Time Dispersion of Showers

R. Wischnewski (DESY), U. Schwanke (HU-Berlin)

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Motivation:

- The time structure of showers in camera plane, with focus on high energy .
  (Topic raised by MC-WP)

- Does time structure (spread) of gamma / proton showers change
  from the canonical o(10ns) toward high energies (>>1TeV) ?
- What about off-axis observation & large impact distances ?

- Do we
  (1) read out trigger the shower information efficiently ?
  (2) do we trigger telescopes with medium / large images efficiently at highE ?
  (3) at array level: if telescopes don't trigger or are only partially read,
  at what level is array data quality distorted ?

Update; For details, see CTA-meeting, 5/2010

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 ?

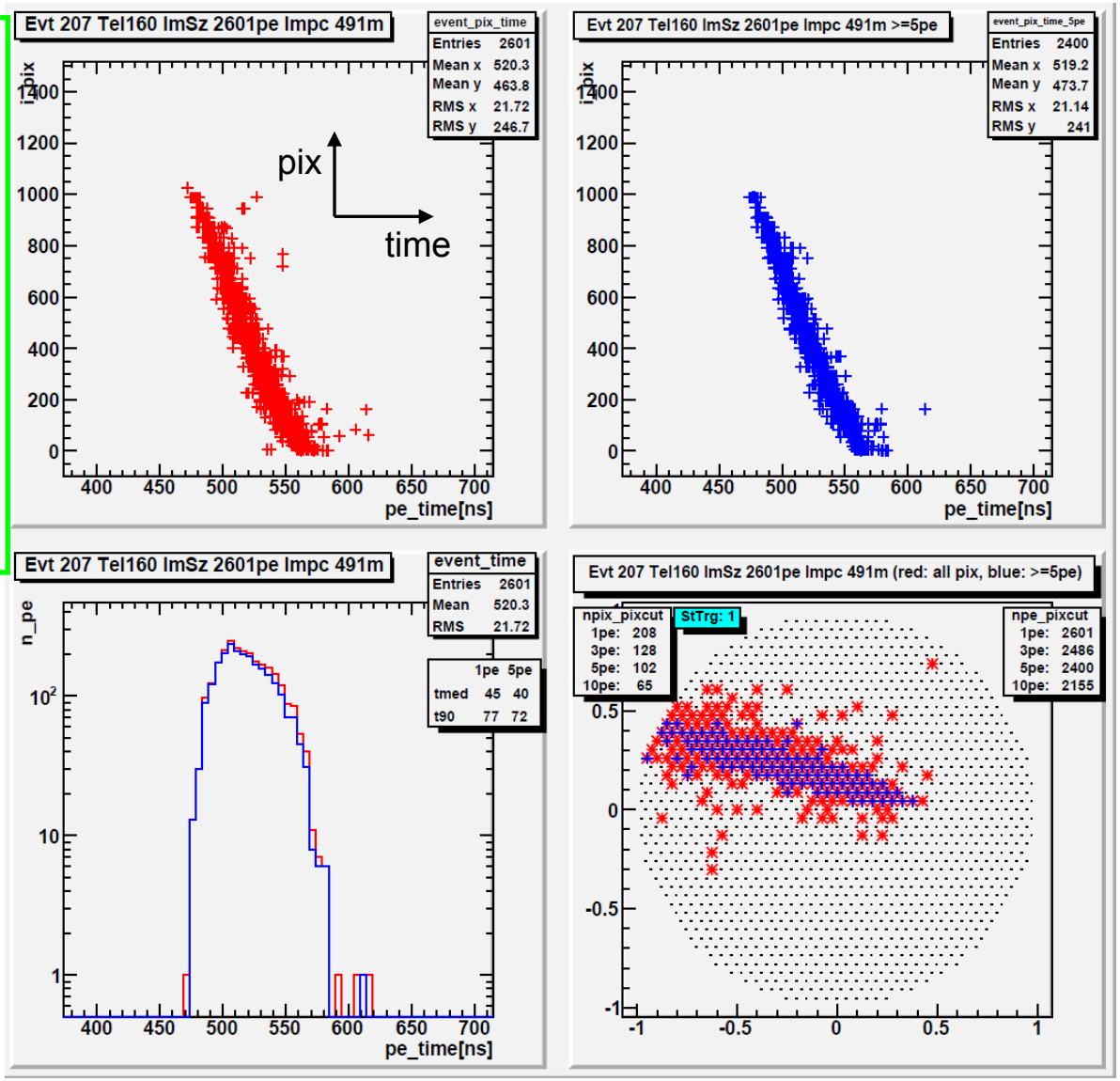
Time Dispersion / Gamma 100TeV

- **A simple „Event Display" with:**
  - **Pixel# vs time**
  - **pe-time distribution for**
    - **all_pixels (≥ 1pe), and**
    - **pix(≥ 5pe)**
  - **Camera w/ pix cuts (1/5pe)**
  - **SimTelTrigger Flag**
  - **Times T50/T90, ...**

