Facility Overview Report : Detector Status at PAL-XFEL

IFDEPS VT

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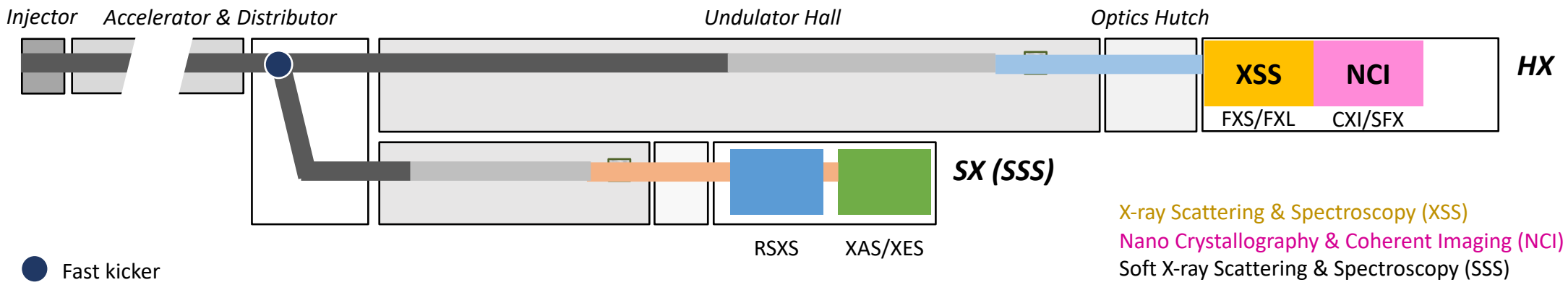
Contents

- PAL-XFEL Overview
- Requirements and Strategy for the Detector Introduction
- Current Status of the Detectors at PAL-XFEL
  - for Hard X-ray beamline
  - for Soft X-ray beamline
- R&D Activity : PIN Photo-Diode
- Future Outlook

PAL-XFEL Overview



	Hard X-ray	Soft X-ray
Photon energy	**2.0 ~ 15 keV** (0.6 ~ 0.08 nm)	**250 ~ 1250 eV** (5 ~ 1 nm)
Electron beam energy	4 ~ 11 GeV	3 GeV
Wavelength tuning	electron energy	gap
Repetition rate	10 Hz, 30 Hz, 60 Hz	10 Hz, 30 Hz, 60 Hz
Band width of pink beam (ΔE/E)	~ 0.4 %	~ 0.5 %
Photon flux (pink beam)	> 1.0×10^{11} phs/pulse	> 1.0×10^{12} phs/pulse @ 800eV

Requirements

From single photon to about 10^4 photons within 100 fs

- **Integrating method**
- **Wide dynamic range**
- Low noise & high Q.E.

Large data amount with high frame rate (60 Hz)

- **Fast data transfer rate**
- Multi-port readout system

Radiation damage

- Critical issue of life time of the sensor ; Radiation hardness

Science goals and samples

- **Geometrical restriction** ; Pixel and detector sizes, distance between sample to detector, and so on

Strategy for Detector Introduction

Construction	Commissioning	Pilot Exp.	Operation

2014	2015	2016	2017	2018	2019	2020	2021

MPCCD
0.5M & 1M

Rayonix
MX225-HS & LX255-HS

PyLon1300R

JUNGFRAU
0.5M, 4M & 16M

Newton DO940P-BN

PI-MTE 2048B

Join the development consortium : **PERCIVAL**

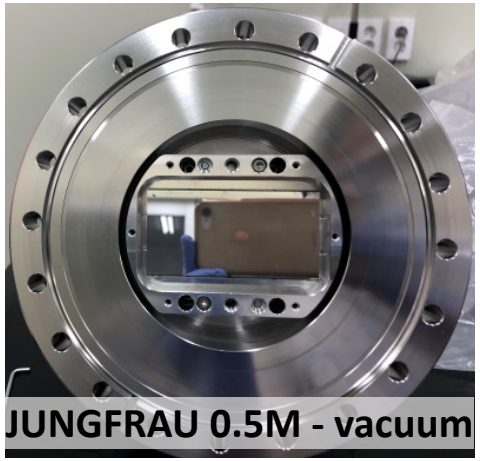
Detectors for HX Beamline

+ PD, APD

FXS (Femtosecond X-ray Scattering)

