HANARO SANS Instruments at KAERI, Korea

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Tsukuba, Japan

Young Soo Han[1], Baek Seok Seong [1]and Man Ho Kim[2]

1. ***Korea Atomic Energy Research Institute***
2. ***Korea Institute of Science and Technology***

KAERI 한국원자력연구원 Korea Atomic Energy Research Institute

Contents

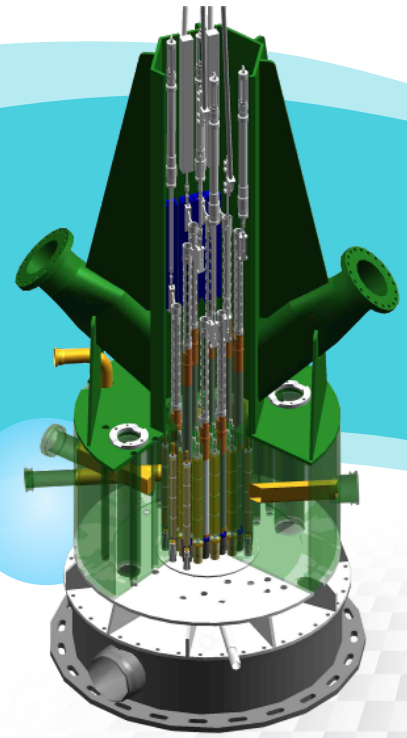
HANARO Reactor

High-flux
Advanced
