DESIGN OF COMPACT PULSED 4 MIRROR LASER WIRE SYSTEM FOR QUICK MEASUREMENT OF ELECTRON BEAM PROFILE

PRESENTED BY-

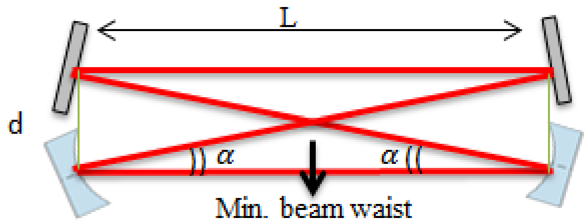
ARPIT RAWANKAR

THE GRADUATE UNIVERSITY FOR ADVANCED STUDIES, HAYAMA

INDEX

1. ***Concept of Aspect ratio***
2. ***Selection of design values***
3. ***Scheme to obtain small beam size***
4. ***Results of compact resonator***
5. ***Mirror alignment scheme in Vacuum***
6. ***Merits of Compact Resonator.***

INTRODUCTION



Aim: To obtain, minimum beam waist in one plane (sagittal plane)
$\boldsymbol{\sigma \leq 6\mu m}$ **(***using green Laser oscillator, 532 nm***)**

In present optical bench set up, we use IR (1064 nm) Laser oscillator

We define term, Aspect ratio as ratio of mirror separation between adjacent plane and concave mirror to length of resonator

$$R\ (Sagittal) = R/\cos\alpha/2$$

$$R(Tangential) = R * \cos\alpha/2$$

Aspect ratio

$$\boldsymbol{\alpha = tan^{-1}\frac{d}{L}}$$

Present Laser Wire System in ATF damping ring is 2 mirror CW green laser wire system

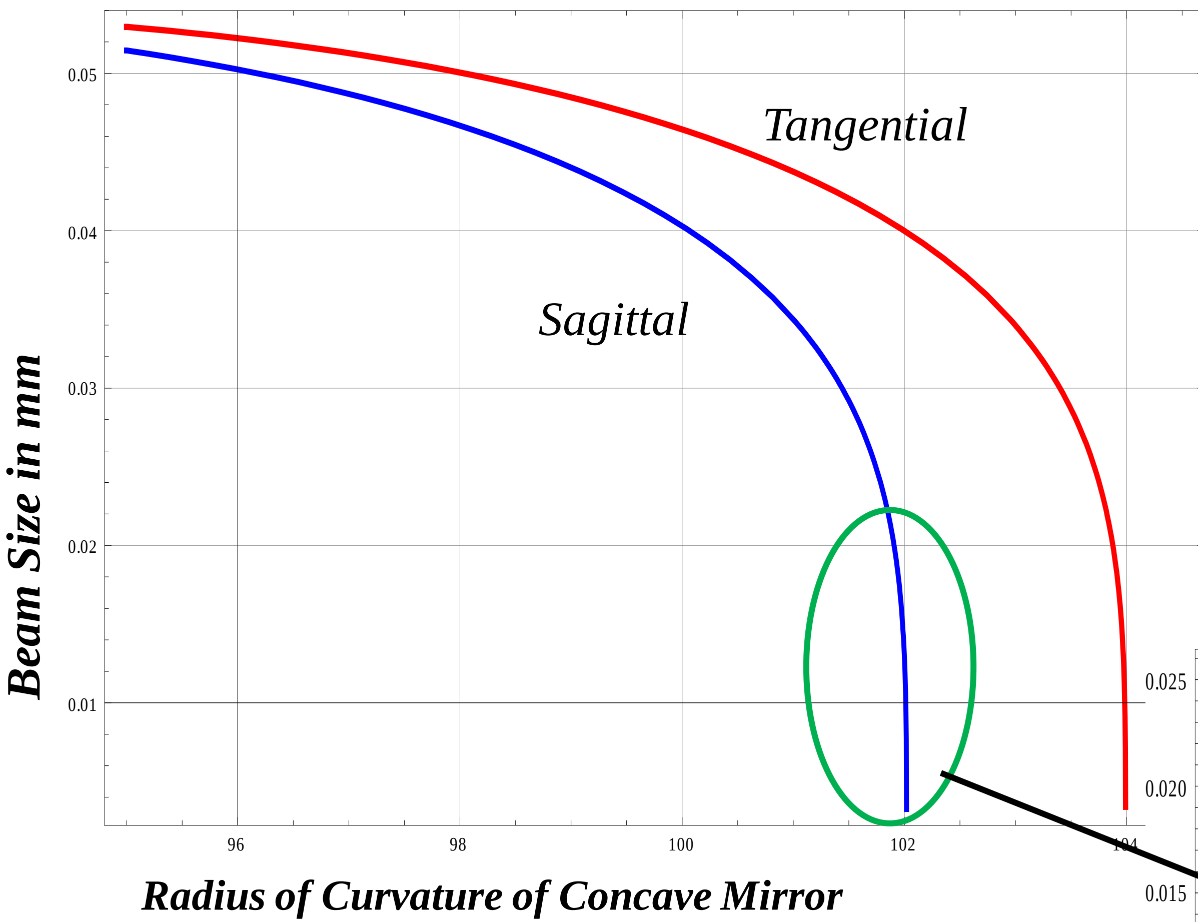
ASPECT RATIO AND MINIMUM BEAM WAIST

Length L (mm)	**412**	**206**	**103**
Distance d (mm)	**116**	**58**	**29**
Curvature ρ (mm)	**408**	**204**	**102**
Total path length (Lcav.) mm	**1680**	**840**	**420**
Aspect ratio (α) rad	**0.2745**	**0.2745**	**0.2745**
Min. beam waist (ω_S, ω_T)	**(30,80)um**	**(21,57)um**	**(14,40)um**

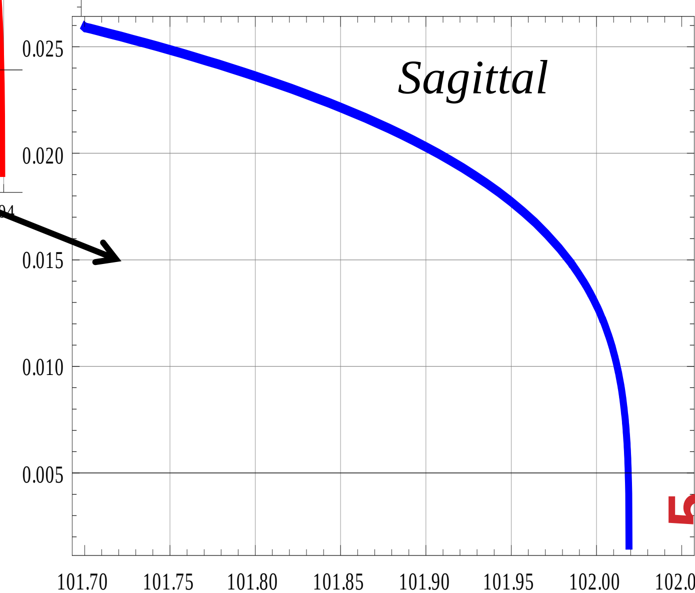
If we fix aspect ratio of resonator, and scale down the long length resonator,

we approach towards smaller minimum beam waist

SELECTION OF CURVATURE

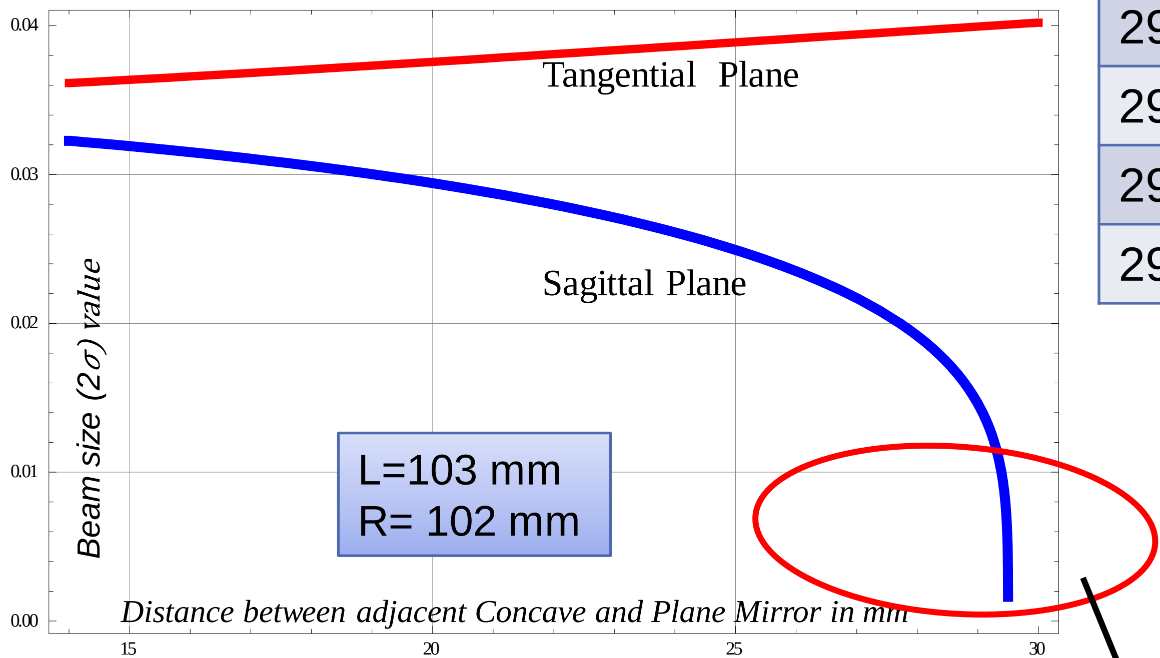


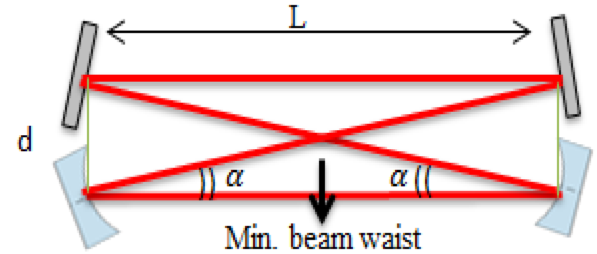
R (mm)	(2σ), IR Laser
102	(12.8, 40) um
102.01	(10.6, 39.9) um



