IMPROVEMENT OF SCREEN MONITOR WITH SUPPRESSION OF COHERENT-OTR FOR SACLA

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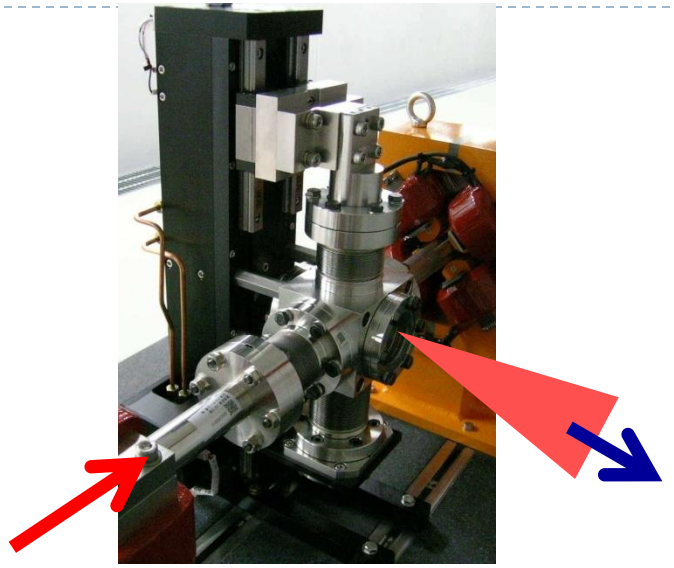
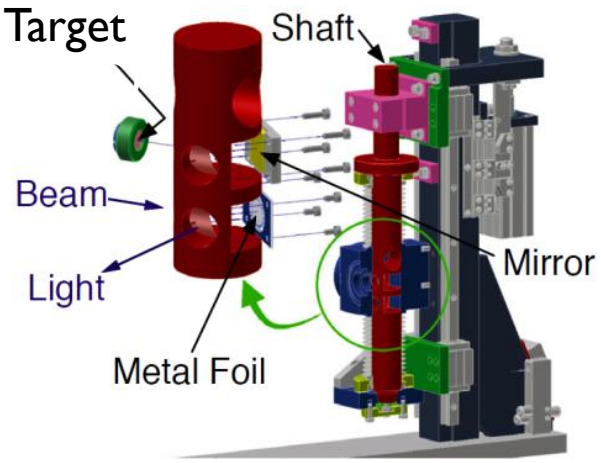
Outline

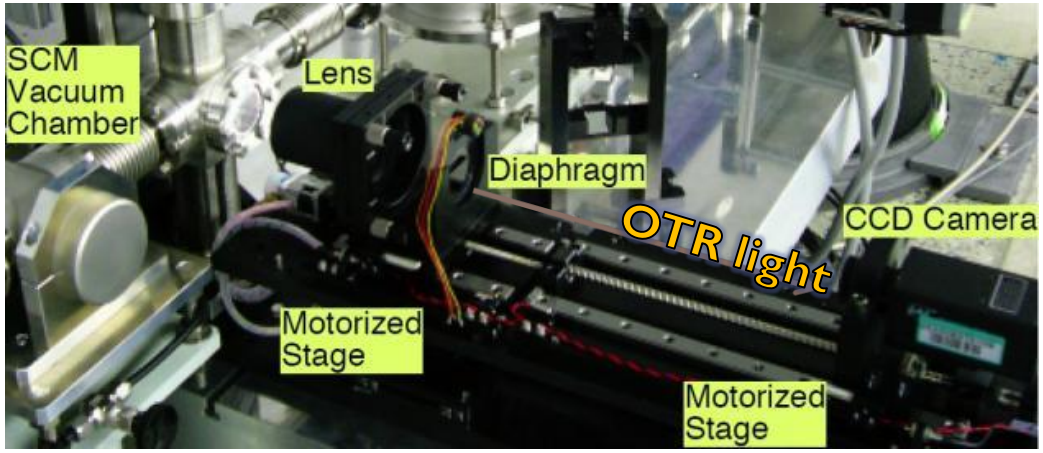
- State of profile monitors in SACLA
- Mitigation of the COTR light
- Next mitigation scheme
- Summary

Setup of Profile Monitor (Screen Monitor)

- Ce:YAG and OTR (SUS foil) target was employed.
- Target is mounted on a shaft driven by a pneumatic actuator.
- Custom-made lens system to obtain high spatial resolution.
- Images are taken by a CCD.

