Status of beam transport and shielding for HEIMDAL

Paul Henry
Instrument Scientist HEIMDAL
ESS Instrument Scientist – Powder Diffraction

www.europeanspallationsource.se
12 May 2016

All information taken from accepted paper

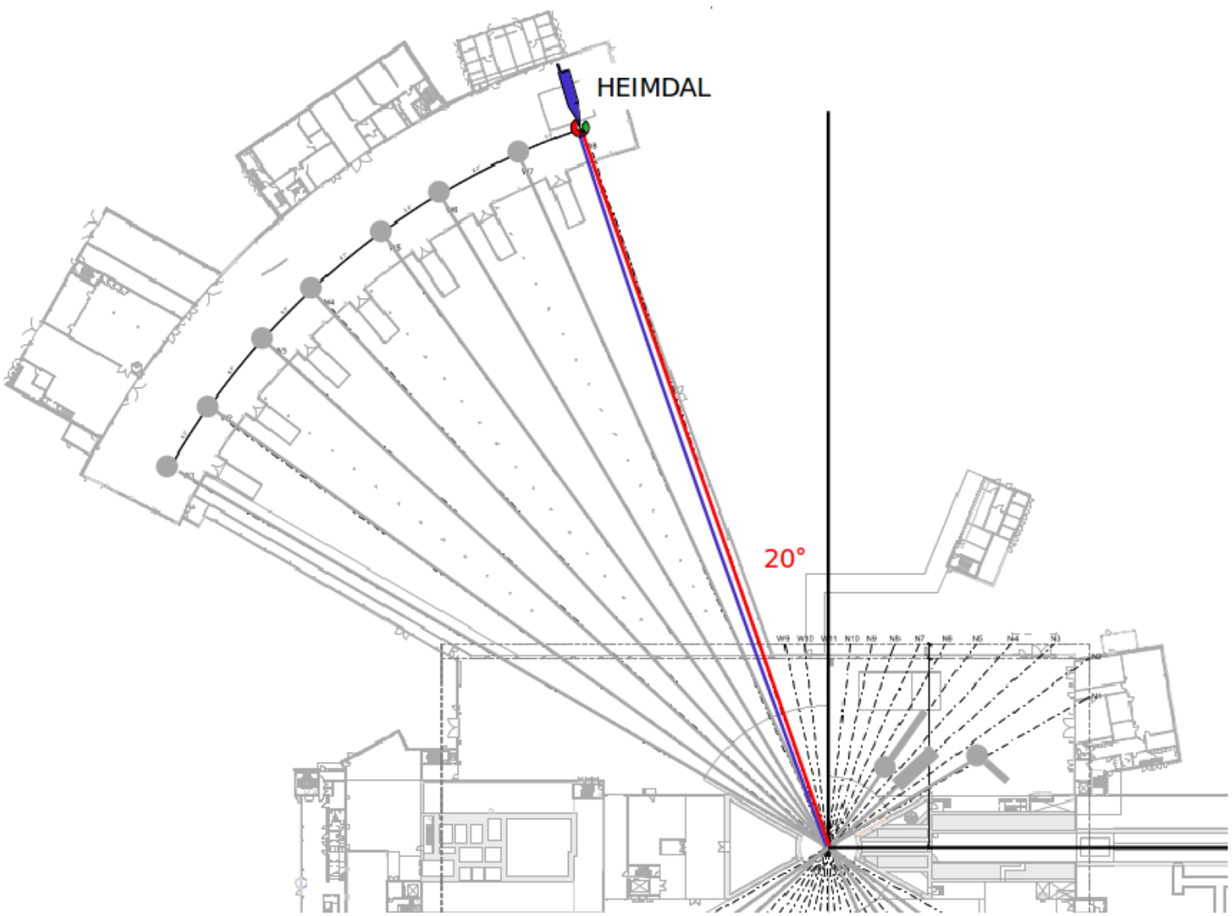
Communication

HEIMDAL: A thermal neutron powder diffractometer with high and flexible resolution combined with SANS and neutron imaging - designed for materials science studies at the European Spallation Source

Sonja L. Holm[a], Kim Lefmann[a], Paul F. Henry[b], Mads Bertelsen[a,b], Jürg Schefer[c], Mogens Christensen[d]

