Delft
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PNCMI-2010

Larmor labeling: History and Development

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Contents

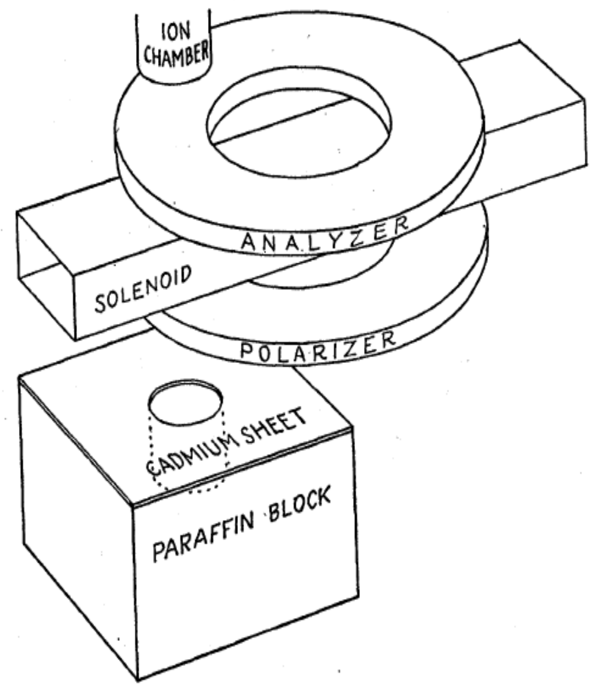
1. Introduction

O.R. Frisch, H. von Halban, Jr and Jorgen Koch,
Phys. Rev.**53**, (1938) 719-726

Some Experiments on the Magnetic Properties of Free Neutrons

O. R. FRISCH, H. VON HALBAN, JR.,* AND JØRGEN KOCH
Institute of Theoretical Physics, University, Copenhagen

(Received February 5, 1938)



|P|~0.01

μ_n affected by B not H

Alvarez 1940

resonance method
μ_n=1.93+-0.02

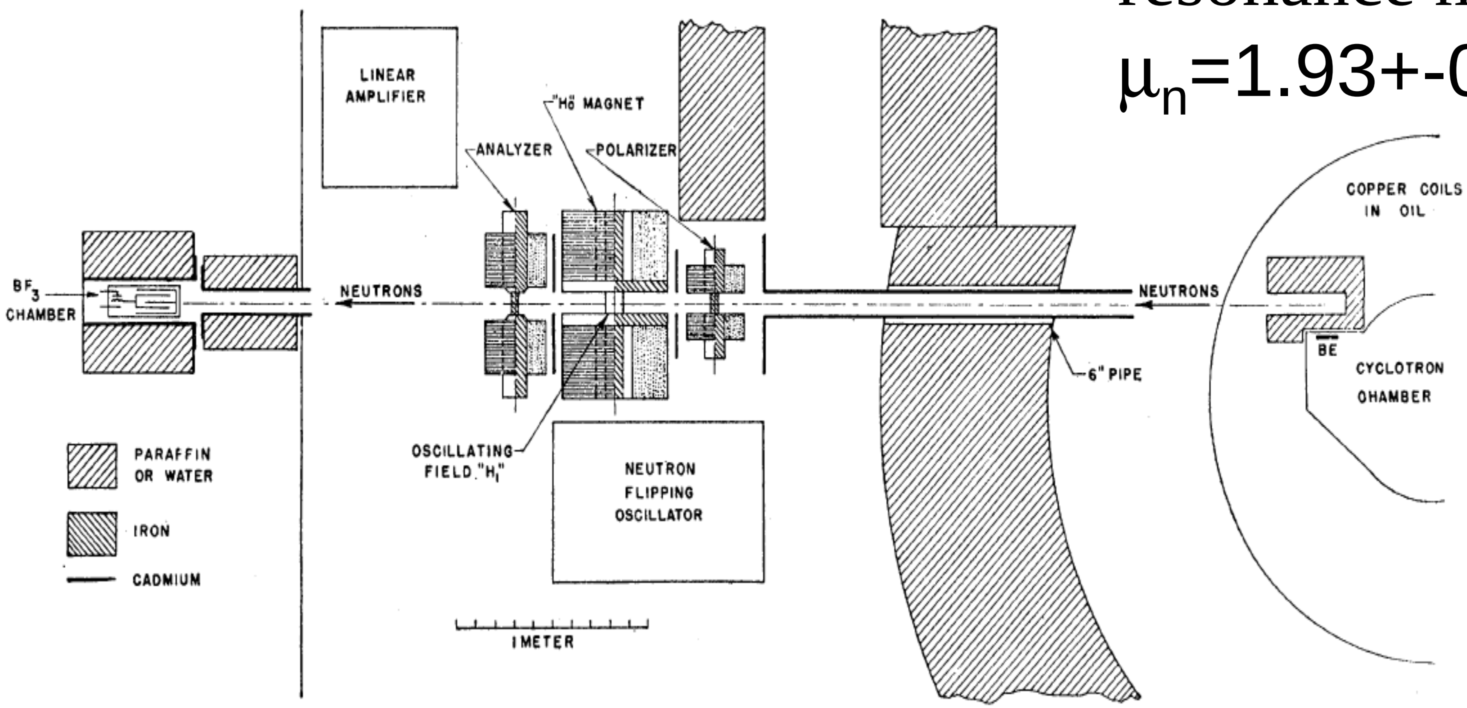


FIG. 3. Plan of the apparatus. Section taken 85 cm above floor of cyclotron room.

- O. Halpern, T. Holstein, Phys. Rev.B, Condensed Matter, **59** (1941) 960.

  Using Larmor precession

  in derivation Depol. formulae

- E.L. Hahn-Phys. Rev. L. **76** (1949) 145

  Spin-echo in NMR:

- G.M. Drabkin, E.I. Zabidarov, Ya.A. Kasman, A.I. Okorokov and V.A. Trunov, Sov. Phys. JETP **20** (1965) 1548.
- H. Rauch, Z. Physik **197** (1966) 197.
- M.Th. Rekveldt, J. de Physique, **32** (1971) C579.

Depolarization in different directions.

Drabkin 1969

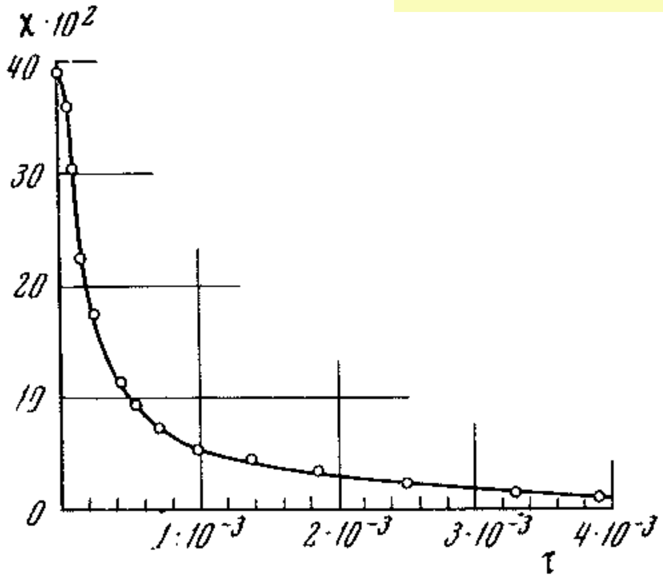


FIG. 7. The temperature dependence of the susceptibility for a single crystal of nickel [$\tau = (T - T_C)/T_C$].

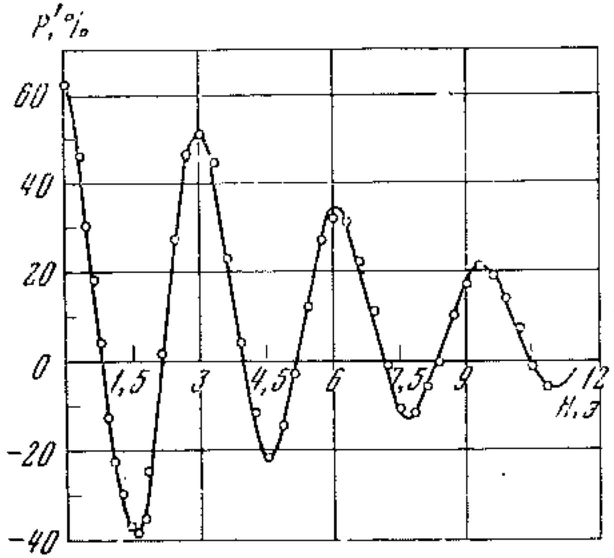
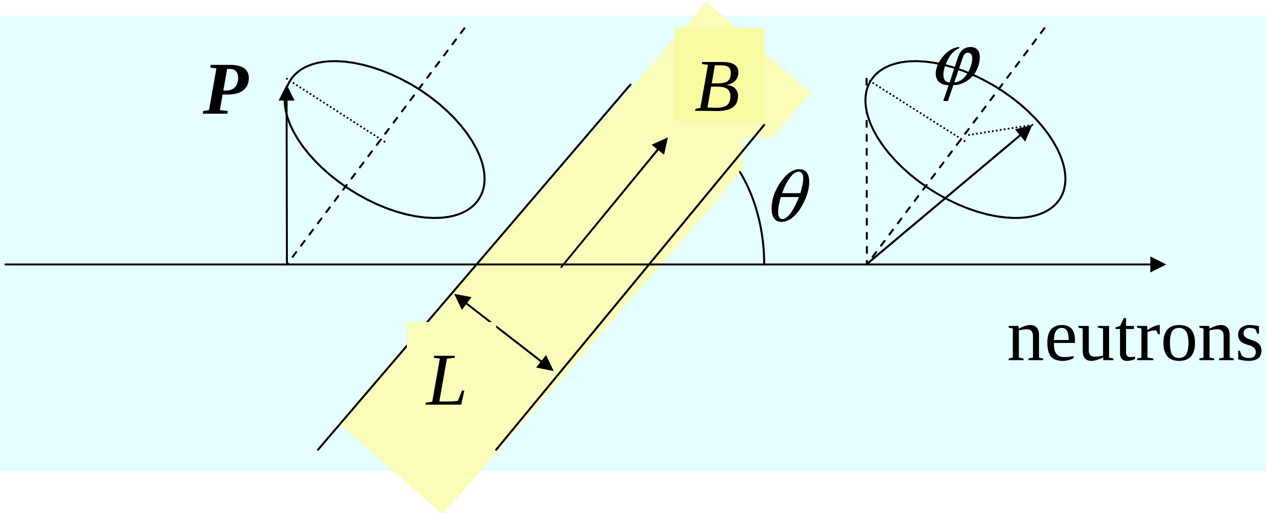


FIG. 8. Rotation of the polarization vector in the sample with the field **H** perpendicular to $\mathbf{P}_0$.