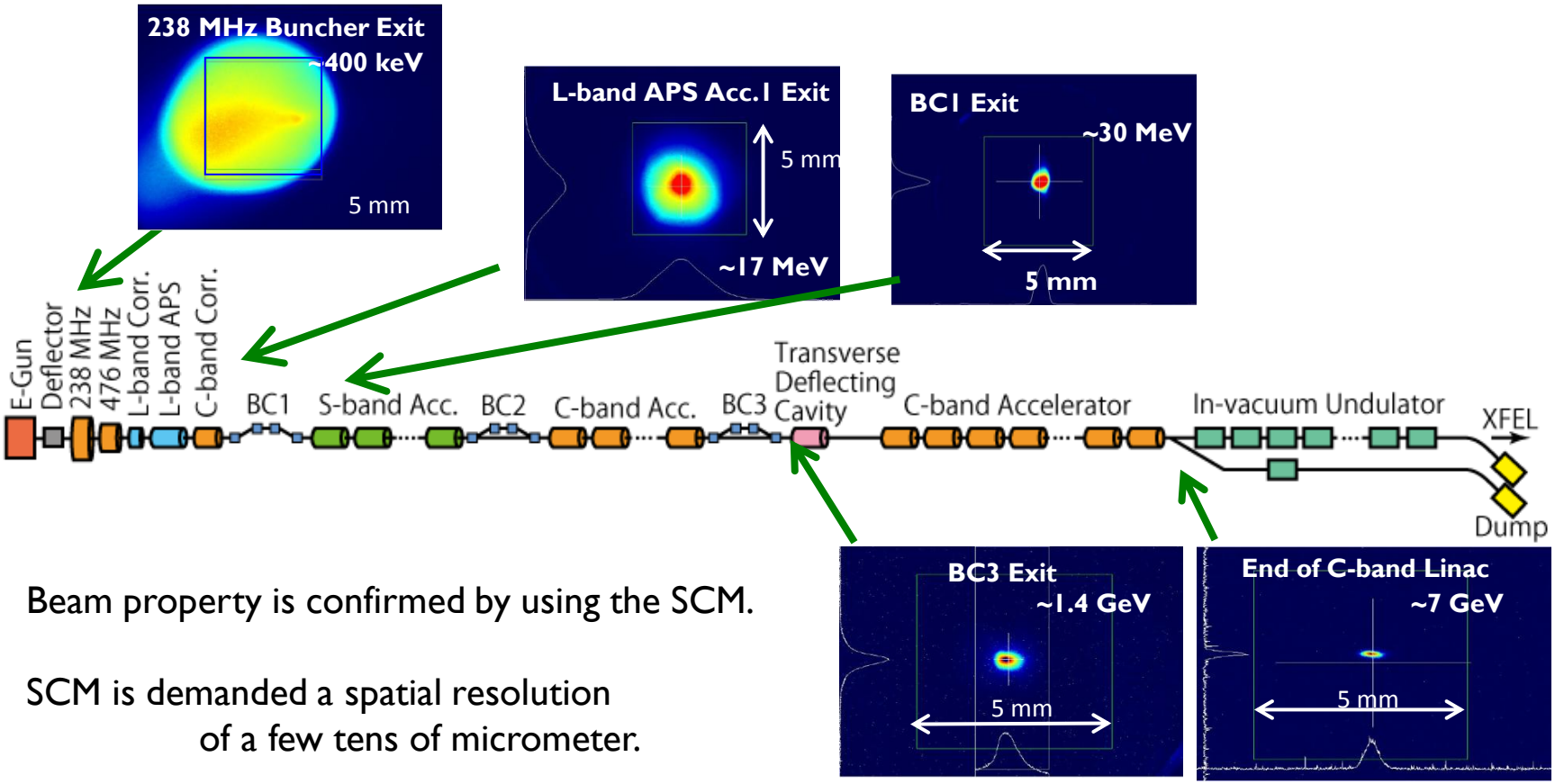






Installed SCMs along Accelerator

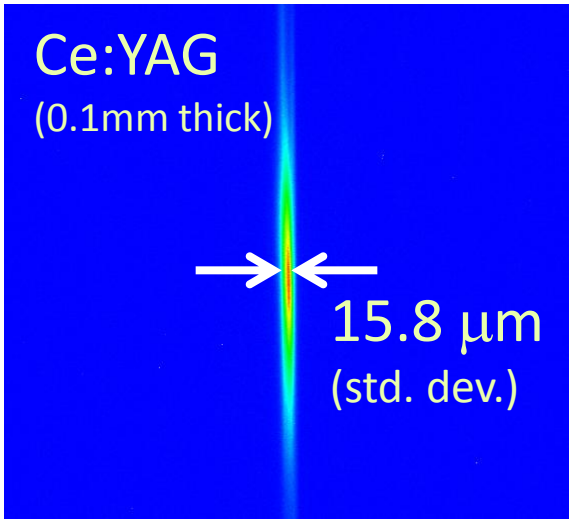
50 SCMs are installed along the accelerator.

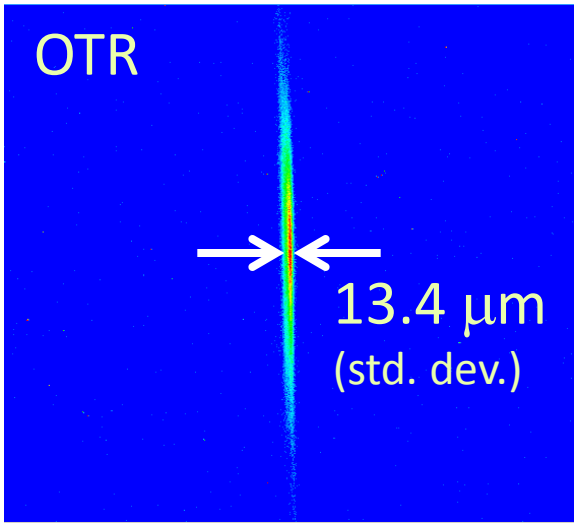


Beam property is confirmed by using the SCM.

SCM is demanded a spatial resolution
of a few tens of micrometer.

