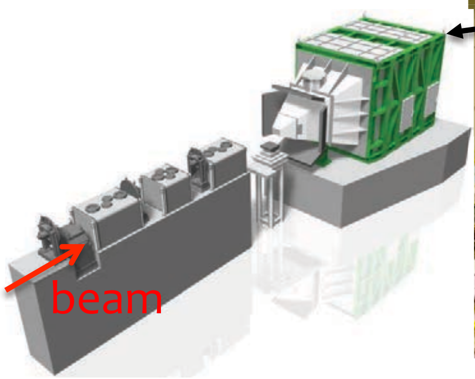
Current Status of the Small and Wide Angle Neutron Scattering Instrument (TAIKAN) at J-PARC

S. Takata[1], J. Suzuki[2], K. Ohishi[2], H. Iwase[2], T. Shinohara[1], T. Oku[1], T. Nakatani[1], Y. Inamura[1], T. Ito[2], K. Suzuya[1], K. Aizawa[1], M. Arai[1], T. Otomo[3], and M. Sugiyama[4]

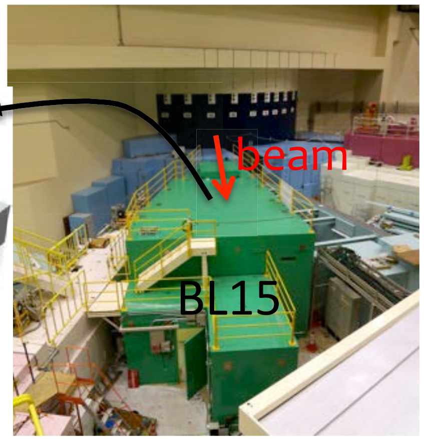
1. J-PARC Center, JAEA, Tokai, Japan
2. CROSS, Tokai, Japan
3. J-PARC Center, KEK, Tsukuba, Japan
4. KURRI, Osaka, Japan

TAIKAN「大観」

Instrument Scientists
J. Suzuki(CROSS) responsible person (j_suzuki@cross.or.jp)
S.Takata(J-PARC) sub – (shinichi.takata@j-parc.jp)
K. Ohishi(CROSS)
H. Iwase(CROSS)



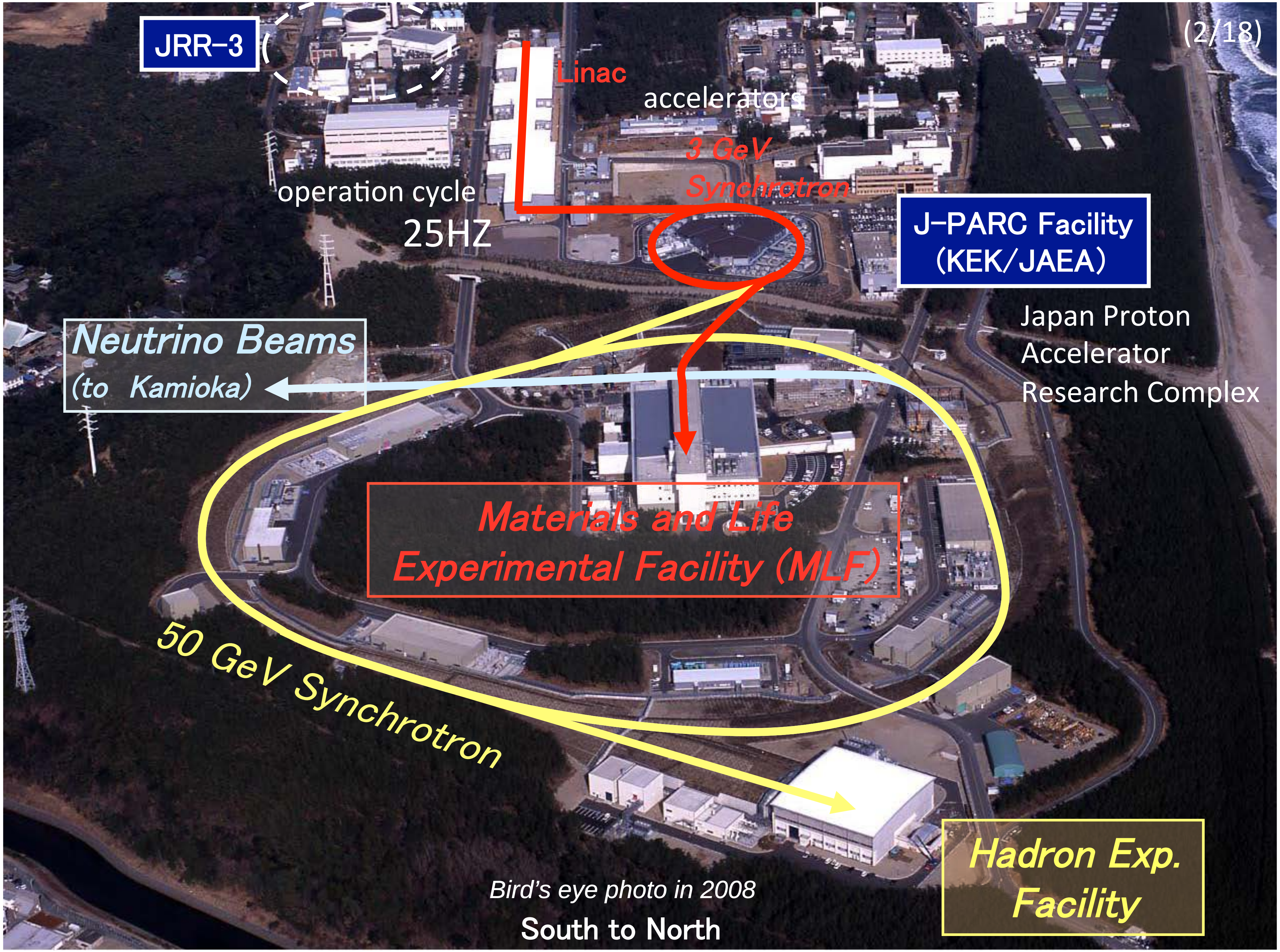
TAIKAN



2nd Experimental hall in MLF building

history

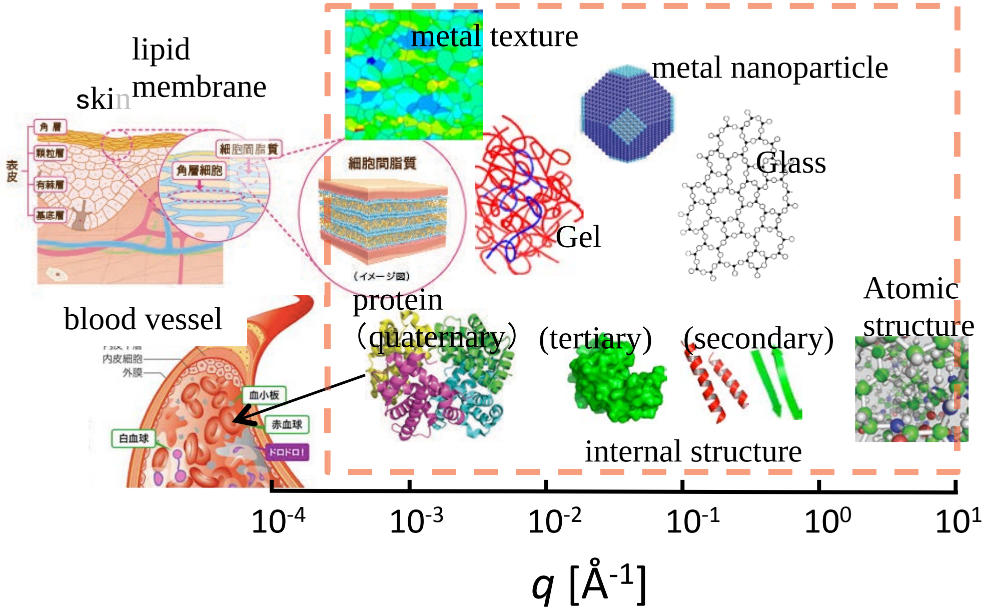
2011. Mar. 8	first Beam
2011. Mar. 11	the Great Earthquake (East Japan)
↓	
2012. Jan.	Commissioning
2012. Mar.	User program
↓	
2015. Apr.	present (3 years)

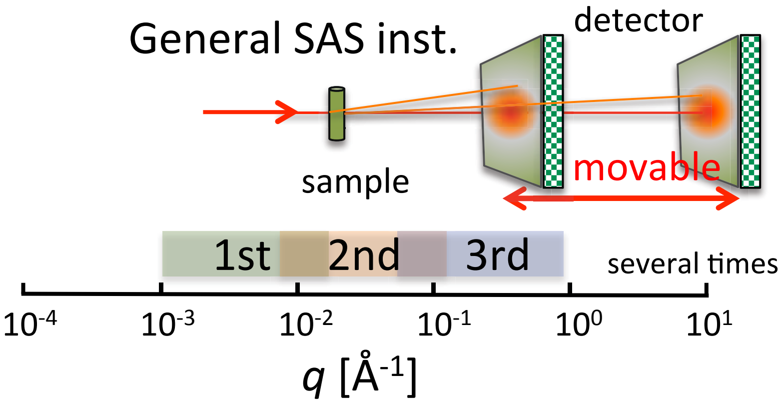

JRR-3
Linac
accelerators
3 GeV
Synchrotron
operation cycle
25HZ
J-PARC Facility
(KEK/JAEA)
Japan Proton
Accelerator
Research Complex
Neutrino Beams
(to Kamioka)
Materials and Life
Experimental Facility (MLF)
50 GeV Synchrotron
Hadron Exp.
Facility
Bird's eye photo in 2008
South to North

