Team Members:
Aliesha Garrett
Yuxin Guan
George Herring
Patrick Varin
Junjie Zhu

Faculty Advisor:
Bradley A. Minch

Liaison:
John O'Connor
Doug Abraham
Basak U. Karbeyaz

analogic | Olin College of Engineering SCOPE

2013-2014

Spectral Imaging for Computational Tomography

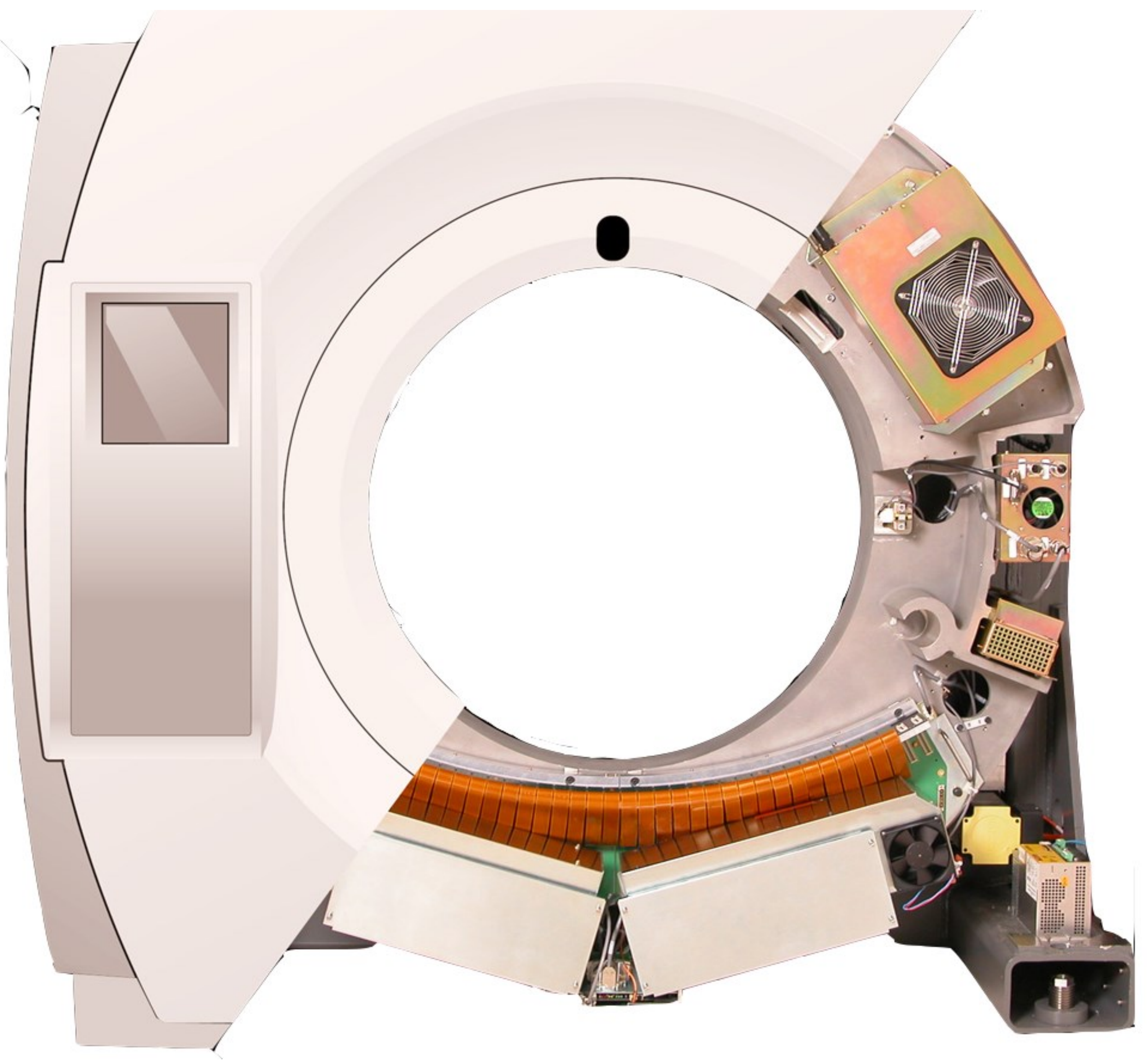
CT scanners provide doctors with a 3D view of a patient. The scanned images are exquisitely detailed but require a dose of radiation that can be 50-100 times that of a standard X-ray.

