Enabling Technologies for Assessing and Assisting Independent Living

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Project Goal: Track and detect

- Medication taking
- Falls and other key activities

Technology: Indoor position that is

- accurate
- non-intrusive
- multi-persons capable, and
- real-time

Technology Choices

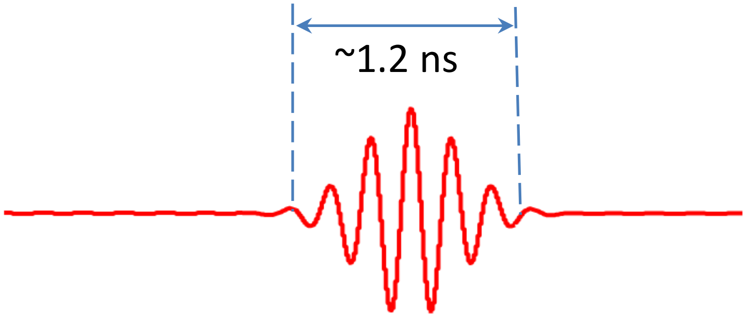
- **Video:** very "intrusive"
- **Indoor location technologies**

Technology	Advantages	Disadvantages
Optical	• Very accurate • Excellent for ranging with line-of-sight (LOS)	• Not suitable for tracking multiple people indoors
Acoustic	• Could cover a large area	• Not suitable for indoors
Relative motion (e.g., accelerometer)	• Simple • Small form factor	• Error accumulates (inaccurate over time)
Radio frequency (RF)		
Angle of arrival (AOA) (bearing)	• Generally simple • Signaling bandwidth is not a concern	• Inaccurate • Not suitable for multiple users
Received signal strength (RSS)	• No synchronization of any kind is needed • Signaling bandwidth is not a concern • Very simple to deploy	• Accuracy is generally poor • Requires site-specific path loss survey • Not robust in changing environments
Time of arrival (TOA)	• Much higher accuracy than RSS & AOA systems if a large bandwidth is available • Easy to support multiple users	• Requires synchronization of transmitter and all receivers • Multipath might affect accuracy
Time difference of arrival (TDOA)	• Much higher accuracy than RSS & AOA systems if a large bandwidth is available • Easy to support multiple users	• Requires synchronized receivers • Multipath might affect accuracy

