Charge Resolution Simulations for Camera Electronics

THE COMPACT HIGH ENERGY CAMERA FOR THE CHERENKOV TELESCOPE ARRAY

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VTH INFIERI WORKSHOP: INFIERI AT CERN

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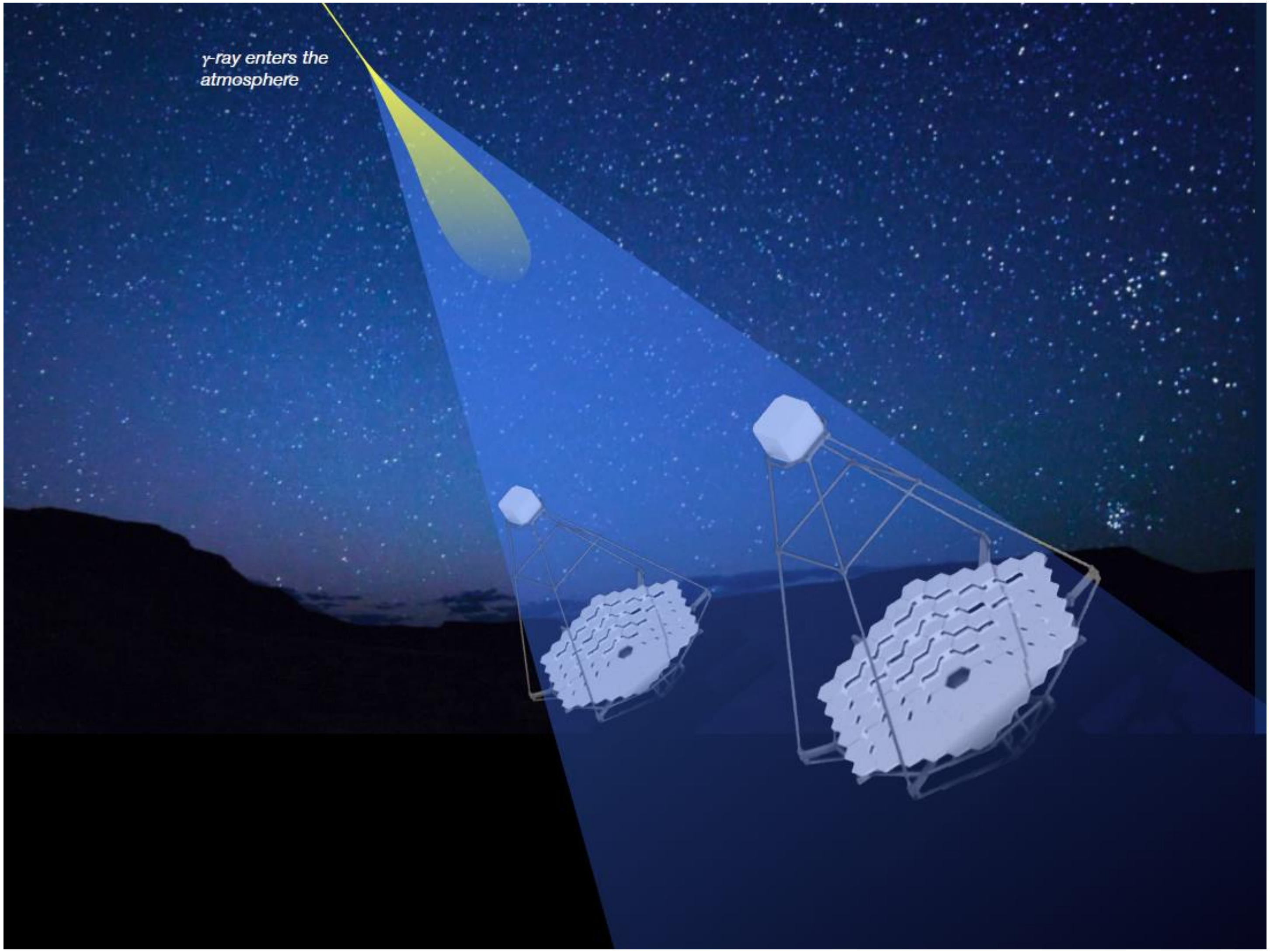
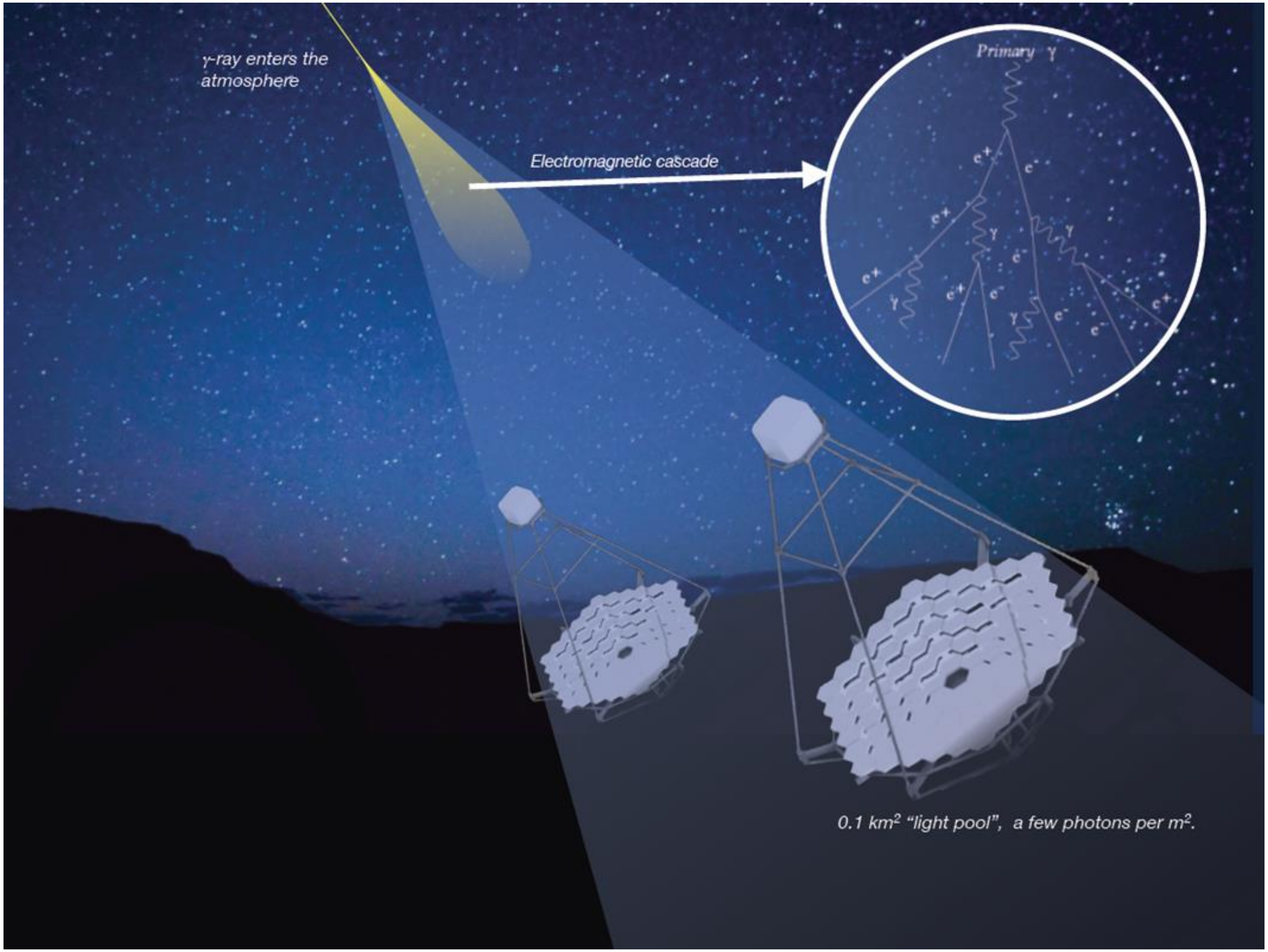
The Cherenkov Telescope Array