Neutron
Application
Reac**t**o**r**

Multi-purpose Research Reactor

HANARO Complex

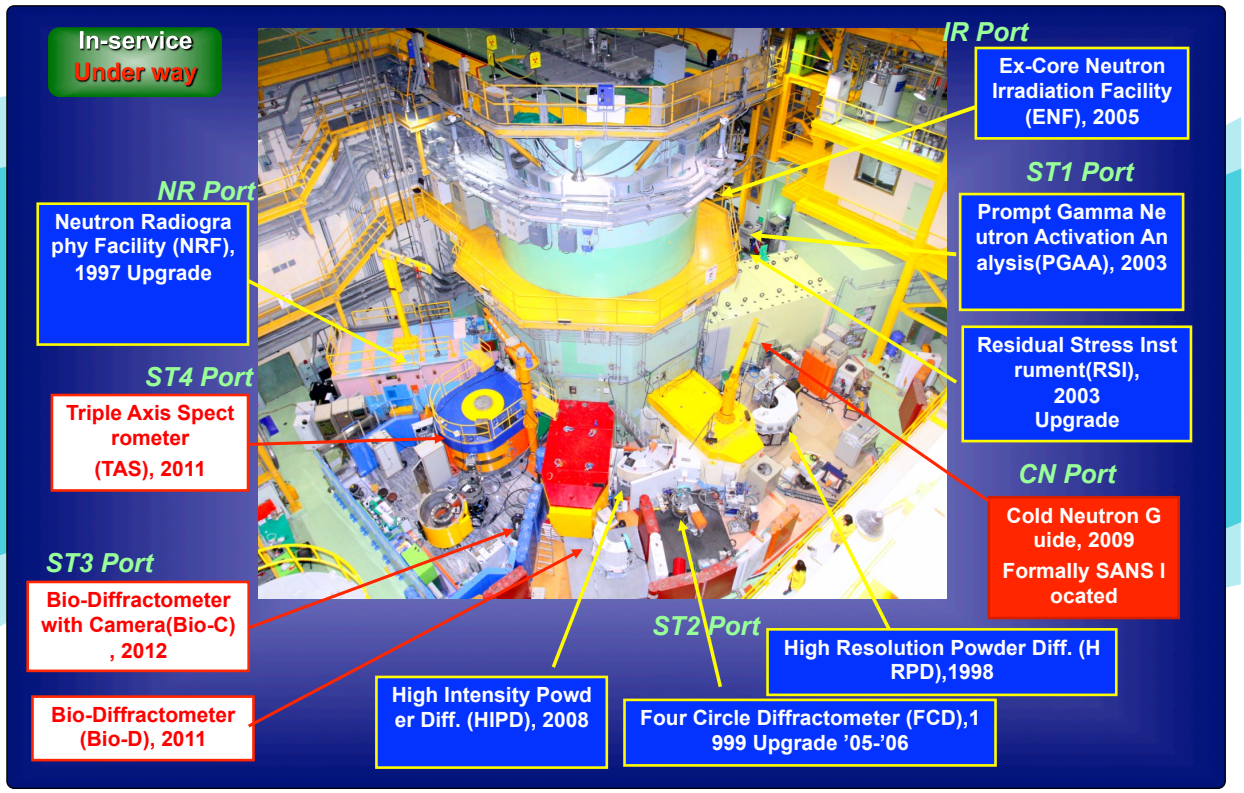
Reactor Structure and Characteristics



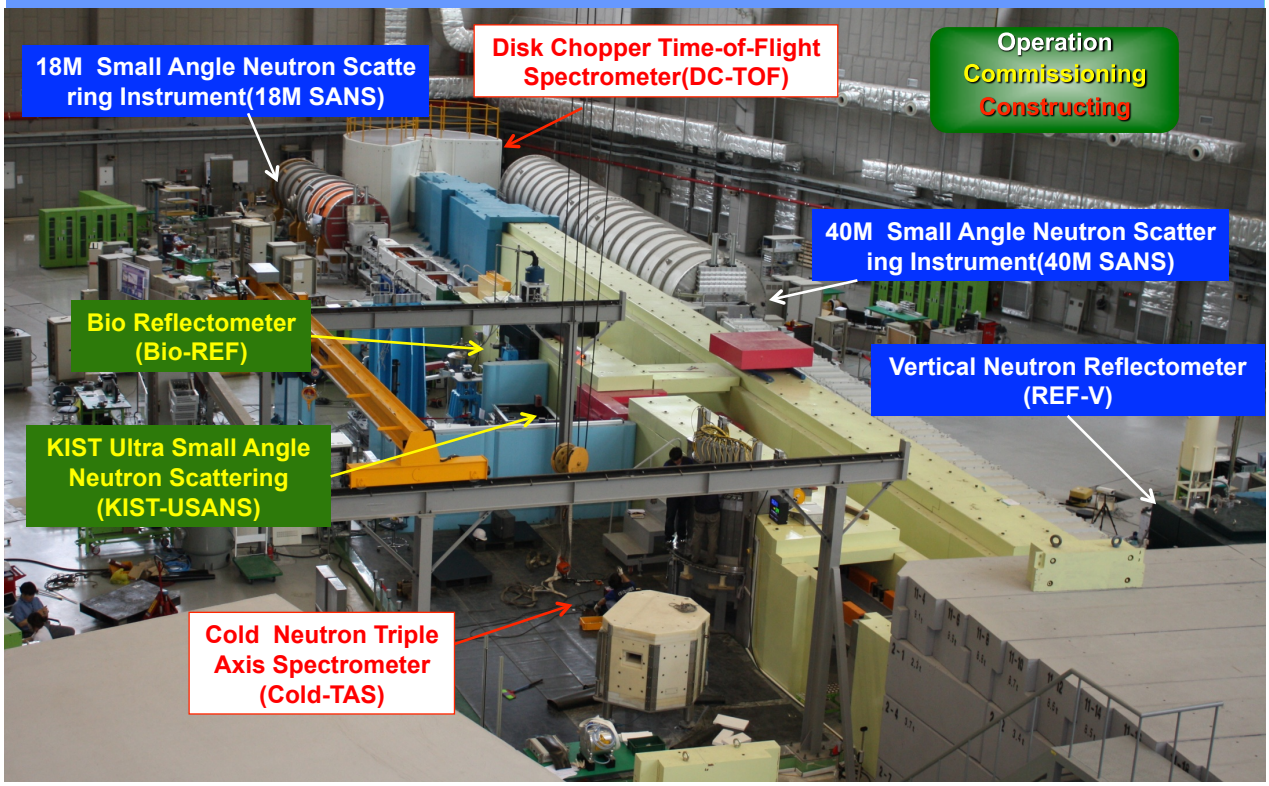
Features

- Type: Open-tank-in-pool
- Power: 30 MW_{th}
- Coolant: Light Water
- Reflector: Heavy water
- Fuel Materials: U_3Si, 19.75% enriched
- 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

