Abstract. This document describes the mechanical design of the acquisition camera for the Goodman spectrograph. It also covers the electronics and software. The concept and optical design are covered in "Concept of an acquisition camera for the Goodman spectrograph" (ACTR 802-v1, Oct. 9 2014).

1 Mechanical design

The mechanical design has been done by P. Schurter, following the concept by A. Tokovinin.

1.1 Structure

![Figure 1: General view of the acquisition camera and its attachment to the spectrograph (right side).](image)

The structure is based on two plates, wall A and wall B, at right angle to each other (Fig. 1). As shown in the right side of the Figure, this angle is placed on top of the slit-assembly table of the spectrograph and clamped to the 45° triangular plate. The wall A touches the triangle at 3 points defined by the heads of the screws. The installation of the camera is thus done without modification of the spectrograph. The camera can slide along the optical axis, so that the pick-off mirror can be located at the right distance in front of
the collimator. This distance is set and adjusted by another screw (not shown) that touches the slit plate of the spectrograph.

The field lens L1 and the fold mirror M2 are located in a small “box” inside the angle formed by the walls A and B. Below this box, we see the motor and its driver electronics. The axis of the pick-off arm is attached to the same box. The camera with a short tube containing lenses L2 and L3 is attached to the wall A. The axes of the motor, pick-off arm, and camera are parallel to the axis of the spectrograph collimator.

1.2 Motion of the pick-off arm

![Figure 2: Kinematics of the pick-off arm motion.](image)

Figure 2 shows the kinematics of the pick-off arm. It rotates by slightly more than 45° between the IN and OUT positions. In the IN position, the arm rests firmly on the fixed point, defining this position precisely. In contrast, the OUT position is not critical, the only requirement being to leave the full collimator aperture without vignetting.

The motor rotates by 180° between the IN and OUT positions, this rotation being controlled by two limit switches. The limit switches are activated by the dip in the cylinder. The cylinder is connected to the pick-off arm by two rotational pivots and the flexible rod. The length of the rod is adjusted in such way that in the IN position it provides enough force to press the pick-off arm against the fixed point, thus defining its position independently of the exact rotation of the motor. The OUT position is defined by the radius of the attachment of the lower pivot to the cylinder. The relation between the angle of the motor and the angle of the pick-off arm is approximately sinusoidal, so the pick-off arm approaches its two positions with a low speed while the motor rotates with a constant speed.

The motor is model RE-max 21 (Maxon) with a planetary gear-head GP22 (reduction 850:1). The IN-OUT motion will take approximately 5 s (rotation speed 6 RPM). The gearhead provides maximum torque of 1 Nm and can transmit constant power up to 1.3 W (max. continuous torque 1.6 Nm), while the motor’s maximum power is 5 W. The gear-head supports maximum radial load of 55 N applied at 10mm from the flange. The force of the flexible rod in the IN position should be a fraction of this maximum load. To assure constant operation in all orientations w.r.t. gravity, the pick-off arm is balanced by the counterweight.
The motor, limit switches, and drive electronics are mounted on a small panel. This panel can be removed for service or testing the whole unit without its dis-assembly.

1.3 Optical mounts and alignment

Figure 3: Cross-section view of the optics.

Figure 3 shows the cross-section containing the folded optical axis. The lens L1 is mounted in a fixed position, pressed into the cylindrical groove by the Delrin ring and 3 clamps. The folding mirror M2 is mounted similarly to the pick-off mirror (see below). It is adjustable in two tilts and position perpendicular to the mirror. The push-pull adjustment screws are accessible from the outside of wall A. After the adjustment, the mirror will be fixed.

The lenses L1 and L2 are mounted in a tube which uses commercial elements from Thorlabs and custom adaptor to the C-mount of the camera. The distance between L2 and L3 is adjustable by the retaining rings inside the tube. The camera will be focused by adjusting the C-mount of the GC650. This focusing is critical. It will be refined after mounting the camera to get sharp image of the slit.

The details of the pick-off mirror mount are illustrated in Fig. 4. One side of the mirror is clamped in two V-grooves. The third point is adjustable within a small range, with a flat spring providing the restoring force for all support points. The mirror is fixed in one direction by friction, so it can “slide” laterally. To prevent this, the V-grooves and the space behind the adjustment screw will be filled with silicone, after angle adjustment. The other angle is adjusted by two pull screws acting against semi-cylindrical axis. The pick-off mirror of 50x50mm will be cut down to 50x40mm, with corners removed for light-weighting.

We plan to align the optics in the lab using the on-axis laser beam. There is no intention to align the angles of mirrors M1 and M2 after installation of the camera. The only adjustment after installation will be the daytime focusing on the slit.
2 Electronics

The suggested electronic scheme is presented in Fig. 5. Both the CCD camera and the motor are powered from the common 12V power supply, connected through the small panel that is attached to the spectrograph main board-board. This panel also holds the Ethernet connector. Two internal cables join the panel to the Prosilica GC650 GigE camera. The camera has two TTL inputs and two outputs (one pair opto-isolated, another not). We will use the output to command the pick-off arm position, with the low level (zero) corresponding to the OUT position (default after power-on) and the high level to the IN position. To simplify the software, we do not plan to generate and read the feedback signals that would tell whether the pick-off arm actually moved to the commanded position. If needed, such signals can be provided by two Hall sensors and a permanent magnet attached to the arm.

The power connector of the camera will have an internal cable leading to the driver board. We will use the LAM1820 bridge to drive the motor. The camera signal will be connected to the pin 3 (direction), with pins 4 and 5 in the low and high states, respectively. The two outputs are connected to the motor through the limit switches. Both switches are normally closed. They are opened when the motor reaches the commanded position. The switches are shunted by diodes to allow the reverse motion.

The driver board is attached to the same panel as the motor and the limit switches, eliminating the need of extra connectors. It has only one connector for the camera cable.

3 Software

R. Cantarutti developed a viewer for Prosilica cameras that is used in SAM. The same software will be used here with minor modifications listed below.

- Add control of the CG650 output port through the viewer’s GUI, also display the state of this port (IN or OUT).

- Enable socket connection to the Goodman software to receive commands for pick-off motion (IN or OUT). The Goodman control SW will be modified to display the state of the pick-off and to command its motion. However, this modification is outside the scope of the present project, being totally independent. Initially, the acquisition camera will be controlled only through its own GUI.
• Automatically adjust the intensity scale of the displayed image to show 90% of signal values. This is optional, as the scale can be manually controlled through the camera GUI. If the existing min/max automatic scale is used, the exposure time becomes the longest possible (0.5s) and the display shows isolated hot pixels on the black background.

The GigE camera requires a reserved Ethernet connection and a dedicated network adaptor in the computer. It is an open question which computer to use. If the SAM AOM computer is used, for example, an extra Ethernet adaptor will be needed. For the initial tests, the existing adaptor can be used, connecting the acquisition camera instead of the SAM camera. In the definitive solution, it might be more convenient to operate the camera through the Goodman computer. This remains TBD.

4 Work plan

• Review the current design, update if necessary.
• Test the optics in the lab setup (confirm the image quality), cut the pick-off mirror.
• Make the mechanical fabrication drawings
• Mechanical fabrication
• Driver fabrication and cables (in parallel)
• Software modification (in parallel)
• Assembly and testing of the camera in the lab.
• Installation and daytime tests, focusing.
• Night-time tests, documentation, acceptance.