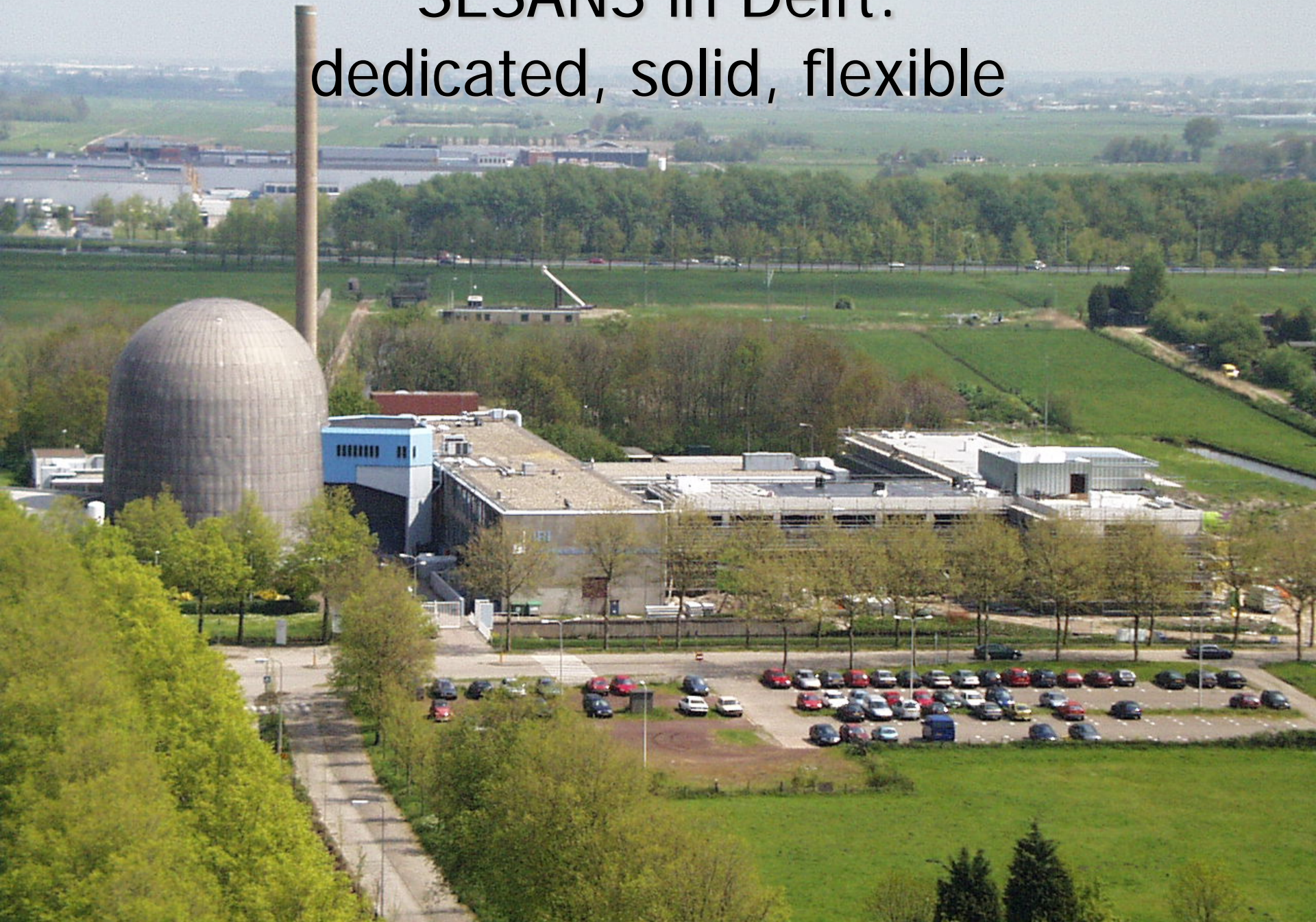


# SESANS in Delft: dedicated, solid, flexible



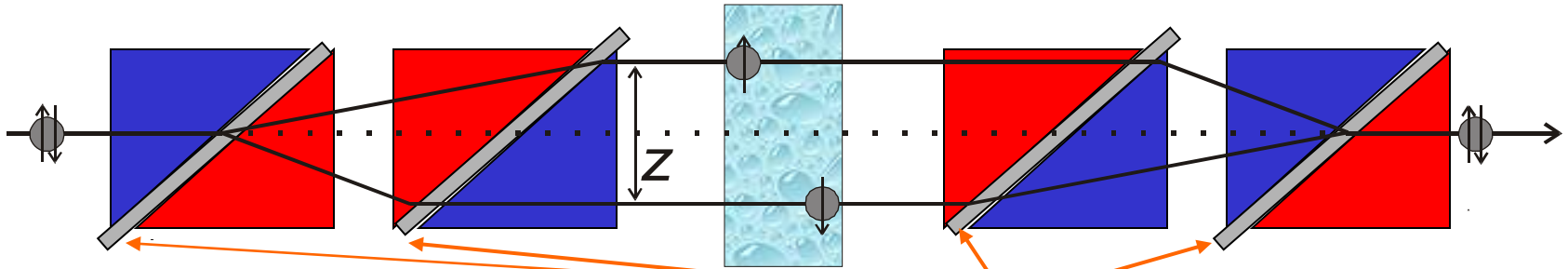
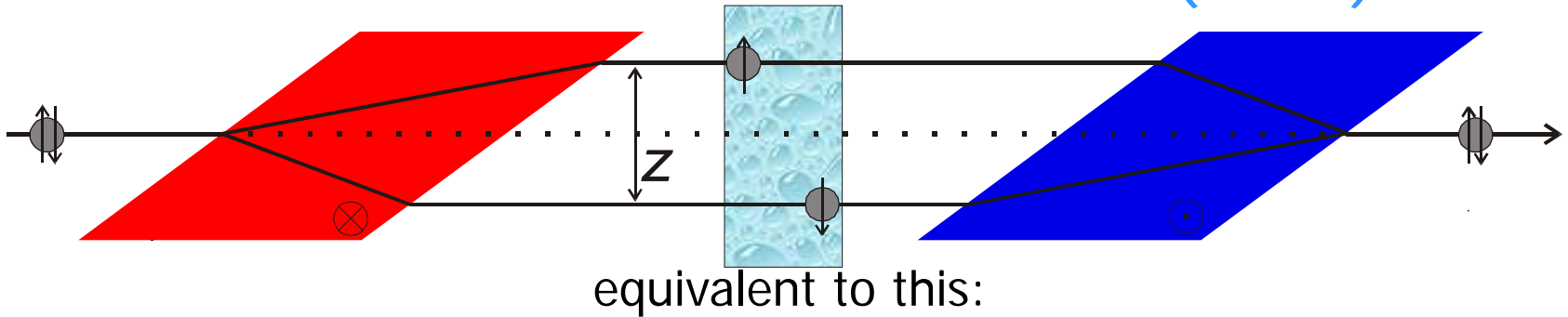
## Contents of this lecture

- **Components and setup Delft SESANS**
- Some extreme measurements
- SEMSANS
- Dissemination of SESANS technique

## History Delft SESANS

- 1995 Theo Rekveldt concept to build on depolarimeter
- 1999 Funding to build dedicated instrument  
Promised spin-echo length 1  $\mu\text{m}$   
Tests  $\pi/2$  and  $\pi$  foil flippers
- 2002 Present dedicated instrument ready  
Spin-echo length 20  $\mu\text{m}$

# Practical realisation of SESANS (2002)



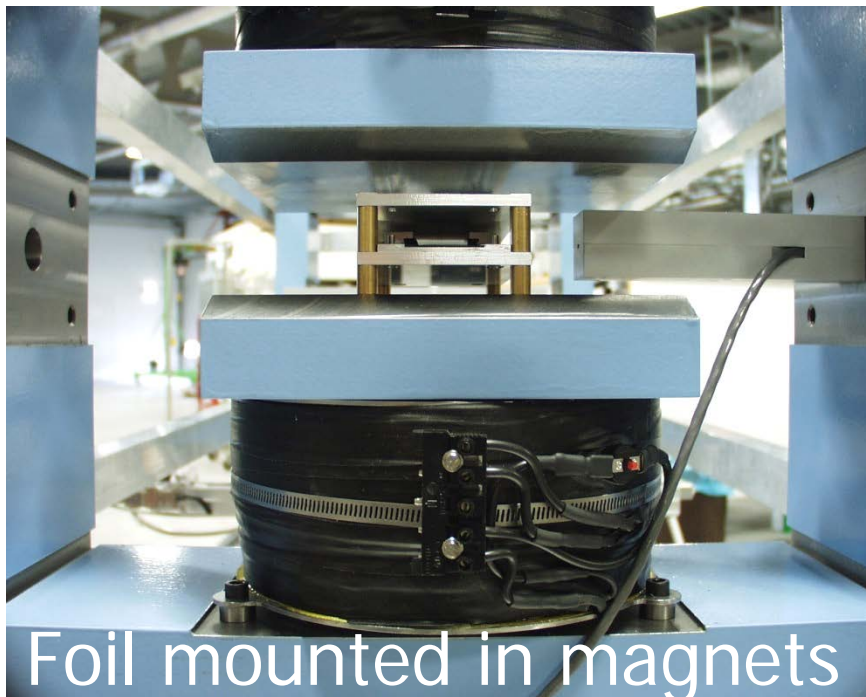
Use rectangular magnetic fields with magnetised foil as spin flipper to "reverse" the precession field



