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14. ABSTRACT This is the interim progress report of agreement number: W911NF-09-1-0293. Research topic is "Performance Limits of Non-Line-of-Sight Optical Communications". Report Period is August 2011 to January 2012. During this report period, the following have been achieved: 1. Developed a long distance UV channel test bed. 2. Proposed a Neighbor Discovery Protocol for UV network.				
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## **Report Title**

Performance Limits of Non-Line-of-Sight UV Communications

### **ABSTRACT**

This is the interim progress report of agreement number: W911NF-09-1-0293. Research topic is "Performance Limits of Non-Line-of-Sight Optical Communications". Report Period is August 2011 to January 2012. During this report period, the following have been achieved:

1. Developed a long distance UV channel test bed.
2. Proposed a Neighbor Discovery Protocol for UV network.
3. Modeled long distance NLOS UV channel
4. Designed a UV communication system working on USRP software defined radio platform.



# Performance Limits of Non-Line-of-Sight UV Communications

Progress report  
1 August 2011–1 January 2012

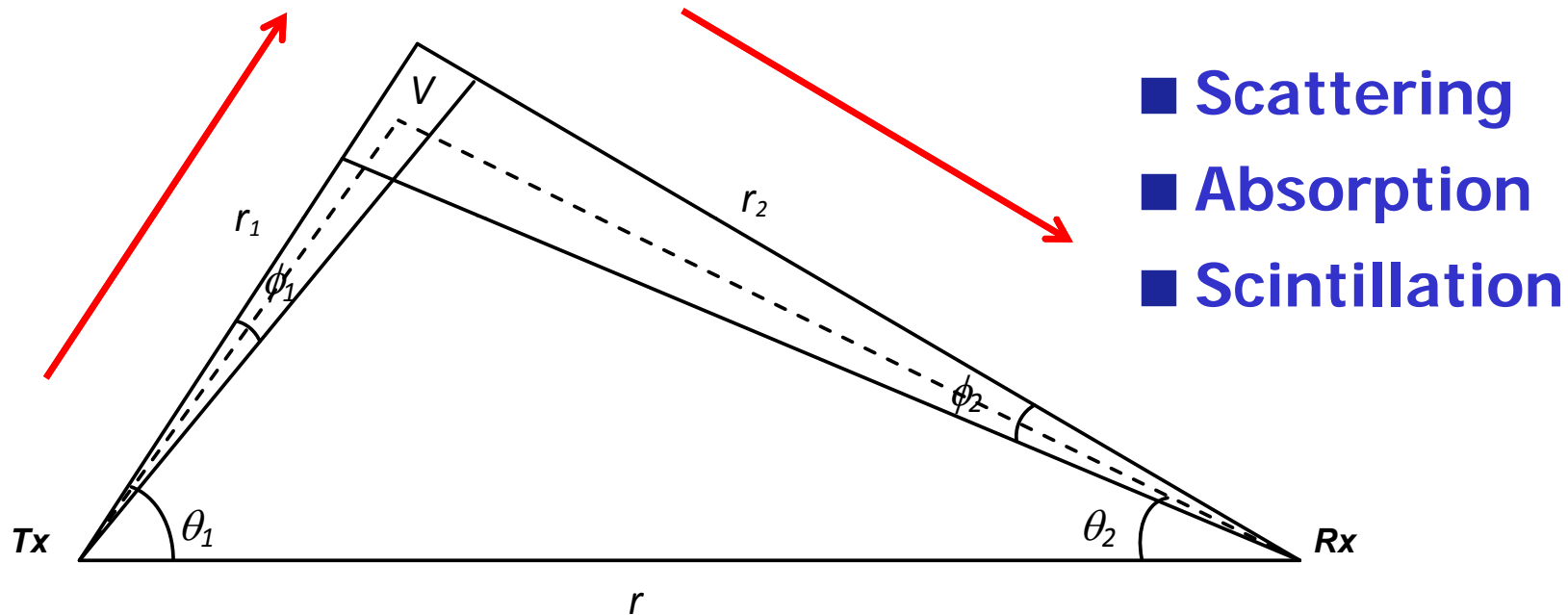
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# 1. Turbulence modeling for NLOS UV scattering channels



