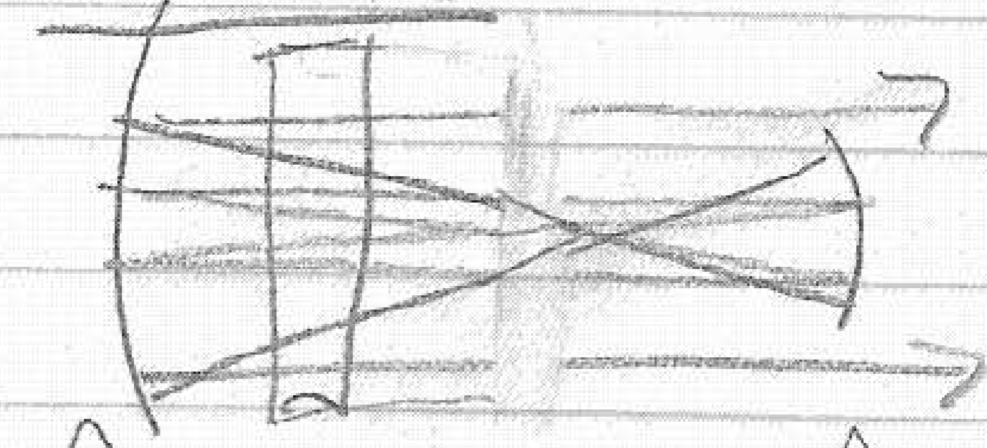
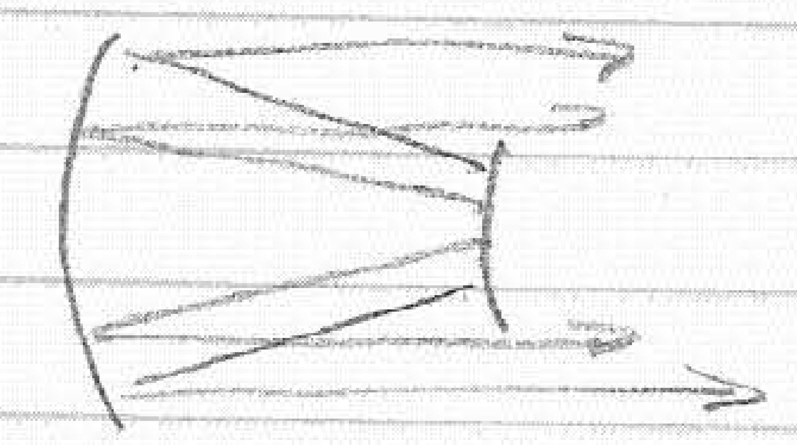
Unstable resonators
- purpose: high gain, large mode volume
- diffraction losses are often used as the output coupling

confocal:



"negative branch"
intermediate focus



"positive branch"

confocal design → plane wave output
- magnification: $f_2/f_1 = M$
- loss/output coupling: $L = \frac{A_2 - A_1}{A_2} = 1 - \frac{A_1}{A_2}$

