ANALYSIS OF A NLOS CANYON IN AN INSAR IMAGE OF A URBAN AREA AT KA-BAND

Phd student: Azza Mokadem
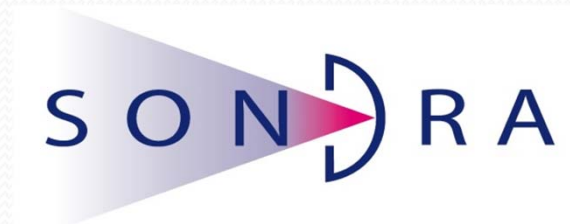
Supervisors:
Laetitia Thirion-Lefevre
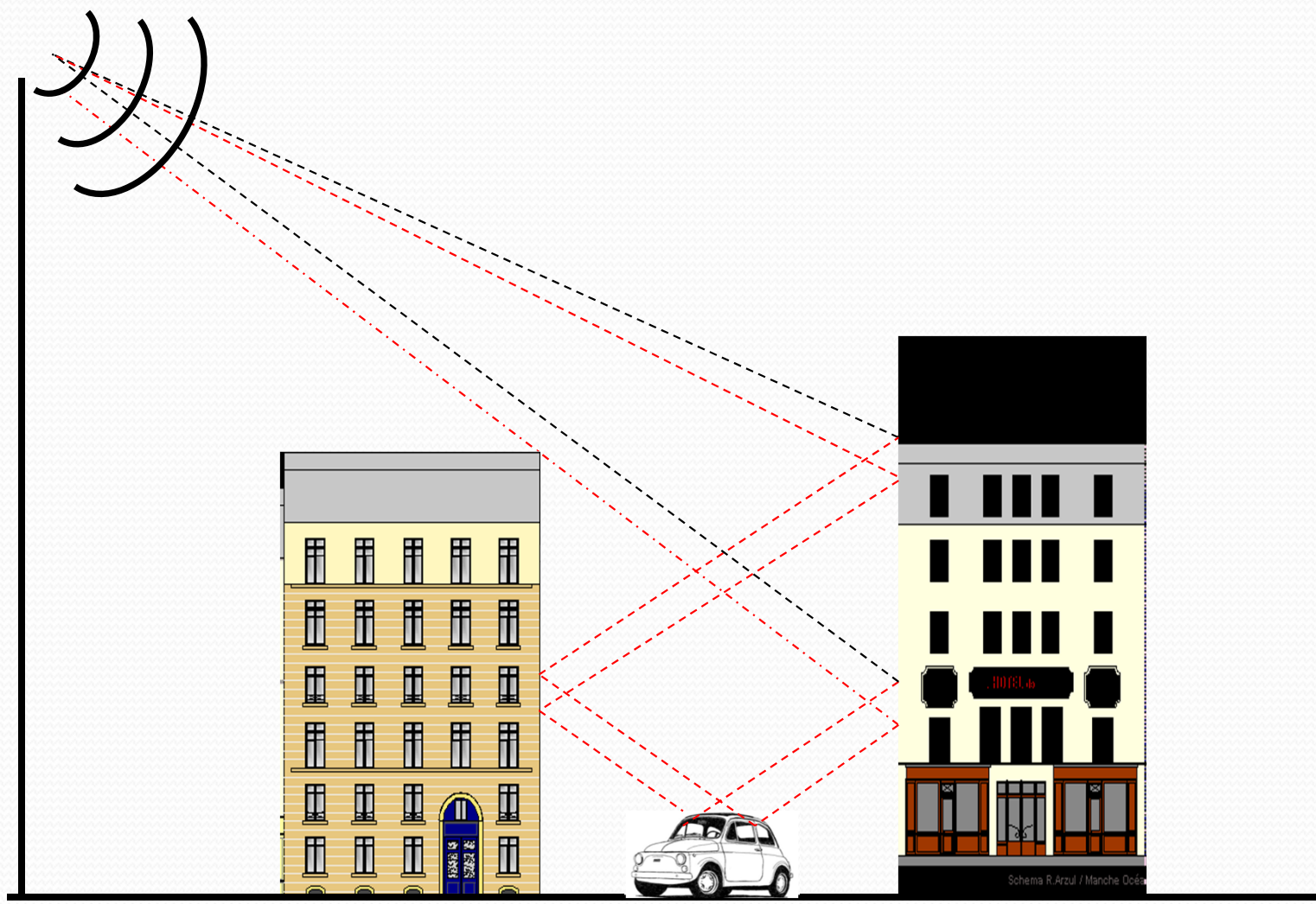*SUPELEC / E3S-EA4454 / SONDRA, France*
Elise Colin-Koeniguer
ONERA/DEMR/TSI, France

