USING A SPLIT MODEL IMPROVES THE SIMULATION OF INDUSTRIAL ENVIRONMENT PROPAGATION CONDITIONS

Sabri Benferhat, Michel Misson

LIMOS-CNRS, Network and Protocols Team, Blaise Pascal University B.P. 86, 63172 Aubiere Cedex, France

{Sabri, Misson}@sancy.univ-bpclermont.fr

ISART 2-4 JUNE 2008

Outline

- **Industrial Environment**
- **Measurement Process**
- **Obtained Measurements**
- **Results per Track**
  - Pr Vs D Model per Track
- Comparison with ITU R-1238
- **Results per Link Type**
  - Pr Vs D Model per Link
- **Simulation and Results**

Industrial Environment

- **Lack of information about industrial environments**
  - **Not much information available about performance of wireless technologies in industrial environments.**
  - **In most literature only office use is considered.**

- **The purpose of our study**
  - **Wireless LAN deployment in an industrial environment**
  - **Developing propagation models reflecting our environment for simulation tools**
  - **Determining coverage area of different transmitter**
  - **Compare measured performances and those given by a simulation process**

- **The goal of the study is to propose a way to simulate traffic conditions within an 802.11 cell overlapping an industrial area.**

Industrial Environment

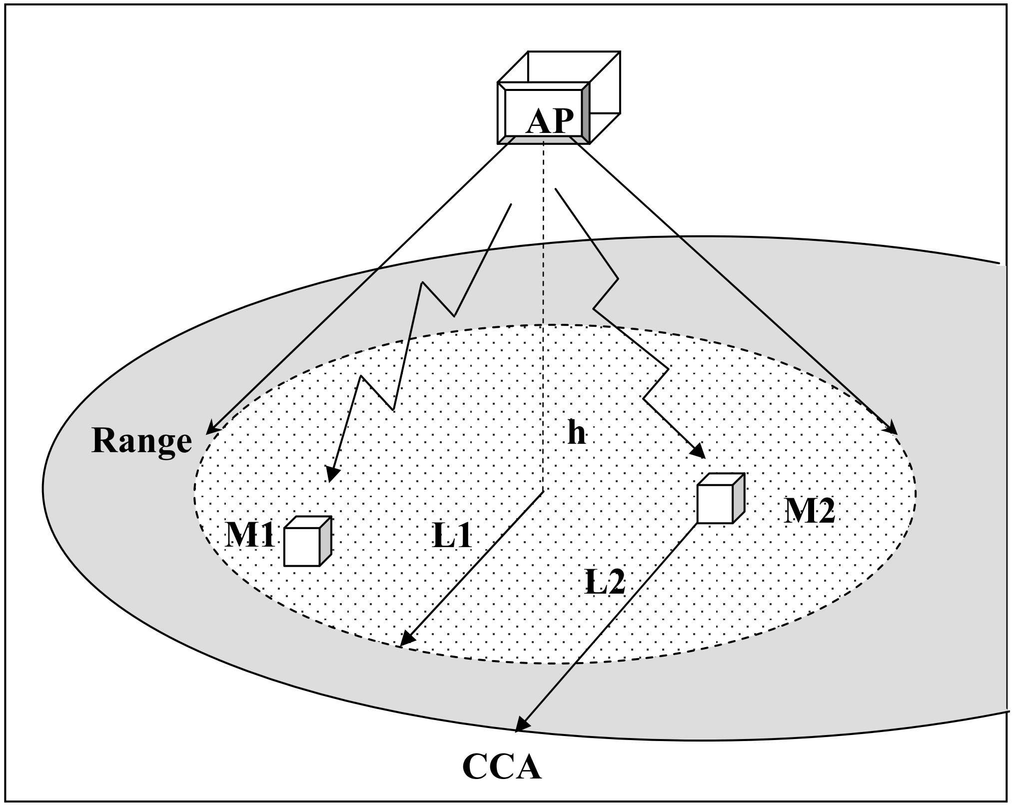
- **Industrial environments**
  - Harsh
  - Obstructions
  - Steel constructions
  - Extreme temperature
  - Nearby machinery, vibration
- **Results**
  - interference
  - Heavy multi-path fading
  - Fast/slow fading
  - Local variations in received power
  - **Hidden node problems**

Industrial Environment

- Deployment by positioning Access point
- Cell depend on propagation
- Cartography the received power
- Ensure QoS (throughput, delay,…)
- Performance measured very different from those obtained from simulation
- Impact of physical layer on higher layer in simulation

Industrial Environment

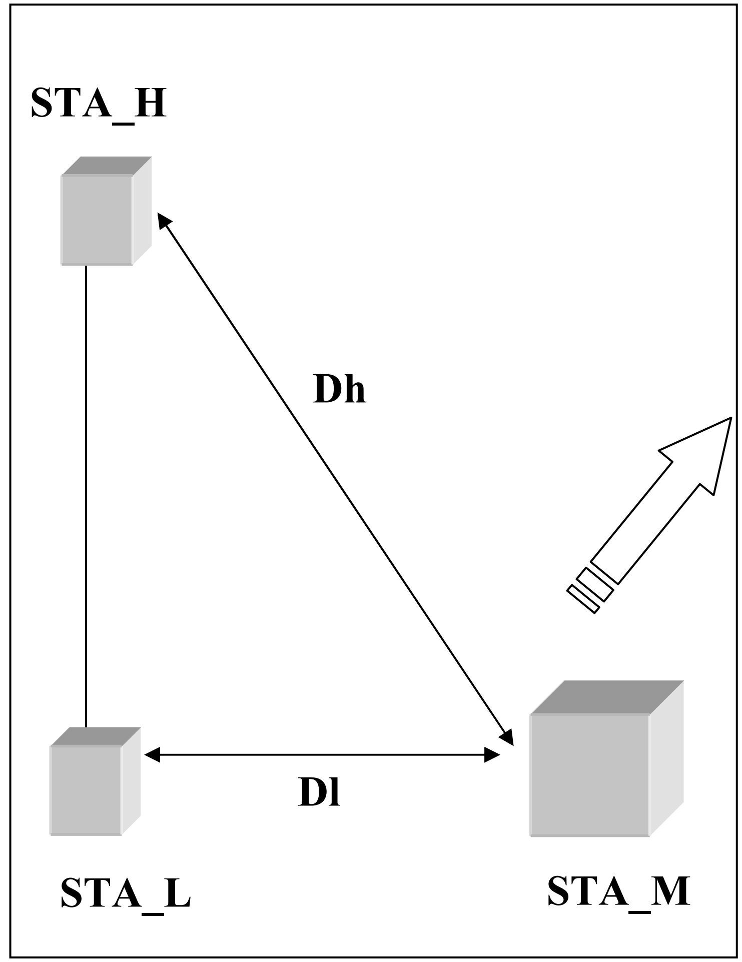
- 802.11
- Infrastructure mode
- Access Point (AP)
- L1 range of AP at 11Mbps Receive Sensitivity = -82 dBm
- L2 detection activity CCA_threshold = -95dBm
- Any activity is detected by station
- Impact of machinery on propagation conditions



