Single-frequency, TEM_{00}-mode Nd:YLF laser with image - rotation resonator

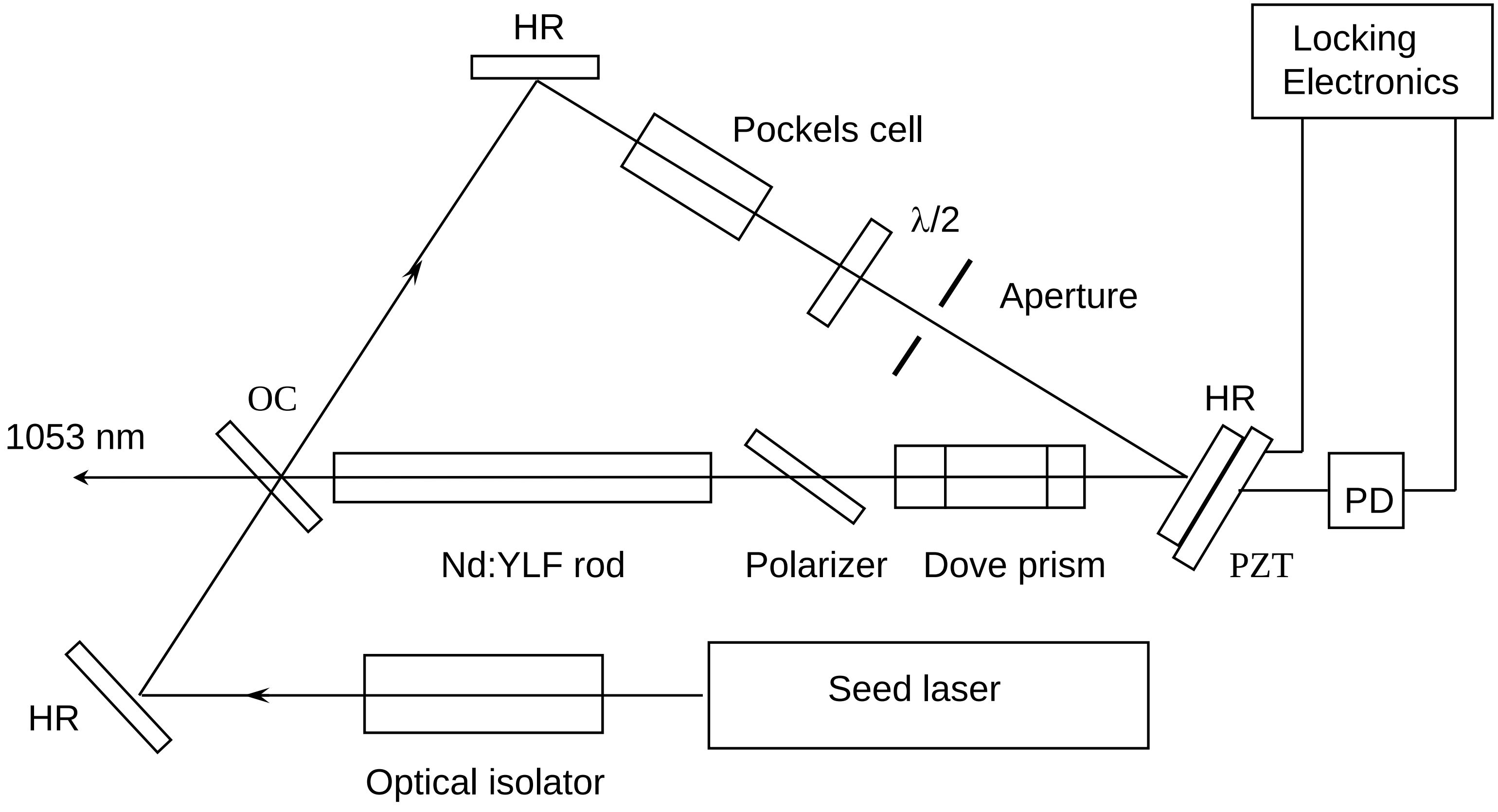
Yelena Isyanova, John H. Flint, and Peter F. Moulton

