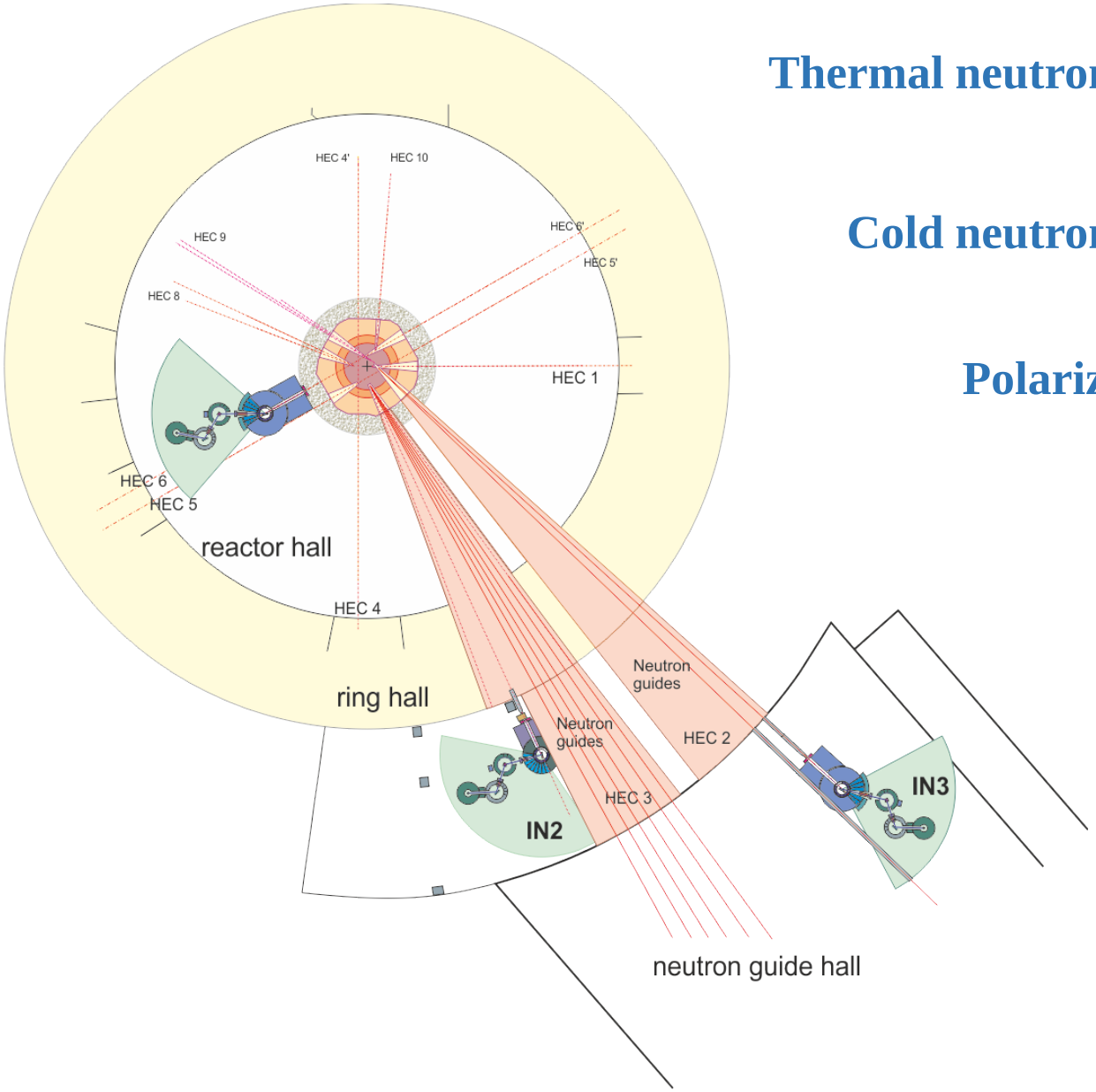
Three-axis spectrometers at PIK reactor

Спектрина

Current placement



IN1
Thermal neutron three-axis spectrometer

IN2
Cold neutron three-axis spectrometer

IN3
Polarized neutron spectrometer

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IN1 – Thermal neutron three-axis spectrometer

Measurements of the scattering function $S(\mathbf{Q}, \omega)$ in single crystals at well defined values of the reciprocal lattice vector $\mathbf{Q}$ and the energy ω.

