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Development of a Gas Distribution Measuring System for 2-D Beam Profile Monitor Using Gas Sheet

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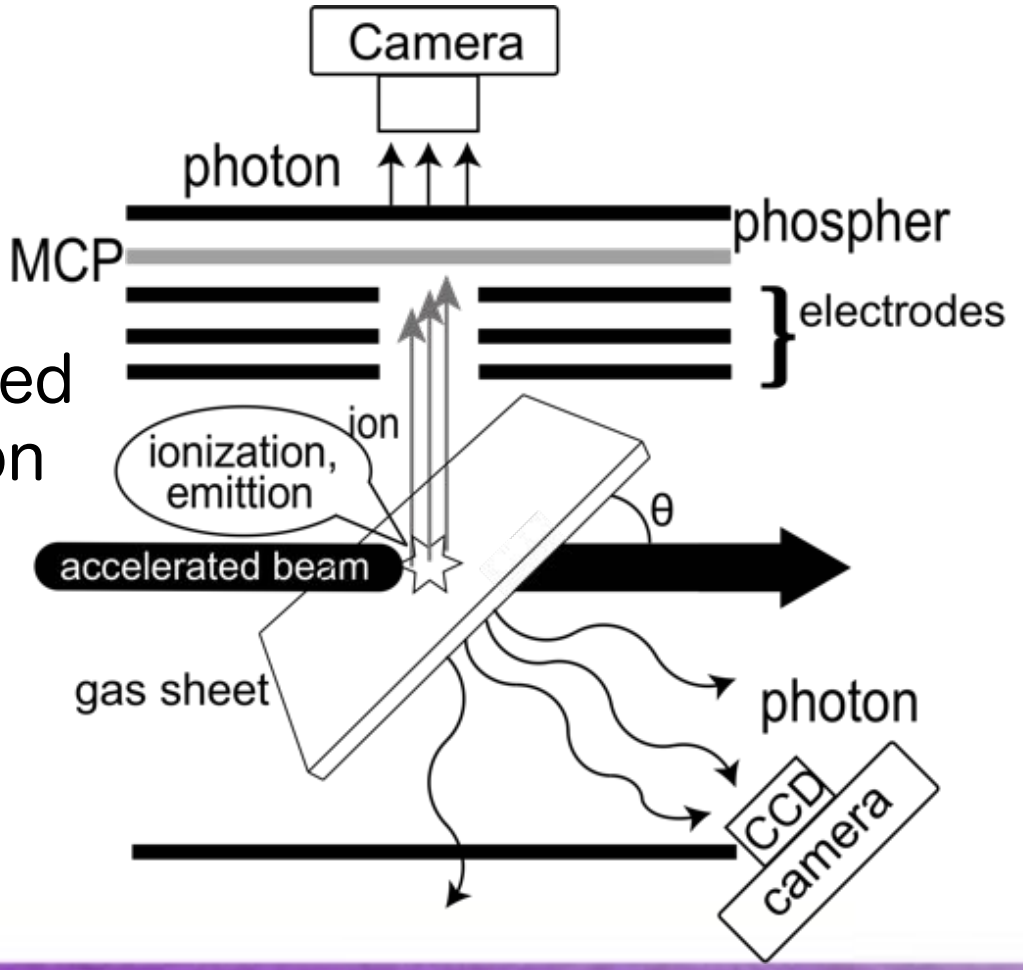
Background

Detecting ions or photons that is produced as accelerated beam pass through the introduced sheet-shaped gas

Important point

- How is the sheet formed
- What is gas distribution



Background

One of the issuers of profile monitors using gas is measuring accuracy

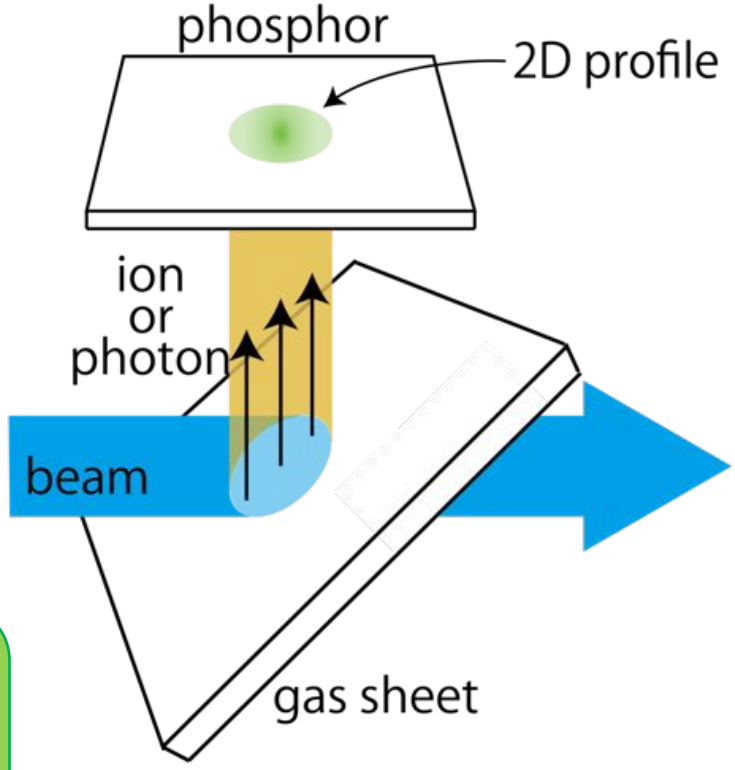
Gas distribution in sheet

homogeneous

→ data reflects correct profile

inhomogeneous

→ data need to be calibrated



In the case of gas sheet monitor, Gas distribution in the sheet determines measuring accuracy