COMPANY BACKGROUND

Analogic produces imaging systems for original equipment manufacturers to incorporate into their most advanced medical and security imaging scanners including Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultrasound, and Digital Mammography machines. These products are used in most major healthcare facilities around the world to improve the practice of medicine and save lives.

OUR GOAL

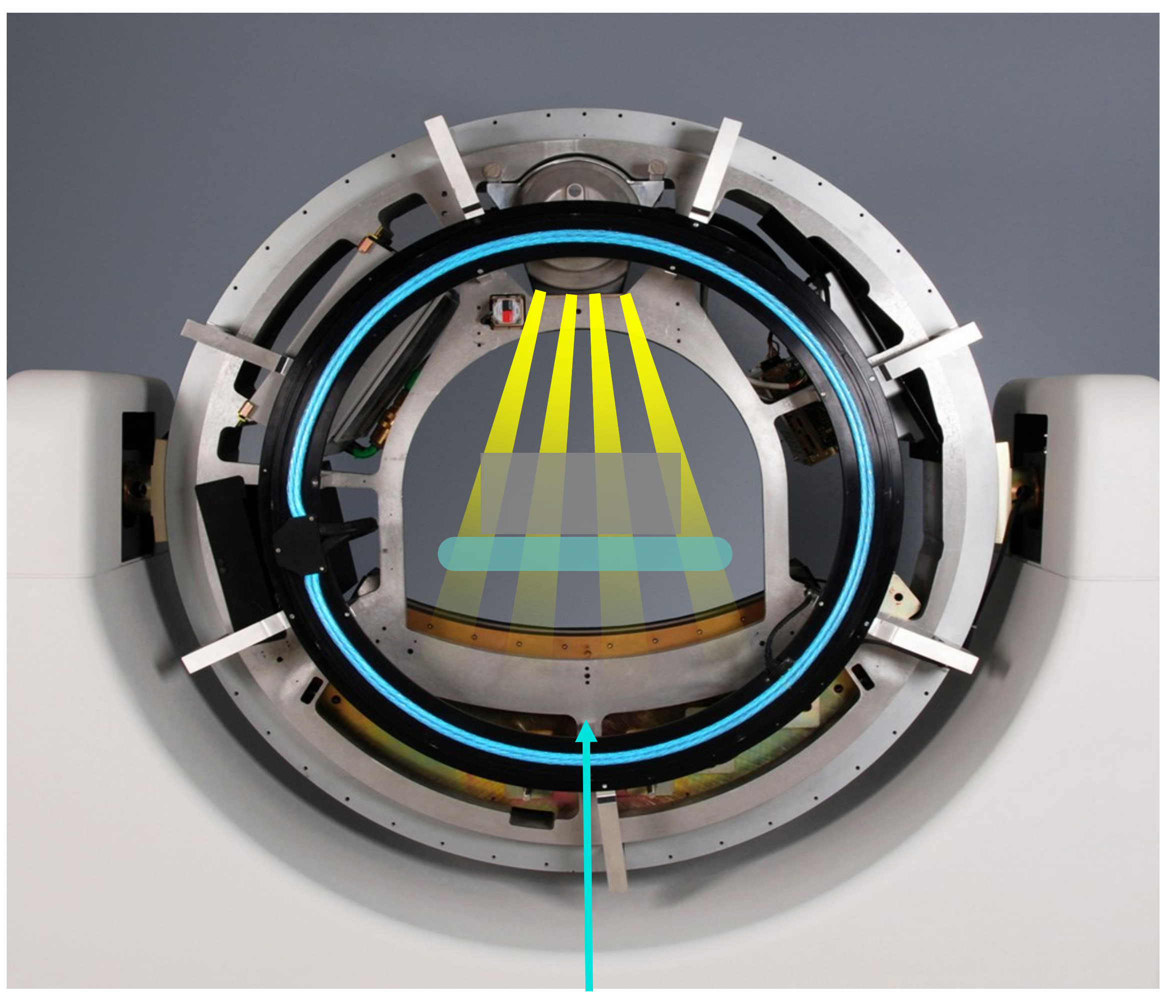
The Analogic-Olin SCOPE team is working on a new imaging technology involving spectral imaging to enhance image quality. In the medical imaging field, the more detailed information captured, the better the final image and the better doctors can see and diagnose medical conditions. Spectral Imaging may improve image quality by reducing sources of noise during the imaging process. Additionally, doctors try to minimize the radiation dose to which patients are exposed to, as it has been suggested to be linked to complications such as cancer. With spectral imaging, it may be possible to provide the same image quality at a lower radiation dose as another option for clinicians. The team's goal is to develop signal processing algorithms which will optimize the quality of the image output by a spectral imaging system.



