Camera Readout & Shower Time Dispersion

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Summary :

- CTA high energy regime aims at E>>10TeV and covers o(1km2)
  → HE-shower core impact distances are >100m for showers hitting instrumented area.

- For off-axis observation and E>10TeV gammas show significant time spread: >>10ns scale.
  (same for protons; for on-axis gammas much less spread.)
  For the time structure ("duration") see talks CTA-DESY meeting, MST-Paris and FPI/ELEC-Tenerifa 10/2010 (http://www.cta-observatory.org/ctawpcwiki/index.php/WP_ELEC/2010Tenerife)

- We observe
  (1) Loss of Images @trigger-level, even for cameras w/ >>100pe
  (2) Loss of PE's in triggered cameras, since baseline R/O window (o(20ns)) skips them.

(2) → See attached plots for comparisons of default 20ns window versus a 50ns window.
(1) → work in progress

How much a significant gain in (1) and (2) this will improve physics (gain insensitivity/pointing) – is subject of a separate study.

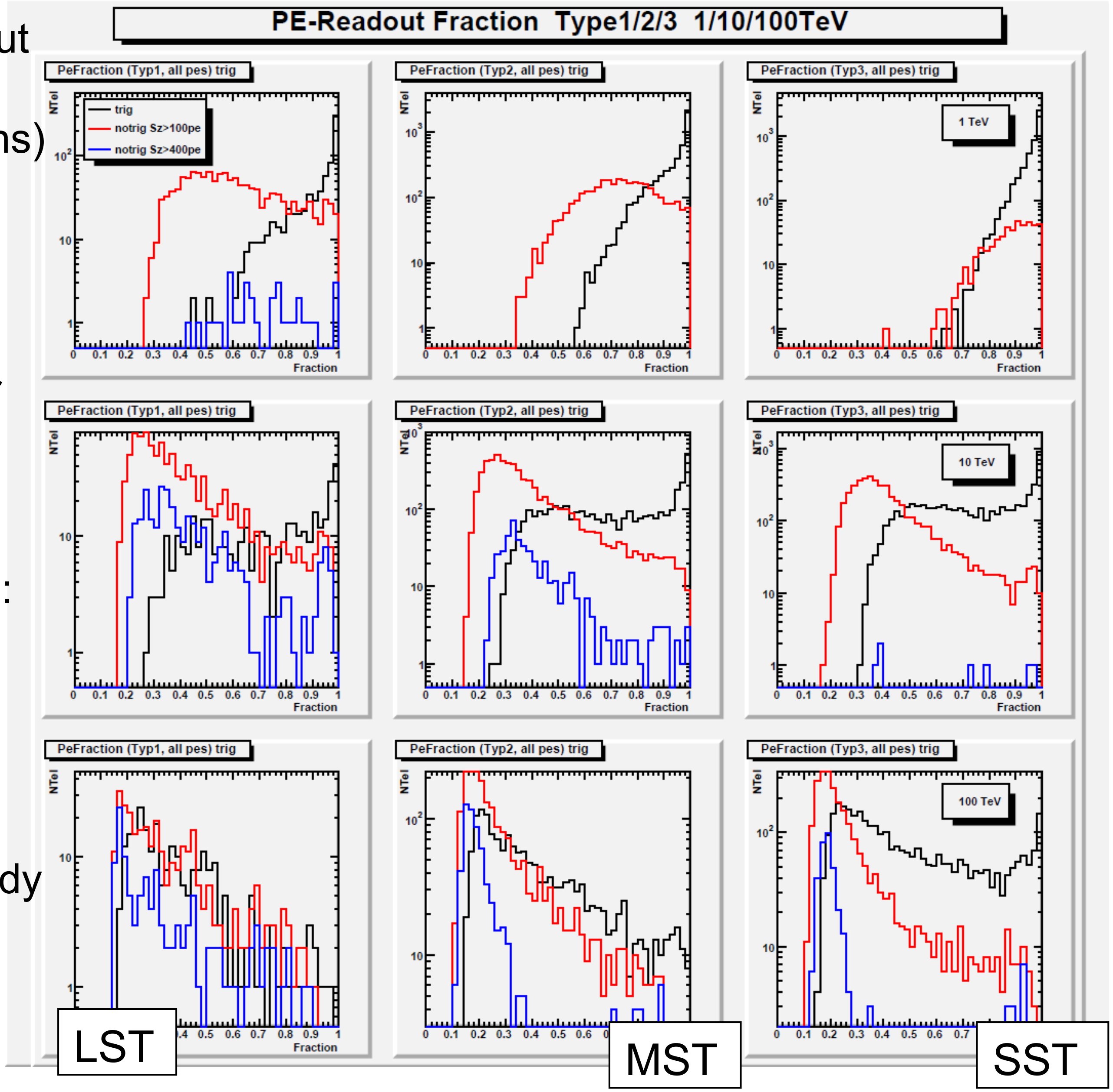
Image Losses: a 20ns R/O-Window

Chose a generic 20ns readout window.
(Hess2/Magic2 use:14ns/25ns)

Plotted:
Maximal Image fraction F_i, that a floating 20ns window will readout (ie. optimized for maximal covered image size for each image).

Shown is for Array E (Ultra3):
- StimTel-triggered images (black)
- non-triggered telescopes
  >100pe (red)
  >400pe (blue)

→ Serious R/O-losses already present for ≥10TeV !



Larger Window: Improvement 50ns.

- 50nsec R/O window as an example:

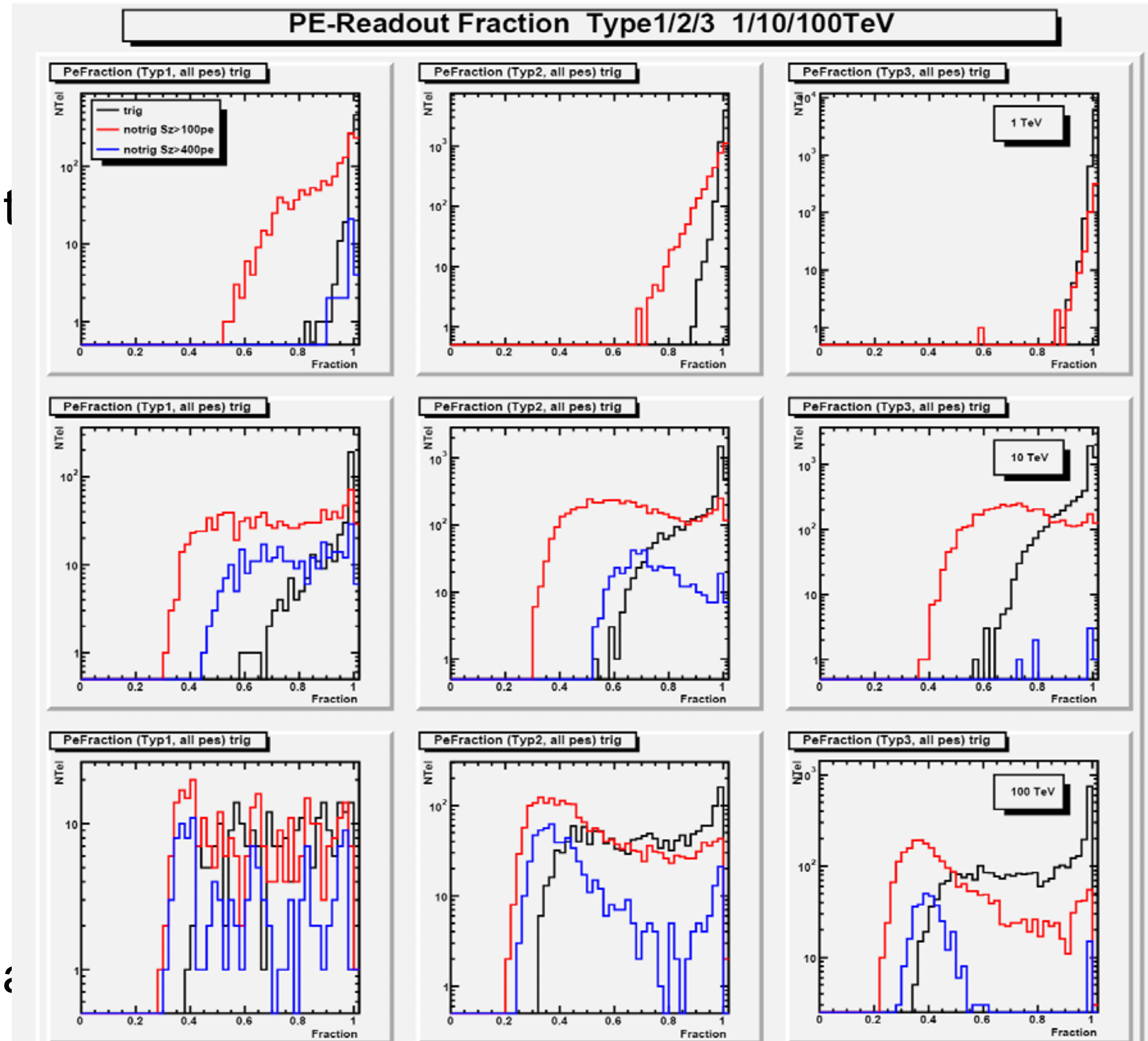
→ Significant improvement

- Avg.RO-fraction (%):
-

	20ns	50ns
1 TeV	95%	99%
10 TeV	75%	95%
100 Tev	45%	75%

- Improved also the non-triggered (simtel NN3) images !!

  (note: we are targeting them as well)



LST

MST

SST

Summary

- **Image timespread is o(50-100ns) for E>>10TeV & large impact & offaxis.**
- **Investigated the pe-arrival times (electronics-independent) and assumed a fixed 20ns R/O-window. Find significant losses for**
  - **Readout of triggered telescopes (NN-Trig - SimTel-default) !!**
    Ie. not for „weak images", as suggested in discussions
    - **Images at ≥ 10TeV are cut down to 20%**
    - **for 100TeV MST, SST readout <fraction> ~ 0.3-0.4, m.p. ~ 0.2, even for large Images.**

- **We suggest, that MC-optimization of the HE-performance is checked wrt this findings. We should find arguments in favour of expecting „optimal CTA performance" (energy resolution, sensitivity) while**
  - **Cutting out 16ns out of o(100ns) spread of triggered Image,**
  - **Not aiming at triggering more telescopes w/ „bright images"**
- Is the potential of current CTA array layout optimally used – by ignoring significant fraction of light in the array (trigger, R/O, analysis) ?
- Is it worth a MC test w/ full (larger) image R/O and adapted analysis ?

→ **Discussion back to MC-WG.**
→ **ELEC: what could be a compromise R/O-window ?**

Summary (2)

→ **Readout Window of >20ns seems indicated (for HE regime).**
Optimization criteria need to be defined.

Next:

- **All discussion so far:**
  at trigger level & additional Image cuts

- **Open:**
  - **What is situation at array level (multi-telescope events) ?**
    Are large images relevant ?

