Wireless Power and Data Acquisition System for Large Detectors

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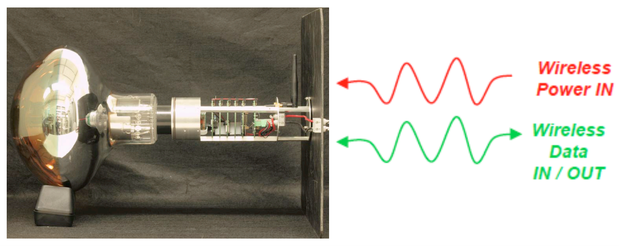
Motivation for Wireless DAQ

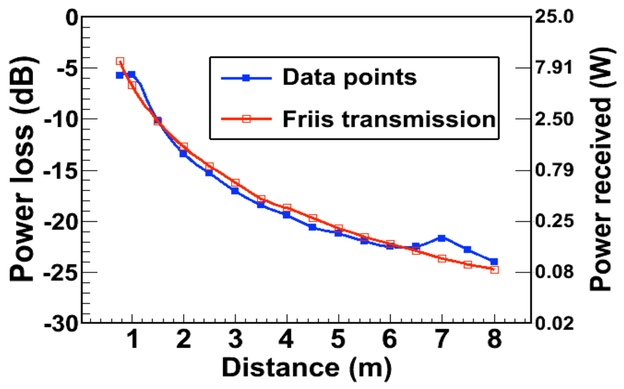
To develop a wireless data acquisition system with the intended application to read-out instrumentation systems having thousands of channels. This R&D project is for a large detector containing photomultiplier tubes; motivation is the elimination of massive cable plants, cost reduction and simplified installation.

A feasibility study to build a stand-alone PMT base detector in free space.



Radio Frequency Power Transmission

Transmitter : 14 dBi gain Yagi antenna
Receiver : 11 dBi gain Patch antenna
Frequency : 915 MHz

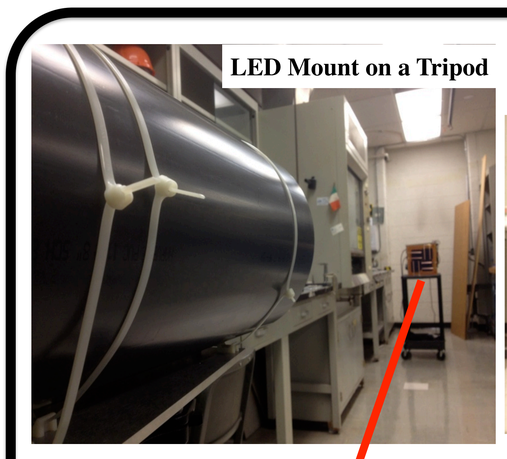


Friis Transmission Equation:

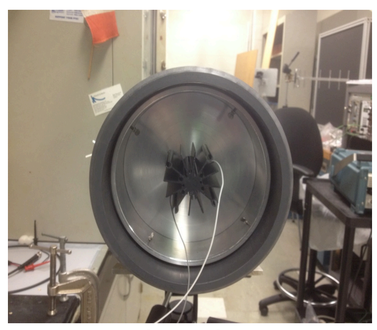
$$\frac{P_r}{P_t} = G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2$$

20 dB power loss at a distance of five meters from the transmitter, which requires a 25 W source to receive 250 mW. RF to DC conversion is required at the receiver end.

