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Current Status of 40m SANS Instrument and SANS-related Research at HANARO

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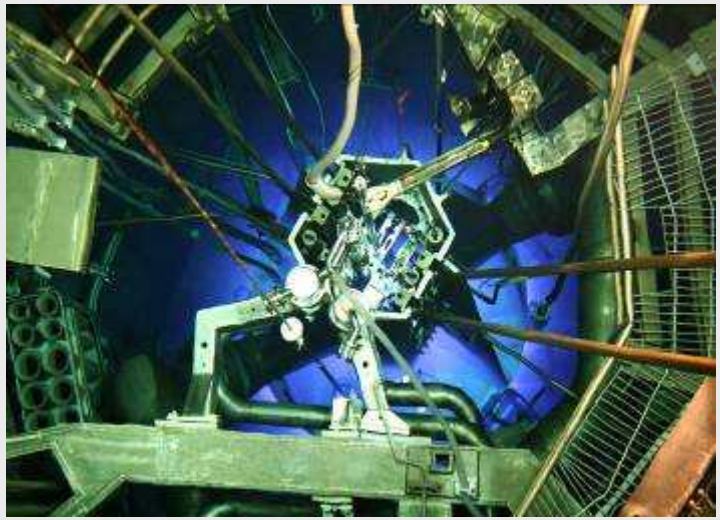
- Introduction of HANARO
- History of SANS Instrument at HANARO
- Current SANS Instruments
- Performance and Activities of SANS
- Soft matter Research with SANS
- Closing Remarks

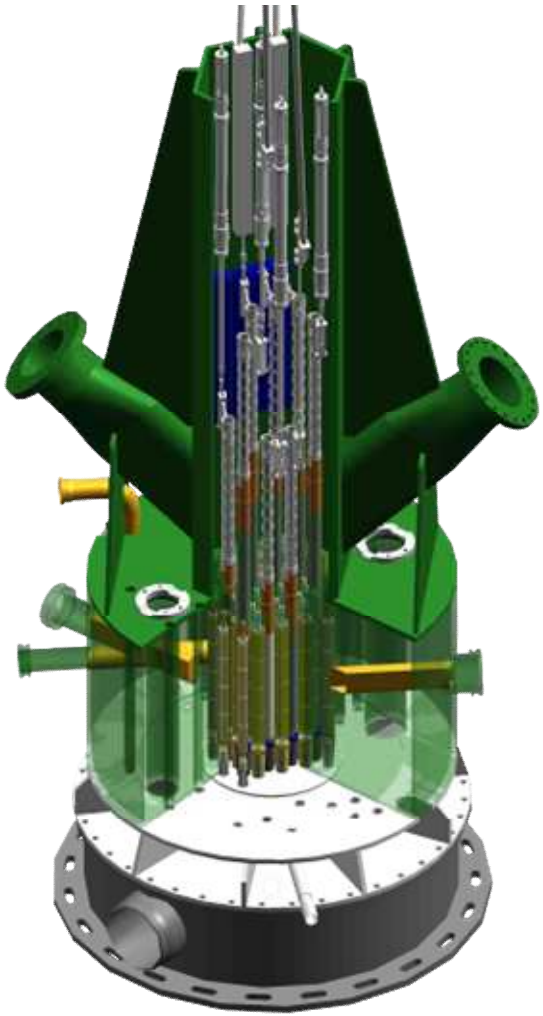
HANARO Reactor

High-flux
Advanced
Neutron
Application
ReactOr

Multi-purpose Research Reactor



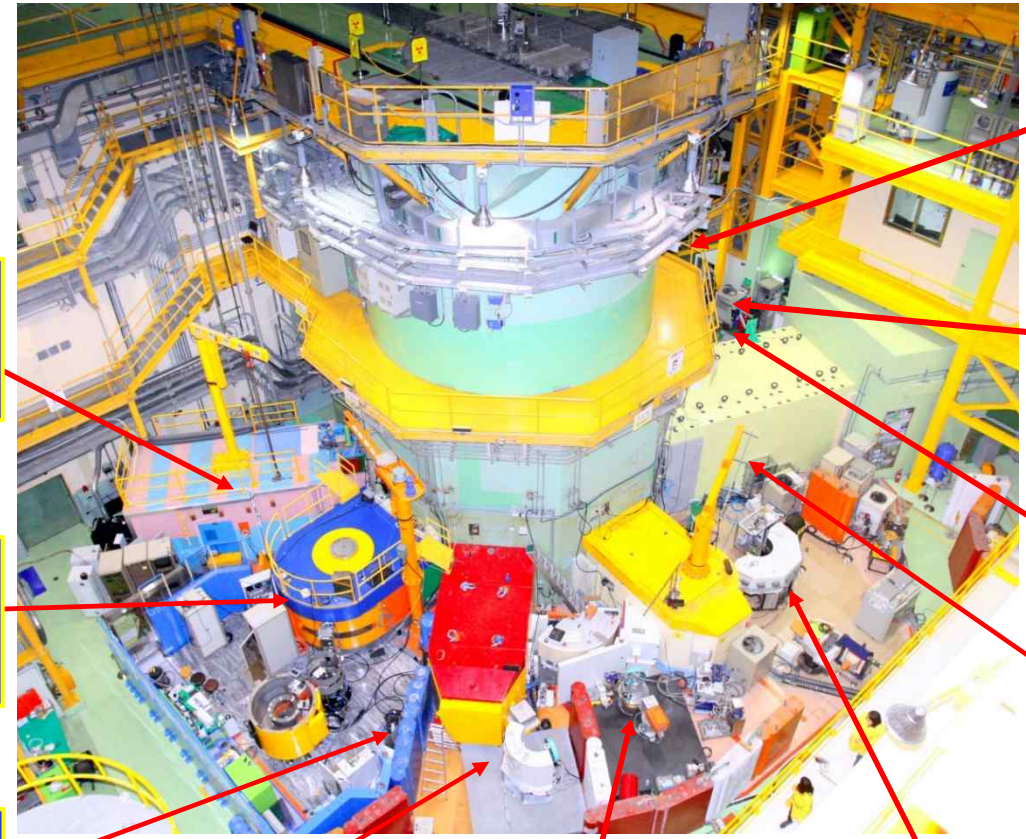
Reactor Structure and Characteristics



Features

- Type — Open-tank-in-pool
- Power — 30 MW
- Coolant — Light Water
- Reflector — Heavy water
- Fuel Materials enriched — U_3Si, 19.75%
- Absorber — Hafnium
- Reactor Building — Confinement
- Max Thermal Flux — $5x10^{14}$ n/cm^2s
- Typical flux at port nose — $2x10^{14}$ n/cm^2s
- 7 horizontal ports & 36 vertical holes
- Vertical hole for cold neutron source
- Operation Cycle — 28 days@6 weeks
- Operation Days — 224 days/year
- Stop operation : 2014. 07~ current
- Restart operation : 2016. 09