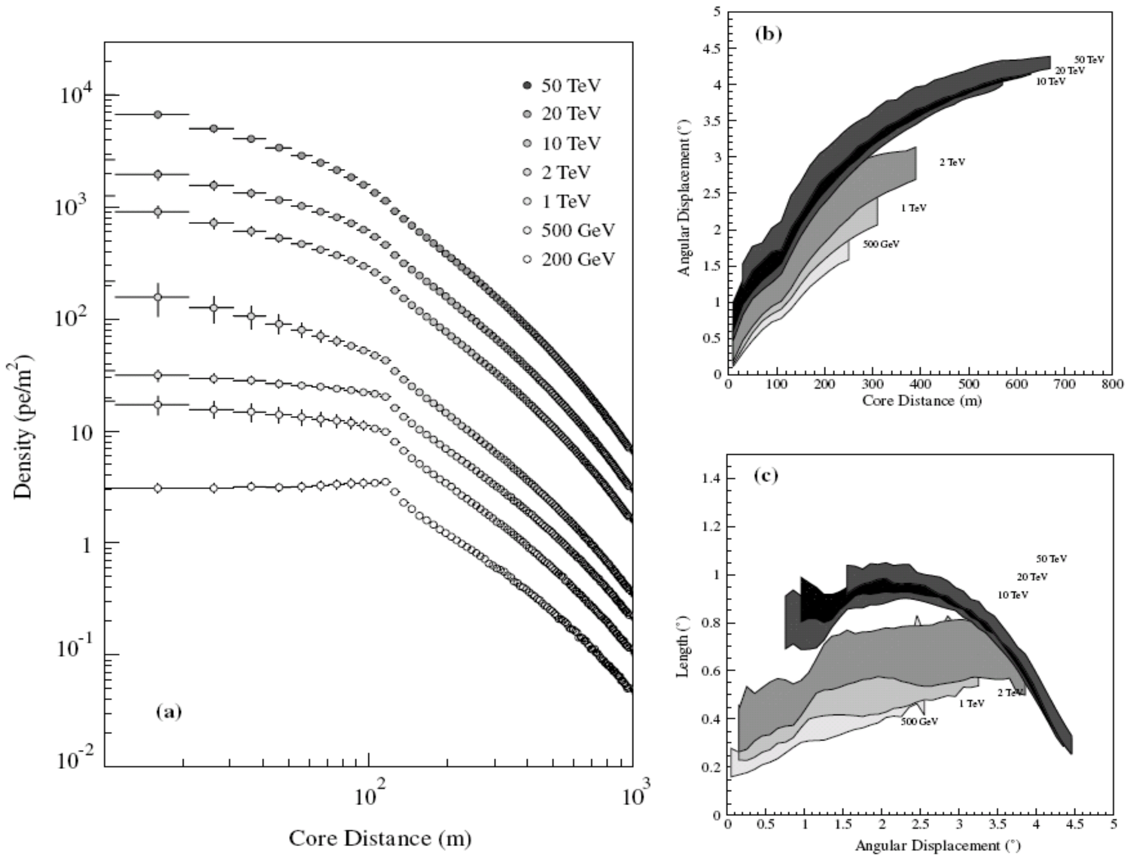
  - **What is the influence on reconstruction / sensitivitiy / angular resolution ?**

…backup…

Lightpool vs. Energy / Distance

Photondensity vs. core distance

Image displacemnt vs. core distance



1. (a) Simulated average Čerenkov lateral distribution for showers initiated by γ-rays of various energies, convolved with atmospheric extinction, ›or reflectivity and typical photomultiplier tube efficiency. All simulated showers were generated from a zenith angle of 0° with an assumed observation . for detection of 2400 m above sea level. (b) Image angular displacement ($\mathscr{D}$) as a function of core distance and (c) image length ($\mathscr{L}$) as a function of ılar displacement for 0.5, 1, 2, 10, 20 and 50 TeV γ-ray showers. The shaded bands include 68% of the events about the median. The observed turn- · of the image length distribution for higher energies and larger displacements is due to image truncation by the camera edge (with a radius of ∼5°).

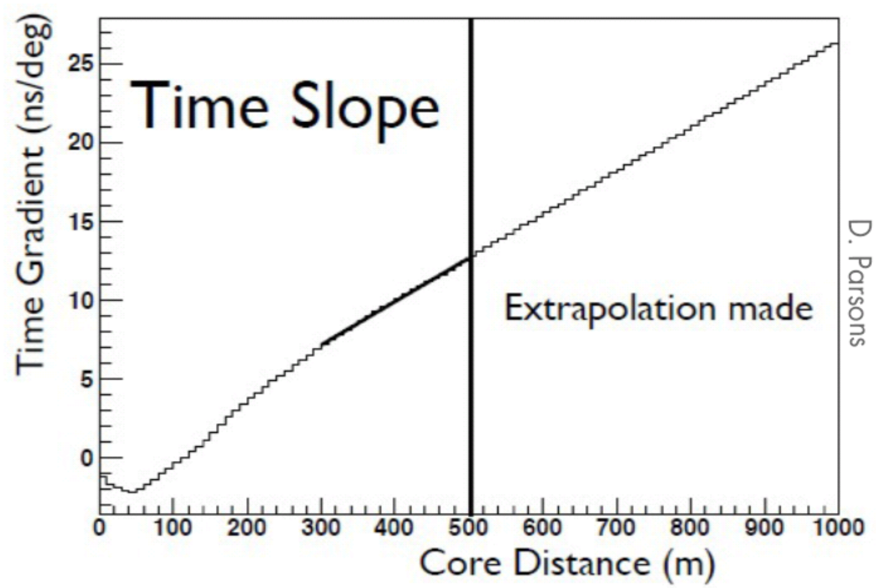
Biller, APP2006

Shower time spread

With large core distance and higher E:

Images become longer/wider; displaced from center

For time slope, see eg. D.Parsons plot.



