Bunch ID by Sci. Fi. Tracker

based on the work
by
Indiana-Notre Dame Collab.

Y. Sugimoto

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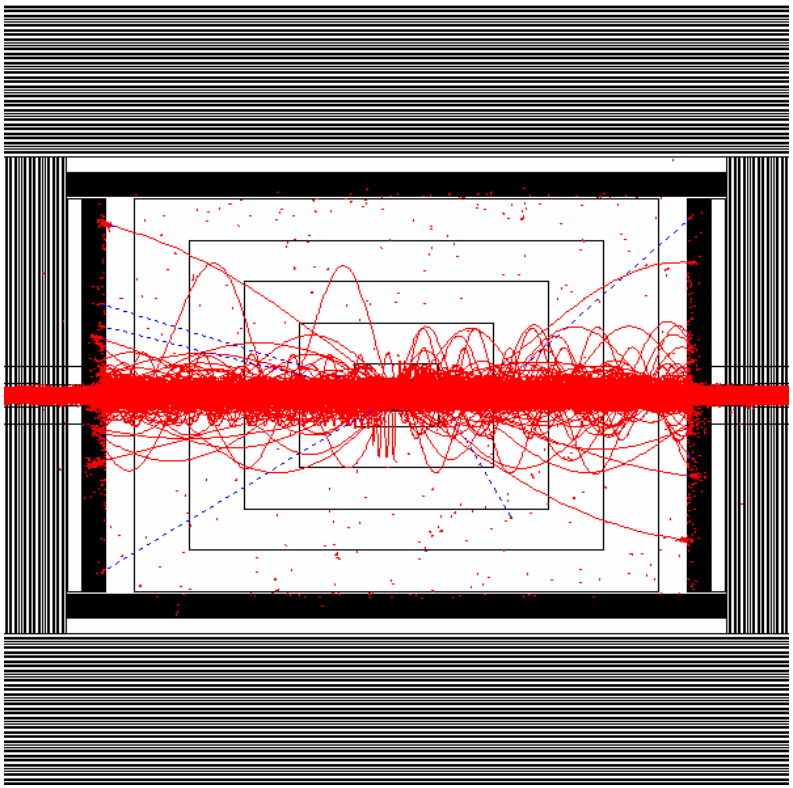
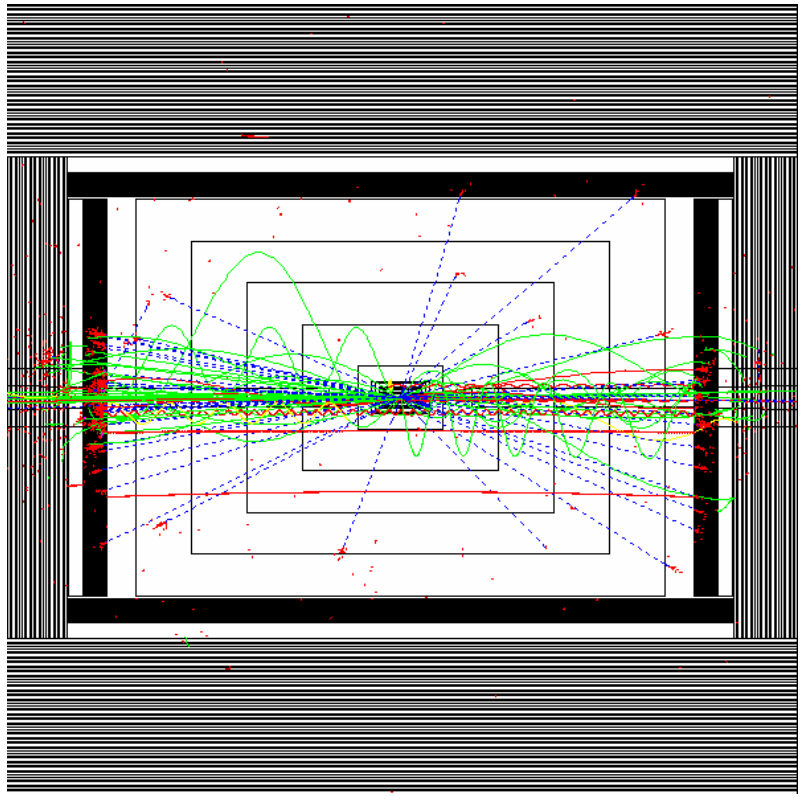
Motivation of Bunch ID

