Temporal diagnostics at SACLA

RIKEN, SPring-8 Center

Shigeki Owada,

on behalf of XFEL beamline development team

Arrival timing diagnostics

Major techniques for arrival timing

❖ Light field streak camera (THz, MIR…)

FLASH

- I. Grguras *et. al.*, *Nat. Phot.*, **6**, 276 (2012).

PSI

- P. Juranic, *et al.*, *Opt. Exp.*, **22**, 30004 (2014).

❖ Optical transmittance change

FLASH

- T. Maltezopoulos, *et al., New J. Phys.,* 10, 033026 (2008).

LCLS

- M. Harmand, *et al.*, *Nat. Photon.*, 7, 215 (2013).
- N. Hartmann, *et al., Nat. Photon.* 8, 706 (2014).

SACLA

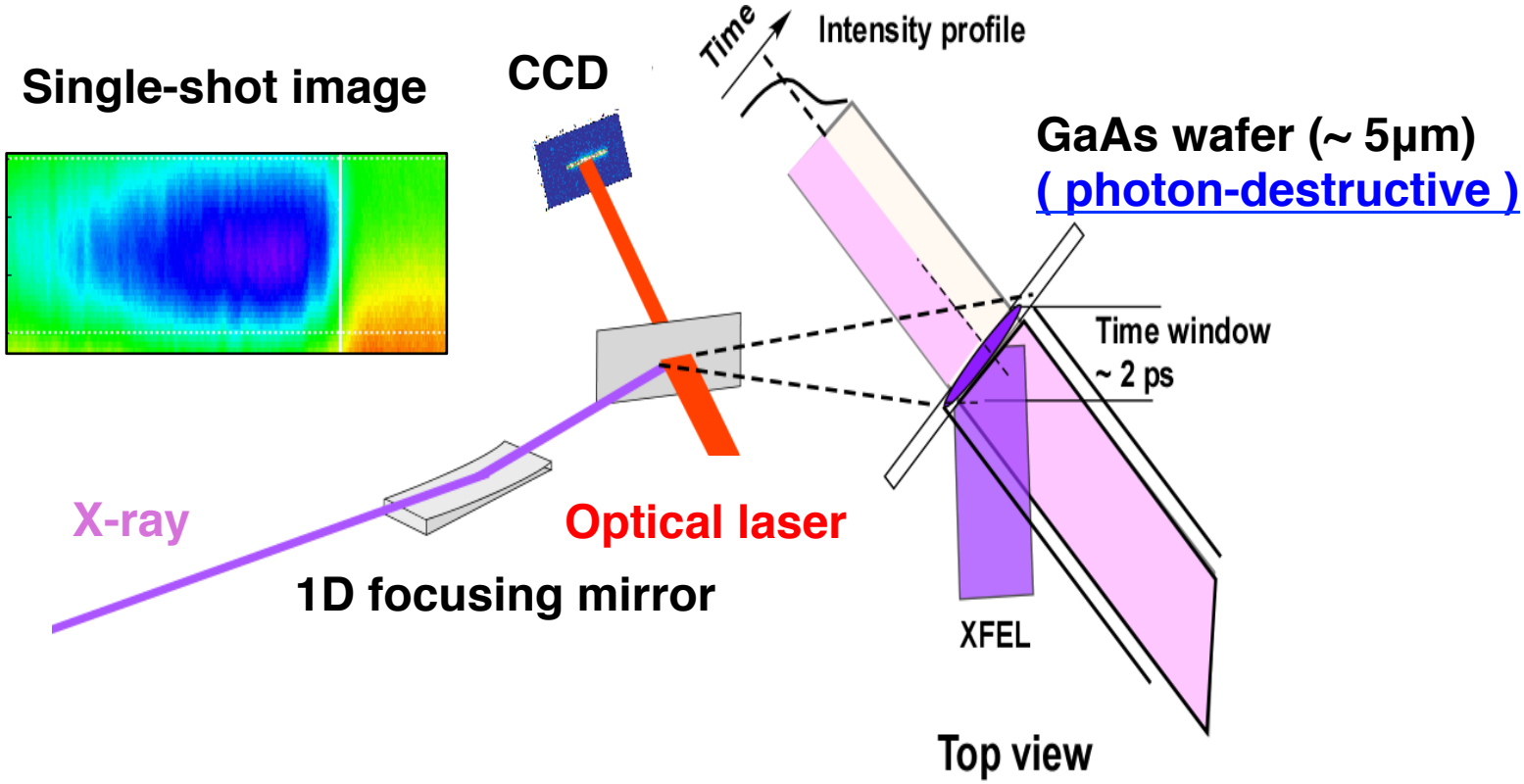
Challenges for timing tool at SACLA

- ***Moderate pulse energy (~ 500 μJ @10 keV)***
- ***High X-ray photon energy (> 10 keV)***

Arrival timing measurement at SACLA

T. Sato, *et al.*, *Appl. Phys. Express,* 8, 012702 (2015).

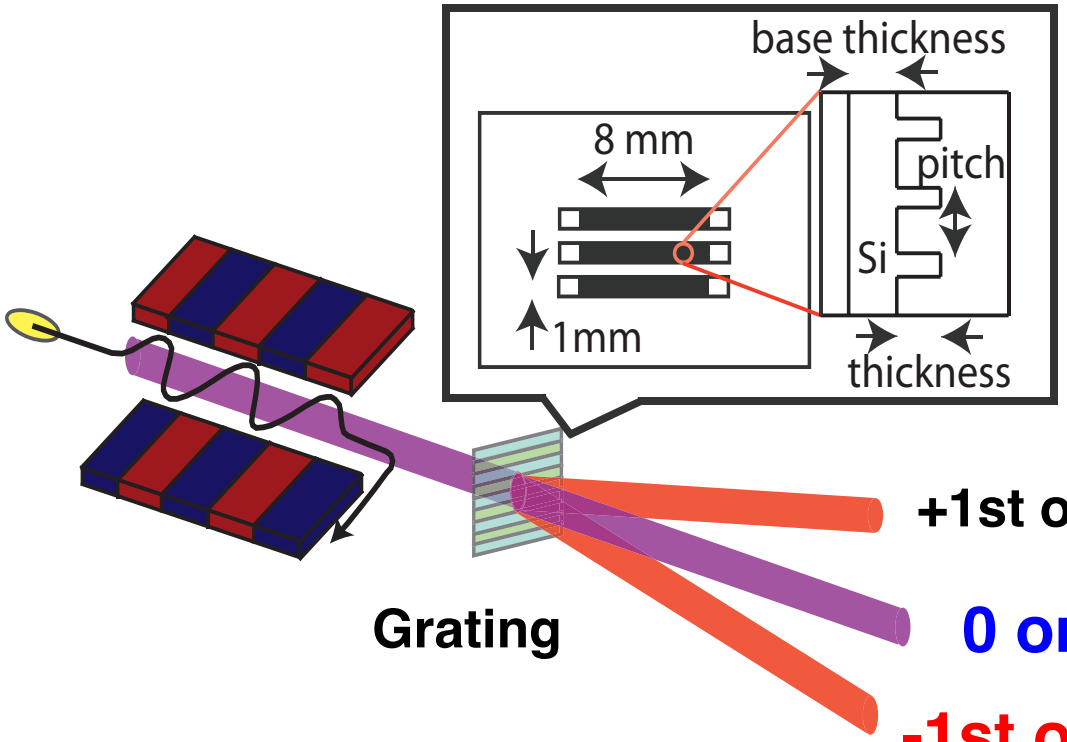
Spatial decoding + 1D focusing = Enhancing pump efficiency

