LD2 Moderator neutrons through Large Beam Port at ESS

Validation of files sent by Richard Wagner

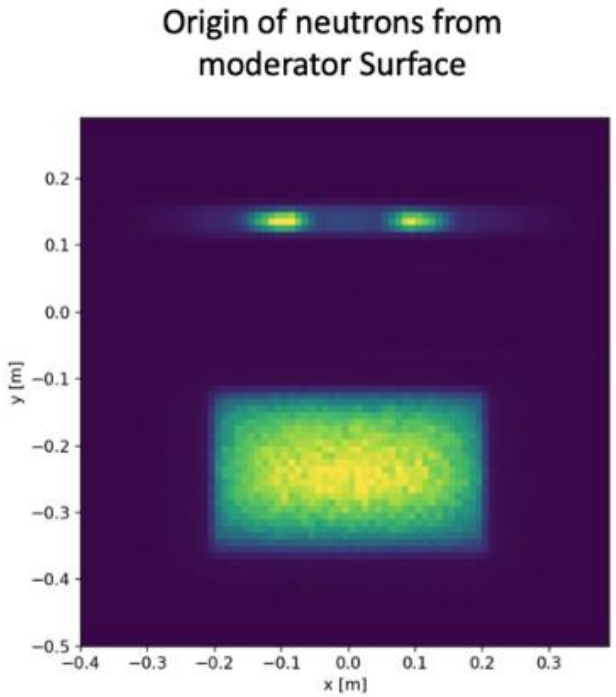
1. ESS LBP Neutron Files received from R.W. in June 2022

~~LBP_FILE_V1.txt before some "problems" fixed, 4,246,892 events, sum of weights 0.121623322~~

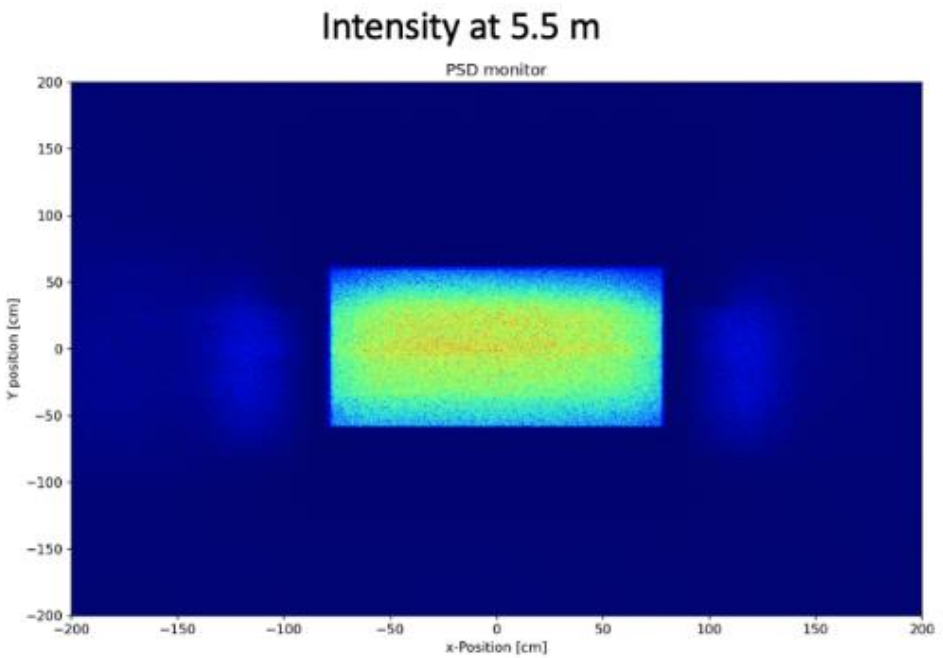
LBP_FILE_V2.txt was used in calculations. Ref: Richard June 03, 2022, 4,347,960 events, sum of weights 0.123948768

z_start is 0.225 m

The source is retrieved from an MCPL-file from simulations of the latest moderator design "HIGHNESS LD2 MODERATOR VERSION 1.02" In the MCPL-file all particles started at z=2m.



40x24 cm^2



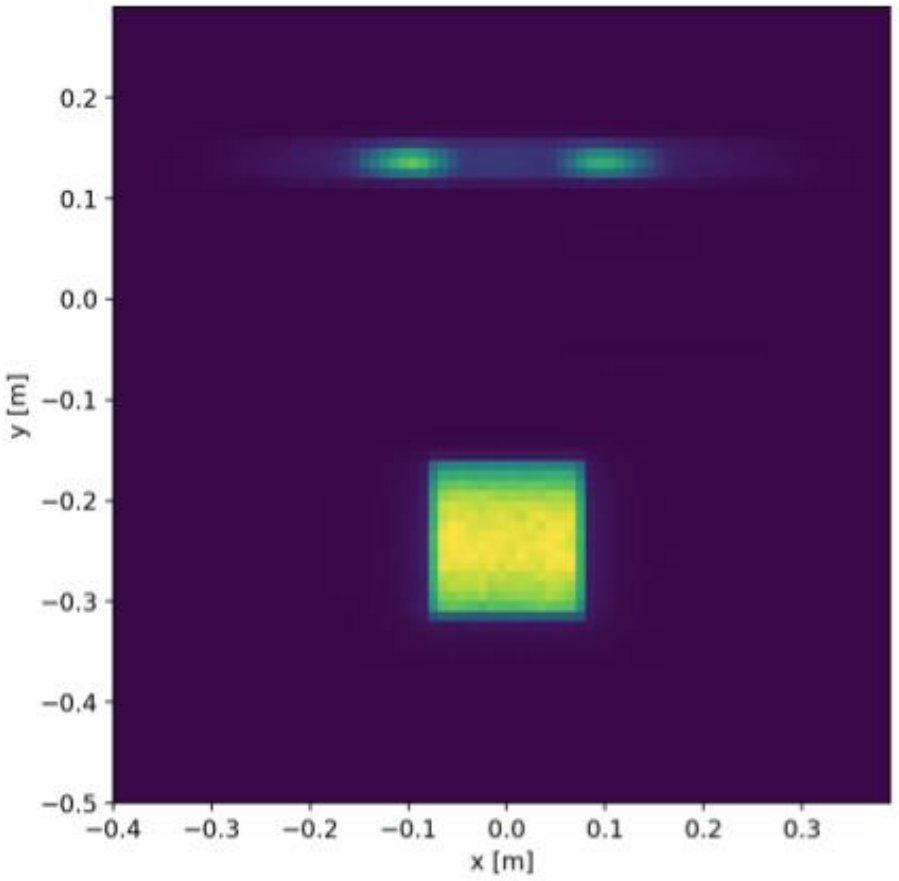
LBP size :
≈156.7x119.1 cm^2

LBP size (eng. dwg):
148.4 x 111.8 cm^2

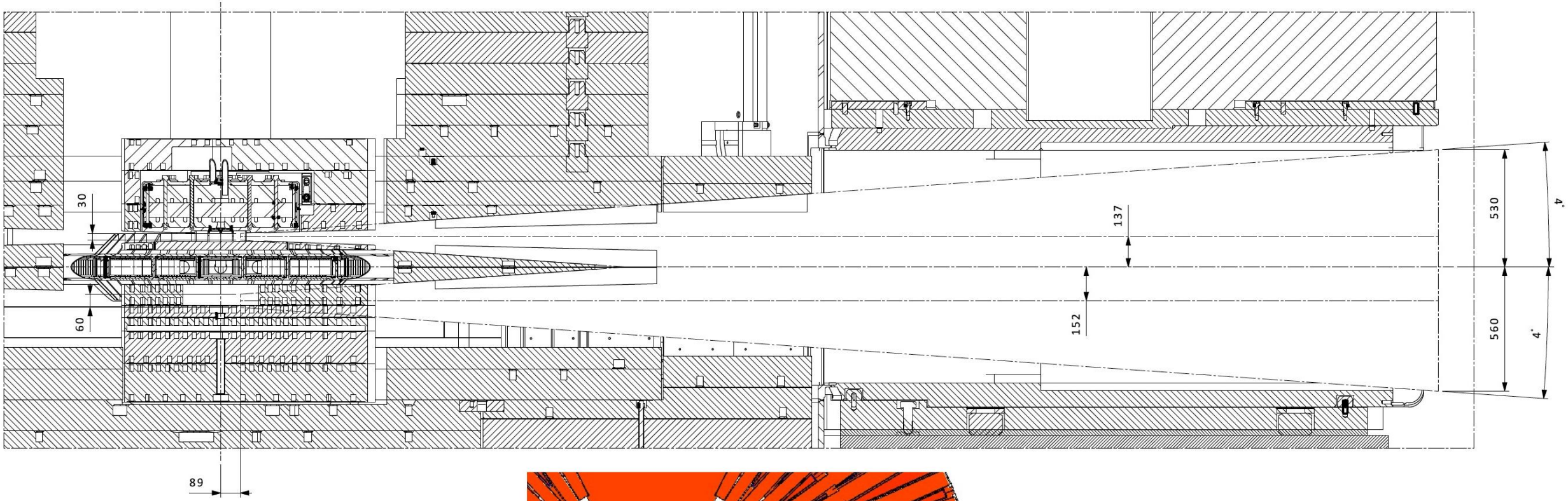
2. File “neutrons_at_LBP_exit_from 15x15” received Sept. 2, 2022

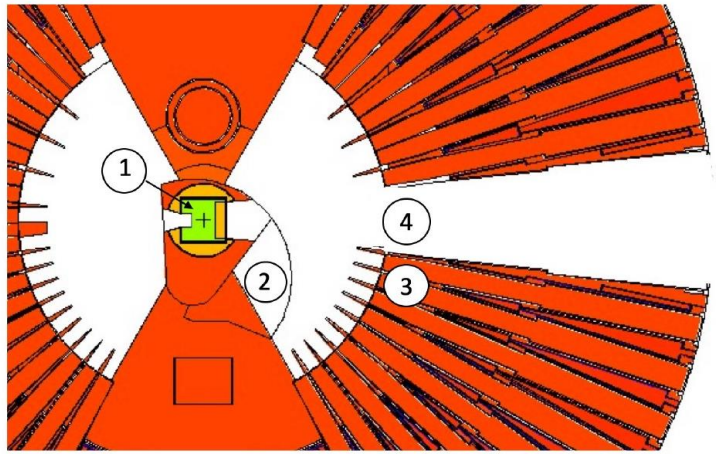
event file for neutrons at 5.5m from a 15x15cm opening

z_start is 0.25 m



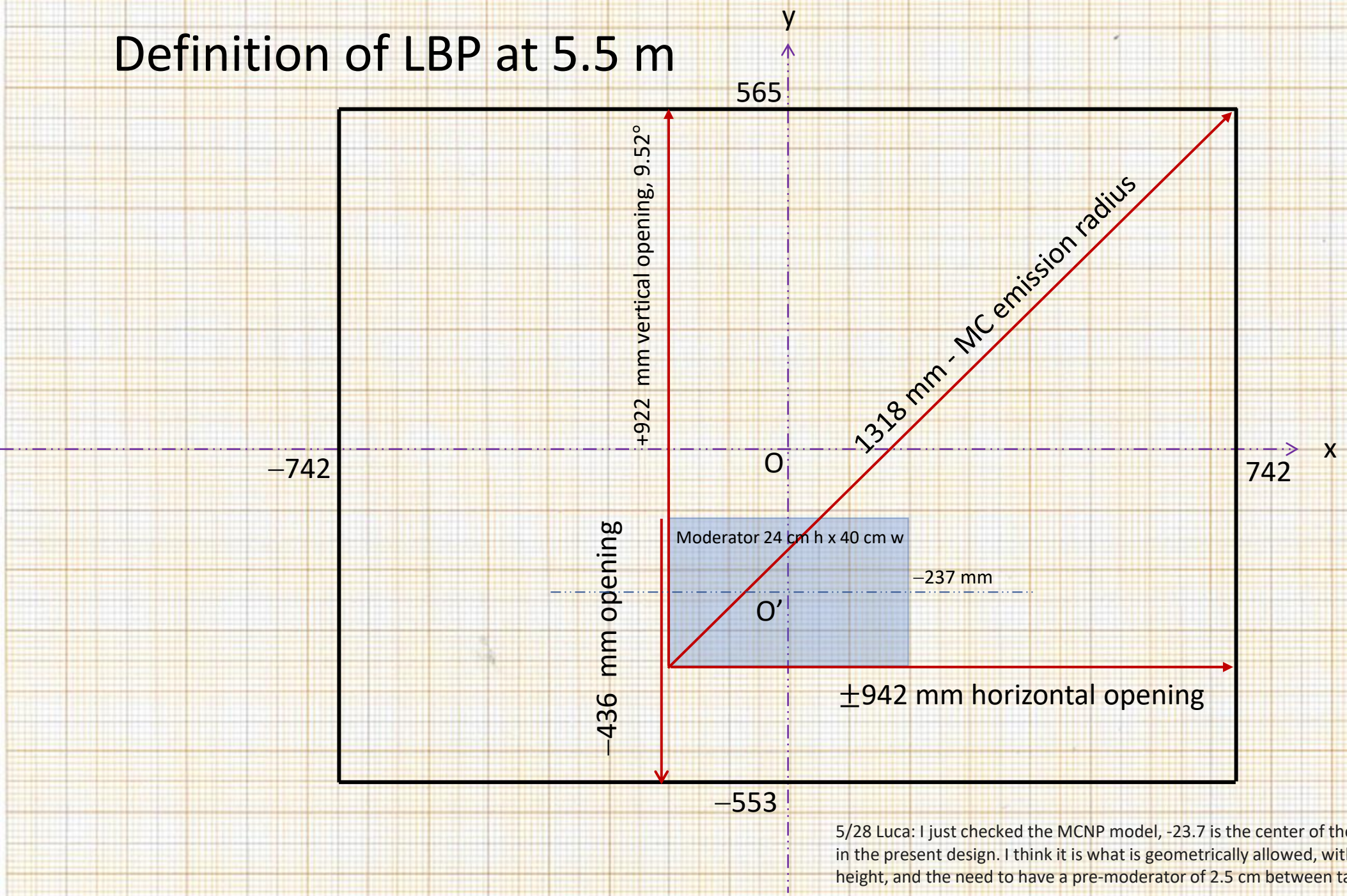
LBP at ESS





Definition of LBP at 5.5 m

May 27, 2022

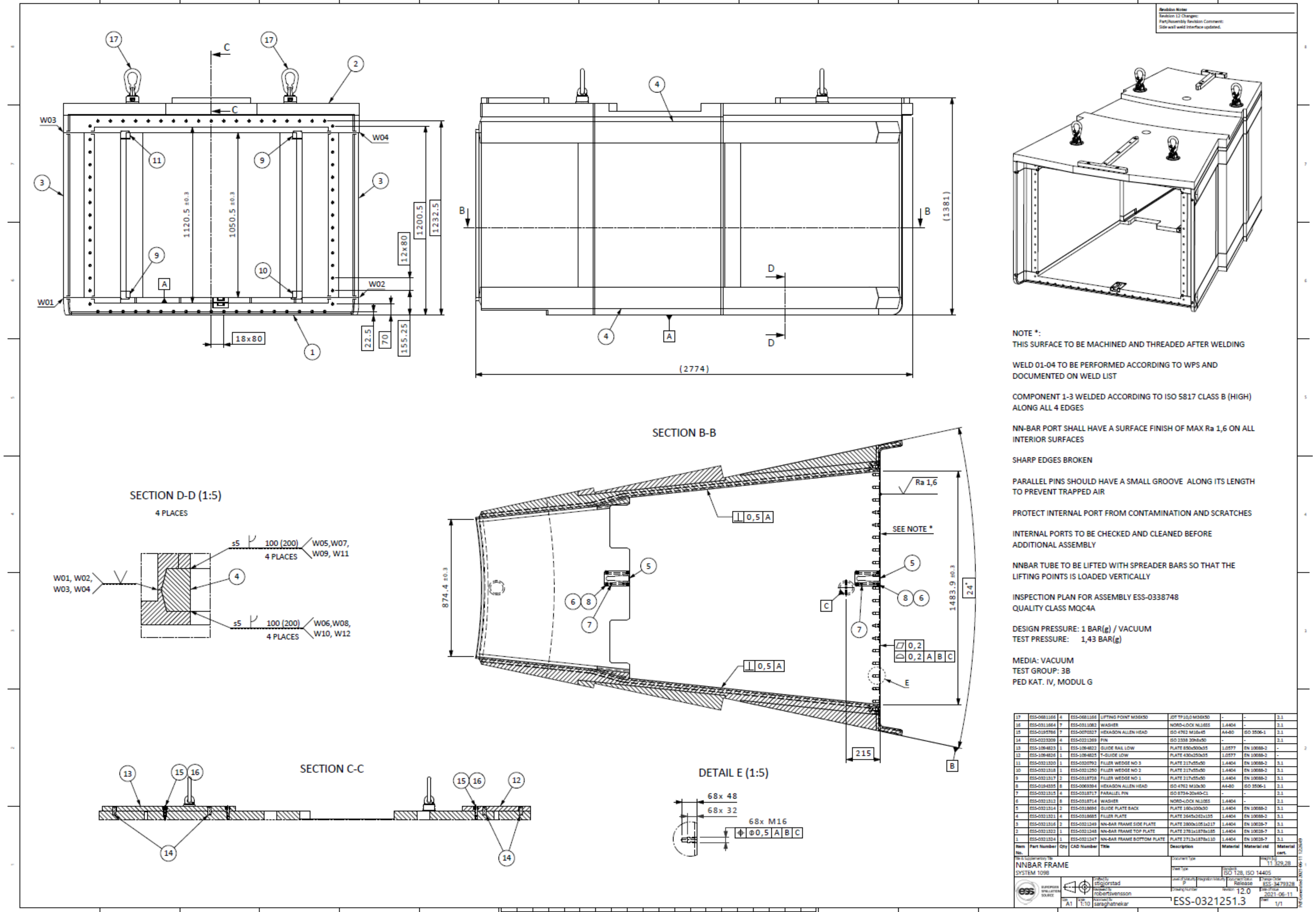


LBP size:
148.4 x 111.8 cm^2

LBP opening
X-opening ±8°
Y-opening ±6°

5/28 Luca: I just checked the MCNP model, -23.7 is the center of the liquid deuterium moderator, in the present design. I think it is what is geometrically allowed, with a viewed surface of 24 cm height, and the need to have a pre-moderator of 2.5 cm between target and moderator.

