PO27

Current Status of UVSOR Synchrotron Radiation Facility

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Abstract

We present the current status of UVSOR-III electron storage ring. It is a 750 MeV machine dedicated to synchrotron radiation in UV, VIS, IR and SX region, including LCS gamma-rays. We are accepting about 4,000 person-day researchers yearly from nationwide and outside Japan. The accelerator complex consists of a 15 MeV linear accelerator, a 750 MeV booster synchrotron and a storage ring of 53 m circumference, in which 6 undulators are operational. The operation time is from 9 am to 9 pm from Tuesday to Friday, including overnight bonus operation on Thursday night. All 60 hours operation is in top-up mode. Eight technical staffs with several beamline scientists are managing total 14 beamlines, while four technical staffs operate all accelerators. Most of the beamline control softwares and some of the accelerator control softwares are made in-house. UVSOR-III is reaching 40 years old and facing severe aging problems, especially of cooling water leakage from electromagnets and vacuum leakage from beam ducts. We are managing the troubles with various solutions, including partial replacement of coils, applying sealants, and so on.

Activity as Inter-University Research Facility

36 Weeks User Operation/year,
Total 4000+ (person*day) Users

History

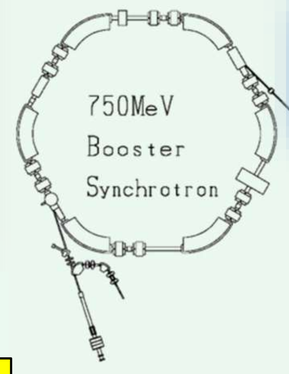
1975: Institute Established
1983: First Light
1984: User Operation Start
1986: FEL Study Start
1997: FEL Lasing at 239nm (World Record)
2003: Upgrade to UVSOR-II
(Combined Function Quadrupole etc.)
2004: THz CSR Study Start
2007: Full Energy Injection Start
2010: Top-Up Operation Start
2012: Upgrade to UVSOR-III
(Combined Function Bend, Pulse Sextupole Injection etc.
2013: STXM beamline BL4U
2020: LCS gamma ray offer @BL1U
2020: Momentum Microscope @BL6U

Steps Toward UVSOR-III

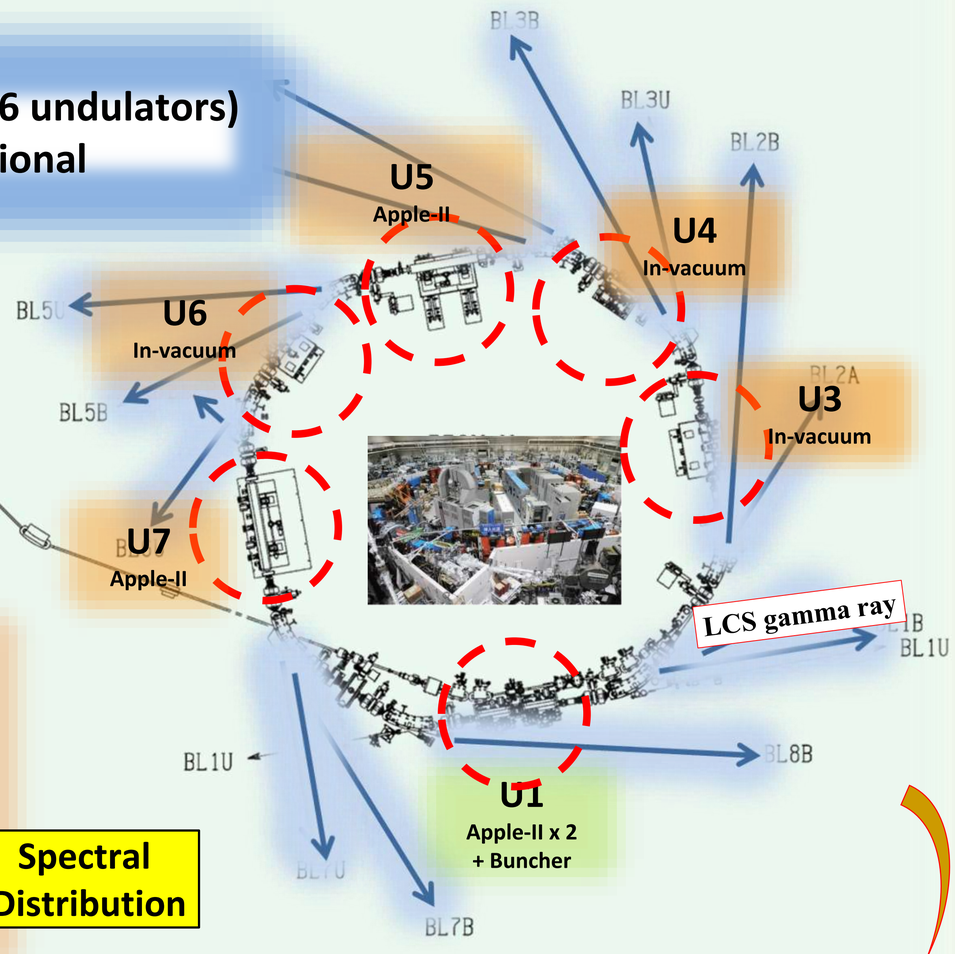
	UVSOR (1983~2003)	UVSOR-II (2003~2012)	UVSOR-III (2012~)
Operation Energy	750 MeV	750 MeV	750 MeV
Injection Energy	600 MeV	600 MeV	750 MeV (Top-Up)
Average BeamCurrent	~150 mA	~200 mA	300 mA
# of IDs	3	4	6
Emittance	~160 nm rad	27 nm rad	17 nm rad
Lattice	DBA	Extended DBA	Extended DBA
		Combined Function Quad./Sext.	+ Combined Function Bend

UVSOR-III Accelerator Complex

parameter	Storage Ring
Operation Energy	750 MeV
Injection Energy	750 MeV
Beam Current	300 mA
Natural Emmittance	17 nm-rad
Circumference	53.2 m
Bending Radius	2.2m
Lattice	Extended DBA x 4
Straight Section for I.D.	4 m × 4, 1.5 m × 2
Betatron Tunes	(3.60, 3.20)
Momentum Compaction	0.030
Energy Spread	5.4×10^{-4}
RF Frequency	90.1 MHz
RF Voltage	120 kV
Natural Bunch Length	128 ps
3rd Harmonic Cavity	One Installed



14 beamlines (6 undulators) operational



parameter	Booster Synchrotron
Operation Energy	750 MeV
Injection Energy	15 MeV
Average Beam Current	~15 mA
Circumference	26.6 m
Bending Radius	1.8 m
Lattice	FODO x 6
Momentum Compaction	0.138
Betatron Tunes	(2.25, 1.25)

parameter	Linac
Injection Energy	15 MeV
Peak Beam Current	~100 mA
Length	2.5 m
Frequency	2856 MHz
GUN HV	70 kV

Insertion Devices

U1 Apple-II Undulator / Optical Klystron

Number of Periods	10 + 10
Period length	88 mm
Pole Length	0.968 m + 0.968 m
Pole Gap	24-200 mm
Deflection Parameter	7.36 (Max. Horizontal) 4.93 (Max. Vertical) 4.06 (Max. Helical)

U3 In-vacuum Undulator

Number of Periods	50
Period length	38 mm
Pole Length	1.9 m
Pole Gap	15-40 mm
Deflection Parameter	2.0-0.24

U4 In-vacuum Undulator

Number of Periods	26
Period length	38 mm
Pole Length	0.99 m
Pole Gap	13-40 mm
Deflection Parameter	2.4-0.19

Bending Magnets

Bending Radius	2.2 m
Critical Energy	425 eV

U5 Apple-II Variable Polarization Undulator

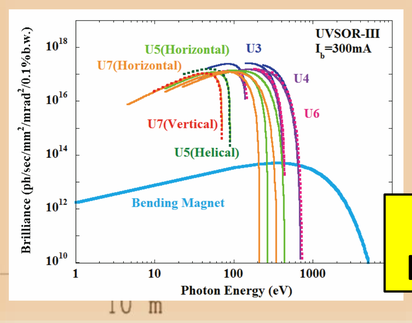
Number of Periods	38
Period length	60 mm
Pole Length	2.35 m
Pole Gap	24-190 mm
Deflection Parameter	3.6 (Max. Horizontal) 2.0 (Max. Vertical) 1.9 (Max. Helical)

U6 In-vacuum Undulator

Number of Periods	26
Period length	36 mm
Pole Length	0.94 m
Pole Gap	13-40 mm
Deflection Parameter	1.78 - 0.19

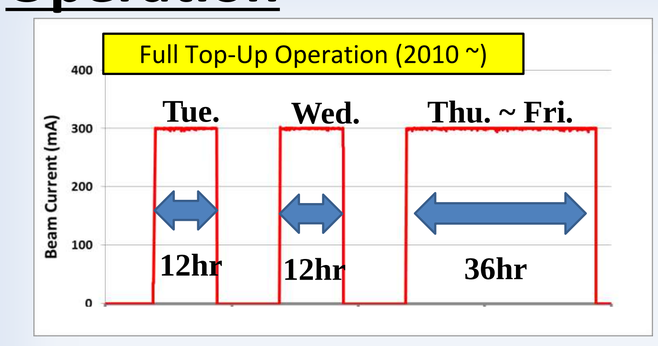
U7 Apple-II Variable Polarization Undulator

Number of Periods	40
Period length	76 mm
Pole Length	3.04 m
Pole Gap	24-200 mm
Deflection Parameter	5.4 (Max. Horizontal) 3.6 (Max. Vertical) 3.0 (Max. Helical)



Spectral Distribution

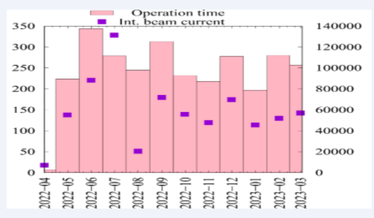
Operation



60 hours / Week
User Operation

Mon: Machine Study
Tue: 9:00 – 21:00
Wed: 9:00 – 21:00
Thu: 9:00 – Fri: 21:00
Sat & Sun: Machine Study (optional)

Operation statistics in 2022



Organization for operation

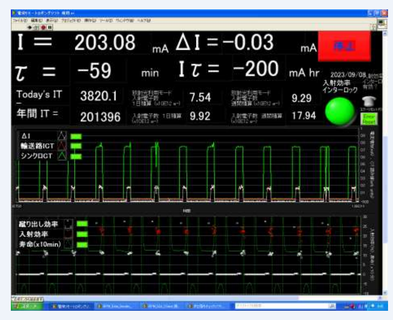
	# of Researchers	Technical Staffs	Supporting Staffs
Accelerator	2	4	1
Beamlines	7	8	2

For 14 beamlines

Including staffs not fully dedicated to beamlines/accelerators:
More posts needed for better working environment.

Control Systems

Most of the devices are controlled by PCs.
As a ~40 years old facility, some of the devices remains in button / potentiometer operations.

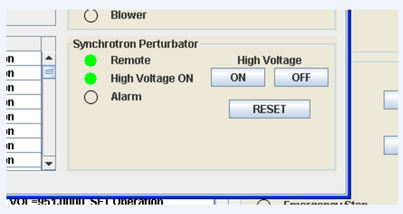


De Fact standard programming language in UVSOR is LabVIEW™.

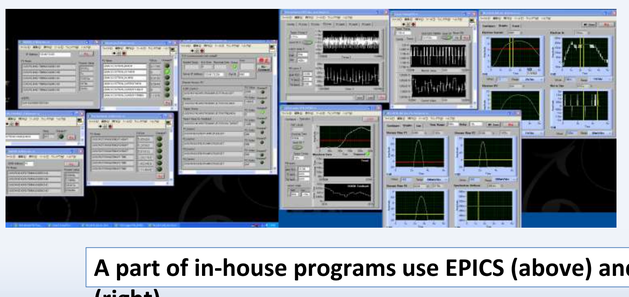
Examples of in-house programs

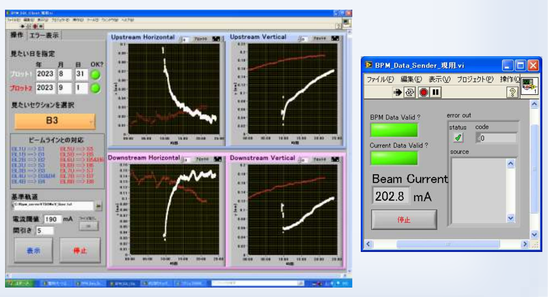
Step by Step:

Manual control system for injection kicker of booster synchrotron.



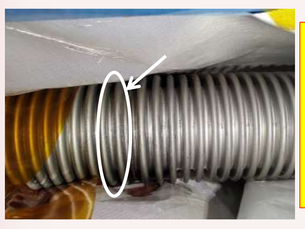
Integrated to injection control system GUI in 2023.





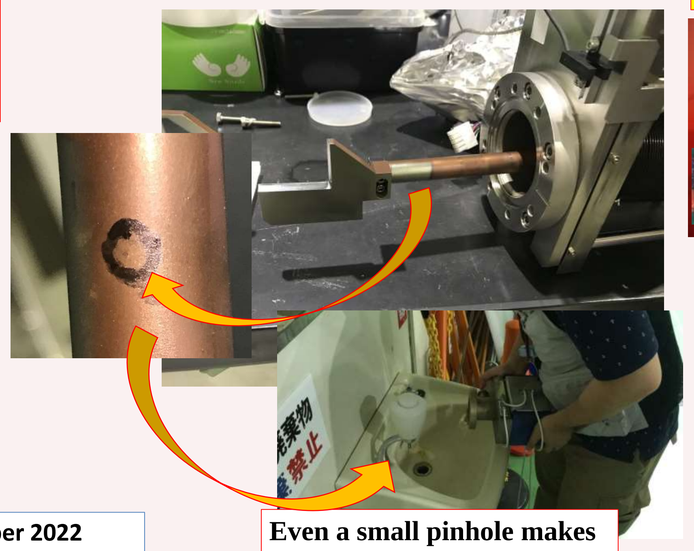
A part of in-house programs use EPICS (above) and SQL (right).

Troubles in Recent Years



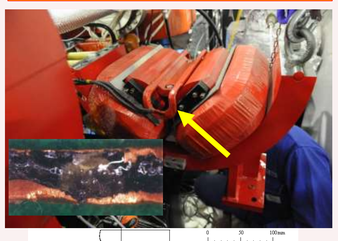
2022/10 & 11: Vacuum Leakage from Bellows duct @Booster Synchrotron
Temporal treatment with Liquid Seal ™

Water Leakage from Beam Slit in 2021 @ BL7U Frontend
Needed 5 weeks for recovery.



Even a small pinhole makes a pool…

Total Replacement of Sextupole Main Coils in 2020 & 2021.
@ Combined function magnets in storage ring



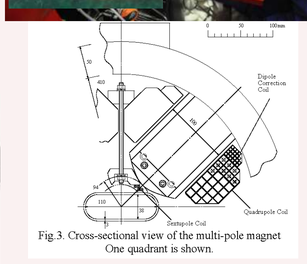
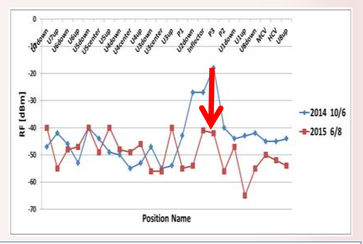


Fig.3. Cross-sectional view of the multi-pole magnet
One quadrant is shown.

Cooling Water Leakage from Booster Synchrotron Quad.

New cooling pipe added.

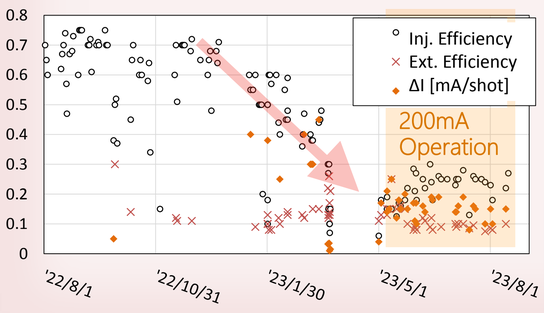
Break @ gold coat of a kicker ceramics duct.



Duct replaced in spring 2015.
RF noise reduced by >20dB.

Beam Injection Efficiency Drop: 200 mA Operation

Efficiency and ΔI (2022/8/1～2023/8/26)



Began ~December 2022
Efficiency 70% => 25%
300mA => 200mA operation
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