

Reproducing “Butterfly” ESS brilliances using McStas

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(Distributed online at the [McStas share archives](#))

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This document is meant to give further clarity on the available ESS source parameterisations for use with McStas. We shall only consider the butterfly type brilliances, as this is the current ESS baseline. (For information on the older TDR and pancake brilliance milestones, please consult the document “[Reproducing ESS TDR and pancake brilliances with McStas](#)”).

As of today, a new revision of the ESS_moderator.comp is now officially available at the McStas share in versions for use with McStas 2.x and 1.12c through the archive

http://mcstas.org/download/share/ESS_moderator_December_2015.tgz

The component comes with a library of ESS source brilliances, each labeled:

- **2001**, legacy "Mezei moderators" from the original F. Mezei documents, rescaled to ESS TDR frequency, pulse-length and power.
- **TDR**, Mezei moderators, with a wavelength-dependent correction term to the cold flux, derived from 2012 MCNPX calculations by ESS neutronics group. Corrections calculated by K Lieutenant (Vitess) NOTE: uses the 2001 brilliance for the thermal moderator!
- **2013**, post-TDR update with non-Maxwellian cold spectrum, Troels Schoenfeldt, BEFORE the ESS pancake geometry was introduced.
- **2014** updated brilliance using formulation by Troels Schoenfeldt, including support for the "pancake", i.e. flat geometry and variation of the brilliance over the moderator surface.
- **2015** updated brilliance using formulation by Troels Schoenfeldt, including support for the "butterfly" moderator in 3 and 6cm height versions. This formulation further includes local variation of the brilliance over the moderator surface, and variation with selected beamport angle.

Of these parameterisations, only the **2015** is considered in detail within this document.

As for the earlier released version of ESS_moderator, selecting one of the above parameterisations defines **both** a cold and a thermal brightness, emitted from a dual-moderator surface with a central thermal moderator and cold wings. The fraction of statistics emitted from each of these can be selected through the cold_frac parameter.

3 and 6cm butterfly moderator:

A 3cm high “butterfly” moderator is selected by choosing the parameter set

```
COMPONENT Source = ESS_moderator(dist=2,  
    focus_xw=guidewidth, focus_yh=guideheight,  
    Lmin=lambdamin, Lmax=lambdamax, cold_frac=0.5,  
    sourcedef="2015", yheight_c=height, yheight_t=height,  
    beamport_angle=5)  
AT (0, 0, 0) RELATIVE Origin
```

The following parameters can be adjusted from their defaults:

- $0 < \text{cold_frac} < 1$ defines the fraction of statistics emitted from the cold source
- yheight_c and yheight_t are used to define the height of the butterfly-moderator. Please select either 0.03 or 0.06 here for the “flat” or “tall” butterfly.
- beamport_angle defines the angle with respect to the central position of the beam-extraction, i.e. orthogonally to the proton beam direction. Allowed values are 5,15,...55°, since the underlying MCNPX simulations were carried out at these fixed positions. Simply pick the

position which is the numerically closest to your position. If your position has a negative sign, please select the positive sign version of that position, since the overall variation is < 10% anyway.

When using the “2015” parameter set, the following parameter definitions are implicit:

- `xwidth_c=0.1`, `xwidth_t=0.18` (the in-plane moderator geometry is fixed)
- `extraction_opening=120` (the neutronics calculations were done at 120 degree extraction-area width)
- The ‘isleft’ parameter is not used - i.e., neutrons can only be emitted from either the closest cold moderator or the central thermal moderator.

Let us also have a quick look at the geometry - see Figure 1 on the right.

If your instrument is solely or mostly cold, we advise the use of an Arm to control the orientation of the neutron optics with respect to the moderator ‘z’ axis which in the 2015 setting is the midpoint of the beam extraction.

The reasoning is that neutrons emitted from the cold moderator is geometrically shifted with respect to the instrument axis. I.e. to effectively transport beams with a high proportion of cold neutrons, you will need to add a rotation of your optical axis at the beampost position.

