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# A neutron polariser based on magnetically remanent Fe/Si supermirrors

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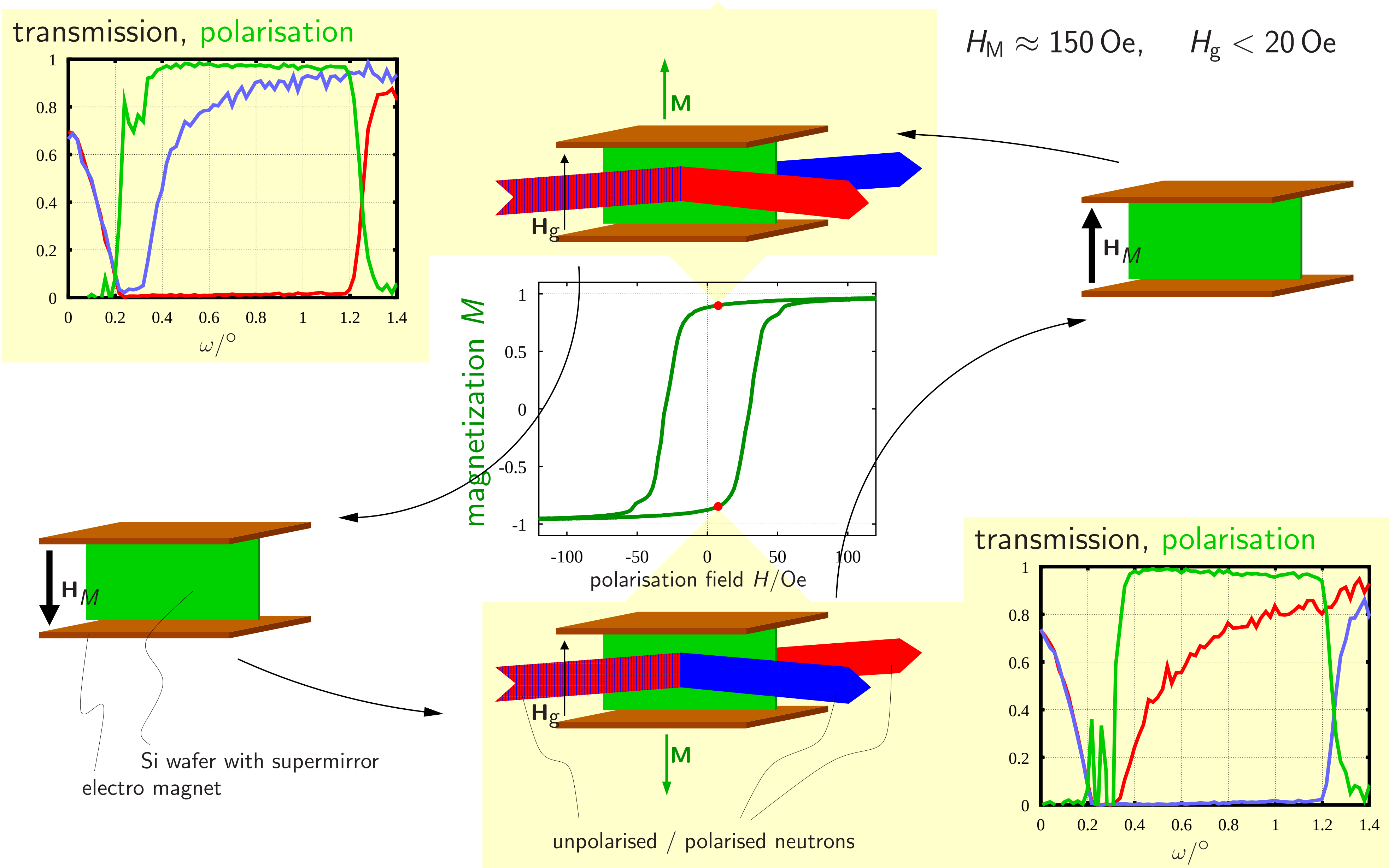
# remanent polariser application principle

$H_M \approx 150$ Oe, $H_g < 20$ Oe



## remanent polariser      material

ferromagnetic material: Fe

- might show easy axis of magnetisation
- almost matches Si for $|-\rangle$
- low absorption (required for transmission, less radiation damage)

spacer material: Si

- low potential
- matches the substrate (for transmission)
- low absorption
- can be influenced (potential and stress) by reactive sputtering

