Hybrid Spectrometer for Single Crystal Studies at the Pulsed SNS: an update.

Neutron Scattering Group

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Outline

- *Principal features of the proposed hybrid spectrometer.*
- *General schematics and tentative placement.*
- *Secondary spectrometer and its operation in the polarized beam mode.*
- *Main features and layout of the primary spectrometer.*
- *Comparison with conventional TOF scheme: some Monte Carlo results.*
- *Current questions and future plans.*

Principal features of the proposed hybrid spectrometer.

Bonus: monochromator shapes resolution function, cutting ugly high-E tail.

- *High flux on sample at E_i = 5 - 60 meV: tall neutron guide + efficient vertical focusing by curved crystal monochromator.*

- *Polarized beam option: polarized incident neutron beam for E_i = 5 - 60 meV, polarization analysis of the scattered beam for E_f < 15 meV.*

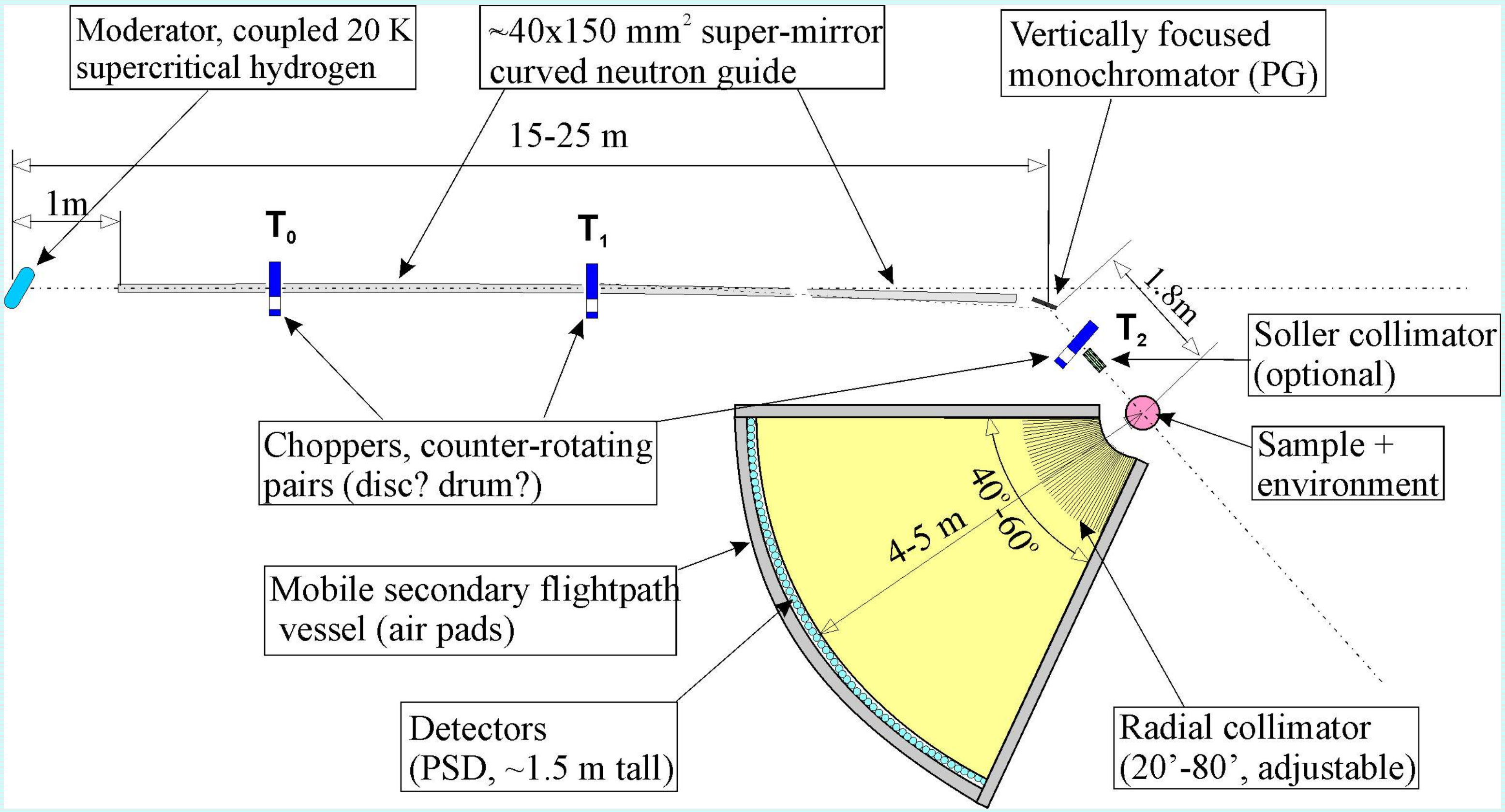
- *Low background even with bulky sample environments: collimator(s)+slit(s) define scattering volume seen by detector(s) and restrict analyzer acceptance to scattering from sample only. Scattering from cryogenic environment, magnet, pressure cell, etc., is rejected.*

- *Continuous wavevector coverage: no "blind spots" caused by spaces in the detector array.*

- *Flexibility: both energy and wavevector resolutions are variable and easily adjustable, typical resolutions are 1% to 5%. In addition, different crystal reflections may be user on monochromator.*

Current schematics of the instrument layout.

