

***CLICCT hits timing for  
MARS background  
and  
IP muons  
(update)***

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- Time of flight (TOF) in MARS background data
- ILCroot CLICCT hits (tracker + vertex detectors) for MARS background and IP particles
- Conclusion



- **MARS background data (Nov. 18, 2010)**  
(<http://www-ap.fnl.gov/~strigano/mumu/mixture/>)
  - 750 GeV  $2e+12$   $\mu^+$  and  $\mu^-$  beams,  $10^0$  nozzle geometry
- **Abs. yields/bunch (weights included, E=750 GeV, both beams,  $2.0e+12$  muons each) on  $10^0$  nozzle surface**

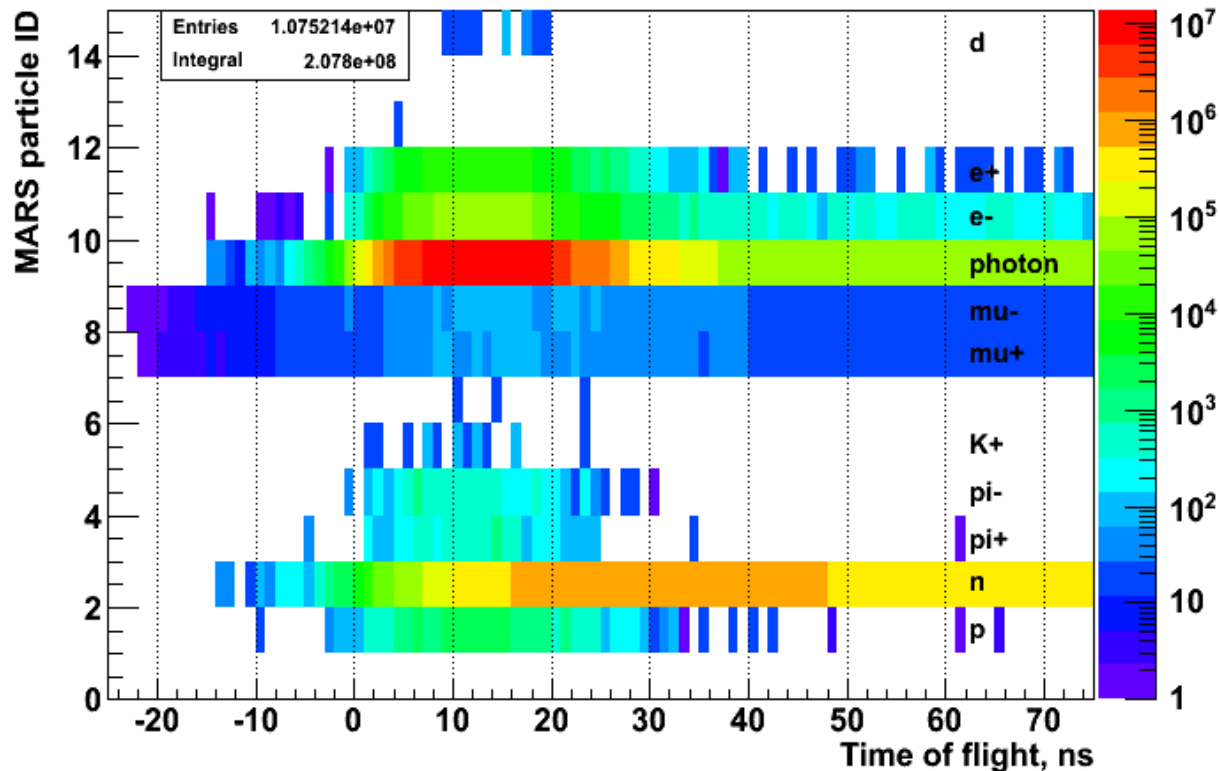
photon	n	$e^{+-}$	p	$\pi^{+-}$	$\mu^{+-}$
<b>1.77e+08</b>	<b>0.40e+08</b>	<b>1.03e+06</b>	<b>3.13e+04</b>	<b>1.54e+04</b>	<b>0.80e+04</b>



# Time of flight in MARS background data

## MARS particle ID and TOF

- Time of flight (TOF) wrt. bunch crossing time, on the surface of  $10^0$  nozzle, MARS particle weights included
- In window  $0 \leq \text{TOF} \leq 25$  ns
  - ~21% of neutrons, ~36% of muons, >94% of other particles
- $\text{TOF} < 0$  corresponds to the particles making straight path to detector





- **Looking at timing in CLICCT (CLICCT = VXD + SiT + FTD) hits (new results)**

- All statistics MARS ROOT files were prepared having all and ID specific background particles for both muon beams
- Run ILCroot\_2.9.1 (new release) simulation for these data (MARS weights included)
  - Use latest GEANT4 (4.9.4.p01)
  - Outputs – CLICCT.Hits.root, CLICCT.SDigits.root and CLICCT.Digits.root
  - CLICCT.Hits.root files were analyzed in standing alone code, ntuples were made
- Run ILCroot\_2.9.1 (new release) simulation for IP muons and protons
  - Originate in IP (Interaction Point) at  $X=0, Y=0, Z=0$
  - Flat distribution in momentum  $P$ , angles  $\Phi$  and  $\Theta$   
 $0.2 \text{ GeV} < P < 100 \text{ GeV}, 10.4^\circ < \Theta < (180-10.4)^\circ$
  - 10 particles per event, total 1000 events or 10,000 muons/protons

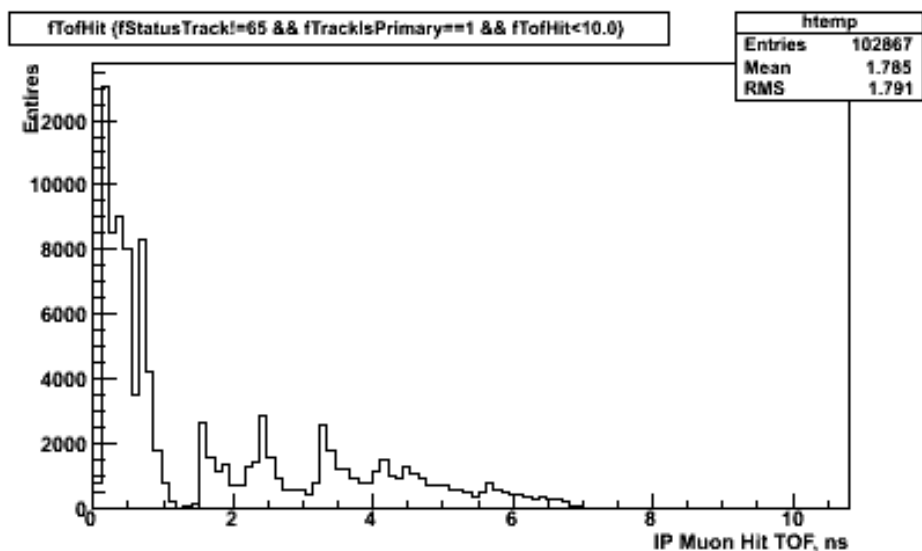


- **Looking at timing in CLICCT (CLICCT = VXD + SiT + FTD) hits (new results)**
  - Available in ILCroot hits TOF (time of flight) timing
    - TOF – “time of flight” for hit in CLICCT.Hits.root, calculated wrt. bunch crossing
    - For MARS particles – TOF from MARS file + detector propagation time
    - For IP particles – detector propagation time
  - Introduce new timing, TOF – T0
    - Define T0 for each hit in each CLICCT layer as arrival time of the photon coming from IP to the point with this hit coordinates (still wrt. bunch crossing)
    - T0 is equivalent to delays in front-end tuned to equalize the hit timing in all CLICCT layers (and within layers with reasonable grouping)
  - Choose TOF – T0 time gate width
    - To detect hits from IP particles with ~100% efficiency (use muons as the fastest, protons as the slowest particles)
    - Then it will define the rejection of the hits from muon collider background particles

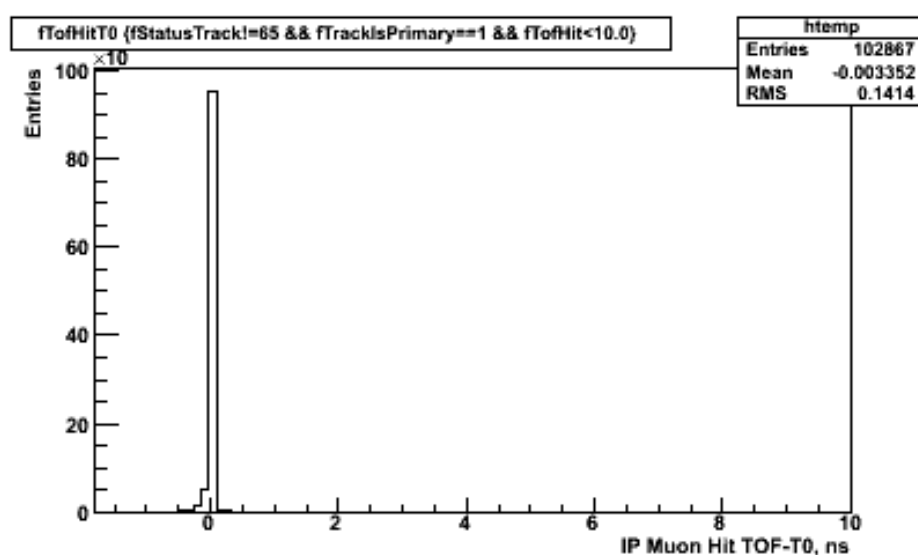


- Timing for IP muons

## TOF



## TOF - T0

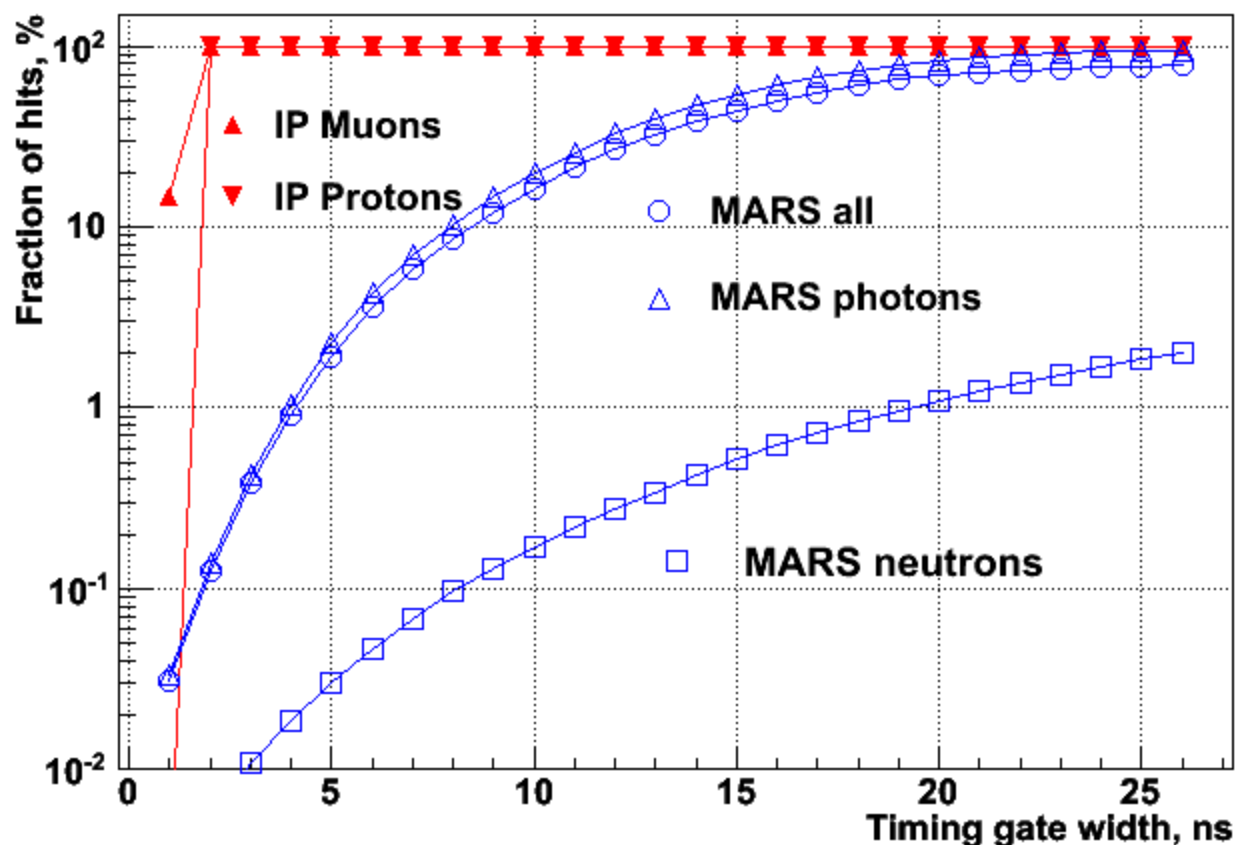




# CLICCT hits for MARS background and IP particles

- Choice of the time gate width and background hit rejection**

(no smearing in CLICCT collection and resolution time, no neutron contribution from beams in previous bunches), timing gate starts at TOF-T0 = -1 ns, GEANT4



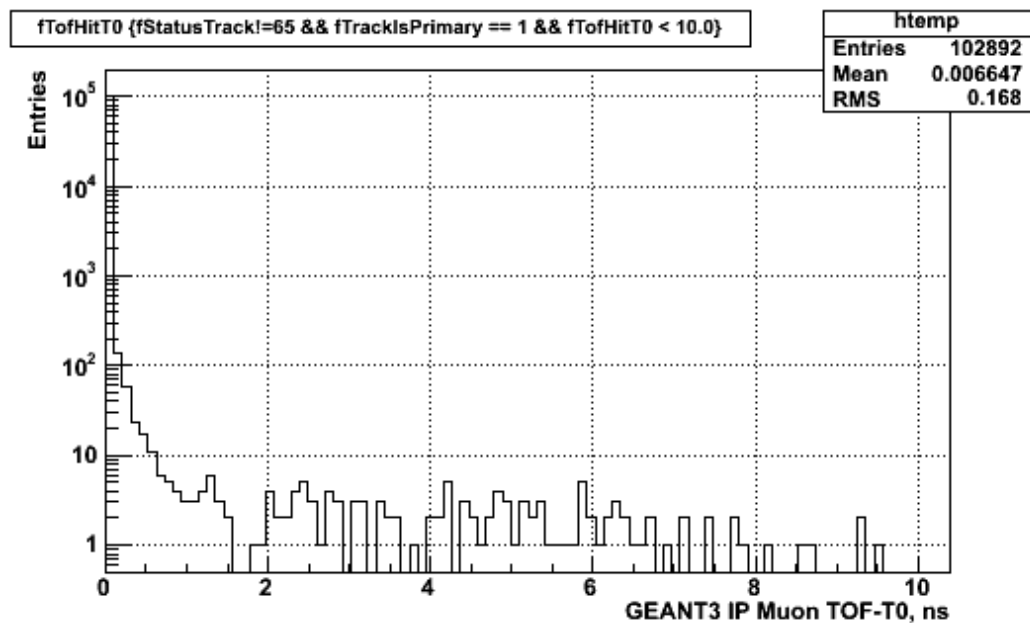
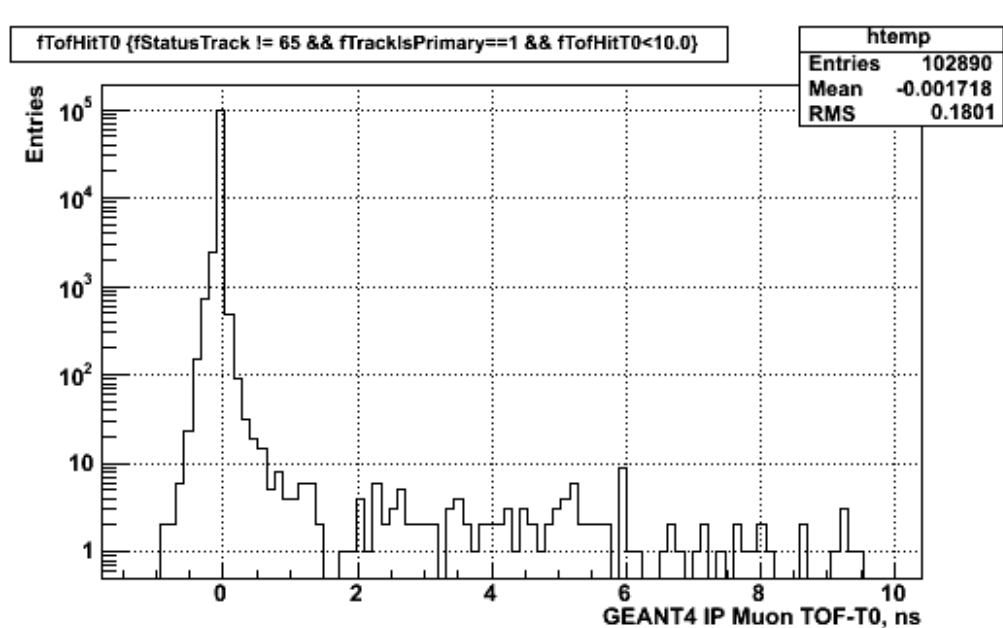
- 3-5 ns time gate width ?**





## Problem

- GEANT4: ~15% of hits from IP muons have negative TOF-T0,  $-1\text{ns} < (\text{TOF-T0}) < 0\text{ns}$  (picture on the left)
- GEANT3: no such hits (picture on the right), as it should be





# Conclusion

- **The new timing (TOF-T0) in ILCroot CLICCT hits for MARS background and IP muons/protons was analyzed**
- **For 3-5 ns (TOF-T0) time gate width**
  - If no smearing in CLICCT collection and resolution time, no neutron contribution from beams in previous bunches
  - Then ~100% efficiency for hits from IP muons and protons
  - And overall MARS background hits rejection  $\sim(250-50)$ , neutrons  $\sim(10,000-3,000)$
- **Problem with timing in GEANT4 (of order  $\pm 1$  ns)**
- **Next step – introduce the space correlation of the IP particles hits and combine it with their time correlation to estimate the total reduction of the random background hits in CLICCT**