Concepts of TAIKAN

✓ **Wide q range measurement**

For understanding the properties of matters in various scientific fields





concerns(difficult things for several times measurement)

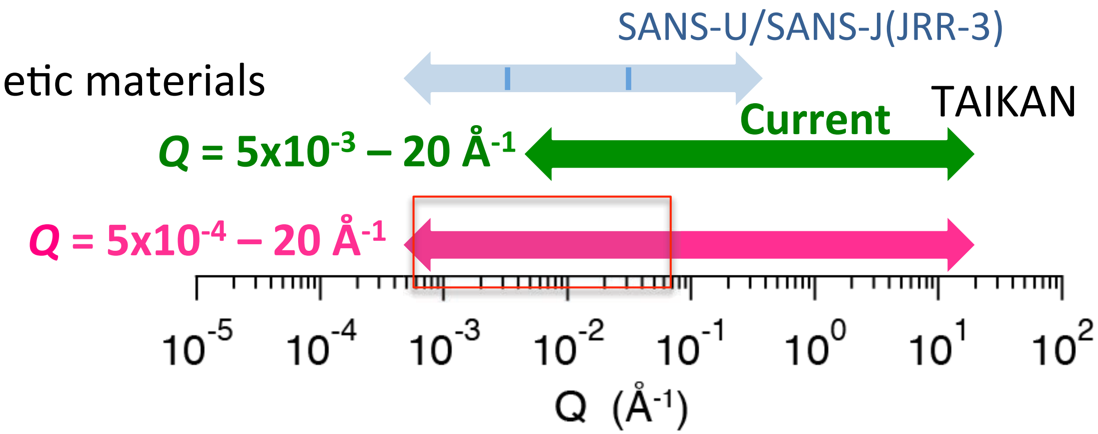
transient phenomenon, precious samples, hysteresis, background(cell,direct,)

→ Detector position is fixed !

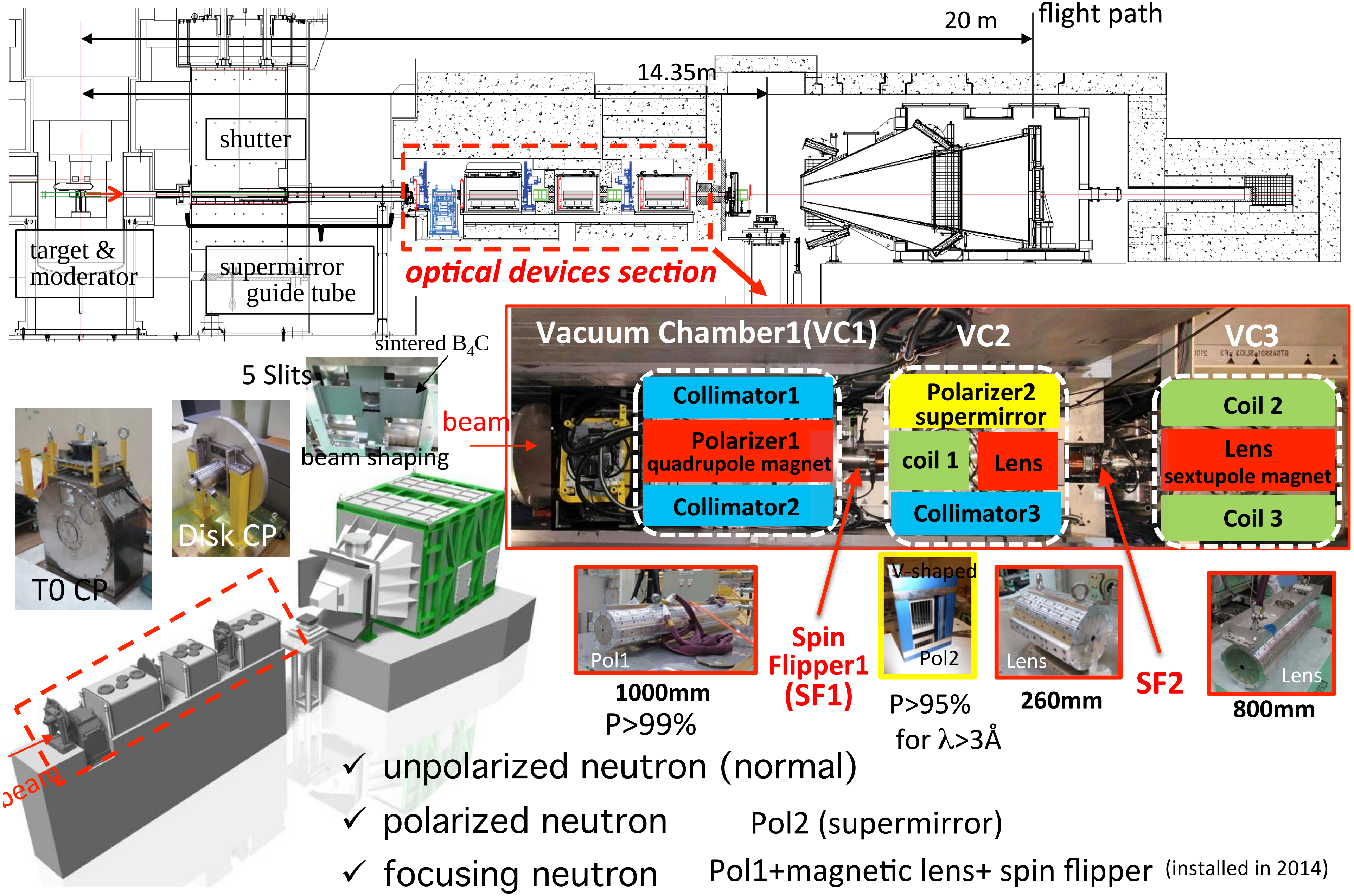
✓ **Usage the polarized neutron**

for the structure analysis of magnetic materials

✓ **Low q measurement using focusing devices**

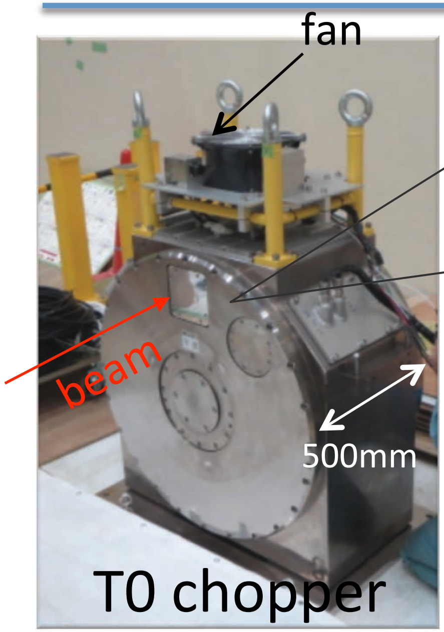


Layout of TAIKAN(*optical devices section*)

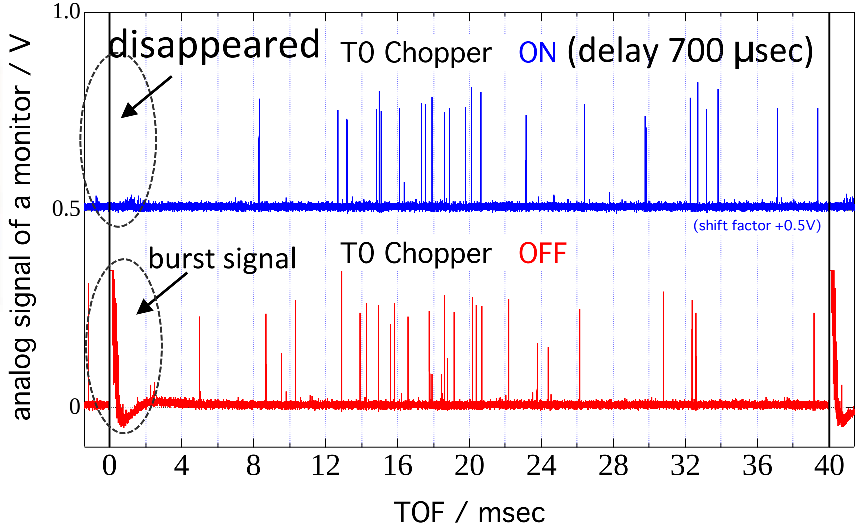


- ✓ unpolarized neutron (normal)
- ✓ polarized neutron Pol2 (supermirror)
- ✓ focusing neutron Pol1+magnetic lens+ spin flipper (installed in 2014)

