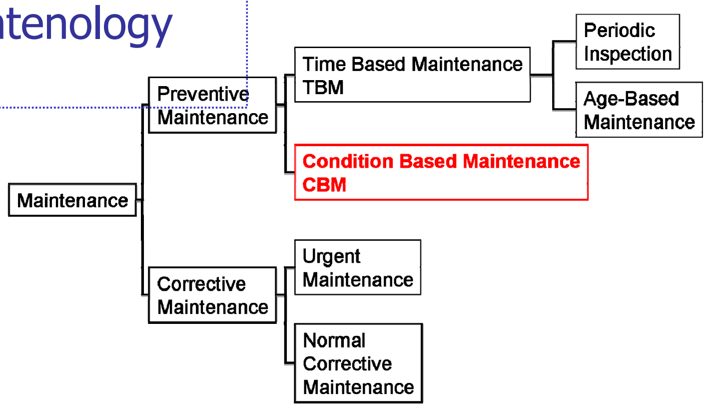
Activity Report of Condition-based Maintenance Technology (CMT) Panel of Japan Society of Maintenology

Panel Chair: Mitsuru Uesaka

Nuclear Professional School,
University of Tokyo

Condition Based Maintenance Technology Panel in Japan Society of Maintenology
Chair: Prof. K. Miya



Establish Reasonable and Quantitative Evaluation of Nuclear Power Plants and contribute to Safety and High Operation Rate.

- Assessment WG chaired by Dr.A.Yamaguchi
- Technology WG chaired by M.Uesaka

-Focused on Pumps containing Bearings now

-Fracture Test and In-situ Measurements by practical methods of Vibration, AE, Oil and Debris Analysis, and Thermography

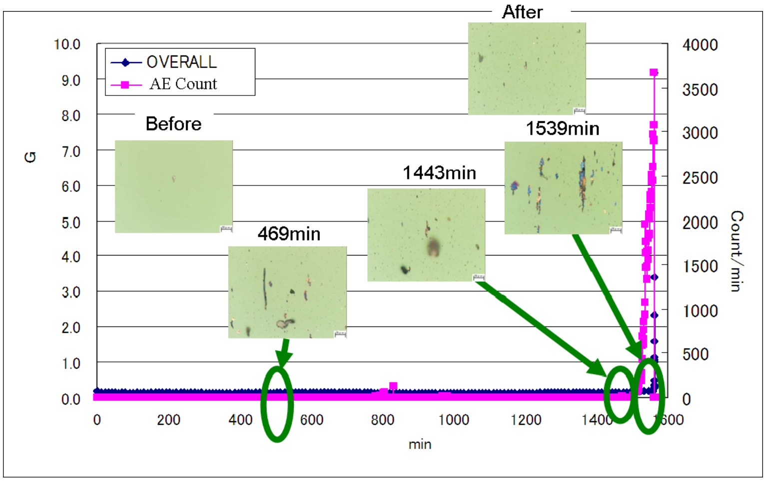
-New Techniques

Guide-wave UT, EMAT, On-site RT, Optical Fiber Brug Peak Measurement.

Collaborated by Mr.N.Sasaki and Mr.M.KawamataTROBOTEX Inc.

Bearing Experiment

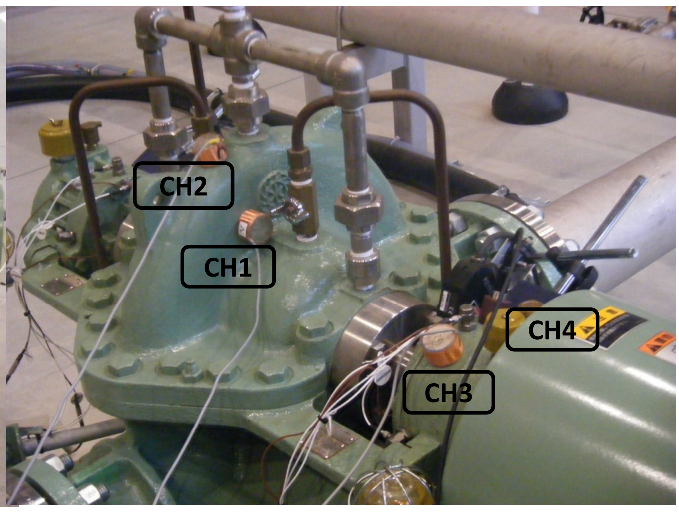
For Condition Based Maintenance to Nuclear Plants