Reactor Hall



IR Port

Ex-Core Neutron Irradiation Facility (ENF), 2005

ST1 Port

Prompt Gamma Neutron Activation Analysis(PGAA), 2003

Residual Stress Instrument(RSI), 2003 Upgrade

CN Port

Cold Neutron Guide, 2009

Formally SANS located

NR Port

Neutron Radiography Facility (NRF),1997 Upgrade

ST4 Port

Triple Axis Spectrometer (TAS), under construction

ST3 Port

Bio-Diffractometer with Camera(Bio-C), 2012

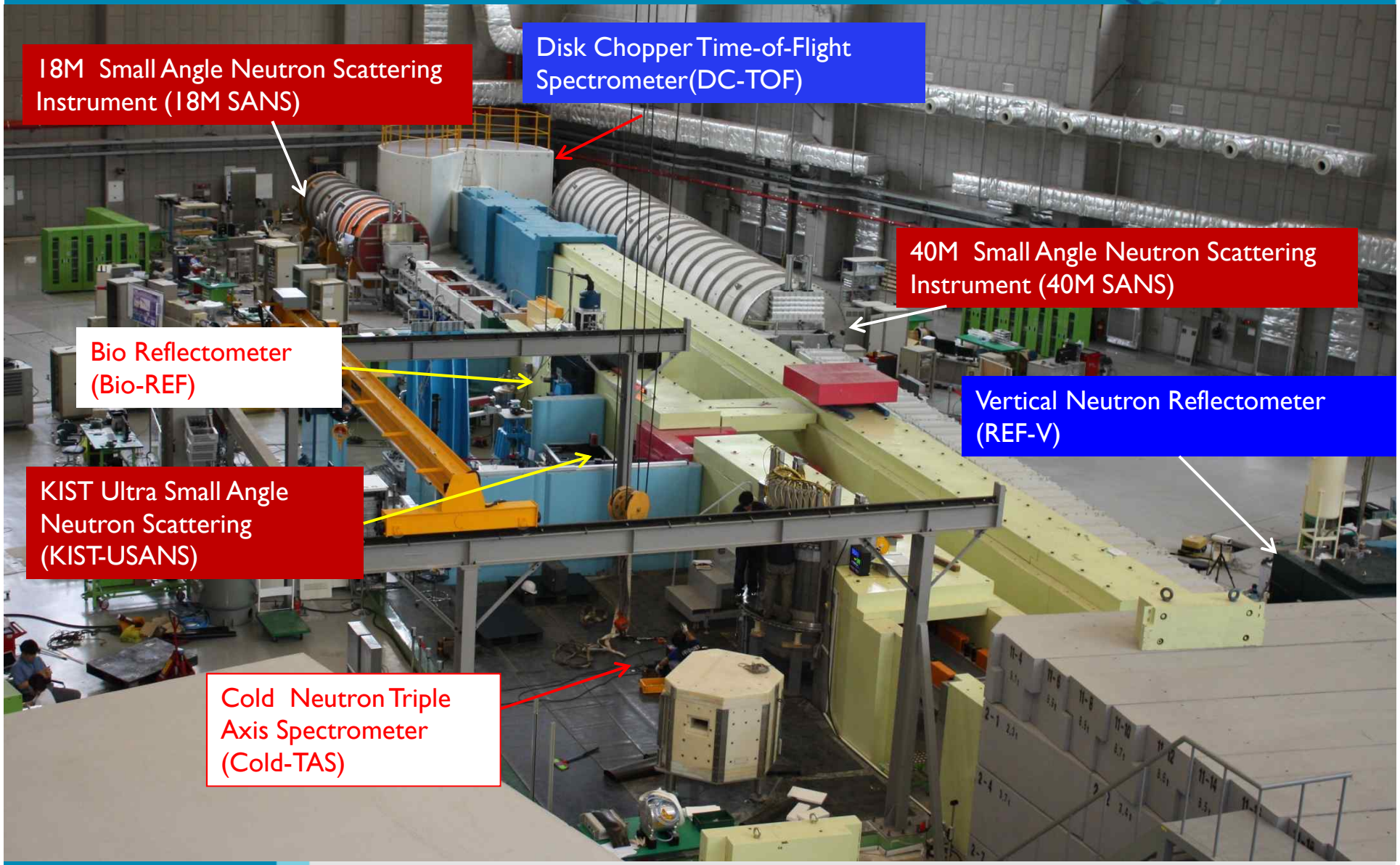
Bio-Diffractometer (Bio-D), 2011

ST2 Port

High Resolution Powder Diff. (HRPD),1998

Four Circle Diffractometer (FCD),1999 Upgrade '05-'06

Cold Neutrons Guide Hall



History of SANS Instrument at HANARO

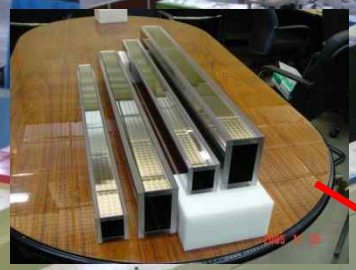
- July 1997 : Development of 9m SANS Instrument at reactor hall started
- Sep. 2001 : 9m SANS instrument was opened to outside users
- July 2003 : Cold Neutron Research Facility(CNRF) Project was launched

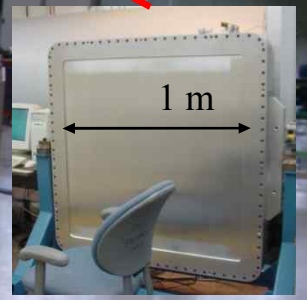
→Upgrade and relocation of 9m SANS instrument and development of new 40m SANS instrument were included in the project

- May 2007 : Period of CNRF project changed from 5 yrs to 7 yrs
- Sep. 2007 : Development of KIST-USANS started
- April 2010 : The CNRF project was finished
- Nov. 2010 : 18M/40M SANS instruments were opened to outside users
- Nov. 2012 : Inauguration Ceremony of KIST-USANS was held

- Jul. 2014 : stop operating (earthquake-proof…)

40M SANS Instrument at HANARO





Information
http://hanaro4u.kaeri.re.kr
Email: useroffice@kaeri.re.kr

- Total Instrument Length: 40 m
- Sample to Detector Distance: 1.1-19.8 m
- Max. Detector offset: 50 cm
- Wavelength: 4 – 20 Å
- Accessible Q-range: 0.0007 - 1.0 $Å^{-1}$ (with Focusing Lenses)
- Neutron Flux at Sample: 2.5 *10^7 n/sec cm^2
- Neutron Velocity Selector: Astrium
- Detector: Ordela 21000N (1*1 m^2)
- Neutron Transmission Polarizer & RF Flipper

