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Generation of Neutron Beam with the Cylindrical Discharge type Fusion

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Outline

- Background
- Objective
- Simulation by MCNP5
  – model
  – effect of reflector materials
  – problems   optics! & current working
- Experiment update
- Summary

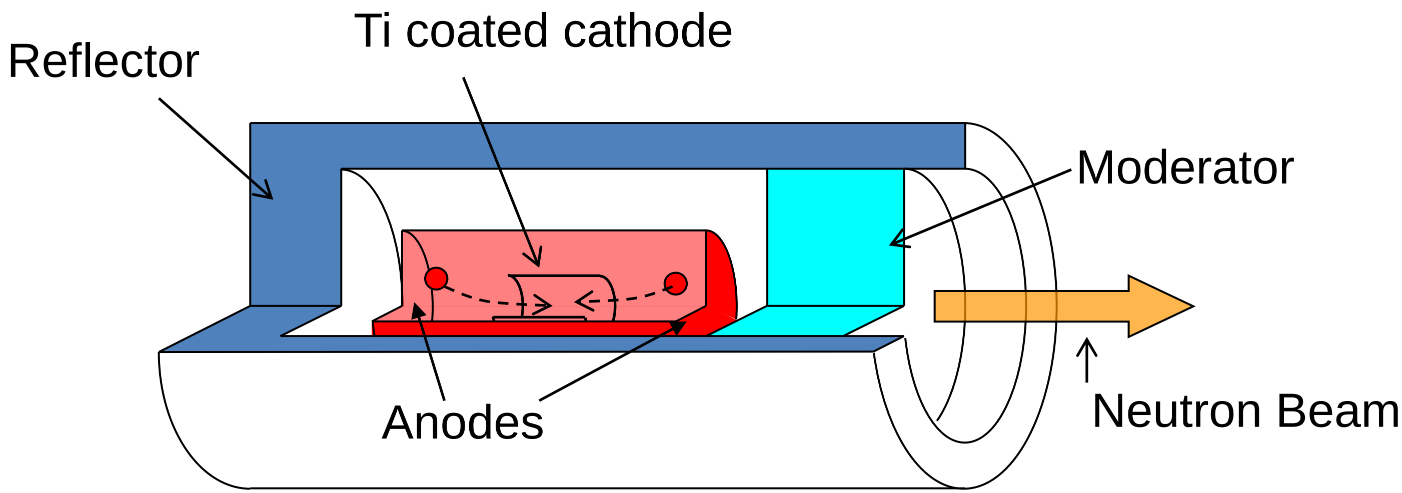
Background

Non destructive analysis (radiography, diffraction analysis):

- Compared with X-ray analysis, it can specify the position of light atoms such as hydrogen. This is ideal method for the analysis of biological macromolecules.
- Currently, neutron beams are supplied by large scale facilities (fission reactor or particle accelerator).

Development of small scale neutron beam source using cylindrical neutron source and neutron optics (reflector, moderator).

Objective



Cylindrical discharge type neutron source

- Fusion reaction oh the electrode surface.
- 2.5MeV fast neutron
- Isotropic

Neutron Optics (Reflector Moderator)

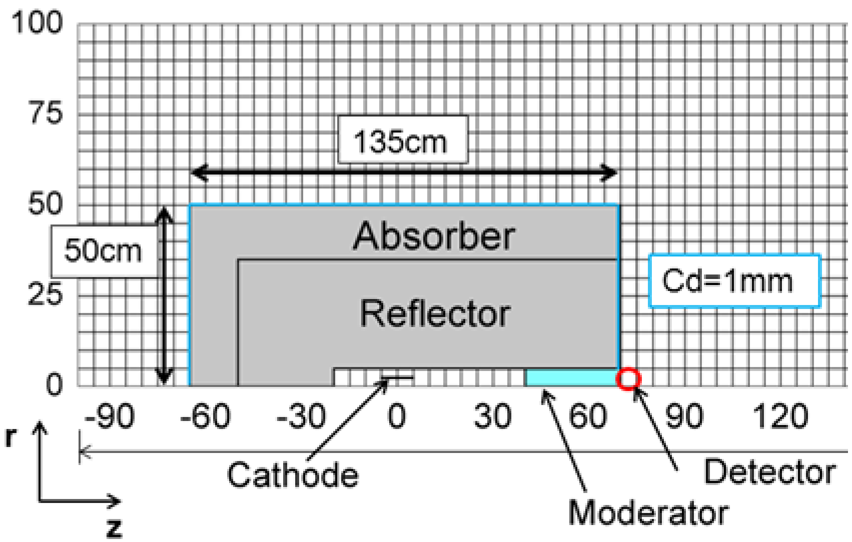
- Material
- Geometry

Neutron Beam

- Single directional
- Thermal neutron (<room temp.) or
- Fast neutron

Simulation Method

Analysis on effect of combined materials



MCNP(Monte Carlo N-Particle) transport code & JENDL 3.3

---Model---

・Cylindrical coordinate

・Source: cylindrical cathode surface (Dia. 5cm, L10cm) 2.5MeV and isotropic neutron

Thermal beam

Reflector: PE, D_2O (O.D.=70cm, I.D.=10cm, L=120cm)

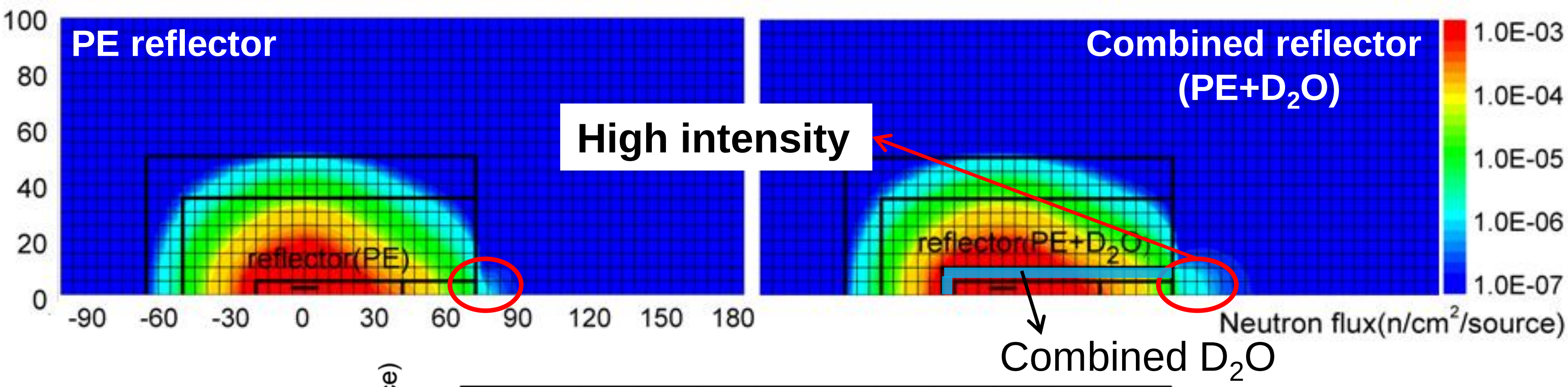
Moderator: D_2O (O.D.10cm, L=30cm)

