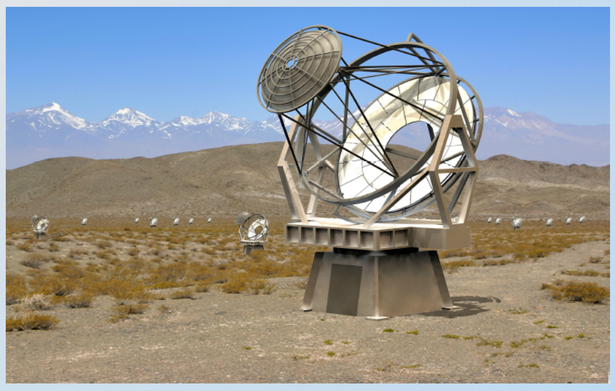

Photon Detector Developments for the Advanced Gamma-Ray Imaging System (AGIS)

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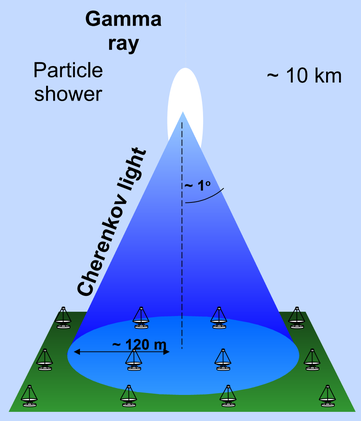
Summary: We present photosensor testing and the conceptual design of the focal plane for the camera for the AGIS very high energy gamma-ray observatory.

The Advanced Gamma-Ray Imaging System (AGIS) [1] is a concept for the next generation observatory in ground-based very high energy gamma-ray astronomy. Design goals are ten times better sensitivity, higher angular resolution, and a lower energy threshold than existing Cherenkov telescopes. Simulations show that a substantial improvement in angular resolution may be achieved if the pixel diameter is reduced to the order of 0.05 deg, i.e. two to three times smaller than the pixel diameter of current Cherenkov telescope cameras. At these dimensions, photon detectors with smaller physical dimensions can be attractive alternatives to the classical photomultiplier tube (PMT). Furthermore, the operation of an experiment with the size of AGIS requires photon detectors that are more reliable, more durable, and possibly higher efficiency photon detectors. Photon detectors we are considering for AGIS include multi-anode photomultipliers (MAPMTs) and Geiger-mode APD (G-APD). Here we present results from laboratory testing of these devices.

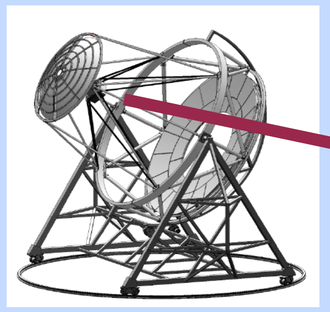
Requirements

- Blue sensitivity 280 nm – 600 nm
- Reliable, robust, little aging, and long life
- Fast response (~ns)
- Single photoelectron count rate capability
  1 phe / mm² sensor area / µs
- Intrinsic dark rates of << 100kHz/mm²
- Dynamic range of 100 phe per mm² sensor area
- Large packing fraction / no dead area between sensors
- Low cost

AGIS

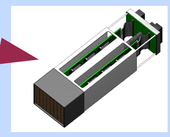


- Array of 36 Imaging Air Cherenkov Telescopes
- Sensitive to VHE Gamma-rays 50 GeV - 100 TeV
- 10 times more sensitive than existing Cherenkov telescope arrays



One AGIS Telescope
-Schwarzschild Couder
→ small platescale
→ large field of view

Camera comprises several camera module



Photon detectors
MAPMT or G-APD

Multianode Photomultiplier

MAPMT H8500D by Hamamatsu

Baseline design for AGIS: Hamamatsu H8500D
- just now available with super bialkali photocathode
- 64 pixels:
  size 6.125 x 6.125 mm per pixel
- active size 49 x 49 mm
  89% active Area
- geometrical collection efficiency 75%

