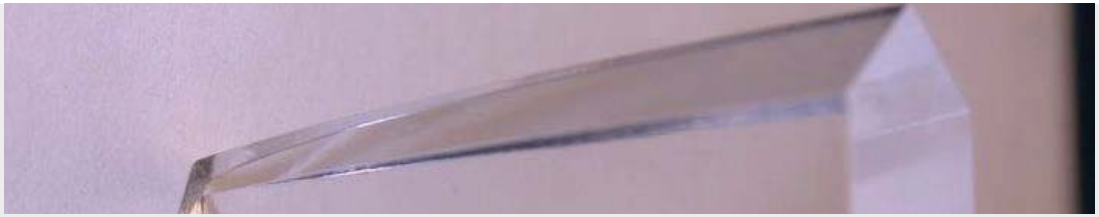
ETH Institute for Particle Physics



First G-APD Cherenkov Telescope

The FACT Collaboration:
- TU Dortmund, Germany
- ISDC, Geneva, Switzerland
- EPFL, Lausanne, Switzerland
- University of Würzburg, Germany
- ETH Zurich, Switzerland

08.09.2010

Isabel Braun
ETH Zurich

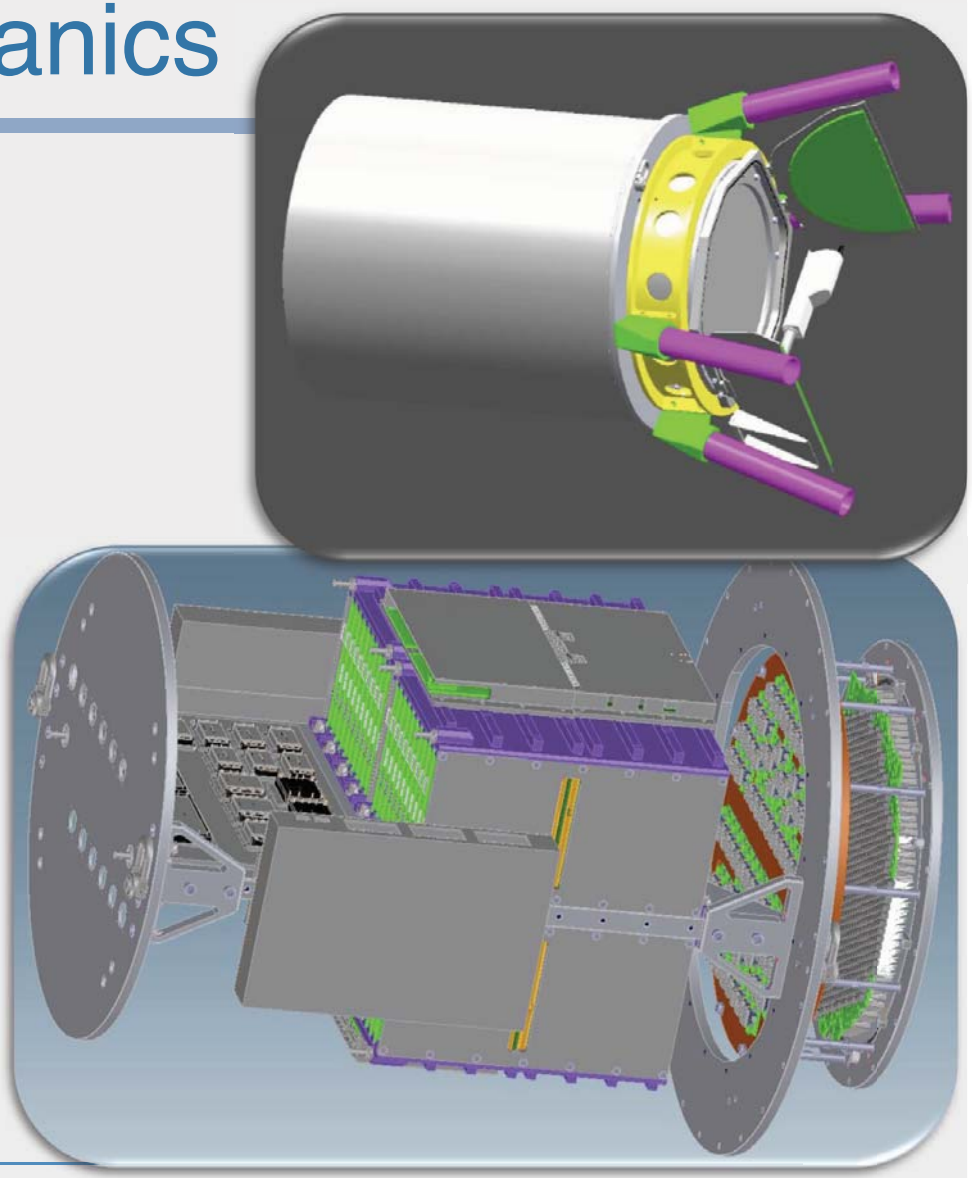
for the FACT Collaboration

Telescope

- Former Hegra CT3
- CT1 mirrors
  - spherical mirrors with hexagonal shape
  - diameter (inner circle) 60.5 cm
  - Al honeycomb, weight ~ 6 kg
- refurbished @ LT ultra
  - diamond milled
  - mean focal length (4.890 +/- 0.008) m
  - av. spot size @ 2f: 16.0 mm^2 ()
  - av. reflectivity ~ 90% (300-500 nm)
  - maximum @ 450 nm
- Drive (downscaled MAGIC)

