CHEC Camera MC Params

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1 Camera

1.1 Camera Pixels

- Number of pixels per camera.
- Value adopted: 2048
- Description of source: By design
- Status: Agreed
- Agreed by: T Armstrong,

1.2 Camera Config File

- Configuration file for the description of the camera with pixel types, positions and the circuitry for trigger decisions.
- Value adopted: checs_pixel_mapping_v2.txt
- Description of source:
  - Pixel diameter: 0.623 [0.62?] - prototype by design
  - Pixel shape: Square - by design
  - Funnel Shape: same as pixel
  - Funnel Depth: 0 - by design
  - Funnel Diameter: same as pixel
  - Pixel positions: See file 02_cameraConfigFile/ checs_pixel_mapping_v2.txt, the origional excel file 02_cameraConfigFile/CHEC-S camera quadrant 512 pixels 19-02-2018-1.xlsx (For reference, on page 1, +X is positive elevation, $\pm$Y is Azimuth, Z is optical axis) and Figure 1.1, output from CAD design model (extracted by Duncan Ross - University of Leicester). The rotation of the camera is important as there is a slight asymmetry in the pixel layout. The mapping has been corrected by Jason Watson to match that used in the camera which can be seen in Fig 1.2.
  - transmission(λ): None - Moved to seperate parameter: Camera Filter(41)
  - transmission(θ): transmission_pmma_vs_theta_20150422.dat [NEEDS UPDATING?] See Figure 1.3