Q-Peak, Inc.,
135 South Road, Bedford, MA 01730

Outline

- Image-Rotation (IR) resonator setup
- Injection-locking technique based on a pulse buildup time control
- Alignment sensitivity of IR resonators
- Polarization losses of IR resonators
- Transverse mode selection in IR resonators
- 90^0 -IR, N=3 Laser performance
- Summary

Q-switched Nd:YLF ring laser with image rotation and injection locking



Oscilloscope traces of the HV- and laser pulses

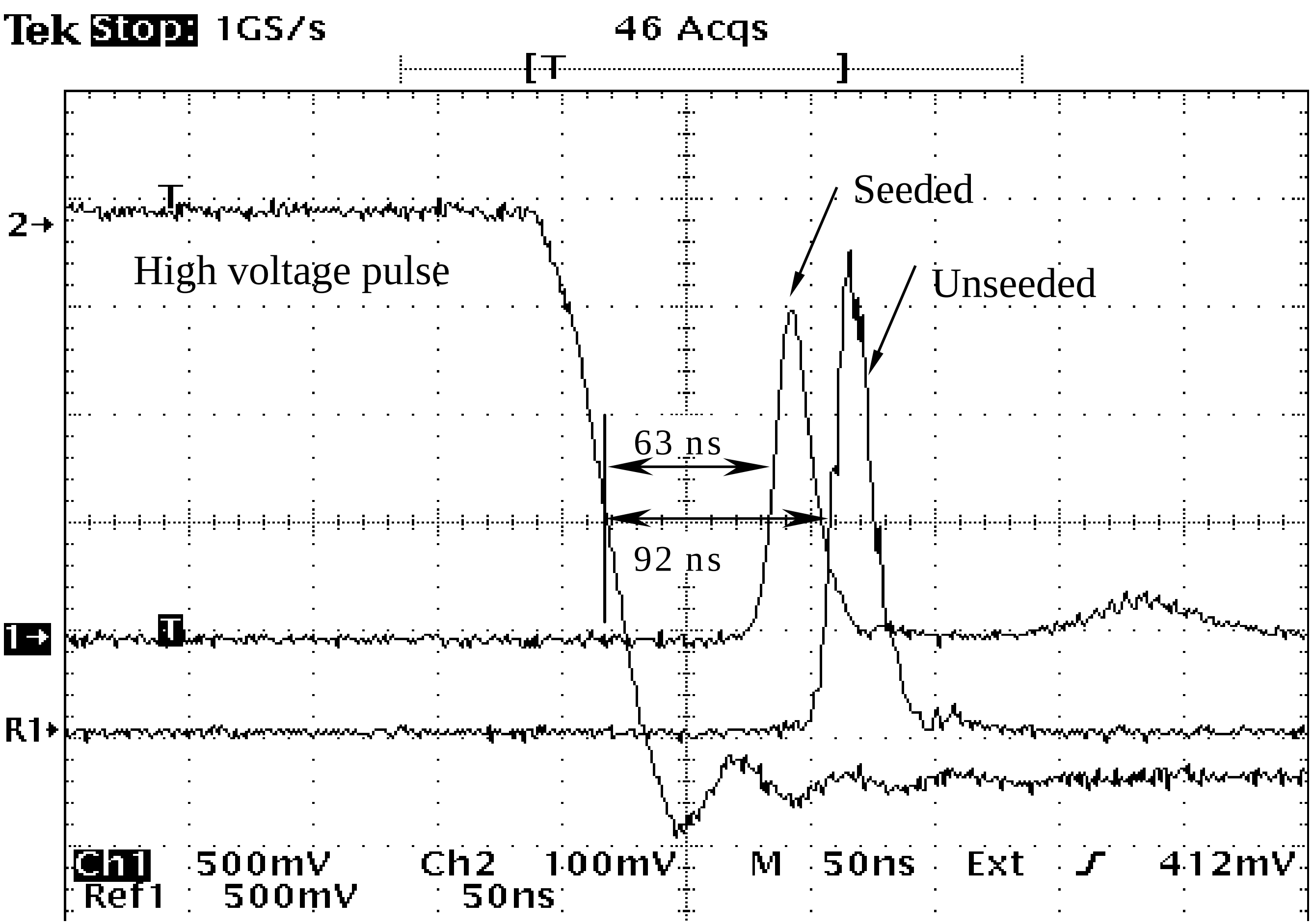


Image Inversion and Rotation in Ring Resonators

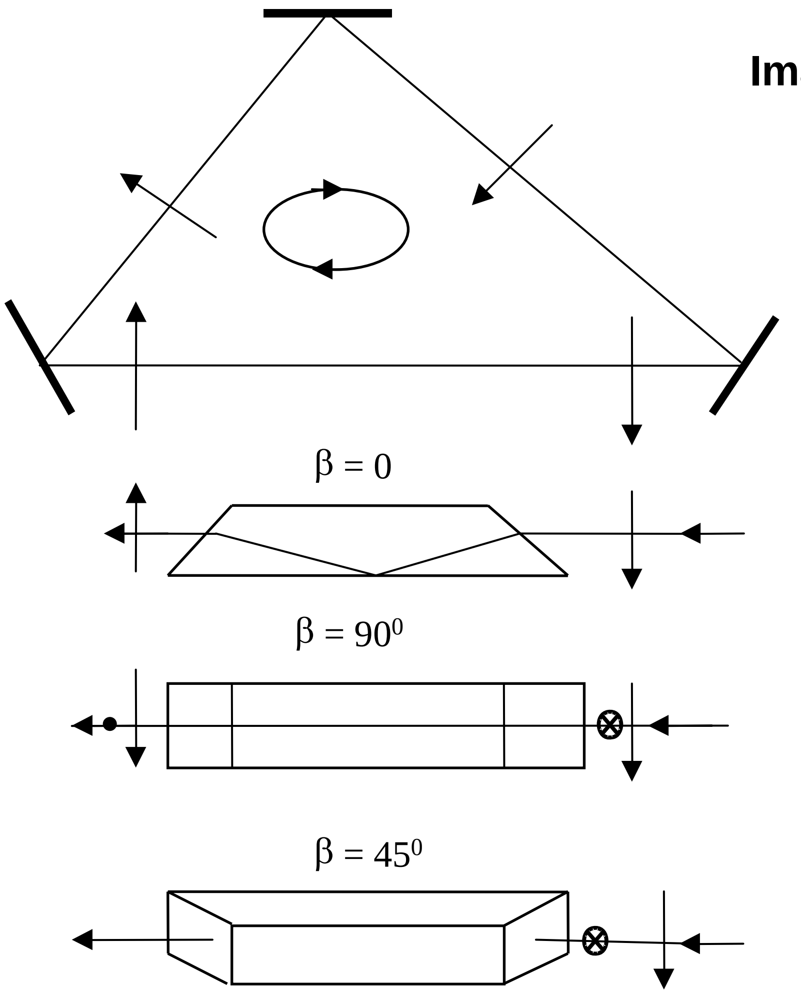
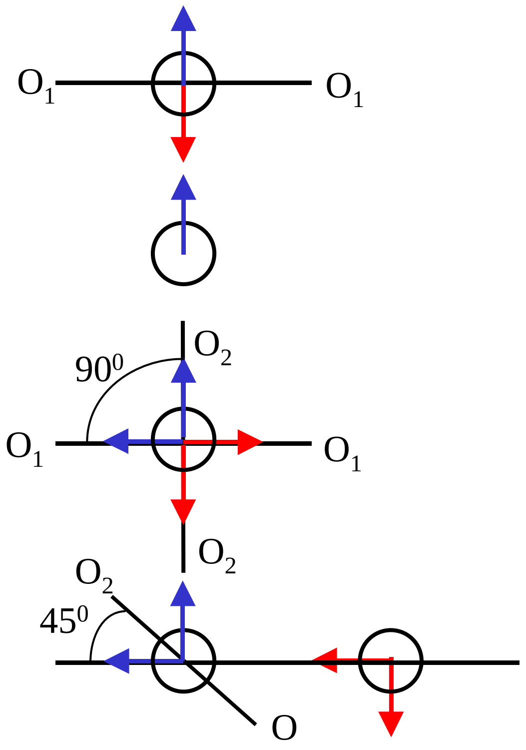


Image rotation angle, Ω, is twice the angle between inversion axes, i. e.

$$\Omega = 2\,\beta$$



Alignment Sensitivity of the Image Rotation Resonators

$x_0 = -L\,\varphi_x / (1 - \cos\Omega)$ $\alpha_{x0} = -\varphi_x - \varphi_y \sin\Omega/2\,(1 - \cos\Omega)$

