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| ID: | Title:  **Development of the electronics and its synchronization for Hyper-Kamiokande**  |
| Project Leader | **French Group** | **Japanese Group** |
| Name and email | **Title** | **Lab/Organis.** | **Name and email** | **Title** | **Lab/Organis.** |
| stefano russosrusso@lpnhe.in2p3.fr | Dr. | LPNHE/IN2P3 | Yoshinari Hayato hayato@suketto.icrr.u-tokyo.ac.jp | Dr. | ICRR, The Univ. of Tokyo  |
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| **Spending on French Funds** |
| **Description** | **€/unit** | **Nb of units** | Total (€) | Provided by:1 |
| Contribution to student internship grant  |  |  | 3000 | IN2P3 |
| Contribution to student internship grant |  |  | 1500 | CEA |
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| Total |  |  | 4500 |  |
| **Spending on KEK Fund** |
| **Description** | **k¥/Unit** | **Nb of units** | **Total (k¥)** |  |
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| Total |  |  | 350 |  |
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| **Additional spending on French funds** | **Additional spending on Japan funds** |
| **Provided by:2** | **Type** | **€** | **Provided by:3** | **Type** | **k¥** |
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| Total |  |  | Total |  |  |

1 For example: IN2P3, Irfu;. 2 French Embassy, other CNRS or CEA programs, PICS, European grants… 3 JSPS, RIKEN, Universities,….;

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| **Summary****of****2020 Activities** | The Hyper-Kamiokande detector will be the largest underground water Cherenkov detector ever built with a 68 m diameter and 72 m height cylindrical tank, equipped with up to more than 50,000 photo-sensors. Timing synchronization of each PMT signal is crucial for a precise reconstruction of the particle tracks due to the triggerless nature of the detector. Moreover, the association between the local time base and the Coordinated Universal Time (UTC) is fundamental to synchronize the data acquisition with the beam sent from the J-PARC particles accelerator in Tokai and to correlate the astronomical events with other detectors. IN2P3 and University of Tokyo have established a strong collaboration and are co-responsible for both these tasks. To achieve them, an R&D campaign is started with the goal of building a high-speed serial link with embedded clock based on the Field Programmable Gate Arrays (FPGA) serializer-deserializer. The final architecture foreseen a signal that originates from an atomic clock to guarantee a very stable and precise cadence (in the order of 1 ps) associated to a Global Navigation Satellite System (GNSS) receiver to get an UTC reference. It is then distributed, embedded into a data stream, from a master entity to all the front-end nodes. Each front-end extracts the clock with a deterministic phase shift and a less then 100 ps RMS jitter. The data stream is used to exchange critical slow control information between the front-ends and the data acquisition system. In 2020 the group has focused his attention to check the proposed requirements against the experimental needs. The group worked also on the architecture definition and on a preliminary R&D to evaluate the performances of the selected technologies. An extensive lab test campaign has shown that all of proposed solutions are well inside the requirements and their performances will allow to add a negligible contribution to the final charge and time measure. The total jitter measured on the first tests is as low as 3 ps RMS where the requirement for this parameter is 100 ps RMS. Progresses have been made also on the time base generation and, in particular, the architecture has been established and the components identified. A GNSS with the associated antenna have been purchased and the characterization will start soon. Due to the pandemic situation however, no travel has been allowed so it has been difficult to integrate the time distribution concepts with the existing front-end prototypes. The allocated resources have thus been used to attract students to the project by covering a part of their internship grants and the group hopes to achieve this integration goal in 2021. |
| **Workshop / satellite session at annual workshop** **(if applicable)** | s.russo: oral presentation at the 22nd virtual IEEE Real Time Conference. Title: **Time Synchronization Schemes for the Future Hyper-Kamiokande Experiment** S. Izumiyama et al: oral presentation to 2020 IEEE Nuclear Science Symposium & Medical Image Conference. Title: **A clock synchronization System for Large Volume with Sub-ns Resolution Designed for Hyper-Kamiokande Experiment.**  |
| **Common Articles****(if applicable)** |  |
| **Seconded / Jointly Supervised Students****(if applicable)** |  |