# Time Dispersion of Showers

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**Motivation:**


- **Does the time structure (spread) of gamma / proton showers change from o(10ns)**
   **at  high energies  (>>1TeV) ?**
- **With large telescope spacing:   showers with large impacts become important**
➔

   **-  specify readout  &  trigger  requirements for cameras ➔ WP_FPI / ELEC**
      **➔  readout-time window,  trigger-timing (+logic)**
   **- with the current and alternative (affordable) FE-electronics**
      **- how much "raw signal" (p.e.'s) do we loose for  Signal &  BG ?**
                                                              **(this study)**

      **- influence on physics performance  (eff.area / sensitivity)**
         **and γ/h - separation**                                    **(tbd)**      1

# Time Dispersion of Showers

**The method:**

    **- Analysis is based entirely on shower-generated photoelectrons (pe's) in camera .**

      **I.e. currently on purpose:**

        **- w/o electronics simulation**

        **- w/o NSB**

        **- w/o an "trigger scheme"  ( solely:   >15pe in camera / simtelarray )**

          **[ the default trigger-flag is partially used fro comparison ]**


    **- This difference to other timing studies could be interesting,**

      **since conclusions are not biased by any electronics + trigger model implemented.**


**MC:  Standard Corsika/SimTelarray**                          (tune CSCAT for >10TeV)

    **- Trigger MC-Data Base generated  (Zeuthen PC_cluster, non-grid):**

      **- protons  0.3, 3, 30, 300 TeV   for CTA-ULTRA3**

      **- gamma   0.1, 1, 10, 100 TeV**        **pointing + diffuse** (theta=20deg, VCone=0 / 10deg)

         **using eventio format, with pe's included**

              (DBase available on the web; please inquire)

**Analysis:**

    **- with  *trigsim*  ( version 00-03 / see preceding talk by  Ulli Schwanke )**


**-  Step-1:    investigate  " time dispersion" (gamma vs proton; vs energy)  ← this talk**  2

**-  Next:       timing issues of various trigger concepts (local majority, NxtNeigb,sum-trigg,...)**
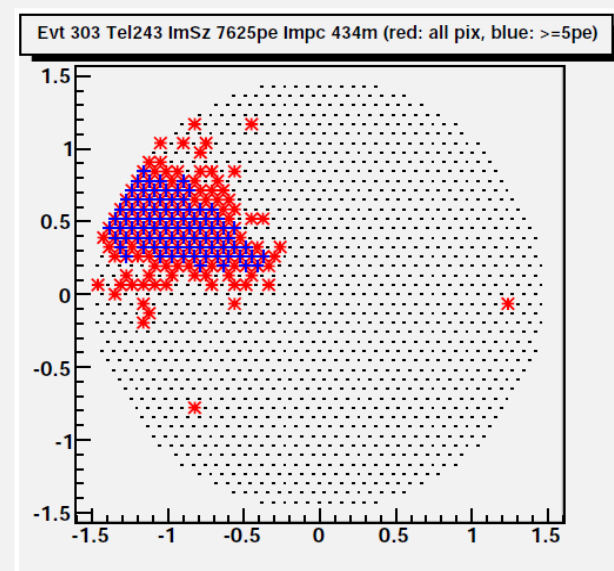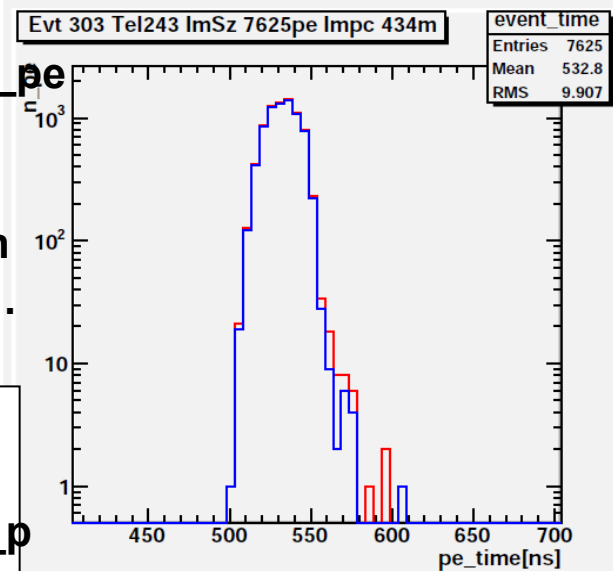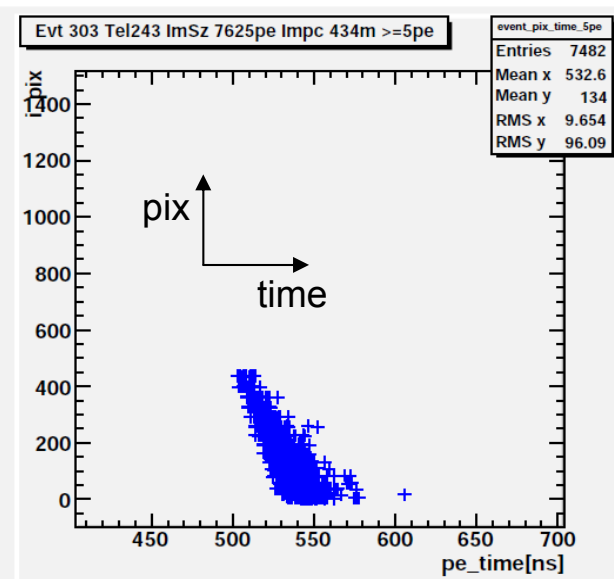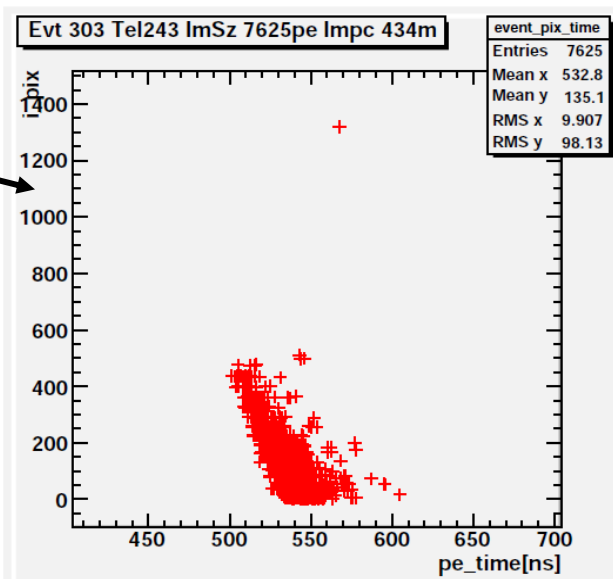
# Gamma 100TeV (pointing)

**A Poor-man's display for "Camera timing":**

1. **Pixel# vs time (red: no-cut)**
2. **Pixel# vs time (blue: ≥ 5pe)**
3. **Time distribution ( all/ ≥5pe)**
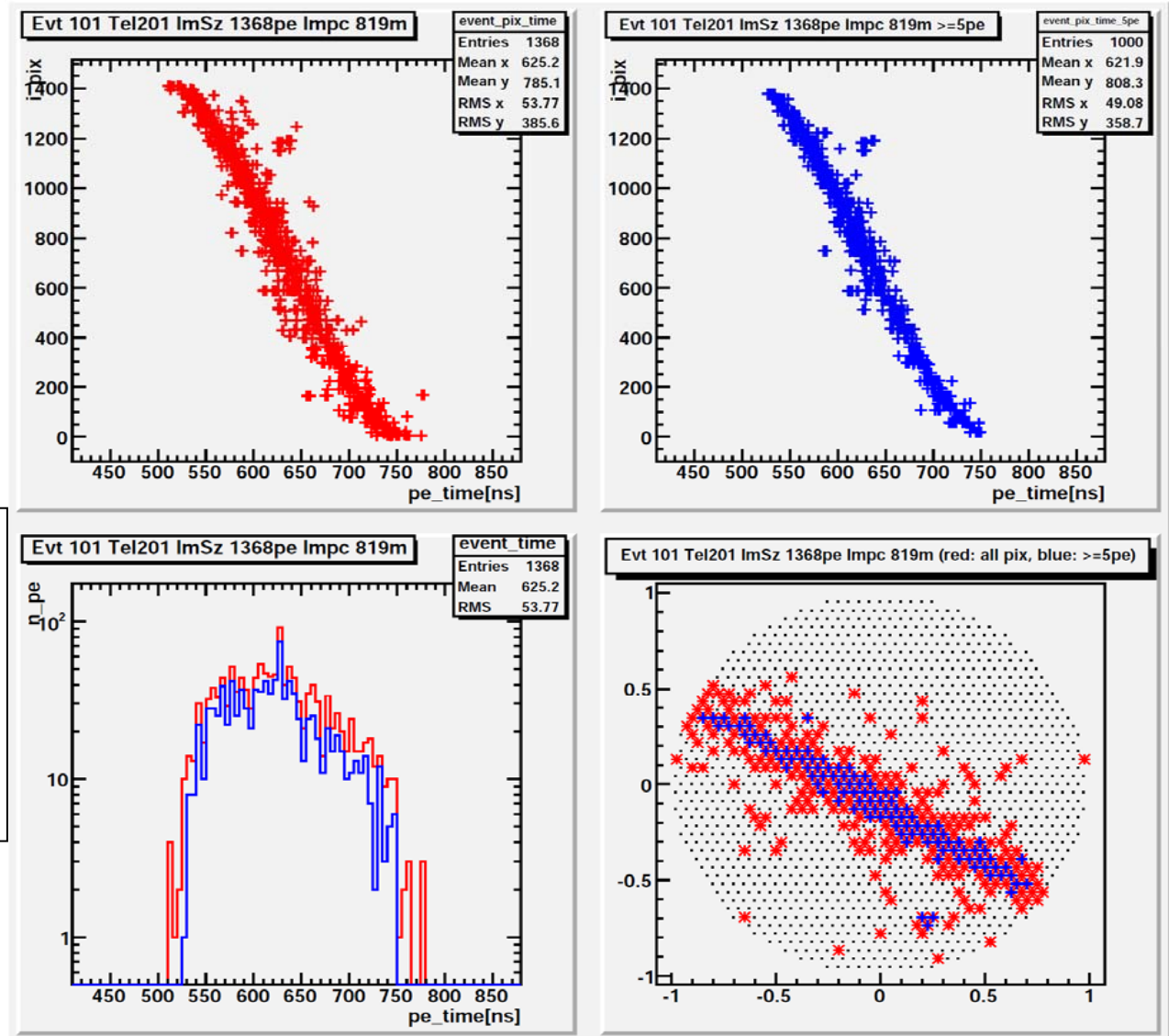4. **Camera display ( all/ ≥5pe)**

