Unsupervised workflow is fully functional
- Supervised learning
Objective: Categorize known and recurrent defect
Deep Computer Vision model inspired by Detectron2
=> Identify common defect categories
Integration with the unsupervised tool
Data preparation and training ongoing

Results

- Unsupervised identification example
Training using ~50 high resolution images of Flex PCB
=> **Use data augmentation techniques**
Test on image where a new defect have been found
=> **single occurrence anomaly**

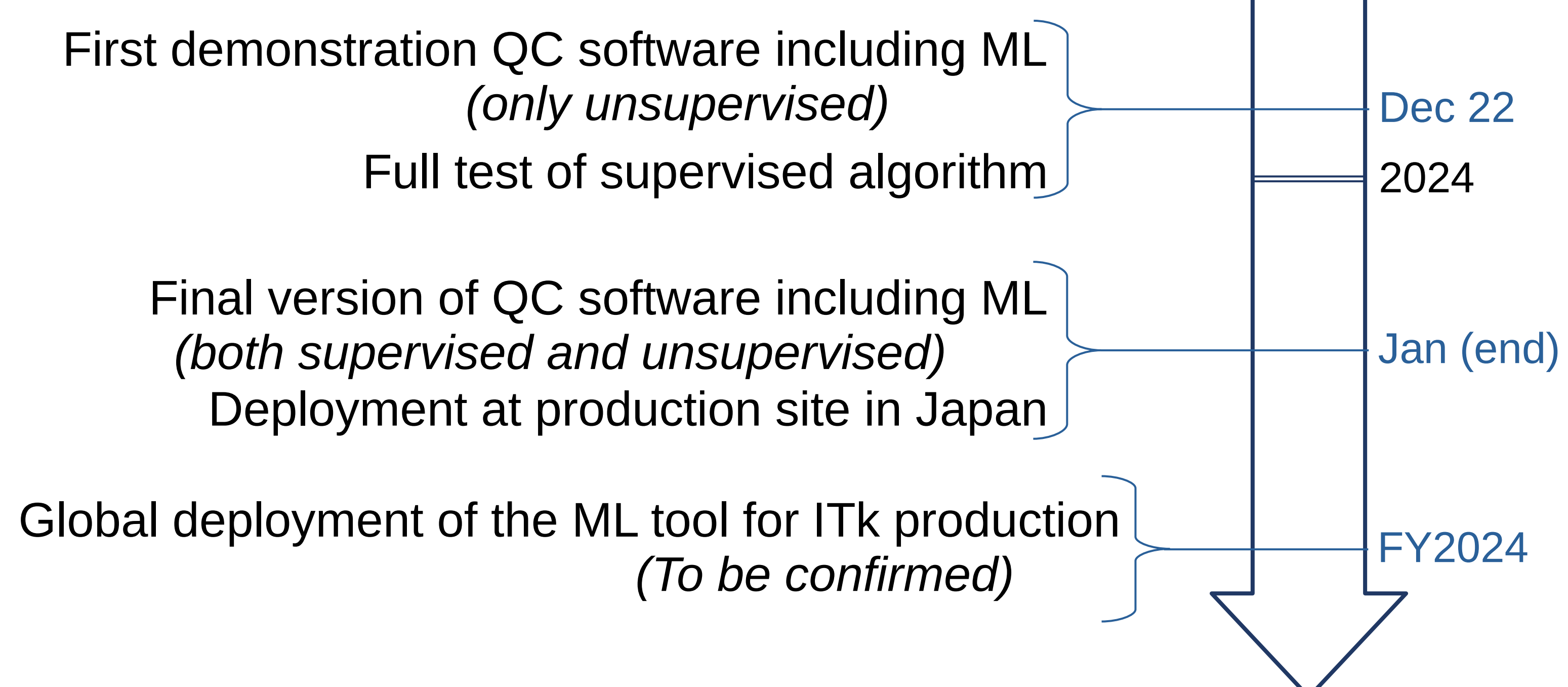


The anomaly have been properly identified

Time required to process the full image : <10s
=> **Fast inference using CPU only**

Next steps

- Near future schedule



- Long term plan
Preparation of a generic Anomaly Detection tool for **Visual Inspection** of detector components
Aiming to reach beyond ATLAS and other LHC experiments