Images acquired by Jean-François Nouvel
ONERA/DEMR/RIM, France
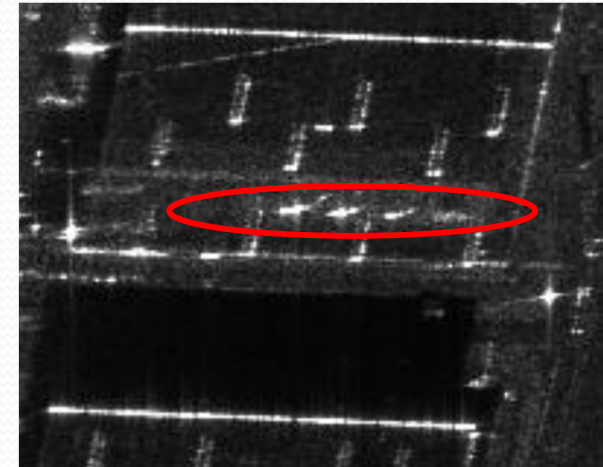
Schema R.Arzul / Manche Océan

Introduction

- ## Main idea:
  - ❖ NLOS target can be detected via multipath
- ## Problematic:

Scene under study: two buildings of 14 m height are seperated by a distance of 33 m. Three trihedral corners and a truck (illustrated in red) are located in front of the second building

Corresponding radiometric image acquired in Ka band

- ## Goal:
  - ❖ *Long term:*
    - ✓ To study the cases where a NLOS target can be detected
  - ❖ *Short term:*
    - ✓ To understand the mechanisms happening inside a urban area in the case of monostatic SAR in far field
- ## Approach:
  - ❖ To study simple configurations (the urban canyon) via geometric tools with strong assumptions
  - ❖ To provide an automatic analysis of urban areas in SAR images

Plan

➢ **Presentation of the urban canyon**

➢ **Presentation of the developed geometric codes for a canyon with the presence of point/extended target**

➢ **Interpretation of a radiometric image of a urban area**

➢ **Interpretation of an interferometric image of a urban area**

➢ **Conclusions and perspectives**

Presentation of the urban canyon

➤ **Choice of the urban canyon:**

  ❖ To understand the mechanisms within a simple configuration before moving to more complex areas
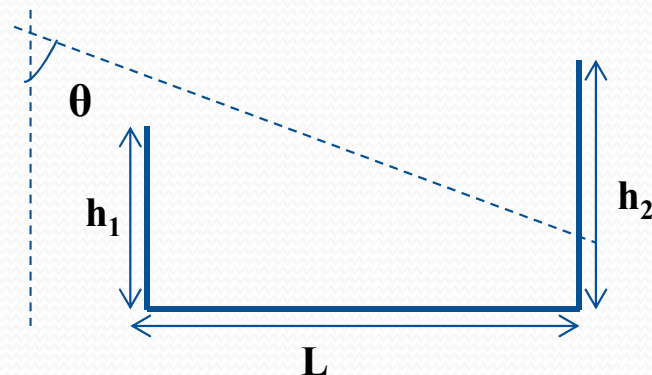
➤ **Urban canyon:**

