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Status R&D of directional DM search with Nuclear Emulsion

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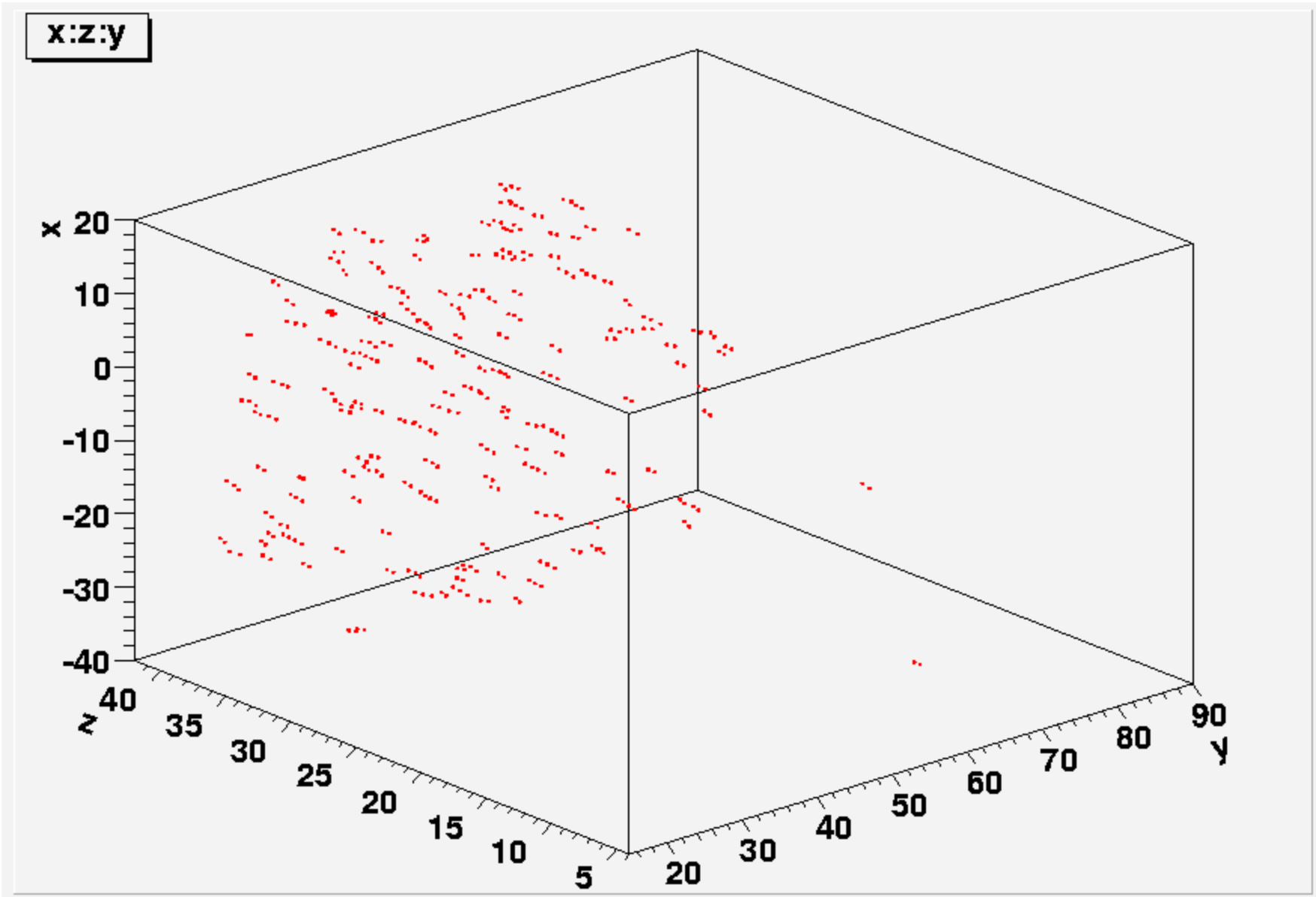
CYGNUS2009 09.June.11-13 @MIT,USA

600keV Kr 3D image of optical microscope

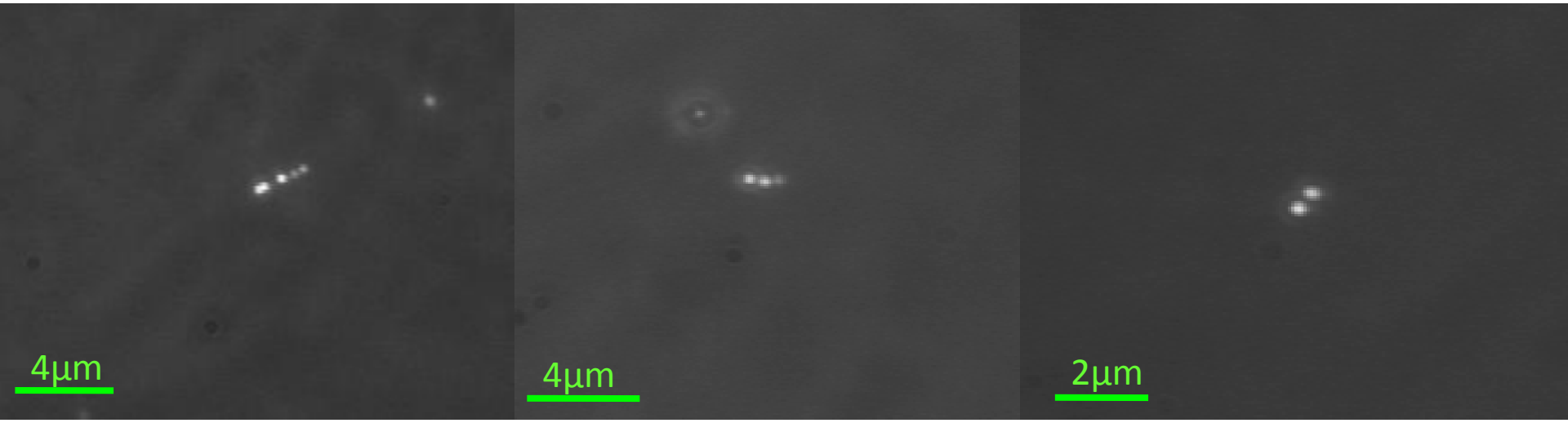


Test of automatic readout of expanded track

-Neutron source : DD neutron (2.5MeV)