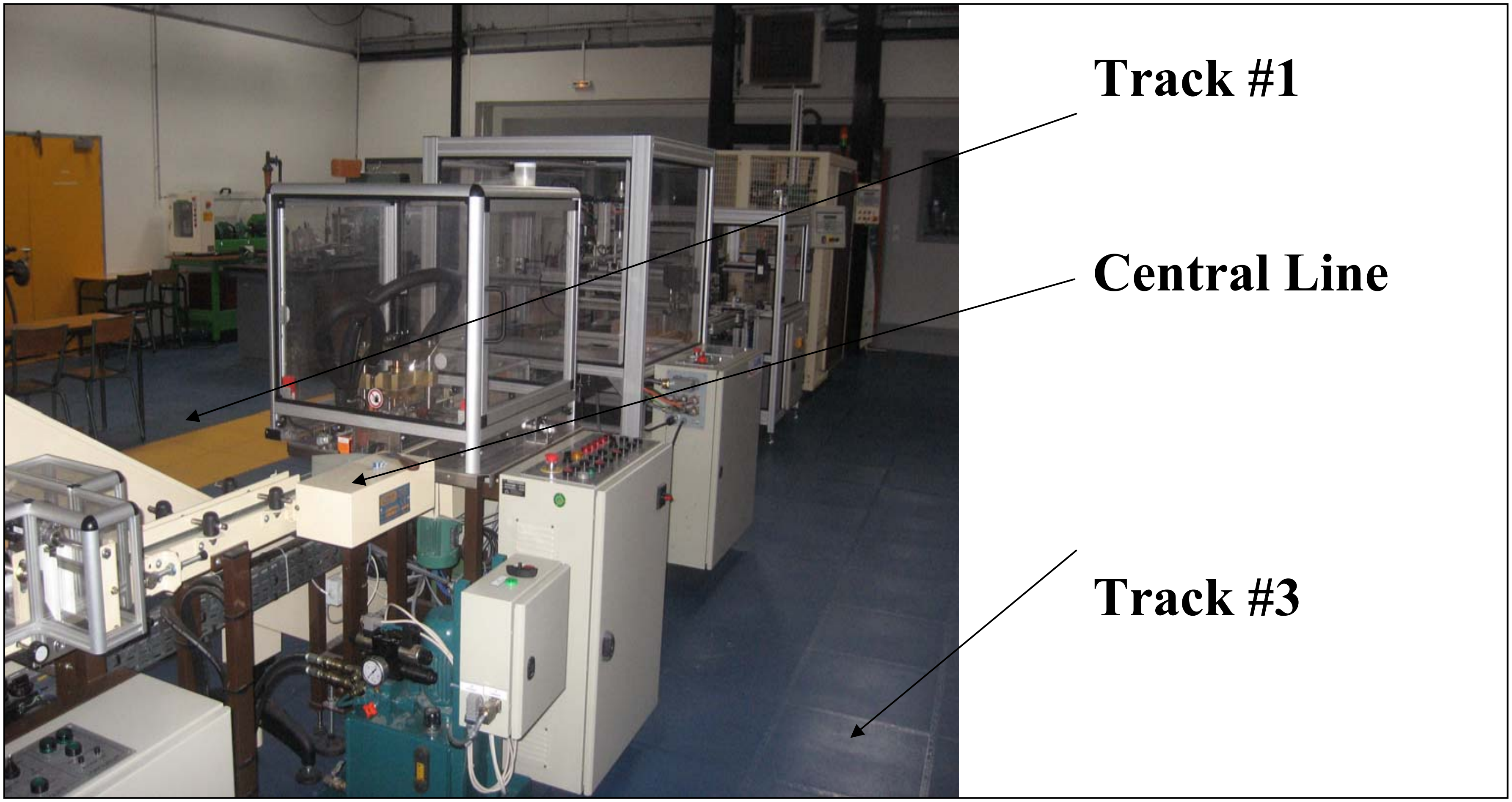
Stations on ground are able to detect any activity on channel ?

Measurement Process

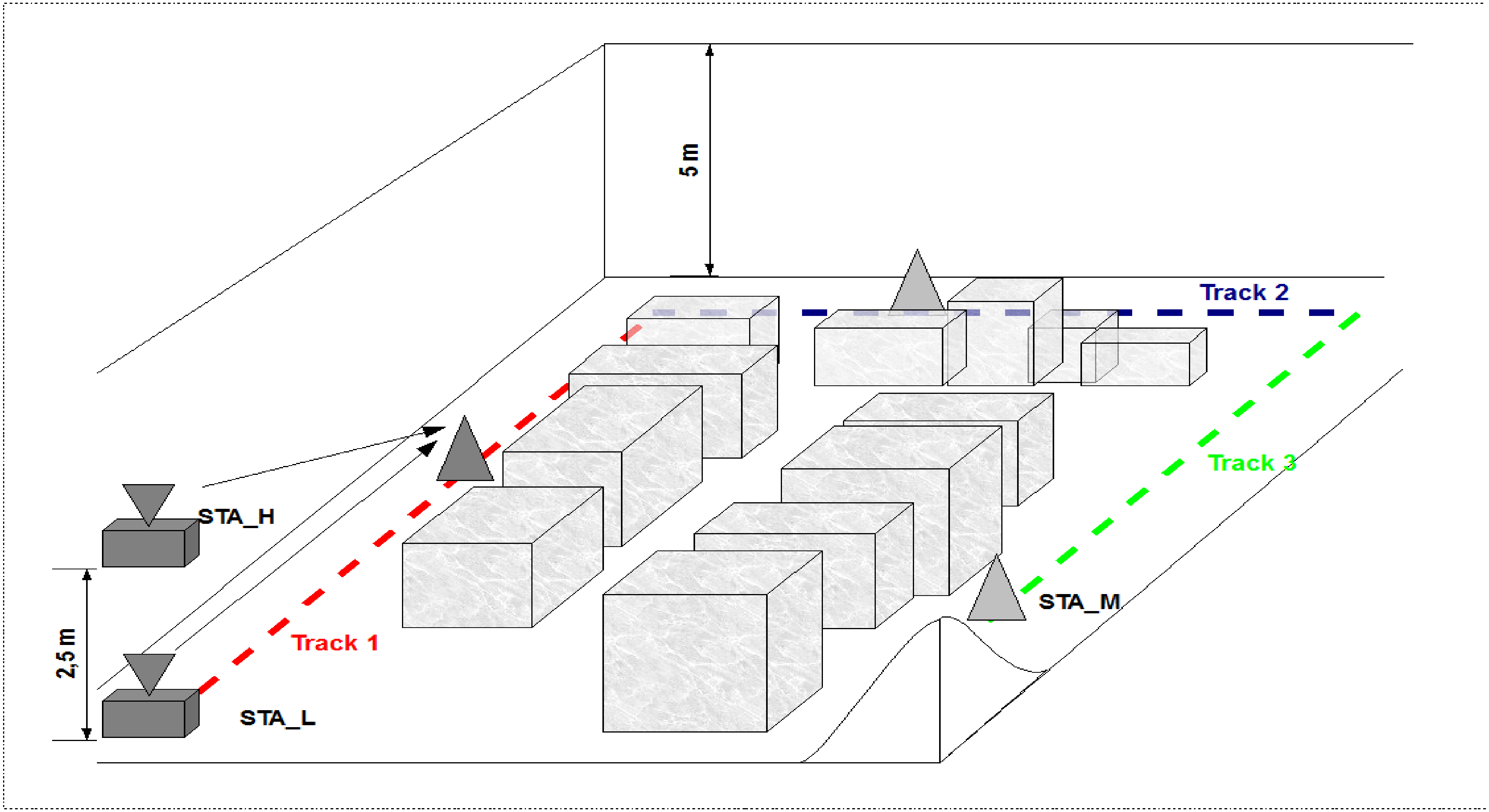
- **Difference in propagation conditions**
- **The CCA (-95 dBm) is defined with a model other than the one which defines receive threshold (-82 dBm)**
- **Study the conditions of propagation**
  - Path loss effects between mobile and 2 fixed stations
  - High station (STA_H) located at 2.5m
  - Low and mobile station at 50cm above ground.
  - Measure received power strength at both fixed point



