



FACT First GAPD Cherenkov Telescope

CHIPP Plenary meeting

23-24 August 2010, Gersau, Switzerland

W. Lustermann, ETH Zurich

Collaboration

- TU Dortmund, Dortmund, Germany
- ISDC, Geneva, Switzerland
- EPFL, Lausanne, Switzerland
- University of Würzburg, Würzburg, Germany
- ETH, Zurich, Switzerland

Content

- Introduction
- FACT 1440 Camera
- Mechanics / Electronics
- Summary / Outlook



Introduction

FACT project objectives

- Construction of the first imaging air-shower Cherenkov telescope using G-APDs (Geiger mode avalanche photo diodes) as photo-detectors
- gain operation experience and observe the Crab-nebula

Former HEGRA CT3 telescope
La Palma, Canary Islands



FACT instrument: Hegra CT3 Telescope, La Palma

- **Owner:** MPI for Physics, Munich
- **Location:** European Northern Observatory, Roque de los Muchachos, Canary Island La Palma
 - altitude: 2199.4 m
 - longitude: -17deg 53m 26s
 - latitude: 28deg 45m 42s
- Close to the MAGIC telescopes
- Operation stopped in 2003

Mirror Dish

- **Number of mirrors:** 30
- **Mirror arrangement:** 1 ring of 6 and two rings of 12 mirrors, no central mirror
- **Diameter:** 3.885 m
- **total mirror surface:** 9.51 m²
- **Surface coverage:** 82.9 % (not counting the missing central mirror)

Administrative arrangements

- MoU with MAGIC collaboration is existing
- Agreement with IAC on creating of infrastructure existing



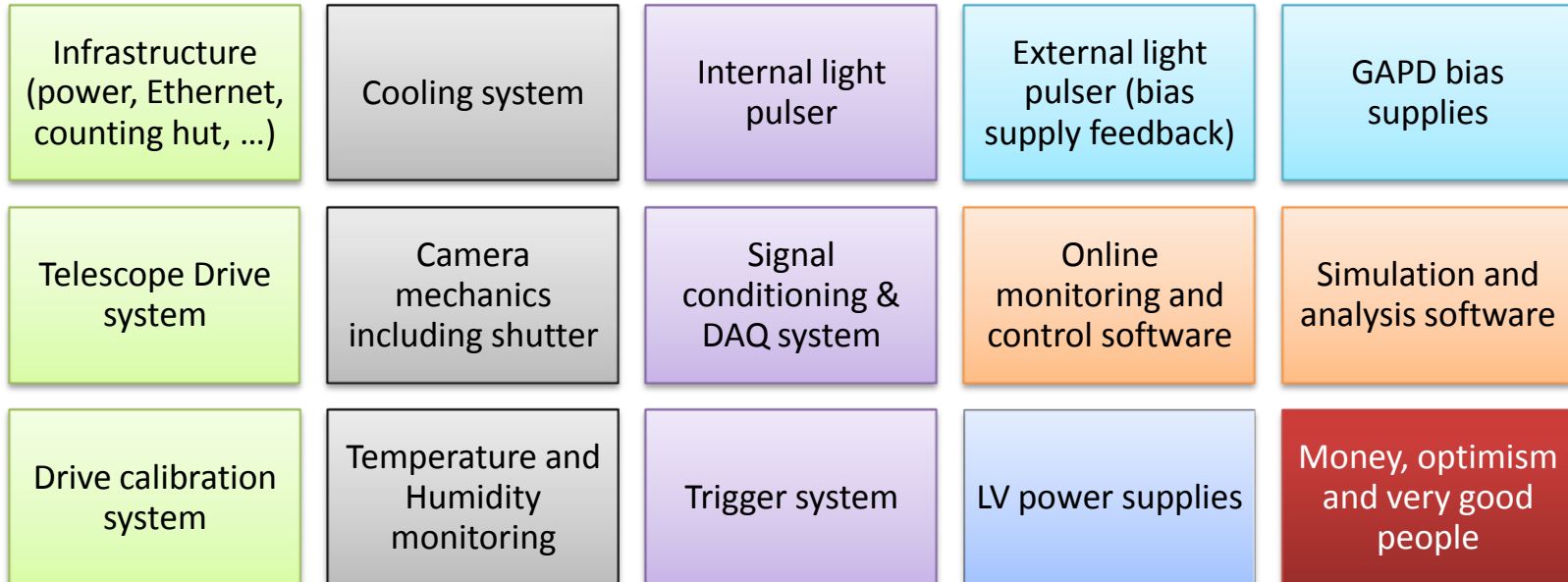
FACT Camera

Camera

- PMMA 7M entrance window, transmission $> 82\%$ for > 300 nm
- Solid light concentrators (Winston-cones)
- 1440 pixels (G-APDs)
- FOV: 0.11 deg / pixel (4.5 deg total)

Design requirements

- Dynamic range: 333 photons / pixel
- Resolution: 0.5 photons (for less than 10 photons)
- Timing resolution: 300 ps
- Double hit resolution: 5 ns
- Operation also under twilight/moon (background rate up to 1 GHz / pixel)





Mirrors

Mirrors (re-use existing Hegra CT1 mirrors)

- Spherical mirrors with hexagonal shape
- Diameter (inner circle): 60.5 cm
- area: 0.317 m²

Sandwich construction:

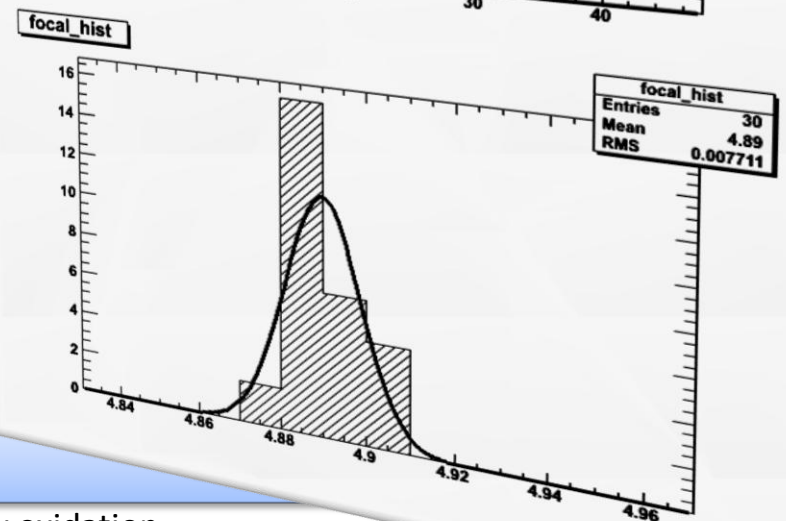
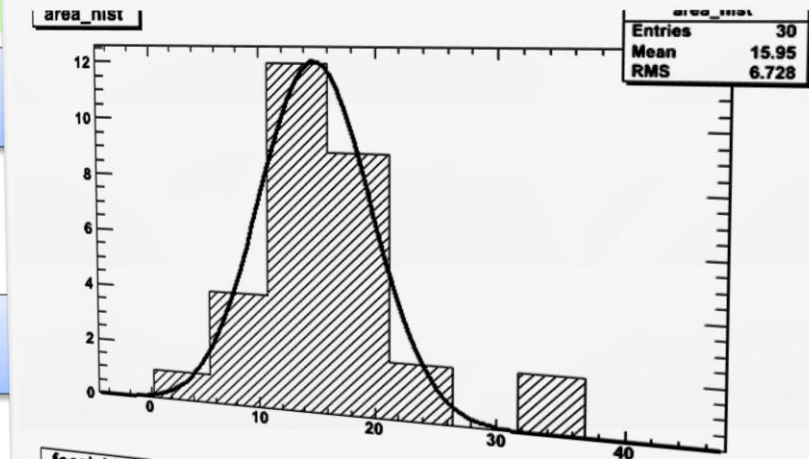
- Al base plate, 1 mm thick
- Al honeycomb (hexcell)
- Al alloy (AlMgSi 0.5) front plate, 5 mm thick
- Weight: ~6 kg

Surfaces were re-machined

- diamond milling by LT ultra Precision Technology GmbH
- Mean focal length: (4.890 ± 0.008) m
- Average spot size at 2f: 16.0 mm²

Surface finish

- Sputtering of Silicon in a Methan-atmosphere followed by oxidation
- Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung – IFAM (Bremen)
- thickness: ~120 nm
- reflectivity maximum around 450 nm, average reflectivity of ~90% between (300 and 500) nm



