EMBEDDED SYSTEM AS CONTROLLER FOR AN ARRAY OF GAMMA RAY TELESCOPES

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Himalayan Altitude GAmma Ray (HAGAR) TELESCOPE

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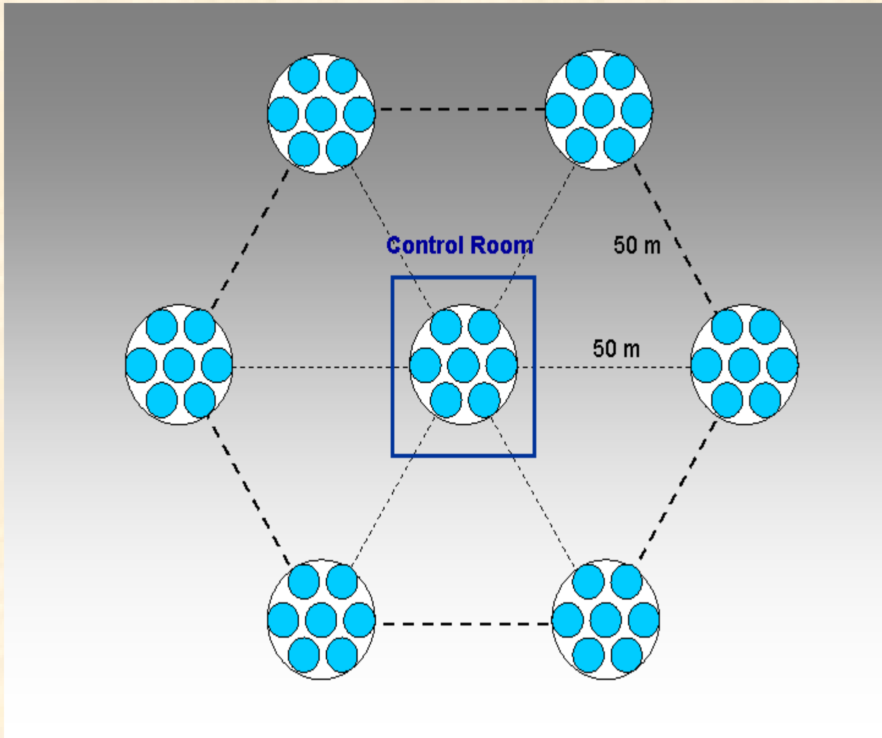
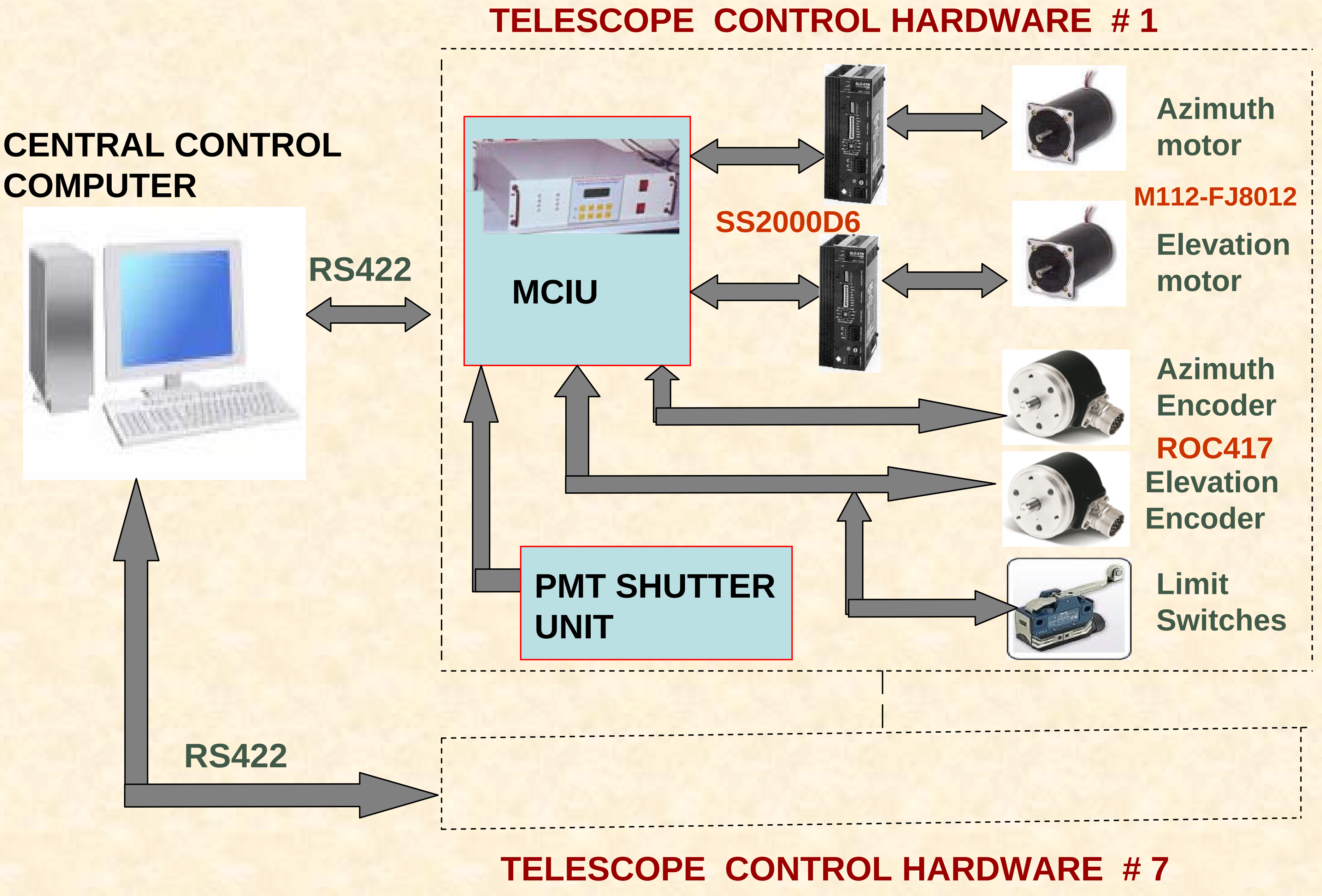
1st TELESCOPE, CREST