- **100TeV Gamma (diff.)**
- **Impact=490m, 2600pe**
- **SimTel-triggered**

Duration = 130ns
T50 = 45ns
T90 = 90ns
Ev_207_160_100T_gam_d

SST / Tel160

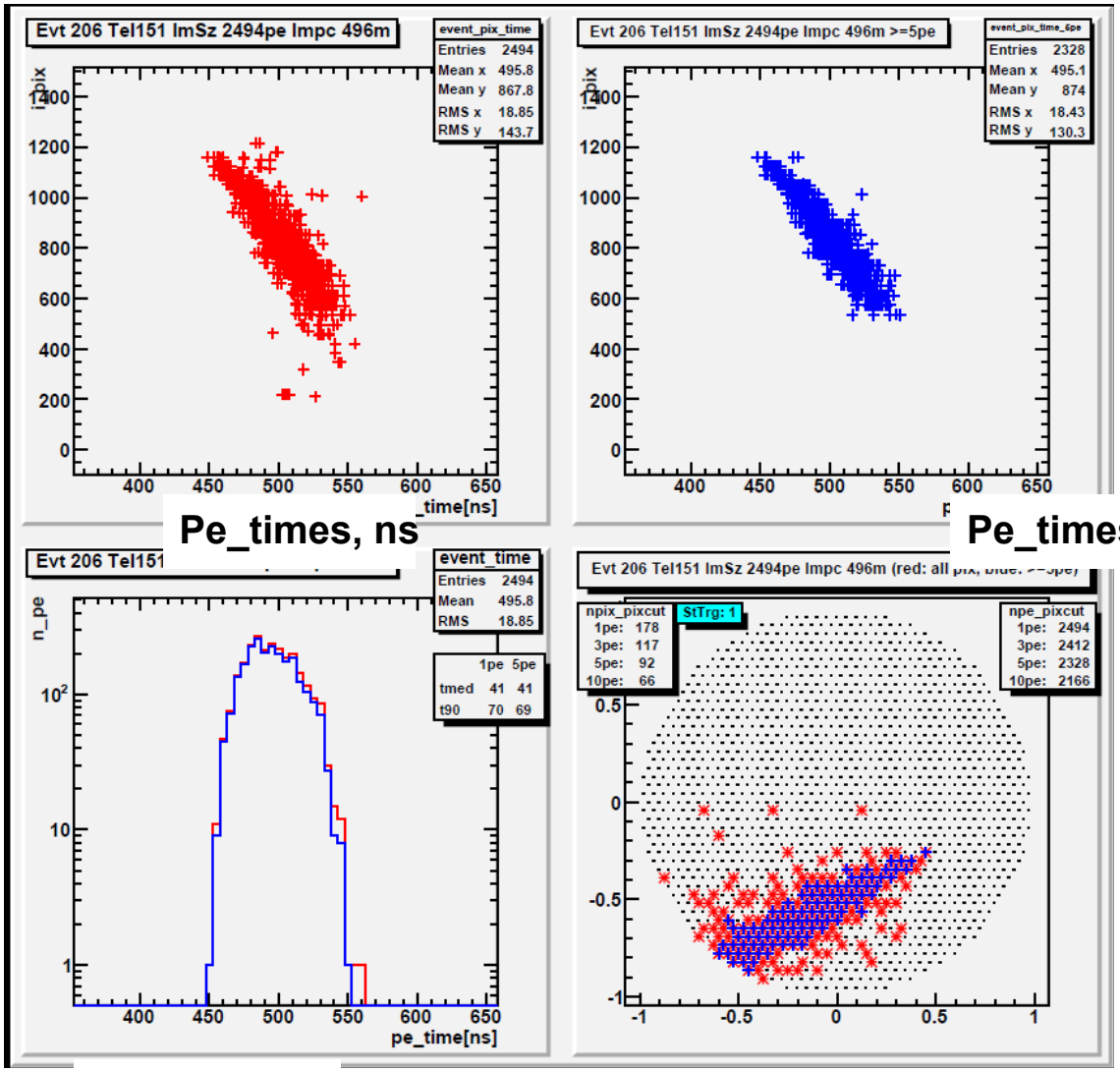


Gamma 100TeV

- **100TeV Proton(diff.)**
- **Impact=490m, 2500pe**
- **SimTel-triggered**

Duration = 170ns
T50 = 41ns
T90 = 70ns
Ev_207_151_100T_gam_d

SST / Tel151

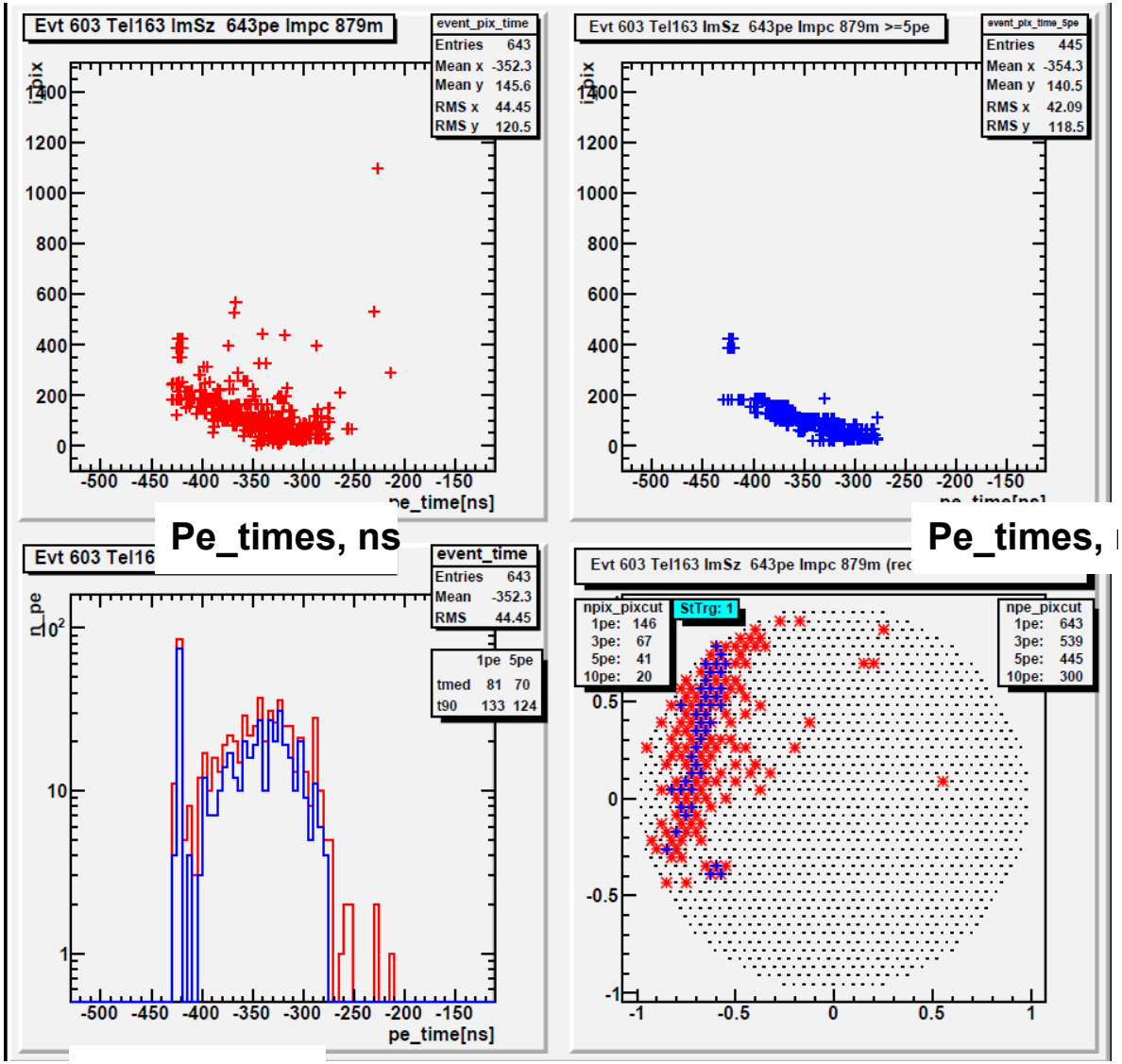


Proton 300TeV

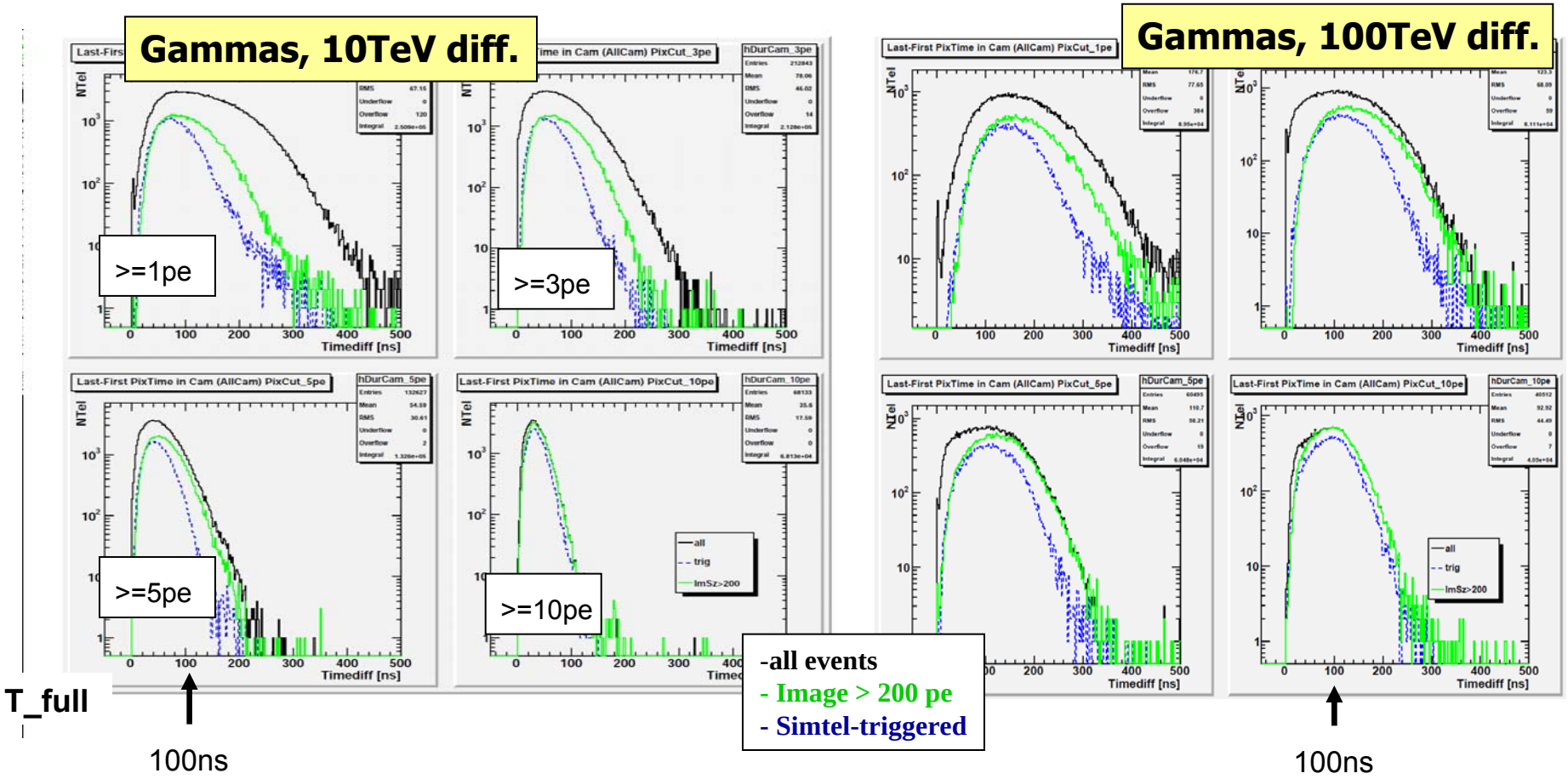
- **300TeV Proton(diff.)**
- **Impact=490m, 2600pe**
- **SimTel-triggered**

Duration = 170 ns
T50 = 81 ns
T90 = 133 ns
Ev_603_163_30T_prot

SST / Tel163



Event duration: T_full



Time-Duration T_full for all pe's contained in pixels with ≥1, 3, 5, 10 pe's.

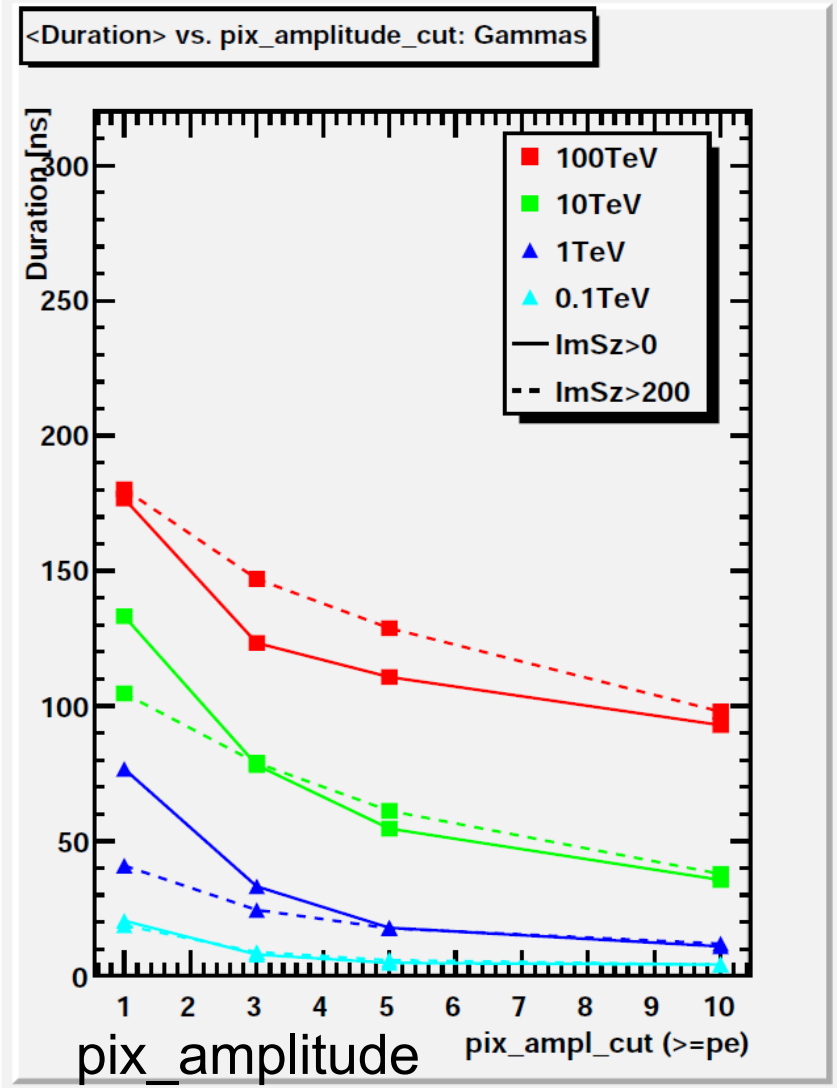
T_full rises with energy:

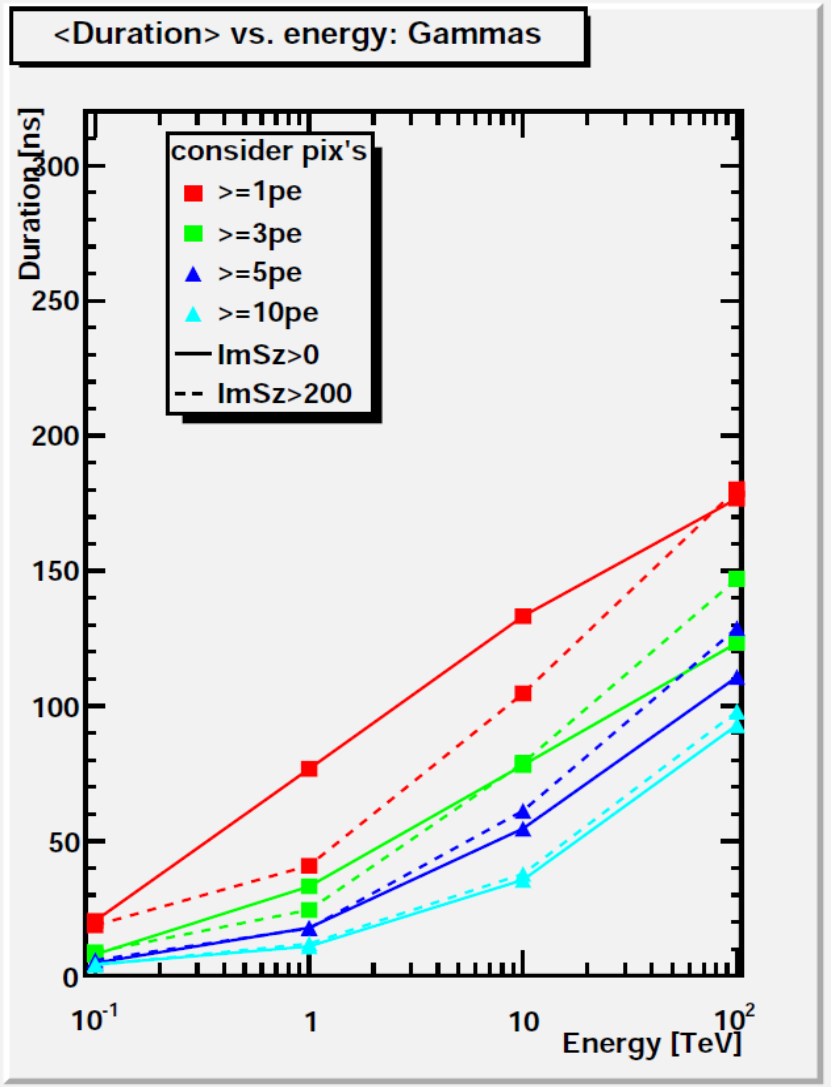
➔ **<time> to read all pe's**

for all 5pe pix's is .... 60...110ns for 10...100 TeV,

for all 10pe pixels is still .... 30...90ns ! **(details: Zeuthen-Meeting)**

Avg. EventDuration vs. Energy: Gammas (diffuse)

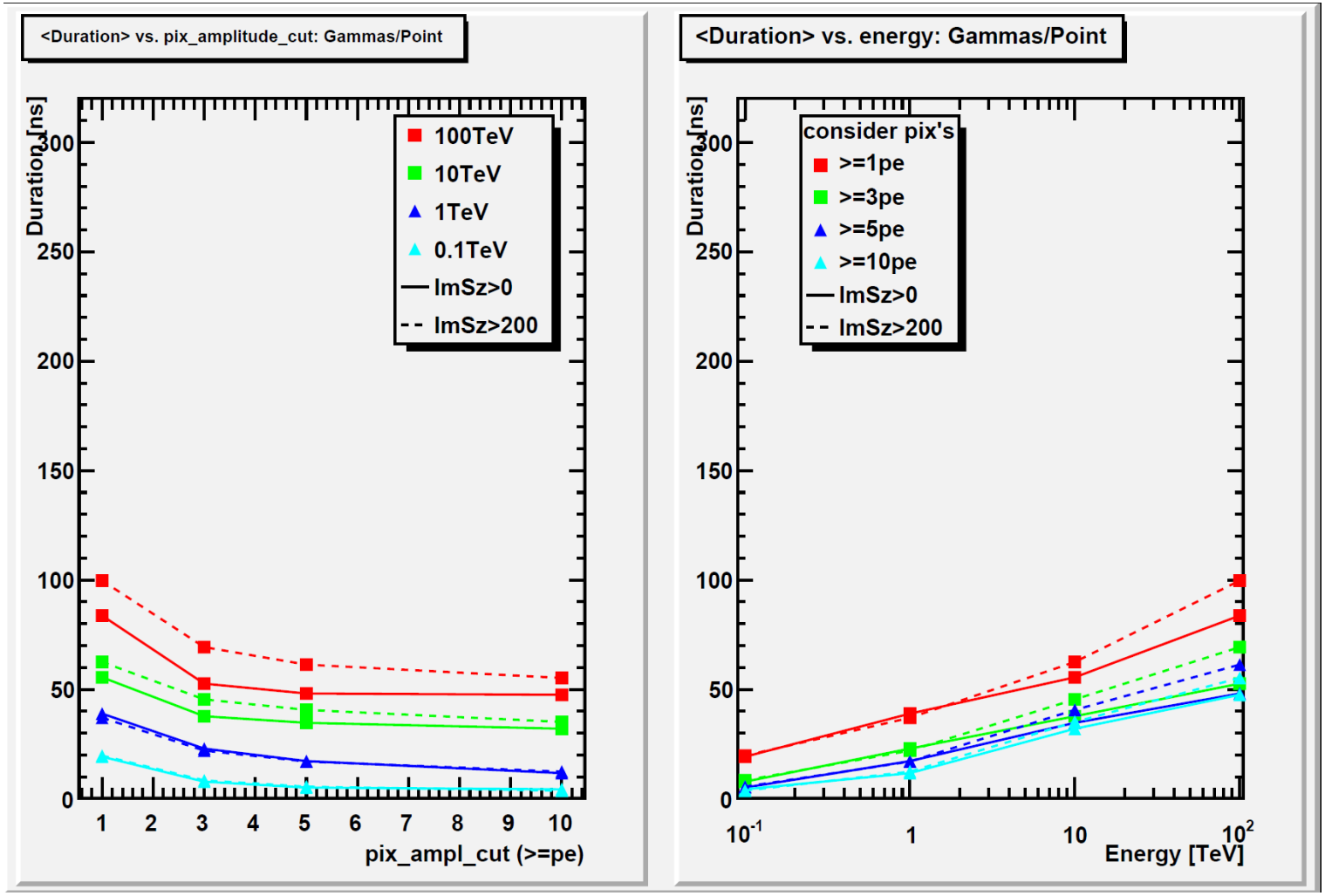




Energy

Consider pe's from pixels with ≥1pe, ≥3pe, ≥5pe, ≥10 pe.

Avg. EventDuration vs. Energy: Gammas (pointing)

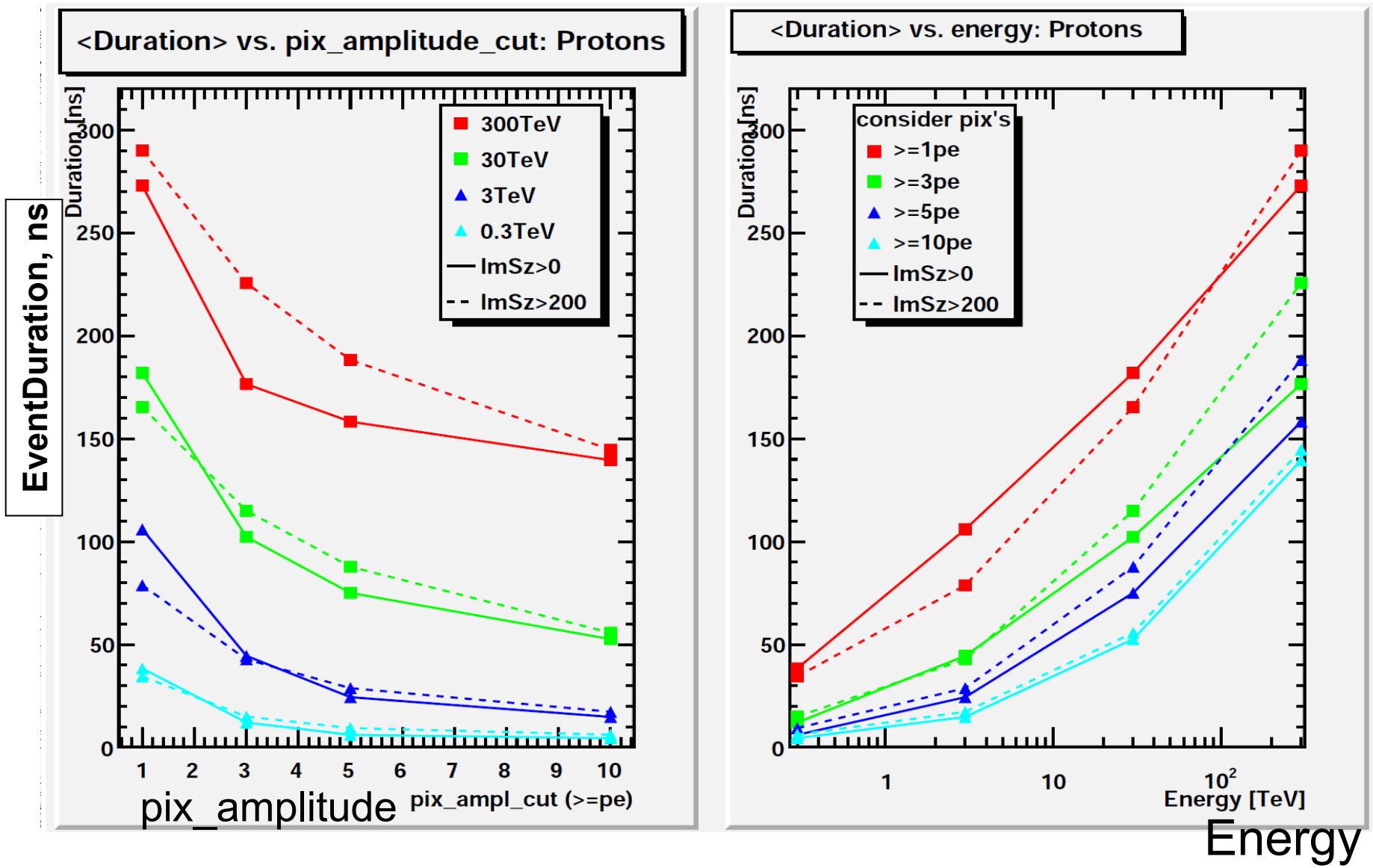


pix_amplitude

Energy

Consider pe's from pixels with ≥1pe, ≥3pe, ≥5pe, ≥10 pe.