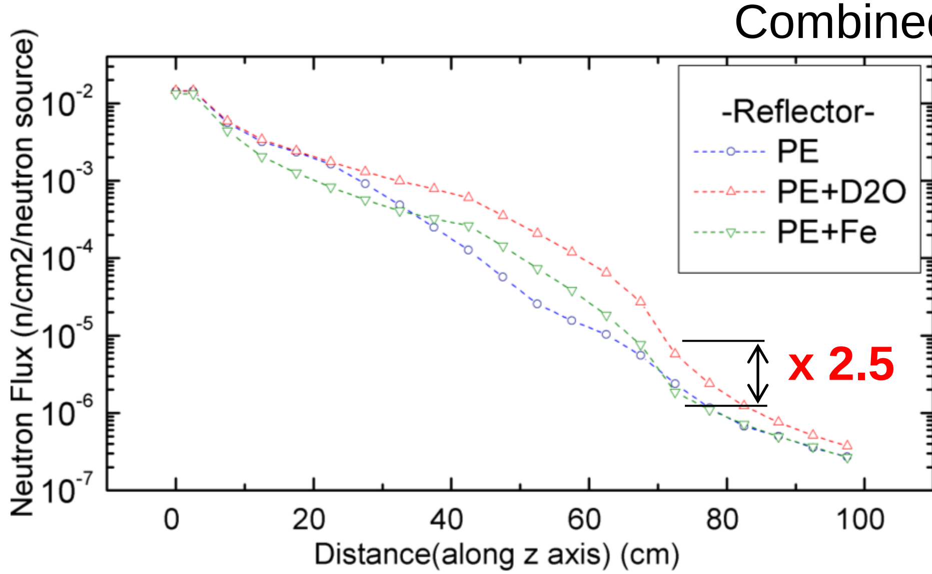
Fast beam

Reflector: W, Fe, V (O.D.=70cm, I.D.=10cm, L=120cm)

Absorber(for shield): H_2O,Cd(1mm)
(O.D.=100cm, I.D.=70cm, L=135cm)

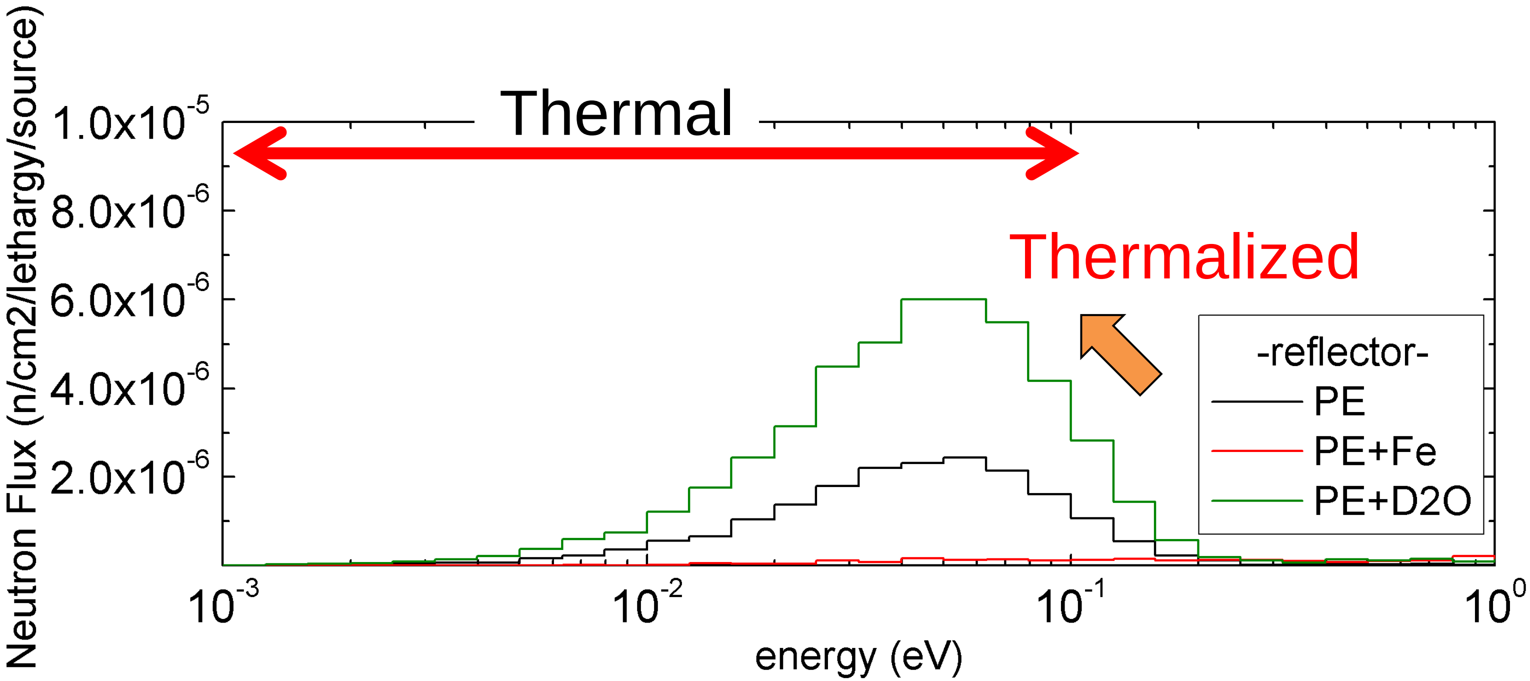
Effect of combined reflector materials on the neutron flux distributions





Compared with PE reflector, **PE+D_2O reflector was obtained high intensity neutron beam** x 2.5

