EUROPEAN SPALLATION SOURCE

About Flat Moderators
Current Status of Neutronic Work

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Flat Moderator Kickoff Meeting
2013-10-02

TSDU Baseline 2011 December

EDMS No 1166507 (extracts from Tables 1-3)

Conventional Moderator

Total range for beam extraction view angles on each side of the moderator	125°	ESS Beam Extraction Baseline / Science Division
Angular separation between neutron beam guides	5°	ESS Beam Extraction Baseline / Science Division
Number of available neutron beam ports inside the monolith	48	ESS Beam Extraction Baseline / Science Division

Moderator shape	Cylindrical
Moderator diameter (inner vessel dimension)	0.16 m
Moderator height (inner vessel dimension)	0.13 m
Moderator fluid	Para-H_2
Moderator temperature	20 K
Pre-moderator fluid	H_2O + 0.1(vol)%He[1]
Pre-moderator temperature	330 K
Moderator window surface viewable by the beam lines[2]	0.12 m x 0.12 m
Thickness of optional cooled Be filter-reflector in front of the moderator	0.1 m
Optional extended pre-moderator surface at the side of the moderator to be viewable by beam lines for bi-spectral beam extraction[3]	0.12 m x 0.11 m
Inner reflector material	Be
Outer reflector material	Steel
Inner reflector diameter	0.6 m
Vertical distance between centre of target wheel and centre of moderator vessel	0.18 m
Distance between target wheel tungsten maximum horizontal radius and centre axis of moderator vessels	0.10 m
Minimum gap between the target wheel outer surface and the surface of each pre-moderator facing the target for operating conditions and handling	10 mm
Thickness of the pre-moderator water layers facing the target wheel (excl. water containment)	20 mm

PMR plug outer diameter	1.3 m
PMR plug height (both upper and lower part included)	1.5 m
Inner reflector thickness above and below moderators	0.2 m
Moderator vessel material	Al

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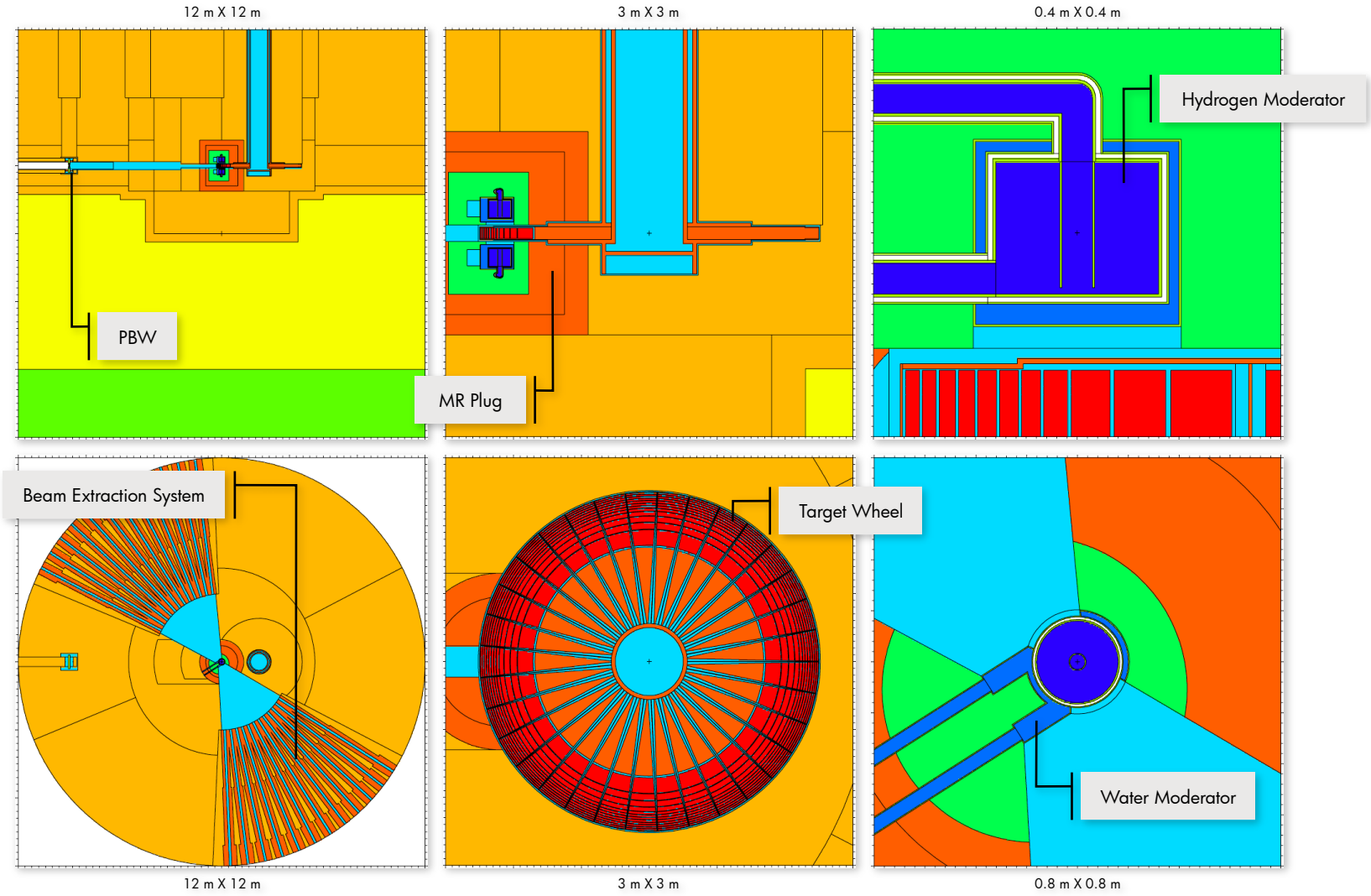
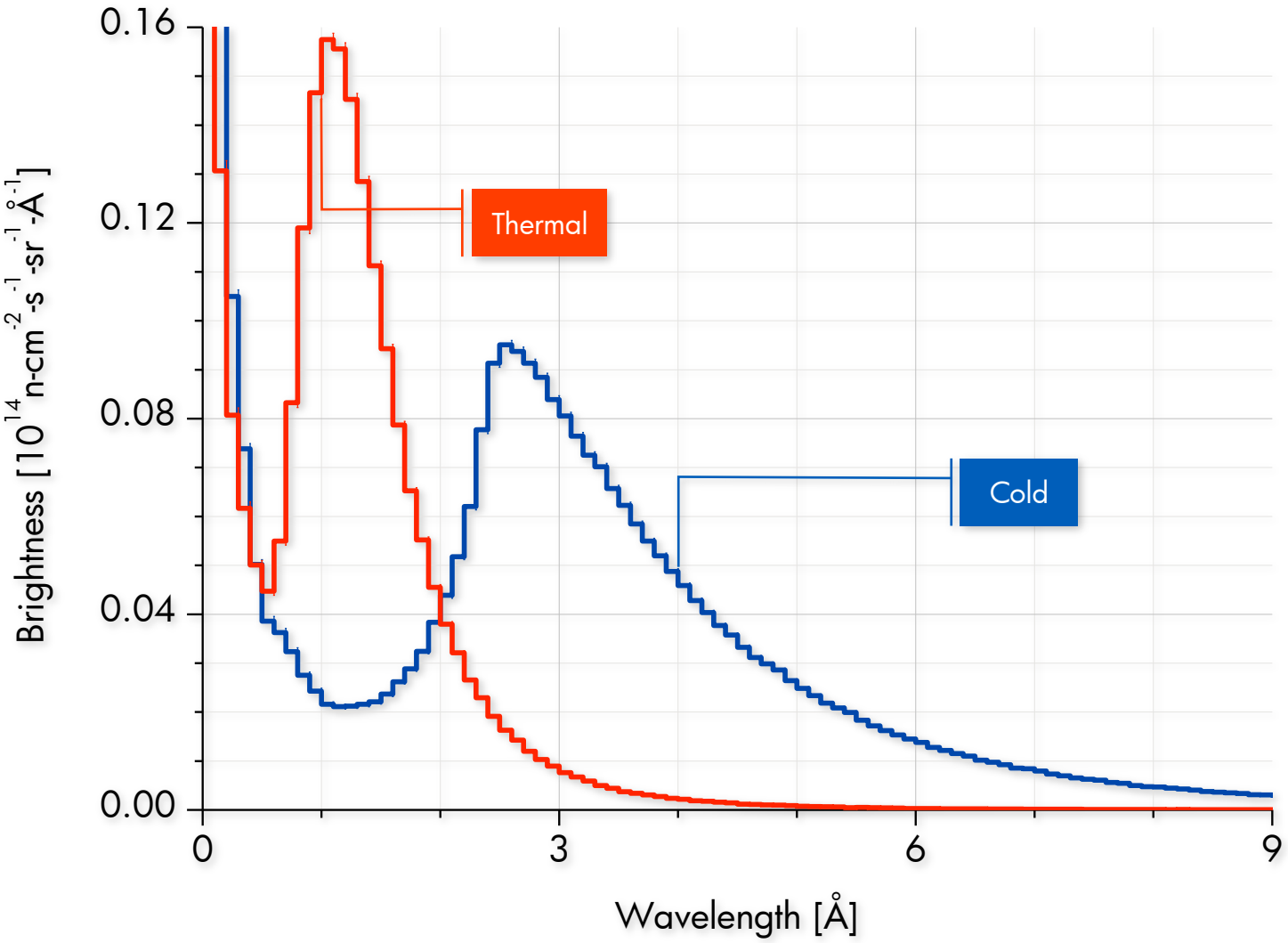
TARGET STATION MONOLITH

