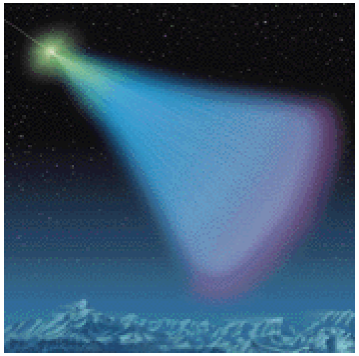
Sep 24, 1999 @ Shimane U.

1999物理学会秋の分科会　宇宙線シンポジウムI

外国のチェレンコフ望遠鏡計画
Cherenkov telescope projects in the world



森　正樹

東京大学宇宙線研究所

Masaki Mori, ICRR, U. Tokyo

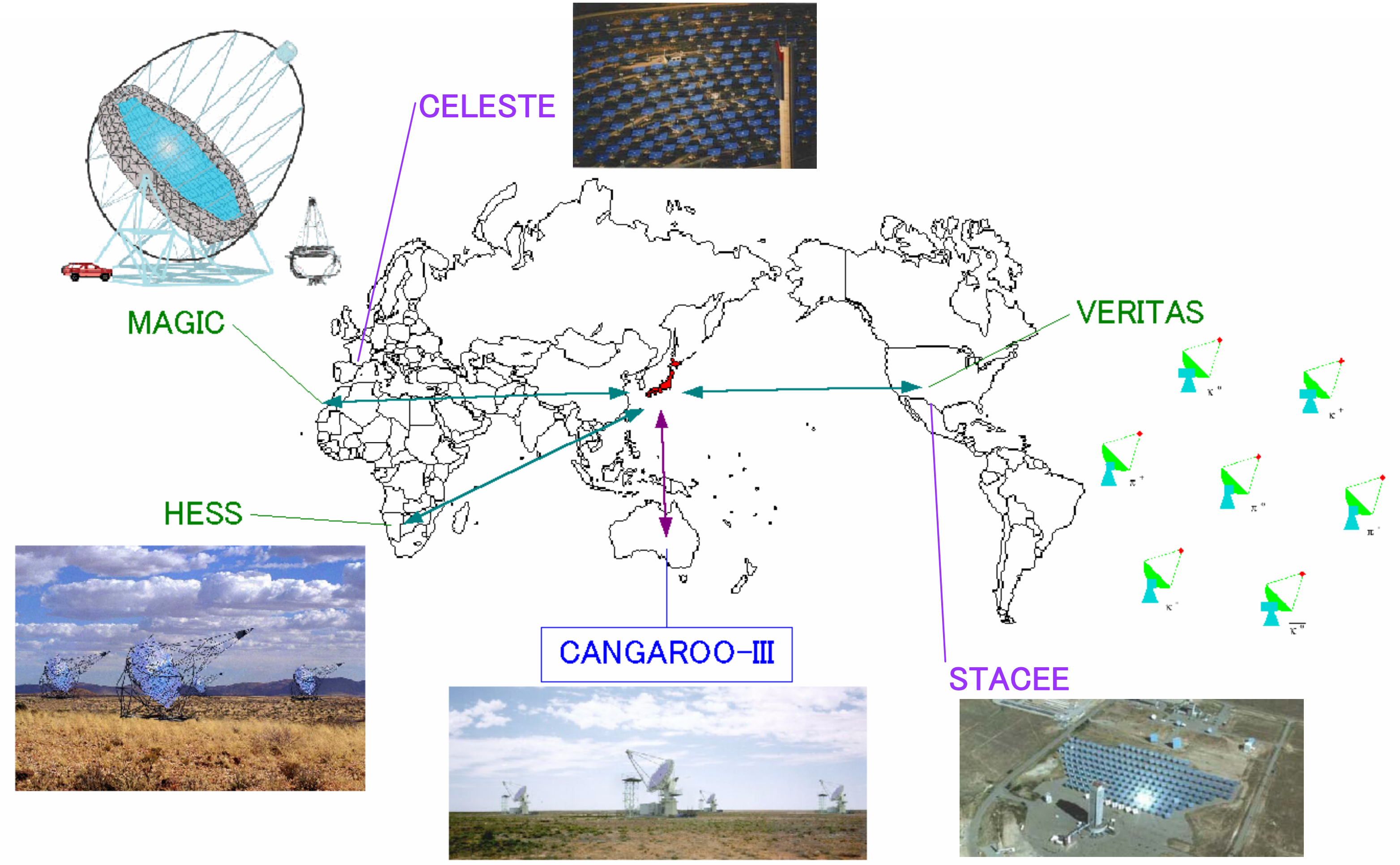
Key issues for Next generation telescopes

- S: Larger effective area
- Φ: Better flux sensitivity
- E_{th}:Reduction of energy threshold
- ΔE: Increased energy resolution
- $\Delta\theta$: Increased angular resolution
- Ω: Increased field-of-view
- S/N: Improved p/e/μ rejection

Strategies for Next generation telescopes

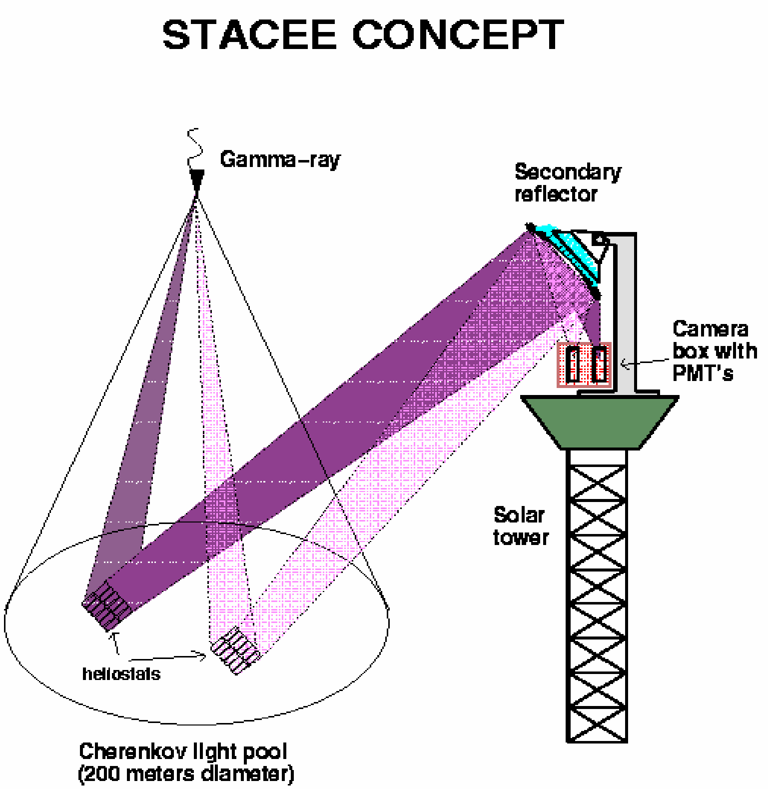
- More light collection ⇒ E_{th} , Φ
  - Larger reflector
  - Higher QE devices (APDs,...)
- Multiple telescope ⇒ S, Φ
- Stereo observation ⇒ ΔE, $\Delta\theta$, S/N, Φ
  - Locating shower cores
  - Reduction of CR muons
- Better signal processing ⇒ E_{th}, S/N, Φ
  - Reduction of night sky background