The Cherenkov Telescope Array



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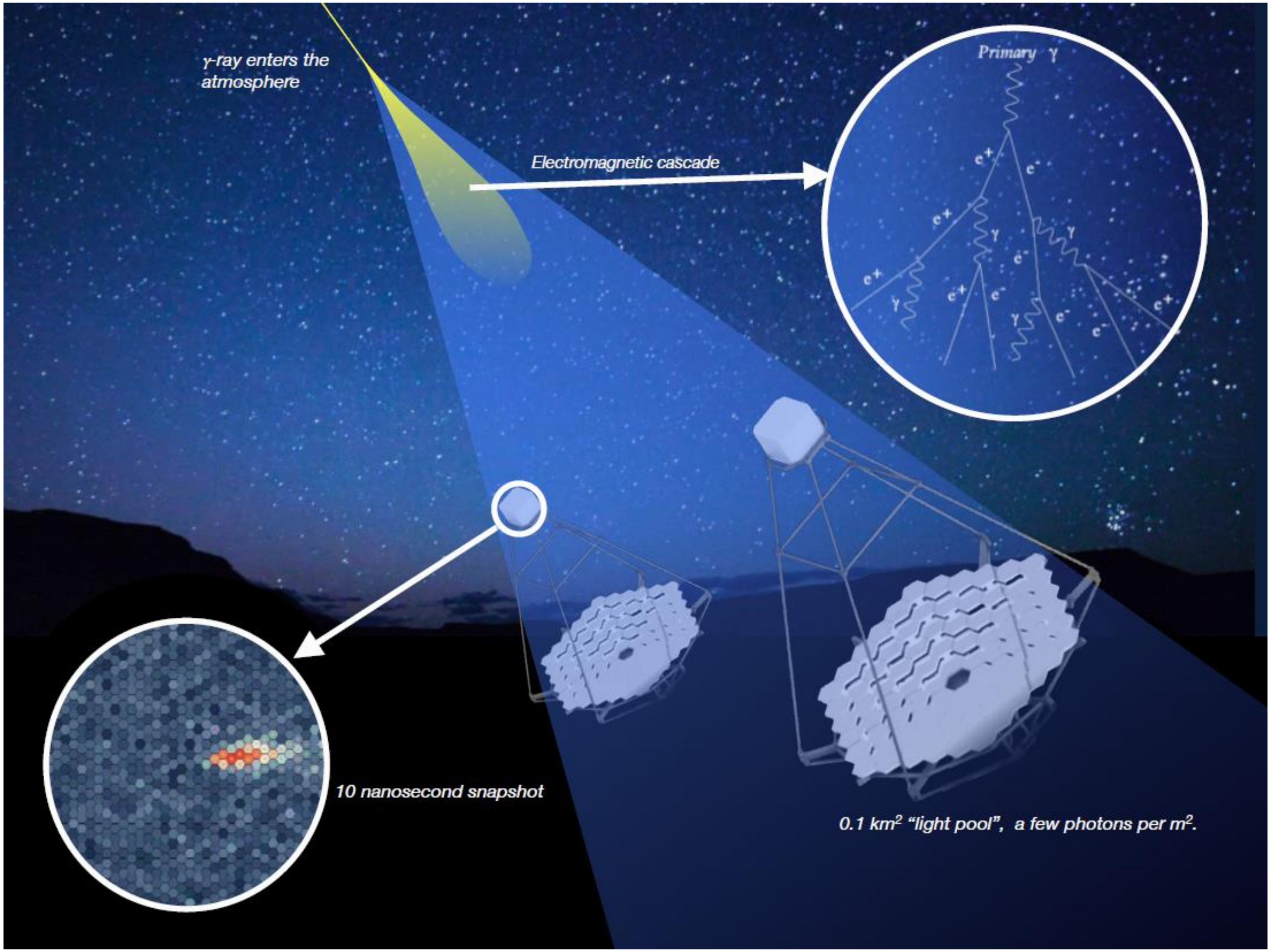
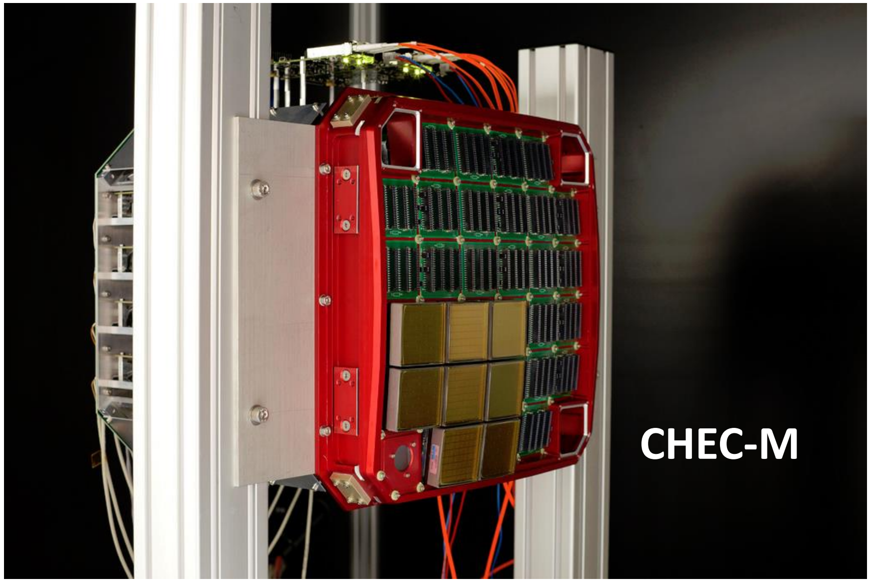


