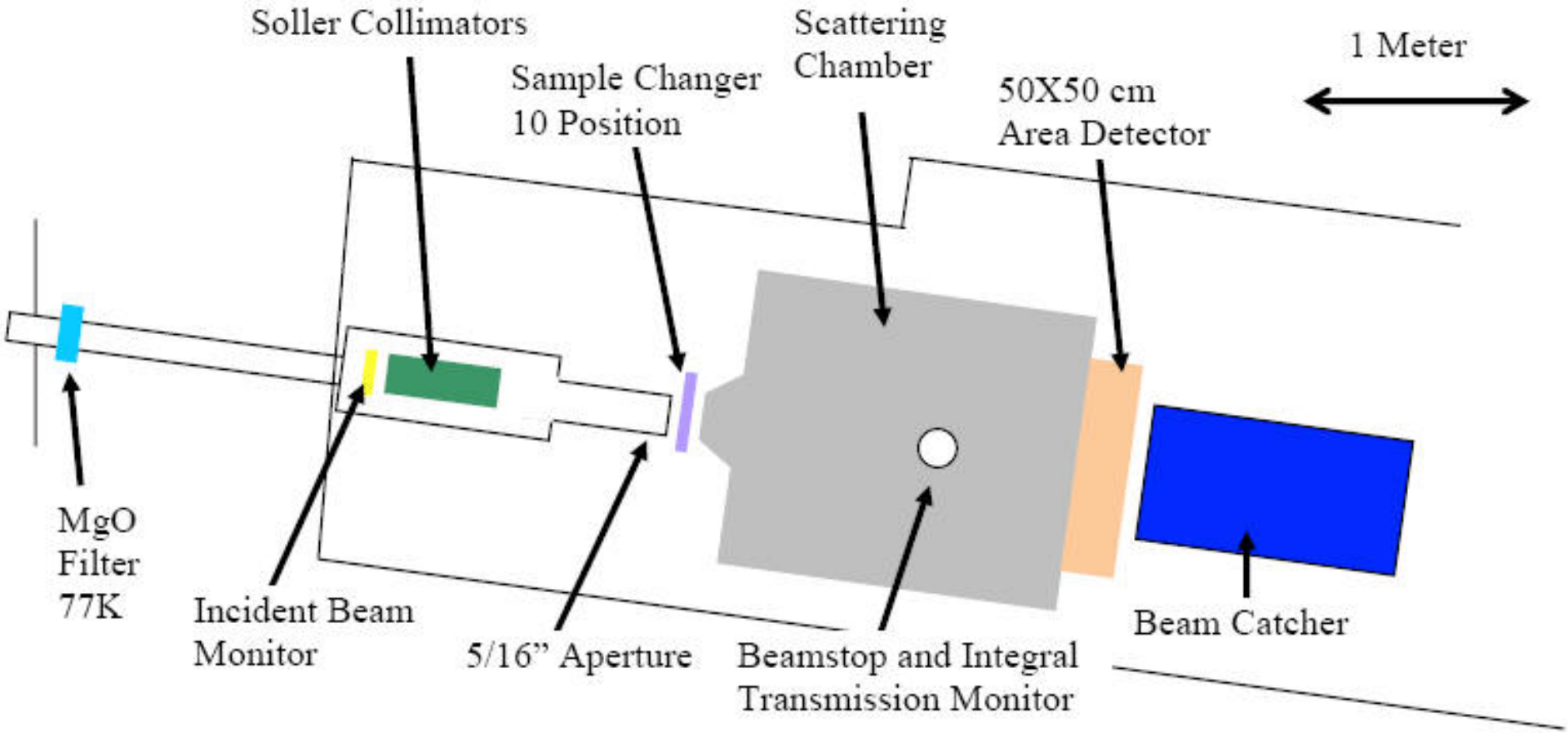
Polarized Small Angle Neutron Scattering on a pulsed Source

M. Bleuel, 09/29/2006

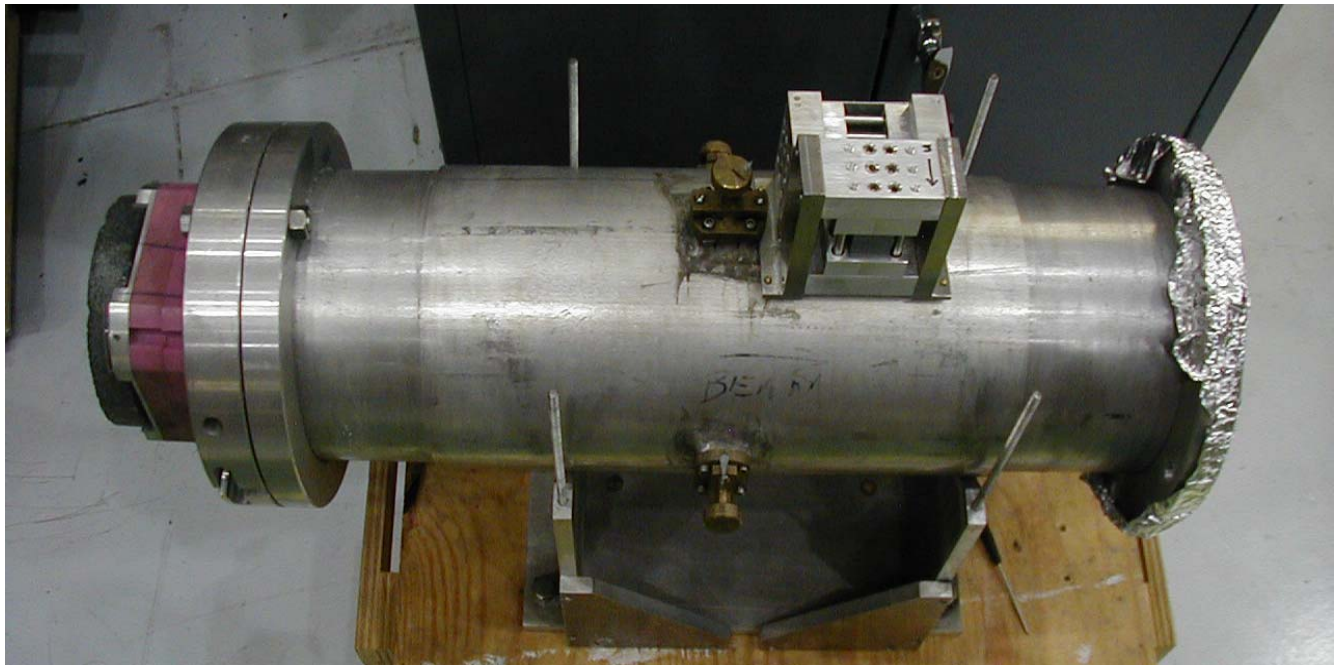
1. **Components:**
   Collimators, Polarizer, Spin Flipper
2. **Measurement**
3. **Conclusion**

