HZB Helmholtz Zentrum Berlin
BESSY VSR

Diagnostics for BESSY VSR, an overview

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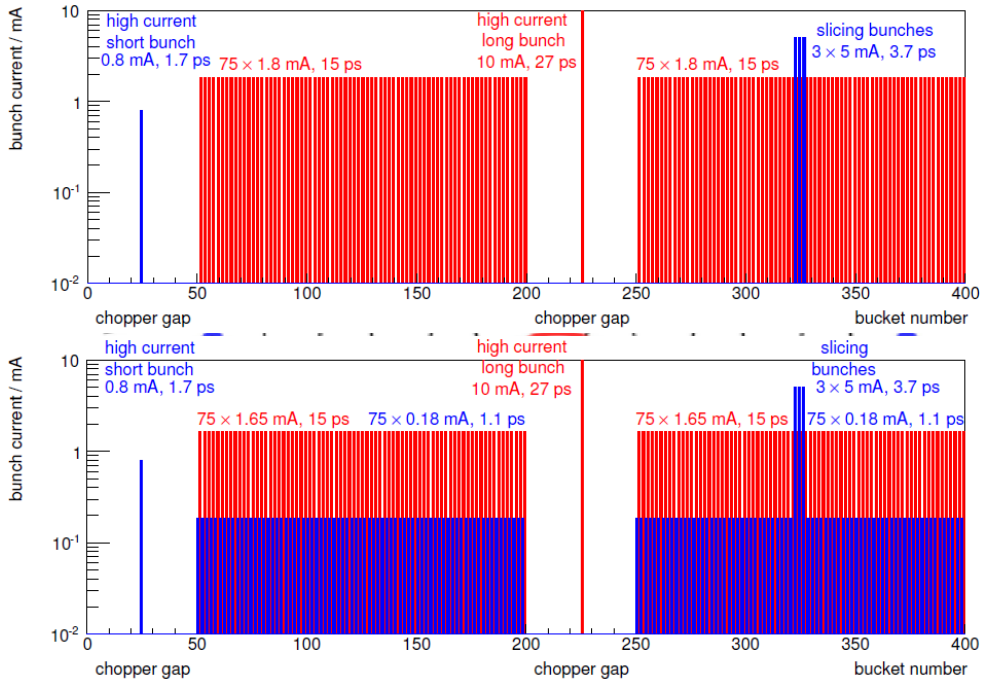
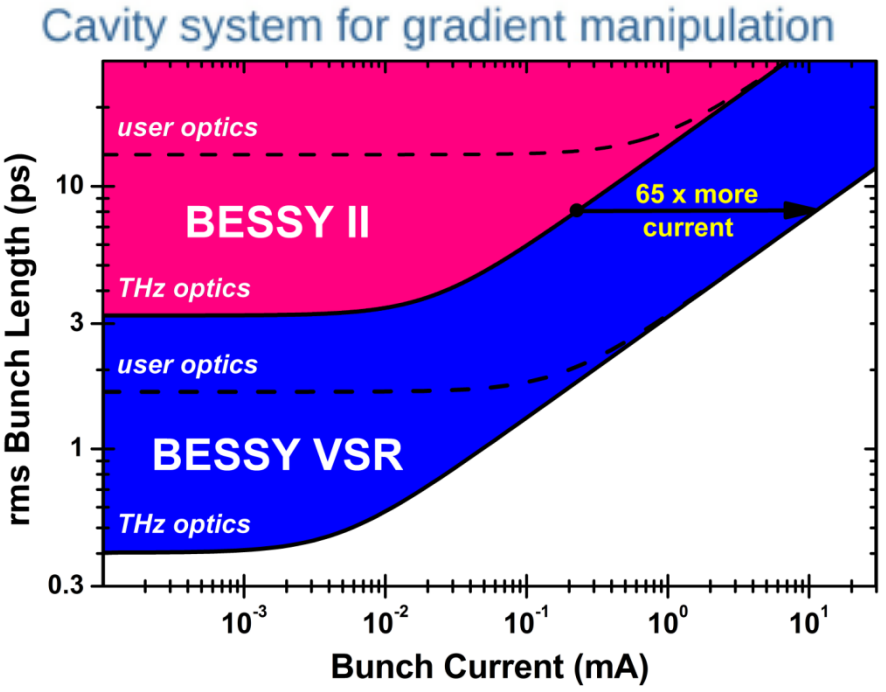
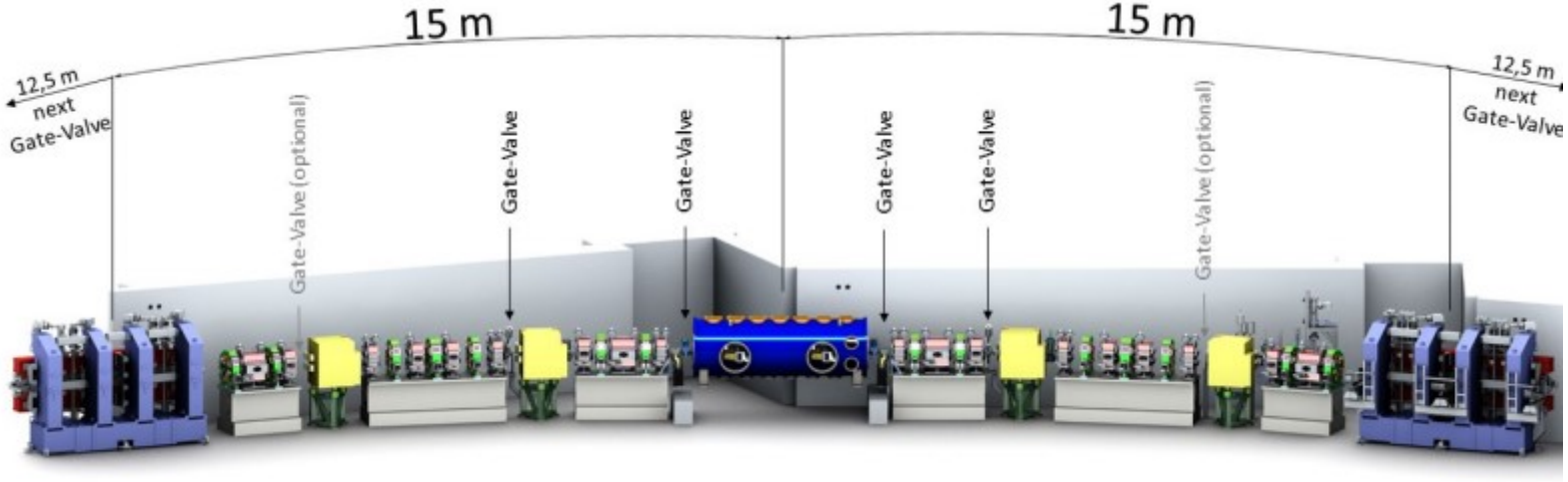
BESSY Variable pulse-length Storage Ring (BESSY VSR)



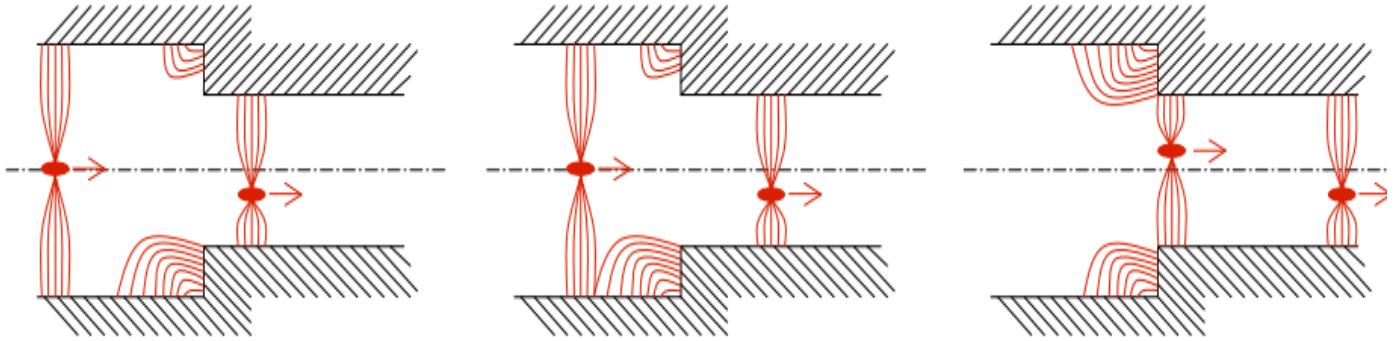
"Technical Design Study BESSY VSR"