BASIC SCHEME

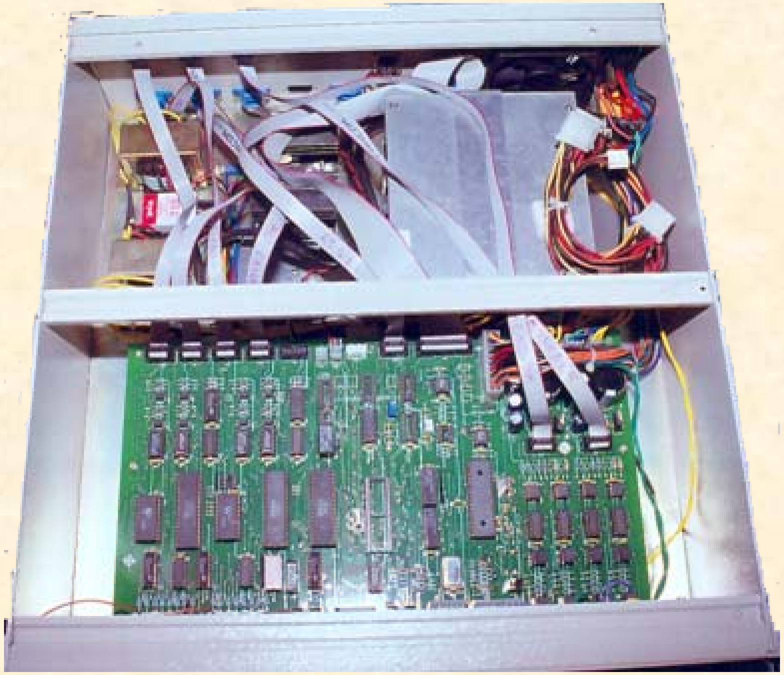
- **7 Alt-Azi Telescopes with 7 para-axially mounted front coated Mirrors of dia 0.9m.**
- **Distance between central and any peripheral Telescope is 50m.**
- **Photonic phototube (XP2268B) at the focus of each mirror.**