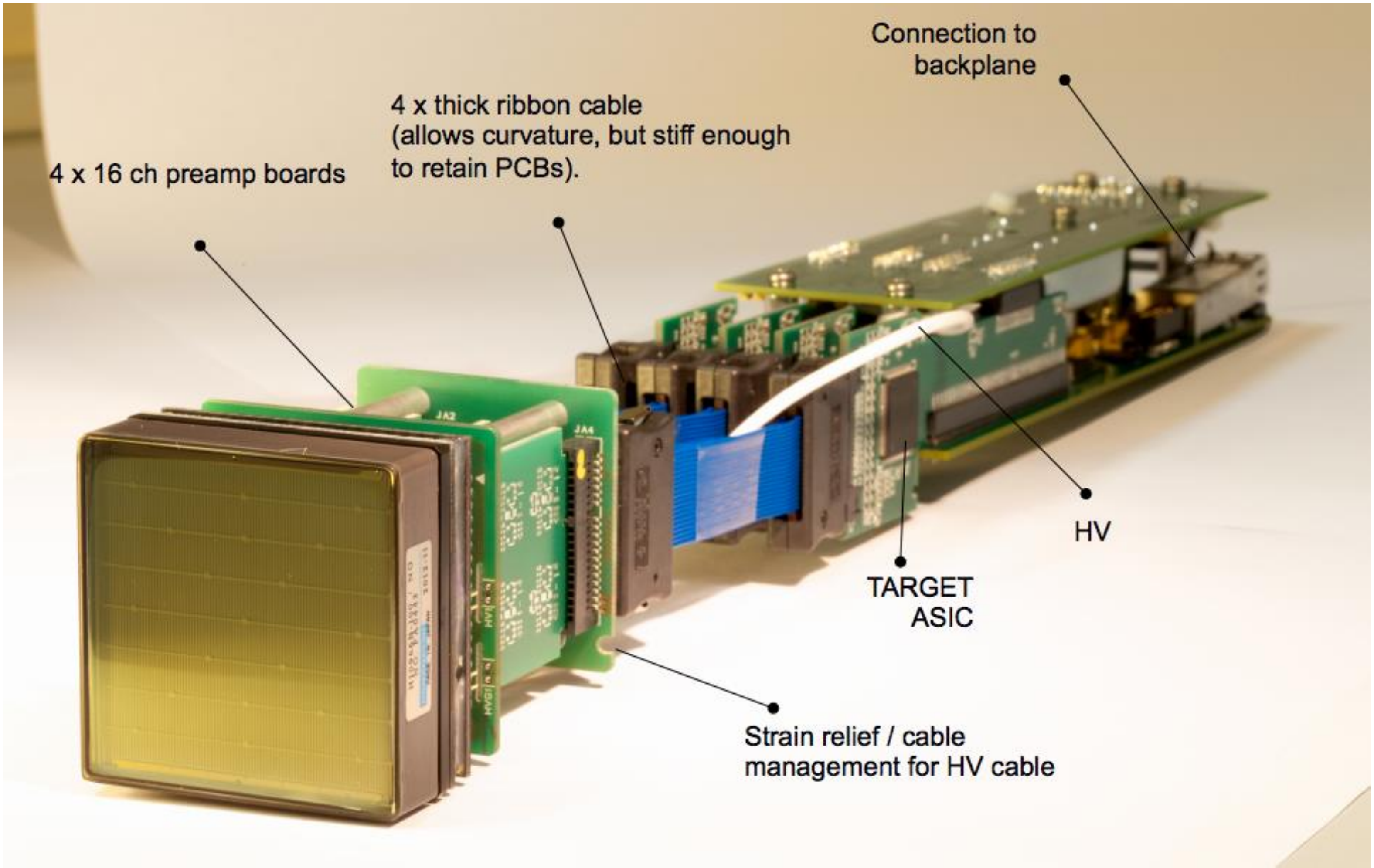
The Compact High Energy Camera (CHEC)