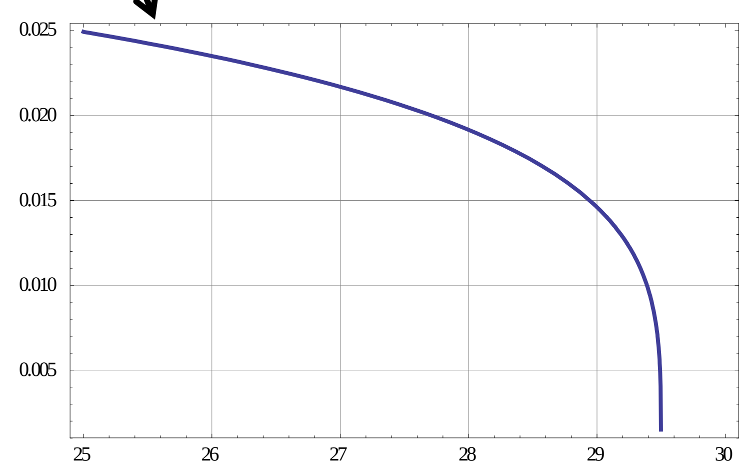
BEAM SIZE VARIATION w.r.t. “d"

“d” mm	(σ_S,σ_T) value, IR Laser
29	(7.3, 20) um
29.1	(6.91,20) um
29.2	(6.43, 20) um
29.3	(5.81,20) um

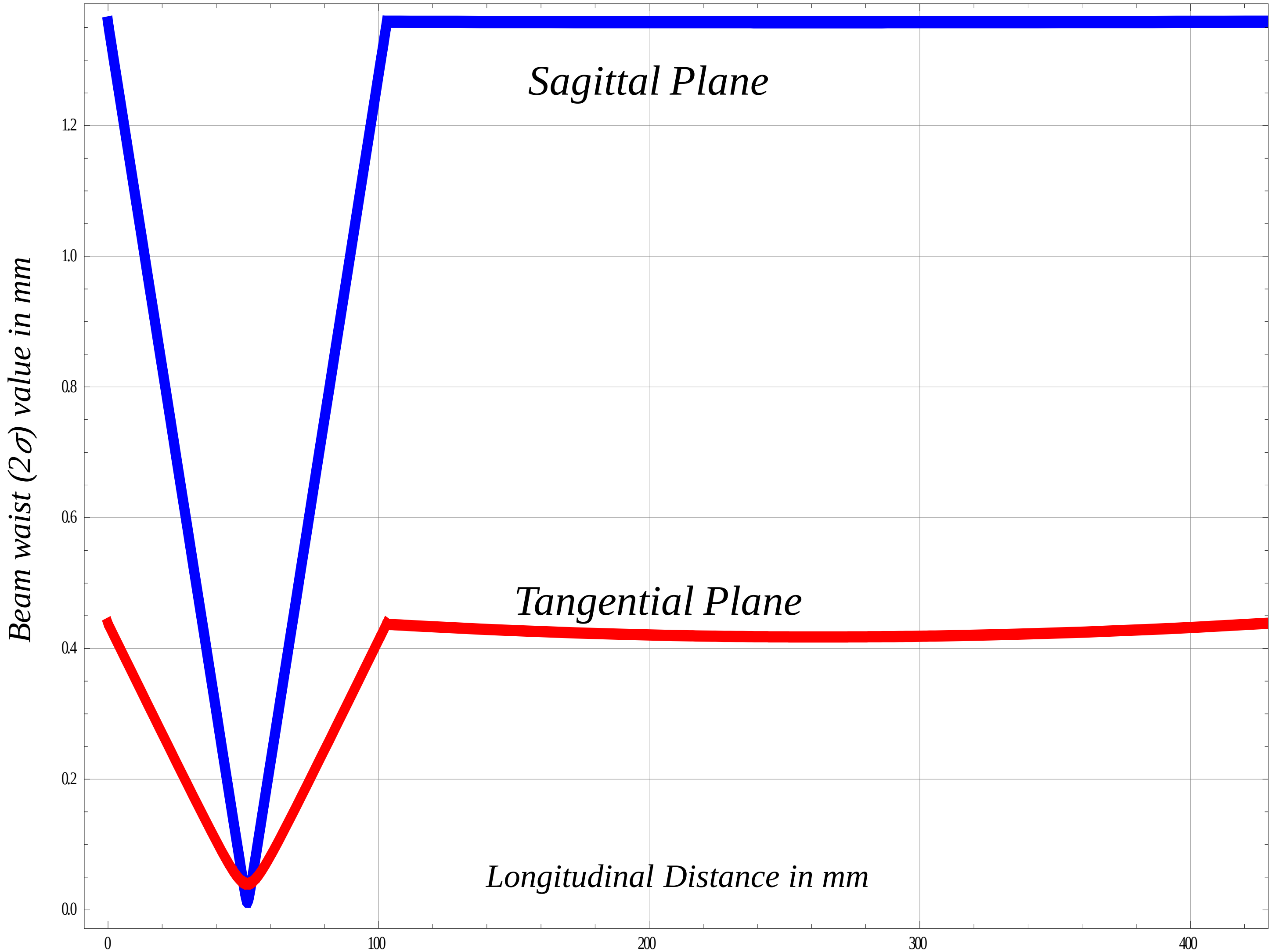




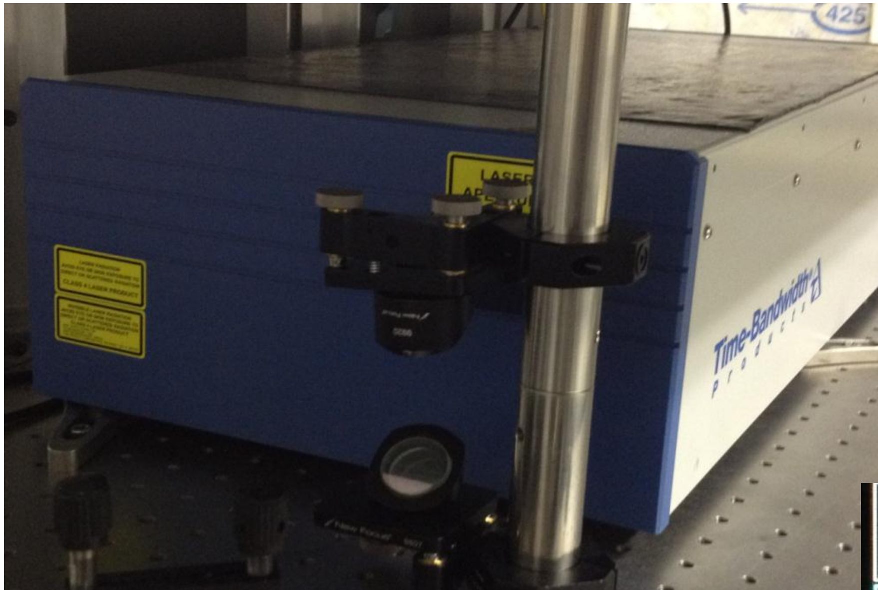
Curvature “R” mm	(σ_S,σ_T) value, IR Laser
102	(6.43, 20) um
102.01	(5.33,20) um
101.9	(10.15, 20.2) um
101.5	(14.4,21) um