Next generation projects



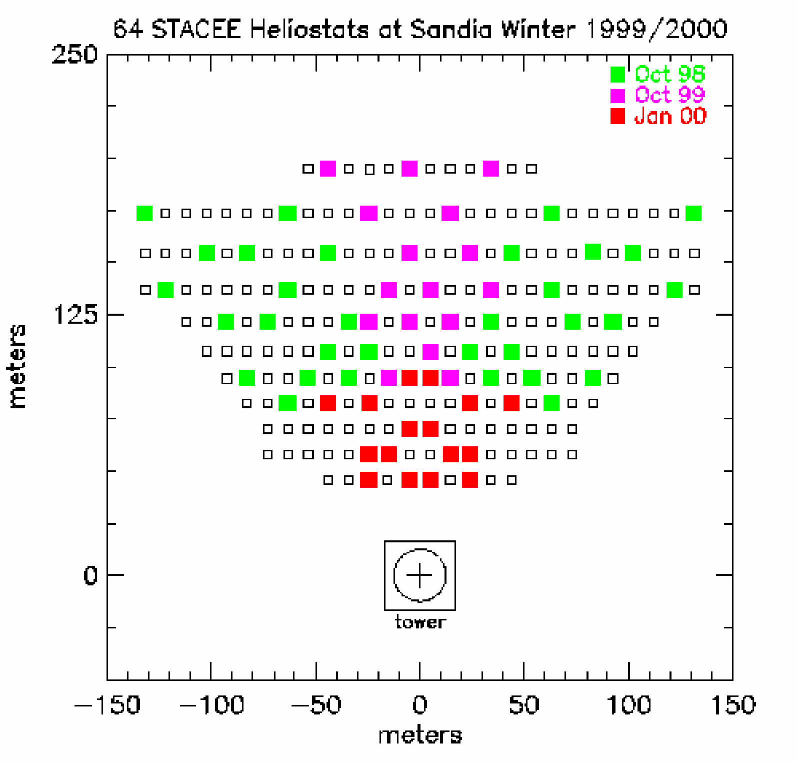
STACEE/CELESTE

- Large collection area using existing heliostats for solar power $\Rightarrow$ low E_{th}
- Non-imaging $\Rightarrow$ use of timing info.
- Part of them are in operation
  - *detection of Crab*
- Area will be increased near future



(*Solar Tower Atmospheric Cherenkov Effect Experiment*)

STACEE features



Secondary mirrors and photosensors of STACEE

(CE*renkov* L*ow* E*nergy* S*ampling* & T*iming* E*xperiment*)

CELESTE features

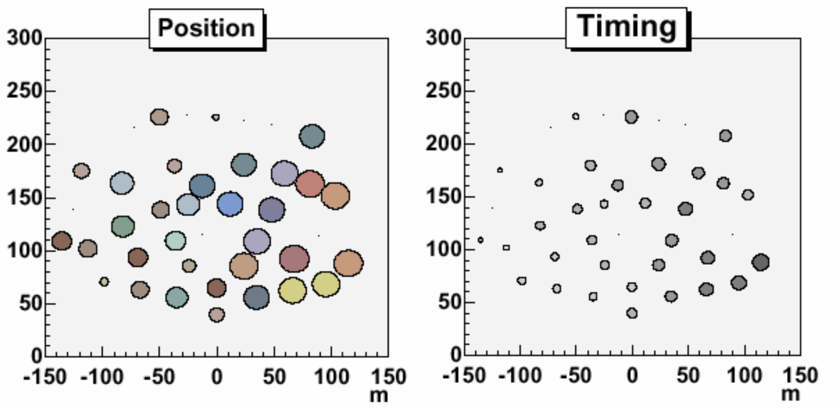


Figure 1: Typical event from CELESTE. Distribution of the light amplitude collected on each heliostat is shown on the left plot. The right plot shows the arrival time of the shower on each heliostat. Each circle corresponds to one heliostat, and distances are given in meters with the origin at the tower.

Typical event from CELESTE

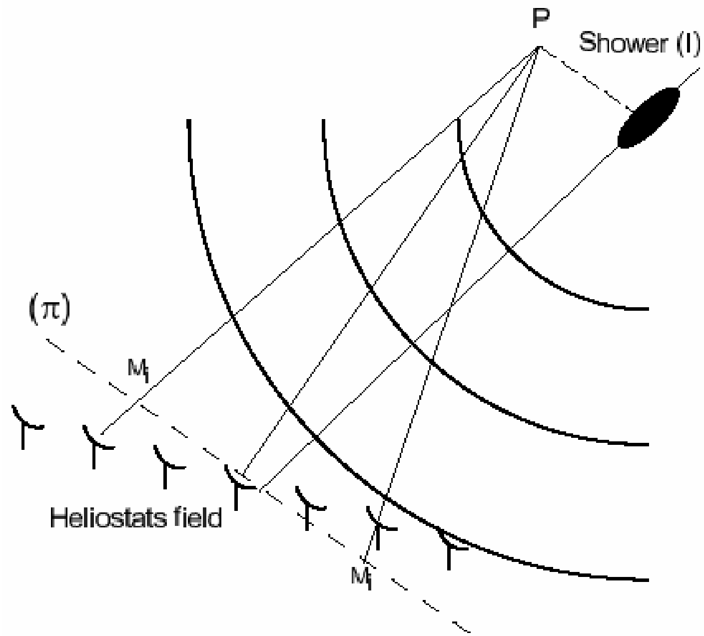


Figure 2: Shower Maximum reconstruction.

VERITAS

(*Very Energetic Radiation Imaging Telescope Array System*)

- Seven 10m telescope at Whipple observatory, AZ (1390m a.s.l., 32^{o}N, 114^{o}W)
- Collaboration

  USA: Boston, Caltech, DePauw, Iowa State, JPL, NASA/MSFC, Northwestern, Purdue, Smithsonian, UC Riverside, Chicago, Utah, Washington

  Ireland: Cork I.T., GMIT, St. Patrick's, UC Dublin, UC Galway

  U.K.: Imperial College, Oxford, Leeds

VERITAS site and array

Montosa Canyon, AZ

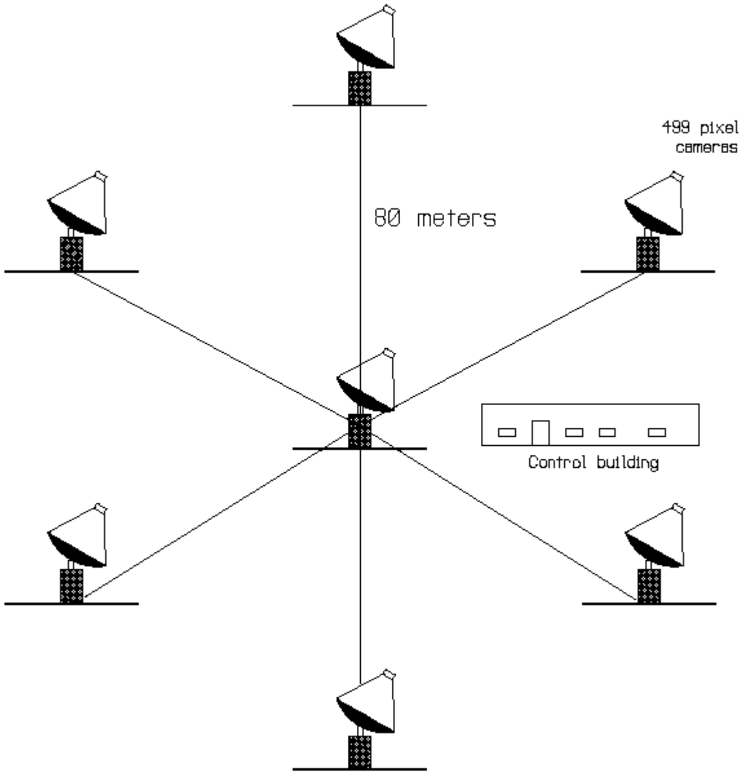


Figure 11: Layout of telescopes in VERITAS.