MPCCD 0.5M

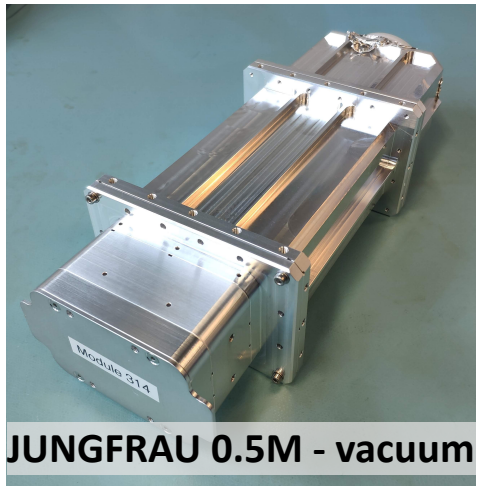
JUNGFRAU 0.5M - air



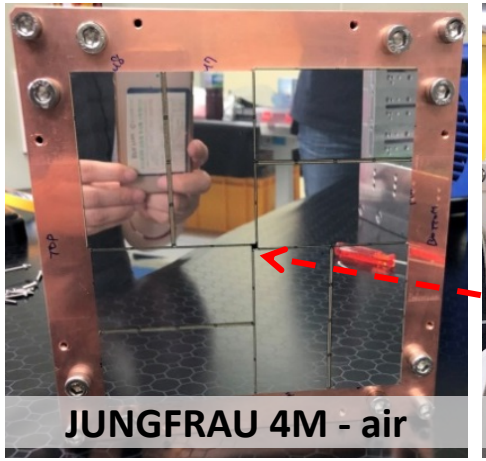
JUNGFRAU 0.5M - vacuum

CXI (Coherent –ray Imaging/Scattering)

