NOTES from the flat moderator meeting, 2/10/13

Luca Zanini and Ken Andersen

Participants:
Ken Andersen, Feri Mezei, Phil Bentley, Peter Willendrup, Kim Lefmann, Klaus Lieutenant, Jochen Stahn, Mads Bertelsen, Niko Tsapatsaris, Pascale Deen, Uwe Filges, Werner Schweika, Troels Schönfeldt, Douglas Di Julio, Natasha Cherkashyna, Konstantin Batkov, Alan Takibayev, Luca Zanini, John Haines, Christian Schanzer, Zsolt Ludanyi, Gyorgy Kaszas

Apologies:
Jan Saroun, Markus Strobl, Harald Häse, Andreas Knoepfler, Esben Klinkby

AGENDA

11:00 Ken Andersen: welcome, ESS news, agenda, timescale, plan of action
11:30 Feri Mezei: the pancake moderator idea
12:00 Lunch at Medicon
13:00 Alan Takibayev: Current neutronics work on pancake moderators
13:45 Werner Schweika: the bispectral powder diffractometer guide
14:15 Mads Bertelsen: the guide_bot simulation tool
14:45 Feri Mezei: guide alignment issues
15:30 Ken & Feri: wrap-up and summary of actions from meeting
16:00 end

11:00 Ken Andersen: welcome, ESS news, agenda, timescale, plan of action

Gives news from ESS. There are 3 instruments recommended for construction, which will start in January next year. There was recently a decision to go for light shutters. There will be 16 more proposals for instruments in the next weeks.
Mark Hagen is now head of DMSC (Data Management Software Center) starting 7/10/13. New interim Machine director is Feri Mezei. Acting Head of Target division is Eric Pitcher; John Haines senior Expert in Target.

As you change the moderator height, you change the brightness, for both thermal and cold moderator. We should now look at the reference suite of instruments, as given in the TDR. They are arranged in 4 sectors. In any sector you can look at cold and thermal, or bispectral. The goal is to evaluate the performance of the reference suite with the flat moderators.

There is a table, for each instrument the performance boundary conditions are given: length, maximum size of sample, divergence, wavelength range. Then the preferred height of the moderator, as estimated now. A few contact persons are given for the instruments which are expected to need some effort over the next few months.

The time scale: by mid-January meet again and report the results. By end of April we need to freeze the moderator design, and arrive to a new reference instrument layout.

Suggested format of the results: two types of curves. For each instrument performance of instrument vs moderator height. We should define the figure of merit: fixed sample size, wavelength range and divergence, then we look at the flux with these constraints. We should take into account the uniformity of the divergence. Then we will have a distribution of number of instruments as a function of moderator height.

Questions: How do we handle background in the figure of merit? How about divergence and beam profile uniformity? It's up to each instrument to define an appropriate figure of merit, but it needs to be sufficiently simply that the work can be done within the given time frame.

From the moderator side, there should be a lot of work until January.

11:30 Feri Mezei: the pancake moderator idea

The main milestone for the target was the TDR. That was needed for funding reasons, showing the feasibility of the project. From the schedule, we have more than 1 year for optimization. Optimization means improving cost and/or performance. Neutrons will be produced before end of 2019.
In the TDR the main approach was to use best practice, whenever we could use it. For instance, mercury would not be possible to use, because of licensing issues in Sweden. For the moderator, the TDR choice was a volume moderator, bigger than the box moderator originally proposed for ESS in 2003. A bigger volume of pure para H2 gives a factor of 2 gain in cold flux.
Compared to ILL, we are nearly 100 times higher than the Yellow Book. However, it seems that the ILL cold flux is about two times higher than published in the yellow book, while the ILL thermal flux is overestimated by a factor 2-3.
The beam on the target will be rastered, for the same beam footprint as in the TDR. There are consequences for instruments. At short wavelengths we will see the remnants of the beam movements. At longer wavelengths there will be almost no effect, because of the response time of the moderator system.
In the optimization phase, we optimized the size of the moderator, keeping the shape. After optimization study, we found that the optimum size of the moderator is a large diameter, with a smaller height. SNS had another approach: they defined a series of viewed windows, and found the best moderator sizes. One of the window sizes was 3 X 3 cm2. In this case the optimal size was 3 X 8

cm2. This is in reasonable agreement with our results. The smaller diameters could be due to the smaller footprint at SNS.
We looked at the unperturbed moderator flux, to simplify the problem. This is what is used commonly in reactors. There is a distribution on the moderator surface of brightness, so that it is higher near the target.
We have two moderators in the baseline, to reduce the losses by removing beryllium, otherwise we would use only one moderator. But, if we perturb the small moderator, we remove a small amount of beryllium, so the flux will go down very little. For the perturbed flux, we can get a gain of about 3.5 compared to the baseline, using a 1.4 cm moderator.

In any guide, you have higher probability that neutrons come from the center.

