

2006.12.7 MCRG Tokyo Tech

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# The Influence of the Fresnel Zone on Ray Tracing in Radio Propagation

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レイトレース計算の停留位相近似による  
問題点について  
-フレネルゾーンの影響-

Yukiko Sanoh

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# Outlines

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- ◆ Self Introduction
  - ◆ Ray Tracing Method
  - ◆ The Influence of the Fresnel Zone
    - Street model
    - Path loss & IQ figure in the street model
    - Proposal to delete the diffraction wave in the Fresnel zone
    - Conclusion
    - Summary & Future Work
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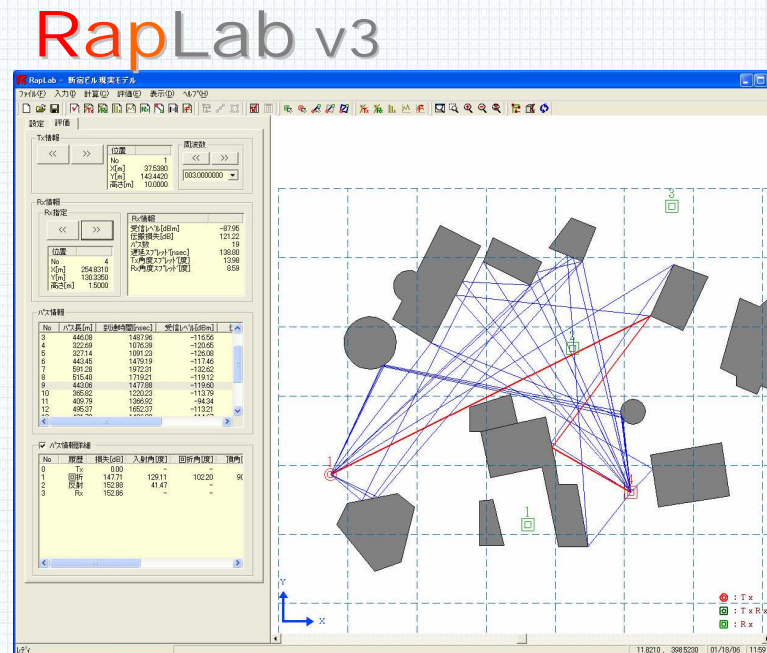
# Nice to meet you.

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- ◆ I am ...Yukiko Sanoh (now.. Yukiko Kishiki)
  - ◆ Part-time doctoral student
    - Laboratory : on Mon., Tue. and Thu.
    - My company: on Wed. and Fri.
  - ◆ Personal History
    - March 1979 Born in Itabashi-ku, Tokyo, Japan
    - March 2001 Bachelor's degree,  
The University of Electro-Communications
    - March 2003 Master's degree  
The University of Electro-Communications  
  
[Master's thesis topic]  
-Modulation in atmospheric electric field and current and ionospheric perturbations during the seismic activity-
    - April 2003 Employee  
KOZO KEIKAKU ENGINEERING Inc. (KKE)
-

# RapLab

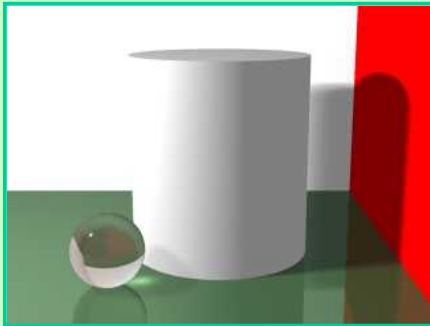
- ◆ This is a radio propagation simulator using ray tracing method.



# Ray Tracing is ..

“Ray tracing is a technique to track the path of light.”

[Computer Graphics]

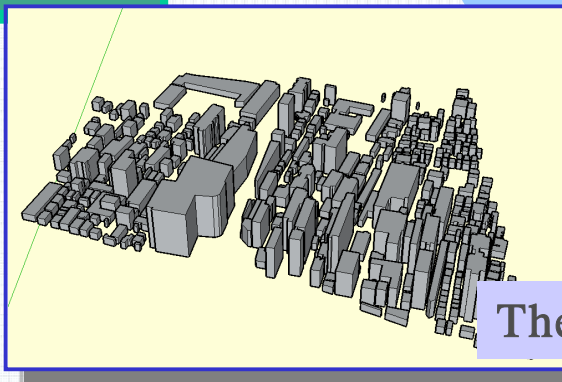


[Electric Wave Propagation]

“Simulate the course of an electric wave”



