CAMEA

Guide Report

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1 Guide for CAMEA proposal

The CAMEA guide was made by extensive use of the optimizer guide_bot. The guide_bot tool generates the McStas instrument and iFit files necessary for guide optimization, making it easy to investigate a large number of possibilities. The baseline requirements for the CAMEA guide is a 15x15 mm^2 sample 0.6 m from the end of the guide, with a divergence requirement of $\pm 0.75°$ in the horizontal direction and $\pm 1.0°$ in the vertical direction. The distance between moderator and sample is 165 m. The guide does provide flux in a larger area than the requirement and at larger divergences, but the phasespace illumination is only uniform within the requirement. The guide is intended to be used for the wavelength range 1.65 Å to 6.4 Å, but was optimized for a wavelength range of 1.0 Å to 3.6 Å, because experience with the optimizer shows that the results are better when optimizing for a slightly lower wavelength range than needed.

1.1 Guide description

The guide geometry can be seen on figure 3 for the horizontal and vertical plane respectively. The overall guide geometry is a parabolic feeder which starts 2.16 m from the moderator followed by a 10 cm gap at 6.5 m to accommodate a pulse shaping chopper. The width at 6.6 m has been fixed to 30 mm. Widths of 25 mm and 35 mm were also investigated, but the smaller pinhole reduced performance by almost 15% and the larger did not show any improvement. The height at 6.6 m was not restricted, the optimal solution had a height of 8.8 cm. In the horizontal direction the feeder works as a funnel, but in the vertical direction it seems to be an extension of the ellipse which follows the gap. The rest of the guide is a double ellipse with a kink to escape line of sight. The kink is designed to loose line of sight 25 m before the end of the guide. On either side of the kink there is a straight section, the total length of this is 13.9 m. They effectively makes the guide narrower at the centre which means the kink angle can be made smaller while still escaping line of sight. In the horizontal direction the maximum width of the ellipses is 11.4 cm and 12.4 cm respectively. In the vertical direction the first ellipse is 17.8 cm high and the second is 20.8 cm high.

1.2 Guide geometry

As guide_bot allows for fast automatic optimization of many guide geometries about 150 different geometries where tested. The best performing guides with respect to brilliance transfer were then further manually investigated for the spacial and divergence distribution and robustness to degradation of the mirrors. The chosen guide performs well in all categories.

1.3 Phase space on sample

Both the illuminated sample area and the divergence on sample were scanned and it was found that the chosen numbers do almost not influence the maximal brilliance transfer while keeping a homogenous illumination of the sample area and a smooth divergence distribution. The 1.5 x 1.5 cm^2 sample space was thus chosen even though the instrument is optimized for maximum 1 x 1 cm^2 samples to allow some freedom of sample rotation. Likewise the divergence limits where chosen as to be $\pm 0.75°$ horizontally and $\pm 1°$ vertically. Note however that this is not the maximal possible divergences but the maximum divergences that contributed to the optimisation. Hence divergences above these will hit the sample though the will decrease fast above the limits. Divergence jaws will enable users to choose a small divergence if they desire.

1.4 Moderator height

As the design of the instrument neared its end the moderator division at ESS released data showing how the brilliance of the moderators could be increased by reducing the moderator height. As a part of the ESS investigation of this effect the 4 most promising guide geometries were tested for other moderator heights. It was found that the chosen geometry would also be preferable at lower heights and that a gain factor of 1.8 can be achieved by going from 10 to 2 cm moderator height (se figure 1). Note that even at 10 cm the flux is the double of what it was at 12 cm. This is both due to the new better moderator model provided by the moderator group and the fact that the flux here is not displayed in a 1.7 Å wavelength band but for the entire band of interest. However since the official ESS policy that the instrument proposals should use the old 12 cm high moderator this is also done here.

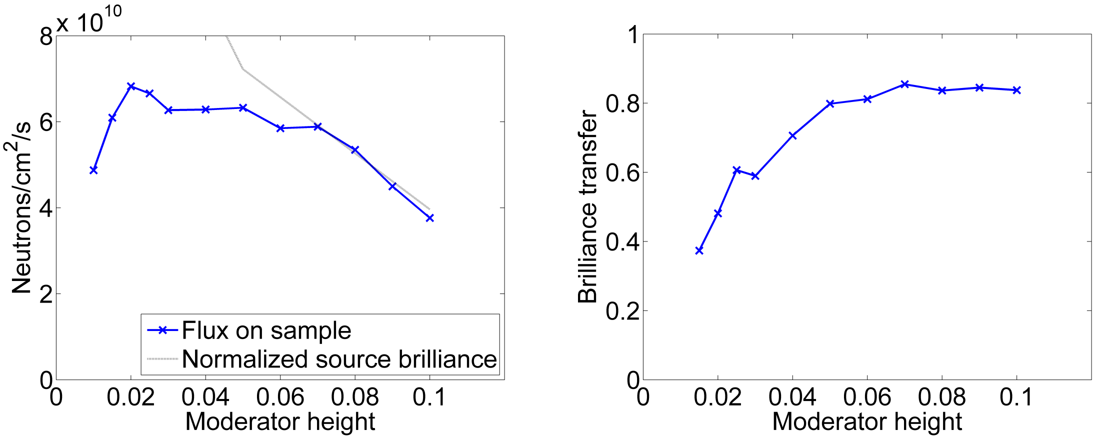

Figure 1: Simulation of the influence on the instrument performance it the new ESS moderator geometries are chosen.

