

> 19Sep2014 - Radiation equation, Antennas

> 26Sep2014 - Propagation models: Yun Ai

> 26Sep2014 - ~~Range~~ of wireless communications - Raul

17.0ct

Oct2014 - LTE - Solomon

> Oct2014 - Voice in LTE - Mikhail Yakubovich

WiFi

20.0ct

> Oct2014 - WiMAX - Qihaoli

> Oct2014 - Security in NFC - Seraj

WIFI - Mohsen 802.11g, n, ac, ...

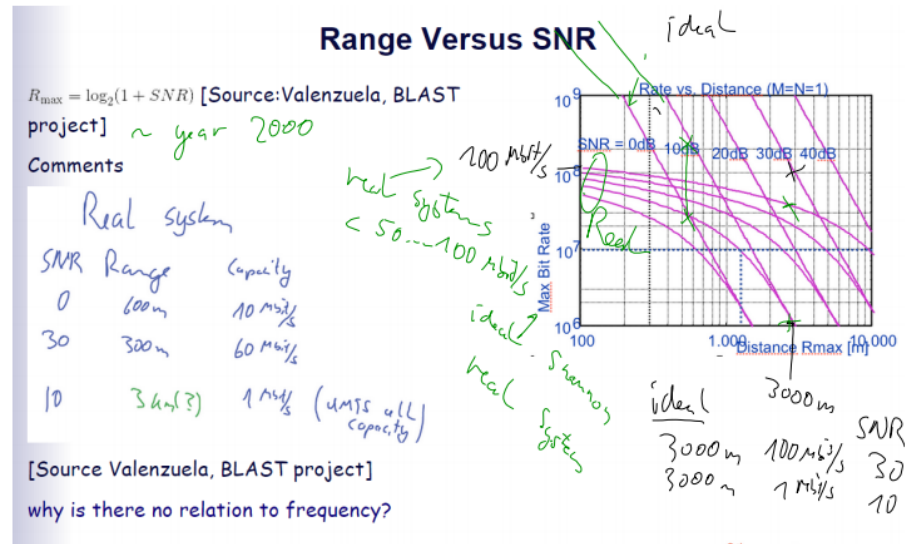
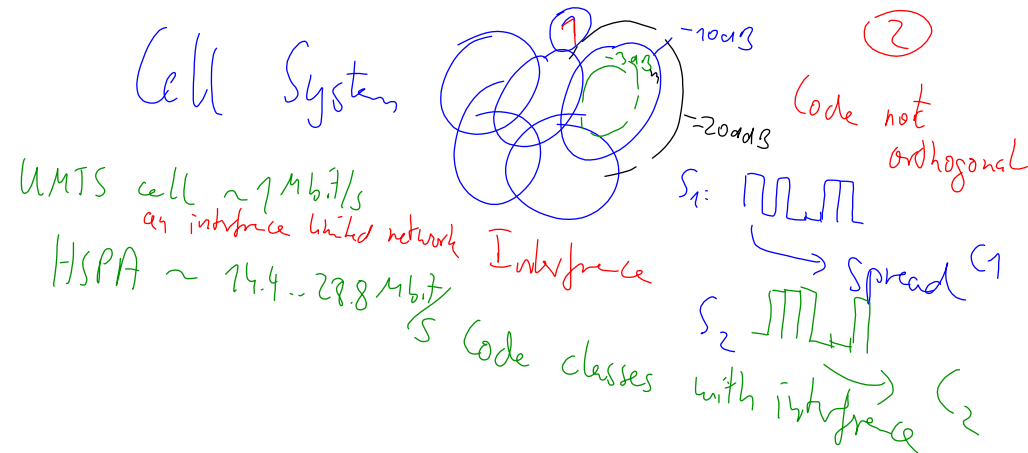
~~3.0ct free~~

