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Overview

- Design and fabrication of AC-LGAD strip sensors with optimized geometry for timing, i.e. larger gain thanks to deeper p+ implantation;
- Production of large-area pixel AC-LGAD with a geometry compatible with a new version of the EICROC chip, e.g. with 8x32 channels. The process will make use of the optimisation made in FY24;
- QA tests after irradiation with protons and gammas;
- QA stress-tests in different and extreme environmental conditions;
- Assembly and testing of AC-LGAD+EICROC and AC-LGAD+HGCROC modules, using wire-bonding as well as flip-chip technologies. Distribution of thsoe modules to members of the consortium

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AC-LGADs design and fabrication

- Deeper gain layer (done in FY24 but possibly needs another iteration)
- Large area devices compatible with EICROCX
  (8 pixels x32 pixels 500um Pitch)
- Open to collaborators' requests

  - TCAD simulations (with UCSC)
  - Static Testing before distribution (I-V, C-V)
  - TCT, gain test, …

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Assembly, Testing and Characterisation

3.1.4 Assembly and readout characterisation of AC-LGADs with ASICs

In addition, the BNL team will continue to assemble and test modules of EICROC and AC-LGAD, either bump- or wire-bonded, for characterizing the read out functionalities of the assembly of the sensor+ASIC. Several of these assemblies will be distributed to collaborators in the consortium and a sufficient number of them will be kept at BNL for in-house testing with pulse generators, lasers and radioactive sources. We will use the test-boards designed and fabricated by IJCLAB/Omega, we will fix any remaining issue and then mount ASICs and sensors. More emphasis will be given to flip-chips and bump-bonding. To this end, we will use the process that we developed in FY24, i.e. using stencils rather then high temperature compression for the flip-chip. We expect several tens of such flip-chips will be produced using BNL- and HPK-made sensors with different layouts and thicknesses, which will be tested initially at BL to establish basic functionalities then they will be sent to collaborating institutes after being mounted on test-boards.

Specifically for the application of long-strip AC-LGADs in the barrel TOF, we plan to make an assembly of an AC-LGAD with a differnet ASIC, namely HGCROC, which has been developed by the same team at IJCLAB/Omega who is developing the EICROC. Such an ASIC was designed for the CMS High Granularity Calorimeter, is fast-time, and can function with larger input capacitance. It is therefore most promising for reading out the long-strip AC-LGAD sensors that are expected to be used in the barrel TOF.

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Assembly, Testing and Characterisation

3.1.2 AC-LGAD wafer and sensor testing

After fabrication, **devices will be tested for functionality** by means of current-voltage and capacitance-voltage characterizations (I-V and C-V) and then distributed to collaborators for further detailed testing. At BNL, not only the static characterization at the probe station, but also functional tests with laser beams (TCT scans) and with radioactive sources, such as Sr-90 etc., will be carried out. More specifically, we will be using an IR and a red laser to measure gain and uniformity of the signal. and Sr-90 to test the response to minimum-ionising particles.

A cold probe station has also been set up such that it can now test 4-inch wafers and individual sensors at -40 degrees Celsius, after they are irradiated.

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Assembly, Testing and Characterisation

3.1.3 Quality Assurance tests for AC-LGAD sensors

We also plan to continue long-term QA and stress-test reliability studies of AC-LGADs, using the experience gained on LGADs as a stepping stone. We will use the same ambient chamber that we used for LGADs and we will change the environmental conditions. More specifically, we will test AC-LGADs kept under bias voltage over periods of months, at different temperatures, ranging from $-60°$ C to $+80°$ C and under different humidity conditions. Under these extreme conditions we will carry out I-V and C-V scans and collect signals from beta particles from a Sr-90 source to study any deterioration in noise or charge collection.

As part of our QA strategy we also plan to test BNL-made sensors post-irradiation. We have developed a collaboration with UNM that allows us to irradiate AC-LGADs at various fluences in a proton beam at LANSCE and in a gamma beam at SANDIA, and then test them in a cold probe station that we have re-furbished at BNL: post-irradiation I-V and C-V scans at cold temperatures, i.e. $-40°$ C. Our colleagues at UNM have irradiated several sensors with gamma and protons and have started testing them on their probe station. More irradiation campaigns are planned for FY25.

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Budget

Inst.	Activity	FTE	Budget (k$)
BNL	2 batches of Sensor design/fabrication	mult.	75
BNL	Wire/bump-bonding, module assemblies	0.20 (Tech)	40
BNL	wafer dicing, testing, test-board/module testing	0.20 (Tech+Scientist)	40
BNL	sensor QA and ASIC testing	0.10 (Tech+Scientist)	10
Total			**165**

Table 2: BNL FY25 budget request for eRD112 activities that serve the whole consortium, including sensor fabrication, sensor+ASIC module and test-board assemblies, wire- and bump-bonding, sensor QA tests as well as ASIC testing. All entries in thousands of dollars.