Neutronic Study on Coupled Hydrogen Moderator

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Present Coupled H_2 Moderator Design

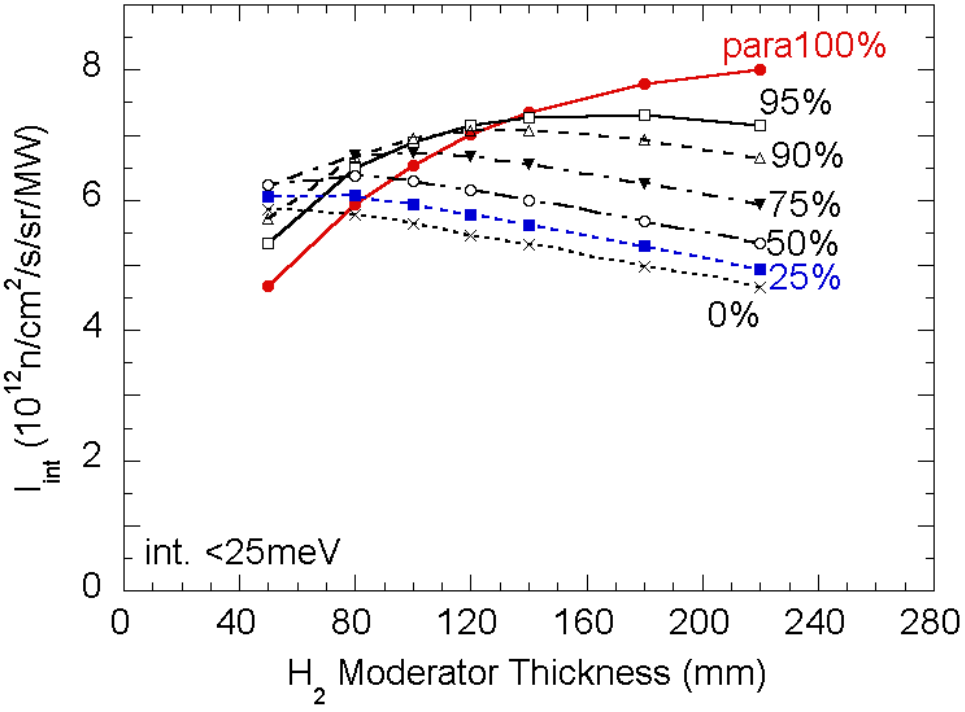
- Design criteria
  - Highest I_{int} (time-integrated cold neutron intensity)
  - Highest I_{peak} (pulse peak intensity)
  - Wide angular coverage with smallest angular dependence
- 100% para supercritical H_2
- Larger volume of cylindrical Shape
  - Diameter: 140 mm
  - Height: ~100 mm
- Beam extraction angular coverage : 45.0° and 50.8°
- Viewed surface: 100 mm x 100 mm
- Optimized H_2O PM without extension
- Be reflector (D_2O cooled)

Para H_2 Content vs Moderator Thickness

- I_{int}(para100%) > I_{int}(other ratios)
  (at H_2 thickness > 140 mm)
- Optimum PM dimensions were same as those of normal one.
- Thick para 100% moderator is adopted.

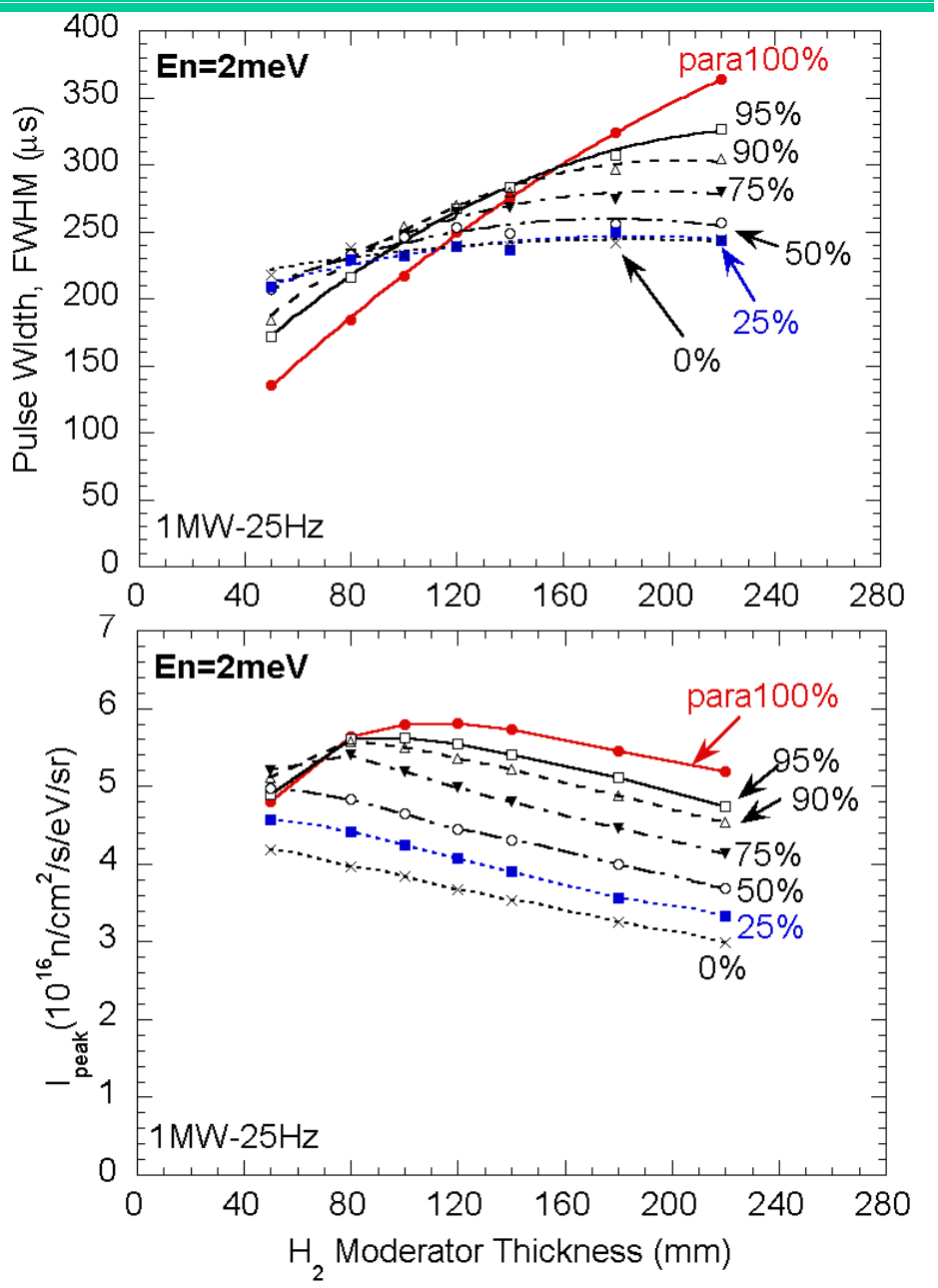
Calculation model

- **Lateral dimension:**
  120^W x 120^H mm
- **Premoderator thickness:**
  20 mm (near), 10 mm (side, far)
- **No PM extension**
- **Viewed surface 100mm x 100mm**