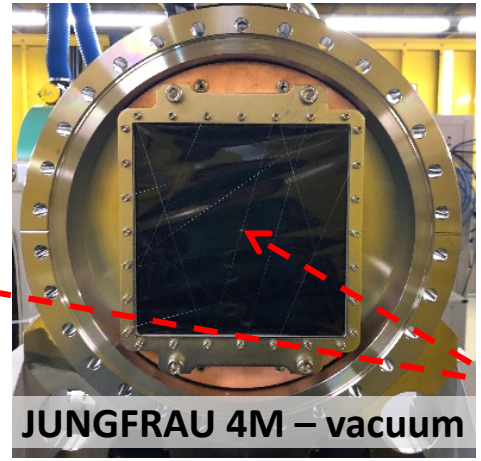
MPCCD 1M



JUNGFRAU 0.5M - vacuum



JUNGFRAU 4M - air



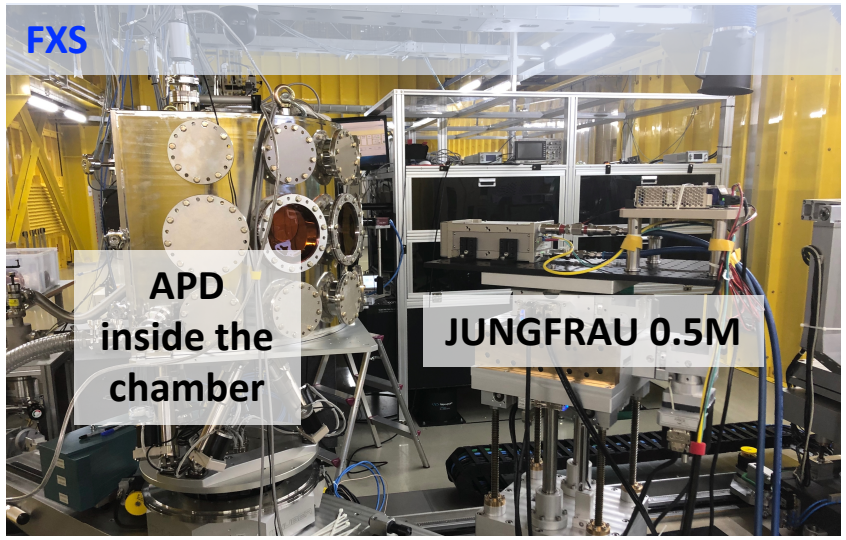
JUNGFRAU 4M – vacuum

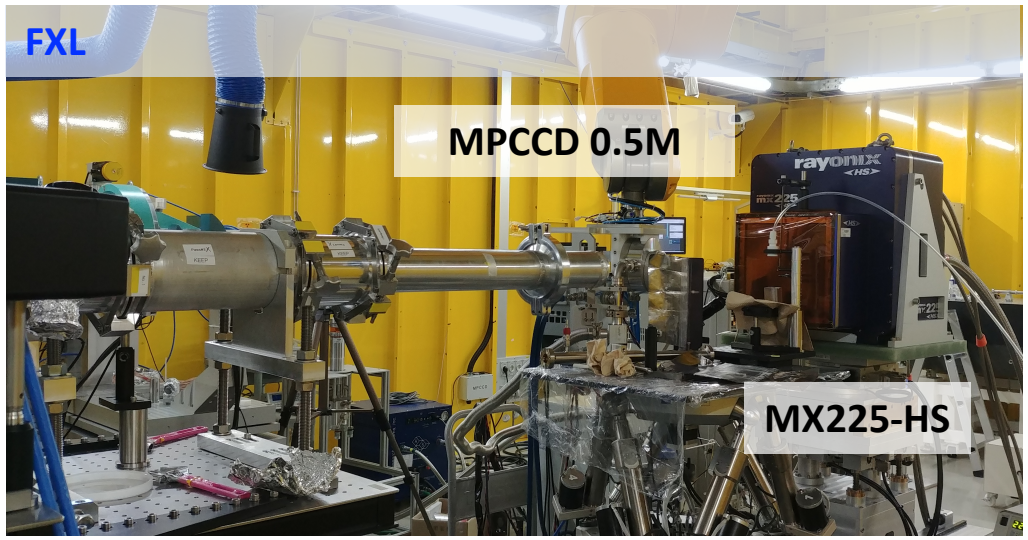
~ 3 × 3 mm^2 fixed hole

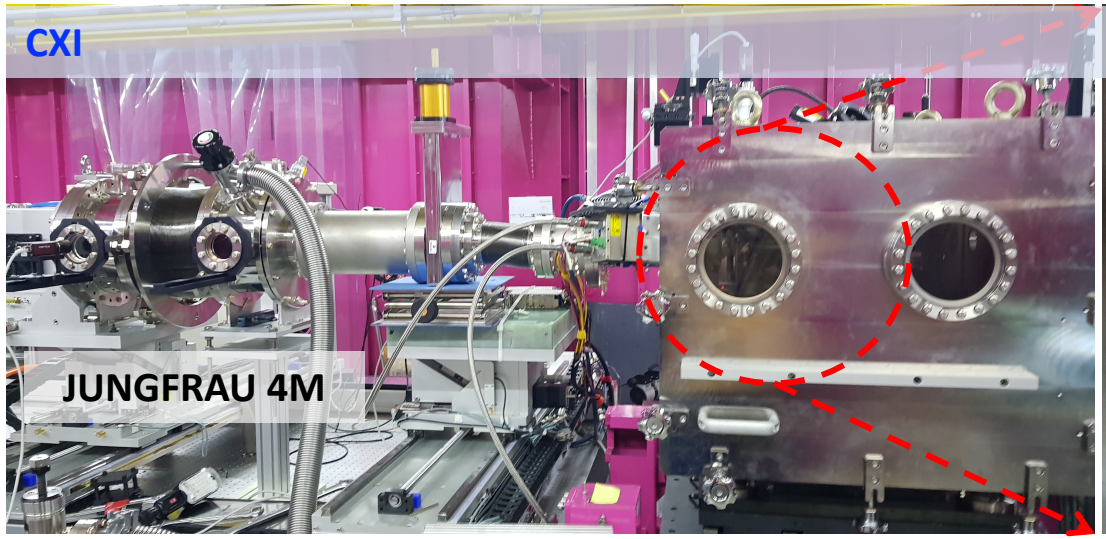
FXL (Femtosecond X-ray Liquidography) **/**
SFX (Serial Femtosecond Crystallography)

