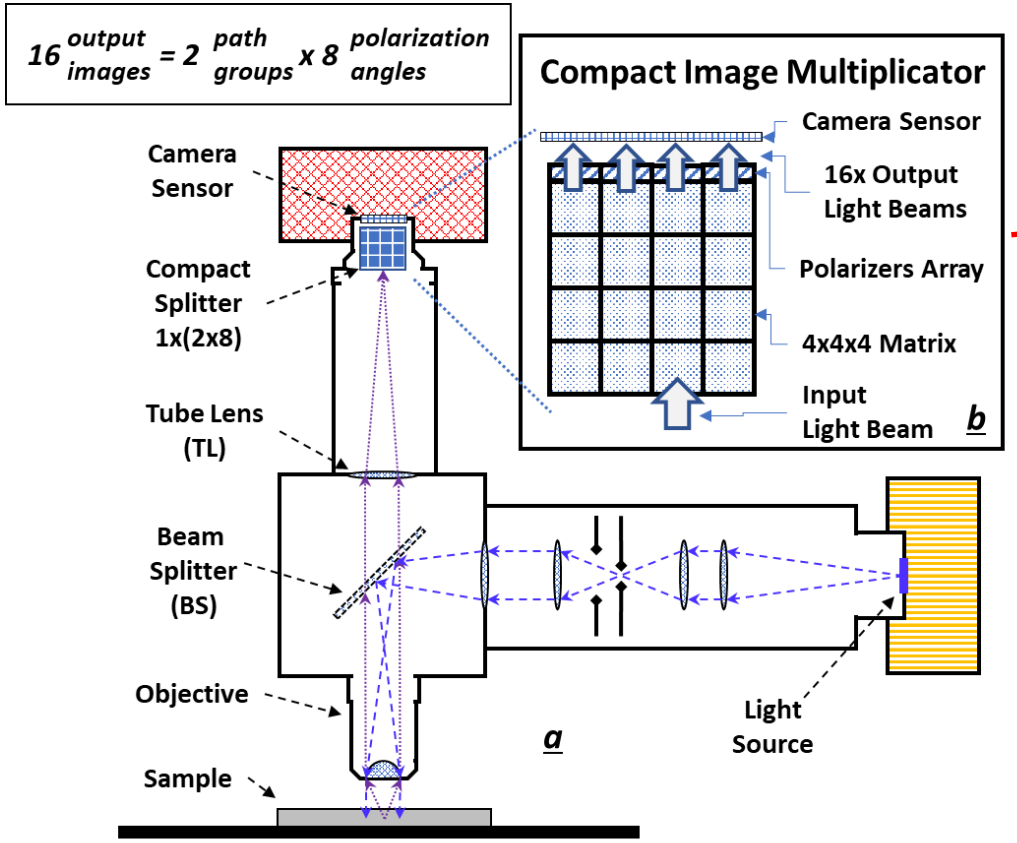
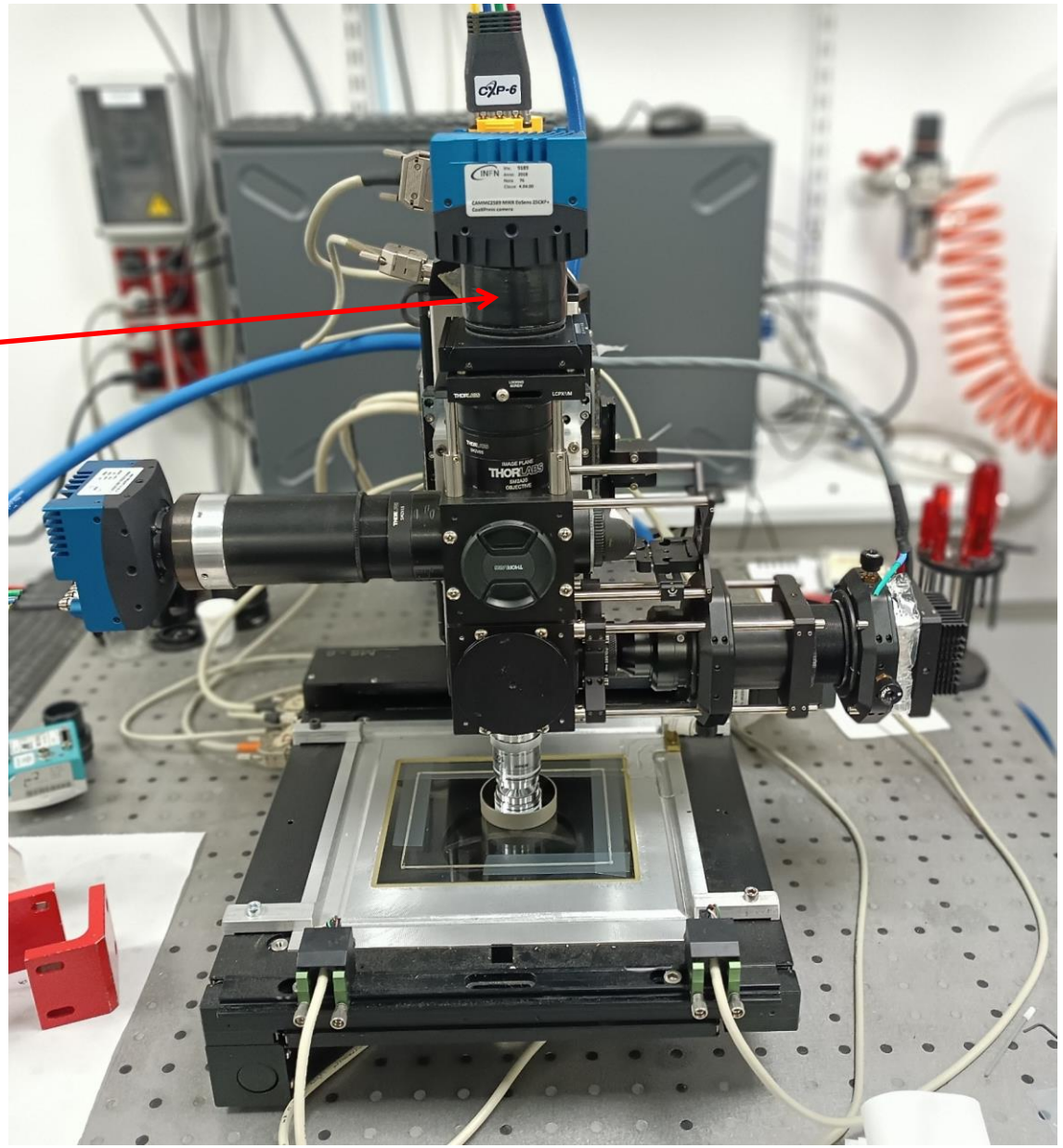
3D Super-Resolution microscopy R&D

