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Contributed paper

# Variable line spacing plane grating monochromator for first LNLS undulator beamline

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In early 2007 an elliptically polarized Apple II undulator was installed on an LNLS storage ring. It will provide photons to the first PGM beamline at LNLS designed to deliver photons ranging from 100 to 1000 eV with a resolving power of over 10 000. The beamline is about to start the commissioning process and this paper describes mainly the monochromator design and construction.

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## 1. Conceptual design of the monochromator

This monochromator was constructed within principles of high stiffness and stability used in new synchrotron instrumentation design. This is probably the last beamline (Tosin *et al.* 2006) to be designed for the current LNLS machine. Hence, we have tried to push forward many important concepts (Zangrando 2002) for new Brazilian synchrotron machine, Sirius, and its beamlines.

Also very important is the decision to construct as much as possible monolithic pieces, making the equipment 'easily mountable'. This can cause an increase in costs, but assembling time is shortened.

A completely decoupled vacuum chamber from the mechanics and optics proved to be very important for our site. In that way, all the mechanics are placed in new block separated from the original concrete slabs of the experimental floor. It is a 0.8 m high concrete block with 0.3 m diameter 2 m long piles. The vacuum chamber is totally decoupled from the concrete block, fixed through a square steel tube frame in the experimental floor (figure 1).

An extremely tough goal was placed in terms of working vacuum pressure, mainly due to the high quality of the optics inside the chamber. Any cleaning process means risks, costs and time. To achieve the low 10E – 10 mbar working pressure, the chamber is equipped with a 600-litre Gamma Vacuum<sup>®</sup> pump, two titanium sublimation pumps, He<sub>5</sub>O<sub>2</sub> plasma coating and titanium nitride coating on screws and absorbers.

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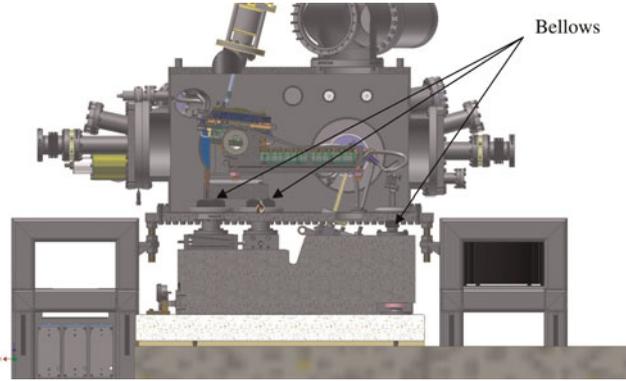


FIGURE 1. Internal mechanics isolated from the chamber by bellows.

In order to improve stiffness, all moveable components are preloaded and some design modification was applied in order to move heavy parts closer to the floor and required movements next to the optics.

A huge nodular cast iron block set on a  $3\ \mu\text{m}$  flat granite plate provided yaw adjustment of the monochromator (chamber does not move). The base plate and side flanges, on which are mounted the bearings, are constructed in a single block set over three Z-stage through kinematic points. All mechanics, including the actuators are set over this iron block.

Optics are side cooled by copper strips, clamped with a wire form springs. This design is supposed to provide small torsion on the mirrors and gratings. The cooling lines are carefully supported in order to prevent unwanted movements during energy scans.

In a plane grating monochromator, the grating and mirror rotation axis must be precisely placed in predetermined positions in order to provide a fixed exit beam. In our case, the distance between these two axes is around 10 mm. The chosen design is described below, where the mirror is supported by the two inner bearings and grating by the outer bearings (Warwick *et al.* 2004; Reiningger & Castro 2005) (figure 2).

## 2. Mechanical design, construction and testing

We have tested which subsystem of the monochromator to ensure proper functioning of the complete system.

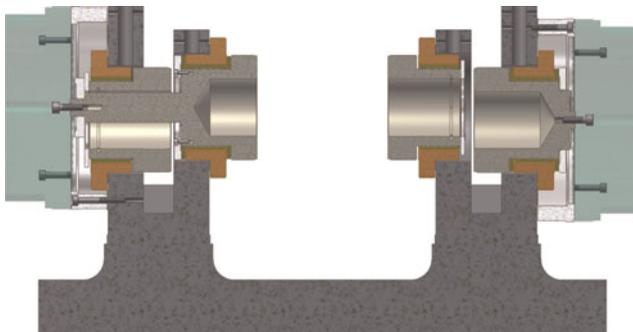


FIGURE 2. Bearings mounting scheme with two RON905 encoders.

