DESIGN
GRADE DE BRAGG

SEMANA 1

ESTUDO DE REFERENCIAS

ESTUDO DE REFERENCIAS

Ref: T. Erdogan, "Fiber grating spectra," in Journal of Lightwave Technology, vol. 15, no. 8, pp. 1277-1294, Aug. 1997, doi: 10.1109/50.618322.

Para uma grade do tipo FBG, é interessante calcular analiticamente sua transmissão e refletância teorica

Para um caso mais simples as variáveis que podemos controlar são:

Neff, Comprimento da grade, refletância maxima

ESTUDO DE REFERENCIAS

Podemos calcular a através da seguinte equação:

$$r = \frac{\sinh^2\left(\sqrt{\kappa^2 - \hat{\sigma}^2}L\right)}{\cosh^2\left(\sqrt{\kappa^2 - \hat{\sigma}^2}L\right) - \frac{\hat{\sigma}^2}{\kappa^2}}.$$

Logo, so precisamos definir k e $\hat{\sigma}$

ESTUDO DE REFERENCIAS

K pode ser calculado a partir da reflexão maxima:

$$r_{\max} = \tanh^2(\kappa L)$$

$$k = \frac{arctang(\sqrt{r_{max}})}{L}$$

ESTUDO DE REFERENCIAS

E sabendo que:

$$\hat{\sigma} \equiv \delta + \sigma - \frac{1}{2}\frac{d\phi}{dz}$$

Dado que a grade é uniforme: $\frac{d\phi}{dz} = 0$

Desprezando o self-coupling: $\sigma = 0$

Logo: $\hat{\sigma} \equiv \delta = 2\pi n_{\text{eff}}\left(\frac{1}{\lambda} - \frac{1}{\lambda_D}\right)$

ESTUDO DE REFERENCIAS

E sabendo que:

$$\hat{\sigma} \equiv \delta + \sigma - \frac{1}{2}\frac{d\phi}{dz}$$

Dado que a grade é uniforme: $\frac{d\phi}{dz} = 0$

Desprezando o self-coupling: $\sigma = 0$

Logo: $\hat{\sigma} \equiv \delta = 2\pi n_{\text{eff}}\left(\frac{1}{\lambda} - \frac{1}{\lambda_D}\right)$

