CTA Design Study
- Swiss Hardware Contributions

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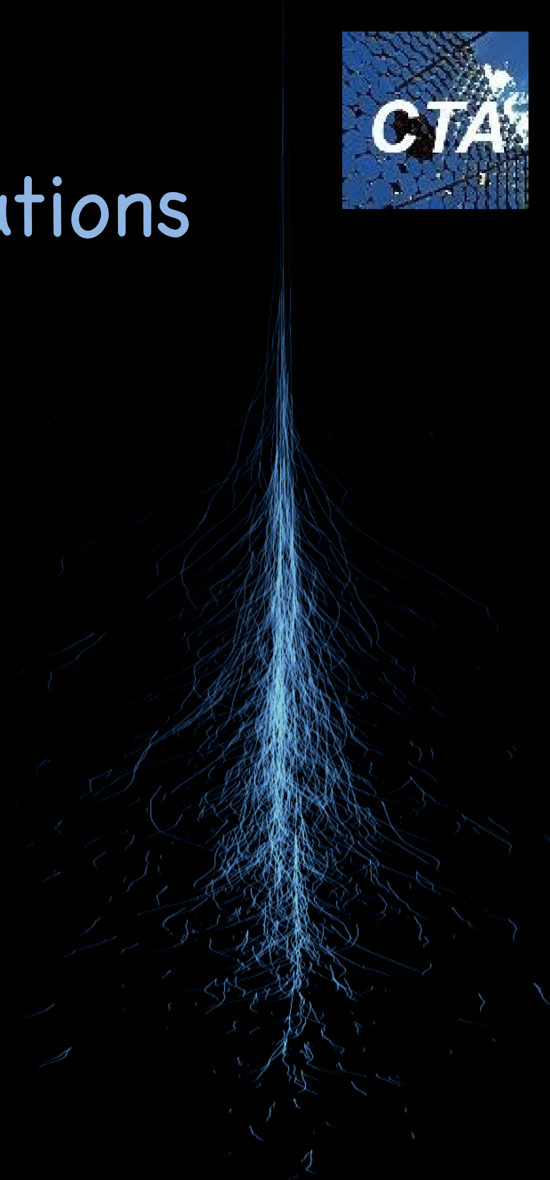


ETH Institute for Particle Physics

CHIPP Plenary Meeting 2009, Appenberg

Participating Institutes

ETH Zurich - Electronics, Winston Cones

University of Zurich - Electronics, Active Mirror Control

ISDC Data Center for Astrophysics, University of Geneva - see prev. talk

EPFL - High Energy Extension

PSI - G-APDs, DRS support

DPNC, University of Geneva

Front-end Electronics for CTA

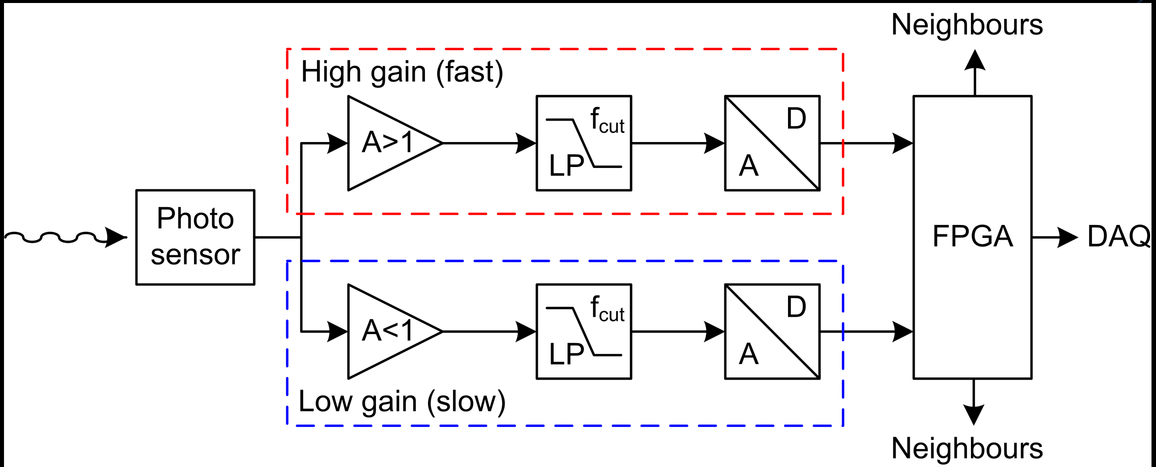
The University of Zurich is investigating the front-end electronics of the camera of the new generation Cherenkov Telescope CTA.

Possible topology for one camera sensor (pixel):

Two separate signal channels with **real-time** digitization

- High gain channel
  - For low energy gamma-rays (signals of 1 – 20 photons)
  - Amplif cation of analogue signal A > 1
  - High sampling frequency (~320 MHz)
  - Amplitude resolution 10 bit

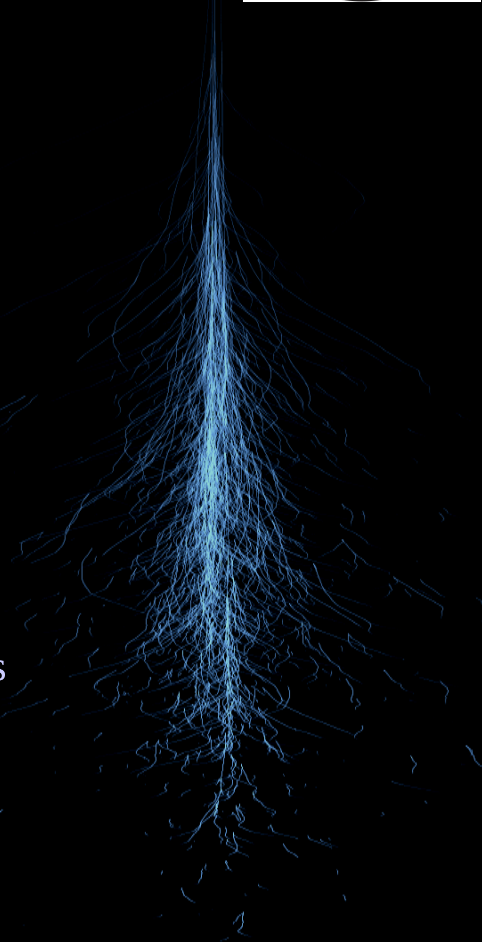
- Low gain channel
  - For high energy gamma-rays (signals of 10 - 4000 photons)
  - Low sampling frequency (~80 MHz)
  - Amplitude resolution 12 bit