Pulse Peak Intensity & Pulse Width

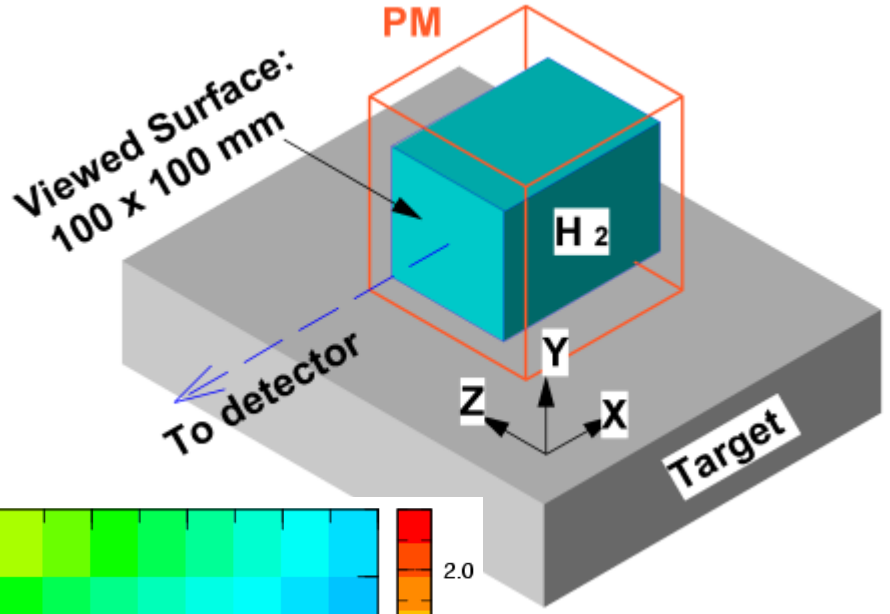
- Increase of I_{int} is due to pulse width increase.
- 100% para H_2 provides the highest I_{peak} with 100~140 mm thickness.
- Results in optimum H_2 thickness: ~140 mm

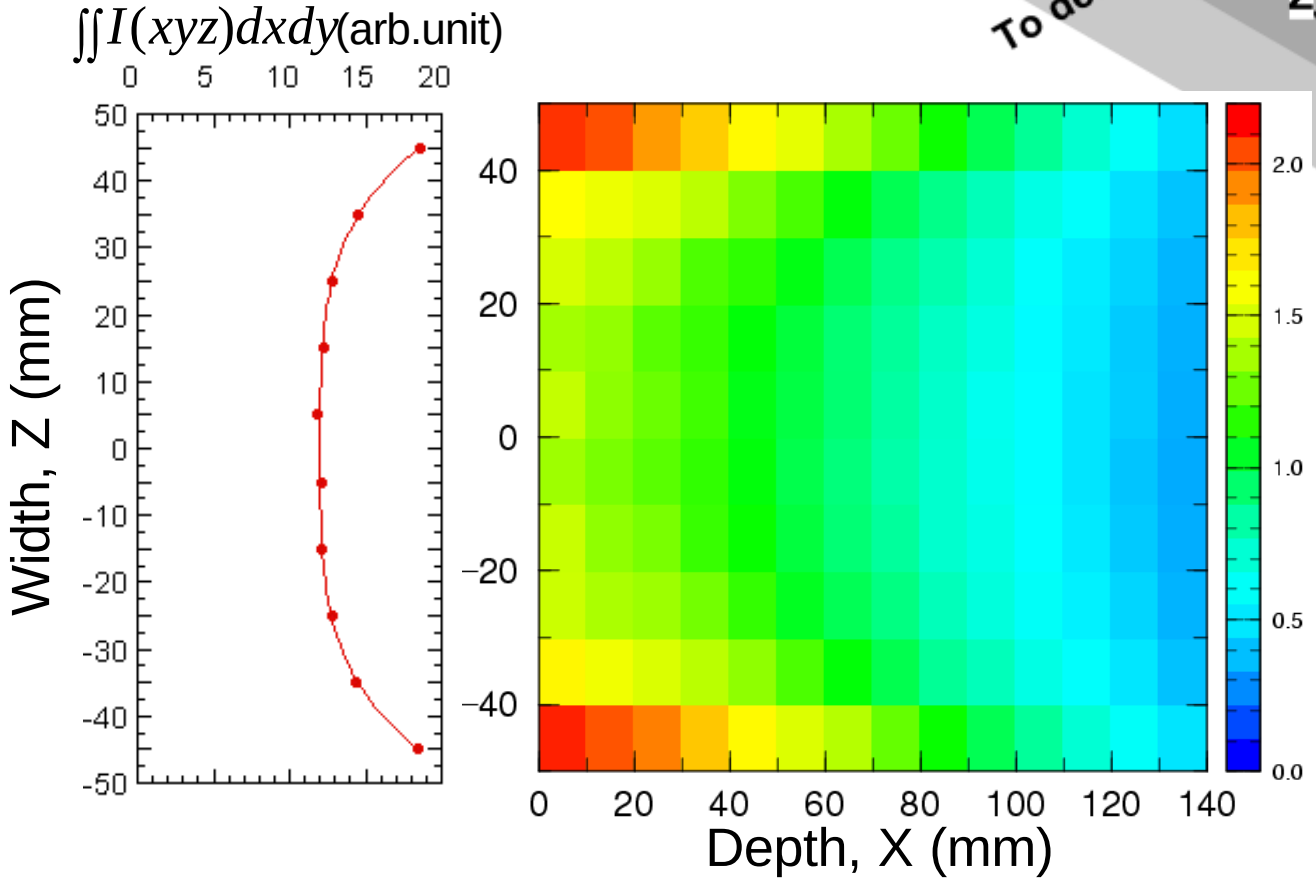


Neutron Spatial Distribution in 100% para H_2 Moderator

Rectangular Shape

- Edge parts near PM are brighter than the central.
- Edge parts should be in use.





