Memo
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Pulse characteristics estimation for 23 neutron beam lines at JSNS

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1 Outline

Neutron pulse characteristics at 23 neutron beam lines planned at JSNS have been calculated on the basis of the target-moderator-reflector assembly design on August, 2003. The calculation models are shown in **Figs. 1 to 6**. The major parameters and conditions used in the calculation are summarized in **Table 1** in which the names of employed codes are also listed. The neutron characteristics have been evaluated using point detector on the neutron beam line center at 10 m from the surface of moderator. The neutron beam ports from No.7 to No.9 and those from No.18 to No.20 view front and rear surface of the poisoned moderator, respectively, in which the distances from surface to Cd poison are 2.5 cm for the former ports and 3.7 cm for the latter. It is noted that the neutron beam line is modeled as just a rectangular port of 10 x 10 cm^2 located in a shielding without complicated beam line components such as neutron beam windows, collimators, guide tubes. Once a particle has gone out of the neutron beam line at the outer region of target monolith with a radius of 4 m, its trajectory is not traced in the calculation by setting the importance as zero.

2 Results

Time-integrated neutron intensities, peak intensities and the full width at half maximum (FWHM) of peak at some neutron ports are shown in **Figs. 7 to 9**. Here, target is located on the positive direction on the Y-axis for the coupled moderator. It is located on the negative direction on the Y-axis for the decoupled ones. The proton beam goes from positive to negative direction of X-axis for neutron beam ports No.3, 8 and 11. On the other hand, the proton beam goes reverse direction on X-axis for neutron beam ports No.15, 19 and 22. The neutron brightness distributions on the viewed surfaces of moderators are shown in **Figs. 10 to 15**. The absolute brightness is normalized to unity when it is integrated over the whole moderator surface of 10×10 cm^2. Brightness was obtained in the mesh of 1×1 cm^2. This means that the brightness at a single mesh is 0.01 if neutron is emitted uniformly from the moderator surface. For coupled moderator, i.e. neutron beam ports No.3 and No.15, the intensity of neutrons with energies lower than 10 meV is about 1.5 times higher at the edge than the center. On the other hand, it is about twice at the center as much as at the edge for the decoupled moderator. This position dependence of neutron intensity is evaluated to be about half for neutrons with energies from 10 meV to 1 eV. Furthermore, the intensity of neutrons higher than 1 eV shows gradual decrease as the distance from the target increases.

3 Notes

1. Some deviations caused by poor statistics can be seen in the present data because any smoothing correction has not been done to the calculated results. This deviation is obvious at the tail part of the neutron pulse and at the high energy part of the neutrons from the decoupled moderator.

2. In this calculation, proton beam power is assumed to be 1 MW at the proton beam window position. Considering a beam delivery to 50 GeV ring and a consumption at the muon target in front of the neutron source, in fact, the beam power decreases to 0.9 MW in time average even though full power (1 MW) operation. The neutron intensity decreases according to this fraction, *i.e.* 0.9.

3. Present calculation uses a scattering kernel obtained under the condition of free gas model for aluminum which is main structural material of the moderator. This may cause small ambiguity of neutron pulse characteristics.

4. If some design changes are made in the manufacturing process because of inevitable reasons, pulse characteristics would change, too.

5. The proton beam is planned to be delivered with two bunch structure in time scale. This is not taken into account in this evaluation. The time difference between the two bunches is about 0.6 μs so that this could affect peak shape in case the pulsed neutrons with energies higher than 1 eV are used in experiments.

Table 1: Major parameters used in the calculation.

Item	Sub-item	Tools and parameters
Computation codes	Transport for high energy protons and neutrons	PHITS Ver.1.52
	Sub-neutrons	MCNP-4C3
Model version		Ver.20.12.04
Proton beam	Beam power	1 MW at proton beam window
	Beam profile	Uniform of 81mm mrad in phase space
		18×7 cm^2 at target surface
	Repetition rate	25Hz
	Deviation	$1\sigma = 0.68$ cm (Horizontal)
	of beam center	$1\sigma = 0.06$ cm (Vertical)
Proton beam window	Material / thickness	Aluminum alloy (A5083) / 2.5 mm^t $\times$ 2
	Coolant / channel width	Light water / 3.0 mm^t
Moderator	Material	Liquid hydrogen(Para 100%), 20K
	Container	Aluminum alloy (A6061)
	Coolant	Light water
Reflector	Inner: Material / dimension	Beryllium / ϕ50 cm$\times$100 cm
	Outer: Material / dimension	Iron / ϕ100 cm$\times$100 cm
	Container	Aluminum alloy (A6061)
	Coolant	Heavy water
Water-cooled shielding	Material	Mixture of 90% SS304L and 10% light water in volume fraction
Middle section of helium vessel	Material	Mixture of 90% SS304L and 10% light water in volume fraction
Neutron beam duct	Size	10$\times$10 cm^2
Tally	Type	Point detector
	Position	Center of each neutron beam duct
	Distance	10 m from the viewed surface of moderator
	Number	24 including 2 positions in different height for beam port No.16

