Expression of Interest for participating in the H2020 Innovation Pilot on detector technologies at accelerators

Title: *fast crystal calorimeter for high background environments.*

Participants (max. 6): *list the participating institutes, laboratories and industrial partners*

Name of the legal entity	Type (university, institute, laboratory, company)	Country
Uni-PG / INFN Perugia Institute	University/Institute	Italy
Uni-NA/ INFN Napoli Institute	University/Institute	Italy
BINP	Institute	Russia

Contacts: *One name + e-mail per participant*

Participating institute / company	Main contact person	E-mail
INFN PG	C. Cecchi	claudia.cecchi@pg.infn.it
INFN NA	G. De Nardo	guglielmo.denardo@na.infn.it
BINP	A. Kuzmin	A.S.Kuzmin@inp.nsk.su

Description: *(max. 1 page)*

- *Brief description of the planned activity and the main results*

The use of scintillating crystals characterised by a very fast decay time is of extreme importance in colliders where it is necessary to distinguish inside the electromagnetic calorimeter between signal events and machine background. When increasing the luminosity of the machine a consequent growing of the dependent luminosity background occurs, which results in pile-up events and higher occupancy in the detector. In order to maximise the selection of physics events against background ones a good measurement of the timing in the detector is mandatory. Exploiting a very short decay time of a scintillating crystal can result in a good improvement in rejecting pile-up events and in coping with increased occupancy. Many crystals appear to have a very fast decay time of the scintillation light, some of them can already be grown with dimensions compatible with the construction of a calorimeter for high energy physics experiments (from 2x2 up to 6x6 cm^2 face area and 20-30 cm length) while for others this is not yet possible and more R&D would be necessary. Between the available crystals there are for example LYSO and pure CsI. A corresponding photodetector is necessary to read out the produced scintillating signal, which depends very strongly on the crystal itself. Indeed, some crystals show a good scintillation light yield (LYSO) and, in this case, amplification produced by the photodetector is not an issue, while for some others, which have a very low light yield (pure CsI), the amplification of the signal would be of extreme importance. Between known photodetectors Avalanche Photodiodes and Silicon Photomultipliers can be taken into account. The first has the advantage of being radiation hard but has low gain (increasing in gain is possible in dedicated developments) and highest Quantum Efficiency in the region of of 500-600 nm (not good for example for pure CsI scintillators); the second one has a very high gain, but not radiation hardness. On the other hand, there exist SiPMs which are sensitive to light signal in the near UV region. Another parameter which plays an important role in the choice of the crystal is the radiation hardness. Some measurements are available, but a control of the absorbed dose can be very useful when the background machine is not known with high precision. Radiochromic films can be used to measure the level of the dose absorbed by the detector and by the photosensors allowing the monitoring in time. The studies will result in a classification of scintillating crystals in terms of light yield, radiation hardness, decay time measurements and in the best coupling with photosensor detectors, matching the different characteristics of the proposed scintillators. There is also a possibility of investigating if some new materials can be developed in relatively big dimensions to be used in future calorimeters or other high energy physics applications.

- *Relevance to future accelerator-based HEP project or an upgrade of existing facility*
  This research program can be inserted in a future upgrade of the Belle II detector at SuperKEKB and could be also of interest for other future e+e- colliders (tau-charm factory, BES III upgrade) in which the calorimeter has to be fast and radiation hard.
- *Common interest and added value for the community*
  The study of radiation hardness of photosensors that can be used in high background environment can be of interest not only for electromagnetic calorimeter development, but also for other detectors in the high energy physics application. For example, SiPMs are widely used in astroparticle detectors for space applications.
- *Role of industrial partner(s) (if any)*
- *Innovative aspects: what is new compared to existing R&D programmes and projects, what is the progress beyond work done in AIDA-2020, what is the level of novelty w.r.t. to the State of the Art, is it a new or an improvement of existing technology, etc.*
  The investigation of new materials (LaBr3, CeF3, CeBr3, BaF2) to be used in growing large size very fast scintillating crystals can open a very interesting path for future experiment or upgrades of existing detectors. As of today, LYSO crystals are by far the best performing scintillating crystal with very large light output and very short decay time, but its huge cost prevents its employ in large scale detectors. In this context the possibility of monitoring the absorbed dose with radiochromic films allow also to perform an online measurement and the subsequent evaluation of the light output degradation.

Deliverables (max. 3): list the expected deliverable(s) of the proposed activities

- Deliverable 1:
  Definition of the best performing setup made of scintillating crystal with coupled photosensor in terms of light yield, radiation hardness, time stability.

- Deliverable 2:
  Definition of the radiation dose monitoring program correlated with the foreseen background level.

- Deliverable 3:
  Test beam with the best classified detector prototype

Budget estimate

- *Man-power (total number of person-months which are needed to achieve the objectives)*
  42 PMs, of which 18 from funded Post-Doc and 24 from participants

- *Full cost including personnel and other direct costs (typically 1/3 EC contribution, 2/3 matching resources)*
  126 kEUR from EC contribution: 45 kEUR for 18 PMs Post-Doc and 81 kEUR for consumables,
- 252 kEUR from Matching funds

- *DO NOT include overheads, which will be added to the EC contribution at the proposal preparation phase*

Total number of PMs	EC contribution (in kEUR) (a)	Matching funds (in kEUR) (b)	Full costs (in kEUR) (a) + (b)
42	126	252	378