UPDATE ON NIT EMULSION PILOT TEST

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PRIN Proposal Approved!

Project title: **DAMON: Direct meAsureMent of target fragmentatiON**

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University: **Università degli Studi di BARI ALDO MORO**

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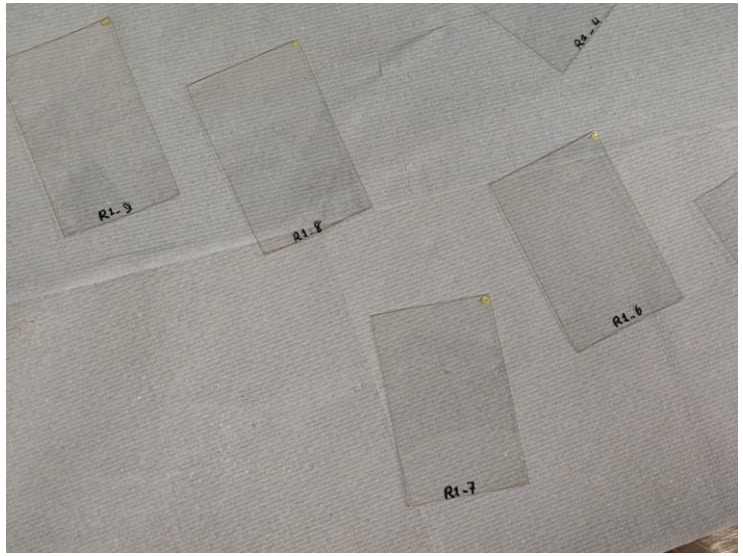
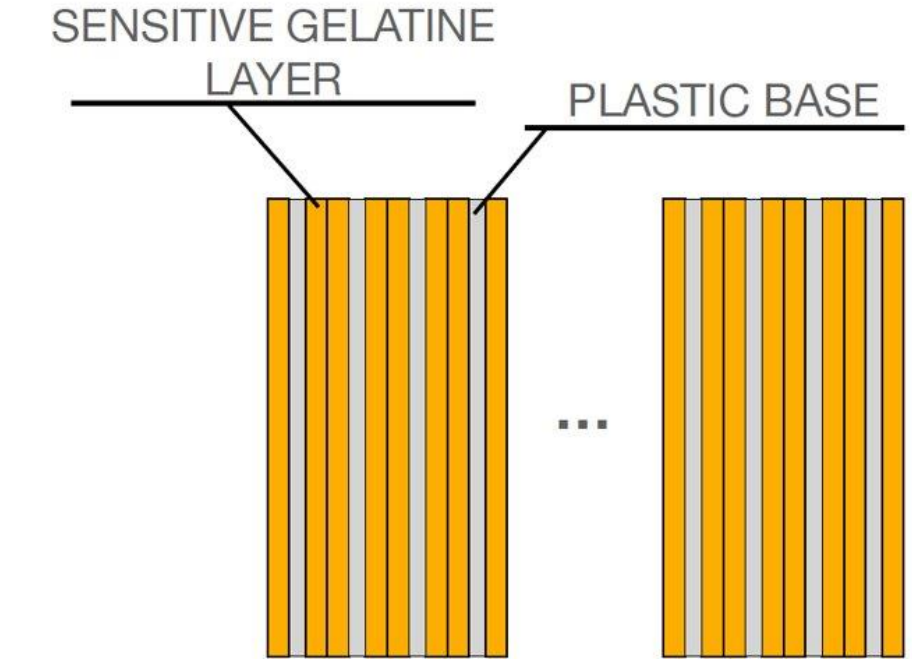
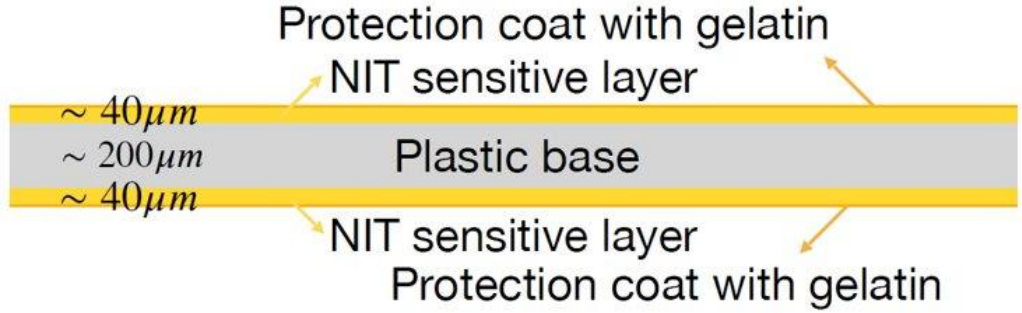
Direct Measurement of Target Fragmentation

- The goal of the project is the ***direct*** **measurement** of target fragments produced by a proton beam
- Nano Imaging Trackers (NIT) emulsions act both as target and tracking devices
- Each NIT film has two sensitive layers (40 μm thick) deposited on both sides of a plastic support (200 μm thick)