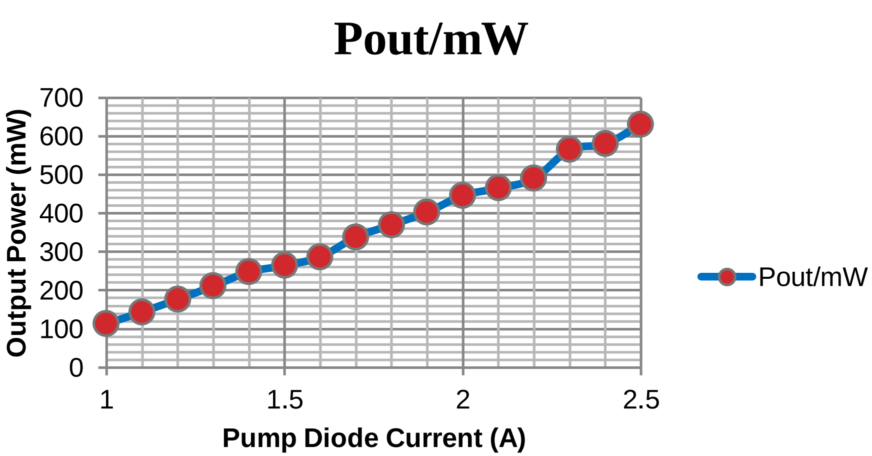
BEAM EVOLUTION INSIDE RESONATOR

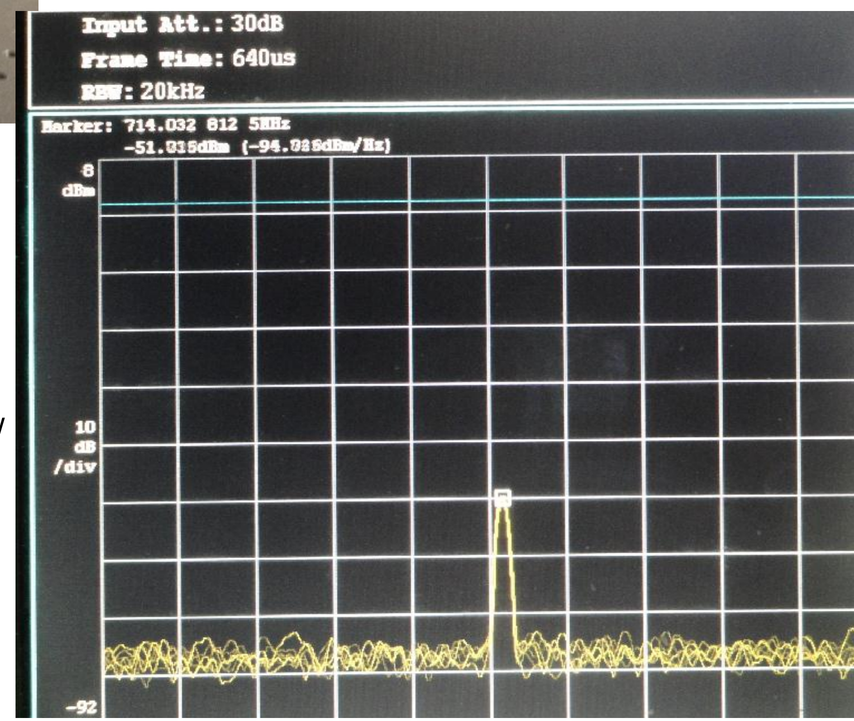


PULSED MODE-LOCKED LASER OSCILLATOR

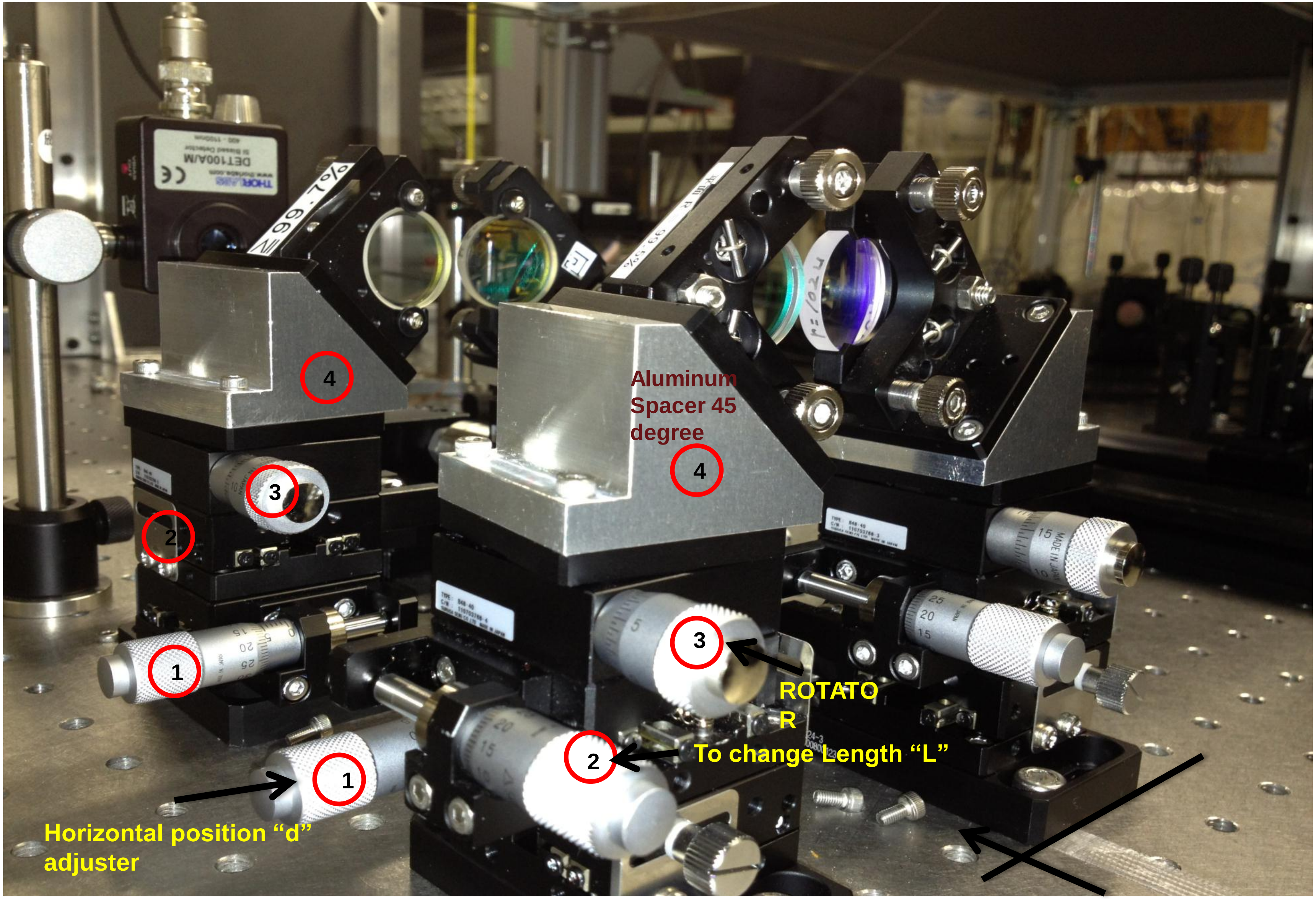


Crystal	Nd:VAN
Wavelength	1064 nm
Repetition rate	714.037 M Hz
Pulse width	7.5 ps (FWHM)
O/P Power @ $I_{2.25}$ A	520 mW

