STREAMING IN NBEX

Status of Neutronic Simulations

Alan Takibayev

European Spallation Source ERIC | Target Division

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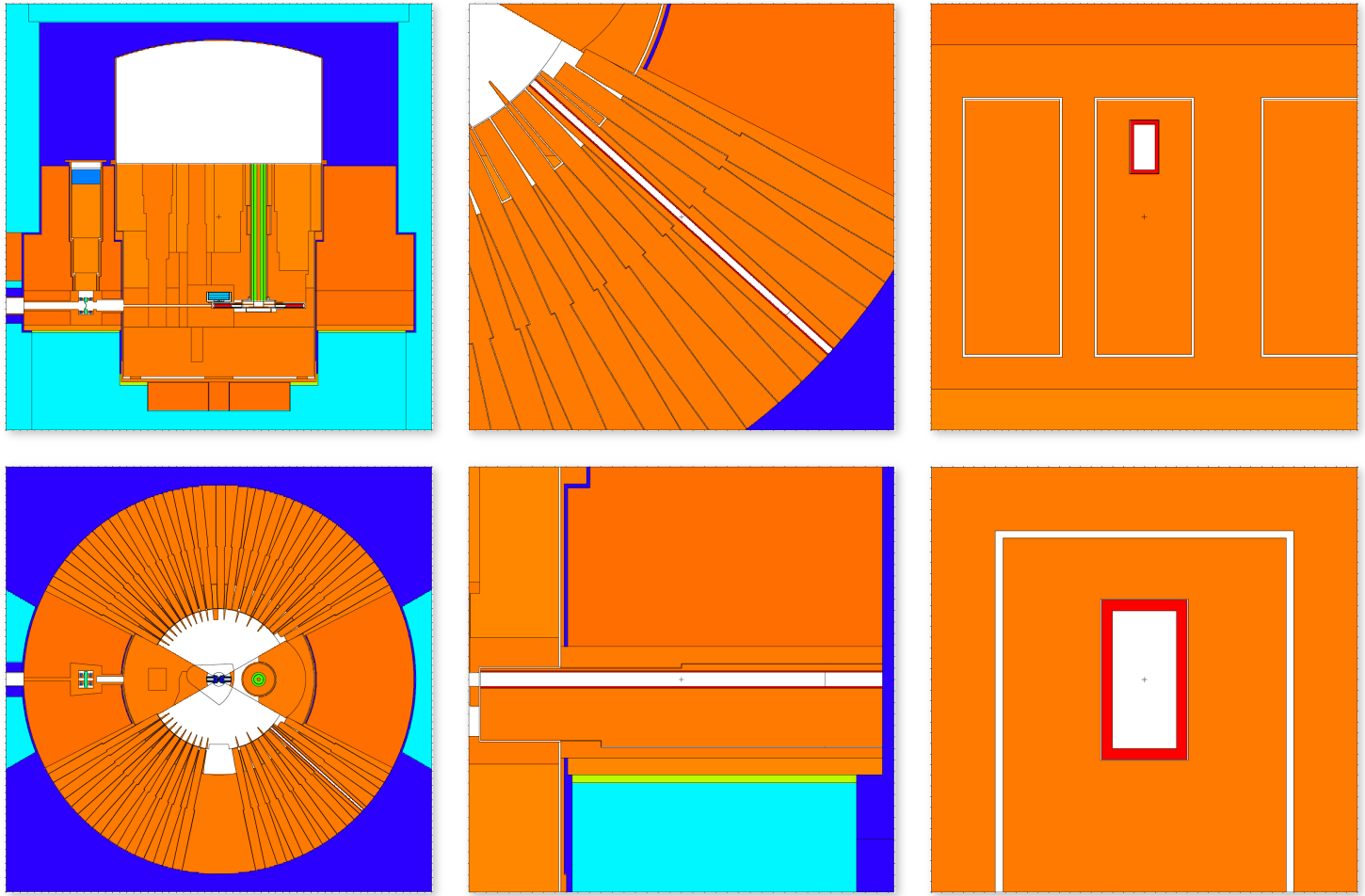
Short reminder what has been done before
Model update
Preliminary results
Source validation
Final results
System-wide streaming estimation

[Old results available in ESS-0409841]



Straight 60 mm H X 130 mm V NBOA without steps
NBOA-NBPI-NBPB gaps: 1 mm + 7 mm (5 mm + 2 mm)

[Old results available in ESS-0409841]

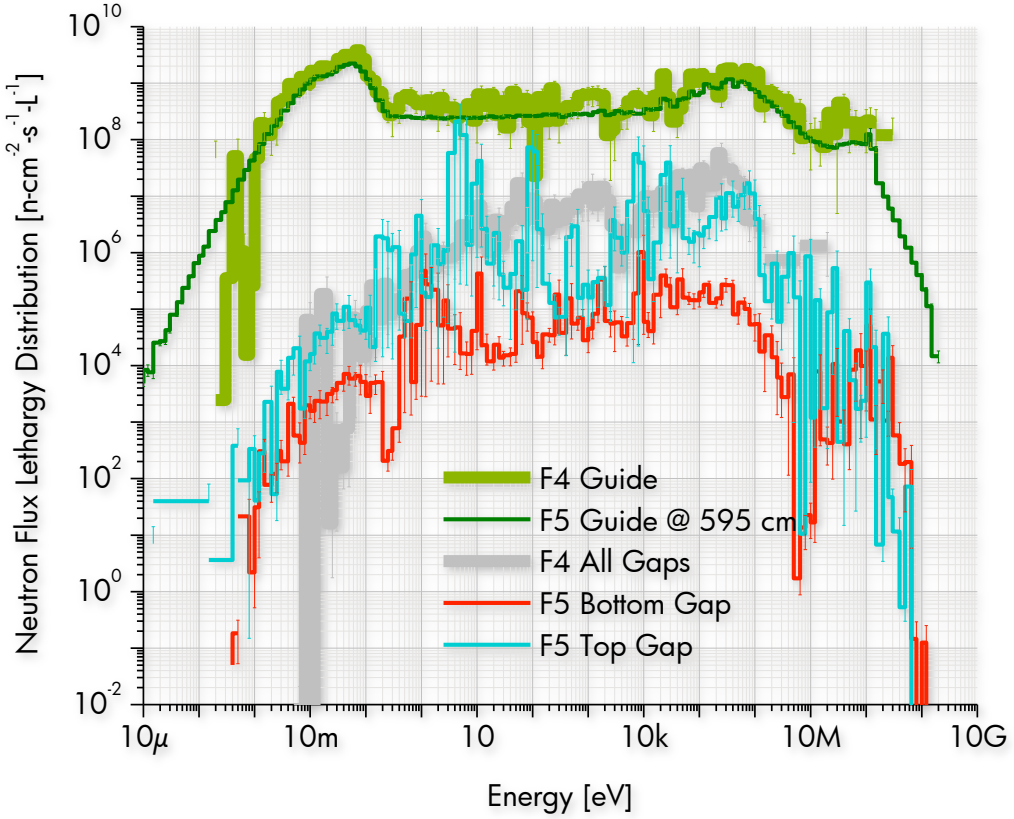
5. RESULTS

Both F4 and F5 flux estimators were utilized. The F4 tally was averaged over the last 500 mm (at 5000-5500 mm distance from the moderator axis) of the gap between NBGI and NBPB. The F5 tallies were placed at 5450 mm distance from the moderator axis in the top, bottom and side gaps between NBGI and NBPB. Prompt neutron doses calculated with and without weight windows are summarized in Table 1.

Table 1. Prompt neutron dose [mSv-hour^{-1}]

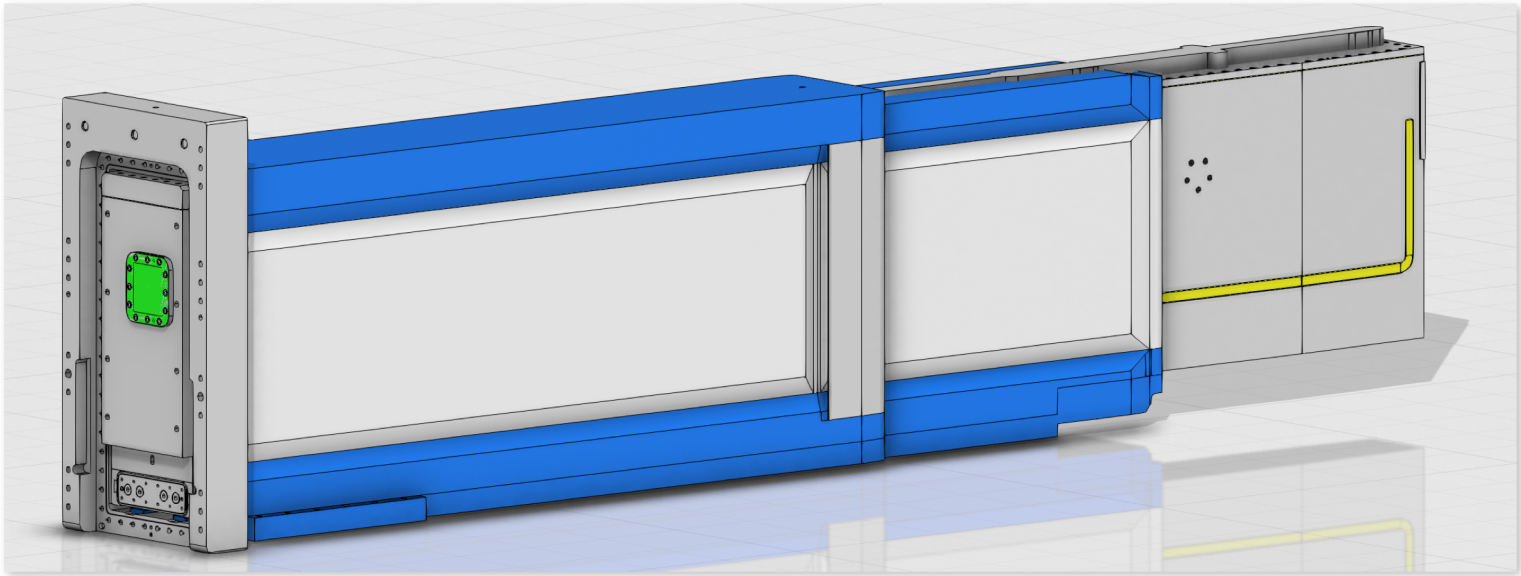
Tally	Blind NBGI Without Weight windows	Blind NBGI With Weight windows	NBGI + Guide Without Weight windows	NBGI + Guide With Weight windows
F4	N/A	190 ± 12	22000 ± 4600	27000 ± 3100
F5-Side	52 ± 14	69 ± 4.2	N/A	N/A
F5-Bottom	170 ± 19	250 ± 4.9	270 ± 41	840 ± 73
F5-Top	42 ± 29	32 ± 1.9	18000 ± 5200	52000 ± 9000

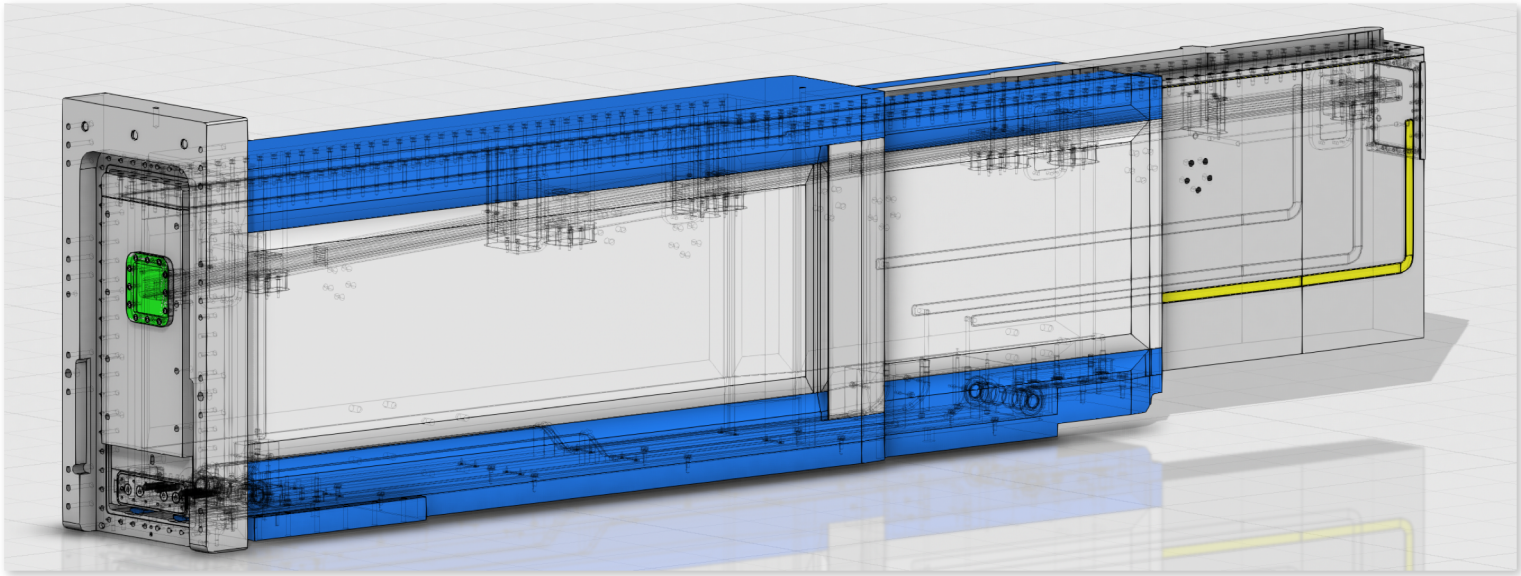
Neutron spectra calculated for all 4 cases – blind NBGI and NBGI with a guide, with and without weight windows – are shown in Fig. 3-6. One can see that the spectra calculated without weight windows are generally of low quality. The spectra calculated with weight windows are better. However, the spectra calculated with weight windows somehow lost the low energy part (see conclusions and recommendations below).



Conclusion (LZ): streaming from beam port inserts adds radiation in the bunker at the level of 1% or lower.

