# CHEC A Compact High Energy Camera for the CTA

David Jankowsky Gamma Ray Astrophysics with CTA Sexten, 26.07.2017









### **CTA** and the sky at high energies





### **CTA** and the sky at high energies





### **CTA** and the sky at high energies





### GCT (The Gamma-ray Cherenkov Telescope)

- Dual-mirror telescope proposed for the SST sub-array
  - Schwarzschild-Couder design (never used before)
  - M1 = 4 m, M2 = 2 m
- Alt-Az mount, compact Mirro and light structure (~12 t)
- Compact and light camera (CHEC)





### The GCT camera (CHEC)

- Compact High Energy Camera
  - 0.35 x 0.35 x 0.5 m<sup>3</sup>
  - 45 kg
  - FoV > 8 deg
  - 2048 pixels (6 7 mm)
  - Full waveforms
- Low costs: ~150 k€
- Currently two prototypes
  - CHEC-M (first light 2015)
  - CHEC-S (underway)
- Custom built Asics as FEE:
  - T5TEA for triggering
  - Target C for sampling and digitization





### **GCT Prototype with CHEC-M**

First Cherenkov light with the GCT prototype and CHEC-M

• Elliptical Cherenkov images of particle

showers visible





### **GCT Prototype with CHEC-M**

First Cherenkov light with the GCT prototype and CHEC-M

Elliptical Cherenkov images of particle showers visible





### **GCT Prototype with CHEC-M**

#### First Cherenkov light with the GCT prototype and CHEC-M





Samtec 40 pin connector to the backplane carrying raw data, trigger, clock signals, electronics power (12 V) and SiPM bias voltage (~70 V)

Amplifier and shaper

to-noise

circuits for optimal signal-

Cables used to remove radius

of curvature in focal plane

Samtec individually shielded coaxial

ribbon cables for analogue signals

Temperature sensor

Power board provides low voltages, SiPM bias voltage trimming and monitoring

- Shielding for all switching components and ASICs

Low-voltage power on separate cable to buffer

SiPM bias voltage

Front-most front-end buffer PCB forming the interface to the focal plane plate

Copper heat-sink arrangement to focal | plane plate

SiPM Tile

~50 mm

 Buffer circuits for noise immunity

Basic information:

• Compact, inexpensive design

- Digitization with 12 bit resolution
- High sampling rate (~1 GSa/s) & large storage (16k cells/channel)
- Formation of trigger signals (analog sum of 4 neighbor channels)
- Digitization and transmission of waveforms on demand

### FEE - Target

Target Module with:

- SiPM & PreAmps
- Target Asics
- FPGA
- 4 x 16 channels

Primary board and auxiliary

FPGA

boards each contain 32 channels of readout

TARGET C and T5TEA ASICs provide 16 channels of digitisation and triggering. Slow ADCs provide a parallel readout stream for monitoring of DC signal component

10



### **Performance: T5TEA – Asic for Triggering**

- First level trigger on module:
  - 4 pixels combined to a superpixel
  - Settable via various parameters
- Second level trigger on backplane:
  - Check if trigger requirement is met
  - Initiate readout of whole camera





### **Performance: T5TEA – Triggering**

- First level trigger on module:
  - 4 pixels combined to a superpixel
  - Settable via various parameters
- Second level trigger on backplane:
  - Check if trigger requirement is met
  - Initiate readout of whole camera





### **Performance: T5TEA – Triggering**

- First level trigger on module:
  - 4 pixels combined to a superpixel
  - Settable via various parameters
- Second level trigger on backplane:
  - Check if trigger requirement is met
  - Initiate readout of whole camera

Some results:

- Low threshold: < 3 mV</li>
- Low noise: < 0.5 mV</p>





### **Performance: T5TEA – Triggering**

- First level trigger on module:
  - 4 pixels combined to a superpixel
  - Settable via various parameters
- Second level trigger on backplane:
  - Check if trigger requirement is met
  - Initiate readout of whole camera

Some results:

- Low threshold: < 3 mV</li>
- Low noise: < 0.5 mV
- Settable to large range of amplitudes with low noise





### **Performance: Target C – Sampling & Digitization**

- Settable on the fly via parameters
- Digitization: Wilkinson counters at 500 MHz
- Simultaneous digitization of 16 x 32 samples
- Sampling frequency of ~1 GSa/s





### **Performance: Target C – Sampling & Digitization**

- Settable on the fly via parameters
- Digitization: Wilkinson counters at 500 MHz
- Simultaneous digitization of 16 x 32 samples
- Sampling frequency of ~1 GSa/s
- Dynamic range of > 1.9 V and noise of ~ 1 mV





### **Performance: Target C – Sampling & Digitization**

- Settable on the fly via parameters
- Digitization: Wilkinson counters at 500 MHz
- Simultaneous digitization of 16 x 32 samples
- Sampling frequency of ~1 GSa/s
- Dynamic range of > 1.9 V and noise of ~ 1 mV
- Storage of full waveforms





### **Summary and Outlook**

- CHEC-M:
  - Complete characterization in the lab
  - Used regularly on telescope structure in Meudon for field tests
- CHEC-S:
  - All components are currently under test
  - Start of camera integration expected by September this year
  - Features further improvements in regards to CHEC-M
- First pre-production telescope GCT-01 likely part of the first partial operations of CTA in Chile in 2018-2019



## **Thanks for your attention!**



Bundesministerium für Bildung und Forschung

