CHEC Concept for the Cherenkov Telescope Array

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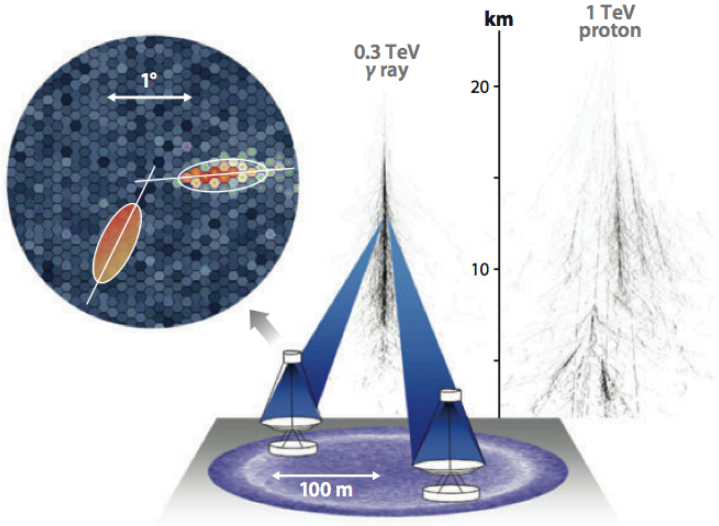
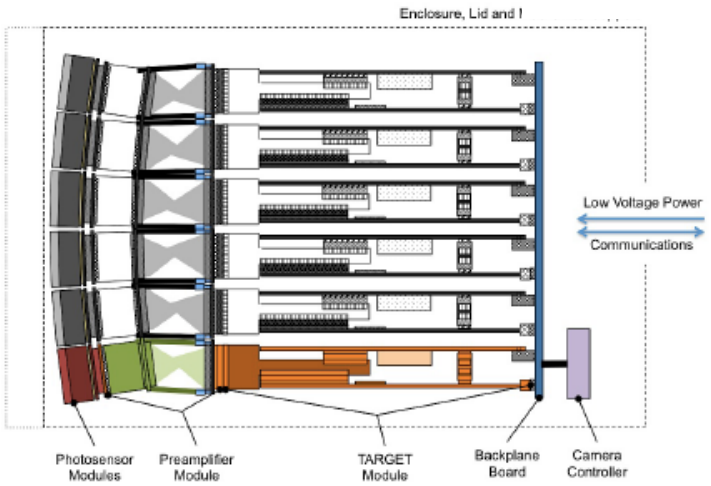
Cherenkov Telescopes –
From Air Shower to Voltage Pulse