It is essential, for a small moderator, to keep pure para-H2. We need catalyzers for that. The para concentration was measured in J PARC, which was more than 99%. The continuous monitoring of the ratio has not been implemented yet.

Are these results good for anything? The conventional wisdom is that the moderator should be bigger than the guide entrance. The vertical and horizontal beam propagations are more or less independent. The vertical dimension of the guide has approximately no influence on the chopper action.

The origin of the 12X12 surface, was when there were no supermirror guides (reflectometry with direct view of the moderator). The conventional approach for the guide entrance height is a few cm at 2 m from the source.
We have the lucky circumstance that the moderator in one dimension is big. If we looe a bit in one dimension, we do not in two dimensions.

He gives a demonstrative example of 160 m phase space transformer. The transmission of the brightness is more than 90% about 2 Å. At the sample, you have the full brightness up to a few mm sample, then it drops. No surprise.

If you want more divergence, then you have to make the entrance higher than the moderator. The best approximation for good point to point focusing, is to have two elliptical guides. He calculated the transmission at the sample for this type of guide, showing a big gain for the small moderator.

He took into account the gravity effects, comparing ellipse and double ellipse. Gravity has some effects at 6 Å.
There is a hole in the middle in the angular distribution, and we will have to look at the effect of this. This is an issue that we have to look at, when we have large divergence. This could be a problem for some instruments. For diffraction it may not a problem for instance.

The actual maximum brightness is below 1 cm. That may not be optimal for maximizing the flux at the sample.

13:00 Alan Takibayev: Current neutronics work on pancake moderators

Starts with the baseline from Dec. 2011. The dimensions of the moderator are 16 cm diameter, 13 cm high. The unperturbed brightness of the small moderator is 2 times higher than for conventional moderator. However, the gain for the perturbed brightness is higher.
The average mean free path of neutrons entering the moderator is 1.5 cm. This explains why flat moderators work: 1.5 cm is enough to moderate neutrons. This concept of flat moderator will work with other hydrogen materials, including water. The advantage of para H2 is that you extract neutrons from the whole volume, while for other materials you extract from the surface. For deuterium, the MFP is about 6 cm, so this concept will not work.

With two 60 degree openings, the gain is of 3.2. With two openings of 120 degree, the gain is of 2.8. So there is not a big loss in increasing the opening. From this geometry, inserting water extensions, and making a first round optimization, we have a gain of 3.4. For this particular solution, the increase in brightness is not uniform. Between 2 and 3 A, we have an increase of a factor of 5, while for neutrons above 4 A it is 3.5. For thermal neutrons the increase is about 2.

This flat moderator is also better for fast neutron neutron background.

Kim: a lot of instruments are interested in the region between 5 and 20 meV. We should consider using that as an integration region for optimizing the moderator performance.

For moderator heights significantly above 1.5 cm, the penalty when increasing the openings in the reflector become significant. One promising solution is to have one 1.5 cm moderator with two 120 degree openings and another, taller moderator with smaller openings. That would allow instruments in some sectors to choose the best moderator.

It is still possible to increase performance by going to thicknesses lower than 1.5 cm.

One important conclusion: there is no need to have more than 1 flat moderator. The second one can be bigger than the flat one.

It is very important to keep the purity of the para-H2. It seems that it is not a big issue at J PARC, but we are not sure at ESS.

We have to redo the calculations with the rastered beam profile. For this, accelerator can provide either a random phase (so that effects are averaged over time), or always the same phase.

DISCUSSION

From the McStas side, what is the situation?
For fast work, we need correction factors with respect to the baseline. Just the curve of the ratio to the baseline, for different moderator thicknesses.

Still a considerable amount of engineering work to do: it is not yet clear that the increased power density (despite the reduced total power) for a flat moderator is possible to cool. Also not yet clear that the hydrogen flow is OK is a flat moderator. Help from Juelich in making these calculations.

13:45 Werner Schweika: the bispectral powder diffractometer guide

There are at present no data from Berlin on the bispectral extraction.
With the small moderator, we don't want the needle eye vertically; one must bring the ellipse closer to the moderator. We can use the Selene concept.
He looked into gravity effects. There is a gain at 4.6 A, a penalty at 8.4 A.

It appears, in agreement with the findings of Jochen Stahn and Feri Mezei, that the double ellipse system provides good focusing (without catastrophic gravity aberrations) provided the wavelength-length product of the instrument is below about 500 Å.m.

Next thing to look at will be coma aberration.

Which other possibilities do we have to change the moderator with better performance?

Q. Can guides go closer than 2 meters? A. We have to be sure how long the guide lasts. Vertically one does not shadow the neighbors. Werner would like to go to study the possibility of starting at 1 meter. The minimum distance is a social rule that one has to agree with the neighbors. How close can we come to the moderator? Current state-of-the art is about 1.5 m.

The main limiting factor in guide degradation near the moderators is temperature, not radiation damage.