- NLOS = LOS (Tx -> V) + LOS (V -> Rx)
- LOS path follow LN PDF

# NLOS UV Scintillation Model

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Tx -> V: PDF at the common volume

$$f_x(x) = \frac{1}{x\sigma_x\sqrt{2\pi}} \exp\left(-\frac{\left(\ln\frac{x}{E[x]} + \frac{1}{2}\sigma_x^2\right)^2}{2\sigma_x^2}\right)$$

V -> Rx: assume single scattering

$$f_y(y|x) = \frac{1}{y\sigma_y\sqrt{2\pi}} \exp\left(-\frac{\left(\ln\frac{y}{E[y|x]} + \frac{1}{2}\sigma_y^2\right)^2}{2\sigma_y^2}\right)$$

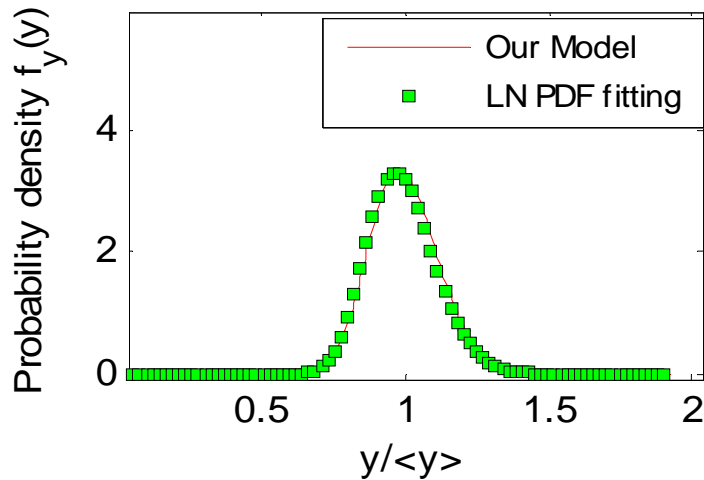
Conditional PDF

$$f_{x,y}(x,y) = f_y(y|x)f_x(x) \quad \text{Joint PDF}$$

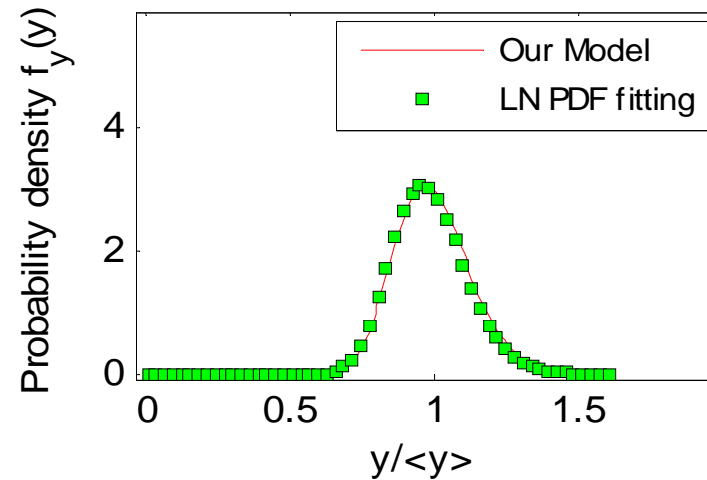
$$f_y(y) = \int f_{x,y}(x,y)dx \quad \text{PDF at Rx}$$

