



Design consideration for TA FD

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Original "Telescope Array"

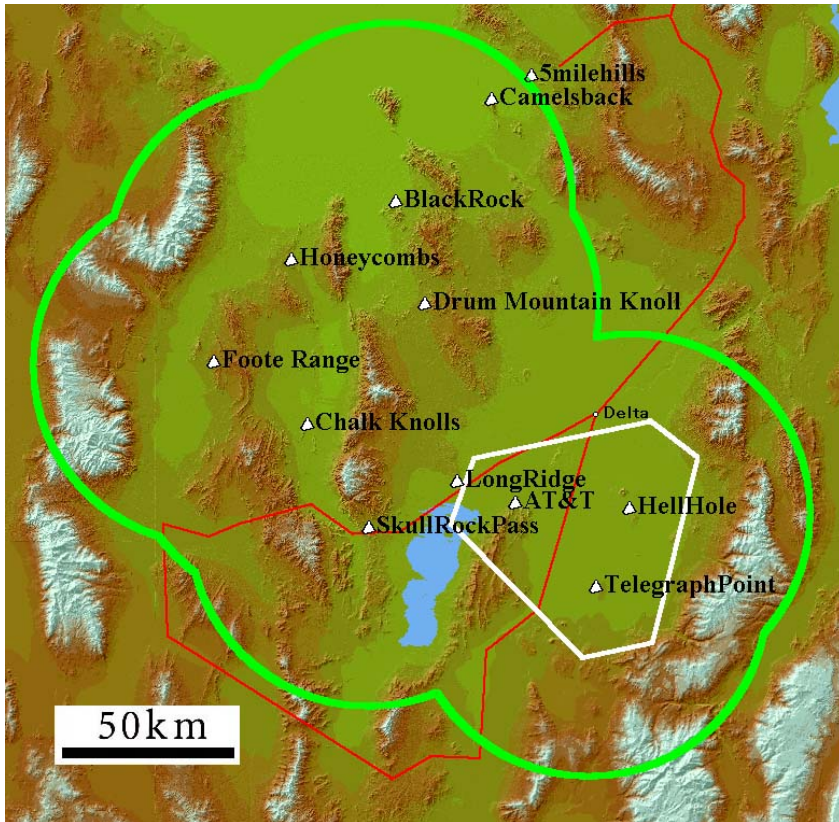


FIG. 2.1: Station deployment of Telescope Array.