ESTUDO DE REFERENCIAS

Exemplo 1

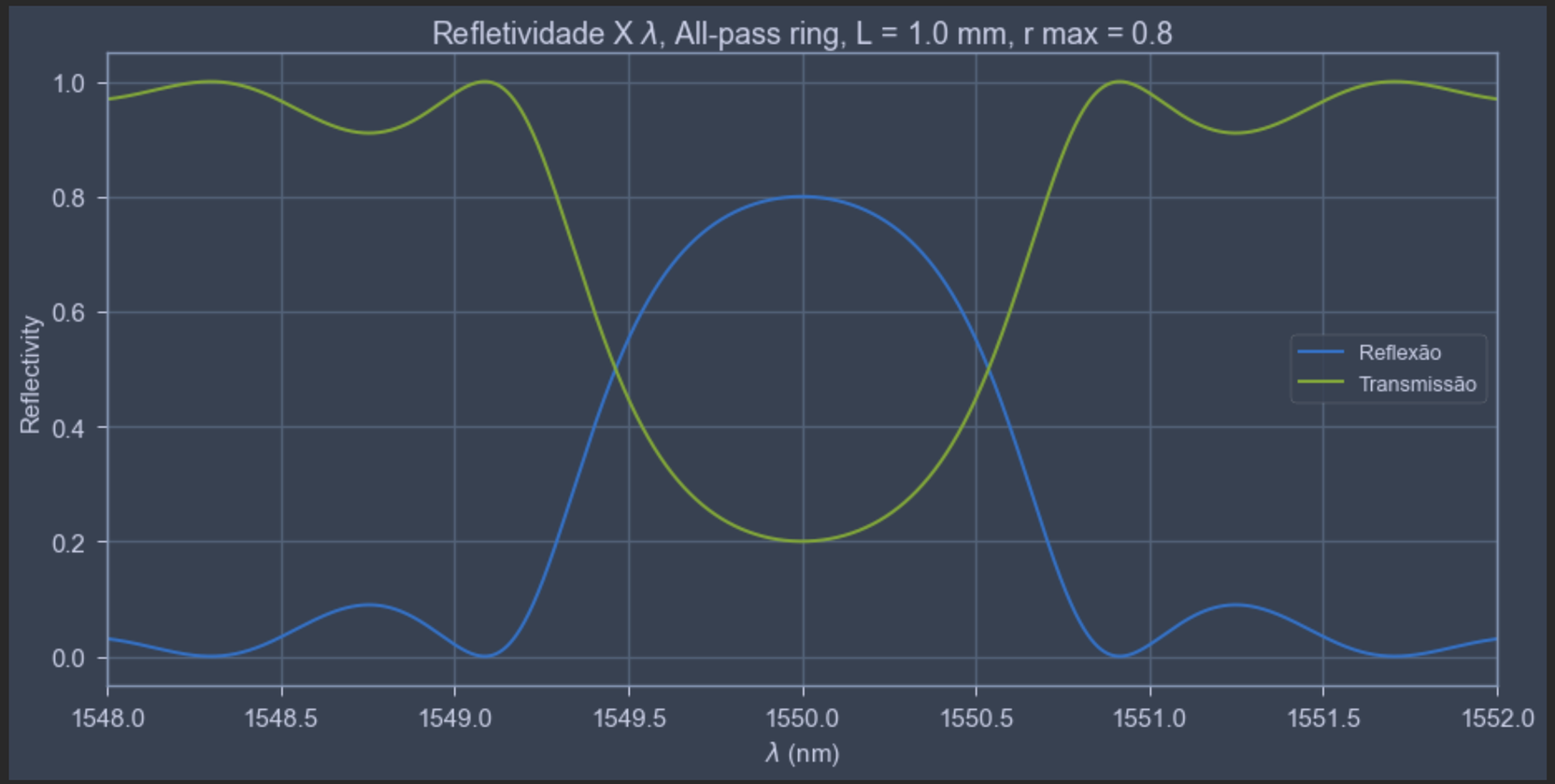
L = 1 mm ,

r max = 0.8,

Comprimento central = 1550 nm

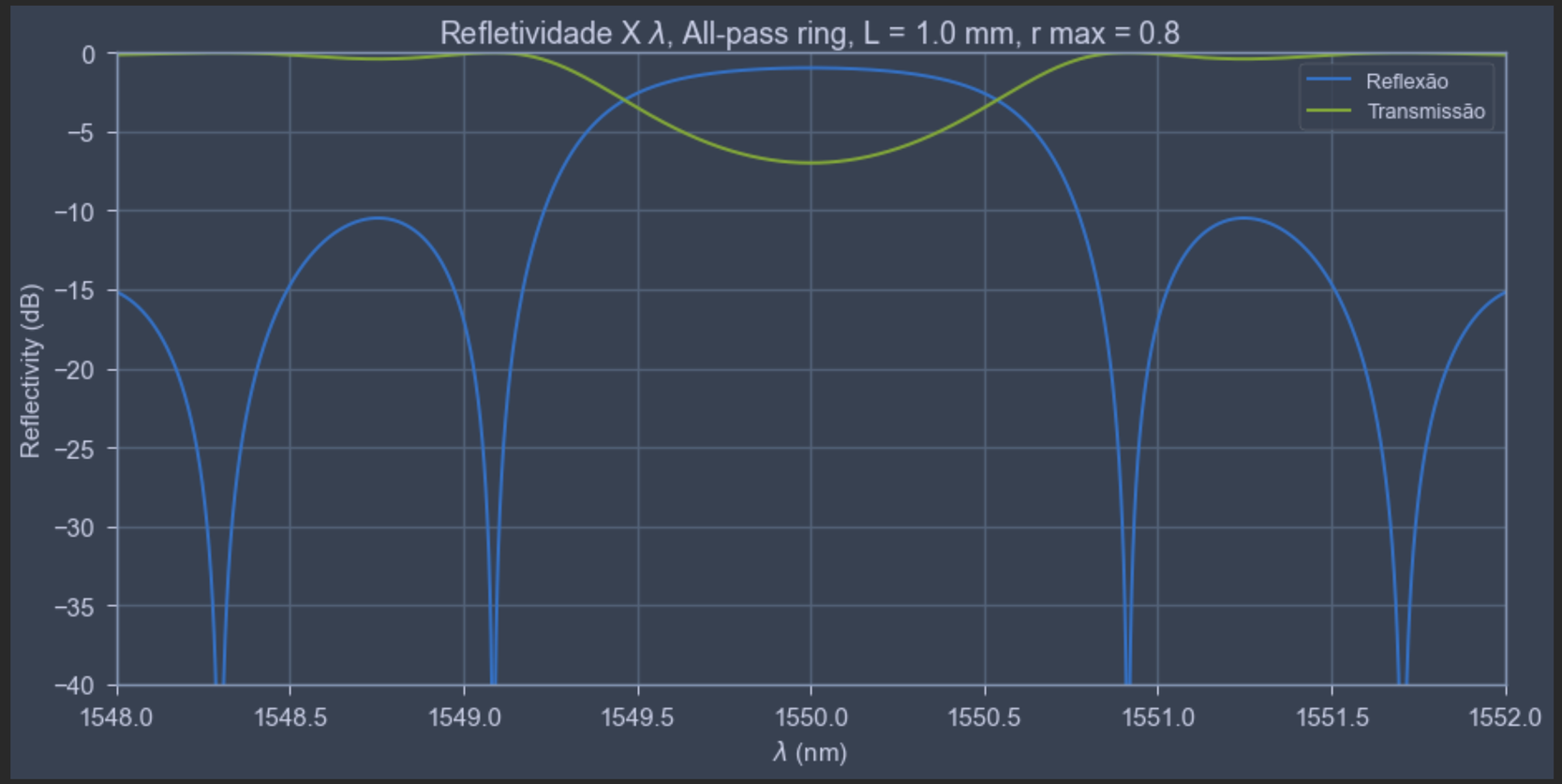
ESTUDO DE REFERENCIAS

Exemplo 1



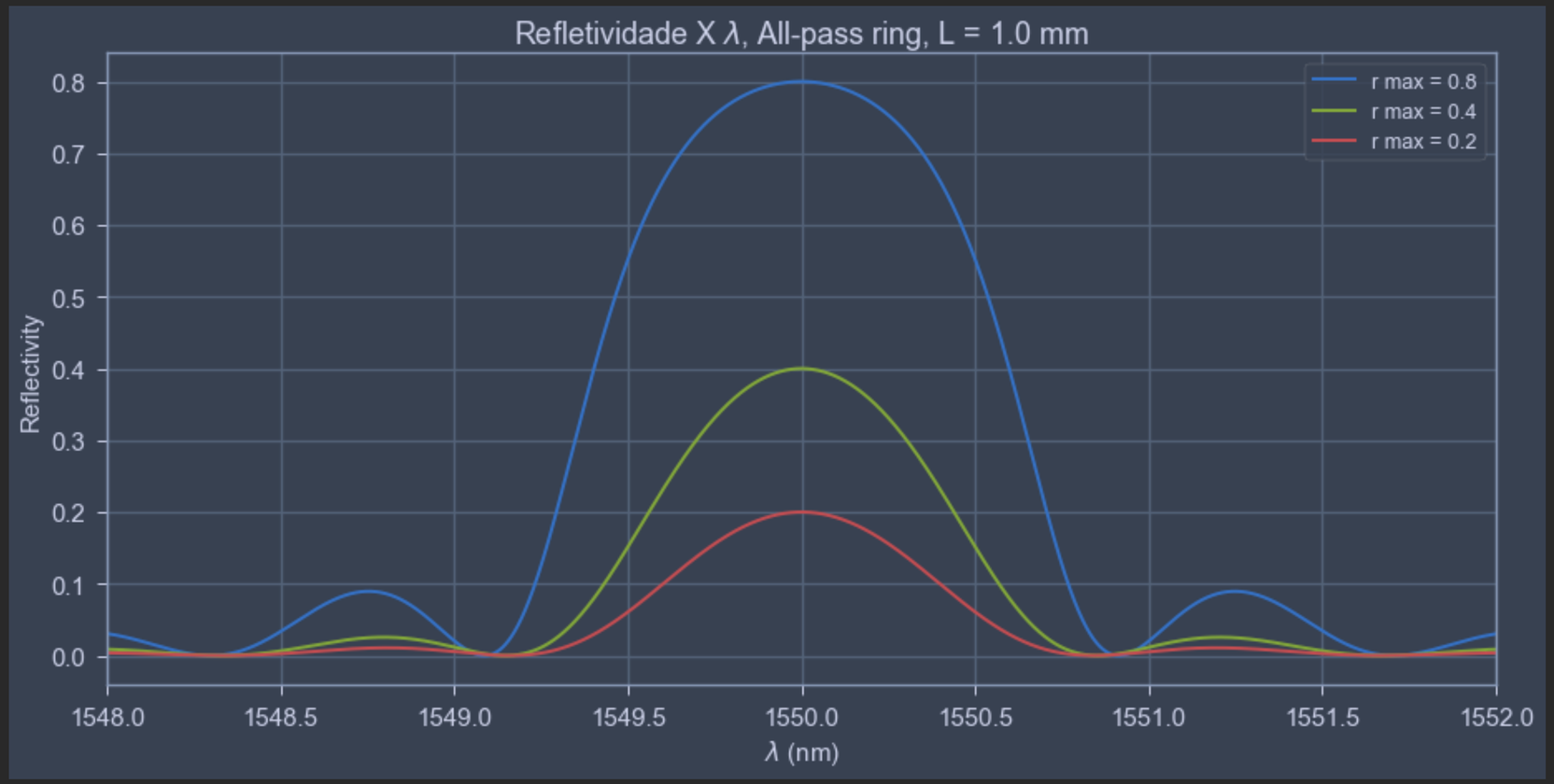
ESTUDO DE REFERENCIAS

Exemplo 1



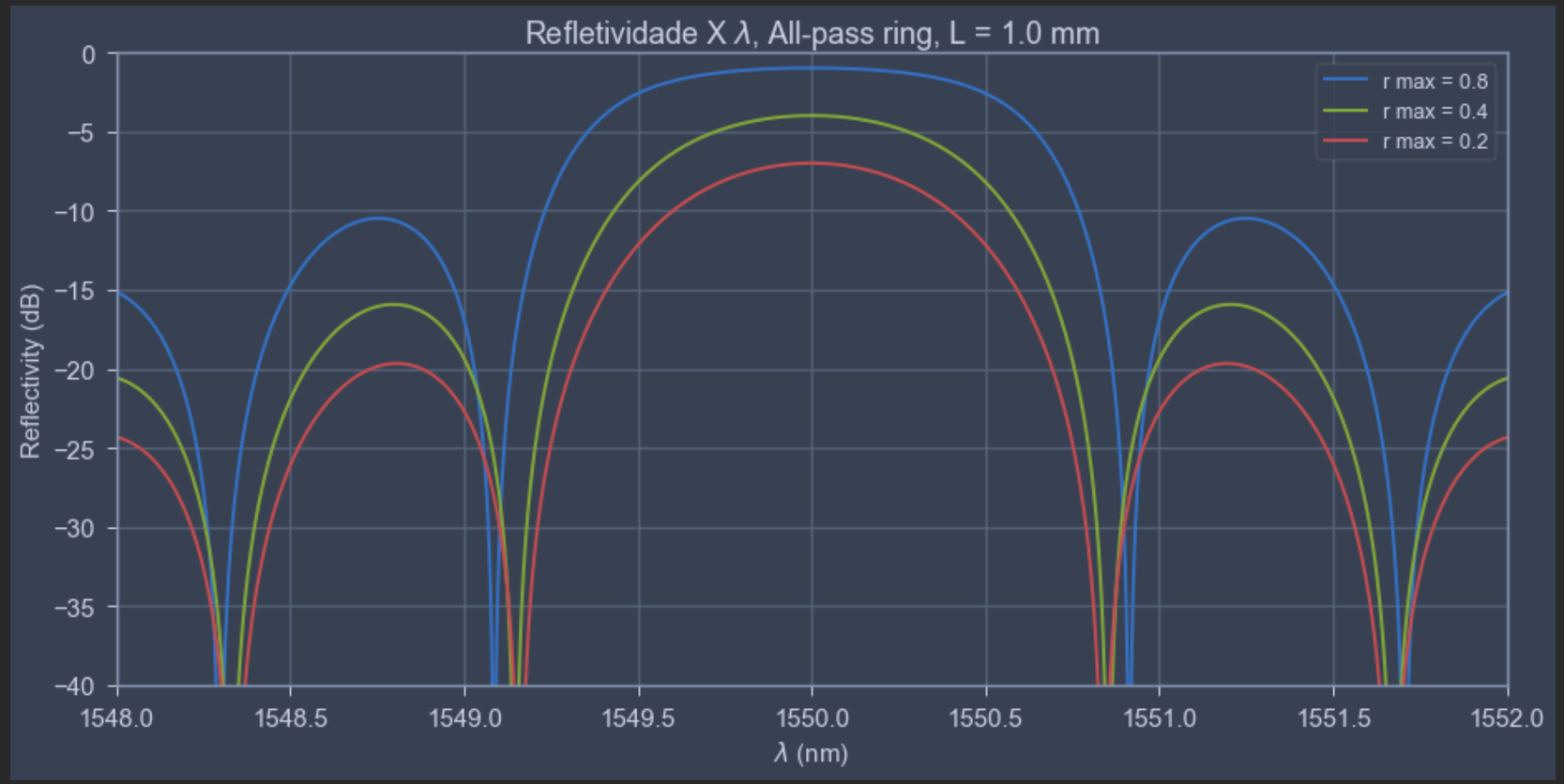
ESTUDO DE REFERENCIAS

Exemplo 1



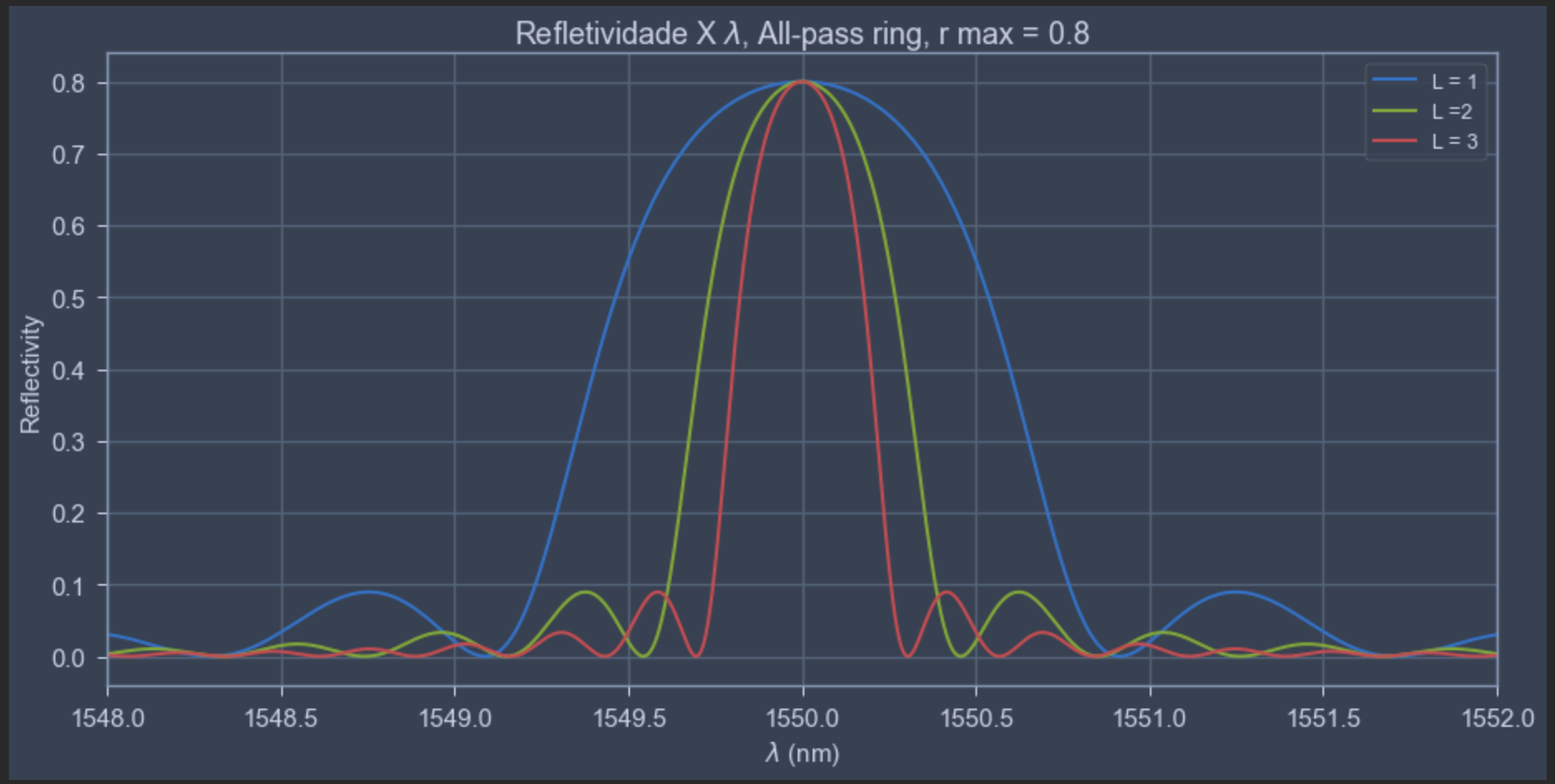
ESTUDO DE REFERENCIAS

Exemplo 1



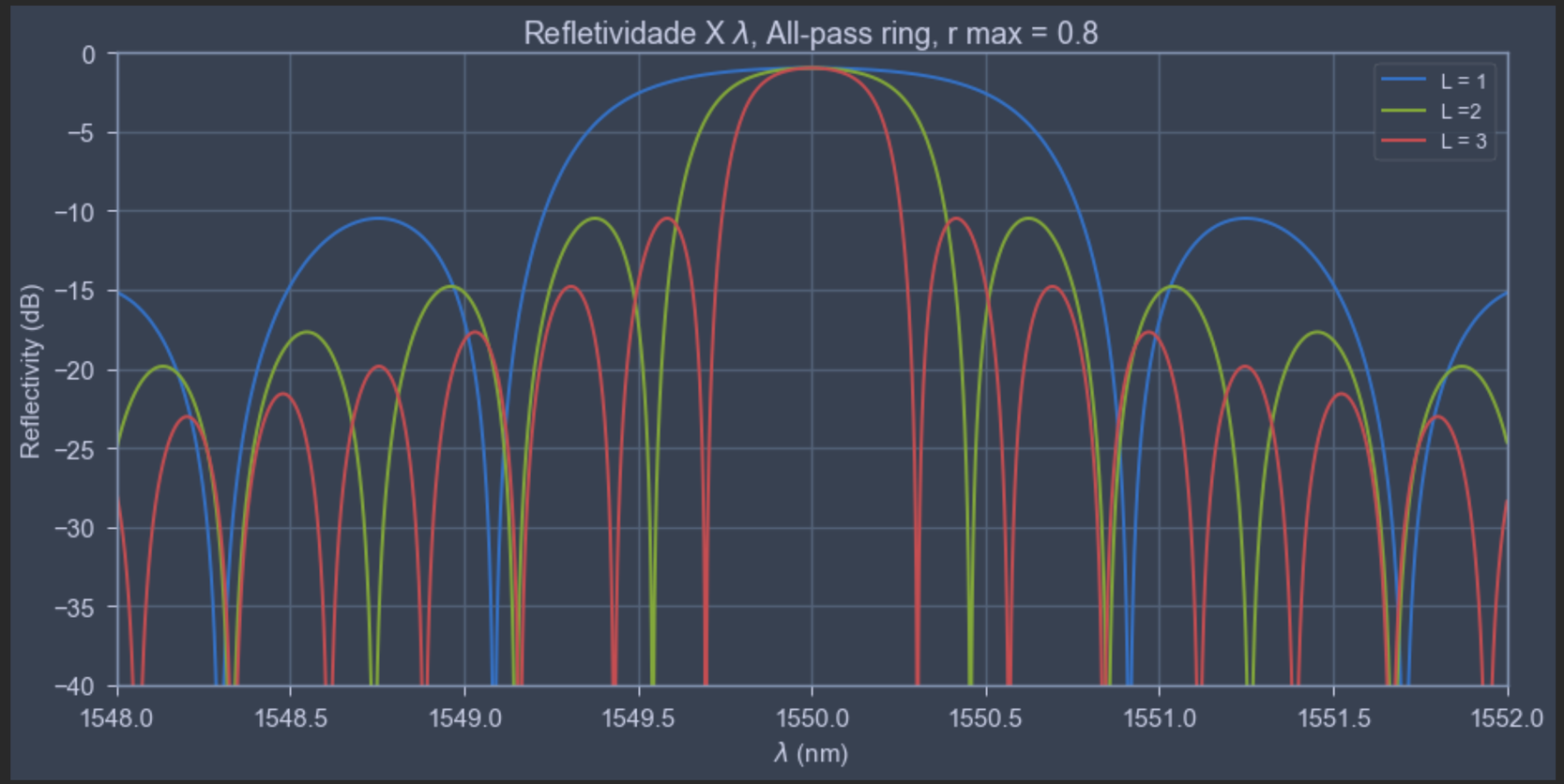
ESTUDO DE REFERENCIAS

Exemplo 1



ESTUDO DE REFERENCIAS

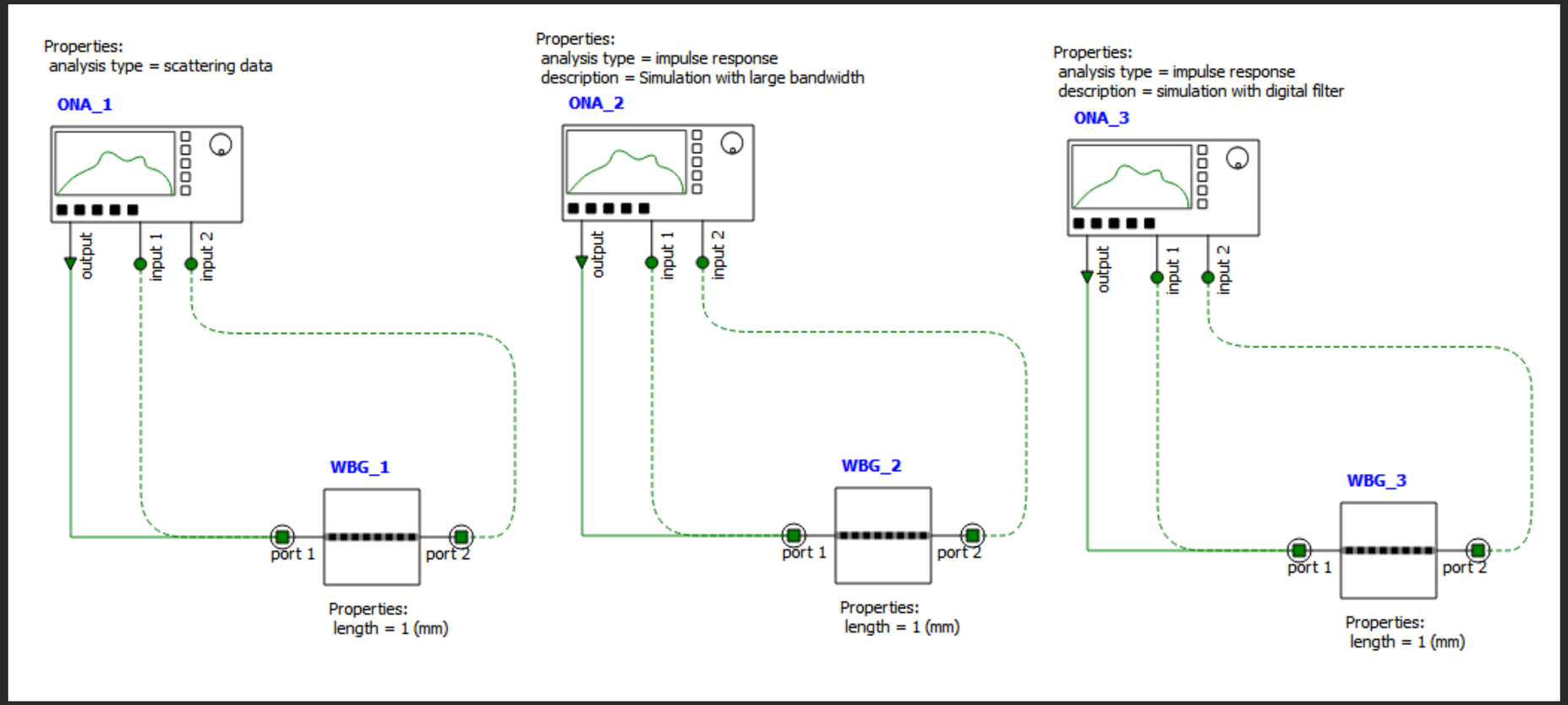
Exemplo 1



ESTUDO DE REFERENCIAS

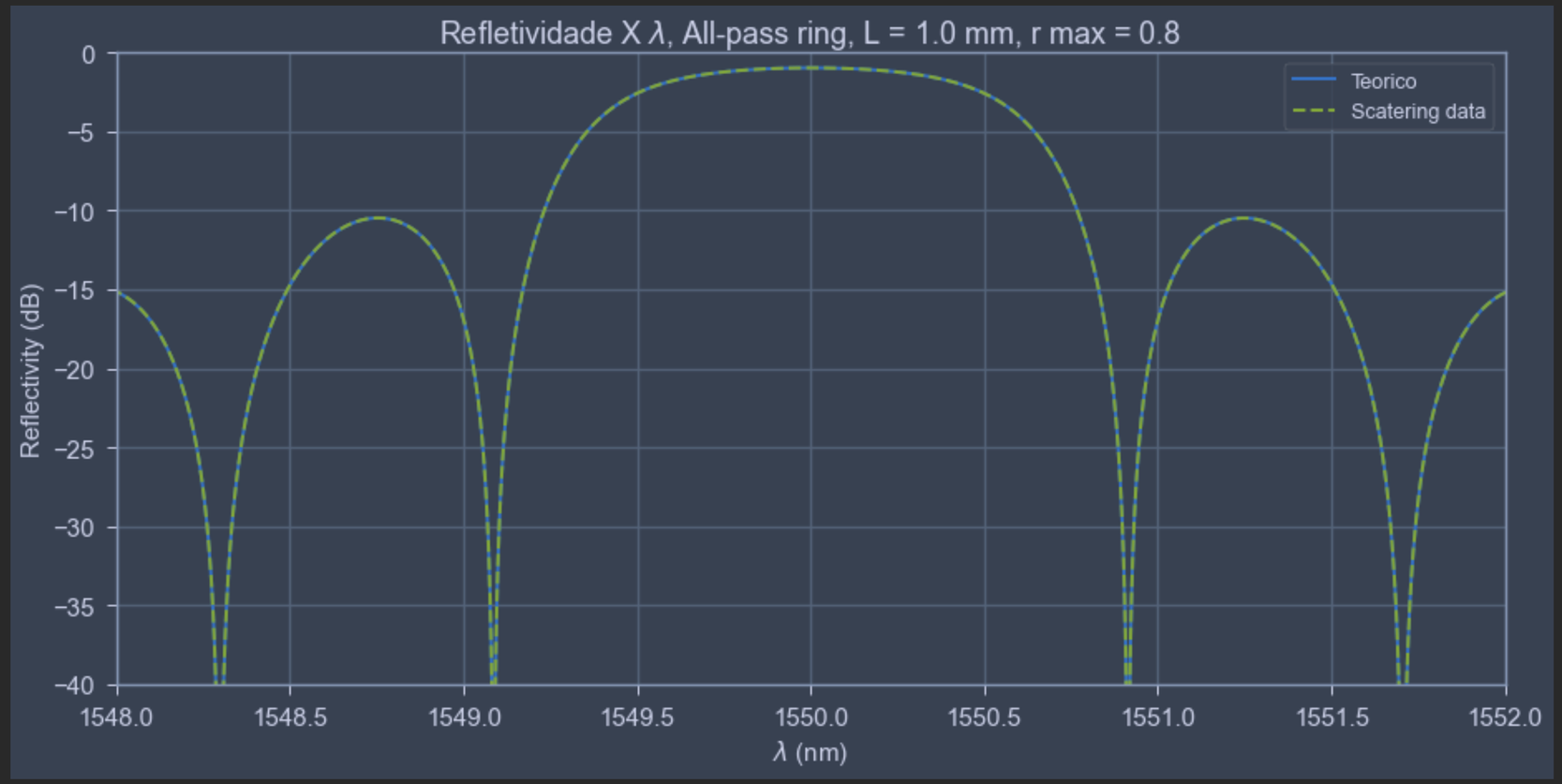
Simulação interconect

Exemplo 1



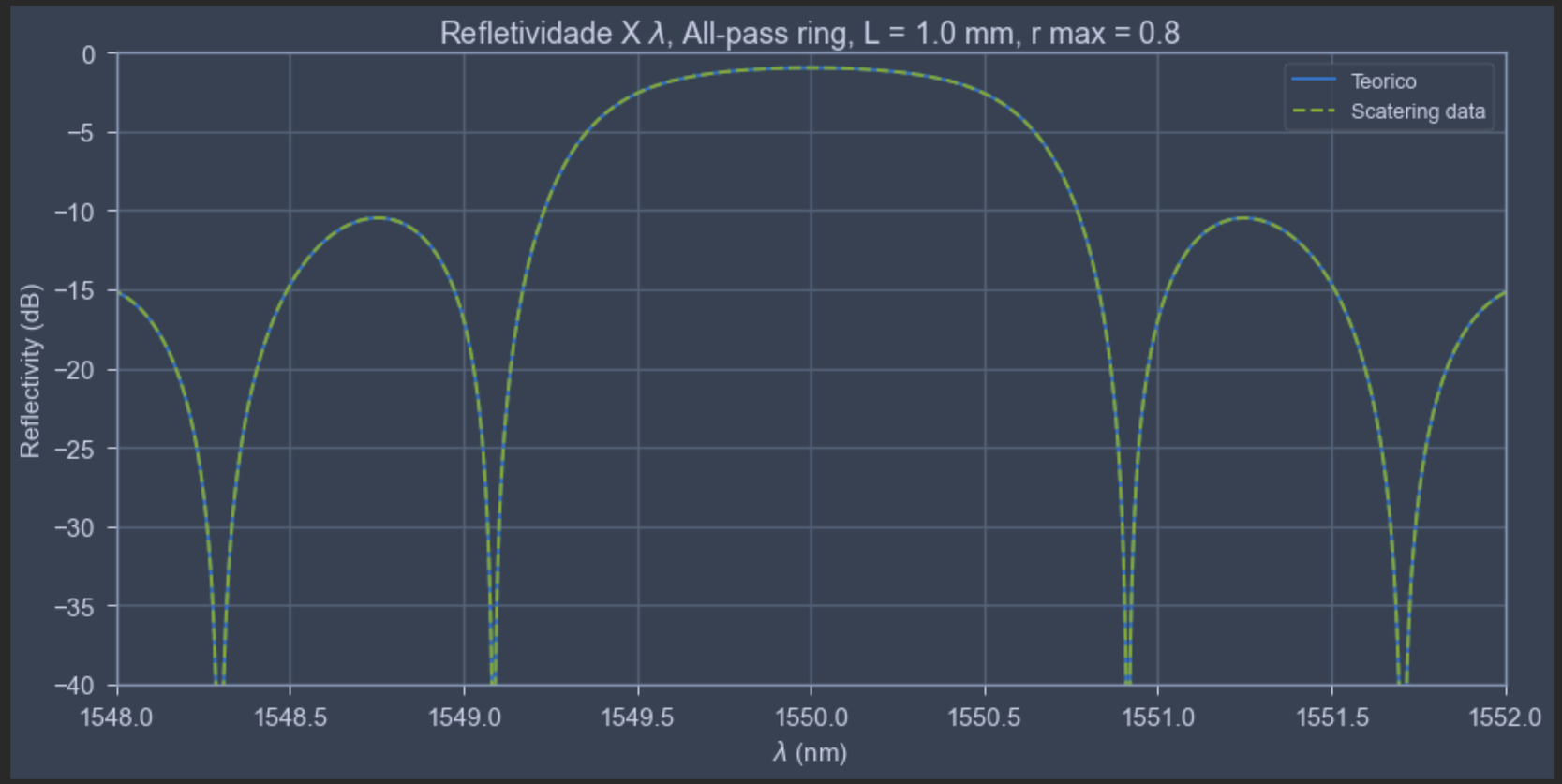
ESTUDO DE REFERENCIAS

Resultados



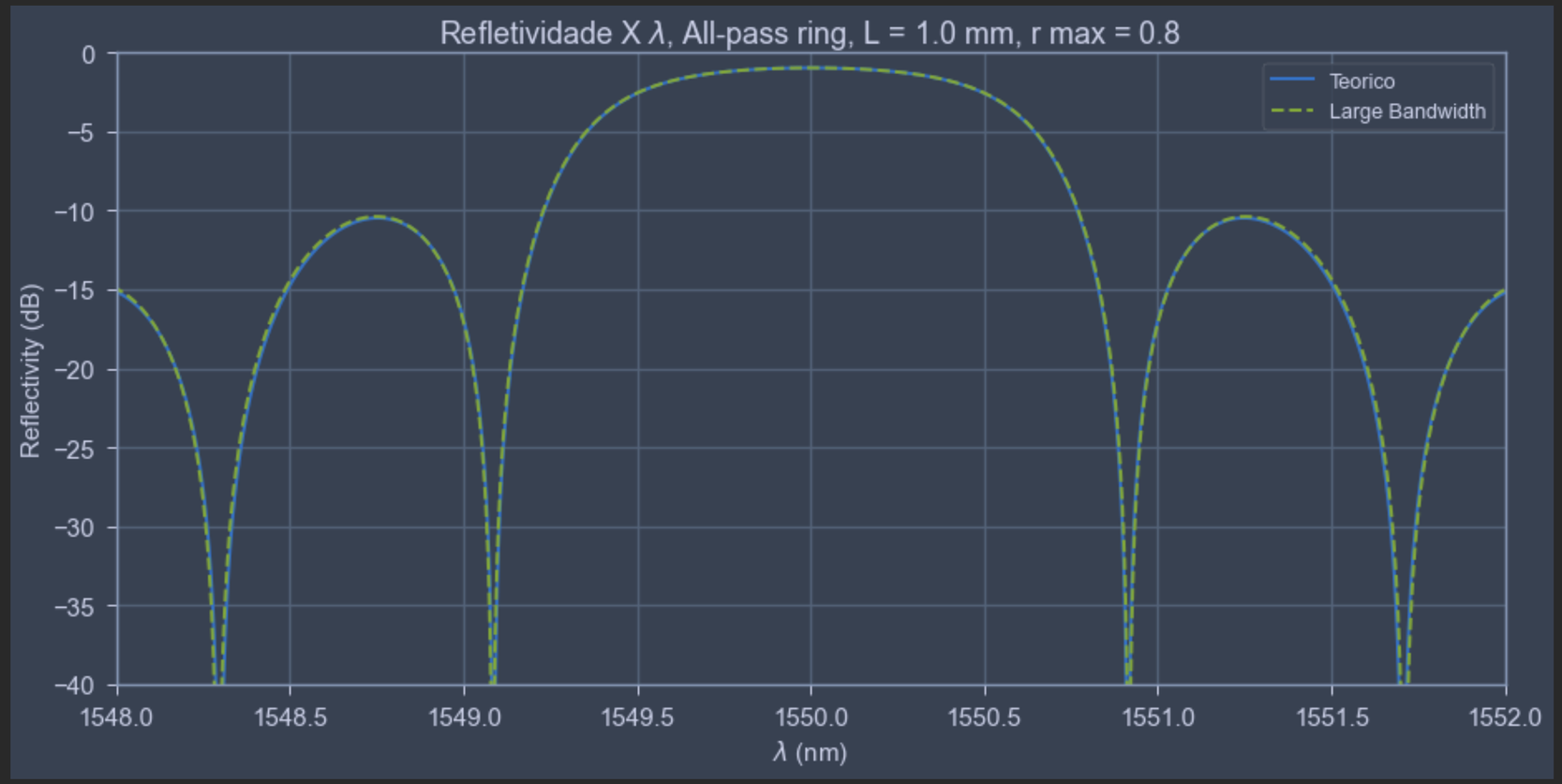
ESTUDO DE REFERENCIAS

Resultados



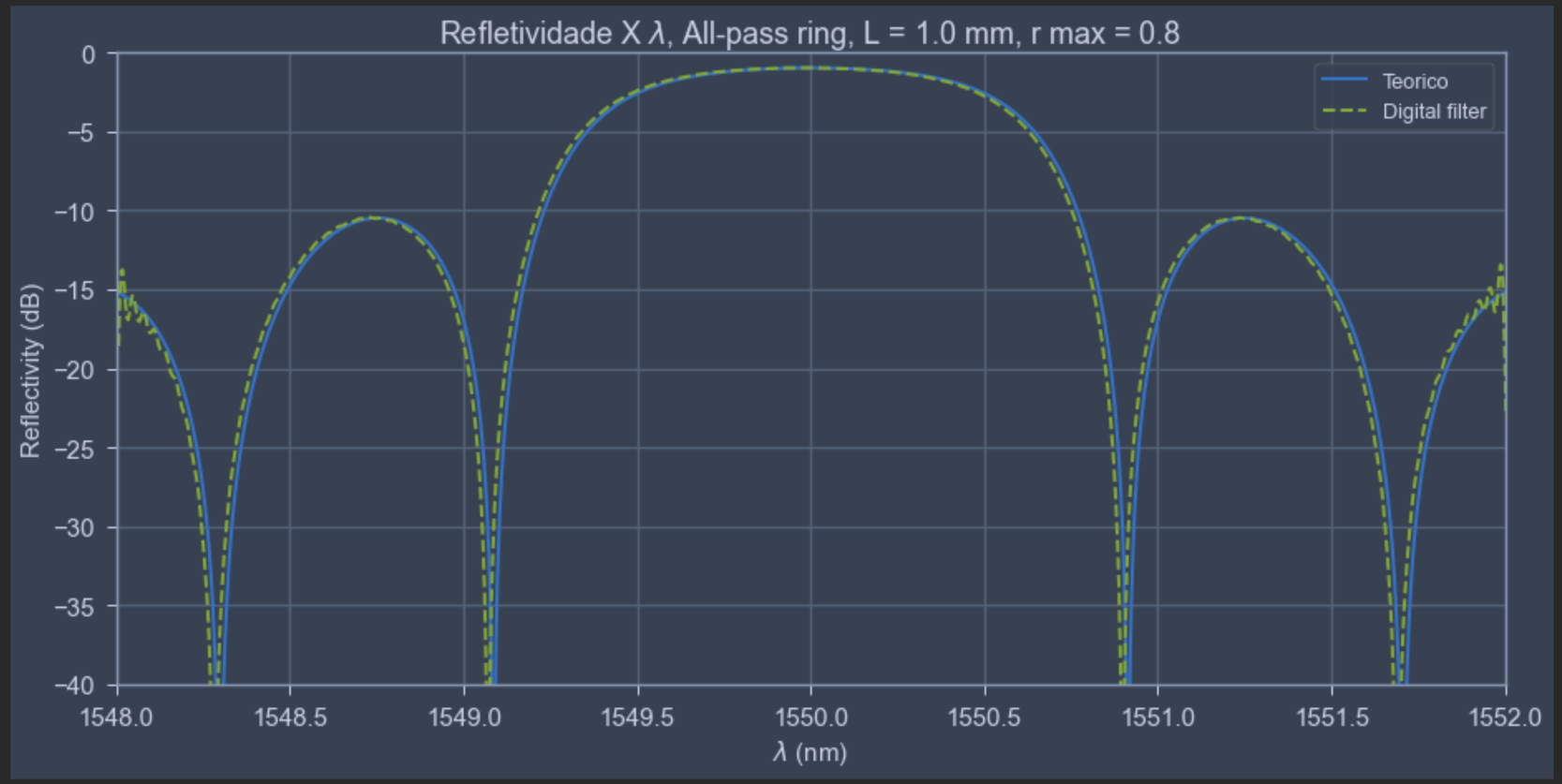
ESTUDO DE REFERENCIAS

Resultados



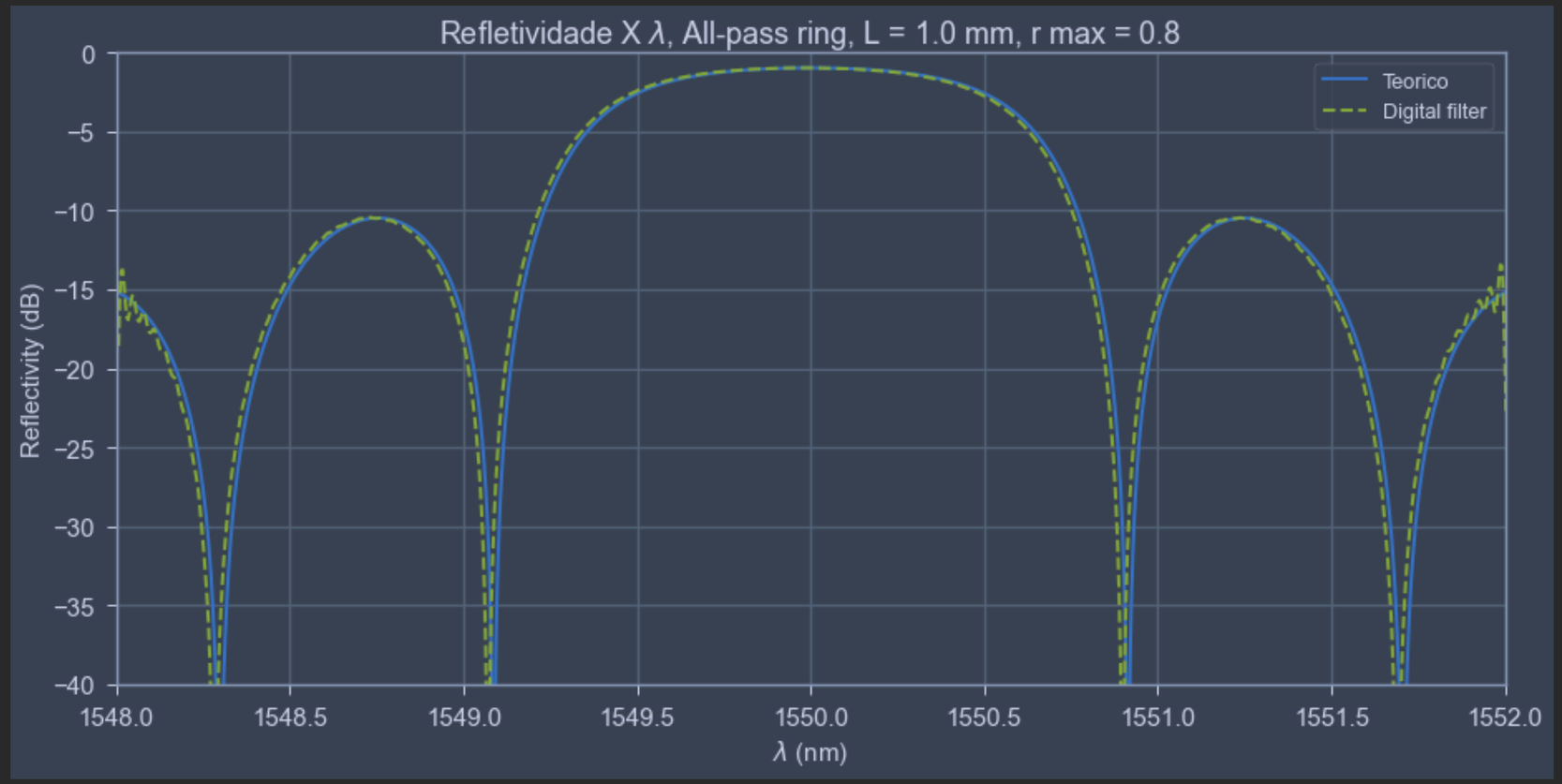
ESTUDO DE REFERENCIAS

Resultados



ESTUDO DE REFERENCIAS

Resultados



SEMANA 2

DESIGN DE FILTRO COM GRADE DE BRAGG

SEMANA 2

Design de filtro com Grade de Bragg

DESIGN

Parametros

Comprimento central = 1540 nm

Fwhm = 20 nm

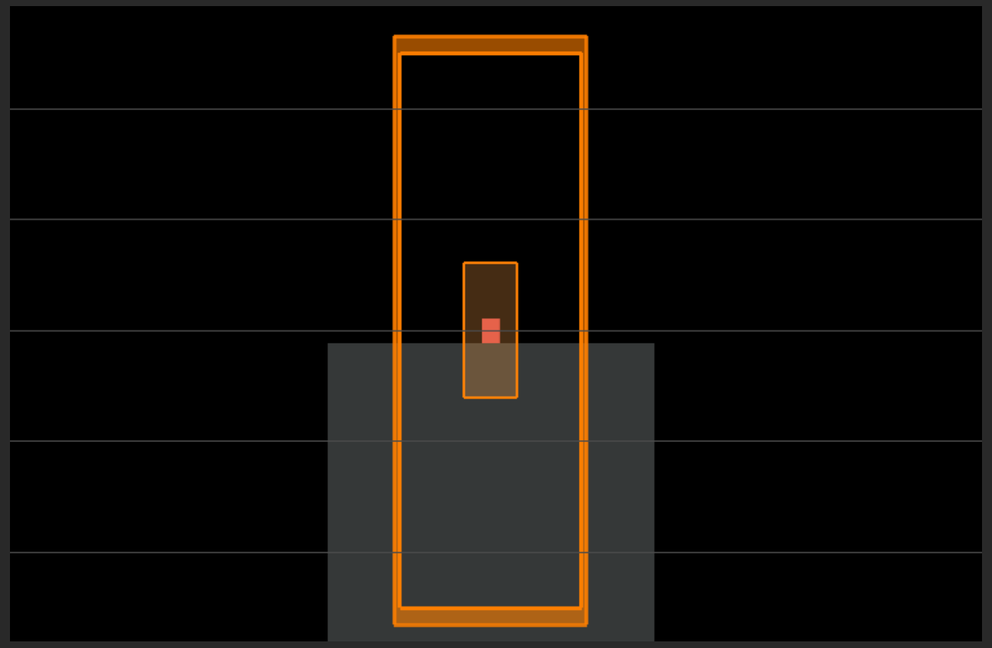
Guia: 450 x 220 nm, SOI

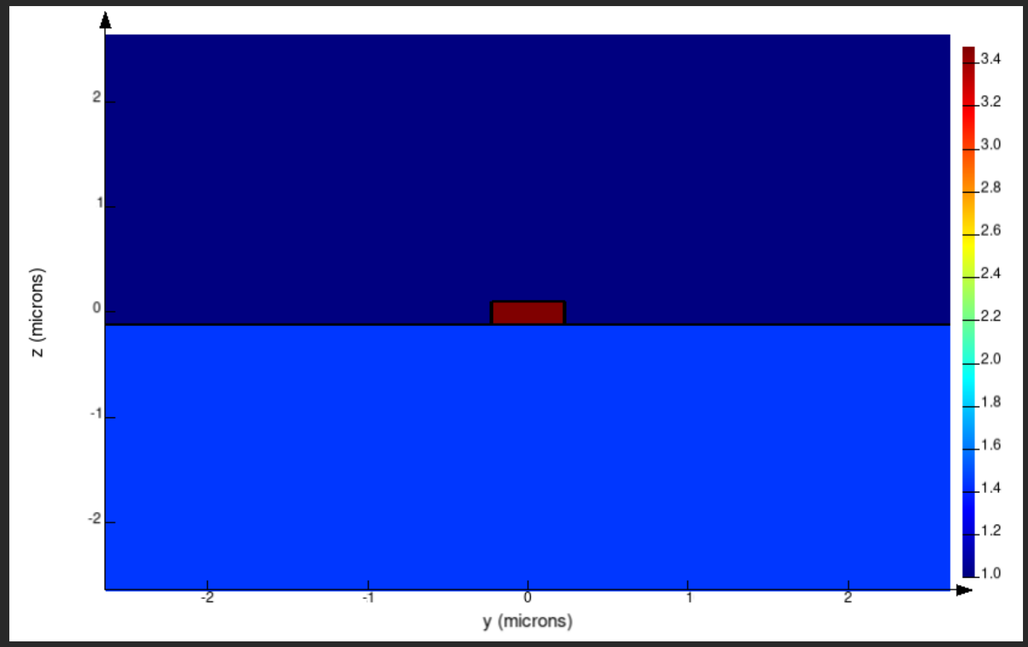
Neff = 2.2875

Ng = 4.5878

DESIGN

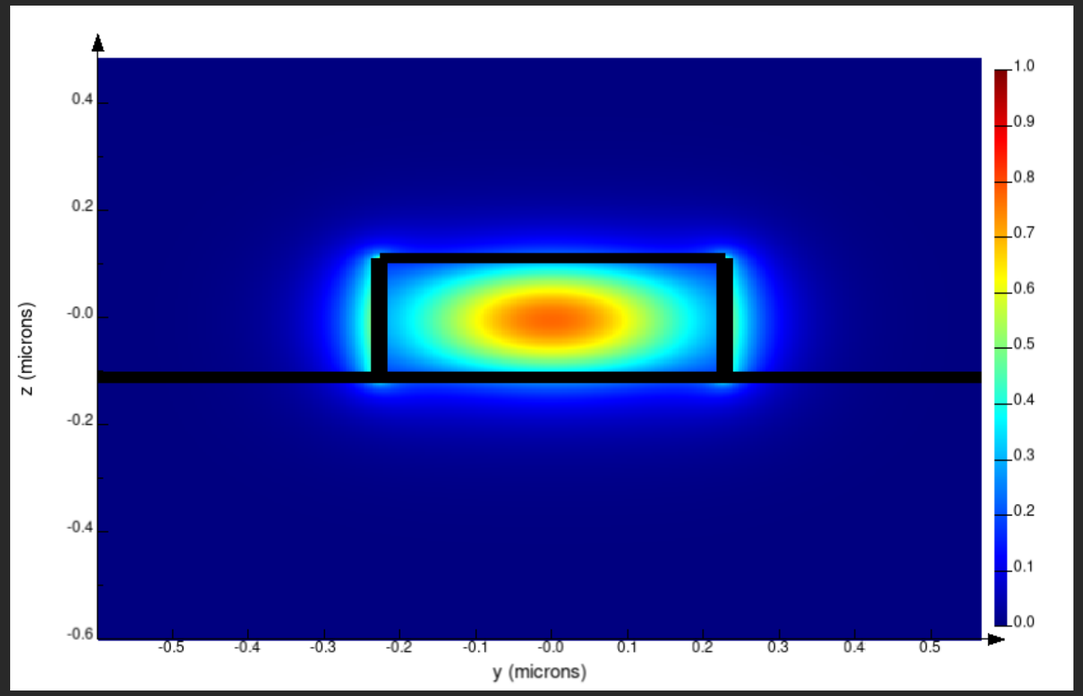
Parametros

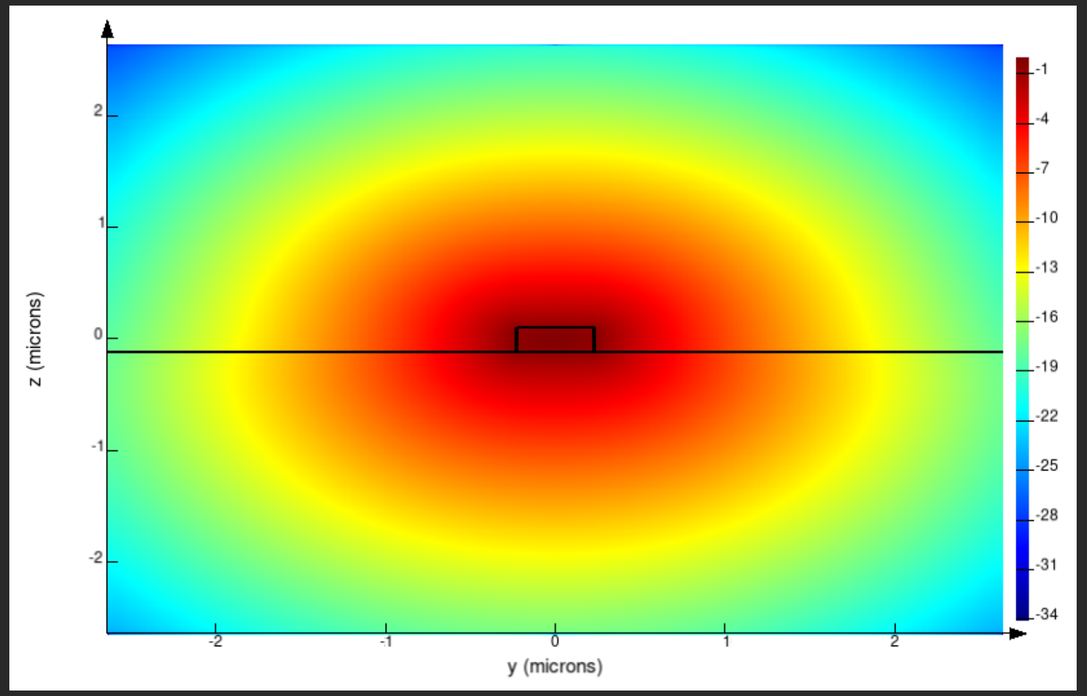




DESIGN

Simulação do guia





mode #	effective index	wavelength (μm)	loss (dB/cm)	group index	TE polarization fraction (Ey)	waveguide TE/TM fraction (%)
1	2.287553-6.070278e-18i	1.54	-2.1512e-12	4.587824-8.341346e-16i	97	68.69 / 82.03
2	1.553599-2.755374e-07i	1.54	-0.097646	3.383983+2.583202e-05i	8	73.55 / 87.94

DESIGN

Parametros:

Para neff = 2.287: Periodo da grade = 336.612 nm

Para Numero de periodos = 100: L = 33.6612 um

Para L = 336.612 um, deltaNeff = 0.09331

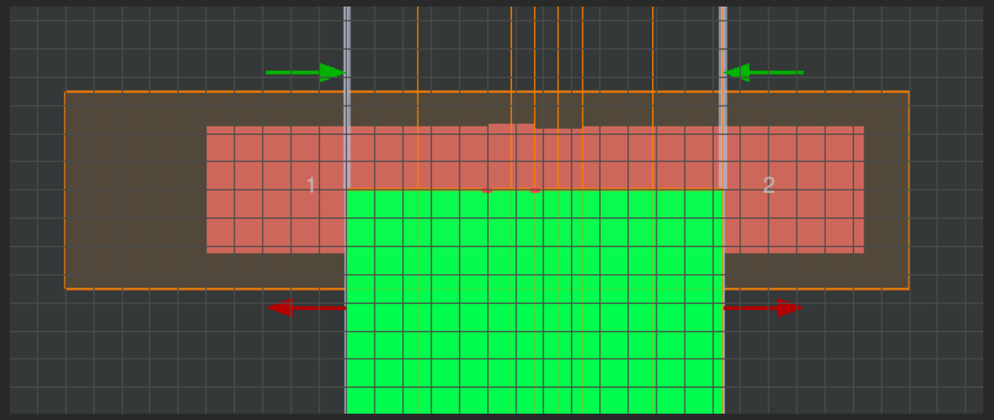
DESIGN

Calculo do Delta W

DESIGN

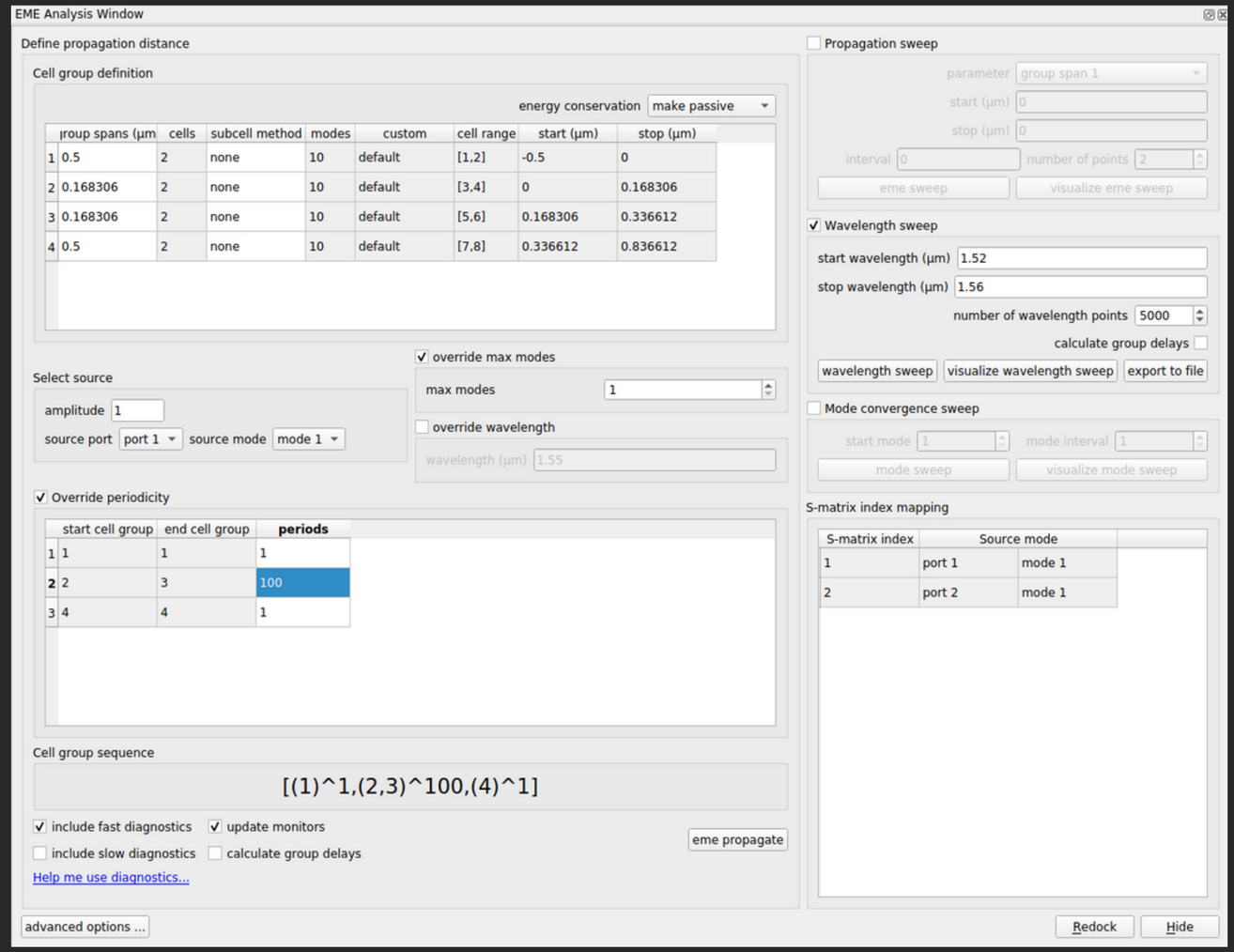
Simulação no EME

#	Name	Type	Value	Unit
1	W	Length	0.45	um
2	altura	Length	0.22	um
3	deltaW	Length	0.0354	um
4	periodo	Length	0.336612	um
5	material	Material	Si (Silicon) - ...	
6	substrato	Material	SiO2 (Glass) -...	