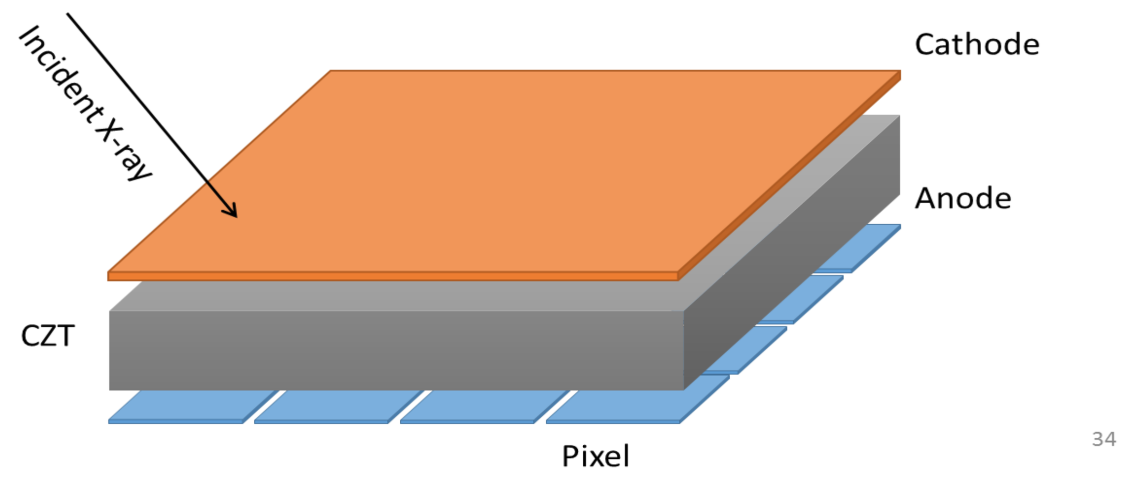
UNDERSTANDING X-RAY IMAGING

- X-Ray photons are generated
- A filament is heated
- Free electrons are accelerated towards a target
- Electron energy is dissipated as photons (X-Rays) at the anode
- Fluorescent Radiation
  - Electrons excite other electrons and induce photon emission
  - Electron-Electron Interaction
- Braking Radiation
  - Electrons decelerate upon interaction with nucleus
  - Electron-Nucleus Interaction
  - Electrons excite other electrons and induce photon emission
  - Electron-Electron Interaction

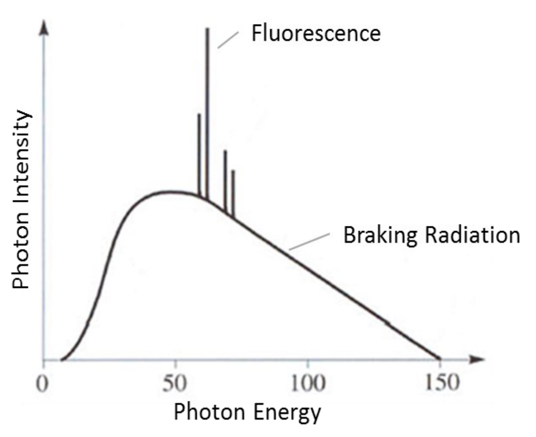
Advanced detectors data acquisition systems detects flux spatial distribution, spectrum or other properties of X-rays.