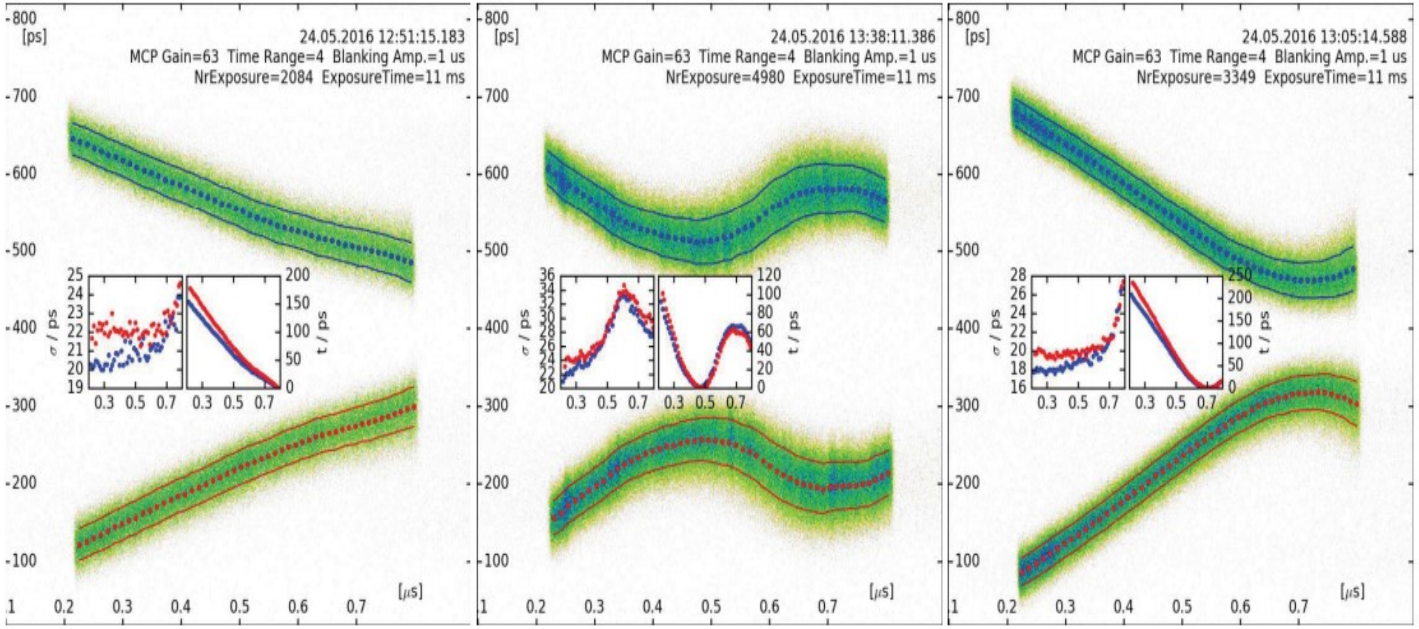
alternating large and small V'



Transient beam loading



The effect of the beam on the accelerating field is called **BEAM LOADING**. The superposition of the accelerating field established by external generator and the beam induced field needs to be studied carefully in order to obtain the net **Phase** and **Amplitude** of acceleration.



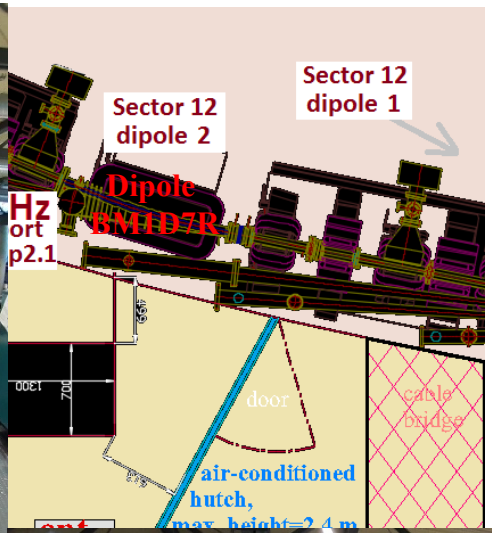
Diagnostics platform refurbish for BESSY VSR

