

25. Seminar Radijske Komunikacije

# Meritev smernosti anten

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$$D = \frac{4\pi}{\Omega} \equiv \text{Smernost (Directivity)}$$

$$EIRP = D P_{sevana} = G P_{TX}$$

Žaromet  $D$

$$P_{sevana} = \eta P_{TX}$$

Žarnica  $\eta$

$P_{TX}$

$$0 \leq \eta \leq 100\% \equiv \text{Izkoristek}$$

$$G = \eta D \equiv \text{Dobitek (Gain)}$$

Prostorski  
kot  
 $\Omega [\text{srd}]$

$$A = \Omega r^2$$

$$\vec{S} = \vec{1}_r \frac{P_{sevana}}{A}$$

$r$

$\vec{S}$

$$\vec{S} = \vec{1}_r \frac{\eta P_{TX}}{\Omega r^2} = \vec{1}_r \frac{\eta D P_{TX}}{4\pi r^2} = \vec{1}_r \frac{G P_{TX}}{4\pi r^2}$$

Slika 1 – Sevanje usmerjenega izvora

$\vec{S}(r, \Theta, \Phi) \equiv \text{Gostota pretoka sevane moči} [\text{W} / \text{m}^2]$

$|F(\Theta, \Phi)| \equiv \text{Amplitudni smerni diagram antene}$

$$D = \frac{|\vec{S}(r=R, \Theta_{MAX}, \Phi_{MAX})|}{\langle |\vec{S}(r=R, \Theta, \Phi)| \rangle} = \frac{|F(\Theta_{MAX}, \Phi_{MAX})|^2}{\langle |F(\Theta, \Phi)|^2 \rangle} =$$
$$= \frac{4\pi |F(\Theta_{MAX}, \Phi_{MAX})|^2}{\oint_{4\pi} |F(\Theta, \Phi)|^2 d\Omega} = \frac{4\pi |F(\Theta_{MAX}, \Phi_{MAX})|^2}{\int_0^\pi \int_0^{2\pi} |F(\Theta, \Phi)|^2 \sin \Theta d\Theta d\Phi}$$

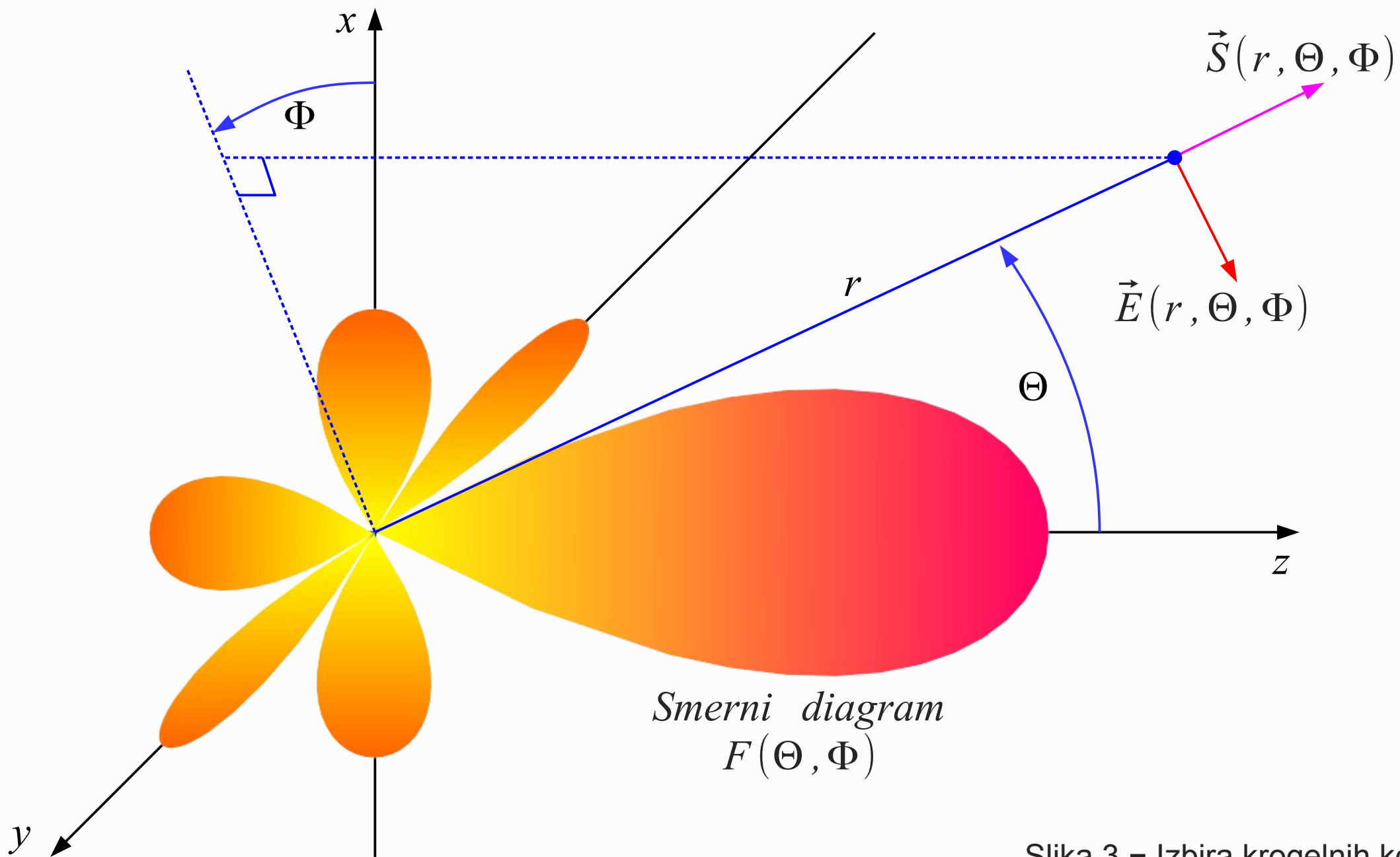
$D_{\text{dBi}} = 10 \log_{10} D \equiv \text{Smernost v logaritemskih enotah} [\text{dBi}]$

$r \equiv \text{Oddaljenost od antene}$

$\Theta \equiv \text{Polarna razdalja}$

$\Phi \equiv \text{Zemljepisna dolžina}$

$|F(\Theta, \Phi)| \equiv \text{Funkcija dveh spremenljivk !}$



Slika 3 – Izbira krogelnih koordinat

$$\oint\limits_{4\pi} |F(\Theta, \Phi)|^2 d\Omega \approx \frac{2\pi}{N} \sum_{j=1}^N \int_0^\pi |F(\Theta, \Phi_j)|^2 \sin \Theta d\Theta \equiv \text{Meritev } N \text{ rezov } \Phi_1, \Phi_2, \Phi_3 \dots \Phi_N$$

$$\oint\limits_{4\pi} |F(\Theta, \Phi)|^2 d\Omega \approx \frac{\pi}{N} \sum_{j=1}^N \int_{-\pi}^\pi |F(\Theta, \Phi_j)|^2 \sin |\Theta| d\Theta \equiv \text{Meritev } N \text{ rezov preko tečaja}$$

$$D_j = \frac{4|F(\Theta_{MAX}=0, \Phi_{MAX}=\Phi_j)|^2}{\int_{-\pi}^\pi |F(\Theta, \Phi_j)|^2 \sin |\Theta| d\Theta} \equiv \text{Delna smernost reza pri zemljepisni dolžini } \Phi_j$$

$$D \approx \frac{N}{\frac{1}{D_1} + \frac{1}{D_2} + \frac{1}{D_3} + \dots + \frac{1}{D_N}} = \frac{N}{\sum_{j=1}^N \frac{1}{D_j}} = \frac{1}{\langle 1/D_j \rangle} \equiv \text{Skupna smernost iz delnih smernosti}$$