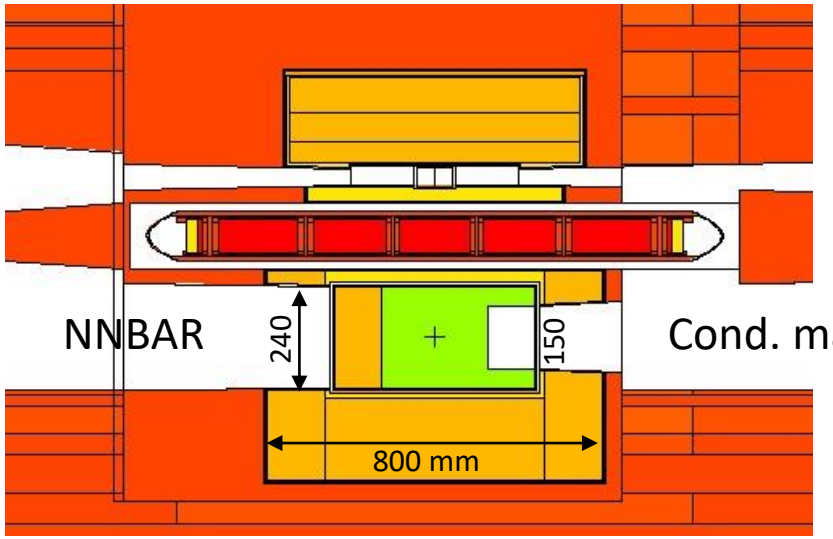
LBP
May 2022

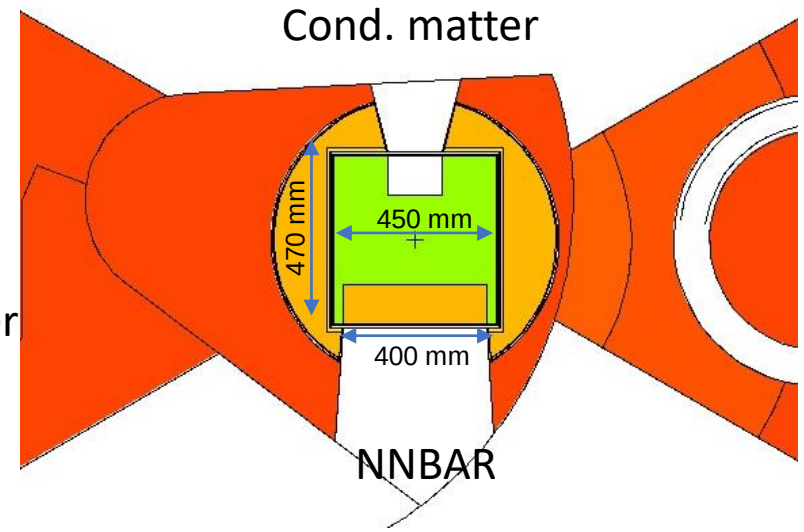


Item No.	Part Number	Qty	CAD Number	Title	Description	Material	Material std	Material cert.
17	ESS-0681166	4	ESS-0681166	LIFTING POINT M36X50	JDT TP10,0 M36X50	-	-	2.1
16	ESS-0311664	7	ESS-0311082	WASHER	NORD-LOCK NL16SS	1.4404	-	2.1
15	ESS-0195786	7	ESS-0070327	HEXAGON ALLEN HEAD	ISO 4762 M16x45	A4-80	ISO 3506-1	2.1
14	ESS-0223209	4	ESS-0221269	PIN	ISO 2338 20h8x50	-	-	2.1
13	ESS-1094823	1	ESS-1094822	GUIDE RAIL LOW	PLATE 850x500x35	1.0577	EN 10088-2	-
12	ESS-1094826	1	ESS-1094825	T-GUIDE LOW	PLATE 430x250x35	1.0577	EN 10088-2	-
11	ESS-0321320	1	ESS-0320792	FILLER WEDGE NO 3	PLATE 217x55x50	1.4404	EN 10088-2	3.1
10	ESS-0321318	1	ESS-0321250	FILLER WEDGE NO 2	PLATE 217x55x50	1.4404	EN 10088-2	3.1
9	ESS-0321317	2	ESS-0318728	FILLER WEDGE NO 1	PLATE 217x55x50	1.4404	EN 10088-2	3.1
8	ESS-0194335	8	ESS-0069394	HEXAGON ALLEN HEAD	ISO 4762 M10x30	A4-80	ISO 3506-1	2.1
7	ESS-0321315	4	ESS-0318717	PARALLEL PIN	ISO 8734-20x40-C1	-	-	2.1
6	ESS-0321312	8	ESS-0318714	WASHER	NORD-LOCK NL10SS	1.4404	-	2.1
5	ESS-0321314	2	ESS-0318696	GUIDE PLATE BACK	PLATE 160x100x30	1.4404	EN 10088-2	3.1
4	ESS-0321321	4	ESS-0318685	FILLER PLATE	PLATE 2645x262x135	1.4404	EN 10088-2	3.1
3	ESS-0321316	2	ESS-0321249	NN-BAR FRAME SIDE PLATE	PLATE 2800x1051x217	1.4404	EN 10028-7	3.1
2	ESS-0321322	1	ESS-0321248	NN-BAR FRAME TOP PLATE	PLATE 2781x1878x185	1.4404	EN 10028-7	3.1
1	ESS-0321324	1	ESS-0321247	NN-BAR FRAME BOTTOM PLATE	PLATE 2712x1878x110	1.4404	EN 10028-7	3.1

Design of the Cold Source

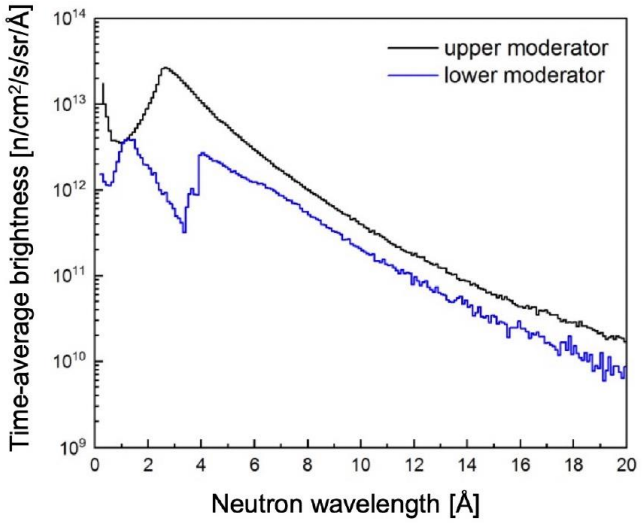
cold	2-20 Å
very cold	10–120 Å
ultracold	> 500 Å



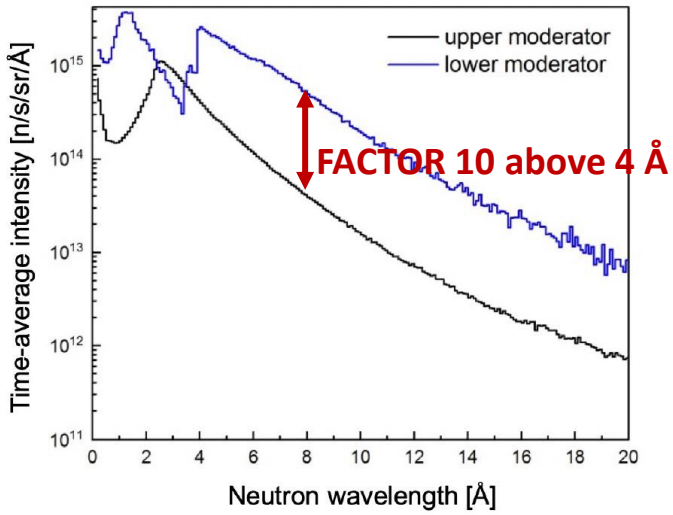


The high-intensity liquid deuterium moderator has been designed with two openings, for NNBAR and neutron scattering instruments

Brightness

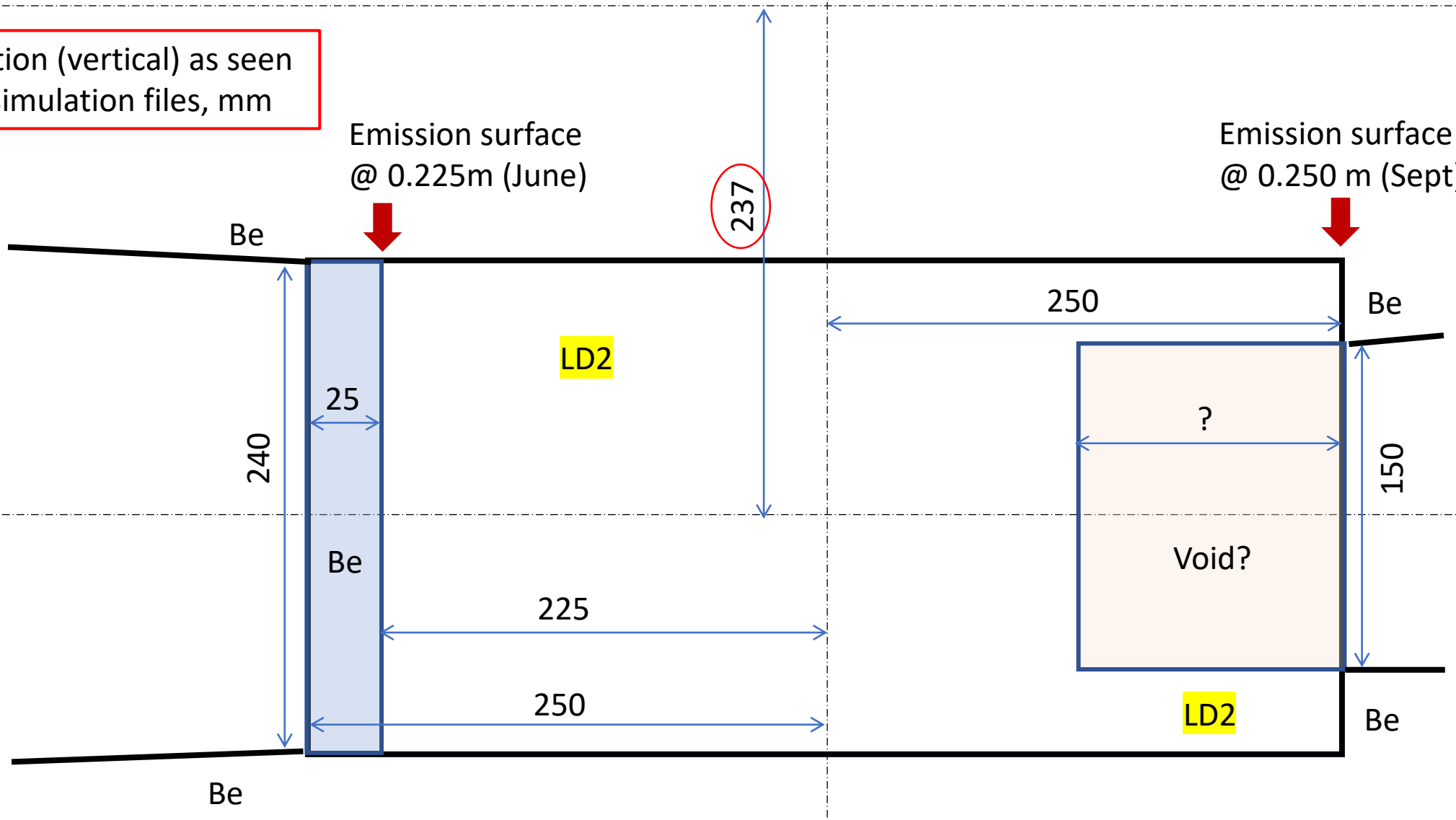


Intensity

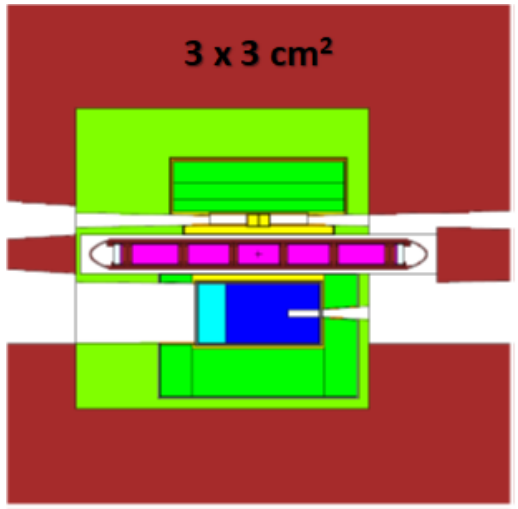


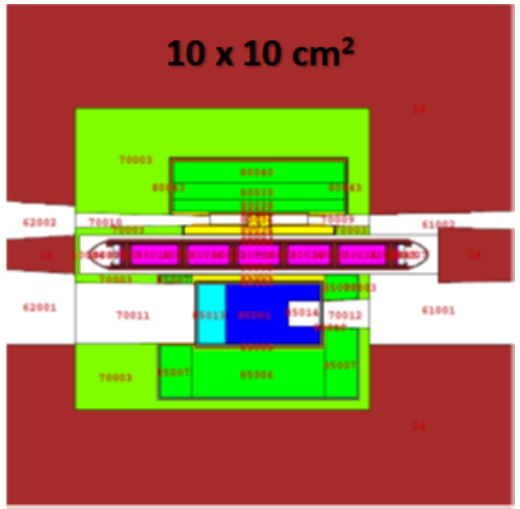
400 x 249 mm^2 source for nnbar

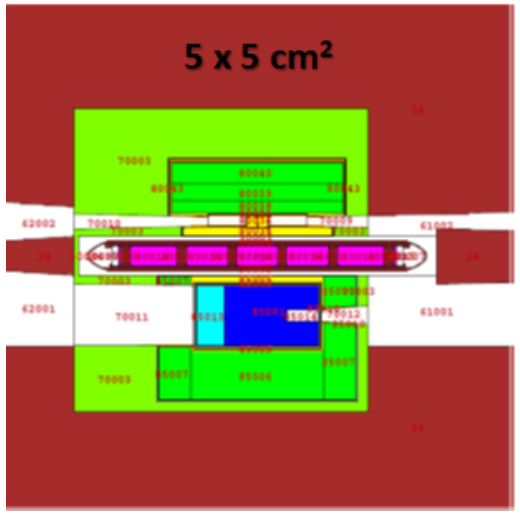
Configuration (vertical) as seen from the simulation files, mm