CONTROL SYSTEM BLOCK DIAGRAM



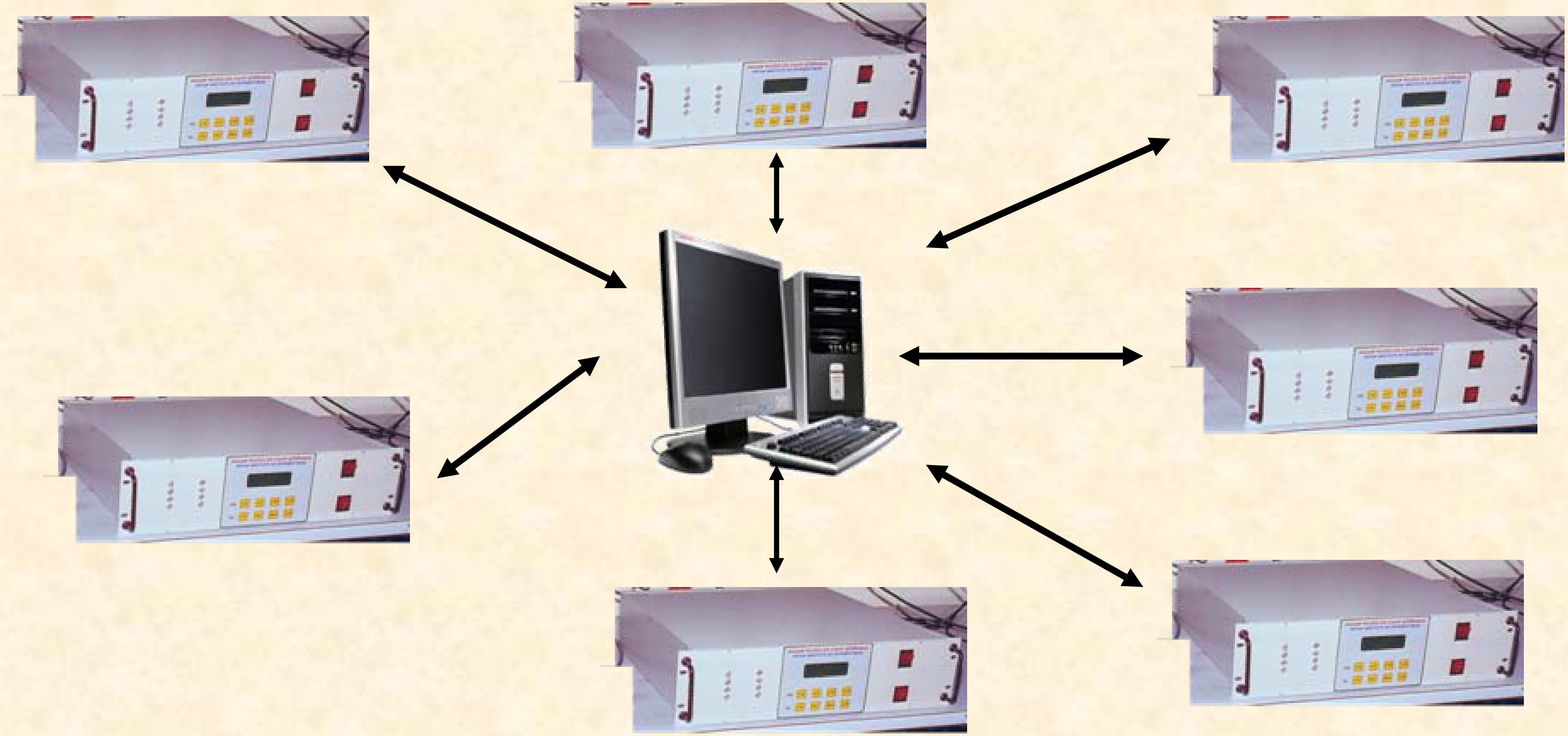
Details of the embedded controller



- The embedded controller consists of :

