Electron and fog background ~ next approach~

Tatsuhiro Naka
Nagoya University

Intrinsic radioactive background

Radioactivity [mBq/kg]

U-238	Th-232	K-40	Ag-110m	C-14
27	6	69020	(~400) preliminary	24000
~27	~6	35	(~400)	24000
1-10	~ 1	< 35	(~400)	< 100

Ra-226 ~ 1/10
Ra-228 < 1/30

~1/2000

Present device

- normal gelatin
- AgBr production from KBr

- de-ionized gelatin
- AgBr production from NaBr

- gelatin → synthetic polymer

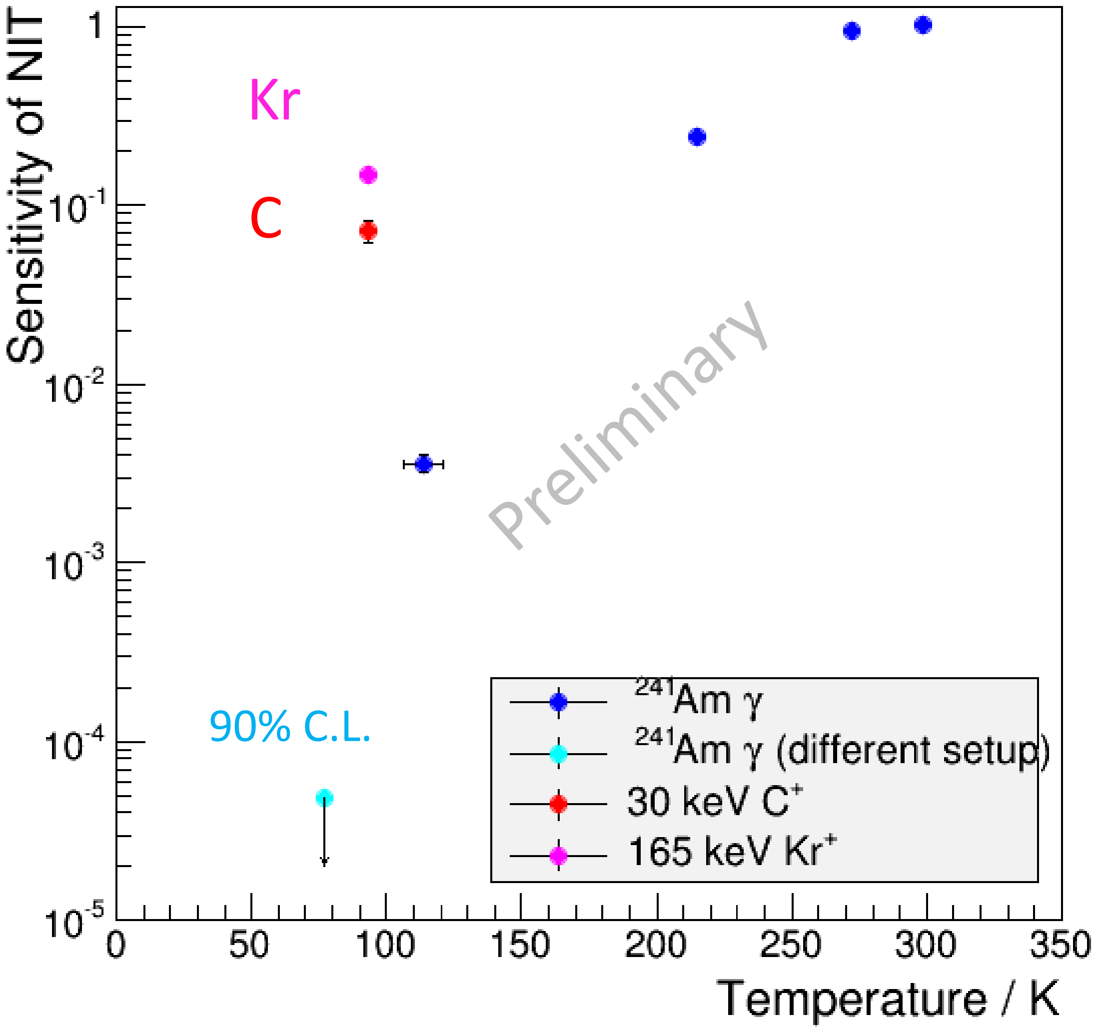
$T_{1/2}$~ 250 days
⇒ should we use old Ag?