Applications

- Investigations of lattice dynamics (phonons) and magnetic excitations (magnons and excitations in strongly correlated electron systems) in a wide variety of materials.
- Study of the critical phenomena at phase transitions in materials with different type of ordering.
- Studies of three-dimensional distributions of intensity of inelastic and quasielastic scattering.
- Studies of an doping and external influences (temperature, electric and magnetic fields, pressure) on the nature of phase transitions and dynamics of a lattice.
- The energy analysis of scattering in order to separate scattering from collective excitations and from slow relaxing clusters with short-range ordering.

Thermal neutron spectrometer IN1

HEC 6 thermal channel

Monochromators

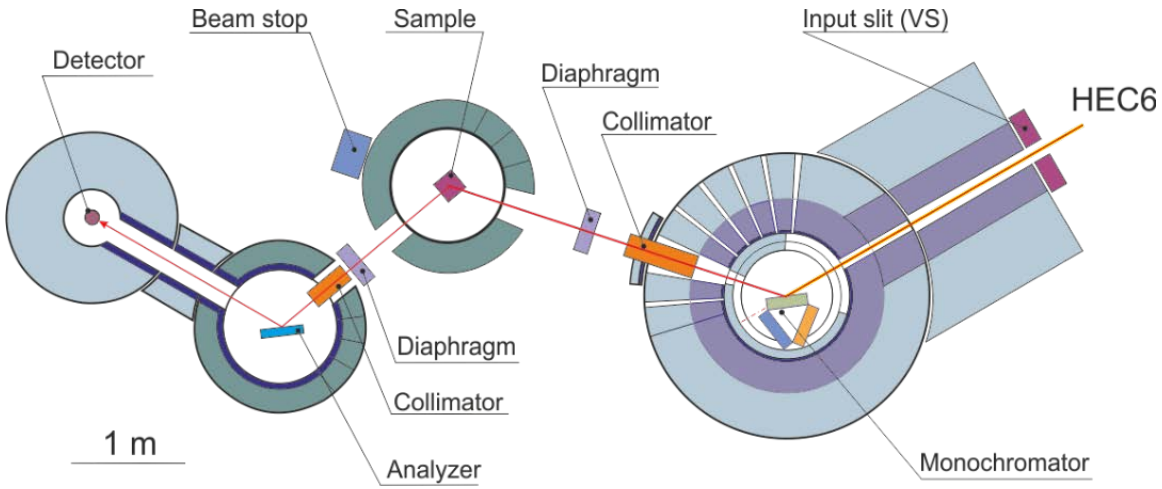
PG (002) double focusing
Cu (200) double focusing

k_i = 2.66 Å^{-1} - 7.0 Å^{-1}
λ_i = 0.9 Å - 2.36 Å
E_i = 15 meV – 100 meV
Take-off angles 26° - 90°

Beam cross section
25×25 cm^2
Beam size at sample
1×1 cm^2 ÷ 3×3 cm^2
Analyzer
PG (002) (double focusing)
Detector
Single ^{3}He detector

Distances

Thermal source – monochromator	575 cm
Virtual source – monochromator	200 cm
Monochromator - sample	200 cm
Sample – analyser	80 cm
Analyser – detector	60 cm



