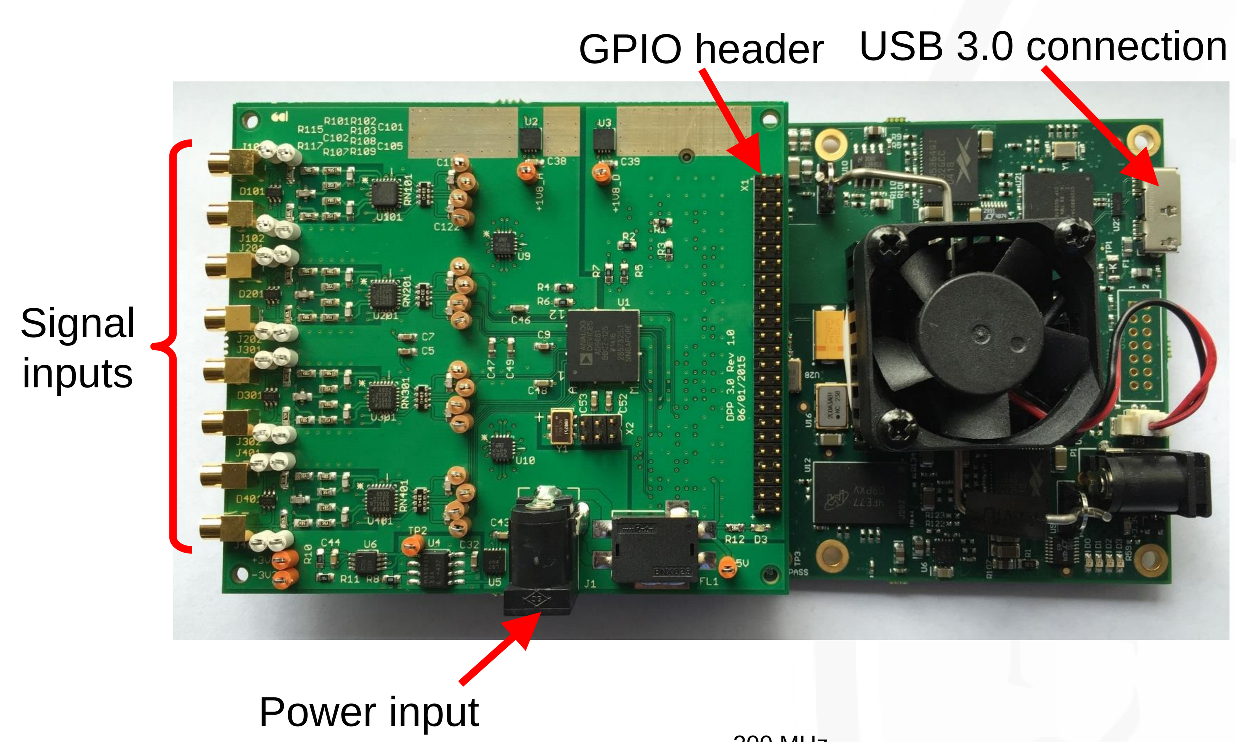
Eight-Channel Digital Spectrometer for Coincidence Measurements in Multi-element Detectors

