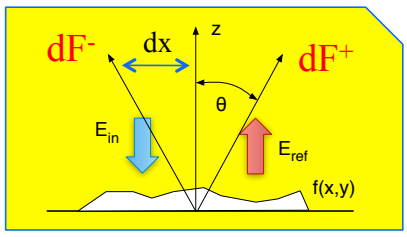
Effects of small size anomalies in a FP cavity

- Scattering loss by tiny aberrations using near field calculation
- Small defects in a FP cavity
  - » Localized loss
  - » Localized bump
- Heating of small area
- T1000154

Scattering loss by tiny aberrations

$$E_{ref} = E^0_{ref}\exp(i\omega t - ikz)\cdot\exp(2ikf(x,y))$$
$$= E^0_{ref}\exp(i\omega t - ikz)(1 + i2kf - 2(kf)^2)$$
$$= E^0_{ref}\exp(i\omega t - ikz)(1 - 2(kf)^2) + E^0_{ref}\exp(i\omega t - ikz)i2kf$$

dF



$$f(x,y) = \sum_{nx,ny} a_{nx,ny}\sin(n_x\omega_x x + n_y\omega_y y + \varphi_{nx,ny})$$

$$dF = E^0_{ref}k\sum_{nx,ny} a_{nx,ny}(\exp(i\Phi^+_{nxny}) - \exp(i\Phi^-_{nxny}))$$

$$\Phi^0 = \omega t - kz$$

$$\Phi^{\pm}_{nxny} \equiv \Phi^0 \pm (n_x\omega_x x + n_y\omega_y y + \varphi_{nx,ny})$$

Small size aberration

lossy area

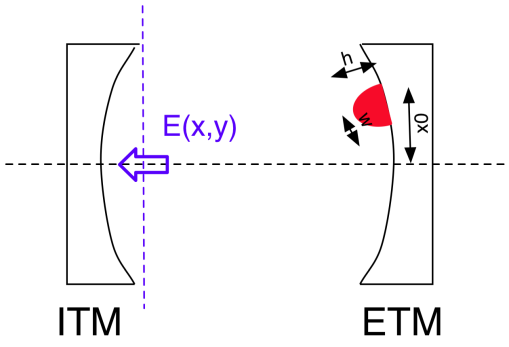
$$dP = \iint dx\,dy\left|E^0_{ref}\right|^2 4k^2f^2$$
$$\approx P^0_{ref}4k^2\iint dx\,dy f^2$$
$$= P^0_{ref}4k^2\sigma^2 S$$
$$= P^0_{ref}\left(\frac{4\pi\sigma}{\lambda}\right)^2 S$$

$$\theta \sim n\sqrt{\omega_x^2 + \omega_y^2}\,/\,k \sim n\cdot\lambda/a \quad (a \text{ is typical spacial size})$$

$$dx = L_{cav}\cdot\theta \sim L_{cav}\cdot\lambda/a = 4/a(mm)\ m$$

$$\sigma^2 = \frac{\iint dx\,dy f^2}{S}$$

Small defects in a FP cavity

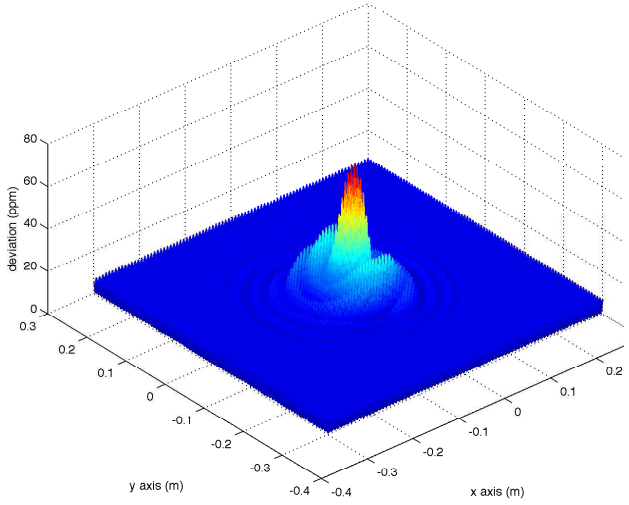


Small area loss or shape anomaly

$$d(x,y) = h \cdot \exp(-\frac{(x-x_0)^2 + y^2}{w^2}) : \sqrt{(x-x_0)^2 + y^2} < 2w$$
$$= 0 : \sqrt{(x-x_0)^2 + y^2} > 2w$$