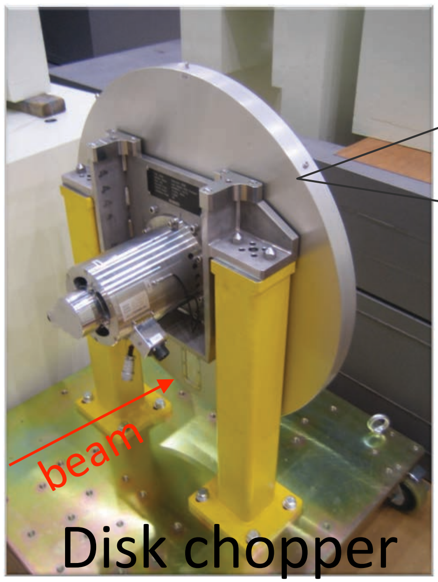
Chopper(T0 and Disk)

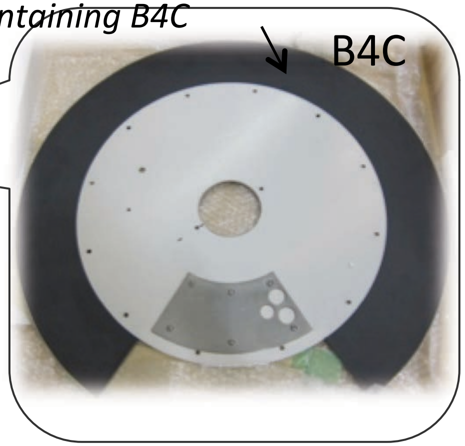


removing the burst beam
(gamma ray, high energy neutron)

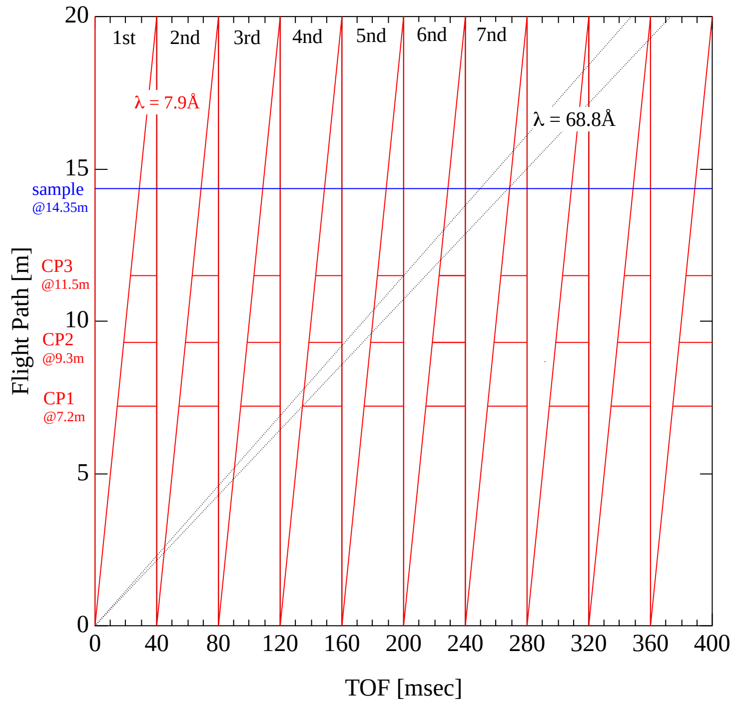


carbon-fiber-reinforced plastic (*CFRP*) *containing B4C*

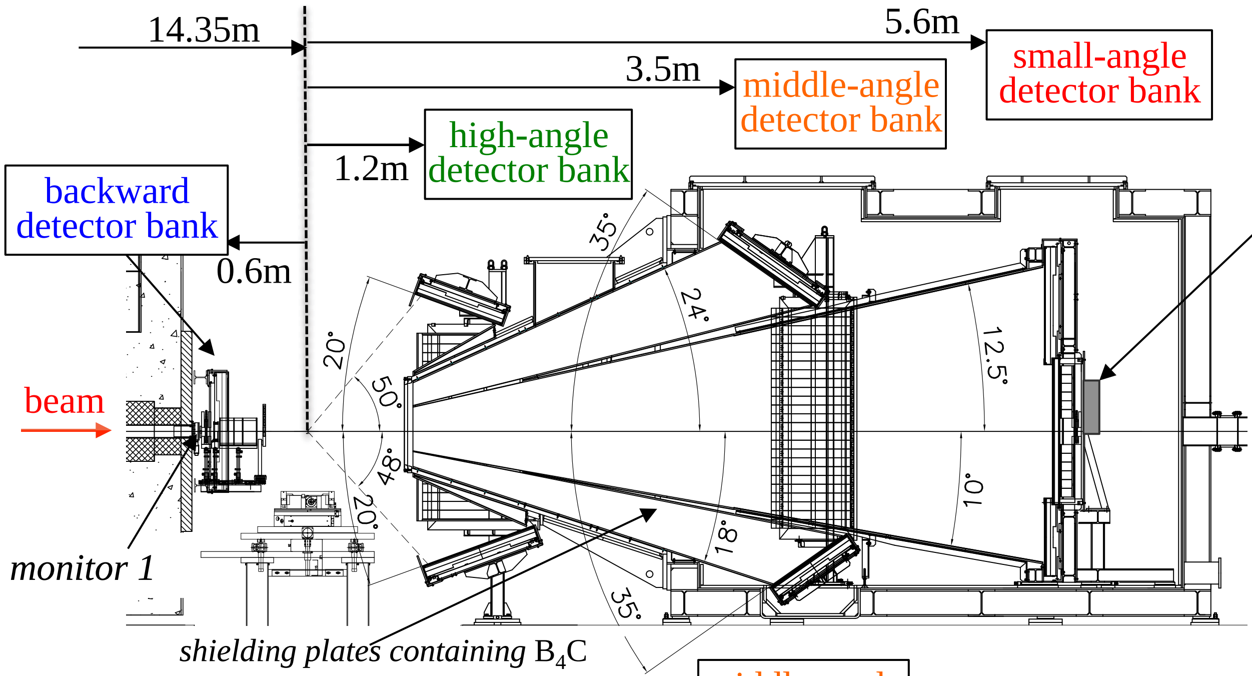


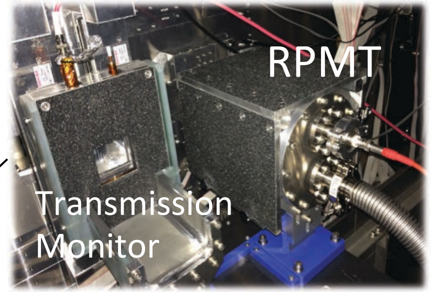


removing long wavelengths from 7.9Å up to 68.8Å by three disc choppers.



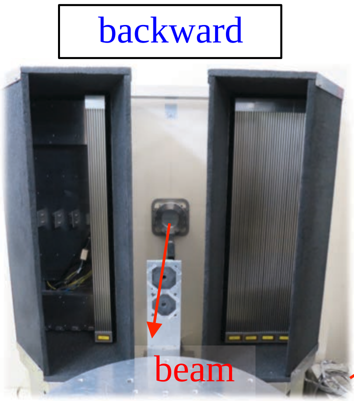
Layout of TAIKAN(detector)

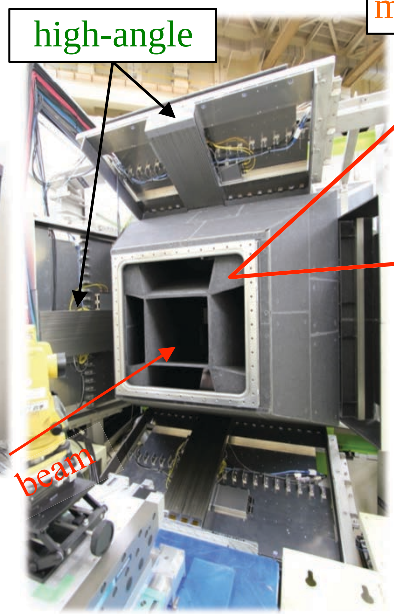


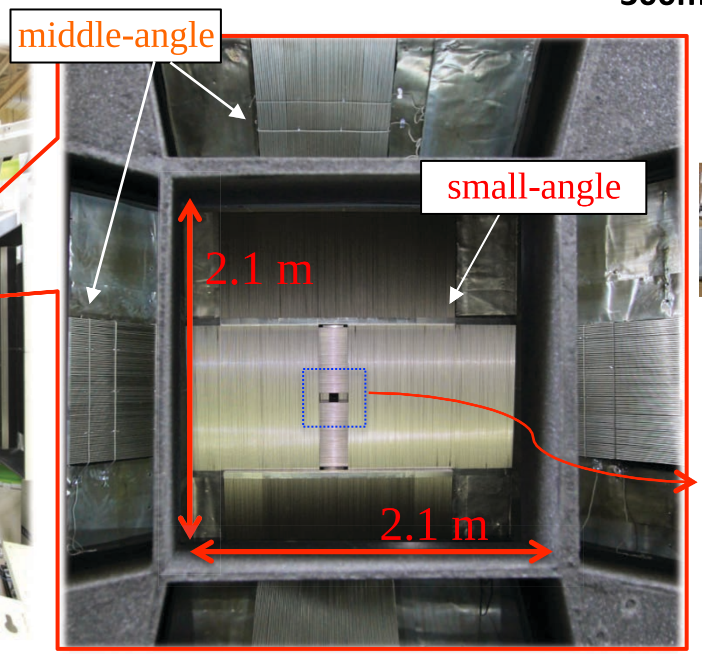


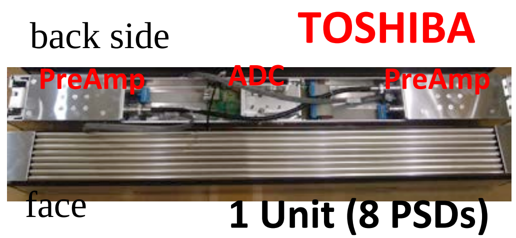
^{3}He PSDs (8mmϕ, 0.6MPa)	Num. of PSDs Current/max
1000mm length	Small: 760/ 936
800mm	Middle: 304 / 784
600mm	High: 104 / 624
500mm	Backward: 48 / 80
300mm	