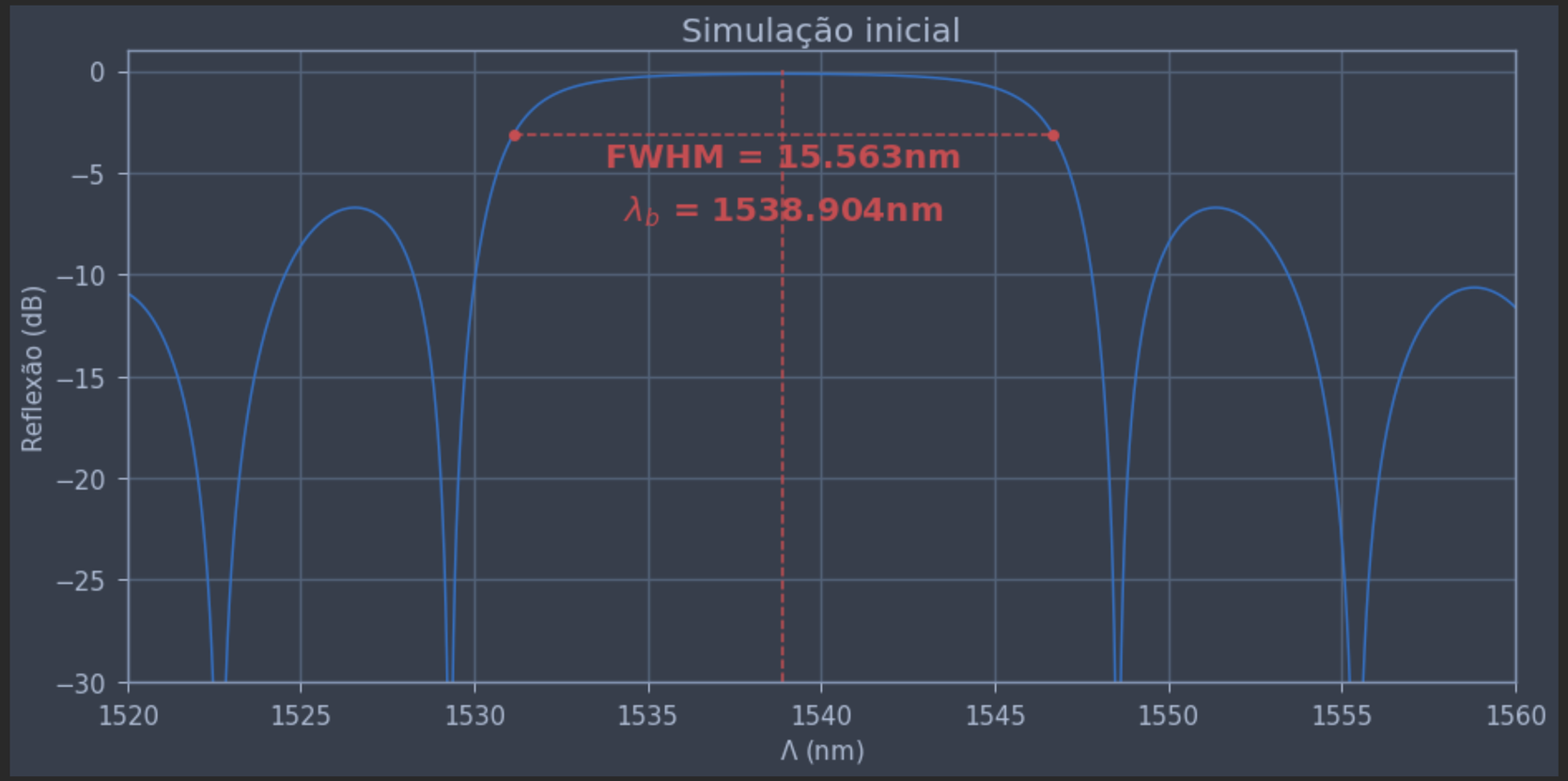
DESIGN

Simulação no EME



DESIGN

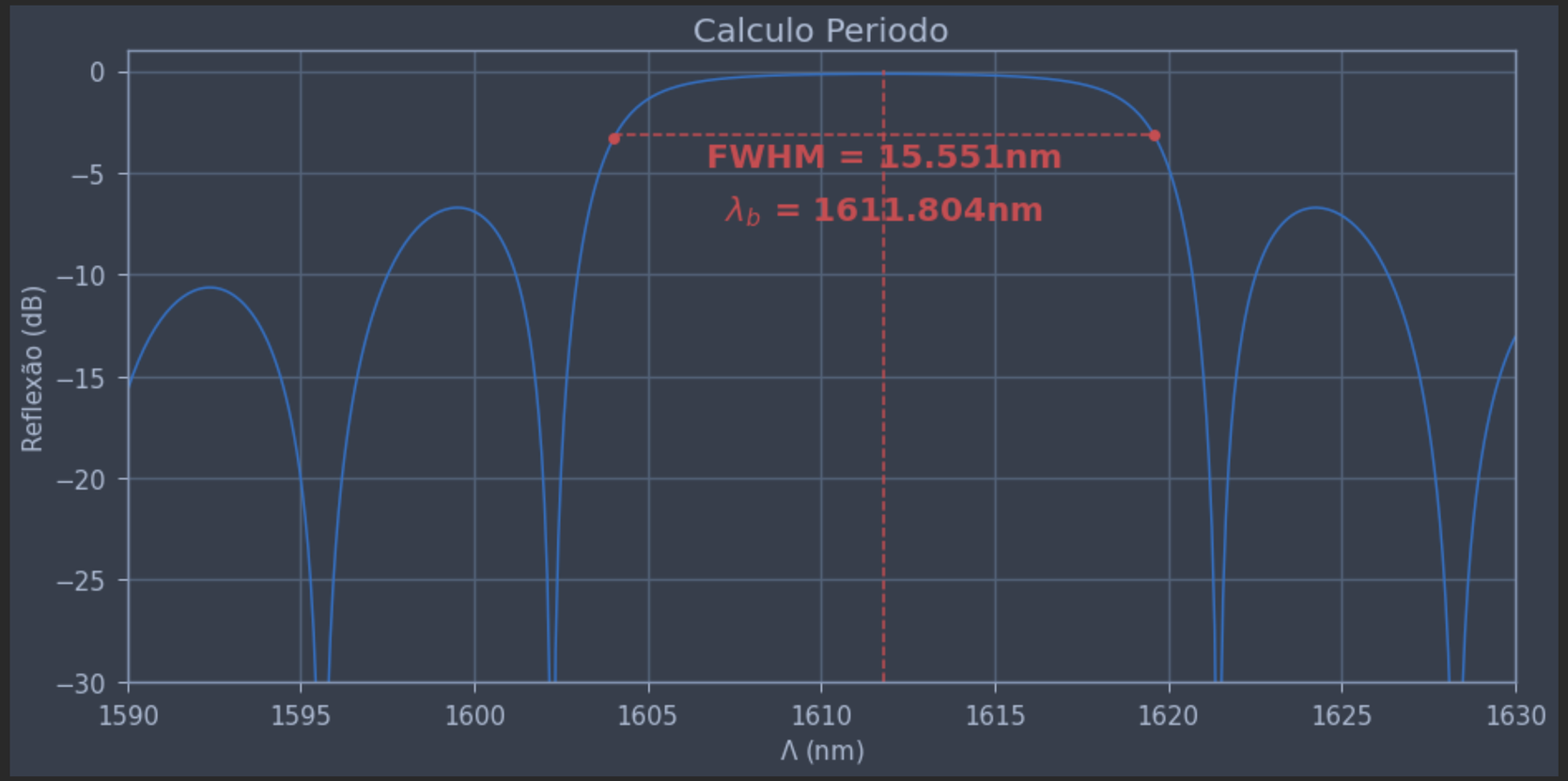
Resultados Iniciais



DESIGN

Calculando novo periodo ideal

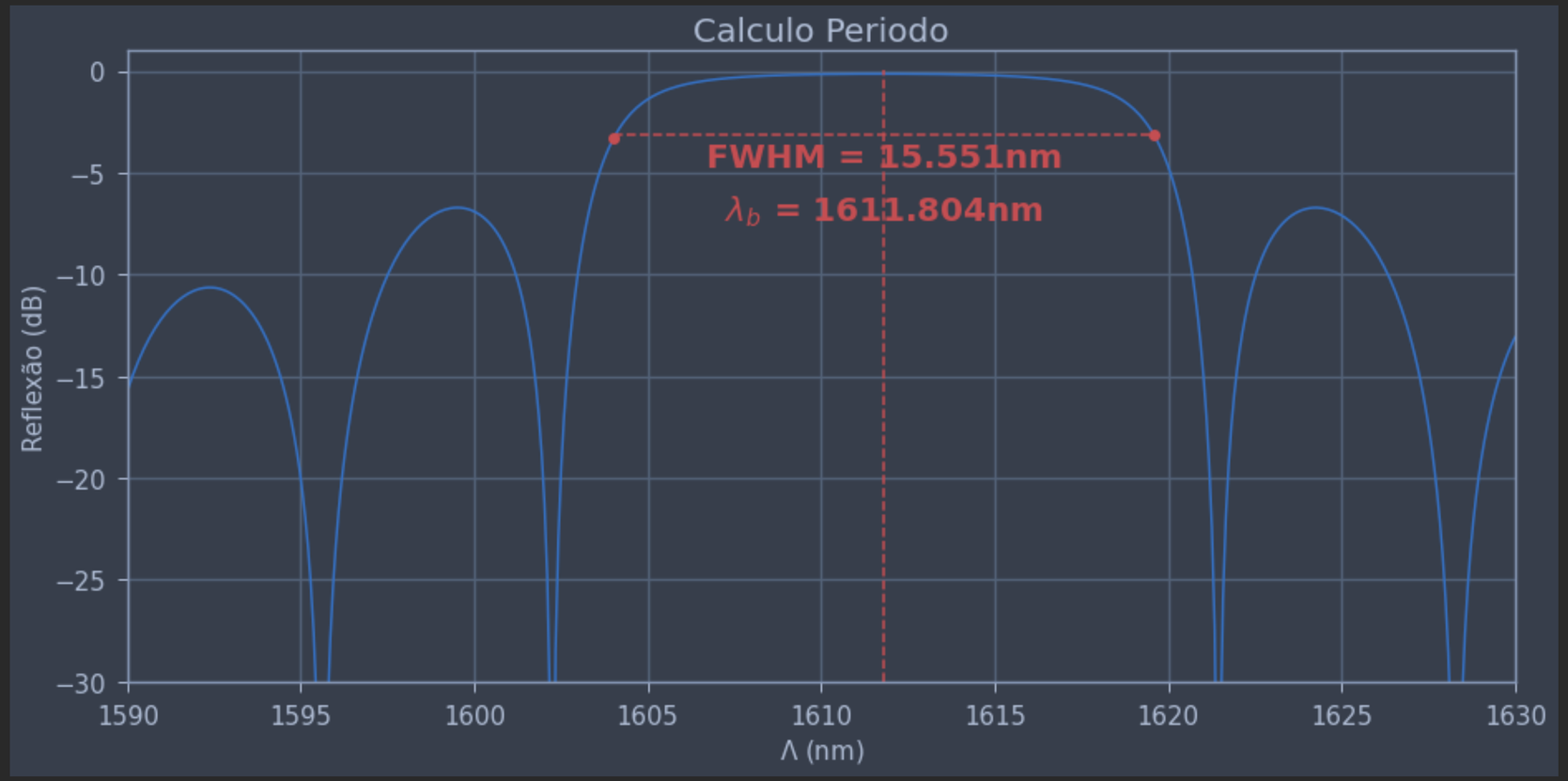
P = 0.3534426 nm (x1.05)



DESIGN

Calculando novo periodo ideal

P = 0.3702732 nm (x1.1)



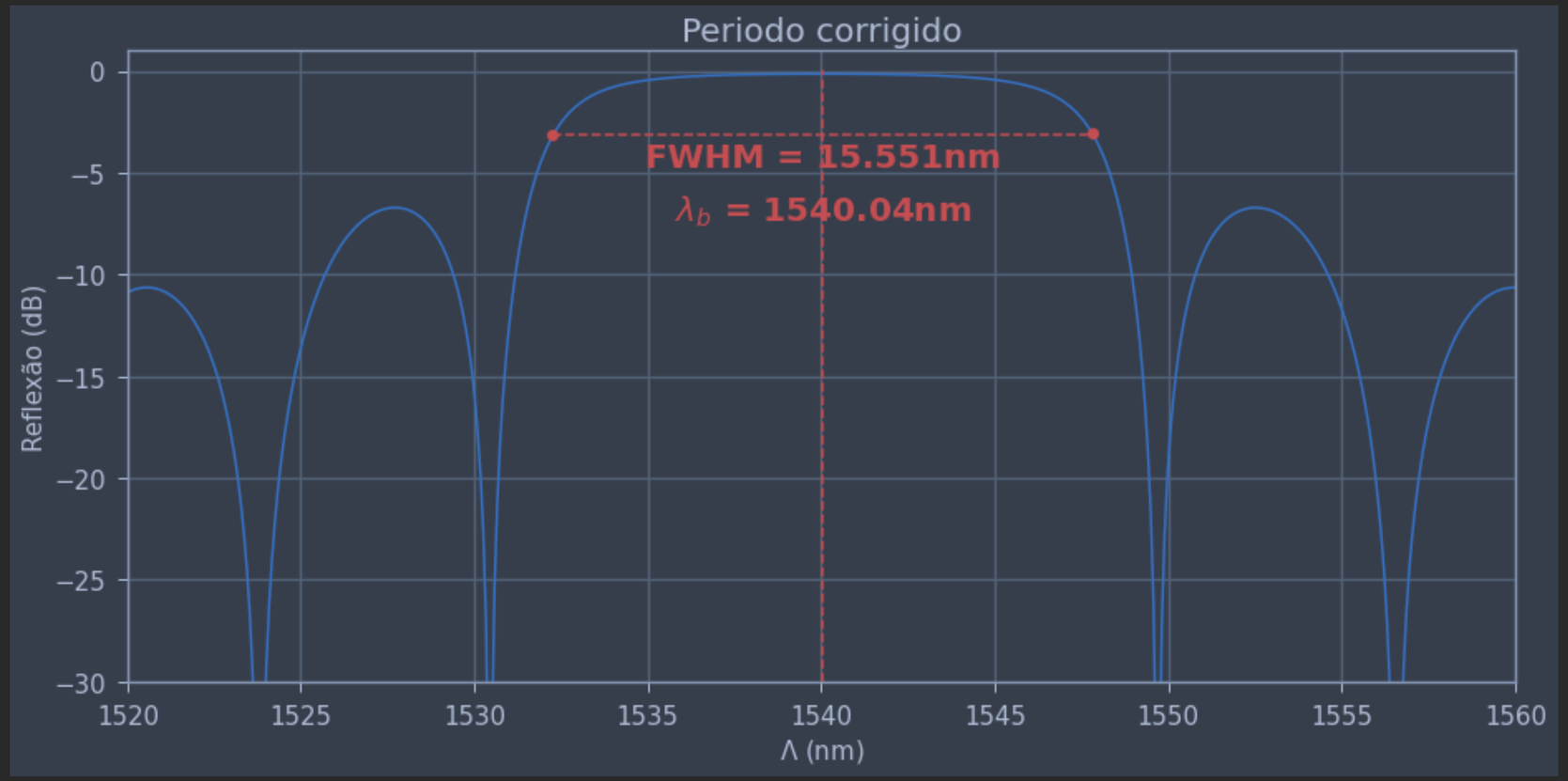
DESIGN

Calculando novo periodo ideal

DESIGN

Novo periodo teorico

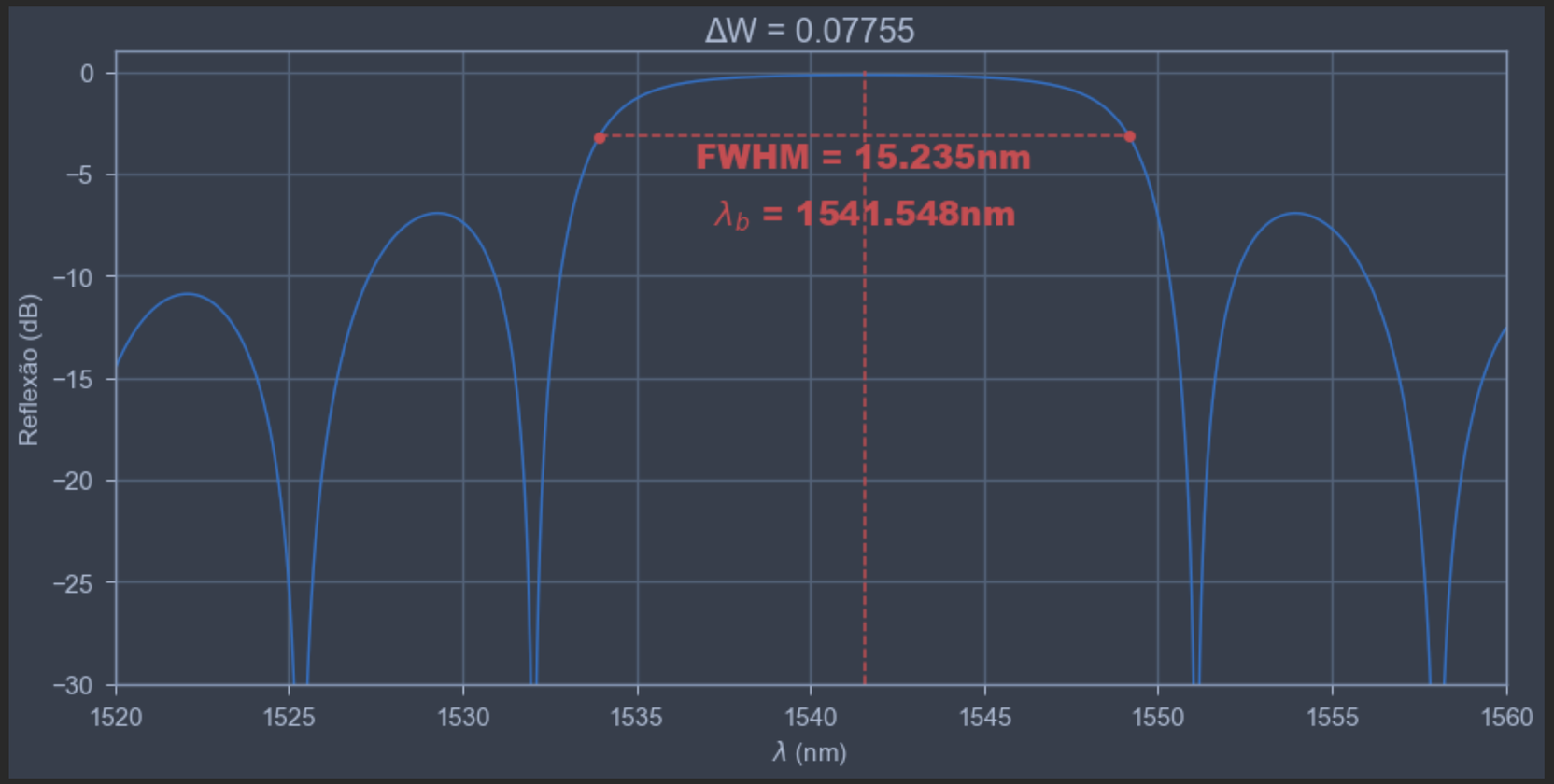
P = 0.337118 um (E = 0.15%)



DESIGN

Corrigindo o FWHM, calculo de ΔW

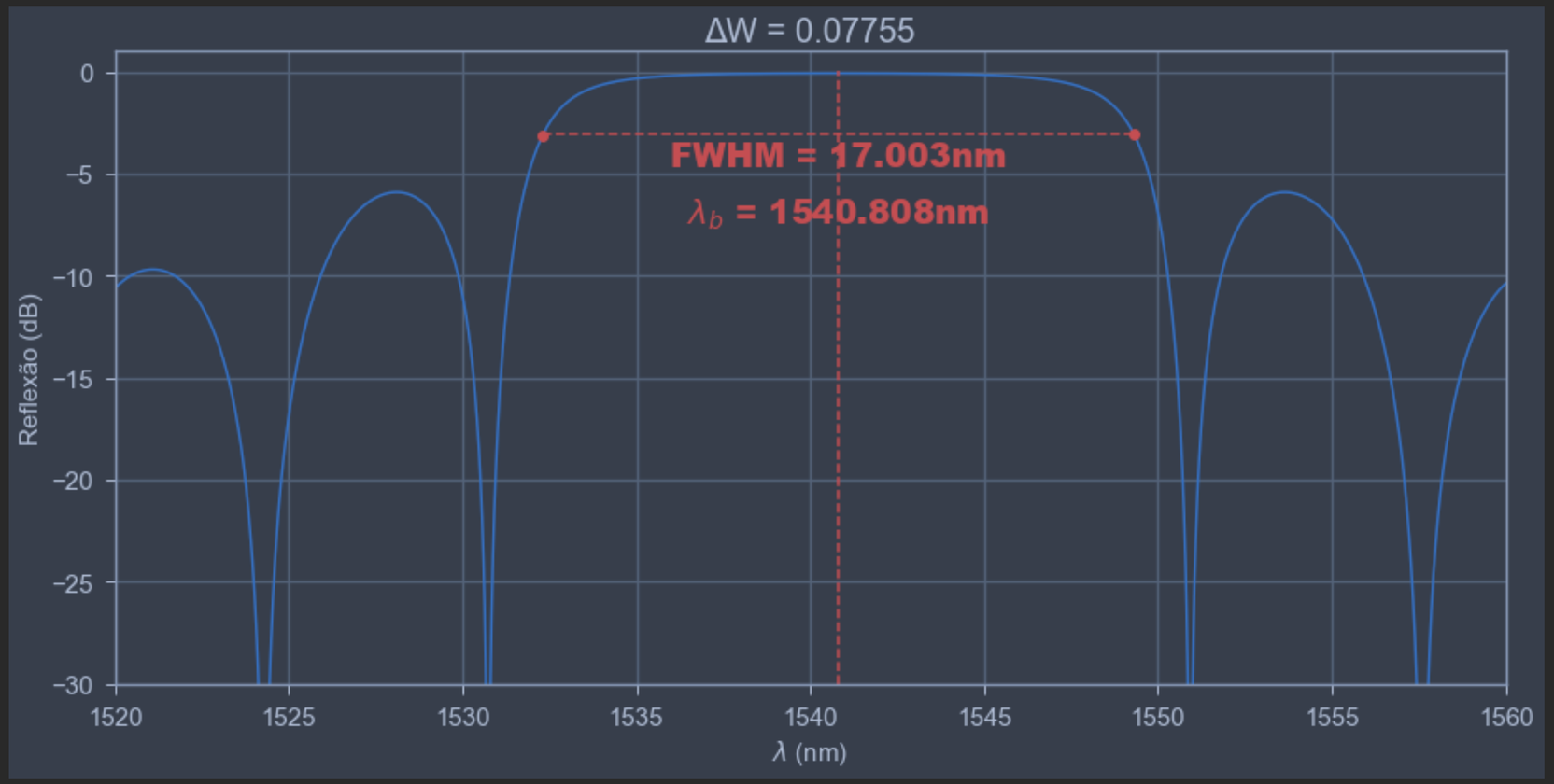
ΔW = 0.03894 (x1.1)



DESIGN

Corrigindo o FWHM, calculo de ΔW

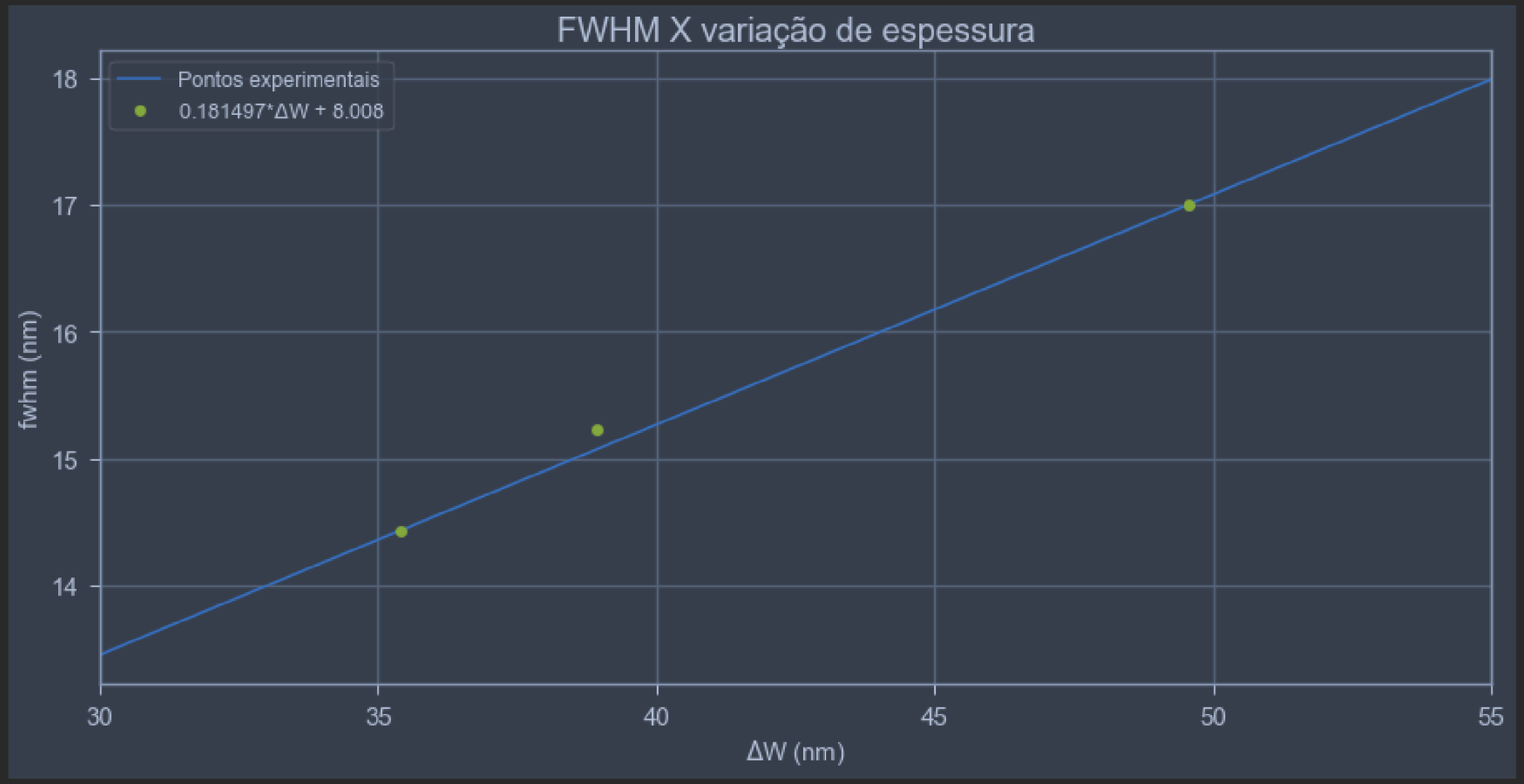
ΔW = 0.04956 (x1.5)