Neutron Intensity : (2～3) × 10^7n/sec
Exposure time : 9.5h

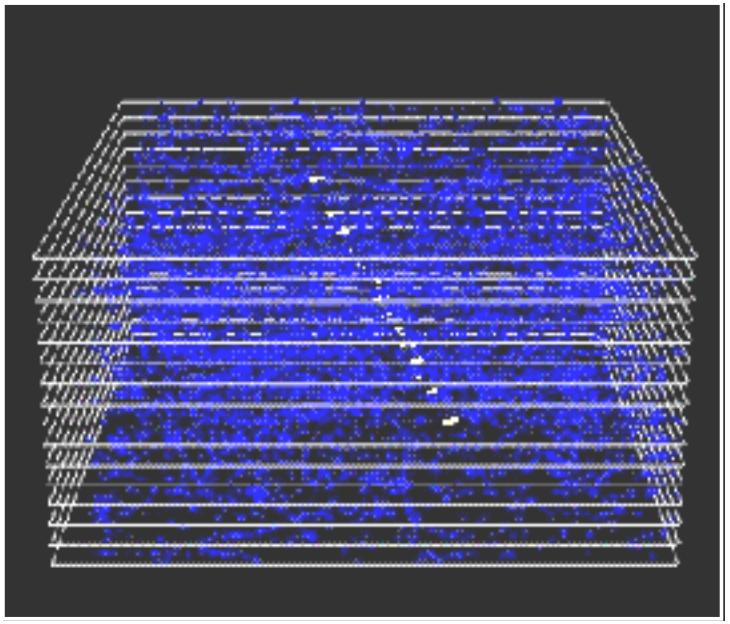
Cross section image of Expanded track (original range<1μm)

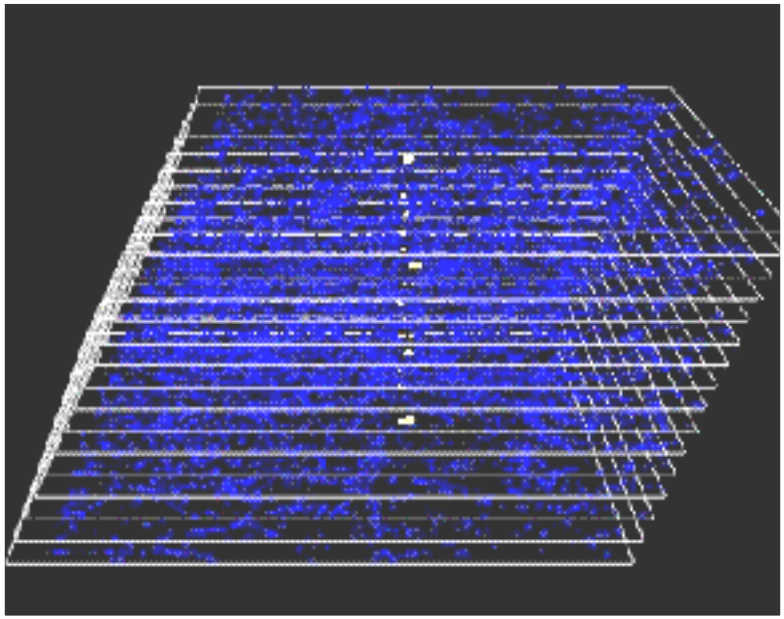


Such tracks were been object of automatic scanning R&D.

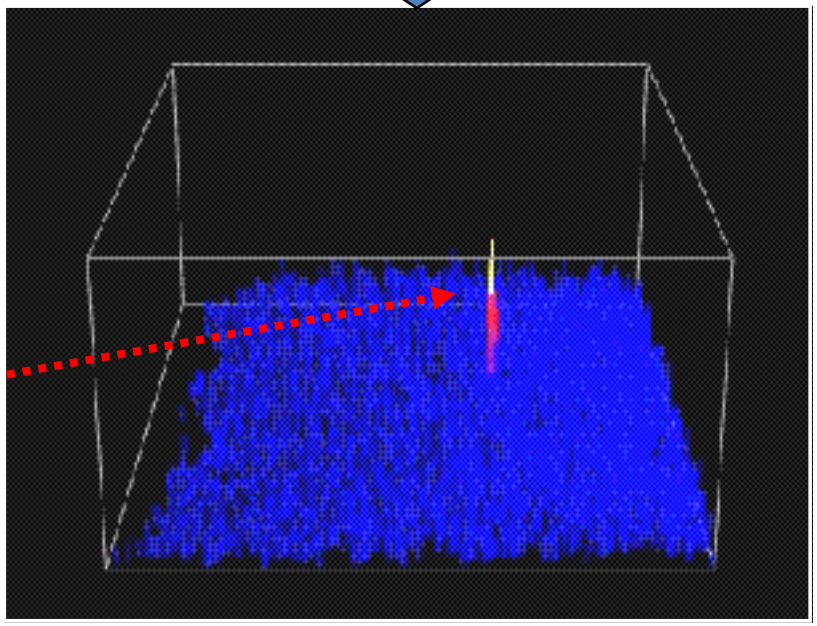
UTS

Track recognition algorithm





Repeat on angle space

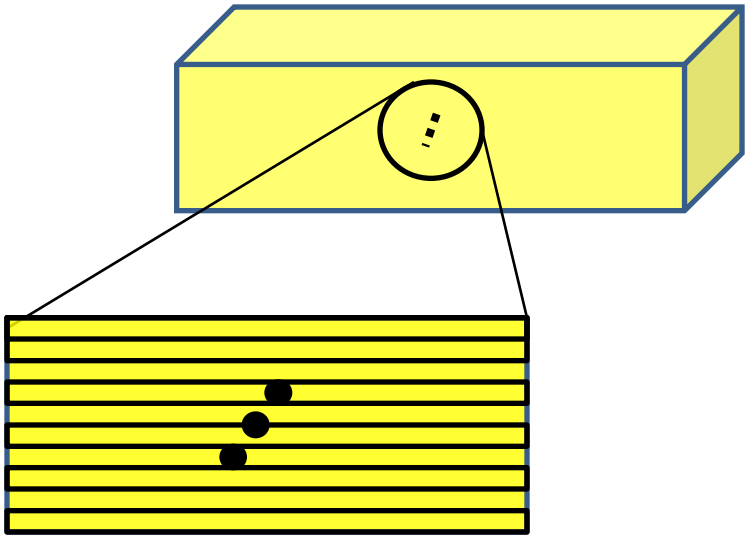


- Take 16 tomographic images by microscope.
- Shift images aiming an angle
- Sum up all images to examine coincidence
- Appear tracks as peaks