Channel height – 170 cm

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IN1

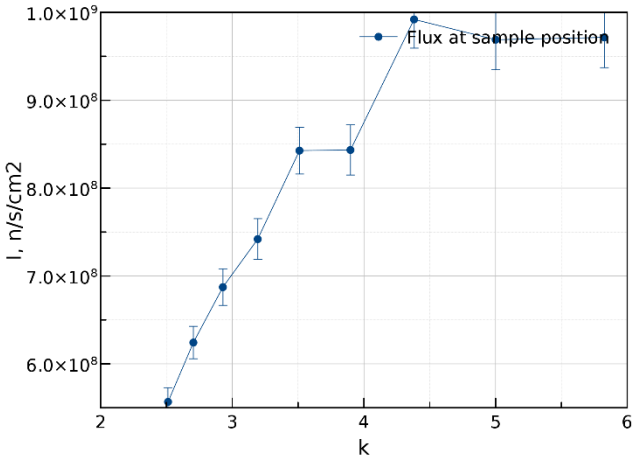
Flux simulation with PG monochromator

PG monochromator:
Double focusing
WxH = 300 x 300 mm²

VS slit:
WxH = 40 x 40 mm²

PG analyzer:
Double focused
WxH = 200 x 200 mm²

IN1@PNPI (simulation)
~ $1.0 \cdot 10^9$ n/cm²s at 1.0 Å (6.3 Å^{-1})
~ $1.0 \cdot 10^9$ n/cm²s at 1.5 Å (4.2 Å^{-1})
~ $5.5 \cdot 10^8$ n/cm²s at 2.5 Å (2.5 Å^{-1})



On the sample position

IN8@ILL
$6.5 \cdot 10^8$ n/cm²s at 1.5 Å
$2.0 \cdot 10^8$ n/cm²s at 2.5 Å

PUMA @MLZ
~ $4.8 \cdot 10^8$ n/cm²s at 1.5 Å

Polarized analysis option

Heusler polarizer
Helmholtz coils on sample
Heusler analyzer
Two flippers (Mezei type)

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IN2 – Cold neutron three-axis spectrometer

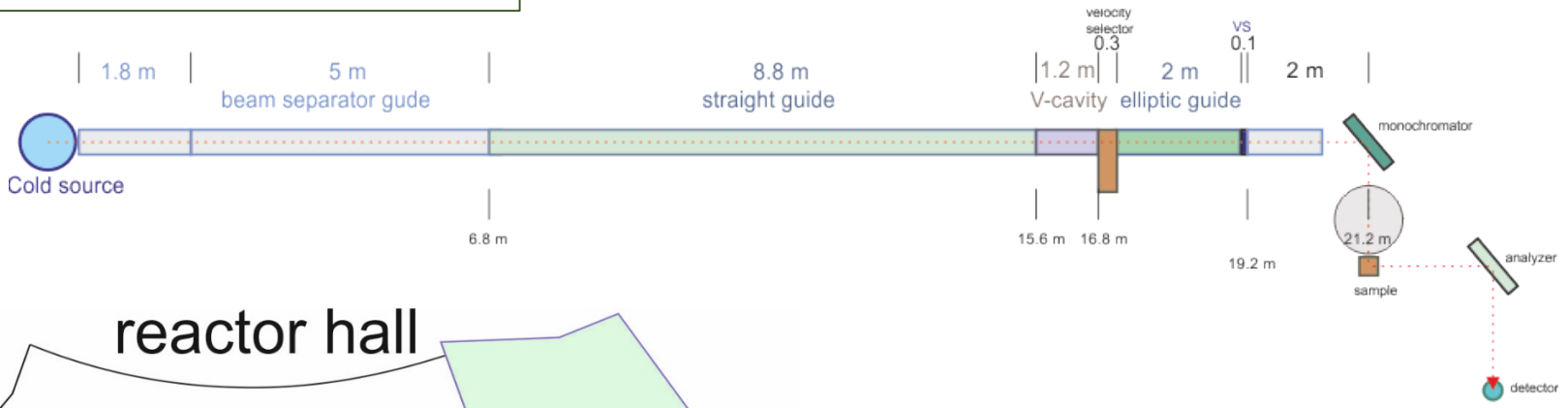
Measurements of the scattering function S(**Q**, ω) with low energies and with high resolution.