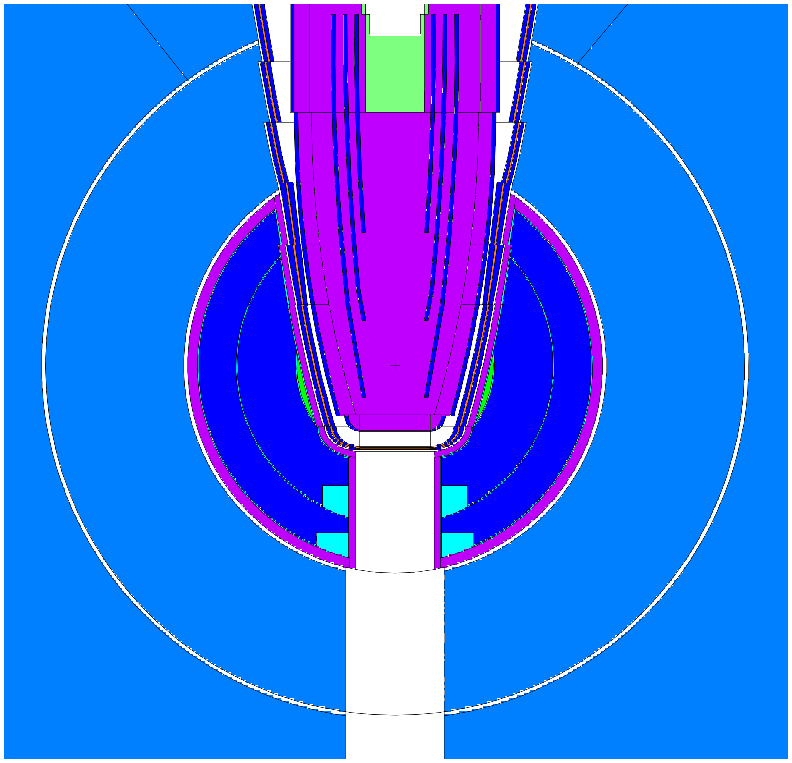

Figure 1: Monte Carlo model of the target and reflector showing plan view at the center elevation of the target.

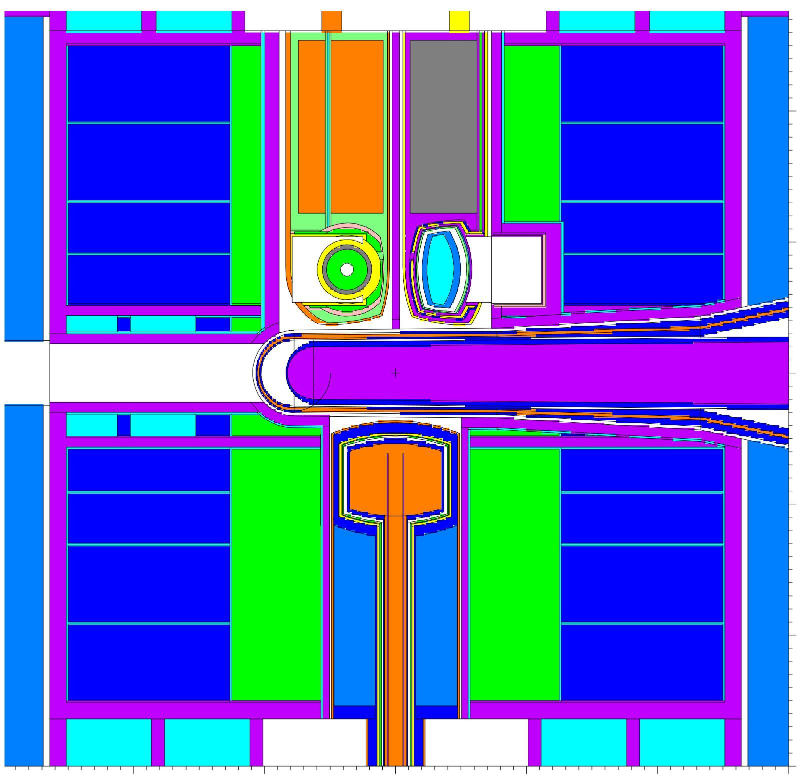

Figure 2: Monte Carlo model of the target-moderator-reflector assembly showing elevation view.