40M SANS Instrument

Dr. Tae-Hwan Kim

History

- April. 2008 :
  1st fabrication was ordered
  (Detector Vessel)
- Sep. 2009 :
  1st cold N-beam arrived
- Nov. 2009 :
  Major hardware was finished
- Feb. 2010 :
  First SANS data was obtained
- Nov. 2010
  Open to users

Dr. Tae-Hwan Kim
Dr. Young-Soo Han
Dr. Eunhye Kim
Mr. Ki-Jeong Park

18M SANS Instrument

Dr. Eunjoo Shin

Dr. Eun-Joo Shin
Dr. Baek-Seok Seong
Dr. Tae-Kyu Shin
Mr. Seong-Soo Kim

History

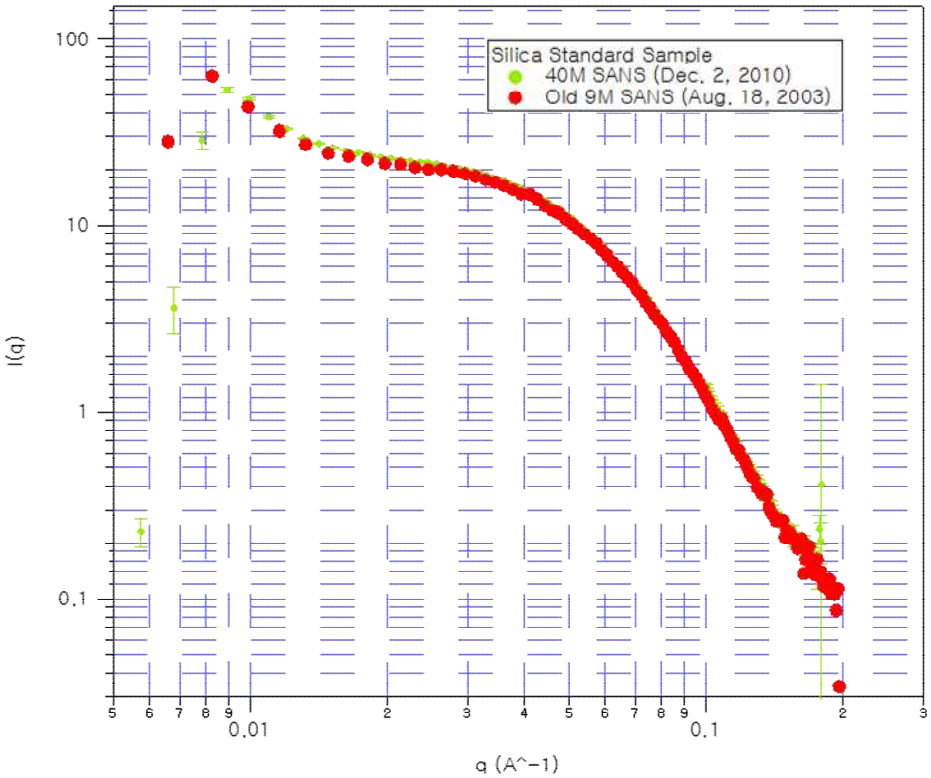
- June 2008 : Old 9m SANS was dismantled
- Sep. 2008 : Upgrade plan has changed (12m -> 18m)
- Dec. 2008 : 1st fabrication ordered (Collimator box)
- Nov. 2010 : Open to users

Main Parameters

Parameter	40M SANS	18M SANS
Total Instrument Length (m)	40	18
Detector Dimensions (cm^2)	100 x 100	64 x 64
Detector Resolution (cm^2)	0.5 x 0.5	
Detector supplier	ORDELA, 21000N	ORDELA, 2660N
Velocity selector supplier	ASTRIUM	
Source to sample distance (m)	2 - 20 (steps : 2m)	3 - 9 (steps : 2m)
Sample to detector distance (m)	1.1 – 19.8	1 .3– 9
Max. detector offset (cm)	50	30
Q-range ($Å^{-1}$) (with lenses)	0.001 – 1.0 (>0.0007)	0.003 – 0.5
Neutron polarizer	YES	To be installed
Refractive Focusing Optics	YES	To be installed

