University *of* Leicester

CHEC Camera: Monte Carlo Trigger Studies

MAPM-based Camera
(→ all details on the wiki!)

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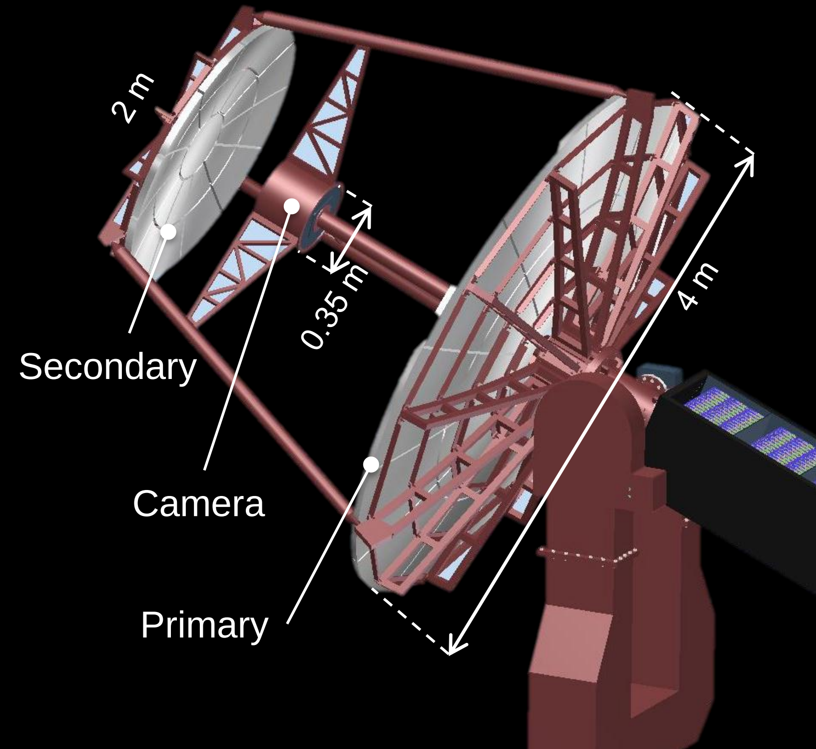
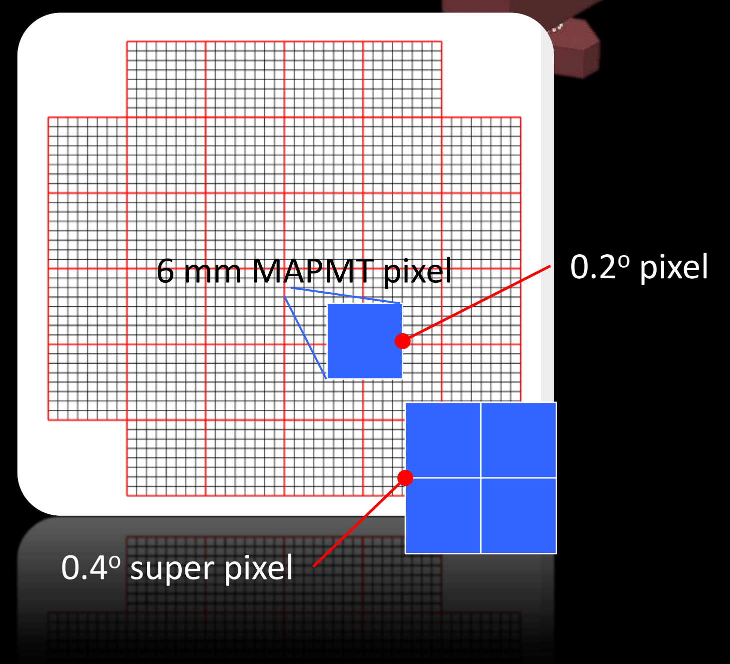
CTA-UK meeting, Liverpool

Aims and outline

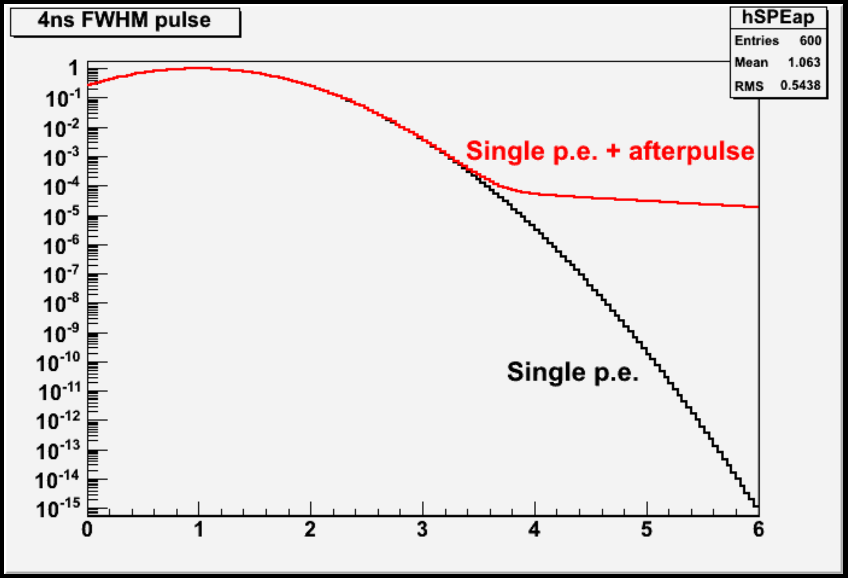
- Preliminary optimisation of the CHEC camera design, based on MAPMs
- Based on Target electronics: 4 x 0.2° pixels are summed on the ASIC (current implementation). Studies also performed with 16 x 0.2° and 1 x 0.2° "super pixels".
- Trigger Studies: Target v5 has majority trigger and analogue sum of 4 pixels implemented. Not so sure about analogue sum of 16, or digital sum…