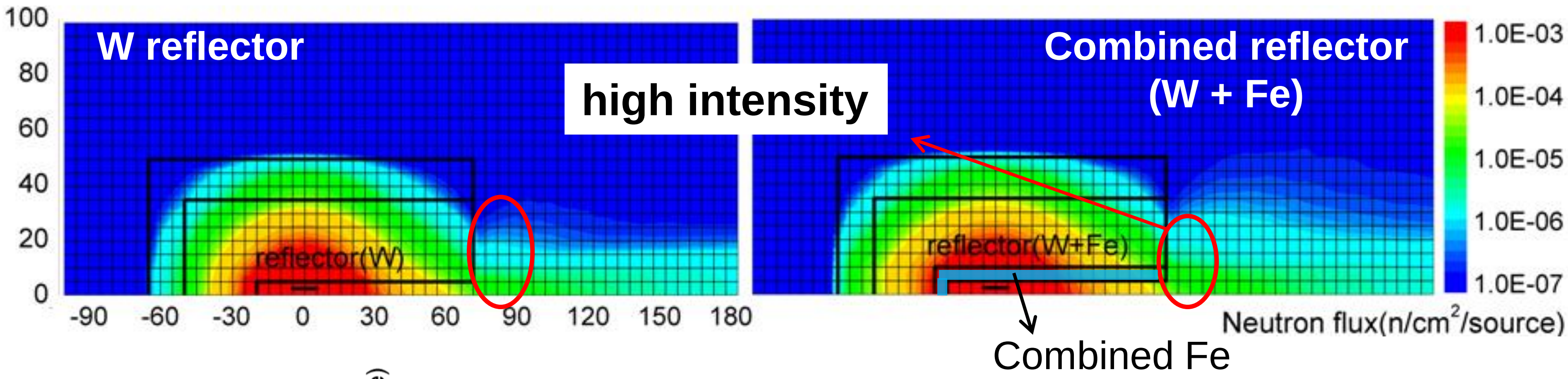
Effect of combined reflector materials on the energy spectrum at (z, r)=(70,0)

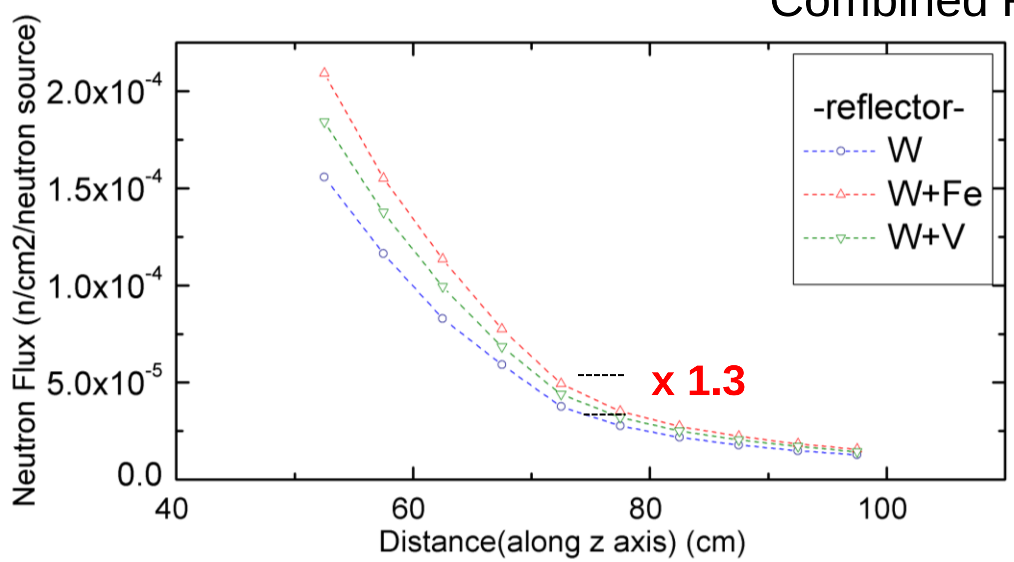


Reflector Material	Total Neutron Flux (n/cm^2/source)	Thermalized Neutron (E<0.1eV) (n/cm^2/source)	Ratio (thermal/total)	Fast Neutron (E>1MeV) (n/cm^2/source)	Ratio (fast/total)
PE	2.26×10^{-6}	1.71×10^{-6}	75.7%	1.86×10^{-7}	8.20%
PE+ D_2O	5.73×10^{-6}	4.20×10^{-6}	73.4%	2.66×10^{-7}	4.64%
PE+Fe	1.91×10^{-6}	9.25×10^{-8}	4.85%	6.36×10^{-7}	33.3%

Combined reflector(PE+D2O) is obtained high intensity thermal neutron, but PE reflector is effective for thermalizing fast neutron than combined reflector

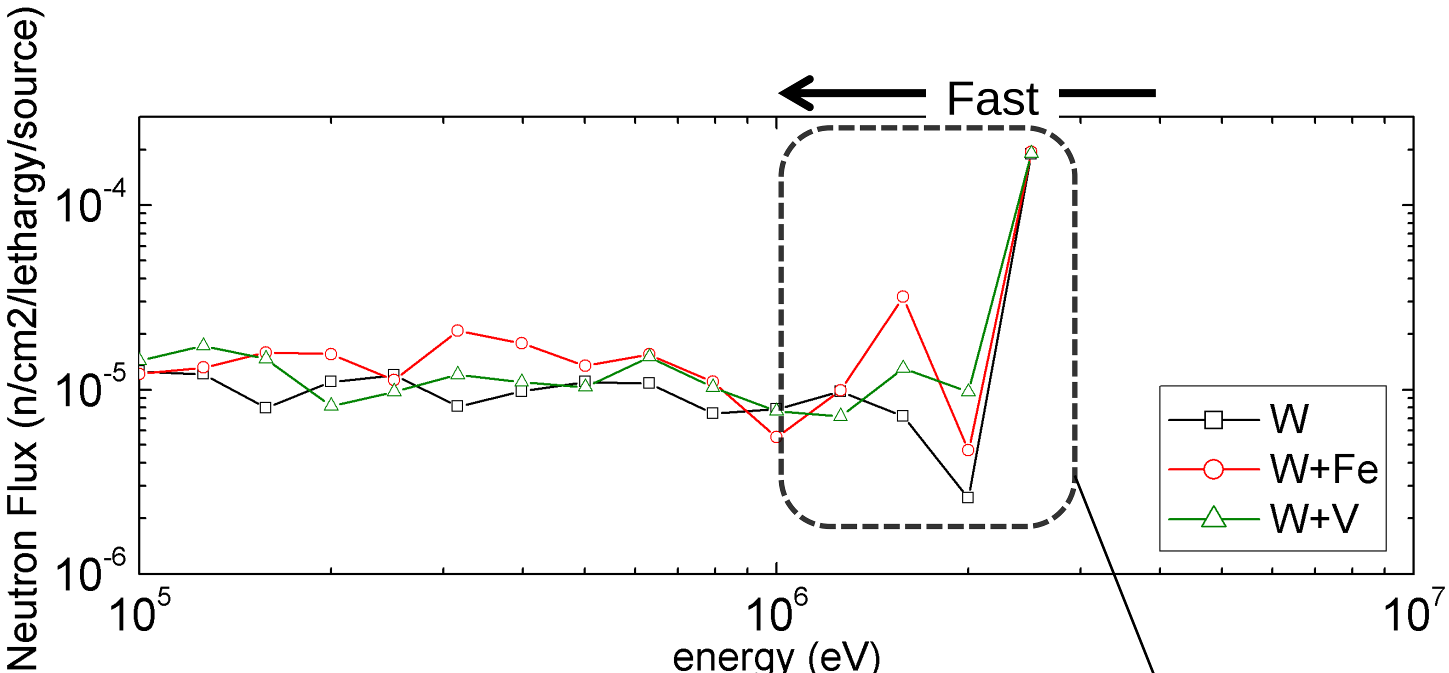
Effect of combined reflector materials on the neutron flux distributions





