New questions and comments from April 23rd 2021

LUXE Conceptual Design Report : Preliminary Comments

Overall: The potential of this experiment to explore the transition into the non-perturbative region and the phenomena expected to occur there seems to be sufficiently exciting that one could question the logic of constraining its timescale by forcing the majority of the installation into an already scheduled 2024 XFEL shutdown and by proposing termination by ~2029 to make way for a new XFEL beamline. Assuming there are indisputable external factors justifying these constraints, it then becomes particularly important to prioritise goals and the apparatus essential to achieving them, most particularly to understand exactly what must be installed in the shutdown and what could be postponed. Priorities may have to be established for both reasons of schedule and possibly spending profile. So, for instance, a concentration on performance for key initial goals might entail ensuring that a 4'th tracker layer is built, but focusing the alignment strategy on survey and track based rather than an additional dedicated optical system. Similarly, the post-beam-dump detectors focusing on BSM searches could be pursued as part of a 2'nd phase, with yet another phase introducing polarization dependent measurements. The full physics programme outlined seems as if it could profitably extend over a 10-year period.

Answer: At present it seems unlikely that there will be another extended shutdown that we could use parasitically before the end of the decade. So, missing the 2024 window for the beam extraction would delay everything by about 5 years. All other installations can be done in shorter shutdowns which occur every year but the beam extraction and transfer needs at least seven weeks (with very skilled personnel). It is true that there is a lot of room for staging/prioritising the various aspects of the experiment. We will need to be flexible and have indeed discussed several options on how to do this. In particular, we can start just with electron-laser collisions and indeed don't need the entire photon detection system on day one. And, the optical alignment system is indeed not the highest priority initially either as you say. We will discuss a few options for staging the installation that would still get us to do physics data taking in 2025.

Detectors: Though relatively small, the experiment proposes to use a substantial number of different detector technologies, most of which, even if established technology, are challenging and some of which are cutting edge. While certainly producing motivational objectives, producing a small detector to high standards of reliability is usually a substantial part of the effort needed to produce a much bigger one, with fewer escape routes from error. The

simulation, analysis and interpretation of results are also, by nature of the main objectives, not straightforward, thus it is reasonable to ask whether the present relatively small group of (90?) authors, though highly skilled, has the availability to execute the construction, operation and analysis. In particular the subprojects of WP4 will most likely each require a small team of experts to deliver and will very likely involve individuals who are single points of failure once the operation phase is established.

Answer: We agree with these concerns. We are actively working on attracting more collaborators for the detector systems. We hope that in particular when it is clear that it will actually happen this will attract further people, in particular as this would make it easier to apply for funding at the national agencies. In general, we are aiming to have at least two institutions working on each detector system to shield us against e.g. funding fluctuations and to help ensure there is enough personnel to commission and operate the detectors. We are in discussion with several other institutions.

Organisation: the text on P105, while in principle covering all the tasks to be done, and consistent with common EU practice, seems to be mixing up the WP (task or task-stream) breakdown and grouping with the organizational structure necessary to execute the design, construction and operation. An organizational chart would be a useful addition. This could also indicate the intended relationship between the project structure and the international LUXE collaboration. Safety should be mentioned explicitly somewhere (with a budget) - possibly WP6 could be: “Technical Coordination and Safety”. The relationship and responsibilities of DESY safety, LUXE safety officer and LUXE laser safety officer will have to be carefully defined. There appears to be some confusion in the text between WP1 and WP7, highlighting the need for an org chart. Technical Coordination is indeed part of Project Management, but the TC is also clearly the lead for the Technical Coordination workstream.

Answer: We apologize, indeed this was not yet so clear and rather confused. We are working on clarifying and documenting this better, also in compliance with the DESY and EU.XFEL legal and safety rules. We will not be able to present this at this review but would be very interested in feedback when we are ready.

It would be good to have a short description of the roles of the TC, Resources Coordinator and each WP leader similar to that given for the Spokesperson.

Answer: We agree. We are working on this but are not yet ready.

The list of capital costs looks reasonable but it is important, given the short timescale to move quickly towards an understanding of personnel and operations costs, at least at the envelope level. The overall contributions expected from the participating institutes and well as DESY as host lab would be good to clarify early, so that no gasp appear later due to unvoiced expectations or assumptions.

