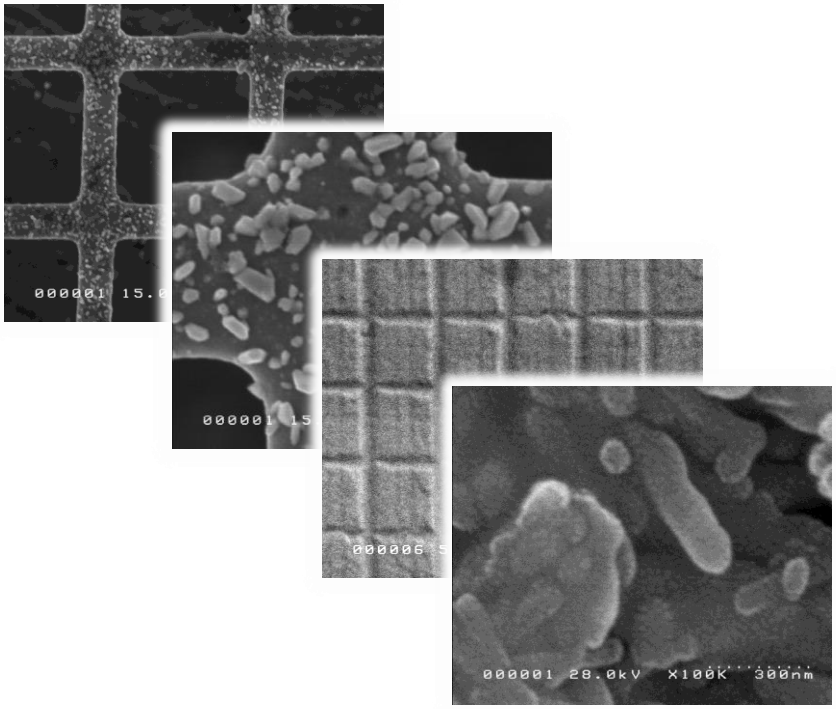
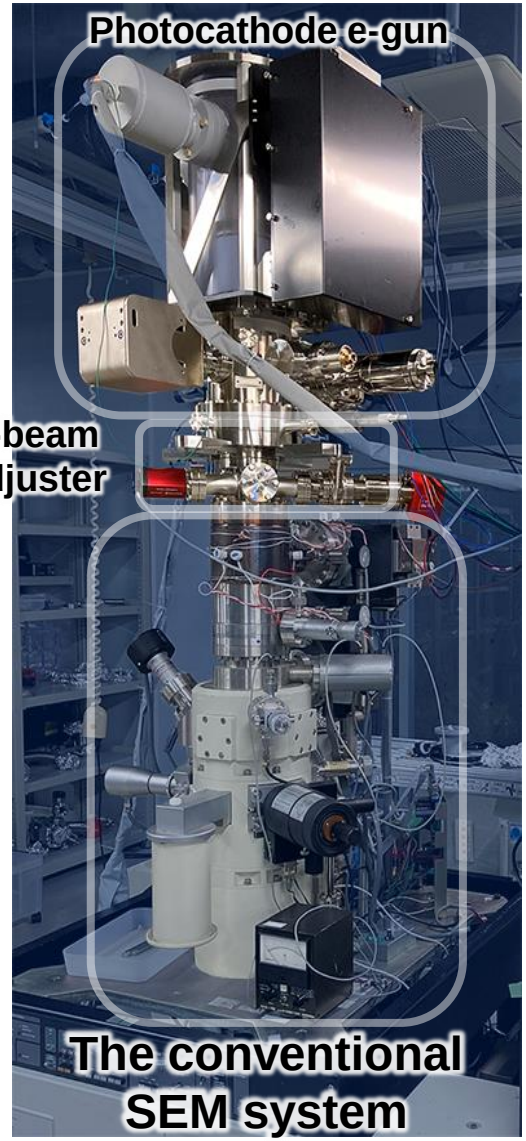
Experimental setup for proof of concept

- High probe current with high resolution for high throughput
- Extreme small energy dispersion for brighter e-beam

PC-SEM : CFE e-gun replaced with PeS product e-gun on the conventional SEM system

The conventional SEM replaced with PeS product e-gun (**PC-SEM** system) consists of a photocathode e-gun with the laser and a photo-electron beam adjustment system and the SEM.
The beam axis, convergence, and divergence of the electron beam into the SEM column were optimized by the e-beam adjuster.