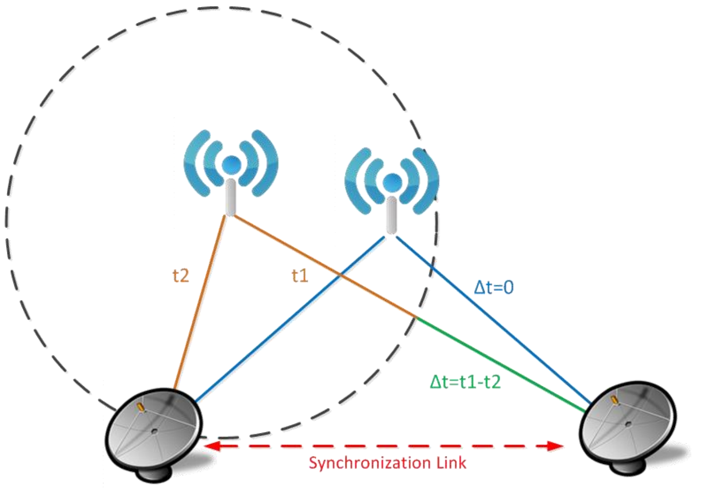
Prototypes 1 and 2 – Technology

Pulsed Ultrawideband

- Operates in 3.1-4.6 GHz

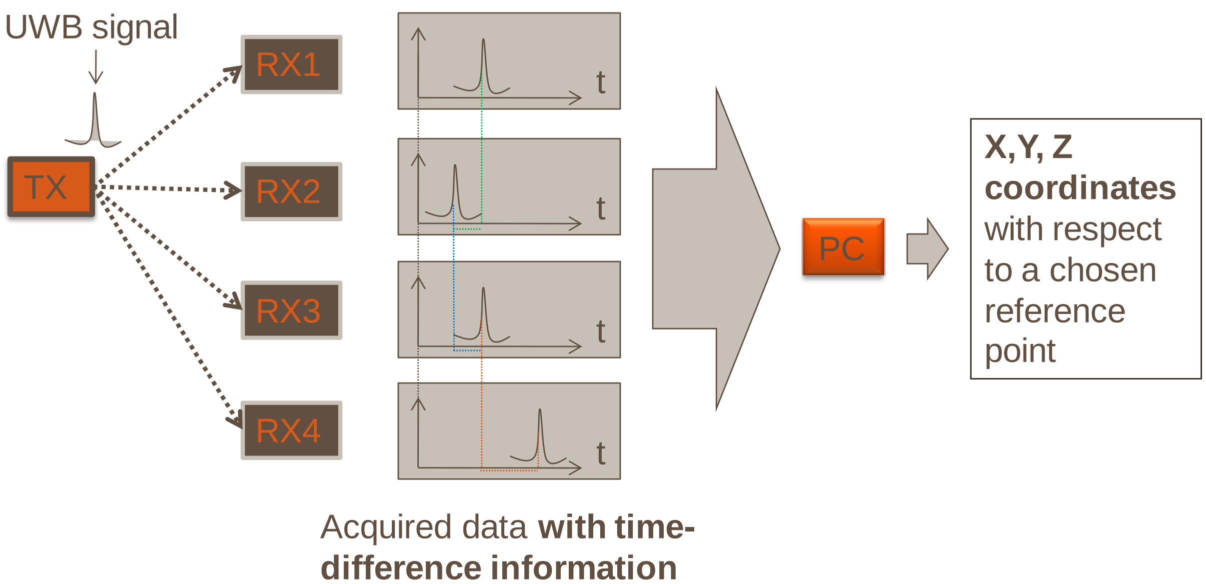


- TDOA for 3-dimensional (3D) position
  - ➢ Minimum of 4 receivers
  - ➢ Multipath reduction
  - ➢ Wire-connected or Wirelessly synchronized receivers



Prototype 1 – System

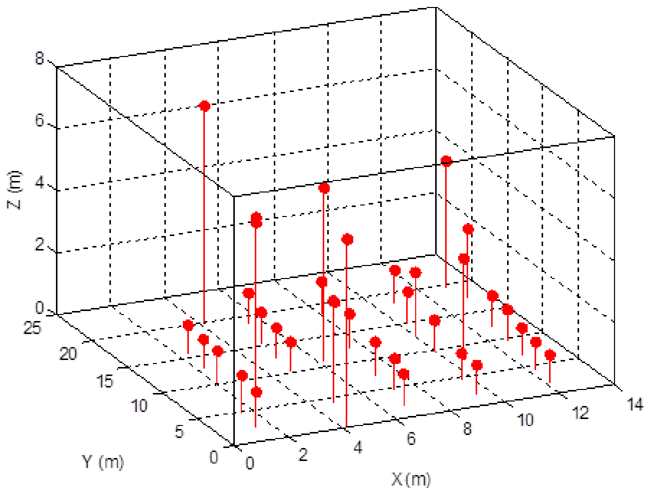
- Wire-connected receivers
- System functional blocks



- Laser measured receiver and target locations as reference

Prototype 1 – Measurement Results

- Experiments in a large vacant building
- Coverage area: ~25 x 20 x 4 m^3
- Grid of target locations

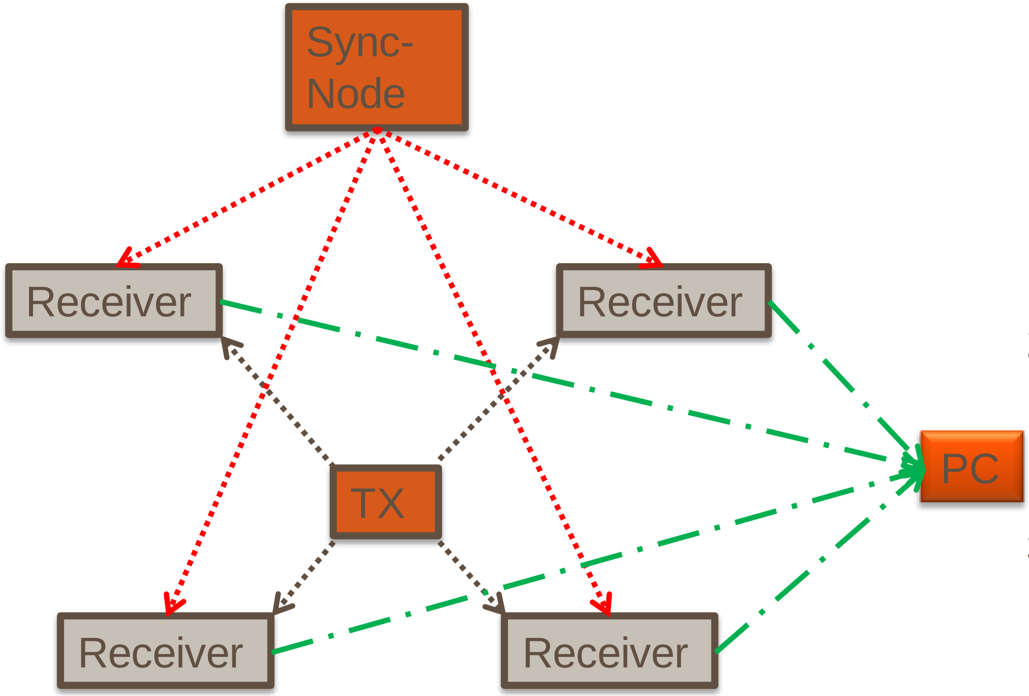


- **Results:**

	x-coordinate	y-coordinate	z-coordinate
Ave. error (cm)	1.697134	1.080181	8.650963
Error std (cm)	1.231737	0.904521	6.149895

Prototype 2 – System

- Wirelessly synchronized receivers
- System functional blocks

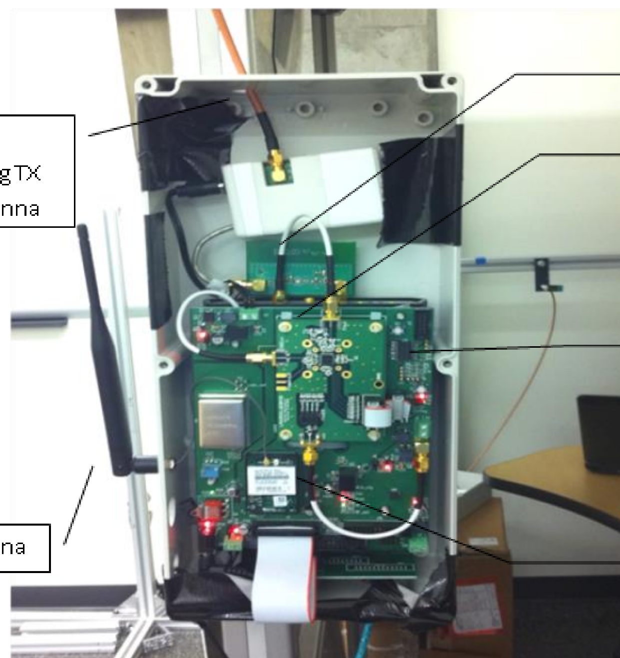


1. System synchronizes on an UWB signal (⋯>) and transmits data to the PC (→)
2. After synchronization, localization signals are acquired (→) and sent to the PC (⋯>)
3. PC calculates fine synchronization and the location