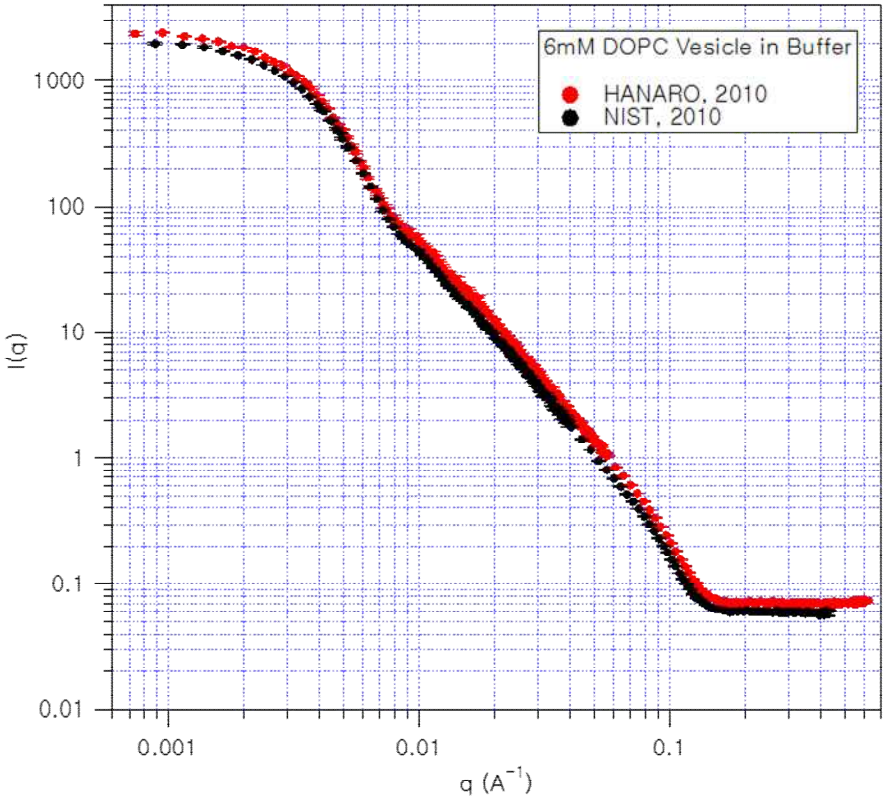
Comparison of SANS Data

Old & New HANARO SANS Instruments



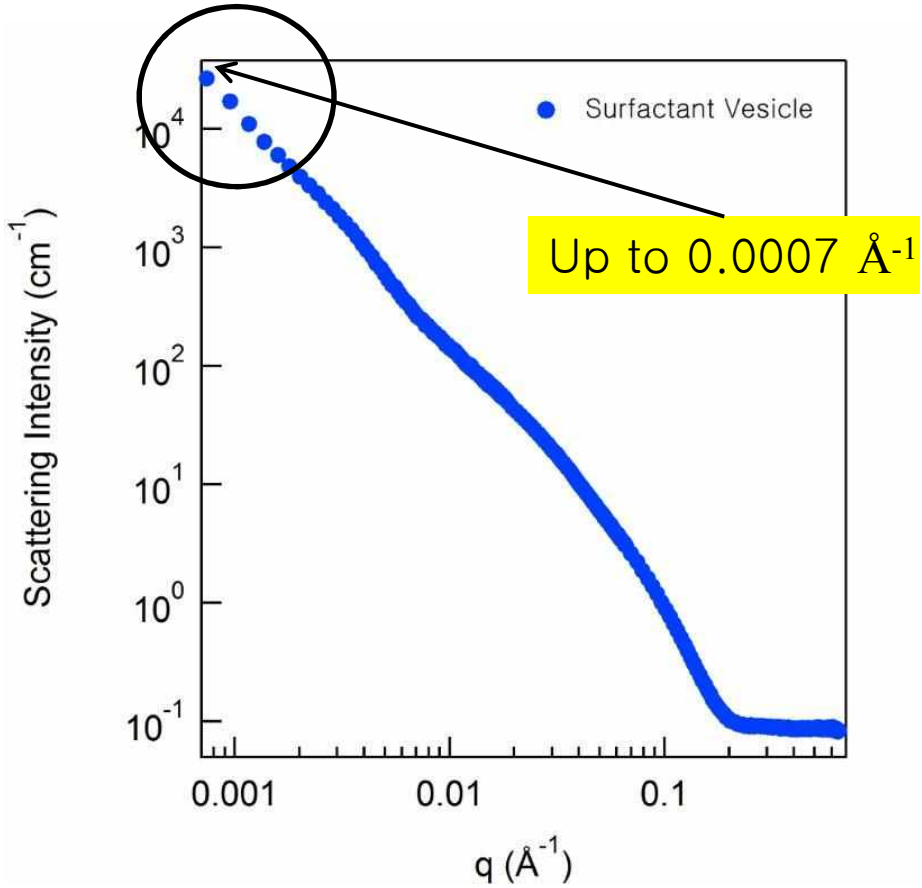
- Both are absolutely calibrated with Silica Standard samples

HANARO & NIST NG-7 SANS Instruments



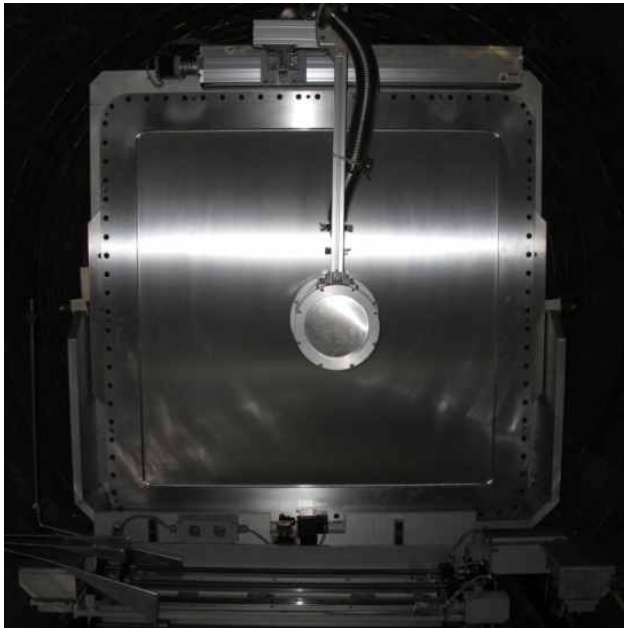
- NIST data are absolutely calibrated with using direct beam method

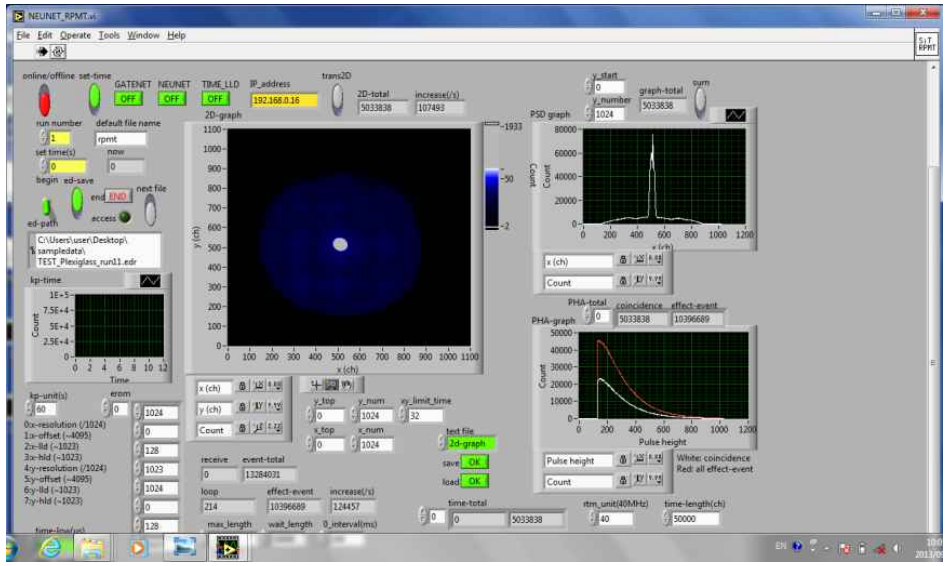
MgF2 Focusing Lenses in HANARO SANS

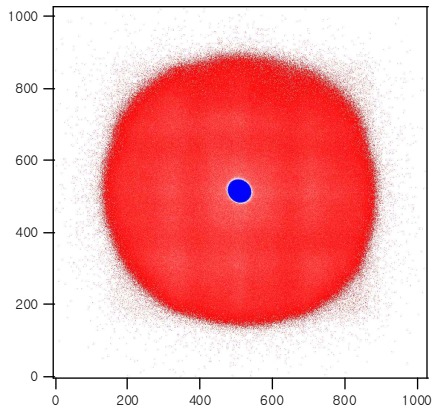


Wavelength of 7.49 Å for lense, 6Å
SDD = 19.85m (with lens), 5m, 1.16m
Q range = 0.0007 – 0.7 Å^{-1}

High Resolution Detector Installation (40M SANS)