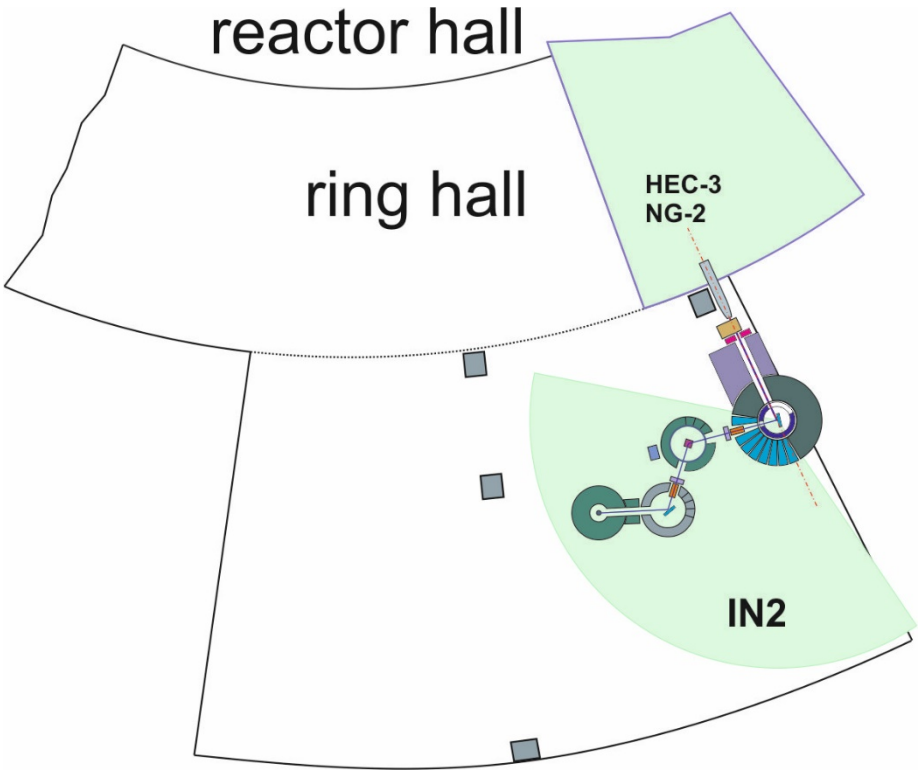
Applications

- Elastic or inelastic high resolution investigations of low energy magnetic and lattice excitations in single crystals.
- Study of the dispersion of acoustic phonons, soft phonons, spin waves, quasi-elastic scattering.
- Investigations with high resolution for the transferred momentum and/or energy.
- Fine study of the modulated structures.
- Investigations of the critical phenomena at phase transitions in materials with different type of ordering.
- Solution of the problems of elastic scattering where the good ratio of peak/background is important.
- Studies of dynamics of disordered spin systems like spin glasses etc.

Cold neutron spectrometer IN2

HEC 3 neutron guide N2





Beam separator neutron guide:
Length 500 cm
Height 20 cm
Width 7 cm

Straight neutron guide:
Length 880 cm
Height 20 cm
Width 7 cm
m = 3

Elliptic neutron guide:
Length 200 cm
Height 20 cm
Nose width 3 cm
m = 3

V-cavity:
Length 120 cm
2 sections
8 channels
Side walls m = 3
V-wafers m = 5

Channel height – 210 cm!

Спектрина

IN2

HEC 3 cold neutron guide N2

Monochromators
PG (002) (double focusing)
Si (111) (double focusing)
Analyzers
PG (002), Si (111)