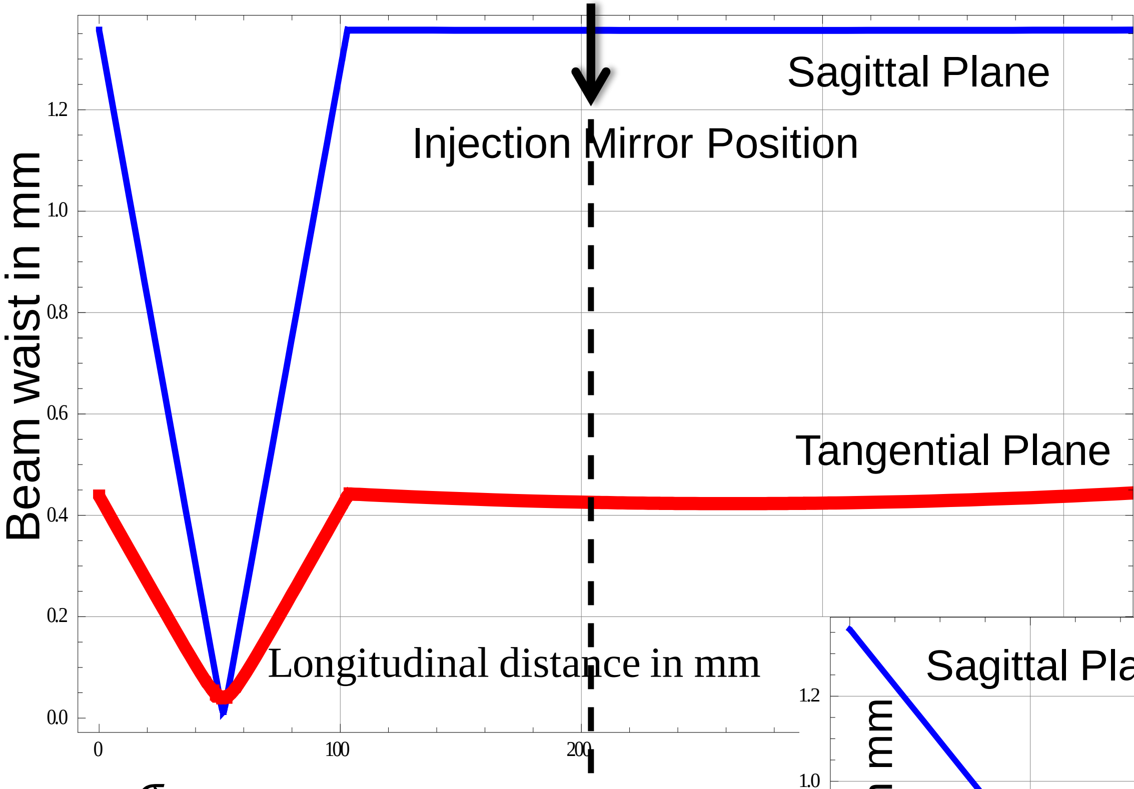




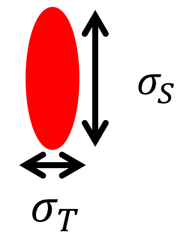
OPTICAL BENCH SETUP



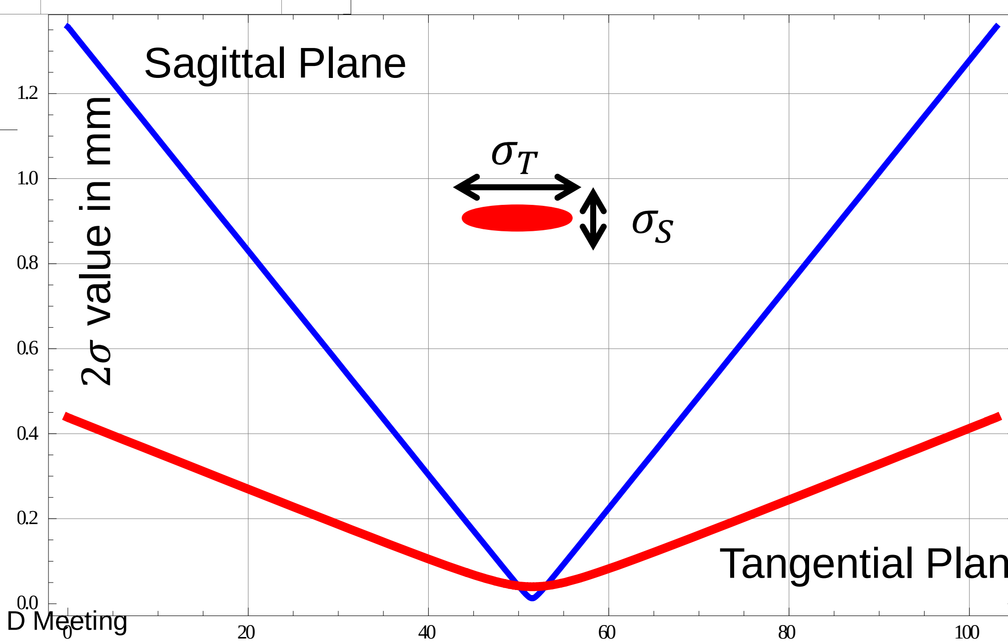
NEED FOR CYLINDRICAL LENS SYSTEM



At injection Mirror
Sagittal beam size is **larger**
Tangential beam size is **smaller**

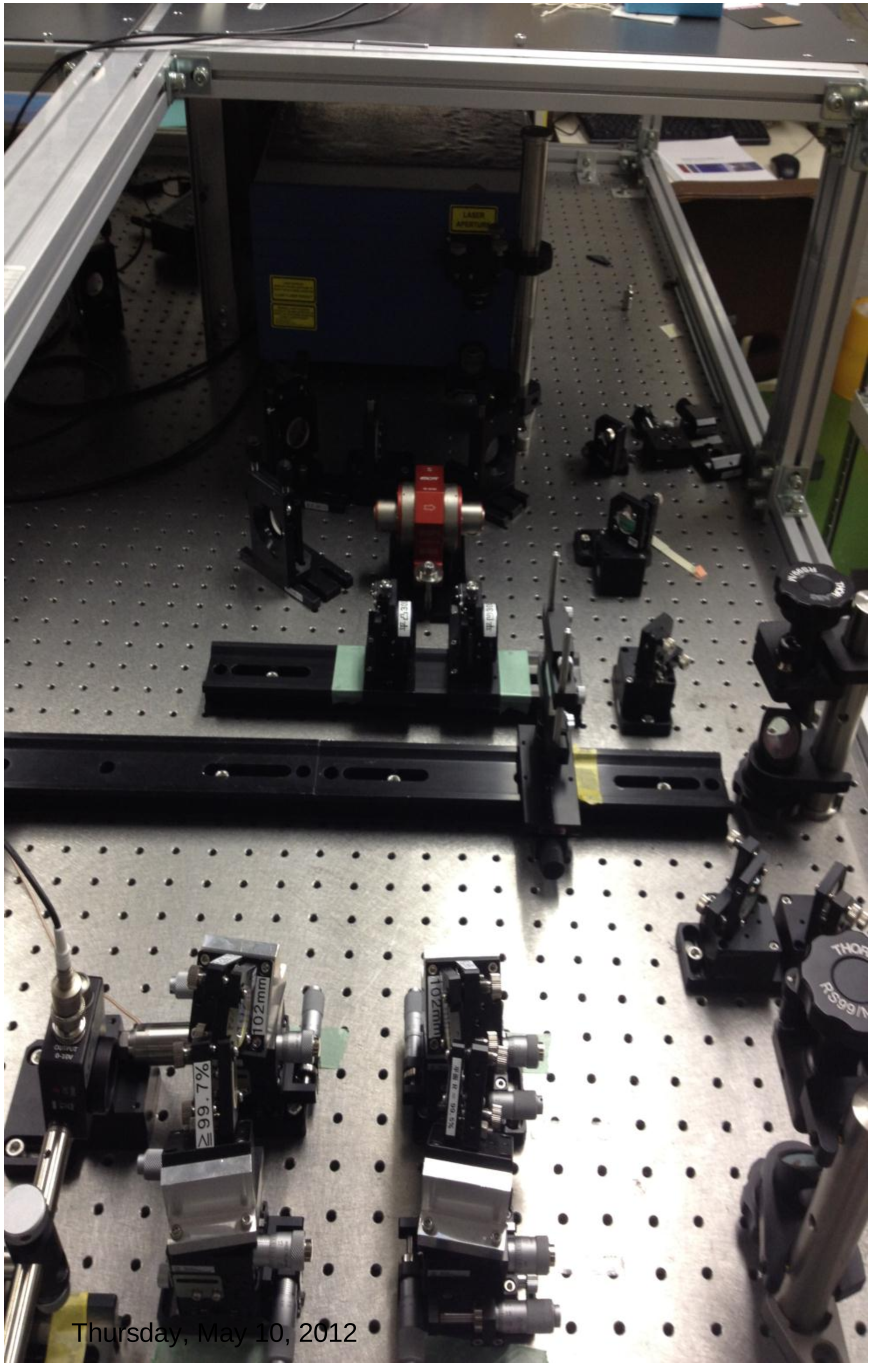


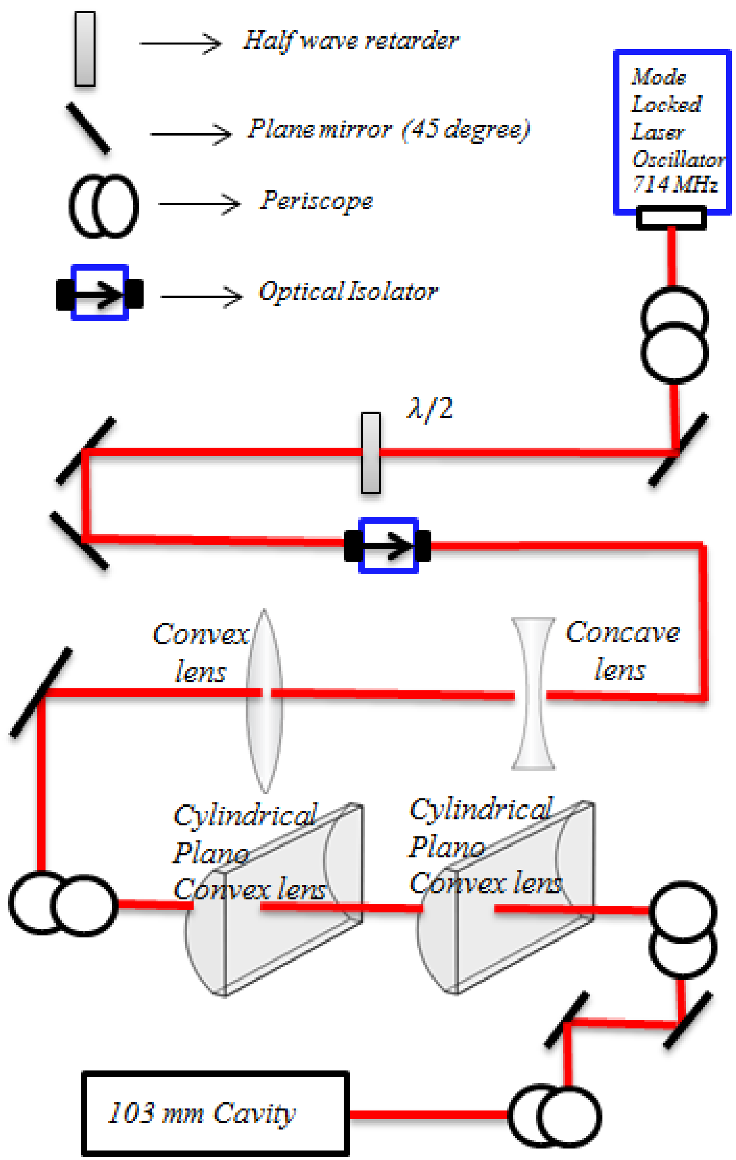
$$\frac{\sigma_T}{\sigma_S} \cong 3$$



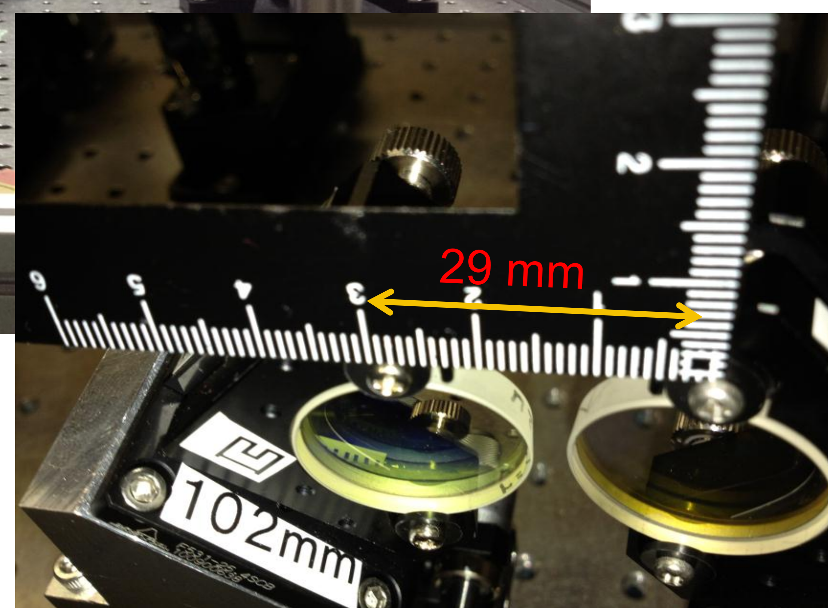
At Minimum beam waist position
Sagittal beam size is **smaller**
Tangential beam size is **Larger**