VERITAS telescope

- Reflector: Davies-Cotton design, D=10m (78.6m^2), f=12m, 244x 60cm hexagonal mirrors (glass)
- Camera: 499x 1” PMTs (0.15^o spacing), 3.5^o FOV
- Trigger: (telescope) 2,3 adjacent pixels
  (array) 3 out of 7, 40ns gate

VERITAS telescope design

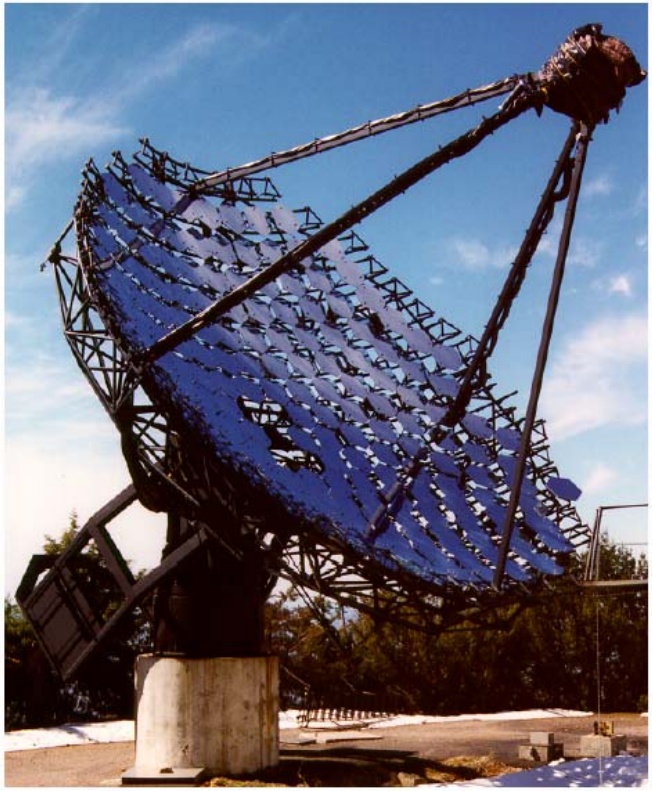


Figure 1: The Whipple Observatory 10m reflector which will be the prototype for the telescopes in VERITAS.

(F/0.7)

?

(F/1.2)

VERITAS electronics

- Constant Fraction Discriminator + pattern trigger
- FADC (8bit 500MHz)
- Readout: 1kHz each

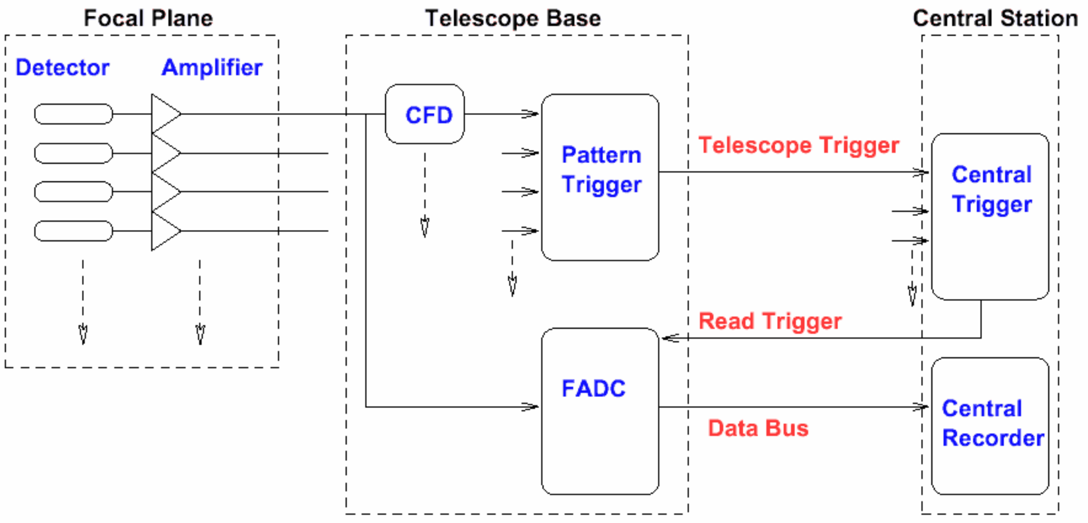


Figure 14: Outline of electronics.

VERITAS schedule

- FY99: detailed design
- FY00: First reflector initiated
- FY01: Performance verification of 1st reflector
- FY02: Add two telescopes
- FY03: Add four telescopes
- FY04: Array verification and operation

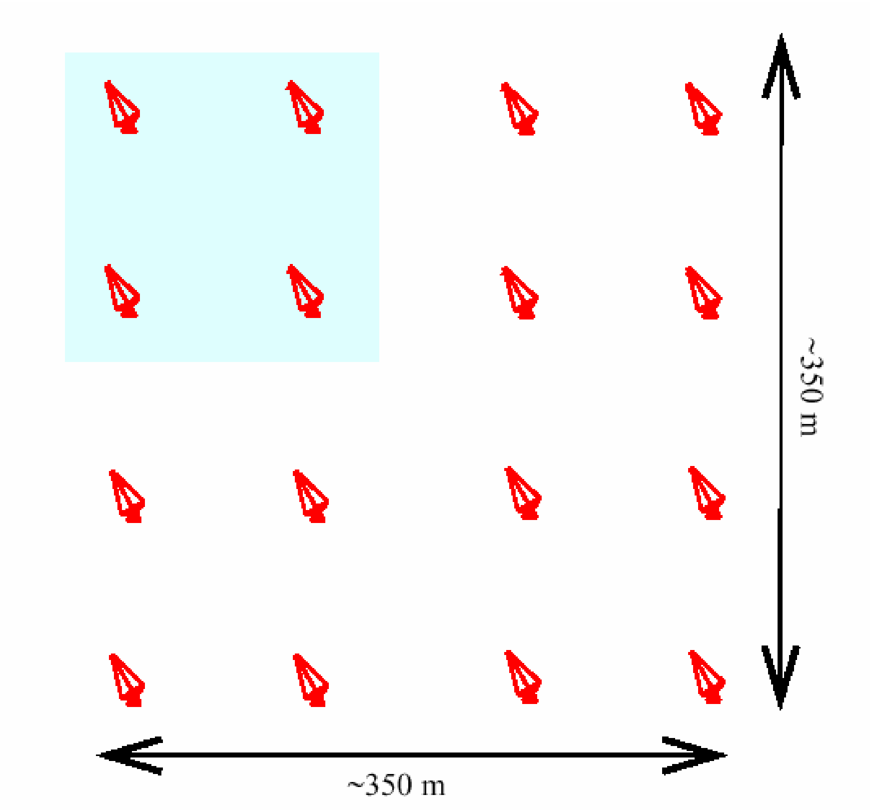
Not funded!

(High Energy Stereoscopic System)

H.E.S.S.

- 16 (init.4)x 10m telescope near Gamsberg, Namibia (1800m a.s.l., 23º20'S, 15º50'E)
- Collaboration
  Germany: MPI Kernphysik, Humboldt, Bochum, Hamburg, Heidelberg, Kiel, France: LPNHE Ec.Poly., LPC, LPNHE Paris VI, CEA Saclay, Italy: IAS-CNR, Ireland: Dublin IAS, Czech: Charles, Armenia: Yerevan, Namibia: Namibia, South Africa: Potchefstroom

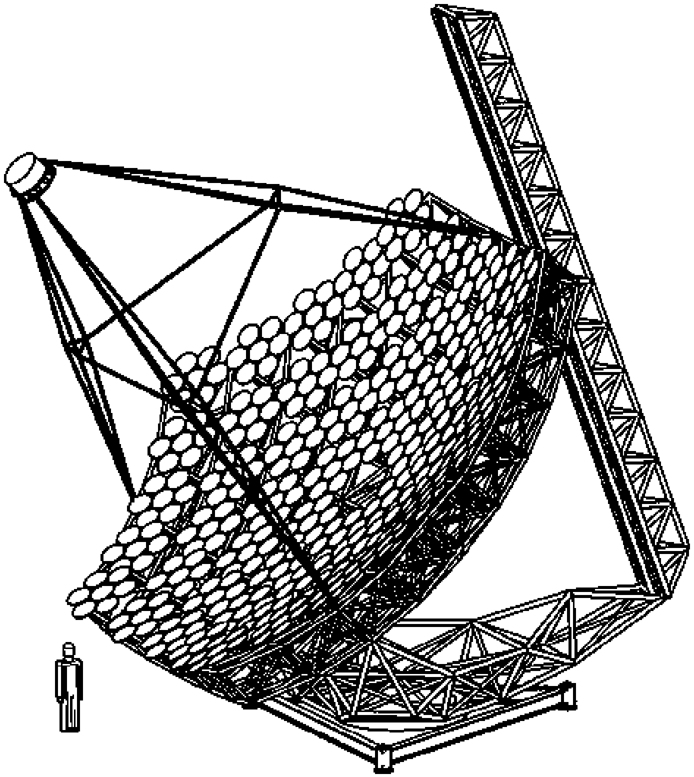
H.E.S.S. site and array



H.E.S.S. telescope

- Reflector: Davies-Cotton design, D=11m (80m^2), f=15m, 300x 60cm round mirrors (glass)
- Camera: ~700x ¾" PMTs (0.16^o spacing), 4.3^o (→ 5^o) FOV, 500kg(?)
- Trigger: (telescope) 2 adjacent pixels
  (array) 3 out of 4