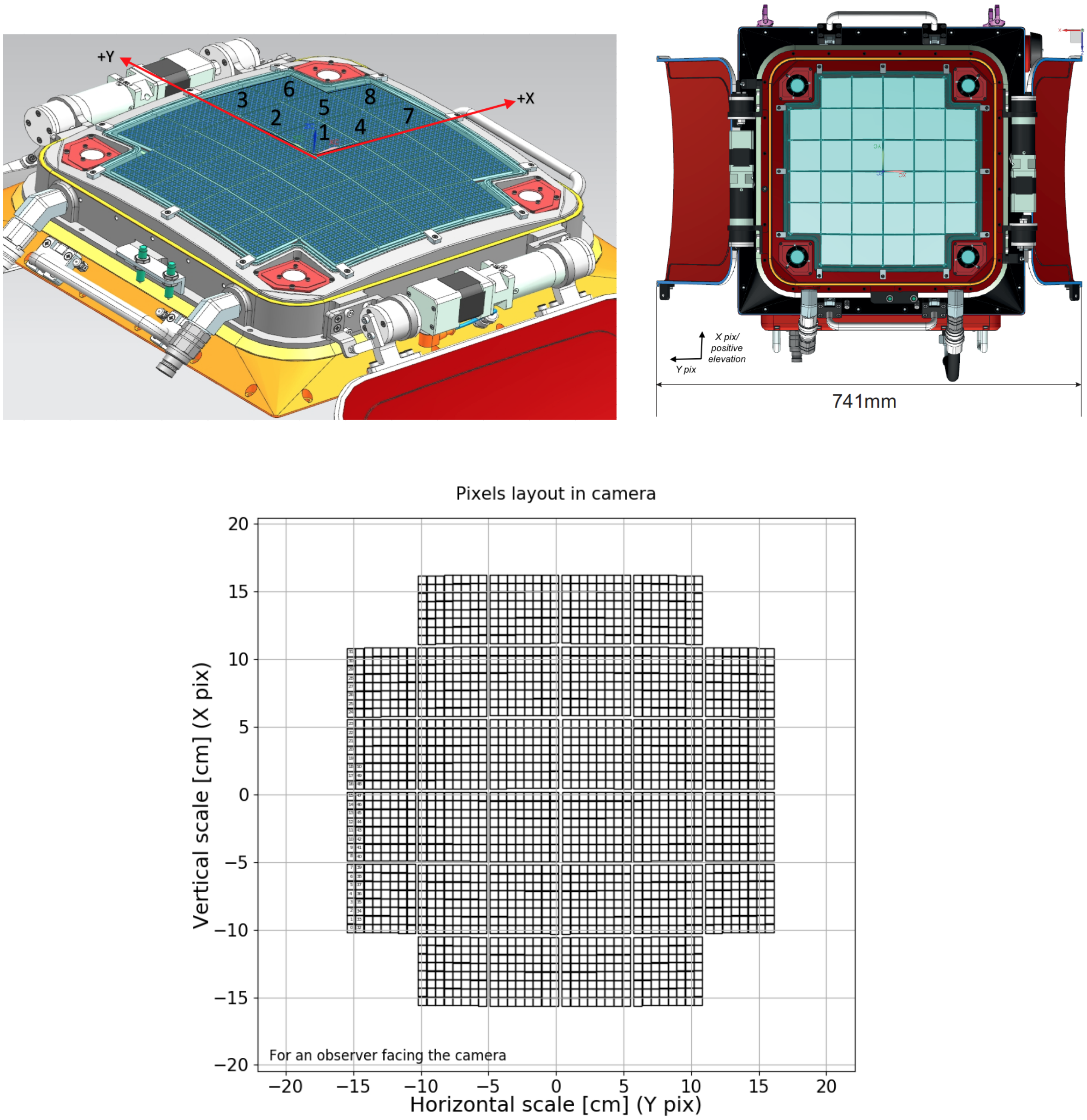

Figure 1.1 – pixel directions related to the camera focal plane. In the right figure, this represents the focal plane as if you were standing inbetween the camera and the secondary mirror. Therefore, the +ve X direction difined in the configuration file represents +ve elevation from the parked telescope position. The bottotm picture is a plot of the x,y coordinates of the pixels in the updated configuration file.

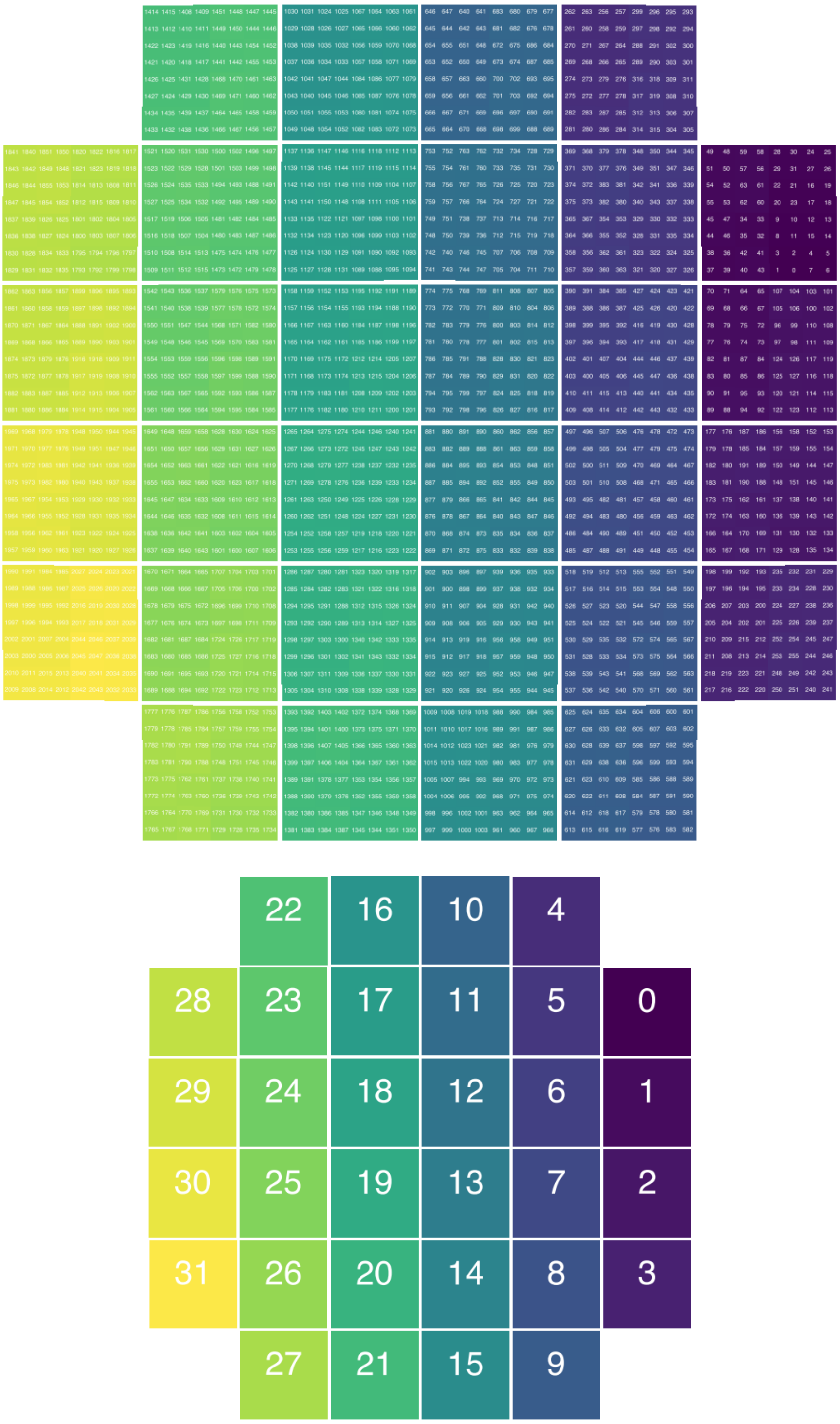

Figure 1.2 – updated pixel (top) and modul (bottom) numbering scheme, such that there is consistency between the camera prototype and the MC model. These values can be found in 02_cameraConfigFile/ checs_pixel_mapping_v2.txt