$y_0 = -L\,\varphi_y / 2\,(1 - \cos\Omega)$ $\alpha_{y0} = \varphi_x \sin\Omega / (1 - \cos\Omega) - \varphi_y / 2$

$x_0, y_0, \alpha_{x0}, \alpha_{y0}$ - coordinates of the axis of the misaligned resonator

$\Omega = 180^0$

$x_0 = -L\,\varphi_x / 2$

$\alpha_{x0} = -\varphi_x$

$\Omega = 90^0$

$x_0 = -L\,\varphi_x$

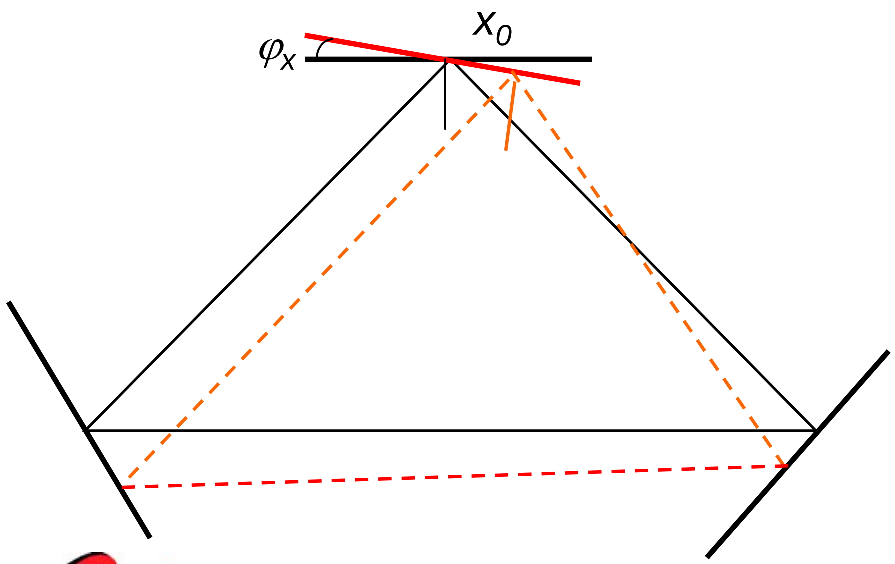
$\alpha_{x0} = -\varphi_x$