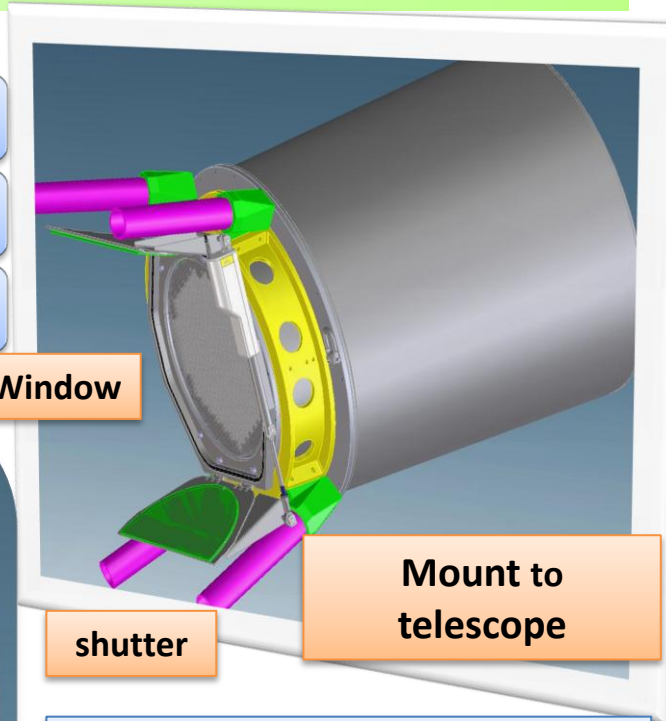
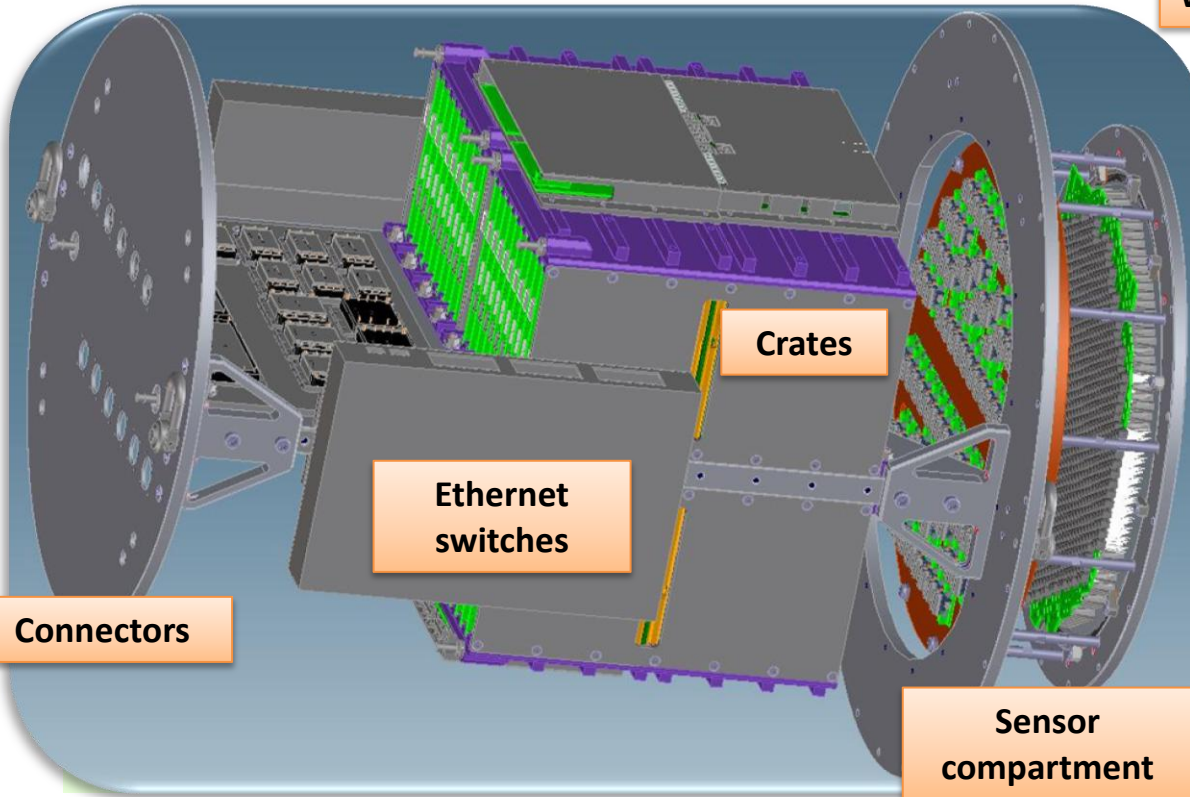


Camera Mechanics

Length 812 mm, diameter 532 mm, weight approx. 100 kg

4 water cooled electronic crates

Sensor and electronics compartment thermally separated



The construction must be water tight (following IP67) specifications:

This concerns the housing as well as connectors on the patch panel





Camera Details

G-APDs with
Winston cones

Front baffle
plate

Cable adapters /
bias feed

Co-axial signal cables, 50 ohm, ~35 cm



Height:
19.939 mm
IN: Hexagon:
9.5 mm
OUT Square:
2.8 mm

Light Concentrating Cones

- Cones and window from UV transparent PMMA
- normal parabolas shape
- Fabricated by injection moulding (IMOS Gubela GmbH)
- Presently prototypes are tested

Thanks for the support of
University of Zurich.



G-APD and single photon spectrum

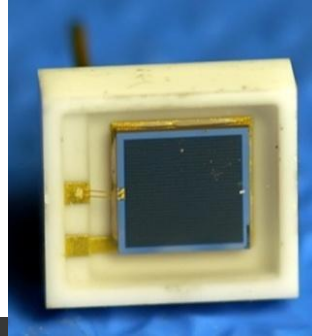
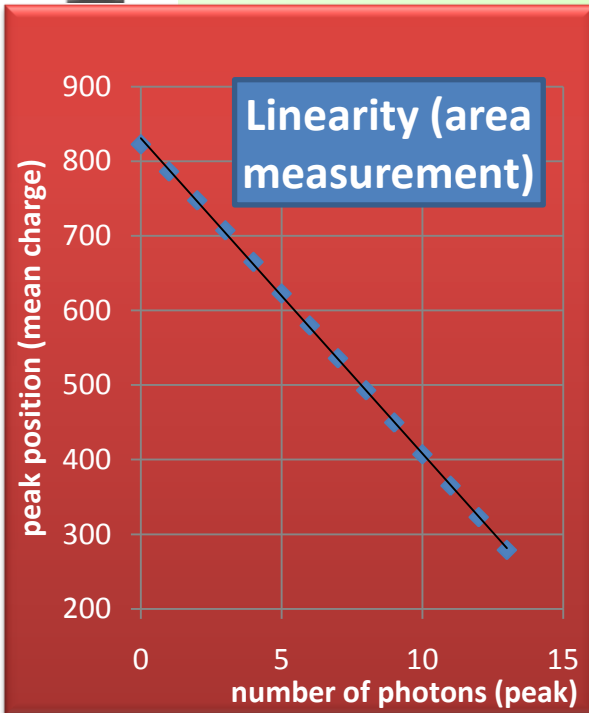