Missing upload:
contact

kaja@unik.no

Remind me of the MIC

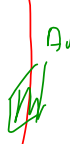
Josef: ca.jroll.net



Capacity $\sim \frac{1}{\text{Range}}$

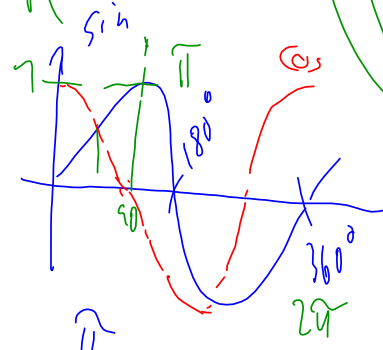
Capacity $\sim f \leftarrow \text{Real System}$

P_{transmit}) 

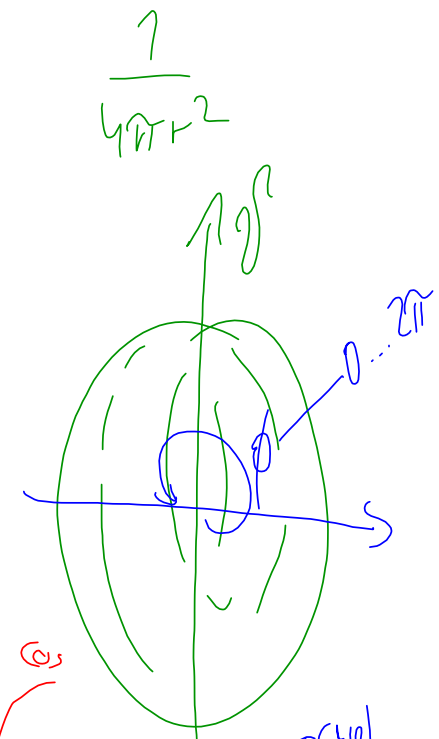
 P_R

Area of Sphere $4\pi r^2$
 $P_r = \frac{P_t \lambda^2}{(4\pi r)^2}$
 $\Rightarrow 4\pi$

P_t	G_t	G_R
0	0	0
30	$\frac{1}{2}\sqrt{1}$	0.5
45	$\frac{1}{2}\sqrt{2}$	0.7
60	$\frac{1}{2}\sqrt{3}$	0.86
90	$\frac{1}{2}\sqrt{4}$	1



$$\int_0^\pi \sin \theta d\theta = \cos \theta \Big|_0^\pi = 2 = \underline{\underline{4\pi}}$$



$$\int_0^\pi \int_0^{2\pi} \sin \theta d\theta d\phi$$

Receive power

$$P_r = P_t \cdot G_t \cdot G_r \cdot \frac{\lambda^2}{(4\pi r)^2}$$

with $\lambda = \frac{c}{f_{\text{Hz}}} = \frac{3 \times 10^8 \text{ m/s}}{f [\text{GHz}] \cdot 10^9} = \frac{30 \text{ cm}}{f [\text{GHz}]}$

