Preliminary development of MCP simulation

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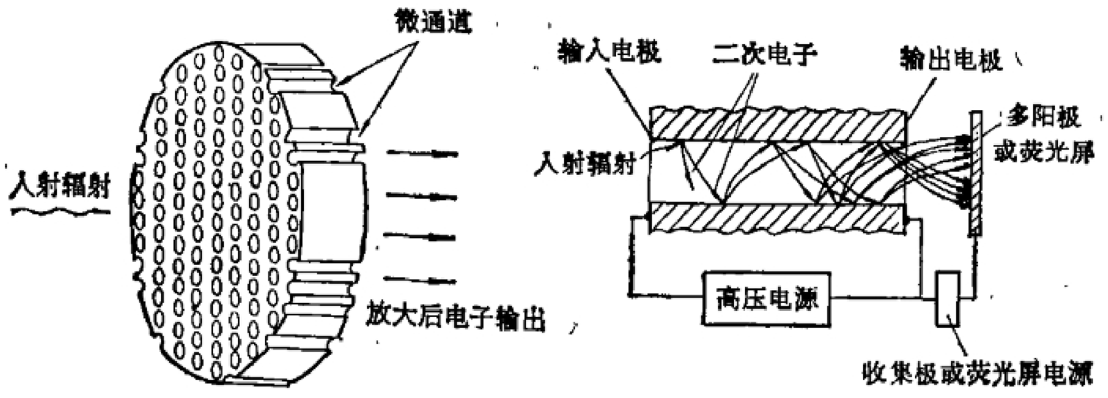
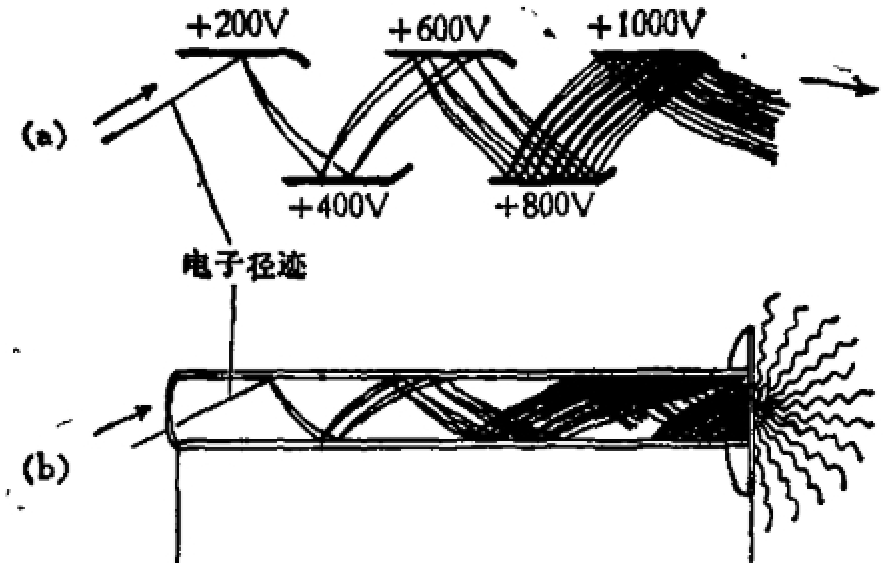
CONTENT

Principle

PART.01

Fundamental Principle





- When incident particle hit the emission material, secondary electrons will be possible to be activated and escaped to the channel
- Secondary electrons will be accelerated as a high voltage are applied to the ends of the channel
- Secondary electrons hit the surface of emission material and more secondary electrons will be created.

Secondary Electron Emmision

- Assuming that this process happens at the surface of the hole in MCP;
- Incident electrons will be transformed to secondary electrons or absorbed by MCP material once they hit the inner surface;
- Furman model is used to sample the secondary electrons emmitted from material

Furman Model

- Secondary electrons are divided to three kinds:
  - elestic backscattered secondary electrons
  - rediffused secondary electrons
  - true secondary electrons
- When the electron hit the surface vertically, the secondary electron yield is obtained experimentally
- If there's an angle between incident and normal direction, the yield can be obtained by multiplying a coefficient:

$$P(\theta) = P(0) \cdot e^{-\frac{L}{\lambda}(1-cos\theta)}$$

$$P(0) - yield\ when\ electrons\ hit\ vertically$$

$$\frac{L}{\lambda} - coefficient\ got\ from\ experiment$$

Furman Model

- The average yields of secondary electrons can be got from the method above
- Then we sample Gaussian distributions whose mean value and standard deviation are both the average yields to got the yields in this certain event.
- The process corresponding the highest yield will happen in this certain event
- The number of electrons is obtained by sampling a Poisson distribution whose mean value is the average yield.