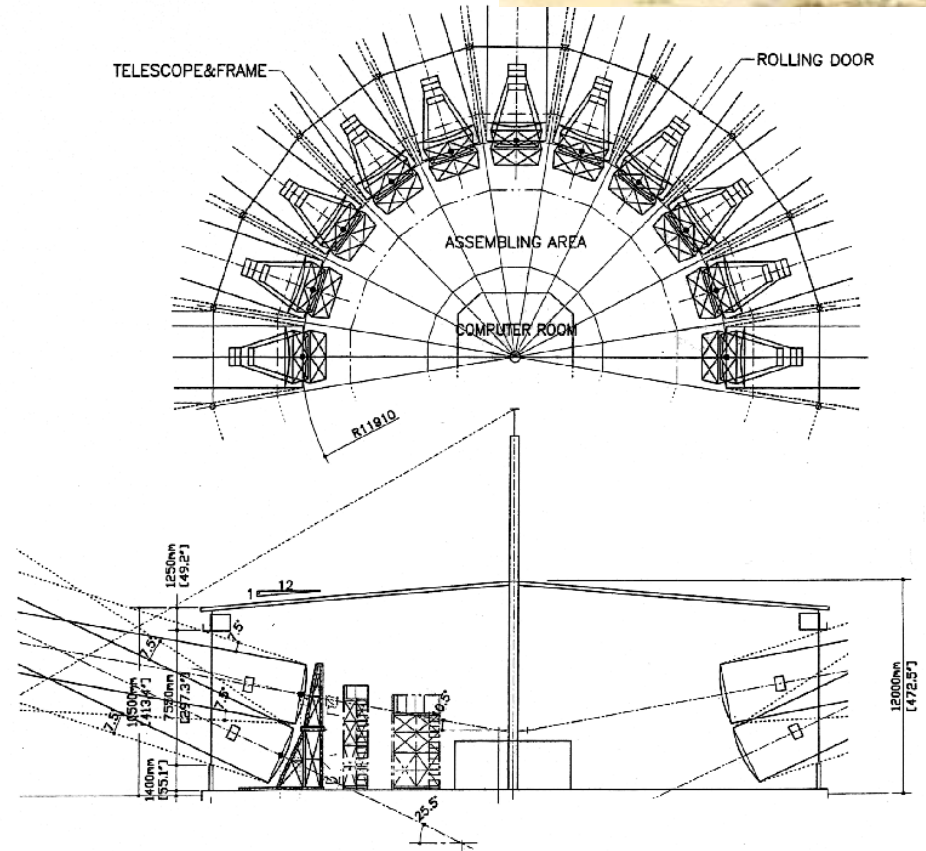
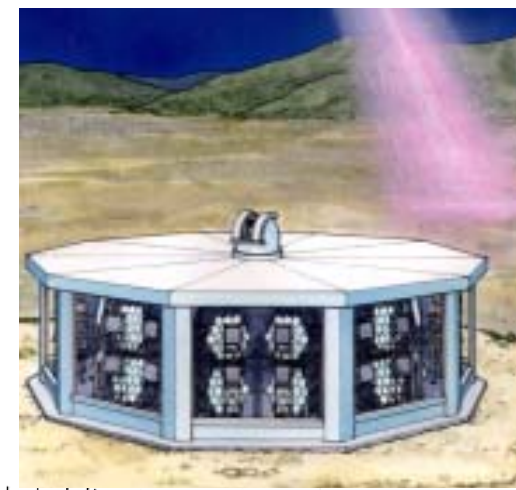
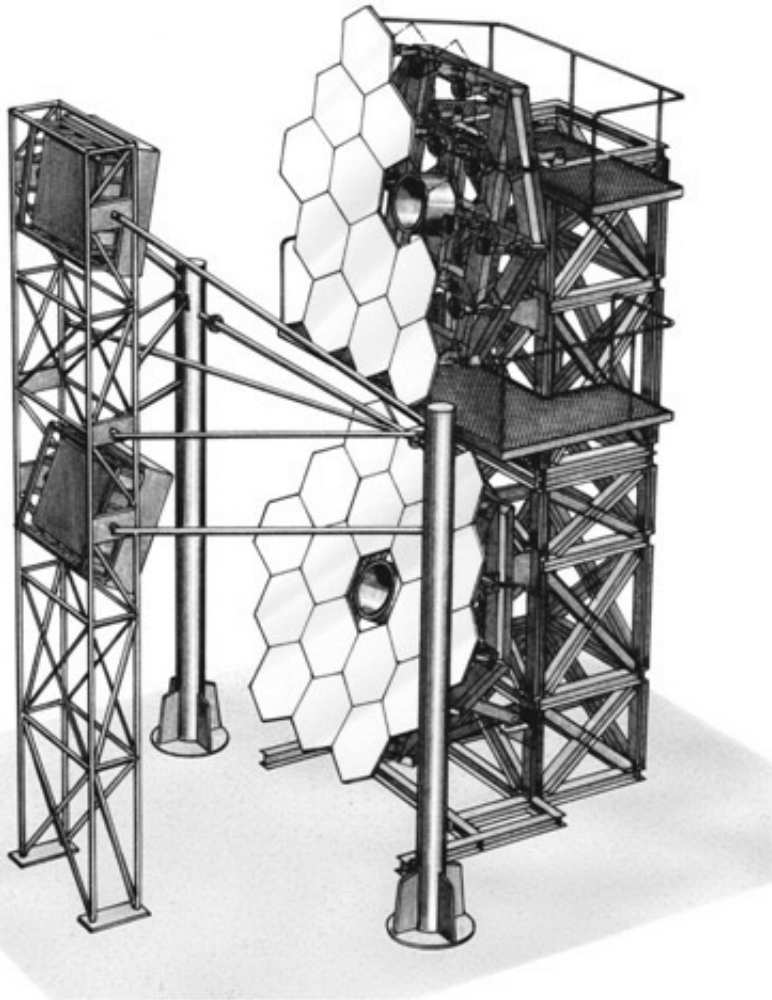


FIG. 2.2: Plan and cross sectional view of the telescope housing.

Original "Telescope Array" → TA FD @ BRM and LR sites



Specification for the optics system of Telescope Array

Ver.9907

External Condition

- | | |
|---------------------------------------|----------------------------|
| 1. Angular Resolution | +/-0.2 deg |
| 2. Spot size (F 1.0 spherical mirror) | 0.5 deg (average) --- 30mm |
| 3. P.M.T. Diameter | 59.5 +/- 0.5 mm |
| | 61mm spacing |
| 4. Telescope F.O.V. | 18 deg x 15.5 deg |
| 5. Elevation Angle Coverage | 3 - 34 deg |