DESIGN

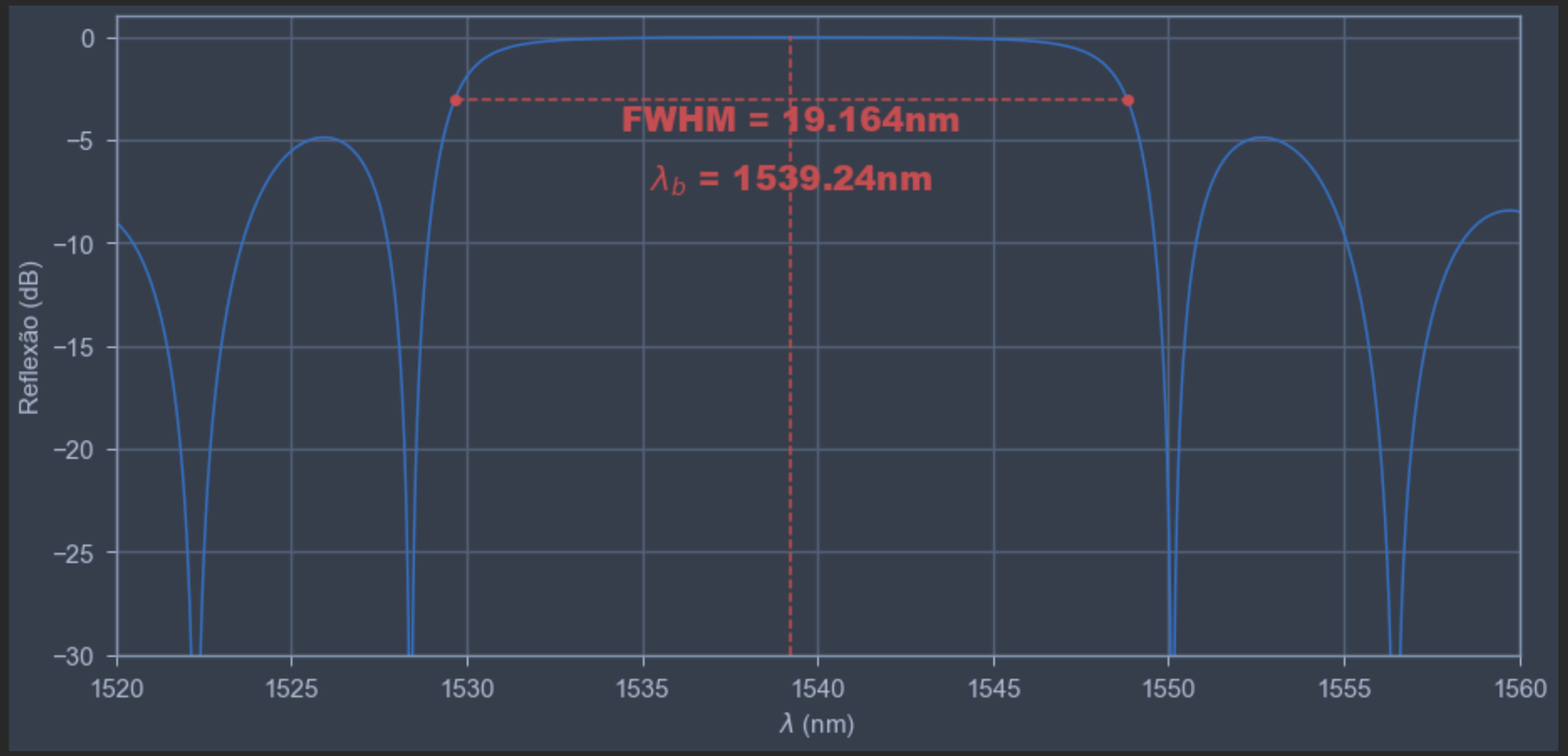
Corrigindo o FWHM, calculo de ΔW

ΔW teorico = 0.0660727 um (E = 87.6%)



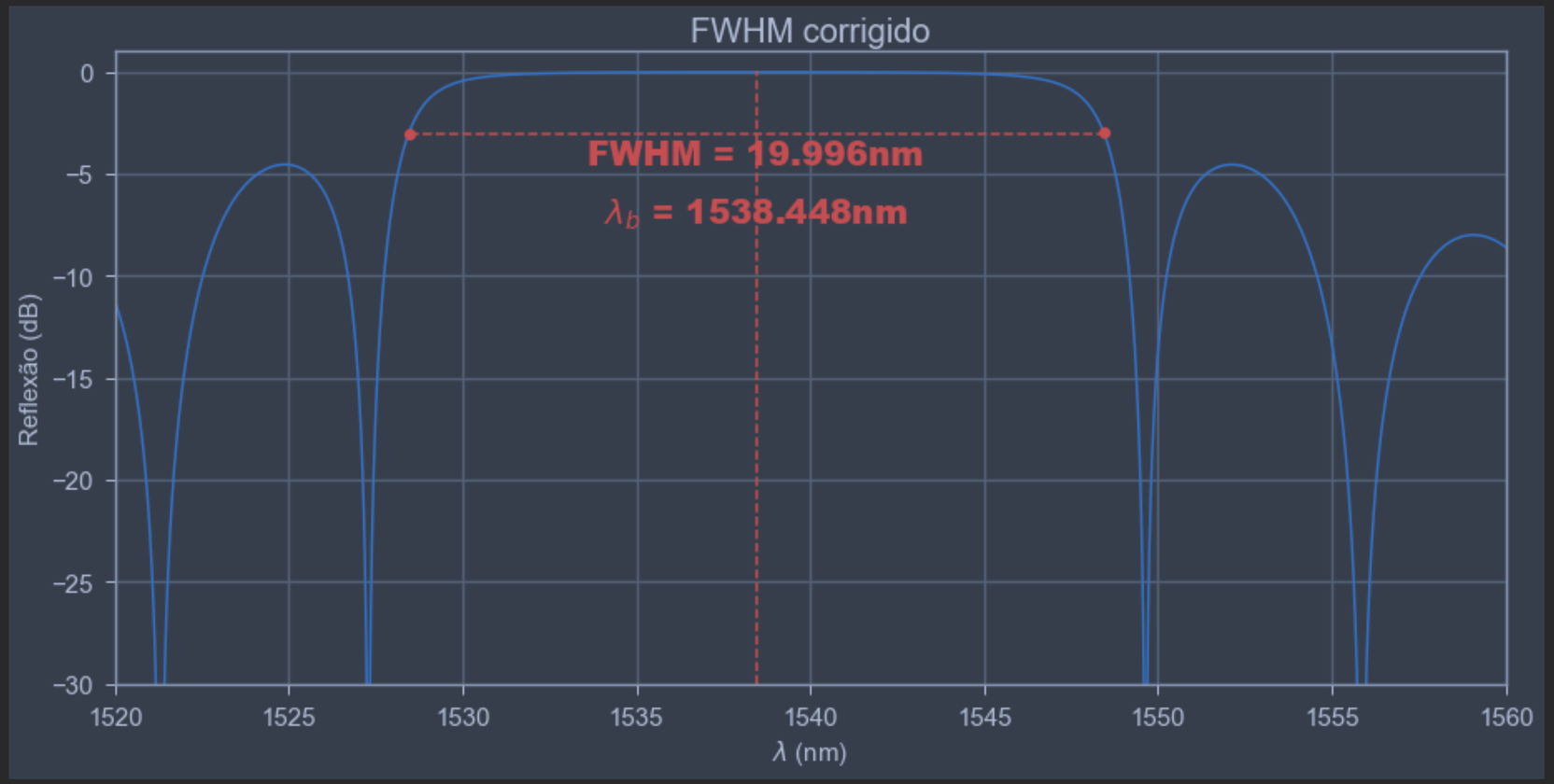
DESIGN

Correção do FWHMW



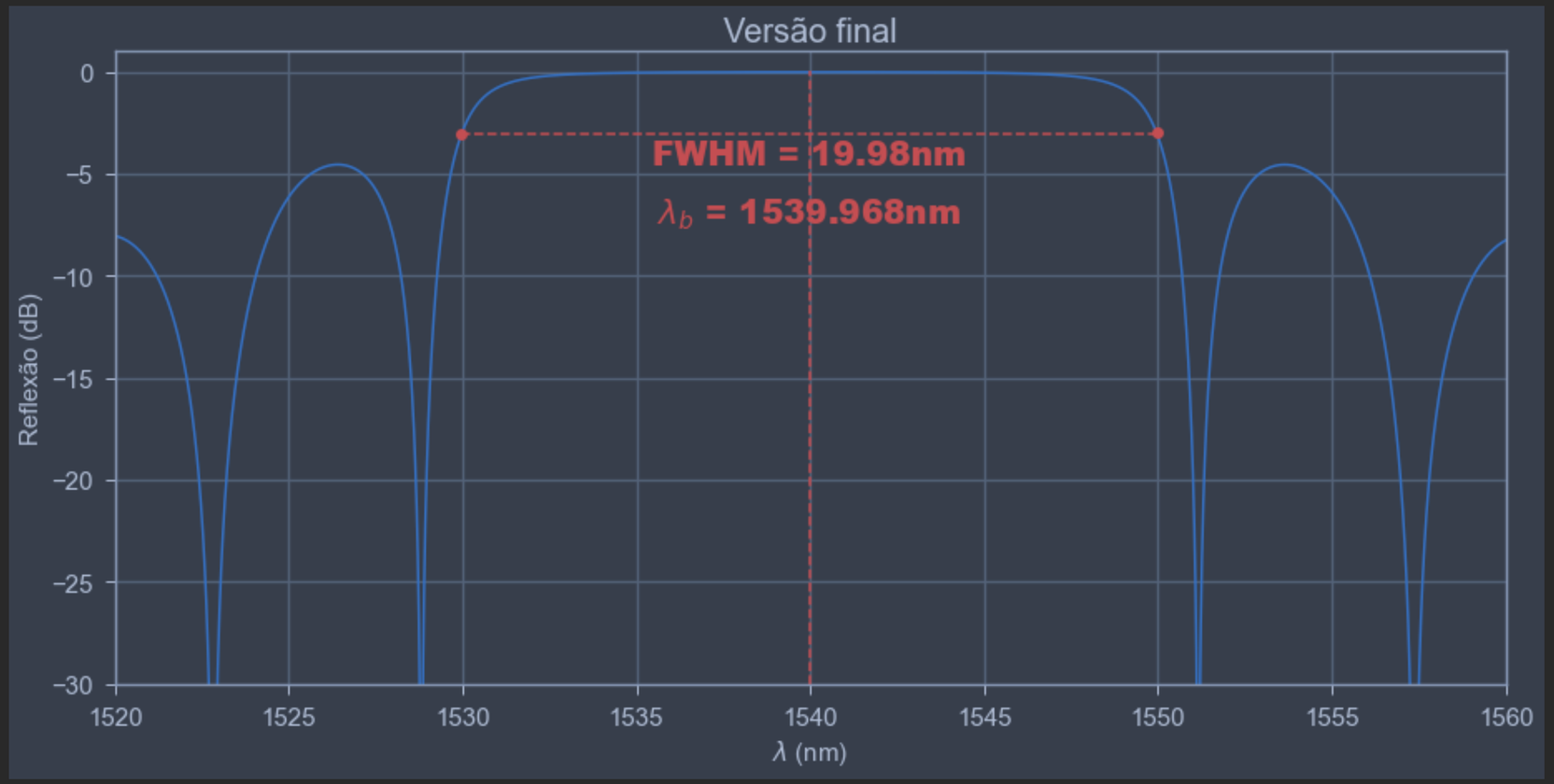
DESIGN

Correção do FWHMW



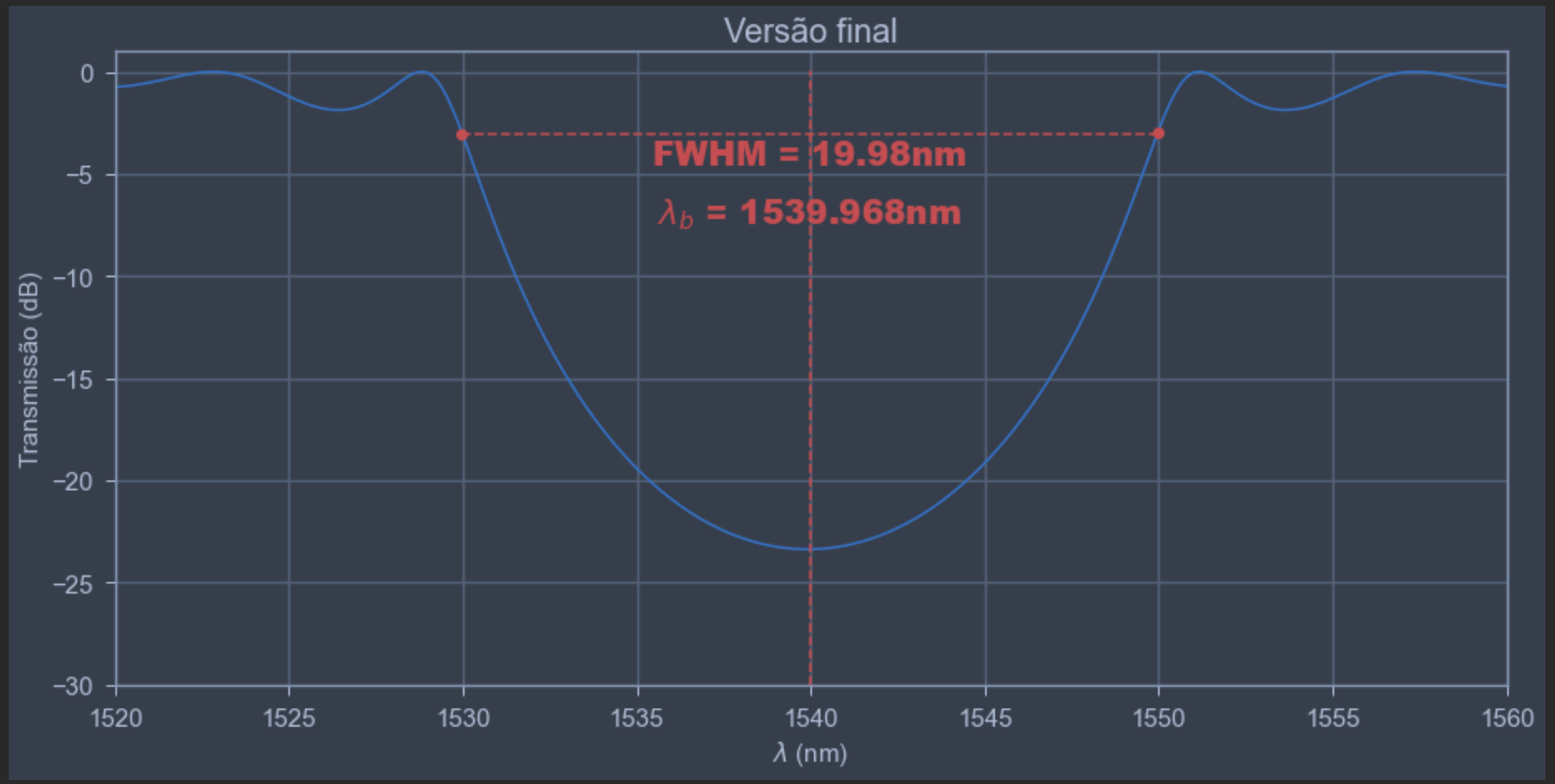
DESIGN

2º correção do periodo



DESIGN

2º correção do periodo



DESIGN

Design Final

1	W	Length	0,45	um
2	altura	Length	0,22	um
3	deltaW	Length	0,0734068	um
4	periodo	Length	0,338535	um
5	N	Number	100	
6	material	Material	Si (Silicon) - Palik	
7	substrato	Material	SiO2 (Glass) - P...	

DESIGN

Analise variação de temperatura

Ref: Handbook of Thermo-optic Coefficients of Optical Materials With Applications

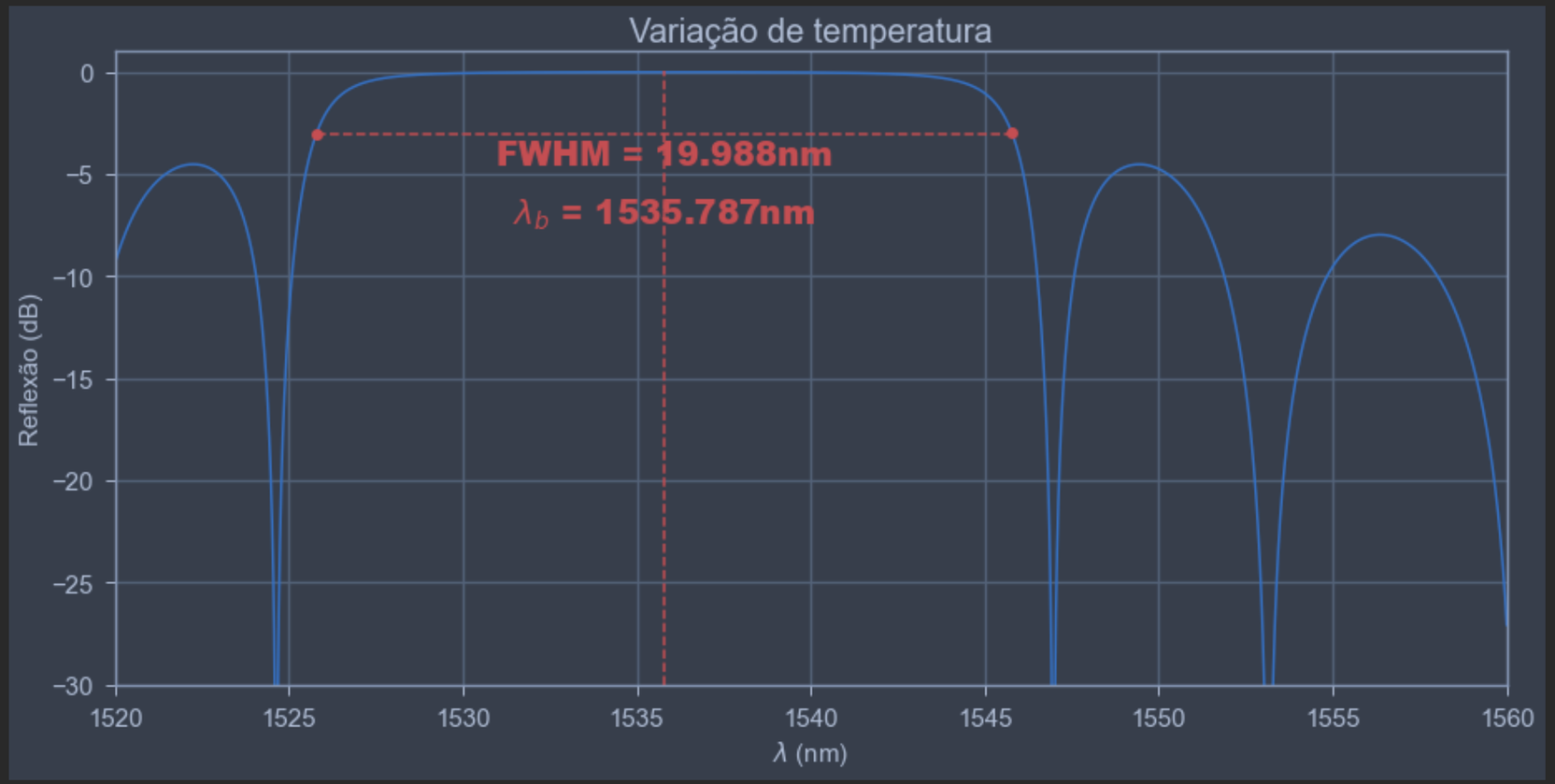
Material [Ref.]	Wavelength [μm]	Refractive index	dn/dT [(10^{-4}/K)] Recom. values	Computed (This work)	Difference	Av. Dev. <-[10^{-6}]->	RMS Dev.
	16.00	3.9999	4.016	4.036	–0.0202		
	17.00	3.9997	4.015	4.035	–0.0198		
	18.00	3.9996	4.013	4.034	–0.0206		
Si	1.20	3.5167	1.983	2.000	–0.0168	0.71	0.80
at 20°C	1.22	3.5133	1.970	1.983	–0.0131		
[144]	1.24	3.5102	1.957	1.967	–0.0103		
	1.26	3.5072	1.945	1.953	–0.0075		
	1.30	3.5016	1.923	1.925	–0.0024		
	1.32	3.4990	1.912	1.913	–0.0009		
	1.34	3.4965	1.902	1.901	0.0009		
	1.36	3.4941	1.892	1.890	0.0020		
	1.38	3.4918	1.883	1.879	0.0036		
	1.40	3.4896	1.874	1.869	0.0046		
	1.50	3.4799	1.835	1.826	0.0089		
	1.55	3.4757	1.818	1.808	0.0099		
	1.65	3.4684	1.789	1.777	0.0116		
	1.70	3.4653	1.776	1.764	0.0117		
	1.90	3.4550	1.734	1.723	0.0110		
	2.00	3.4510	1.717	1.707	0.0098	Note:	
	2.25	3.4431	1.685	1.677	0.0077	The comput-	
	2.50	3.4375	1.662	1.656	0.0056	ed values are	
	2.75	3.4334	1.645	1.641	0.0038	superior to	
	3.00	3.4302	1.632	1.630	0.0022	the estimated	
	4.00	3.4229	1.602	1.604	–0.0020	uncertainty	
	5.00	3.4195	1.588	1.592	–0.0043	in the	
	6.00	3.4177	1.581	1.586	–0.0050	recommended	
	7.00	3.4165	1.576	1.582	–0.0063	value of	
	8.00	3.4158	1.573	1.580	–0.0068	15 X 10^{-6}.	
	9.00	3.4153	1.571	1.578	–0.0071		
	10.00	3.4150	1.570	1.577	–0.0069		
	11.00	3.4147	1.569	1.576	–0.0070		
	12.00	3.4145	1.568	1.575	–0.0074		
	13.00	3.4144	1.567	1.575	–0.0078		
	14.00	3.4142	1.567	1.574	–0.0075		

T base = 293.1

DESIGN

Analise variação de temperatura

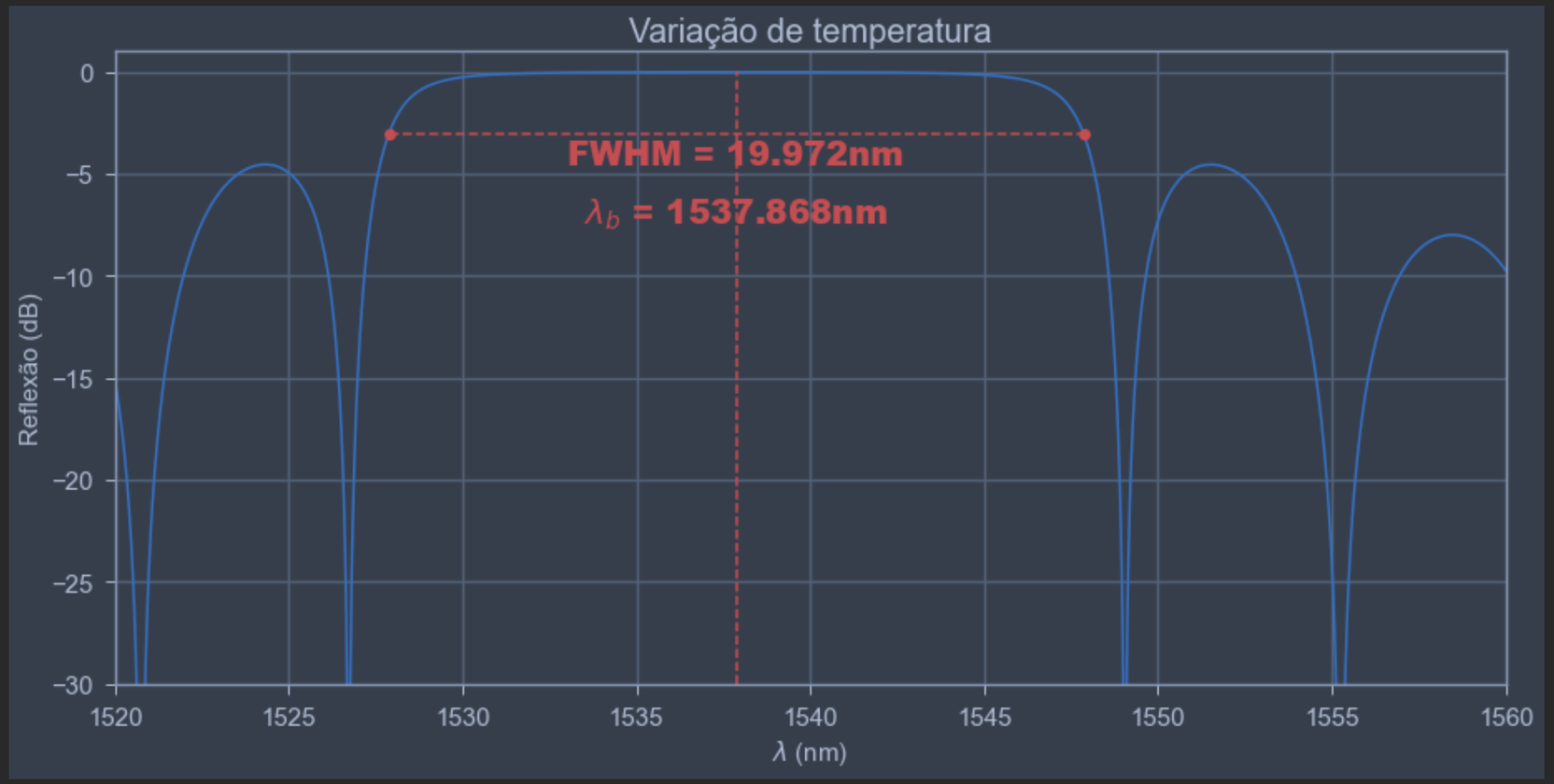
T = 234.5 (x 0.8)



DESIGN

Analise variação de temperatura

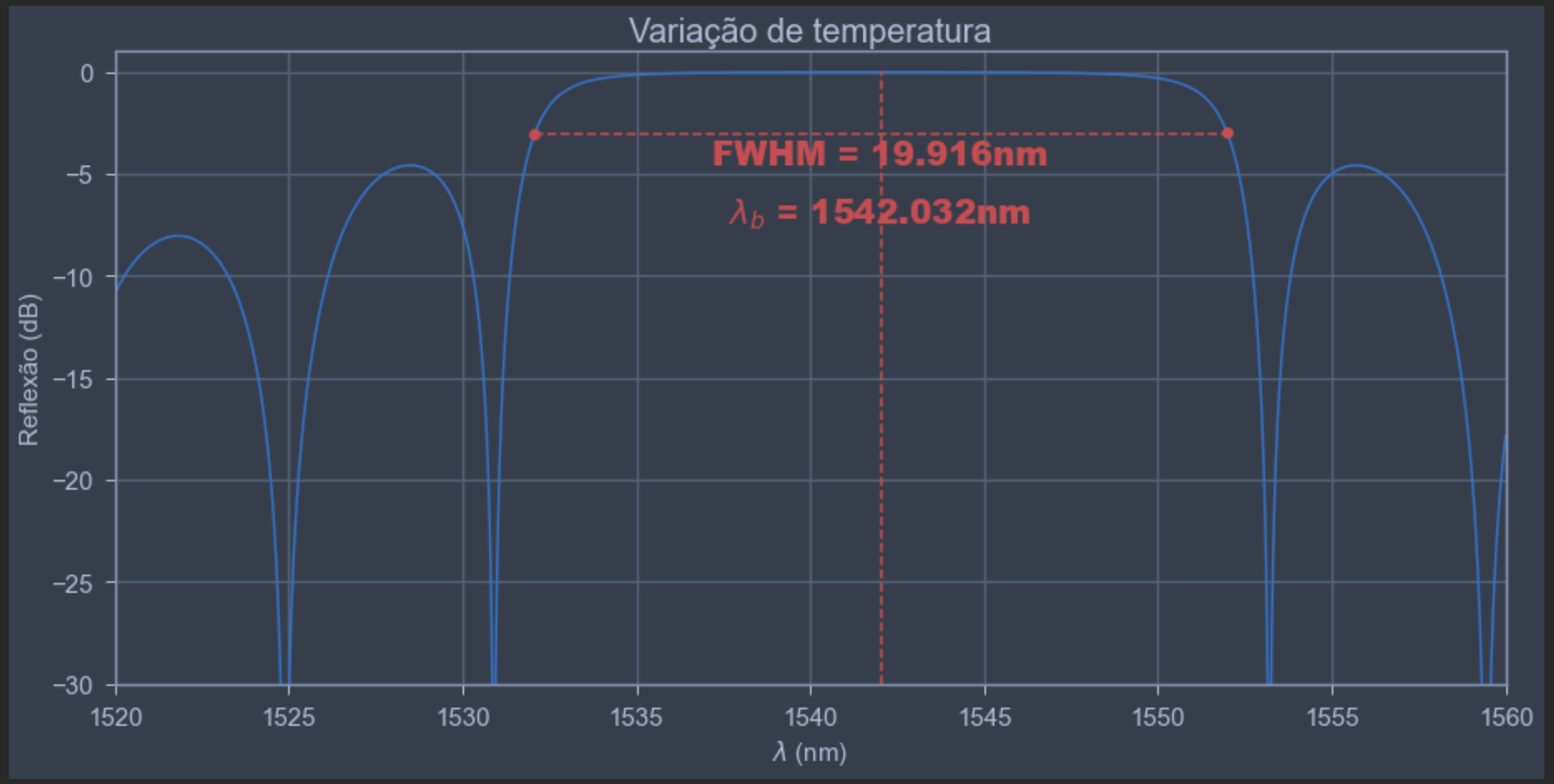
T = 263.8 (x 0.9)



DESIGN

Analise variação de temperatura

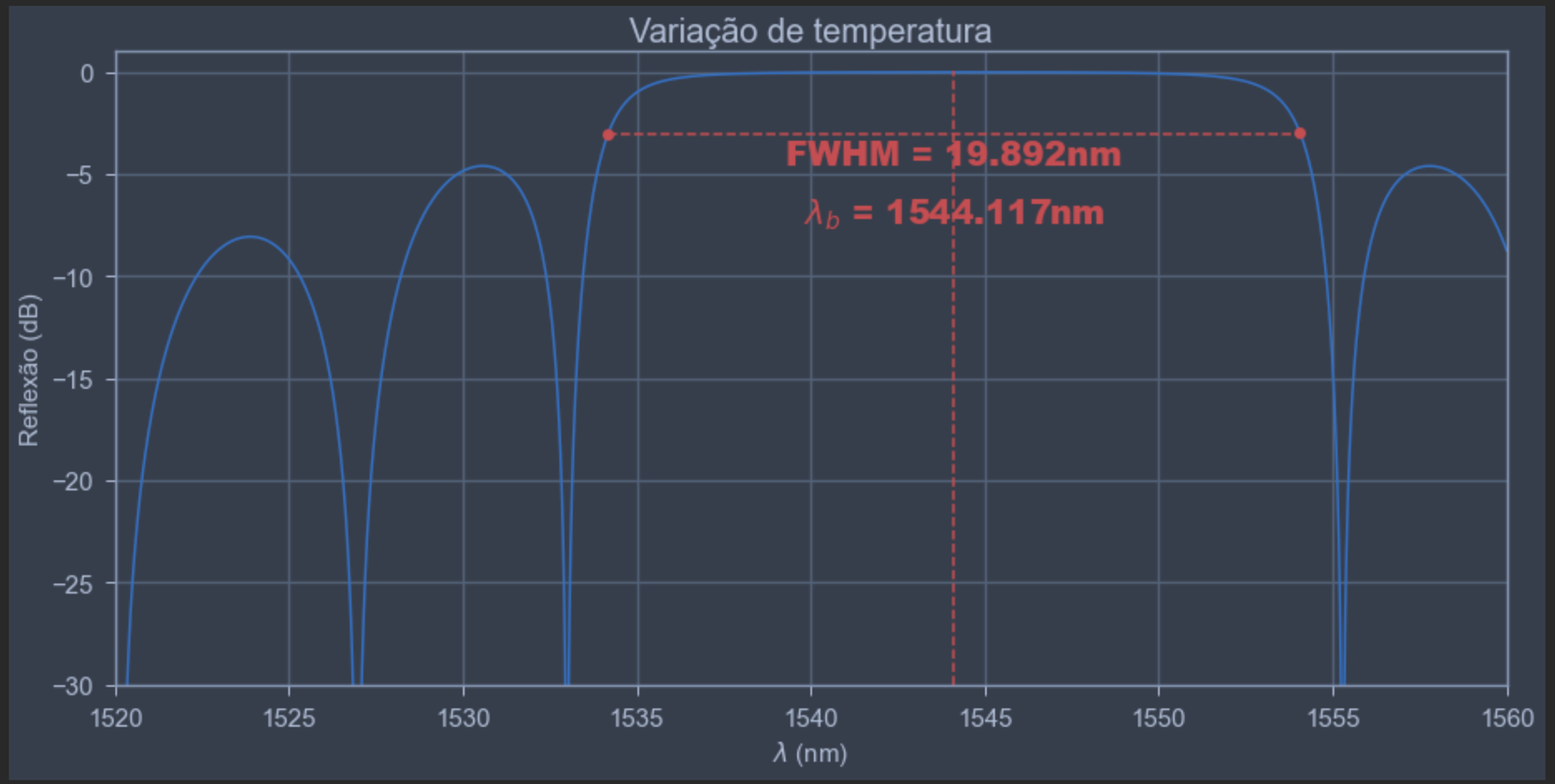
T = 322.4 (x 1.1)