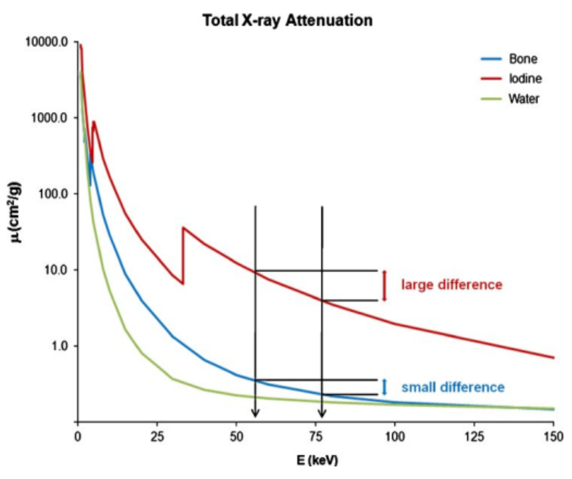


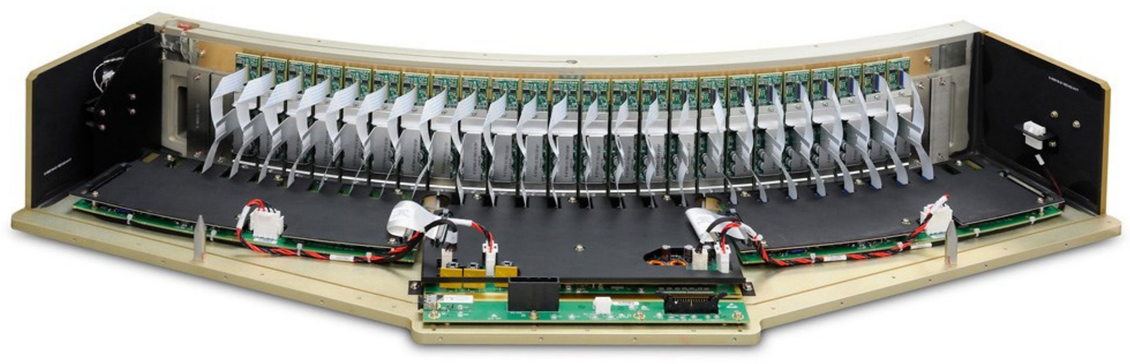
Most CT X-ray detectors utilize scintillators. Important parameters are scintillator material, size and geometry, and the means by which scintillation events are detected and counted.



Different materials absorb photon energies differently.