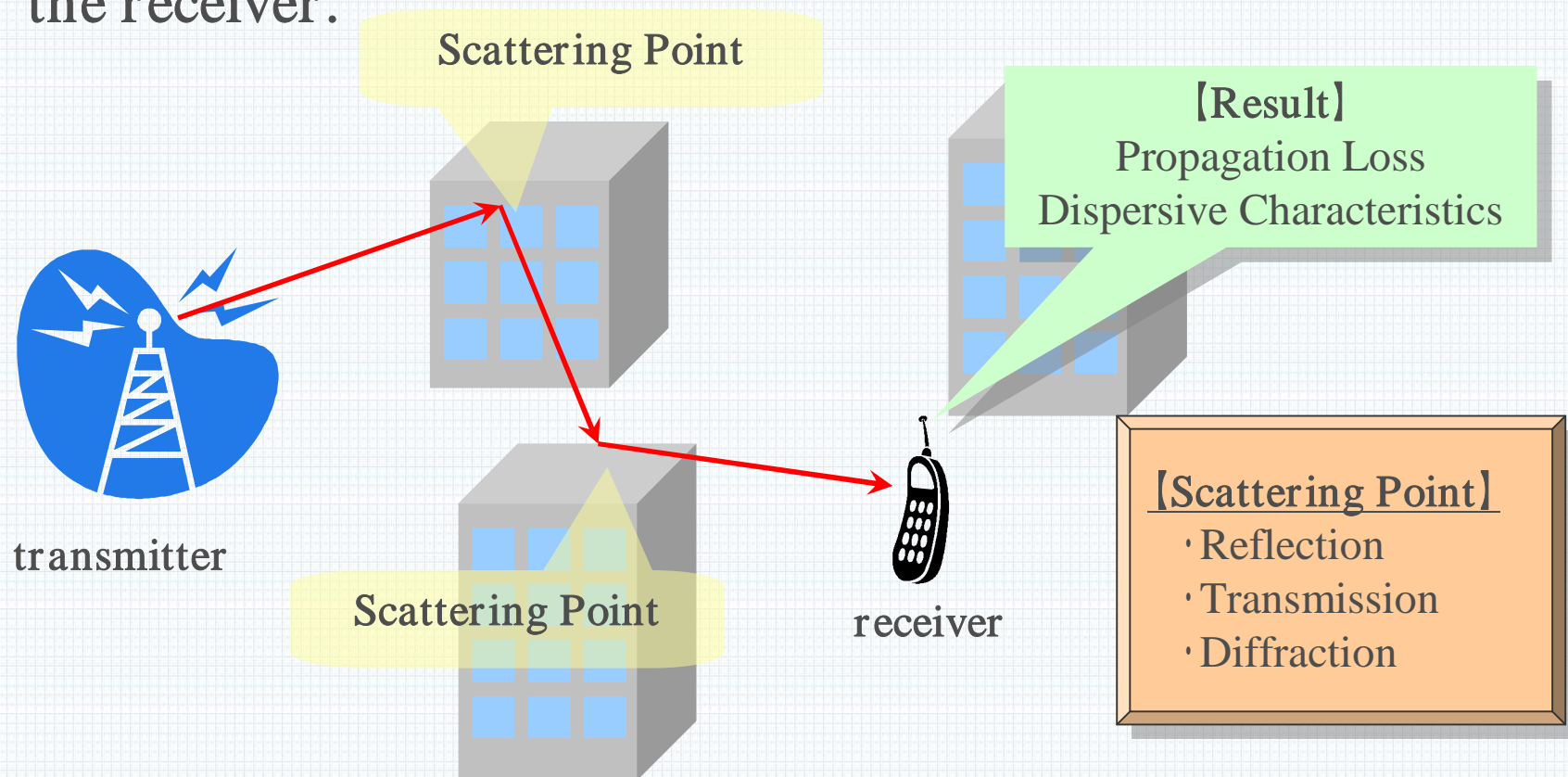
Ray tracing can estimate a propagation characteristic from the object database, such as buildings.



The object database

# Simulation of Radio Wave Propagation Using Ray Tracing

Rays emitted from the transmitter are repeatedly scattered by the walls and the edges of the buildings and finally reach the receiver.



# The Field Of Application

◆ The ray tracing method has attracted attention recently.

- Mobile communications

- Wireless LAN

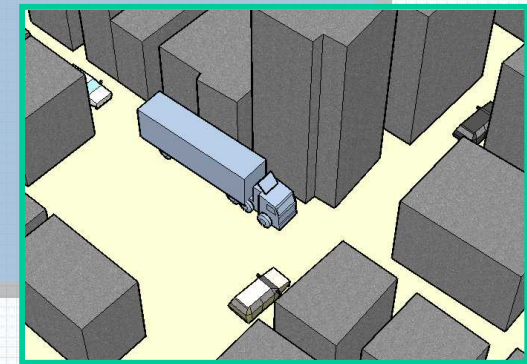
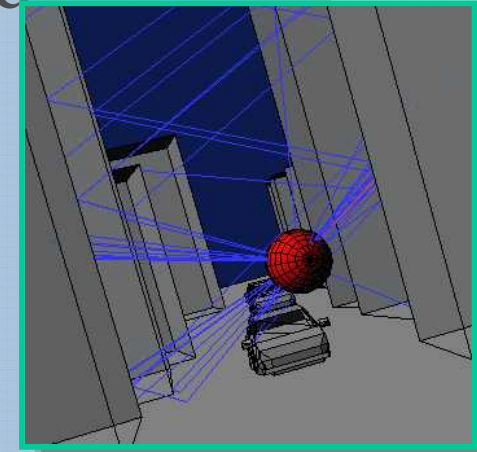
- ITS (Intelligent Transport Systems)

  - Influence of the car body (Influence of a truck)

  - The street and crossing propagation

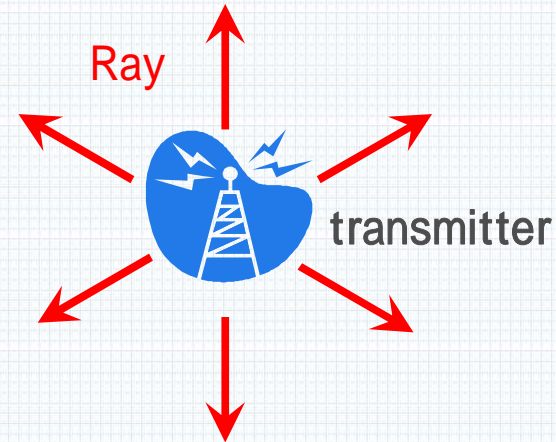
  - Inter-vehicle communication

- IC tag (RFID)