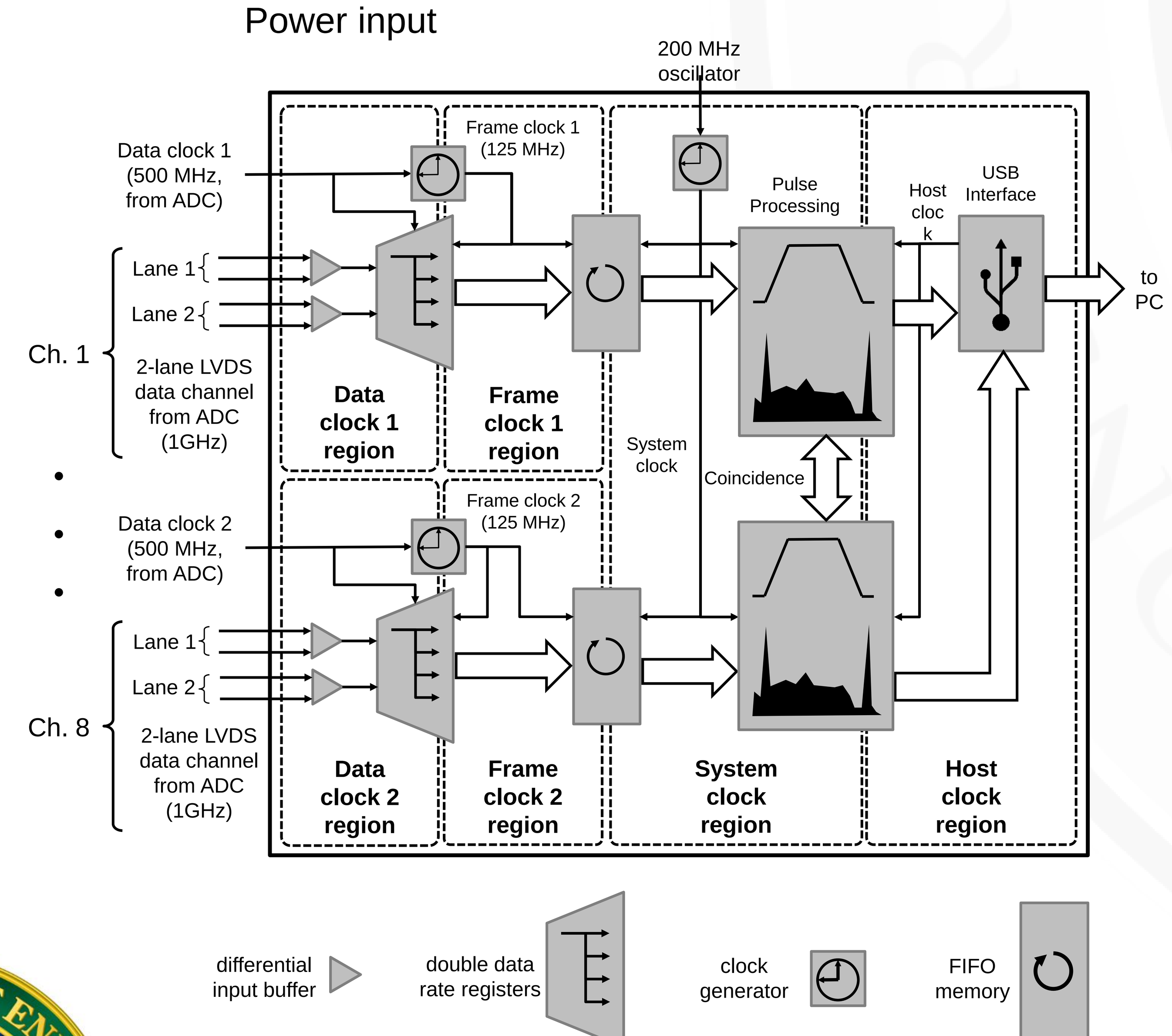
Eric Becker[1], Mitchell Mannino[1], Abi Farsoni[1], Chee-Sing Lee[2]
[1]Oregon State University, [2]BigML, Inc.
Abi Farsoni, abi.farsoni@oregonstate.edu
Consortium for Verification Technology (CVT)

INTRODUCTION

Modern and developing radiation detection systems often use multiple detectors, coincidence modes, and time-of-flight measurements to make accurate and precise measurements. The increasing prevalence of these types of systems is increasing the demand for multi-channel processors. Current commercial multi-channel processors are expensive and do not allow users to modify the pulse processing source code. The DPP8 seeks to afford users a flexible, customizable detector readout platform at a lower cost than commercial models. Presented here are the preliminary evaluation results for the first prototype DPP8 system.