Slika 4 – Meritev rezov smernega diagrama

$D_E \equiv$  Delna smernost v ravnini  $E$

$D_H \equiv$  Delna smernost v ravnini  $H$

$$D = \frac{2}{\frac{1}{D_E} + \frac{1}{D_H}} \equiv \text{Smernost iz dveh rezov}$$

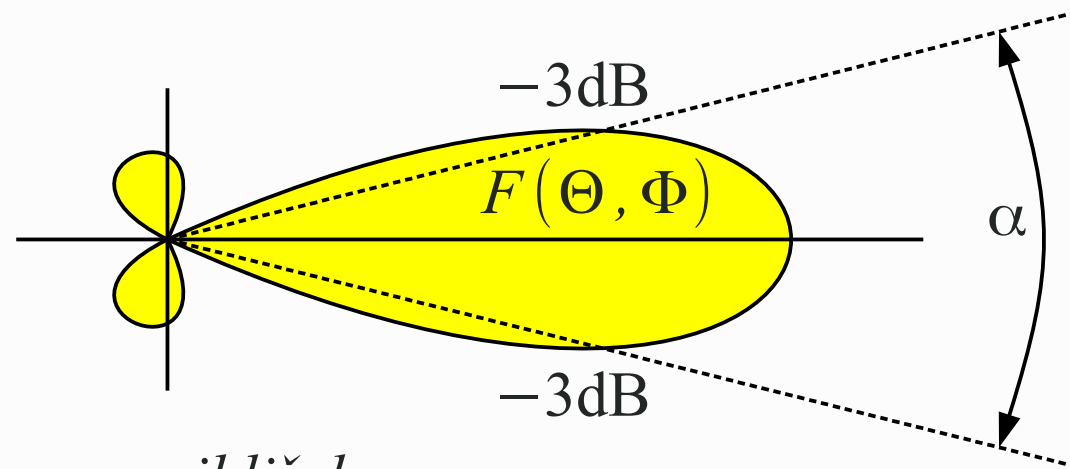
$\alpha_E \equiv -3\text{dB}$  širina snopa v ravnini  $E$

$\alpha_H \equiv -3\text{dB}$  širina snopa v ravnini  $H$

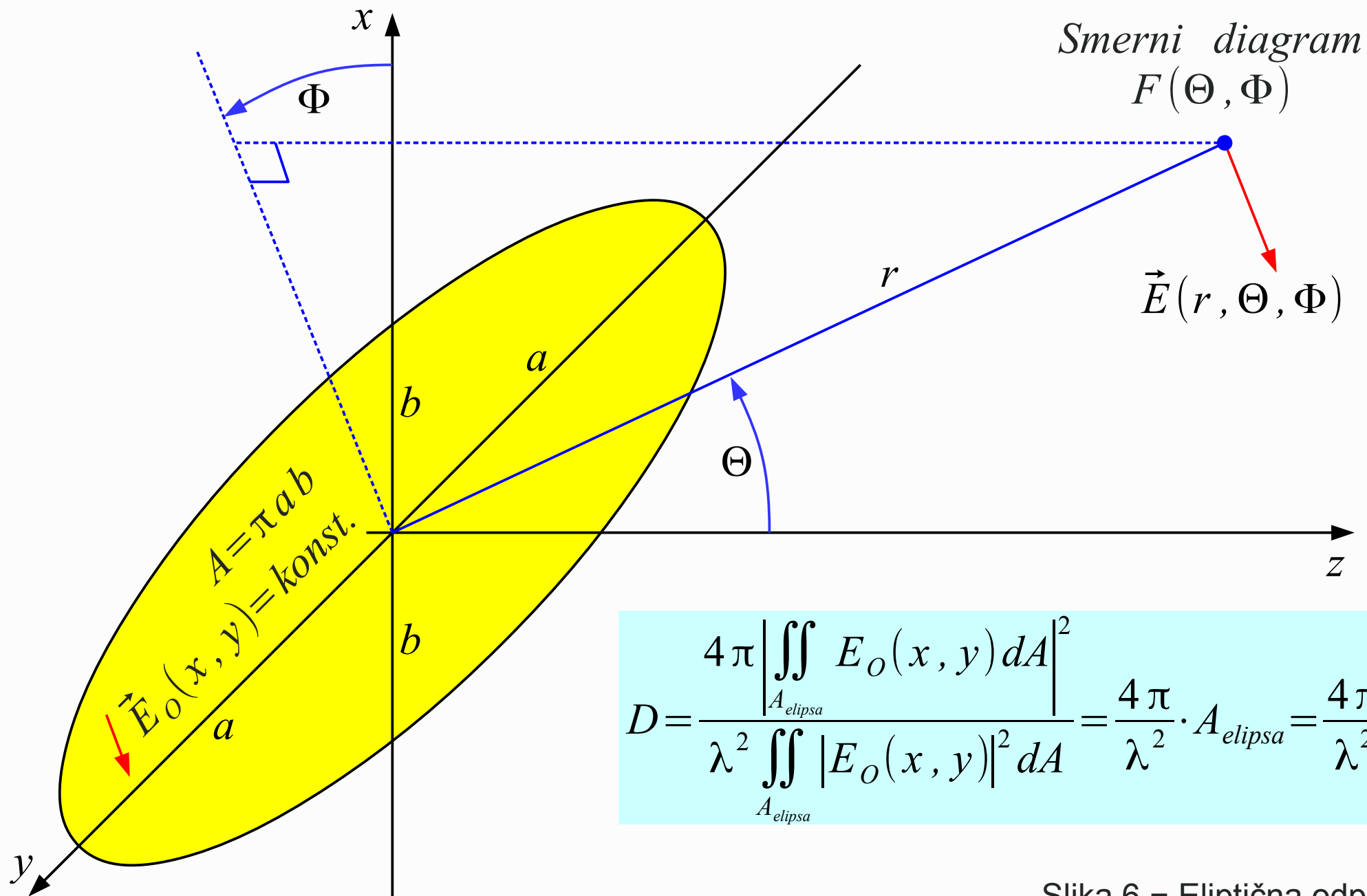
$$D = \frac{4\pi}{\Omega} \approx \frac{4\pi}{\alpha_E[\text{rd}]\alpha_H[\text{rd}]} \approx \frac{41253(^{\circ})^2}{\alpha_E[^{\circ}]\alpha_H[^{\circ}]} \equiv \text{Krausov približek}$$