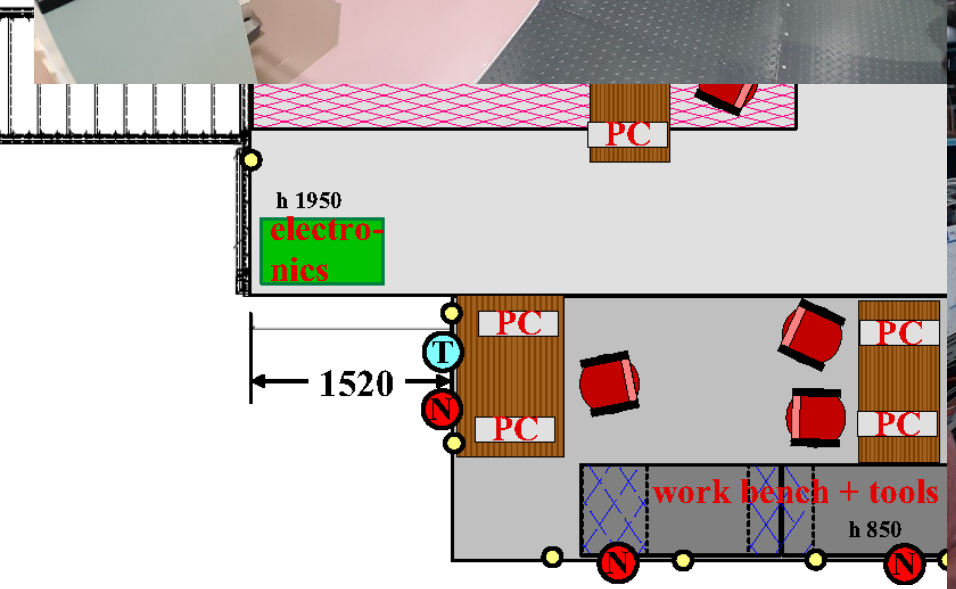
Optical diagnostics

2018
Move to new platform

2
Streal
with
optic

Diagnostics platform refurbish for BESSY VSR

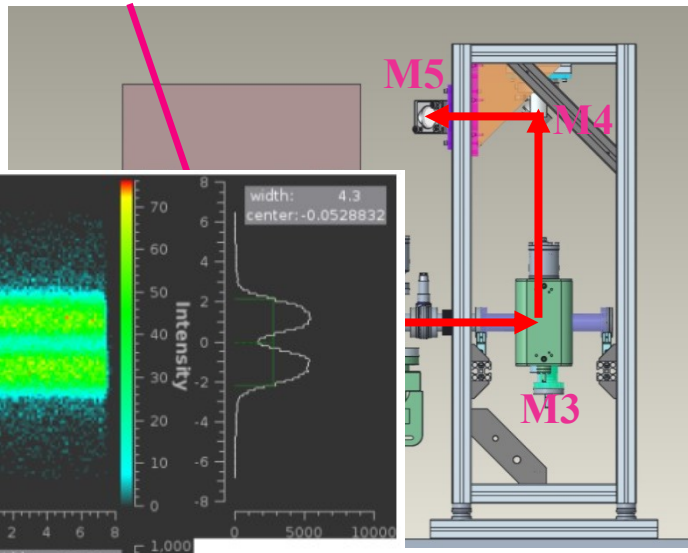




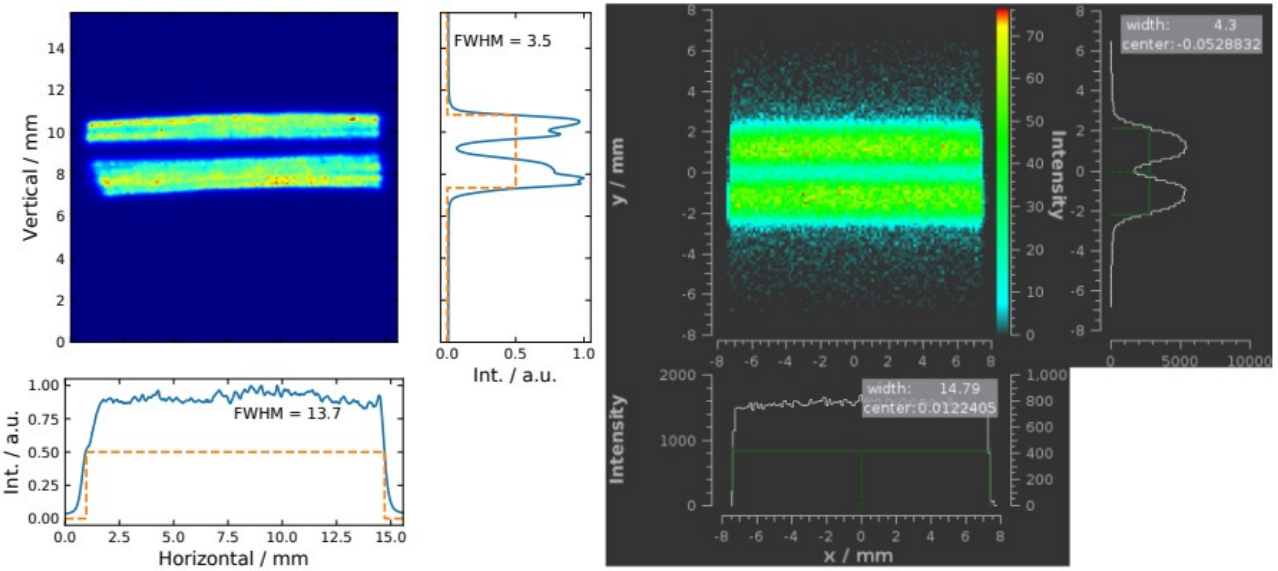
Bunch-resolved temporal distribution monitor

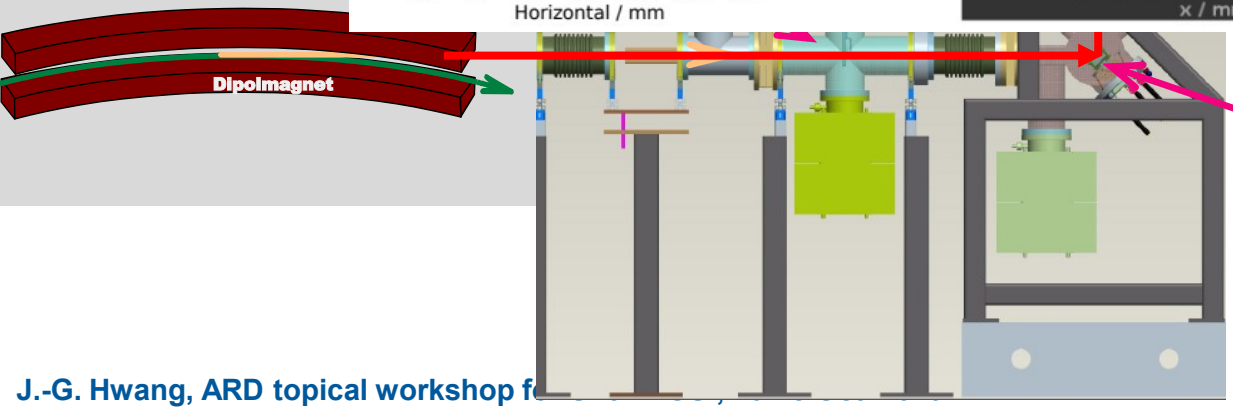
Sector 12 Dip1.1 - BM2T6R
Longitudinal Bunch Size
(timing: streak Camera etc.)

Toroidal Mirror M2



X-R
Block
Baf



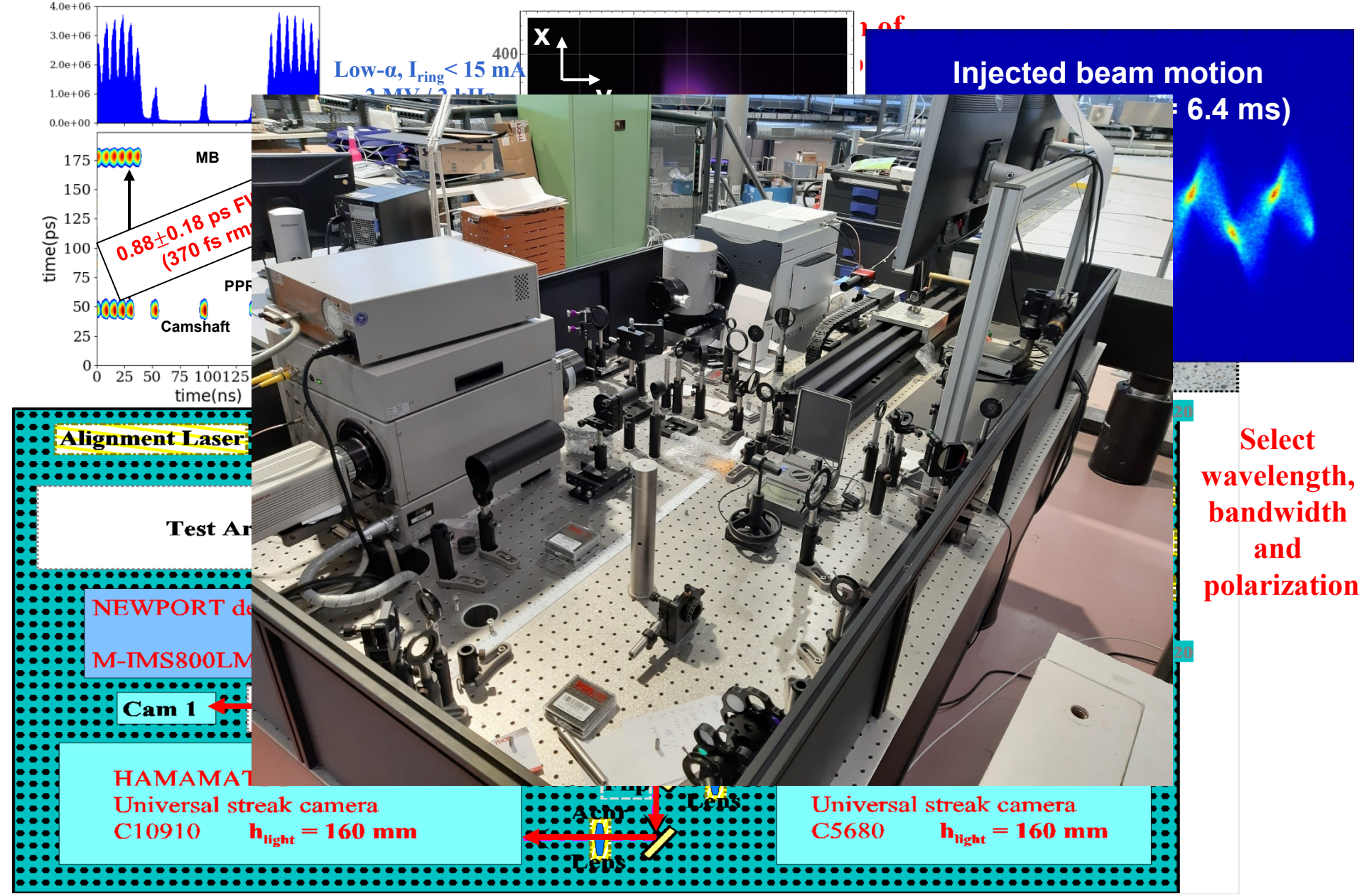


and Slit

Ellipsoidal
Mirror M1

Planar
Mirrors
M4&M5:
Select
transverse
direction

Bunch-resolved temporal distribution monitor



2D (t-x or t-y) measurement

Standard BESSY-II user fill-pattern at top-up conditions

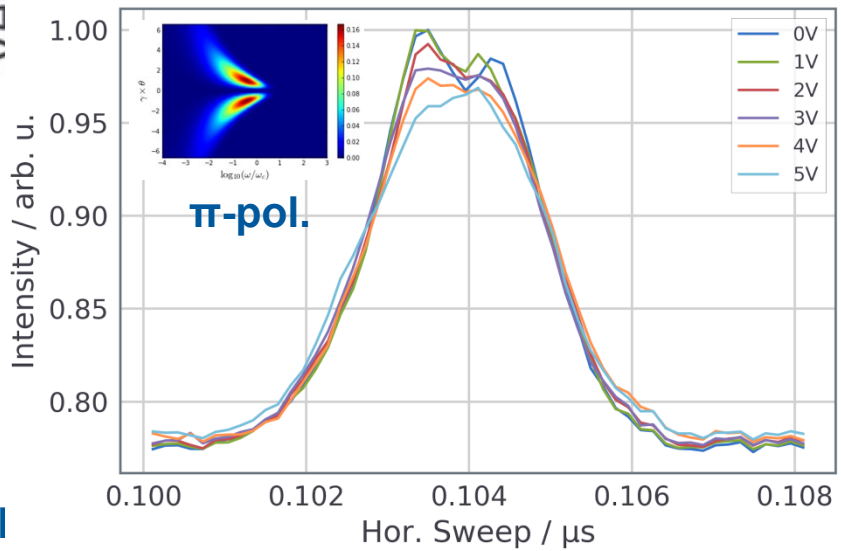
near the center of the pseudo-single-bunch gap

