National University
The Graduate University for Advanced Studies [SOKENDAI]

KEK-JAPAN

# PULSED GREEN LASER WIRE SYSTEM FOR EFFECTIVE INVERSE COMPTON SCATTERING

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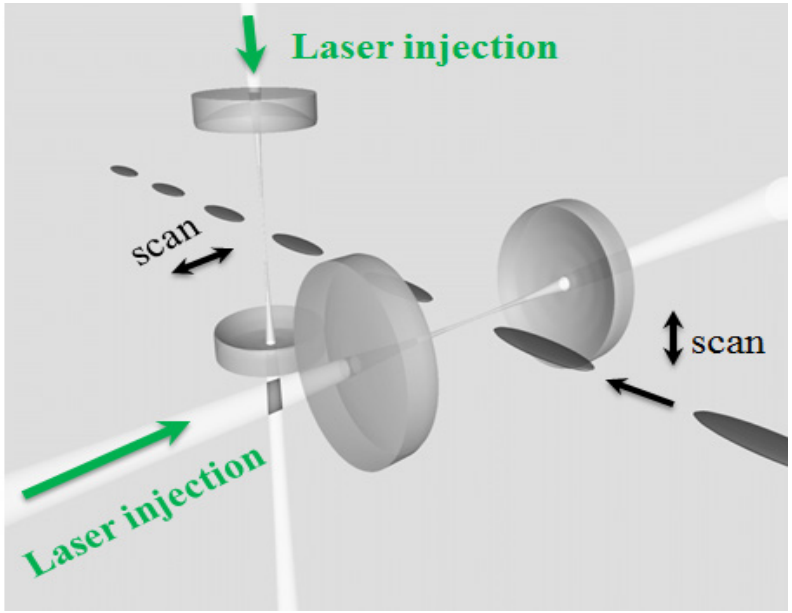
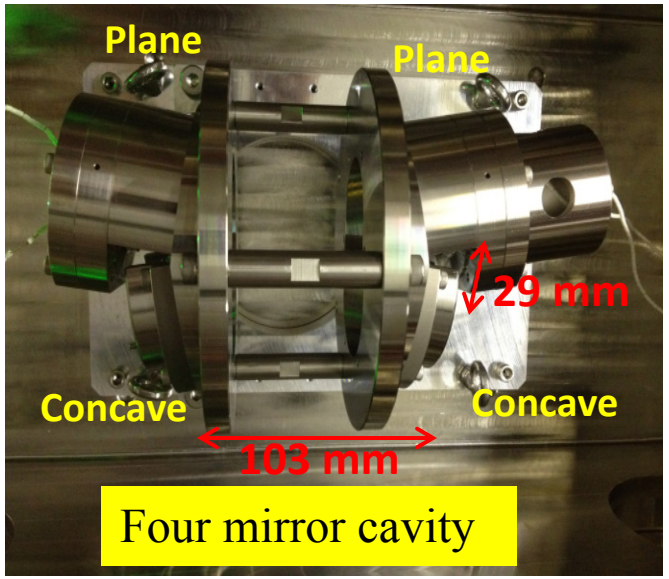
# Purpose and Motivation




**CW Green Laser**
**Two Mirror Laser Wire system**

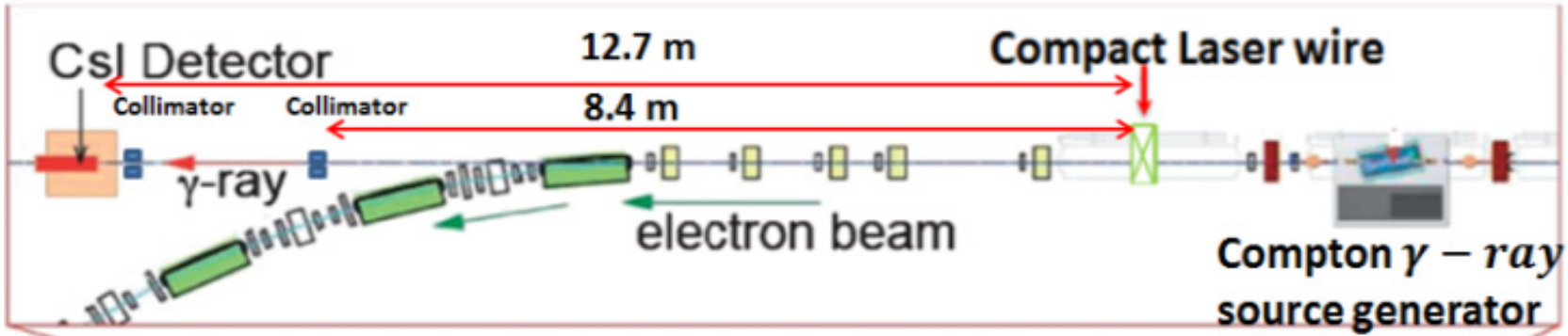
**Pulsed Green Laser**
**Four Mirror Laser Wire System**

ATF DR has vertical electron beam size of 5 $\mu m$.