# Primary results

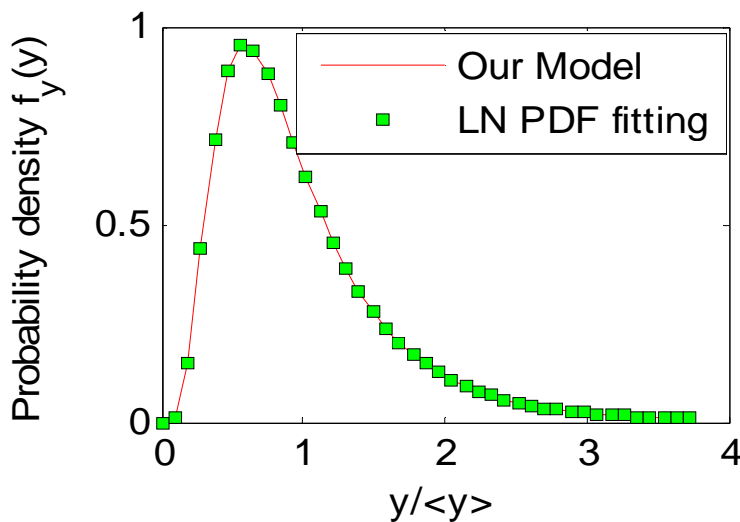
Scitillation PDF for  $(\theta_1, \theta_2) = (20^\circ, 20^\circ)$



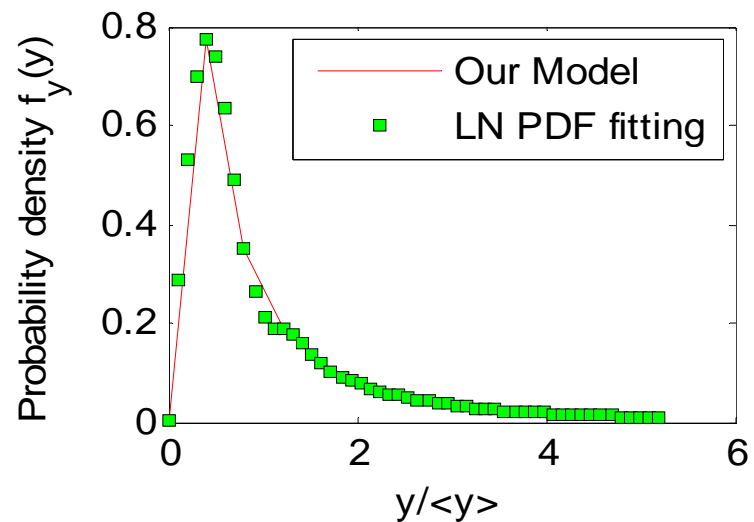
Scitillation PDF for  $(\theta_1, \theta_2) = (30^\circ, 30^\circ)$