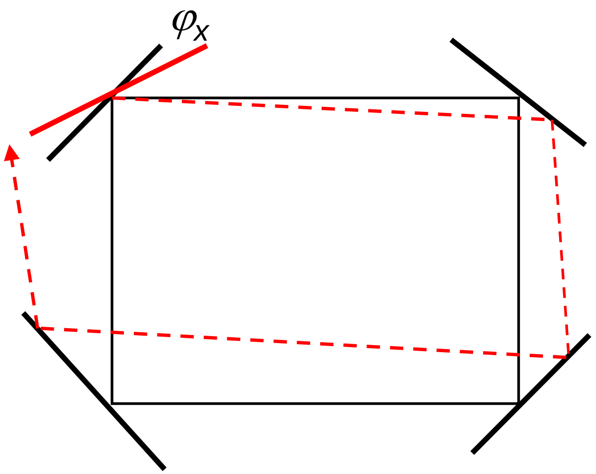
$\alpha_{y0} = \varphi_x$

$\Omega = 0$

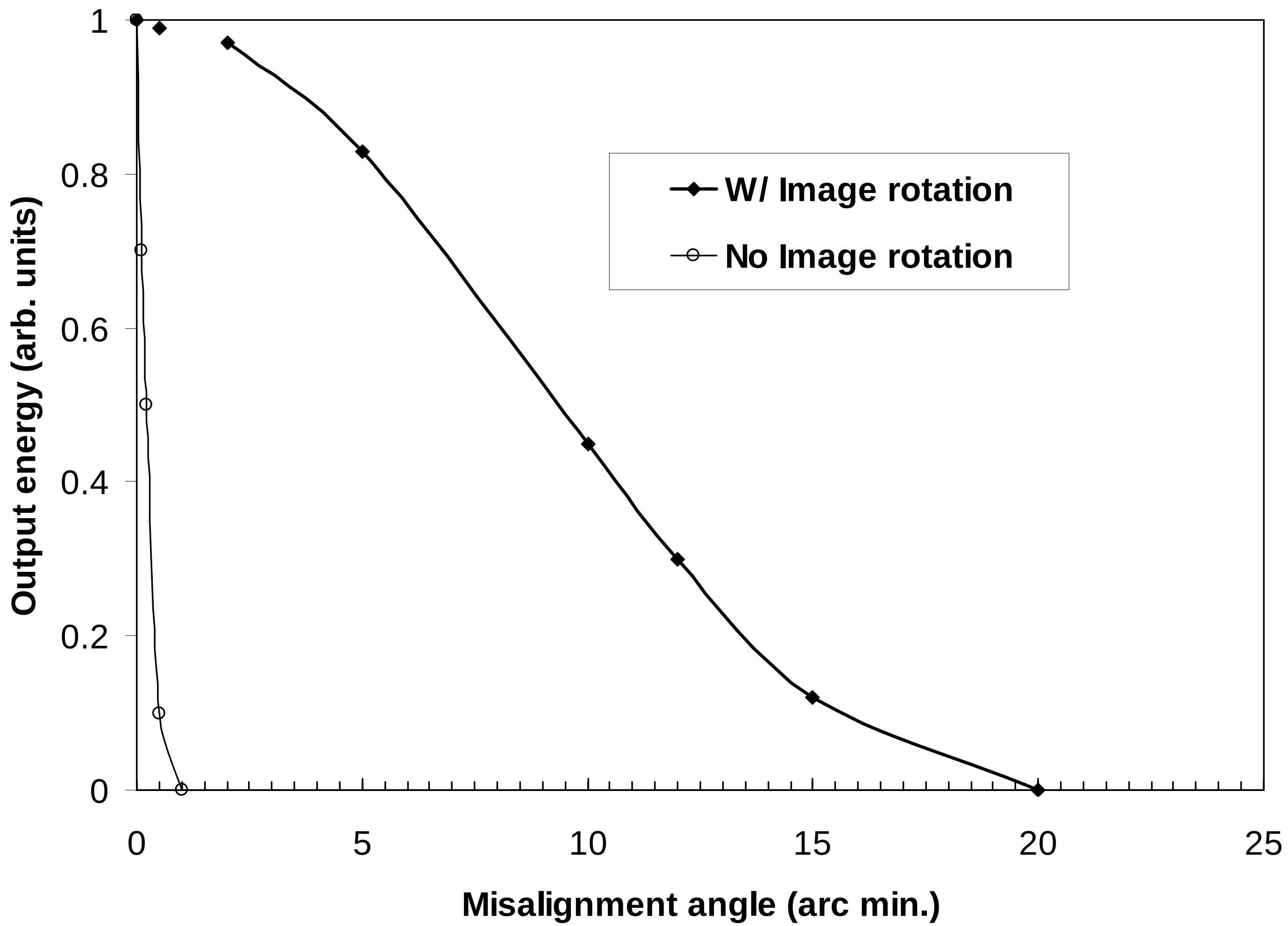
$x_0 = \infty$

$\alpha_{x0} = -\varphi_x$

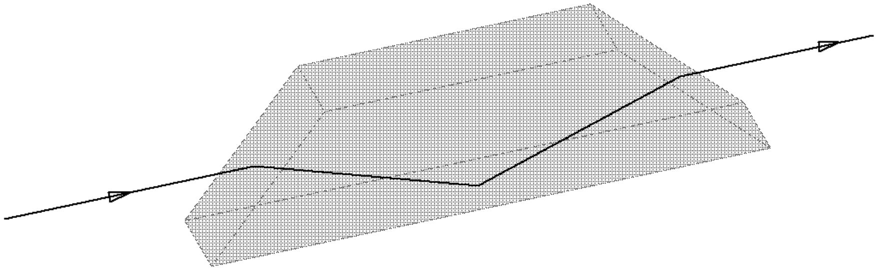


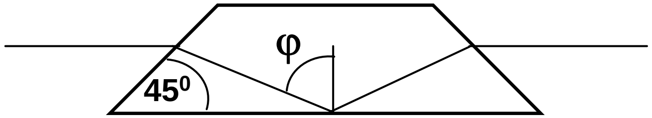


Misalignment Tolerance of Different Resonators



Polarization Properties of IR-Resonators





Transformation of polarization caused by a Dove prism :

