How to write a good proposal for synchrotron radiation time

*Adapted from the Guidelines of the European Synchrotron User Organization working group on proposals (**Federico Boscherini, Julian Stangl, and Martin Feiters**)*

Here we provide some guidance on how to write a proposal for a Synchrotron Radiation (SR) experiment on XMaS which will stand a good chance of being approved. XMaS is funded to provide a service to the scientific community, but beamtime is relatively expensive and in large demand; therefore, the facility's management cannot provide beam time for just any experiment proposed. Instead, there is a review process in place to select those proposed experiments that:

1. take advantage of the instrumental characteristics of the source and/or the beamline,
2. address an interesting and possibly topical scientific issue or material.

The proposal will be rated according to its potential to be ground-breaking both in technique and topic. Thus, it is usually not sufficient for a proposal to be merely scientifically correct for it to be approved: it will have to be evaluated and prioritized in relation to other submitted proposals according to the criteria mentioned above.

To this purpose, proposals for experiments on XMaS are examined by an independent review panel composed of knowledgeable scientists. Members of the review panel are not beamline staff, but the beamline scientists will be asked to give their opinion on the technical feasibility of any proposed experiment. Experiments which are judged technically not feasible are not forwarded for evaluation on scientific merit by the review panel and will be looked at very critically in any case. Thus, it is important that you, as the proposer, seek advice from the beamline scientists on any technical or instrumental aspects of your proposal before submitting it.

As with other SR facilities, the review panel physically meets twice a year for an intensive meeting in which all proposals are comparatively evaluated and prioritized; sometimes, additional advice from referees external to the review panel is obtained. In any case, you should be aware that these meetings are quite intensive; review panel members must make decisions on many proposals in a limited amount of time and will typically not have the time and means to perform in-depth literature searches on every proposal before or during the meeting. Therefore, please put *all necessary references* in the proposal text, including those to your own work.

The use of synchrotron radiation should be considered a necessary tool for the proposed experiment. It may be important to show in the proposal that *relevant in-house characterization methods* have been used to set the background of the SR experiment; for example, for a structural investigation it might be useful to quote or report the results of in-house X-ray diffraction measurements, possibly with a short table or small figure reporting the results. A *clear experimental plan* is indispensable. State the number of samples, their characteristics, the number of measurements planned, and the estimated time required. It is often important to show that the samples exist before a panel considers awarding time. In case the technique proposed for the measurements is not standard on the requested beamline, give all necessary details. If you plan to bring specific additional instrumentation to the beamline, give details, highlighting the extra value you will add to the experiment.

The allocation panel's view of proposals

At first sight it seems rather obvious how to write a good proposal for SR beamtime: explain the scientific case and pop in some practical aspects of the experiment and upload it. However, anyone who downloads the templates to put together a proposal for beamtime at one of the European synchrotron facilities might be a bit surprised, however: there are strict length limits and specific questions, and some of them seem to be asked more than once.

The XMaS template is based on the ESRF template which has (beside the "technical" data such as how many shifts are needed, the energy range, how large are the samples etc.) contains the following sections:

- Proposal Summary
- Aims of the experiments and background (scientific background)
- Experimental Methods (measurement strategy)
- Results Expected
- References

Everything should fit onto two pages anyway, so why is a summary required on a proposal? The expected results should be clear anyhow from such a brief proposal, so why repeat this in a summary? One might think that either this is some deliberate tactic to check whether the user will contradict themselves within the proposal, or that the referees are rather dumb scientists. None of these suspicions is correct, however, and the outline is required for very good reasons. To understand this, one must know how the beam time allocation process works.

So, let's look at it from the "other side": Assume, in a completely made-up example, that we want to find out the distribution of strain and chemical species within InGaAsP nanostructures, which could be used for faster electronic devices. We would like to do so using X-ray diffraction with SR and we want to study a small series of samples to find out under which growth conditions one gets the best results, say a sharp interface which is needed for optimum functionality.

A referee will receive a bunch of proposals and is asked to read them carefully and grade them, several weeks before the proposals are discussed in a review panel consisting of typically 4-10 referees. Each proposal will be assigned to several referees, one or more of which may not be an expert in the particular area of the proposal. Each reviewer will typically have to grade 8-10 proposals. Remember that referees have to plan their reviewing activities in parallel with their other work. We can estimate that before spending 10-20 minutes on our proposal, a reviewer will already have read several others, with a similar number more to go. From this it follows directly, that in order to have a chance to get the referee's attention and convince him/her to give a sufficiently high grade, we need to make our point crystal clear.