Thanks to Jyotsana Lal, Ed Lang and Thomas Krist!

Small Angle Scattering Instrument



Collimators

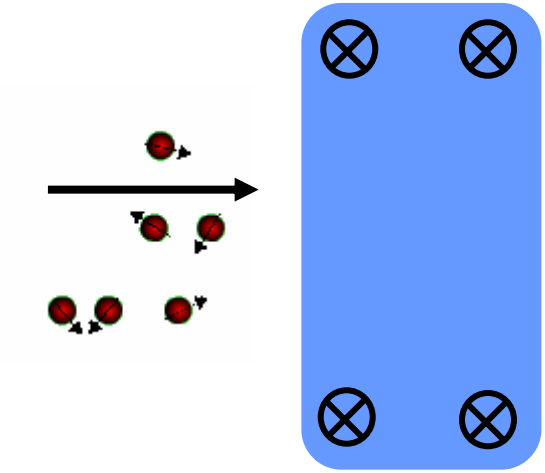


Same d/L ⟶ same resolution est. 0.007A^{-1} @ 10A

First focusing solid state collimators

A little upgrade is still needed . . .

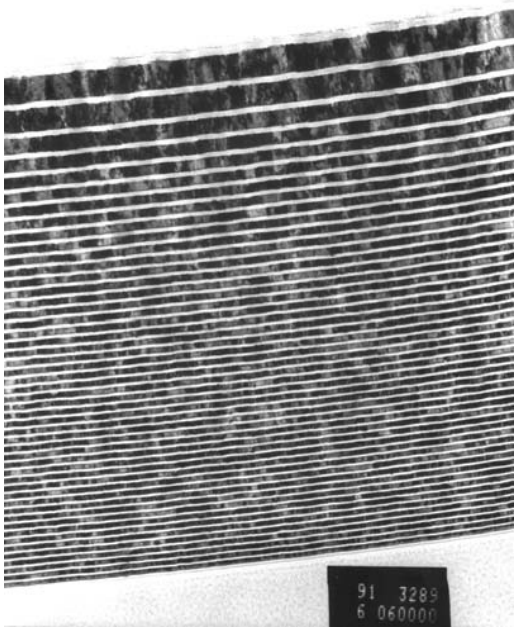
How do we measure polarization?