- Camera for the dual-mirror Small-Sized Telescopes (SST-2m)
- International involvement
  - within INFIERI both Oxford and Amsterdam
- Designed to work with both the ASTRI and GATE SST-2m telescope structures
- Contains 2048 pixels (32 x 64 pixel modules)
- CHEC-M (MAPM camera) prototype is almost finished
- CHEC-S (SiPM camera) testing has started



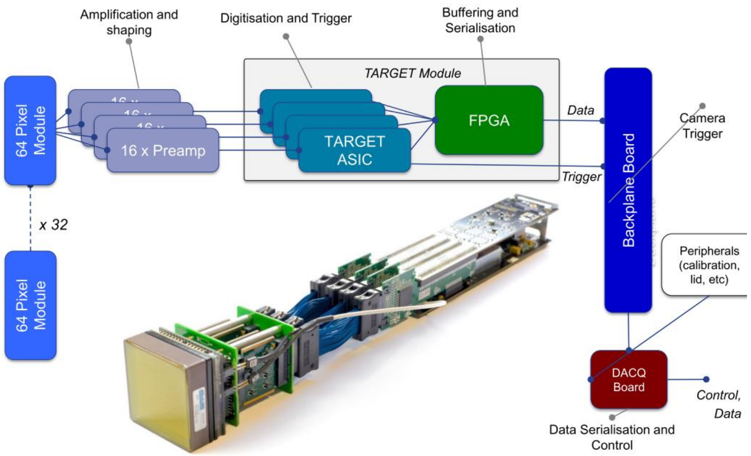
SSTGate

CHEC Electronics

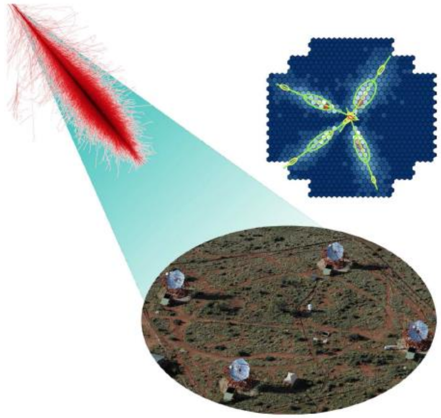


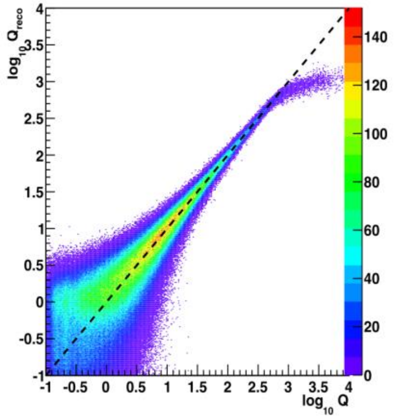
CHEC-M MAPM: Hamamatsu H10966B

CHEC Electronics Simulations



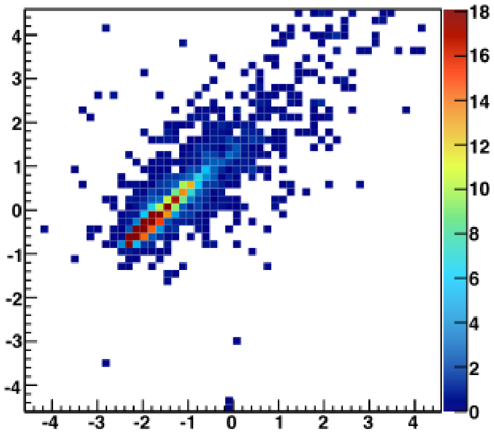
CORSIKA → LTools → Investigations of camera capabilities