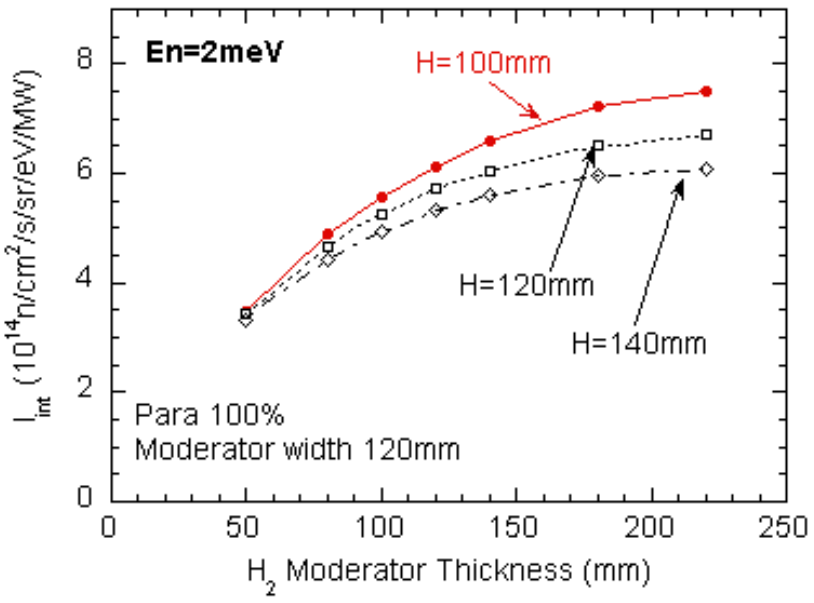
Moderator Height Optimization

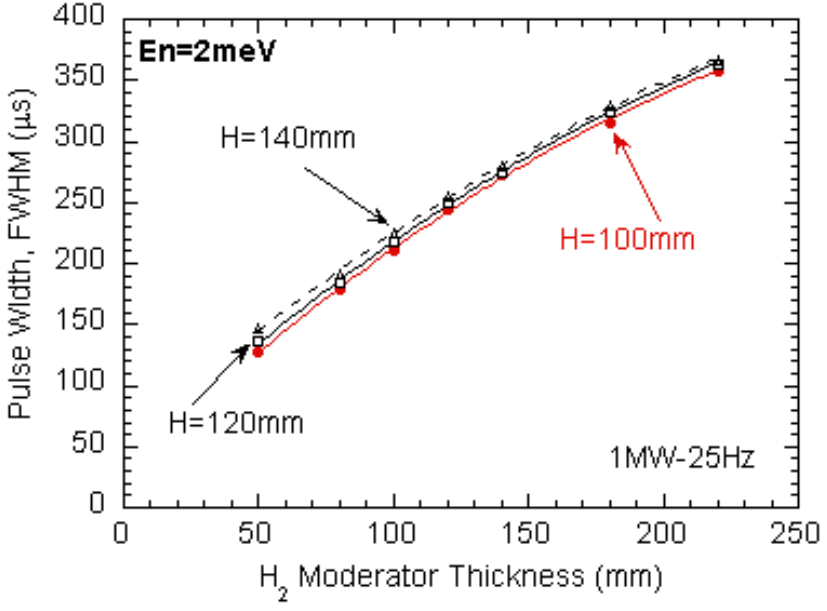
In case of rectangular shape

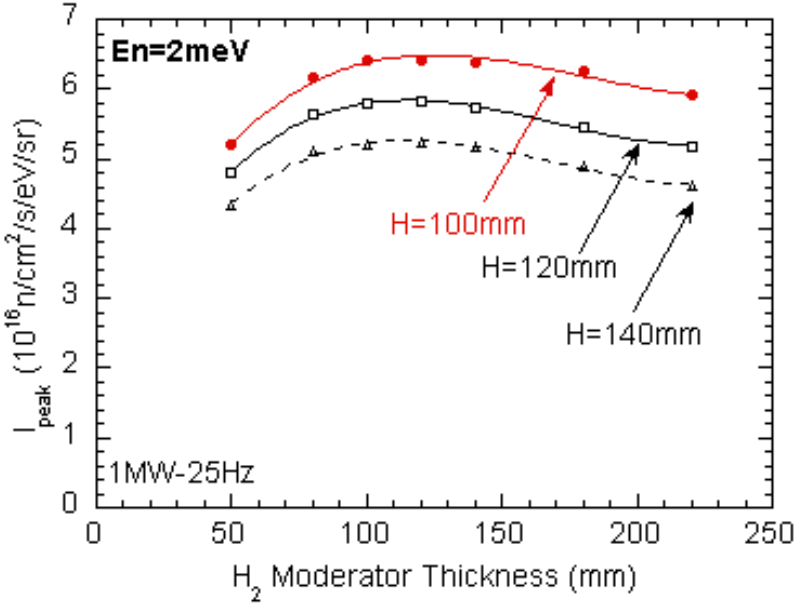
- H=100 mm is optimal for

  I_{int} & I_{peak}.