Camera Mechanics

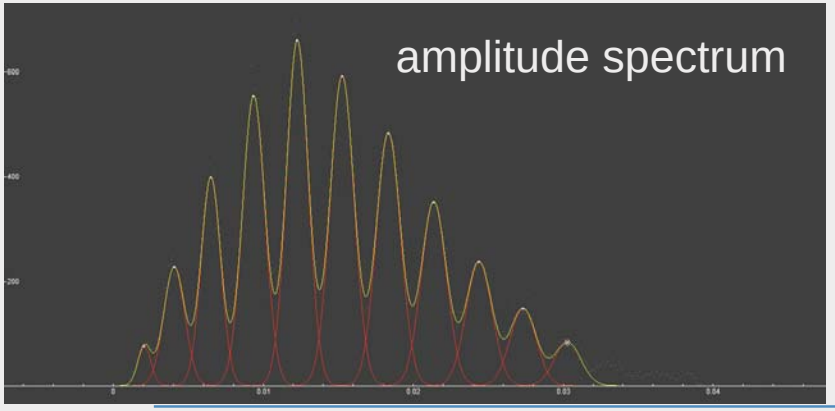
- length 812mm
- diameter 532mm
- weight approx. 100 kg
- water cooled
- thermal separation between sensor and electronics compartment
- housing / connectors must be water tight (IP67)

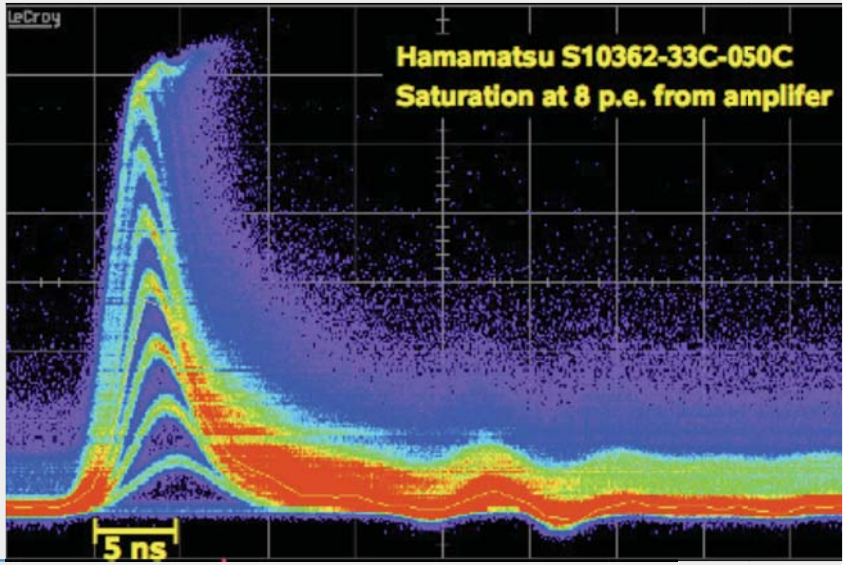


G-APDs

- 1440 pieces
- Hamamatsu MPPC S10362-33-50-C
- active area 3x3 mm^2
- 50 μm cells (less saturation than 100 μm version)
- package 5.9x6.6 mm^2

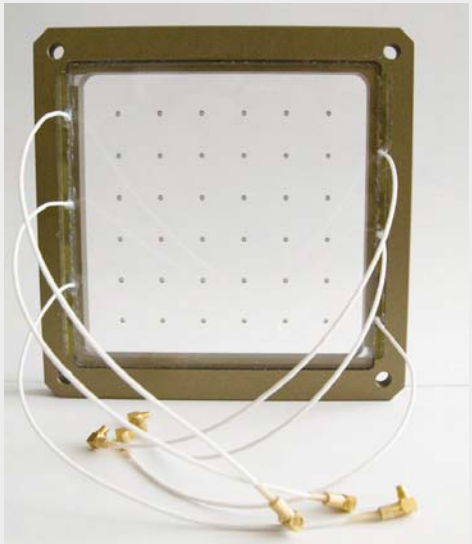
- peak photo detection efficiency 33%
- operation voltage ~ 70 V
- gain 7.5 10^5



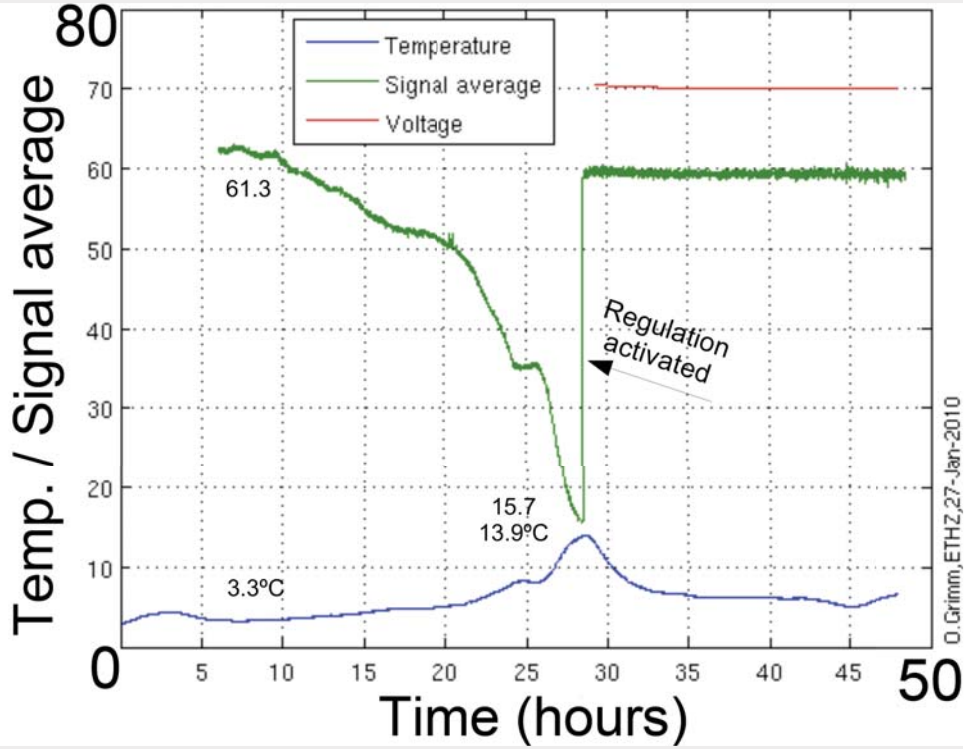


Bias Voltage Feedback System

- Temperature influences breakdown voltage -> overvoltage
- => changes photo detection efficiency, crosstalk probability, gain