Andrey Alexandrov

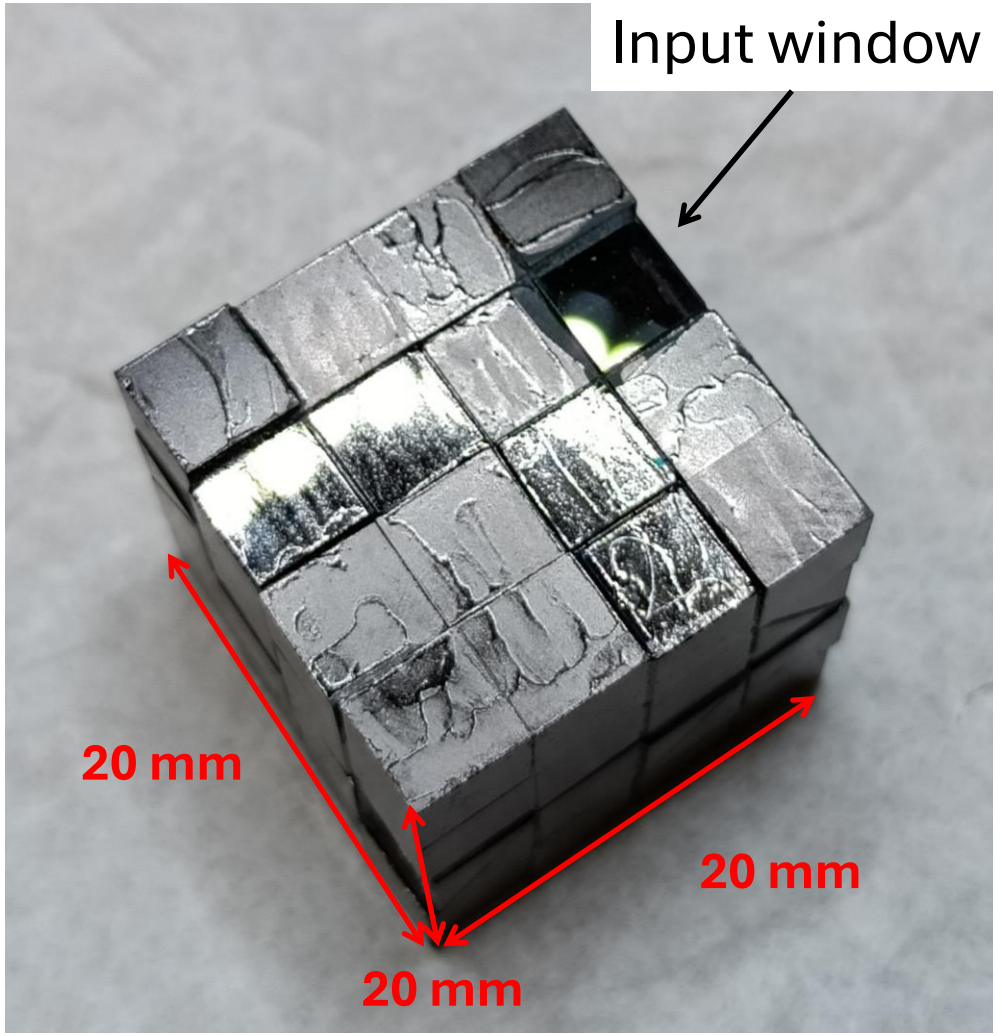
Prototype microscope

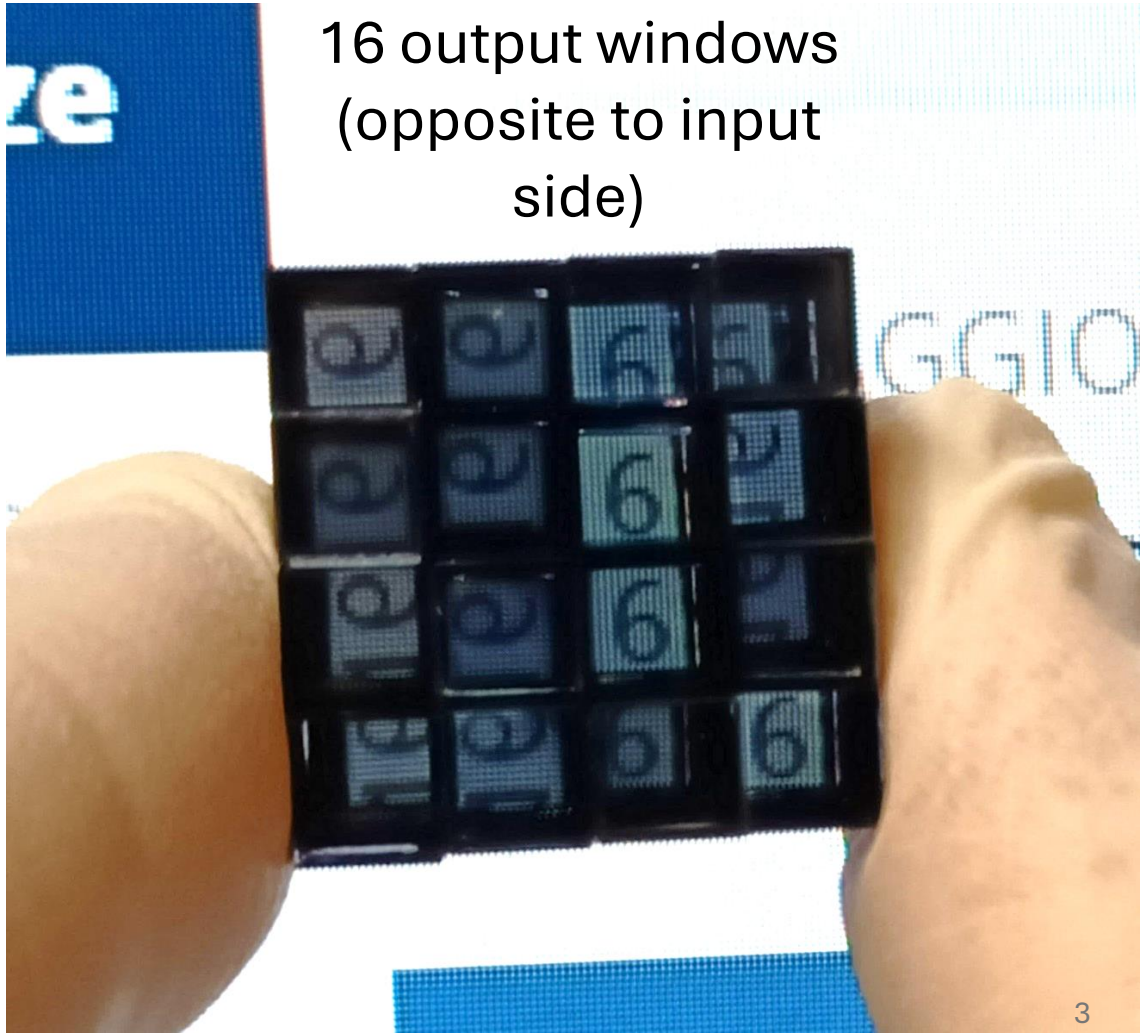




- 100× objective lens
- white LED illumination
