

# FPGA Authentication

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Field programmable gate arrays (FPGAs) present an opportunity for use in treaty applications where trust is needed by both the host (certification) and the inspector (authentication). Once the FPGA has been programmed, functional testing must be performed in order to test the program loaded onto the FPGA. This functional testing can be difficult to perform with conventional testing, as radioactive sources and radiation detectors can complicate the testing process. The goal of this project is to replace required conventional radiation test equipment with a simple, cheap, embedded solution.

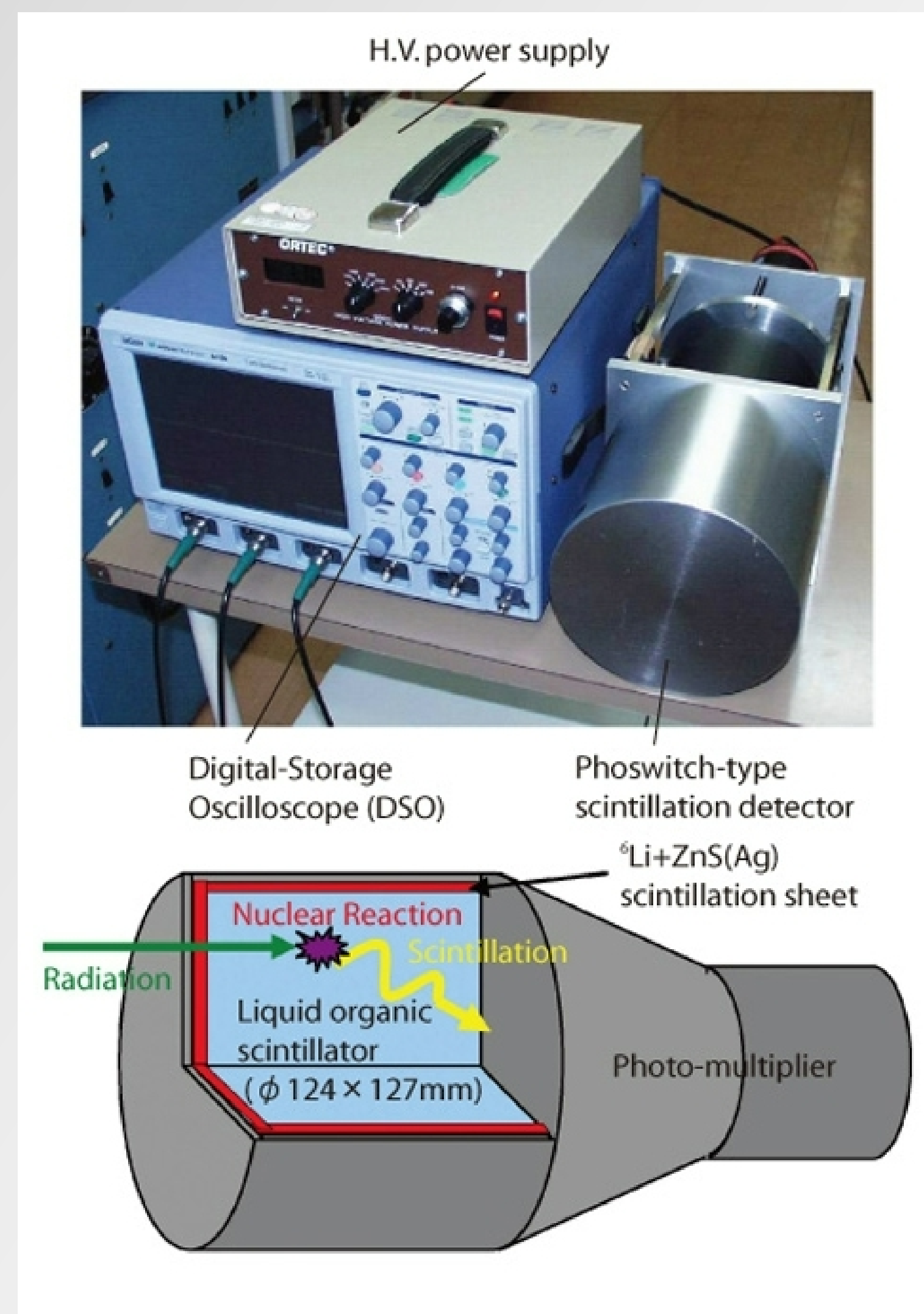
The focus of this part of the project deals with a functional test of the FPGA detection system by utilizing simulated inputs.

Neutron detectors are expensive, fragile, and bulky. Neutron detectors also require an large amount of equipment to operate.