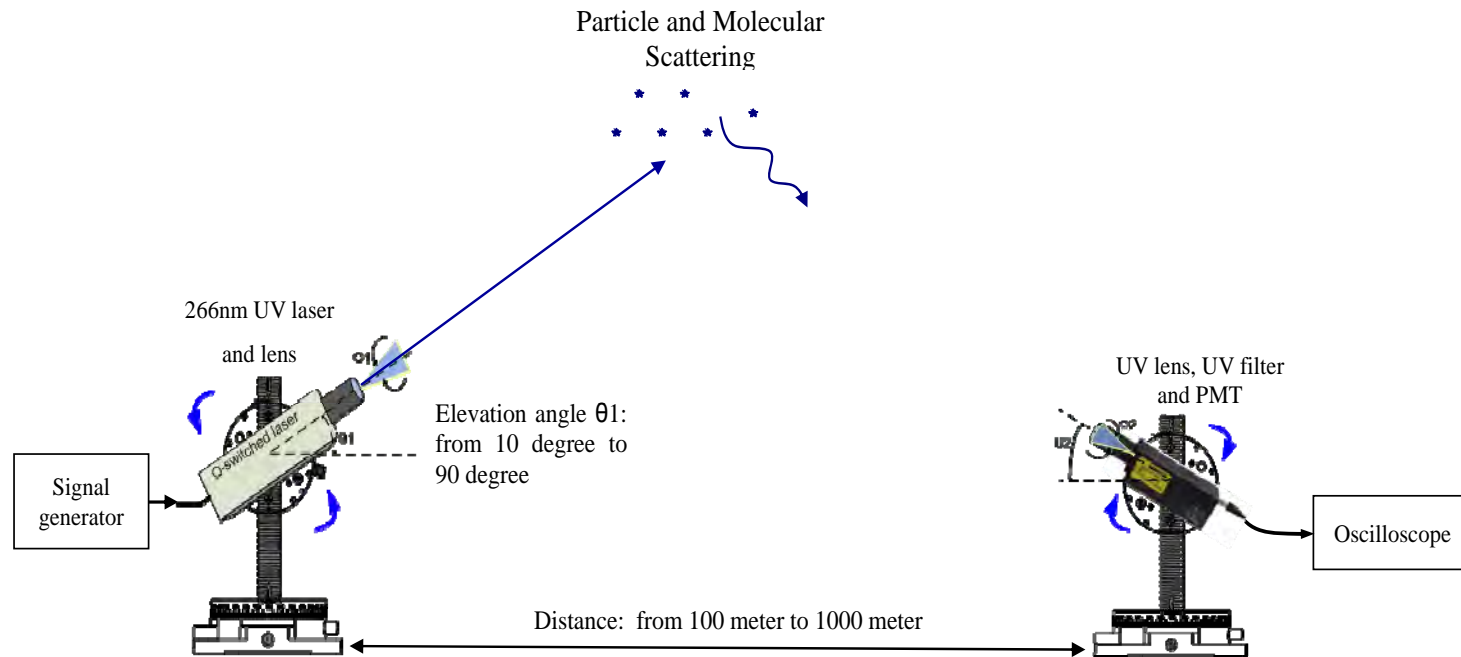
Scitillation PDF for  $r = 500m$



Scitillation PDF for  $r = 1000m$



## 2. UV long distance test bed

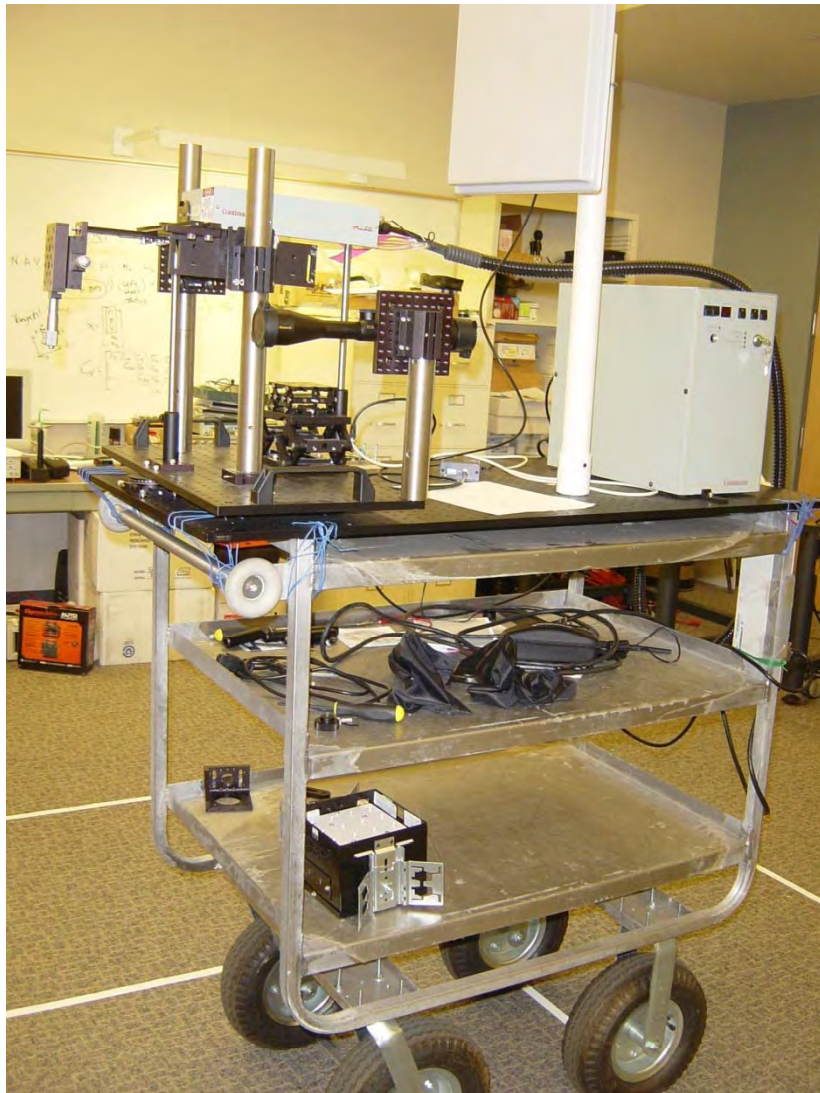


Transmitter :Q-switched fourth harmonic Nd:YAG laser at 266nm  
 15 Hz with pulse width (3-5) ns and energy (3-5) mJ  
 Rotation angle  $\theta_1$   $10^\circ - 90^\circ$