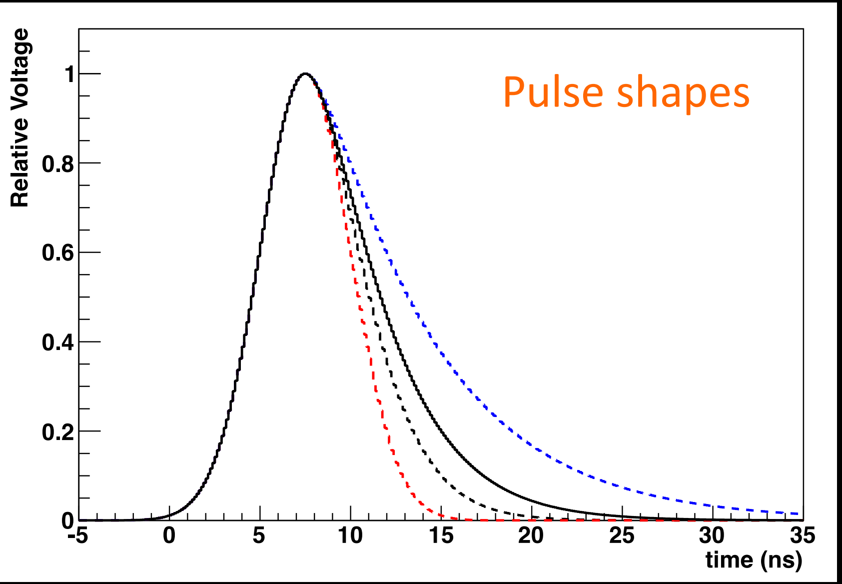




Key Ingredients

- MAPM SPE spectrum
  - Simple fit based on lab measurement (one channel H10966 MAPMT)
- Pulse shape
  - Pulse shape used in P. Cogan's thesis (VERITAS)
  - Represents preamp output, rather than MAPM
  - tested different pulse shapes
- NSB
  - Scaled from MST rate to the DM SST
  - 12 MHz per pixel (corresponds to the "aggressive" trigger definition of the MC group.)
- Jitter/Gain
  - different jitters and gain variances have been tested as well

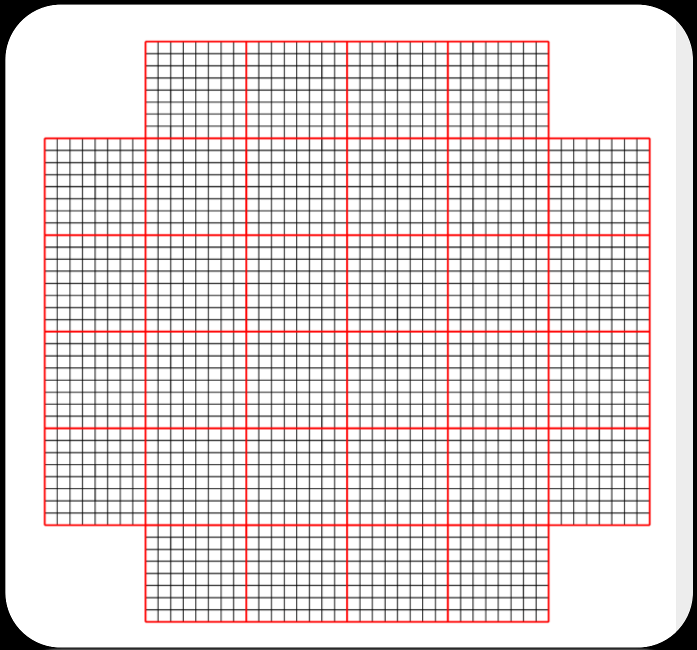




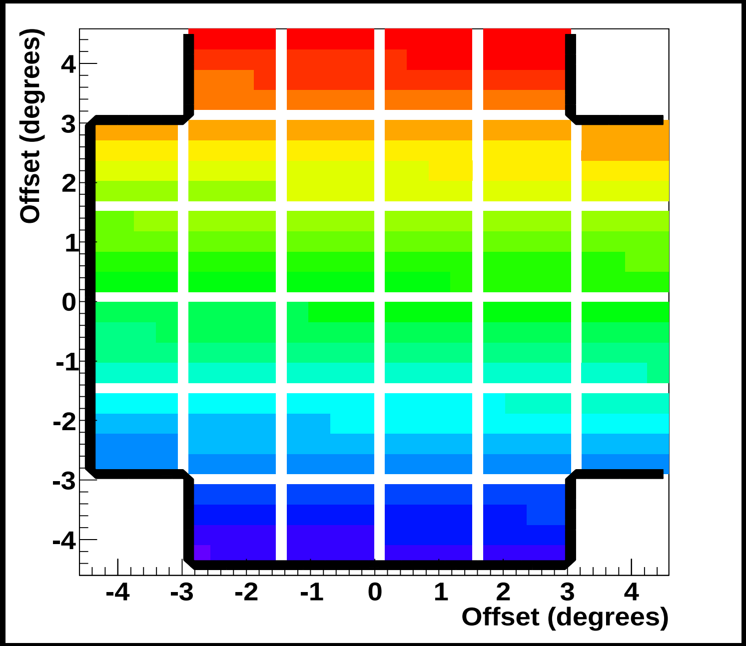
Simulation

- CORSIKA shower simulations are used to generate lists of photo-electrons
- convert these to a ROOT-based image format assuming perfect PSF
- Use *LTools* simulation package to perform the actual study
- assume 32 x 64 pixel MAPM modules
- gaps between modules taken into account (1 pixel wide)

