NEUTRON GUIDES AND SCIENTIFIC NEUTRON EQUIPMENT AT CILAS / GMI

P. GAUTIER-PICARD
CILAS, 8 avenue buffon, BP 6319, 45063 Orléans, FRANCE

ABSTRACT

CILAS company is the world's leading supplier of complete neutron guides systems. The neutron optics with multilayer coatings produced by CILAS have become an international standard for neutron beam transportation in the modern research institutes.

During the last 30 years, CILAS designed, produced and installed more than 5000 meters of guides in many European, American and Asian countries.

To reinforce its leadership and presence in neutron research, CILAS acquired the company Grenoble Modular Instruments (GMI), a leading company in high precision mechanics, engineering and manufacturing of spectrometers and scientific equipment for neutron and synchrotron research.

I Introduction

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By these projects, the company has acquired a very strong experience with conception, design, manufacturing and setting up of neutron guides.

In most cases, CILAS was in charge of the design, as well as the manufacturing of the **whole system**, comprising optical and mechanical components, vacuum system, shutter and shielding definition. By our long experience we have also acquired good knowledge of the materials used in this specific nuclear environment and their behavior under radiation such as glass, borated or not, coatings, glue or metal.

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This merger allows us to design and to supply a complete range of high precision **optical and mechanical** equipment for neutron research. CILAS and GMI have designed, manufactured and installed a High Resolution Powder Diffractometer for the 30MW Korean Hanaro Reactor. This project included the calculation, design and supply of the complete biological shielding of the instrument as well as for the primary beam shutter on the thermal beamport.

II CILAS's Neutron Guide Department

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By these projects the company has acquired a very strong experience with:

- conception,
- design,
- manufacturing,
- setting up of Neutron Guides.

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Actually, we are in charge of: - a new complete guide system

- one at SNS for the guide system for the Backscattering Spectrometer beam line 2TU.
- two in Oak Ridge to update the HFIR reactor with a set of cold neutron guide in a guide hall, and a set of thermal neutron guide in the reactor hall,

- several improvements

- in ILL: modernization of D11 chopper disks with non-standard neutron guides.
- in NIST: replacement of a Be filter by guides of special configuration increasing the cold neutron intensity at the sample of a SANS and enhancing its Q-range by transmitting intensity below 4Å.

2.1 References

We give, underneath, a list of references with the name of the scientist responsible of this job in different European and American Neutron Centers.

France

ILL	Dr W. KAISER P. MALBERT
LLB	Dr R. KAHN

Germany

KFA	Dr. B. ALEFELD
HMI	Dr. F. MEZEI

Switzerland

PSI	Dr WAGNER

U.S.A.

NIST	Dr. M. ROWE
	Dr I. SCHRÖDER
ORNL	Dr. D. SELBY
BNL	Dr D. SCHNEIDER
Los Alamos	Dr PYNN
	Dr M.BOURKE
SNS	Dr K. HERWIG

Switzerland

PSI	Dr WAGNER

KOREAN

HANARO	DR. C. HEE LEE

INDONESIA

BATAN

2.2 Manufacturing

During these 30 working years, we developed many special optical devices like multichannel benders, deviators, monochromators, polarizers as well as diverging or focusing elements.

Furthermore, we had continuously improved the performances of our guides arriving now to **a very high level of quality**, due to:

- a continuous improvement of all the manufacturing processes, controlled by a very strict quality plan, which is under the responsibility of our Quality Department,
- the use of the best materials,
- the serious narrowing of manufacture tolerances especially for the geometry of each element, quality of the polished surfaces (flatness, roughness, local defects), and precision of alignment.

Type of glass

The neutron guides can be done using three kinds of glass. Hereafter is a table presenting the consequences on the neutron guide according to the chosen type of glass.