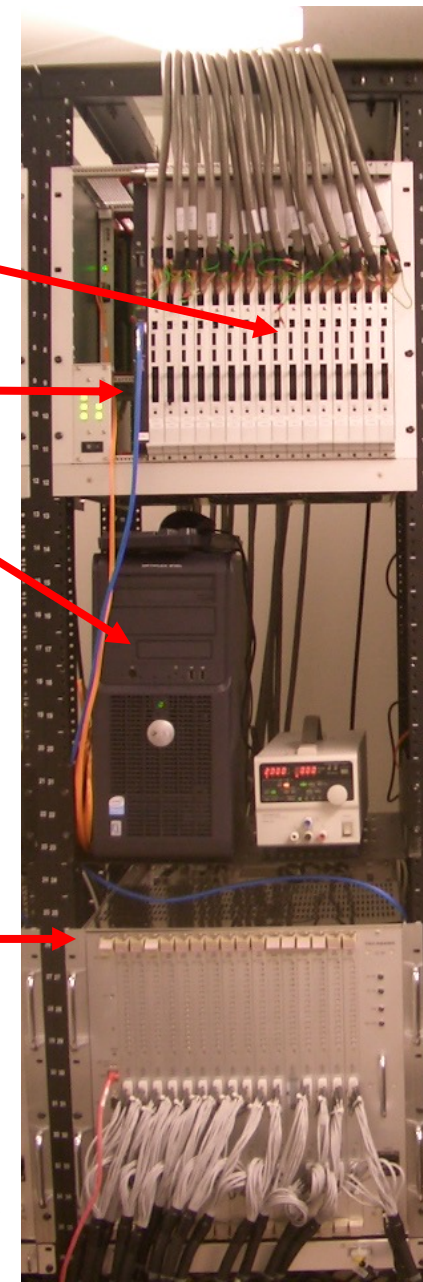
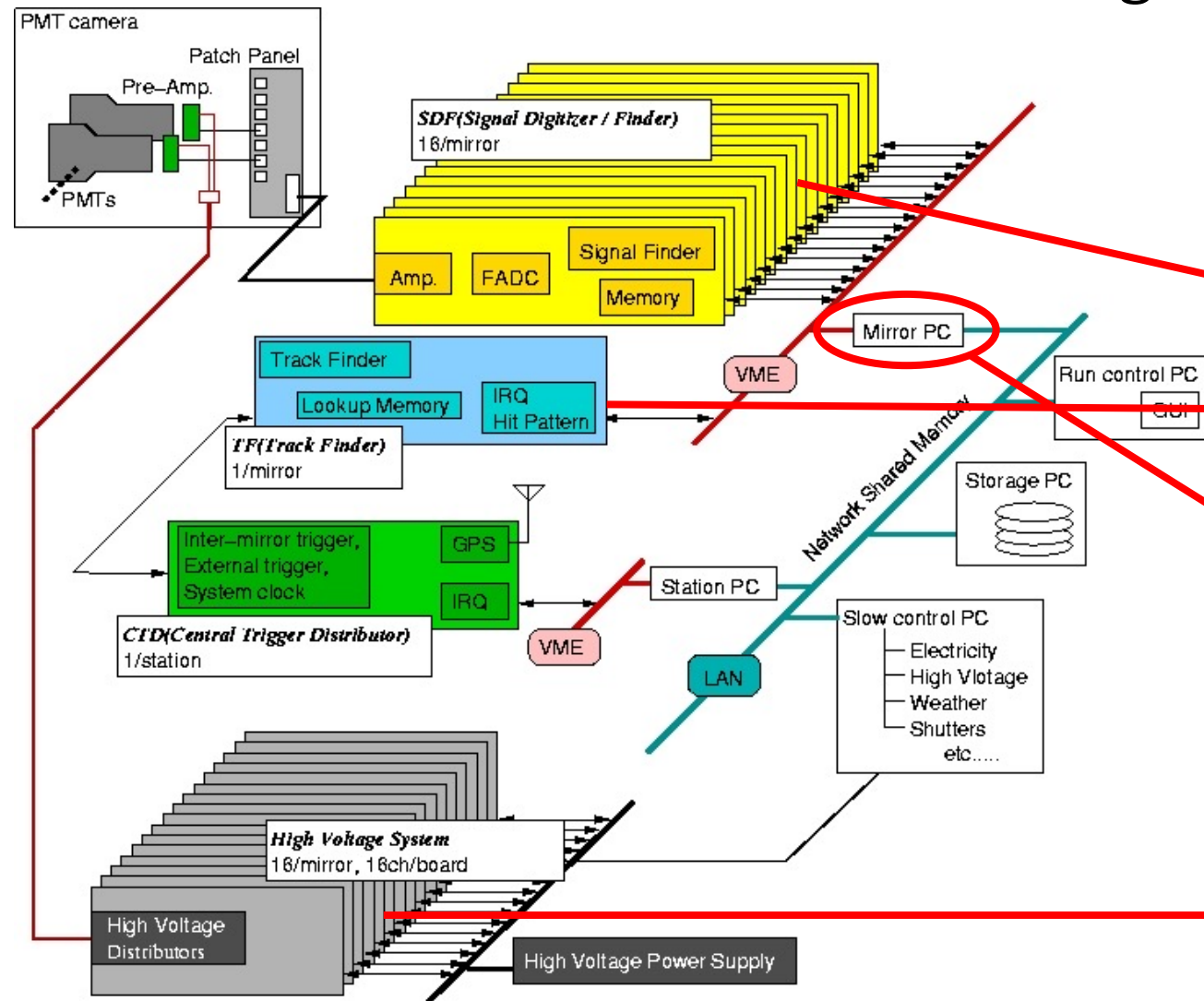
Specification of Segment mirrors

- | | |
|--|------------------------------------|
| a) Mirror curvature and focal length | |
| L = 0.488 x R = 0.976 x R/2 (Between Mirror and PMT) | |
| Best Focus | R = 6067mm, f = 3107mm, L = 2960mm |
| b) Spot Size of segment mirror at R | ~20mm |
| Spot Size for Parallel beam at f | ~10mm (0.2deg) |
| c) Allowance for mirror curvature | +/-40mm |
| d) Thickness | 10mm - 15mm (maker depend) |
| e) Material | Plexi glass / Float Glass |
| f) Orientation on X-Y plane | 0.1deg |