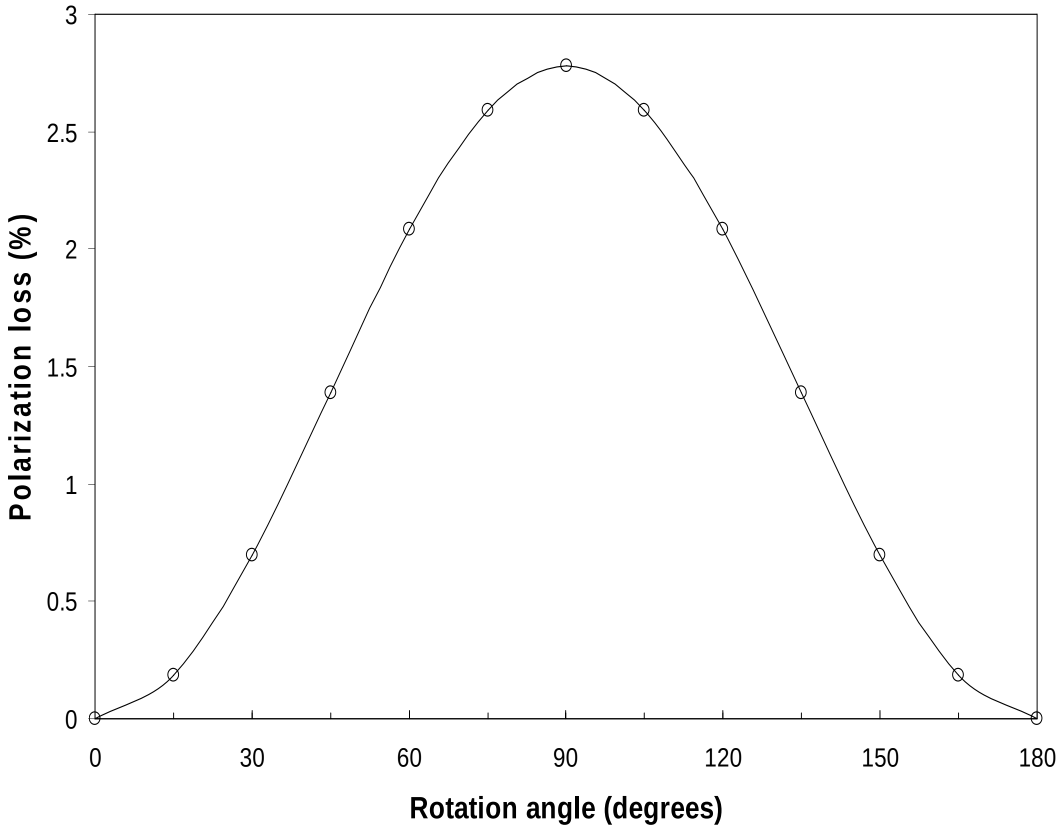
M(-β) M(δ) M(+β), ***where***

$$\tan(\delta/2) = \sqrt{\sin^2\varphi - n^{-2}} \, / \sin^2\varphi$$

$$M(\beta) = \begin{bmatrix} \cos\beta & \pm\sin\beta \\ \mp\sin\beta & \cos\beta \end{bmatrix}, \quad M(\delta) = \begin{bmatrix} e^{(i\delta/2)} & 0 \\ 0 & e^{(-i\delta/2)} \end{bmatrix} \quad J_D = \begin{bmatrix} (1-e^{-i\delta})\cos\beta\sin\beta \\ \sin^2\beta + e^{-i\delta}\cos^2\beta \end{bmatrix}$$