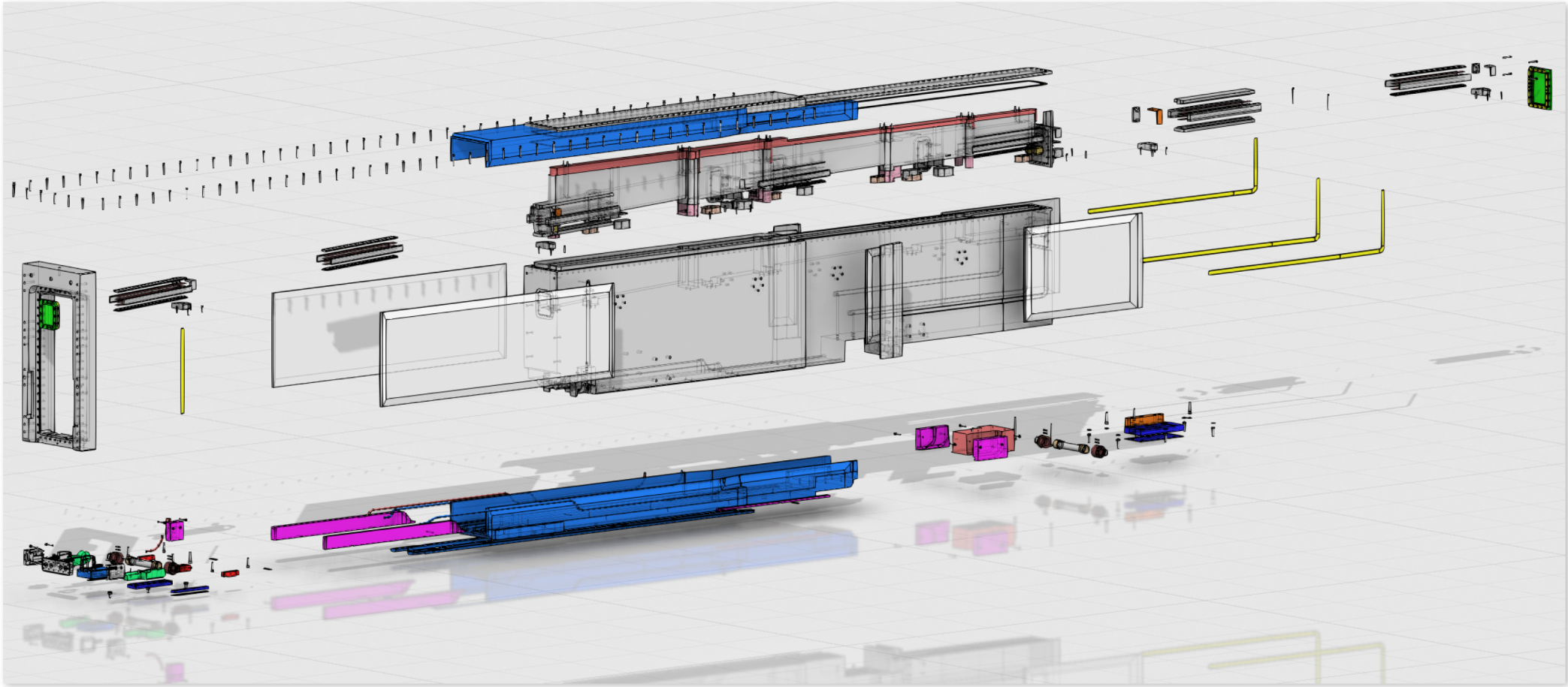
CURRENT NBEX MODEL





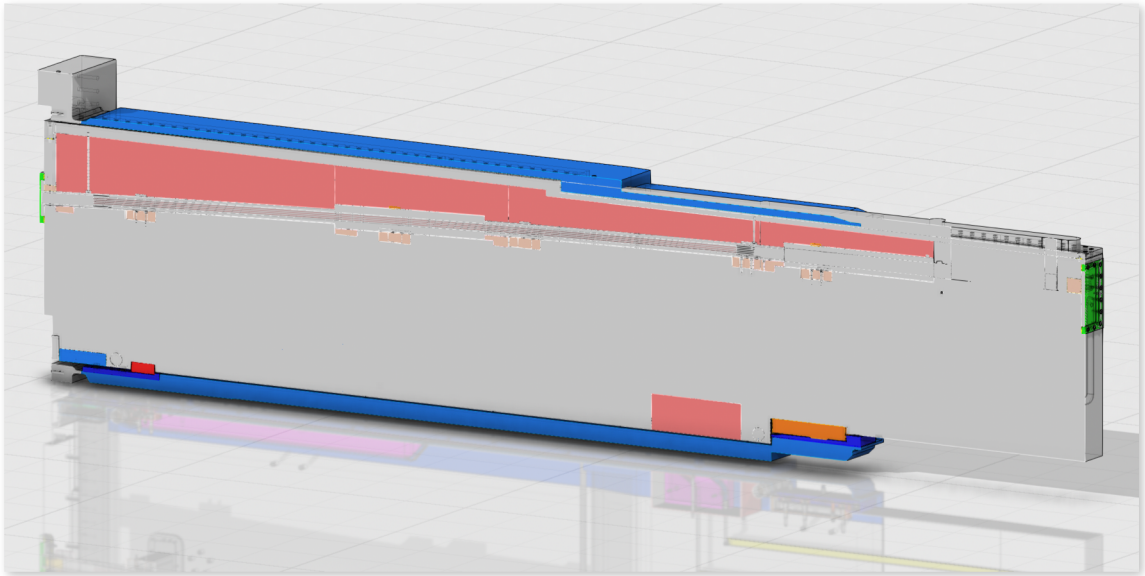
[Courtesy of Stig Jörstad]

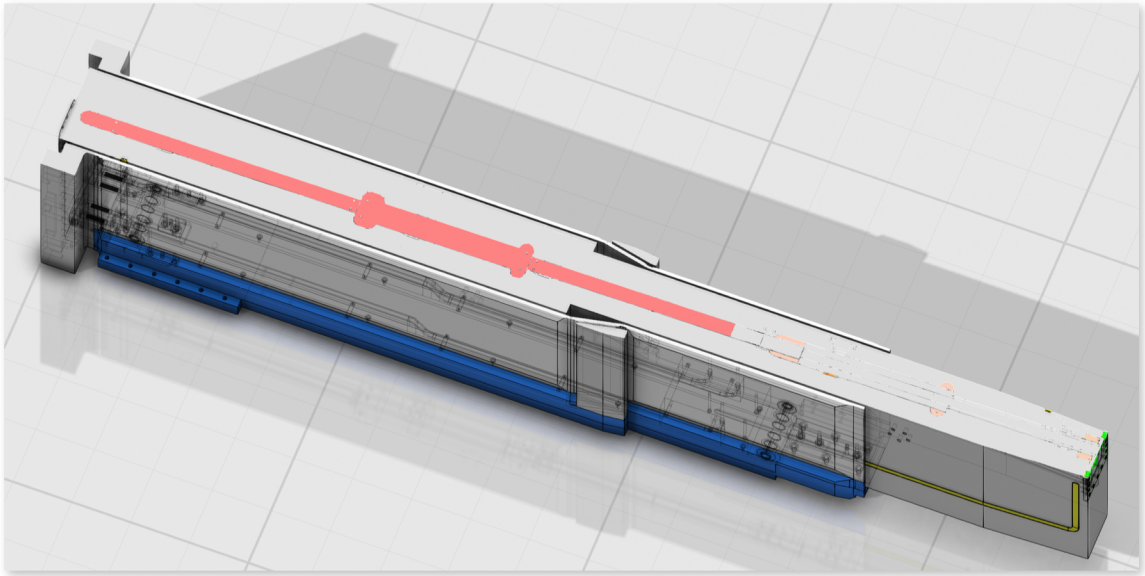
CURRENT NBEX MODEL

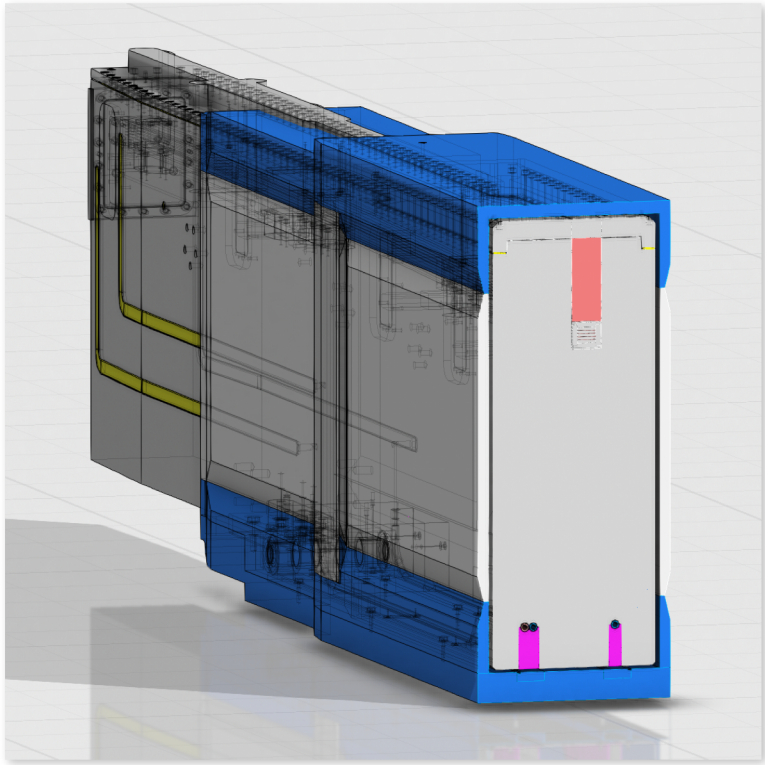


[Courtesy of Stig Jörstad]

CURRENT NBEX MODEL

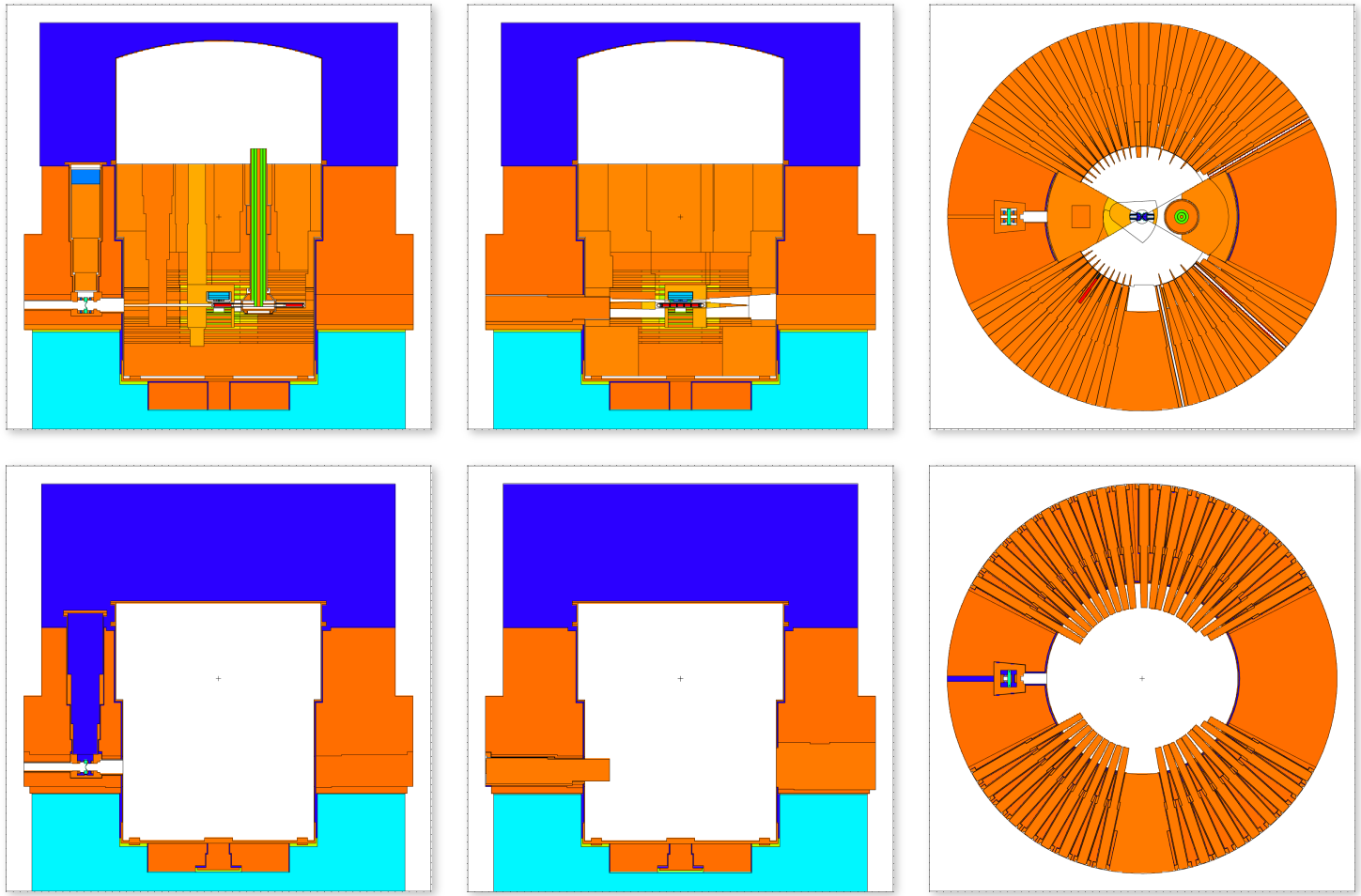






[Courtesy of Stig Jörstad]