Measuring method

Objective : Measuring gas distribution of gas sheet

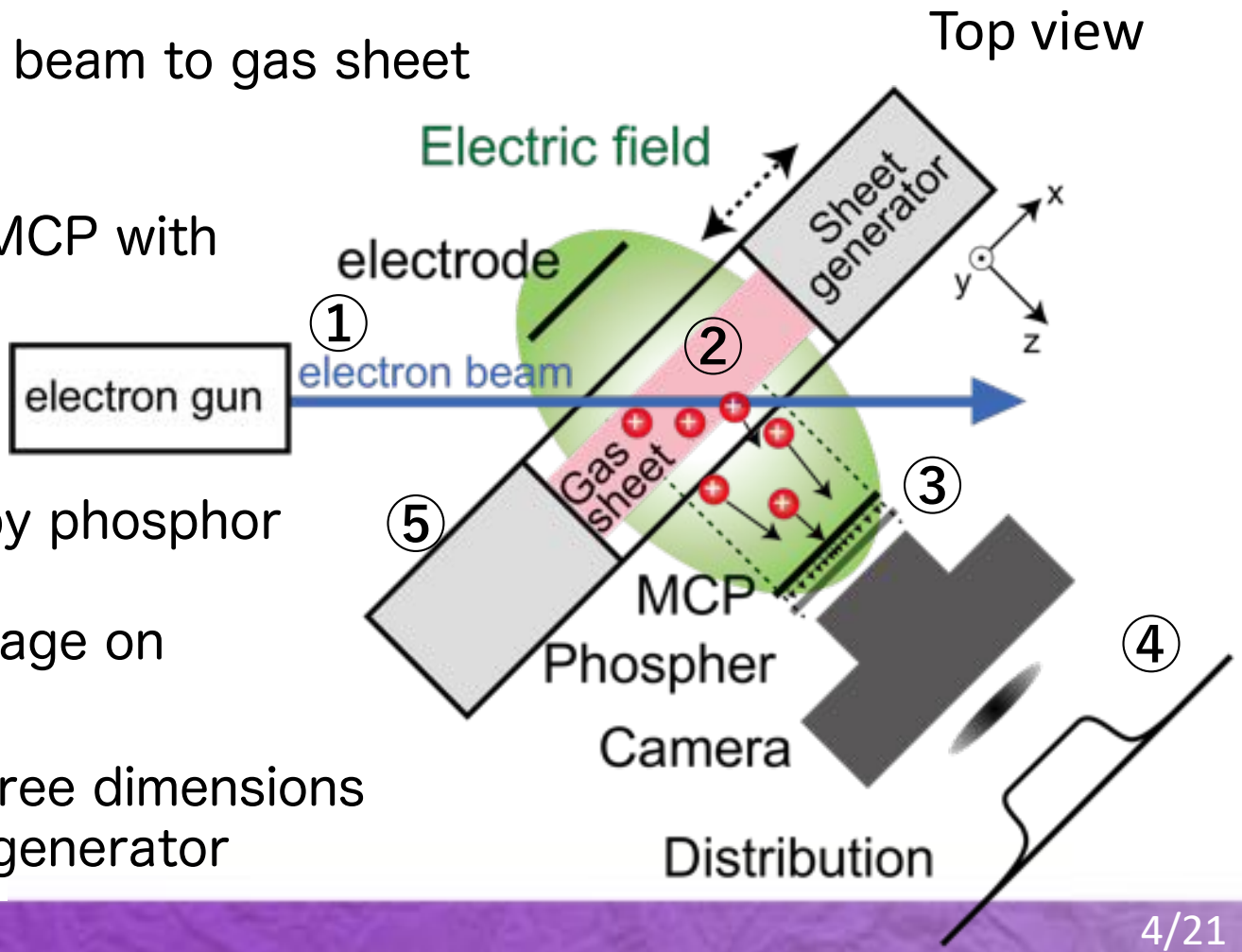
① injecting electron beam to gas sheet

② inducing ions to MCP with electric field

③ detecting signal by phosphor

④ take photos of image on the phosphor

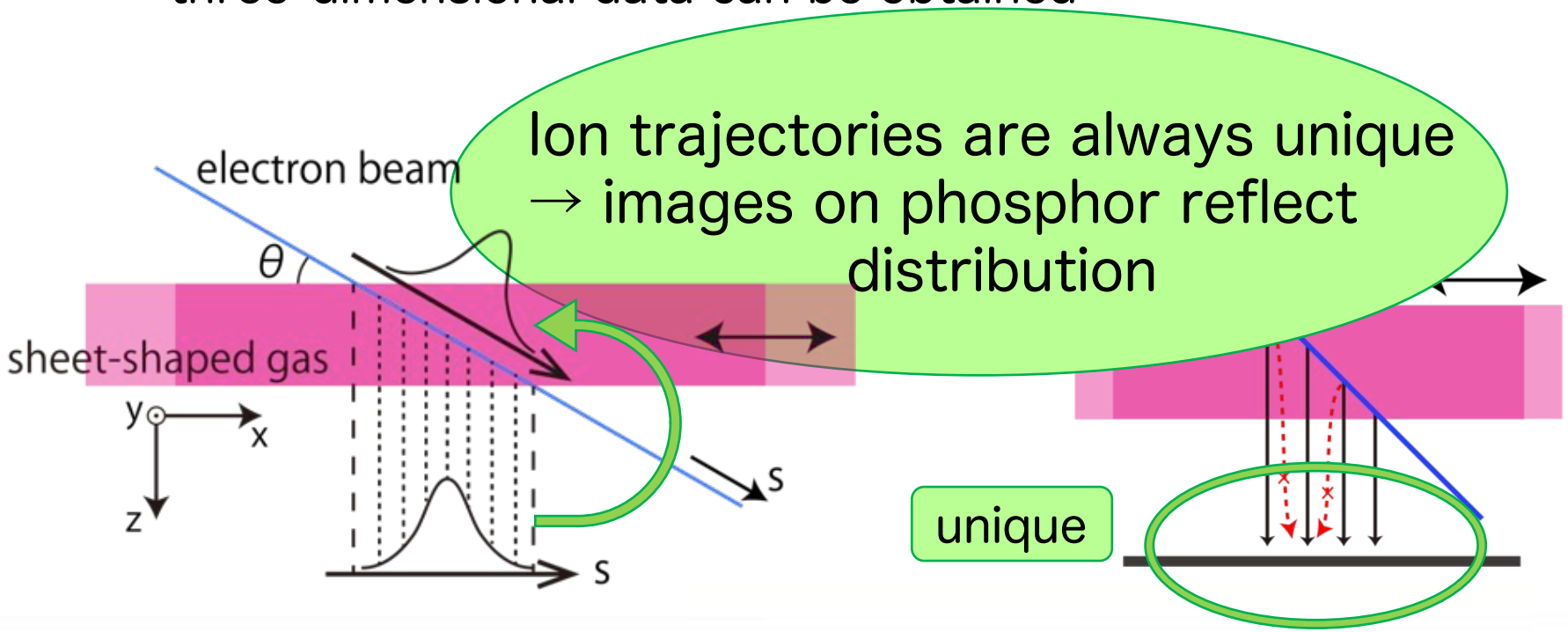
⑤ measuring it in three dimensions by moving sheet generator



Measuring principle

Three-dimensional distribution

- using electron beam with ignorable diameter
  → gas distribution along beam direction(s axis)
- moving sheet generator in X-Y plane,
  three-dimensional data can be obtained



Confirmation of ion trajectory

The system needs ion trajectory
that keeps the ion generating position

→ Calculating electric field and ion trajectory

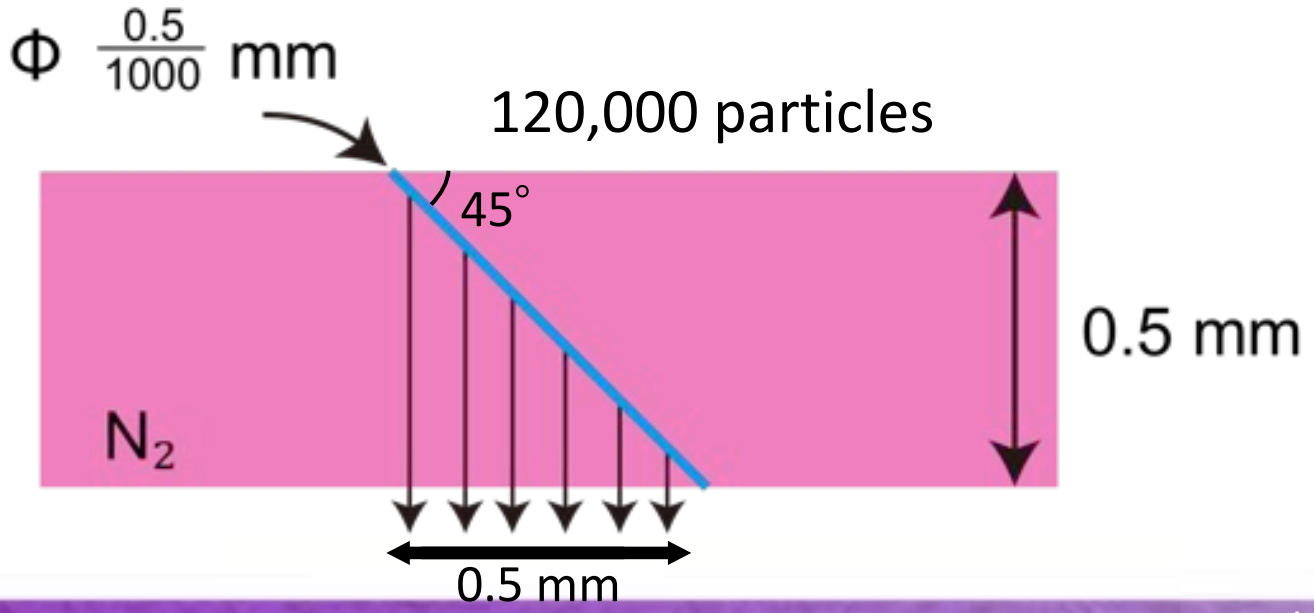
① influence to the field by moving gas generator
② influence to the trajectory by thermal velocity

Ion source of simulation

Model

electron beam with ignorable diameter is injected to 0.5 mm thick gas sheet and ions are produced.

→ ionization effect with one cross section is not taken into account.