OPTICAL BENCH SETUP



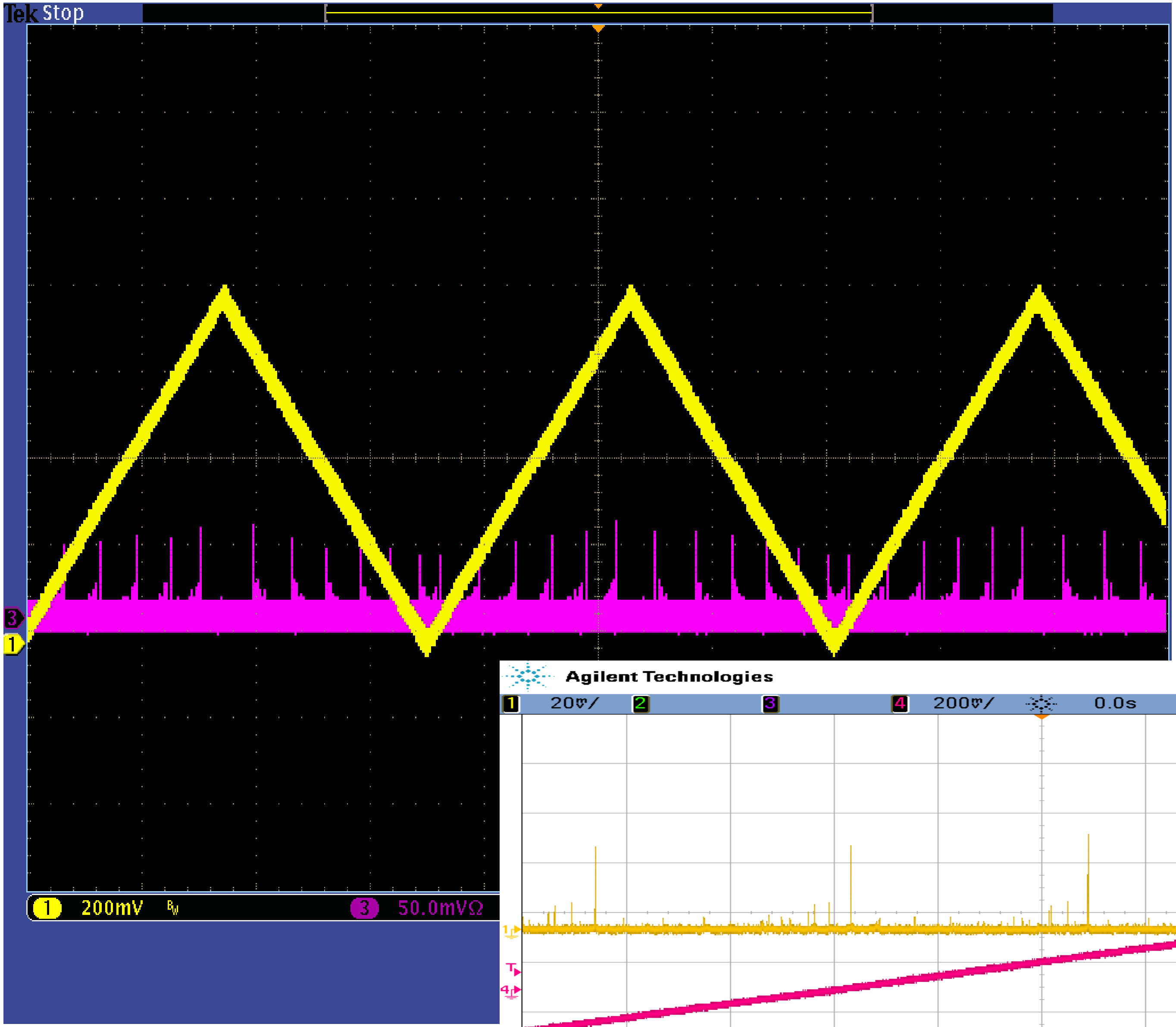


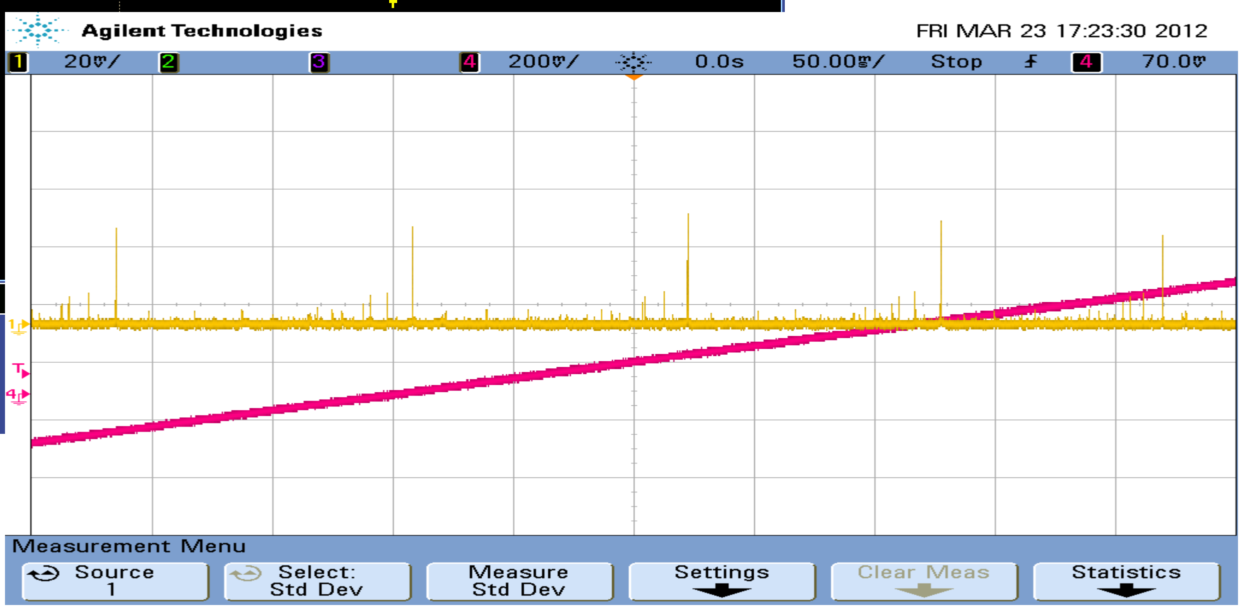
OPTICAL BENCH SETUP



Thursday, May 10, 2012

Mode Locked fiber laser and high power optical cavity R & D Meeting

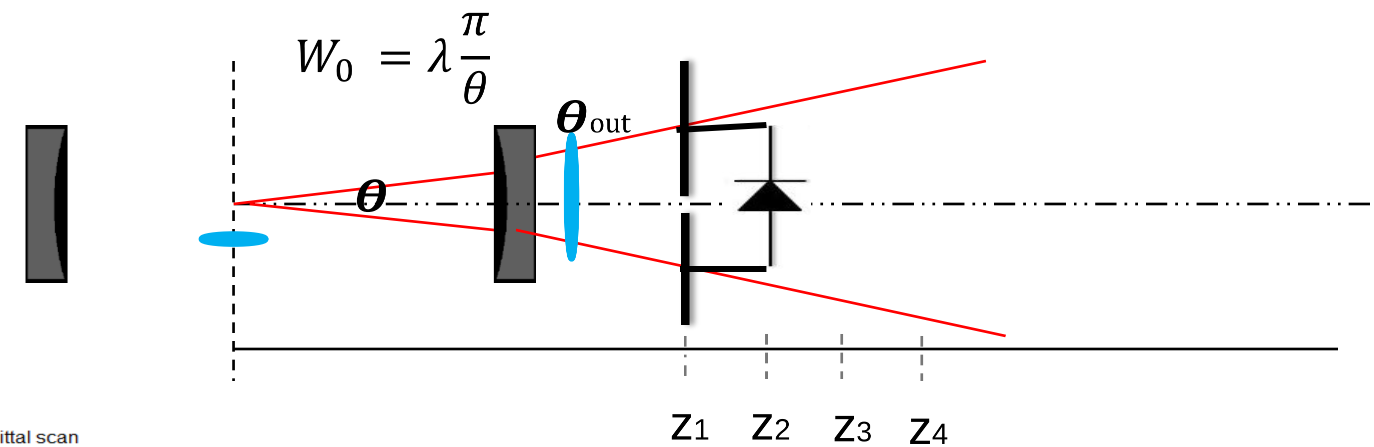


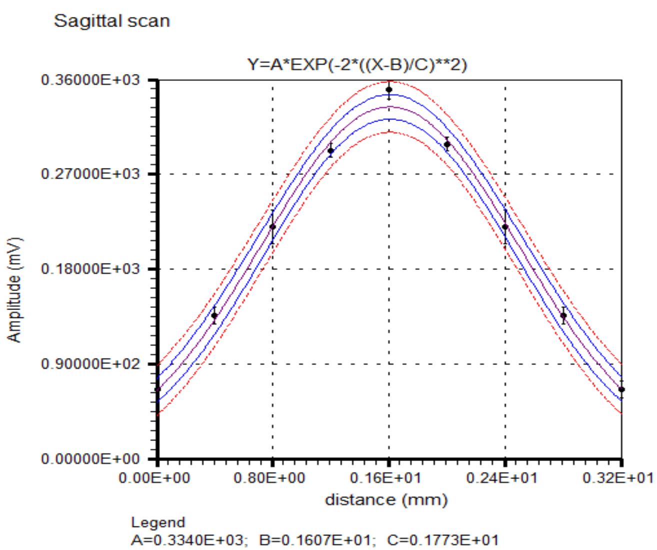


Cavity length is varied by PZT.