Rekveldt et al. (2005)  
Rev. Sci. Inst. **76**

# Magnetised foils strong labelling effect and well defined interface

3  $\mu\text{m}$  permalloy film



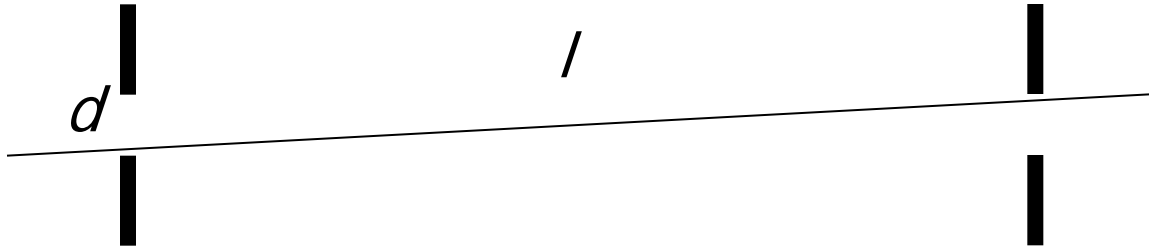
Foil mounted in magnets



Permalloy on Silicon wafer

# Why is Delft SESANS resolution higher than SANS?

SANS

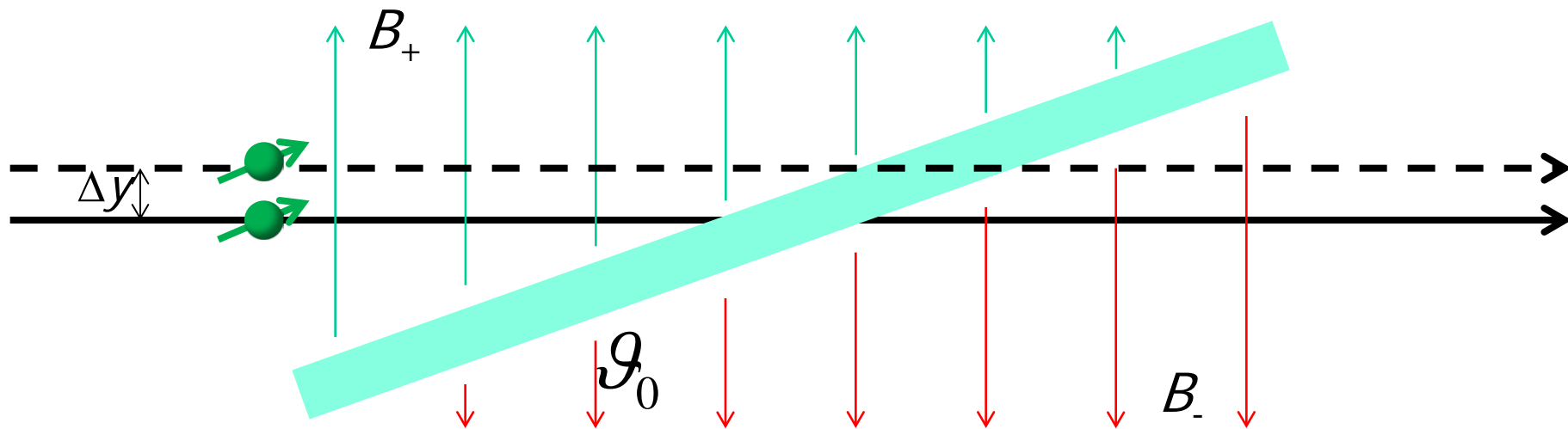


$$\delta\theta = d / l = 10\text{mm}/10\text{m} = 1\text{mrad}$$

$$\varphi = cL\lambda B \quad c = \frac{\gamma m}{h} \quad \Delta\varphi = c\Delta y \cot(\mathcal{G}_0)\lambda\Delta B$$

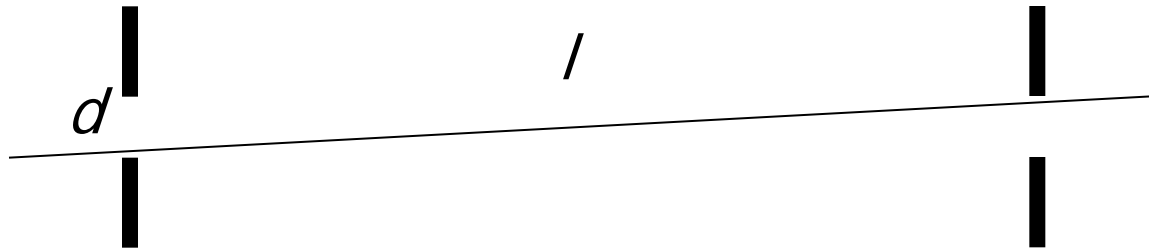
$$\Delta y = \frac{\Delta\varphi}{c \cot(\mathcal{G}_0)\lambda 2B} = \frac{1}{(5 \times 10^{14} \text{T}^{-1} \text{m}^{-2})(10)(2 \times 10^{-10} \text{m})(2 \times 0.2 \text{T})} \approx 3 \mu\text{m}$$

Effective slit width of foil flipper?



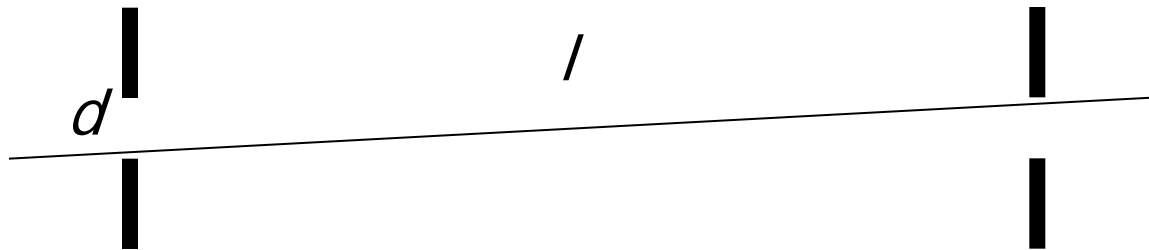
# Why is Delft SESANS resolution higher than SANS?

SANS



$$\delta\theta = d / l = 10\text{mm}/10\text{m} = 1\text{mrad}$$

SESANS



$$\delta\theta = d / l = 3\mu\text{m}/1\text{m} = 3\mu\text{rad}$$



# Realisation SESANS

monochromator  
polariser  
V-coil  
magnet 1

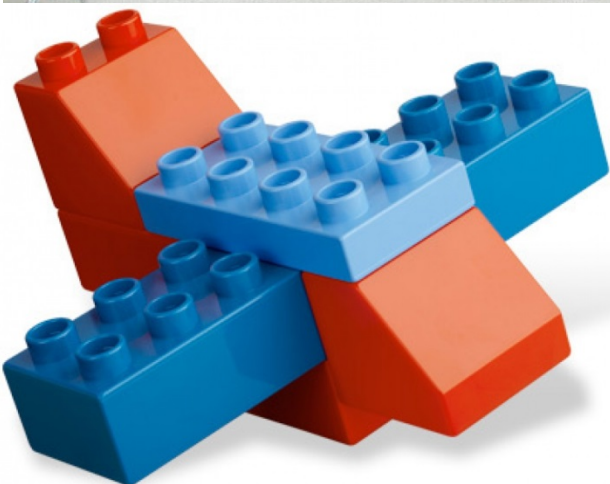
field stepper

guide field

V-coil

analyser

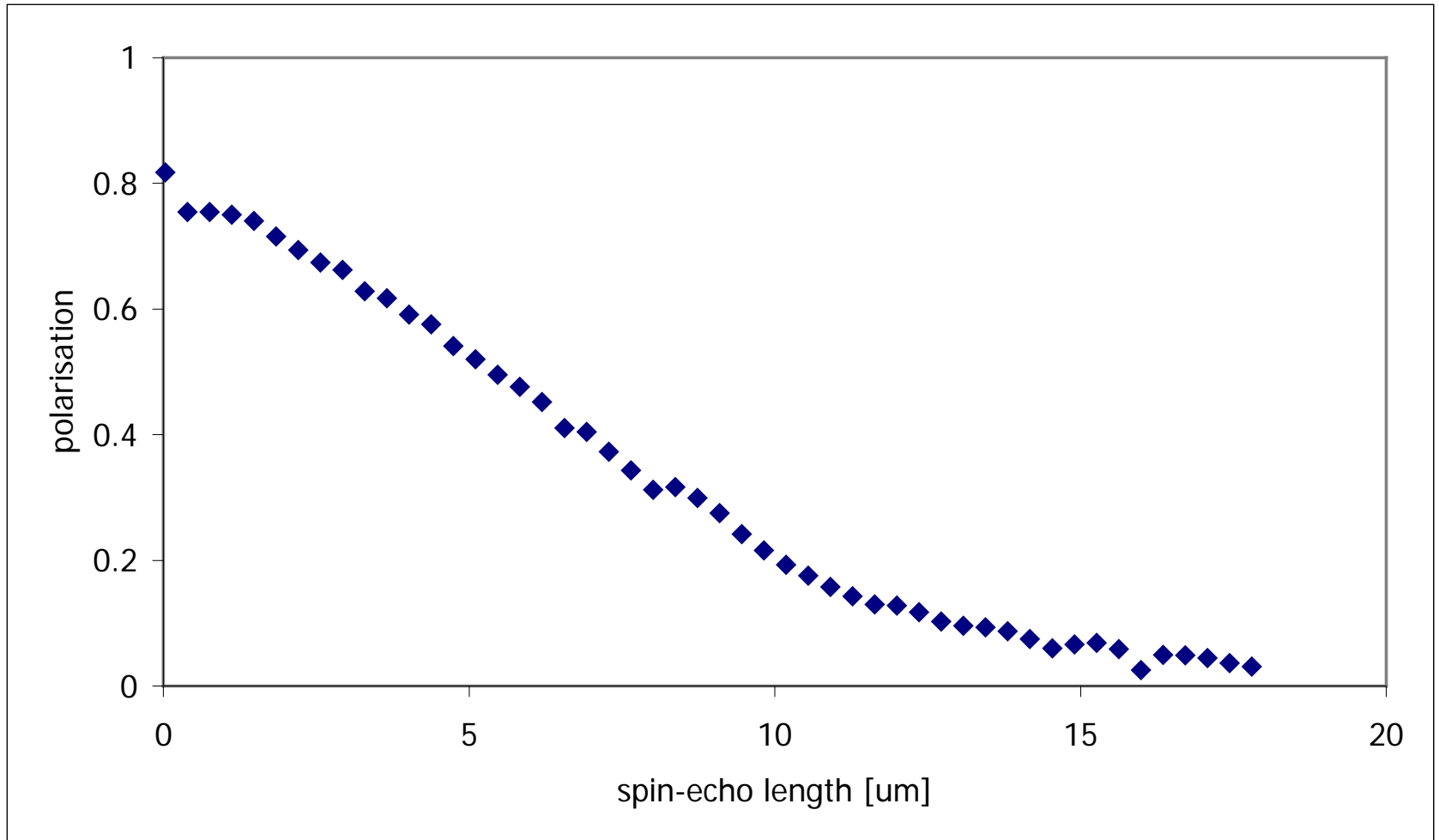
detector



## Technical details

- Graphite monochromator  $\lambda=0.21$  nm,  $\Delta\lambda/\lambda=0.01$  or  $0.05$
- Stacked bent supermirrors
- Controlled electromagnets 0.3 mT-0.18 T
- Beam cross section 18 mm x 8 mm
- 1000 or 5000 neutrons/s
- Spin-echo length 30 nm – 20  $\mu\text{m}$