- active HV Feedback!
- light pulse signal stabilized
- signal stable within ~ 0.5%



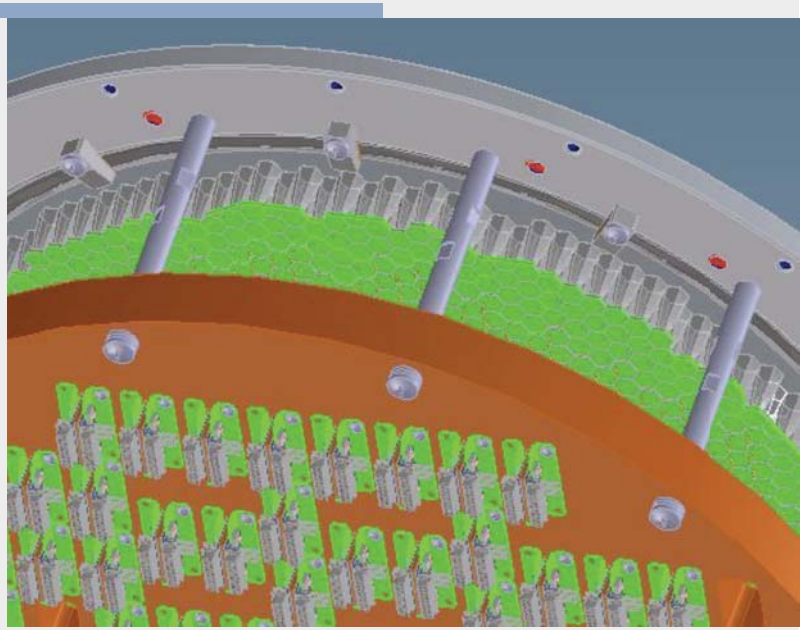
Solid Light Guides

Design:

- hexagon (9.5mm flat to flat) -> square (2.8mm sides)
  (C_{Area}= 8.7 rel. to G-APD)
- height 19.939mm
- wall shape parabolic (in our case 2% better than Winston)
- optimized for S(inner 20°)/sqrt(N)

Material:

- UV transparent Plexiglas 7N
- injection moulding (IMOS Gubela GmbH)

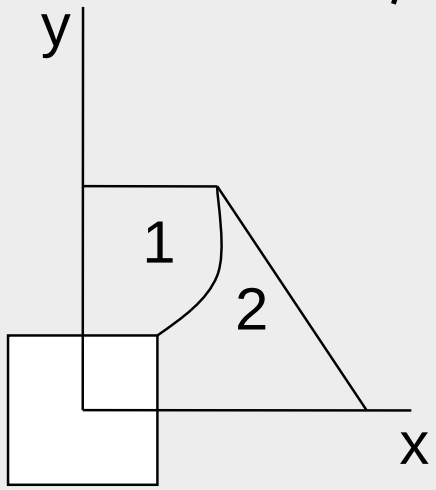


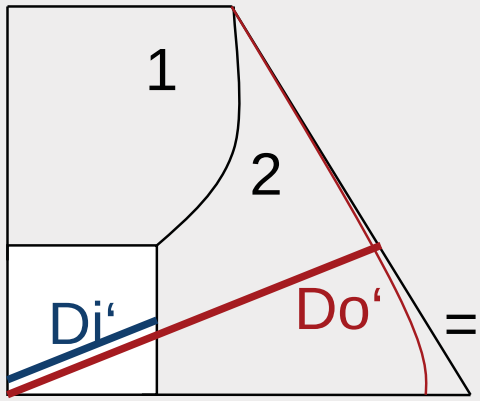
In cooperation with University Zurich!

Challenges

a few slides for Jim...

- Shape
  - type 1 without problem
  - edge (type 2) has changing input/output ratio, hence changing angle (OK) and changing height (not OK!)
- Compromise: Part-Winston
  - type 1: Winston, type 2: regular parabola
  - loose 2% efficiency
- Or back to full Parabola?
  - very first shape tested
  - UZH prototypes