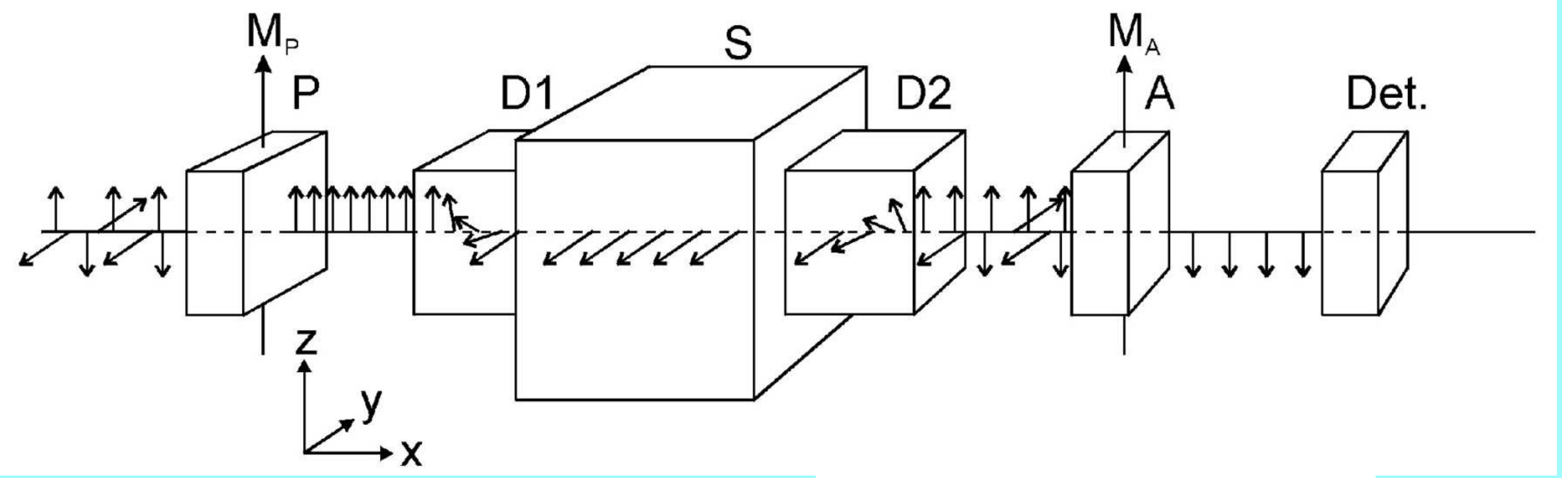
Precession and labeling



$$\varphi = \omega t \equiv \frac{\gamma B L m}{h} \frac{\lambda}{\sin(\theta)}$$

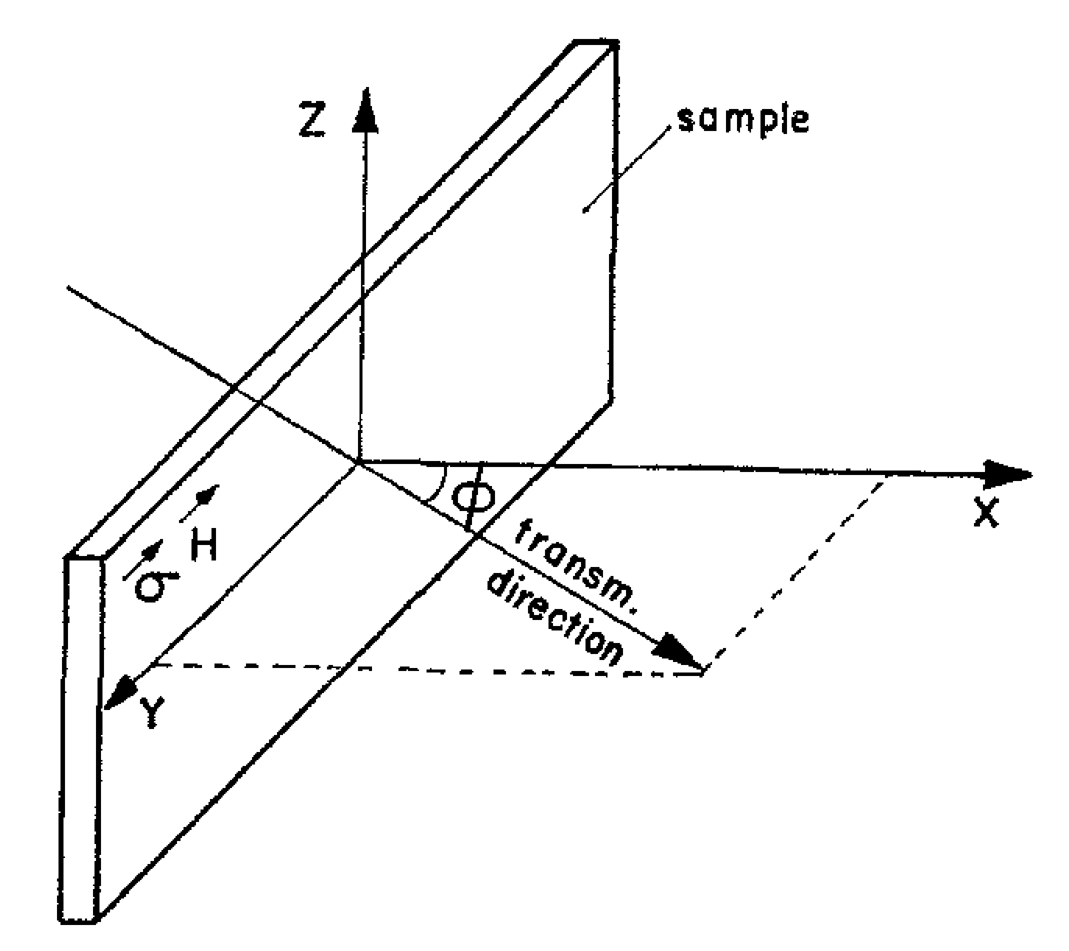
2. Magnetic field labeling and depolarization