Prototype 2 – Hardware

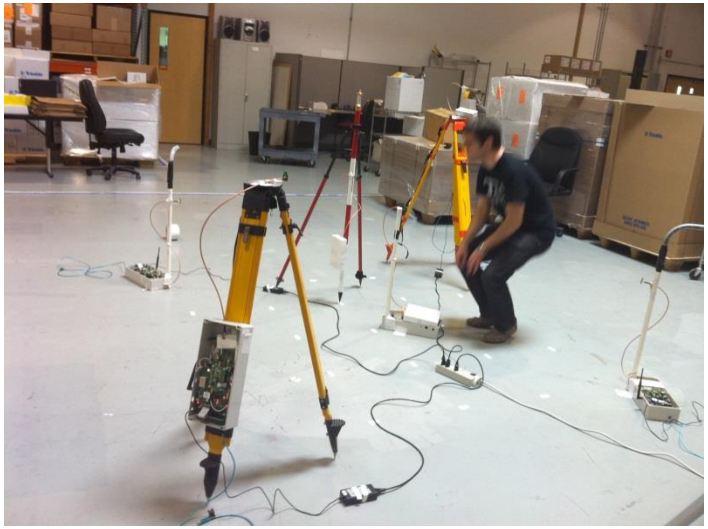
Algorithms and control of the whole system

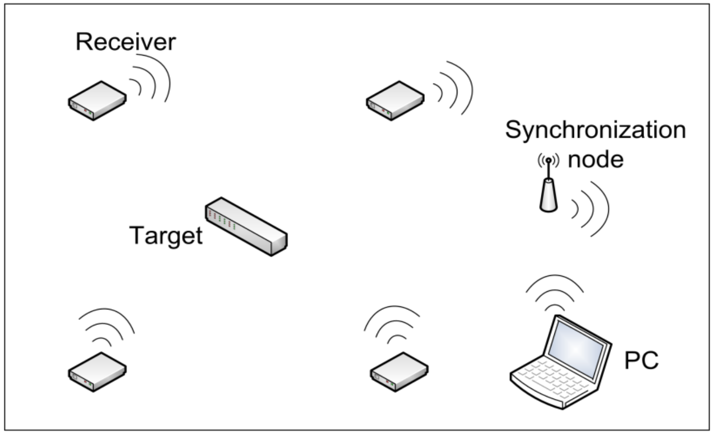
Receiver (Rx) prototype: all Rx's operate independently, all data exchange via a wireless channel



Prototype 2 – Measurement Results

- Experiments in a lab
- Coverage area: ~5 x 5 x 3 m^3
- Four receivers per network with 1 synchronization node
- **Results**
  - ➢ Timing synchronization precision: ~80 picoseconds
  - ➢ Location accuracy: 2-3 cm