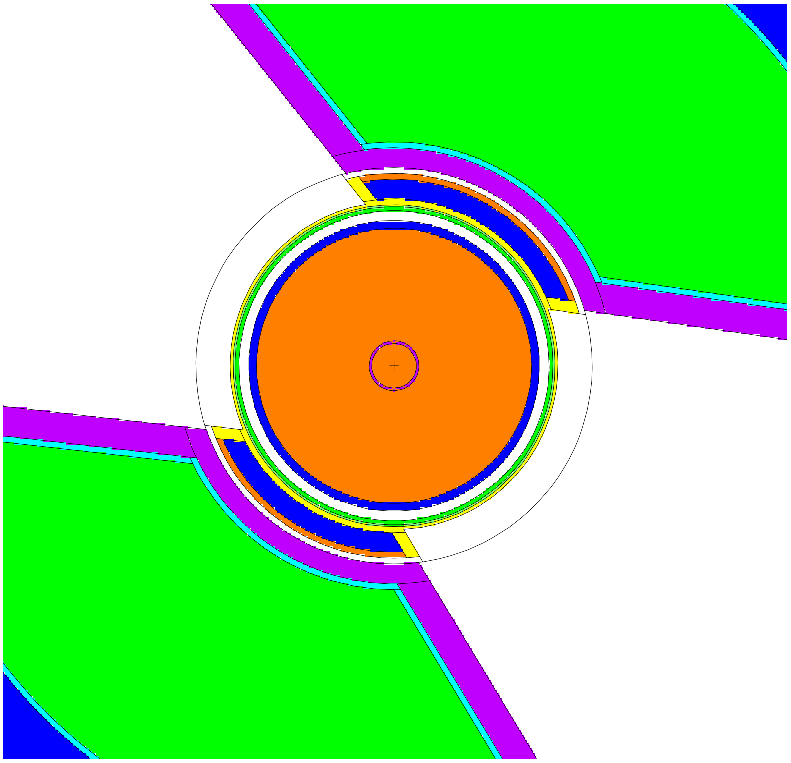

Figure 3: Monte Carlo model of the coupled moderator and its surroundings showing plan view.

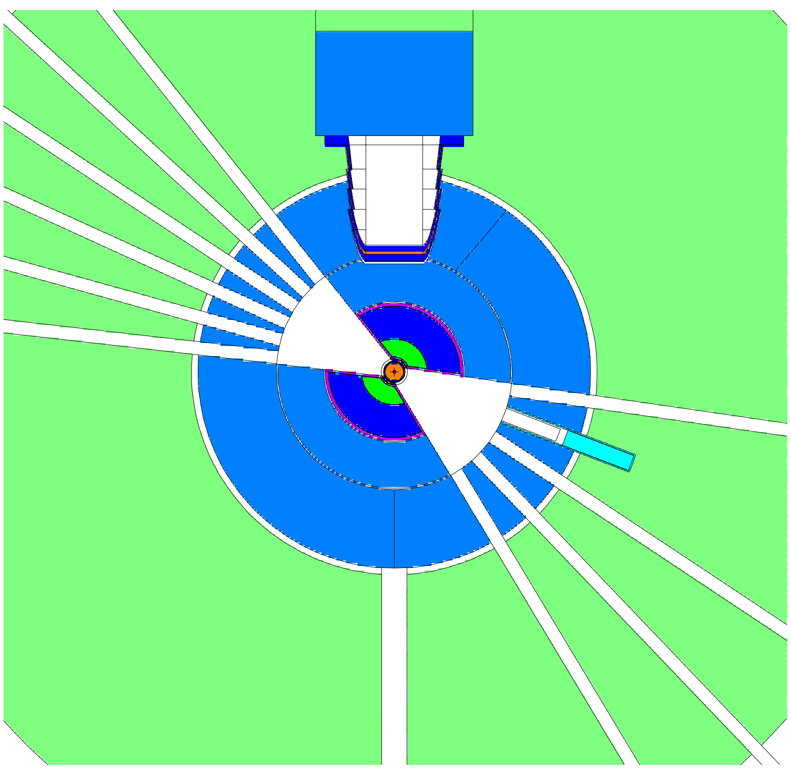

Figure 4: Monte Carlo model of the target station showing plan view. The plan view is taken at the elevation of the couple moderator.

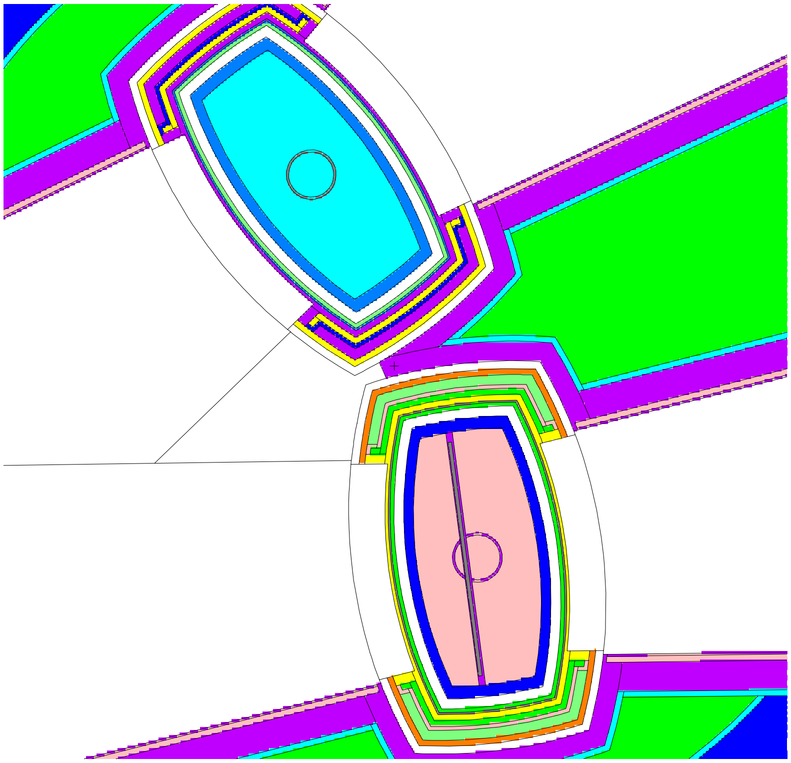

Figure 5: Monte Carlo model of the decoupled moderators and its surroundings showing plan view.