Tentative placement: beamline 14.



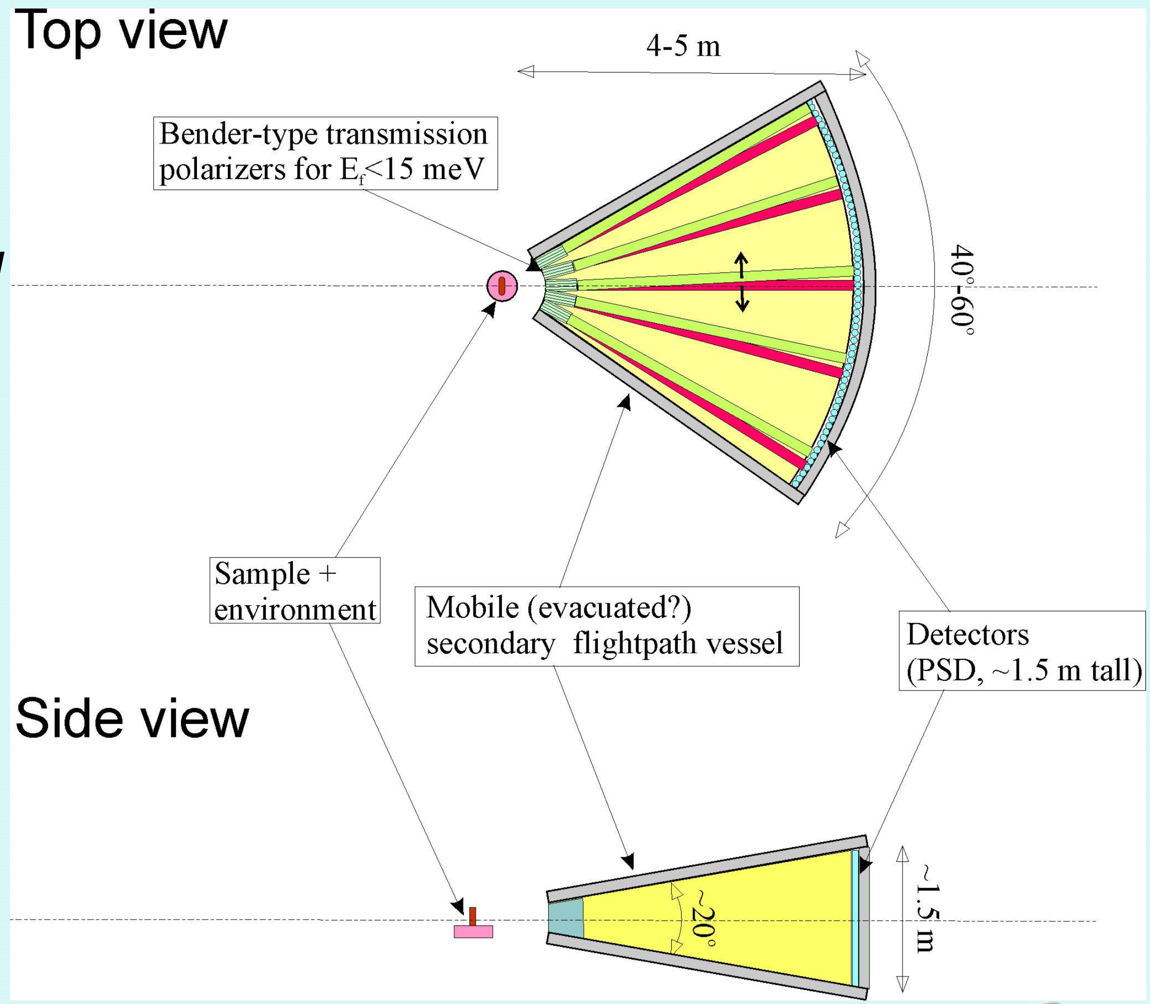
Important but not shown:

- *Monochromator shielding + beam stop*
- *Guide and analyzer shieldings*

Secondary spectrometer (TOF analyzer) and its operation in the polarized beam mode.