- 25 MP color camera
- 4.5 µm (square) sensor pixels
- 5120×5120 pixels

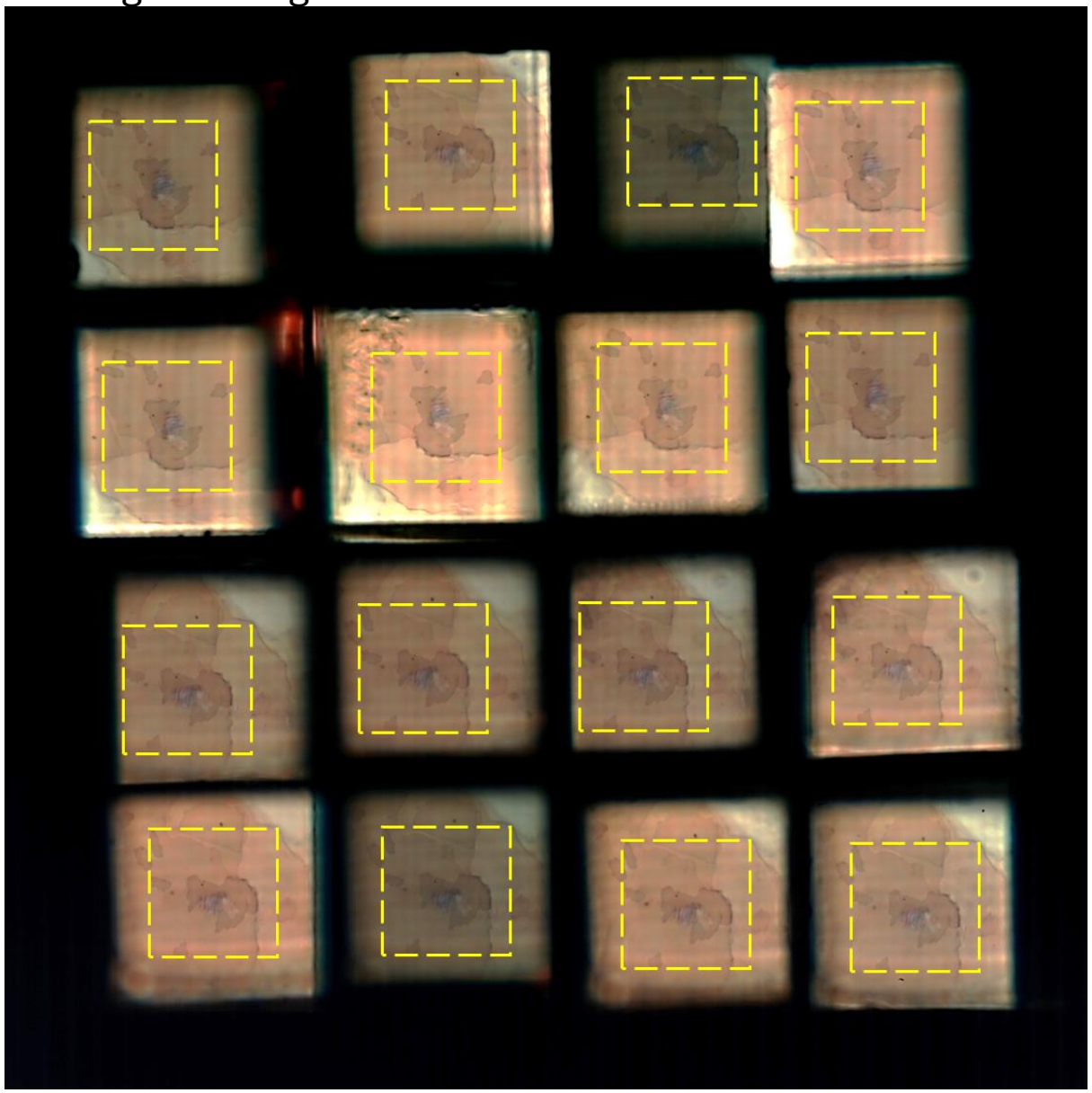
16x compact splitter (20×20×20 mm^3)