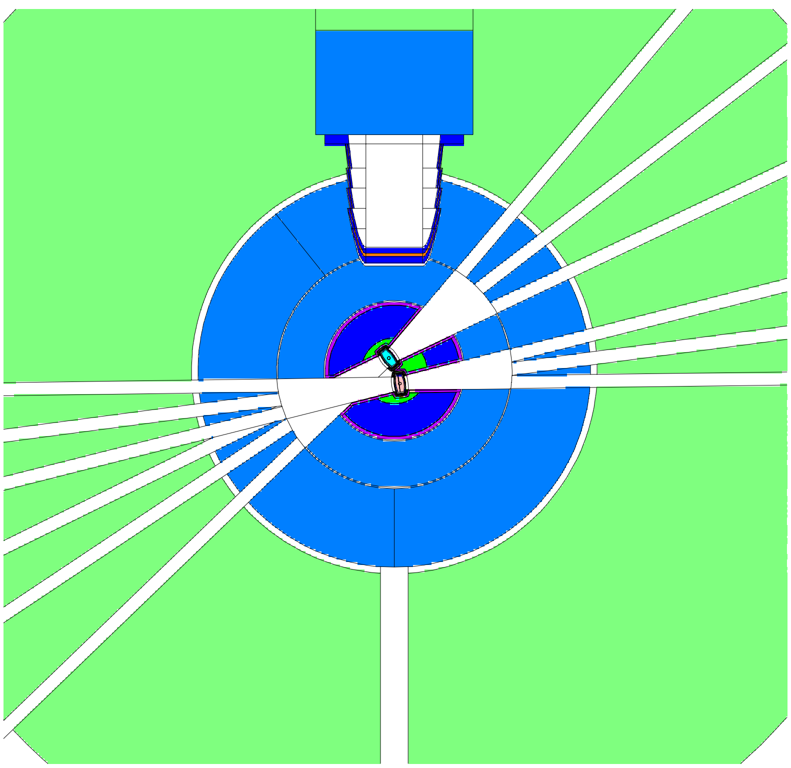

Figure 6: Monte Carlo model of the target station showing plan view. The plan view is taken at the elevation of the decoupled moderators.

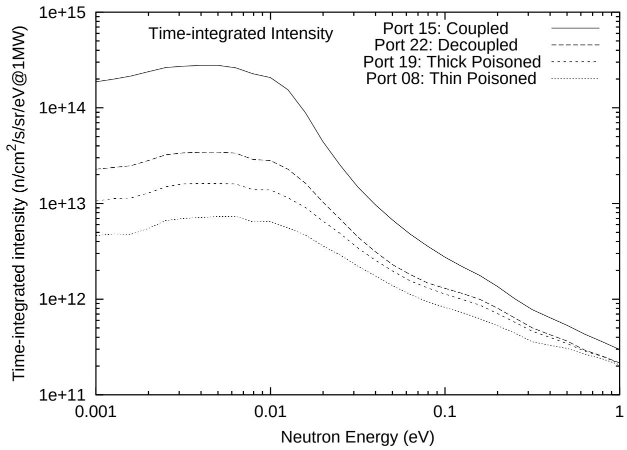

Figure 7: Calculated time-integrated neutron-intensities at the beam ports of No.8, 15, 19 and 22.

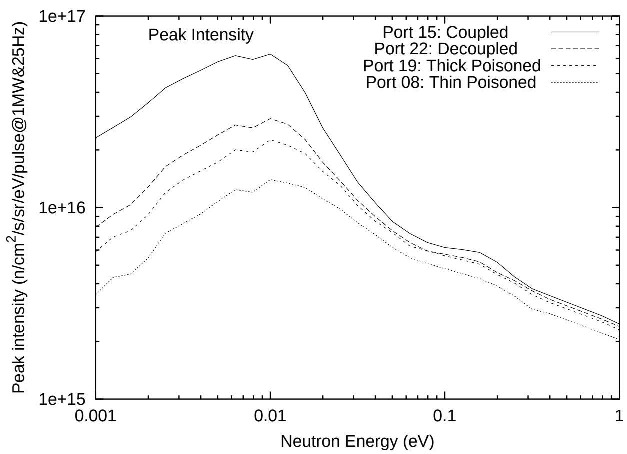

Figure 8: Calculated peak-intensities at the beam ports of No.8, 15, 19 and 22.

