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| **Project Number (assigned by DPO)** | T0153 | |
| **Project Name** | to design A rotatable slits for Diamond-ii front end | |
| **Project Board** | **Title** | **Signature** |
| Project Sponsor - authorises and champions the project | Technical Director - Richard Walker |  |
| Senior Supplier –  – senior resource provider(s) | Head of Engineering Group – Stewart Scott |  |
| Senior User –  Stakeholder(s) most likely to benefit | Any Beamline requiring small aperture slits |  |
| Project Manager | Senior Mechanical Project Engineer - Xia Liu |  |
| Project Planner or DPO | Claire Gibbison |  |

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| **Project Planning Standards** | **Signature** |
| Resource Engagement Requests Approved |  |
| Baseline 0 & 10 set in Project Professional |  |

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| **Governance assigned by DPO** | |
| Complexity rating | Medium |
| Following EDP | No |
| Funding Stream | CapOps |
| IT/Software Projects | N/A |
| Project Highlight Report Required | No |
| Other special requirements | None |

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| **Stakeholders to be considered** | |  |
| Construction work packages | **N** | **If yes see Building Projects Manager and Head of Commercial Management.**  BPM & HCM to sign off |
| Changes to labs/offices or hall floor | **N** | **If yes see Head of Science Infrastructure Group OR Synchrotron Facilities Coordinator (for offices and hall floor)** |
| Space allocation requirements (including during construction) | **N** | **If yes see Synchrotron Facilities Coordinator or Head of Science Infrastructure Group.** Consider any requirements for space for assembly, storage or staff during the project. Requestor should **confirm availability with the Synchrotron Facilities Coordinator in advance of the PRP being submitted**. Location drawings/details to be attached to confirm. |
| Shutdown key resource usage | **Y** | *Please state if effort from any of the following Technical Division teams will required during one or more shutdowns and please specify the shutdown(s)* **Technical Division Project Planner to be consulted.**  *Lifting Team*  *Survey & Alignment Team*  *Vacuum Group*  *IFM* |
| Commissioning Time | **Y** | *Consider any beam commissioning time required for operations/upgrades projects and impact on the User schedule.* **PBS should inform Science Directors in advance of the PRP meetings of specific requirements.** |
| Other special requirements | |  |