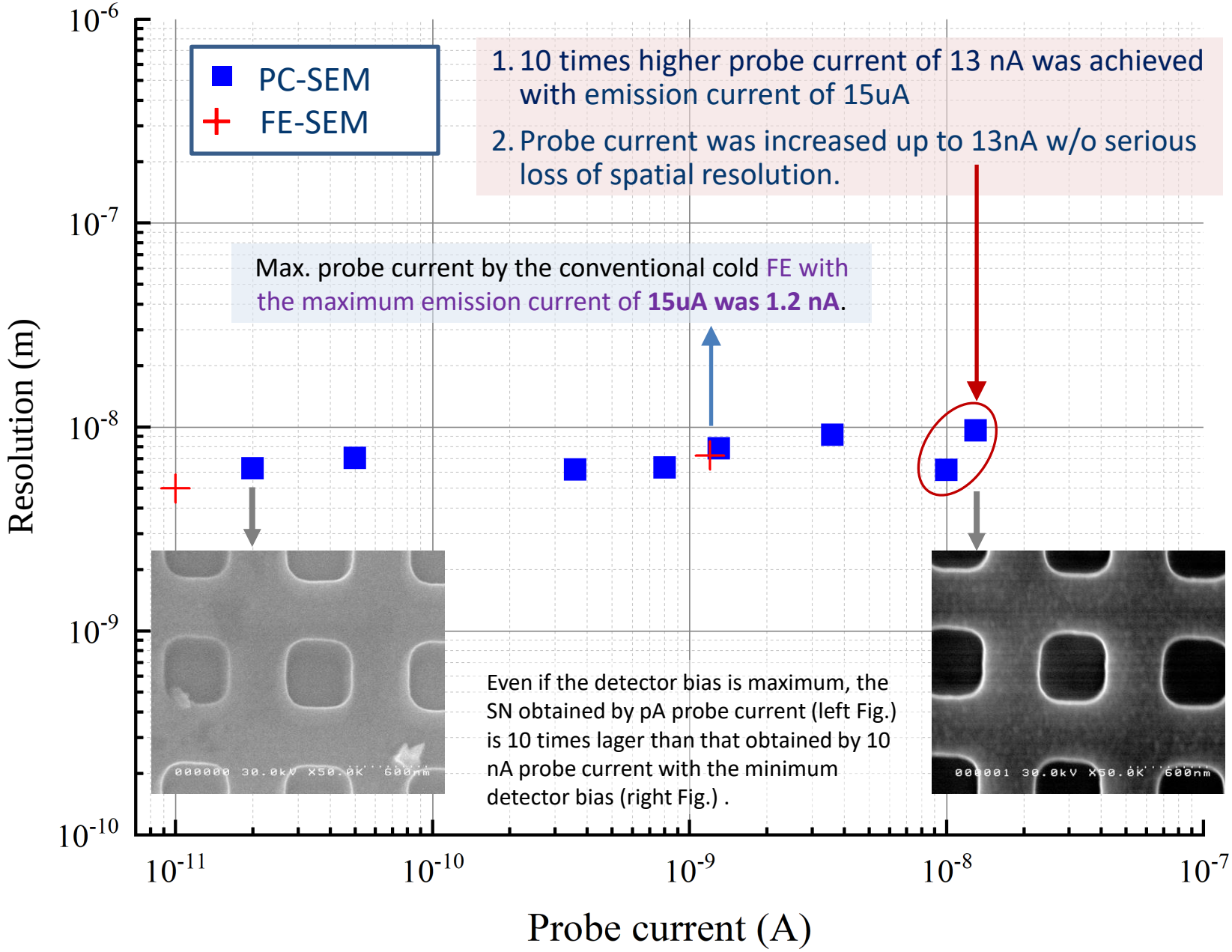




Measurement data

- High probe current with high resolution for high throughput -

Result: Probe current dependence based on 10 nm resolution

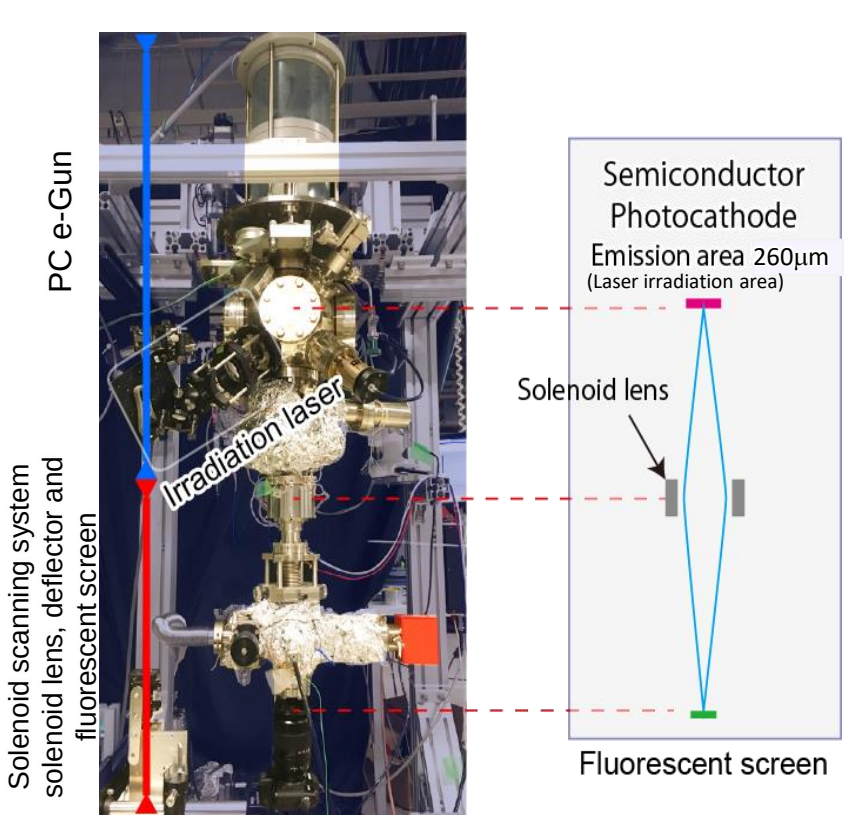


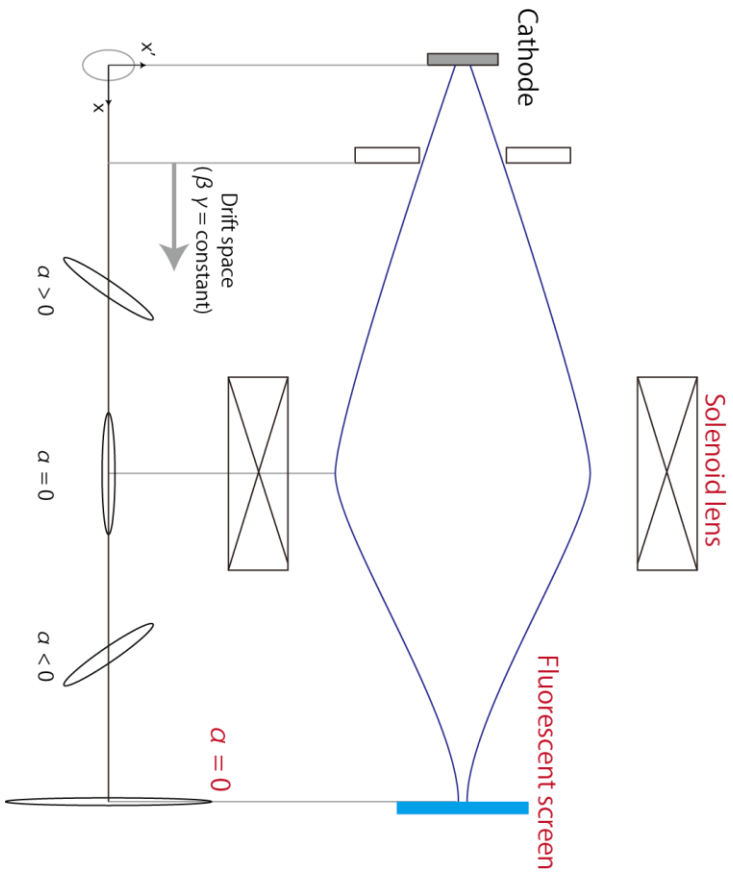
Measurement data

- Extreme small energy dispersion for brighter e-beam -

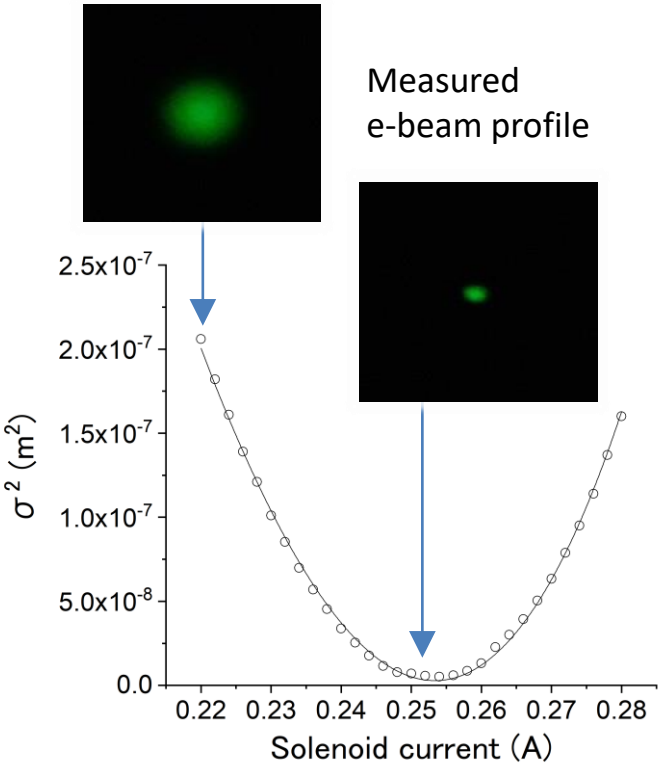
Measurement of electron energy dispersion by solenoid scan method

Brightness, electron energy dispersion (k_BT) can be calculated by the geometric emittance.