Rekveldt 1971



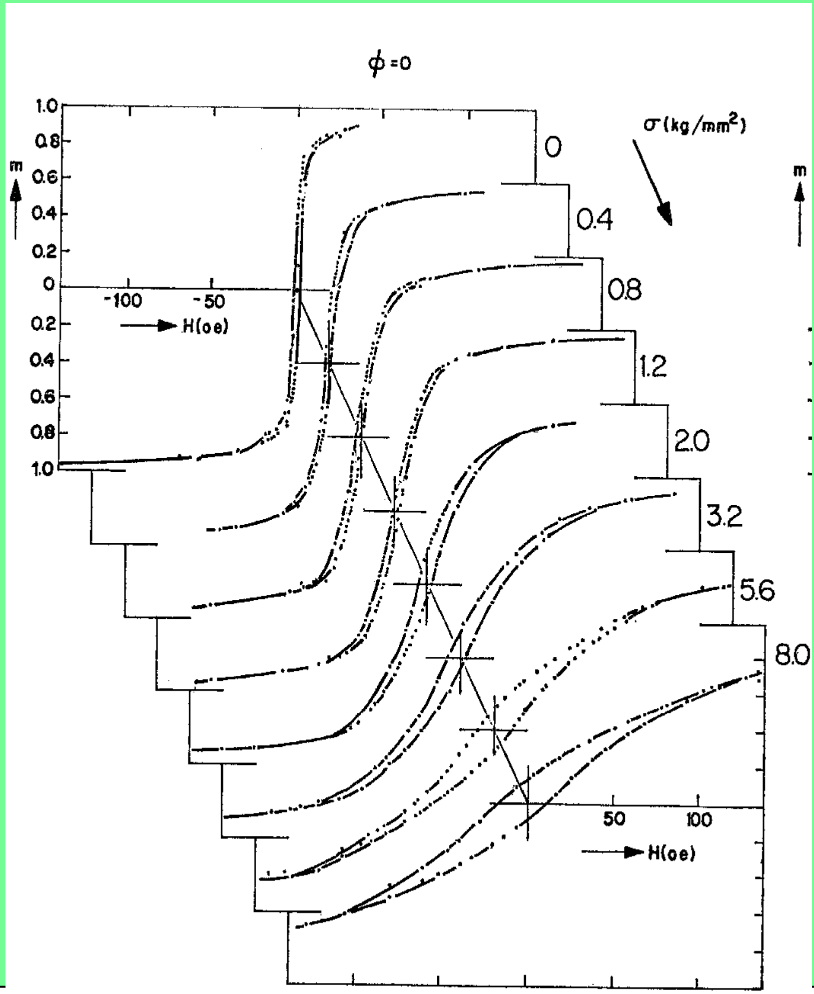
$$D_{ij} = \frac{I_s - I_{ij}}{I_s}$$

Experiments Ni-foil under stress

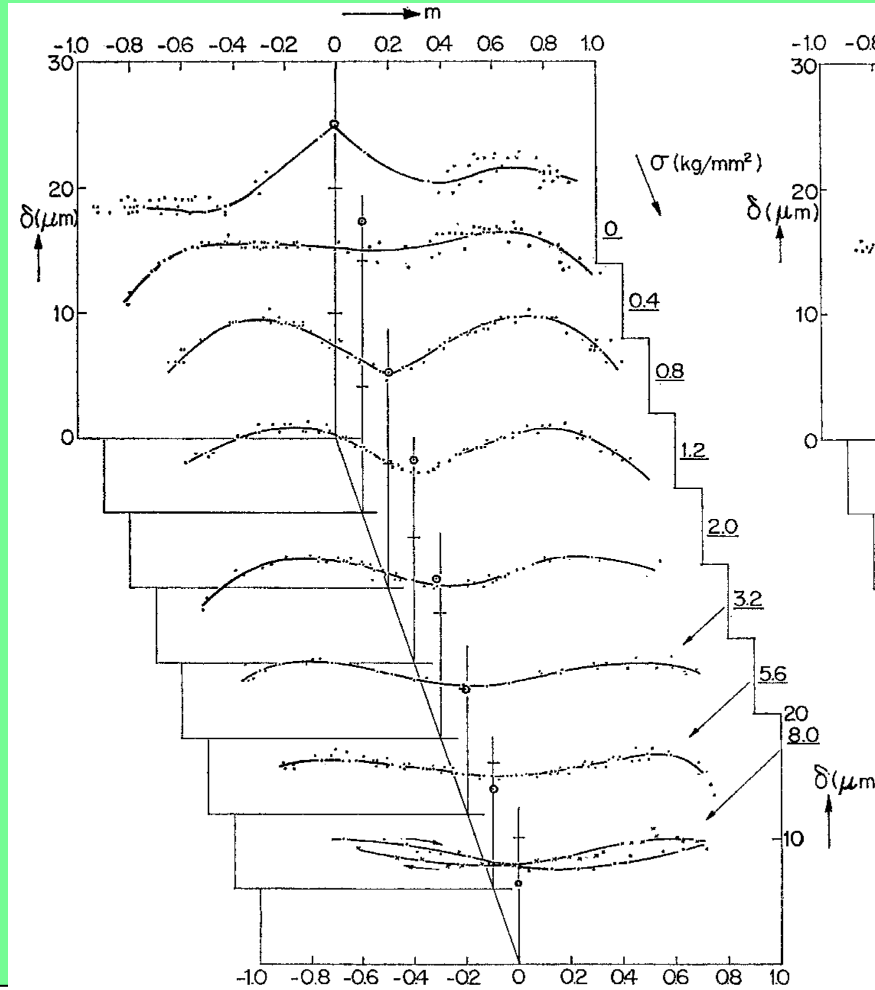


Results Ni-foil under varying stress.

Magnetization

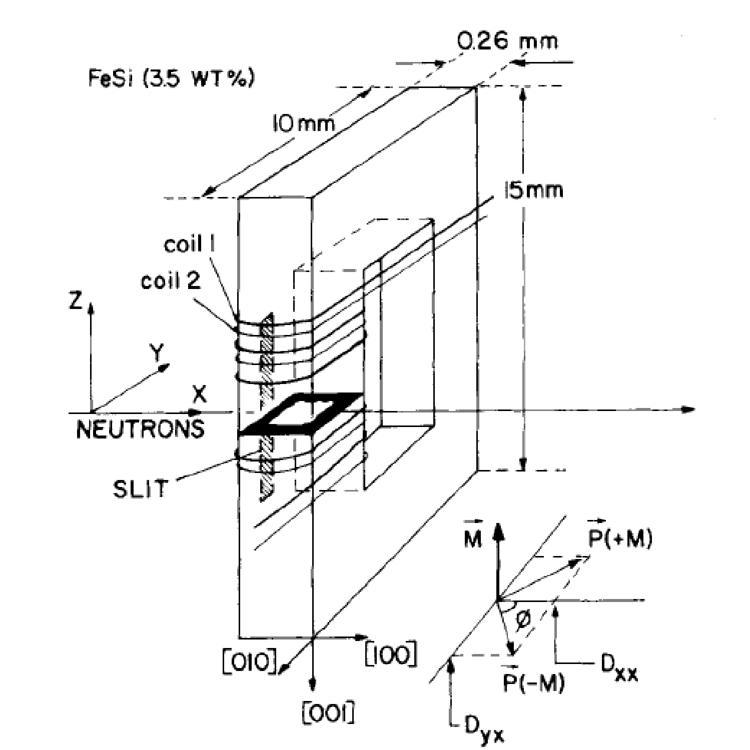


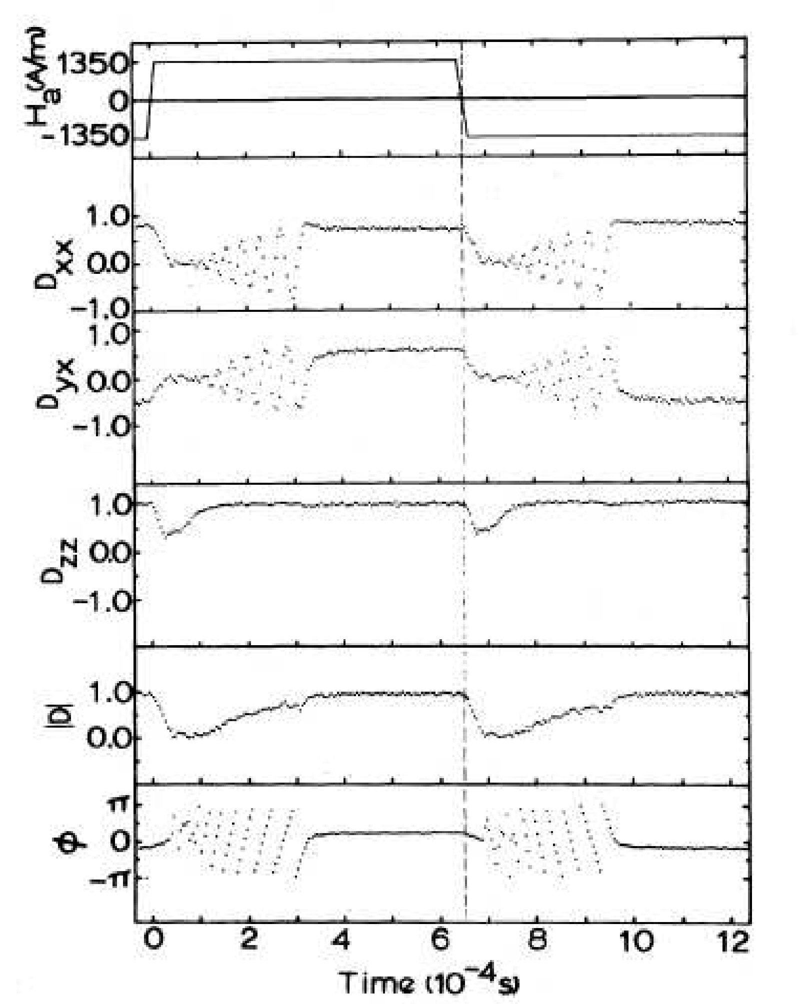
Domain size



Dynamic Depolarization FeSi 1X-crystal (time dependent labeling)