  ❖ Free space located between two PEC vertical plates

➤ **Main approximations:**

  ❖ Roughness effects, diffraction, antenna pattern are neglected

  ❖ Far field

➤ **Canyon configuration:**

  ❖ h_1, h_2, L

  ❖ θ

Urban canyon v1, v2, v3

➢ **Developed geometric codes:**

  ❖ **Urban canyon v1**

    ❑ Identification of the NLOS areas illuminated by specular reflection mechanisms

  ❖ **Urban canyon v2**

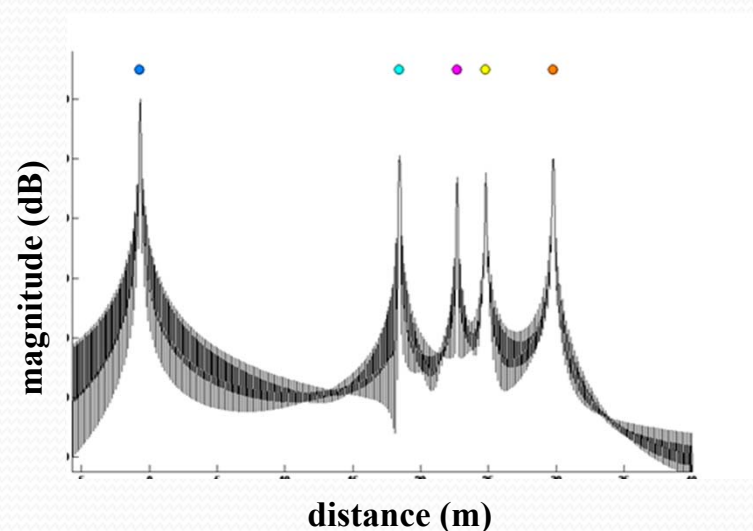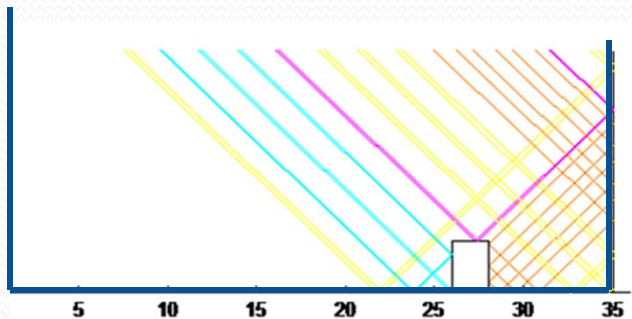   ❑ Detection of point targets inside the canyon

  ❖ **Urban canyon v3**

    ❑ Detection of extended targets inside the canyon

➢ **Results of geometric codes:**

    ❑ To predict the radar range profile for any canyon (number of peaks, positions, corresponding mechanisms)