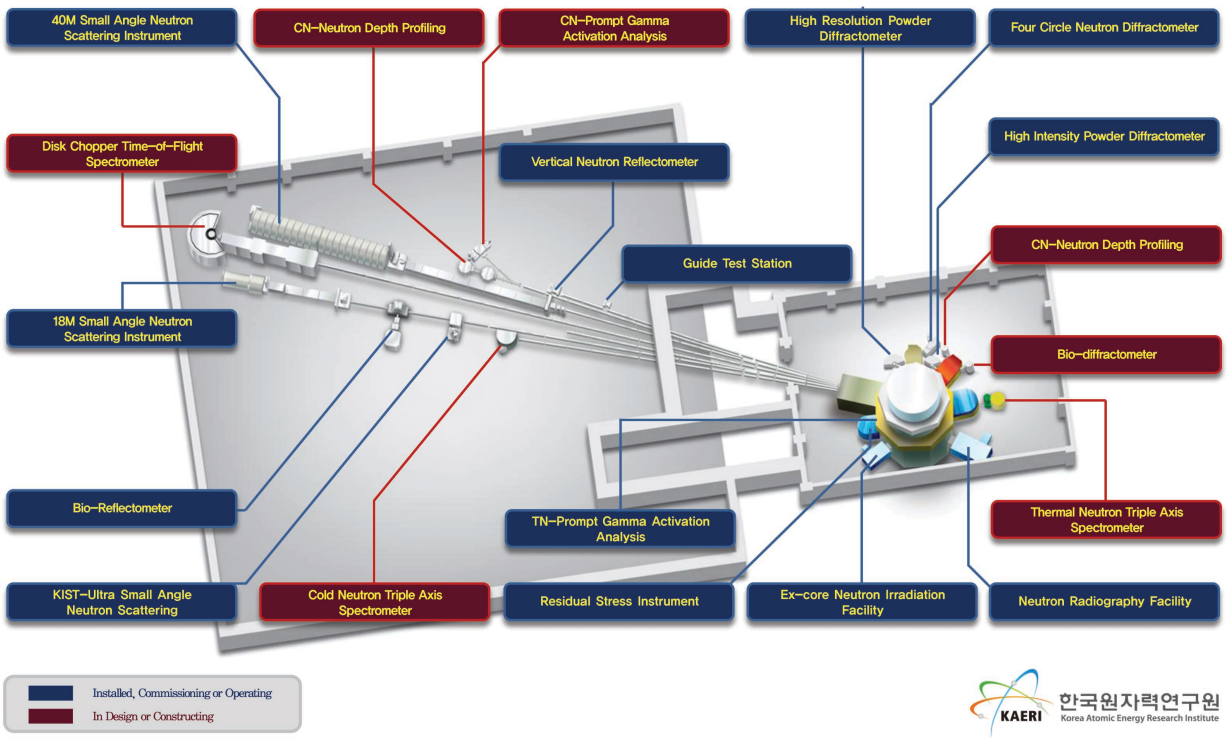
Reactor Hall, 2011



Cold Neutron Guide Hall, 2011



HANARO Neutron Beam Instruments



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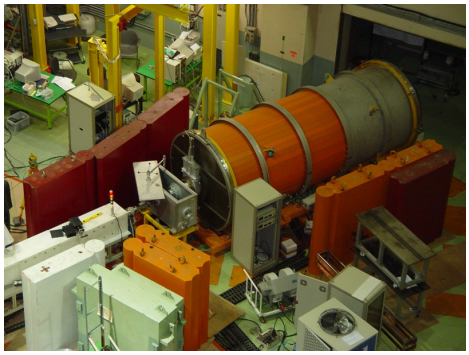
History of SANS Instrument at HANARO

- 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
- Present : 18M/40M SANS instruments are operating(over 200 days) and KIST-USANS is in commissioning stage

9m SANS Instrument(2001-2008)



- **Installed @CN port in 2001**
- **Sample Environment**
  - **Circulation bath (- 20~80C)**
  - **Heating block (RT~200C)**
  - **Electromagnet (0~1.5 T)**

Design Characteristics

- **γ/n – Filter** LN_2 cooled Bi/Be filter
- **λ** 4.3 ~ 8.5 0.85 Å (by NVS), Δλ/λ(FWHM)~10%
- **Collimator** Pin hole type
- **Detector** 2D-PSD(^{3}He), 65x65cm^2 with 5mm^2 resolution
- **Sample** 5~15mm diameter
- **Q-range** 0.06 to 6nm^{-1}
- **Flux @sample :**

Q_{min}(nm^{-1})	I_s (n/cm^2·s)
0.06	5 x 10^3
0.1	1 x 10^4
1.0	1 x 10^5

Applications

- **Defects in metallic and ceramic materials**
- **Critical phenomena in phase transitions**
- **Kinetics of diffusion controlled phase separation**
- **Complex liquids (microemulsions, colloids, LC …)**
- **Structure and morphology of polymer systems**
- **Structural studies of biological macromolecules.**

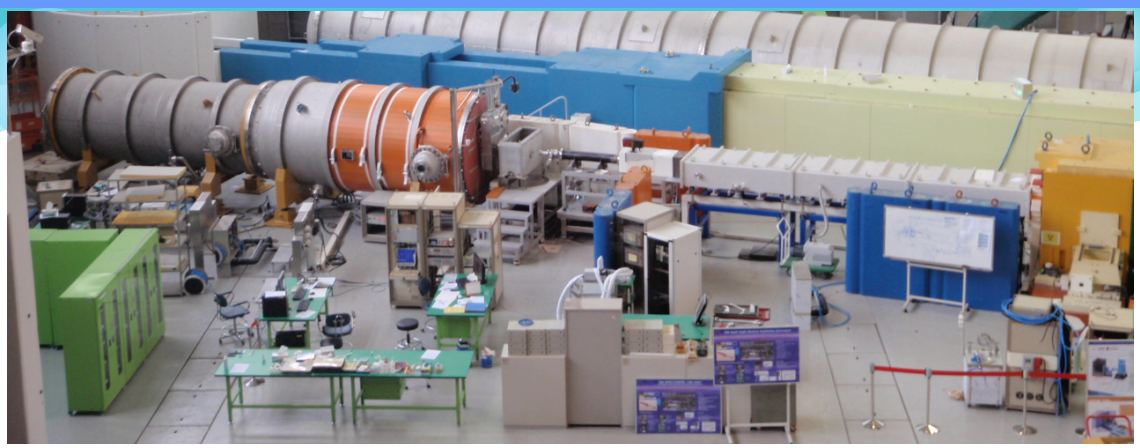
40M SANS Instrument

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♪

Principal Investigator	Sung-Min Choi (KAIST)	Project Management Decision on the Top Level Spec. Promotion of Scientific Program for SANS
HANARO Staff Instrument Scientist	Young-Soo Han	Co-work with PI for the Top Level Spec. Identification of the Detailed Tech. Spec. Supervision of Engineering Group