MCNP/PHITS neutronic model 2013-03-18



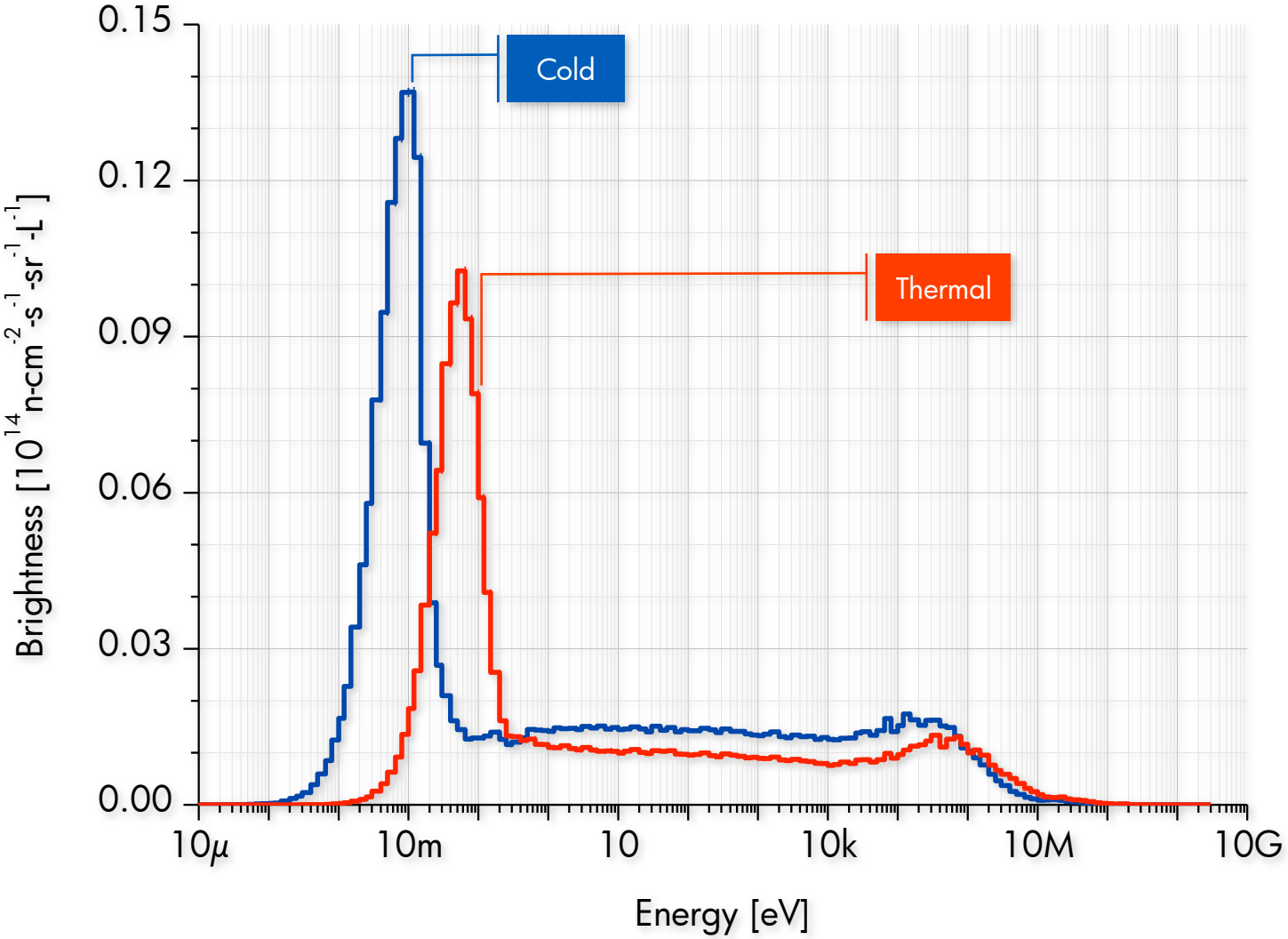
Spectral Brightness

Time-average brightness vs wavelength



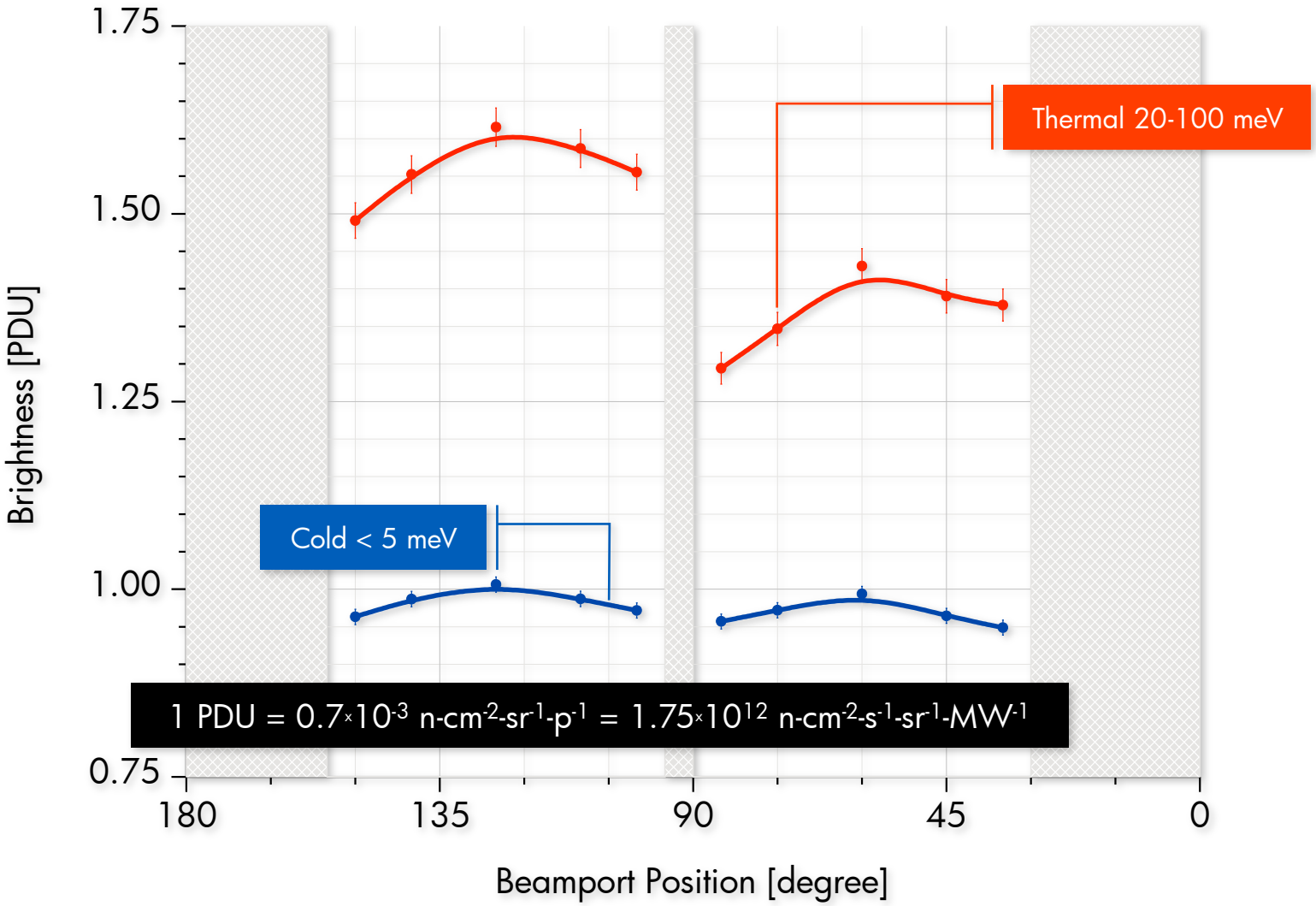
Brightness Lethargy Distribution

Time-average brightness vs energy



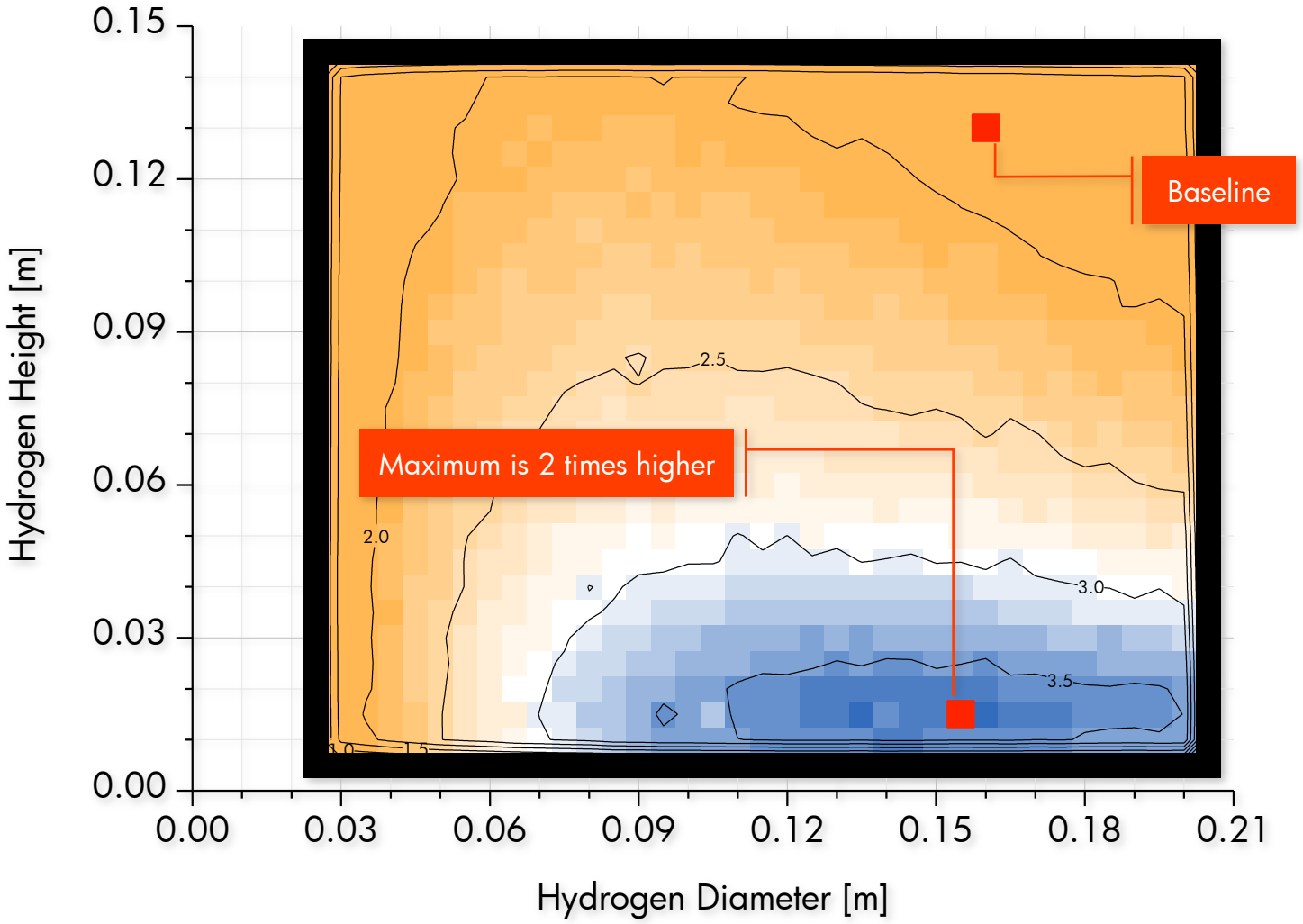
INTEGRAL BRIGHTNESS

Time-average brightness vs beamport position



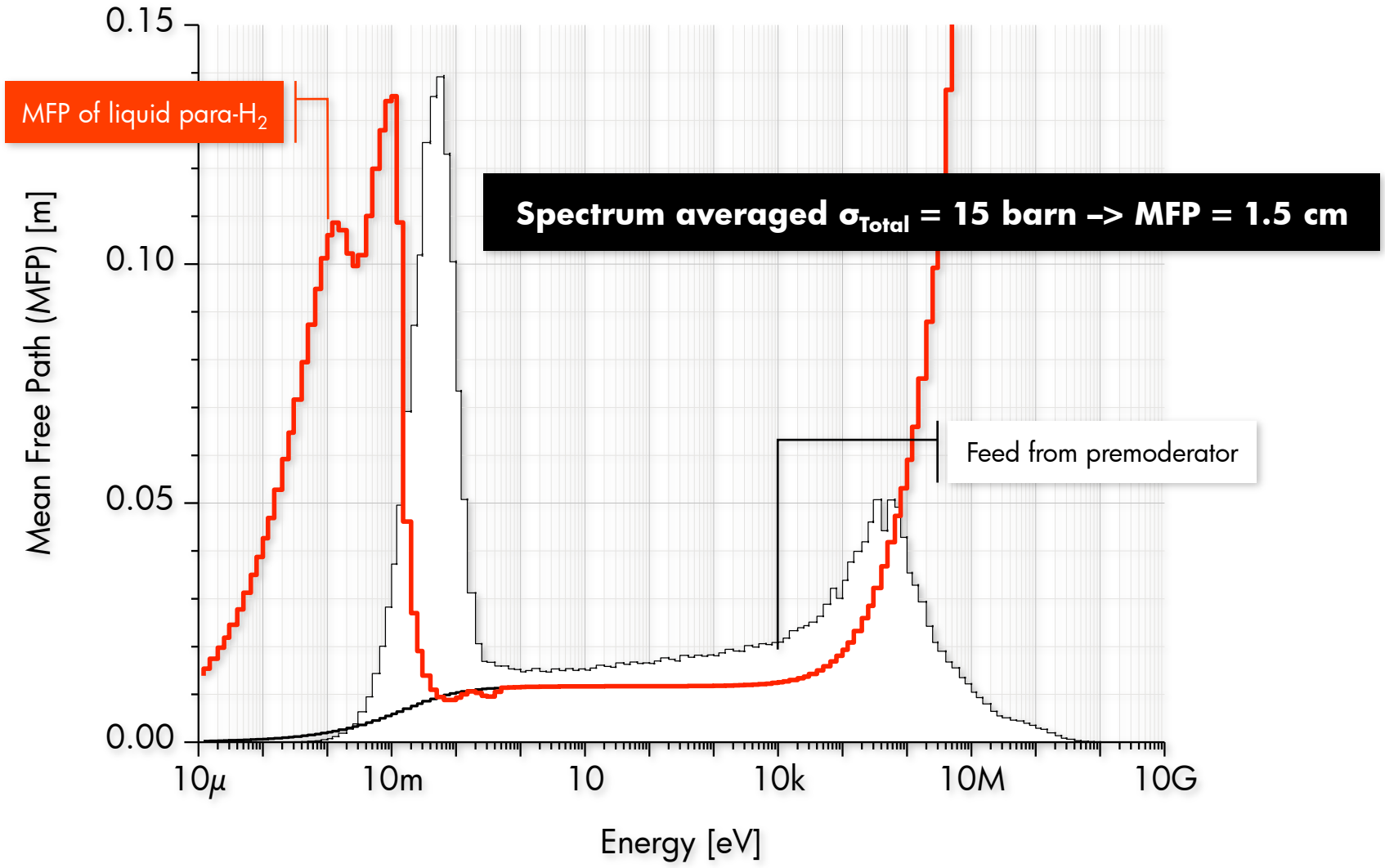
UNPERTURBED BRIGHTNESS

Map of cold brightness < 5 meV | Ref:. NIMA 729 (2013) 500-505



WHY FLAT MODERATOR WORKS