- Pulse width with H unchanged

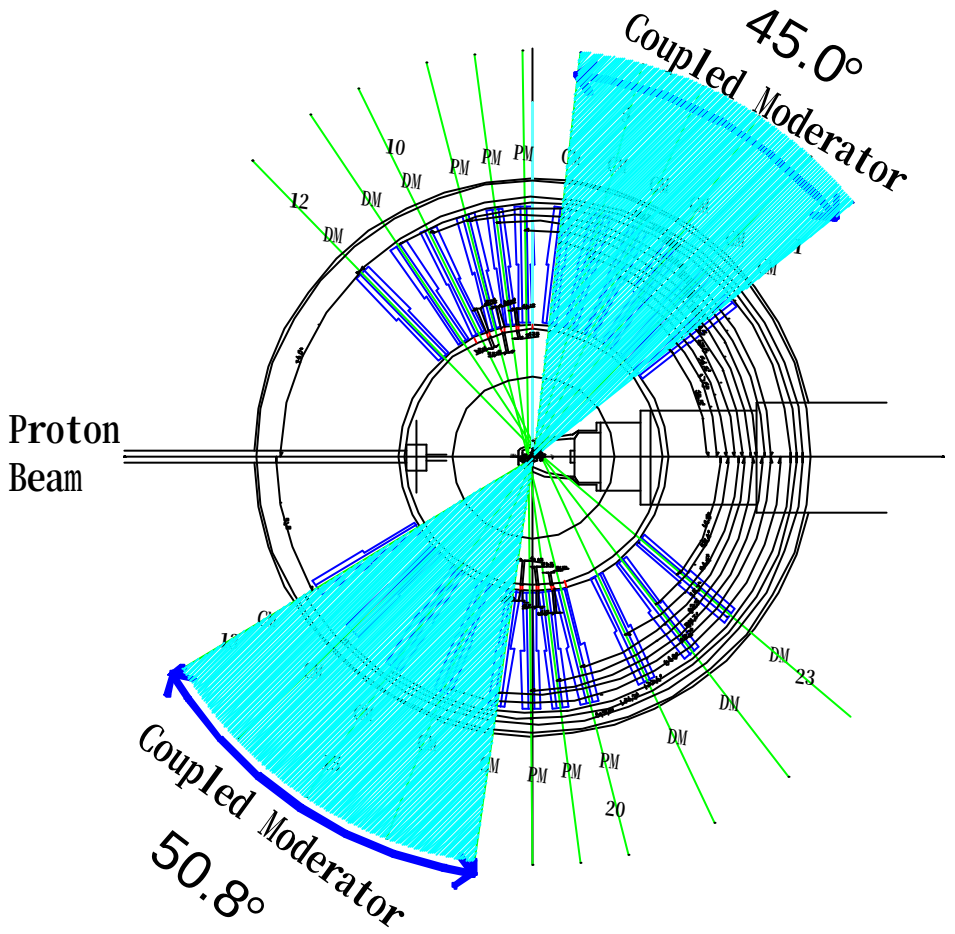






Neutron Beam Line Arrangement

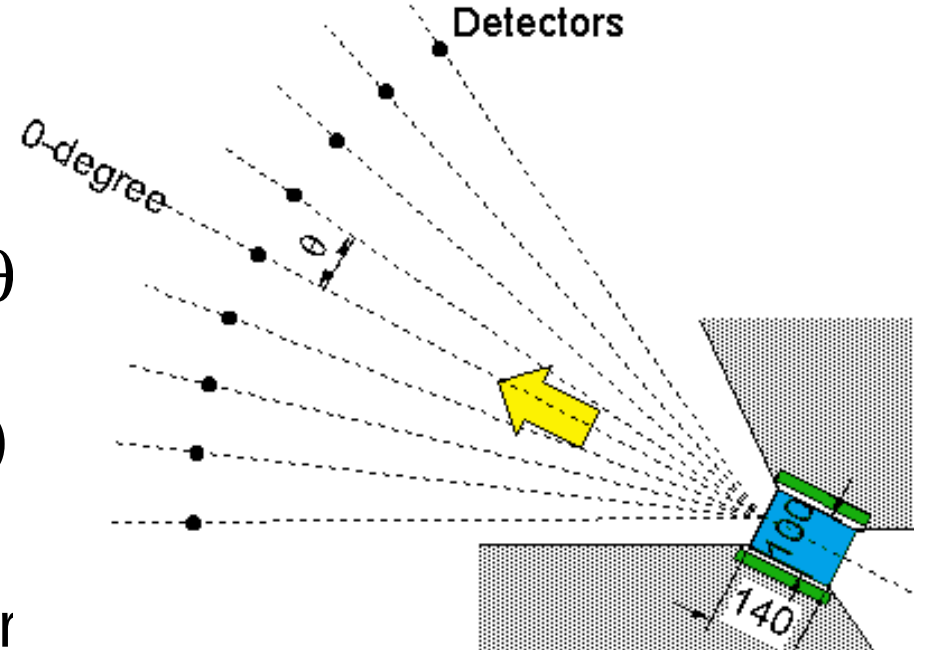
- 11 out of 23 instruments request the beam from the coupled moderator.
- Wide angular coverage (50.8° at max.) is indispensable for the coupled moderator.

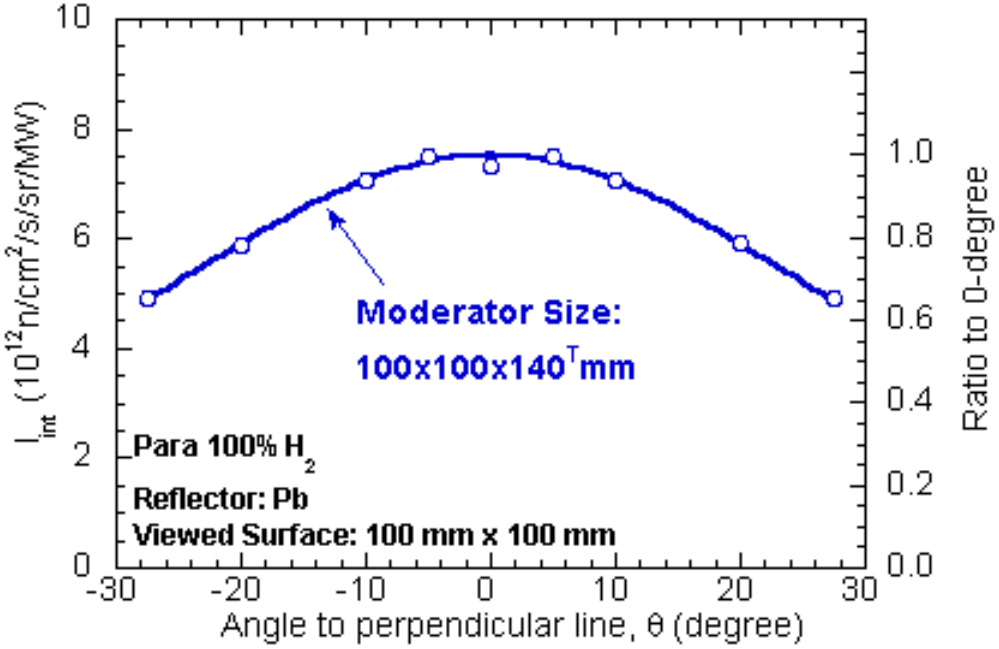


Angular Dependence

In case of rectangular shape

- I_{int} decrease with increasing θ
- $I_{int}(\theta = 25.4°) \sim 0.7 \times I_{int}(\theta = 0°)$
- Large decrease in I_{int} at larger θ is due to the decrease of effective viewed moderator volume with θ.