What is the acceptable temperature of the guide? A. 200 C is already critical. For supermirror is 150 C. The helium will be moving around the monolith, so temperature will be kept low. The advice from the SwissNeutronics and Mirrotron representatives is to stay below 100 C to be on the safe side.

14:15 Mads Bertelsen: the guide_bot simulation tool

He developed a program to speed up the guide simulation task. Motivation: guide simulation and optimization take time. Writing the code for all the ideas to check takes time. Input parameters: sample size, divergence requirement, lambda interval, distance from moderator to the sample, distance from guide to sample. Requirements are moderator size, earlier and later possible guide start, and the source spectrum. Then one specifies the guide system.
Once the guides are selected, there is an optimization process.

He shows various examples.

Different types of instruments, give different brilliant transfers. For the SANS example the optimum moderator size is 3 cm.

Conclusions: there will be not one perfect moderator size for all instruments. The perfect height was not 12 cm. Conventional guides struggle with the flat moderator. He will try with unconventional guide designs.

This tool can be used to simulate all the 22 instruments.

Requests for improvements:
Suggestions to include the intensity profile in the figure of merit.
One could also clarify the intensity outside the region of interest.

Kim: we could organize a workshop to define a common figure of merit for the beam profile. This was discussed several times, Klaus Lieutenant came with different solutions, he will circulate that. Still, Kim suggests to sit together around December.

14:45 Feri Mezei: guide alignment issues

If we do point-to-point focusing, we may need more precise guide alignment than up to now.
Feri shows a graph of flux on 4 mm sample vs alignment precision. Does this scale with divergence? With small guide, it will be less sensitive. Alignment 600 pieces of guide with the precision shown, is not practical. One needs bigger pieces.
Another issues is thermal expansion of the moderator: this needs to stay +- 1

mm, which will give around a 3% change for the focused part. This is some engineering homework that needs to go into the specification.

Guide manufacturers currently guarantee 10^-4 rad alignment precision. The point-to-point focusing guides needed for some instruments using flat moderators need alignment precision twice as low.

What are the requirements for guide alignment inside the monolith? Phil: you cannot maintain the alignment inside the monolith. You prealign the optics offline, with a rig which is a replica of the real stuff, check the alignment. There were a lot of discussions with CF, and they suggest to use clay, which is very stable. In real life applications, clay has weather cycles. We have to assume that the ground will not be static. The area inside and outside the monolith will be piled. The CF guys asked SNS: when they deployed shielding, the ground moved by about 3 mm. Phil likes the idea of J PARC, which should be adapted into the current thinking. This will work with ballistic guides.

In pile parts is a 4 m solid part, prealigned, made for each opening. When it is aligned, this defines the axis of the guide. Eventually the ground outside will move with time. We will need fiducial points to be able to put the guides back

Phil: we are piling along the length of every guide. We have two piles going down, we have a bridge between. The shielding will not seat in the pile.
Feri: In Japan, the pile section did no move, despite the soil moving down by 30 cm.

What is the opinion of guides people?

A. This kind of alignment (factor 2 improvement) is doable in the lab. What can have an effect on the price, is if you have shorter sections, then you need more alignment work, more glass cutting. This should be considered for the cost.

For Selene, there are 4 guide parts of 7 m. The idea was to use this as a rigid unit (support of 7 m); each part can then be aligned independently.

One has to be careful where to put the references for the guide alignment, in case the building moves. There is now a new head of alignment group, he is aware of the issue and will take care of that. He is planning a mesh of reference points, inside and outside the building. Deformation will happen in any case. The best practice is to take the neutron source in the target as point zero.

Szolt Ludanyi: Waviness of floatglass is already around the 10^-4 mark, so better alignment means you cannot use regular float glass. Existing solutions are superpolishing or the Mirrotron sandwich method.

15:30 Ken & Feri: wrap-up and summary of actions from meeting

We have the list of instruments for the reference suite, we want to find the optimum moderator size for each instrument. From Mads, we have a general method, we can use to get the answer in all the cases.
We should add wavelength in the table. Phil and Ken will coordinate to fill the table with names. These people will contact Mads.
They should is put maximum ranges, and representative ranges for beam size, divergence and wavelength.

Need updated versions of the spectra, for different moderator heights as input for these calculations.

Neutronic group keeps optimizing the moderators, considering even crazy ideas, for further gains.

We meet again in January for the results.

Agreed actions from meeting:

Luca: Provide curves of brightness ratio of new moderators to baseline, as a function of wavelength.

Ken & Phil: Coordinate filling out of instrument requirements table (divergence etc for each of the reference suite instruments). Include both maximum and representative numbers.

Contact people for each instrument: define figure of merit (usually flux) for the instrument. Calculate and plot the FoM as a function of moderator height with the guide system optimized independently for each moderator height. Provide data to Ken before next meeting.

Mads: provide support for contact people

Ken: organize next meeting in mid-January.

Klaus Lieutenant: Circulate his findings on choosing a figure of merit for optimizing the guide geometry.