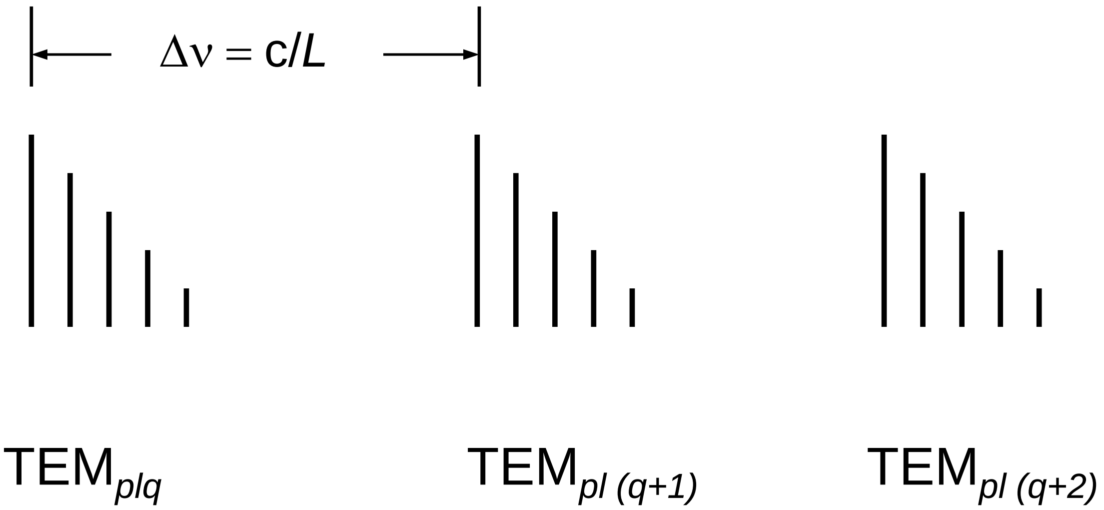
Polarization Losses of the IR Resonators

$$\gamma = \cos^2(\delta/2) - \sin^2(\delta/2)\cos^2(2\beta)$$



Transverse mode frequencies in ring stable gaussian resonators

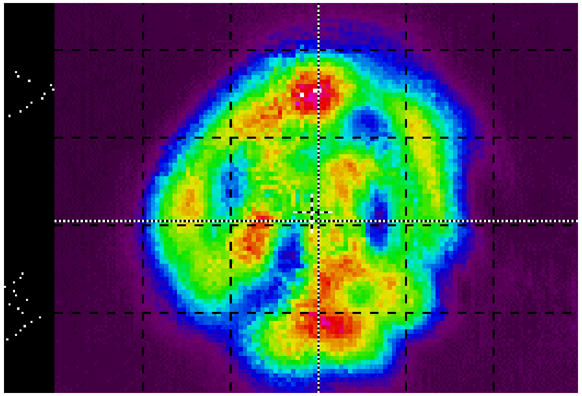
$$\Delta \nu = \left(\frac{c}{L} \right) \left[\Delta q + \Delta(2p + l)\, arc\cos(1 - \frac{L}{R}) \right]$$



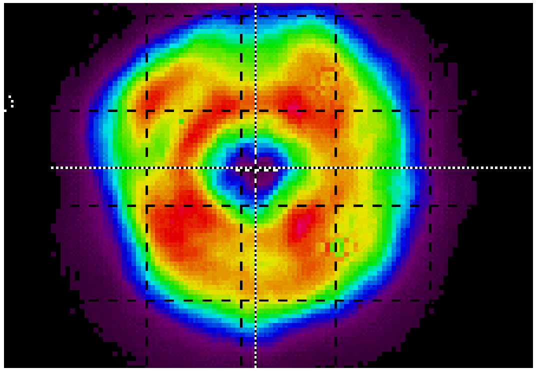
Transverse modes with odd function distribution undergo additional π or c/2*L* frequency shift in odd-number-mirror resonators

Near-Field Beam Profiles of the Ring Resonators (1)