Test in SCSS test accelerator





- These images was taken <u>at the SCSS test accelerator</u>
  - Beam energy : 250 MeV
  - Bunch length : 200 fs
  - Focused horizontally with a Q magnet.

Prototype facility of SACLA

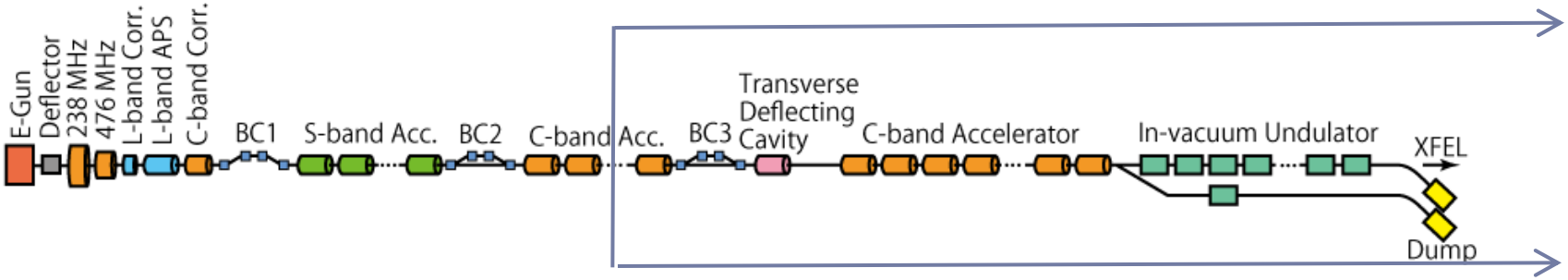
- The beam size of about 10μm (std.dev.) was set.

COTR was not observed at SCSS test accelerator.

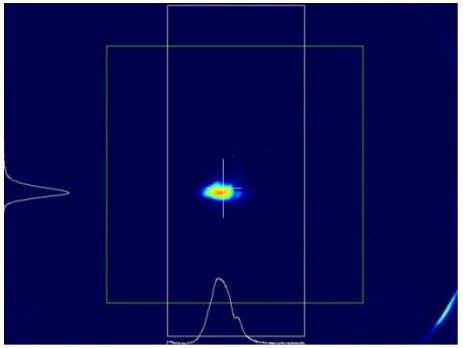
However, the COTR problem was observed in SACLA.

COTR after bunch compressor in SACLA

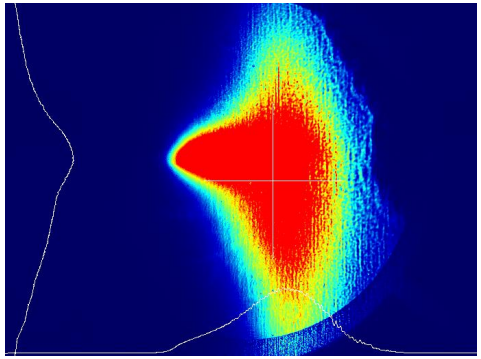
- For the downstream of BC3, COTR was observed on the OTR screen.
- Short-bunch (<100fs) beam produced intense COTR.



OTR



Intense COTR



COTR light made an incorrect beam profile.

Mitigation scheme of the COTR light

Fluorescence light from scintillator has different properties from COTR light in the emission time structure and the angular distribution.

The mitigation of the COTR light is possible to use the different properties.

① Temporal separation method

The technique has been employed at FLASH.

M. Yan et al., "Beam Profile Measurements Using a Fast Gated CCD Camera and Scintillation Screen to Suppress COTR", Proceedings of FEL 11, THPB16 (2011).

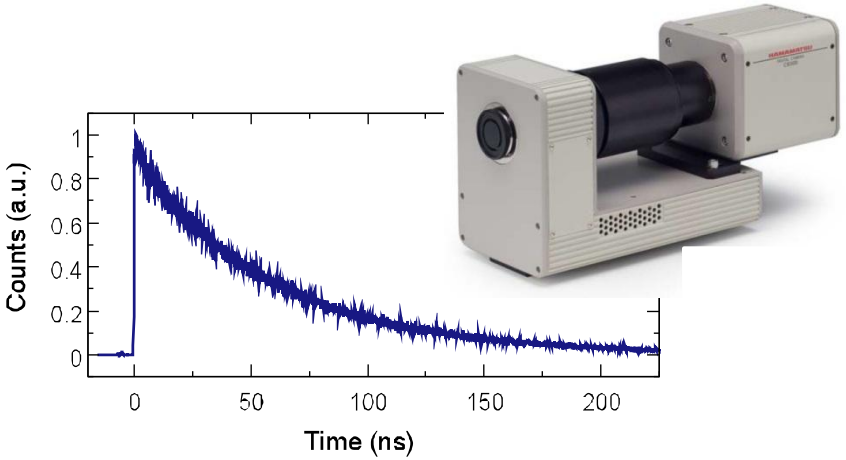
② Spatial separation method

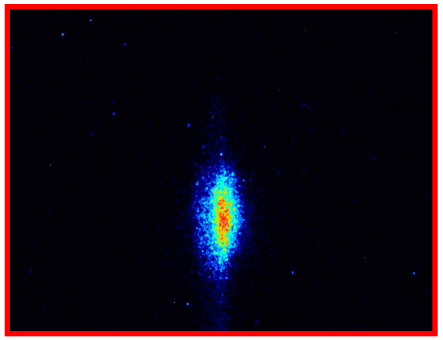
Separation of COTR light in time domain

- Fluorescence time is longer than COTR.
  - Emission time of OTR and COTR : ~ fs
  - Lifetime of Ce:YAG : ~ 60 ns