Electron rejection power

Sensitivity control toward low-background device

- Q.E. control of AgBr crystal due to structure inside of crystal
- Formation efficiency control of latent image specks on the surface of crystal
  e.g., Tz compound
- Development sensitivity control
  ⇒ output the difference of activation energy for latent image specks
- Temperature
  ⇒output the energy-loss mechanism, especially low velocity atom and β-ray

Temperature dependence on the sensitivity for current NIT device



- S/N (NR /electrons) is increase in lower temperature.
  ⇒ Dependence of energy loss mechanism

Nuclear recoil : thermal spike in the AgBr crystal due to nuclear stopping power and high electron stopping power
Electrons: only ionization and low dE/dx

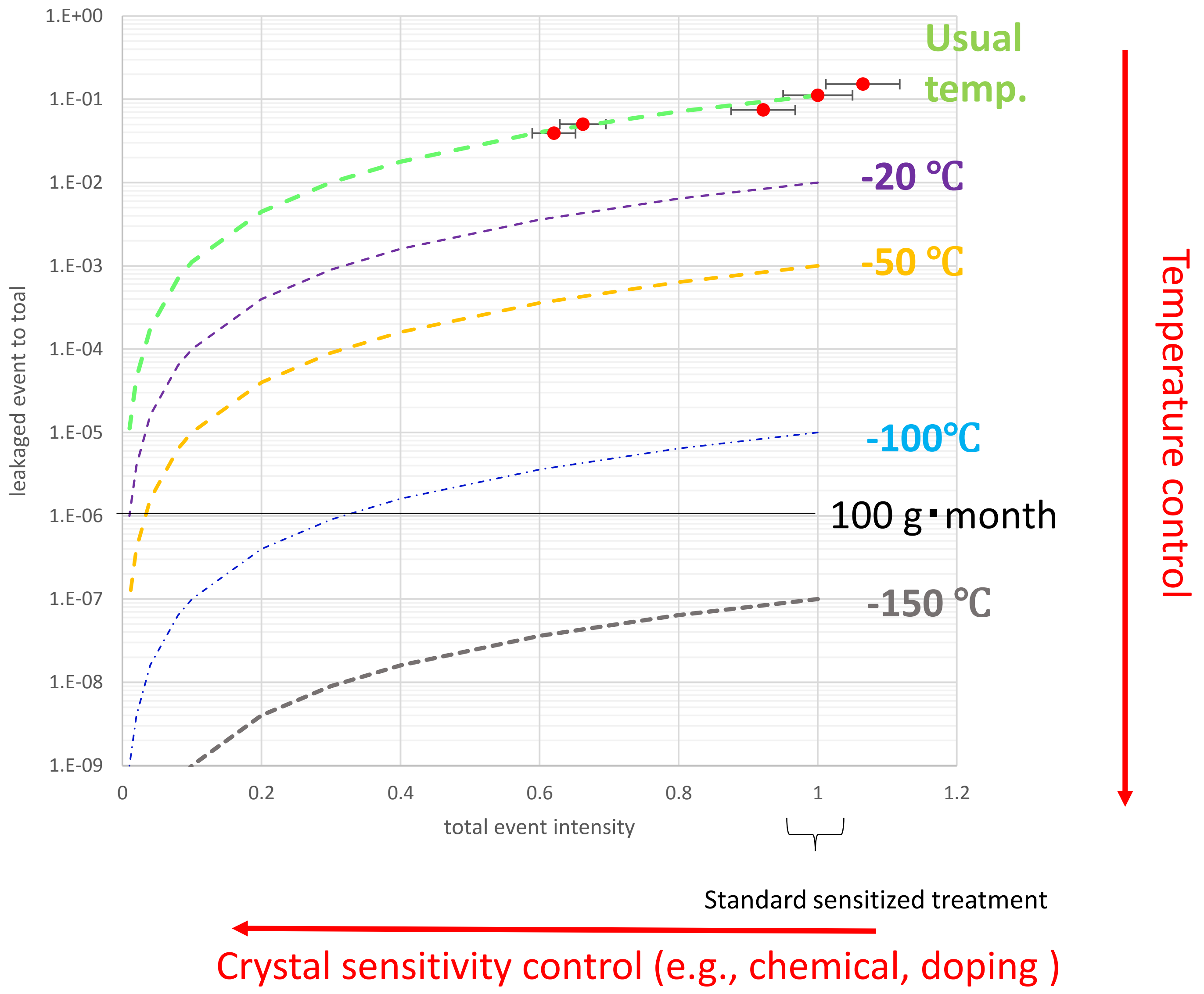
- Cryogenic condition is critical for electron background rejection .