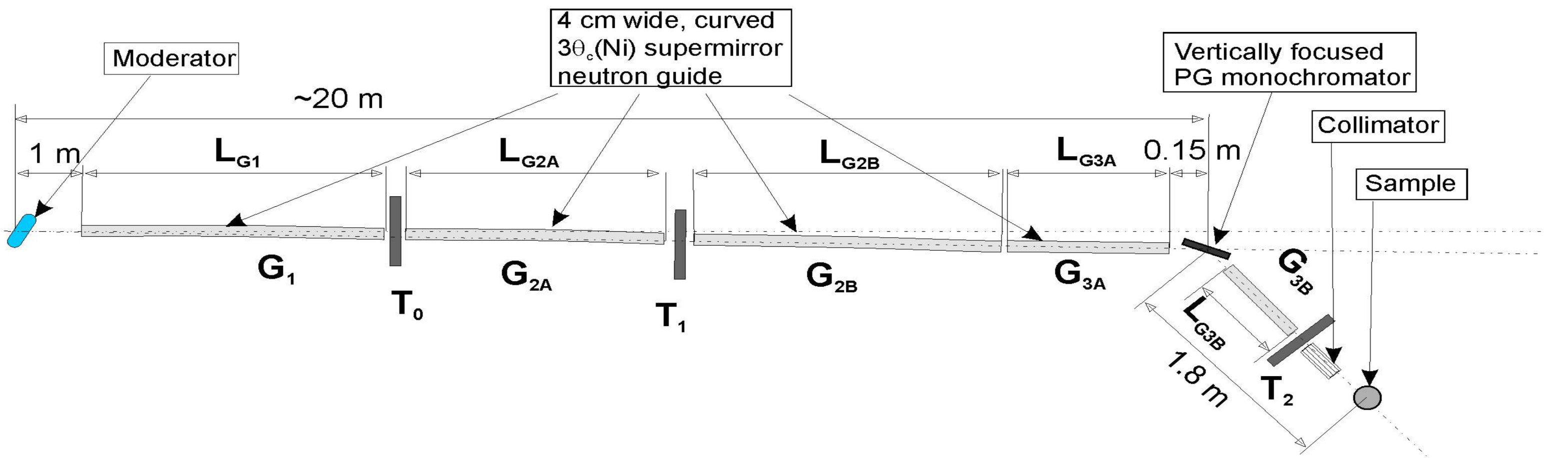
All scattering angles of interest in the polarized mode are filled in by appropriately moving the detector bank!

- *E_i=5-60 meV incident polarized beam is produced by reflection from VF Heusler crystal monochromator*
- *Set of 5-10 bender-type polarizers provide for the polarization analysis for E_f<15 meV.*
- *Scattering from the BULKY SAMPLE ENVIRONMENT (aluminium, etc.) is outside analyzer acceptance.*

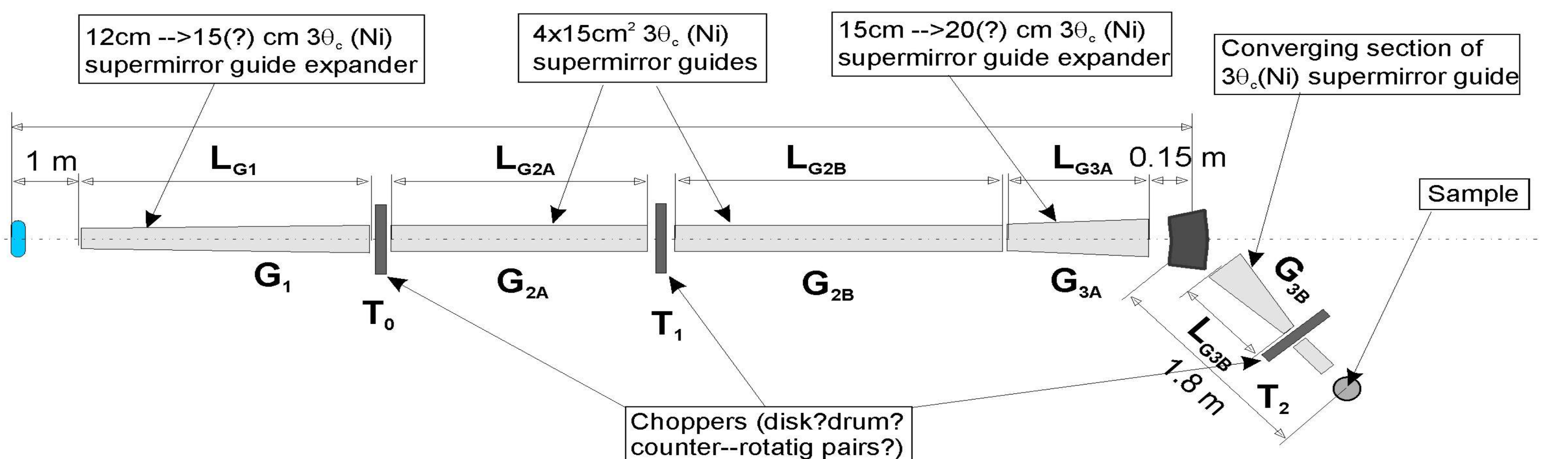


Schematics of the proposed primary spectrometer.