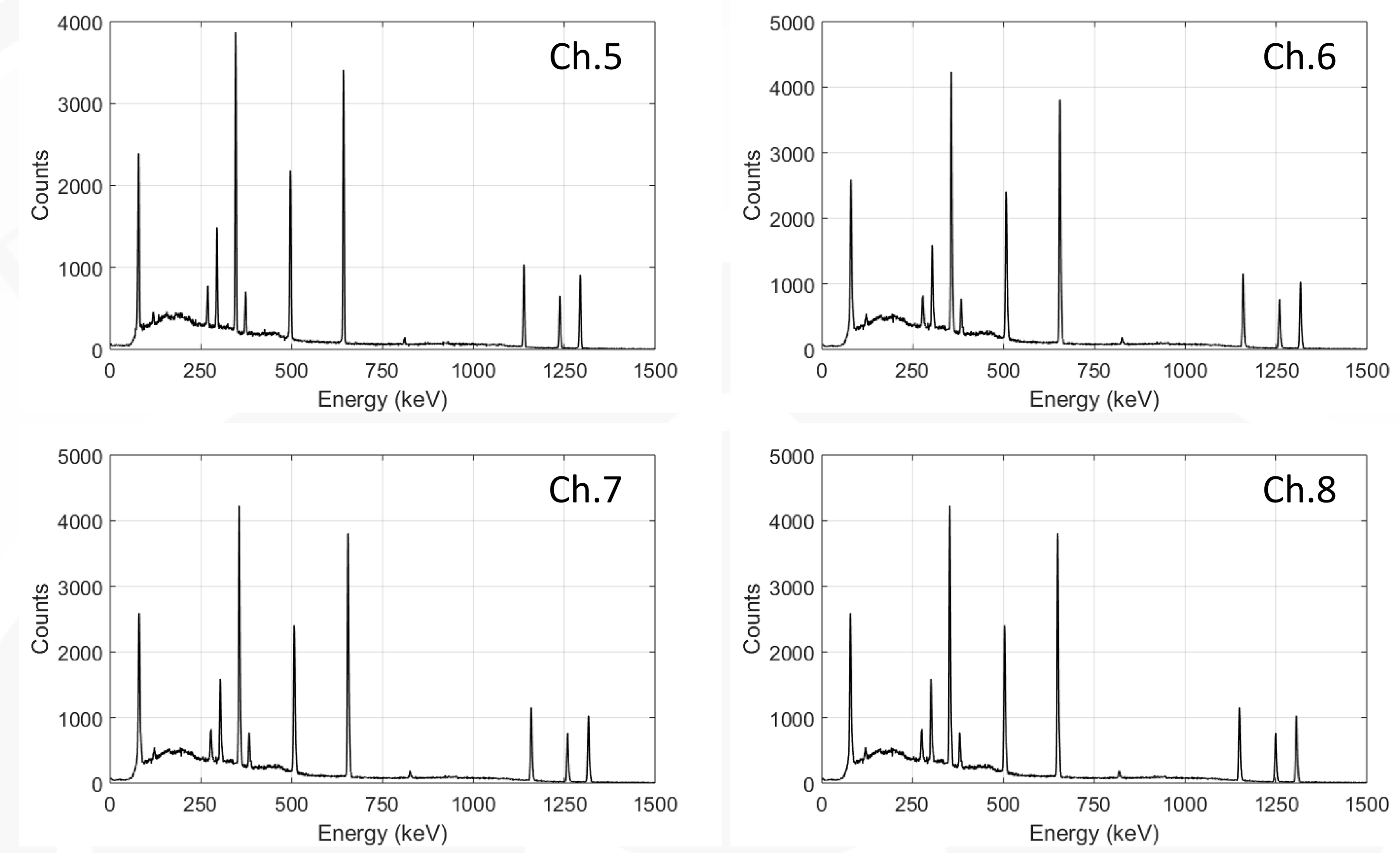
SYSTEM ARCHITECTURE





ENERGY RESOLUTION

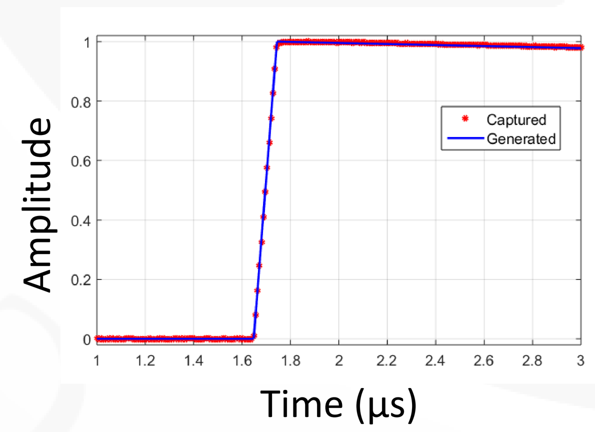
An energy spectrum was generated using each channel coupled to a 70% HPGe detector. Sources used were Ba-133, Cs-137, Mn-54, Na-22, and Co-60.