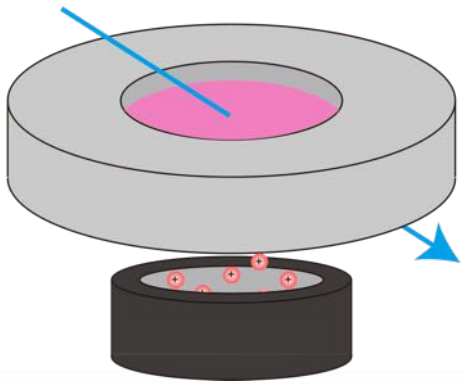


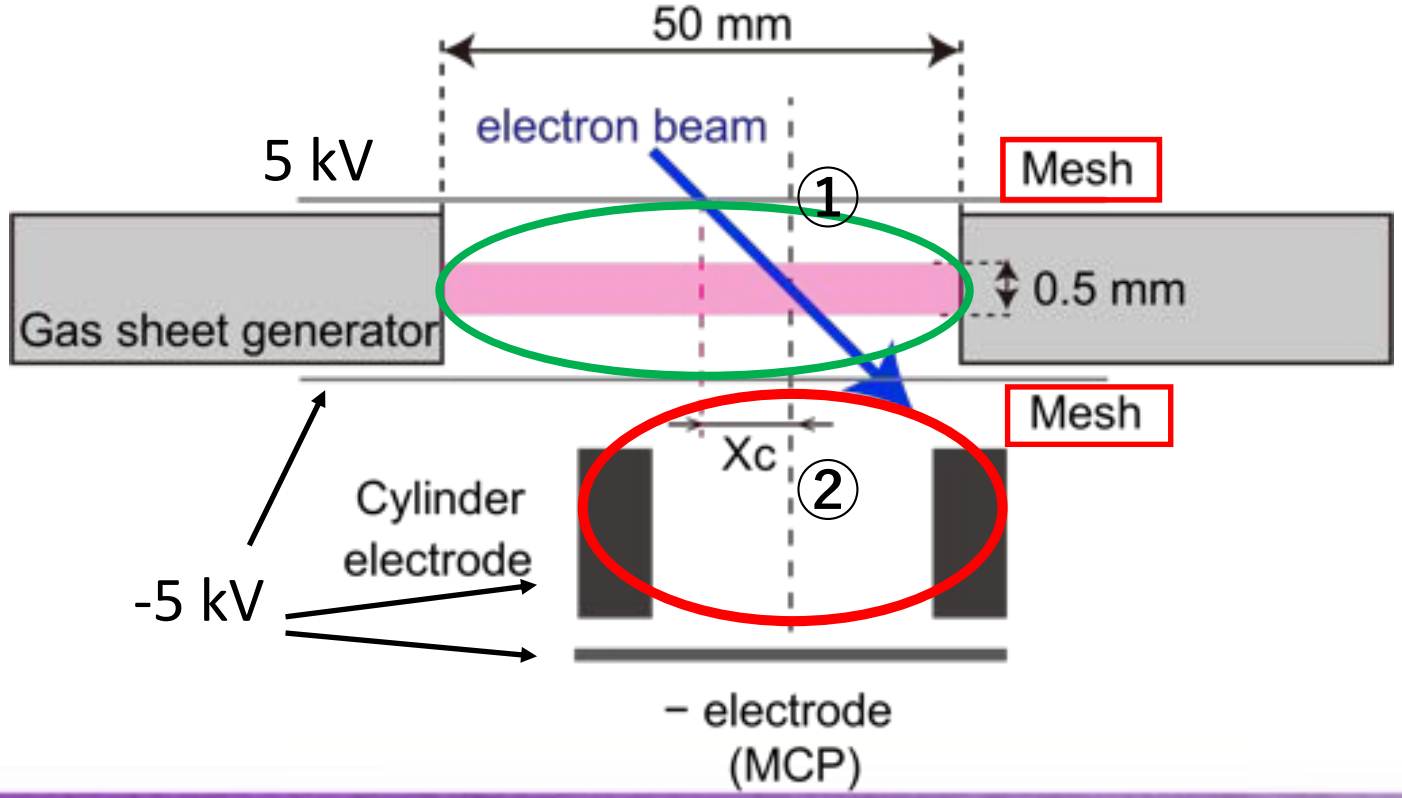
Geometry of electrodes

Metal meshes are put on the both side of the generator due not to affect the electric field by moving generator(GND).

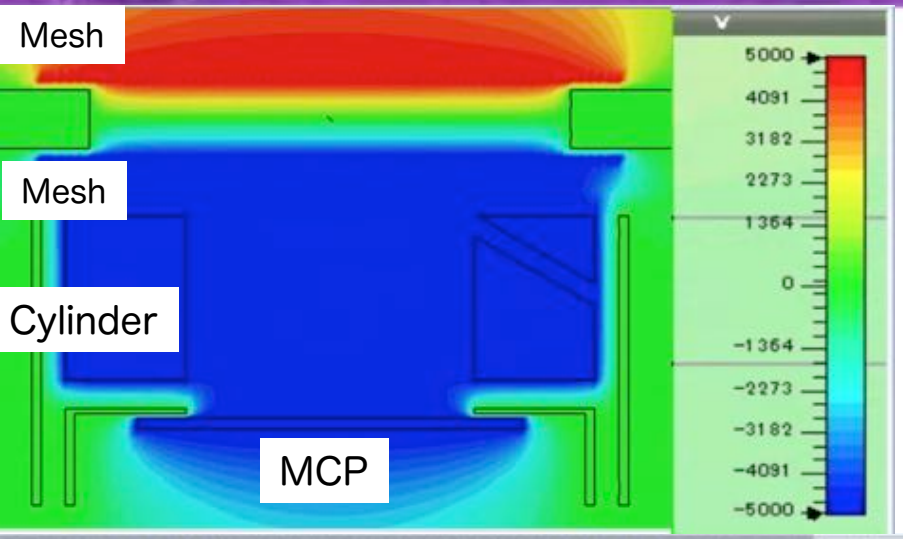
① parallel field

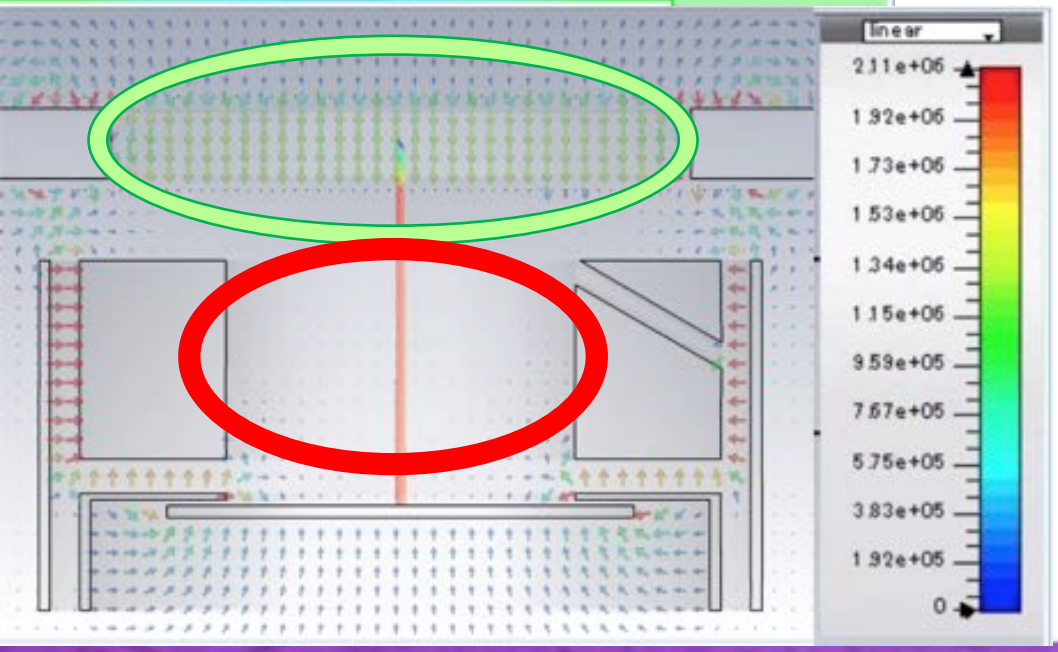
② non-influence to ion trajectory





The field and trajectory





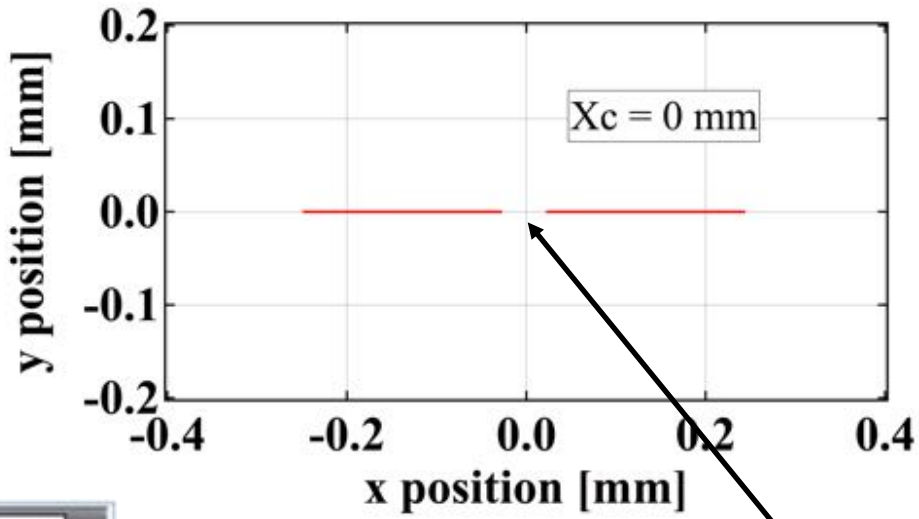
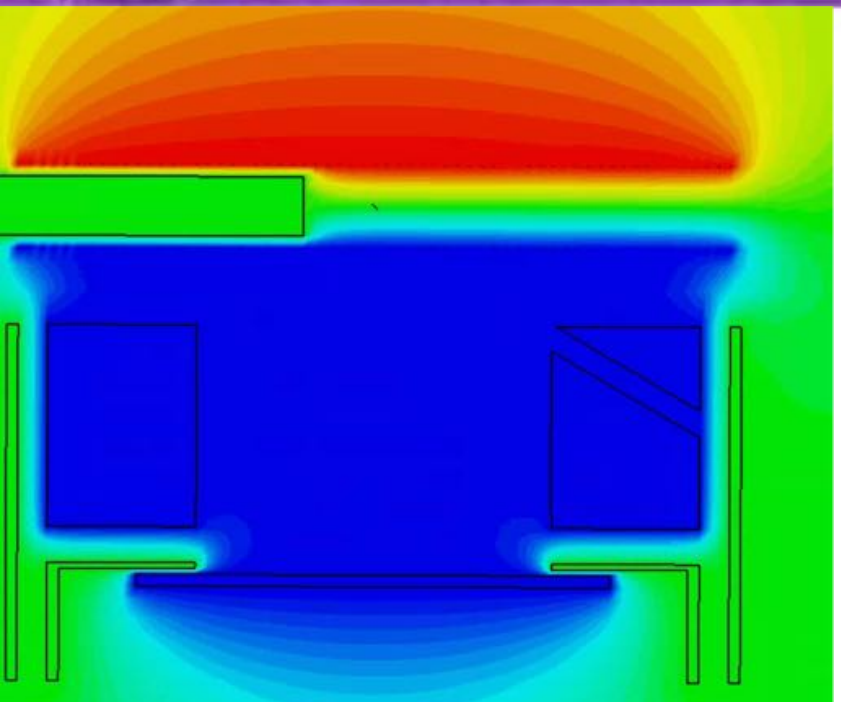