Photo detectors: MPPC

Manufacturer: Hamamatsu

Type: S10362-33-50-C

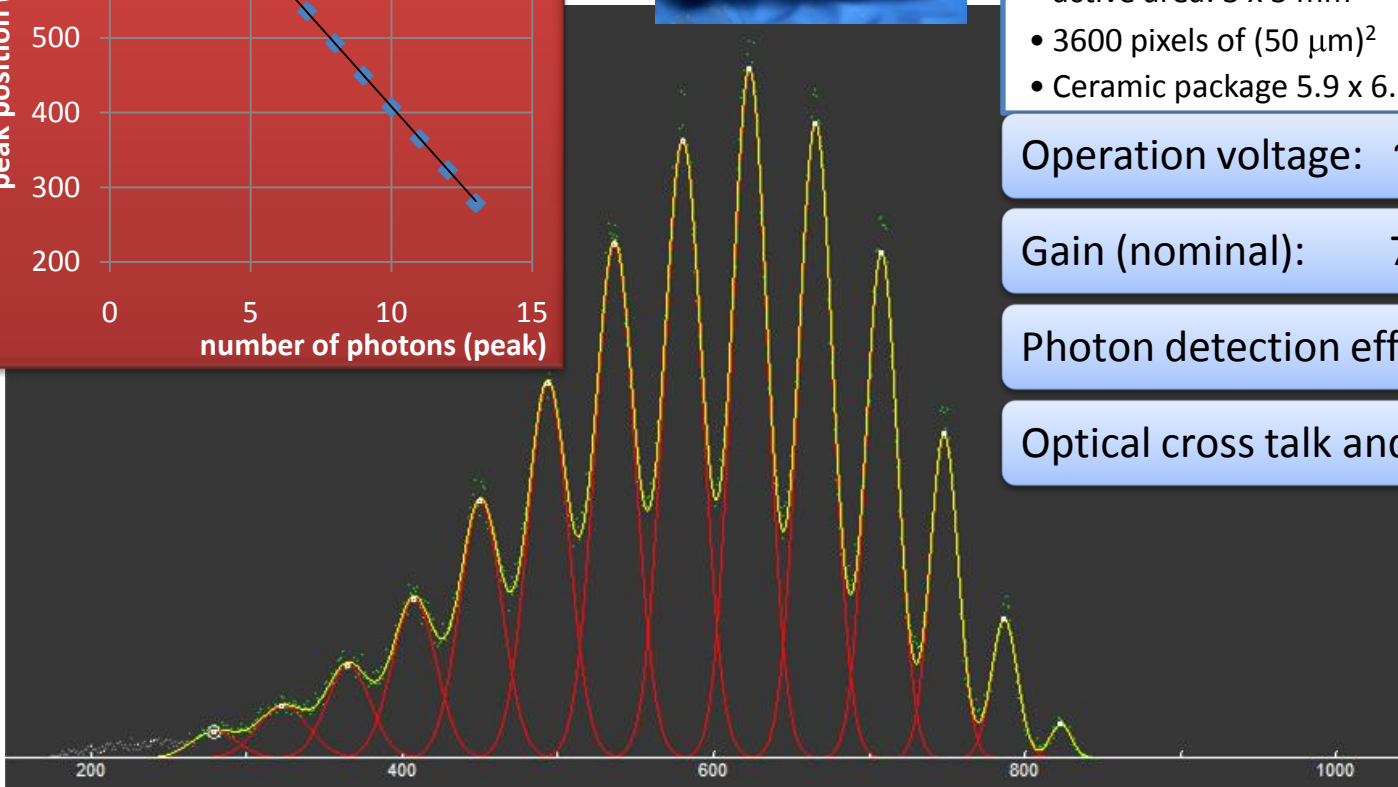
- active area: 3 x 3 mm²
- 3600 pixels of (50 μm)²
- Ceramic package 5.9 x 6.6 mm²

