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Design of the neutron guide system for the PIK reactor

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PIK reactor
Main parameters

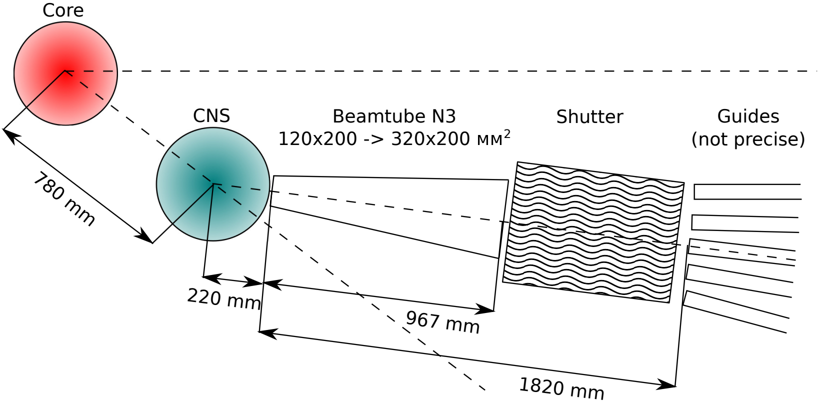
Main parameters

- Thermal power 100 MWt
- Fuel HEU
- Reflector D_2O
- Max flux (central channel) 5×10^{15} n/s/cm^2
- Max flux (reflector) 1.3×10^{15} n/s/cm^2
- 10 horizontal beamtubes
- 2 CNS and 1 HNS planned

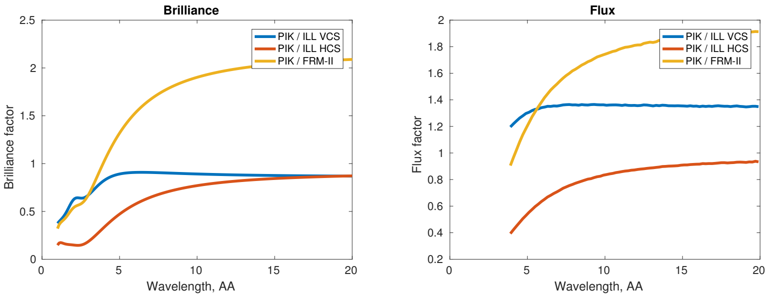
Reactor starts in late 2018!

Cold neutron source

Configuration



Cold neutron source
Comparable to the ILL VCS



2nd CNS of HCS-type is planned

Our task
Neutron guide system

Design features

- Extensive use of modern optics
- One guide — one instrument

Restrictions

- Only one beamtube!
- Beam requirements not frozen
- Narrow space in the bunker (25 m)
- 11.5^0 between beamtube axis and guide hall axis
- Time and budget constraints

Konik, P. I., and E. V. Moskvin. "Ways of upgrading the neutron guide system of the PIK reactor." Journal of Surface Investigation. X-ray, Synchrotron and Neutron Techniques 9.6 (2015): 1121-1125.

Instrumentation

14 cold instruments in the guide hall

I stage 2014–2018 (Modernization)

- 2× SANS
- 2× reflectometers
- SESANS
- DCD

PIK-GGBase collaboration

II stage 2017–2021 (New instruments)

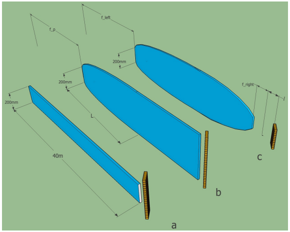
- Powder diffracometer
- 2× SANS
- 2× reflectometers (1 replacement)
- TAS
- Direct TOF spectrometer
- NSE spectrometer
- DEDM (fundamental physics line)

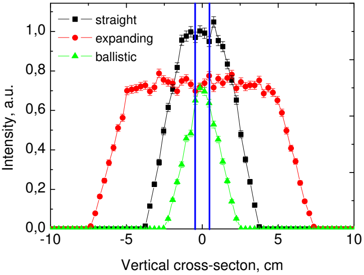
Additional thermal instruments from the reactor hall

General approach for the design

1. Define the beam requirements for each of the instruments and optics needed
   - Some are known from the previous experience
   - Some need additional study
2. Group the instruments according to the defined requirements
3. Fill the guide hall with instruments
4. Optimize horizontal shape of each guide
   - Curvature radii
   - Bender length
   - Focusing noses
5. Optimize vertical shape of each guide
6. Check the effect of the shutter optics ($\sim$970 mm from the CNS)

Monochromatic instruments optics

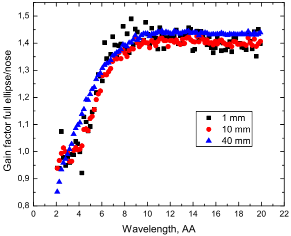




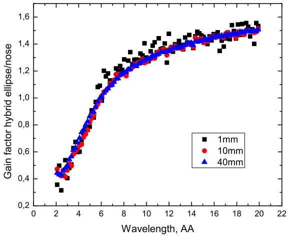
Constant cross-section is preferable

Konik, P., S. Grigoriev, and E. Moskvin. "Neutron guide optimisation for monochromatic reflectometry." Journal of Neutron Research Preprint: 1-10.