schematic view



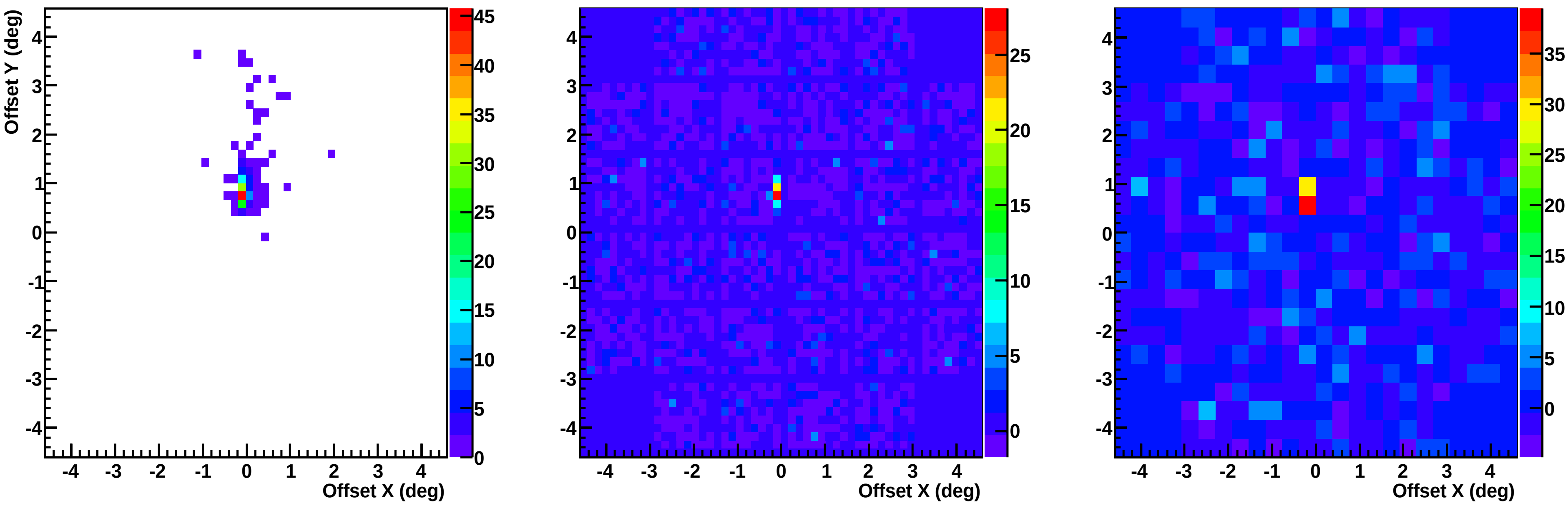
simulation



Simulation

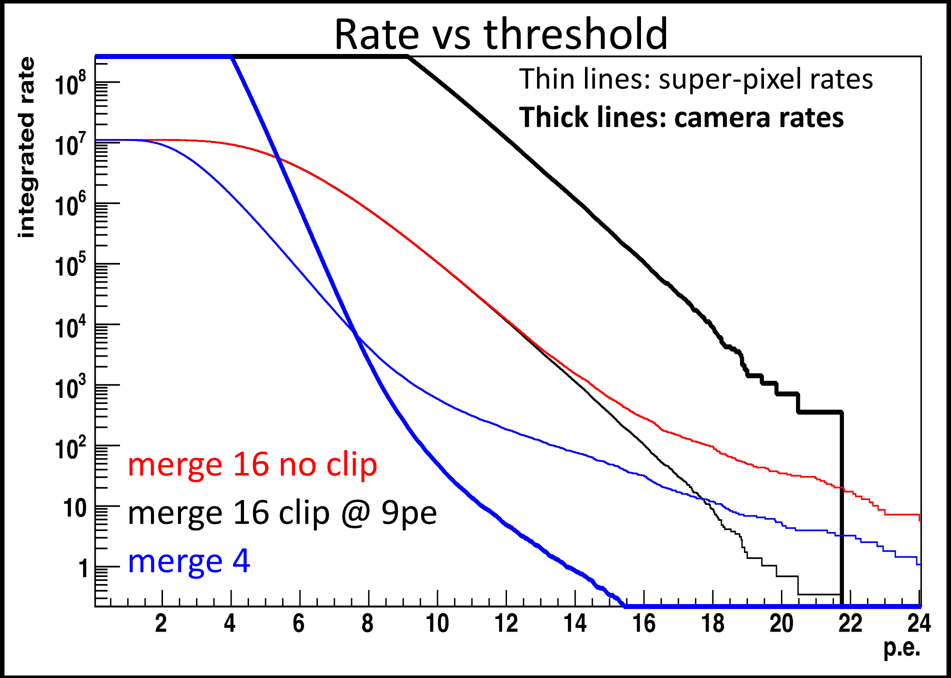
- take raw images
- add electronic noise (0.4 p.e. rms per pixel) and NSB
- make analogue sum of 4 (or 16) pixels → generate trigger image
- apply trigger criterion on minimum pixel intensity in the triggered image

simulated shower image → + NSB, + electronic noise → resulting trigger image (merge 4)



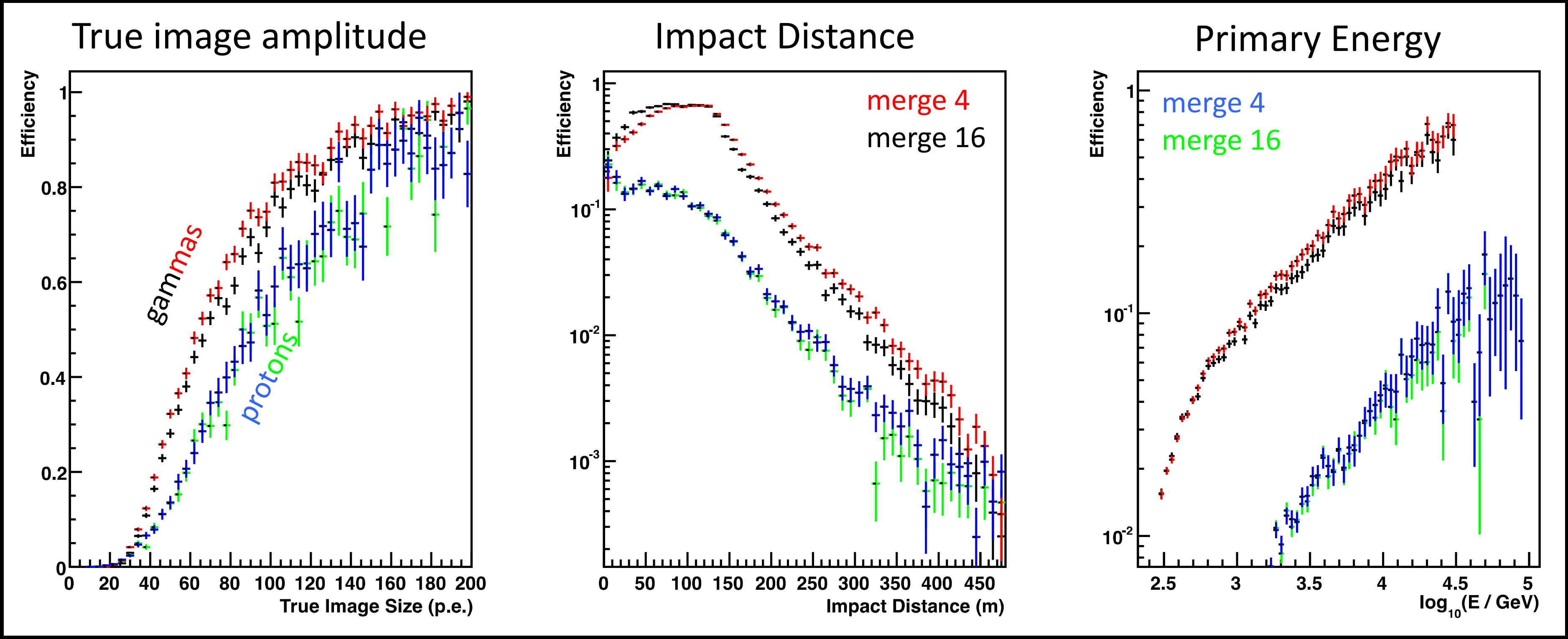
How to get the Trigger criteria?