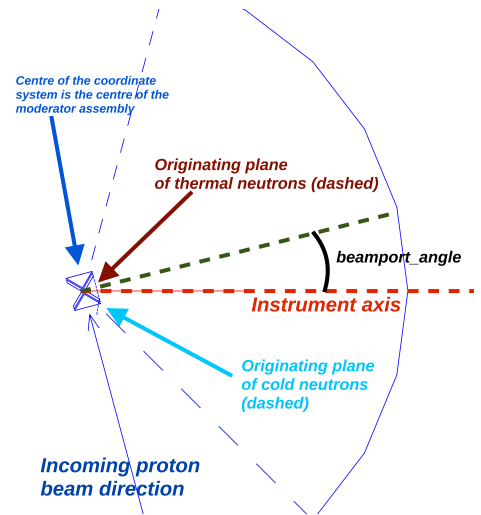


Figure 1: illustration of the geometry

In Figure 2 below, a moderator-setup with a mixture of thermal and cold neutrons has been selected, with cold neutrons emitted from the ‘off-center’ part of the moderator. The shown monitor outputs give a) the spectrum and b) a wavelength-divergence diagram. The outputs on the left are measured *without* a rotation of the monitors, i.e. the thermal neutrons from the thermal slab give a peak at ~6 degrees. The outputs on the right shows that this can be rectified by a rotation of the monitors, here the output from the cold slab is measured around the ~0 degree direction.

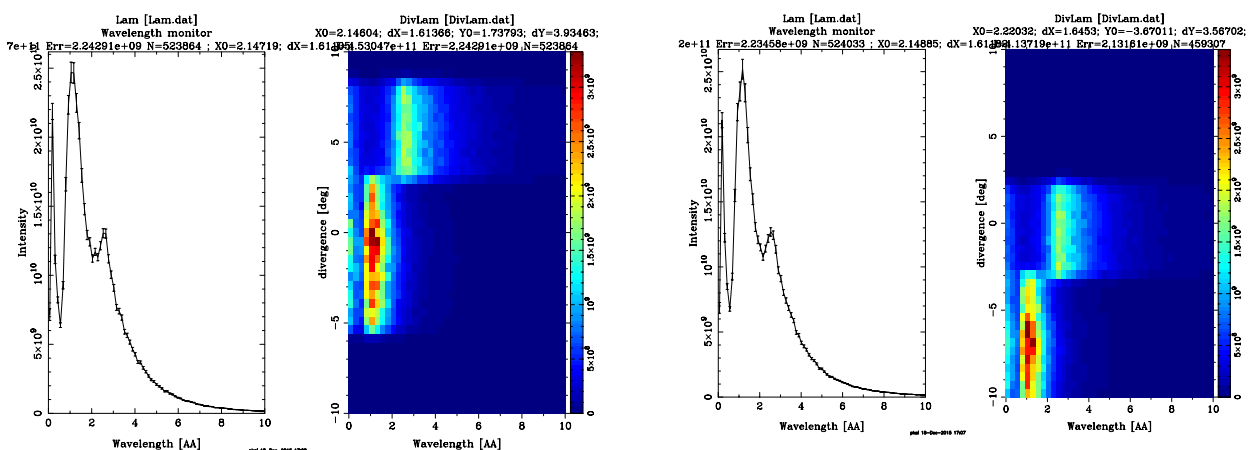


Figure 2: Illustration of the divergency-shift of neutrons from the ‘left’ cold slab.

The left-most figures in Figures 3 and 4 below show fits and histograms of ESS neutronics data from the paper “*Functional description of the thermal and cold brightness distribution at ESS*” by Troels Schönfeldt et. al (submitted to NIMA). On the right part of the same figures, the corresponding McStas simulation output is shown (produced via the `ESS_brilliance_2015` instrument file).