[a]*Nano-Science Center, Niels Bohr Institute, University of Copenhagen, Universitetsparken 5, 2100 Copenhagen Ø, Denmark*
[b]*European Spallation Source ERIC, 22100, Lund, Sweden*
[c]*Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institute, 5232 Villigen, Switzerland*
[d]*Department of Chemistry & Interdisciplinary Nanoscience Center (iNANO), Langelandsgade 140, 8000 Aarhus C, Denmark*

Beamline overview



- Separate thermal and cold beam extraction
- Both guides curved to be non line-of-sight
- Position W8 in hall 3
- Very close to guide hall wall
- Smaller available sector than other instruments

- Model based on extraction from upper and lower moderators

Beamline overview

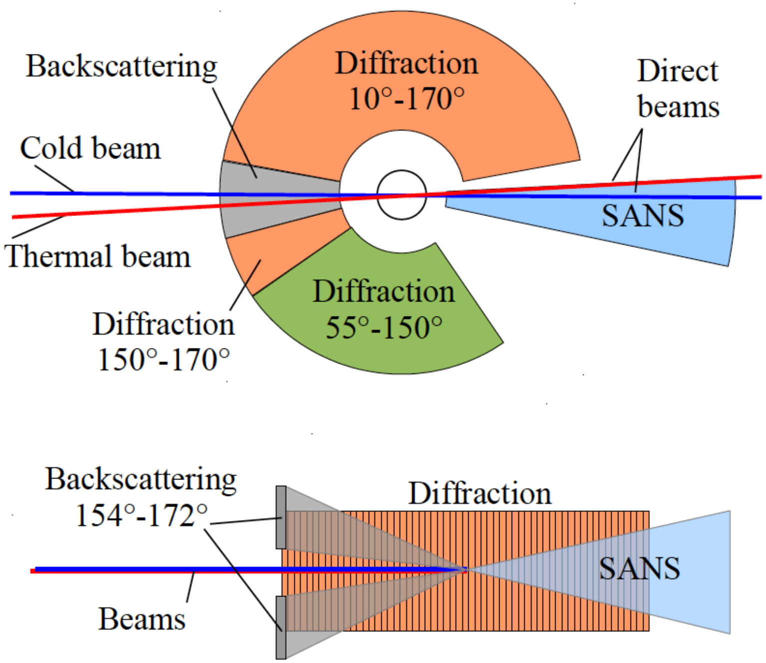


Figure 7. Diffraction detector setup view from above (top), and from the side (bottom). The primary diffraction banks are shown in orange and the backscattering detectors placed above and below the incoming beams are drawn in gray. The green diffraction bank indicates area for future upgrade. The nose of the SANS detector is shown in blue.

Beamline overview

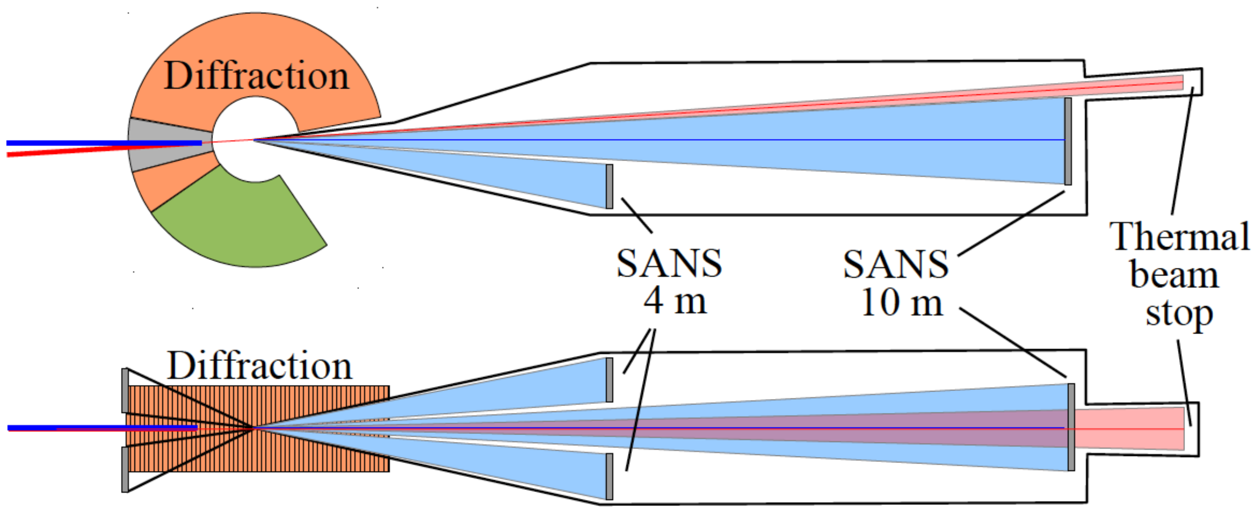


Figure 9. SANS detector setup view from above (top), and from the side (bottom). The thermal beam passes by the SANS detectors which can also be seen in figure 15.