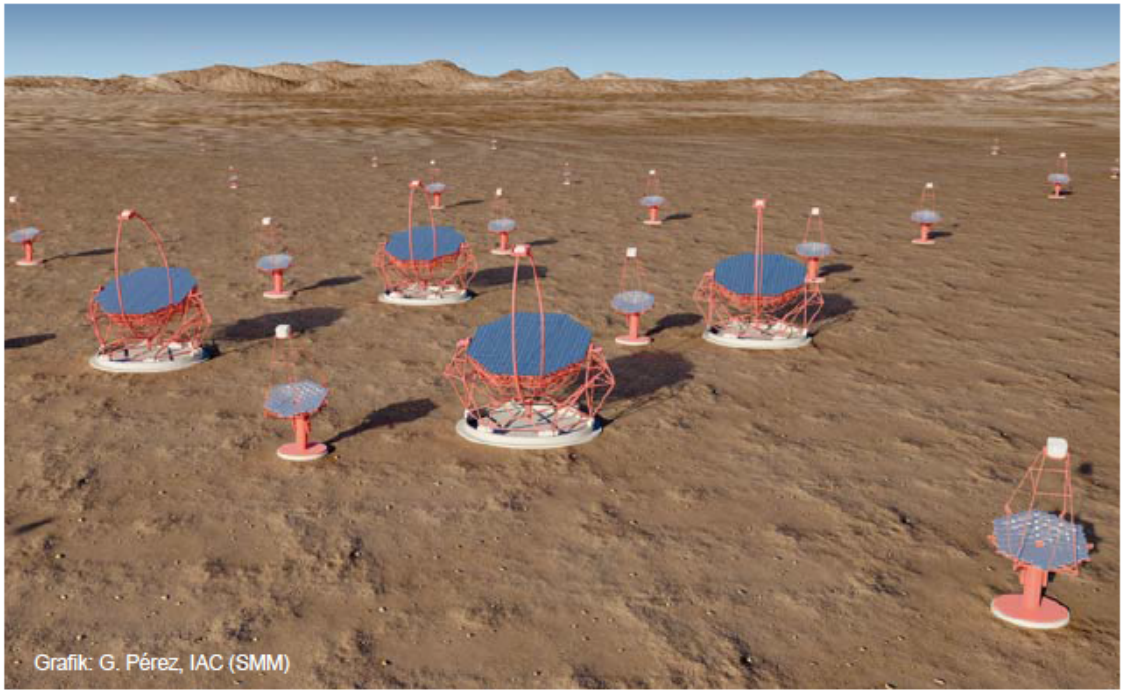


- Cosmic rays generate air showers in the atmosphere
- Cherenkov photons hit pixel (PMTs) of cherenkov telescope camera
- Voltage pulse as output signal from PMT
  → Input signal for readout electronics



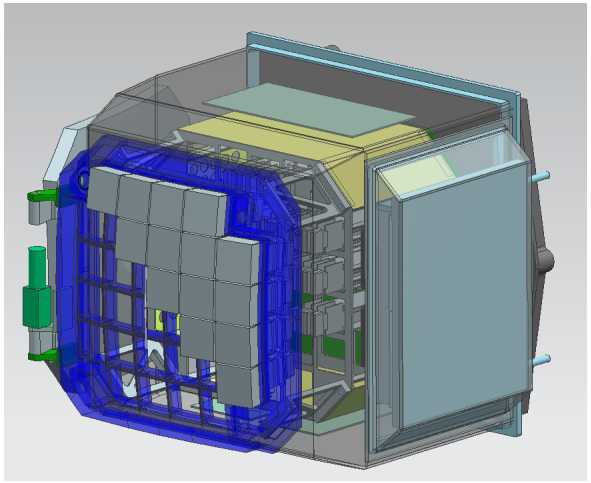
Compact High Energy Camera (CHEC) Concept for CTA

The Cherenkov Telescope Array (CTA)

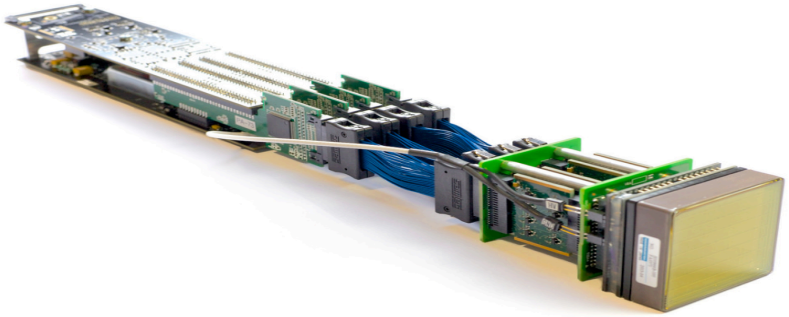


- Future ground based gamma ray experiment with > 100 telescopes
- Multiple types of telescopes together cover the energy range from 10 GeV to above 100 TeV
- Big array of telescopes → Costs / pixel matters !