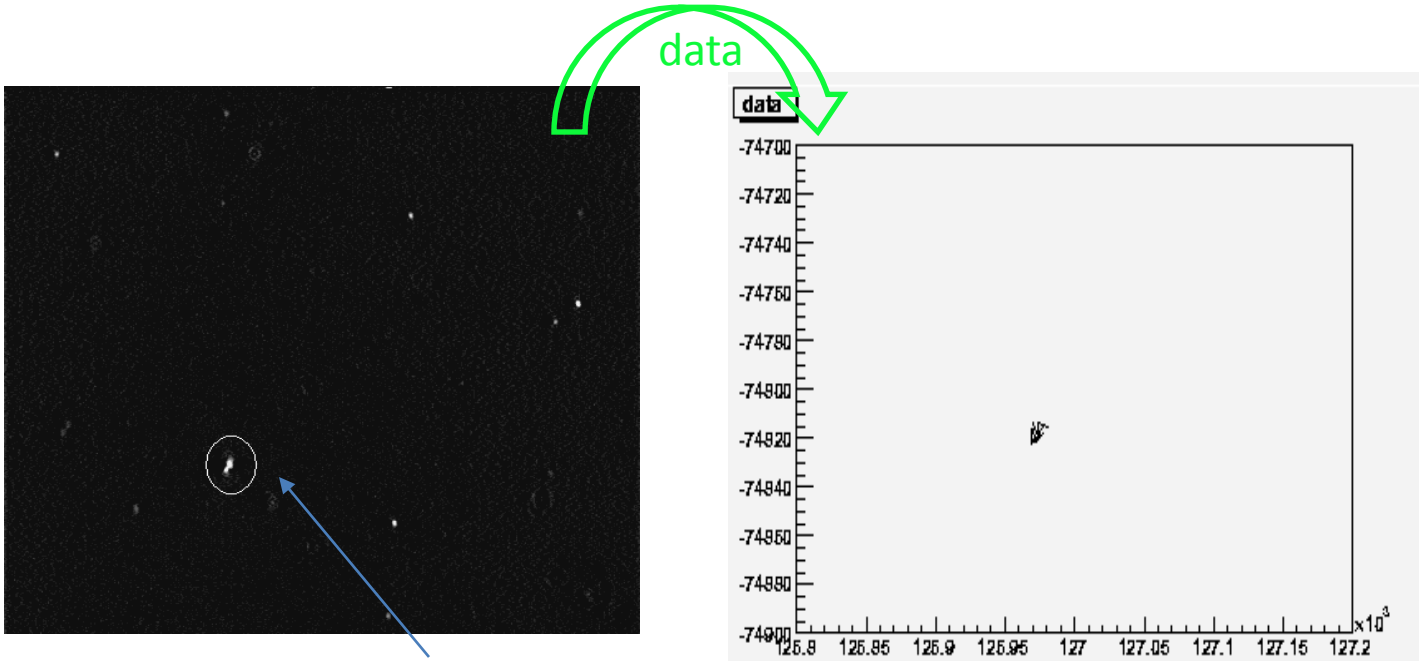
Number of hit in 16 tomographic image : <u>pulse height (ph)</u>

Scanning R&D status for NIT

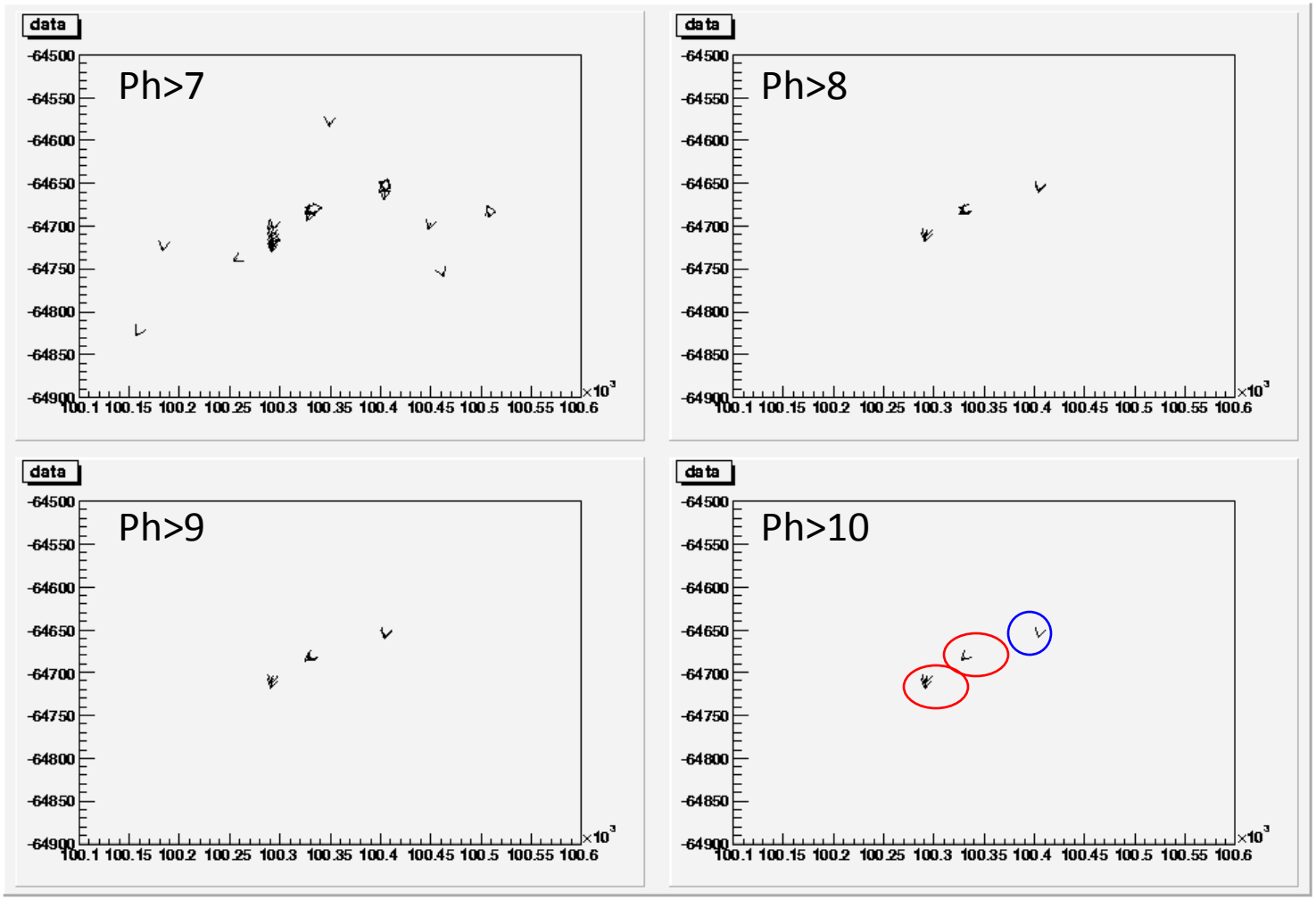
- light field (transmission) -> dark field
- 10μm thick scan per 1view
- checked scanning data by manual check every 5 view scanning⇒recognize the track