DESIGN

Analise variação de temperatura

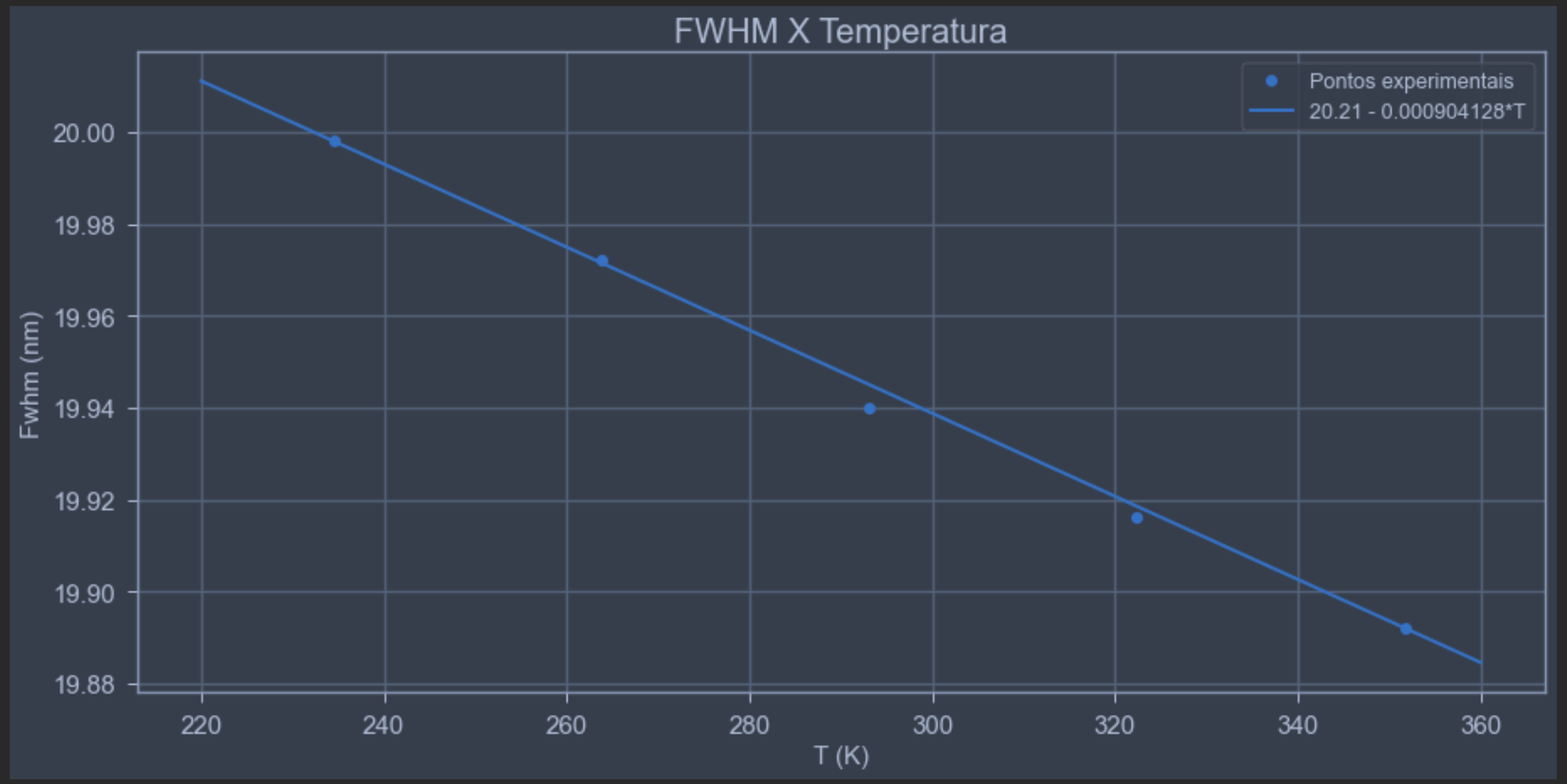
T = 351.72 (x 1.2)



DESIGN

Analise variação de temperatura

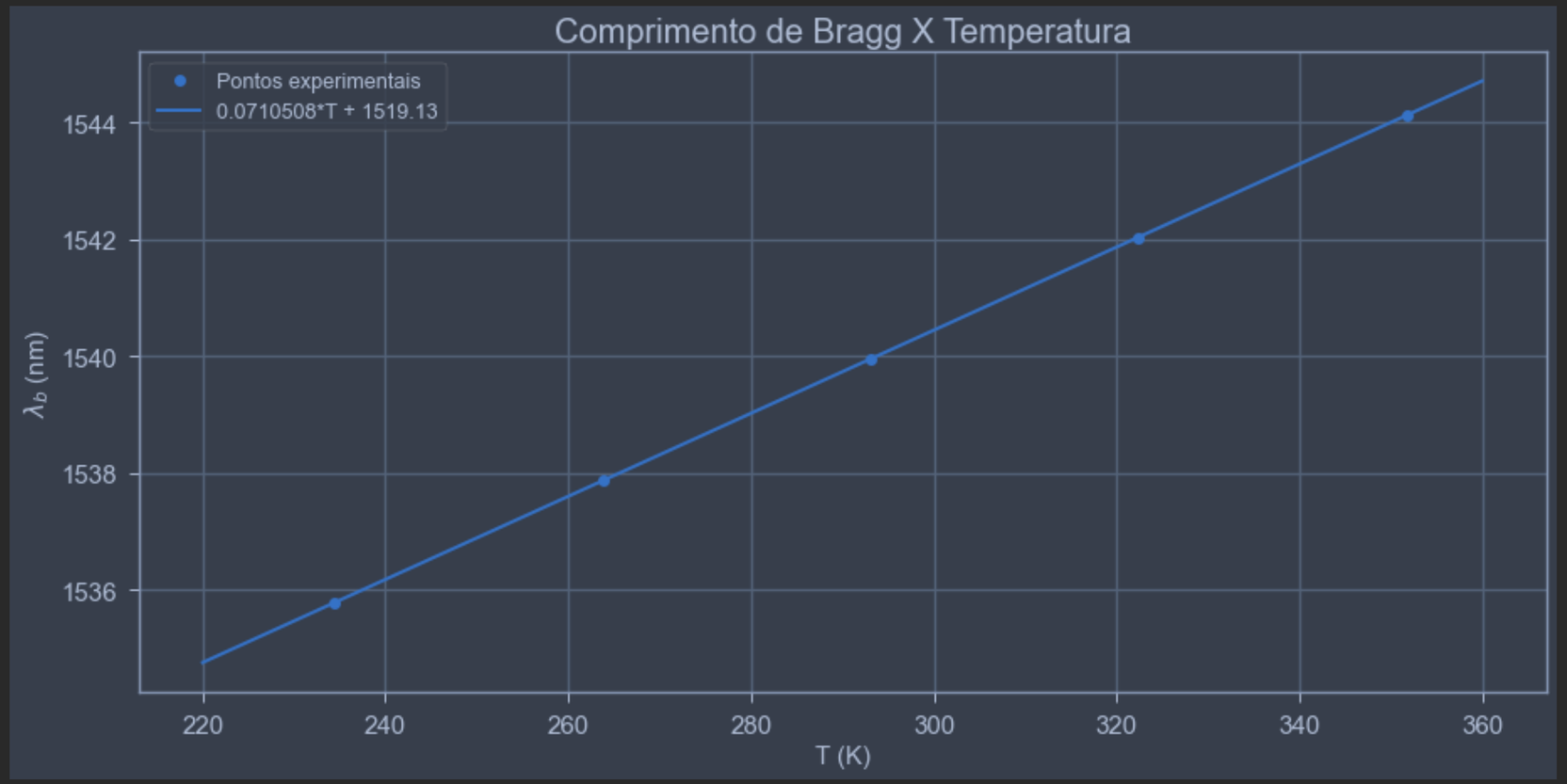
Fwhm



DESIGN

Analise variação de temperatura

Banda central

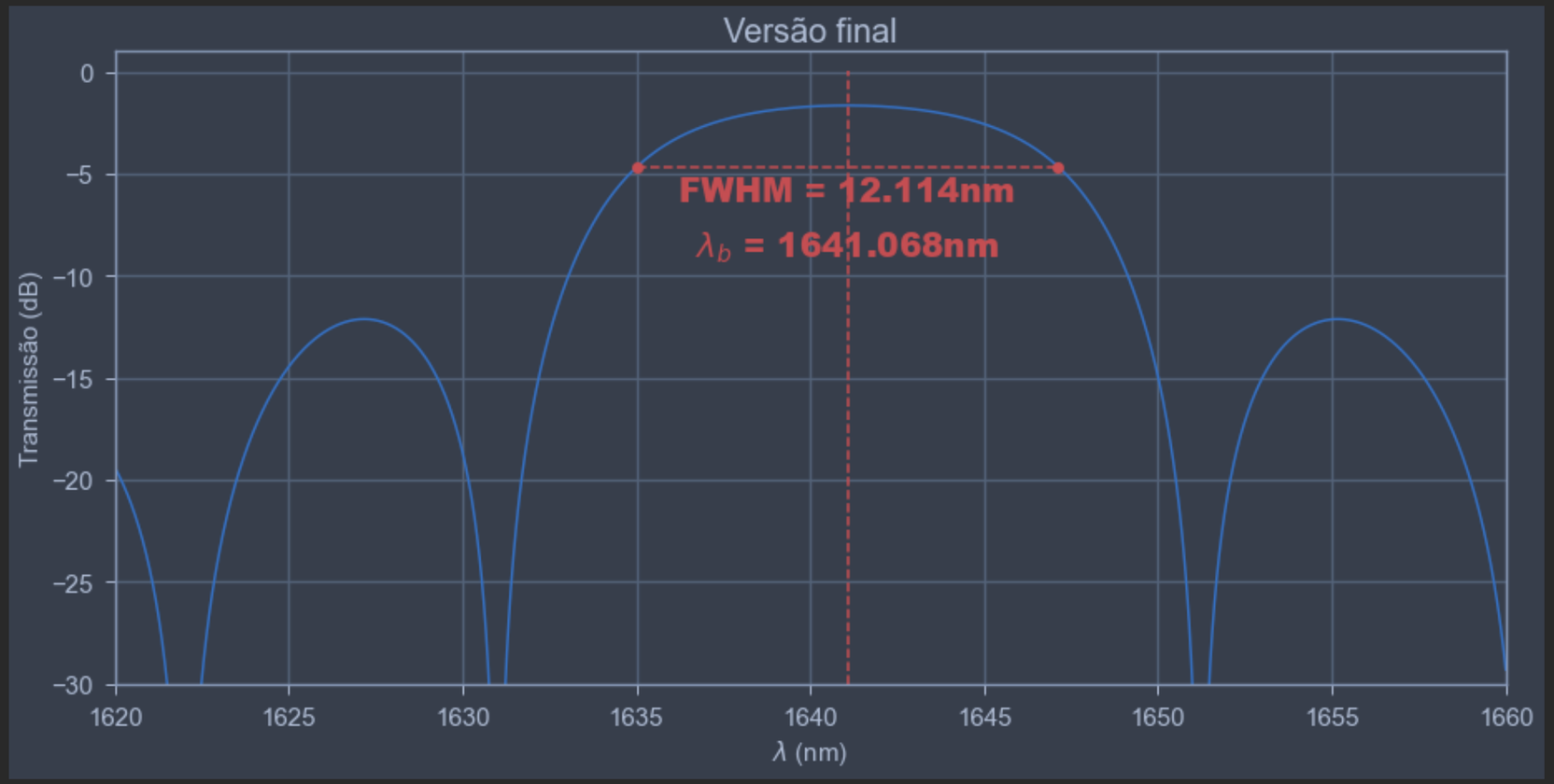


DESIGN

ALTERANDO O GUIA PARA 600 NM

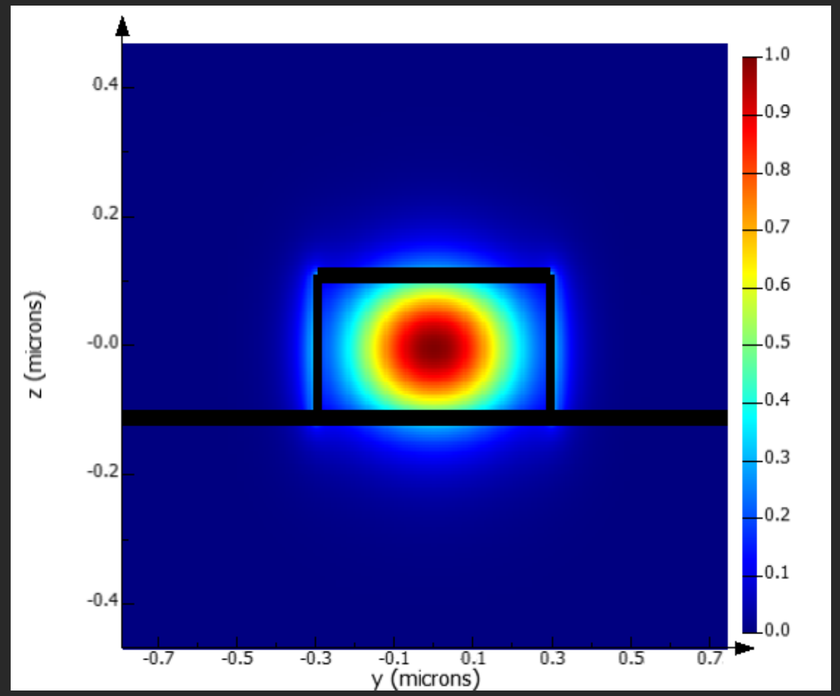
DESIGN

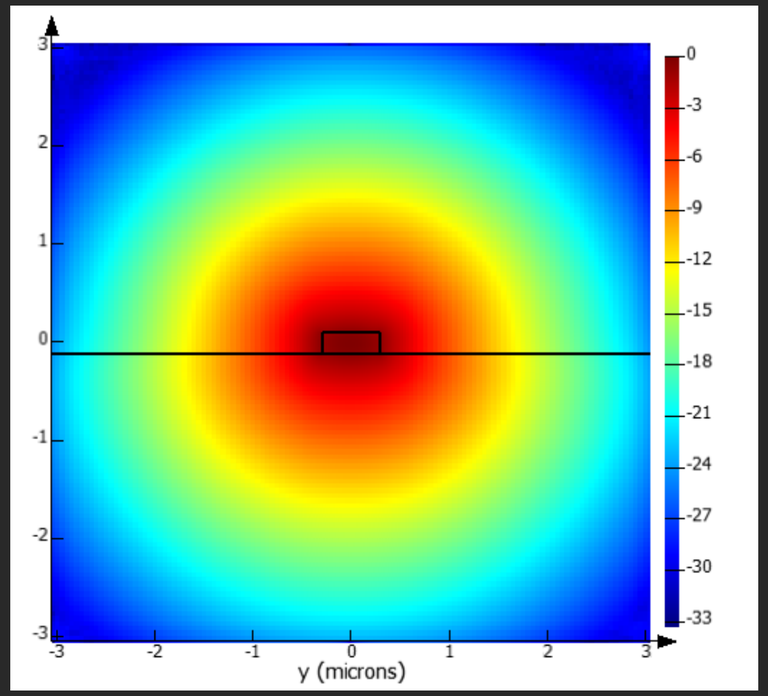
Alterando o guia para 600 nm



DESIGN

Simulação do guia





mode #	effective index	wavelength (μm)	loss (dB/cm)	group index	TE polarization fraction (Ey)	waveguide TE/TM fraction (%)
1	2.537329+8.301567e-17i	1.54	2.9419e-11	4.198189+3.531844e-17i	99	80.25 / 81.12
2	1.667813+5.340745e-11i	1.54	1.8927e-05	3.920935-4.571173e-09i	12	67.94 / 90.11

DESIGN

Parametros:

Para neff = 2.5373

Periodo da grade = 303.468 nm

Para Numero de periodos = 250: L = 75.867 um

Para L = 36.416 um, deltaNeff = 0.05405

Rmax = 0.988

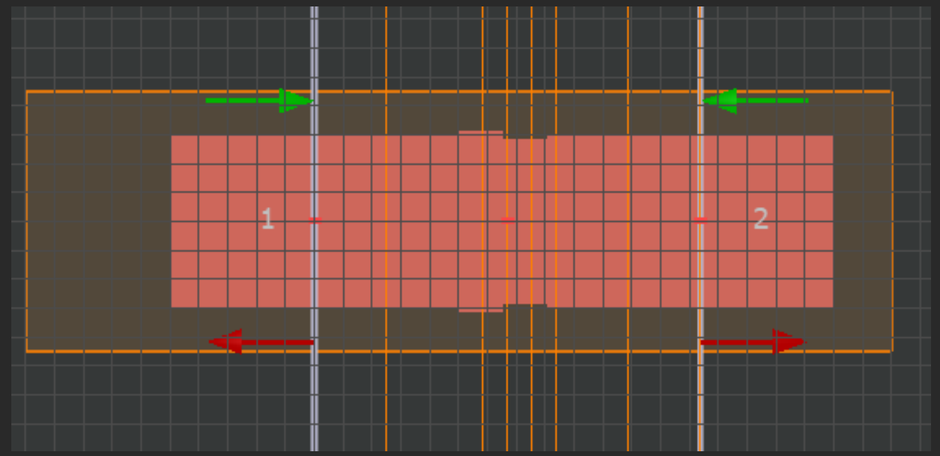
DESIGN

Calculo do Delta W

DESIGN

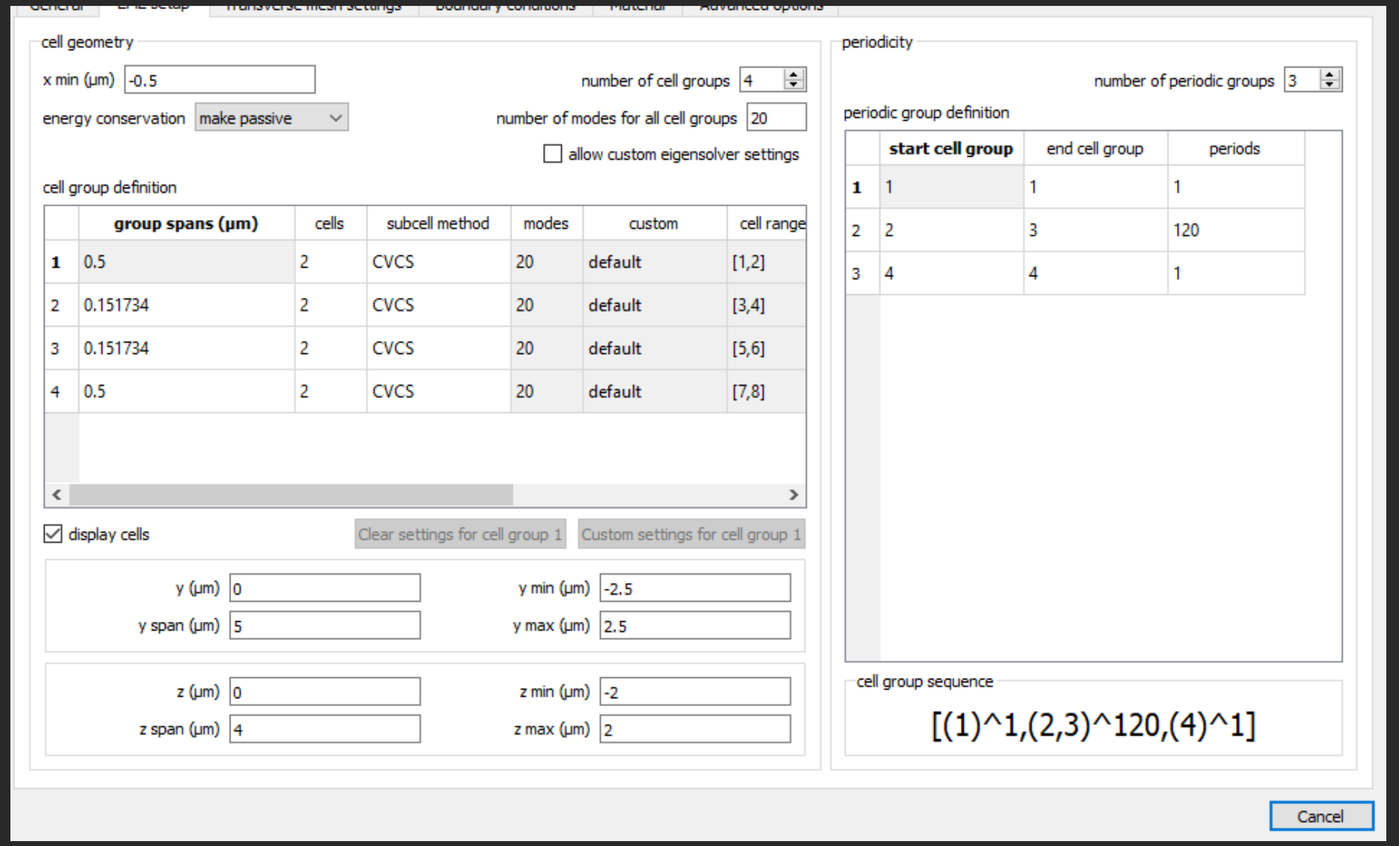
Simulação no EME

1	W	Length	0,6	um
2	altura	Length	0,22	um
3	deltaW	Length	0,0517	um
4	periodo	Length	0,303469	um
5	material	Material	Si (Silicon) - Palik	
6	substrato	Material	SiO2 (Glass) - P...	
7	N	Number	120	



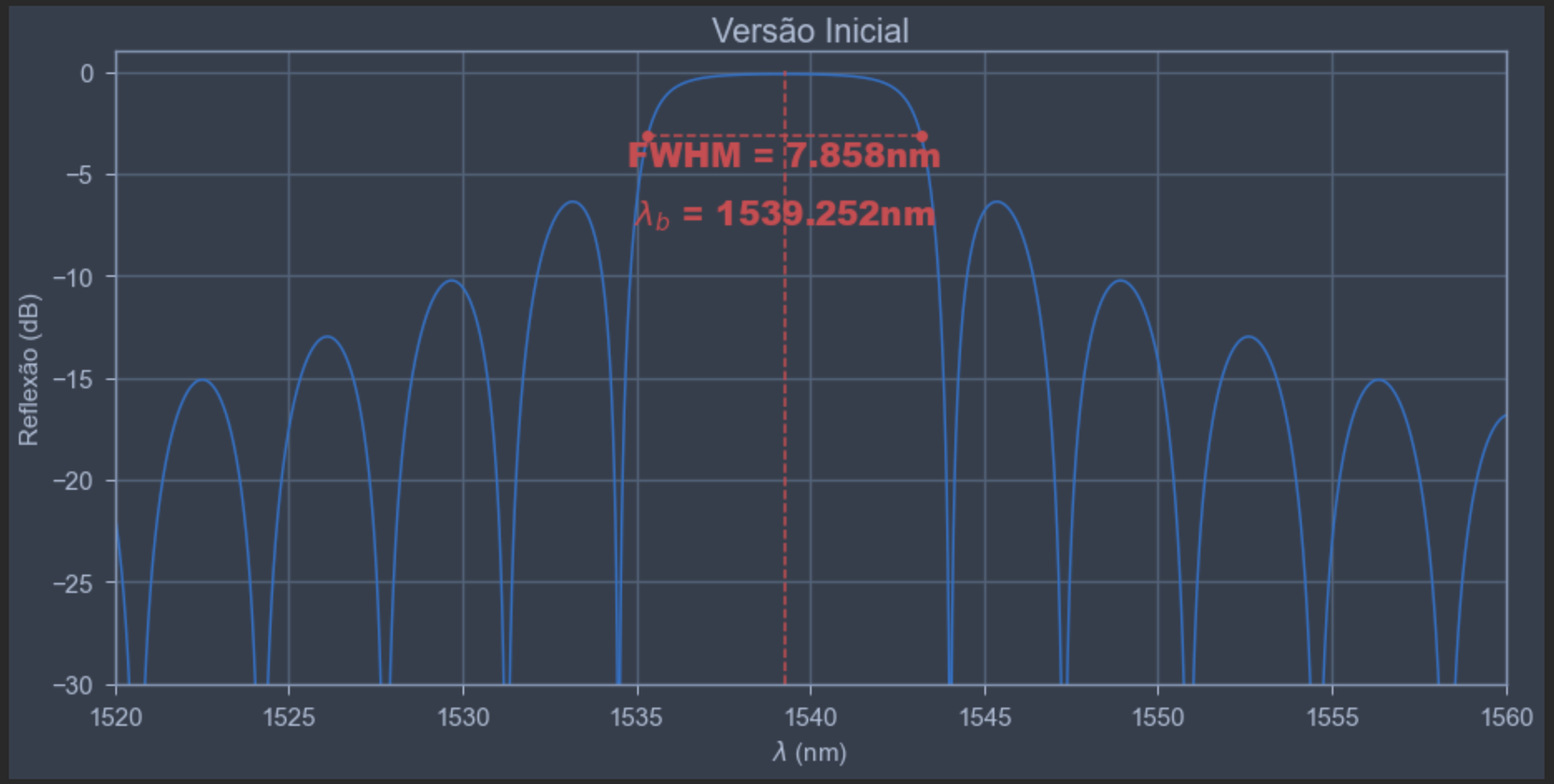
DESIGN

Simulação no EME



DESIGN

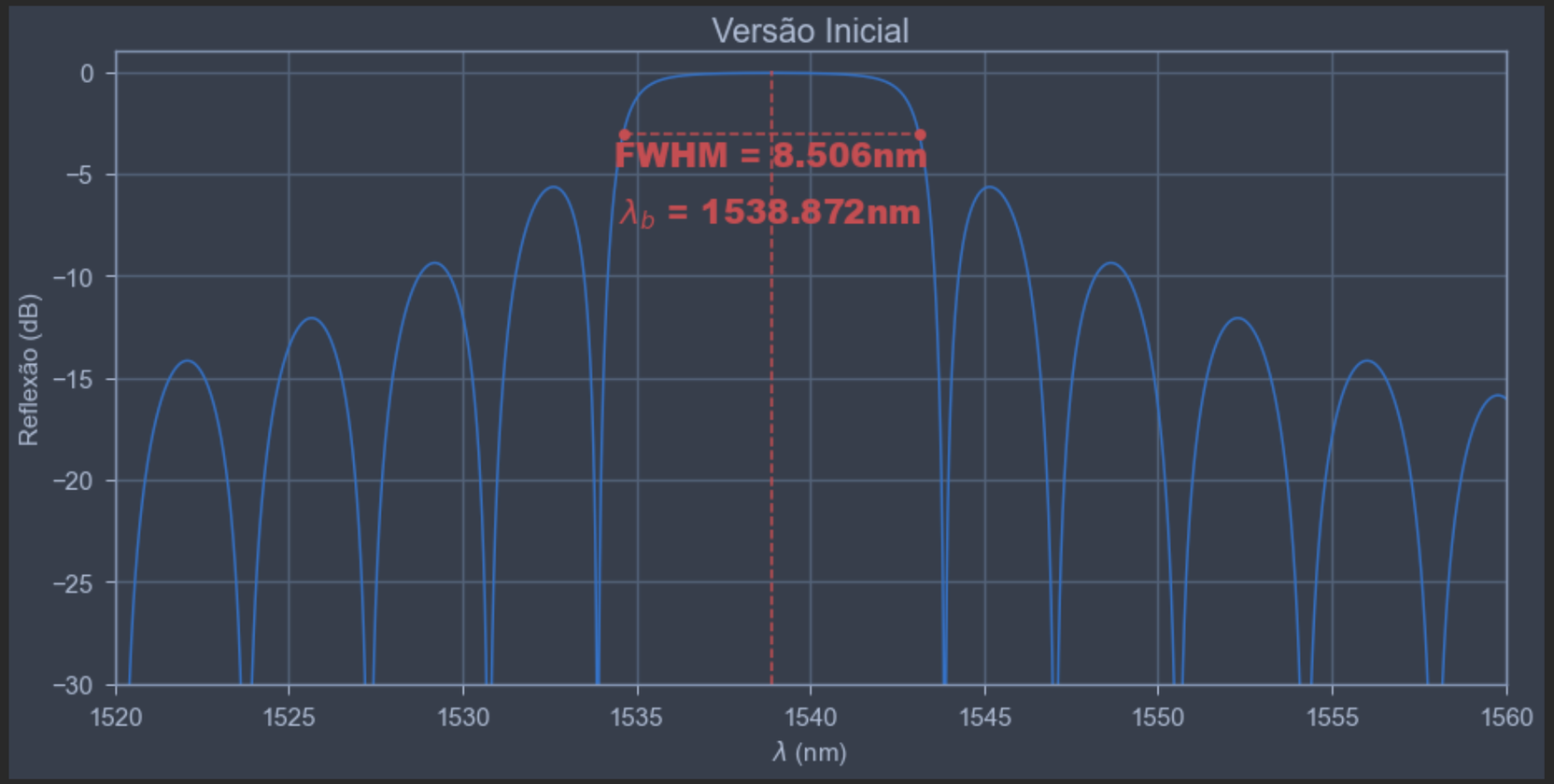
Resultados Iniciais



DESIGN

Correção do FWHM

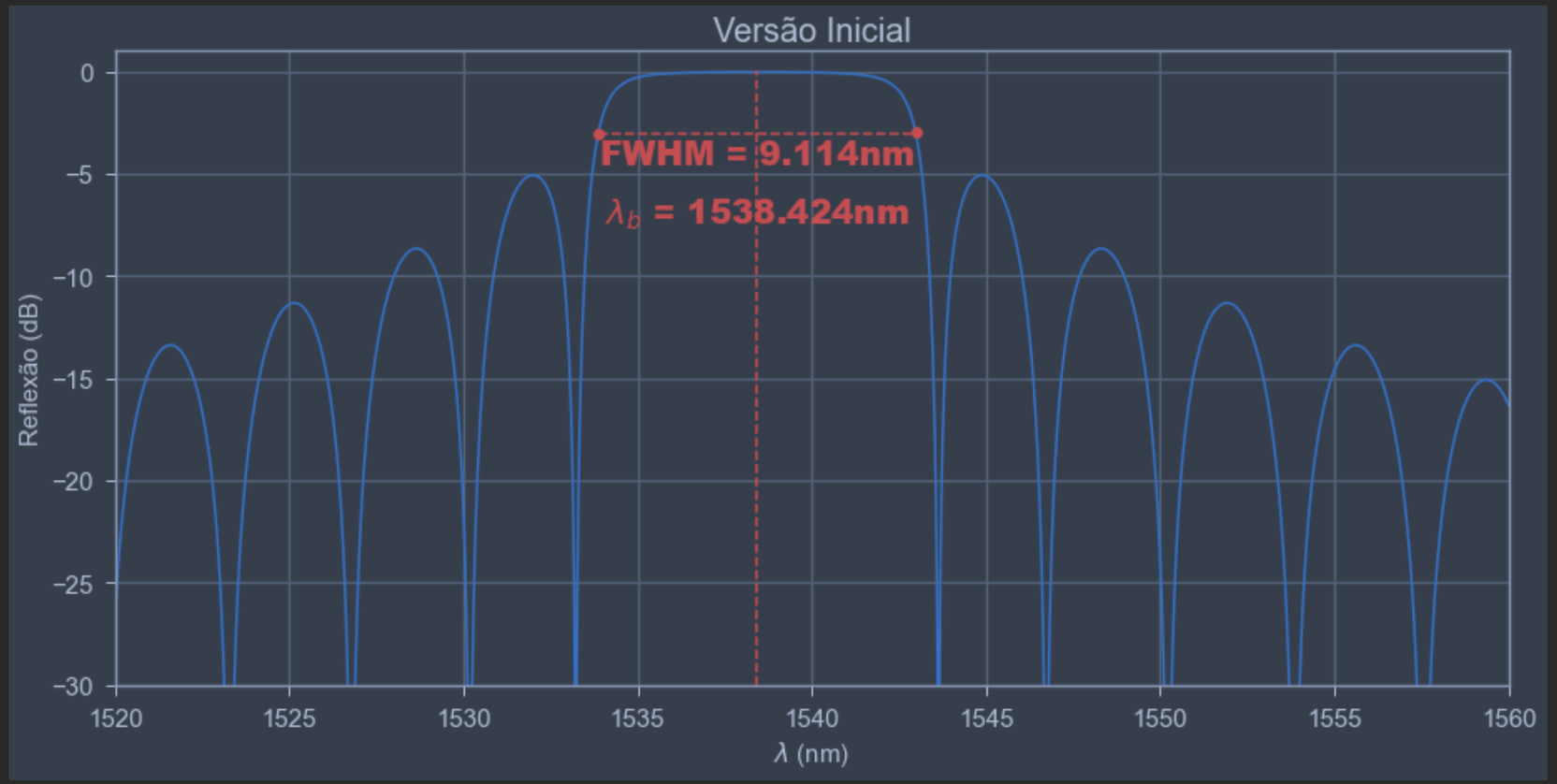
ΔW = 0.064625 (x1.25)