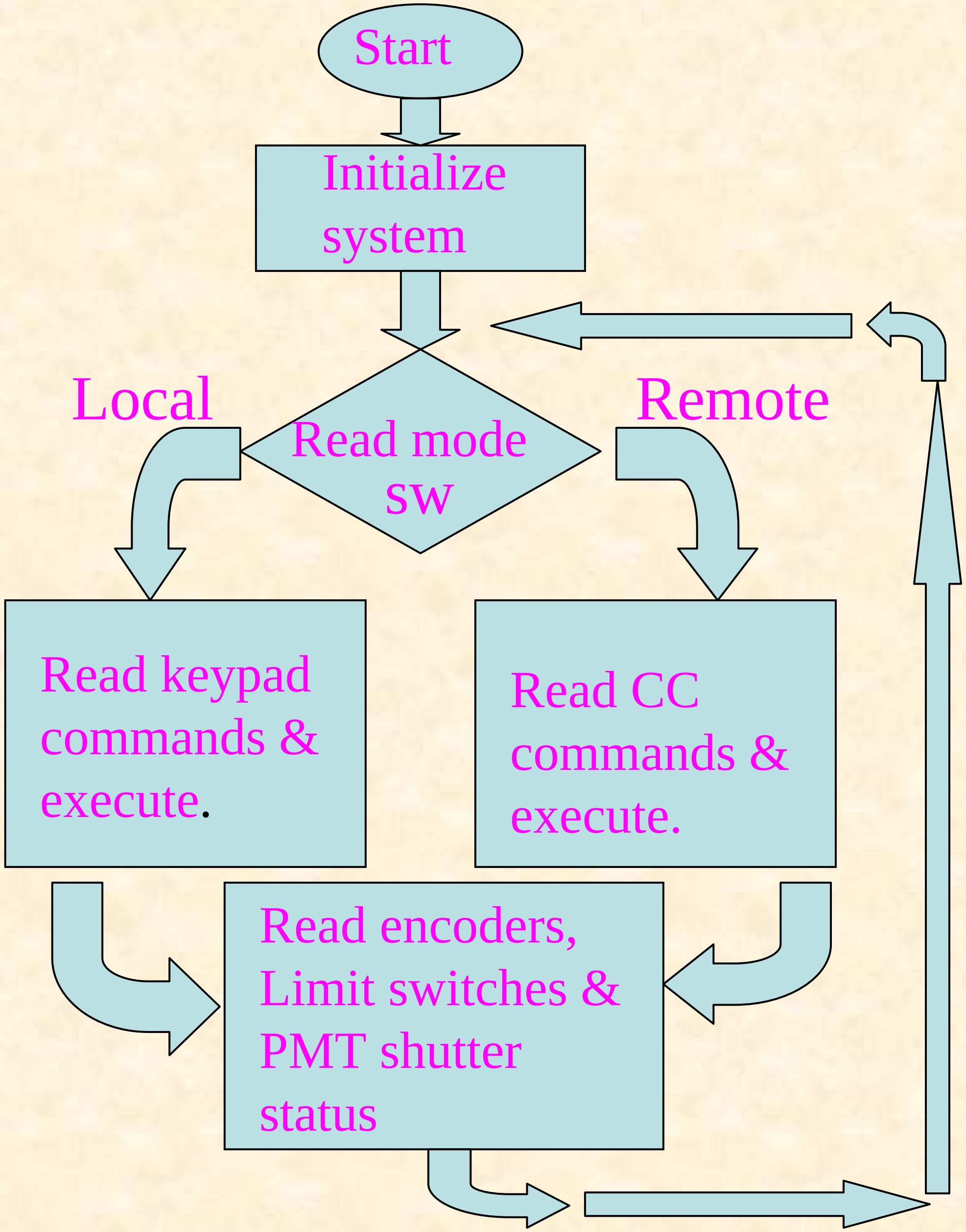
  - CPU ----PIC 16F877A @ 4 MIPS speed
  - DIO -----Intel82C55
  - PIT ------Intel82C54 and
  - Display & key pad