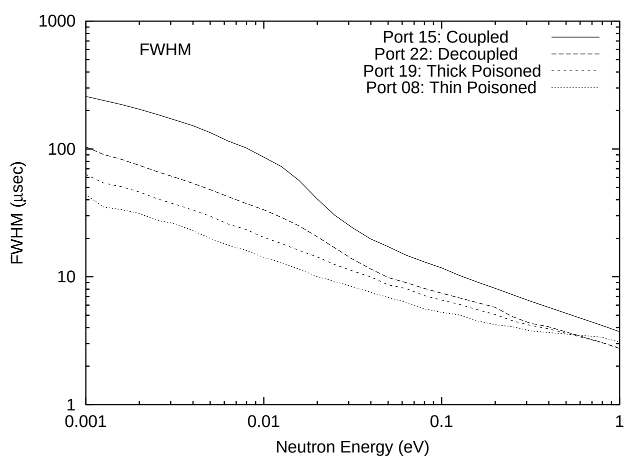

Figure 9: Calculated FWHM of neutron pulses at the beam ports of No.8, 15, 19 and 22.

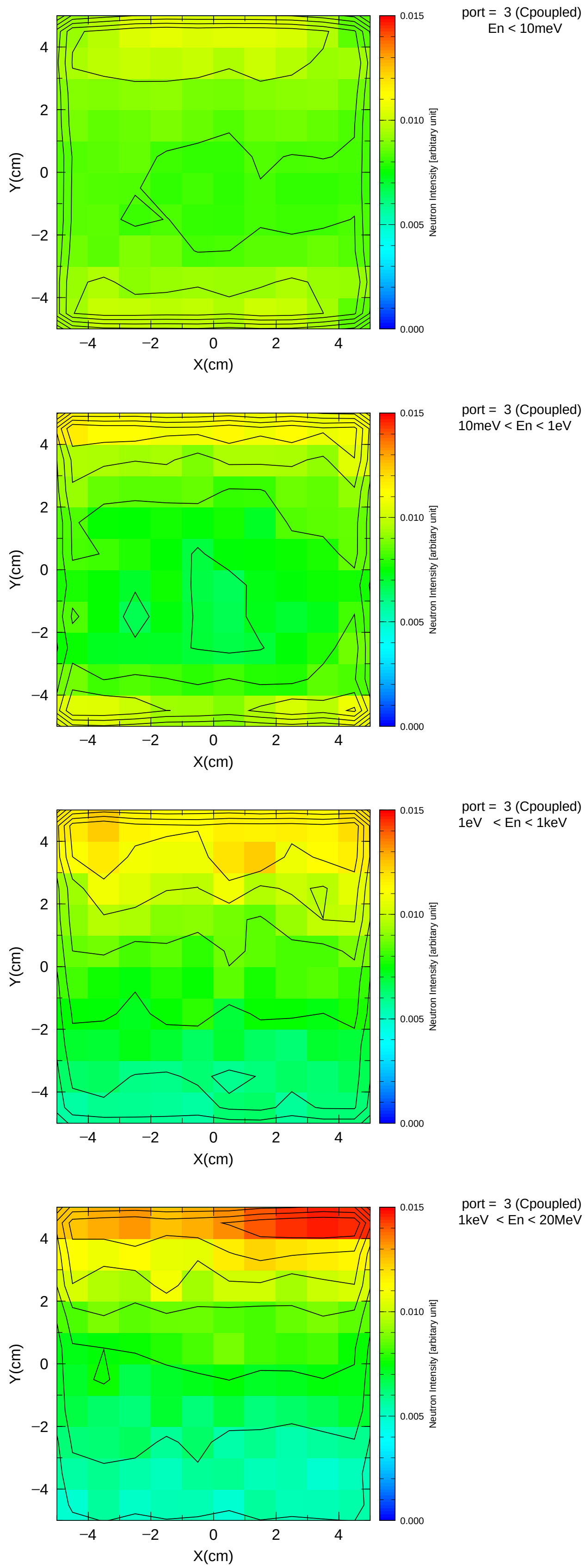

Figure 10: Contour of calculated neutron brightness at the viewed surface of coupled moderator for beam port No.3.