Specification of Mirror System

- | | |
|--|--|
| a) Allowance for optic axis direction | after calibration |
| <+/-0.07 deg (1/3 of ang. res.) | |
| b) Adjustment resolution of segment mirror direction (screw pitch) | |
| <0.03 deg (1/2 of optic axis) | |
| c) Allowance for the distance between mirror and Camera | +/-3mm (0.02deg shift at the edge of FOV) |
| d) Tilt of Camera frame | +/-0.07deg (~1mm 1/3 of ang .res.) |
| e) Gap between segment mirrors | 2-3cm |
| f) Z-direction adjustment for seg. Mirrors | not necessary |
| g) Z-direction adjustment for camera | not necessary / +/- 10mm |

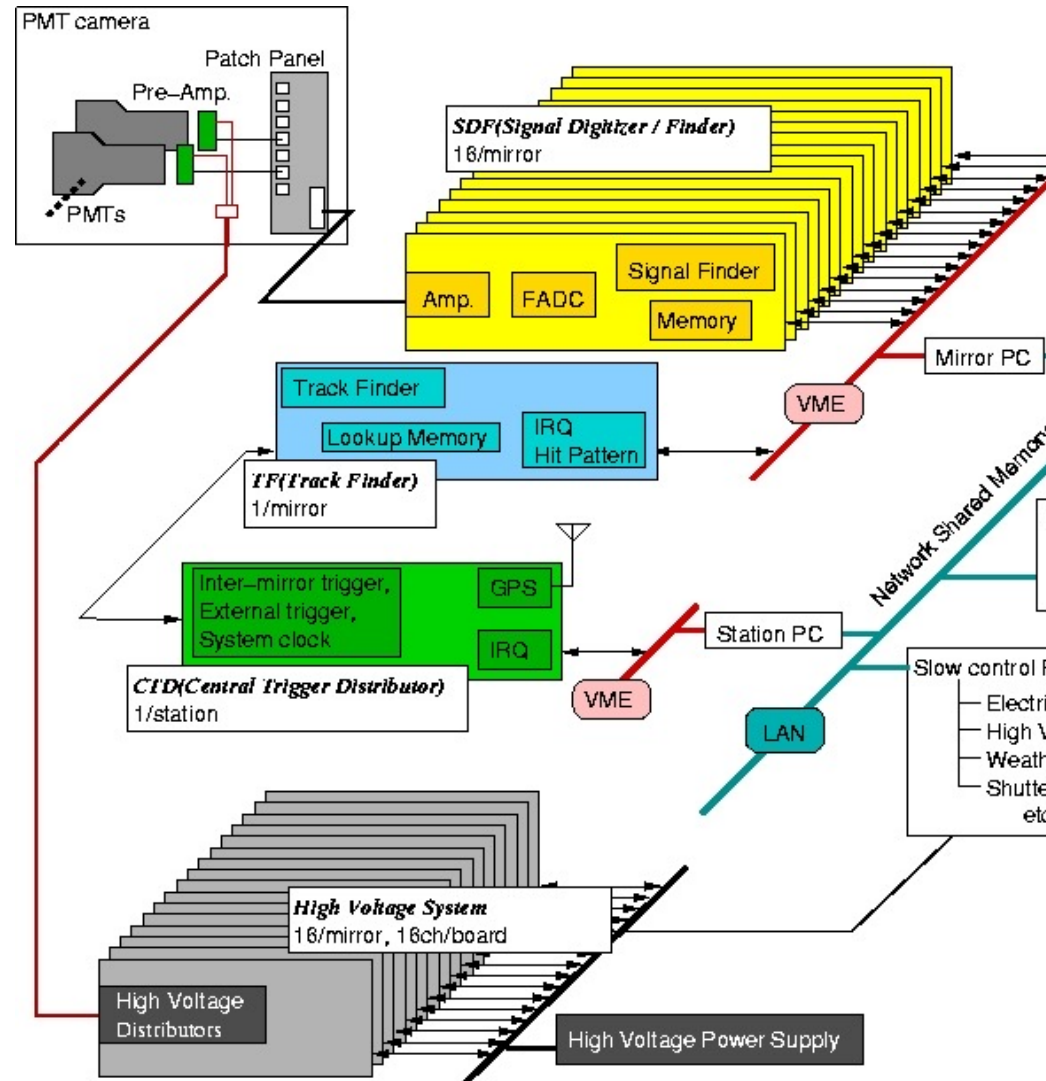
TA FDs at Black Rock Mesa and Long Ridge sites



Electronics design was changed from "original"
 = Newly designed for BRM and LR FDs


HV PS:
 individual HV

TA FDs at Black Rock Mesa and Long Ridge sites



Signal Digitizer / Finder (SDF)

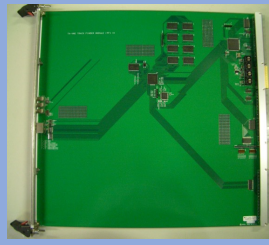
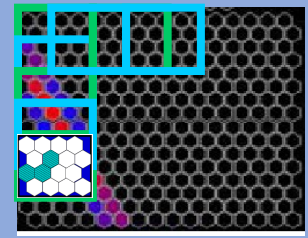
16 input channel/board, Recorded waveform: 51.2 us
 Resolution: 14 bit, 100 ns, Dynamic range: 7,000 p.e./100ns