- Get the pixel threshold by requiring 200 Hz camera accidental trigger rate for given NSB level
- A digital pulse based on a pixel (or combination of neighbouring pixels) exceeding this threshold is assumed to be sent to camera-level trigger
- Apply neighbour requirement and test
  - merge 4 with multiplicity of 1 & 2, merge 16, multiplicity of 1
- Check efficiency with which images of certain amplitude trigger



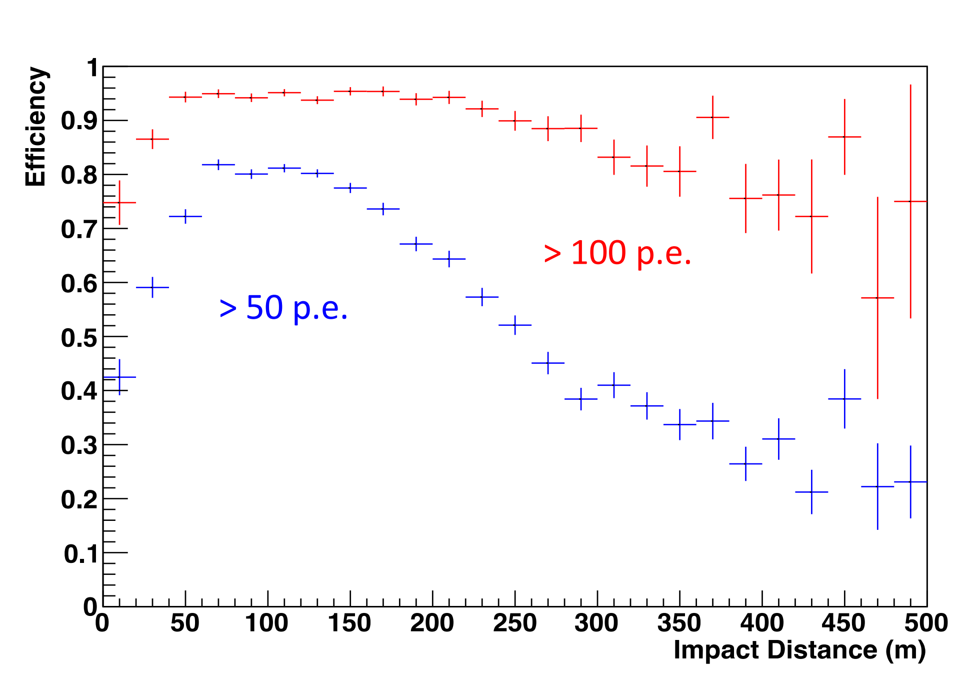
Trigger efficiency

- CTA level B specifications of 50% trigger efficiency at 100 p.e. can be met
- Reach 50% around 60-70 p.e. (and coincidence window of 9ns & 6.5ns FWHM pulse, see later)
- good trigger efficiency at largish shower impact distances (important for SSTs as many high-energy shower are far away)



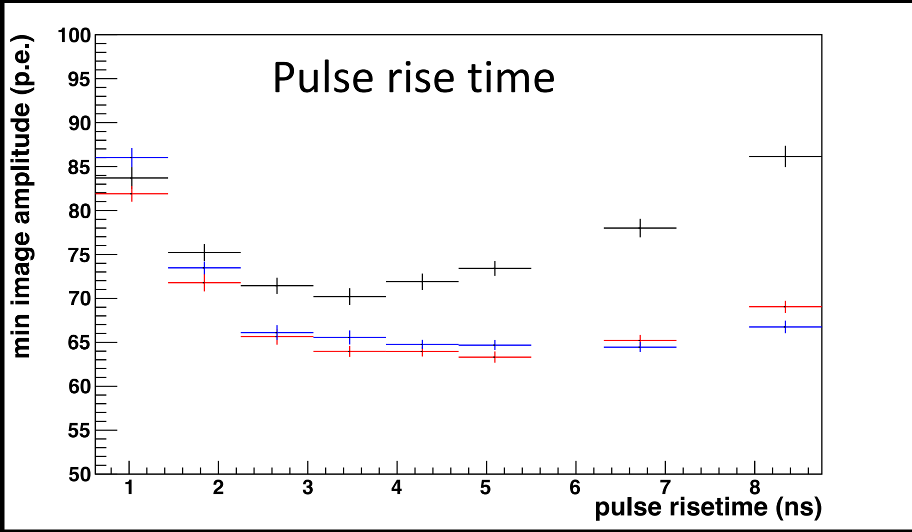
Trigger efficiency

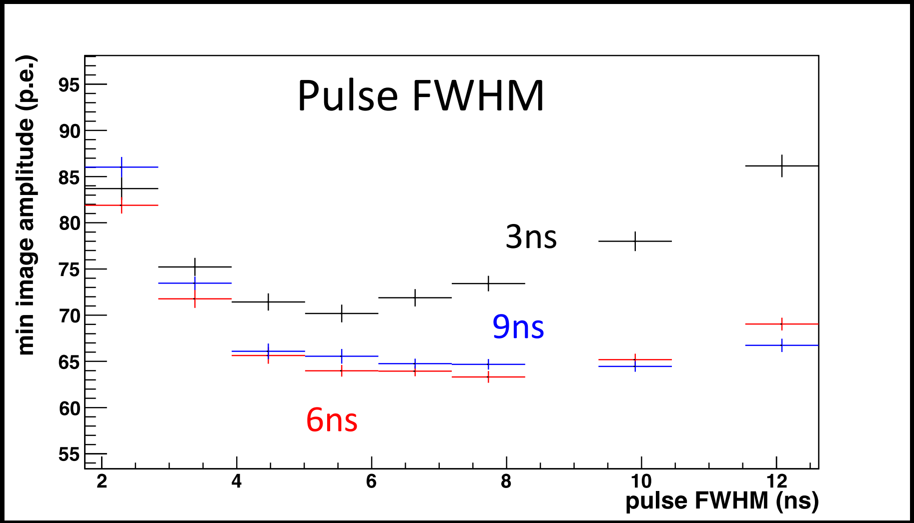
- CTA level B specifications of 50% trigger efficiency at 100 p.e. can be met
- Reach 50% around 60-70 p.e. (and coincidence window of 9ns & 6.5 ns FWHM pulse)
- good trigger efficiency at large shower impact distances (important for SSTs as many high-energy shower are far away)
- Nearly all images with size > 100 p.e. and impact distance between 50m and 300m trigger



Trigger efficiency: pulse FWHM, rise time

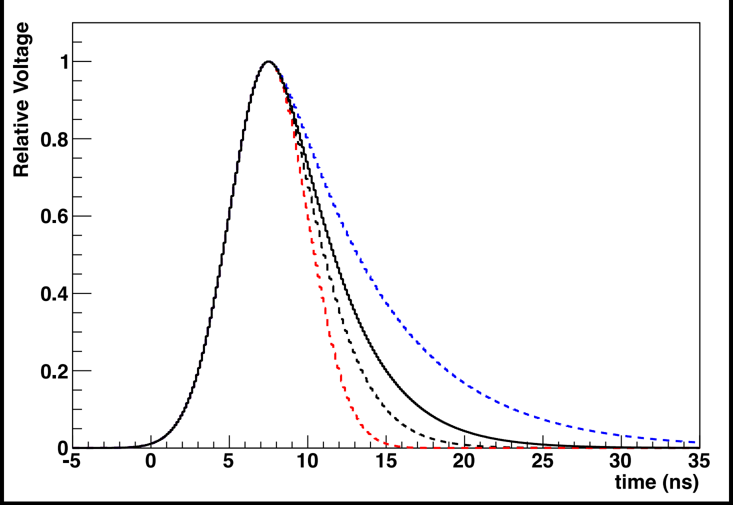
- In the following, show image size at 50% trigger efficiency as a function of pulse shape, coincidence window between pixels, gain variance, …
- For fixed pulse shape:
  - Very short pulses don't overlap/build up in the merge 4
  - If coincidence window between pixels is too short, long pulses don't overlap (get cropped)
  - optimum rise time between 3.5ns and 6.5 ns

