POHANG ACCELERATOR LABORATORY

The Development of PAL-XFEL Beamline

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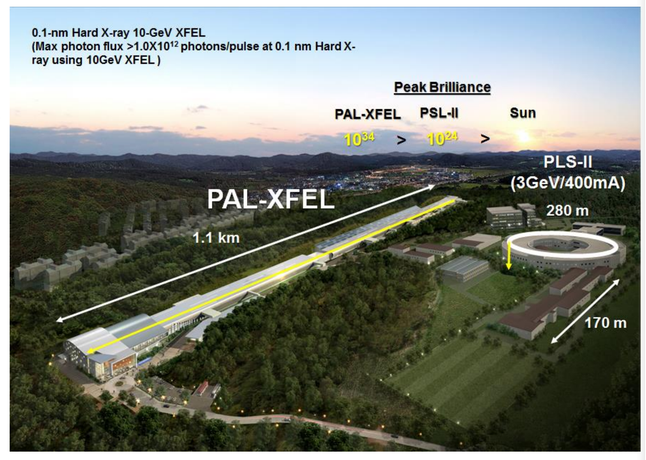
Abstract

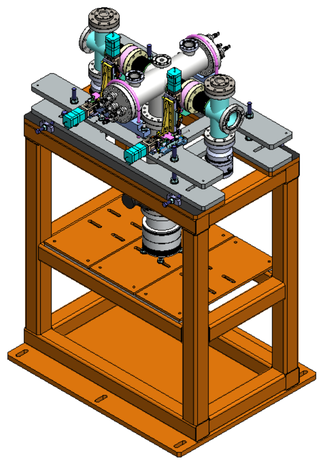
Pohang Accelerator Laboratory X-ray Free Electron Laser(PAL-XFEL) is a research facility, which is designed to generate extremely intense (assuming 1x10^{12} photon/pulse at 12.4 keV) and ultra-short (10-200 femtosecond) pulsed X-rays. Now two beamlines were constructed, the one is hard X-ray and the other is soft X-ray. The beamline is consist of UH (Undulator hall) and OH (Optical hall), EH (Experimental hall). The UH is usually the same as the front end of a beamline, and OH has the same function as PTL (Photon Transfer Line). We have two hutches including XSS and NCI(SFX & NCI) in hard X-ray beamline. The two hutches are connected each other, and sharing main optics (Mirrors and DCM, etc). PAL-XFEL is a very precise facility and has very large heat power, so thermal and structural analysis as well as vibration analysis is essential. Now many vacuum components of beamline were installed and completed the test of performance.

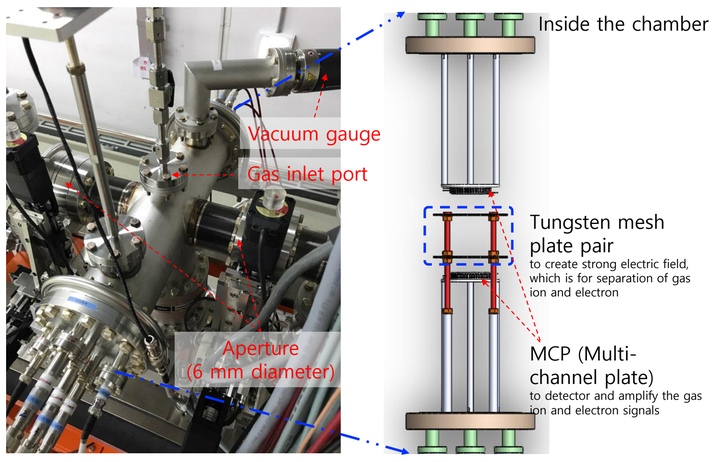


Characteristics of the XFELs

- X-ray energy: 2.5 ~ 12.7 keV (HX) & 300 ~ 1200 eV (SX)
- Repetition rate: 10 Hz, 30 Hz, 60 Hz (in plan)
- Pulse duration: <20 fs
- Bandwidth: <0.4%

Gas Monitor Detector





- A gas-based transmissive measurement has some advantages
  - On-line intensity monitoring of each pulse is possible
  - The wavefront of the coherent beam is preserved
  - The gas target does not degrade with time
  - The gas detector is not easily saturated by the peak power of the highly intense and strongly XFEL
- The Gas Monitor Detector (GMD) of PAL-XFEL
  - is installed at the downstream of the solid attenuator in the UH
  - used Xenon gas with < low × 10^{-5} torr gas pressure

