New mounting for grating G1 of the Astra TA2 compressor

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Introduction

Operations in Target Area 2 of Astra have been more difficult in recent years, due to problems with maintaining alignment of the compressor optics. The principal source of instability was the mounting of grating G1, which is a circular grating of approximately 150 mm diameter. Part of the difficulty arose because replacement gratings were slightly smaller in diameter, whereas the grating holder was designed to accept optics up to 156 mm. Securing the smaller gratings in the holder required longer retaining screws that allowed the grating to shift when the chamber was disturbed, throwing the compressor out of alignment. A full re-optimisation was needed before the experiment could resume, which was time-consuming and required significant staff effort. For operations to continue without high levels of intervention, it was essential to replace the grating mount with a better one, which was stable and could carry gratings of different sizes. The process of changing a grating was also extremely awkward with the original mount, because of limited access to the chamber interior. There was a significant risk of the operator dropping the grating, or of it falling out of the mount before it could be secured.

Specifications

The mount for G1 in the TA2 compressor chamber is suspended from a frame that bridges the internal breadboard at the back of the chamber. The rear mirror of the compressor is located just behind the frame, and the beam to it passes under the frame and also under G1. Supporting the new G1 mount from below was therefore not possible without a major redesign of the compressor, and it was decided to retain the frame and fit the new mount onto it. The new mount also needed to retain compatibility with the RF cleaning system installed in the compressor chamber. The planned improvements to the mount were: (1) finer adjustments of the grating angles and the groove rotation, including motor control of the groove rotation which was previously a manual adjustment; (2) use of better-quality bearings for the rotational motions; and (3) introducing cassette-type grating holders that could be custom-made for different sizes of grating, but which would all attach easily to the mount and ensure the grating remained in the same plane. The grating would be loaded into the cassette outside the chamber, with the grooves close to the correct orientation, and the cassette would then be attached to the mount. The accuracy of the adjustments needed to be such that changes of order 1 microradian could be made easily and precisely.

Design and construction

The design of the new mount is shown in Figure 1. The top plate is attached to the support frame (not shown) and carries the yaw bearing. A yoke attached to the yaw bearing has two arms, with the torsion bearings for the pitch axis near their ends. A horizontal yoke mounted between the pitch bearings carries the ring bearing for groove rotation, and that in turn carries the mounting plate for the grating cassette. The yaw and groove rotation bearings are pre-loaded ring bearings. Vacuum-compatible picomotors are used for the adjustments in pitch, yaw and groove rotation.

The grating cassette has a holder for the grating substrate which locates the grooved face in a fixed plane that contains the intersection of the three rotation axes. A rear retaining ring made of hard plastic holds the grating in place without applying any great force to it. The cassette has three dowel pins which locate into holes on the grating mount, and three retaining screws to lock it in place. Fitting the cassette into the mount is relatively easy, even in the confined space of the compressor chamber, and there is far less risk of the grating slipping, falling or being otherwise damaged in the installation process.

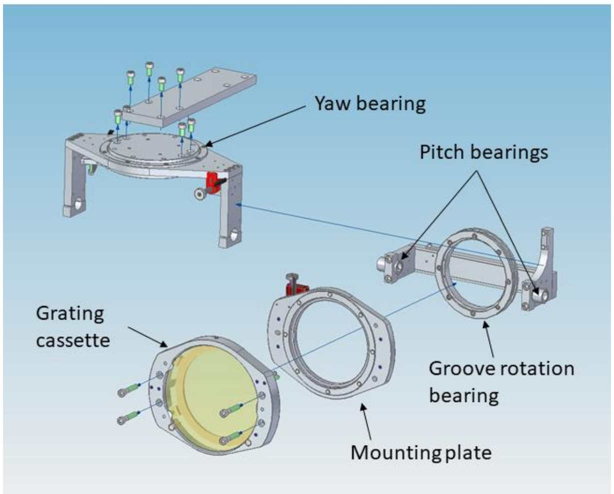

Figure 1. Exploded CAD diagram of the new mount showing the key components and their relationship

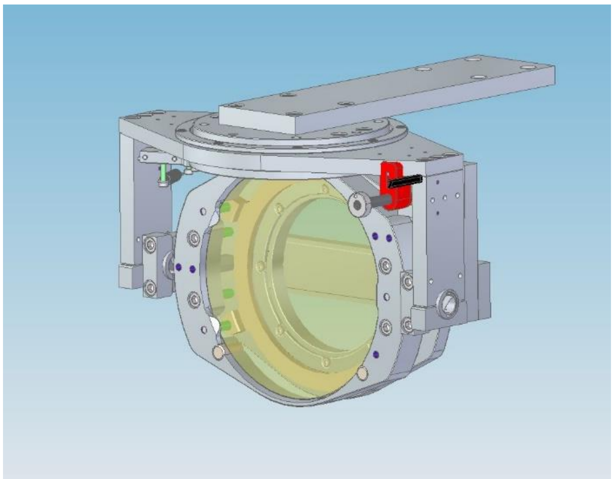

Figure 2. CAD drawing of the assembled grating mount

Testing the new mount

The mount was set up in the development lab, with a PC to control the picomotor drives. A 6-inch mirror was installed in the grating holder to reflect a He-Ne beam that was used to measure the angular sensitivity of the adjustments in pitch and yaw. The reflected beam was steered to a screen positioned

4.30 metres away, and the spot position recorded. The grating mount was driven in increments of 5000 steps in yaw, and the position of the spot recorded after each movement. The same procedure was used with the pitch adjustment. The groove rotation was measured by clamping a dial gauge with 10 micron sensitivity to the breadboard, with its tip against the side of the mount. The gauge reading was recorded for a series of movements, each of 10,000 steps. Measurements of all three motions were made in both directions of travel, to evaluate the repeatability as well as the precision of the adjustments.

For each adjustment, the average angular movement for one step was calculated based on the spot positions and the dial gauge readings, taking into account the doubling of the angle in the reflected beam, and the geometry of the setup. The results are listed in Table 1, below.

Table 1. Angle sensitivity of grating mount adjustments

Adjustment	Angle change for 1 step
Pitch	0.46 microradian
Yaw	0.28 microradian
Groove rotation	0.1 microradian

The step sizes are appropriate for the accuracy required to ensure accurate adjustment of the compressor. The picomotors exhibit some backlash when changing direction, so absolute positions determined from step counts are not reliable, but the step sizes were consistent in both directions. In practice, the compressor is normally adjusted using optical references, such as the far-field of the compressed beam or a CW beam with dual wavelength. This ensures beam pointing is maintained with respect to the target area alignment diagnostics, and any backlash can be allowed for during the procedure.

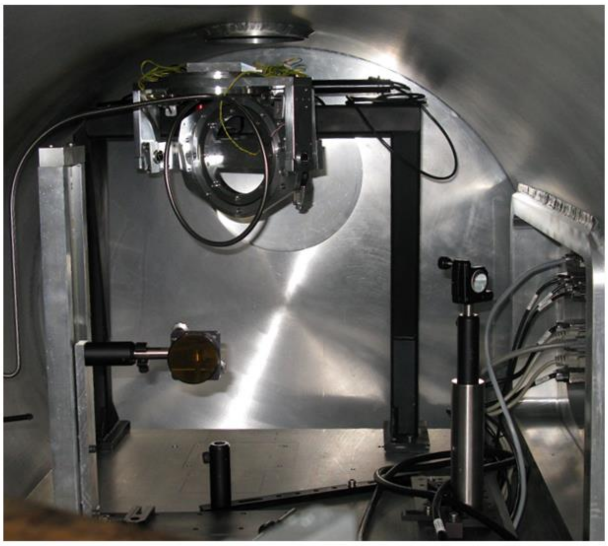

Figure 3. The new G1 mount in place in the chamber, without the grating. The antenna for RF cleaning can be seen in front of the mount. The back mirror and its mount fit on the back of the breadboard behind the black frame.

Conclusions

The new mount was installed in the compressor chamber and connected to the TA2 area drive system. Loading the grating into the cassette and installing it in the mount was found to be straightforward and much easier than with the previous mount. The compressor was realigned and adjusted to give a short pulse using optical diagnostics and the Spider instrument in the target area. The smaller step sizes of the adjustments made the alignment procedure far easier than before. The stability of the compressor has been evaluated over the course of several experiments, and the random movements and instability that were seen with the previous mount have not reappeared. The new mount has significantly enhanced the usability of TA2 for future experiments and work on testing components and techniques for EPAC.