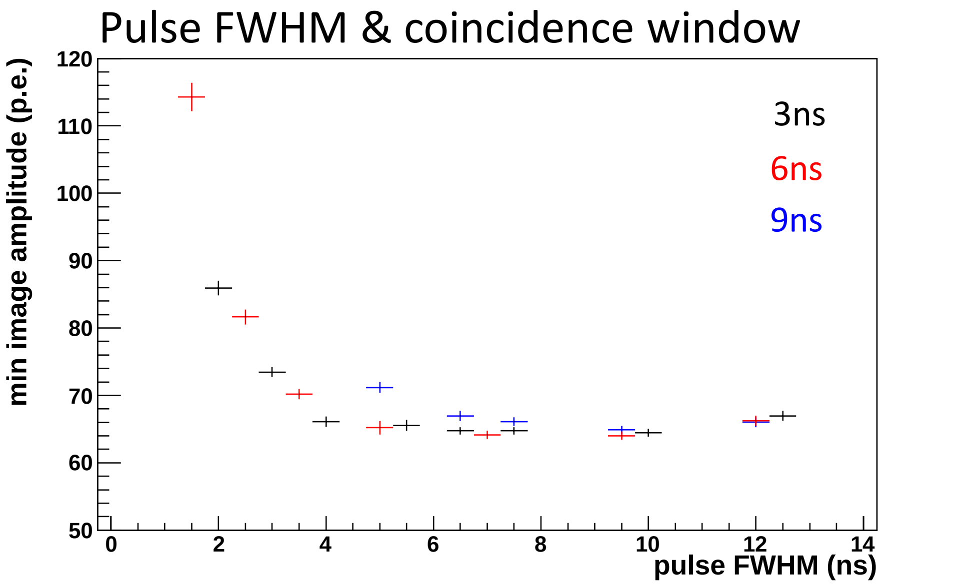




Trigger efficiency: pulse shape

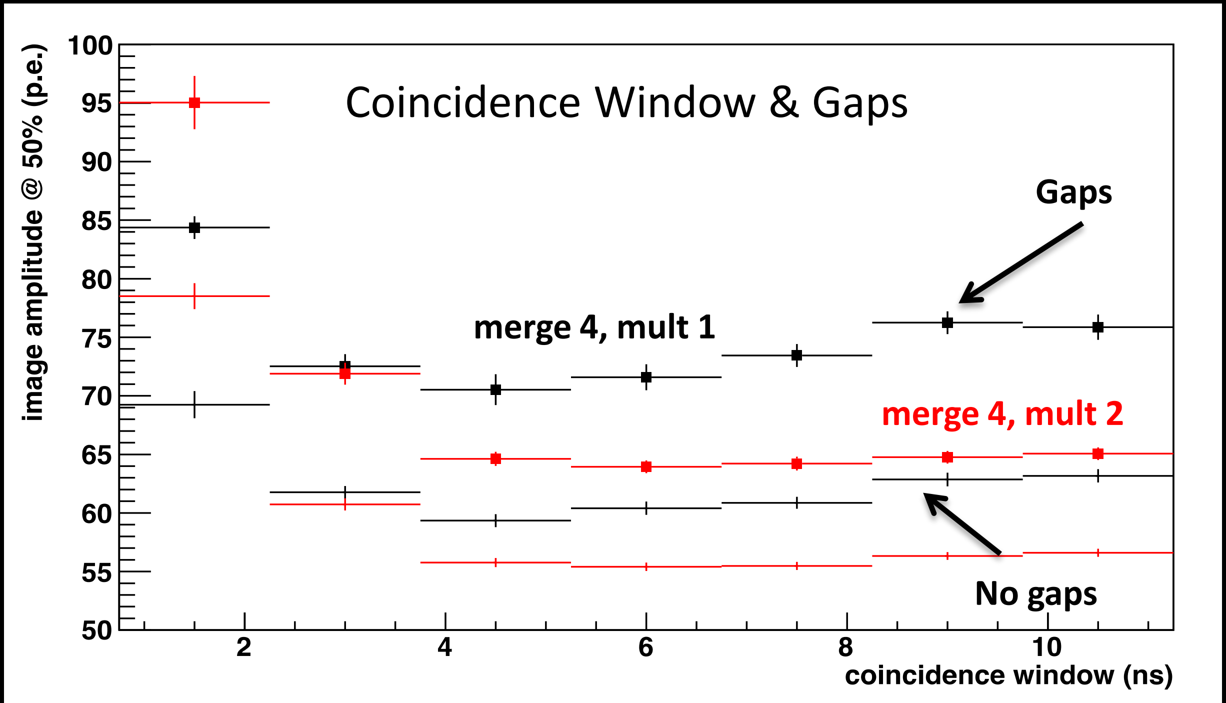
- In the following, show image size at 50% trigger efficiency as a function of pulse shape, coincidence window between pixels, gain variance, …
- Change pulse shape:
  - again, very short pulses don't overlap
  - optimum around 5.5 – 10.5 ns