Signal trigger (hit condition, Lv-1 trigger):
 S/N ratio for 1.6, 3.2, 6.4 or 12.8 us window
 exceeds 6 sigma -> Lv-1 trigger -> TF

Track Finder (TF)

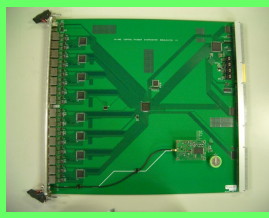
Track trigger (Lv-2 trigger):
 > 5 adjoining hits in a camera or > 3 adjoining hit on a boarder
 within 25.6us -> Lv-2 trigger

Slow control P
 - Electric
 - High V
 - Weather
 - Shutter
 etc

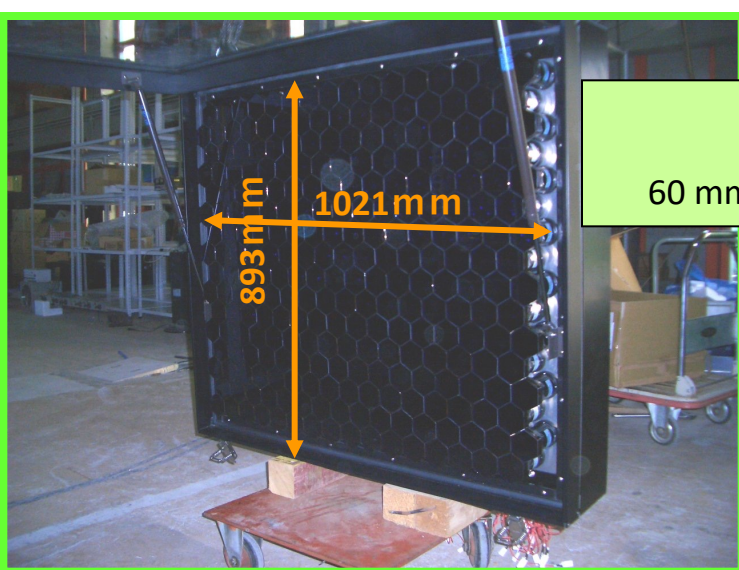
Central Trigger Distributor (CTD)

Mirror, Inter-mirror, External trigger -> Lv-3
 Distribute Lv-3Trigger to all the FDs

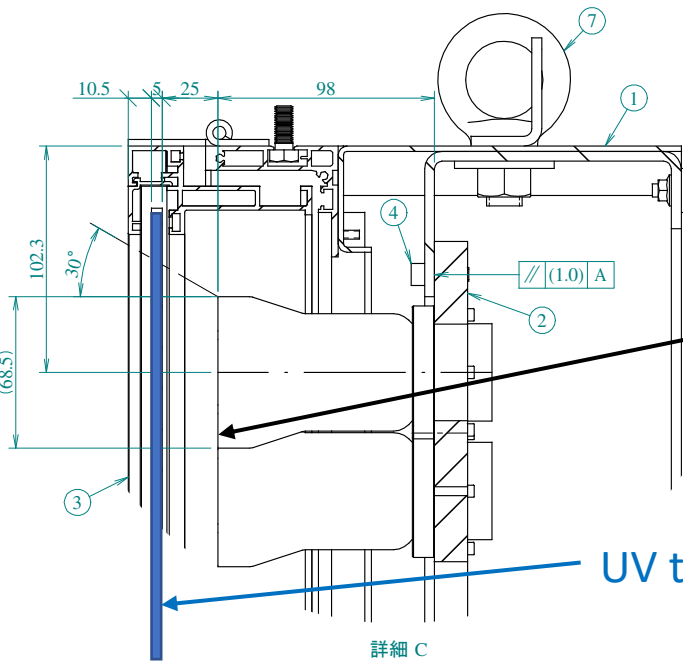
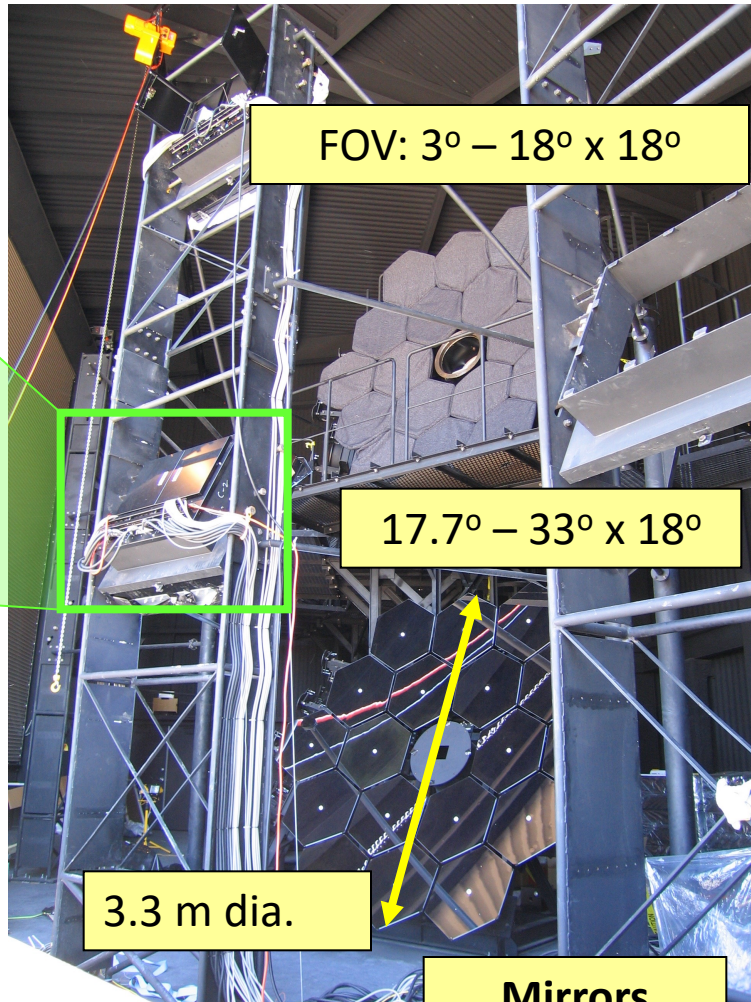