Operation voltage: ~70 V

Gain (nominal): 7.5 x 10⁵

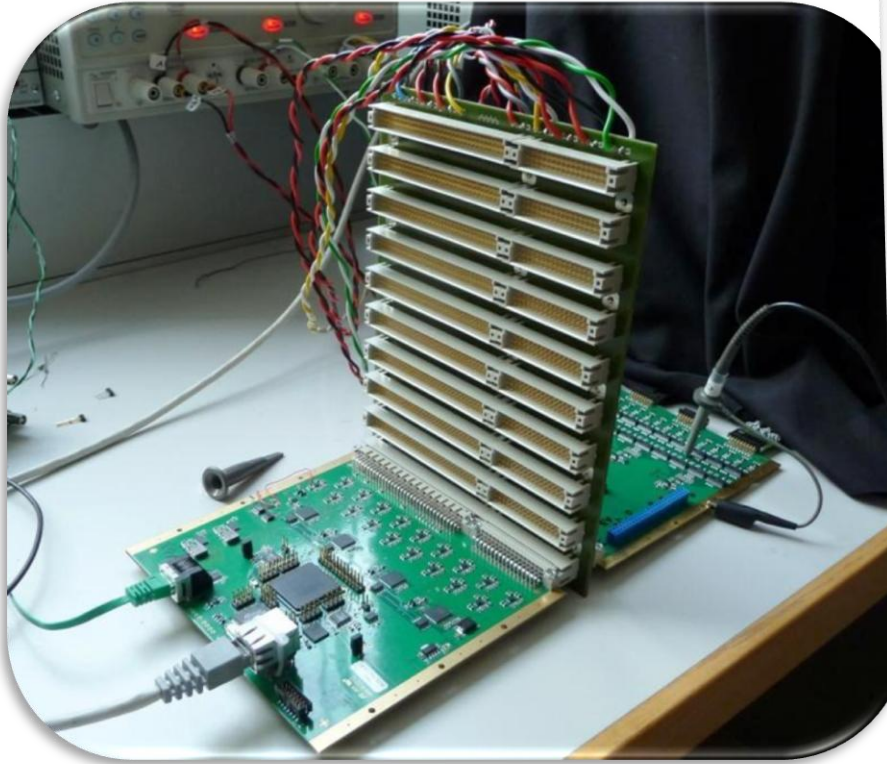
Photon detection efficiency: ~35%

Optical cross talk and after pulsing: ~25%

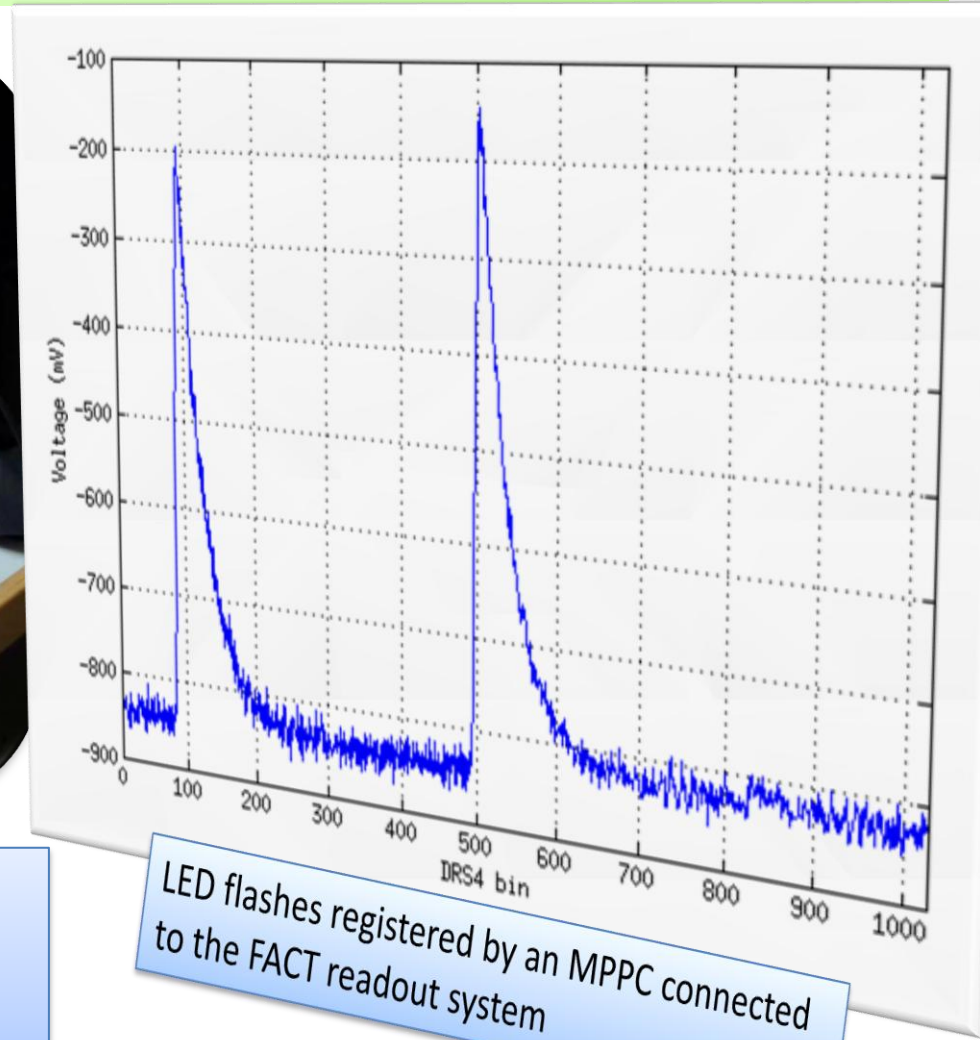




FACT DAQ – LED pulses



Pre-amplifier board (FPA) and analog pipeline (DRS4) & digitization board (FAD) connected via the mid plane (FMP) distributing power and slow control signals





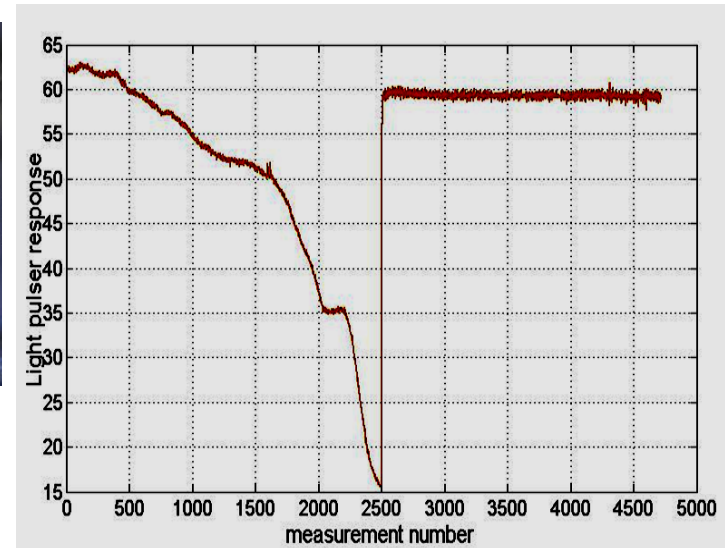
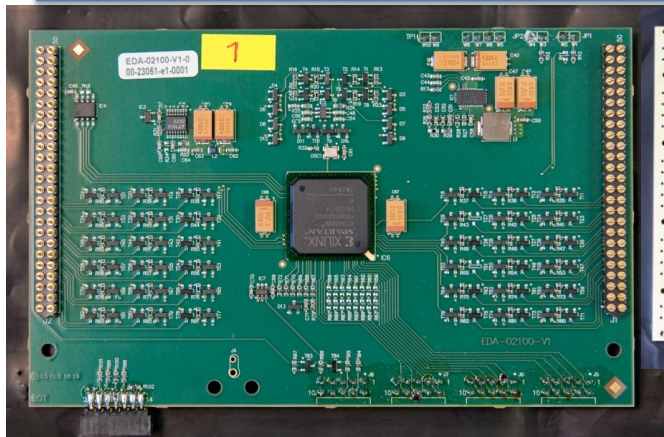
Trigger system & HV Feedback

