

A **telecentric lens** is a compound lens that has its entrance or exit pupil at infinity; An exit pupil at infinity makes the lens image-space telecentric. Such lenses are used with image sensors that do not tolerate a wide range of angles of incidence. For example, a three-CCD color beam splitter prism assembly works best with a telecentric lens, and many digital image sensors have a minimum of color crosstalk and shading problems when used with telecentric lenses.

Science behind Telescopes- in each case an image is focused by a telescope onto the detector where it is converted to digital data.

Detector works on the principle of photoelectric effect.

Optical performance can be improved by improving orbit lens alignment, larger aperture, higher pixel count CCDs. & improved satellite stabilization.

Usually push broom scanners are given preference over whiskbroom scanners because whiskbroom scanners have short dwell time. But in some cases preference is given to whiskbroom scanners because pushbroom scanners always cover FOV (i.e. full swatch width) but whiskbroom scanners deals with IFOV (smaller than FOV). Hence there are less distortions at the swatch edge for whiskbroom systems.

Requirement imposed by payload on ADCS:

- 1) Command the instrument to take science data
- 2) Receive science data from the instrument
- 3) Send science data to the COMM subsystem

X-ray telescopes are used to study mainly the Sun, stars and supernovas

Gamma ray telescopes detect bursts of gamma rays. They help astronomers confirm events in outer space like supernovas, pulsars and black holes.

Some techniques used to detect rays of high frequencies

An **air shower** is an extensive (many kilometres wide) cascade of ionized particles and electromagnetic radiation produced in the atmosphere when a *primary* cosmic ray (i.e. one of extraterrestrial origin) enters the atmosphere. One way of learning about cosmic rays is using different detectors to observe aspects of a cosmic ray air shower.

Bremsstrahlung – electromagnetic radiation produced by the deacceleration of a charged particle after passing through the electric & magnetic fields of a nucleus.

Scintillation is a flash of light produced in a transparent material by the passage of a particle (e^- , alpha particle, ion or high energy photon).

Scintillation counter – Scintillator generates photons in response to incident radiation, a sensitive photomultiplier tube converts the light to an electrical signal and electronics to process this signal.

Cherenkov radiation is electromagnetic radiation emitted when a charged particle (such as an electron) passes through a dielectric medium at a speed greater than the phase velocity of light in that medium. When a high-energy (TeV) gamma photon or cosmic ray interacts with the Earth's atmosphere, it may produce an electron-positron pair with enormous velocities. The Cherenkov radiation emitted in the atmosphere by these charged particles is used to determine the direction and energy of the cosmic ray or gamma ray, which is used for example in the Imaging Atmospheric Cherenkov Technique (IACT), by experiments such as VERITAS, H.E.S.S., MAGIC. Cherenkov radiation emitted in tanks filled with water by those charged particles reaching earth is used for the same goal by the Extensive Air Shower experiment HAWC, the Pierre Auger Observatory and other projects. Similar methods are used in very large neutrino detectors, such as the Super-Kamiokande, the Sudbury Neutrino Observatory (SNO) and IceCube. Other projects operated in the past applying related techniques, such as STACEE, a former solar tower refurbished to work as a non-imaging Cherenkov observatory, which was located in New Mexico.

Astrophysics observatories using the Cherenkov technique to measure air showers are keys to determine the properties of astronomical objects that emit Very High Energy gamma rays, such as supernova remnants and blazars.

IACT stands for **Imaging Atmospheric (or Air) Cherenkov Telescope or Technique**. It is a device or method to detect very-high-energy gamma-ray photons, in the photon energy range of 50 GeV to 50 TeV. The IACT works by imaging the very short flash of Cherenkov radiation generated by the cascade of relativistic charged particles produced when a very-high-energy gamma ray strikes the atmosphere. This shower of charged particles, known as an Extensive Air Shower (EAS), is initiated at an altitude of 10–20 km. The incoming gamma-ray photon undergoes pair production in the vicinity of the nucleus of an atmospheric molecule. The electron-positron pairs produced are of extremely high energy and immediately undergo Bremsstrahlung or "Braking Radiation". This radiation produced is itself extremely energetic, with many of the photons undergoing further pair production. A cascade of charged particles ensues which, due to its extreme energy, produces a flash of Cherenkov radiation lasting between 5 and 20 ns. The total area on the ground illuminated by this flash corresponds to many hundreds of square meters, which is why the effective area of IACT telescopes is so large.