CHEC Concept

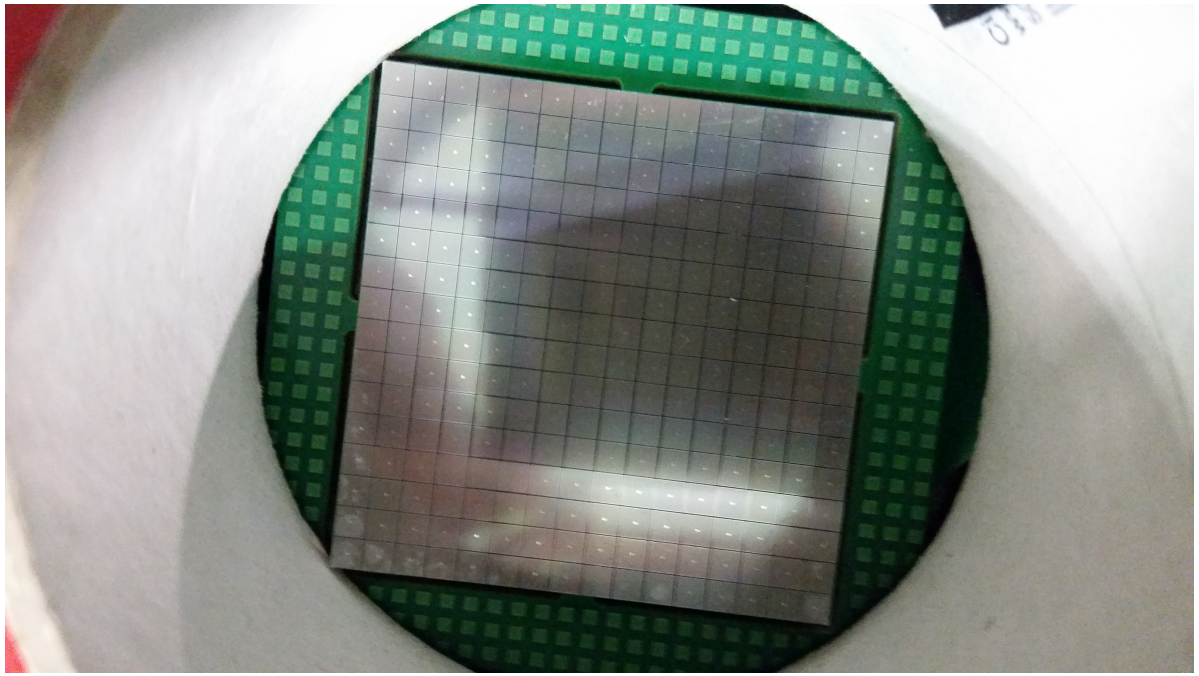


- Camera concept for one type of CTA telescope
- One camera features 2048 Silicon Photomultipliers (SiPm) → 2048 channels per camera
- TARGET 7 readout module for sampling and digitization
- One Target 7 module
  → 4 TARGET 7 ASICs
- → 4 * 16 channels



Silicon Photomultipliers

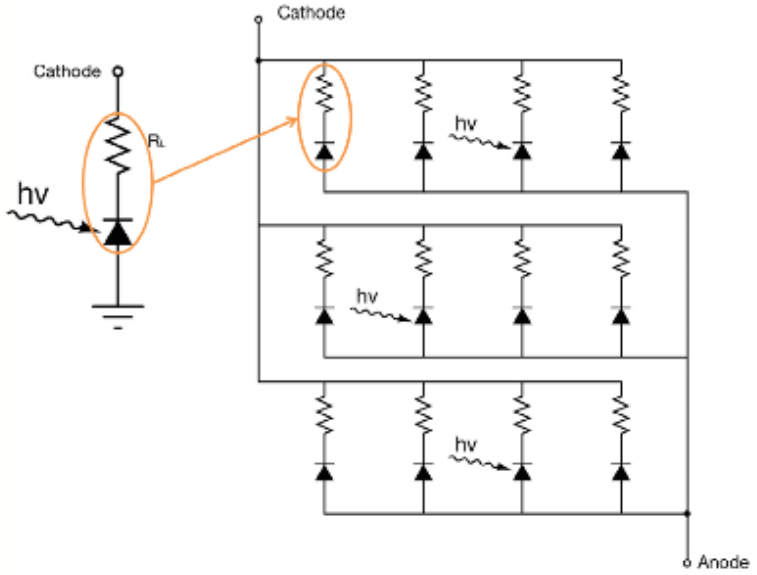
- Silicon p-n junction driven with reverse bias
- If reverse bias exceeds breakdown voltage
  → Avalanche breakdown
  → No information about number of photons