*Samo dva reza premalo?*

*Premajhna za pahljačast snop!*



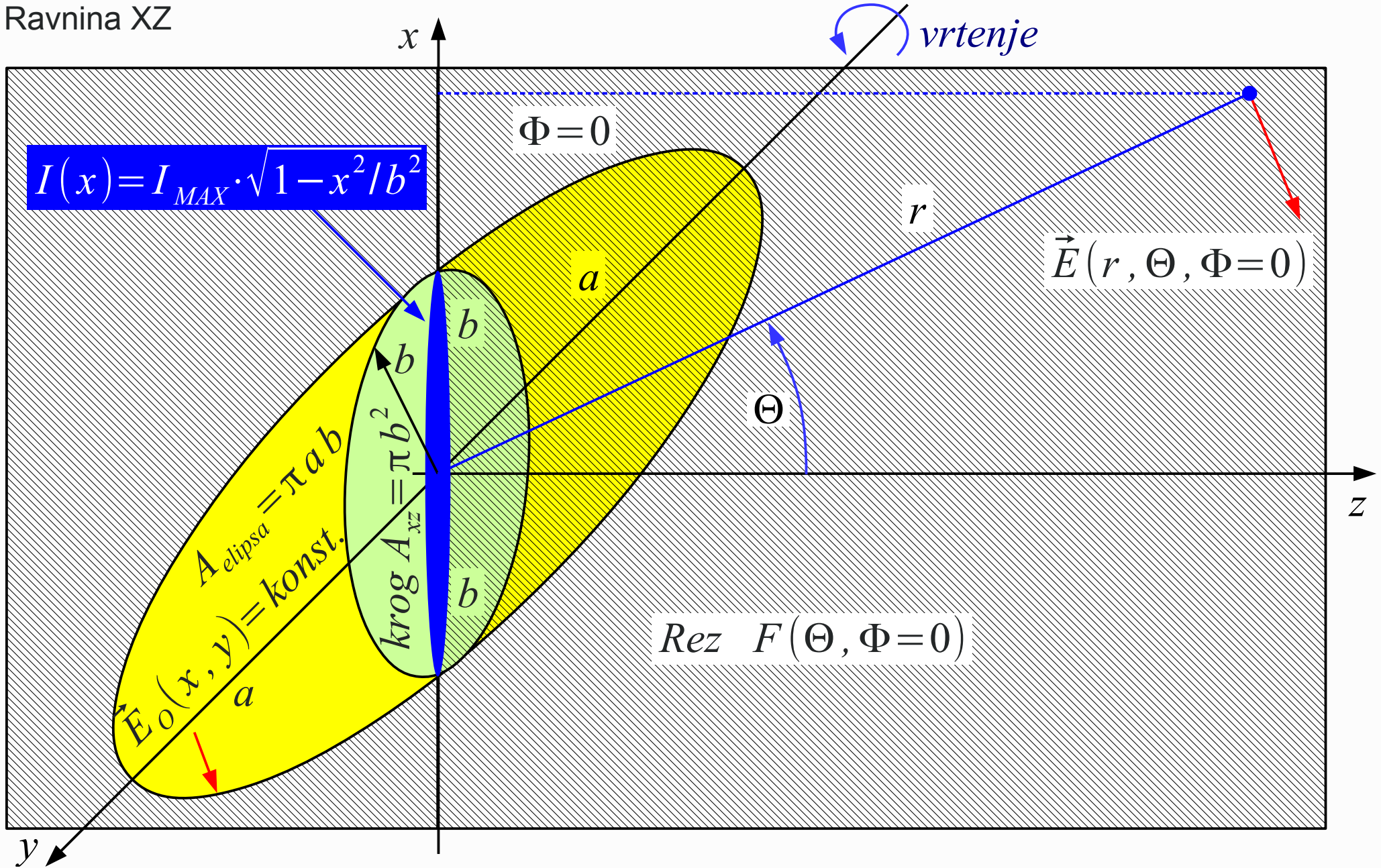
*Prevelik zaradi stranskih snopov*



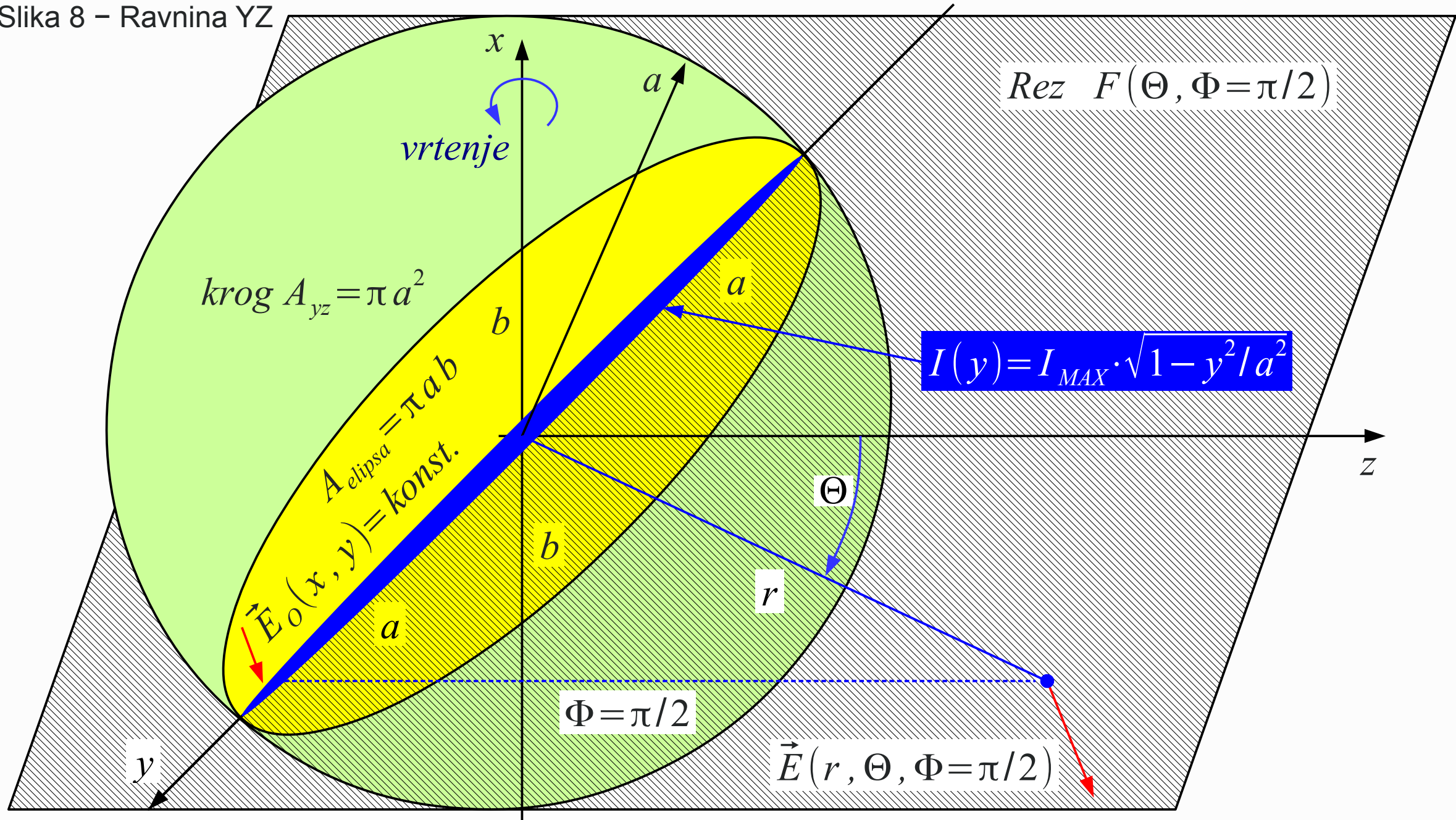
Slika 6 – Eliptična odprtina (skupina)