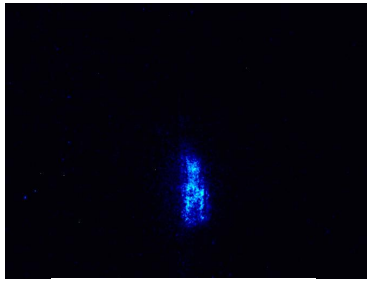
- Using high speed gate CCD camera

Gate time : 5 ns





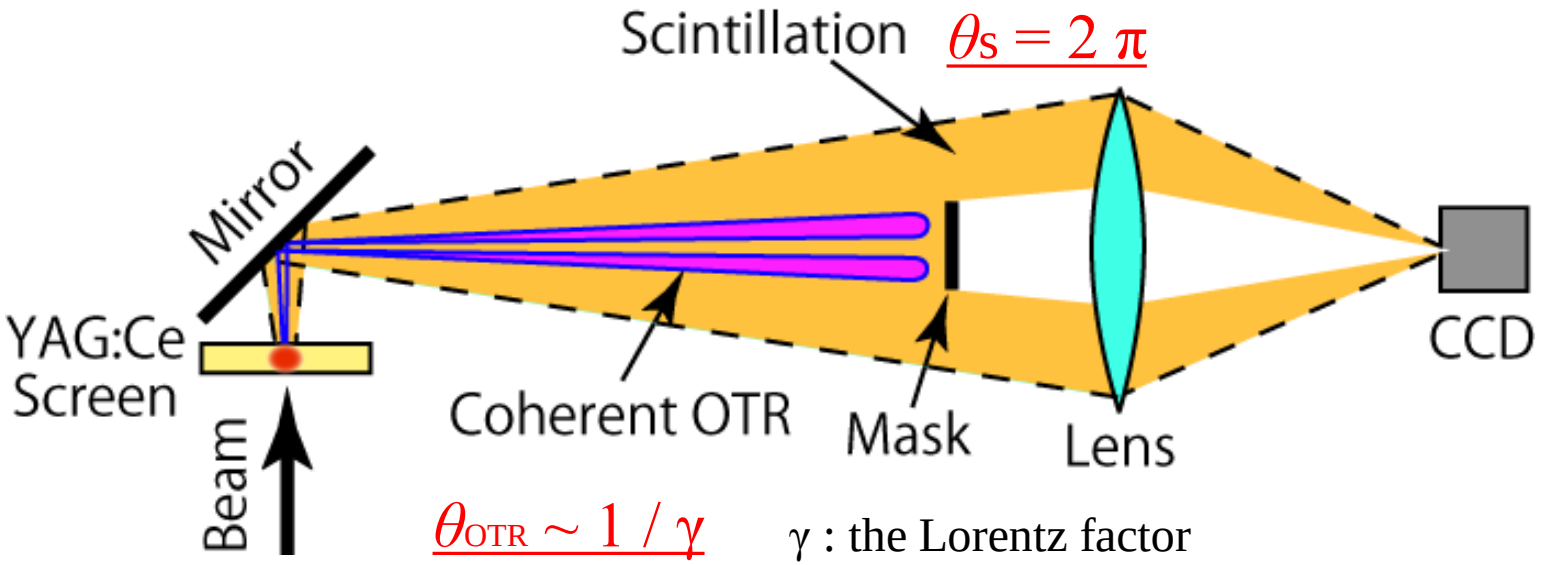
Without COTR



COTR light

- The high speed gate camera is expensive.

Countermeasure against COTR



- Divergence of COTR light is smaller than fluorescence light.

Scintillation light has no angular dependence.

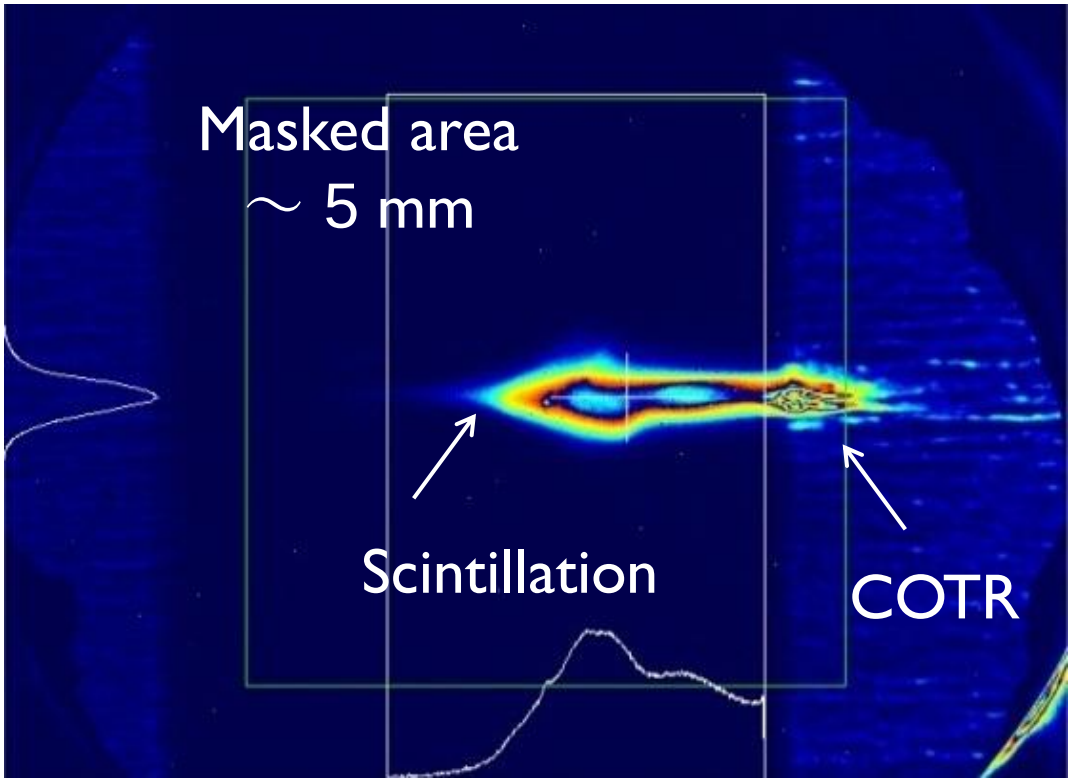
Angular divergence of OTR and COTR light $\theta_{OTR} < 0.5$ mrad @ >1 GeV