Analyser

$$I = \frac{I_0}{2}(1+\cos\varphi)$$

$$P = \frac{I^+ - I^-}{I^+ + I^-}$$

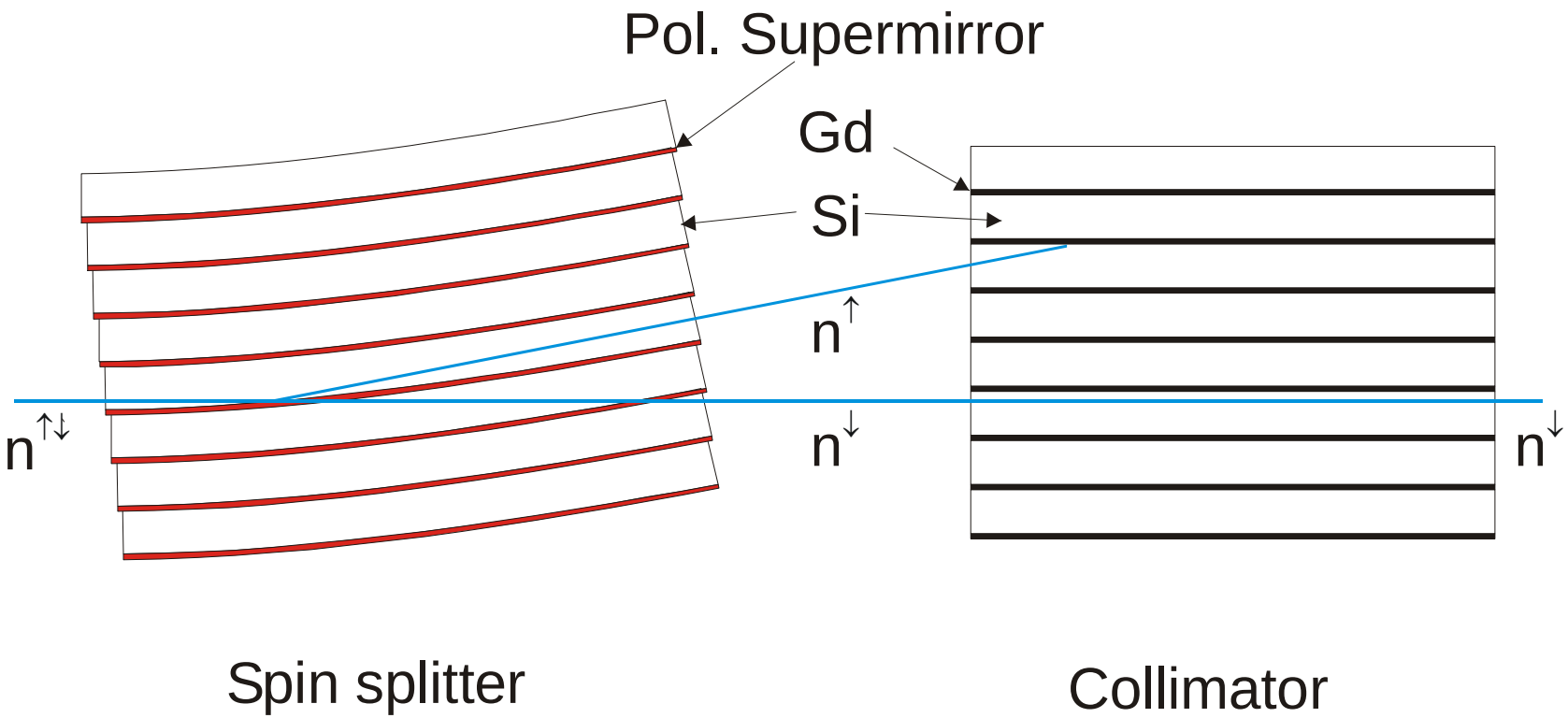


Purpose of a neutron polarizer:

- **Polarize the beam and look at the sample with polarized neutrons**