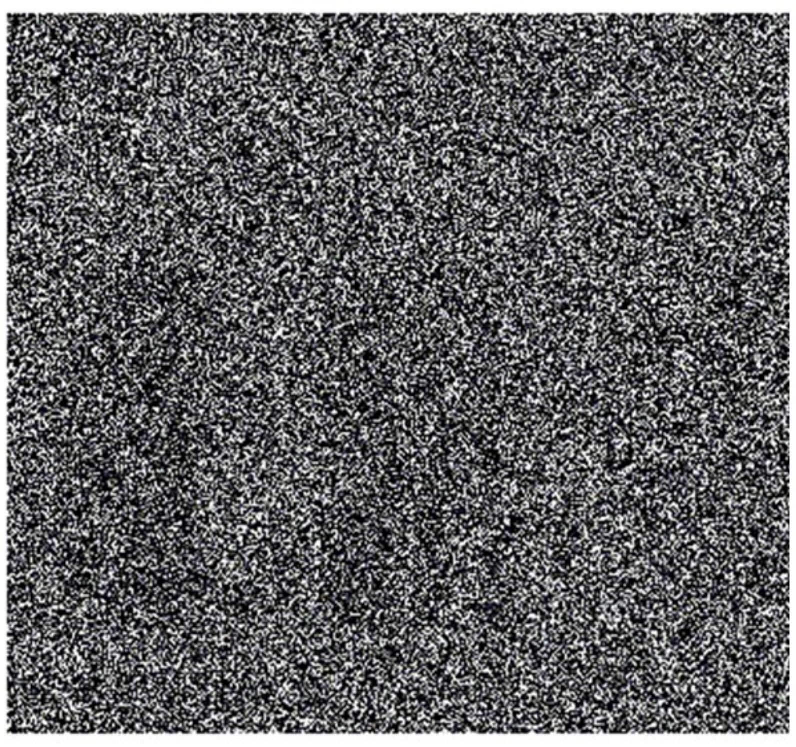




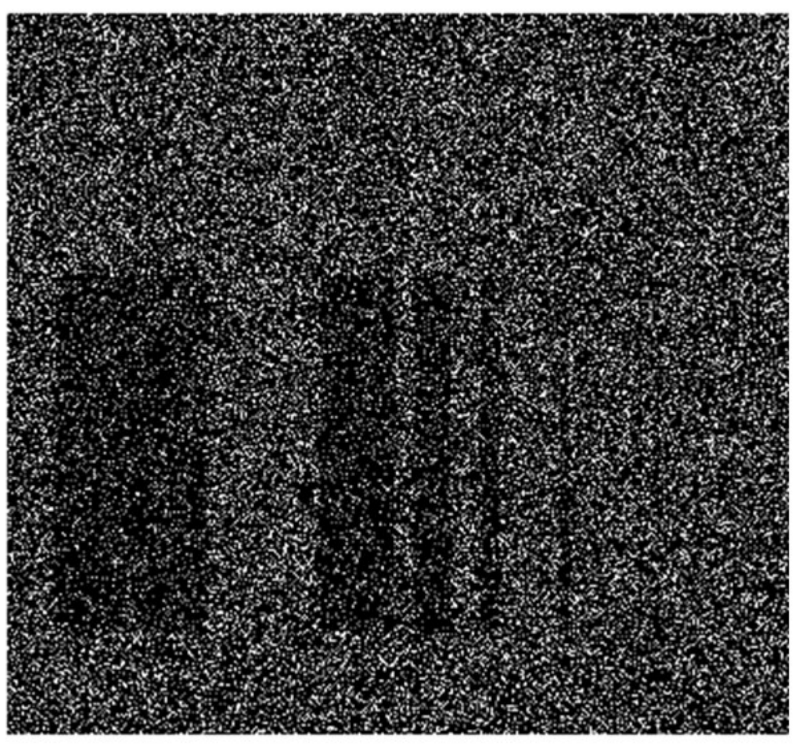


PRIOR WORK

Analogic has studied innovative methods to improve CT image qualities by increasing the spatial resolution and reducing the contrast-to-noise ratio. In other words, to achieve the same image quality, a patient can intake less dosage.