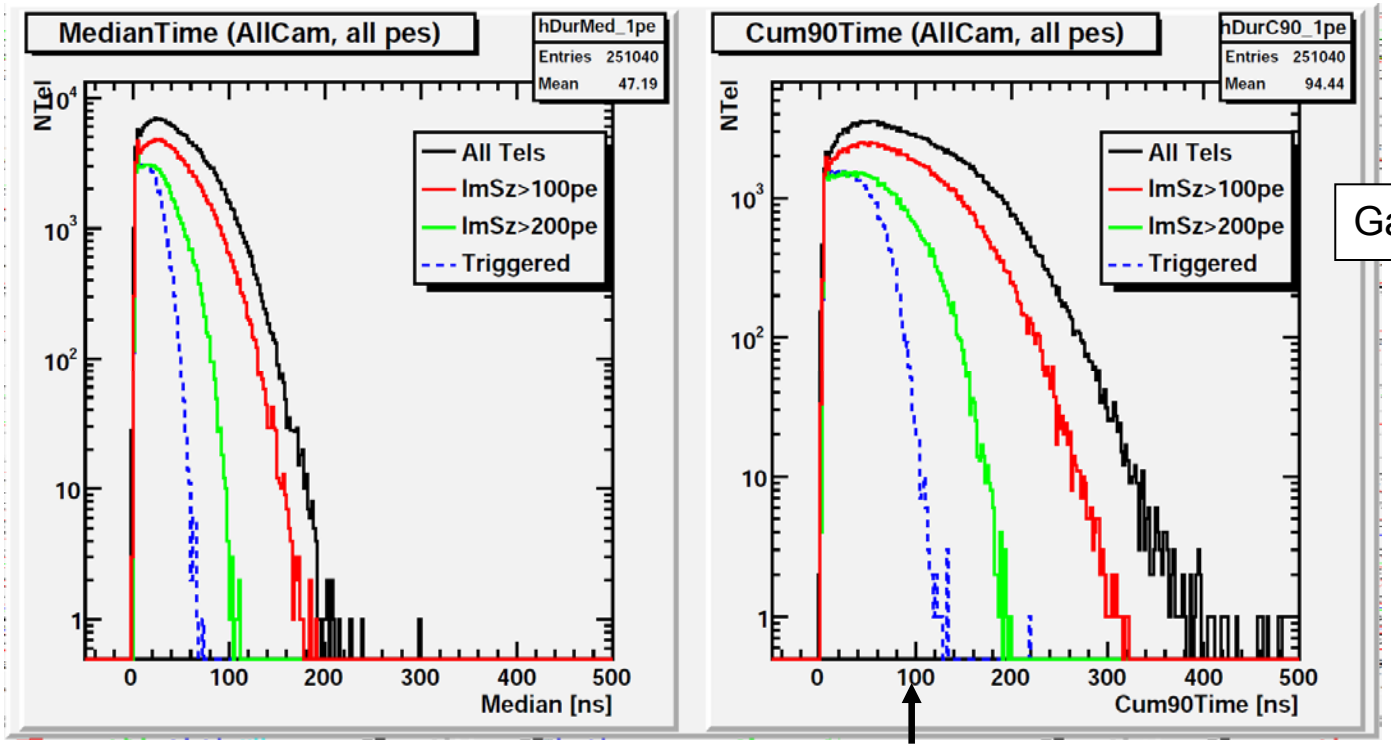
Avg. EventDuration vs. Energy: Protons



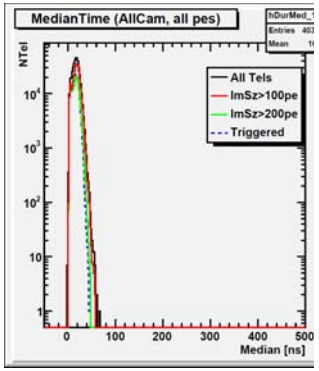
Consider pe's from pixels with ≥1pe, ≥3pe, ≥5pe, ≥10 pe.

ReadoutTime T50 / T90

- **Distribution of time to readout 50% and 90% of all pe's for: all events, ImSize>100pe, >200pe and „triggered" (simtel)**
- **We find: <u>Gammas 10TeV (diffuse) → median(T50) is 40ns !</u>**



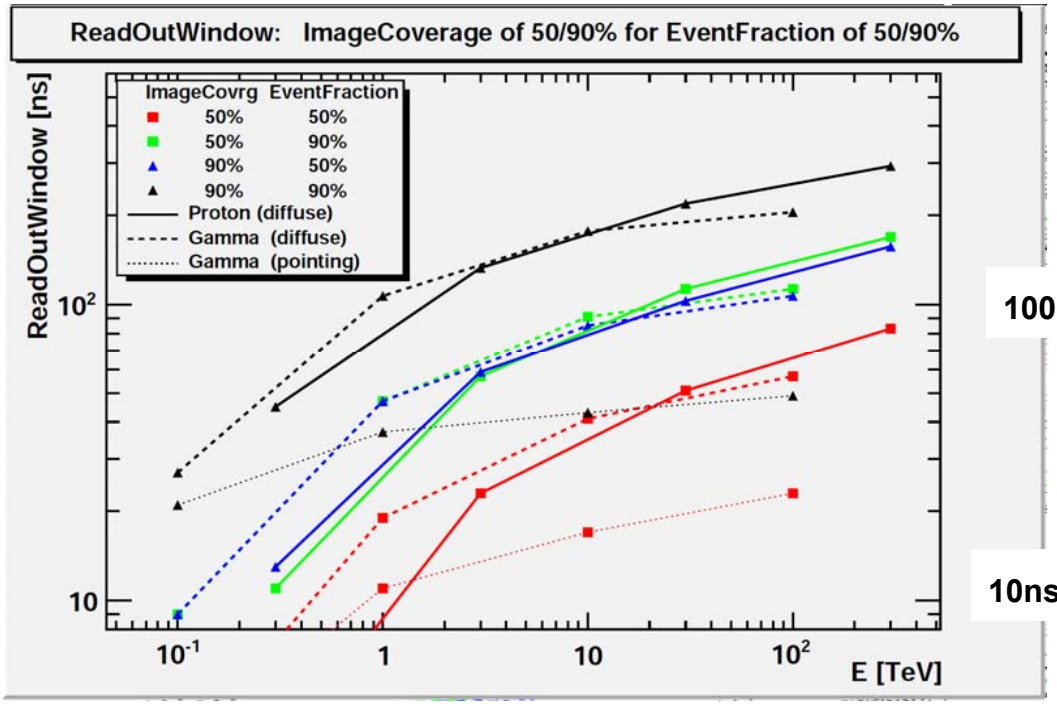
Gammas 10TeV (diff)



Note: (1) in pointing mode: gammas have much less time spread
(2) BG has same (or larger) spread like diffuse gamma.

