Development of the 4-mirror Compton cavity

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Collaboration

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- **KEK**

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- **Waseda University**

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- **Seikei University**

  Hiromi Kataoka, Tadashi Kon

Special thanks to French team!!

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- Property of 3D 4-mirror cavity
- Preparation for installation
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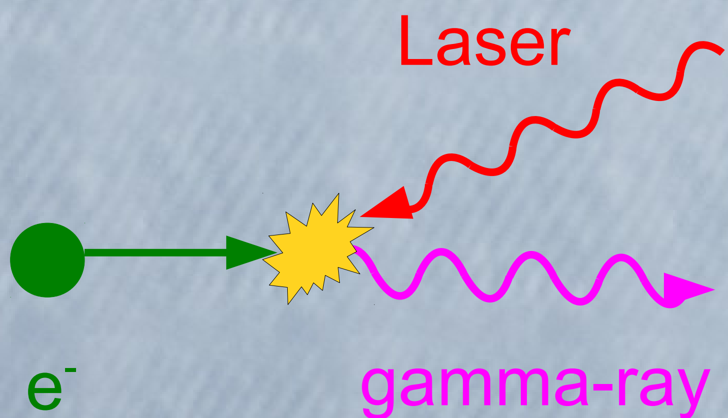
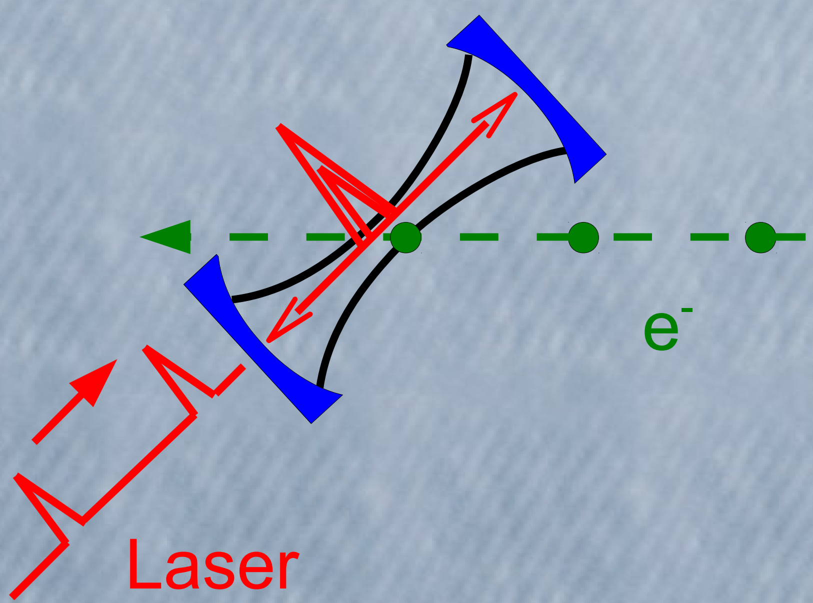
Development of an optical cavity



Increase laser power
for high intense gamma-rays
with an optical cavity



High finesse
Small spot size
} required

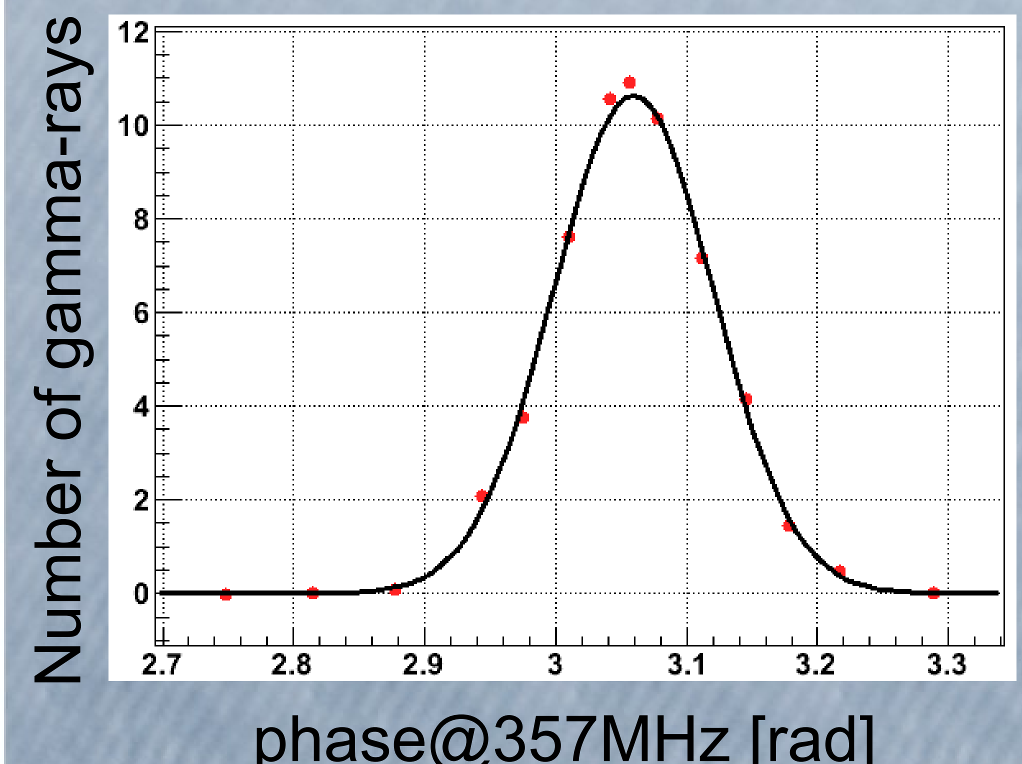
➡ 3D 4-mirror cavity

Gamma-rays generation with a 2-mirror cavity@KEK-ATF

Parameters of the 2-mirror cavity

Waist Size(σ)	30μm
Enhancement factor	760
Stacking laser power	1.5kW

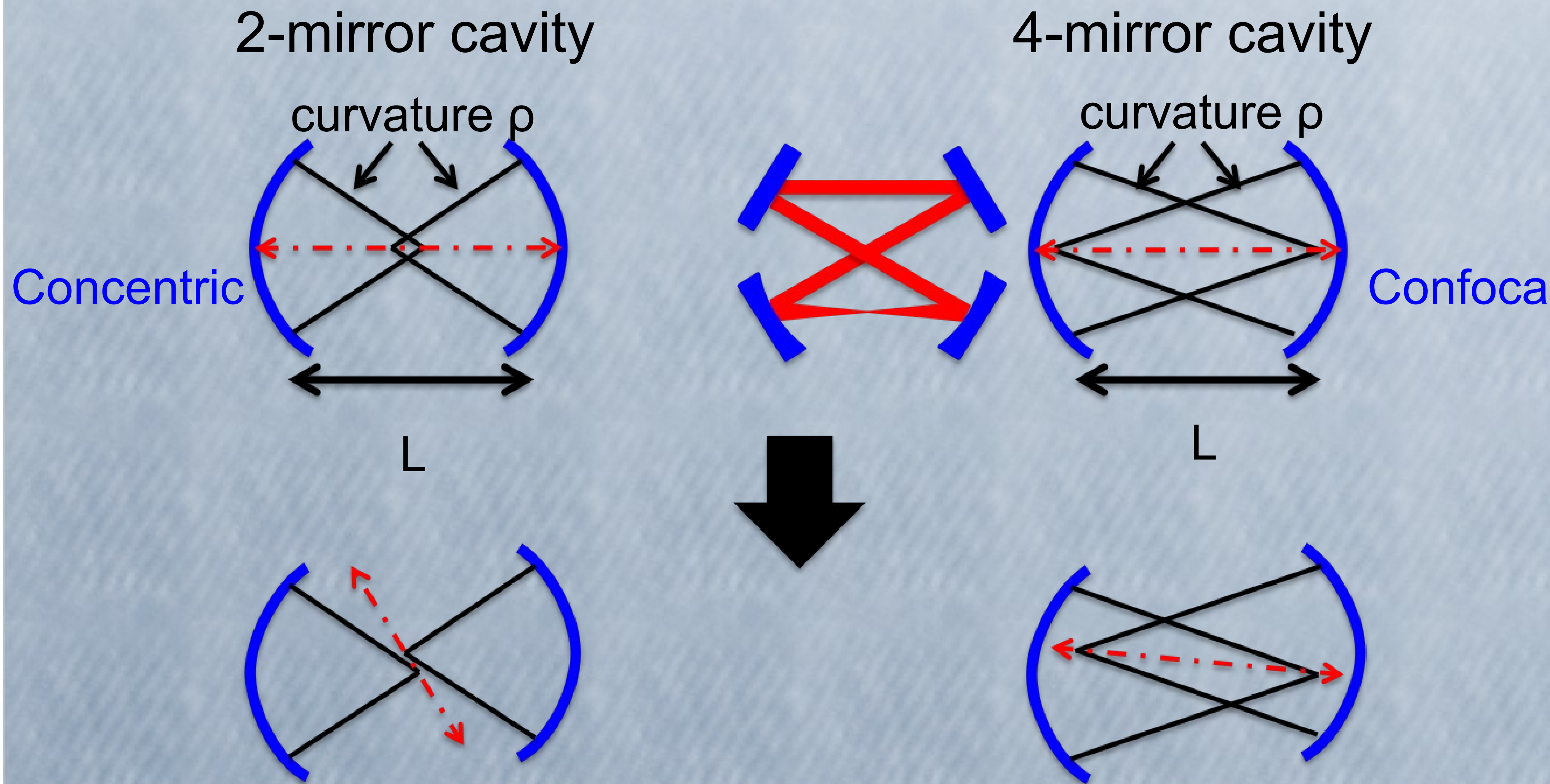
Number of gamma-rays
10photons / bunch / crossing