Next comes the panel meeting itself where every proposal is discussed amongst the experts, including those who have not necessarily read the proposal. Typically, the 20-30 proposals will be discussed over a couple of hours, so again the review panel can only spend a few minutes on each proposal to determine the final mark and ranking. Now we also must consider another boundary condition that the panel has to consider: XMaS is typically oversubscribed by a factor of between 2 and 3, and the panel has to turn down about half of the proposals. A panel typically consists of several experts with complementary experience, so from the three reviewers grading our proposal there maybe just one expert with more or less the same expertise we have ourselves, one who might have a rather good idea about the field and method and another who will either not know the scientific field or the method in very great detail – they might know the method we propose in general, and what can be

learnt, but not know whether our idea to study InGaAsP material is actually new and exciting, or just an iteration of a standard characterization, which has been done for InAs, GaAs, InP, GaInP, GaAsP, but just not for InGaAsP. It is therefore essentially to clearly spell- out how important and timely the results really are. This will almost certainly be a matter of discussion in the panel, and it is important that the panel members are able to find this information quickly in our proposal, either because we have made this a separate item in the "results expected" section, or because we made a good summary where we explain why our experiment is particularly important and how it is embedded into the wider scientific field. Be aware that (for this hypothetical proposal) the proposal will not only be graded by X-ray diffraction panel members who themselves might be experts/more interested in studies on e.g., lipid-DNA complexes. The proposal will also have to be prioritized relative to other experiments which may be using other techniques, so be sure to provide the panel members speaking for your proposal with well-organized ammunition to give it a high grade during the discussion. If your proposal is not rated sufficiently high, it may end up in a range of grades just around or below the "cut-off", below which proposals will not be allocated beamtime.

The proposal step by step

From the scenario given above, we understand how the outline of the proposal is evolving:

Aims of the experiments and background (scientific background)

We need to explain in a rather compact manner the status of our research proposal, clearly stating what the open questions are, and what is needed to answer the question we are concerned with. It is actually rather difficult to do this in a very compact format of ½ page or so. We have to give an introduction in only few sentences; we have to make the point of what is still problematic, unsolved, unknown; and we need to explain how we are addressing this particular question. It is also important to show that our sample has already been characterized by as many non-SR techniques as possible. We must use literature references, but not too many, because space for them at the end of the proposal is limited, and we also want to refer to our own work on the topic, with or without SR, as well. Since at least a number (if not all) of the panel members are experts of the field and know the literature, they will get an impression from the references whether we know the literature: quoting one or two important references is therefore a good idea, since this indirectly shows our expertise. A figure is often useful to provide context. This is also the section that really needs to address the "why" and "so what" type of question. It is important that you articulate a clear scientific question that is being addressed by the proposal.

Experimental Methods (measurement strategy)

In this section we need to explain to the reviewer how in particular we are going to perform the measurement, what do we need for instrumentation (this can be shifted in part in the next section), and how we are going to analyse the data. It may be useful to add some simulations to highlight how the analysis will proceed and how the information may be extracted from the data set. This section has two purposes: first, beside the referees also the beamline scientist will review our proposal and has to comment whether the proposed experiment is feasible. Second, the referee will be able to judge from this section how experienced we are, how difficult and feasible the experiment is. This does not mean that the experiment should be described as rather easy. If it is particularly challenging and ground-breaking, this can also be very attractive as synchrotron facilities are not the places to do standard characterization but prefer to host the most forefront experiments.

Justification for Using XMaS

Here we must justify why we are asking for beamtime on XMaS, highlighting what aspects of the facility are well aligned to the proposed experiments. We also need to justify (within the wider experimental strategy) how much beamtime is required for our experiment.

Suppose we know already that XMaS is well suited for the experiment we propose – i.e., we can use the proper X-ray energy, the primary beam properties (monochromaticity, brilliance) are all right, the goniometer allows to use the scattering geometry we propose, the detectors available enable collection of the required data in a reasonable time frame. The amount of beamtime is another question: on the one hand, while we want as much as possible, asking for unrealistically many "shifts" (typically 8 hours, so one day are three shifts) will rather be seen as a negative aspect of the proposal: reviewers will assume we know how synchrotrons operate and how beamtime is allocated, and boldly asking too much might appear as an offence. Asking for one shift extra for setup of the beamline is usually o.k. It is a good idea to detail succinctly how one comes to the requested number of shifts, especially for those experiments which can take some time. In the case that our proposal is close to the cut-off, the referees might suggest beamtime be granted but with somewhat less shifts than requested. Such a move is easier if the referees can make a useful suggestion like: they asked for 15 shifts for 5 samples, if they can measure 3 samples in 9 shifts, they can show that the method works and request beamtime again, with first data and the proof of success already given. If it is unclear whether shortening is possible or not (there are experiments that cannot be shortened in a meaningful way), this option is already ruled out. The amount of beamtime allocated to a proposal can even be cut down despite it being above the cut-off, if the panel agrees that the requested amount is excessive, or the experimental plan is not clearly justified.