Trigger unit (FTU) – 40 pieces

- Uses 4 sums of 9 pixels for a majority decision
- Mezzanine card on the FPA

Trigger master (FTM) – 1 piece

- Provides trigger decision upon 40 FTU inputs
- Provides CLOCK, TRIGGER and RESET signals



32 channel GAPD bias card

- Computer controlled (USB)
- Counting hut



Active bias supply feedback

- Light pulses of 9 LEDs (FLP) are triggered by the FTM and read out
- Deviations from nominal values are converted into GAPD bias corrections and applied.



Summary / Outlook

Telescope

- Mirrors and drive system ready for installation
- Necessary agreements signed

Mechanics

- Design including cooling finalized
- Fabrication of components started

Photo Detection

- all G-APDs available
- Winston cone fabrication ongoing

Electronics

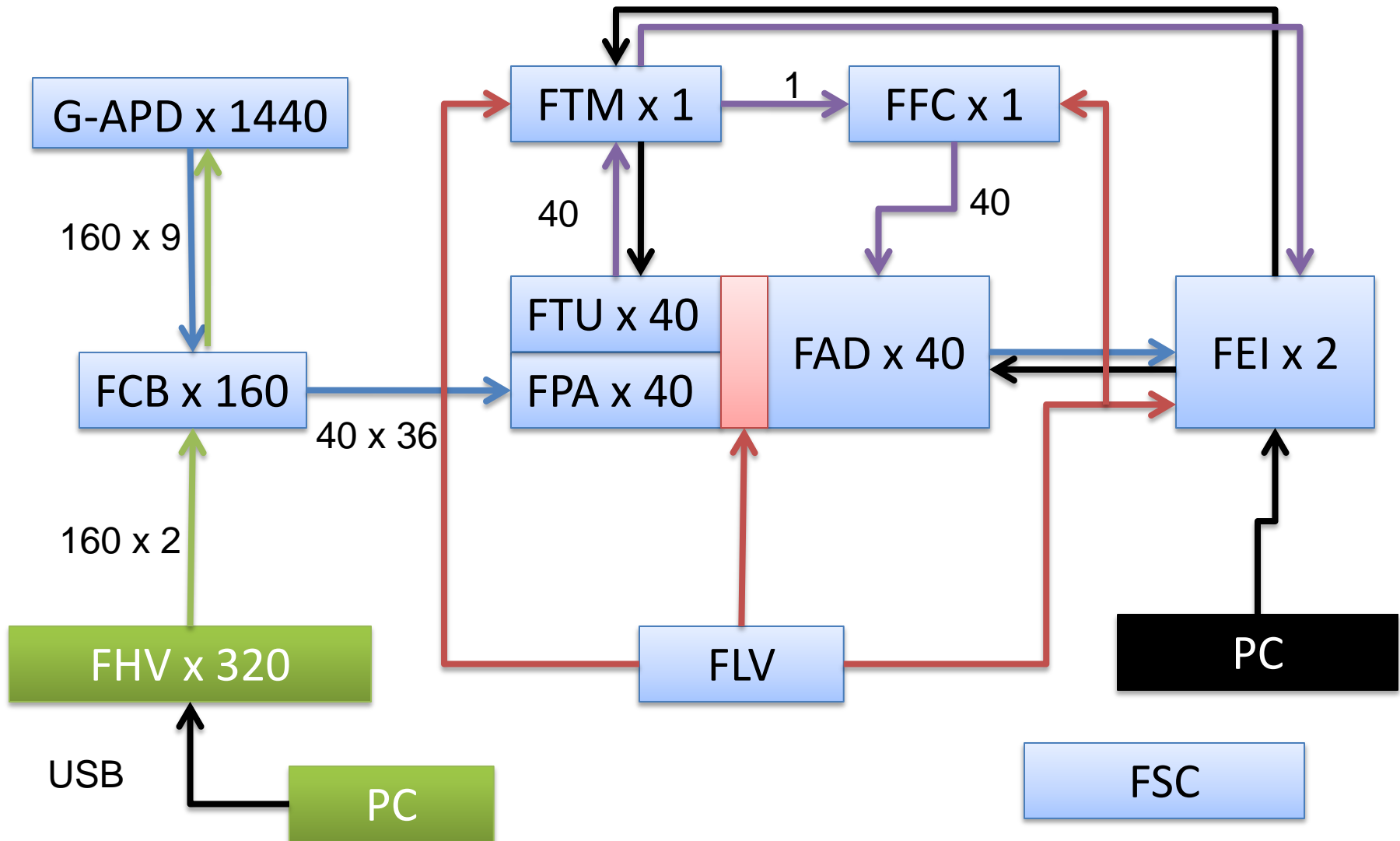
- Fully integrated into the camera
- Prototypes of all PCBs fabricated, tests ongoing