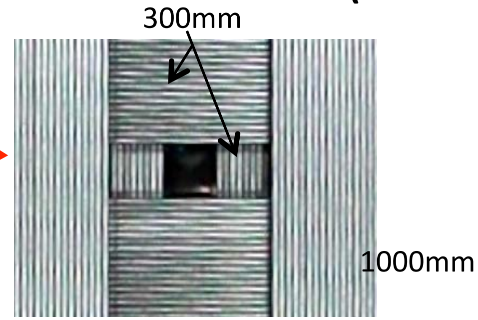
Total: 1,216 / 2,424











Data Reduction

scattering cross section

solid angle (calculation value)

$$I_{obs}^{S}(\lambda,\theta)=I_0(\lambda)NV\frac{d\sigma^s}{d\Omega}(\lambda,\theta)Tr^S(\lambda)\eta(\lambda)\Delta\Omega+I_{background}$$

(1) Incident beam (measurement value)

(2)transmission (measurement value)

(3)detector efficiency (calculation value)

correctly!
for the correction of wavelength dependency

$I_0(\lambda)$: Incident neutron (measurement value)

$\eta(\lambda)$: detector efficiency (calculation value)

$\Delta\Omega$: solid angle (calculation value)

[Instrument Dependence]

N : number density

V : sample volume

$Tr^S(\lambda)$: transmission (measurement value)

$\frac{d\sigma^s}{d\Omega}(\lambda,\theta)$: differential scattering cross section

[Sample Dependence]

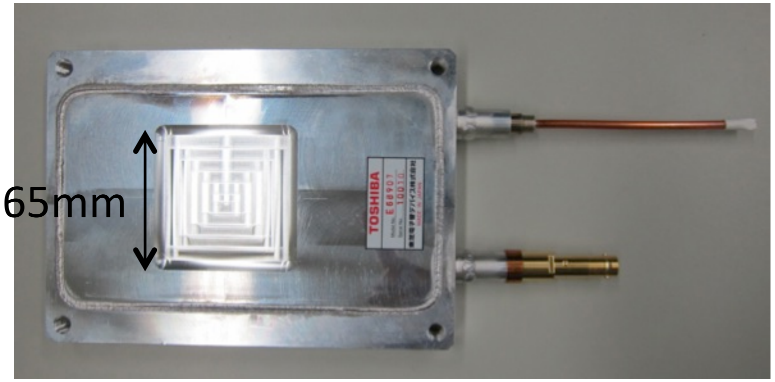
$$\frac{d\sigma^s}{d\Omega}(\lambda,\theta)=\frac{1}{NV\Delta\Omega\cdot I_0(\lambda)\cdot Tr^S(\lambda)\cdot\eta(\lambda)}\left(I_{obs}^{S}(\lambda,\theta)-I_{background}\right)$$

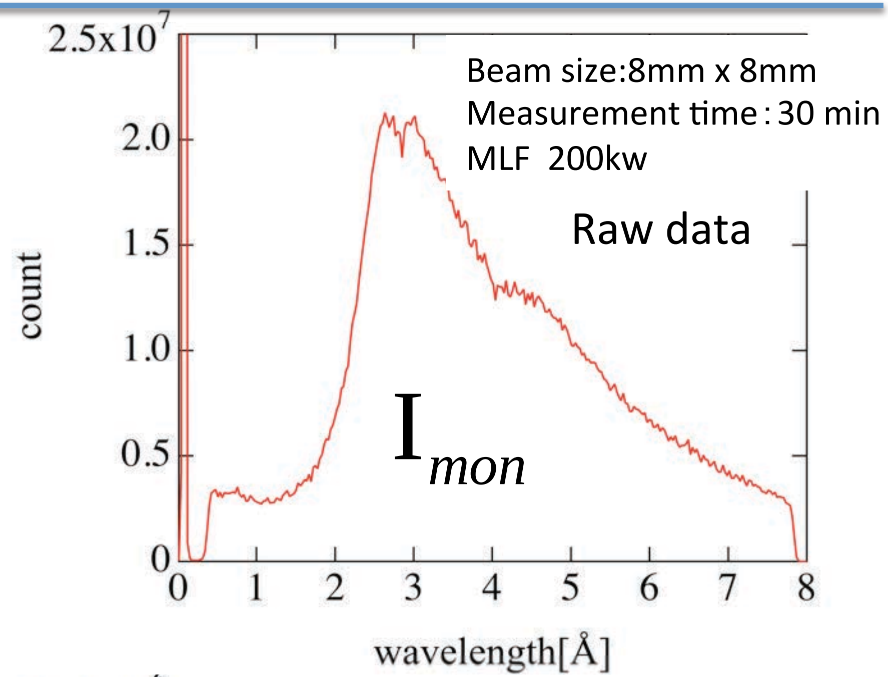
Development of a Neutron Beam Monitor & Incident Beam profile