The instrument used to detect the Cherenkov radiation usually comprises a large segmented mirror which reflects the Cherenkov light onto an array of photomultiplier tubes. The tubes are coupled to fast electronics which amplify, digitise and record the pattern or image of the shower. The most effective mode of operation is to use an array of such telescopes, which can be typically located 70 to 120 meters apart. The primary advantage of this mode of operation is

that the energy threshold (the peak sensitivity) of the telescope can be lowered as local muons produced by cosmic ray induced showers can be eliminated. This is because the narrow Cherenkov light cone produced by local muons will only be recorded by a single telescope. The shower reconstruction and background rejection offered by an array of telescopes provides an order of magnitude increase in sensitivity and improved angular and energy resolution as compared to a single telescope. This advantage has been used to great effect by the H.E.S.S. telescope array which has detected several new sources of very high energy gamma-ray photons in recent years.

Higher energy X-ray and Gamma-ray telescopes refrain from focusing completely and use coded aperture masks: the patterns of the shadow the mask creates can be reconstructed to form an image. **Coded Apertures** or **Coded-Aperture Masks** are grids, gratings, or other patterns of materials opaque to various wavelengths of light. The wavelengths are usually high-energy radiation such as X-rays and gamma rays. By blocking light in a known pattern, a coded "shadow" is cast upon a plane. The properties of the original light sources can then be mathematically reconstructed from this shadow. Coded apertures are used in X- and gamma ray imaging systems, because these high-energy rays cannot be focused with lenses or mirrors.

Ultra-high-energy cosmic ray observatories

1) **AGASA**-large area(it was ground based observatory)

2)The **Antarctic Impulsive Transient Antenna (ANITA)** experiment has been designed to study ultra-high-energy (UHE) cosmic neutrinos by detecting the radio pulses emitted by their interactions with the Antarctic ice sheet. This is to be accomplished using an array of radio antennas suspended from a helium balloon flying at a height of about 37,000 meters. The neutrinos, with energies on the order of 10^{18} eV, produce radio pulses in the ice because of the Askaryan effect.

3)The **Extreme Universe Space Observatory onboard Japanese Experiment Module (JEM-EUSO)** is the first space mission concept devoted to the investigation of cosmic rays and neutrinos of extreme energy ($E > 5 \times 10^{19}$ eV). Using the Earth's atmosphere as a giant detector, the detection is performed by looking at the streak of fluorescence produced when such a particle interacts with the Earth's atmosphere.

4) **Gamma Ray Astronomy PeV Energies phase-3** GRAPES-3 is designed to study cosmic rays with an array of air shower detectors and a large area muon detector.

In the EUV, the surface of the Sun appears dark, and hot structures in the solar corona appear bright; this allows study of the structure and dynamics of the solar corona near the surface of the Sun, which is not possible using visible light.

Solar irradiation varies over 11 years cycle.

The instantaneous swath of any imaging instrument is the width of the region that is actually observed across the track of the instrument at any time during any particular overflight.

Earth's radiation belts are usually divided into the inner belt, centered near 1.5 earth radii (R_E) from the center of the Earth when measured in the equatorial plane, and the outer radiation belt that is most intense between 4 and 5 R_E . These belts form a torus around the Earth, and many important orbits go through them, including those for GPS satellites (MEO) and spacecraft in GEO and in highly inclined LEO.

Spacecraft should carry active (e.g., transponder) or even passive (e.g., RFID, retro-reflectors) tracking devices so that they can easily be tracked. CubeSats should be given some level of onboard propulsion to allow them to maneuver out of the way if needed.