Slika 7 – Ravnina XZ



## Slika 8 – Ravnina YZ



$$F(\Theta, \Phi=0) = \frac{2 J_1\left(\frac{\pi b}{2\lambda} \sin \Theta\right)}{\frac{\pi b}{2\lambda} \sin \Theta} \cdot \frac{1 + \cos \Theta}{2} \rightarrow D_{xz} = \frac{4\pi \left| \iint_{A_{xz}} E_o(x, y) dA \right|^2}{\lambda^2 \iint_{A_{xz}} |E_o(x, y)|^2 dA} = \frac{4\pi}{\lambda^2} \cdot A_{xz} = \frac{4\pi}{\lambda^2} \cdot \pi b^2$$

$$F(\Theta, \Phi=\frac{\pi}{2}) = \frac{2 J_1\left(\frac{\pi a}{2\lambda} \sin \Theta\right)}{\frac{\pi a}{2\lambda} \sin \Theta} \cdot \frac{1 + \cos \Theta}{2} \rightarrow D_{yz} = \frac{4\pi \left| \iint_{A_{yz}} E_o(x, y) dA \right|^2}{\lambda^2 \iint_{A_{yz}} |E_o(x, y)|^2 dA} = \frac{4\pi}{\lambda^2} \cdot A_{yz} = \frac{4\pi}{\lambda^2} \cdot \pi a^2$$

$$D = \frac{4\pi}{\lambda^2} \cdot \pi a b = \sqrt{\left(\frac{4\pi}{\lambda^2} \cdot \pi b^2\right) \cdot \left(\frac{4\pi}{\lambda^2} \cdot \pi a^2\right)} = \sqrt{D_{xz} \cdot D_{yz}} \equiv \textit{Geometrijska sredina delnih smernosti} !$$

$$\log D = \frac{1}{2} [\log D_{xz} + \log D_{yz}] = \langle \log D_j \rangle \equiv \textit{Povprečje logaritmov delnih smernosti} !$$

Slika 9 – Postopek izračuna skupne smernosti

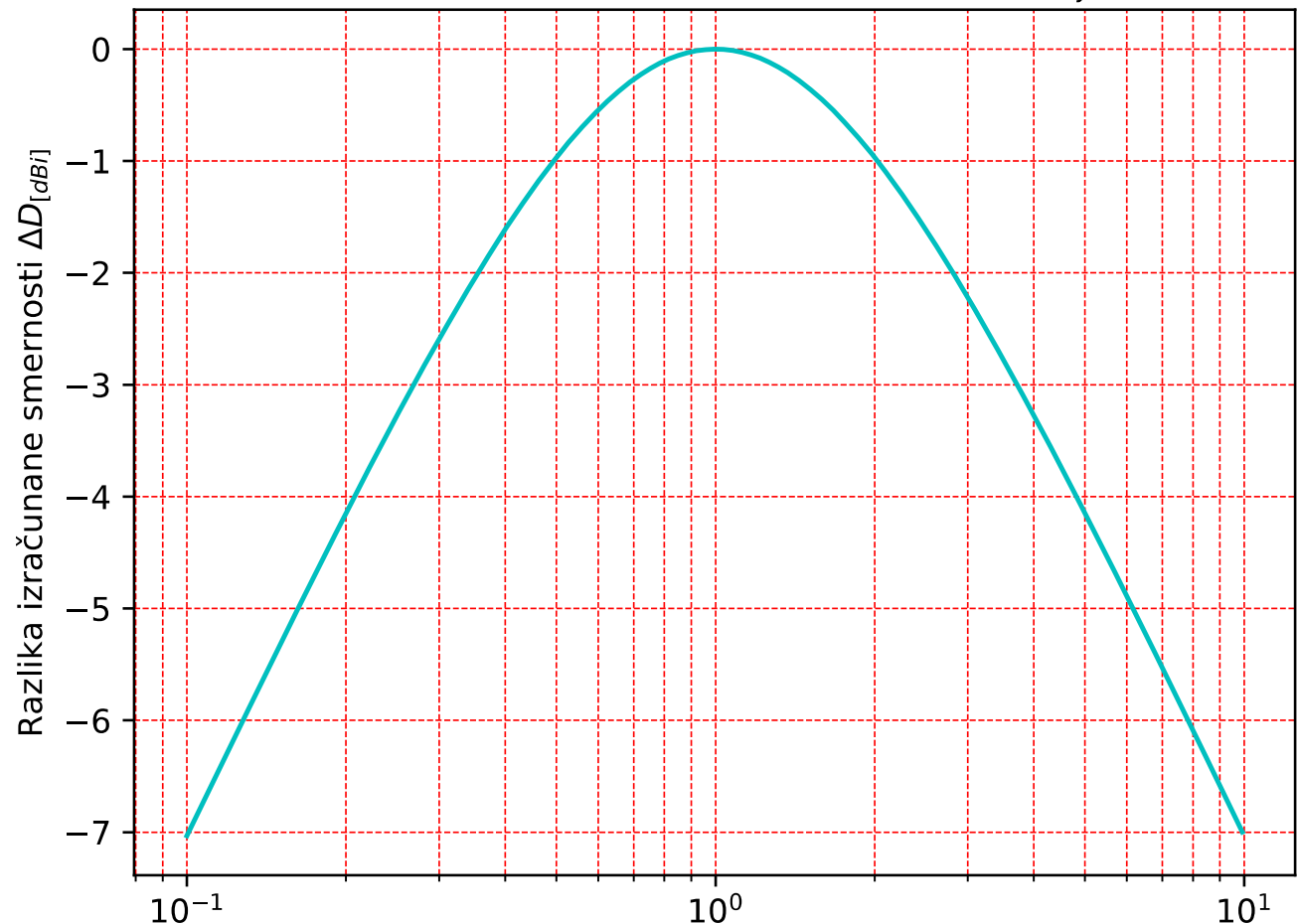
$$\Delta D_{[\text{dBi}]} = 10 \log_{10} \frac{\frac{2}{\frac{1}{D_{xz}} + \frac{1}{D_{yz}}}}{\sqrt{D_{xz} \cdot D_{yz}}} =$$

$$= 10 \log_{10} \frac{\frac{2}{\frac{D_{yz}}{D_{xz}} + 1}}{\sqrt{\frac{D_{xz}}{D_{yz}}}} =$$

$$= 10 \log_{10} \frac{2R}{1+R^2} \leq 0$$

$$R = \frac{b}{a} = \sqrt{\frac{D_{xz}}{D_{yz}}} \approx \left( \frac{\alpha_{xz}}{\alpha_{yz}} \right)^{-1} \equiv \text{Oсно razmerje}$$

Razlika izračunane smernosti med povprečenji  $\langle 1/D_j \rangle$  in  $\langle \log D_j \rangle$