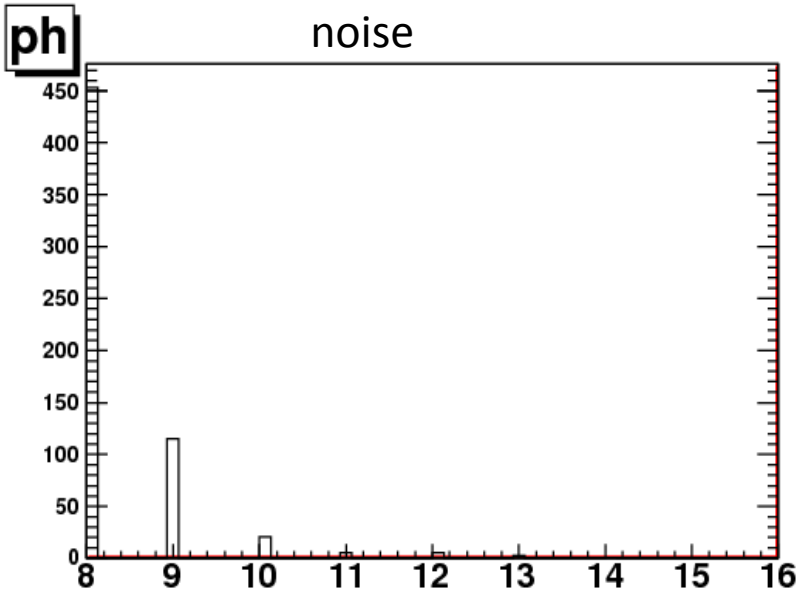
Ex image)

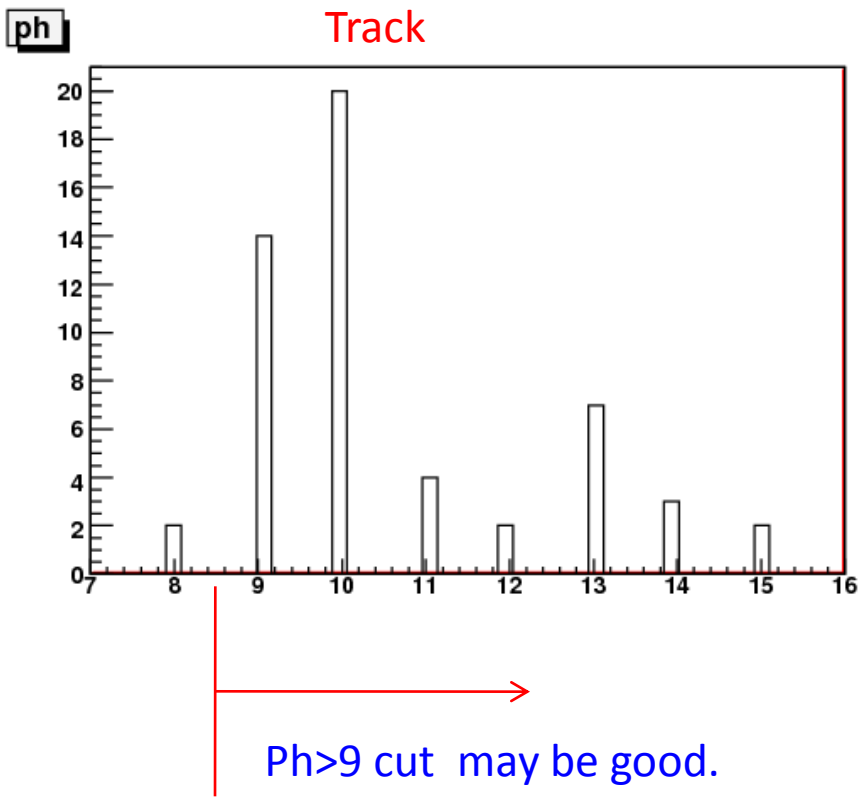


3grain track (4.56μm range)



track up ph:100099
down ph:130250
fog ph:100097


ph
noise
450
400
350
300
250
200
150
100
50
0
8
9
10
11
12
13
14
15
16


ph
Track
20
18
16
14
12
10
8
6
4
2
0
7
8
9
10
11
12
13
14
15
16
Ph>9 cut may be good.

Result

Tracking efficiency

scanning data →confirmed by manual check

5view scanning area : 3450μm^2 × 10μm thick
⇒scanning volume 1.9 × 10^{6}μm^3

Number of found track 56

ph>10	**39**
ph 9	**15**
ph 8	**2**

Tracking efficiency

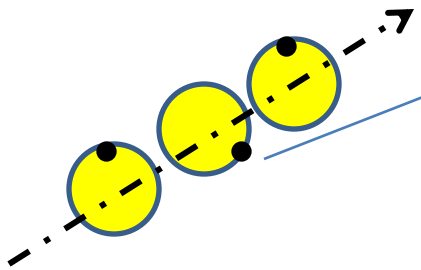
ph>9 cut	**86+-11%**
ph>10 cut	**81+-13%**

The tracks that couldn't detect by track selector [9 track] { **small grain**, **large angle** }

・improvement of image processing ⇒ improvement of measurement accuracy of angle
・improvement of development treatment and sensitivity of NIT

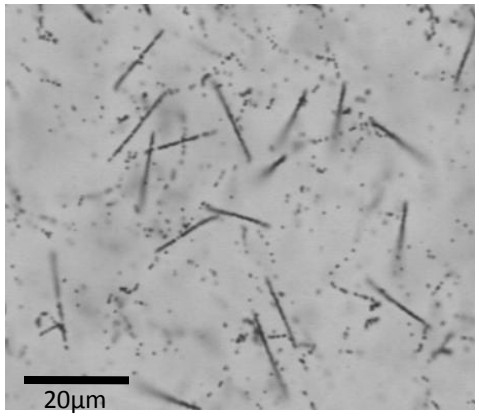
Background rejection by development treatment

Generation of latent image is needed for AgBr that particle penetrated is developed.

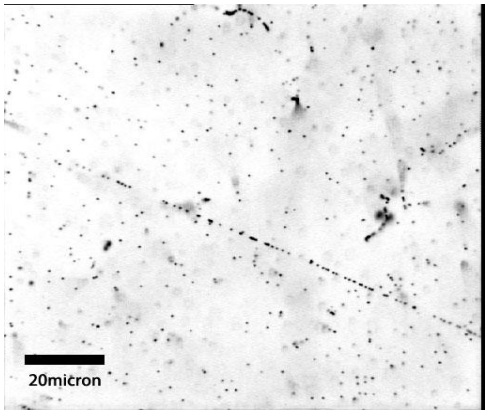


Possibility of generation of latent image depends on dE/dx of particle.