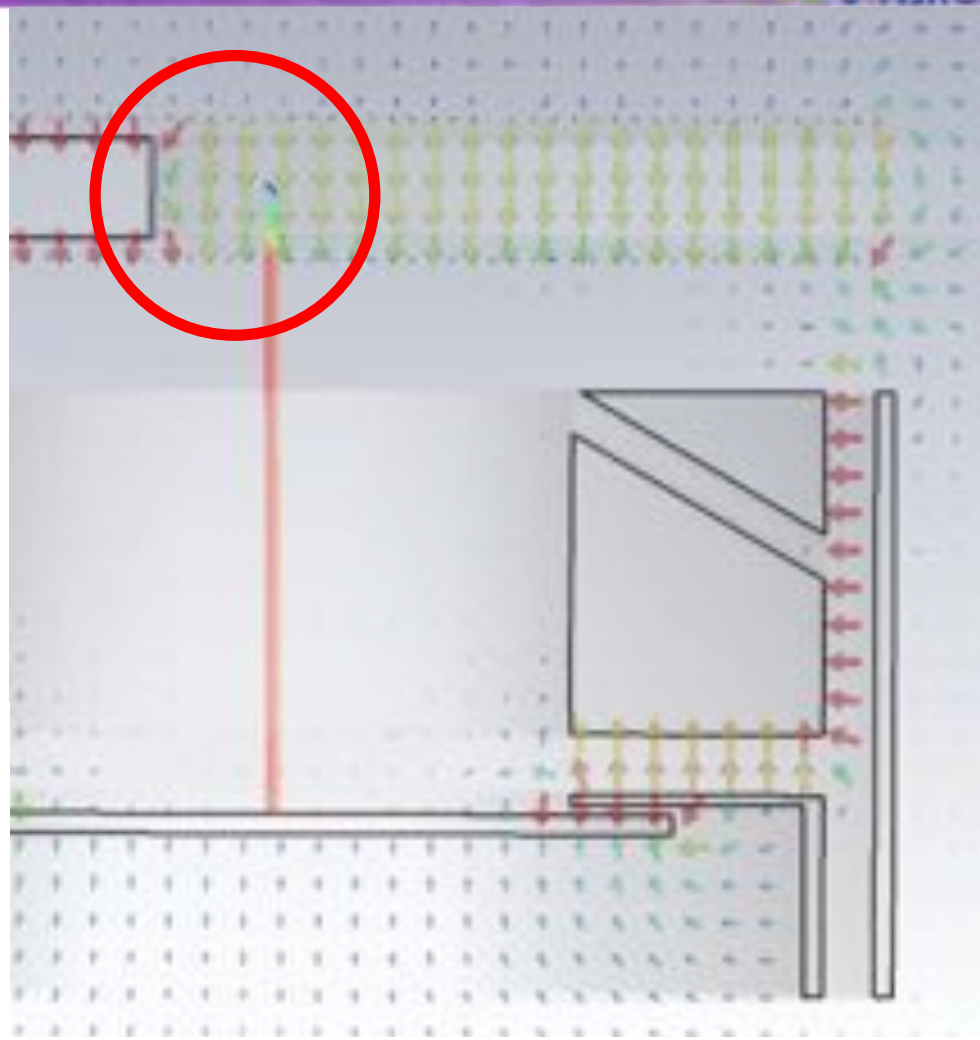
Image on the phosphor

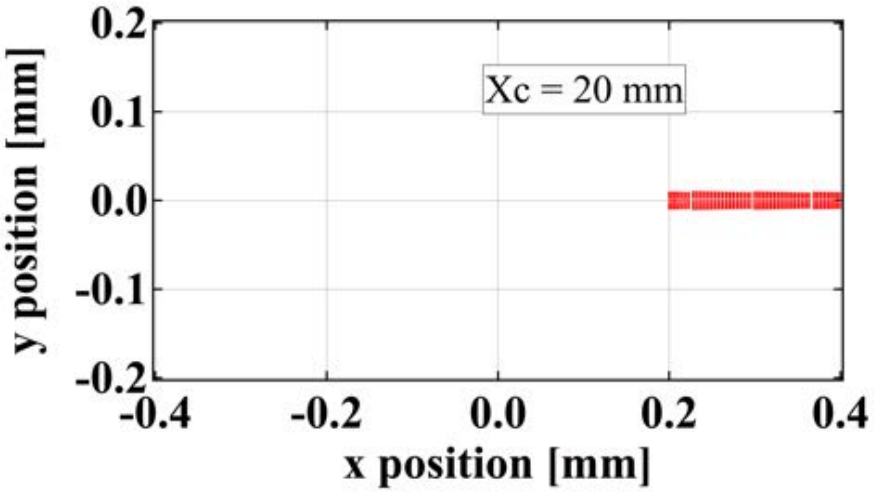
Effect of metal mesh

Confirmation of the trajectory uniqueness against position

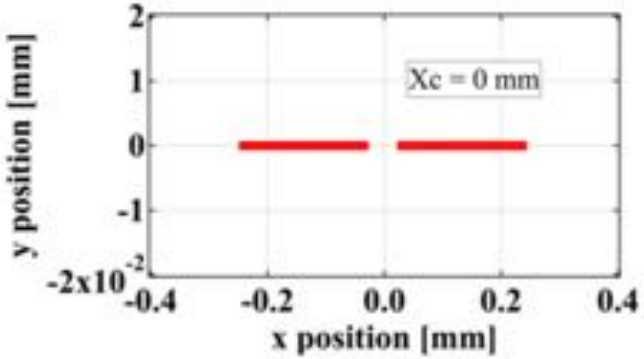
Near the generator boundary

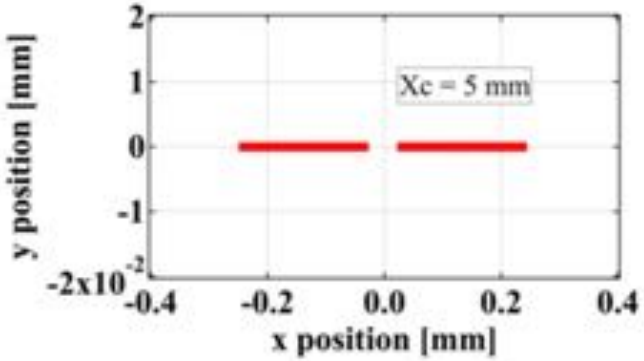


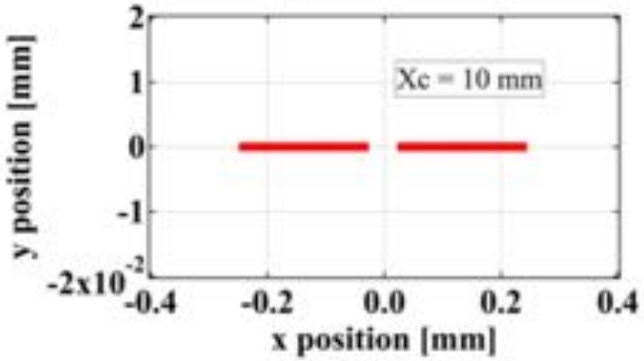


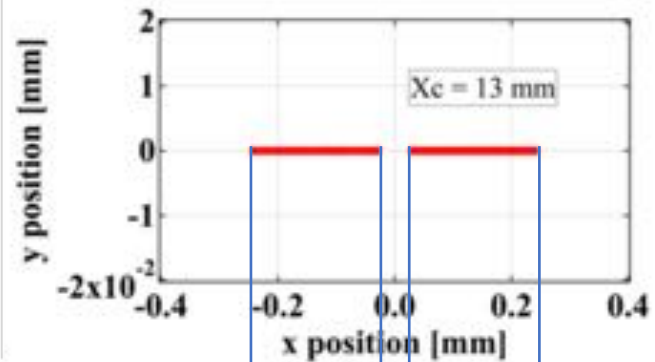


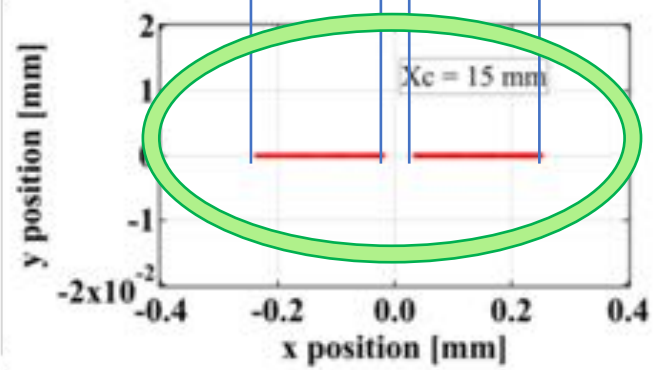
Influence of moving generator

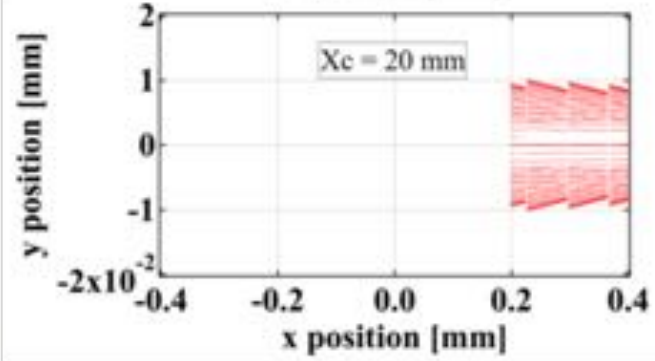












Model2 : with thermal velocity

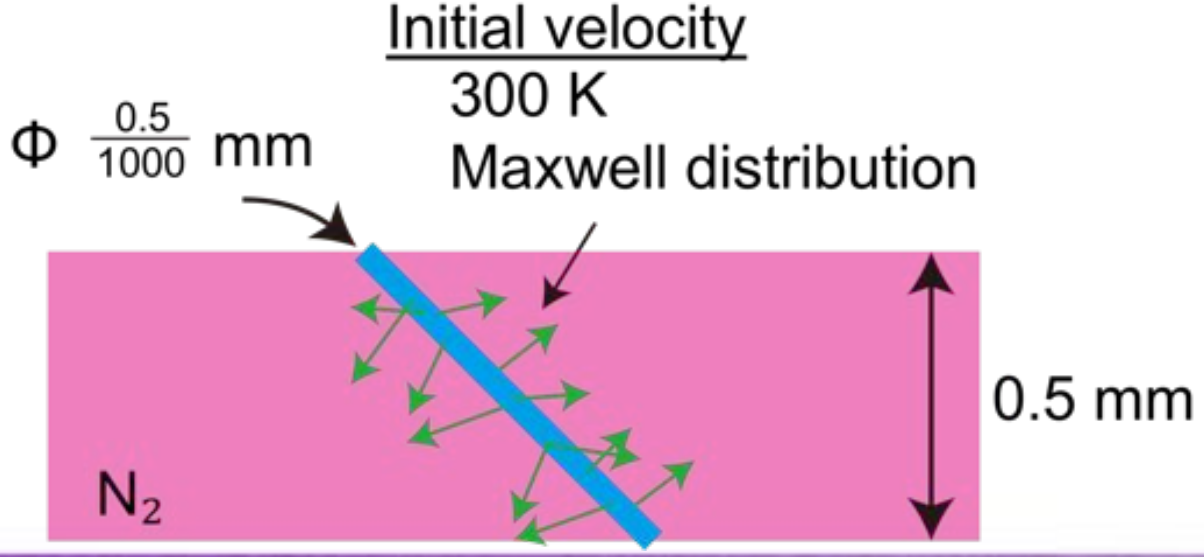