H.E.S.S. telescope design



(LOI, March '97)

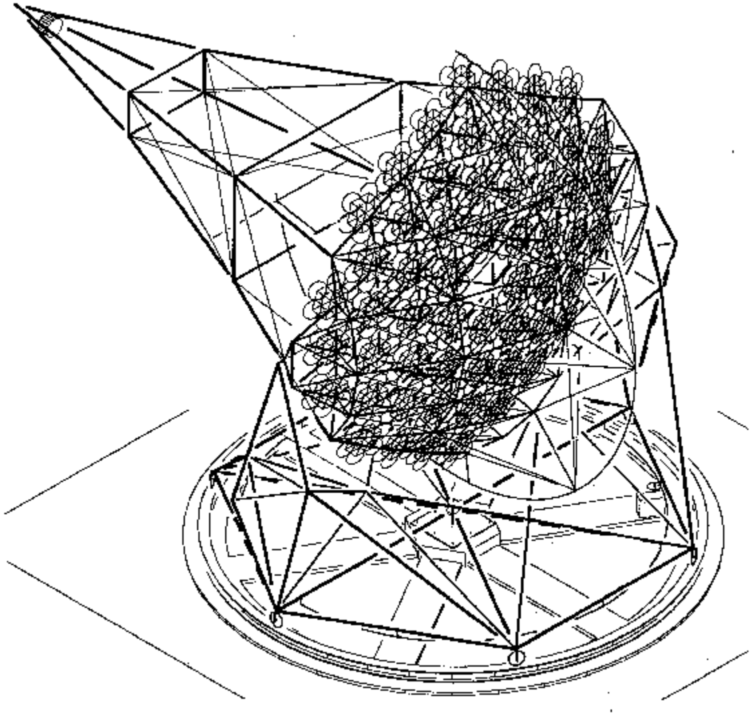
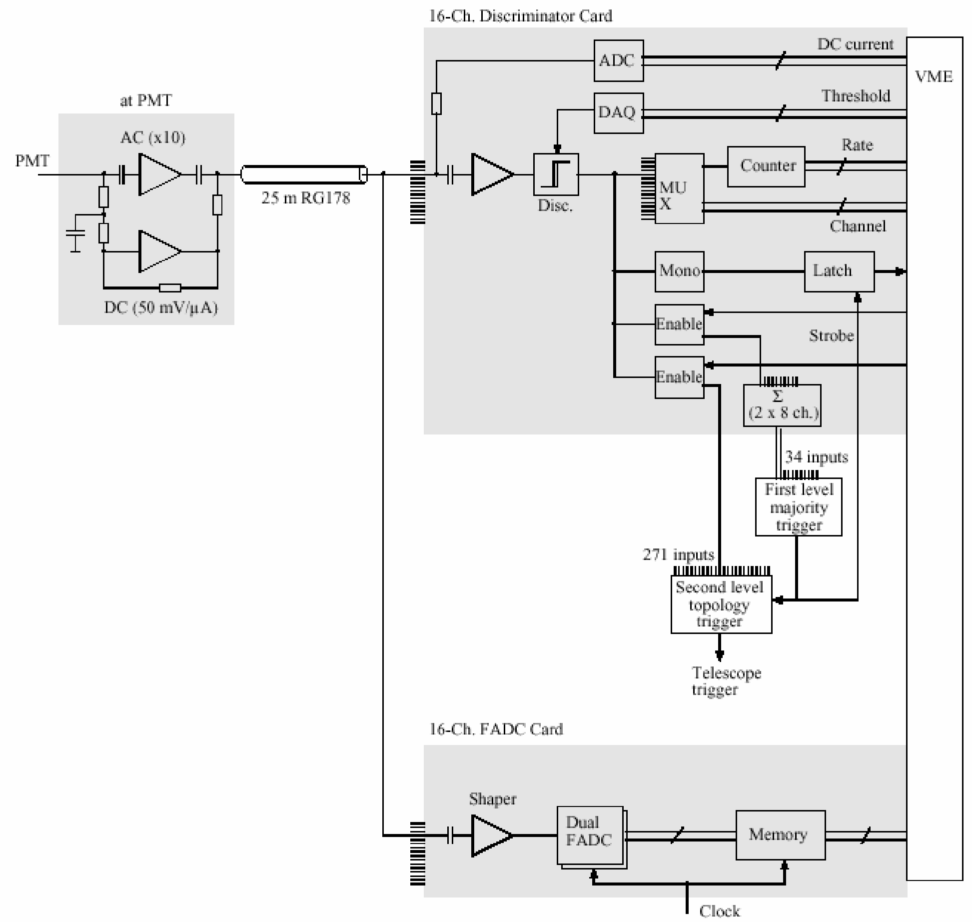


Figure 2: *The telescope structure (design study).*

(ICRC, August '99)

H.E.S.S. electronics

- FADC (1GHz ARS0?)
- Trigger in camera?
- Readout: 10-100Hz



H.E.S.S. schedule

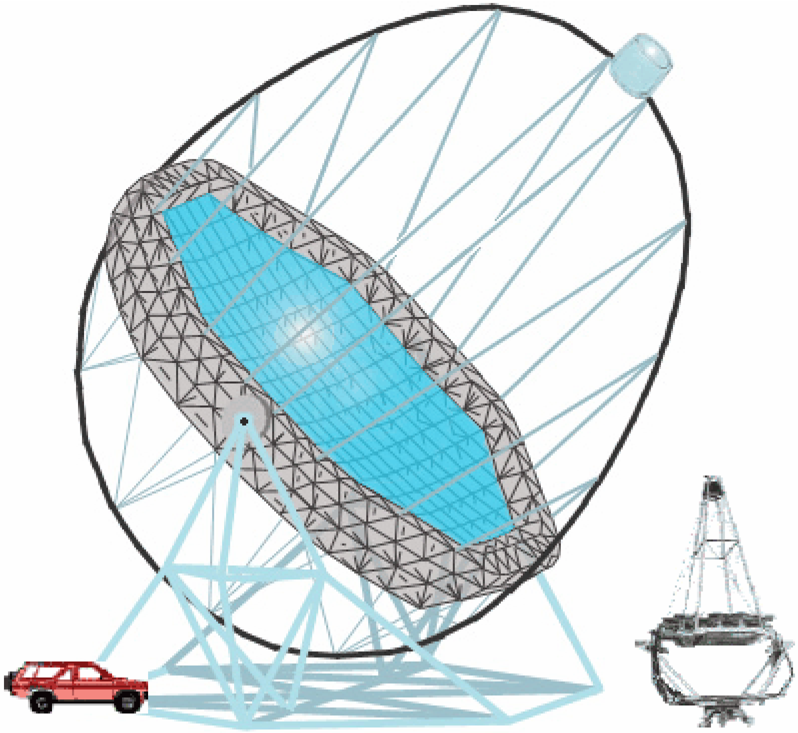
- Jan. 2000: Infrastructure
- Fall 2000: First telescope installed
- 2002: Four telescopes in operation
- 200?: 16 telescopes Not funded!