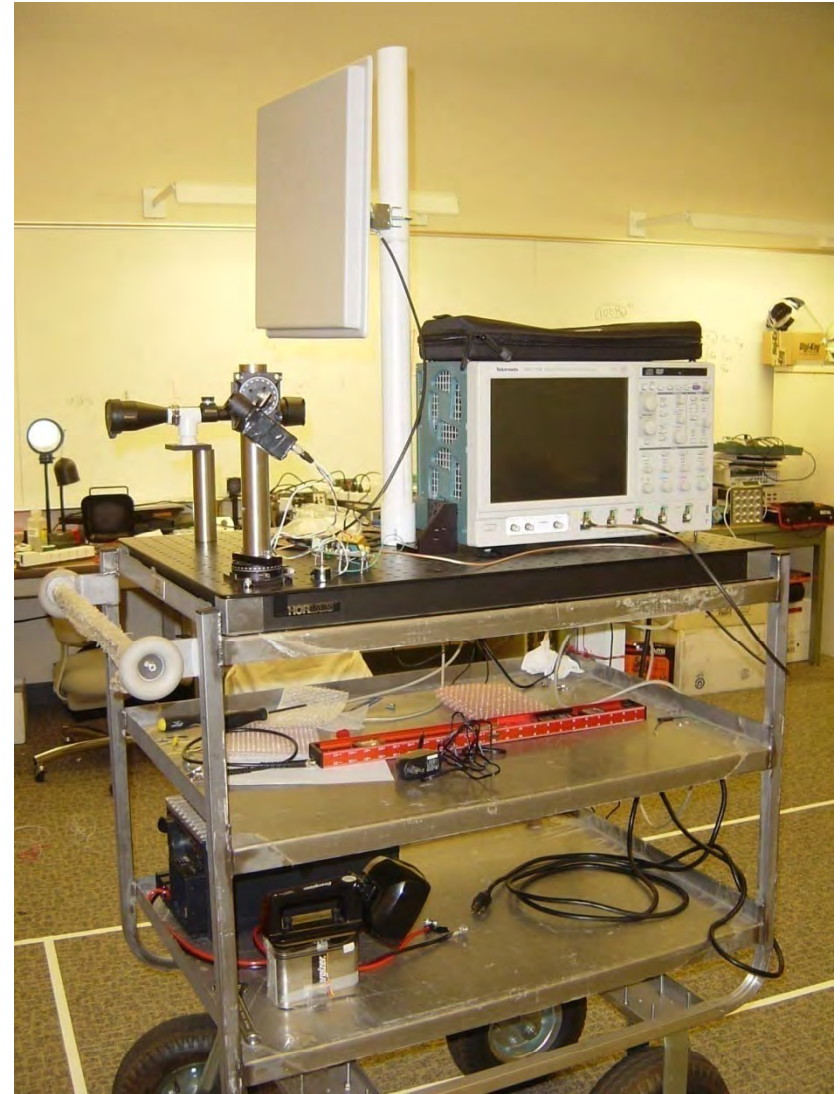
Receiver: PMT detector +high speed preamplifier  $\rightarrow$  3 GHz oscilloscope  
 Waveform record