1.5 Line-of-sight

guide_bot includes a ray tracer that makes it possible to do automatic optimization for any guide geometry a scan of optimal solutions were performed for line-of-sight losses at different points in the guide (see figure 2). The guide were found to be quite resilient to more demanding line of sight requirements and in the end it was decided that loosing line-of-sight to the moderator 25 m before the guide end provided a good compromise between guide background dampening and brilliance transfer. Note that most of the fast neutron background will leave the guide at the kink, but the last direct source of fast neutron background is 25 m before the end.

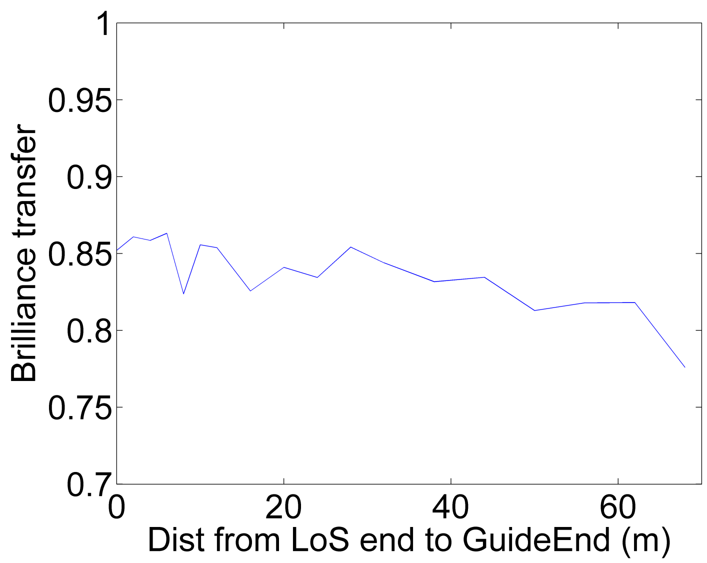

Figure 2: Simulation of the influence on the guide performance when the point where line-of-sight to the moderator is broken is moved from the end of the guide and closer to the guide start.

1.6 Coating

The optimizations were done with a coating with m=3.5 everywhere in the guide system and perfect ellipses. The resulting optimal guide geometry is used, but afterwards the guide was divided into 25 segments that were

Component	length of coating segment	coating value	position relative to moderator
Feeder	1.74 m	3	2.16 m - 3.90 m
Feeder	1.74 m	3.5	3.90 m - 5.63 m
Feeder	0.87 m	3	5.63 m - 6.5 m
Ellipse	6.52 m	3.5	6.6 m - 13.12 m
Ellipse	6.52 m	2	13.12 m - 19.64 m
Ellipse	39.12 m	1.5	19.64 m - 58.78 m
Ellipse	6.52 m	2	58.78 m - 65.28 m
Ellipse	6.52 m	3	65.28 m - 71.80 m
Straight	13.94 m	2	71.80 m - 85.74 m
Ellipse	15.73 m	2	85.74 m - 101.47 m
Ellipse	47.20 m	1	101.47 m - 148.67 m
Ellipse	7.87 m	2	148.67 m - 156.53 m
Ellipse	7.87 m	3.5	156.53 m - 164.4 m

Table 1: Overview of the guide coating and position of each guide element measured from the surface of the moderator.

individually scanned to investigate what m values were needed in that part of the guide. It was found that the coatings in table 1 were sufficient and that the ellipses could be segmented into 75 pieces each, and still maintain above 90% of the performance. It is expected that these coatings can be reduced further by allowing different coatings in the left and right side of the guide as it is asymmetrical after the kink.

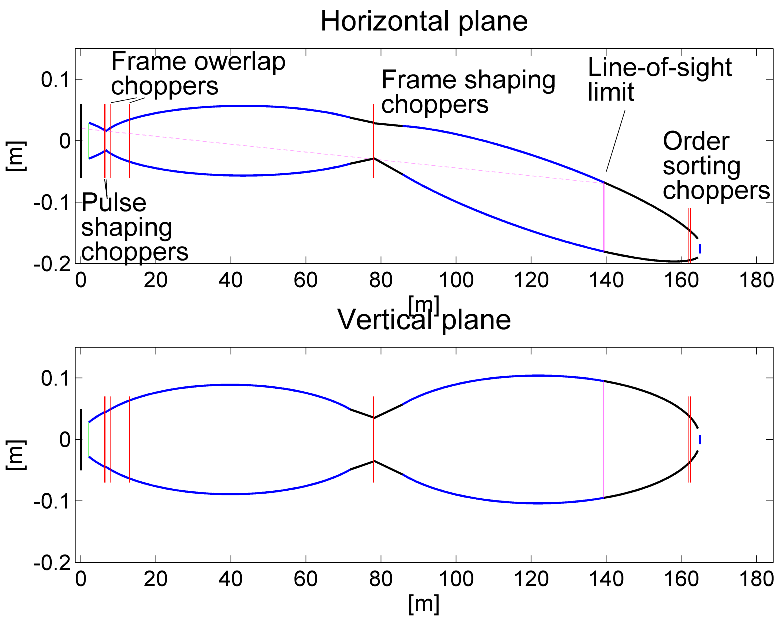

Figure 3: The guide geometry. The pink lines illustrate the line-of-sight and the red lines choppers.