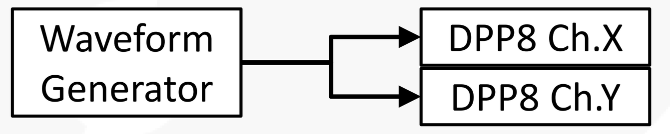


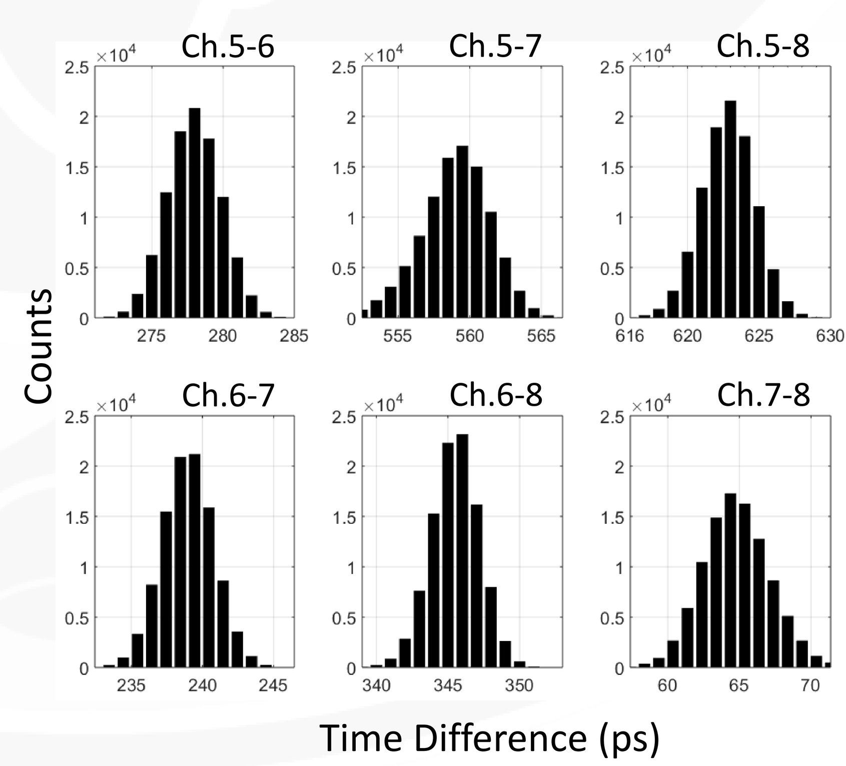
Full-Energy Peak (keV)	Energy Resolution (keV FWHM)			
	Ch.5	Ch.6	Ch.7	Ch.8
662	3.9	4.3	4.1	4.0
1173	4.3	4.9	4.6	4.4
1332	4.4	5.1	4.7	4.6

TIMING RESOLUTION

The timing resolution between channels was measured using a single waveform-generator output split into two channels, and capturing pulses from both channels, which were triggered at the same time. Offline constant fraction discrimination was used to measure the difference in arrival times between the channels.