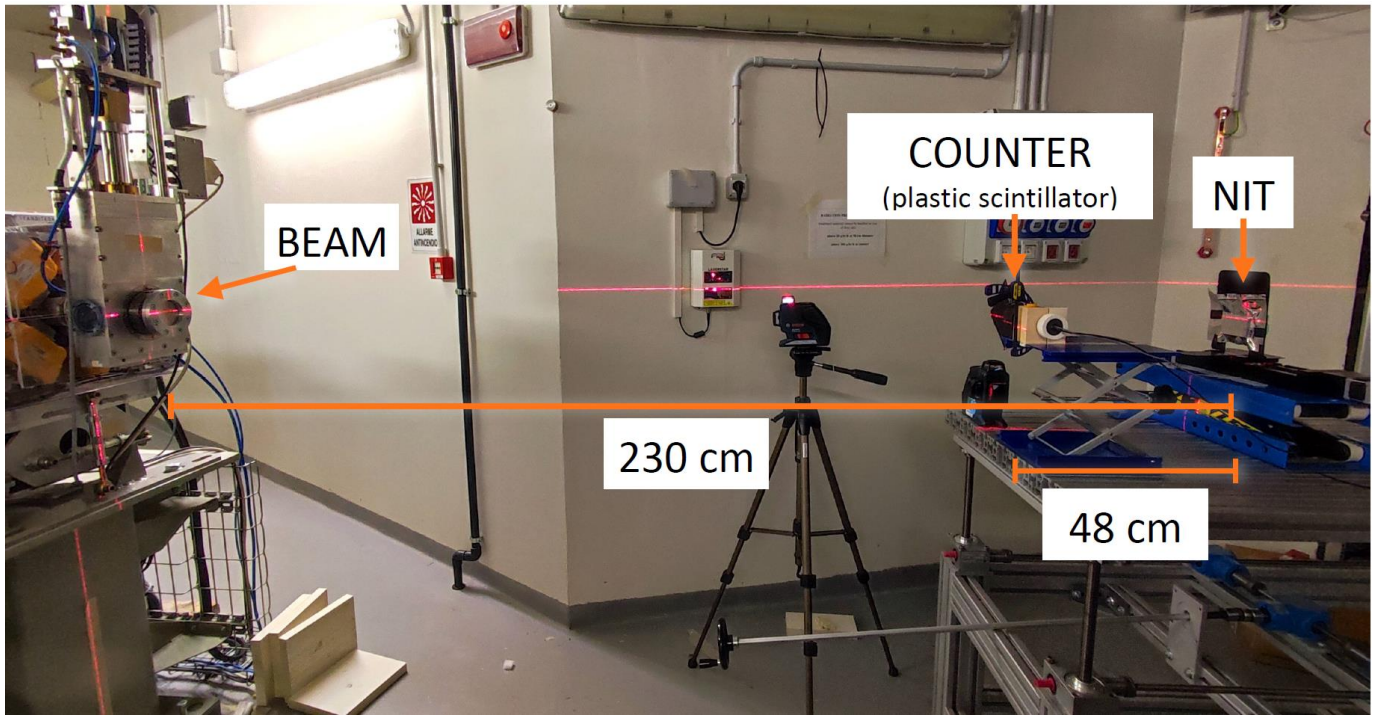


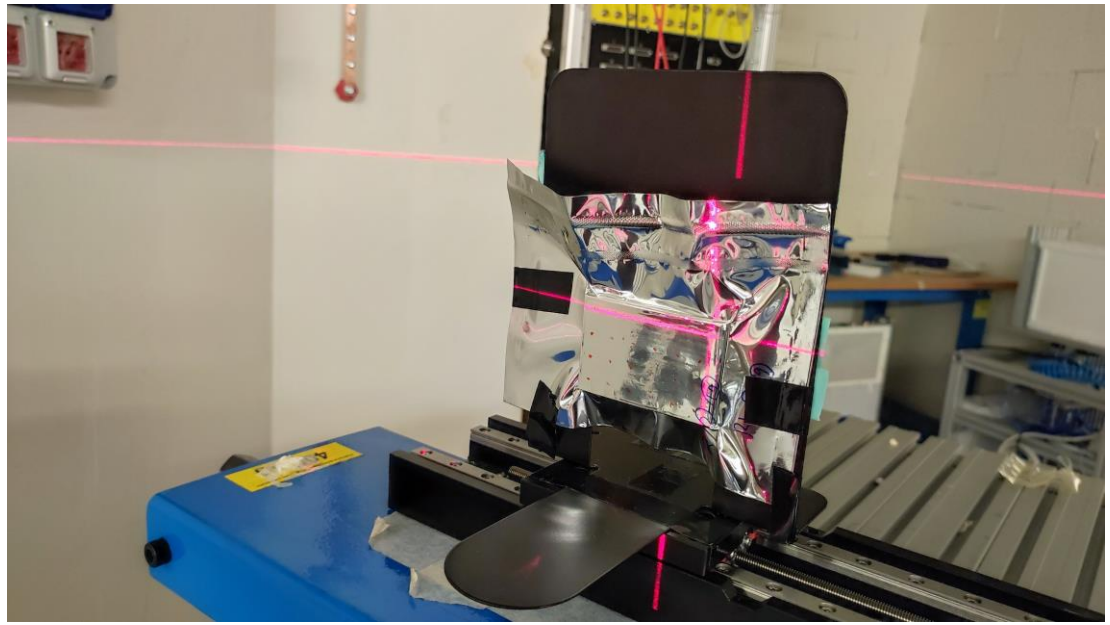




Data Taking in Trento

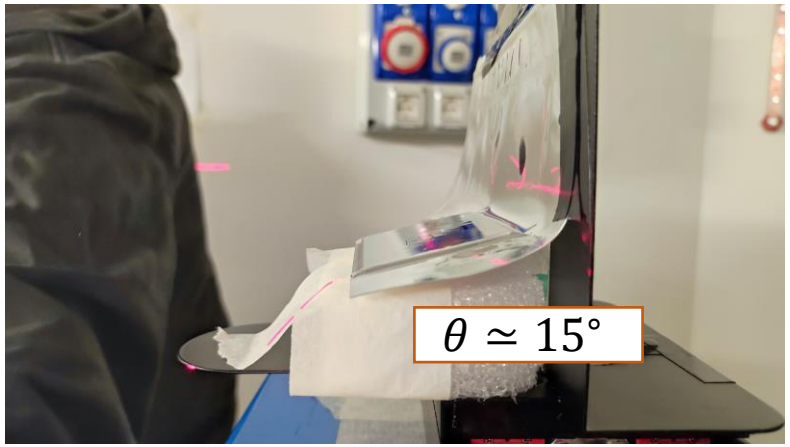
- 19 NIT films (~ 6.4x4 cm^2) for the brick, 1 film for sensitivity tests
- Fixed pencil beam @211 MeV (FWHM ~ 1.5 mm)
- 230 cm from beam exit window
- 6x4 grid for a uniform exposure of the NIT emulsions (about 11.000 protons per spot)

