Charge determination for high-Z nucleus by fine grain Nuclear Emulsion

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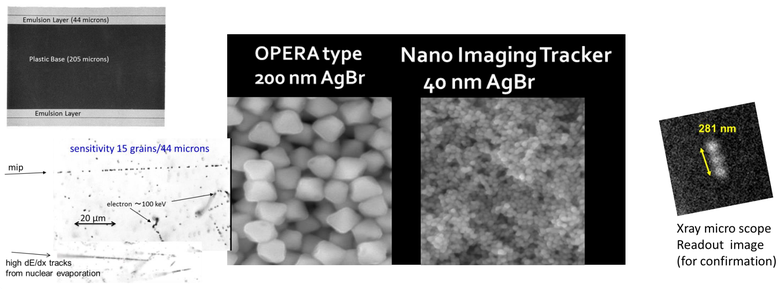
Fine grain Emulsion **NIT (Nano Imaging Tracker)**

- Standard nuclear emulsion ,OPERA type emulsion, is made with 200 nm AgBr crystal .
- NIT was developed at Nagoya University F-lab for Dark matter detection. The AgBr Crystal size is 40 nm to detect short as 100 nm recoiled nucleus by Wimp Dark Matter.
- NIT have less sensitivity than OPERA type emulsion. Energy deposition with several 10th x MIP can be recorded as track.

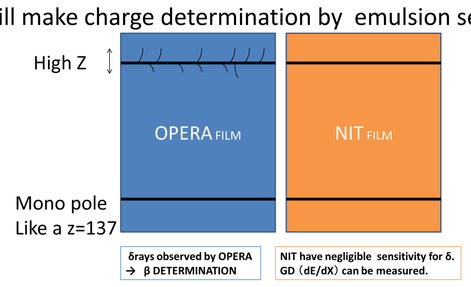


Motivation on the study

- **Mono Pole, Z=137 like , search by Emulsion Cloud Chamber.**
- We have not satisfied with OPERA type films for high-z (z>26) particle's charge determination by following reasons.

A) Poor charge determination power
B) Huge number of δ rays are recorded and tracking by usual automatic track selector developed for MIP dose not work.

- NIT have less sensitivity than OPERA type emulsion, **blind for energy deposition less than several 10th x MIP.**
- So **no delta ray tracks is recoded in NIT,** just track core will be recorded
- We will make charge determination by emulsion sensitivity control.



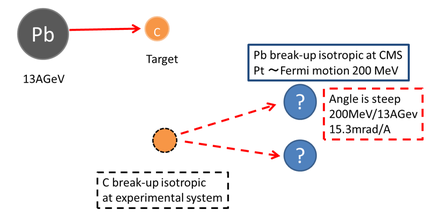
Sample for the study

- **Pb (z=82) beam exposure at CERN at 2016 Nov. and Dec.**

A) Tracking of Pb track itself
B) Pb breakup tracks with target nucleus , C in plastic.

- Breakup product track slopes are very close each others !

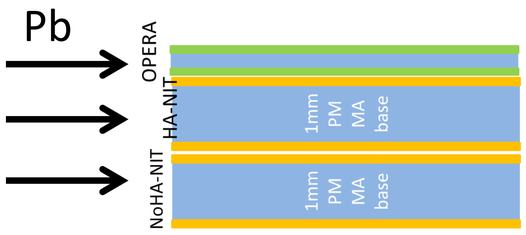
Two body breakup by 50:50 (ie. Two A=207/2) breakup case , angle 15.3mrad/A . → around 0.15mrad.
To separate two particles, Z distance between interaction point to NIT is needed.
Assuming 5um is enough to separate tracks,
0.15mrad * dZ > 5um dZ > 33333 um = 3.3 cm
dZ = 4cm space was used for test beam.



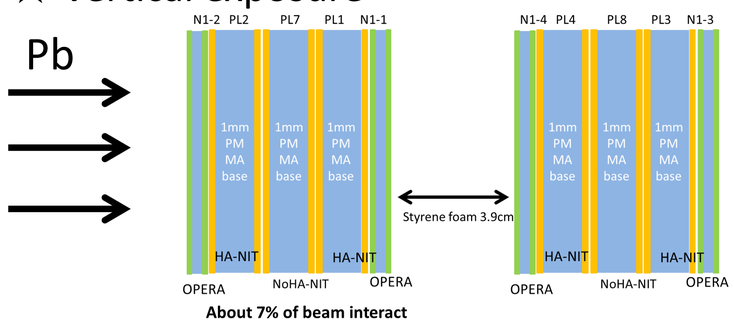
Pb ion beam exposure at CERN H4

ECC made by NIT and OPERA were exposed.
18th Nov and 8th Dec 2016.