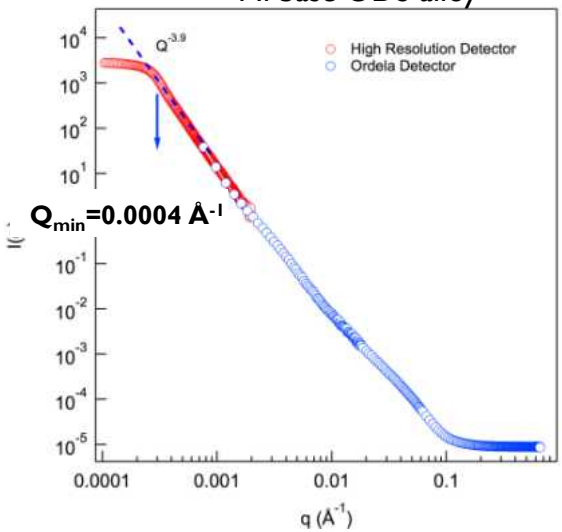




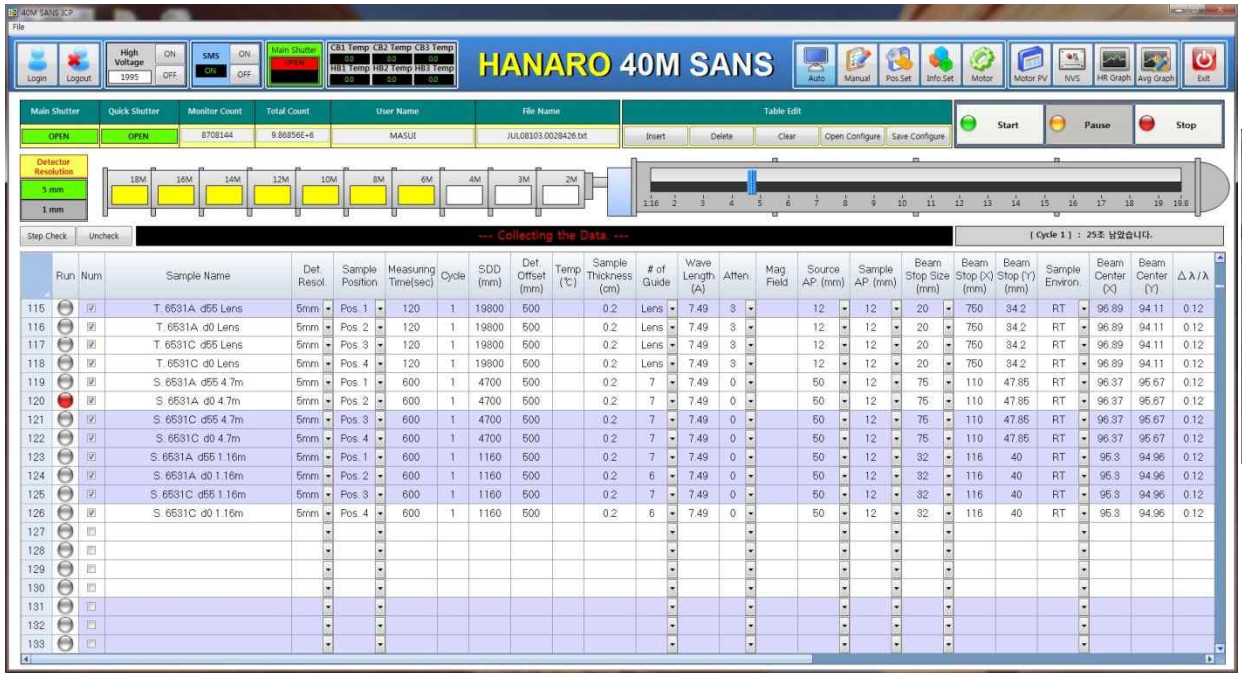


2D image : plexi glass

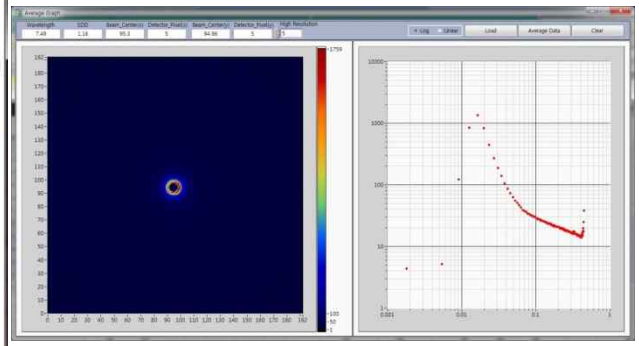
Ni base ODS alloy



Instrument Control Program



Real Time 1D Average



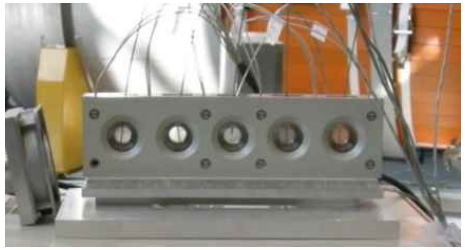
Data Reduction Program

- Both the large PSD and the high resolution detector can be automatically controlled by the ICP
- Real time display of I vs Q(right figure) can be realized during measurement
- Data reduction program can treat the data obtained from both the large PSD and the high resolution detector

Sample Environments in 18M/40M SANS

❖Temperature Control

Heating/Cooling
(-10C ~ 80C)



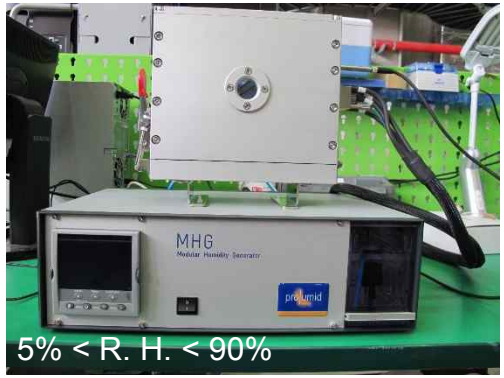
Heating (~300C)

Furnace (~600C)

❖ Magnetic Field

Horizontal Field
Electromagnet (1.5T)