Answer: We are working on estimates of the FTEs needed as well, separated into technical manpower and postdocs and students. We will present preliminary information on this.

Interface with accelerator and technical groups:
i) It isn't entirely clear how the interface with XFEL and DESY support groups is organized, presumably a single point contact through technical coordination?
Answer: At the moment the interface is made through technical coordination indeed. However since the project is not yet approved, only point-to-point contact with key representatives of the supporting group is currently authorized.

ii) Dipole: The construction, mapping, installation, survey and operation of the dipoles appears to be 100% in the hands of the DESY MEA group and there is little description of these rather critical elements other than the fact that they will be custom-built based on a DORIS magnet design which is too power hungry. It would be advisable to define the specifications and foresee a liaison structure to make sure the magnet project is fully integrated from design through deployment and that the factors affecting the energy scale are all under control. Does this task fall under WP2 or WP6..again an organisation chart which showed the communication interfaces would be valuable.
Answer: We have indeed been working on the specifications after it became clear we cannot use the old DORIS magnets. We will show it in the talks. We still hope that we might get them in-kind if an adequate magnet can be found at another HEP lab. But at present we have costed them at 200-250K per magnet + about 200K for power supplies and cooling.

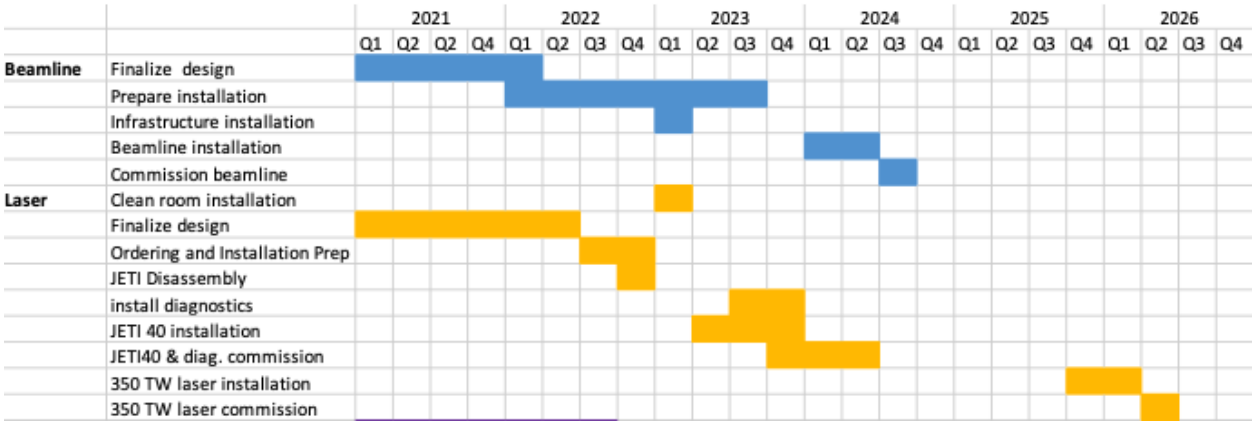
iii) How does the LUXE control system and control room interface with the XFEL control system and control room. eg who authorizes and executes control of beam-related elements like the bremms target?
Answer: Beam operation in all XFEL beamlines is governed by the machine protection system and the timing system. The MPS ensures beam readiness of hardware through a defined interface and dedicated communication network. LUXE is responsible to provide a 'ready for beam' signal to the XFEL MPS system to allow beam is send towards LUXE. In addition the timing system is flexibel in such a way that LUXE can freely trigger bunches to be send into the LUXE beamline when allowed. Bunches that are not needed for LUXE will be dumped prior to the LUXE extraction.
The accelerator operates with the DOOCS control system and muTCA for the front-end electronics. LUXE has to interface with the DOOCS control system to obtain beam information and evoke action commands, or even better use DOOCS as a control system.

iv) What coordination structures are envisaged for managing the XFEL interface?
Answer: The coordination structure has still to be agreed with the European XFEL GmbH. At present, for the shutdown planning the technical coordinator and the acting Spokesperson attend the relevant meetings. And, Winni Decking, the head of the European XFEL Accelerator and Development, is part of LUXE and acts as liaison.