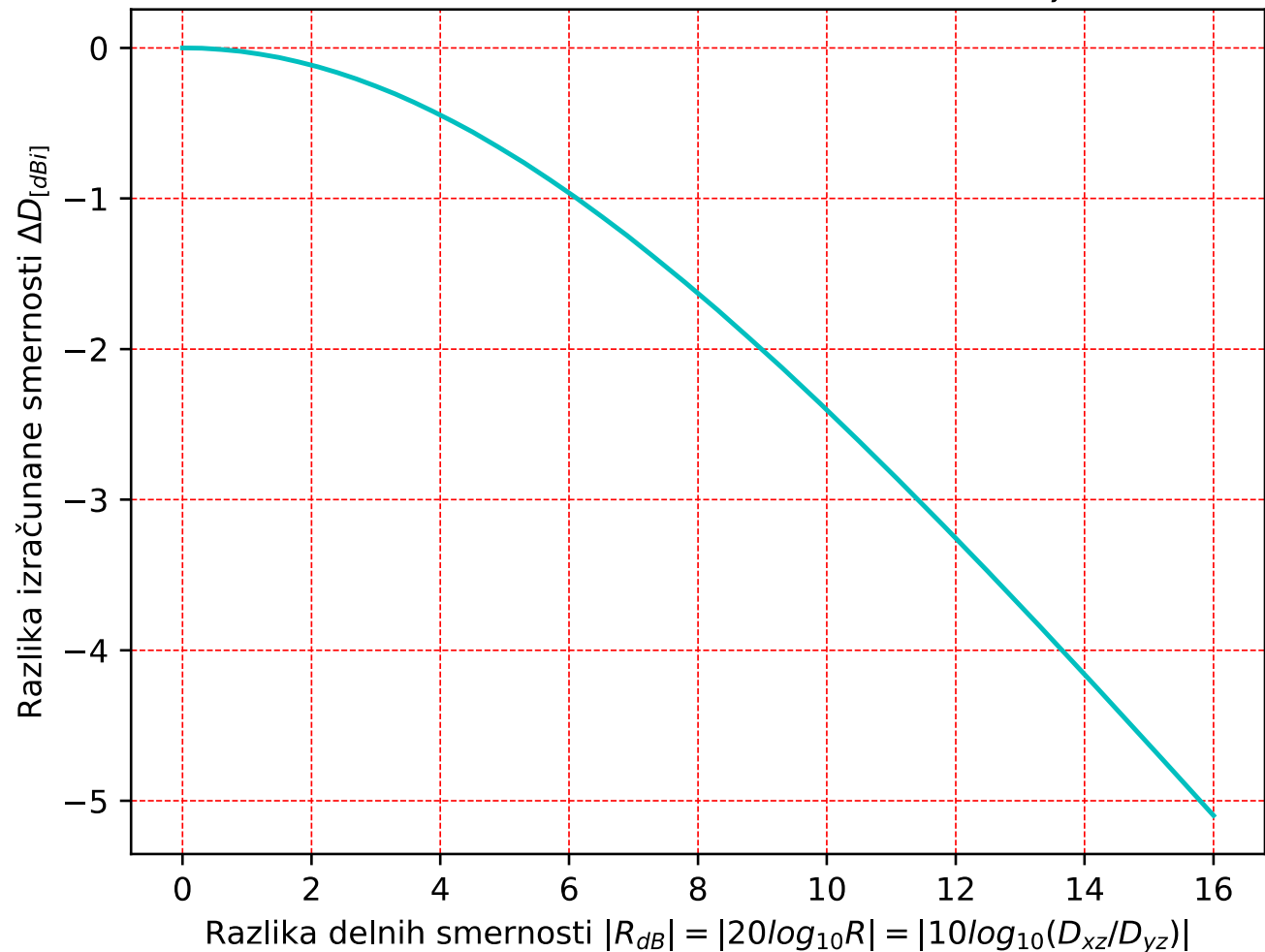
$$\text{Oсно razmerje } R = b/a = \sqrt{D_{xz}/D_{yz}} \approx (\alpha_{xz}/\alpha_{yz})^{-1}$$

Slika 10 – Razlika povprečenj smernosti

$$R_{\text{dB}} = 20 \log_{10} \left( \frac{b}{a} \right) = 10 \log_{10} \left( \frac{D_{xz}}{D_{yz}} \right) \approx -20 \log_{10} \left( \frac{\alpha_{xz}}{\alpha_{yz}} \right) \equiv \textit{Razlika delnih smernosti} [\text{dB}]$$

$$\Delta D_{[\text{dBi}]} = 10 \log_{10} \frac{2 \cdot 10^{R_{\text{dB}}/20}}{1 + 10^{R_{\text{dB}}/10}}$$

Razlika izračunane smernosti med povprečenji  $\langle 1/D_j \rangle$  in  $\langle \log D_j \rangle$

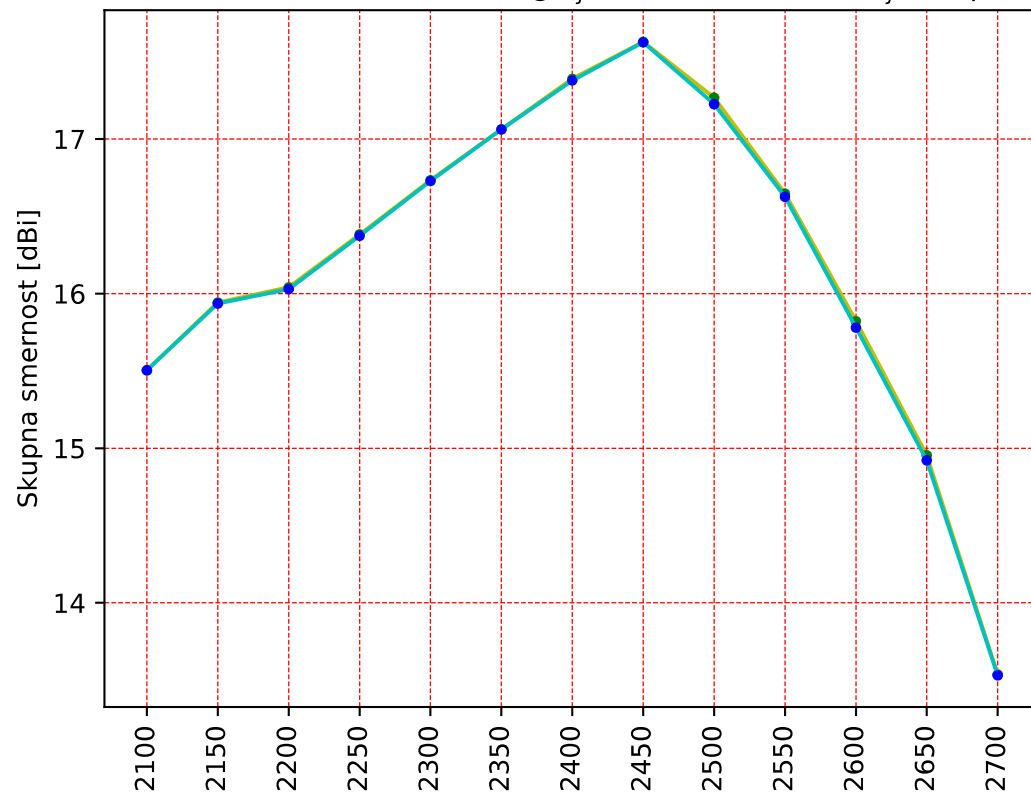


Slika 11 – Razlika iz delnih smernosti

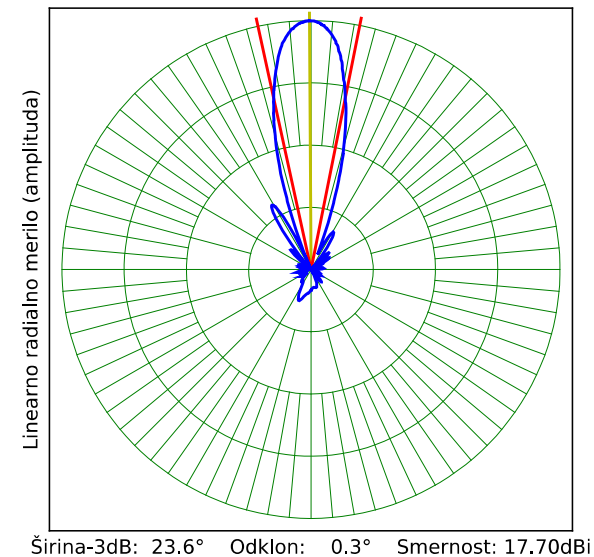


*Kraus*  
 $D \approx 18.85\text{dBi}$

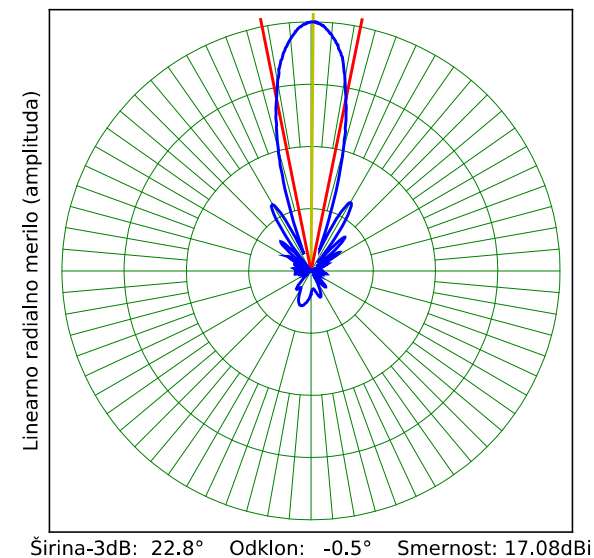
Smernost iz obeh rezov  $\langle \log D_j \rangle = \text{rumena}$   $\langle 1/D_j \rangle = \text{plava}$