- In addition, stability for emulsion device should be improved.

M. Kimura *et al., NIMA (VCI2016) 2016*

Background rejection expectation

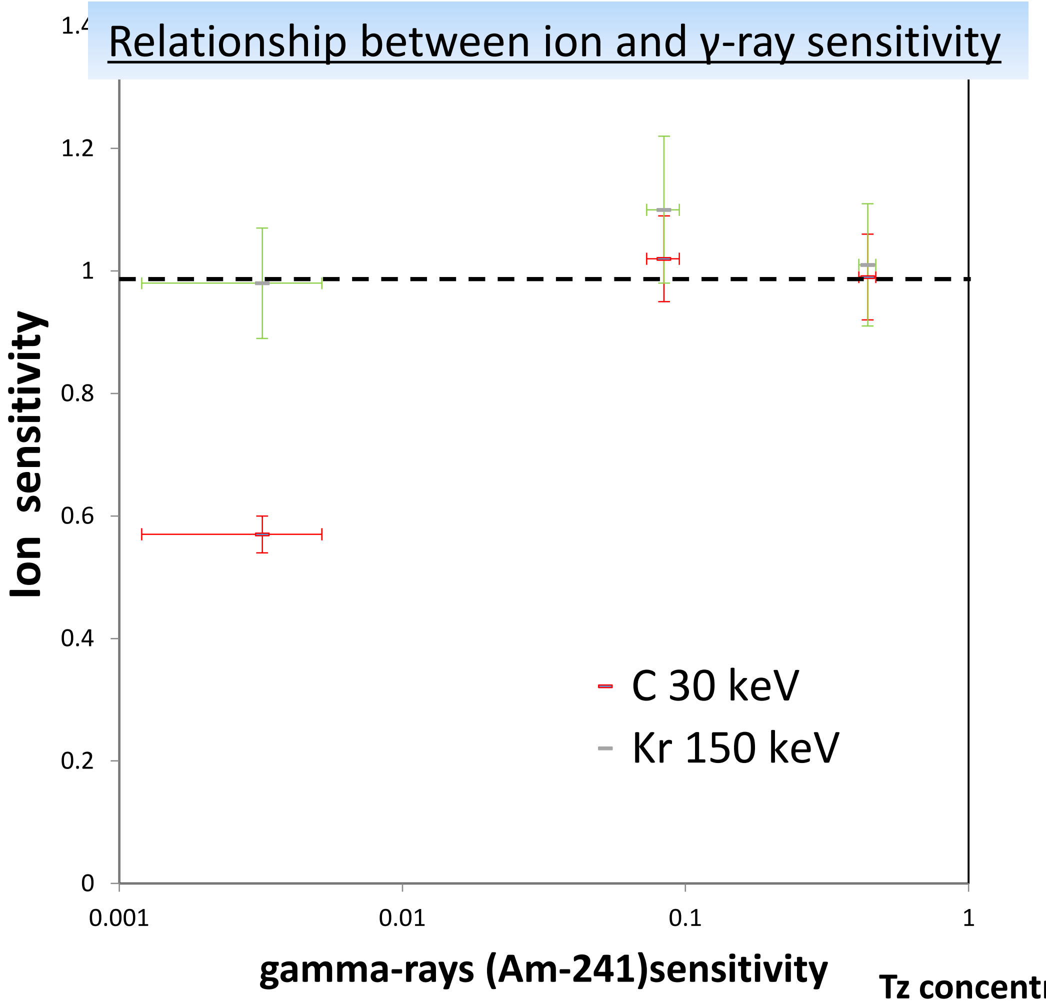
Electron background rejection power using only elliptical analysis ≒