1.7 Performance - Brilliance transfer

In this section the performance of the guide is investigated in terms of brilliance transfer. The source used is uniform in space, divergence and wavelength distribution. All figures have wavelength snapshots, which are simulations done using a very narrow wavelength band. The snapshots shown are for 1.0 Å, 1.7 Å, 2.3 Å, 3.0 Å and 3.6 Å.

Performance for the proposed guide is shown in figures 4, 5 and 6. Brilliance transfer is about 55% at the lowest used wavelength 1.65 Å, going to the maximum value of around 85% at approximately 3.0 Å. The divergence profile does show slight horizontal asymmetry caused by the kink at the lower wavelengths. The spatial distribution is also affected, but to a smaller extent. The vertical distributions are well behaved apart from small dips in the divergence for the lowest used wavelength. Though gravity was included, the simulations show almost no signs of gravity affecting the vertical distributions. It does however cause a slight decrease in brilliance transfer at the very longest wavelengths.

The red line in the plot showing brilliance transfer as a function of wavelength on figure 4 show the performance in the case of a 20% reduction of the m value and a 40% increase in the slope of the reflectivity. This can be used to gauge how resistant the guide is to mirror degradation. It can be seen that such a loss in mirror quality would only be relevant below 2.5 Å, and would cut the brilliance transfer roughly to half at 1.7 Å.

1.8 Performance - Absolute units

In this section the proposed guide is investigated in terms of absolute flux. The guide have been simulated with the newest McStas 2.0 ESS source. The resulting performance is shown on figures 7, 8 and 9. The guide was placed at the center beamport and pointed directly at the center of the cold moderator. The flux is above 8×10^9 n/s/cm^2/Å from 2.5 Å to 3.3 Å. The flux on sample declines below 2.5 Å. Even though the brilliance transfer at 1.7 Å is above half, the total flux is below 20% of the peak flux because of the source spectrum. Figure 10 shows the flux integrated over the natural 1.7 Å wide wavelength band, as a function of the center of the wavelength band.

Notice that when calculating brilliance transfer, the intensity is summed only over the figure of merit box, and thus adding for example divergence limits on the position monitor. On the figures in this section all neutrons are counted regardless of their divergence. This makes the spatial positions sharper, which can be a problematic characteristic, and will be addressed in future iterations of the guide design.