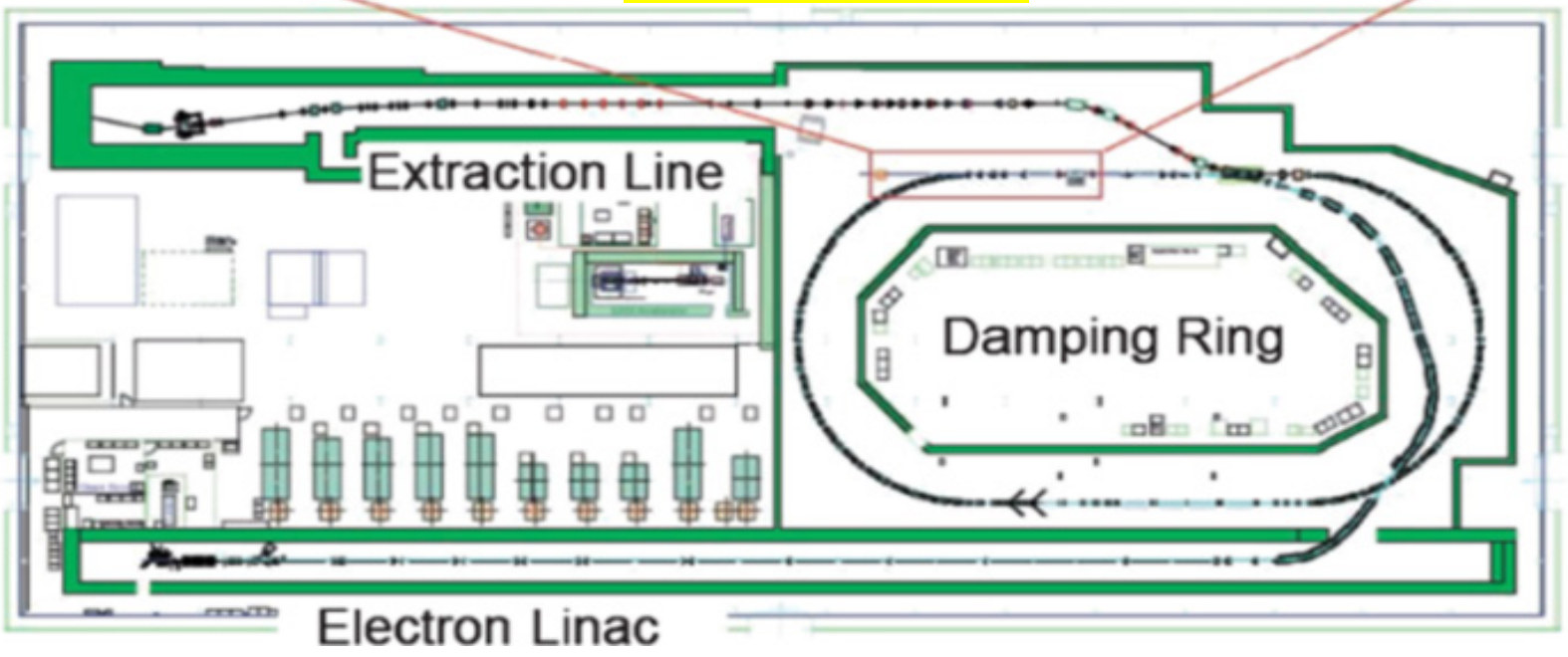
Small waist size of laser is required to measure small electron beam in vertical direction.

Replace CW two mirror laser wire system with pulse four mirror laser wire system for fast scanning of electron beam and stability of laser system