Using several thousand p-n junctions in parallel per pixel
→Photon counting possible

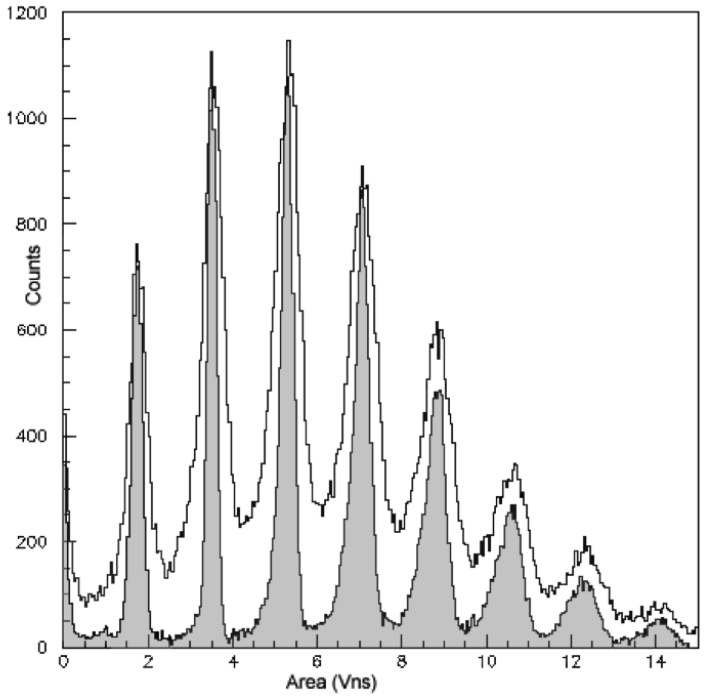
Silicon Photomultipliers

SensL



SiPM network with quenching resistors

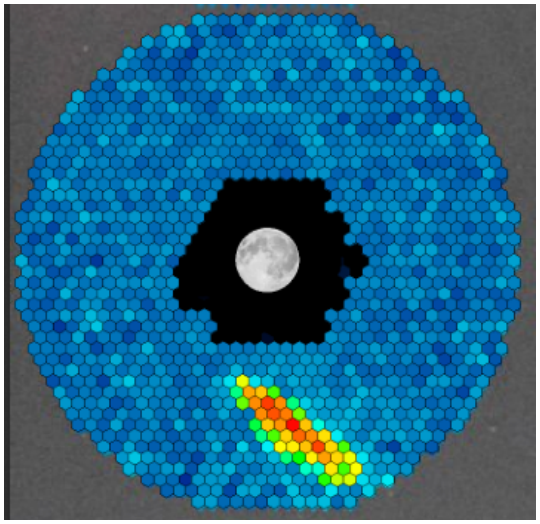
P.K. Lightfoot et al.