Next step

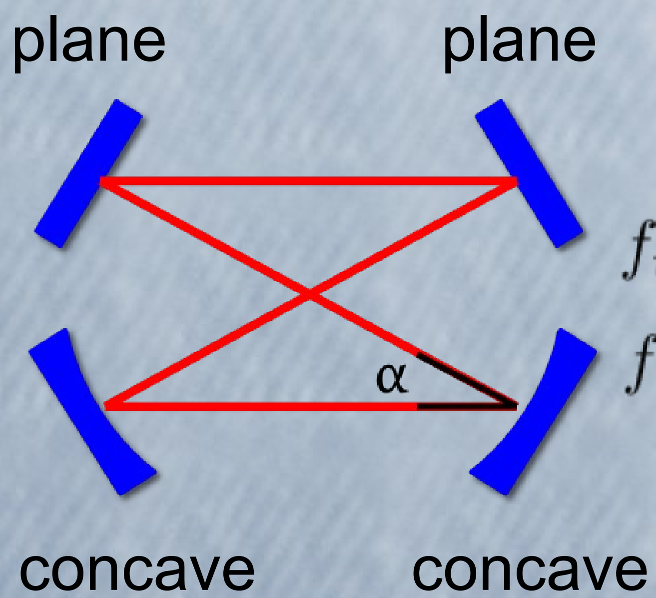
Smaller waist size
More enhancement

2 -> 4-mirror cavity



4-mirror cavity is stable with a small spot size

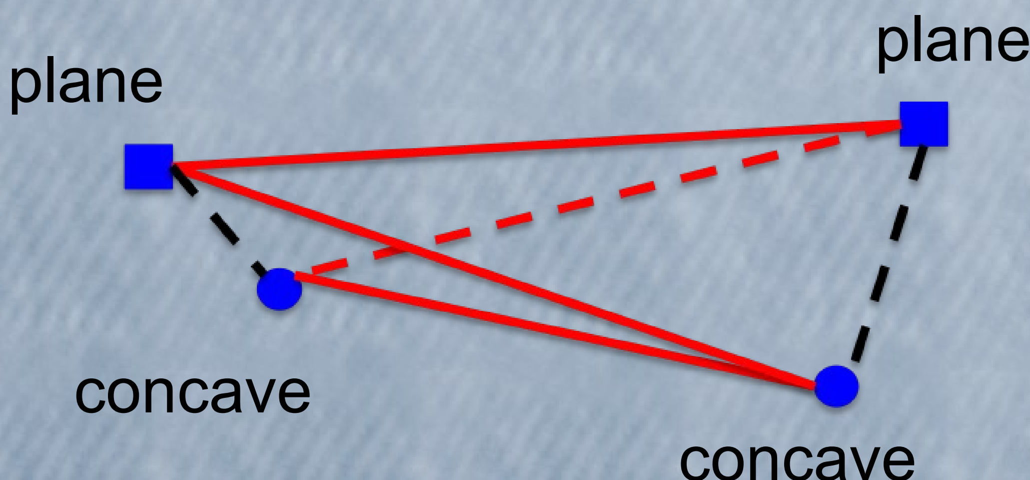
Why 3D 4-mirror cavity?