GPS, System clock
 Reset/Interrupt

Flat surface of the FD cameras



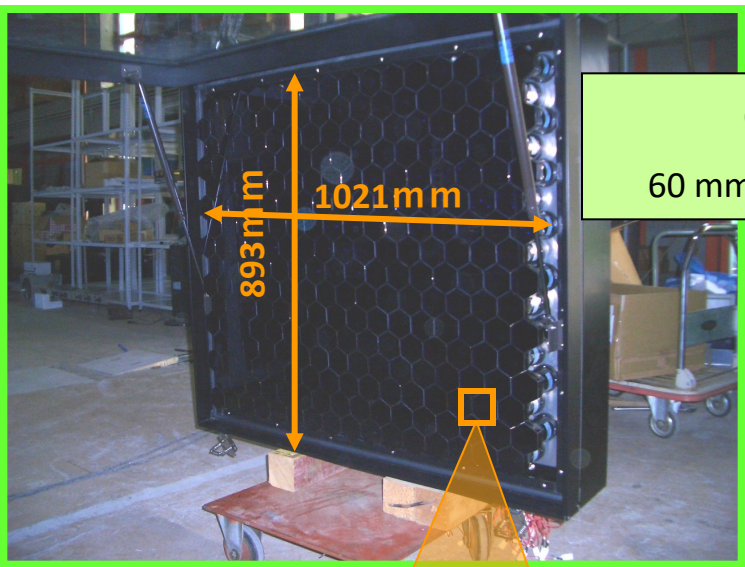
camera
60 mm Hex., 256 PMTs



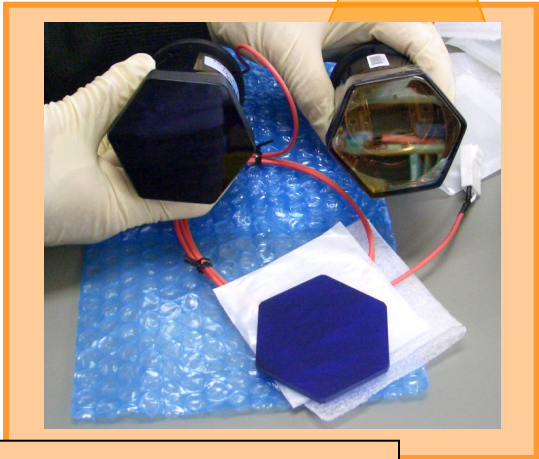
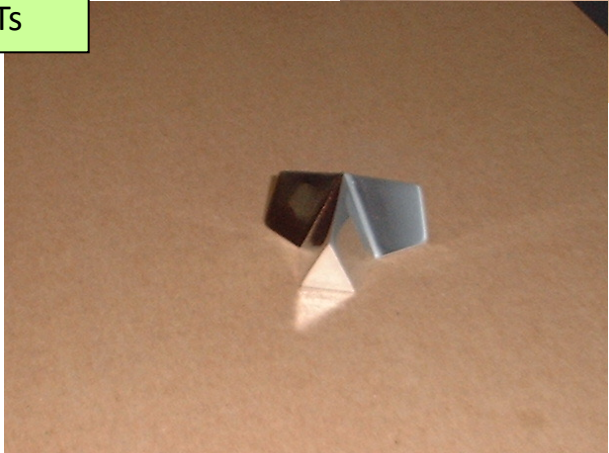
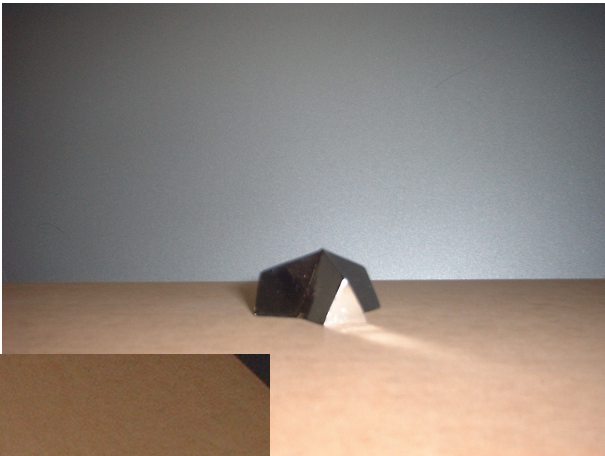
Flat surface of camera