**Define TimeParameter:**

- **"EventDuration" = last - first_pe in camera (after amp_cut)**

- **"T90/50" = time within which 90% (50%) of the pe's arrive .**

**Duration = 100ns**
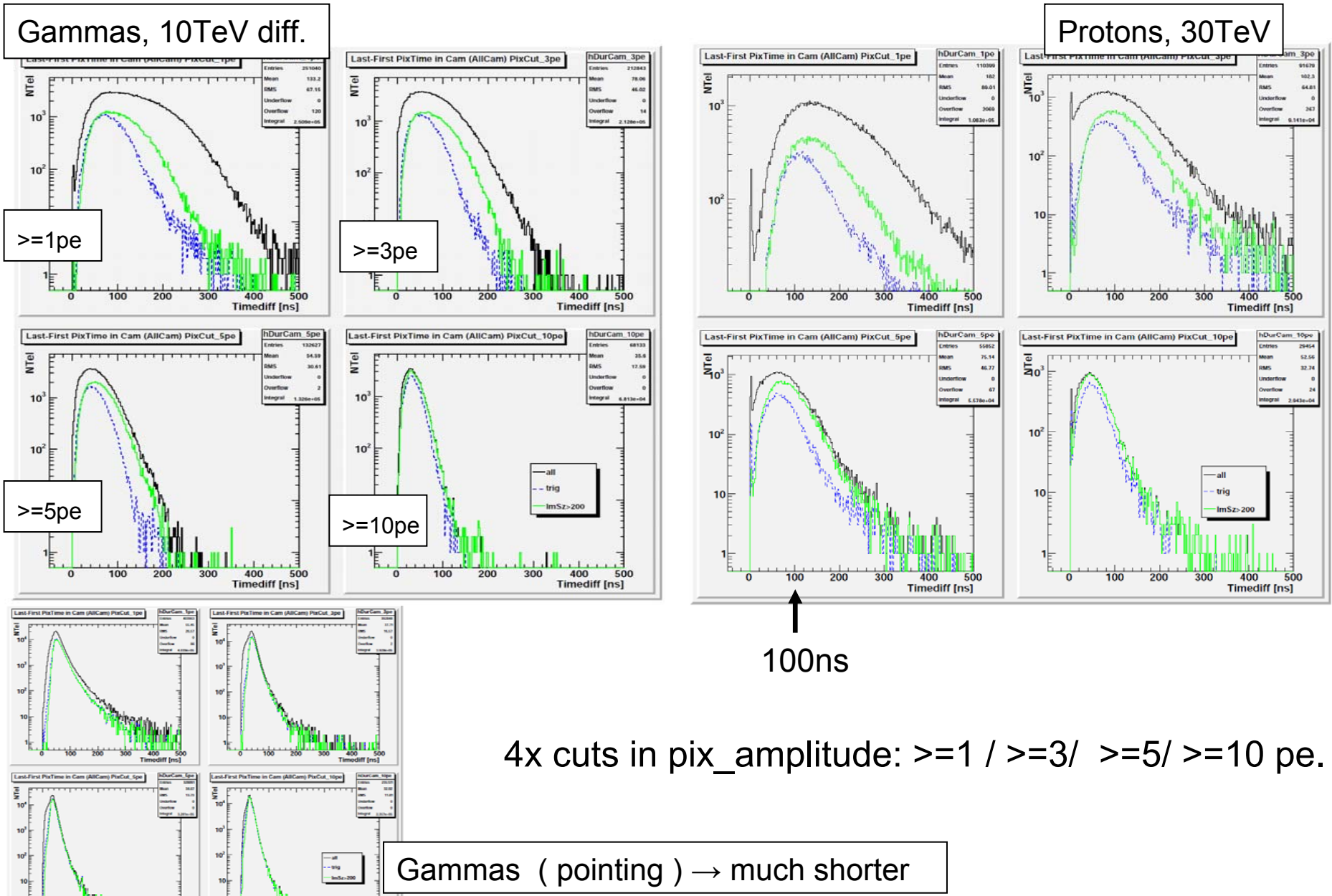**T_90 = 42ns**
**Ev_303_243_100T_gam_p**

# Proton 30TeV



Evt 105 Tel233 ImSz  427pe Impc 857m

| event_pix_time | |
|---|---|
| Entries | 427 |
| Mean x | 757 |
| Mean y | 1036 |
| RMS x | 57.86 |
| RMS y | 321.9 |

Pe_times, ns

Evt 105 Tel233 ImSz  427pe Impc 857m >=5pe

| event_pix_time_5pe | |
|---|---|
| Entries | 202 |
| Mean x | 732.9 |
| Mean y | 1166 |
| RMS x | 50.43 |
| RMS y | 255.5 |

Pe_times,

Evt 105 Tel233 ImSz  427pe Impc ......

| _time | |
|---|---|
| Entries | 427 |
| Mean | 757 |
| RMS | 57.86 |

Pe_times, ns

Evt 105 Tel233 ImSz  427pe Impc 857m (red: all pix, blue: >=5pe)

Imp=860m;   427pe

Duration = 250ns
T_90       = 170ns

Ev_105_233_30T_prot

# Proton 300TeV



1400pe, Imp=820m

Duration = 250ns
T_90        = 150ns

Ev_101_201_300T_prot

# EventDuration: gamma / p   at 10/30 TeV

Gammas, 10TeV diff.

Protons, 30TeV

>=1pe

>=3pe

>=5pe

>=10pe

100ns

4x cuts in pix_amplitude: >=1 / >=3/  >=5/ >=10 pe.

Gammas  ( pointing ) → much shorter

# Impact   vs.  EventDuration



R vs Duration in Cam (AllCam) PixCut_1pe
hR_DurCam_1pe
Entries 110399

**No pixel_cut**

Impact, m

R_impact [m]

Timediff [ns]

100ns

**EventDuration, ns**

R vs Duration in Cam (AllCam) PixCut_5pe
hR_DurCam_5pe
Entries 55852

**pix_amp >=5pe**

R_impact [m]

Timediff [ns]