Compared with W reflector, **W+Fe reflector was obtained high intensity neutron beam** → **x 1.3**

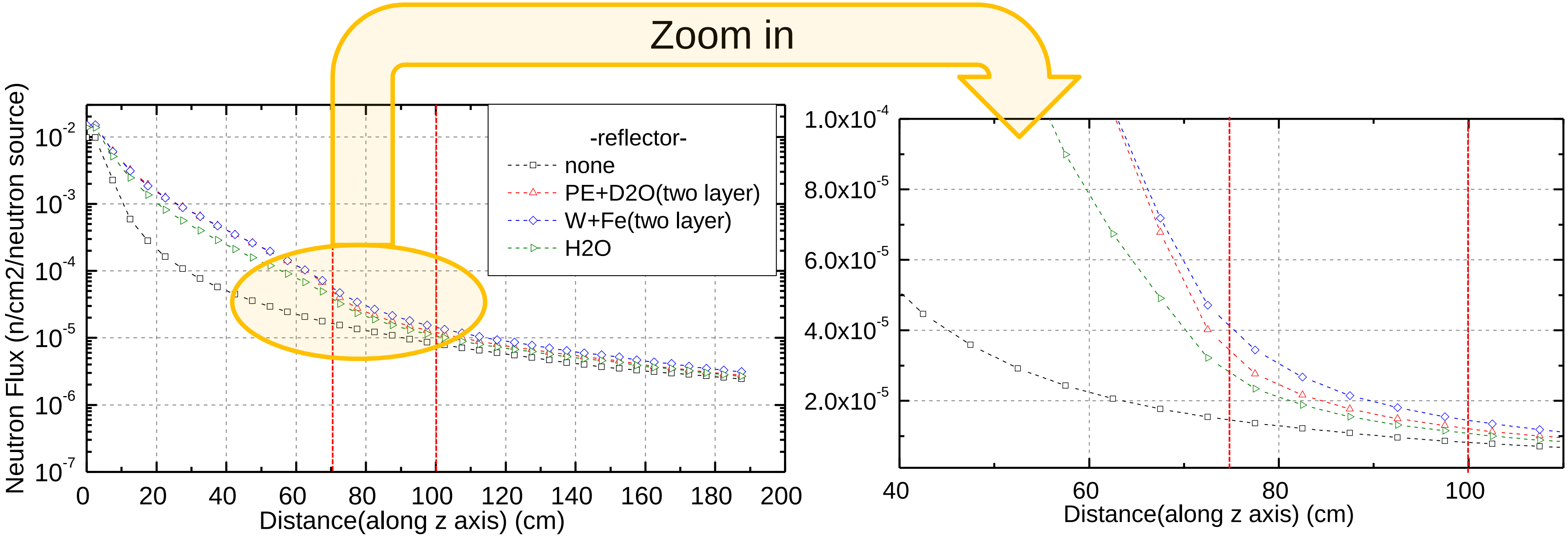
Effect of reflector material on energy spectrum at (z, r) = (70cm, 0cm)



Reflector Material	Total Neutron Flux (n/cm^2/source)	Thermalized Neutron (E<0.1eV) (n/cm^2/source)	Ratio (thermal/total)	Fast Neutron (E>1MeV) (n/cm^2/source)	Ratio (fast/total)
W	3.76×10^{-5}	0.0	0%	3.07×10^{-5}	81.4%
W+ Fe	4.95×10^{-5}	0.0	0%	3.81×10^{-5}	76.9%
W + V	4.47×10^{-5}	0.0	0%	3.36×10^{-5}	75.3%

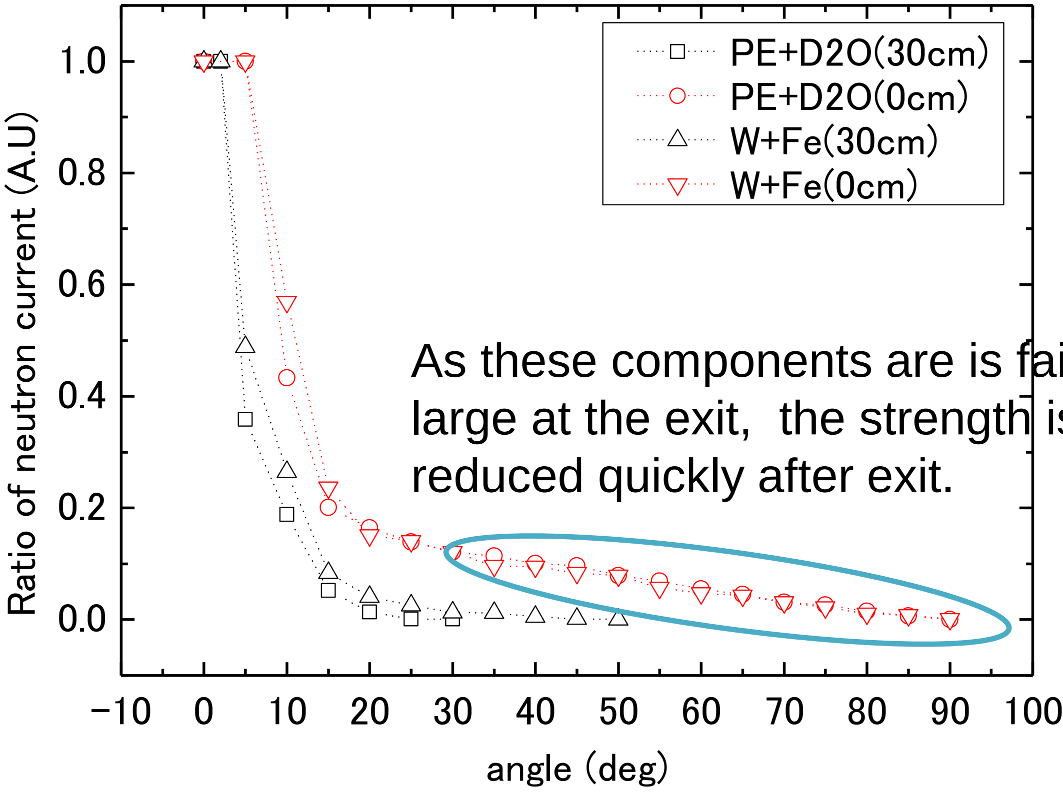
W reflector is effectively obtained fast neutron.