$$A_2 = M^2 A_1 \rightarrow L = 1 - 1/M^2$$

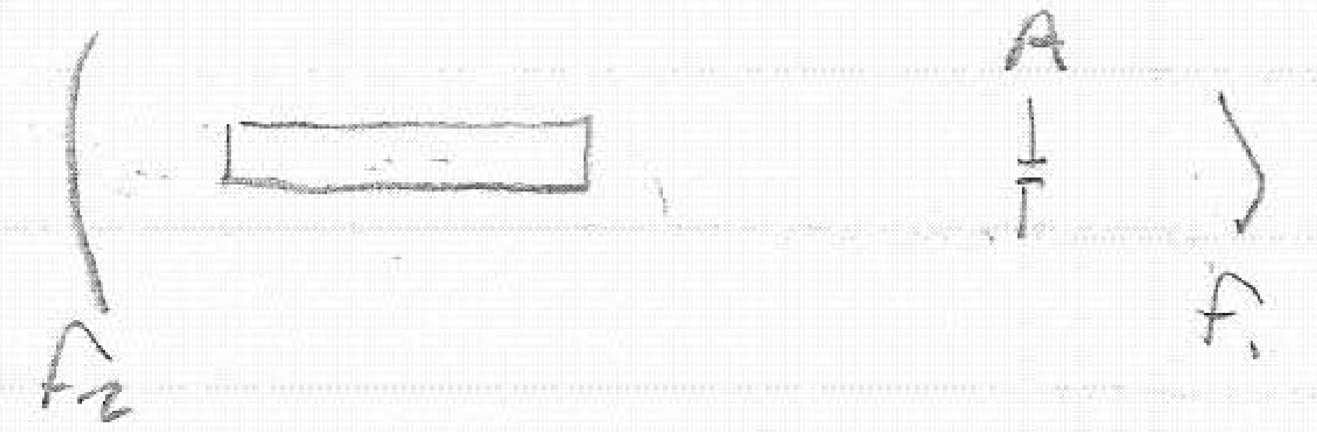
- this geometric limit over-estimates the loss
  - actual mode develops around aperture.
- output beam w/ central hole.
  - can still be focused reasonably well

Variable reflectivity mirrors:
output coupler has a radial reflectivity profile to shape output beam
- easier to fill larger mode volume
- can get super-gaussian / flattop output

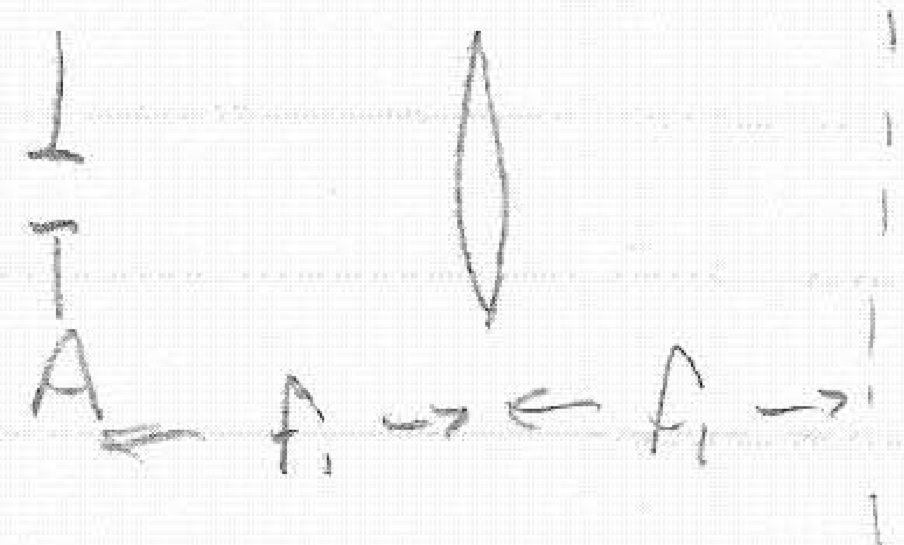
often used in Q-switched Nd:YAG lasers.

Self-filtering unstable resonator — ref Gobbi, Opt Comm 52, 195 (1984)

- negative branch, confocal



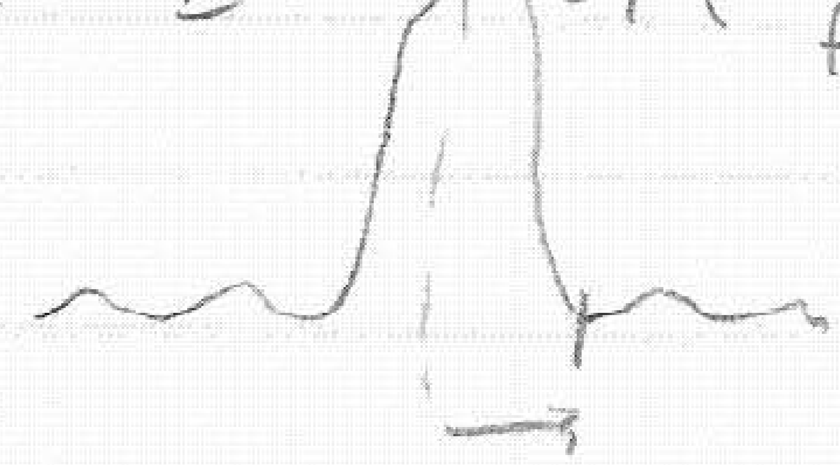
1) collimated beam headed toward M_1
2) clipping of beam on aperture A
   → diffraction; Airy disk pattern
3) M_1 refocuses beam:



↳ Fourier plane $E \propto \mathcal{F}\{circ(\frac{r}{a})\}$

at focal plane,

→ $E \sim J_1(\frac{ka}{f_1} r) \big/ (\frac{ka}{f_1} r)$ w/ 1st zero at $r = 1.22 \frac{f\lambda}{2a}$



4) choose aperture size so that

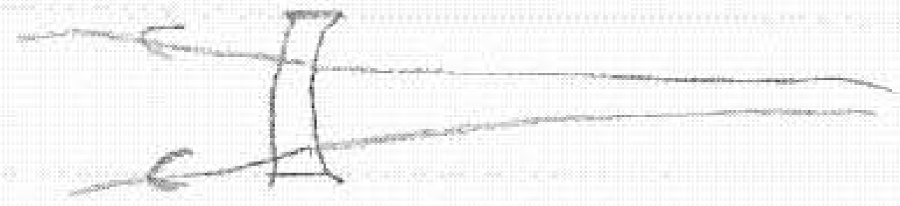
$a = 1.22 \frac{f\lambda}{2a}$ 84% of energy passes thru

this way, the aperture passes only the central maximum
- no (or very little) diffraction rings b/c clipping is at $E = 0$
- still some, since central max of $J_1(\,)$ isn't $\doteq$ gaussian.

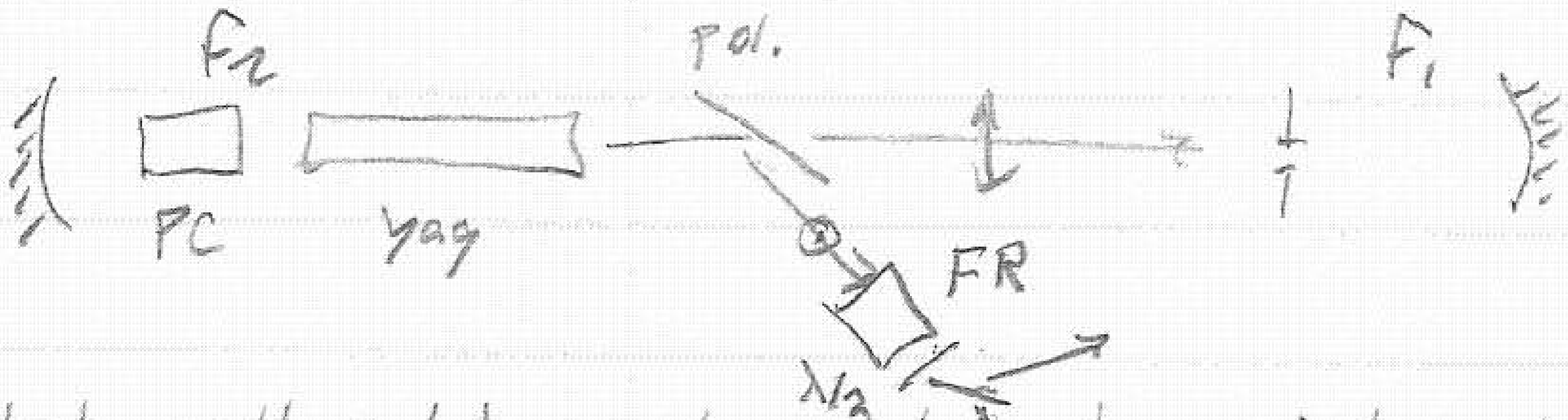
5) recollimate with M_2. magnification $= \frac{f_2}{f_1}$ controls r.t. loss

roundtrip transm ~30% at M = 3 ∴ high gain output coupling:

- partial reflecting M_2



- cavity dump:



pockels cell rotates polarization to eject pulse.

- regenerative amplifier.
  - > inject pulse through Faraday isolator