Overview

- **Application of *trigsim* (see preceding talk) as a tool for pe-file analysis and emulation of trigger concepts**

- **Read MC-files of raw pe's (from simtelarray) (local Desy-DB)**
  - all pe's are available (minimal cut >15pe in camera)
  - no CamElec simulation (optional)
  - no NSB included (optional)
  - compare with default NN-trigger: SimtelarrayTrig

- **Aim:**

  A. Study the „event duration" **in raw pe's (neglect ELEC) :**

  (1) T_full = full event spread: (t_last_pe – t_first_pe) for all pe's from
  - all pixels, or
  - restricted to pixels with amp-cut (≥3pe, 5pe, 10pe, …)

  (2a) T50 = arrival time for 50% of all pe's

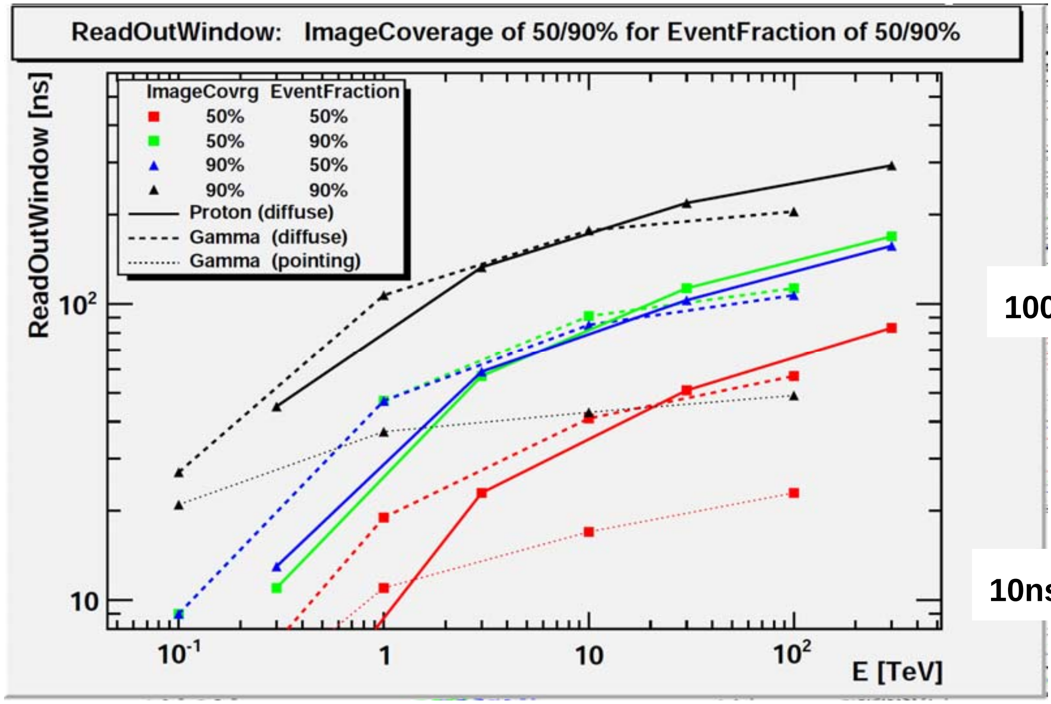
  (2b) T90 = arrival time for 90% of all pe's

  B. Image Losses due to Readout:

  14…25ns R/O window → which pe-fraction is readout ?

Time dispersion: ReadoutWindow

- **ReadoutWindow to cover 50% or 90% of all pe's for 50% or 90% of all events for gammas (diff/pointing) and protons:**