# Length range



# User hostile software

## Cumbersome standard measurements

## Extreme flexibility

The screenshot displays a complex software interface for scan control, consisting of several overlapping windows and a dense array of controls. The main window, titled "Scan control", features a menu bar (File, Edit, Operate, Tools, Browse, Window, Help) and a toolbar. It is divided into several sections:

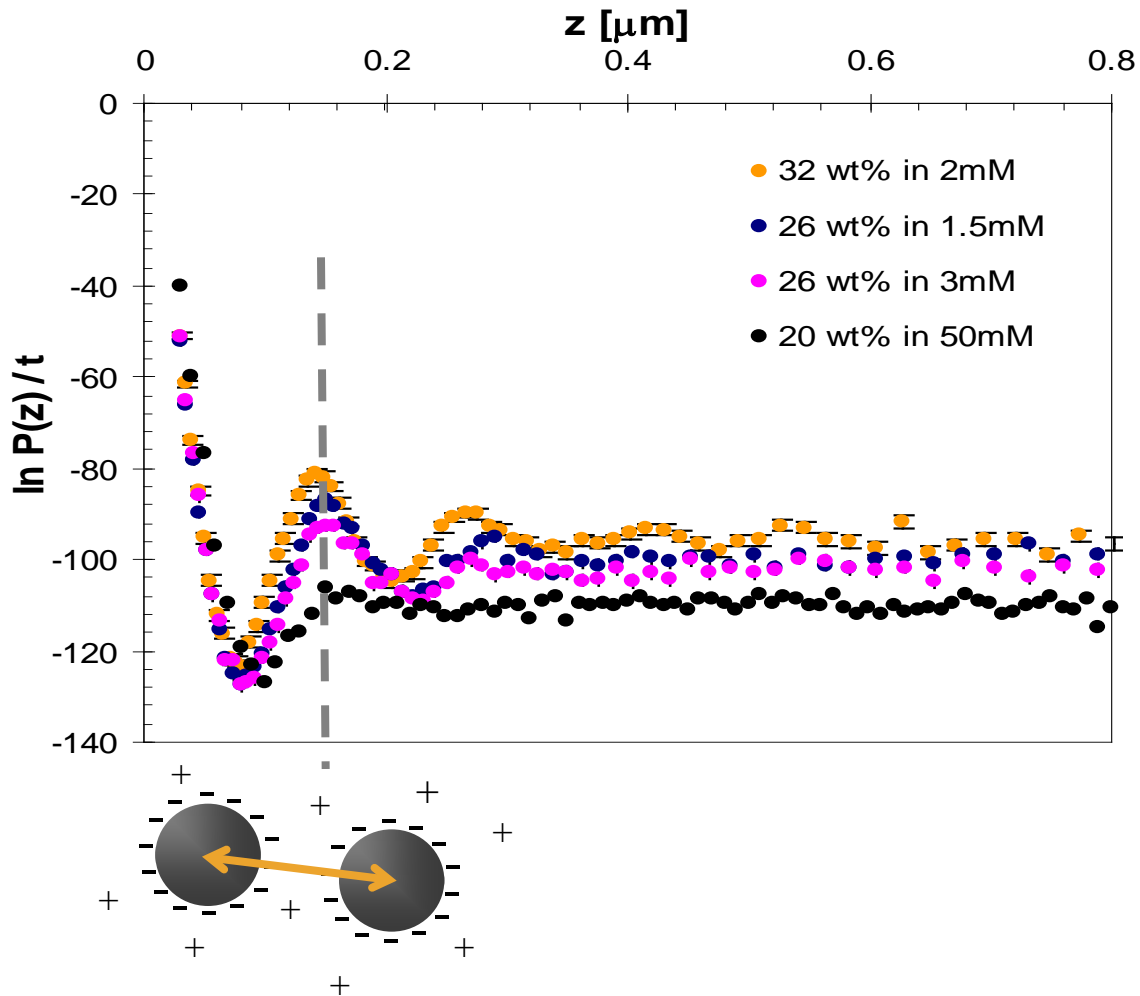
- Info and sample:** Displays user information (User: ap, User level: A.P., Machine name: PC-RND1) and measurement status (READY). It also shows the date/time (wo 17 apr 2002 14:50:16) and a list of machines on line (PC-RND1).
- Control:** Shows the current control status (ON) and user information.
- Sample changer:** A table with columns for Nr, Name, and Thickness (nm). The table is currently empty.
- Adjustments:** Includes sliders for Tilt angle (°) and Wavelength 1-4 (nm), all set to 0,00.
- Buttons:** Save, Load, and Empty buttons are located below the sample changer table.

Other windows include "Scan configuration" (with tabs for Initial values, Scan setup, Logging, DHM) and "Info and sample" (with tabs for Initial values, Scan setup, Logging, DHM). The interface is cluttered with numerous buttons, sliders, and text boxes, illustrating a user-hostile design. A bottom toolbar contains function keys F1 through F12, labeled with their respective functions: Main, Measurement info, Scan configuration, Scan control, Element manager, Info sample, Analog input, and F8-F12.

## Contents of this lecture

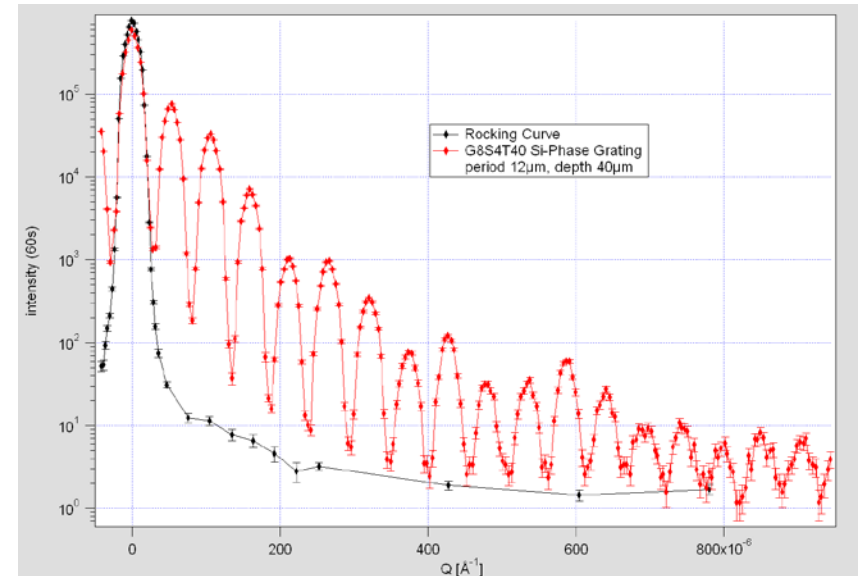
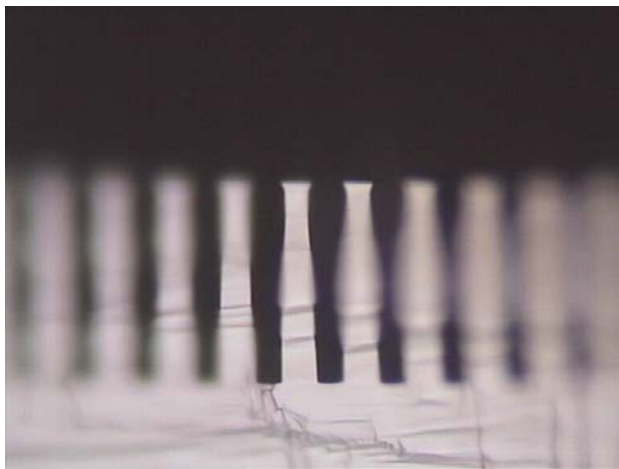
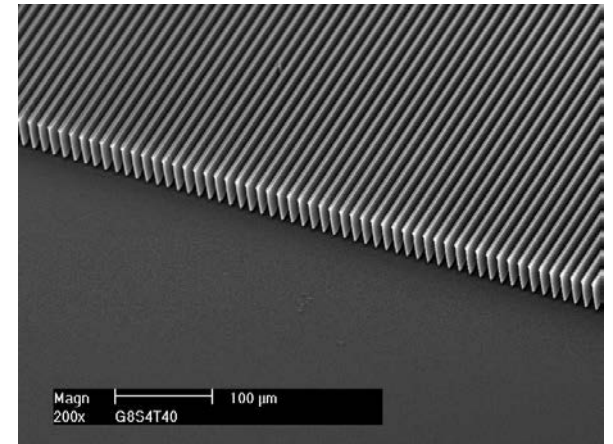
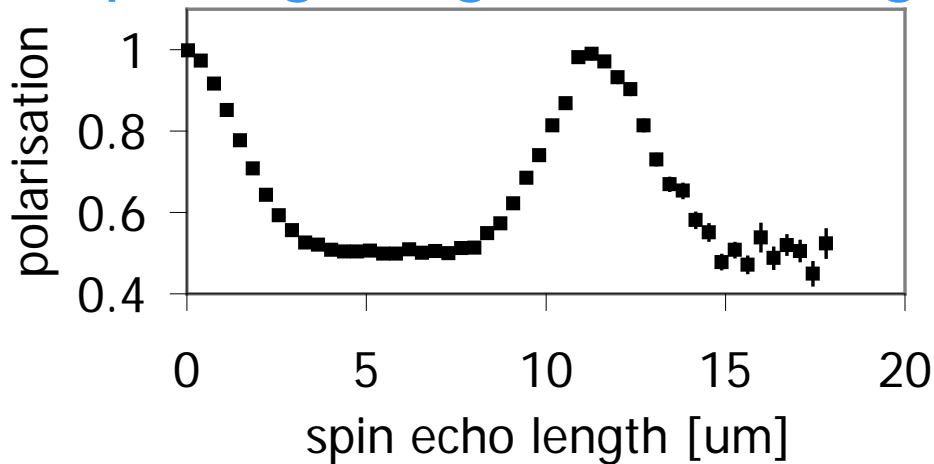
- Components and setup Delft SESANS
- **Some extreme measurements**
- SEMSANS
- Dissemination of SESANS technique