$e^{j(\omega t - \vec{k} \cdot \vec{r})}$ with $k = \frac{2\pi}{\lambda}$

$\omega = 2\pi f$

$= \frac{2\pi c}{\lambda}$

$f_m \approx 88.8 \dots 108 \text{ MHz}$

$\lambda \sim 3 \text{ m}$

antenna "is best" at $l = \frac{\lambda}{2}$

$\lambda = \frac{30 \text{ cm}}{f [\text{GHz}]}$

λ

$\sim 16 \text{ GHz}$

65M $\sim 30 \text{ cm}$

UMTS $\sim 15 \text{ cm}$

2.1

WLAN, LTE $\sim 12 \text{ cm}$

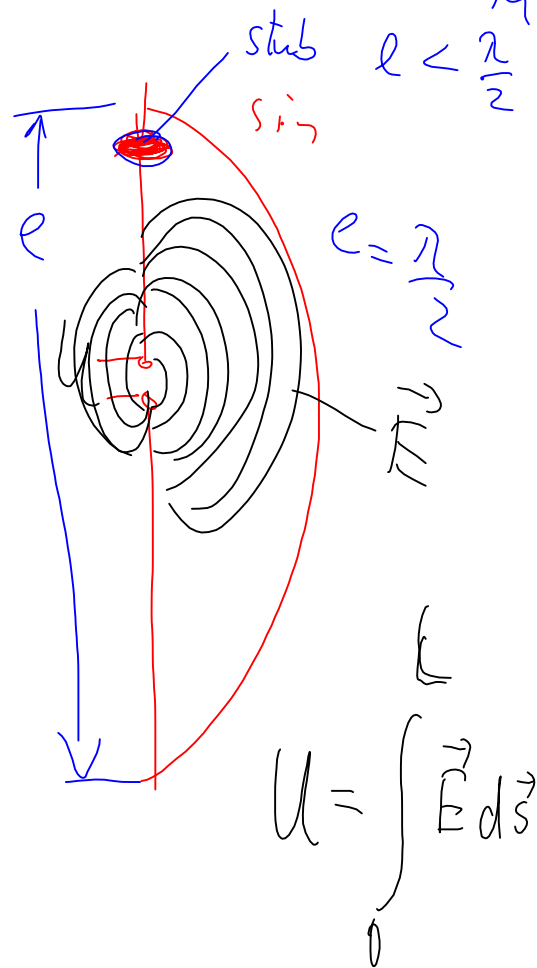
2.4

802.11g $\sim 6 \text{ cm}$

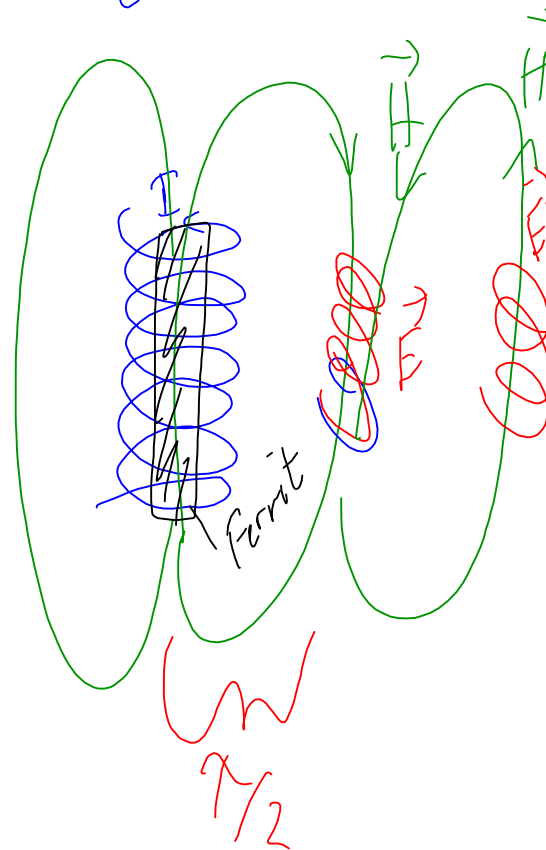
5 GHz

Antenna design

electrical antenna



magnetic antenna



iPhone 4 antenna problems

UNIK

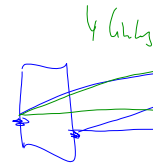
diversity 2 or more antennas

patch antenna

a) diversity
b) MIMO

4G: $\lambda = 12 \text{ cm}$
 $\frac{\lambda}{2} = 6 \text{ cm}$

~16 Hz
GSM 800 ~ 30 cm
UMTS 2.1 ~ 15 cm
WLAN, LTE ~ 12 cm
802.11g ~ 6 cm



D-Link DWR-921 4G router

Multifrequency
800 --- 2.6 GHz
Antennas
 $\frac{\lambda}{2}$ 15 cm 6 cm

λ_0 free space wavelength
 $\ell \sim \frac{\lambda}{2\sqrt{\epsilon_r}} \approx \frac{15}{\sqrt{3.5}}$