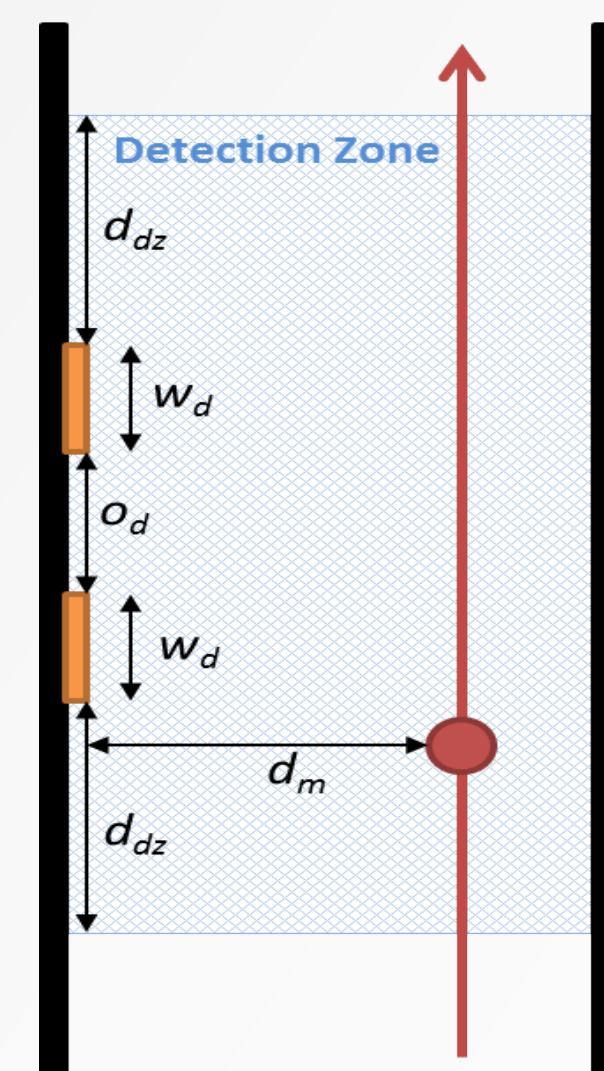
Radioactive sources require additional considerations for safety and handling which add complications to testing.

Functionally testing the system with real inputs would require: two complete detector setups and additional equipment to utilize them, as well as radioactive source.

Digital signals are easily created on many embedded devices. Additionally, these signals can be controlled from software allowing for a fine granularity of control over the generated signal. As a result a signal can be made to match the output to that of a neutron detector.



Liquid Scintillation Detector system.



Detector layout.



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The BeagleBone Black (BBB) is a simple single board computer. It is inexpensive and has a large number of General Purpose Input/Outputs (GPIOs).

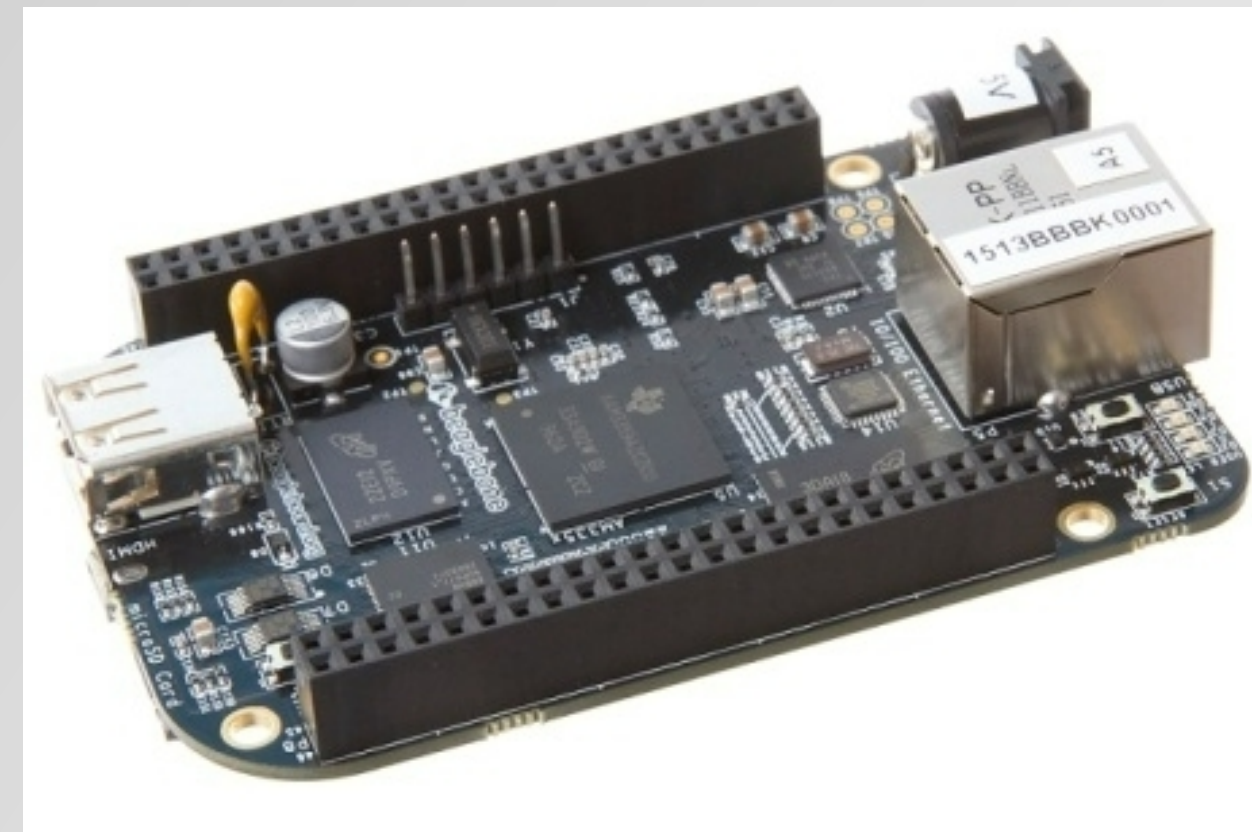
Calculating activity of a radioactive source on a BBB significantly simplifies a functional test of the FPGA detection system. The radioactive source, detectors, and pre-amplifiers can all be replaced with a single BBB.