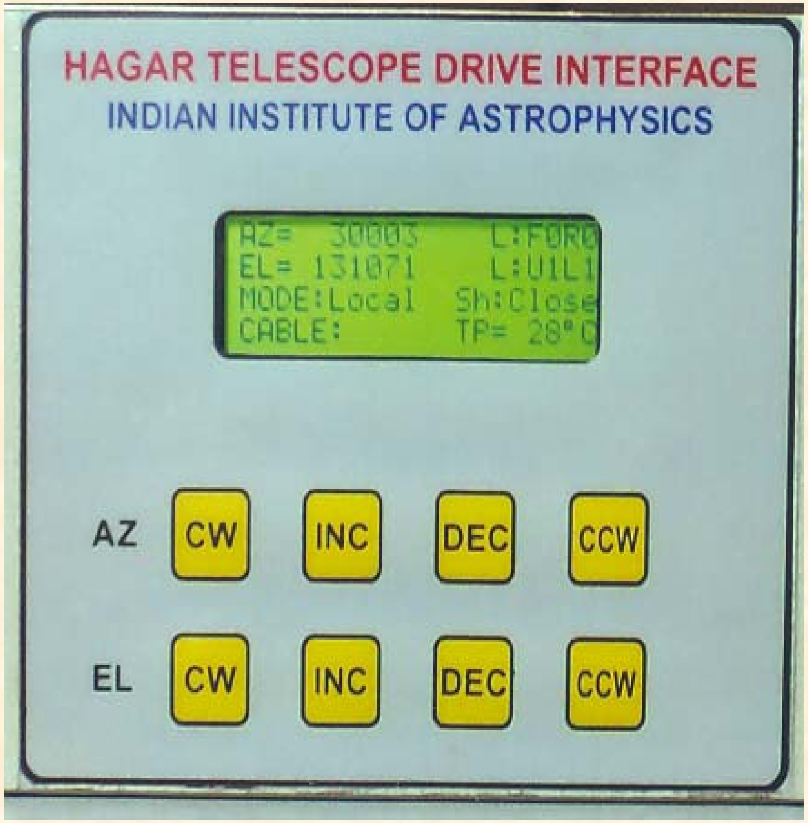
Configuration of the computer and embedded controllers



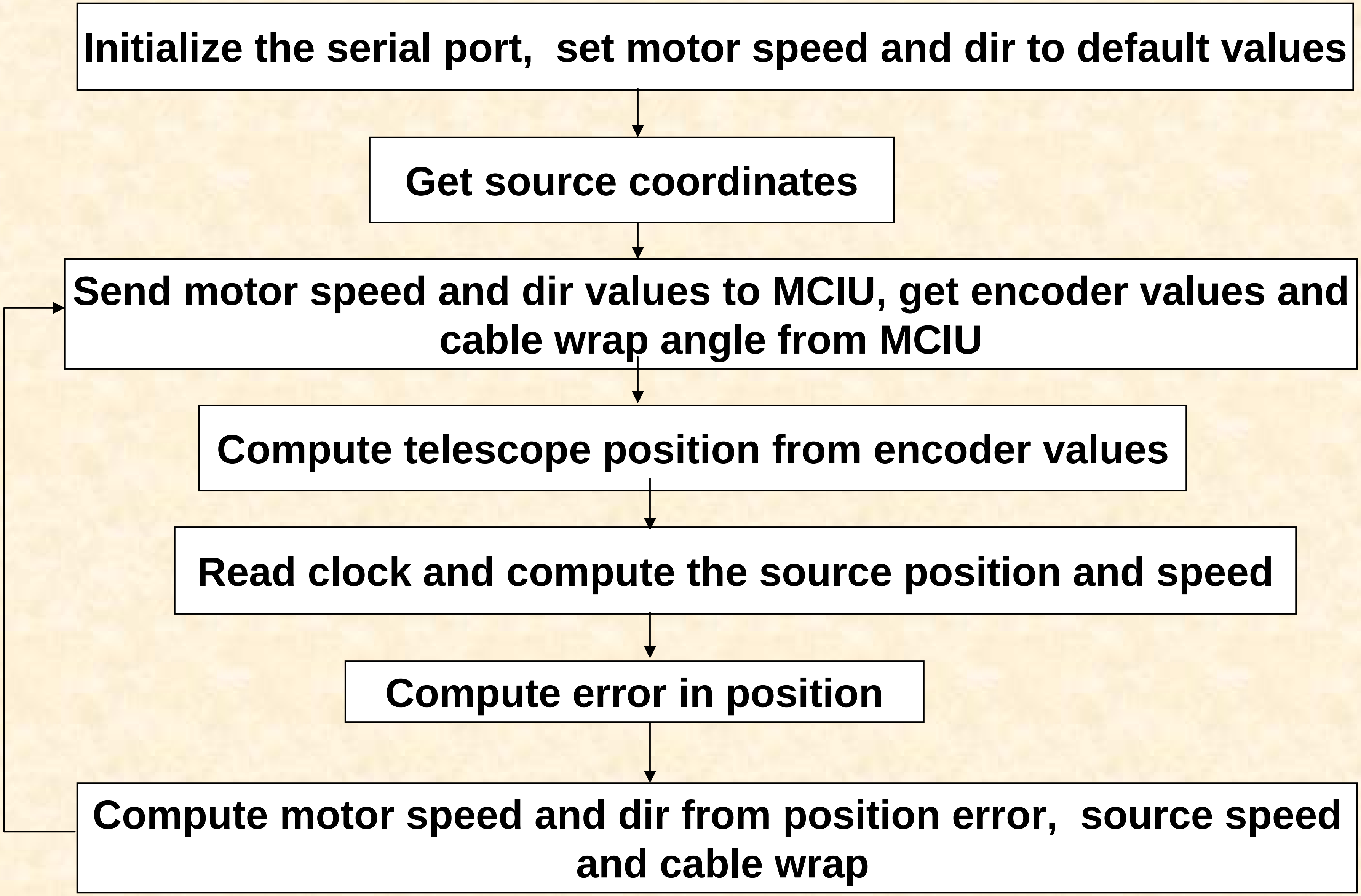
- 7 Embedded controllers are connected with central computer in a star topology through a RS422 network.
- The computer communicates with one controller at a time on time share basis.