$$f_t = \frac{\rho}{2}\cos(\alpha/2)$$

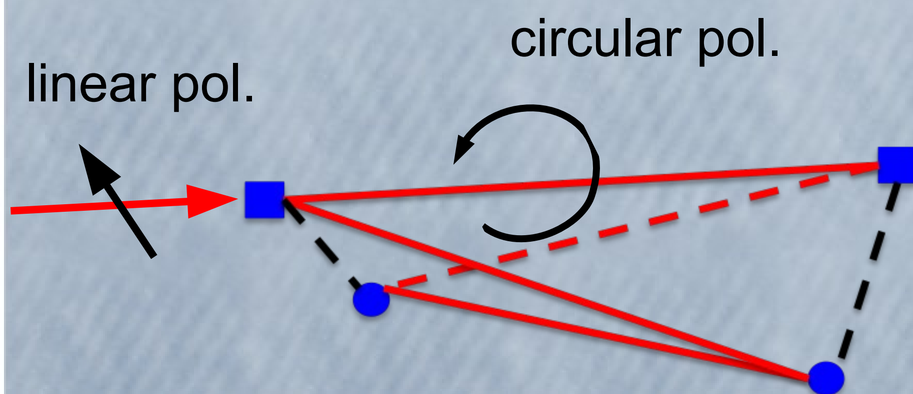
$$f_s = \frac{\rho}{2\cos(\alpha/2)}$$

2D 4-mirror cavity
has astigmatism

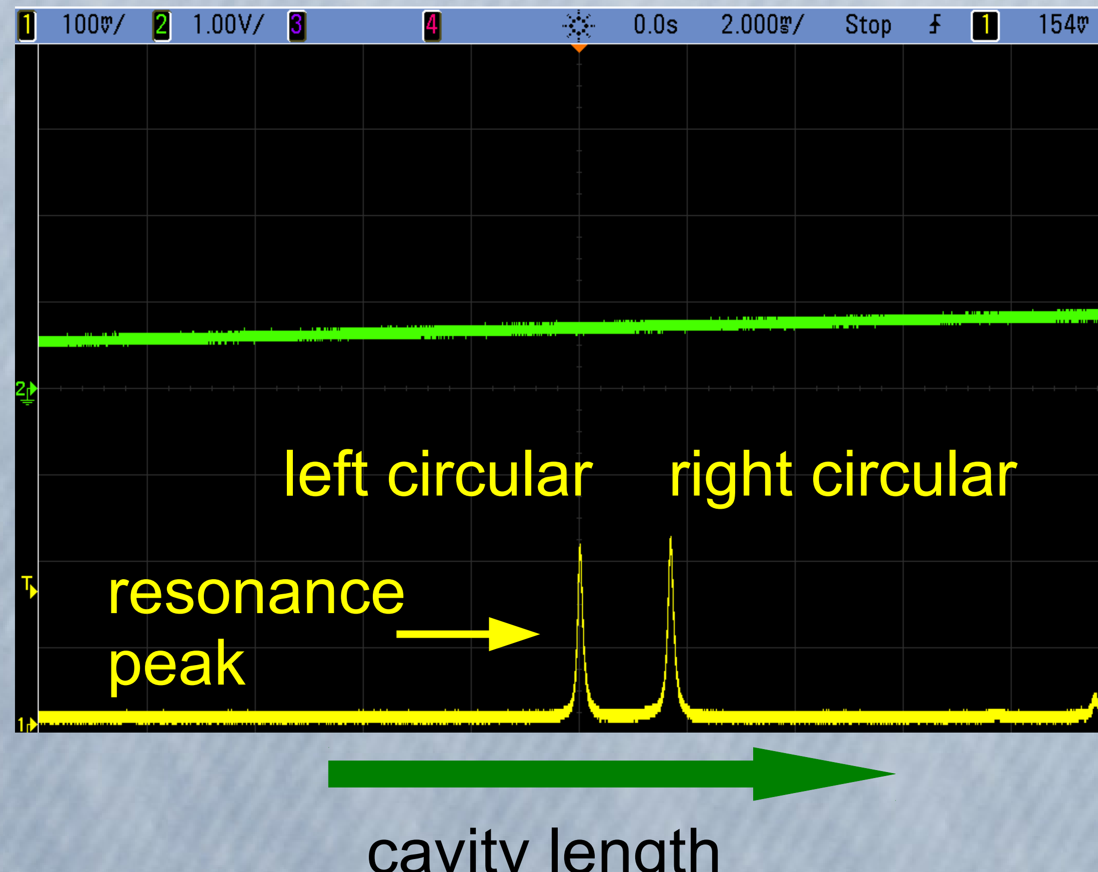


3D 4mirror cavity

Polarization property of 3D 4-mirror cavity

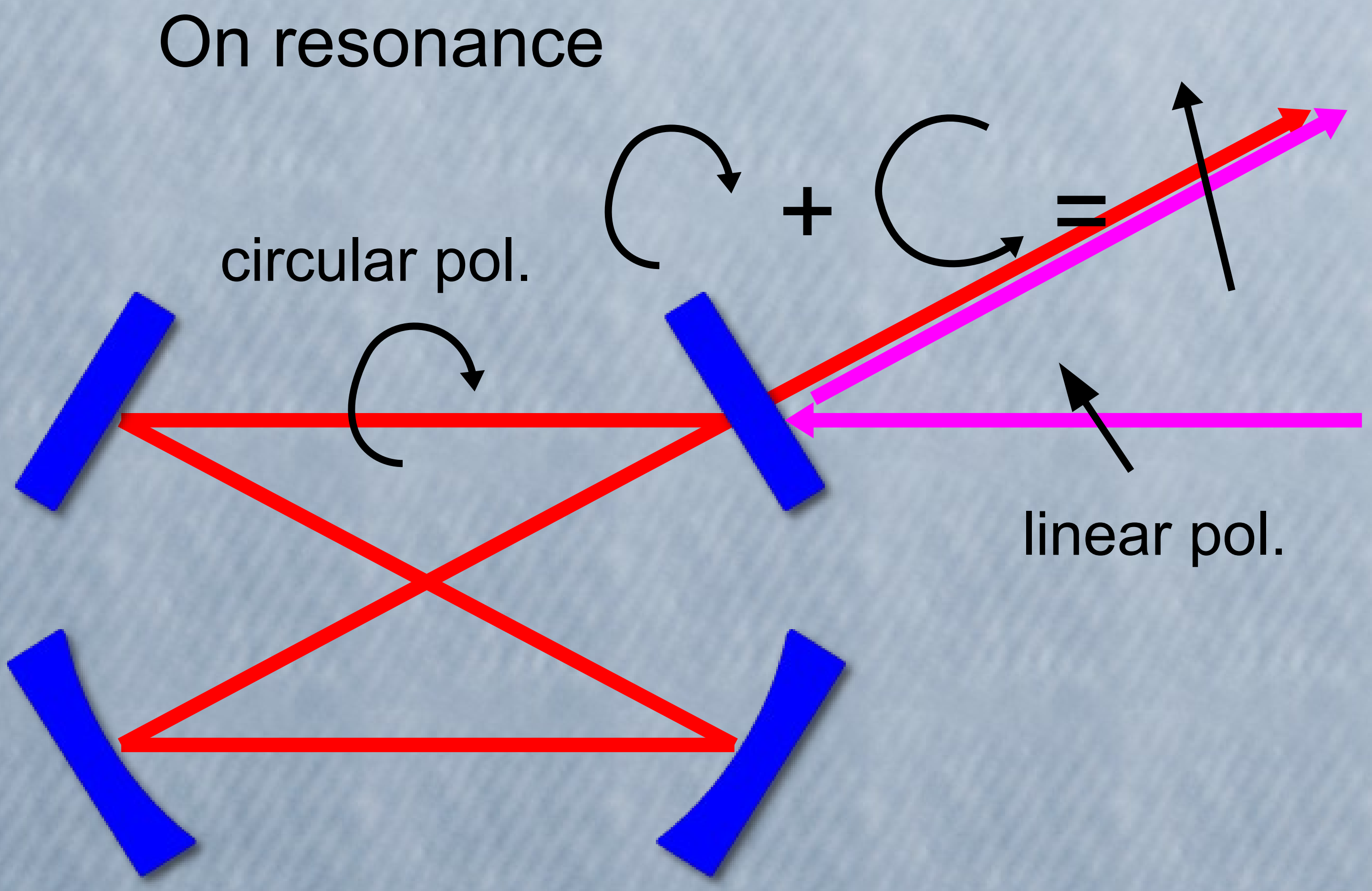


the cavity only resonate
circular polarization

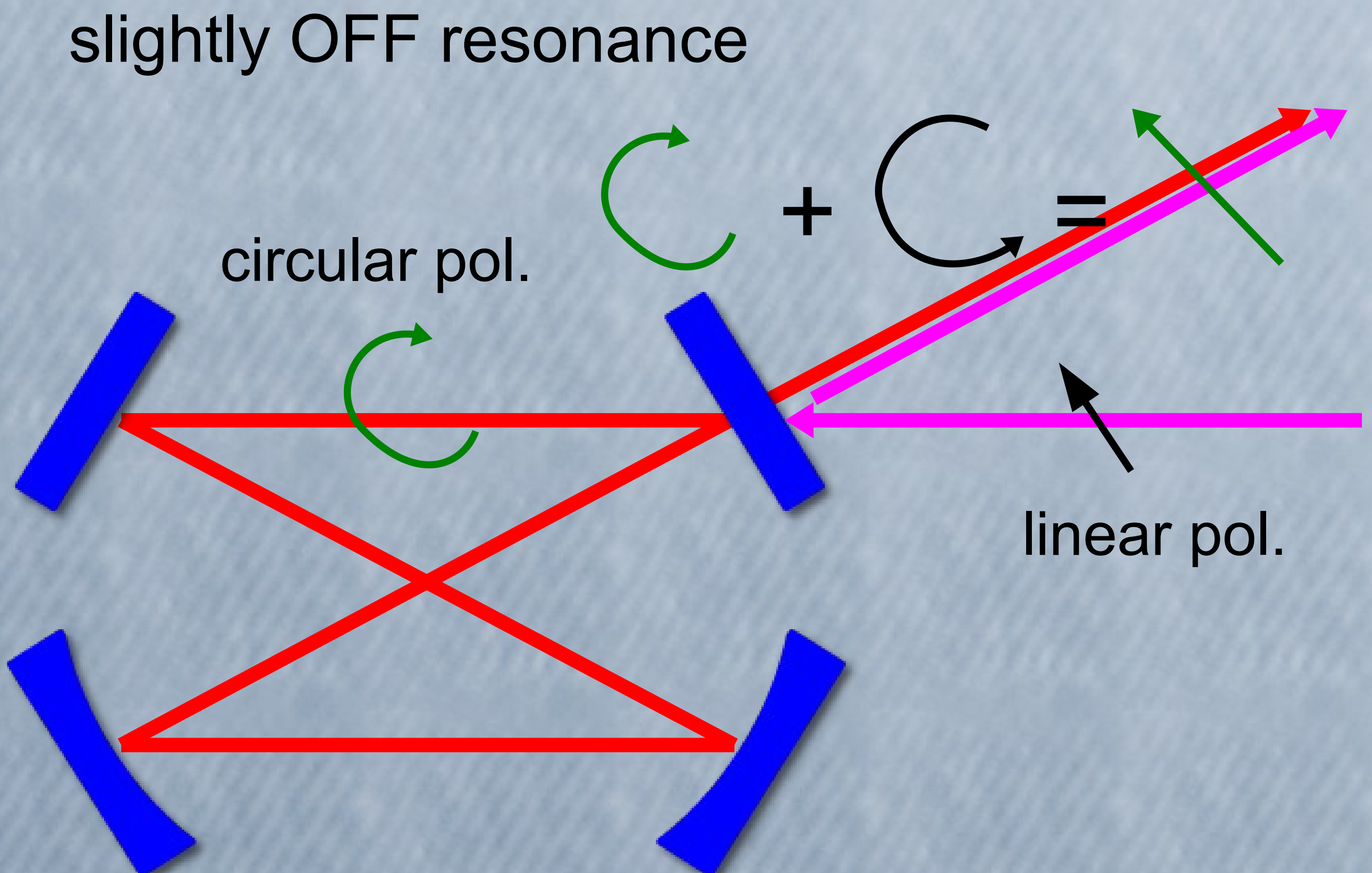


3D 4-mirror cavity has circular polarization dependence due to the rotation of the image.