Ex.) α ray



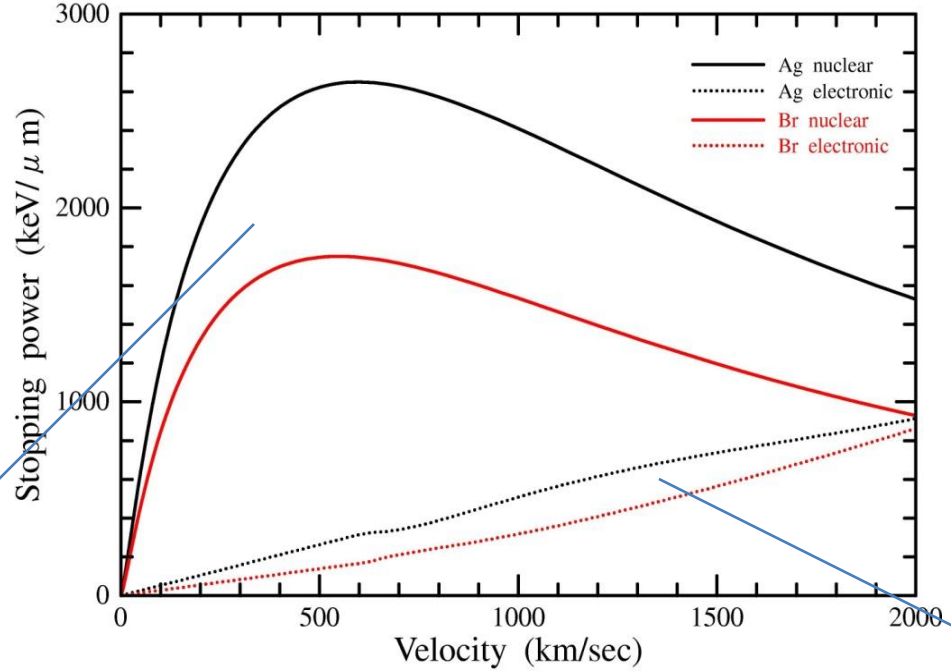
electron(MIP)



In the case of nuclear recoil track and BG track..
-Difference is very large of dE/dx between nuclear recoil and BG track(γ, e)
-dE/dx process of nuclear recoil is Lindhard-Sharf region and nuclear stopping power diminant.

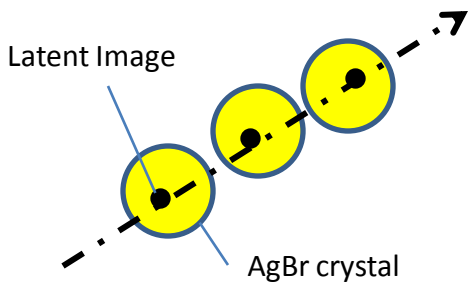
You can expect there is difference of generated mechanism of latent image.

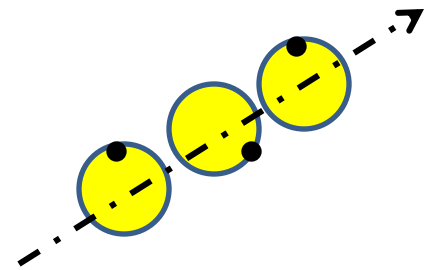
Separation of dE/dx between Nuclear and electron stopping power



<u>Nuclear Stopping Power</u>
It is expected that Lattice Defect is generated into the AgBr crystal.

<u>Electron Stopping Power</u>
It is expected as normal ionization. Then latent image is generated on the surface of AgBr crystal.

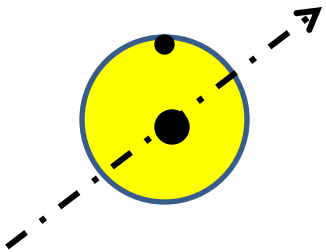




Background track discrimination

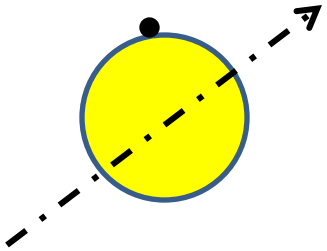
<u>Nuclear recoil track</u>

Nuclear stooping power dominant



<u>Background track (γ, β)</u>

Ionization dominant



There may be difference between nuclear recoil and background track from the place of generated latent image and size of latent image.

By preceding development of internal latent image, signal/BG efficiency may be improved.

Recognize of the place of latent image

Dissolution Physics Development

This can develop while AgBr is dissolved.

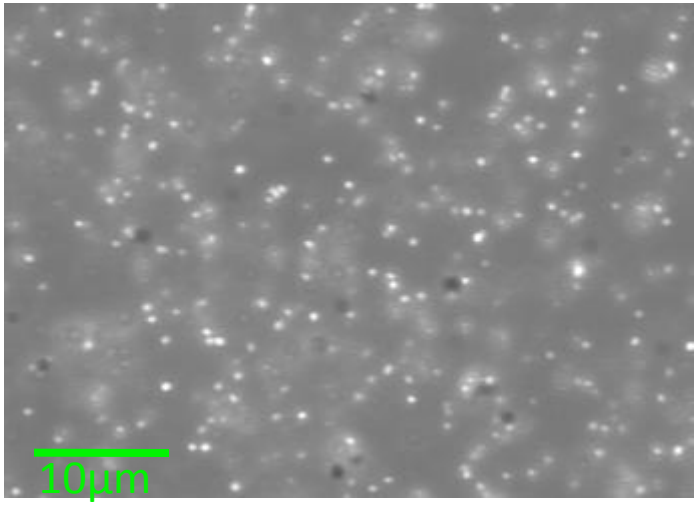
internal latent image is able to be developed.

Physics Development

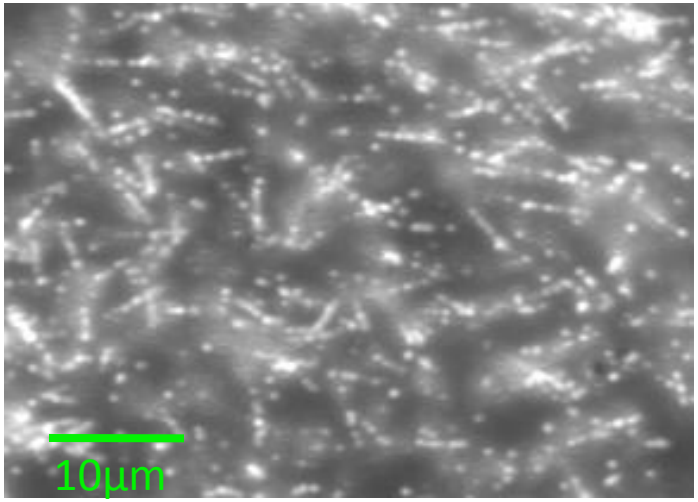
Only surface latent image is developed because AgBr is not dissolved.

