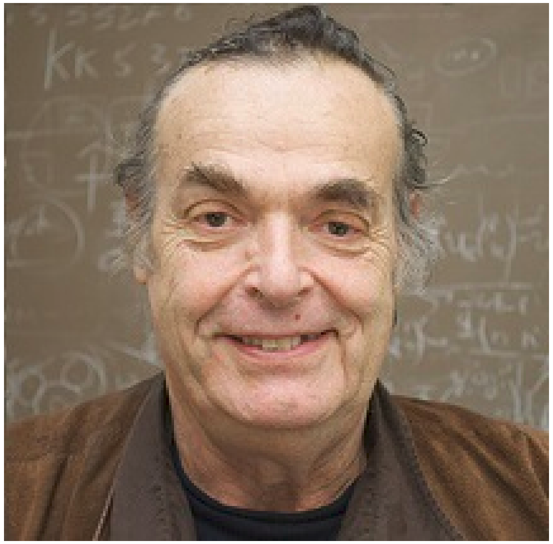
Mieze

(modulation of intensity with zero effort)

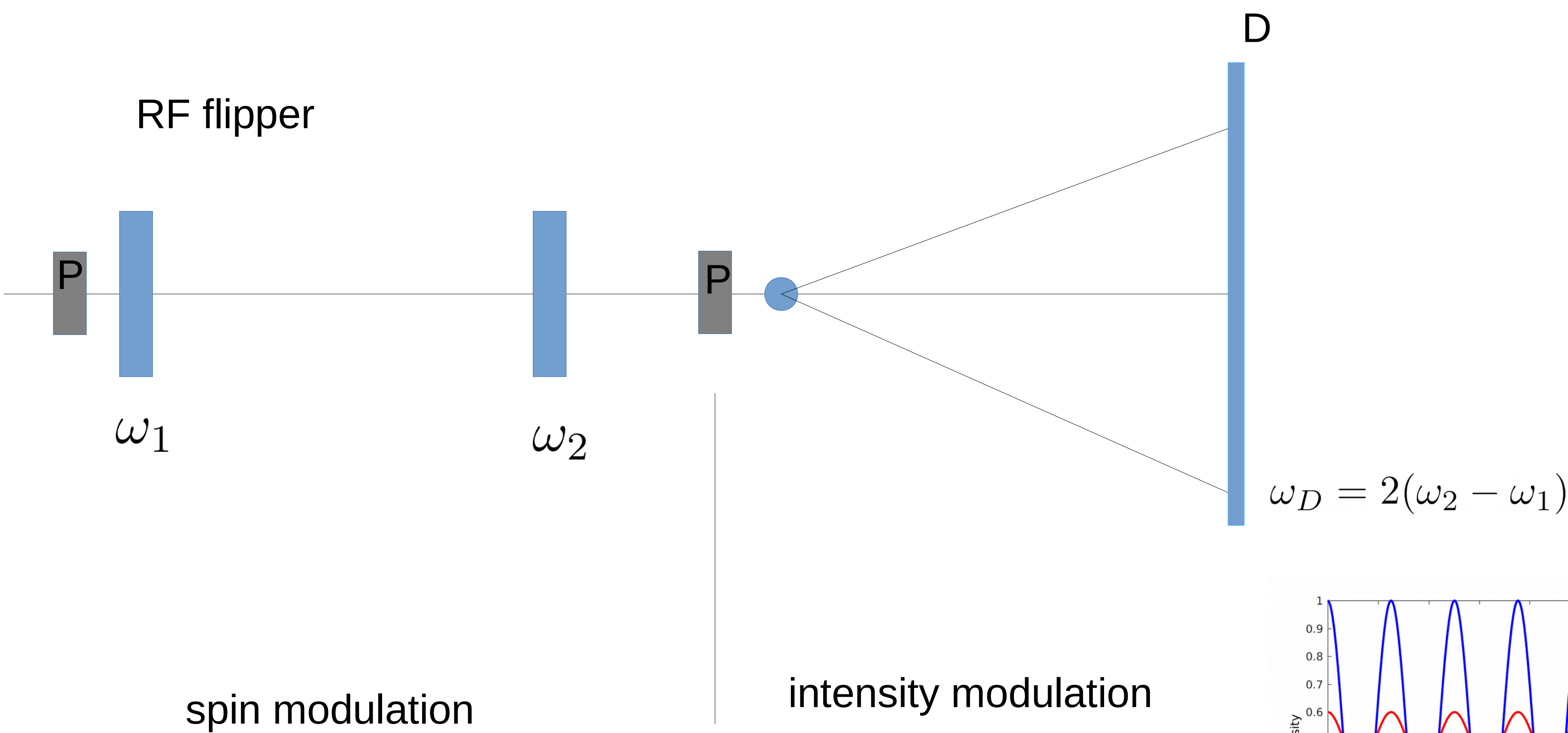
Roland Gähler

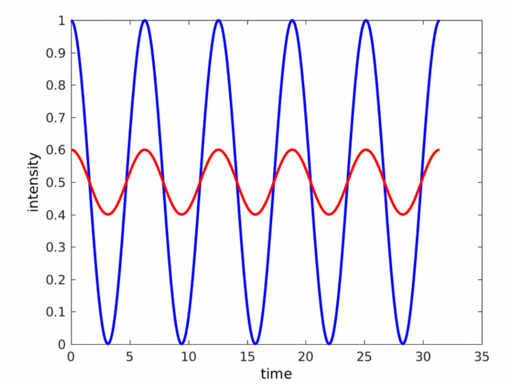


Bob Golub

Thomas Keller
Max Planck Institute for Solid State Research, Dep. Keimer

Mieze - principle