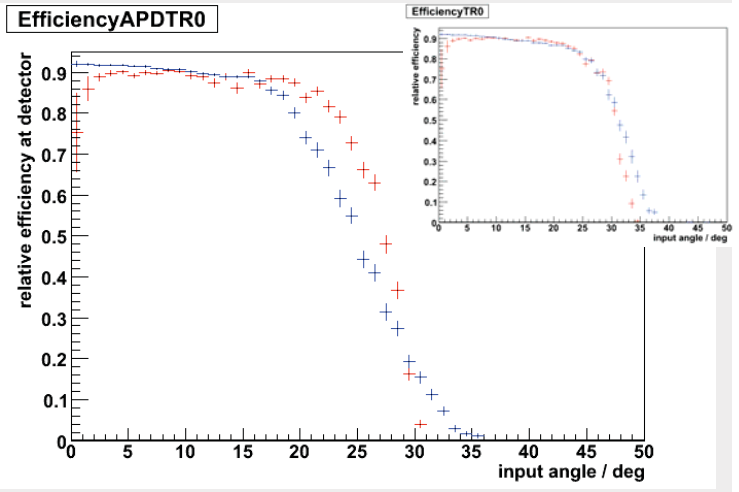


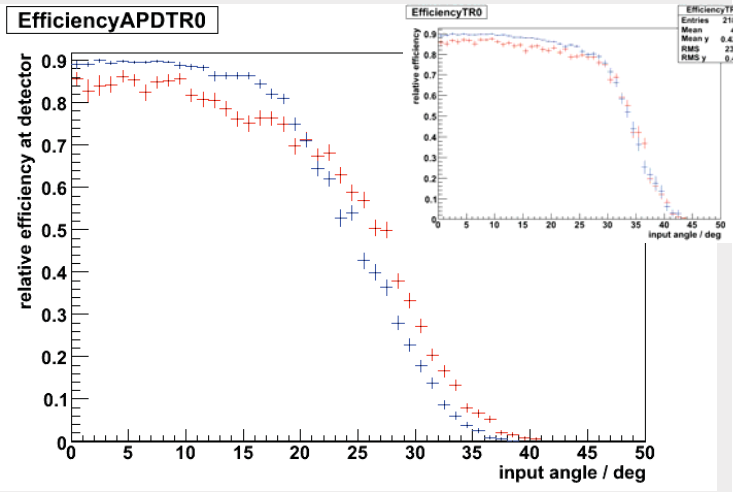
=> ϕ‘ => **H‘!**

1.3mm

3D Cone Types Compared

- Differences in 3D
  - Winston Cone not ‘ideal’ for non-center rays
  - Winston edge sharper than in parabola
  - consider difference at detector
- Parabola is better than its reputation!
  - in circ-circ Winston is superior
  - but already for square-square parabola wins!
- Options
  - full-Winston
  - part-Winston
  - full parabola (*z(F)=-1.5mm*)

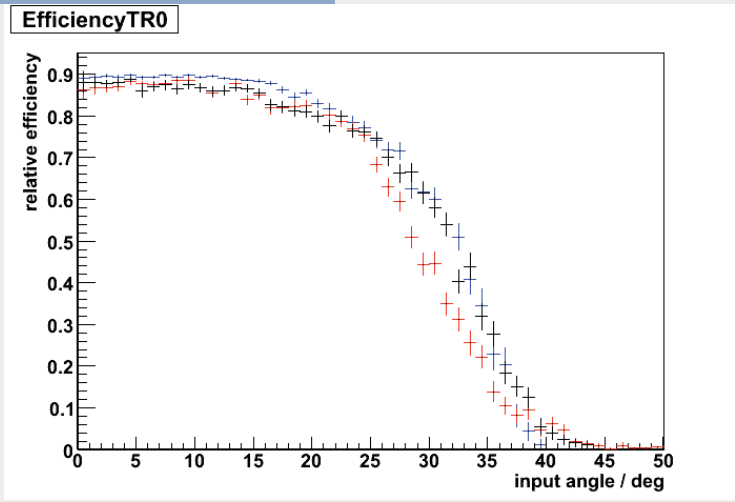


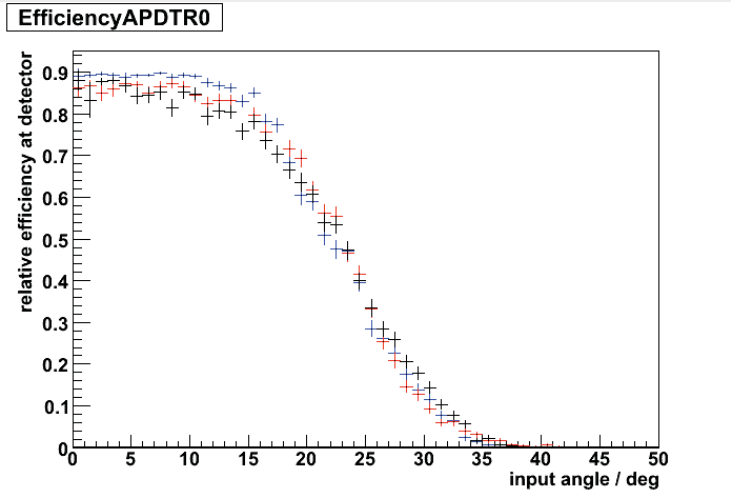


3D Cone Types Compared

- Options
  - full-Winston 85.0% / 79.0%
  - part-Winston 84.9% / 76.9%
  - full parabola 88.0% / 81.4%

- ... produced parabola after checks





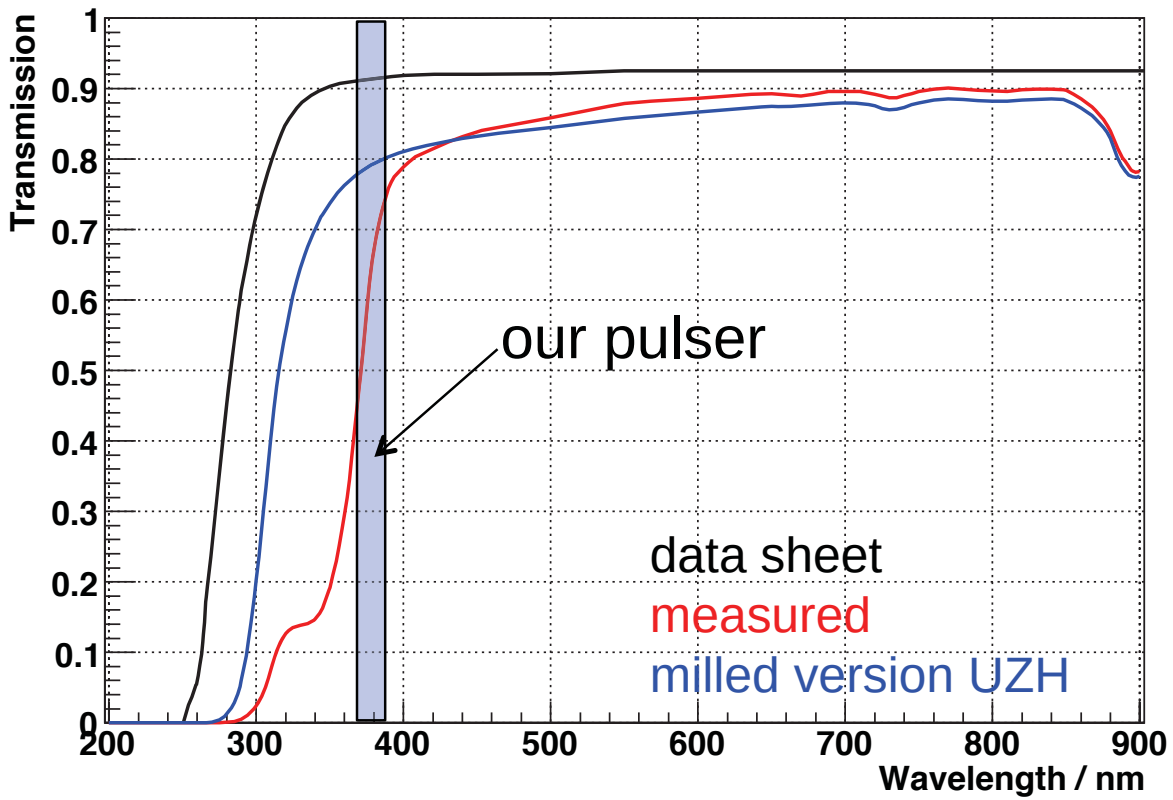
Prototypes arrived...