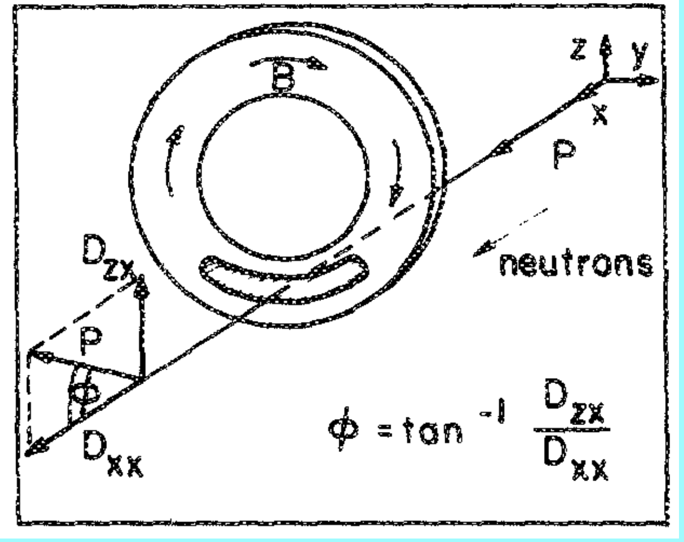
Van Schaik e.a. 1981

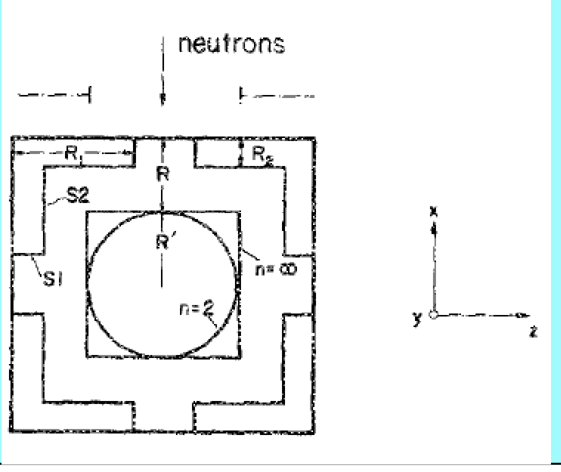


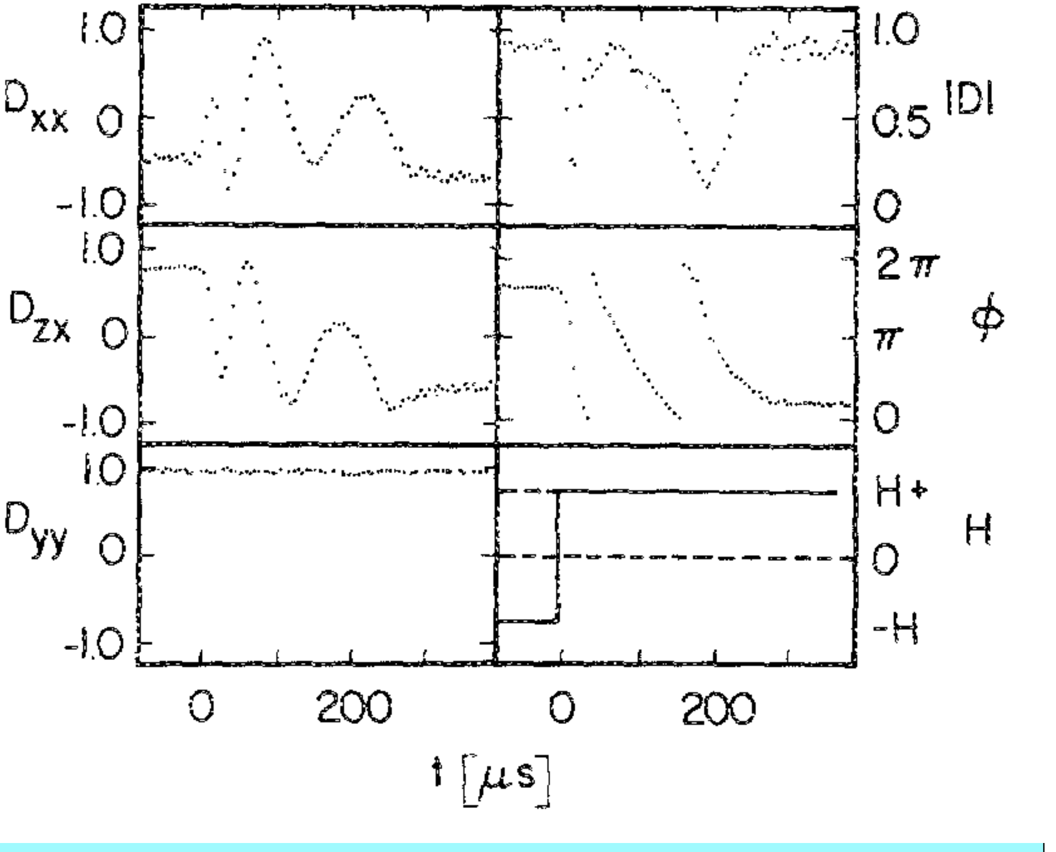


Critical region Fe, Ni

Stuesser e.a. 1985

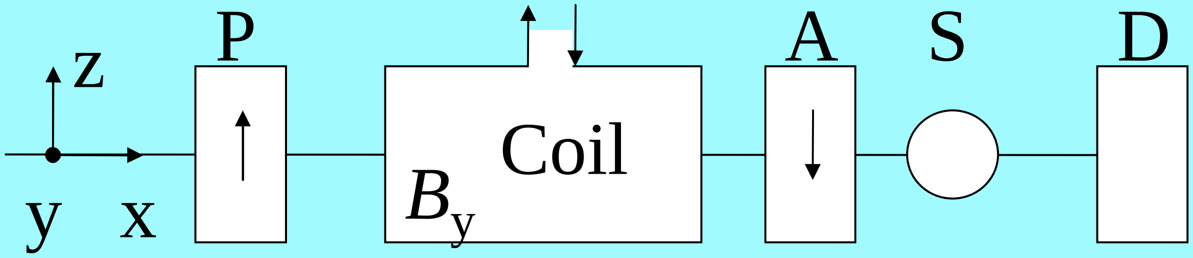






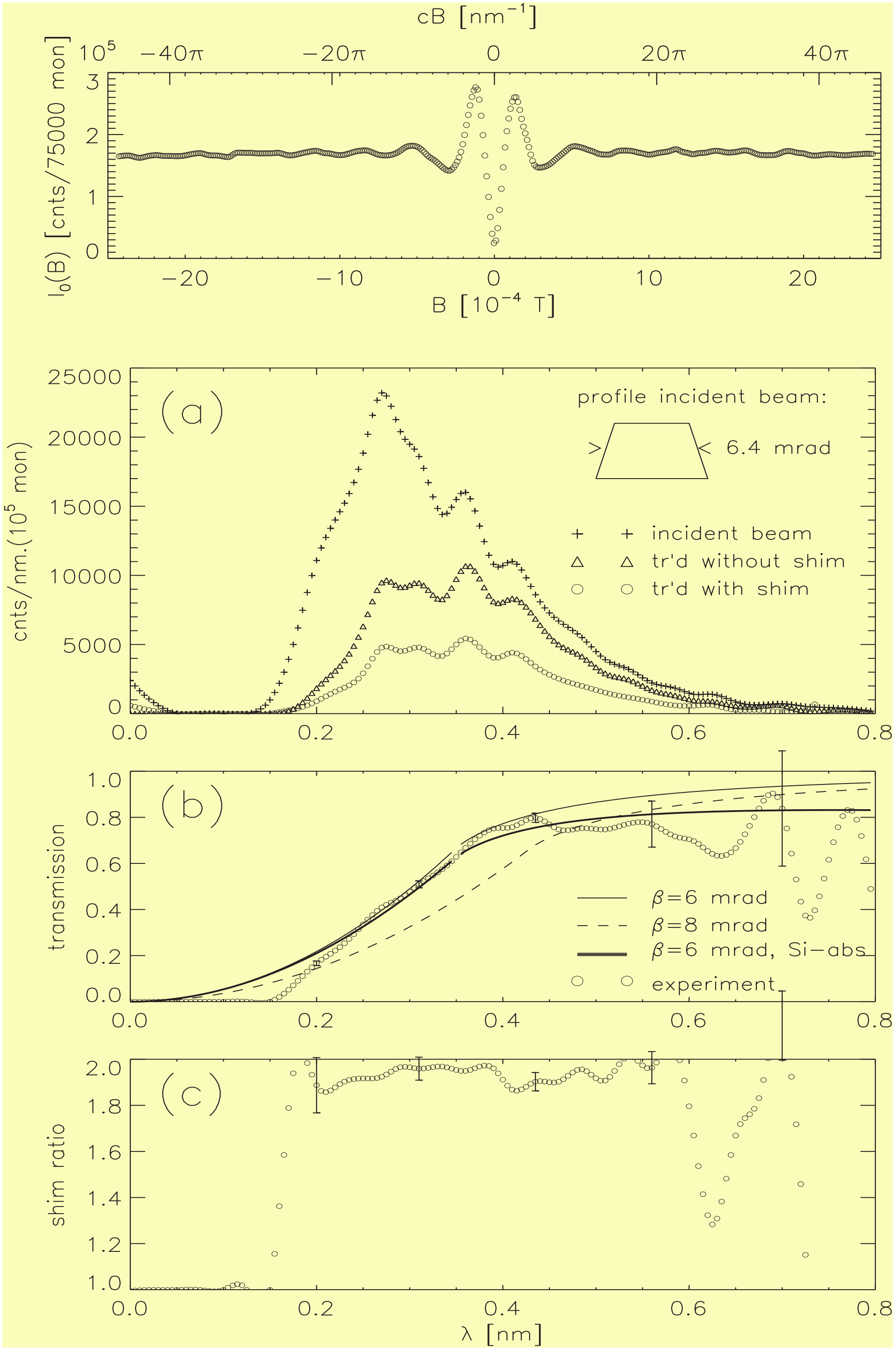
3. Wavelength labeling

Kraan e.a. 1989

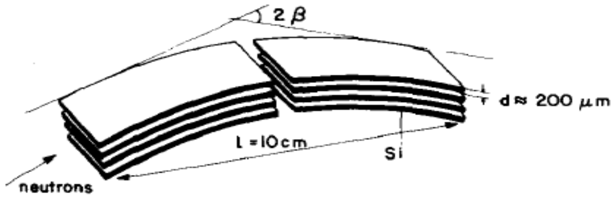


$$I(\lambda) = \int I'(B)\cos(cB\lambda L)dB$$

$$\frac{\Delta\lambda}{\lambda} = \frac{2\pi}{cB_{max}\lambda L}$$



Transm., pol. of mirror system



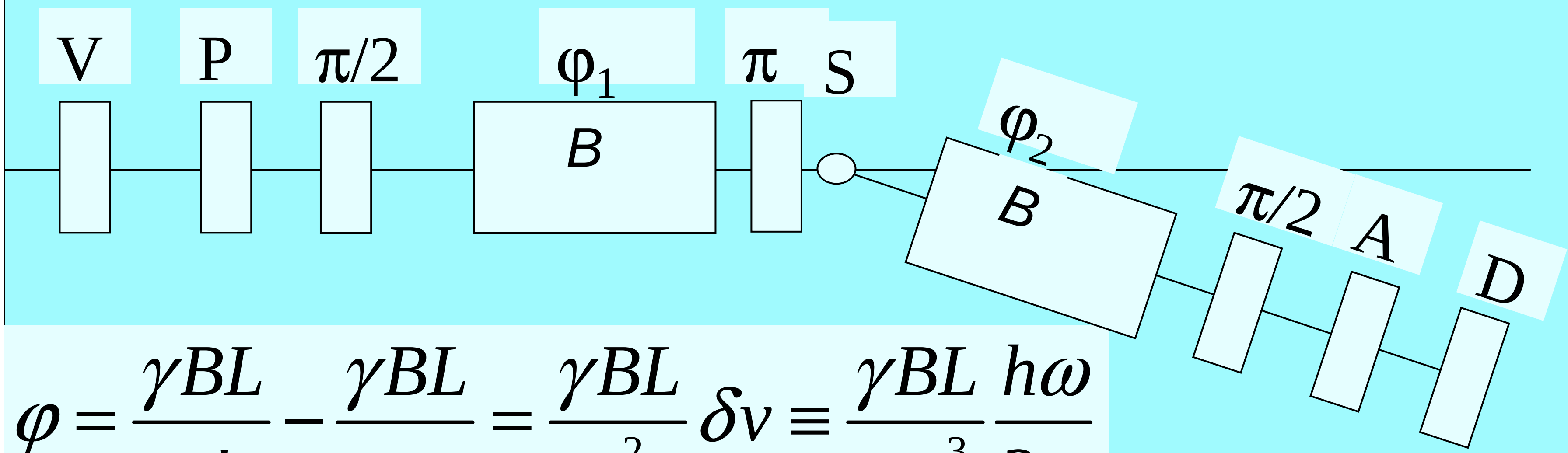
Int. empty pol. beam
mirror system in pol.b.
mirror syst. In depol.b.

Transm.
mirror system

Polarisation

4. Spin-echo to label wavelength changes

Mezei 1972



$$\varphi = \frac{\gamma BL}{v'} - \frac{\gamma BL}{v} = \frac{\gamma BL}{v^2}\delta v \equiv \frac{\gamma BL}{mv^3}\frac{h\omega}{2\pi}$$