Front-end Electronics for CTA

Main topics of investigation for the CTA camera readout:

- Camera topology studies:
  - Module size = # of PMTs mechanically connected
  - Horizontal or vertical topology of readout electronics
- Determination of needed analogue bandwidth for:
  - Physics questions
  - Best time and amplitude resolution
  - Maximal ADC sampling frequency needed (costs reduction)
- Investigation of readout electronics:
  - Technology studies for different preamplif ers, ADCs and FPGAs
  - Studies of the matching of different ADCs and FPGAs
  - Cost and power consumption estimations / calculations
  - Preamplif er topologies
- Trigger algorithm
  - Full signal shape analysis algorithm
  - FPGA implementation
- **Building of at least two prototypes with different topologies**



for more details contact:
Arno Gadola, UZH

The Active Mirror Control (AMC) - Why?

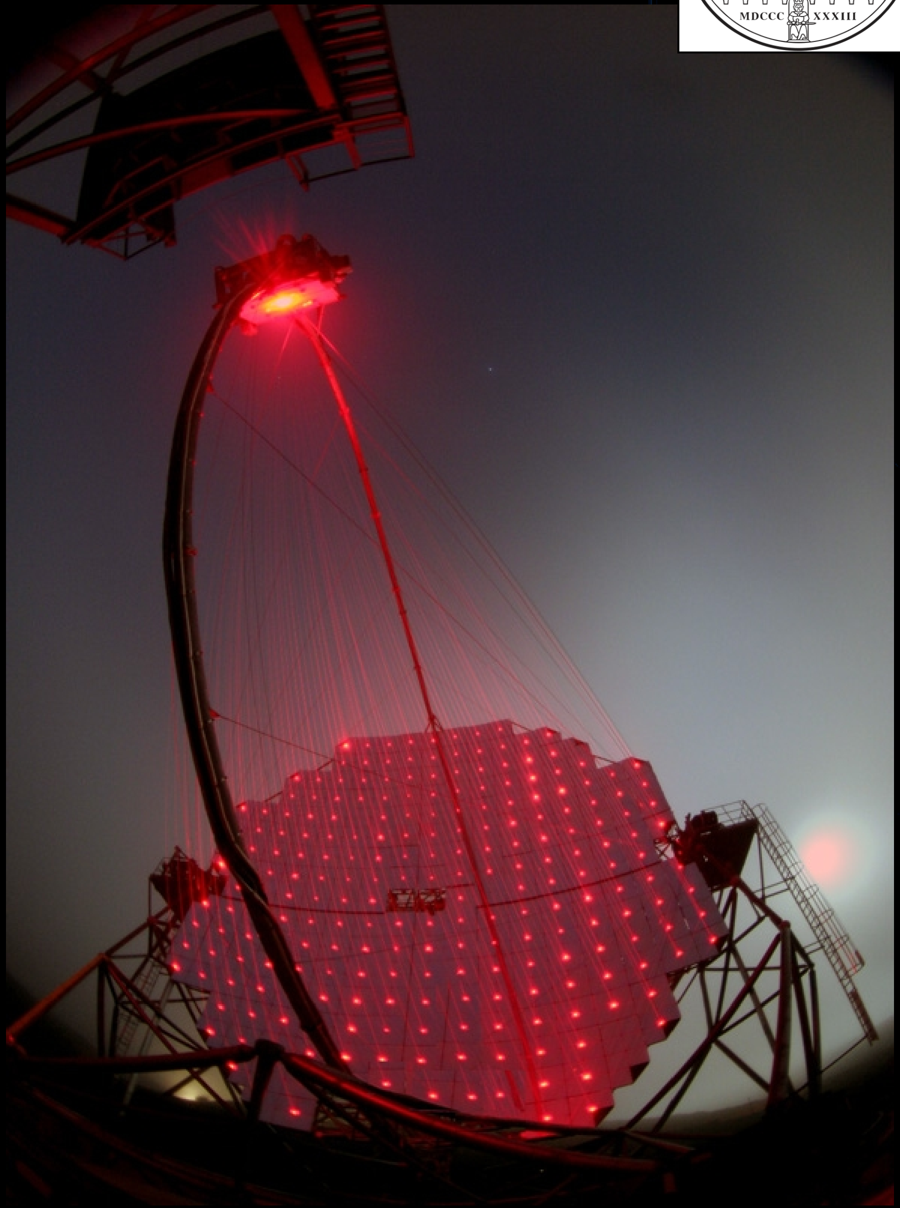
large mirror is easier to produce in segments