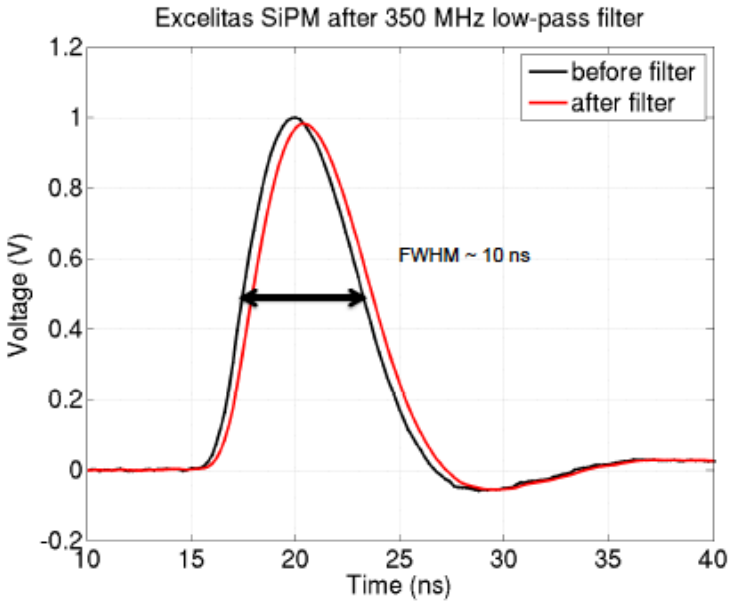
Single photon peaks from SiPM

Silicon Photomultipliers

Photo: D. Dorner, T. Krähenbühl

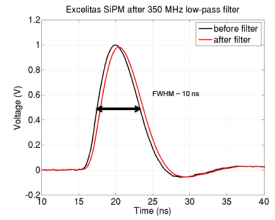


Advantage of SiPMs:
Observation during full moon possible
→ higher duty cycle



Voltage pulse from SiPM after amplification and shaping
→ Input signal to readout electronics