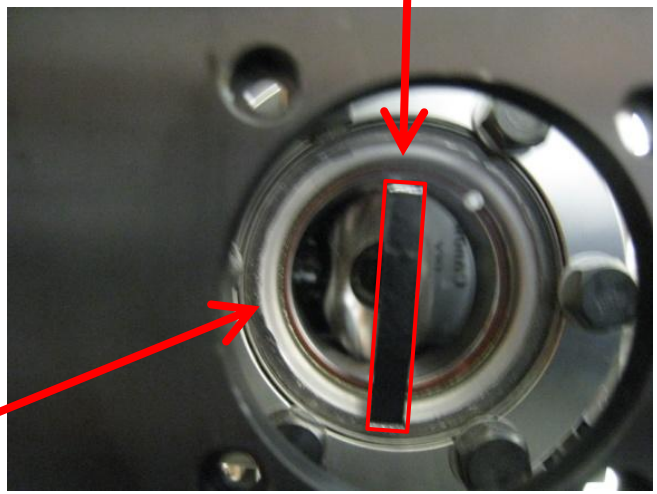
Diffraction divergence $\theta_{dif} \sim \lambda/d$, $\theta_{dif} \sim 100$ mrad @ d = 10 μm

λ : Wavelength

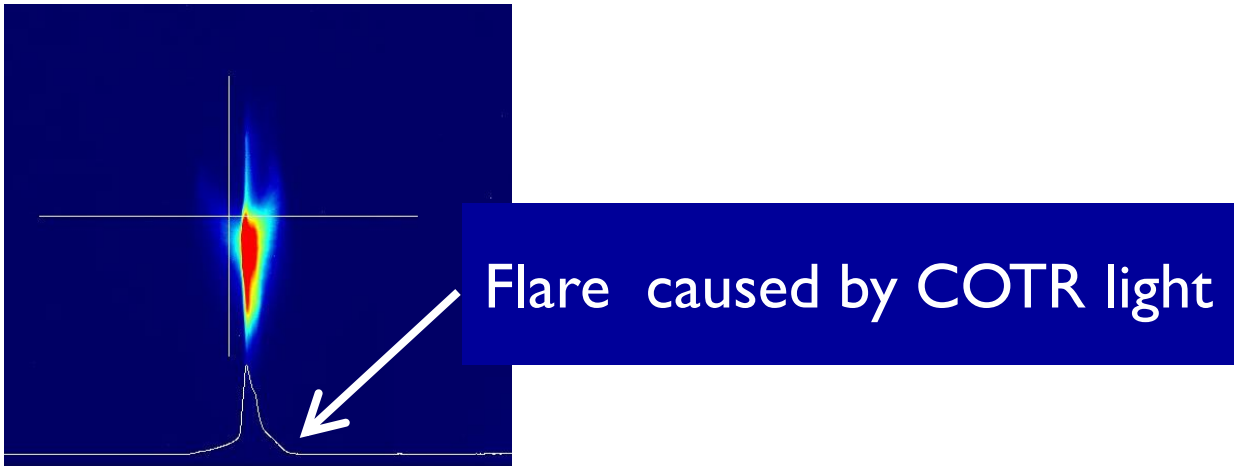
d : Diameter of the light source

Observation and Mitigation of COTR





Beam profile with blur

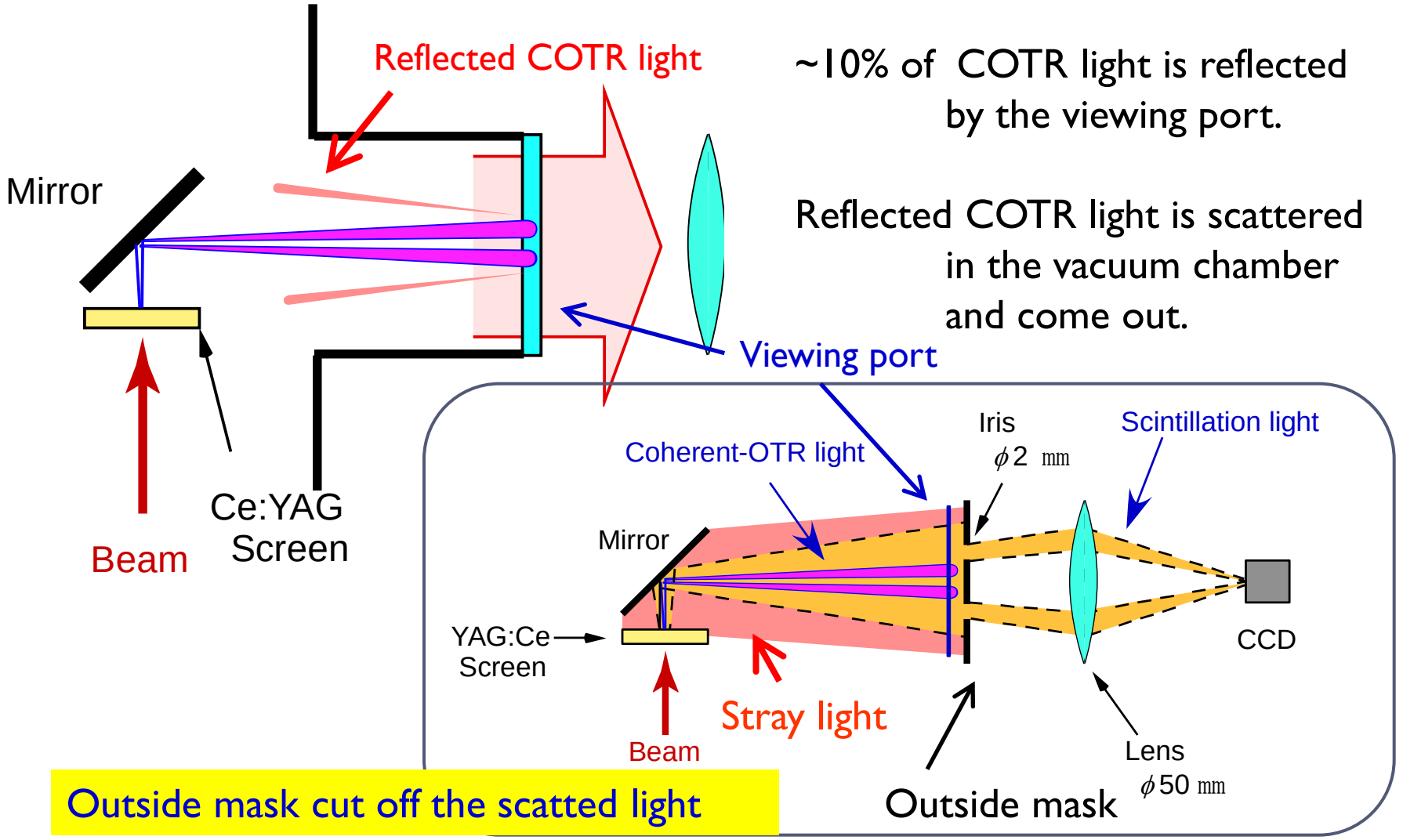


Finding problems to degrade spatial resolution

Stray light from high-intense COTR light
in the vacuum chamber

Out of focusing due to changing the focusing point
by diffraction effect of the spatial mask

Mitigation of stray light of COTR



~10% of COTR light is reflected by the viewing port.

Reflected COTR light is scattered in the vacuum chamber and come out.