7.5 --- 3 cm

patchy $\epsilon_r \approx 3-5$

$$\lambda = \frac{c}{f} = \frac{1}{\sqrt{\mu_r \epsilon_r} f}$$

$\mu_0 \cdot \mu_r$
magnetic permeability
 $\mu_r = 1$

$\epsilon_0 \cdot \epsilon_r$
permittivity

D-link. antenna coupling between patches

Antenna puts up an electric field based on a current/signal

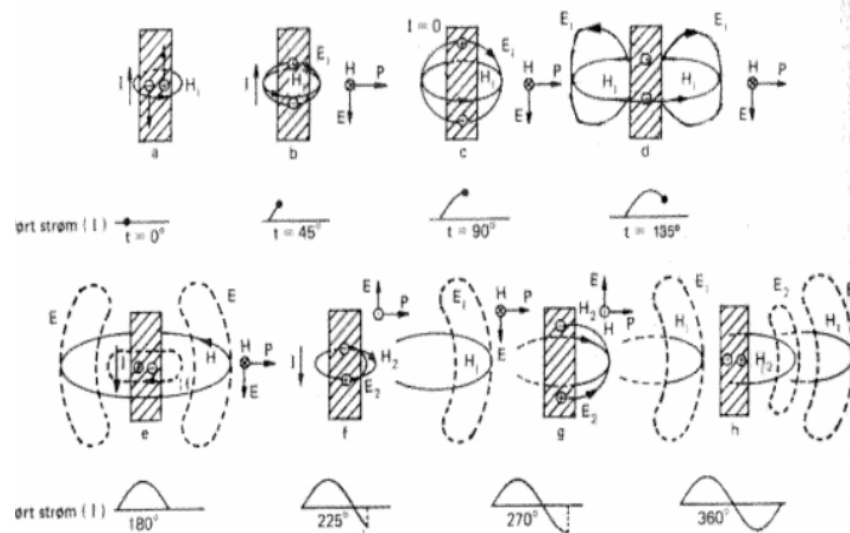
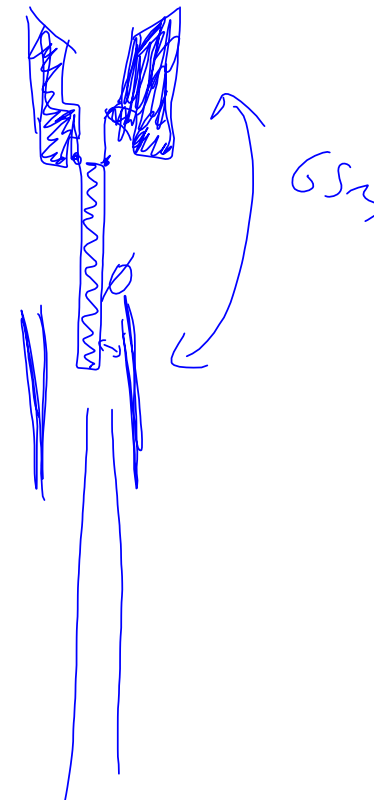
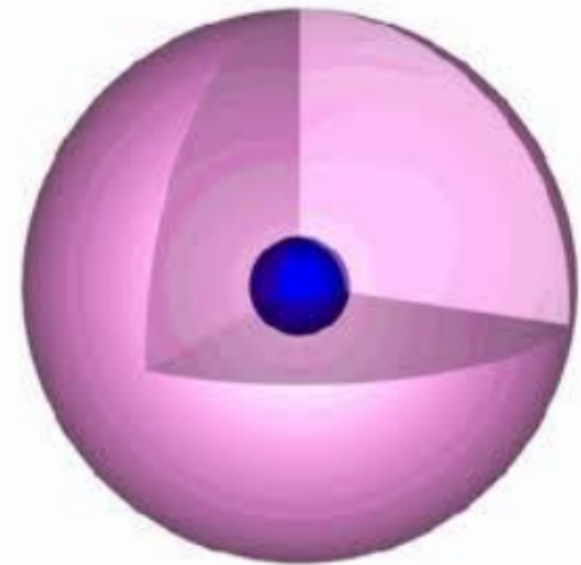