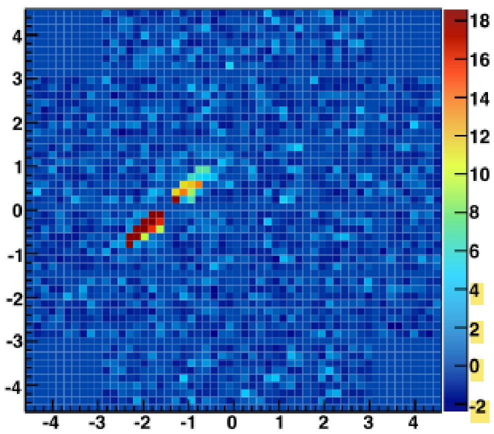




Camera Image from Simulations

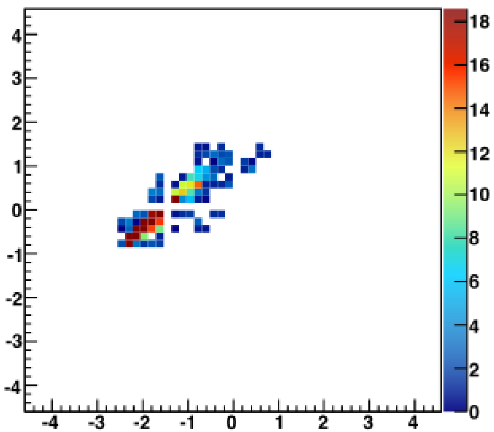
Simulated Shower Image





Added NSB and electronic noise

Cleaned image using tailcuts of 6pe/12pe

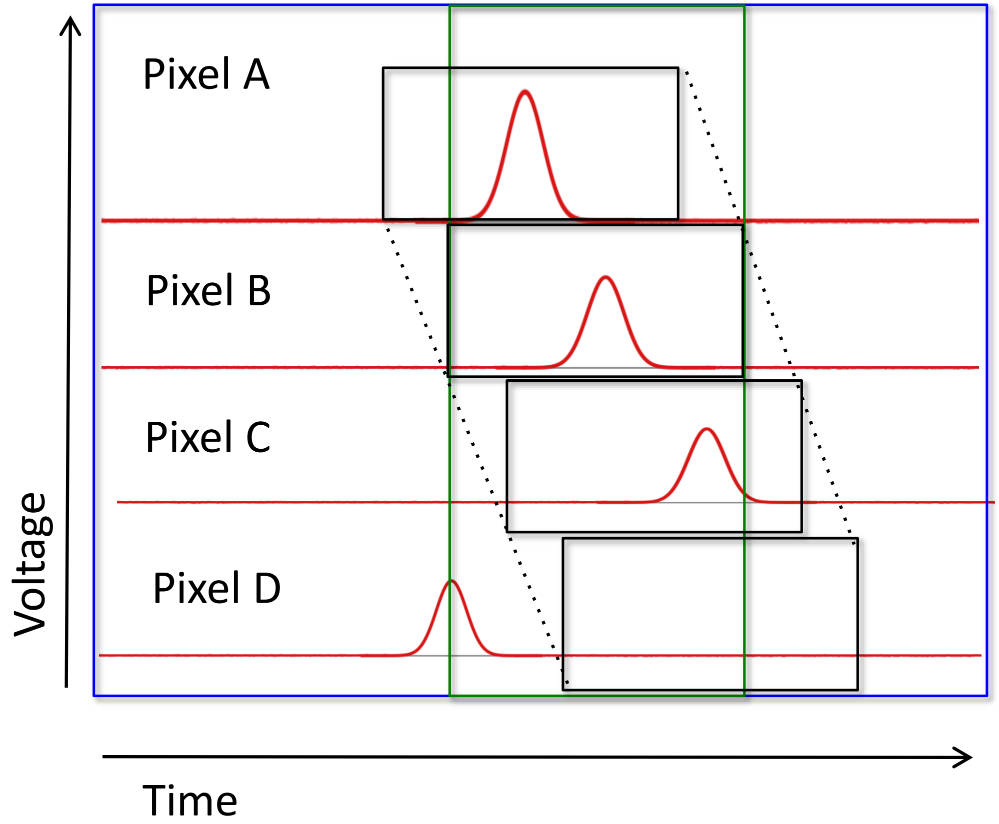


Charge Reconstruction

Integration of the pulse.

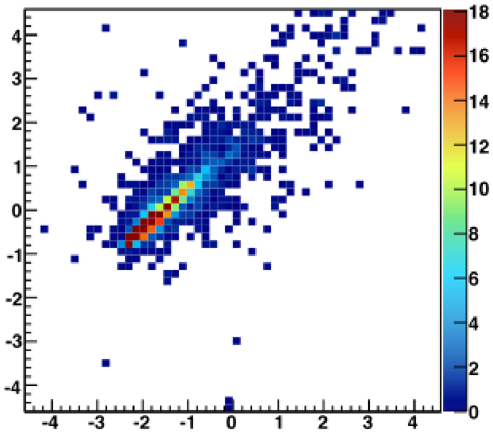
- Method 1 (Blue):
  - Integration is performed on entire readout window (by default 90ns)
- Method 2 (Green):
  - Integration is performed in a window of fixed length around the intensity-weighted average peak time in all pixels with more than 4 pe charge.
- Method 3 (Black):
  - integrated in a window of fixed length around the gradient of peak times along the major image axis
  - Pixels with arrival time that don't match the time for that position along the major axis are removed. (Pixel D)