Beam Transport (thermal)

Moderator to sample		167.3 m
Moderator to guide start		2 m
Guide end to sample		1.6 m
Space for resolution chopper centered at 6.5 m from moderator		0.1 m
Moderator height		60 mm
Moderator width		126 mm
Guide height at chopper position		60 mm
Guide width at chopper position		38 mm
Sample height		20 mm
Sample width		5 mm
Horizontal divergence on sample (η_{min})		0.7196°
Vertical divergence on sample (η_{min})		1.0°
Out of line-of-sight		-
m-value for the guide		5
Wavelength band		0.63 Å - 2.37 Å
Upper limit for the guide height before chopper	(inside bunker)	0.1 m
Upper limit for the guide width before chopper		0.1 m
Upper limit for the guide height after chopper	(outside bunker)	0.2 m
Upper limit for the guide width after chopper		0.2 m
High priority area sample height		10 mm
High priority area sample width		3 mm
High priority area horizontal divergence on sample		0.081°
High priority area vertical divergence on sample		0.5°

Table 2. Summary of fixed parameters used in the Guide_bot optimization for the thermal guide.

Beam transport (thermal)

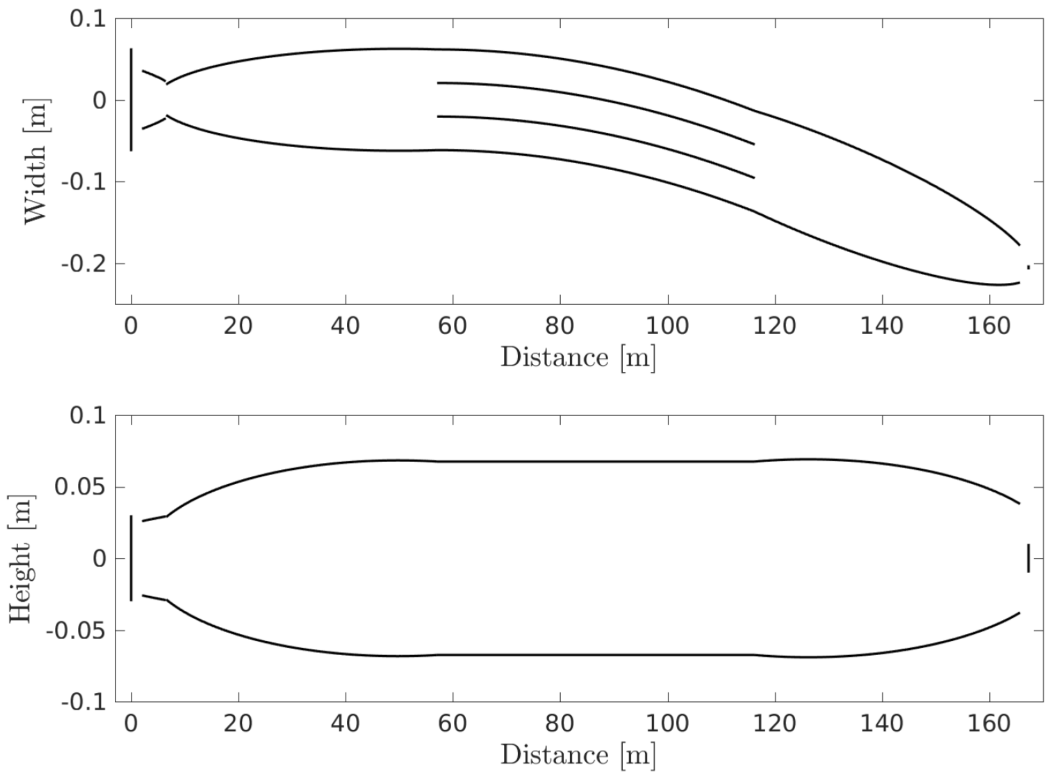


Figure 5. Geometry of the thermal guide. The top view shows a feeder followed by an elliptic defocusing system, a curved guide to escape line of sight and then a elliptic section that will refocus the beam. The bottom panel shows the side view where the beam height is first expanded elliptically, followed by a constant section, and then an elliptical compression section.