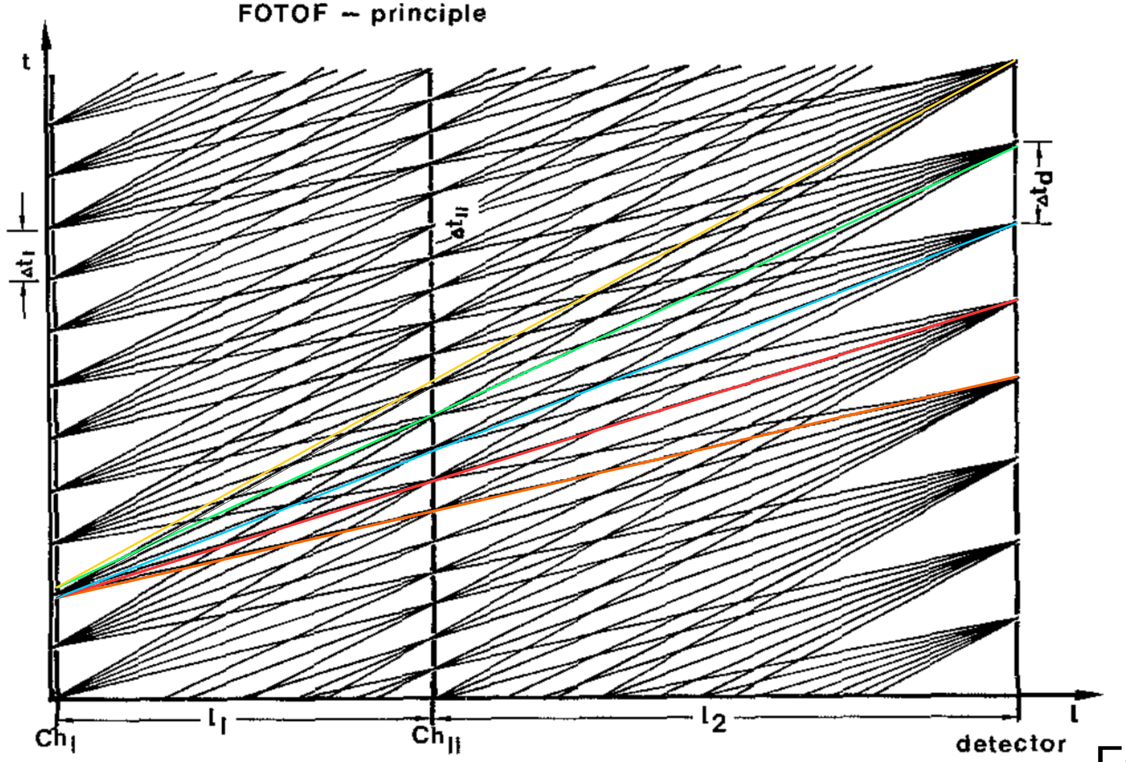




-> MHz

Gähler et al., Physica B180, 899 (1992)

FOTOF - frame overlap time of flight

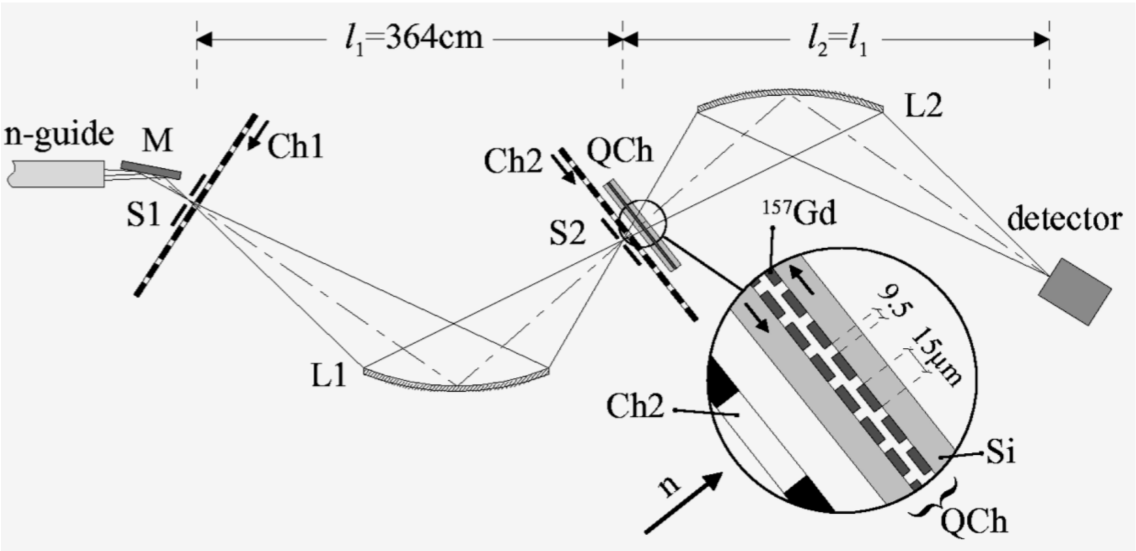


FOTOF: 50kHz

$$\frac{\Delta t_1}{\Delta t_2} = \frac{l_1 + l_2}{l_2} \qquad \frac{\Delta t_D}{\Delta t_2} = \frac{l_1 + l_2}{l_1}$$