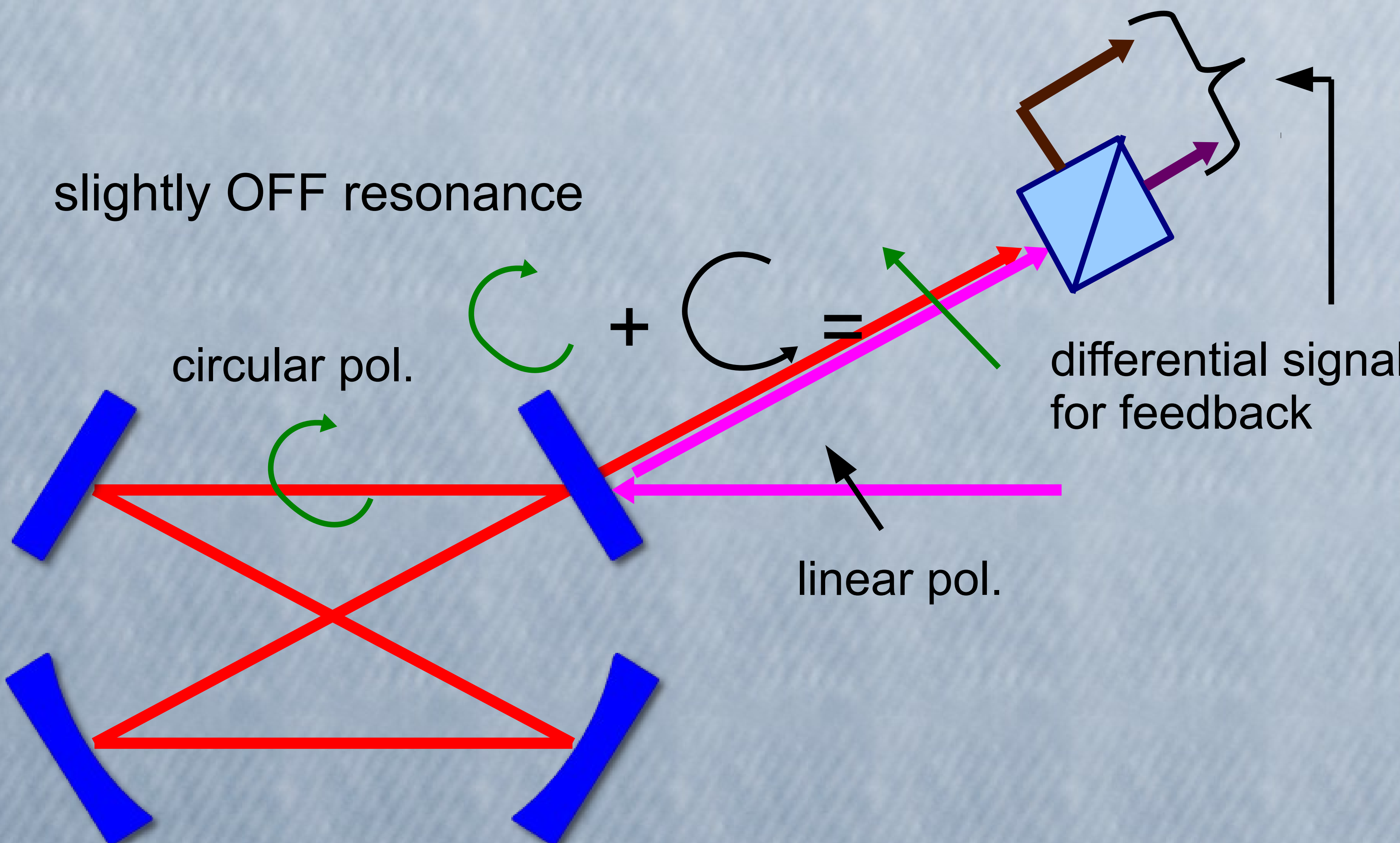
Feedback with 3D feature



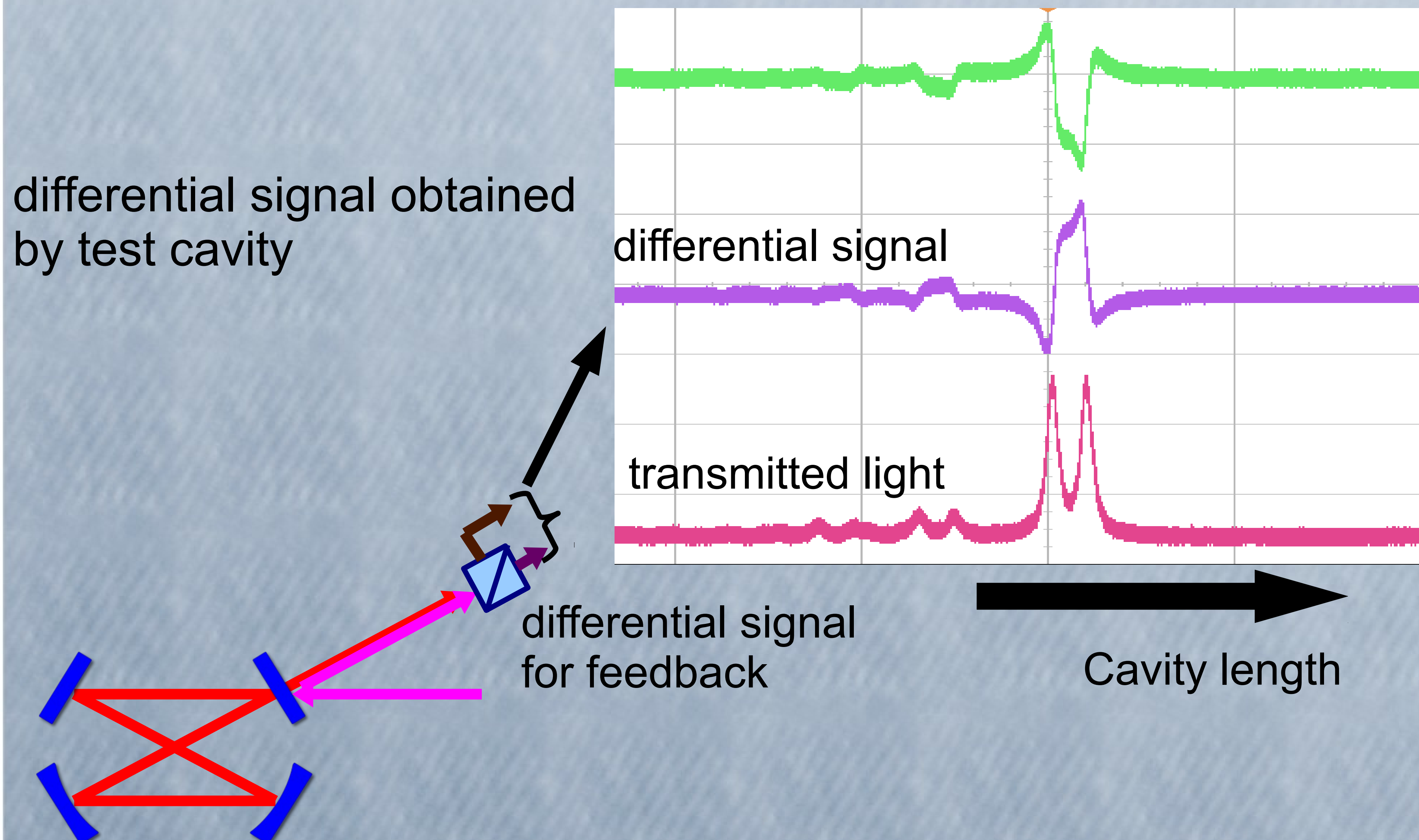
Feedback with 3D feature



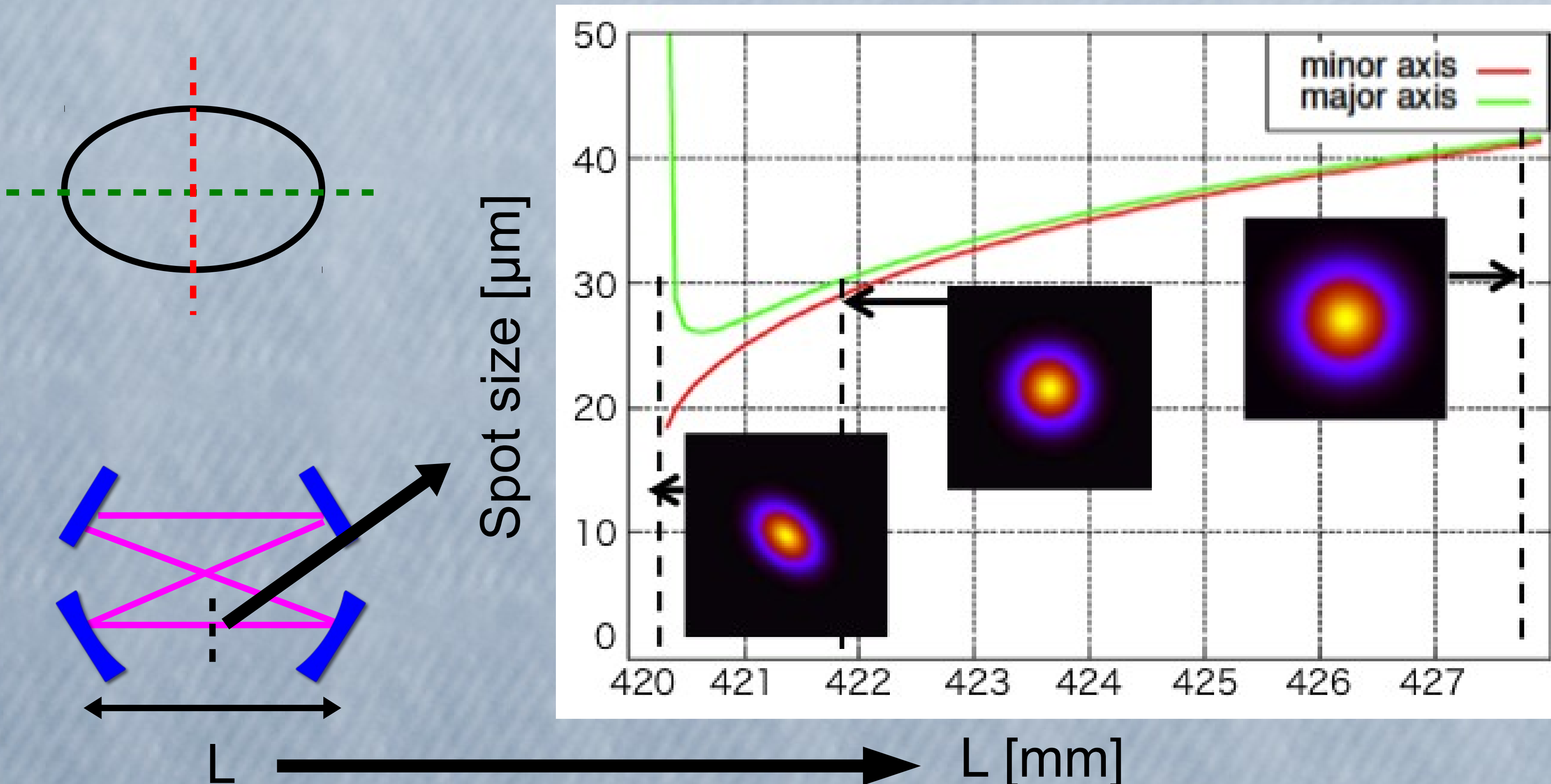
Feedback with 3D feature



Feedback with 3D feature



Calculation of spot size

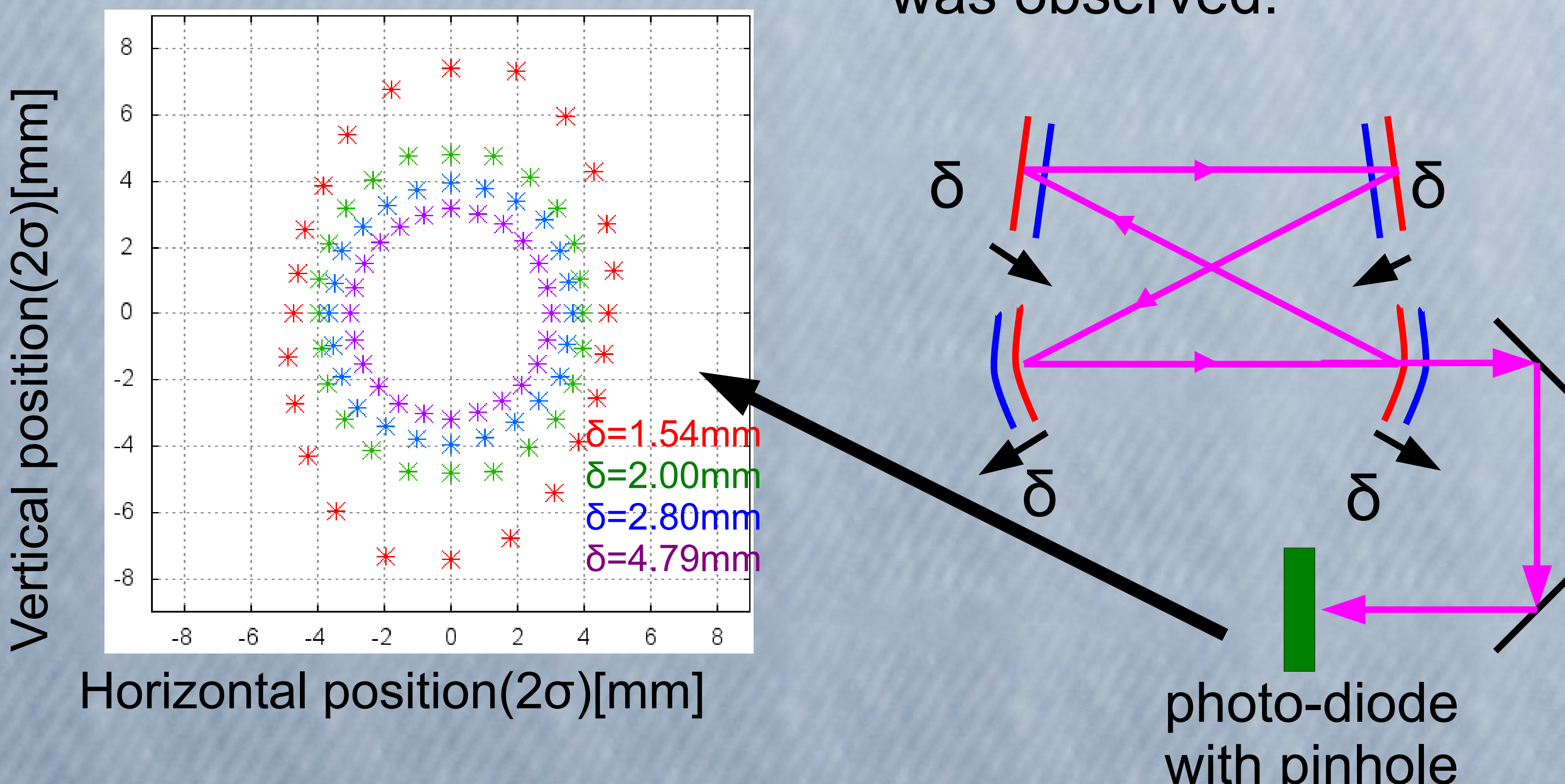


L is small ➡ laser profile is small and ellipse

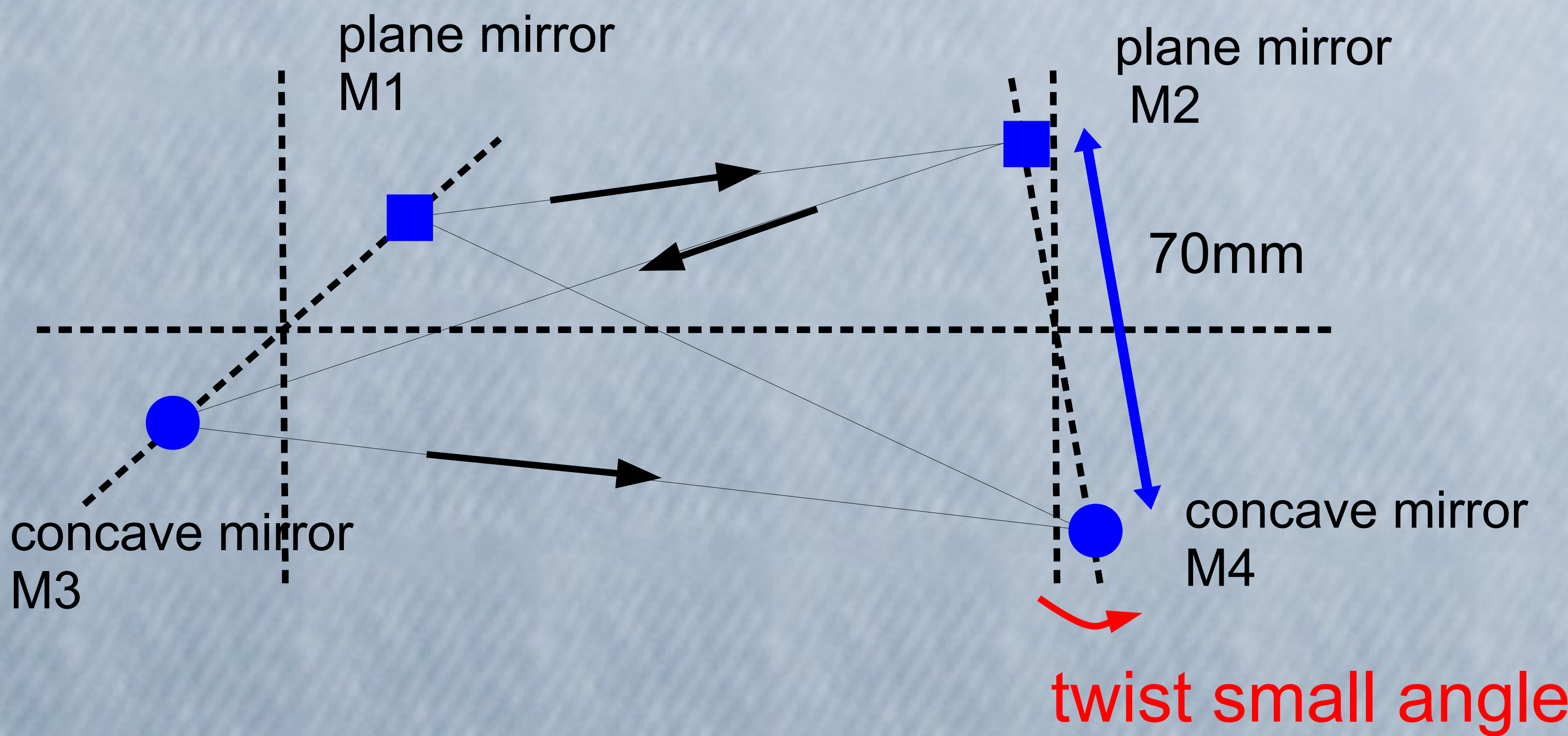
Measurement of transmitted light

Profile of the transmitted light

Elliptical transmitted light was observed.