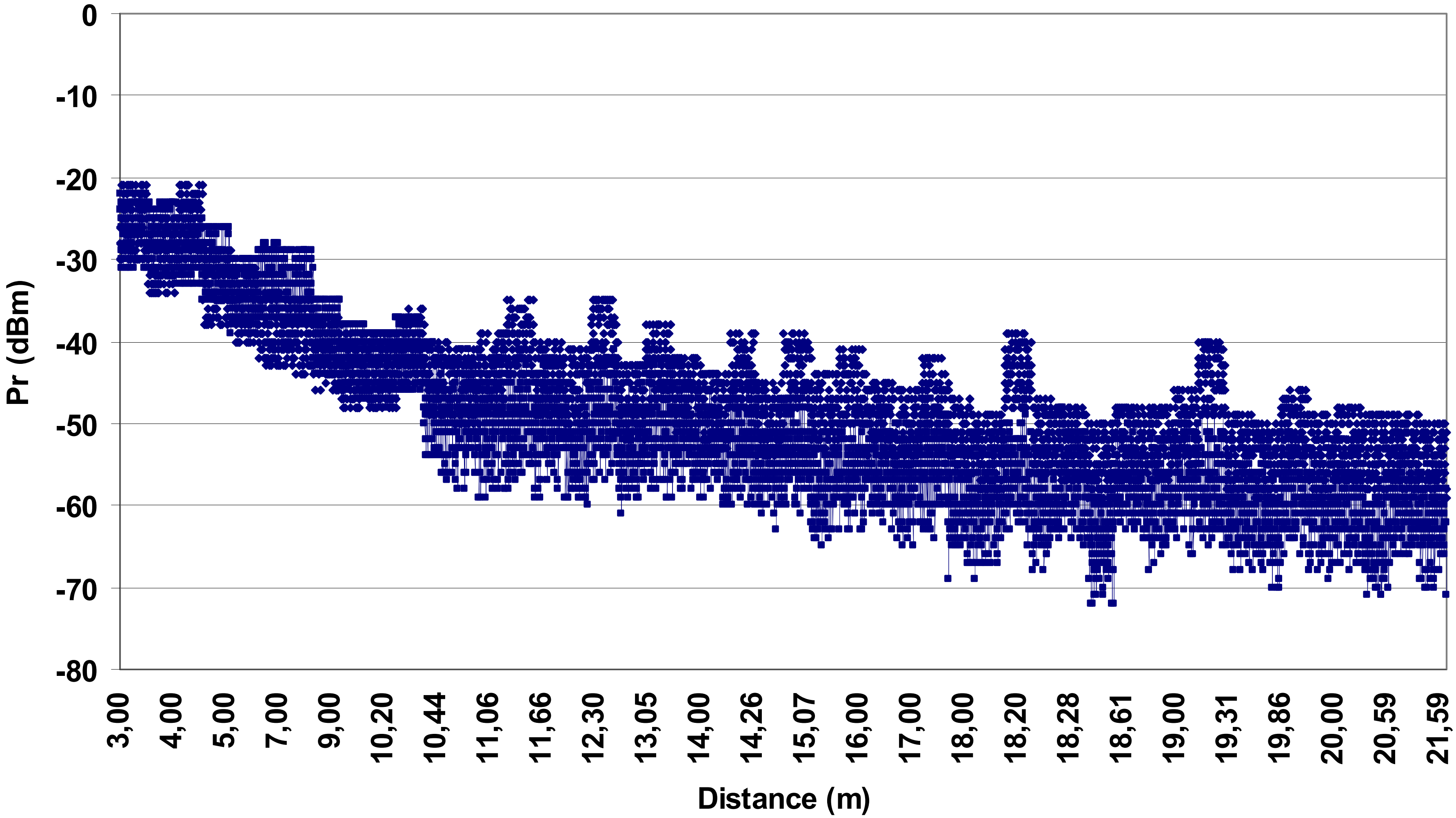
Industrial Environment



Measurement Environment

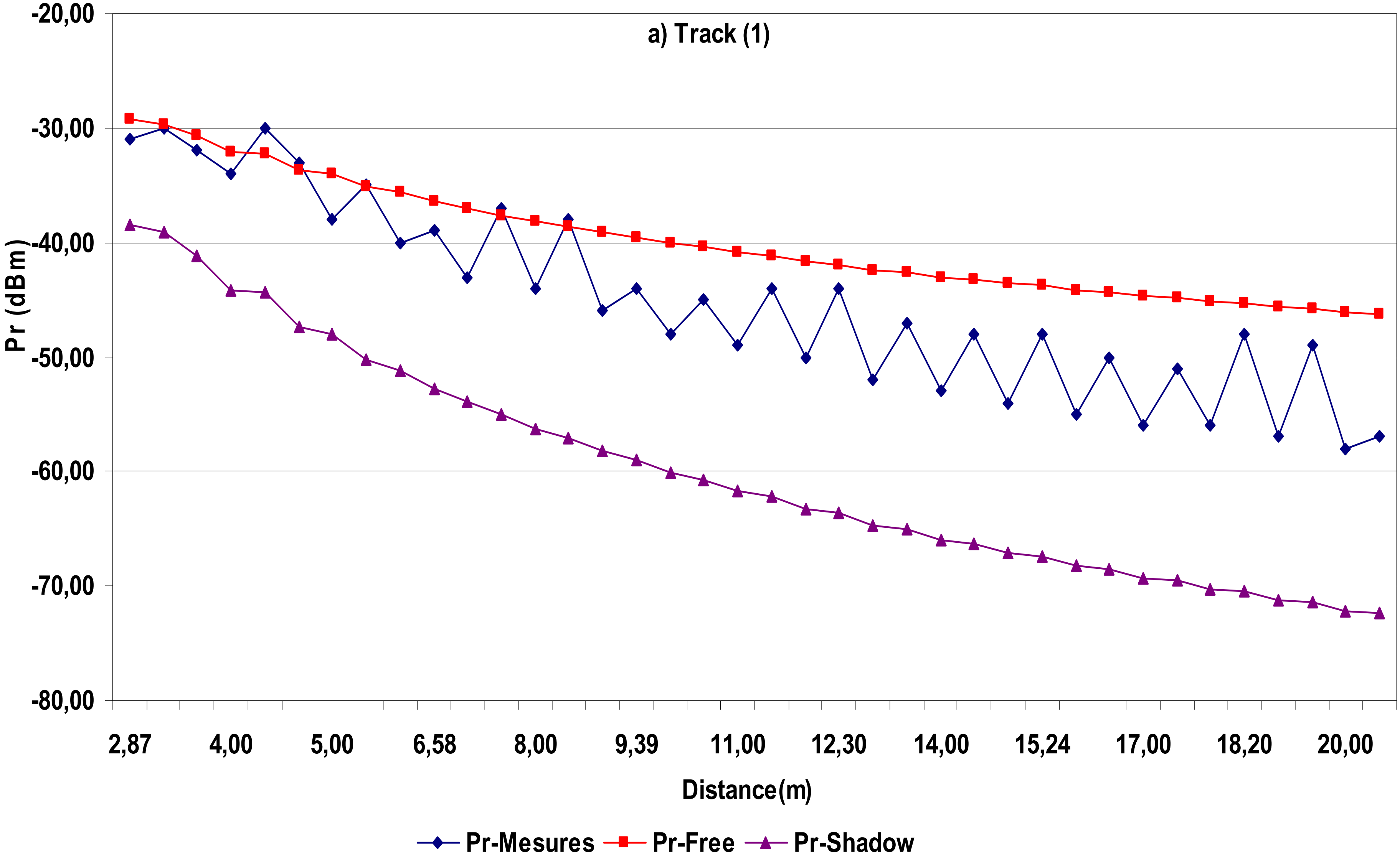


Obtained Measurements

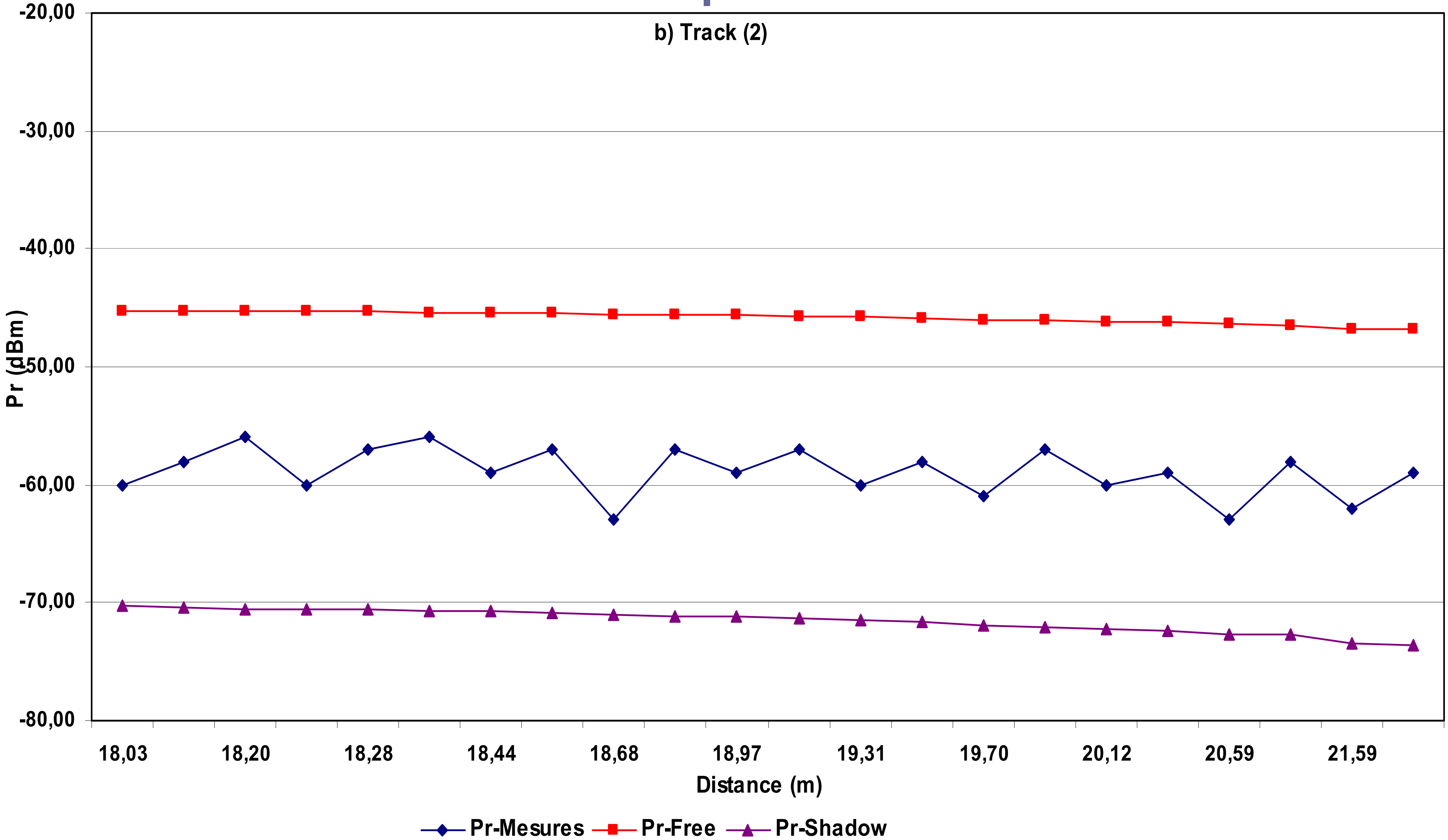


received power at a distance (d)

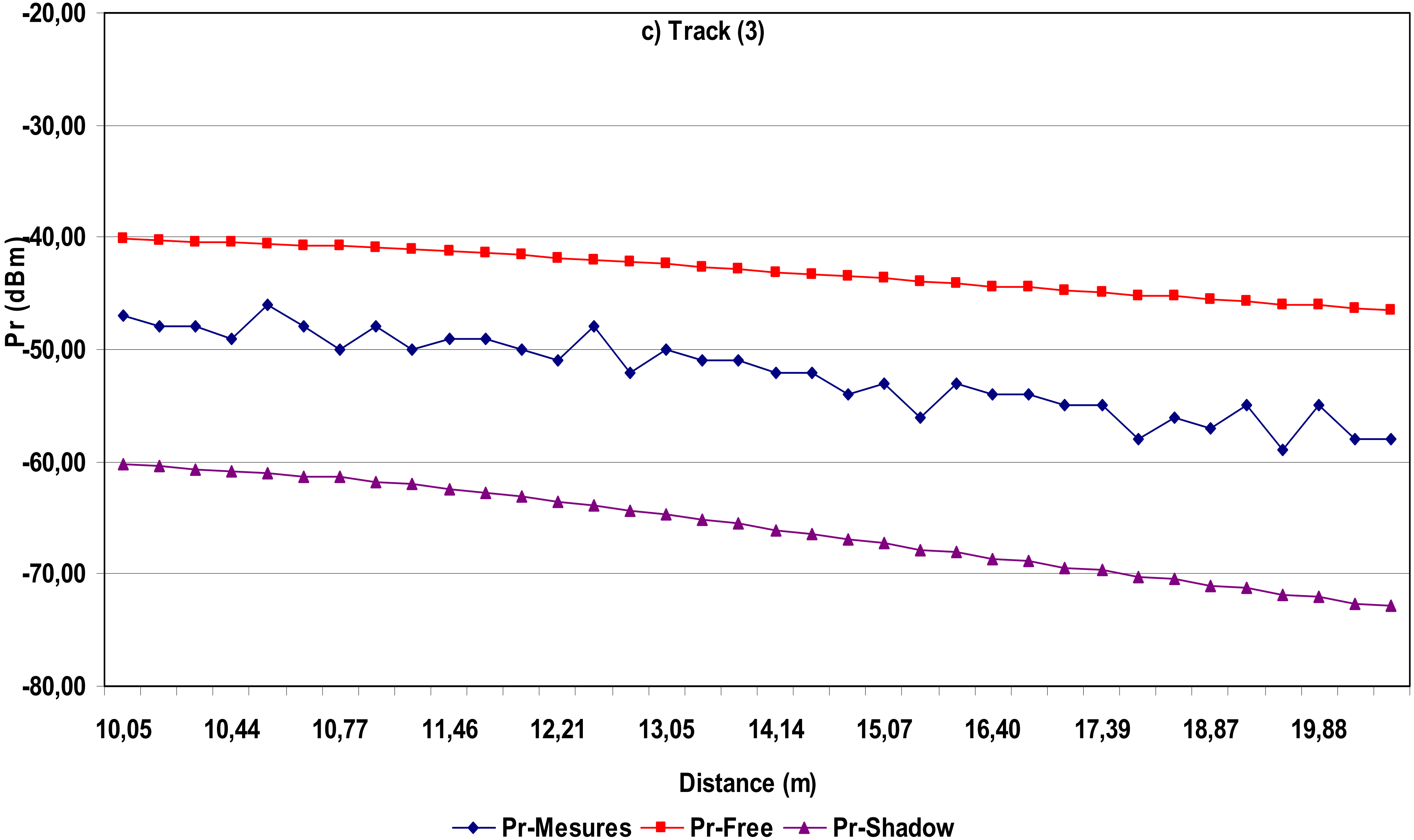
Results per Track



Results per Track



Results per Track



Obtained Measurements

- **Adjusting the parameters of the generic formula:**
  $Pr = Pt+Gt+Gr-(Ctv+N*Log10(D)+X(\delta))$
  - Pr received power
  - Pt transmitted power in dBm (in our case 20 dBm)
  - Gt and Gr transmitter and receiver antenna Gain
  - Ctv takes into account the frequency used, antenna cable losses …
  - D distance between the transmitter and the receiver
  - X(δ) random component with δ standard deviation to take into account shadowing effect
- **D and Pr are known**
- **N and δ depend on the type of building**
- **Use linear regression evaluate path loss exponent N and Ctv**
- **Evaluate standard deviation δ**