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:**



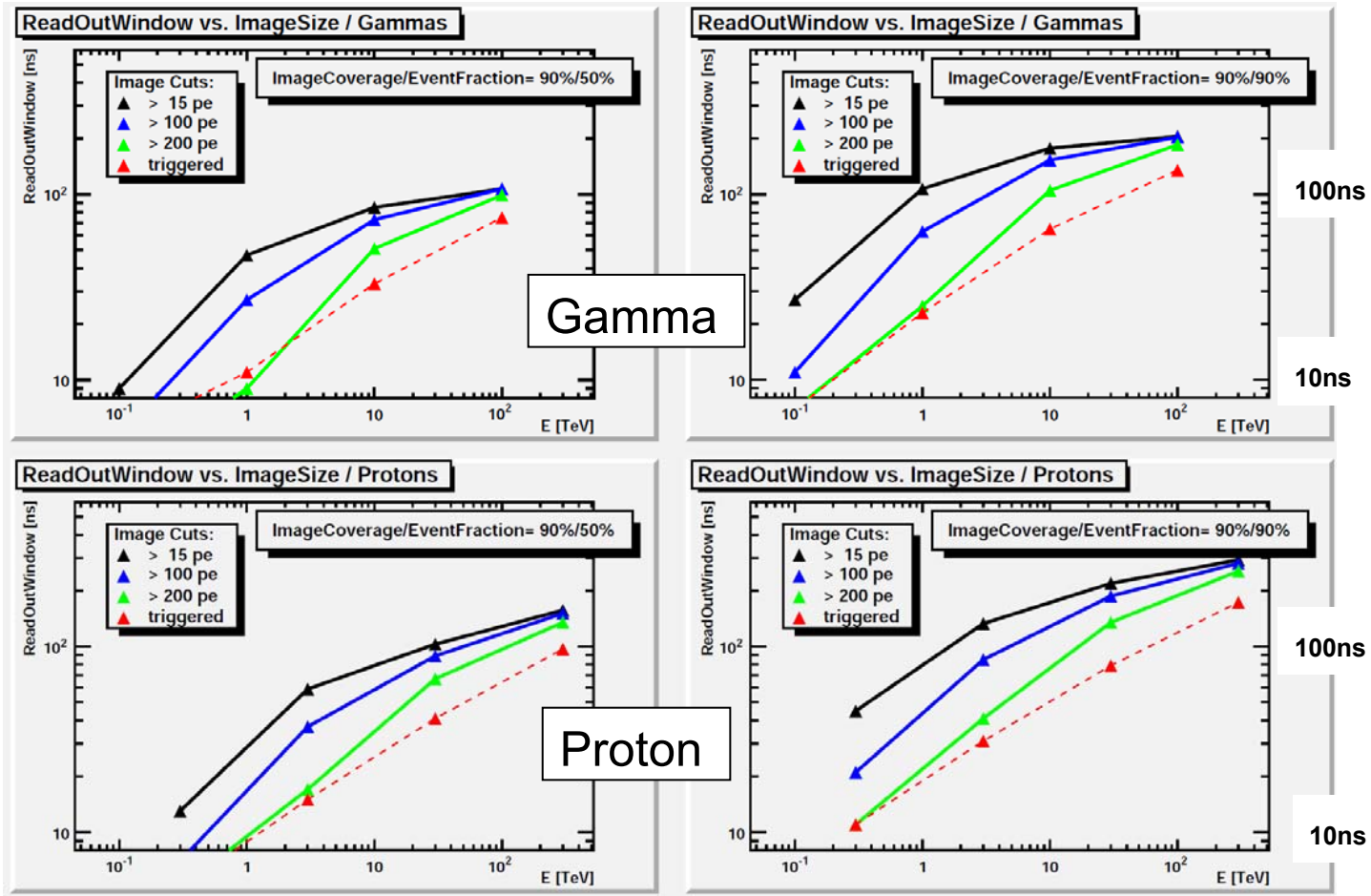
➔ **To readout**

- **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 !**

Image Losses: a 20ns R/O-Window

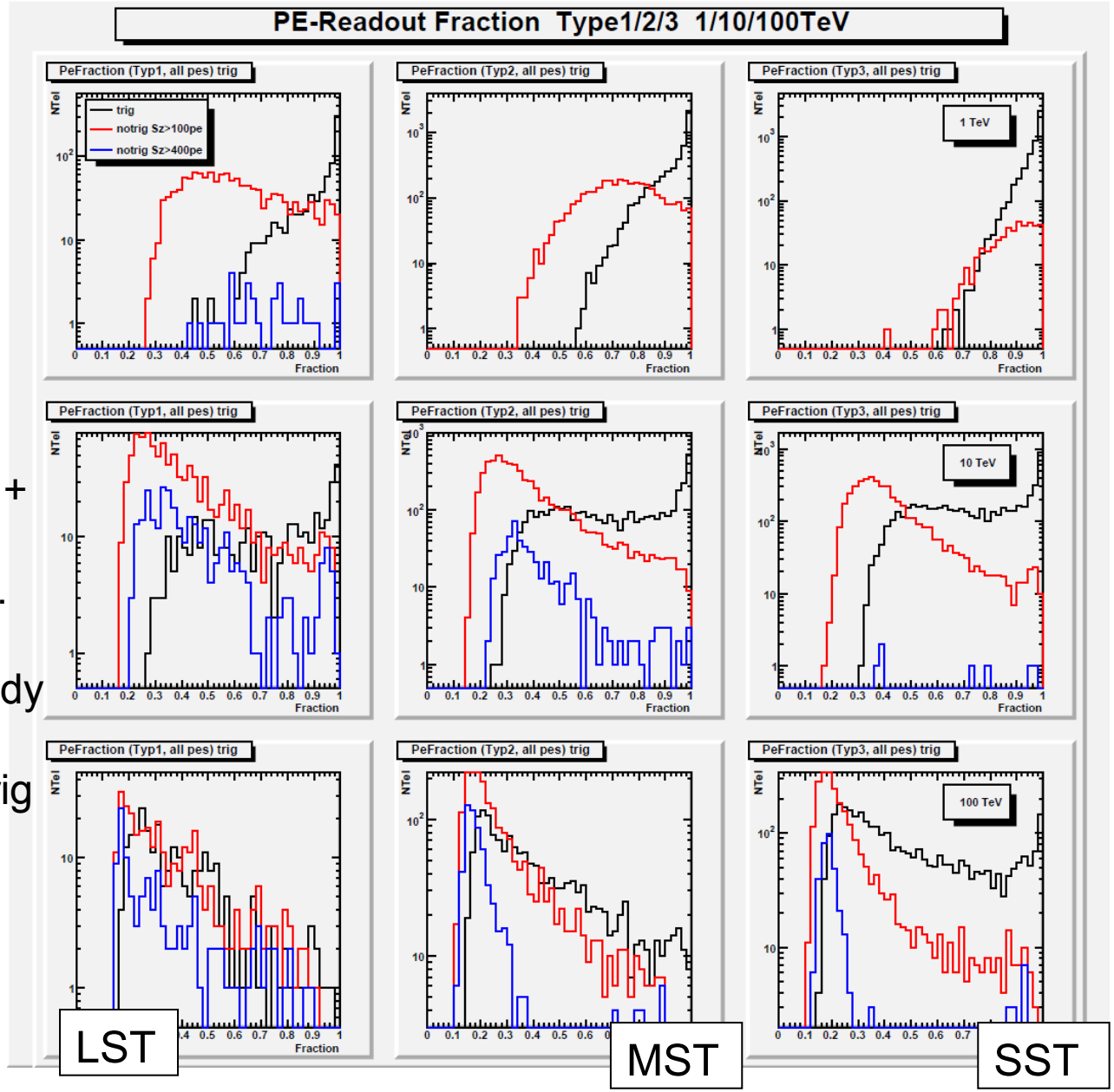
Hess2 / Magic2:
R/O window of 14ns / 25ns.

Plot:
Maximal Image fraction F_i, that a floating 20ns window will readout (ie. optimized pixelwise).

Shown for StimTel-triggered + non-triggered telescopes w/ 100pe/400pe (for ArrayE).

→ Serious R/O-losses already present for ≥10TeV !
(for LST also at 1TeV: non-trig evts in interm. ImSize?)

F_Im (10TeV) xx% < 0.8
F_Im (100TeV) xx% < 0.8



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 ?**

… thanks …

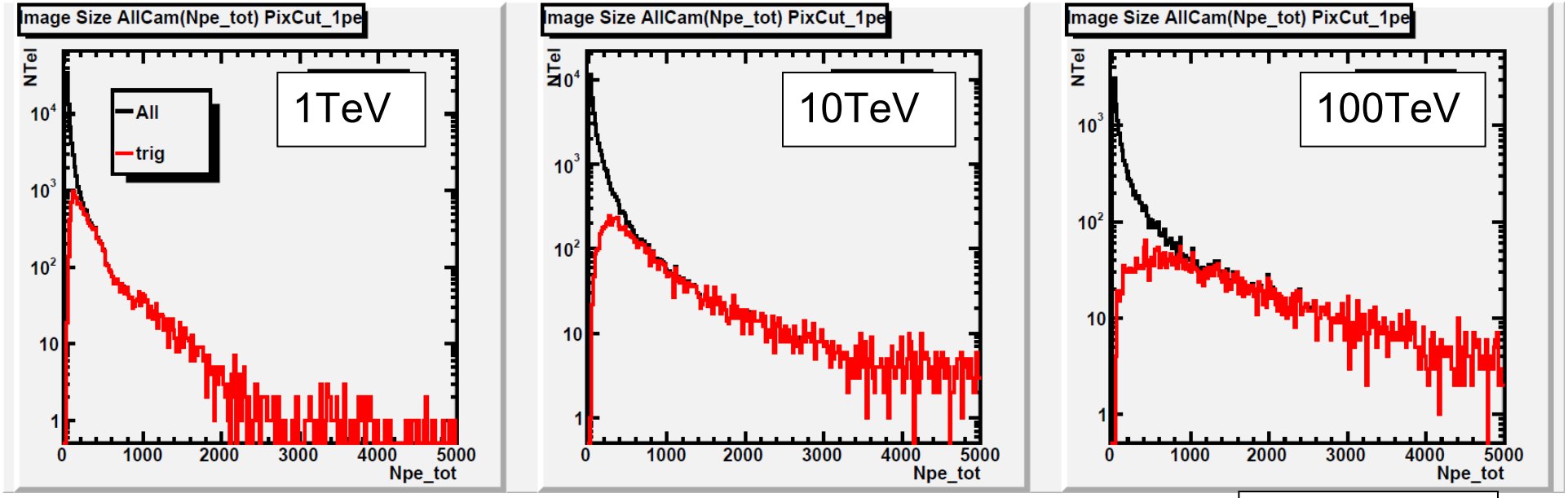
… Backup …

Triggering vs. Image Size

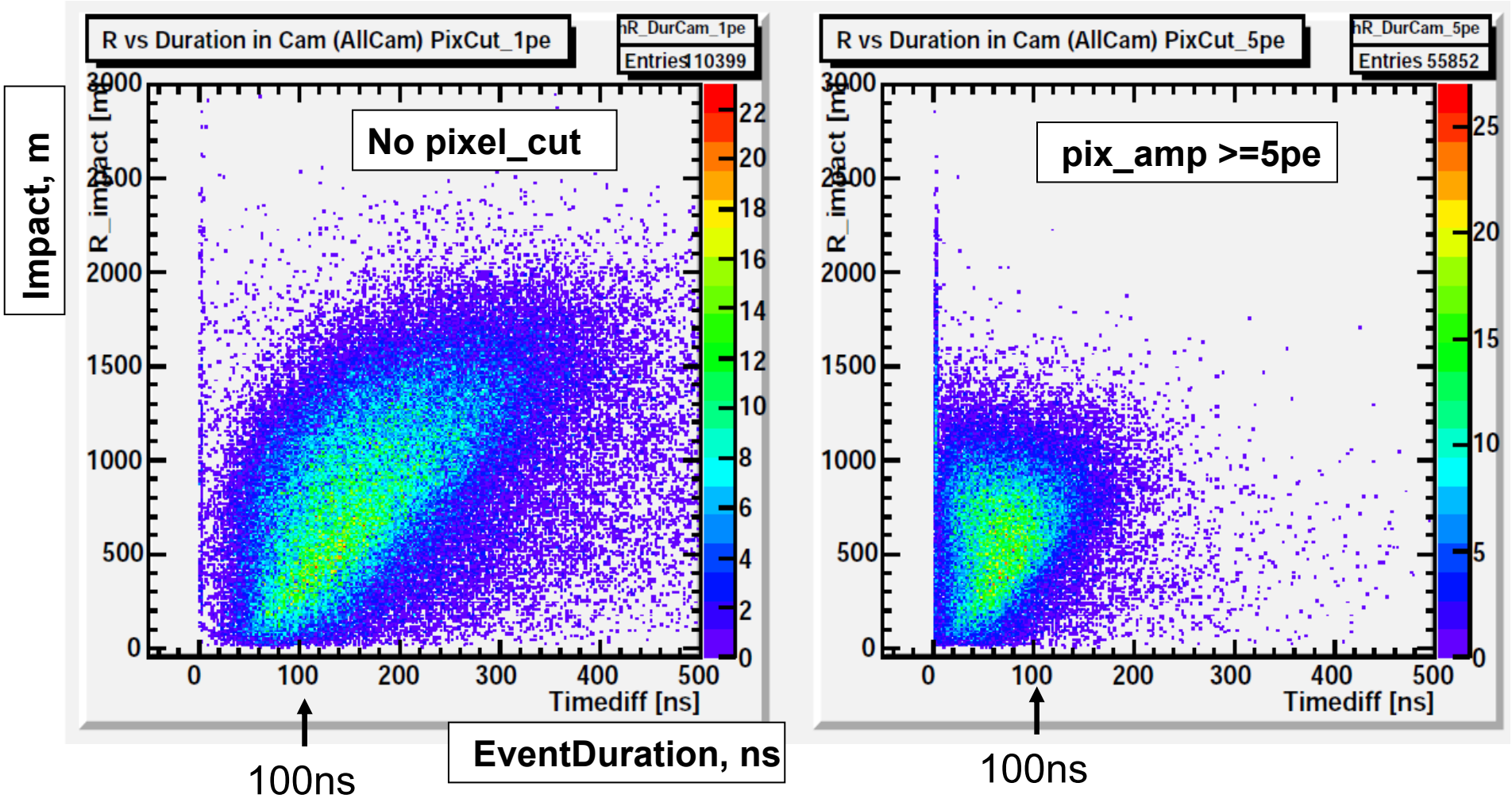
The fraction of medium+large size Images (<<1000) that are trigger varies with energy.