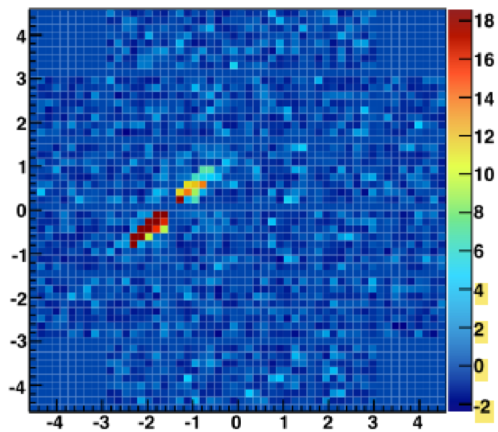
Timeseries of the pulse in each pixel



Camera Image from Simulations

Simulated Shower Image





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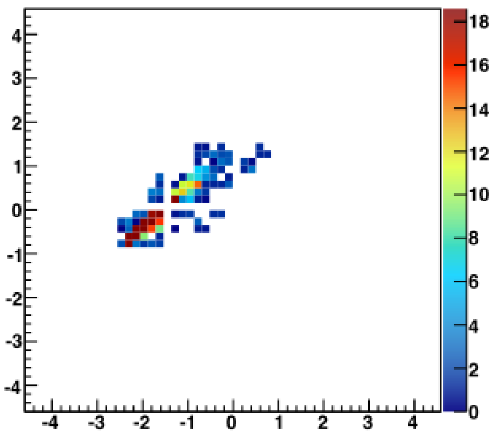
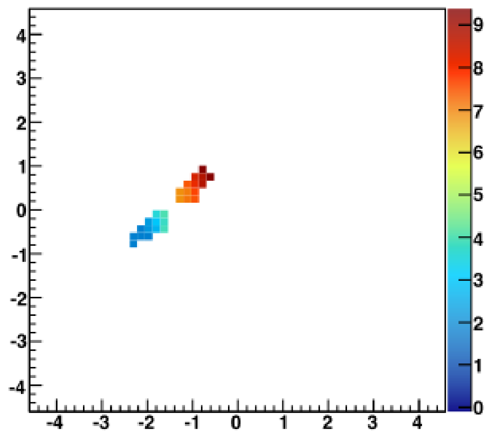
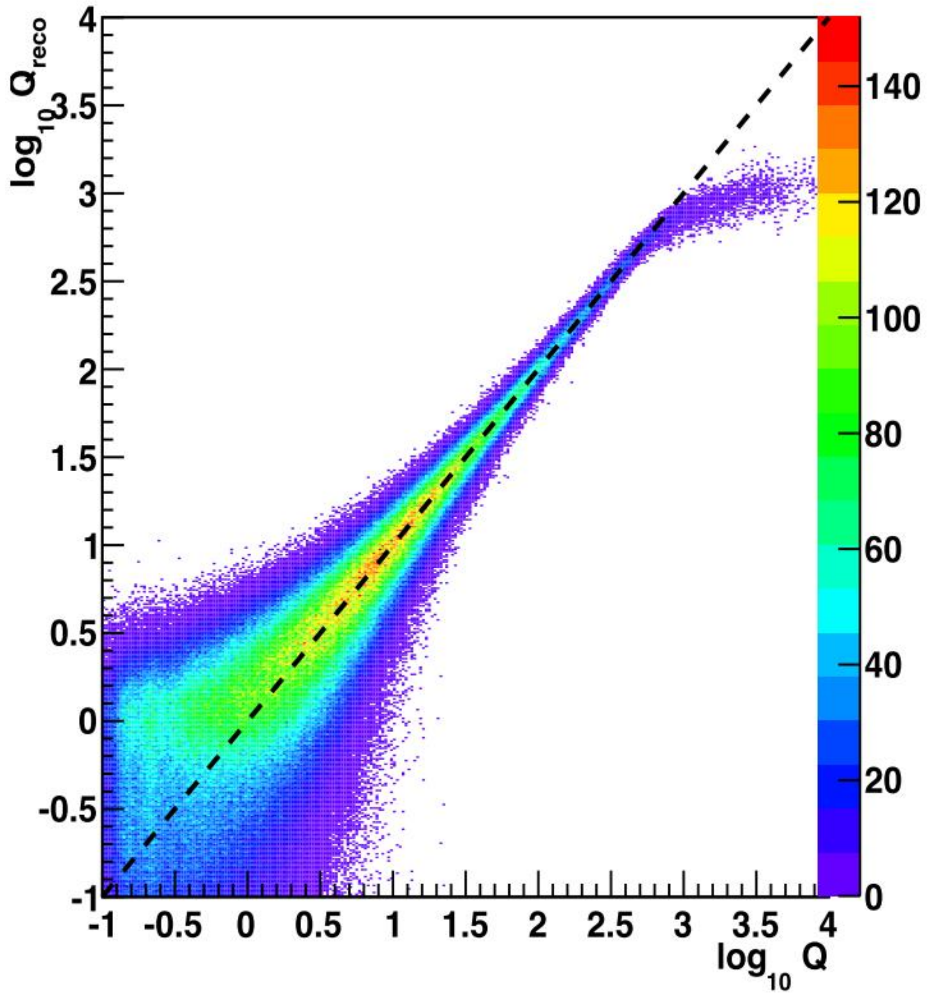
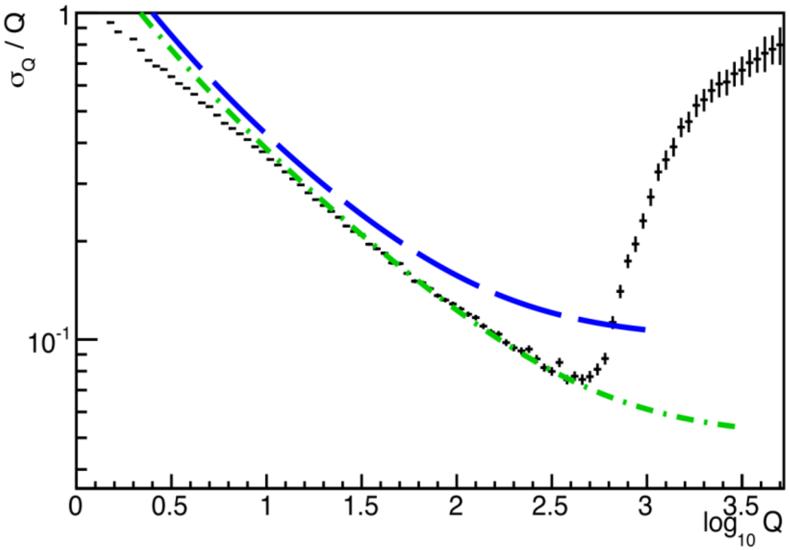