TARGET 7 ASIC Architecture



Input Signal

x 16

Sampling Buffer

Storage Buffer

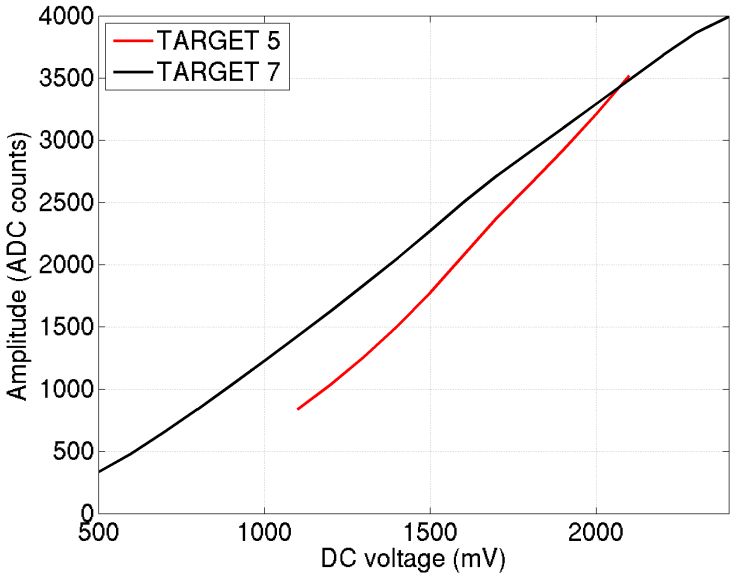
READ

Digitized Pulse

Internal Trigger

External Trigger

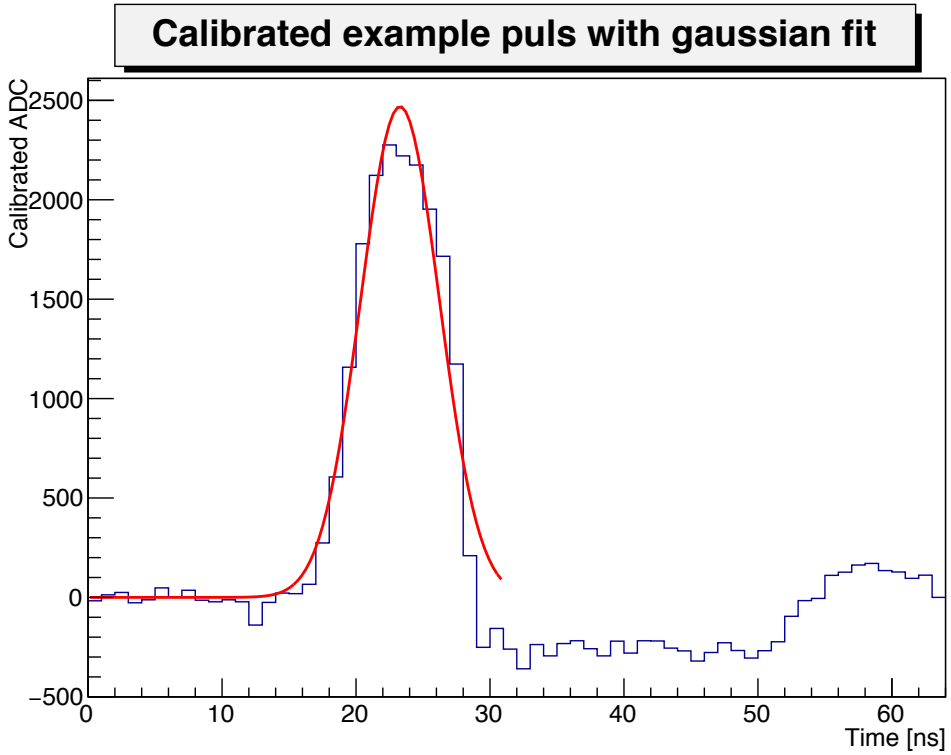
TARGET 7 Features



- Configurable sampling rate (up to 2 GSamples/s)
- Deep analog buffer: 16384 samples per channel → 16 µs for 1 GSamples/s
- Dynamic range of transfer function: ~ 800 p.e.
- Internal and external Trigger
- Low cost / channel (~ 20 $ / channel for full module with PreAmplifiier)

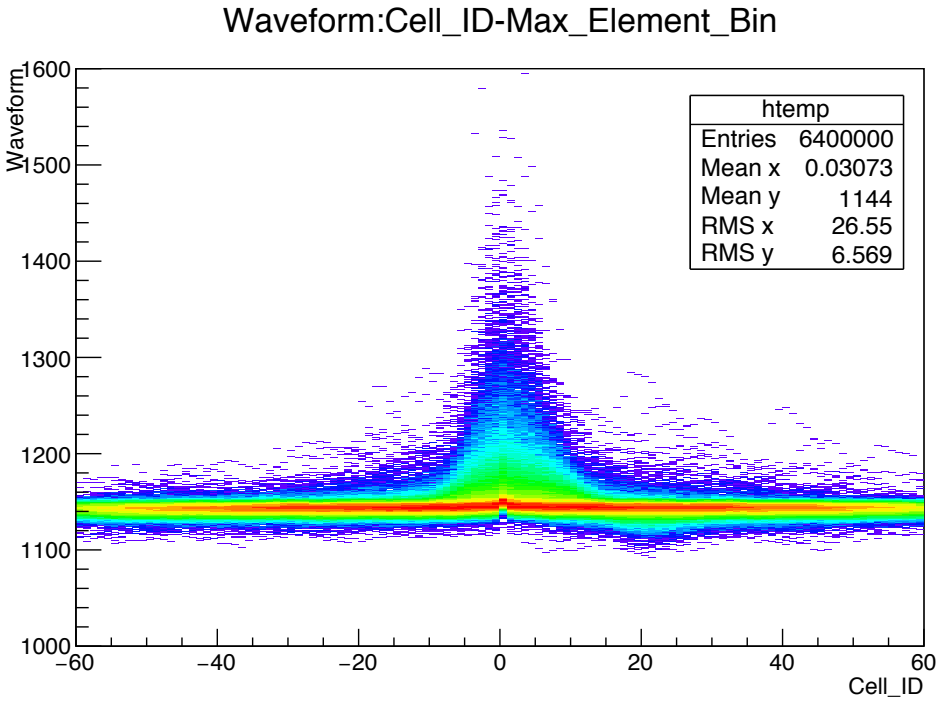
Performance Testing in Erlangen

Performance of Sampling Circuit



- Observable of interest: Integral of pulse (charge)
- How to extract charge efficiently and deal with saturated pulses?