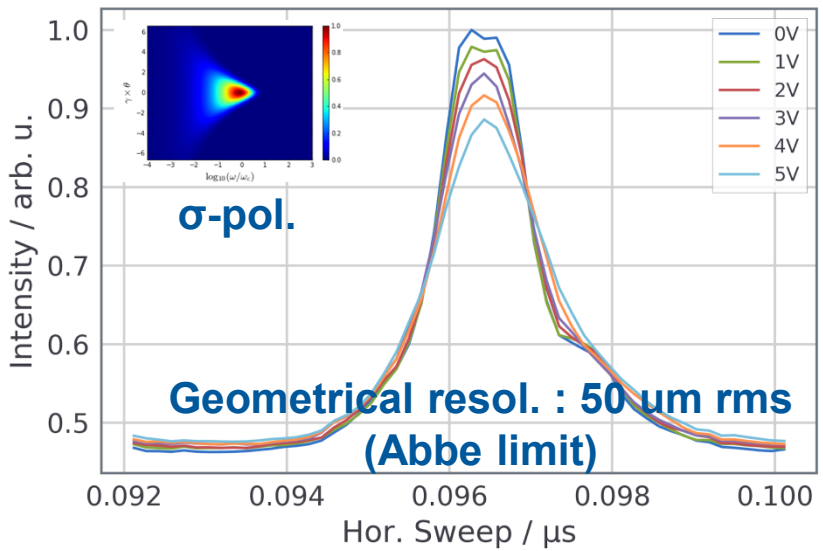
M. Koopmans's presentation "Bunch-resolved 2D measurements at BESSY II" in TODAY poster session

1 x C
(with 4m

1 x
(3mA)
resc

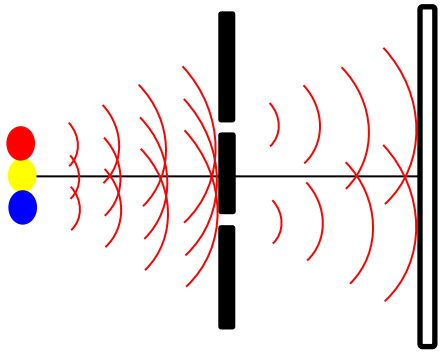
➢Profile of a single bunch for both polarizations as function of

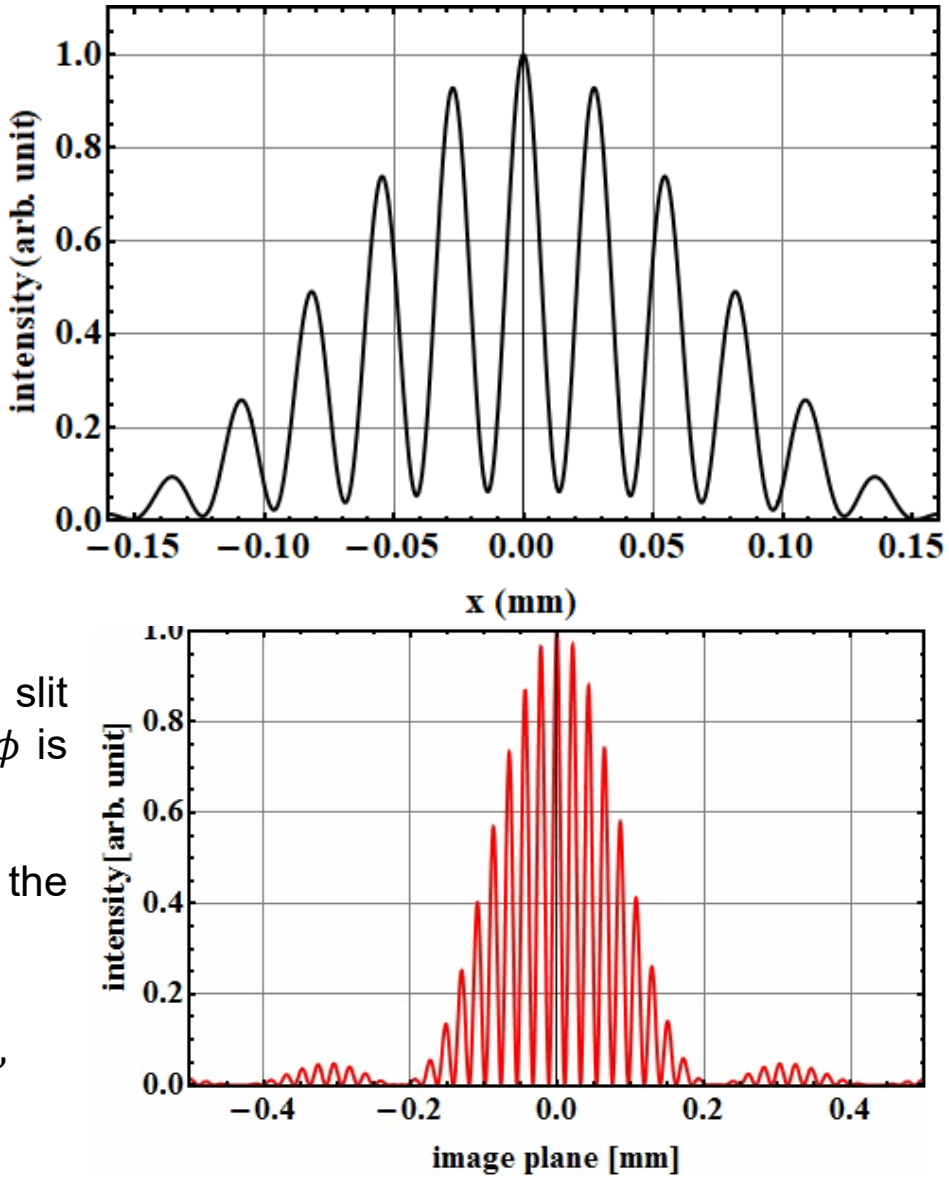




M. Koopmans et al.,
IPAC'19 proceedings, pp. 2491 (2019)

Bunch-resolved lateral beam size monitor





An interference pattern produced by double with a "point-like" source is given by

$$I(x) = I_0 sinc^2\left(\frac{\pi a}{\lambda R}x\right) cos^2\left(\frac{\pi d}{\lambda R}\,x + \phi\right),$$