MODEL INTEGRATION



TSV32NPW0

Latest Complete Model

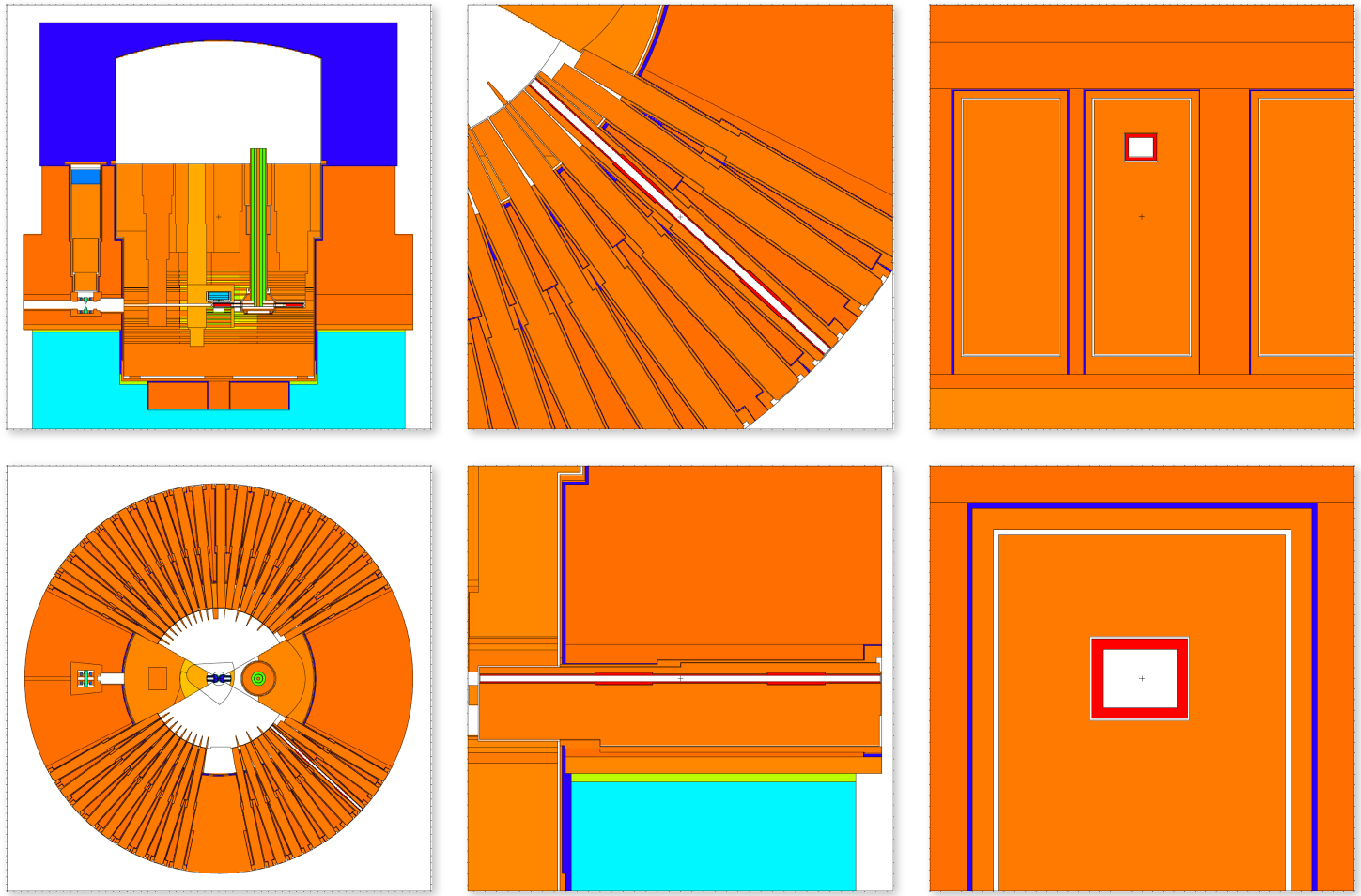
2018 June

TSV33

New (Unfinished) Model

Work Started 2018 Spring

MODEL INTEGRATION

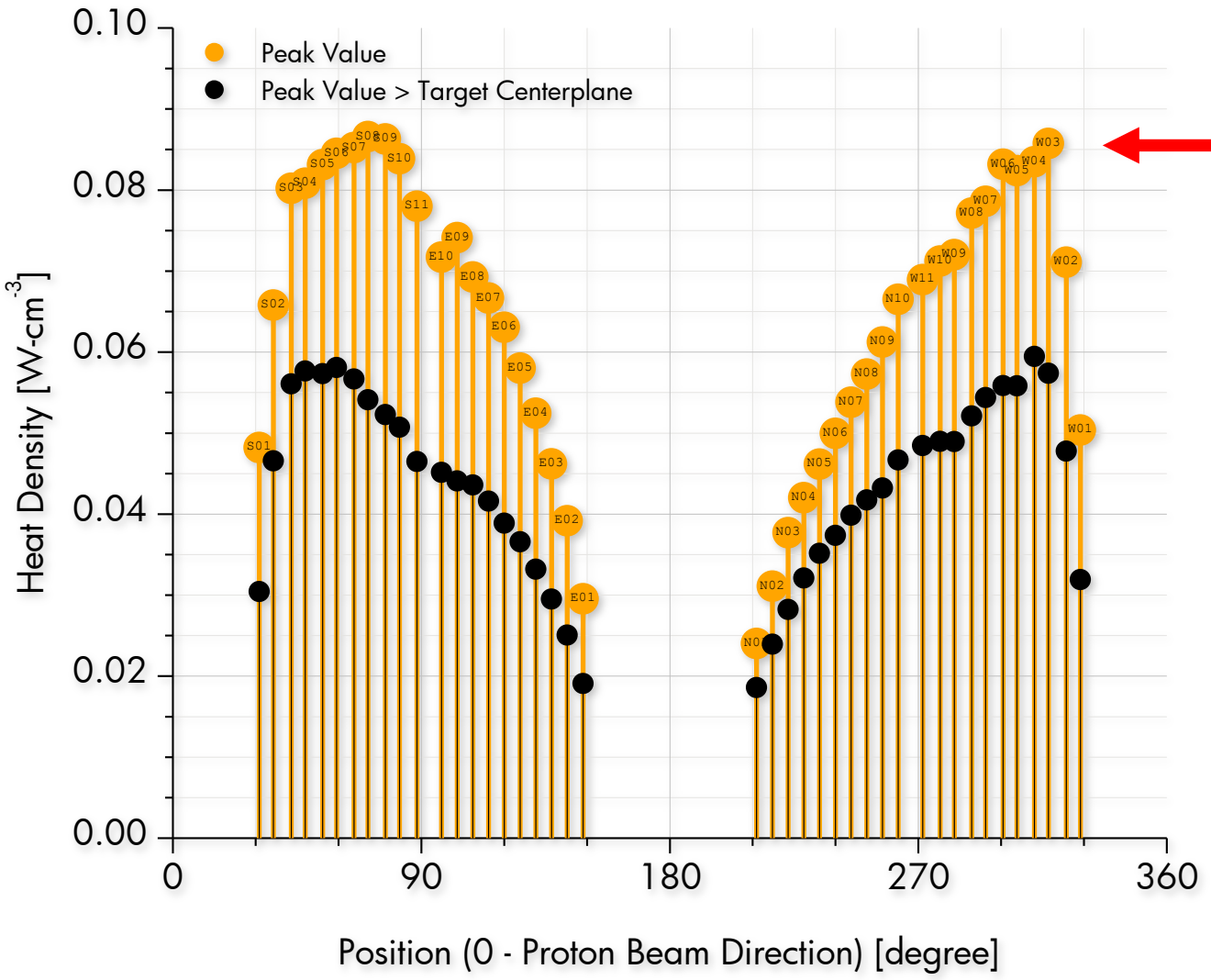


TSV32NPW0NBEX

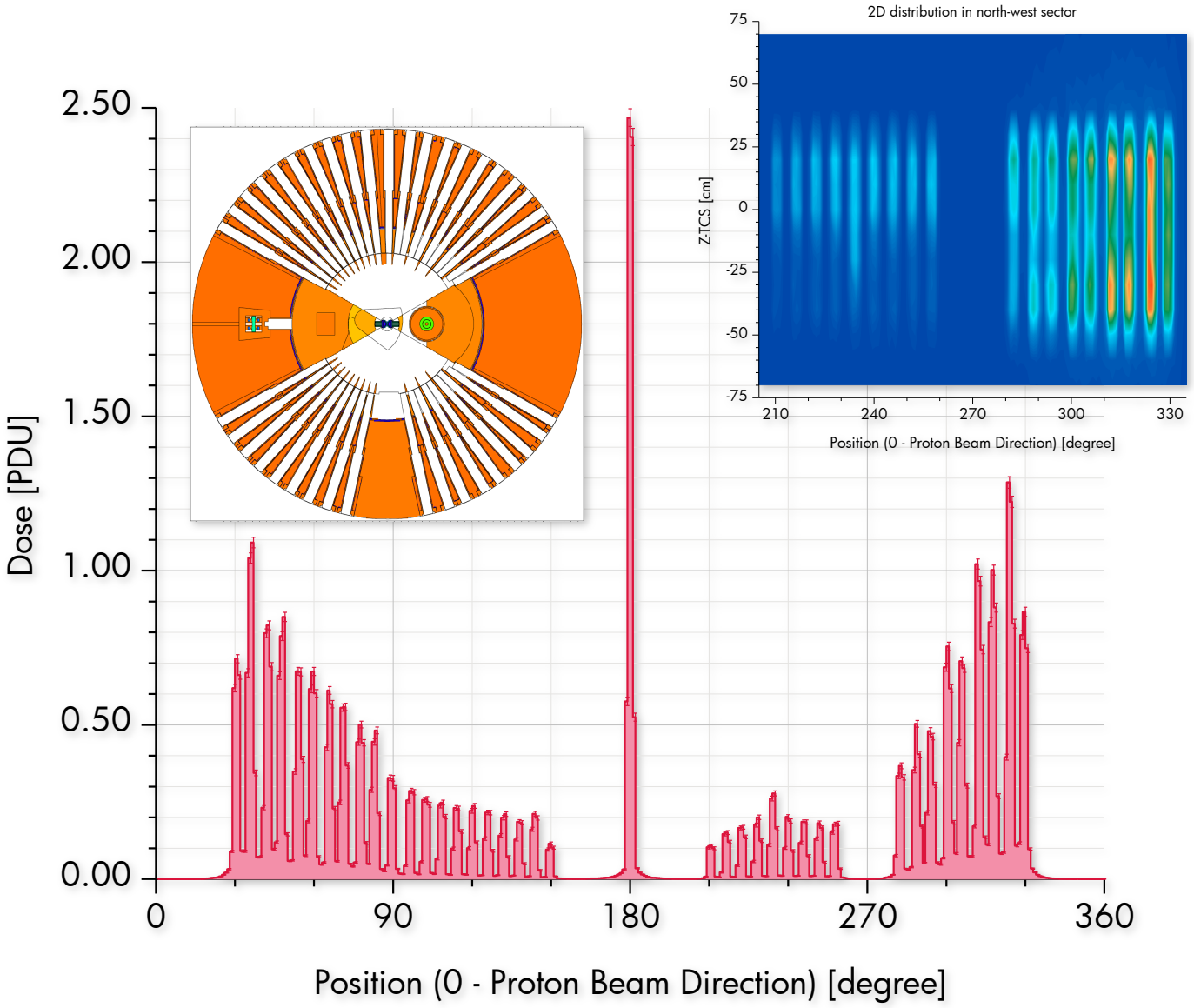
Merger of 2 Models Above

2018 November

Peak heat load is at the tip of NBPI in Port W-03



It does not mean that the strongest streaming is also there!



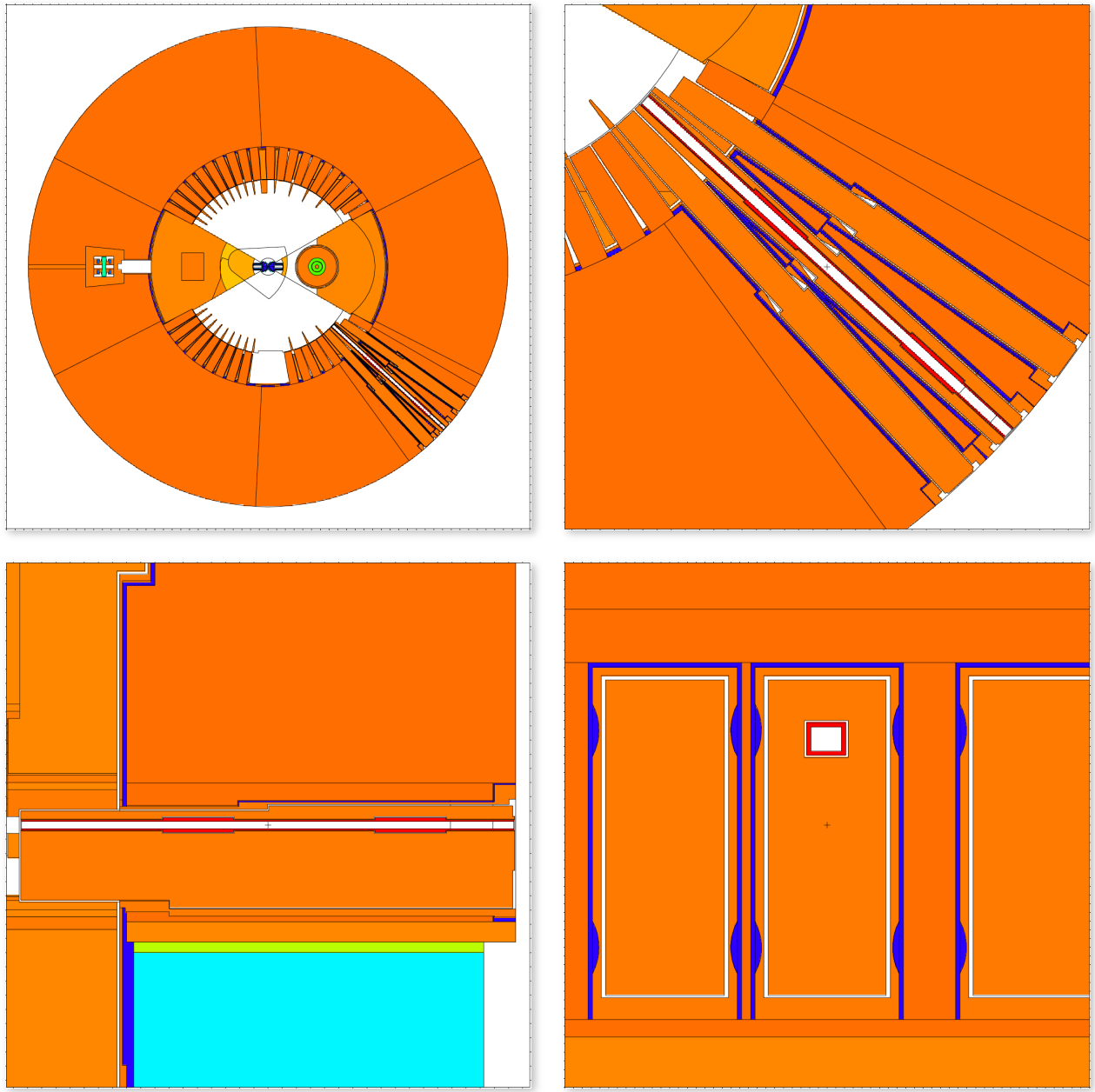
In order to quickly check relative streaming, NBPI were removed and the dose outside of the monolith (5.5-6.0 m distance) was calculated.

The strongest streaming was observed in Port W-02.

Note that Port W-02 contains a non-standard NBPI.

Note that streaming through Port W-03 is also among the strongest.

Therefore, selection of Port W-03 for further analysis seems justified.



Neutronic model based on Target Station Master Model Version 3.2 was simplified to speed up calculations.

Only Ports W-02, W-03, W-04 were left in the model.

NBPI in Port W-03 contains straight 70 mm H X 55 mm V NBOA (CSPEC).

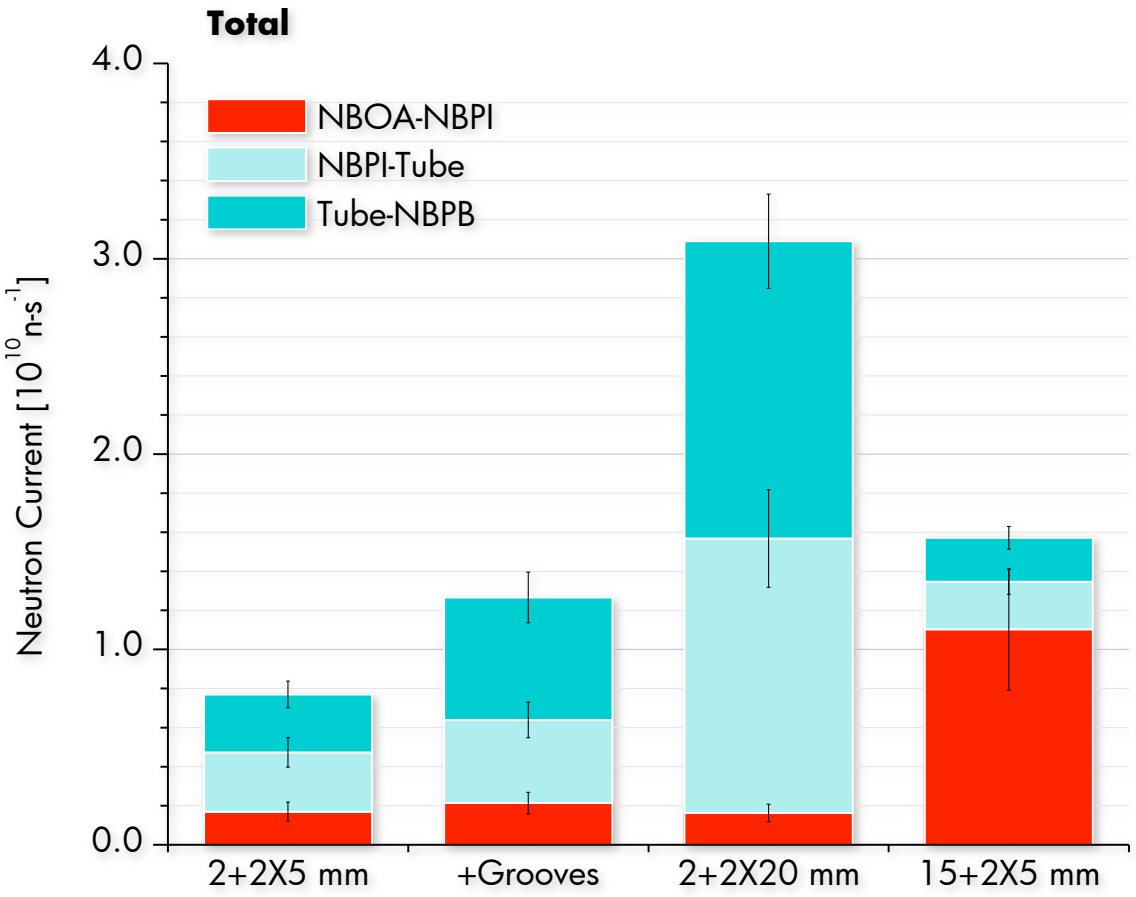
The data were tallied over 504-534 cm section of Port W-03 (due to geometry constraints).