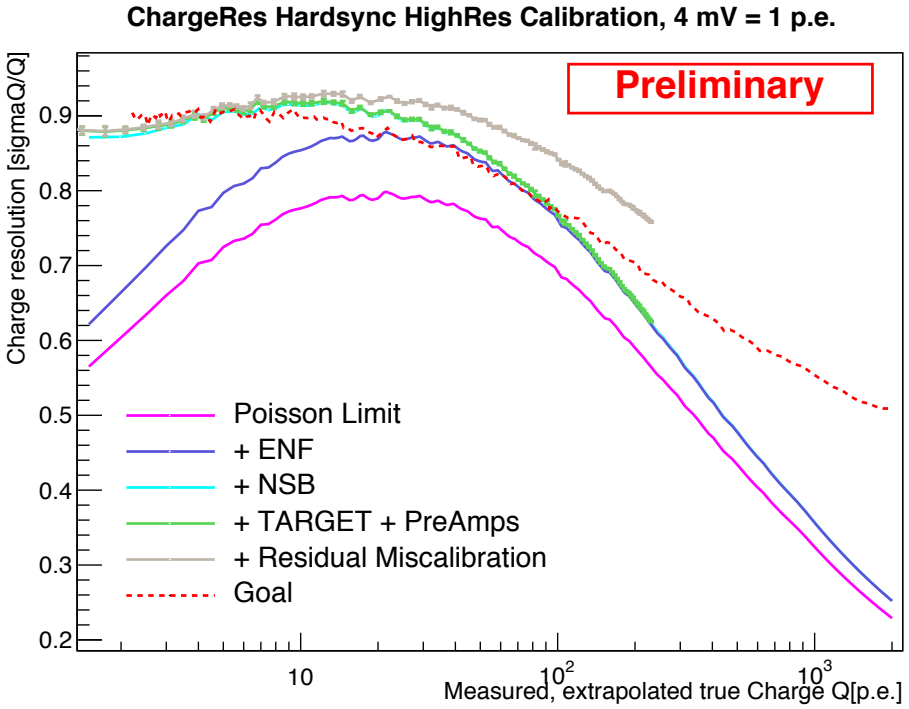
First SIPM measurements



Positive: Pulses have “correct” shape and “look nice”

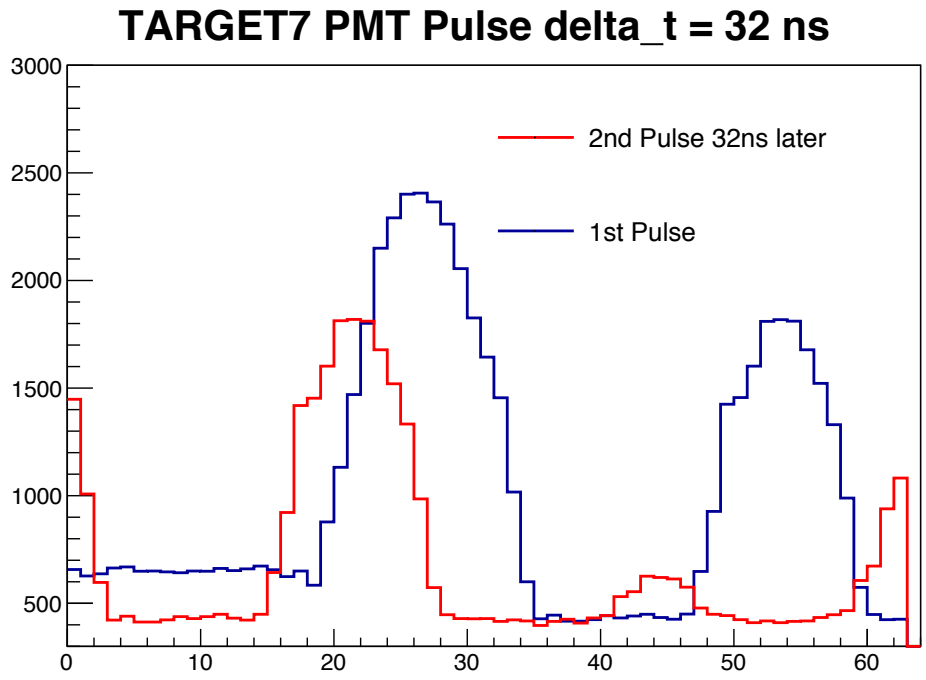
Negative: SIPM module too noisy, no single pe spectra visible → SIPM quality will improve (only mechanical samples so far)