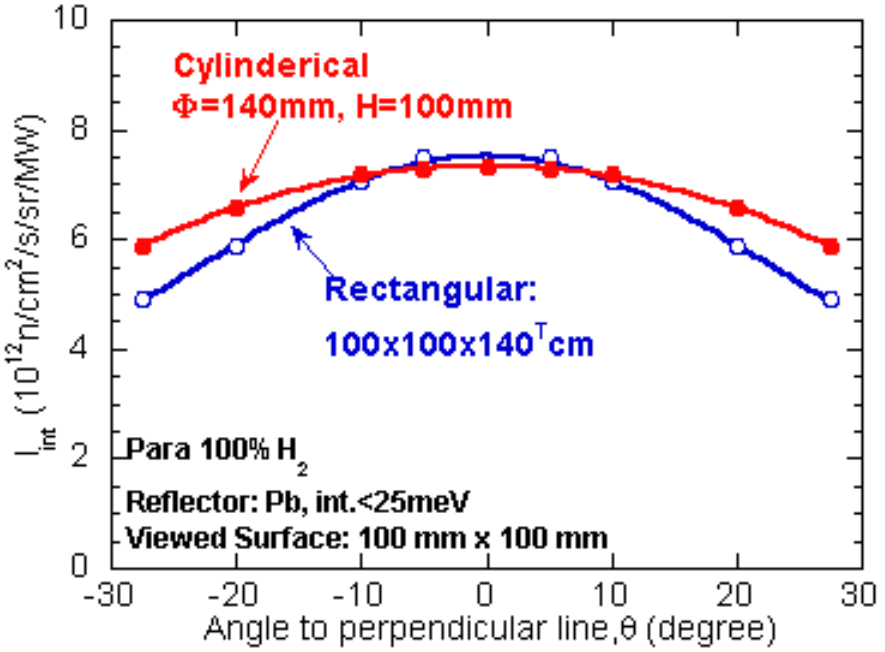


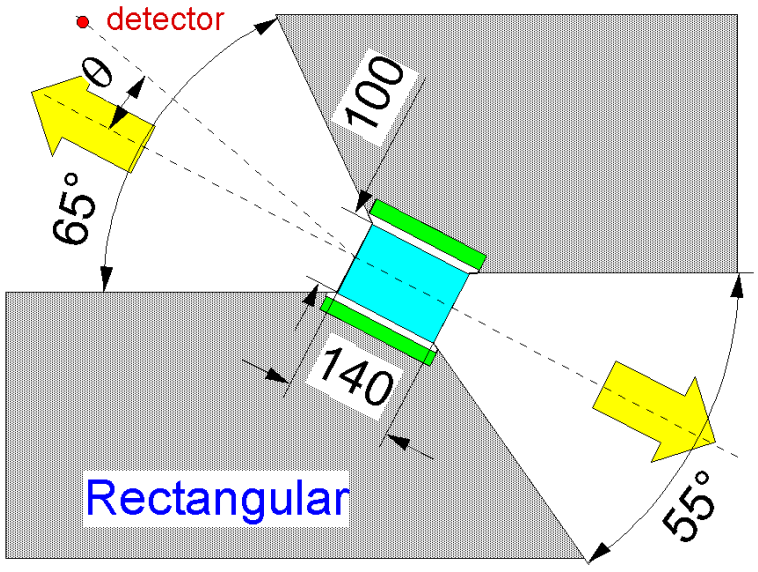


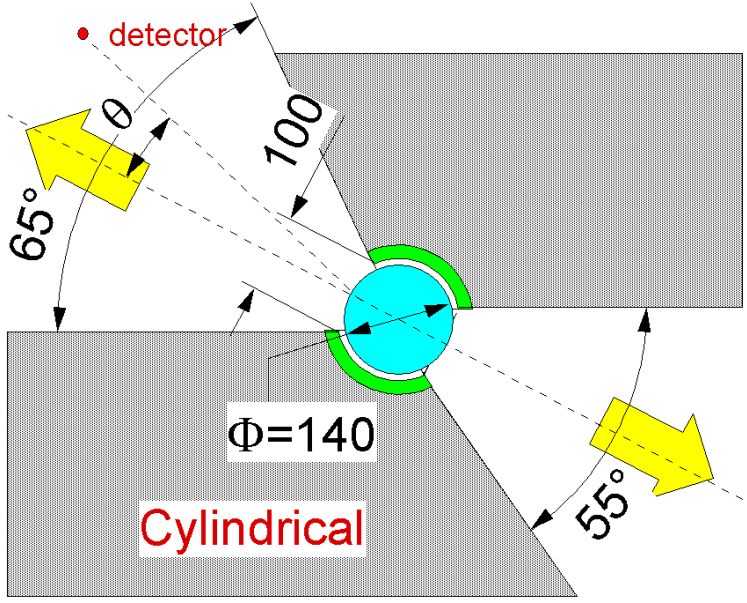
Proposal of Cylindrical Shape Moderator

- In order to improve θ dependence, cylindrical shape was proposed.
- $\int_{\theta\,\min}^{\theta\,\max} I_{\mathrm{int}}(q)dq$ increases

  by adopting the cylindrical.