18M SANS Instrument



Dr. Baek Seok Seong♪

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 Instrument Parameters

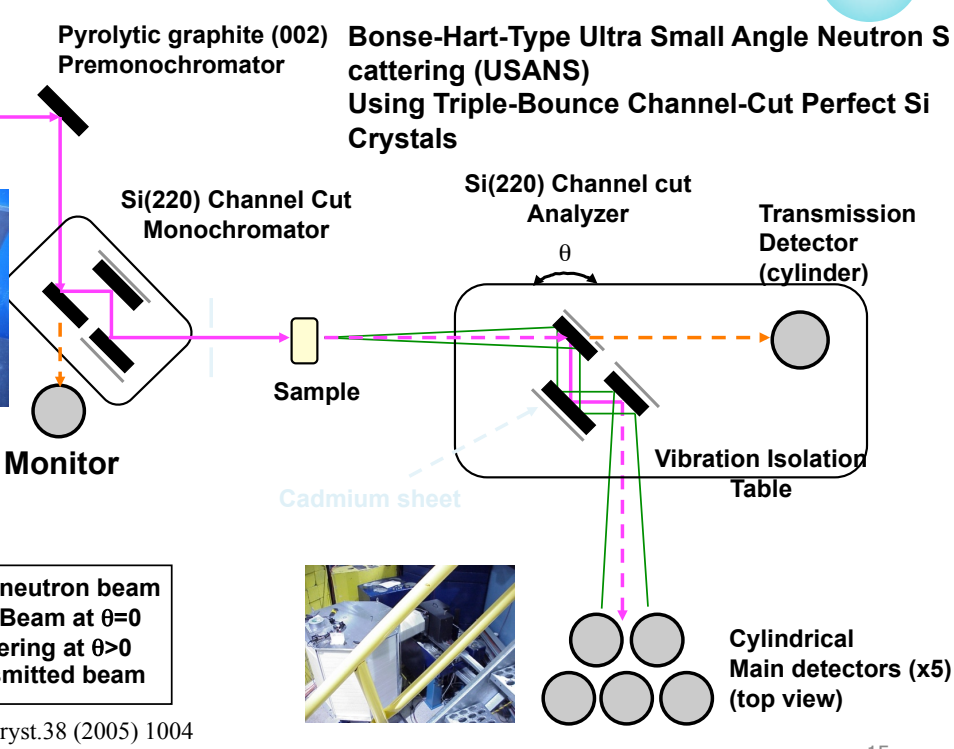
Parameter	40M SANS	18M SANS
Total Instrument Length (m)	40	18
Detector Dimensions (cm^2)	100 x 100	64 x 64
Detector Resolution (cm^2)	0.5 x 0.5	
Detector supplier	ORDELRA, 21000N	ORDELRA, 2660N
Velocity selector supplier	ASTRIUM	
Source to sample distance (m)	2 - 20 (steps : 2m)	3 - 9 (steps : 2m)
Sample 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

HANARO SANS Personnel

Title	40M SANS	18M SANS
1st Instrument Scientist	Dr. Young-Soo Han	Dr. Baek-Seok Seong*
2nd Instrument Scientist	Dr. Tae-Hwan Kim	Dr. Eun-Joo Shin
Post-doc	-	Dr. Tae-Kyu Shin
Researcher	Mr. Jong-Dae Jang	Mr. Han-Sik Jeon

* Dr. Seong is also a leader of the project named of "Development of Industrial Application Techniques by neutron Scattering"♪

Concept of USANS



J.G. Barker et. al. J. Appl. Cryst.38 (2005) 1004
M.-H. Kim & C. J. Glinka Micropor. Mesopor. Mater. 91 (2006) 305

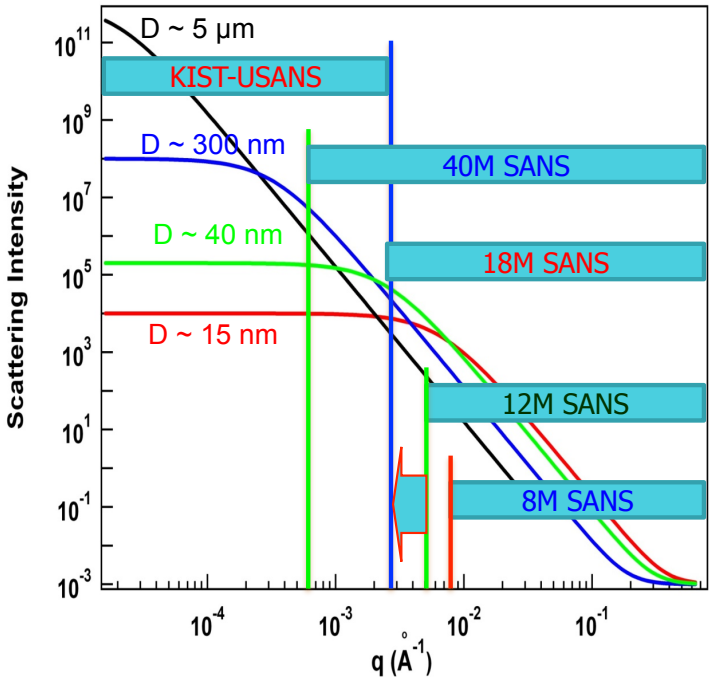
KIST-USANS

- Dr. Man Ho Kim is responsible of KIST-UANS
- KIST : Korea Institute of Science and Technology

