Review of the proposal for the project

"R&D for the ALICE Photon Spectrometer Upgrade (JINR Participation) "

The ALICE photon spectrometer PHOS was designed and built as a setup to detect and measure the momentum of the direct/thermal photons from the fireball produced in collisions of ultra-relativistic HI of LHC. It is believed that such photons will carry the signal of the QGP formation in the fireball which is the primary goal of the ALICE project.

Currently, PHOS comprises three 64x56 cells of $PbWO_4$ scintillation crystals modules, - the number to be increased by one during the LHC planned shutdown in 2013-2014. Thus, finally PHOS is to cover the |r(| < 0.13-and 17.8^0 azimuth angle ranges with each scintillating crystal, elementary unit of the calorimeter, having a length of 18 cm providing 20 units of radiation length (X_0=0.89 cm). Crystals squared cross-section of 22*22 mm^2 fits to the Moliere radius of lead tungstate, R_M= 20 mm.

The existing PHOS readout electronics comprises the APD photo detector, charge sensitive preamplifier (CSP), analog shaper with one fast channel to the PHOS trigger and two energy channels with xl and xl6 gain optimized for S/N ratio. The energy channels are digitized in two 10-bit ALTRO ADCs sampled at 10 MHz to obtain a 14-bit dynamic energy range up to 80 GeV. The readout is over a buss connection to the Readout Controller Unit (RCU). Both the ALTRO ASIC and the RCU initially developed for the ALICE Time Projection Chamber (TPC) could not offer optimal solutions for the PHOS requirements but were chosen due to economical reasons.

Since the thermal photon signal in central Pb-Pb collisions at LHC is located in relatively narrow range of 1-10 GeV/c, this makes the experiment sophisticated since the background of secondary particles, both charged and neutral, is heavy in this part of momentum spectrum with the expected photon signal to be only a few percent of the background.

Discrimination of the photon signal from the background is based on: a) charged particle identification using the ALICE tracking system; b) topological analysis of the shower development in the PHOS spectrometer; and c) time of flight (TOF) measurement. While charged particle discrimination exploits all these methods, discrimination of photons from signals from neutrons and anti-neutrons solely based on b) and c) methods. Using the topological analysis one can reduce the neutral hadron contamination at low pT down to 5% , which is still comparable with the direct photon signal.

Further improvement of the discrimination power is possible to reach by the measurement of time of flight, which, in particular, is important for discrimination against anti-neutrons.

The PWO crystals produce fast light output signals and the current time resolution of PHOS of~ 2.5 ns at 1.5 GeV is possible to improve by the value of 0.5 ns after implementation of the new relatively inexpensive readout scheme. If achieved, this will reduce the contamination of the experimental data with the background from the neutrons and antineutrons to ~1% with resulting ratio of the direct photon signal to the background value close to 1/3.

In more details, the PHOS electronics upgrade program from the JINR team proposal is as follows:

To develop and manufacture new high-speed electronic electronics based on the use of HAMAMATSU S8664-1010 avalanche photodetectors (APD) with a sensitive area of 100 mm^2:

- to increase the upper energy threshold of the registered photons from 100 to 200 GeV;
- to maintain the interaction speed up to 50 kHz in Pb-Pb and 2 MHz in p-p collisions;
- to increase the working temperature of the calorimeter to 18.5 degrees;
- to increase the time resolution is better than 500ps.

The proposed PHOS upgrade project is a part of the overall upgrade strategy for the calorimeters in the ALICE central barrel. However, since the technical solutions put forward by the JINR team are quite novel, the announced goals call for the R&D effort to be undertaken in 2019-2020 with the moderate level of financing of 30KUSD/year from the budget of JINR which is applied for.

The work plan for this R&D project with timelines and milestones is clearly indicated by the applicants:

To develop and manufacture a new pre-production 32 channel FEC in the PHOS ALICE standard with the following main functions: two channels for processing the amplitude of a signal with different gains with an accuracy of 14 bits; time measurement system based on the use of picosecond TDC; distributed power supply system of individual APD.

Taking into account the importance of the work not only for the upgrade plans of the ALICE Collaboration but to the in-the-house plans for the technical upgrade of the VBLHEP within the NICA mega-Project where the results of the work could be implemented, I hereby strongly support the reviewed project with allocation of required financing in 2019-2020.

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