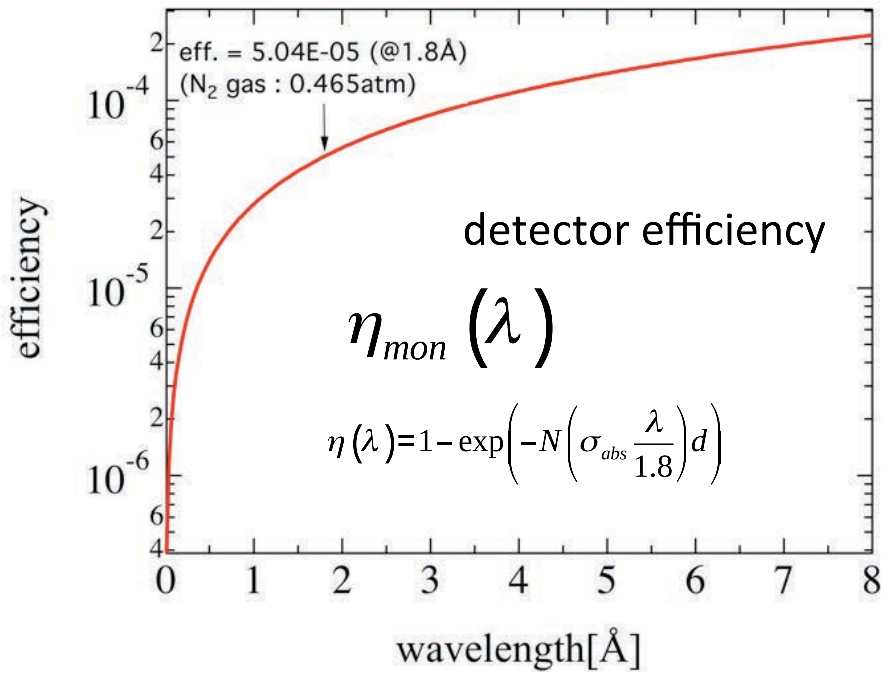
N_2 gas type Neutron monitor

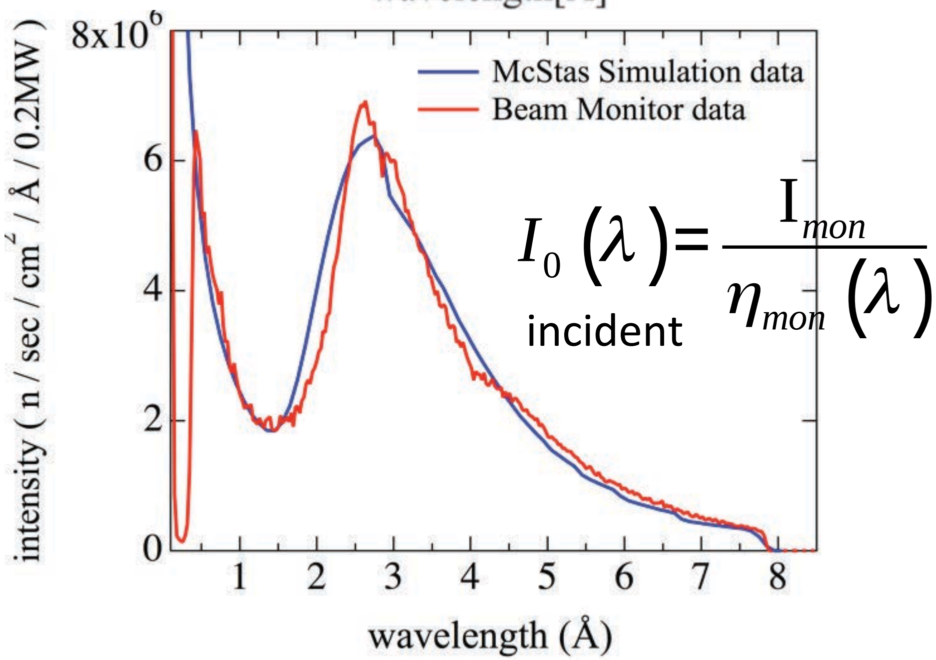
efficiency : 10^{-5} - 10^{-7}

length of conversion gas : 12mm



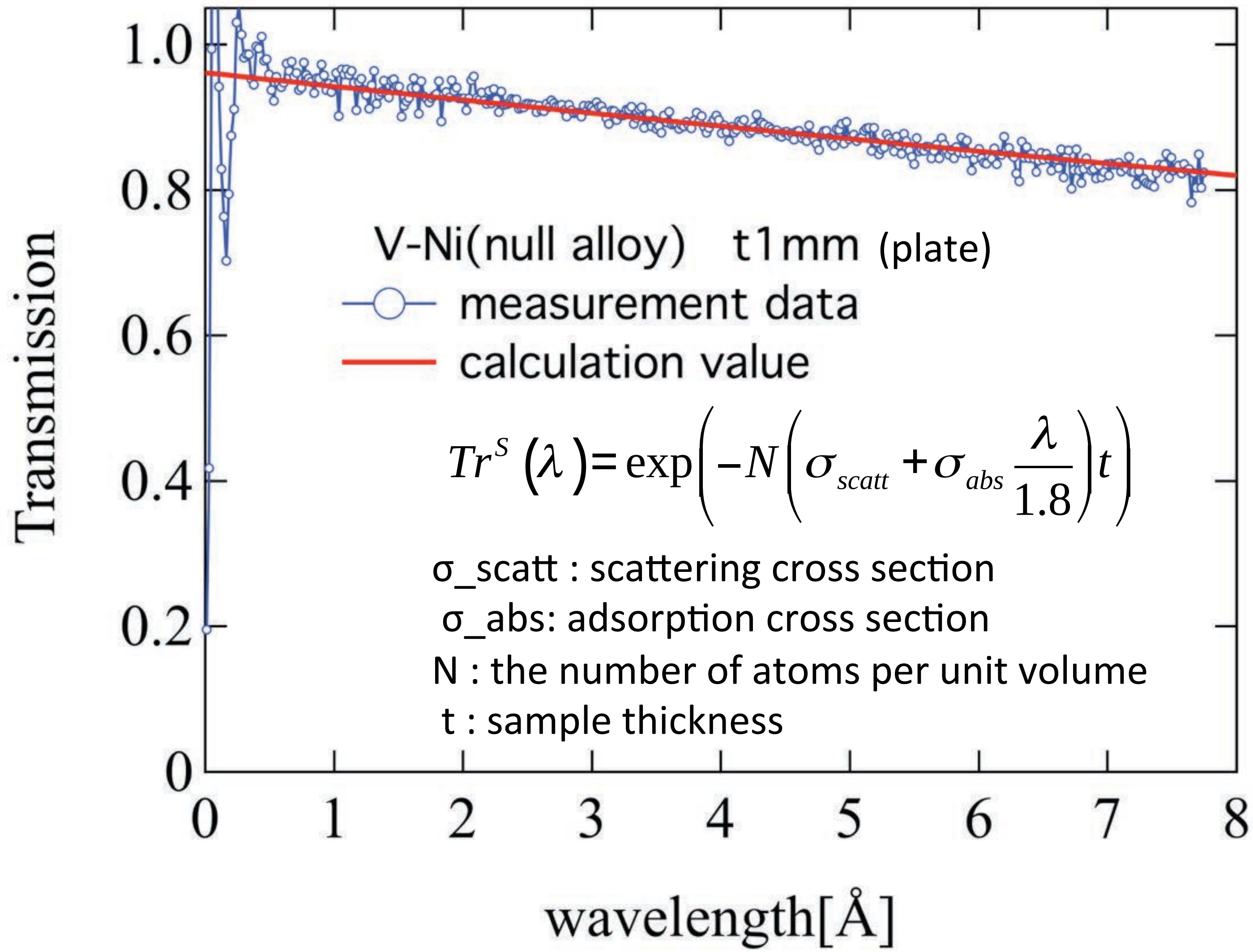






Transmission of sample

sample transmission $Tr^{S}(\lambda)=\frac{\eta_{mon}(\lambda)\cdot I_{mon\_sample}}{\eta_{mon}(\lambda)\cdot I_{mon\_direct}}$



This transmission data is in good agreement with the calculation data

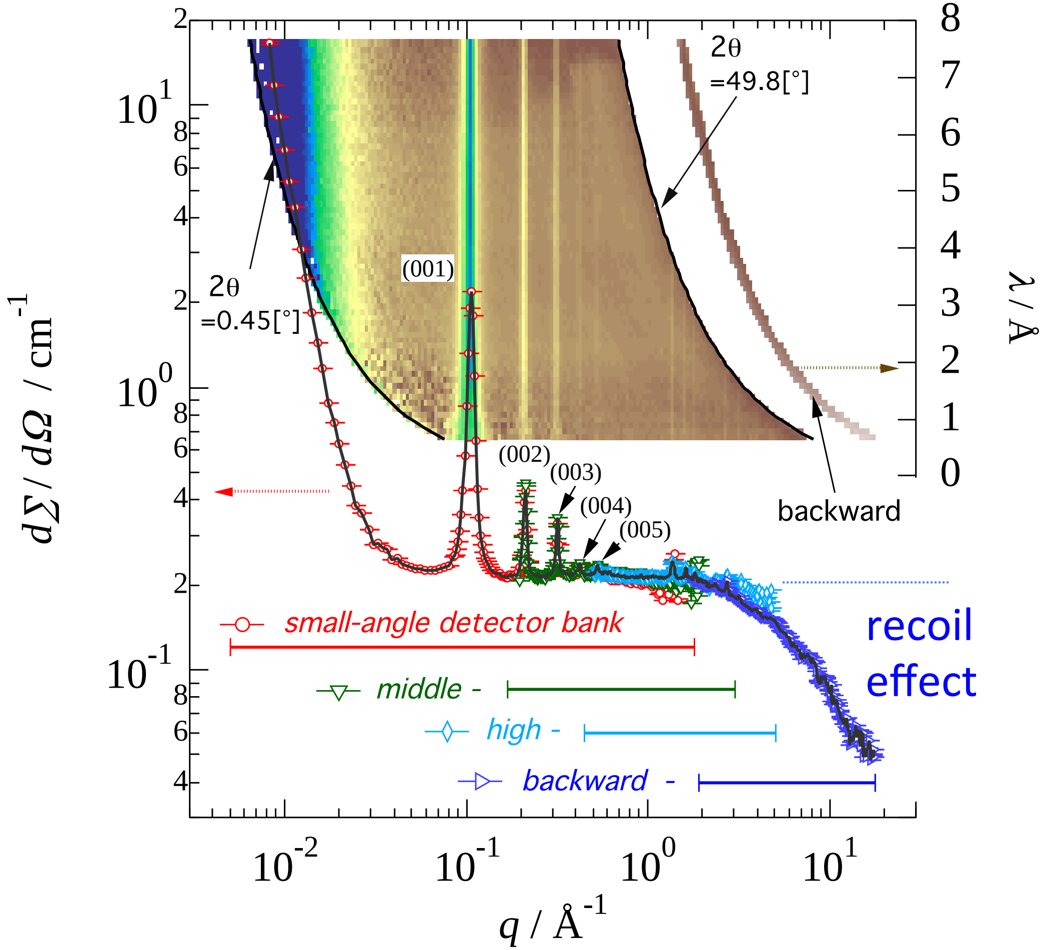
Silver behenate (AgBE)

Silver behenate: $C_{22}H_{44}O_4Ag$ (d=53.38 Å)