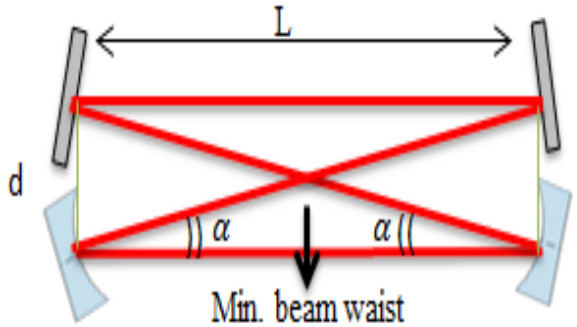
# ATF Damping Ring

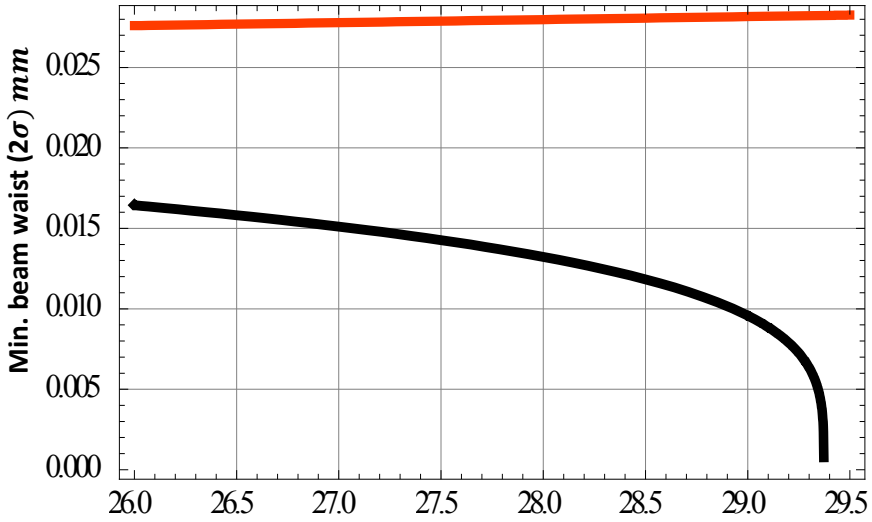



$$\sigma_{obs}^2 = \sigma_{lw}^2 + \sigma_e^2$$

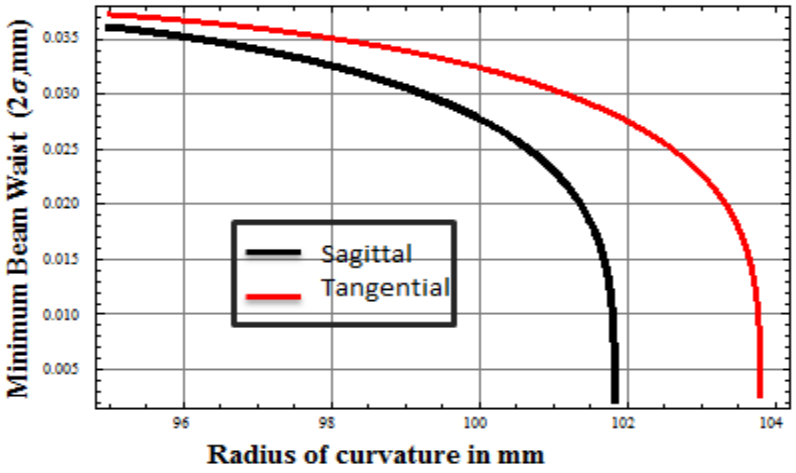


# Four Mirror Cavity Design Values ( R, d)



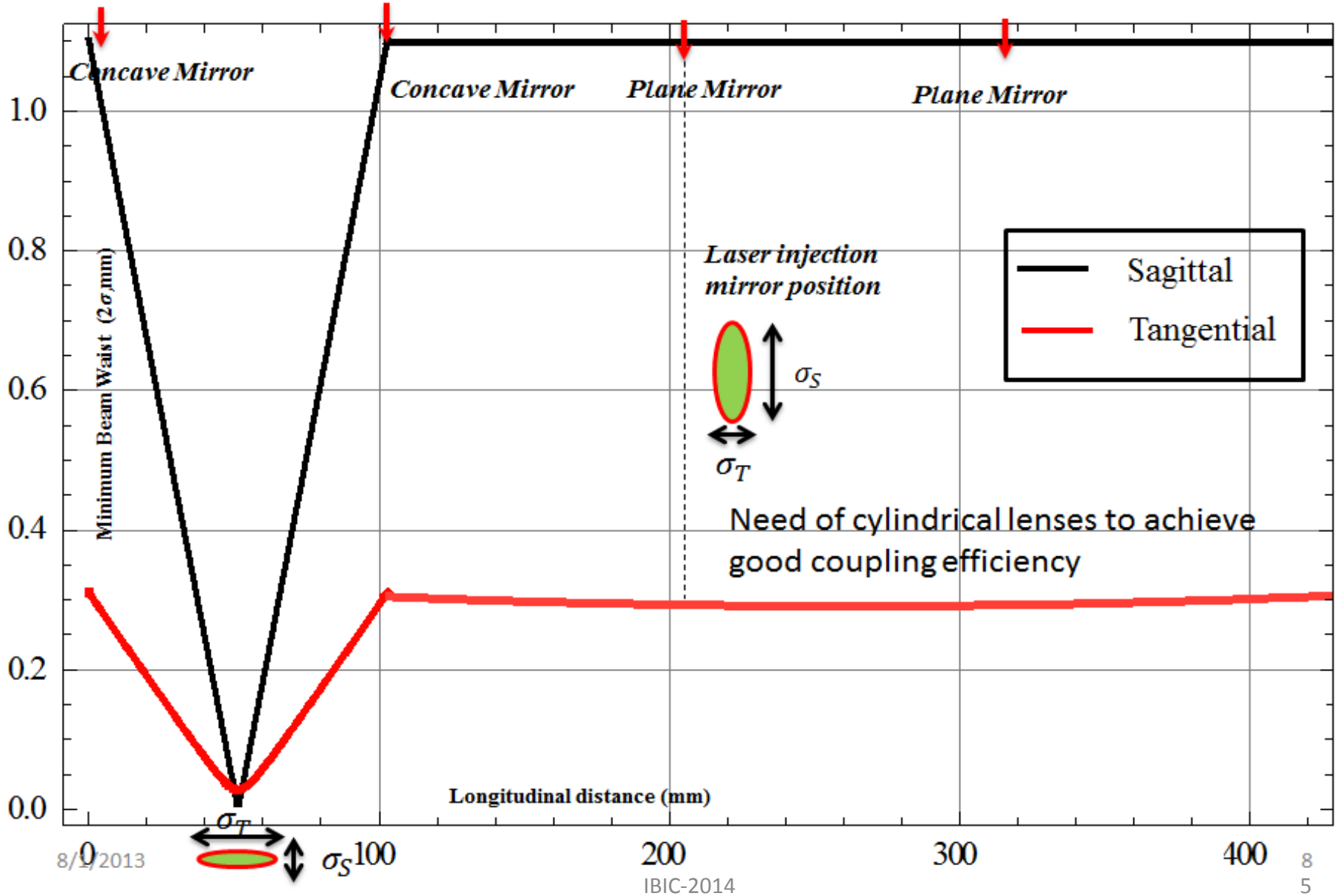

**Adjacent Plane mirror-concave mirror distance in mm**



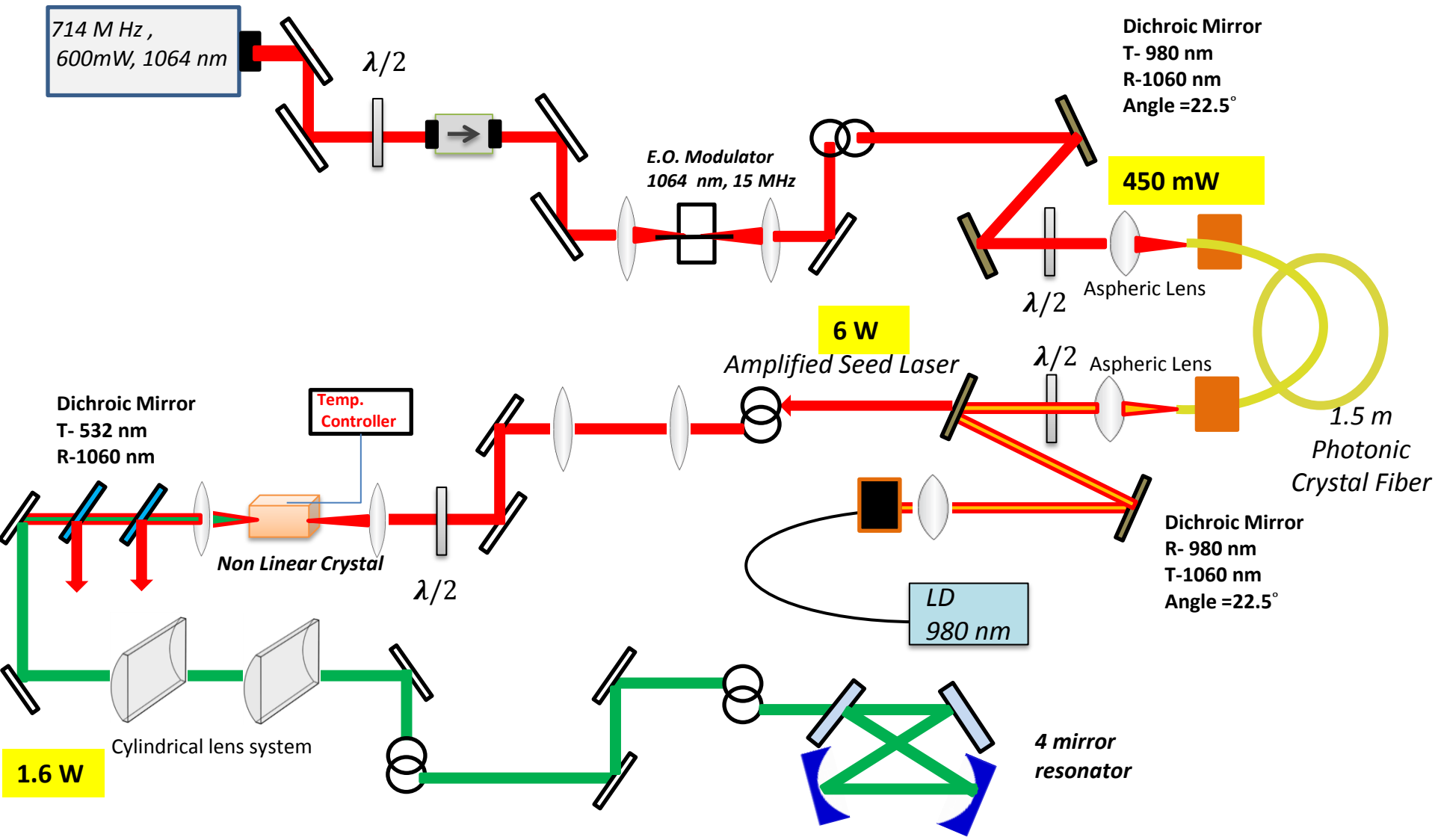