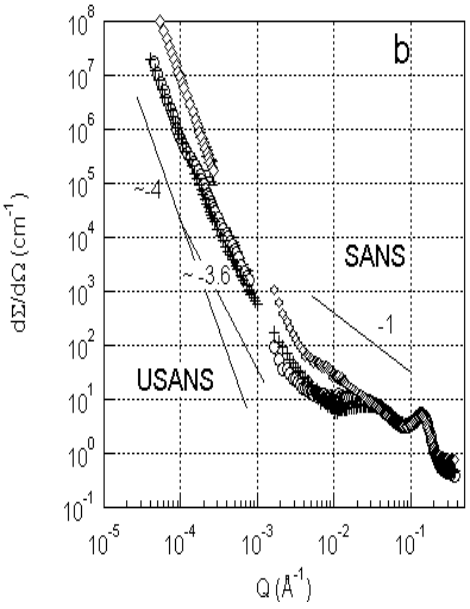
Features of KIST-USANS

- ❑ (Resolution) Qmin ~ 5×10^{-5} Å^{-1} for l=4 Å & Qmin~4×10^{-5} 2 Å
- ❑ (Wavelength) =4 Å & 2 Å
- ❑ (Focusing) vertically focusing with OPG(002) (div.=0.4±0.1°)
- ❑ (Flux at Monochromator) ~ 1.2×10^{7} #/cm^{2}sec for l=4 Å , ~ 6×10^{5} for l=2 Å
- ❑ (Monochromator & Analyzer) channel-cut Si (111)
- ❑ (Measurable Size) submicron to ~ 20 um
- ❑ (Low background) due to the curved guide (R=600 m)
- ❑ (High S/N) due to multiple reflections on the channel-cut crystals
- ❑ (Multiple Scattering) can be checked and reduced by a factor of 4
- ❑ (Economics) reduce the measurement time by a factor of 2~3

Q range of SANS



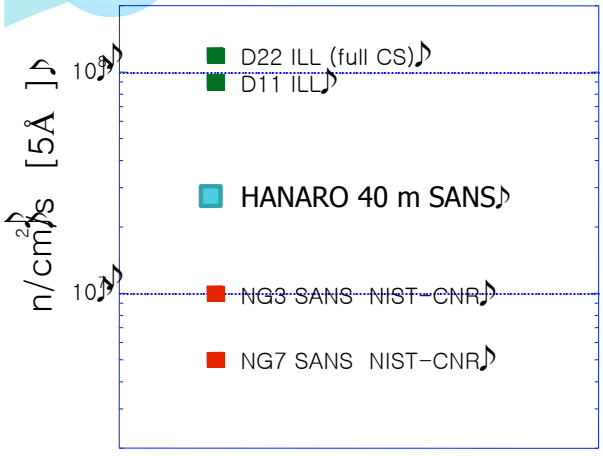
With the thickness of Nafion Membrane



Macromolecules (2006), 39, 4775

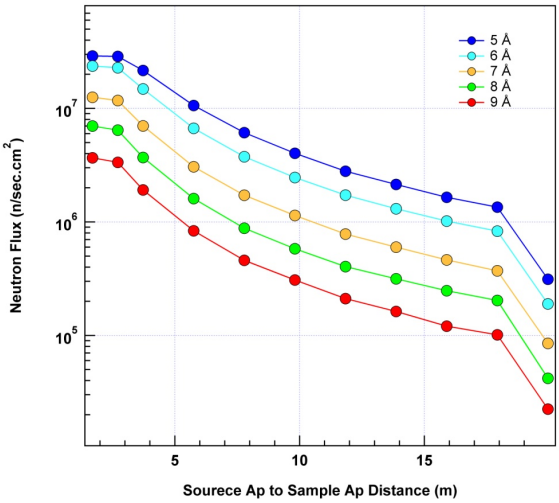
Neutron Flux at Sample Position in 40M SAN$

Neutron flux at sample position



Wavelength of 5Å
Collimation length of1.7 m
Measured using gold foil♪

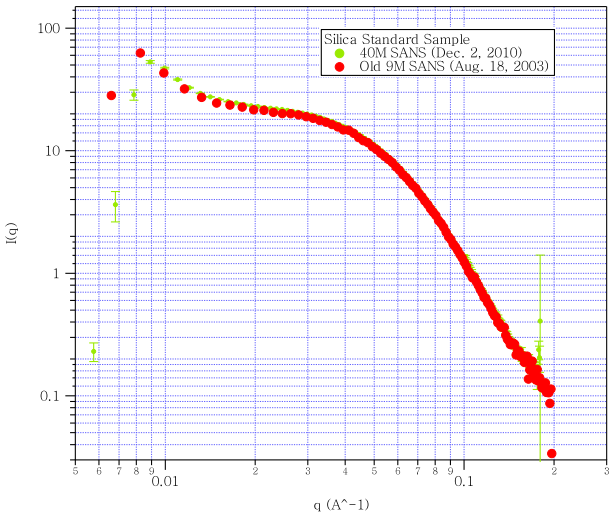
Neutron Flux with various conditions



Measured using neutron monitor
Y-scale is calibrated using the data measu red with gold foil♪