Top view

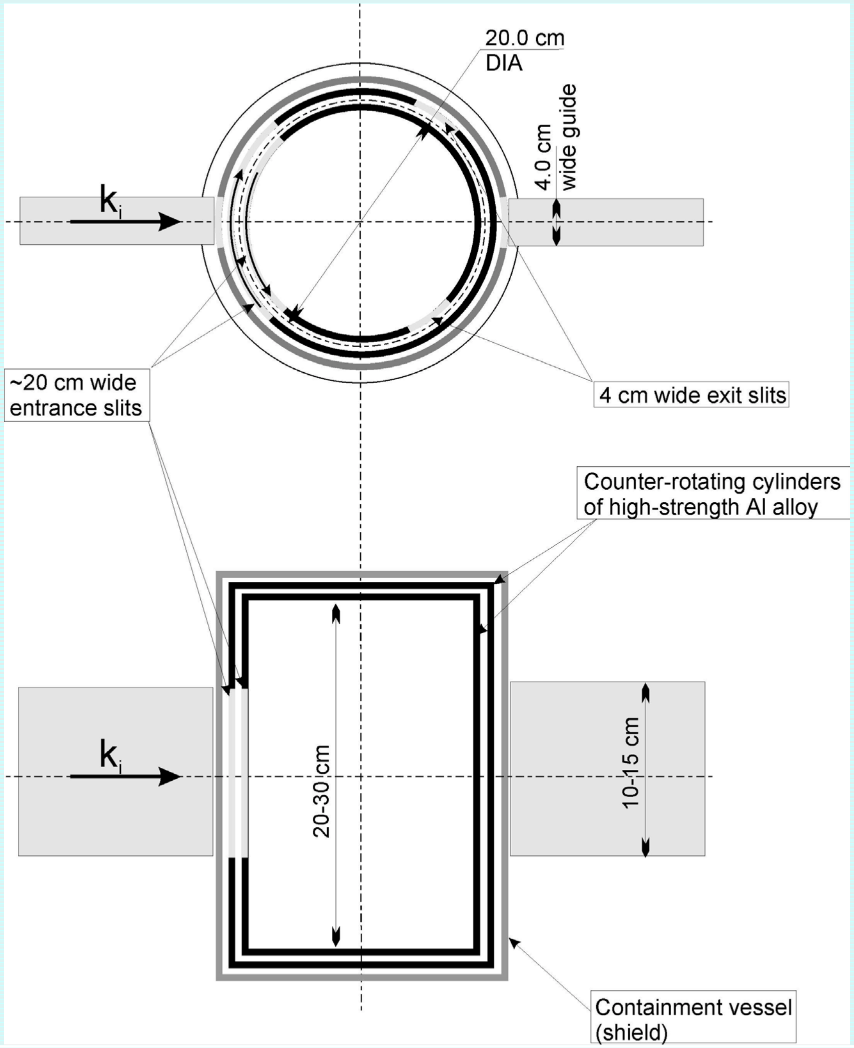


Side view



One of the possibilities for T_2 chopper: counter-rotating "drum" pair.

The closer is T_2 chopper to the sample, the better is analyzer resolution.
Question: could we put it after the monochromator?



Advantages:

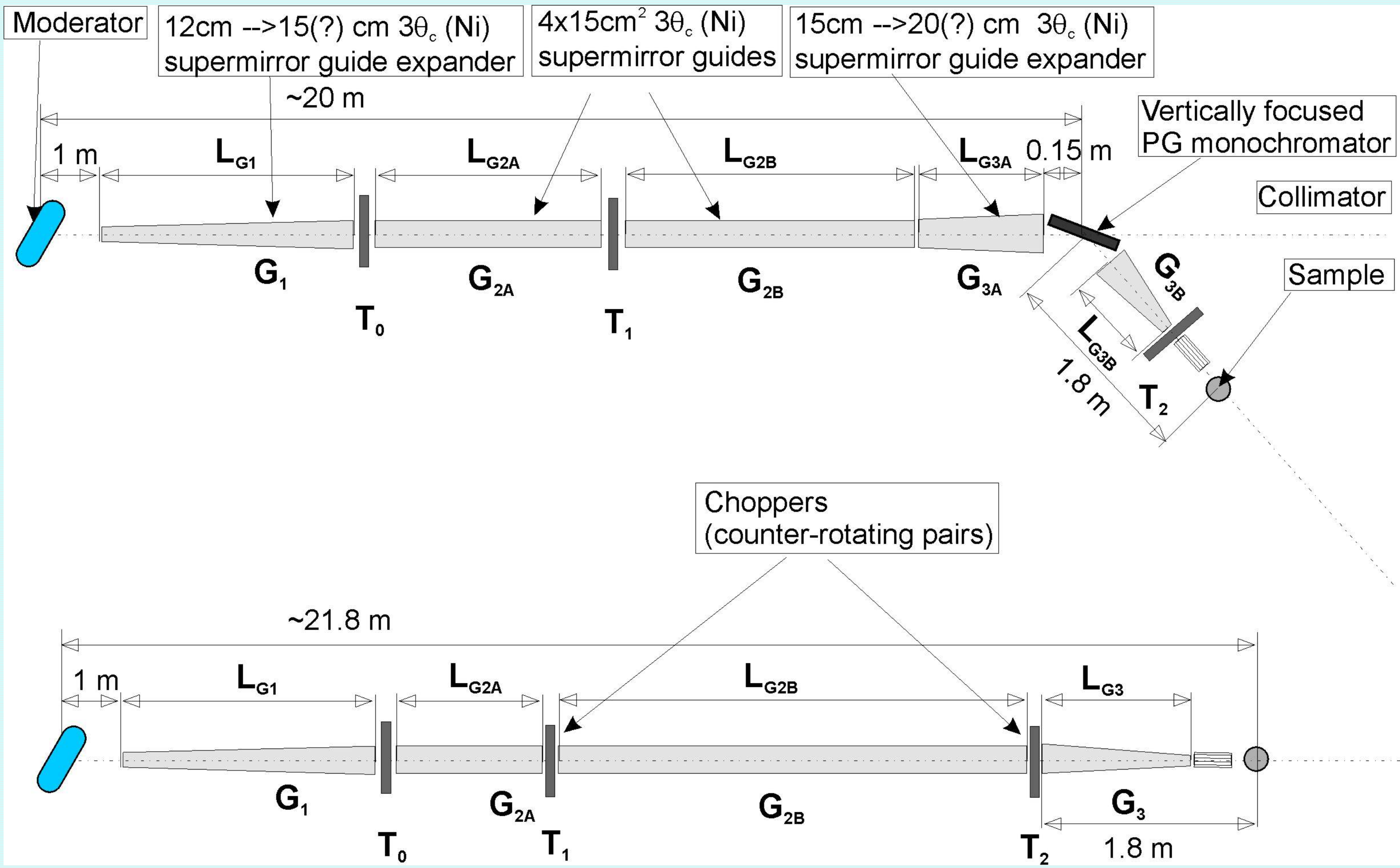
- *Light and compact.*
- *No gyroscopic forces from horizontal displacement.*
- *No restriction on beam height.*
- *Fast to speed up, slow down, re-phase, similar to modern Fermi choppers.*

Problems:

- *High rotation rate, up to 900 Hz is necessary for 50μs pulse.*
- *Nested vertical magnetic bearings.*

Comparative layout of the vertically focused crystal and conventional disk-chopper TOF primary spectrometers.

The side view of the guide cross-section is shown schematically.



Summary of setups used in MC simulation comparing the hybrid and "straight through" primary spectrometers.

Setups with very similar layouts, both optimized for $E_i = E_f = 15$ meV.

Coupled Hydrogen moderator 12cm by 12cm
Distance from moderator to sample = 21.8m
All guides are coated with 3-theta-c supermirror
Guides G2A and G2B are segmented guides, with an offset of 8cm
Distance between collimator and sample is 40cm