- **Analyze the polarization change introduced by the sample**

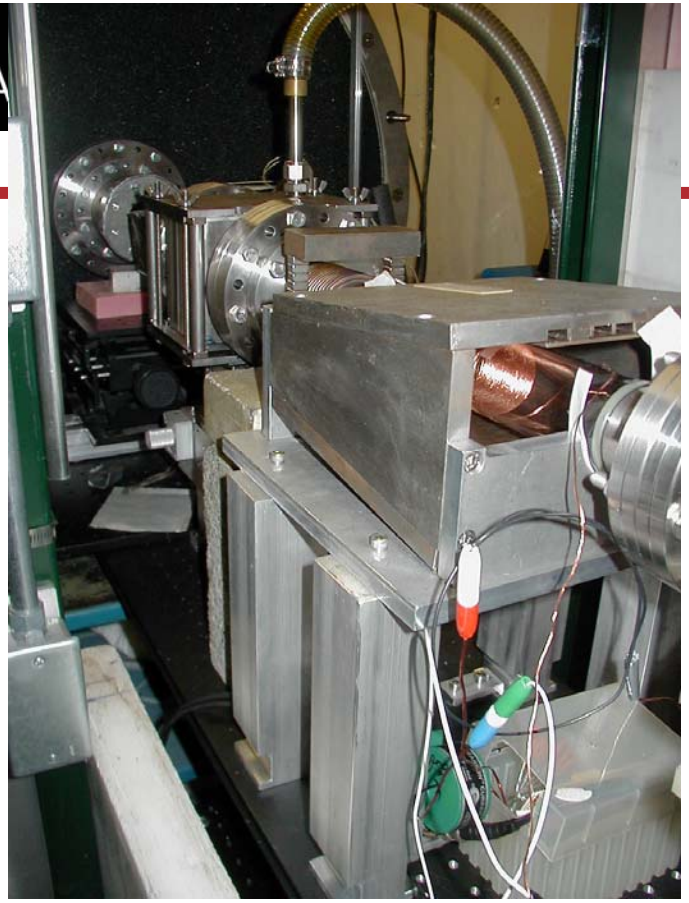
Polarizer

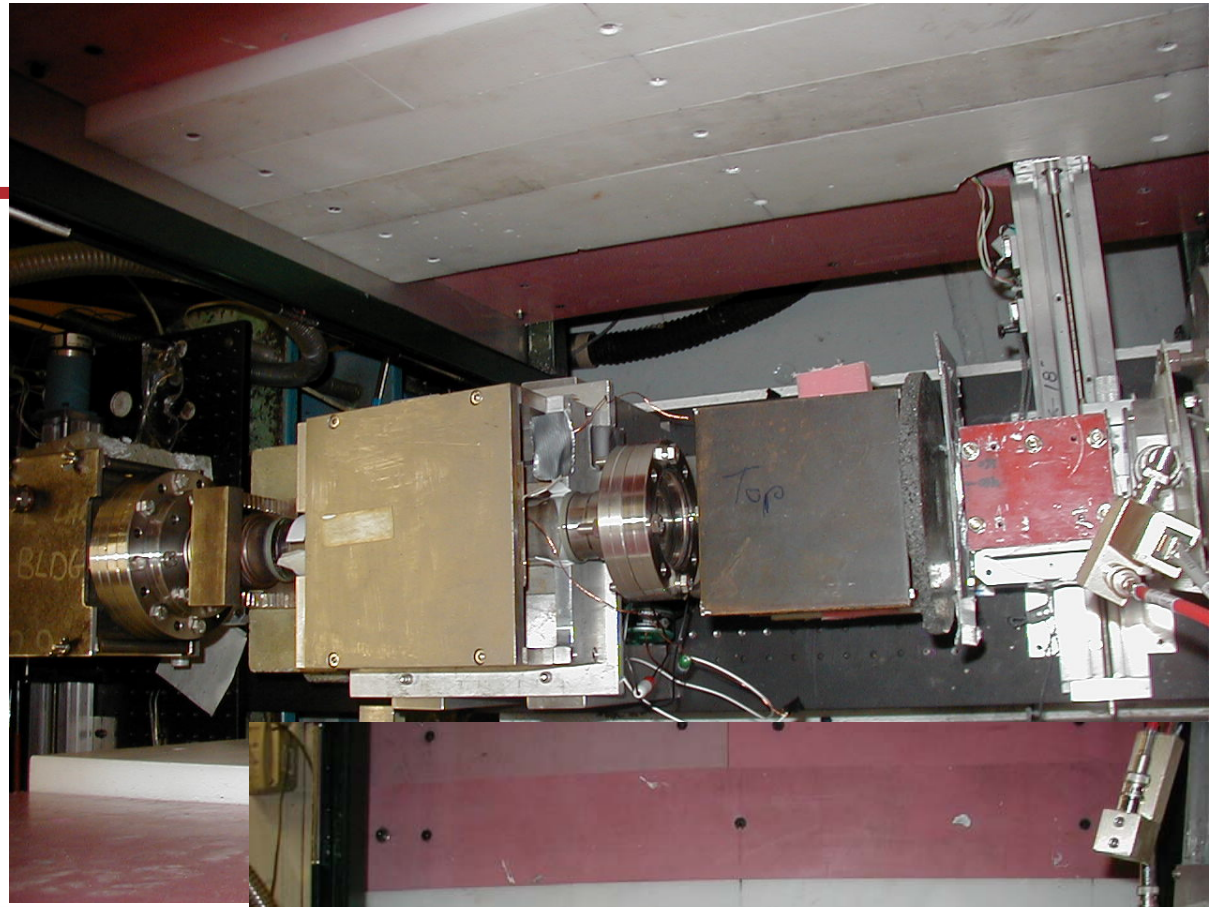
Bender used in transmission with collimator