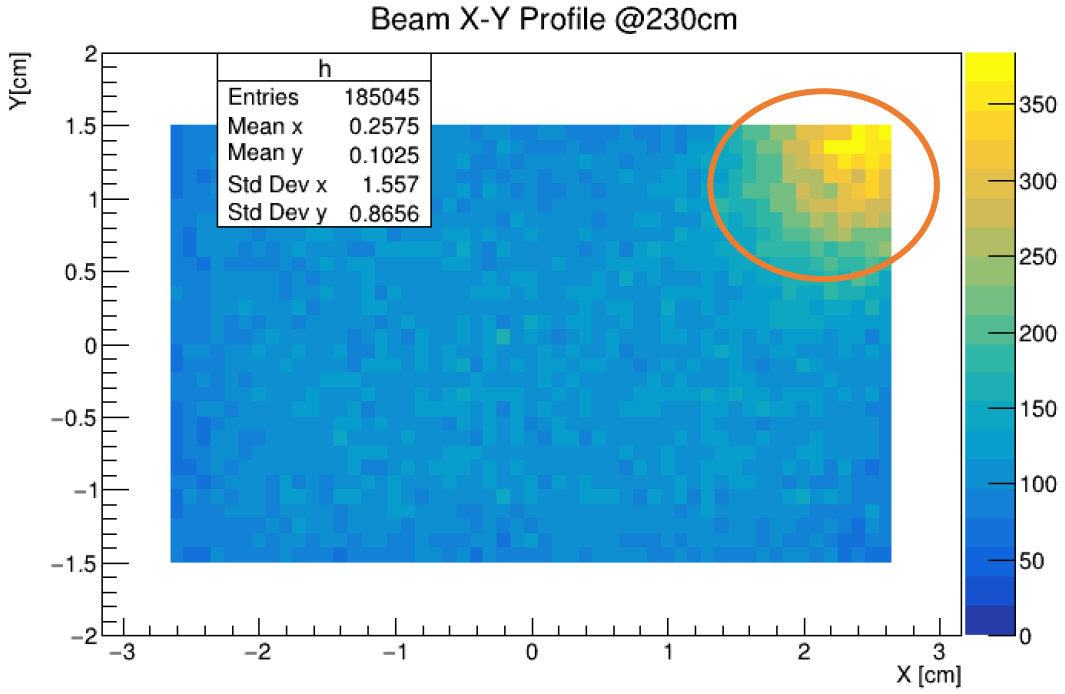


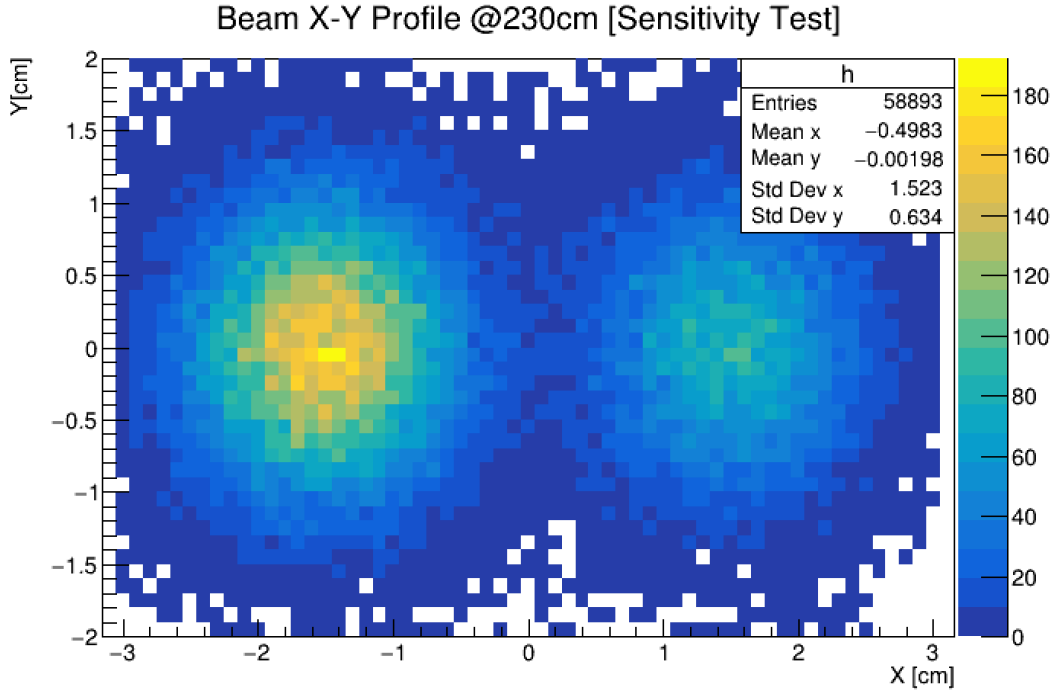


Data Taking in Trento

- The distance from the beam exit window was optimized to achieve a uniform exposure of the brick with TOPAS simulations
- Goal: 10.000 protons/cm^2
- First spot with about 85.500 protons instead of 11.000
- Two spots (20.000 and 40.000 protons) for sensitivity tests







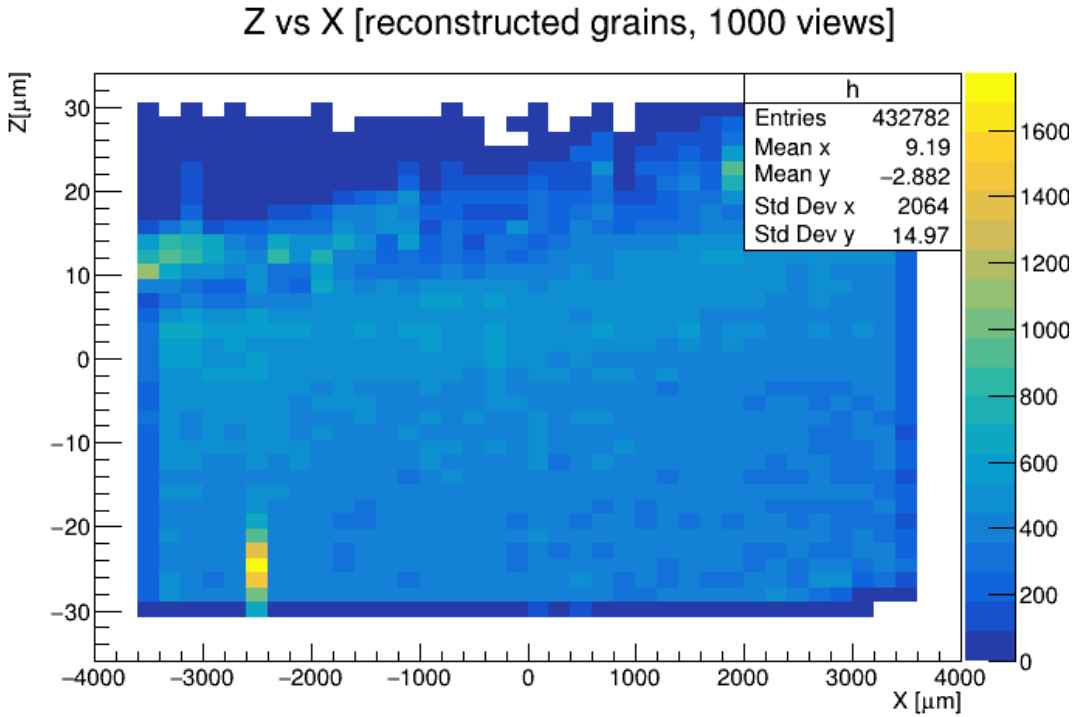
First Scanning Tests

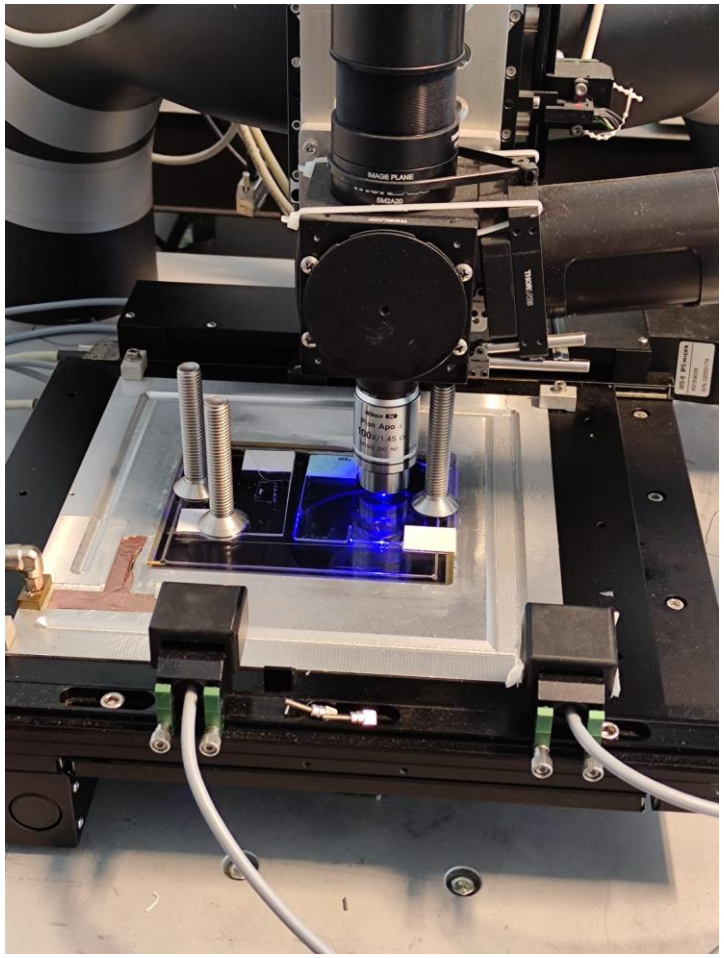
- A preliminary scan was performed in LNGS on the top side of R1-2
- 100x100 views, each view being 50 μm x 70 μm

- Assuming a fluence of 10.000 protons/cm^2 about 3500 primaries are expected (about 1 in every 30 views)