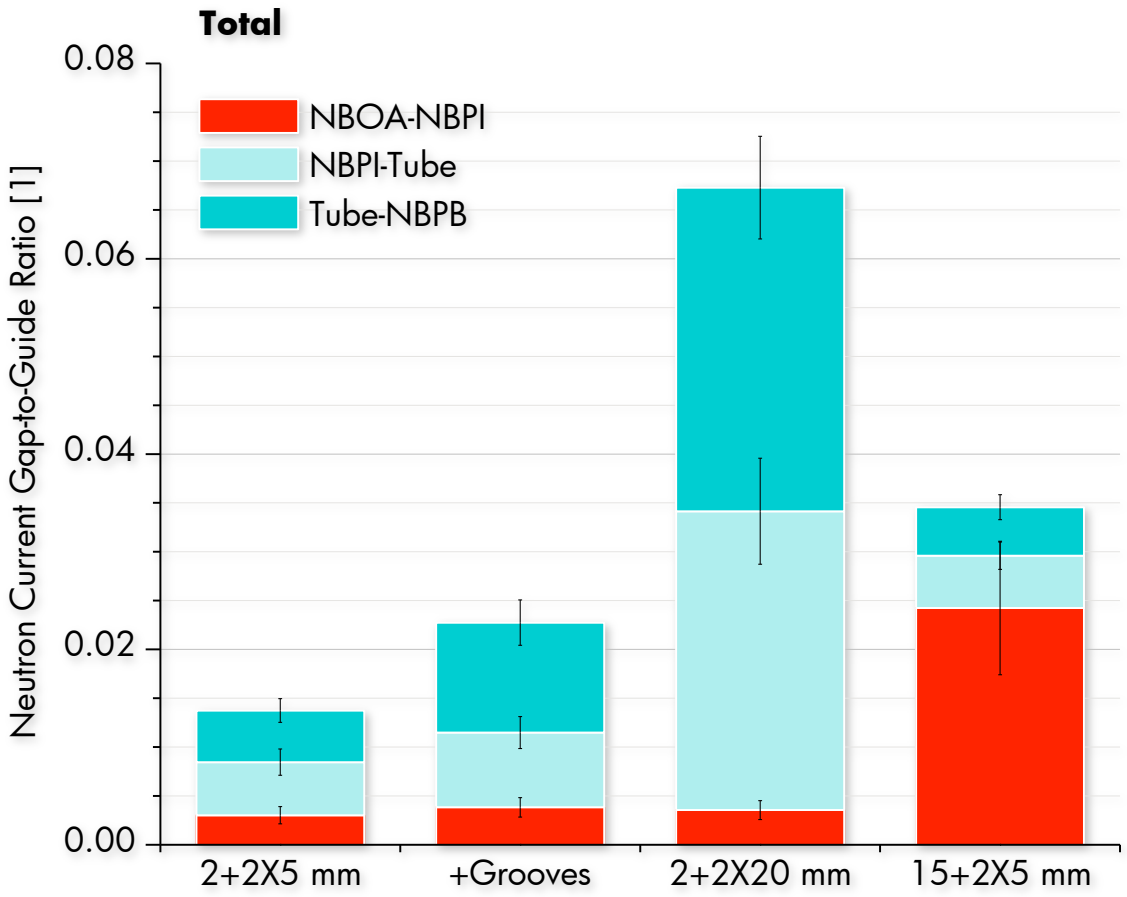
PRELIMINARY RESULTS

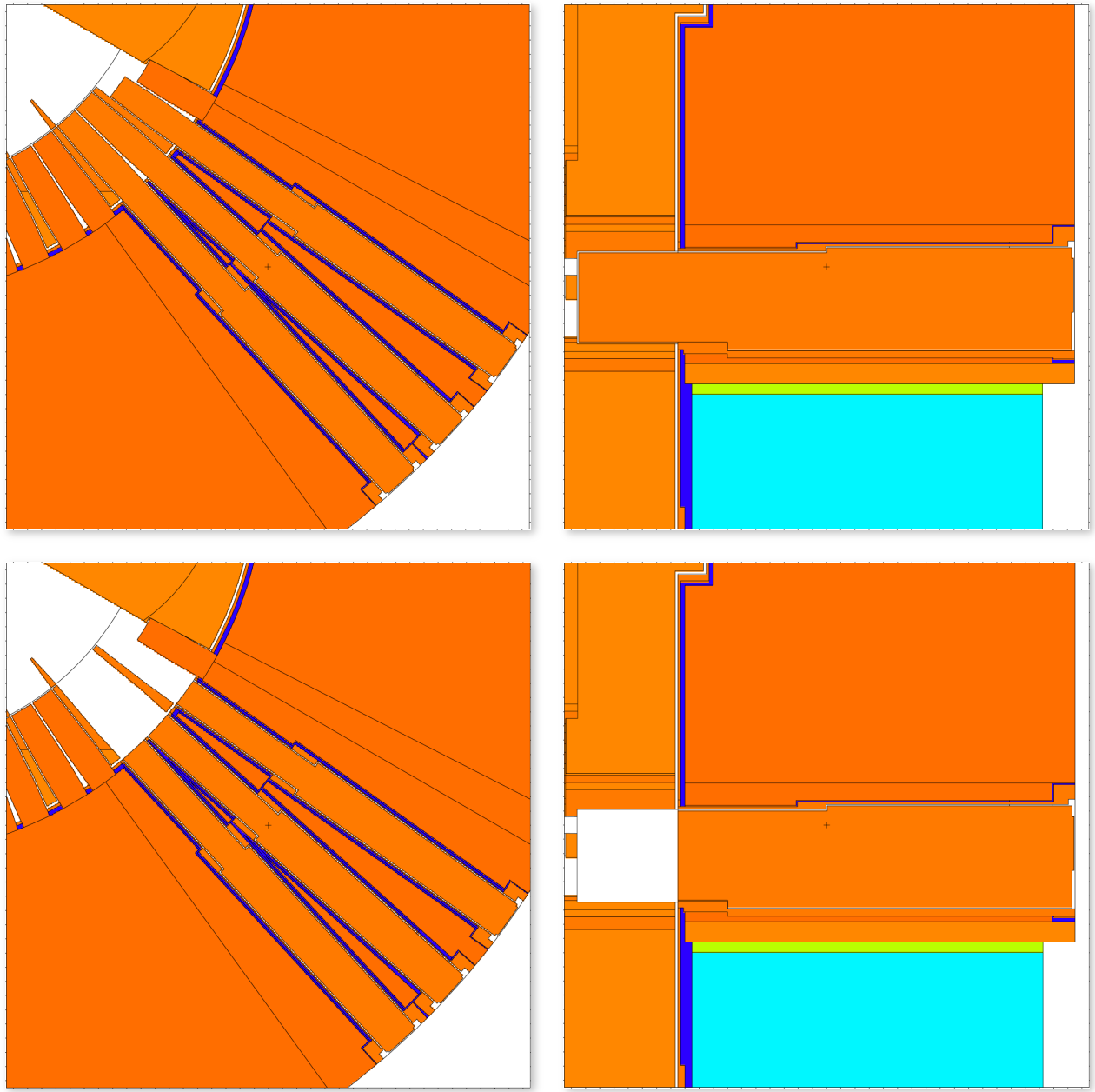
Task ID:	NBOA-NBPI-Tube-NBPB gaps:
Task 1	2 mm + 5 mm + 5 mm
Task 2	2 mm + 5 mm + 5 mm + Grooves
Task 3	2 mm + 20 mm + 20 mm
Task 4	15 mm + 5 mm + 5 mm

NBOA-NBPI gaps refer to side, top, and bottom, while NBPI-Tube-NBPB gaps refer to side and top only
Bottom NBPI-Tube-NBPB gaps are kept the same (5 mm + 0 mm)

NBPI + CSPEC NBOA



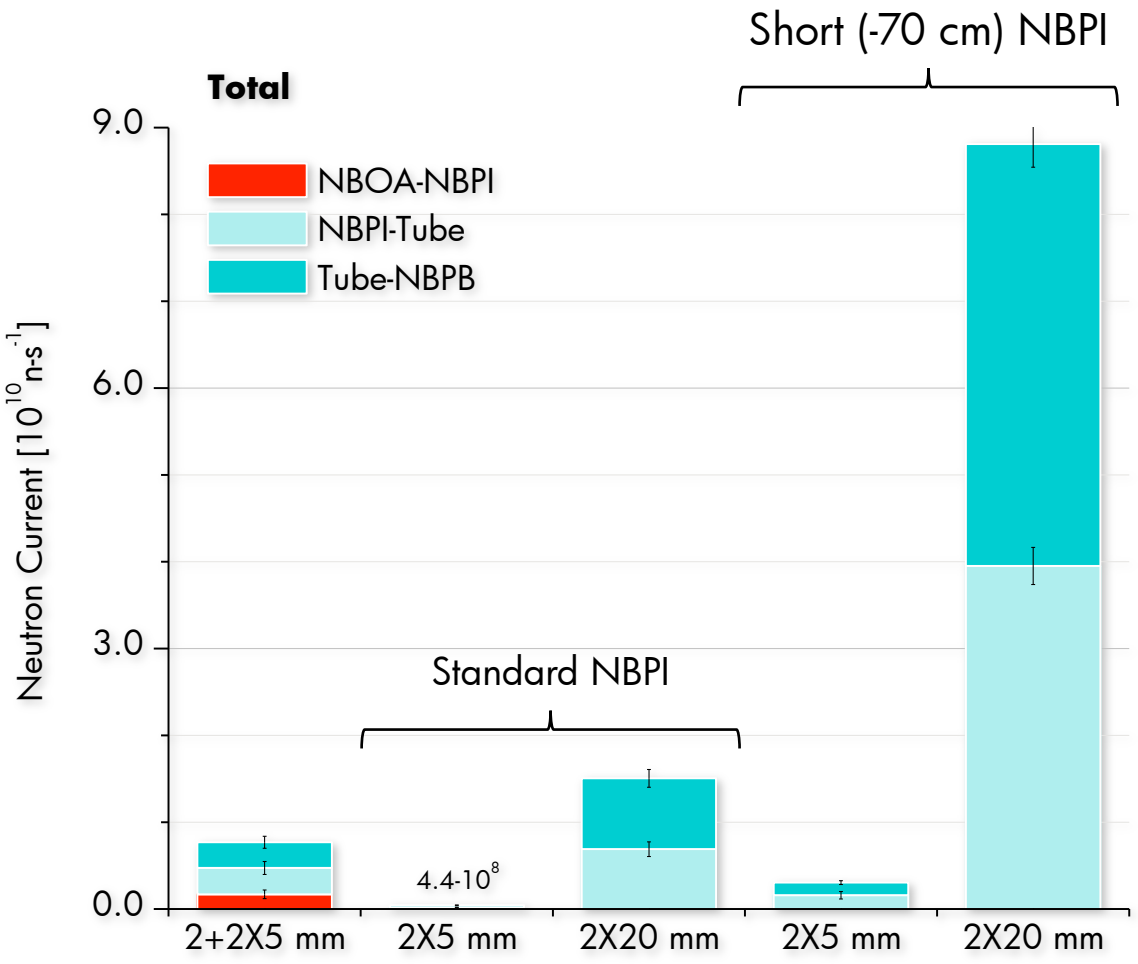




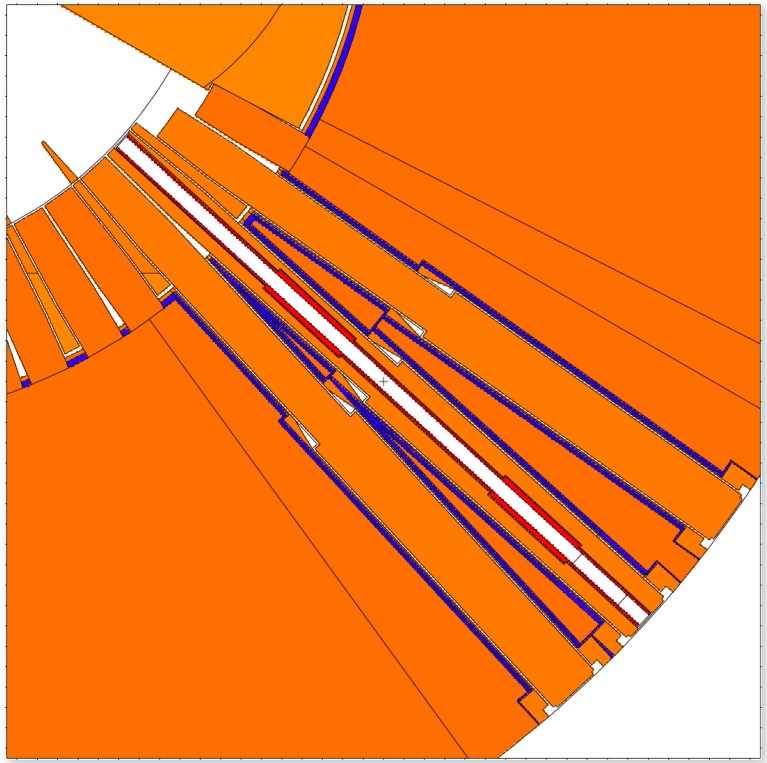
Standard Blind NBPI

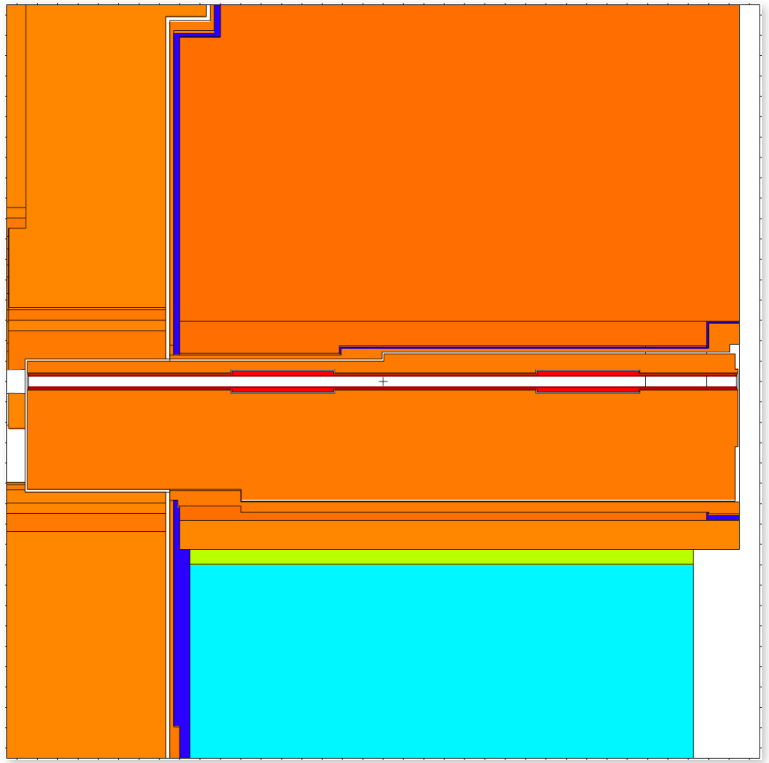
Short (-70cm) Blind NBPI

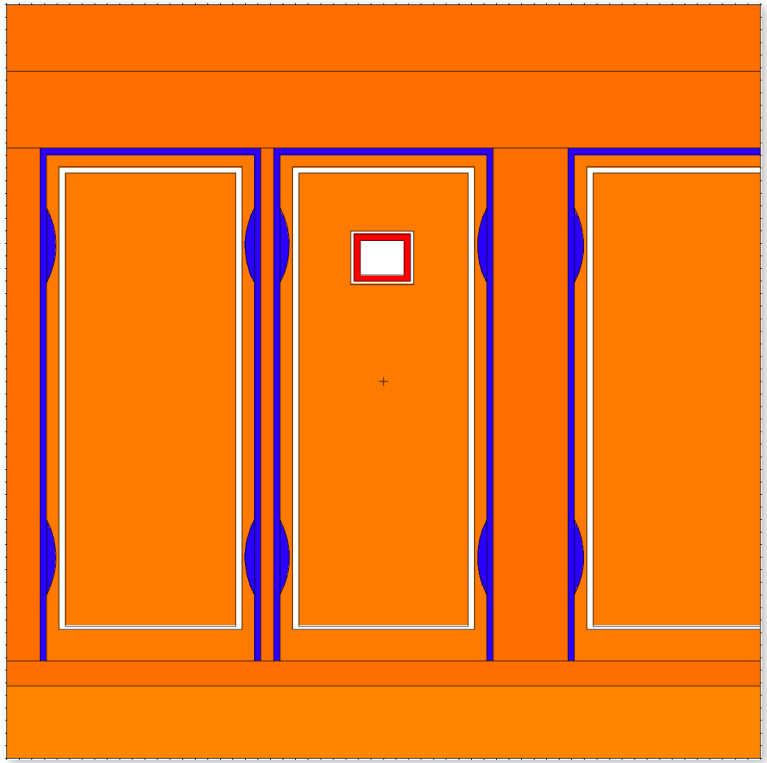
Blind NBPI


Short (-70 cm) NBPI
Total
9.0
6.0
3.0
0.0
NBOA-NBPI
NBPI-Tube
Tube-NBPB
Neutron Current [10^10 n-s^-1]
Standard NBPI
4.4-10^8
2+2X5 mm
2X5 mm
2X20 mm
2X5 mm
2X20 mm

