# Mechanical Structure Pi of the Sky robotic telescope

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## ABSTRACT

"Pi of the Sky" is a robotic telescope aimed for monitoring of large part of the sky and looking for Gamma Ray Bursts with CCD cameras. One of the main parts of the project are: the mechanism pointing the cameras to given area of a celestial sphere. We present the final design of the new mount with four cameras which is now under tests.

**Keywords:** Pi of the Sky, Robotic telescope

## 1. INTRODUCTION

"Pi of the Sky" is a detector designed for search for optical flashes of the cosmic origin in the sky. The mechanical construction is built on the base of a classical parallactic mount. Its main parts are: the mechanism pointing the cameras to given area of a celestial sphere and four cameras working in coincidence. Each cameras has a CCD of 2048 x 2048 pixels of 15 $\mu$m x 15 $\mu$m. Cameras have been equipped with CANON EF photo lenses of f = 85mm., f/d = 1.4 giving $20^o$ x $20^o$ field of view. System observes fields from a predefined list of $20^o$ x $20^o$ fields overlapping by $15^o$ .
We presented new mount holding four cameras which has been tested soon. This construction is based on a prototype designed by G. Pojmanski, which was modified and implemented changes are described below. We'll described mainly mechanical changes and solutions in the new construction.

## 2. ROBOTIC TELESCOPE CONCEPT

There are two versions of robotic - telescopes with four cameras:

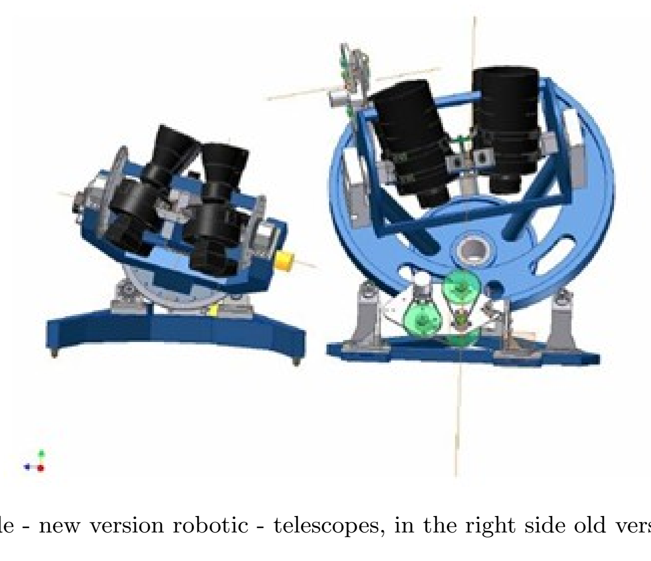

Figure 1. In the left side - new version robotic - telescopes, in the right side old version robotic - telescopes.

The construction to the right is based on the prototype designed by G. Pojmanski and installed in Las Campanas Observatory in Chile. In the new construction (in the left side) we have reduce the size of the right ascention wheel and the mechanism for deflecting the cameras. The next important change was to move the cameras outside of the wheel (more information there are at [1]. The construction is based on a classical two axis parallactic mount concept. The first, called RA (for right ascention) is parallel the Earth axis, while the second one, called Dec is perpendicular to the first one. These two axis enable to point the cameras to any point of the celestial sphere, assuming the overall construction is properly aligned with the Earth axis ( small control of the setting are possible).

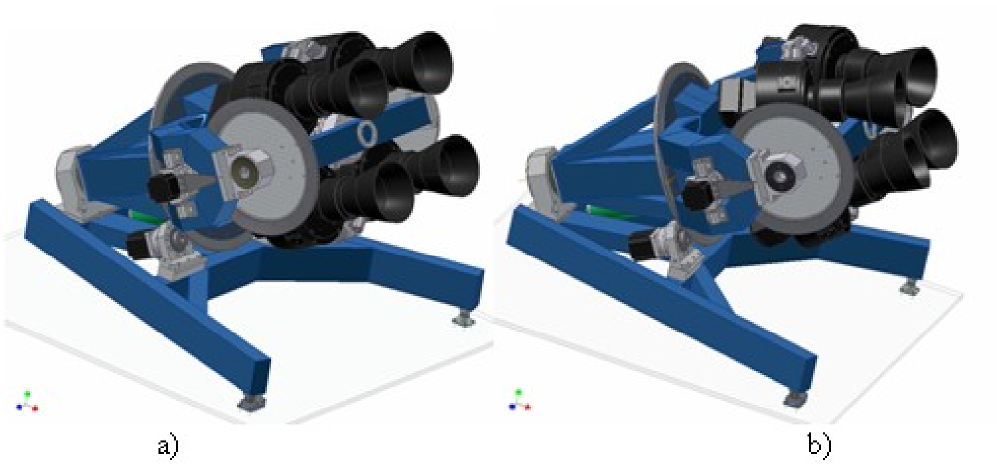


Figure 2. Two working modes: side by side: cameras cover adjacent field (in the right side) and common target: all cameras observed the same field (in the left side)

There are two working modes: a common FoV (field of view) and adjacent FoVs which are provided by the mechanism of the deflecting cameras. Each of the cameras has two possible positions - one with the camera axis parallel to themselves, the second one deflected by $15^o$ along the diagonal of the CCD chip.

## 3. MECHANICAL DESIGN DETAILS

In previous chapter I said that the construction is based on a classical two axis parallactic mount concept, which are described below.