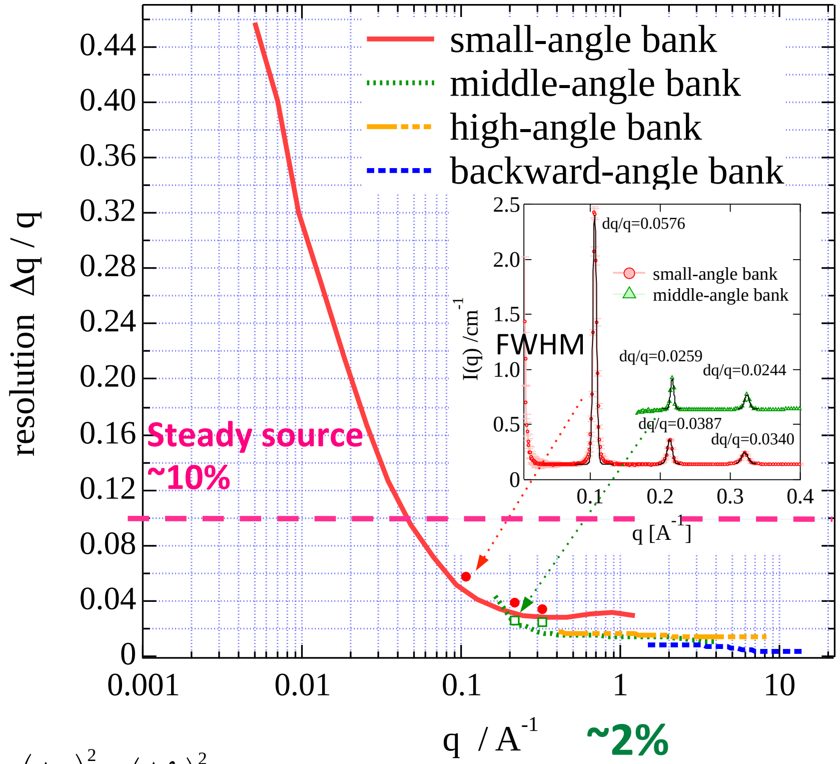
powder diffraction pattarrn

2D(λ,q)

small –angle <------> high-angle



Calc. ***q* resolution**



~2%

<0.5%

$$\left(\frac{\Delta q}{q}\right)^2 = \left(\frac{\Delta\lambda}{\lambda}\right)^2 + \left(\cot\theta\cdot\Delta\theta\right)^2$$

$$\Delta\theta = \frac{1}{2}\sqrt{\left(\frac{A_0^2}{L_1^2} + A_S^2\left(\frac{1}{L_1}+\frac{1}{L_2}\right)^2 + \frac{A_d^2}{L_2^2}\right)}$$

L1: moderator to sample distance
L2:: sample to detector distance
A0 : moderator width
AS : sample width
Ad : detector width

Pulsed neutron+TOF→
High *q* resolution at higher *q*

Glassy Carbon as a standard sample (Dr.Ilavsky)

Kazuki Ohishi
Research Center for Neutron Science & Technology
CROSS
Rm. B304, Bldg. IQBRC,
162-1 Shirakata, Tokai, Ibaraki 319-1106, Japan
e-mail: Kazuki Ohishi <k_ohishi@cross.or.jp>

thickness :1mm

10mm

Dear Kazuki:

Please find data for sample of Glassy carbon sample designated as "H16". This Glassy carbon sample was calibrated as absolute SAS intensity standard using APS USAXS instrument at 15ID beamline, Advanced Photon Source. I am providing you with measured intensity data through e-mail.

If you need to communicate with me about this sample in the future, please include the full description of the sample: "Glassy carbon type 2, sample H16". Note, that 1.0 mm was measured thickness of this sample and it is assumed in our absolute intensity calibration calculations.

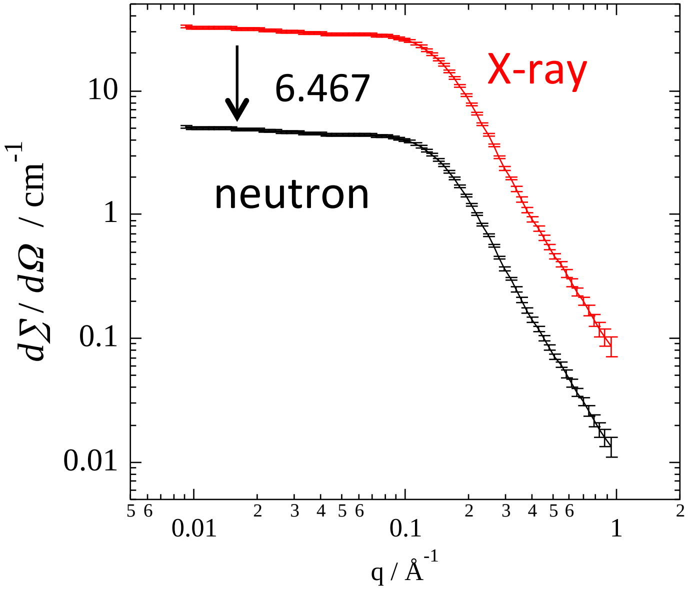
Please note, that the intensity data provided are dSigma/dOmega values in cm^2/cm^3. They have been corrected for all known corrections though some flat instrumental background is present.

If you need to use this sample for neutrons, please note, that you need to divide the absolute intensity by 6.467, the ratio between the X-ray and neutron contrasts for carbon-air interface.

The measurements were performed on large set of samples sectioned from the same flat plate and we assume that they are good to within about +/- 5% for all samples. The estimated error bars provided are generated by statistical analysis of the measured data as well as by using original USAXS estimated error bars. I have tried to subtract most of the flat background from the measurements, but since that varies among the instruments and geometries, it is common to see the high Q range of data vary. The best method of using this sample is to select overlapping range of reliable data measured by your instrument and using the "area under the curve" (For example in *Irena* package using *Data manipulation tool*) scale the data together to get calibration for your specific setup.

Sincerely,

Jan Ilavsky
Staff scientist, Advanced Photon Source, ANL

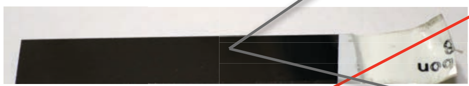


Glassy Carbon as a standard sample

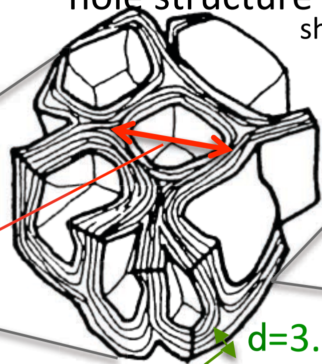
Glassy Carbon (H16)

thickness :1mm
density : 1.45 g/cm^3
Non-hydrogen

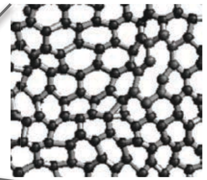
ignorable correction multiple and incoherent scattering of H



hole structure
shirakawa model

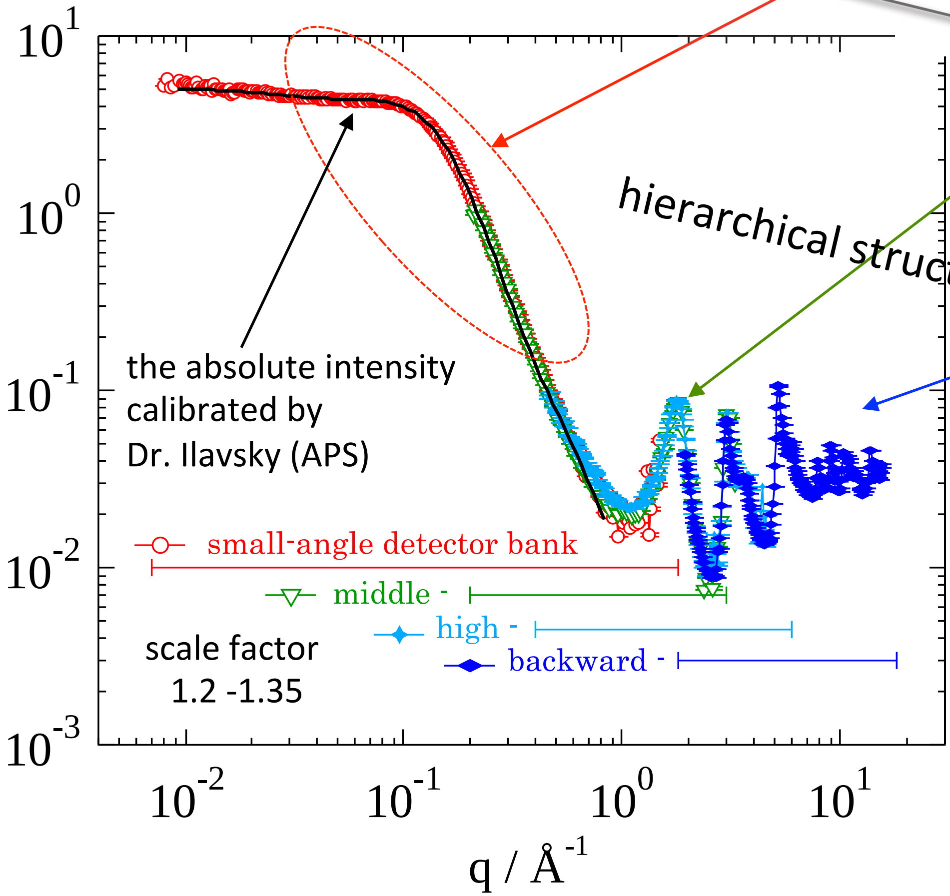


atomic array



d=3.5Å
the spacing of Graphite layer (d_{002})