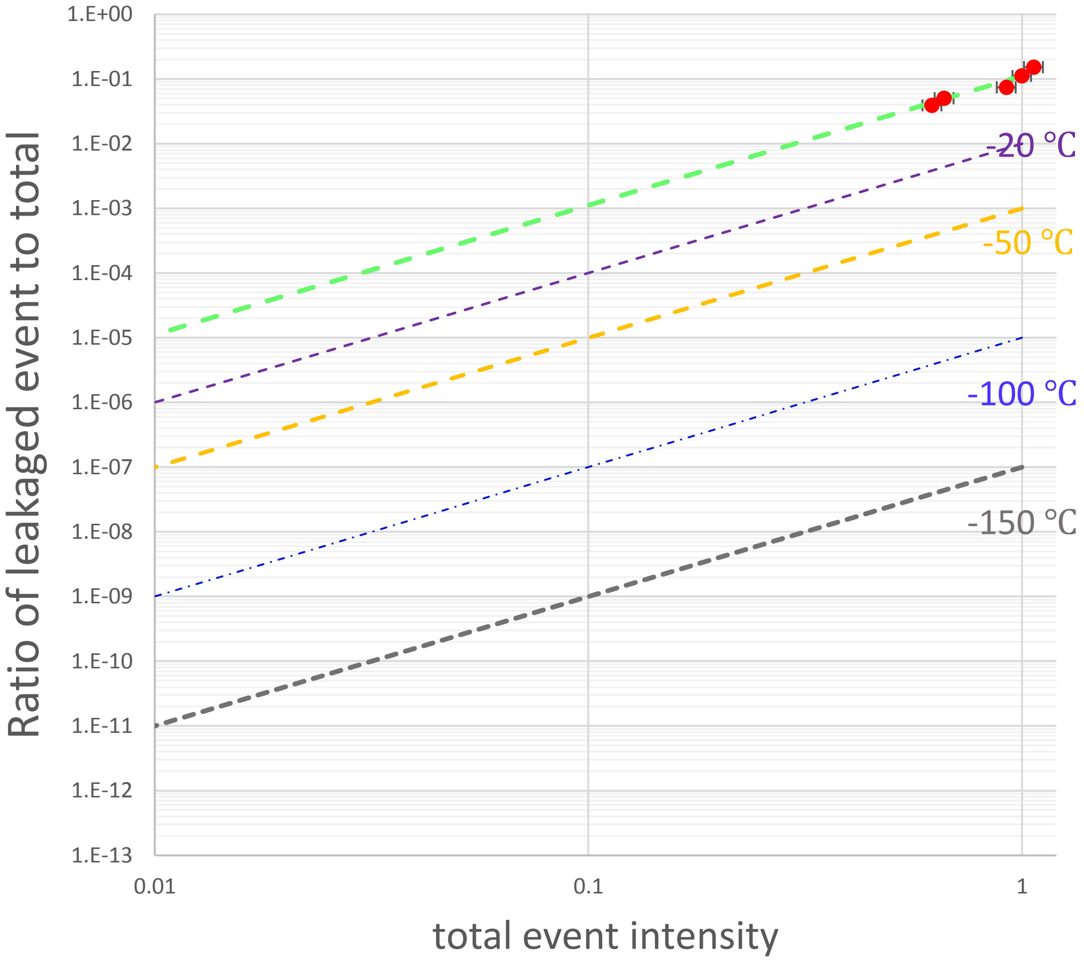
Leakage rate ∝(crystal sensitivity)^2

Summary of Sensitivity relationship between ion and γ-rays (Am-241)