Objektives

- Fabrication of all components in 2010
- Observation of Crab-nebula beginning 2011



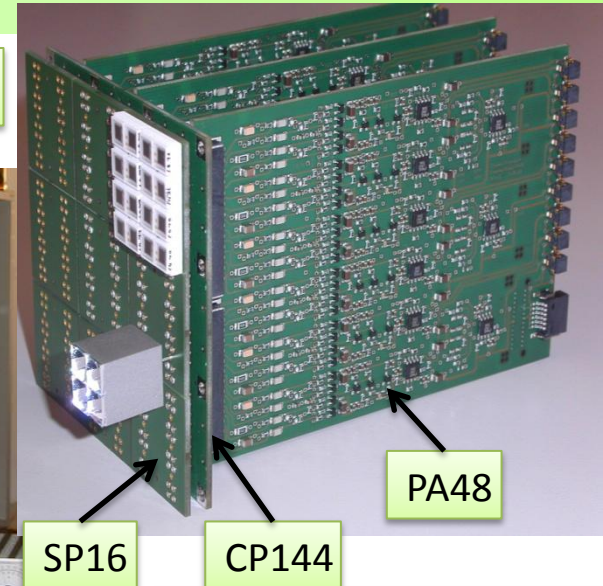
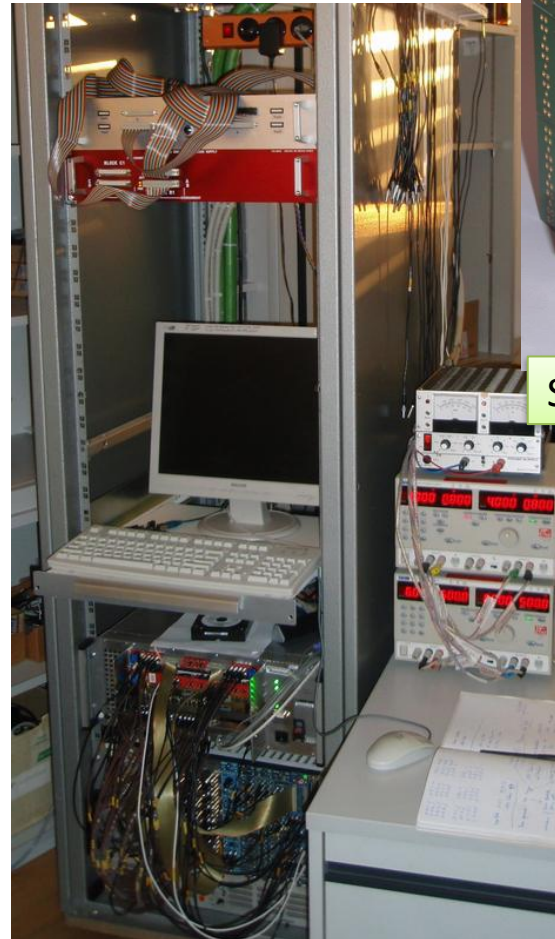
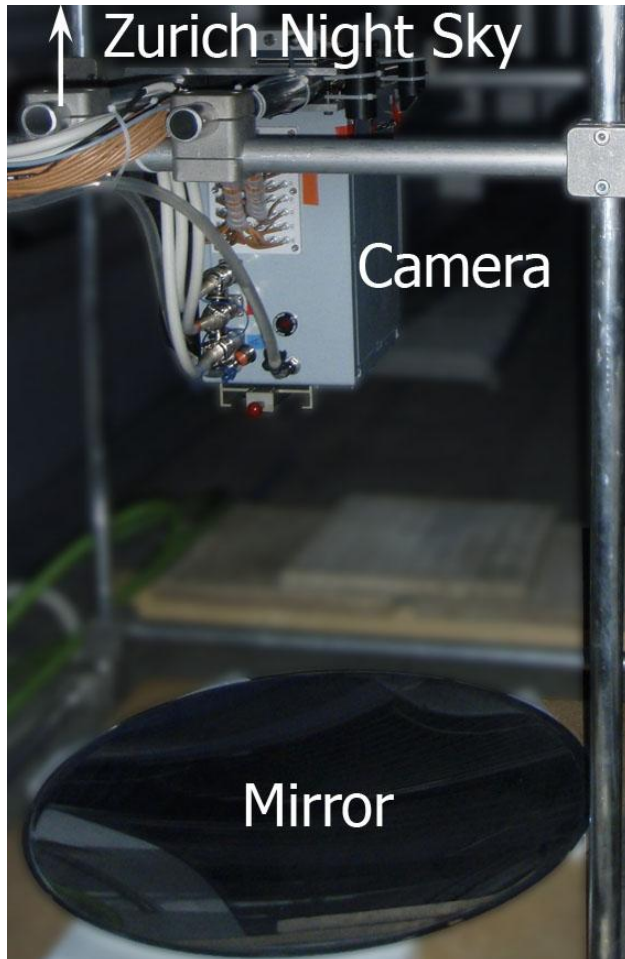
Electronics Systems Overview