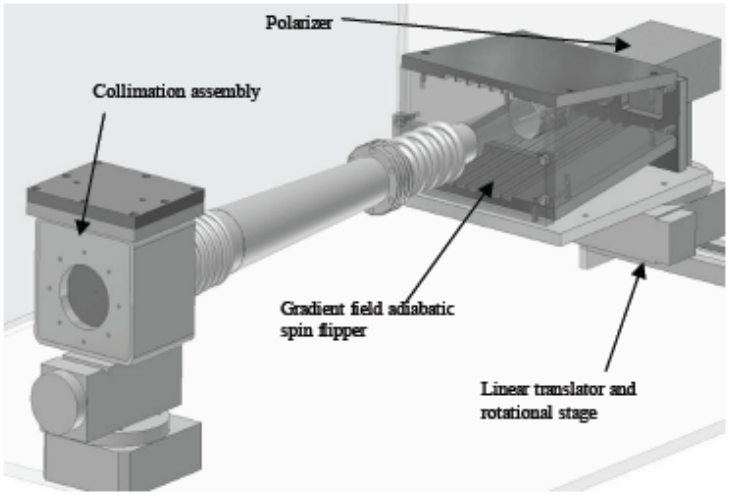


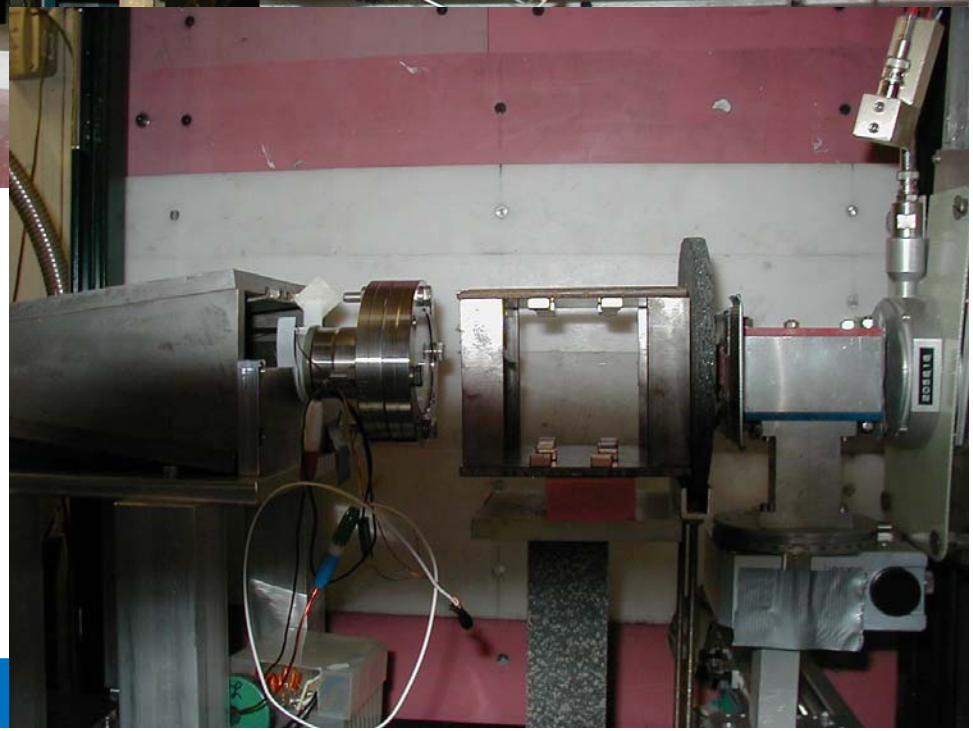
Thomas Krist

A

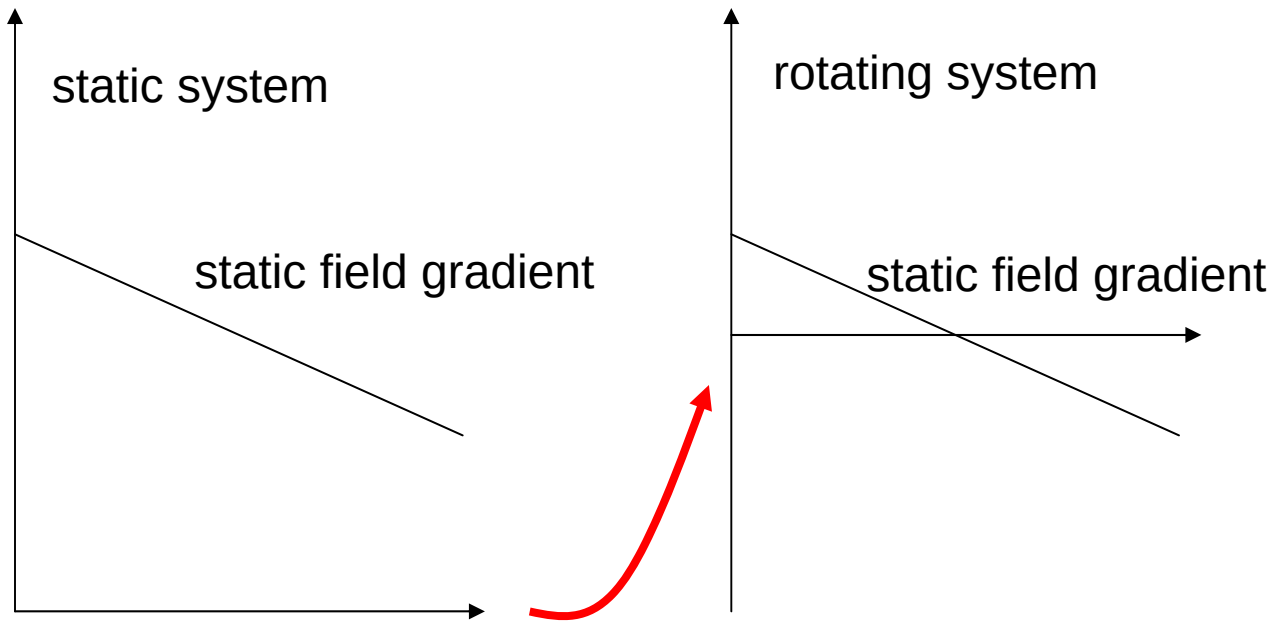



Top


Polarizer
Collimation assembly
Gradient field adiabatic spin flipper
Linear translator and rotational stage

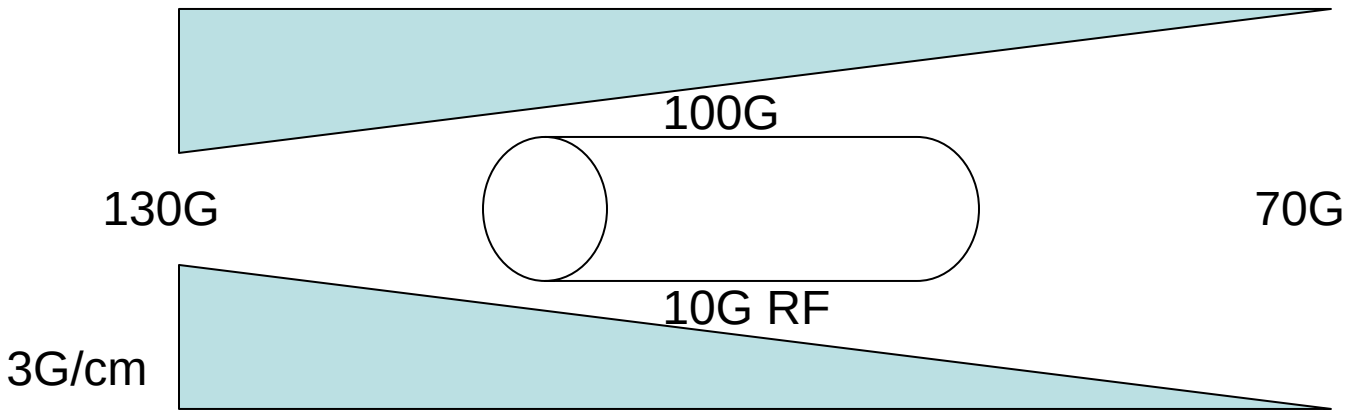


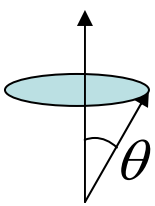
Spin flipper



$$\vec{B} = \vec{B}_0 + \vec{B}_r = \begin{pmatrix} B_r \cos(\omega_r \cdot t) \\ B_r \sin(\omega_r \cdot t) \\ B_0 \end{pmatrix} \xrightarrow{rot.\ System} \begin{pmatrix} B_r \\ 0 \\ B_0 - \omega_r/\gamma \end{pmatrix}$$