$$P(\tau) = \frac{\int I(\mathbf{Q},\omega)\cos(\omega\tau)d\omega}{\int I(\mathbf{Q},\omega)d\omega} \quad \text{with} \quad \tau = \frac{\gamma BLm^2}{2\pi h^2}\lambda^3$$

$$\varphi_m = \frac{\gamma BLm\lambda_i}{h} \quad \text{and} \quad \tau_m = \frac{m\lambda_i^2}{2\pi h^2} \equiv \frac{\varphi_m}{4\pi E_0}$$

Mezei-Murani 1979

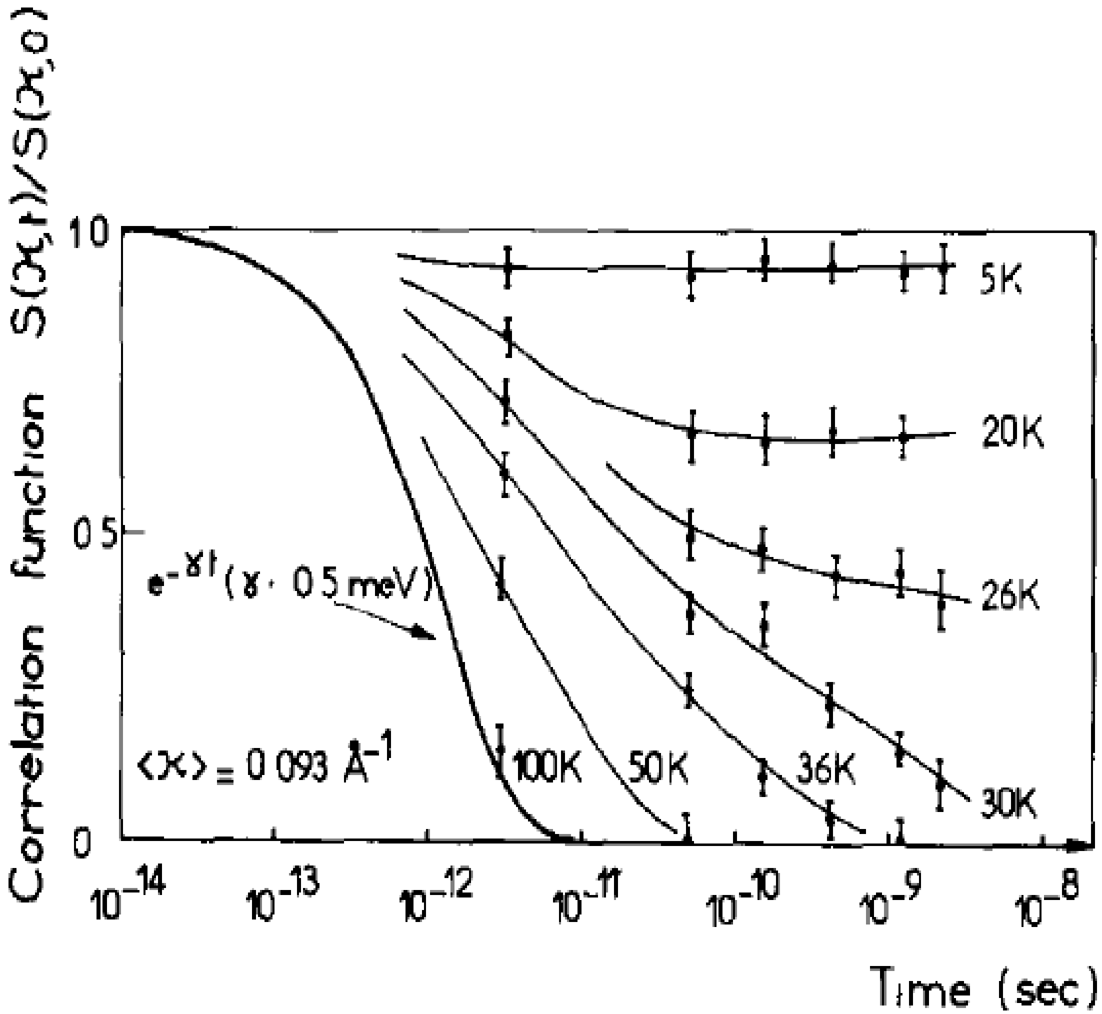


Fig. 3. The measured time dependent spin correlation function for Cu–5 at% Mn at various temperatures The thick line corresponds to the simple exponential decay. The thin lines are guides to the eye only

Spin-Echo References

- F. Mezei, Z. Phys.,**255** (1972)146,
- F. Mezei, in: *Neutron Spin Echo*,Lecture Notes in Physics, Vol.**128**, ed. by F.Mezei (Springer Verlag, Berlin, 1980) pp.3
- Monkenbusch, Farago, Pappas: in F. Mezei, C. Pappas, T. Gutberlet (Eds.), Spectroscopy: Basics, Trends and Applications, Springer, Berlin, 2002.
- Bela Farago, Recent results from the ILL NSEs, Physica B **397** (2007) 91–94.