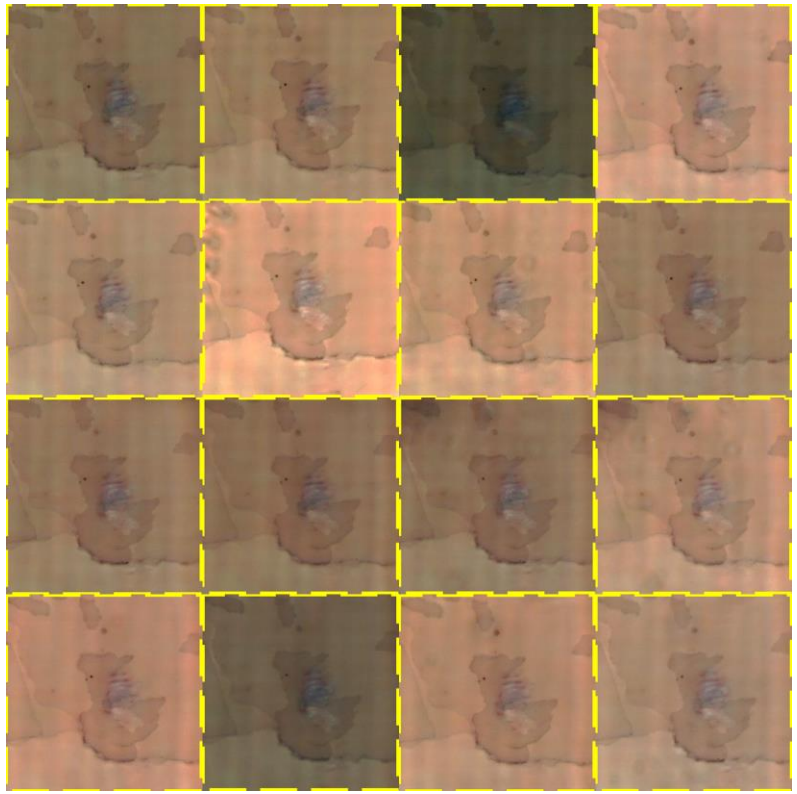




Same visible area extraction

Original image

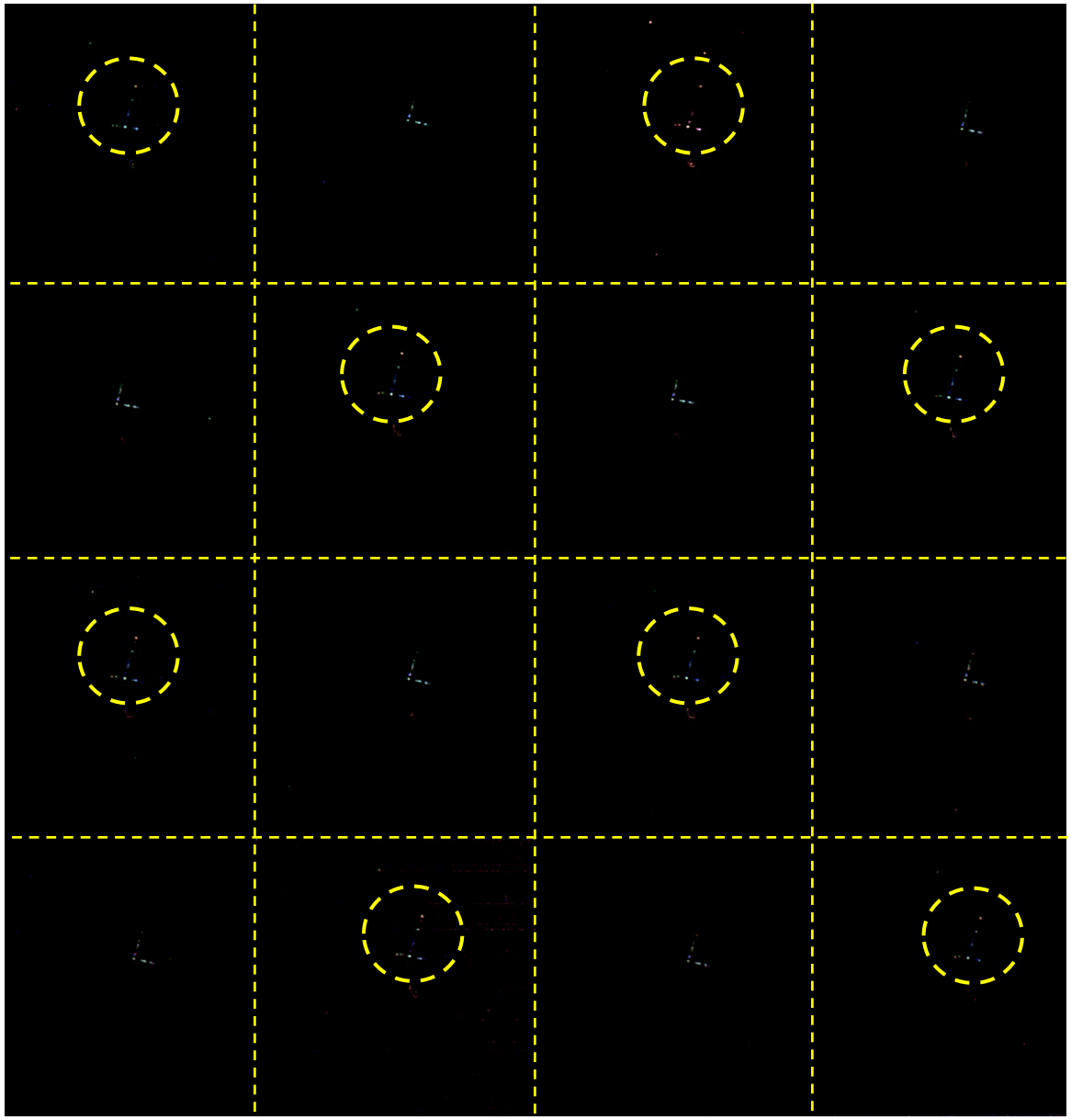