Furman Model

- Angular distribution of secondary electrons:

$$\frac{dP}{d\theta} = Ae^{-\frac{c}{cos\theta}}$$

$$A - normalization\ coefficient$$

$$c - coefficient\ got\ by\ experiment$$

- Energy spectrum of secondary electrons:
  - elestic backscattered secondary electrons

$$f(E) = \frac{2exp[\frac{(E-E_p)^2}{2\sigma_e^2}]}{\sigma_e \cdot erf(\frac{E_p}{\sqrt{2}\sigma_e})}$$

$$E_p - incident\ energy$$

$$\sigma_e - standard\ deviation\ of\ emission\ spectrum$$

Furman Model

- rediffused secondary electrons:

$$f(E) = \frac{(q+1)E^q}{E_p^{q+1}}$$

$$E_p - incident\ energy$$

$$q - coefficient\ by\ fitting$$

- true secondary electrons:

$$f(E) = E^{\rho_n - 1} e^{\frac{-E}{\kappa_n}}$$

$$\rho_n, \kappa_n - coefficient\ by\ fitting$$

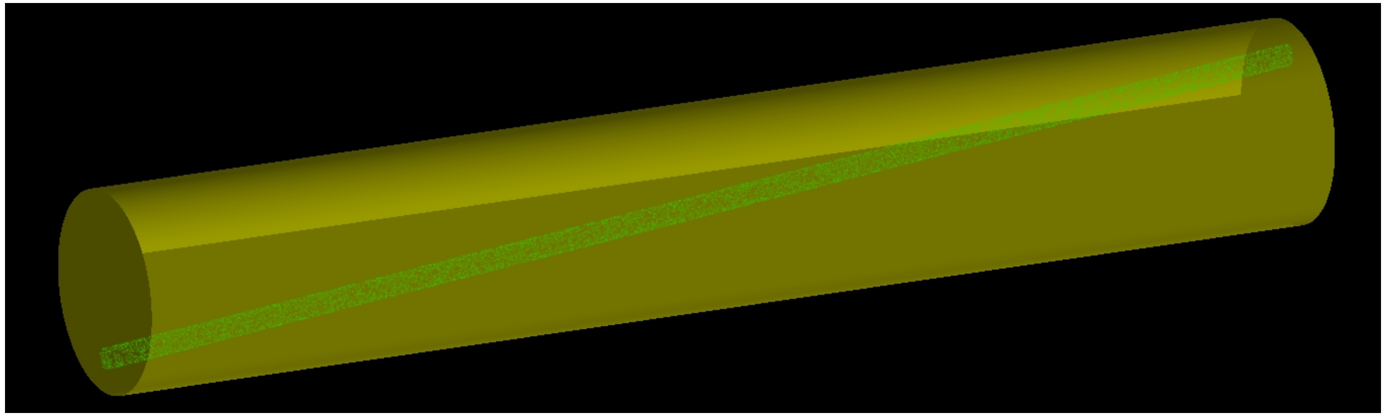
Preliminary development

PART.02

Detector Construction

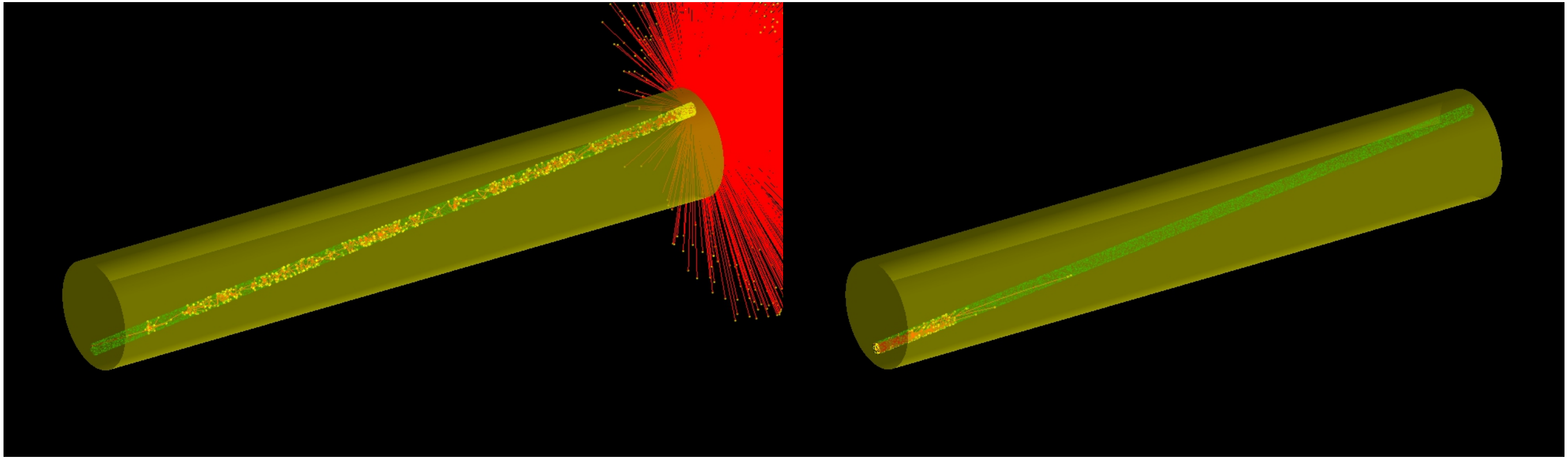
- Only one channel is taken into simulation for now
- The parameters of MCP are got from manual provided by factory:

Parameter	Value
Thickness of MCP	0.38 mm
Radius of MCP	3e-2 mm
Radius of channel	3e-3 mm
Rotation of channel	6 degree
High voltage	500 V



Simulation

- 100 eV electrons are set to be the particle source
- When the yields of secondary electrons are fixed to be 2, the process works properly
- If the yields are got from sampling, secondary electrons cannot be created properly



We are trying our best to fix this problem

Summary

PART.03

Summary

- Furman model has been used in our simulation work
- Detector model has been successfully constructed in program
- Secondary electron emission process still has some problems and we are trying to figure it out

Next work

PART.04

Next work

- Solve the problem we meet when implementing new process
- Construct the complete geometry of MCP
- Calculate the eletric field in the channel
- Get the response of MCP

Thank you !