PARIS Detector: A suggestion for the array and detectors geometry

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The PARIS detector being developed is primarily for measuring the energy spectrum of High Energy Gamma ray (HEG) along with the fold of the accompanying Multiplicity Gamma ray (MG). A two shell structure with the inner detector being LaBr3 and the outer one as CsI, or BGO, or BaF_2 is under consideration. The LaBr3 having fast timing and good energy resolution could be bonded to CsI crystal (like Phoswich detector) to be seen by single PMT, this way the size of outer shell will be small. The two configurations for the array which are being discussed are:

1. spherically symmetric where detectors are placed radial
2. cubic tiled to fit around a sphere

The merits of the two configurations are reported (June 10, 2008) with the following observations. The first option is better for angular distributions. The second option is more efficient and offers variable geometry (simpler to change radius). In the referred report the figure shows the size of LaBr3 and CsI crystals as 2" cubic and 2" x 2" x 6" respectively, which are tiled around to have inner radii of 15 cm (~50 detectors) to 25 cm (200 detectors).

For 15 cm radius the tiling should be around a cube of 30 cm (12") sides that means 6 x 36 = 216 detectors unless the detector size is 4" x 4" and not 2" x 2".

It would be nice to know at this juncture that what is the possible size and shape of the LaBr3 and CsI which can be obtained from the manufacturer. What would be the preferred cross-section geometry (square, hexagonal, circular) of the detectors from the manufacturing point of view? Is tapering of front end of the detectors possible?

We would also like to know the feasibility of segregating the energy deposited in the inner and outer crystals using the timing and energy signals from the PMT. This will be crucial in reconstructing the event.

Our suggestions in this regard are:

1. To have radial configuration with tapering of detectors to have the following advantages:
   (a) Tapering of detector will provide close packing and hence efficient reconstruction of HEG. Tapering also helps to have smaller LaBr3 coupled to larger diameter CsI which should be more cost effective.

(b) The taper detector for a compact assembly of given diameter can also be kept at different distances with not so much close configuration, but always better than those without tapering.

(c) The radial detector will have advantage as HEG will effectively confine to fewer detectors and provide:

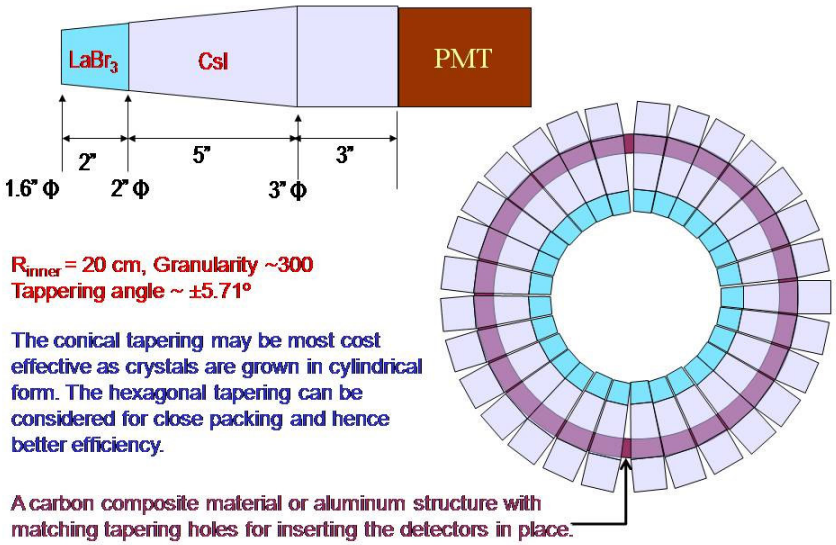
I. less angular uncertainty hence better Doppler correction

II. effectively lesser confusion of HEG and MG mixing, and hence better HEG energy and MG fold construction

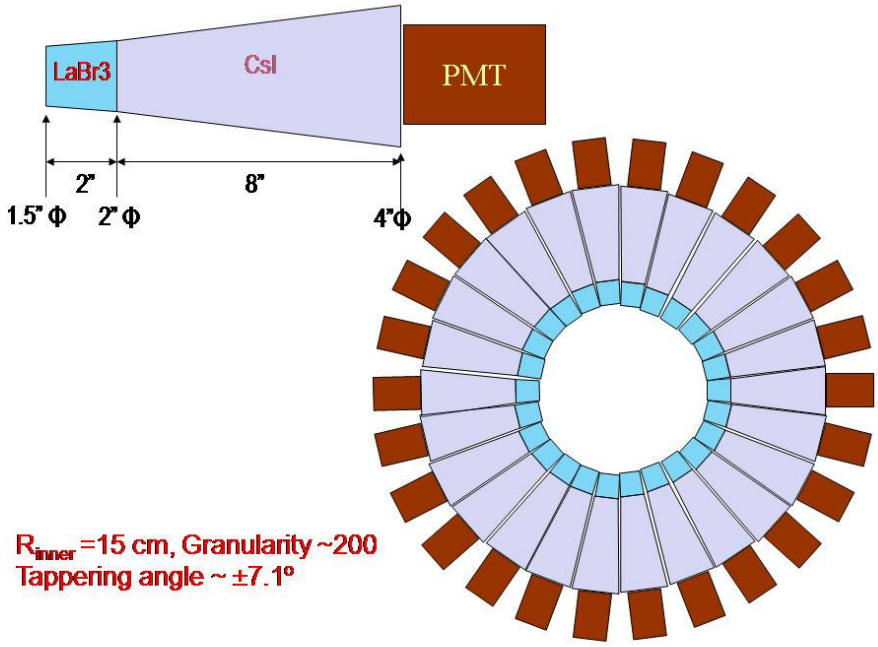
2. An EGS calculation to simulate the event with MG indicates that the 2" thick LaBr3 is not sufficient for it. If possible larger thickness of LaBr3 to have MG confine to inner shell hence minimize its contribution to the HEG shower in outer shell. This will also improve the line shape of MG.
3. An optimum higher granularity (with reasonable size detectors) and hence higher inner radius of PARIS should be preferred for better fold and neutron discrimination

As the crystals are grown in cylindrical form is it economical to opt for hexagonal instead of square? For that matter circular cross-section with tapering, i.e. truncated conical geometry with not so much compact packing can also be considered.