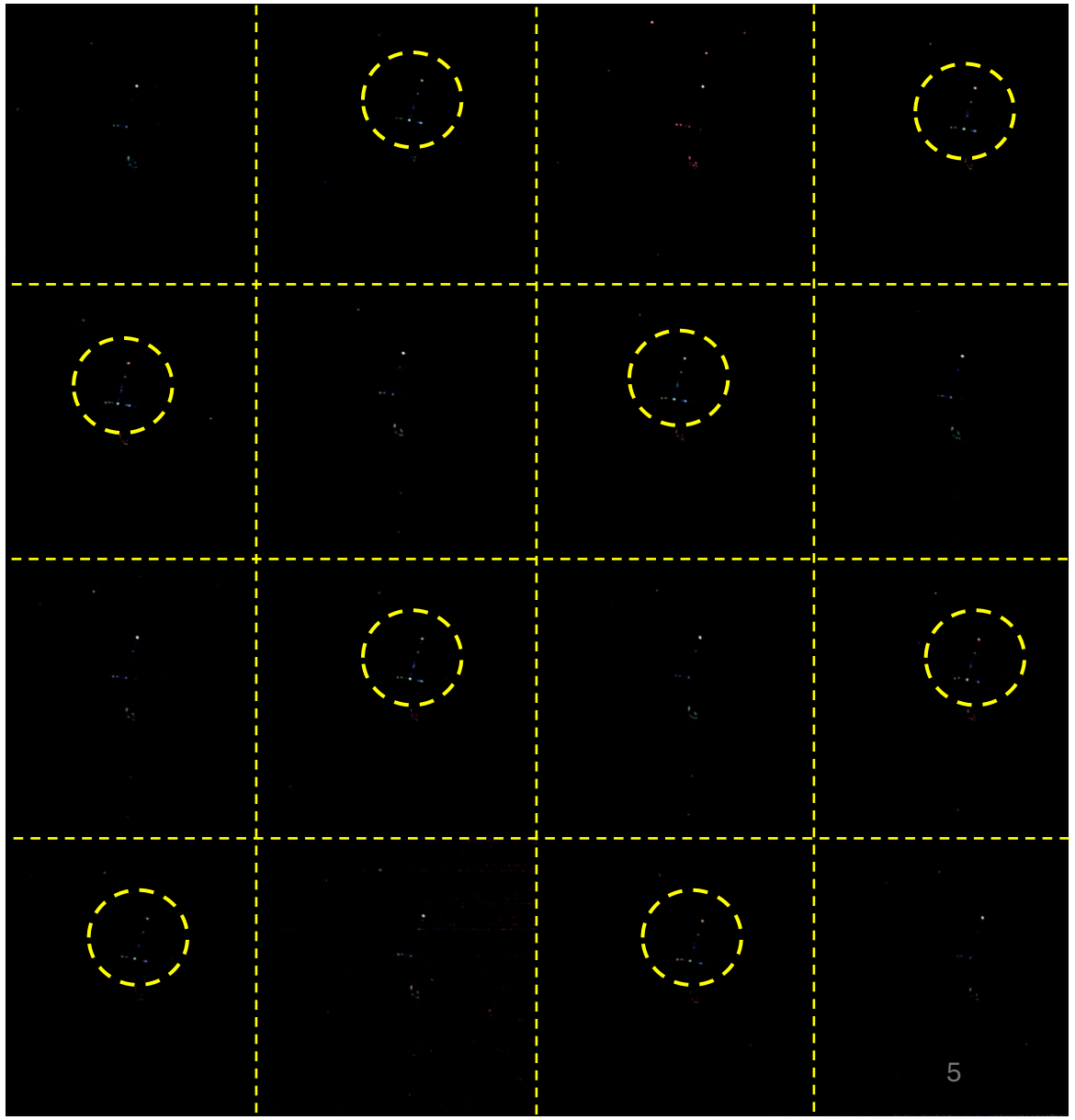
- Same visible area extracted from all output windows
- If needed images were rotated/mirrored to have same orientation