5. Spin-Echo SANS

Thomas Keller (HMI)   Neutr. News 1995

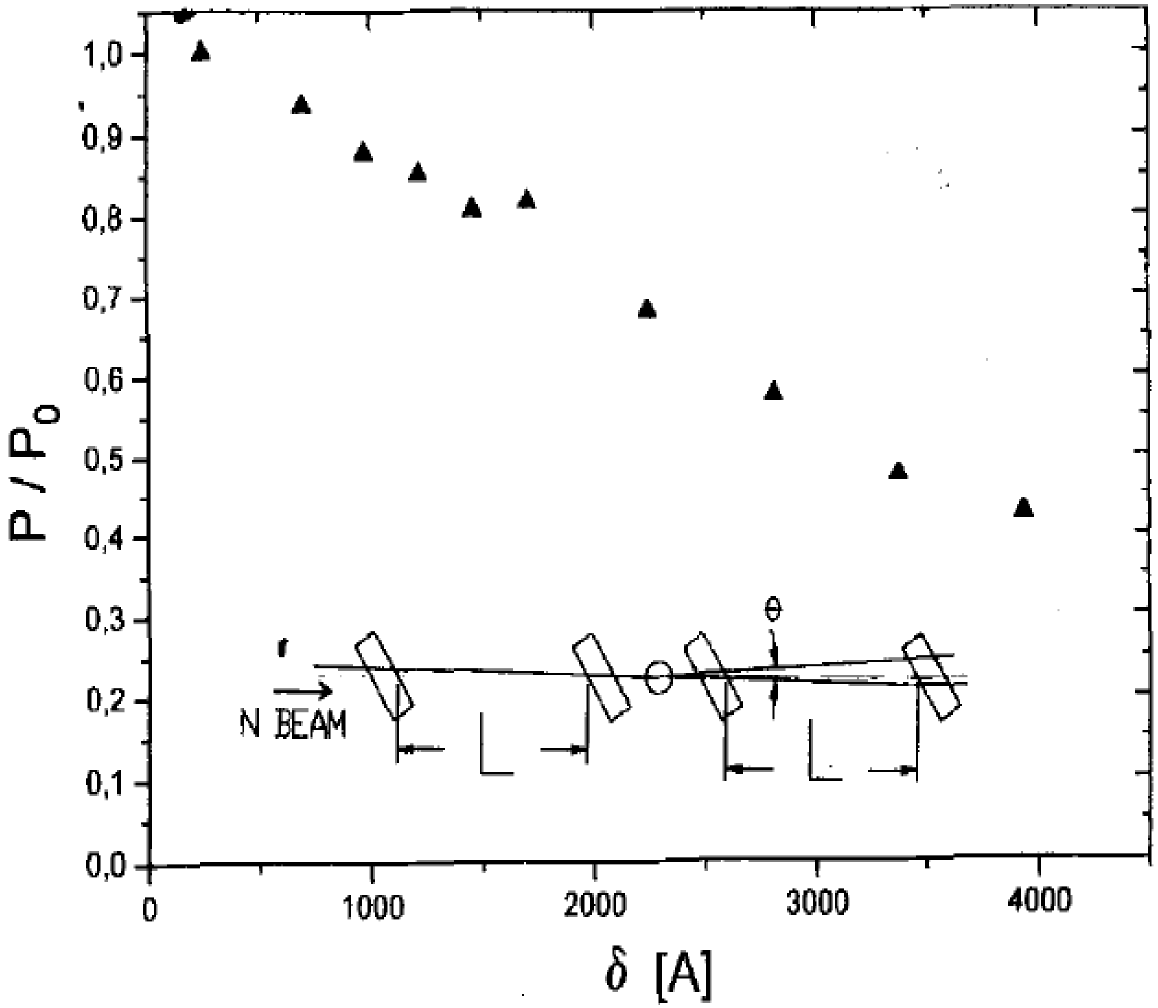
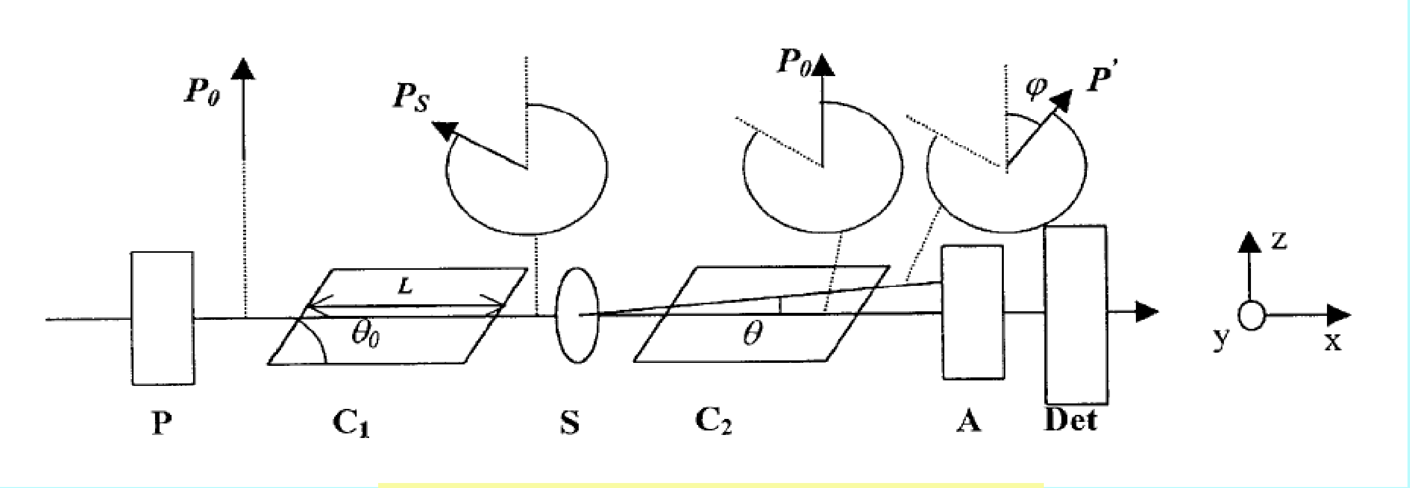


Figure 2. *Density-density correlation function, G(d) measured for a sample of porous glass. Insert: Schematic of the experimental setup for spin echo elastic small angle scatter-*

Concept:
Roger Pynn
1978

Spin-Echo SANS - technique



$$\varphi = c\lambda BL\theta \cot\theta_0 \equiv ZQ_z$$

$$Z = \frac{c\lambda^2 L\cot\theta_0}{2\pi} B$$

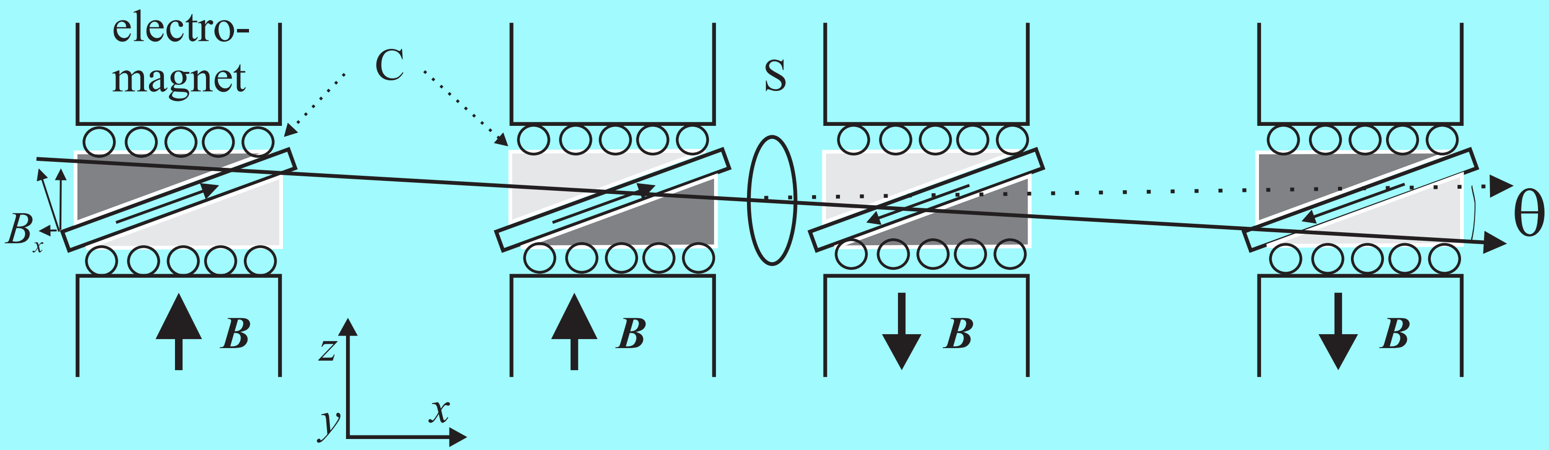
$$Q_z = \frac{2\pi\theta}{\lambda}$$

$$P(Z) = \exp[-s_t(1\text{-}G(Z))]$$

$$s_t = \frac{1}{k_0^2}\int_{-\infty}^{\infty} d^2\mathbf{Q}\ S(\mathbf{Q})$$

$$G(Z) = \frac{1}{s_t k_0^2}\int_{-\infty}^{\infty} d^2\mathbf{Q}\ S(\mathbf{Q})\cos(ZQ_z)$$

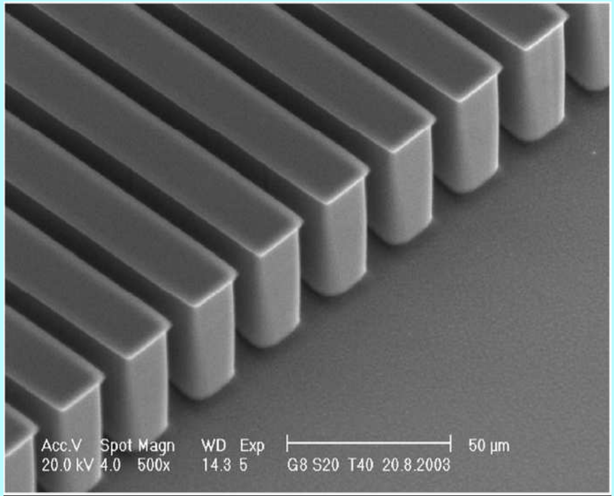
Inclination by Magn. Foils

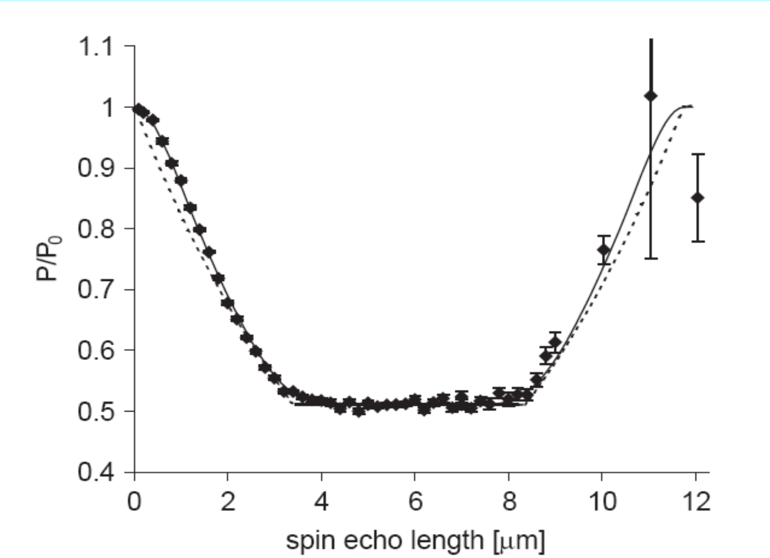


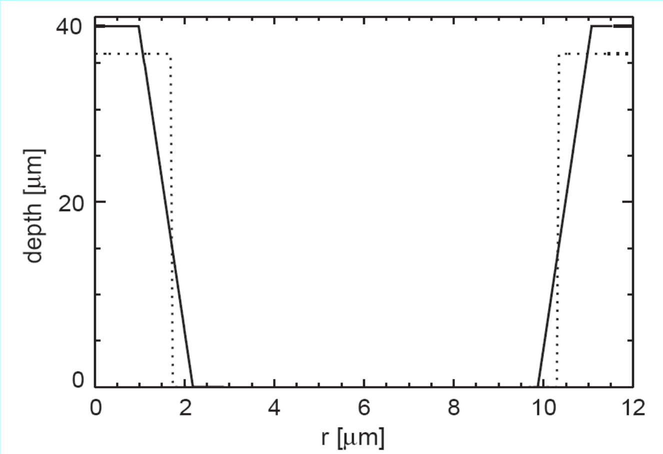
Z_{max} (0.2nm)~20 µm
Zmax (1nm)~0.5 mm achievable