Neutron flux on the axis at reflector exit (z=70cm)



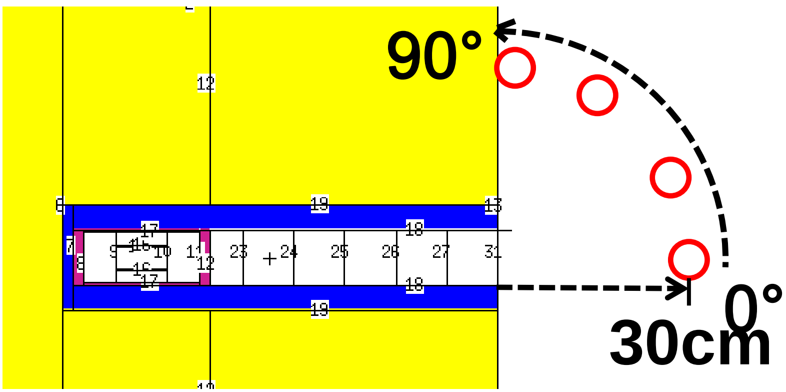
- Neutron flux near the reflector exit is increased by adding combined reflector, but it quickly decreases after the exit.
- To find out reasons for this, we look at the direction of particles go through the exit, this time using current tari.

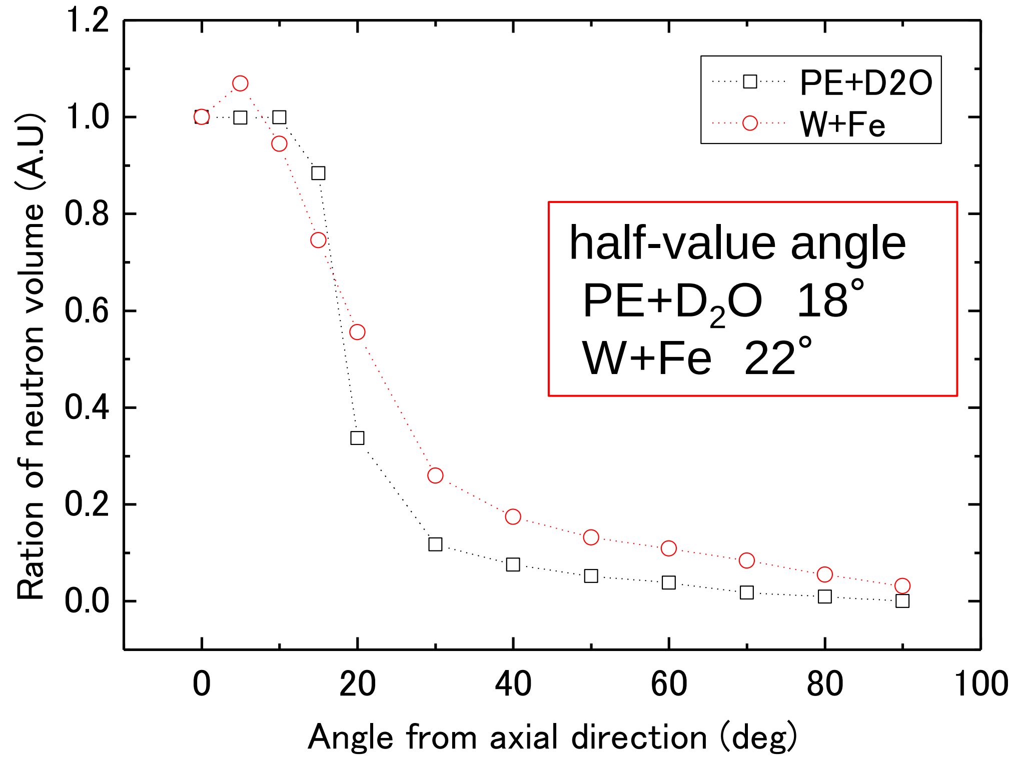
Direction of neutron velocity



As these components are is fairly large at the exit, the strength is reduced quickly after exit.

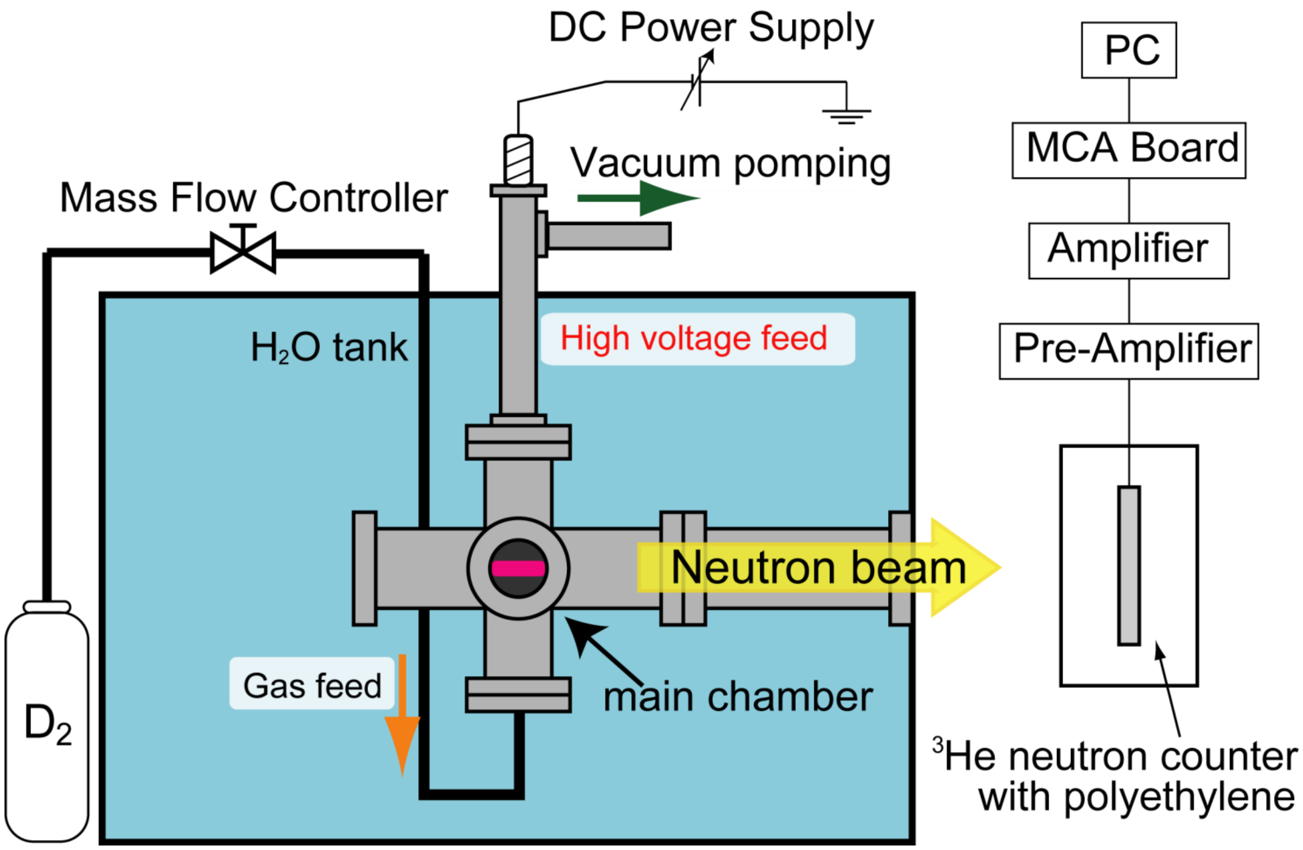
Comparison of beam profiles for different reflector configuration

