Contribution aux exercices de prospective nationale 2020-2030

*Détecteurs et instrumentation associée*

**Titre de la Contribution – R&D for AGATA**

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1. **1. Informations générales**

**Titre : R&D for AGATA**

**Acronyme :** *(optionnel) AGATA*

**Résumé** *(max. 600 caractères espaces compris)*

The Advanced GAmma Tracking Array (AGATA) collaboration was established to demonstrate the feasibility of gamma-ray tracking and to construct the European 4 tracking spectrometer. Steadily growing over the years, AGATA comprises now 41 operational detectors, corresponding to ~1500 channels of high-resolution & high-throughput electronics [1]. The AGATA collaboration is now preparing the 2nd phase of the project, which consists in the upgrade of the infrastructure, hardware and software required to instrument the 4 array (180 crystals). In parallel, R&D is being pursued to investigate new avenues, most notably in the detector and instrumentation subsystems.

***Préciser le domaine technologique*** *(plusieurs choix possibles)*

* o Détecteurs semi-conducteurs (Si, Ge, HgCdTe, Diamant…)

***Préciser la motivation principale de recherche visée par la contribution :***

* o R&D Détection de gammas
1. **2. Description des objectifs scientifiques et techniques  *(1 page max incl. figures)***

**Detectors:**

The tracking efficiency, the precision of the Doppler correction, as well as the imaging capabilities of AGATA rely on the detector sensitivity in terms of position resolution of the interaction points. The determination of these positions is made possible thanks to the use of highly electrically segmented Germanium detectors (36 segments), combined with a complete digital readout of the signals. The positions and energies of the interaction points are then obtained using a Pulse-Shape Analysis (PSA) algorithm, comparing the measured signals to a simulated database of signals. This allows to reach today an average energy resolution of 0.1%-0.2% and a position resolution of 5 mm (FWHM). Nevertheless, one of the current PSA limitations is intimately linked to the segmentation that is used. The position sensitivity, corresponding to the minimal distance at which different pulse shapes become distinguishable over the noise, peaks at the segment borders and decreases toward the center of the segment. Moreover, the discrepancies between real and simulated electric fields lead to an inhomogeneous position sensitivity. As a result, instead of observing homogeneous hits distributions, patterns and clustering of interaction points are observed. The electrical segmentation of the Boron contact is presently done in 6 slices each sub segmented in 6 sectors (figure 1a).



Figure : Current (a) and envisaged segmentation patterns of an AGATA crystal.

In collaboration with Mirion Technologies, it is proposed to shift the sector segmentation from one slice to the next. Two different segmentation patterns are envisaged (half a segment shift for figure 1b) and one third a segment shift for 1c)) and will be tested by measuring the detector response on a fast scanning table available at IPHC.

**Cryostat embedded electronics:**

The huge advantage of integrating the electronics inside the cryostat is to eliminate the existing preamplifiers cables that transmit the signals to the digitizers. The reduction of the digitizer distance to the preamplifiers will reduce the noise and the high Power dissipation produced by the actual preamplifiers to support a 10 m differential signal transmission. It will also reduce the volume and the weight of such existing cables (1m3 and more than 1900 kg for the full AGATA array). Long term developments, e.g. cold VLSI (Very Large Scale Integration) fast reset preamplifiers with warm digitizers in close proximity. These highly integrated digital preamplifiers necessitate in a first step the development of a test cryostat to test the performance of the new electronics. The cold VLSI CSP (Charge Sensitive Preamplifier) has been developed for different experiments in the past but not with the same requirements as those of AGATA. It will be an exciting challenge to reach the AGATA requirements using cold VLSI high resolution CSPs. The cold VLSI will be placed in the cold part of the cryostat at liquid nitrogen (LN2) temperature just behind the Ge crystal and will replace the first (cold FETs and RC feedback loop) and second (warm) stages of the presently used segment charge preamplifiers. The warm Digitizers will sample the 40 segments signals of the Ge crystal @ 100 MHz. All data will be transferred to highly integrated preprocessing digital electronics to reduce the crystal full data rate from 64 Gbps to < 6Gbps. The readout system will be composed of 4 x 10Gbps optical fibers, using UDP over Ethernet protocol, per crystal. The system designed today for the phase 2 electronics using multiple 10 Gbps optical fibers over UDP ethernet protocol is an excellent universal solution that can be used for the next 15 years in any computer architecture.

1. **3. Livrables associés, calendrier et budget indicatifs (1 page max. incl. figures)**

*Préciser les objectifs décrits (étude conceptuelle, expérience, prototypage, construction…) et leur échéance, en précisant si possible les partenaires envisagés.*

*Evaluer grossièrement l’ordre de grandeur du financement nécessaire (coût complet, en distinguant équipements/consommables et ressources humaines). Préciser s’il existe déjà ou s’il est envisagé d’autres sources de financement.*

**Detectors:**

The development by the Ge manufacturer of each new segmentation scheme and its subsequent scan and validation should last about 15 months.

Estimated costs: 200 k€ + manpower for scanning 12 man.month (mm)

**Cryostat embedded electronics:**

The test cryostat development should last 3 years (manufacturer + IKP Cologne) and the integrated electronics 5 years (CSNSM + Milano). Tests of the whole system will be performed at IPHC.

Estimated costs for front-end electronics development : 150 k€ + 119 mm

Estimated costs for the integration of the new electronics in a largely modified AGATA Triple Cryostat (cryostat bought by IKP Cologne 200 k€): manpower for tests: 68 mm

1. **4. Impact *(1/2 page max.) (optionnel)****.*

**Detectors and cryostat embedded electronics:**

The final product may be further improved by the detector manufacturer for industrialization. Advanced applications of this new technology may be foreseen in compact Compton cameras for nuclear decommissioning and medical applications.

1. **5. Références**

[1] AGATA, A. Akkoyun et al., Nucl. Instr. Meth. A 668 (2012) 26 (DOI [10.1016/j.nima.2011.11.081](https://arxiv.org/ct?url=https%3A%2F%2Fdx.doi.org%2F10.1016%2Fj.nima.2011.11.081&v=51a11a6e))