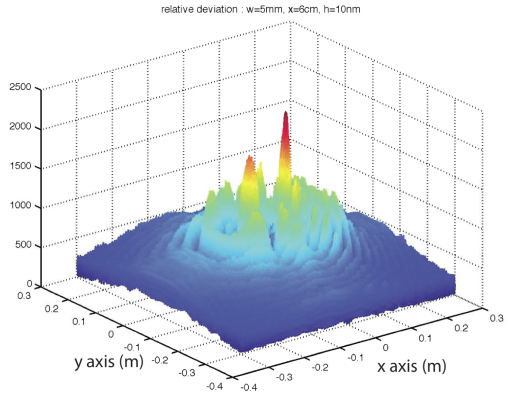
$$\delta(x,y) \equiv \frac{E(x,y)}{E(0,0)} - \frac{E_0(x,y)}{E_0(0,0)}$$

Small lossy area in a FP cavity



- W=2mm, x0=2cm
- Loss ~$(4\pi\sigma/\lambda)^2$
- Weak dependence on w
- Ripple spreads out
- Spatial wavelength of the ripple is determined by x0

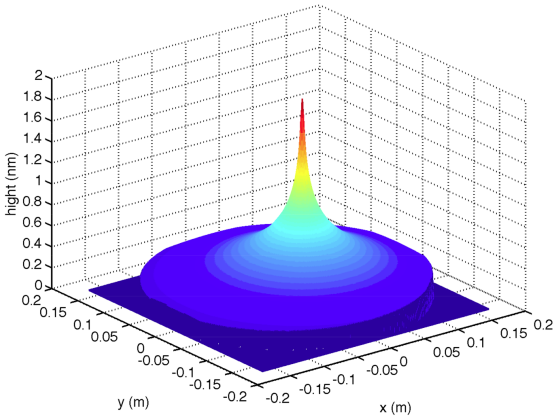
Small area bump in a FP cavity



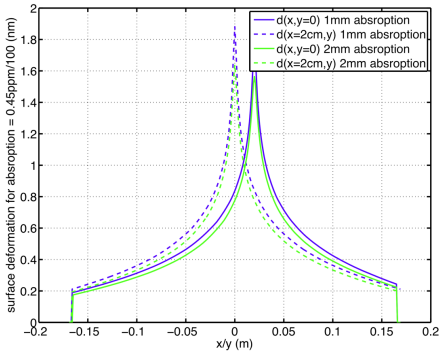
- W=5mm, x0=6cm, h=10nm
- Loss(w=5mm) ~0.7ppm h^2
- Loss(w=1mm) ~0.04ppm h^2
- Ripple spreads out
- Spatial wavelength of the ripple is determined by x0

Heating of small area

Muzammil hearted surface using laser with size of 0.5, 1, 2mm at 2cm away from the center

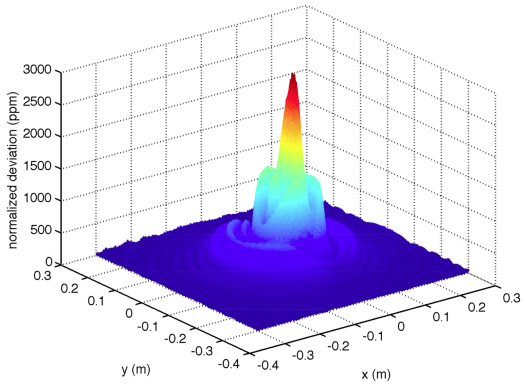


Surface deformation with 1mm size beam, 0.425W/100 absorption

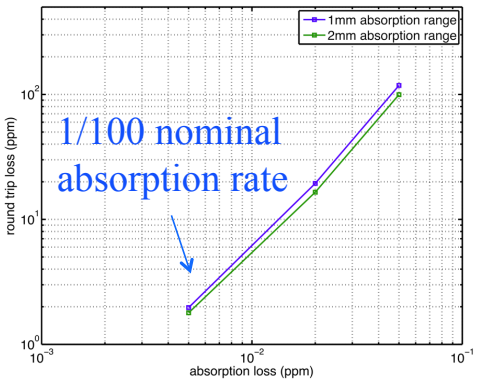


Surface deformation with 1and 2 mm size beam, 0.425W/100 absorption

Loss by small area heating



Field deformation with 1mm size beam, 0.425W/100 absorption



Round trip loss vs absorption rate

$$\begin{aligned} &absorbed\ \ power \\ &= local\ \ absorption\ \ rate \times area \times power\ \ density \\ &= (local\ \ absorption\ \ rate \times \frac{area}{beam\ \ size^2})(beam\ \ size^2 \times power\ \ density) \\ &\sim (local\ \ absorption\ \ rate \times 10^{-4})(beam\ \ size^2 \times power\ \ density) \end{aligned}$$