Further cleaned through application of arrival times as described in method 3

Charge Resolution



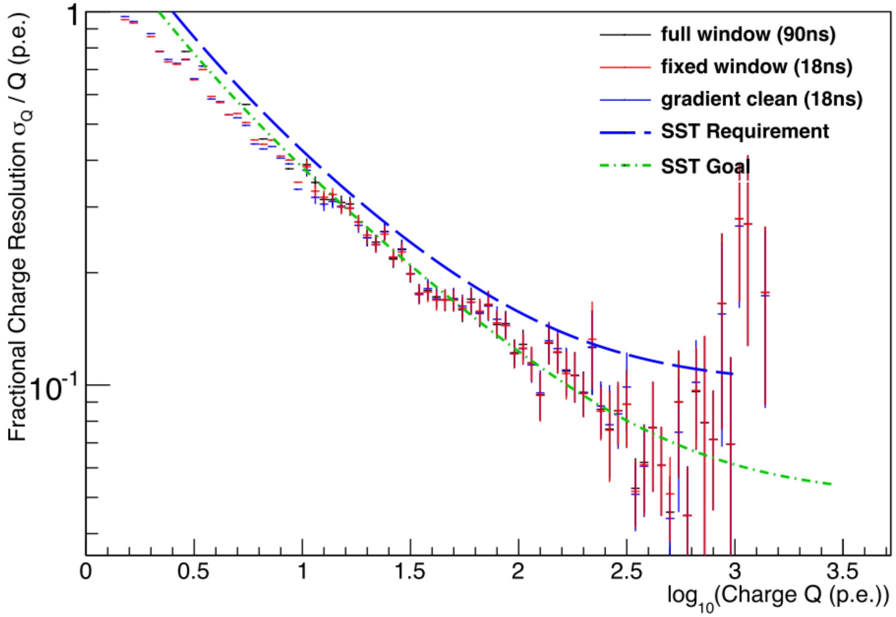


Model 1 (whole window integration)
Sampling speed: 666 MHz
Adc2pe: 8

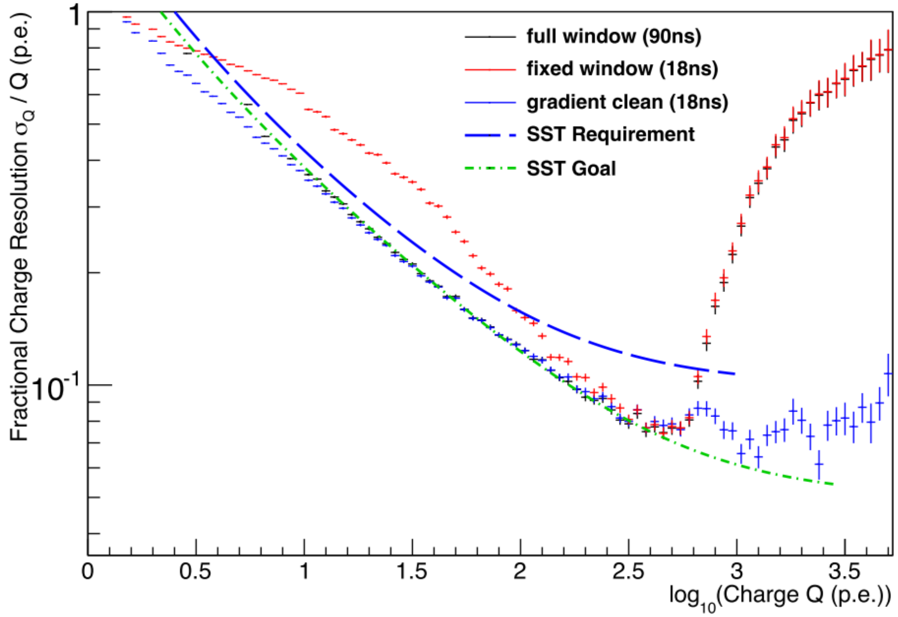
Blue line: SST requirement
Green line: SST Goal

Charge Resolution Simulation Results

Comparison of the three integration window methods



Low energy (300 GeV – 60 TeV)

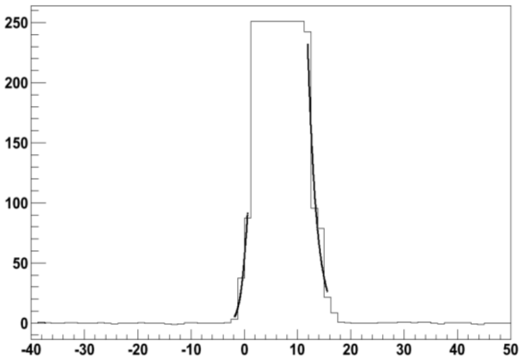


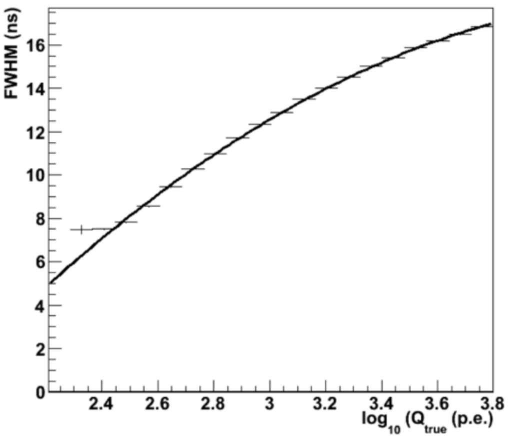
High energy (60 TeV – 300 TeV)