| Curvature "R" mm | ($\sigma_s$,$\sigma_T$) Value, Green Laser |
|---|---|
| 101.8 mm | (3.95, 14) um |

| "d" mm | ($\sigma_s$,$\sigma_T$) value, Green Laser |
|---|---|
| 29 | (4.8, 14.1) um |
| 29.1 | (4.4,14.15) um |
| 29.2 | (3.95, 14.2) um |

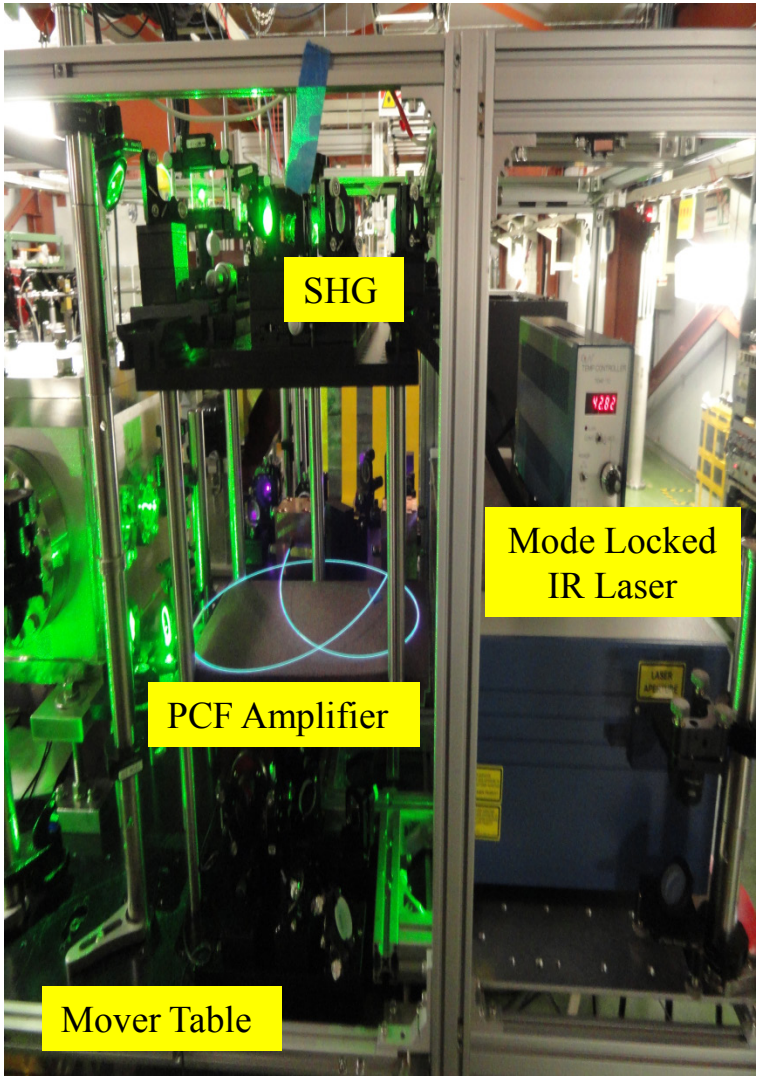
# Beam Evolution Inside Four Mirror Resonator