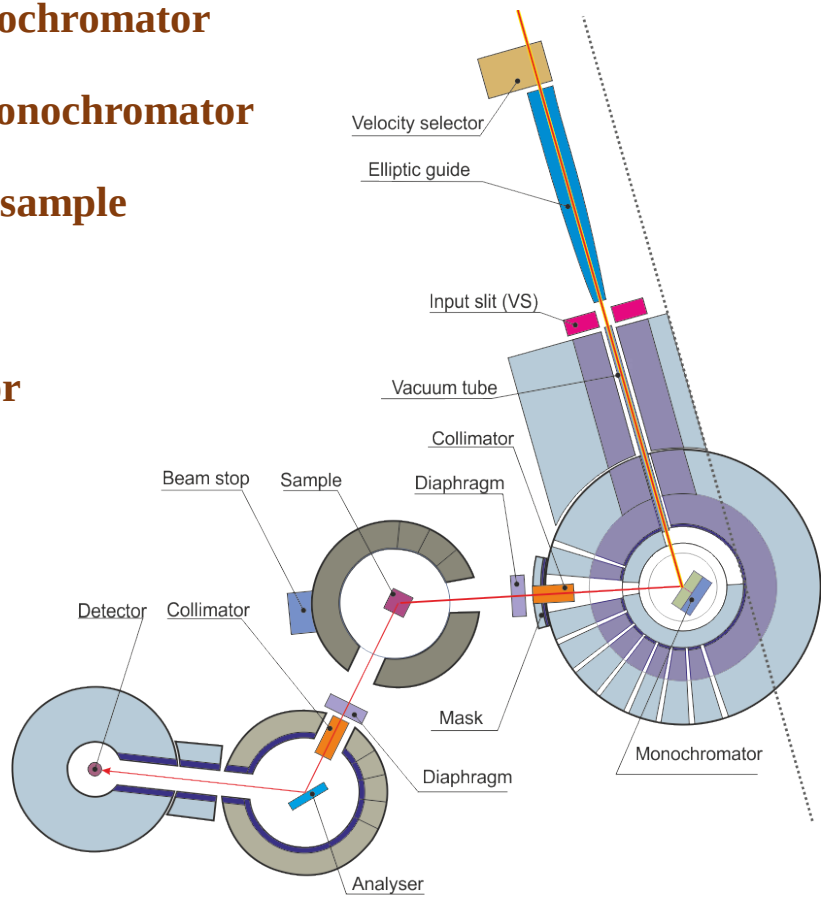
k_i = 1.0 Å^{-1} - 4.0 Å^{-1}
λ_i = 1.5 Å - 6.0 Å
E_i = 2.3 meV – 36 meV
Take-off angles 26° - 140°

Beam size at sample
1×1 cm^2 ÷ 3×3 cm^2
Flux at sample (4.0 Å)
2.15·10^8 n/cm^{2}s

Detectors
Single ^{3}He detector

Distances

Cold source - monochromator
2120 cm
Virtual source - monochromator
200 cm
Monochromator - sample
200 cm
Sample – analyzer
100 cm
Analyzer – detector
100 cm



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IN2

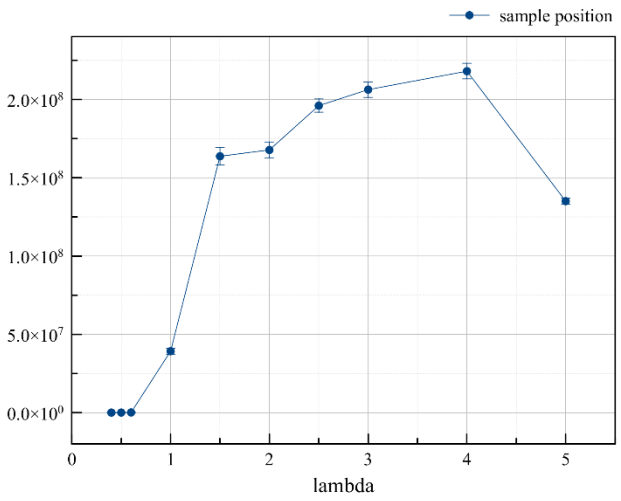
PG monochromator:
Double focused
WxH = 320 x 220 mm²

Velocity selector:
Length **30 cm**
Number of blades **50**
Screw angle **24º**

PG analyzer:
Double focused
WxH = 200 x 200 mm²

Estimated flux with PG monochromator

IN2@PIK (simulation)
~ $2.15 \cdot 10^8$ n/cm²s at 4 Å
~ $1.6 \cdot 10^8$ n/cm²s at 2.3 Å



ThALES
~$1.2 \cdot 10^8$ n/cm²s at 4 Å
~ $2.4 \cdot 10^8$ n/cm²s at 2.3 Å

IN12 ~ $7 \cdot 10^7$ n/cm²s at 4Å
~ $1 \cdot 10^8$ n/cm²s at 2.3 Å
without velocity selector