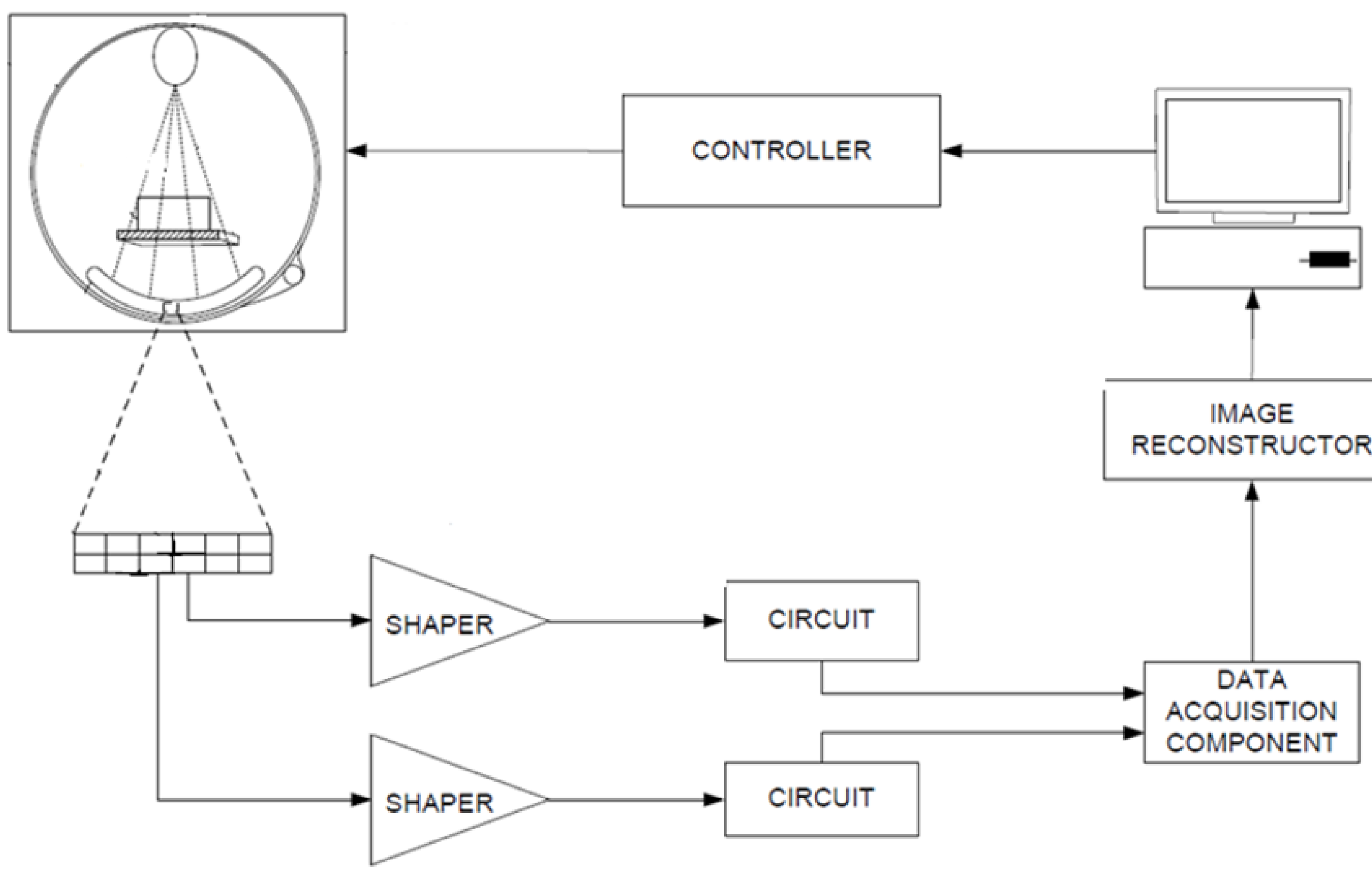
Conventional Imaging



Analogic Spectral Imaging

OUR PROJECT

Inspired by Analogic's experimental results and previous design prototypes, we improved spectral imaging techniques that can not only outperform conventional techniques in theory, but also become feasible to implement in reality. As such, our solution consists of two main components, analog circuit designs and digital signal processing.