Proposed guide

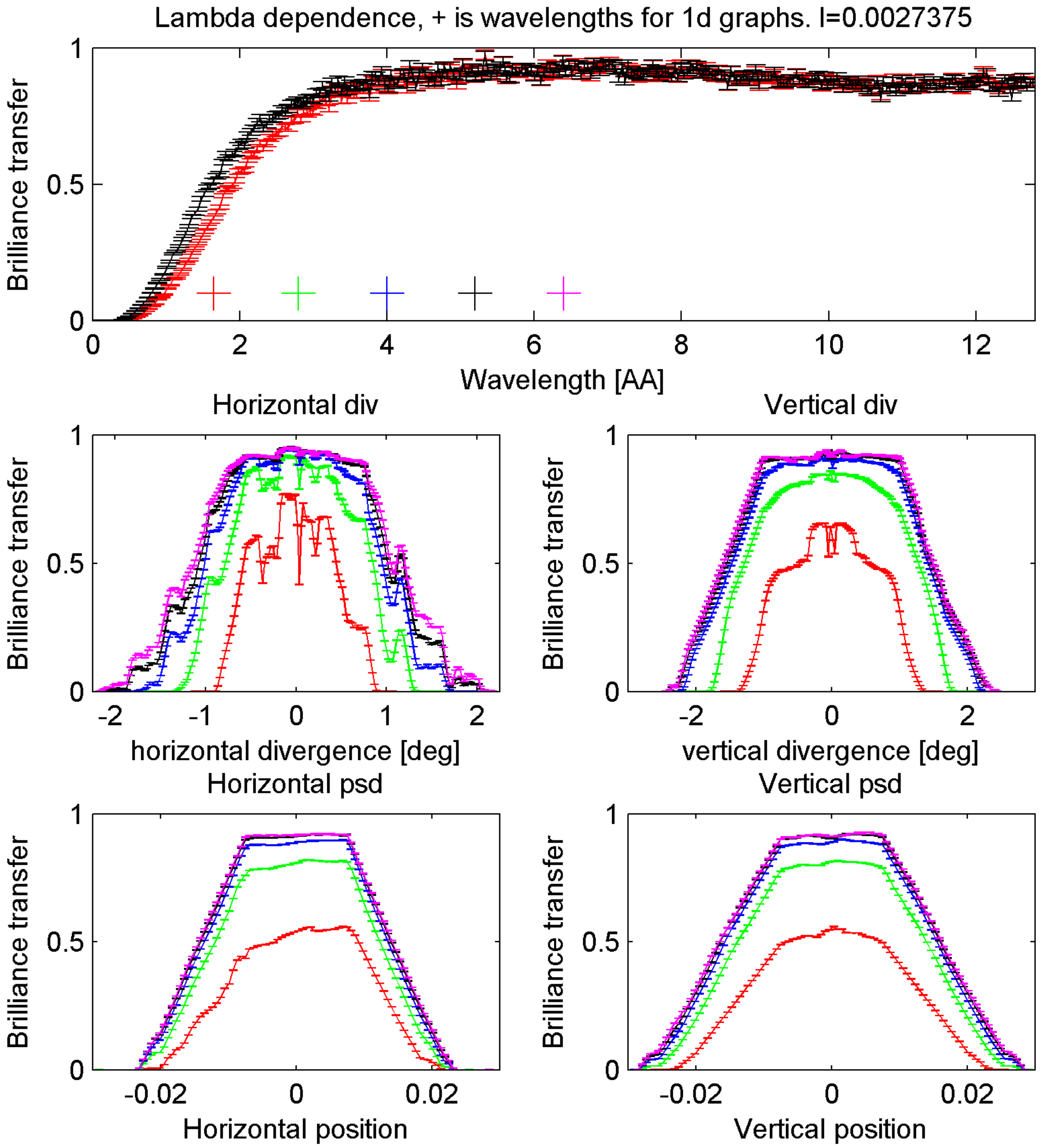

Figure 4: Summary of the overall results showing brilliance transfer as function of wavelength, spatial distribution and divergence distribution in terms of brilliance transfer. The red line in the brilliance transfer as function of wavelength plot shows the performance of the guide in case of a reduction mirror quality. The wavelength snapshots are at 1.0 Å 1.7 Å, 2.3 Å, 3.0 Å and 3.6 Å.