Software flow diagram for the controller





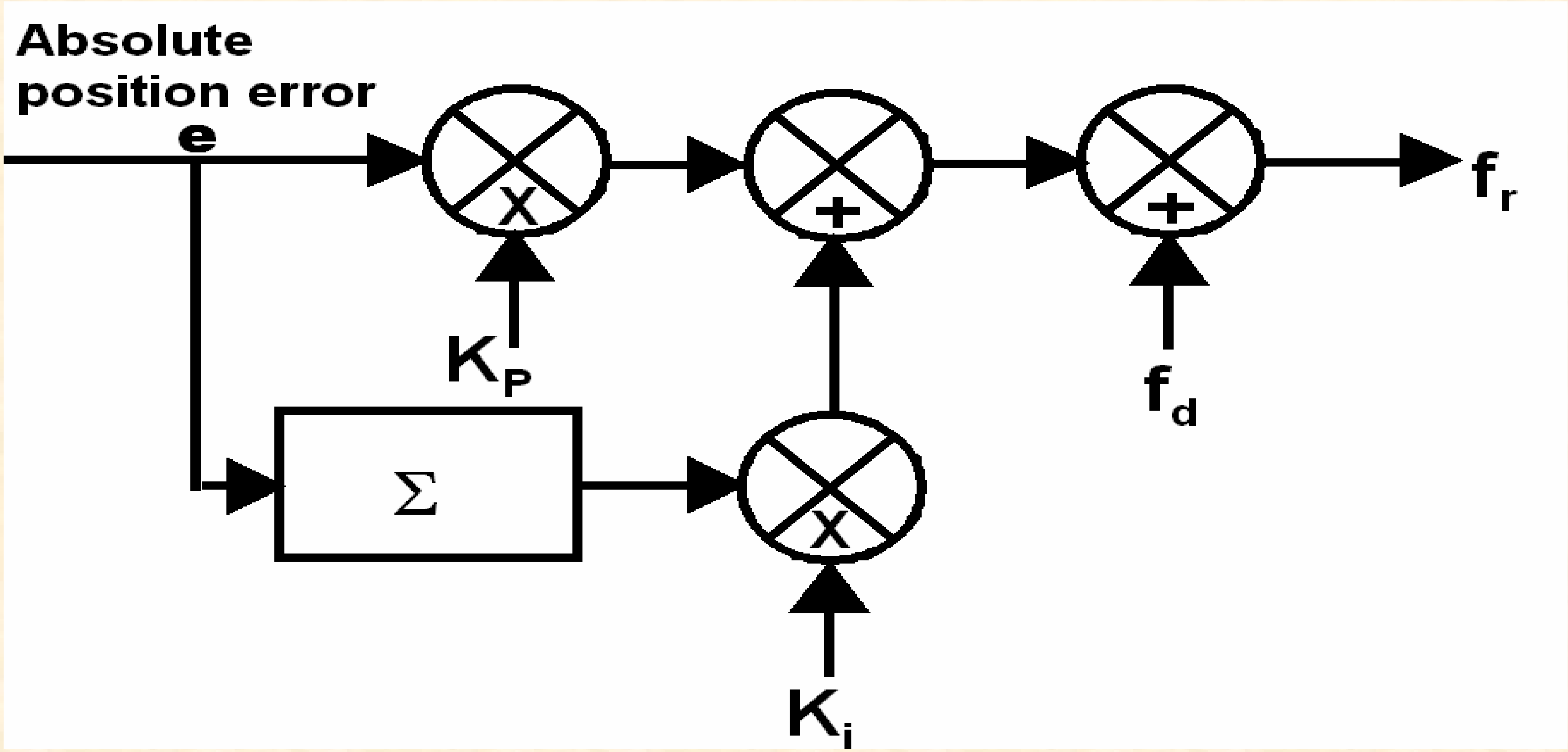
FLOW CHART FOR THE CONTROL PROGRAM



CONTROL SYSTEM OBJECTIVES

- Operational range of zenith angle : 0^0 to 85^0
- Operational range of Azimuth angle : ± 270^0 with respect to due North.
- Steady state Pointing …. ±20 arcsec
- Control bandwidth….. 10Hz
- Zenith blind spot <1.5deg
- Azimuth Speed …. 0.5deg/sec

BLOCK DIAGRAM OF PIV CONTROL



$$f_d = K_p\, e + K_i\, \Sigma e + f_r \qquad \text{---(6)}$$

f_d = desired frequency for the drive

f_r = reference / track frequency of the telescope.

e = position error

PERFORMANCE OF THE CONTROL SYSTEM

- With ‘proportional plus feed forward ‘ type of control, the servo parameters are tuned to give ± 10 arc sec tracking accuracy for the servo, < 20 arc sec of overshoot.

- The resonance frequency of the telescope structure is measured to be 25 Hz.

- The control bandwidth is fixed at 10 Hz.

POINTING MODEL

- **The pointing model used is based on the real physical effects (geometrical misalignments, flexures in the telescope tube etc.)**
- **CCD camera (ST-8) mounted at the focal point of one of the mirrors on the telescope, move the telescope so as to centre the star image in the CCD.**
- **The data collected is then used to compute the coefficients of the terms in pointing model. We use the software called TPOINT.**

- **Azimuth correction:**

  A = AN * sin(A)*sin(E) + AW *cos(A)*sin(E) + NPAE * sin(E) - CA + IA * cos(E)

  Altitude correction:

  ΔE = AN *cos(A) – AW*sin(A) – IE + TF * cos(E)

  AN = Azimuth axis north of vertical.

  AW = Azimuth axis east of vertical.

  NPAE = altitude axis not perpendicular to azimuth axis.

  CA = telescope axis not perpendicular to altitude axis.

  IA = azimuth encoder zero point.

  IE = altitude encoder zero point.

  TF = flexure in the telescope tube.