Piezo actuator is driven by triangular wave through a HV amplifier

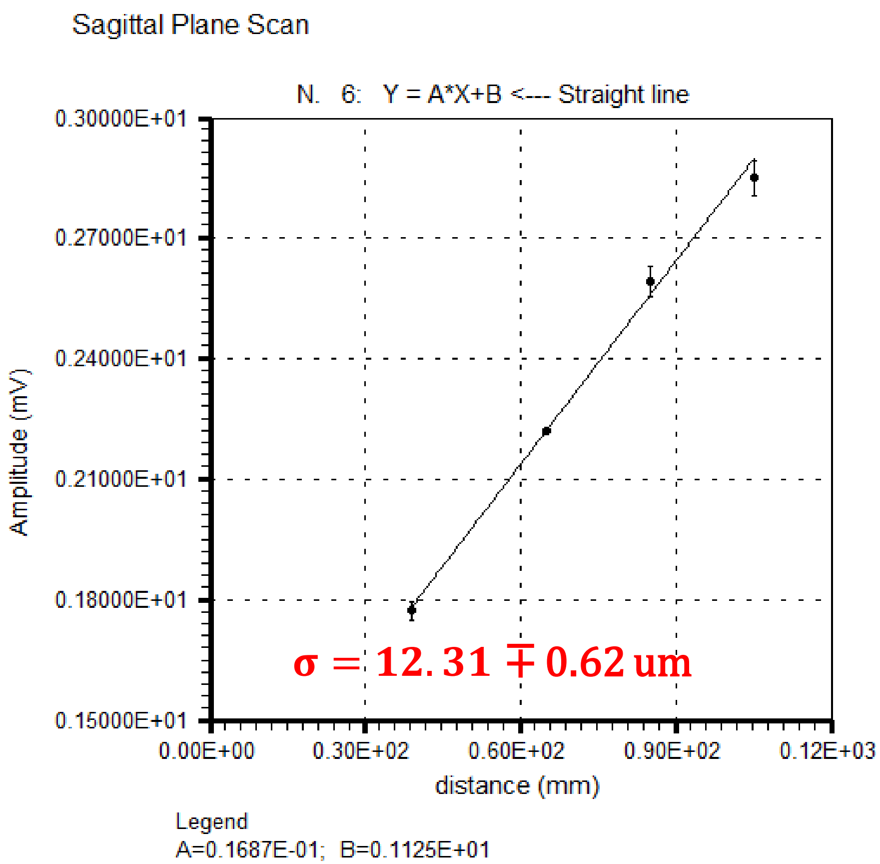
DIVERGENCE METHOD FOR BEAM WAIST MEASUREMENT

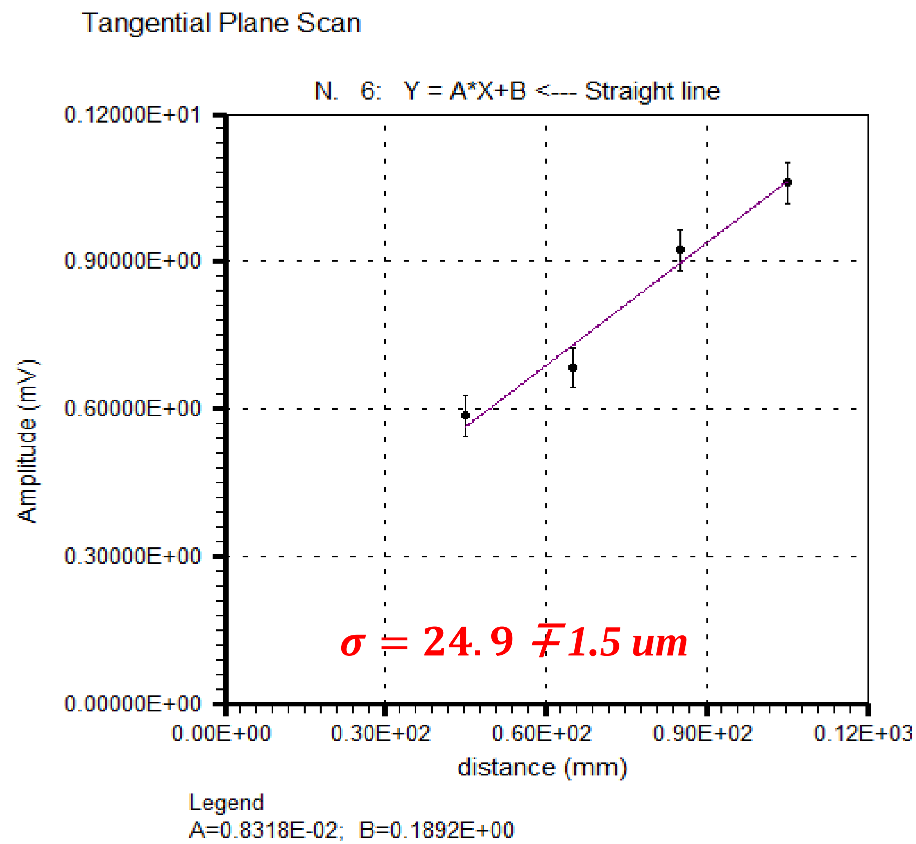




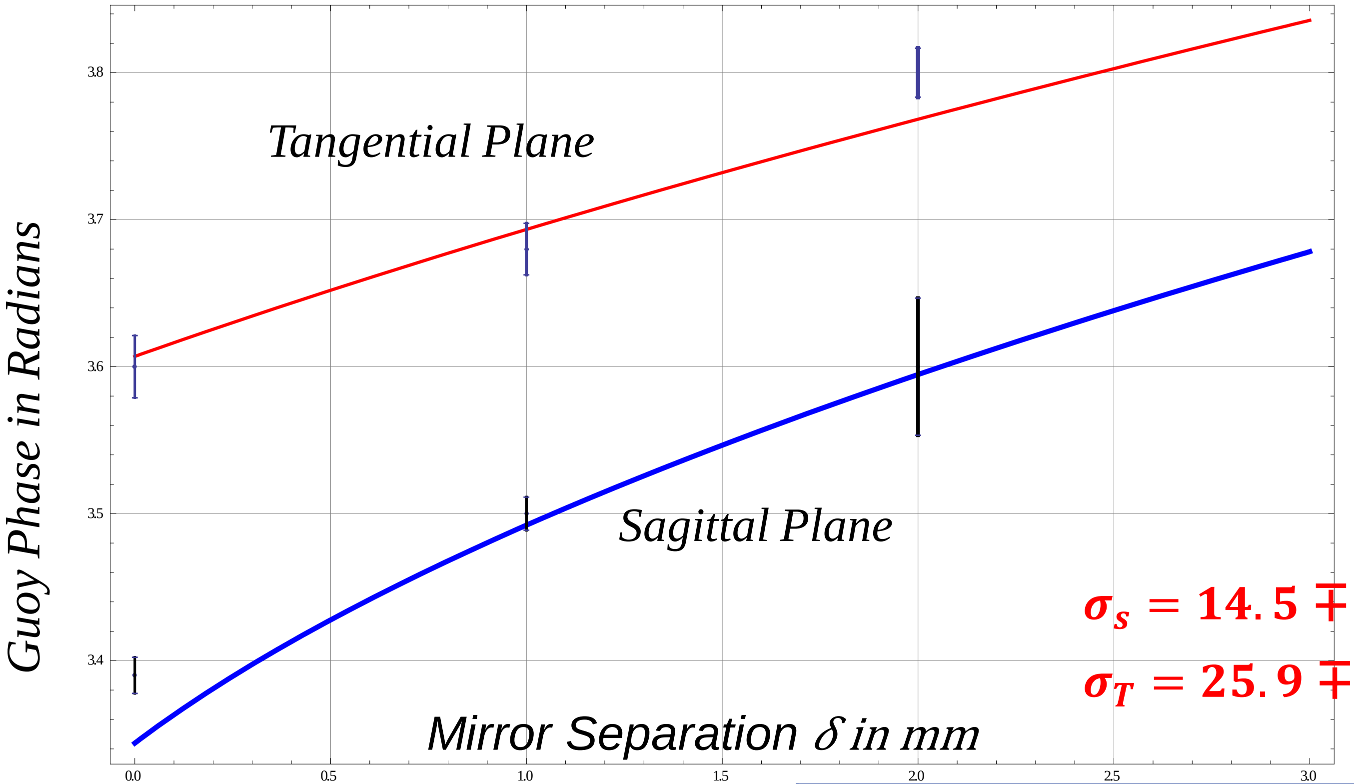
Laser beam at output mirror need to be scanned both in horizontal and vertical direction.