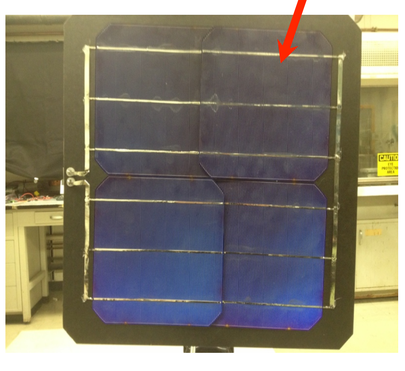
Optical Power Transmission



Lens attached to the front



Heat sink with support on the back

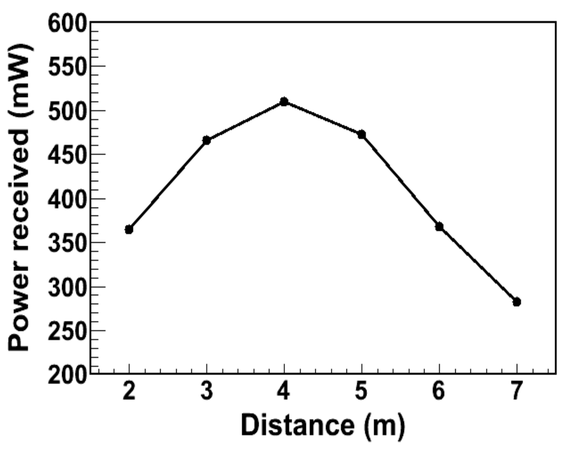


Photovoltaic cells (15.6×15.6 cm^2)

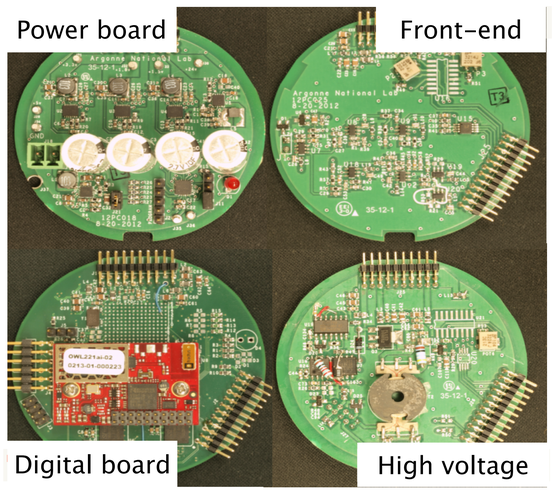
- Wavelength: 940 nm (infrared)
- Optical Power of LED: 3.5 Watt
- Peak power of the beam: 20 mW/cm^2
- Beam diameter: 8 inch
- Lens: 8 inch diameter, 400 mm focal length

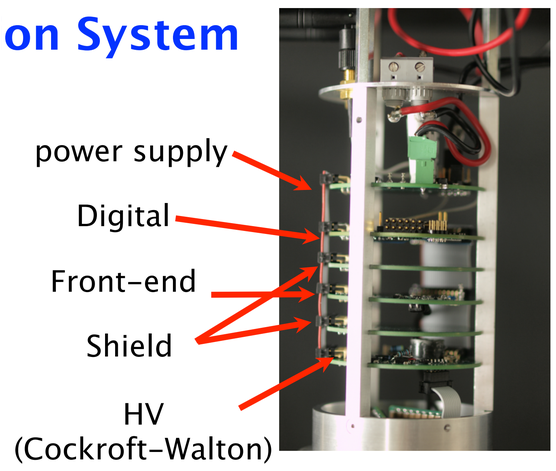
Nearly 470 mW DC power is received at a distance of five meters from the LED source of power 3.5 Watts.

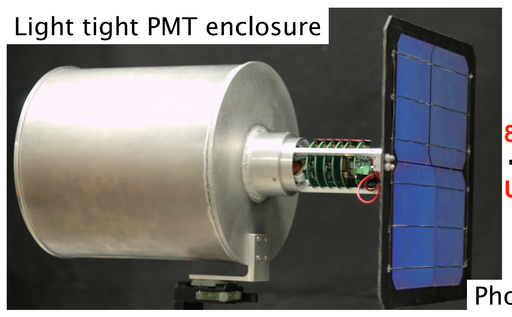
Optical power transmission is chosen for this project.