Beam transport performance (thermal)

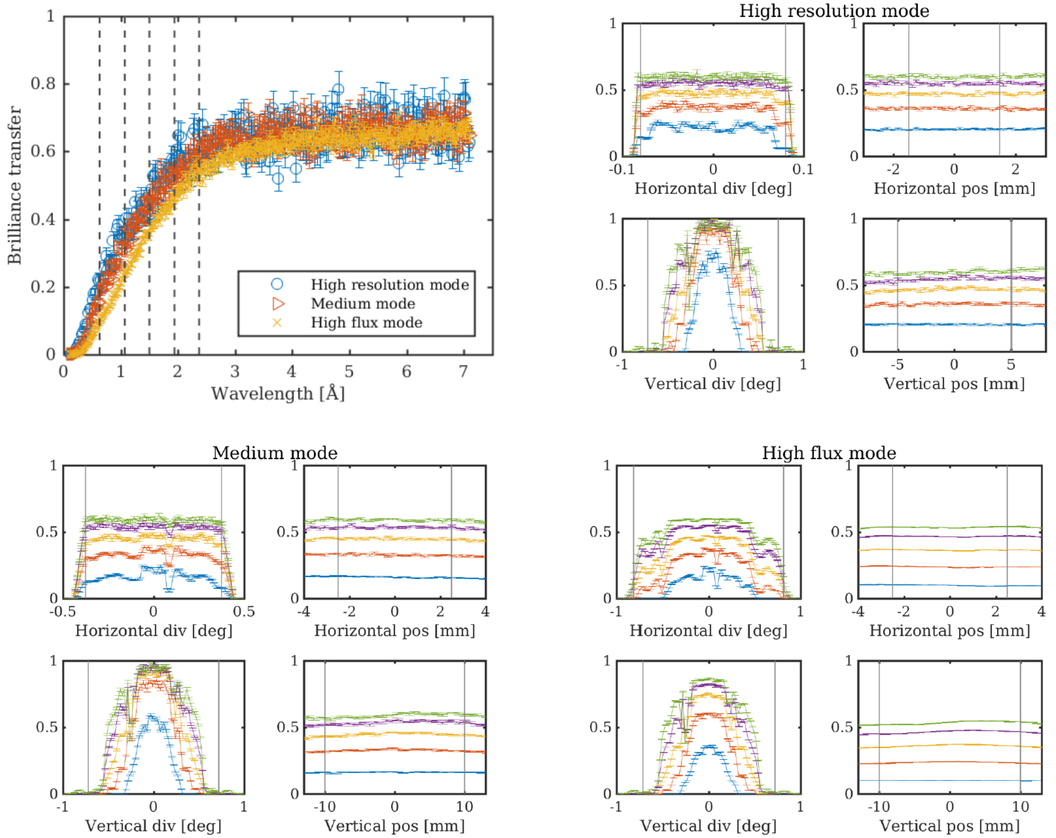


Figure 6. The brilliance transfer as a function of wavelength for the three modes of operation is shown in the top left figure. The three other panels show the divergence and spatial distributions in terms of brilliance transfer for the five wavelength snapshots indicated with dashed lines in the top left figure. The solid gray vertical lines indicate the limits for the brilliance transfer phase space volumes used for each wavelength snapshot. The blue lines correspond to 0.63 Å, the read 1.07 Å, the yellow 1.5 Å, the purple 1.94 Å and the green 2.37 Å.

Diffraction performance (3 modes thermal)