Results Expected

This section is one of the sections that at first sight seems superfluous for such a short proposal. It is not. We need to give a very compact view of what we hope to learn from the proposed experiment. So do not put general phrases here that sound like "don't worry, we will learn something anyhow" or "we will for sure clarify every possible detail of the material system under investigation". Of course, you would never do that on purpose. But read your phrases again: could the impression the referee gets go in that direction? It is better to be very clear and put well-defined, attainable results in this section. Making a list is not a bad idea, it makes it easier for the reviewers to orient themselves in the proposal. A particular problem is to find the balance between important enough results and not overdoing it. Remember that the panel, with its diverse background, may need to have the main goals of the proposal explained highlighting that the scientific issue is topical and of a wider interest. "Identifying the growth mechanism of …" might be more attractive than "determining the dependence of layer growth rate on growth temperature and the rate of …", but on the other hand "our results are crucial for solving the world's energy production problems" would be a claim that needs an extremely good proposal to support it. It Is important to make a strong link between the results expected and the wider scientific questions articulated in the introduction.

References

As mentioned above, references do not serve the same purpose in a short proposal than in a publication. Of course, we must refer to the original literature when we make a claim that is not our work and not obvious, but a finding of somebody else. But since we do not have too much space, we can restrict ourselves to a few important papers of the field to show that we know the relevant literature. We must also refer to our own publications on the topic, with or without application of SR,

to show that we are already experienced (to some extent) in the field, have done previous work (including characterization of the material by in-house, non-SR techniques), know the method etc. All this primarily serves the purpose of convincing the referee that we will manage to perform the proposed work. Beside the scientific attractiveness of our work, this is a very important point to make.

Proposal Summary

The summary will usually be the last thing we write, although it will appear at the beginning. Its purpose is the following (in line with what we explained about how the panel works): reviewers that are forced to read many proposals will not memorize all of them very well. We need to give them a very quick way to remember what our main point was and allowing them to "defend" our proposal in the review panel meeting, and grade it appropriately.

Further general recommendations

Following the lines above, several other elements of a proposal become clear:

Figures may be a good means to transmit information in a compact way, and for some reason most people memorize figures better than paragraphs of text. Figures also help to break up the proposal which would otherwise be overly dense. Including a figure, a catchy one, might be a good idea as it increases at the very least the "memorizability" of the proposal. However, it is important to make sure that any figures included should be clear, at sufficient resolution and with font sizes that are readable.

Title: the same is true here. A good title is important. A tip here: even if this is not foreseen in the proposal template, "smuggling" the title onto the first page of text can be a good idea as it helps the referee if they can see the title and link the text part of the proposal to it.

Colour: many proposals are sent out to referees as black-and-white copies. This will certainly change as electronic reviews are becoming more common. It is especially important that any images or figures are designed in such a way that they look attractive even in black-and-white printing.

Font sizes and formatting: sometimes you might have the impression that your proposal is already condensed to the maximum and cannot be shortened any further. Since you are too long by only four lines, why not fiddle around with the paper margins or reduce the font size slightly? Do not do it! The proposals are printed with size reduction to reduce the amount of paper in printing, and fonts are already rather small. Consider that reviewers might be senior scientists already wearing glasses, and they hate it if they cannot read the text - and this will impact negatively on your potential grade. Check in particular the labels of figures etc., they frequently are too small.

Weak points of your proposal: if you are aware that your proposal has a weak point, e.g., you do not know enough about a sample, it is not clear the method will really yield the parameters you want, etc., there are always two ways out. One is to try to hide those weaknesses, hoping nobody will notice. This can be dangerous for two reasons: if the reviewers find such an aspect and discuss it, they will likely downgrade the proposal, as – for good reasons – they do not like the attempt at tricking them, or they get the impression that you are not aware of the evident weakness and hence did not consider your experiment well enough. It is usually much better to openly discuss the weaknesses. Admittedly this has the danger that reviewers will conclude that the proposed experiment is not likely to be successful, but the danger that you will be considered not to have thought enough about your proposal, or were trying to mislead the referees, is avoided.

Why XMaS: if you are writing your first proposals, you might probably not have a clear idea how to choose the right beamline, and it is not an easy task. Consider the sample environment you need,

consider the energy range, the brilliance and coherence of the primary beam that match your needs (often one is tempted to go for the highest brilliance and coherence available; sometimes a lower coherence, but larger flux match the experimental needs better), the detectors. What else does your experiment need? Other means of sample characterization in proximity to beamtime or that can be performed simultaneously with the x-ray data? Do you need access to sample preparation facilities? If you are already an expert in the field, you might be reading this only for curiosity, and you for sure know exactly which beamline to use. Think again. Do you know about all the recent developments at many of the European beamlines following on from storage ring upgrades?