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| Business Case  *The level of detail provided should be appropriate for the size and risk of the project and will be determined by the Project Sponsor and DPO.* |
| **Project definition**   1. **The needs of the technology**   It is becoming clearer that there is an increasing demand for having more compact and vibrationally stable slits in Diamond Front End. A new design utilising rotatable absorbing blocks is proposed and requires prototyping and testing.  One of the applications is at Front End I13. I13 beamline will have a CPMU upgrade. It is envisaged that the front end slits will be replaced with an upgraded version capable of handling more beam power. The proposed design concept could be considered for the reasons described below.  As an example of a beamline that could benefit from this style of slit, I13 beam line has two canted in-vacuum undulators for the imaging and coherence branches. In the long straight of I13, the slits function as virtual focus points. This function requires the opposite beam defining blades facing each other directly at the same location. A typical white beam slits assembly was not be suitable for this function because the opposite slit blades face indirectly to each other, with one blade being placed at an upstream position and another blade being placed at a downstream position.  Another application that could benefit from this new concept of slit design in the front end is K07. In recent proposals for Diamond-II, it has been proposed to run two branches of light in the beamline, having variable apertures for each branch of the light and keeping first mirror of the beamline in the front end. The front end will be crowded with equipment. While the traditional slits design would require a large amount of space, a rotatable slits design will suit the space constraint easily because of its compact geometry.   1. **The rotatable slits design**   A rotatable slit design was publish on MEDSI 2014 by Oliver Schmidt from APS. The slits use a single assembly defines all four edges of x-ray beam. The slits work by pivoting on an axis centred between internal opposing edges in both the horizontal and vertical planes. Because the pivot point is centred, the slits open and close symmetrically about the x-ray beam. These specialized slits can be designed to vary the size of one x-ray beam while allowing the second beam to pass through unaffected. Schmidt described in the MEDSI paper how to allow the second beam to pass through unaffected. The second aperture is tapered in such a way that as the body is rotated about the pivot point, the overall size of this aperture is virtually unchanged as shown in the previous figure. Figure 1 shows the slits at their maximum rotation limits from fully open to fully closed. Please note that the size of the second aperture remains unchanged while the slits is rotating.  Figure 1- Slits apertures at open and closed positions  Linear actuators acting on lever arms at a fixed distance from the centre of rotation provide precise control of the aperture. A single slits body and actuator assembly, as shown in figure 2, can thereby define all four edges of the x-ray beam, taking up half the space of conventional slits and in turn provide a significant cost savings.  Figure 2 The rotatable slits assembly by APS   1. **Diamond rotatable slits prototype**   It is beneficial to develop a Diamond prototype of rotatable slits using the concept described above. This would allow the technology ready for I13 CPMU ID upgrade and Diamond-II new front end projects.   * 1. **Scope of design**   Although a double slit unit will be required by the beamline that has two branches of photon light, a single unit will be manufactured and tested for performance. The slits should meet the following design requirements:   * The internal geometry of the slits block should suit the typical beam geometry and the requirements of I13 would be a good target specification. The two units of rotatable slits should work with other existing components at the front end. Support structures are required to install the slits units onto existing granite base that supports the current I13 front end slits. * It is envisaged that the motions should include horizontal & vertical translations and pitch & yaw rotations. * A principal requirement of the slit motion mechanism and its support structure must be to maximise its stiffness to resist vibration generated by the cooling water. Also when the slits are under vacuum, parasitic motion of the slits motion and support mechanism is not allowed. * The slits block target power handling can be the typical existing undulator output at 3 GeV and 330mA on each branch. * For testing, a short vacuum line will need to be constructed to fit the slit in the middle of the line with bellows connection. It is envisaged to reuse existing vacuum vessels found on site for the construction. Supports and structures will be designed to enable the build of the short vacuum line for testing.   1. **Vibration test**   The current front end I13 slits assembly has vibration issues that could not be resolved despite all the efforts over the years. Cooling water at higher flow rate is the main cause of the vibration. The flow rate for the rotatable front end slit will be 2 - 2.5 m/s. Vibration test on the slits will be carried out with the flow rate. The vibration test data will be compared with those of current front end I13 slits.   * 1. **Motion test**   Motion stability is critical for the success operation of the slits. The proposed functional requirements for the slits are shown in Table 1 for the design and test reference. The motion test will be carried out with in-vac setup. Backlash and any parasitic motions should be checked during the test.  Table-1 Specifications of motions for I13 Beamline slits S1m   |  |  |  |  | | --- | --- | --- | --- | | **Name** | **Parameter** | **Horizontal Motions** | **Vertical Motions** | | S1-Im | Range | -5mm to +5mm | -5mm to +5mm | |  | Resolution | <0.5µm | <0.5µm | |  | Repeatability | <1µm | <1µm | |  | Accuracy | <2um | <2um |  * 1. **Parasitic Motion test**   The motion stage stack of some front end slits suffers from parasitic motion. The prototype should be measured and checked for any parasitic motion.  **How is your project aligned to Diamond’s objectives, what is its relevance and potential impact?**   1. Technology readiness for Insertion Device upgrades 2. Technology readiness for Diamond-II front end or beamline application   The average project time for Diamond-II front ends is around five months. This development time has been scheduled with the expectations of using existing front end designs with modest modifications. For the rotatable slits, technology readiness is crucial for keeping the Diamond-II front end development timescale on track.  **Options considered**  1) What is your preferred option?  Rotatable Slits made of OFHC Copper. The brazing process of OFHC copper body to stainless steel water pipes is familiar, which could potentially save development time of the beam absorbing copper body.  2) What alternatives have you considered?  Rotatable slits made of Chromium Zirconium Copper. It is planned to use a low flow rate for cooling. If the OFHC copper body could not pass FEA test, we should consider using CrZrCu for the copper body.  **What are the benefits this project will deliver?**  I13 beamline could have stable front end slits that function as its virtual sources. A stable virtual source would enable better scientific results. The I13 ID upgrade project will be benefit from the redyness of the technology, so as to the Diamond-II front end design for I13 beamline.  For Diamond-II front ends that will require a compact slit design to fit into a small space, it will save the development time and keep project delivery on track. |
| Project Product Description |
| **Key Deliverables**  *What work does you project include?*  *A rotatable slit unit will be built for testing. A short vacuum line will be built for testing the prototype.*  *What is excluded?*  *The resource to build the slit motion and support mechanisms, vacuum commissioning and testing in house.*  *The spare vacuum vessels and vacuum gages, valves and pumps required to construct the short vacuum line.*  **Acceptance Criteria** *(Measurable)*  *How will you know you have achieved your requirements?*   * *FEA of the copper body for power handling* * *Vibration measurement and comparison to the measurements with existing measurements from front end I13 slits* * *Motion test according to ISO standard for positioning accuracy to the specification in Table-1* * *Survey and measurements of the parasitic shifts of the stage structure* * *Beamline scientists test the slits once it is installed* |