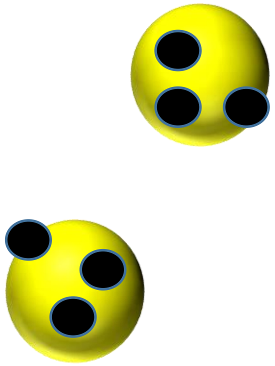
Very preliminary result for NIT sensitivity using Tz compound

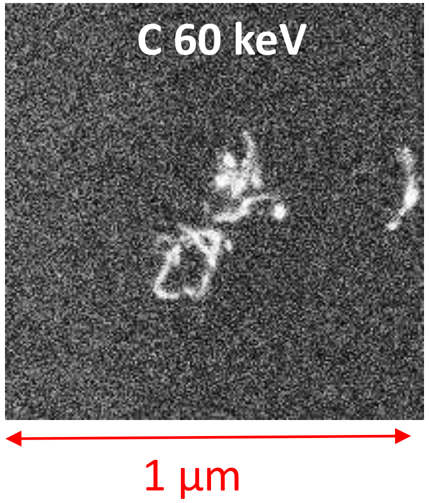


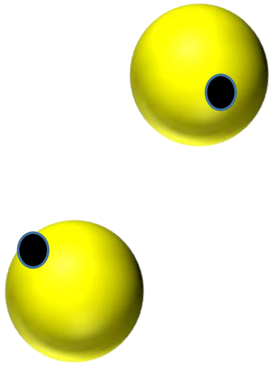
Tz concentration
(5-8 mmol/Agmol)



Obtain the information of nano-structure







not have image yet

- Generation of filament

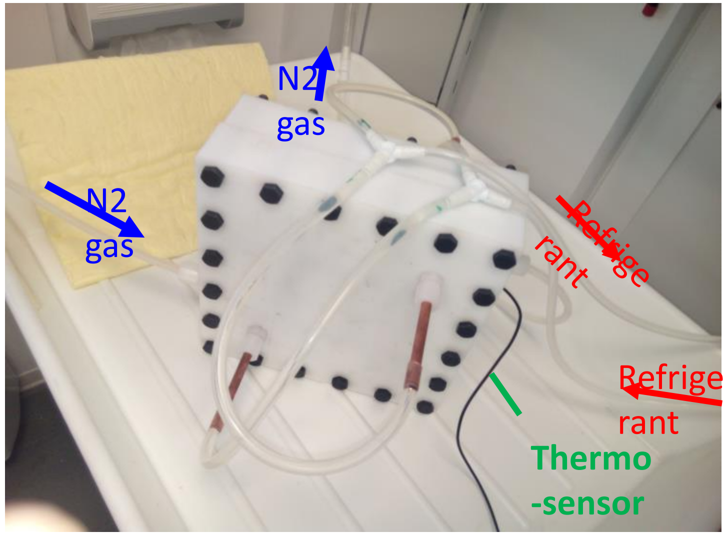
⇒ unique information of latent image specks (i.e., by particle, not dust)

- Filament structure

⇒ nuclear recoil is very complicated structure, but electron should be very simple.

These information should be reflected in the localized surface plasmon resonance, especially reflection spectrum and reaction due to polarization of light.

How do we check that?



- current achievement is around -15 ℃
  ⇒ Can we keep lower temperature?
- How do we check the sensitivity of low-temperature device?
  ⇒ high intensity radiation if expose from outside of system
  ⇒ natural radiation source if set inside the system

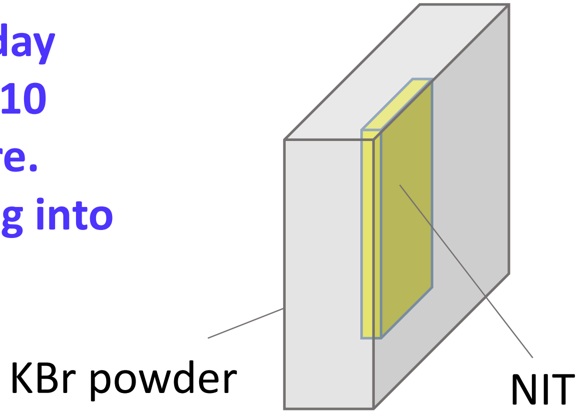
Ex.) K-40 (N.A. 0.0117 %)

β-decay : Q-value 1.311 MeV (89 % D.P.)
γ-decay : 1.461 MeV (10.7 % D.P.)