Full efficiency at 1TeV 200pe, 10TeV 800pe, 100TeV 1000pe

(data are summed for LST/MST/SST for the “Ultra3Array E”, diff. gamma).



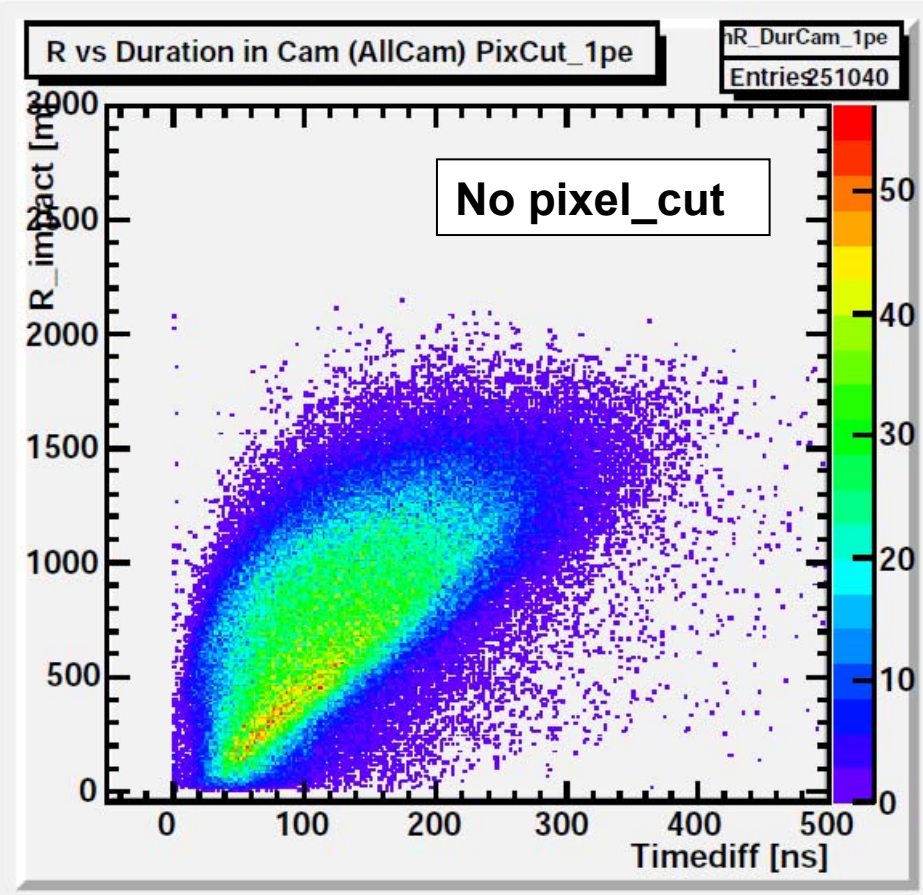
Impact vs. EventDuration

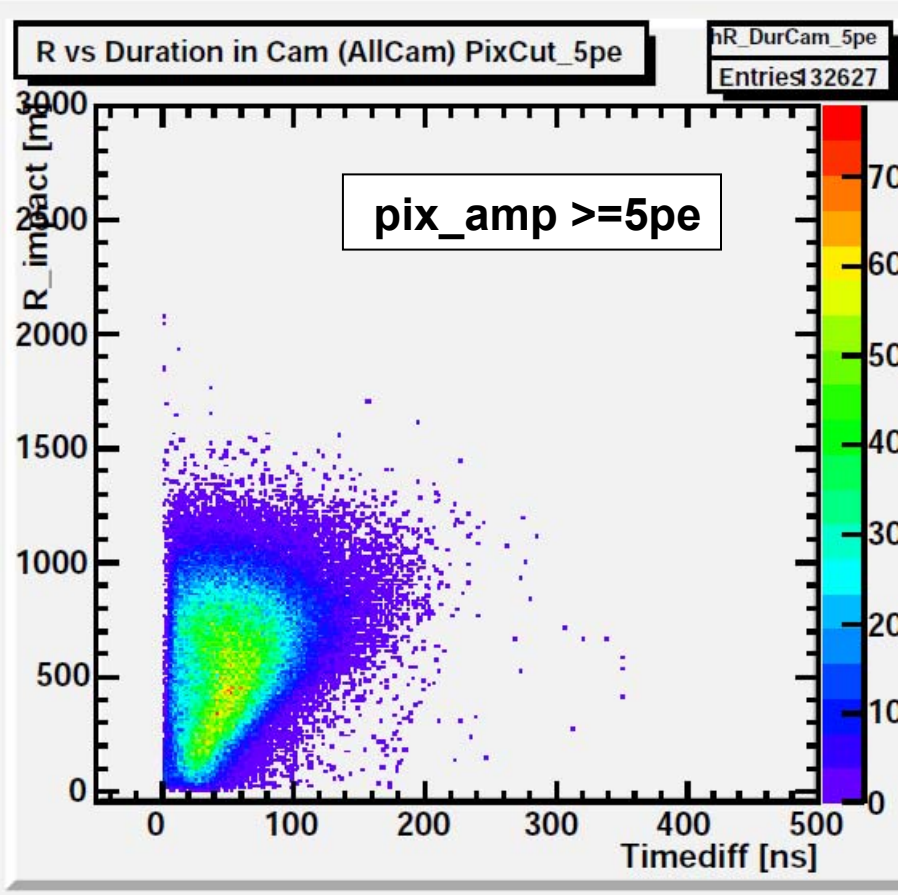


Protons 30TeV

(for two amplitude cuts).