Fig. 4.3. Modell for elektromagnetisk bølgeudbredelse

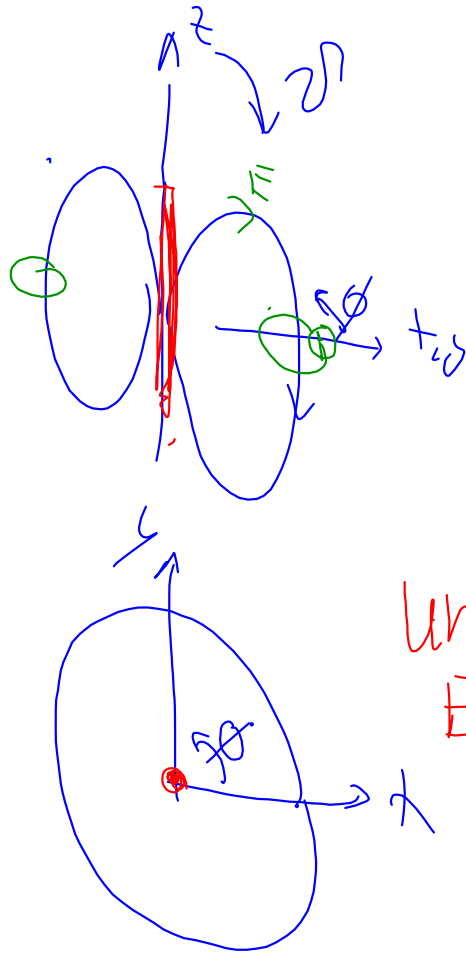


Isotropic antenna

- Theoretical reference antenna (ideal)
- Uniform radiation
- 0db Gain



$\lambda/2$ el antenna



$$E_{\theta} = E_0 \sin \theta$$

Sinoidal

x/y, z plane

$$E_{\phi} = 0$$

Uniform
E in xy

H_{ϕ}

Antenna pattern

$$\vec{E}(\theta, \phi)$$

θ - plane

ϕ - plane

Polarization

Dipole $\frac{\lambda}{2}$
Vertical



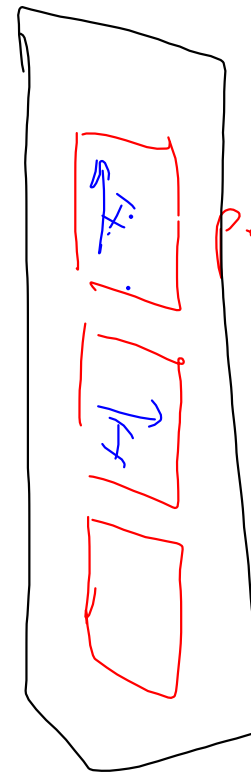
vertical
horizontal



Combination
of h, Vertical
polarisation

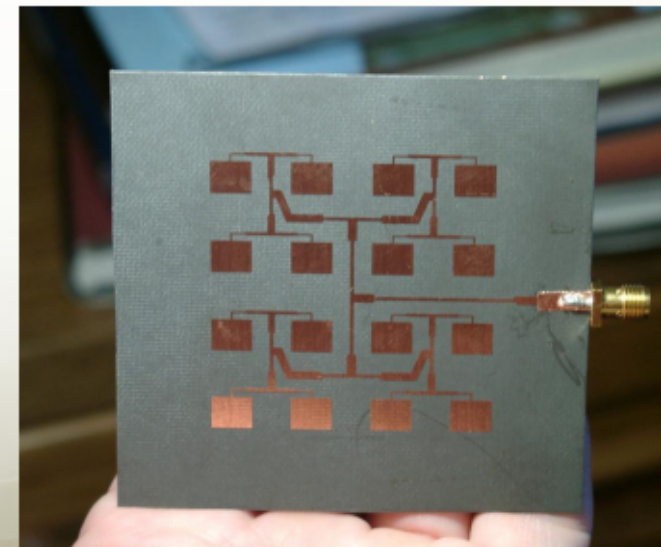
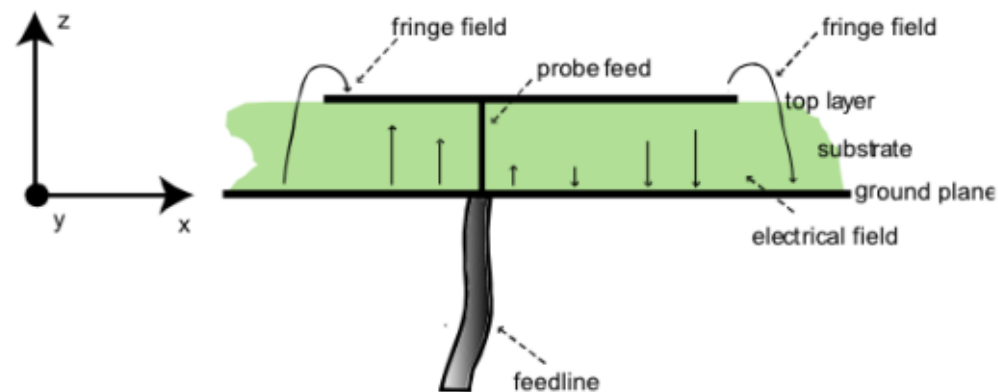
electronically
& adapt