Fri Dec 10 11:49:43 2021  
 E2400MHz



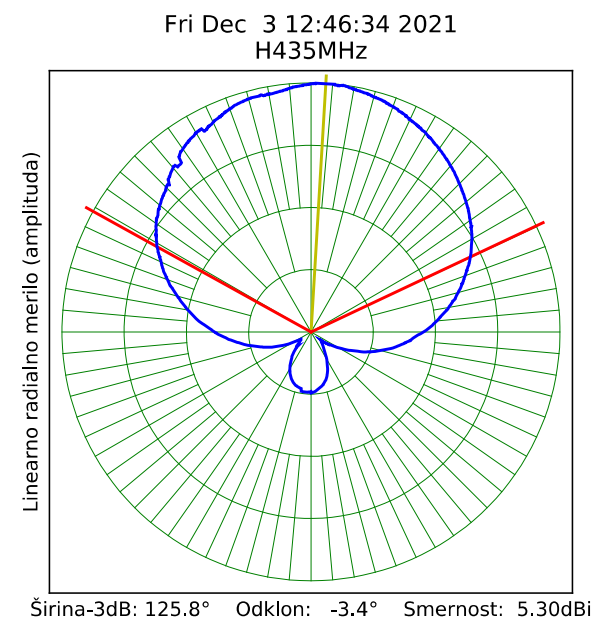
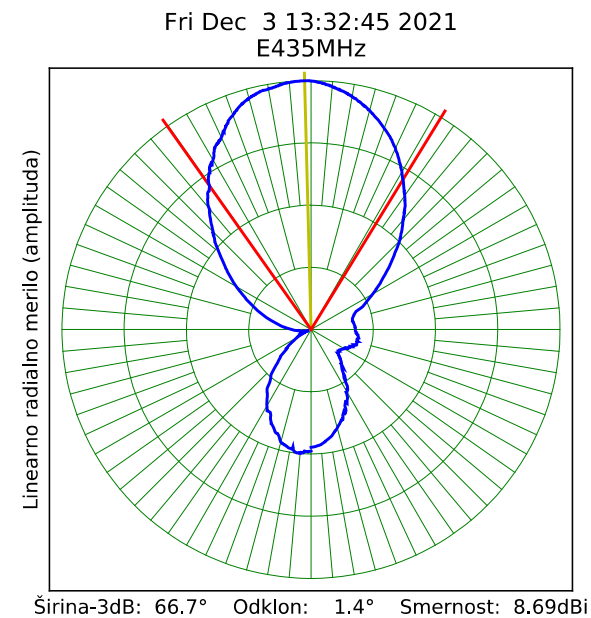
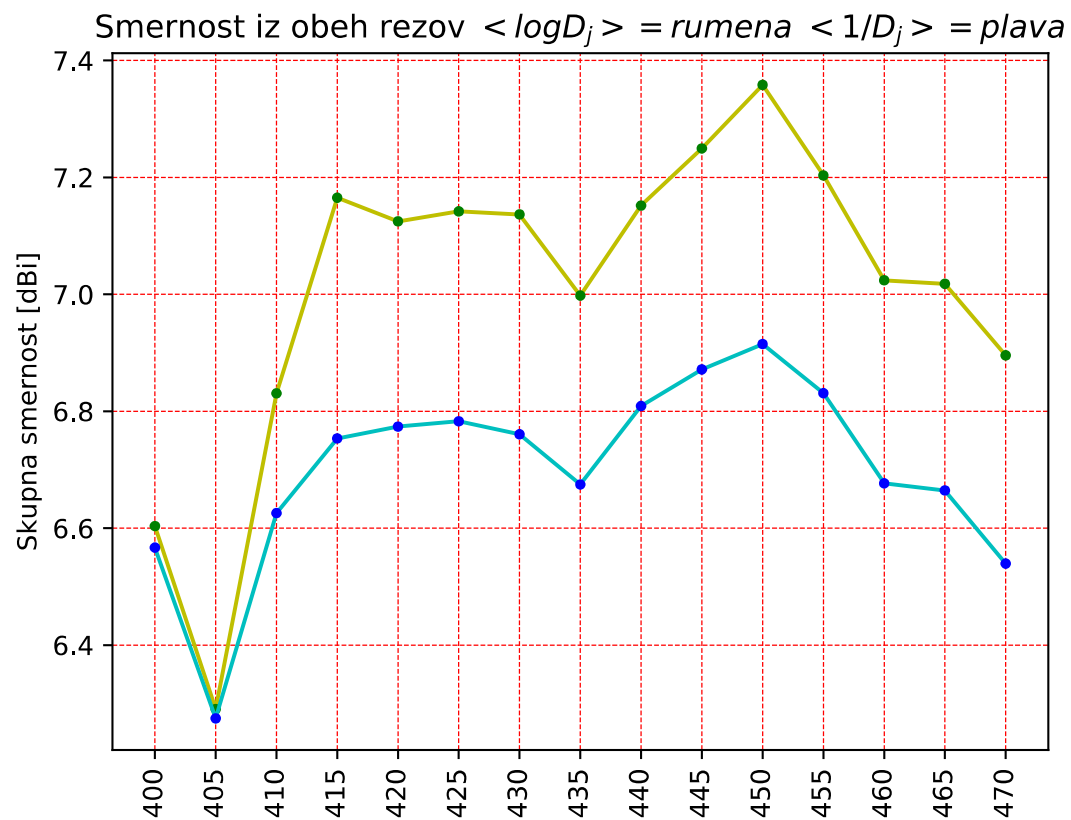
Fri Dec 10 12:31:11 2021  
 H2400MHz