PANDA ~ $1.9 \cdot 10^7$ n/cm²s at 4Å
~ $5.5 \cdot 10^7$ n/cm²s at 2.5 Å
with filters

Polarized analysis option

V-cavity
Helmholtz coils on monochromator and sample
Heusler analyzer
Two flippers (Mezei type)

V-cavity:
Length 120 cm
2 sections
8 channels
Side walls m = 3
V-wafers m = 5

Спектрина

IN3 – Polarized neutron three-axis spectrometer

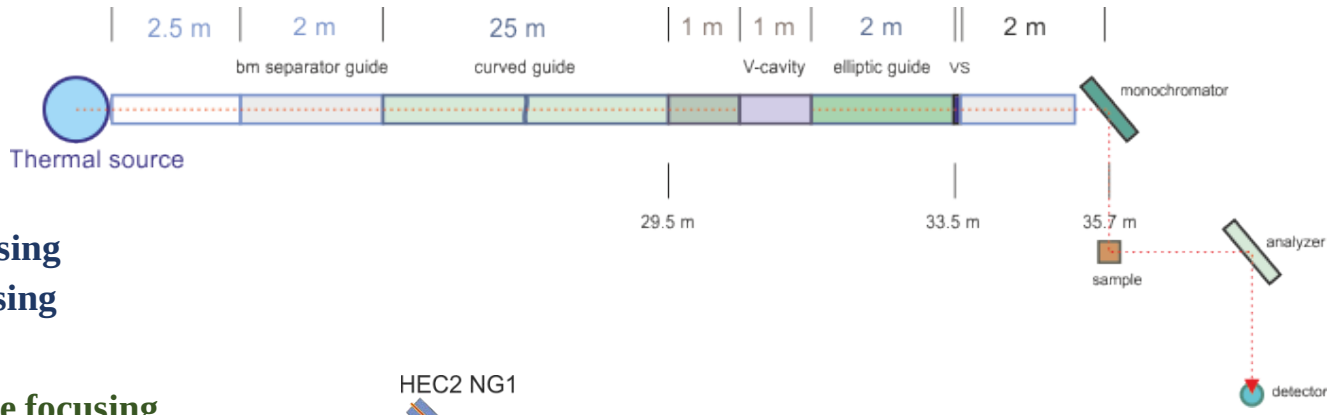
Measurements not only of the scattering function S(**Q**, ω), but also the spin state of scattered neutrons.

Applications

- Separation of phonons and magnons in magnetic crystals.
- Direct study of complex phenomena with entangled physical degrees of freedom of spins, charges, orbitals, lattice vibration by polarization analysis.
- Study of the critical phenomena at phase transitions in materials with different type of ordering.
- Studies of three-dimensional distributions of intensity of inelastic and quasielastic scattering.
- Studies of dynamics of disordered spin systems like spin glasses etc.