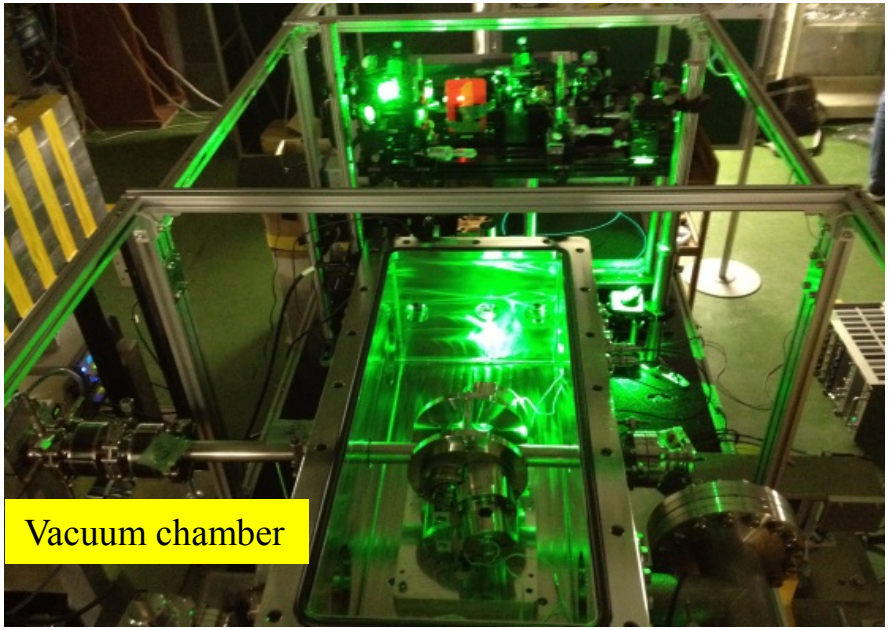


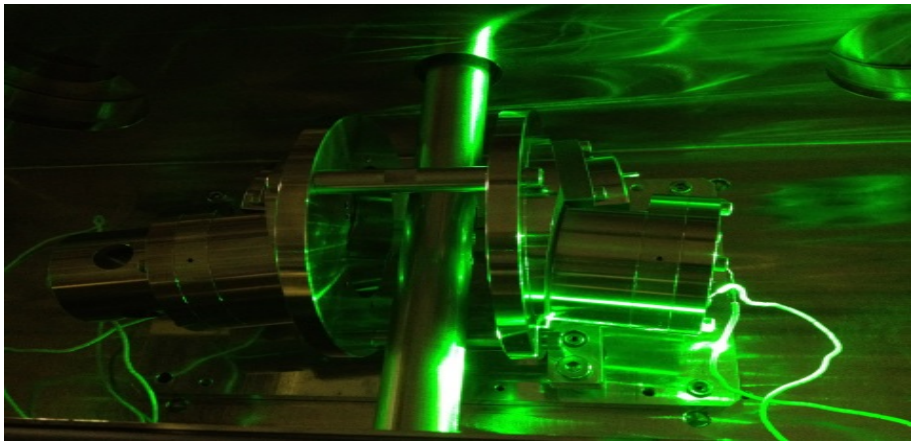
# Total System for Pulsed Green Laser Generation