➢ **Examples of a range profile for a canyon with a parallelepiped target using Urban canyon v3**
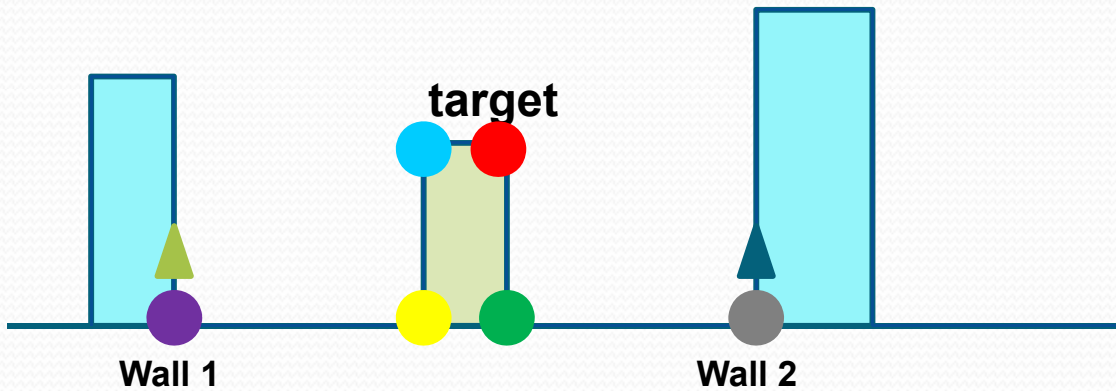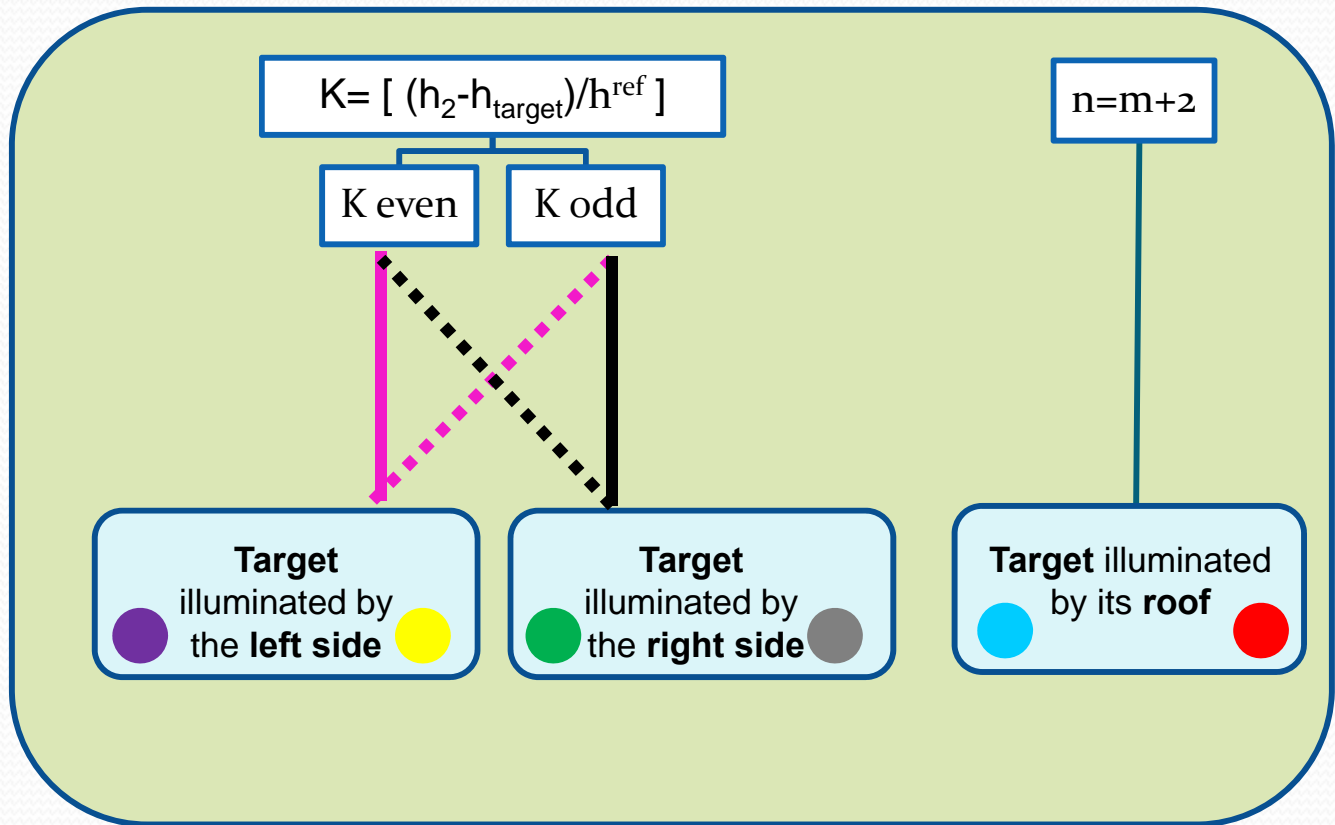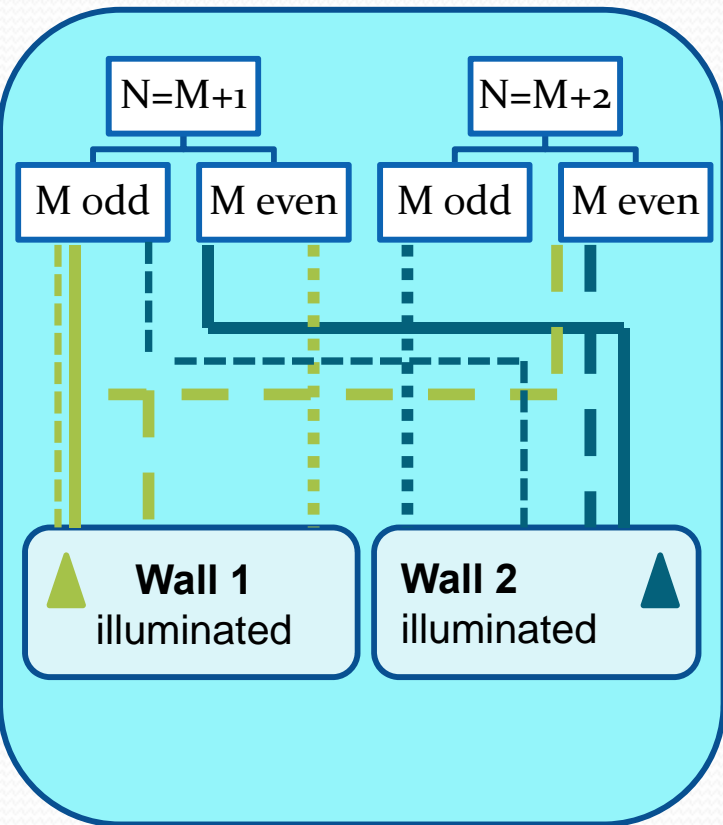
Logigramm for Urban canyon v3