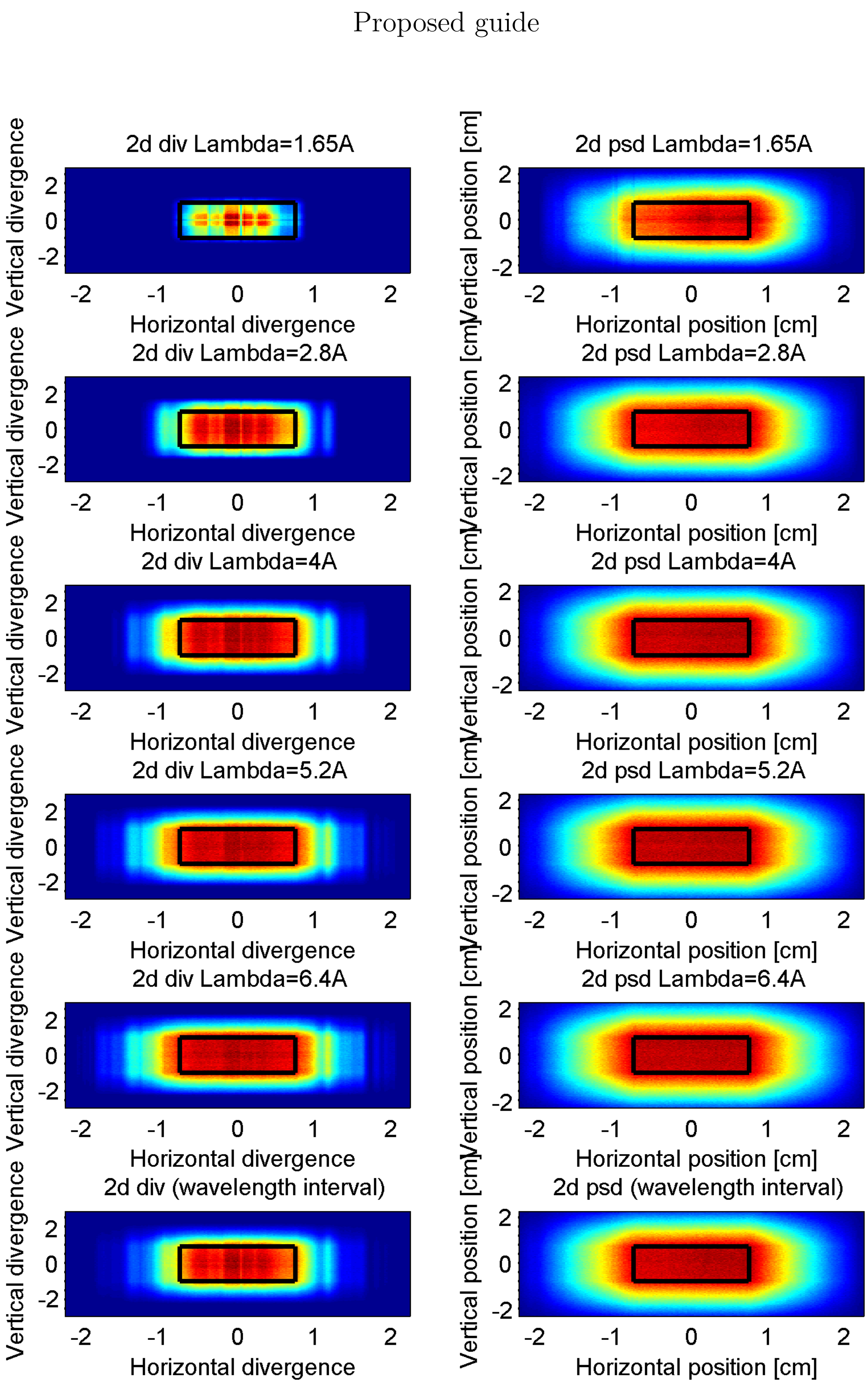

Figure 5: The two dimensional spatial and divergence distributions for wavelength snapshots and for the entire wavelength range. The box indicates the figure of merit.

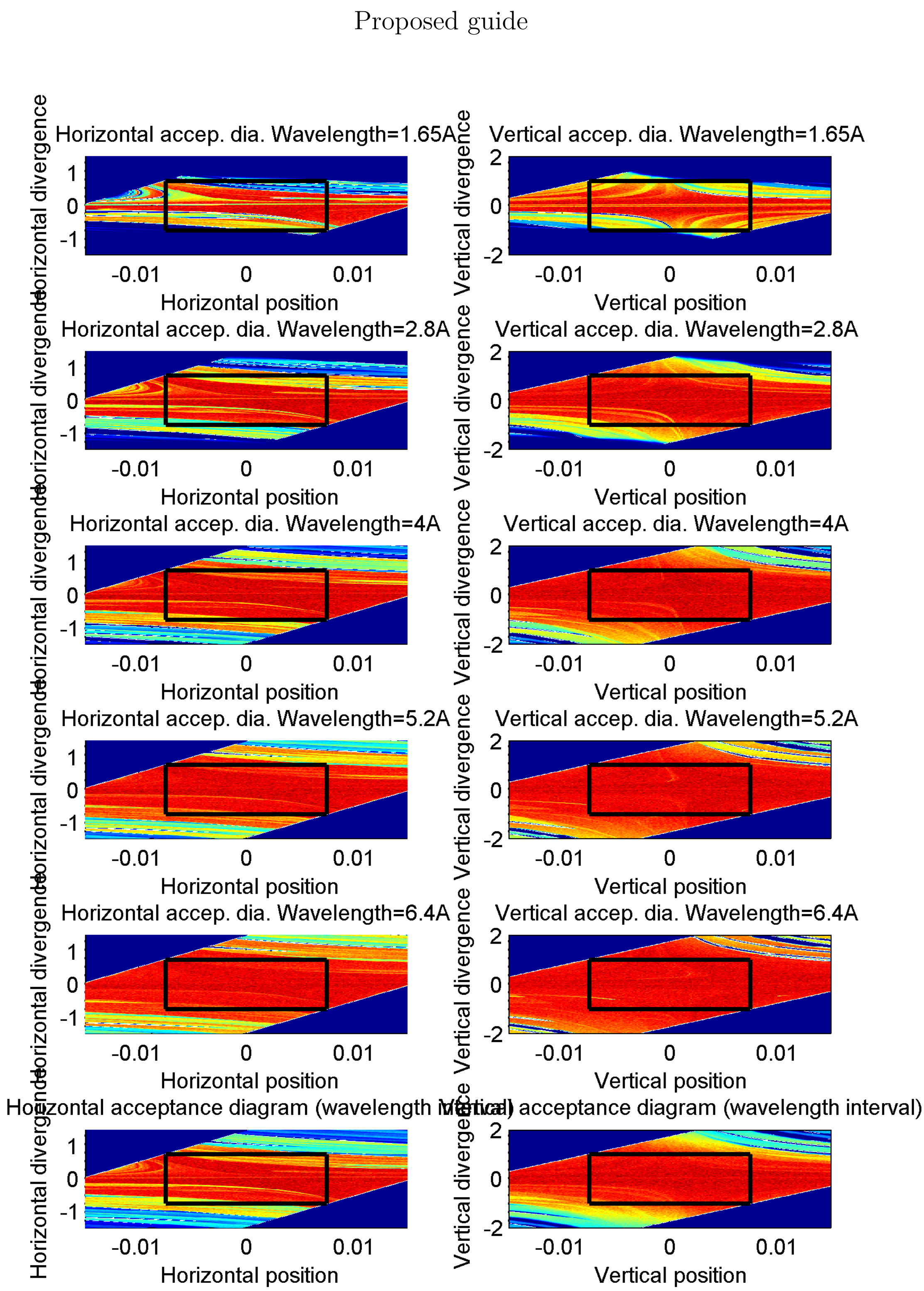

Figure 6: Acceptance diagrams for the horizontal and vertical directions for different wavelength snapshots and for the entire wavelength range. The box indicates the figure of merit limits.