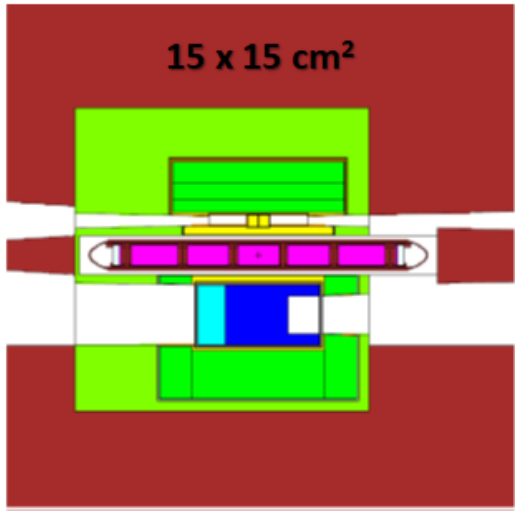


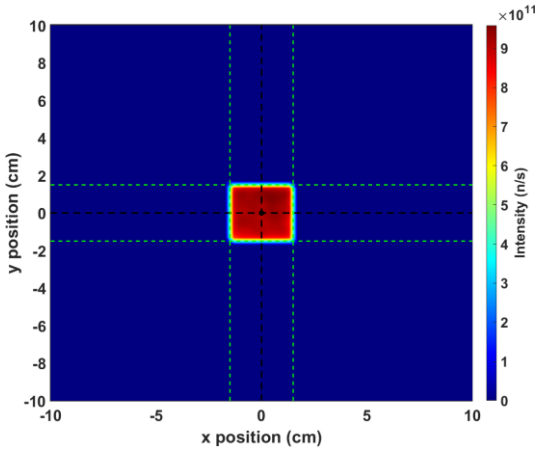
SANS Basic Calculations & Comparisons

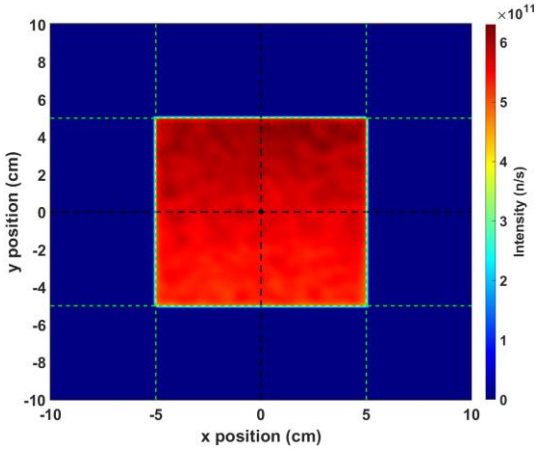


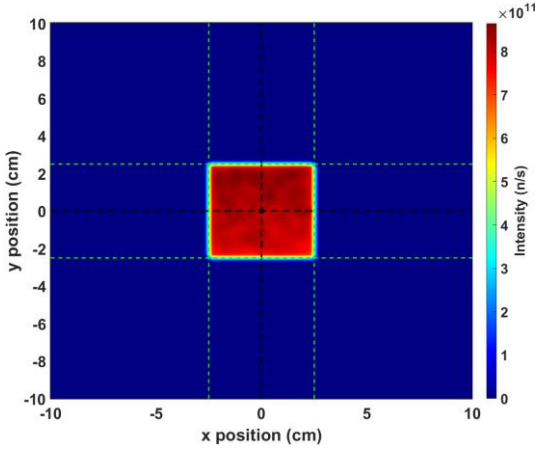


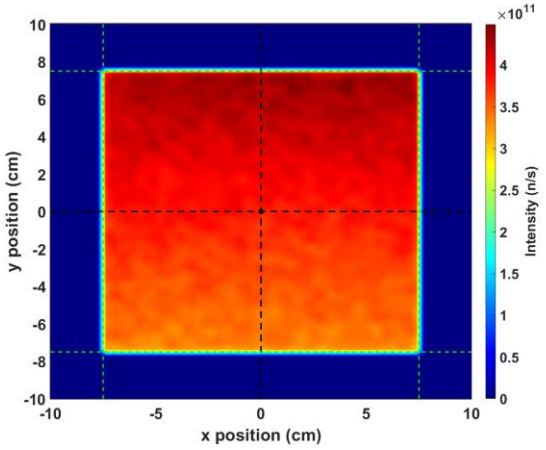








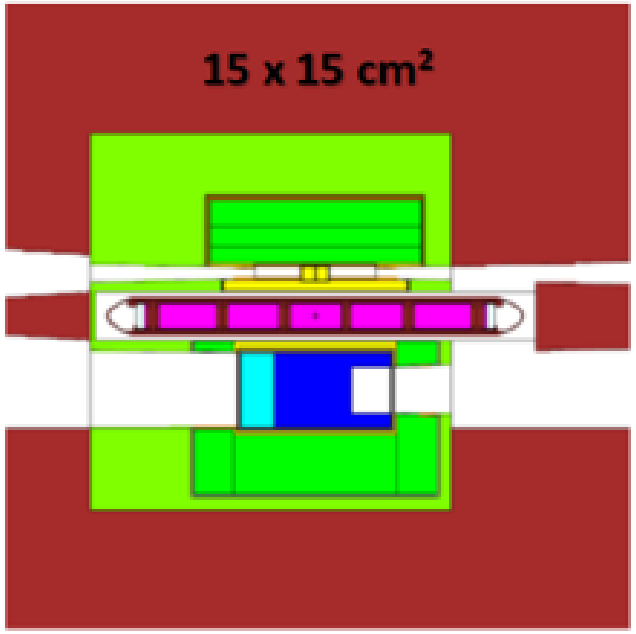


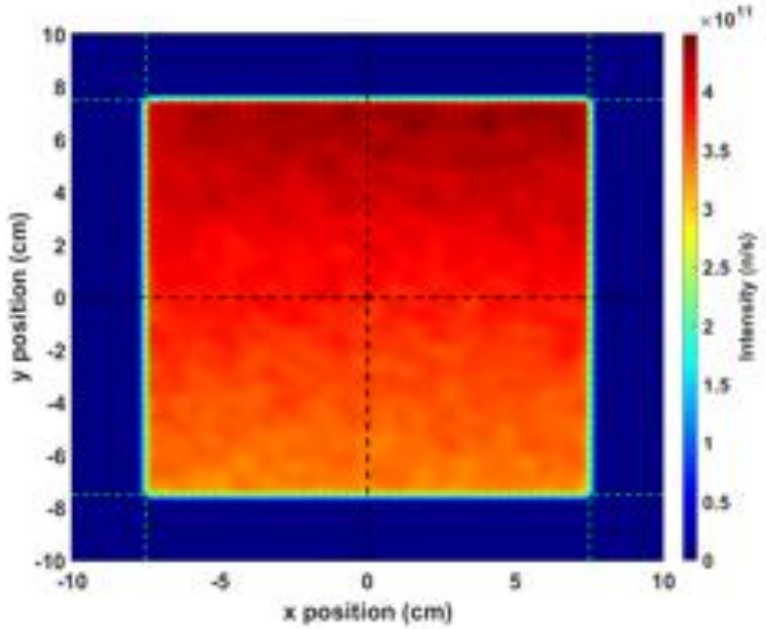


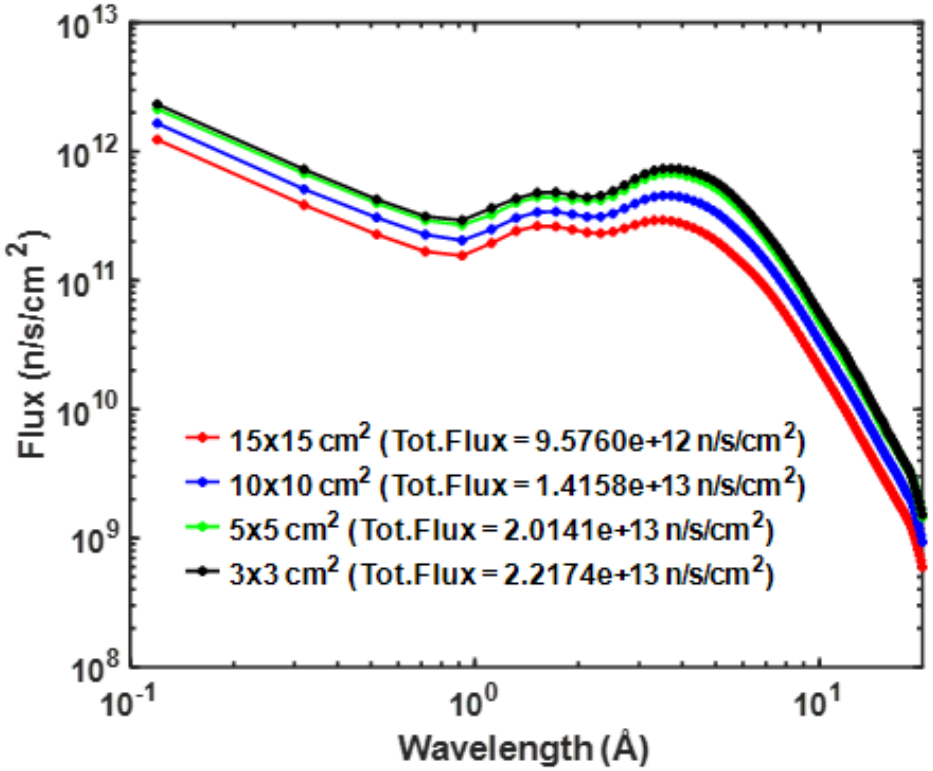
SANS Basic Calculations & Comparisons

(From June 2022 HighNESS meeting)

What is MCPL version?







Two files prepared by Richard W. from MCPL simulations:

```
 03/23/22 09:15:56
HIGHNESS LD2 MODERATOR VERSION
 1.02
```

?

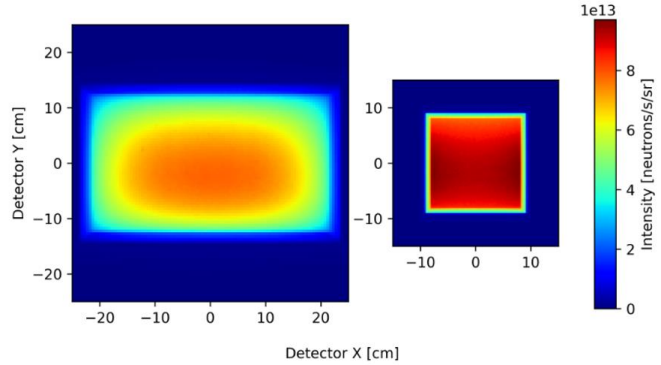
NNBAR_tests_162 Ncount: 8,604,876 Events in file: 4,347,960 nnbar file → 3,464,056 in LBP

NNBAR_tests_5p5_15x15_6 Ncount: 18,929,637 Events in file: 9,257,268 15x15 file → 7,369,859 in LBP

Both files give X and Y at Z = 0 (≡ 5.5 m)
Both include upper and lower moderators as source
Both are with weights p per 2 GeV protons (5 MW ESS operation)

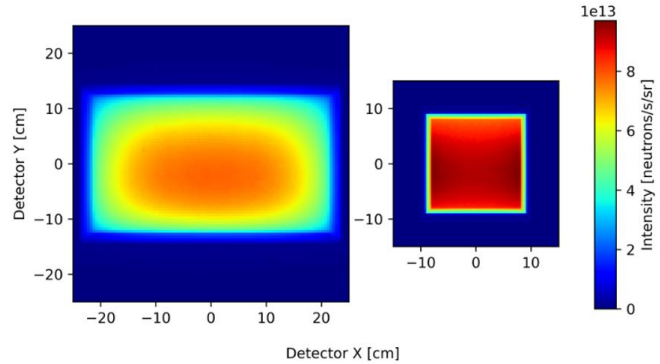
variables: p x y z vx vy vz t U1 U2

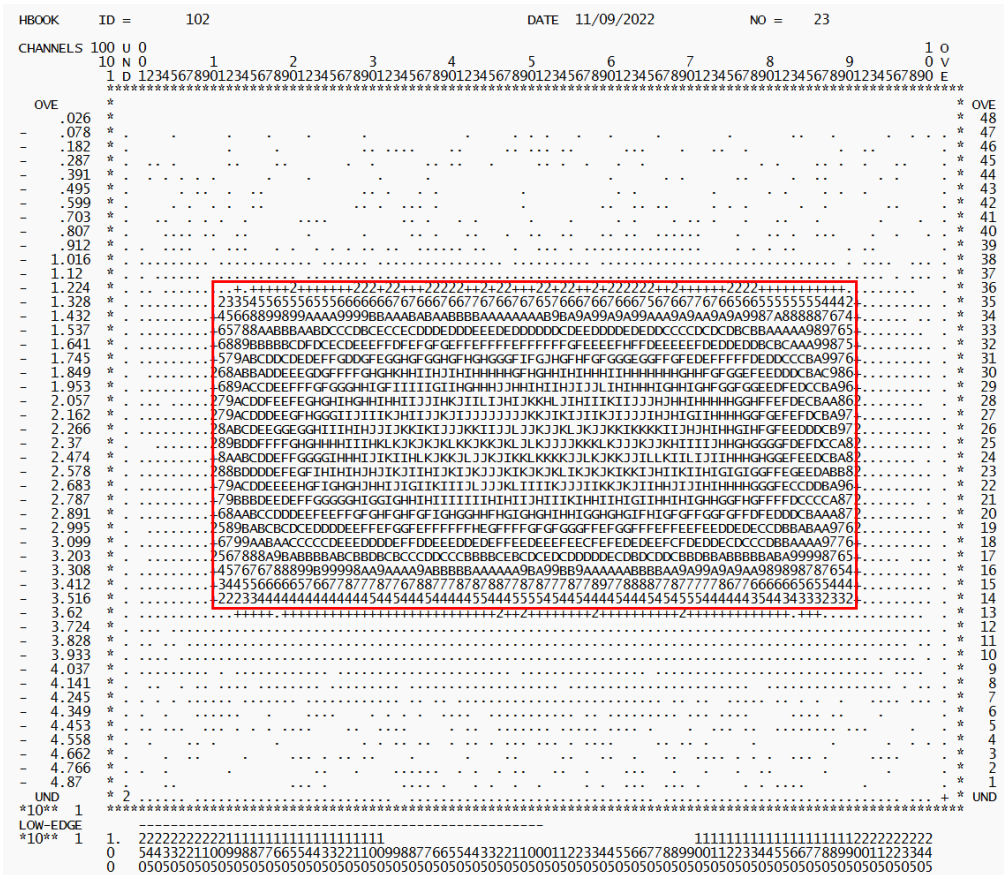
Origin coordínates: U1(@z=0.225) U2 (@z=0.225) for nnbar file 40x24
Origin coordínates: U1(@z=0.25) U2 (@z=0.250) for 15x15 file



confirmed

Total weigh	Total	in LBP	from LD2	$> \lambda = 4\text{Å}$	in 10x10 cm2
In 40x24 file	0.12395	0.09848	0.06932	0.0204126	3.01808E-3
In 15x15 file	0.08174	0.06348	0.03531	0.0083716	3.88022E-3