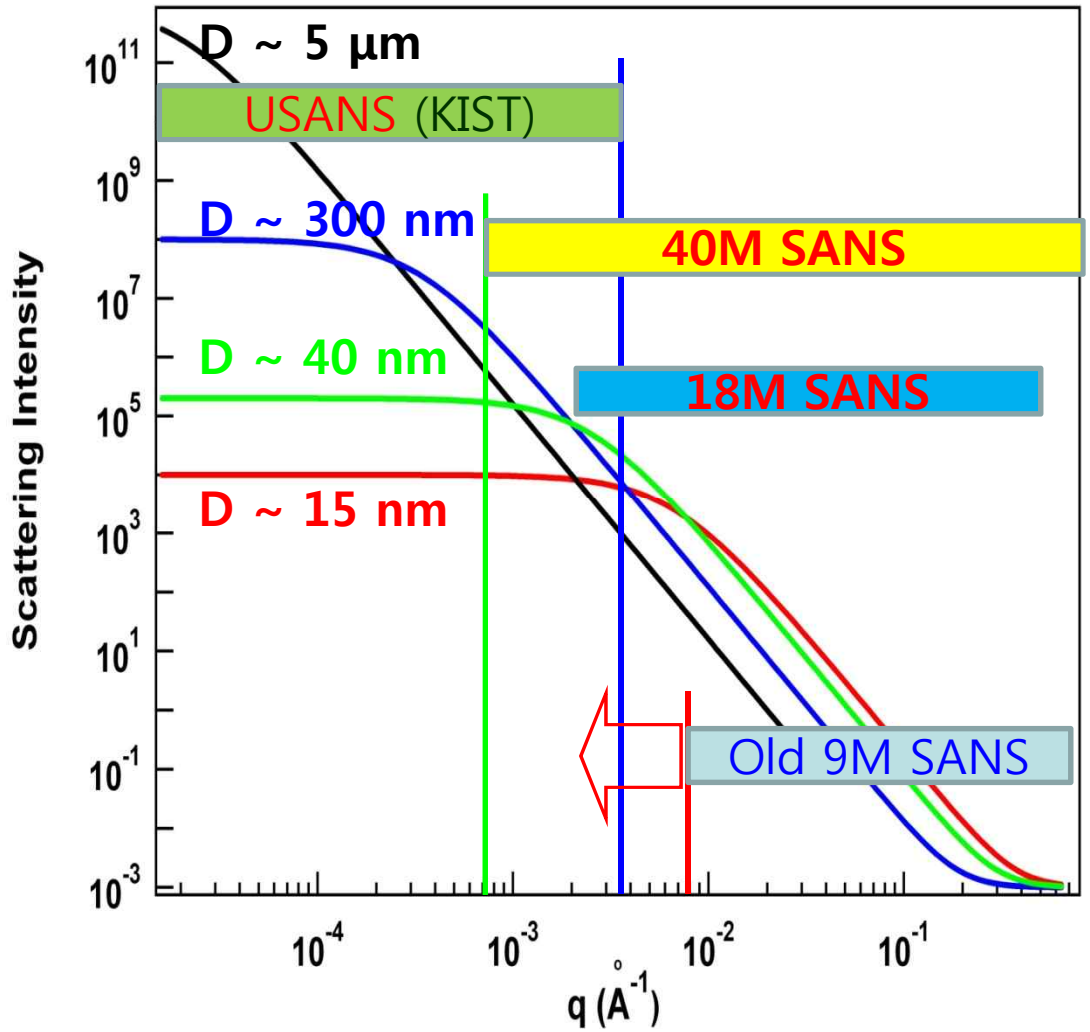
❖Humidity Chamber



❖ Pressure cell

❖Rotating Sample Stage

Accessible Q range of SANS Instrument at HANARO



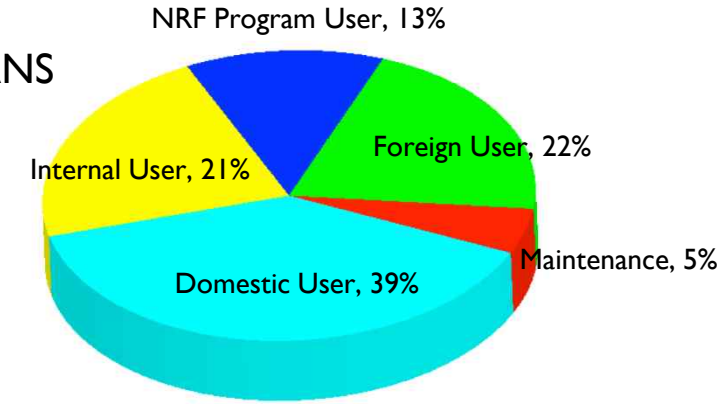
Accessible Q range

$2 \times 10^{-5} < Q < 1.0$ Å^{-1}

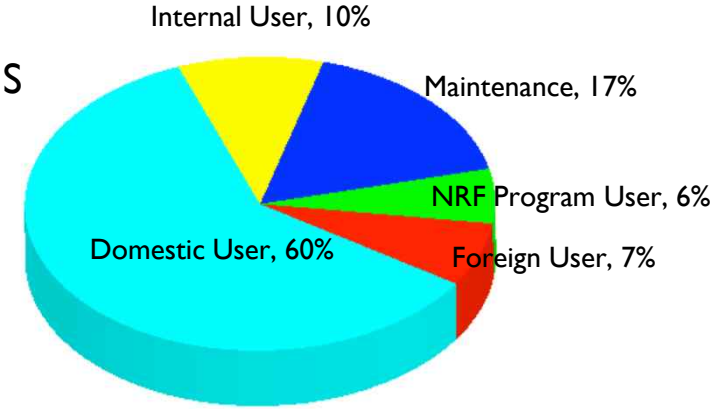
User Statistics

❖ Beam Time Distribution by User

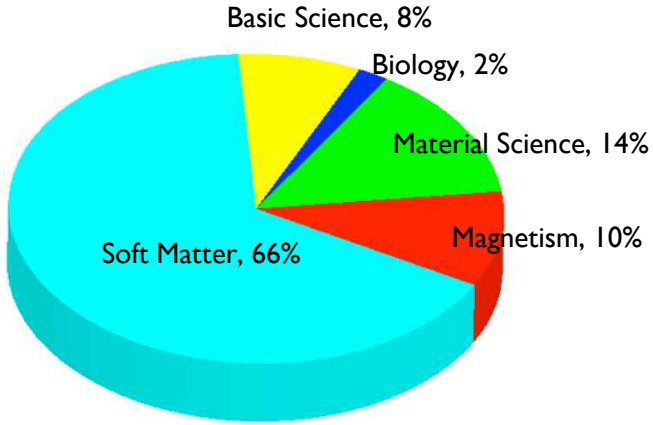
40M SANS