# Colloids 70 nm, tunable interactions



# SESANS on grating: Direct visual data analysis

## Spacing, ridge width, height



Trinker et al. NIMA **579** 1081 (2007)

## Contents of this lecture

- Components and setup Delft SESANS
- Some extreme measurements
- **SEMSANS**
- Dissemination of SESANS technique

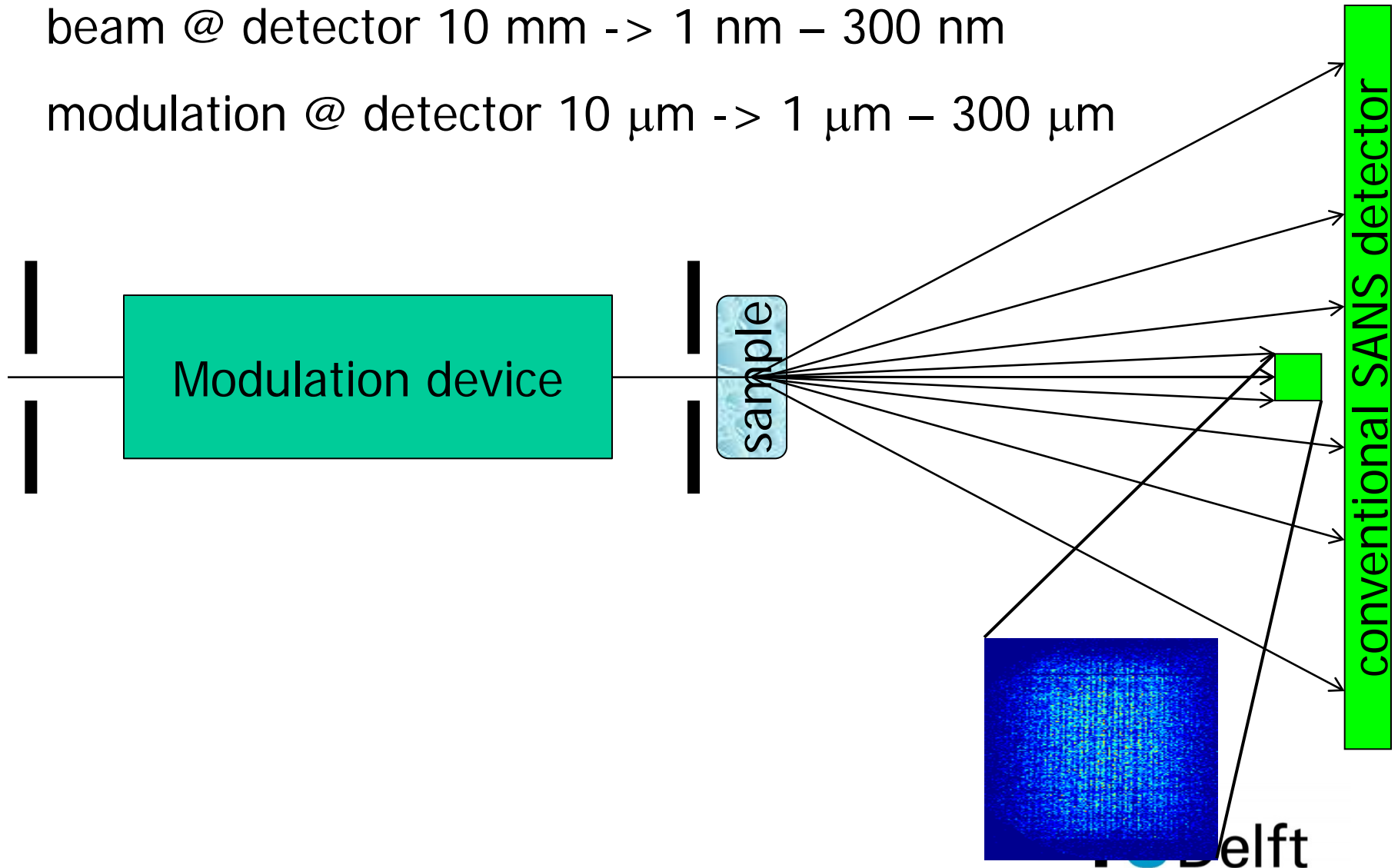


# SANS + SESANS with "green box"

Roland Gahler (2006)

beam @ detector 10 mm  $\rightarrow$  1 nm – 300 nm

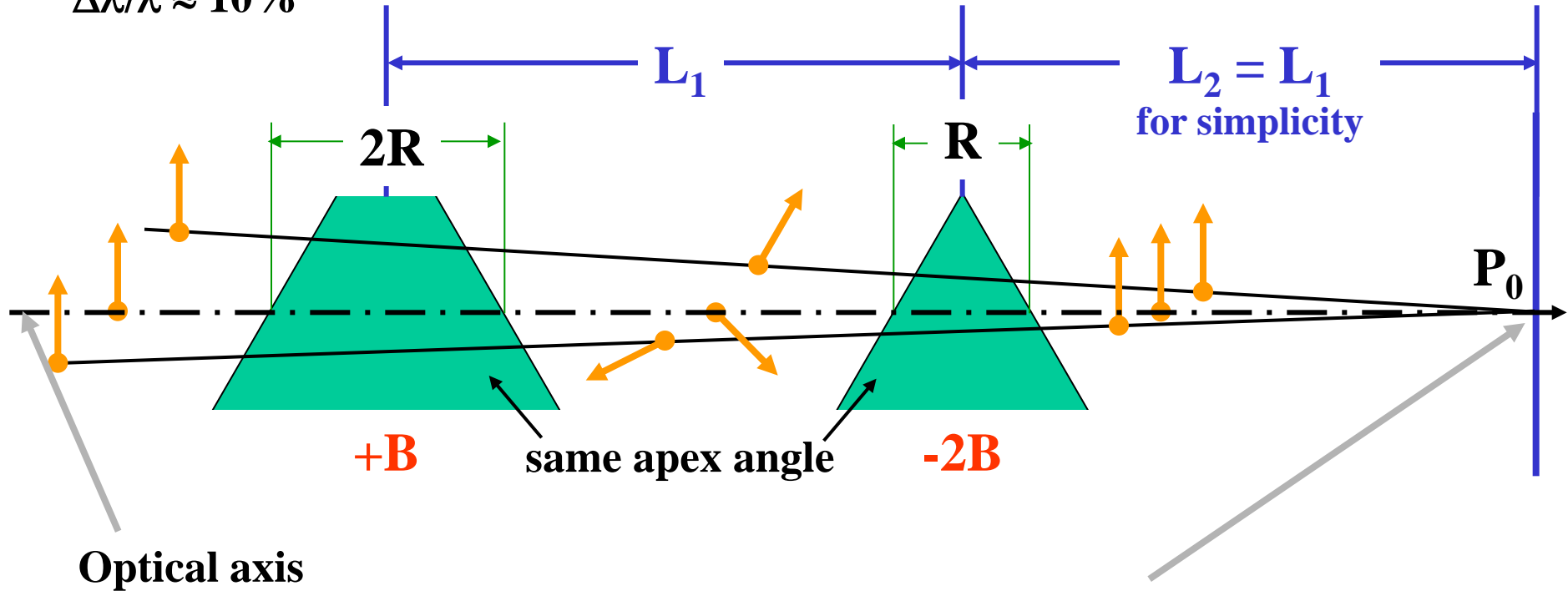
modulation @ detector 10  $\mu\text{m}$   $\rightarrow$  1  $\mu\text{m}$  – 300  $\mu\text{m}$