SCANNED AREA

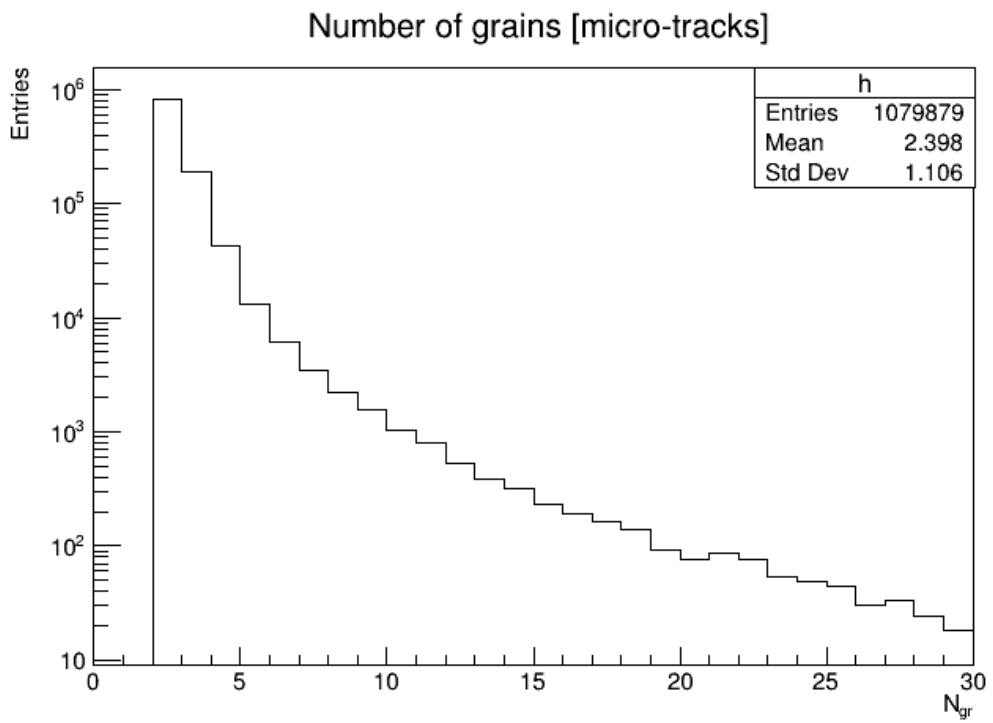
Actual emulsion layer thickness around 35 μm

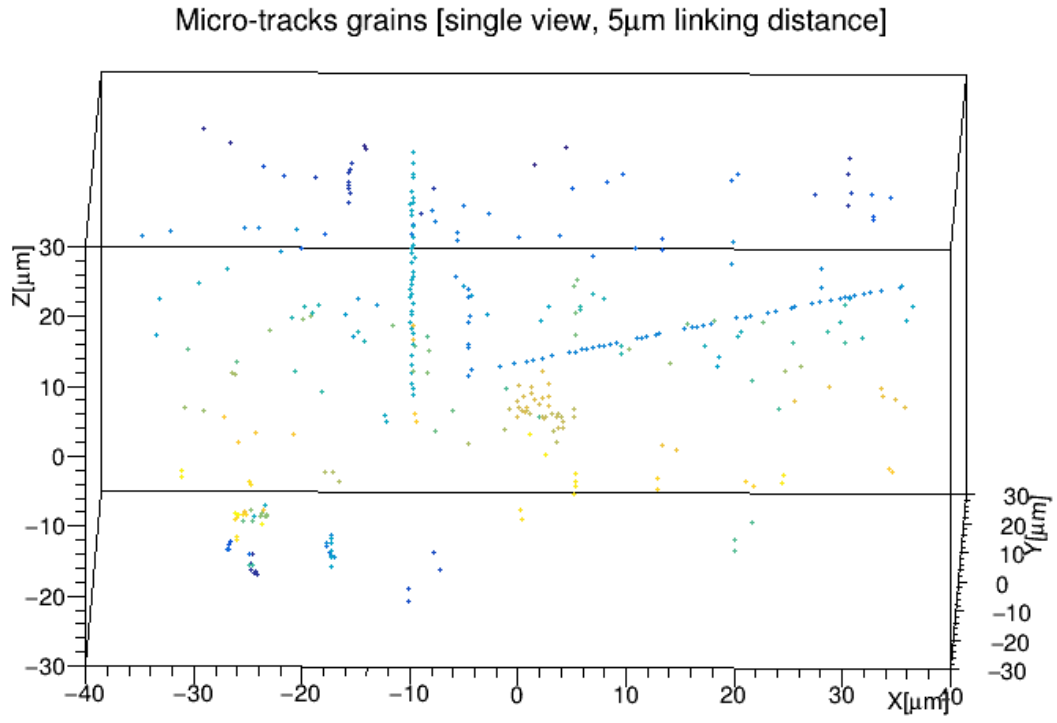




Micro-track Reconstruction

- Once grains are reconstructed, the linking procedure takes place
- The scan performed @LNGS was used to optimize the parameters for the linking algorithm
- Among the parameters:
  - Minimum Number of grains = 2
  - Maximum kink angle between grains = 0.8 radians
  - Maximum linking distance = 5 μm