Based on the results presented –
The following gap dimensions were adopted



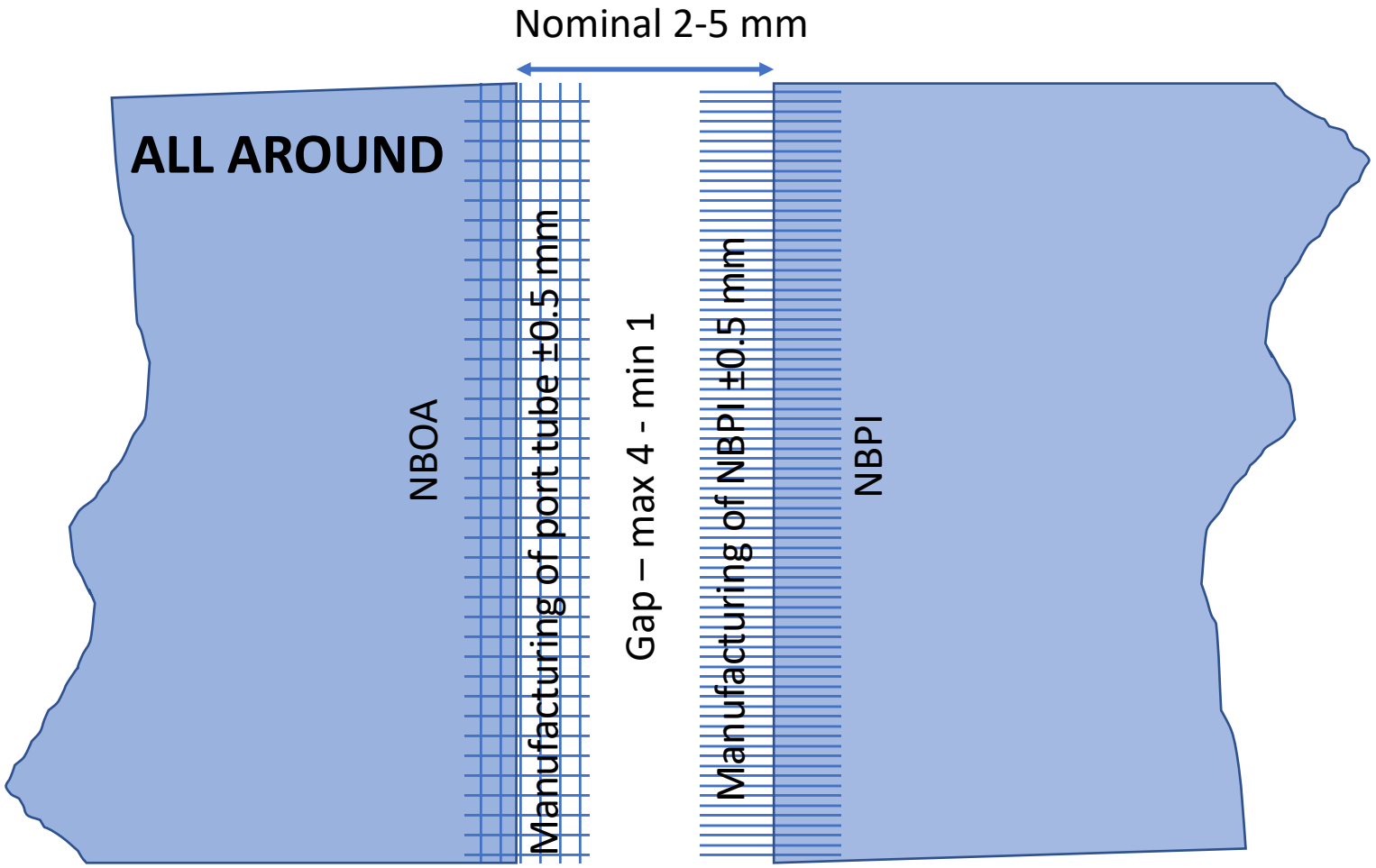




NBOA-NBPI-Tube-NBPB gaps: 5 mm + 10 mm + 10 mm with grooves

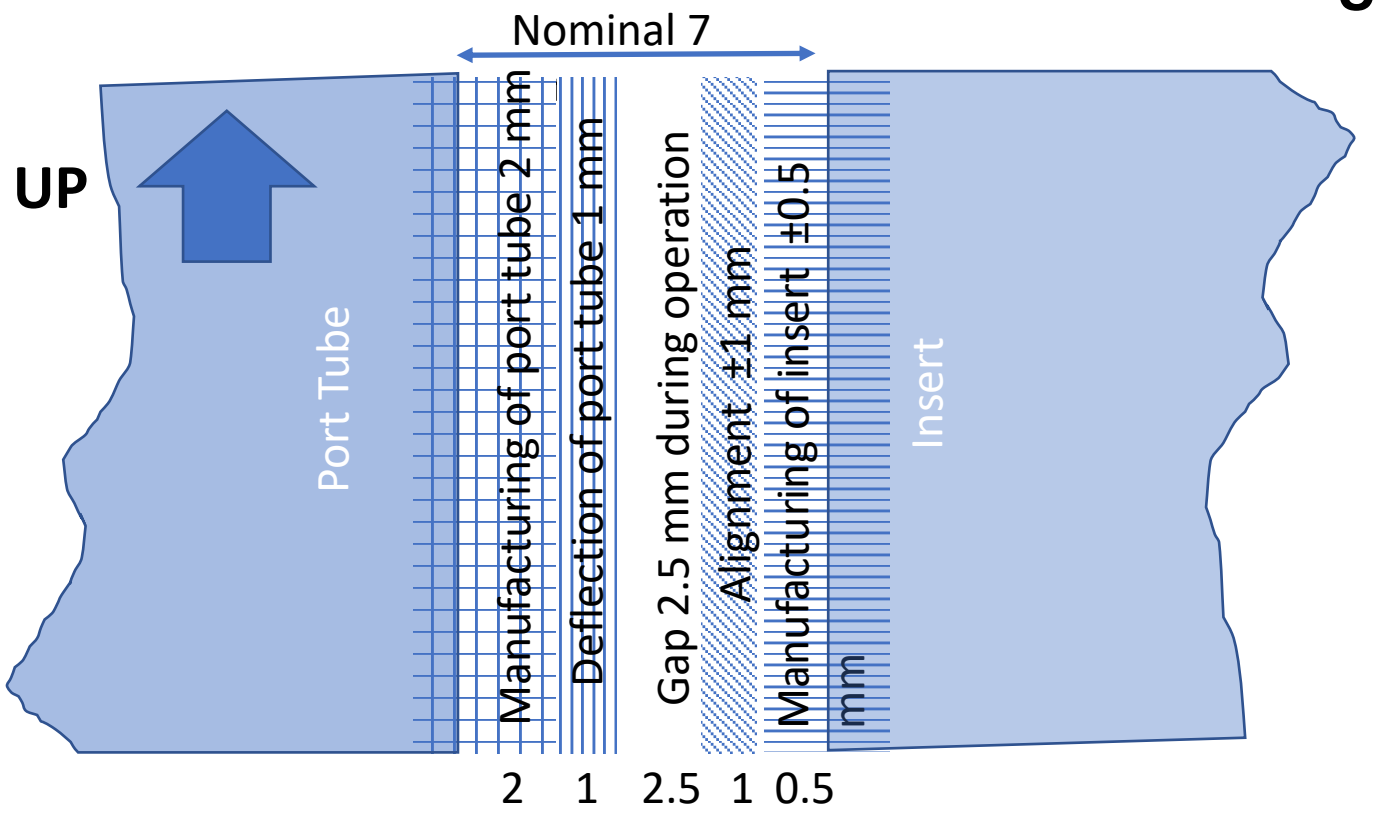
NBOA-NBPI gaps refer to side, top, and bottom, while NBPI-Tube-NBPB gaps refer to side and top only
Bottom NBPI-Tube-NBPB gaps are kept the same (5 mm + 0 mm)

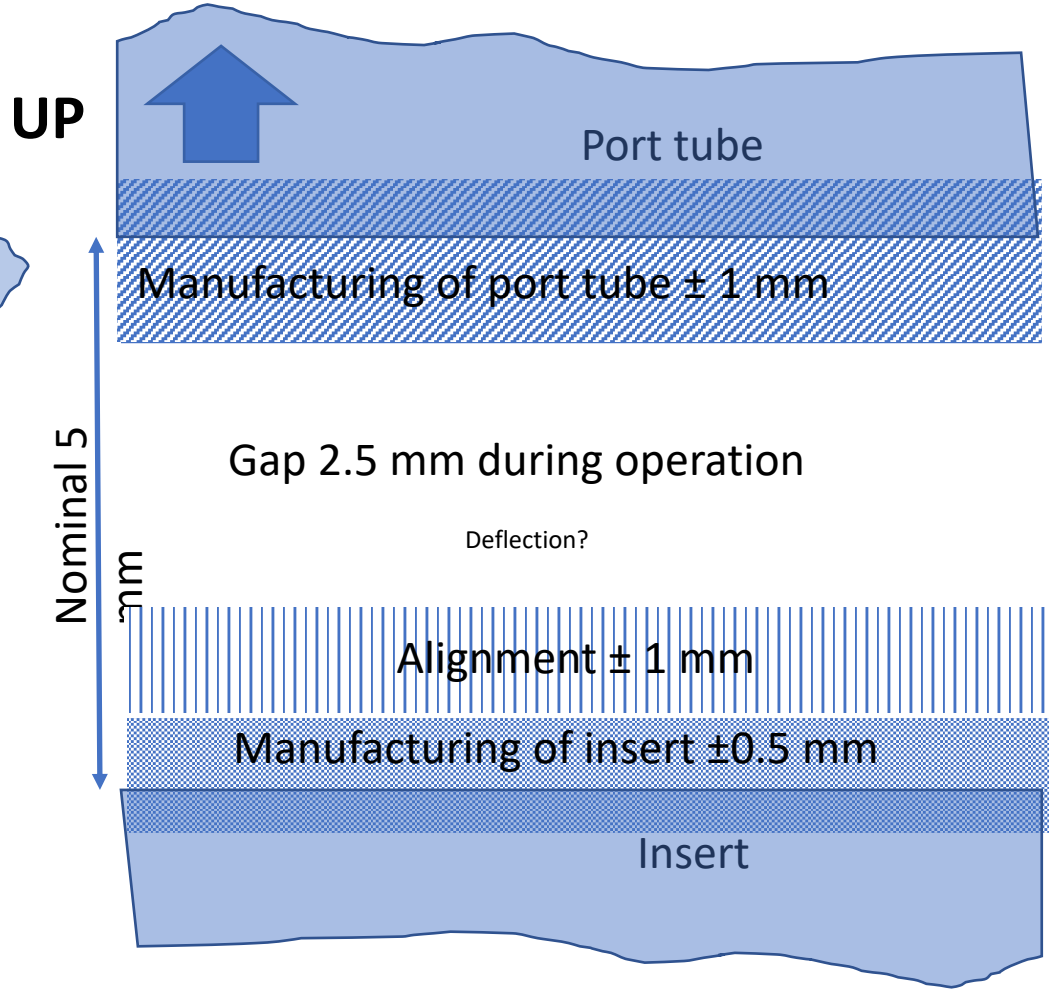
Tolerances NBOA-NBPI



[Courtesy of Naja de la Cour]