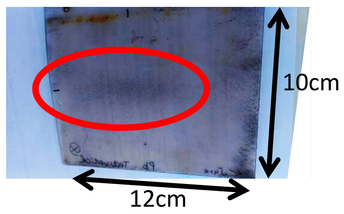
☆ Horizontal exposure



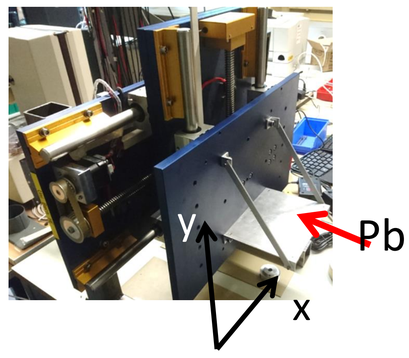
☆ Vertical exposure



Spot size of the beam

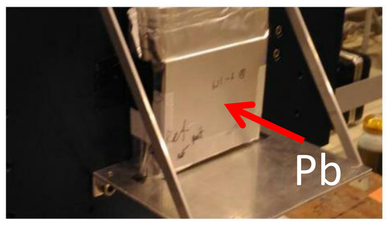


Target xy axis mover for uniform exposure



Horizontal exposure 10^4 Pb/cm^2 Full area Nov 18th

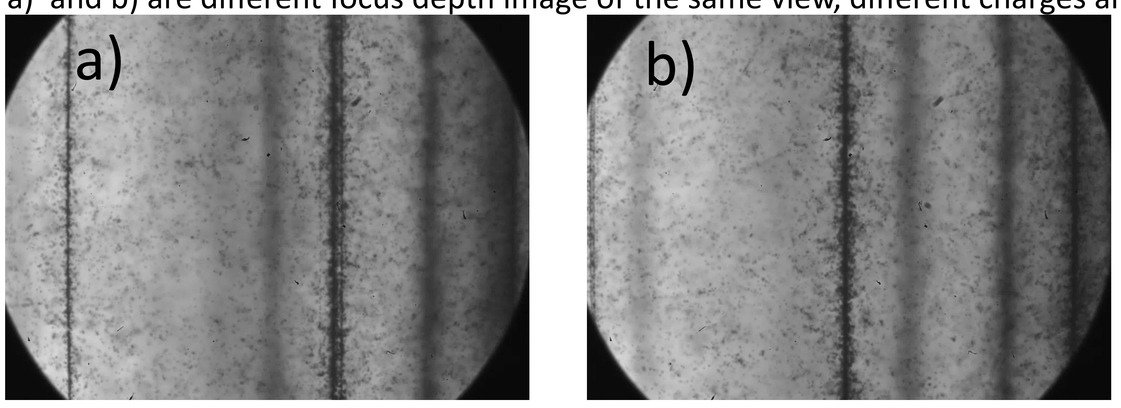
Vertical -1 4000 pb /cm ^{2} Nov 18th



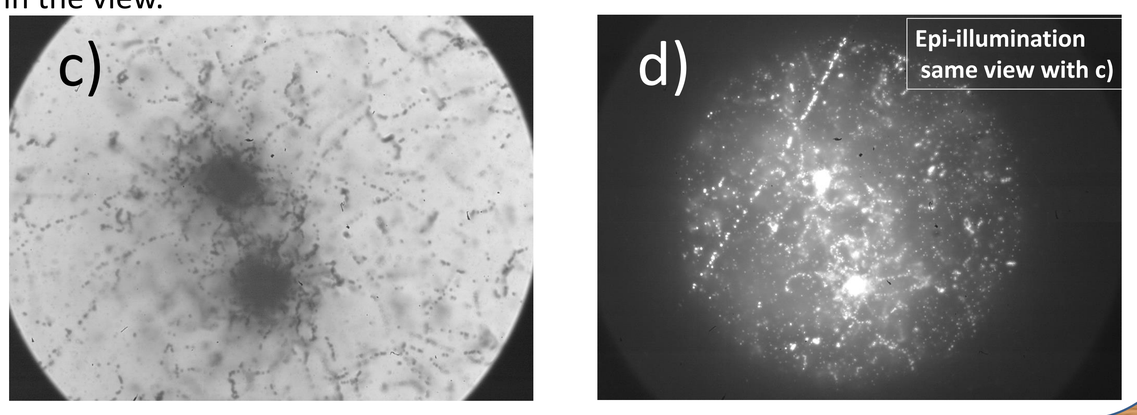
Pb ion track recorded in OPERA type film

Horizontal samples (no sensitized)

a) and b) are different focus depth image of the same view, different charges are seen in the view.