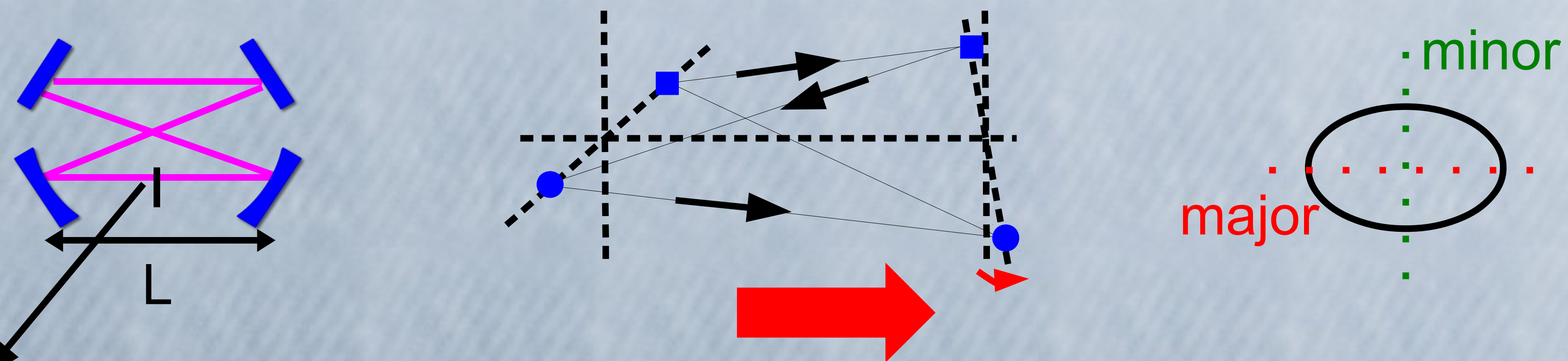


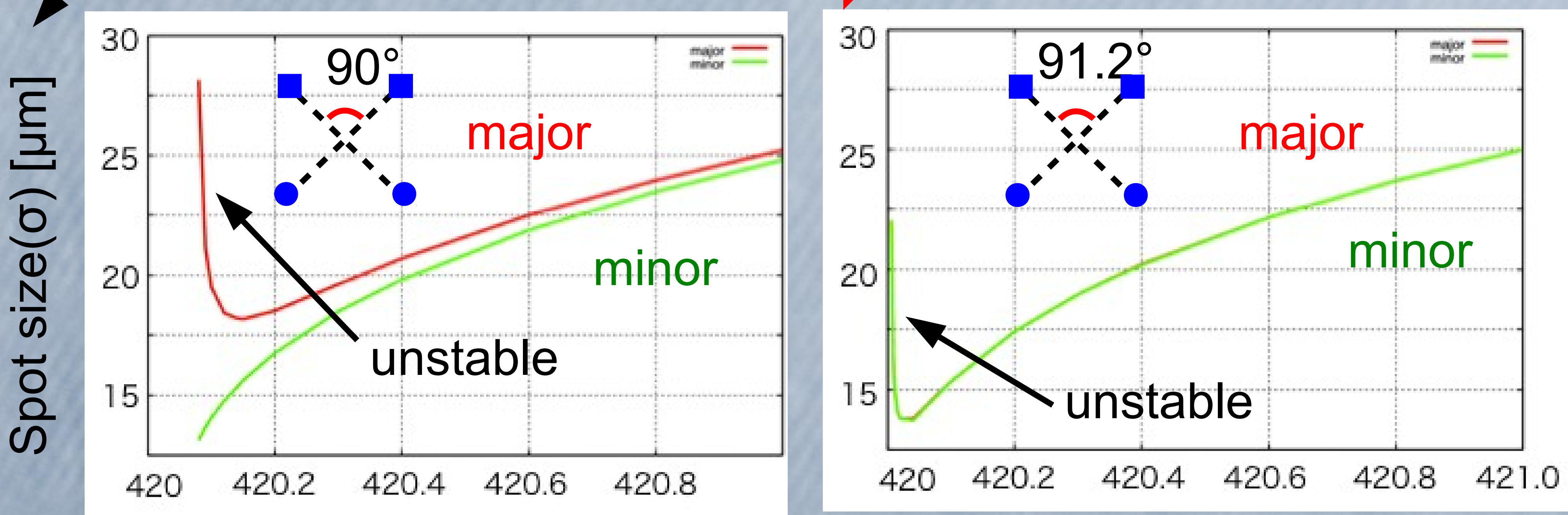
cavity design



L1=M1-M2=420mm M2-M4=70mm
L2=M2-M3=420mm M1-M3=70mm
L3=M3-M4=420mm
L4=M4-M1=420mm

Model calculation of spot size



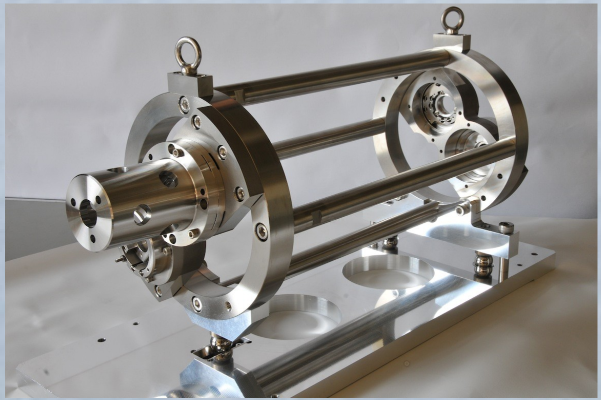


L [mm]

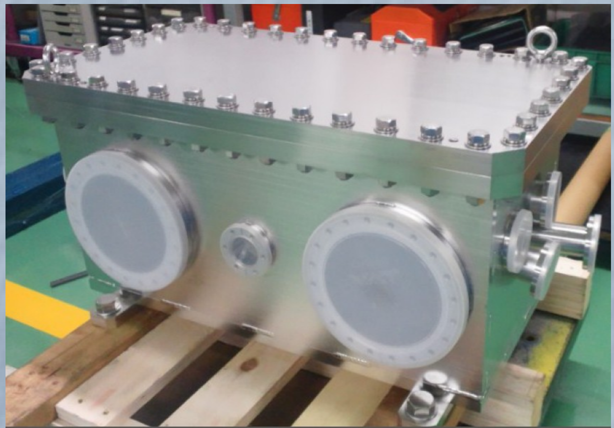
It can acheve
the small spotsize

Preparation of the cavity installation

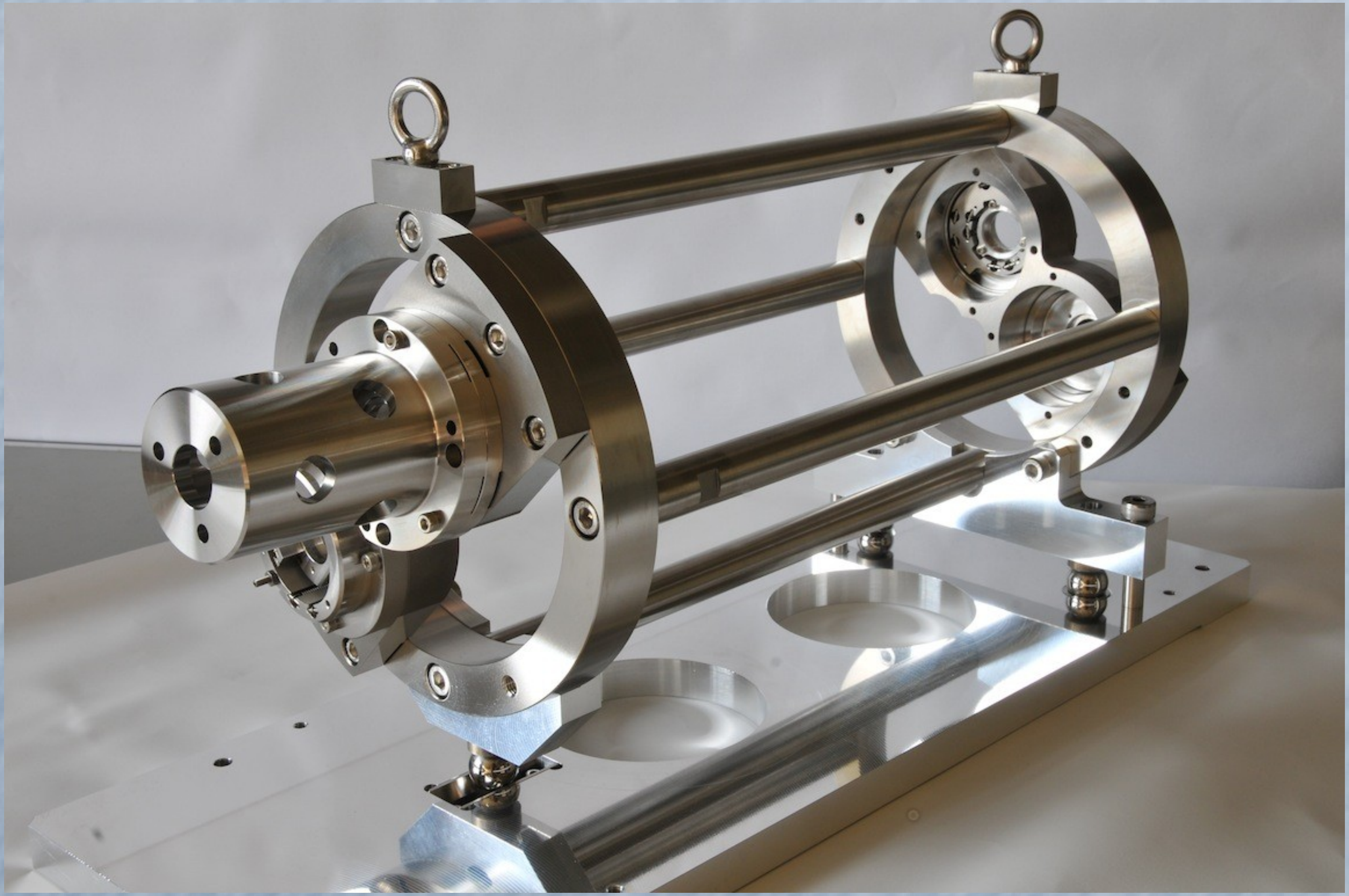
- new 4-mirror cavity
  - High finesse(~5000)
  - injection test in the air