100ns
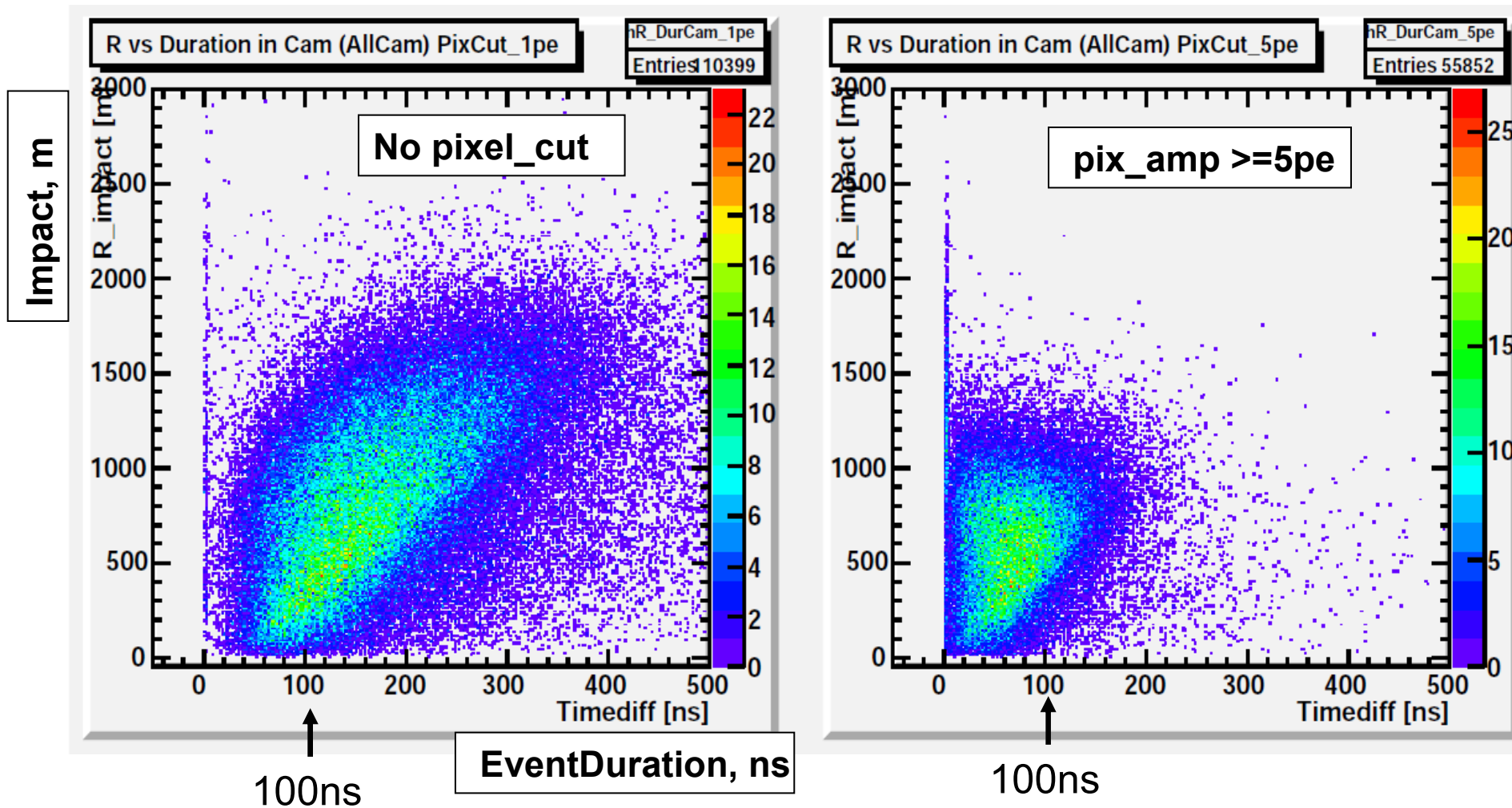
**Protons 30TeV**

(for two amplitude cuts).

# Impact vs. EventDuration
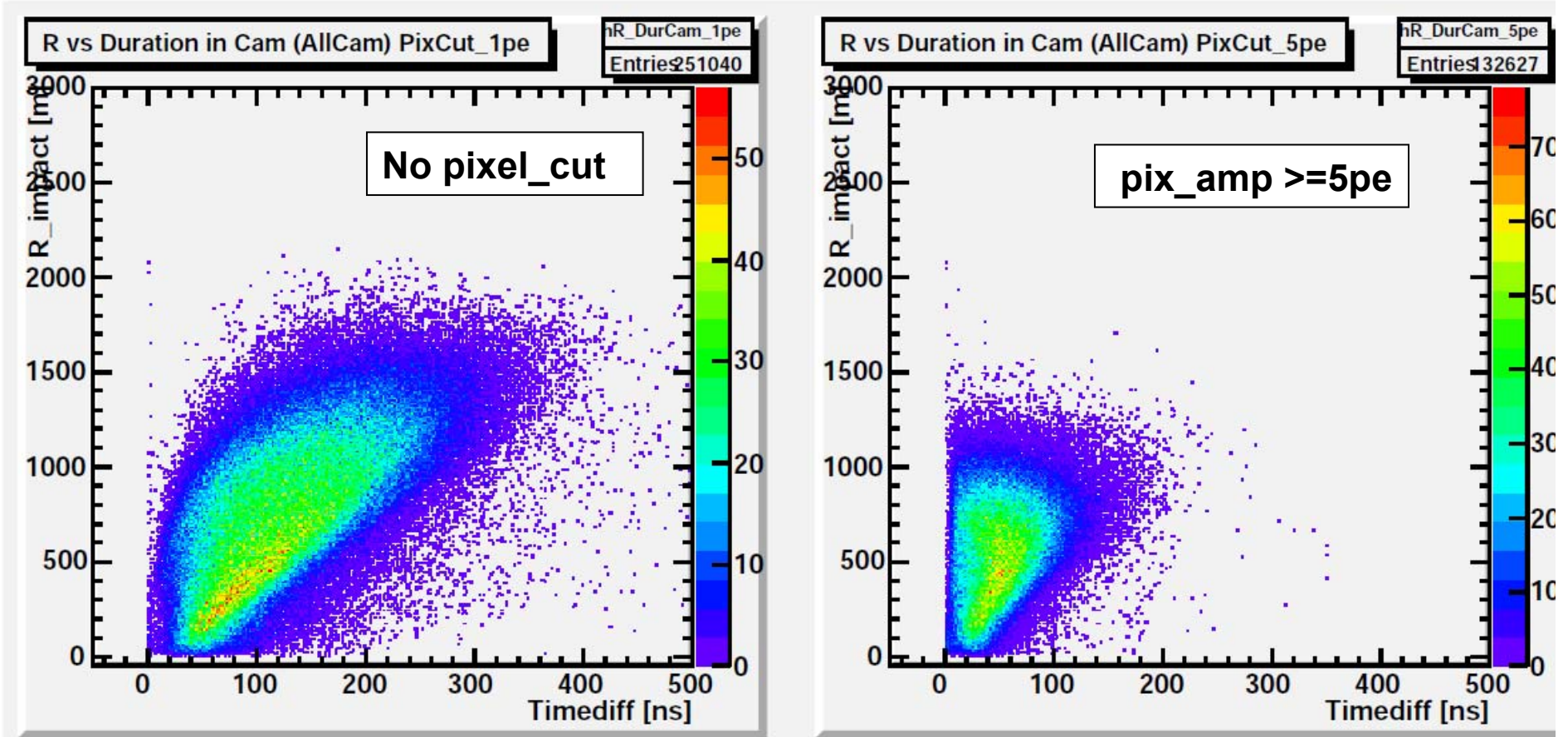


Gammas 10TeV (diffuse)