# Total System in ATF-DR

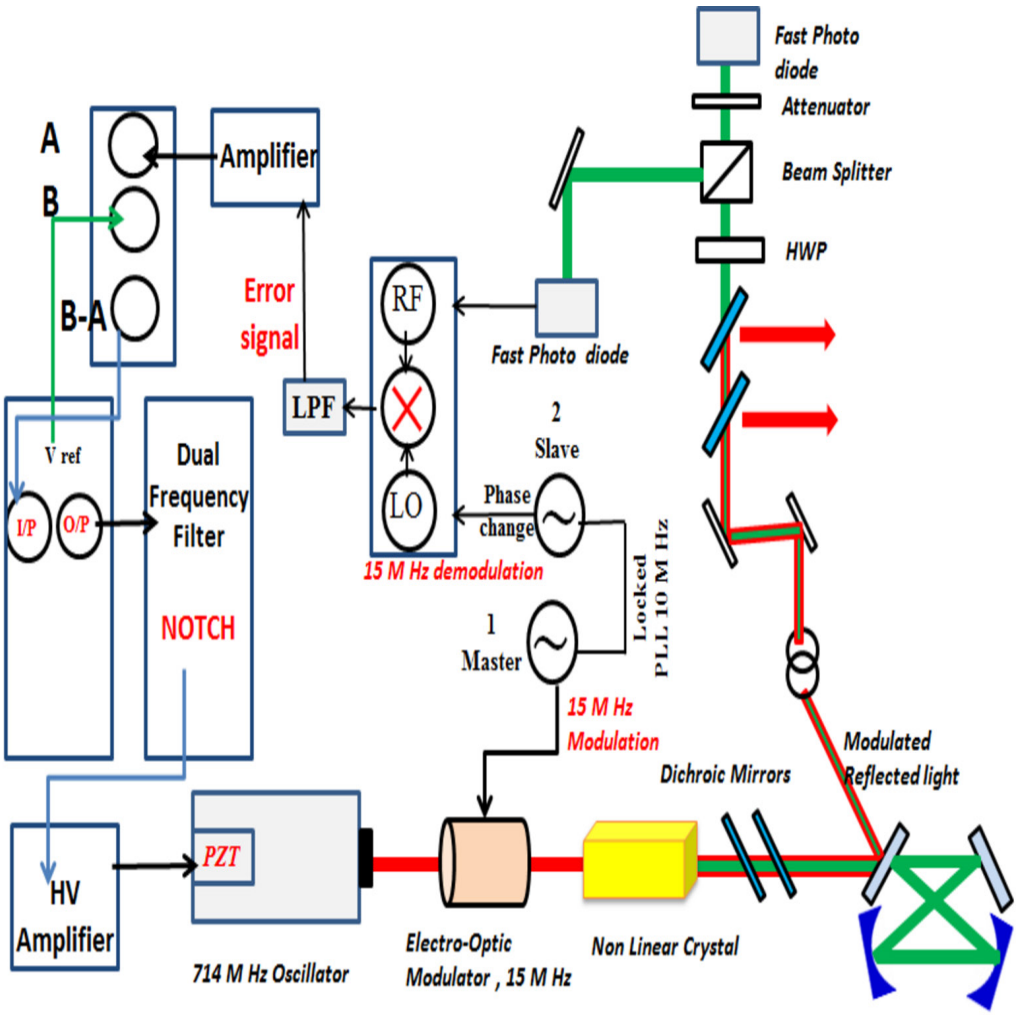


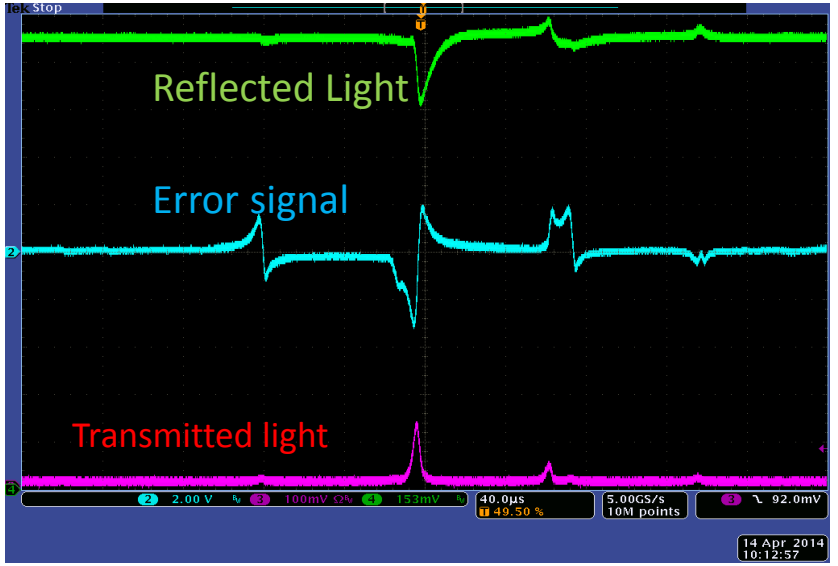



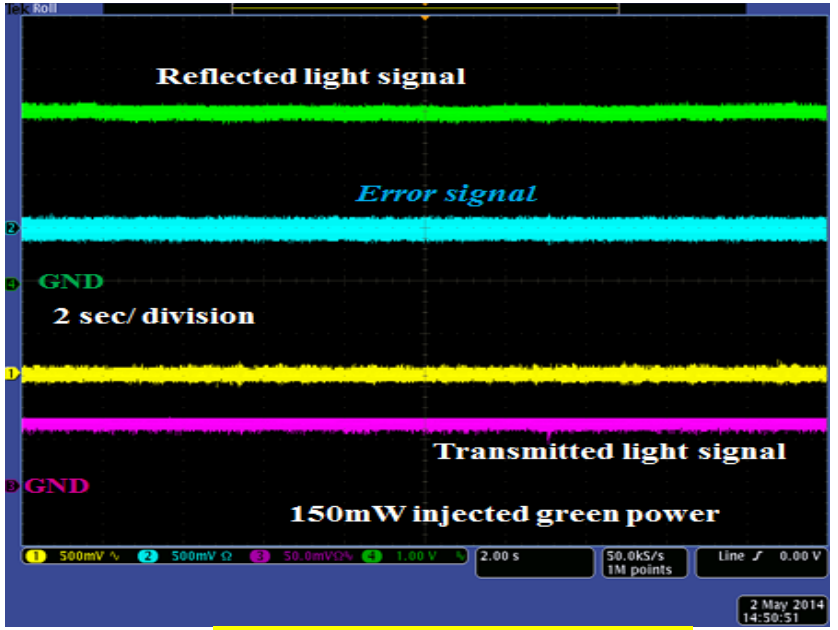



Electron beam pipe inside four mirror cavity 90° collision

# Pound-Drever-Hall Feedback Scheme

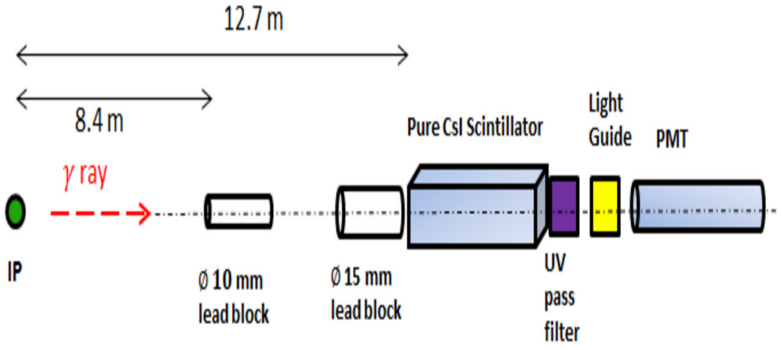


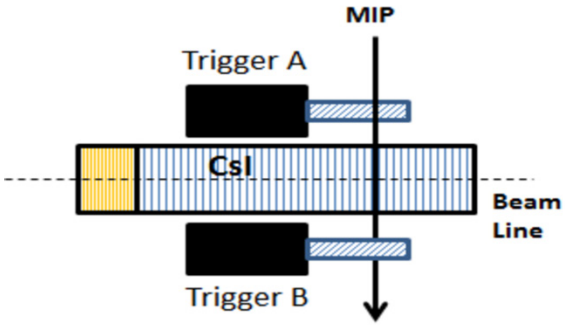