light-weighted telescope dish suffers from deformation during movements

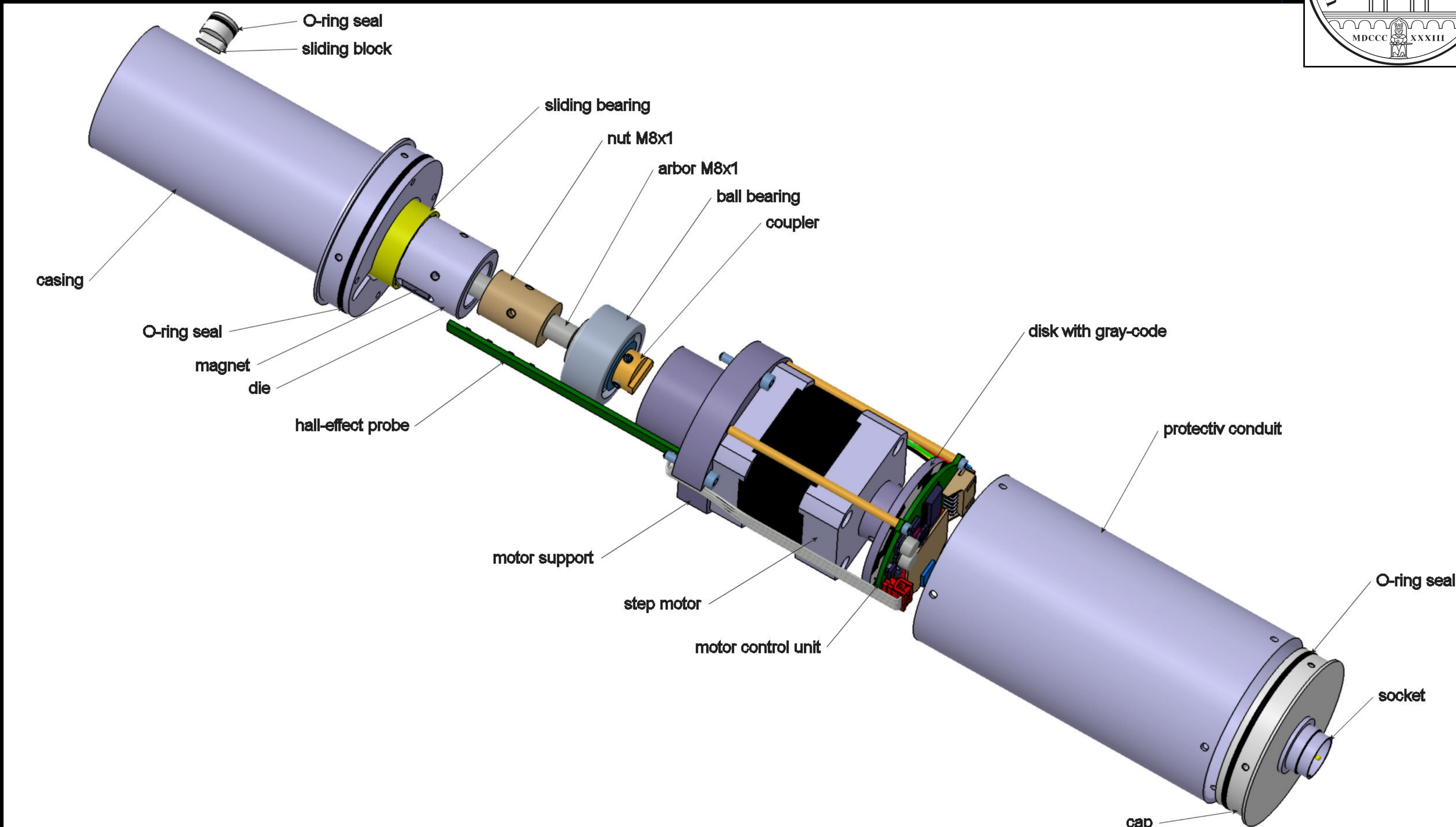
with the aid of AMC: each mirror segment is individually adjustable

3 point gimbal and 2 actuators per mirror segment

refocussing of the telescope during observation



The Active Mirror Control (AMC) - Actuator Design



- driven by stepper motor
- absolute positioning via 4 hall sensors
- wireless communication (ZigBee Standard)
- different types of spindels will be tested

The Active Mirror Control (AMC) - Prototype Testing

teststand with real weather conditions

current teststand status:

1 actuator cycle:
extend 3mm, retract 3mm

so far: 322323 cycles completed

corresponds to 8.2 year real-life telescope operation

for more details contact:
Ben Huber, UZH

EPFL Contribution to CTA High-Energy Extension

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

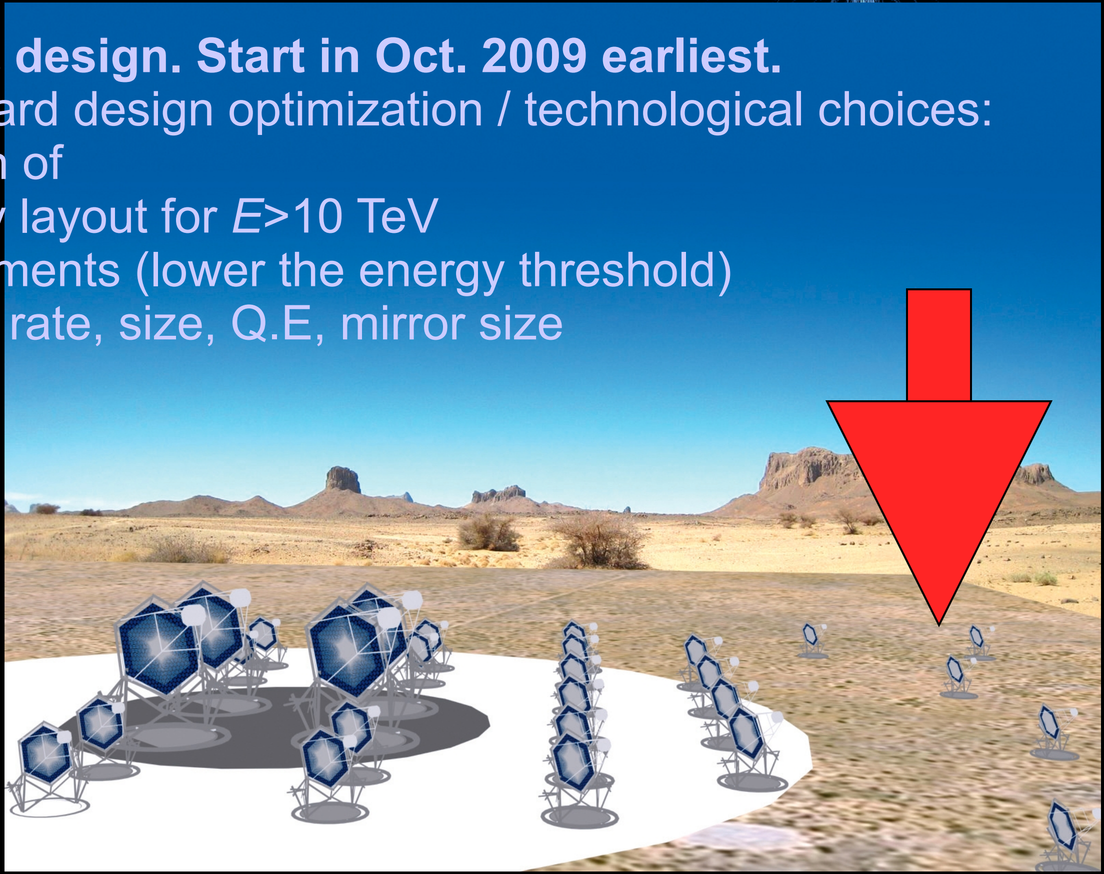
Many TeV sources do not reveal high energy cutoff but are out of reach of current generation instruments at 100 TeV, as it would necessitate eff. Area much larger than 0.1 km^2. An increase of the collection area by a factor >30 above 10 TeV can be achieved with an array of 30-50 small telescopes with a large FoV

Phase 1: Define requirements & design. Start in Oct. 2009 earliest.

- Based on simulations, readout card design optimization / technological choices:
  - Simulation: Determination of
    - an optimized array layout for E>10 TeV
    - the trigger requirements (lower the energy threshold)
    - the pixel sampling rate, size, Q.E, mirror size

Phase 2: Prototype

- Readout board construction
- Trigger implementation
- Test



for more details contact:
Mathieu Ribordy, EPFL

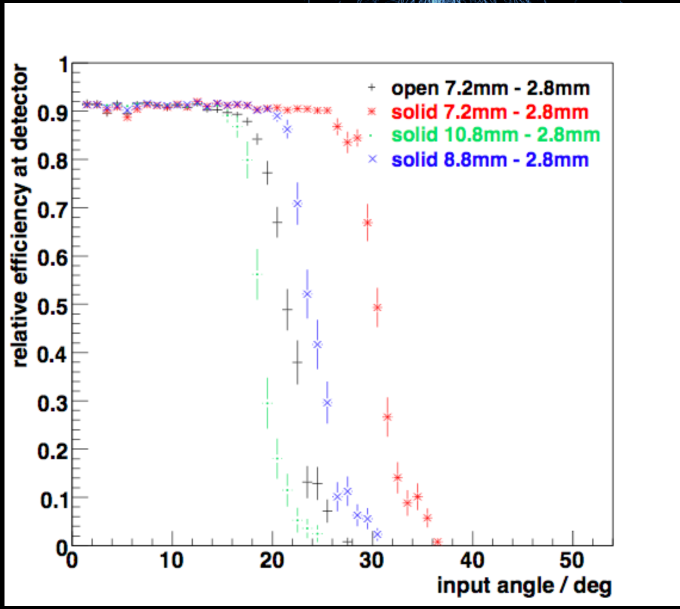
Winston Cones

ETH Zurich + University of Zurich

Design & Development of solid Winston Cones
+ total reflection
+ gain in area concentration ratio (-> cheaper camera)
+ mass production (moulding)
- mounting (optical connection required)

In Standard CTA option (PMTs, fixed pitch):
+ gain sensitivity by using only central part of PM

will enter into Conceptual Design Report for CTA



First G-APD Camera Test

Technological project (R&D): independent of CTA

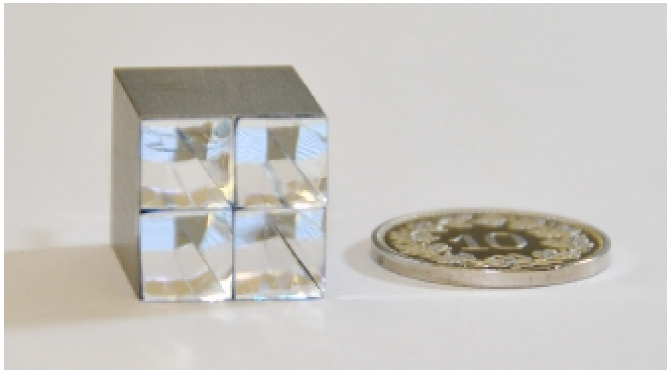
Goal: complete Cherenkov Camera based on G-APDs

ETH Zurich, University of Zurich, PSI, UniGe, EPFL
in cooperation with Universities Dortmund & Wurzburg:
DWARF (Dedicated multi-Wavelength AGN Research Facility)