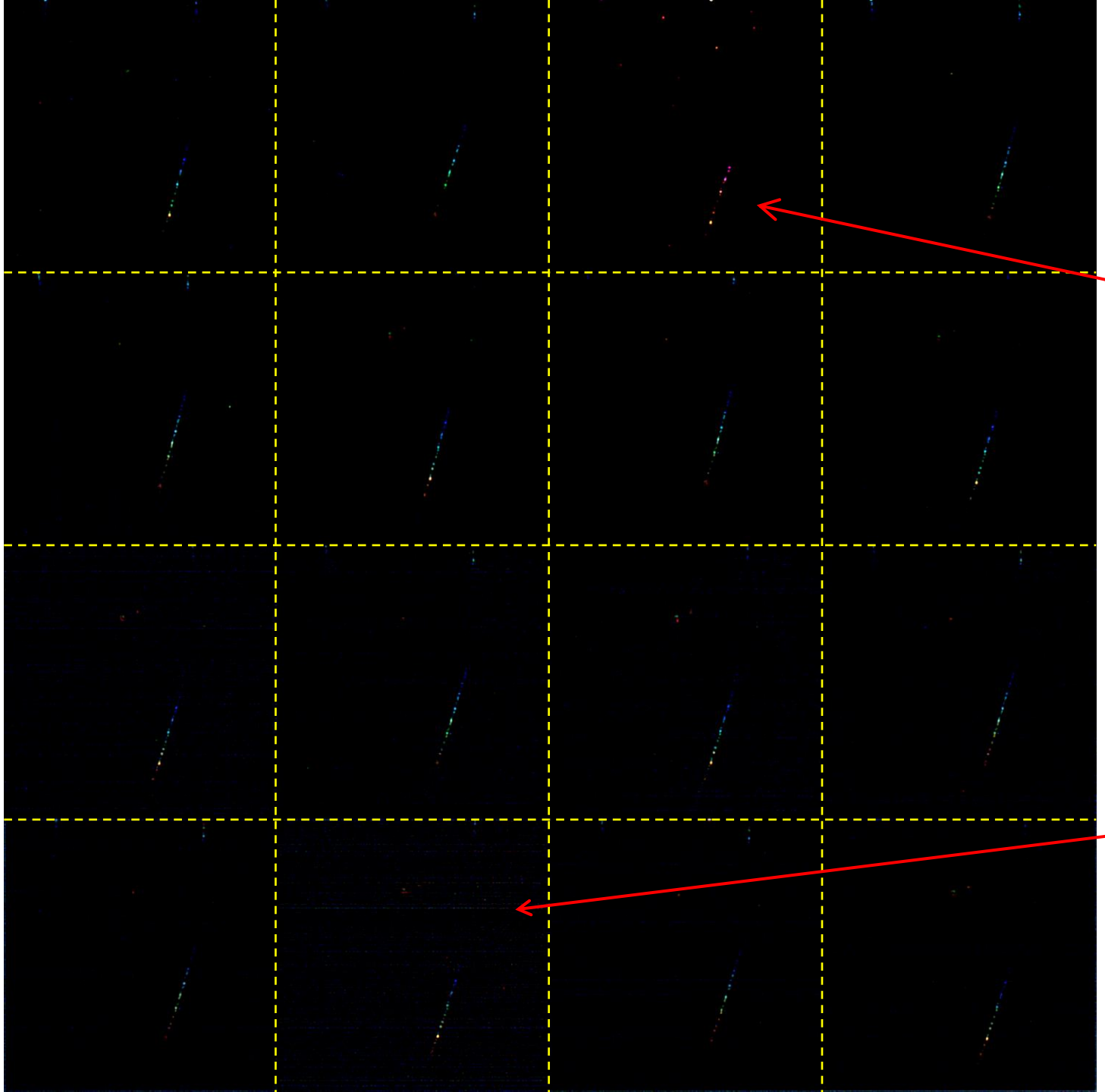
Adjacent output windows are displaced by ~510 nm in Z (by design)