First Measurements

Night of 2.-3. June on the roof of our ETH physics building



Mirror

- 80 cm focal length
- FOV: 1 deg / pixel

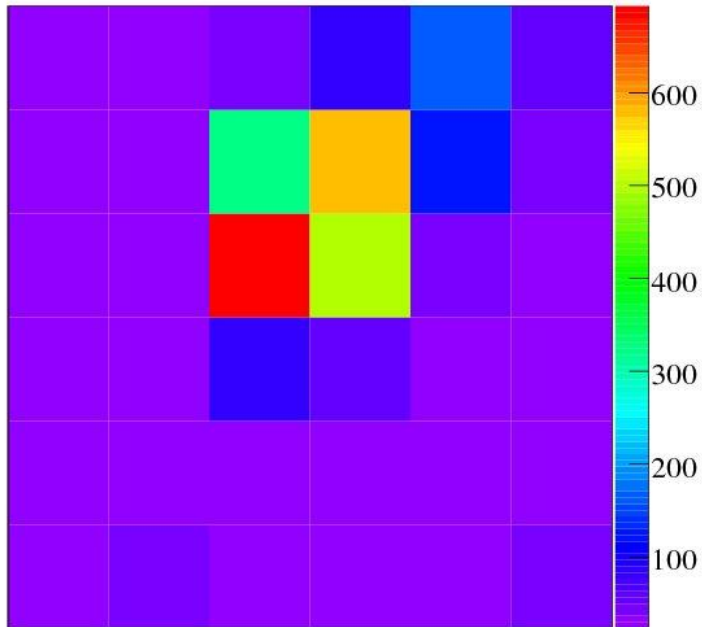
NSB

- from buildings and moonlight:
- 1.2 GHz / pixel

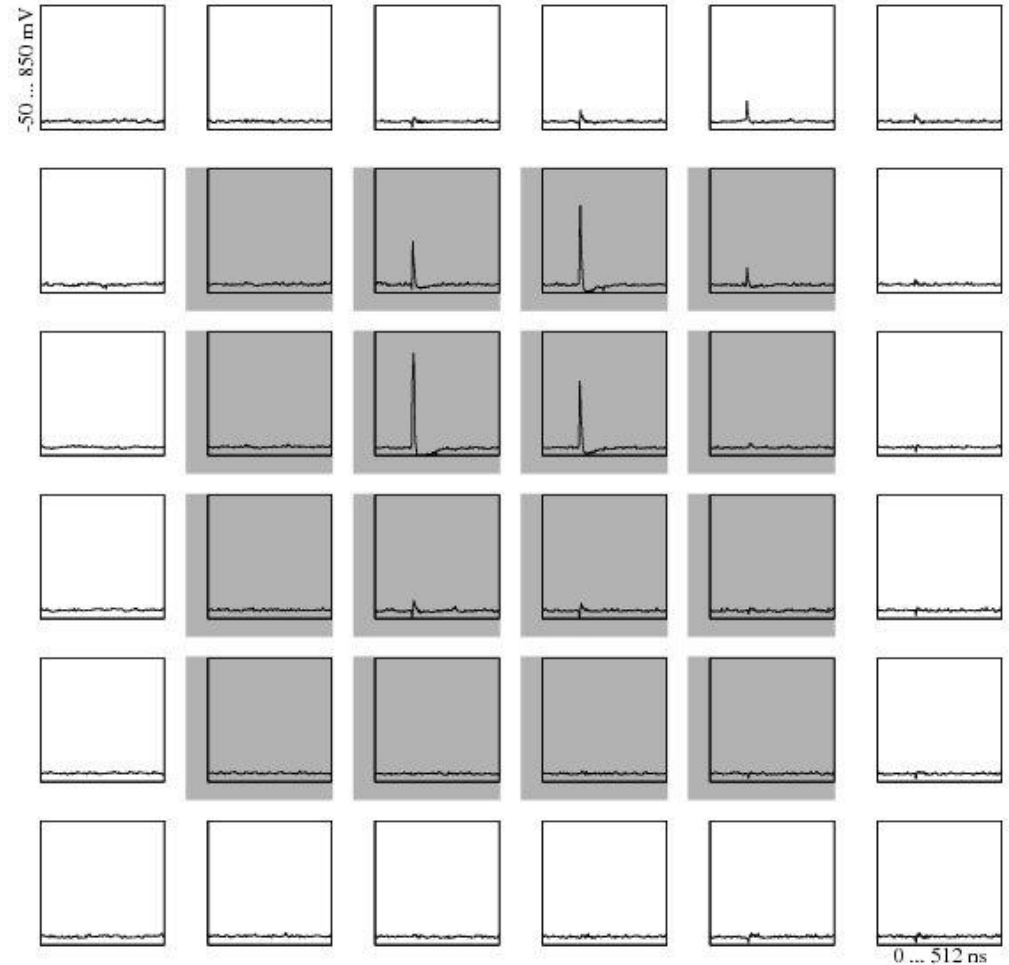


Event 21 Run 201

Maximum Amplitude (mV)



- 25mV single pixel threshold (4 p.e.)
- Majority 4 out of 16
- 100 kHz trigger rate per pixel
- 0.1 Hz total rate
- 2 GHz sampl. freq.



Horizontal: 0 ... 512 ns, Vertical: -50 ... 850mV