(***M****ajor* ***A****tmospheric* ***G****amma-ray* ***I****maging* ***C****herenkov Telescope*)

MAGIC

- 17m telescope at La Palma, Canary Is. (2300m a.s.l., 28.75^{o}N, 17.9^{o}W)
- Collaboration
  Germany: MPI Physik, Hamburg, MPI ETP, Wuppertal, Kiel, DESY, Spain: Complutense, Autonoma de Barcelona, Croatia: Ruder Boscovic Inst., Italy: INFN Padova, INFN Pisa, South Africa: Potchefstroom, Armenia: Yerevan

MAGIC site and design



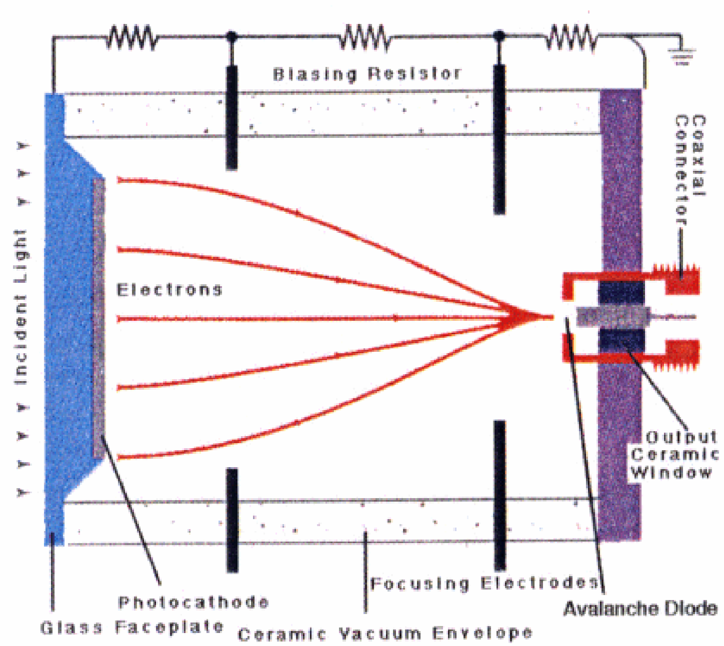
La Palma, Canary Is.

MAGIC telescope

- Reflector: parabolic, D=17m (234m^2), f=17m, 976x (50x50cm^2) Al mirrors
- Camera: [classical] 397x 1” PMTs (0.10^o)+ 126x 1.5” PMTs (0.20^o), 3.5^o FOV, ~100kg
  [standard] HPDs (center) + PMTs
- Trigger: any 4 neighboring pixels above 7p.e.

MAGIC Photosensor (2nd phase)

- GaAsP-intensified photocell (Intevac)



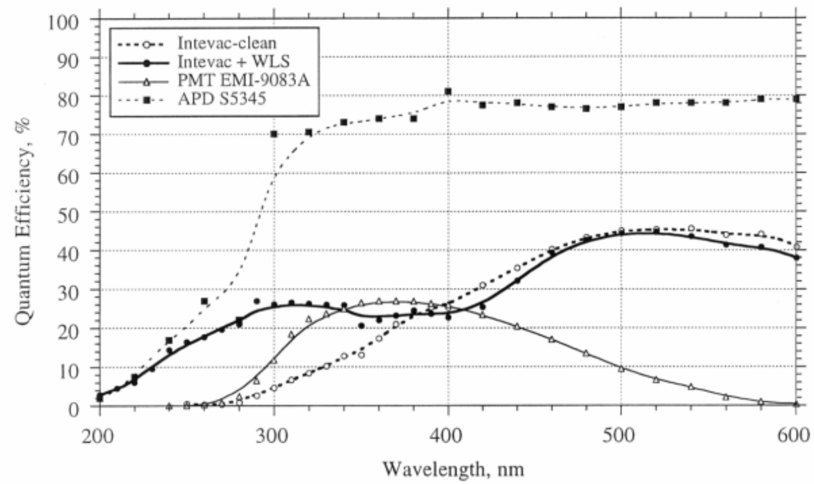


Figure 4.23: Cross section of a hybrid photomultiplier with avalanche diode readout.

MAGIC electronics

- Optical fiber (analog) transmission
- FADC (8bit, 300MHz, 32ch/crate)
- Readout: ~1 kHz

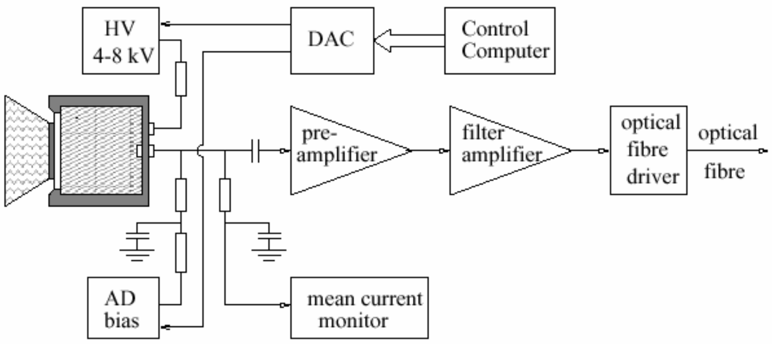


Figure 12: Basic block diagram of a single camera pixel readout chain.

MAGIC schedule

- June 21, 2001: First light
- Early 2002: Physics run

Not fully funded!

- DUO project – up to 3 telescopes

GLAST mission

Launch in July 2004 ?

Silicon GLAST

(PI:P.Michelson, Stanford)

Fiber GLAST

(PI:G.Pendeleton, Alabama)

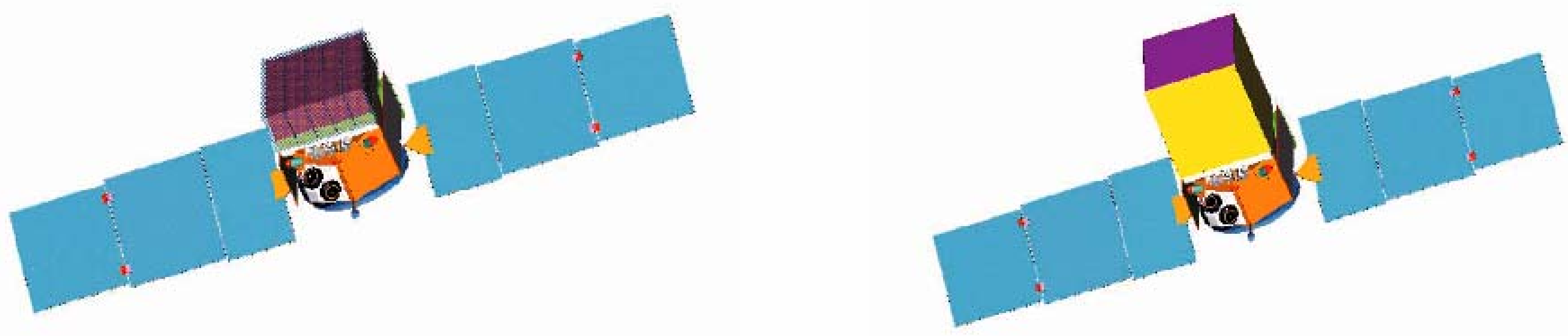


Figure 2-2 Two instrument/spacecraft concepts for GLAST (see §11).

(**G***amma-ray* **L***arge* **A***rea* **S***pace* **T***elescope*)

GLAST

- Silicon or fiber-scintillator tracking detector
- 20 MeV – 300 GeV
- Large FOV (2 sr)
- Angular resolution: $<3.5^o$ (@100MeV)
- Energy resolution: 10%
- Mass: 3000 kg
- Orbit: 550 km (28.5^o incl.)