Acoustic Emission Count

We will plan to get still images of *rotating bearing*.
->Collaboration with AE, Neutron, and X-ray

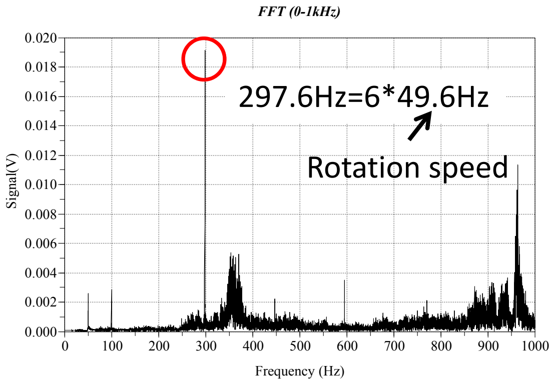
Electromagnetic Signal Pick-up for Real Horizontal Circulating Pump by IIU Co.Ltd at Technical Training Center, Nuclear and Industrial Safety Agency, METI



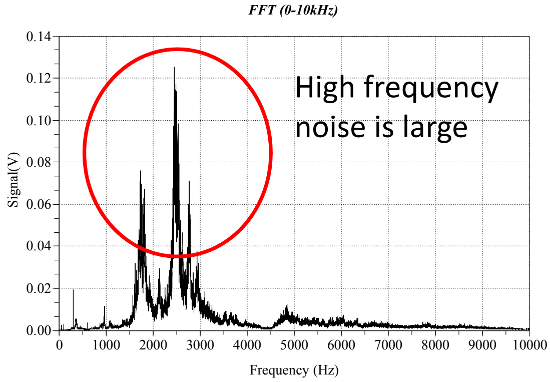
Measurement

1. Impellar Axial Electomagnetic
2. Impellar Radial Electomagnetic
3. Bearing Radial Electomagnetic
4. Bearing Radial Vibration

Spectrum of Electromagnetic Signal from Impeller（CH1）



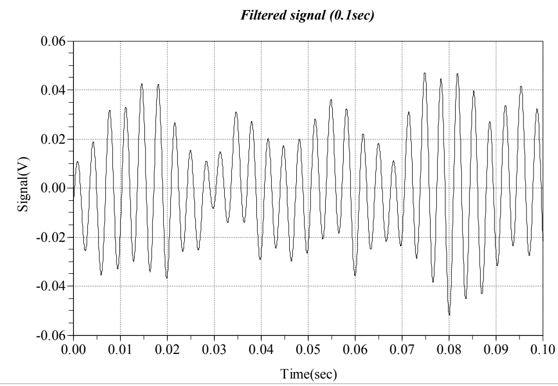
Spectrum of EM signals (0-1kHz)



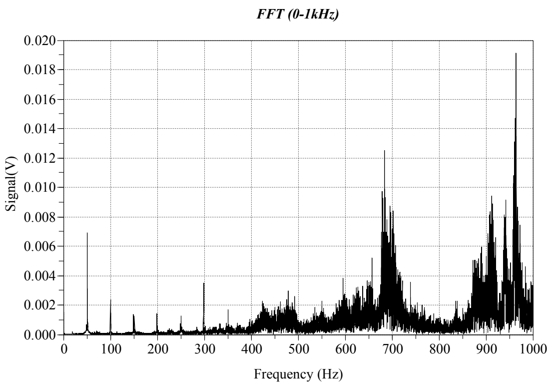
Spectrum of EM signals (0-10kHz)

Frequency of the impeller (297.6Hz) is detected according to the spectrum. High frequency noise is very large. It is not easy to identify the impeller from the raw signals.

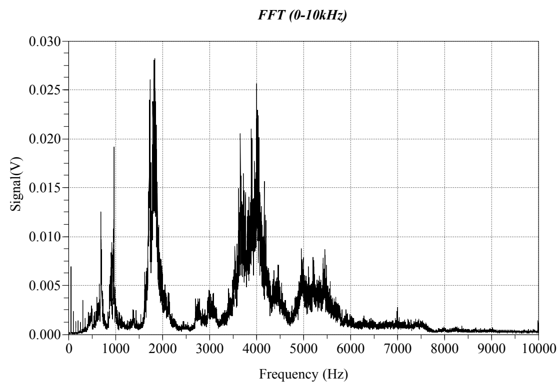
It is possible to identify the impeller after applying a LPF (Low passed filter) to the raw signals.