# IX The 'green box' for beam modulation in space:

Input: Polarized  
divergent beam

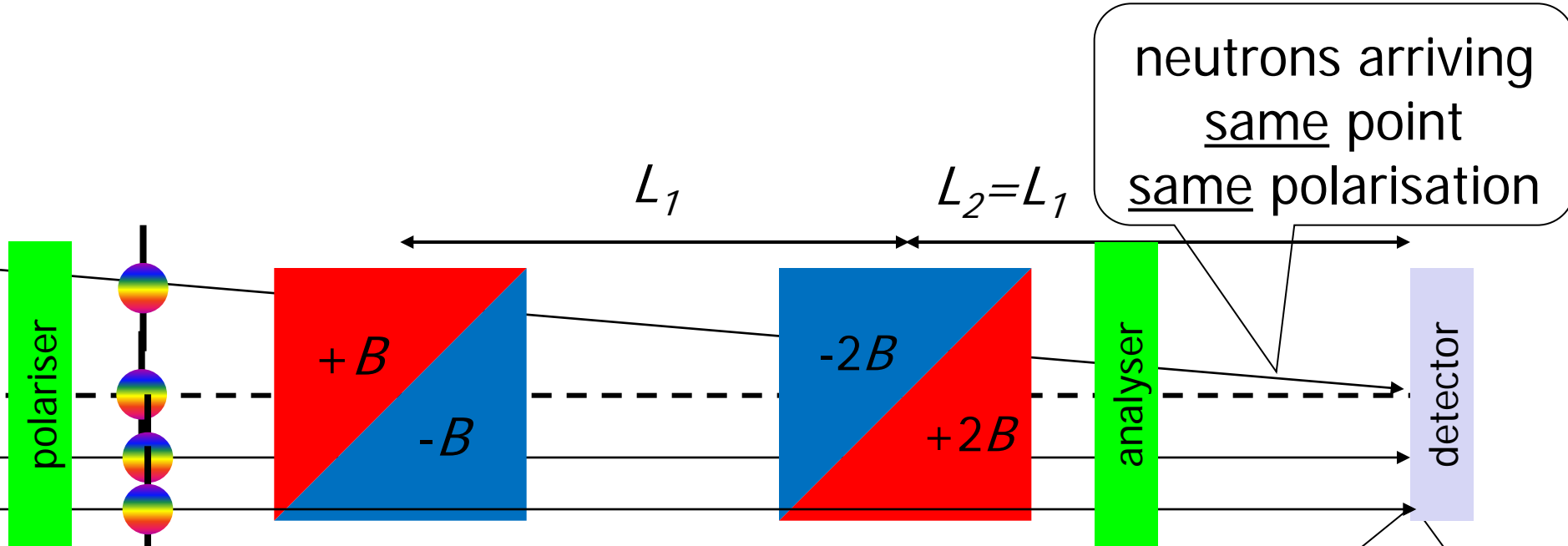
$$\Delta\lambda/\lambda \approx 10\%$$



All neutrons arriving at this point  $P_0$   
have the same polarization

# Beam modulation by Larmor precession

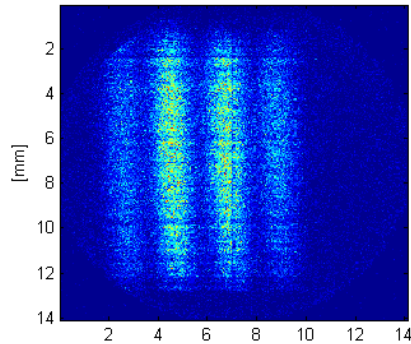
## Even for large divergent beam



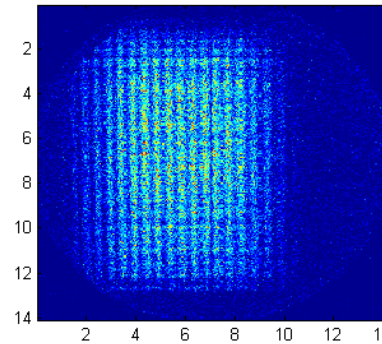
intensity  $(1 + \cos(z))$

# Monochromatic modulation with increasing fields

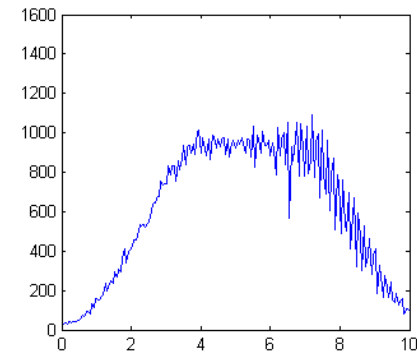
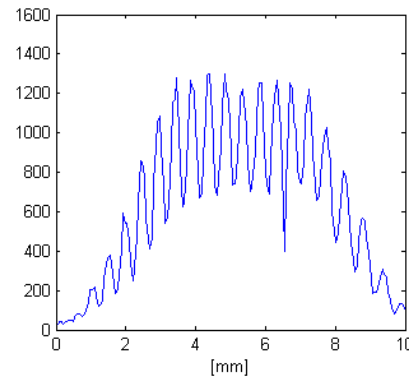
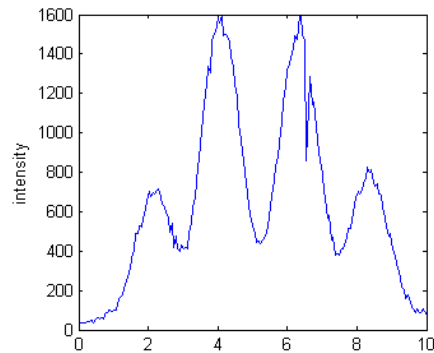
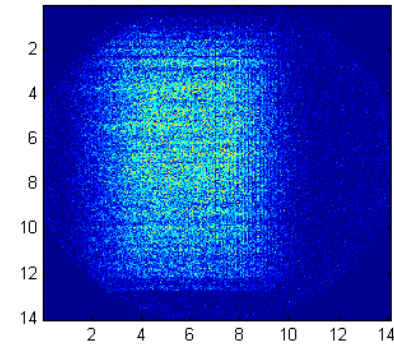
1-1.7 mT  
2 mm



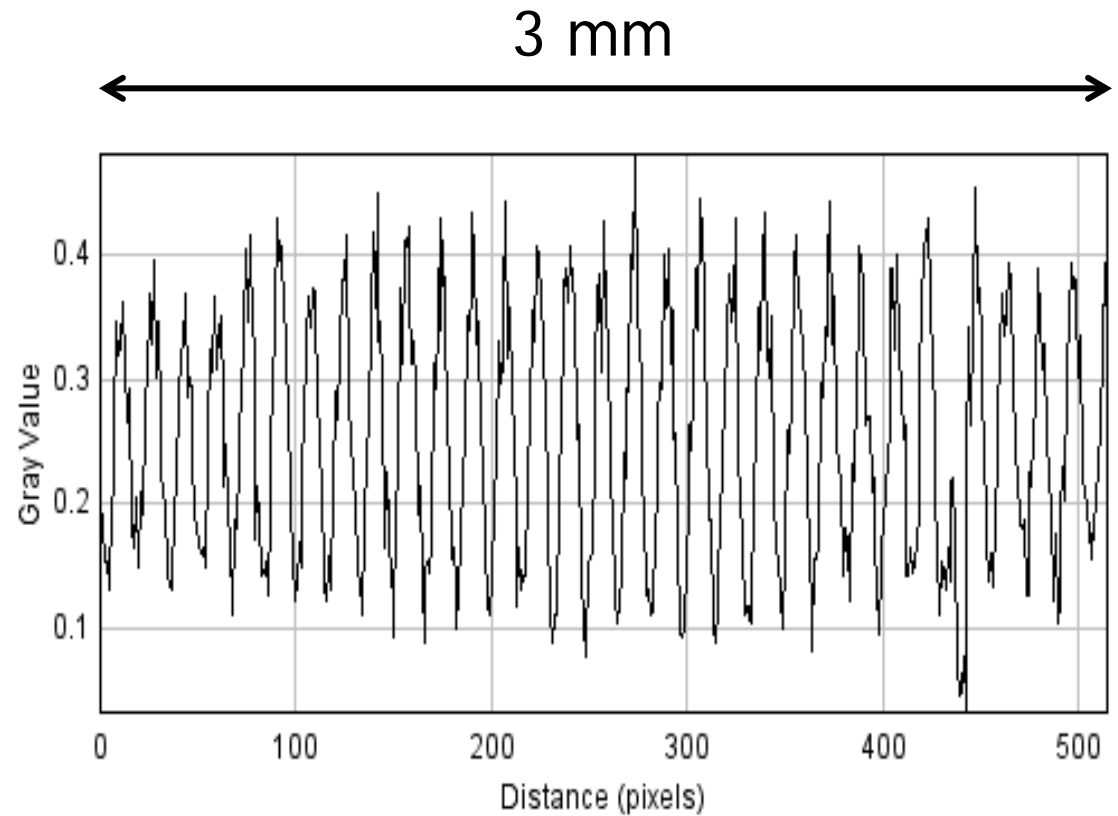
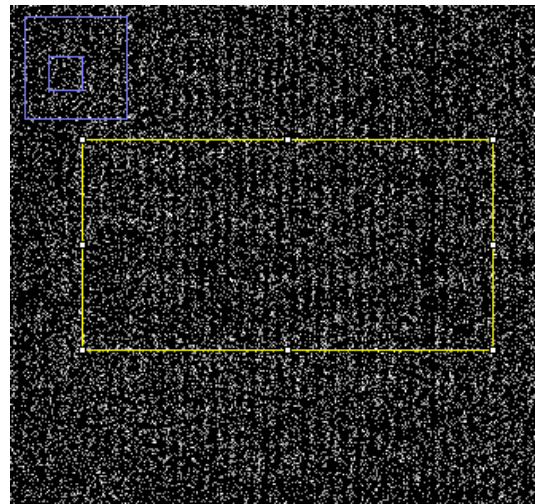
4.4-7.9 mT  
0.5 mm



16-26 mT  
0.13 mm

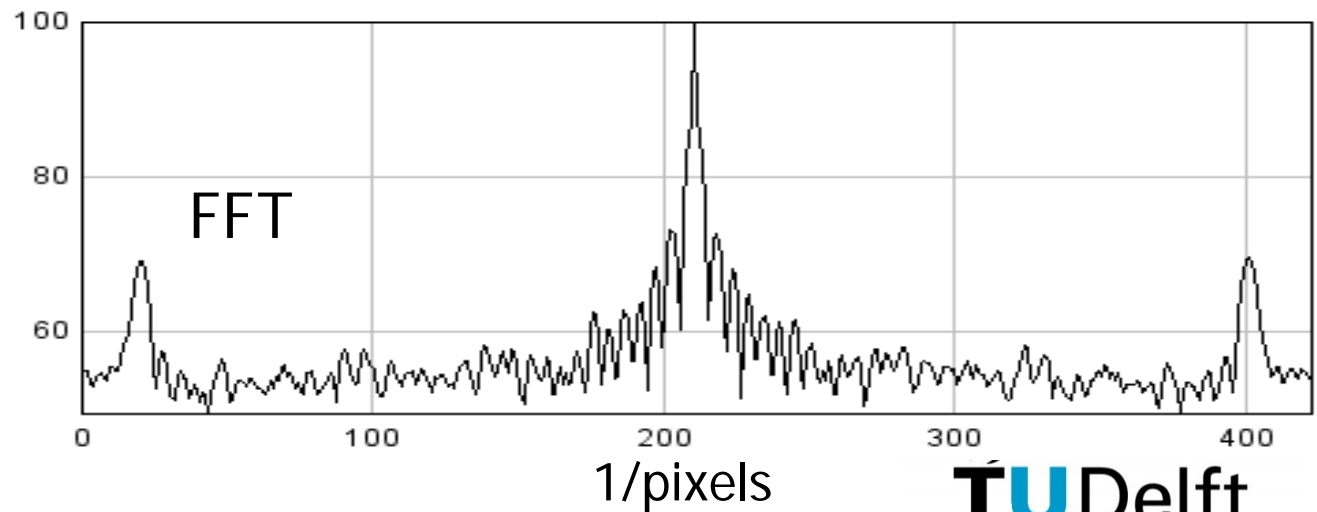
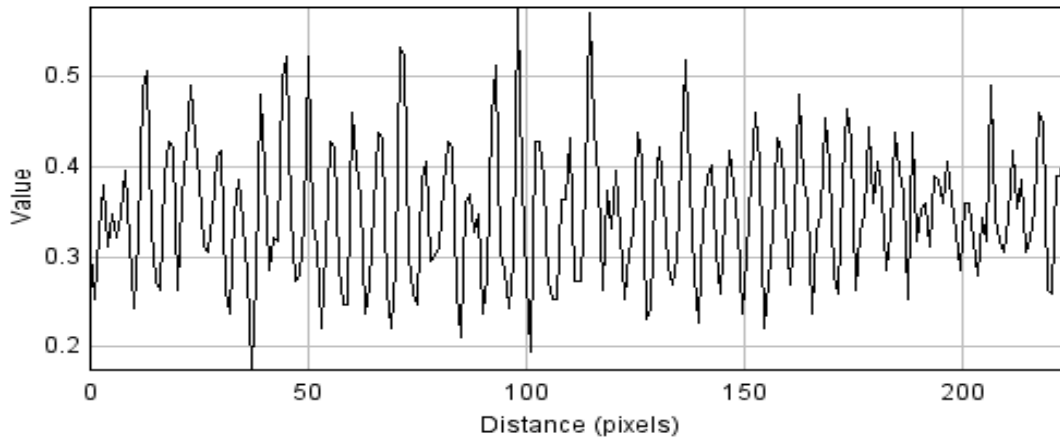