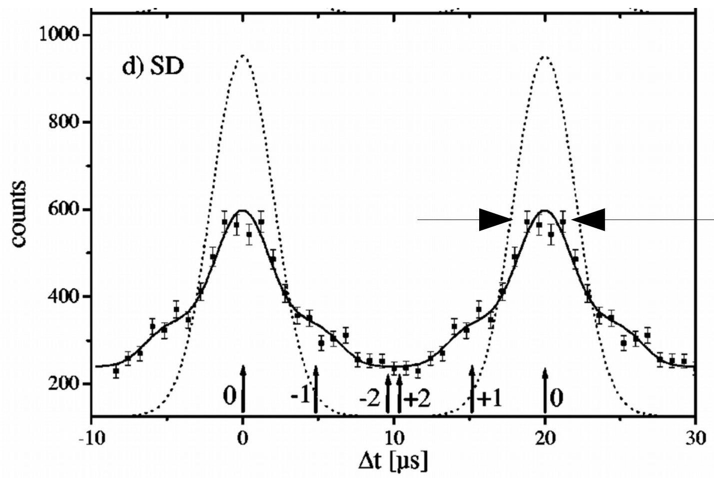
R. Gähler, R. Golub, Z. Phys. B 56, 5 (1984)

diffraction in time



$\lambda = 30\text{Å}$

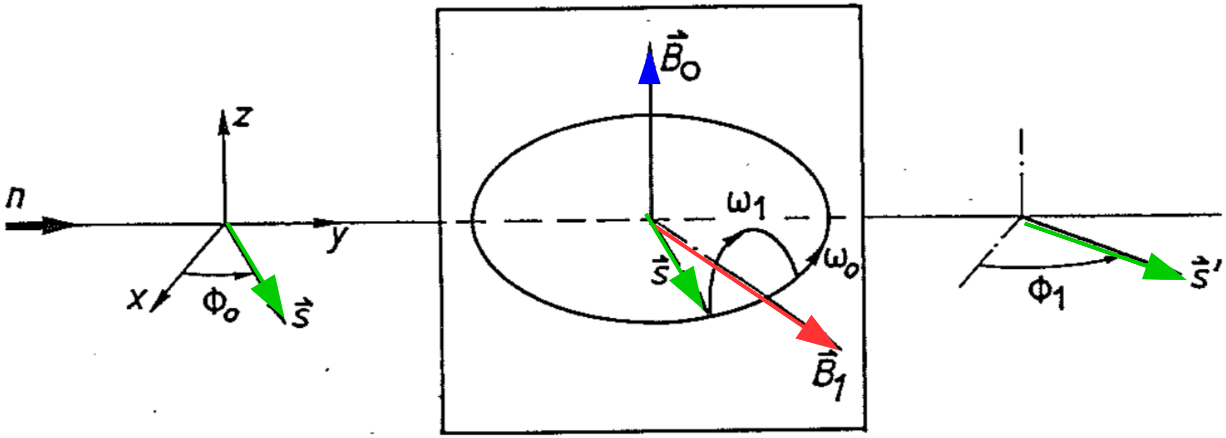
Quantum-chopper: opening 33ns



$4.7\,\text{ns}(22\,\text{neV})$

Hils, Felber, Gähler, Golub, Habicht et al., PRB 58, 4784 (1998)

RF flipper



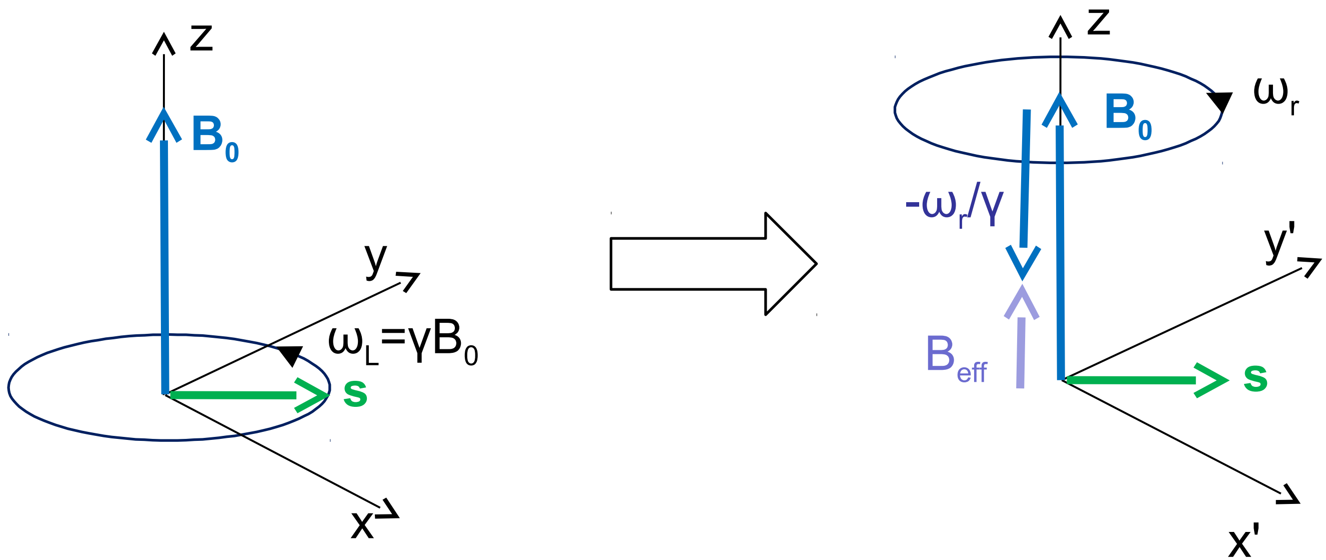
Larmor resonance: $\omega_0 = \gamma B_0$

$\boldsymbol{B_1 \perp B_0}$

three possible orientations:

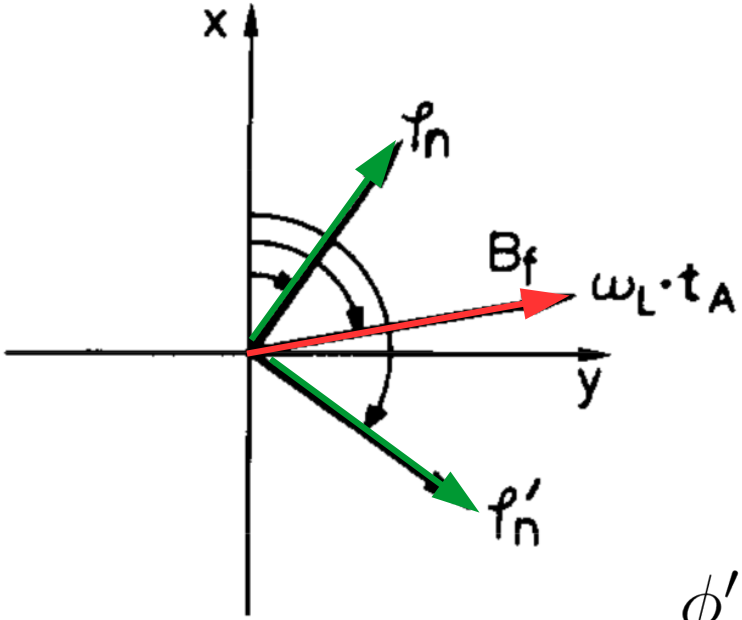
B_0	B_1 (linear, not rotating)	
trans	trans	TRISP, FLEXX
trans	long	Delft (Offspec, Larmor)
long	long	LNRSE (RESEDA)

transformation to a rotating system



Rabi, Ramsey, Schwinger, Rev. Mod. Phys. 26, 167 (1954).

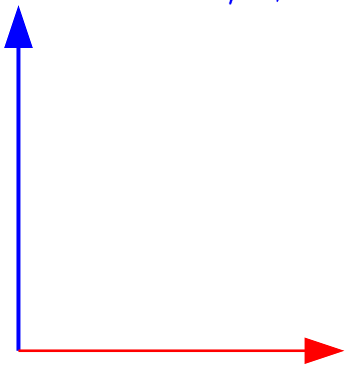
pi-flip



$$\phi'_n = 2\omega_L t_A - \phi_n$$

RF flipper low-frequency limit

$$B_0 = \omega_{\mathrm{RF}}/\gamma$$

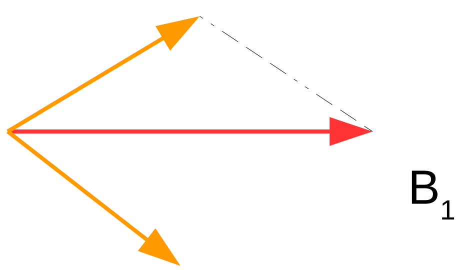


$$B_1 = \frac{\pi}{\gamma} \times \frac{v_n}{d_{\mathrm{coil}}}$$

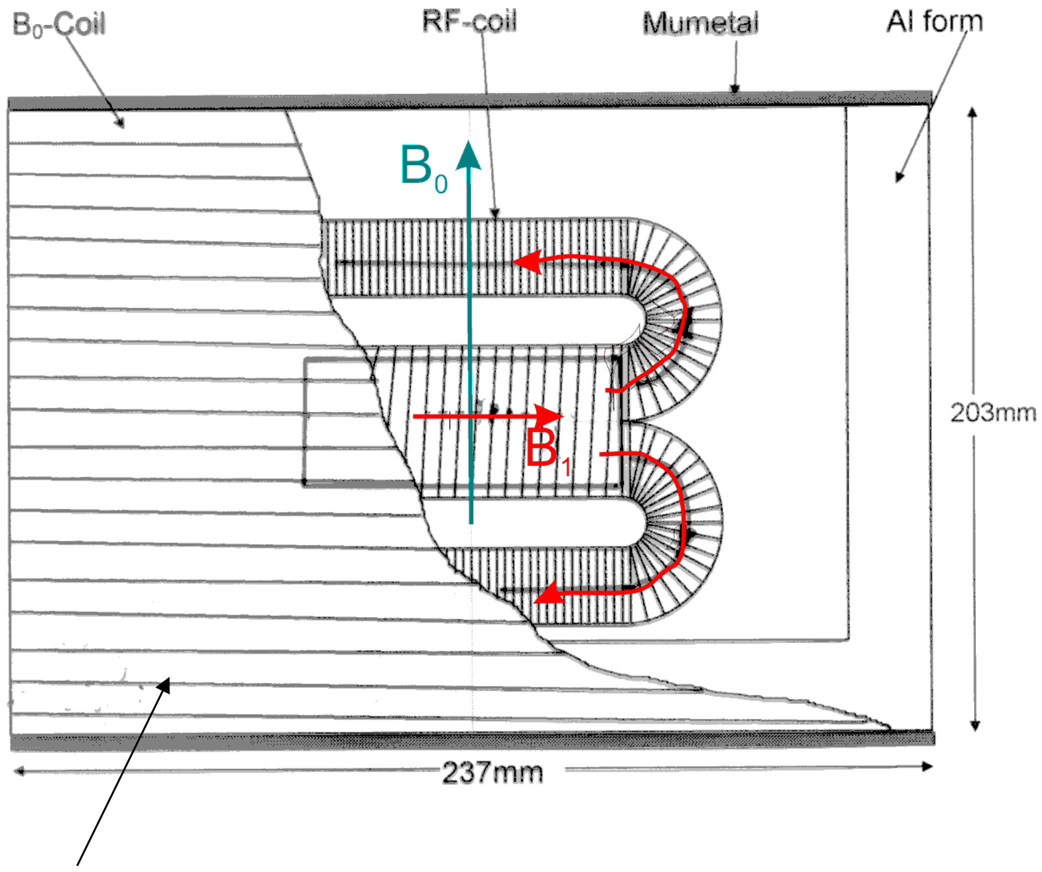
RF flipper only works properly for $B_0 \geq B_1$

example: 8Å, d_{coil} = 1cm -> freq > 25kHz

reason: using linear instead of rotating B_1
(Bloch-Siegert effect in NMR)