SMALLER VALUE OF δ INDICATES BETTER ACCURACY OF THE PATH LOSS MODEL

Pr Vs D Model per Track

Area	Model	Average X(δ) Normal law
Track #1	$Pr = 20 - (49.54 + 24.65 \, Log_{10}(D) + X(9.07))$	-3.89^{E-12}
Track #2	$Pr = 20 - (28.66 + 46.05 \, Log_{10}(D) + X(8.00))$	-0.01
Track #3	$Pr = 20 - (43.51 + 32.92 \, Log_{10}(D) + X(8.98))$	3.48^{E-13}
Track 1&2&3	$Pr = 20 - (43.52 + 32.57 \, Log_{10}(D) + X(9.04))$	1.87^{E-12}

- Path loss coefficient **N** is between 2 and 4
- Great value for **δ**

Comparison with ITU R-1238

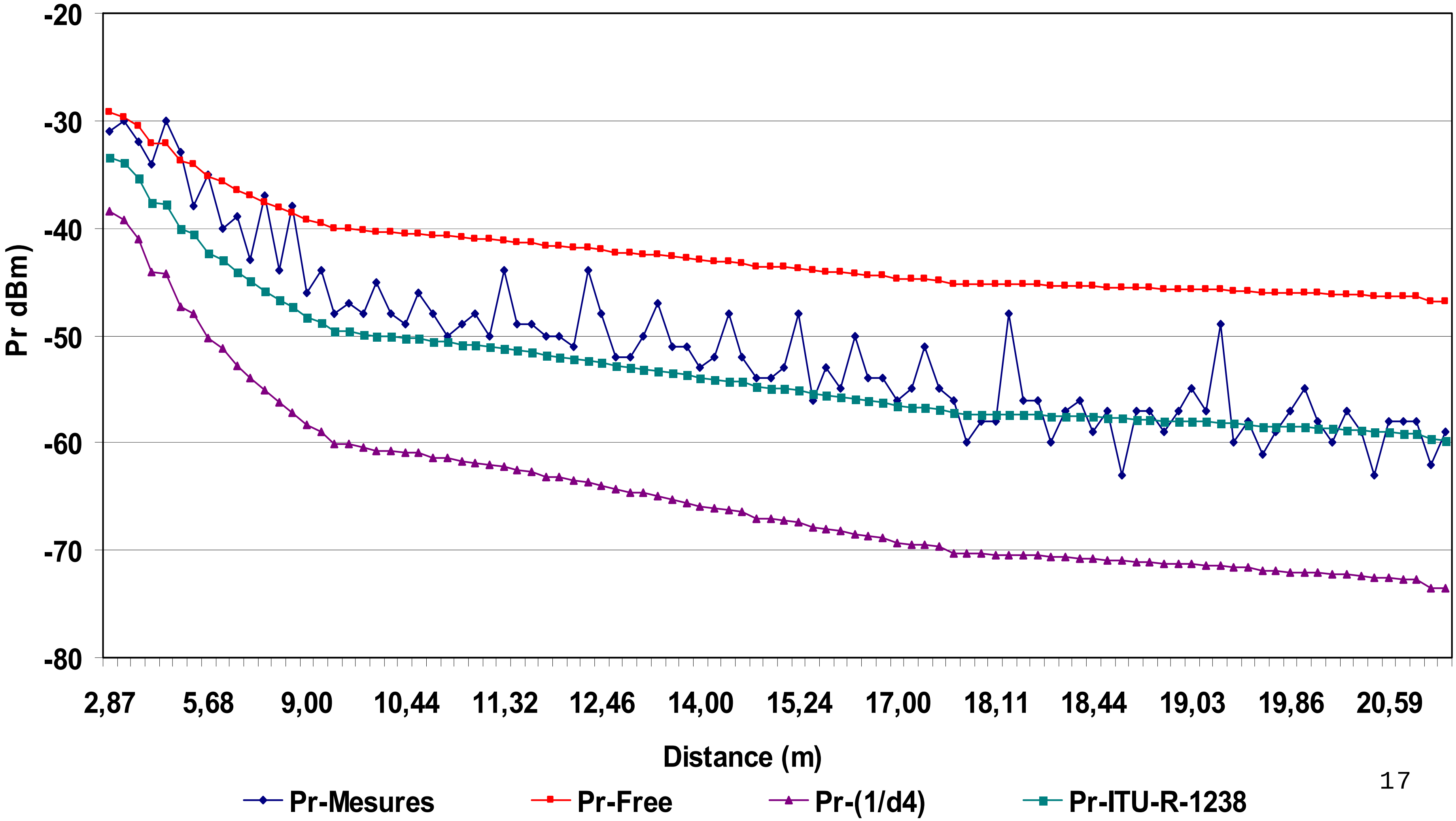
- $Pr = Pt – (20 \, Log10 \, f + N \, Log10 \, (D) + Lf – 28 + X(\delta))$

Where:

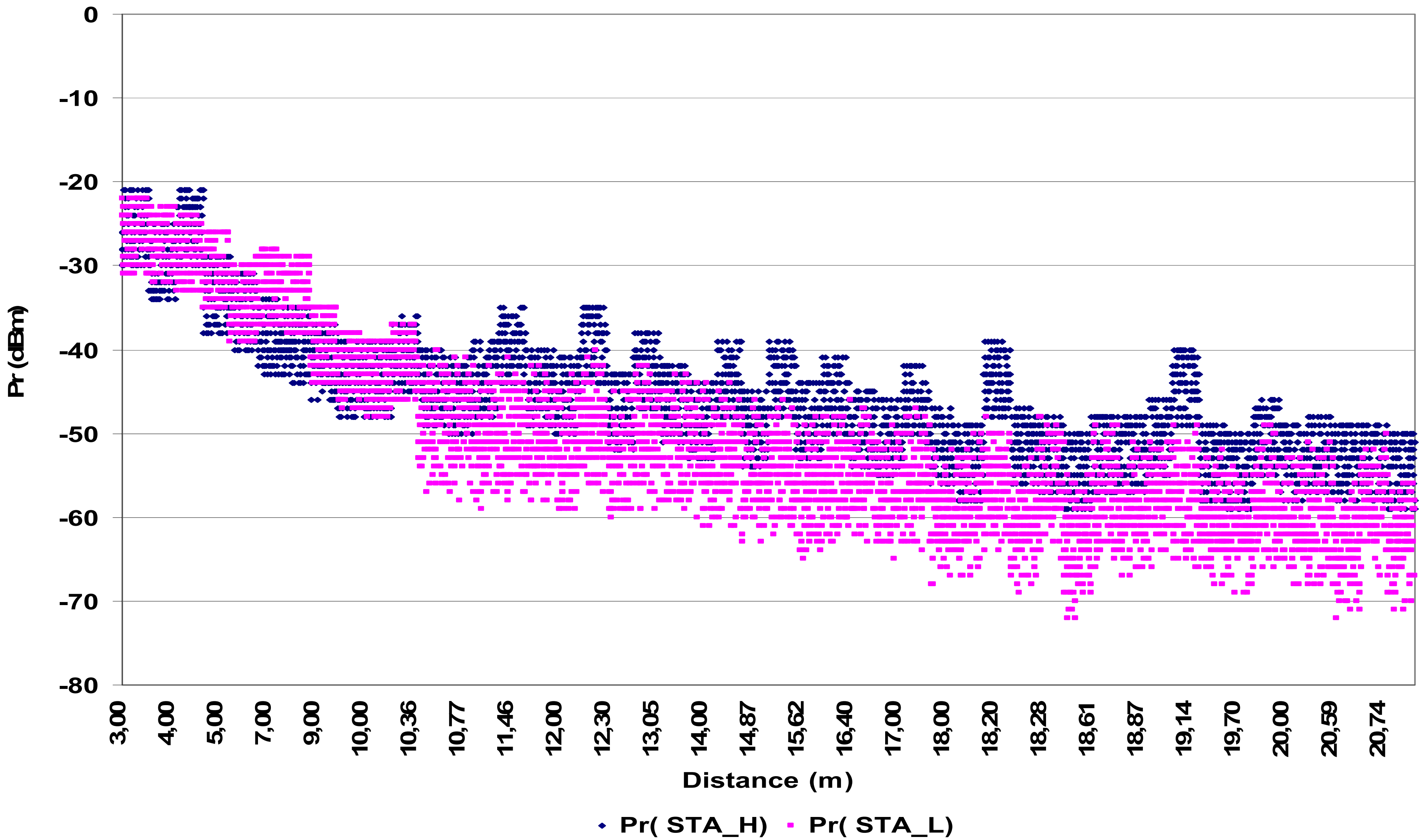
- N: distance power loss coefficient, depend on the type of building
- f: frequency (MHz)
- D: separation distance (m) and D >1m
- Lf: floor penetration loss factor (dB)
- $X(\delta)$ random component

Comparison with ITU R-1238

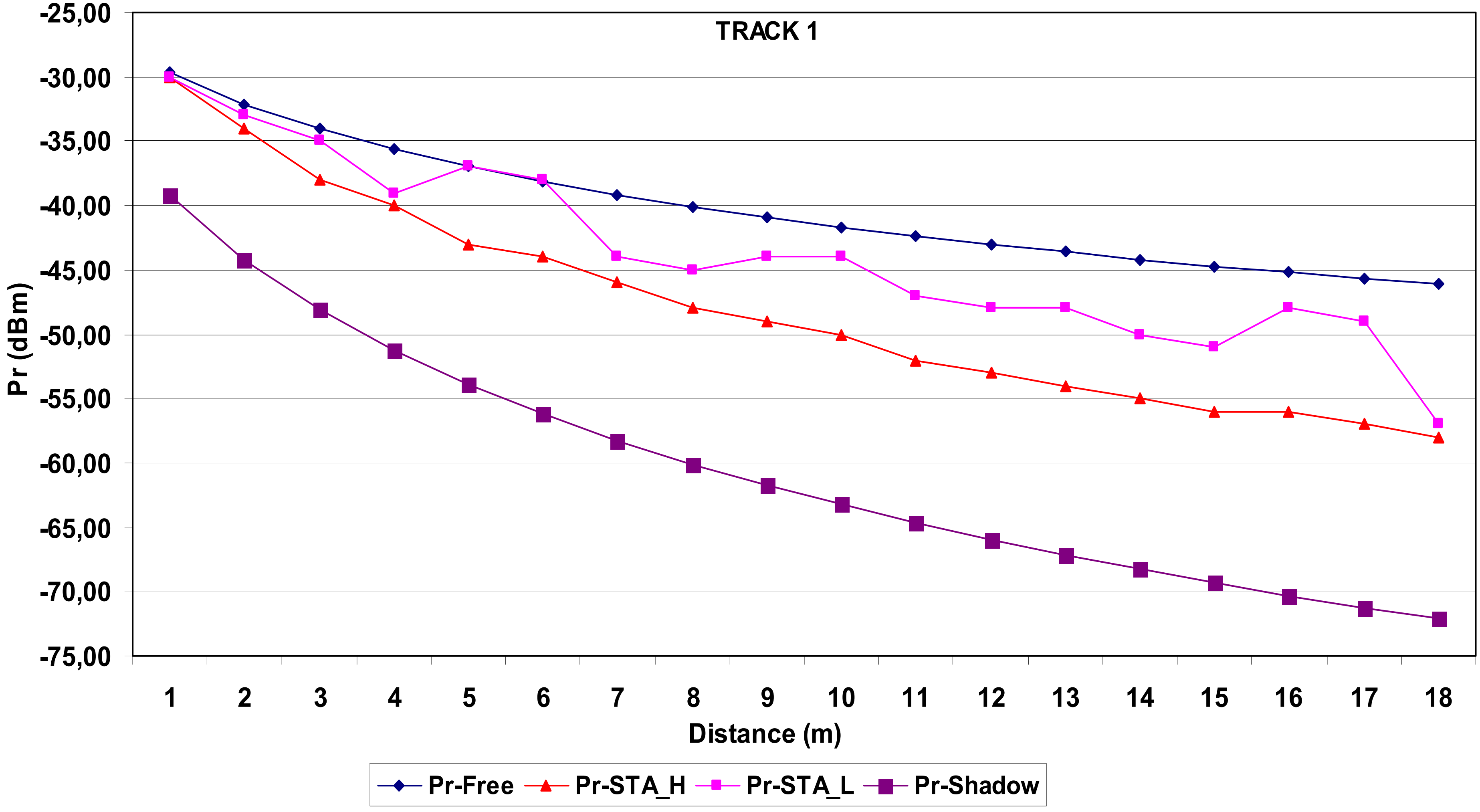
- Pr = Pt – (20 Log10 f +N Log10 (D) + Lf– 28)