~100  $\mu\text{m}$  modulation period (20-34 mT)



~35  $\mu\text{m}$  modulation period (60-103 mT)

1.4 mm



## Contents of this lecture

- Components and setup Delft SESANS
- Some extreme measurements
- SEMSANS
- **Dissemination of SESANS technique**

# Peter Falus: Dissemination SESANS?

- SESANS comparable USANS (~ 10 times more efficient in counts)\*
- Microscopy, SAXS with focussing lenses same length scales
- Data-analysis methods
  - Use of SANS software
  - Combining other length scales

\*Rehm et al. J. Appl. Cryst. **64** 354 (2013)

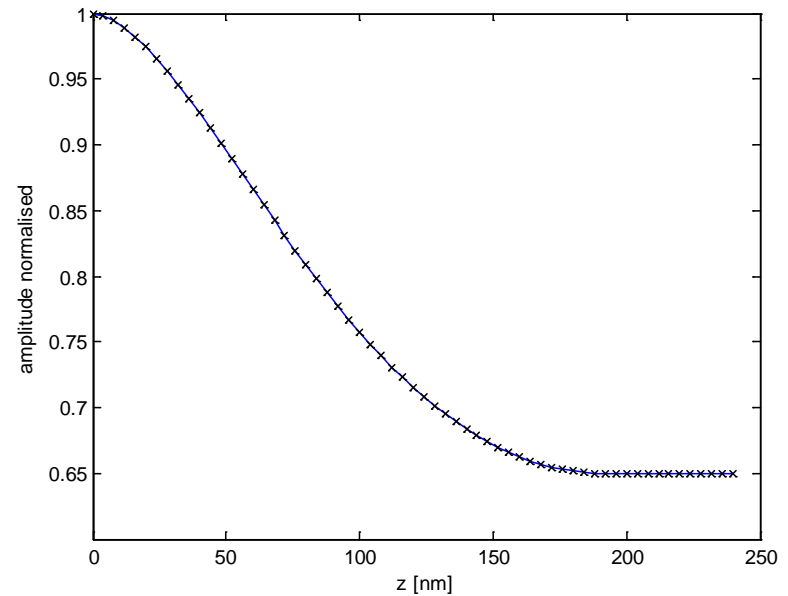
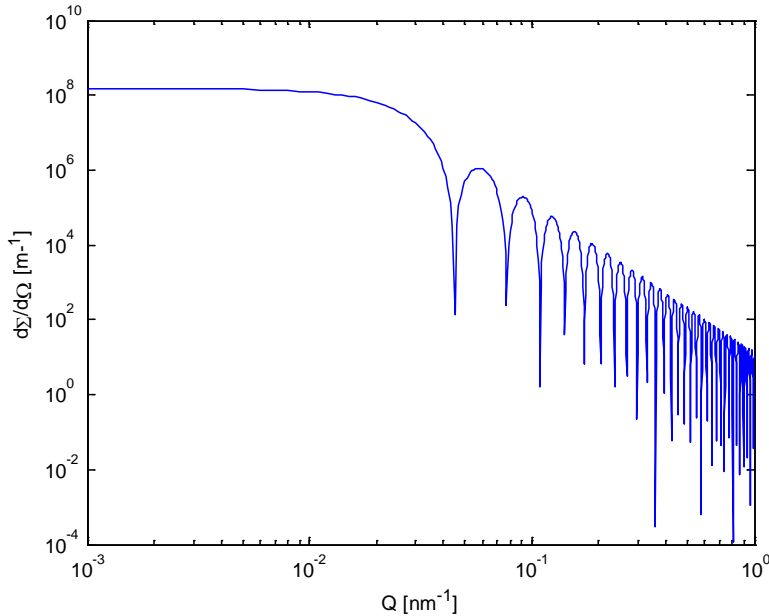


## Science case Delft

- Colloids 50 nm – 2  $\mu\text{m}$
- Fine powders 50 nm - 10  $\mu\text{m}$
- Protein gels 50 – 2  $\mu\text{m}$
- Fat emulsions 0.3 – 15  $\mu\text{m}$
- Cellulose dispersions 30 nm - 10  $\mu\text{m}$
- Liposomes 50 nm - 3  $\mu\text{m}$
- Oil water emulsions 30 – 500 nm
- Porous materials 30 nm - 20  $\mu\text{m}$

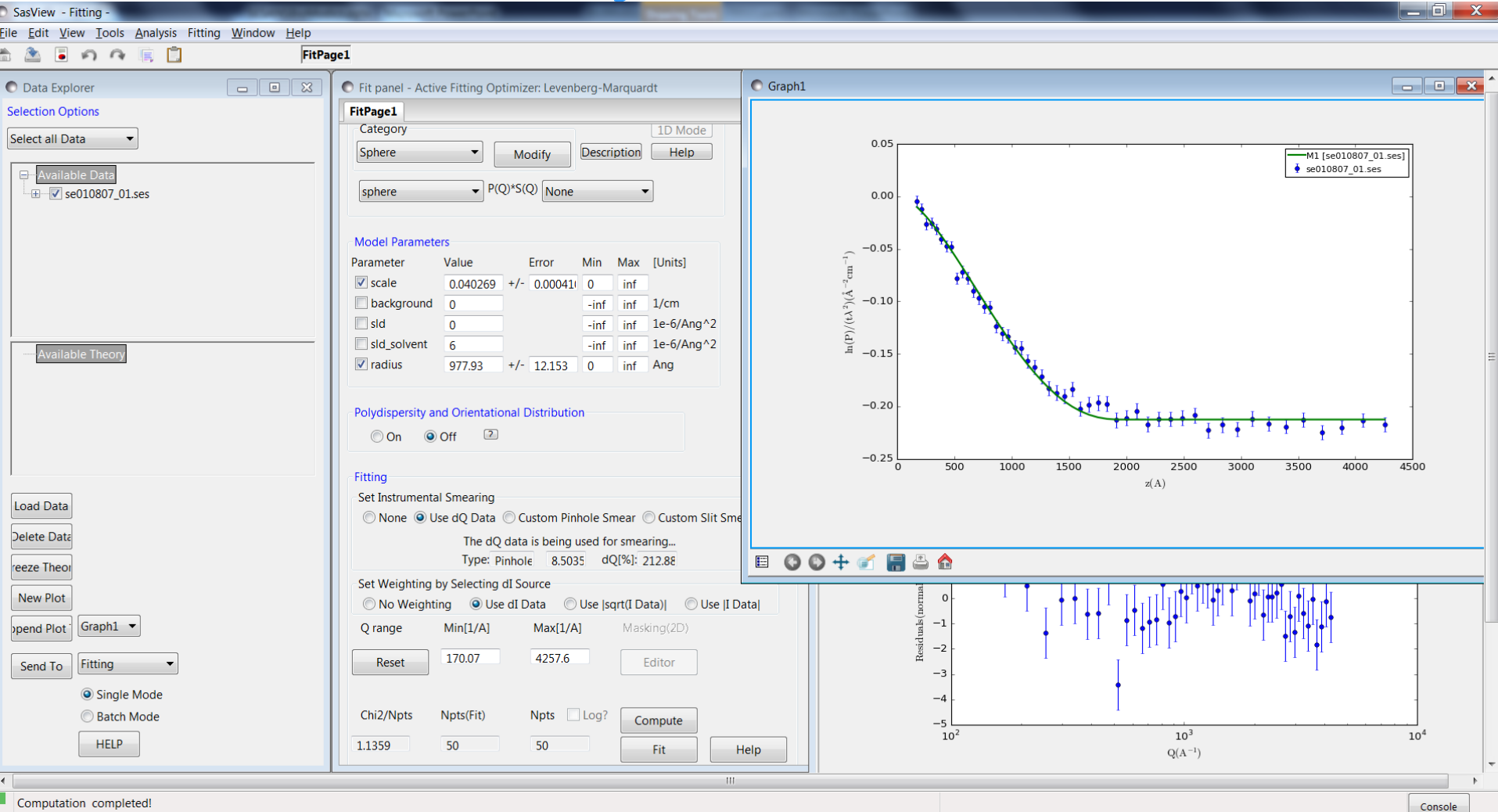
# User-friendly software for dissemination