Trigger efficiency: Coincidence Window

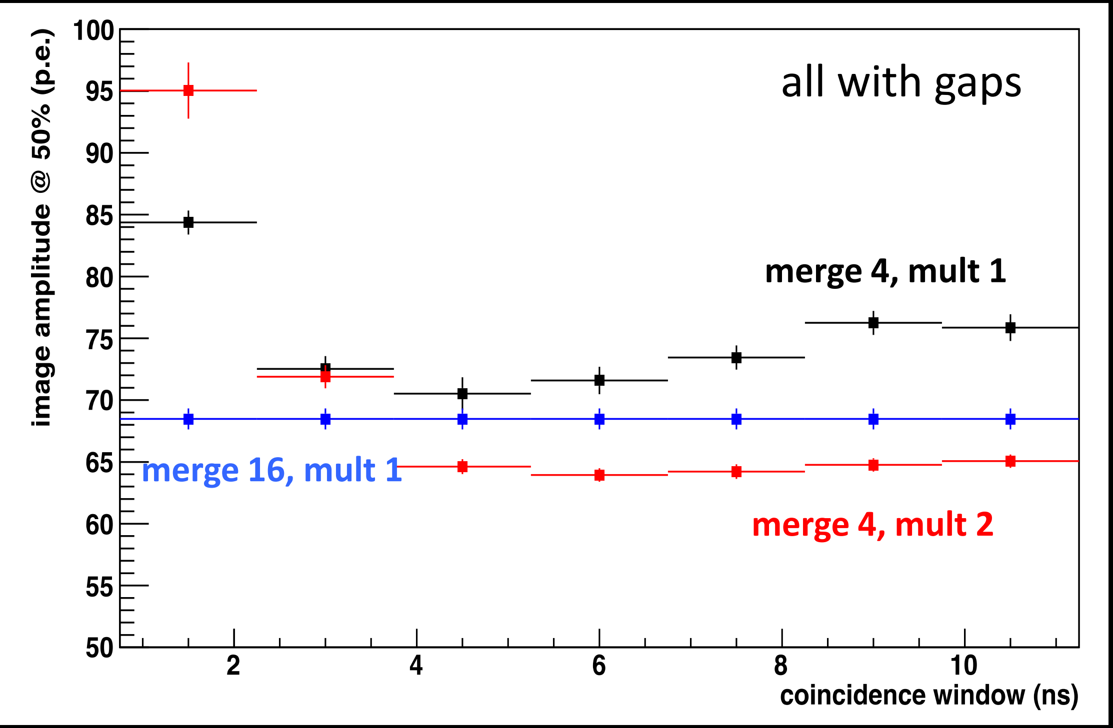
- Coincidence window of 6ns – 10ns desirable
- Gaps increase minimum image size @ 50% trigger efficiency by ~10% - 15%
- Merge of 4 pixels and single pixel trigger has inferior performance compared to merge of 4 pixels and a multiplicity of 2



Trigger efficiency: Coincidence Window

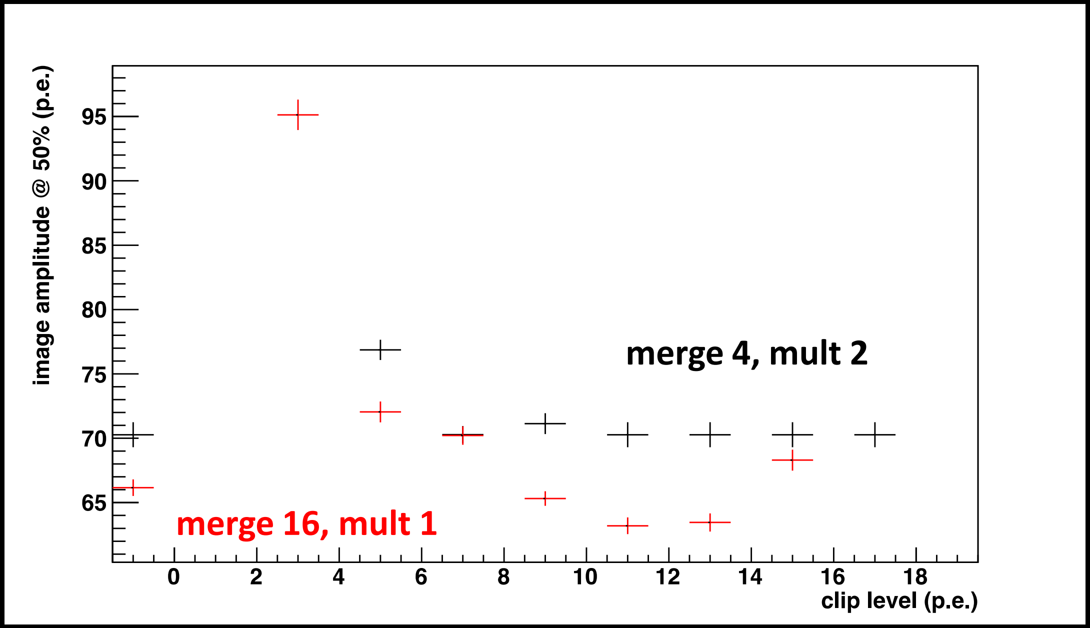
- Coincidence window of 6ns – 10ns desirable
- Gaps increase minimum image size @ 50% trigger efficiency by ~10% - 15%
- Merge of 16 pixels looks like a desirable solution

→ check how clipping improves things



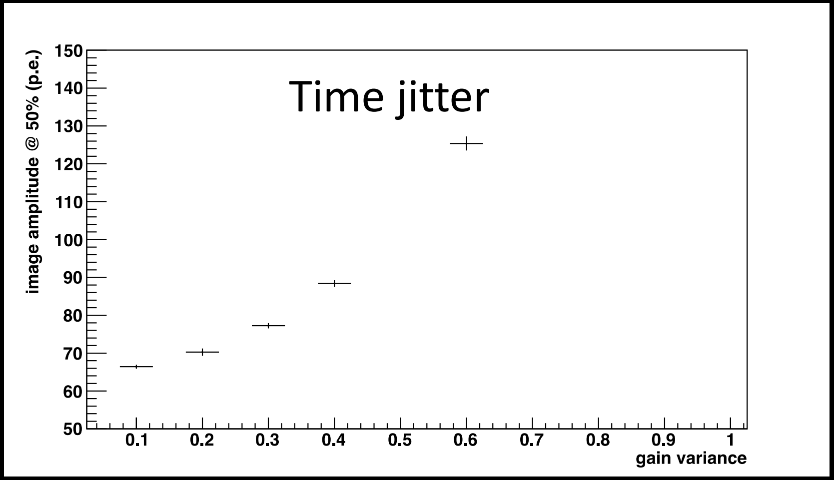
Trigger efficiency: Clipping

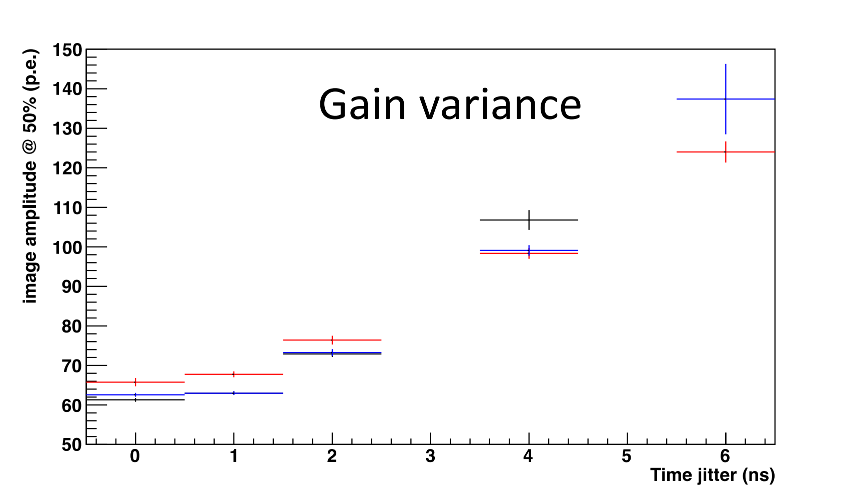
- No significant effect for merge 4, mult 2 config, but 10% improvement for merge 16, mult 1 → could make this trigger very powerful