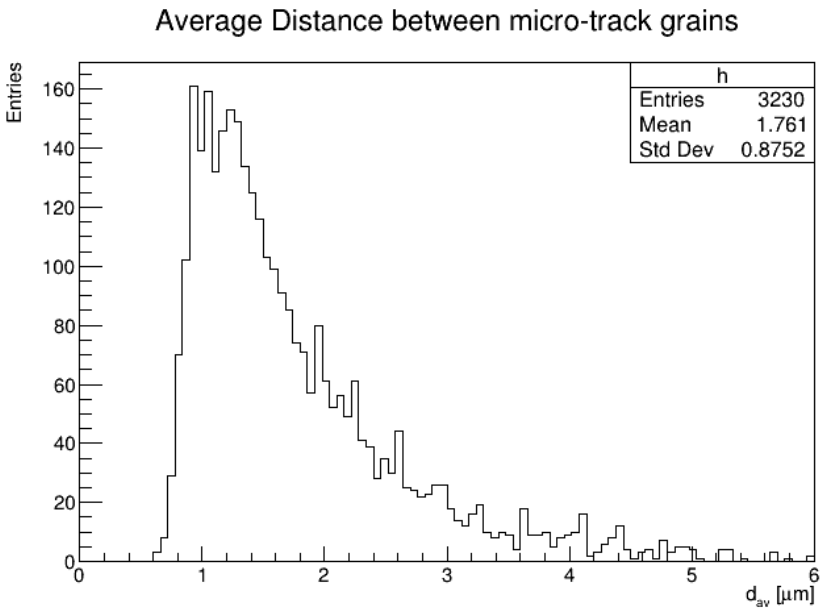


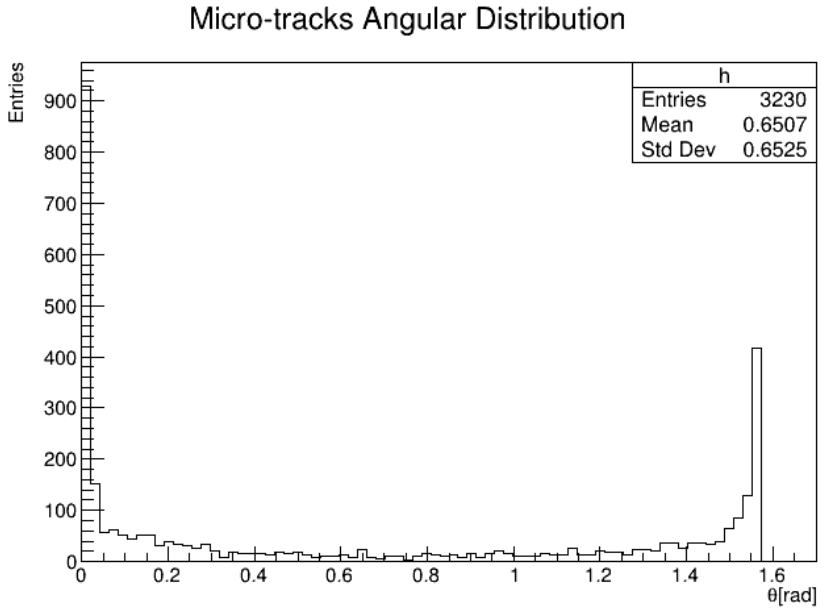


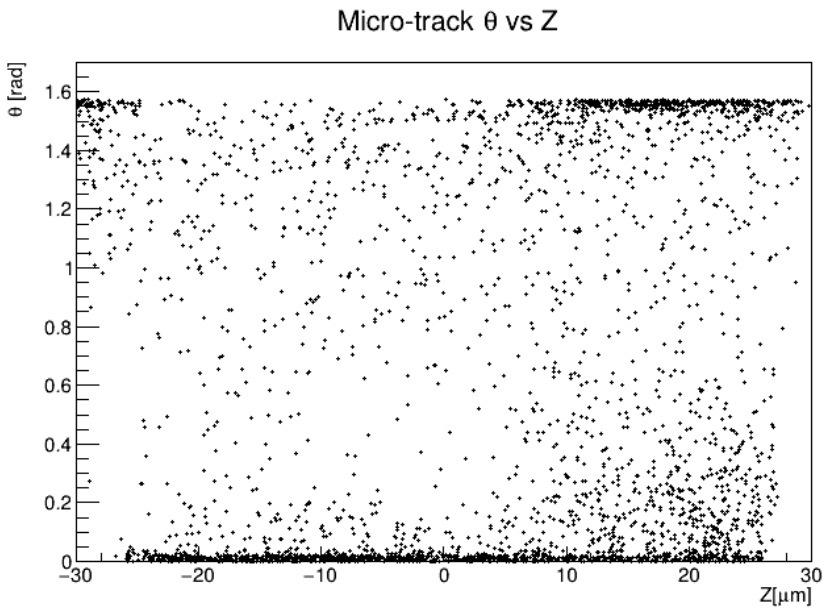
Micro-track Reconstruction

- A score can be given to each microtrack: $Score = -\log(\langle gap \rangle \cdot \langle kink \rangle)$
- Cuts on the score and the number of grains identify the best microtracks
  - At least 10 grains, score > 0.75 ($\langle gap \rangle \sim 1\ \mu m$ and $\langle kink \rangle \sim 30°$)

- The horizontal micro-tracks are closer to the surfaces and they in part due to scratches
- The vertical micro-tracks are less than expected





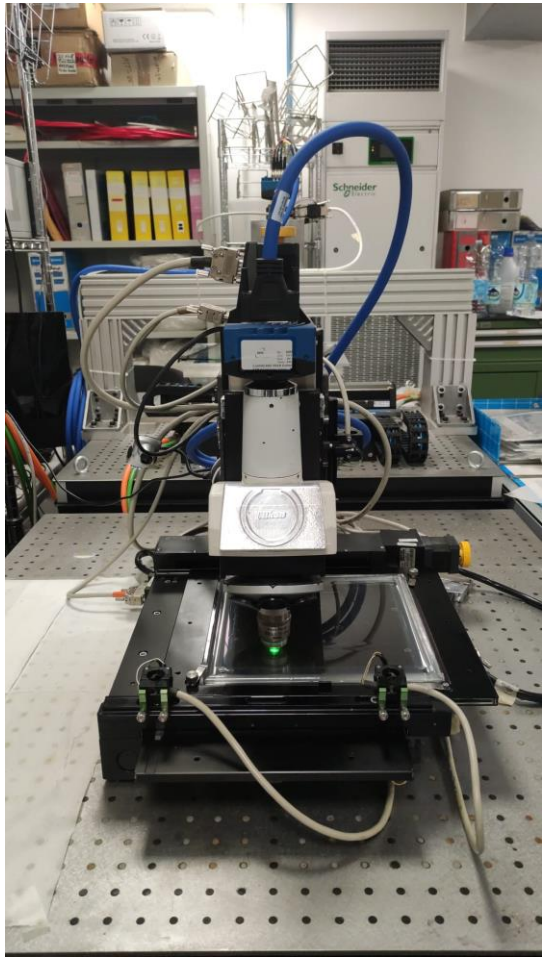


Microscope Upgrades

- Target fragmentation measurements with NIT emulsions → need new hardware!

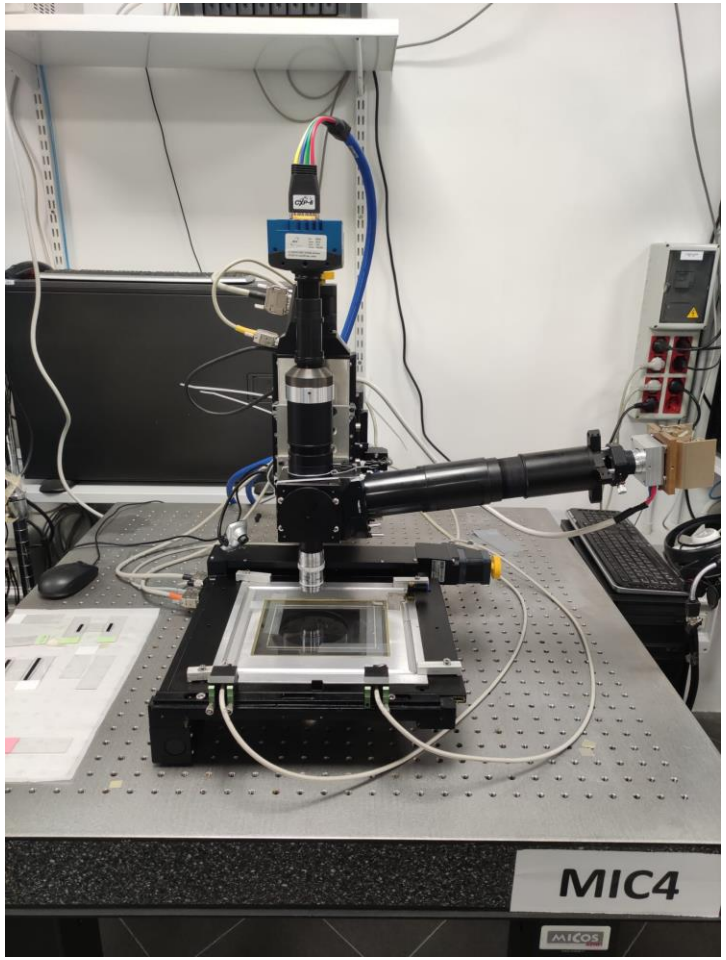
Standard FOOT microscope

- Standard nuclear emulsions (grain size = 200 nm)
- Works in transmission
- 20x objective
- 7 μm physical pixel size → 350 nm pixel size
- Z Step = 1.75 μm
- High scanning speed (~ 20 cm^2/h, up to 190 cm^2/h)
- Small grains **not** visible