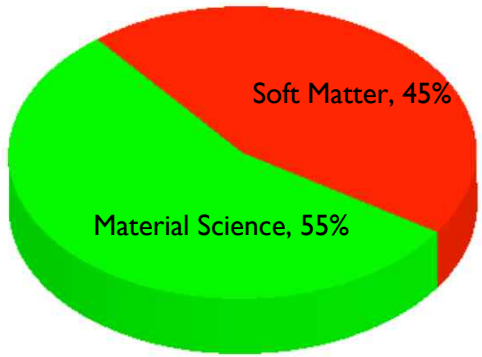


18M SANS



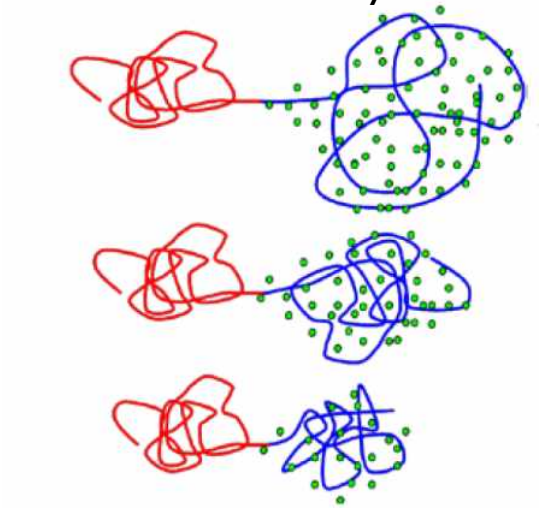
❖ Beam Time Distribution by Topics

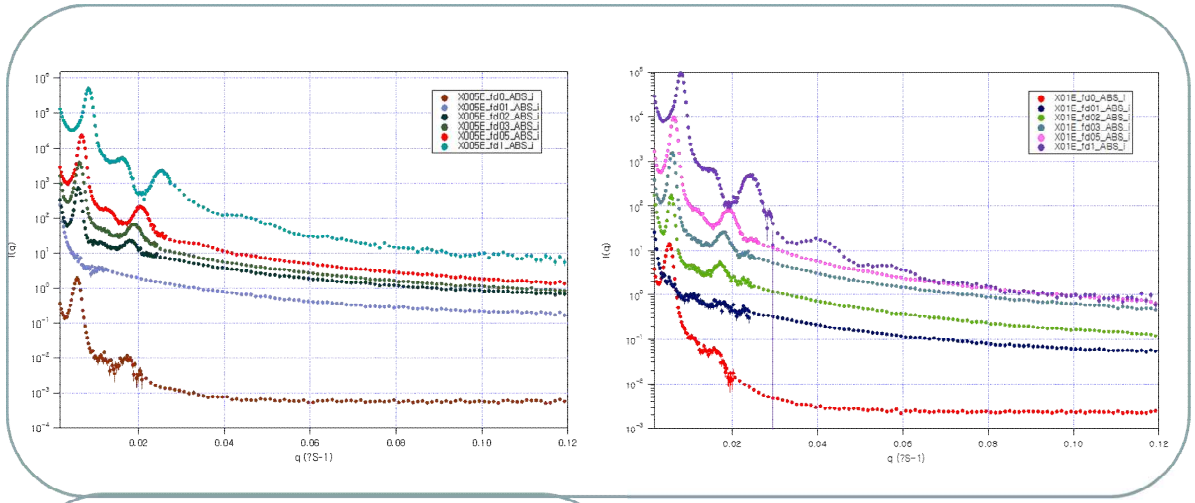


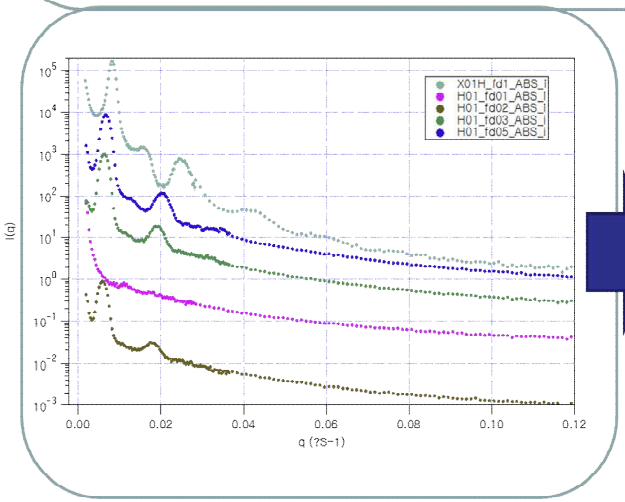


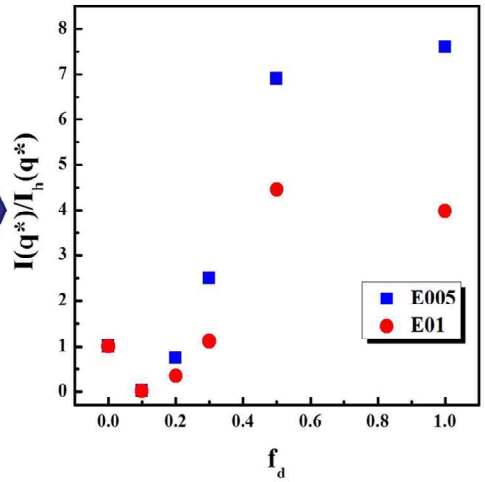
Soft Matter_ polymers in bulk

- SANS Intensity of the Block copolymer and ionic liquid mixtures with contrast matching method