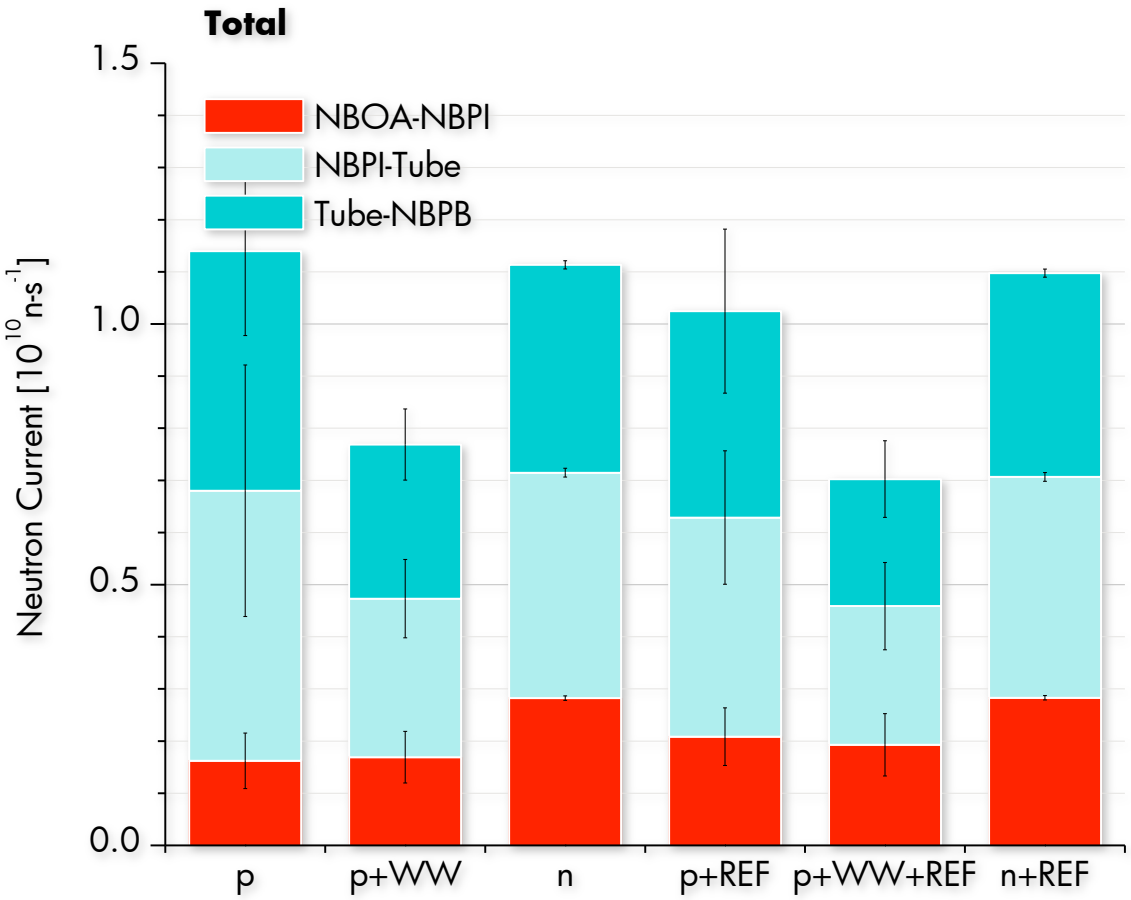
Tolerances NBPI-Tube

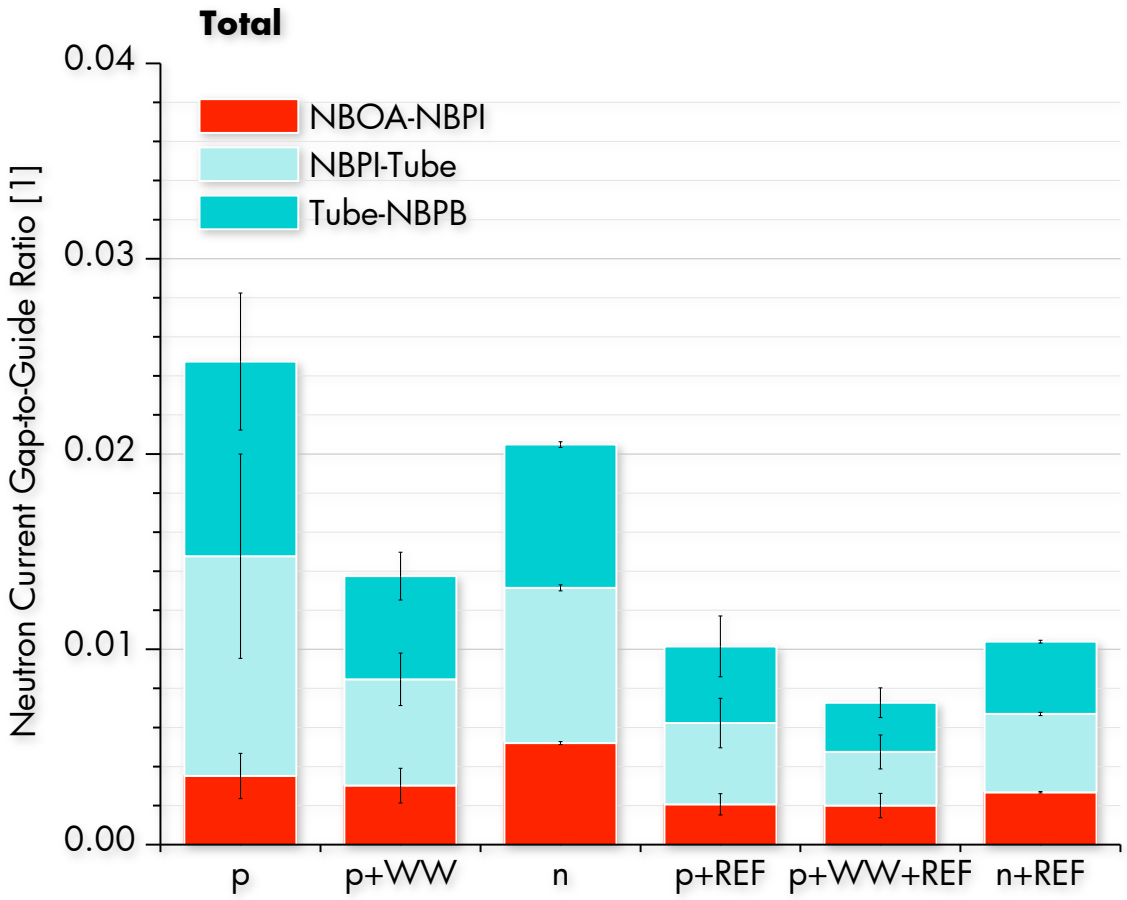




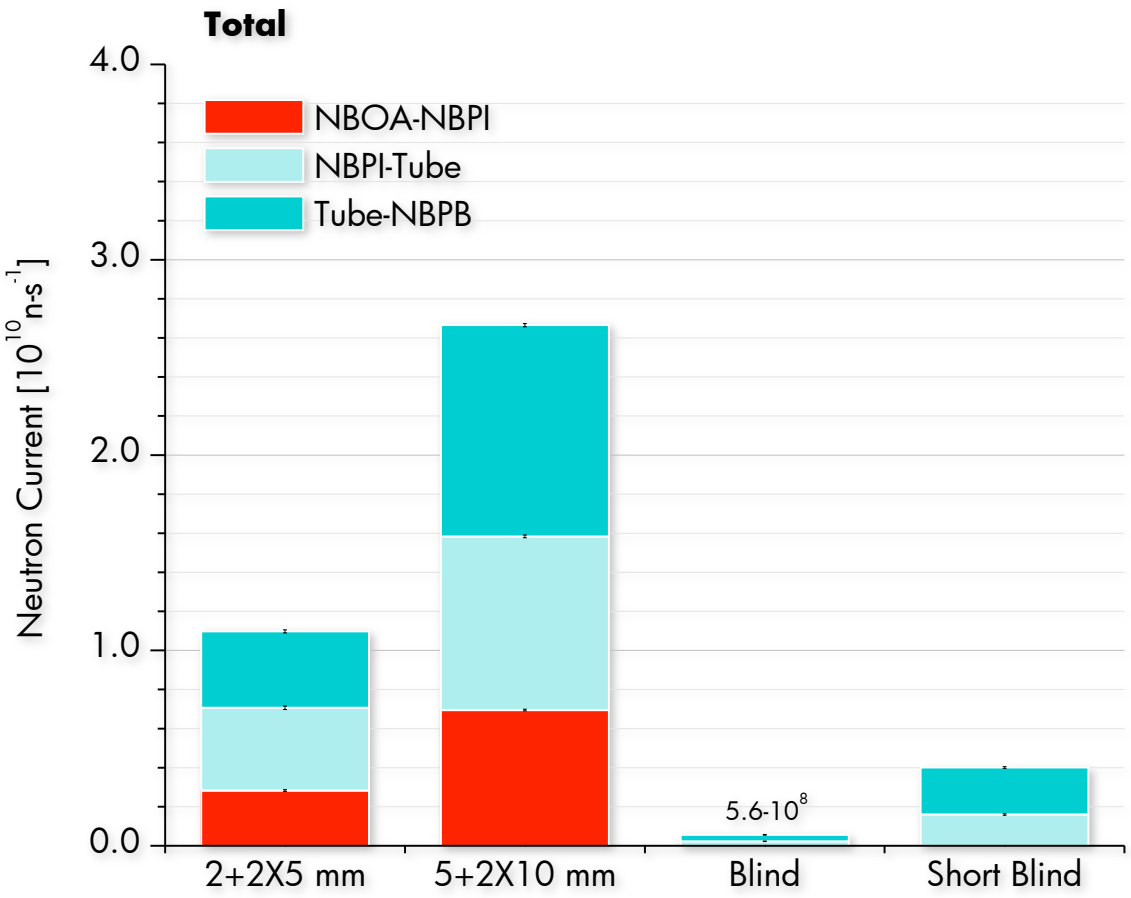
[Courtesy of Naja de la Cour]