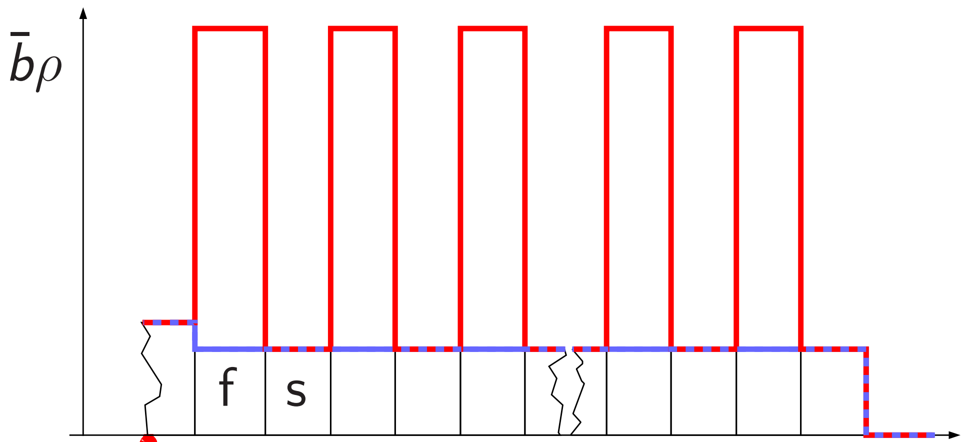
but

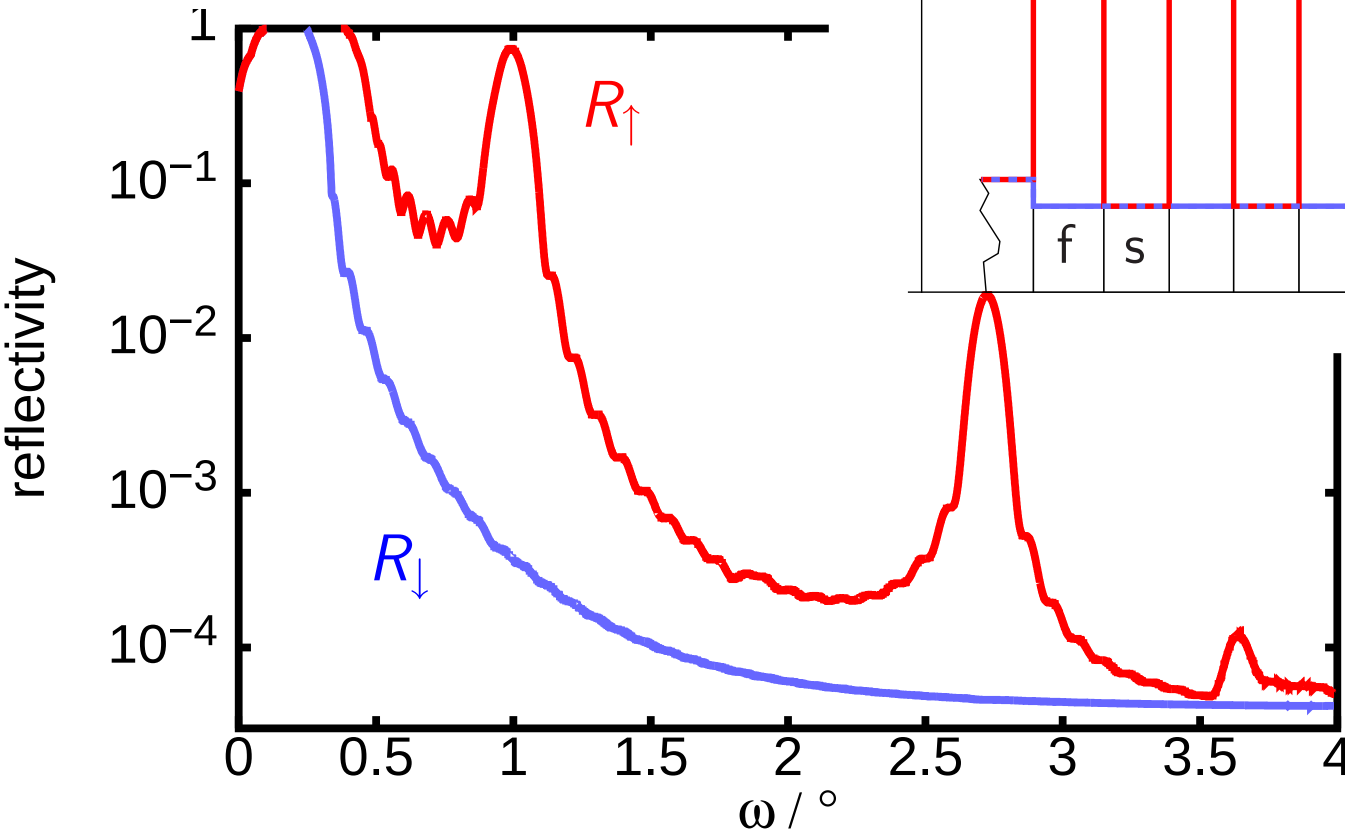
- rather low contrast for $|+\rangle$
  $\Rightarrow$ larger number of layers reqired
- total reflection for low $q$

# remanent polariser    ideal ml

$$(\bar{b}_f + \bar{p}_f)\rho_f \gg \bar{b}_s\rho_s, \qquad \bar{p}_s = 0, \qquad \text{ferromagnet}, \quad \text{spacer}$$

$$(\bar{b}_f - \bar{p}_f)\rho_f = \bar{b}_s\rho_s$$

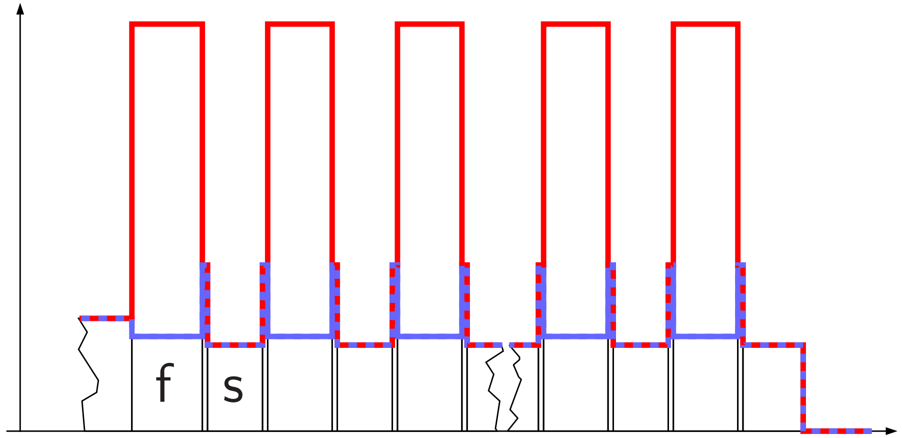


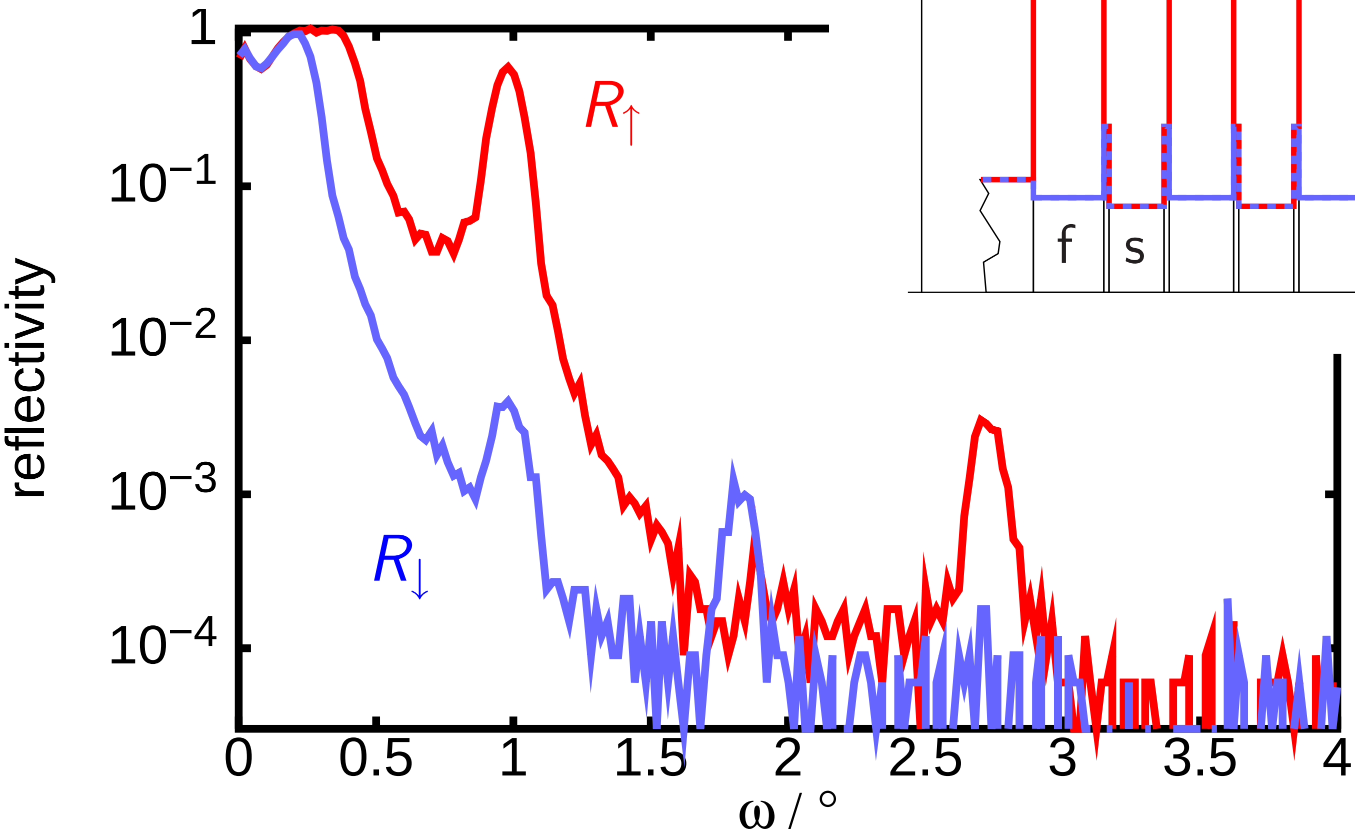



# remanent polariser real ml: Fe/Si:N:O

$$(\bar{b}_f + \bar{p}_f)\rho_f \gg \bar{b}_s\rho_s, \qquad \bar{p}_s = 0, \qquad \text{ferromagnet}, \quad \text{spacer}$$

$$(\bar{b}_f - \bar{p}_f)\rho_f \approx \bar{b}_s\rho_s$$




interdiffusion

⇒ mag. dead layers

⇒ 2nd order peak

## **remanent polariser** **magnetic properties**

anisotropic in-plane stress

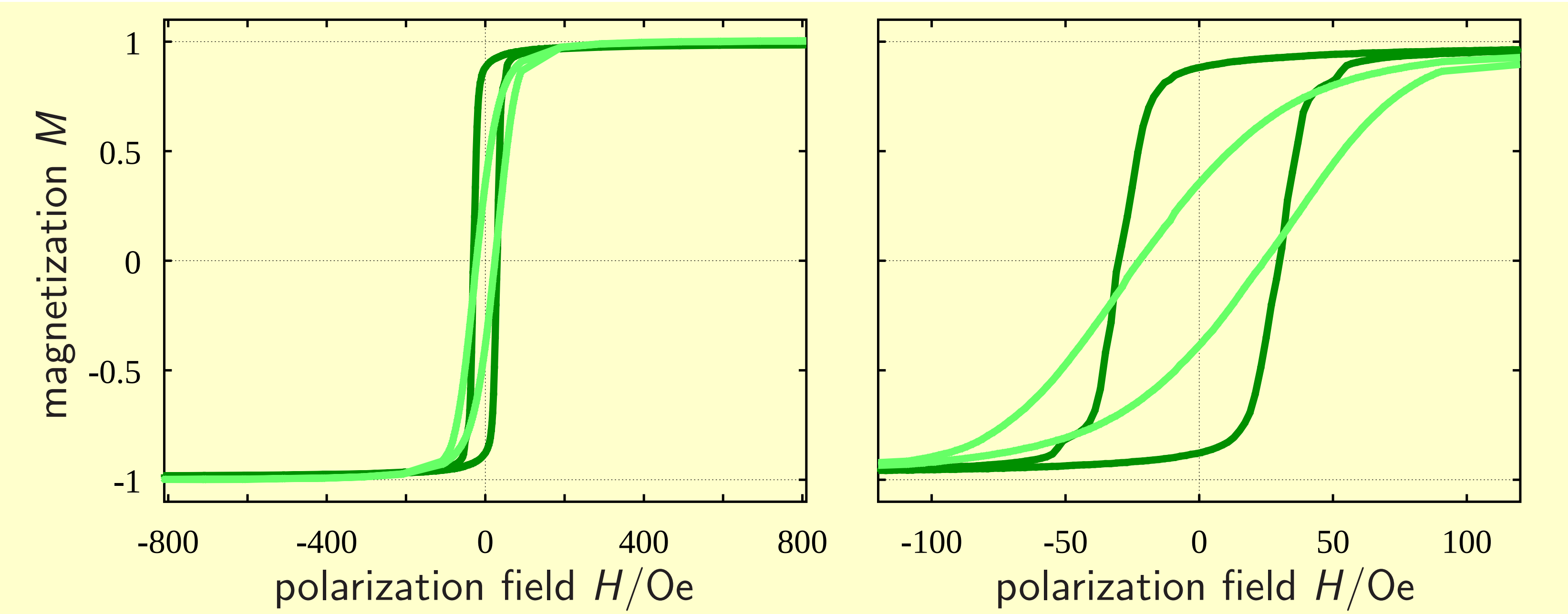
causes anisotropic magnetic properties (magnetostriction)

reason: shape of sputter target and aperture (ca. $100 \times 400\,\mathrm{mm}^2$)

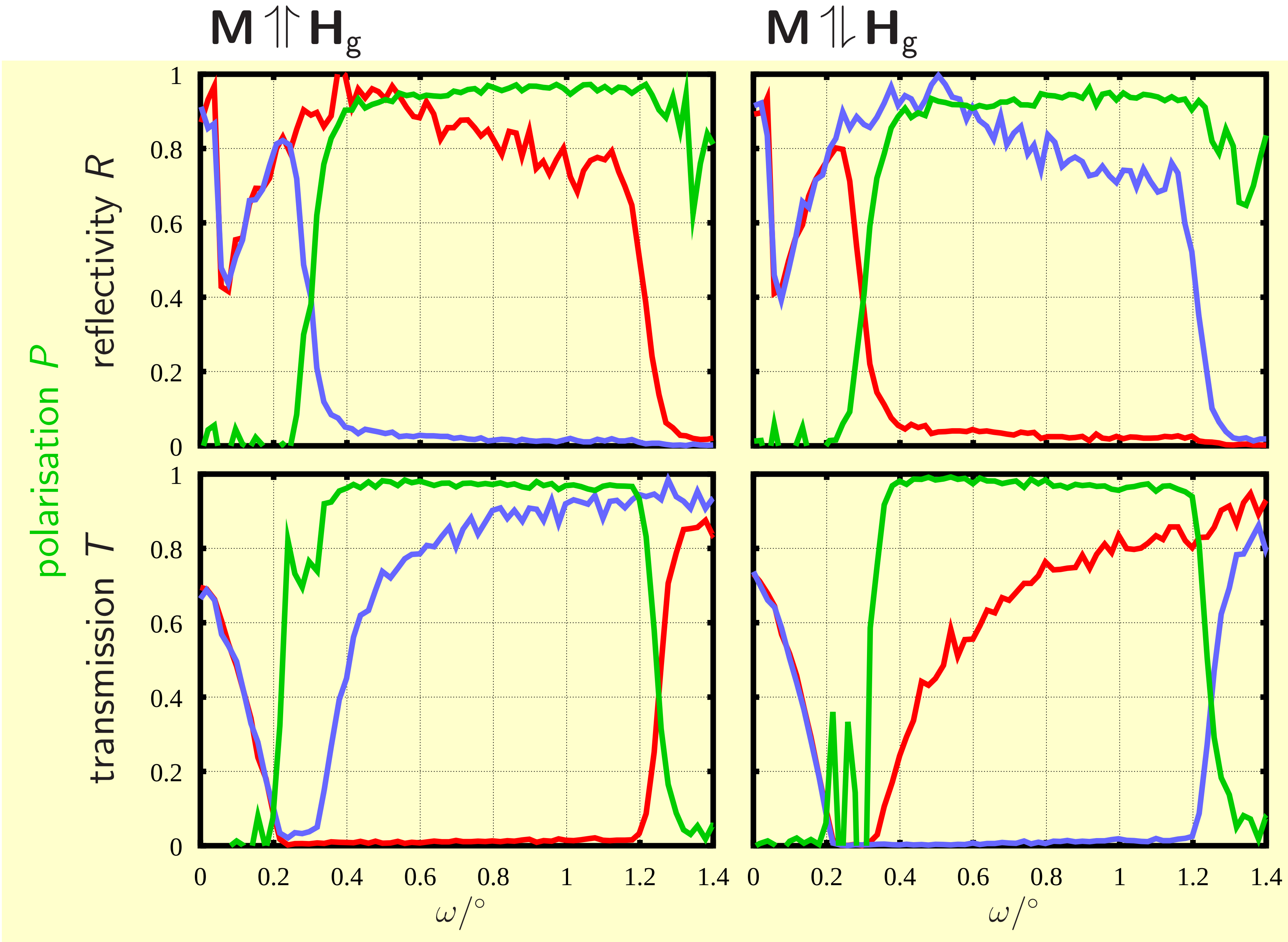
⇒ spread of angle of incidence of sputtered atoms is anisotropic

⇒ growth and thus strain formation is effected

⇒ easy axis of magnetisation requires strained filmes!



# remanent polariser performance



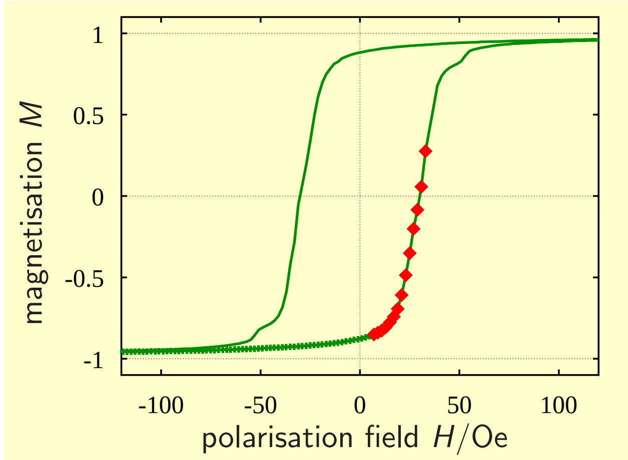

$H_g = 15$ Oe
$H_M = 200$ Oe
$\lambda = 4.74$ Å

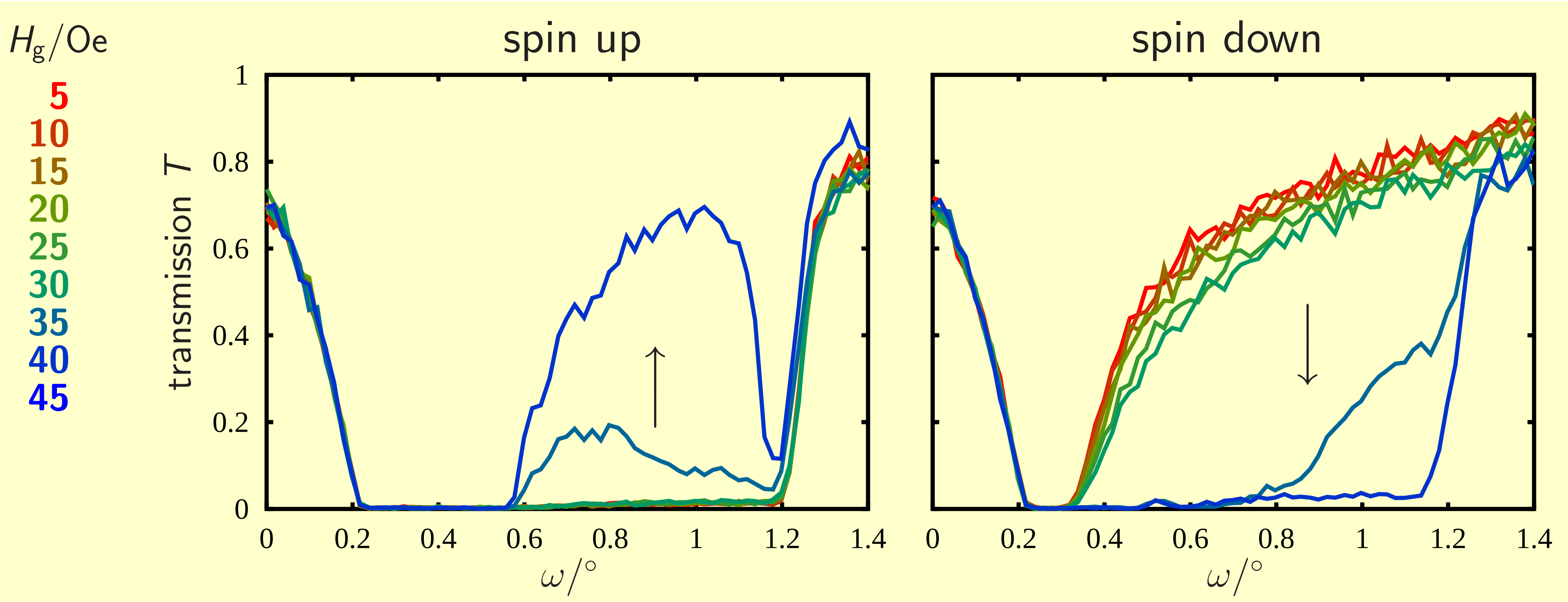
# remanent polariser $H_c$ vs. layer thickness

saturation in $H = -700\,\text{Oe}$

transmission measured in guide fields

$$H_g = +5 \ldots +45\,\text{Oe}$$



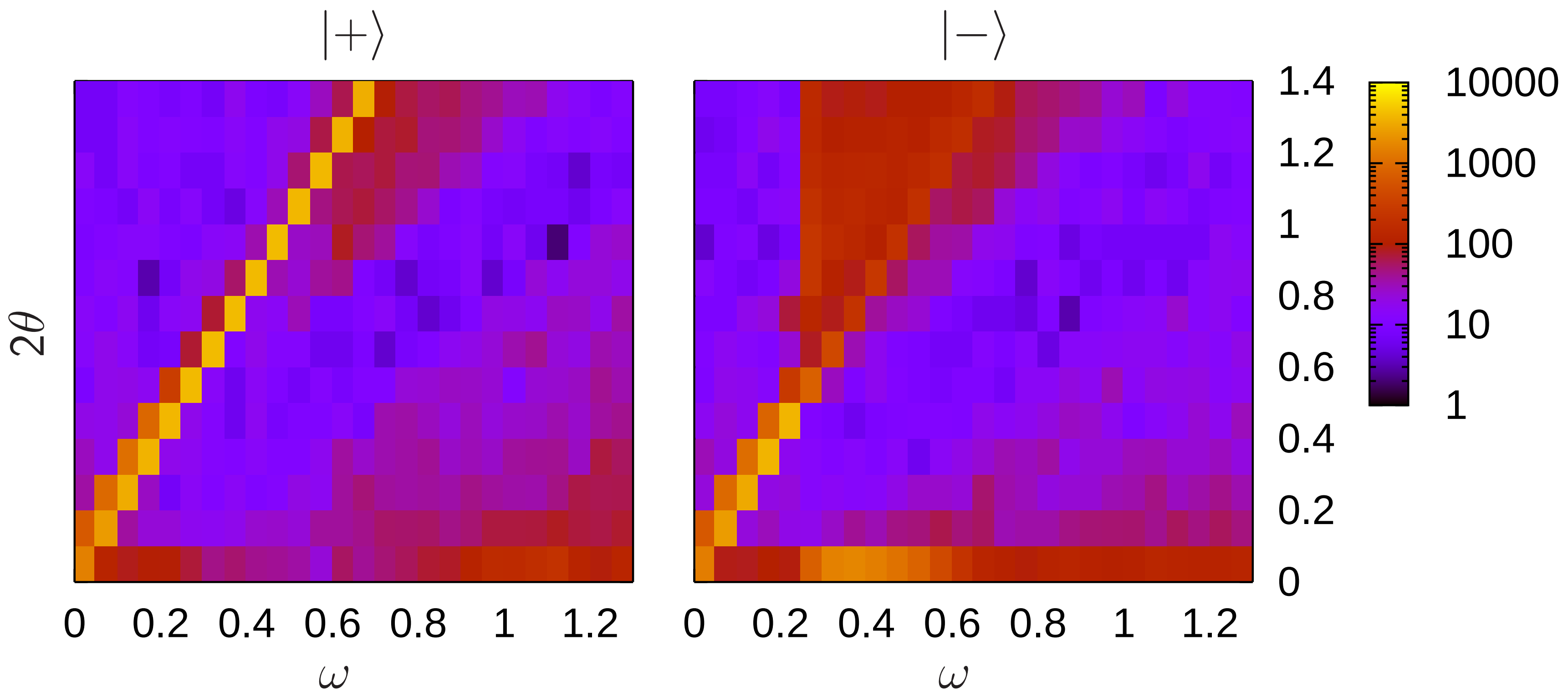
## remanent polariser off-specular scattering

polarised beam, no spin analysis

Fe/Si:N:O sm, $m = 2.4$

assymetric off-specular signal

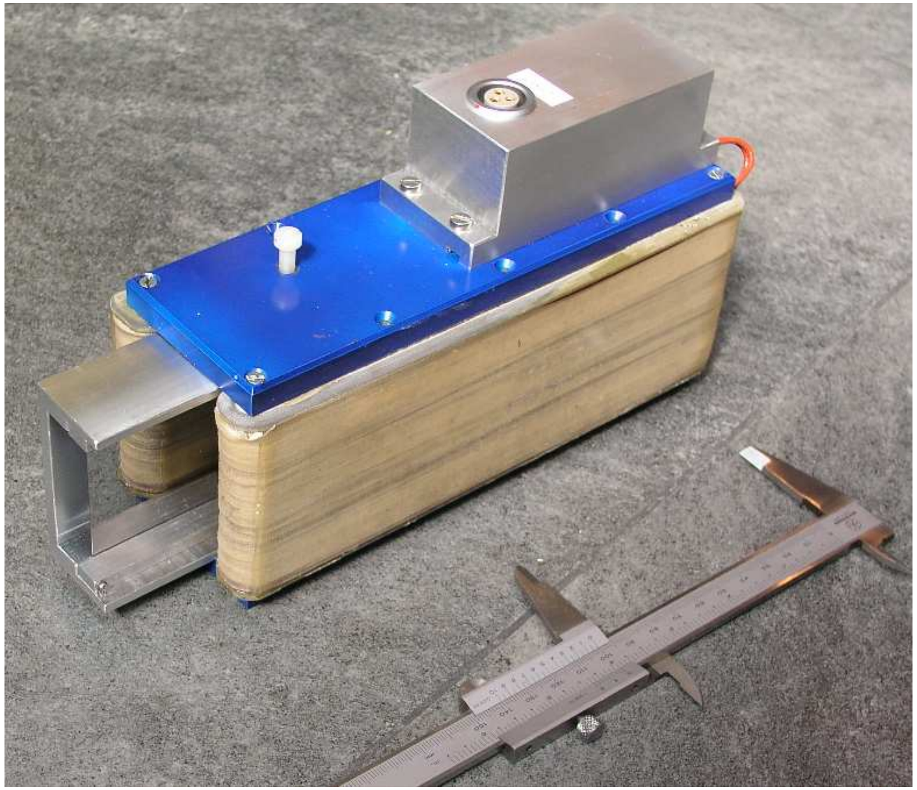
$\Rightarrow$ weak spin-flip scattering



# **remanent polariser** **applications: analyser**

at Morpheus, Narziss (SINQ)

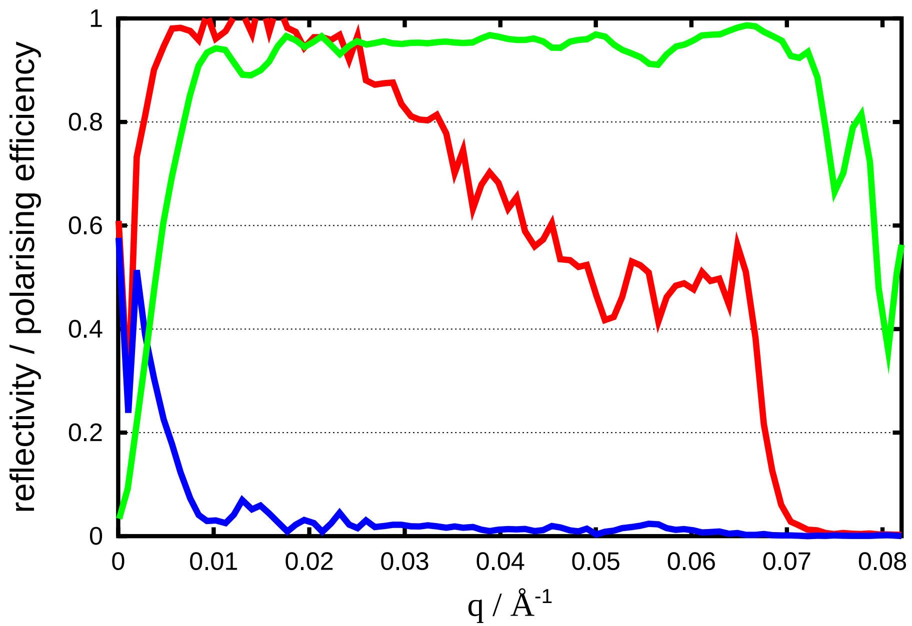
| | |
|---|---|
| coating | Fe / Si:N:O |
| | $m = 3$, 599 layers |
| substrate | Si-wafer, 0.6 mm |
| mirror size | $200 \times 60\,\text{mm}^2$ |
| magnet size | $200 \times 100 \times 100\,\text{mm}^3$ |
| $B_M$ | 200 Oe |
| $B_g$ | 20 Oe |
| $P_{T,\upuparrows}$ | $> 97\,\%$ |
| $P_{T,\upharpoonleft\downharpoonright}$ | $> 95\,\%$ |

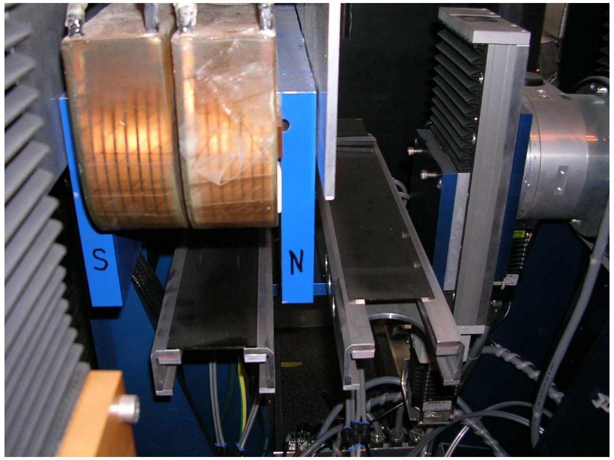


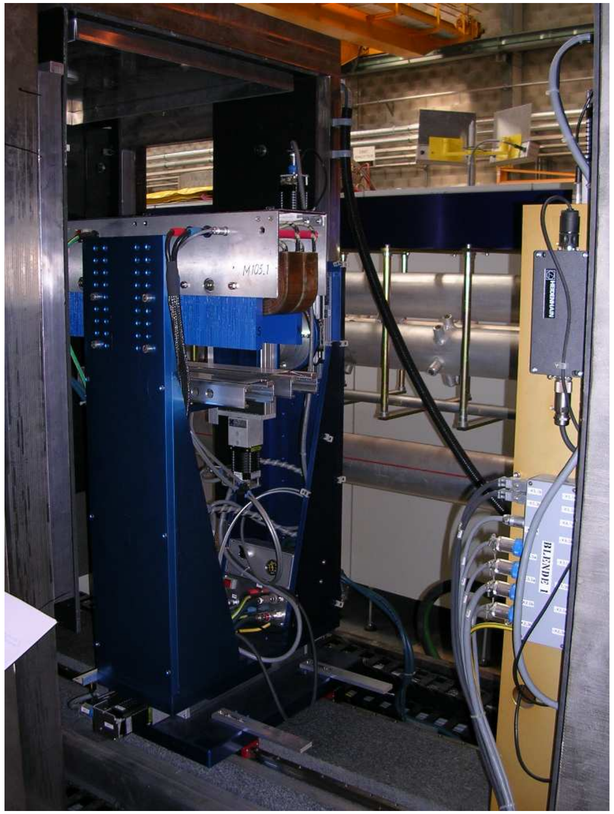
# remanent polariser applications: switchable polariser

at Amor (SINQ)

- FeCoV/TiN on glas
- operated in reflection mode
- saturation fields: ±400 Oe
- guide field: +20 Oe

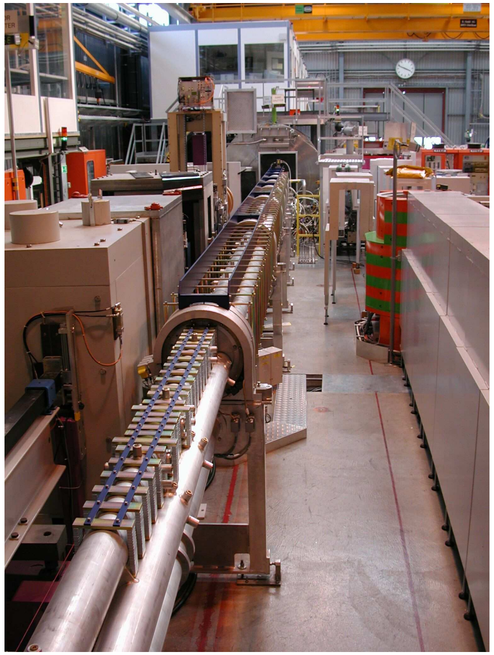


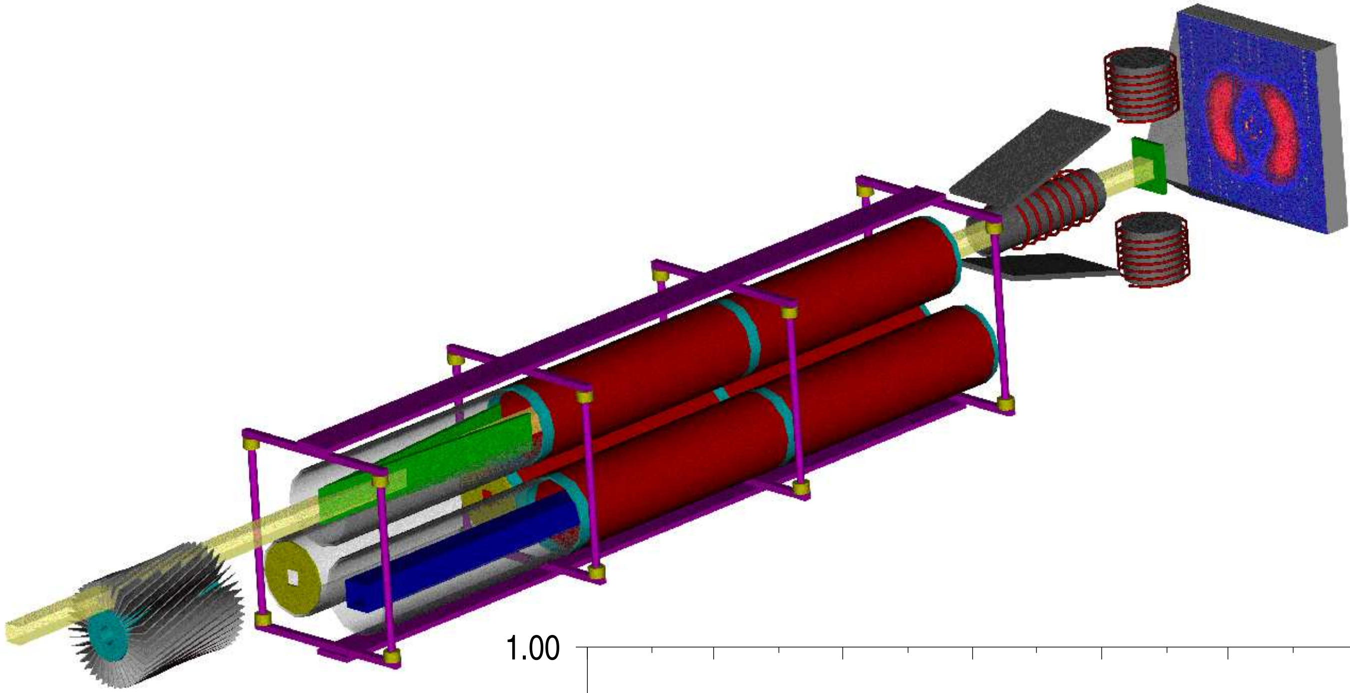



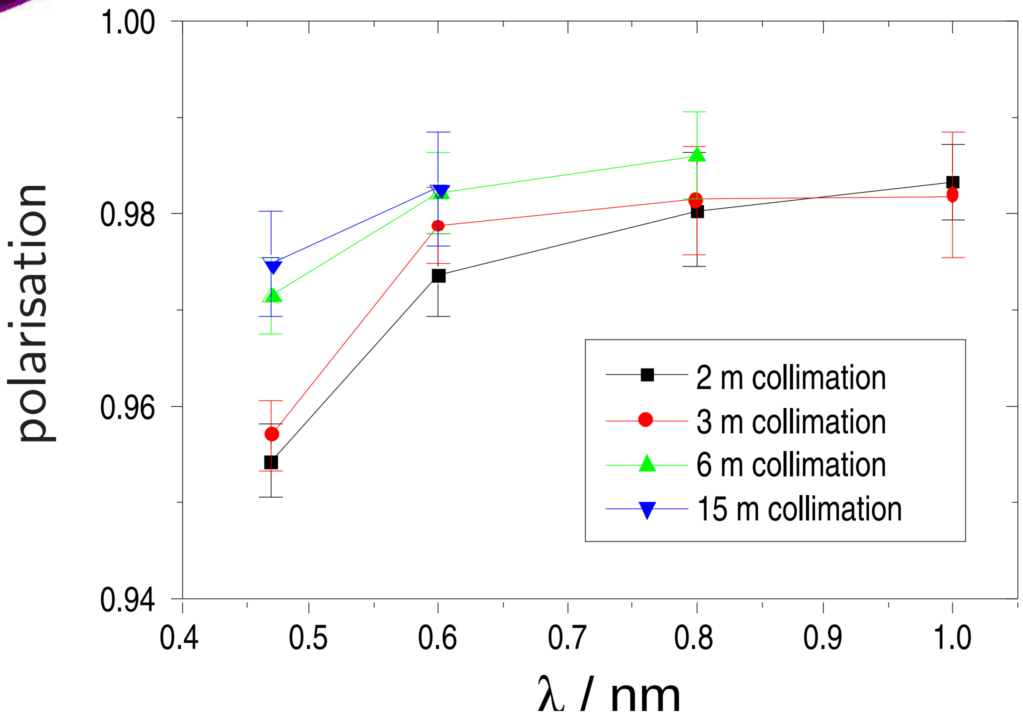
## remanent polariser applications: white beam polariser

at SANS I (SINQ)





| | |
|---|---|
| coating | Fe / Si:N:O |
| | $m = 2.4$, 299 layers |
| substrate | Si-wafer, 0.6 mm |
| mirror size | $200 \times 6\,\mathrm{cm}^2$ |



## remanent polariser conclusion:

we produced supermirrors with Fe and Si:N:O which
- polarise neutrons ($P > 95\,\%$ to $P = 99\,\%$)
- can be operated in transmission and reflection mode
- show a magnetic remanence
- thus need guide fields of 20 Oe, only
- can be operated antiparallel to the guide field

the reactive gases $N_2$ and $O_2$ in Si are needed to
- match the potentials for $|-\rangle$
- tailor strain in Fe layers (anisotropic stress), but
- keep the overall stress small

limitations:
- stress limits the number of layers $\Rightarrow m < 3$
- FeSi layer causes 2nd Bragg peak
  $\Rightarrow |-\rangle$ contamination in reflection mode