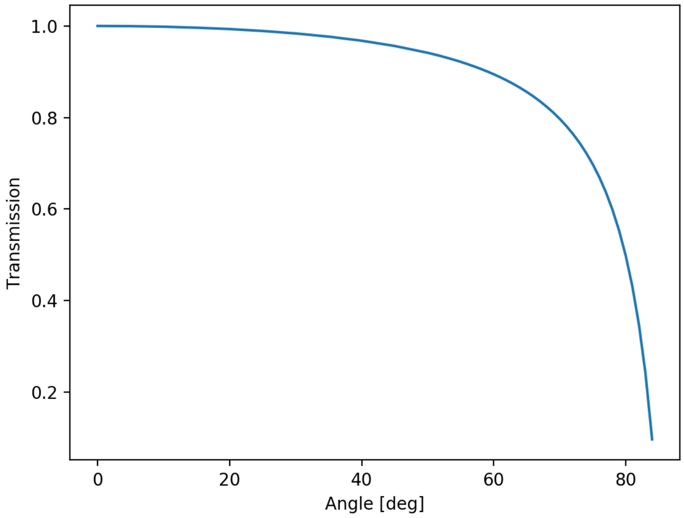

Figure 1.3 – Angular transmission of the detectors as used in Prod3.

- Status: awaiting agreement
- Agreed by:

1.3 NSB

- Number of photo-electrons per nanosecond per pixel due to nightsky background. Note that the number here takes into account all photo-electrons, including those not properly amplified or lost at the first dynode. A range of pixels can be given with nightsky background = (0-1236): 0.2, (1237-1854): 0.15. Alternatively, all pixels can be set with nightsky background = all: 0.2.
- Value adopted:
- Description of source:
- Status: To be derived at end
- Agreed by:

1.4 SPE

- File name for single p.e. response distribution.
- Value adopted: 04_SPE/checs_spe_spectrum_v2_normalised.txt
- Description of source: See Figure 1.4. X Needs data description . The fit to the data is then normalised such that the c.o.g. of the distribrution is at 1.0, as is required by sim_telarray (this was performed using the sscript norm_spe which is available with the corsika_simtel package)
- Status: awaiting agreement
- Agreed by:

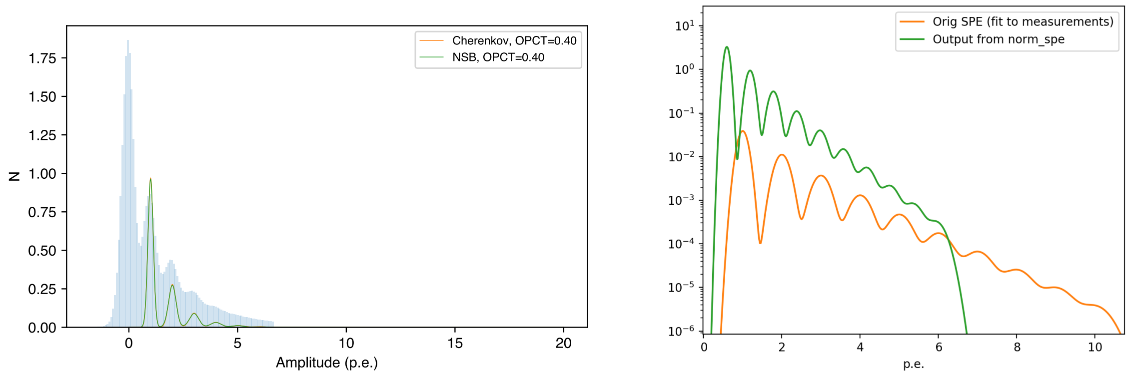

Figure 1.4 – Left: SPE curve for CHEC-S, where the histogram shows the lab measurements and the green and orange line the parameterised fit (exluding the pedistal). Right, the normalised spe curve (orange) required by sim_telarray (The c.o.g. of the spe distribution must be at 1.0 after normalising)

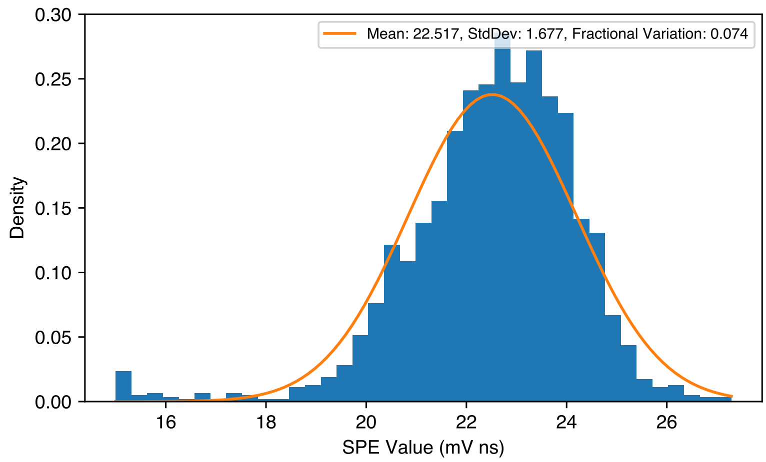

Figure 1.5 – Gain variation between pixels, i.e. how the p.e. value changes between pixels.