Outside mask cut off the scatted light

Changing focus point by diffraction

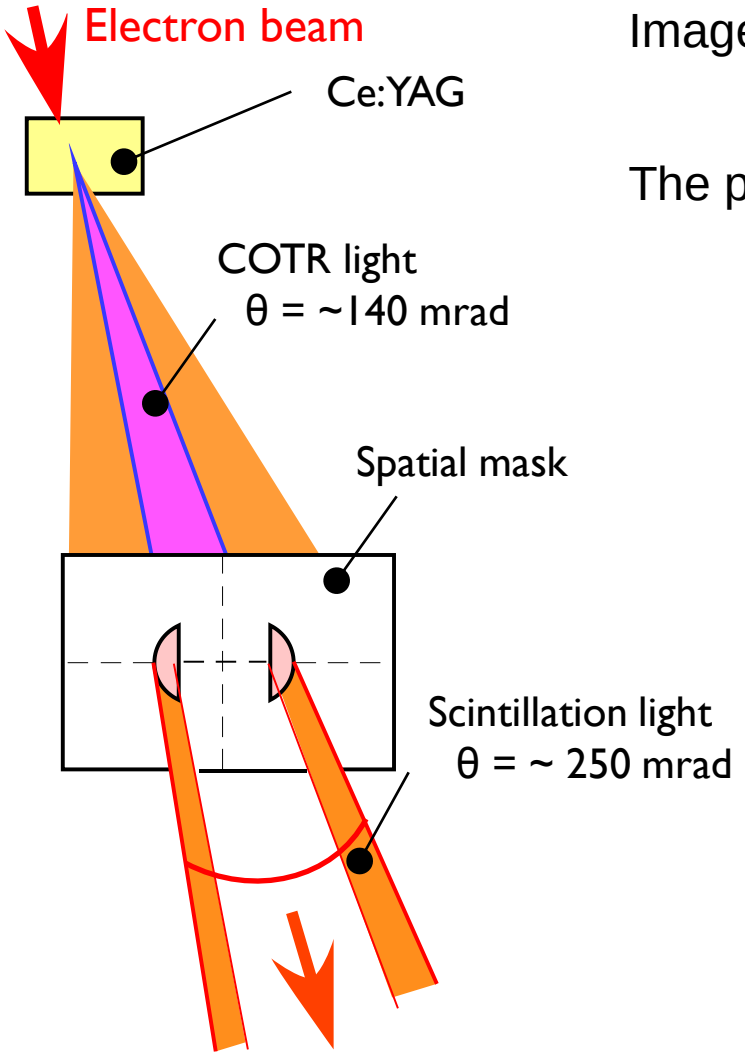
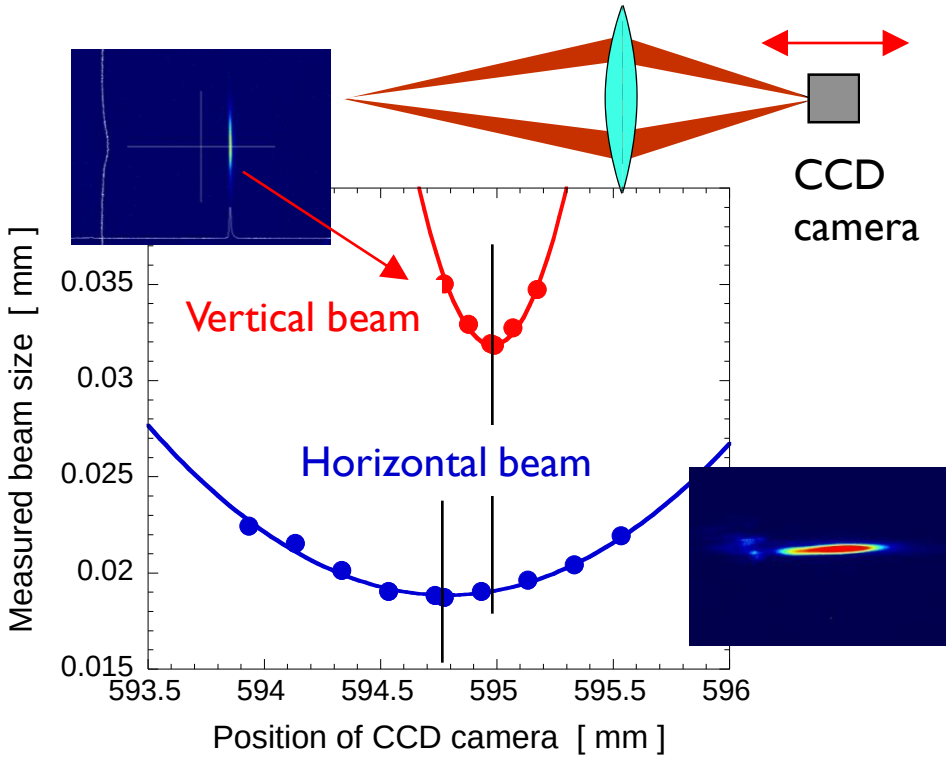
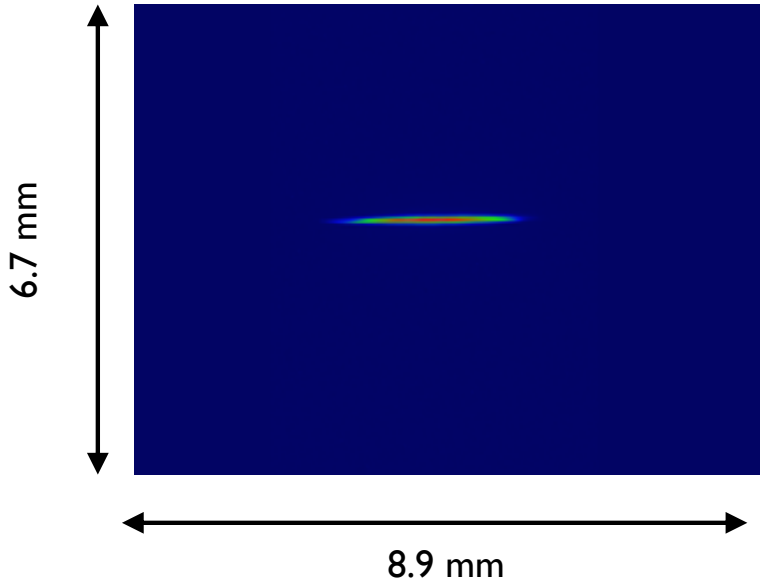