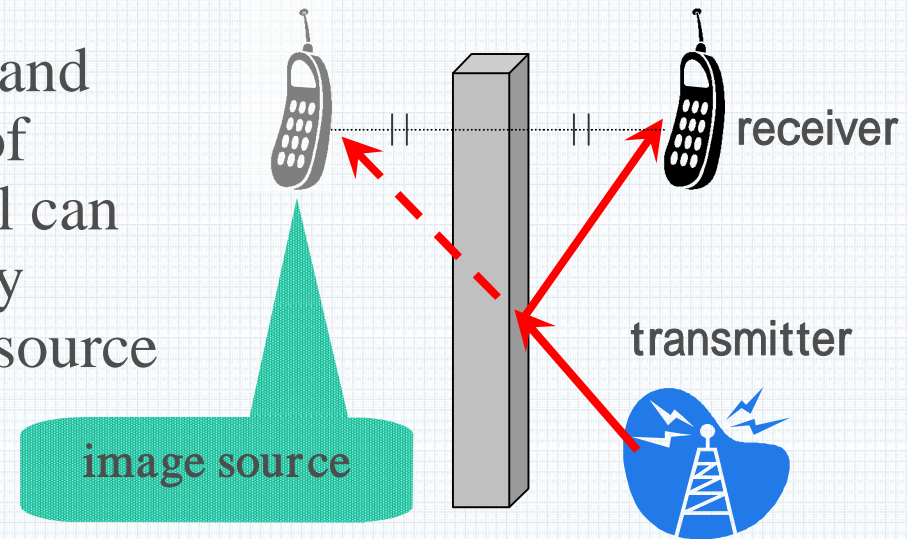


# Two Kinds Of Ray Tracing Methods are ..

- ◆ Ray Launching Method
  - To emit rays at set angles from the transmitter to the receiver.



- ◆ Image Method
  - To give a source point and the wall, and the path of reflection from the wall can be considered as the ray radiates from a virtual source point.





# Why Image Method

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The image method can be calculated so that performance of machine rises.

## ◆ Calculation time

- The ray launching method has a short simulation time.
- The image method has a long simulation time.

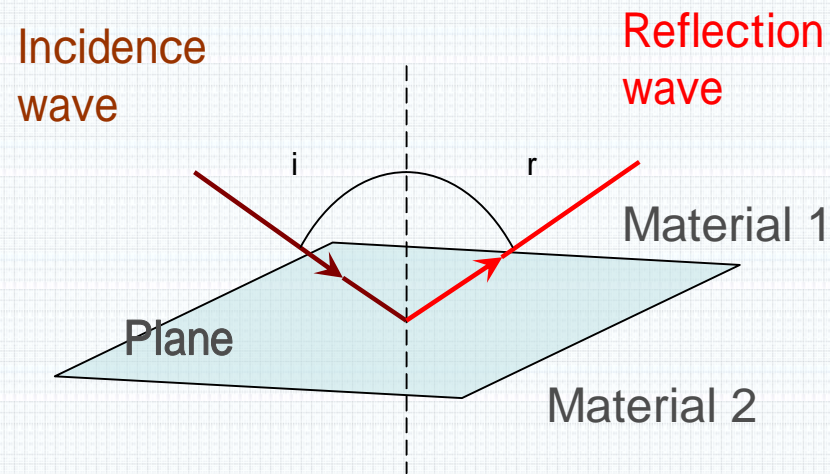
## ◆ Calculation precision

- By ray launching method, a result changes by the setting angles.
    - The calculation precision improves if the emission angles set are small. But calculation time becomes too long.
    - The calculation precision decreases if the emission angles set are large. But calculation time becomes too short.
  - The image method's calculation precision is good.
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# The General Concept Of Reflection and Transmission

## ◆ Reflection

The angle of incidence and reflection are the same.

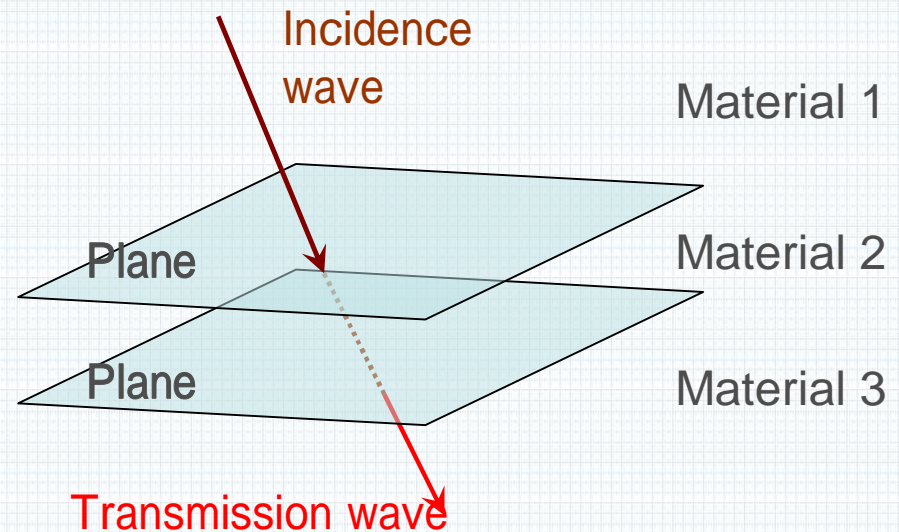


<Snell's Law>

$$i = r$$

## ◆ Transmission

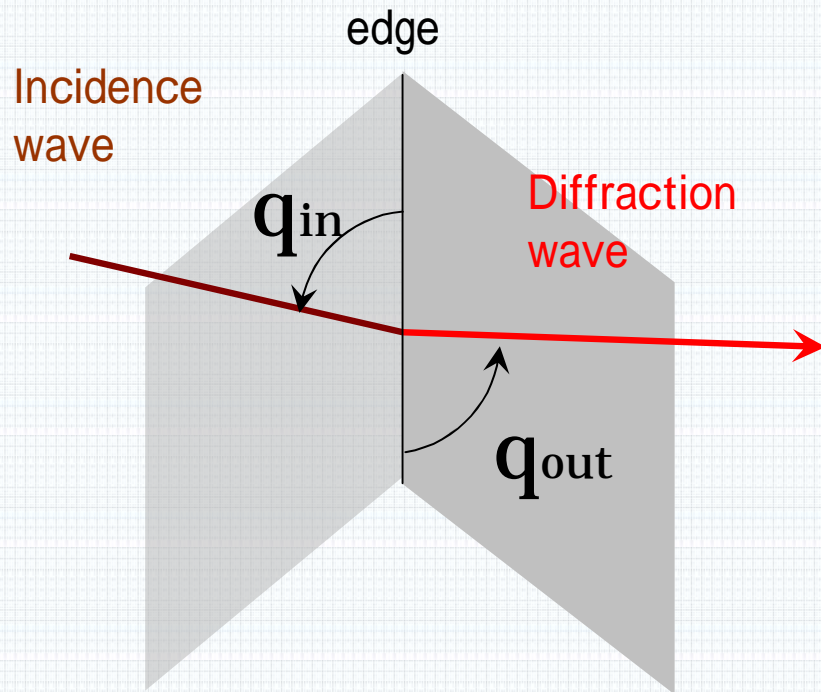
Transmission waves are transmitted at same the angle as incidence waves.