Trinker
Bouwman

2007

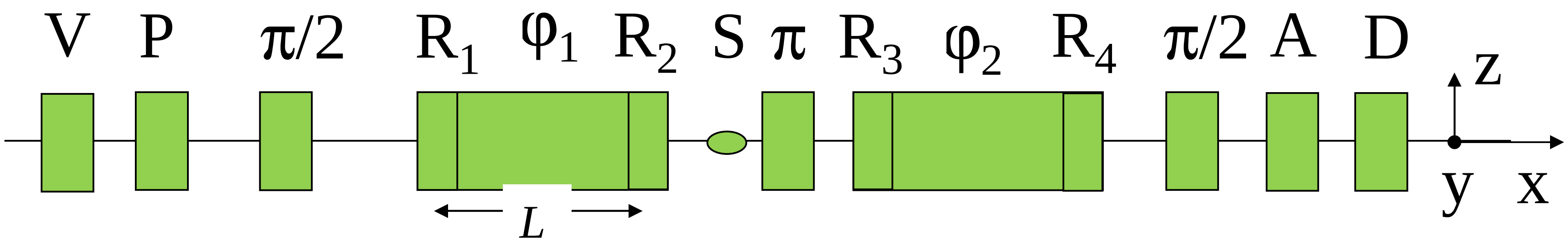






6. Spin-echo using resonance Larmor precession

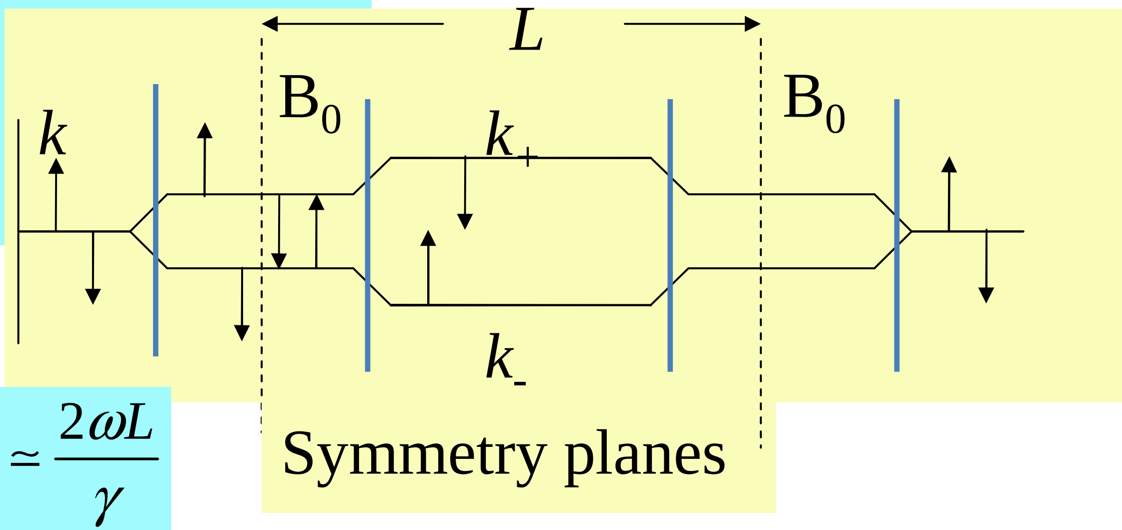
Gahler, Golub 1987



$R_1..R_4$ resonance coils in field B_0 in z- with

$B_y = B_a\cos(\omega_0 t)$

$\omega_0 = \gamma B_0$

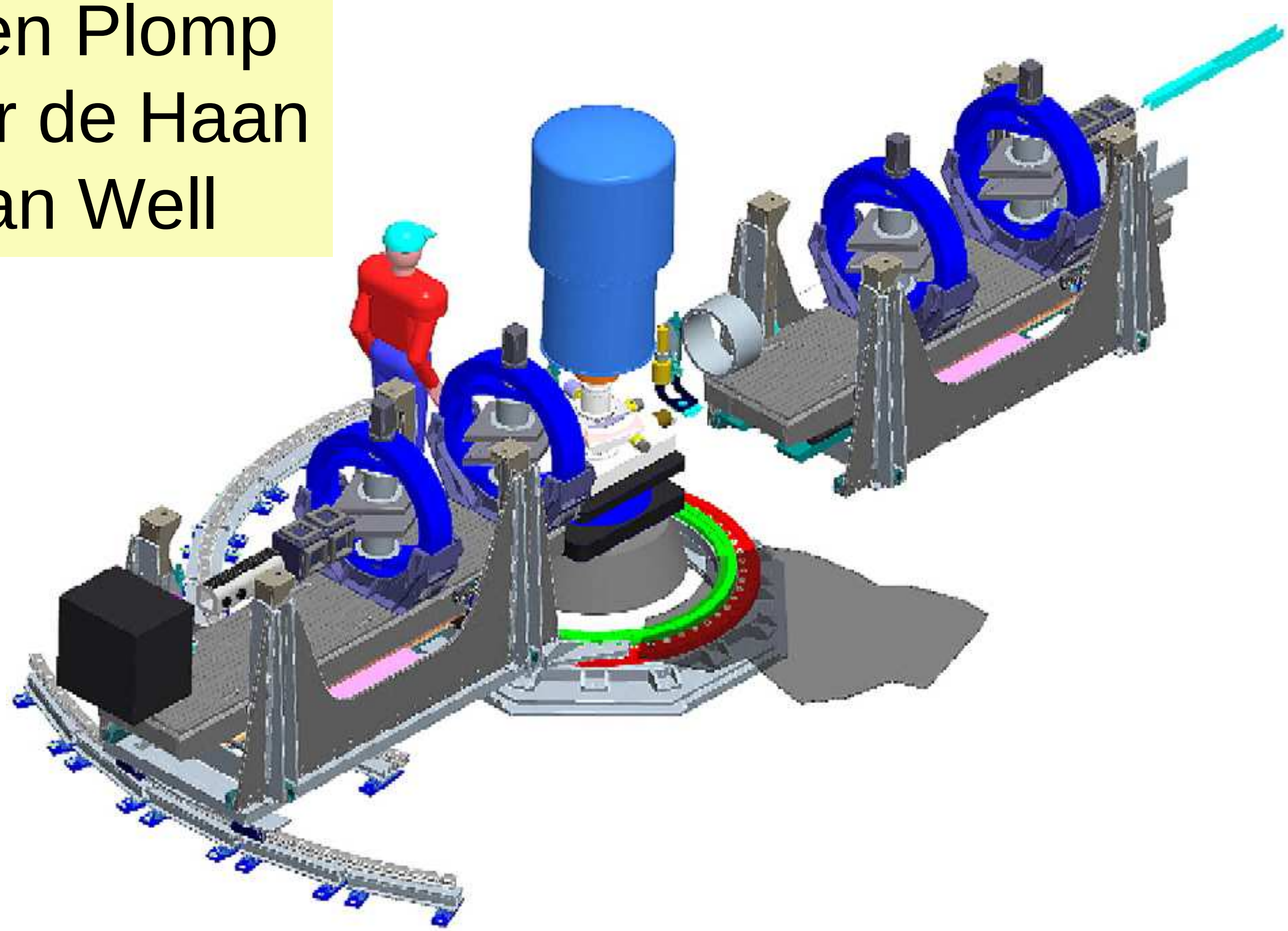


$$\varphi = \int dx\,(k_+ - k_-) = (k_+ - k_-)_{max.}\, L \simeq \frac{2\omega L}{\gamma}$$