Hybrid spectrometer

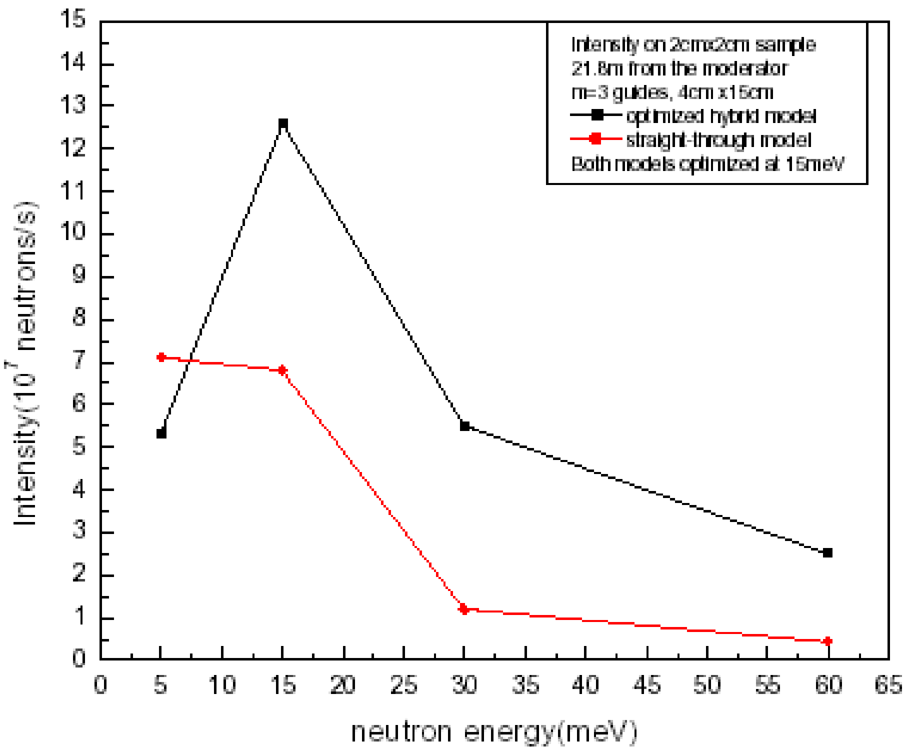
Element	Distance from moderator (m)	Length (m)
Guide G1	1.0	6.0
Guide G2A (segmented)	7.0	5.0
Chopper T1	12.05	
Guide G2B (segmented)	12.1	5.65
Chopper T3	17.8	
Guide G3	17.85	2.0
Detector D1	19.85	
PG crystal	20.0	
Detector D3	20.14	
Converger	20.15	1.0
Chopper T2	21.20	
Collimator (vertical)	21.25	0.15
Sample	21.8	

Straight through (no crystal) model

Element	Distance from moderator (m)	Length (m)
Guide G1	1.0	6.0
Guide G2A (segmented)	7.0	3.0
Chopper T1	10.05	
Guide G2B (segmented)	10.1	9.05
Chopper T2	19.20	
Guide G3	19.25	2.0
Collimator	21.25	0.15
Sample	21.8	

Neutron intensity for 2 cm tall sample obtained from MC simulation using NISP package.

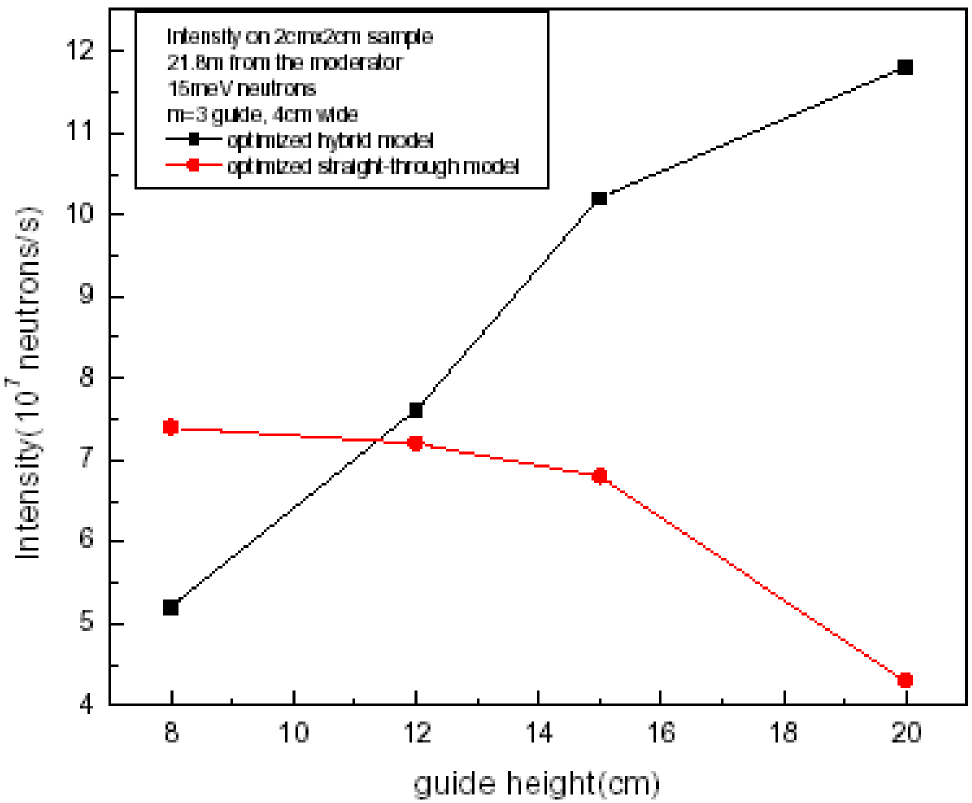
Focusing monochromator yields a gain of factor 2 or more for E_i>15meV!