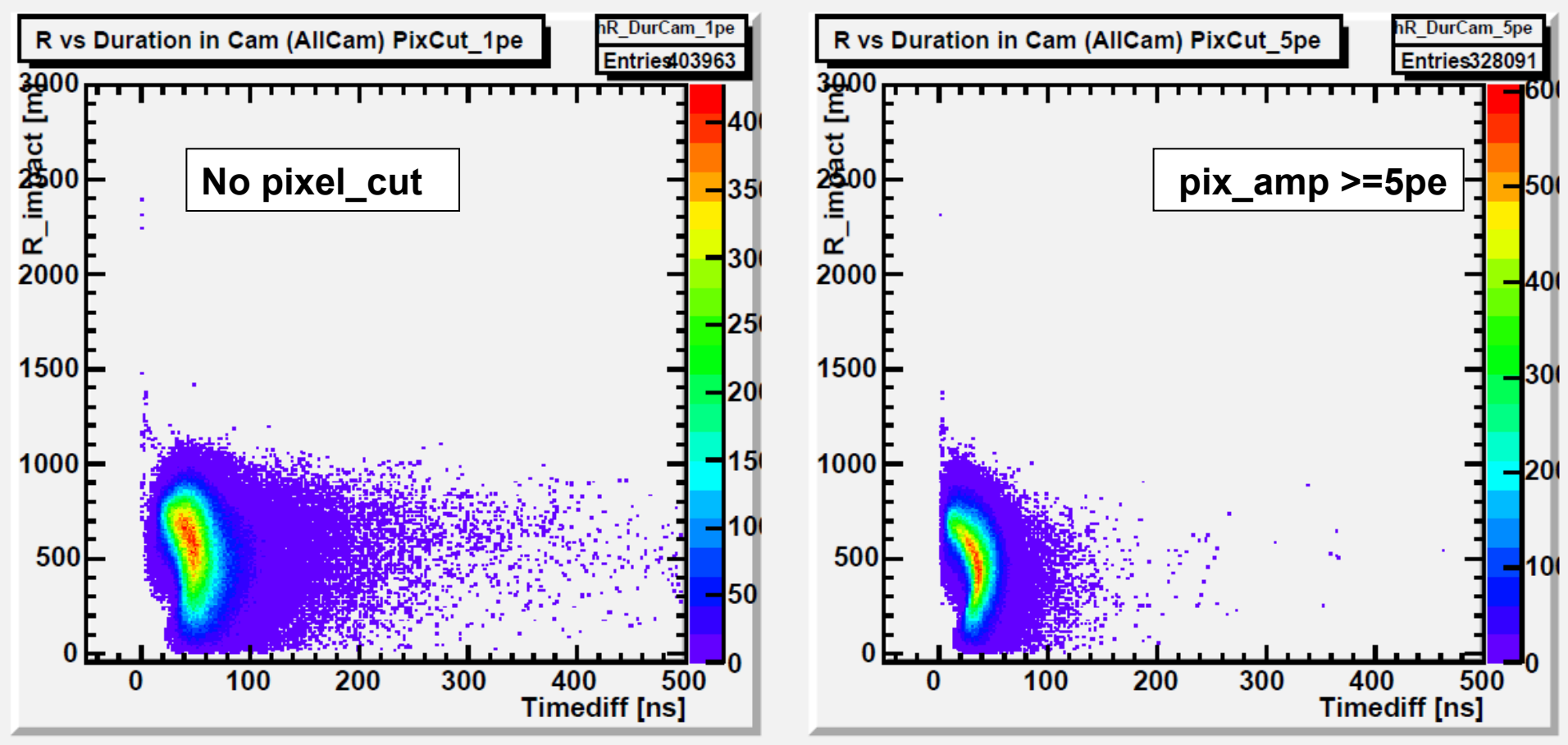
Impact vs. EventDuration





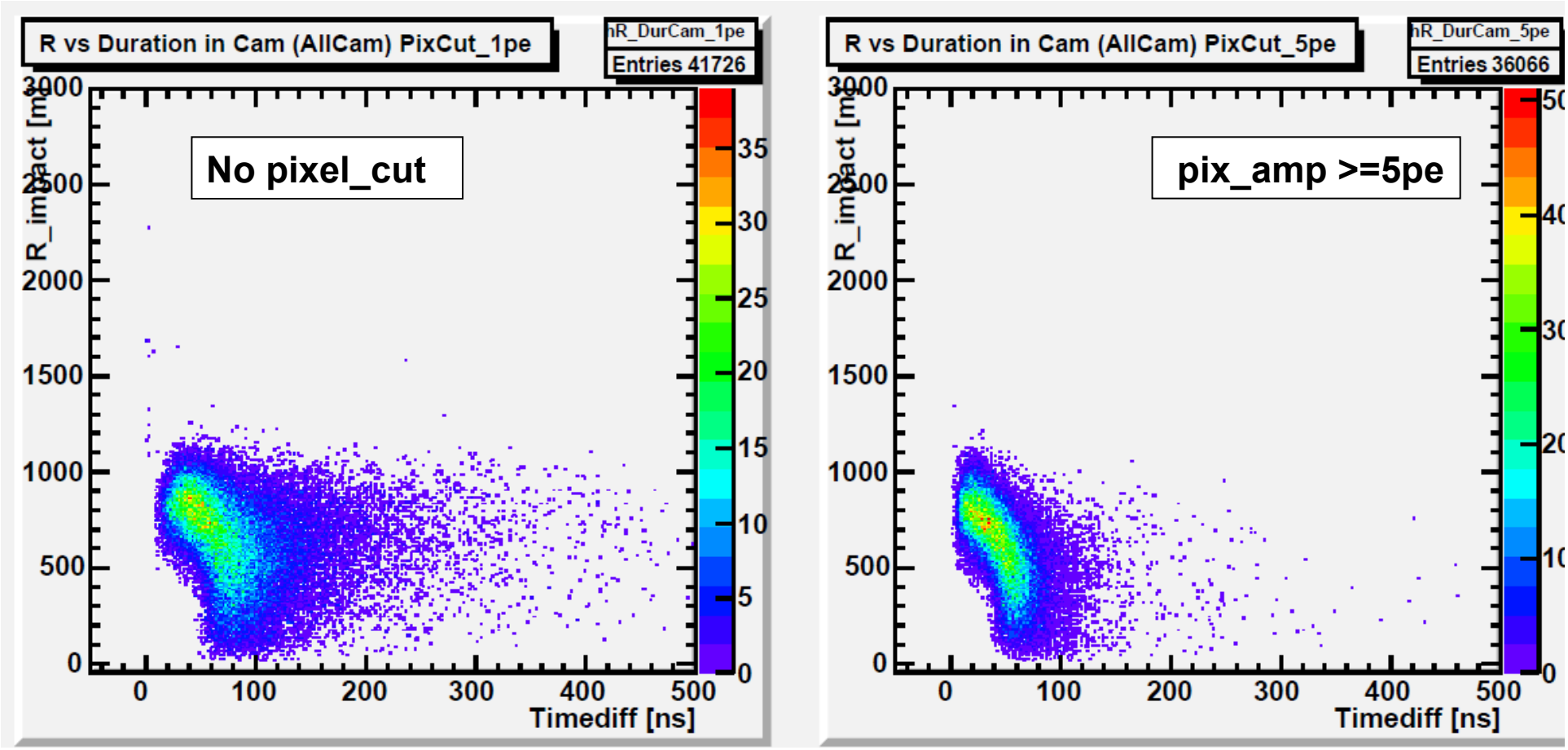
Gammas 10TeV (diffuse)

Impact vs. EventDuration



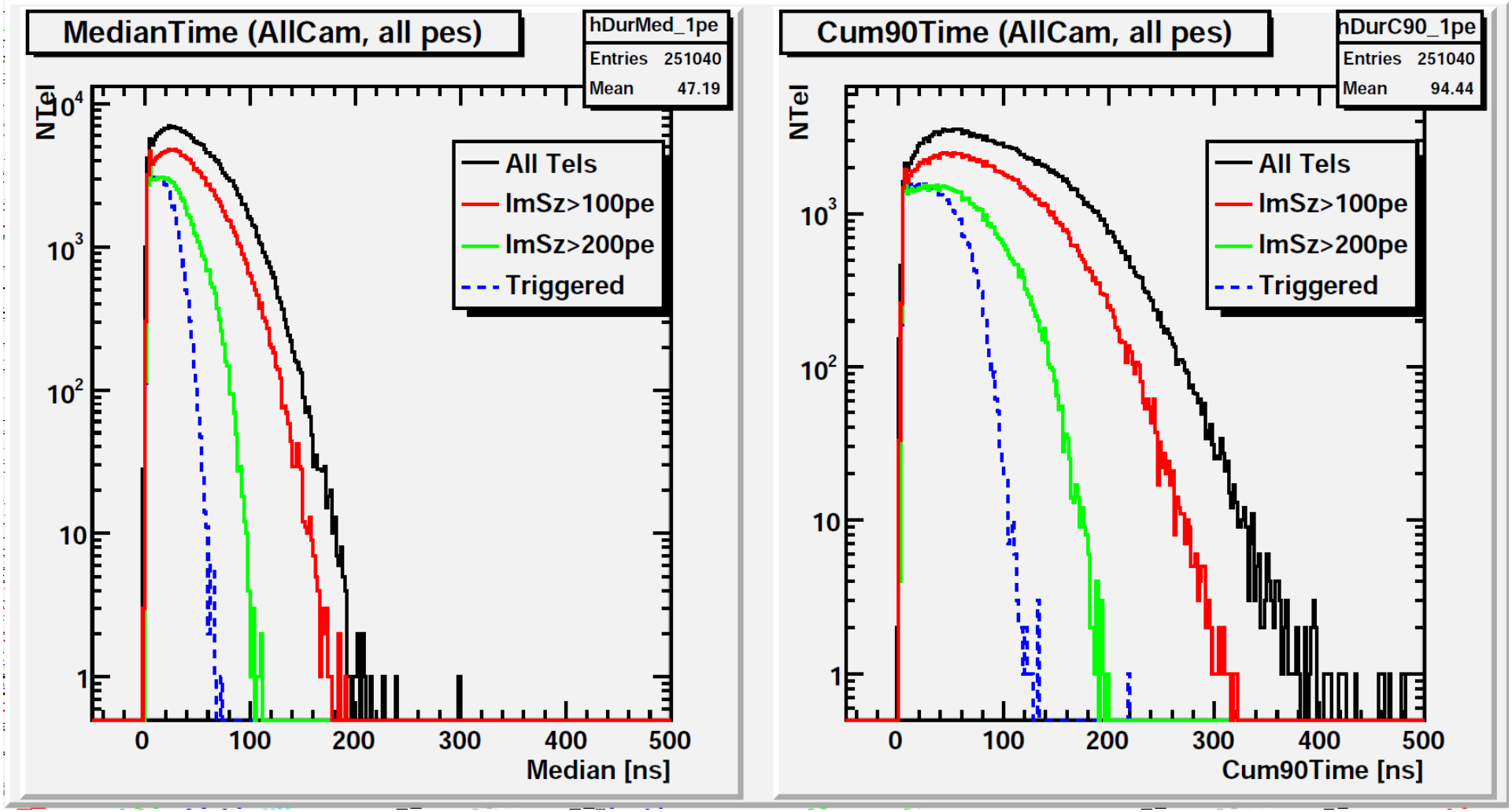
Gammas 10TeV (pointing)

Impact vs. EventDuration



Gammas 100TeV (pointing)