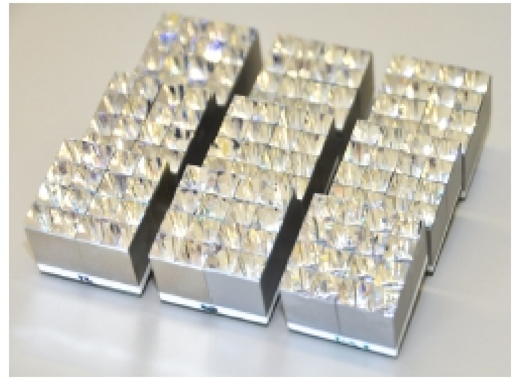
test a promising technology
for future IACT projects

First G-APD Camera Test

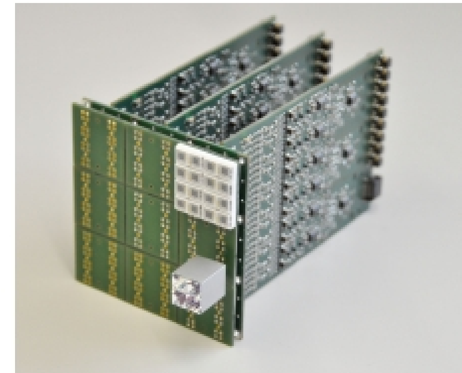
36 pixel prototype, operation at high NSB and room temperature



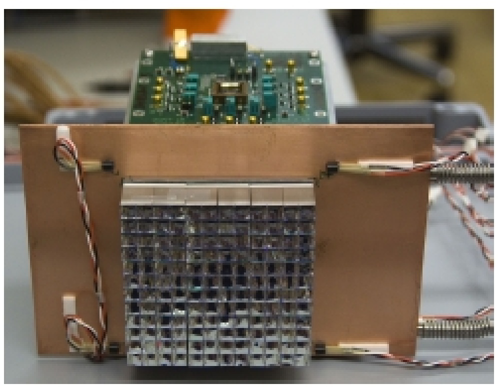
Winston Cone: $(7.2\,\mathrm{mm})^2 \rightarrow (2.8\,\mathrm{mm})^2$
1 cone per G-APD, blocks of 4



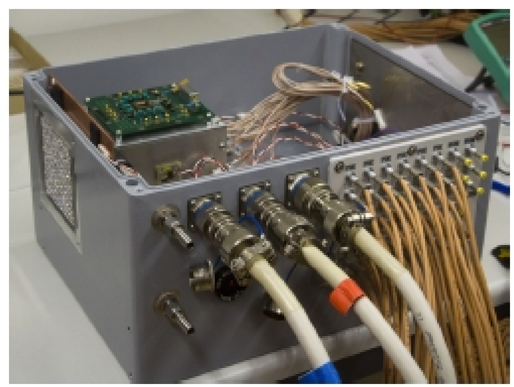
4 G-APDs/pixel = 1 channel
36 pixels, each $(14.4\,\mathrm{mm})^2$



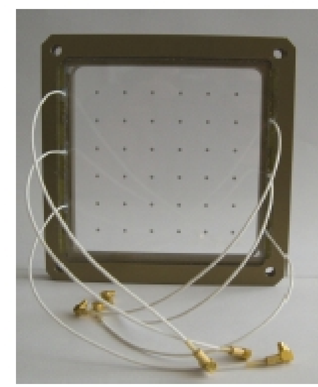
3 analog preamplifier boards
Distribution of bias voltage