hierarchical structure

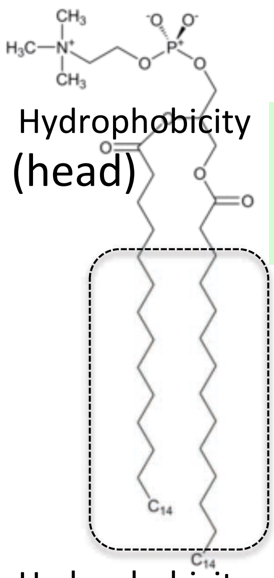


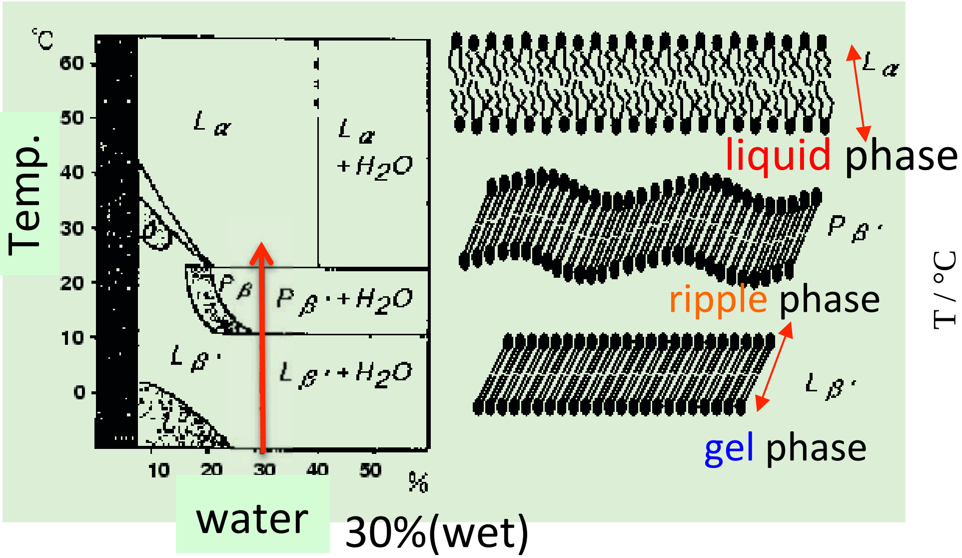
a secondary standard sample

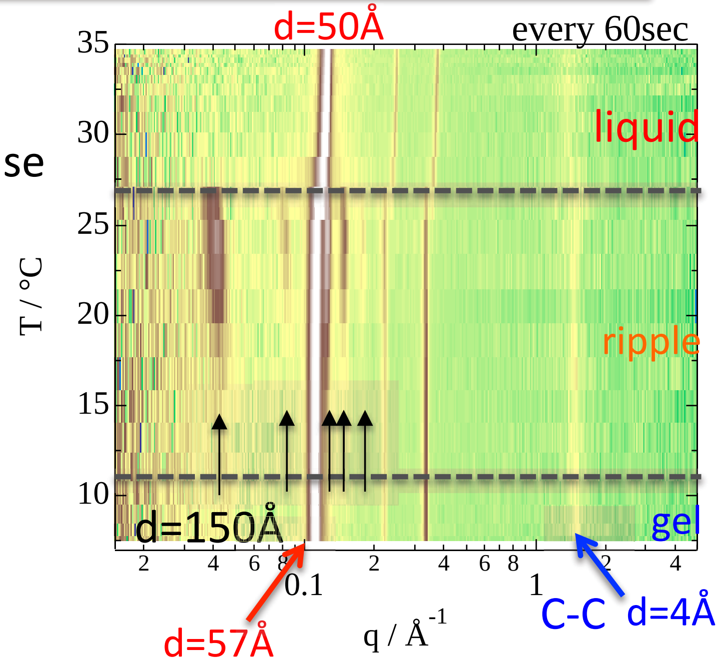
Glassy Carbon(type2)

Alfa Aesar

Temperature Dependence of a lipid sample (DMPC)



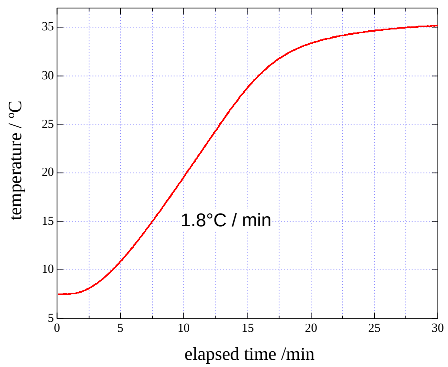


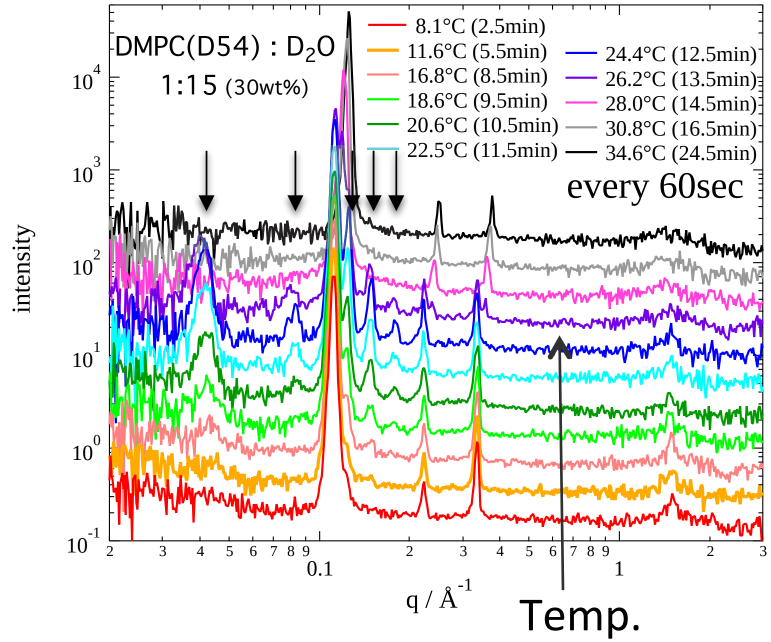


Measurement condition

7 °C → 35°C (1.8°C / min)

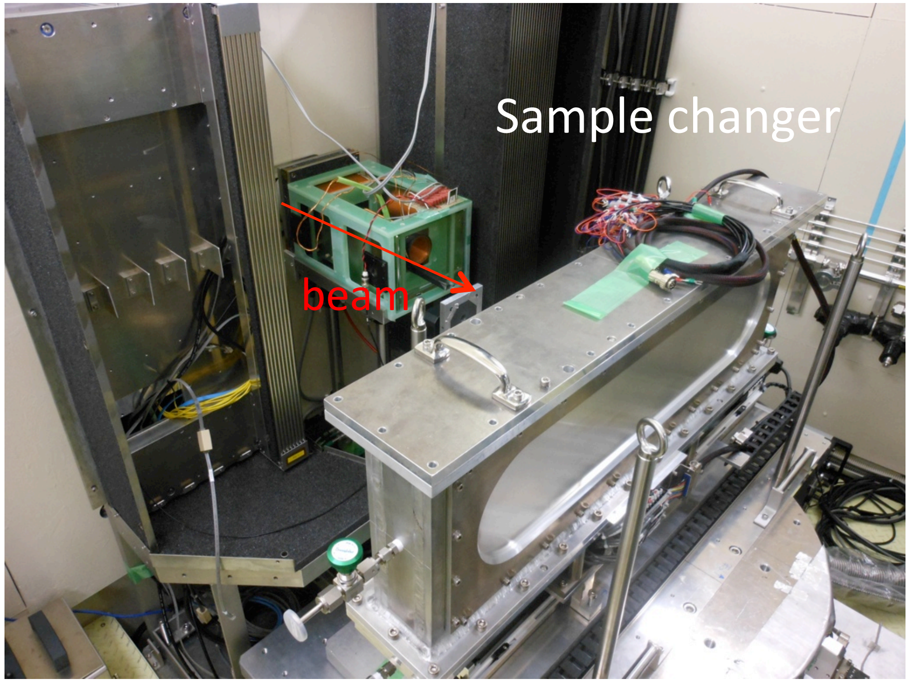
30min

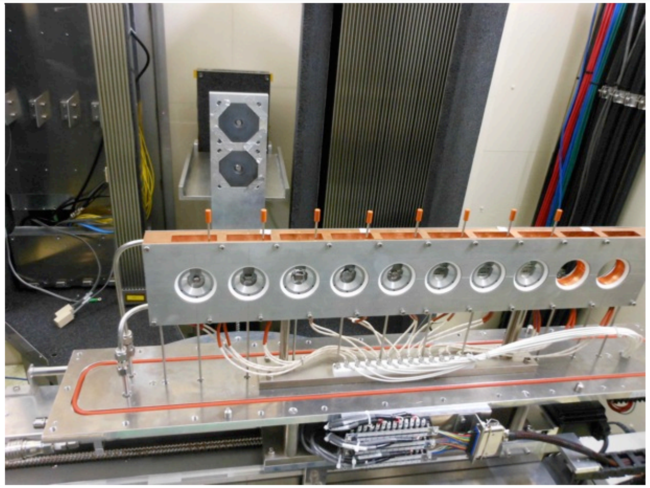




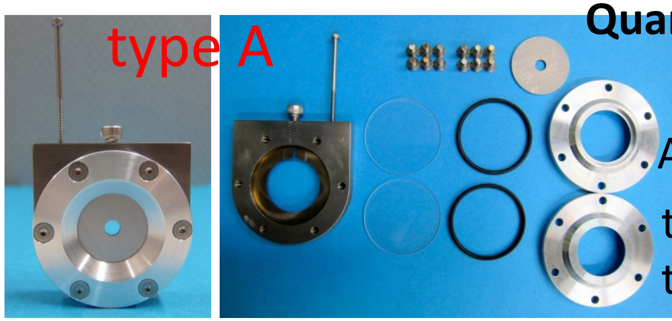
The event recording is useful for the studies of transient phenomenon and critical phenomenon. (except that an accelerator may stop during the measurement)