Offspec at ISIS

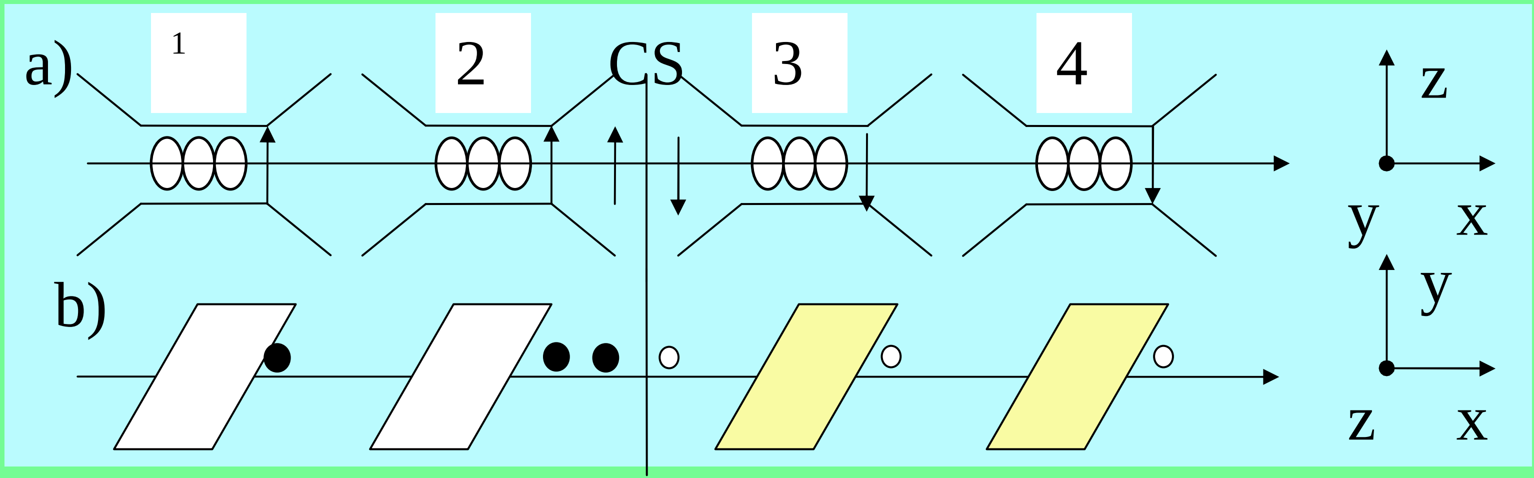
Res.Prec. + SESANS 2007

Jeroen Plomp
Victor de Haan
Ad van Well



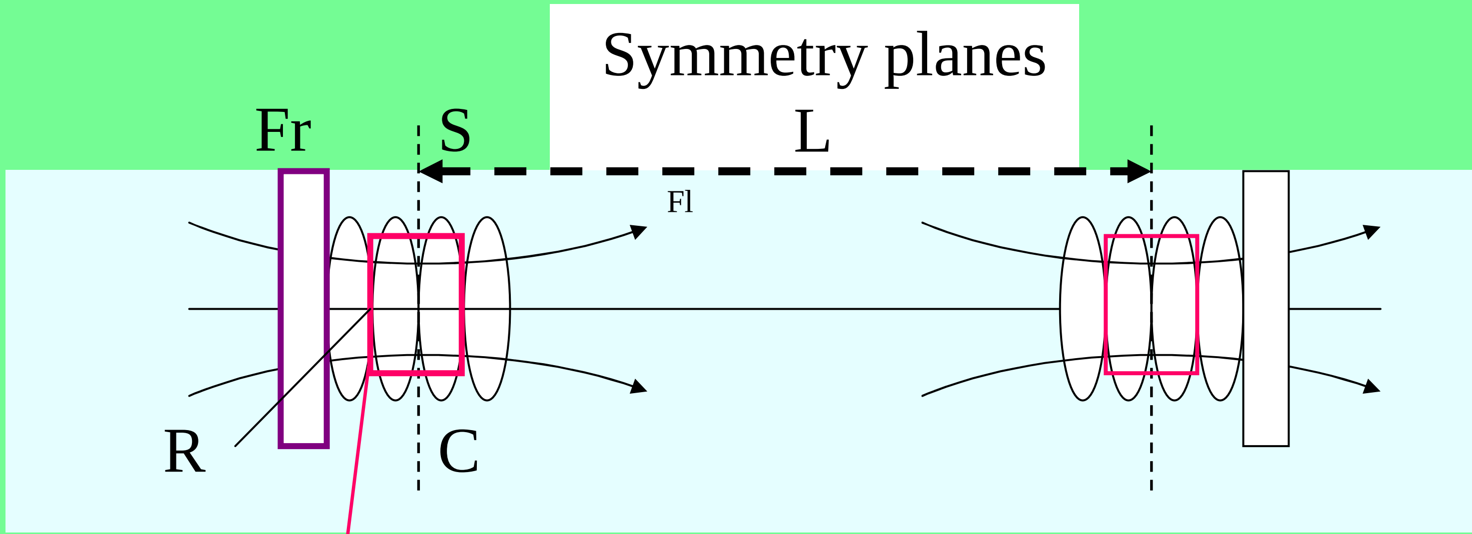
with coil field // beam between pole shoes

Rekveldt e.a. 2003



-Less material in beam
- No correction coils

with main field //beam



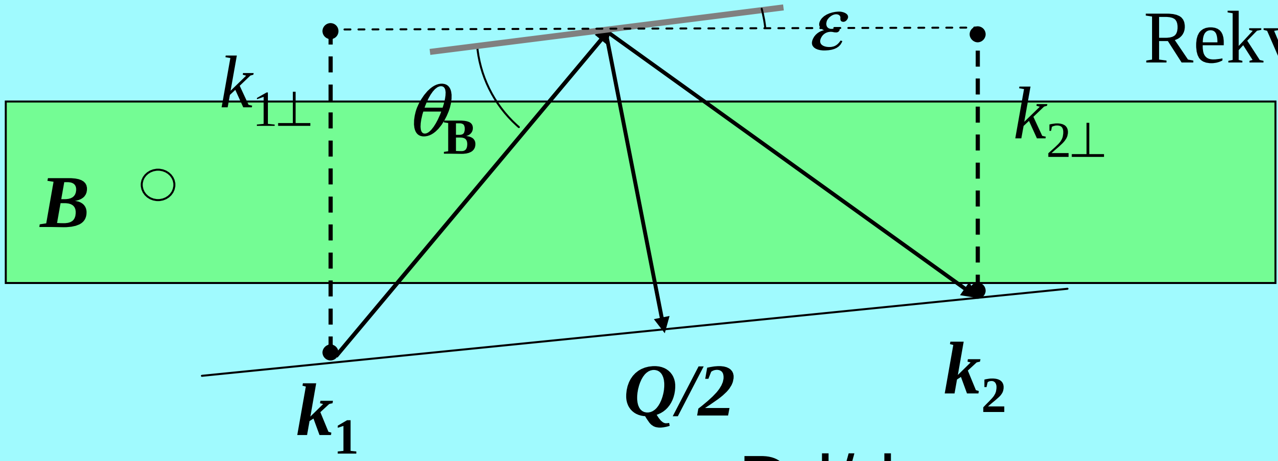
Res. coil

$\varphi \sim \omega L$

Advantages Res. Precession

- High precession angles
- Low sensitivity for field inhomogeneties and stability, (ω_0 electr. more stable)
- Correction coils for beam divergence and field inhomogeneities in transition regions simpler. (No radial dependence of field line integral)

7. High Resolution Larmor Diffraction



Rekveldt e.a. 2001

T. Keller
R.Golub

Dd/d

$$\varphi = cB\left(\frac{1}{k_{1p}} + \frac{1}{k_{2p}}\right) = cB\frac{1}{Q_p}\left(1 + \cot^2\theta_B \tan^2\varepsilon\right) \approx d$$

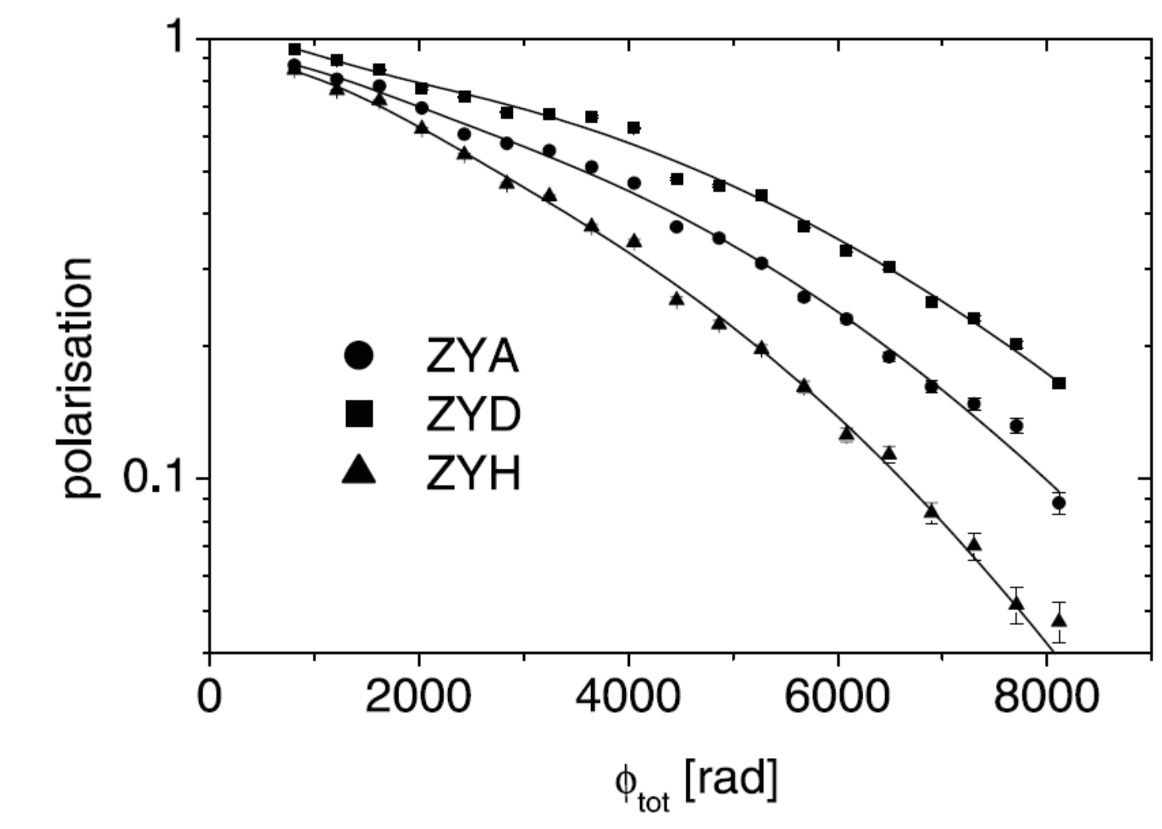
$\Delta d/d = 10^{-6}$

$$P(\varphi) = \int d\varphi F(\varphi)\cos\varphi$$

F(φ) – distribution function of Δd/d

Application on Pyrolytic. Graphite

By Thomas Keller at al 2002



Precise line shapes can be analysed.

Acknowledgement

- Numerous students PhD-students in last 45 years.
- Organisers for invitation and colloboration

  Wim Bouwman

  Wicher Kraan

  Niels van Dijk

  Jeroen Plomp

  Katia Pappas