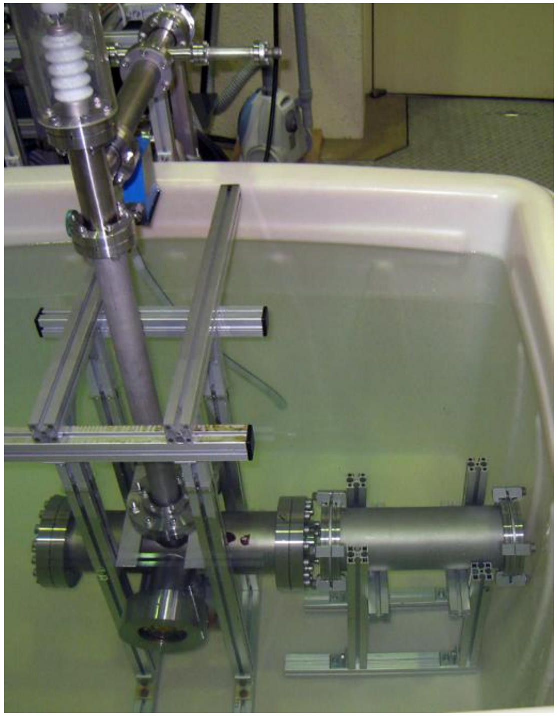




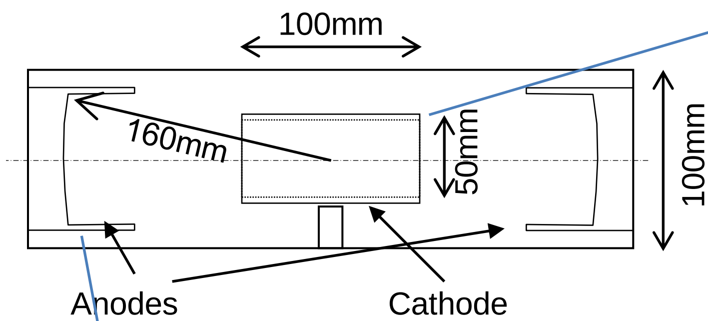
Last year's experimental setup

The discharge chamber is put into a water tank so that the chamber is covered completely except for upper port (voltage feed-thru and evacuation) and beam direction.