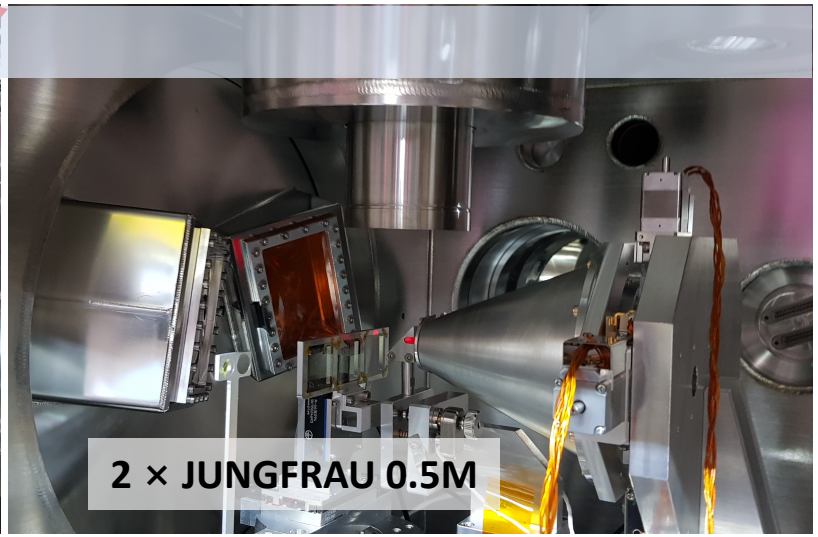
MX225-HS

Applications of HX Detectors





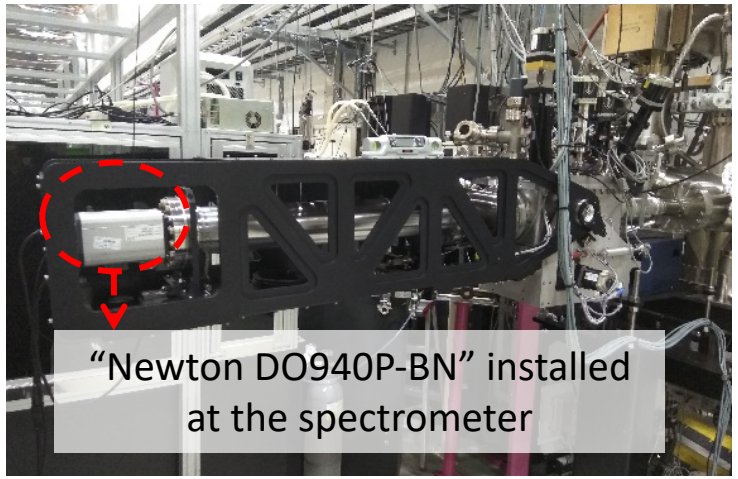




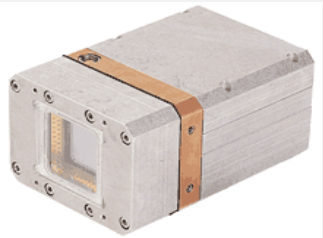
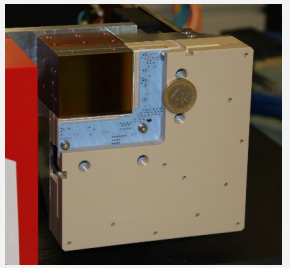
- Detectors with more complex configurations are used in most experiments

Detectors for SX Beamline

- Avalanche photo-diode (APD) and microchannel plate (MCP) are mainly used for most scientific experiments at SX beamline