- Total efficiency for vertical light in first UZH and ETH measurements too low (expected 83-92% (roughness))
- angular behaviour as expected
- Inspection of the cone shows some surface structures (flow lines, injection hole)

simulated loss at hole < 0.5%

- Transmission? Surface? Light coupling?

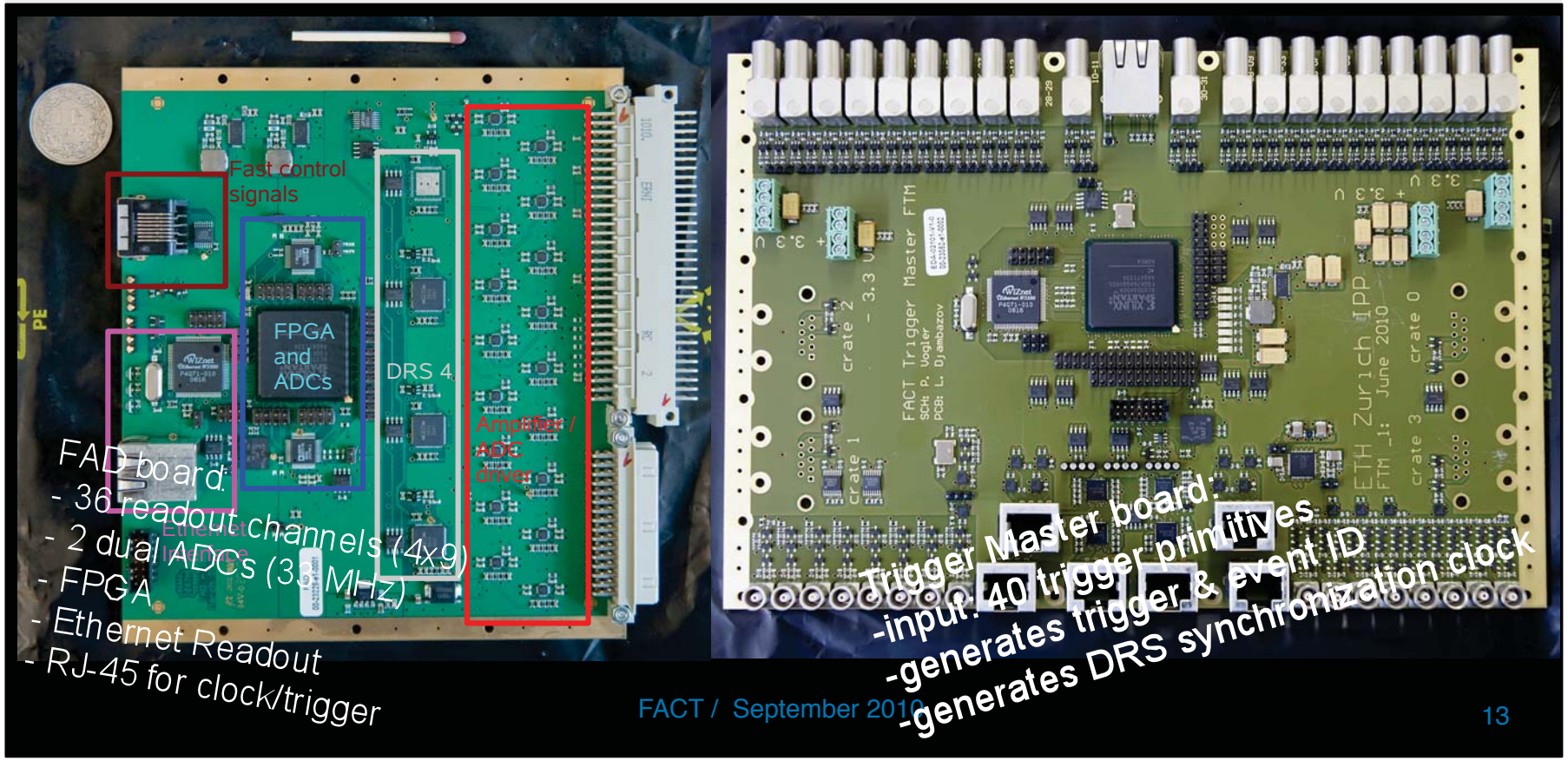
Measured Transmission



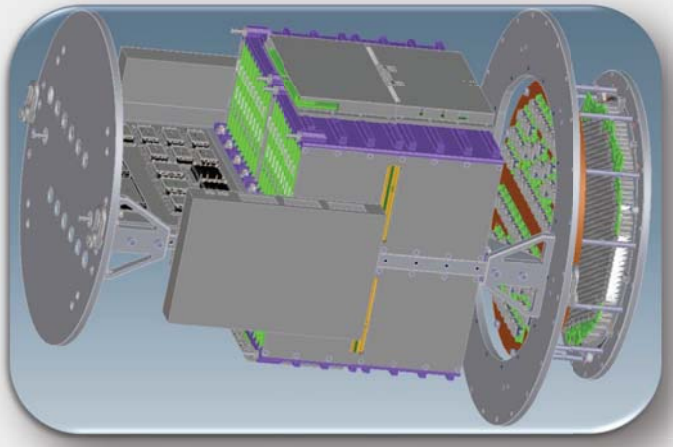
- apparently wrong material -> investigating...