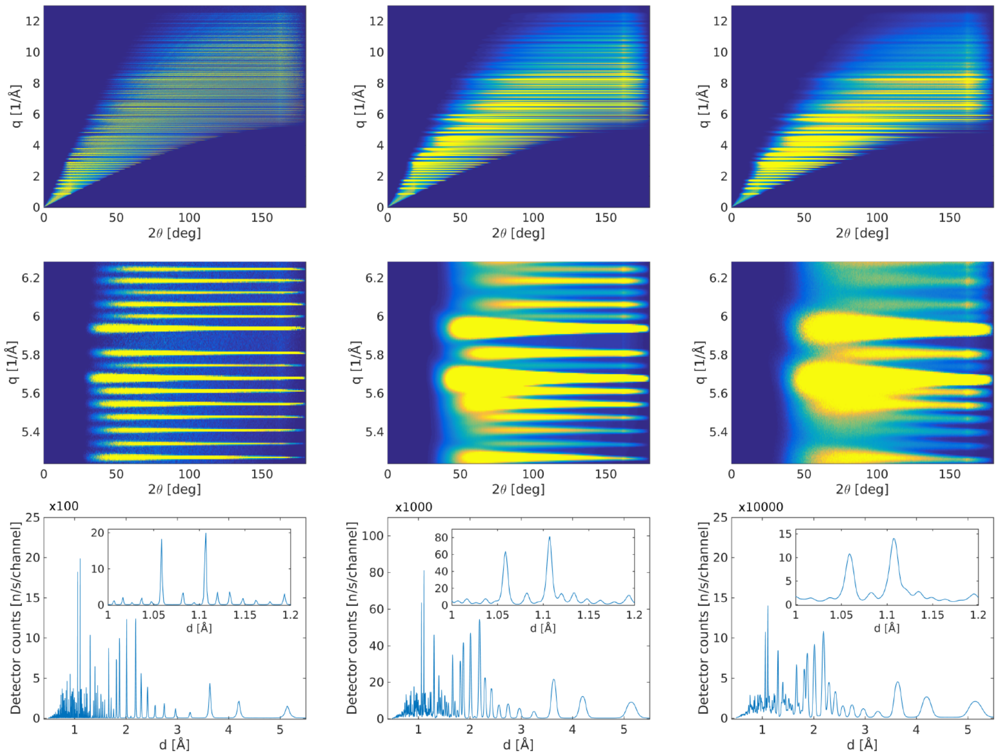


Figure 14. Virtual data from the HEIMDAL TNPD simulation in the three operation modes with a cylindrical $Na_2Al_{12}Ca_3F_{14}$ sample. The simulated detector is run in event mode and neutrons are assigned a q-value calculated from the pixel position on the detector and the time delay from the chopper to the detector. The shape of the Debye-Scherrer cones are taken into account. The three plot on the left are data from the high resolution mode, the center plots are from the medium mode, and on the right are the high flux mode data. The 2D maps at the top are the full data sets and the center plots are a smaller sample of the data. The bottom plots show the data summed from 10° to 180° and converted from q-value to d-spacing. The insert show the same data as displayed in the center panels. The somewhat stronger scattering intensity at 17° and 163° this happens just where the size of the Debye-Scherrer cone matches the detector hight.

PAUL SCHERRER INSTITUT

AARHUS UNIVERSITET

EUROPEAN SPALLATION SOURCE

Beam transport performance (cold)

SANS guide 20 x 20 mm, m=2, radius of curvature 1.2 km (to bring to sample position)

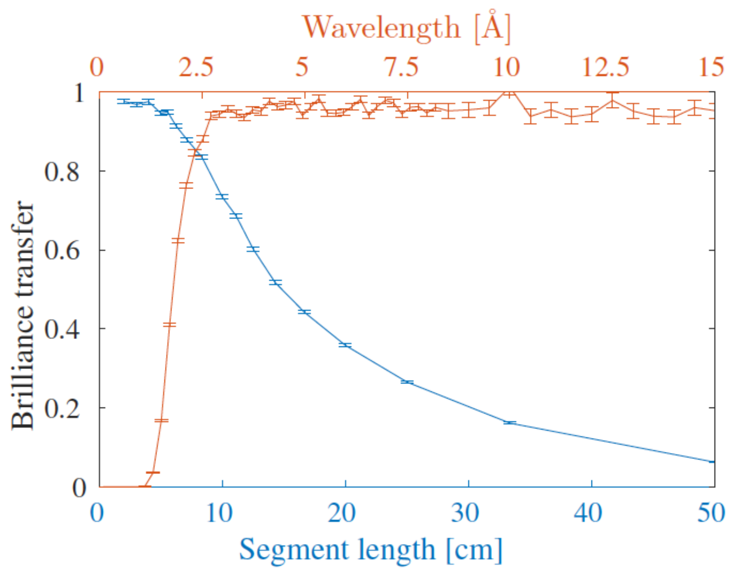
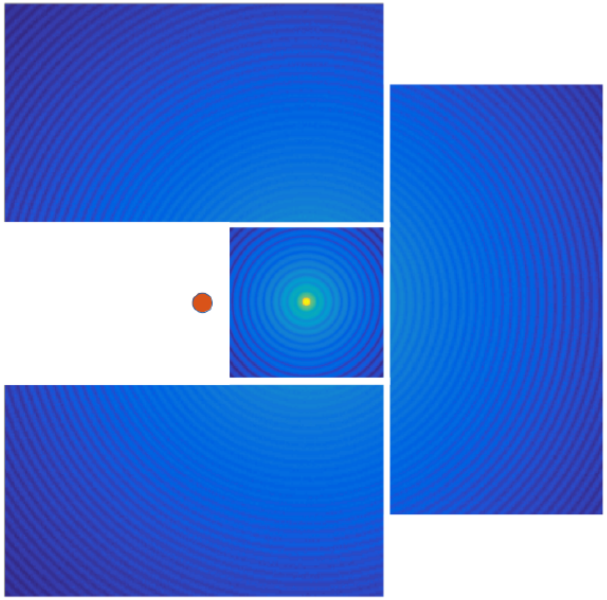