Proposed guide

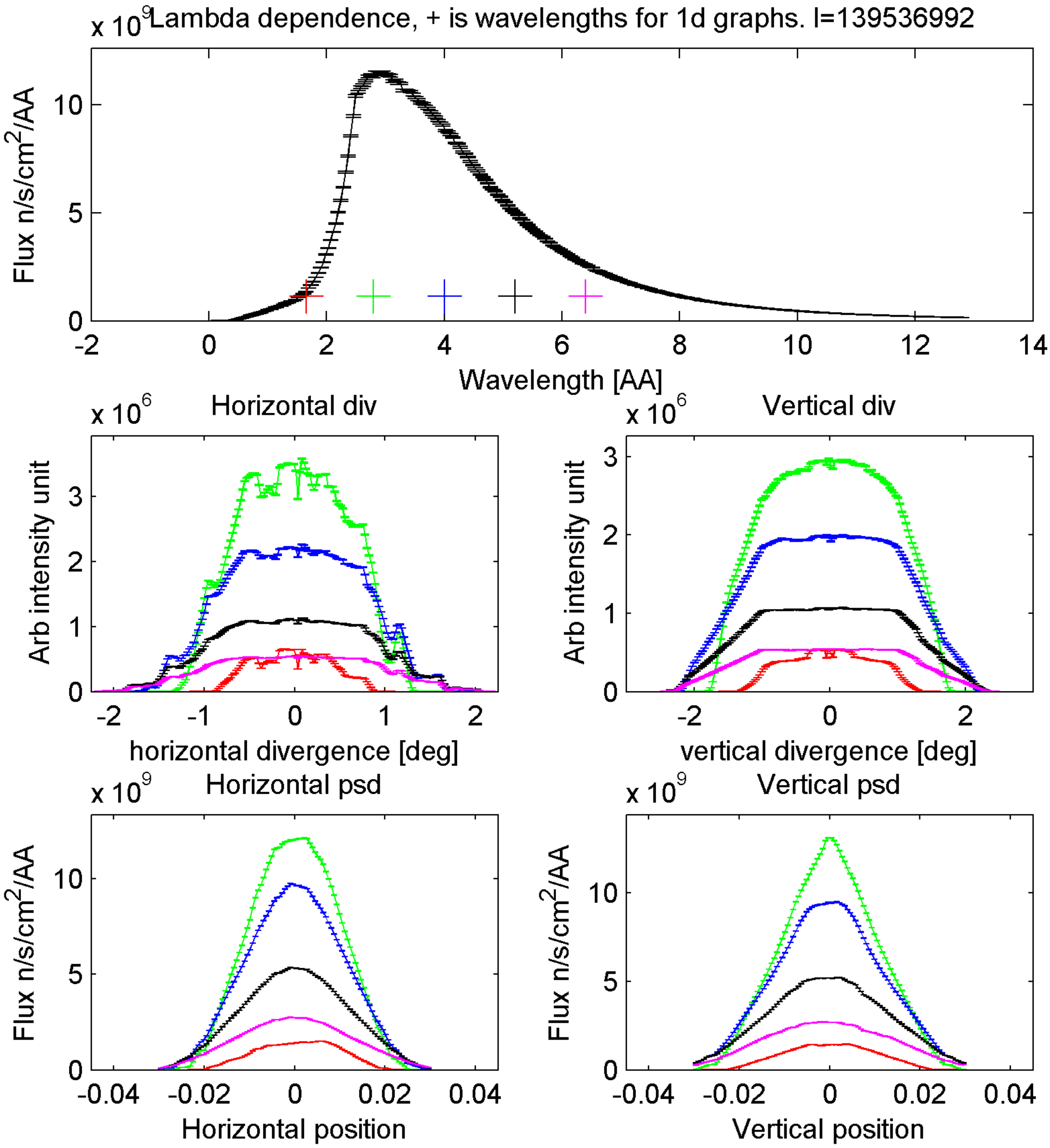

Figure 7: Summary of the overall results showing absolute flux on sample when using the ESS cold moderator. Shown as function of wavelength, spatial distribution and divergence distribution. The wavelength snapshots are at 1.0 Å 1.7 Å, 2.3 Å, 3.0 Å and 3.6 Å, the colors correspond to the markers in the plot showing wavelength dependence.

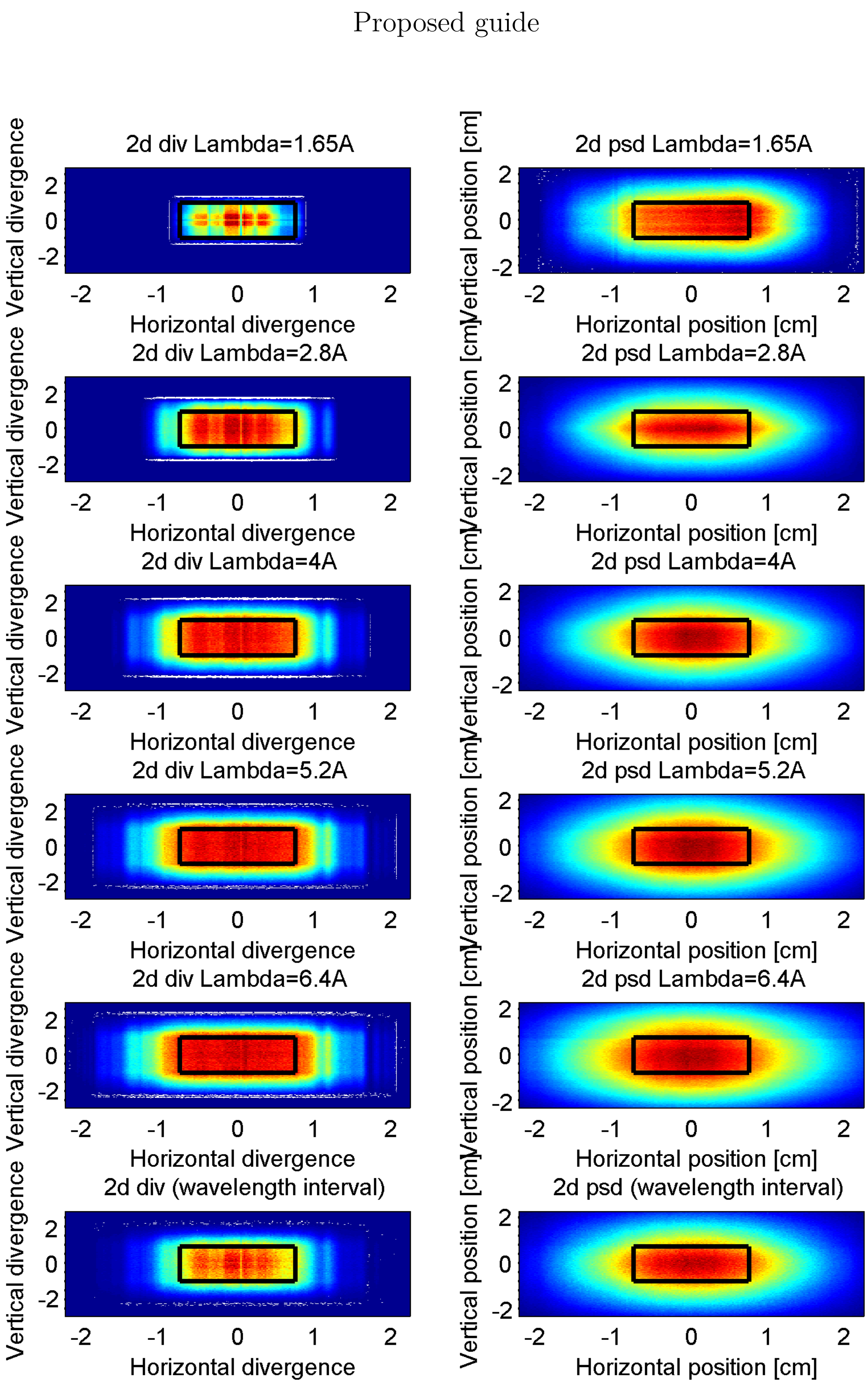

Figure 8: The two dimensional spatial and divergence distributions for wavelength snapshots and for the entire wavelength range. The box indicates the figure of merit limits. Simulated using the ESS cold moderator.