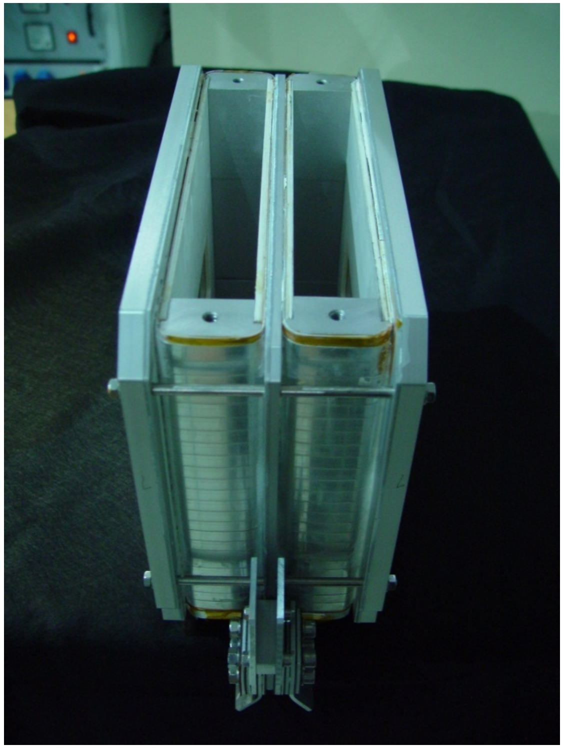
TRISP

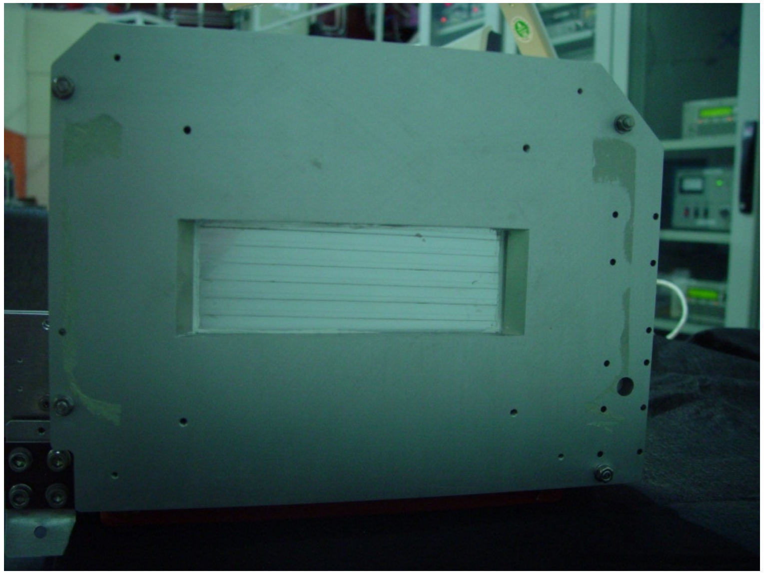


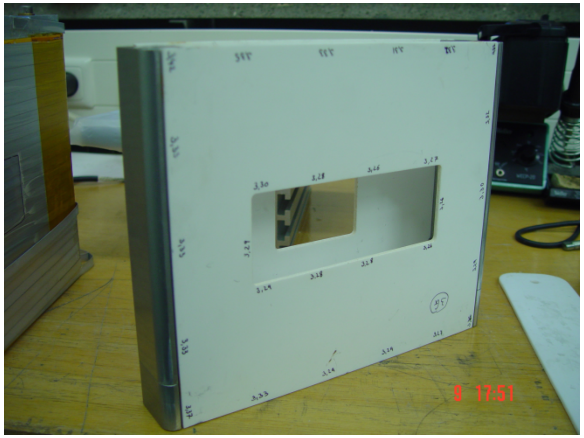
Al-tape (anodized)