Gas moves with thermal velocity

→ it becomes noise against the ion position

Model

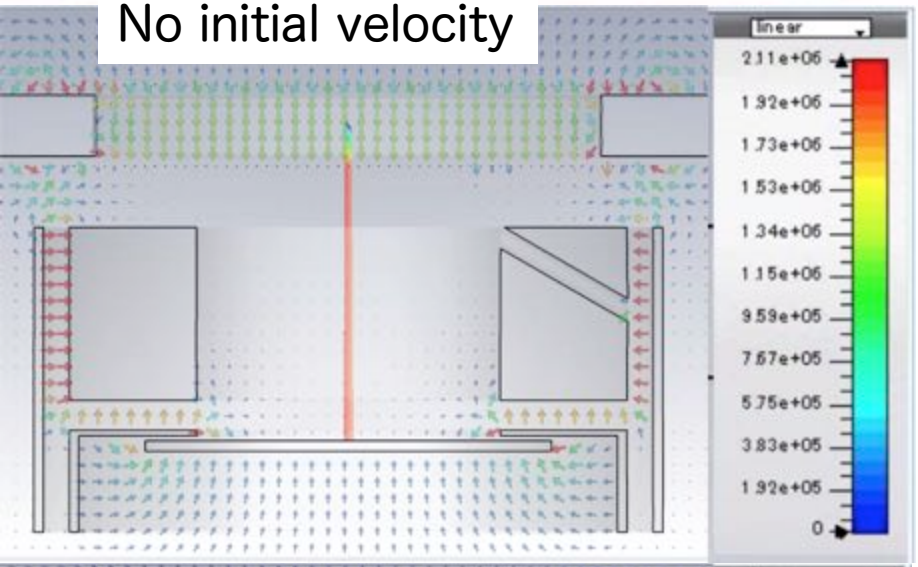
The initial velocity is defined as 300 K of Maxwell distribution thermal velocity

The other conditions are same as before.

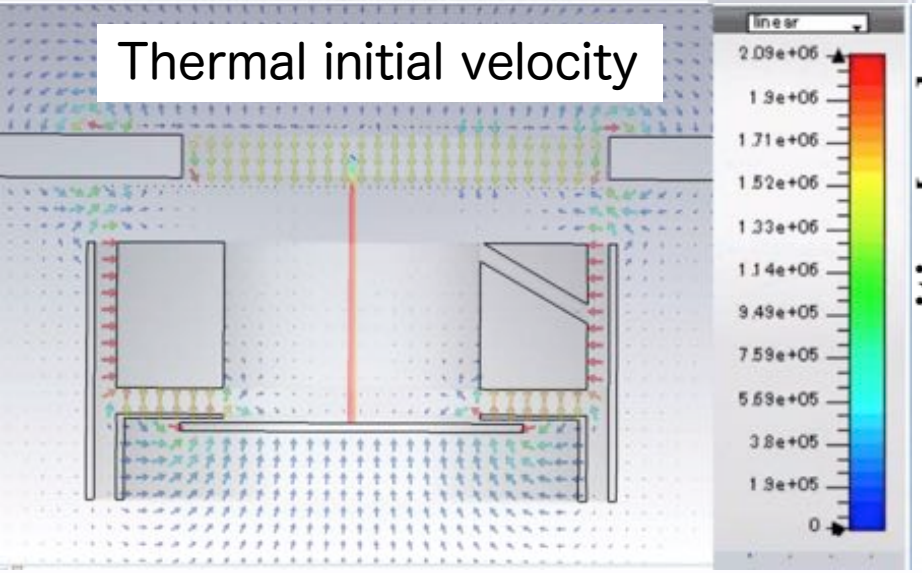


Influence of thermal velocity

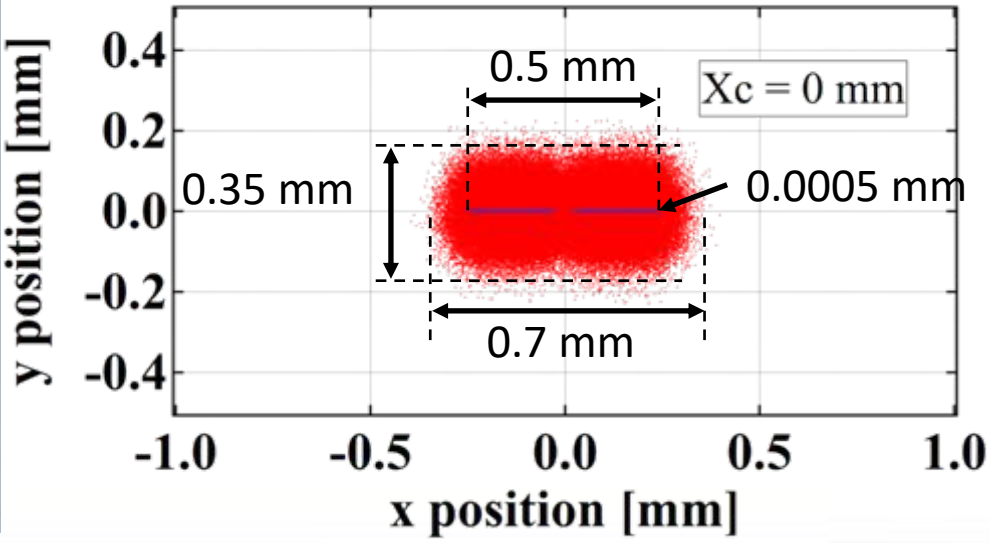
No initial velocity



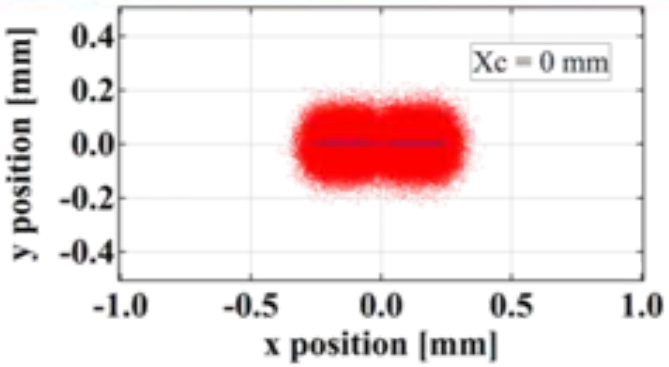
Thermal initial velocity

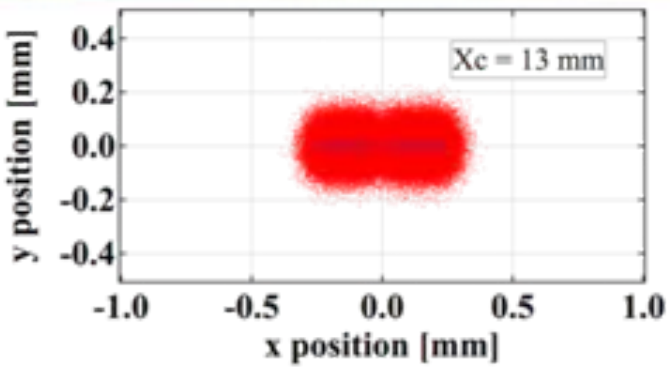


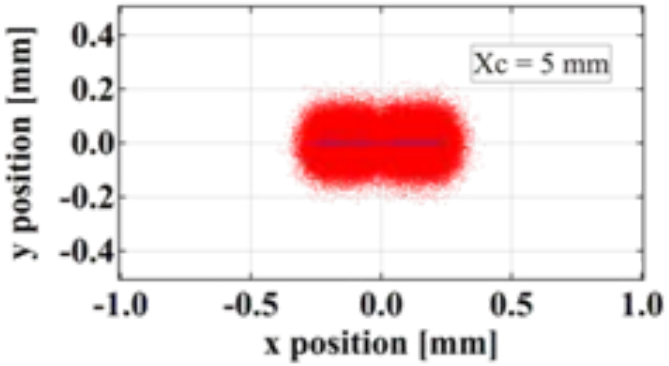
The detection area expand
X direction : 0.2 mm
Y direction : 0.35 mm