Silicon GLAST option

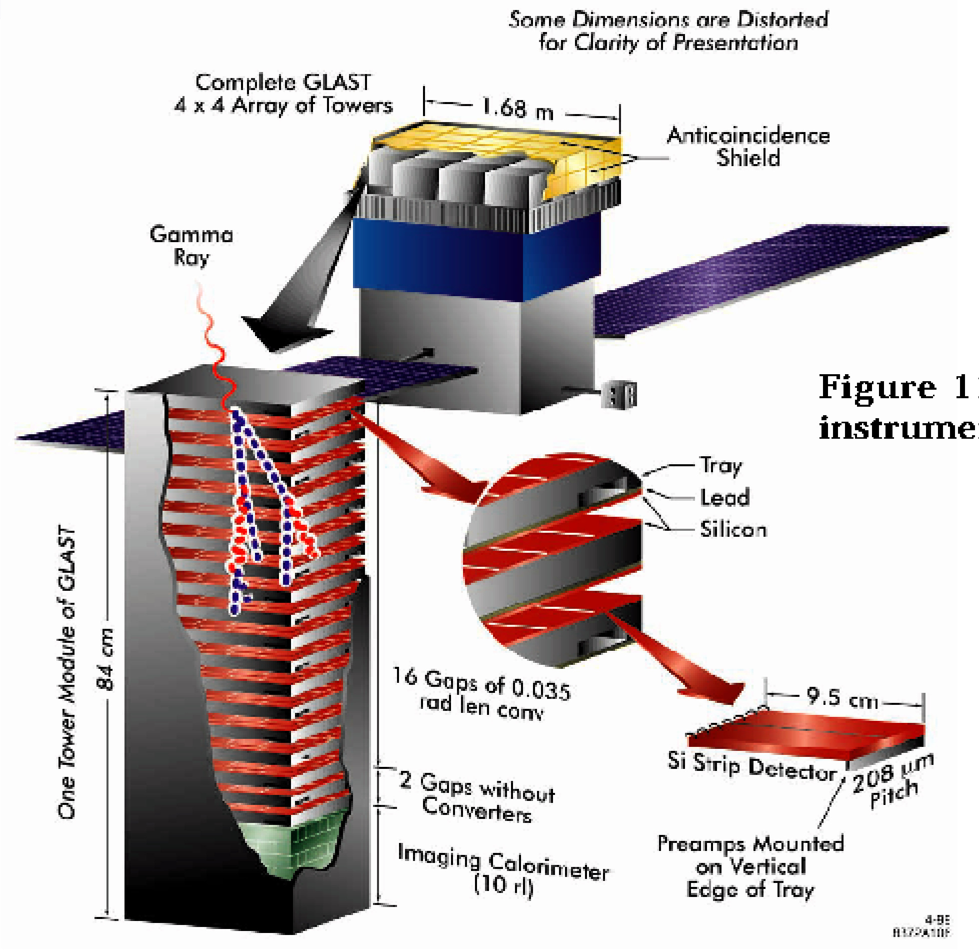


Figure 11-6 The Silicon GLAST baseline instrument.

Fiber GLAST option

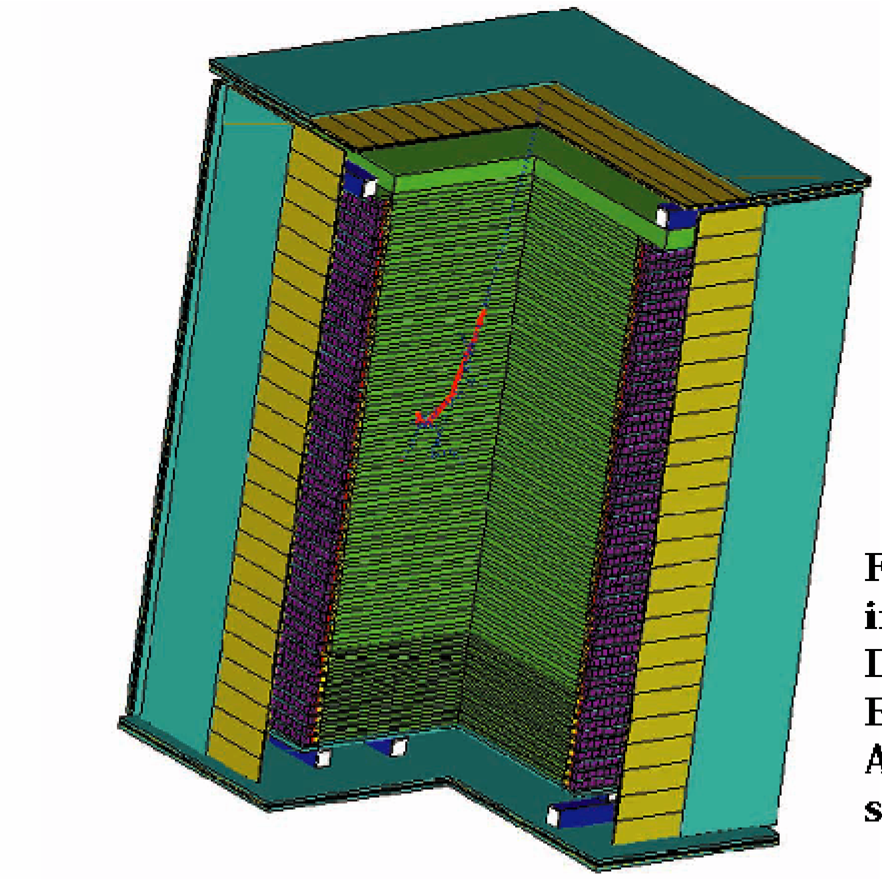
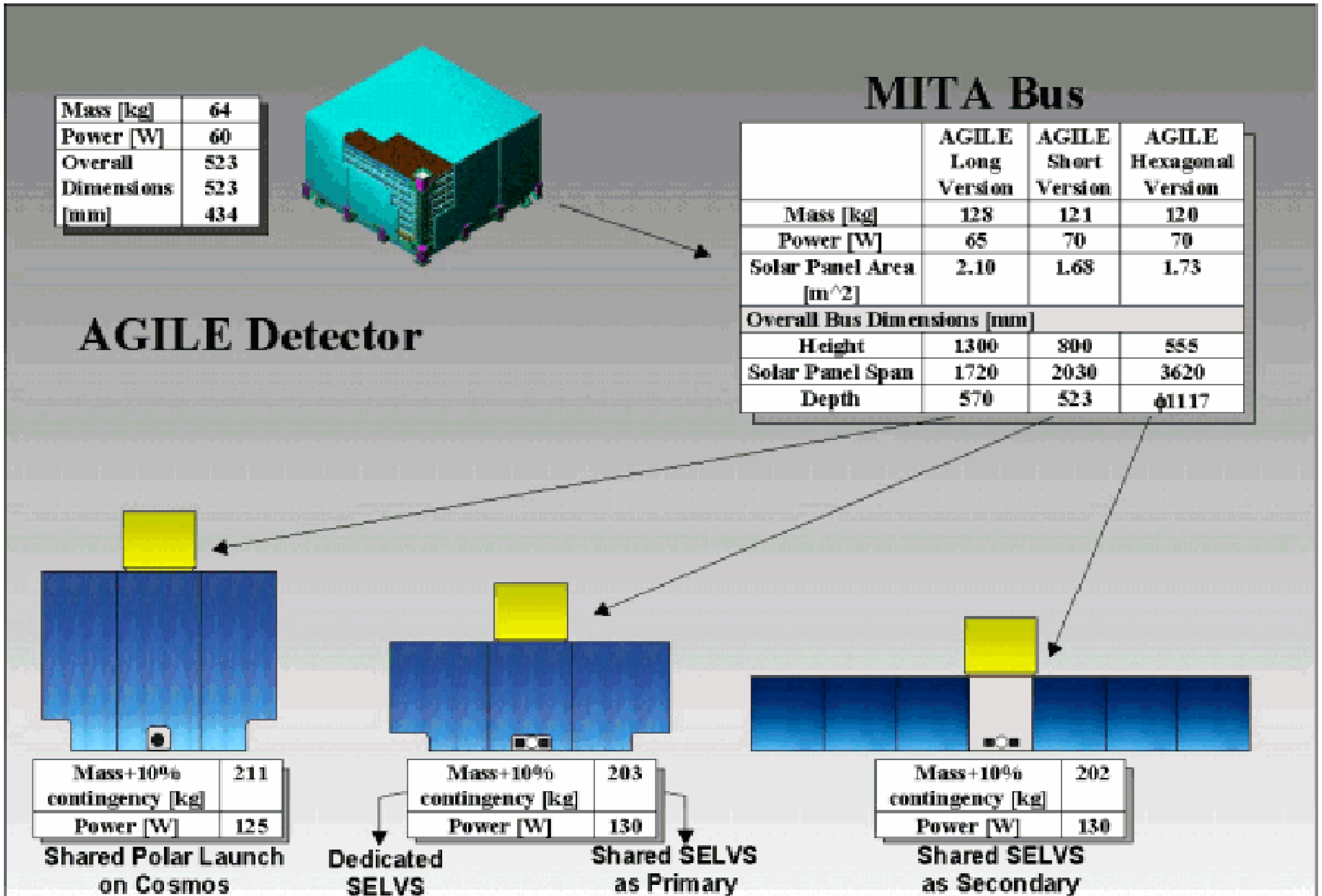