$$h_1 - h_2 \leq h^{ref}$$

Wall detection

Target detection

$N = M+1$

$N = M+2$

M odd M even M odd M even

$K = [(h_2 - h_{target})/h^{ref}]$

$n = m+2$

K even K odd

△ **Wall 1** illuminated

Wall 2 illuminated △

Target illuminated by the **left side**

Target illuminated by the **right side**

Target illuminated by its **roof**

target

Wall 1

Wall 2

c'_1
c''_1
c'_2
c''_2
c'_3
c'_4
c'_5
c'_6

$c_1 \| c_2$
$c_3 \| c_4$
$c_7 \| c_8$
$c_5 \| c_6$

On the use of Urban canyon v3 to interpret a radiometric/interferometric image-1-
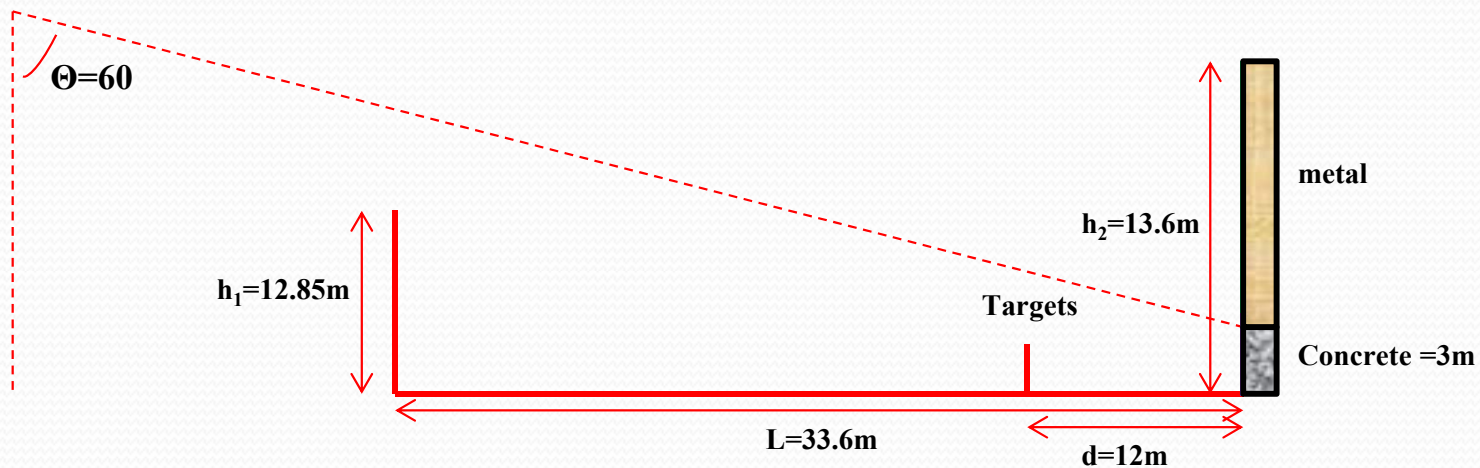
➢ **Description of the scene under study:**