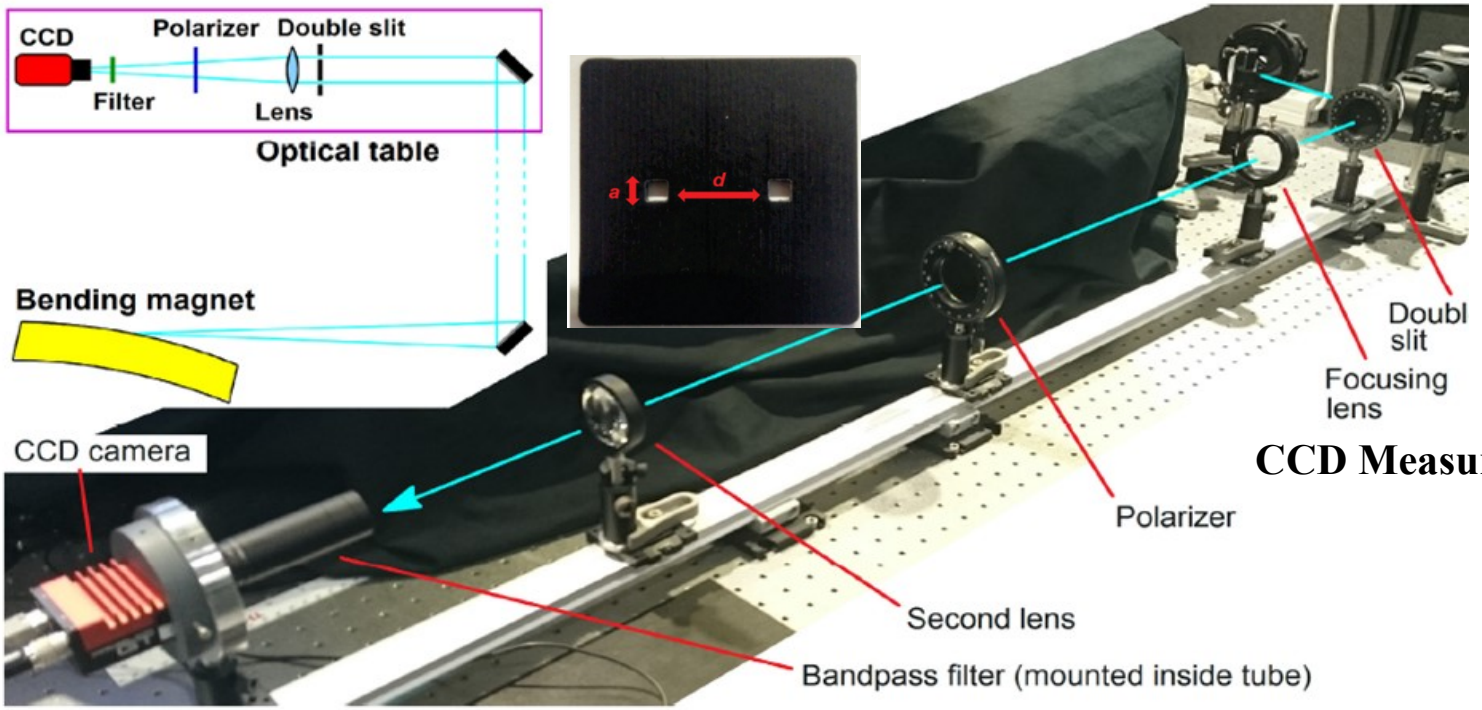
where λ is wavelength, R is distance between slit and screen, d is slit separation, a is slit width, ϕ is phase difference.

For a **Gaussian distributed light source**, the interference pattern is

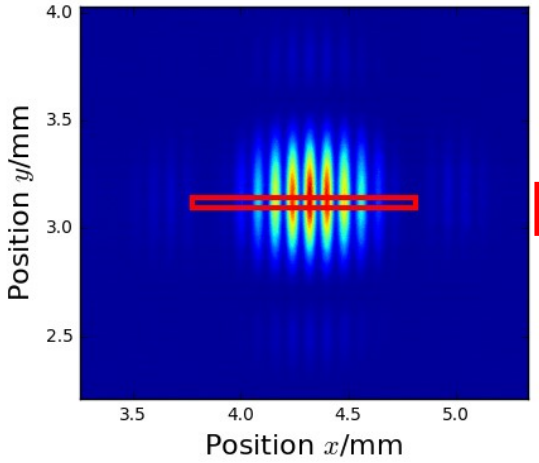
$$I(x) = I_0 sinc^2\left(\frac{\pi a}{\lambda R}x\right)(1 + \gamma cos\left(\frac{2\pi d}{\lambda R}\,x + \phi\right),$$

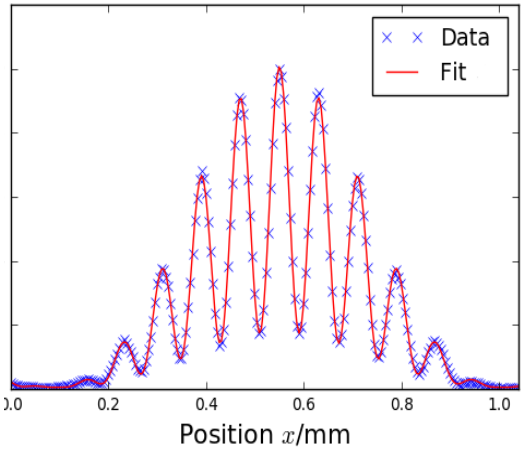
where γ denotes the visibility.

Bunch-resolved lateral beam size monitor



CCD Measurement





Visibility(γ) is given by the van Cittert-Zernike theorem :

$$\gamma = \int dx\, f(x)\, e^{-i\frac{2\pi D}{\lambda s}x}$$

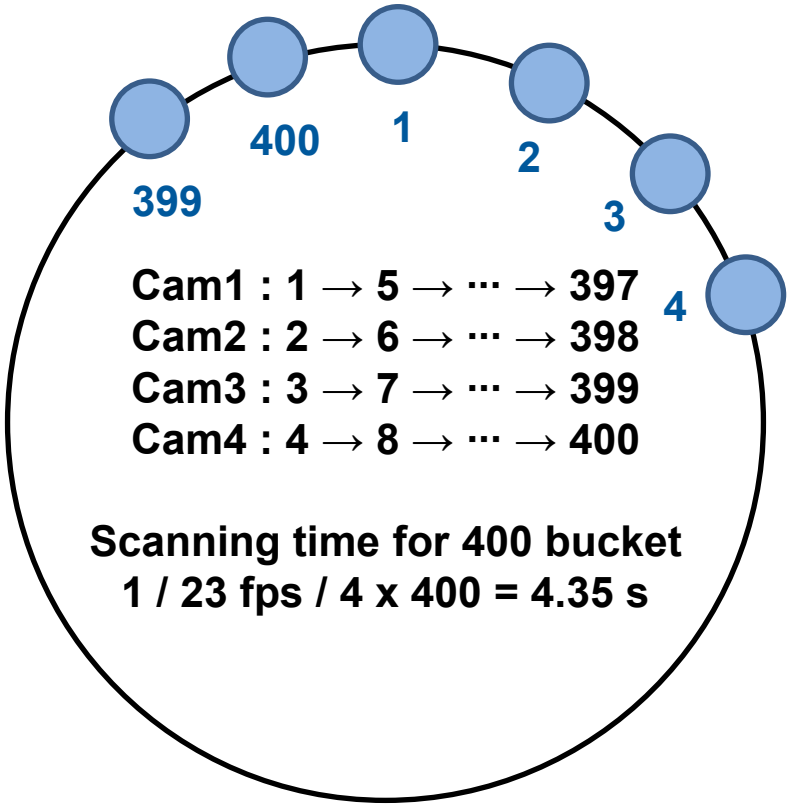
For Gaussian Distribution

$$\sigma_{x,y} = \frac{\lambda\, s}{\pi\, D_{x,y}} \sqrt{\frac{1}{2}\, ln\, \frac{1}{|\gamma_{x,y}|}}$$

Bunch-resolved lateral beam size monitor

XXRapidFrame
Based on 4 x 4 Picos ICCD camera
Exposure time: 200 ps to 80 s
Delay time: 0s, 10 ps to 80 s
Delay and Exposure time step: 10 ps
Low jitter : < 10 ps
Multiple gate repetition frequency:
- up to 200 kHz continuous
- up to 3.3 MHz in burst mode