### 3.1 The right ascention axis

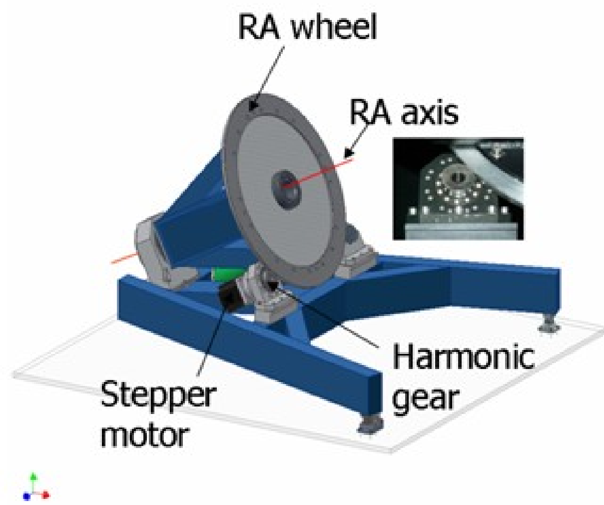


Figure 3. *The righ ascention axis.*

Fig 3.1.1 shows the right ascention axis. The RA wheel is drive by friction gear. Stepper motor with a step of $1.8^o$ (200 steps for full rotation) are used. Every step has 64 micro steps. Kinematics transfer for the RA gear is equal 1142.85. It is 5.67 arcsec for one step of the motor. Pressure between the wheel and drive roll is constant, given by gravitation. In this construction we use harmonic gear dedicated for precise devices [3]. We used a steel ring instead of aluminum-alloy. The wheel surface which contact with the drive roll has a barrel shape to improve the friction gear quality. The radius of the barrel is 200mm.

### 3.2 The declination axis

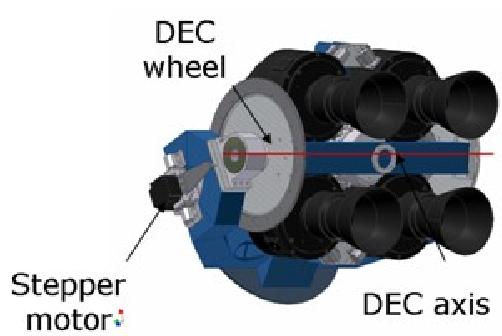


Figure 4. The declination axis

In declination axis, the kinematics transfer is equal 857.14, equivalent to 7.56 arcsec for one step of the motor. Declination angle is changed between $123^o$in relation to the plane crossing by the RA axis. Pressure between the wheel and drive roll is control by the plane spring.

### 3.3 Stepped motor coupling

Stepper motor with a step of $1.8^o$ (200 steps for full rotation) are used in this construction. Vibrations from the stepper motor are insulated by the polymers coupling. It's consist with two elements filled by Solithane 113. The solution is tested but we observed considerable decrease of the vibration level. The polymers coupling is used in DEC and RA axis.

### 3.4 Deep and Wide driver

Each single parallactic mount have four cameras. They can work in two modes: - side by side: cameras cover adjacent field (WIDE - Fig. 2b) - common target: all cameras observed the same field (DEEP - Fig. 2a) System observes fields $20^o$ x $20^o$ fields overlapping by $15^o$ . DEEP/WIDE positions are realized by the screw propeller which is drive by DC motor with reduction gear. Change positions from one to other takes 54.2 s.

## 4. FINAL DEVICE

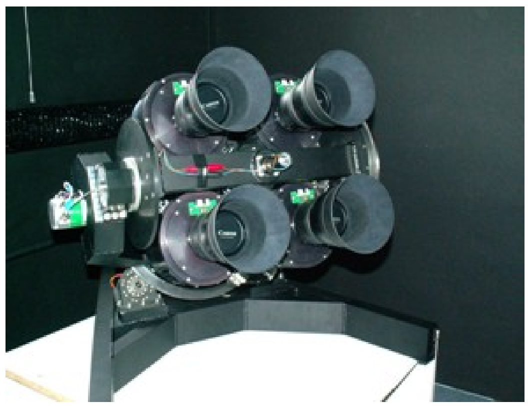

Figure 5. The declination axis

The mount is equipped with end-switches used to limit the movement of the mount in a save range. Together with a "home" switch in the middle, they are also used for absolute position estimate. The automation consists of stepper motors steered by controllers from TRINAMIC company. To read the angle values, 13 bit multiturn Absolute Encoders are used. It has over 8192 counts per revolution. That gives a resolution of about 0.46 arcmin. In the tests construction is controlling by testing program.

## 5. CONCLUSION

The first robotic telescope is testing. Other robotic telescopes will start when the testing of the prototype is complete. That is planned to occur around October 2007

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References [1] M. Cwiok , J.Grygorczuk, J.Juchniewicz, L.Mankiewicz, J.Mrowca-Ciuacz, Status of the Full Scale 'Pi of the Sky project, Proc. SPIE Volume 6347, 2006

[2] M. Cwiok, K. Malek, L. Mankiewicz, J. Mrowca-Ciulacz, K. Nawrocki, M. Sokolowski, G. Wrochna, Pi of the Sky robotic telescope, Proc. SPIE Vol. 6159, 2005

[3] Harmonic Drive web page http://www.berton.com.sg/bap1/hds/mechanism.shtml