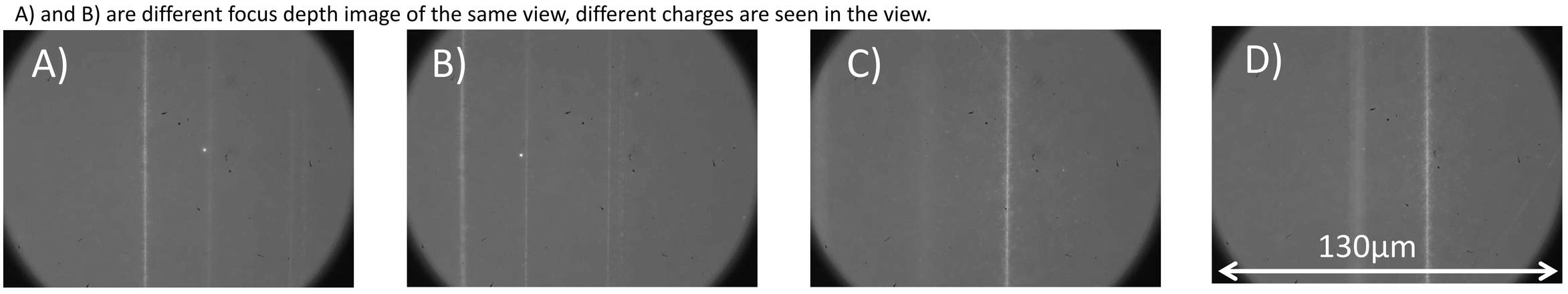
Vertical samples (AuS)



Pb ion track recorded in NIT (HA) film

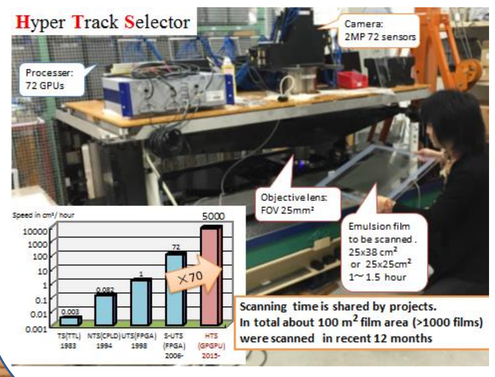
Horizontal sample Epi-illumination

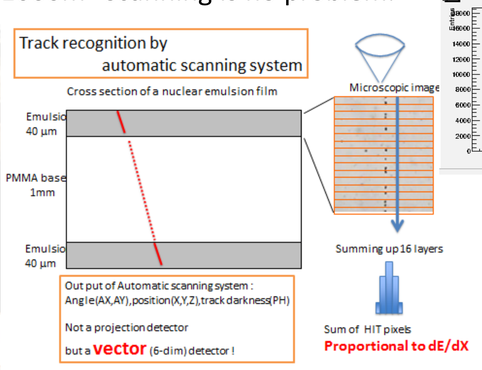
A) and B) are different focus depth image of the same view, different charges are seen in the view.

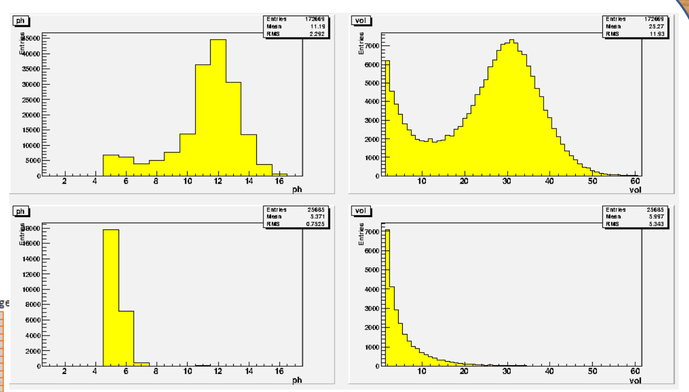


Pb ion Vertical track scanning by automatic scanning system

12cm × 10cm full are of NIT film were scanned as a trial.
5-6min per one surface by HTS. → 1000m^2 scanning is no problem.







Pb tracks scanned by HTS
Top: Tracks in beam angle
Bottom : Tracks in side band angle
Left : Pulse height
Right : Pulse height volume

Pb ion tracks are recognized by HTS
Consistent track density with exposed density

Summary

Fine grain emulsion, NIT have nice feature to detect high-Z particles.
It could be used as ECC with standard nuclear emulsion for high-Z particles charge determination at Mono Pole Search.
A test exposure of ECC made by NIT, OPERA type films was done in 2016 autumn.
As the preliminary results.
a) Pb(Z=82) ion tracks can be scanned by automatic-track selector.
b) It looks charge of the interacted Pb remnants can be distinguished.

In future, a large scale Mono Pole search can be done by ECC detector surface of 100m × 10m.