UV transparent acrylic window in front of PMTs

PMT surface



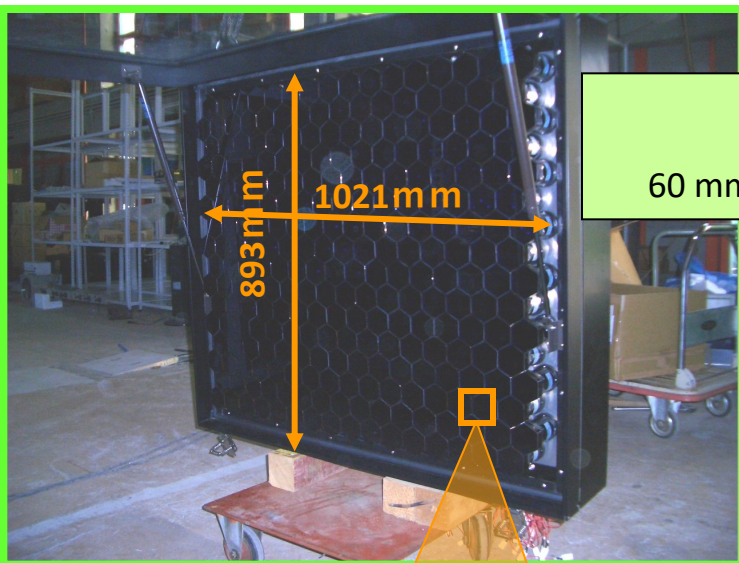
camera
60 mm Hex., 256 PMTs



PMT: HAMAMATSU R9508
Filter: BG3

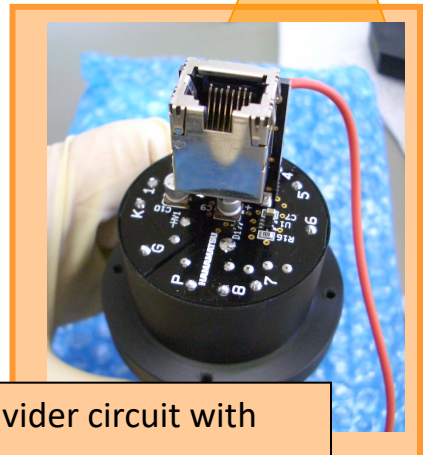
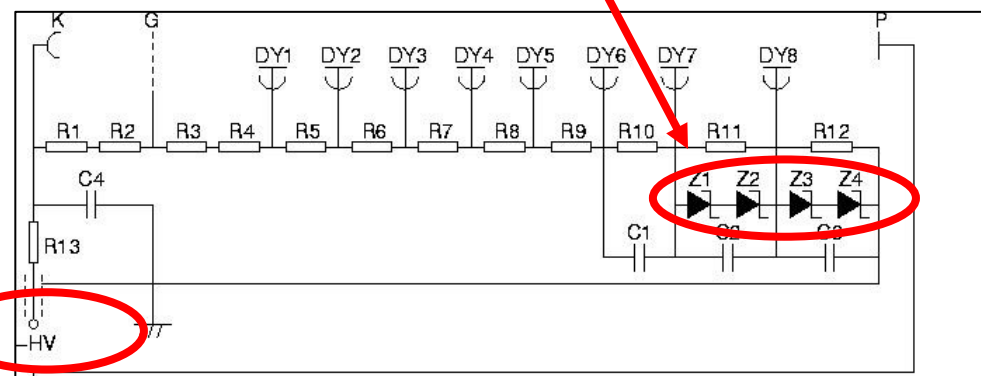
- We **DO NOT** use “Mercedes” , because...
- Negative HV on PMT
 - Quality control (stable surface reflectivity)
 - large photon injection angle on PMT surface