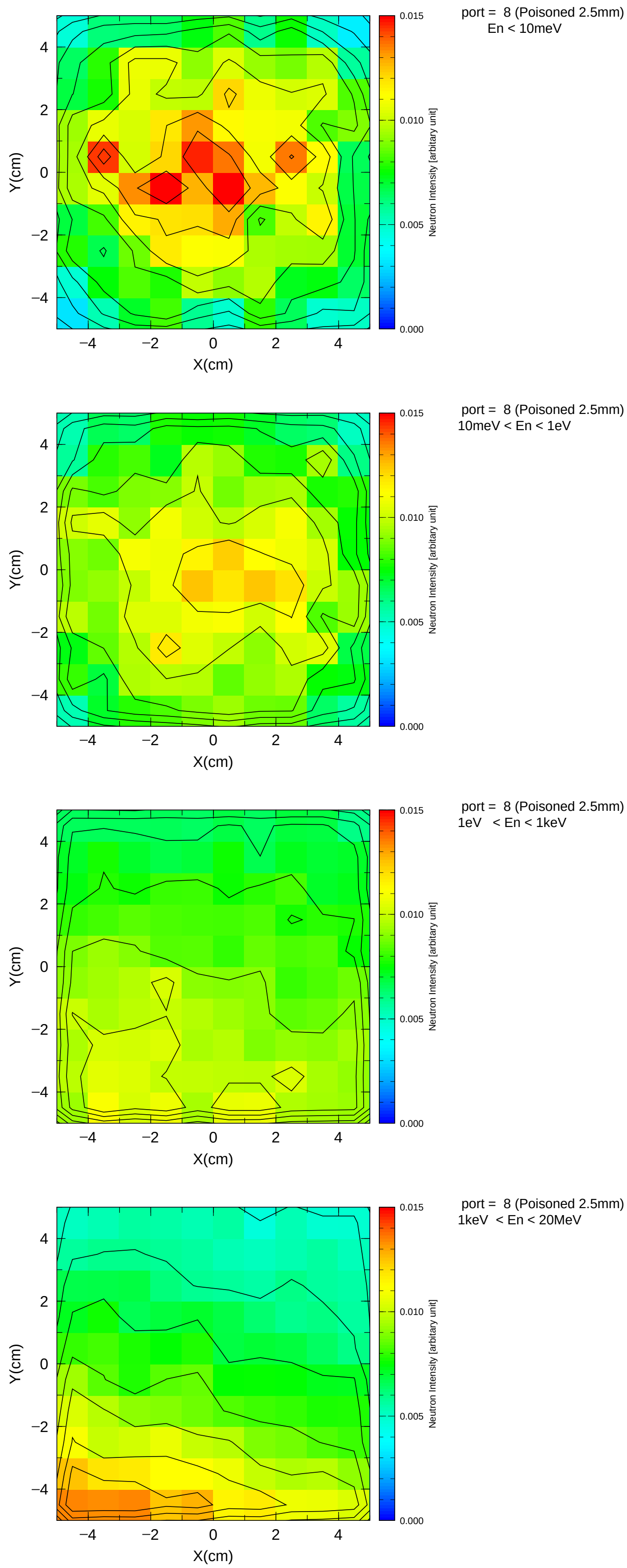

Figure 11: Contour of calculated neutron brightness at the viewed surface of decoupled moderator containing thin Cd poison plate for beam port No.8.

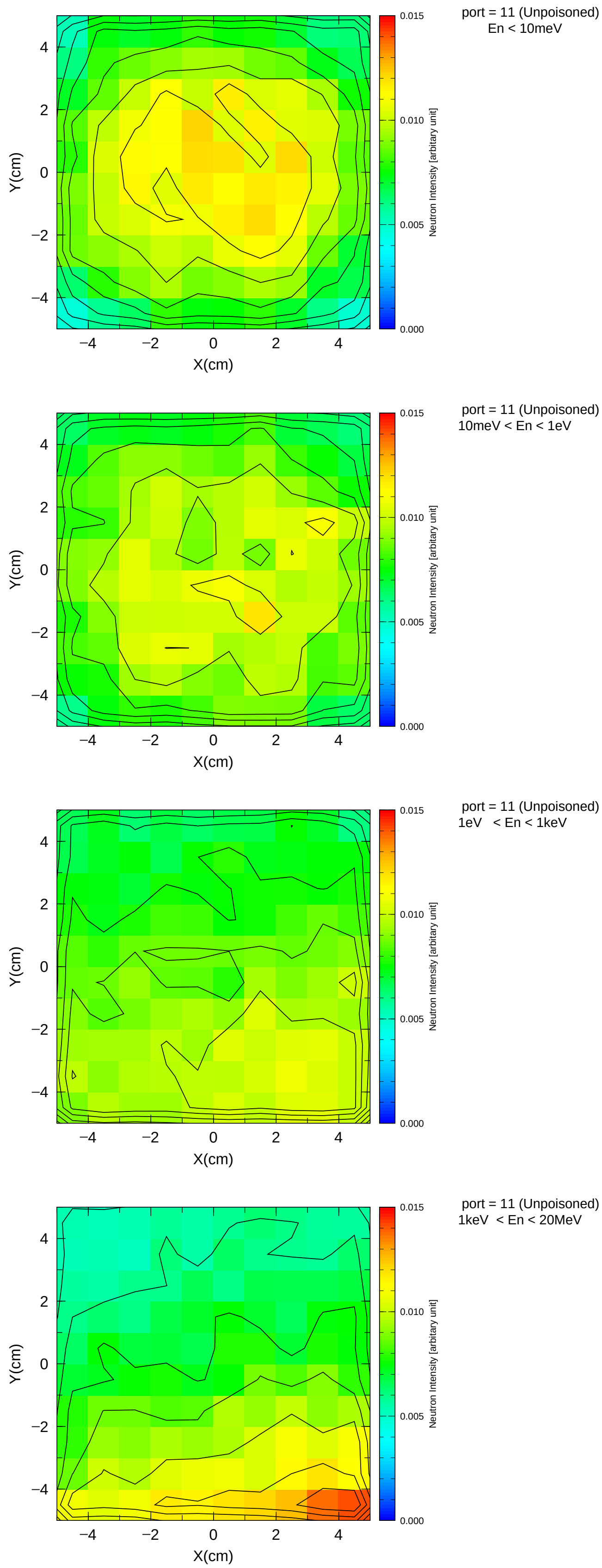

Figure 12: Contour of calculated neutron brightness at the viewed surface of decoupled moderator for beam port No.11.