1e13
Detector Y [cm]
Detector X [cm]
Intensity [neutrons/s/sr]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LOW-EDGE
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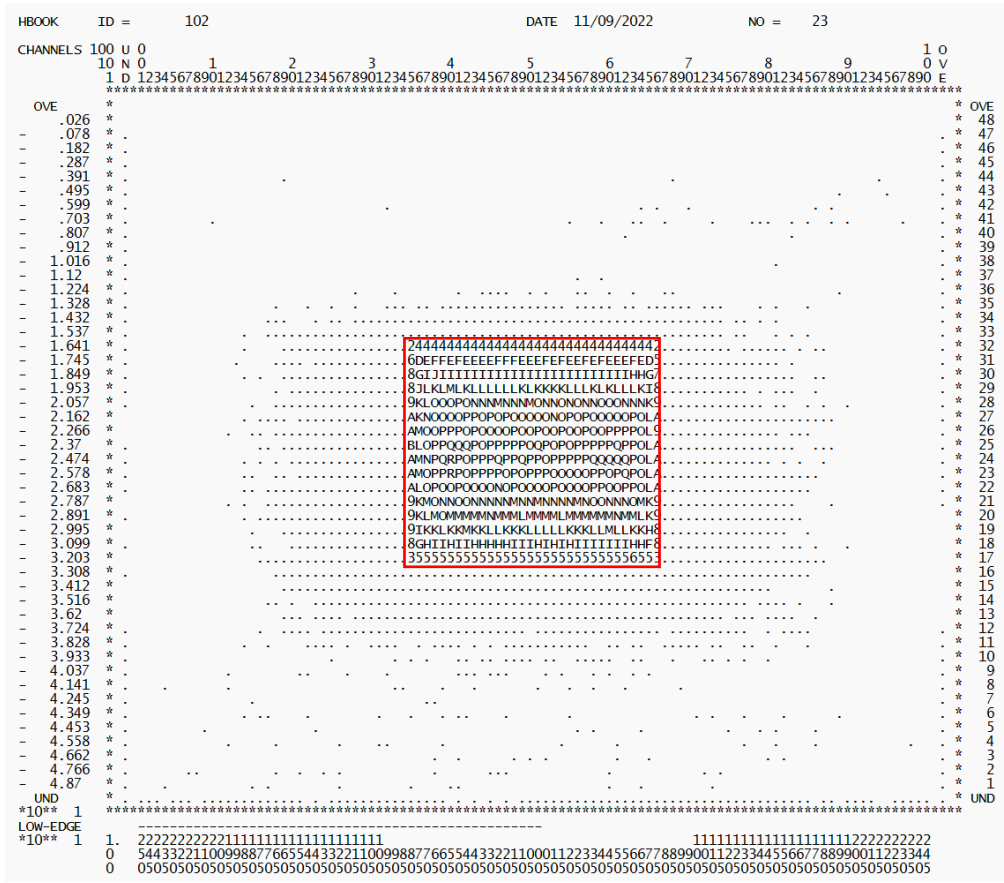
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UND
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LOW-EDGE
*10** 1 1. 22222222222111111111111111111111 11111111111111111112222222222
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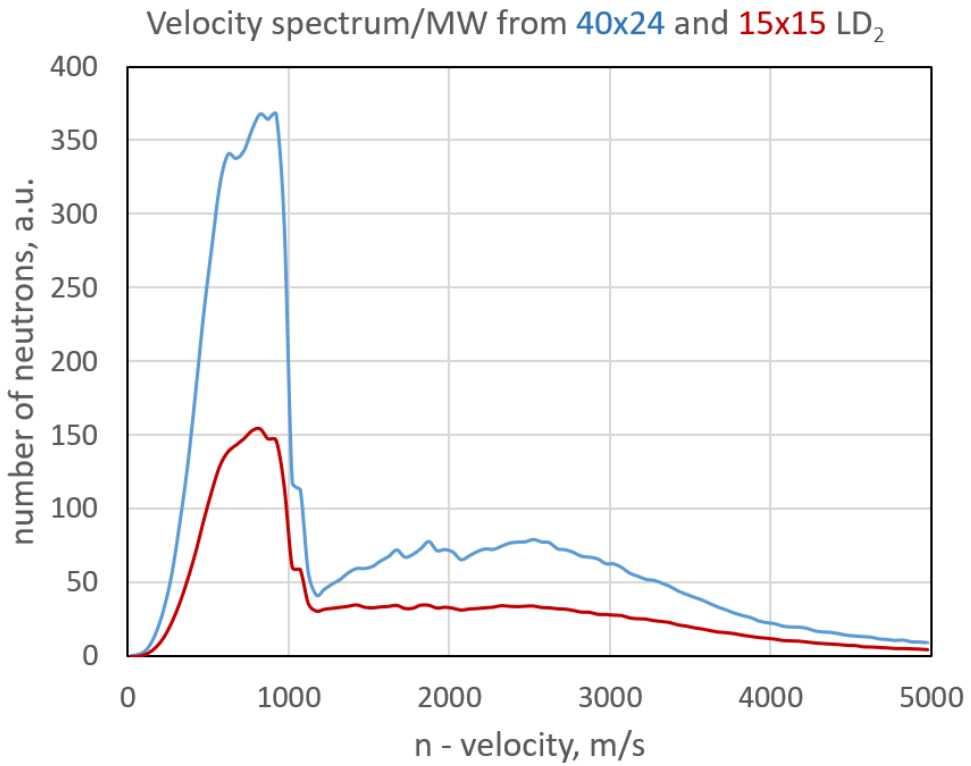
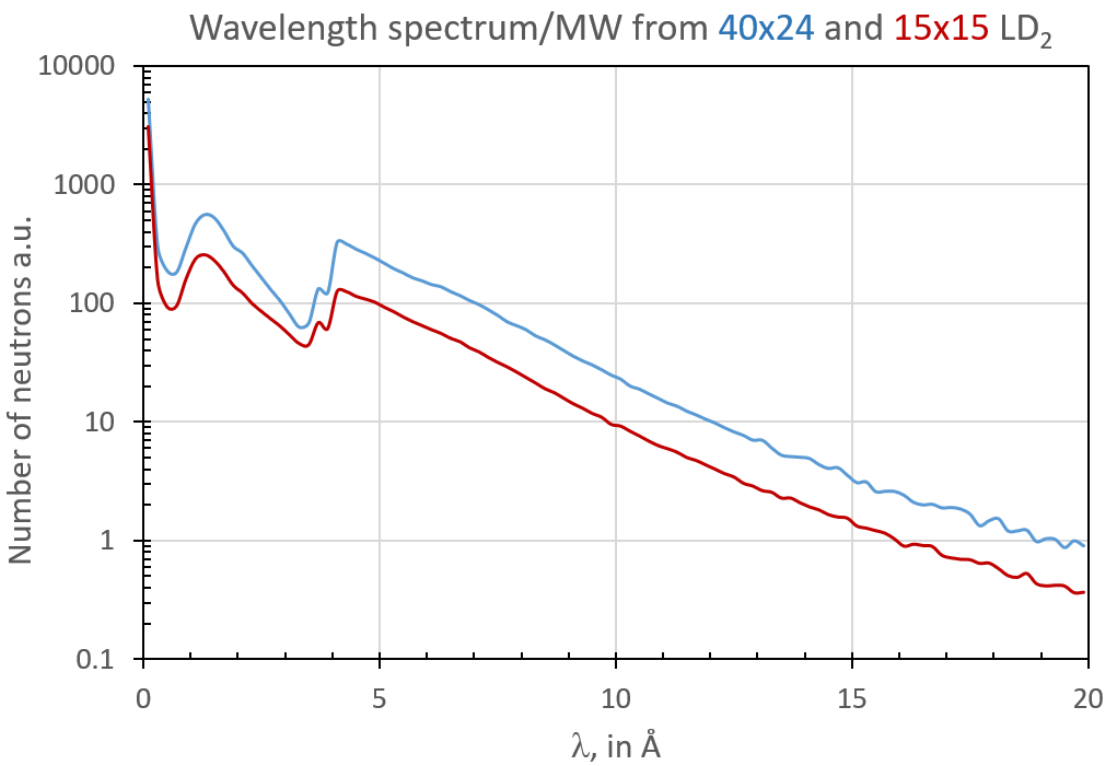
Distributions from the full area of LD2 moderator