- *NISP algorithm seems to under-estimate gain from focusing => actual gain may be even bigger!*
- *Decrease in intensity for hybrid spectrometer at E_i<10 meV is due to the improved energy resolution.*

Hybrid spectrometer: where the gain comes from?

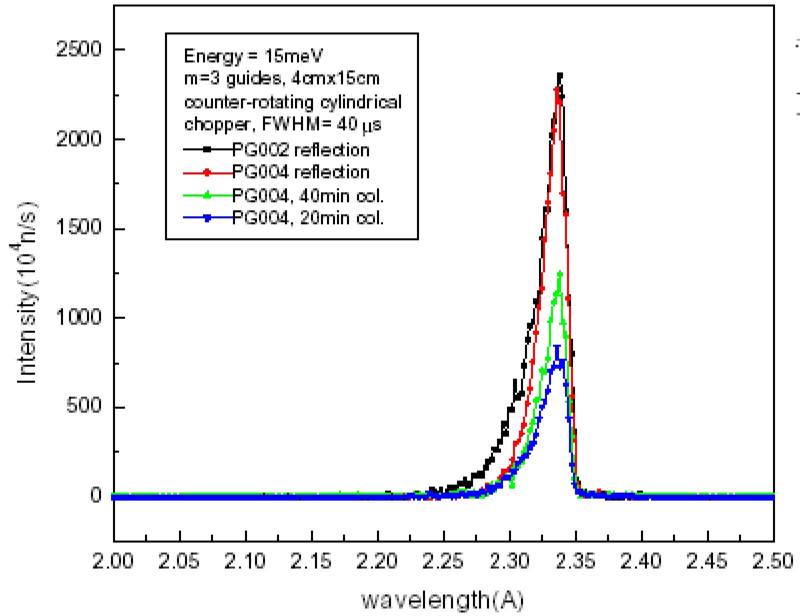
Taller guide!

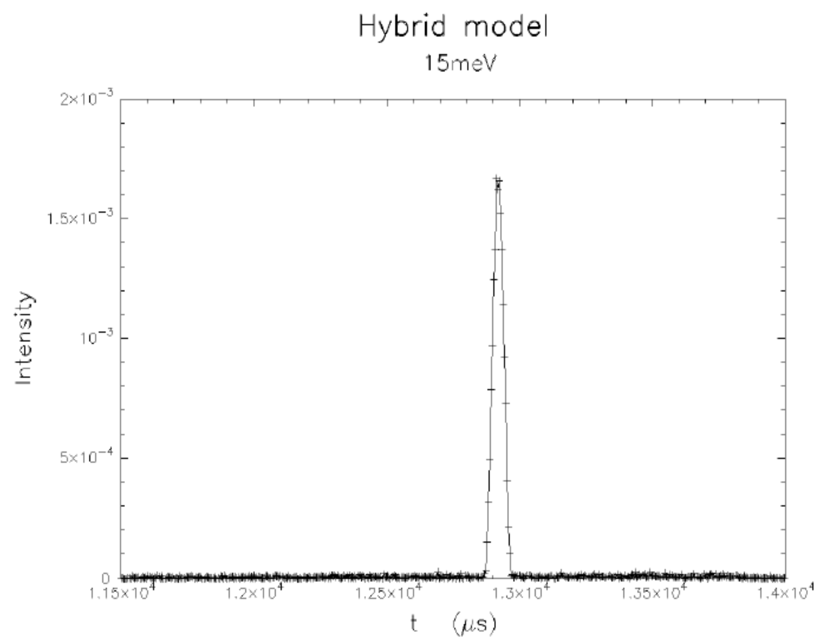


** Although it nicely illustrates the trend, this preliminary calculation contained an error, which underestimated the total intensity for the hybrid model.*

Hybrid spectrometer: some more MC results.