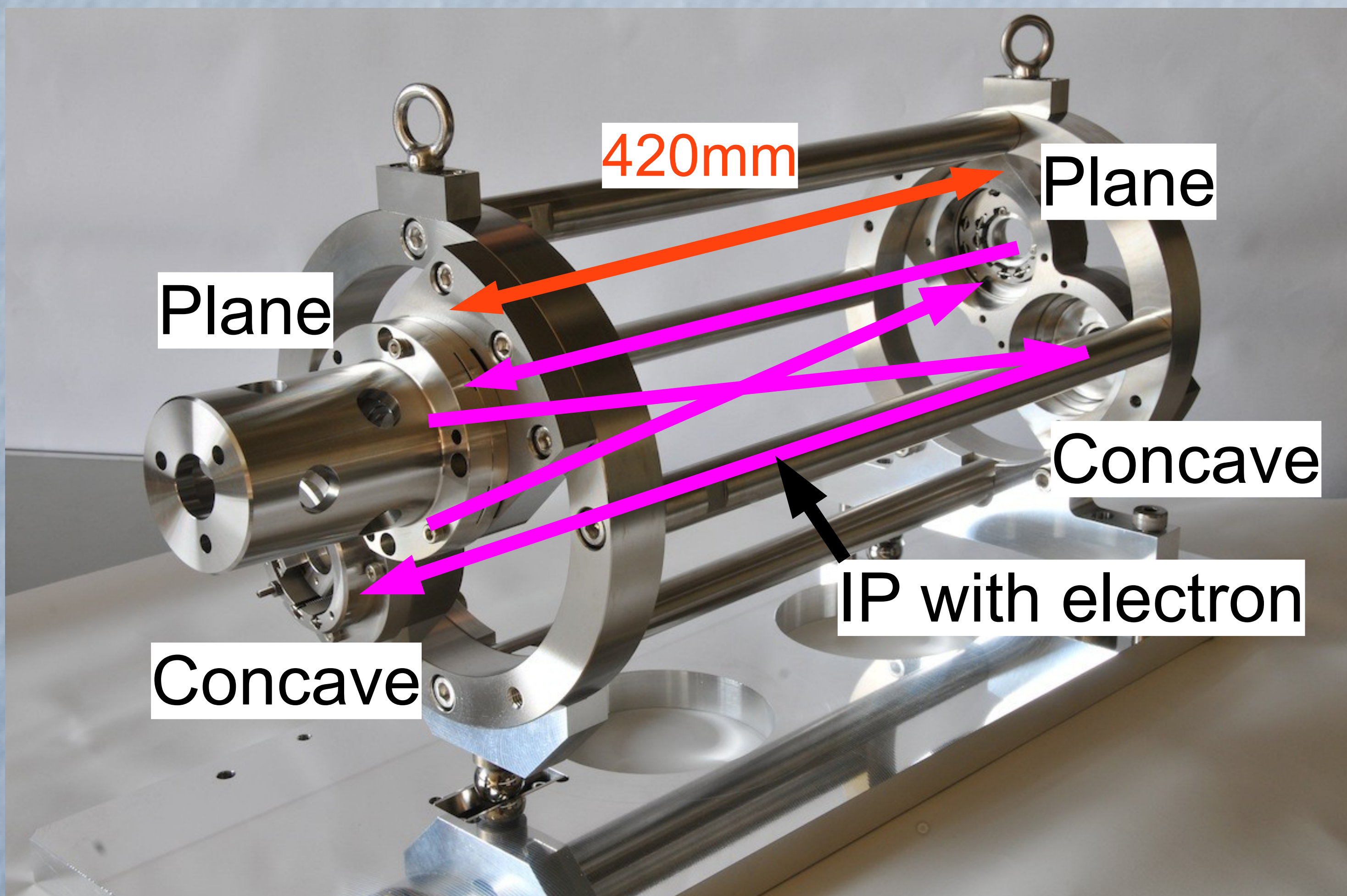
- Vacuum chamber for 4-mirror cavity
  - pre-install near ATF beam line

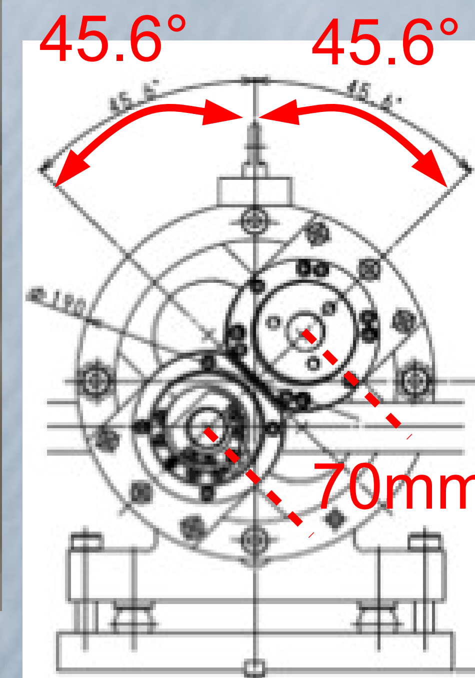


3D 4-mirror cavity



3D 4-mirror cavity

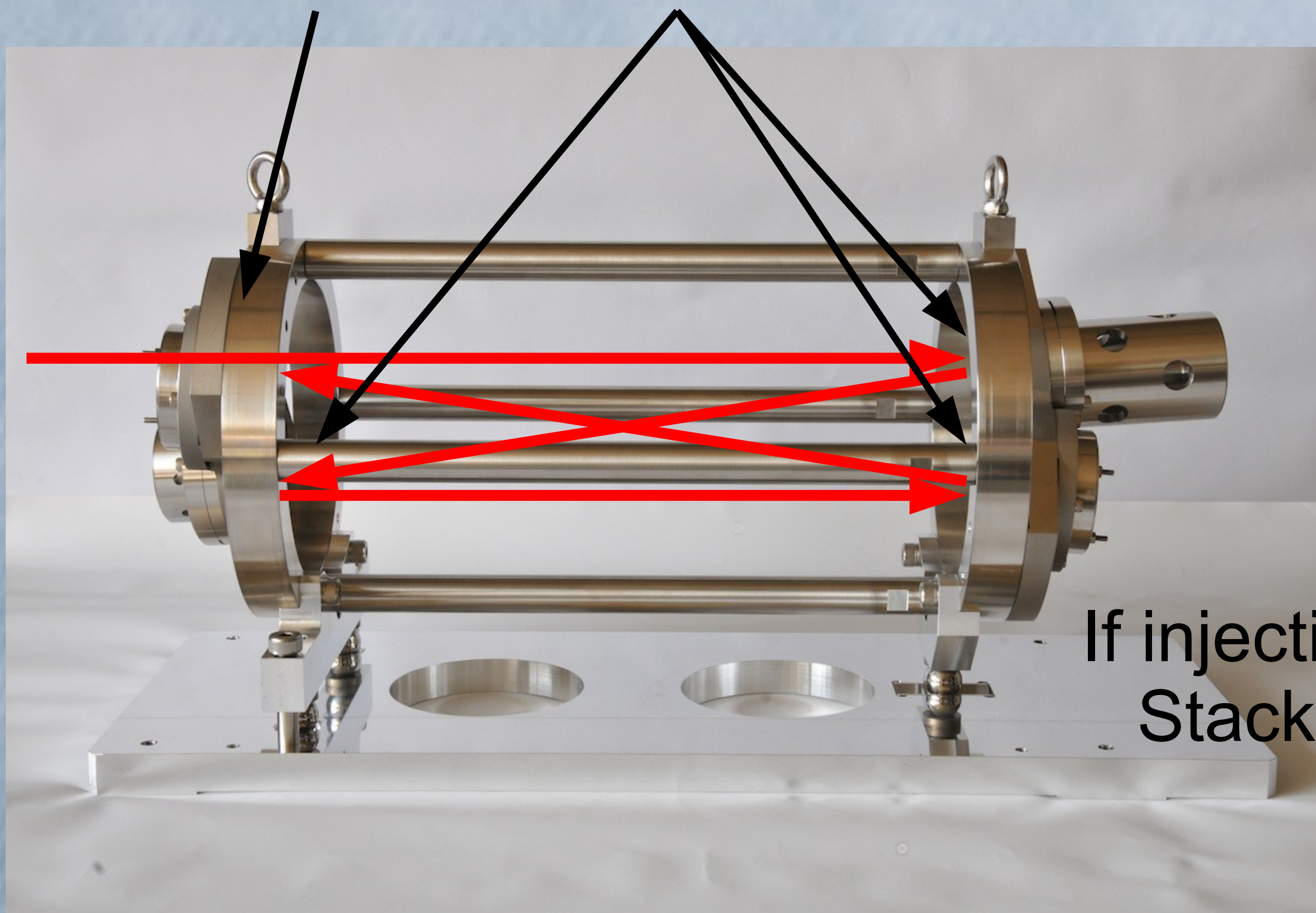




Total cavity length 1680mm

parameters of 4-mirror cavity

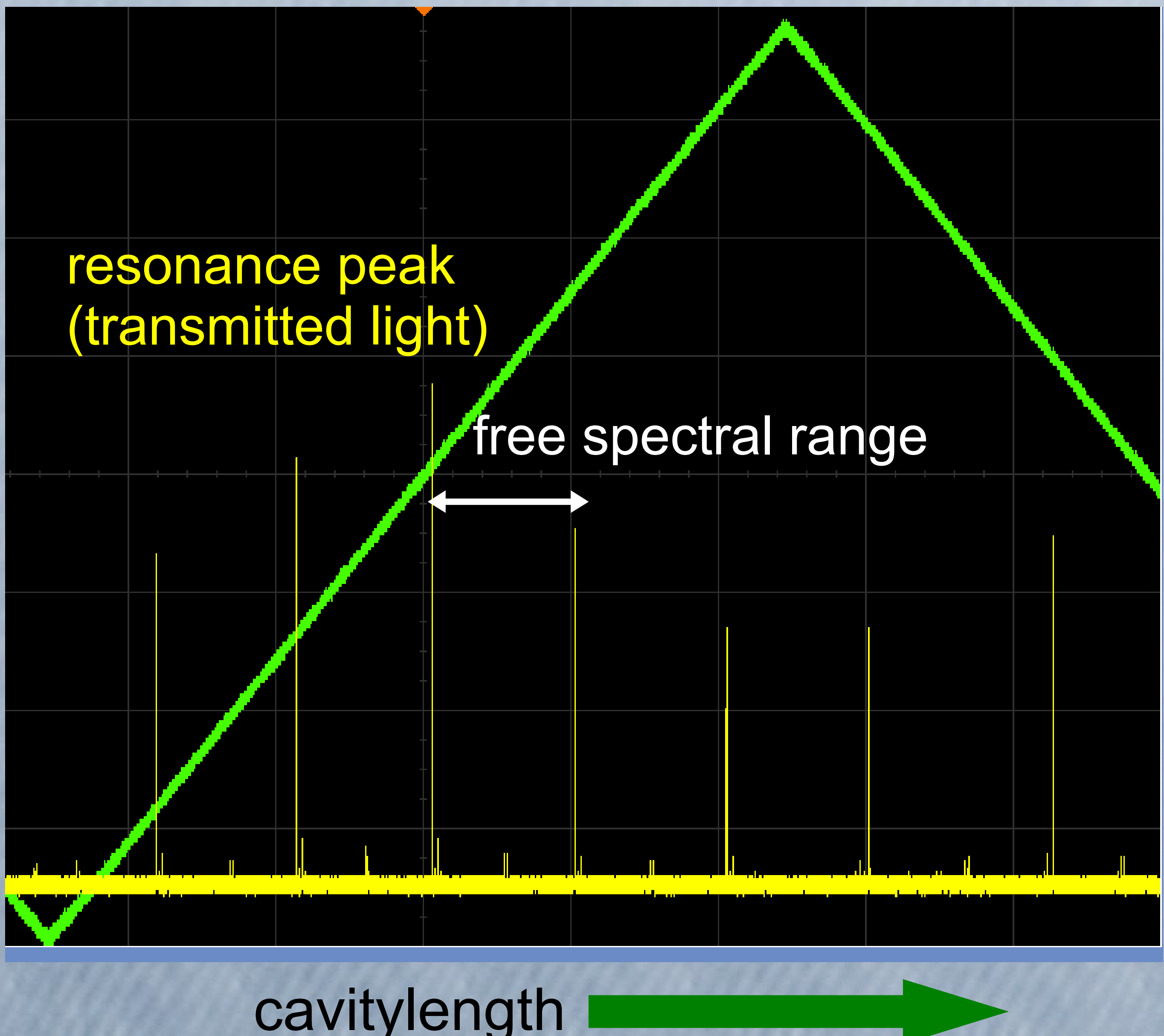
R1	R2,R3,R4	Finesse	Enhacement
99.90%	99.99%	4830	1890