	Float Glass	BoroFloat	Borkron
$B_2 0_3$	0%	12%	12%
MATERIAL			
Behavior under radiation (n/cm²)	10^{20}	2.10^{18}	10^{16}
Shielding efficiency	--	++	++
Low activation	++	++	?
TOLERANCES			
Flatness of the reflective surfaces (rad)	4.10^{-4}	5.10^{-5}	2.10^{-4}
High reflectivity of the coating	++	++	-
precise lateral and angular positioning	++	++	++
Quality and cleanliness of the vacuum	++	++	++
Long time stability of the adjustment	++	++	++
MAINTENANCE AND UPDATING			
Addition and modification must remain easy	++	++	++
Good references for readjustment	++	++	++

Supermiror

About 10 years ago, based on its success in developing and marketing neutron optical devices, CILAS began serious investigations on the fabrication of supermirrors with large critical angles m (or θ). m (or θ) is the ratio of actual critical angle of the supermirror compared to the critical angle of natural Nickel. The thickness profile of the different Nickel and Titanium layers was made according to the algorithm developed by Hayter-Mook (ORNL), but important research on material problems and process parameters was necessary to improve the reflectivity of the coatings.

For that purpose CILAS took serious advantage of its close contact with the Laboratory Léon Brillouin (LLB) in Saclay, allowing the access to neutron beams absolutely necessary for the development and the control of neutron mirror optical coatings.

Today supermirrors are produced by CILAS in large-scale industrial production, and then controlled at the LLB. We have manufactured about 300 m of supermirror coated guides until today.

As an example we have manufactured all m=2 and m=1,2 supermirror coated new guides for NIST and replaced old cold guides and thermal guides in LLB and ILL which had been previously coated with a nickel layer, by new ones with 2Qc supermirror coating.

The effective gain obtained confirms and, many times, overpasses the calculations.

We have also manufactured several meters of m=3 supermirrors, for the ILL, BNL, and NIST with excellent performances. **A bender, 10-m long, m=3 has been manufactured with success for ORNL (HB4 / CG1).** Several meters of m=3.6 neutron guides will be coated in December for SNS.

Due to our permanent neutron control of the manufactured coatings we have and can have complete information of the quality and the reliability of the manufacturing process.

Since 1990 we have also started significant research work about the performance and behavior of multilayer under neutron and gamma radiation. In collaboration with the LLB we have funded several research works on this problem. Various samples have been irradiated at the ORPHEE Reactor for total doses of up to 10^{20} n/cm². This would correspond to a lifetime of the neutron guides of much more than 20 years for most applications. From these experiments, we can conclude that the coatings should have no critical influence on the reflectivity of the Neutron Guides.

2.3 Quality insurance

CILAS is certified ISO 9001 since 1994.

The very strict observance of all specifications is obtained thanks to a QUALITY PLAN adapted to the order.

This **Quality Plan** is drawn up in agreement with the wishes of the customer and with our QUALITY DEPARTEMENT and it describes the different phases of work with all the checkpoints.

Then, **for each step of the manufacturing, a set of control-sheet is filled in to specify all the values, which must be checked, as well as the tolerances.**

At every time, the manufacturing department is in charge of all these controls, but the Quality Department has to be always sure of their truth fullness, and the Project Manager is alone to have the right to accept any small derogation.

III GMI

Grenoble Modular Instruments (GMI) is a French company which was first located at Grenoble and then moved to Orléans in order to merge with the neutron guide department of CILAS. GMI is a leading company in high precision mechanics, engineering and manufacturing of spectrometers and scientific equipment for neutron and synchrotron research. The synergy with CILAS world leading supplier of complete neutron guides systems allows us to supply a very large range of high precision optical and mechanical equipment for research.
Our very close collaboration with neutron research centers (LLB , NIST ….) allows the optimization of our project by working with the physicists, the electronic and informatics departments.

3.1 GMI spectrometer program

The GMI spectrometer program includes:

neutron optical components (diaphragm, collimators, monochromators, …).

adjusting and positioning devices (goniometers, rotation and translation stages, cushion pads…).

shielding materials (flexible boron material,…).

complete instrument (reflectometer, triple axes, …).

engineering (new design, improvement and modification of existing instruments).

3.2 Some example of complete instruments already made

Triple axis IN20 for ILL (France)
HRPD for KAERY (Korea)
Diffractometer four circles for ESRF (France)
Diffractometer EVA for ILL (France)
Monochromator for ILL (France)
SANS collimator for ORNL (USA)
Monochromator line (two axis) for DEMOKRITOS (Greece)

IV CONCLUSION

Thanks to their very long experience in the neutron science business, CILAS and GMI have the best capability to provide:

- an optimal efficiency of the complete system (neutron guide / instrumentation);
- reduction of the price for the same result;
- the best adaptation neutron source / guide and guide / spectrometer;
- the possibility for future improvement.