αray test

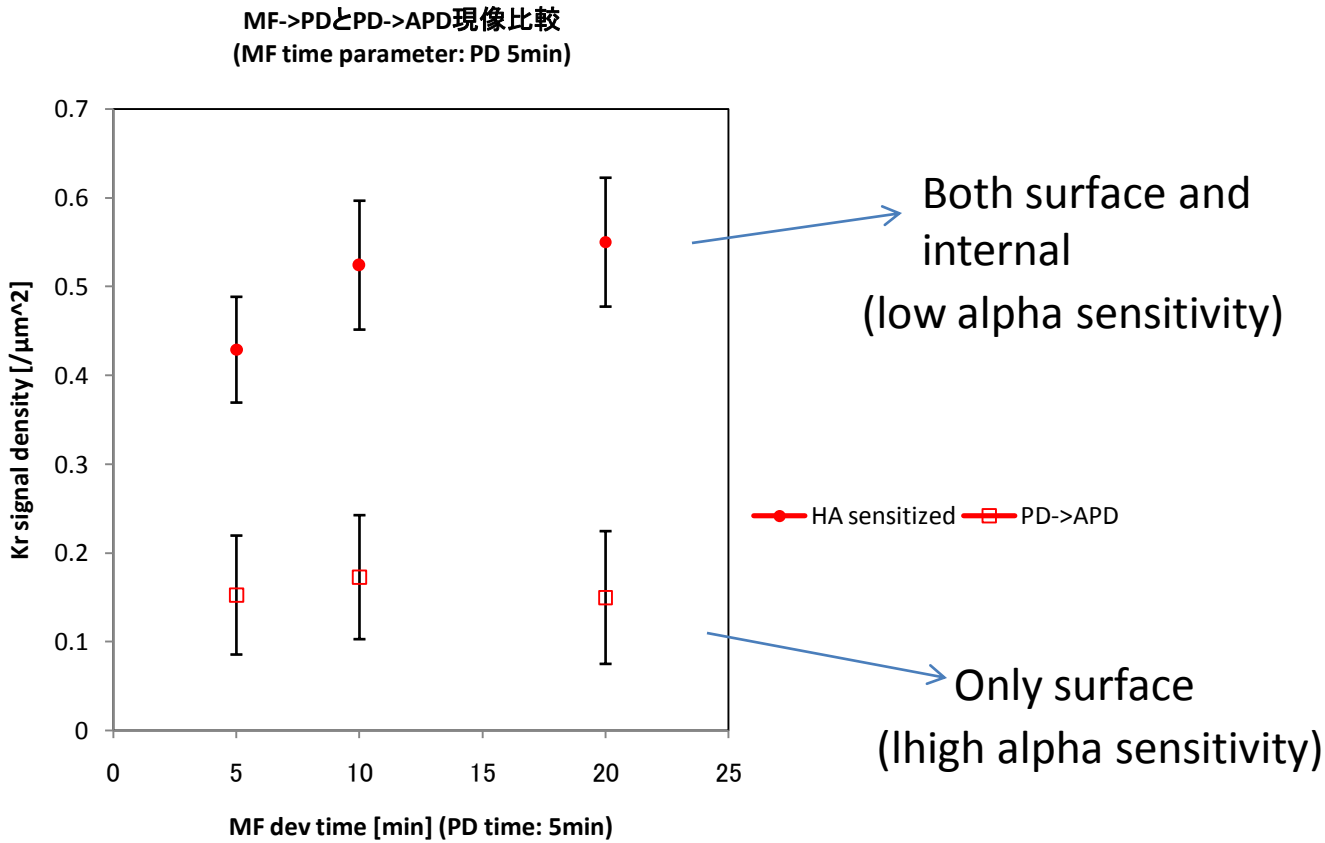
Grain density < 1.0grain/μm
Distinguish track is difficult.



Grain density = 2.5grain/μm



Kr test

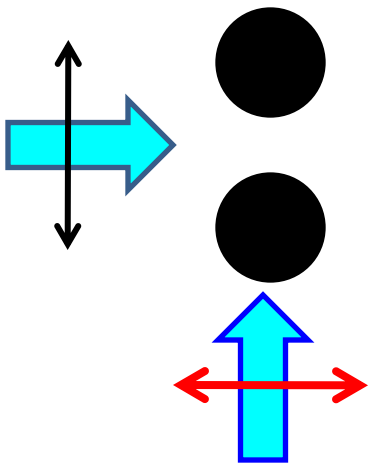


At least, Internal latent image is generated for nuclear recoil track and only surface latent image is generated for the track that ionization process dominant.

From now on, I will measure the background rejection ratio for this method.