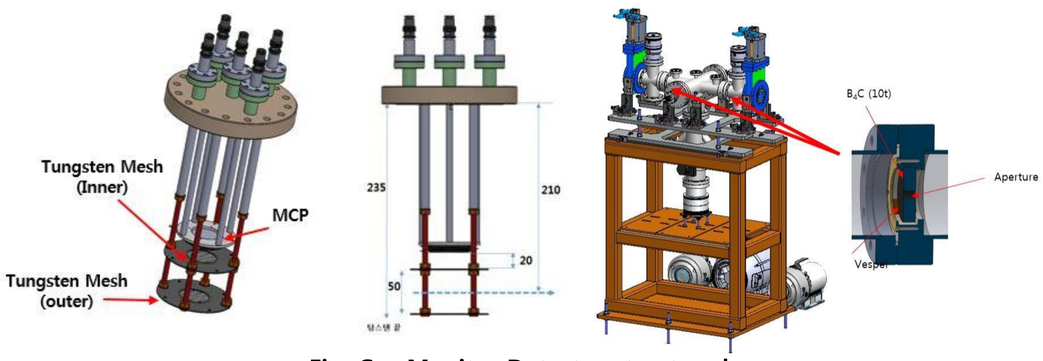
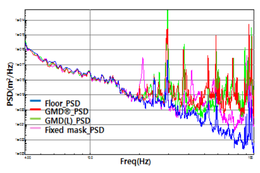


Fig. Gas Monitor Detector structured

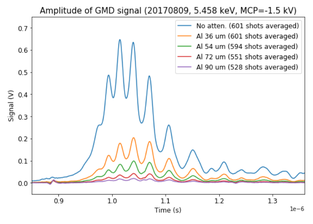
- Motor PV
  - Upstream GMD – BLHX:UH:GMD:M1
  - Downstream GMD – BLHX:UH:GMD:M2
- Motor setting
  - 500 pulse/rev
  - CCW(+) – leak valve OPEN
  - CW(-) – leak valve CLOSE

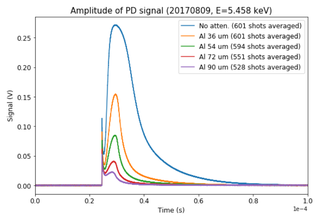


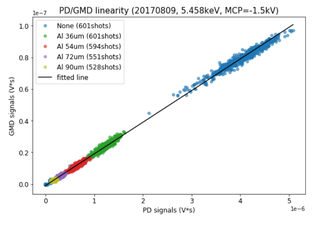
Vibration displacements of GMD

Motor	Upstream GMD	Solid attenuator	Downstream GMD		Safety shutter
	FRG (GMD cell)		FRG (GMD cell)	IG #5	IG #6
-1500	8.06x10^{-7}	3.85x10^{-8}	1.70x10^{-7}	2.1x10^{-8}	3.5x10^{-9}
-1200	8.05x10^{-7}	3.83x10^{-8}	1.73x10^{-7}	2.1x10^{-8}	3.6x10^{-9}
-1000	8.05x10^{-7}	3.84x10^{-8}	1.86x10^{-7}	2.1x10^{-8}	3.6x10^{-9}
-750	8.04x10^{-7}	3.93x10^{-8}	3.01x10^{-7}	2.4x10^{-8}	3.9x10^{-9}
-500	8.03x10^{-7}	4.42x10^{-8}	9.82x10^{-7}	3.7x10^{-8}	5.6x10^{-9}
-250	8.03x10^{-7}	1.11x10^{-8}	9.88x10^{-6}	2.0x10^{-7}	2.7x10^{-8}
0	8.08x10^{-7}	5.68x10^{-8}	4.08x10^{-5}	1.2x10^{-6}	9.7x10^{-8}