# Impact vs. EventDuration
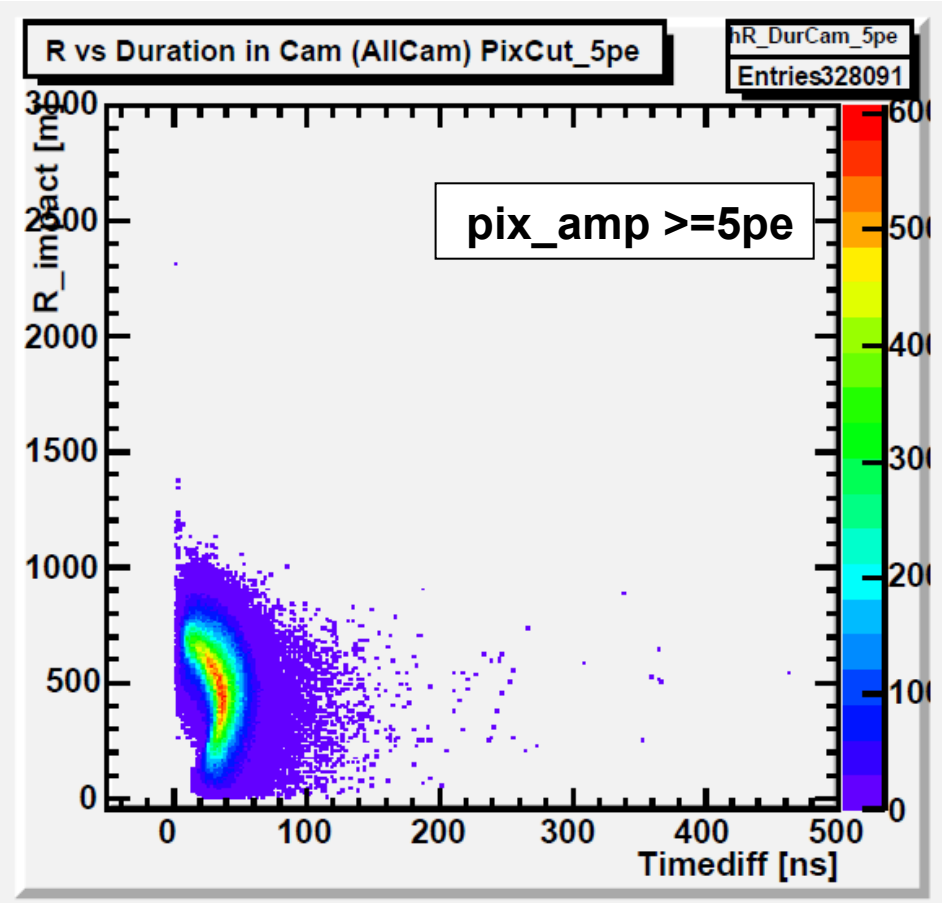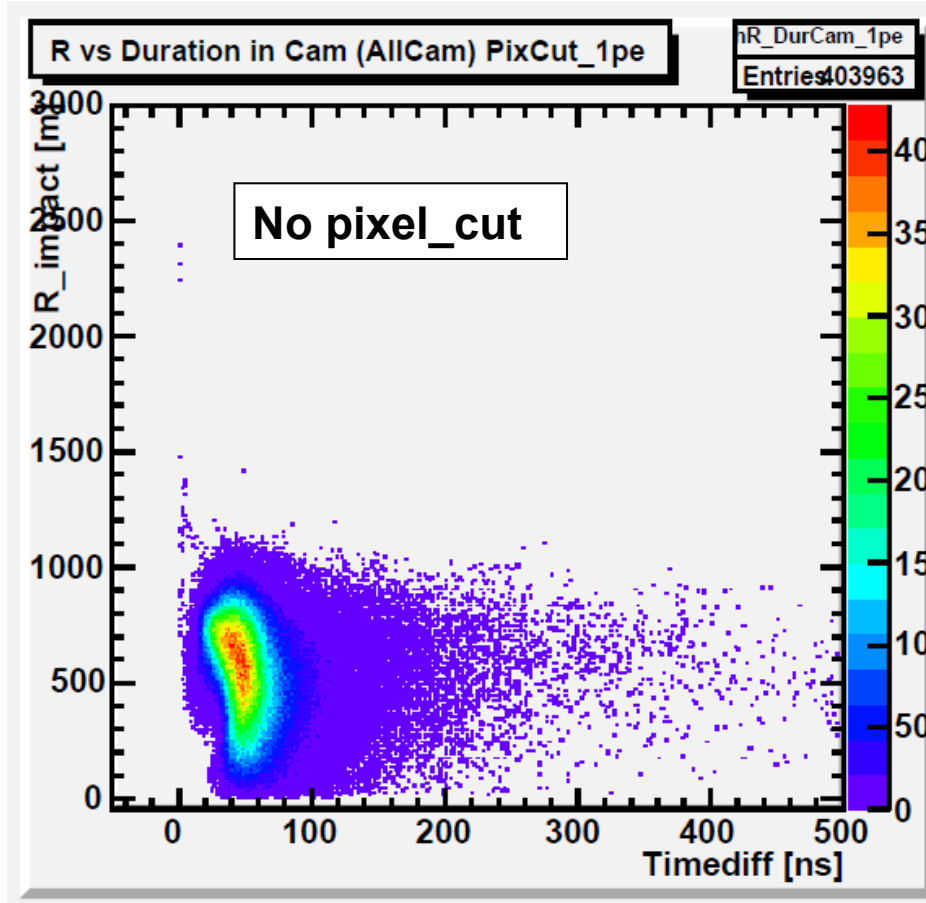


Gammas 10TeV (pointing)

# Impact vs. EventDuration
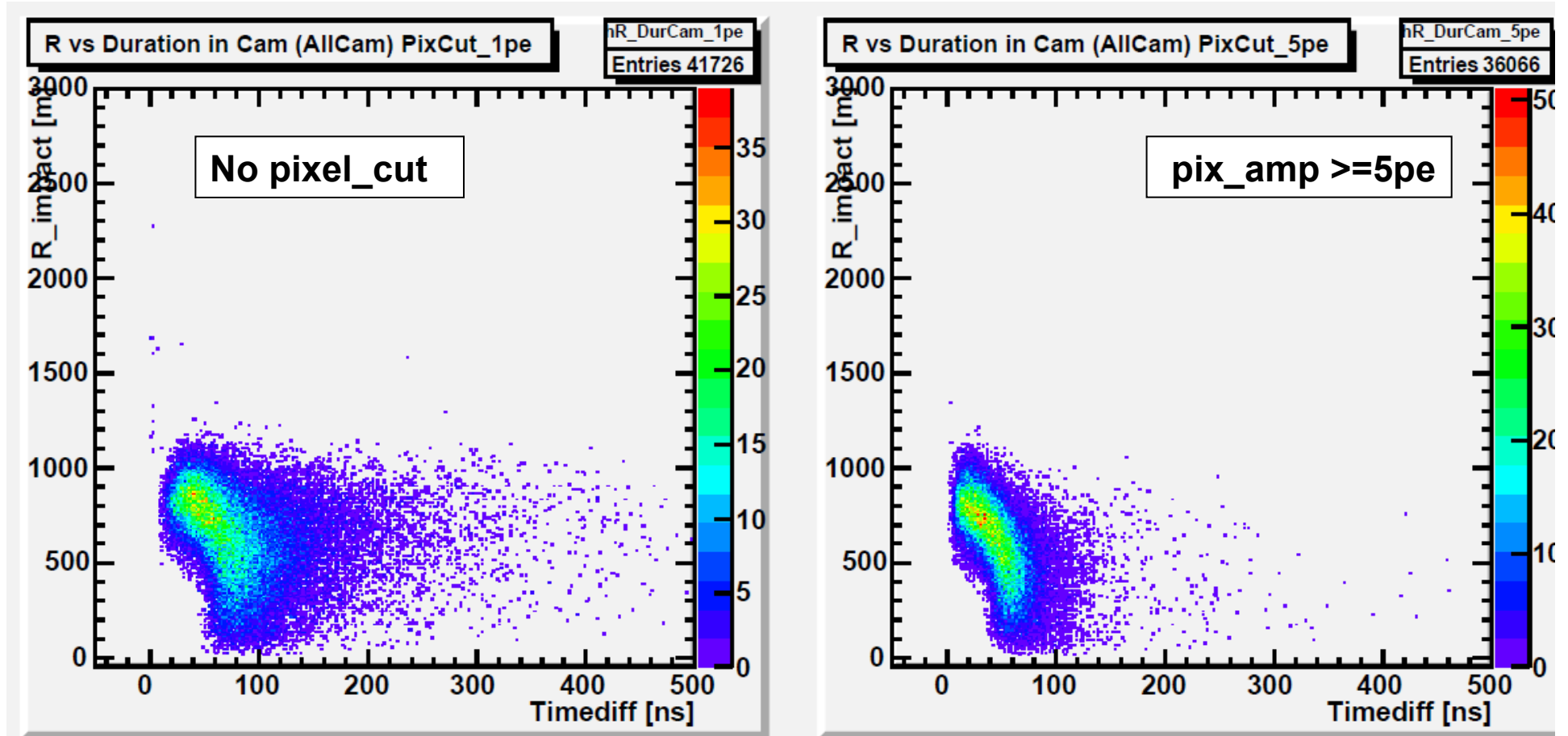


Gammas 100TeV (pointing)