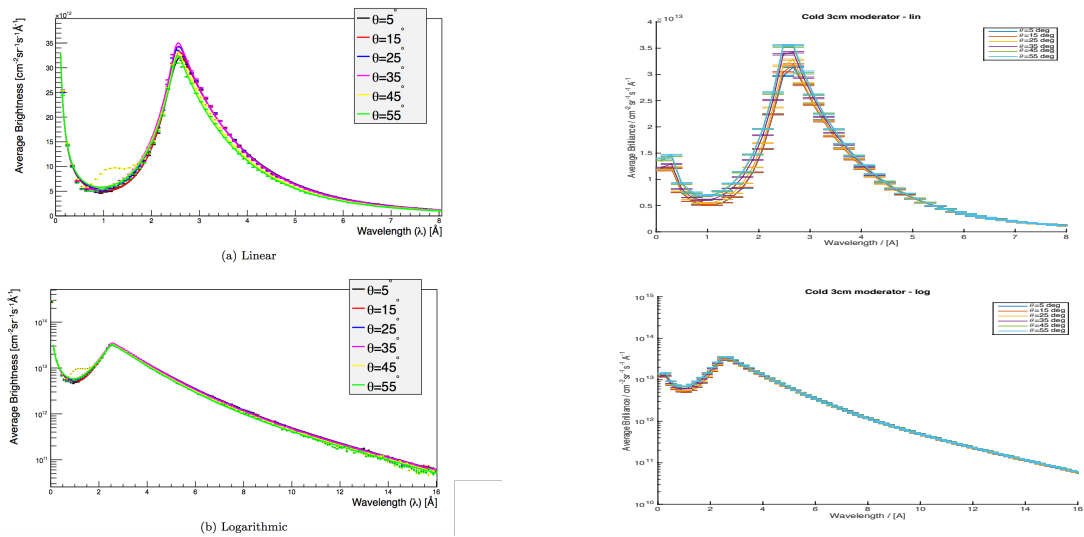


Figure 3: Cold brilliance from the “pancake” as function of moderator height. Left: MCNPX + fits Right: New McStas 2015 ESS_moderator.comp

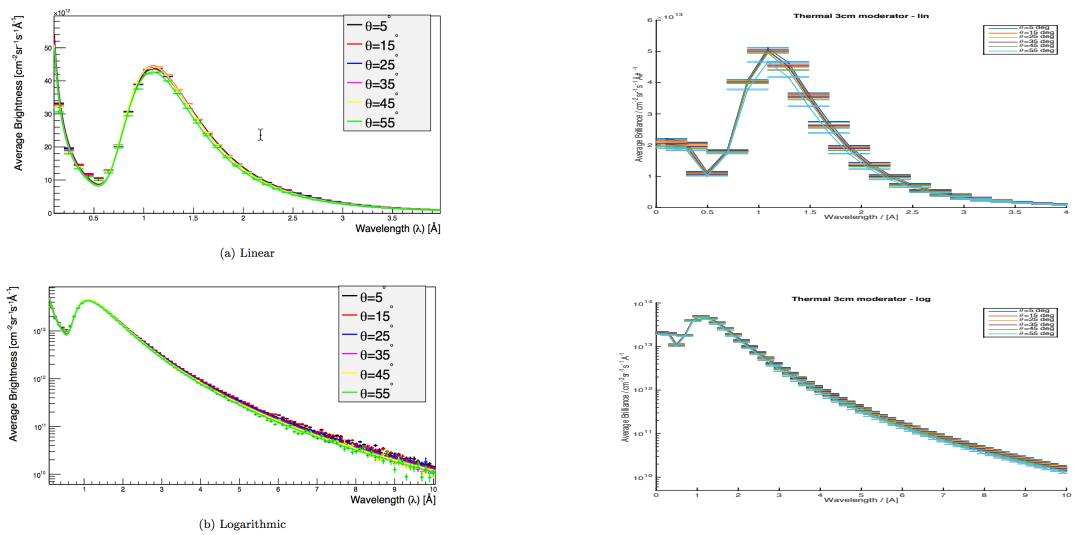


Figure 19: Thermal moderator spectrum.

Figure 4: Thermal brilliance from the “pancake” as function of moderator height. Left: MCNPX + fits Right: New McStas 2015 ESS_moderator.comp