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| **Project plan** |
| **Proposed Start date 01/ 02/ 21 Proposed completion date 14/01/22** |
| *Please attach a simple Microsoft Project plan describing project process and timescale including Key milestones.*  **Key Milestones: Mechanical CDR 19 March 2021**  **Mechanical TDR 16 April 2021**  **Electrical and Controls TDR 07 May 2021**  **Start Build 28 September 2021 Finish Build 16 December 2021**  **Start Test 03 January 2021 Finish Test 04 February 2021** |
| **Risk Statement** |
| *Consider risks and inter-dependencies - related projects/ previous investment, long-term implications / liabilities (including key decision points for any future investments).*  It is envisaged to use commercial motion stages for the horizontal and vertical motions. We are aiming for maximise stiffness of the stages to remove parasitic motions. If the specification of commercial stages could not satisfy this request, we have to design the horizontal and vertical motion stage in house. This will delay the project. |

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| **Change Control Tolerances –** *to be completed by Sponsor and DPO* |
| **For Example**  T- T3 if runs into following financial year  C- C3 if exceeds budgeted contingency  Q- Scope/Performance  R- Resource if there is significant change to resource needs or availability or change in personnel – to be implemented when Remus project fully rolled out.  **Example for Ops Projects below** |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | Level | Definition | Stakeholders | Approval | Reporting action | | T3 | Delay to installation or first-user of 1 shutdown.  Equivalent delay to project completion. | Project manager, All Group Leaders involved, and Project Planner, | Project Sponsor Programme Manager and Division Director(s). | TWG,  Project Board,  PRB, | | C3 | Exceeds budgeted contingency.  Requires change >10%  or >£25k to a Project budget.  Requires change across the financial year boundary | Project Manager,  Project Planner | Programme Manager, Project Sponsor  Division Director(s), | Change request referred to Finance Business Partner.  TWG, Project Board  PRB report. | | Q3 | Impact on major Project deliverable | Project Manager,  Project Planner , Group Leaders involved, | Programme Manager, Project Sponsor  Division Director(s), | TWG  Project board  PRB | |

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| **Finance** | | |
| **Costs including VAT -** *estimated costs (e.g. staff, construction design & M&E costs, equipment, consumables, travel, training) including contingency note for UKRI costs do not include VAT!* | | |
| **List Items** | **Budgeted Estimate** | **Or Quote** |
| 1off Copper brazing assembly  1off X-Y motion stage + gear boxes and motors + encoders  1 off linear encoder + 1 off rotary encoder  Rotary bearing +housing structure  2 off Motors + gear boxes  Control system  Electrical system  Mechanical components | £15k  £15k  £5k  £4k  £2k  £5k  £5k  £15k |  |
| **TOTAL** | £66k | |

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| **Spend Profile** - identify each financial year | | | | |
| **F/Yr 2021-2022** | **F/Yr** | **F/Yr** | **F/Yr** | **TOTAL** |
| **£66k** |  |  |  |  |