Trigger efficiency: Time jitter & gain variance

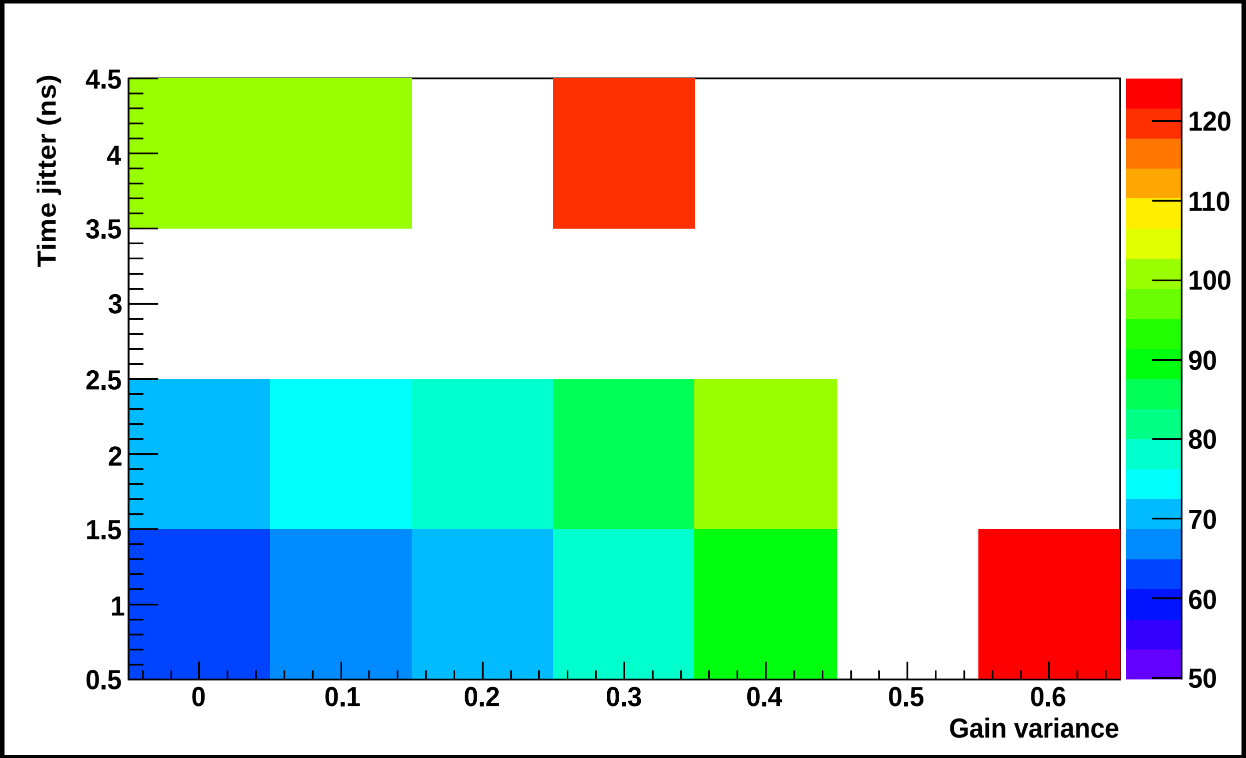
- Time jitter < 2ns for 10ns coincidence window desirable, or < 1ns for 6ns coincidence window
- Gain variance < 25% (35%) rms for 4-pixel (16-pixel) merge





Trigger efficiency: Time jitter & gain variance

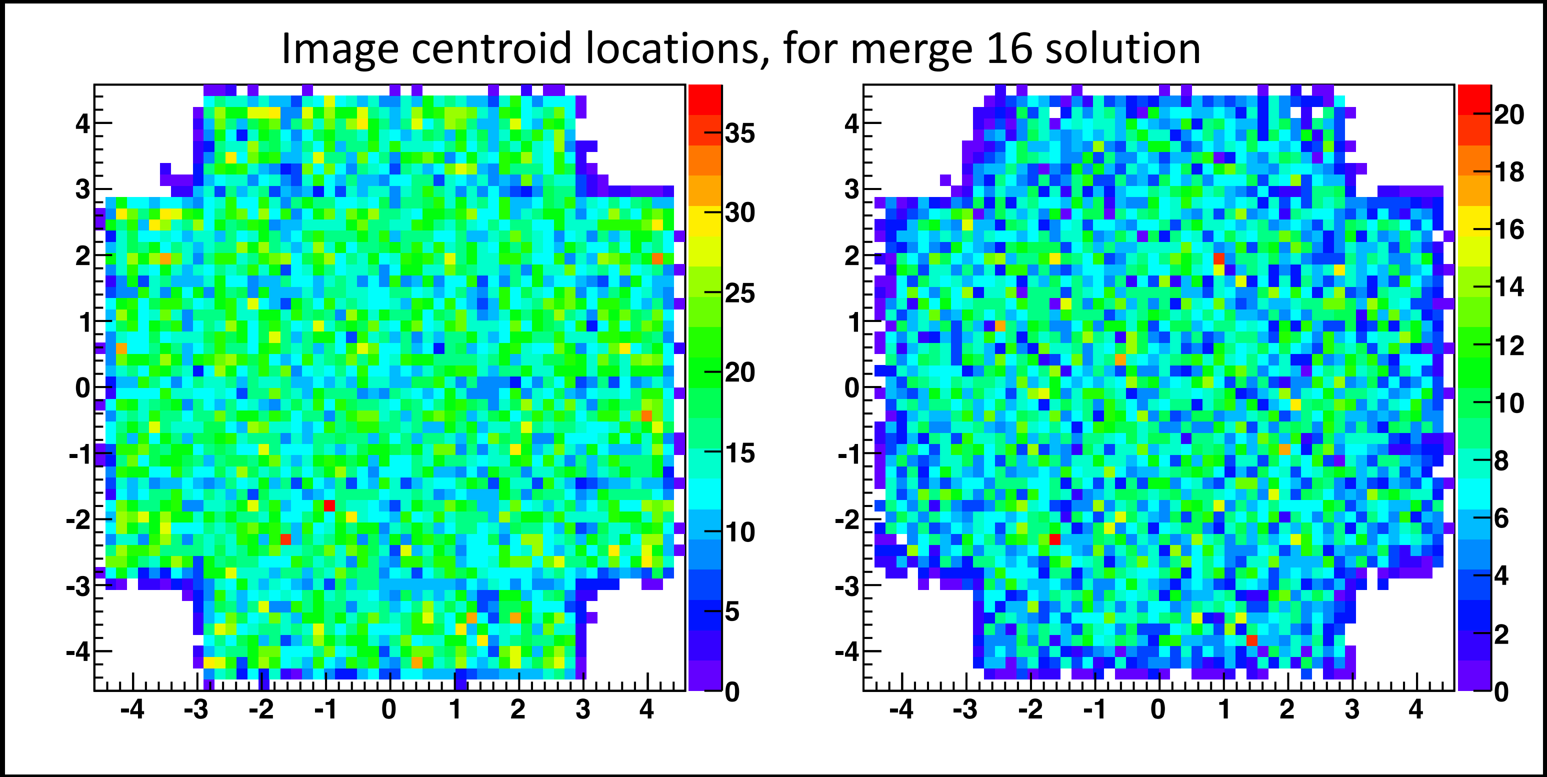
- Combined effect
  - things can turn quite bad if both things get too large, e.g. 2.0ns time jitter and 40% gain variance → threshold increases to ~85 p.e.