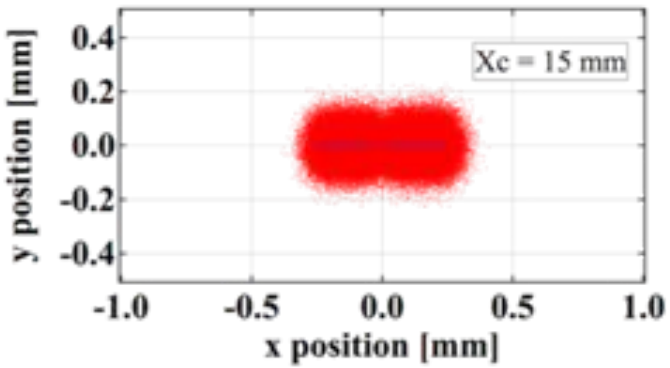


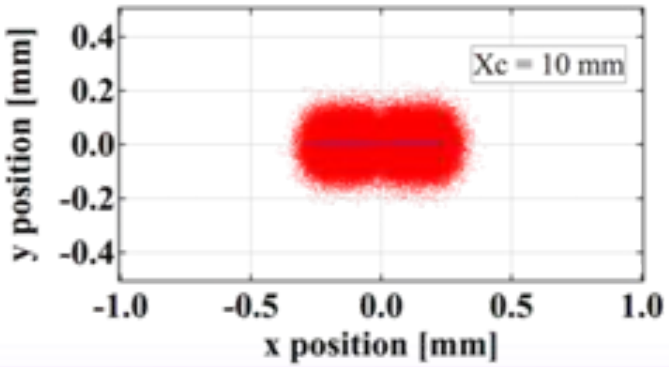
Thermal velocity + generator moving

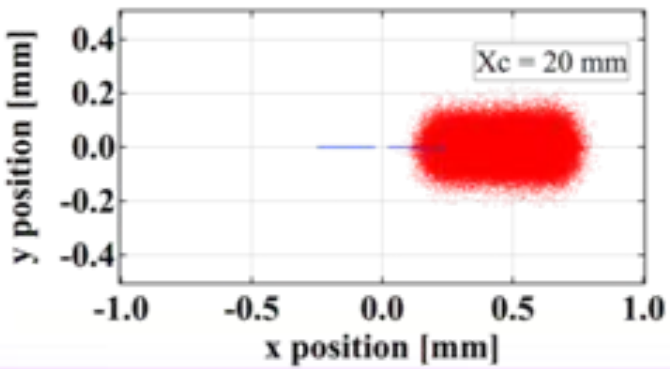








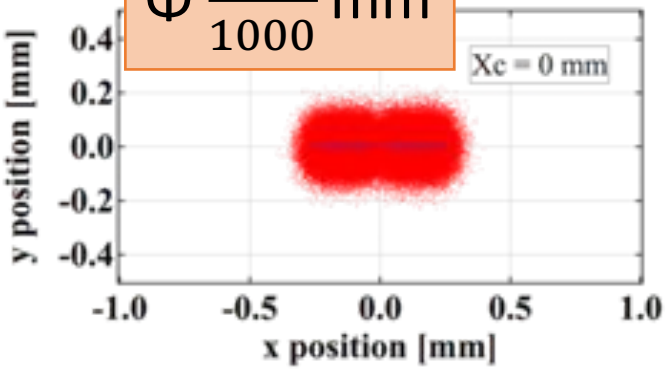


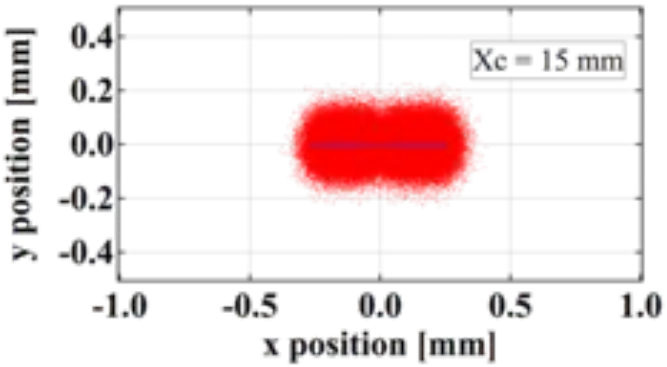


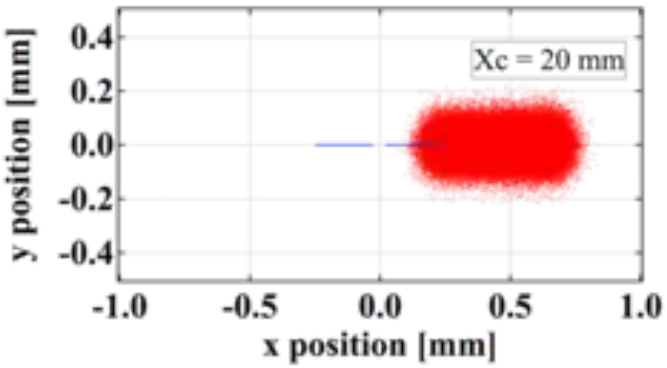
Φ30 mm area can available for ϕ50 mm sheet