# Avg. EventDuration vs. Energy:  Protons
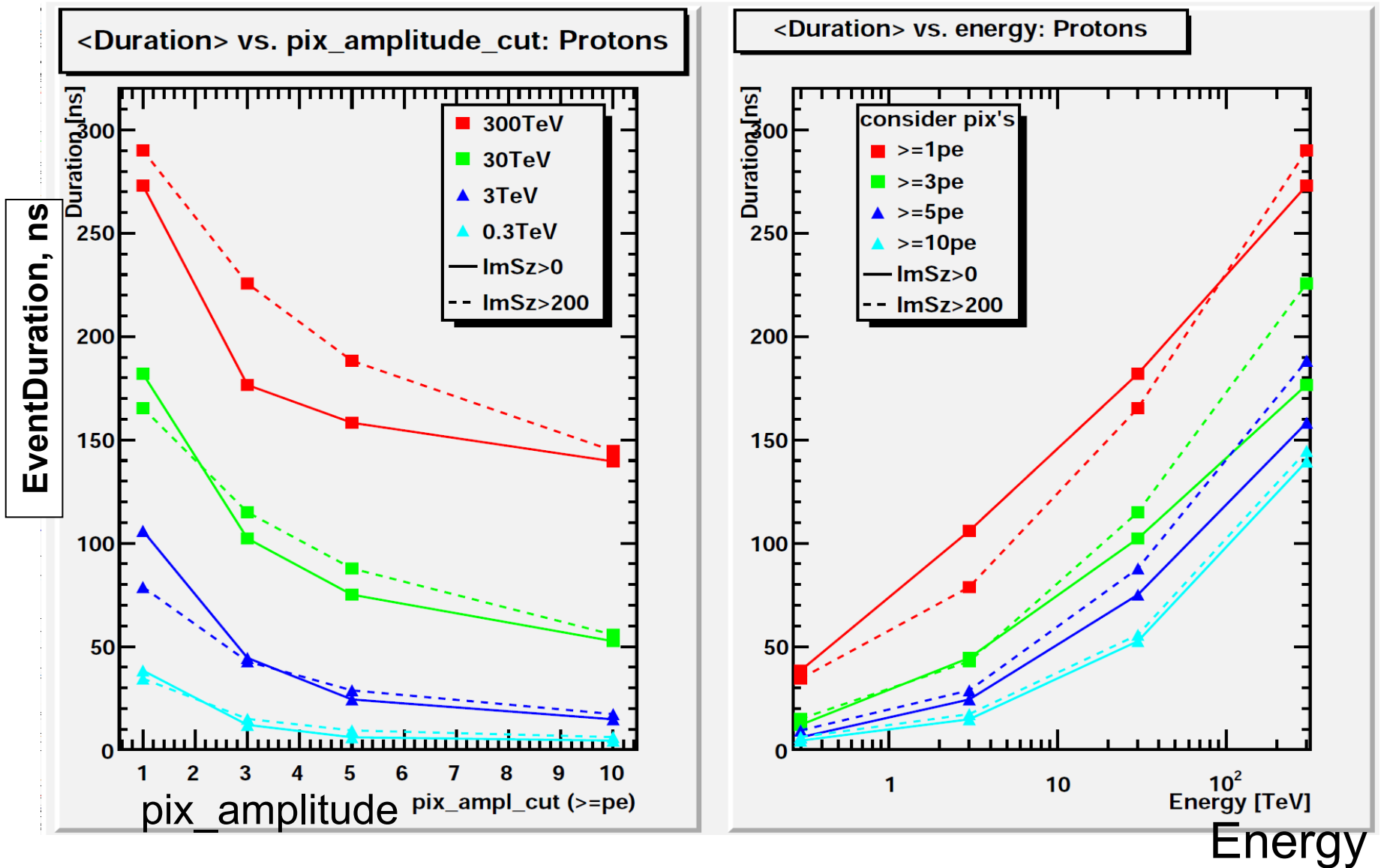


Consider pe's from pixels with >=1 / >=3/  >=5/ >=10 pe.

# Avg. EventDuration vs. Energy:  Gammas (diffuse)
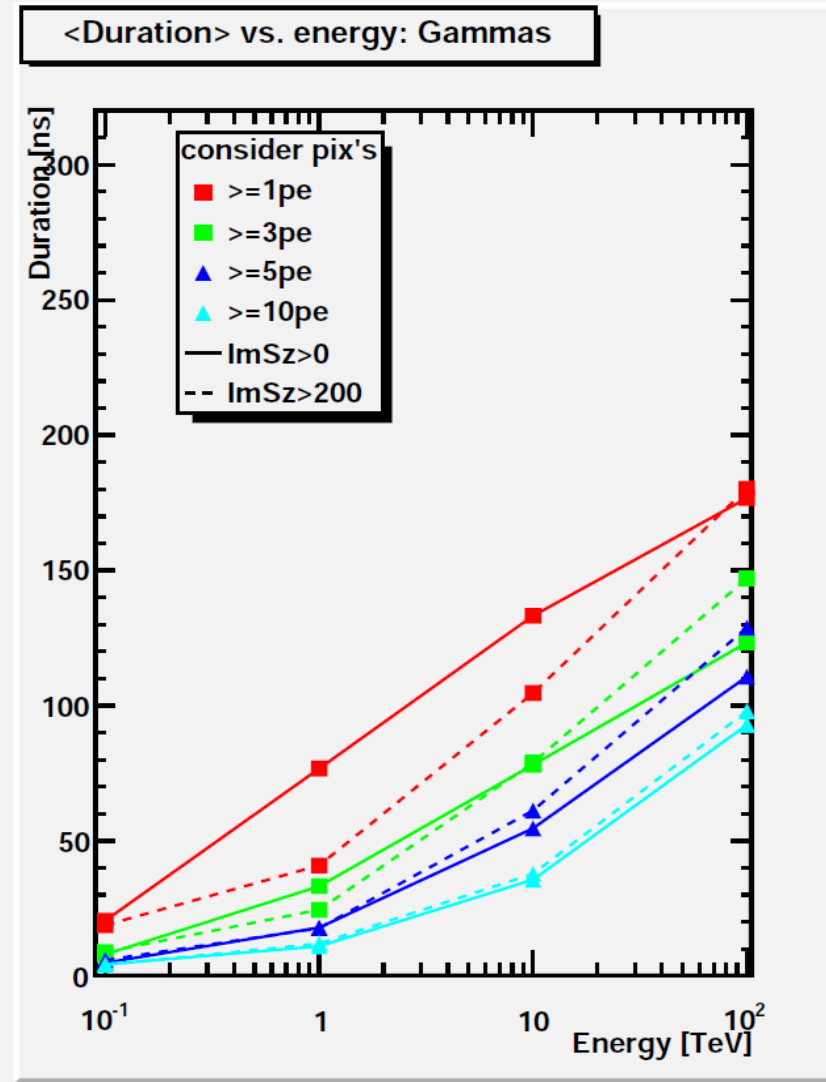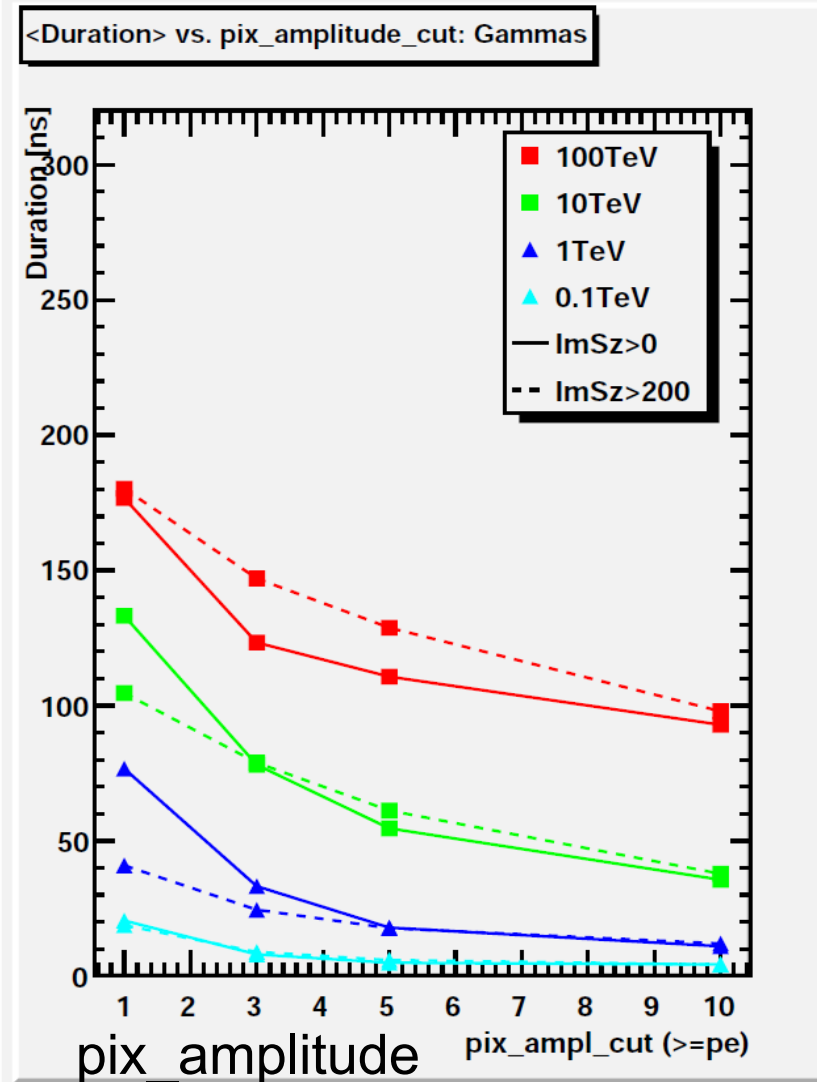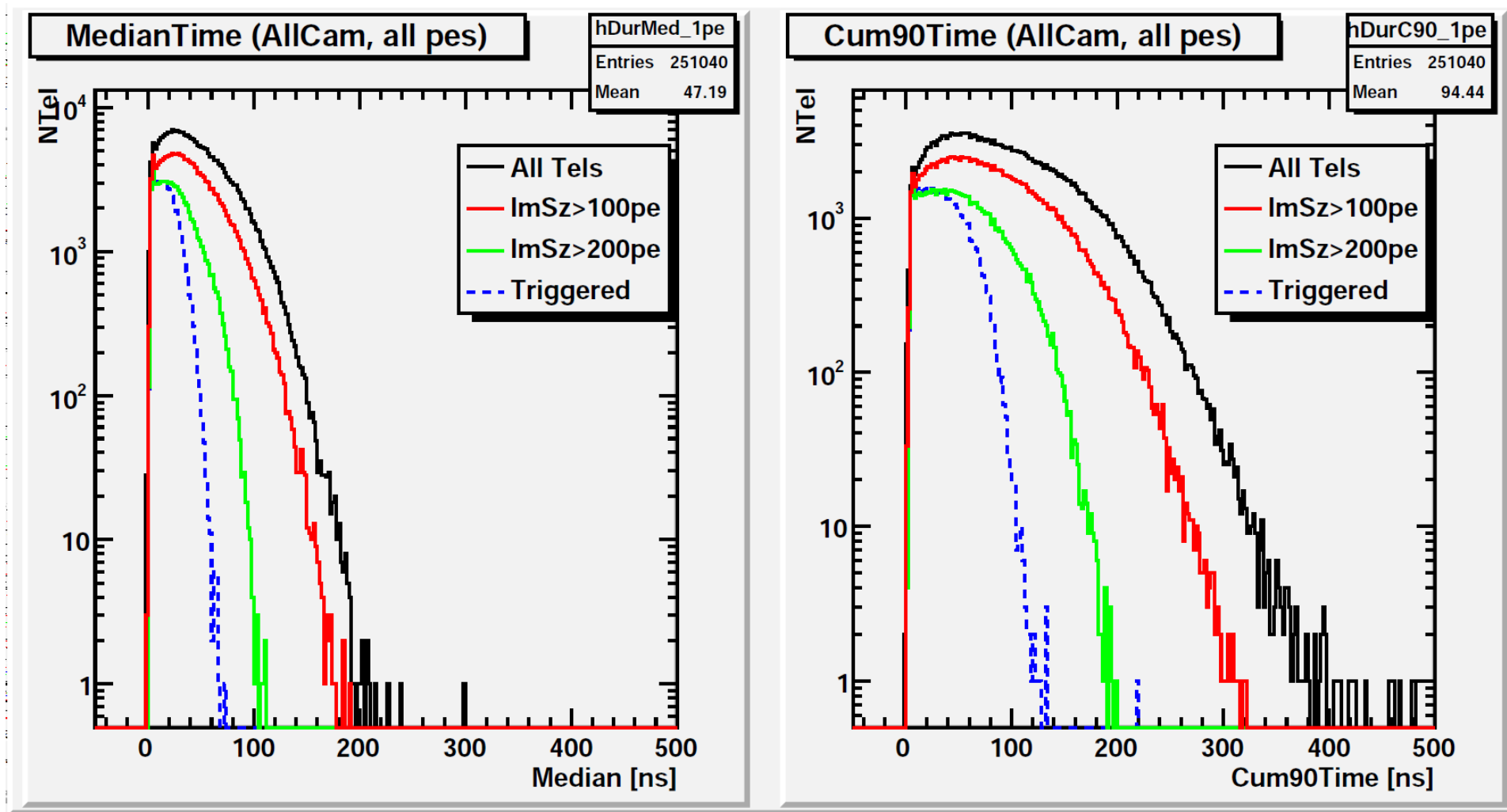