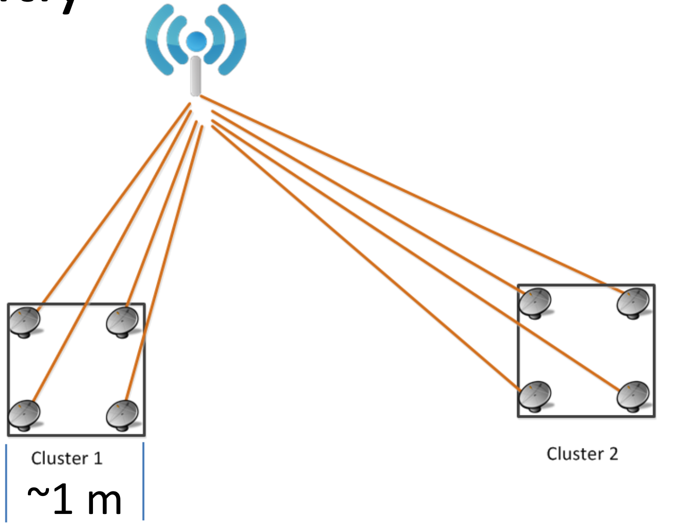




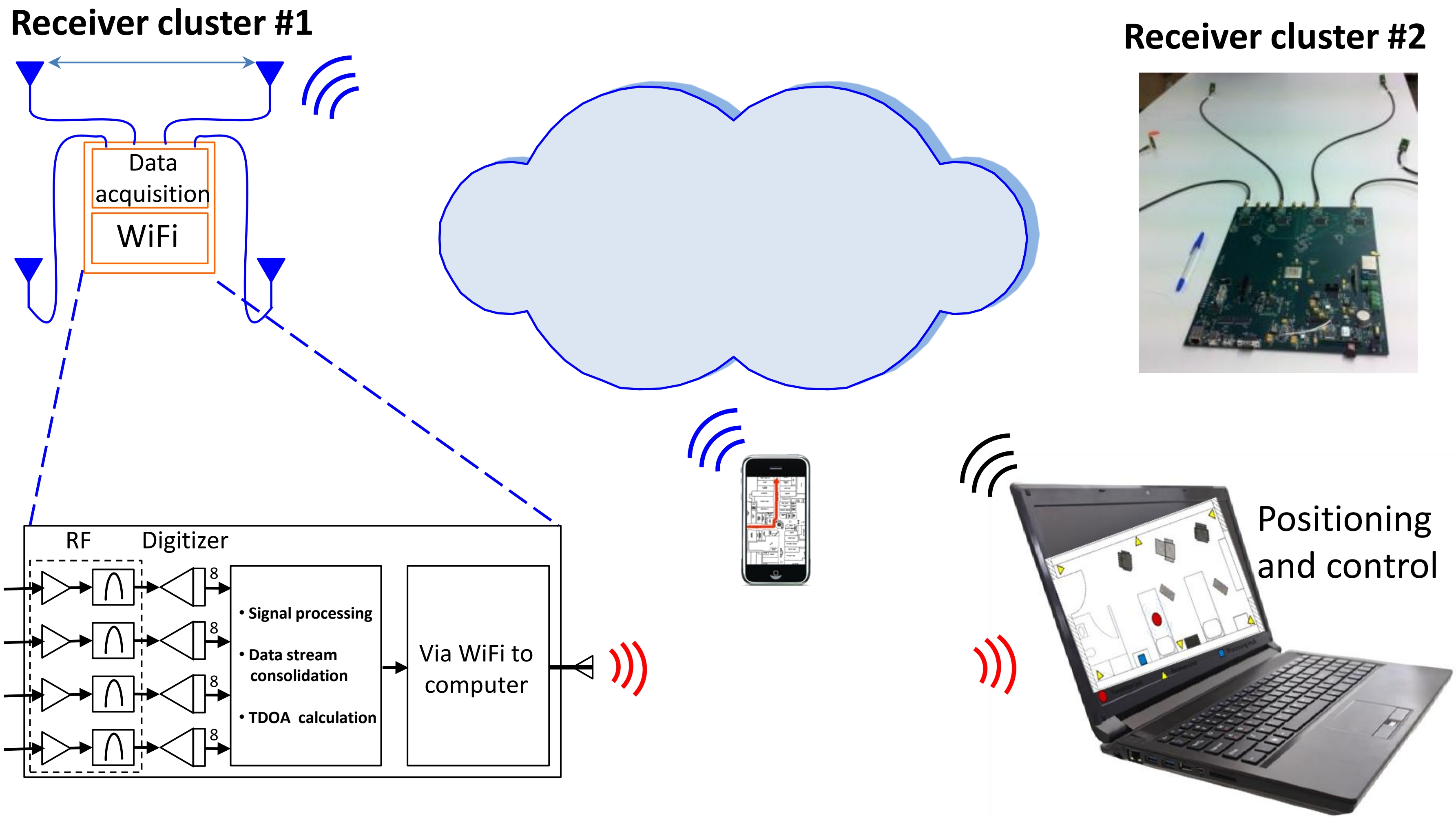
Prototype 3 – Technology

TDOA position without synchronization

- Can operate in WiFi or UWB frequencies
- TDOA with clustered receivers for 3D position
    - ➢ Minimum of 2 clusters per area needed
    - ➢ Clusters operate independently