DESIGN

Correção do FWHM

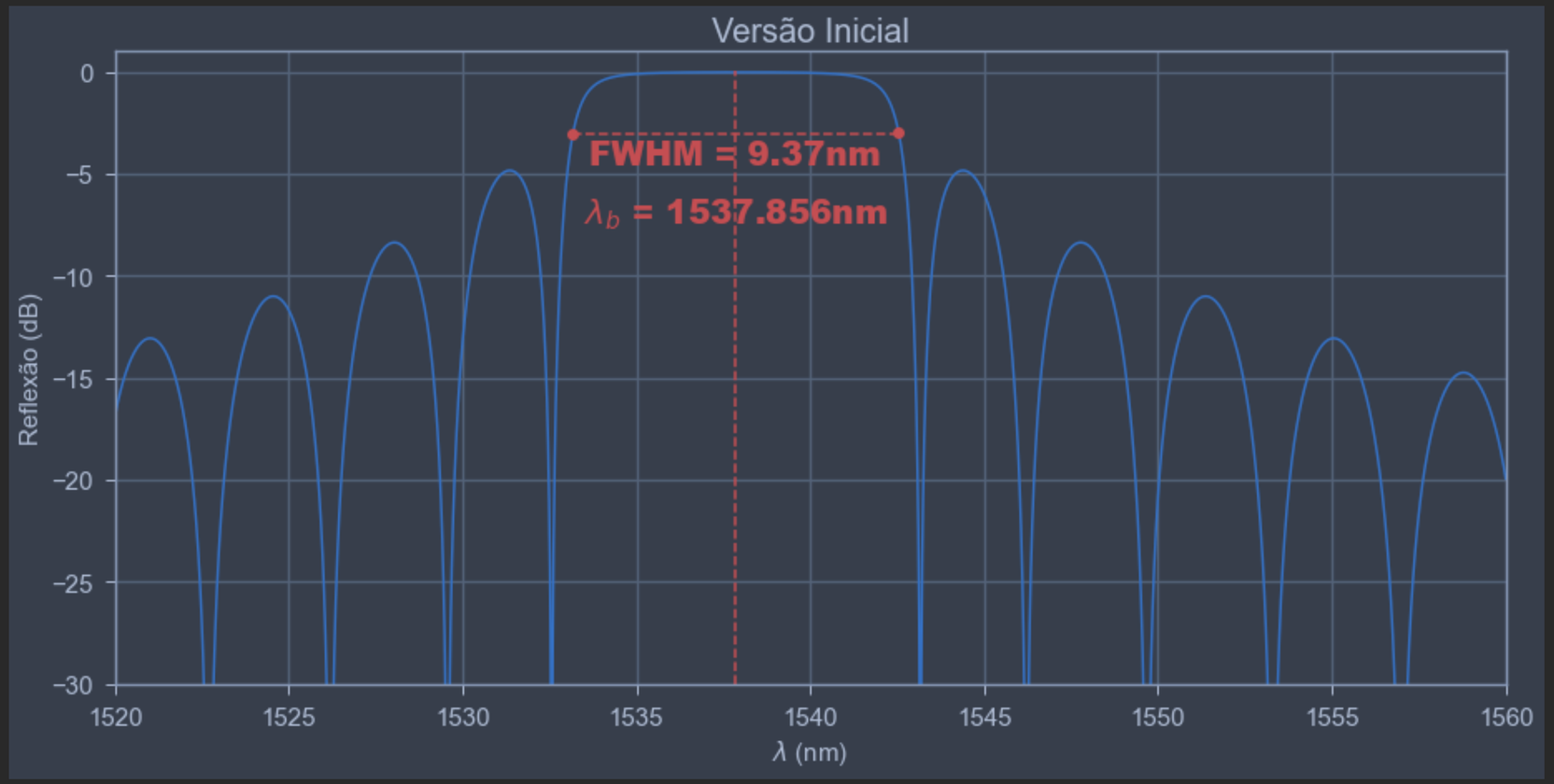
ΔW = 0.07755 (x1.5)



DESIGN

Correção do FWHM

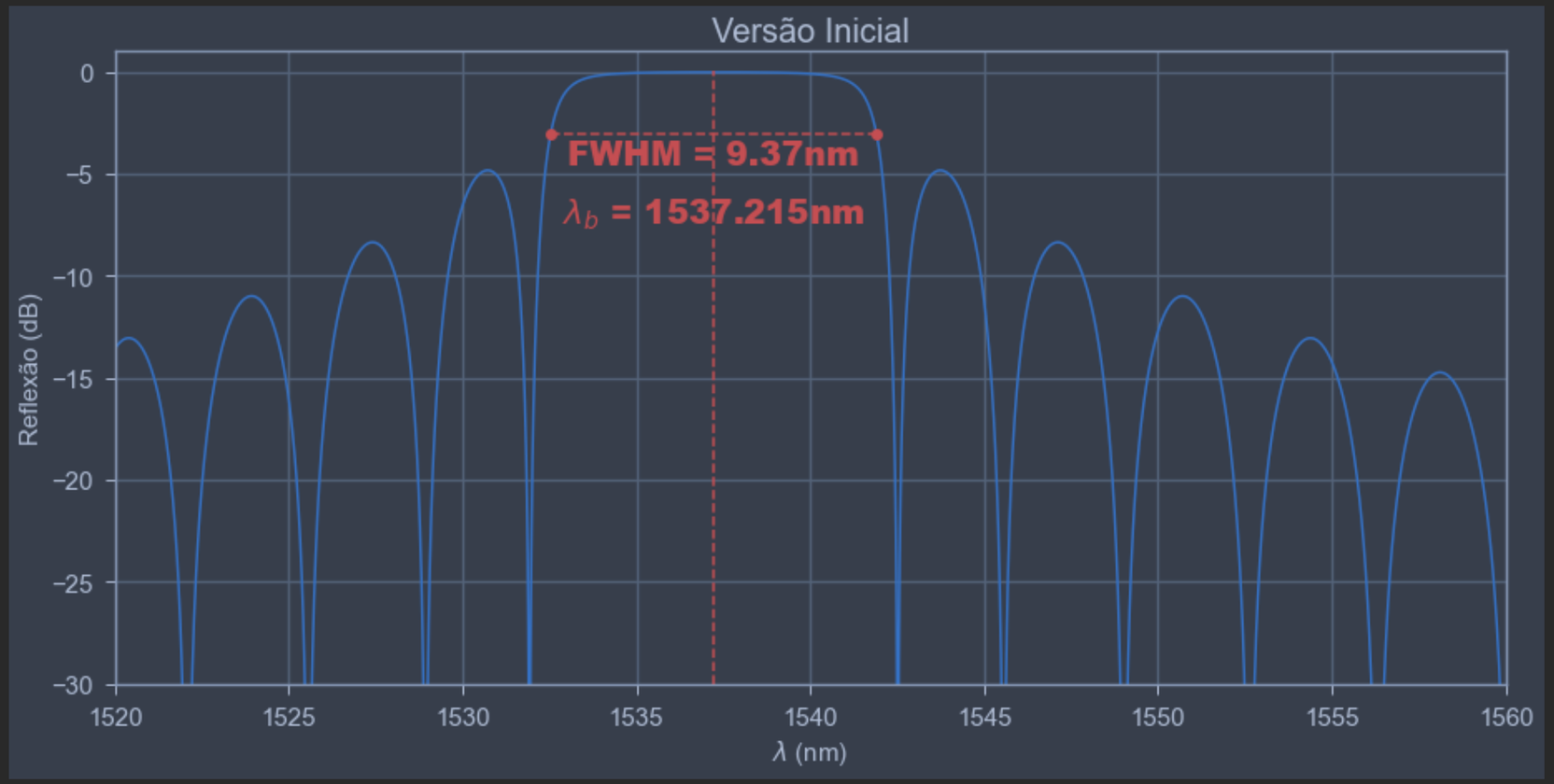
ΔW = 0.090475 (x1.75)



DESIGN

Correção do FWHM

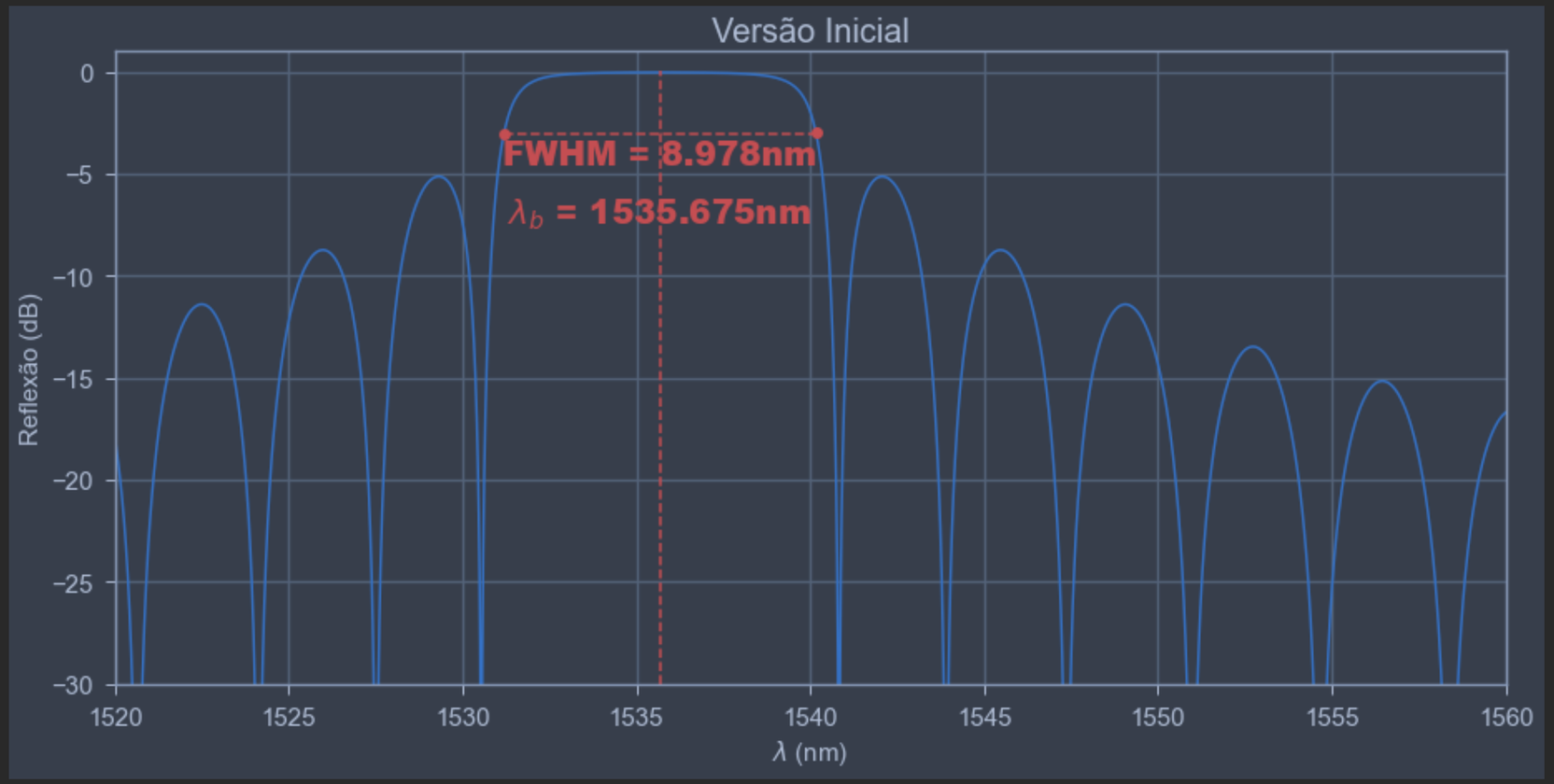
ΔW = 0.1034 (x2)



DESIGN

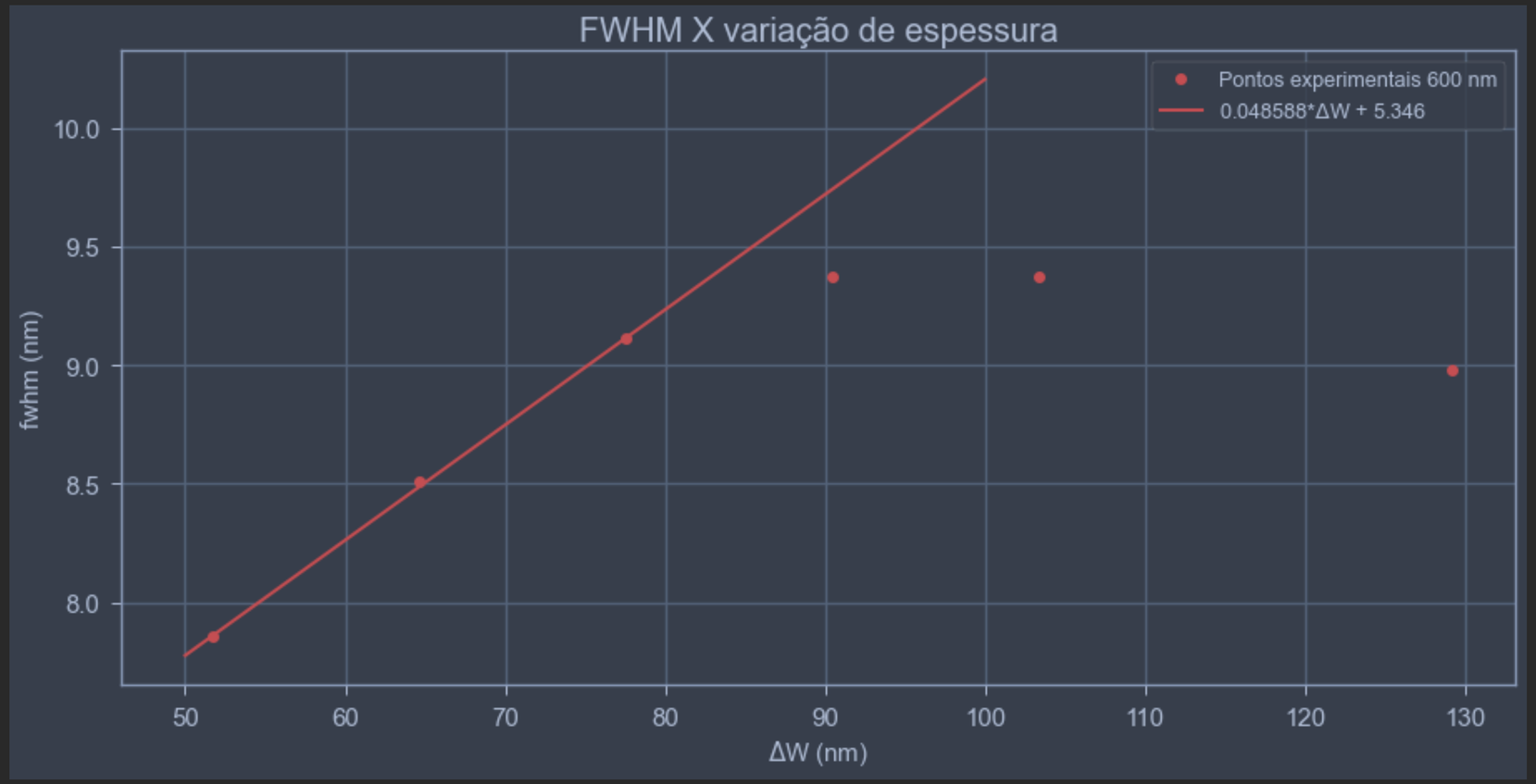
Correção do FWHM

ΔW = 0.12925 (x2.5)