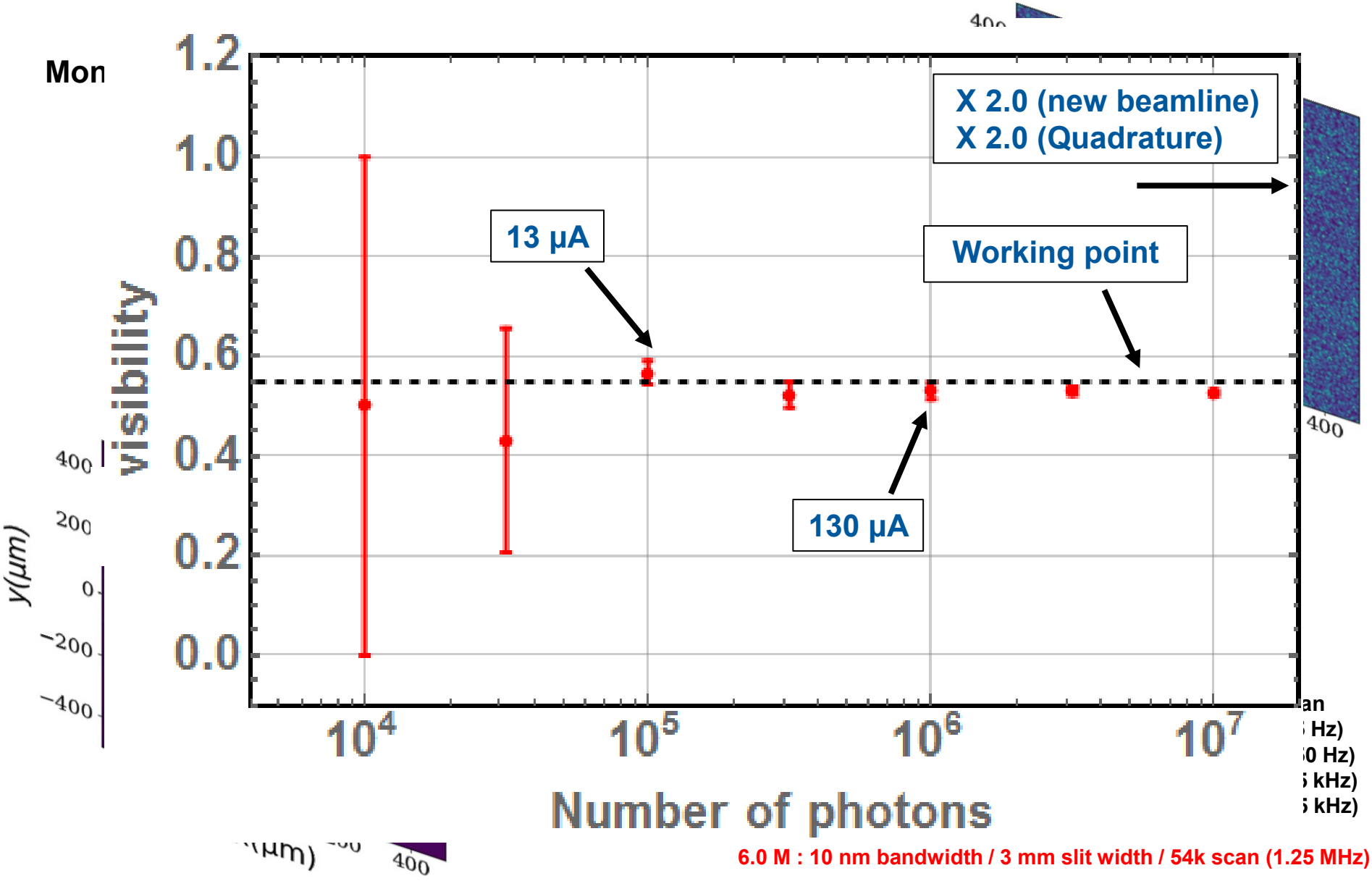
Pixel size: 8.3 x 8.3 µm
High dynamic Range: 12 bit
Frame rate:12.5 / 20.0 / 23.0fps



# of gate repetition rate / frame (23 fps) with burst mode
→ 1 / 23 fps * 1.25 MHz = 54 k

# of photons / frame (23 fps) with burst mode
→ 5.6 k photons * (area ratio) * 54 k
= 6.0 *10^6 photons / frame

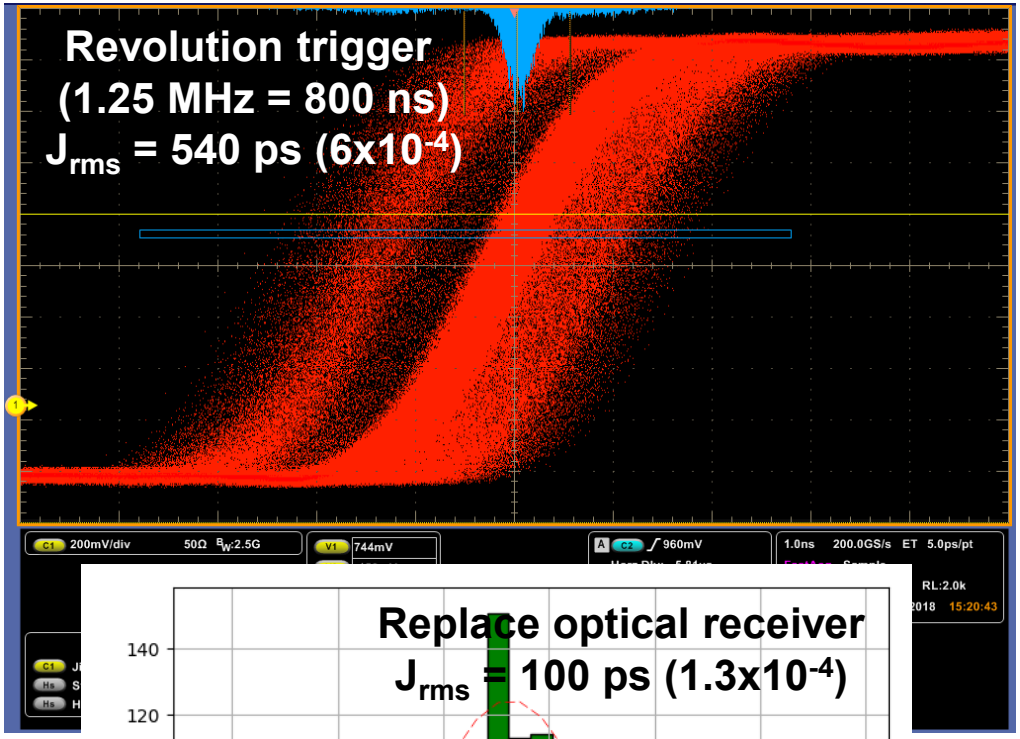
Bunch-resolved lateral beam size monitor

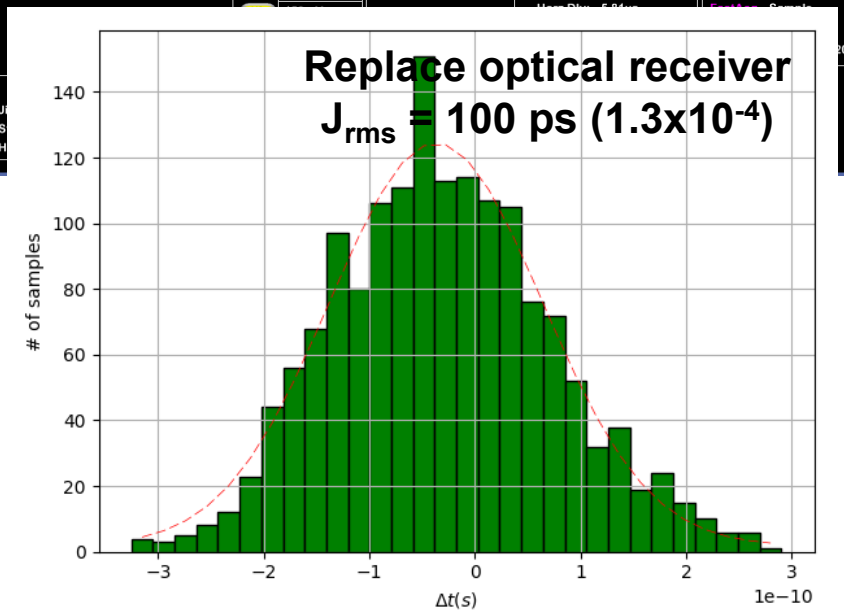


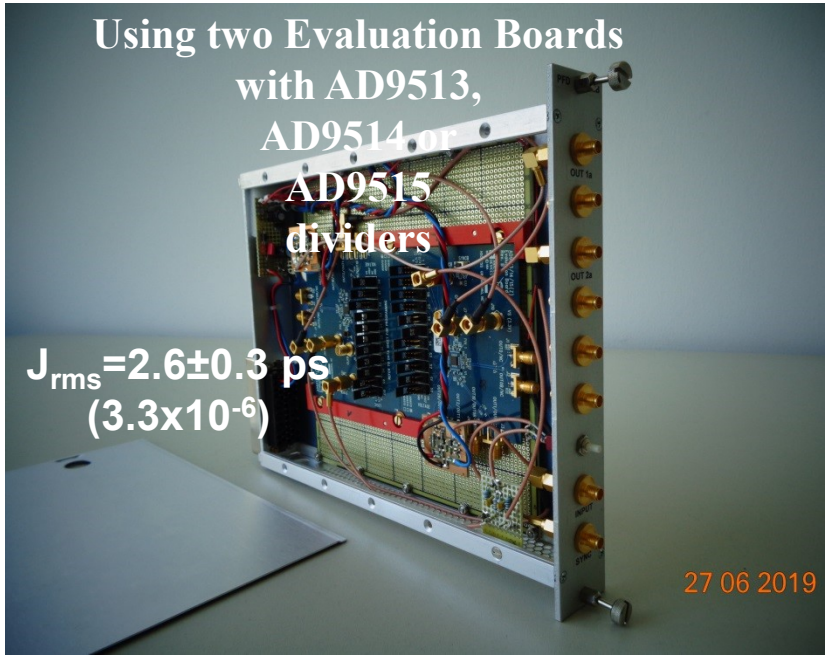
6.0 M : 10 nm bandwidth / 3 mm slit width / 54k scan (1.25 MHz)

