Planned polarized neutron reflectometer at BNC

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Outline

1. Evaluation of status at BNC (2.)
2. Options for a new PNR beamline (3.)
3. Specification of scientific needs (1.)
4. (Detailed technical specification (4.))
5. (Budget planning, … (5…))

Evaluation of status at BNC

1. Structural studies: SANS, PSD, TAS, PRFM
2. Neutron flux, cold source, n-guides:
   all suitable for *high-performance* PNR
3. Present reflectometer: super-mirror *tester*
   - important application, should remain
   - mechanical design, motorization, sample environment: NOT suitable to *upgrade*
   - Large sample size renders PRFM stand-alone

⇒ *New beam line needed in the same guide hall*

Options for a new PNR beam line

PNR Mode	Character	System to apply to
1	„nm-scale"	surfaces, thick films, polimer & multilayer films
2	„Atomic-scale"	Multilayers with small period length
3	„High-sensitivity"	Presision measurement of layer thicknesses ond internal fields
4	„Element-sensitive"	Systems of elements/isotopes with: (n,γ) reactions (σ>100b; 50) (n,p) & (n,α) reactions (σ>0.1b; 20)

Mode 1 – nm-scale PNR

Parameter		Range
Spatial resolution:	Δx	10÷100nm
Internal field resolution	δM	0.1÷ 0.3 T (Fe: 2.26 T)
Reflectivity	R	10^{-5} ÷1
Momentum transfer	Q	10^{-3}÷10^{-1} Å^{-1}
momentum resolution	ΔQ	3×10^{-4} Å^{-1}

Mode 1 – nm-scale PNR

TECHNICAL REALIZATION:

- Monochromator, average resolution
- n-polarizer
- Slit system
- Spin flipper (2×)
- Polarization analyzer
- PSD

Mode 2 – atomic-scale PNR

Parameter		Range
Spatial resolution:	Δx	0.1÷1 nm
Internal field resolution	δM	0.3÷ 1 T (Fe: 2.26 T)
Reflectivity	R	$10^{-6} \div 10^{-3}$
Momentum transfer	Q	$10^{-1} \div 10$ $Å^{-1}$
momentum resolution	ΔQ	10^{-2} $Å^{-1}$

Mode 2 – atomic-scale PNR

TECHNICAL REALIZATION:

- Wide-aperture polarizer
  (cross section: > 50×50 mm^2)
- Number of interfaces
  in sample structure: 100÷1000

Mode 3 – high sensitivity PNR

Parameter		Range
Spatial resolution:	Δx	10÷100 nm
Internal field resolution	δM	1 mT (!)
Reflectivity	R	10^{-3} ÷1
Momentum transfer	Q	10^{-3}÷10 $Å^{-1}$
momentum resolution	ΔQ	$3\times10^{-4} Å^{-1}$

Mode 3 – high sensitivity PNR

TECHNICAL REALIZATION:

- High degree of collimation &
- Monochromatization ($\Delta Q/Q = 10^{-5} \div 10^{-2}$)
- Precise goniometers (novel construction)
- Sample in a sandwich structure (e.g. Gd) for signal amplification

Mode 4 – element-sensitive PNR

Parameter		Range
Spatial resolution:	Δx	10÷100 nm
Momentum transfer	Q	10^{-3}÷10 $Å^{-1}$
momentum resolution	ΔQ	$3 \times 10^{-4} Å^{-1}$

Mode 4 – element-sensitive PNR

TECHNICAL REALIZATION:

- Detectors and spectrometer for the
  (n,γ) and (n,p) & (n,α) reactions
- Sparse usage, but *space* for shielding, etc. should be accounted for in design
- Resonance wavelength adjustment suits better for TOF spectrometers

Specifying scientific needs

- Broad national and regional discussion necessary
- Joint usage during IBR-2 reconstruction
- International board (Beside FLNP & KFKI: HMI Berlin, MPI Stuttgart, ANL, …)

Mode 1 estimated investment

Constituent	(k€)
Monochr., polarizer, analyzer, flippers, slits	160
Goniometers	180
PSD	80
Magnet, PS, cryostat	300
Electronics	50
N-guides	30
Total:	**800**

Conclusions (1)

- *A new PNR beam line at BNC is necessary*

  (with presently strongest interest from magnetic film, surface and multilayer research, others to be further specified)
- *Optimum usage as a Regional EU Facility*
- *JINR-HAS budget alone is insufficient* for realization

but:

Conclusions (2)

- *Collaborative HAS-JINR bilateral project:*
  - Expertise of FLNP can considerably shorten specification period
  - Common interest: Joint usage scheme of beam line during IBR-2 reconstruction (2007-?)
  - Constitutes a firm basis for future EU project application