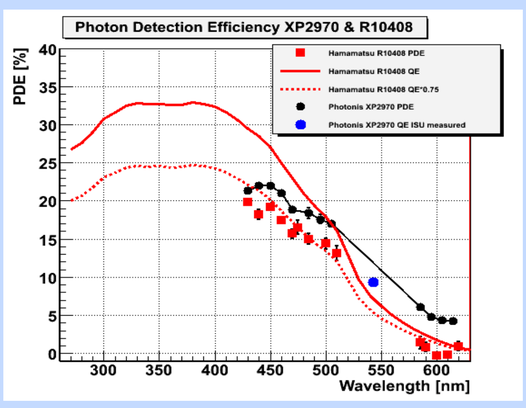
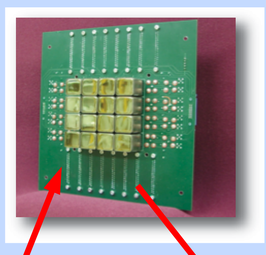


Photo detection efficiency (PDE) and quantum efficiency of the R10408. For comparison the PDE of a photonis bialkali PMT is also show.

Super Bialkali Photocathode:

- Awaiting receipt of first H8500D sample
- SBA performance tested with PMT R10408
  → 35% improvement of Cherenkov photon collection efficiency with respect to bialkali photocathode

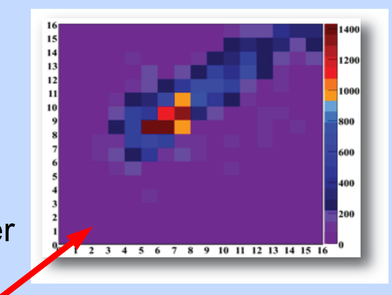
Field tests:

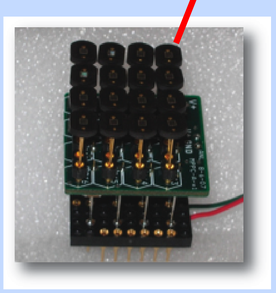


Hamamatsu R8900
4x4 pixel MAPMT
Active pixel area
5.8x5.8 mm²

Left:
16 MAPMT camera

Right:
Recorded shower image





MPPC module tested in TRICE
See right box for information about MPPCs

Test MAPMT camera mounted in TRICE

TRICE:
- Fixed mount imaging Cherenkov Telescope
- Eight 1 m diameter mirrors
- Focal length 4 m
- Used as test bed for photon detectors

Geiger-Mode APD

Devices under evaluation are from Hamamatsu, SensL, ST Microelectronics

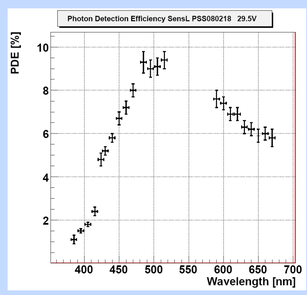
advantages:
- semiconductor photon detector
- mechanically and electrically robust
- not damaged if under bias and exposed to daylight
- low weight
- low power consumption
- bias voltage < 100 V

present disadvantages:
- expensive
- photon detection efficiency similar to bialkali PMT

SiPM from ST Microelectronics

- High overvoltage possible
  → small temperature dependence of gain:
  0.5 % gain change / C°
- Inter pixel grooves → low optical crosstalk of 3% [2]
- Green sensitive device

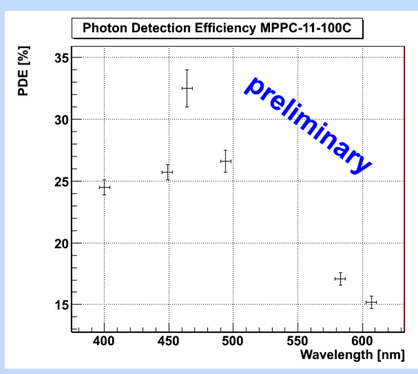
SiPM from SensL



- Green sensitive device
- Peak PDE at 500 nm
- Lowest efficiency of tested G-APDs

MPPC from Hamamatsu

MPPC with 100µm cell size has the highest PDE of all tested G-APD



Significant improvement has been made over the last years and the G-APD could be a viable option for AGIS if prices would be comparable to PMTs

References & Acknowledgement

We thank SensL, ST Microelectronics, and Hamamatsu for lending us samples of their G-APD. We are also grateful to M. Teshima and R. Mirzoyon for lending us one of their R10408 SBA photomultipliers for test purposes.

- [1] www.agis-observatory.org
- [2] IEEE PTL, Vol 18 No 15 2006