pix_amplitude

Energy

# Avg. EventDuration vs. Energy:  Gammas (pointing)
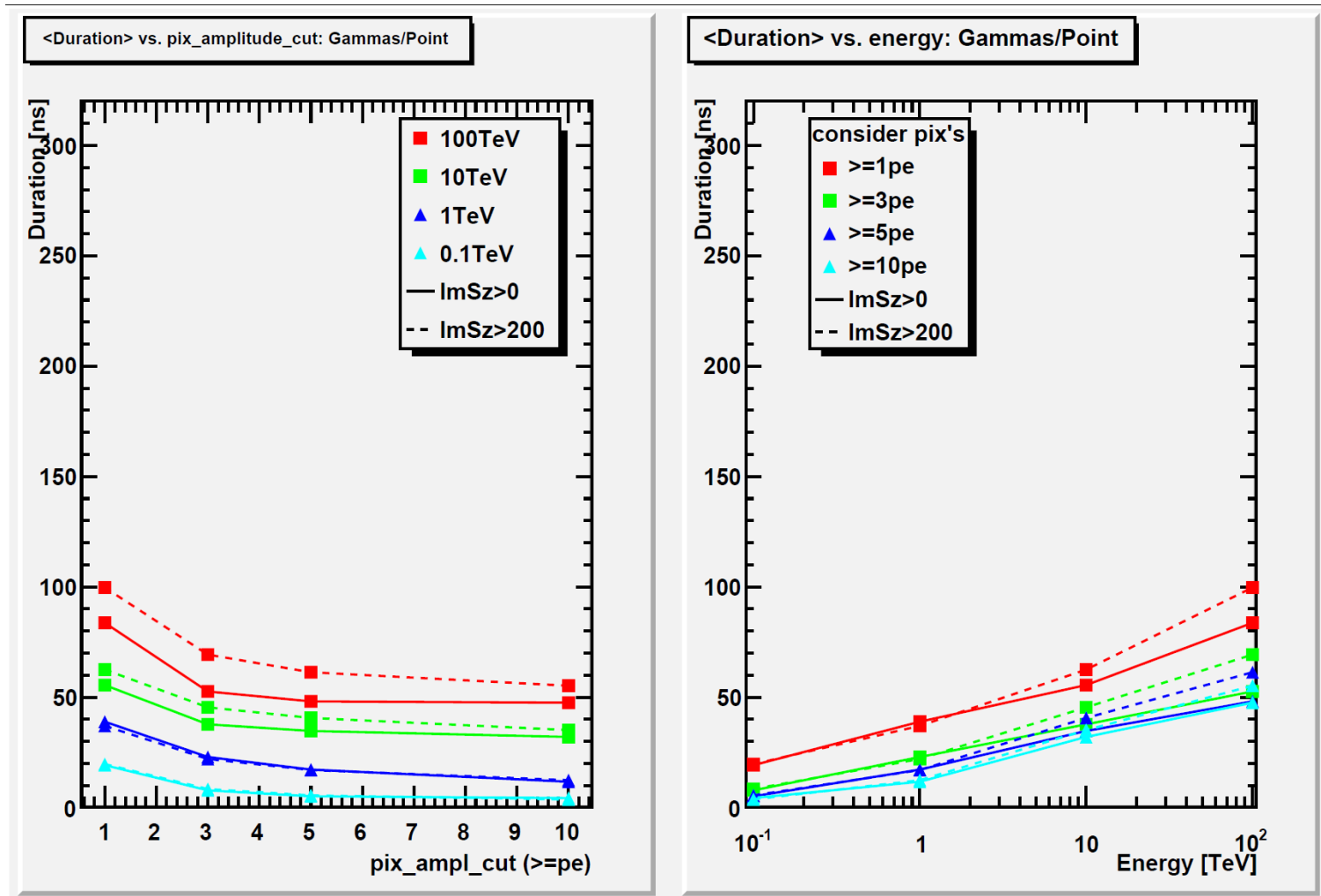

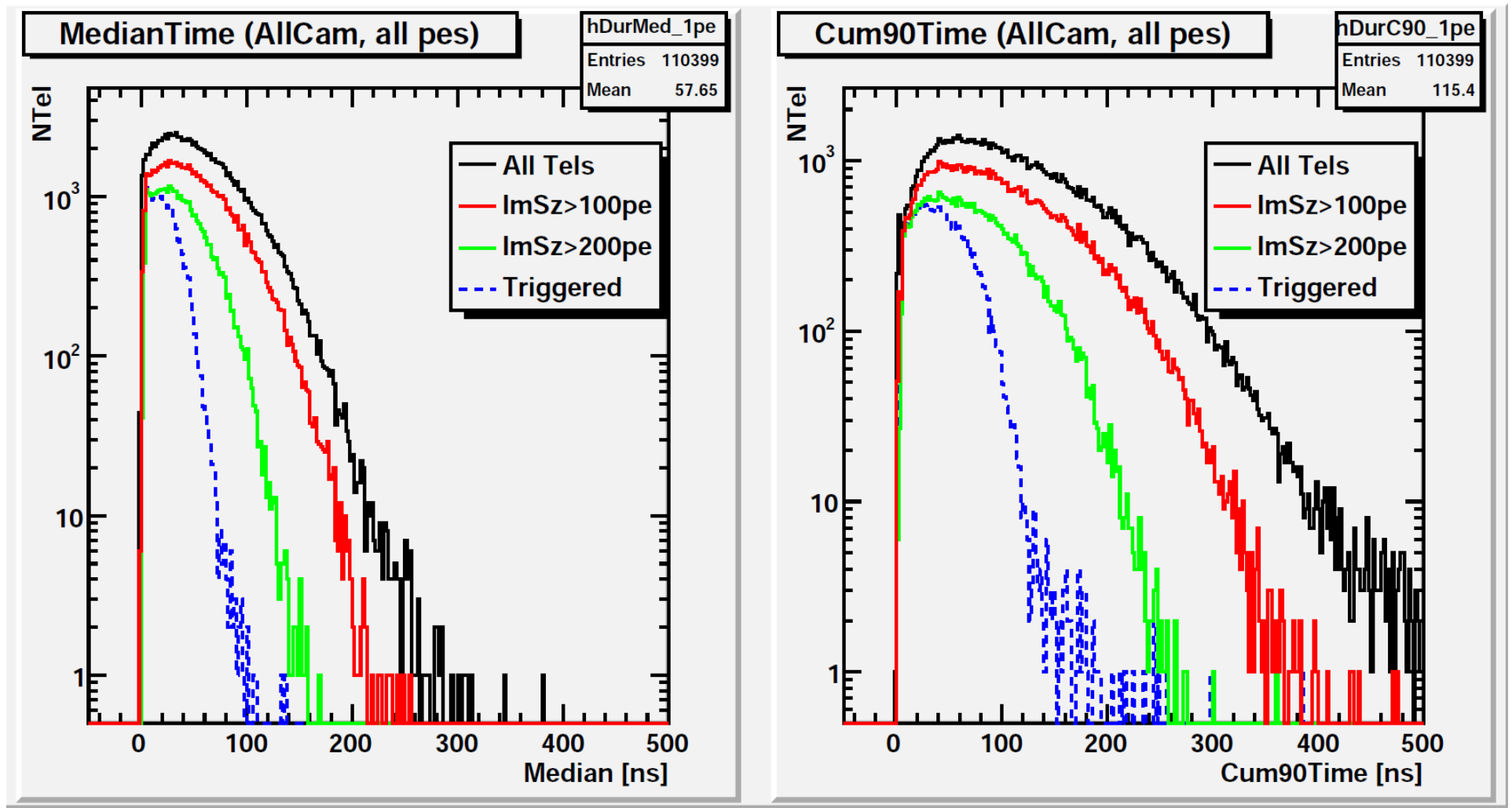
pix_amplitude

Energy

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



50% (left)     90% (right)

Gammas 10TeV (diff)     For: all Images / >100pe / >200pe / triggered
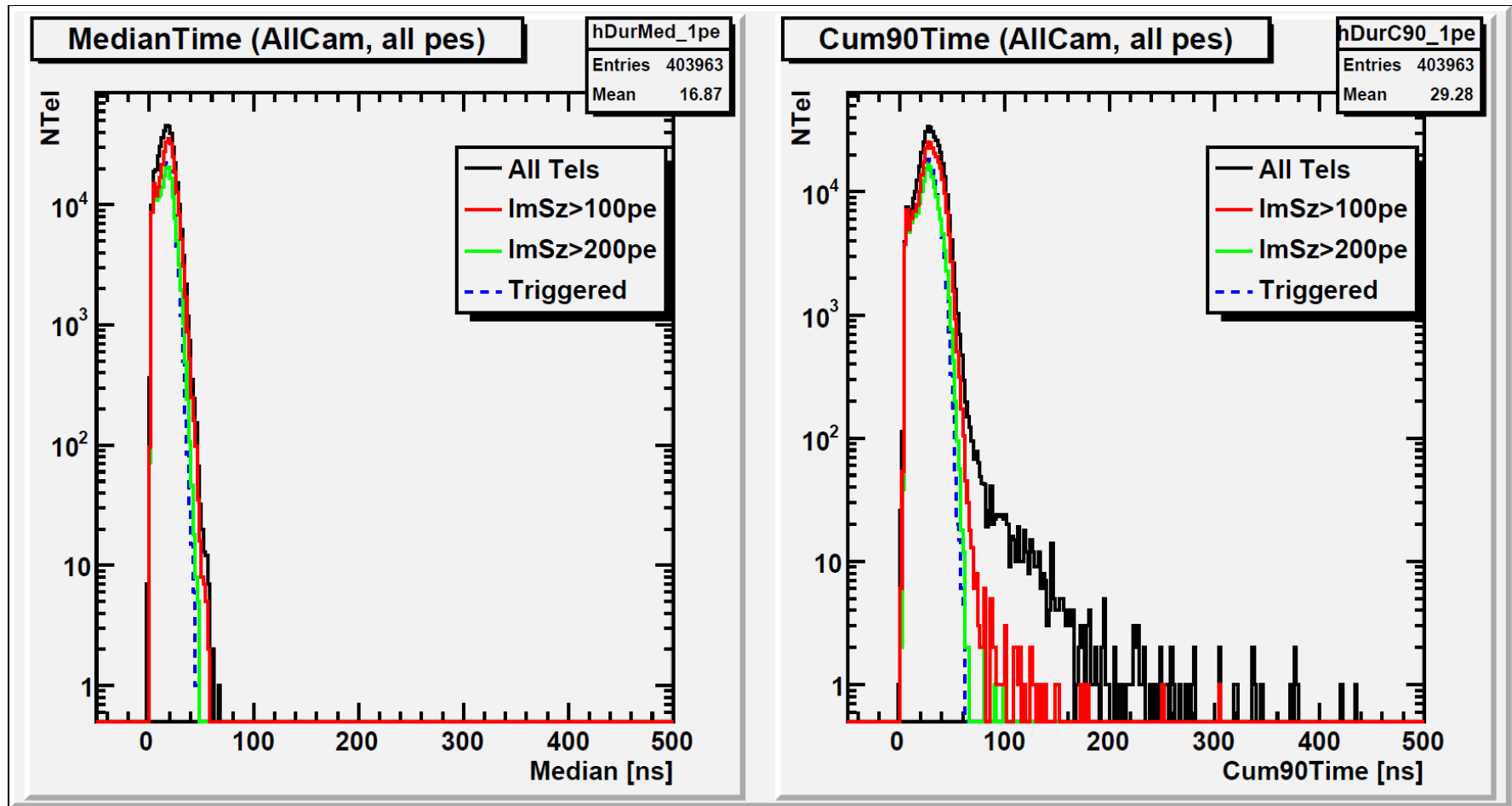
# ReadoutTime T50 / T90: cover 50% and 90% of Image



50% (left)     90% (right)

Protons 30TeV

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

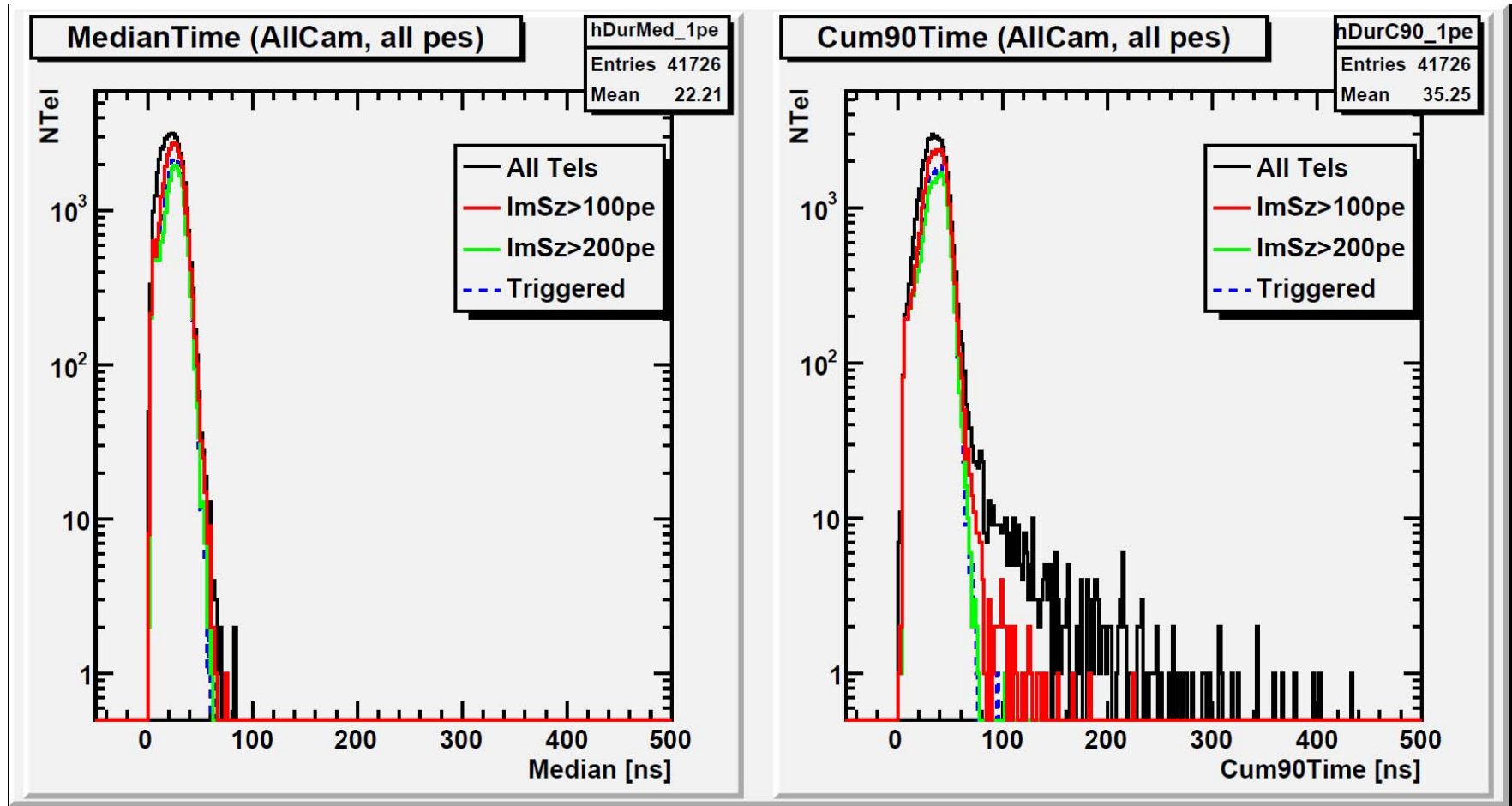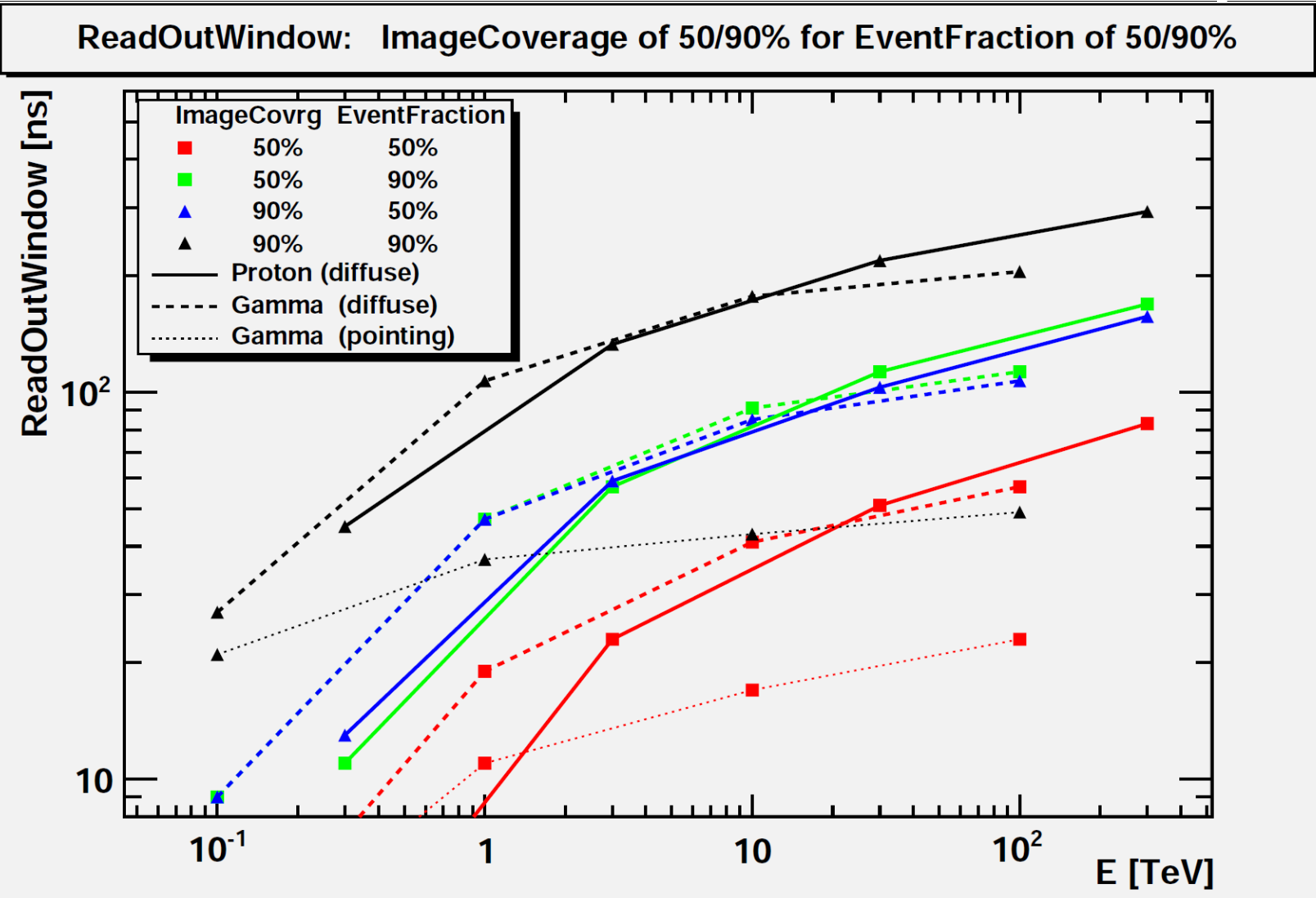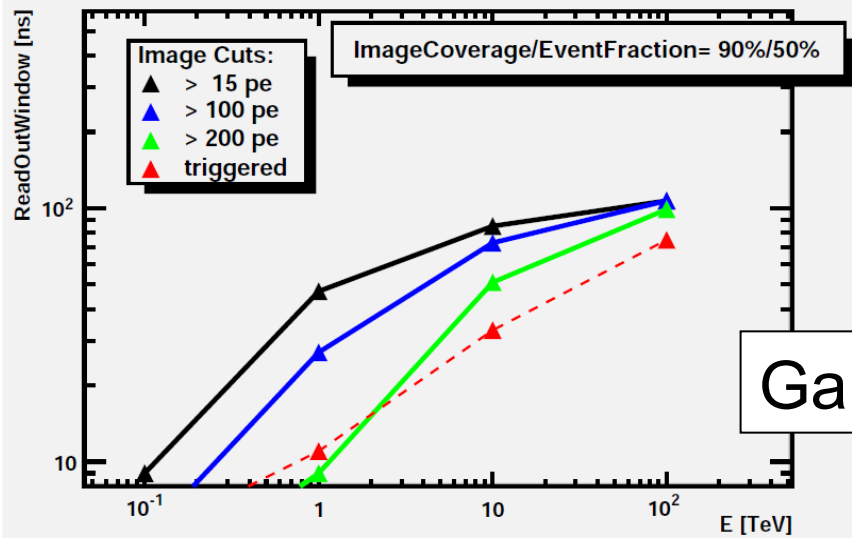# ReadoutTime T50 / T90: cover 50% and 90% of Image



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

# Result: Readout-Window vs E, Proton / Gamma (diff+point)



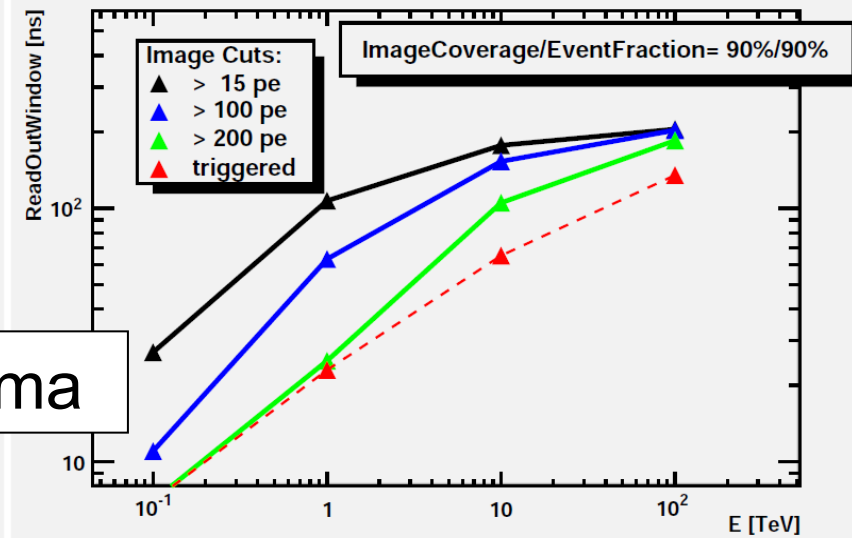ReadOutWindow: ImageCoverage of 50/90% for EventFraction of 50/90%

| ImageCovrg | EventFraction |
| --- | --- |
| ■ 50% | 50% |
| ■ 50% | 90% |
| ▲ 90% | 50% |
| ▲ 90% | 90% |
| — Proton (diffuse) | |
| - - Gamma (diffuse) | |
| ⋯ Gamma (pointing) | |

➔ For 50/90% (90/50%) Coverage/Events : window is o(100ns)

# R/O-Window versus ImageSize: Do faint Images dominate ?

# … Thanks …