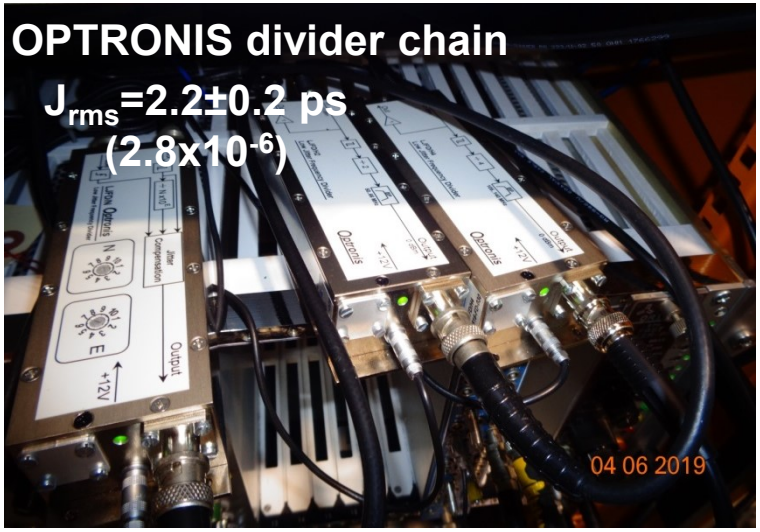
Trigger system upgrade

Needed: improved revolution trigger



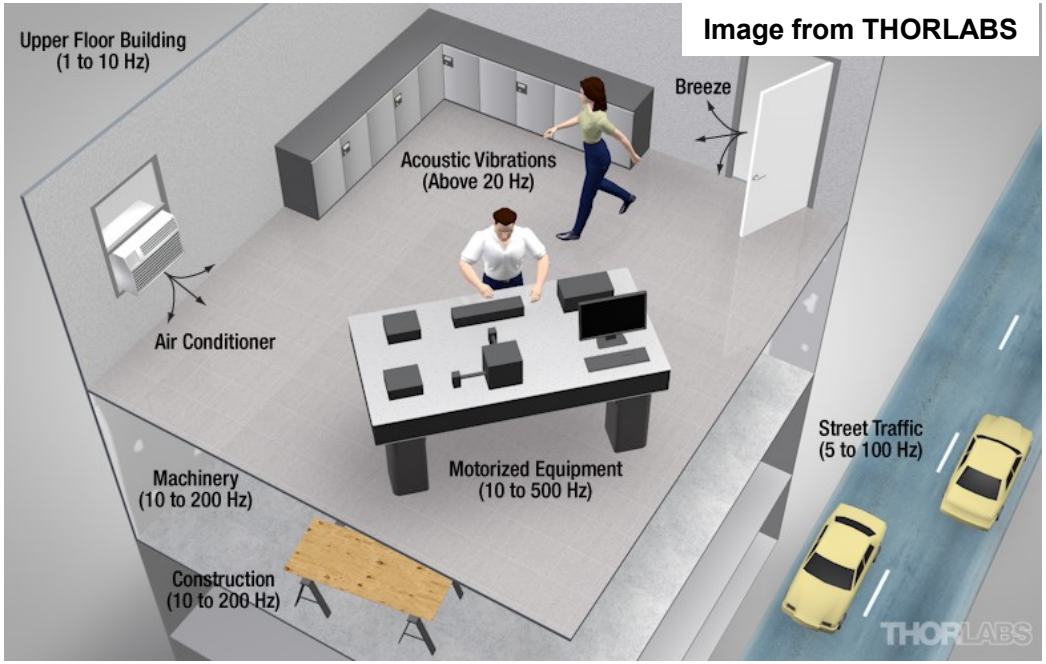


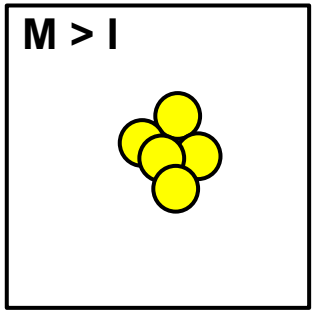




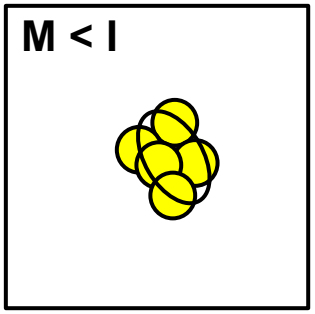
Ground motion

Slow motion (ground motion) of an optical table can cause a misleading result of beam diagnostics which is used slow detectors such as CCD that operate in the tens/hundreds of millisecond range.





M : Ground motion
I : Integration time

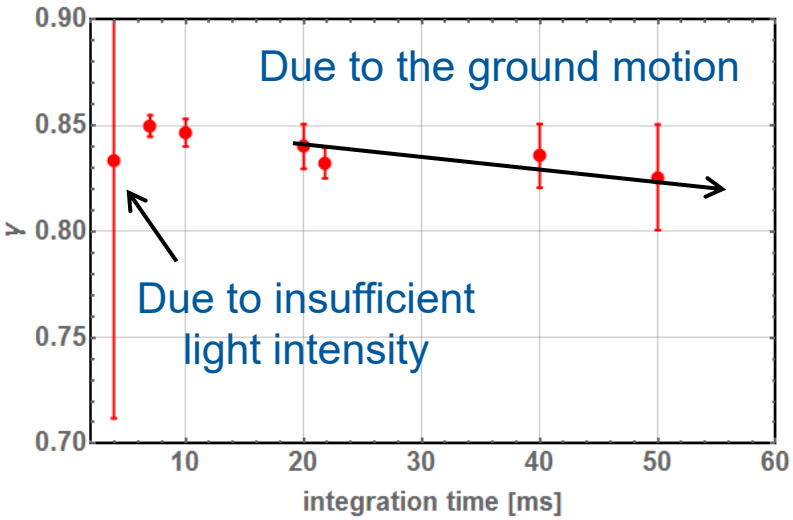


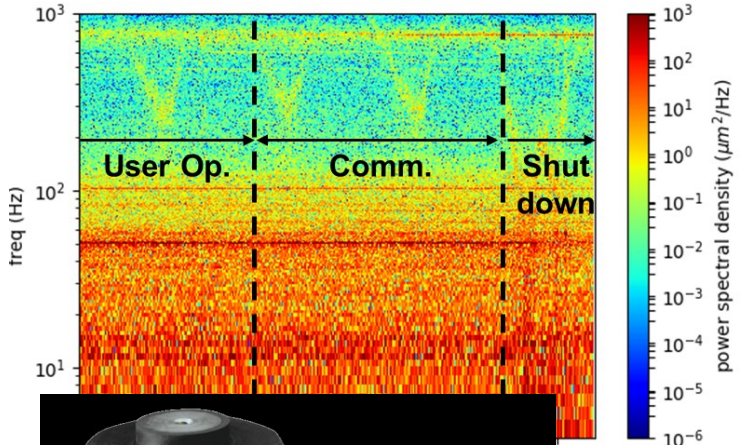
Examples

1) IBSM (CCD / ICCD) : Visibility reduction → Beam size increase
2) Pinhole : Beam size increase
3) Streak camera : Intensity fluctuation
4) Streak camera (+2D measurement) : Beam size increase