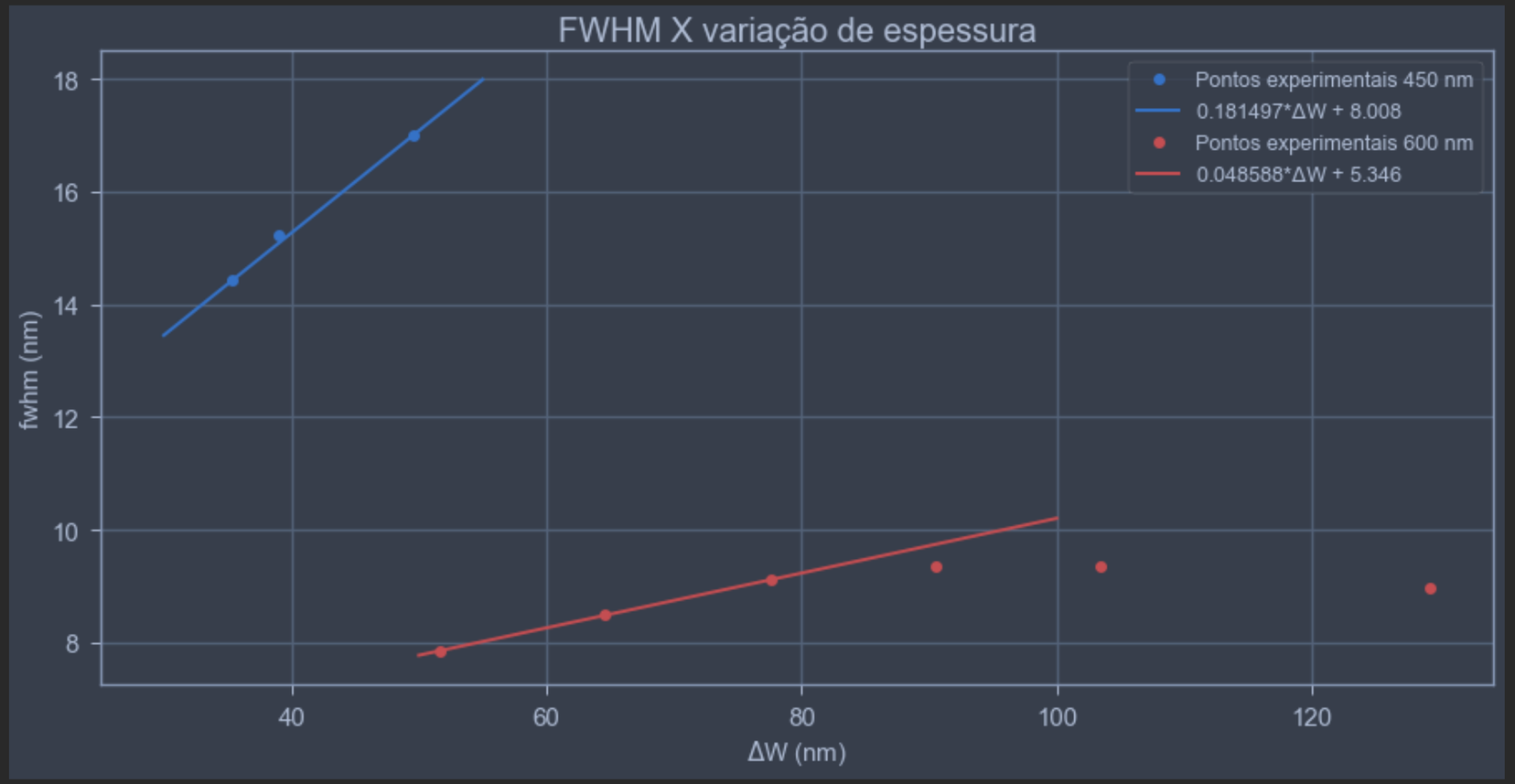
DESIGN

Analise do FWHM



DESIGN

Comparação com a grade anterior

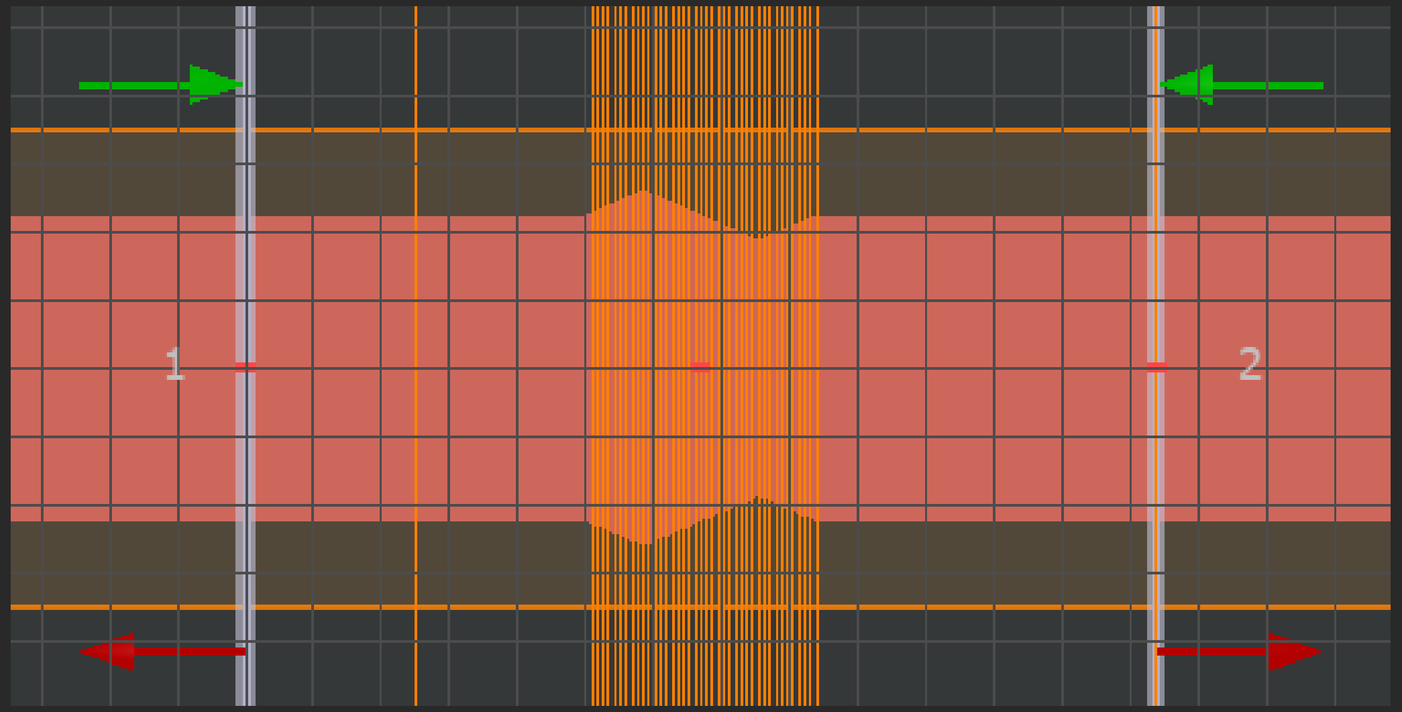


DESIGN

ALTERANDO A GEOMETRIA DA 1 GRADE

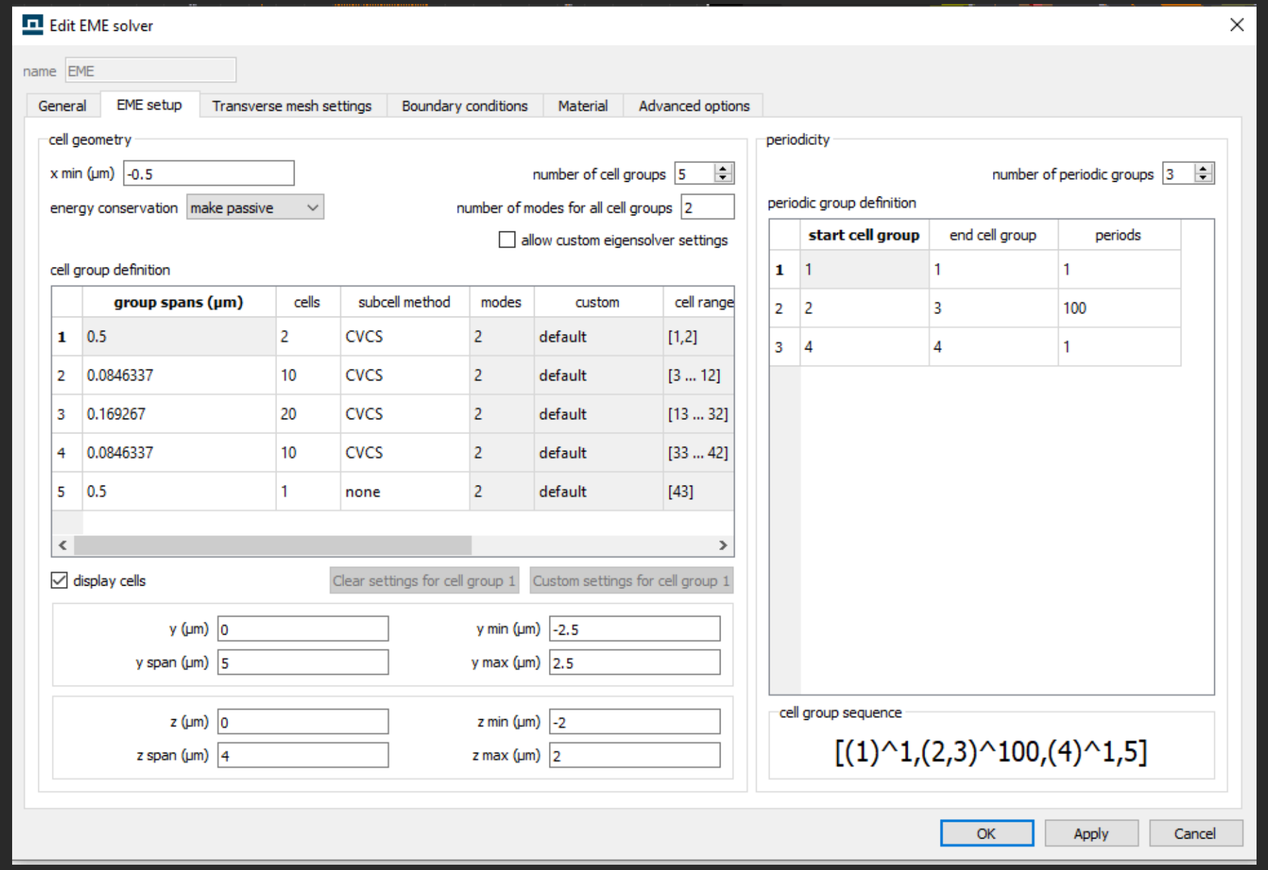
DESIGN

Gemetria triangular



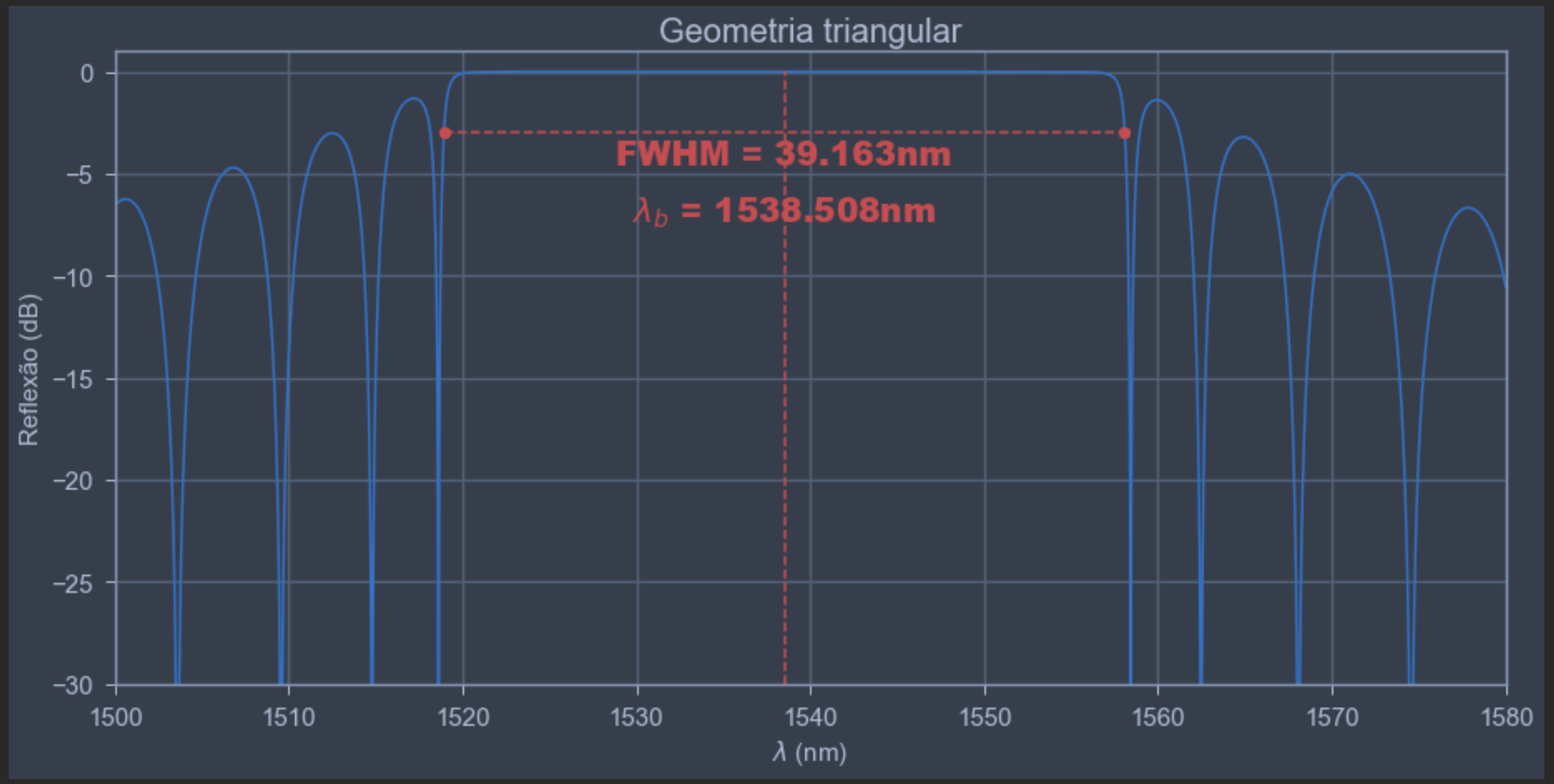
DESIGN

Gemetria triangular



DESIGN

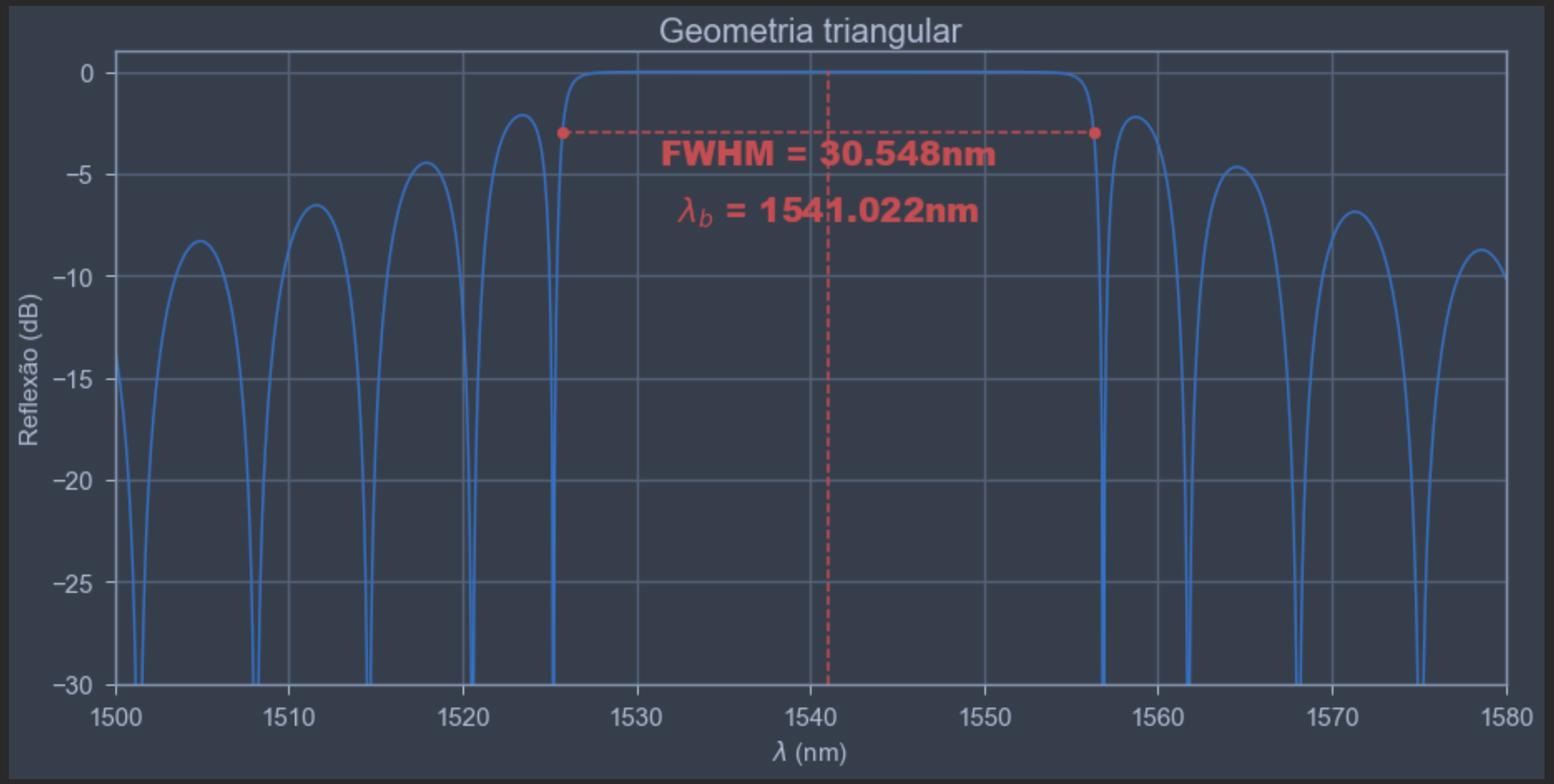
Gemetria triangular



DESIGN

Variando o ΔW

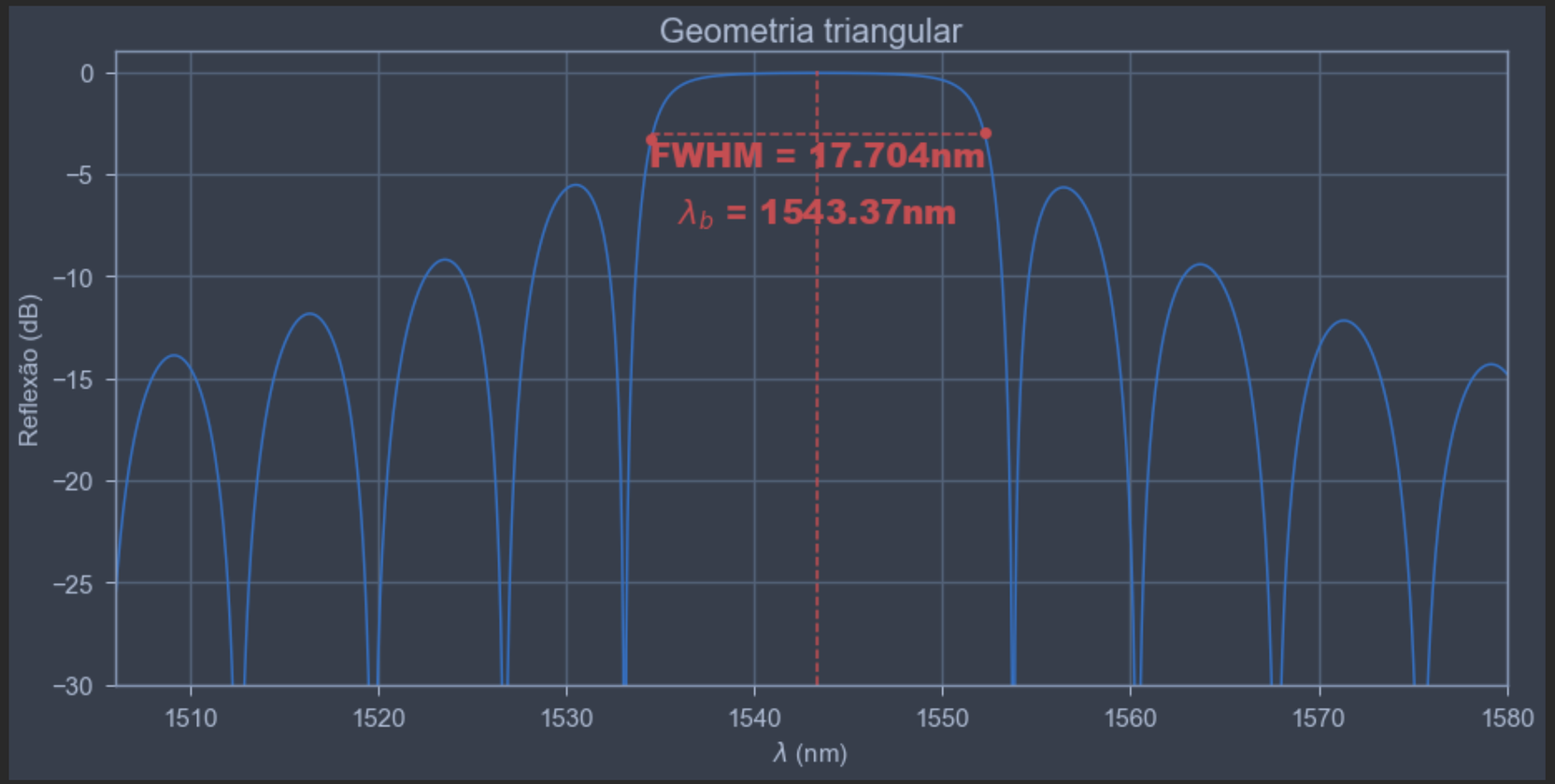
ΔW = 0.0550551 (x0.75)



DESIGN

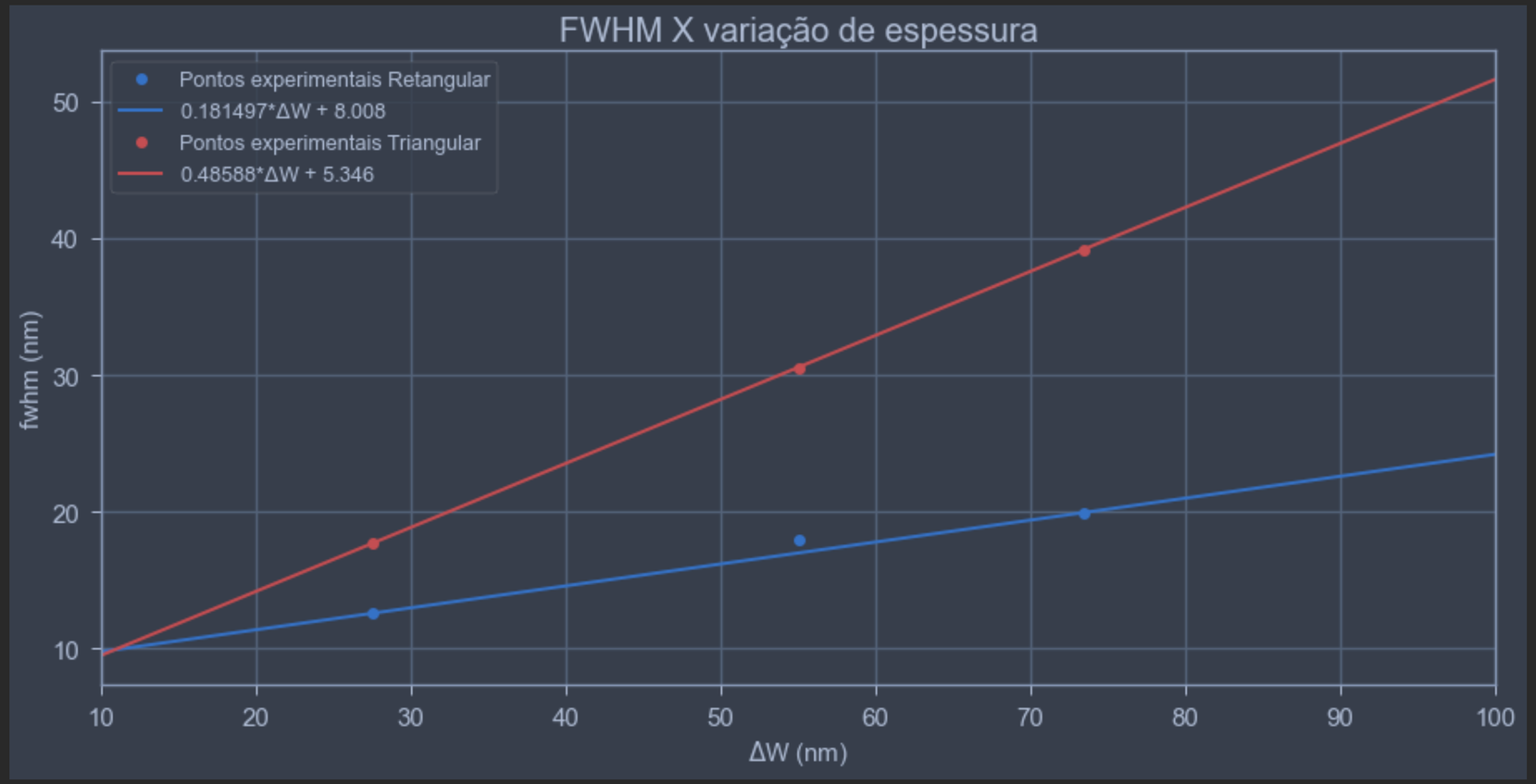
Variando o ΔW

ΔW = 0.02752755 (x0.375)



DESIGN

Comparação entre grades

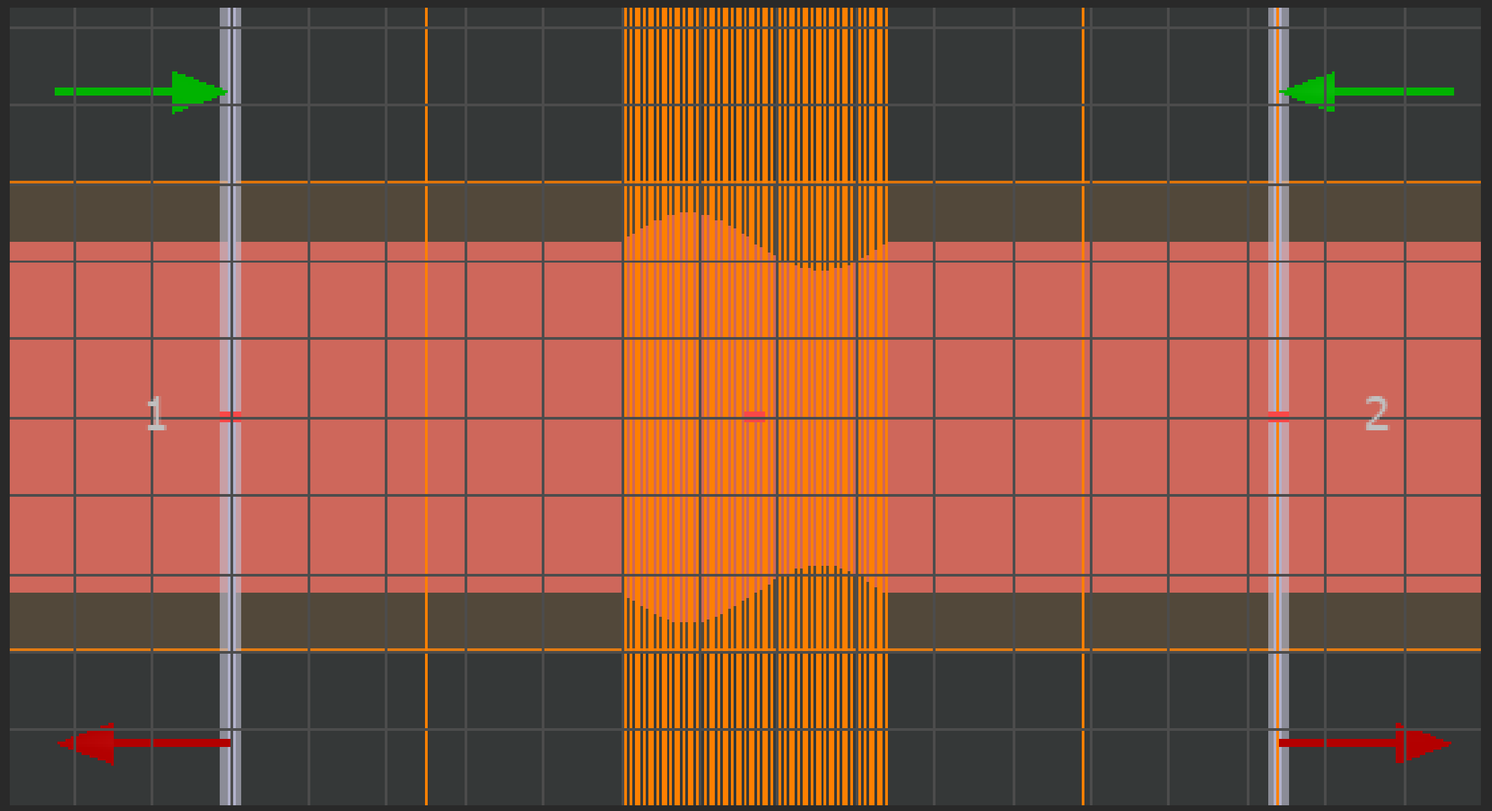


DESIGN

ALTERANDO A GEOMETRIA DA 1 GRADE

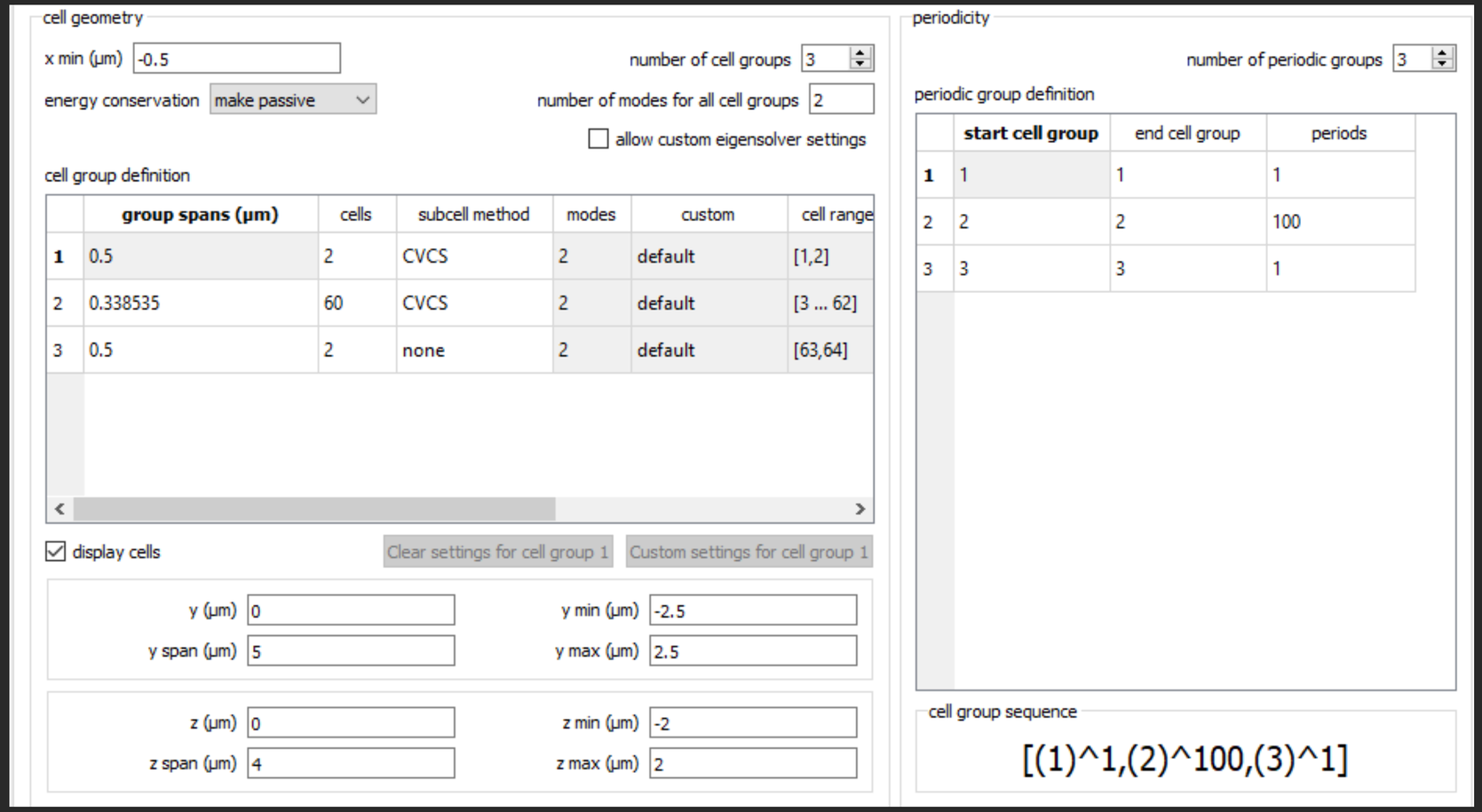
DESIGN

Gemetria Senoidal



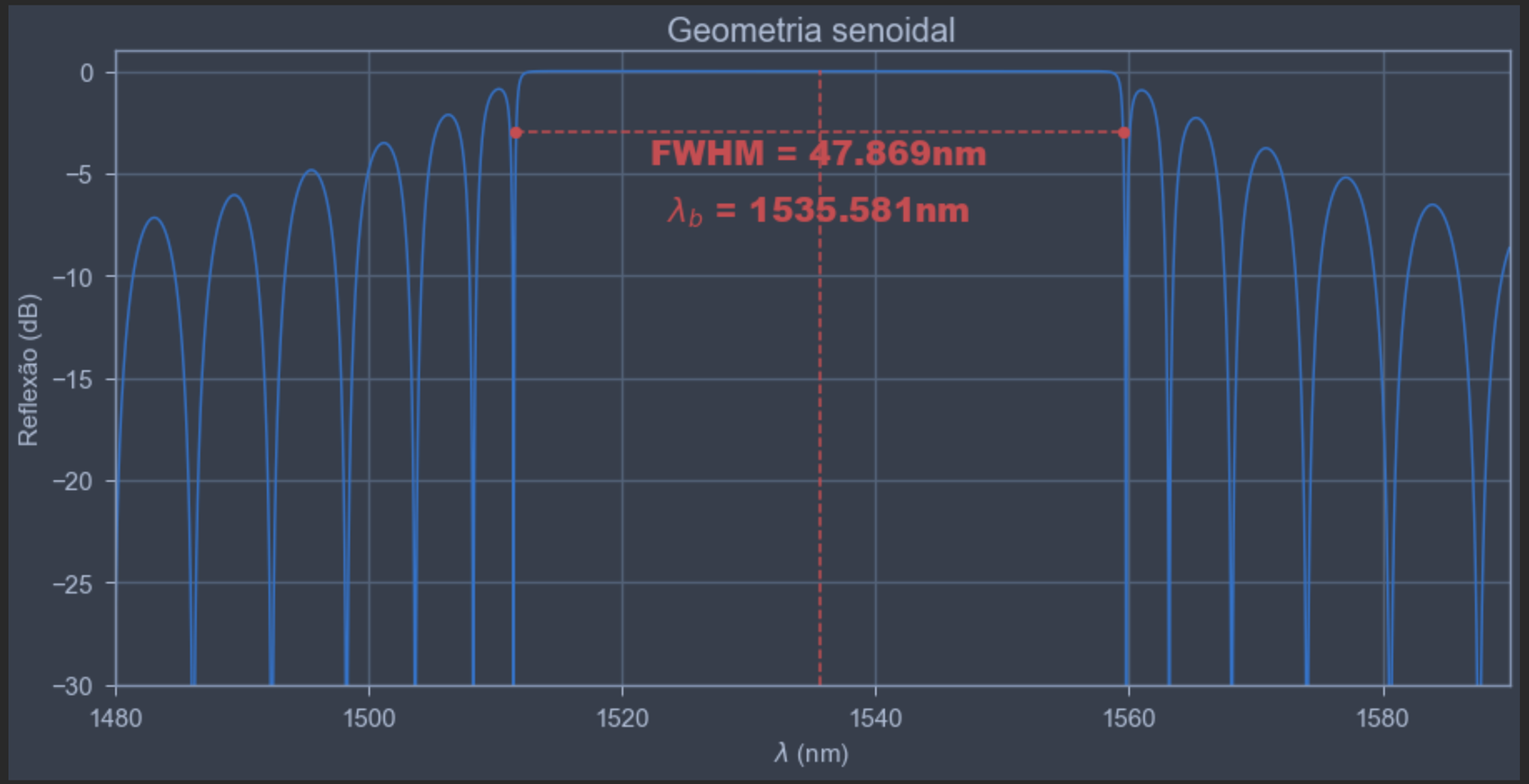
DESIGN

Gemetria triangular



DESIGN

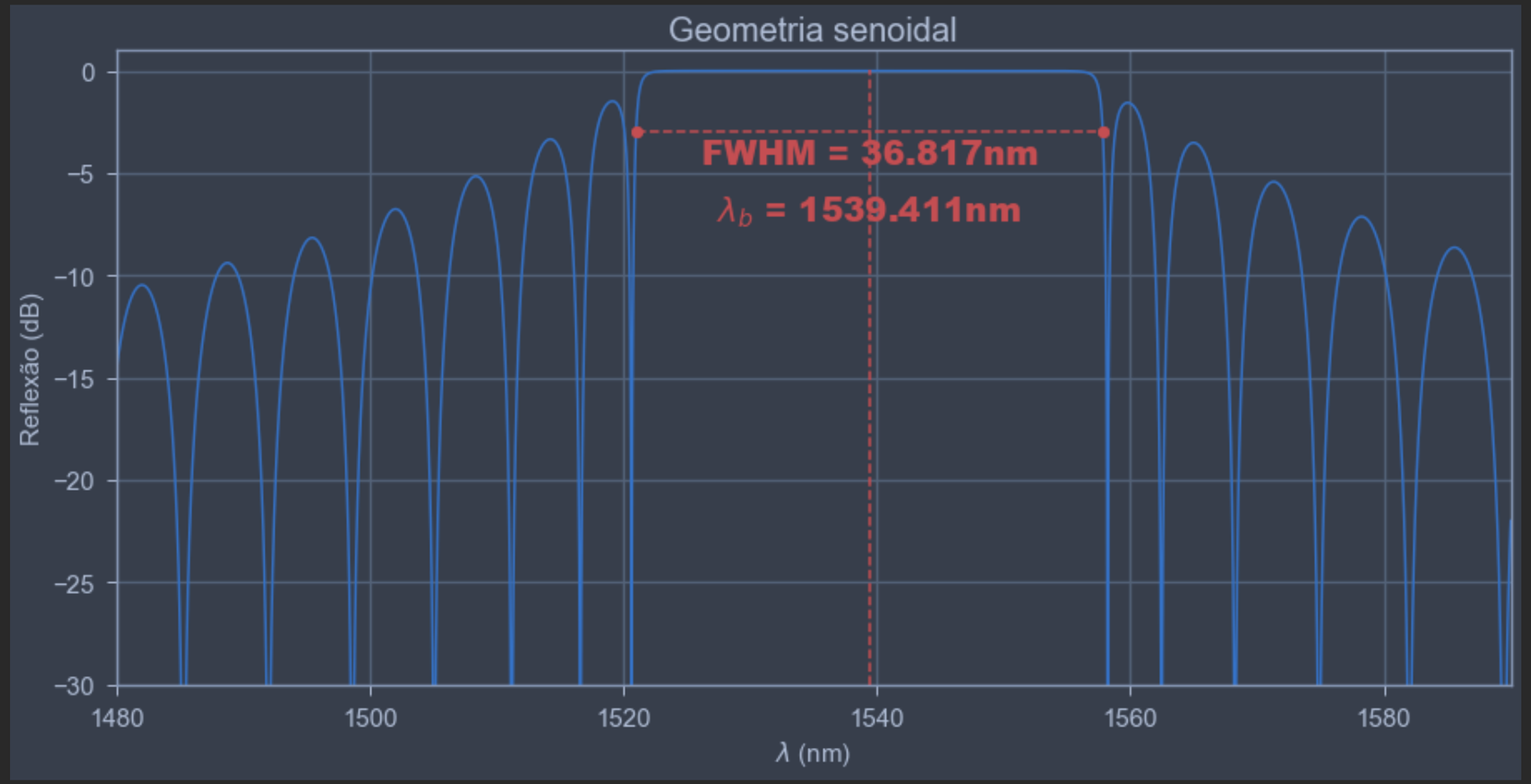
Gemetria triangular



DESIGN

Variando o ΔW

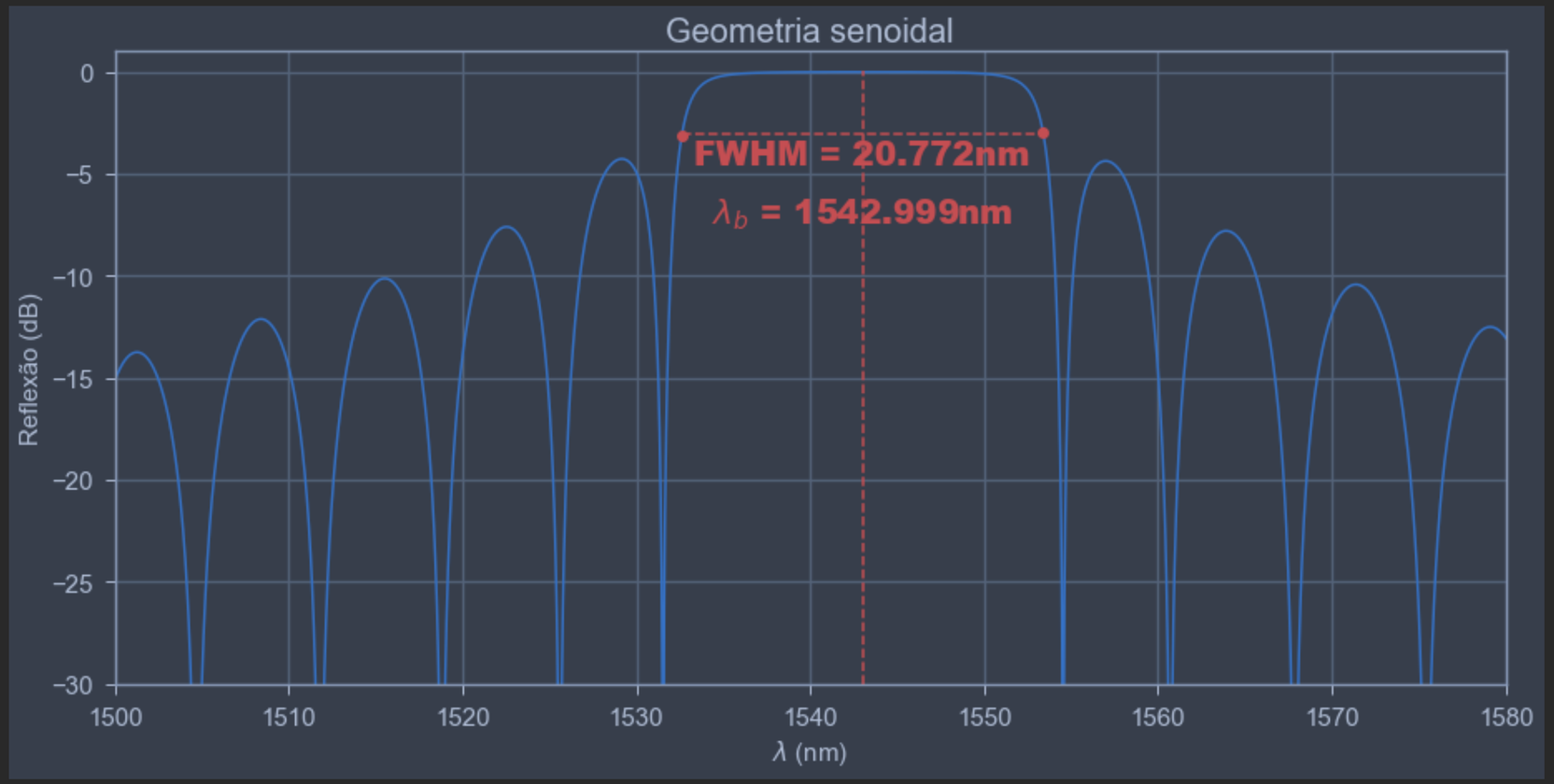
ΔW = 0.0550551 (x0.75)