Spin flipper





$$\theta = \arctan(\omega_R / \gamma B_{eff})$$

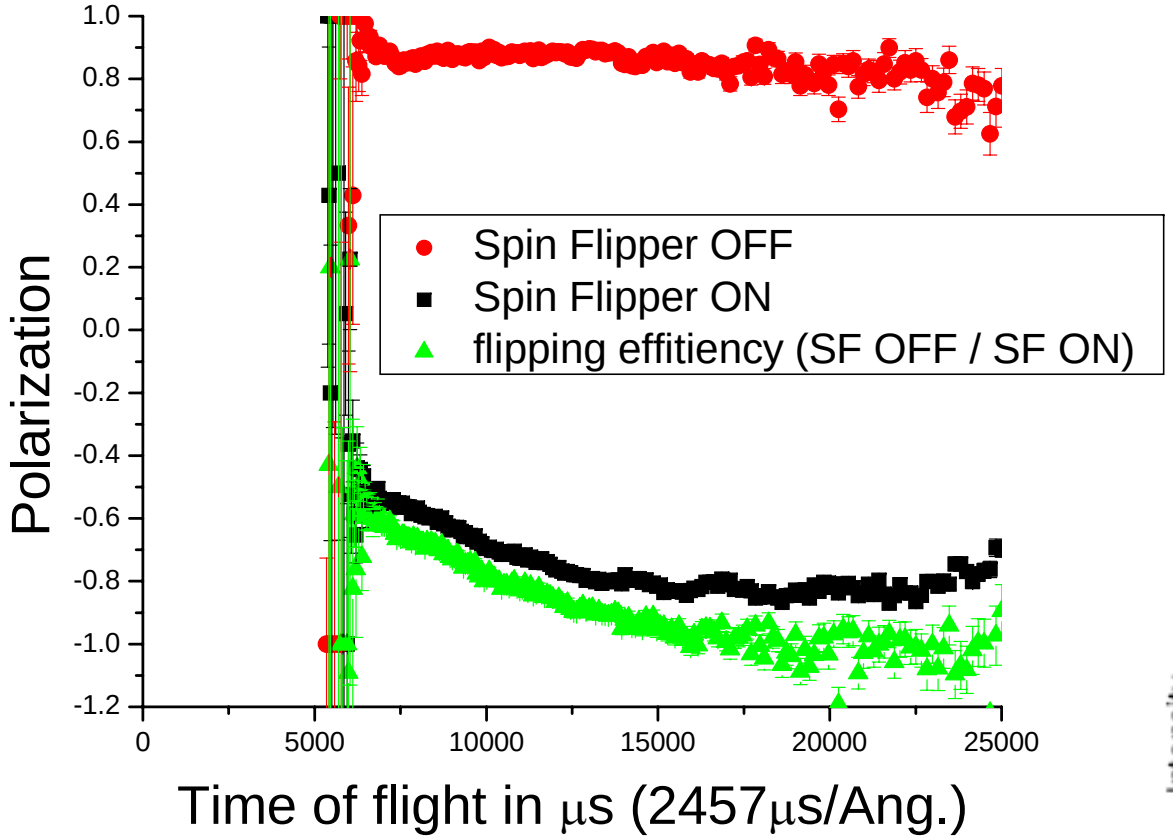
$$\gamma \approx 3kHz / G$$

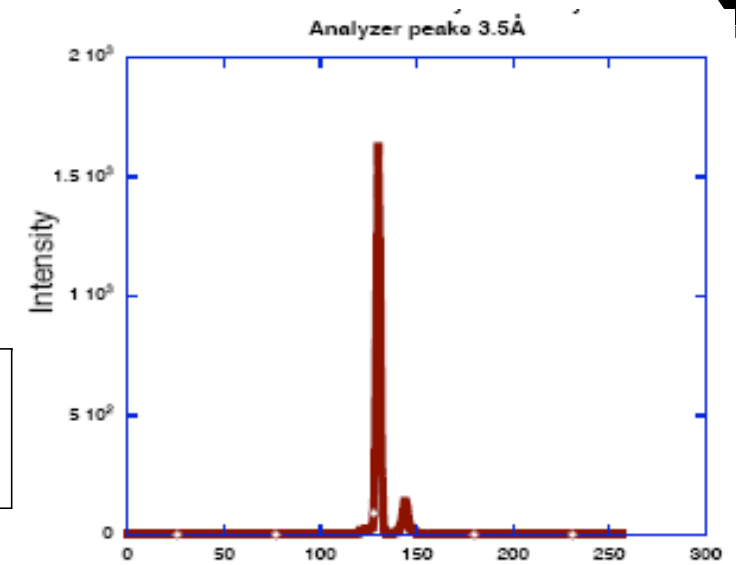
$$D = 1 - P = 1 - \cos\theta / 2 = 2.7\% \quad for \quad \gamma B_{eff} = 2\omega_R$$

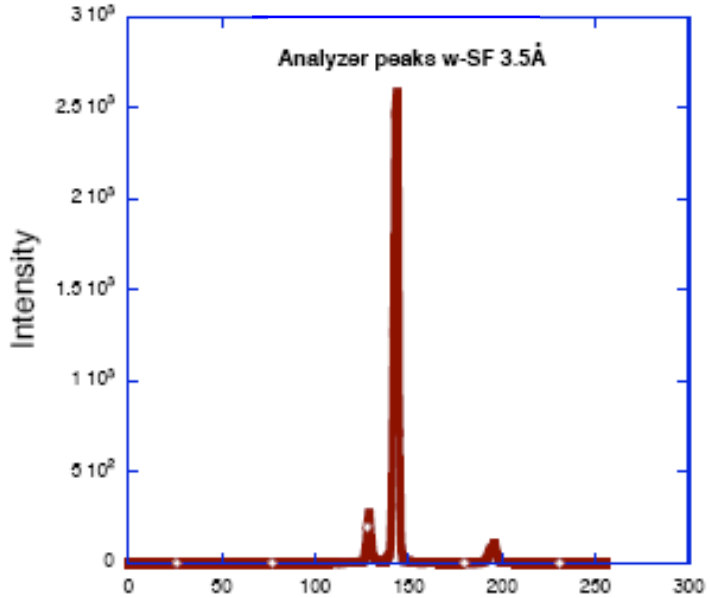
$$\omega_R = 2\pi v_n / L_{RF}$$

$$\Rightarrow B_{RF} = 7G \quad for \quad L_{RF} = 5cm \quad v_n = 1000m/s$$

Spin flipper

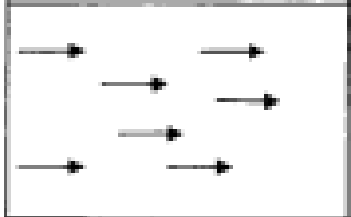
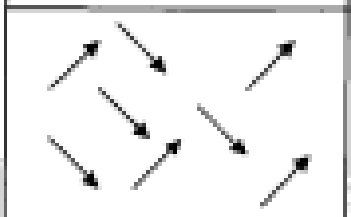






