LDRD Proposal 2011-153-NO:
Development of Wireless Data and Power Transfer Techniques for Large Instrumentation Systems

Zelimir Djurcic, Gary Drake, Maury Goodman, Jon Paley

HEP

Problem

-With the detectors increasing in its size and complexity it is complication to use traditional approach where the signal and the power are distributed with electric cables.

-Cabling may represent a significant cost and complication in experiments.

Approach

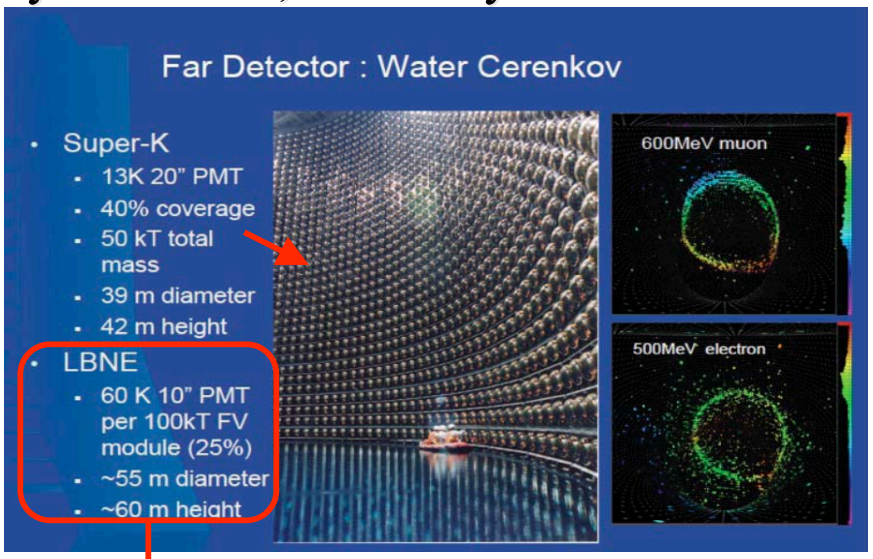
-Proposal has two components, to be addressed:

-data transfer (RF technology)

-power transfer (optical beam)

Goal

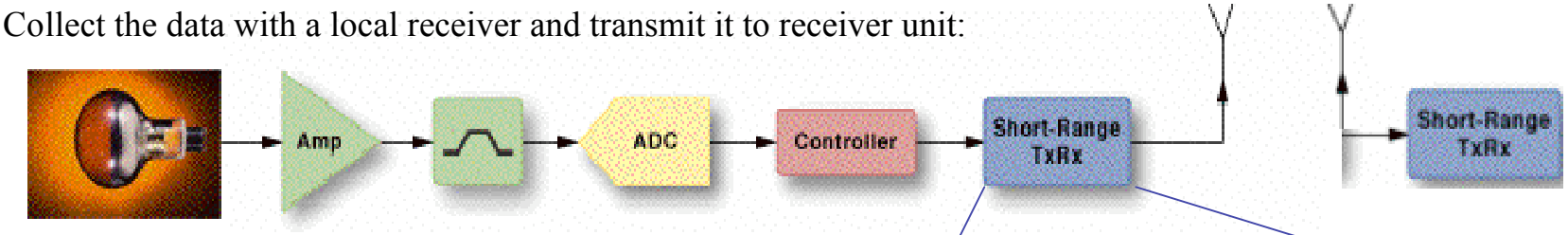
-Elimination of all cables: no physical connection to the detector.



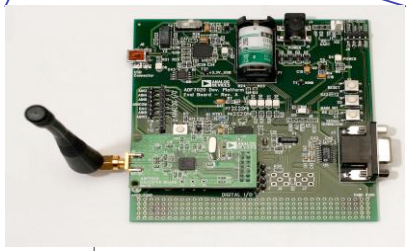
Data Transfer

-Develop a wireless data transfer application based on commercial cheap RF/cell-phone/WiFi tech.
-Technology exists but never used with a high channel count.
-Need to address possible channel interference when sending it over a distance.

Collect the data with a local receiver and transmit it to receiver unit:



Plan: -design a small network of several sources and compare to networking Monte Carlo.
-explore transmission protocols



Candidate mother board for interface to PC + daughter board with RF transmitting/receiving unit.

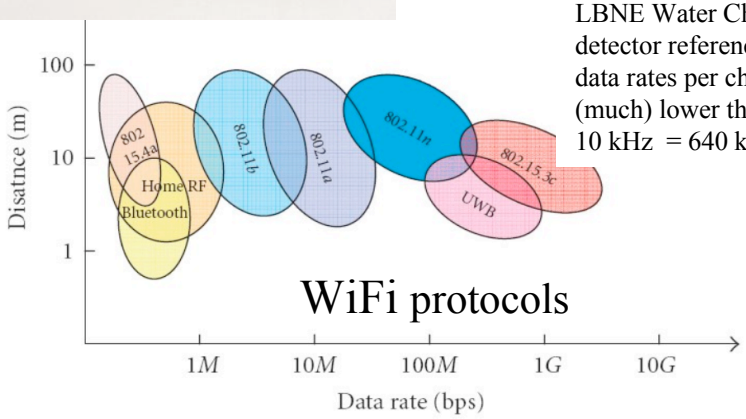
Cell phone standards/protocols

Technology	Bandwidth	Data Rate/User (Theory)	Data Rate/User (Realistic)
GSM	200 kHz	9.6 kbps	9.6 kbps
GPRS	200 kHz	172 kbps	40 kbps
EDGE	200 kHz	474 kbps	100 kbps
CDMA2000 3x	3.75 MHz	2 Mbps	384 kbps
WCDMA	5 MHz	2 Mbps	1 Mbps