1.5 Gain Variation

- Fractional gain variation between different photodetectors after adjusting the voltage to have approximately the same gain in all channels. The parameter sets the Gaussian r.m.s. spread of random fluctuations.
- Value adopted: 10%
- Value adopted V2: 7.4%
- Description of source: See Figure 1.5. X Needs data description
- Status: awaiting measurement
- Agreed by:

1.6 PM Voltage Variation

- Fractional high voltage variation, used to adjust the transit times (/ 1=p(V)). The parameter sets the Gaussian r.m.s. spread of random voltage fluctuations..
- Value adopted: 0

- Description of source: Does not apply to SiPMs
- Status: awaiting agreement
- Agreed by: T Armstrong,

1.7 PM Transit Time

- Total transit time of the photodetector at the average voltage.
- Value adopted: 4ns
- Description of source: Since PM Voltage Variation is set to zero, this is irrelevant
- Status: awaiting agreement
- Agreed by: T Armstrong

1.8 PM Transit Time Jitter

- Jitter (Gaussian r.m.s. spread of random fluctuations) of individual photo-electrons in nanoseconds.
- Value adopted:
- Description of source:
- Status: awaiting measurement
- Agreed by:

1.9 Photon Delay

- An additional delay added to the arrival times of all photons at the photosensors.
- Value adopted: 5ns
- Description of source: Technical MC parameter to place the pulse shape in the simulation time, no need to measure
- Status: awaiting agreement
- Agreed by: T Armstrong

1.10 QE

- File name for the quantum efficiency curve.
- Value adopted: 10_quantumEfficiency/S10362-11-050U-3V.txt (prototype!)
- Description of source: Data provided by Hiro Tajima, data from data sheet(?) for similar device (S10362-11-050U) to that used in CHEC-S (S12642-1616PA) scaled for different OV, see Figure 1.6. Updated measurements being performed in US by Nepomuk and Co.
- Status: awaiting agreement
- Agreed by:

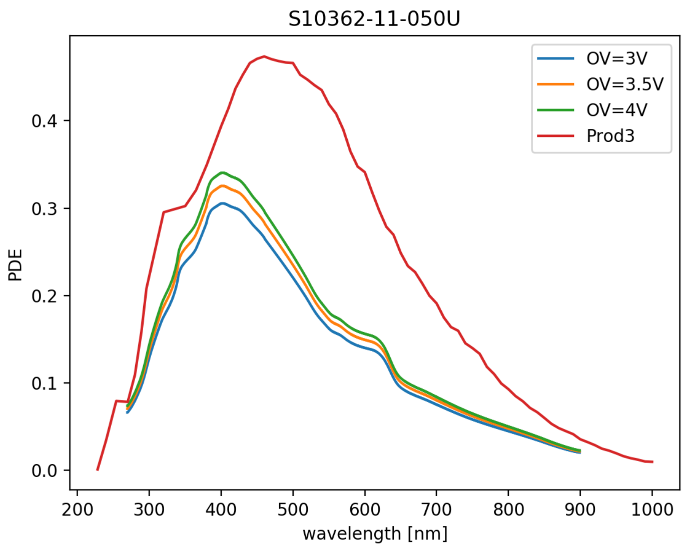

Figure 1.6 – Quantum efficiency for device S10362-11-050U, a similar device to that used in CHEC-S, shown scaled by different overvoltages.

1.11 QE Variations

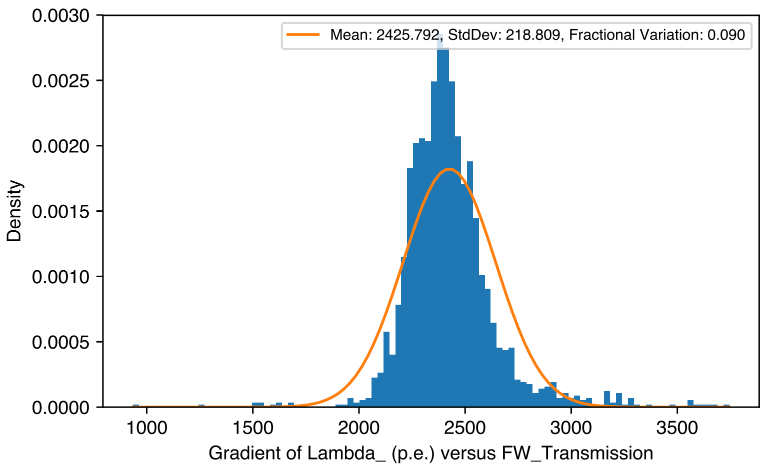

Figure 1.7 – Quantum efficiency variation

- Photoelectron collection efficiency variation (Gaussian r.m.s. spread of random fluctuations) between photodetectors.
- Value adopted: 10%
- Value adopted V2: 9%
- Description of source: See Figure 1.7. Calculated using the gradient of the lambda (illumination at each filter wheel) gradient, gives relative QE efficiency between pixels. X Needs data description
- Status:awaiting measurement
- Agreed by:

1.12 Disc Bins

- Number of time bins used for the discriminator/comparator simulation. The trigger simulation might cover a larger time window than the FADC signals.
- Value adopted: 120 Time bins
- Description of source:
- Status: Needs description
- Agreed by:

1.13 Disc Start

- Number of time bins by which the discriminator/comparator simulation is ahead of the FADC read-out.That is mainly relevant if different time windows are simulated for comparator inputs and digitised ADC values.
- Value adopted: 3
- Description of source:
- Status: Needs description
- Agreed by:

1.14 Default Trigger

- The default meaning of a Trigger line in the camera definition file. If set to Majority, a Trigger line would indicate a MajorityTrigger, for AnalogSum it would indicate an AnalogSumTrigger,and for DigitalSum it would indicate a DigitalSumTrigger.
- Value adopted: Majority
- Description of source: By design, at the end of the camera configuration file (2) there is the definitions of the trigger patches, this includes the “super pixel” (majority sum of a patch of 4 pixels). This has remained unchanged since ∼2013. See diagrnostic plot, Figure 1.8, to see that the pixel numbering and the definistion of the majority trigger of super pixels are still consitent.
- Status: Awaiting agreement
- Agreed by: T Armstrong,

1.15 Pulse Shape

- File name for pulse shape at the discriminator/comparator of an individual pixel. (DISC)
- Value adopted: 15_pulseShape/disc_shape_CHEC-S_27042018.dat and 15_pulseShape/pulse_CHEC-S_FADC_27042018.dat
- Description of source: pulse shape measured in Leicester using a LeCroy scope on the output of the prototype shaper boards using the CHEC-S SiPMs. The prototype shaper is 2 channel test board with unrepresentative layout but using the final component values. This was before the new TARGET boards were available. The origional data is provided in 15_pulseShape/pulse_data.txt but has had the leading baseline removed, has been normalised to a maximum of 1 and has been written out to the required format for the Discriminator and FADC pulse shapes. See Figure 1.9, including the prod3 pulse shape for reference. Data provided by Jon Lapington in Leicester.

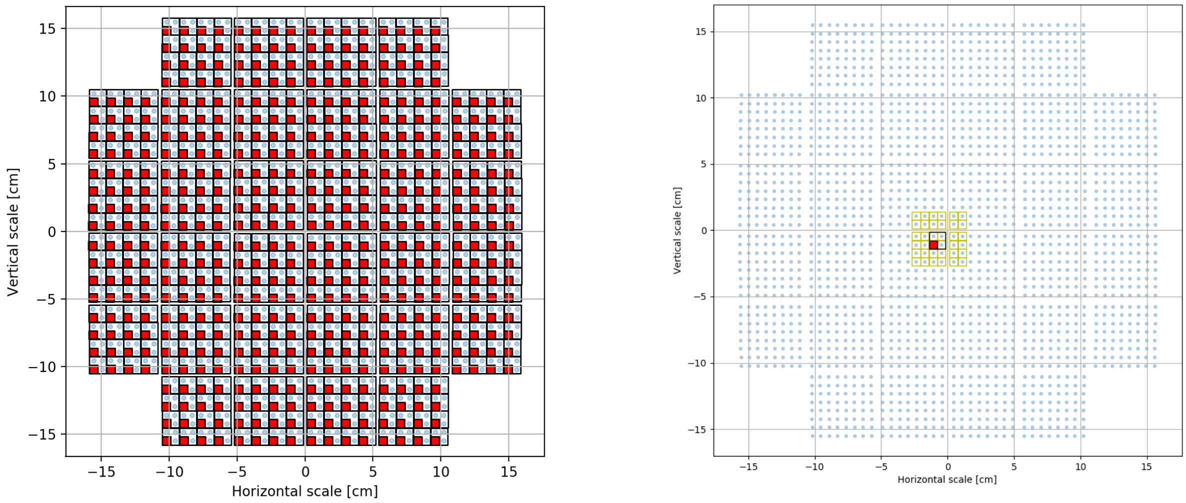

Figure 1.8 – Left: Definition of the Majority sum of 4 neighbouring pixels within the camera configuration (2). Where the super pixels are defined as $n_1[n_2, n_3, n_4]$, the figure displays the first pixel (red) and then the combination of all (black squares). Right: Surounding super-pixel pixels within which to search for a coincidence (i.e. a 3x3 grid of super pixels).