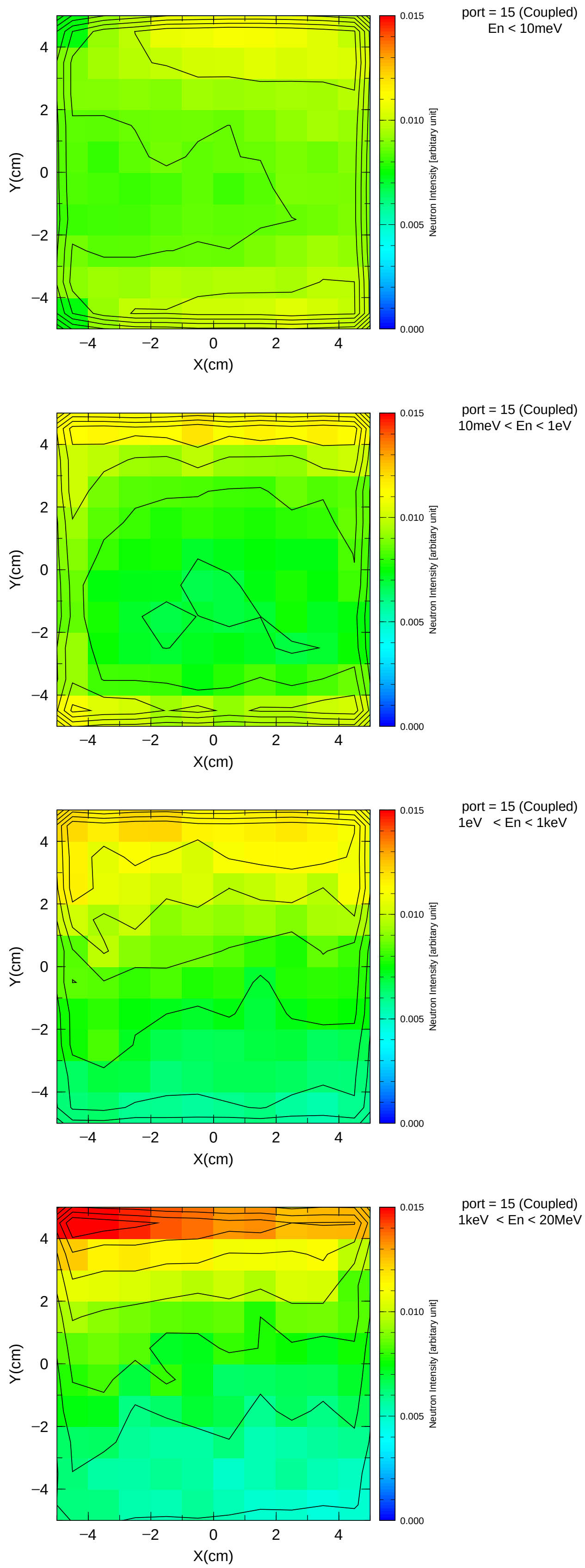

Figure 13: Contour of calculated neutron brightness at the viewed surface of coupled moderator for beam port No.15.