Water cooling, thermal coupling
6 temperature + 1 humidity sensor



Light and rain-tight box
Analog signal transfer



Window + separat shutter
LEDs for artificial signals

First G-APD Camera Test

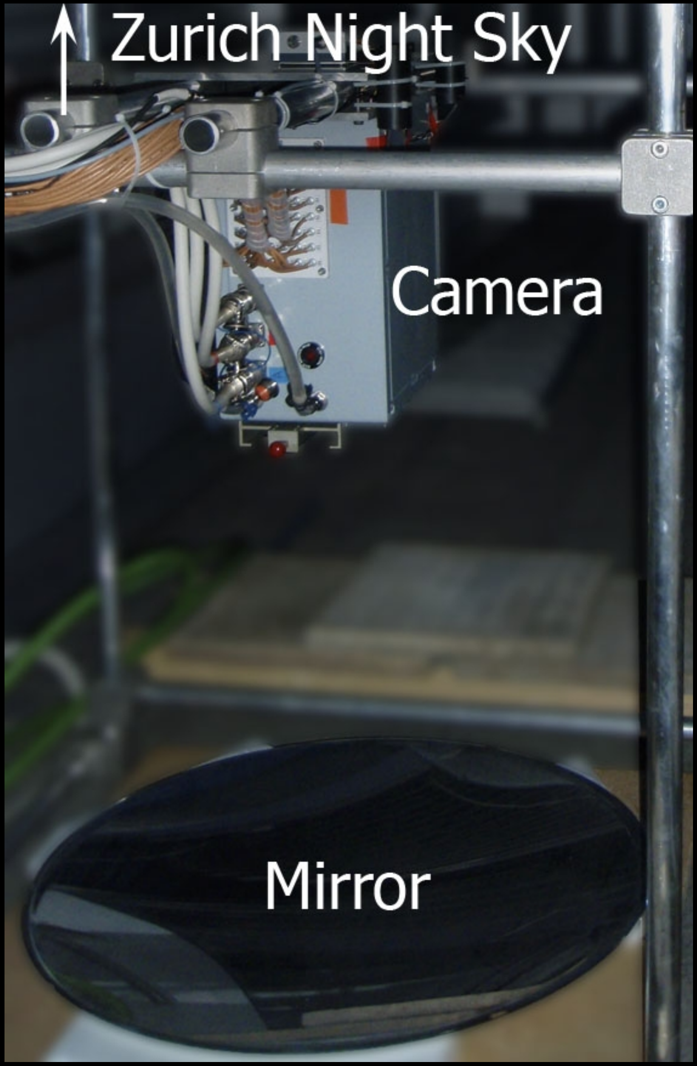
small testing facility @ ETH Zurich

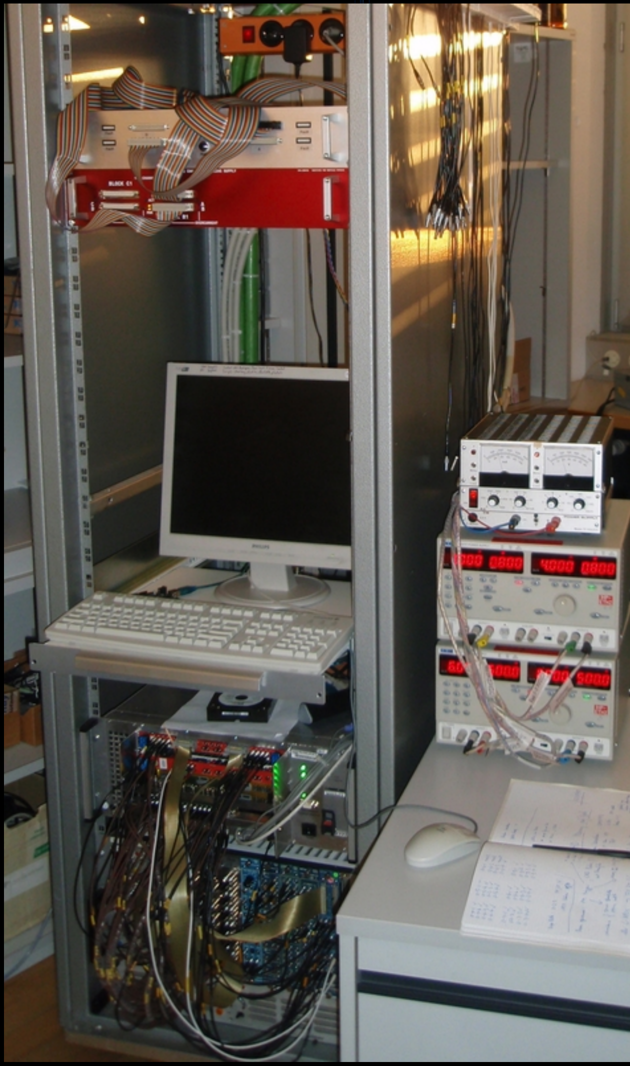
f=80cm Mirror
~ 1º / pixel

1.2 GHz NSB / pixel

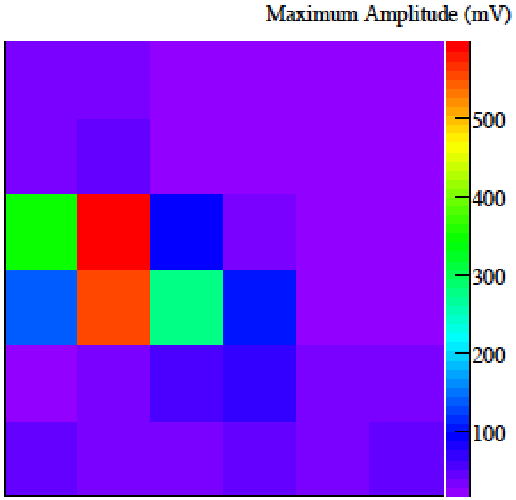
22ºC ambient temp.
G-APDs cooled to 18º C