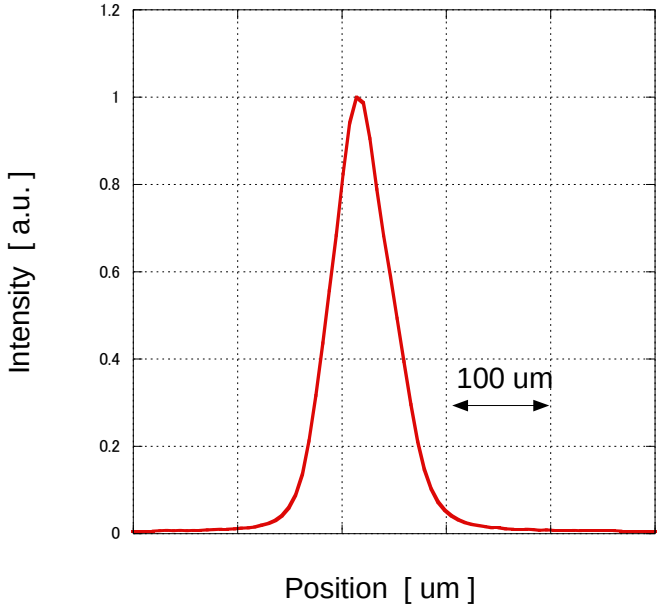
Image was out of focus caused
by diffraction effect of the spatial mask.

The position of the CCD camera
was adjusted to the focus point.



Spatial resolution of the SCM

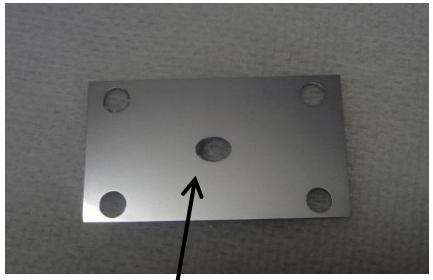


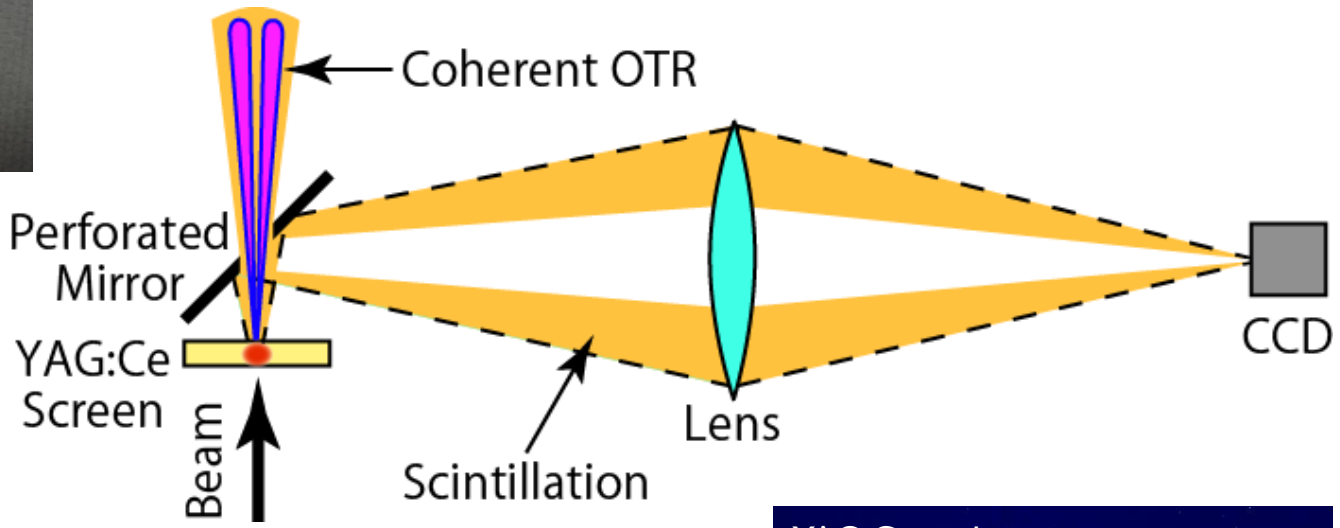


An example of measured beam size is 30 mm (rms) and 65 mm (FWHM).
The improved SCMs have the spatial resolution of
about 10 μm which is demanded from SACLA.

- Next improvement of mitigation scheme

Perforated Mirror for COTR reduction

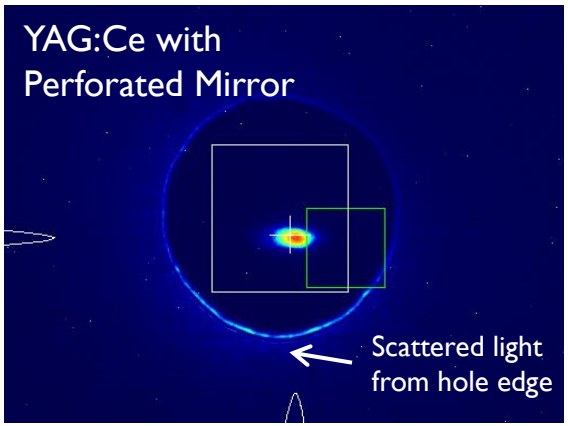




COTR light passes through the perforated mirror.

COTR light is scattered after the mirror.
It does not come out though the viewing port.

The mitigation using the perforated mirror is currently under studying.



Summary

- We have some of issue to measure a beam profile in SCM caused by COTR after bunch compressor.

- COTR effect was mitigated using by a spatial mask.
  - The mask size was decided by a diffraction angle of about 100 mrad in COTR light.
  - SCM with the mask have the spatial resolution of about 10 μm.
  - Mitigation using the spatial mask was easy to improve installed SCM.

- Next improvement of elimination is under studying.
  - A perforated mirror is used instead of the spatial mask.
  - It is under studying.