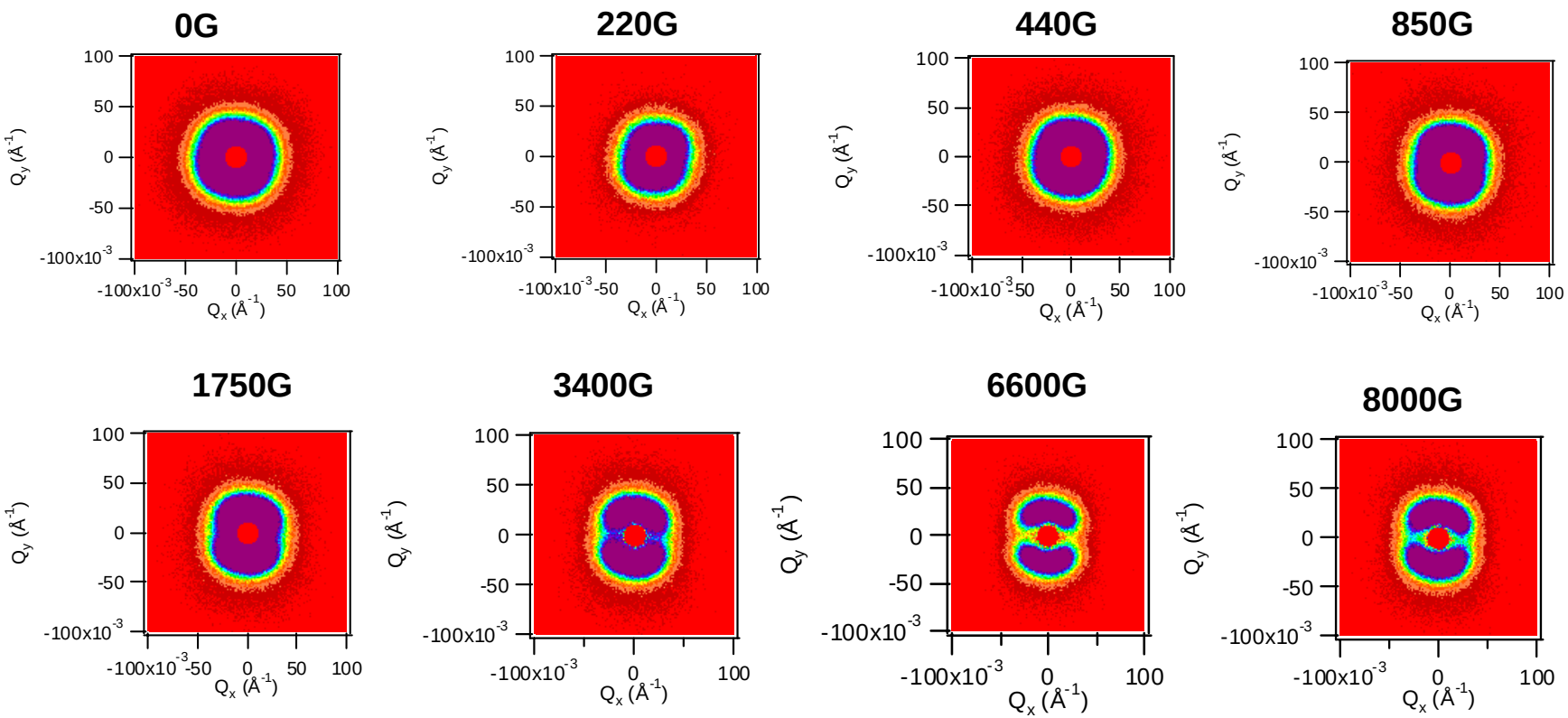
…just works fine!

Sample

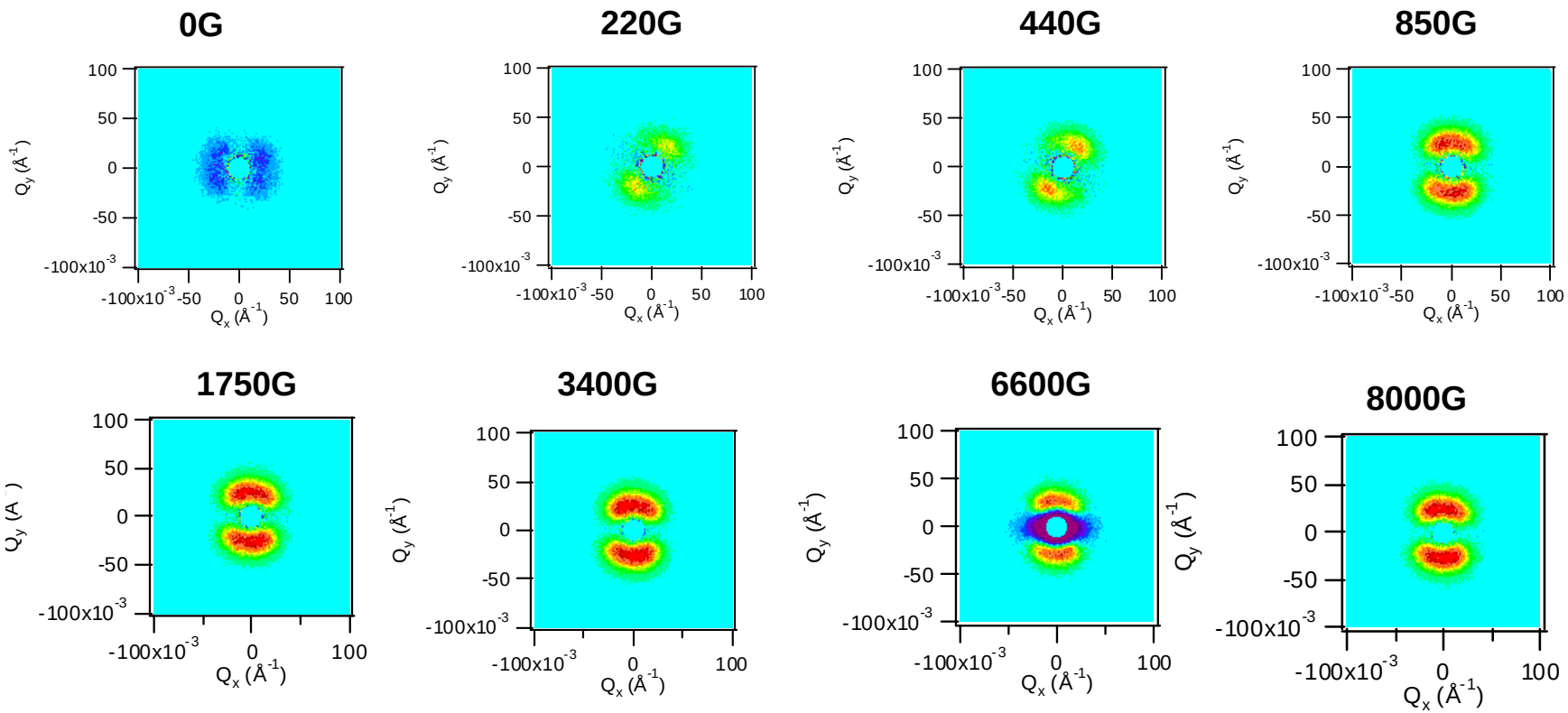
	Case i. random orientation	$\langle F_M^2(Q)\rangle = 2/3\Delta b_M^2 V_p^2 f^2(Q)$ $\langle F_M(Q)\rangle^2 = 0$
	Case ii. Magnetic saturation	$\langle F_M^2(Q)\rangle = \Delta b_M^2 V_p^2 f^2(Q)\sin^2\Psi$ $\langle F_M(Q)\rangle^2 = \Delta b_M^2 V_p^2 f^2(Q)\sin^2\Psi$
	Case iii. Trapped in easy directions ±45° to the field	$\langle F_M^2(Q)\rangle = 1/2\Delta b_M^2 V_p^2 f^2(Q)$ $\langle F_M(Q)\rangle^2 = 1/4\Delta b_M^2 V_p^2 f^2(Q)$
	Case iv. Trapped in easy directions at random, i.e. aligned ±45° and 180°±45° to the field	$\langle F_M^2(Q)\rangle = 1/2\Delta b_M^2 V_p^2 f^2(Q)$ $\langle F_M(Q)\rangle^2 = 0$