KBr powder of 10 g ⇒ ~ 10^7 decay/day

γ-ray effect should be small from decay rate and cross section, but β-ray may be useful to check that

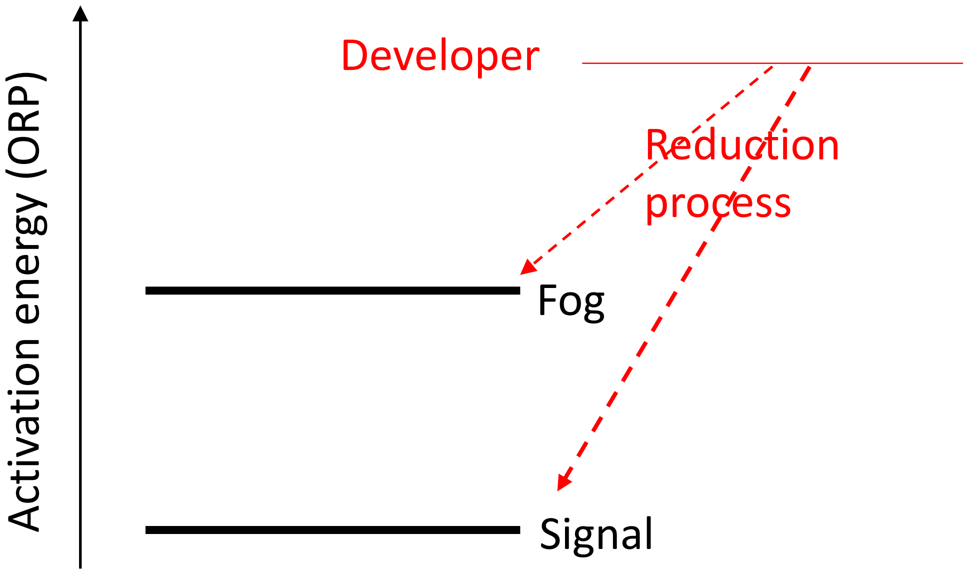
By very rough estimation, β-day will be accumulated about 1-10 /(10μm)^3 for 10 days exposure.
⇒ Simulation is needed taking into account β-spectrum