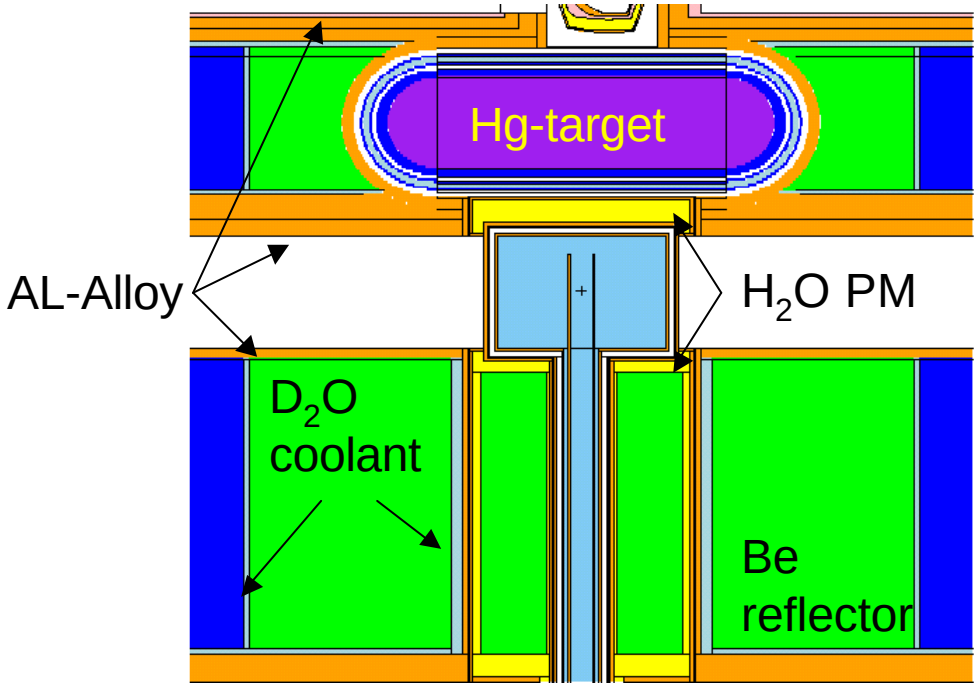


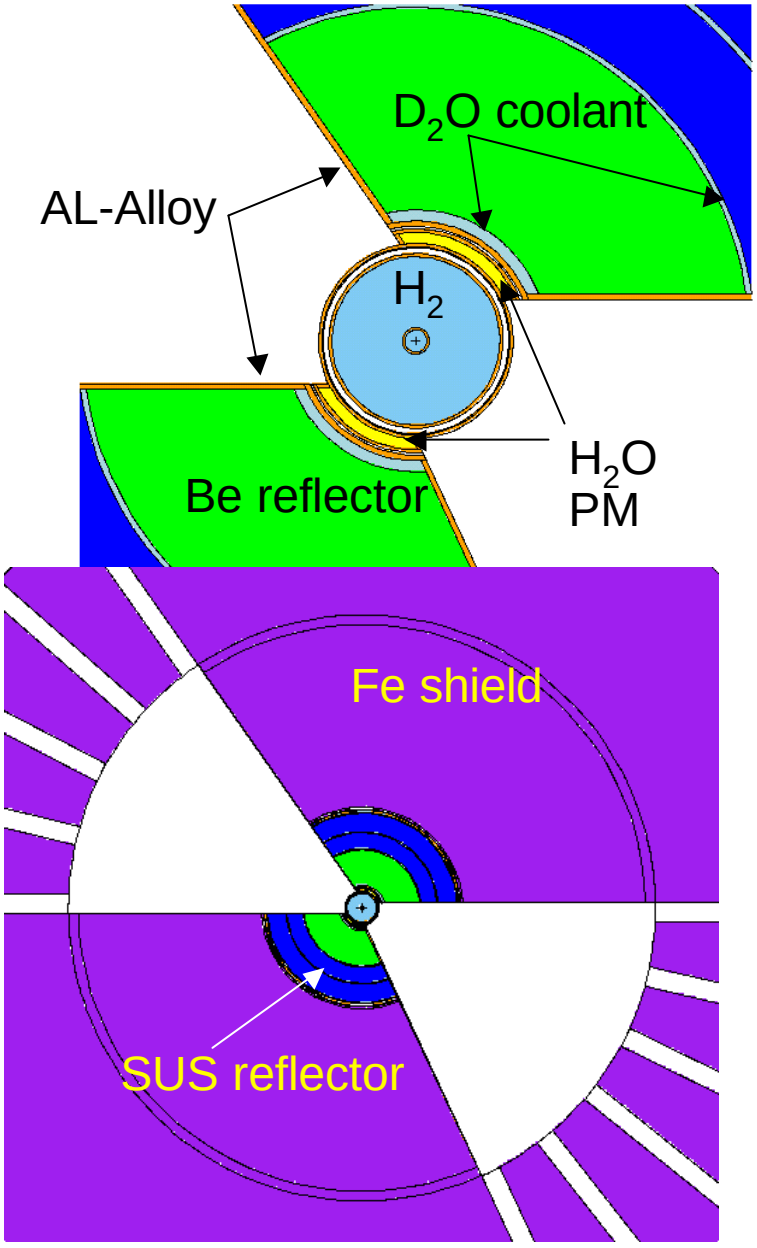




Optimization Study on Cylindrical Shape Moderator

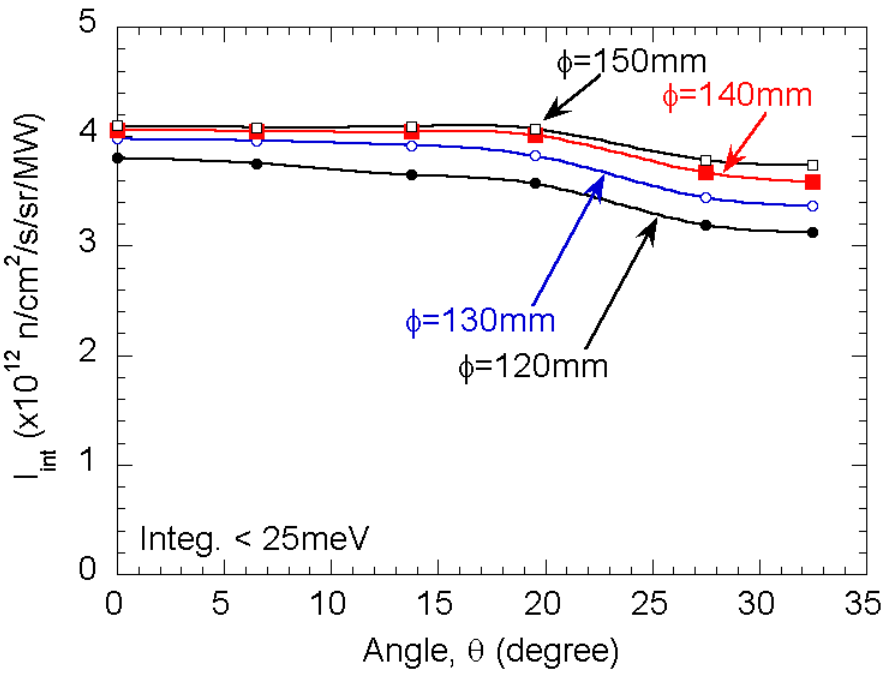
- More realistic model is adopted.
- Optimization studies:
  - Moderator diameter
  - Top and bottom shape of moderator chamber
  - Neutron beam origin

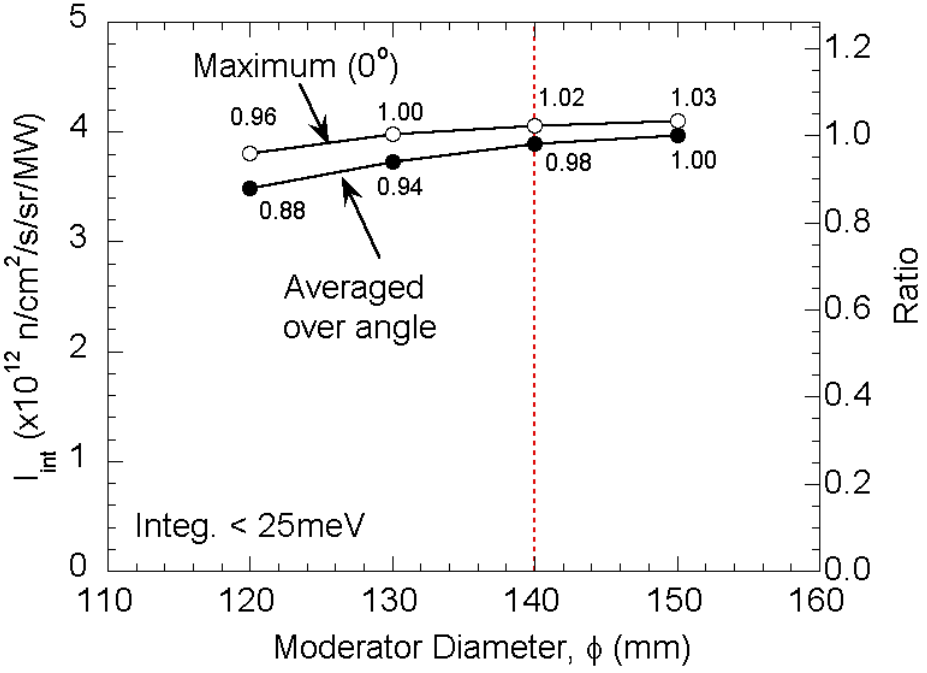




Diameter of Moderator

- θ dependence decreases with diameter (ϕ).
- Increase of I_{int} with ϕ is almost saturated at ϕ=140 mm.
- Optimum ϕ is ~140 mm.