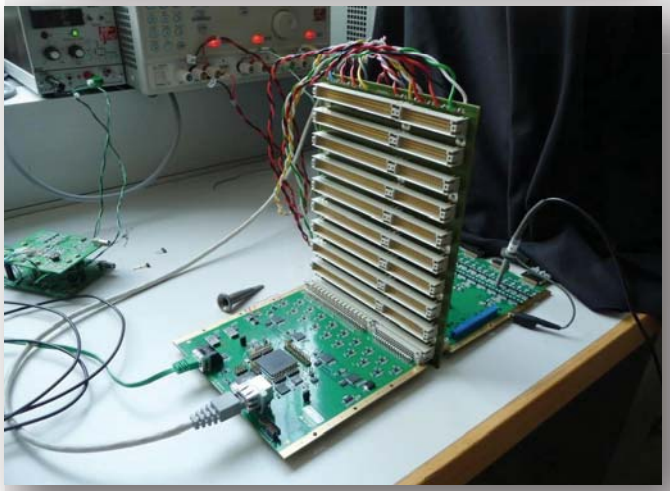
Other Components

- Readout: DRS 4, probably @ 2 GHz
- Trigger: threshold on sum of 9 pixels
- Water Cooling: only electronics compartment, 1 kW



Status

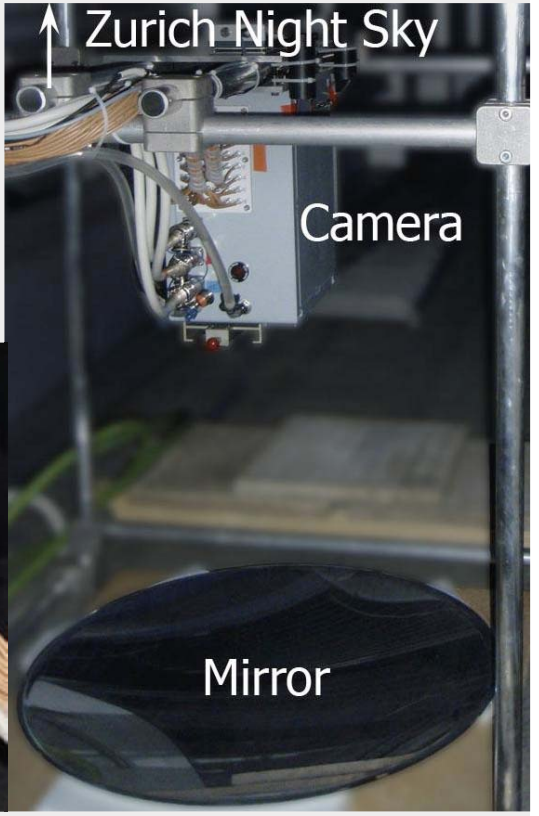


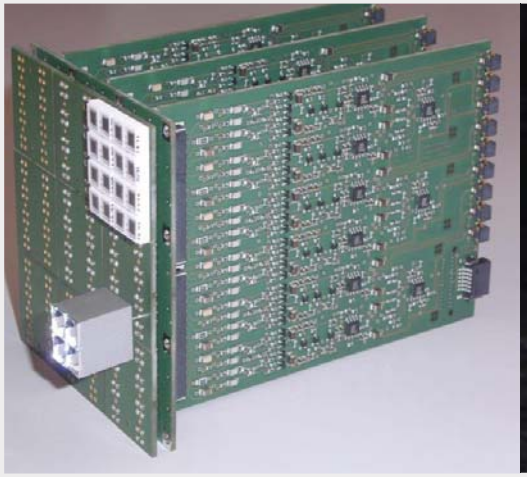


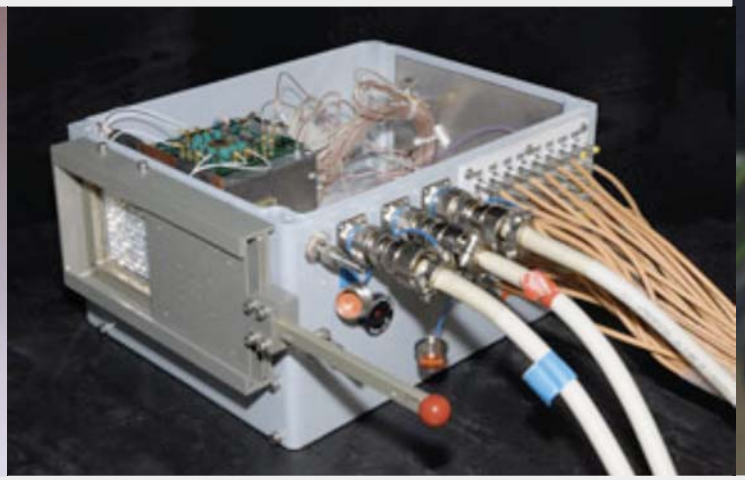
- Telescope:
  - mirrors and drive system ready for installation
- Mechanics:
  - design incl. cooling finished
  - fabrication of components started
- Photo detection:
  - all G-APDs available
  - light guide fabrication ongoing
- Electronics:
  - prototypes of all PCBs fabricated
  - tests ongoing

