Technical specifications

The purpose of the tender is to purchase modules for the GAmma-ray Detector Around the Secondary Target (GADAST). The GADAST is a compact detection array for measurements of gamma-rays to be located in the focal plane FMF2 in the middle of the Super-FRS. The detector has to be able to distinguish most of the simple gamma-ray cascades originating from de-excitations of light and middle-mass exotic nuclei. It must be flexibly rearrangeable around the secondary target depending on the number of the commissioned modules and peculiarities of the physics case under study. This invitation to tender concerns modules based on CsI(Tl) crystals.

Each **module** consists of a scintillator CsI(Tl) crystal wrapped with a reflector and coupled with a photo-multiplier tube (PMT). Each of the requested modules will be coupled to dedicated electronics. The dedicated electronics is not the subject of the tender. The detectors have to be able to sustain a counting rate up to 30000 s^{-1}.

Dimensions and number of modules

Each crystal is tapered to both front and readout facets and can be described as a union of two asymmetrical truncated pyramids. This invitation to tender concerns purchase of 32 modules. The dimensions and tolerances of the crystals are given in the attached drawing.

Physical Quality of Crystals

The following inclusions are allowed in the scintillator material for the crystals:
Size up to 0.3 mm - not specified
Size 0.3 – 0.7 mm – 6 pcs
Size 0.7 – 0.9 mm – 2 pcs
Size > 0.9 mm – not allowed

All crystals shall be examined for inclusions holding them against a white reflecting surface. A high quality photo of the crystal is to be provided as a proof of the quality of the crystal.

The variation in total light output between any two crystals of the same geometry measured with the same PMT by a crystal manufacturer should not be larger than 25%.

Readout

Optical readout shall be realized with the photomultiplier tubes (PMT) which are optically coupled to crystals by two-component, colorless, transparent, clear optical glue with sufficient elasticity.

Frontal surface of the PMT has to be square in accordance with the shape of the crystal readout facet, sensitive area of PMT have to be of the square shape and larger than 20x20 mm^2. Total length of the PMT without voltage divider (including pins) should not exceed 30 mm.

Nominal quantum efficiency of the photocathode should be higher than 9% at light wavelength

600 nm.

Anode to cathode supply voltage should not exceed 1000 V. The dark current at anode should not exceed 100 nA. Pulse non-linearity should not exceed 3% up to anode current of 300 mA. Rise time and transit time should be lower than 3 and 10 ns respectively. Expected operating temperature for the modules is in range from 290 to 320 K.

The part of the delivery has to be one voltage divider of the type which provides the best linearity of the signal to the delivered PMT. The stated values have to be tested with this divider.

Resolution

The resolution shall be measured by irradiating the full front surface of each module (consisting of CsI(Tl) crystal, its own PMT and reflective wrapping), from the distance of 10 cm in direction normal to the readout facet, using the 662 keV γ-ray from an ordinary ^{137}Cs source. The centroid of the full energy peak shall be noted in the measurement protocol. The resolution, in percent, as given by the ratio of the FWHM of the full absorption peak to the centroid of this peak shall be measured and given in the protocol together with information about the measurement conditions.

Energy resolution of each module has to be less than $\Delta E/E = 10\%$ FWHM at $E_\gamma = 662$ keV (^{137}Cs) if the module is irradiated by gamma-rays as described above.

Crystal Light Output Uniformity

The light output uniformity shall be measured along the crystal length for each module (consisting of CsI(Tl) crystal, its own PMT and reflective wrapping).

The first measurement point should be 10 mm from the output surface with consecutive points following at 20 mm distance, and with the last point no closer than 10 mm from the other end surface of the crystal. The measurement shall be made with the collimated ^{137}Cs source positioned perpendicularly to the main axis of the crystal, above one of the thin long facets and by moving the source at the central line of this facet along the crystal length. The lead collimator should be 40 mm thick with aperture of 6 mm in diameter. The light output is determined by the centroid of the full absorption peak as discussed above.

The light output non-uniformity measured in this manner shall not exceed 5%. The requirement is defined using the light output non-uniformity, ΔLO, as given by

$$\Delta LO = (LO_{max} - LO_{min})/LO_{average} < 5\%,$$

where LO_{max} and LO_{min} are the maximum and minimum values of the light output measured along the crystal. $LO_{average}$ is the average of these two values.

The resolution, in percent, as given by the ratio of the FWHM of the full absorption peak to its centroid shall also be measured at each point along the crystal as described above.

The light output and the resolution measurements shall be recorded in the measurement protocol for each measurement point.

Lapping of the Crystals

Individual lapping shall be applied to one or several facets of the crystals if needed to reach the required light output uniformity. These facets may therefore be polished, matted or treated by combinations of these methods.

Wrapping of the Crystals

To improve light collection uniformity, the scintillation crystals have to be wrapped in the waterproof way and to be protected against atmospheric humidity. Wrapping material should provide mirror reflection with at least 97% ratio and not exceed 100 um thickness.

Drawings

Drawings are provided in attachment in the same email (CsI 60x35x150 v2-1.pdf).