- Al tape 8x0.5mm²
- B_0 300G, P=1kW

rf flipper TRISP

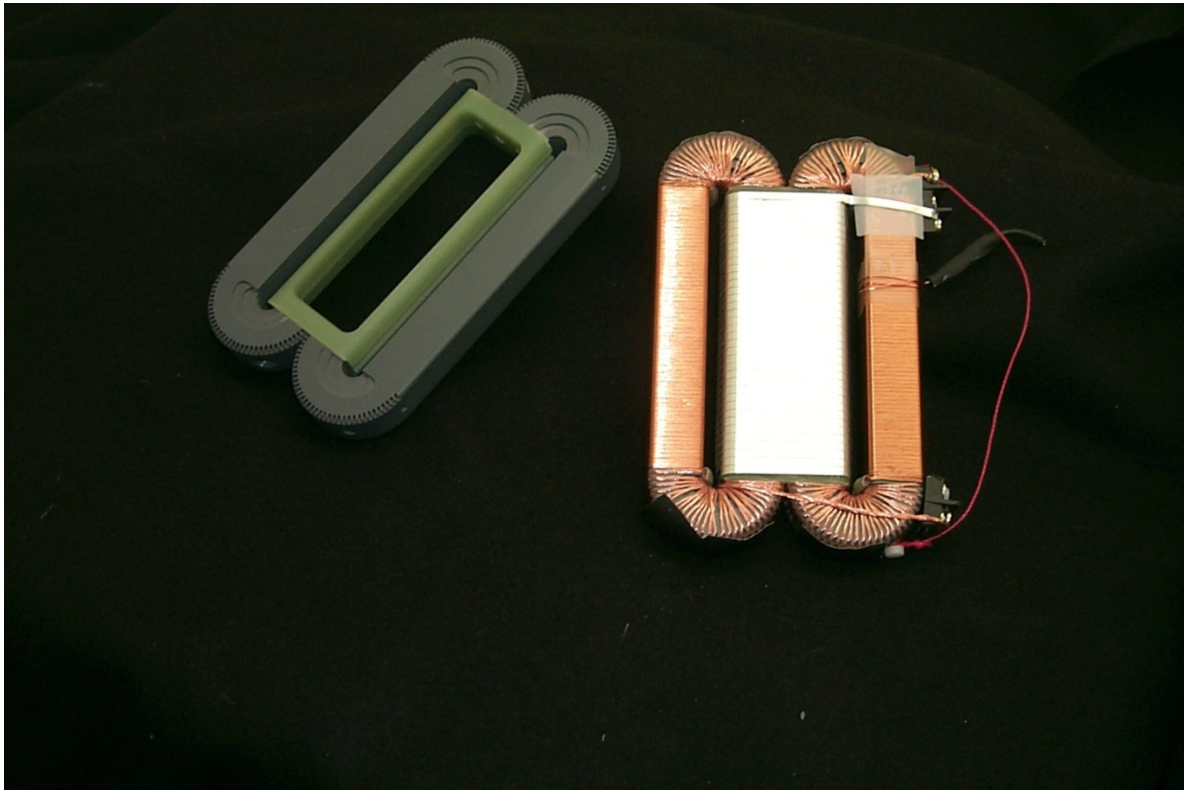




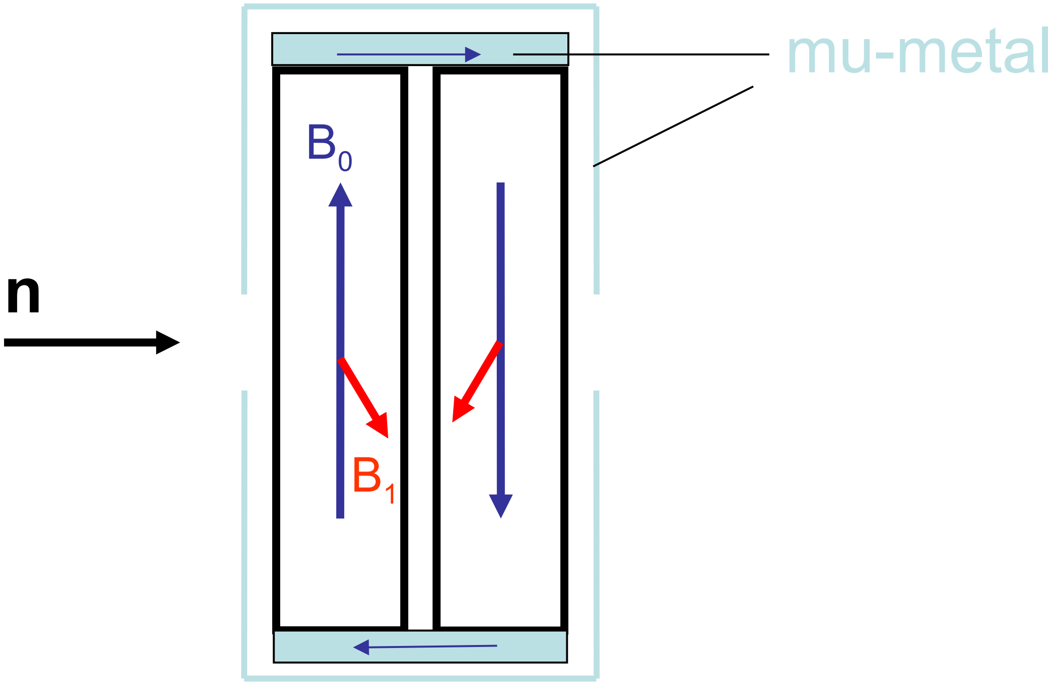


+ precise surface
+ low stray field
- small angle scattering

rf coil TRISP

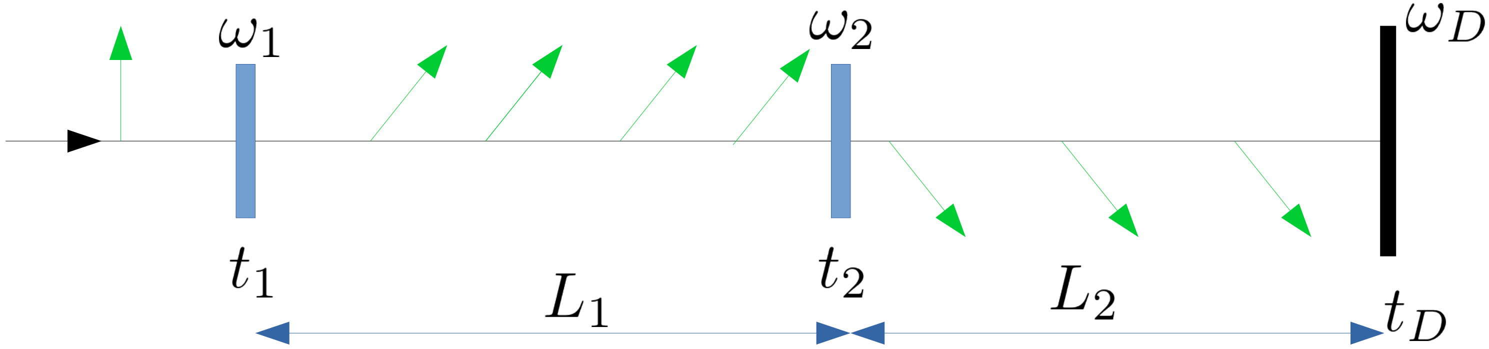


RF spin flipper (*bootstrap* coil)



effective field: $4B_0$

Mieze focusing condition



tracking one neutron

$$\phi_0 = 0$$

$$\phi_1 = 2\omega_1 t_1 - \phi_0$$

$$\begin{aligned} \phi_2 &= 2\omega_2 t_2 - \phi_1 \\ &= 2\omega_2 t_2 - 2\omega_1 t_1 \end{aligned}$$

substitute: $t_2 = t_D - L_2/v$ $\quad t_1 = t_D - (L_1 + L_2)/v$

$$\phi_2 = 2(\omega_2 - \omega_1)t_D + 2\omega_1 \frac{L_1+L_2}{v} - 2\omega_2 \frac{L_2}{v}$$