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| **Identifier Description**  ***(DPO provides)*** |  | **Cost centre** |  |
| **Finance Project**  ***(DPO Provides)*** |  |

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| **Named Authorisers** \*The last two categories are optional. | | | | | |
| **Director >£25k** | **SGL’s £25k-£10k** | **Budget holder £3k-9,999** | | **\*B4/Snr Sci £1k-2,999** | **\*<£1k** |
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| **Operations cost** | | | | | |
| *Consider running costs, staff requirements, maintenance contracts, consumables and utilities (i.e. high electricity demand)* | | | | | |
| Annual cost of operation (£) | | | None | | |
| Lifetime of asset (months) | | |  | | |
| Person responsible for asset | | |  | | |
| Cost centre to take operational cost | | |  | | |

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| **Resource Estimate in Days** *label months with planned dates, change resources as appropriate. Consider availability of staff, infrastructure, equipment.**It is essential that agreement is gained from the relevant resource owners before this form is submitted for approval.* |
| |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Name** *Add or delete roles as required* | **Cost Centre** | **Feb 2021** | **Mar 2021** | **April 2021** | **May 2021** | **Sep 2021** | **Oct 2021** | **Nov 2021** | **Dec 2022** | **Jan 2022** | **Month 7** | **Month 8** | | Project Manager |  |  |  |  |  |  |  |  |  |  |  |  | | Scientists |  |  |  |  |  |  |  |  |  |  |  |  | | Mechanical Technicians |  |  |  |  |  |  |  |  | 15 | 5 |  |  | | Electrical Technicians |  |  |  |  |  |  |  |  | 10 | 3 |  |  | | Optics & Metrology |  |  |  |  |  |  |  |  | 1 | 2 |  |  | | Controls - Systems Engineer |  |  | 5 | 5 | 5 |  |  |  |  |  |  |  | | Controls – Motion |  |  | 5 | 2 | 3 |  |  |  |  |  |  |  | | Controls – PLC |  |  |  |  |  |  |  |  |  |  |  |  | | Controls – Sys Admin |  |  |  |  |  |  |  |  |  |  |  |  | | Data Acquisition |  |  |  |  |  |  |  |  |  |  |  |  | | Scientific Software |  |  |  |  |  |  |  |  |  |  |  |  | | Health Physics |  |  |  |  |  |  |  |  |  |  |  |  | | IFM |  |  |  |  |  |  |  |  |  |  |  |  | | Buildings Project Team |  |  |  |  |  |  |  |  |  |  |  |  | | PSS |  |  |  |  |  |  |  |  |  |  |  |  | | Mechanical Engineers |  | 3 | 5 | 4 | 3 |  |  |  |  |  |  |  | | Electrical Engineers |  |  | 3 | 2 | 2 |  |  |  | 2 |  |  |  | | Electrical Designer |  |  | 10 | 10 | 10 |  |  |  |  |  |  |  | | Mechanical Designer |  | 20 | 23 | 22 | 20 | 5 | 2 | 2 | 2 | 5 |  |  | | Vibration Engineer |  |  | 2 |  |  |  |  |  |  | 3 |  |  | | Survey & Alignment Team |  |  |  |  |  |  |  |  |  | 2 |  |  | | Procurement |  |  |  |  |  |  |  |  |  |  |  |  | | Project Planner |  |  |  |  |  |  |  |  |  |  |  |  | | Vacuum |  |  |  |  | 3 |  |  | 3 | 3 |  |  |  | | Detector Group |  |  |  |  |  |  |  |  |  |  |  |  | | Lifting Team |  |  |  |  |  |  |  |  |  |  |  |  | | Beamtime |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  | |

It is envisaged the Resource Usage Chart from Remus (Generic Resource vs Time) will replace this in time.

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| **Authorisations** | |  |
| **Resource Estimate (staff & space) & Availability Agreed by Resource Manager** | |  |
| **Group** | **Name (signature)** | **Date** |
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| **Proposal reviewed by DPO** | | |
| **Comments** |  |  |
| **Authorised by Director (or delegate)** | | |
| **Comments** |  |  |
| **Authorised by CEO** |  |  |
| **Comments** |  |  |