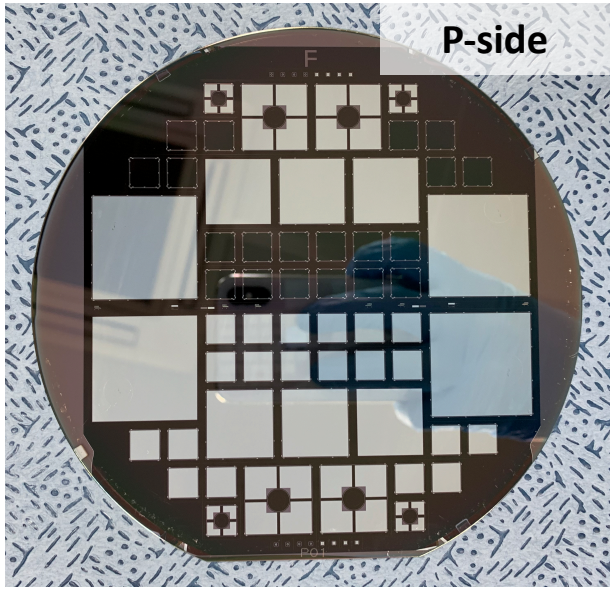


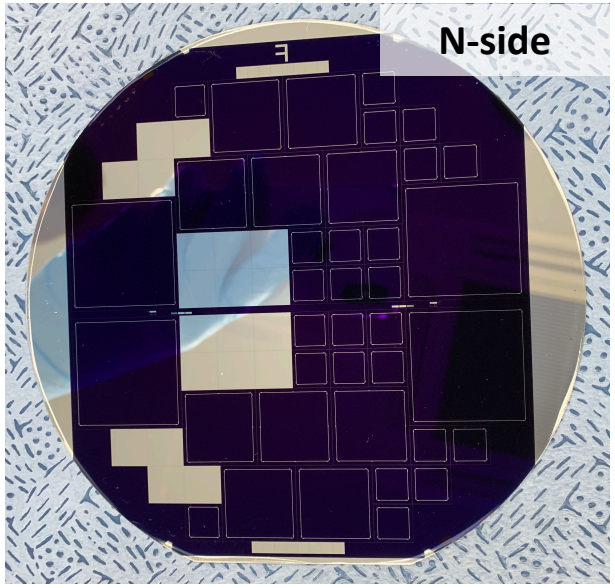
"Newton DO940P-BN" installed at the spectrometer

Detector	Newton DO940P-BN	PI-MTE 2048B	PERCIVAL
			
Energy Range	20 eV ~ 10 keV	30 eV ~ 10 keV	250 eV ~ 1 keV
Pixel Size	13.5 μm × 13.5 μm	13.5 μm × 13.5 μm	27.0 μm × 27.0 μm
Pixel Number	2048 × 512	2048 × 2048	1408 × 1484
Active Area	27.6 mm × 6.9 mm	27.6 mm × 27.6 mm	38 mm × 40 mm Sensor size: 45 mm × 50 mm
Frame Rate	**2.48 Hz (1x1)** **@ 3 MHz readout speed**	**0.4 Hz (1x1) 1.6 Hz (4x4)** **@ 2 MHz readout speed**	**300 Hz**
Dynamic Range	~ 13000 @ 3 MHz & sensitivity mode (Full well / noise)	~ 8000 @ 2 MHz readout (Full well / noise)	1 ~ 10^5 photons/pixel @ 250 eV
Status	Operation for RIXS	Under commissioning for FTH	**Under development**

R&D : Development of PIN Photo-Diode

- The R&D for the development of PIN photo-diode started at the end of 2019
  - Collaboration with Kyungpook National University (KNU, Daegu) and Electronics and Telecommunications Research Institute (ETRI, Daejeon)
- First three wafers were fabricated in 2020
  - N-type silicon wafer with a 6-in. diameter, 500 μm-thick, high resistivity (>5 kΩ·cm), and ⟨100⟩-orientation used
- Characterizations are ongoing
  - Up to now, the performance of the manufactured photo-diode is comparable with commercial one
  - There is no big issue at the fabrication parameters
- Next fabrication will be followed soon