Z = 0 nm



Z = 510 nm



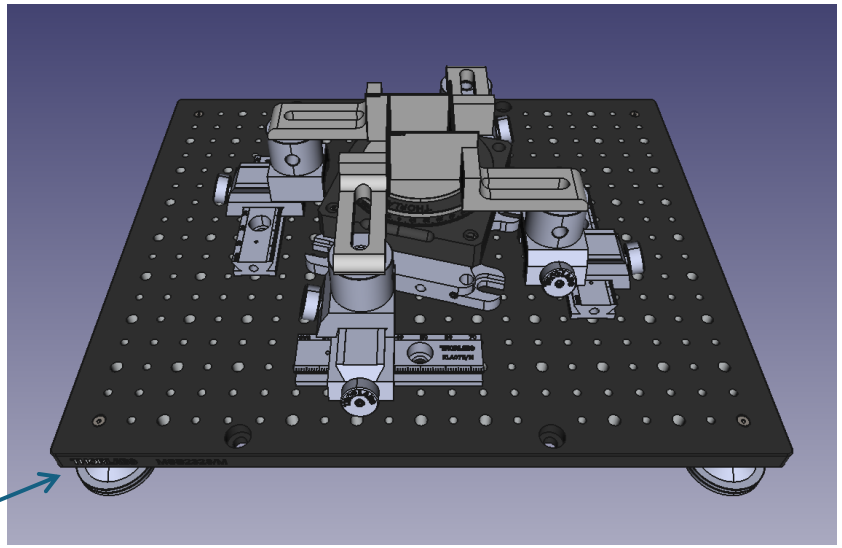


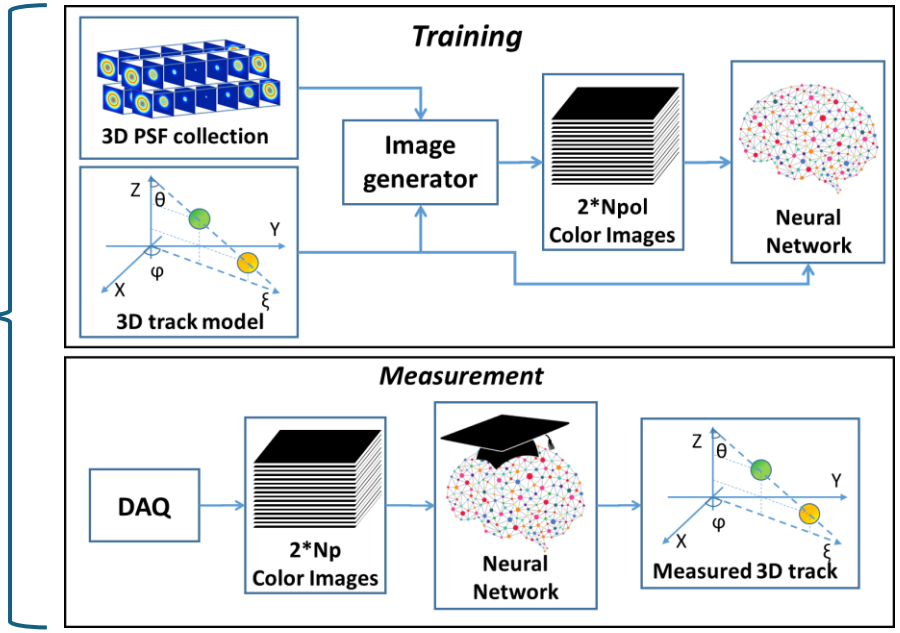
(^{241}Am) alpha particle track in NIT emulsion

- Same alpha track in all images!
- Different color in #3 is due to extremely low original brightness (colors are distorted by image pre-processing)
- Silver grains composing the track have different colors due to the Plasmon Resonance effect! (and a color camera)
- Color gradient along the track is probably due to the increase of the energy loss as the alpha approaches the stopping point (bottom-left edge of the track):
- Stronger energy loss -> larger grains size -> Plasmon Resonance shifted to larger wavelengths -> grain color shifted towards red
- Artifacts in #14 are due to low brightness and contrast (introduced by image pre-processing)
- Output windows #3 and #14 require a dedicated image pre-processing to avoid artifacts and color distortion

3D SR mic development plan

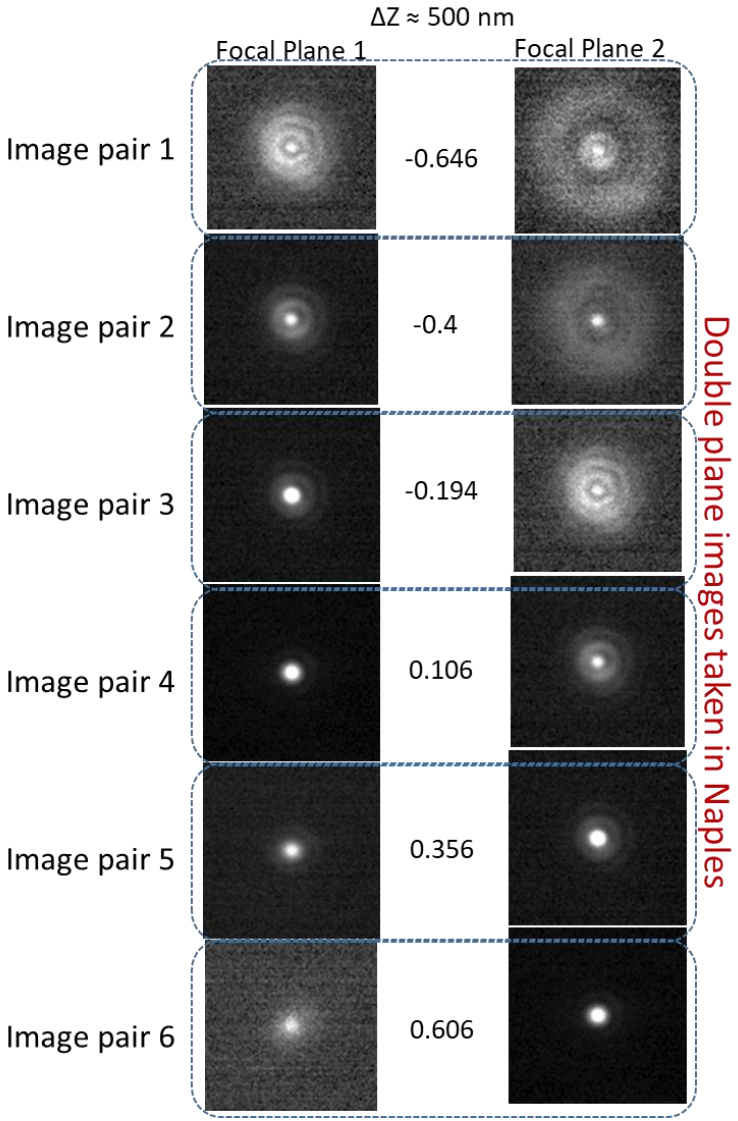
- Splitter produced and delivered
  - Bad alignment reduces usable area to ¼ of design
  - Image quality is satisfactory in 14 (of 16) exit windows
- 4×4 polarizer grid to be produced and glued
  - Tool to fix optical components during glue soldering under UV (Thorlabs, ~3000 euro)
  - Extra material to practice gluing
  - Clean room for final gluing?
- Required for measurement and analysis:
  - Realistic 3D track & filament model in NIT
  - Realistic Image generator with LSPR effect
  - (Original) Neural Network methodology