1.5 cm of liquid para-H_2 is enough to moderate neutrons



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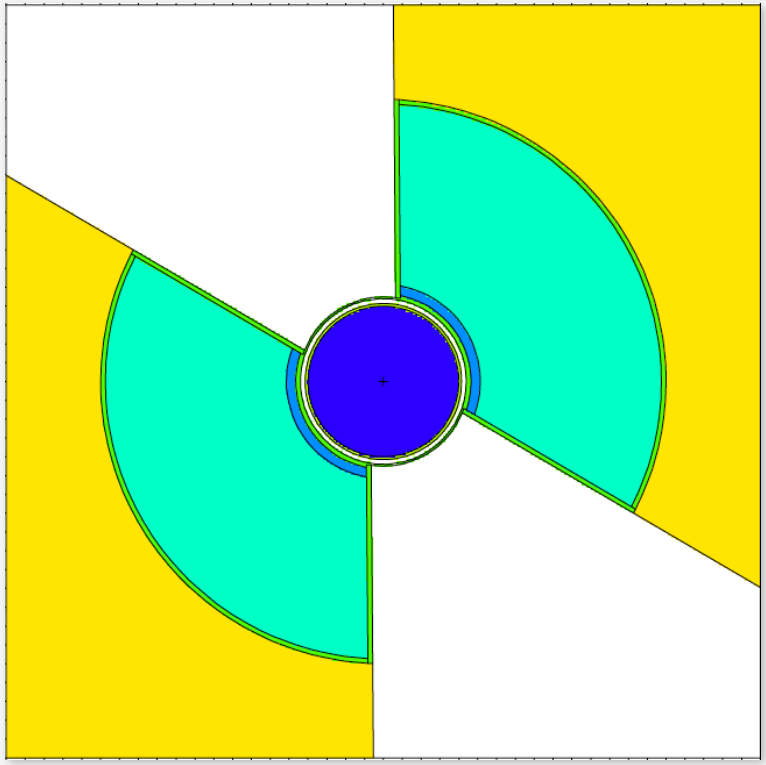
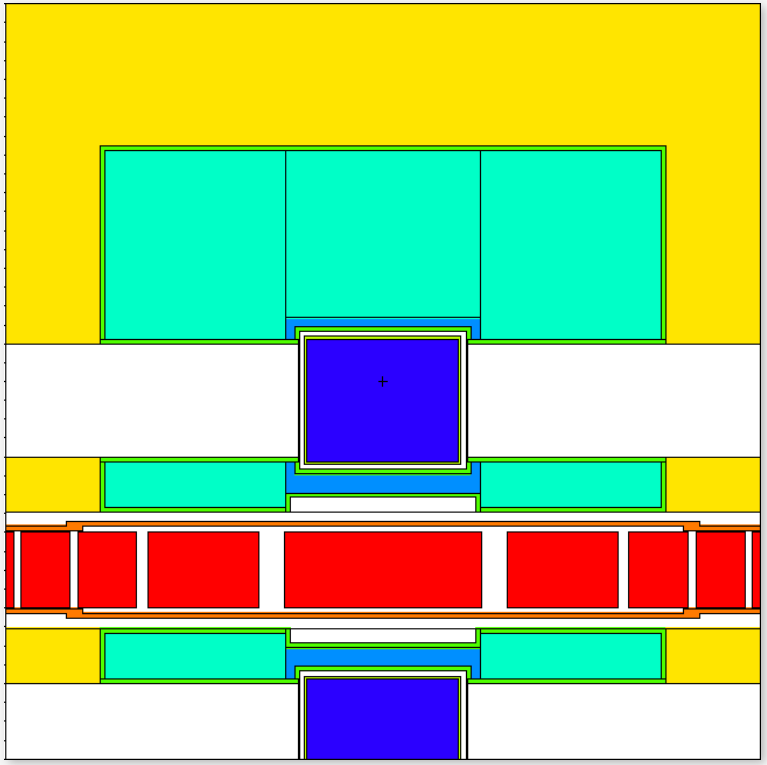
Simplified Baseline MR Plug

Hydrogen moderator: 13 cm height X 16 cm diameter | Emission surface: 12 cm height X 12 cm arcwidth



View from above
Proton beam comes from the left



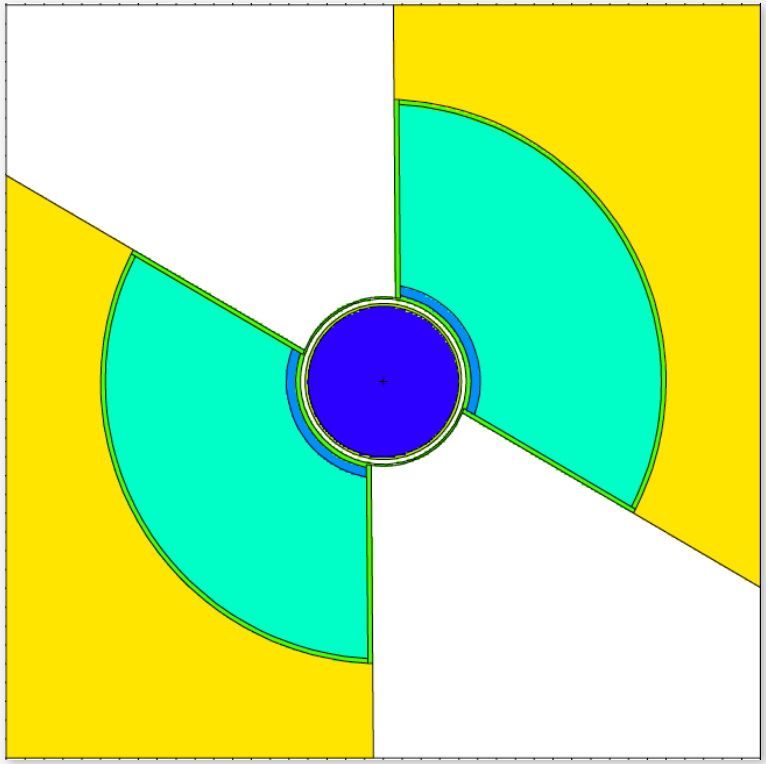
View in proton beam direction
Proton beam comes from behind

Cold Brightness < 5 meV = 1.0 PDU