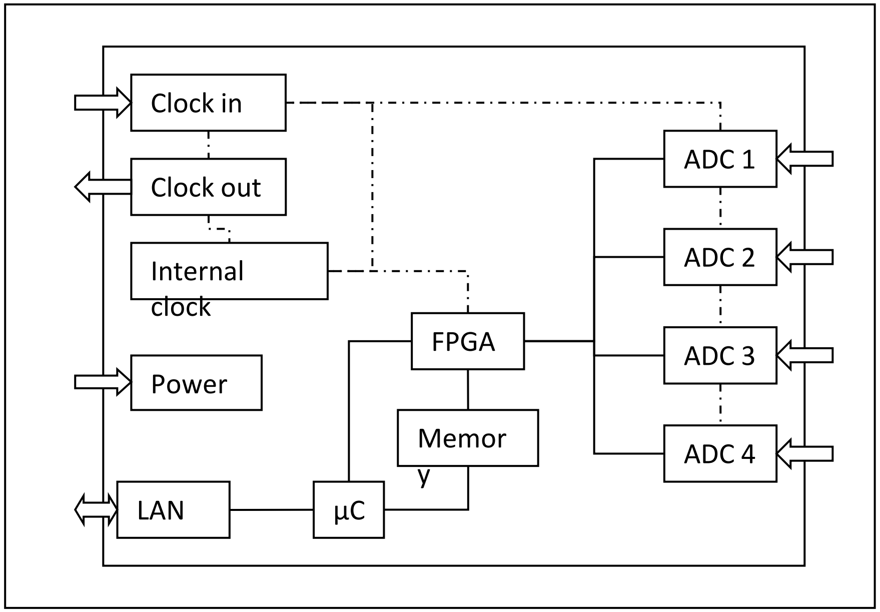
Prototype 3 – System

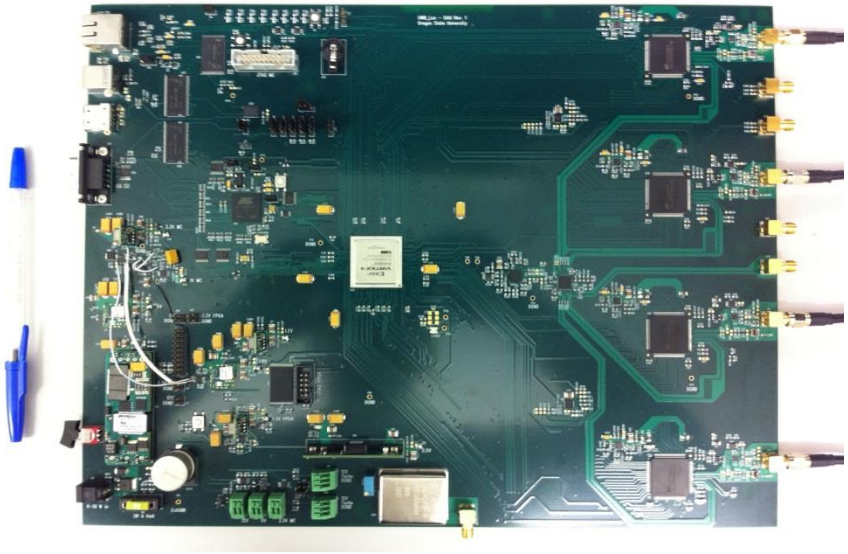


Prototype 3 – Hardware

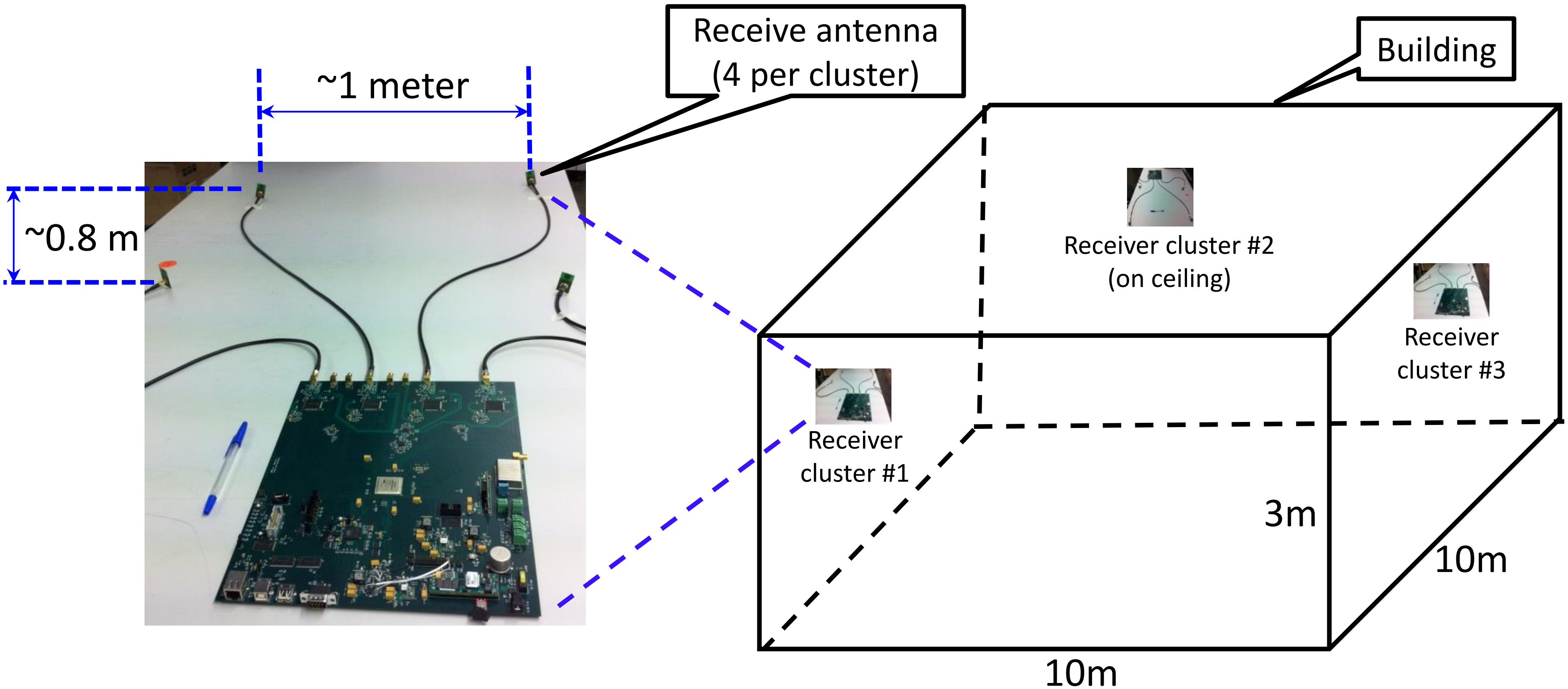
Data-acquisition unit

- Four simultaneous channels, each running at 3 Gsps
- Real-time operation
- Data transfer via Ethernet or WiFi





Prototype 3 – Measurement Results



- **With WiFi at 3 typical locations:**

	x (m)	y (m)	z (m)								
Radio measured	3.5462	3.81	1.524		3.5462	4.88	1.524		4.69	4.53	1.524
Laser measured	3.3312	3.904	1.2853		3.3898	4.9947	2.4855		4.9283	4.7864	1.9136
Error (m)	**0.215**	**-0.094**	**0.2387**	**Error (m)**	**0.1564**	**-0.1147**	**-0.9615**	**Error (m)**	**-0.2383**	**-0.2564**	**-0.3896**

- **With pulsed UWB transmitter (battery-powered, watch-sized): ~5 cm**