Realistic diameter electron beam

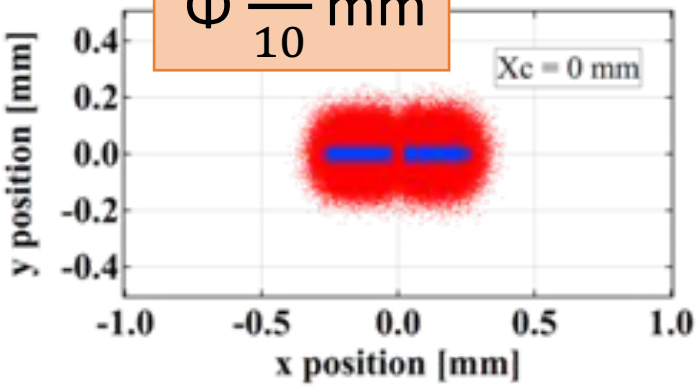
$\Phi \frac{0.5}{1000}$ mm

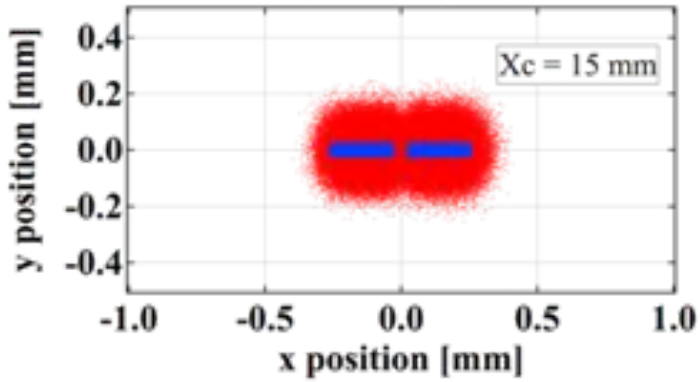


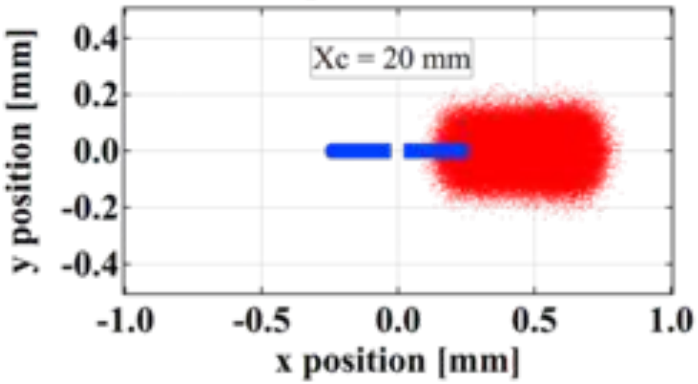




$\Phi \frac{0.5}{10}$ mm







Process

Ion generation

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Detection

Finite diameter do not have an influence

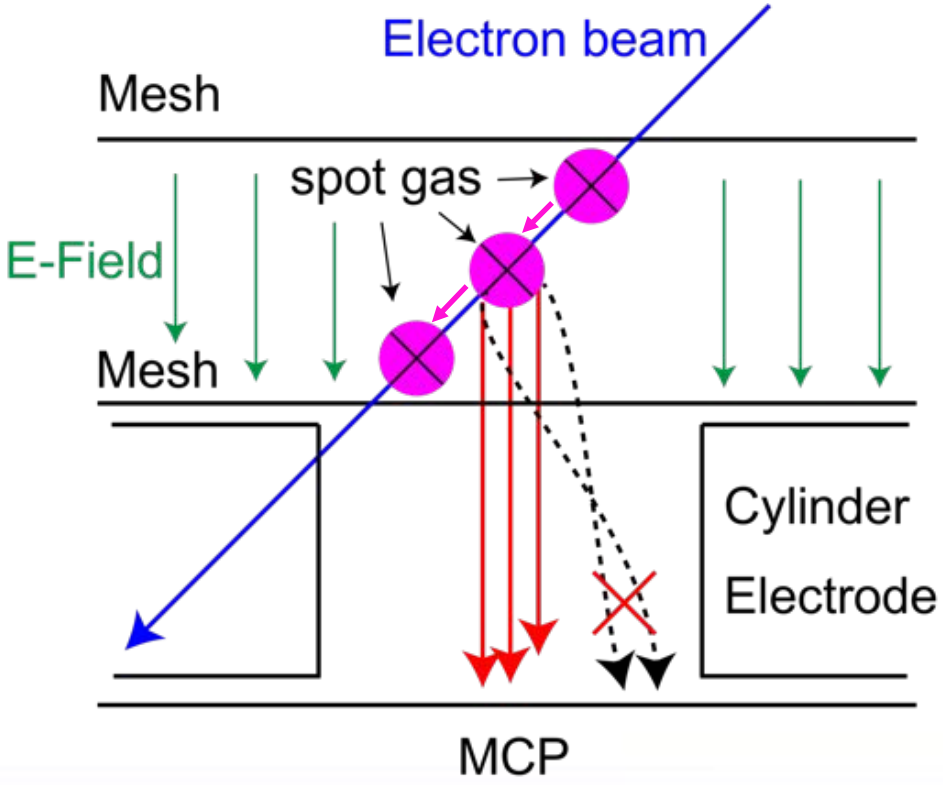
Conclusion of simulation

- This system needs unique trajectory against gas position.
- Sheet generator works as GND electrode and disturbs
  electric field near the boundary.
- The influence of thermal velocity needs to be considered.
- This system can measure distribution in 60% area of sheet.

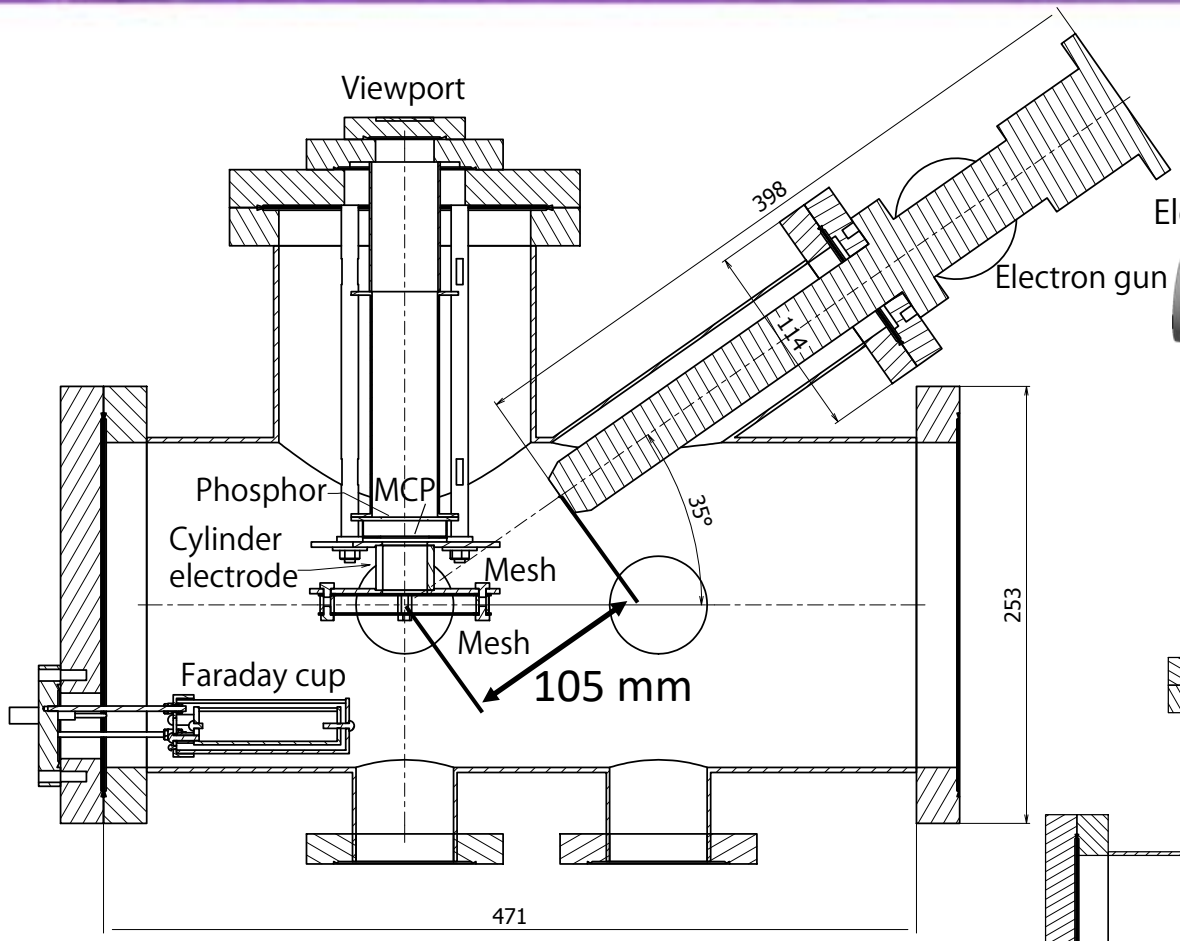
Status quo ~Experiment~

The ion trajectory is most important in developing system

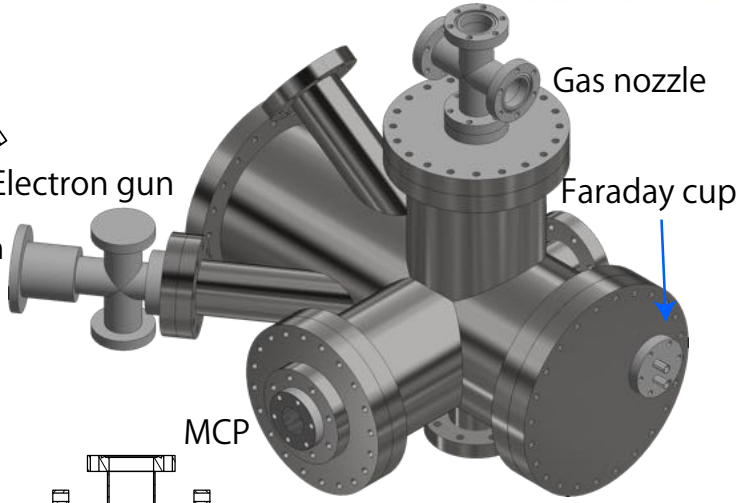
→ For confirming the uniqueness of ion trajectory, we are designing ion trajectory tracking system with spot gas.