= 0 --> focusing

Mieze focusing

$$\frac{\omega_2}{\omega_1} = \frac{L_1}{L_2} + 1$$ focusing condition

$$\omega_D = 2(\omega_2 - \omega_1)$$

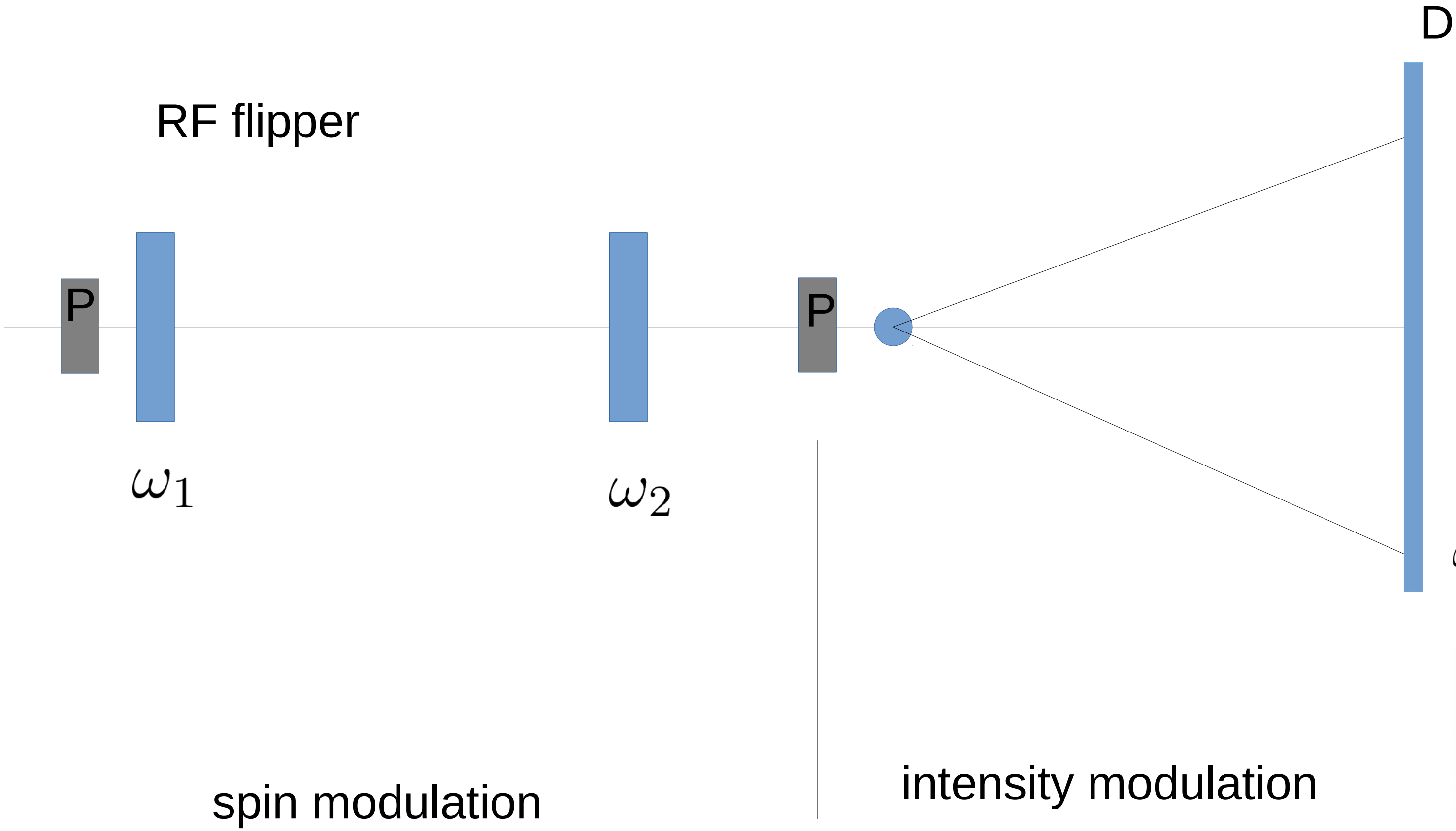
with sample:

$$I(t) = I_0(1 + C \times \cos(\omega_D t_D))$$

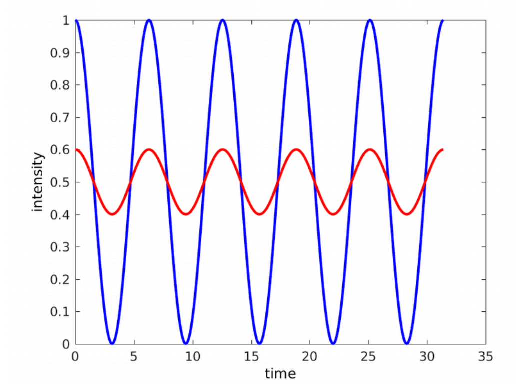
$$C = \int S(\omega) \cos(\omega \times \tau) d\omega$$