Spectral distribution of neutrons incident on the sample





Time profile of the neutron pulse on the sample

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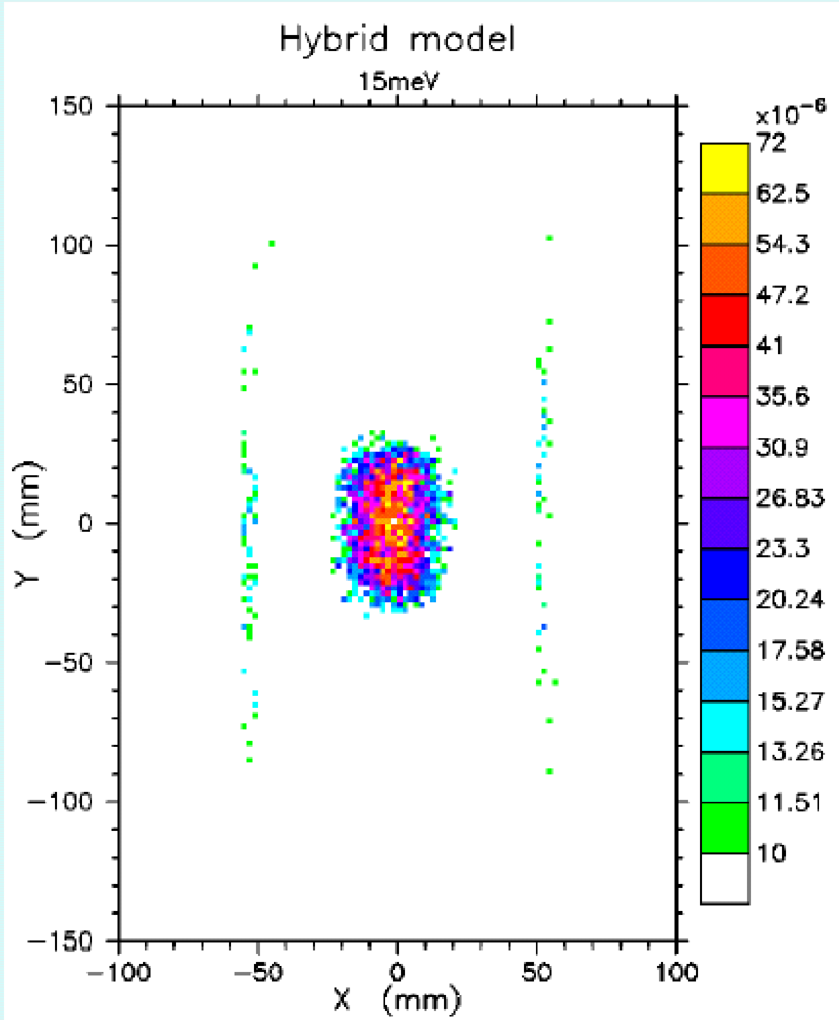
Hybrid spectrometer: vertical beam compression.

Guide is tall (15 cm), but sample is not (2 cm).



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Comparison between the hybrid and "straight-through" primary spectrometers: some figures.

Monte Carlo Results

Straight through model
The neutron flux is for a 2cm by 2cm sample, and a 2MW source

Simulation number	Model Description	Neutron Flux (10^7 neutrons/s)
Pgn214	G1:12→15, G2A=G2B=15, G3: 15→ 15cm	4.8
Pgn215	G1:12→15, G2A=G2B=15, G3: 15→ 7cm	6.7
Pgn216	G1:12→15, G2A=G2B=15, G3: 15→ 5cm	6.0
Pgn217	G1:12→15, G2A=G2B=15, G3: 15→ 6cm	6.8

HYBRID MODEL

Simulation number	Description	Neutron Flux (10^7 neutrons/s)
Pg197	G1(expander) height 12 →15cm, G2A=G2B=G3=15, Rc=1.2m converger height 20→ 20cm	8.4
Pg199	converger height 20→ 8 cm	8.52
Pg201	converger height 20→ 10 cm	8.8
Pg202	converger height 20→ 12cm	8.6
	Guide G1 expanded further: Rc=1.2m	
Pg201	G1 Height 12→15cm, converger height 20→ 10cm	8.8
Pg210	G1 Height 12→18cm, converger height 20→ 10cm	10.0
Pg211	G1 Height 12→20cm, converger height 20→ 10cm	10.8
Pg213	G1 Height 12→24cm, converger height 24→ 12cm	11.4
Pg212	G1 Height 12→30cm, converger height 30→ 15cm	9.6
Pg209	G3 also acts as expander G1 12 →15, G2A=G2B=15, G3 15→ 20 Rc=1.2m converger height 20→ 10	10.1

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Punchline: current questions and future plans.

Questions

- *Placement: beamline 14? Is there enough floor space for the instrument large footprint?*
- *Main beam stop: can it be incorporated in the monochromator shielding? How significant background source would it be?*
- *Beamline shielding: how thick is enough and what restrictions result?*
- *T_2 chopper: can it be mobile and placed after the monochromator?*

Plans

- *Workshop on the proposed Hybrid Spectrometer at BNL, October 12-13.*
- *Assemble Instrument Development Team and submit formal Letter of Intent to the SNS.*
- *Find answers to the above questions.*
- *Put together a comprehensive proposal and search for funding.*