textured iron nanoparticles in copper

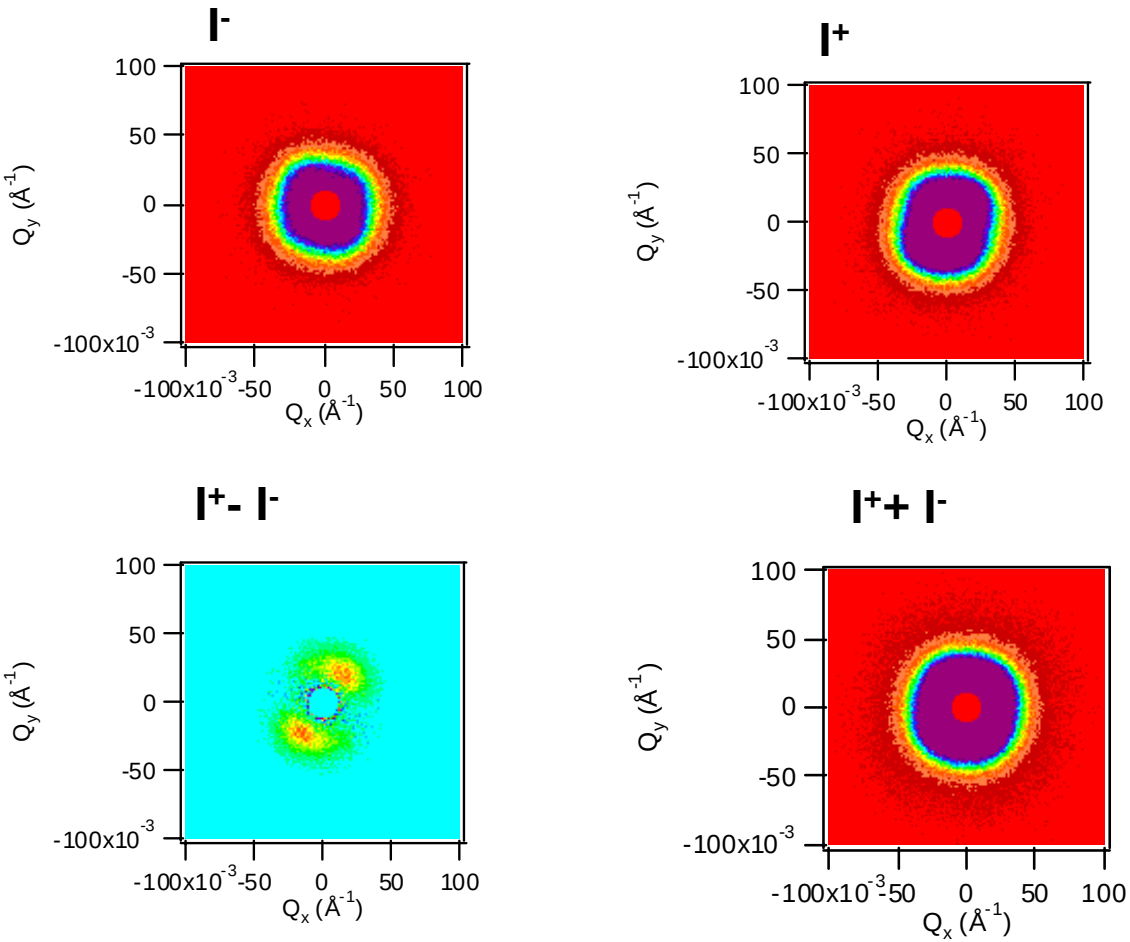
$I^{+} + I^{-}$ ~ unpolarized Scattering



$I^+ - I^-$ ~ magnetic Scattering



Spin dependent Scattering



220G

$$I^{+}(Q,\alpha) = F_N^2 + \{F_M^2 - 2\,P\,F_N F_M\}\sin^2\alpha$$

und

$$I^{-}(Q,\alpha) = F_N^2 + \{F_M^2 + 2\,P_B\,F_N F_M\}\sin^2\alpha,$$

Conclusion

Polarized SANS is possible at a pulsed neutron source

Magnetic scattering from nanoparticles is an interesting field