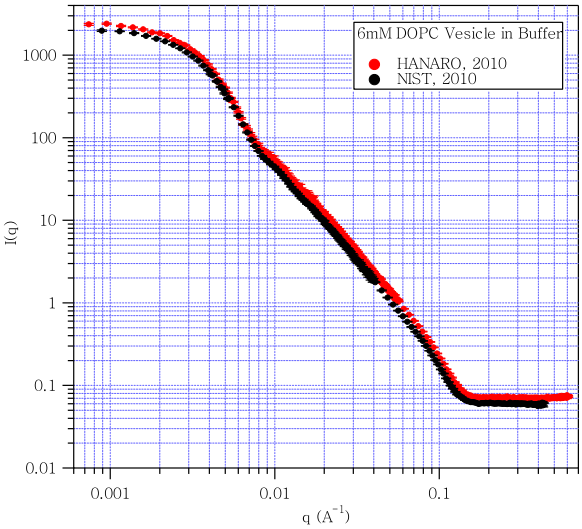
Comparison of SANS Data

Old & New HANARO SANS Instruments



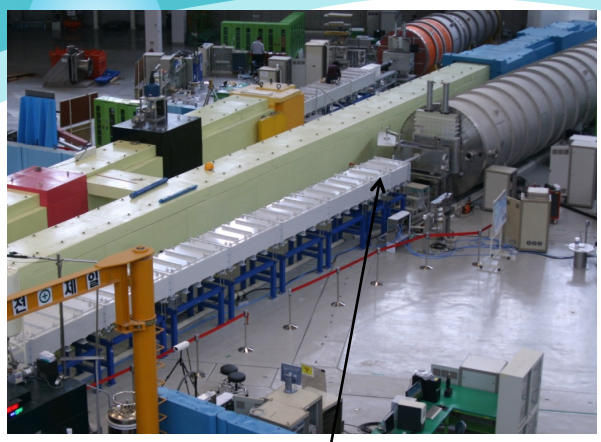
- Both are absolutely calibrated with Silica Standard samples♪

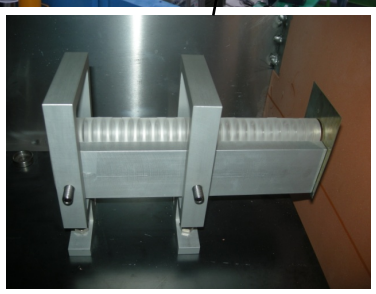
HANARO & NIST NG-7 SA NS Instruments

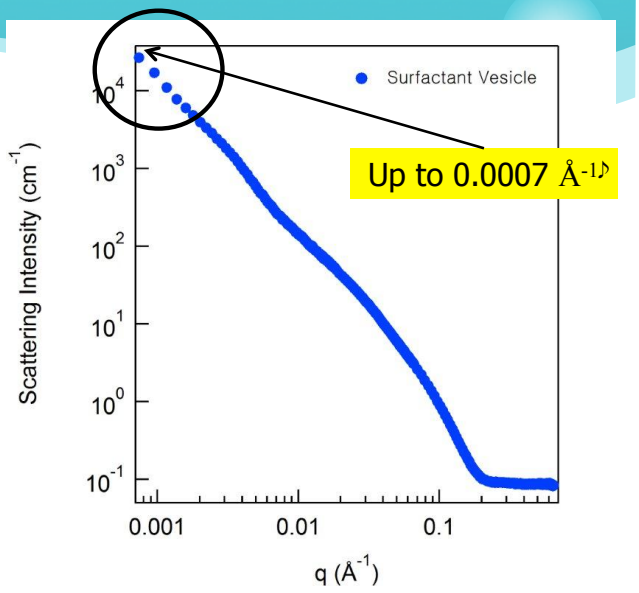


- NIST data are absolutely calibrated with using direct beam method♪

MgF2 Focusing Lenses in 40M SANS





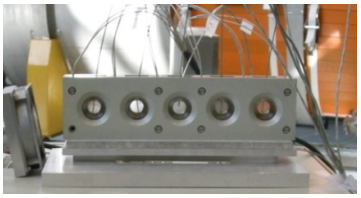


Wavelength of 7.49 Å for lense, 6Å
SDD = 19.85m(lense), 5m, 1.16m
Q range = 0.0007 – 0.7 Å-1♪

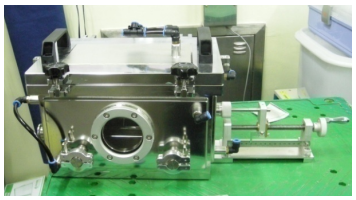
Sample Environments in SANS

❖Temperature Control

Heating/Cooling
(-10C ~ 80C)