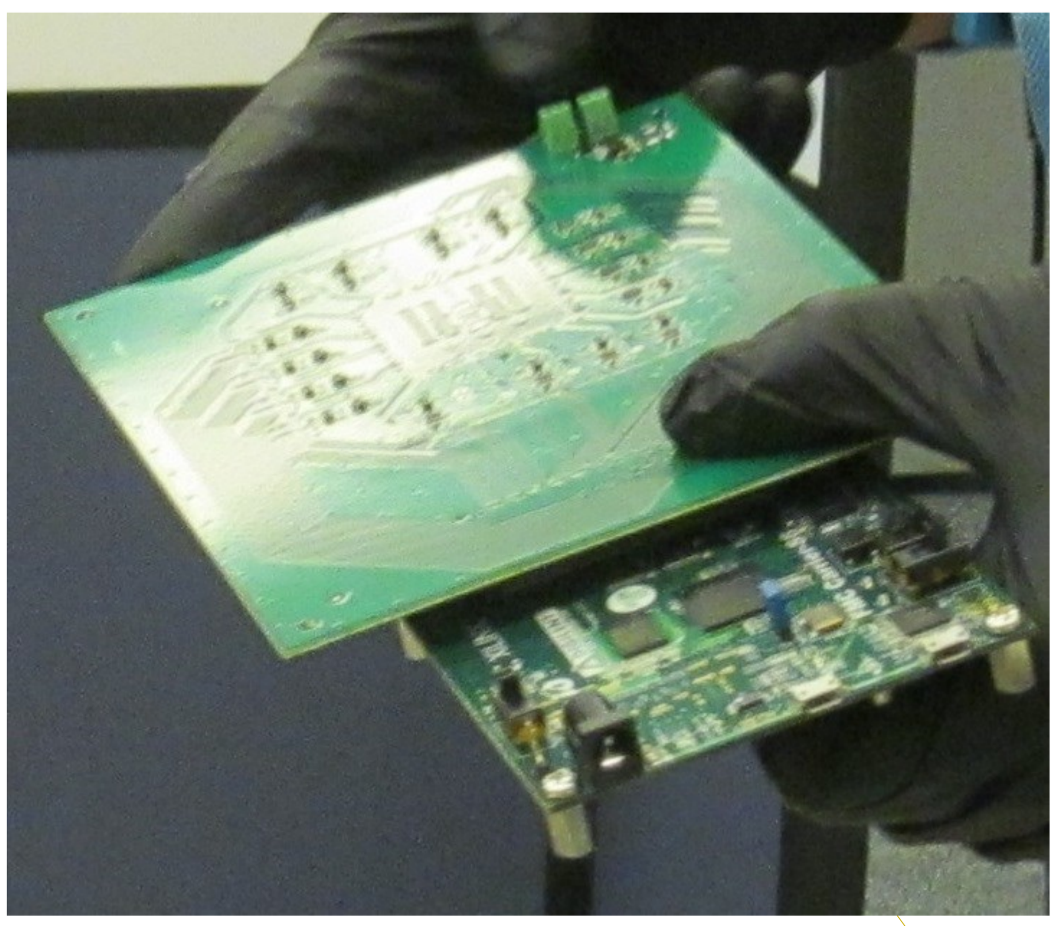


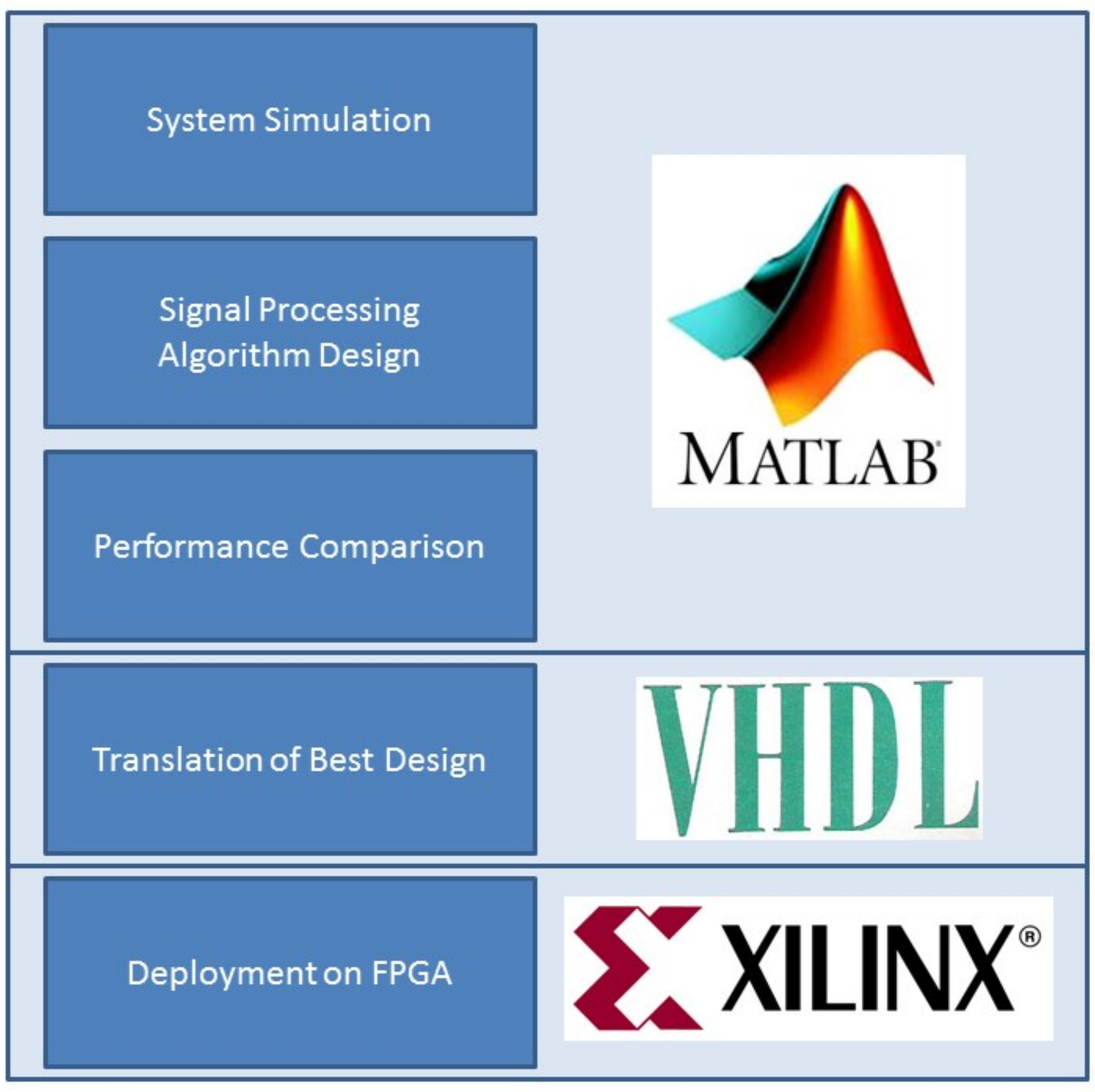
SIMULATING THE SYSTEM

To study the merit of our spectral imaging techniques, we programmed essential processes of the system in MATLAB to under stand the bottlenecks of our system, and identify the cases where the approach needs to be flexible. Conventional techniques and common practice in the literature are used as baselines to compare how well our approaches work.

HARDWARE CIRCUIT DESIGN

An essential part of this project is to create a prototype that incorporates Analogic's previous considerations and features that will support our spectral imaging techniques. In building the physical hardware, we had PCB boards manufactured in a timely fashion, sourced components that balance cost and performance, and identified the most efficient assembly processes that will enable us to deliver our prototype.





DIGITAL PROCESSING WITH FPGA

With a field-programmable gate array (FPGA), we can specify our desired configurations using a hardware description language (HDL). FPGAs provide large resources of logic gates and RAM blocks to implement complex digital computations, so signals can be processed at high-speed. The processing time of spectral imaging is a critical component, because it not only allows measurement to be gathered quickly, but also offers higher quality.

We designed and tested our digital processing algorithms with MATLAB and then implemented the equivalent program in an HDL. After several iterations, we deployed the program to an FPGA and enabled it to interface with the hardware circuit and the data collector.

ACKNOWLEDGEMENT

We would like to acknowledge Analogic Corporation for funding this project and providing resources for its continuing development. Special thanks to Olivier Tousignant and Richard Fournier for providing information and feedback.

Thank you to Alisha Sarang-Sieminski, Tracy Tully, Ruth Levine and the rest of the SCOPE program for making this experience possible.

Thank you Jose Oscar Mur-Miranda, Siddhartan Govindasamy, Wego Wang, and the Raytheon SCOPE team for providing useful feedback and criticism during regular design reviews.