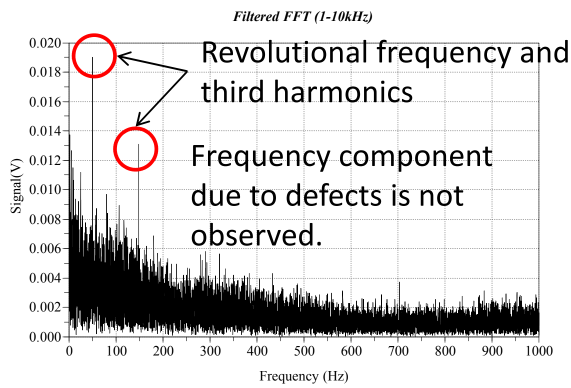
FFT Signal（CH3）for Bearing



0-1kHz



0-10kHz

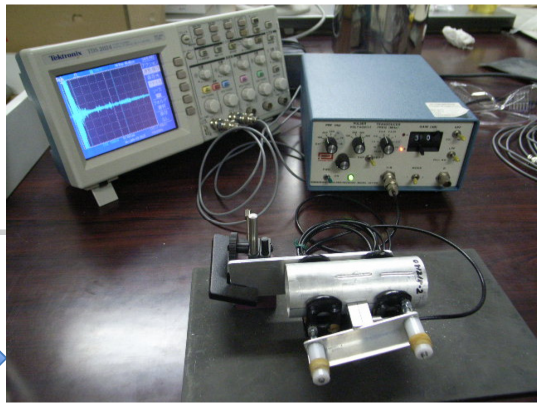


Guided-wave UT method

Tokushima University

Experimental and theoretical study
of circumferential guided waves
for health monitoring
of hollow cylindrical structures

Appearance
of the experimental instrument



Abstract

Following theoretical and experimental studies have been carried out for an efficient defect detections using circumferential guided waves. The primary aim of the research is for health monitoring of hollow cylindrical structures.
(1)Theoretical calculations of dispersion relation and wave structures of the circumferential guided wave.
(2)Specially designed holder for both the specimen and the sensor used.
(3)Experimental identifications of both angular positions and depth of a defect.
The experimental results agreed well with the theoretical estimates.

Identifications of circumferential defect positions

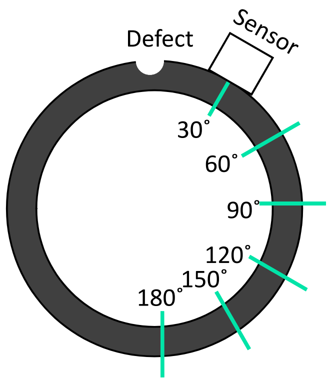


Fig.1 Defect and sensor positions

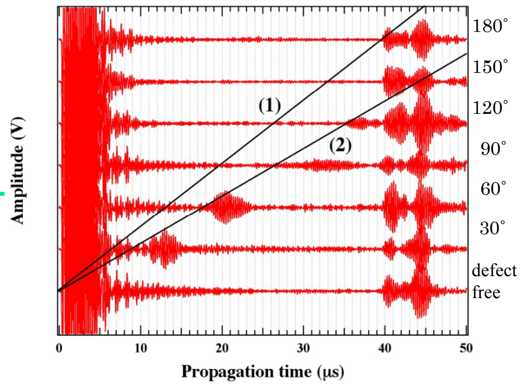
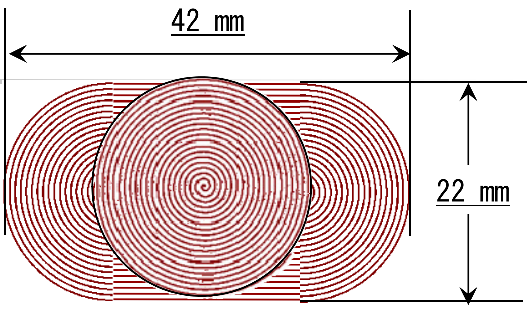


Fig.2 Time domain signals for different defect positions.