Figure 8. Brilliance transfer through the curved SANS guide as a function of guide segment length (blue) and wavelength (red). When obtaining the wavelength dependence of the brilliance transfer of the guide the segment length was fixed to 4 cm and for the segment length dependence the wavelength was fixed to $\lambda = 4$ Å.

SANS simulation performance (cold)



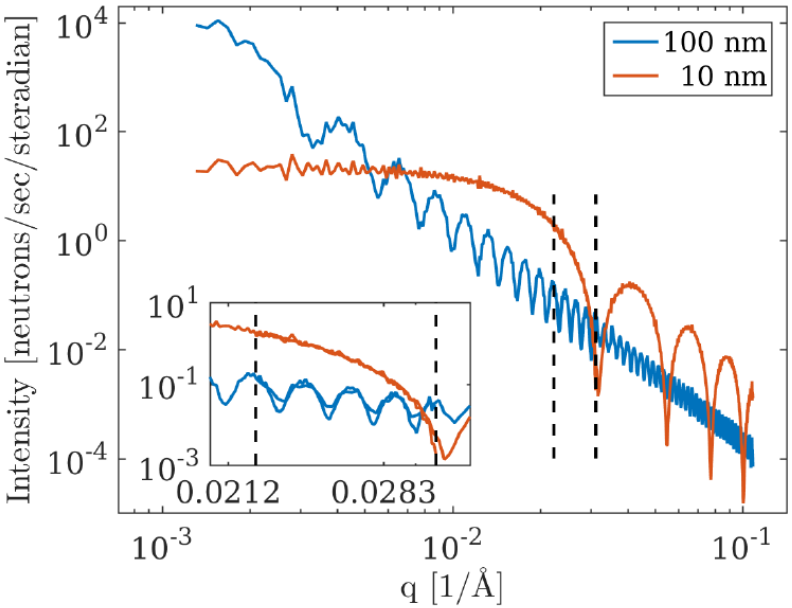


Figure 15. **Left:** The SANS detector coverage in perspective, the quadratic back most detector is 1×1 m^2 and placed 10 m from the sample position, while the rectangular shaped detectors are 1×0.5 m^2 and placed 4 m from the sample. They therefore appear larger in the figure. The red dot indicates the position of the direct thermal beam. The data displayed is a snap shot taken at λ = 10 Åfrom a simulation using a sample of nanoparicles with sizes of 100 nm. **Right:** A radial integration of the simulated data of two particle sizes, 10 nm and 100 nm, at a snap shot with a wavelength of λ = 10 Å. The black dashed lines show where the center detector stops and the outer detector begins. The overlap region displayed in the insert occurs as the distance to the corner of the center detector is further away than the closes point of the side detector.

Beam transport status

- Current proposal based on dual extraction from existing baseline moderator assembly
  - Thermal from bottom 6cm butterfly
  - Cold from top 3cm butterfly
  - Not yet optimised for cost/performance (thermal AND cold)
  - We have resources (KU/DK) to perform work in phase I
- Possible/probable change of moderator baseline in 2016
  - Recent request to look at impact only using top 3cm butterfly
  - Dual guide extraction from the 3cm butterfly requires redesign of whole beam transport system
  - This would be 3rd moderator change requiring partial/complete redesign of the HEIMDAL beam transport!

Need clarity from ESS on moderator geometry

Shielding status

- We need guidance from ESS how to cost or design shielding…why we are here!
  – We have resources from IFE for phase I to do the work
- What level of detail do we need for TG2?
- What impact will ongoing bunker design have on instrument design/layout?
- Will extra beamline components be needed? E.g. a heavy shutter in the bunker wall? Who pays?

Need clarity from ESS on how to approach shielding