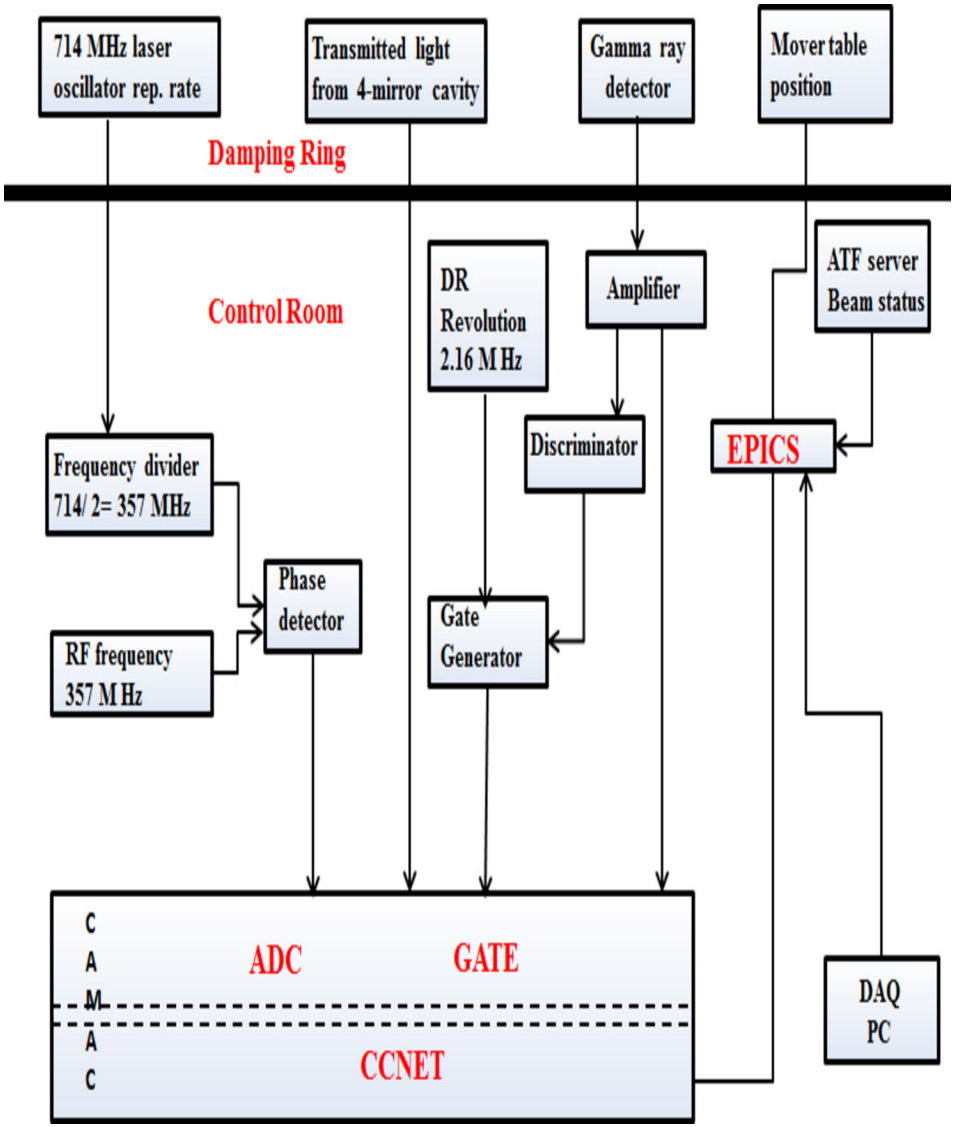




**Holding of Resonance**

# Detector & Data Acquisition System



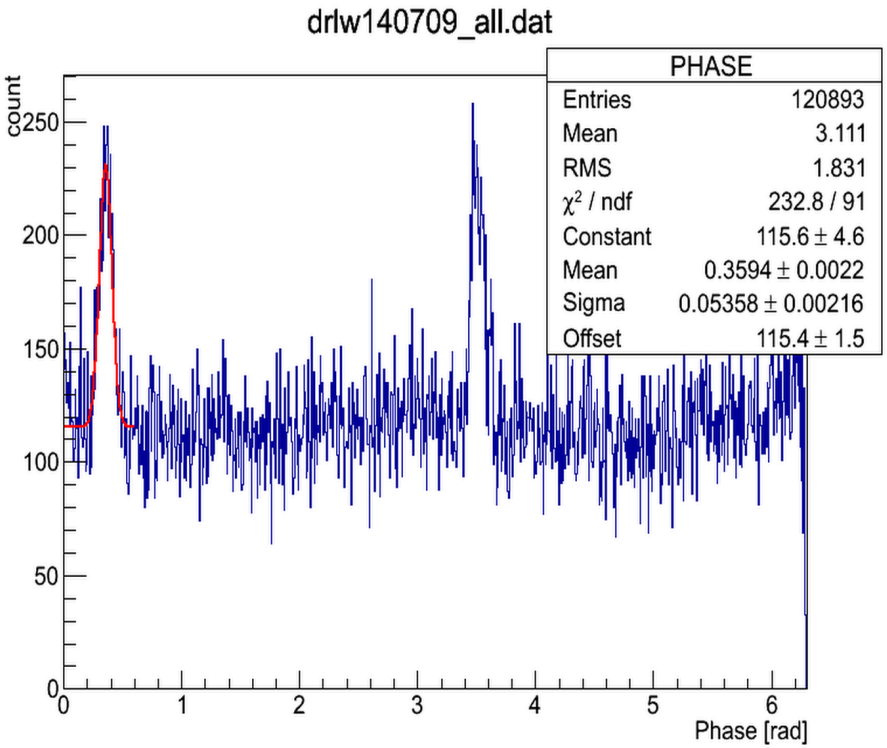



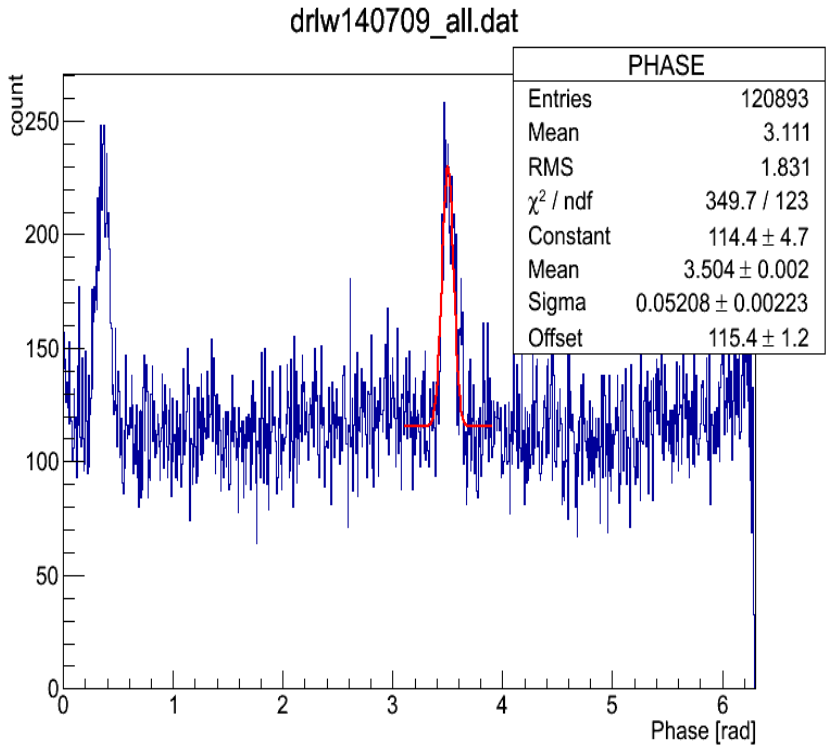




Dimensions of CsI crystal = $70\times 70 \times 300\ mm^3$

When muon passes through 70 mm in CsI crystal, Energy deposition will be 39.2 MeV.