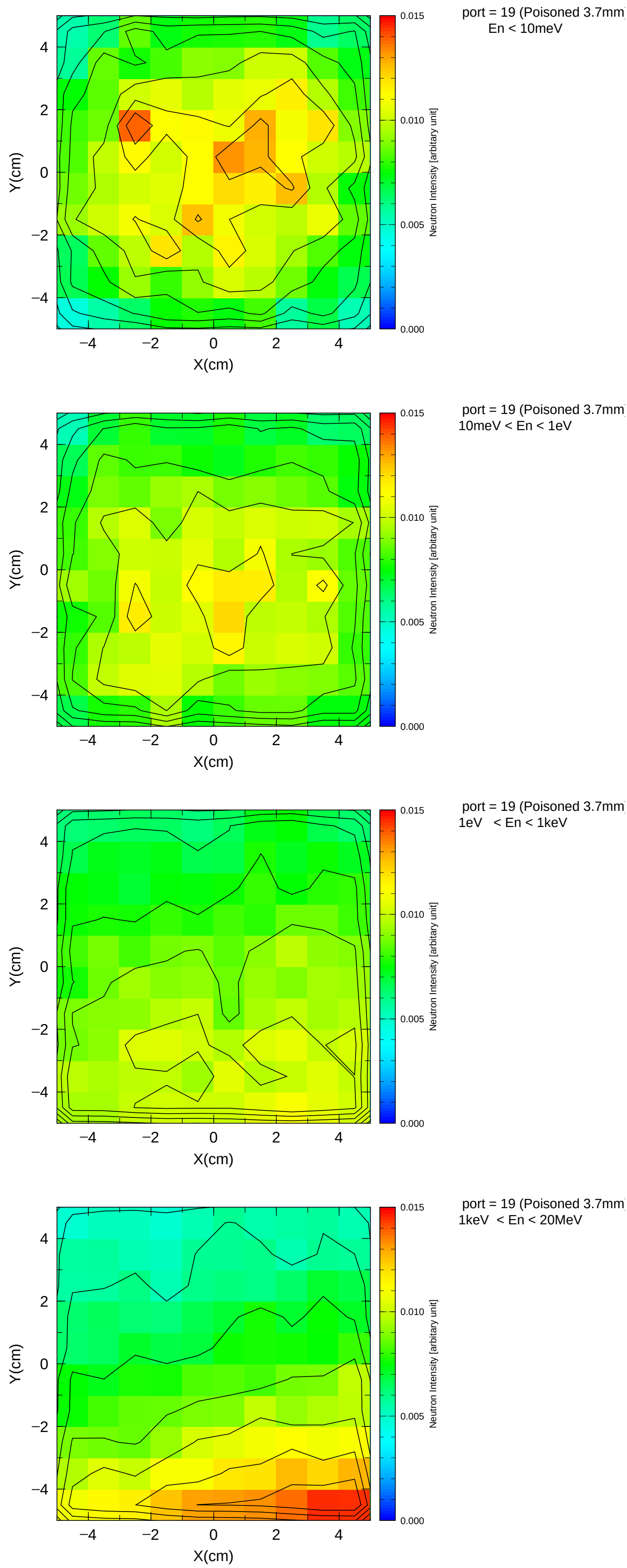

Figure 14: Contour of calculated neutron brightness at the viewed surface of decoupled moderator containing thin Cd poison plate for beam port No.19.

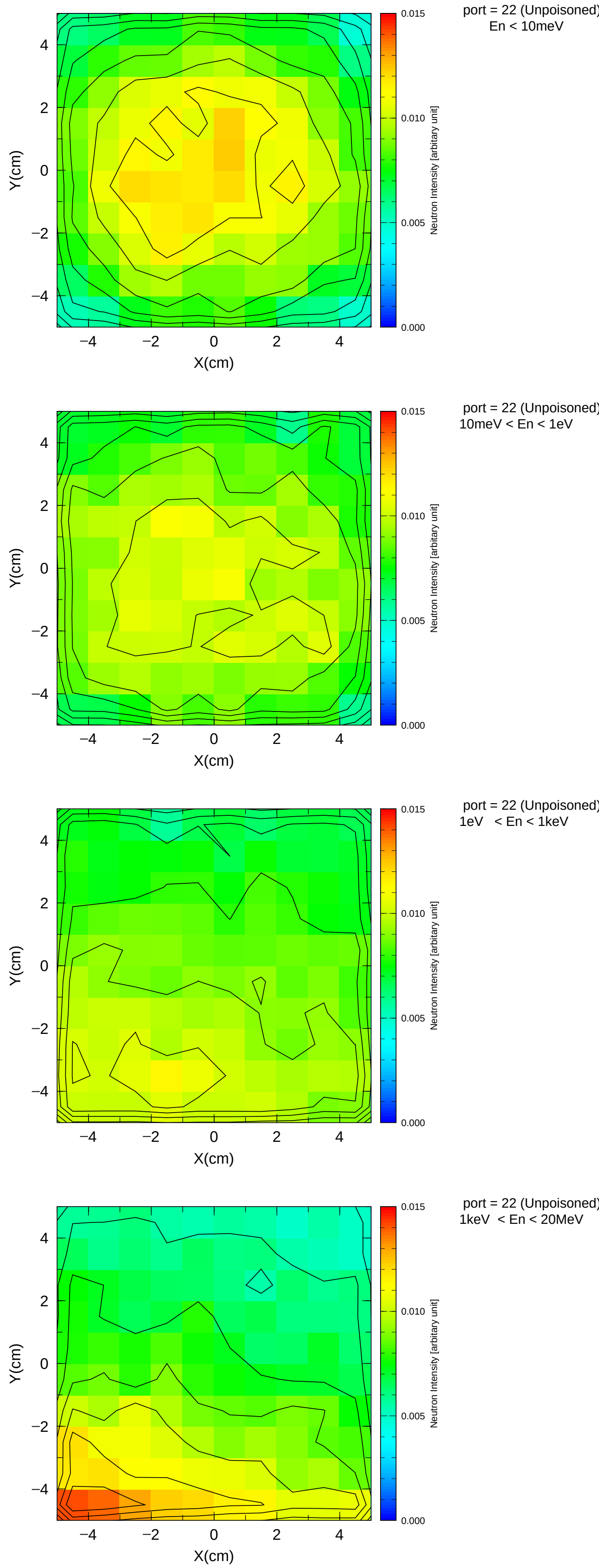

Figure 15: Contour of calculated neutron brightness at the viewed surface of decoupled moderator for beam port No.22.