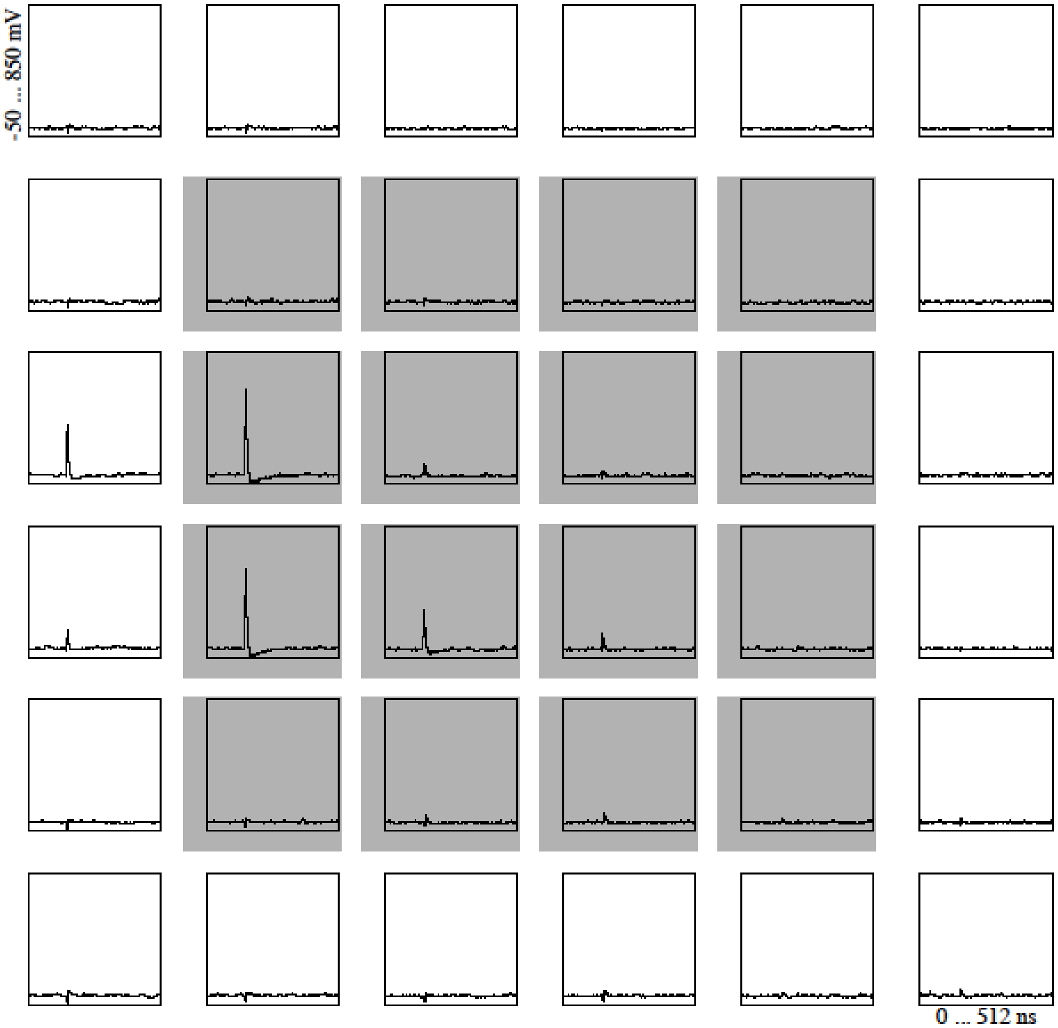
high energy threshold





First G-APD Camera Test





- 40 mV single pixel threshold ($\sim$ 7 p.e.)
- Majority 4 out of 16
- 1-3 kHz trigger rate per pixel
- $\sim$ 0.02 Hz total rate
- 2 GHz sampl. freq.

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

First G-APD Camera Test

Next Steps:

- further testing of prototype components,

- more integrated electronics

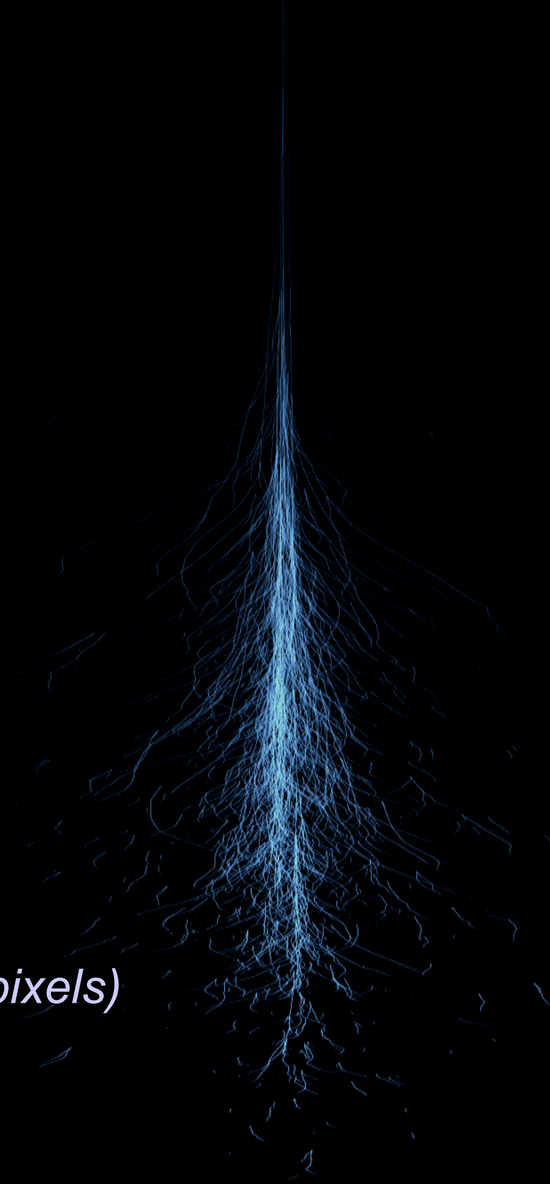
digitization inside Camera

switch from DRS-2 to DRS-4

ethernet-based DAQ

Final Camera for DWARF with 3-5deg field of view (700+ pixels)

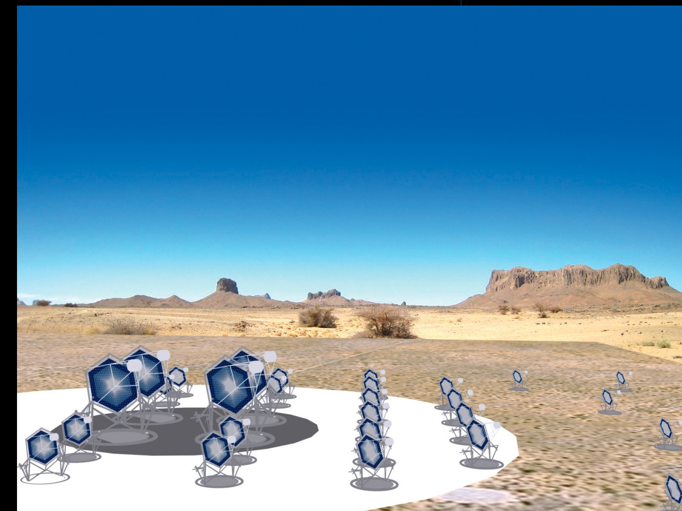
electronic design will be fixed soon



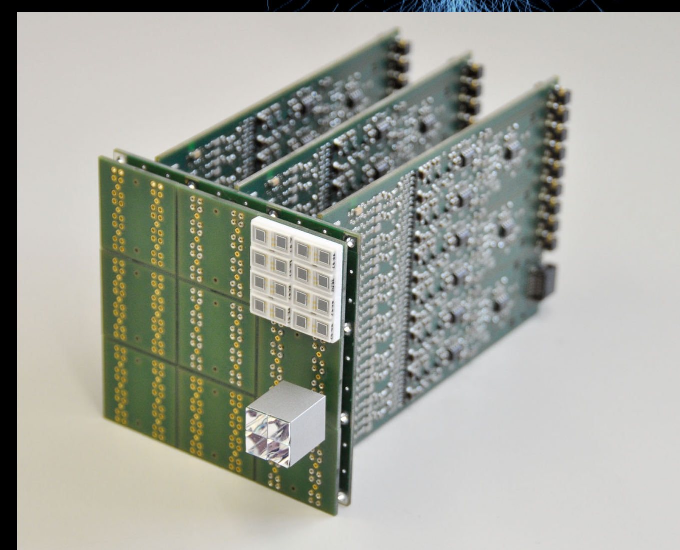
Summary

Active Swiss participation in most working groups of the CTA design study:

Physics: UGe, ETHZ   MC: UGe   Site: ETHZ
Software: UGe, ETHZ   Telescope: UZH, ETHZ
Camera & Electronics: ETHZ, UZH, UGe, PSI



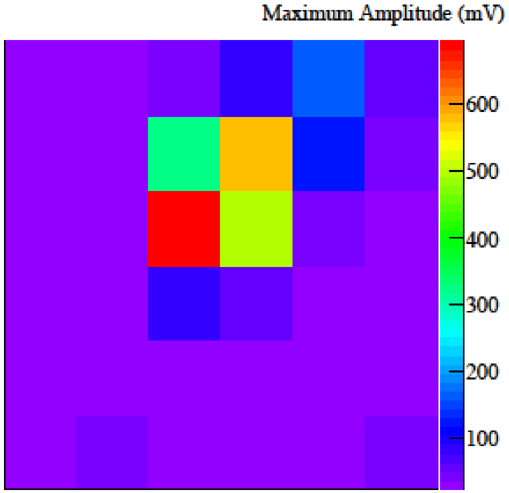
First Cherenkov light from air showers in FACT prototype camera
-> G-APDs on their way to a 'proven technology'



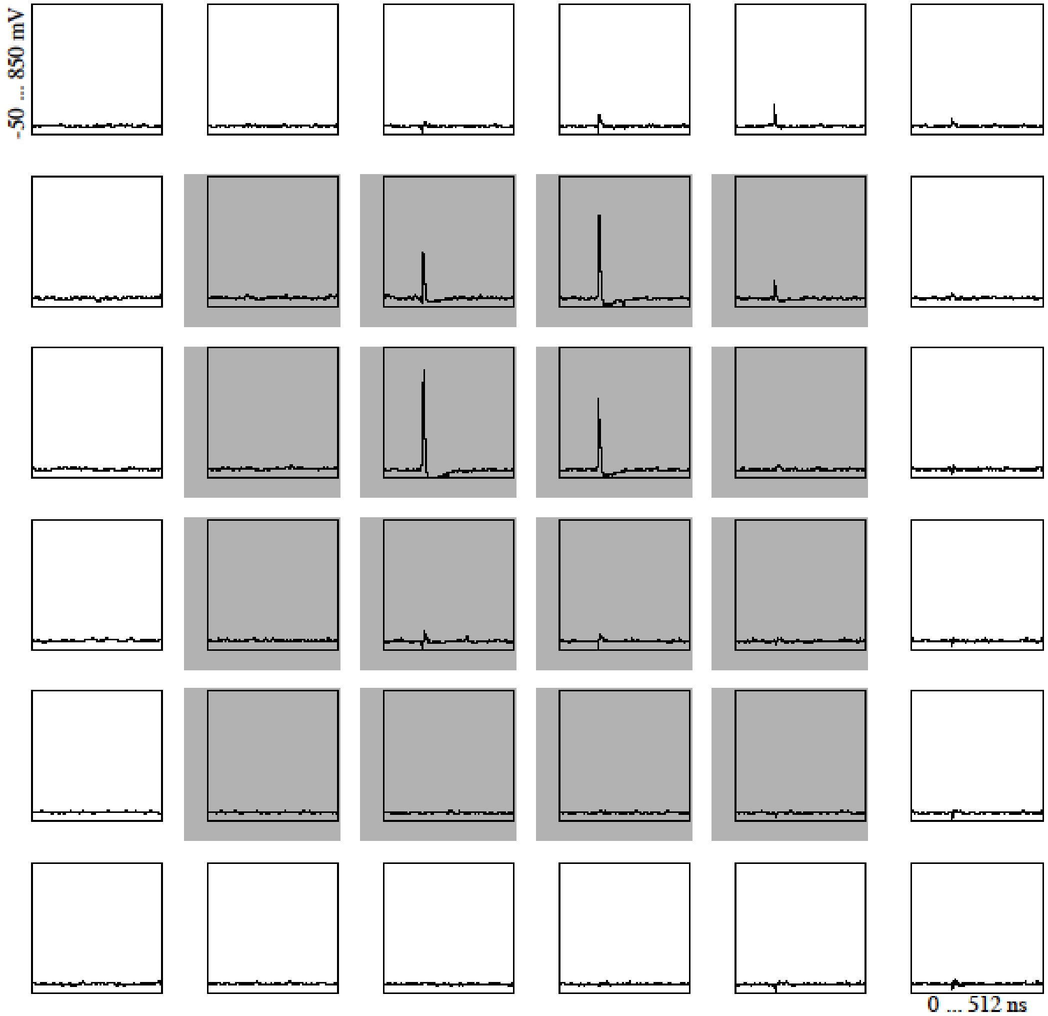
Next General CTA Meeting: October 5-8 , Uni Zurich!

Time to join the party!

First G-APD Camera Test



- 25 mV 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 ... 850 mV