Proposed guide

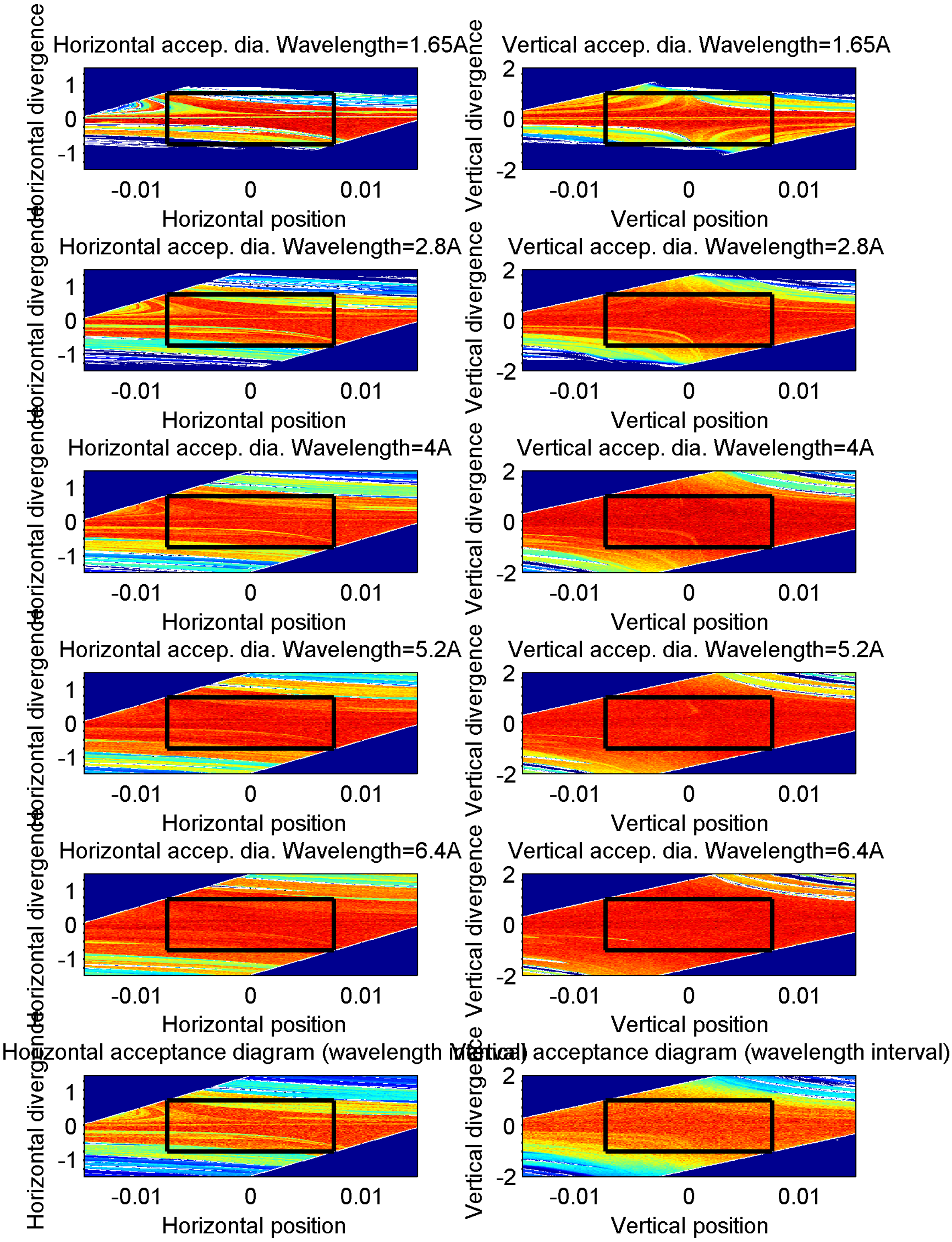

Figure 9: Acceptance diagrams for the horizontal and vertical directions for different wavelength snapshots and for the entire wavelength range. The box indicates the figure of merit limits. Simulated using the ESS cold moderators

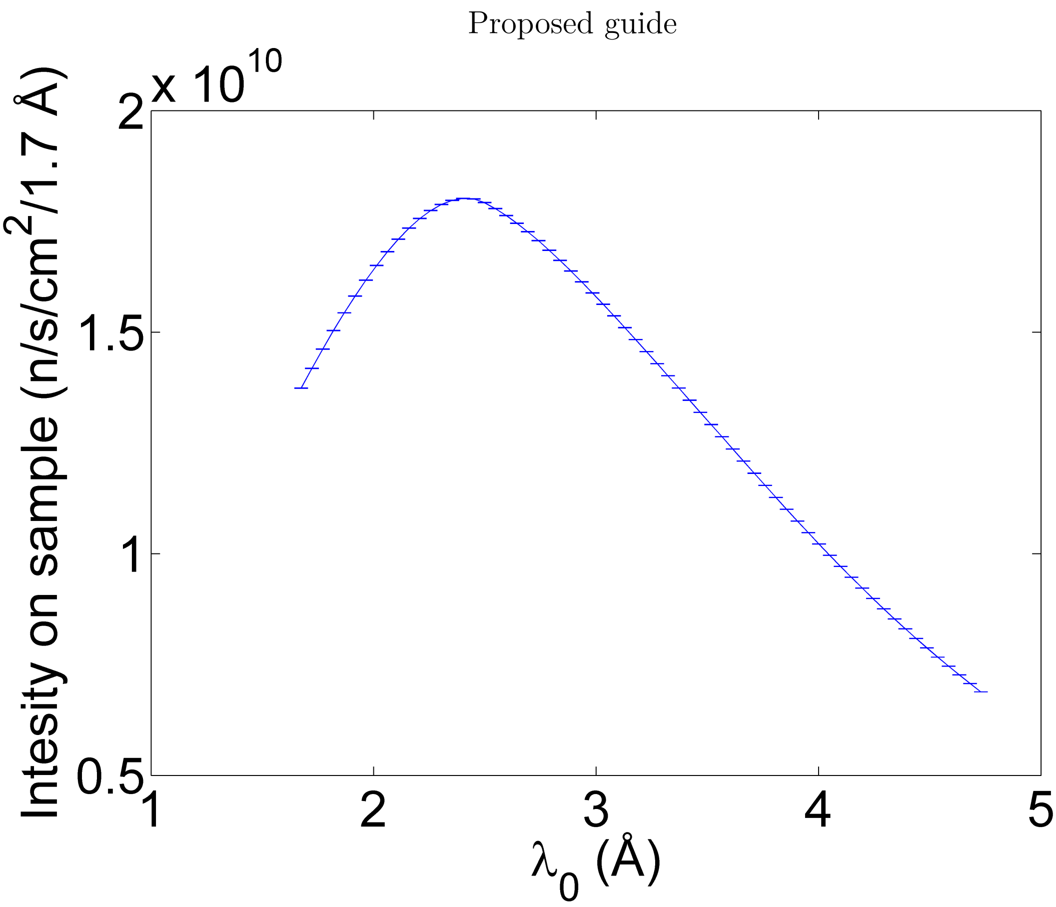

Figure 10: Absolute flux as a function of the lowest wavelength in the 1.7 Å wide wavelength band. For 3 Å the integrated flux is 1.8×10^{10} n/s/cm^2.