Generation of circularly polarized light by the use of a quadruple reflection polarizer

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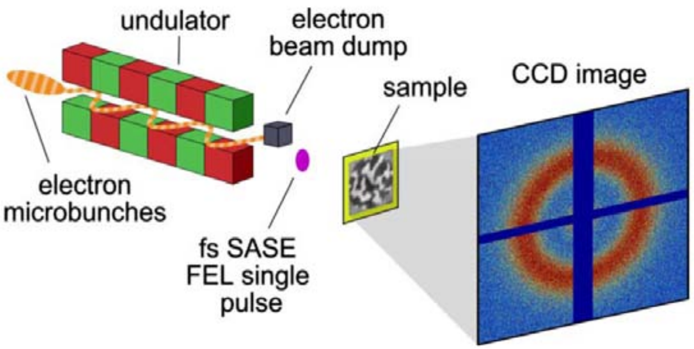
FEL: single-shot small angle x-ray scattering

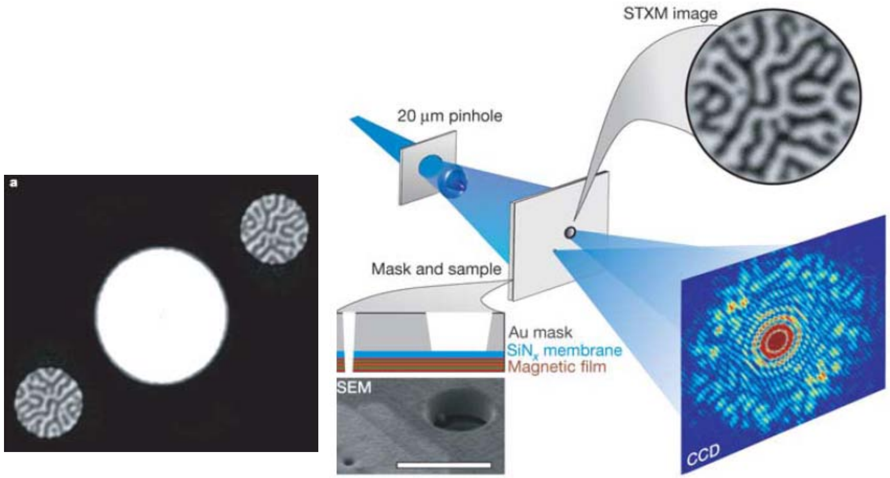


C. Gutt et al., PRB 81 (2010)

Only linear light!

Tomorrow: B.Pfau , 10:50

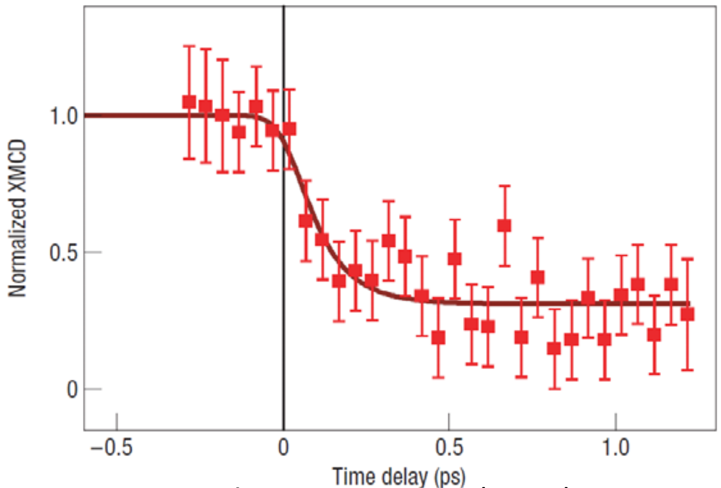
Synchrotron: Fourier-Transform Holography



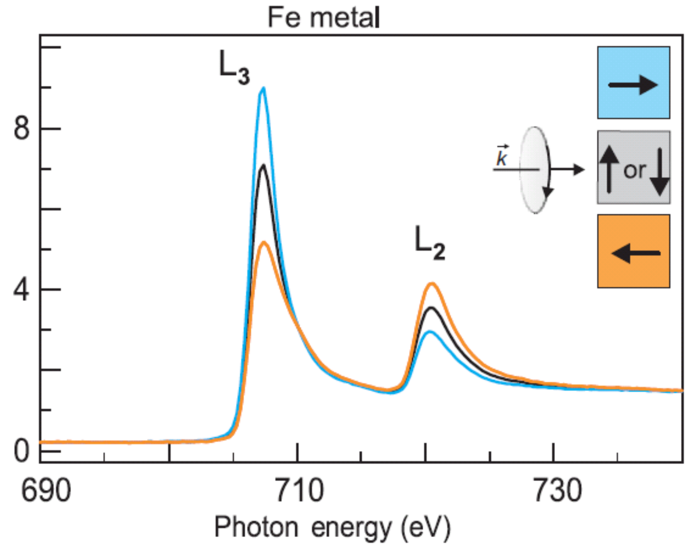
S. Eisebitt et al., Nature (2004)

FTH is single-shot applicable!

Synchrotron experiments at L3 edge energy (ca. 780 eV)



C. Stamm et al., Nat. Mater. 6 (2004)

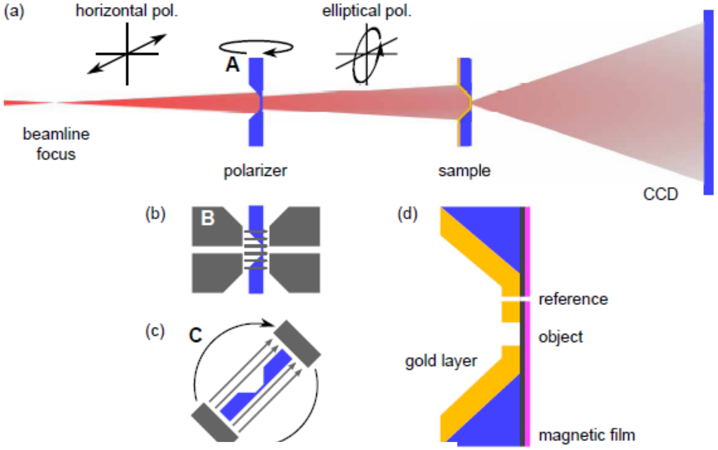


J. Stöhr, H.C. Siegmann: *Magnetism*, Fig. 9.12

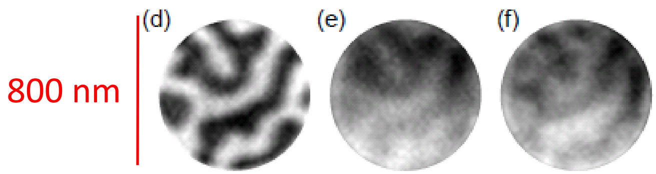
Several minutes accumulated!

Single-shot imaging of magnetic structures requires circular polarization!

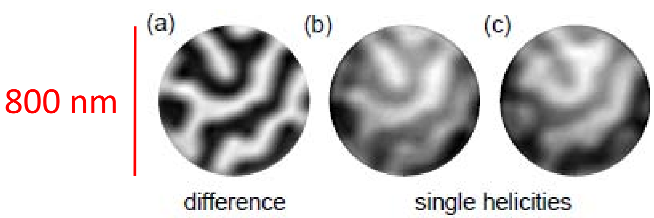
Synchrotron experiments at Cobalt L3 edge



Linear polarization + polarizer

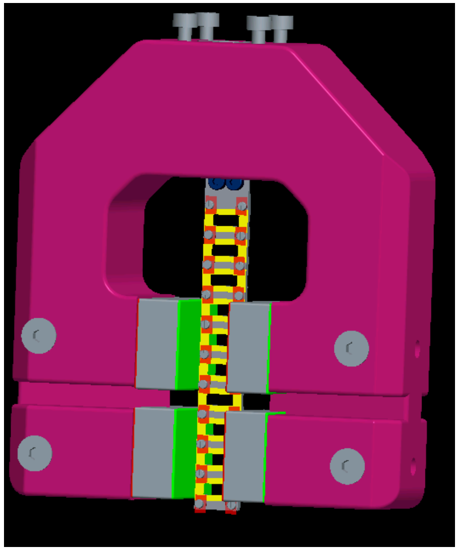


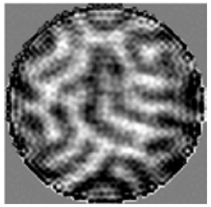
90% Circular polarization from undulator



B. Pfau et al., Opt Express 18 (2010)

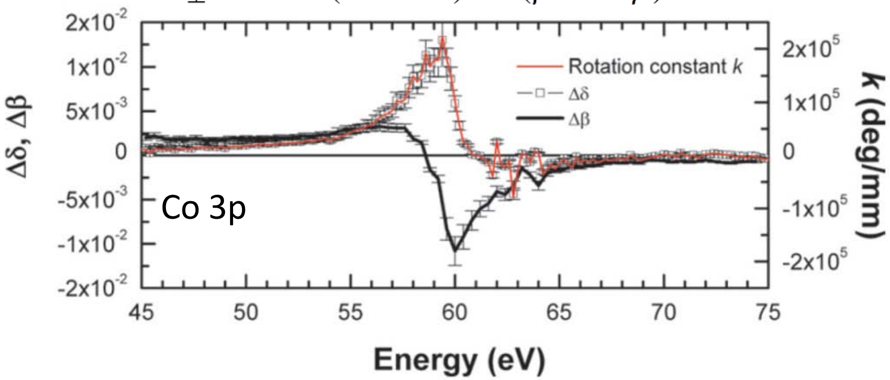
LCLS 2010, single shot, Cobalt L3 edge



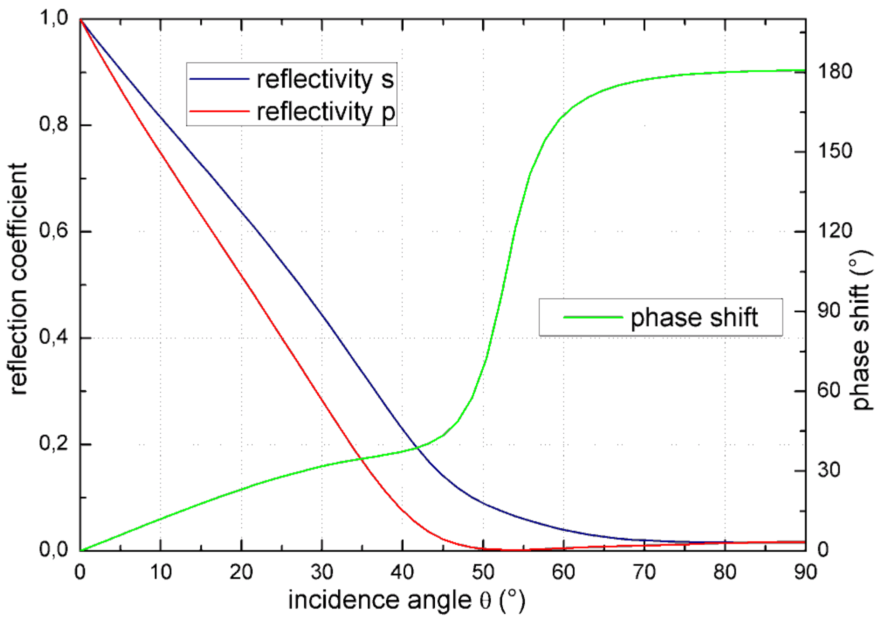


TP² for transmission polarizers at element resonance typically < 10%.

$$n_{\pm} = 1 - (\delta \pm \Delta\delta) + \mathrm{i}(\beta \pm \Delta\beta)$$



S. Valencia et al., New J. Phys. 8 (2006)



Transmission vs. reflection polarizer:

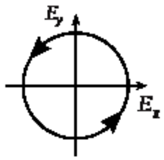
- weaker XMCD at compared to L3
- low transmission
- good reflectivities
- tranmission polarizer only works at resonant energies

→ **Transform linear light into circularly polarized light by reflection!**

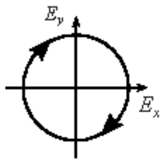
Circularly polarized light:

$$|E_x| = |E_y|$$

$$\Delta = \pm 90^\circ$$



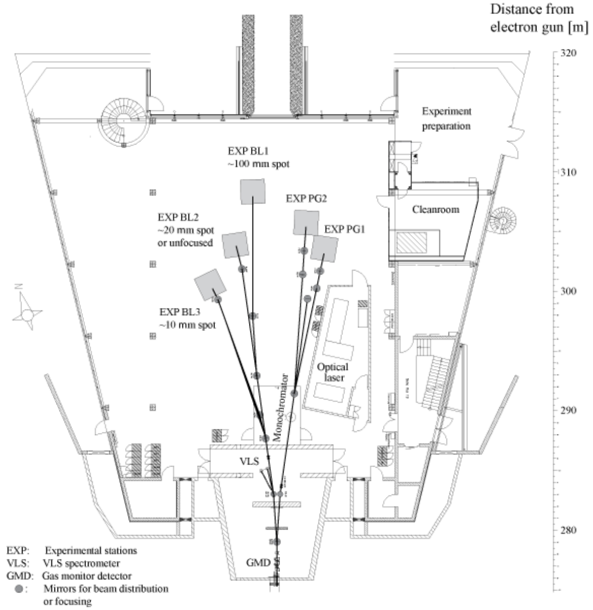
left



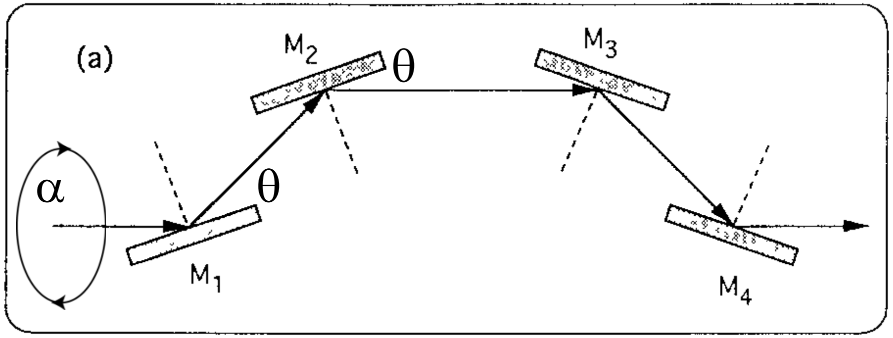
right

Desired features of a polarizer

Major criterion: on-axis design for easy integration into existing beamline.



quadruple reflection polarizer



H. Höchst et al., Nucl. Instrum. Methods Phys. Res., Sect. A 347 (1994)

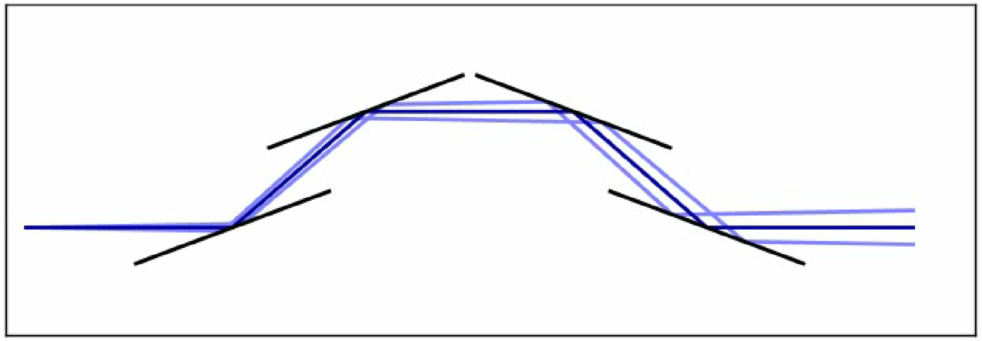
- must be completely removable from beam path during operation
- minimum change of divergence and high pointing stability

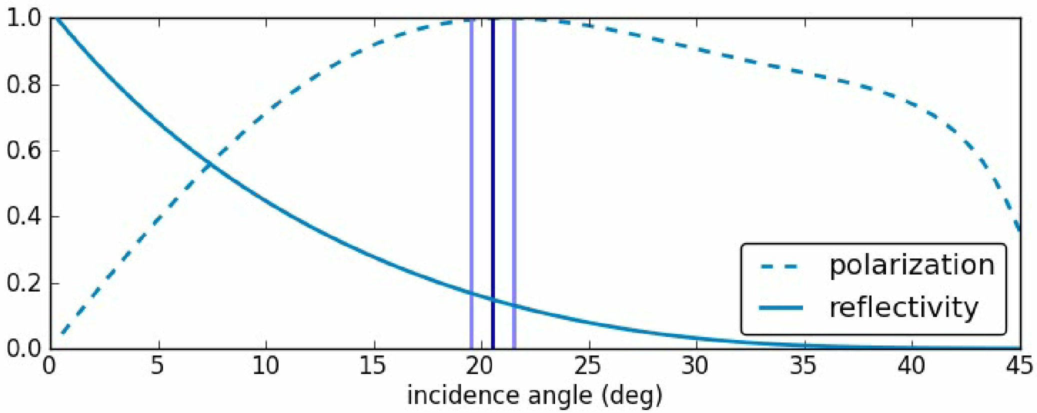
- high degree of circular polarization and/or figure of merit TP^2
- switching between left and right helicity

Quadruple reflection polarizer with 4 plane mirrors

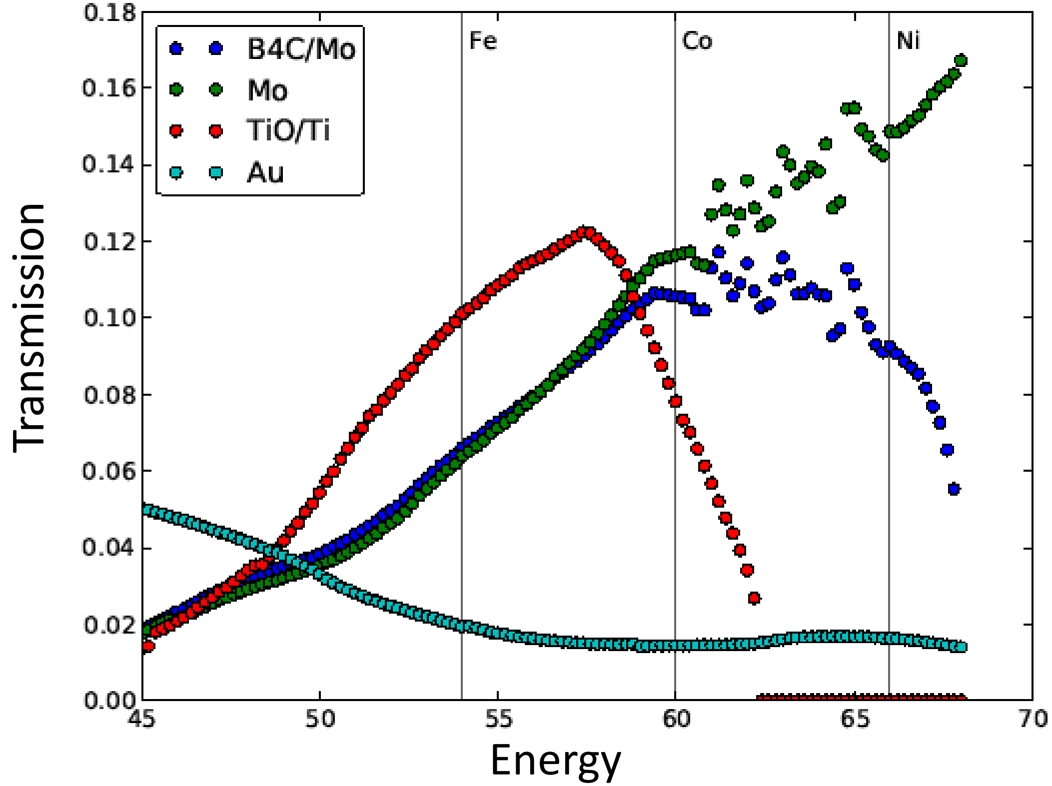
$$R_s^4 = T_{s,tot} \stackrel{!}{=} T_{p,tot} = R_p^4$$

$$\Delta_{tot} = 4\Delta \stackrel{!}{=} \pi/2$$

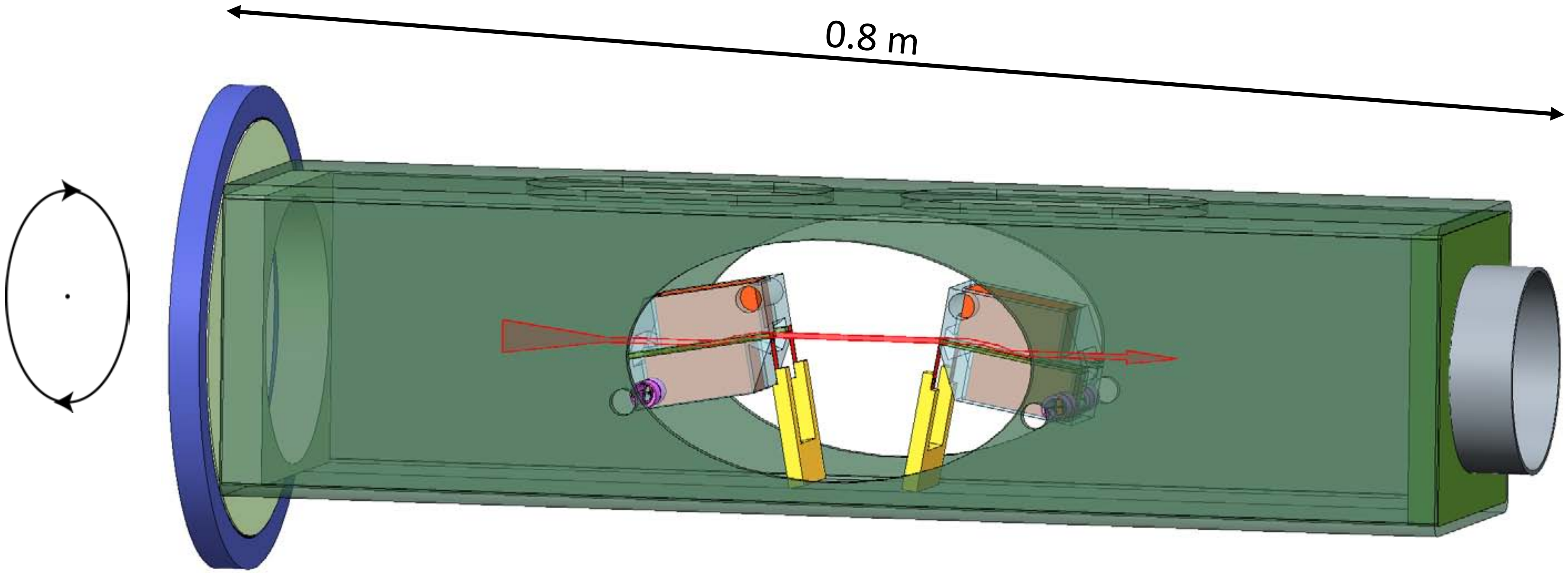




Transmission for P=1 after 4 reflections, refractive indices from cxro

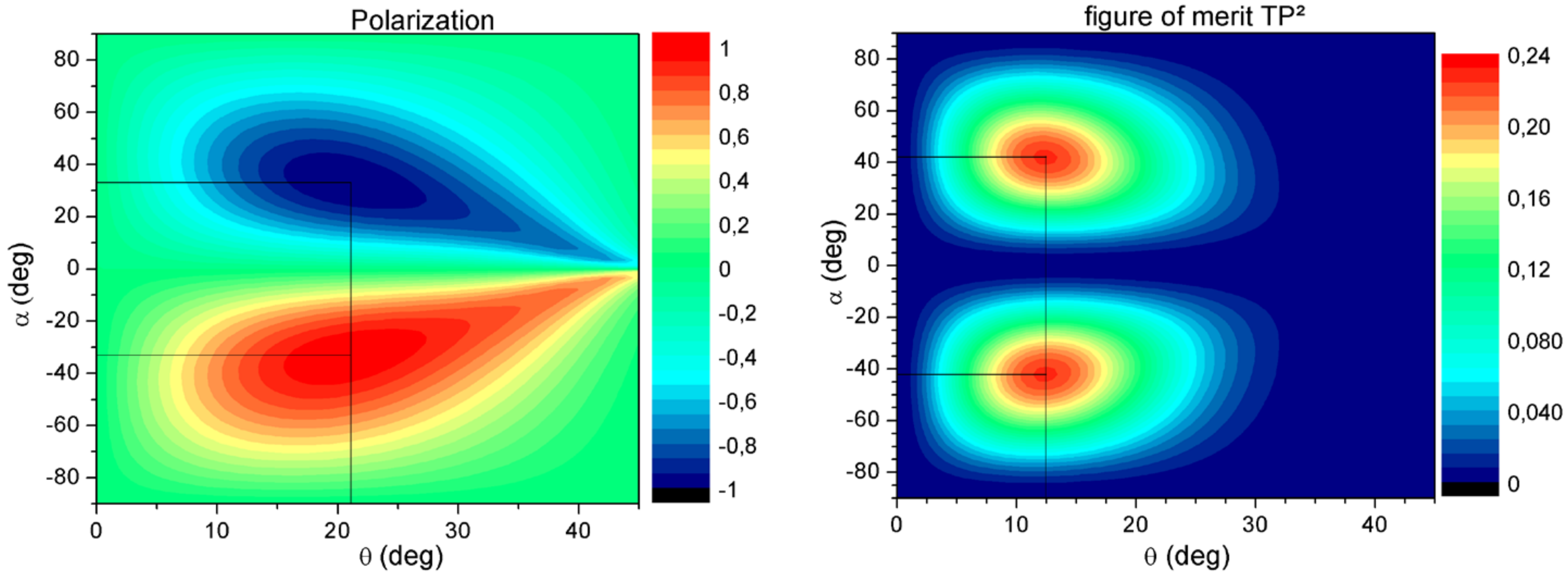


Molybdenum yields the best phase shifting properties in the desired energy range.

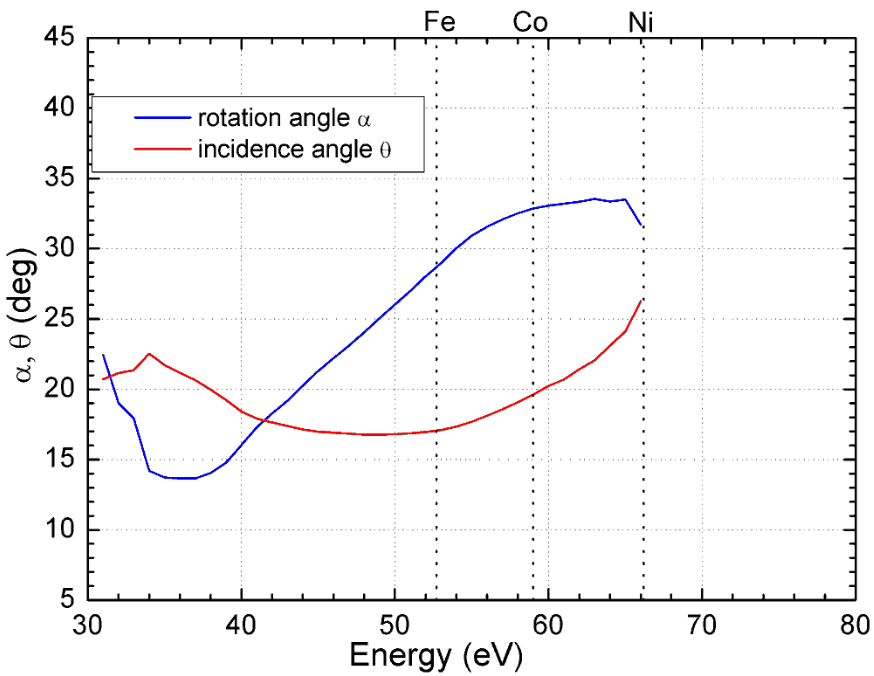


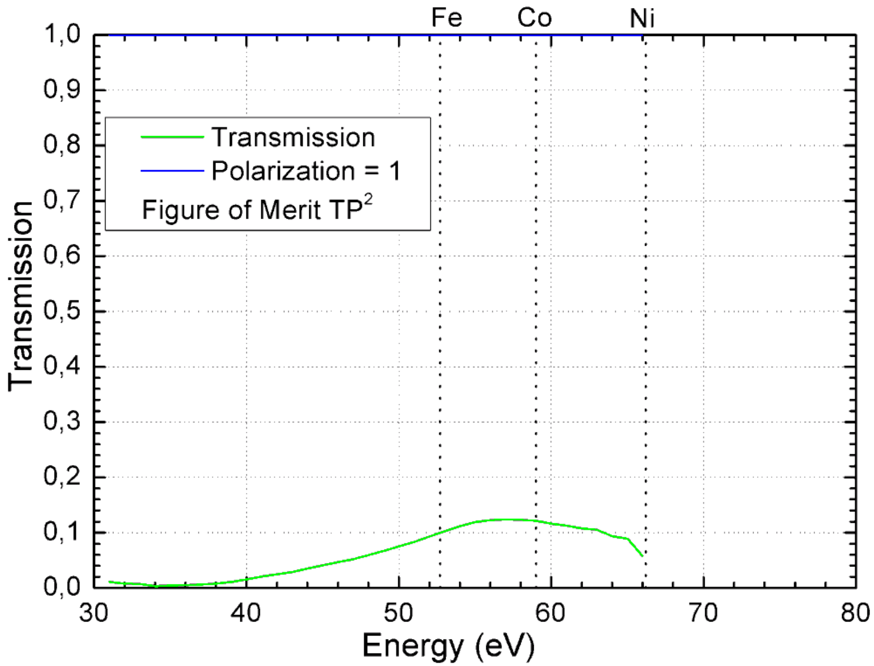
- two pairs of mirrors each rigidly coupled in one mirror carrier
- UHV-compatible bearing for rotation around beam axis

Mo/B_4C(3nm) at 60eV

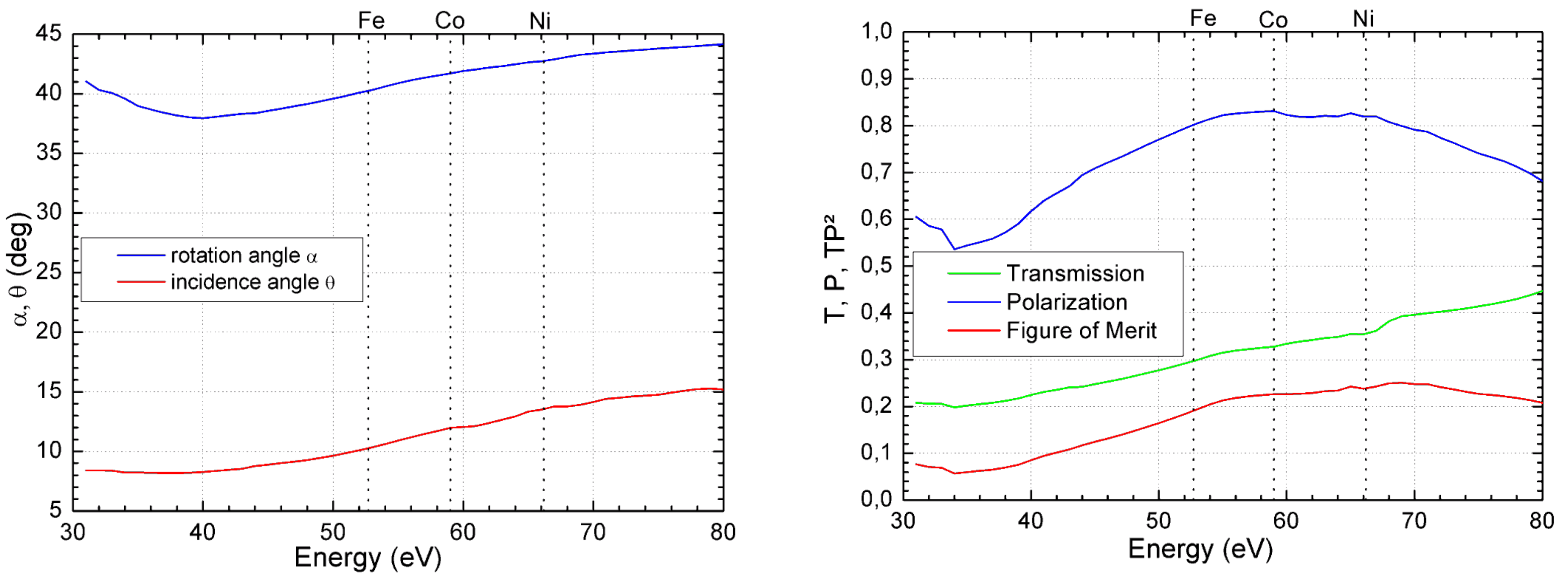


Maximum polarization for 20° grazing incidence and ±33° rotation around the beam axis.



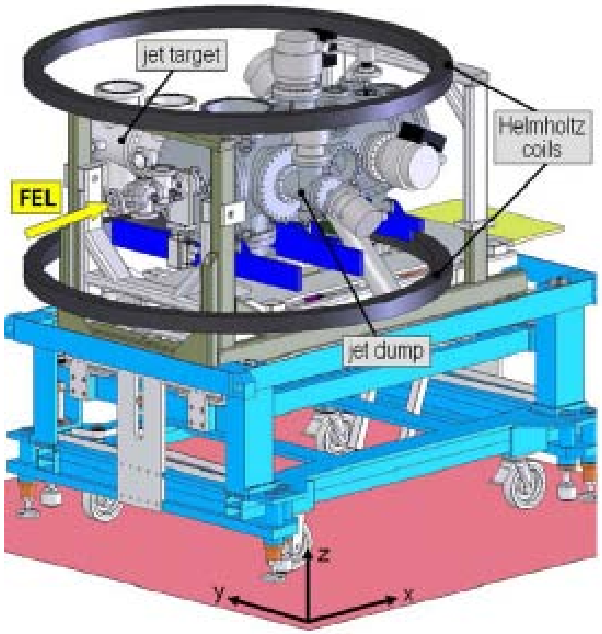


P=1 is possible for E < 66 eV but with low transmission



For optimized figure of merit P> 80% is achievable over the entire energy range of Fe, Co and Ni M-edges!

BMBF Verbundprojekt FSP 301 – FLASH: Multi-Purpose Coherent Scattering Chamber for FLASH and XFEL



L. Strüder et al., NIMA 614 (2010)

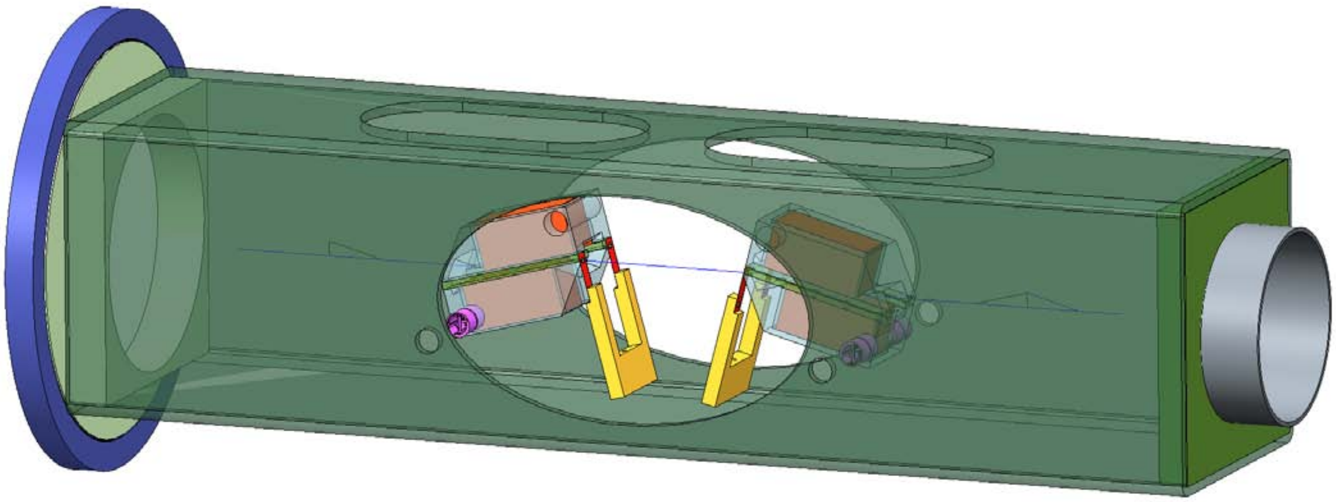
Prof. Dr. T. Möller (TU Berlin)
Prof. Dr. S. Eisebitt (TU Berlin)
Prof. Dr. J. Ullrich (MPIK Heidelberg / ASG)

Sample manipulation stage for CAMP – chamber
Magnetic field sample environment

Separate chamber: **Polarizer to generate circularly polarized light**

Quadruple reflection polarizer:

- delivers circular polarization between 30 and 80 eV (Fe, Co, Ni M-edges)
- P=1 for energies < 66eV or maximum TP^2 with 80% polarization
- superior performance to transmission polarizers (LCLS)
- easy integration into beamline and „take-out“ ability



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Bastian Pfau

Tino Noll (CAD model)

Jan Lüning
Boris Vodungbo (polarizer for HHG source)
Julien Gautier

Thank you for your attention!