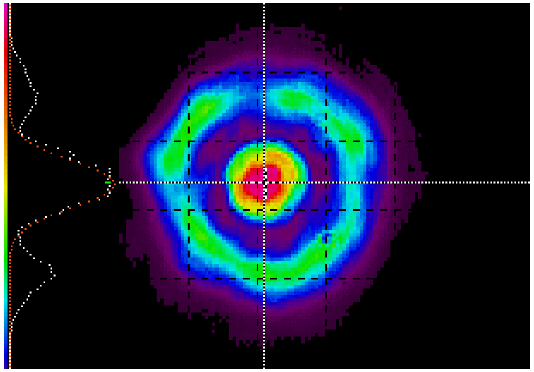
no IR
N=7



90^0- IR
N=7
w/seeding

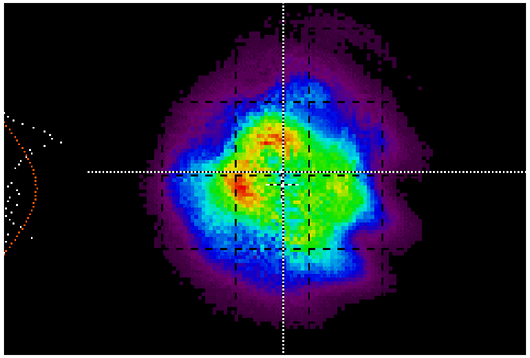


90^0- IR
N=7
w/seeding

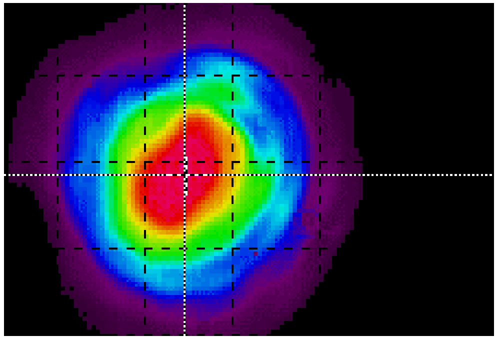


Near-Field Beam Profiles of the Ring Resonators (2)

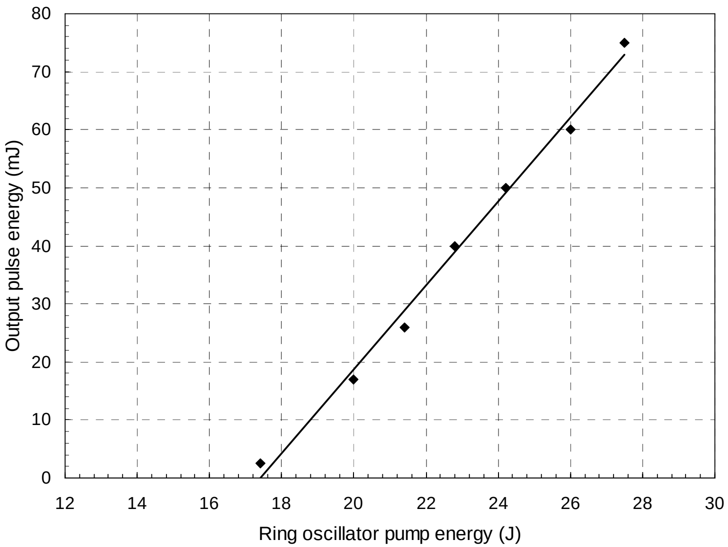
no IR
N=3

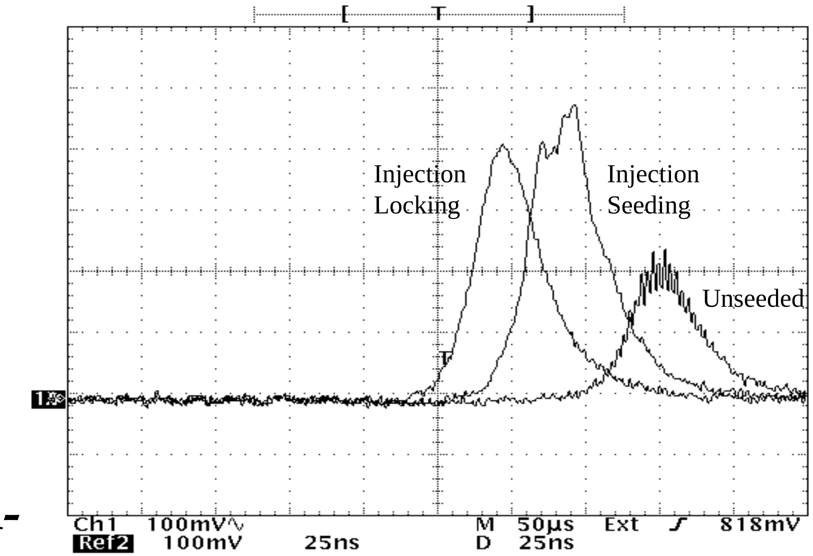


90^0- IR
N=3
w/seeding



90^0 -IR, N=3 Ring Laser Performance





- Up To 75 mJ output pulse energy
- Single-frequency, near diffraction-limited beam
- M^2 = 1.33, 1.24
- 10-30 Hz Repetition Rate

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