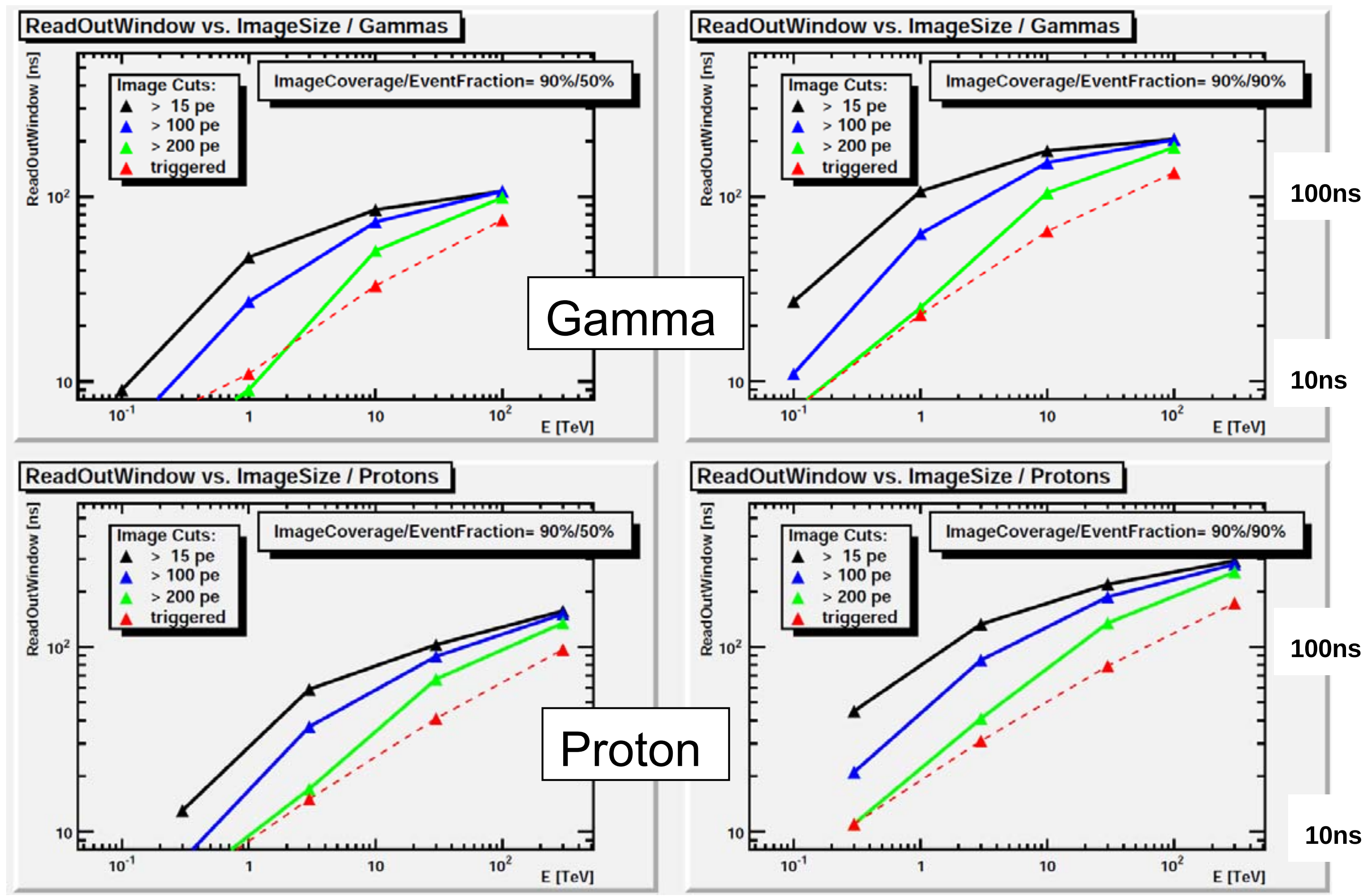
➔ To readout

- **only 50% pe for 50% events: 40ns… 60ns for 10TeV…100TeV**
- **50% pe for 90% evts (or 90%/50%) 80ns..110ns for 10TeV…100TeV**

Note: (1) averaged over all ULTRA3 telescopes, and telescopes (trigg & non-trig)
(2) for default simtel-trig, spread is somewhat lower (30-90ns 10-100TeV), see CTA-Zeuthen.

R/O-window: do nontrig'd / faint Images dominate ?

- **ReadoutWindow to cover 90% of all pe's for 50% of all events for gammas (diff/pointing) and protons, separately for:**
  - **- All Im**
  - **- Im>100**
  - **- Im>200**
  - **- SimTel-trig Tel**



➔

Even for SimTel-trigg'd Telescopes :

- **For only 90% pe for 50% events - 30ns... 80ns for 10TeV...100TeV !**