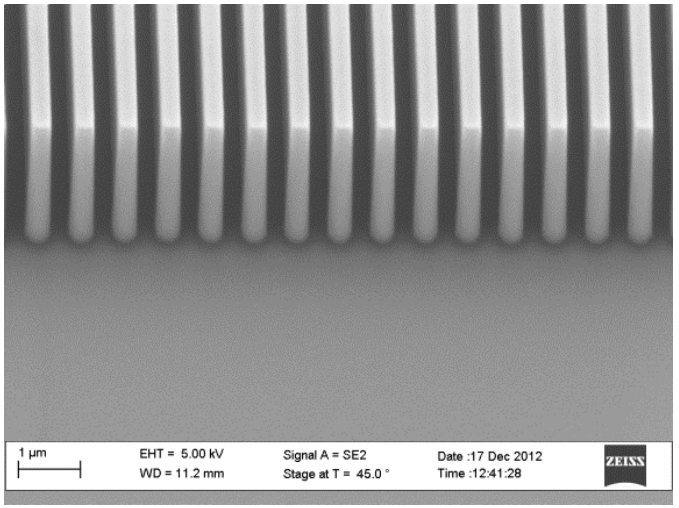


Requirement of Non-destructive Diagnostics

Beam splitting for timing diagnostics

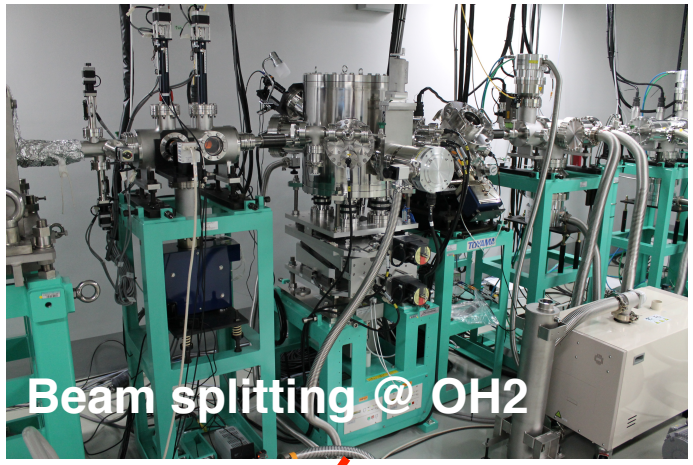
T. Katayama, et al., *Struct. Dyn.*, 3, 034301 (2016).