Figure 11-2 Diagram of Fiber GLAST instrument. Light green section: tracker. Dark green: Calorimeter. Purple: Readout Electronics. Light blue and yellow: Anticoincidence. Dark blue bars: Support structure.

AGILE mission

Launch in 2002 or 2003

(PI: M. Tavani)



(**A***stro-rivelatore* **G***amma a* **I***mmagini* **LE***ggero*)

AGILE

- Silicon tracking detector for a space mission by INFN (Italy)
- 30 MeV – 50 GeV
- Large FOV (0.8π sr)
- Angular resolution: 4.7^{o} (@100MeV)
- Energy resolution: 100%
- Very light (60kg)
- Super-AGILE option for hard X-rays

AGILE detector

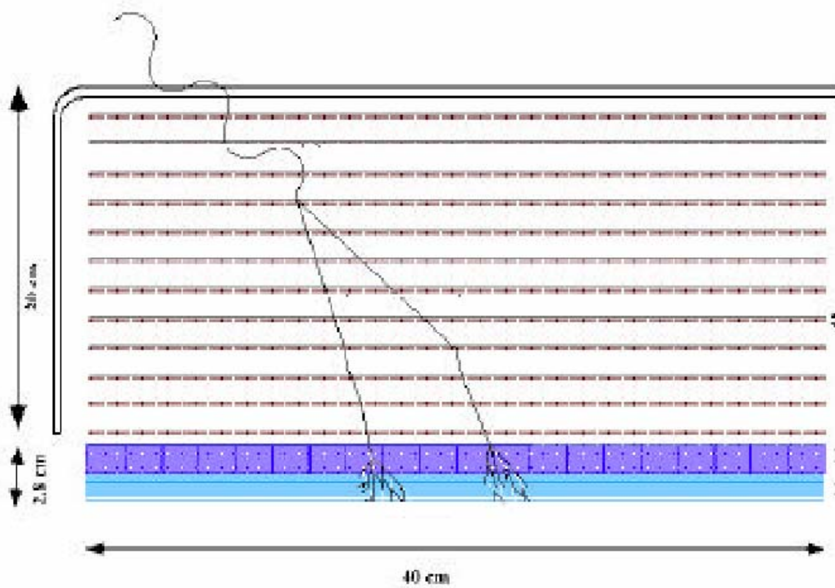


Figure 1: *Schematic of the AGILE baseline instrument.*

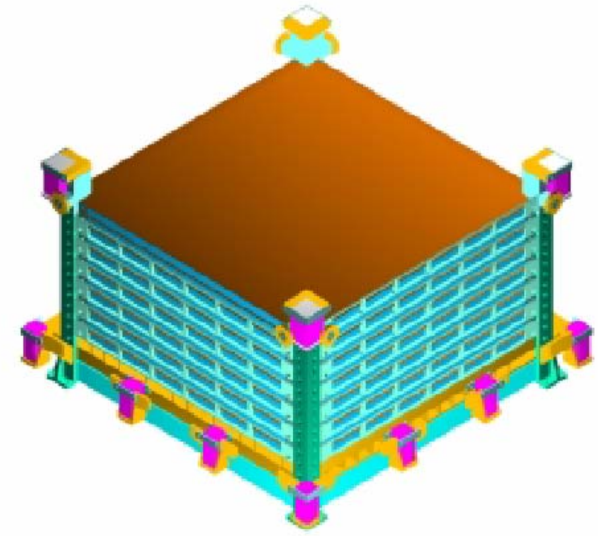
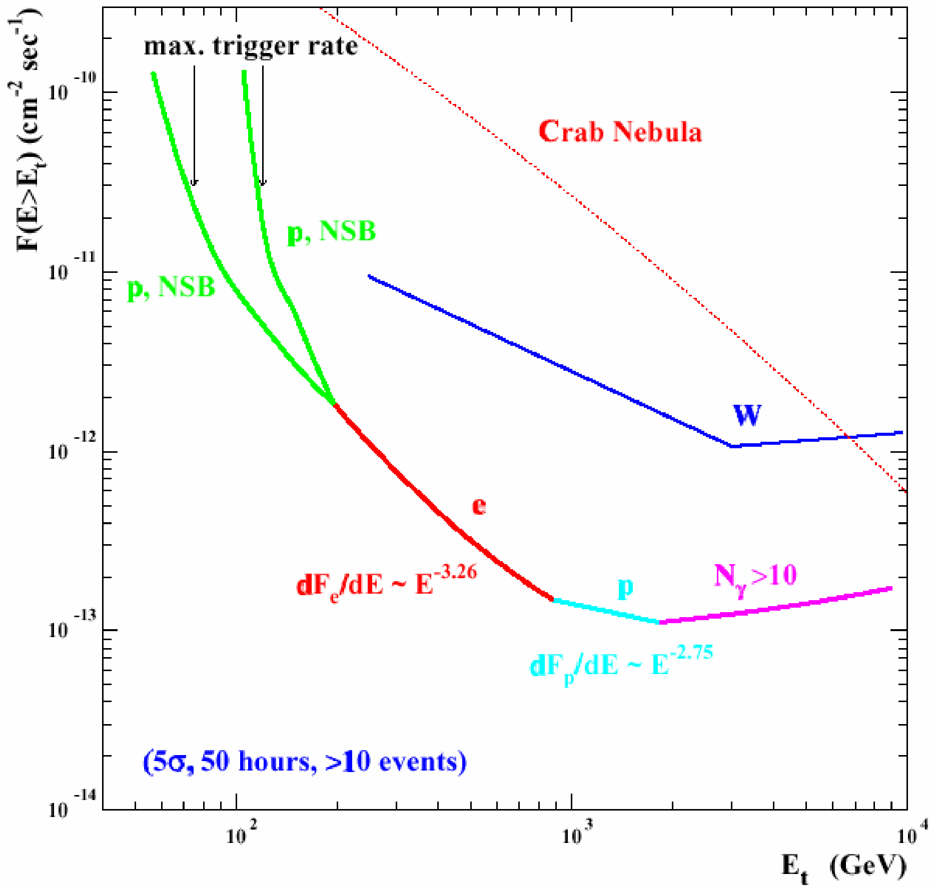


Figure 1: Lateral view (without AC panels) of the AGILE baseline instrument. The frame supports 12 trays of W-Si-Si layers forming the gamma-ray tracker, and the underlying mini-calorimeter formed by overlapping CsI bars. The frame supports also the four photomultipliers (PMs) needed for the top-AC layer (not shown) and the 12 PMs for the lateral AC panels. The lateral size including PMs and AC is 52.3 cm, and the height including the top-AC and support is 33.9 cm.