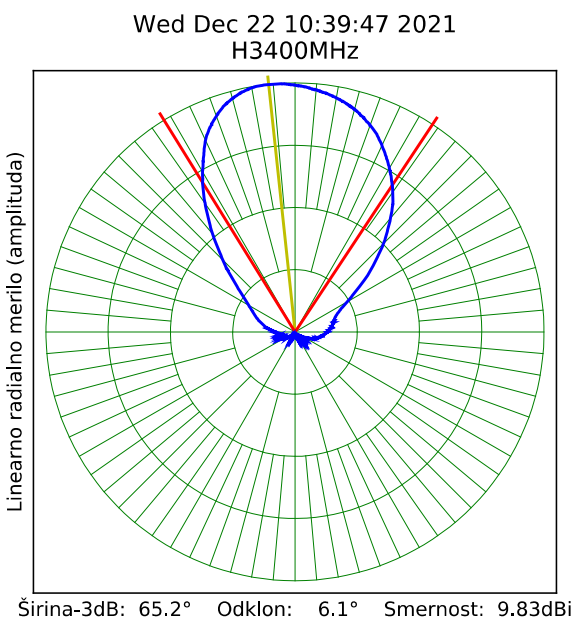
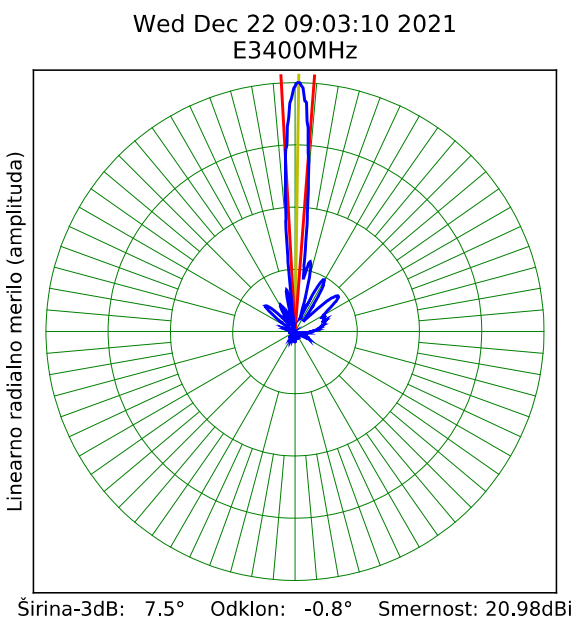
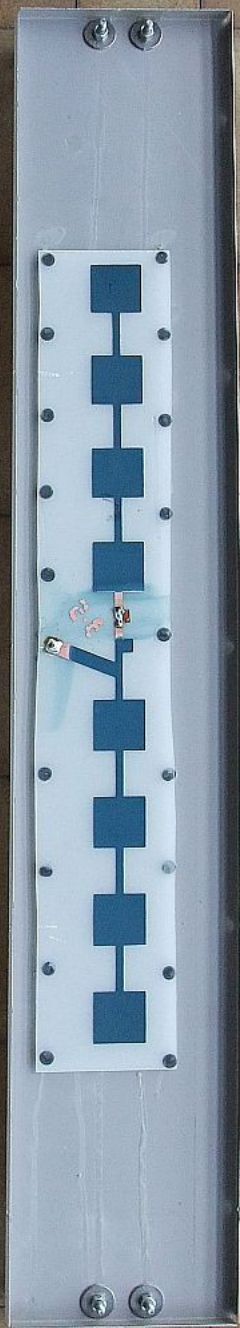
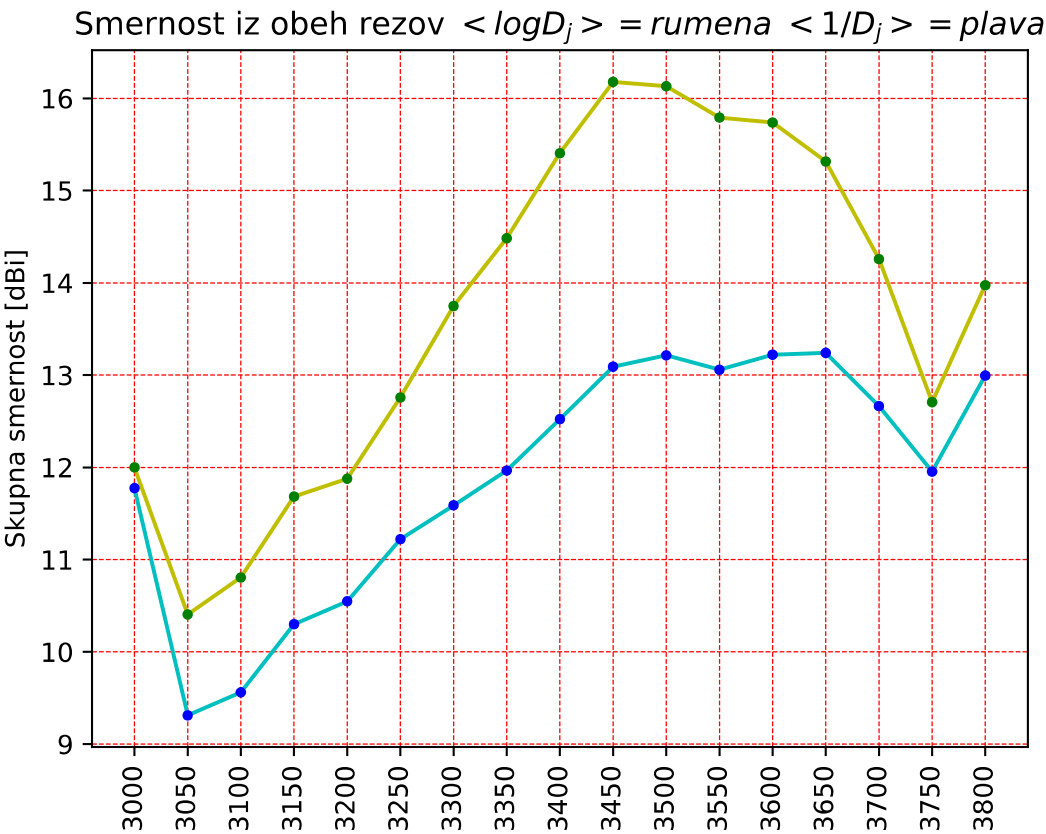