# UV test bed picture



Laser Transmitter



PMT+ Osc Recorder

### 3. UV system design on SDR platform



#### SFF-SDR from Lyrtech

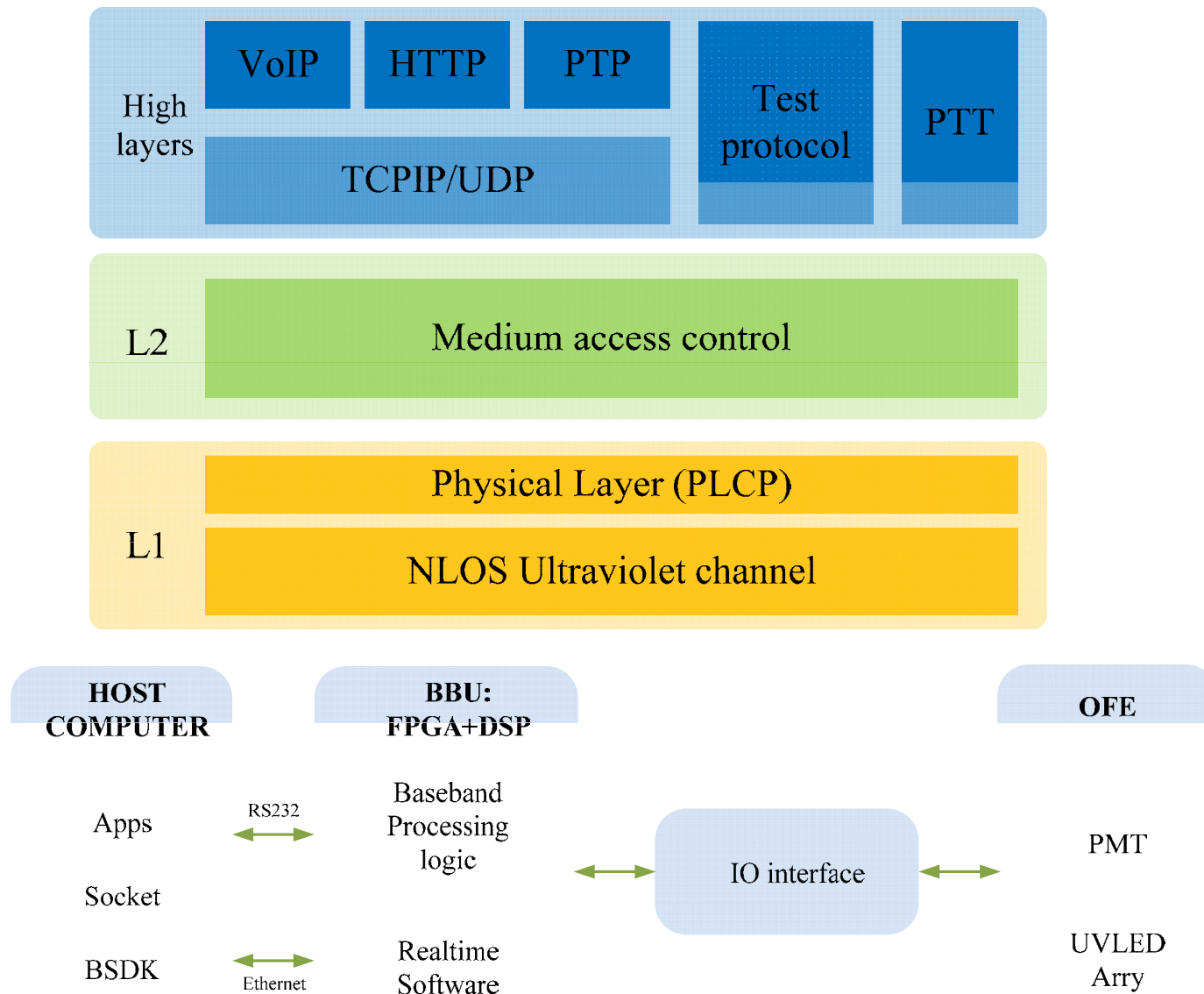
- TMS320DM6446 DM SoC
- 128MB DDR2 SDRAM
- Virtex-4 SX35 FPGA
- 125MSPS, 14-bit ADCs
- Dual channel 500MSPS, 16bit DACs