Users/Cell

56

~196



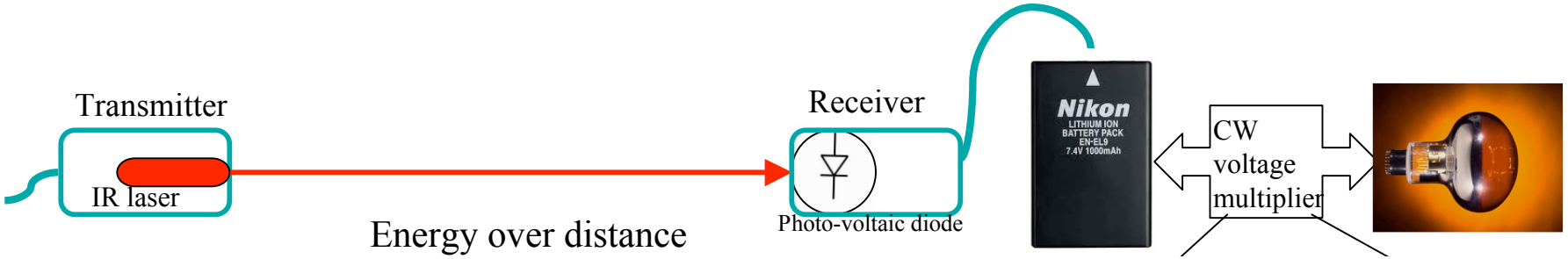
WiFi protocols

LBNE Water Cherenkov detector reference design: data rates per channel (much) lower than 10 kHz = 640 kbit/s.

-study performance of the system i.e. carrier frequencies, transmission data rates (i.e. bandwidth), source to receiver distances, and power consumption.
-input to design a larger network of ~100 sources (hardware setup of 128 PMT channels for measuring muons in hand for real data test.)
-extrapolate to larger system.

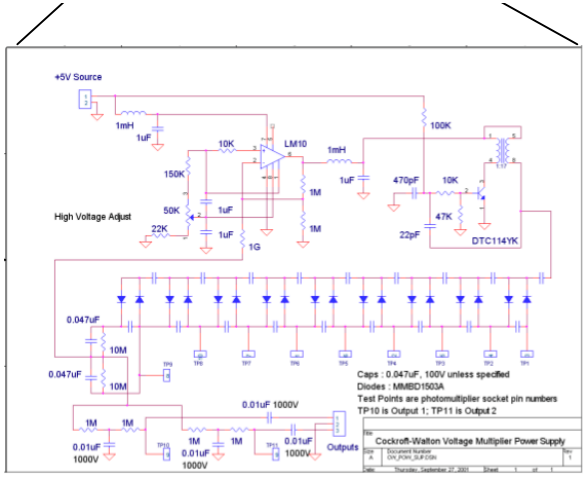
Power Transfer

-Transmission over distance and conversion from a low to high voltage to run PMT.



Conversion from few to ~1000V

HEP designed Cockcroft-Walton base for ZEUS Experiment.



-Use Infra Red laser diodes to turn the electricity into optical, then detect with photodiodes. Similar to a solar cell but higher efficiency.
-Recharge the battery.
-Use Cockcroft-Walton in PMT base converts the low-voltage to high voltage needed for PMTs (~1000 V).

Plan:

-Construct a prototype with a single channel that runs PMT continuously.
-Construct a demonstrator with a reasonable load and several channels to demonstrate potential for a remote application.

Project budget

Funding Profile	2011	2012	2013	TOTAL (All Years)
Hi-value Equipment	$0.00	$0.00	$0.00	$0.00
Materials & Supplies	$50,000.00	$50,000.00	$0.00	$100,000.00
Post Doc Effort	$83,000.00	$86,000.00	$0.00	$169,000.00
Staff/STA Effort	$90,000.00	$93,000.00	$0.00	$183,000.00
TOTAL	$223,000.00	$229,000.00	$0.00	$452,000.00

Staff Effort 4 man months/year: 1 month - design
1 month - layout & build
1 month - test

Post-doc Effort 2 years: year 1 - initial studies (explore communication protocols, simulation studies, build and test small prototype)
year 2 - larger system build and test

Conclusion

-This proposal aims at new developments in high speed data acquisition system in high energy physics with goal of eliminating cables in large systems.

-This technology has the potential to significantly reduce the cost and complexity of the infrastructure needed for the instrumentation of experiments such as LBNE (future key DOE/NSF experiment) or dark matter experiments.

-This positions our group uniquely in development of large wireless DAQ systems in next decade.

-The technology could generate funding for possibly multiple full-scale instruments such as LBNE.