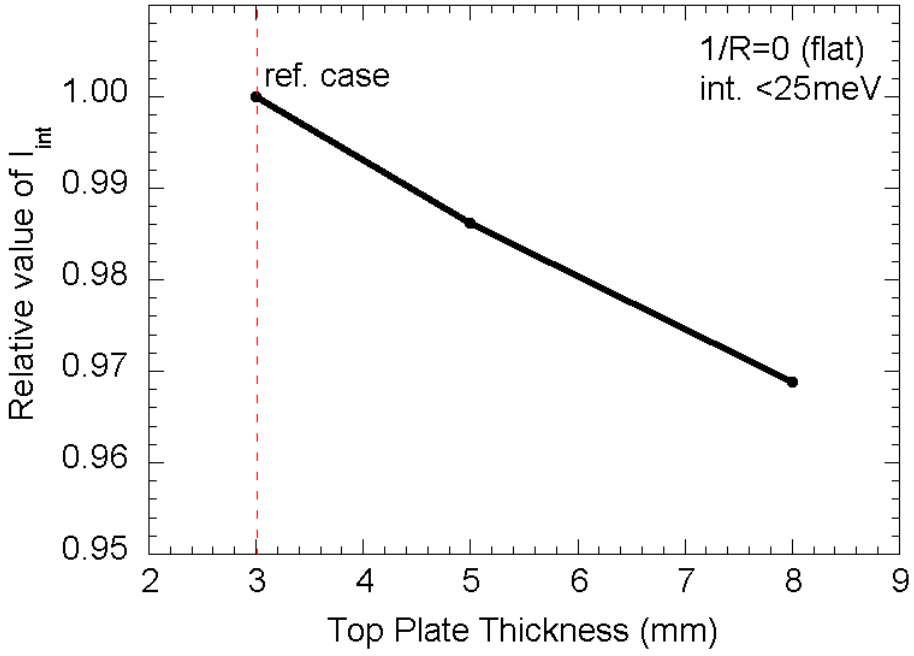


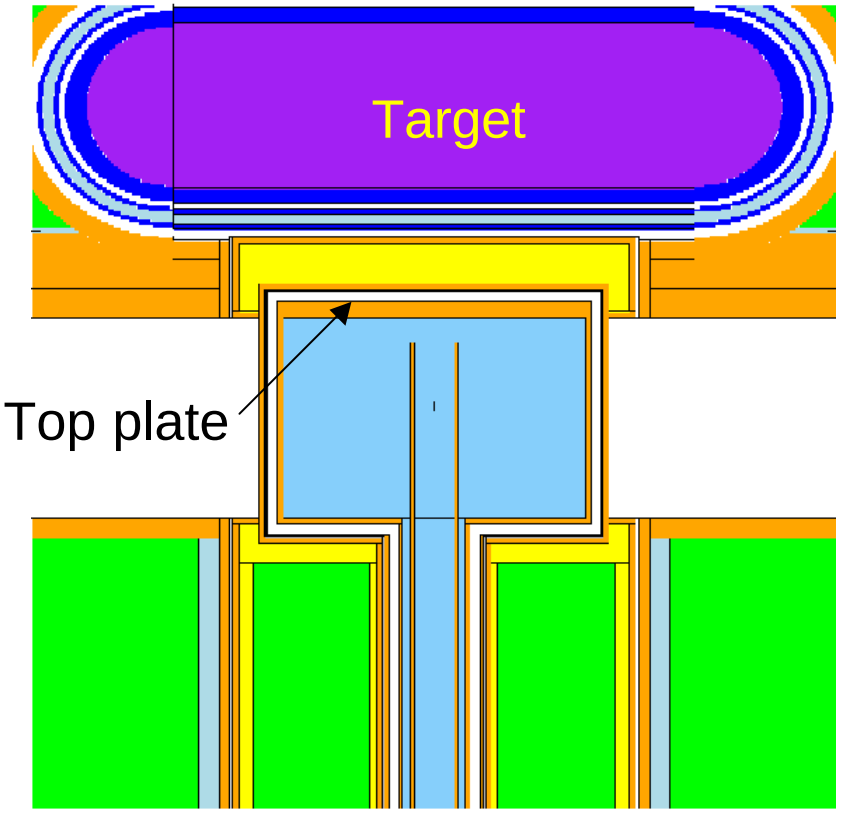


Top shape of Moderator Chamber (1)

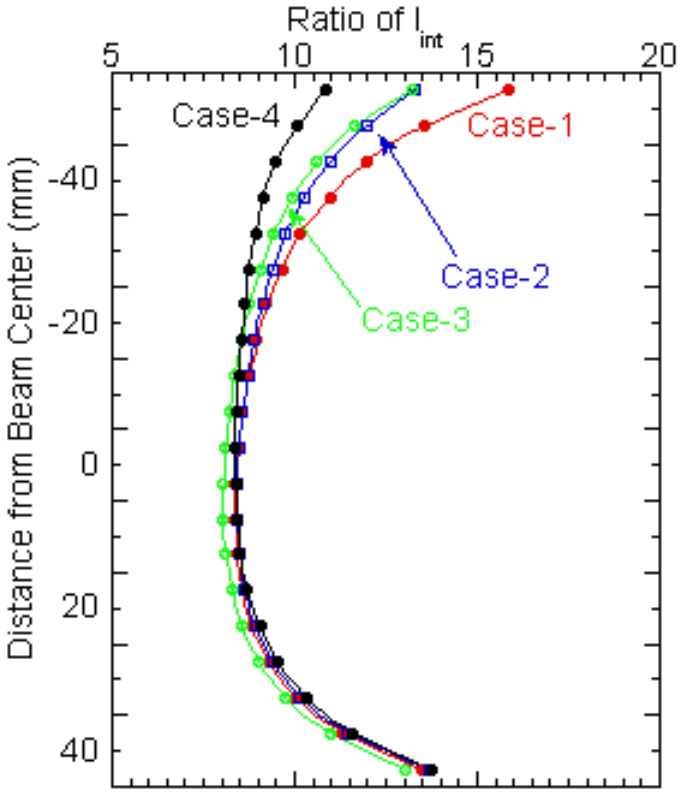
- I_{int} decrease with the top (target side) plate thickness.
- If thin plate is adopted, the plate must have a certain curvature to resist against inner pressure.
- Strategy of engineering design is studied.

  Thick flat or Thin curved?





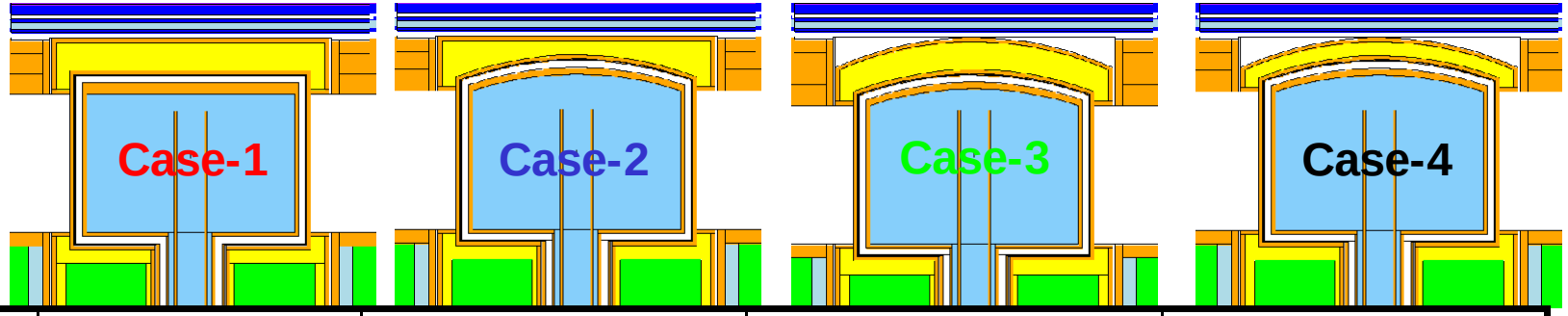
Top Shape of Moderator Chamber (2)



- I_{int} of 4 cases are compared.
- Highest I_{int} is provided by Case-1.
- Comparison of integrated-intensity