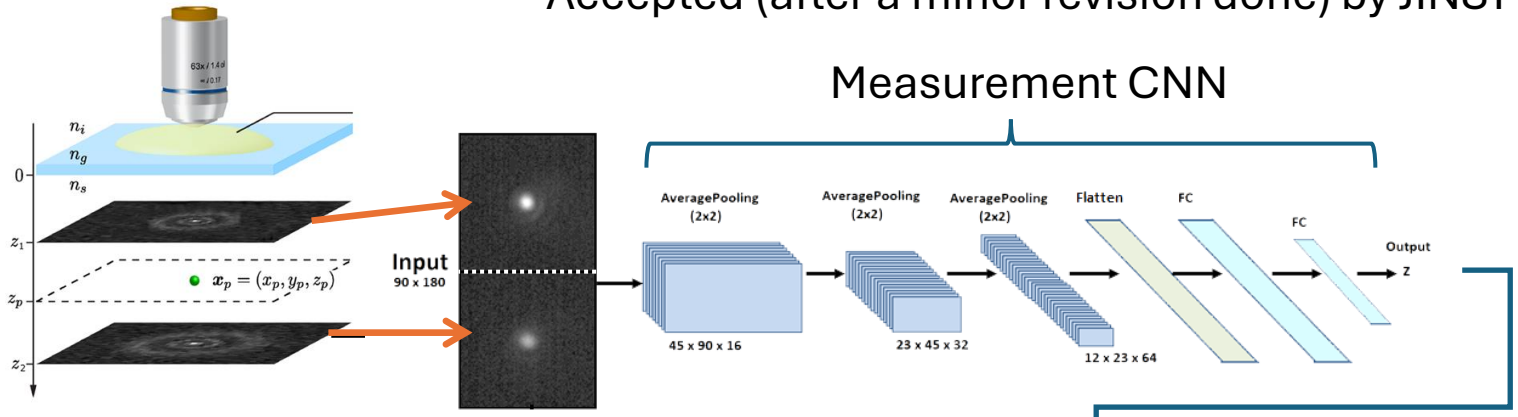


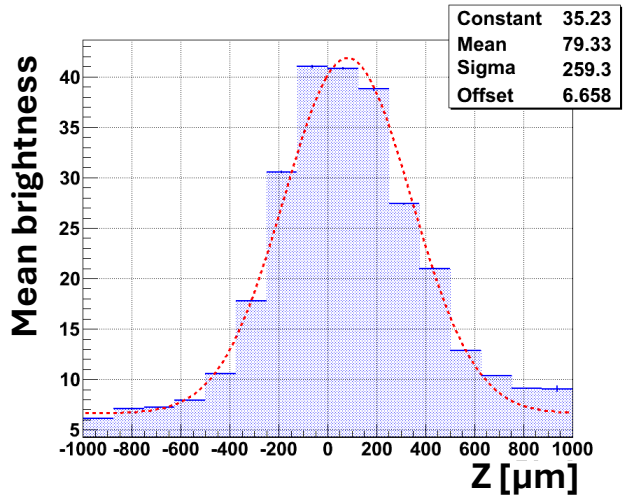


Model-Independent Machine Learning Approach for Nanometric Axial Localization and Tracking

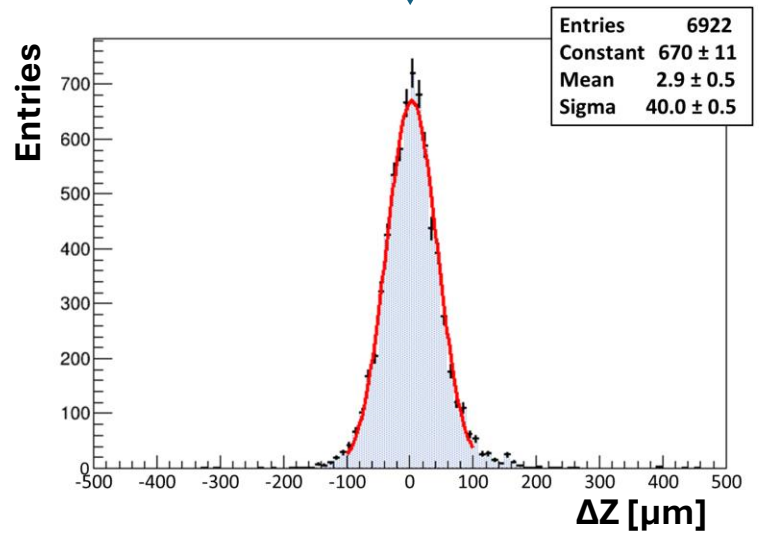
Accepted (after a minor revision done) by JINST







Mean brightness profile along Z



Axial localization accuracy = 40 nm