*Kraus*  
 $D \approx 6.91 \text{ dBi}$



Slika 14 – Sektorska skupina za 3400MHz

*Kraus*  
 $D \approx 19.26\text{dBi}$







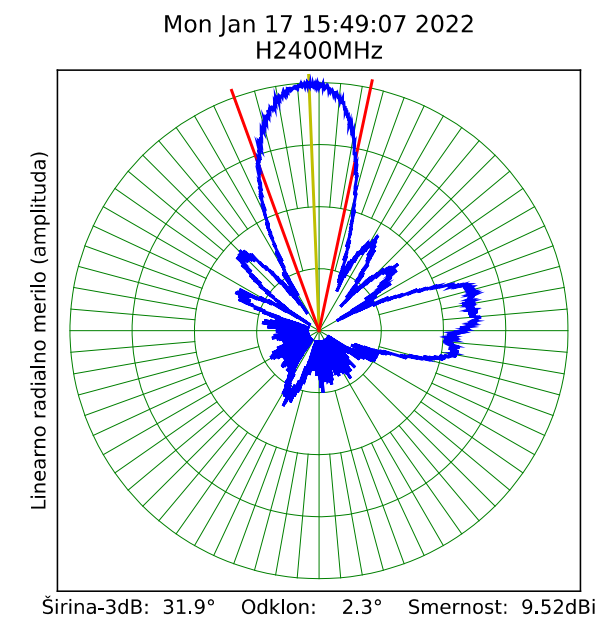
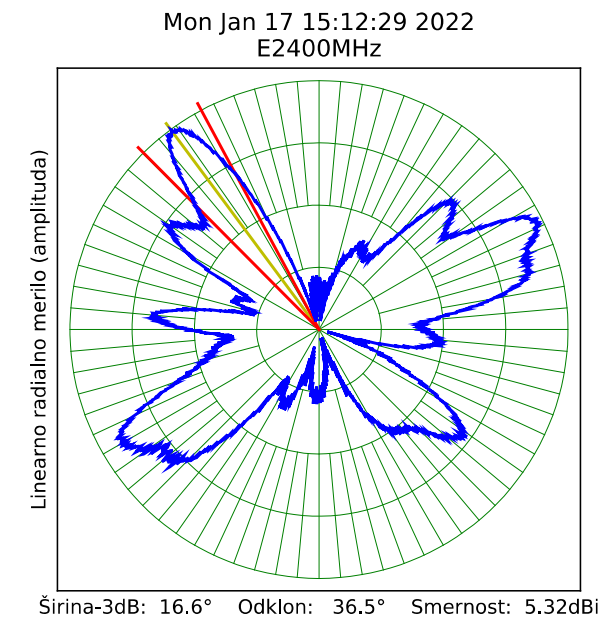
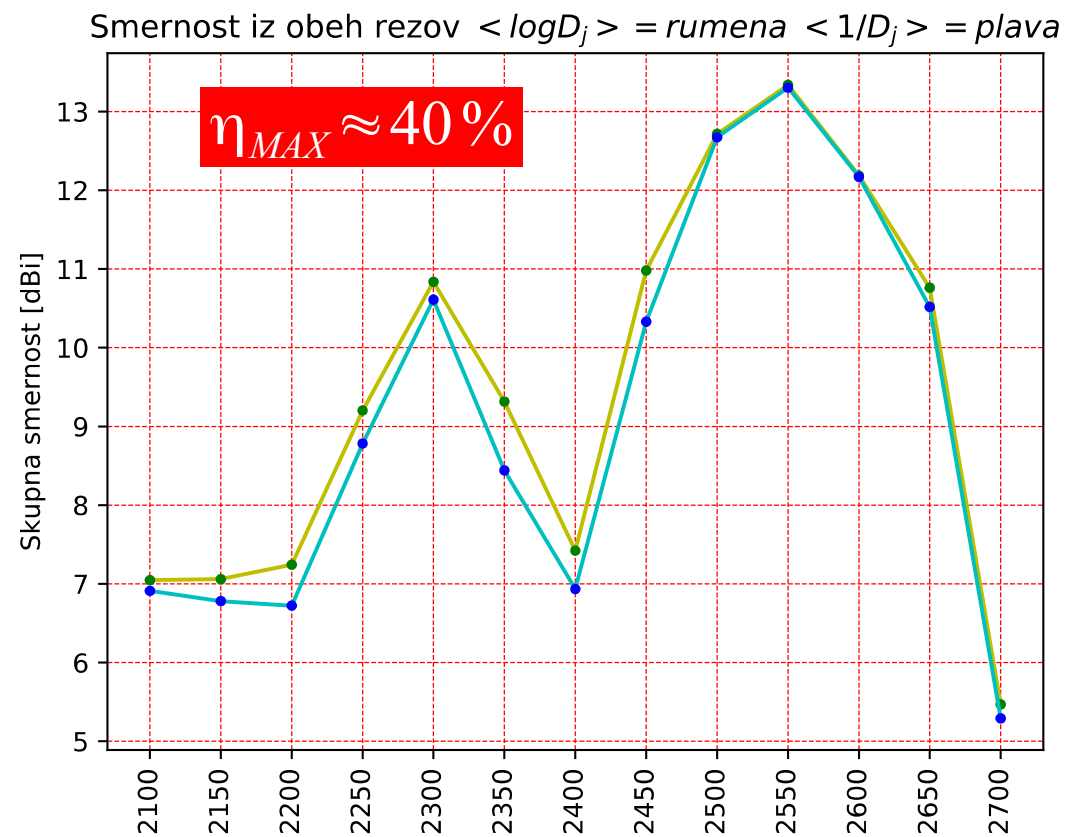
Ravnina E

## Slika 15 – Meritev sektorske skupine

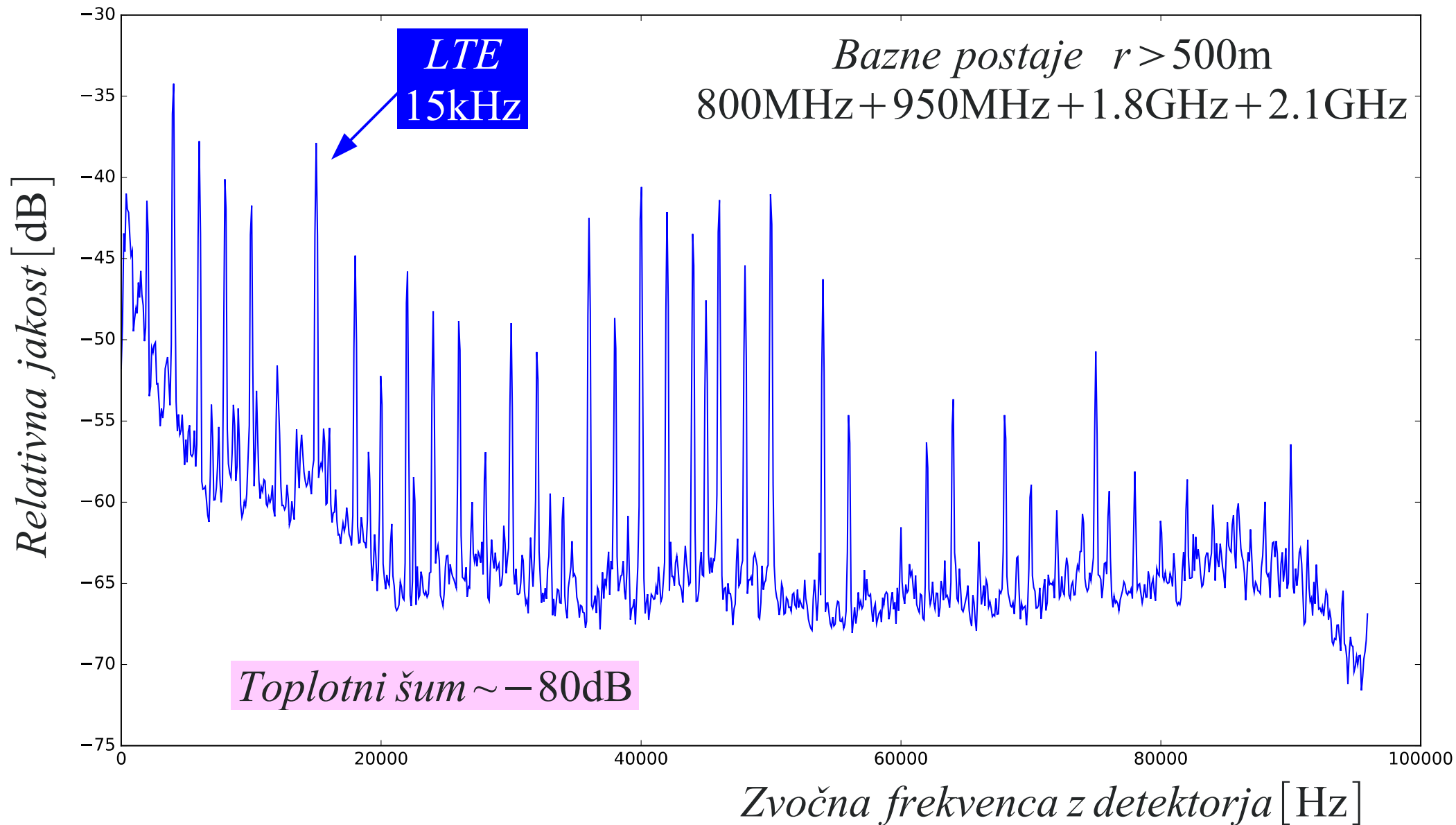
Ravnina H







*Širokopasovna antena 6dBi + dioda + FFT 192kHz na MIC vhodu prenosnika*



Slika 17 – Nizkofrekvenčni spekter detektorja