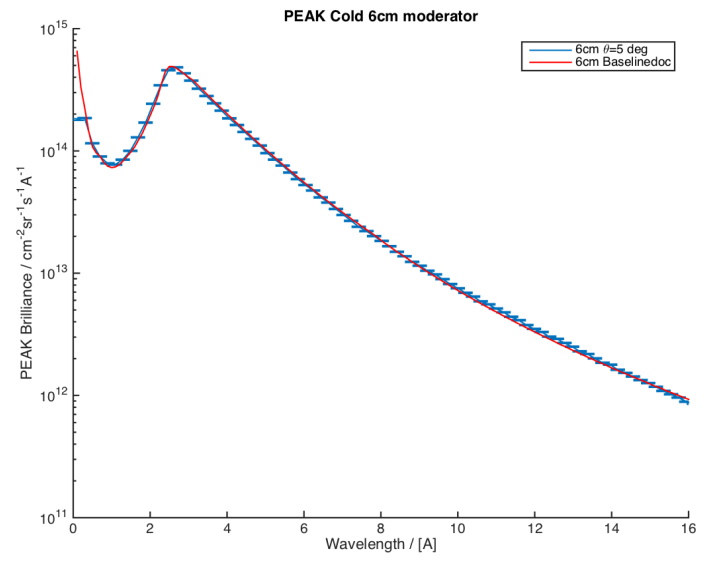
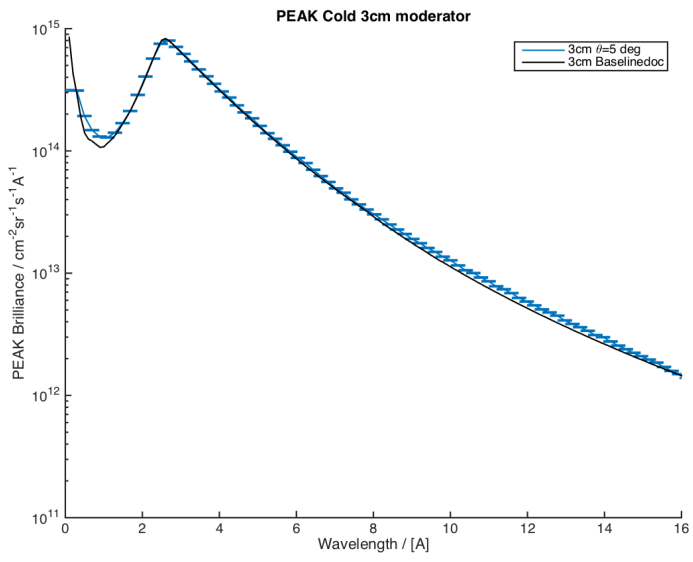


Figure 5: Cold brilliances from the 3cm (left) and 6cm (right) moderator. Plots show comparison between the baseline document “New ESS Moderator Baseline” by Ken andersen and the corresponding McStas moderator.

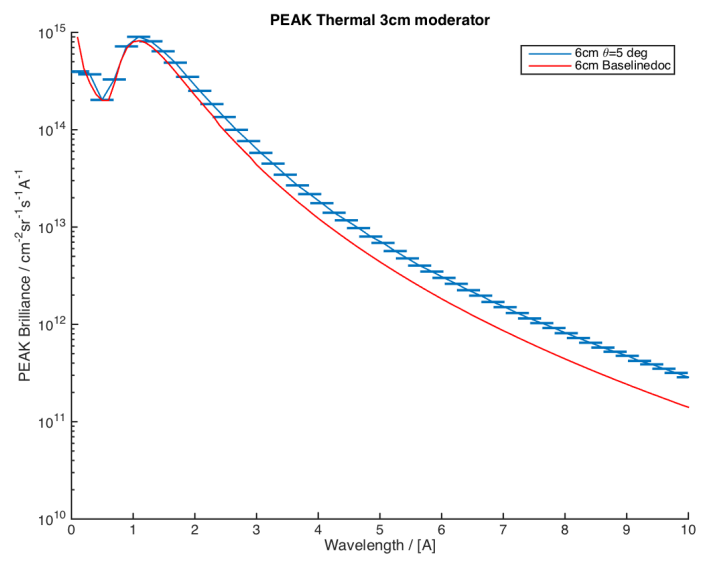
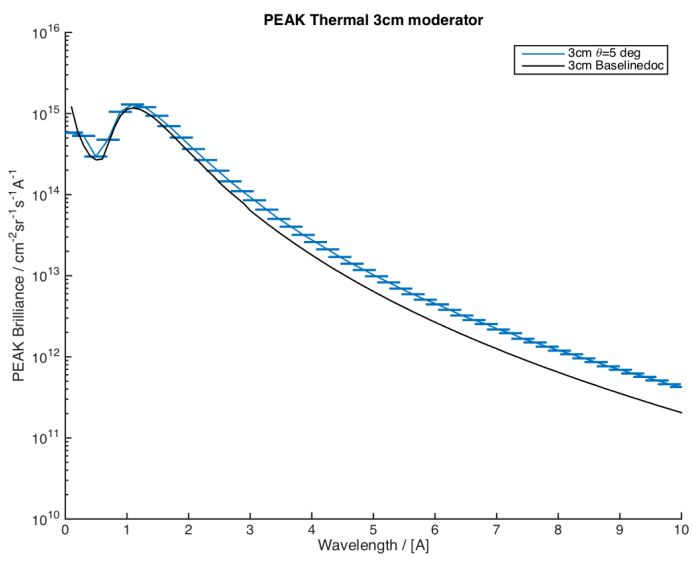


Figure 6: Thermal brilliances from the 3cm (left) and 6cm (right) moderator. Plots show comparison between the baseline document “New ESS Moderator Baseline” by Ken andersen and the corresponding McStas moderator.