NEWSdm microscope

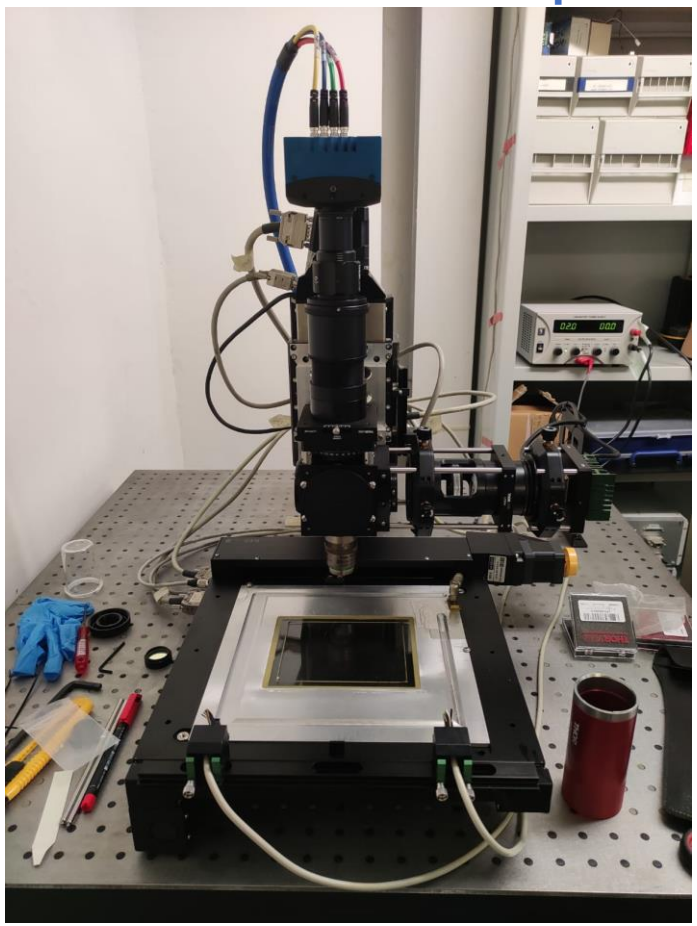
- NIT emulsions (grain size down to 40 nm)
- Works in reflection
- 100x objective + 2.6 zoom lens
- About 27 nm pixel size
- Z Step = 250 nm
- Slow scanning speed (about 14 days to scan top layer of one exposed film! ~ 0.07 cm^2/h)
- Small working distance, only one side at a time
- Blue light → plasmonic resonance



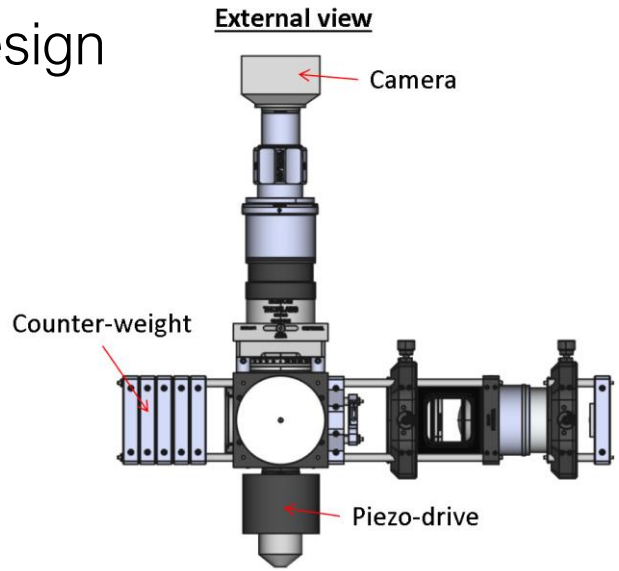
New Microscope to scan NIT emulsions

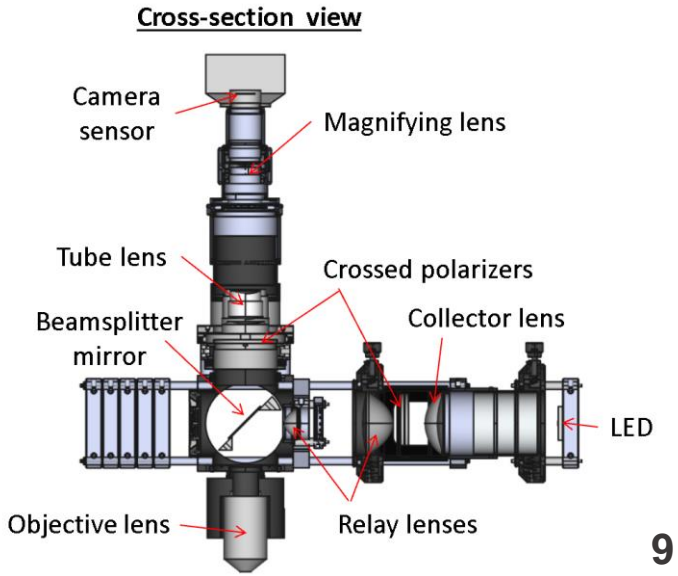
- Our needs are intermediate between the existing solutions → new design
- New optics arrived in May
- Microscope assembly almost completed!

New FOOT microscope



- Works in reflection
- 20x/40x objective + **adjustable** magnifiying lens
- Intermediate Z step
- Better scanning speed
- Larger working distance, possible to scan both sides
- Blue light → plasmonic resonance