SAGITTAL PLANE AND TANGENTIAL PLANE SCAN





BEAM SIZE ANALYSIS USING GUOY PHASE STUDY



$$\sigma_s = 14.5 \mp 0.5\,\mathrm{um}$$

$$\sigma_T = 25.9 \mp 0.7\mathrm{um}$$

	Beam Size (σ value) Divergence Method	Beam Size (σ value) Guoy Phase Method
Sagittal	12.31 ∓ 0.62 um	14.5∓ 0.5 um
Tangential	24.9 ∓ 1.5 um	25.9∓ 0.7 um

FINESSE OF COMPACT RESONATOR

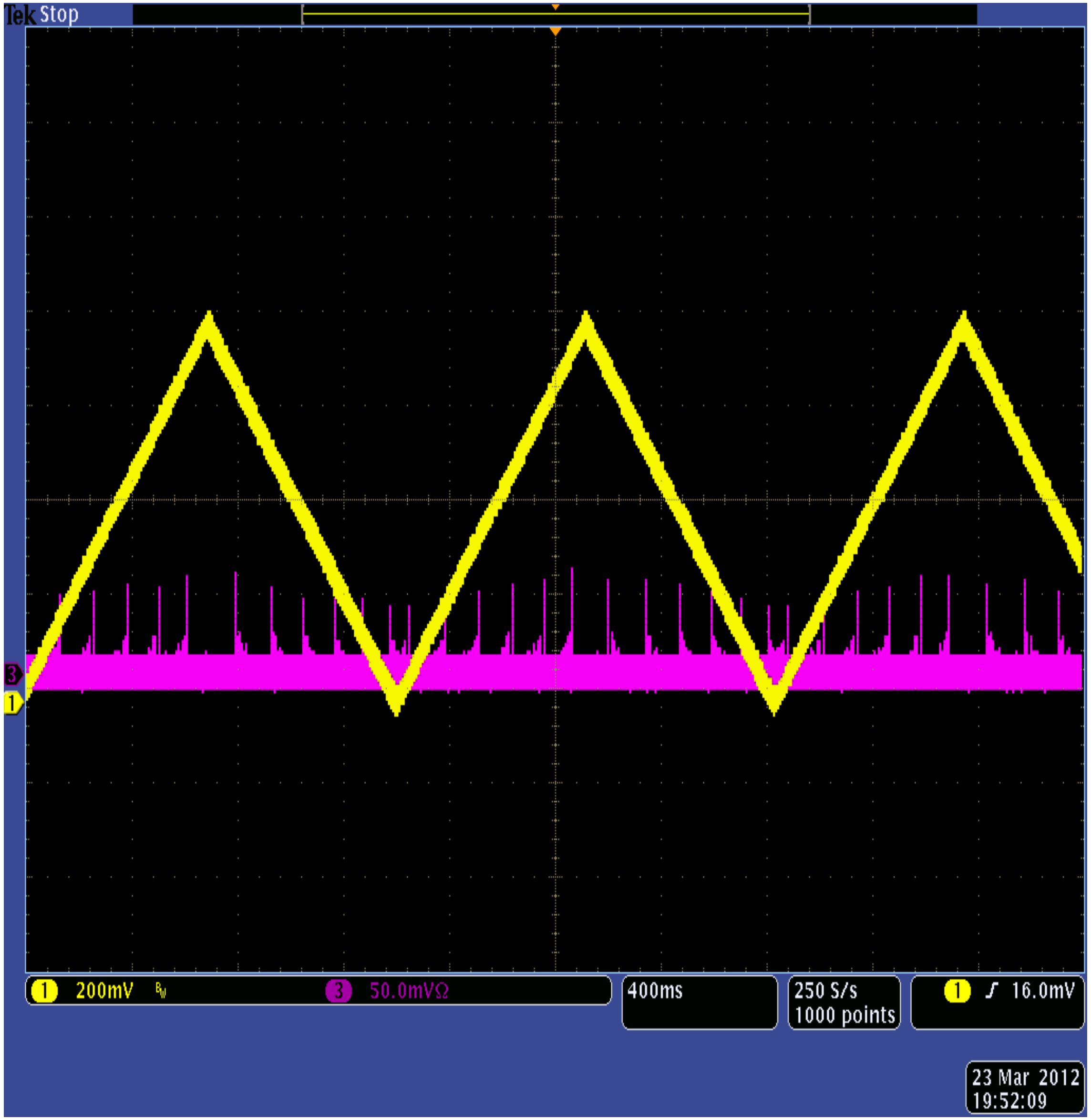
r_1= 99.75
r_2= 99.985
r_3= 99.985
r_4= 99.985

Theoretical Finesse =**1547.5**

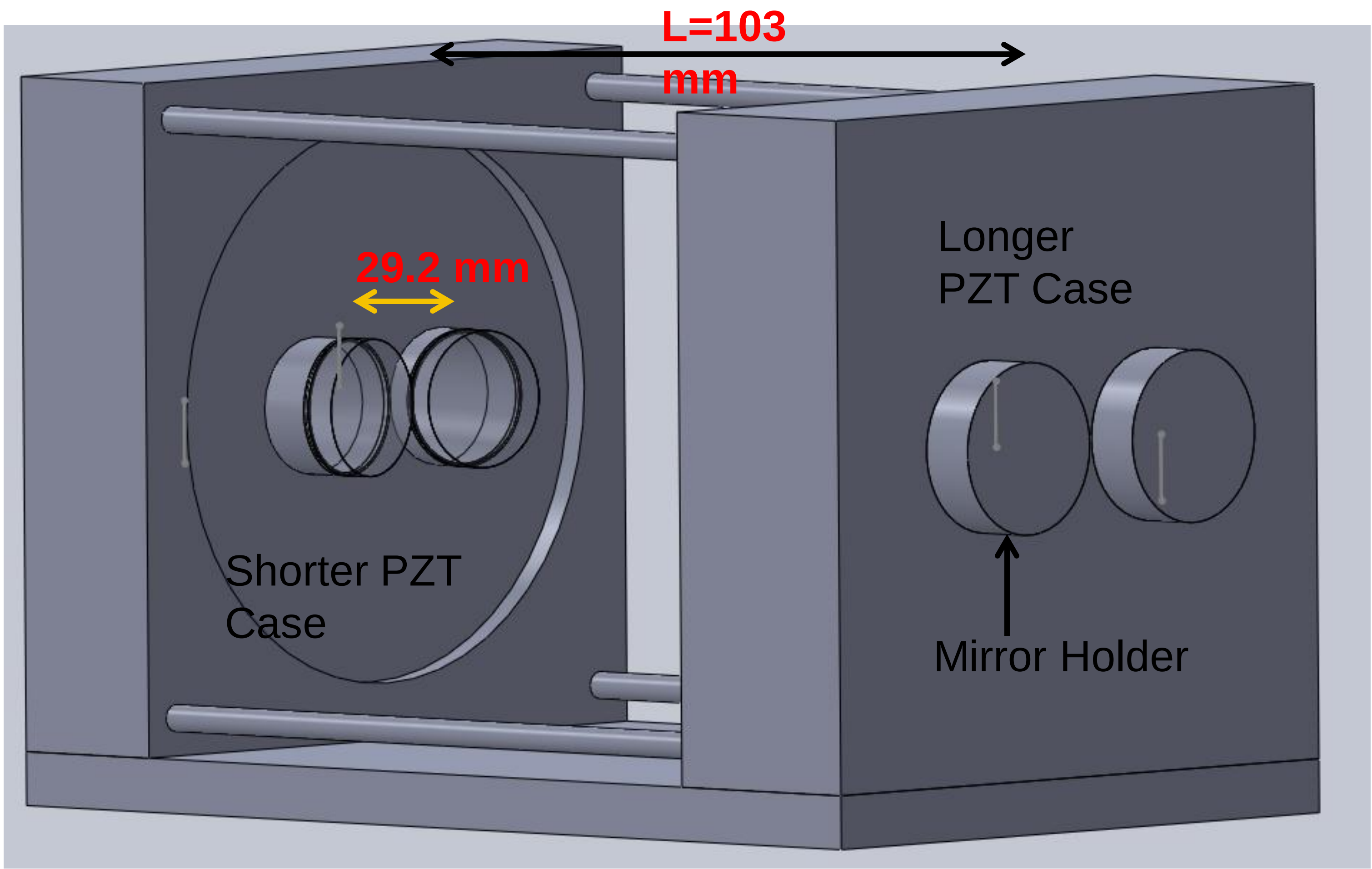
Measured Finesse=
FSR/ FWHM

1325 ∓ 40

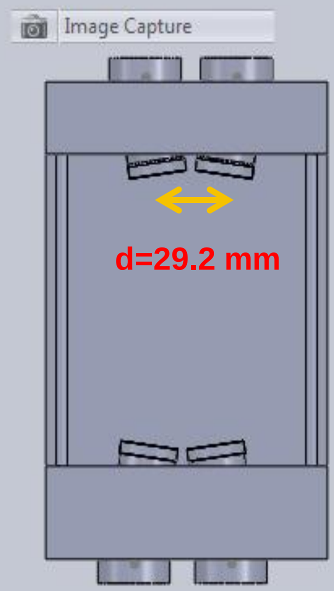
Enhancement Factor
= 710



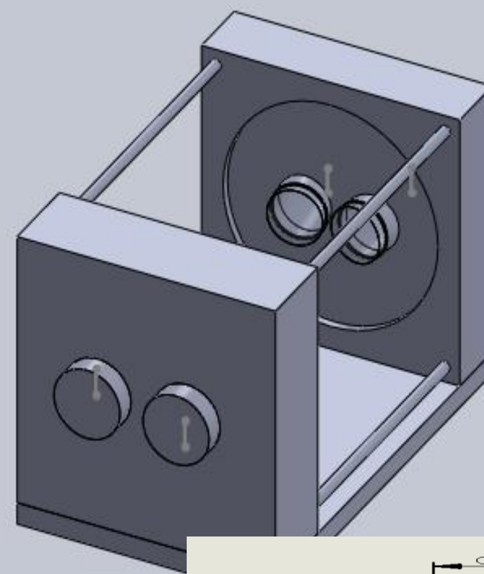
DESIGN OF COMPACT RESONATOR



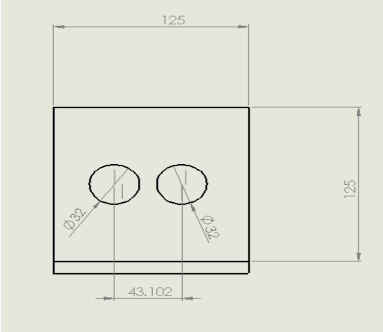
All Mirrors are tilted at 8 degrees.