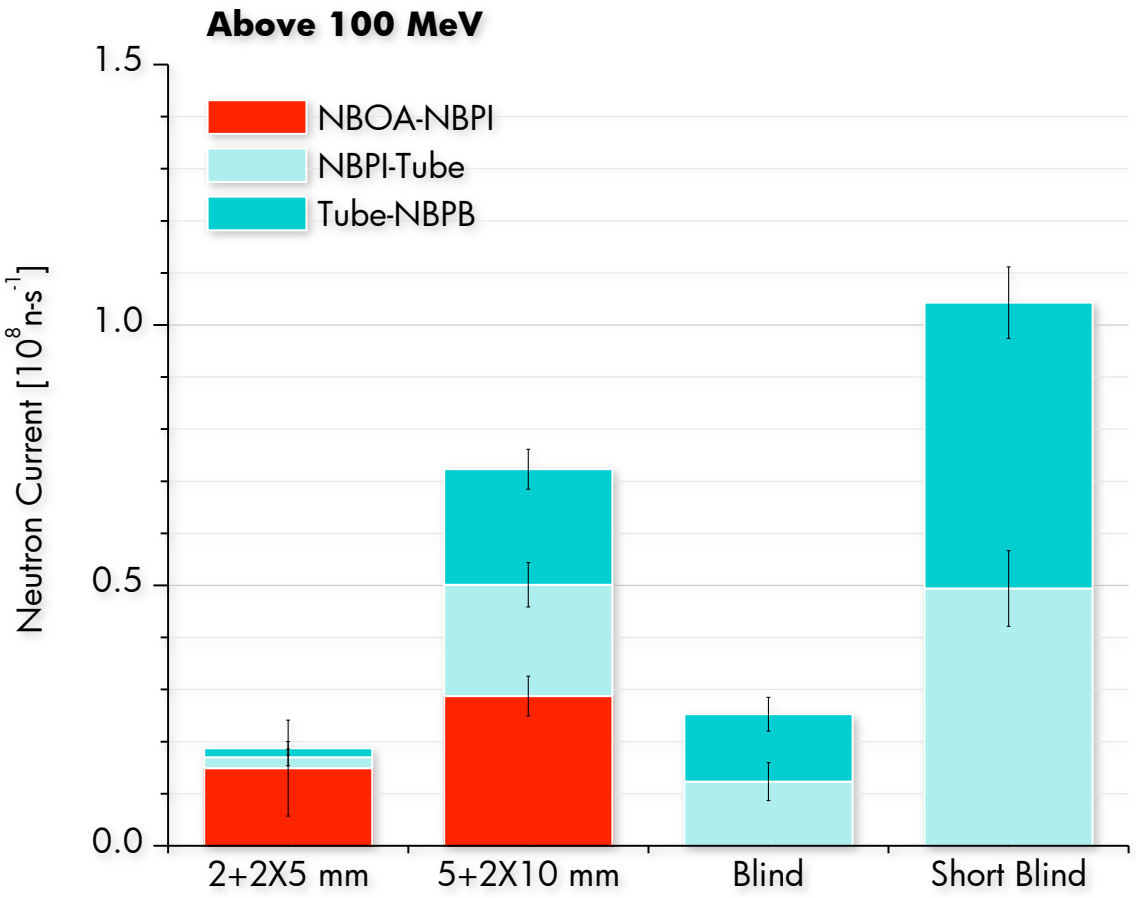
Proton Source vs Neutron Source



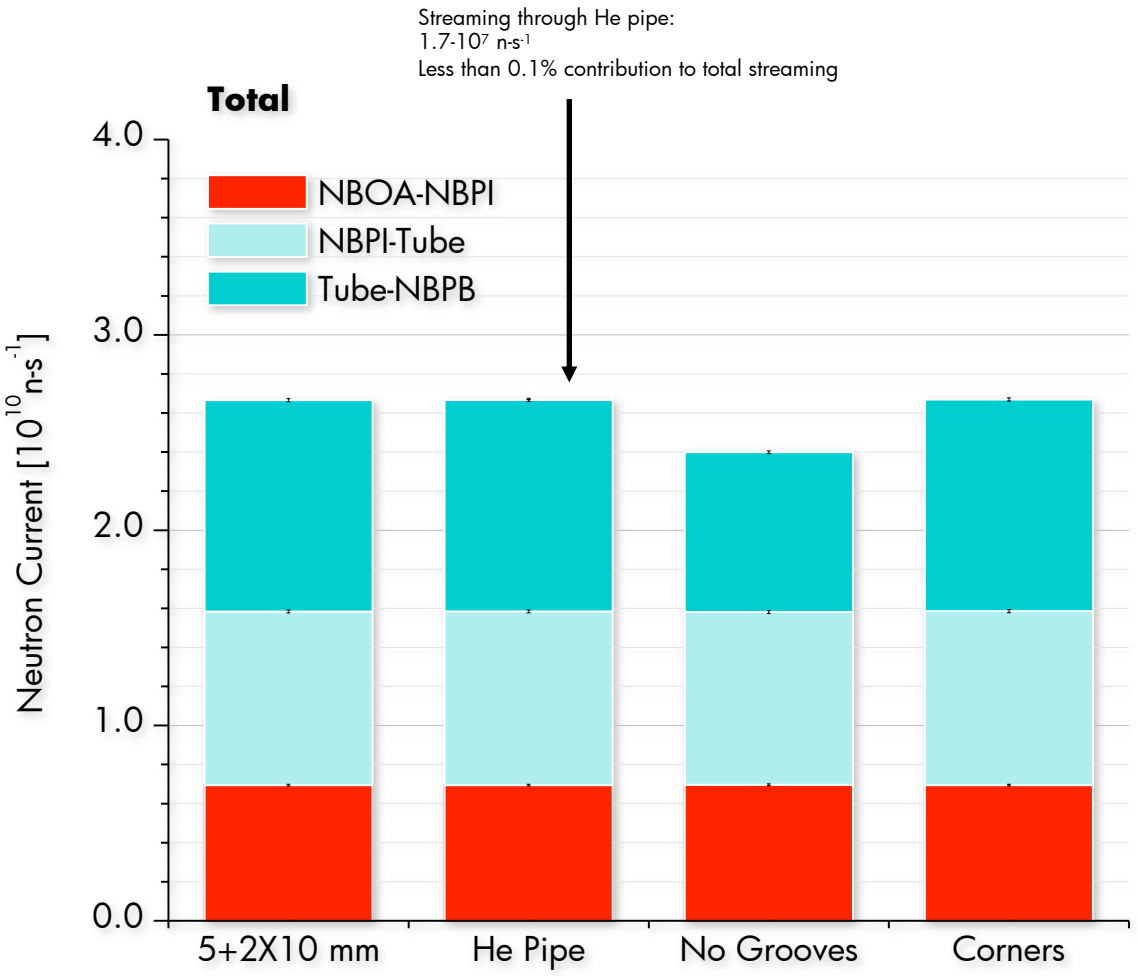


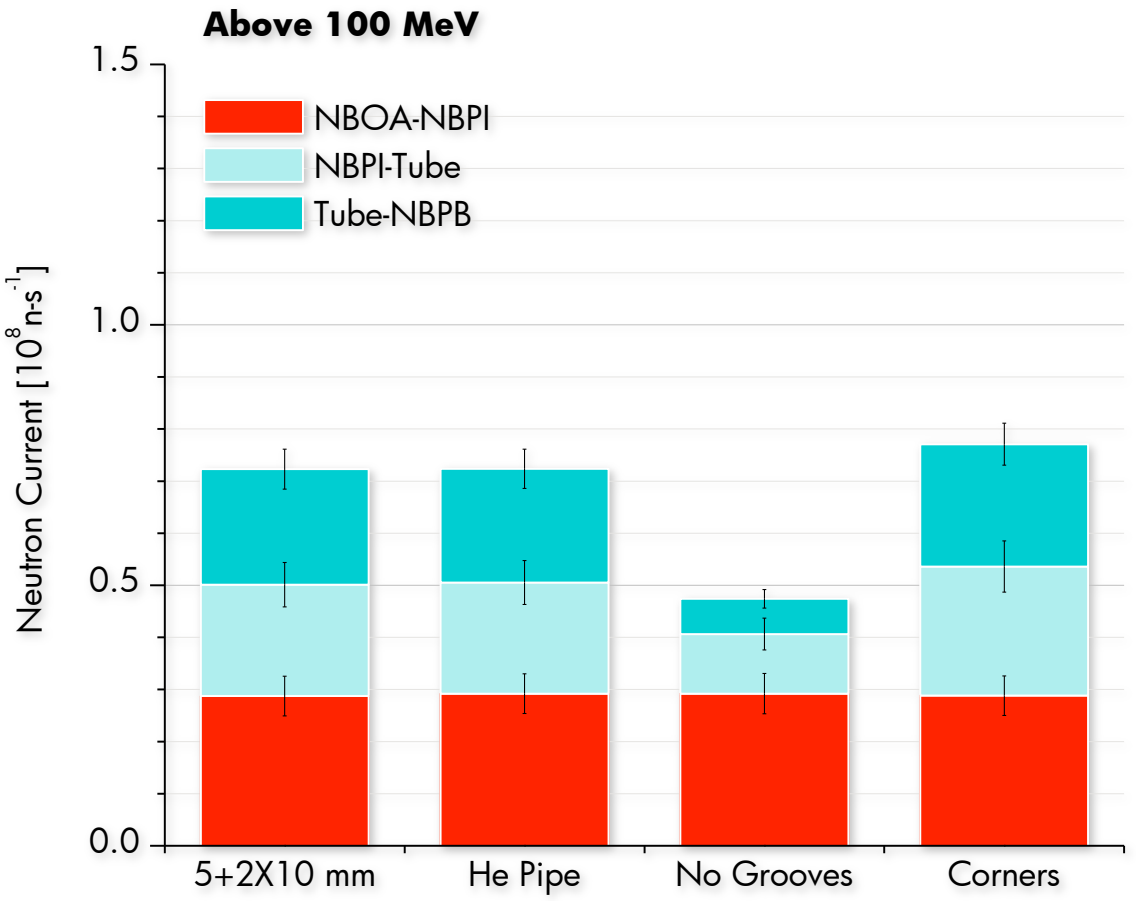
Streaming Update



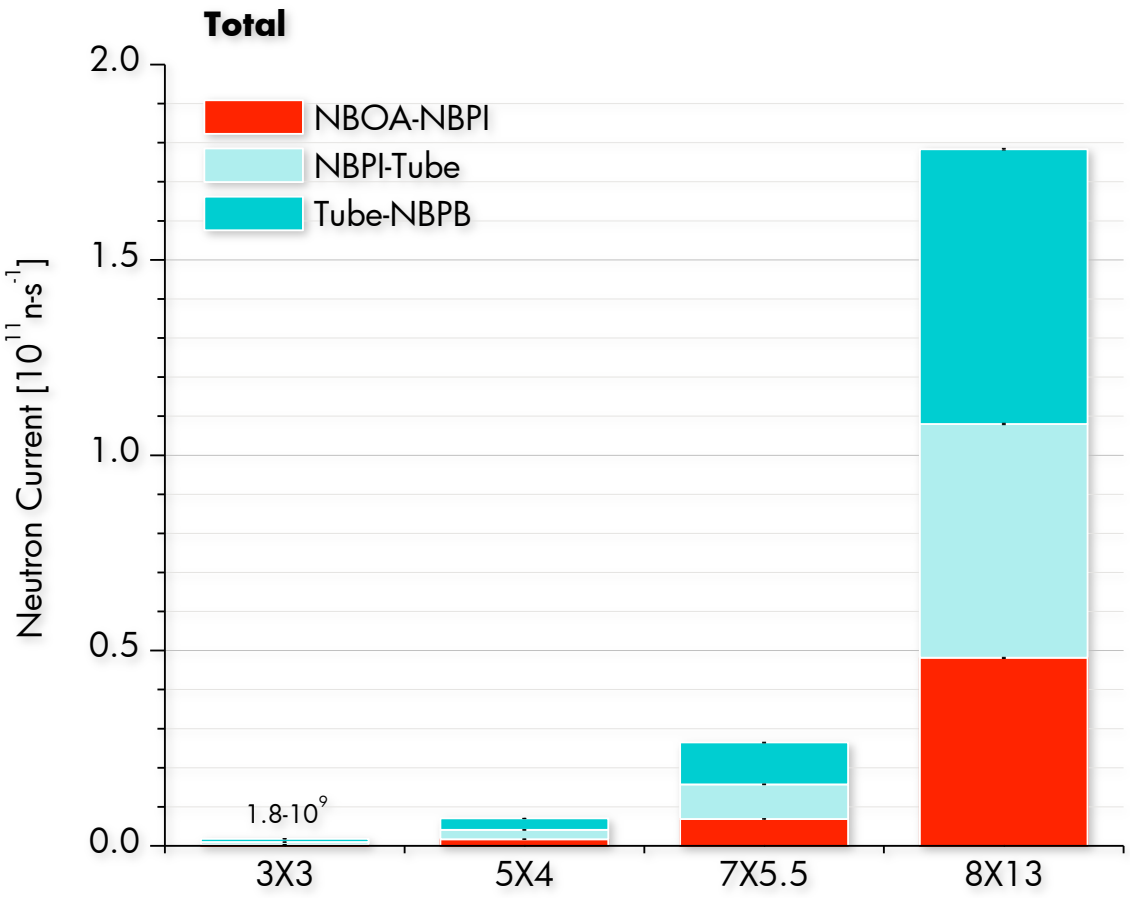


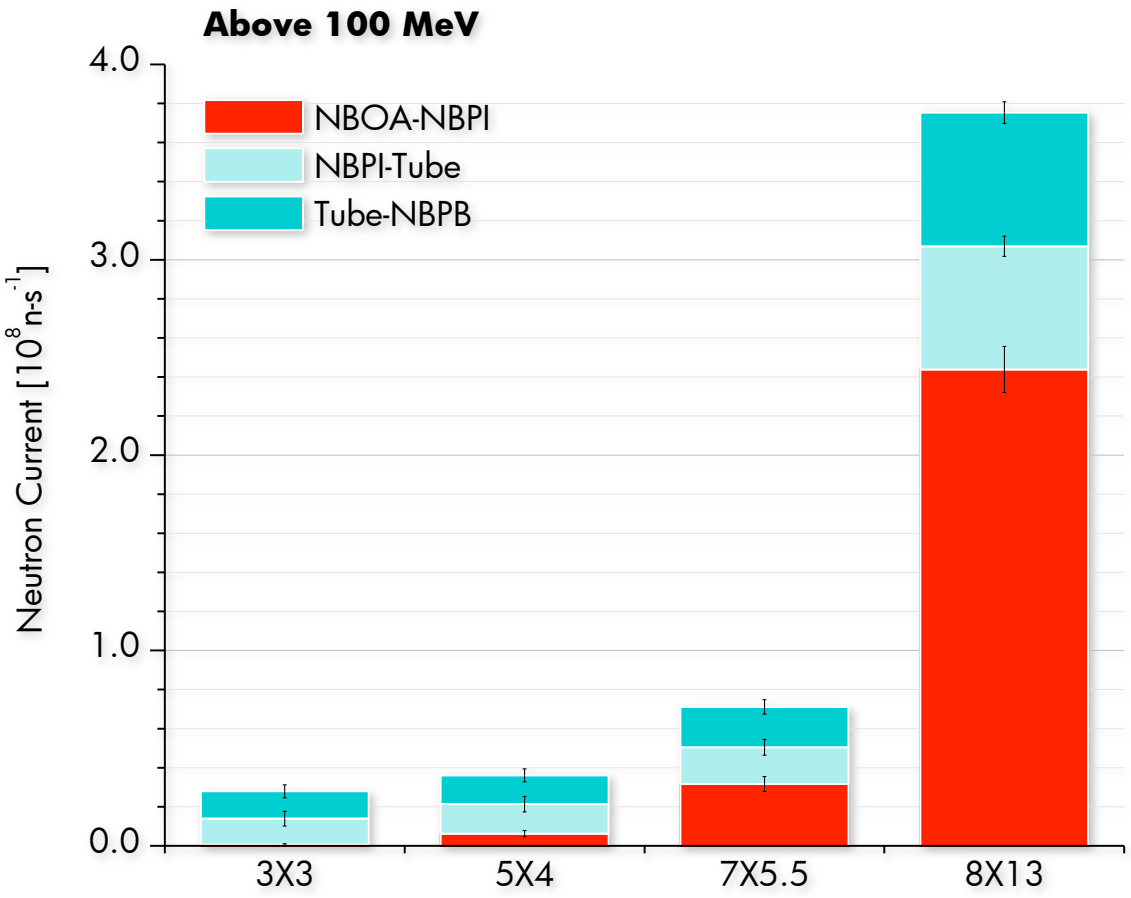
Details ...


Streaming through He pipe:
1.7·10⁷ n·s⁻¹
Less than 0.1% contribution to total streaming
Total
NBOA-NBPI
NBPI-Tube
Tube-NBPB
Neutron Current [10¹⁰ n·s⁻¹]
4.0
3.0
2.0
1.0
0.0
5+2X10 mm
He Pipe
No Grooves
Corners

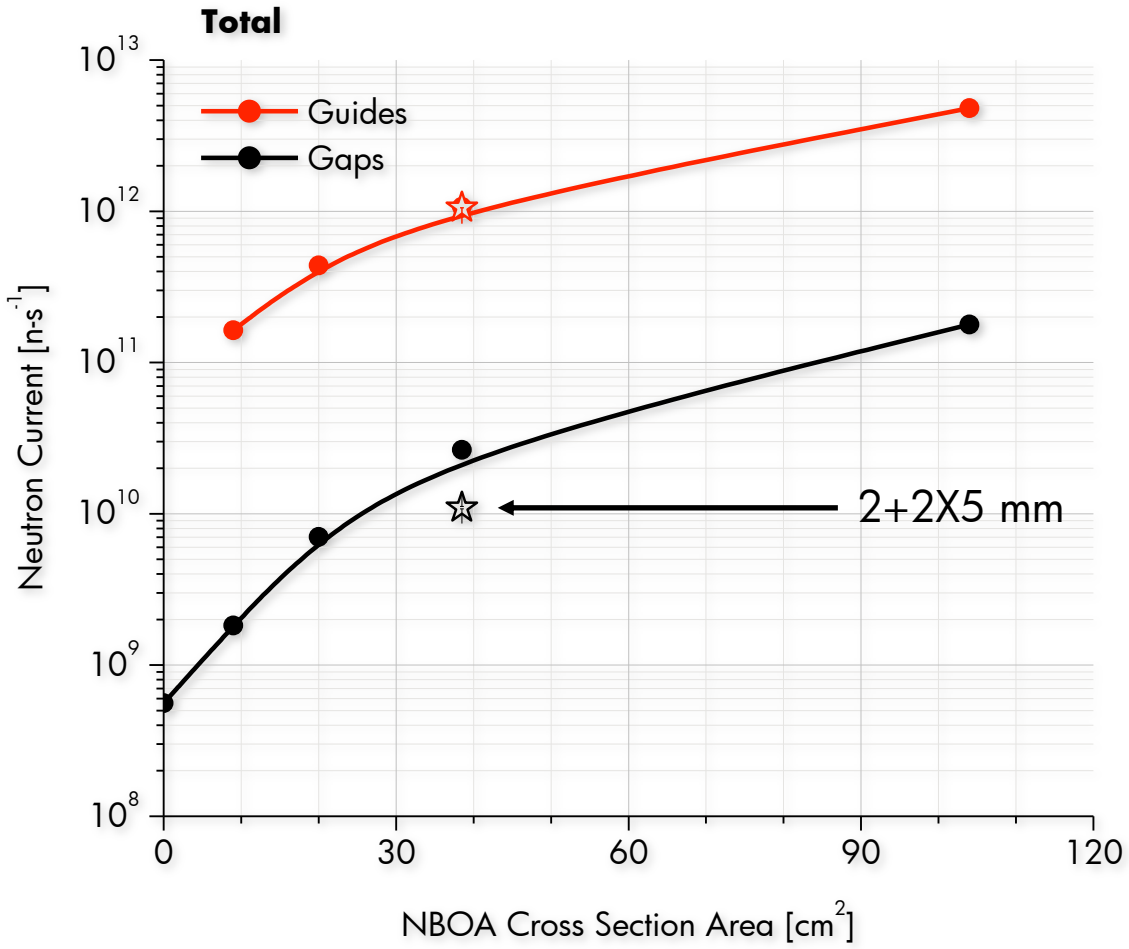

Above 100 MeV
NBOA-NBPI
NBPI-Tube
Tube-NBPB
Neutron Current [10⁸ n·s⁻¹]
1.5
1.0
0.5
0.0
5+2X10 mm
He Pipe
No Grooves
Corners