PMT electronics



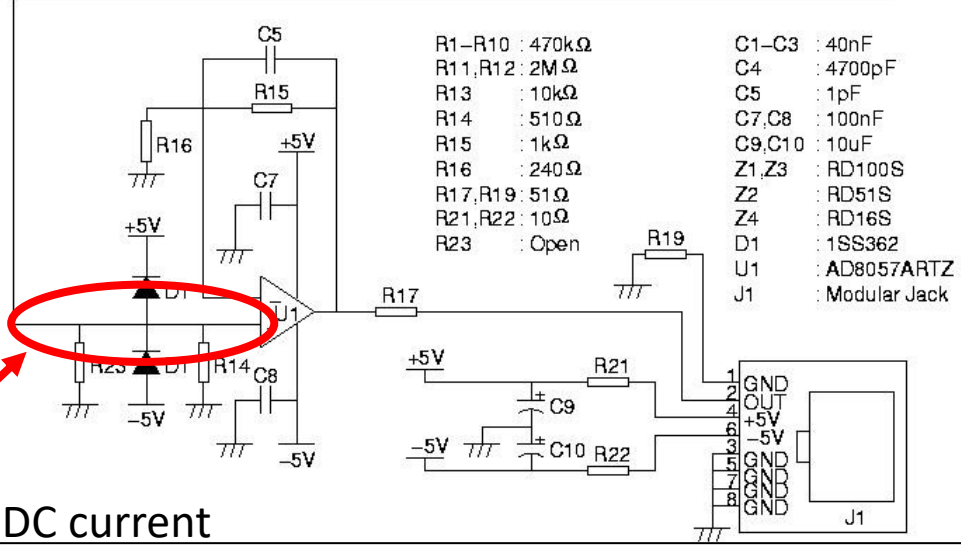
camera
60 mm Hex., 256 PMTs

We use Zener diodes in the HV divider circuit in order to reduce gain variation due to a large PMT current



HV divider circuit with pre-amplifier

Negative HV



DC coupling to measure DC current

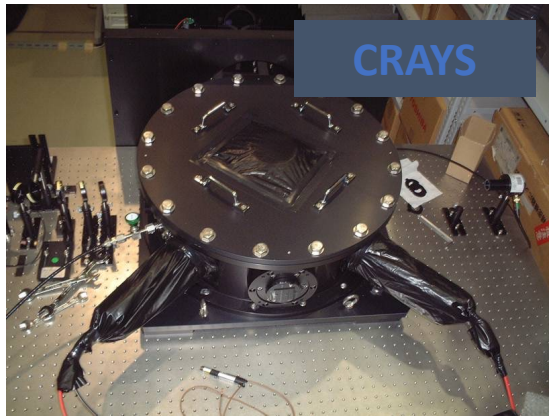
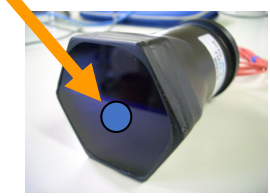
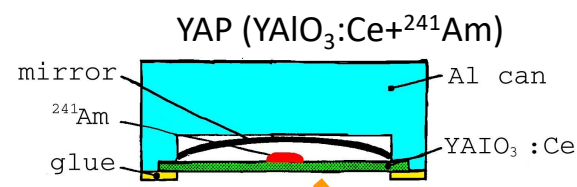
Calibrations of FD camera

(1) Absolute (in lab.)

CRAYS: Laser(337.1 nm)-Rayleigh scat.

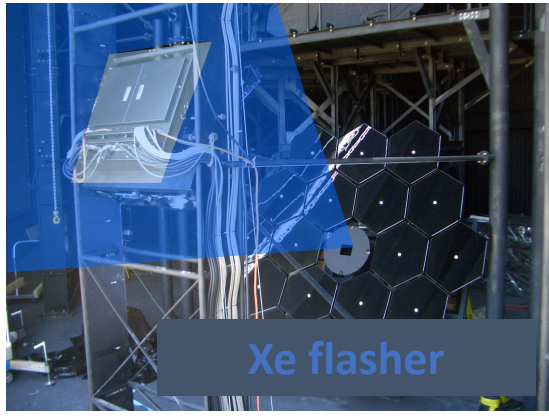
YAP: $^{241}\text{Am} + \text{YAlO}_3:\text{Ce}$

3 PMTs/CAMERA (+-7%)



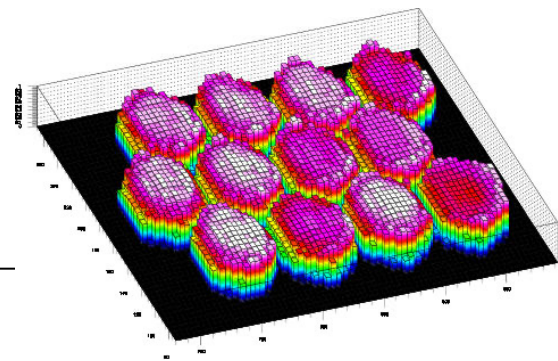
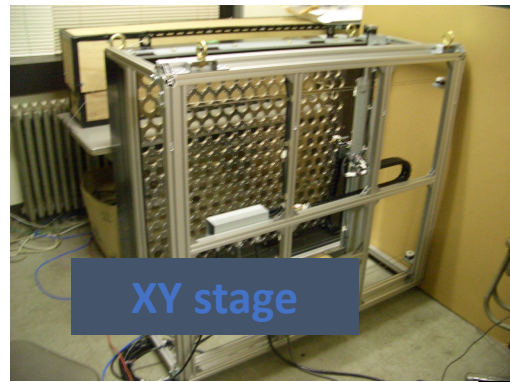
(2) Relative (on site)

Xe flasher (+-1% +-1% +-0.5%)



(3) Uniformity (on site)

LED on large XY stage



resolution: absolute ± 1.0 mm, relative ± 0.5 mm
light source: UV LED, 365 nm, $\phi \sim 1$ mm



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