Configurable simulation parameters:

- Point of radioactive source activity
- Location of both neutron detectors
- Distance of the source from wall
- Velocity of the source
- Path through the detection zone

The simulation calculates the behavior of the radioactive source as it moves through the virtual world. The calculated values are divided into slices of 100ms and output to GPIOs on the BBB which are connected to the FPGA detection system.

The simulator allows for simple, configurable, and flexible functional testing for the correctness FPGA detection system. Moreover, a simulator can easily test for strange operating conditions, such as a radioactive source moving with large changes in the Z-axis. Other physically difficult to test events can easily be simulated and therefore tested.



BeagleBone Black the replacement for a detector system

```
COM7 - PuTTY
root@beaglebone:~/Carl# python FMSimulator.py
Please input the activity of the point source (Ci) [.0000001 Ci]:
Please input the location of the first detector (m) [2 meters]:
Please input the location of the second detector (m) [4 meters]:
Please input the distance from the wall with the detectors (m) [.6 meters]:
Please input the speed that the source is moving (m/s) [1 m/s]:
What type of movement would you like?
1: Straight line
2: Random Movement
3: Straight line (Backwards)
Selection [Straight Line] :
```

Configuration of the radioactive source and detectors in the simulator

```
COM7 - PuTTY
Selection [Straight Line] :
[802.6030368763555, 876.777251184834, 961.0389610389609, 1057.142857142857, 1167.1924290220818, 1293.7062937062935, 1439.6887159533076, 1608.6956521739128, 1804.8780487804875, 2032.9670329670325, 2298.1366459627334, 2605.633802816901, 2959.9999999999995, 3363.636363636365, 3814.4329896907225, 4302.32558139535, 4805.194805194806, 5285.714285714289, 5692.307692307695, 5967.741935483872, 6065.573770491804, 5967.74193548387, 5692.307692307691, 5285.714285714283, 4805.194805194801, 4302.325581395345, 3814.4329896907175, 3363.6363636363585, 2959.9999999999964, 2605.633802816897, 2298.1366459627293, 2032.9670329670298, 1804.8780487804845, 1608.69565217391, 1439.6887159533048, 1293.7062937062913, 1167.1924290220798, 1057.142857142855, 961.0389610389591, 876.7772511848325, 802.6030368763546, 737.0517928286841, 678.8990825688068, 627.1186440677961, 580.8477237048664, 539.3586005830904, 502.0352781546812, 468.3544303797471, 437.8698224852074, 410.1995565410204, 385.01560874089535, 362.03522504892413, 341.01382488479317, 321.7391304347831, 304.0262941659825, 287.71384136858535, 272.6602800294774, 258.7412587412593, 245.8471760797348, 233.88116308470347, 222.75737507525645]
[222.75737507525588, 233.88116308470293, 245.84717607973423, 258.7412587412587, 272.6602800294768, 287.7138413685848, 304.02629416598194, 321.7391304347827, 341.0138248847926, 362.0352250489237, 385.01560874089483, 410.1995565410199, 437.8698224852071, 468.3544303797468, 502.0352781546812, 539.3586005830904, 580.8477237048669, 627.1186440677967, 678.8990825688076, 737.0517928286853, 802.6030368763559, 876.7772511849345, 961.0389610389619, 1057.142857142858, 1167.192429022083, 1293.706293706295, 1439.6887159533087, 1608.695652173915, 1804.8780487804904, 2032.967032967036, 2298.1366459627366, 2605.6338028169066, 2960.000000000006, 3363.63636363703, 3814.4329896907293, 4302.325581395357, 4805.194805194815, 5285.7142857142935, 5692.307692307699, 5967.741935483875, 6065.573770491804, 5967.741935483867, 5692.307692307691, 5285.714285714283, 4805.194805194804, 4302.325581395349, 3814.4329896907234, 3363.636363636376, 2960.000000000004, 2605.6338028169066, 2298.1366459627384, 2032.967032967038, 1804.8780487804931, 1608.6956521739182, 1439.6887159533126, 1293.7062937062988, 1167.1924290220866, 1057.1428571428617, 961.0389610389652, 876.7772511848378, 802.6030368763595]
Movements in X Direction : 0
Movements in Y Direction : 61
Done with output
Done with output
root@beaglebone:~/Carl#
```

Counts per second output of simulator prior to being sent to GPIO