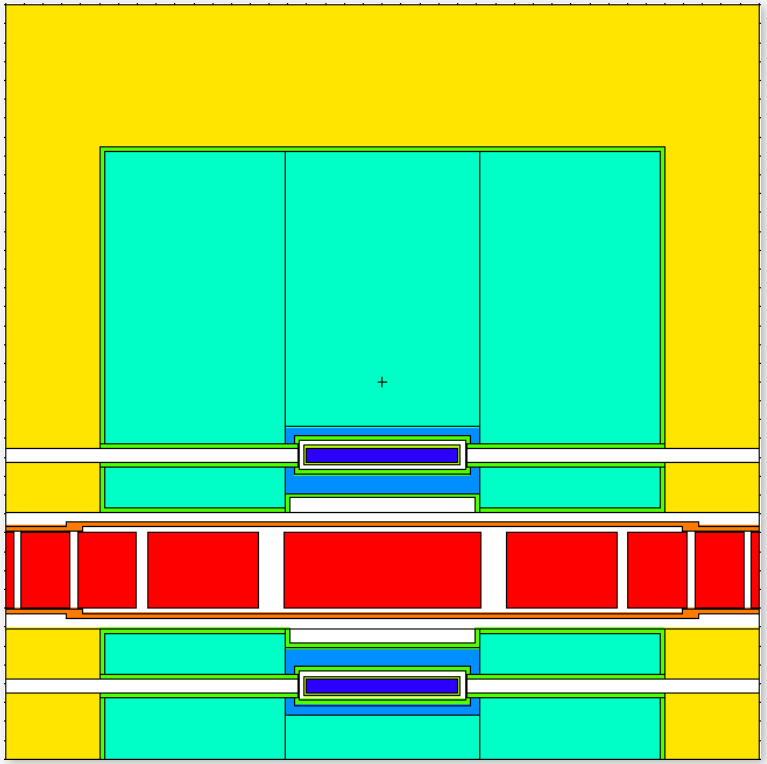
EUROPEAN SPALLATION SOURCE

Flat Moderator

Hydrogen moderator: 1.5 cm height X 16 cm diameter | Emission surface: 1.5 cm height X 12 cm arcwidth



View from above
Proton beam comes from the left



View in proton beam direction
Proton beam comes from behind

Cold Brightness < 5 meV = 3.2 PDU

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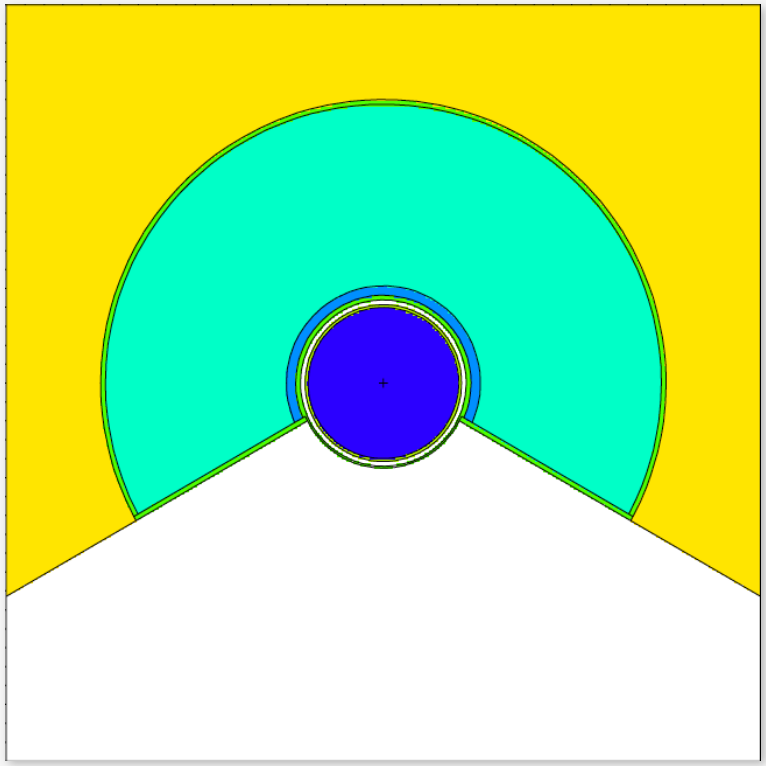
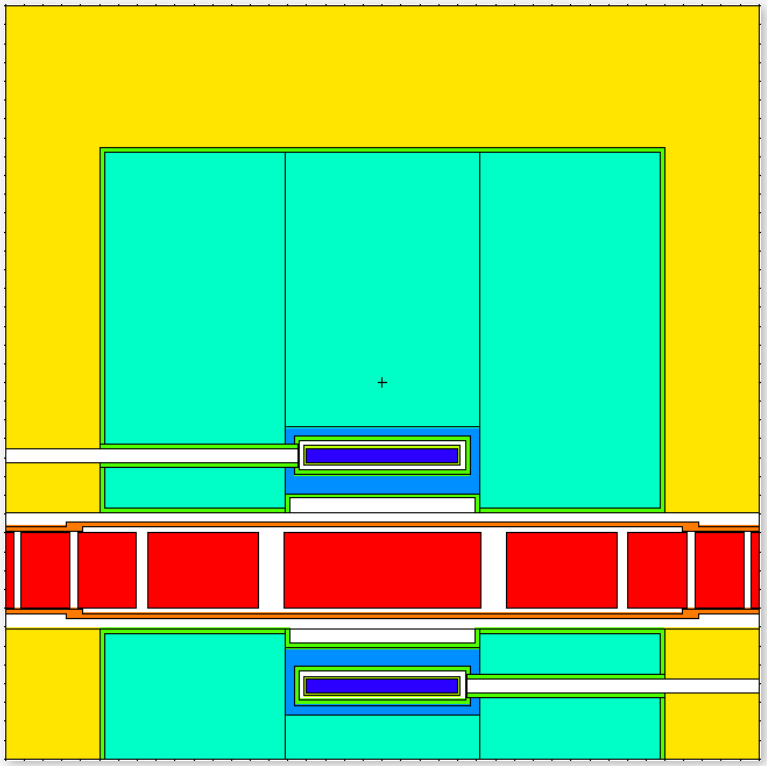
Flat Moderator + One 120 Opening