DESIGN

Variando o ΔW

ΔW = 0.02752755 (x0.375)



DESIGN

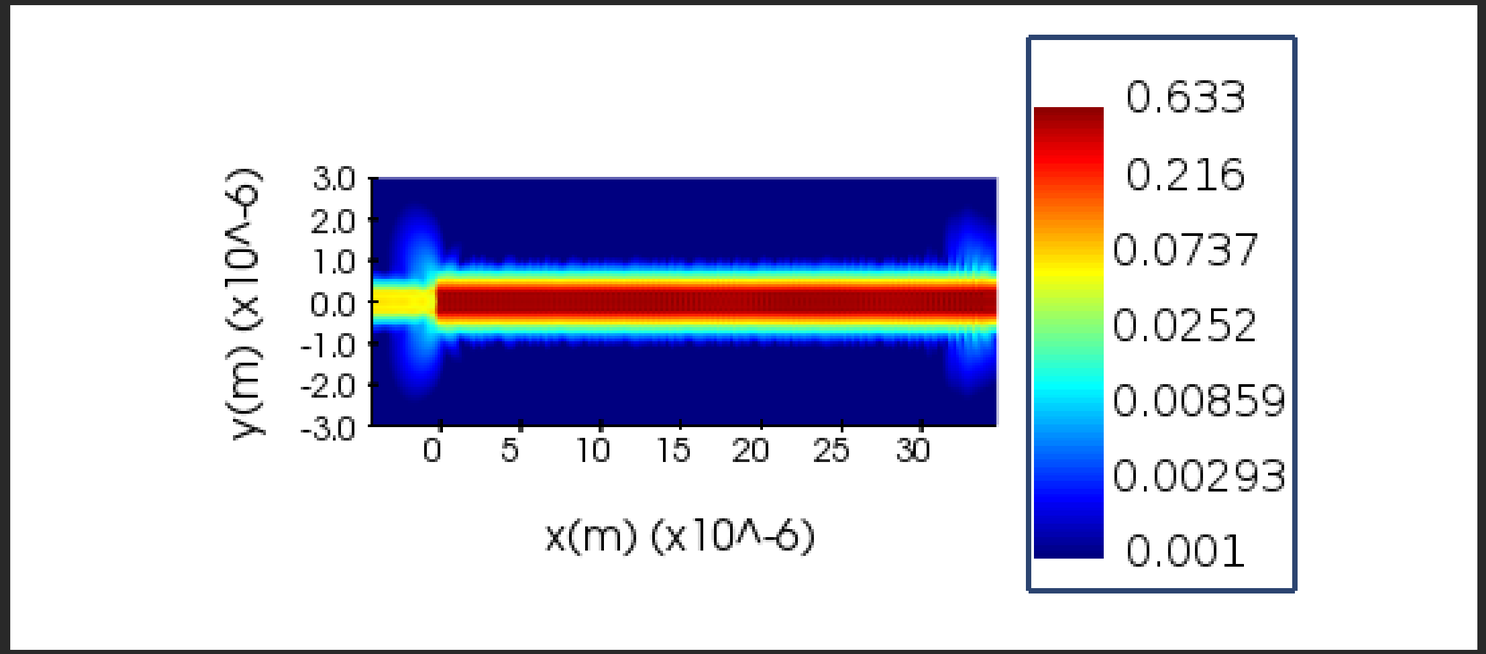
Comparação entre grades

SEMANA 3

Simulação FDTD

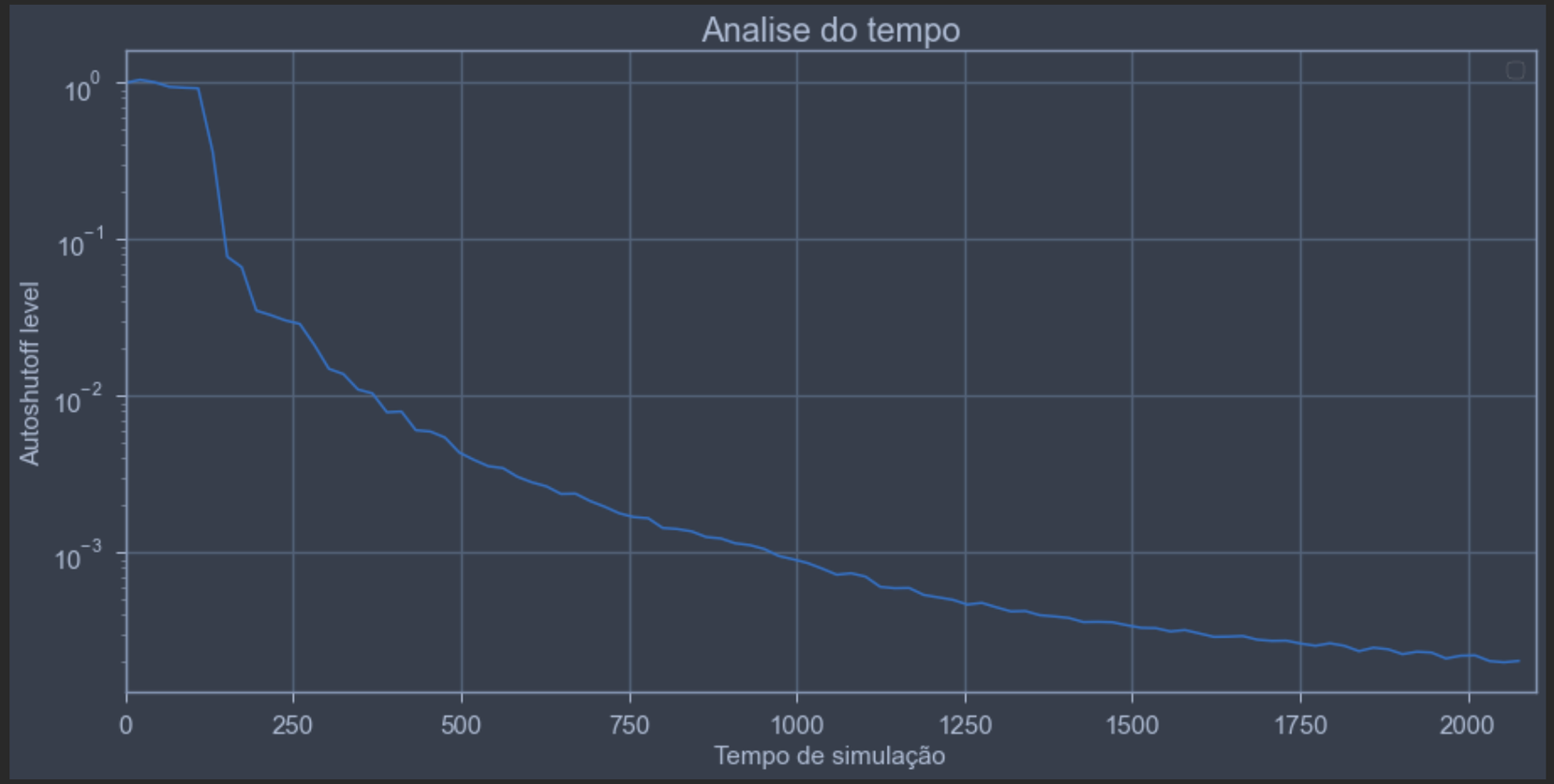
DESIGN

Convergencia do Campo



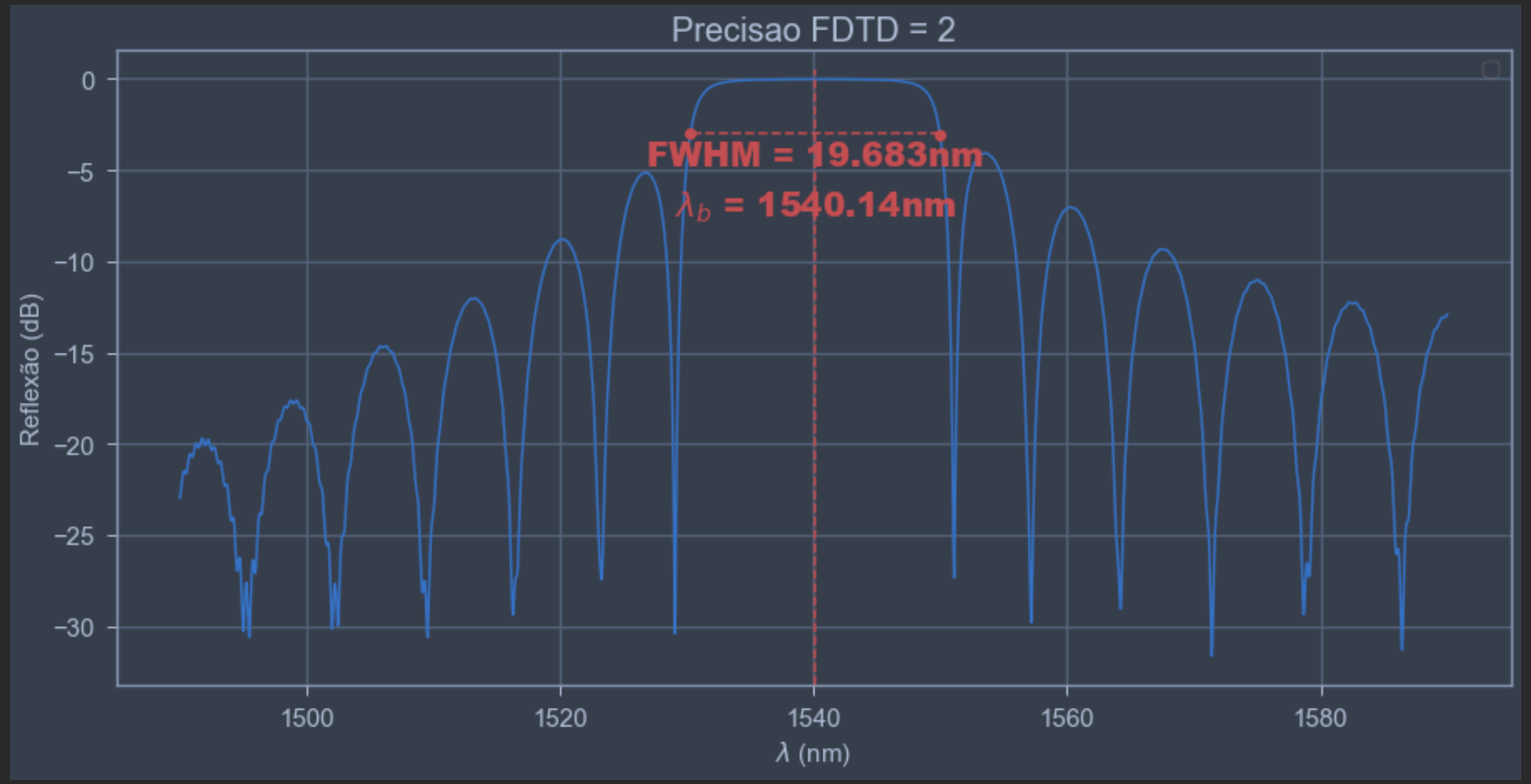
DESIGN

Convergencia no tempo



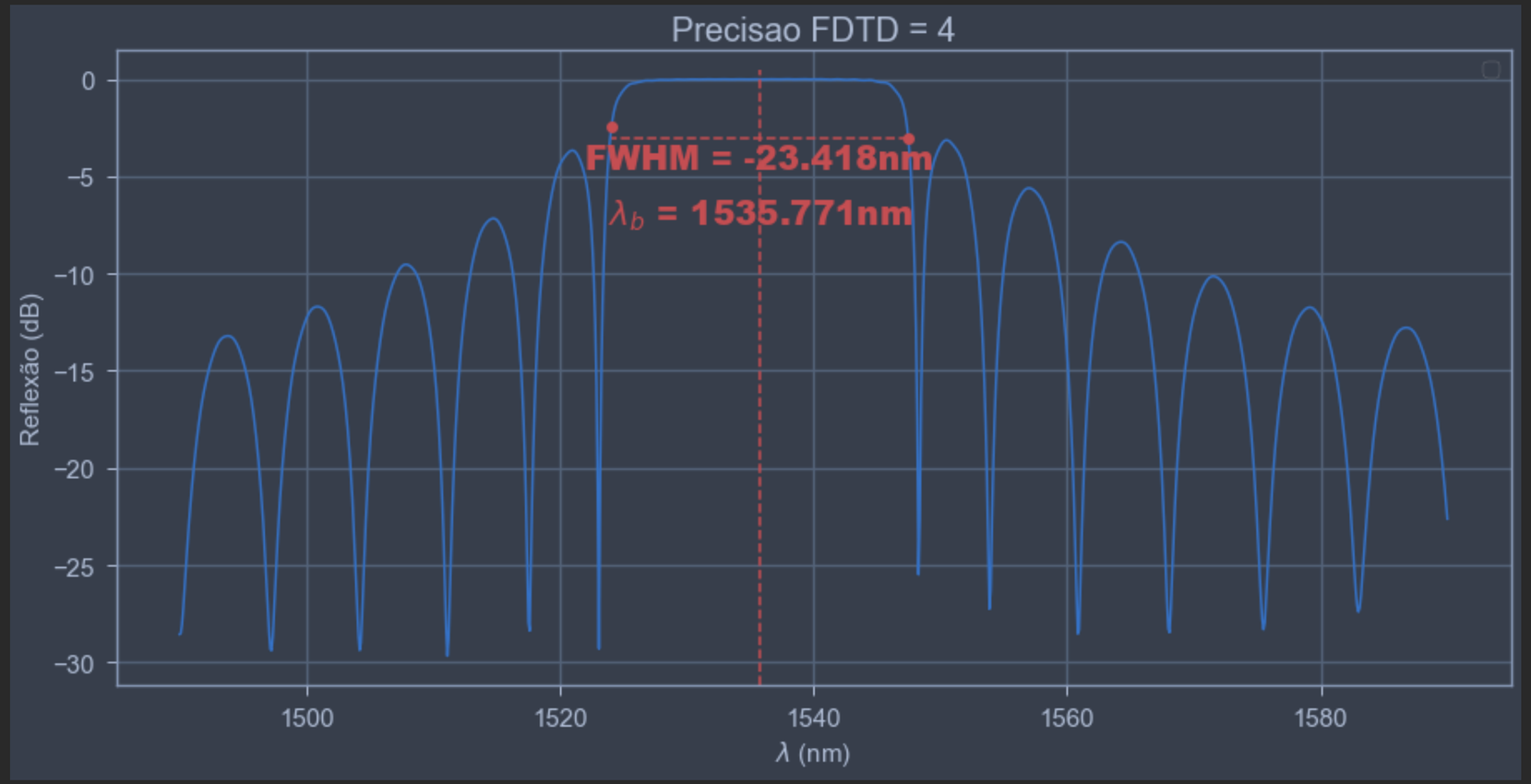
DESIGN

Resultados



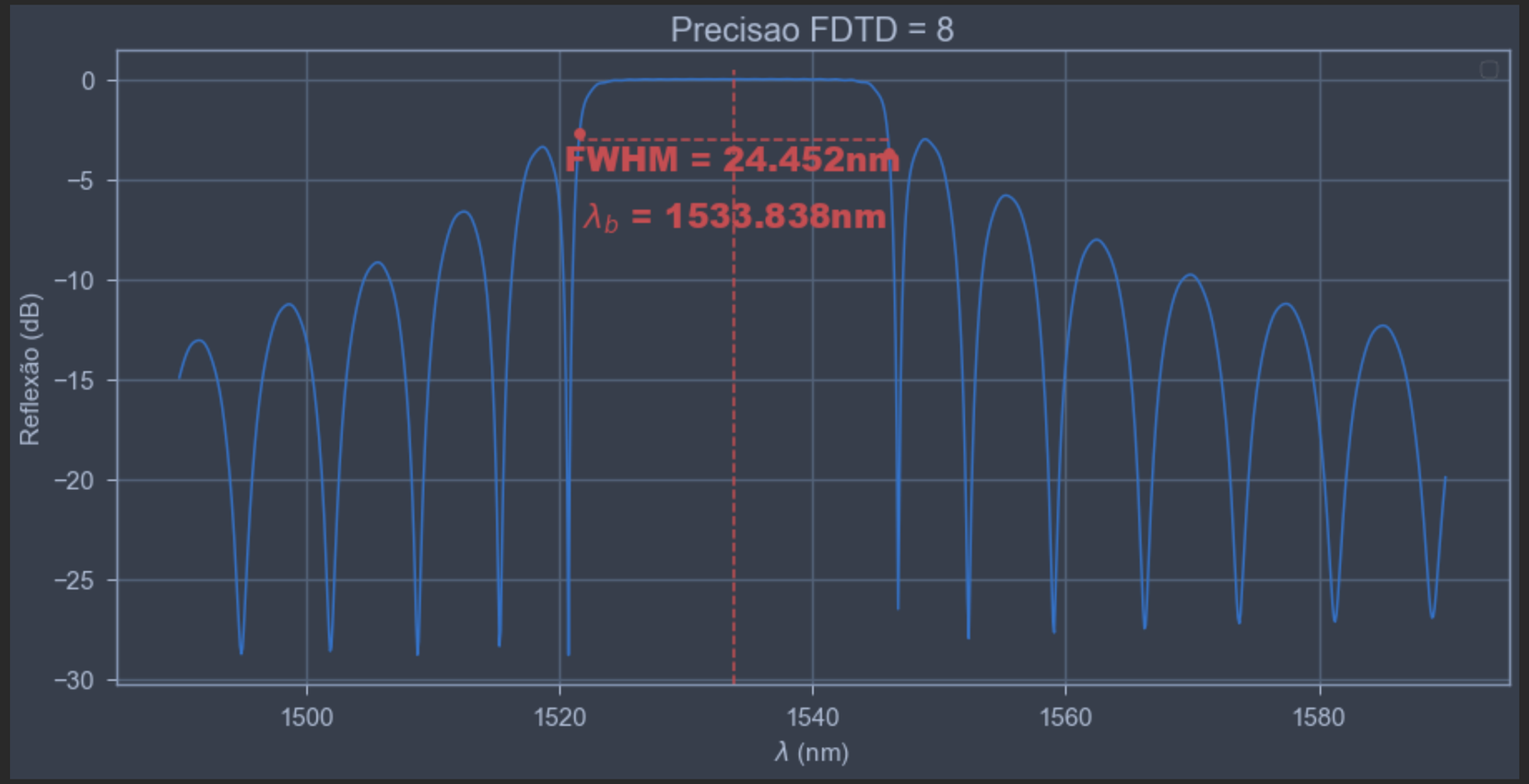
DESIGN

Resultados



DESIGN

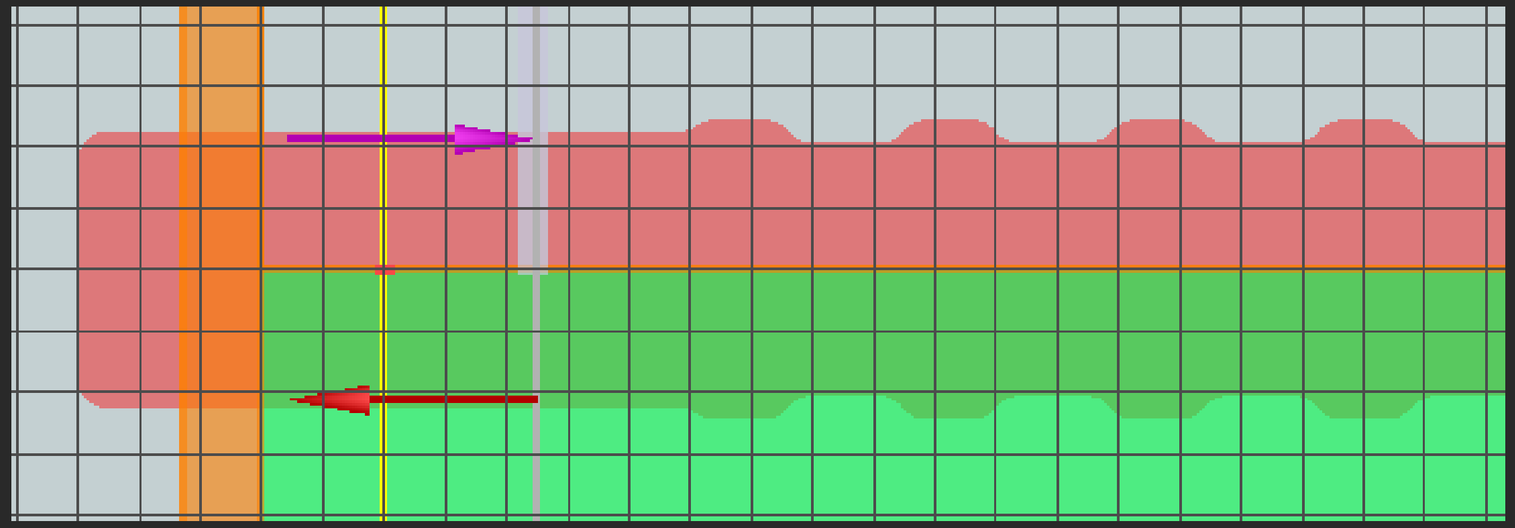
Resultados



DESIGN

Aplicando o filtro de litografia

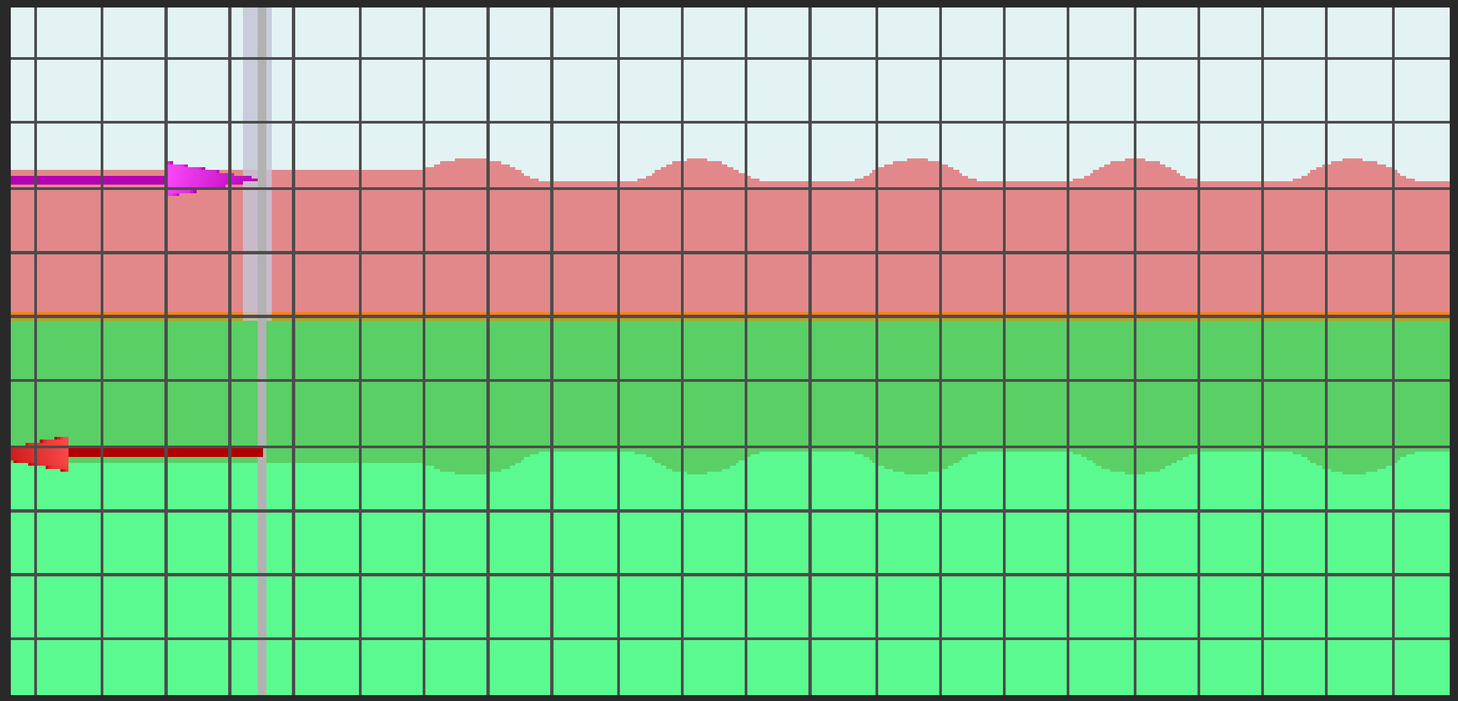
node size = 45nm



DESIGN

Aplicando o filtro de litografia

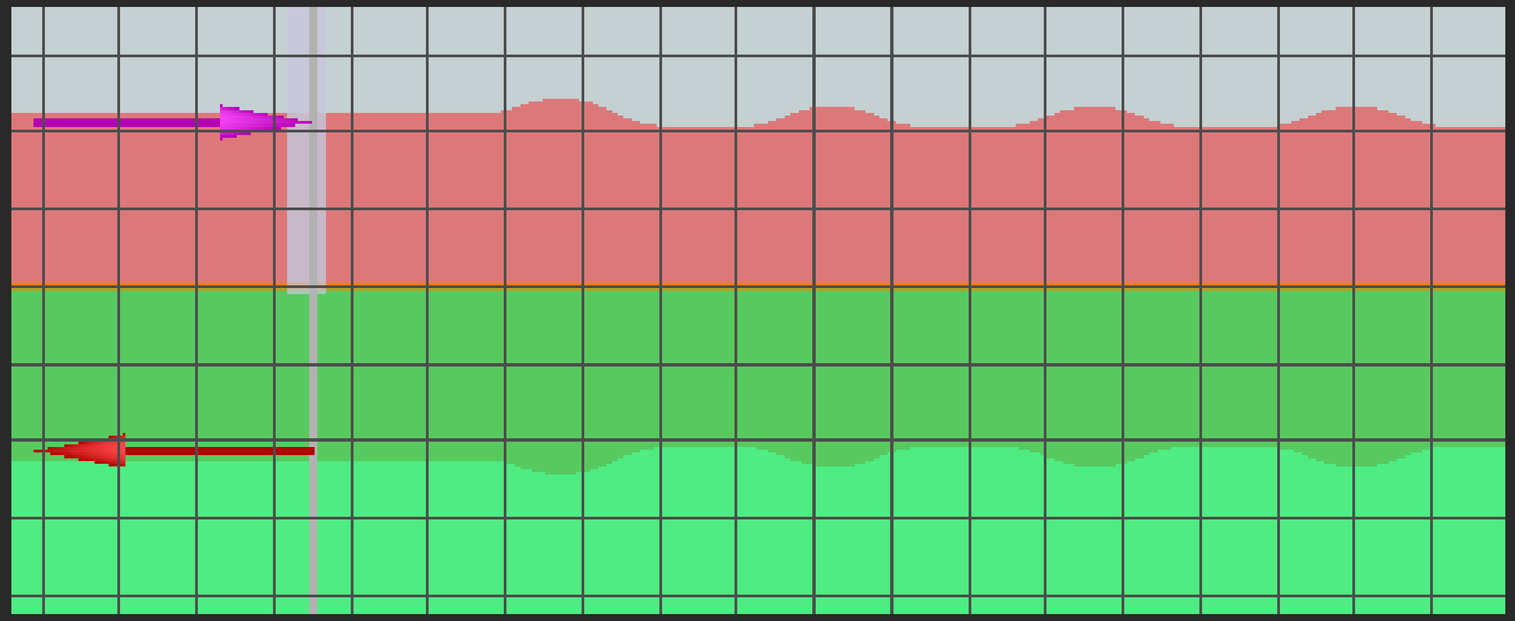
node size = 100 nm



DESIGN

Aplicando o filtro de litografia

node size = 150nm



DESIGN

Resultado do filtro de litografia

node size = 100 nm