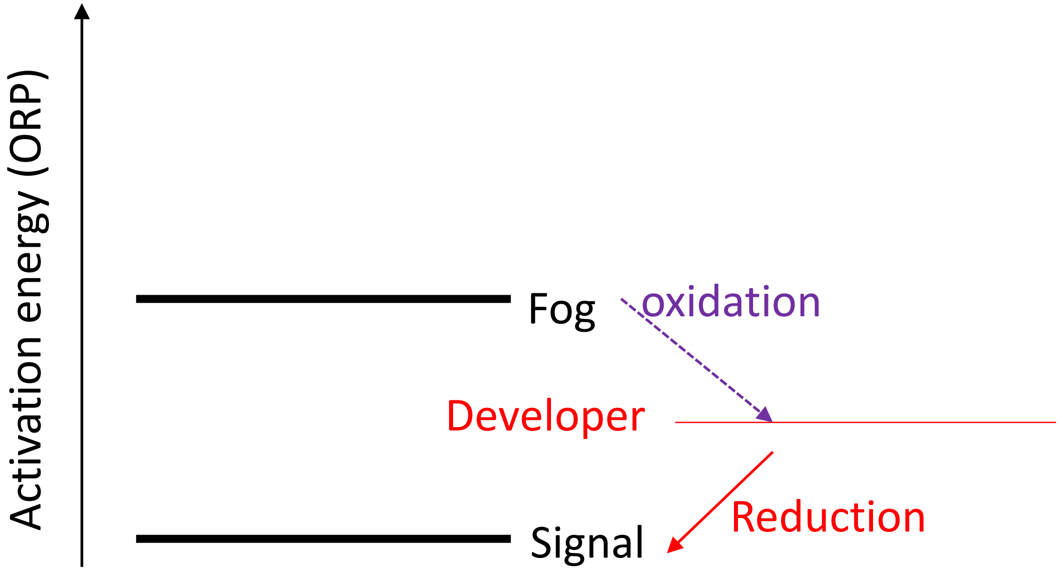
Fog

Development sensitivity tuning

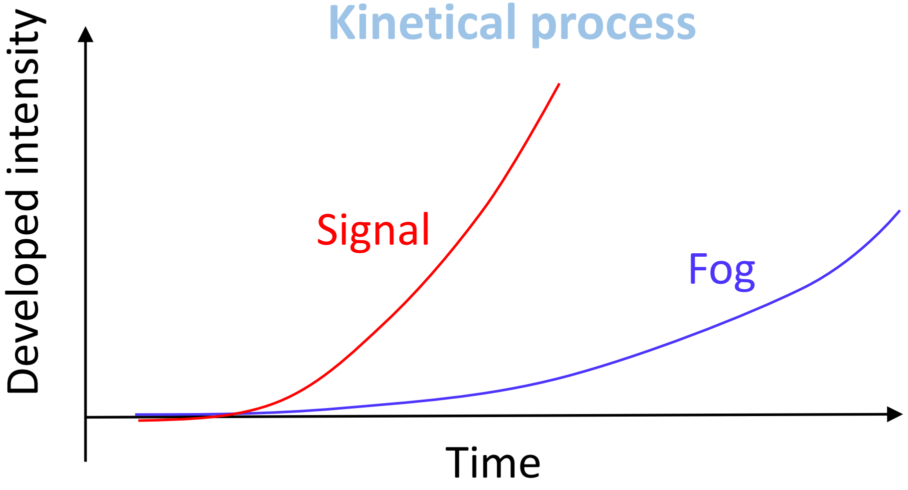
Current (usual) development treatment



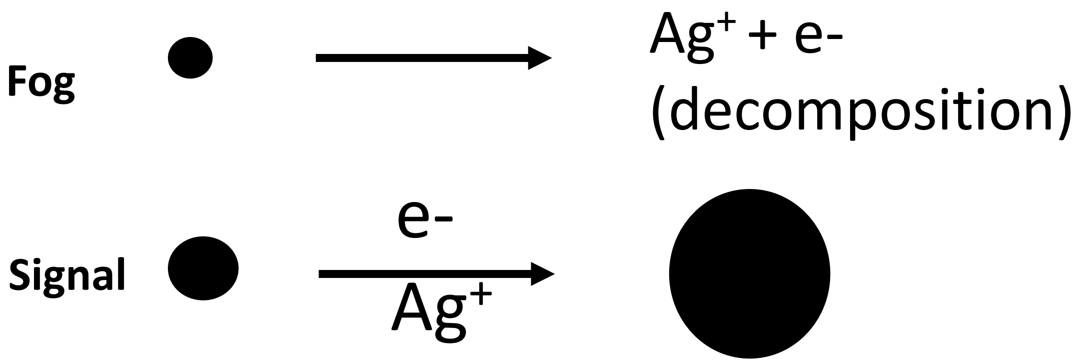
Ideal situation



Kinetical process



Equilibrium process



Current study (task within November)

- We need to know redox potential of latent image specks using Redox buffer ⇒ now on going

- Tuning of redox potential for developer ⇒ it's easy

- Easy method (idea from Prof. Tani)

Diluted developer → **Usual developer**

Size difference of specks between fog and signal should be enhanced.

Ratio of Signal size and contrast to fog will be enhanced.

Conclusions

- Lower temperature should be critical to achieve high electron rejection power

- Combination both low-temperature and chemical sensitivity control is very promising because those processes reveal essentially difference process.

- Development treatment is not optimized yet, and there are room for improvement.

- Redox potential control is under studying, and go to study for improvement of developer to reduce the background