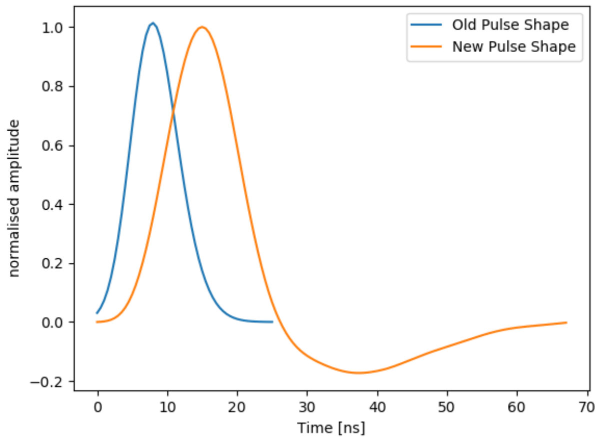

Figure 1.9 – Pulse shape for CHEC-S, measured in Leicester.

- Status: Awaiting agreement
- Agreed by: T Armstrong,

1.16 Discriminator Amplitude

- Signal amplitude after amplifier per mean p.e. at the input of the discriminators/comparators. The unit is arbitrary (typically mV) but the same definition has to be used for the discriminator threshold. For the default value of 1.0, the unit is the average (not the most probable) amplitude of a single photo-electron, implying the same being used for thresholds and switching behaviour.
- Amendment, due to the normalisation of the SPE curve, this might need reconsidering.
- Value adopted: 1 (changed from 20)
- Description of source: Desire to have in units of p.e., for CHEC, only relevant to disc_threshold.

- Status: Awaiting check
- Agreed by:

1.17 Trigger Pixels

- Number of pixels required for single telescope trigger. With flexible camera definitions, this is the default number for the multiplicity required per trigger group. If the camera definition file contains a non-zero number in the definition of any trigger group, that number overrides the default
- Value adopted: 2
- Description of source: Current design implementation, this means a minimum of 2 “super-pixels” are required to be in coincidence for a trigger. These must be neighbouring pixels (see Figure 1.8, the neighbouring pixels would be required to be in the highlighted pixels in the right figure).
- Status: Awaiting agreement
- Agreed by: T Armstrong,

1.18 Teltrig Min Time

- Minimum time of sector trigger over threshold. Used before telescope trigger.
- Value adopted:
- Description of source:
- Status: awaiting measurement
- Agreed by:

1.19 Teltrig Min Sigsum

- Minimum signal sum at sector trigger over threshold. Note that both the minimum time over threshold and the minimum signal sum have to be satisfied before a trigger is obtained. Normally, either of these values being non-zero should be sufficient.
- Value adopted: 0
- Description of source: By design, do not consider the integrated signal of the trigger line.
- Status: Awaiting agreement
- Agreed by: T Armstrong,

1.20 Discriminator Sigsum Over Thresh

- Integrated signal required over threshold. See also discriminator time over threshold above for combined effects. If discriminator time over threshold is not milliVolts, it scales accordingly.
- Value adopted: 0
- Description of source: By design, do not consider the integrated signal of the trigger line.
- Status: Awaiting agreement
- Agreed by: T Armstrong,

1.21 Discriminator Var Sigsum over Thresh

- Gaussian r.m.s. spread of discriminator sigsum over threshold (Pixel-to-pixel variation).
- Value adopted: 0
- Description of source: By design, do not consider the integrated signal of the trigger line.
- Status: Awaiting agreement
- Agreed by: T Armstrong,

1.22 Discriminator Gate Length

- Effective discriminator gate length. To achieve a comparator-type response this gate length must match the time over threshold below.
- Value adopted: -8
- Description of source: Changed to include negative sign, this ensures that the signal drops after 8ns even if the actual signal continues.
- Status: Awaiting agreement
- Agreed by: T Armstrong

1.23 Discriminator Var Gate Length

- Variation of gate length (Gaussian r.m.s.). In comparator-type response, this variable is not used but only discriminator var time over threshold.
- Value adopted:
- Description of source:
- Status: awaiting measurements
- Agreed by:

1.24 Discriminator Rise Time

- Rise time of the discriminator/comparator output. After the discriminator/comparator logical output is set true, the output signal linearly rises from 0 to 100% within the given time period.
- Value adopted: 0
- Description of source: digital pulse
- Status: Awaiting agreement
- Agreed by: T Armstrong

1.25 Discriminator Var Threshold

- Channel-to-channel variations (random Gaussian r.m.s.) of discriminator/comparator threshold.
- Value adopted:
- Description of source:
- Status: awaiting measurement
- Agreed by:

1.26 Discriminator Hysteresis

- The switching off of a comparator is normally with some hysteresis to avoid oscillating behaviour. As a consequence, the signal has to be below the threshold minus the hysteresis before it switches off.
- Value adopted:
- Description of source:
- Status: awaiting measurement?
- Agreed by:

1.27 Discriminator Fall Time

- Fall time of discriminator/comparator output after the logical output is reset to false.
- Value adopted: 0
- Description of source: digital pulse
- Status: Awaiting agreement
- Agreed by: T Armstrong,

1.28 Discriminator Time Over Thresh

- Time over threshold required before logic response switches to true. To achieve a comparator-type response this time must match the gate length above. Note that in addition a minimum signal integral discriminator sigsum over threshold may be set up. If so, both time over threshold and signal integral conditions have to be met before a true output signal starts. Normally, either of them being non-zero should be sufficient.
- Value adopted:
- Description of source:
- Status: awaiting measurement
- Agreed by:

1.29 Disc Var Time Over Threshold

- Pixel-to-pixel variation of the time over threshold required before logic response switches to true.
- Value adopted:
- Description of source:
- Status: awaiting measurement
- Agreed by:

1.30 Discriminator Output Amplitude

- The nominal output amplitude of a pixel discriminator or comparator as seen at the sector (trigger group) coincidence unit.
- Value adopted: 1
- Description of source: arbitrary value, set to 1 in the discriminator is binary with a variance of zero
- Status: Awaiting agreement
- Agreed by: T Armstrong,

1.31 Discriminator Output Var Percent

- Channel-to-channel variation (Gaussian r.m.s.) of the output amplitude of a pixel discriminator or comparator.
- Value adopted: 0
- Description of source: discriminator is binary with a variance of zero.
- Status: Awaiting agreement
- Agreed by: T Armstrong,

1.32 FADC MHz

- FADC sampling rate. A value of 250 (MHz or million samples per second) corresponds to an FADC time interval of 4 ns.
- Value adopted: 1000 MHz
- Description of source: By design
- Status: Awaiting agreement
- Agreed by: T Armstrong,

1.33 FADC Bins

- Number of FADC bins to be filled. In the first place this means the number of bins simulated. The median of all Cherenkov light photo-electrons will be near 40% of the interval length, unless shifted with photon delay. If the photon delay is left at 0, this will also be used as the number of bins read out.
- Value adopted: 128 or ...
- Description of source: To be determined, 128 is fine if useing FADC sum bins of 96, if using 128 then FADC Bins needs to be increased.
- Status: Awaiting confirmation
- Agreed by:

1.34 FADC Sum Bins

- Number of bins summed up in ADC sum data or read out in sampled data. This number corresponds to the experimental length of the readout window. The start of the readout window starts fadc sum offset bins before the calculated time of the trigger, as long as the readout window fits fully in the simulated window. With peak sensing readout, the same interval is used for searching the peak signal.
- Value adopted: 96 or 128?
- Description of source: A tunable parameter
- Status: Awaiting confirmation
- Agreed by:

1.35 FADC Sum Offset

- Number of bins before telescope trigger where summing/reading of sampled data starts (see also description of fadc sum bins). With peak sensing readout, the same offset is used for setting the interval for the searching of the peak signal. For negative values, the summing/reading starts after the trigger.
- Value adopted: 24
- Description of source:
- Status: awaiting desciption
- Agreed by:

1.36 36. FADC Pedestal

- Nominal (F)ADC pedestal value per time slice.
- Value adopted:
- Description of source: Needs measuring, although can set at a level such that the saturation of the undershoot is replicated in sim_telarray at large illuminations?
- Status: Awaiting measurement?
- Agreed by:

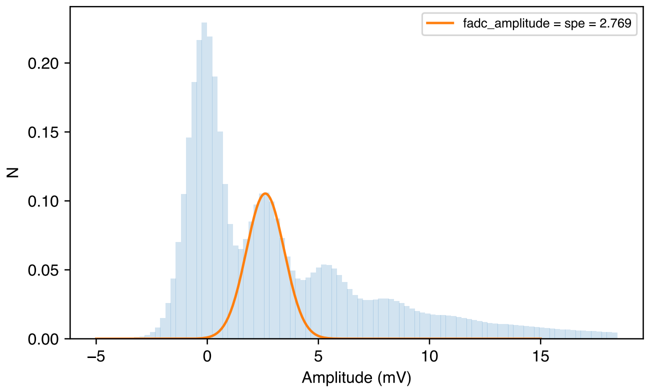

Figure 1.10 – FADC Amplitude, measured from the height of the first p.e. peak

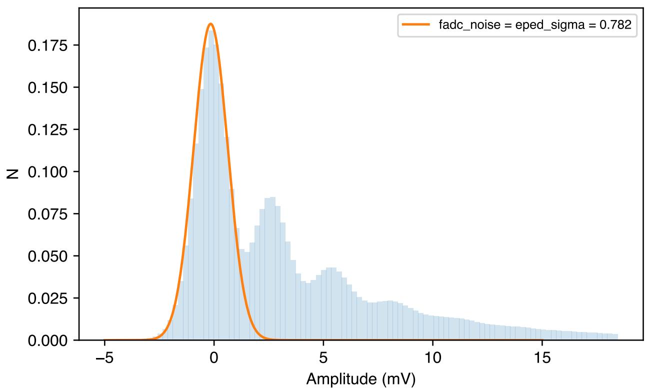

Figure 1.11 – FADC Noise, measured as the width of the pedestal peak

1.37 FADC Amplitude

- Peak amplitude at ADC/FADC (for high gain channel, if different gains are used). fadc amplitude are ADC counts maximum amplitude above pedestal (per time slice) for a photo-electron with average (not most probable) signal. This is after photodetector, preamplifier, cable, and shaper at the input of the ADC or FADC.
- Amendment, due to SPE normalisation this might need checking
- Value adopted: 2.5
- Value adopted V2: 2.77
- Description of source: See Figure 1.10. Value measured from the first peak of the spe. X Needs data description
- Status: Awaiting check
- Agreed by:

1.38 FADC Noise

- Gaussian r.m.s. spread of white noise per time bin in digitisation (for high-gain channel, if different gains are used).
- Value adopted: 0.69

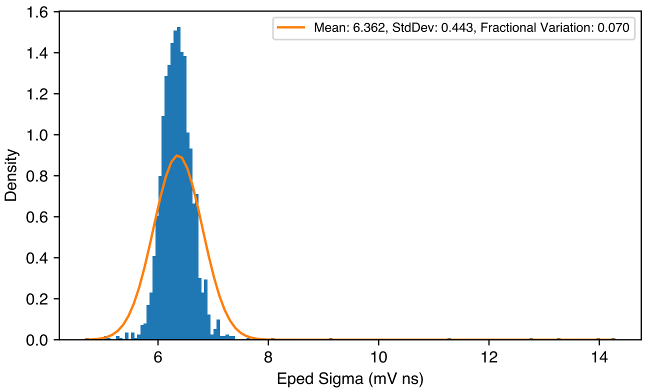

Figure 1.12 – Variation of pedestal values between pixels

- Value adopted V2: 1.4
- Description of source: See Figure 1.11. measured as the width of the pedestal peak which provides a value of 0.782. However in simulations to match the SPE spectrum from simulations to that measured in the lab, this has been increased to 1.4.
- Status: Awaiting confermation
- Agreed by:

1.39 FADC Max Signal

- The maximum value of the digitized signal per sample. For a typical 12-bit ADC this would be 4095.
- Value adopted:
- Description of source: Needs increasing untill we decide how to deal with saturation.
- Status:
- Agreed by:

1.40 FADC Pedestal Variation

- Channel-to-channel (or pixel-to-pixel) variation of the pedestal per FADC time slice.
- Value adopted: 10%
- Value adopted V2: 7%
- Description of source: See Figure 1.12. Variation of pedestal values between pixels X Needs data description
- Status: Awaiting measurement
- Agreed by:

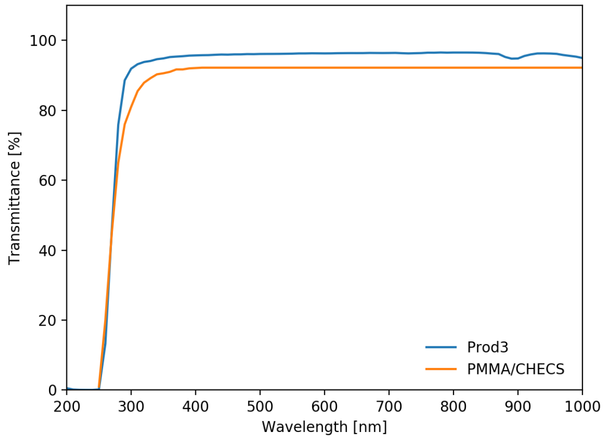

Figure 1.13 – prototype window used for CHEC-S.

1.41 Camera Filter

- Wavelength dependence of the camera transmission, independent of the pixel type and the angle of incidence. If a file name is provided, the table (wavelength and efficiency columns) will be loaded and interpolated. The corresponding efficiency factors will be applied on top of the global CAMERA_TRANSmission factor, and on top of any pixel-type dependent efficiency (both angular and by wavelength), according to the PixType configuration lines in the file specified by CAMERA_CONFIG_FILE. The file is, by default, assumed to be a 1-D table (wavelength-dependent only, in nanometers) but, with a#@RPOL@ header line can be marked and used as a 2-D table (wavelength and angle dependent), with the incidence angles specified in the file in units of degrees but internally converted to radians.
- Value adopted: 41_cameraFilter/xtuvt_ext.dat (prototype, wavelength only)
- Description of source: Final design currently under investigation, for the prototype a hard coated PMMA window will be used. Data provided is from XT UVT curve in the Polycasa data sheet although has been confirmed by measurements in Liverpool in the available wavelength range (see Figure 1.13). It is worth noting, that for any of the validation measurement, the window will not be used.
- Status: Under development
- Agreed by: