Diffuse scattering and complete polarisation analysis

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DNS @ Jülich

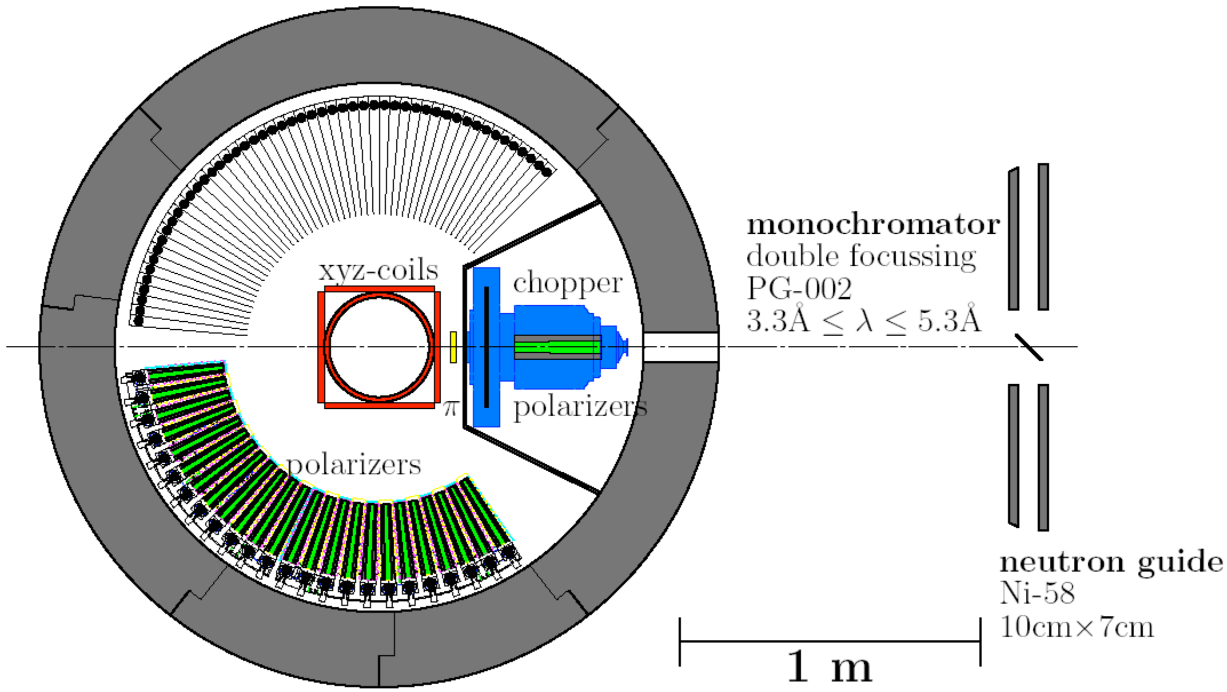
- ➔ single crystal spectroscopy
- ➔ 1D polarisation analysis: soft matter
- xyz polarisation analysis: paramagnets and collinear magnetic structures
- new: vector polarisation analysis

Scheme of the DNS instrument

a very compact design !

*** efficient coverage of a large solid angle

*** high repetition rate, up to 1 200 Hz

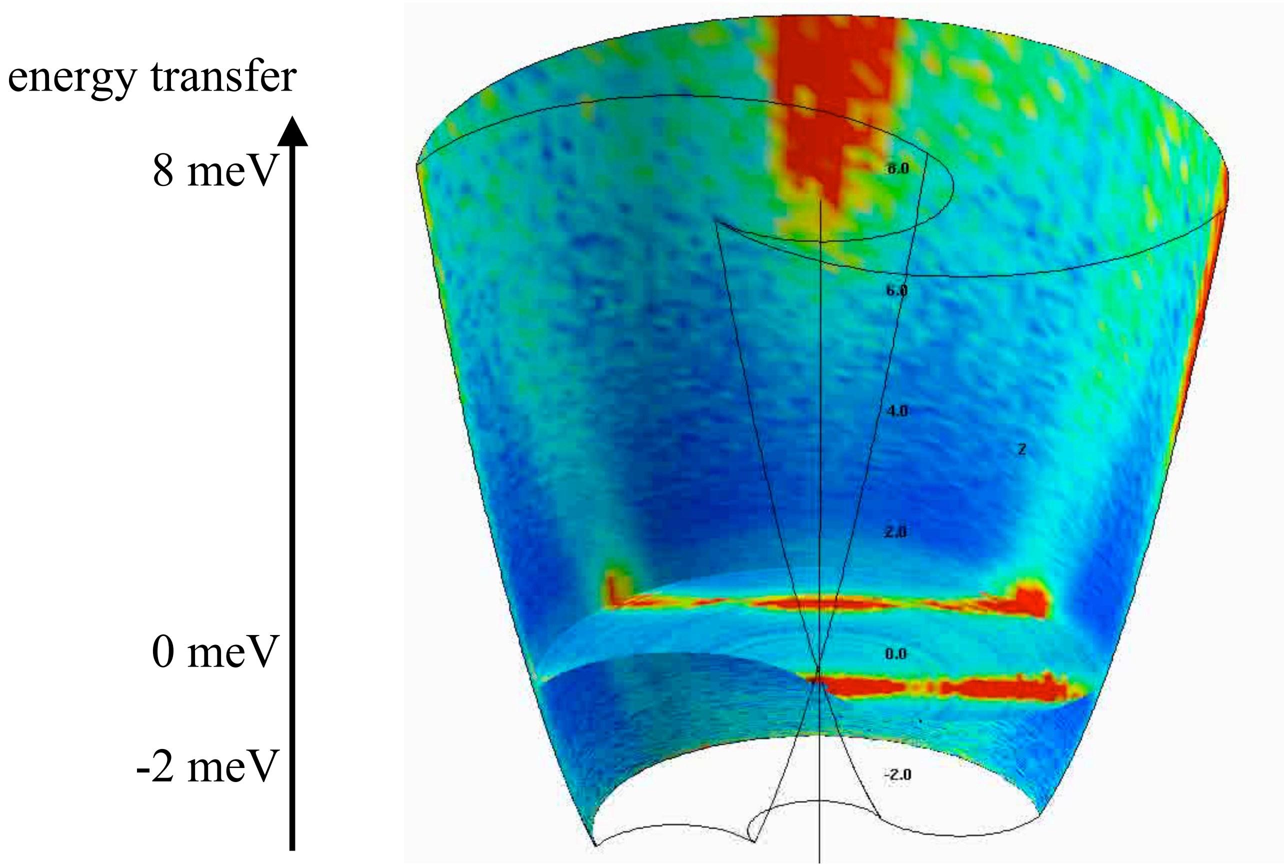


polarizer
focussing benders
supermirror m=2
FeCoV/Ti:N

detectors
He-3 at 4 bar
1inch×15cm
50 units + 12 units for PA

Single crystal spectroscopy

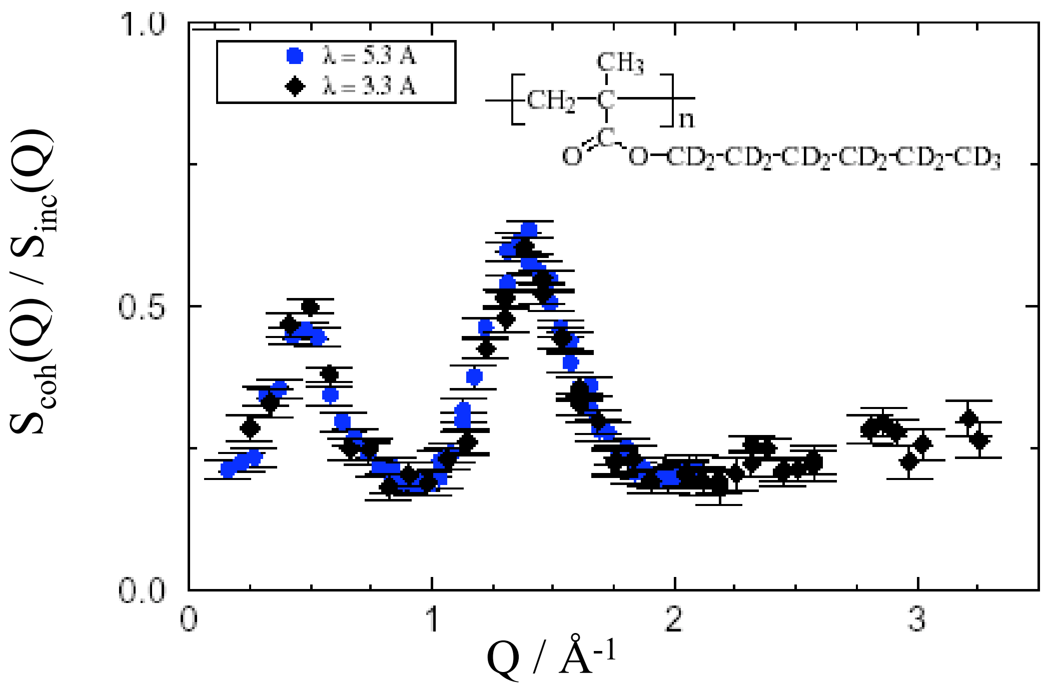
Layered Manganites $La_{1.2}Sr_{1.8}Mn_2O_7$ (D. Argyriou, 2003)



1D polarisation analysis: soft matter

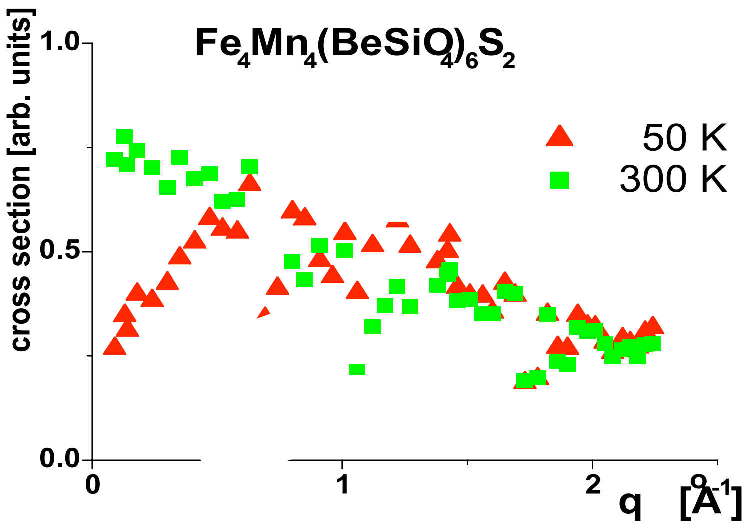
separation of coherent and spin-incoherent scattering
absolute calibration of coherent scattering

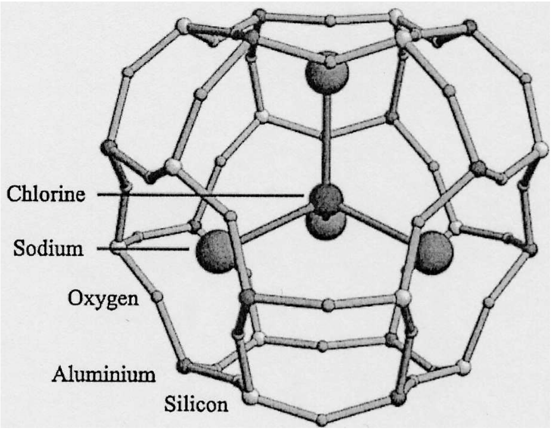
$$\frac{d\sigma}{d\Omega}_{coherent} = \frac{d\sigma}{d\Omega}^{NSF} - \frac{1}{2}\frac{d\sigma}{d\Omega}^{SF} \qquad \frac{d\sigma}{d\Omega}_{spin-incoherent} = \frac{3}{2}\frac{d\sigma}{d\Omega}^{SF}$$



xyz polarisation analysis: paramagnets

$$\frac{d\sigma}{d\Omega_{paramagnetic}} = 2\left(\frac{d\sigma}{d\Omega}_{XX} + \frac{d\sigma}{d\Omega}_{YY} - 2\frac{d\sigma}{d\Omega}_{ZZ}\right)^{SF} = -2\left(\frac{d\sigma}{d\Omega}_{XX} + \frac{d\sigma}{d\Omega}_{YY} - 2\frac{d\sigma}{d\Omega}_{ZZ}\right)^{NSF}$$





anti-ferro correlations of tetrahedral ferro-clusters

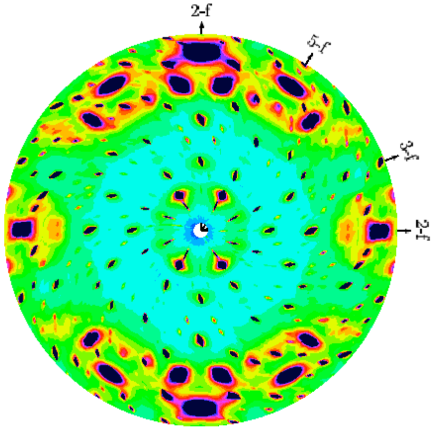
(K. Neumann 2003)

$Fe_4Mn_4(BeSiO_4)_6S_2$

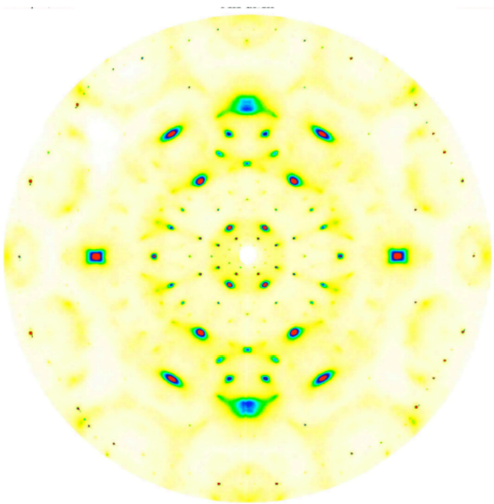
isostructural

$Na_8(AlSiO_4)_6Cl_2$

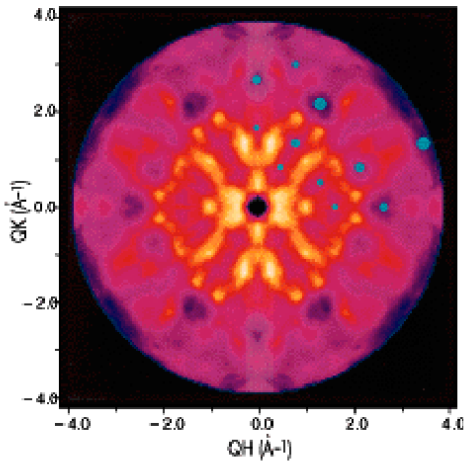
Disorder and diffuse scattering of quasi-crystals



DNS: (day)
elastic neutron scattering
TOF [1meV]
phason disorder in ico-AlPdMn



μ-CAT/APS: (secs)
high energy x-ray diffraction
ico-AlPdMn



D7/ILL(T. Sato [2000]): (week)
polarization analysis
magnetic scattering of ico-ZnMgHo

Theory: S. Maleyev and M. Blume (1963)

final polarised intensity

$$\mathbf{P}\sigma_{el}(\mathbf{Q}) = |N_\mathbf{Q}|^2\mathbf{P}_0 + \left[(\mathbf{P}_0\mathbf{M}^\perp_{-\mathbf{Q}})\mathbf{M}^\perp_\mathbf{Q} + \mathbf{M}^\perp_{-\mathbf{Q}}(\mathbf{M}^\perp_\mathbf{Q}\mathbf{P}_0) - |\mathbf{M}^\perp_\mathbf{Q}|^2\mathbf{P}_0\right] -$$

$$-\hat{Q}([\mathbf{M}_{-\mathbf{Q}} \times \mathbf{M}_\mathbf{Q}] \cdot \hat{Q})$$

$$+(N_{-\mathbf{Q}}\mathbf{M}^\perp_\mathbf{Q} + \mathbf{M}^\perp_{-\mathbf{Q}}N_\mathbf{Q}) + i\left[(N_{-\mathbf{Q}}\mathbf{M}^\perp_\mathbf{Q} - \mathbf{M}^\perp_{-\mathbf{Q}}\mathbf{N}_\mathbf{Q}) \times \mathbf{P}_0\right]$$

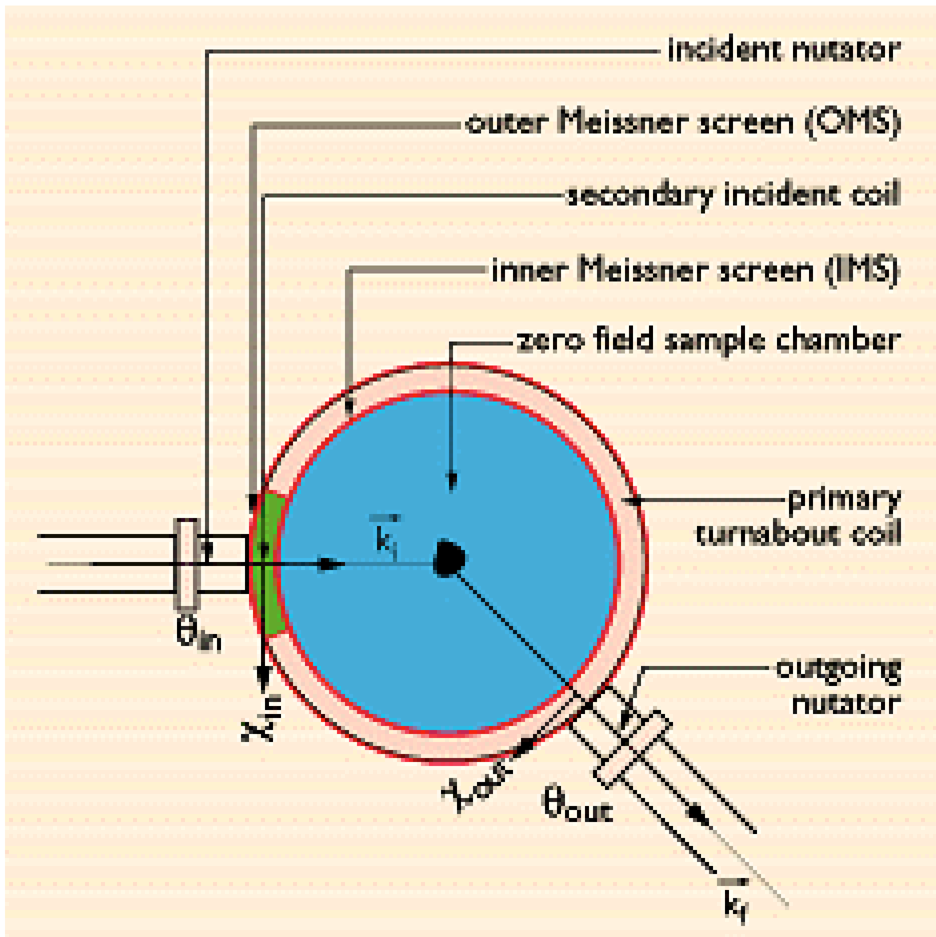
- chiral term, nuclear-magnetic interference

Spherical Neutron Polarimetry

Experimental techniques: zero-field

Th. Rekveldt	*(direct beam, neutron depolarisation)*
G. M. Drabkin, A. I. Okorokov et al.	*(small-angle scattering)*
F. Tasset, J. Brown	*(Bragg scattering)*
L.-P. Regnault	*(excitations)*

cryopad



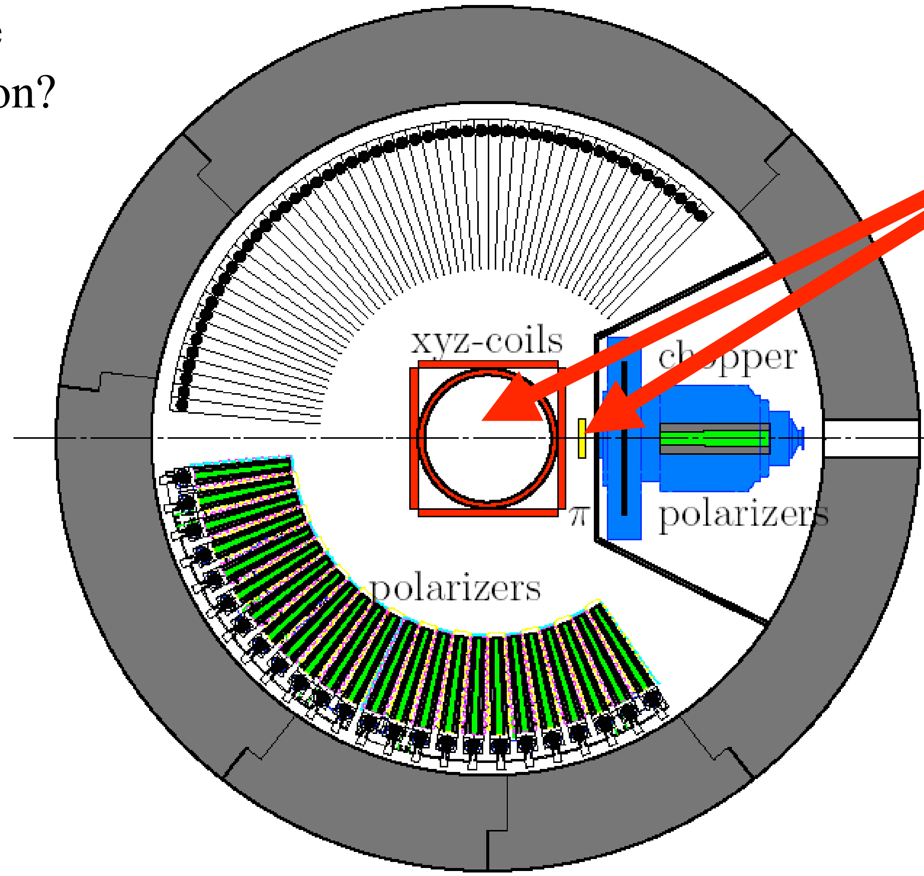
only one $S(Q,\omega)$

Vector polarisation analysis & TOF

$\pi/2$ flipper to analyse precessing polarisation?

(idea: O. Schärpf)

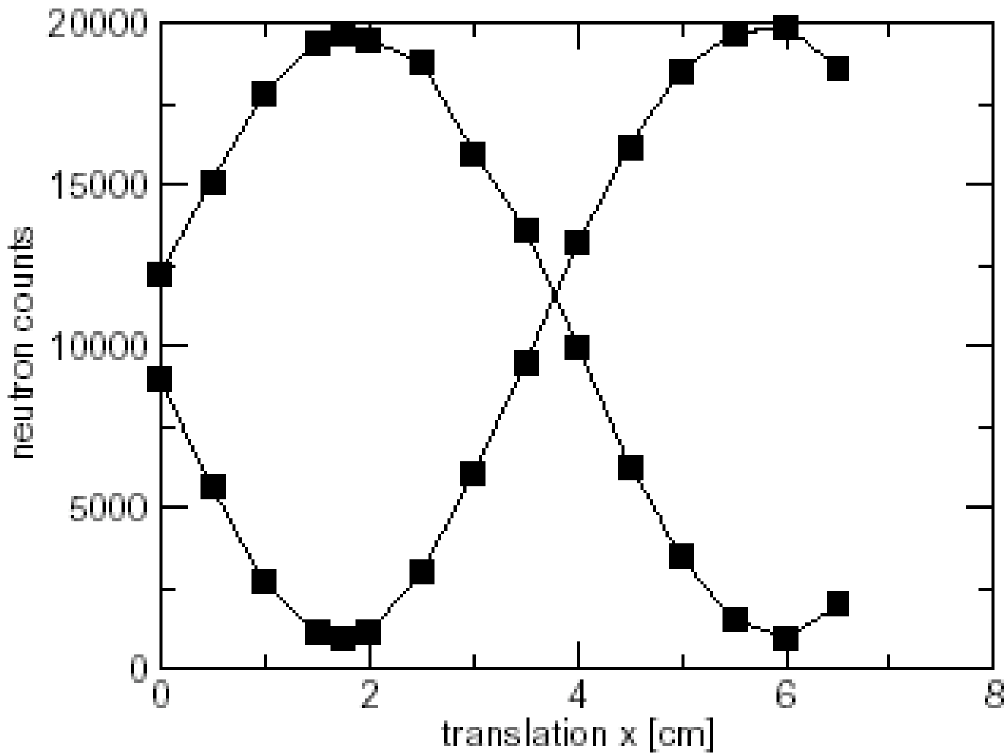
$\pi/2$ flipper

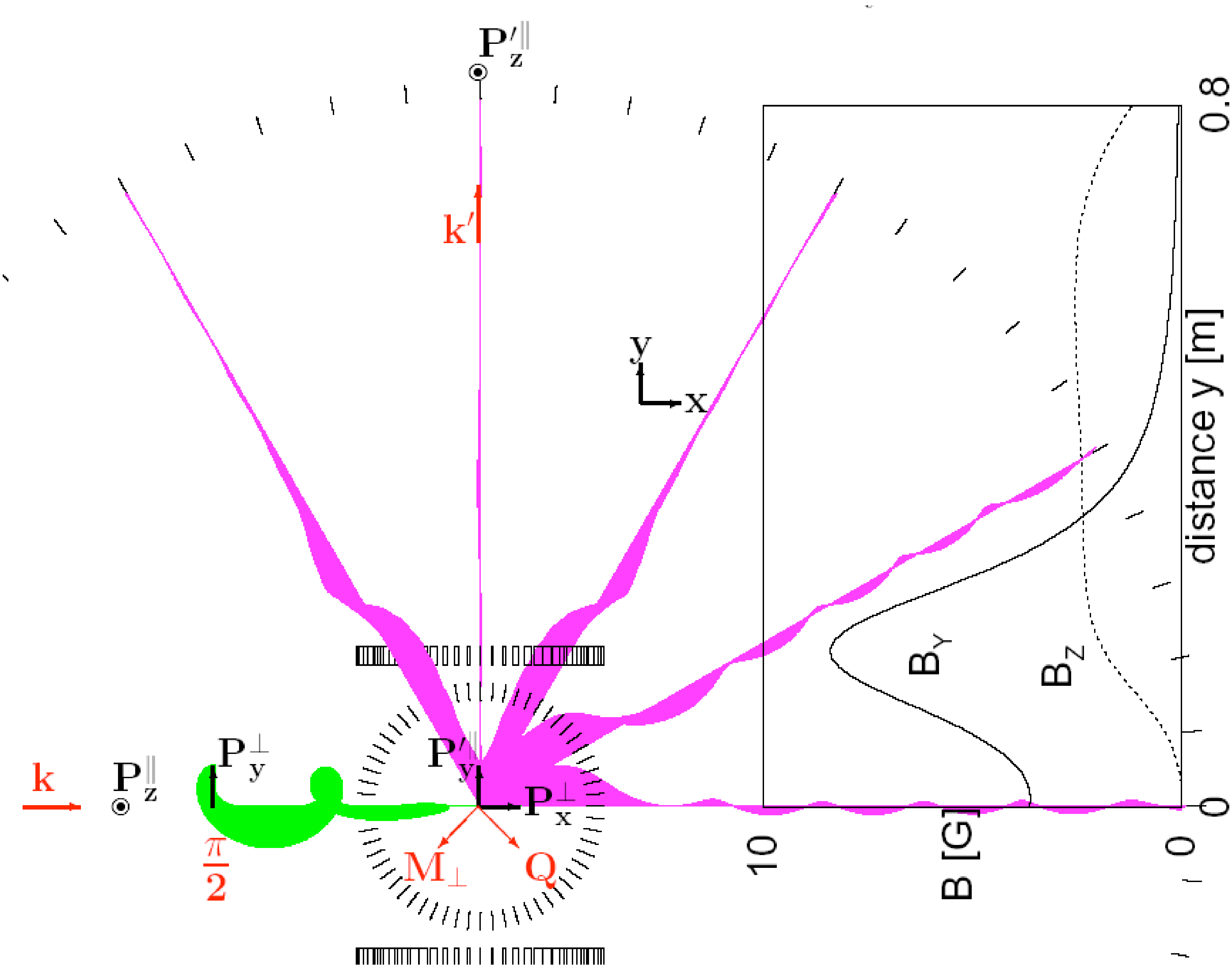


use initial high flipper in $\pi/2$ mode !

Analysing precessing polarisation

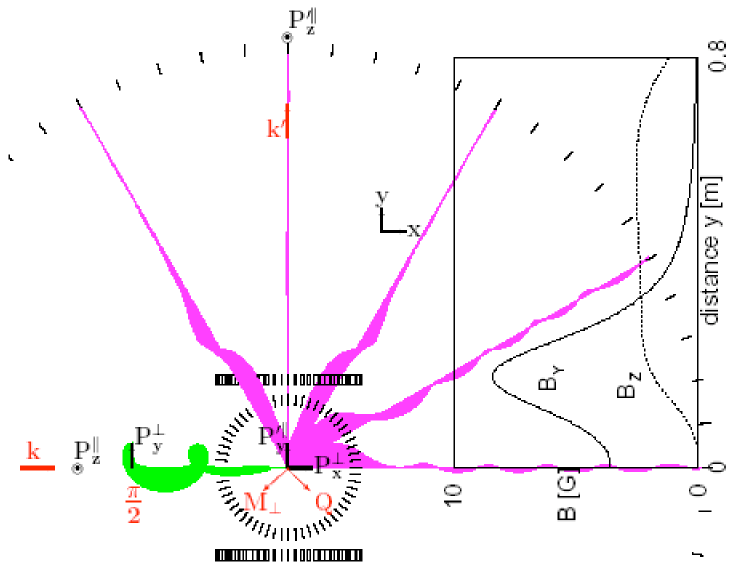
$\underline{k}_i$ → ↑ $P_{z,0}$ □/2 flipper ↑ B_z □/2 flipper translation x P_z

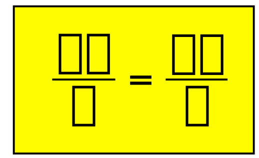




P′z∥
k′
y
x
BY
BZ
distance y [m]
0.8
0
10
B [G]
0
k
Pz∥
Py⊥
P′y∥
Px⊥
π/2
M⊥
Q

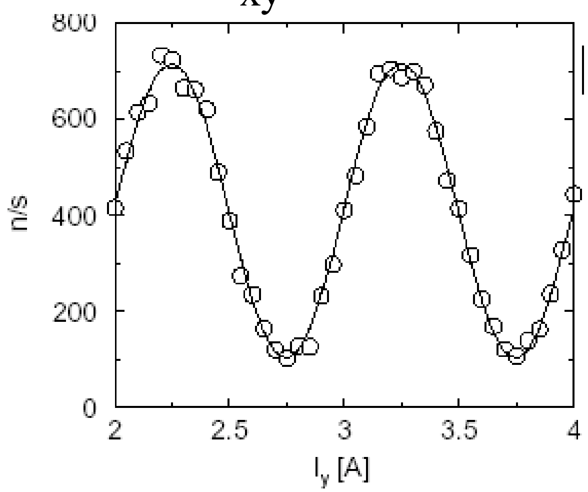
Vector polarisation analysis

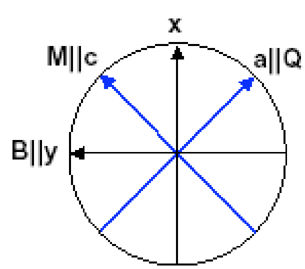


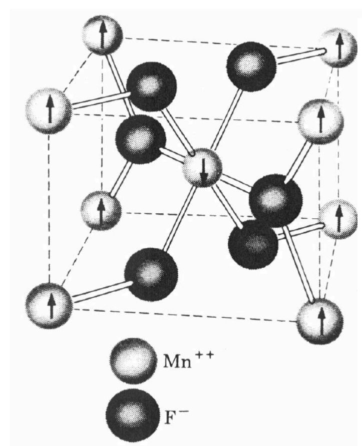


Measurement of P_{xy} with (100) Bragg of MnF_2

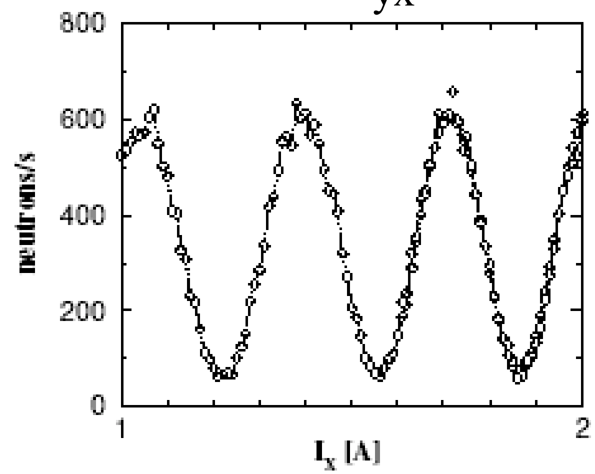
P_{xy}



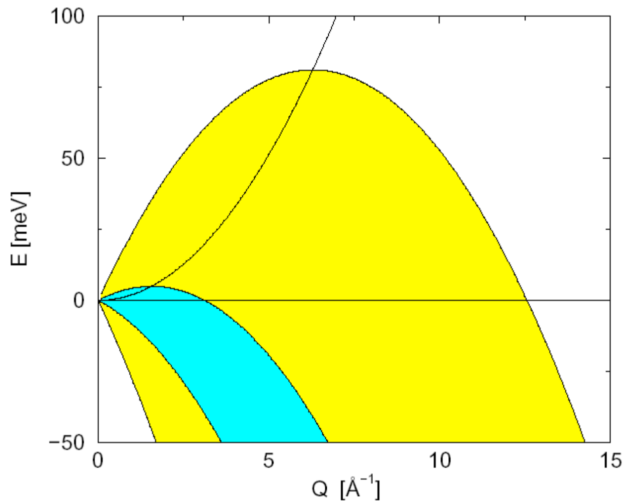




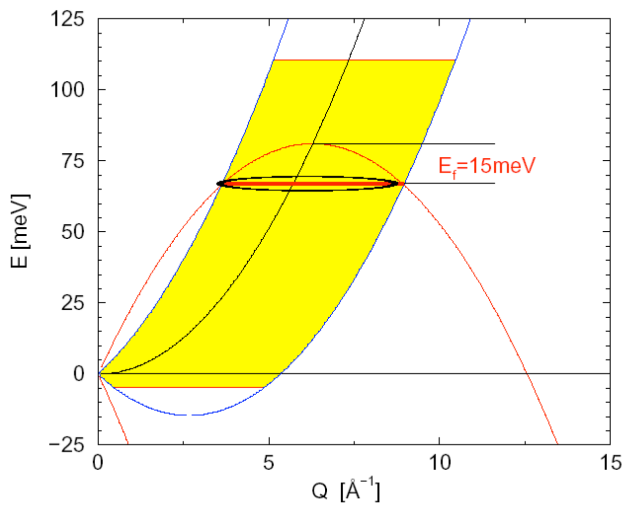
P_{yx}



Kinematics of direct TOF



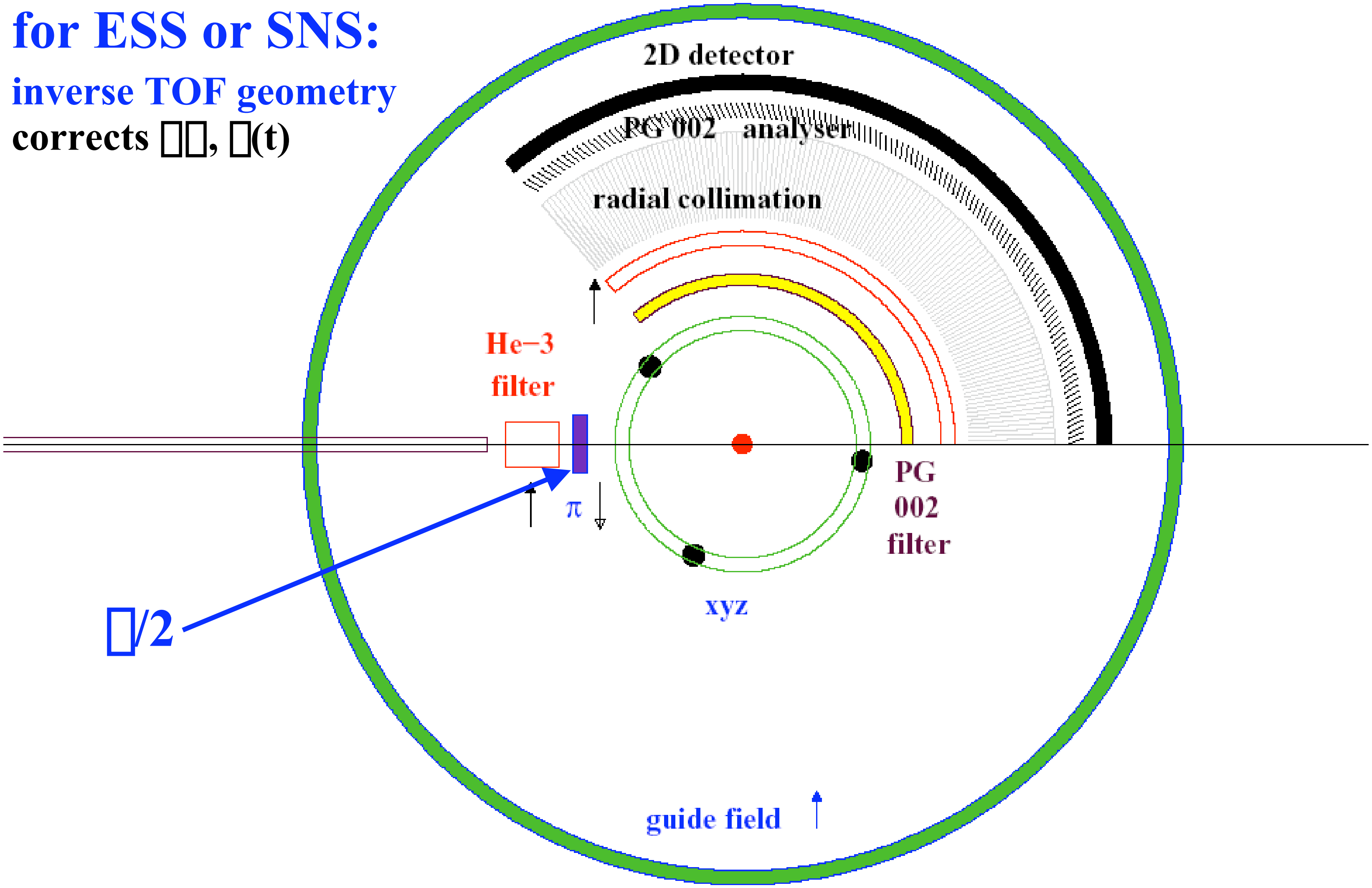
inverse TOF



for ESS or SNS:

inverse TOF geometry

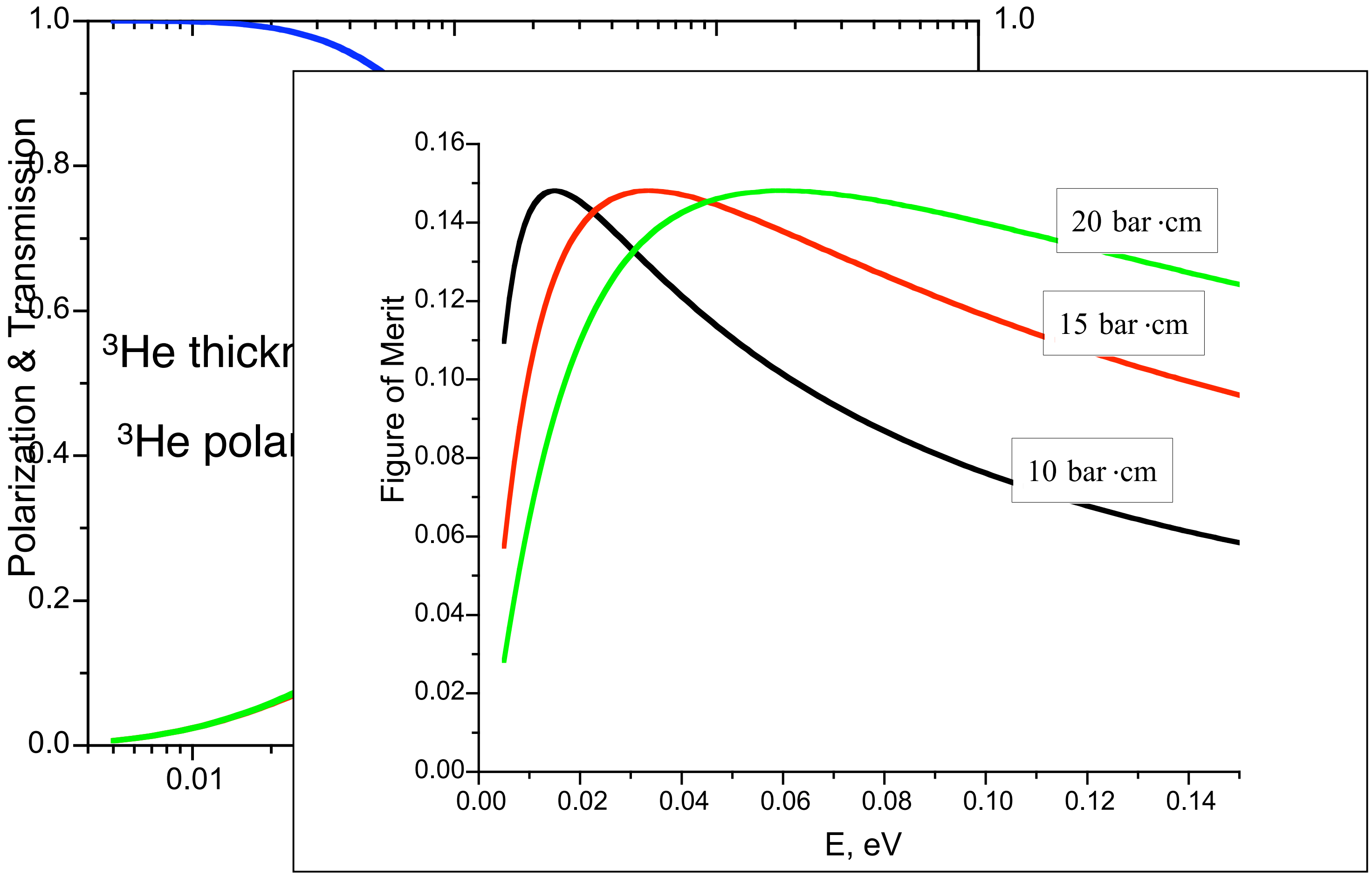
corrects □□, □(t)



super mirrors alternative for polarisation analysis

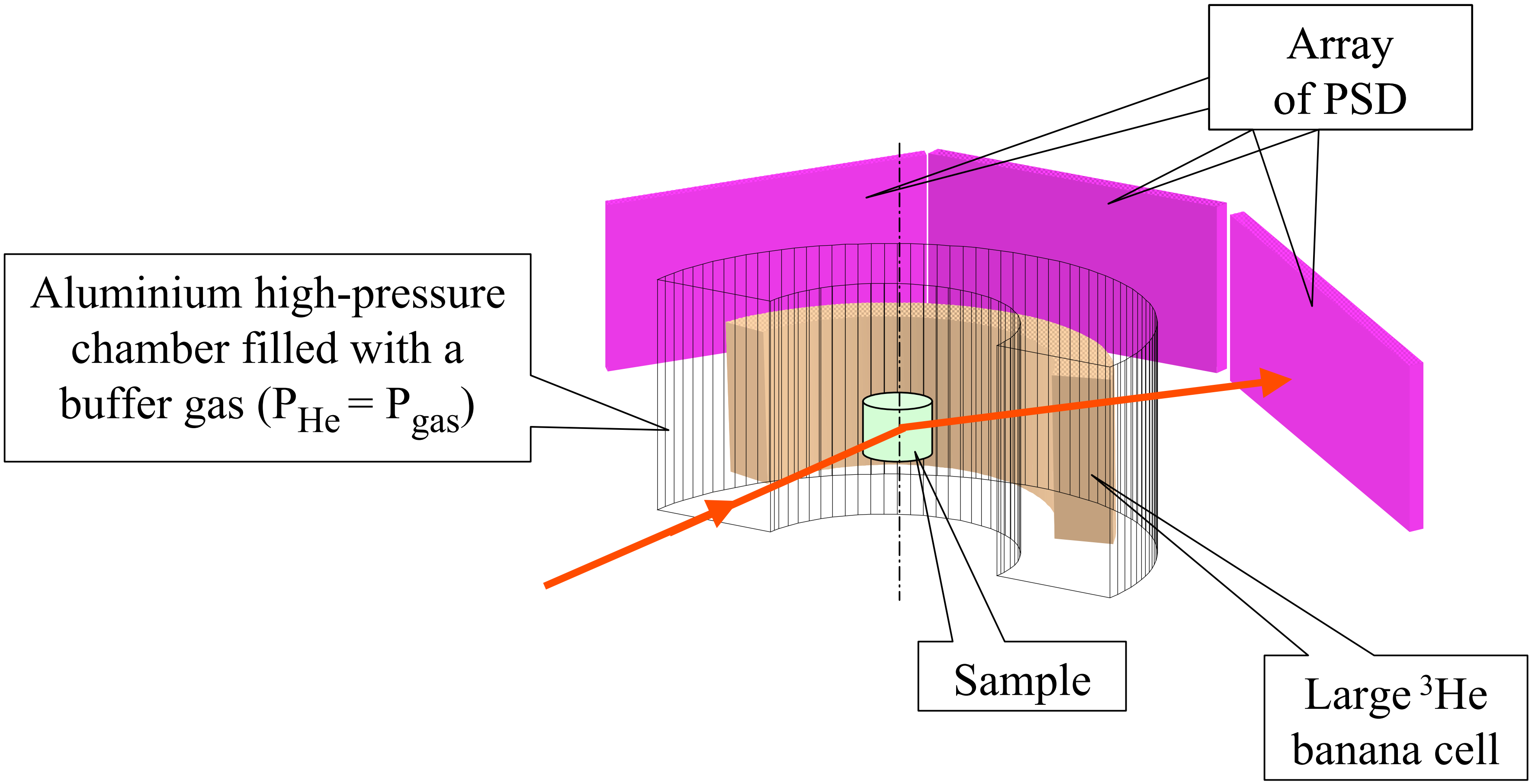
3He spin filter

(A. Ioffe)



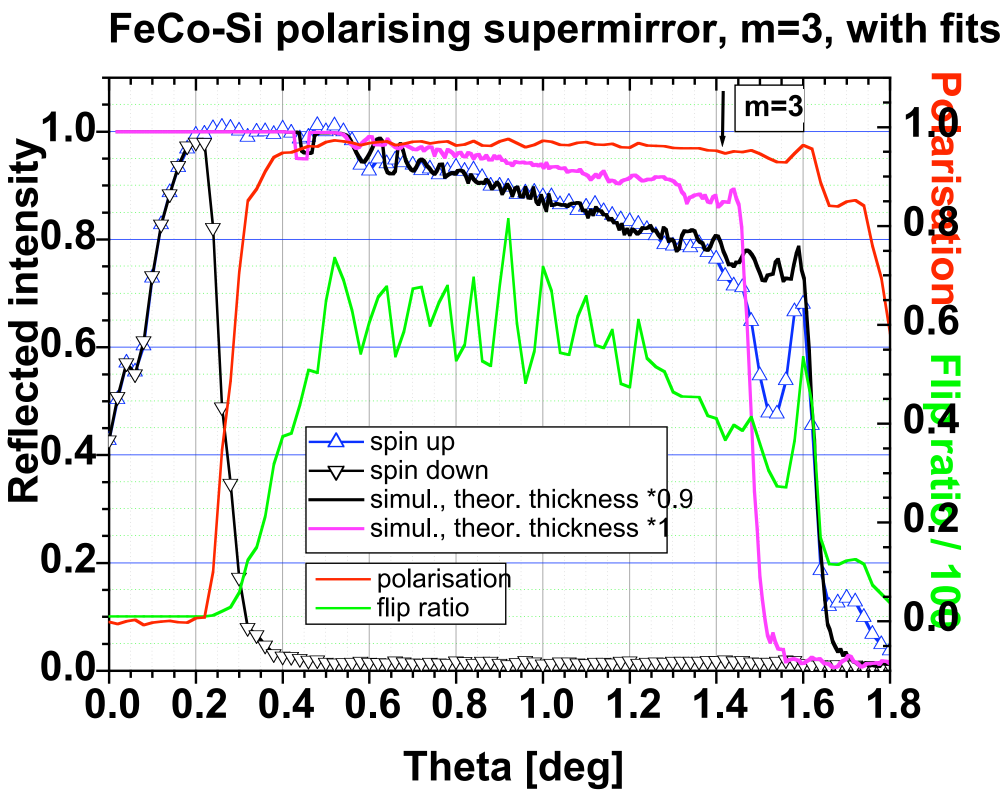
The FOM is inversely proportional to the running time of experiments, whose error is dominated by the counting statistics of a signal depending on neutron polarization.

3He wide-angle analyzer



Supermirror wide-angle analyzer

Usually, SM are considered to be losers against 3He for thermal neutrons. However, we are dealing with wide energy range instrument, so that the gain should be optimised. Moreover, there are constant developments in SM technologies.



HMI (Th. Krist), 2003

- Si substrate (refraction index for component matches refraction index of Si
- Can be extended to m = 3.5
- Simple service free & running costs free construction
- No time degradation of polarization power
- Much higher intensity

One should also consider such a possibility!

Summary and outlook

new: Vector polarisation analysis on TOF instruments based on absolute spin precession technique.

Simultaneous measurements of S(Q,□) in large regions of reciprocal space.

Avoiding zero field requirements.

A new option almost for free and a natural sophistication opening new research fields:

- chiral fluctuations
- spin-orbit coupling
- spin-Peierls systems
- Invar
- diffuse (in-)elastic scattering