Prototype Measurements

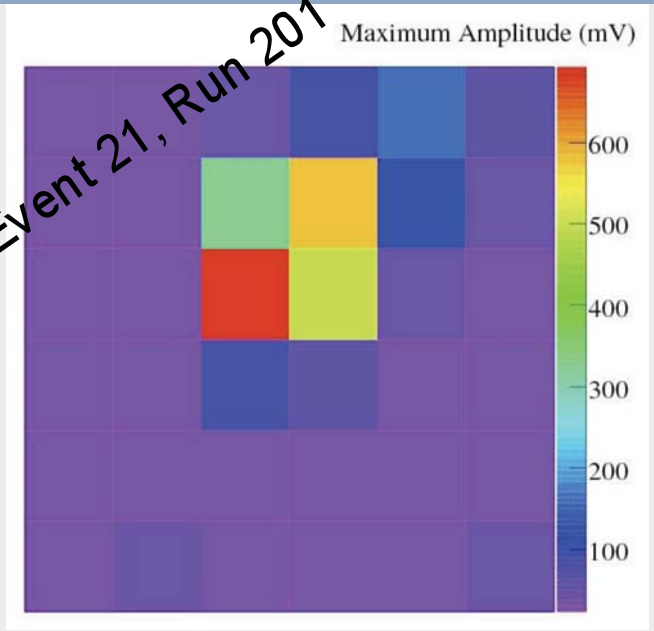
- June 2nd/3rd 2009 on roof of IPP in Zurich (~1 GHz NSB rate / pixel)
- 80 cm focal length
- 1°/ pixel
- 144 G-APDs (4 G-APDs /pixel)
- simple light collectors (pyramidic, Vikuiti 3M)

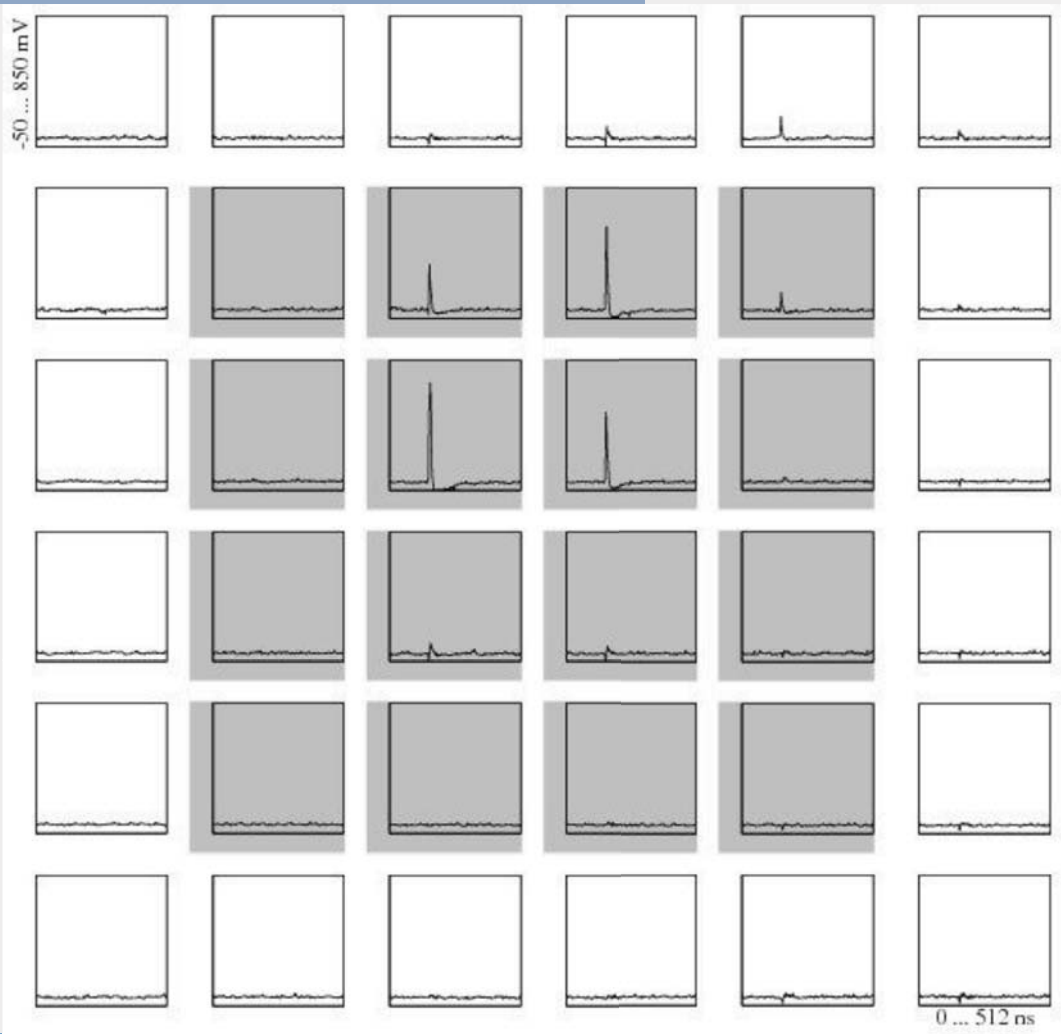






Air Shower Images with G-APDs





- 25mV single pixel threshold (4 p.e.)
- Majority 4 out of 16
- 100 kHz triggerrate per pixel
- 0.01 Hz total shower rate
- 2 GHz sampling frequency DRS2