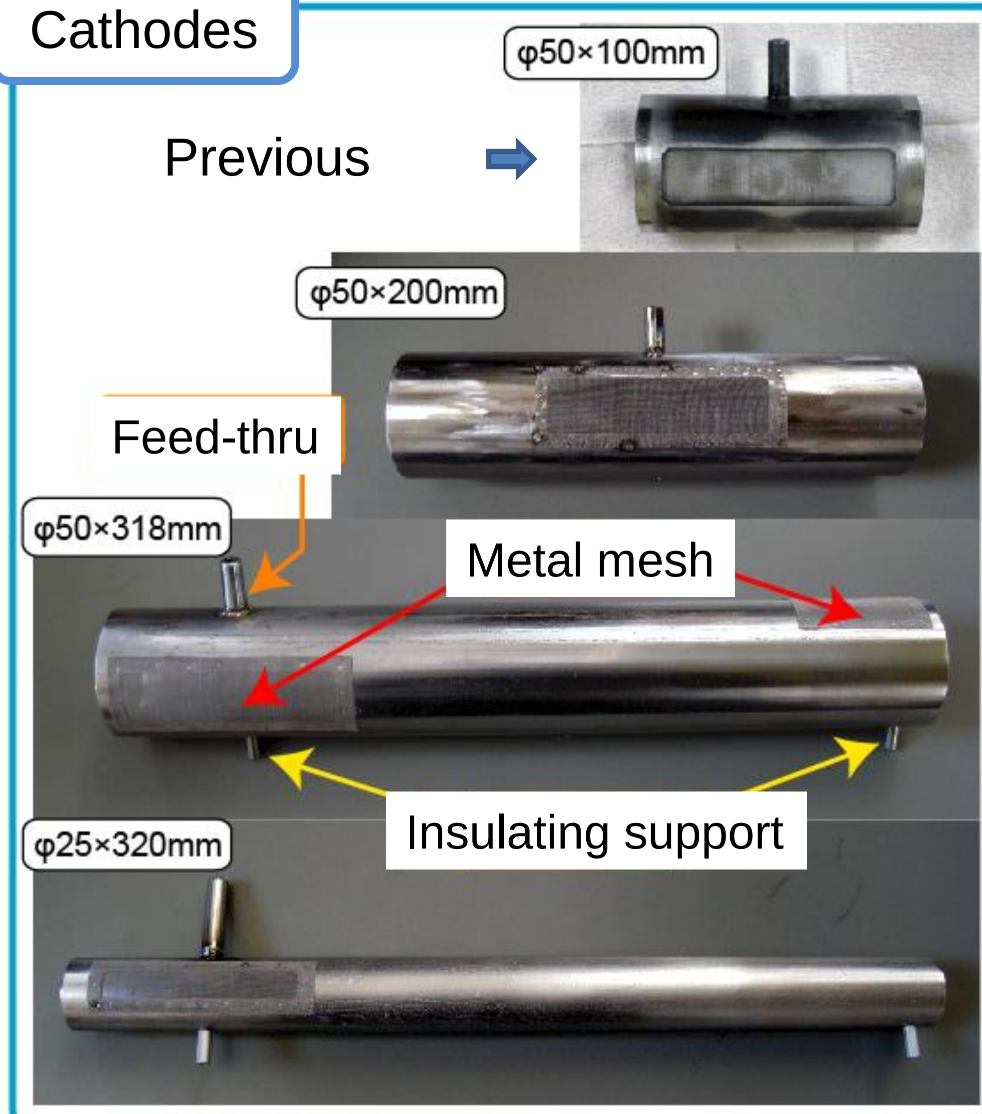


Electrodes

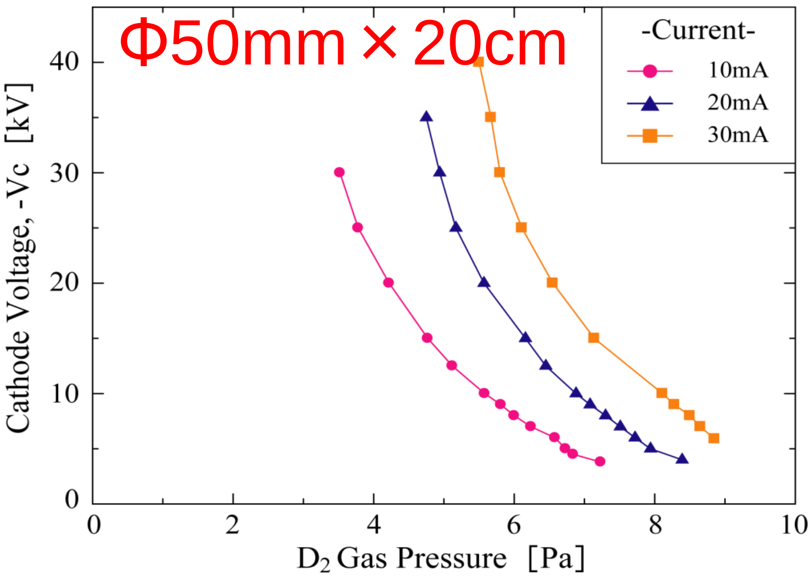


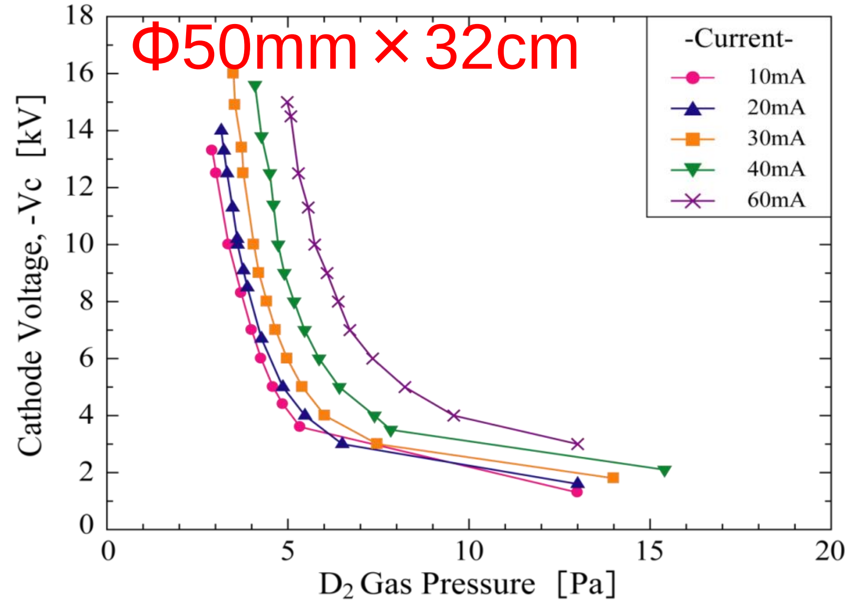
Anode

Cathodes



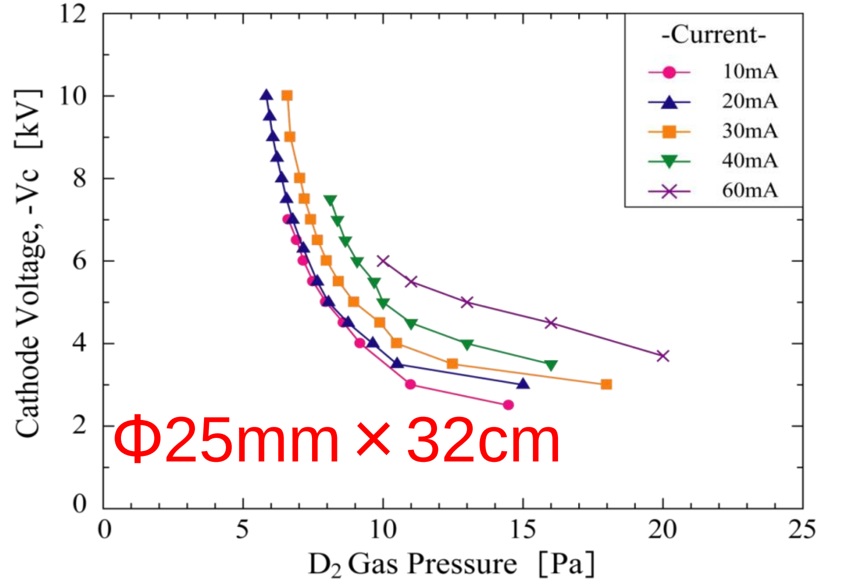
P-*V* characteristics for each cathode





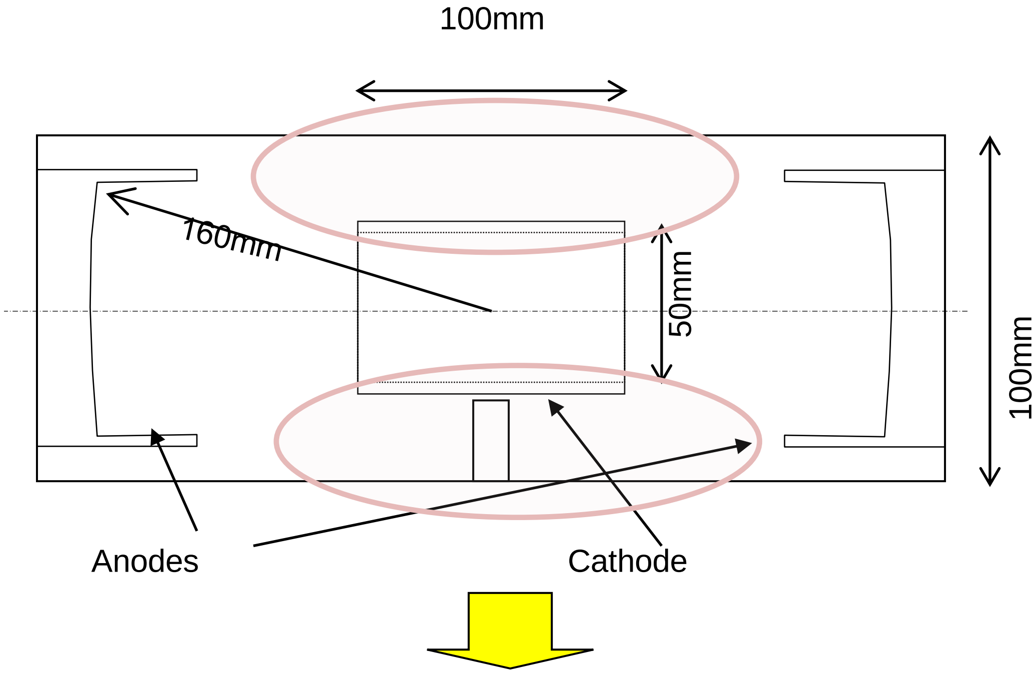
- Long
- Slim

- Low voltage
- High pressure (not sufficient for fusion reaction)



Device update

Discharges in this area (between cathode and cylindrical chamber (anode voltage)) may limit IEC operation ?