Current Status

- **Two Telescopes are tested at CREST, and commissioned at Hanle in 2005.**

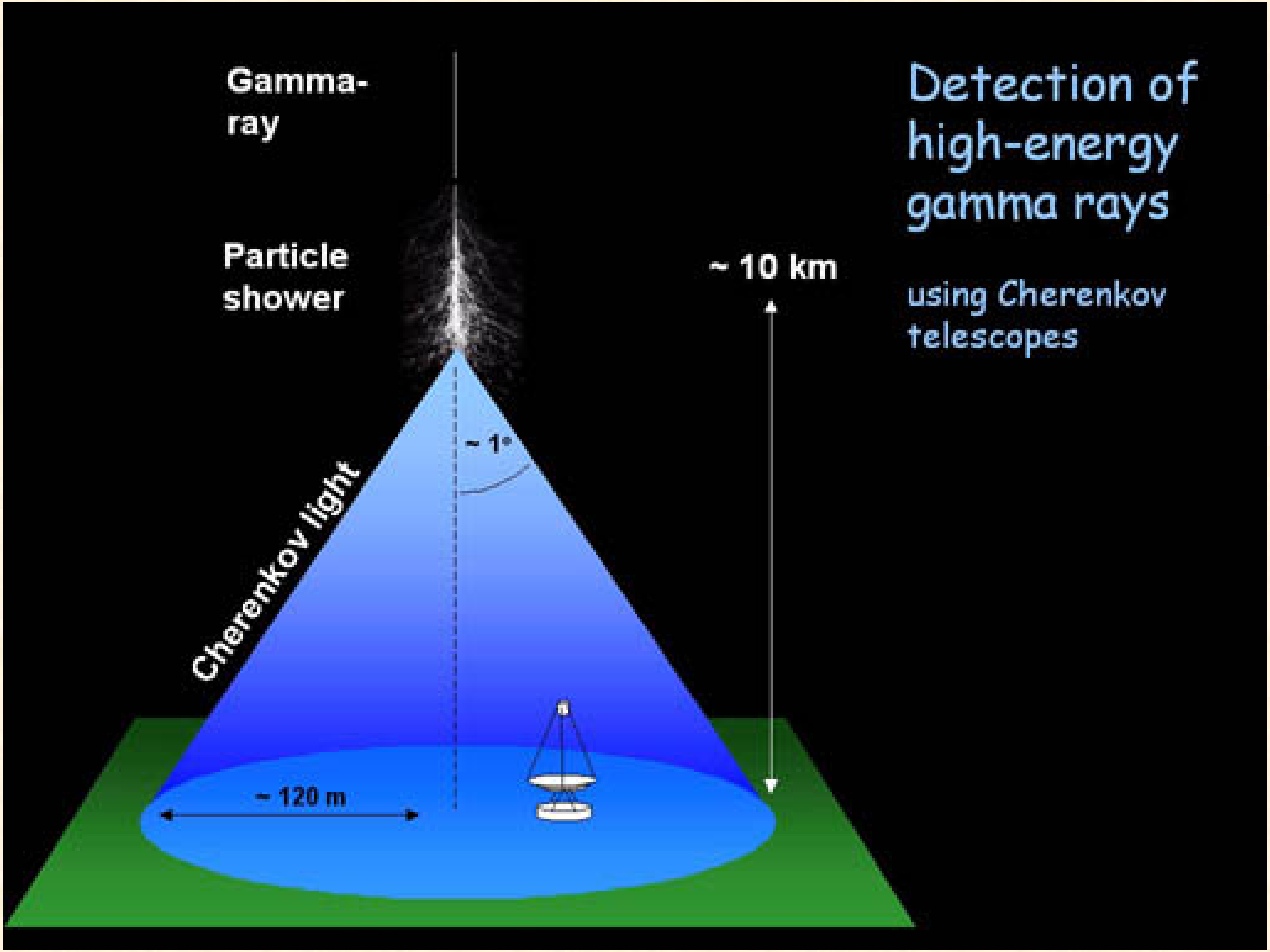
- **M/s Avasarala Technologies Ltd. is awarded the contract for fabricating remaining 5 telescopes. One Telescope would be extensively tested at CREST in May’06.**

- **Balance 5 Telescopes installation at Hanle is planned during this year.**

HAGAR TELESCOPES ARRAY

Extensive Air Shower

Cherenkov Technique



Data measured in this Expt

- Shower incident time.
- Relative arrival time of cerenkov shower front at each of 7 Telescopes as well as at each of 49 mirrors.
- Wave-front tilt is recorded.
- Photon density of shower front (49 channels).
- Latch Information of event reflecting size of shower.


THANK YOU