Targets:
❖ 3 corners reflectors
❖ A truck

Radar parameters:
❖ $\Theta=60$
❖ VV polarization
❖ Frequency=35 GHz

$\Theta=60$

metal

$h_2=13.6m$

$h_1=12.85m$

Targets

Concrete =3m

L=33.6m

d=12m

Canyon parameters

➢ **Interpretation of the radiometric image:**

End of shadow area

Top of wall 2

Dihedral effect due to a change of material of wall 2

Dihedral effect due to the bottom of wall 2

Targets responses

Features on the roof
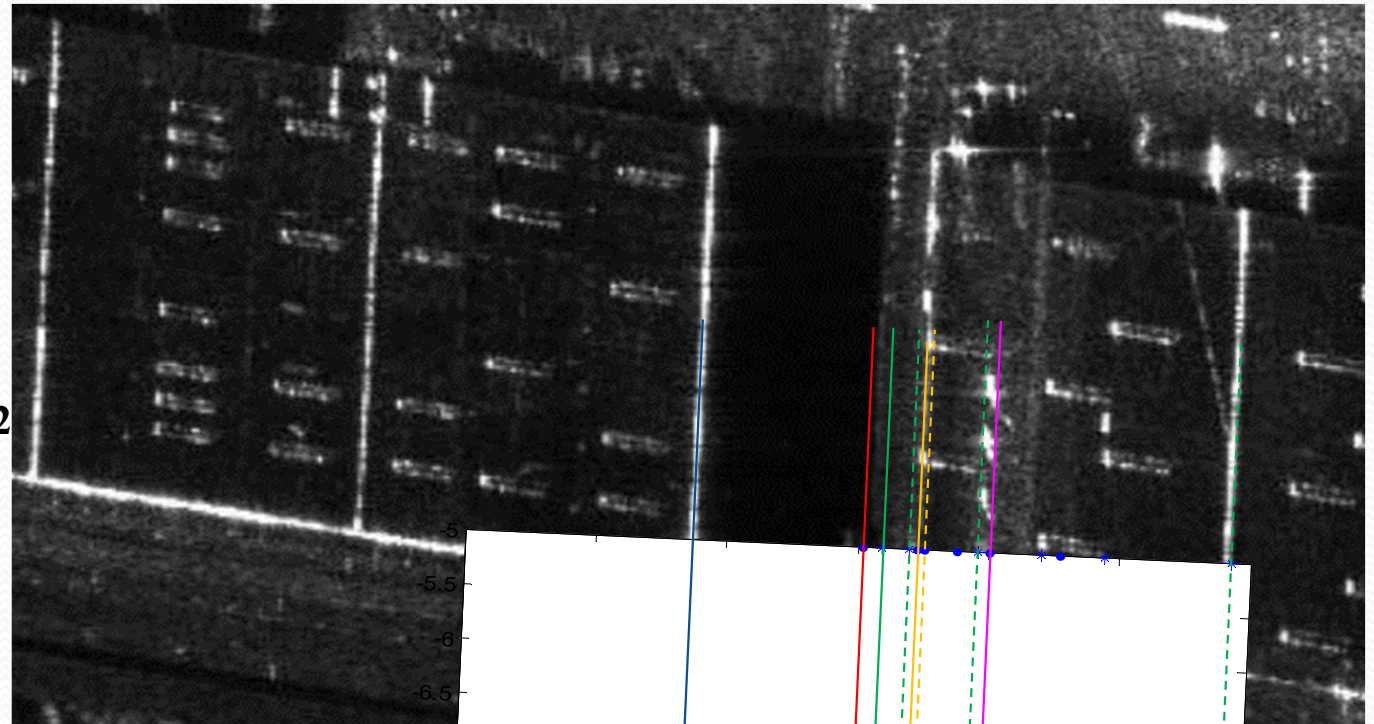
➔ **Agreement between the results of the geometric code and the position of the scatterers responses in the image**