Hydrogen moderator: 1.5 cm height X 16 cm diameter | Emission surface: 1.5 cm height X 20 cm arcwidth



View from above
Proton beam comes from the left



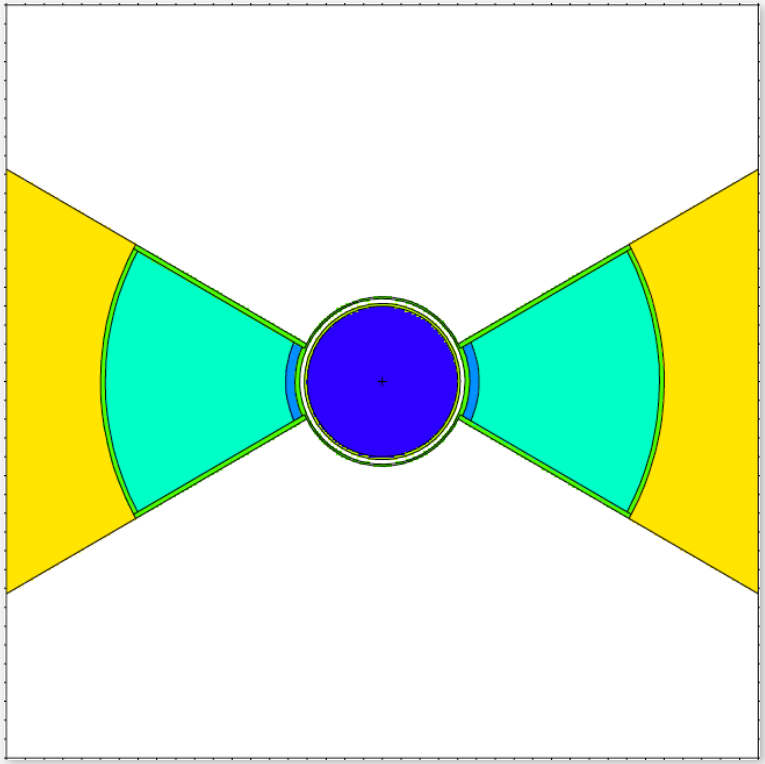
View in proton beam direction
Proton beam comes from behind

Cold Brightness < 5 meV = 3.0 PDU

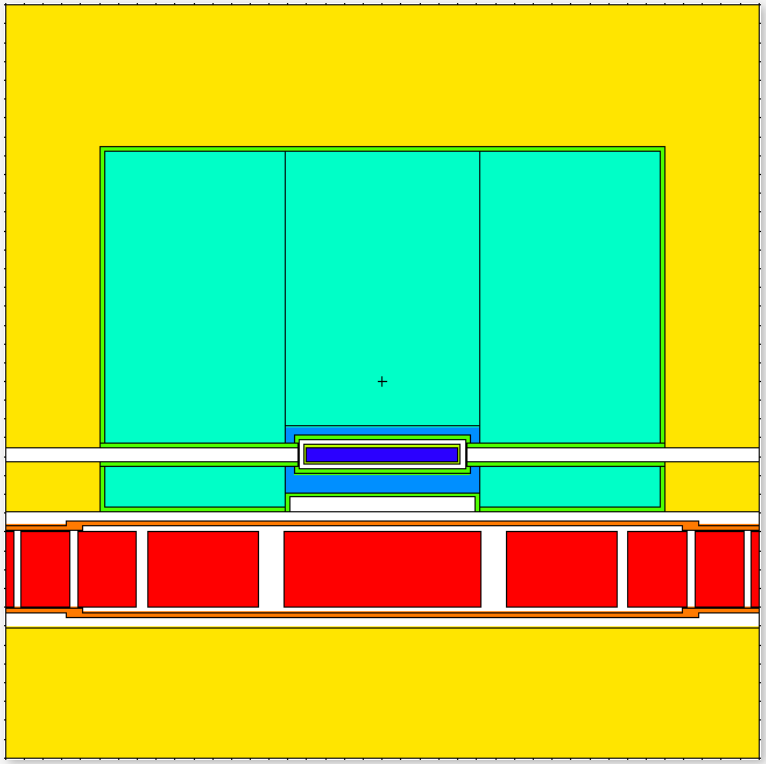
EUROPEAN SPALLATION SOURCE

FLAT MODERATOR + TWO 120 OPENINGS

Hydrogen moderator: 1.5 cm height X 16 cm diameter | Emission surface: 1.5 cm height X 20 cm arcwidth



View from above
Proton beam comes from the left



View in proton beam direction
Proton beam comes from behind

Cold Brightness < 5 meV = 2.8 PDU

PARAMETERIZED MCNP INPUTDECK

Extract from P-STUDY block

FIXED BY ENGINEERING

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C ===========================================================================
C THE_G80001 - MINIMUM GAP BETWEEN TARGET AND PREMODERATOR: 3 CM
C THE_G80002 - TARGET HORIZONTAL OFFSET: 15 CM
C ---------------------------------------------------------------------------
C THE_G80003 - HEIGHT OF CRYOMODERATOR HYDROGEN CONTENT: 1.5 CM
C THE_G80004 - DIAMETER OF CRYOMODERATOR HYDROGEN CONTENT: 24 CM
C THE_G80005 - THICKNESS OF CRYOMODERATOR CONTAINMENT: 0.3 CM
C THE_G80006 - VACUUM GAP BETWEEN CRYOMODERATOR AND PREMODERATOR: 0.5 CM
C ---------------------------------------------------------------------------
C THE_G80007 - THICKNESS OF PREMODERATOR BOTTOM LAYER: 3 CM
C THE_G80008 - THICKNESS OF PREMODERATOR TOP LAYER: 1 CM
C THE_G80009 - THICKNESS OF PREMODERATOR RADIAL LAYER: 1 CM
C THE_G80010 - THICKNESS OF THERMAL MODERATOR WINGS: 2 CM
C THE_G80011 - THICKNESS OF MR PLUG CONTAINMENT: 0.5 CM
C THE_G80012 - THICKNESS OF REFLECTOR TOP LAYER: 20 CM
C THE_G80013 - THICKNESS OF REFLECTOR RADIAL LAYER: 20 CM
C ---------------------------------------------------------------------------
C THE_G80014 - HEIGHT OF EMISSION SURFACE: 1.5 CM
C THE_G80015 - ARCWIDTH OF EMISSION SURFACE: 28 CM
C THE_G80016 - THICKNESS OF EMISSION SURFACE WINDOW: 0.2 CM
C THE_G80017 - HEIGHT OF OPENING AT NEUTRON GUIDE TIP: 12 CM
C THE_G80018 - ANGULAR SIZE OF OPENING: 120 DEGREE
C THE_G80019 - ORIENTATION OF OPENING WITH RESPECT TO PROTON BEAM: 90 DEGREE
C ===========================================================================
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VARIED