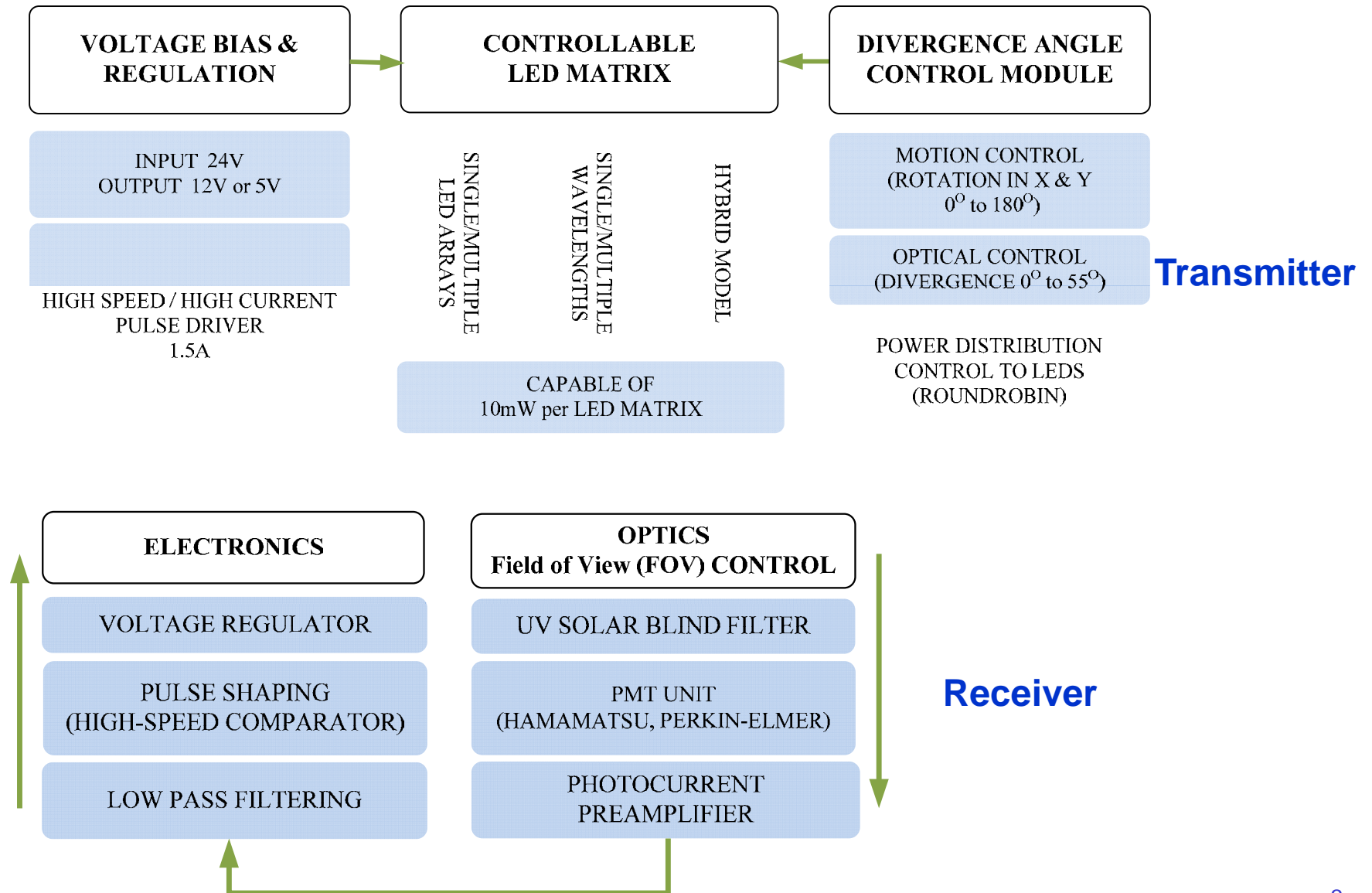
#### The USRP2 from GNU Radio

- Two 100 MS/s 14-bit ADC
- Two 400 MS/s 16-bit DAC
- Gigabit Ethernet Interface
- 2 Gbps high-speed serial interface
- Modular RF daughter boards
- Fully MIMO capable up to 8 nodes
- 1 Megabyte high-speed SRAM

# UV on SDR Architecture and Protocol



# Optical front end design



# Future Work

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- Analytical UV long distance model
- UV long distance channel test and model validation
- Multi-node system protocols design
- Implementation UV front end based on USRP software defined radio platform