➢ **Interpretation of the interferometric image:**
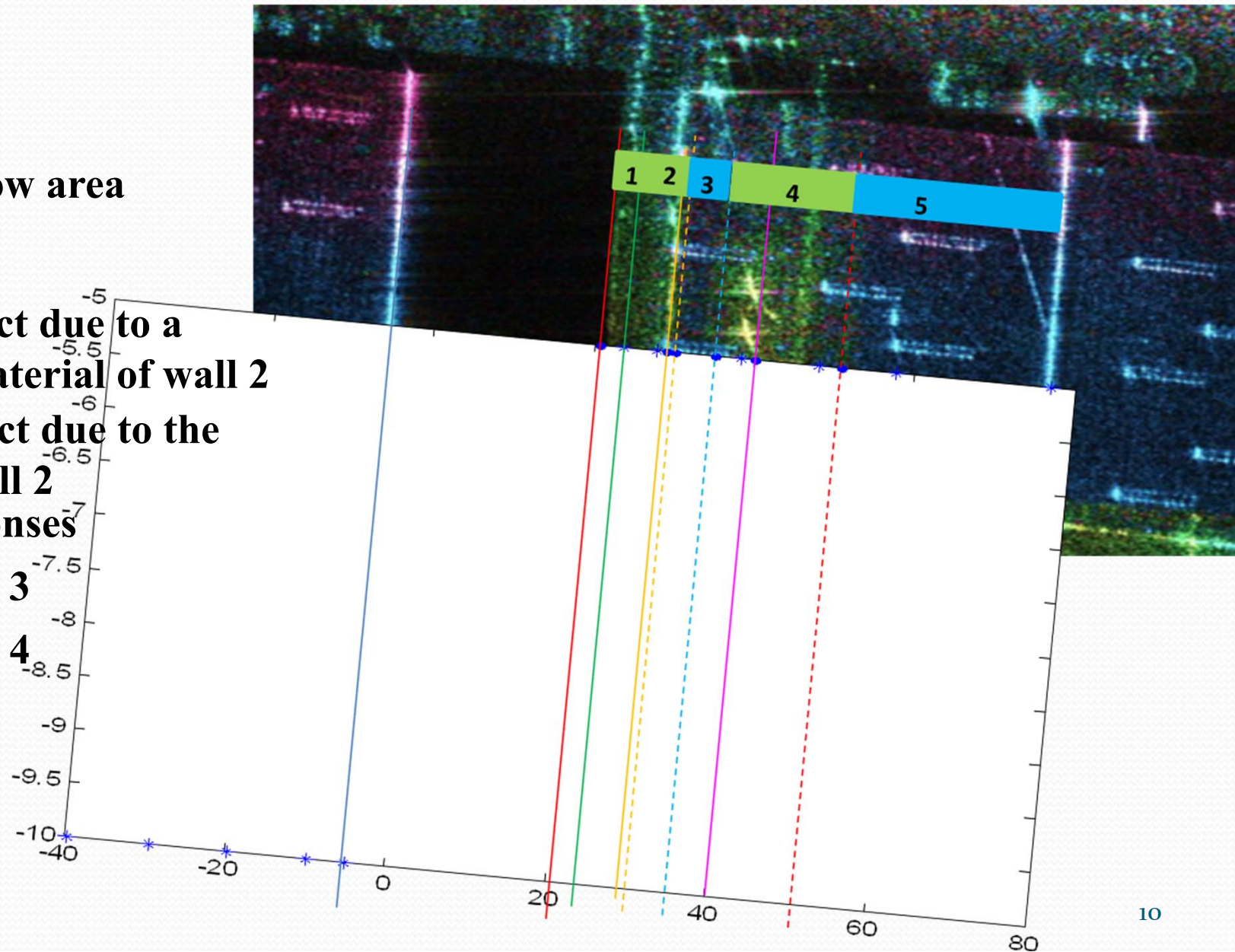
End of shadow area

Top of wall2

Dihedral effect due to a change of material of wall 2
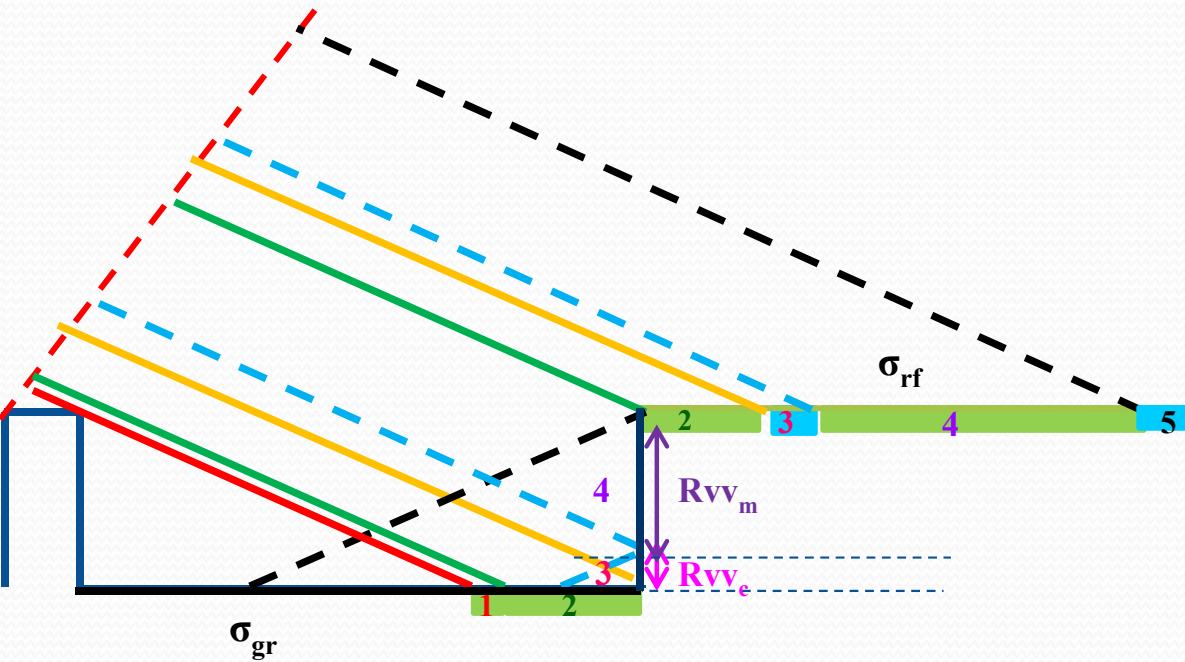
Dihedral effect due to the bottom of wall 2