As mentioned above, yaw adjustment of the monochromator is done moving the cast iron base. Lubrication between this base and the granite plate is done by 70% graphite grease. The proper calculation of pressure on the three support points of the base and the solid grease make it possible to obtain less than 10 arc seconds of positioning accuracy.

The z stages used to move the bearings support were thoroughly tested. Crossed roller bearings guarantee a stiffness of less than  $0.2 \mu\text{m}/\text{kg}$ . Tests have shown an accuracy of  $5 \mu\text{m}$  with  $2 \mu\text{m}$  resolution. After the adjustments, the stages are locked, with maximum random movement of  $4 \mu\text{m}$  during locking.

The optics are positioned by two stepper motors with a compact, in line, low backlash, helical gear box of 100:1 reduction (Wittenstein<sup>®</sup>). A preloaded ball screw is connected directly in the gear box and through an Invar bar with two spherical rolling joint (HEPHAIST SEIKO Co.<sup>®</sup>), the movement is transferred to the optics. The full resolution of the actuator is around 10 times higher than the resolution of the encoder RON905 (Heidenhain<sup>®</sup>) estimated at 0.01 arc seconds. The stepper motors are kept within full current drive and cooled by a copper block, so that no thermal transients are created. Beyond the in vacuum encoder RON905, an external encoder from MicroE Systems<sup>®</sup> was implemented. Also, to prevent collision between the optics, electrical switches and hard stops connect one actuator to another.

Bearings were bought from Mahr<sup>®</sup>, with hardened stainless steel races and silicon nitride balls. Less than  $3 \mu\text{m}$  run out was achieved with a radial stiffness of less than  $0.5 \mu\text{m}/\text{kg}$ .

The bearings support was machined from a 13 inches stainless steel bar in a single piece. On each flange there is a special profile, which was designed to make it possible to achieve parallelism less than  $5 \mu\text{m}$ . Measurements have shown less than  $4 \mu\text{m}$  in bearing flanges and less than  $10 \mu\text{m}$  for the encoders. It was made by electro discharge machining (EDM).

The base plates for mirror and grating were also constructed in the concept of monolithic pieces. These U-shaped supports are made of three welded stainless steel plates. The two holes are also made by EDM and allow less than  $2 \mu\text{m}$  concentricity (figure 3).



FIGURE 3. Left, monolithic bearings support, right, mirror support during EDM.

### 3. Mirror and grating alignment

The concept used to adjust the optics with respect to two axes is a kinematic three-point support (plane, V and cone) with rounded tip titanium screws pointing to polished ceramics. The cone is a fixed ball joint, allowing height adjustment only coupled with pitch angle. In the grating system, the yaw and roll adjustments are reduced by an arm in the ratio 10:1. In those two angles, the expected resolution is around 0.2 arc seconds and can be adjusted under vacuum (Fisher *et al.* 1996; Qian *et al.* 1997).

#### REFERENCES

- FISHER, M. V., KUBALA, T., SEVERSON, M. & REININGER, R. 1996 Mechanical design of a plane grating monochromator for the new undulator at Aladdin. *Rev. Sci. Instrum.* **67**, 3351.
- QIAN, S., SOSTERO, G. & DANIELE, C. 1997 Necessity of precise in-house adjustment for synchrotron radiation monochromator. *Proc. SPIE* **3150**, 114–112.
- REININGER, R. & DE CASTRO, A. R. B. 2005 High-resolution, large spectral range, in variable-included-angle soft X-ray monochromator using a plane VLS grating. *NIMA* **538**, 760–770.
- TOSIN, G., NEUNSWANDER, R. T., CITADINI, J. F., ROCHA, M. C., RESENDE, X. R., TAVARES, P. F., BASÍLIO, R. & POTYE, M. 2006 Conceptual design of an EPU for VUV radiation production at LNLS. *Proc. EPAC*, 3110–3112.
- WARWICK, T., ANDRESEN, N., COMINS, J., KAZNACHEYEV, K., KORTRIGHT, J. B., MCKEAN, J. P., PADMORE, H. A., SHUH, D. K., STEVENS, T. & TYLISZCZAK, T. 2004 New Implementation of an SX700 Undulator Beamline at the Advanced Light Source. In *SRI Eighth International Conference* 458–461, AIP
- ZANGRANDO, M. 2002 Soft X-ray optics and soft X-ray spectrometer for a circularly polarised radiation source at ELETTRA. PhD thesis, Prague Faculty of Mechanical Engineering.