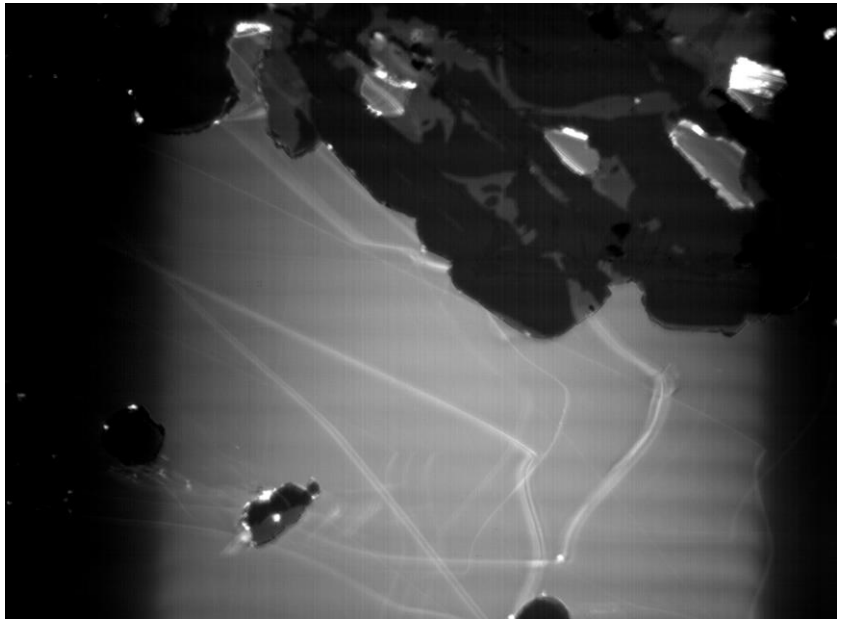


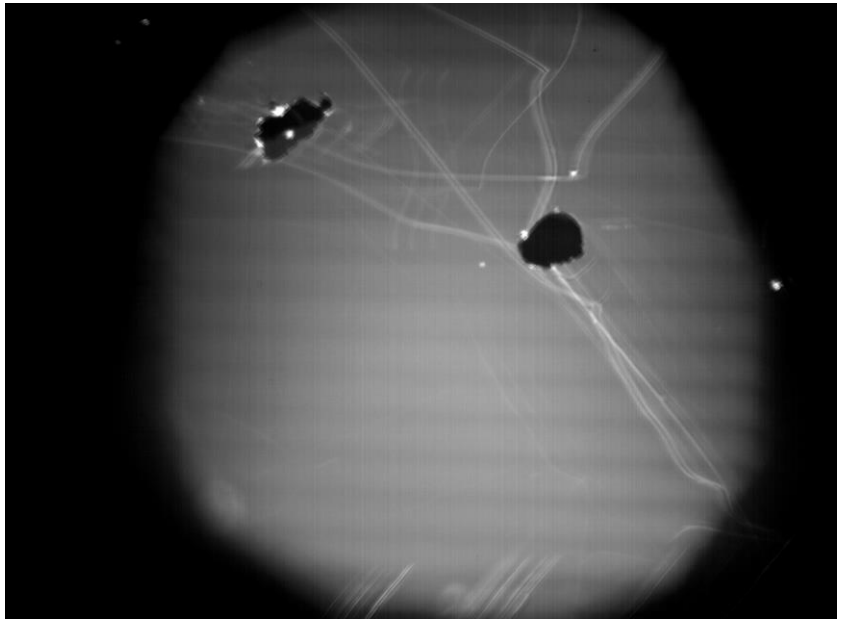


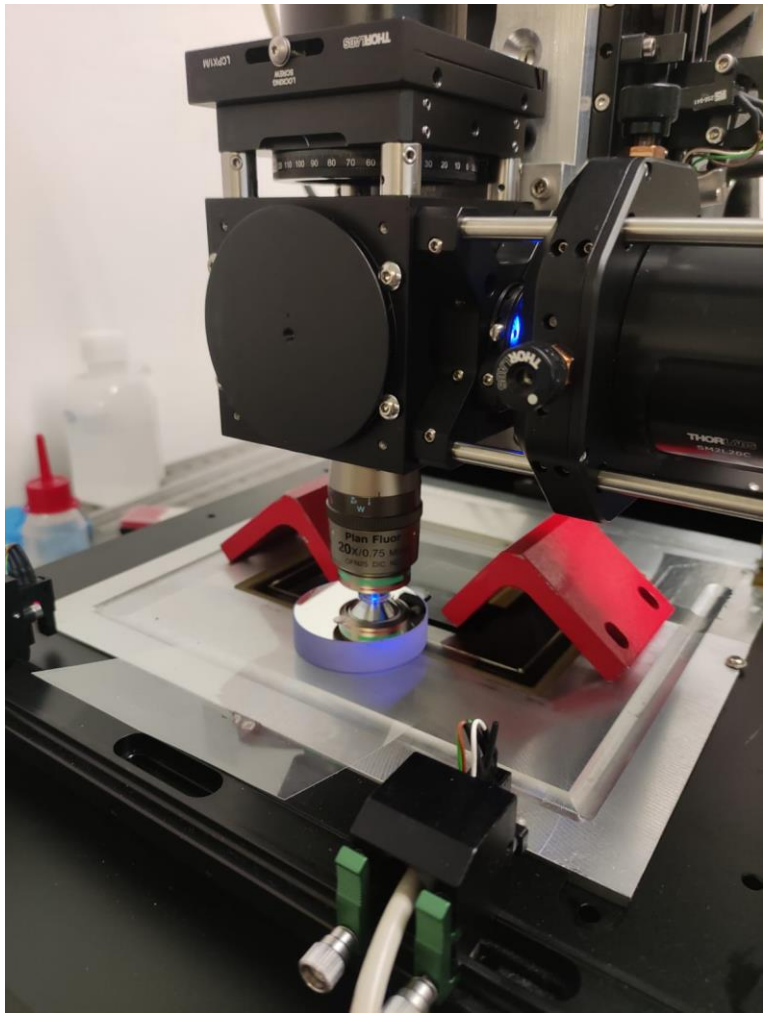
New Microscope Tests (1)

- First images with 20x objective (NA=0.75) installed (no magnification lens)
- Light source: $3 \times 4\ mm^2$ blue LED ($\lambda = 450 - 470\ nm$)