# The General Concept Of Diffraction

10

## ◆ Diffraction



【Existence judgment of a ray】

$$q_{in} = q_{out}$$

$q_{in}$  = The corner which the incidence wave and an edge make

$q_{out}$  = The corner which the diffraction wave and an edge make

# Make Path Pattern

Combinations of scattering points between the transmitter and the receiver are made.

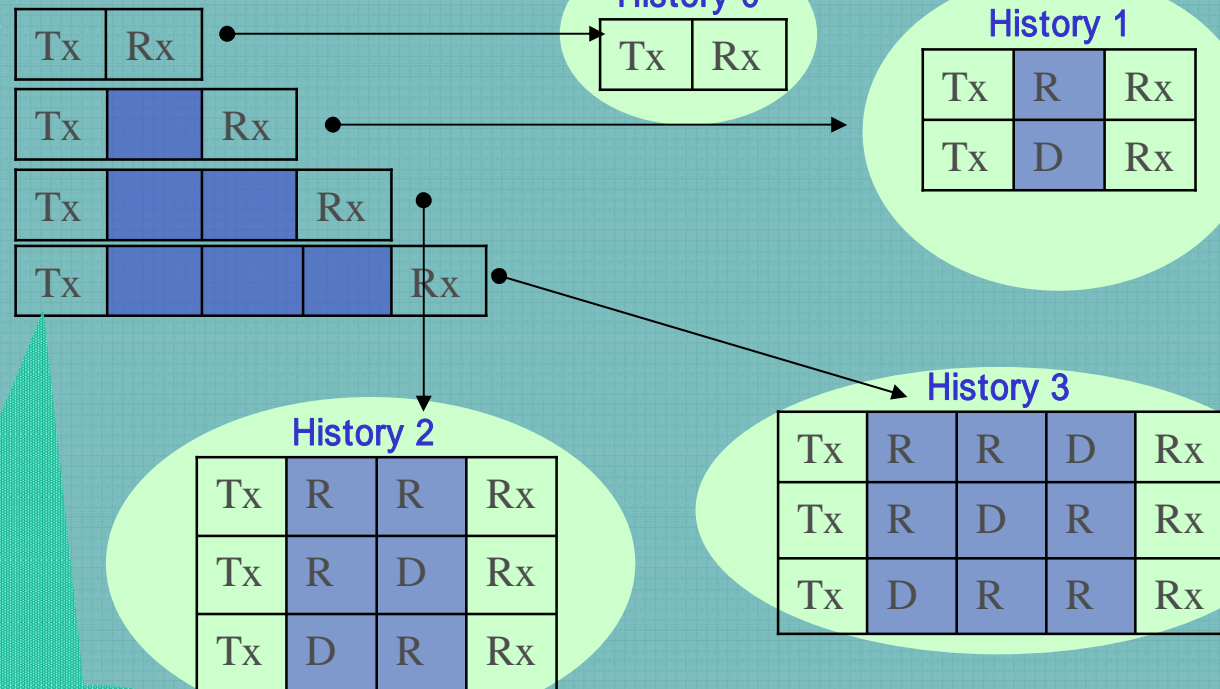
Calculation  
Conditions

	num
Refraction	2
Diffraction	1

the calculation  
condition's number  
is set.

Boxes of total value of  
calculation condition's number  
between Tx and Rx are  
established.