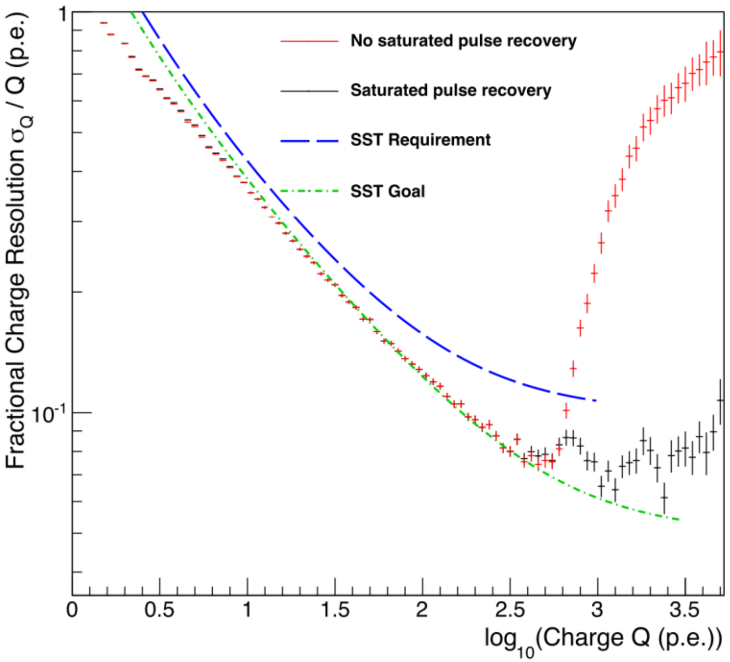
Charge Resolution Simulation Results

Saturated Pixel Restoration

- The TARGET ASIC provides 12-bit digitisation
- Corresponds to a maximum of 4095 digital counts
- A setting of adc2pe of 4 results in the saturation of pixels with intensities of ~1000 photoelectrons







Charge Resolution Simulation Results

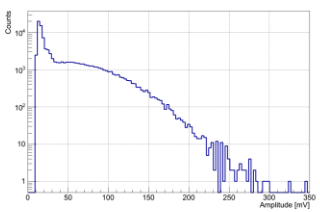
Recommendations:

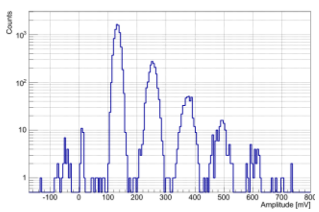
- Sampling speed: 400 MHz - 1 GHz
- (Peak) ADC counts per photoelectron: 1 - 16
- Integration window length: 10 ns - 30 ns
- Readout window length: > 60 ns

Charge Resolution of SiPMs for CHEC-S

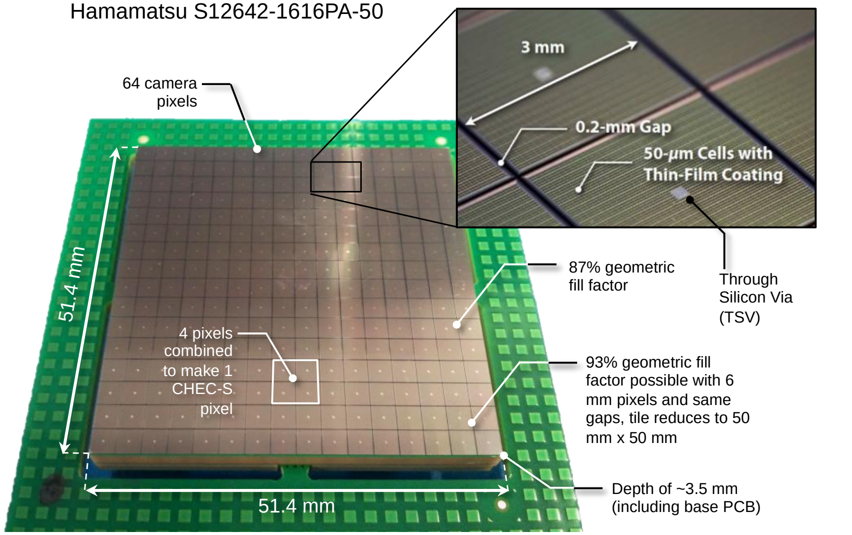
SiPMs have many advantages over MAPMs including:

- Resistance to high light levels allowing observations under moonlight
- Excellent Pulse Height resolution
- Low voltage operation (20 – 100 Volts)





CHEC-S SiPM:
Hamamatsu S12642-1616PA-50



SiPMs require different considerations within the simulation:

- Much wider pulse shape – pre-amp must shorten SiPM pulses
- Cross-talk - Important to consider for cherenkov telescopes, can give NSB high amplitudes

Conclusions and intentions

- The charge resolution of the MAPM camera meets the requirements of the two-mirror small sized telescopes
- The same investigations now need to be performed for the SiPM
- Further investigations are required for the SiPM including cross-talk impact on charge resolution.
- Currently presumes perfect optics – Implementation of Ray-Tracing simulation ROBAST is also intended for the future.