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Simulation of GLAST LAT tracker silicon detectors

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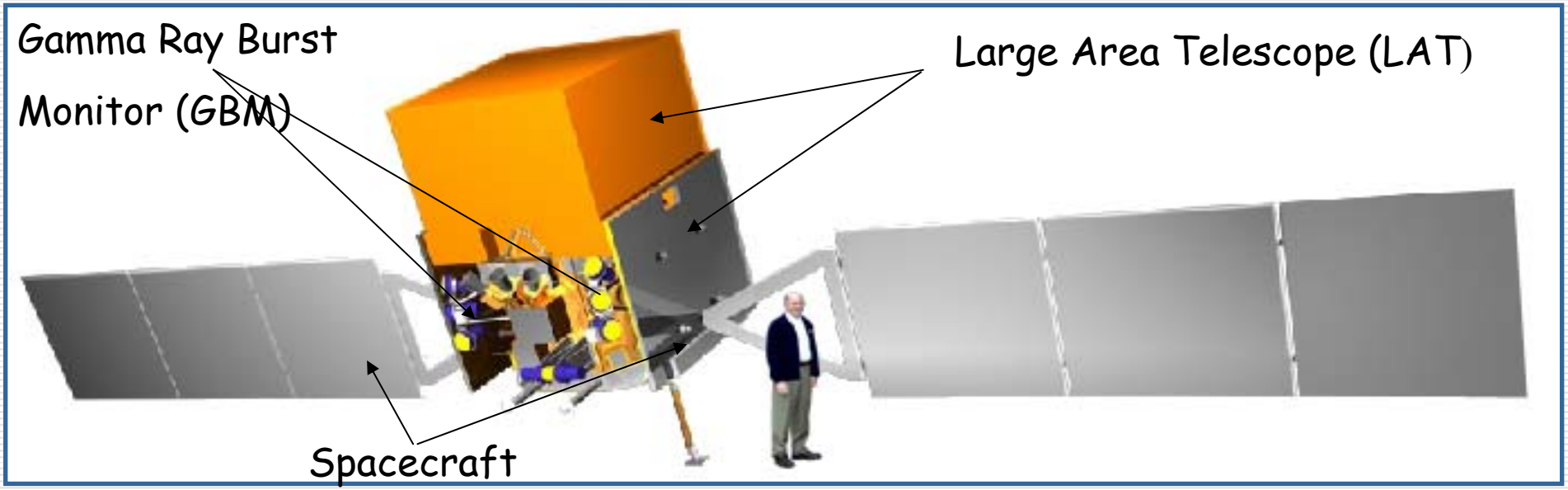
for the GLAST Italian Collaboration

Outline

- The GLAST mission
- The LAT silicon tracker
- A full simulation for SSDs
- Preliminary results
- Conclusions

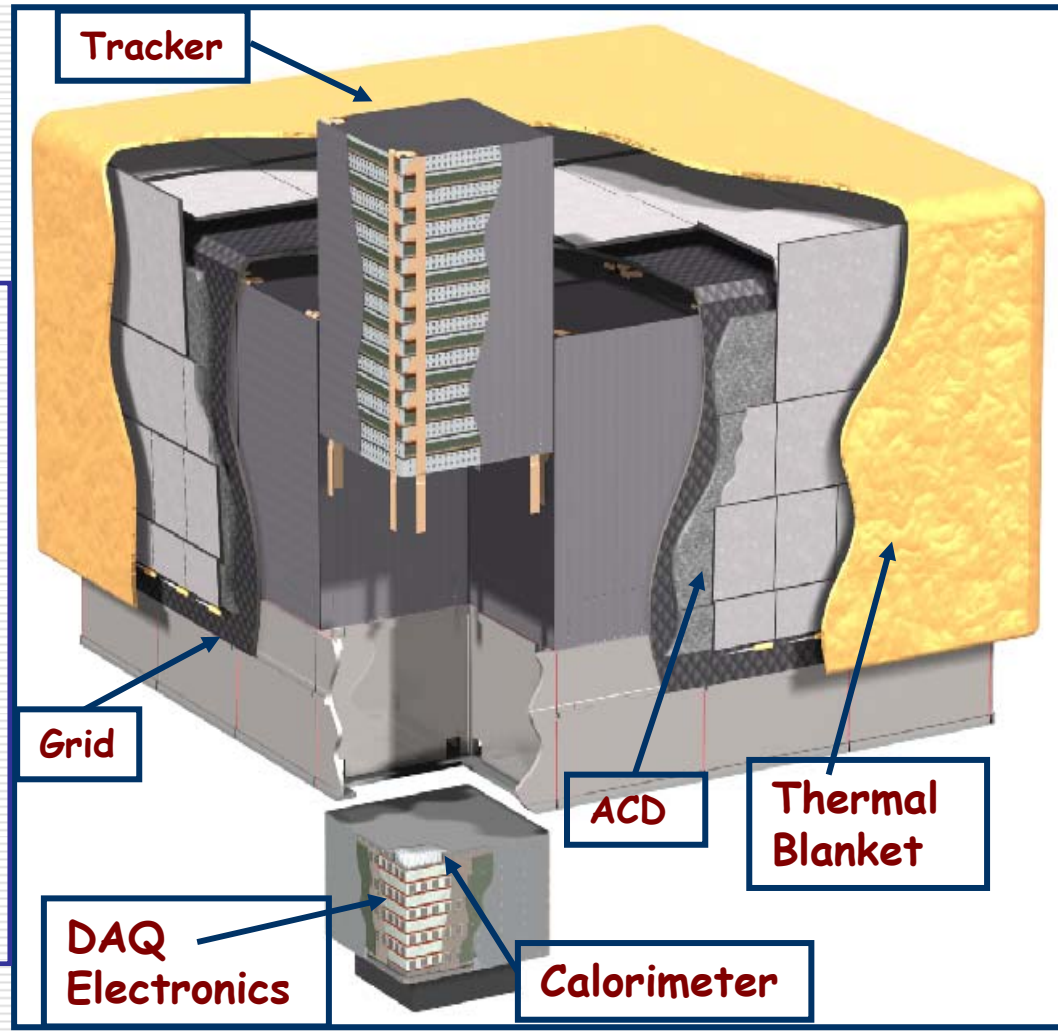
The GLAST Observatory



Launch Vehicle	Delta II – 2920-10H
Launch Location Kennedy	Space Center
Orbit Altitude	575 Km
Orbit Inclination	28.5 degrees
Orbit Period	95 Minutes
Orientation	+X to the Sun

LAT Overview

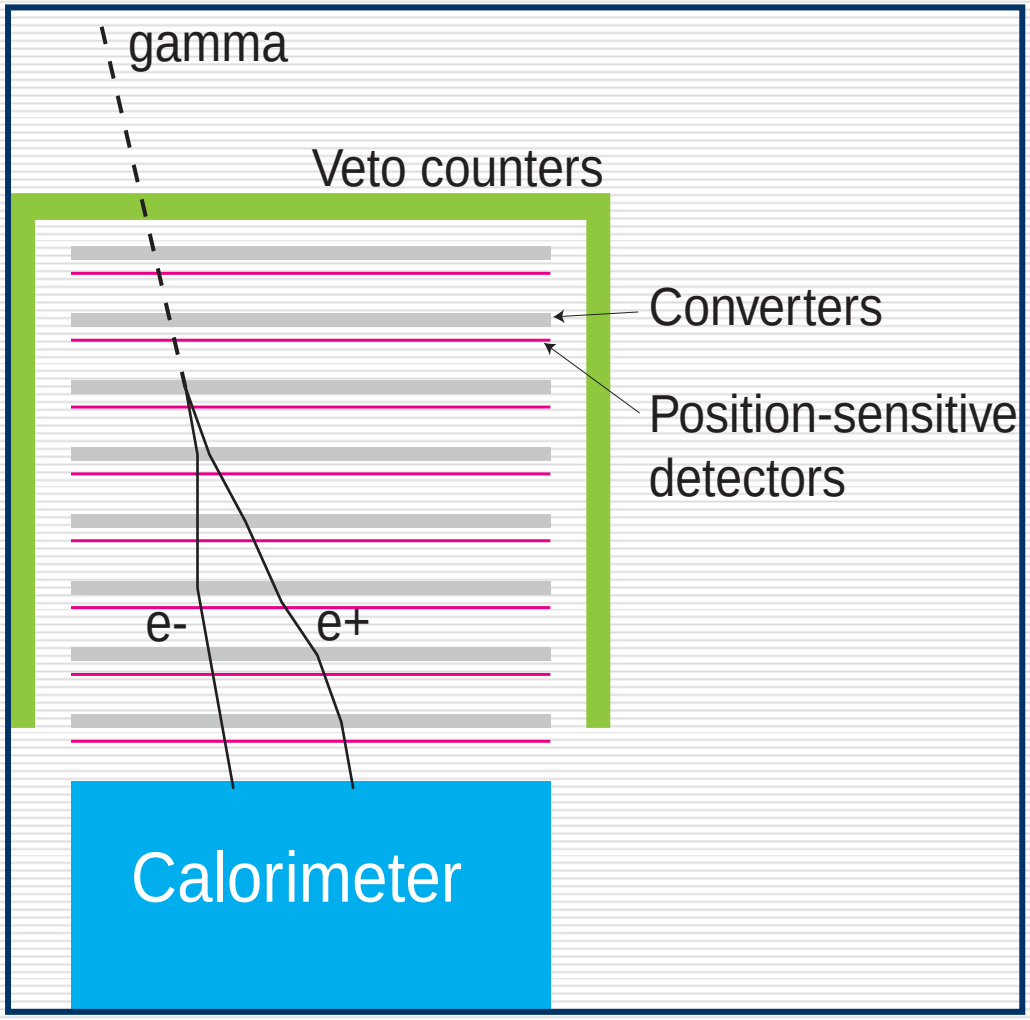
A_{eff}	≈ 8000 cm² (E > 100 MeV)
Ang. Res.	< 3.5^0 @ E=100 MeV
	< 0.15^0 @ E>10 GeV
F.O.V.	≈ 2.4 sr
Source Loc.	< 0.5′
Energy Res.	< 10%
Dead time	< 100 μs
Time Res.	≈ 2 μs
Power	500 W



Systems work together to identify and measure the flux of cosmic gamma rays with energy 20 MeV ->300 GeV.

LAT Tracker system

$\gamma \rightarrow e^+ e^-$

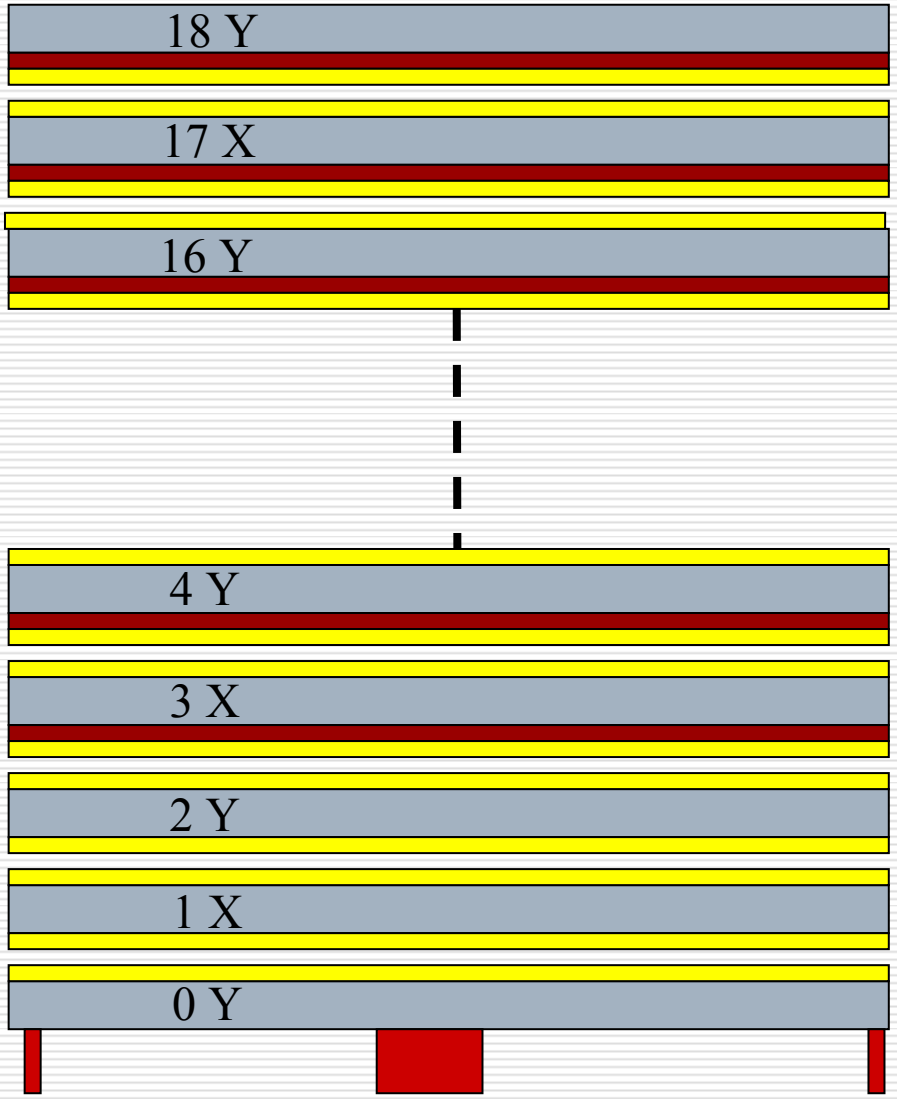


- **Si-strip Tracker (TKR)**
  19 tracking planes.Single-sided silicon strip detectors + W. Measure the photon direction; gamma ID.

- **CsI Calorimeter(CAL)**
  Array of CsI(Tl) crystals in 8 layers. Measure the photon energy; image the shower.

- **Anticoincidence Detector (ACD)**
  89 plastic scintillator tiles. Reject background of charged cosmic rays; segmentation removes self-veto effects at high energy.

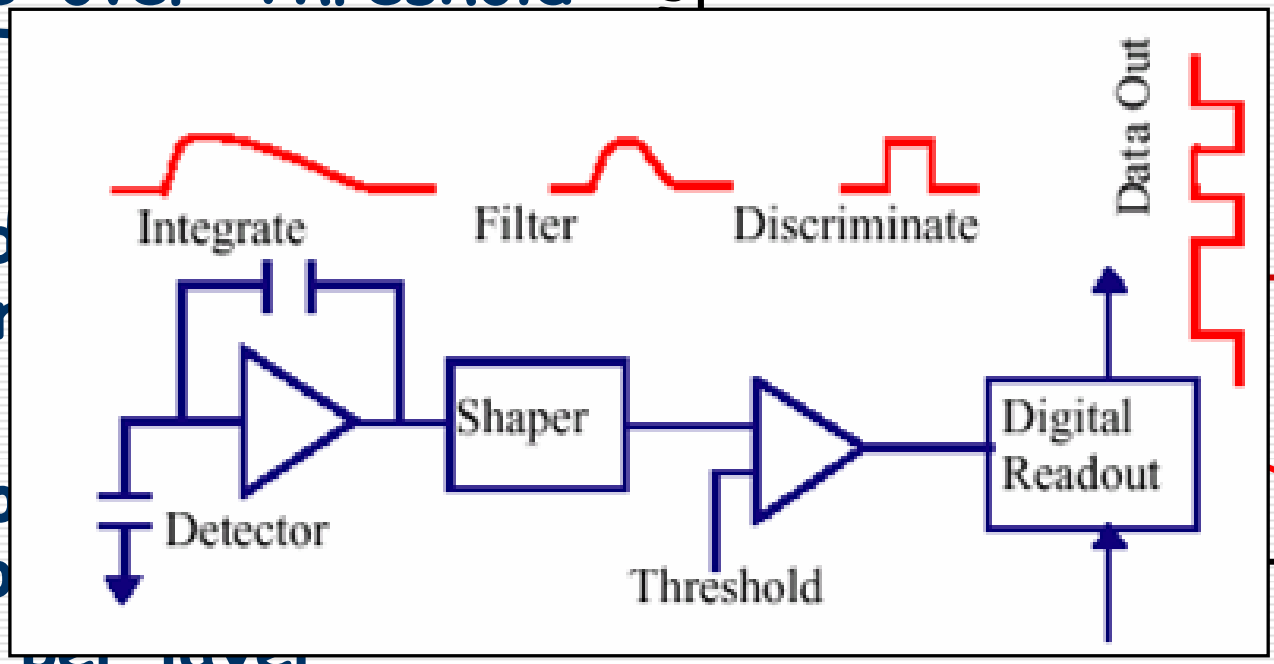
Tracker Tray Configuration

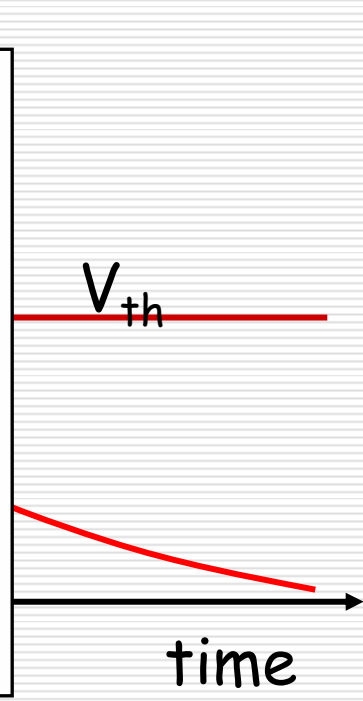


- 16 "tower" (36cm× 36cm)
- 83m^2 of Si
- 11500 SSD
- 18 *x,y* layer per tower
  - 19 "tray"
    - 12 with 3% X_0 *("Front")*
    - 4 with 18% X_0 *("Back")*
    - 3 no converter
- Total length: 1.5 X_0
- SSD(Silicon Strip Detectors)
  - Wafer thickness 400 μm
  - Wafer Area 8.96 x 8.96 cm^2
  - Strip pitch 228 μm
  - Strip thickness 64 μm

LAT Tracker digital signal read-out

- Time-over-Threshold (ToT
- Read layer
- Outp strip ToT



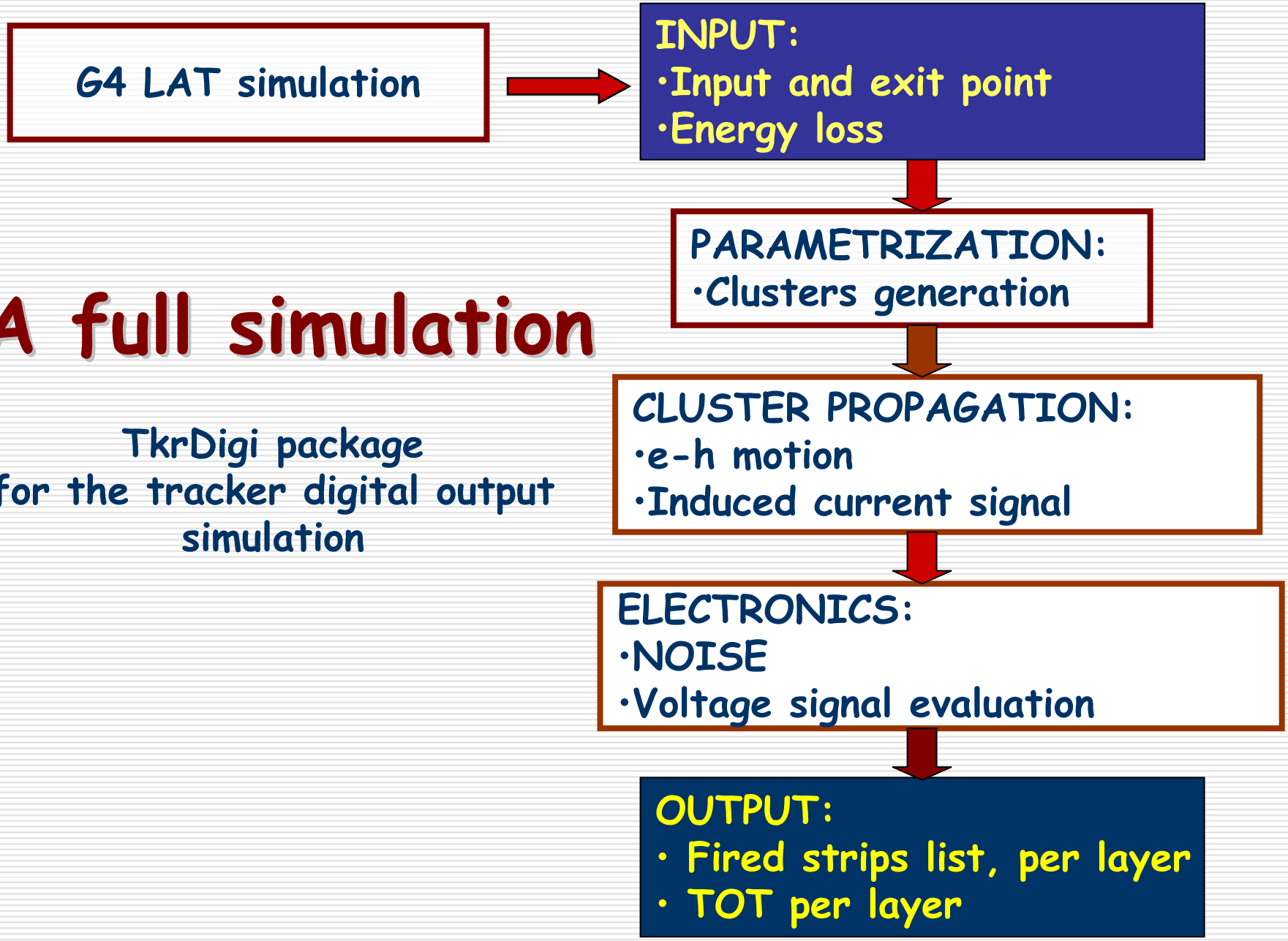


Fast-Or channel/layer

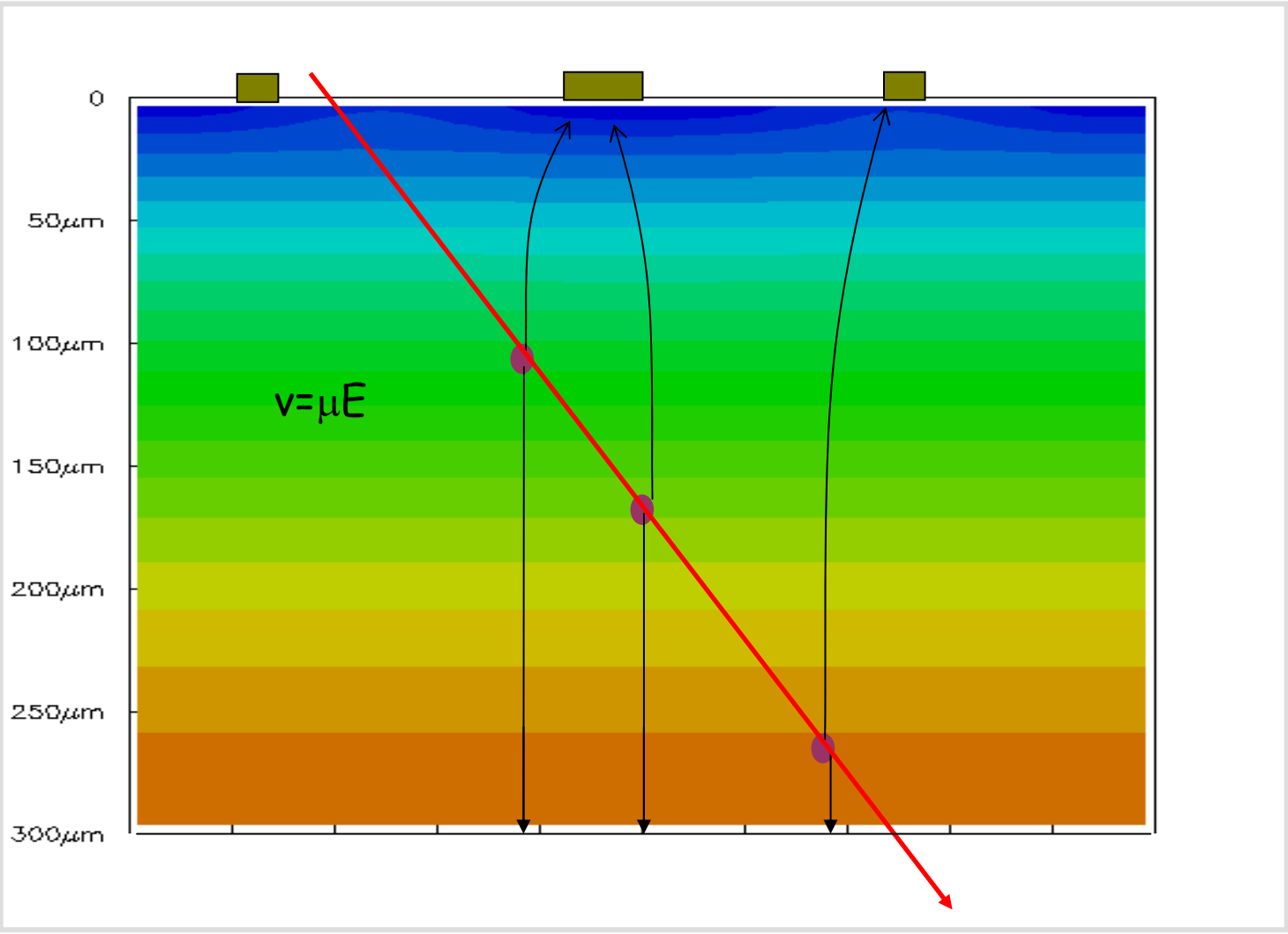
The ToT is an exstimator of collected charge

A full simulation

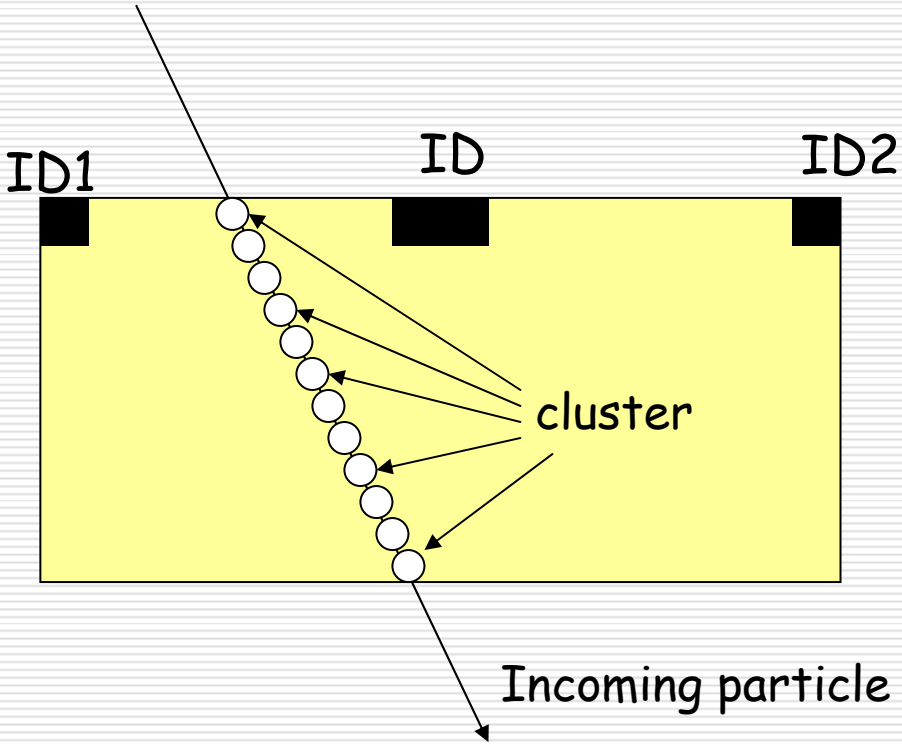
TkrDigi package
for the tracker digital output simulation



Charge particle crossing a SSD



Cluster Generation



- The e-h pair produced in the silicon are distributed along the track and grouped into elements (called *cluster*).
- For each cluster the initial position and charge are assigned
- Clusters are in silicon electric field

Strip signal calculation

$$i_k(t) = -q_0 \vec{v}(t) \cdot \vec{E}_k(\vec{r}(t))$$

E = electric field
E_k = weighting electric field

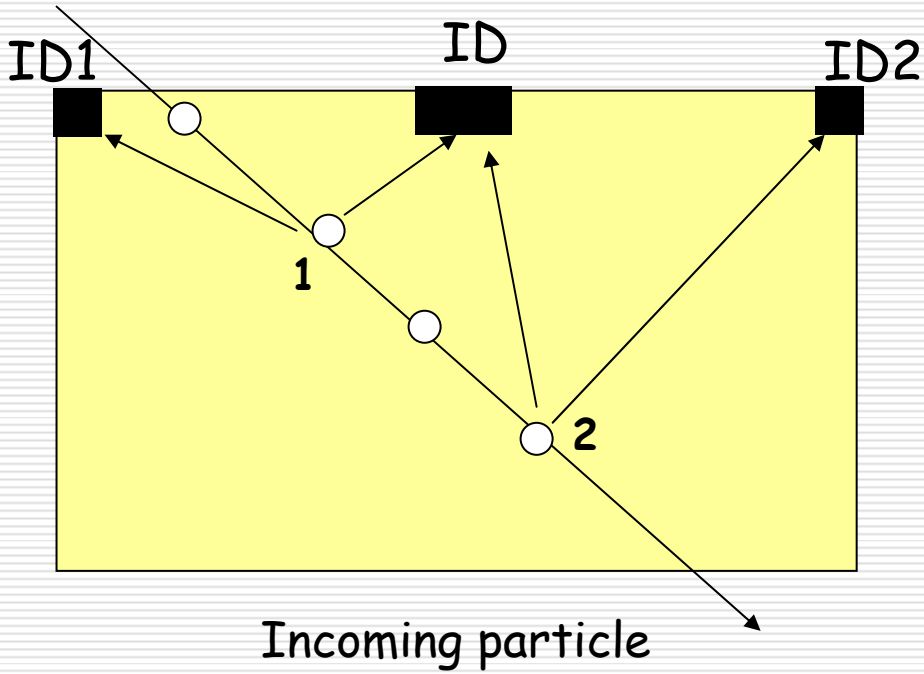
$$\vec{v}(t) = \mu \vec{E}(t) \longrightarrow$$ Drift velocity

- The electric field determines the motion of charge carriers
- The weighting field determines the coupling between the moving charges and the electrode

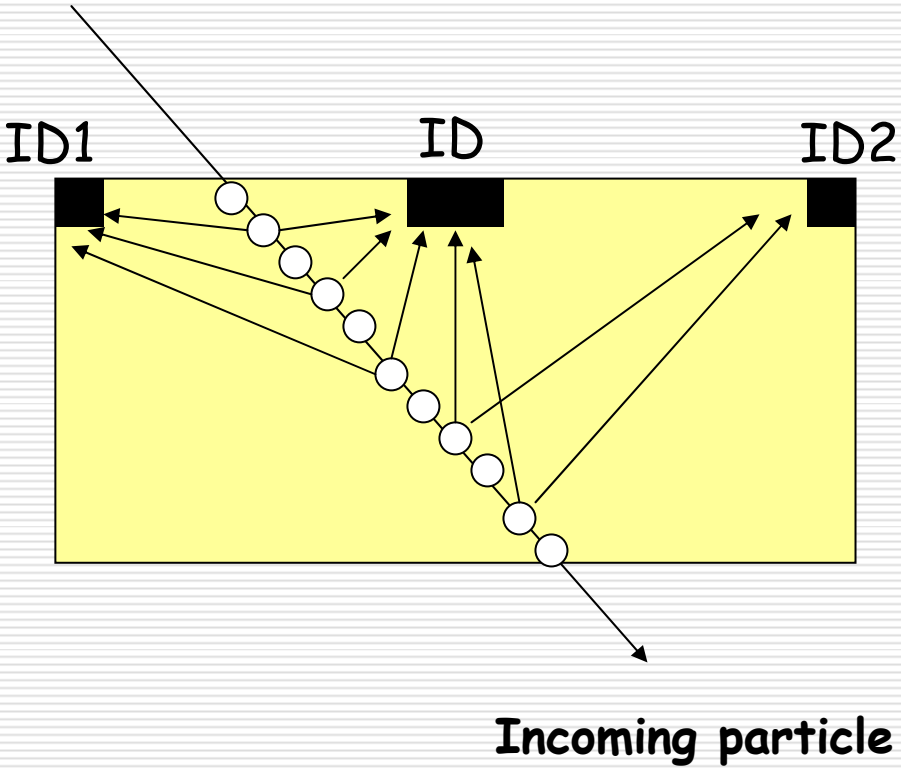
Cluster Propagation

Each cluster drifts towards closest strips

A current signal is induced over ID and ID1 strips by cluster 1; over ID and ID2 by cluster 2



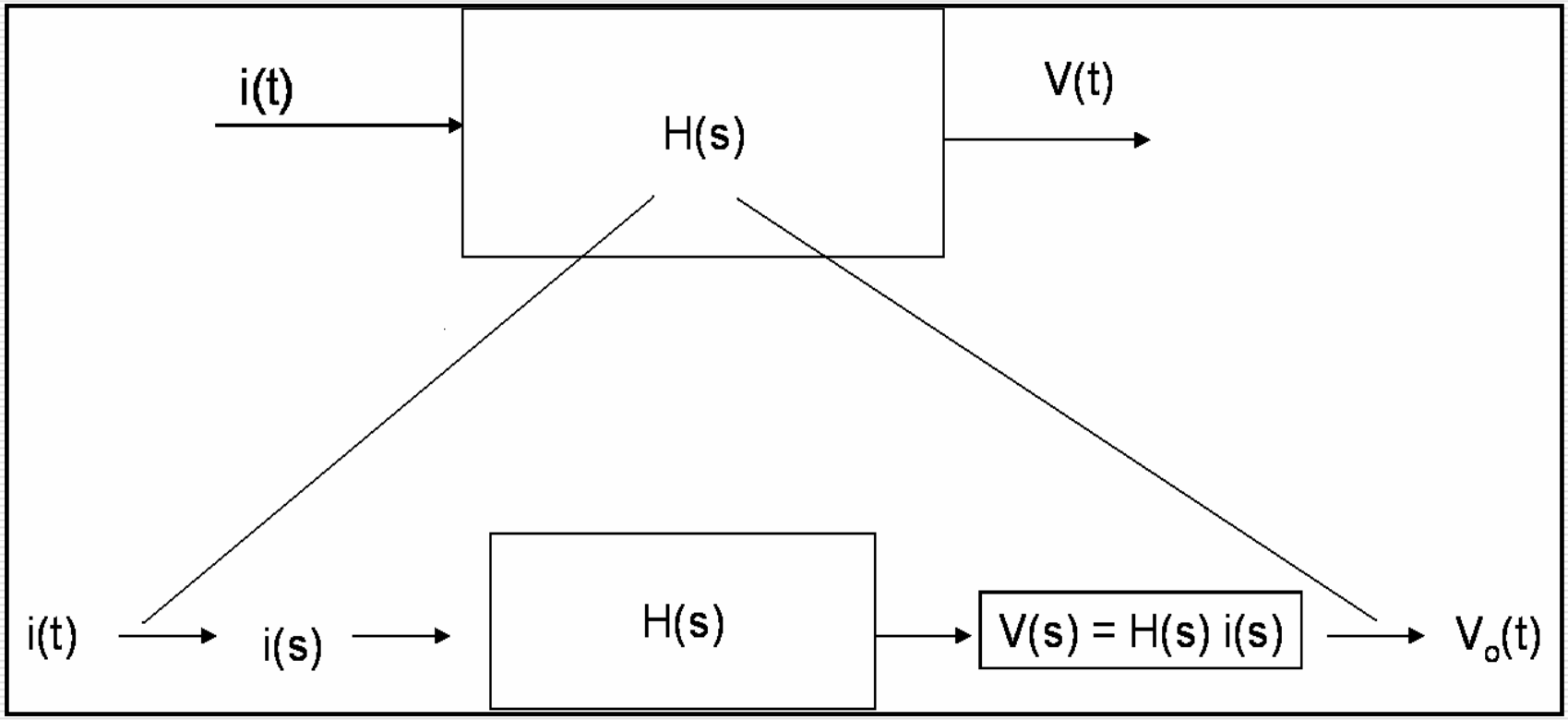
Cluster Propagation



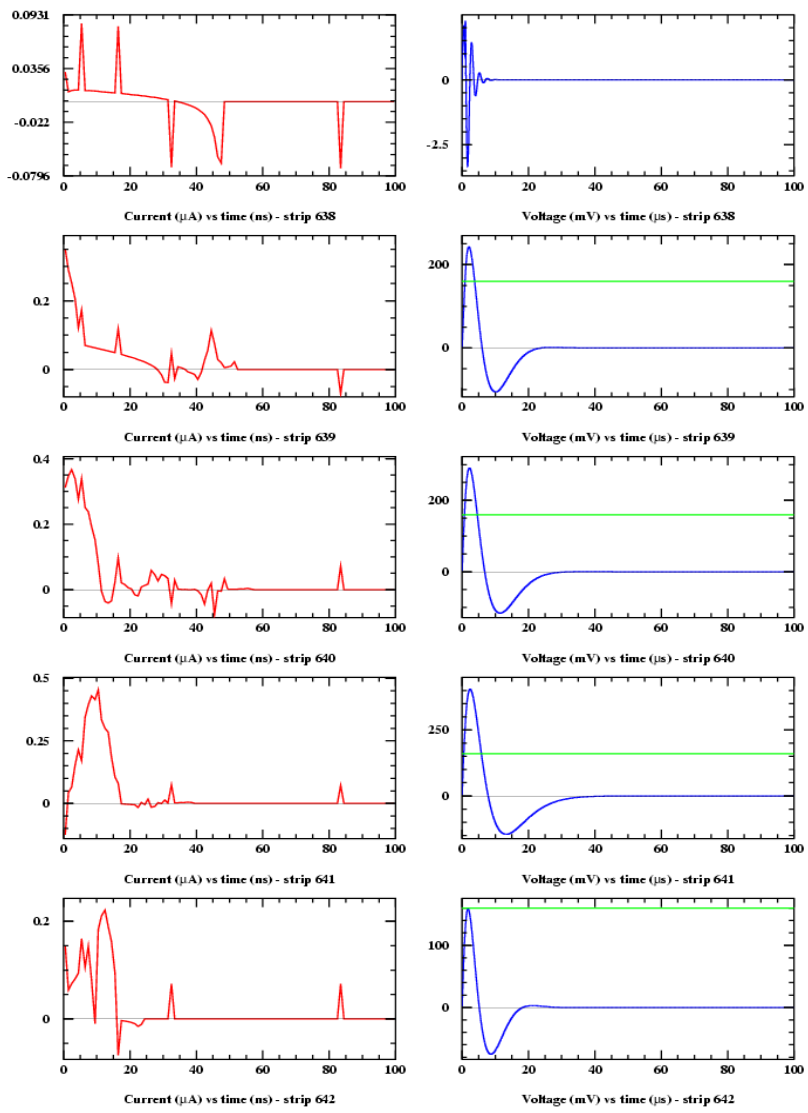
We added the induced current signals from each cluster over the strip ID, and so on over the strips ID1, ID2 etc.

CHARGE SHARING

Read-out electronics simulation

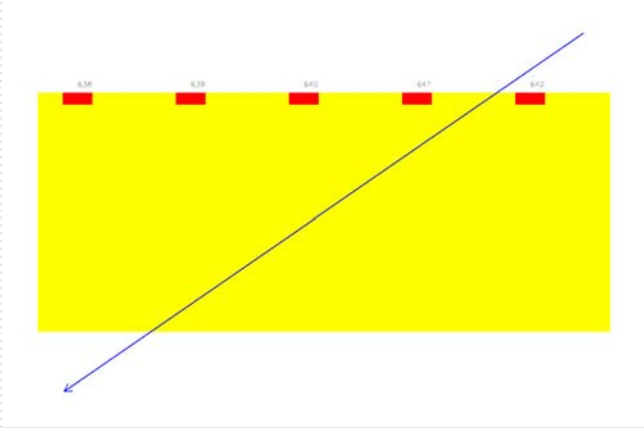


Charge sharing: e^+ 5 GeV

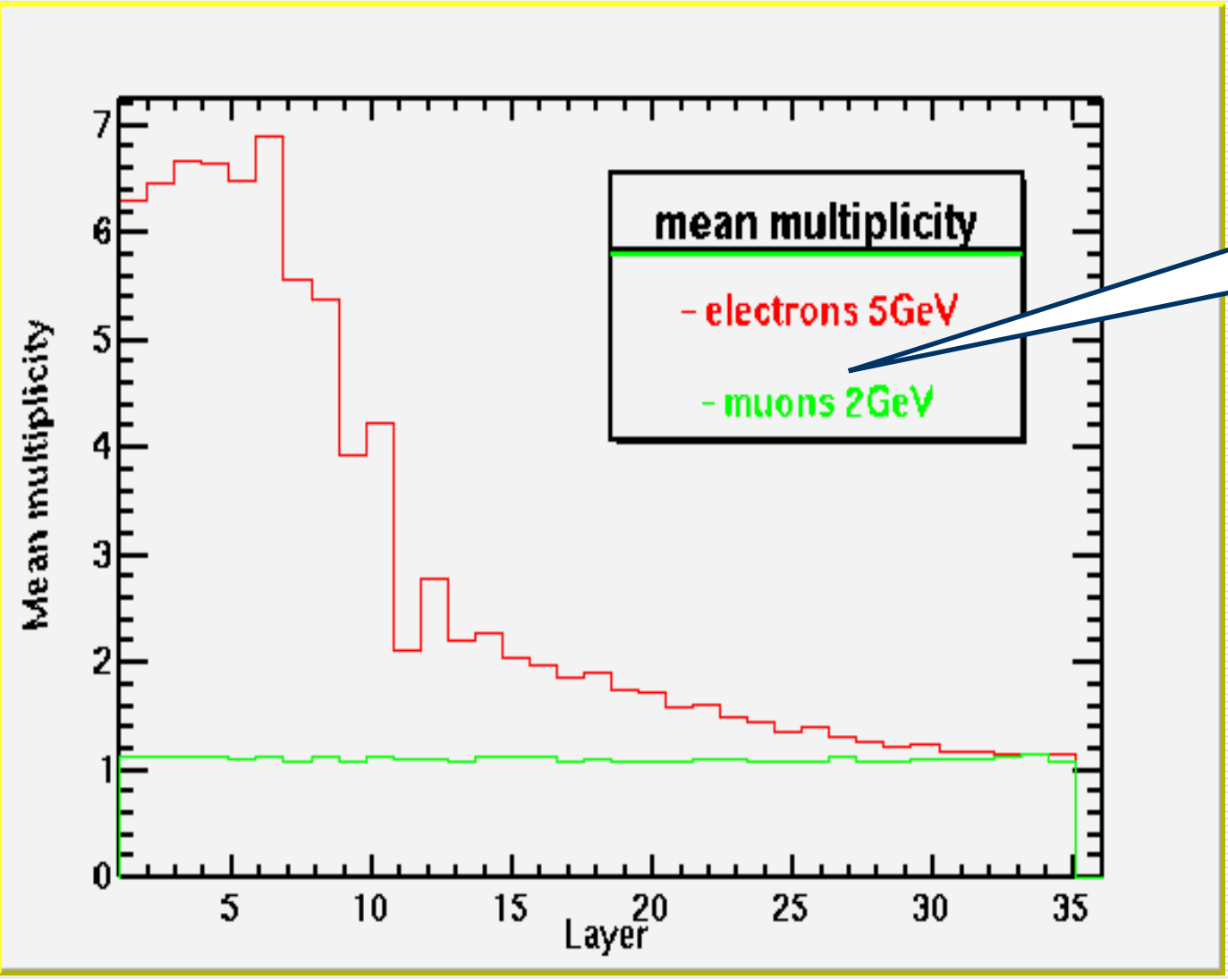


Electron 5 GeV

track 60°



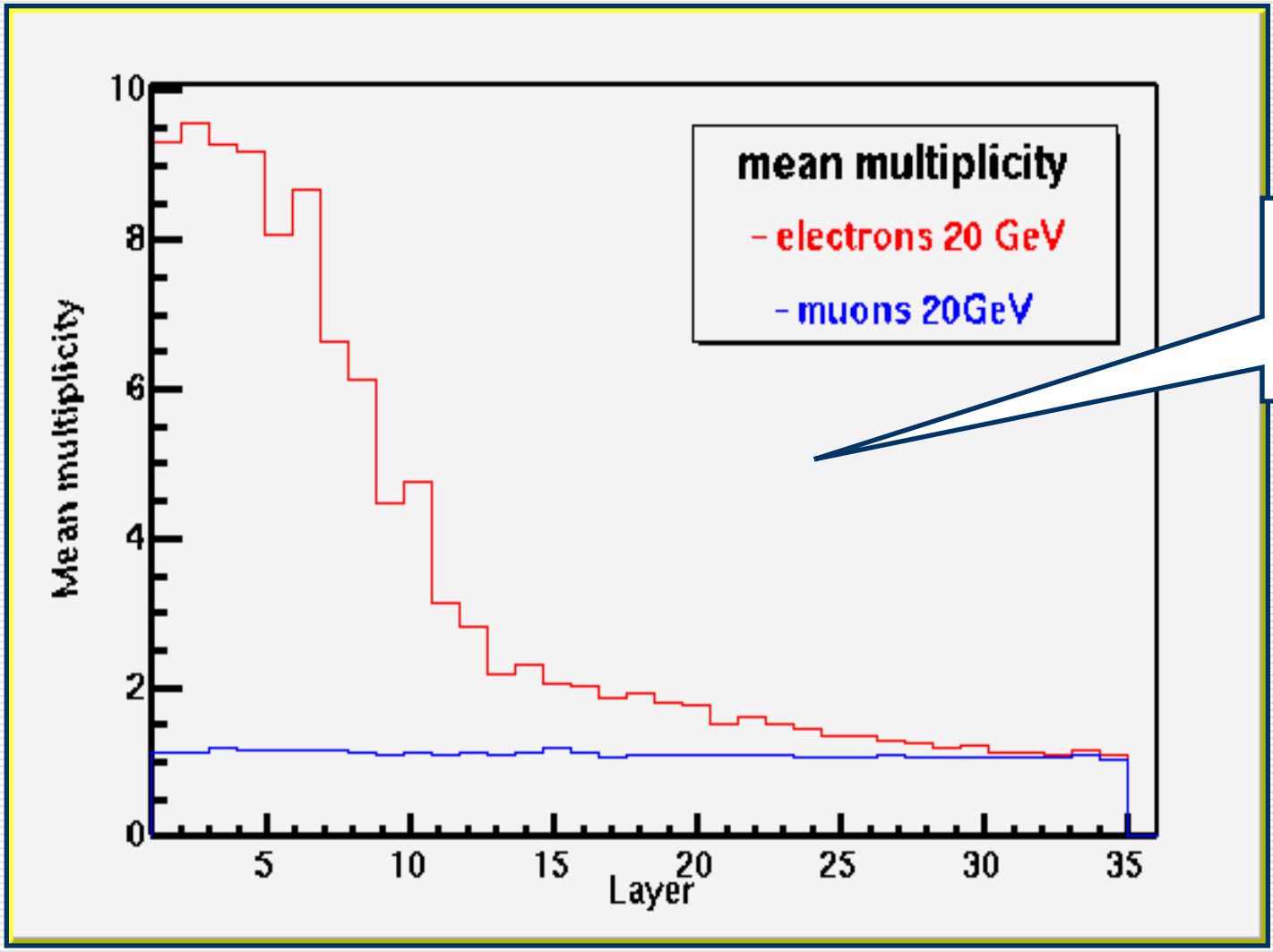
Mean strip multiplicity per layer



Tracks normal
to wafer surface

beam

Mean strip multiplicity per layer



Tracks normal to wafer surface

beam

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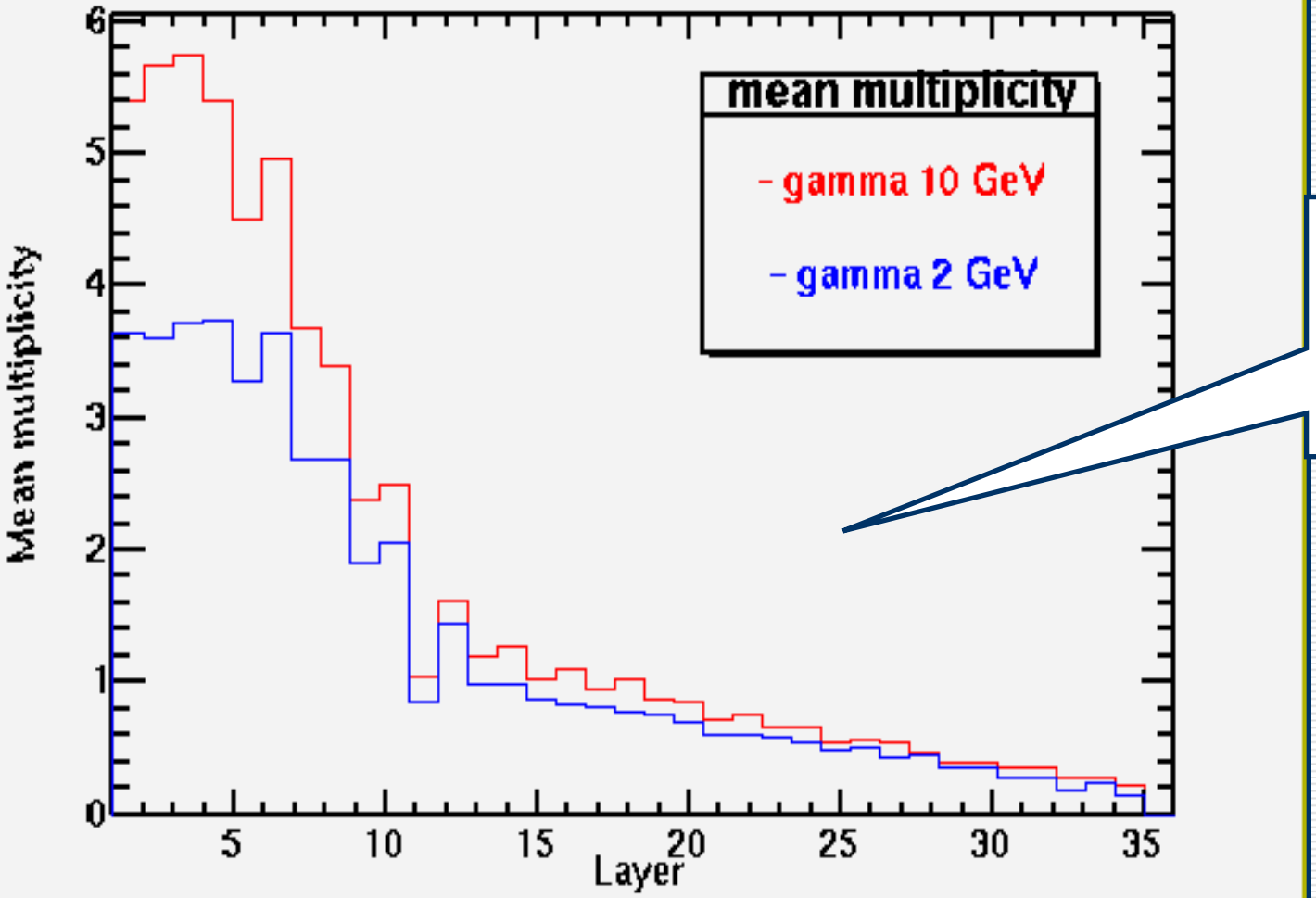
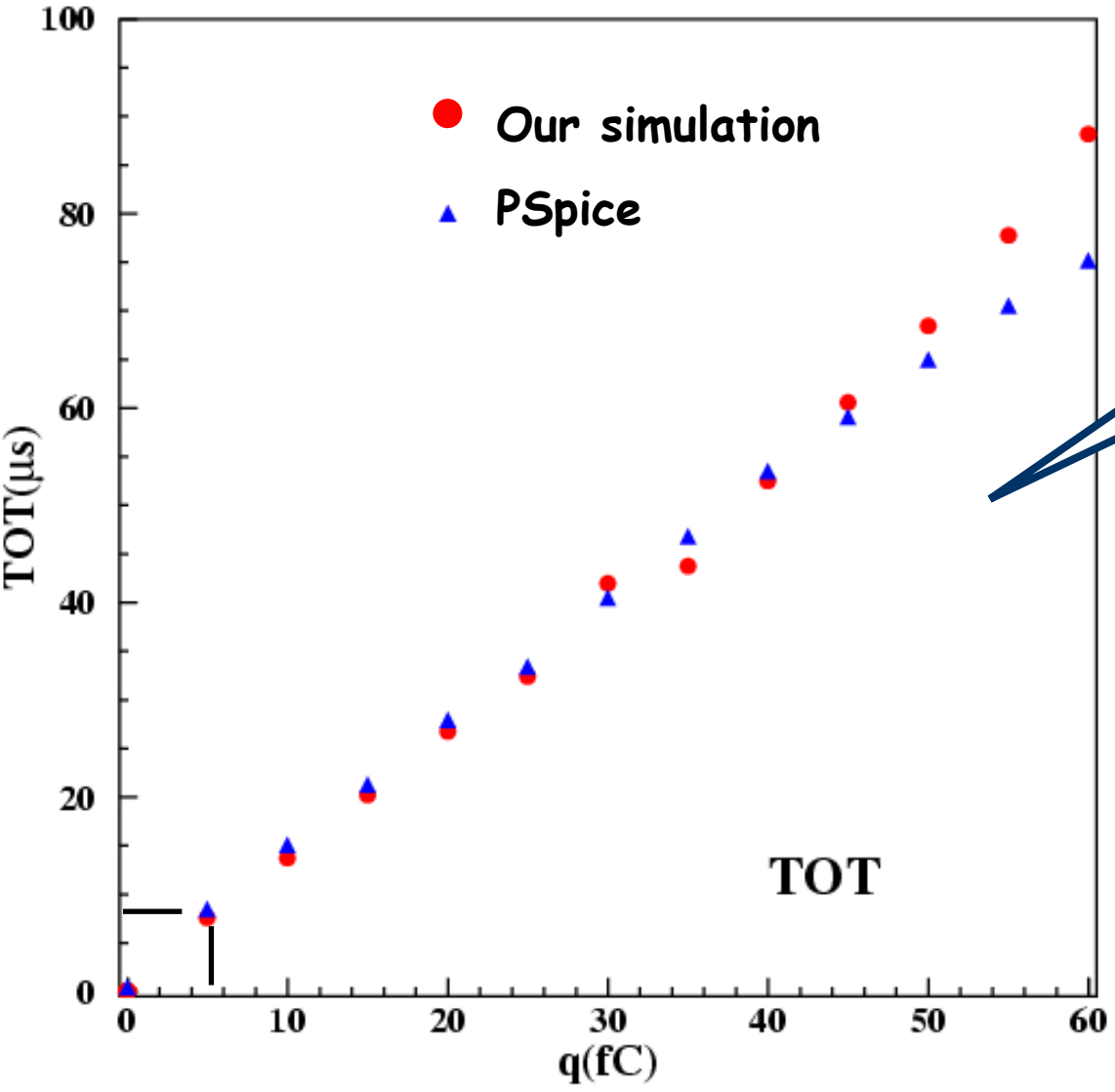


Tracks normal
to wafer surface

beam

ToT vs charge deposited

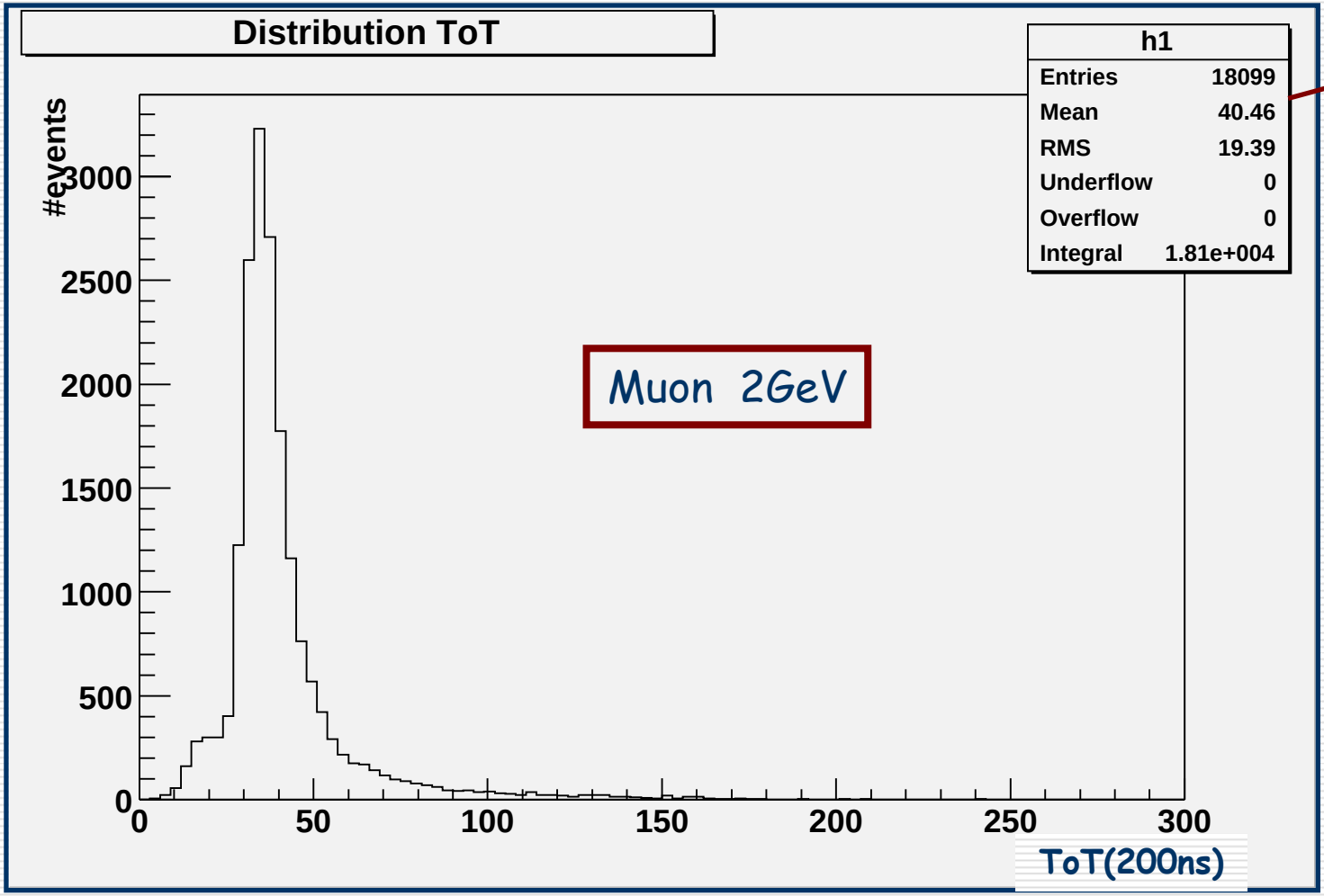


Linear behaviour
(ToT vs Q)

m.i.p. particle in 400 μm of Si

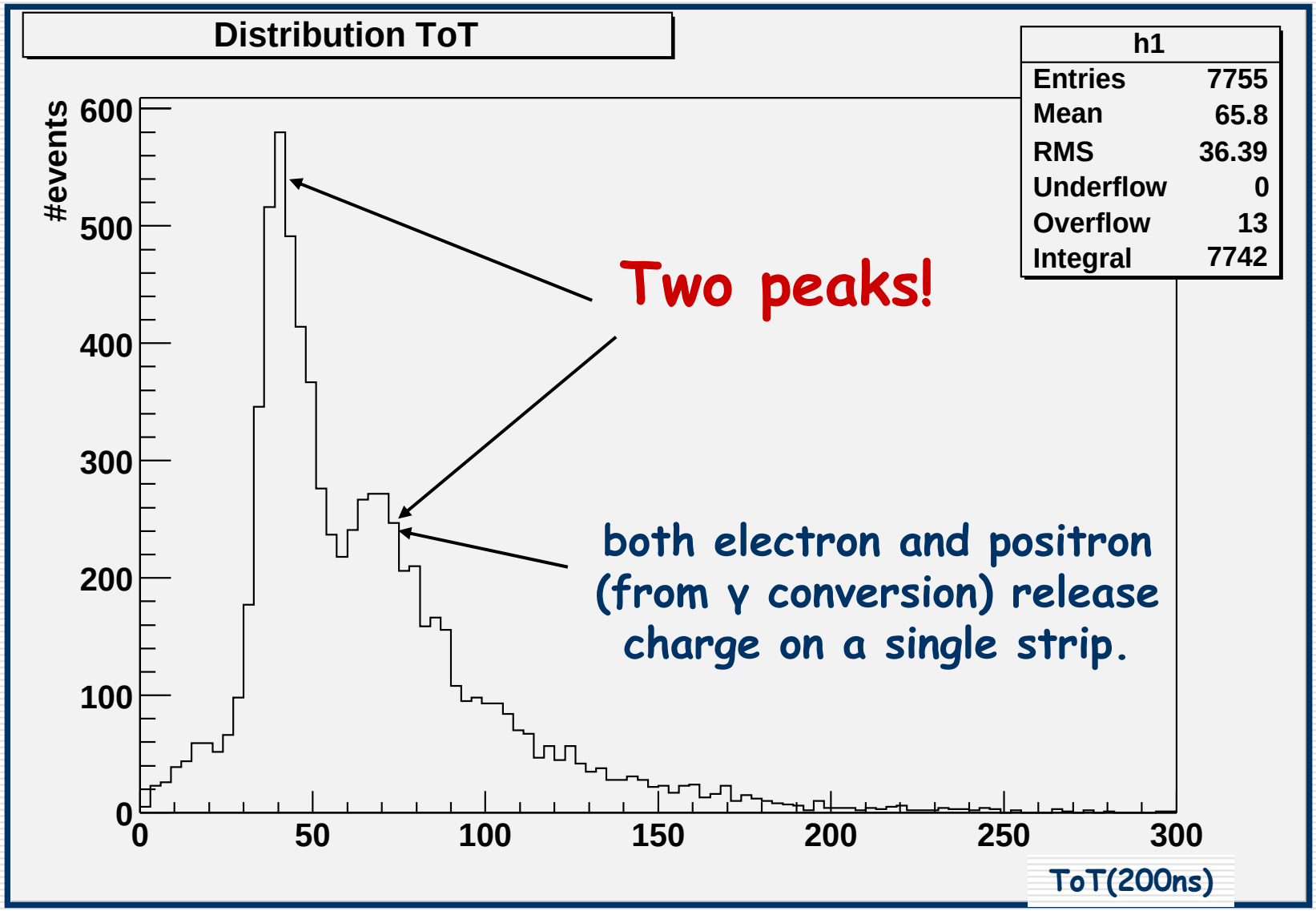
- $\langle E_{loss} \rangle \approx 140$ keV
- $N_{e\text{-}h} \approx 10^4$ e-h
- $Q_{dep} \approx$ 5-6 fC

ToT distributions



8.1μs

ToT distribution (γ 2GeV)



Conclusions

- Current signal simulation in SSD
- Application to GLAST TKR
  - study of TKR behaviour
  - TKR Digit output

- ToT signal read-out
- Applications toTiming study (work in progress)

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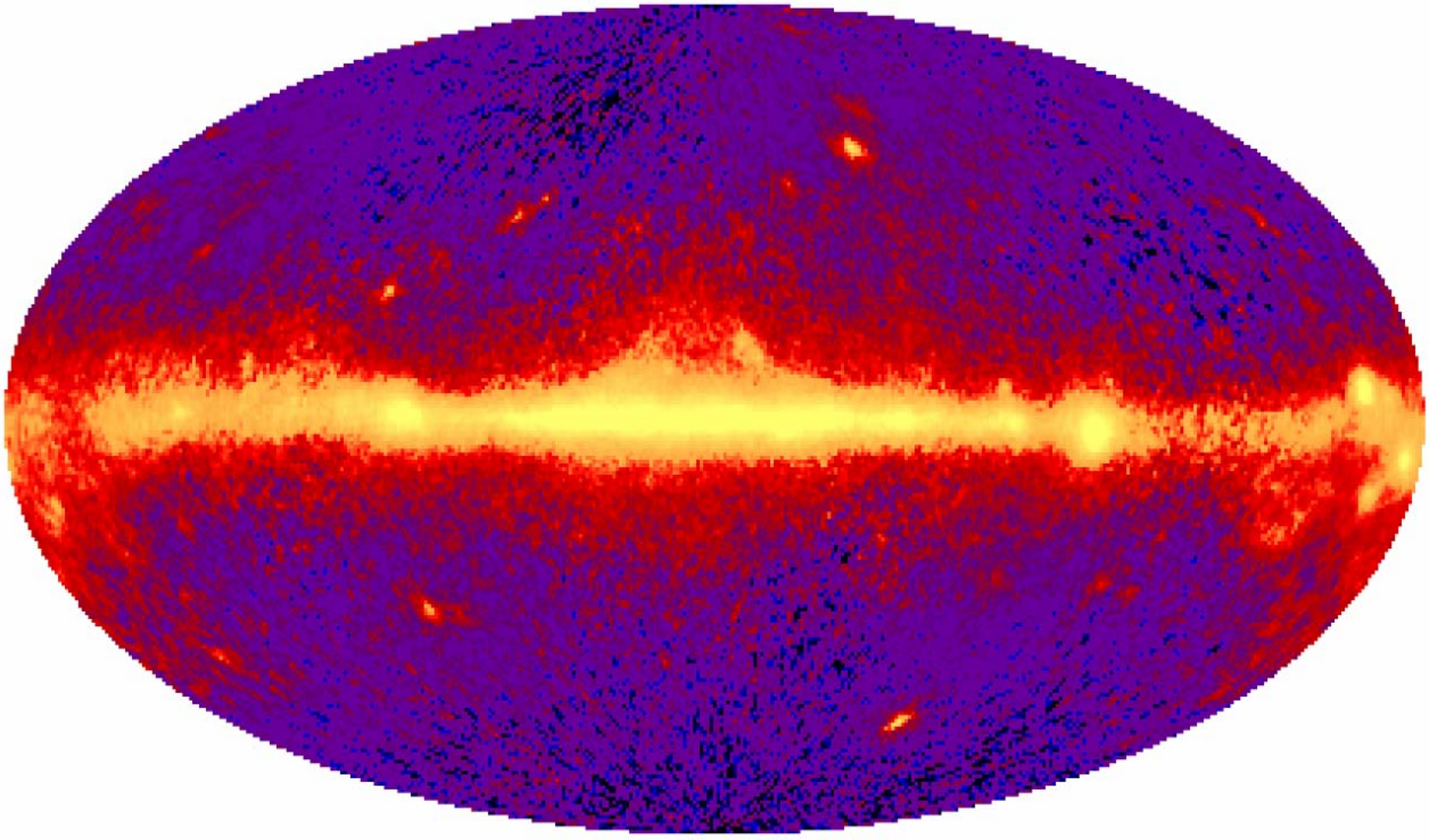

LAT Sim/Recon SW chain