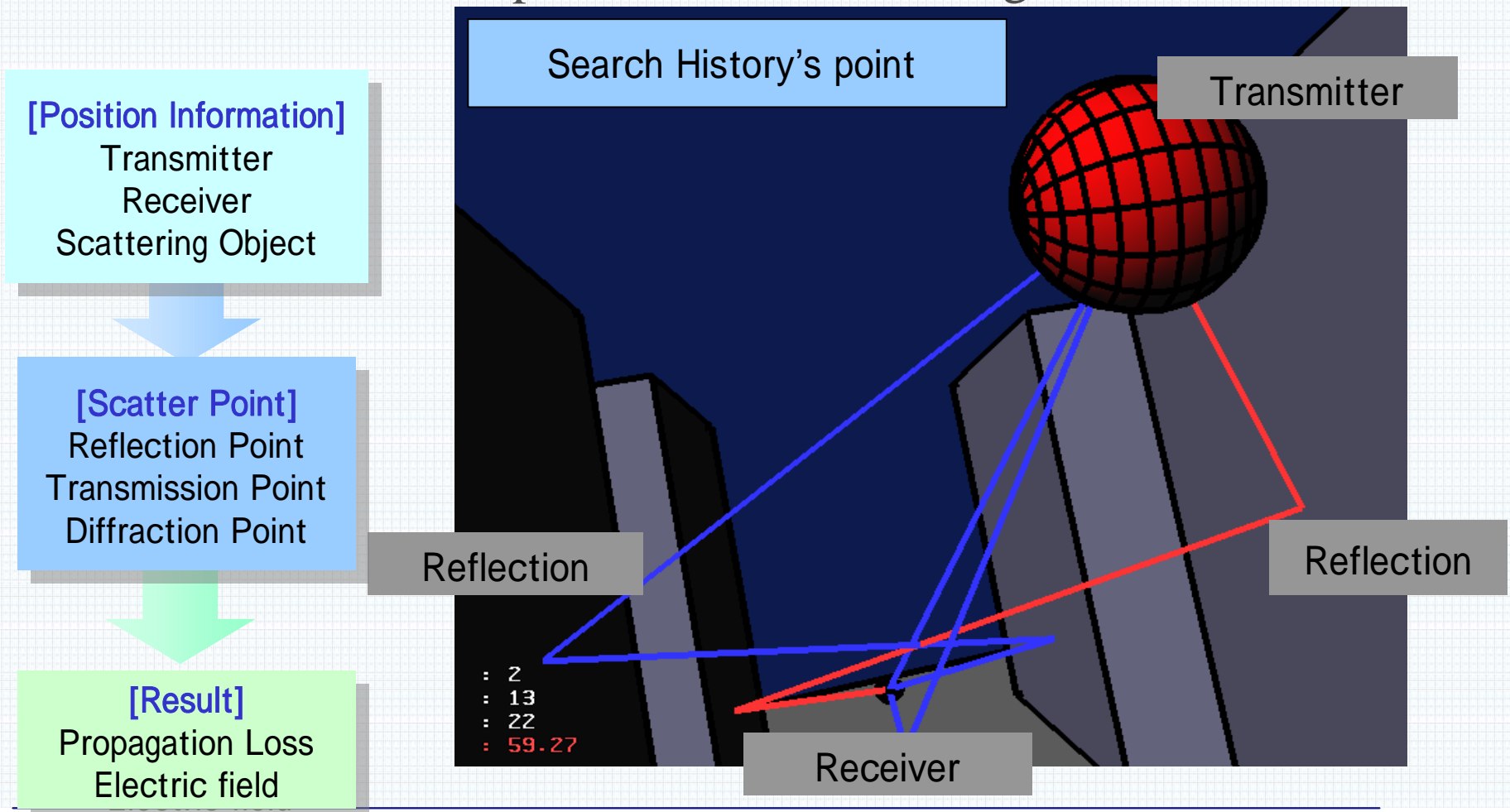
[Make pattern]



Tx: Transmission  
Rx: Receiver

# Make History Point

For each pattern of path, scattering points from the transmitter, the receiver and the positions of the buildings are found.



# Outlines

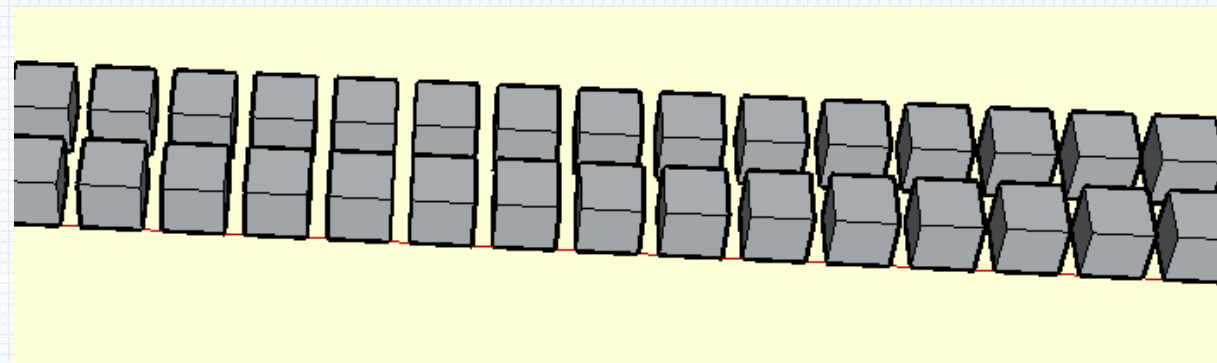
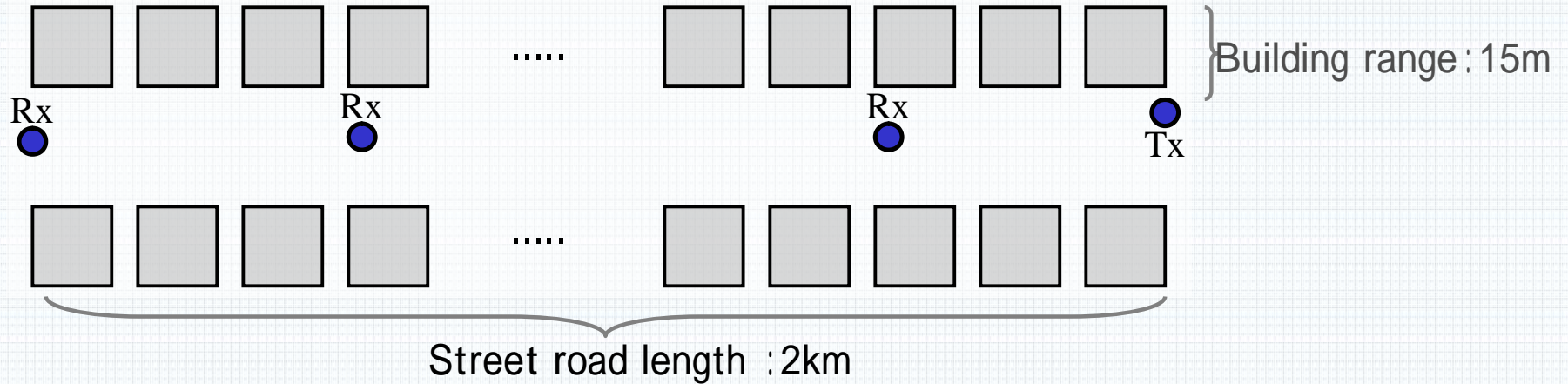
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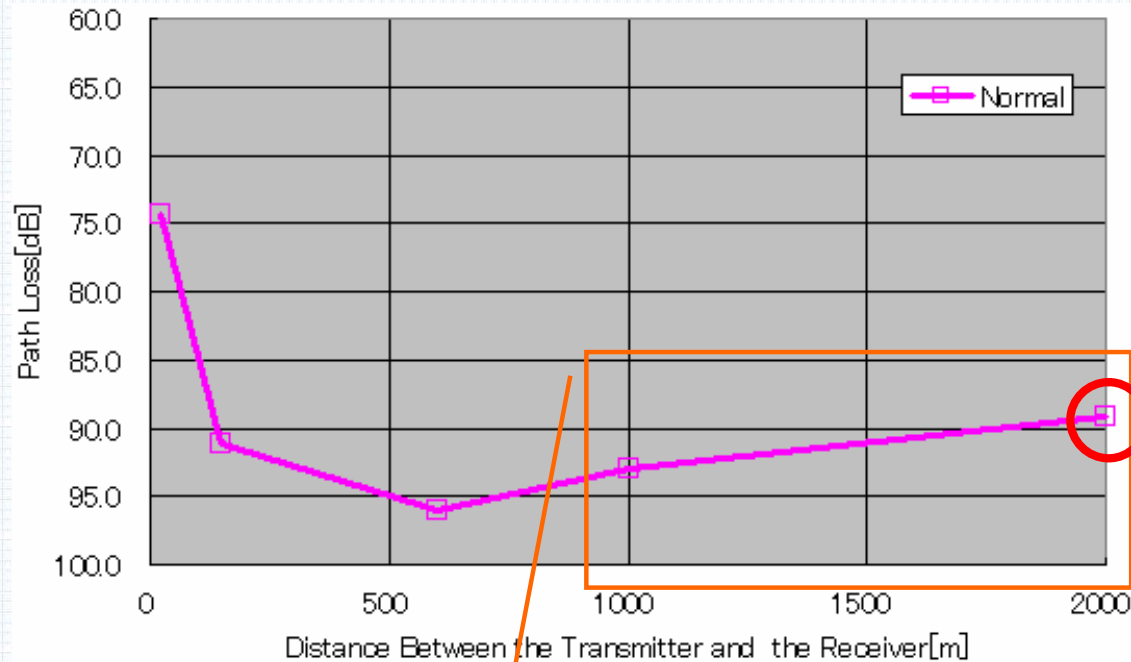
# Street Model