$$\tau \propto \omega_D L_D \lambda^3$$

Mieze - principle

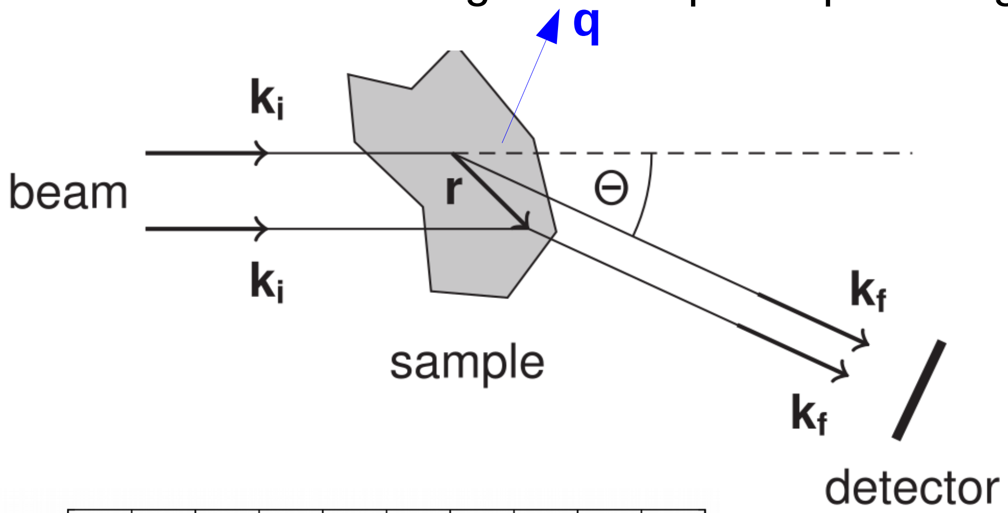


$$\omega_D = 2(\omega_2 - \omega_1)$$

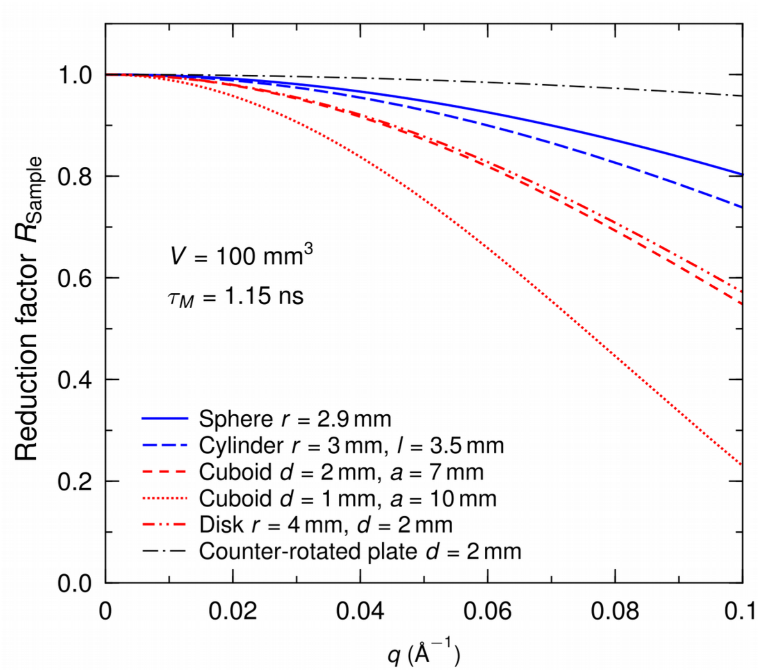


> 1 MHz

Mieze is a time-of flight technique -> path length differences reduce contrast



$$\Delta\phi = \exp(i\vec{q}\cdot\vec{r})$$



$$\begin{aligned}\omega_D &= 2\pi \times 1\,\mathrm{MHz}\\ \lambda &= 8\,\text{Å}\\ \text{phase } 2\pi &\rightarrow 0.5\,\mathrm{mm}\end{aligned}$$

Brandl, Georgii, et al., NIM A 654, 394 (2011)

detector

MAX-PLANCK-GESELLSCHAFT

problem: detector must be thin (~0.2mm) and fast

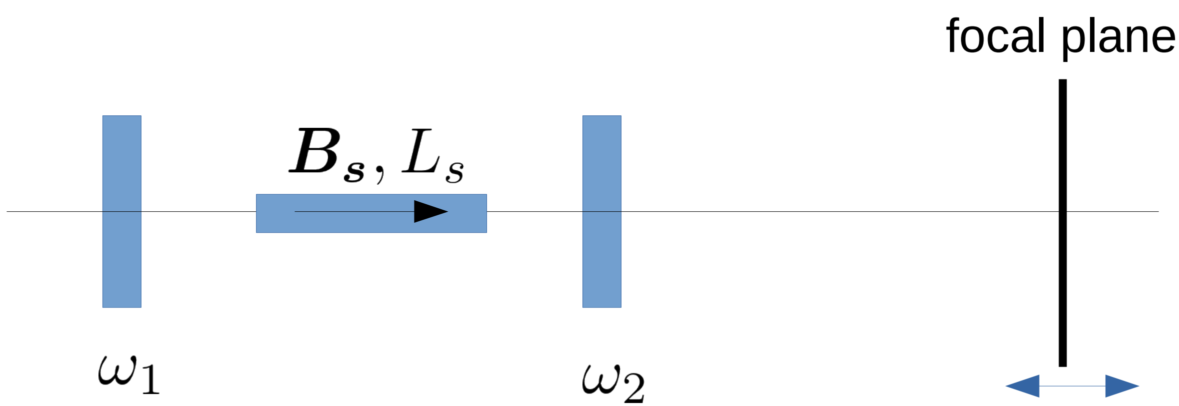
-> good efficiency is hard to achieve

focus tuning

problem: small $\omega_D = 2(\omega_2 - \omega_1)$

$$L_2 = \frac{\omega_1}{2\omega_D} L_1$$

solution: DC field between coils shifts focus
(idea W. Häussler ?)



L_1 L_2 $\Delta L_2 = \pm 2\gamma B_s L_s / \omega_D$

summary

- Mieze is a high resolution TOF technique
- high resolution only at low Q
- good for spin depolarizing samples, magnetic field