FIXED TENTATIVELY

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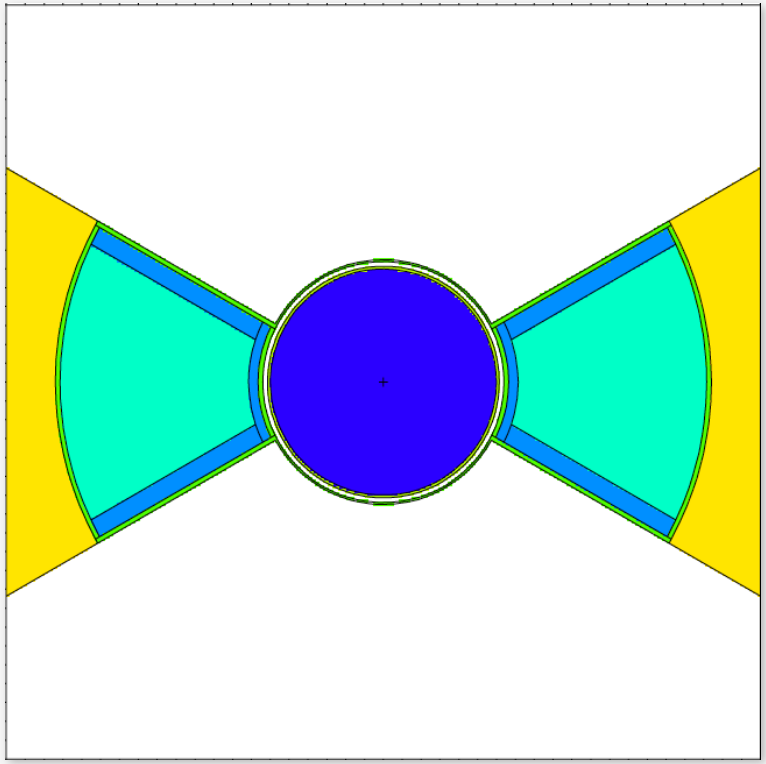
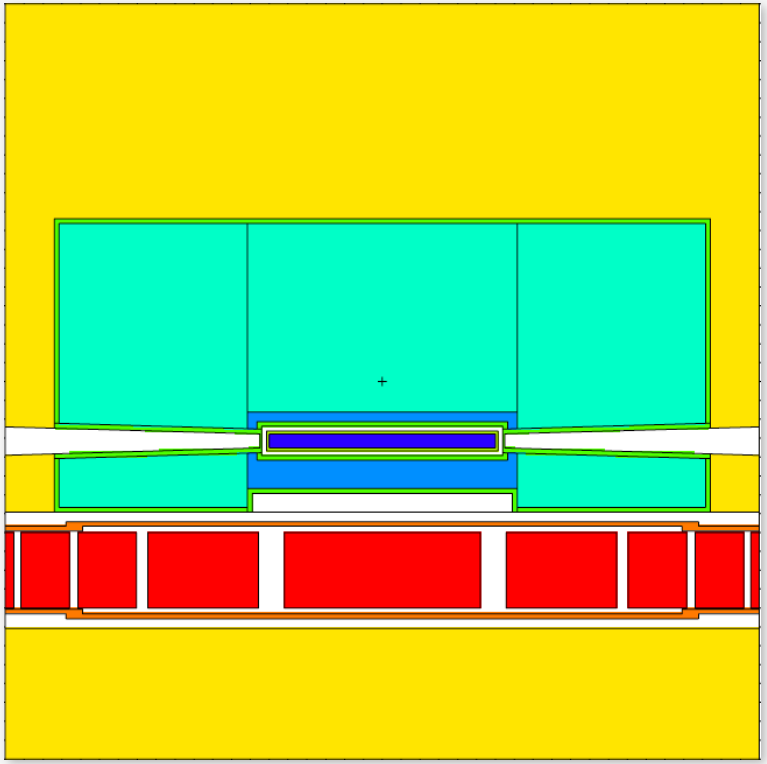
Flat Moderator First Optimization Round

Hydrogen moderator: 1.5 cm height X 24 cm diameter | Emission surface: 1.5 cm height X 28 cm arcwidth