# Bunch Length Measurement

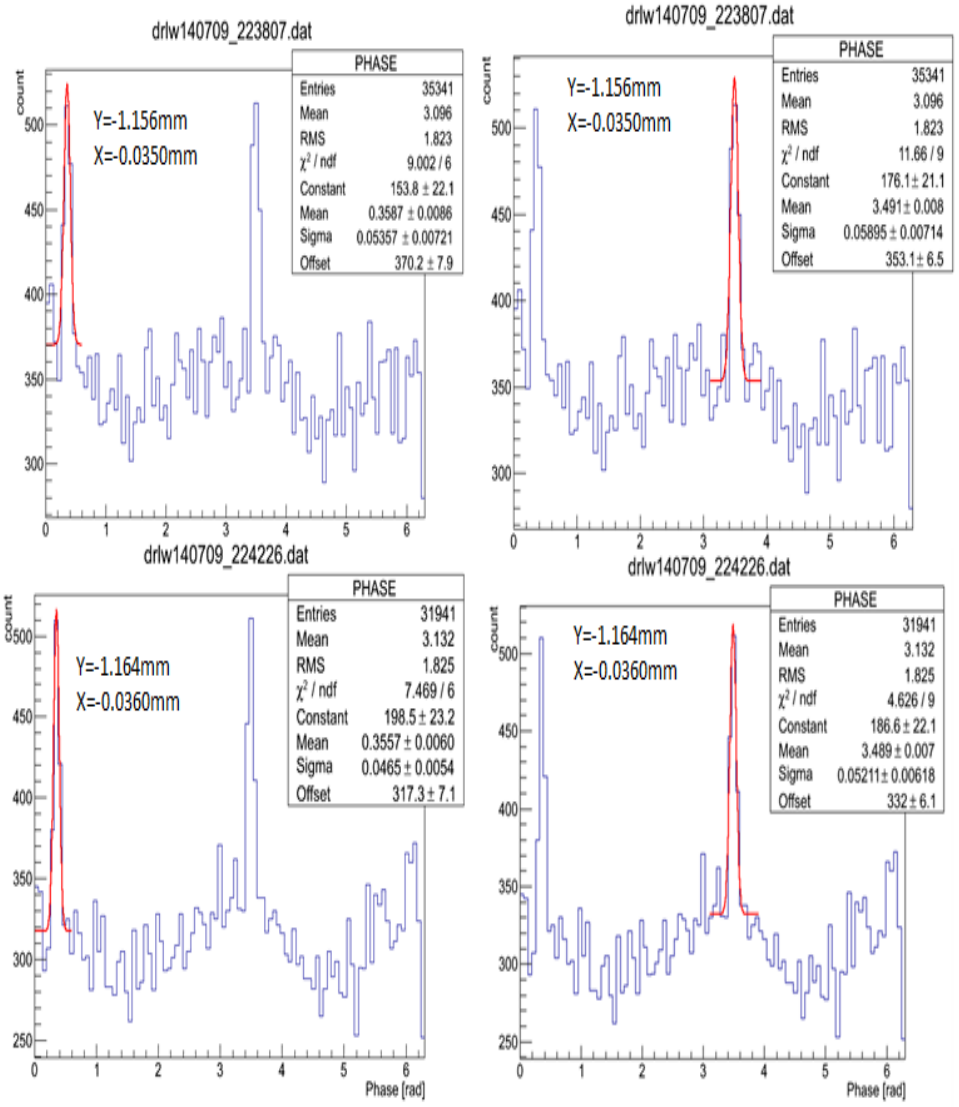


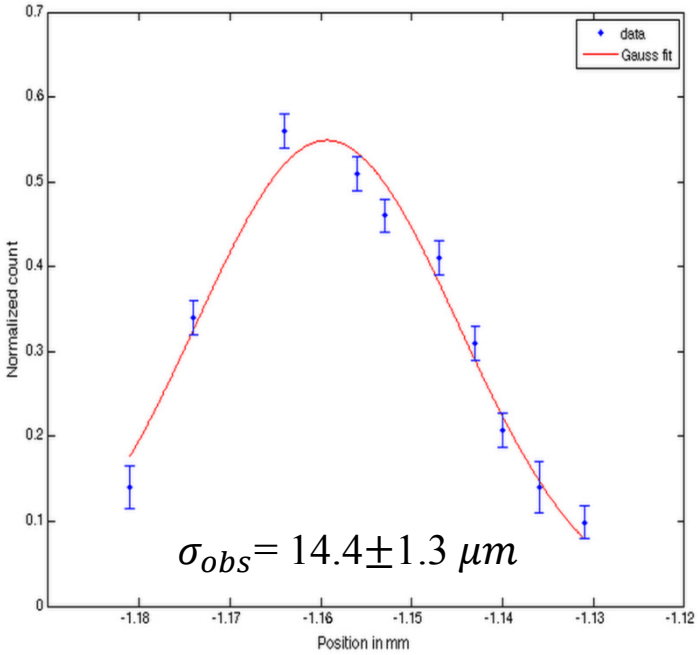

Measured Bunch length
$\sigma_z\ (ps)$ = 23.3 $\pm$0.7 ps.

ATF Clock of 357 MHz is used in Experiment.
Relative phase difference of $2\pi$ corresponds to 2.8 ns

# Vertical Beam Size and Emittance Measurement




For all histogram plots with more than 30,000 events, average background level =332 counts




Normalized peak count is ratio of Peak S/N ratio and normalized background level

Normalized peak S/N ratio = 0.56±0.02

$\sigma_{obs}^2 = \sigma_{lw}^2 + \sigma_e^2$

$\sigma_e^2 = \sigma_{obs}^2 - \sigma_{lw}^2$

$\sigma_{lw}$=7±2 $\mu m$

$\sigma_{ey}$= 12.6± 1.6 $\mu m$.

Vertical emittance

$\sigma_{ey} = \sqrt{\beta_y \epsilon_y}$

$\beta_y$ = 6.58 m

$\epsilon_y$= 24.1 ±6.1 pm-rad

# Conclusion

## 4 mirror cavity

| | |
|---|---|
| L | 103 mm |
| d | 29.2 mm |
| Minimum Laser Beam size ( $\sigma_S$, $\sigma_T$) | 7 $\pm$2 $\mu m$ , 13.4 $\pm$ 3$\mu m$ |
| Storage Power | 17.5 W |
| Enhancement Factor | 960 |
| Finesse | 2315 $\pm$220 |

**Pulsed green generation.**

**Vertical minimum Beam size of laser 7 $\pm$2 µm.**

**Four mirror cavity is less sensitive towards misalignment as compare to two mirror cavity.**

## Electron beam profile measurement

| **Parameter** | **Measured Value** |
|---|---|
| **Normalized count rate** | 6.2$\pm$1.1 kHz/mA |
| **Back ground level** | 11$\pm$1 kHz/mA |
| **Bunch length** | 23.3$\pm$0.7 ps |
| **Electron beam size** ($\sigma_{ey}$) | 12.6$\pm$1.8 $\mu m$ |
| **Vertical emittance** | 24.1$\pm$6.8 pm-rad |

**Bunch length measurement with accuracy of less than 1 pm.**

**Measurement of electron beam profile with free phase scan technique**.

# Thank You
# Very Much