patch
antenna



Patch antennas

- Also known as microstrip antenna
- Metal “sheet” (patch) placed over a ground-plane
- Isolated by a dielectric materia (PCB)
- Inexpensive to produce/design

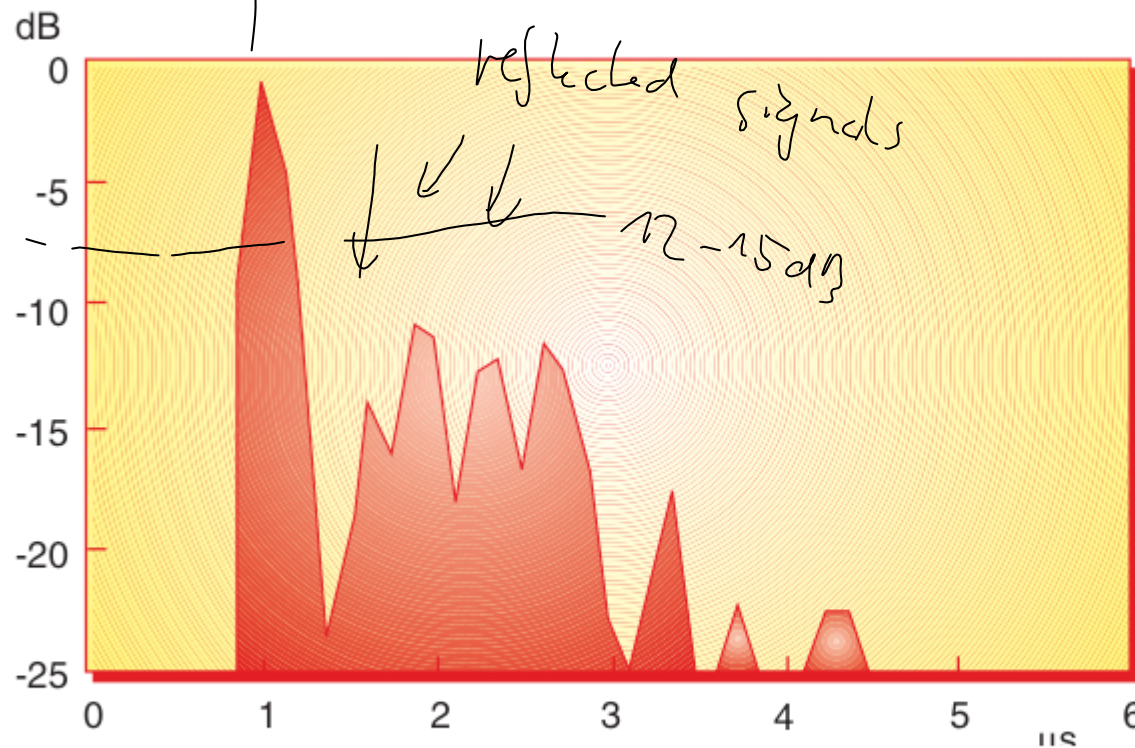


<http://wiki.unik.no/index.php/Courses/UNIK4700propagation>



Measurements in rural farmland

- Typical IR from Farm_1, 1718 Unik/MHz. Total received power was -84 dBm, 20 dB above GSM sensitivity level