View from above
Proton beam comes from the left

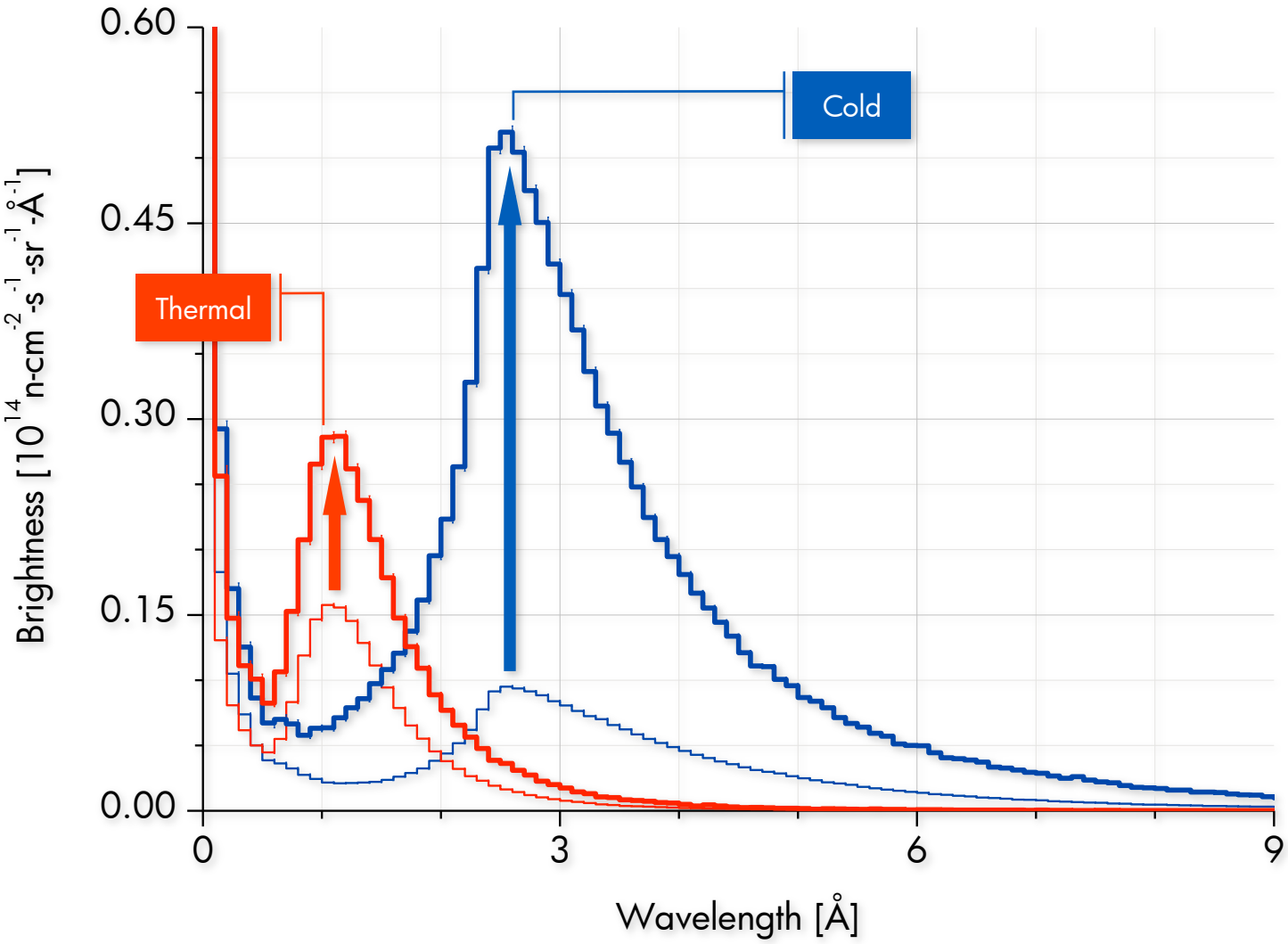


View in proton beam direction
Proton beam comes from behind

Cold Brightness < 5 meV = 3.4 PDU

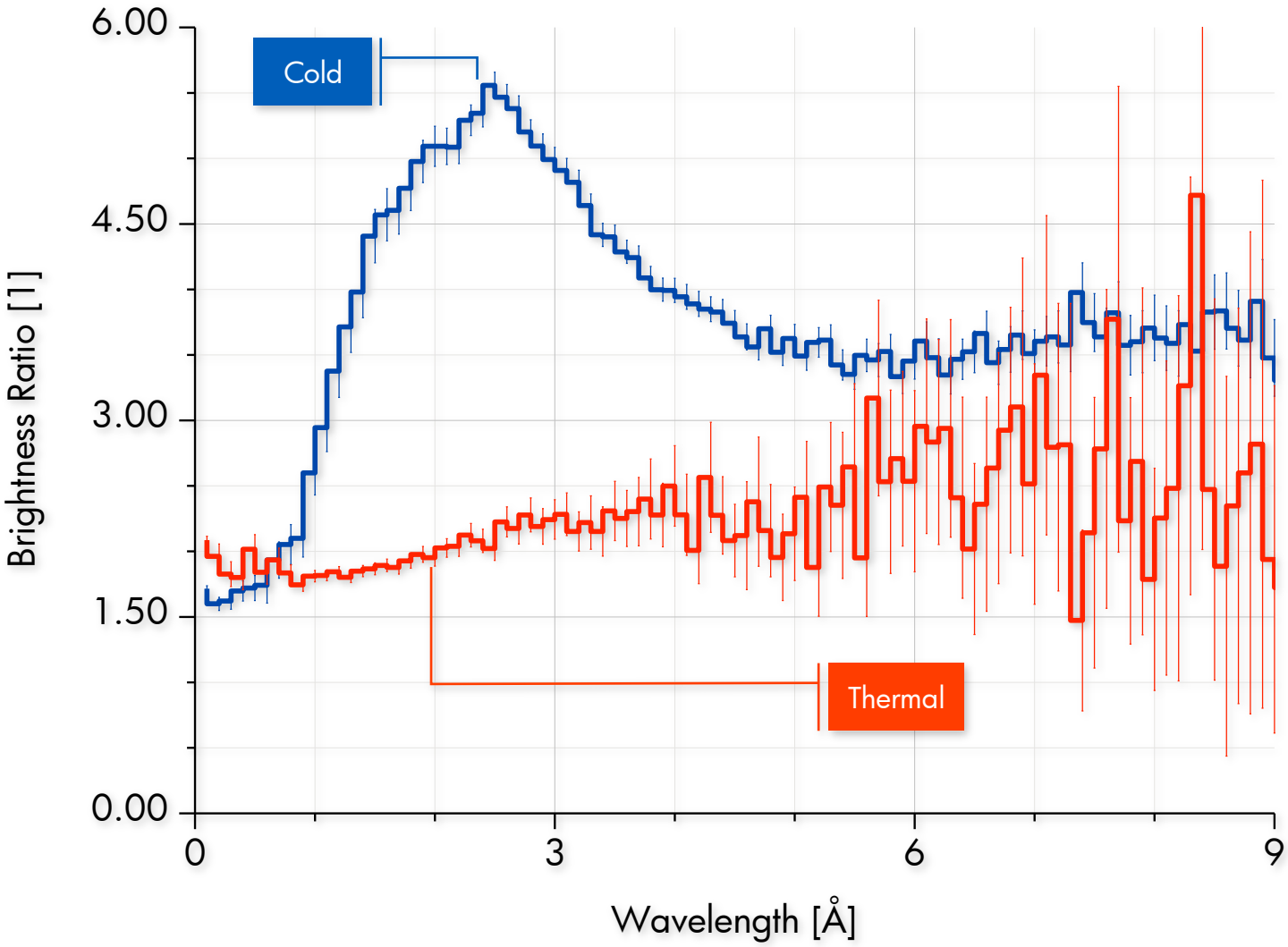
Spectral Brightness

Time-average brightness vs wavelength



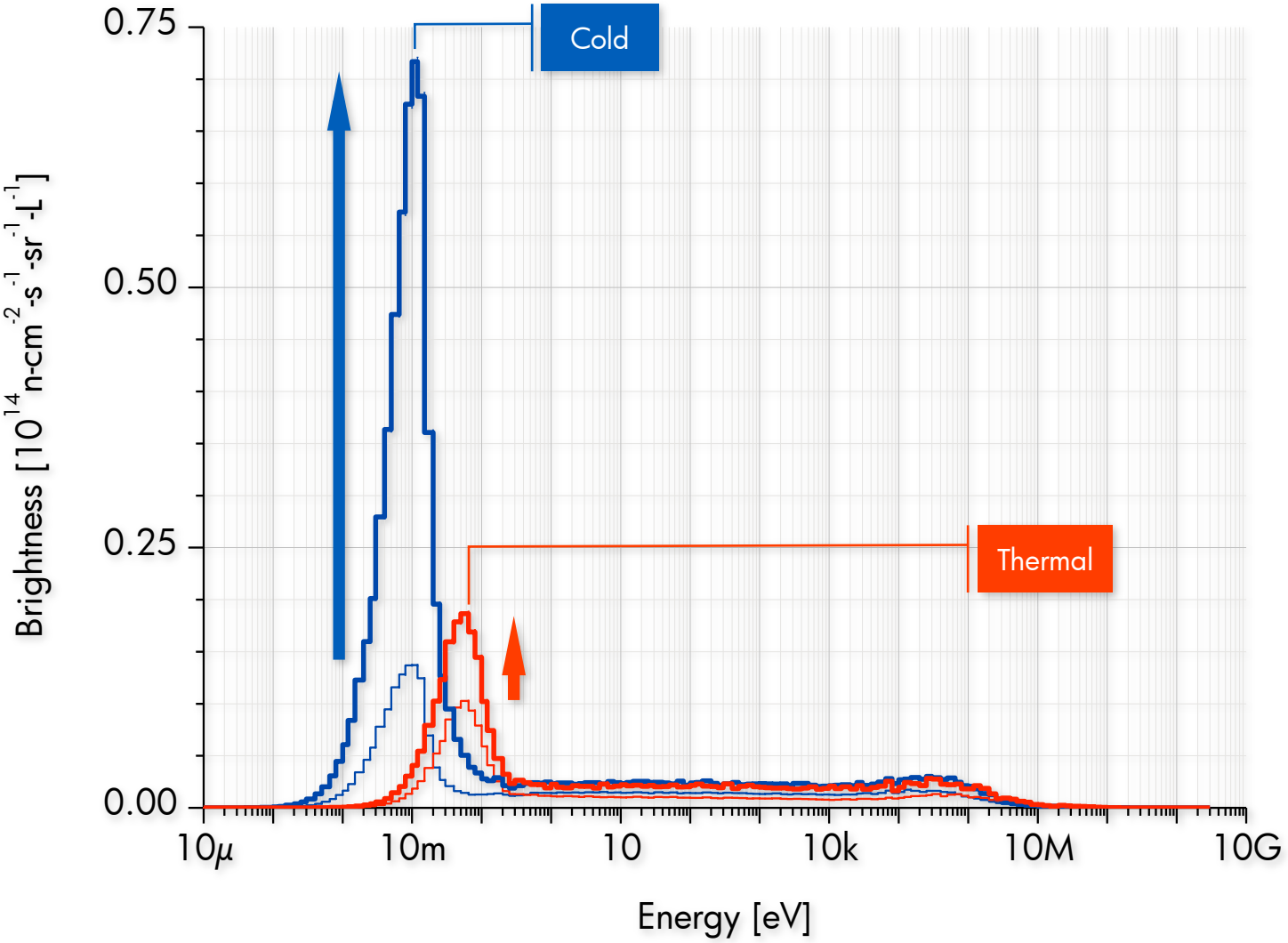
FLAT-TO-BASELINE RATIO

Time-average brightness ratio vs wavelength



Brightness Lethargy Distribution

Time-average brightness vs energy



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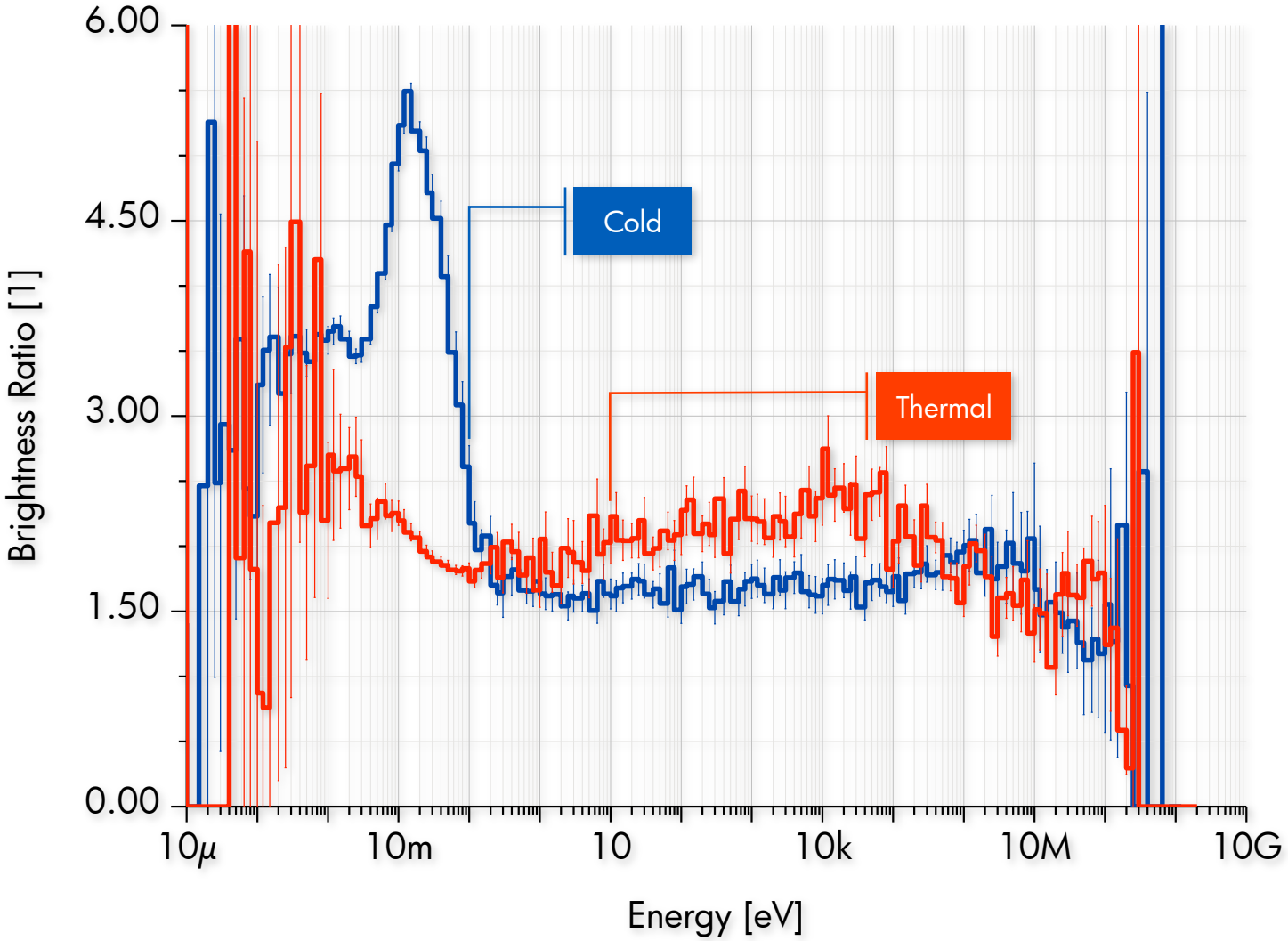
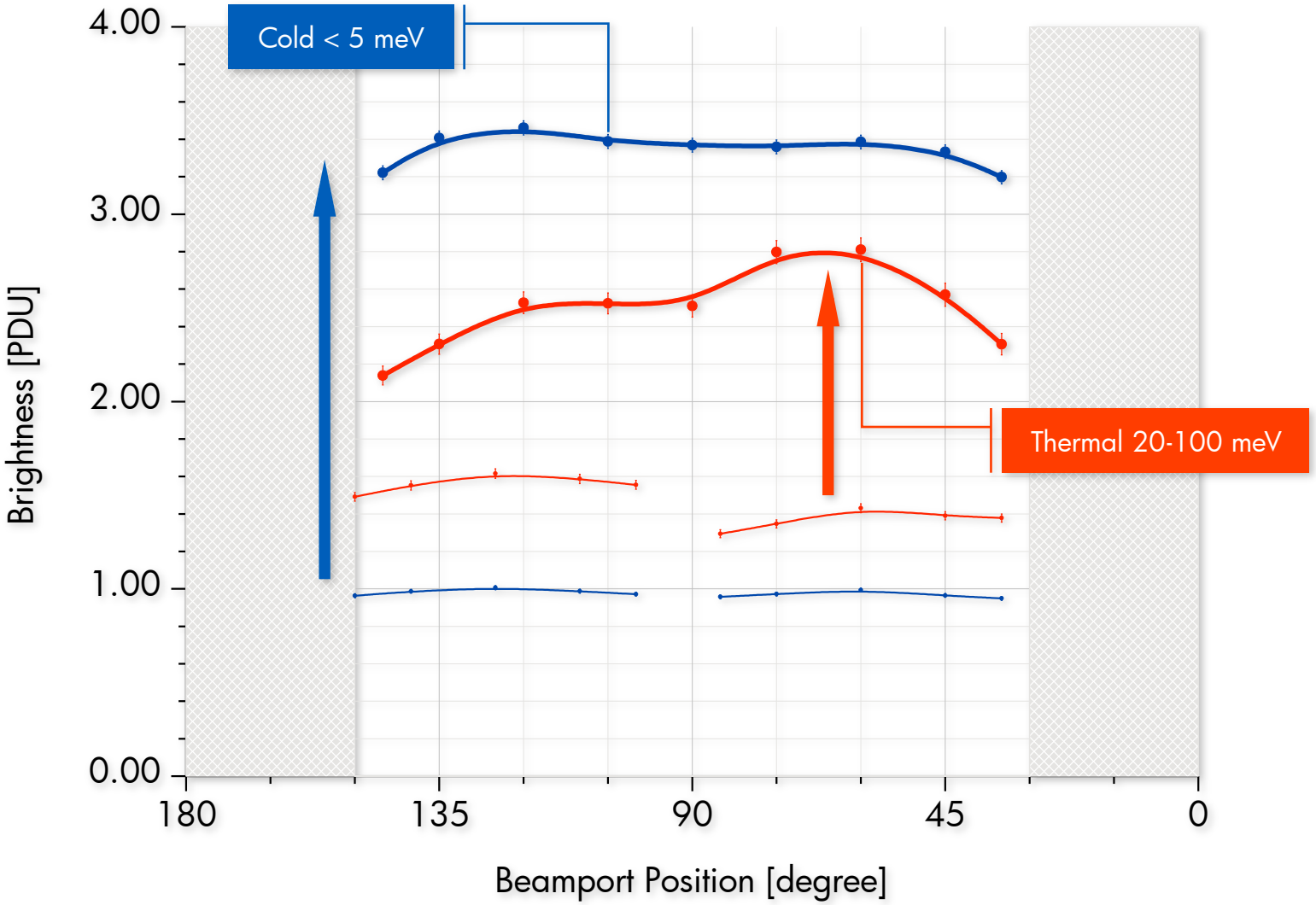
FLAT-TO-BASELINE RATIO

Time-average brightness ratio vs energy



Integral Brightness

Time-average brightness vs beamport position



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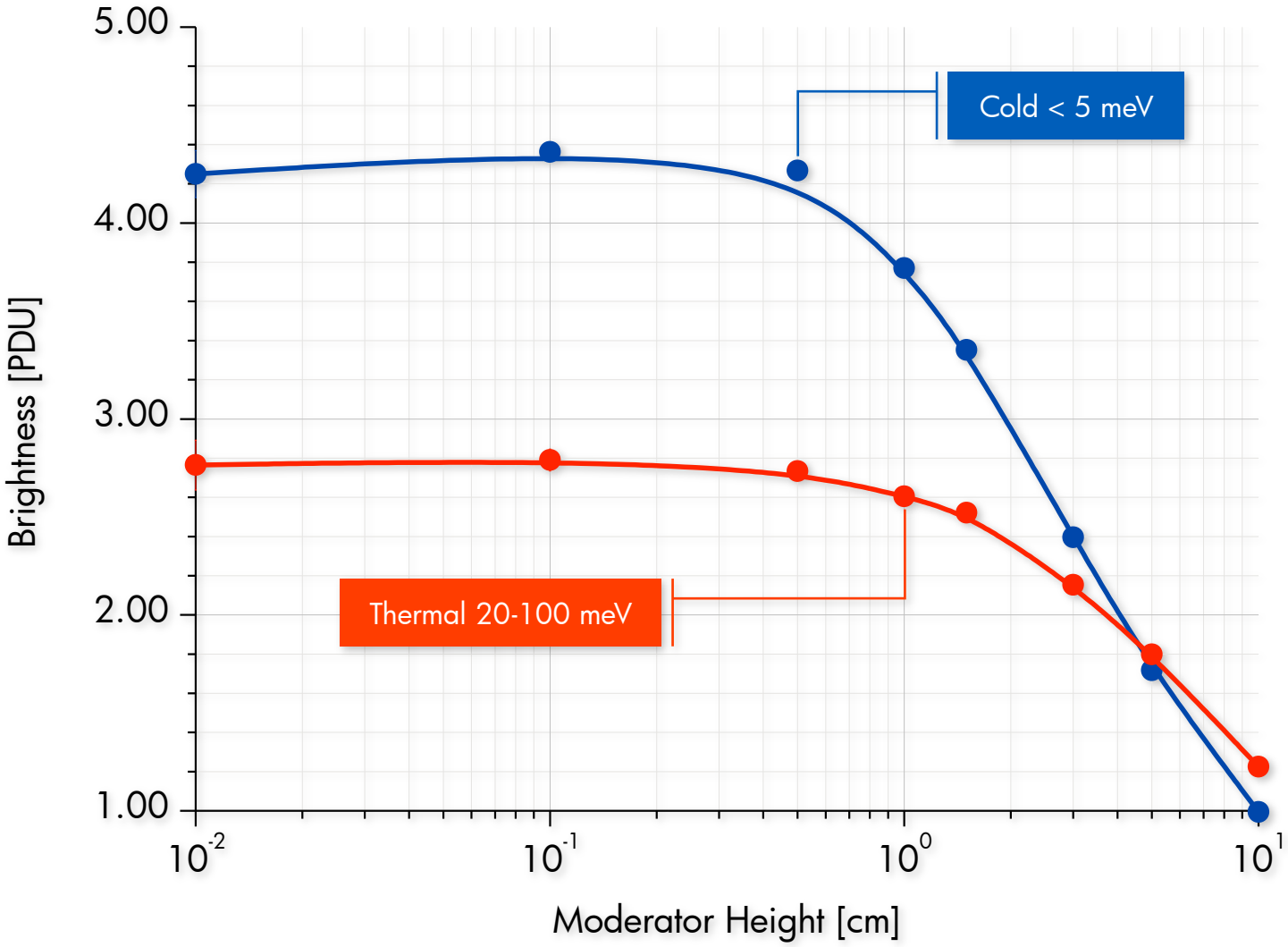
Further Ways to Improve Performance

Brightness can be increased further by going to below 1 cm moderator height



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CONCLUSIONS

Representative model of MR plug with a flat moderator is introduced
First optimization round is done

Cold brightness is more than 3 times higher than that of baseline
There is more than factor of 5 increase in 10-20 meV region

Thermal brightness exhibits up to 100% increase
High energy background is 1.5-2.0 times higher than that of baseline

Prompt heating of 1 flat cryomoderator is 5.4 kW down from 10 kW
Prompt heating in MR plug is 250 kW up from 170 kW

There is no need to have more than 1 flat moderator
1 flat moderator can serve up to 360 degree extraction range

Brightness can be increased further by going to ultra-thin moderators
Cold brightness < 5 meV is up to more than 4 times higher than that of baseline