R1,R2,R3,R4
reflectivity of mirror

If injection power is 10W
Stacking laser power
~19kW

4-mirror cavity test



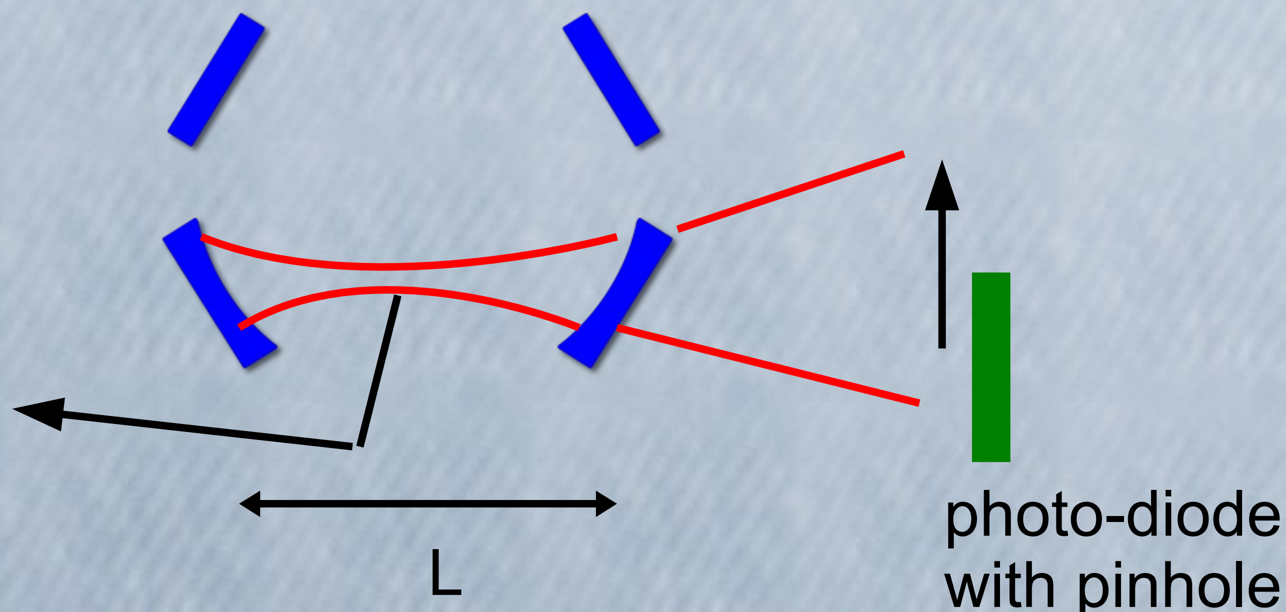
Finesse
5800±800

consistent with
reflectivity of mirrors

spot size measurement

calculated from
beam divergence

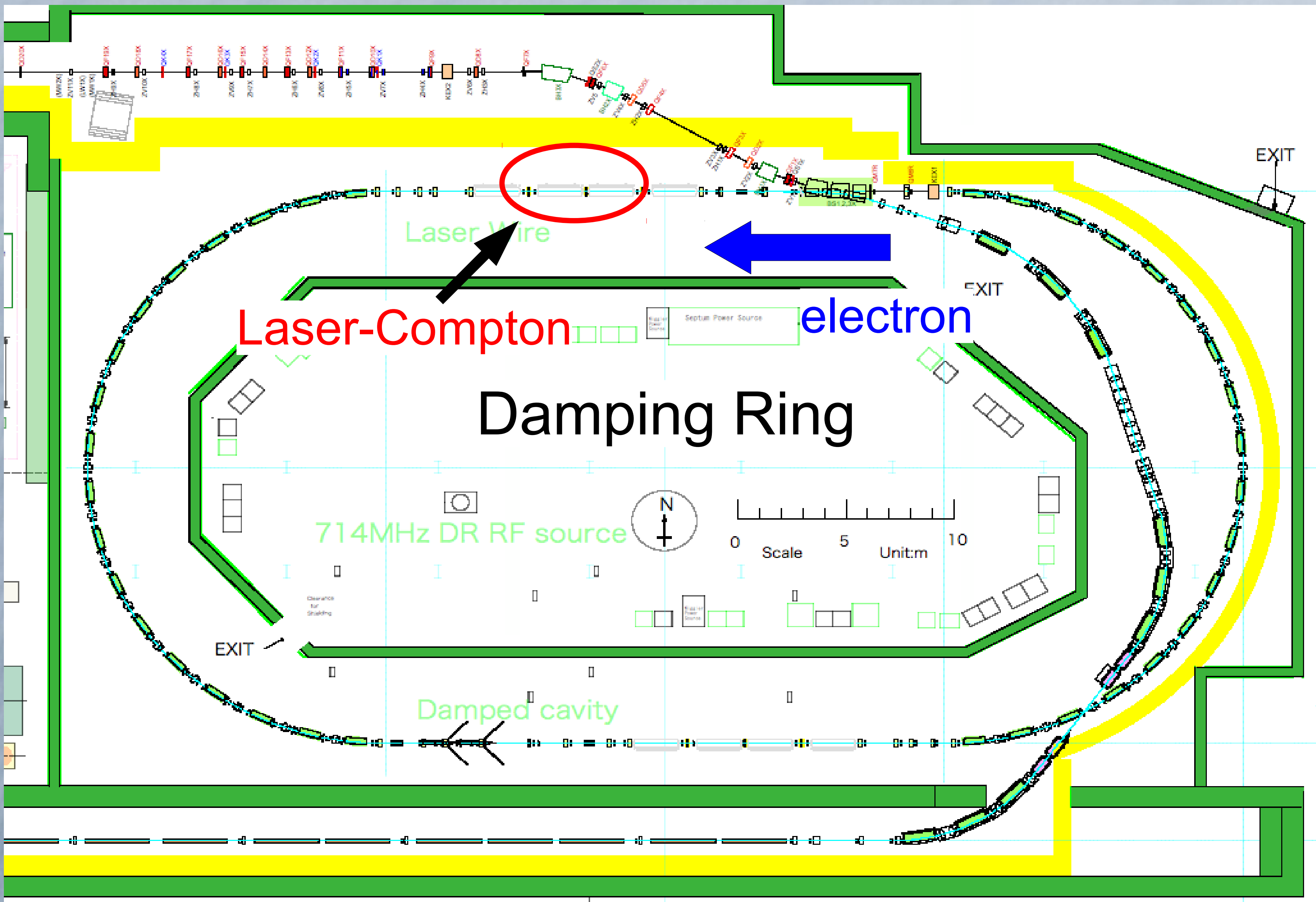
$w_x(1\sigma)$ = 20±2 μm
$w_y(1\sigma)$ = 27±3 μm



Reason

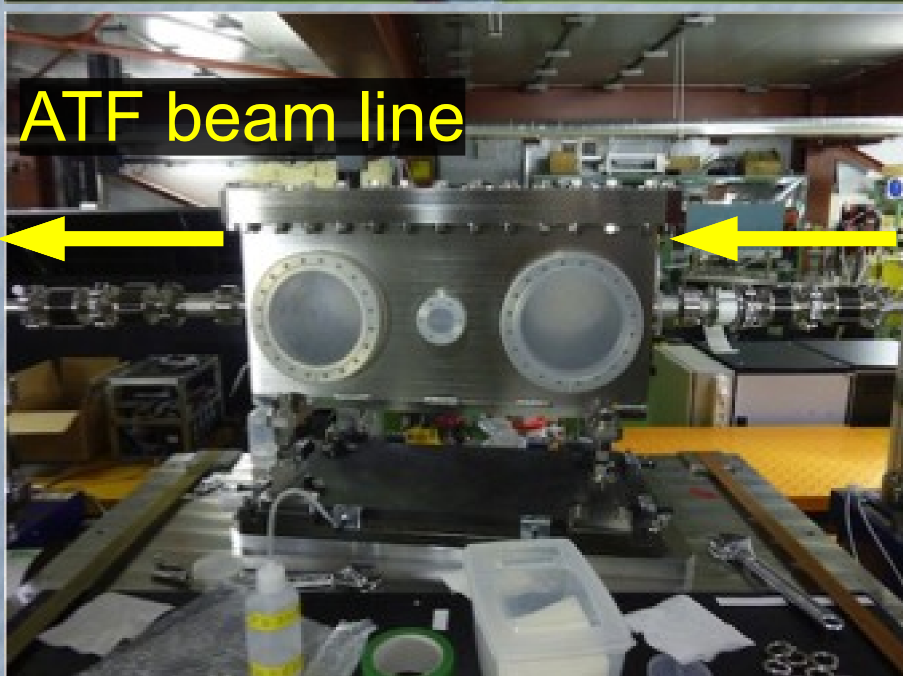
L and mirror alignment of mirrors are not perfect.
Need more tuning.