Targets responses

Limit of zone 3

Limit of zone 4

Backscattering and reflection mechanisms inside the canyon

zones	Existing mechanisms	Dominant mechanism	σ_{gr}, σ_{rf}, Rvv_c, Rvv_m (dB)
1	GB	GB	σ_{gr}
2	RB+GB	GB	$\sigma_{gr} > \sigma_{rf}$
3	RB+GB+RC	RB	$\sigma_{rf} > \sigma_{gr} + Rvv_c$
4	RB+GB+RM	GB	$\sigma_{rf} > \sigma_{gr} + Rvv_m$
5	RB	RB	σ_{rf}

GB: Ground backscattering mechanism ($\sigma_{gr} \sim$ -19 dB)

RB: Roof backscattering mechanism ($\sigma_{rf} \sim$ -22dB)

**RC: Reflection on the concrete part of the wall ($Rvv_c \sim$ -21dB)**

RM: Reflection on the metallic part of the wall ($Rvv_m \sim$ 0 dB)

Brewster angle

Reflection coefficient of concrete according to the incidence angles for a frequency of 35 GHz
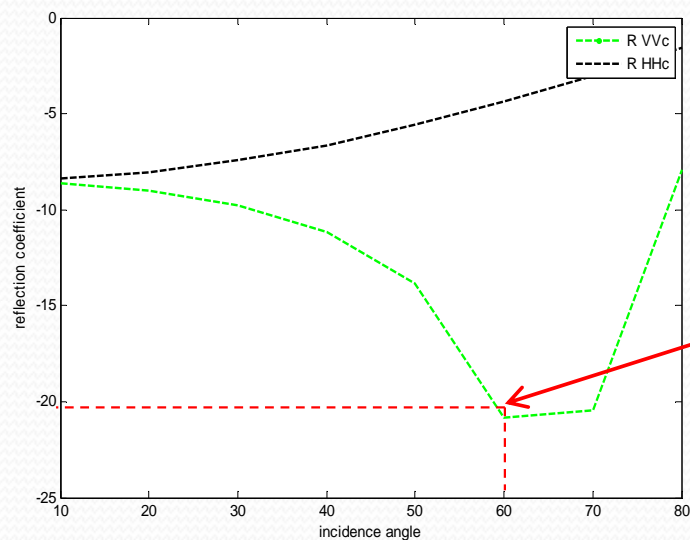
What about polarimetry ?

➢ Expected to help the understanding of such complex environment

➢ Expected to differentiate the different target responses in the canyon
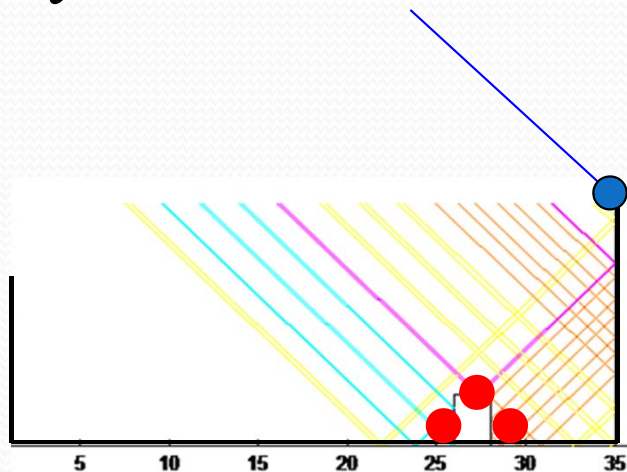
Conclusions and perspectives

➢ Conclusions:

❖ Analyze the different scatterers responses in a radiometric / interferometric SAR image of a urban area

- ✓ Three simple geometric codes
  - ❑ Study the geometric mechanisms
  - ❑ Study of the detection of point/extended target inside the canyon
  - ❑ Prediction of the range profile
- ✓ EM considerations: nature of the material of the building
  - ❑ Impact of the Brewster angle

➢ Perspectives

❖ To use different polarizations

❖ To use different incidence angles

Thank you for your attention

Questions?