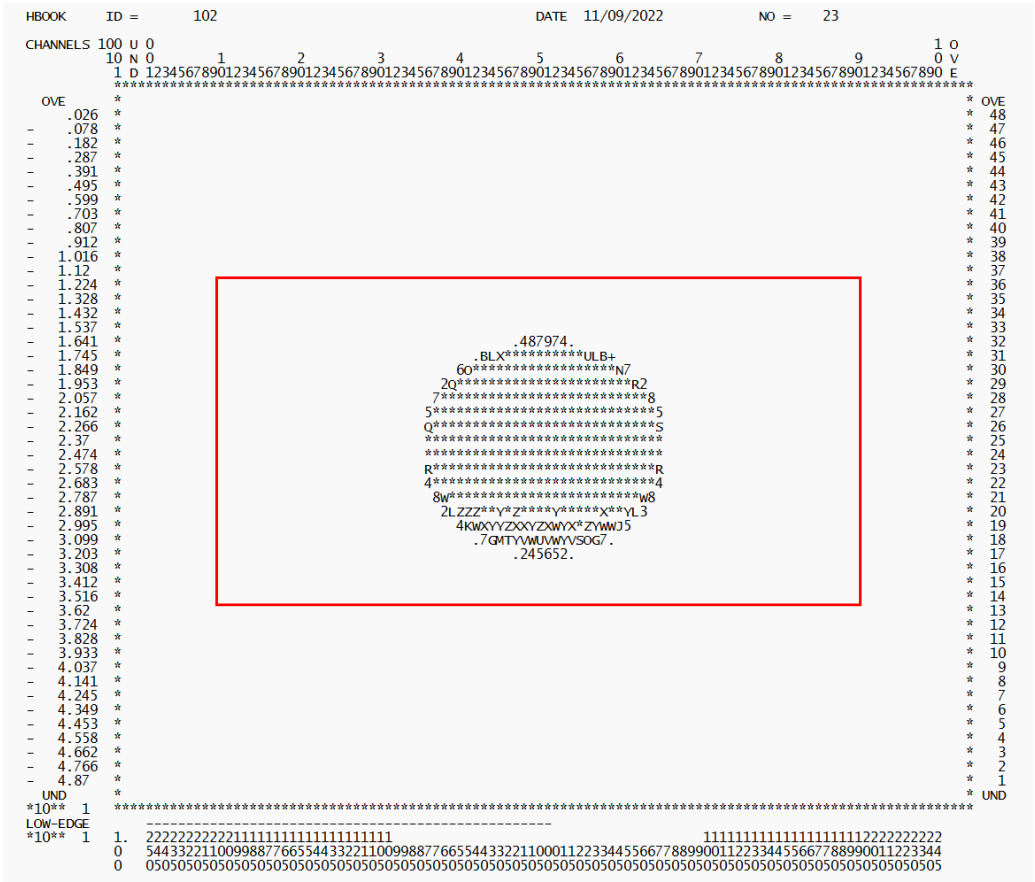


Sum of weights for 5 MW

40x24 cm^2 within dia 15 cm

All λs 1.17354E-2

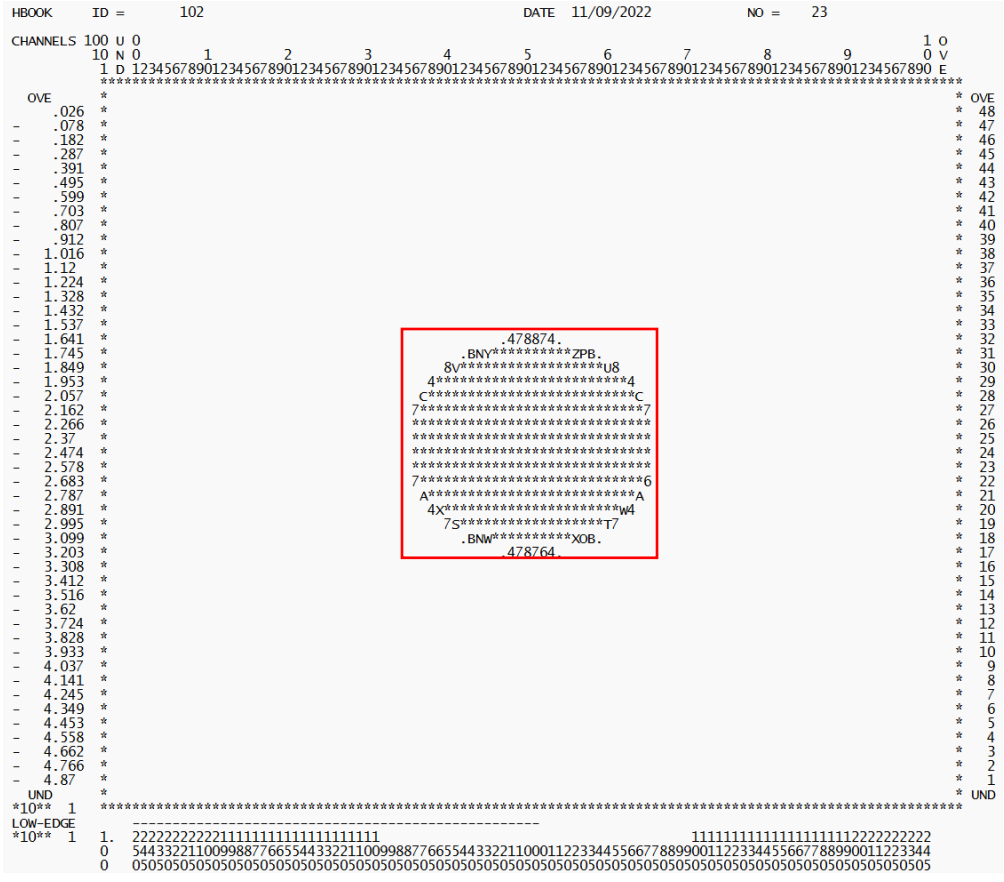
λ > 4Å 5.17202E-3



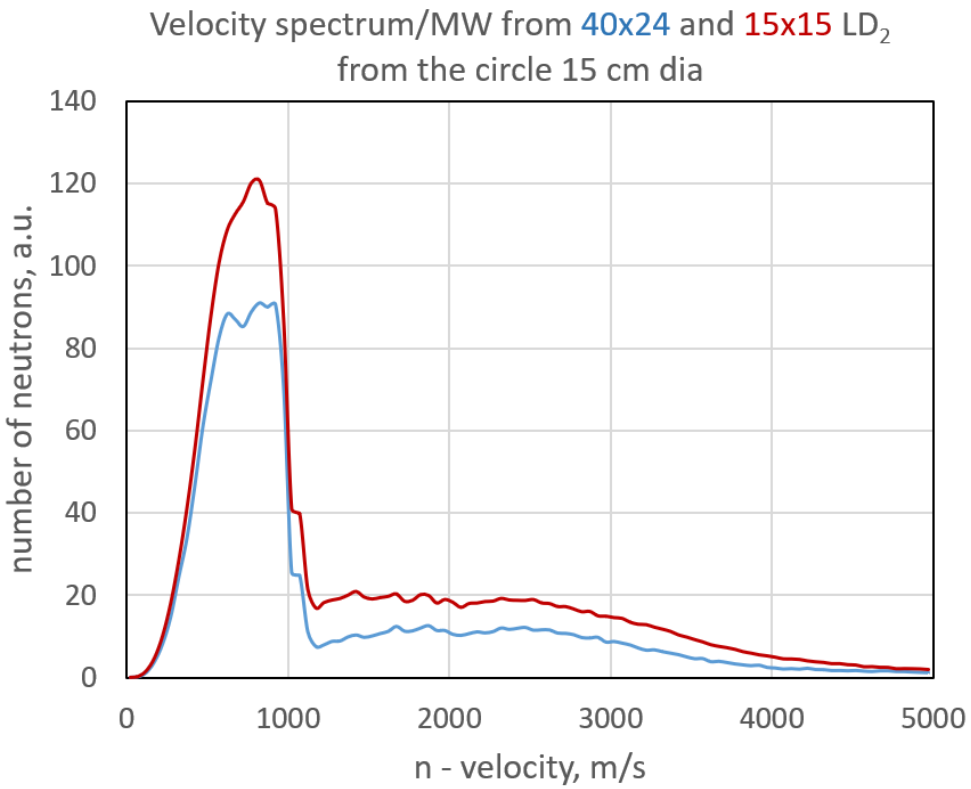
15x15 cm^2 within dia 15 cm

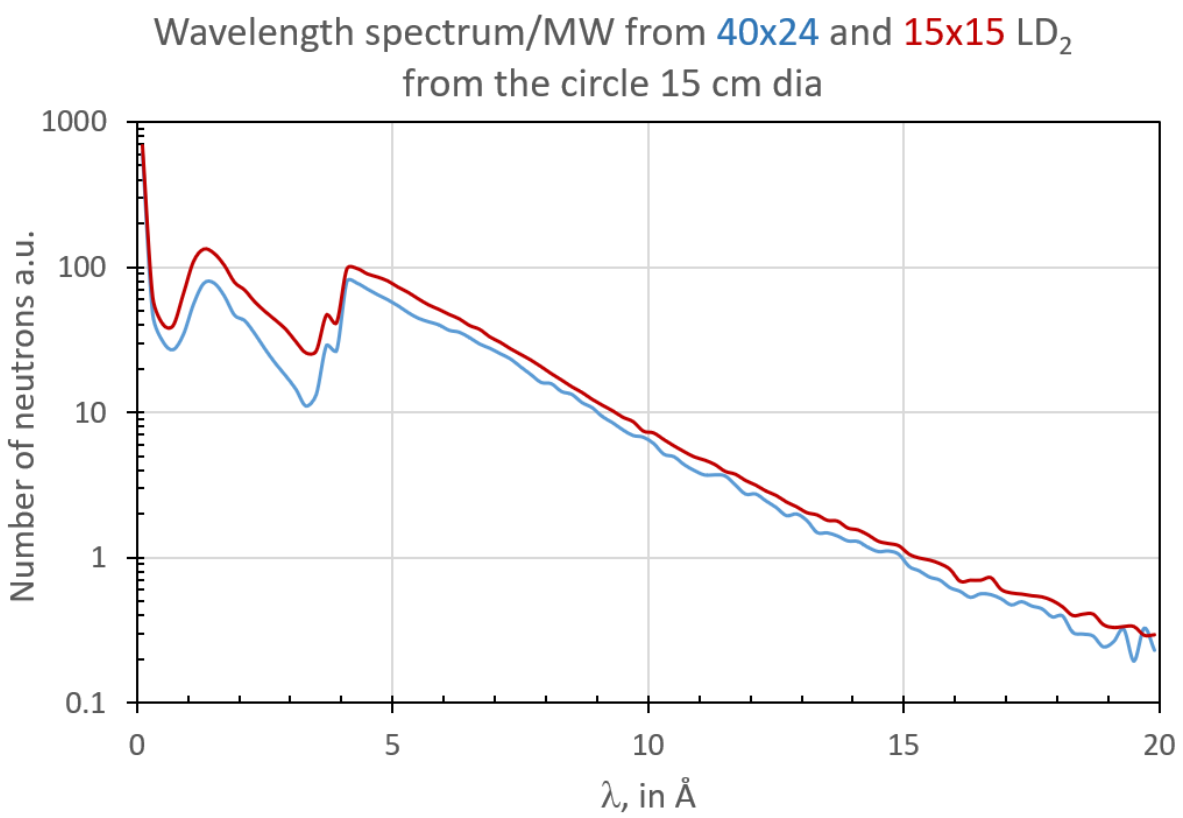
All λs 1.58672E-2

λ > 4Å 6.53302E-3



Distributions from the central circle dia 15 cm of LD2 moderator



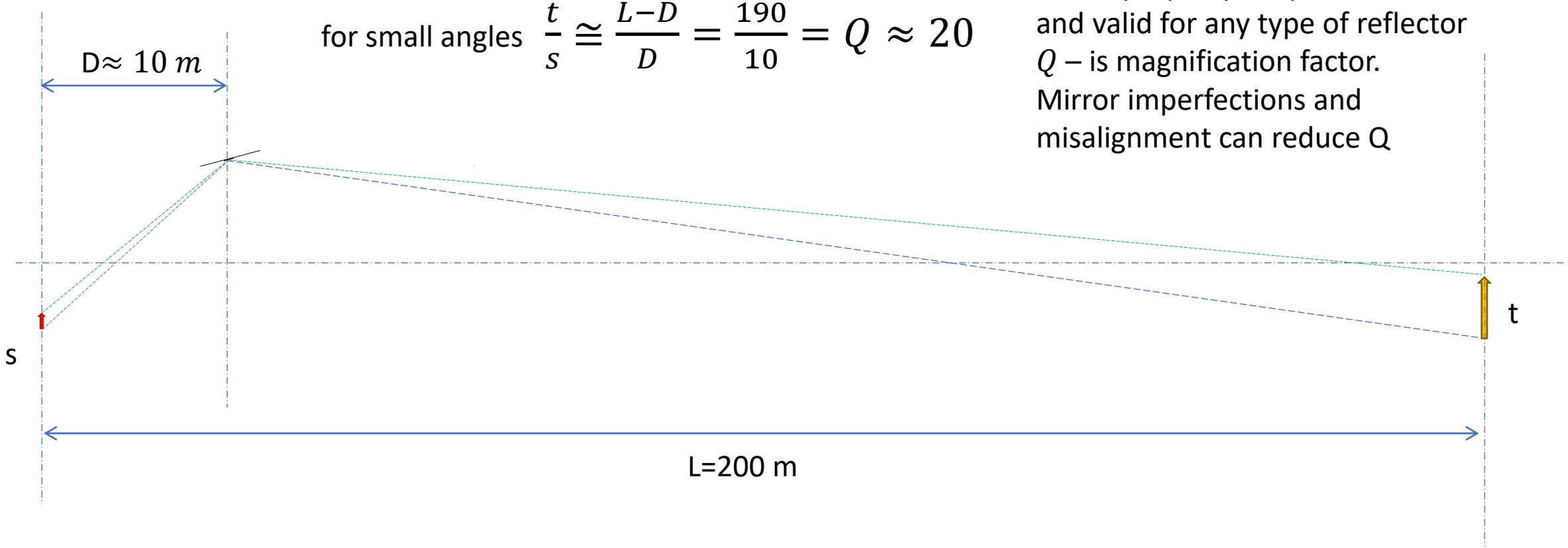


Magnification factor Q

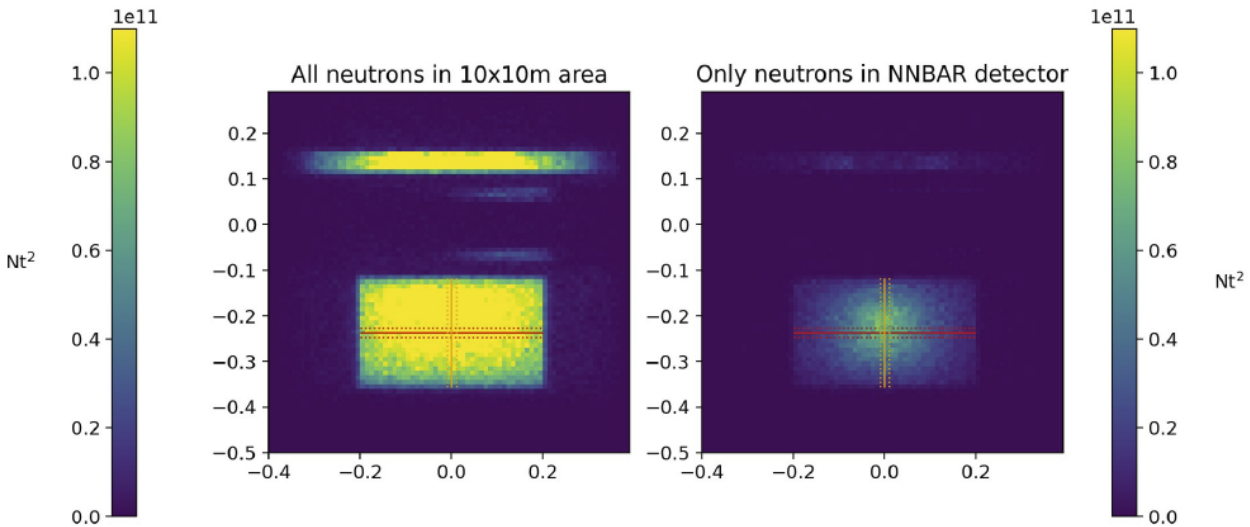
Neglecting effect of gravity
if $\emptyset_t = 2\ m \rightarrow \emptyset_s \cong 10\ cm$

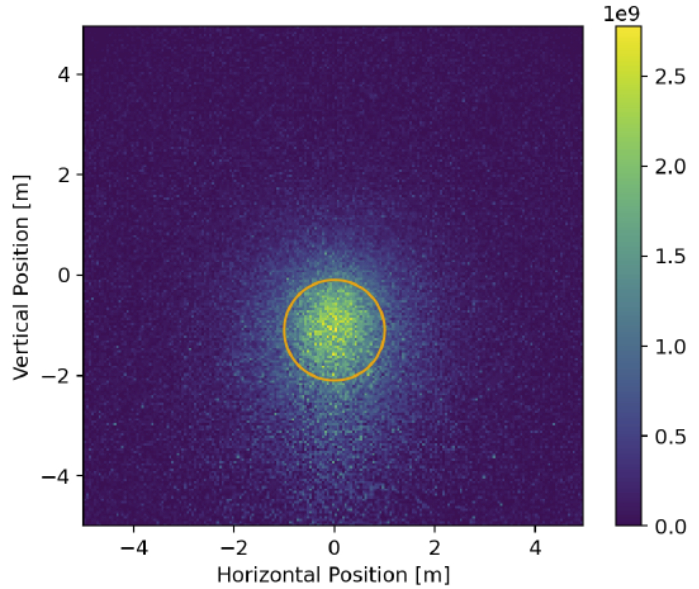
This is property of specular mirror and valid for any type of reflector
Q – is magnification factor.
Mirror imperfections and misalignment can reduce Q

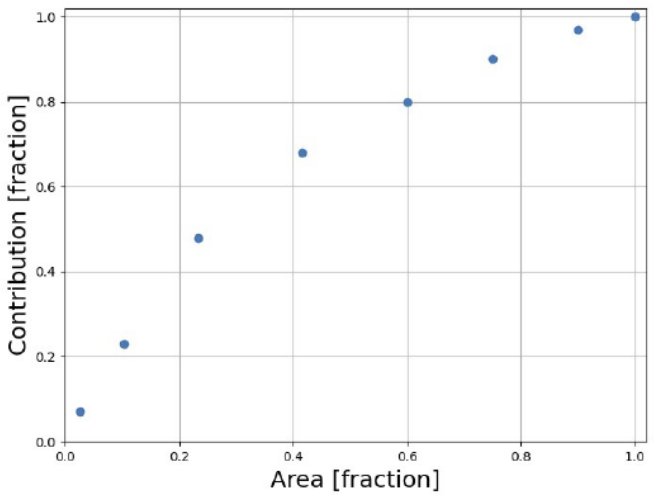
for small angles $\frac{t}{s} \cong \frac{L-D}{D} = \frac{190}{10} = Q \approx 20$



Where do neutrons originate that land in the detector?







Comparison At 5 MW

Richard Wagner on April 12, 2022

Same optics as with Esben spectra (baseline)

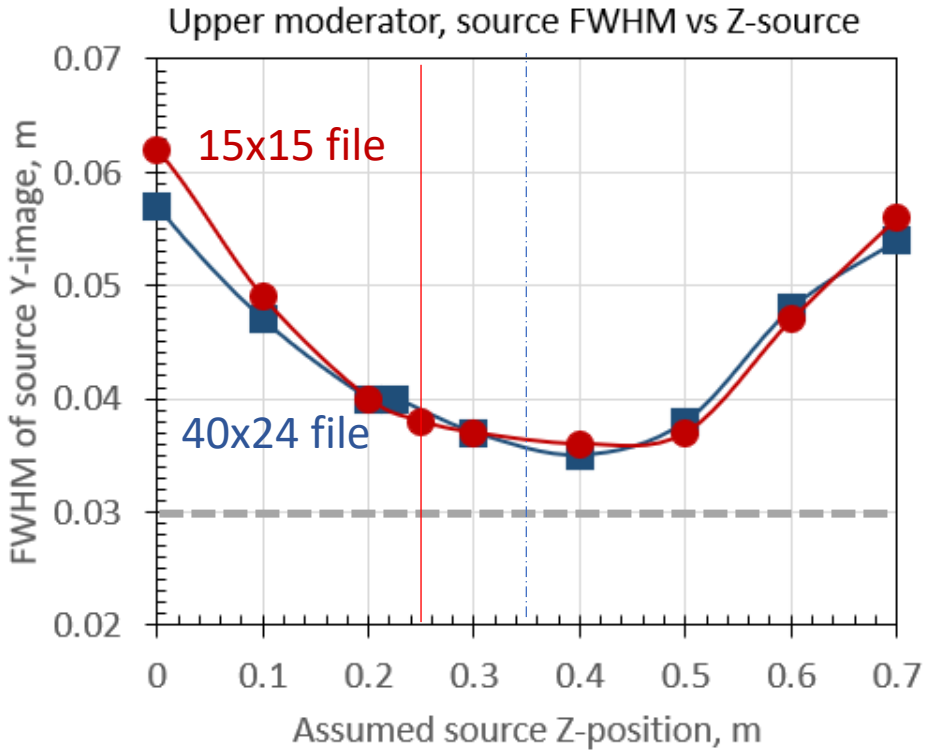
- Ratio FOM: 310 / 468 = 0.66
- Ratio Area: $(15x15)cm^2$ / $(24x40)cm^2$ = 0.23
- FOM for LD2_ESS (Esben's model): 290 (@5MW)

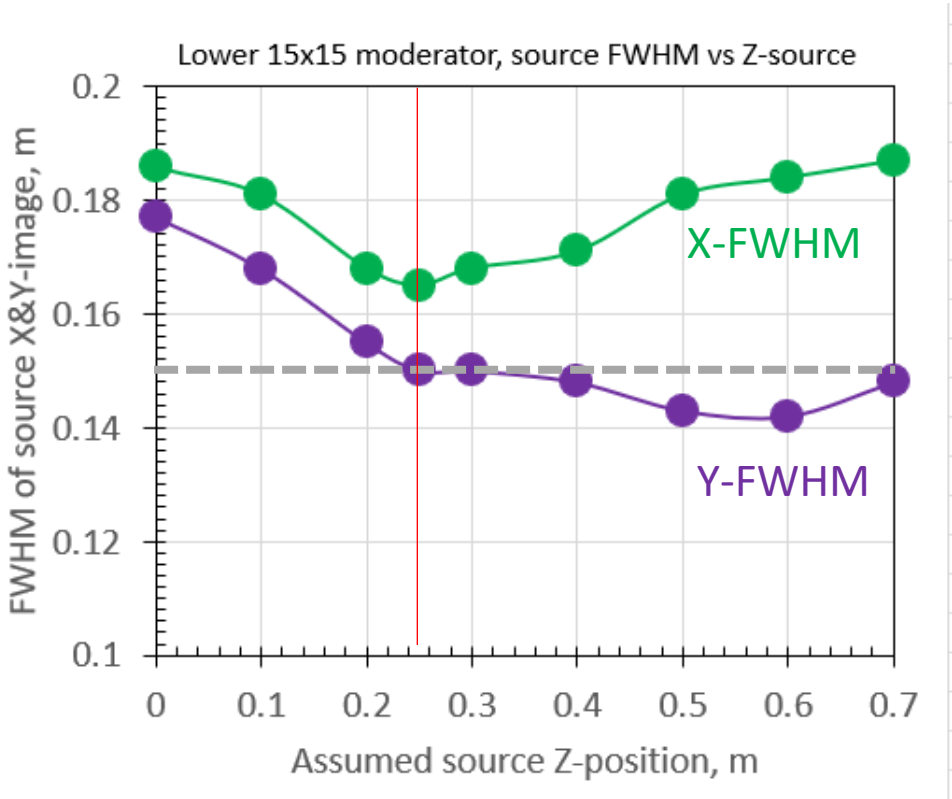
variables: p x y z vx vy vz t U1 U2

$t_1 = (x - U_1)/v_x$
$t_2 = (y - U_2)/v_y$
$(t_1 - t_2)$ peaks around 0
$U_3 = z_{source} = 5.5 - v_z \cdot (t_1 + t_2)/2$

This is tally for MCPL simulation but not emission surface proper

For finding z-position of emitting surface one can calculate
FWHM at different z for the neutrons passing the aperture of LBP