Polarized neutron spectrometer IN3

HEC 2 neutron guide N1



Monochromators

PG (002) double focusing

Cu (200) double focusing

Analyzers

Cu_2MnAl (111) double focusing

PG (002) double focusing

k_i = 2.66 Å^{-1} - 7.0 Å^{-1}

λ_i = 0.9 Å - 2.36 Å

E_i = 15 meV – 100 meV

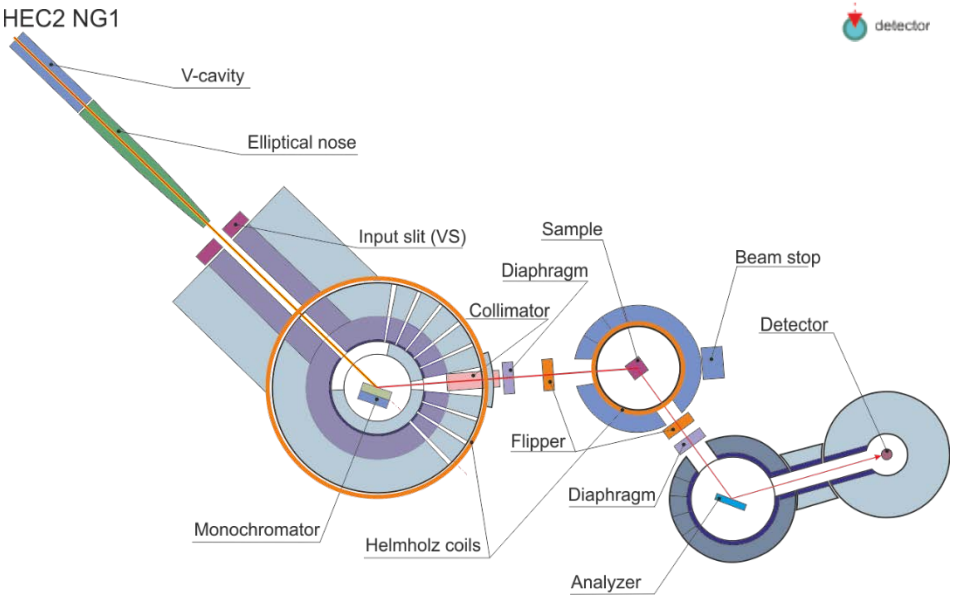
Take-off angles 26° - 90°

Beam size at sample from 1×1 cm^2 ÷ 3×3 cm^2

Detectors Single ^{3}He detector

Distances

Thermal source – monochromator	**35.6 m**
Virtual source – monochromator	**200 cm**
Monochromator - sample	**200 cm**
Sample – analyzer	**80 cm**
Analyzer – detector	**60 cm**



NG height – 120 cm

Спектрина

IN3

Estimated polarized neutrons flux with PG monochromator

PG monochromator:
Double focusing
WxH = 320 x 220 mm²

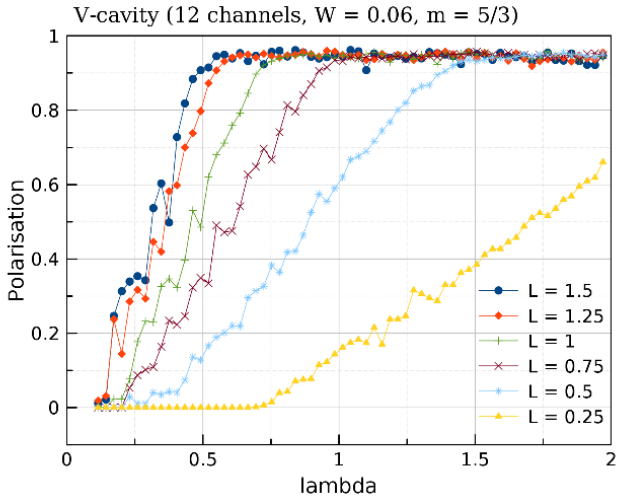
Cu_2MnAl (111) analyzer:
Double focusing
WxH = 200 x 200 mm²

IN3@PIK (simulation)
~ $1.1 \cdot 10^8$ n/cm²s at 1 Å (6.3 Å^{-1})
~ $4.1 \cdot 10^8$ n/cm²s at 1.5 Å (4.2 Å^{-1})
~ $3.1 \cdot 10^8$ n/cm²s at 2.5 Å (2.5 Å^{-1})

IN20@ILL
$0.55 \cdot 10^7$ n/cm²s at 0.8 Å
$1.05 \cdot 10^7$ n/cm²s at 1.5 Å
$7 \cdot 10^7$ n/cm²s at 2.5 Å
with sapphire filter ☺