Case-1	Case-2	Case-3	Case-4
1.0	0.98	0.94	0.93

- Engineering design started with Case-1

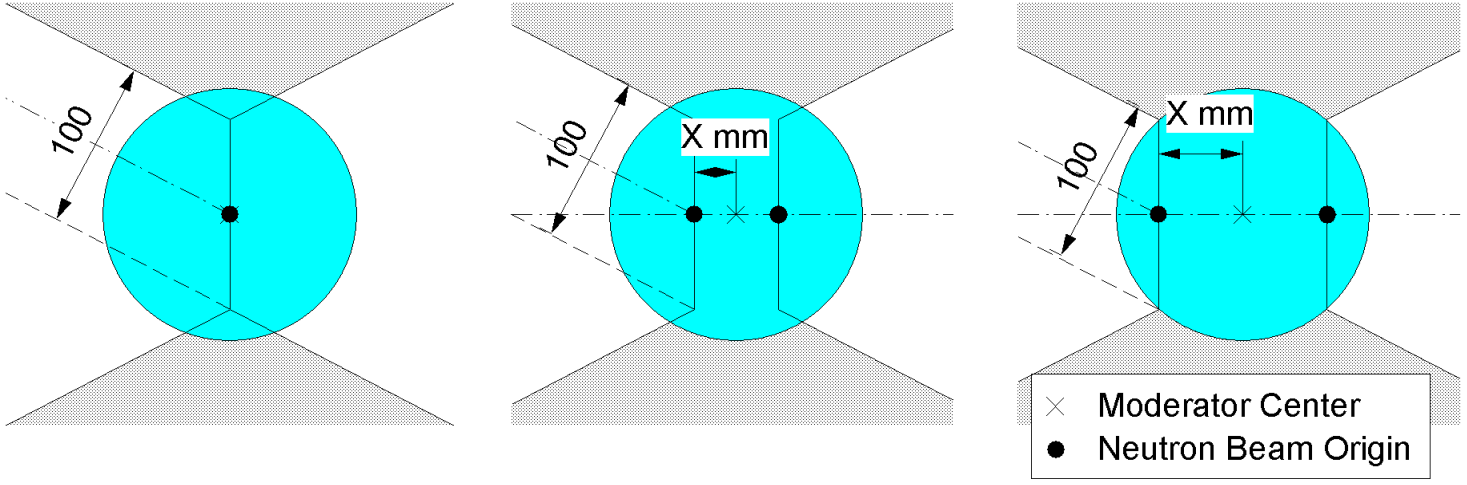


Thickness	8 mm	5 mm	5 mm	5 mm
Curvature	Flat	R=224 mm	R=224 mm	R=224 mm
PM-Thickness	20 mm	10 ~ 20 mm	20 mm	10 mm
Beam height	-156 mm	-155 mm	-165 mm	-155 mm

Neutron Beam Origin(1)

- Viewed surface is 100 x 100 mm.
- “Neutron beam origin” must be fixed.
- Choice of X is an important issue.

  (X: distance between neutron beam origin and moderator center)



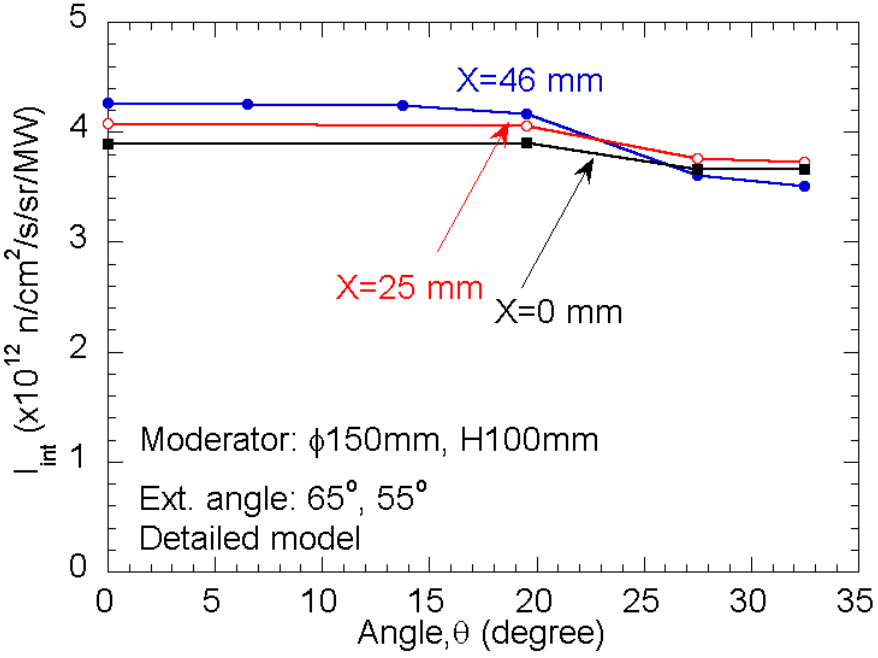
X=0 mm X=25 mm X=46 mm

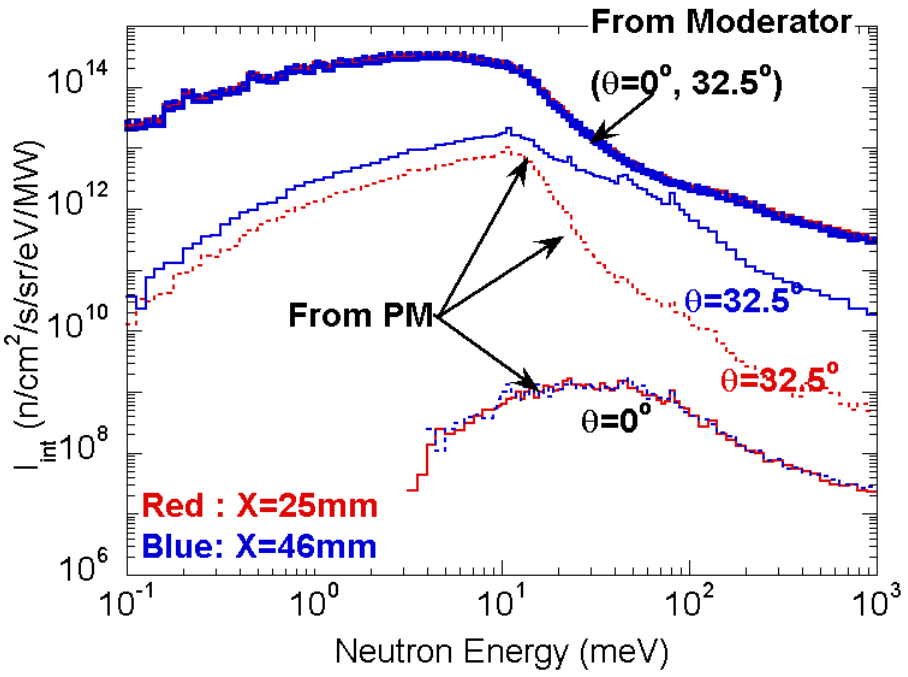
Neutron Beam Origin(2)

- $\bar{I}_{\mathrm{int}} (= \frac{1}{N} \int_{\theta\,\mathrm{min}}^{\theta\,\mathrm{max}} I_{\mathrm{int}}(\theta) d\theta)$ increases with the X value.
- $\bar{I}_{\mathrm{int}}(\mathrm{X} = 25\mathrm{mm}) = 0.97 \times \bar{I}_{\mathrm{int}}(\mathrm{X} = 46\mathrm{mm})$
- To avoid neutrons from PM,

  X=25mm is adopted rather than X=46mm.

  (with X=46mm, neutrons from PM may increase background at large θ.)





Summary

- Neutronic design of coupled H_2 moderator reaches completion.
- More studies will be carried out to give suggestions for engineering design.