## Data-analysis: SANS into SESANS conversion



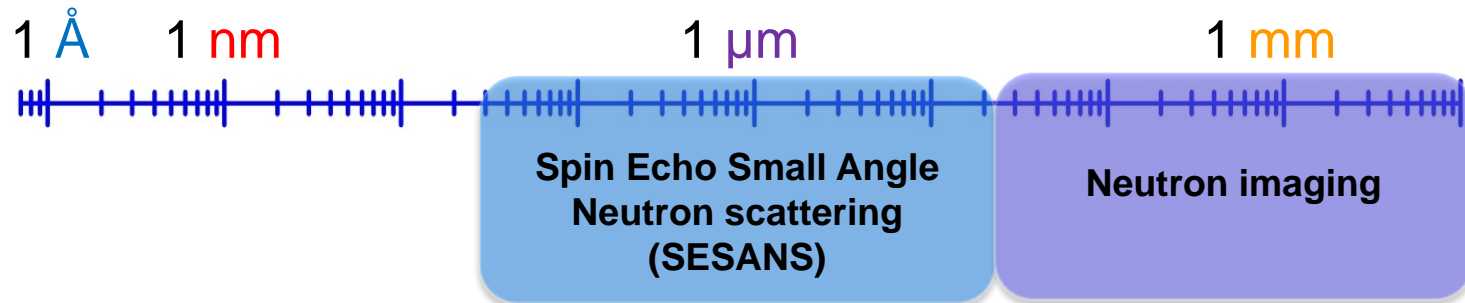
$$\tilde{G}(z) = \int_0^{\infty} J_0(Qz) \frac{d\Sigma}{d\Omega}(Q) Q dQ \quad P(z) = e^{\frac{t\lambda^2}{2\pi}(\tilde{G}(z) - \tilde{G}(0))}$$

# Data analysis with SasView 4.1 and Sasfit by Joachim Kohlbrecher

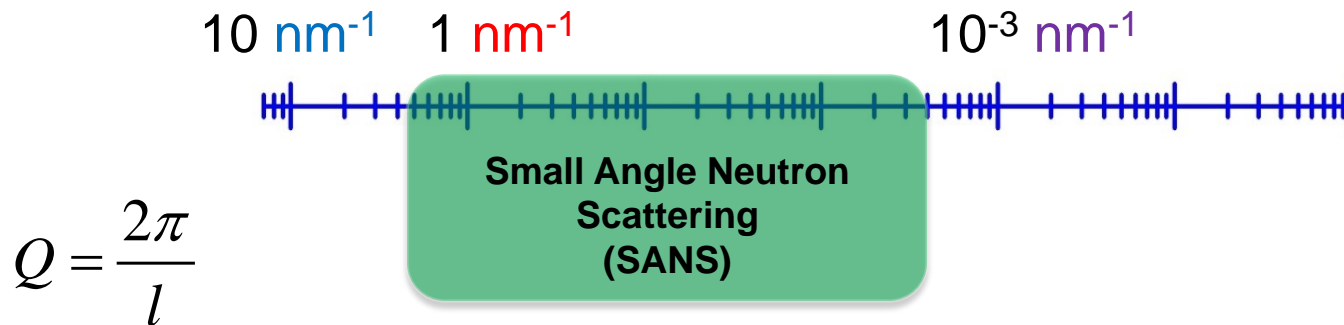


# Combined analysis

## □ Size range (real space)



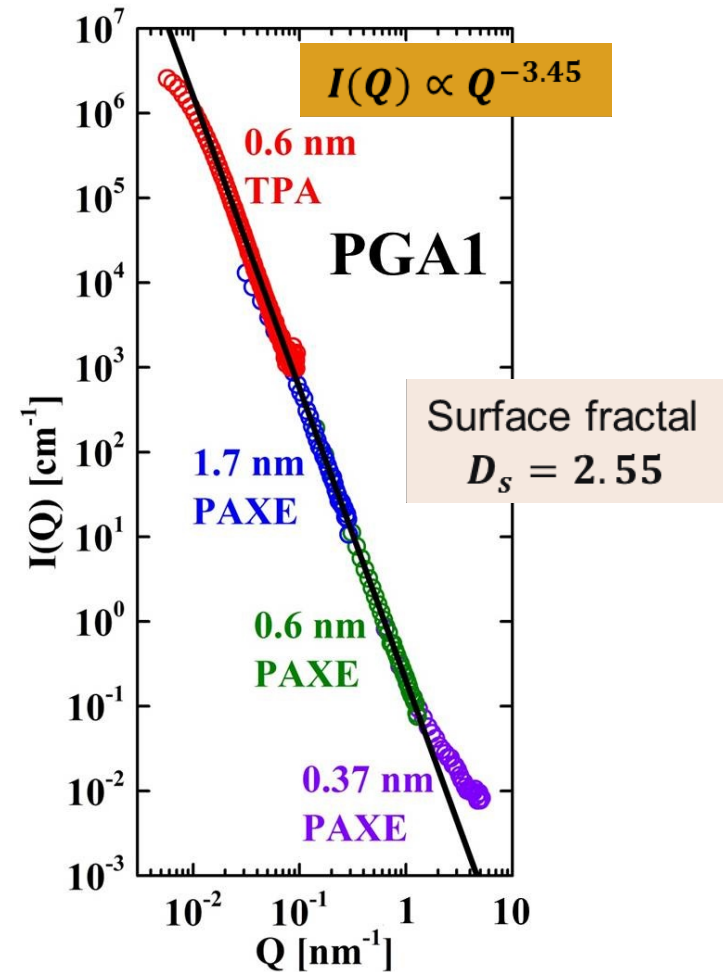
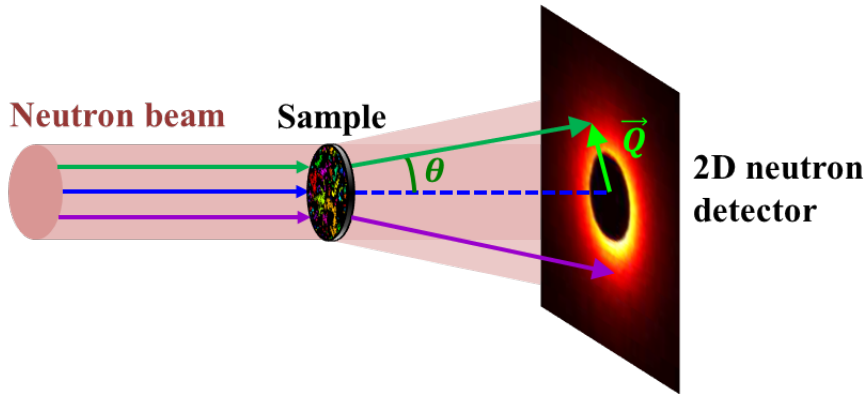
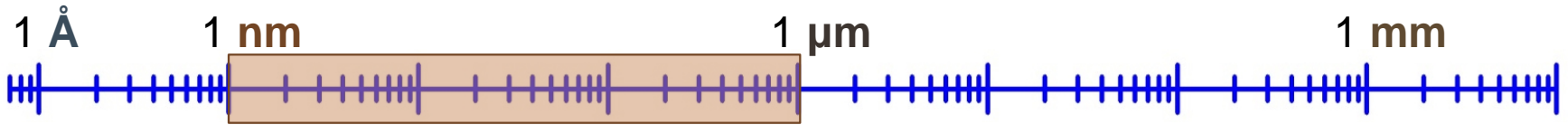
## □ Q range (reciprocal space)



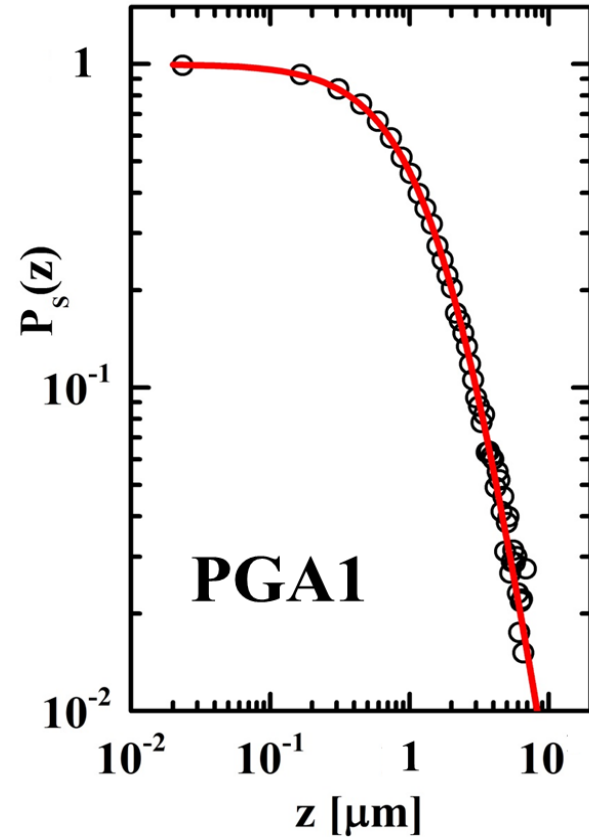
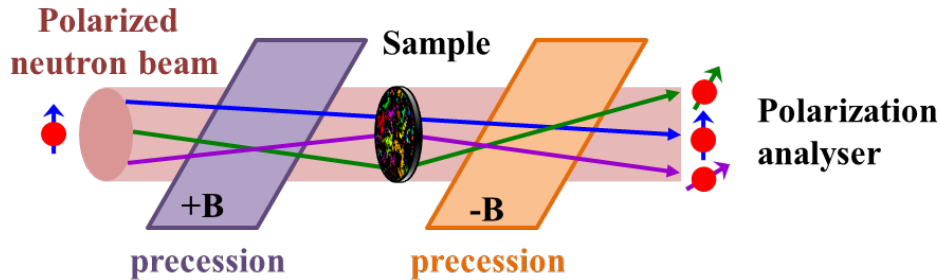
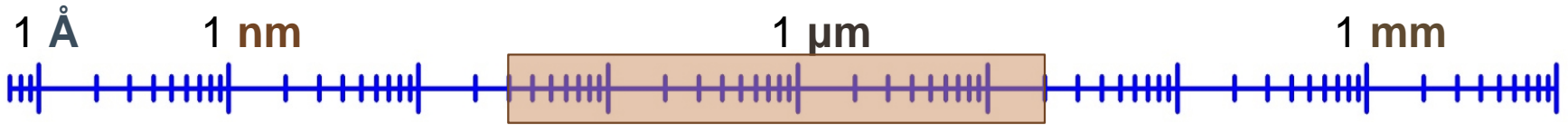
PGA graphite sample