Trigger efficiency: Camera uniformity

- Use diffuse gamma-ray simulations and check if camera responds uniformly to signals

> 50p.e. **> 100p.e.**



Trigger efficiency: Camera uniformity

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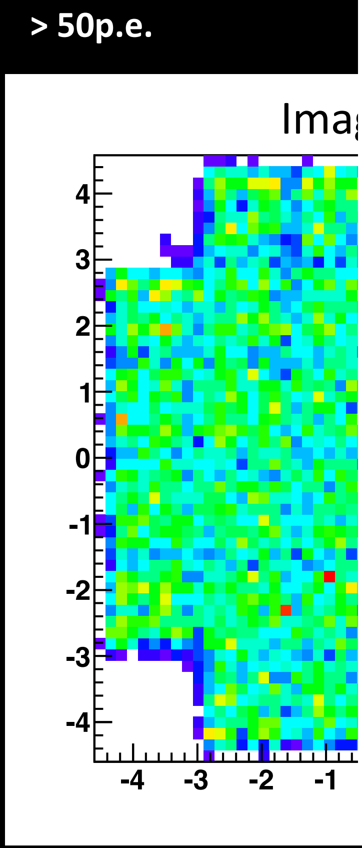

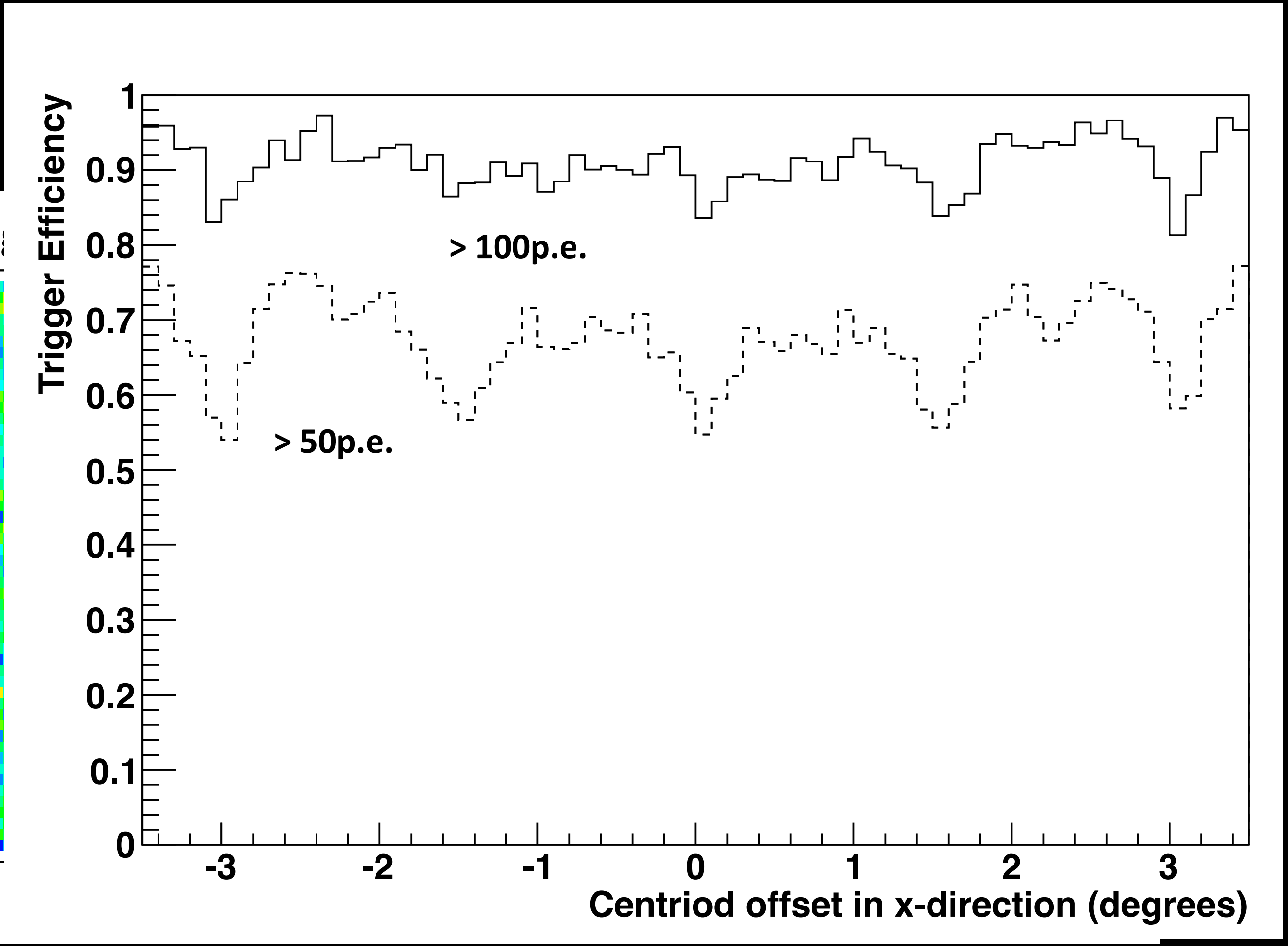

Summary: Recommendations

Recommendations:

Pulse Shape (after pre-amplifier/at Target input):
10-90% risetime **3.5-6.0 ns**, and
FWHM **5.5-10.5 ns**

Trigger logic: analogue sum of 4 pixels, discriminated and sent to camera-trigger where a neighbour requirement and a minimum multiplicity of 2 is applied within a coincidence window (between digital signals on the backplane).

Camera Trigger Coincidence Window: 6-10 ns.

(a simple OR of all discriminated 16-pixel sums is attractive – particularly with clipping, but has inferior performance at larger impact distances – at least when no signal clipping is applied.)

Time jitter on digital inputs to camera trigger: <2ns for a 10 ns coincidence window, <1ns for a 6ns window.

Electronic Noise: <0.5 mV rms per pixel on the trigger path.

Pixel to pixel gain variations: <25% rms (4-pixel sum), <35% (16-pixel sum)

Gaps: <1 pixel=6mm gaps between MAPMs (including glass thickness).