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## Study of cryogenic photomultiplier tubes for the future double-phase cryogenic avalanche detector.

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### Content

We report the results of characterization study of several types of cryogenic photo-multipliers manufactured by Hamamatsu Photonics, namely: compact 2 inch R6041-506MOD tubes, 3 inch R11065-10 and R11065-MOD tubes for operation in liquid Ar and 3 inch R11410-20 tubes for operation in liquid Xe. These types of PMT are proposed for installation into the future double-phase cryogenic avalanche detector that is developed in the Laboratory of Cosmology and Particle Physics of the Novosibirsk State University jointly with the Budker Institute of Nuclear Physics. Compact PMTs are planned to be installed at the side of the cryogenic vessel and they will detect electroluminescence in a high field region above liquid. 3 inch PMTs will be installed at the bottom of the cryogenic vessel in liquid Ar and they will detect primary scintillations from recoil nuclei as well as secondary scintillations. Main task of both PMT systems is to provide fast trigger signal. Therefore the PMTs have to distinguish between single electron and double electron signals to suppress effectively the background. Eight R11065 PMTs and eight R11410-20 tubes were tested and they all demonstrated excellent performance in terms of gain and relative single electron efficiency. All 3 inch PMTs showed maximal gain in liquid Ar above  $5 \times 10^6$  and relative single electron efficiency above 95%. Compact R6041-506MOD tubes have different dynode system and thus their single electron energy resolution and relative efficiency is much worse than that of 3 inch tubes. From 21 two inch PMTs only 12 tubes were selected with acceptable relative single electron efficiency higher than 70% at the maximal gain higher than  $5 \times 10^6$ . However these PMTs are very attractive because these are the only compact type of tubes that can operate in liquid Ar.

### Summary

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