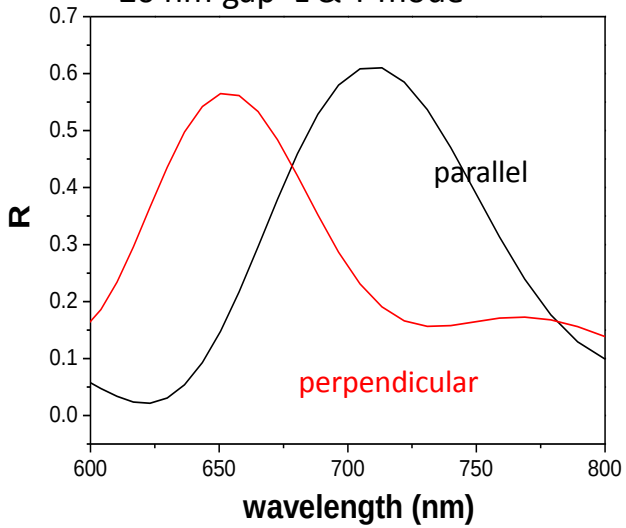
Further large volume readout plan

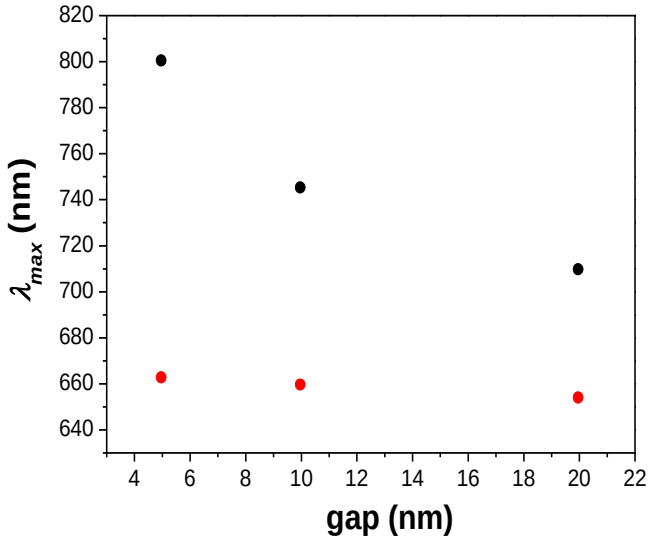
Nuclear recoil



FDTD simulation

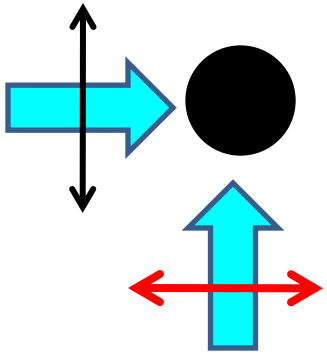
20 nm gap L & T mode





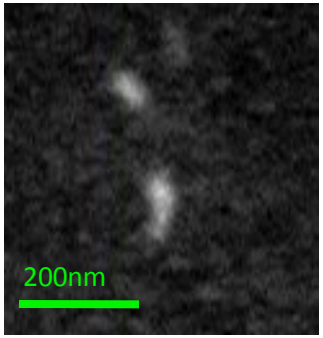
Condition: 100nm Ag into the gelatine

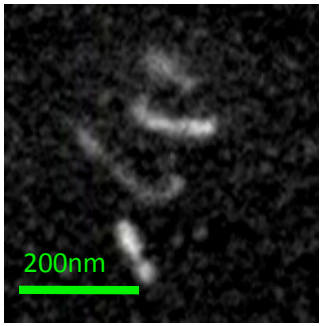
Noise



No wavelength shift

With Pro. Misawa and Dr.Ueno @ Hokkaido Univ.

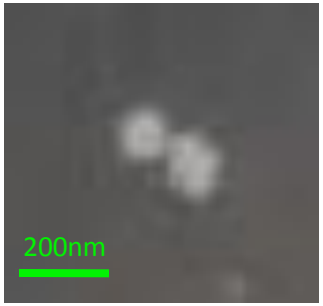


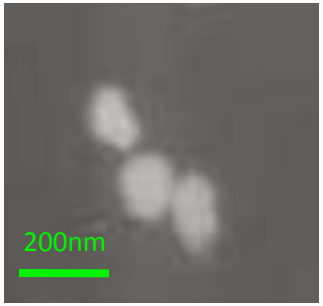


<u>Normal development treatment</u>

Grains grow up as filament

This can't use because grain is anisotropic.



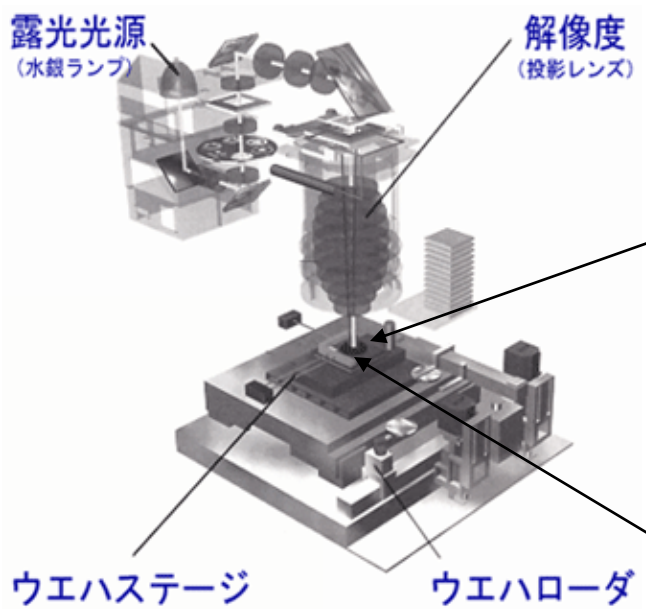


<u>Dissolution Physics development</u>

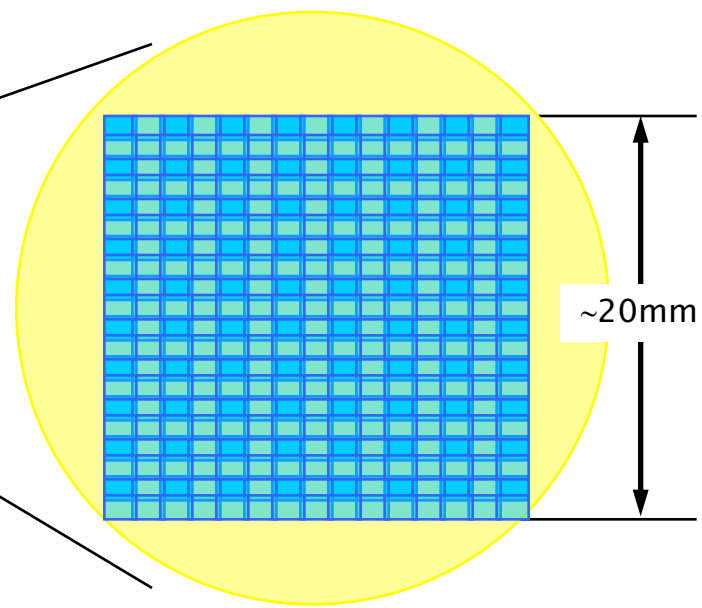
Grains grow up as sphere.

