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# KWS-3: Very small angle scattering diffractometer with focusing mirror

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**Abstract:** KWS-3, which is operated by JCNS, Forschungszentrum Jülich, is a **v**ery **s**mall **a**ngle **n**eutron **s**cattering (VSANS) instrument running on the focussing mirror principle. KWS-3 is designed to bridge the gap between Bonse-Hart and pinhole cameras. Owing to its extended Q range, optimized flux, and good wavelength resolution, KWS-3 has shown good performance and has become scientifically productive to the user community.

## 1 Introduction

The principle of this instrument is a one-to-one image of an entrance aperture onto a 2D position sensitive detector by neutron reflection from a double-focussing toroidal mirror.

The instrument's standard configuration with a 9.5 m sample-to-detector distance allows performing scattering experiments with a wave vector transfer resolution between $4.0 \cdot 10^{-5}$ and $2.5 \cdot 10^{-3}$ Å$^{-1}$, bridging a gap between Bonse-Hart and pinhole cameras. A second sample position at 1.3 m sample-to-detector distance extends the Q-range of the instrument to $2.0 \cdot 10^{-2}$ Å$^{-1}$ and reaches more than one-decade overlapping with the classical pinhole SANS instruments. Another "mobile" sample position can be installed to adept sophisticated sample environment between 8 and 2 m sample-to-detector distance according to the requested instrumental resolution.

Figure 1: Instrument KWS-3 (Copyright by W. Schürmann, TUM).

The instrument covers the Q range of small angle light scattering instruments. Especially when samples are turbid due to multiple light scattering, V-SANS gives access to the structural investigation. Thus, the samples do not need to be diluted. The contrast variation method allows for highlighting of particular components.

Small-angle scattering is used for the analysis of structures with sizes just above the atomic scale, between 1 and about 100 nm, which can not be assessed or sufficiently characterised by microscopic techniques. KWS-3 is an important instrument extending the accessible range of scattering angles to very small angles with a superior neutron flux when compared to a conventional instrumental set up with pinhole geometry. Thus, the length scale that can be analysed is extended beyond 10 μm for numerous materials from physics, chemistry, materials science, and life science, such as alloys, diluted chemical solutions, and membrane systems.

## 2 Typical Applications

- High-flux bridge between Bonse-Hart and conventional SANS diffractometers
- Colloid science: mixtures of particles, particles of micron size, silicon macropore arrays
- Materials science: filled polymers, cements, microporous media
- Polymer science: constrained systems, emulsion polymerisation
- Bio science: aggregations of bio-molecules, protein complexes, crystallisation of proteins
- Hierarchical structures
- Multilamellar vesicles

## 3 Sample Environment

- Anton-Paar fluid rheometer
- Stopped flow cell
- Sample holders:
  4 horizontal x 2 vertical (temperature controlled) for standard Hellma cells 404-QX
  9 horizontal x 2 vertical (room temperature) for standard Hellma cells 404-QX
- Oil & water thermostats (typical 10 °C – 100 °C)
- Electric thermostat (RT - 200 °C)

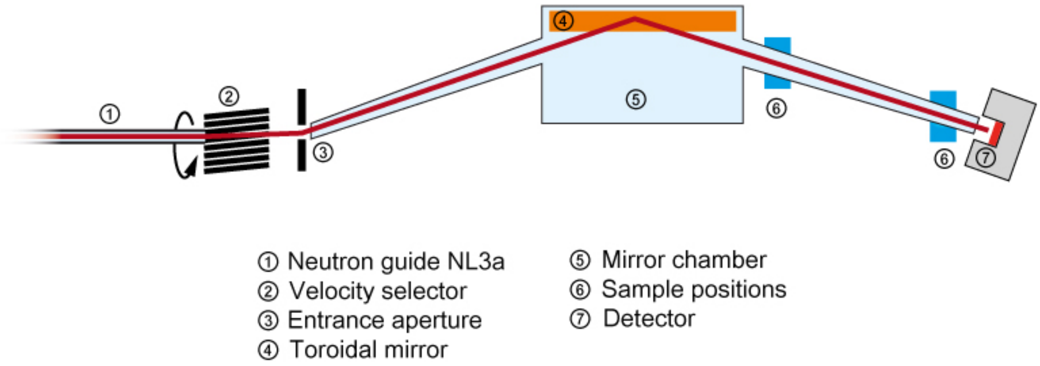


Figure 2: Schematic drawing of KWS-3.

- 6-positions thermostated (Peltier) sample holder (-40 °C – 150 °C)
- Magnet (2 T, vertical)
- Magnet (5 T, horizontal)
- Cryostat with sapphire windows
- High temperature furnace
- Pressure cells (500 bar, 2000 bar, 5000 bar)

# 4 Technical Data

## 4.1 Overall performance

- Resolution:
  $\delta Q = 10^{-4}$ Å$^{-1}$ (extension to $4 \cdot 10^{-5}$ Å$^{-1}$ possible)
- Q-range:
  $1.0 \cdot 10^{-4} - 3 \cdot 10^{-3}$ Å$^{-1}$ at 9.5 m distance
  $1.5 \cdot 10^{-3} - 2 \cdot 10^{-2}$ Å$^{-1}$ at 1.3 m distance
- Neutron flux:
  high-resolution mode: $>$ 10000 n s$^{-1}$
  high-intensity mode: $>$ 60000 n s$^{-1}$

## 4.2 Monochromator

- MgLi velocity selector
- Wavelength spread $\Delta\lambda/\lambda$ = 0.2
- Wavelength range $\lambda$ = 10 - 30 Å (maximal flux at 12.8 Å)

## 4.3 Aperture sizes

- 1 x 1 mm$^2$ – 5 x 5 mm$^2$

## 4.4 Beam size at 9.5 m

- 0 x 0 mm$^2$ – 100 x 25 mm$^2$

## 4.5 Beam size at 1.3 m

- 0 x 0 mm$^2$ – 15 x 10 mm$^2$