The results of differential pumping test

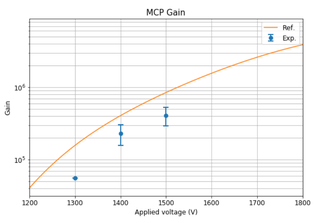




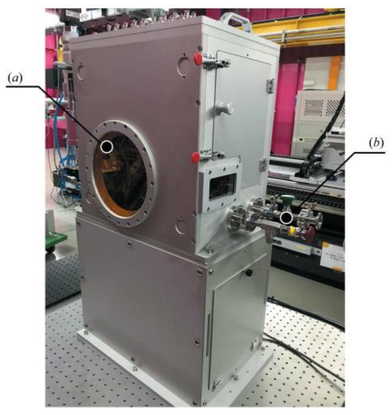


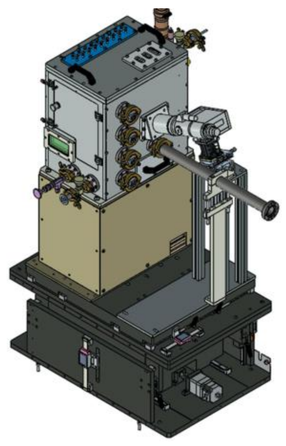
5.46 keV, MCP=-1.5 kV (Ref. GMD G:8.47 × 10^5)		
UH Atten.	Photon Number Φ_0 [#/pulse]	
	GMD	PD
0	0.67 × 10^{10}	1.93 × 10^{10}
Al 36 um	0.85 × 10^{10}	2.42 × 10^{10}
Al 54 um	0.83 × 10^{10}	2.50 × 10^{10}
Al 72 um	0.73 × 10^{10}	2.40 × 10^{10}
Al 90 um	0.72 × 10^{10}	2.76 × 10^{10}
Average	**0.76 × 10^{10}**	**2.40 × 10^{10}**

MCP Applied Voltage	Φ_0 of GMD [× 10^{10} #/pulse]		
	5.46 keV	9.67 keV	11.9 keV
-1.5kV (G:8.47×10^5)	0.76	0.18	0.26
-1.4kV (G:4.07×10^5)	0.74	0.18	0.39
-1.3kV (G:1.58×10^5)	0.70		
Φ_0 of PD	2.40	0.64	0.33



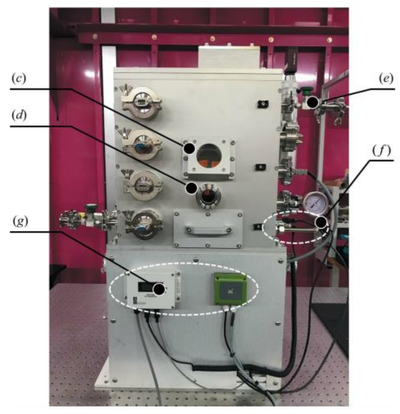
Multifarious Injection Chamber for molecular Structure study System(MICOSS)



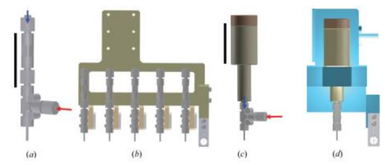


MICOSS and Position manipulation stage

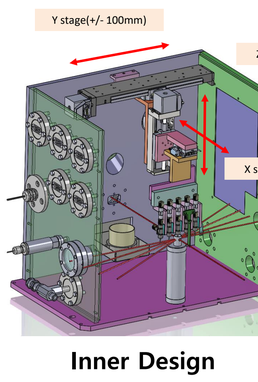
- A helium-gas filled sample chamber to provide relatively a low signal to noise
- Two type of sample injector developed
  - Multi injector type (Magnet type)
  - LCP(Liquid Cubic Phase) Injector type



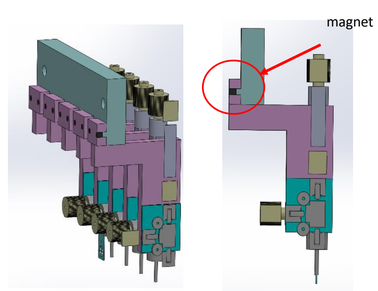
(a) Window for passing diffraction signal to detector
(b) Pumping port (c) View port for microscope
(c) XFEL pulse input port (d) Helium gas input port
(f)(g)Sensors & Signal



(a,b) Multi-injector nozzle
(c,d) LCP injector nozzle

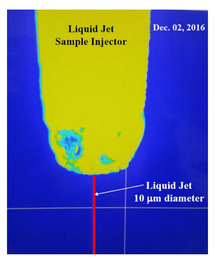


Inner Design

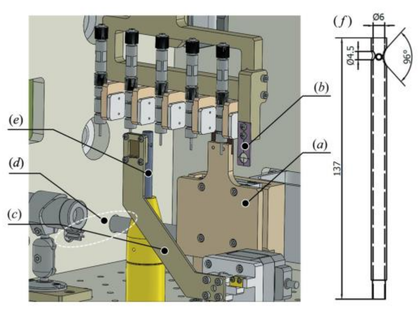


Magnet type is to assemble & de-assemble

Stage (Micronix)		
Y – stage	VT50L -13310	Travel : 200mm, Resolution : 0.05μm
Z – stage	VT50L -12310	Travel : 100mm ,Resolution : 0.05μm
X – stage	PPS-28-23320	Travel : 51mm, Resolution : 0.1μm



Sample Monitoring



(a) Pinhole position (b) Cross wire holder
(c) PD manipulator (d) Oxygen & humidity sensor
(e,f) Sample catcher