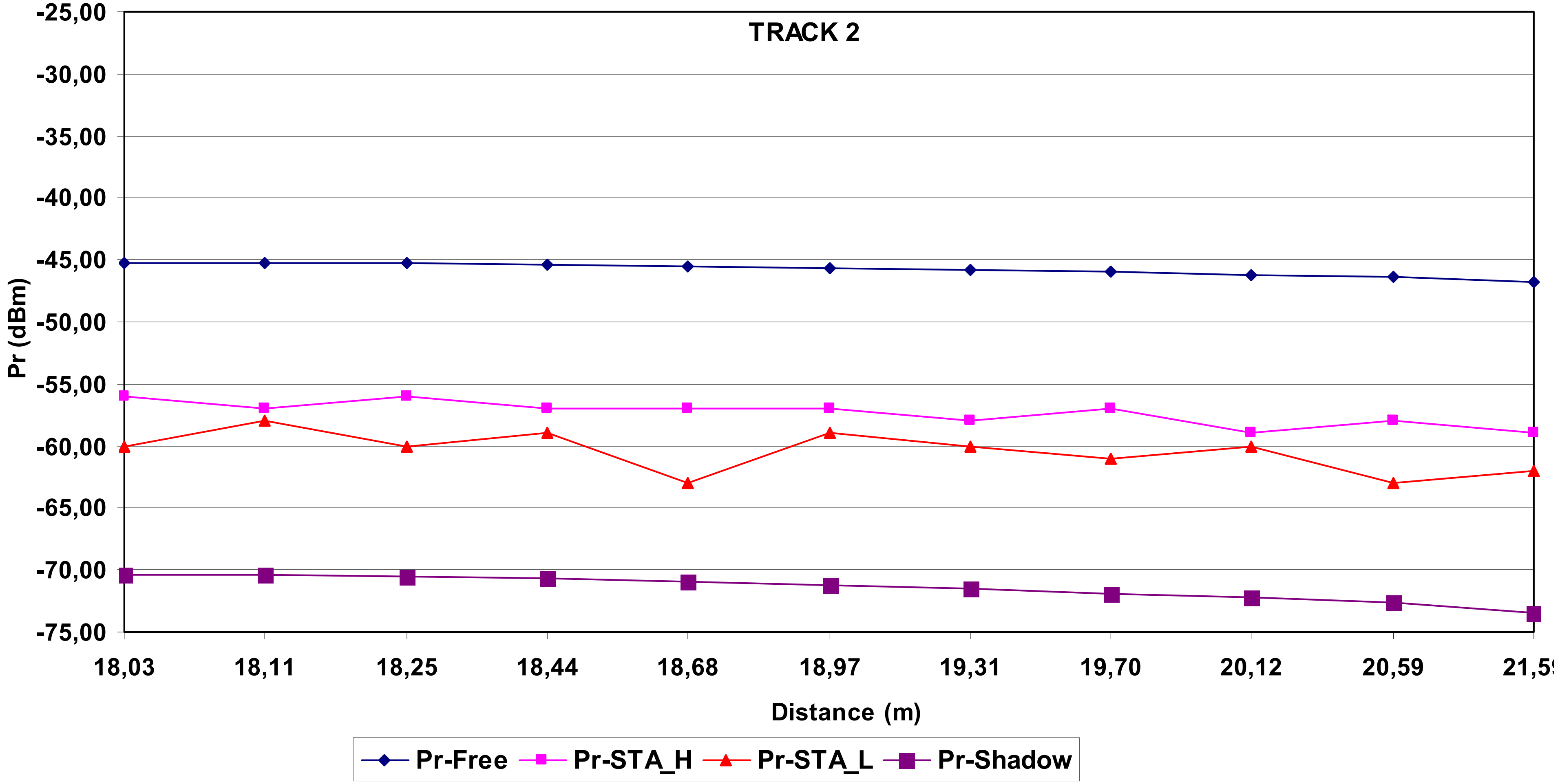
Obtained Measurements



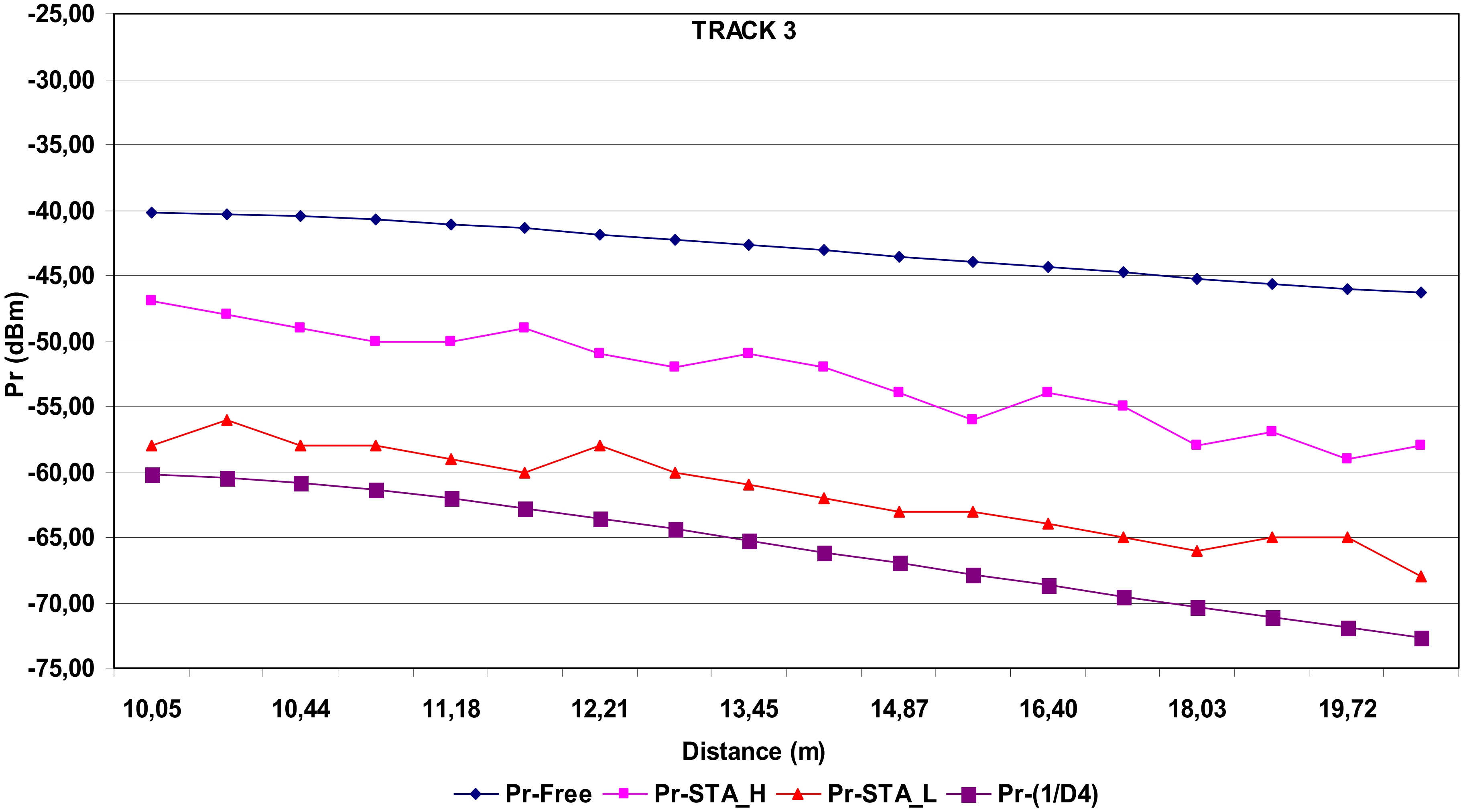
Results per link type



Results per Link Type



Results per Link Type

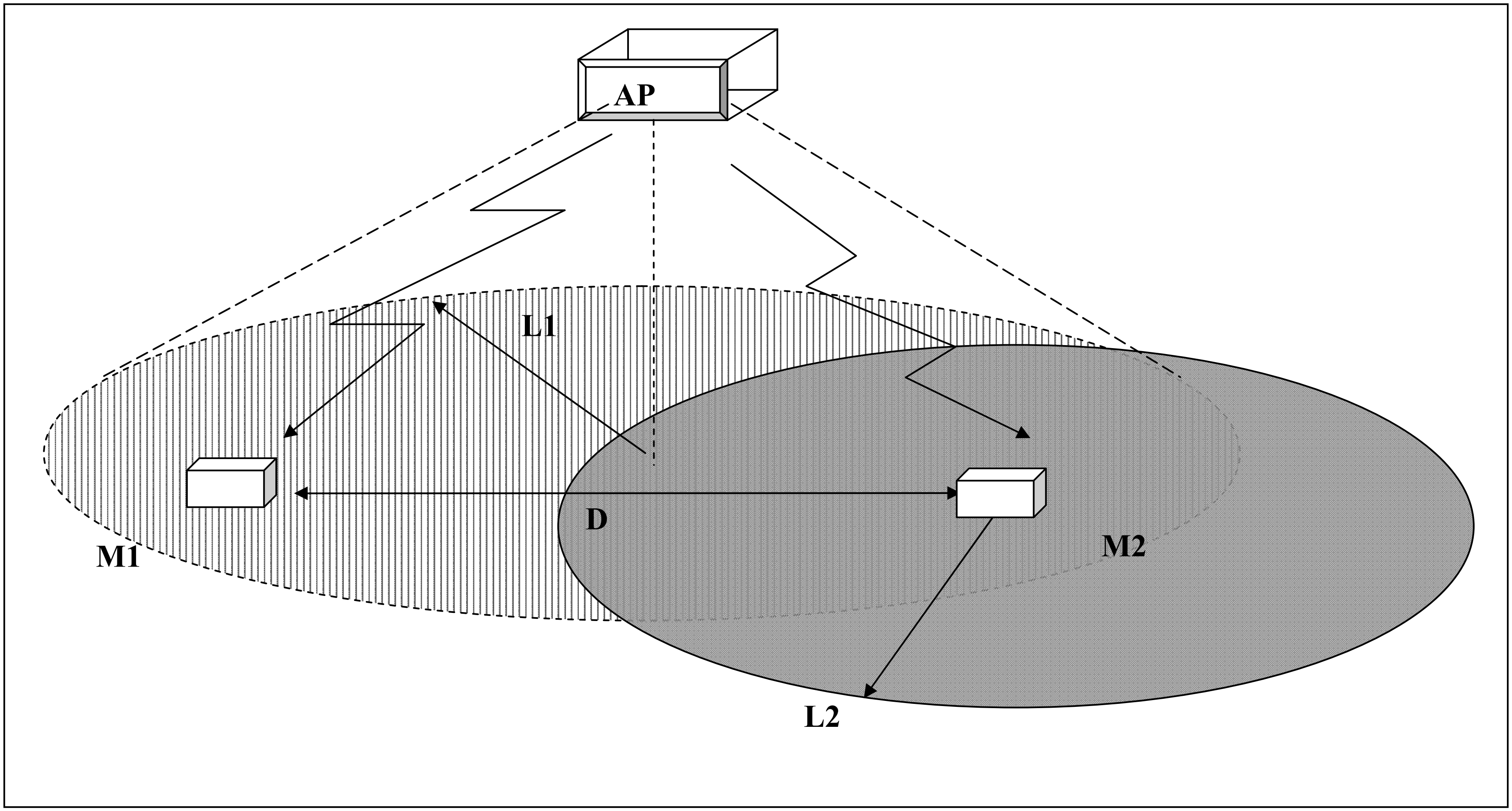


Pr Vs D Model per Link

Area	Model	X(δ) Average Normal law
AP-Mobile	$Pr = 20 – (47.80+28.91 \text{ Log}_{10}(D) + X(3.36))$	2.61^{E-13}
Mobile-Mobile	$Pr = 20 – (44.85+37.54 \text{ Log}_{10}(D) + X(3.87))$	-1.76^{E-12}

- Great difference between path loss exponent (2.891,3.754)
- Small value for δ