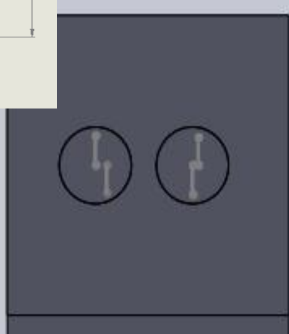


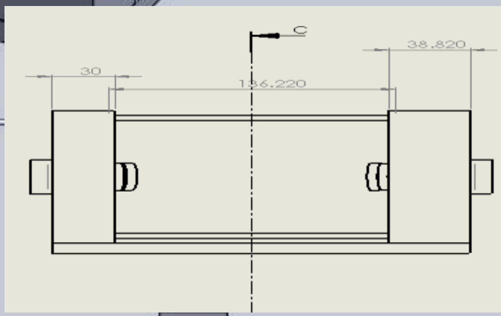
Top View

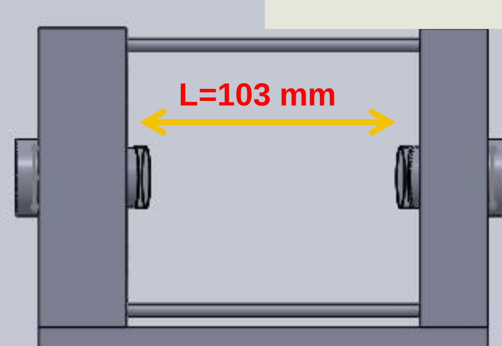


Isometric View



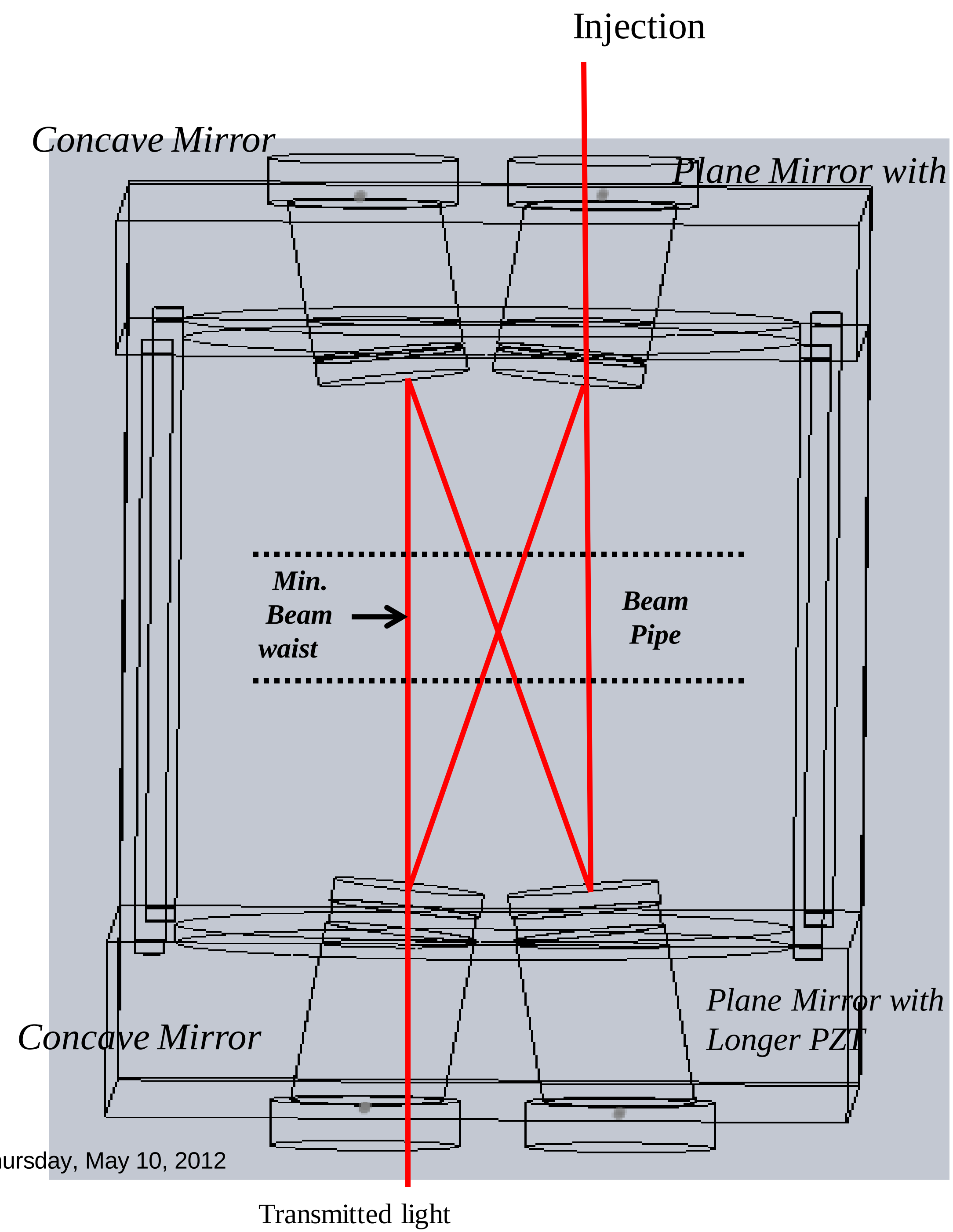




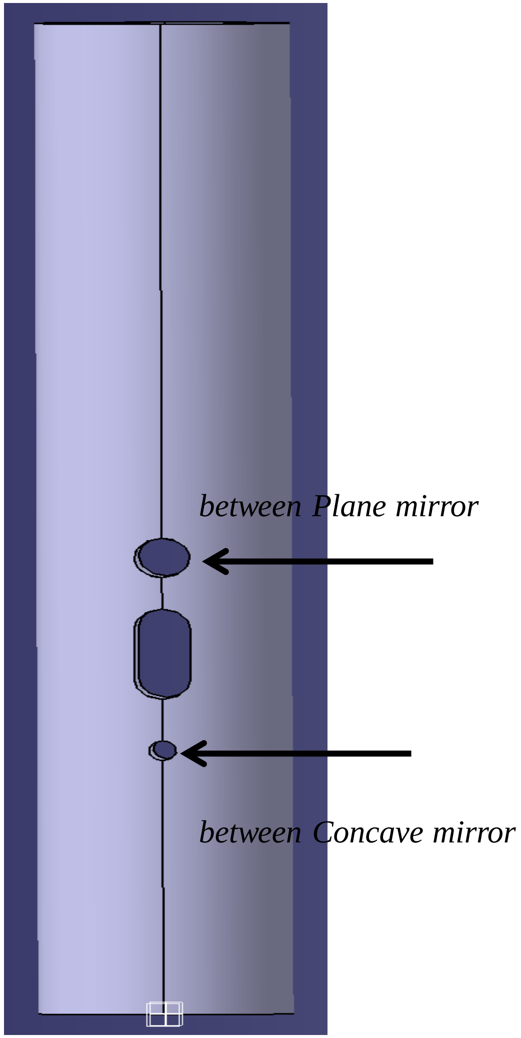


Front View

Right View



Cutting of beam pipe



COMPACT CAVITY USING GREEN PULSED OSCILLATOR

L	103 mm
d	29.2 mm
α	0.1381 rad
ρ (Curvature)	102 mm
Beam size (IR) $\omega_{S,}$ ω_T (σ)	(7, 20) um
Beam Size (Green Laser) ω_S, ω_T (σ)	(3.75,14.1) um

Green Laser Oscillator with Repetition rate 714 MHz, will give beam size less than 5 um in sagittal plane

MERITS

1. Four mirror resonator reduces the sensitivity to the misalignment of mirror compared to two mirror resonator, thus more stable.

2. At present, CW Laser Wire has been used to measure the small emittance beam. If we replace it to pulsed laser wire, more efficient laser-beam collision can be realized.

3. CW laser wire system takes more time in scanning of electron beam compare to Pulsed laser.

4. With green laser oscillator, beam waist less than 5 um can be obtained in one plane.

ANALYSIS

Compact Cavity is very sensitive to mm accuracy.

Scheme to obtain very small beam size requires proper mirror alignment scheme for fixing of mirrors.

Green laser oscillator will give smaller beam size compare to IR oscillator