-Buildings form continuous lines like a street-

Frequency 5.8GHz



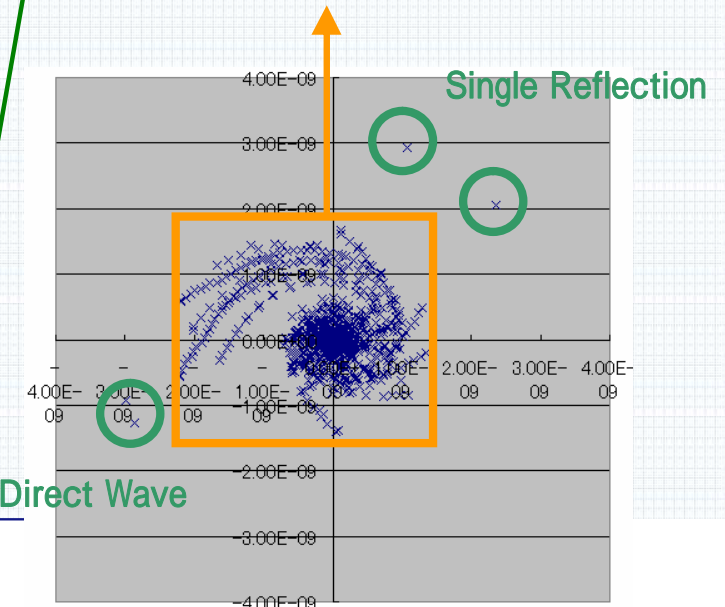
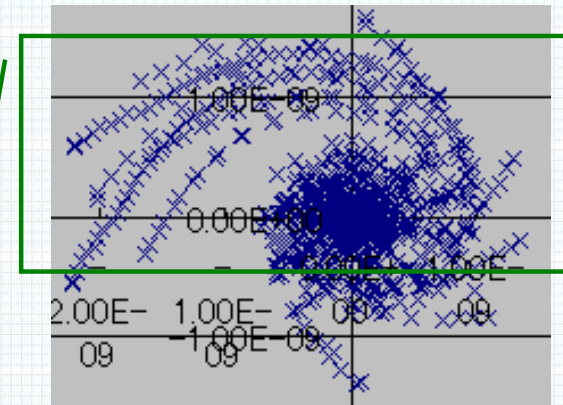
# Path Loss in the Street Model



Though propagation losses should increase according to distance,  
The result is that it doesn't drop below 1,000m.