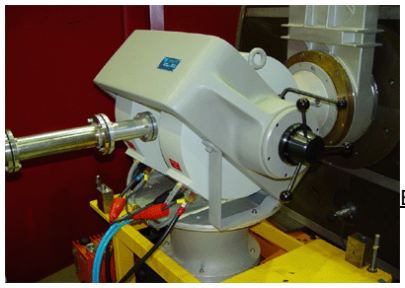


Heating (~300C)



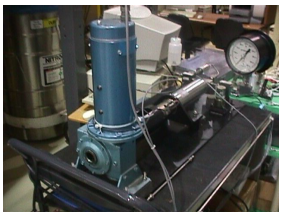
Furnace (~600C)

❖ Magnetic Field



Horizontal Field
Electromagnet (1.5T)

❖ Pressure cell

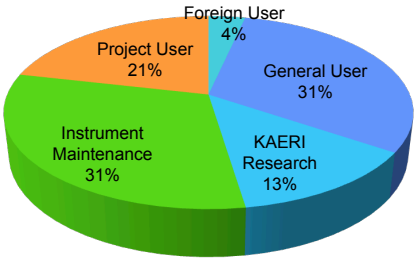


~ 3 kbar & Heating

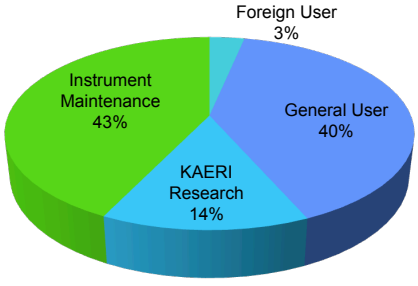
67th – 73th Cycles(From Nov. 2010 – June 2011)

❖ **Beam Time Distribution by User**

40M SANS

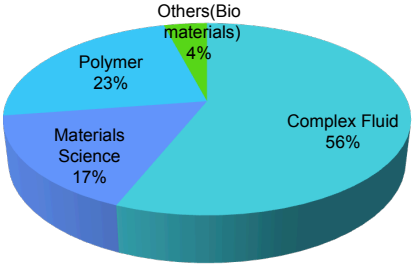


18M SANS



❖ **Beam Time Distribution by Topics**

40M SANS



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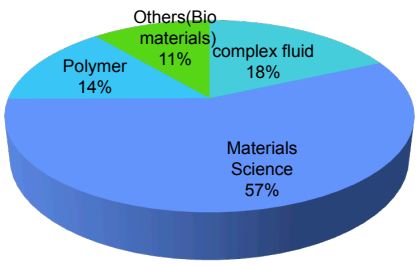
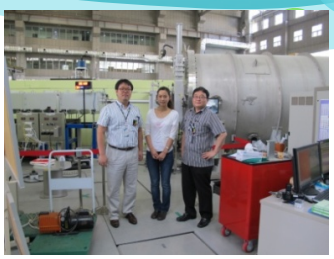