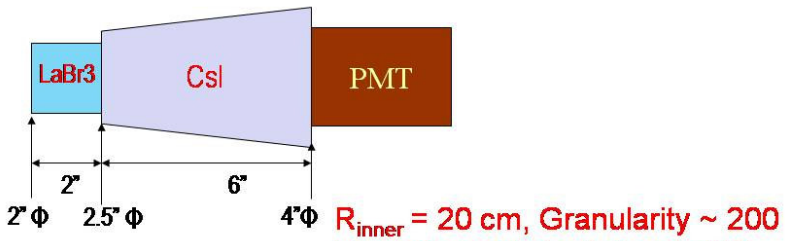
Through the following figures we have tried to illustrate the geometry of detector and array. The detectors' mechanical support can be a carbon composite material or aluminum structure with matching tapering holes for inserting the detectors in place. Against gravity the lower detectors can be held in place with suitable mechanism. The array along with its holding structure can in principal be used for small increase of radial distance at the cost of not so compact geometry. If these suggestions are felt suitable by the community and inputs from detector manufacturer are obtained we can work really on the details of close packed geometry of the array.

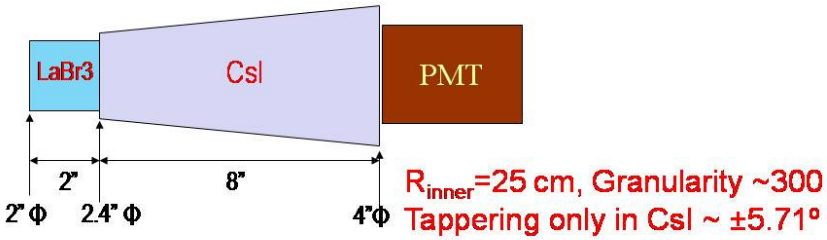


Tapering can be extended to the full length of the detector as shown below. There are various possibilities to choose depending on the availability of detectors and the cost involved. Some of the possible options are mentioned below.

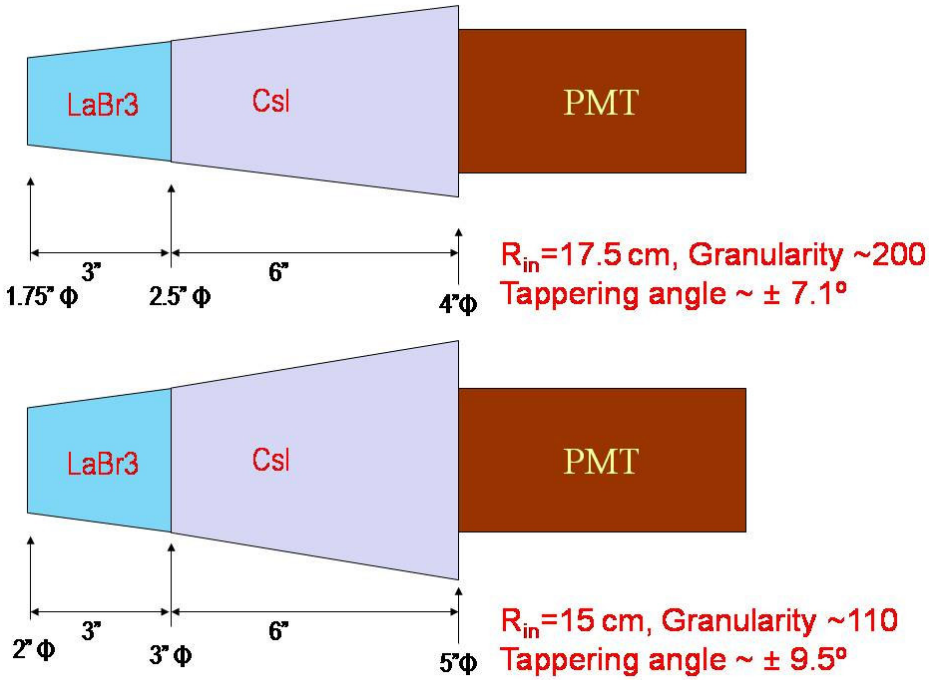


Higher inner radii is preferable and suppose we do not go for larger LaBr3 then one optimum option is the following geometry where 2" diameter LaBr3 is not tapered.





As we suggested higher thickness of inner shell is preferable for confining the MG to inner shell and better line shape. The following possibilities with 3" long BaF2 crystals are possible. In fact in all the illustration we have chosen the dimensions as integeral multiple of inches. The possible real dimensions of crystals will decide the final geometry.



Summary:

Our suggestions are basically to have radial placed tapered detector of hexagonal or circular cross-section to have a high efficiency for PARIS array which will provide better reconstruction of energy and fold of the events. We also feel that if it is not very expensive we should go for higher thickness of LaBr3 crystal for the reason discussed above.