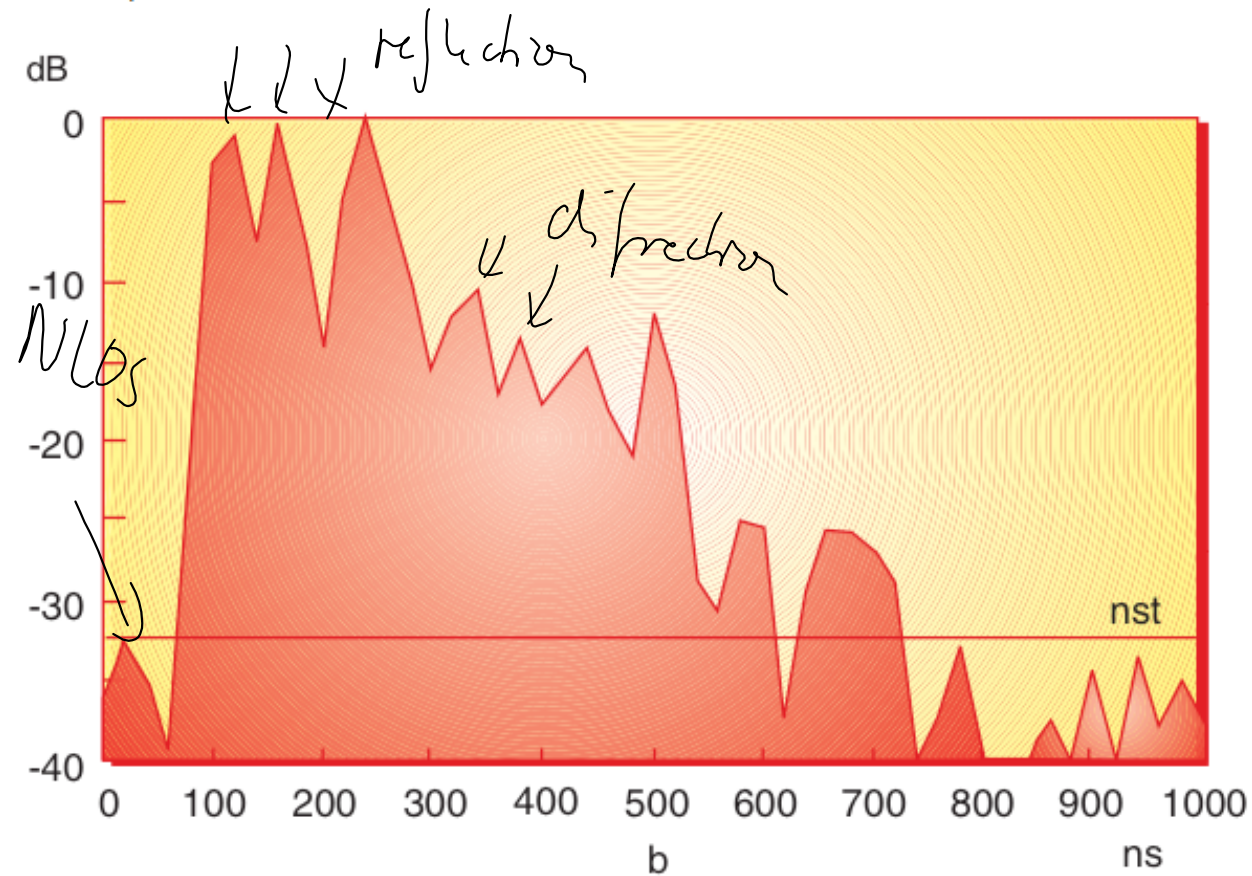
[Source: R. Rækken, G. Løvnes, Teletronikk]

These questions are valid for all of the following impulse responses

- from delay, calculate reflection factor and free space attenuation
- describe characteristics of reflection

Measurements in cities

- Typical IR from City street measurements, 1950 Unik/MHz, Oslo. Output power 25 dBm (in mW?). Omnidirectional $\lambda/4$ - Dipoles used as transmit and receive antennas.



[Source: R. Rækken, G. Løvnes, Teletronikk]

why almost equal distribution? What effect?