Summary

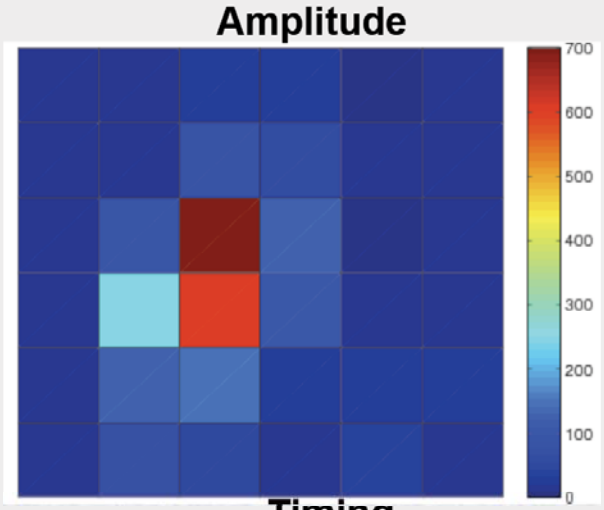
- 1440 channels (G-APDs)
- solid light concentrators (plexiglas)

- field of view 0.11°/ pixel, 4.5° total
- integrated electronics
- ~ 100 kg!

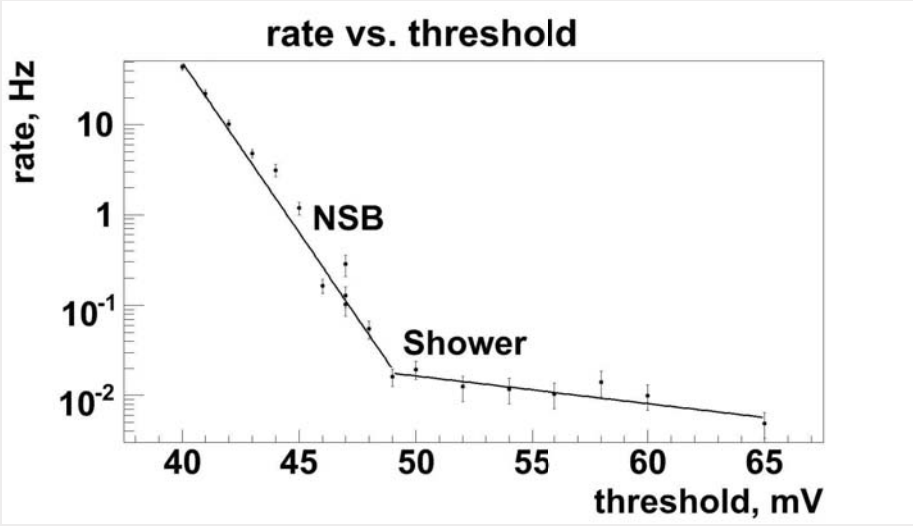
- 2009: prototype measurements with 36 pixels recorded air showers
- 2011: we will present Crab analysis
- will become part of DWARF physics program

Backup

Air Shower Images with G-APDs



- G-APD Camera records first air showers
- rate scan behaves as expected



Possible explanations

- The light distribution for vertical incidence is not homogeneous => the G-APD has locally saturated?

  => maybe, but no influence on Poisson mean calculation!

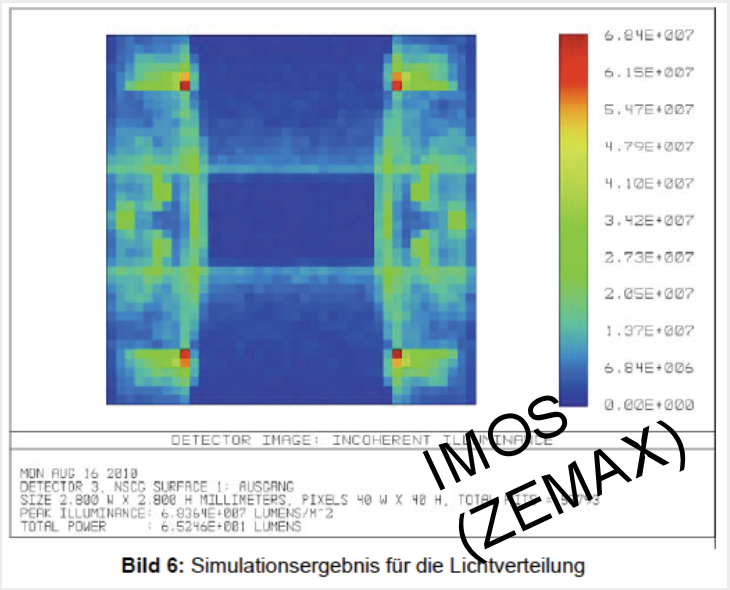
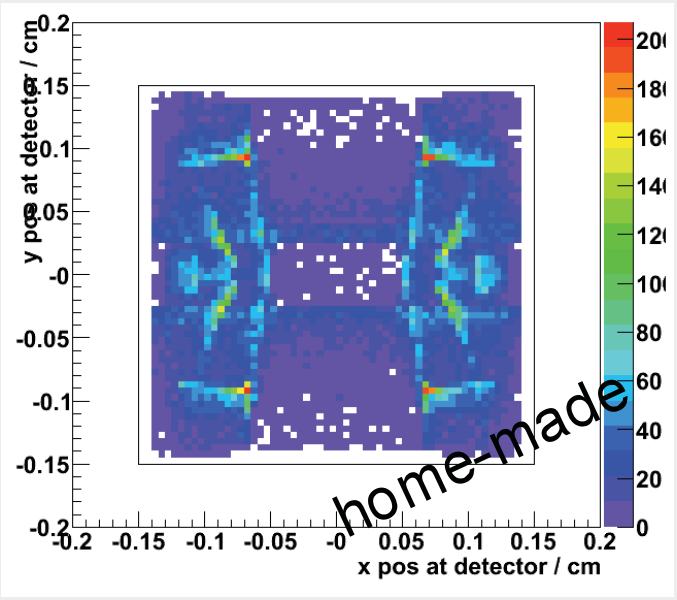


Bild 6: Simulationsergebnis für die Lichtverteilung



- but: ETH light pulser operates at 380 nm...