SANS Experiments by Foreign Users

U. Of Sydney@ 18M SANS♪

Ibaraki Univ. @ 18M SANS♪



U. Of Adelaide@ 40M SANS♪

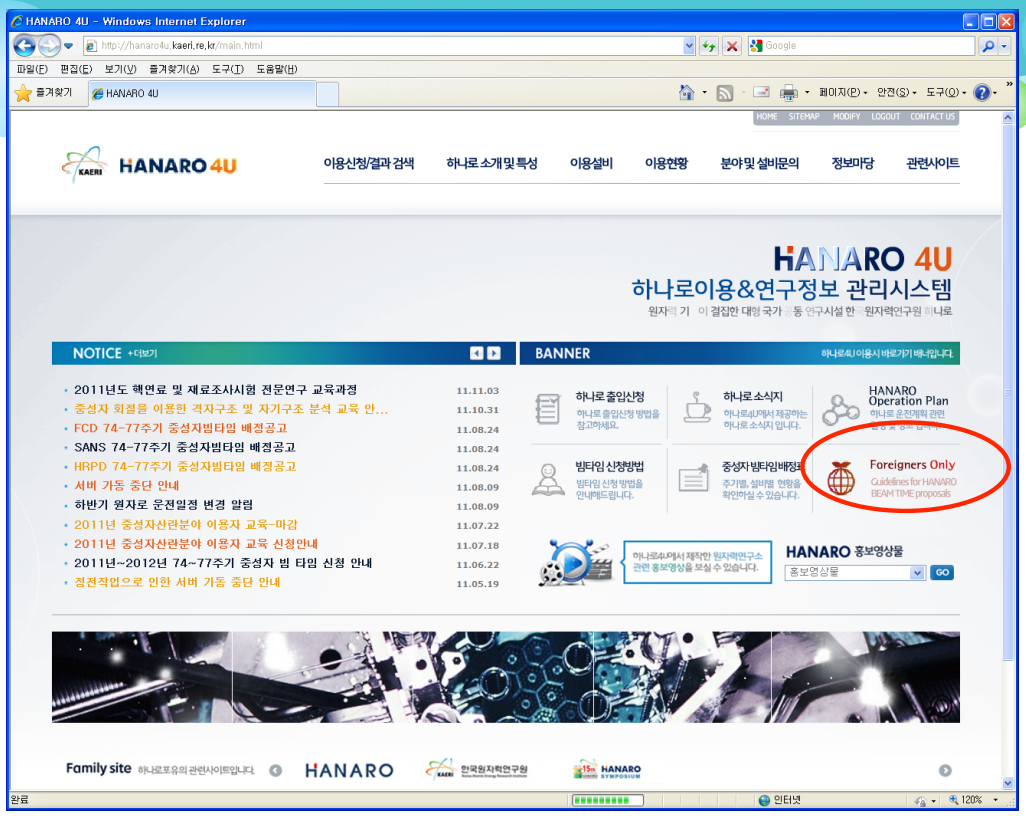
U. Of Tokyo@ 40M SANS♪

Sumitomo Rubber@ 40M SANS♪

Guide for Beam Time Request

- Basically, the HANARO instruments are to be offered, after going through a commissioning process, for open use by outside researchers.
- There are two kinds of beam time request processes depending on the instruments. One is general request and the other is on-demand request.
  * General request : 2 SANS instruments, HRPD and FCD
  * On-demand request : NRF, ENF and RSI
- For general requests, calls for proposals are issued approximately twice a year.
- Our instruments are open for use by foreign users as well.
- In case the users' demand for beam time exceeds our capacity, the users' proposals should be subject to a peer review.
- Users can submit their applications for the beam time on our website: http://hanaro4u.kaeri.re.kr.

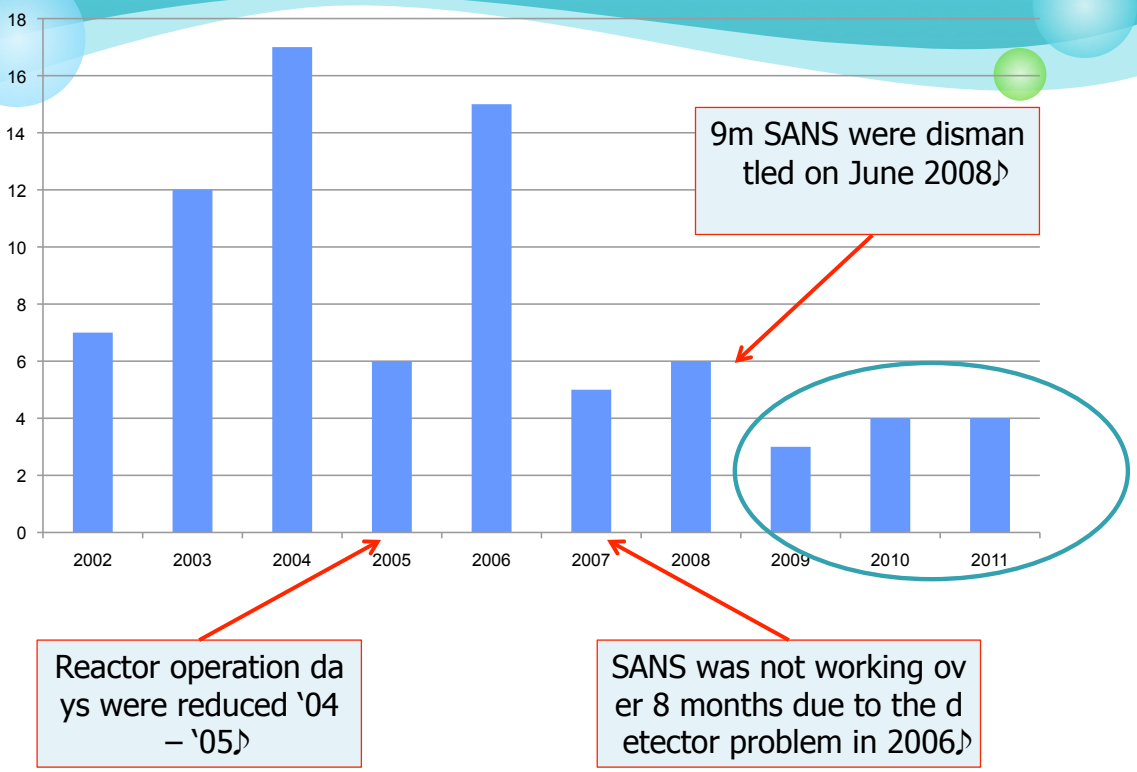
HANARO4U



Concerns & Challenges

- Solo practice by users is prohibited for security concerns.
- There is no budget set aside exclusively for instrument ope ration and user support.
- Korea has no more than ten experienced SANS user groups .
- There are no advanced sample environments such as a su perconducting magnet, a rheometer, etc.
- Technical support for instrument maintenance is extremely limited.
- At the moment, the cold neutron flux would O.K. The flux i s not stable.

of SCI papers produced by 9m SAN$



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 Qu ality Science.
3. HANARO is Ready to Share Experiences with All in Every A rea of Science.


Thank You!
KAERI
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Research Institute