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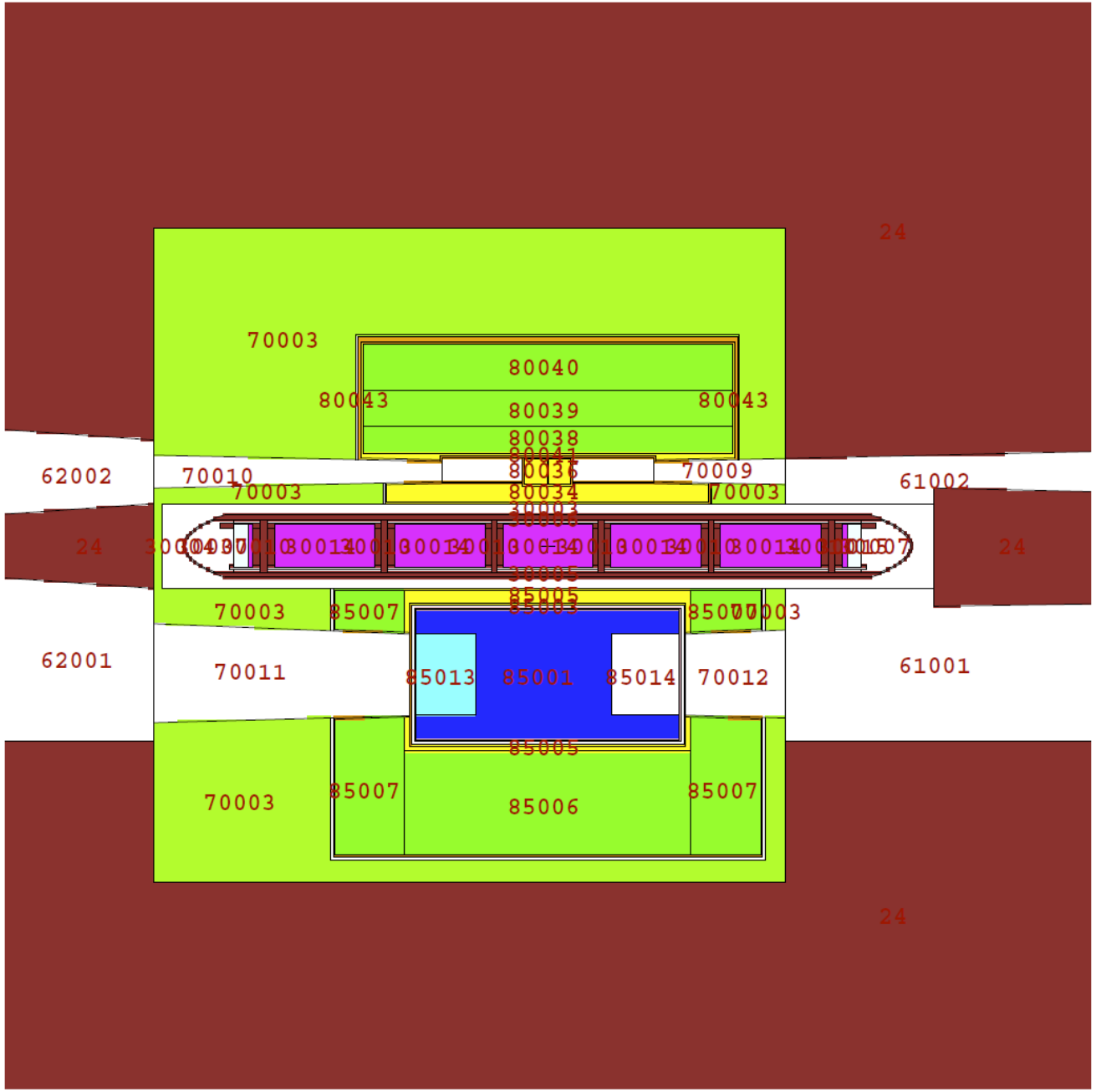
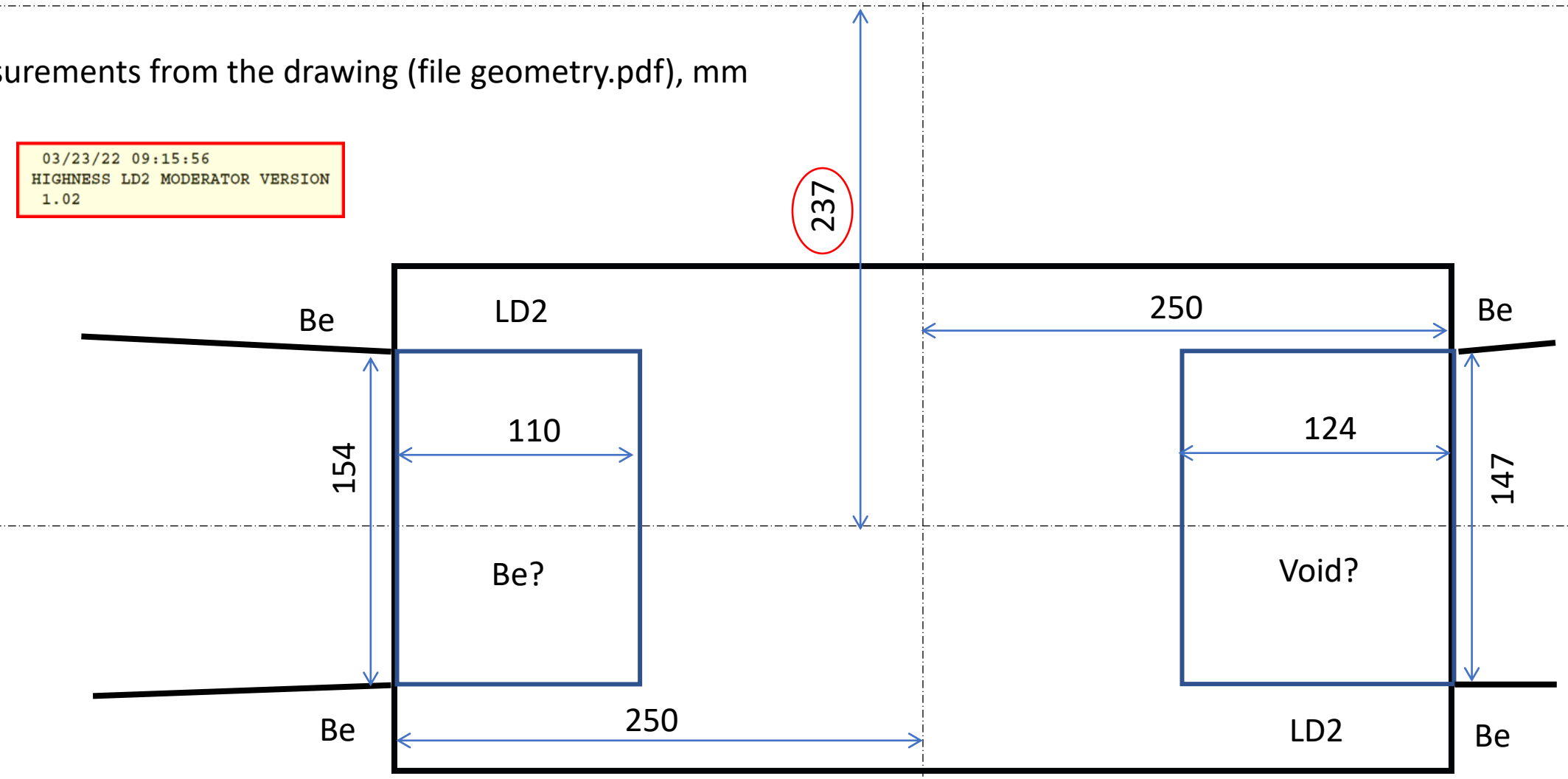
 03/23/22 09:15:56
HIGHNESS LD2 MODERATOR VERSION
 1.02
```