- Split model to describe path loss effect on different links

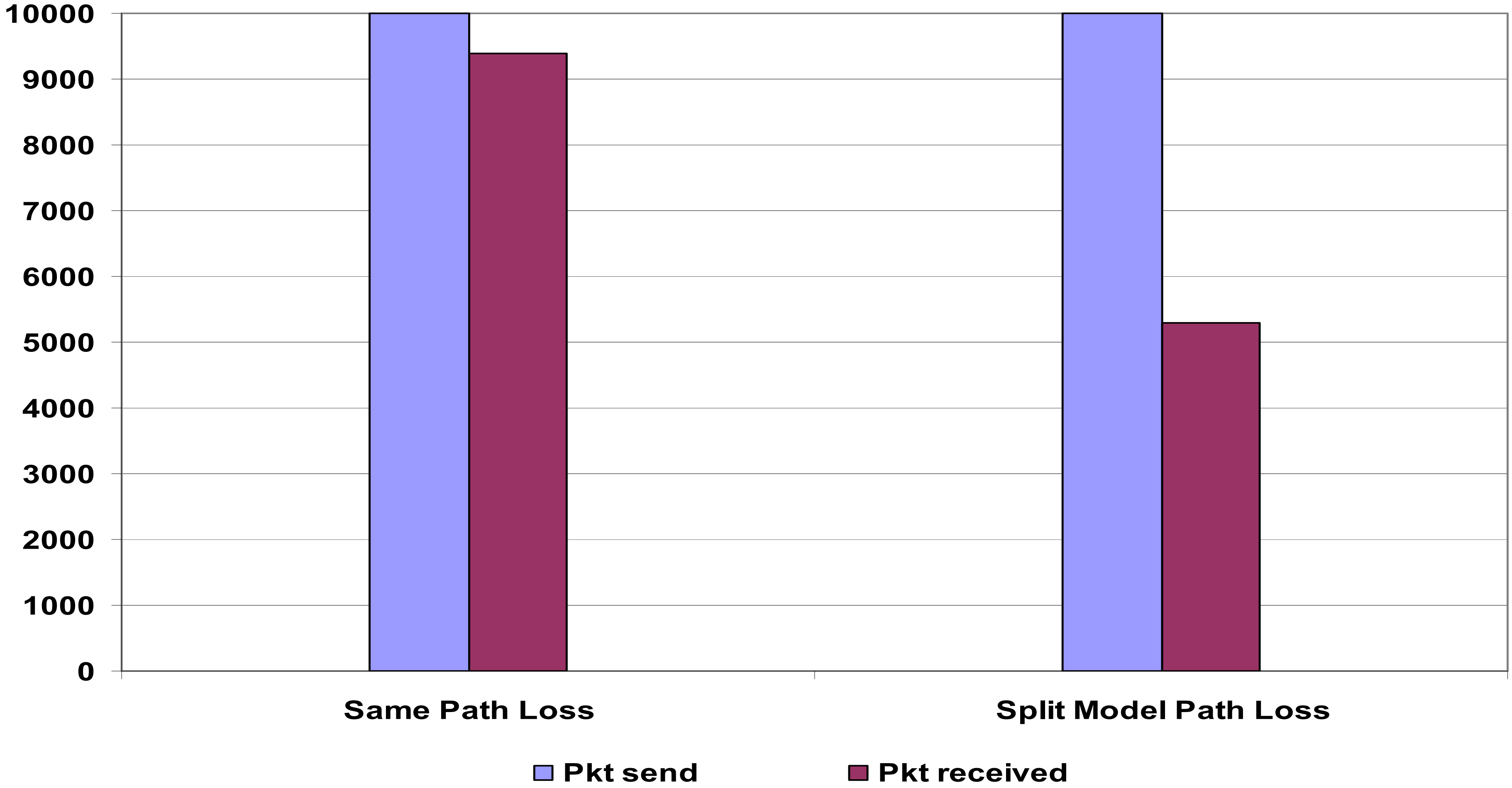
Simulation and Results



Simulation and Results

- OPNET simulation
- Use of ITU-R1238
  - Same propagation condition
- Split model
  - Links AP/Mobiles and Mobiles/Mobiles

Simulation and Results



Conclusion

- **The same model of path loss is used for all the stations**
  - no hidden station phenomenon
  - hidden area appears when n exceeds 4.32
- **The split model**
  - show the hidden station phenomenon

Questions