# Review of the Proposal for "R&D for the ALICE Photon Spectrometer Upgrade (JINR Participation) " Project Extension for 2019–2020

Aim of the project is to upgrade photodetector of the cell and front end card of the electromagnetic calorimeter PHOS of the ALICE detector in a way that allows both to preserve high linearity of the photon energy measurement in the energy range 5 to 200 GeV and to measure time of the particle projection with time resolution better then $\sigma_t$=300 ps while detecting photons with energies above 1 GeV. PHOS main task is to measure standalone photon production cross section. Expected signal is weak (few percent) as compared to background from hadron decays. More then that, neutral hadrons additionally contaminate photon spectrum. It is necessary to be able to reject neutrons, mainly neutrons annihilation, to identify photon clusters. Discrimination relies on topological analysis of the shower and time measurements.

During R&D at CERN using electrons with energies from 1 to 10 GeV in 2016–2018 9 crystal setup (3x3) showed energy resolution of 2%. Large area 10x10 $mm^2$ HAMAMATSU type S8664-1010 Avalanche Photodiode (APD) was selected to be $PbWO_4$ crystal's photodetector. It is proven experimentally that large surface (10x10 $mm^2$) of the APD and new version of the front end card improves energy resolution for PWO crystals at +18" as compared to previous "cold" version of the photodetector and the electronics. In the previous setup PWO crystals and 5x5 $mm^2$ APD S8664-55 photodetectors worked at -25° temperature. At this temperature APD thermal noise is reduced and light yield of the PWO crystals increases by a factor of 3, but even this benefits don't allow to overcome energy resolution of the large area APD. Time resolution for nine crystals when detecting signals with APD (S8664-1010) with surface area (10x10 $mm^2$) was found to be (420÷850 ps.) which depends on APD gain (gain range 50÷200) and on threshold of the amplitude discriminator. Authors of the project choose operational temperature for further studies to be +18° (at this temperature operates CMS electromagnetic calorimeter) and the HAMAMATSU type S8664-1010 silicon photomultiplier with surface area 10x10 $mm^2$ have been chosen to measure shower energy. APD is a linear receiver with a relatively good time resolution of 0.5 ns. suitable for measurements in a large dynamic signal range and the large surface area (1 $cm^2$) allows effectively yield light from PWO crystals. At the same time this photon spectrometer must have high time resolution of ~0.2 ns. at 1 GeV. To provide measurements with high energy and time resolution from every single crystal it was proposed to develop and produce combined photodetector which consists of APD (energy resolution) and SiPM (time resolution). High time resolution for detected electromagnetic showers will allow to suppress physical background and increase standalone photon's detection efficiency. PWO crystals are scintillators with short (~10 ns.) time of light output and by equipping them with SiPM type photodetectors one will be able to achieve high time resolution at this optical detector. To develop such a combined photoreceiver it is necessary to develop compact electronics based at the face of each crystal with surface area of 20x20 $mm^2$. Complexity of such a development arrases from proximity of two photoreceivers (APD and SiPM) with different gain and corresponding preamplifiers. In the later reports it will be useful to provide information on expected radiation background in the area of crystal and photoreceiver installation at electromagnetic calorimeter PHOS as soon as real parameters ( time and energy resolutions) will depend on radiation damage of both crystals and photoreceivers. This development requires financial support, qualified experts and time for research. Necessity of new detecting electronics for PHOS calorimeter development is defined by new version of combined photoreceiver and higher requirements for time resolution due to increase in LHC luminosity. As a result a technical documentation will be written and a FEE prototype will be developed and tested. After testing prototype it will be provided to ALICE collaboration for examination. Development of such electronics is in line with modern tendencies of measurement technics development and will be useful for megaproject NICA development.

For this purpose authors reasonable request finance support of 30K/year US dollars from JINR budget for 2019—2020.

I propose to approve the project and approve requested financial support for two years of 2019—2020.

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October 06, 2018.