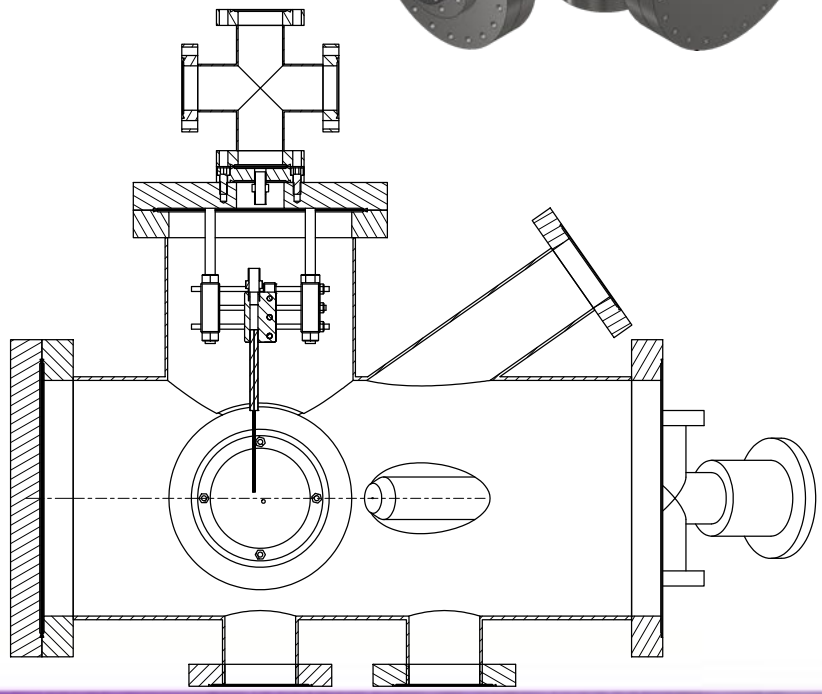


Experimental system



Top view

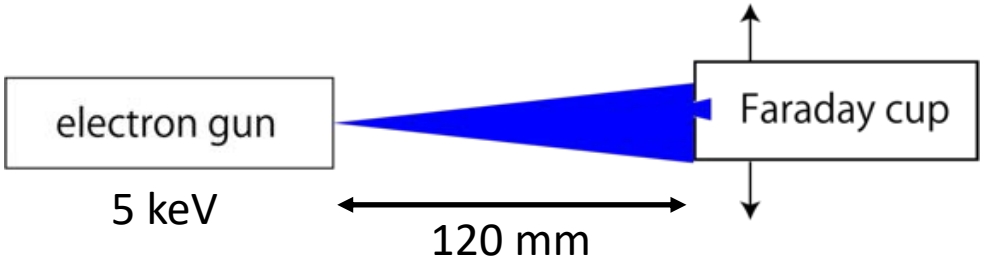


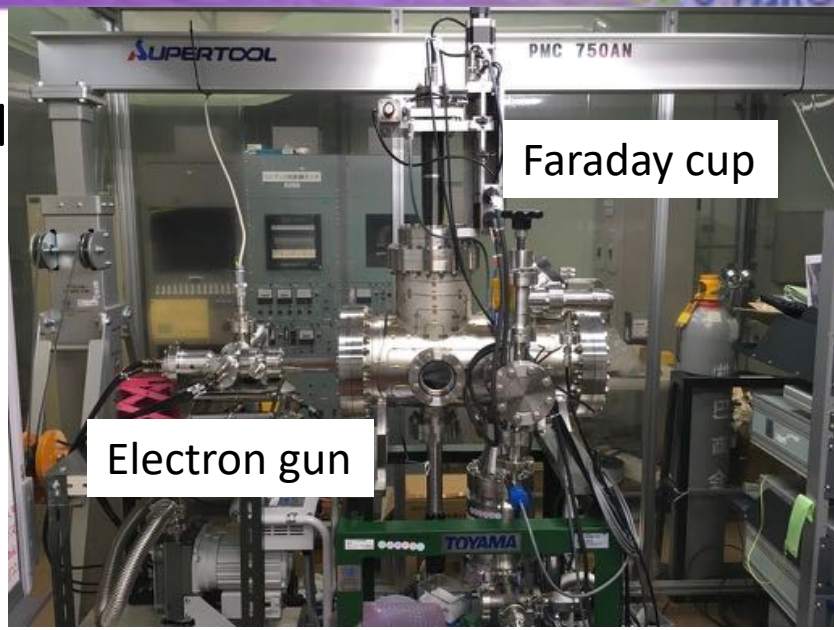


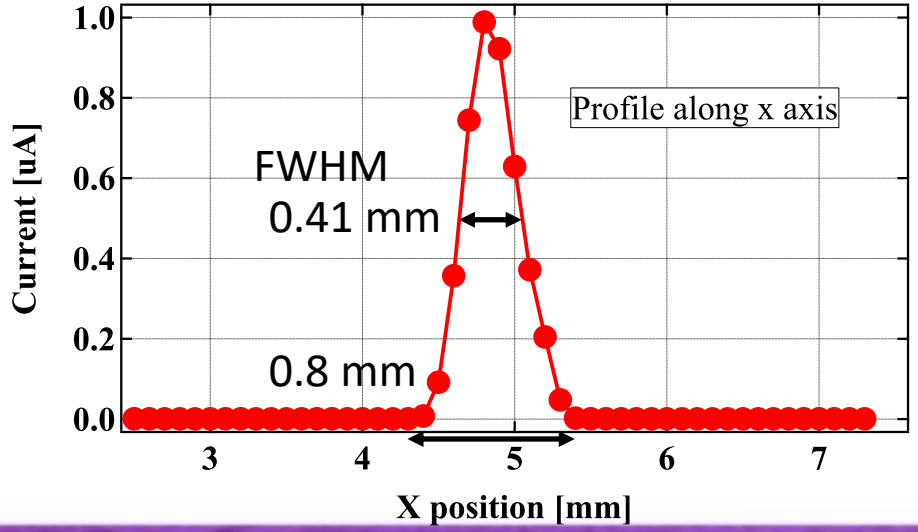
Side view

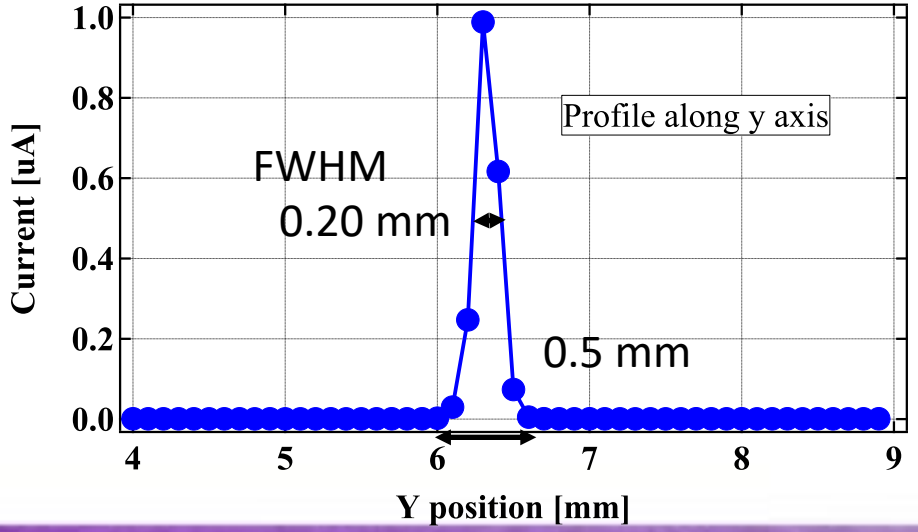
Electron beam profile

The electro beam profile was measured using movable Faraday cup



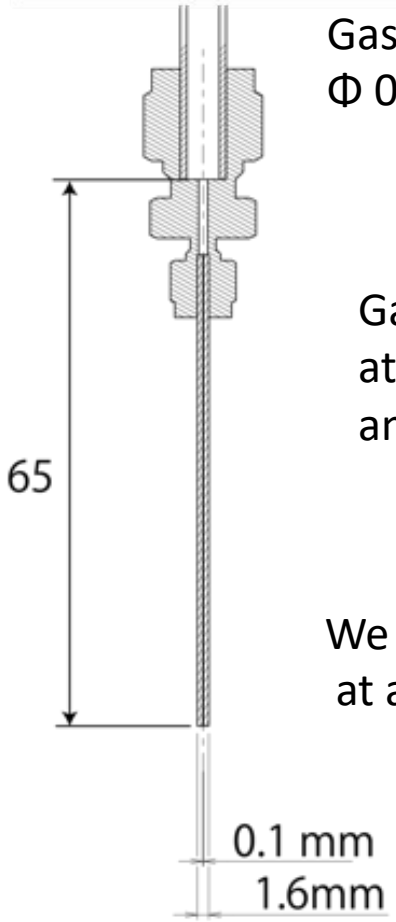






Simulation result of gas distribution

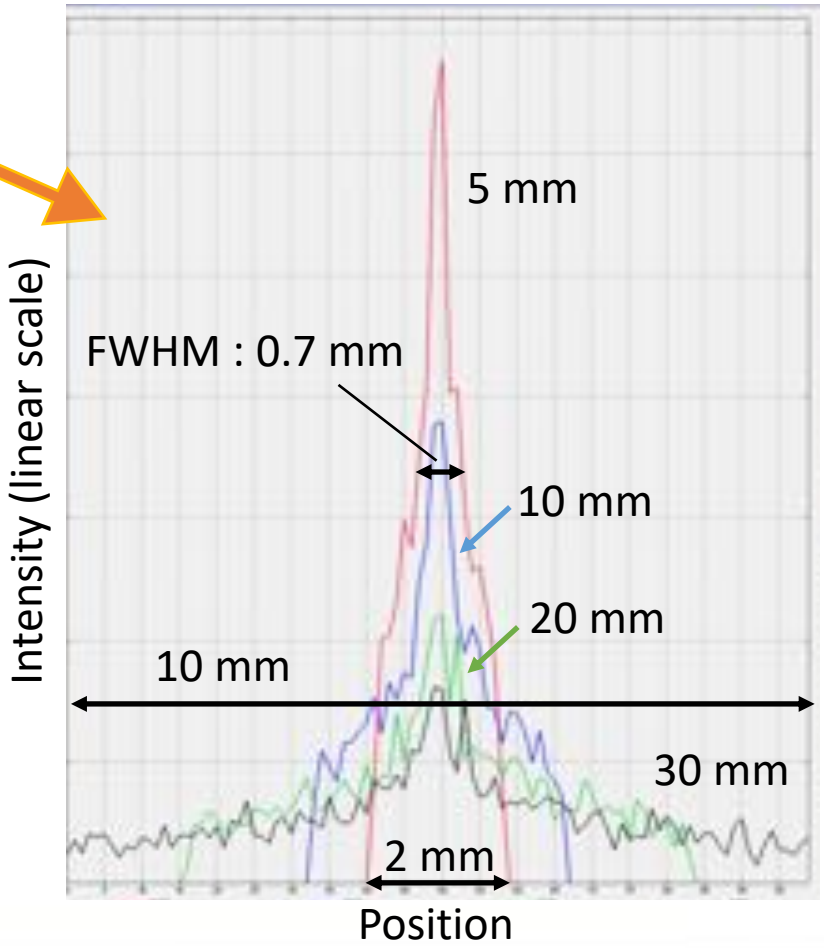
Simulation results of gas distribution using molecular flow Monte Carlo code



Gas nozzle (cylinder-shaped)
Φ 0.1 mm × 65 mm long

Gas distribution
at a distance pf 5, 10, 20,
and 30 mm from nozzle end

We will measure distribution
at a distance of 5～10 mm



Conclusion

- We suggest 3-D gas distribution measuring system using electron beam.
- Designing ion trajectory inspection system is finished with spot gas.
- We will experiment using the system.
- The spot image is expected less than 1 mm diameter area from calculations.
- Gas distribution measuring system will be designed.