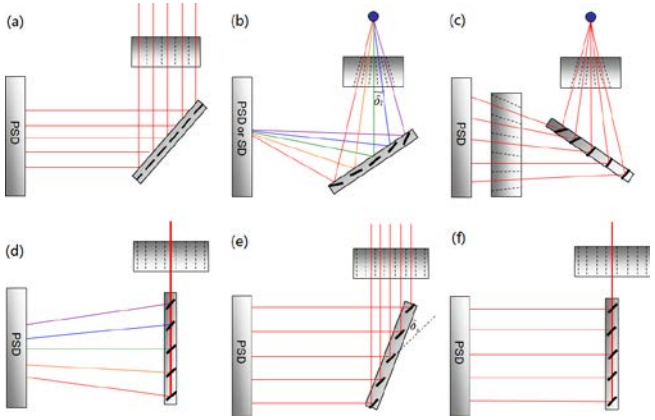
Polarized analysis units

V-cavity:
Length 100 cm
12 channels
Side walls m = 3
V-wafers m = 5

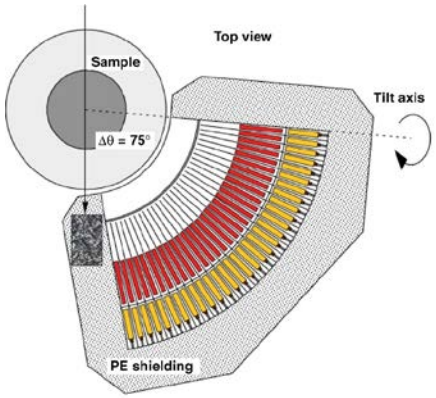


Helmholtz coils on monochromator and sample
Heusler analyzer
Two flippers (Mezei type)

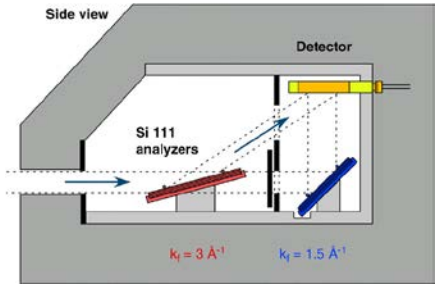
Option – Multiplexing analyzer

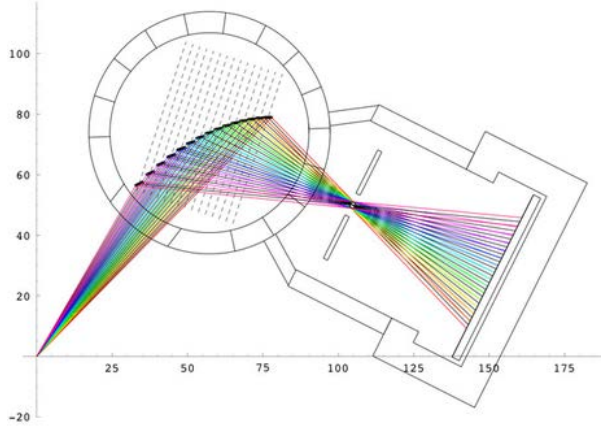


Multiplexing analyzer @ANSTO

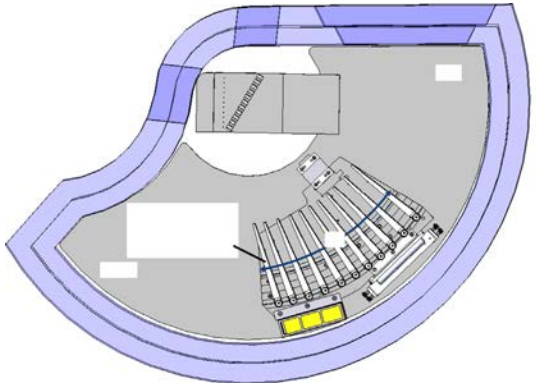


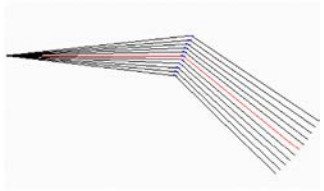
Multianalyzer FlatCone @ILL





Multi-analyzer UFO (Universal Focusing Option) @ILL





Multianalyzer system PUMA@MLZ

Спектрина

PNPI TAS group

Igor Zobkalo – project leader
Sergey Gavrilov – instrument scientist
Yury Kireenko – PhD student, MC simulations

+ in nearest future

Alexandr Ovsyanikov – PhD student, future instrument scientist
Anna Matveeva – PhD student, future instrument scientist
Maria Yuzvuk – PhD student, future instrument scientist

Спектрина

Thank you for your attention!