Laser Many laser stability parameters affect the quality of the physics output…the monitoring plan already looks very comprehensive but it is not entirely clear how all this information is used either in a reactive control system or a part of the data-stream to ensure that the characteristics of each pulse used in data-taking are well understood. Although 350TW pulsed lasers are already not exceptional, the stability requirements of LUXE are very stringent and it would be good to seek experience of other groups who have operated similar lasers before freezing the design of the optical pathways and components. In general, given the short timescale, it would be good that the master schedule reflected more completely the laser development work that has to go on at Jena, as well as the transfer and recommissioning at DESY. (presently Q3 22 through Q1 23 show no work on the laser project!) Are the skilled staff available in both locations to execute the plan? It would be interesting to understand the operational consequences of the upgrade from 40 to 350TW. Is it still possible to deliver "pilot pulses" at the lower power? Does the dynamic range of the monitoring systems cover this power increase or do sensors need to be changed?

Answer: Right, these are good questions.

- HI Jena currently operates a laser (JETI200) with peak paramters of 6.8J on target in 17fs successfully (400TW) with routine operation at 300TW (6J, 20fs). We have a data logging system active on JETI 200 and there is a data logging system on many other lasers (Gemini etc) that connects shot number to acquired beam parameters. Our DAQ system will operate a tagging system that allows data to be uniquely connected to each BX event. We are in constant exchange with our colleagues on many topics and will cross-check for best implementation practice before freezing design - as we have done in the past also.
- We have a more detailed list of milestones that is just not part of the CDR. Here is a screen shot. We will present this in the review



- Several studies are already now ongoing in Jena that related to the precision laser diagnostics of LUXE and the to Inverse Compton Scattering option.
- For the staff, this is strongly related to the funding model and this still needs to be worked out. At present two people (1PD and 1 PhD student) are funded and work on the

Jena lasers already. An experienced staff from Jena will also come to Hamburg to get the laser running reliably. For the longer term it is not yet clear as it depends on the funding.

- The Upgrade from 40TW to 350 TW will not effect our ability to operate at any power level below 350TW (including also at 40TW. It will therefore be possible to cross check 40TW data with the upgraded laser.
- The dynamic range of the monitoring systems is routinely adapted even for a 40TW system as alignment work is undertaken at lowest power possible. We note that adapting from 40TW to 350TW involves a single additional reflection from an uncoated glass surface for essentially achromatic, dispersion free attenuation.

Miscellaneous:

i) **drawings**: the generation of CAD drawings from GEANT simulation volumes (and more particularly vice-versa) is a useful technique, even at the level of conceptual design it would be useful to the project as well as to reviewers to have preliminary CAD technical drawings that are larger, are labeled and show substantially more practical detail, especially ancillary services that interconnect volumes. eg Fig 6.16, Figs 8.4, 8.5. Especially in view of the tight schedule, there is a risk of underestimating the amount of work needed to get from the present point to a practicable design approvable for construction whose necessary details (supports, services etc) may well have to be fed back into the simulations to get a true performance picture, understand backgrounds, shielding etc.

Answer: All the detectors have been, are being, or will be designed properly from CAD drawings by engineers. The Geant4 implementation of the different elements used in the experiment was done manually to avoid any performance issues related to the tessellation of the models that can significantly impact the transport of particles in the simulation. The automatic translation from Geant4 to CAD allowed us to check within the CAD model of the building whether each element would fit properly. For this reason the CAD model of the experiment is relatively well synchronised with the simulation, which allows iteratively to correct any inconsistencies that can arise during this conceptual phase.

The CAD models of the different elements are kept in a single repository:
https://syncandshare.desy.de/index.php/s/cfw6pLebTKCSYaY

For instance the calorimeter, tracker, IPBox, etc can be found there. This is particularly useful to keep them synchronised with the simulation. We have already done once the exercise to produce a map with some detailed measurement of the experiment in:
https://syncandshare.desy.de/index.php/s/7SMXkSpcByr2cCf

Of course once a project engineer will be accessible for the project we intend to make sure that all the level of details will be accessible for the construction and fed back in the simulation to avoid underestimating anything.

ii) **electrical system:** the text (P104) reads as if there are several separate UPS units for each piece of sensitive equipment. For safety reasons and to allow the UPS to also act as a power spike filter, it might be worth considering consolidating into a single unit.

Answer: Sorry if the text is not clear, we indeed intended to feed all the equipment that need to be on UPS using a single UPS unit. This being said, we will have two different units for the laser and the detectors since they are physically not located at the same position.