Sample environment(I)





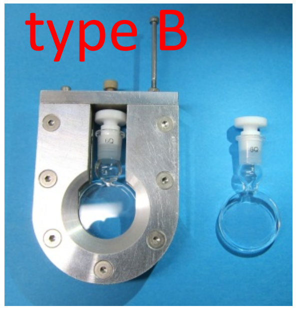
Sample changer
10 samples
T=−10 ～ 125℃



Quartz Cell

Assembly type
t=1mm 0.38ml
t=2mm 0.76ml

gel,viscosity

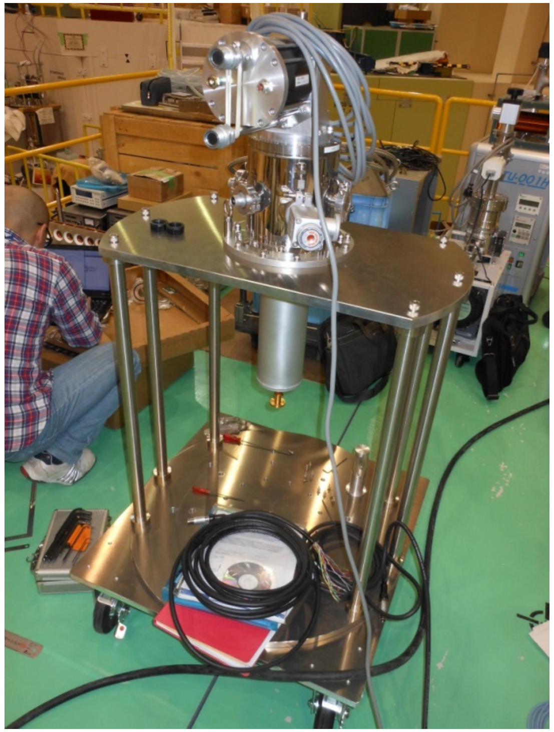


t=1mm 0.32ml
t=2mm 0.64ml

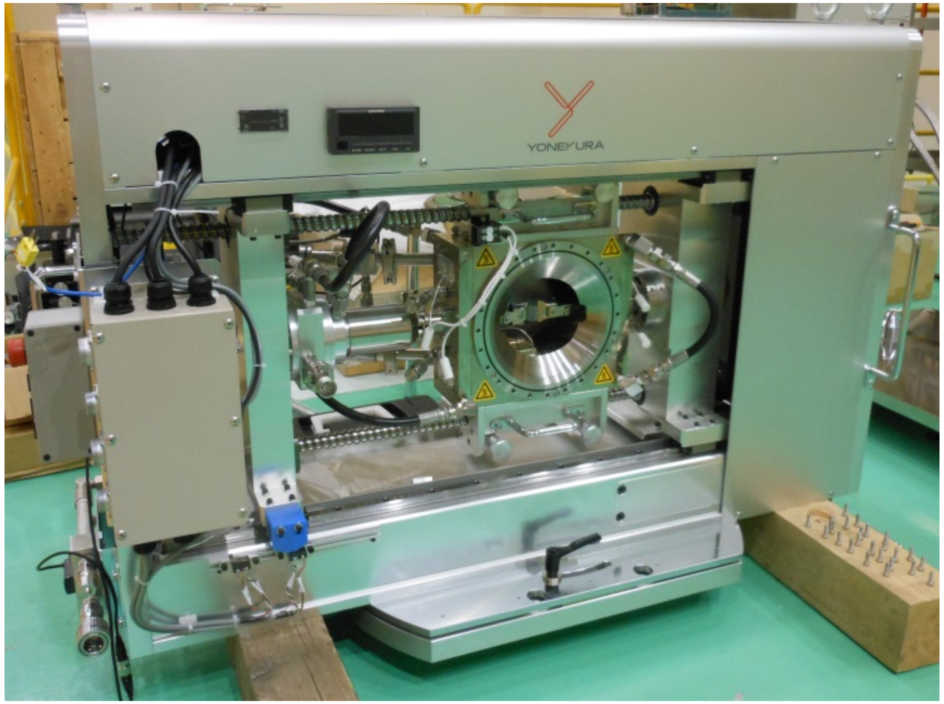
t=1mm 0.15ml
t=2mm 0.30ml

Sample environment（II）

refrigerator (T_{min}=3.5 K)



Tensile tester



stroke： ＜100mm
sample size： 25～40mm
load stress： 100N～1kN (精度1%程度)
head speed： 0.01～100mm/min
temperature: ～300 °C

Sample environment（III）

Magnets, Refrigerator and Furnace with laser heating

1 Tesla Magnet (Vertical Field)
+Refrigerator (T_{min}=4 K)

10 Tesla Magnet (Vertical Field)
+Furnace (T_{max}=1,200°C)

Future

✓ Increase of Beam Power

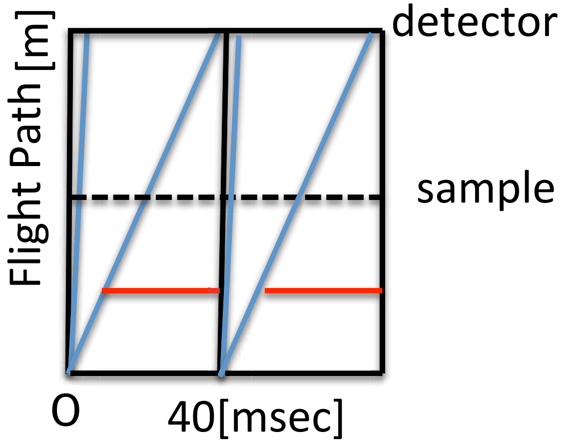
now

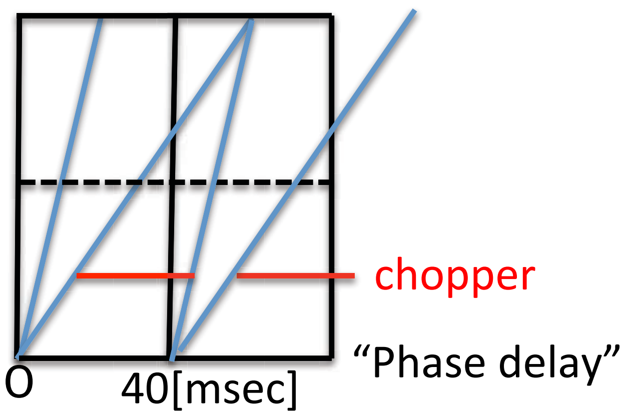
→ 400kW(March) → 500kW(April,14th) → 800kW(December)

✓ much more Low q region

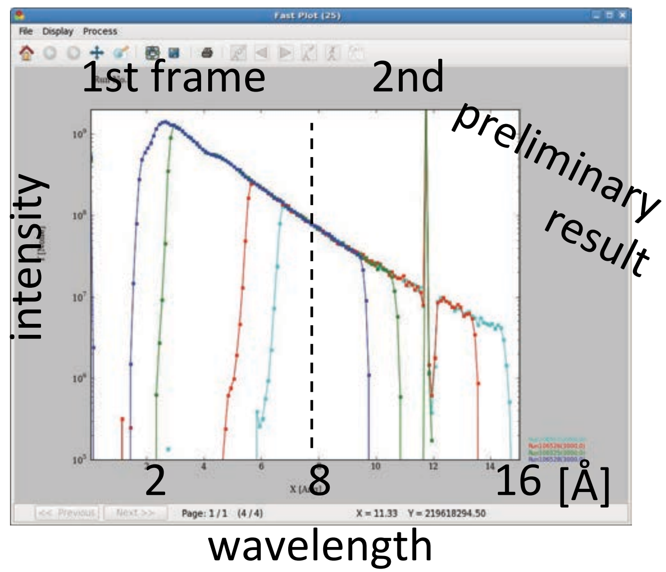
(1) commissioning of the focusing beam measurement using Magnetic lens and a scintillator 2D-detector ∼ q=0.0005 Å^{-1}

(2) usage long wavelengths on 2nd frame ∼q=0.0025 Å^{-1}





Incident beam profile




Thank you for your attention!