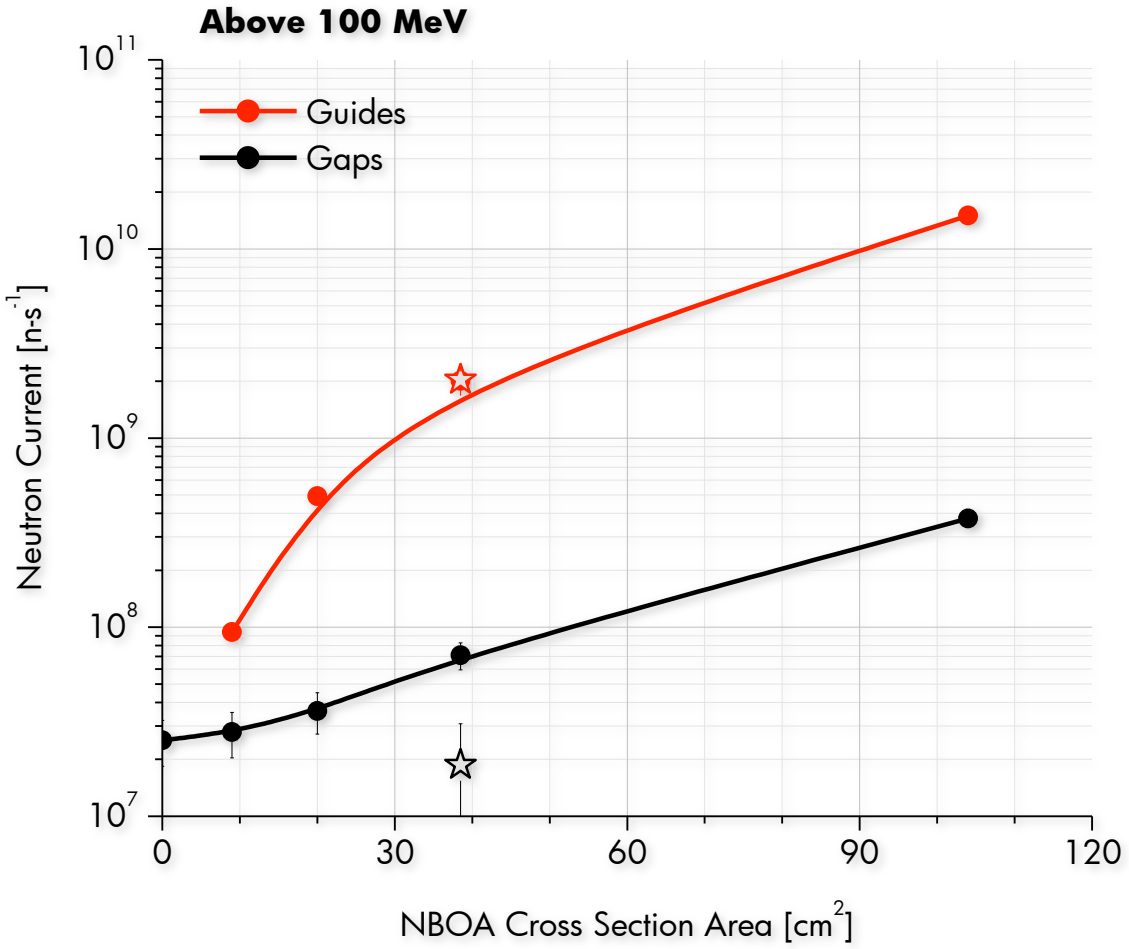
Different NBOA in Port W-03



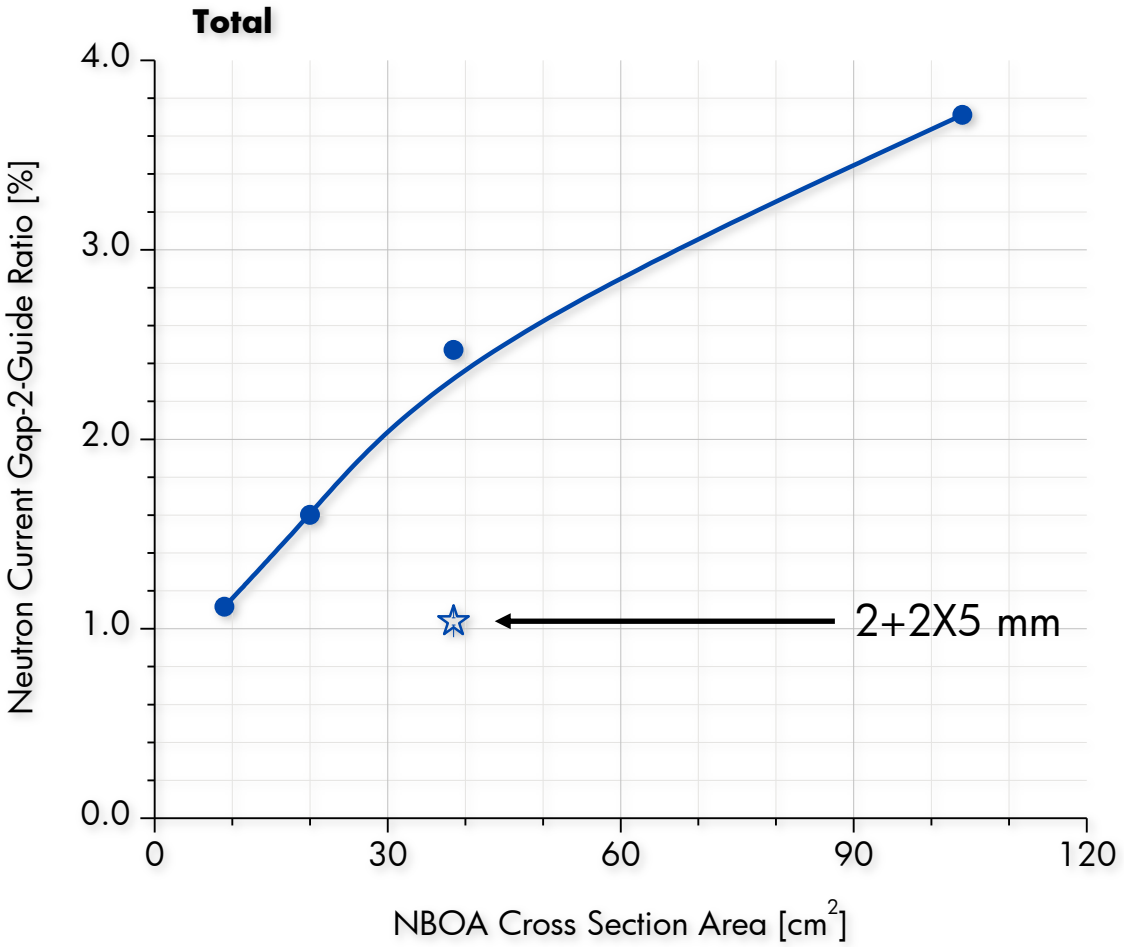


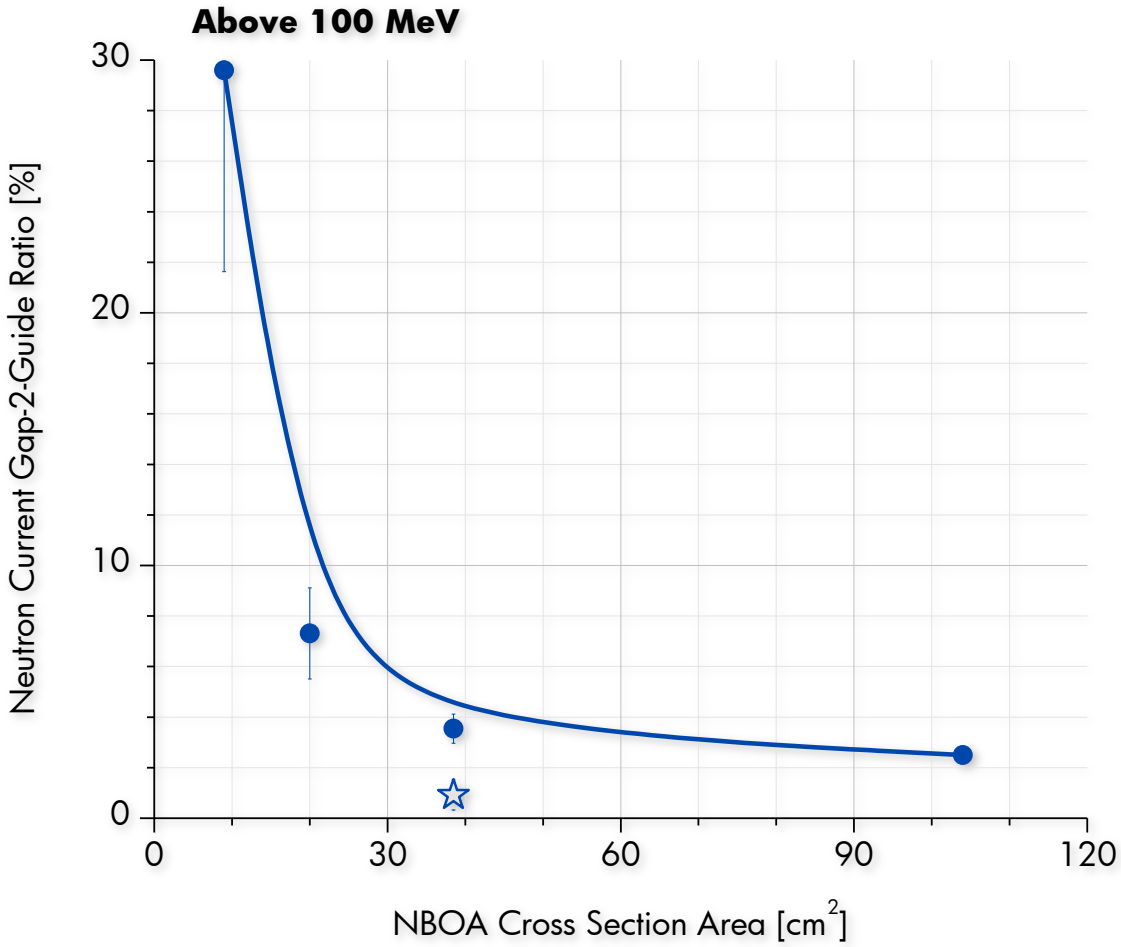
Neutron Current vs NBOA Area



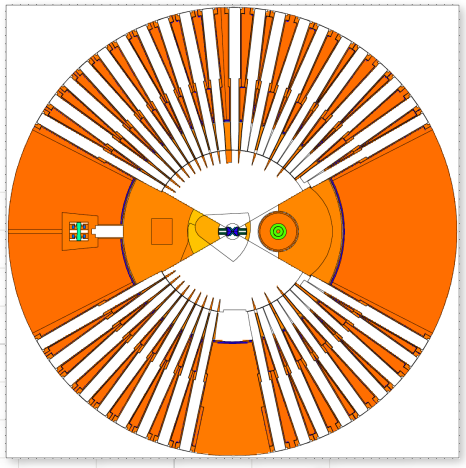


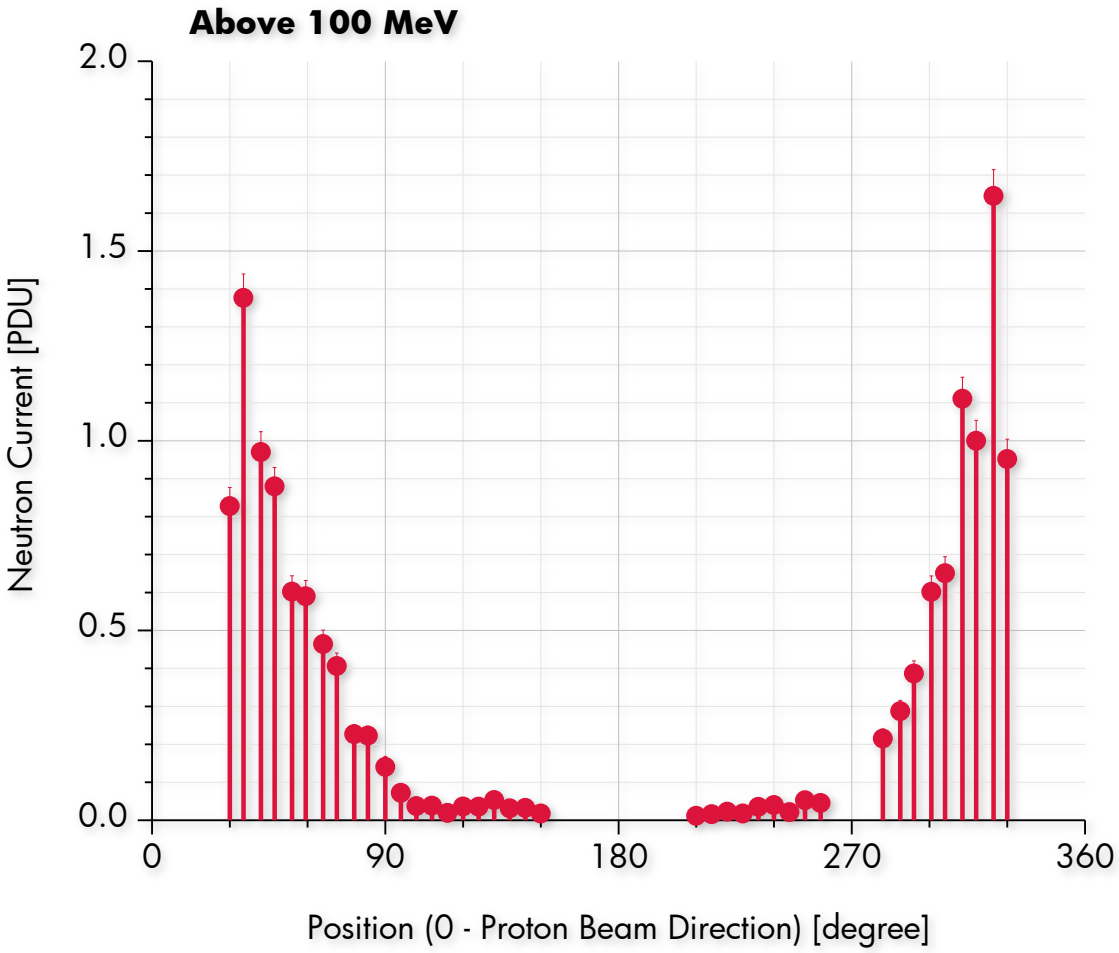
Neutron Current vs NBOA Area



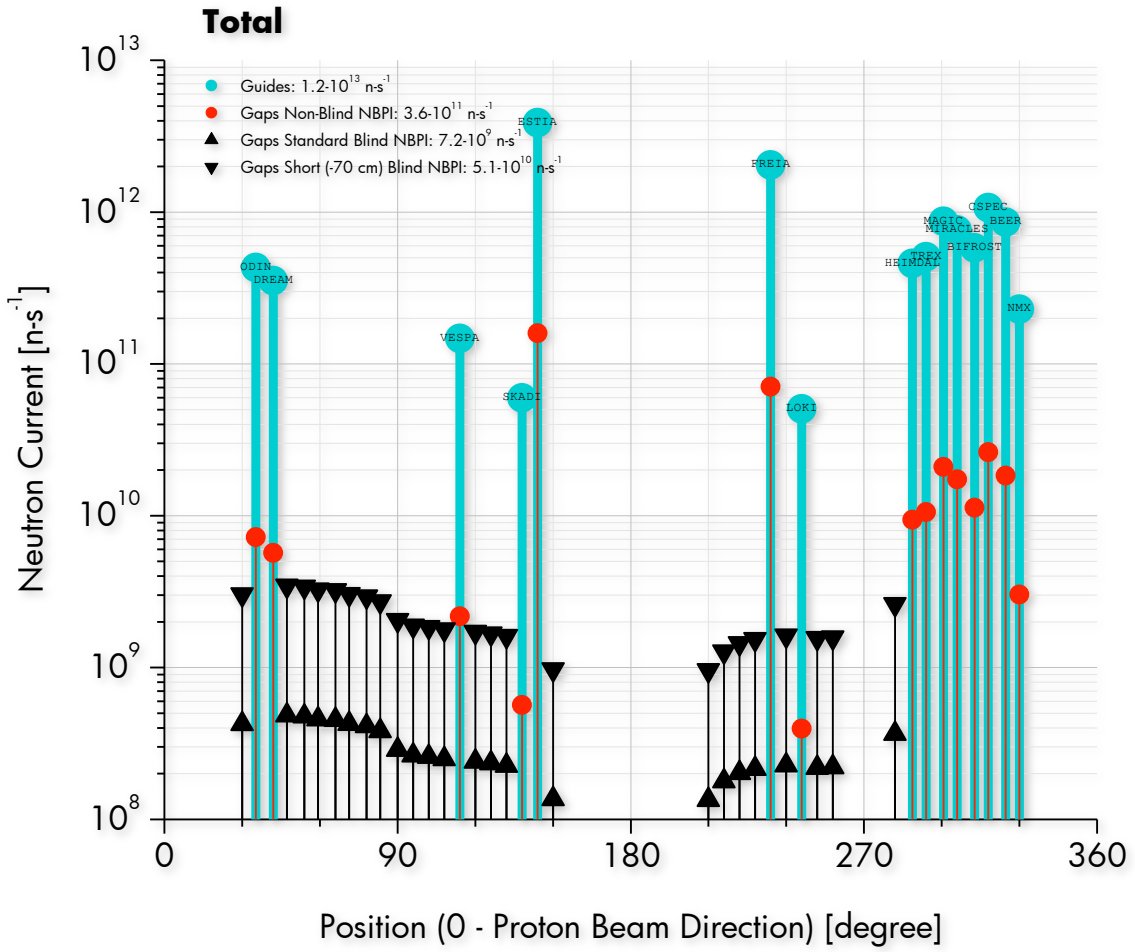


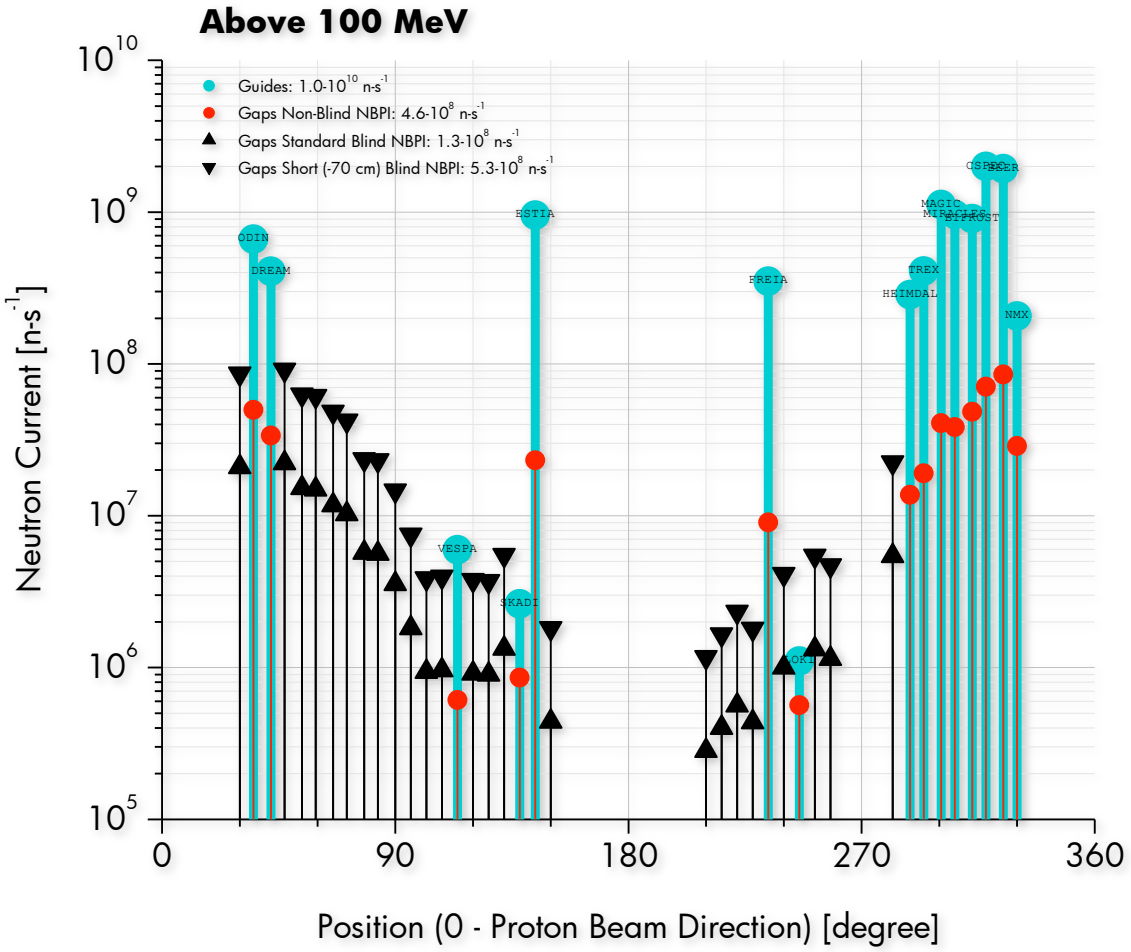
Neutron Current Angular Distribution





System-Wide Streaming





Contribution of gaps to
total neutron current:

3.0%

Contribution of gaps to
neutron current above 100 MeV:

5.8%

[The same numbers with short (-70 cm) blind NBPI are 3.4% and 9.7% respectively]