Elliptic guides performance



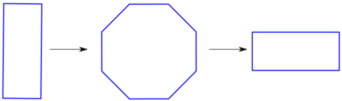
Ellipse

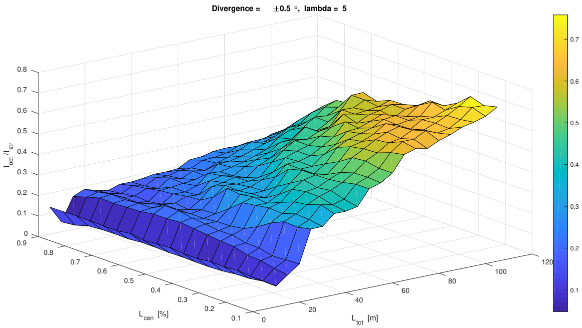


Constrained ellipse

Nosed guides are preferable

Tilting the beam



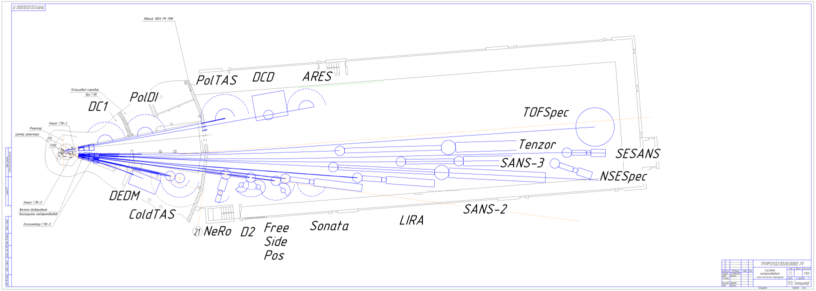


Instrument groups
Primary guides

Guide	Instruments	Main features
H0	DEDM (f.physics)	«general purpose»
H1	ColdTAS	straight, h-focusing nose
H2	PD, cm-Ref	c-curved
H3	h-Ref, v-Ref	v-nosed, 2 branches
H4	3$\times$SANS, SESANS, NSE	5 branches
H5	TOF	vh-nosed

Hall plan

Saving space for the future



High instrument density!

- put some instruments outside of the guide hall
- classify instruments into «lateral» and «straight» beamlines
- special cases of NSE and TOF

Loss factors

L	S	wavy	R_0	A_v	A_h	A_{rot}	shift	gap	all
10	30 × 30	0.97	0.88	1.00	0.94	1.00	0.98	1.00	0.80
	30 × 60	0.99	0.91	1.00	0.94	1.00	0.99	1.00	0.86
	30 × 120	0.99	0.93	1.00	0.94	1.00	0.99	1.00	0.88
	30 × 180	0.99	0.93	1.00	0.95	0.99	0.99	0.99	0.88
30	30 × 30	0.91	0.70	1.00	0.83	1.00	0.96	1.01	0.54
	30 × 60	0.93	0.76	1.00	0.83	0.99	0.96	1.00	0.59
	30 × 120	0.95	0.80	1.01	0.83	0.99	0.97	1.00	0.64
	30 × 180	0.95	0.81	1.01	0.83	0.99	0.98	1.00	0.66
60	30 × 30	0.84	0.52	1.00	0.69	0.99	0.91	1.00	0.32
	30 × 60	0.87	0.61	1.00	0.68	1.00	0.94	1.00	0.38
	30 × 120	0.89	0.65	0.99	0.68	0.99	0.95	0.99	0.43
	30 × 180	0.91	0.67	1.00	0.71	0.98	0.95	1.00	0.45
100	30 × 30	0.77	0.37	1.00	0.53	0.99	0.86	1.00	0.17
	30 × 60	0.81	0.45	0.99	0.53	0.98	0.89	0.99	0.22
	30 × 120	0.84	0.51	0.99	0.55	0.97	0.91	0.99	0.25
	30 × 180	0.85	0.54	0.99	0.55	0.96	0.92	0.99	0.27

Summary

- PIK reactor will start by the end of 2018
- The general approach to design guide system is presented
- The current system design is presented
- Acknowledgment to NSAC members

Thank you for attention!