```
probid =  03/23/22 09:15:53
basis:   XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
(     0.00,     0.00,     0.00)
extent = (   100.00,   100.00)
cell labels are
 cell names
```

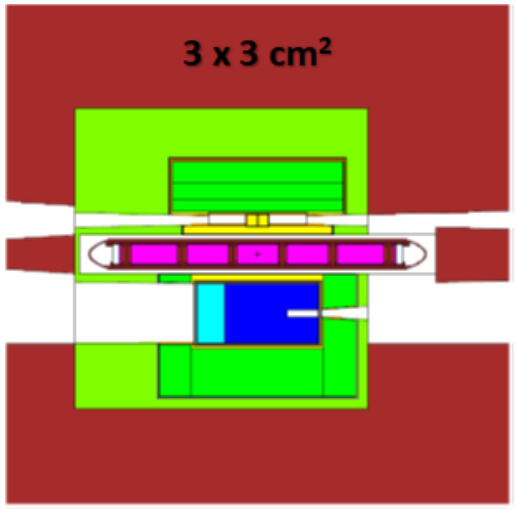
File “geometry.pdf”

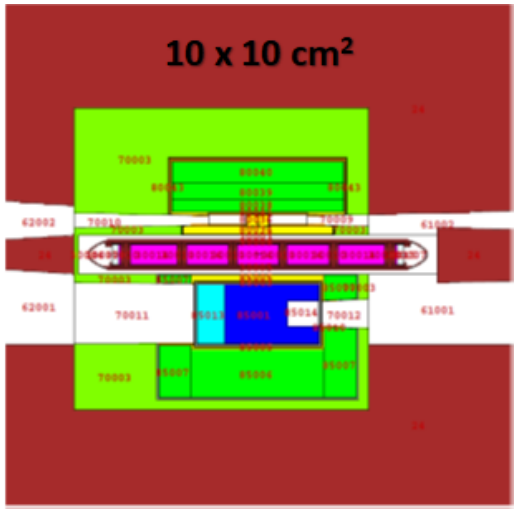


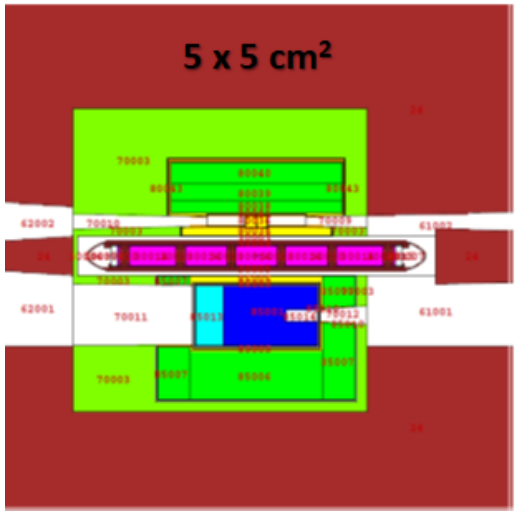
Measurements from the drawing (file geometry.pdf), mm

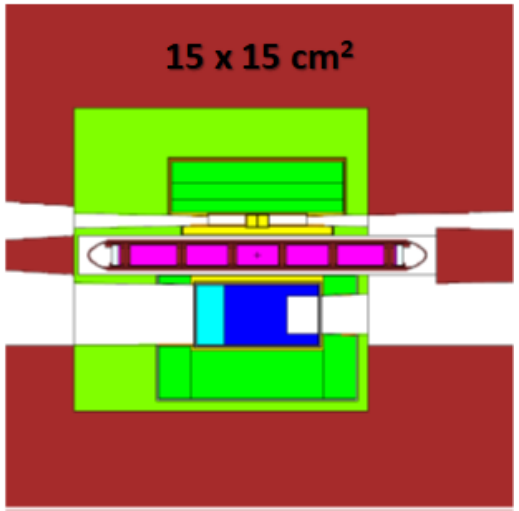


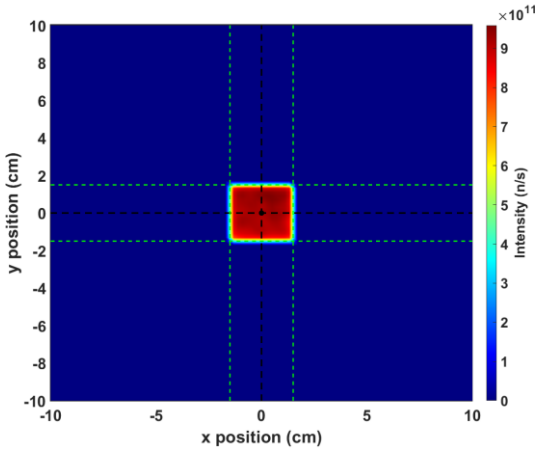
SANS Basic Calculations & Comparisons

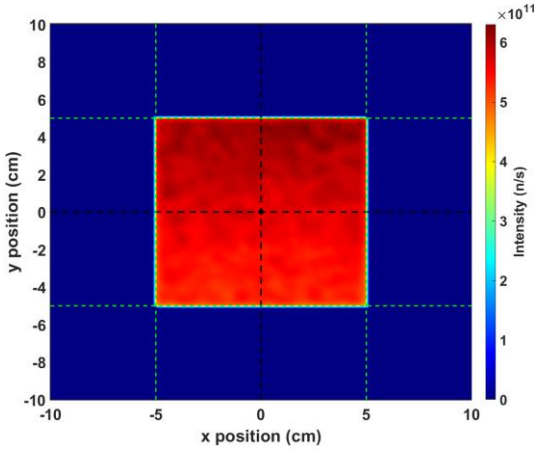


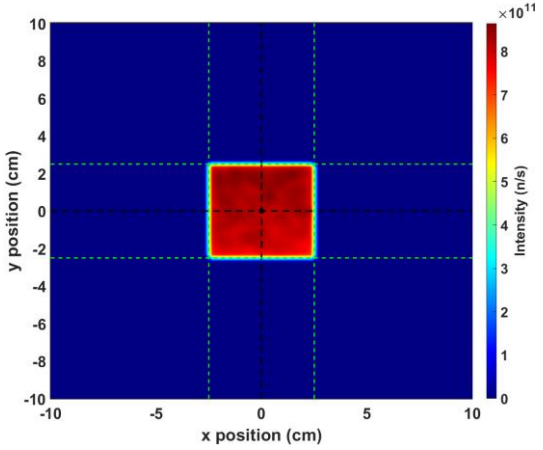


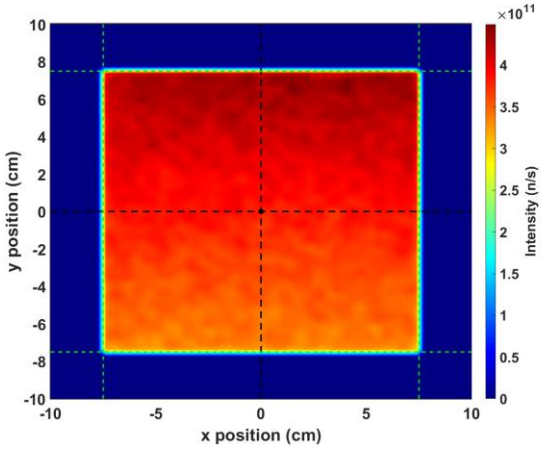




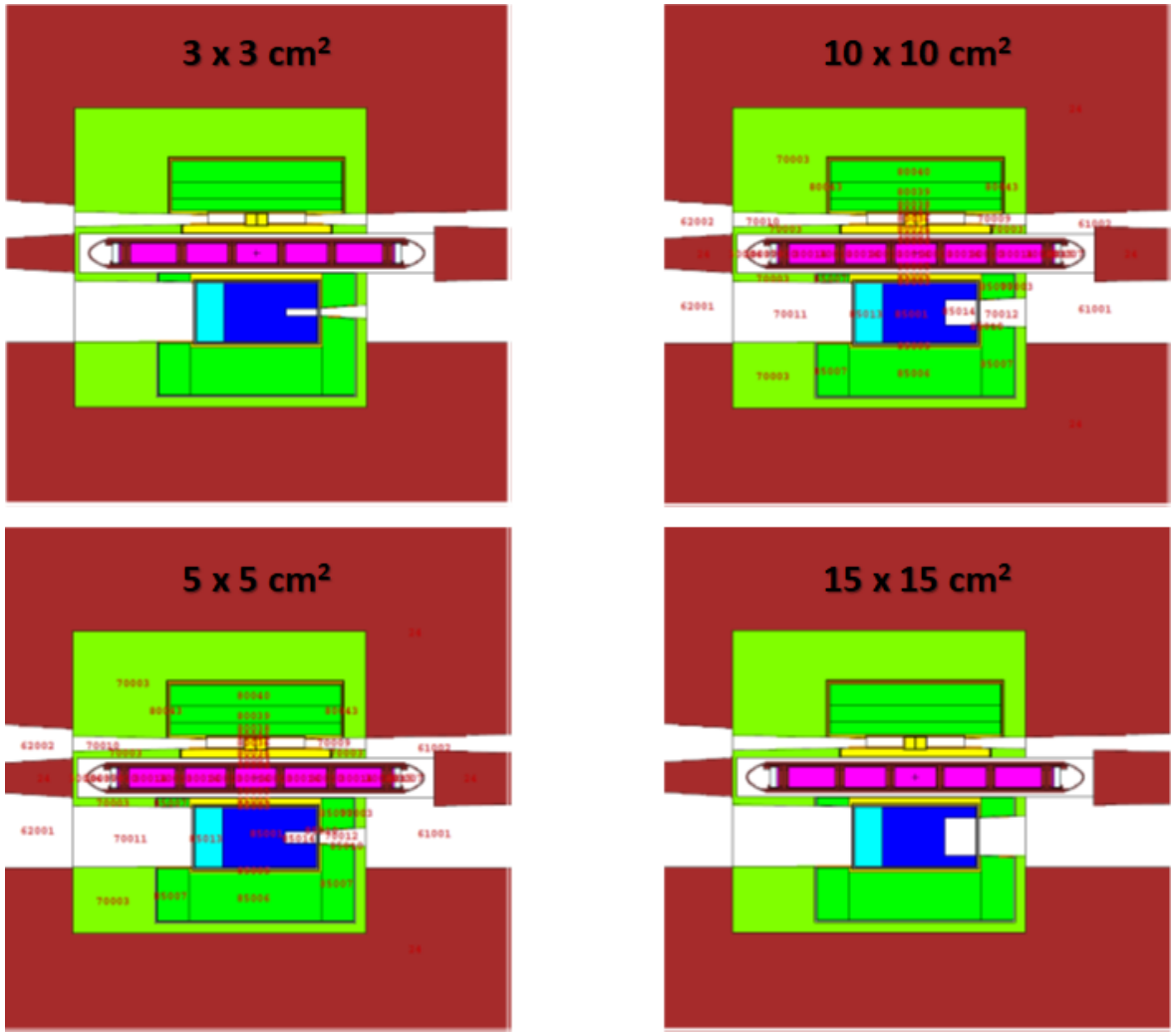


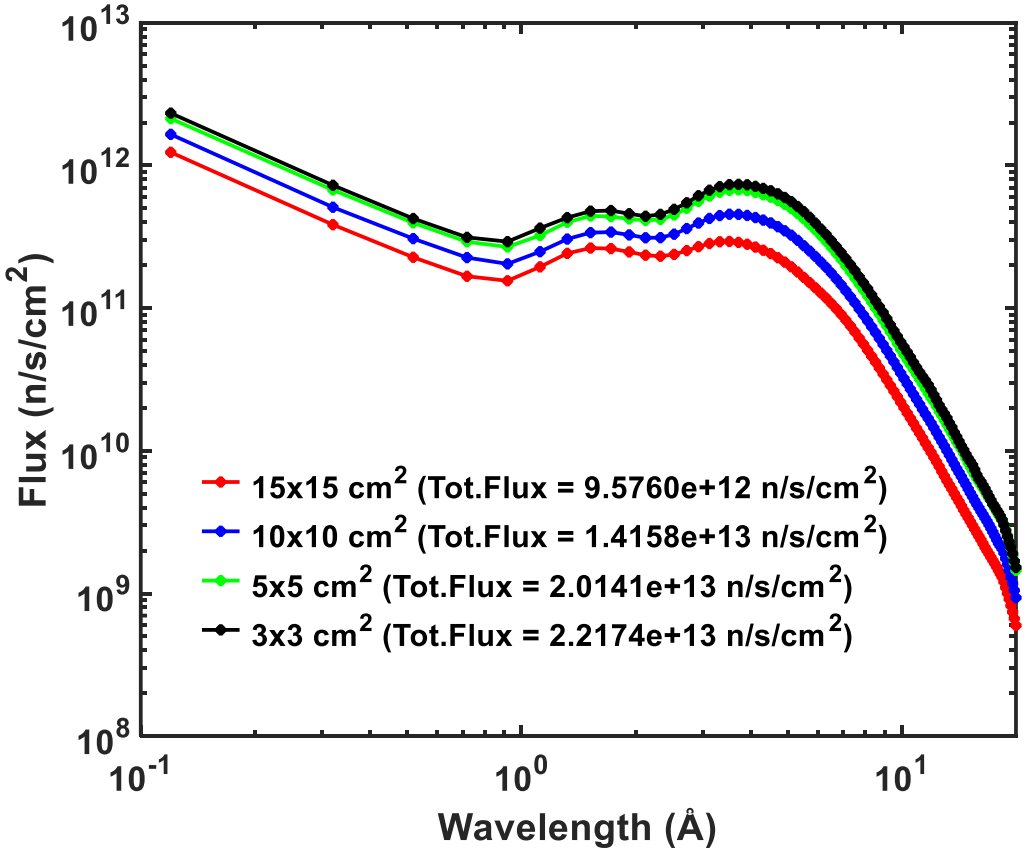


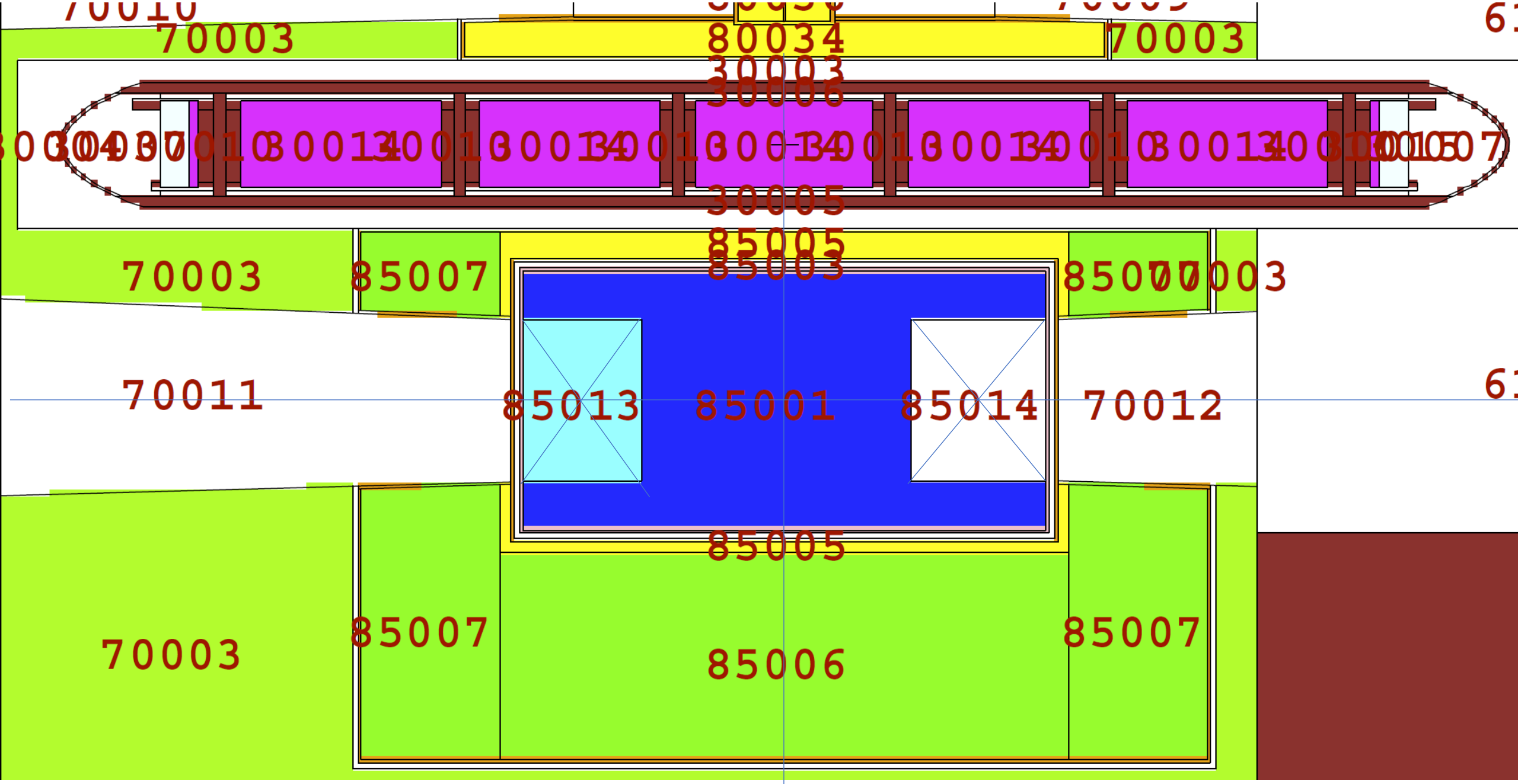




SANS Basic Calculations & Comparisons

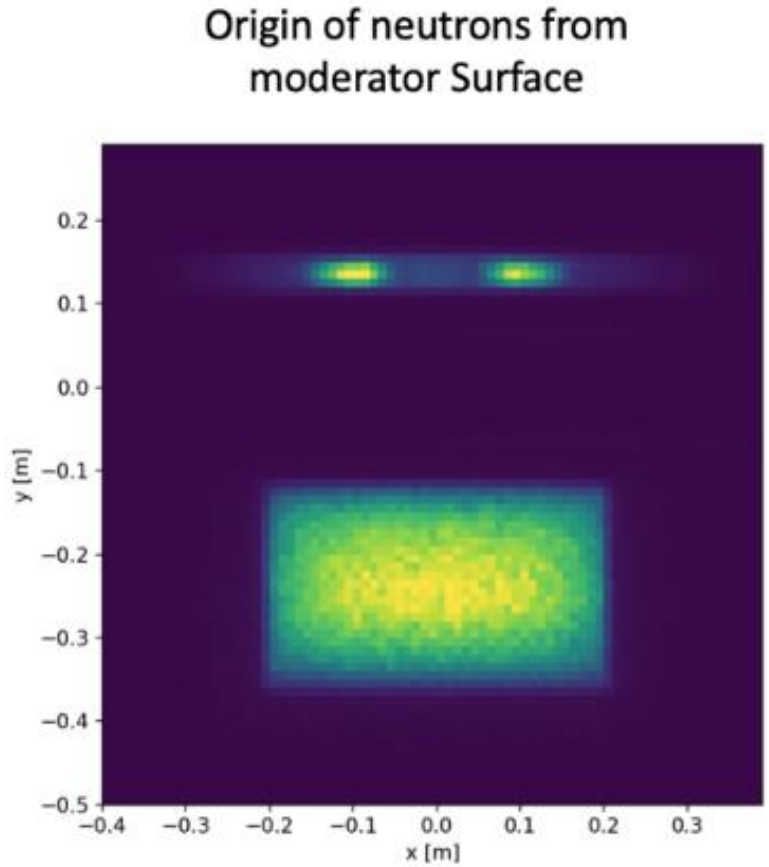


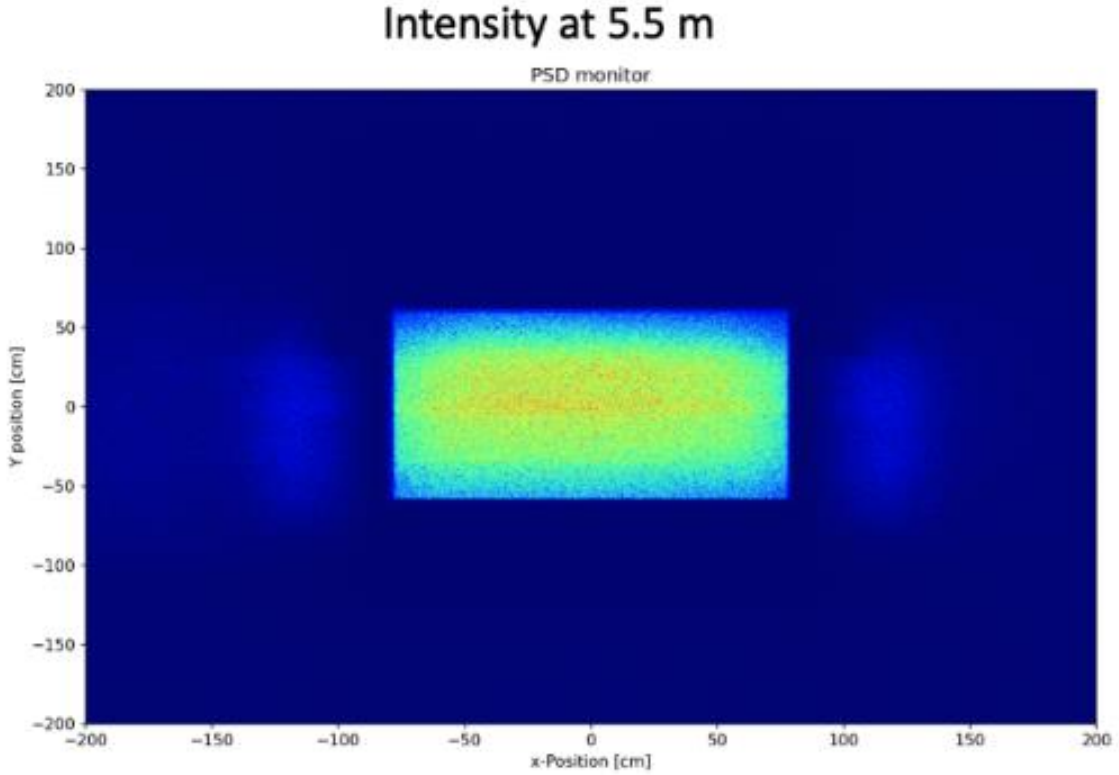


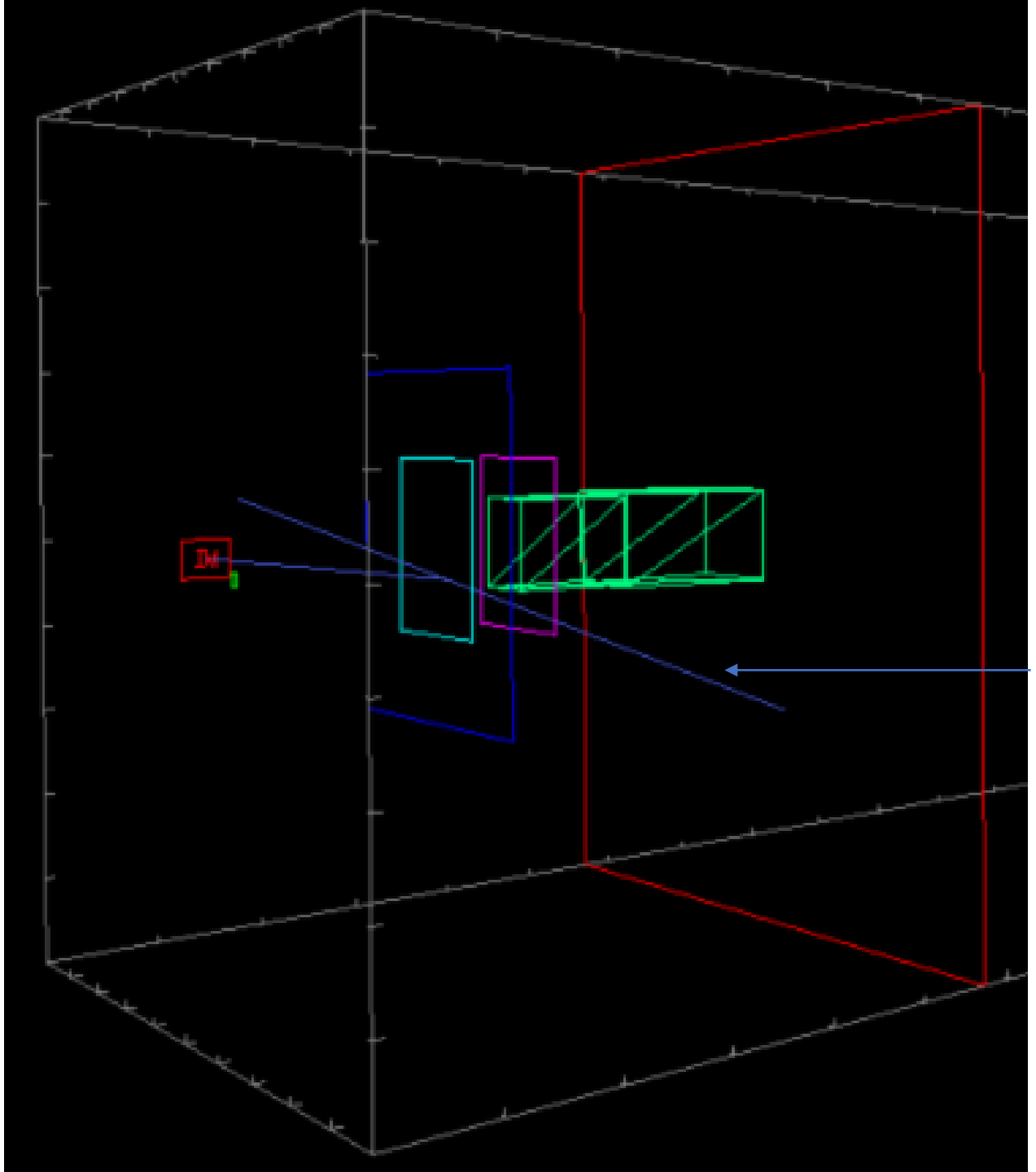

70003
80034
70003
30003
30006
30005
85005
85003
70003
85007
85007
70003
70011
85013
85001
85014
70012
85005
70003
85007
85007
85006

LOGBOOK for ESS LBP Neutron File produced by Richard Wagner in June 2022

LBP_FILE_V1.txt before some “problems” fixed, 4,246,892 events, sum of weights 0.121623322
LBP_FILE_V2.txt was used in calculations. Ref: Richard June 03, 2022, 4,347,960 events, sum of weights 0.123948768

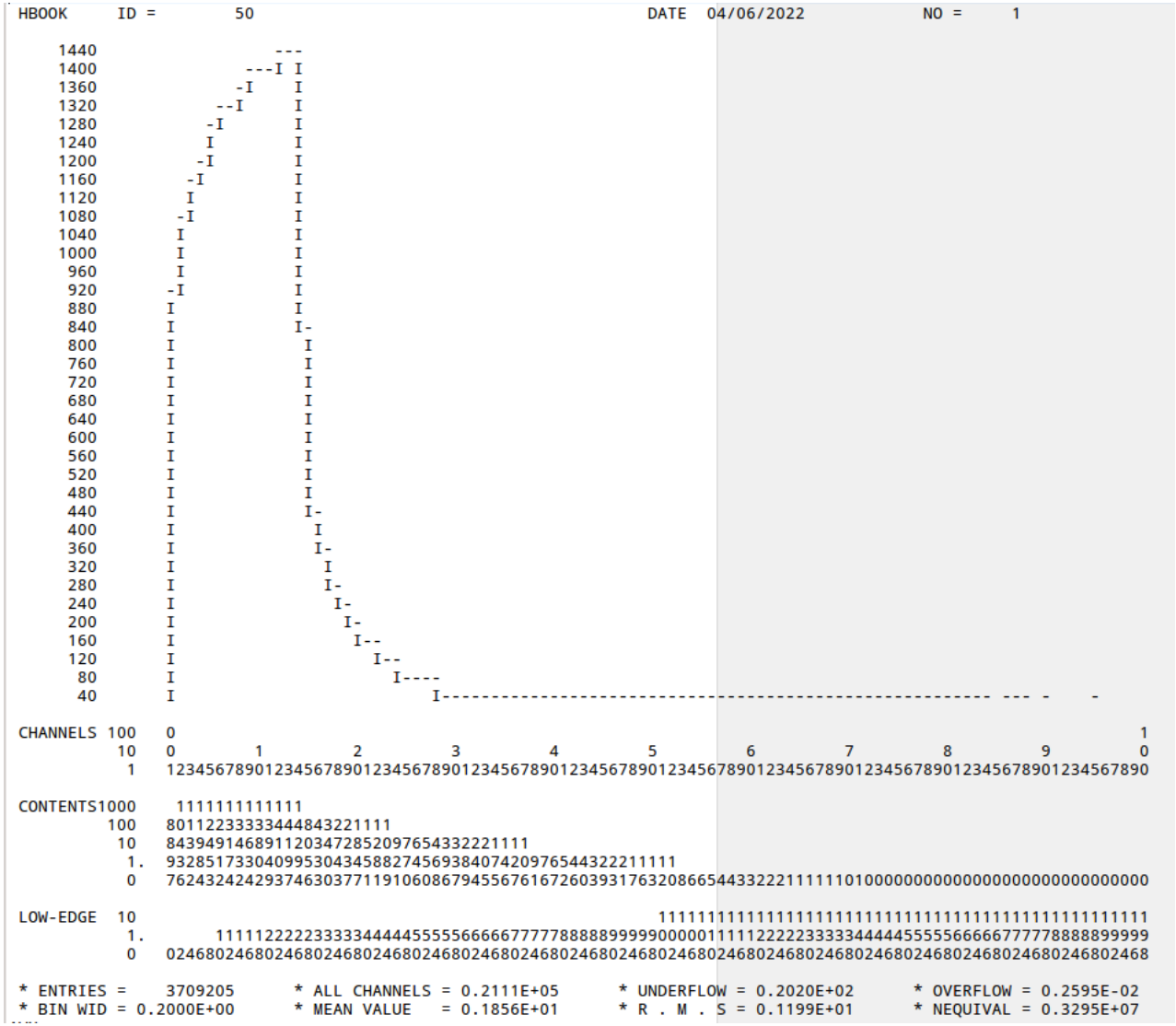




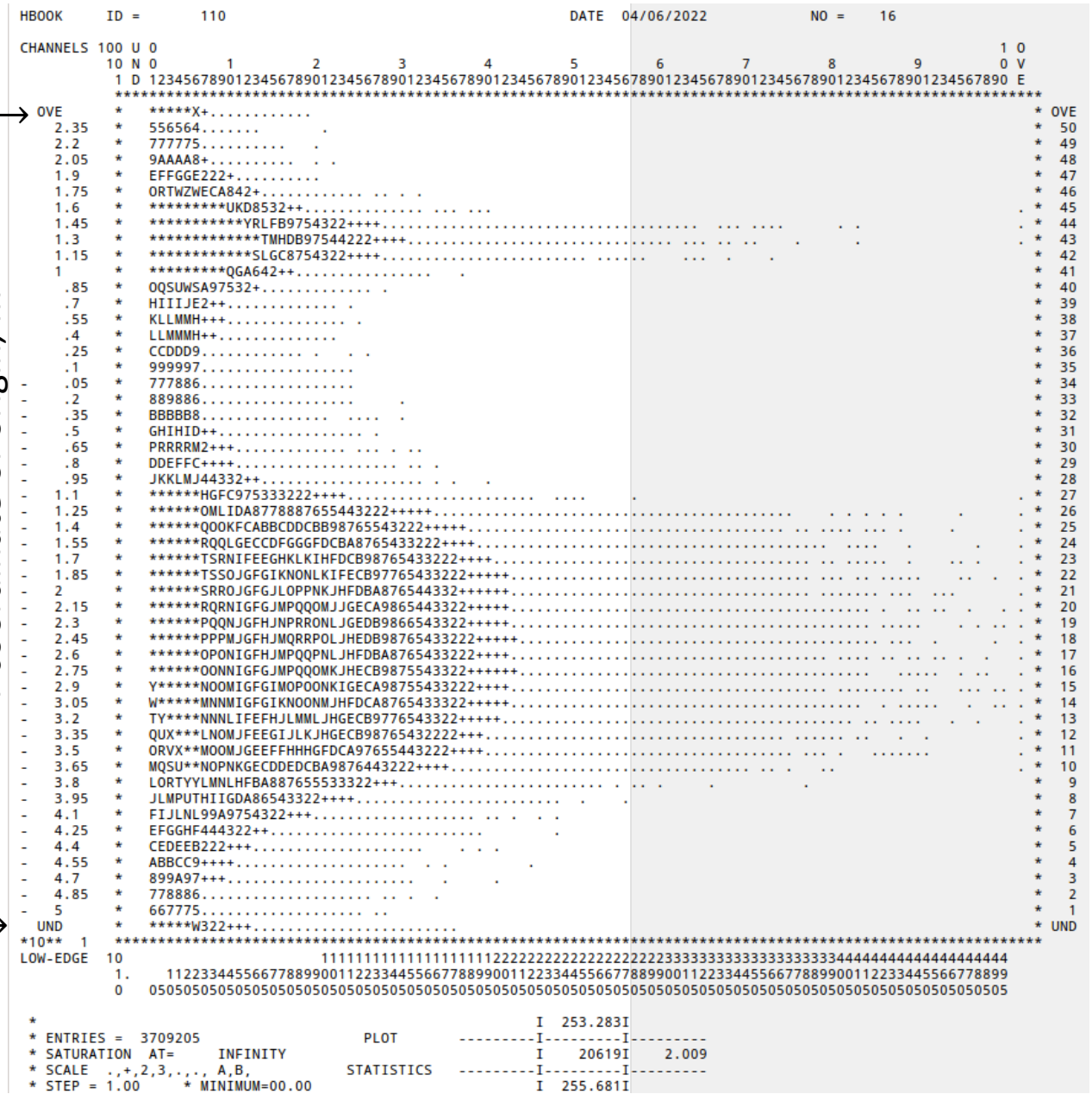


Track from
upper moderator?