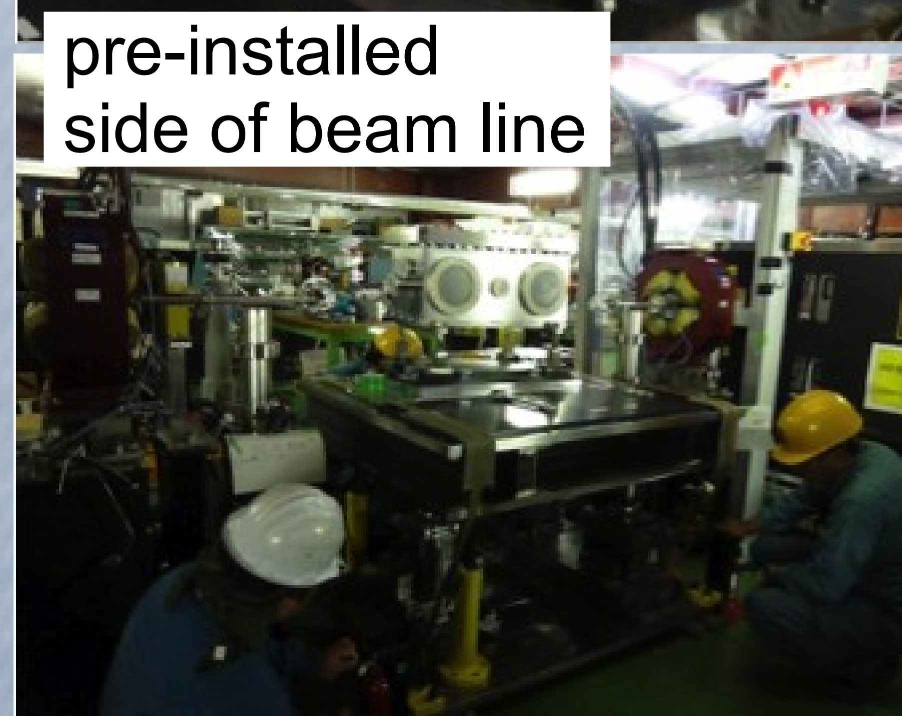
KEK-ATF



EXIT
EXIT
Laser Wire
Laser-Compton
electron
Damping Ring
714MHz DR RF source
N
0
Scale
5
Unit:m
10
EXIT
Damped cavity

Vacuum chamber pre-install@KEK-ATF



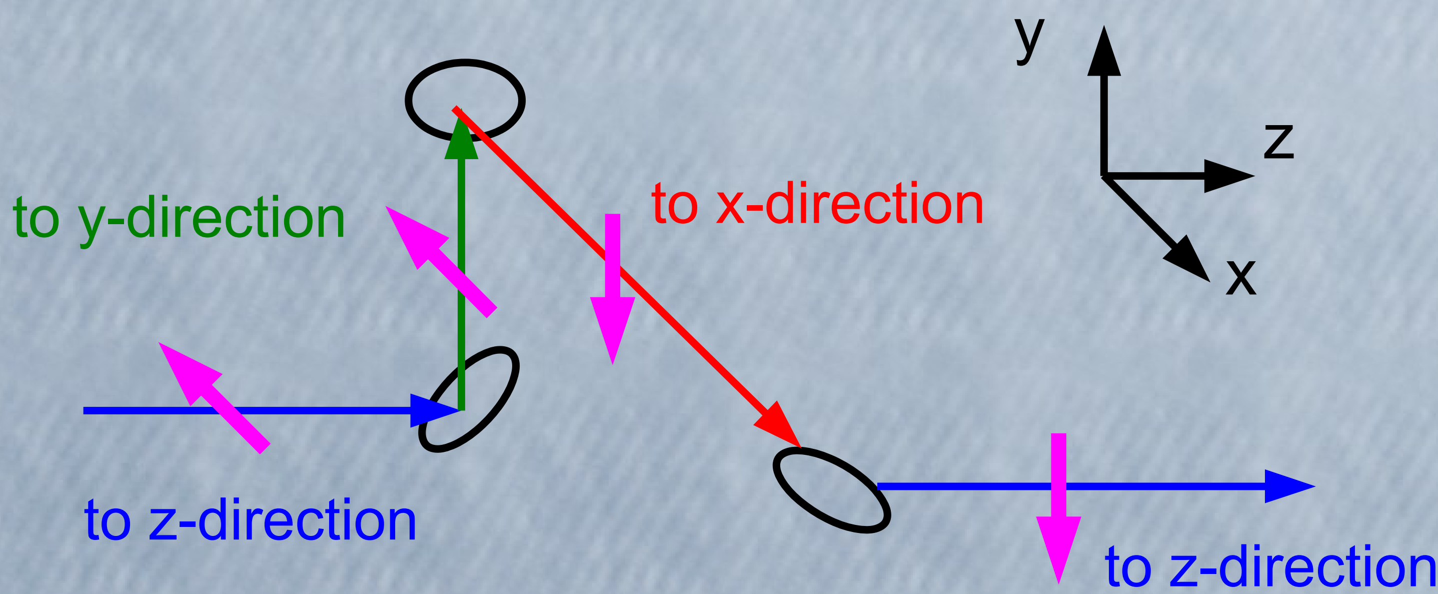


Summary

- We are developing 3D 4-mirror cavity for high intense gamma rays generation by laser-Compton.
- Installation preparing is going on with new 4-mirror cavity.
- Installation plan this October

Rotation of the image

The image rotates
in the three-dimensional optical path.

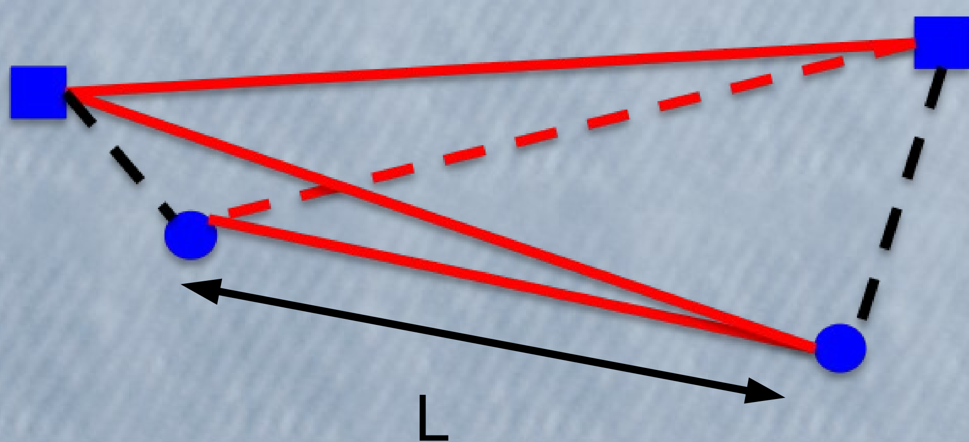


An example of the rotation of the image

Calculation of light propagation

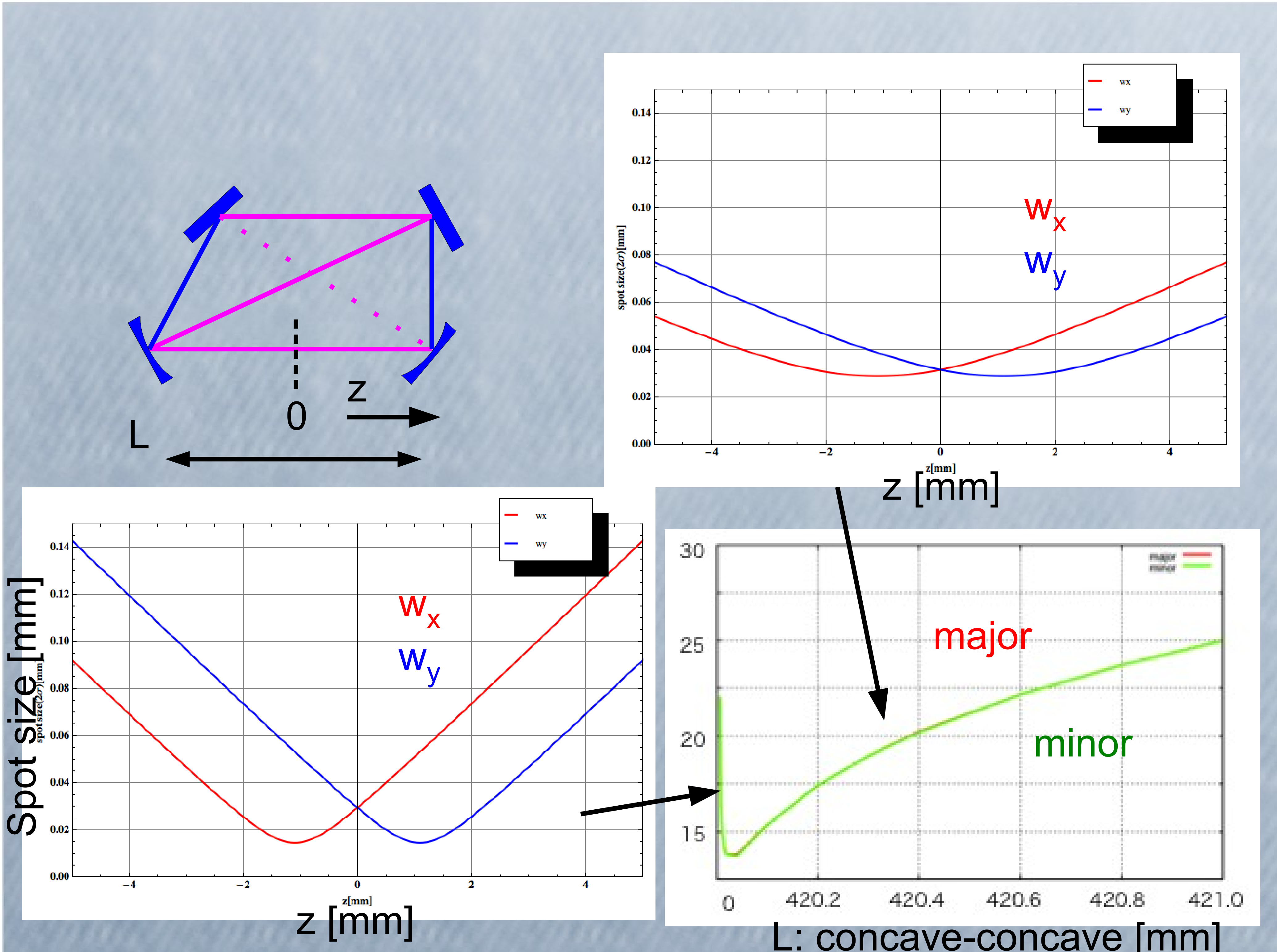
M(z):Transfer matrix of a single roundtrip

$$M(z) = D(L/2+\delta+z)\cdot R(\theta)\cdot F(f_t, f_s)\cdot R(\theta)\cdot R(\theta)$$
$$\cdot D(3L-2\delta)\cdot R(\theta)\cdot F(f_s, f_t)\cdot D(L/2+\delta-z)$$



D(L):Drift space
F :Concave mirror
R(θ):Image rotation

Laser spot size depends on geometry of the mirrors


L
0
z
wx
wy
w_x
w_y
spot size(2σ)[mm]
z[mm]
z [mm]
Spot size [mm]
major
minor
L: concave-concave [mm]