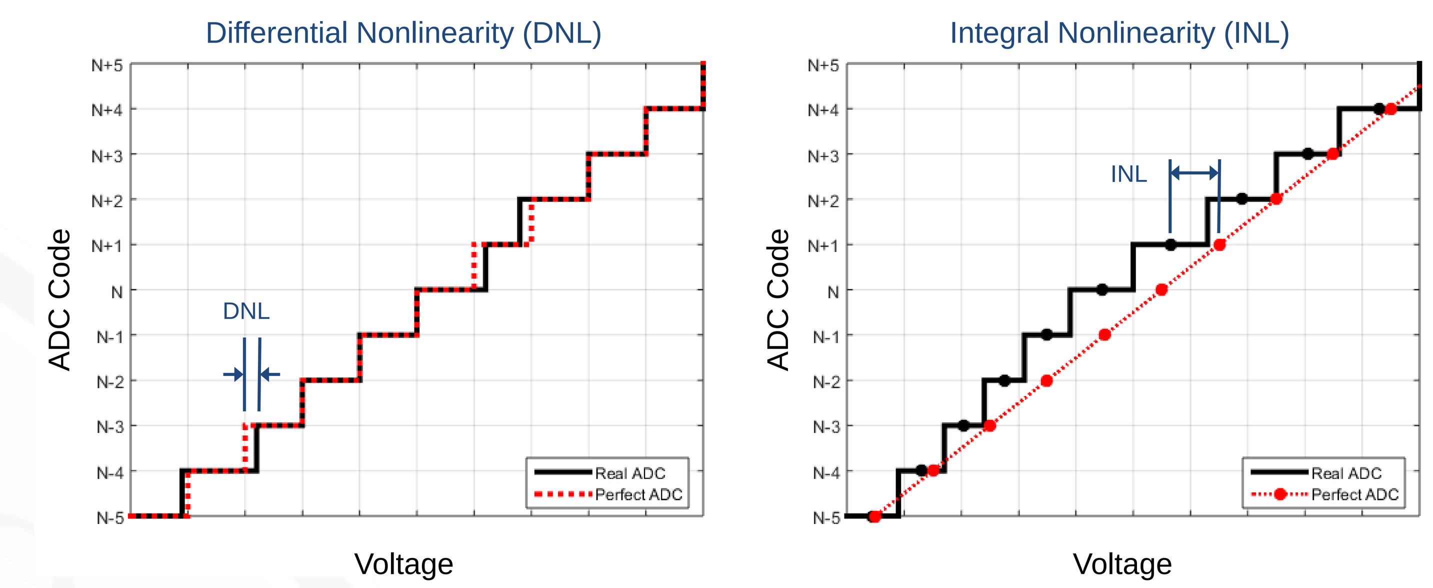






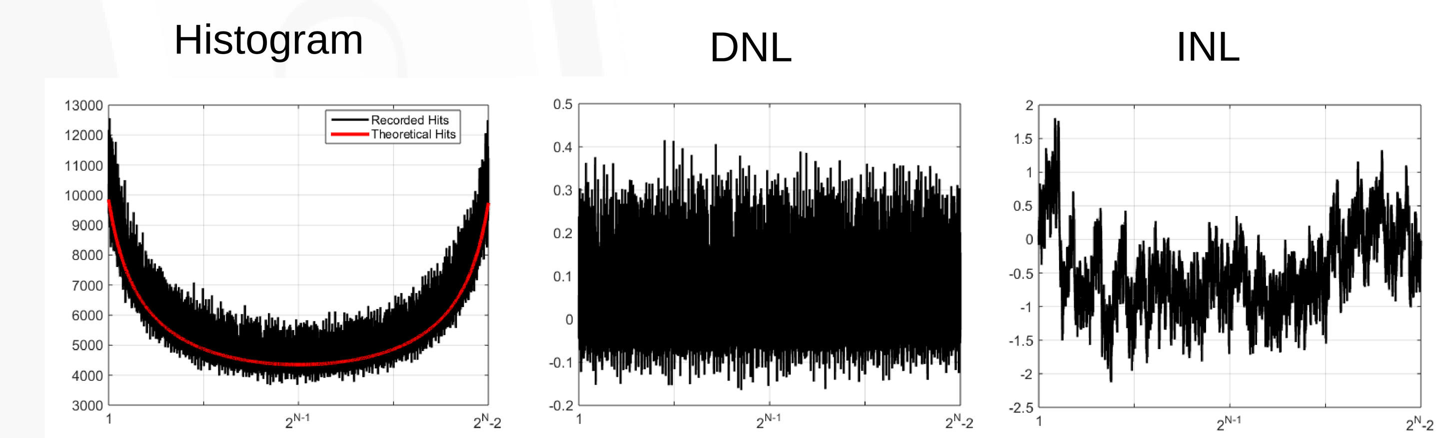
Ch.	mean (ps)	FWHM (ps)
5-6	278	4.5
5-7	559	5.5
5-8	623	4.4
6-7	239	4.3
6-8	346	3.9
7-8	65	5.4

NON-LINEARITY



Non-linearity measurements are typically performed using the histogram method, in which a low-frequency waveform is applied to the ADC input and the number of "hits" in each ADC code is recorded. The recorded number of hits is then compared to the theoretical number of hits using the equations below.

$$DNL(n) = \frac{h(n)_{recorded}}{h(n)_{theory}} - 1 \qquad INL(n) = \sum_{i=0}^{n} DNL(i)$$



Parameter	Ch.5	Ch.6	Ch.7	Ch.8
Max DNL (LSB)	0.41	0.42	0.45	0.42
Min DNL (LSB)	-0.11	-0.16	-0.11	-0.13
Max INL (LSB)	10.04	1.81	3.39	0.84
Min INL (LSB)	-0.61	-2.13	-0.38	-7.86

NEXT STEPS

The results presented here represent only the first stage of development. Several issues were encountered during the course of the evaluation of the first prototype, both with the analog conditioning hardware, and with the firmware implemented in the FPGA. These issues, such as analog signal cross-talk and digital timing errors, will be addressed during the development of the second DPP8 prototype, with additional electronics and firmware expertise provided by collaboration with Pacific Northwest National Laboratory.

This work was funded in-part by the Consortium for Verification Technology under Department of Energy National Nuclear Security Administration award number DE-NA0002534.

National Nuclear Security Administration