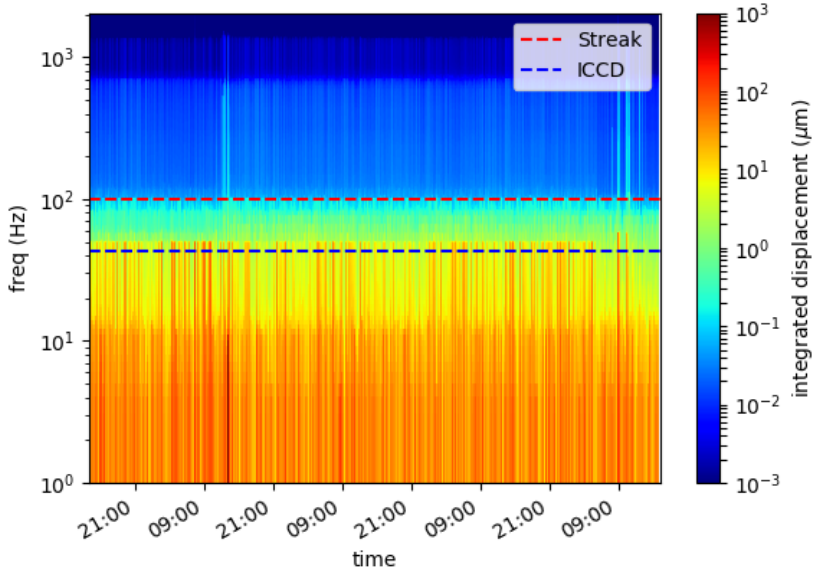
Ground motion

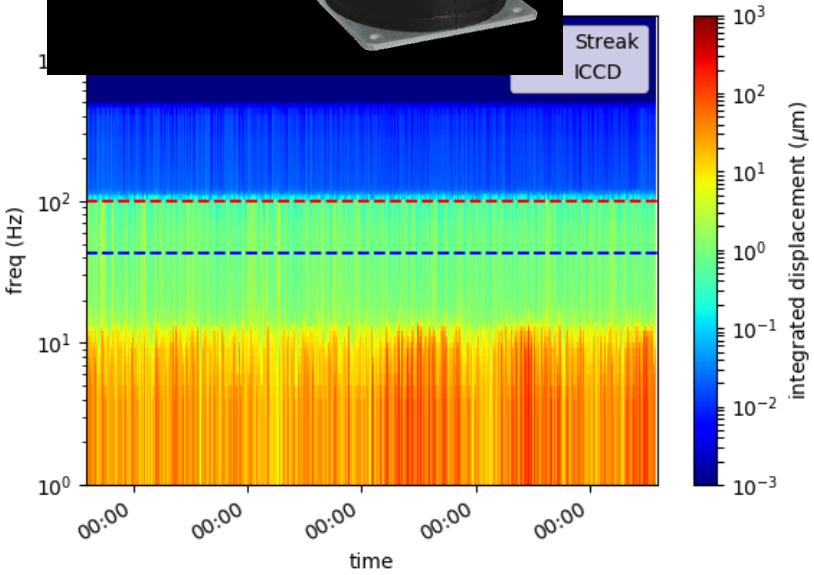
The visibility is measured with various integration time (shutter speed) of the camera.





The total(integrated) rms displacement





Summary

VSR project launch

Streak camera + IBSM

1. Performance optimization
2. Verification of IBSM

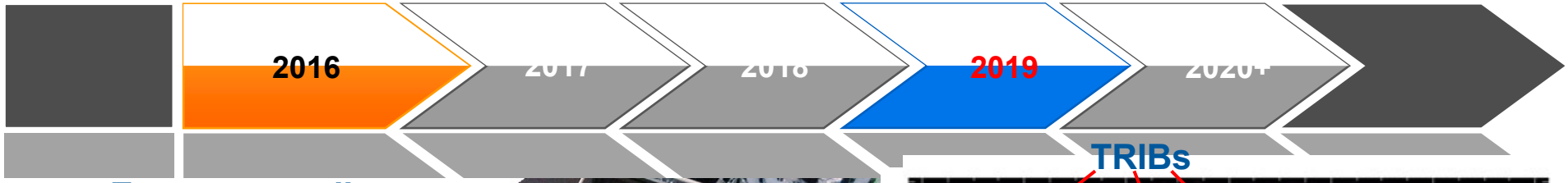
New streak camera (Dec. 2018)

1. High resolution : 0.9 ± 0.1 ps (FWHM)
   → Experimentally verified with fs laser
2. 2D (t-x / t-y) measurement

Move to new platform

ICCD Delivery (Nov. 2019)

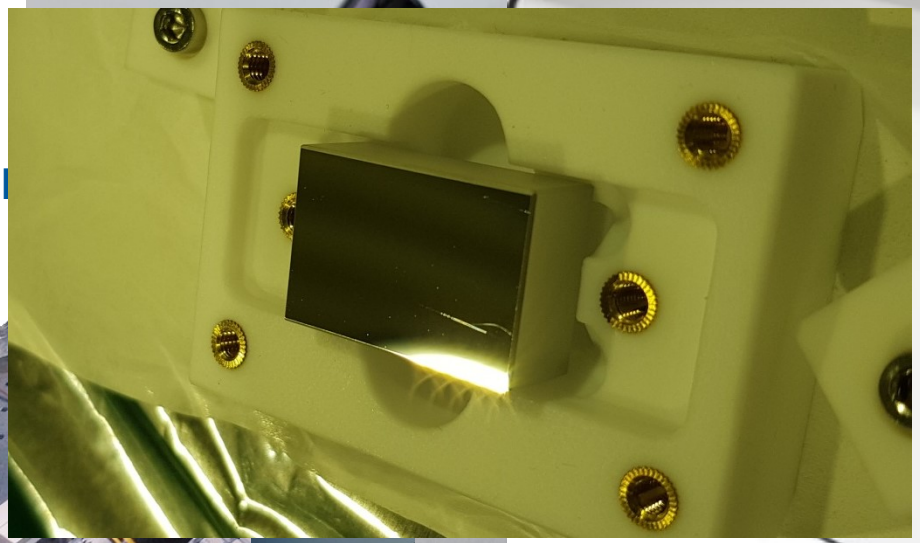
1. Stanford computer optics
   → Several delays due to their MCP supplier
2. Bunch-resolved lateral profile measurements

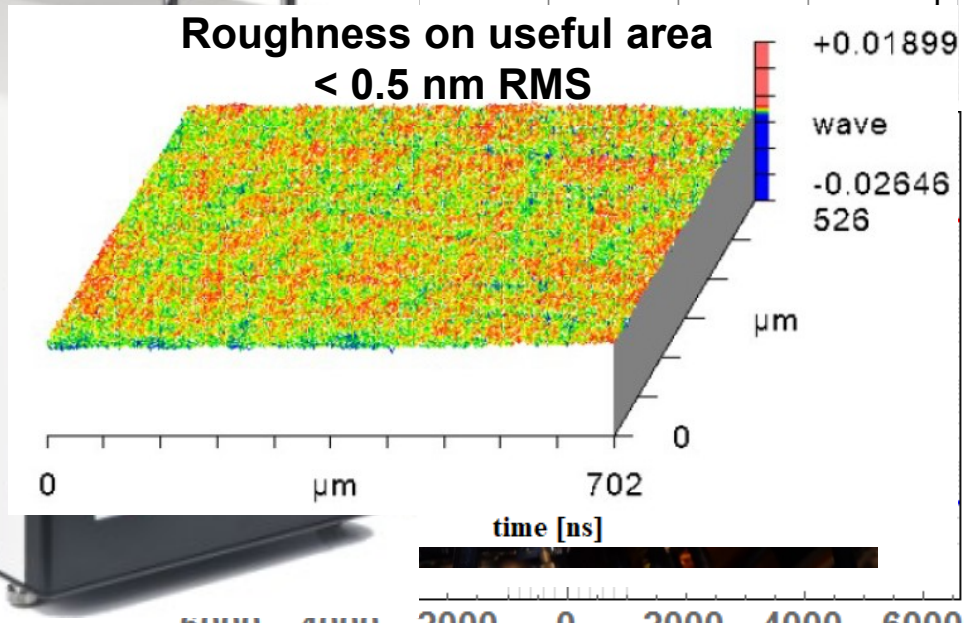


Entrance pupil

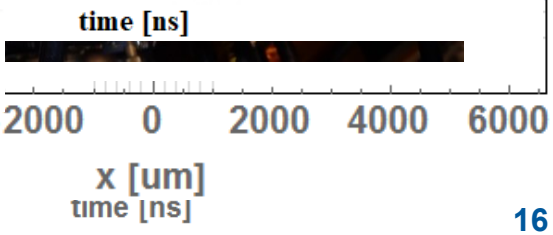
Objective lens

TRIBs





CCD cam



Thank you for your attention