ReadoutTime T50 / T90: cover 50% and 90% of Image

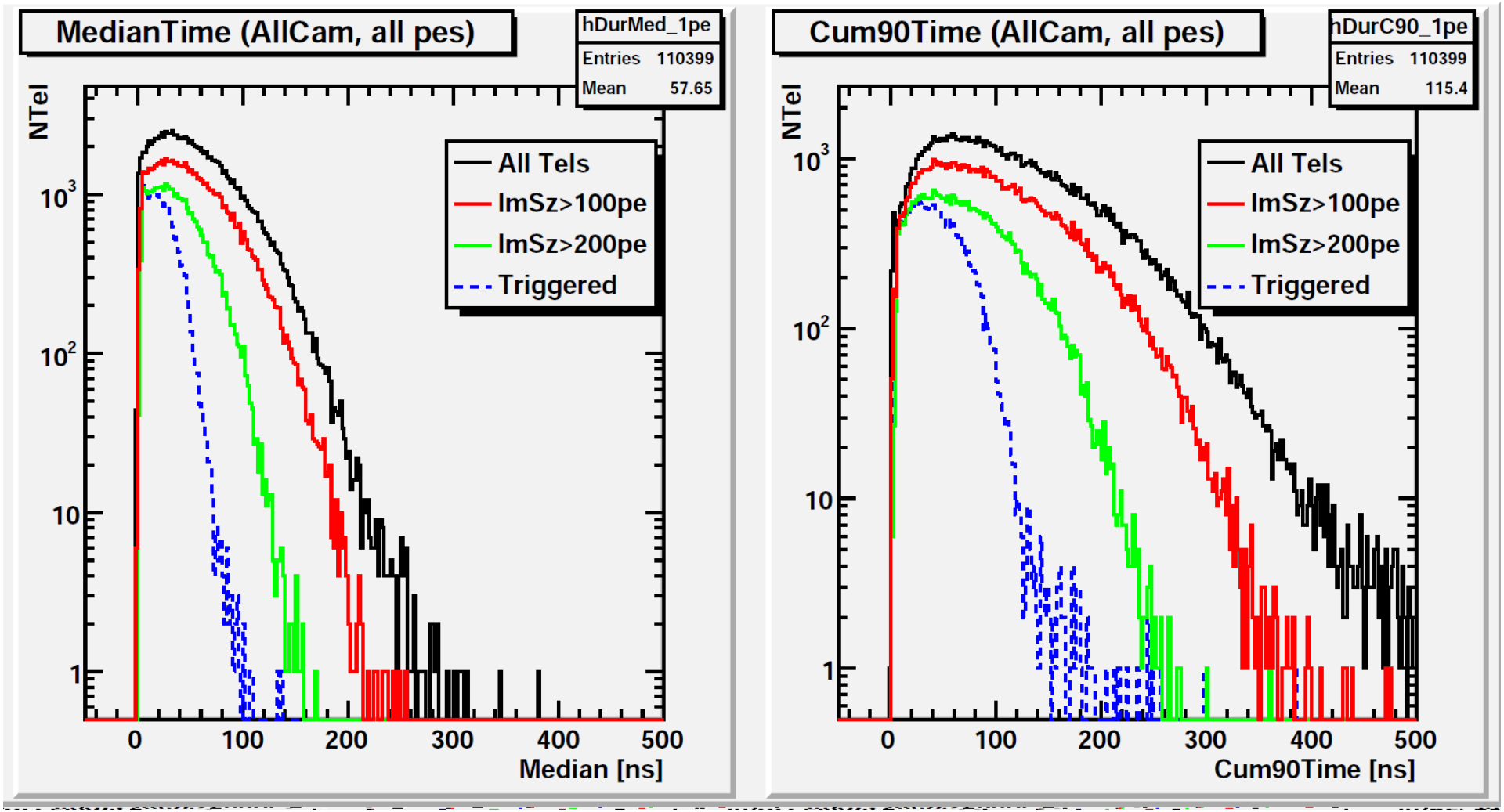


50% (left) 90% (right)

Gammas 10TeV (diff)

For: all Images / >100pe / >200pe / triggered

ReadoutTime T50 / T90: cover 50% and 90% of Image

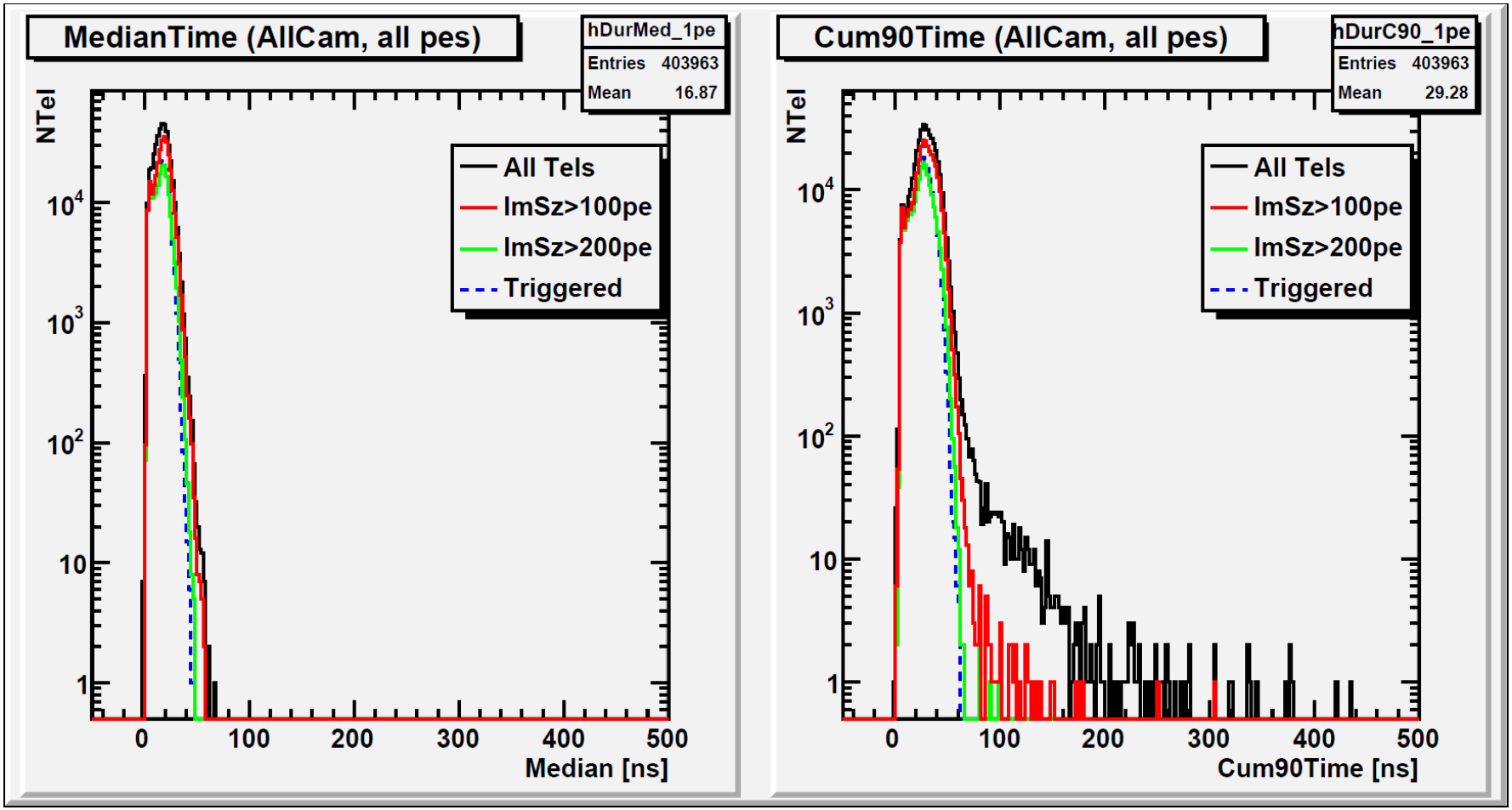


50% (left) 90% (right)

Protons 30TeV

For: all Images / >100pe / >200pe / triggered

ReadoutTime T50 / T90: cover 50% and 90% of Image

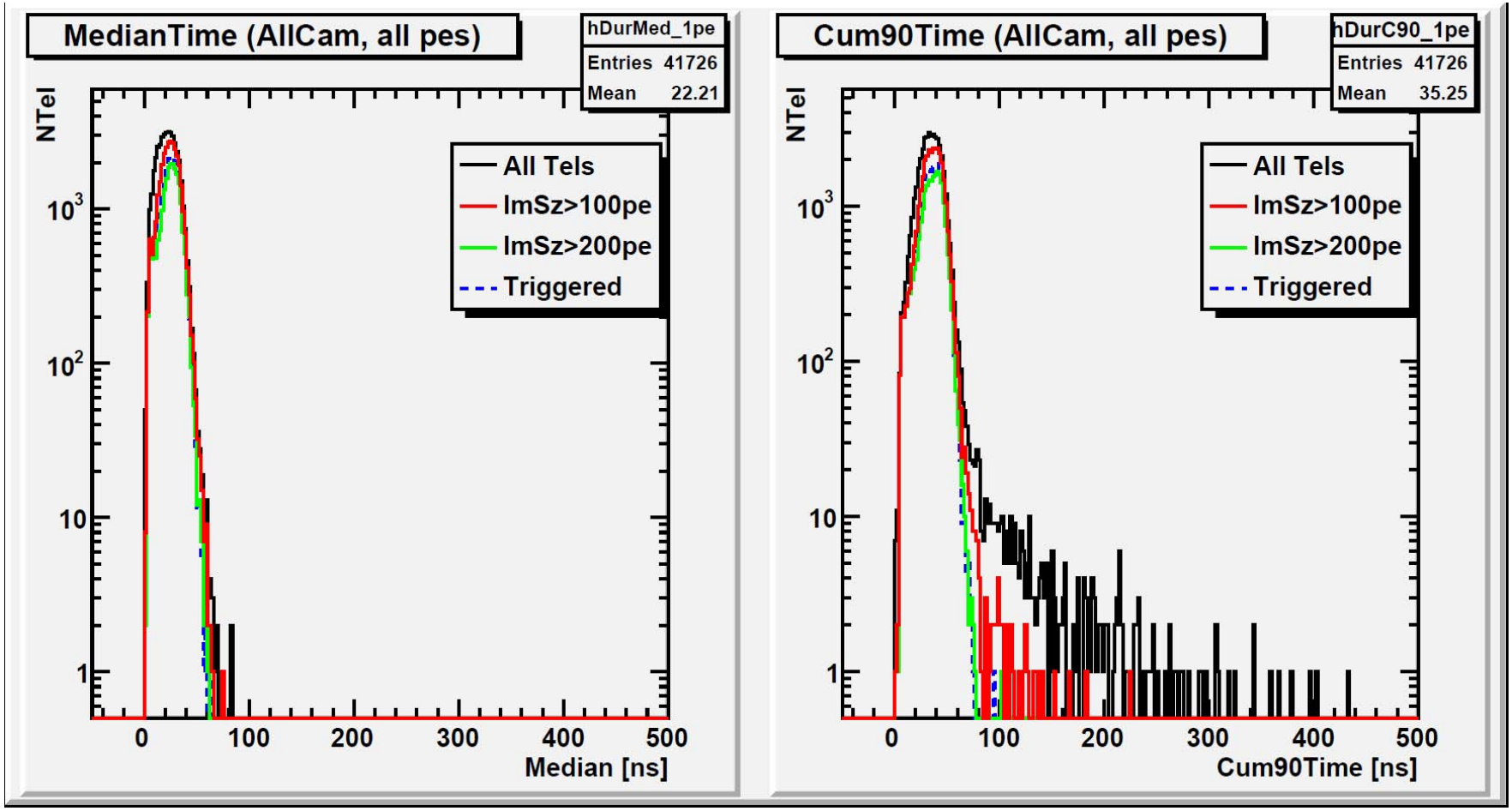


Gamma 10TeV (pointing)

50% (left) 90% (right)

For: all Images / >100pe / >200pe / triggered

ReadoutTime T50 / T90: cover 50% and 90% of Image



Gamma 100TeV / pointing

50% (left) 90% (right)

For: all Images / >100pe / >200pe / triggered