Time in ms extrapolated to the origin from z = 5.5 m



Selection: exist through LBP
-0.80 m < x < +0.78 m
-0.60 m < y < +0.60 m



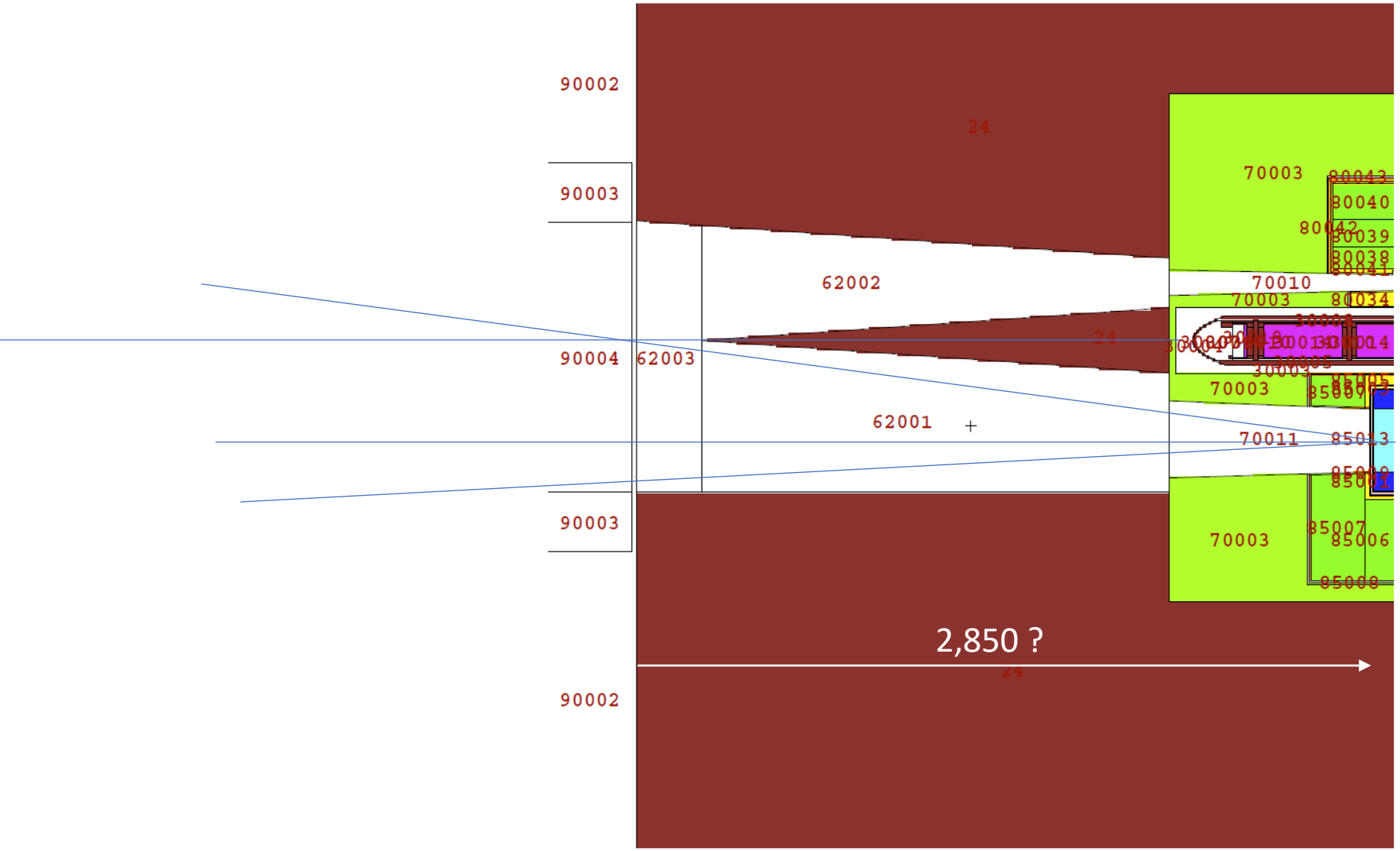
$+0.25\ m \rightarrow$

$-0.5\ m \rightarrow$

Y coordinate of origin, m

Time at 5.5 m, ms

15 x 15 files from Richard Wagner, September 3, 2022, with Luca's design of 40x24 cm2 LD2



Richard file from Sept 03,2022 for 15x15 cm2 side of moderator
events tot and in LBP 9257268 9257268 with no LBP cut
total weight, within LBP, and low 8.17385167E-02 mms 4.52227704E-02

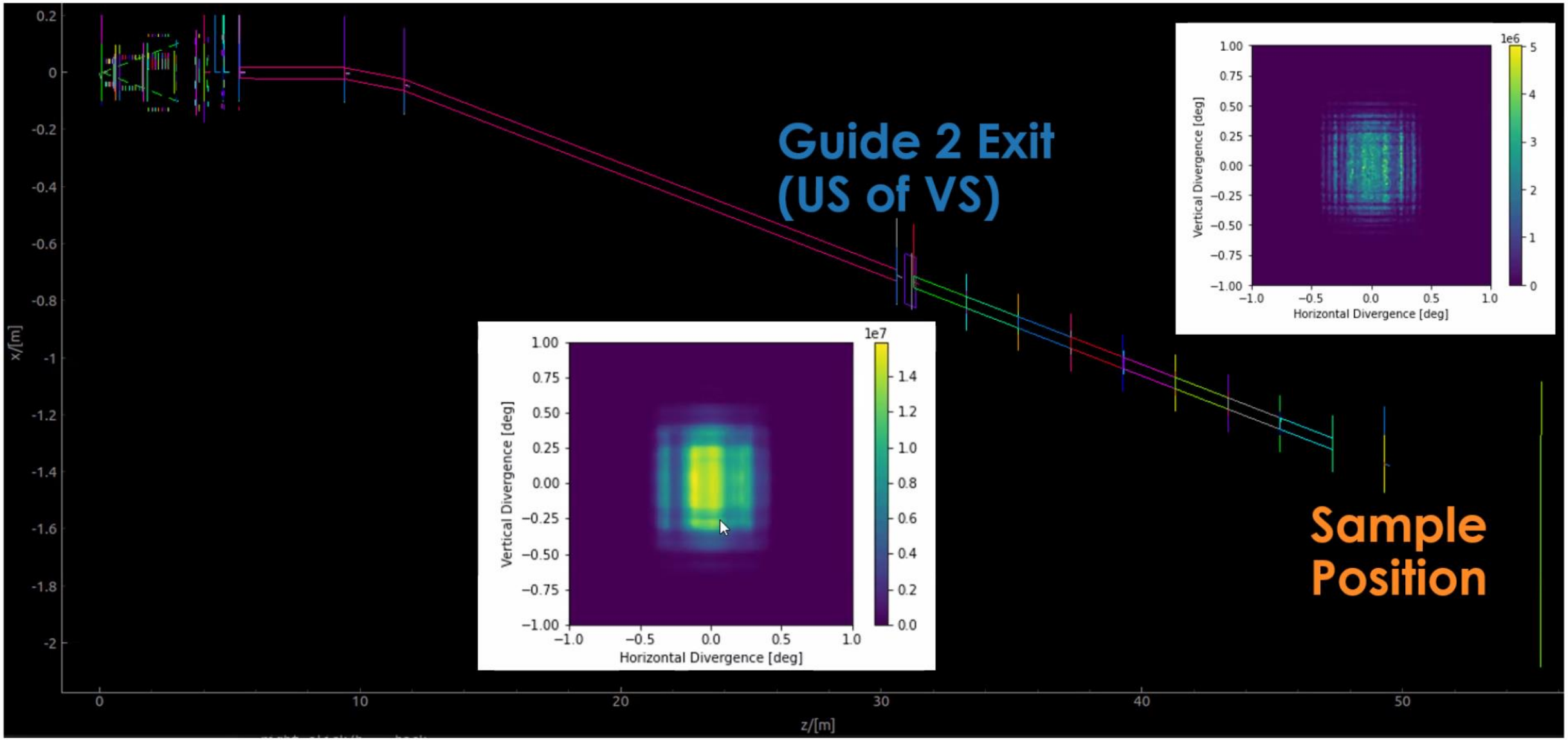
events tot and in LBP 9257268 7369859
total weight, within LBP, and low 8.17385167E-02 6.34839758E-02 3.53177823E-02

Lowell's BM Intensity Measurement – Run 24902

- BM average count rate ~28,500
  - Assume 5% loss due to dead time
  - Yields approximately **9.96×10^8 neutrons/second**

- Gold Foil Activation intensity value determination still pending

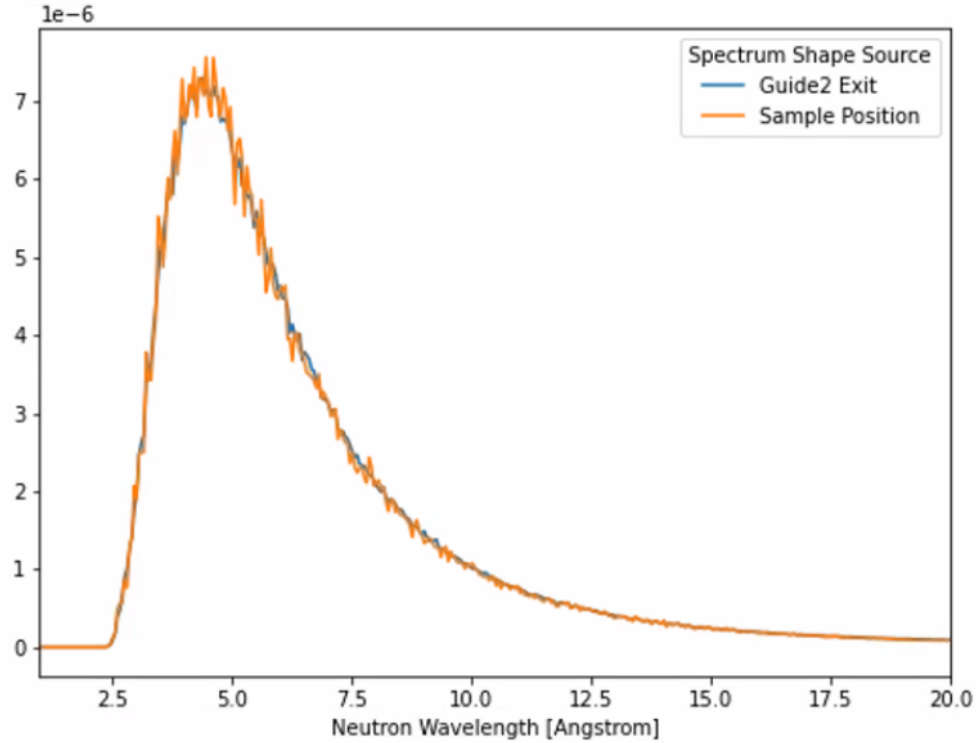
UPDATE: New McStas Simulation Run



t substantial.

Guide2 Exit: 3.024e-5

Sample Position: 3.014e-5



ew Intensity Measurement

Lowell BM 9.93 x 10^8 neutrons/second

Au Foil 7.4 x 10^8 neutrons/second

cStas Intensities

Guide2 Exit: 2.29x10^{10}

Sample (2cm dia. Aperture): **3.78x10^9**

ominal Factor of 4 discrepancy between simulation and measurement.

oes this matter? Do we trust idealized simulations or measured values?

OGE
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