- 2-Photon Background:Expected # of B.G. has been increased x10 in recent re-estimation

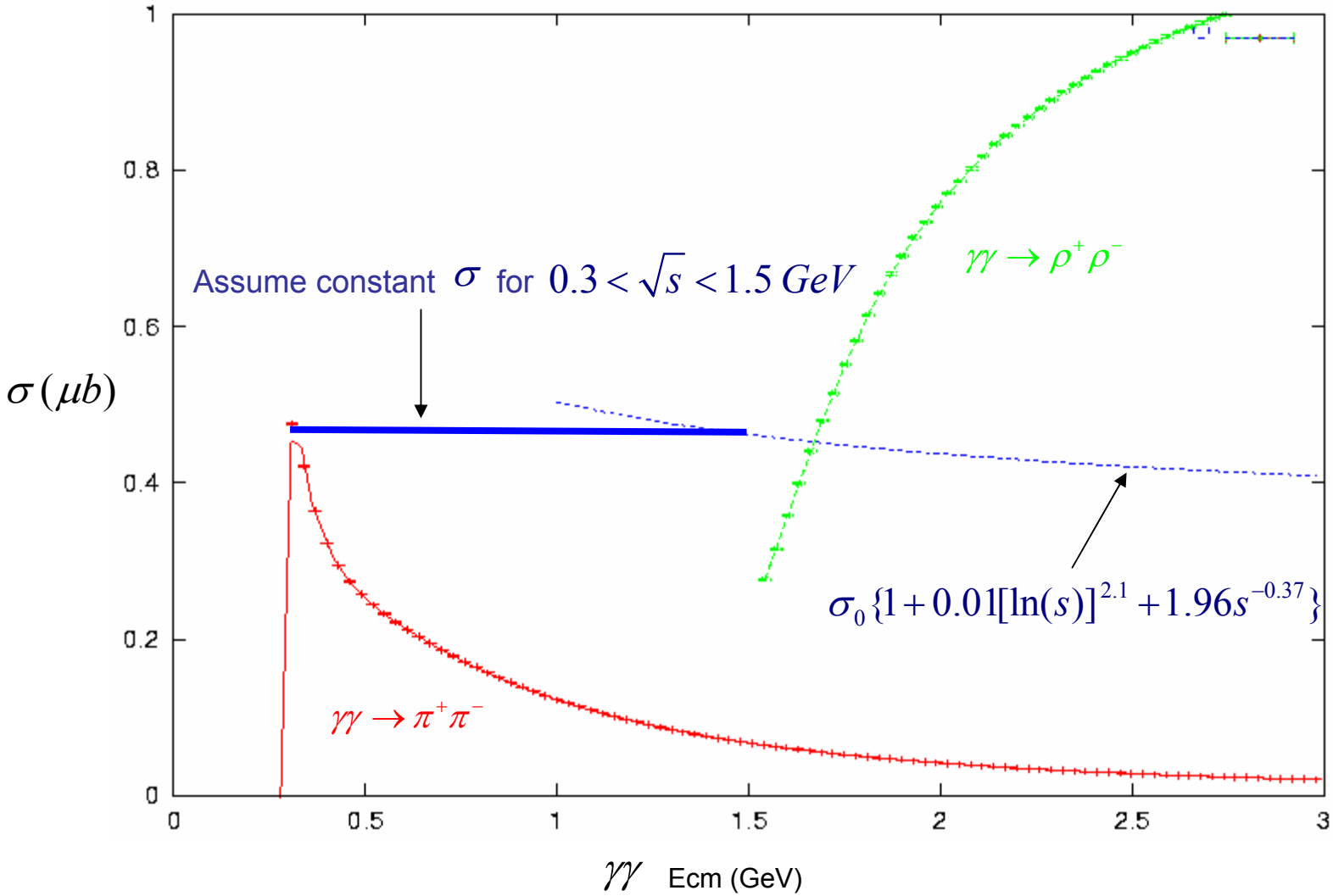
JLC-I (DG model, p_T>1.6GeV)	1.2 ev/train
JLC-I (VDM model, $W_{\gamma\gamma}$>2GeV)	4.6 ev/train
TESLA TDR (p_T>2.2GeV)	0.02 ev/BX (=1.8 ev/train@NLC)
Tim Barklow's new estimation	56 ev/train
# of charged tracks ($\|\cos\theta\|<0.8$)	48 track/train
# of charged tracks ($0.8<\|\cos\theta\|<0.995$)	390 track/train

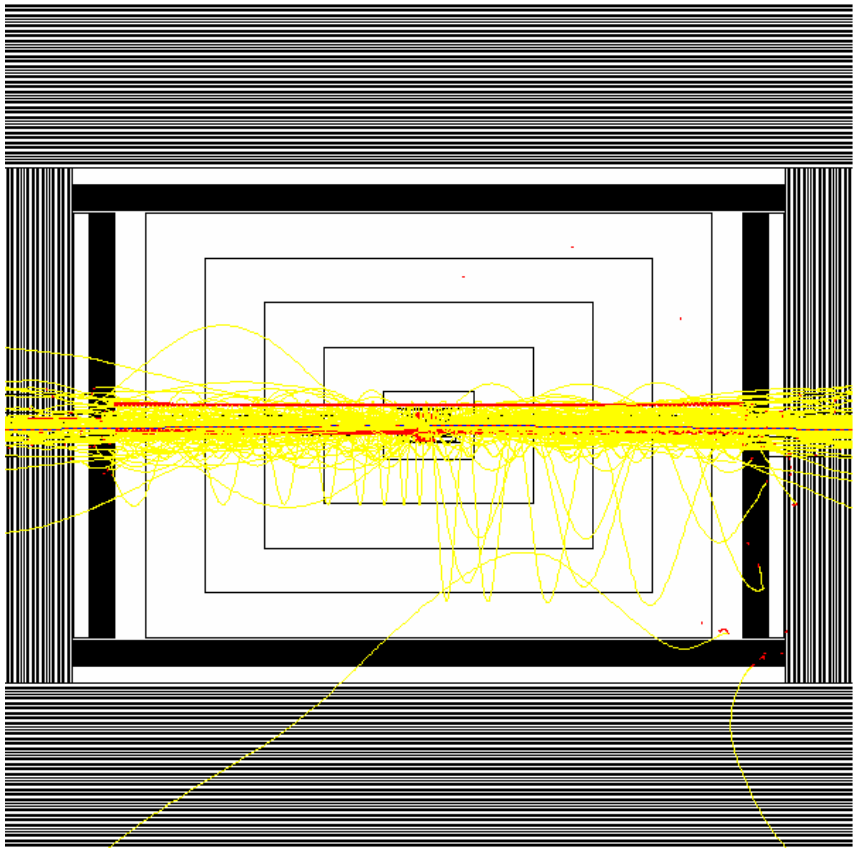


$8600\ e^+e^-$ pairs / train strike detector

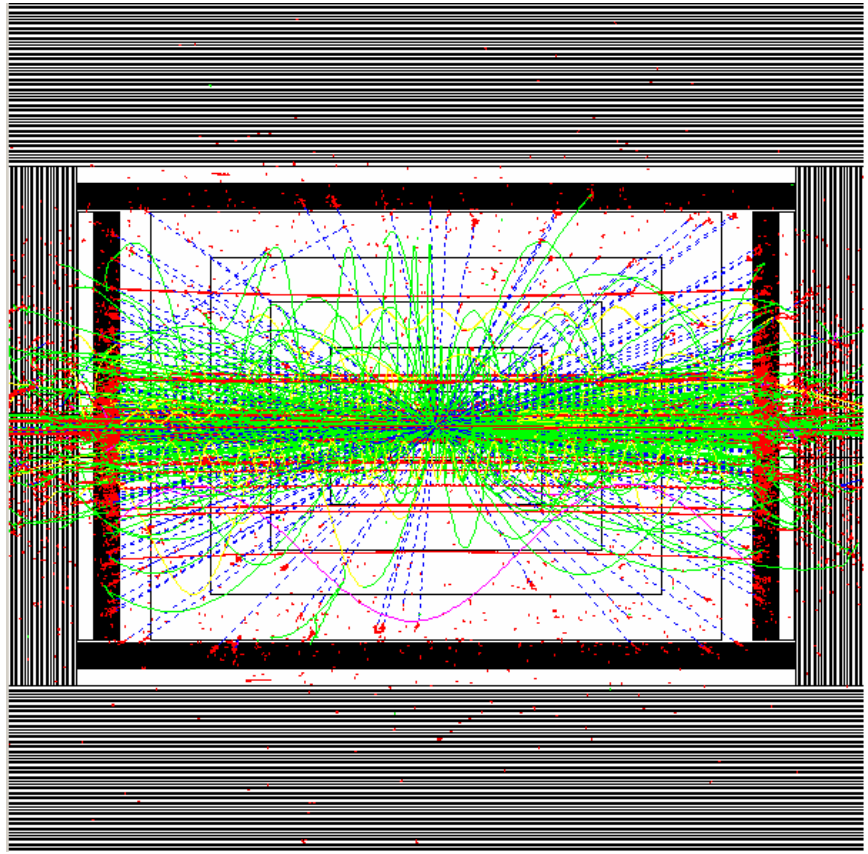


1.8 hadronic events / train with pt>2.2GeV


Assume constant σ for $0.3 < \sqrt{s} < 1.5\ GeV$
$\gamma\gamma \to \rho^+\rho^-$
$\sigma_0\{1 + 0.01[\ln(s)]^{2.1} + 1.96s^{-0.37}\}$
$\gamma\gamma \to \pi^+\pi^-$
$\sigma(\mu b)$
$\gamma\gamma$ Ecm (GeV)
0
0.2
0.4
0.6
0.8
1
0
0.5
1
1.5
2
2.5
3



$154\ \mu^+\mu^-$ pairs / train



56 hadronic events / train

Impact of Large B.G.

- Warm machine:
  - GLC Detector (Jet Chamber) : too much occupancy (R_{min} must be increased significantly)
  - Resolutions of physics outputs degrades unless event overlap is resolved by bunch ID
- Cold machine:
  - Event overlap within one bunch (irreducible) is significant (~0.5 ev/BX; x2 more than warm machines)
- Common:
  - Significant positive ion generation in TPC (z- and t(in a train)-dependent in cold machine)

Bunch ID by Sci.Fi. Tracker

- Possible design:
  - 2-layers (axial+stereo) of Scintillator Fiber ($1mm^2$) tracker just inside the main tracker
  - Covers only barrel part
  - R=40cm, L=1m ➔ $|\cos\theta|<0.8$
  - Readout by SiPM at both ends
- Occupancy:
  - $N_{track}/N_{channel} \sim 2\%$
  - Increases due to curring tracks and inclined injection

Expected Performance

- Simulation work by Indiana-Notre Dame Collab.
  - 1m Sci. fiber(τ_{decay}=8ns) + 8m clear fiber + VLPC
  - $\sigma_{\Delta t}$ ~ 2.5 ns ➔ σ_t ~ 1.8 ns (?)
  - ~10 photons at VLPC
- In our case
  - No clear fiber ➔ x2 more photons
  - Efficiency of SiPM : 1/4 of VLPC
  - Readout at both ends : x2 more photons
  - 2-layers : x2 more photons

    ➔ 1.2 ns resolution for a track
- Necessary R&D
  - Faster scintillator fiber
  - SiPM: Higher efficiency (geometrical efficiency)

Vertex Detector Works

- Isolated vertex on the beam-line:
  - Can be removed even w/o timing info, if the vertex mass is low enough (not c- b- jet)
  - If n-tracks are associated with the isolated vertex, vertex-time-resolution=σ_{track}/sqrt(n)
  - x2 faster sci., x2 higher SiPM efficiency, and 4 tracks associated with isolated vertex

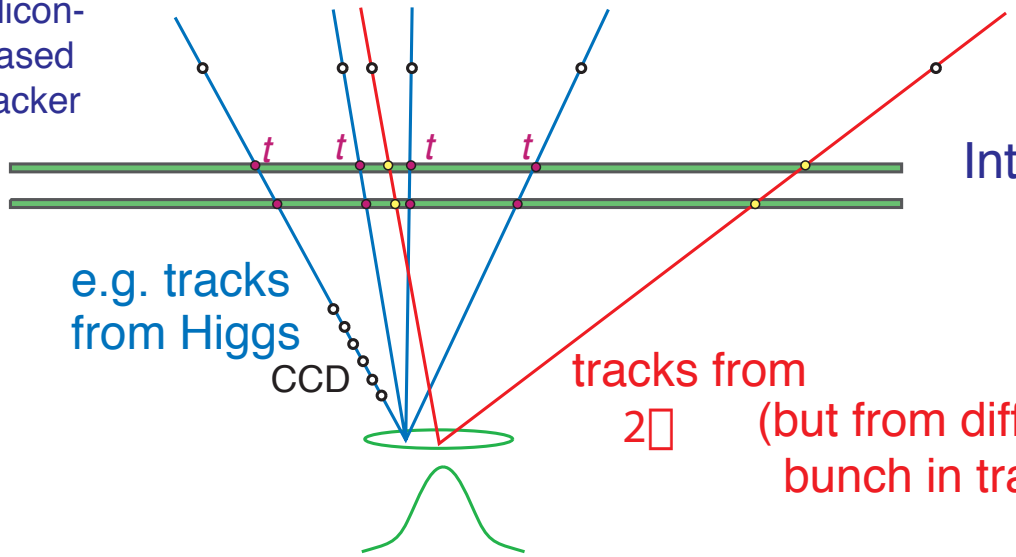
    ➔ 300 ps vertex time resolution << 1.4 ns

Solution? Bunch identification via track timing

Time Projection Chamber (TPC) (integrates over ~4–5 bunches)

or

Silicon-based tracker



Intermediate tracker (e.g. mounted on inside of carbon-fiber tracker support structure)

tracks from 2$\gamma\gamma$ (but from different bunch in train)

Scintillating fiber tracker, σ_t~ 1 nsec
system wide should be possible, resolve single bunches,
R&D on appropriateness as external device for timing

"Strawman" for typical llinear collider detector:
Two axial layers, two 3 degree stereo layers
Half-length of 29.5 cm, average radius of 48 cm
(mounted on inside of inner support structure of TPC)
[or in a silicon detector]

~15,000 channels

LCDTRK studies: extra material + new measument point at least does not degrade impact param. resolution

Conclusion

- For charged tracks in the barrel region, almost perfect bunch ID looks possible by scintillator fiber tracker at Warm Machines
- What about the end-cap region (x10 more 2γ-b.g. tracks) ?
- What about neutral tracks ?