A lot of diffraction waves that had very strong energy increased

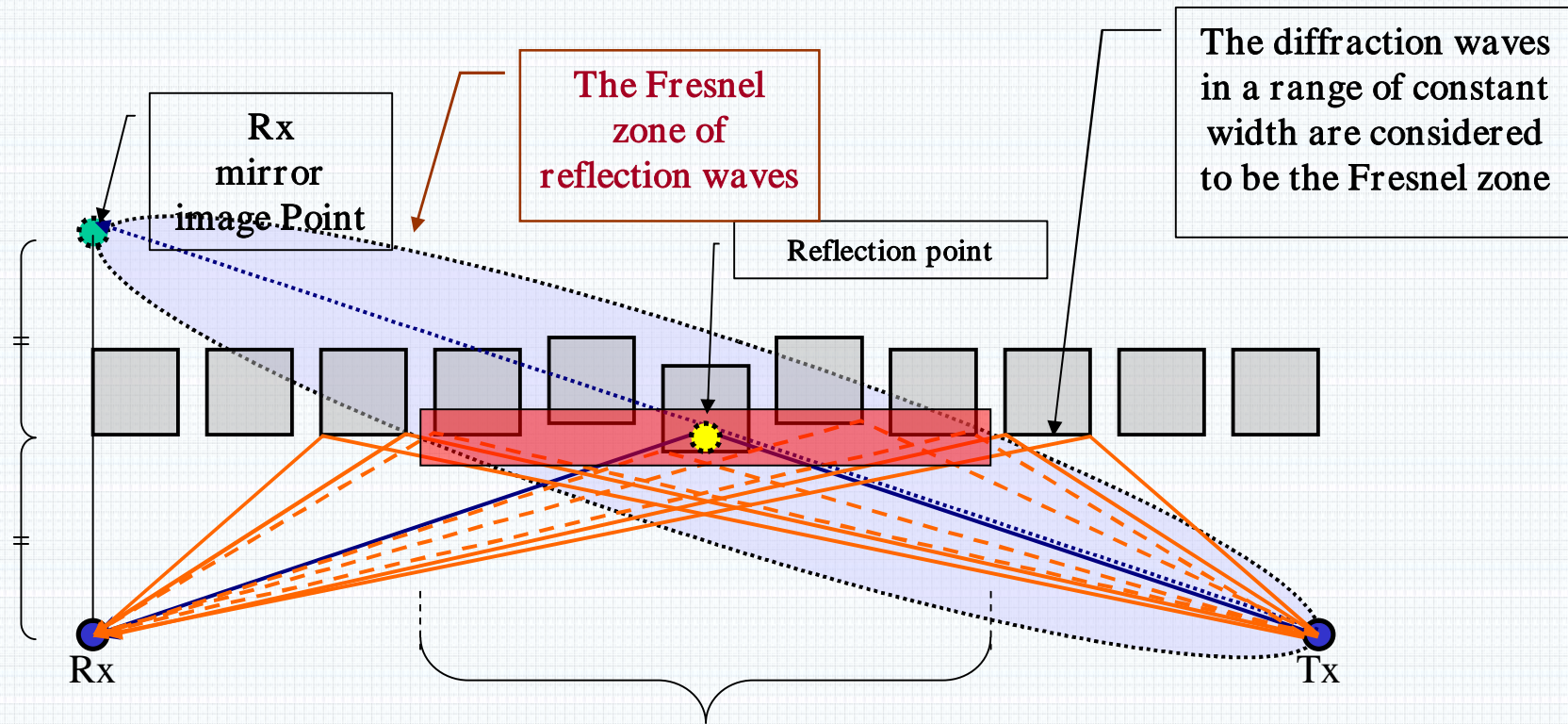
IQ Figure at 2000m





# In the case of a single scattering point (single reflection or single diffraction)

## a single reflection wave is made

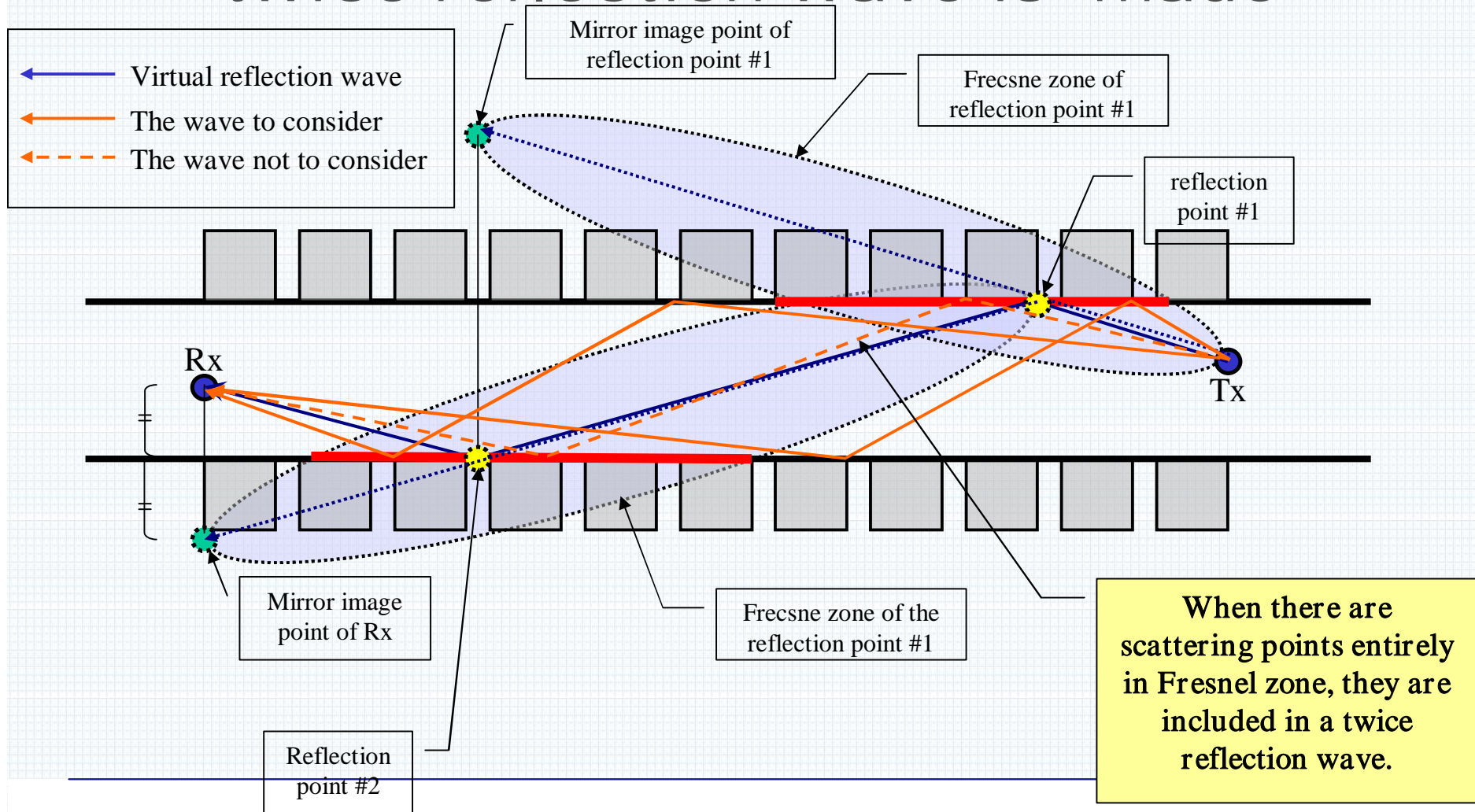


Diffraction waves in this range aren't considered.  
 (those waves are thought to be included in the reflection waves for physical optics. )

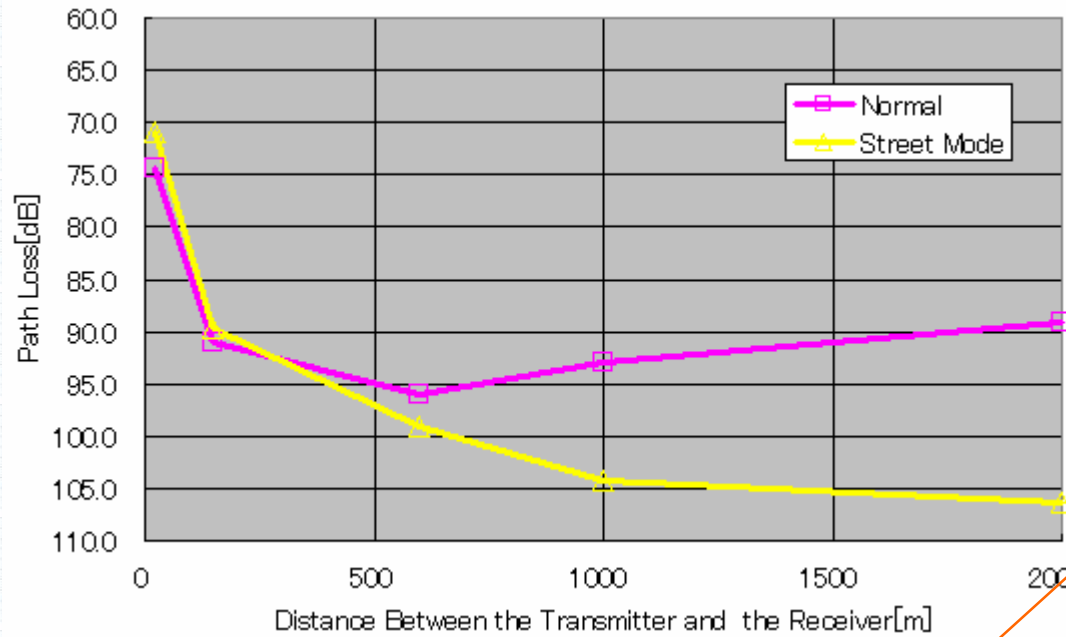
- ← Virtual reflection wave
- ← The wave to consider
- ← The wave not to consider

# In the case of a twice scattering points

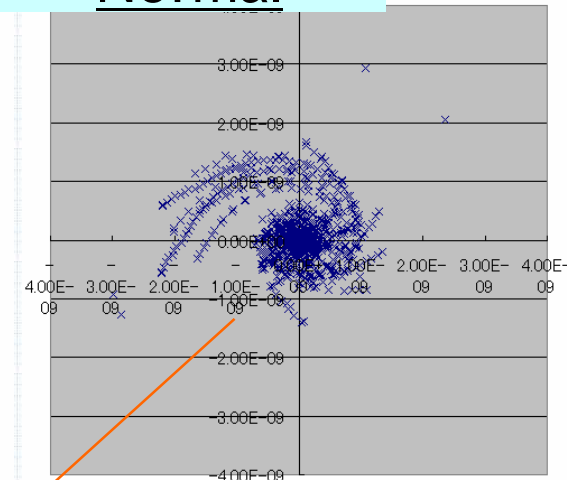
## twice reflection wave is made



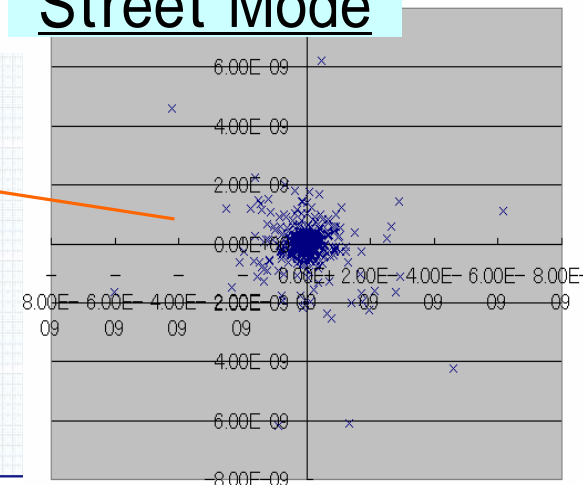
# Conclusion



Normal



Street Mode



The diffraction waves becoming whirlpools are deleted in the Fresnel zone.

# Summary & Future Work

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## ◆ In this Work

- 1) The influence of the diffraction waves that were not able to be approximated by geometrical optics was confirmed.
- 2) That the propagation loss had increased with the distance was confirmed by the proposal of deleting the diffraction waves in the Fresnel zone.

## ◆ Future Work

- 3) Survey of the deletion area of waves that cannot be approximated by geometrical optics
    - The area is decided from the length of the edge.
  - 4) The diffraction waves that cannot be approximated by geometrical optics are considered.
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Thank you very much  
for your kind attention.

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