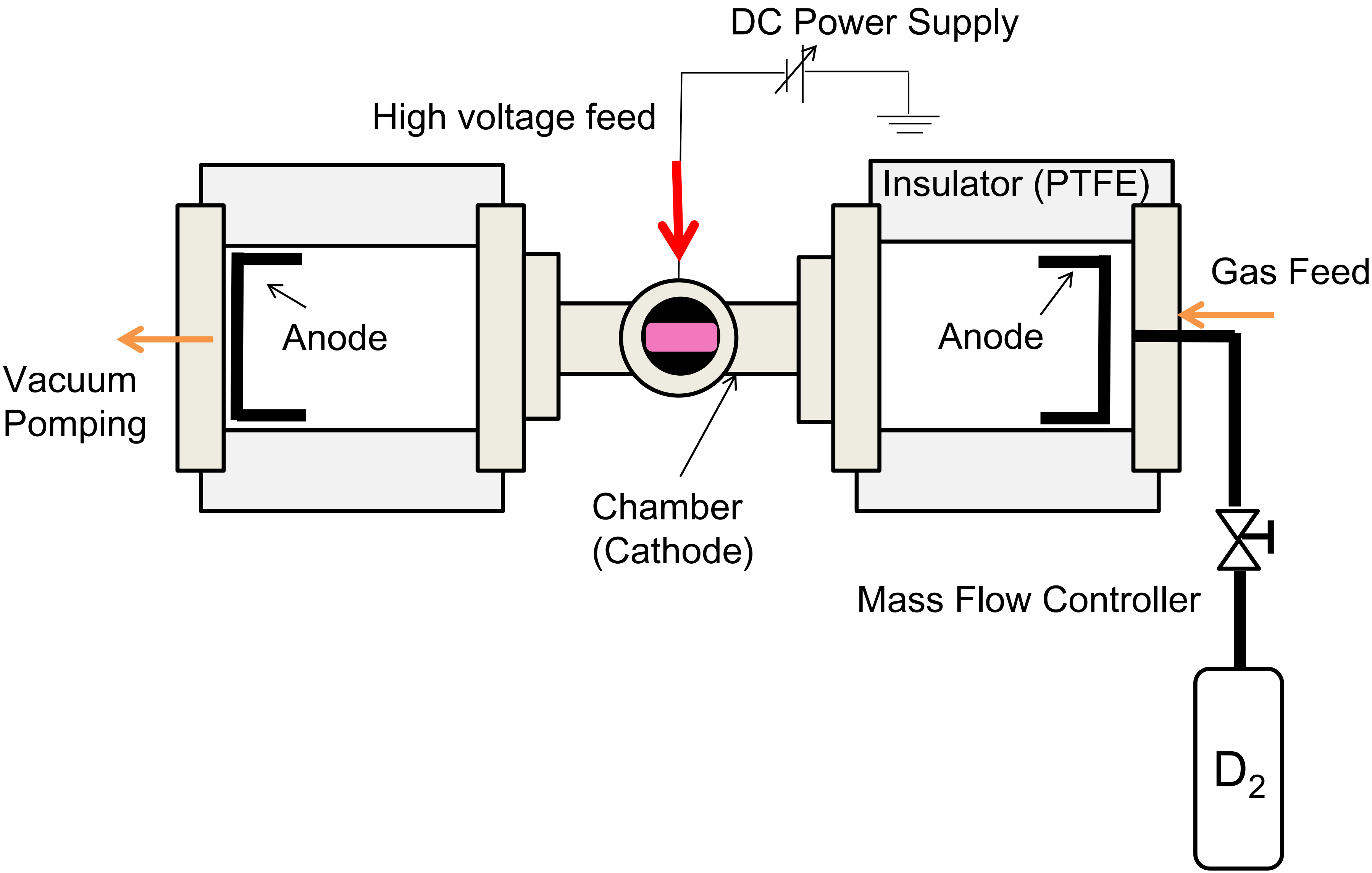


Remove this area

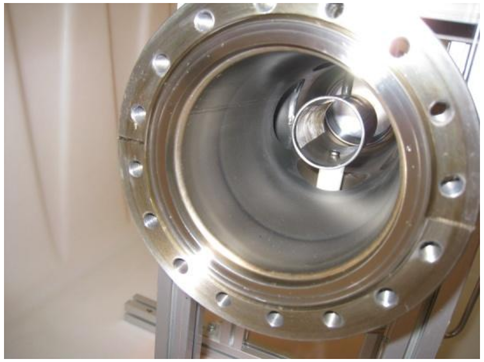
support cathode from outside &

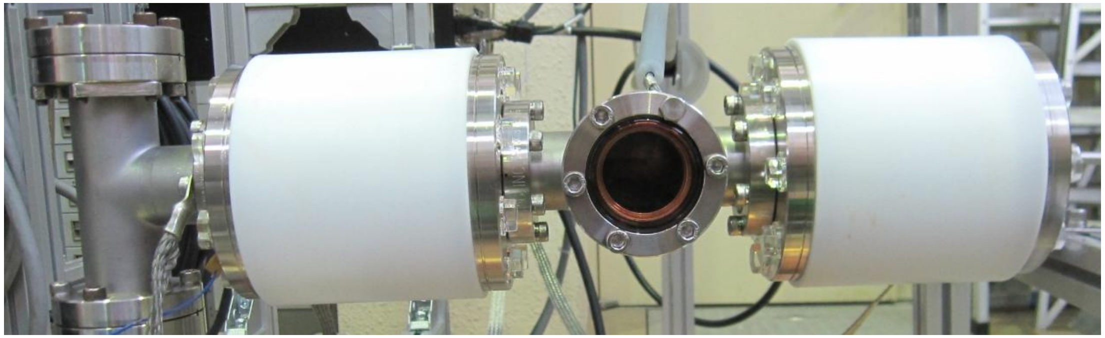
put isolate material between anode and cathode

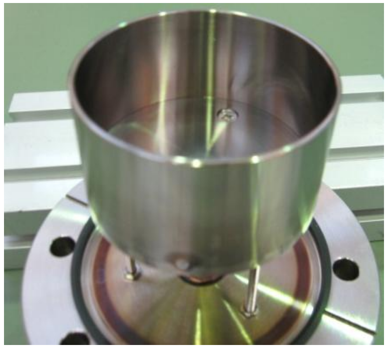
Schematic of setup



Photos







Summary

- Neutronics calculation suggested that generation of thermal or fast neutron beam is possible with adequate reflector designs.
- Generation of neutron beam is confirmed to be possible, with a table top fusion neutron source.
- Until recently we focus to increase neutron flux at the exit, but it decreases quickly after there. We are now focusing the optics and make more optimization.
- In the experiments, new device is under development.