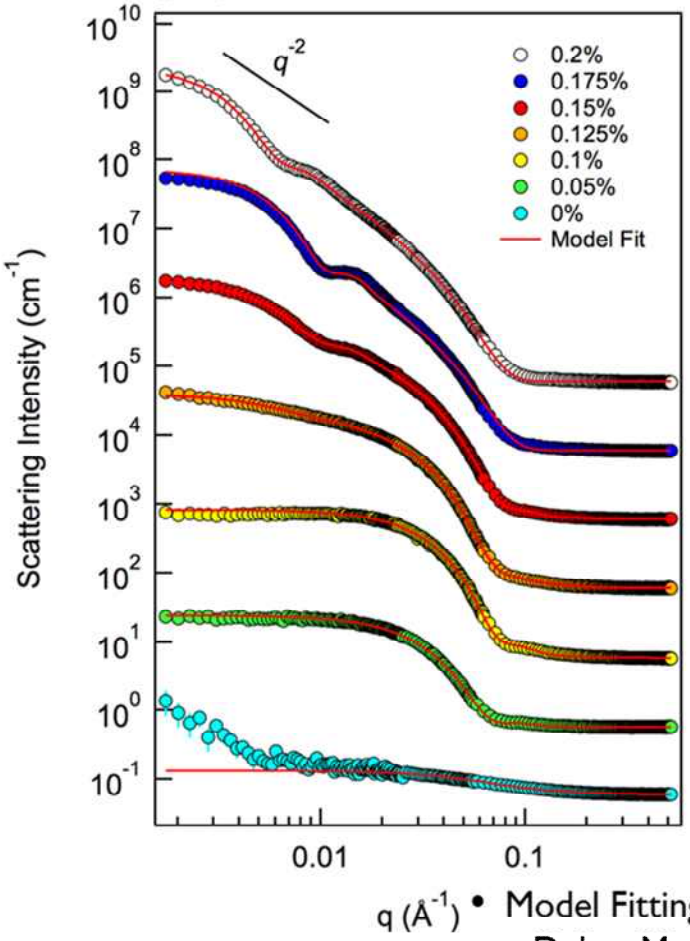
- Neutron Scattering Length Density

component	SLD (10^6Å^{-2})
PS	1.41
dPS	6.40
PVP	1.96
Ionic liquid	~3.0

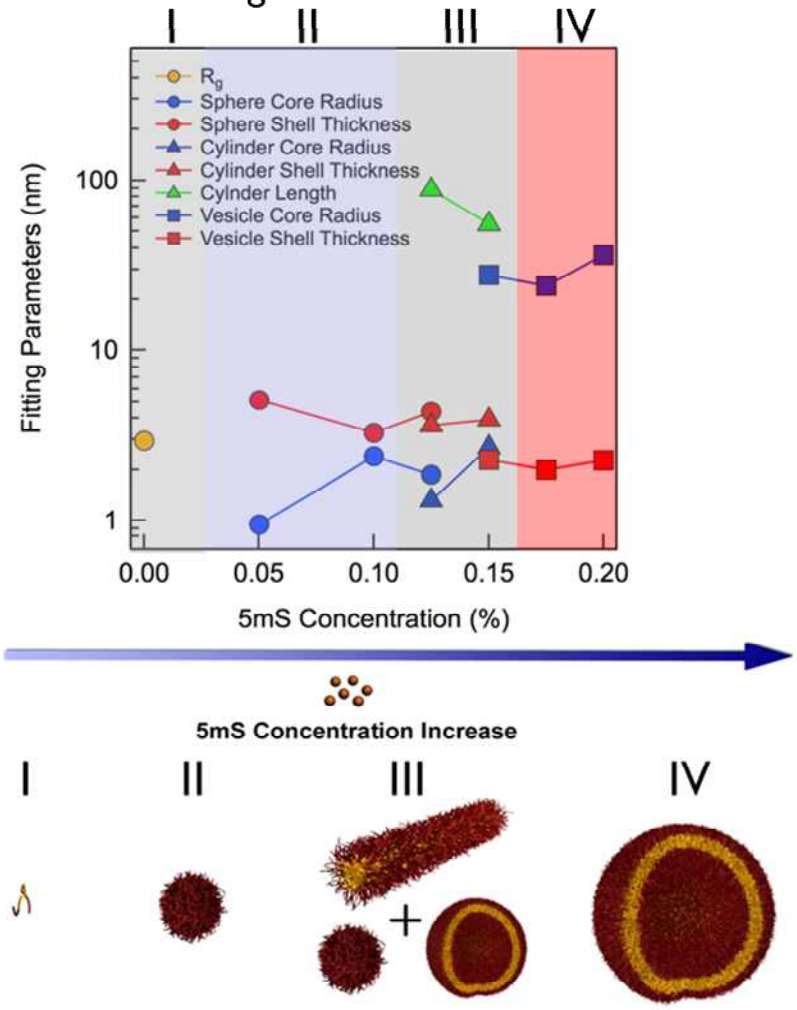
$$I(q^*) \propto (b_{s,eff} - b_{v,eff})^2$$

Soft Matter_ polymers in solution

- SANS Intensity of the P85-5mS complex at varying 5mS concentration



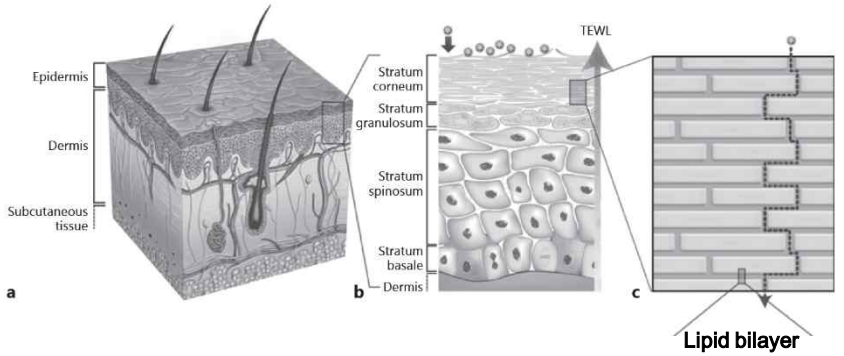
- Fitting Parameters



- Model Fitting:
  - Debye Model (0 %)
  - Spherical and Cylindrical Core-Shell Model (0.05 ~ 0.15 %)
  - Vesicle Model with Gaussian Distributed Shell (0.15 ~ 0.2 %)

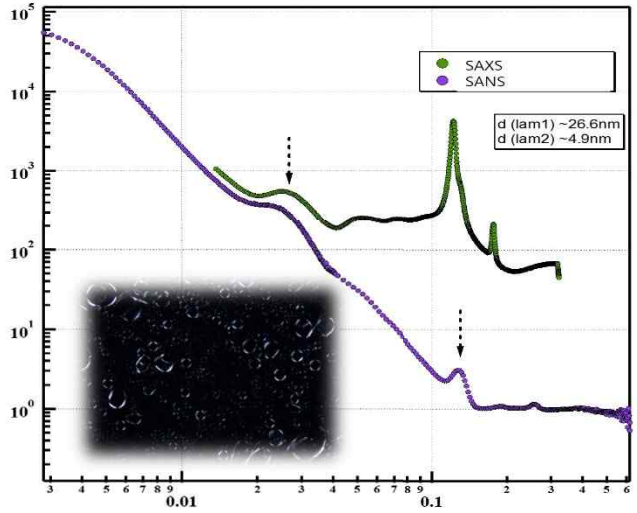
Soft Matter_ Technical support to Cosmetic company

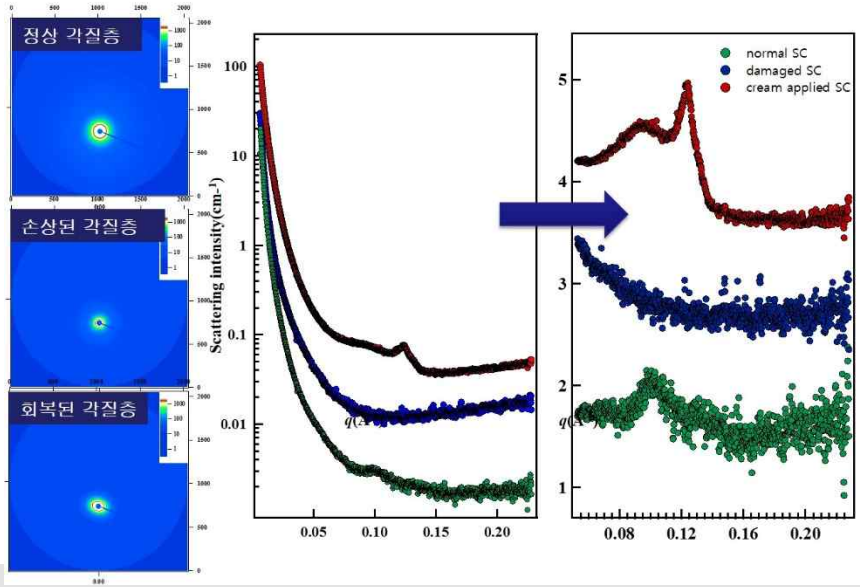
Evaluation of the effects of cosmetics on the restoration of skin barrier



Observation of rearrangement of lipid bilayer by small angle scattering

Nanostructures of cream with SANS and SAXS





Closing Remarks

1. HANARO Neutron Research Facility is National Facility and Open to Users Worldwide.
2. More Scientists Will Support the Users and Create High Quality Science.
3. HANARO is Ready to Share Experiences with All in Every Area of Science.