Concept of the next generation emulsion readout

Optics	Technology transfer from photo lithographic system
Imager	Mosaic CMOS imager (multiple 4k2k imager)
Effective FOV	21.55 × 20.9 mm^2 × 0.28 (1450 × 1100μm^2 × 80)
Effective pixel size	0.35-0.5μm
Repetition time	1.5 sec /16depth/fullarea (4 steps/view)
Max. scan speed	12000cm^2/h (150cm^2/h × 80)



IC-Stepper (Lithographic system)

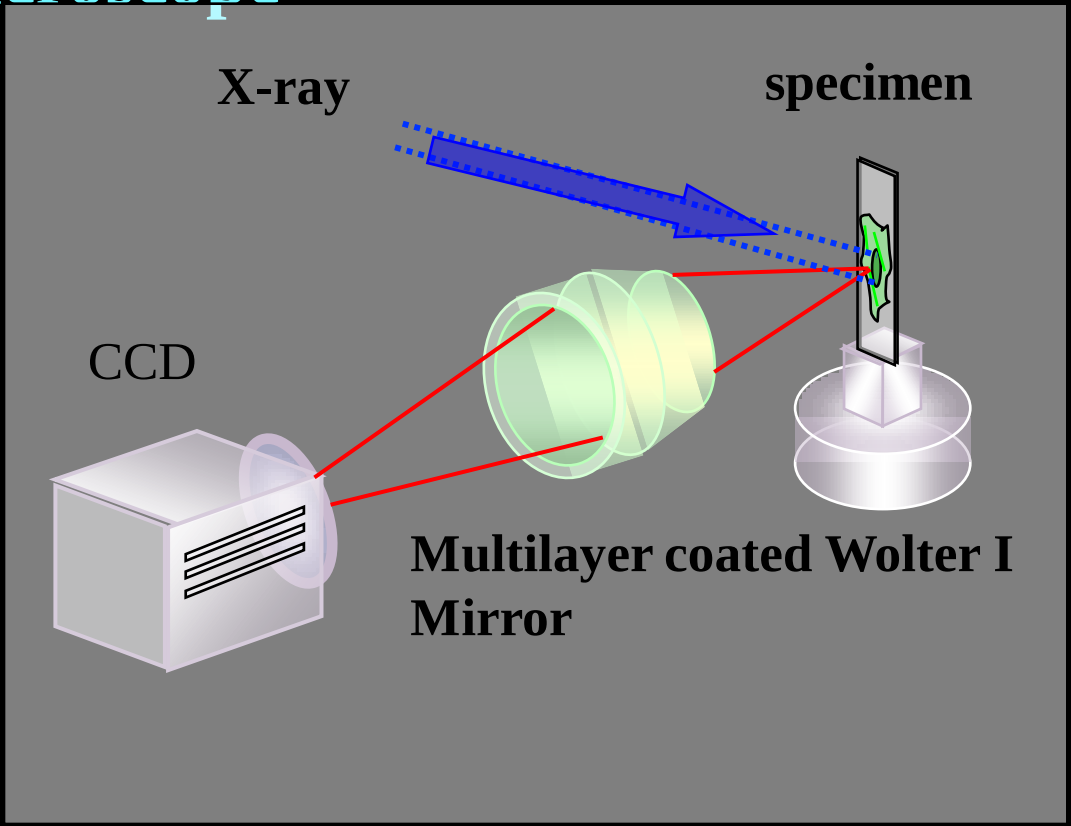


Current system : 0.2mm

FOV comparison New vs. Present

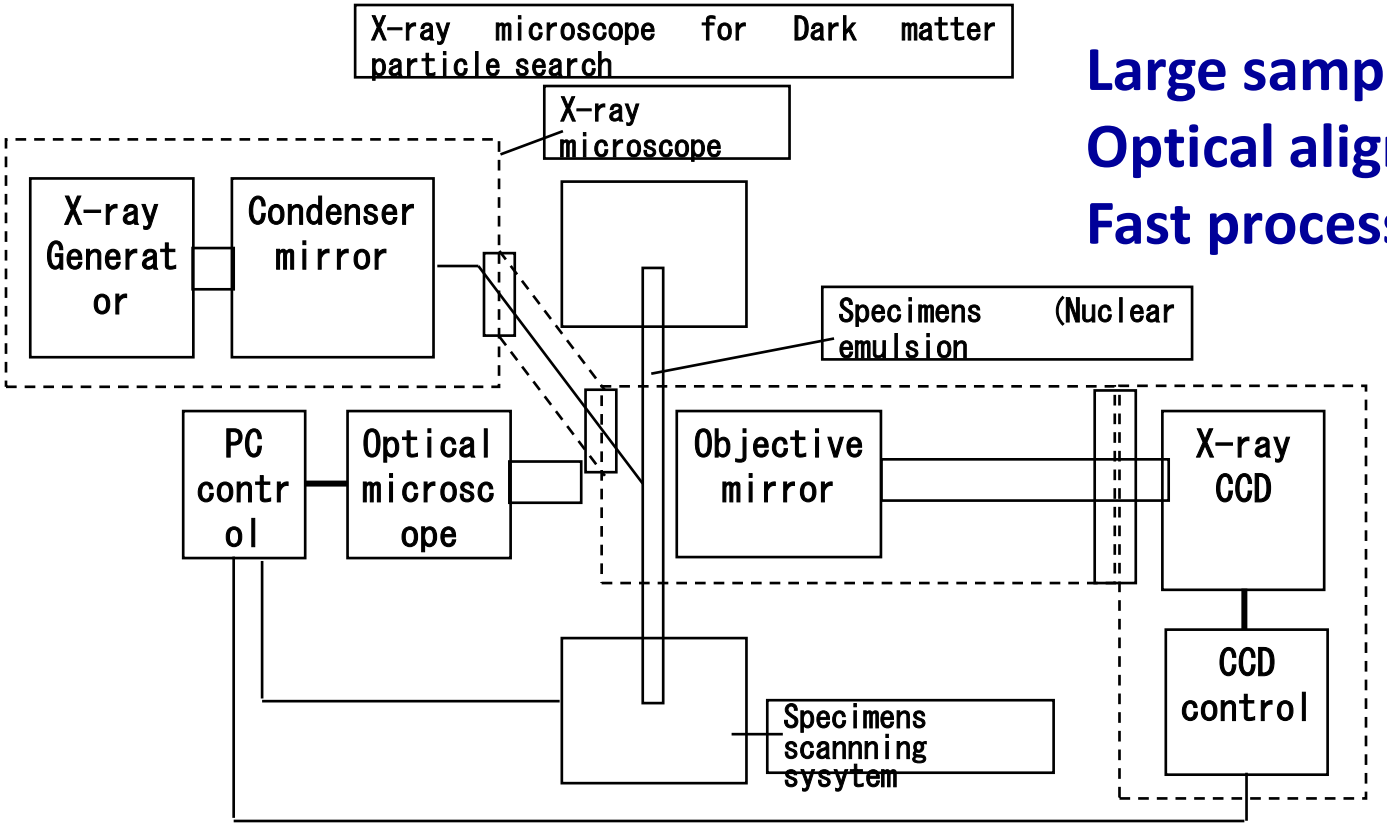
Example of the system

Imaging fluorescence X-ray microscope



with Prof. Tawara

System Plan



Large sample
Optical alignment
Fast processing

Conclusion

- Automatic scanning system
  - developed 100 times speed track selector
  - developed readout system of short range track
- Development treatment for background rejection
  - using the difference of generated process of latent image
  - possibility of head-tail discrimination
- New tracking system
  - using the wavelength shift by direction of polarized light
- Xray microscope