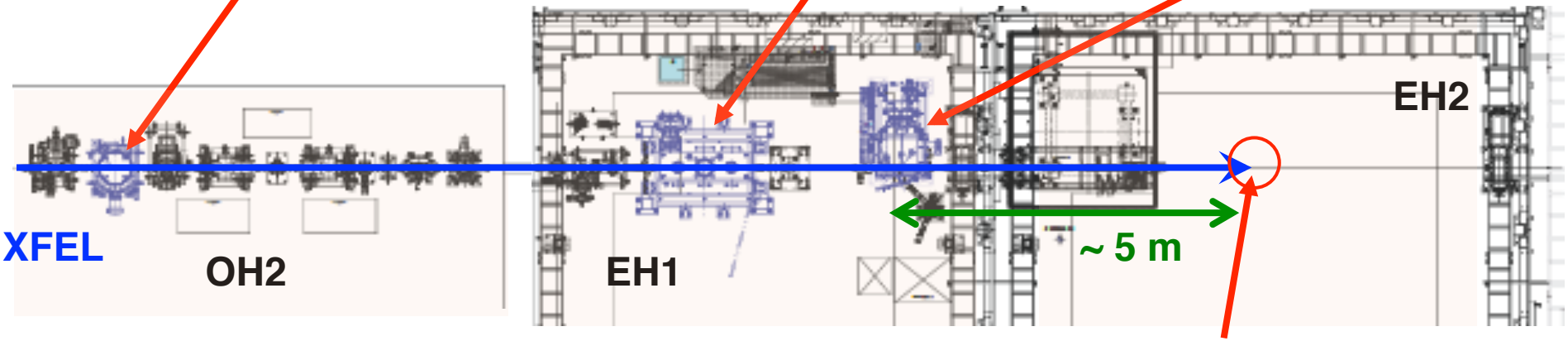




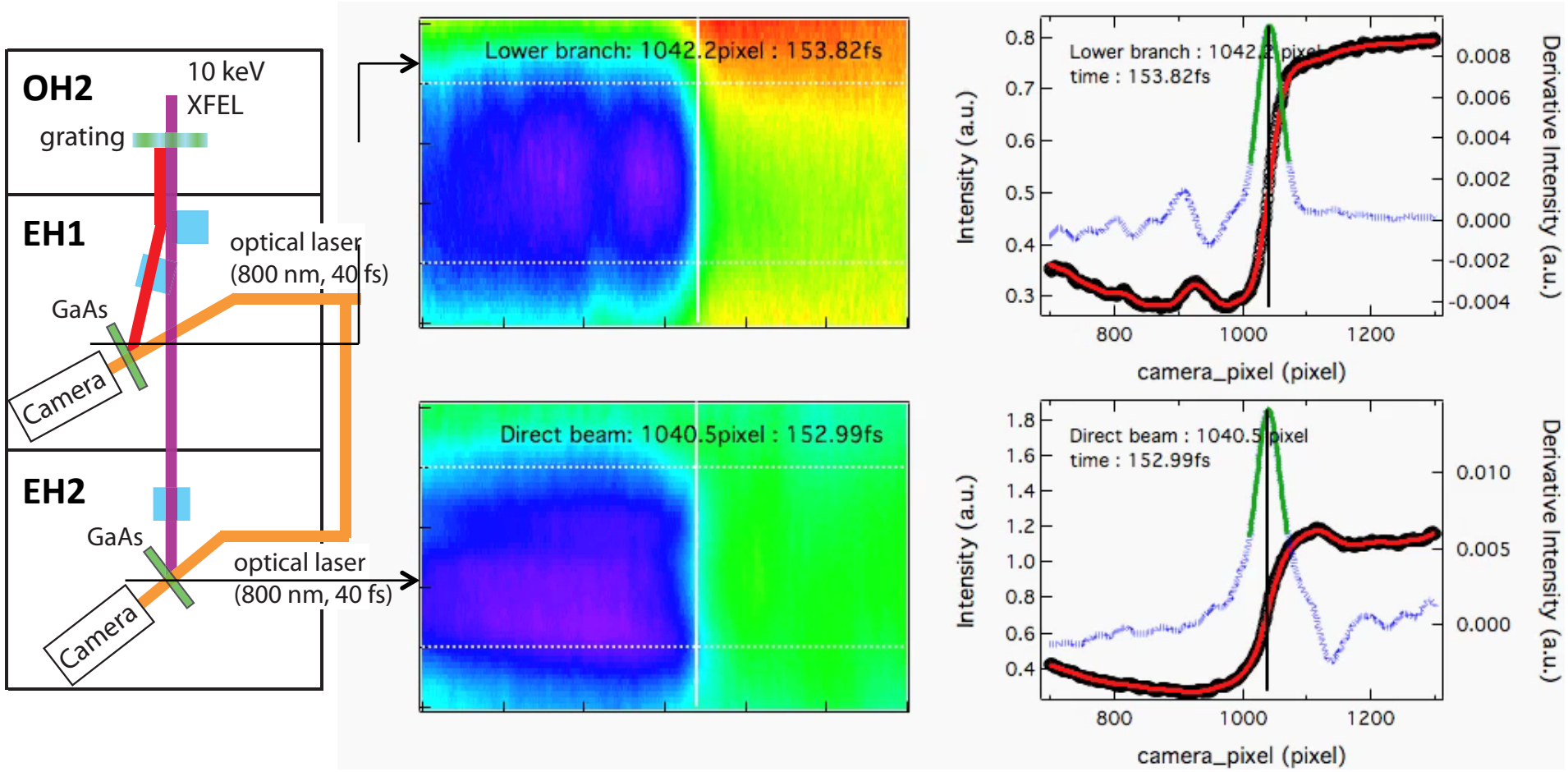
Collaborated with Prof. C. David (PSI)

Instruments





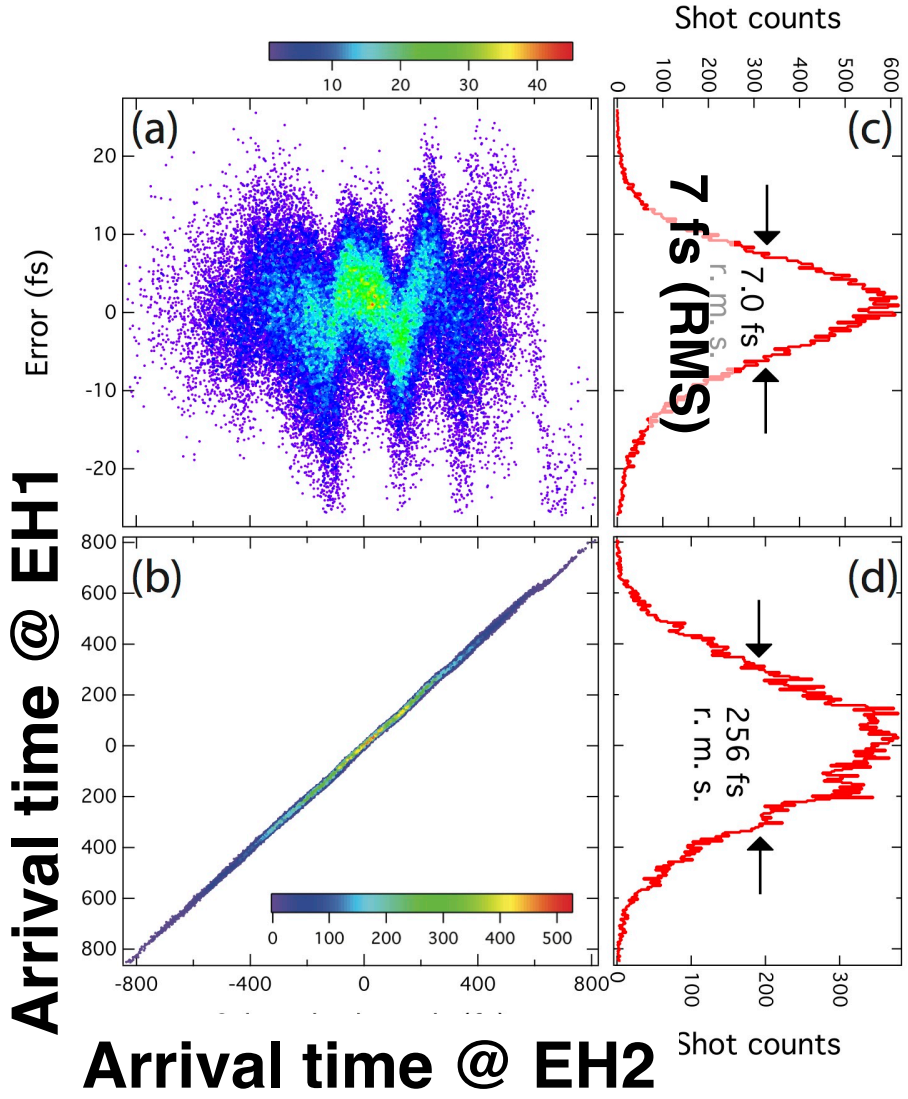
Correlation measurement



Excellent correlation between two branches.

Correlation statistics

T. Katayama, *et al.*, *Struct. Dyn.*, 3, 034301 (2016).



(b) Correlation: EH1 & EH2

(a) Residual of the linear fit

(c) Error from the linear fit

=> 7 fs (rms)

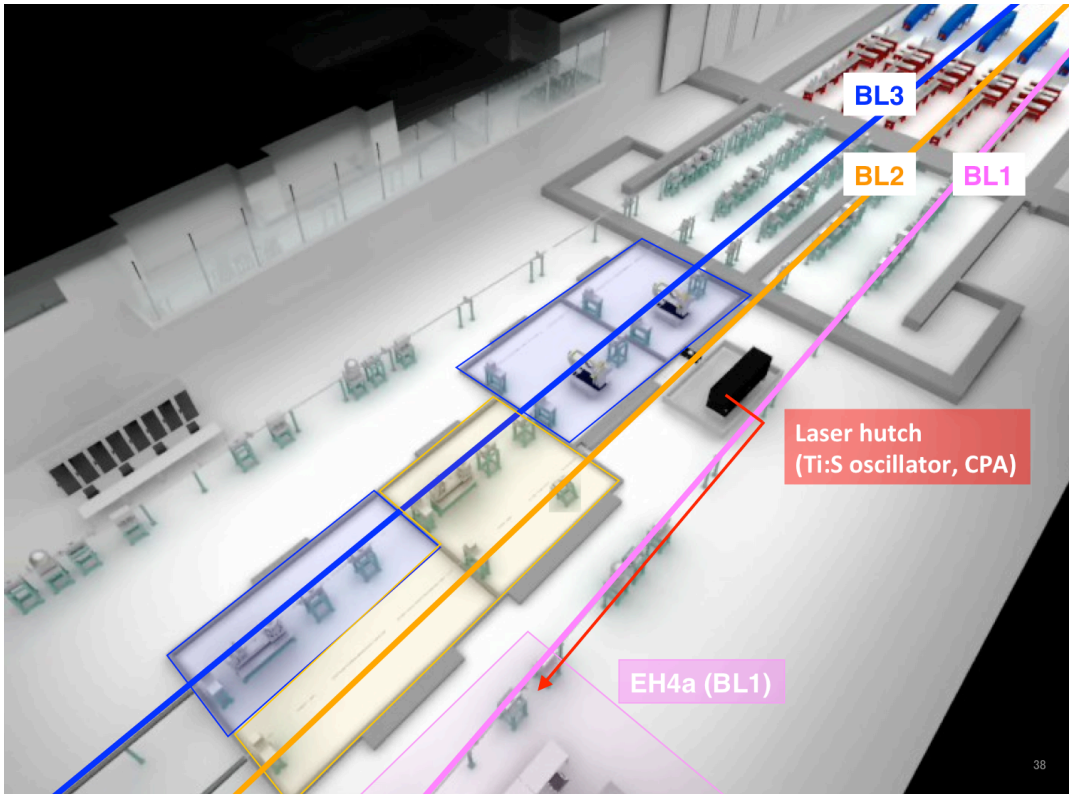
Used pulse energy ~7μJ

T > 90 % @ 10 keV

(d) Intrinsic jitter: 256 fs (RMS)

Future plan

- SXFEL beamline (BL1) started user operation.
- We started the development of arrival timing tool in EUV/SX. (Transmittance change & Spatial decoding)



E-beam energy	350 - ~800 MeV
Photon energy	20 - ~110 eV (K = 2.1)
K value	1.5 - 2.1
Pulse energy	~ 20 μJ

Temporal overlap diagnostics

t = 0 measurement at SACLA

- **Coarse t = 0 measurement**

  Fast photodiode (~ 20 ps)

- **Fine t = 0 measurement**

  X-ray pump / optical probe transmittance change (~ 1 ps)

  - GaAs : Low X-ray intensity (< 0.01 J/cm^2), ~800 nm only
  - YAG : High X-ray intensity (> 0.1 J/cm^2)

  Coherent Phonon of Bi crystal

  - Complicated experiment (diffractometer etc.)

Summary

- The arrival timing tool was installed in BL3 as a permanent non-destructive system.

  (Accuracy < 10 fs)

- We started the development of arrival timing tool for SXFEL.

- We performed simple temporal overlap measurement by observing laser induced fast melting of Bi.

Thank you for your attention