Wireless Data Acquisition System





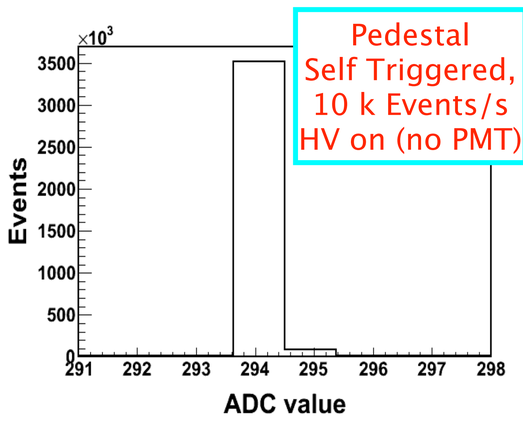


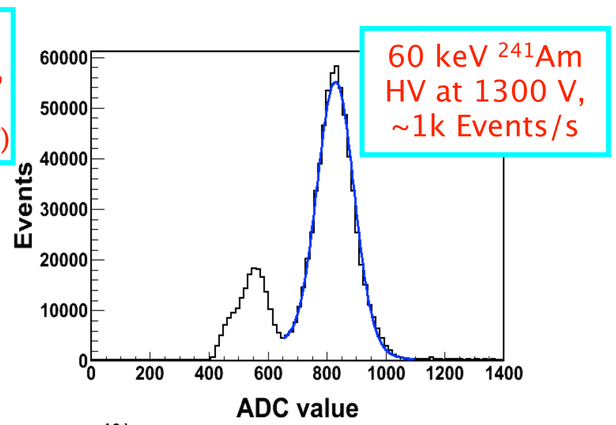
The front-end transmits data once per second as a single UDP packet using 802.11n in 5 GHz band. For each PMT trigger, the pulse height (2 bytes) and time stamp (4 bytes) are stored.

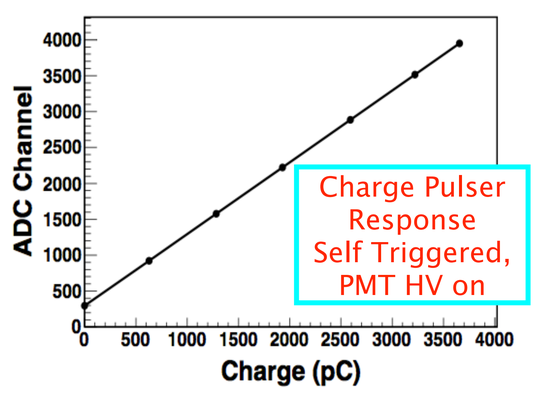
Prototype Performance:

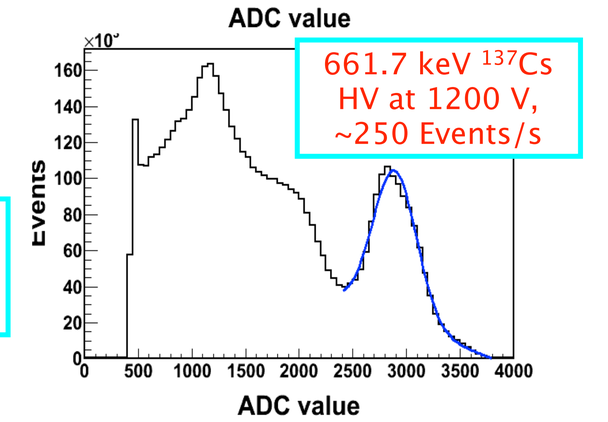
- Total Power consumption (at 10 kHz): 386 mW (Digital: 216 mW, Front-End: 39 mW, HV: 131 mW)
- Maximum event rate: 80 kHz
- Data transfer rate: 11 Mb/s
- Bit Error Rate: Dropped packets

Test Results with Wireless DAQ









We have successfully designed and built a wireless data acquisition system implemented in a photomultiplier tube base that operates from wireless power and sends data wirelessly.
We thank to the Argonne's Laboratory Directed Research and Development (LDRD) program for supporting this R&D project.