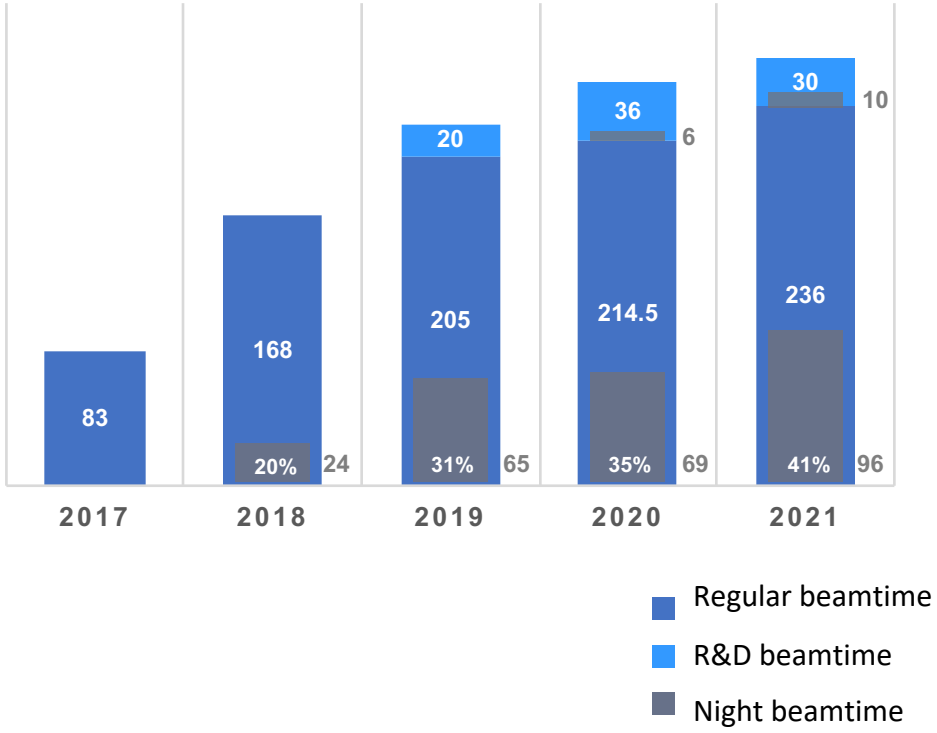
Future Outlook

- Most detectors are well established at PAL-XFEL
- Large amount of data is created → The expansion of **data storage server** is being prepared
- **JUNGFRAU 16M (in air type) will be delivered by end of 2021, and it will be available for SFX and FXL experiments in the 2nd half of 2022**
- **PERCIVAL 2M**
  - DAQ integration works is ongoing by using FSI detector head
  - **BSI will be used for RSXS and FTH experiments**
- **R&D of the photo-diode will spread to variety branches over long period**

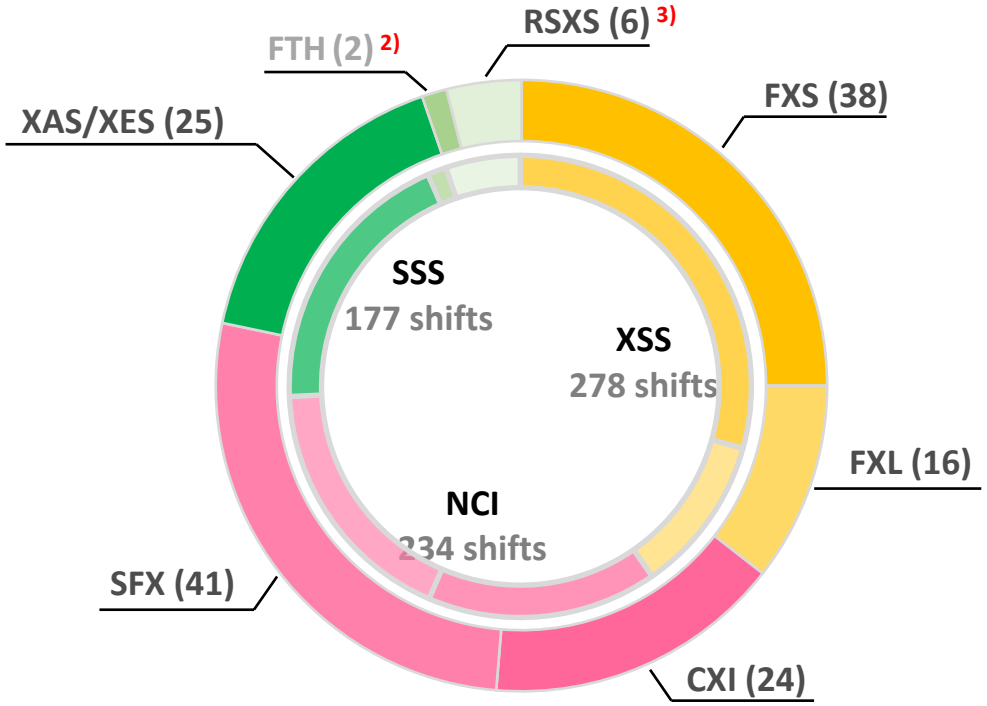
BACKUP SLIDES

Operation Statistics of PAL-XFEL

	2017	2018	2019	2020	2021
User beamtime (days)	83	140	160	170	180
Beamtime shift (12h)	83	168	225	250.5	266[1)]



No. of proposals (No. of shifts supported) (2017 ~ 2020)



[1)] Subject to change depending on the allocation situation in the second half of the year

[2)] 2019-2nd ~ 2021-1st not provided (equipment repair)

[3)] Start of operation in 2020