Geometric emittance evaluation by measurement of beam envelope around focus point.





Results of electron energy dispersion by solenoid scan method



- Measurement of beam size (σ) dependence on solenoid coil current (i)
- Calculation of beam envelope by the following fitting function:

$$\sigma^2 = A(i^2 - B)^2 + C$$

A, B, C are fitting parameters

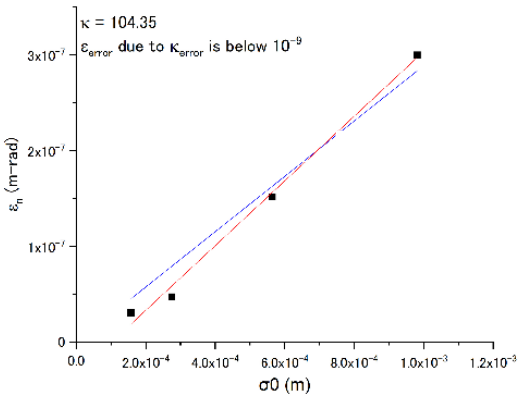
- Geometric emittance can be expressed by fitting parameters:

$$\varepsilon = \frac{\sqrt{AC}}{L^2\kappa}, \quad \frac{1}{f} = \kappa I^2$$

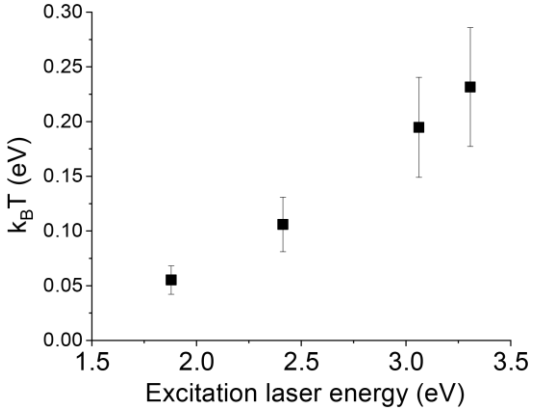
- Brightness and k_BT:

$$B = \frac{I}{(\pi\varepsilon)^2}, \quad \varepsilon = \frac{\sigma_0}{\beta\gamma}\sqrt{\frac{k_BT}{mc^2}}$$

I: emission current, σ_0: emission size



Dependence of irradiation laser energy on e-beam emittance.



Dependence of irradiation laser energy on electron energy spread

Electron energy dispersion:

0.05eV (AlGaAs)

0.08eV (InGaN)

***Energy spread of the cold FE: 0.3 eV**

"Observation of a 0.055 nm Spacing Lattice Image in Gold", Takeshi K AWASAKI, Tsuyoshi MATSUDA, Junji ENDO and Akira TONOMURA, J APANESE JOURNAL OF APPLIED PHYSICS, VOL. 29, No. 3, pp. L 5 08-L 510, 1990