Sensitivity of Cherenkov telescopes



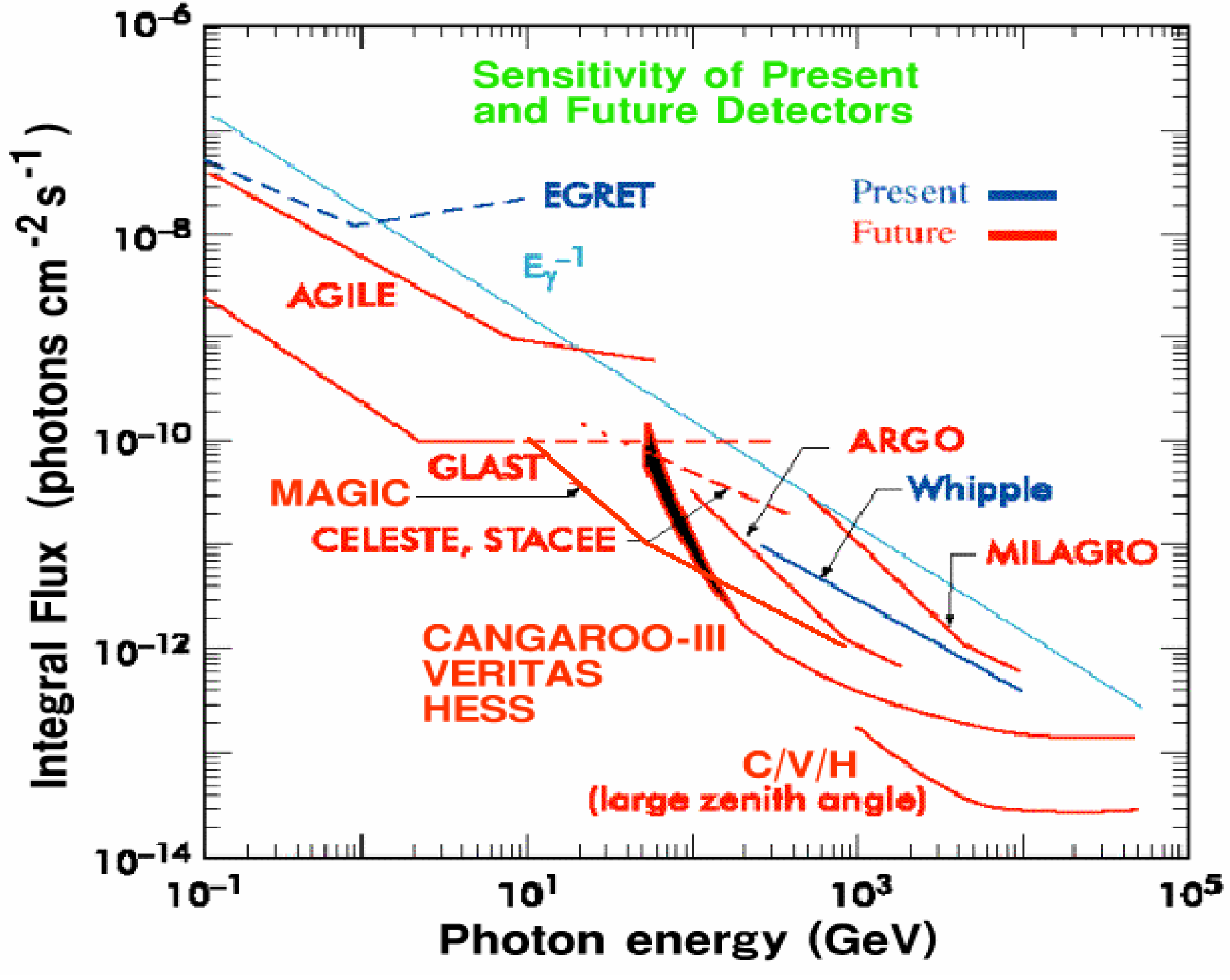
Major backgrounds:

- p: CR proton
- e: CR electron
- μ: CR muon
- NSB: night sky background

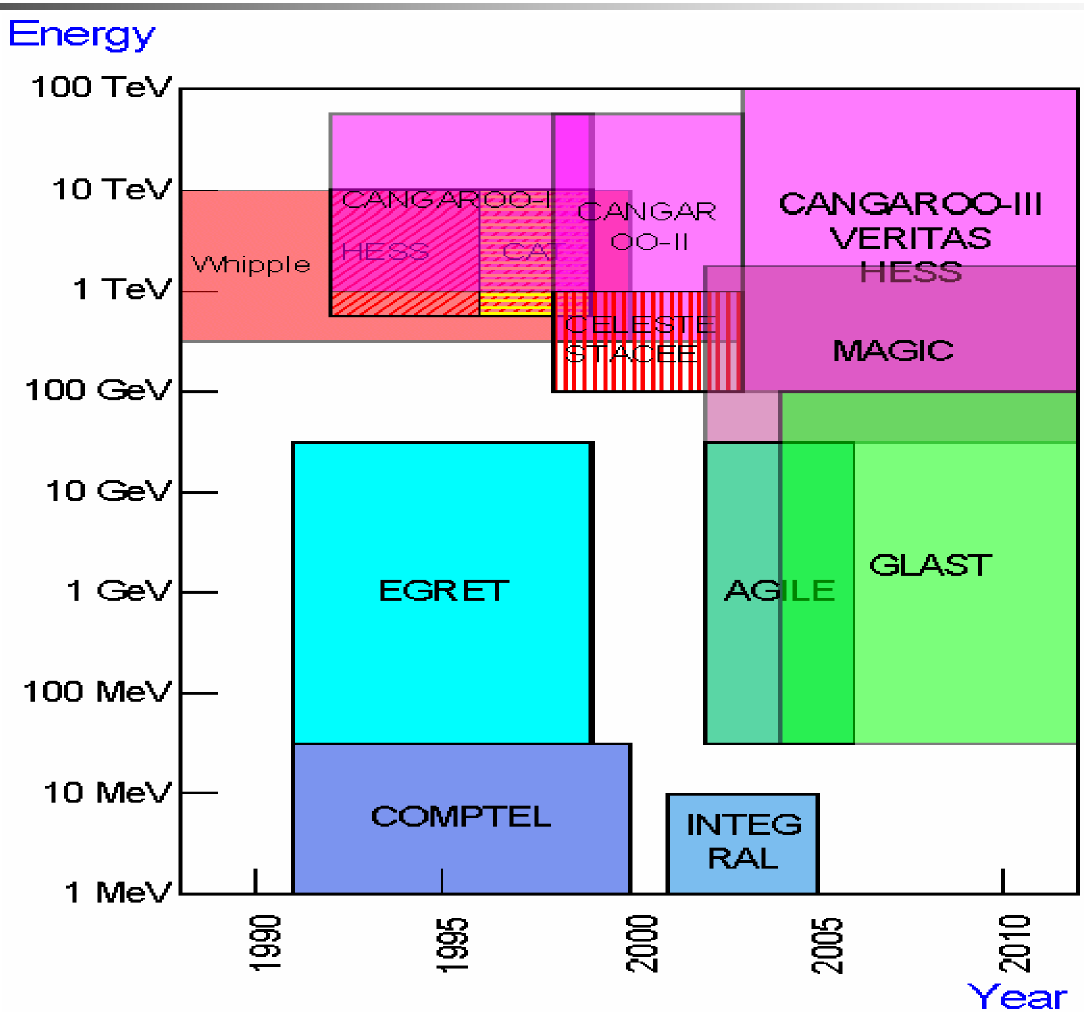
Figure 3: The sensitivity of VERITAS to point-like sources in 50 hours of observing. The dominant background as a function of energy threshold is indicated (see text for details). The two curves at low energies indicate the sensitivity of VERITAS in dark (lower curve) and bright (upper curve) NSB regions. The integral flux from the Crab Nebulae (Hillas et al. 1998) and estimated sensitivity of the Whipple telescope are given for comparison.

VERITAS, ICRC1999

Expected sensitivity



Monitoring the gamma-ray sky



Gamma-ray sky coverage