Field of View: $\sim 800 \times 600\ \mu m^2$

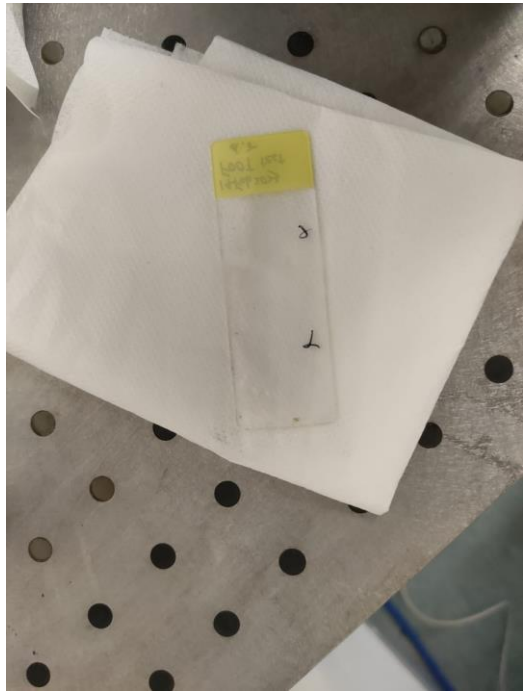


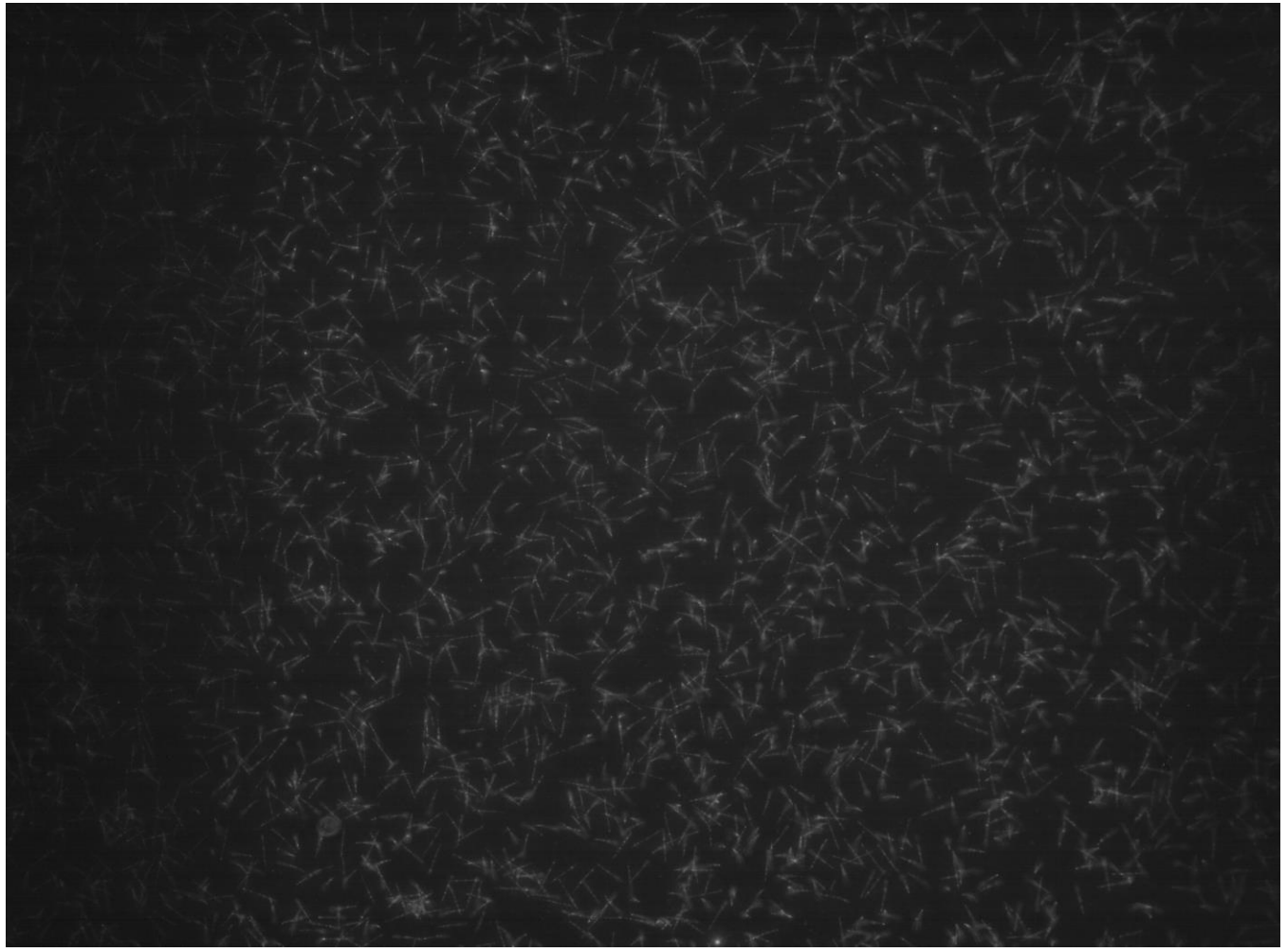




New Microscope Tests (2)

- First images with 20x objective (NA=0.75) installed (no magnification lens)
- NIT sample exposed to Am alpha source (Trento exposure batch)
- Good contrast for alpha tracks

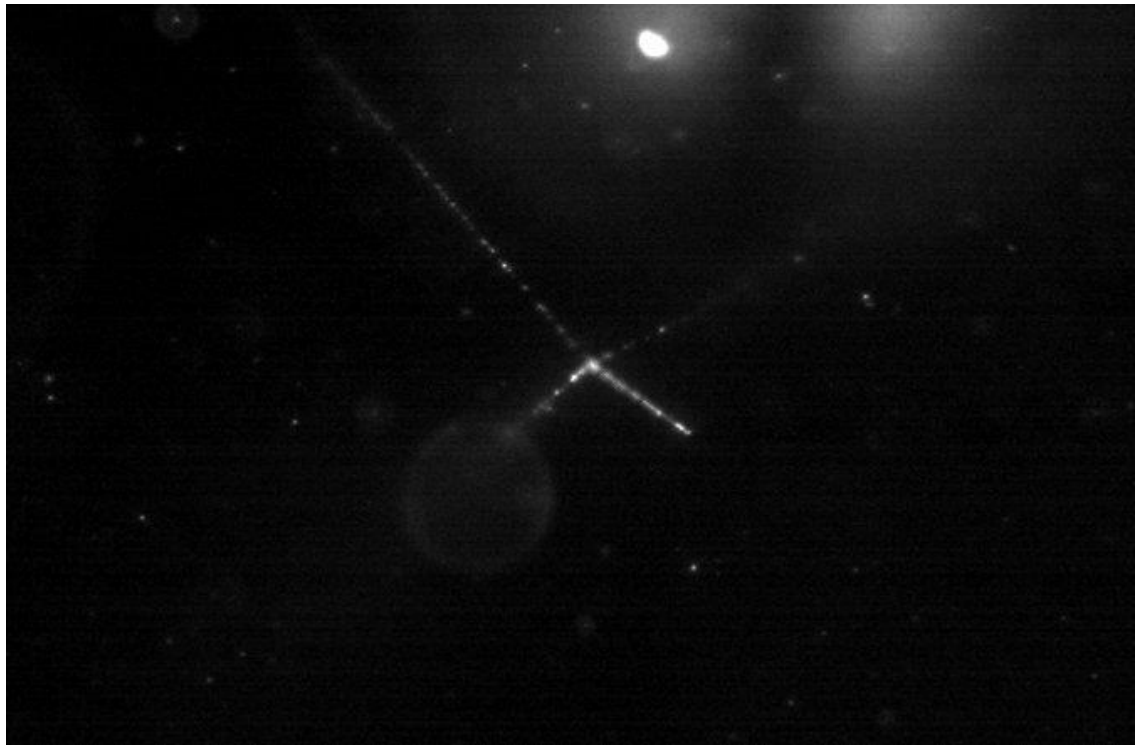




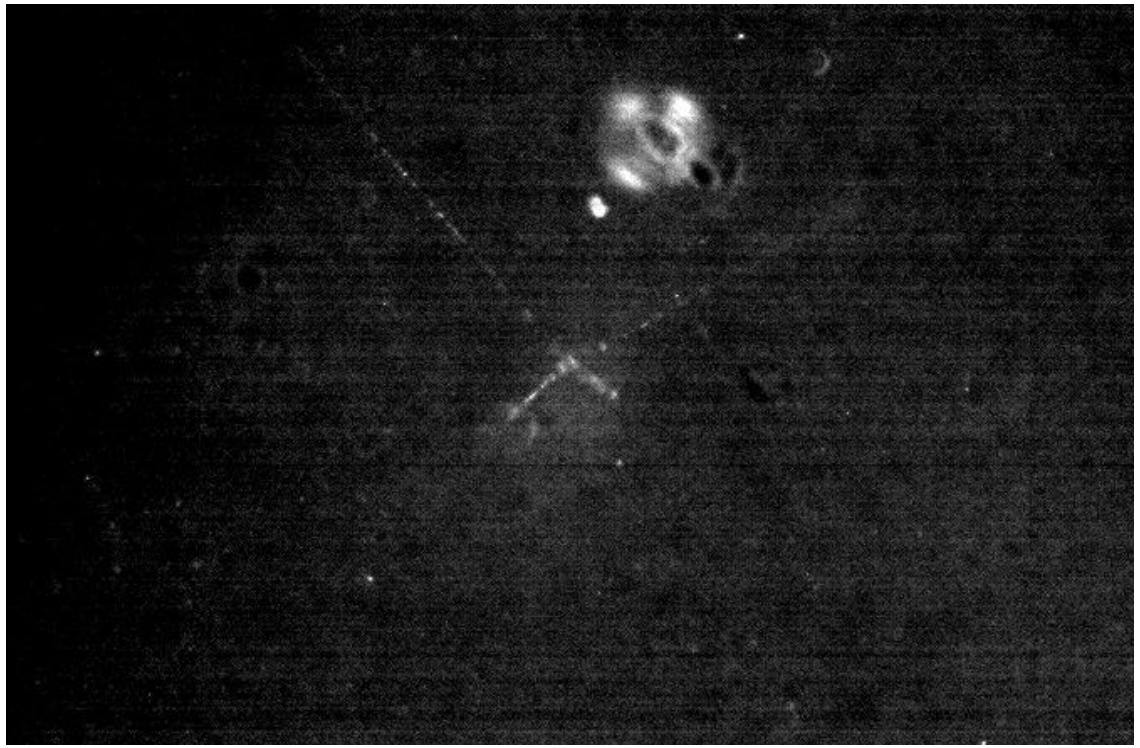
New Microscope Tests (3)

- Comparison between 20x (NA=0.75) and 40x objective (NA=1.3)
- R1-17 film from the brick
- Manual search for interaction vertices

Rayleigh criterium: $R = 0.61 \frac{\lambda}{NA}$



40x objective



20x objective

Conclusions

- Preliminary scan @LNGS → optimization of linking algorithm parameters
- Assembly of new microscope almost completed (ETA ~ 1 month)
  - Correct light source position
  - Optimize Z step
  - Test adjustable magnifying lens
  - Test top side scanning / bottom side scanning
- Good contrast observed for alpha tracks (NIT sample poured on glass)
- Difficulty in reconstructing vertical proton tracks!
  - To be confirmed with full area scans: further studies on-going