# Mesososcopic scale - SANS

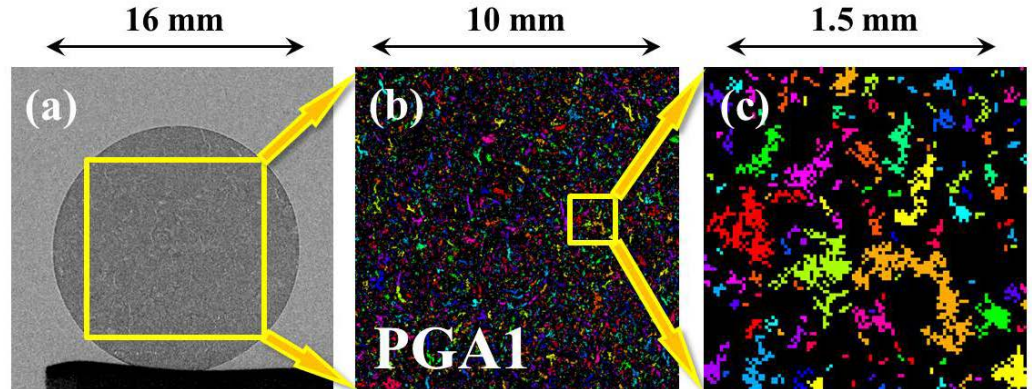
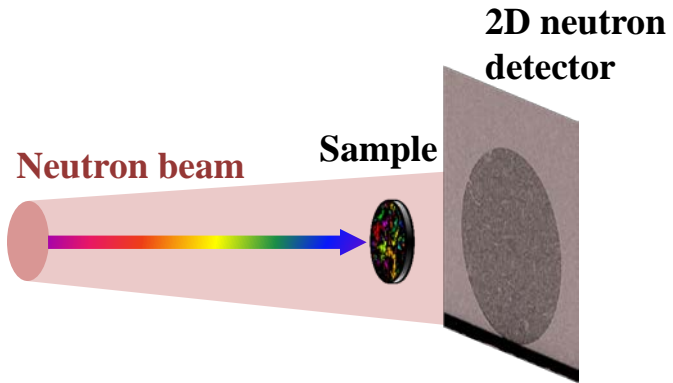


# Mesososcopic scale - SESANS



- ✓ Structural in-homogeneities extend beyond 10 μm.

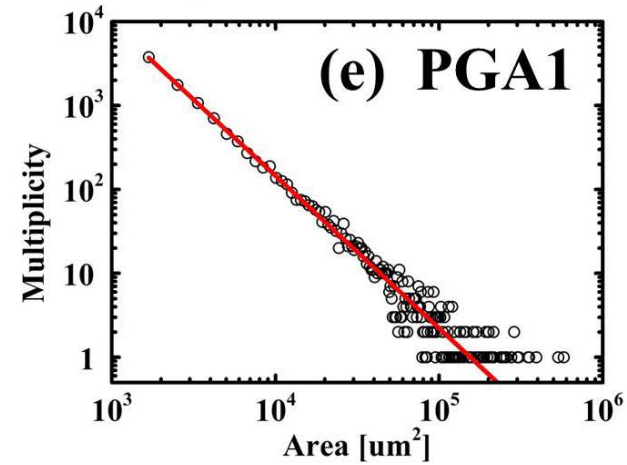
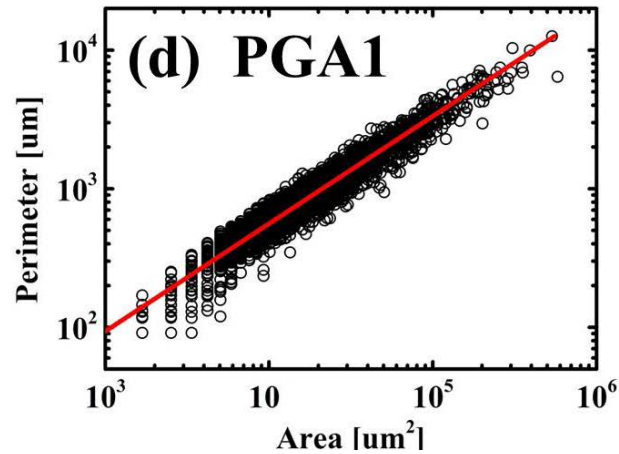
# Neutron imaging



Perimeter-Area relationship  
*M. Beech, et al. 1991*

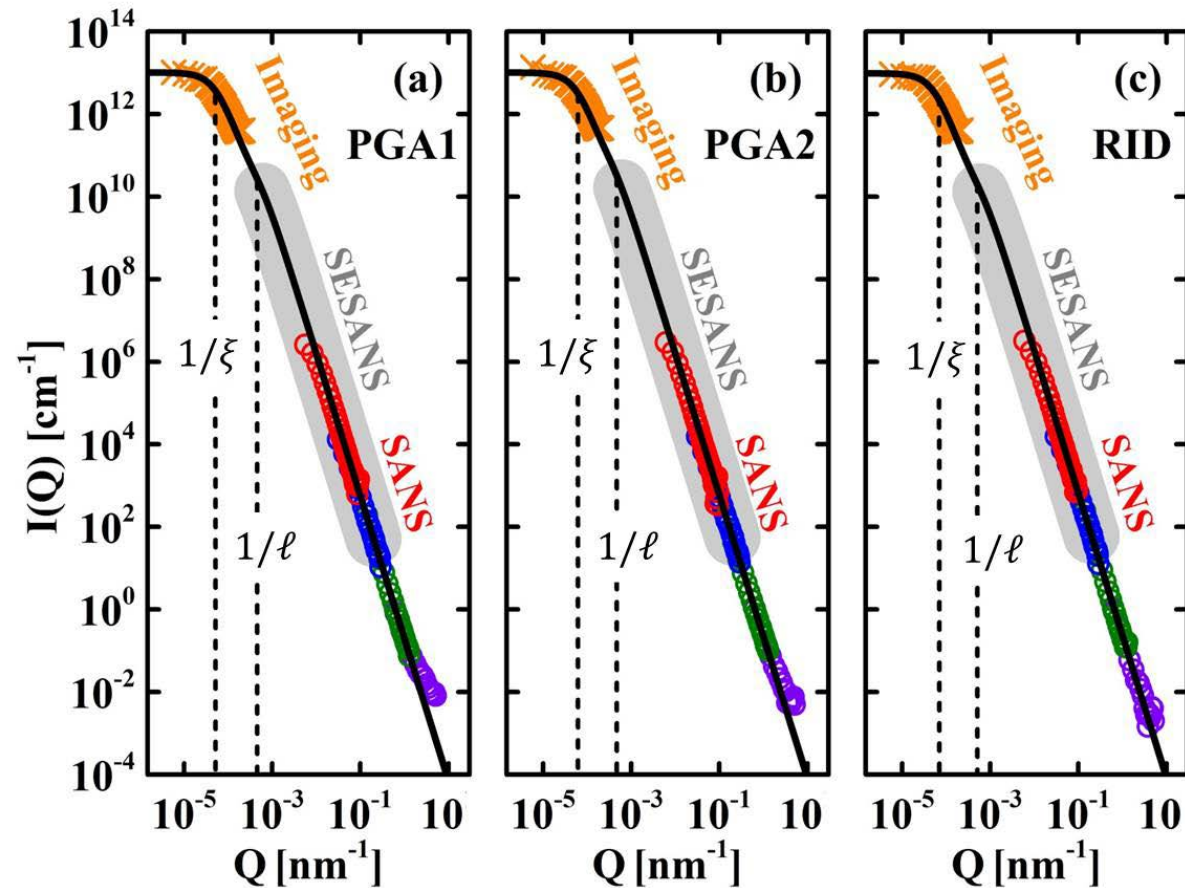
$$P \propto A^{(D_s-1)/2}$$

$$\Rightarrow D_s = 2.54$$



# Data interpretation → Fractal model

$$I(Q) = \mathcal{B} \cdot P(Q, D_s, \ell) \cdot S(Q, D_m, \ell, \xi)$$



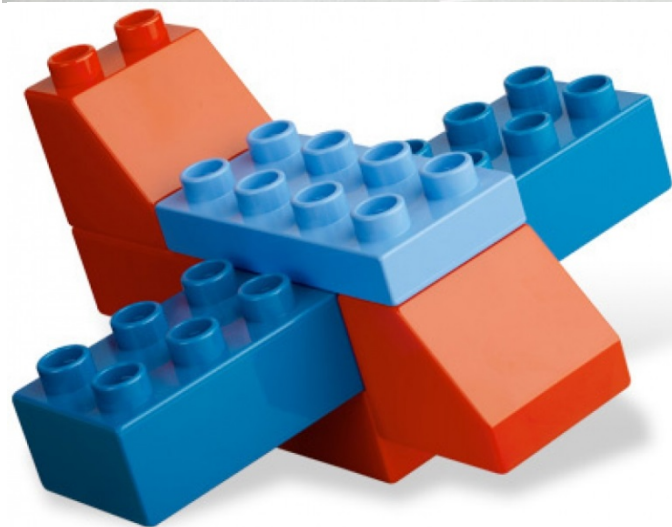
pre-factor  $\mathcal{B}$  from SANS fit



## SESANS instruments, outdated list when I made it ;-(

place	name	method	mono/ TOF	dedi- cated	max $\delta$ [ $\mu\text{m}$ ]
Berlin	FLEX	bootstrap	M	no	0.7
Delft	SESANS	$\pi$ -flip foils	M	yes	20
<del>Delft</del>	<del>WESP</del>	<del>RF-flippers</del>	<del>TOF</del>	<del>no</del>	<del>+</del>
ILL	EVA	bootstrap	M	refl	
FRM II	MIRA	bootstrap	M	no	1
FRM II	N-REX <sup>+</sup>	BS + $\Delta$	M	refl	
LENS	SESANS	triangle		yes	1
SNS		triangle	TOF	refl	> 0.1
ISIS	OFFSPEC	RF-flippers	TOF	refl	15
PNPI	SESANS	RF-flippers	M	yes	
ISIS	LARMOR	RF-flippers	TOF	no	10-20

# SESANS in Delft, dedicated, solid and flexible



Wim Bouwman  
Theo Rekveldt  
Jeroen Plomp  
and many others