EMAT-EC Multi-probe

Institute of Fluid Science, Tohoku University

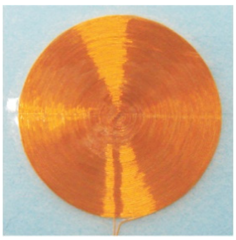
Multi-probe for evaluation of fatigue cracks



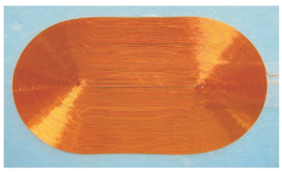
Φ0.12 mm, 70turn

Center frequency : 1.0 MHz
(Shear Wave)

Incident angle θ : 39°



Coil 1: 70 turns
(Disk type)

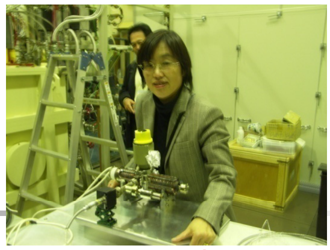


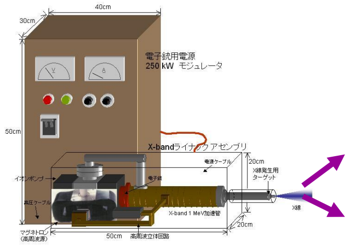
Coil 2: 70 turns
(Race-track shape)

EMAT mode : coil 2 is used as transmitter and receiver.

ECT mode : coil 1 is used as an exciter, coil 2 as an detector.

Portable!!





Schematic configuration

Introduction

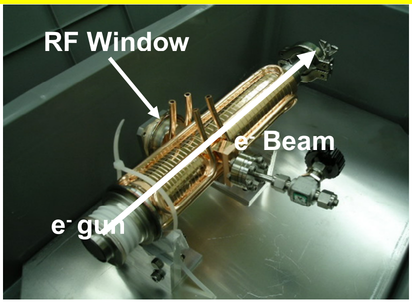
Development of X-ray Nondestructive Testing System with Portable Linac

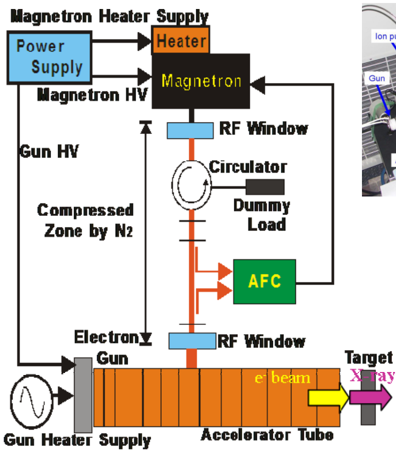
Conventional Linac Based X-ray NDT System -> Big!

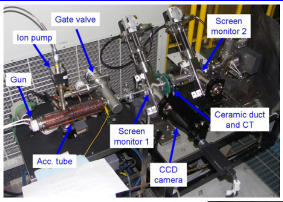
Our Feature

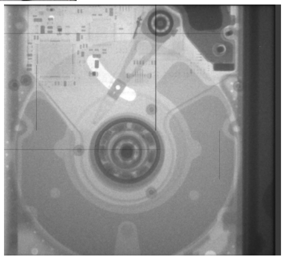
Development of Portable & Compact X-ray NDT System with X-band Linac

- 250 kW *Magnetron*
- *X-band Linac* (9.4 GHz)
- *Max Energy* 950 keV









Comparison with other system

	VARIAN LINATRON	A.S.&E Inc. Design	Out system **Developed**
Frequency	S-band (2.856GHz)	X-band (9.5GHz)	X-band (9.4GHz)
Acceleration method	Linac	Linac	Linac
Size of linac	600mm	100mm	300mm
RF source	Klystron	Magnetron	Magnetron
RF power	some MW	1.2MW	250kW
RF source size	$1\times1\times1$ m^3	$1\times1\times1$ m^3	$0.1\times0.2\times0.2$ m^3
Use	Off-site	On-site	On-site
Dose rate	0.15Gy@1m/min	0.2Gy@1m/min	0.2Gy@1m/min
Spatial resolution	3mm	Undecided	1mm
Stability of Intensity	±3%	±3%	±1.5%

Beam energy is 950keV in all system.

Regulation of Radiation Safety in Japan for Electron Linear Accelerators

- Below 1 MeV

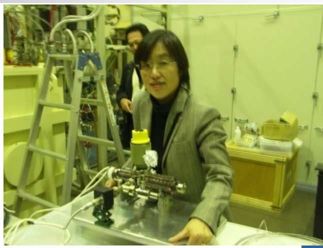
Allowed to be used outside radiation controlled area with reasonable local shielding and protection system

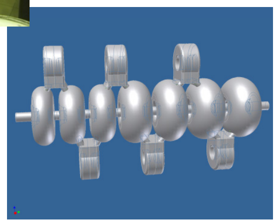
- Below 4 MeV

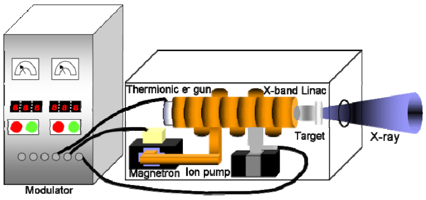
Allowed to be used outside radiation controlled area only for inspection of bridges

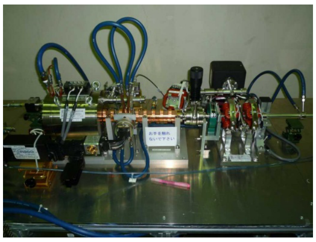
- Over 6 MeV

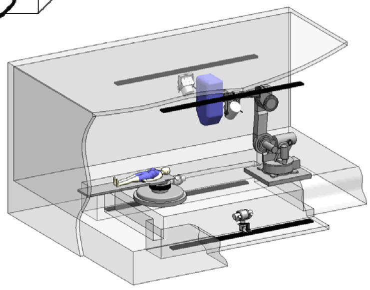
Should be used in radiation controlled area for Medical use and Scientifc and security- applications







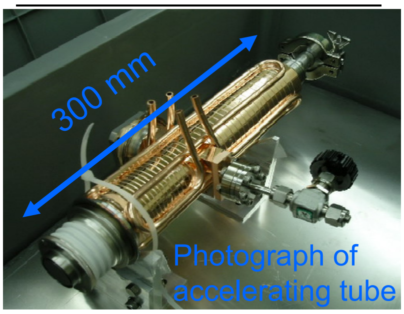


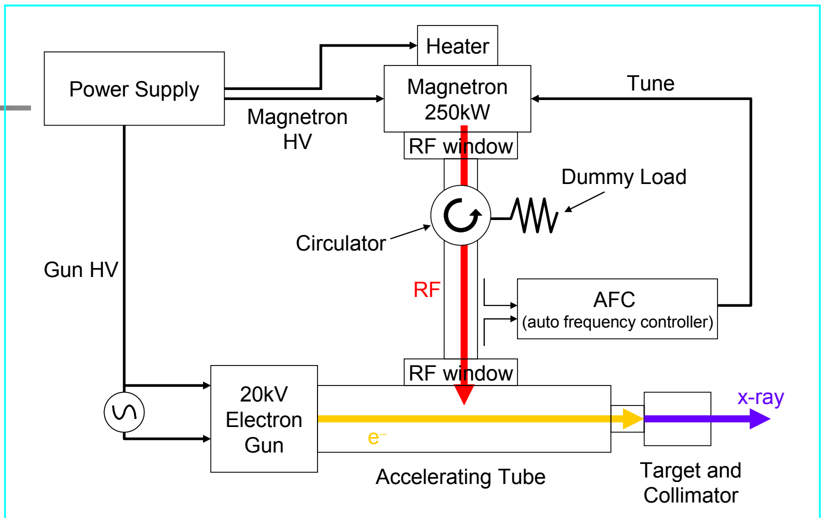


System configuration

Design parameter

Frequency	X-band (9.4GHz)
Length of linac	300mm
RF source	Magnetron
RF power	250kW
Beam energy	950keV
Gun current	400mA
Pulse length	2μsec
Repetition	500pps
Dose rate	0.2Gy/min@ 1m





Block diagram of our system

A 20kV electron beam is generated by the thermonic gun. This beam current is 400mA. The magnetron feeds RF to accelerating tube, and electromagnetic field is generated in accelerating tube. The electron beam is accelerated to 950keV. Finally, the electron beam collide to metal target and generates X-ray by bremsstrahlung.

Measurement of discrimination ability by using wire type penetrometer

Thickness of iron plate :17.2 mm
We can distinguish as far as 0.5 mm wire. We can NOT distinguish 0.4 mm wire.

Thickness of iron plate : 12.9 mm
We can distinguish 0.4 mm wire.

X-ray spot is ~2mm.

$$\text{Discrimination ability} = \frac{\text{Diameter of wire}}{\text{Thickness of plate}}$$

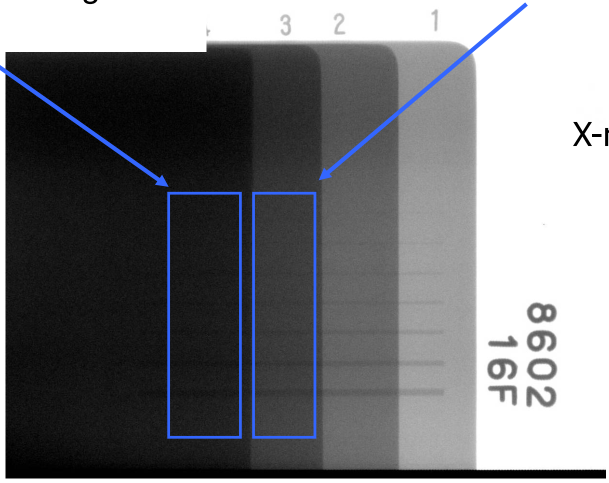


Image of wire type penetrometer

The discrimination ability is about 3 %

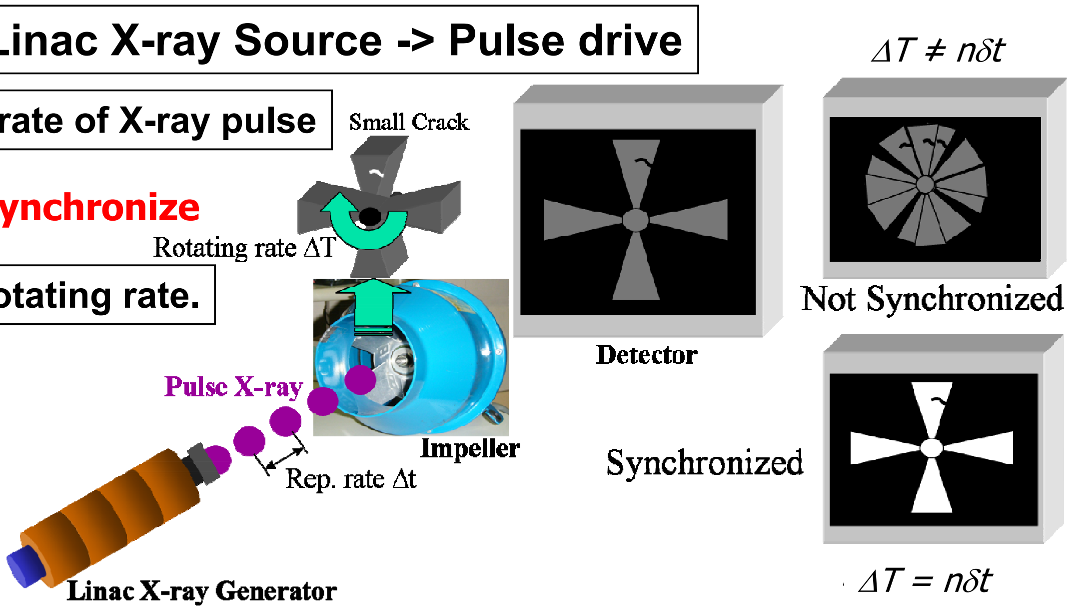
Concept of Real-Time Imaging

Linac X-ray Source -> Pulse drive

Reputation rate of X-ray pulse

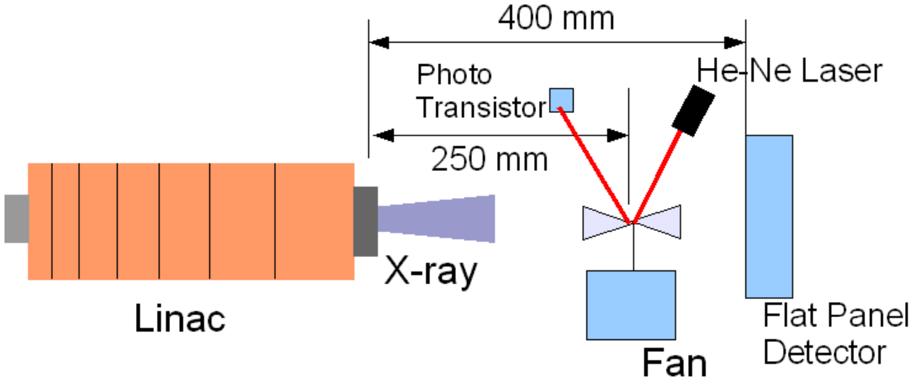
Synchronize

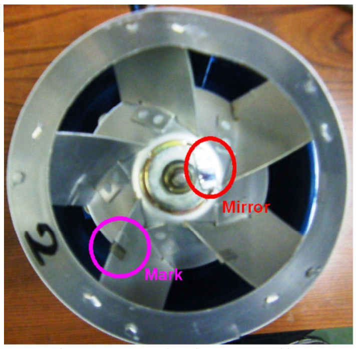
Impeller's rotating rate.



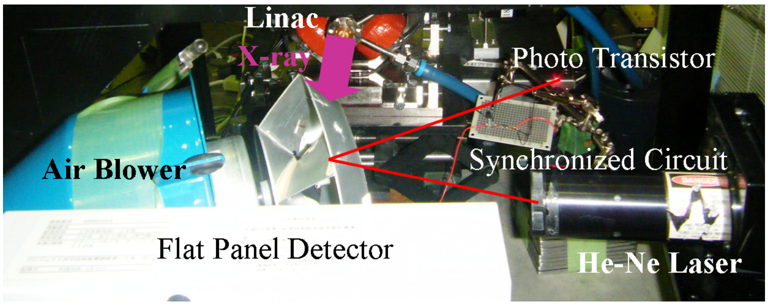
We can get still images without rotation stopping.

Experimental Setup

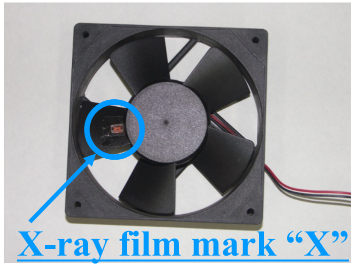




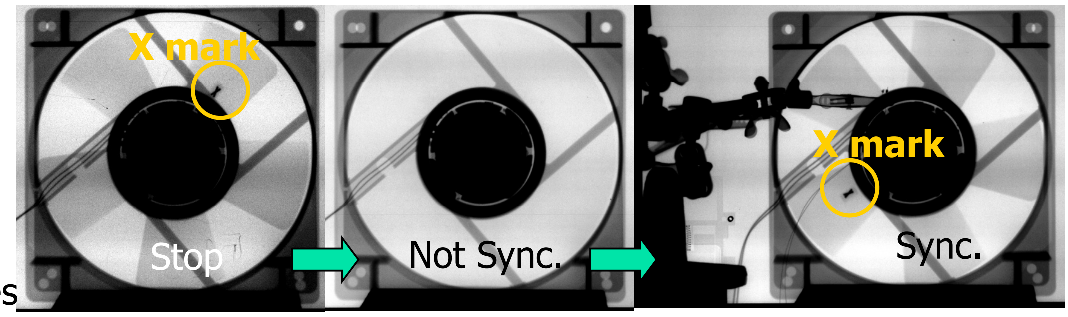
Mirror: Light Reflector
Mark: Sign (Pb plate)



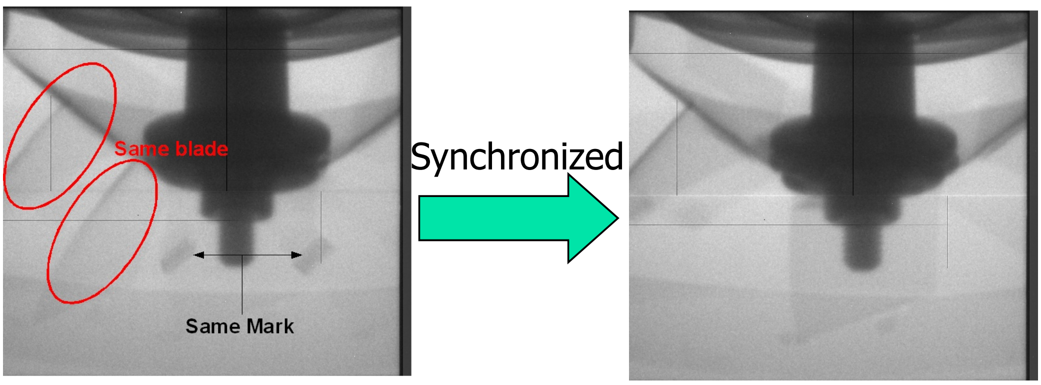
PC fan



Results



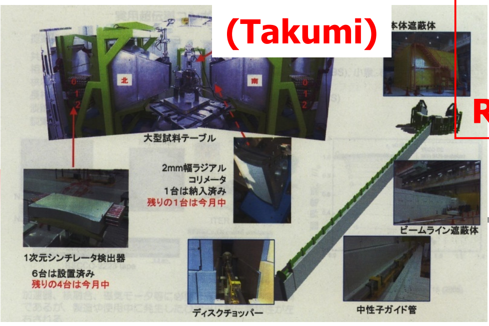
IP Images

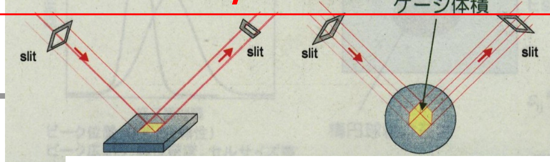


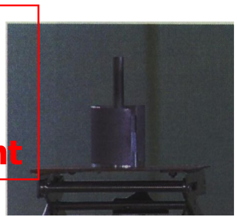
CsI Images

J-PARC Proton Synchrotron and Neutron Spallation Source And Residual Strain/Stress Measurement

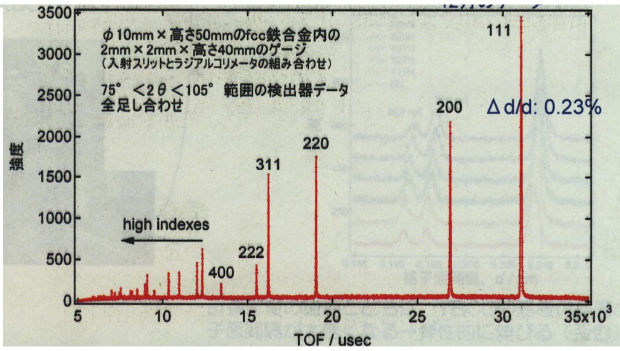
Neutron Diffraction Devise (Takumi)



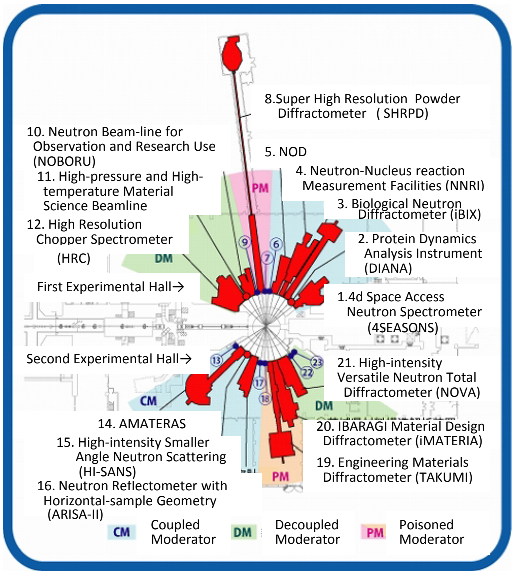




γFeAlloy
Φ10mm x h50mm

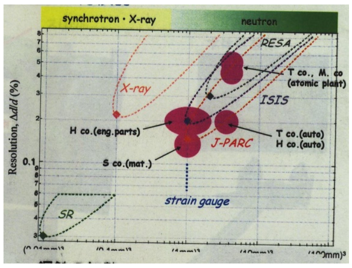


J-PARC Neutron Beamlines



Resolution of Strain

	⊿d/d (%)
Super HRPD(Powder@KEk)	0.03
iMATERIA(Mat Struc Analy)	0.1
NOVA(All Scattering Angle)	0.2
TAKUMI(Residual Stress)	0.15



Summary & Subjects

- Synchronized transmission on-line imaging by 950 keV portable X-ray source has been performed.
- Practical bearing containing ~0.5 mm defect at impeller plans to be tested.
- Further, the lifetime evaluation test by vibration, AE, oil and debris analysis and thermography is under way.
- Residual strain/stress before macroscopic cracks is going to be measured.
- Reliable lifetime evaluation of bearing using overall high-tech measurements is the final target of the CMT panel.