Charge Resolution



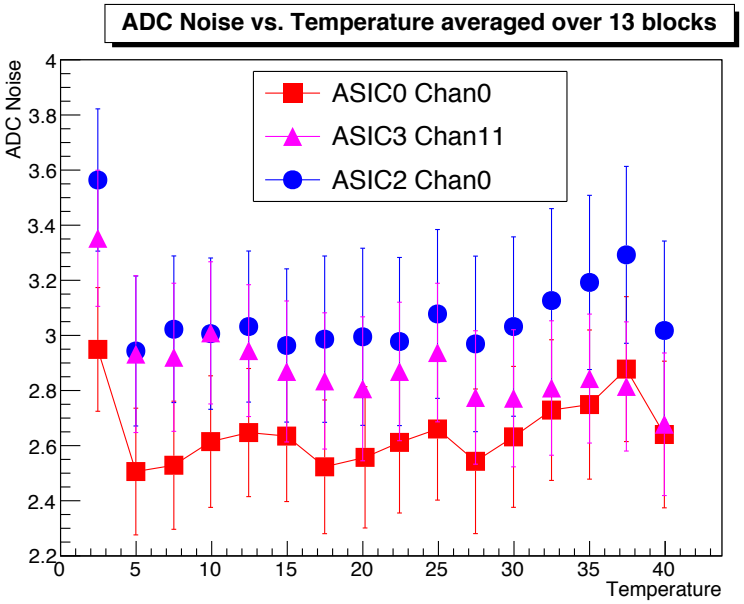
- Dynamic range of TARGET 7 up to ~ 600 p.e.
- Goal for TARGET 7 module: ~ 2000 p.e. → Need to extract correct charge from saturated pulse

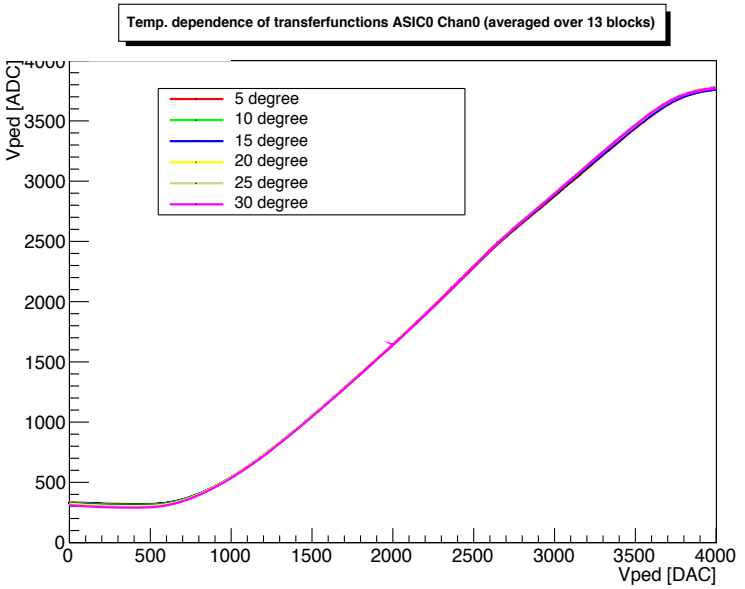
Deadtime measurements



- Sampling does not stop when reading out (like HESS)
- Deadtime free with duty cycle of 99.997 % @ 1 kHz
- TARGET can deal with mean rates up to 10 kHz

Temperature Dependence Measurements





- According to CTA requirements observation window ranges from 15 to 40 degree
- Electronic noise and transfer functions seem to be stable in this regime

Towards TARGETC and CCTV

- Switch from integrated to companion (CCTV) trigger circuit
- Even further reduce noise
- Keep or enhance TARGET 7 dynamic range
- Trigger circuit can easily be replaced if needed
- First contact to TARGETC last week =)

Thank you for your attention!