SiD Tracking using VXD

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Plan

- Motivation
- Track reconstruction algorithm
- Performance for single tracks
- Does it have any limits ?
- With backgrounds
- To do

Motivation

- Tracking in SiD is a challenge, especially pattern recognition. We need to understand performance of current design and ways to improve it.
  - Small number of layers to use
  - No (or very poor) z resolution of central tracker
  - VXD can help a lot, but it has only 5 layers and it can't help with reconstruction of decays far from IP
  - High level of backgrounds makes reconstruction a very difficult task

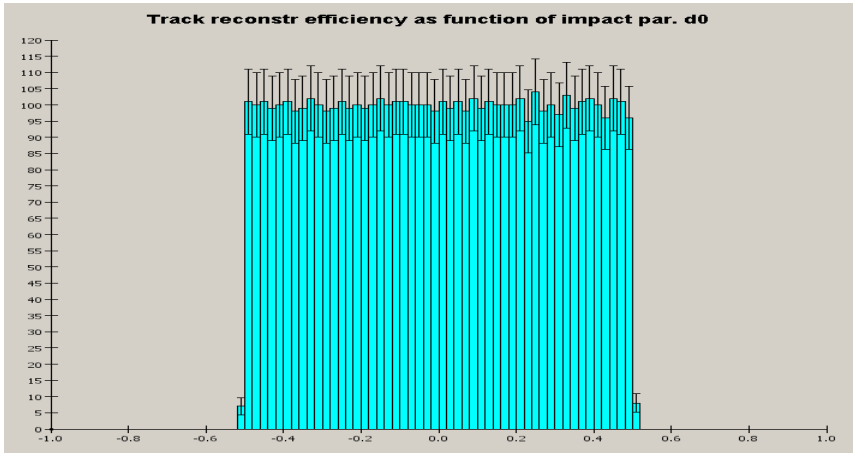
Reconstruction algorithm

- Use same algorithm as used in JAS full tracking reconstruction (select 3 points in 3 layers, make seed track from them and try to attach more hits. If there is more than required number of hits close to seed track within errors, track is accepted)
- Difference is only in that, that all 3 layers for seed track are VXD layers, and attaching hits to seed track we use very large error for Z-coordinate of hit (10 cm).
- In calculating track parameters for accepted track we use hit in the last tracker layer reached by the track to improve precision of track curvature calculation, but track deep angle is calculated only from VXD hits.

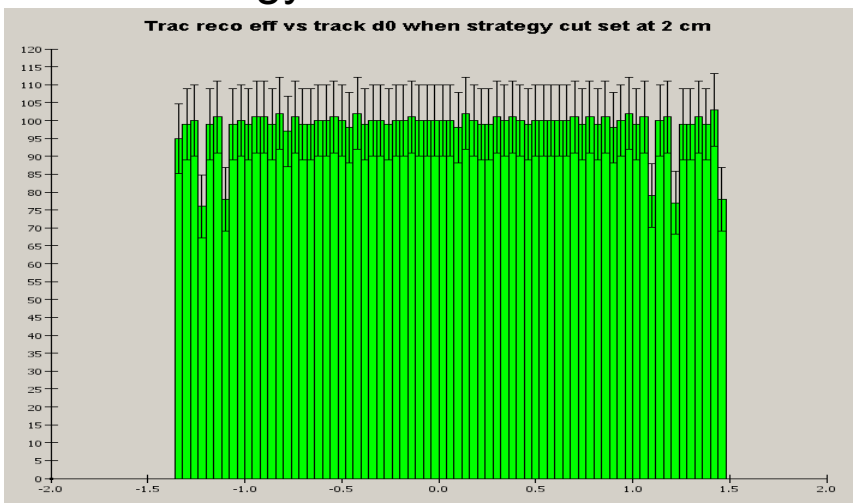
Limitations caused by reconstruction speed consideration

- In the presence of high number of background hits, number of 3-point combinations used as track seed became enormous if we consider all combinations. Track reconstruction for single event start taking hours of fastest CPU. So, we need to limit somehow search area for selecting combinations. Limiting track starting point to close to ip position allows significantly reduce number of combinations. In my reconstruction code I made limits on impact parameter as one of the adjustable parameters of the code.

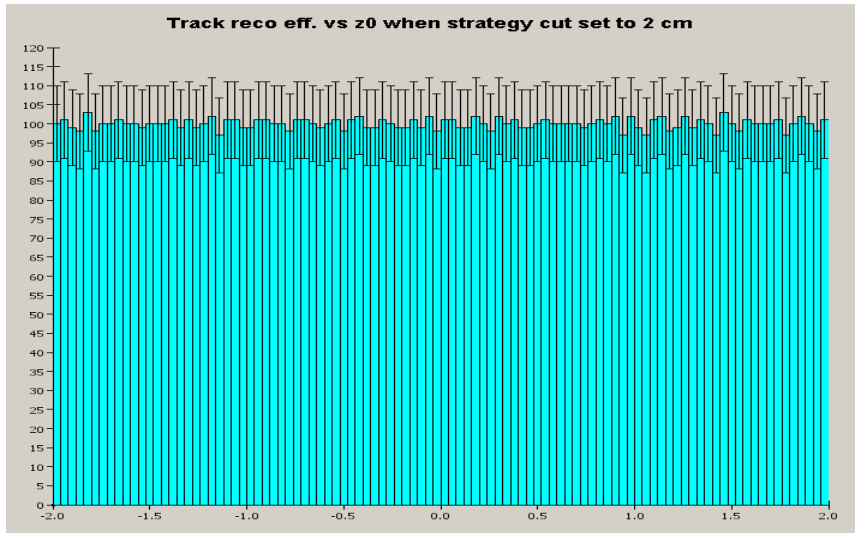
Reconstruction of single tracks



Reconstructed tracks impact par. D0 when strategy cut set to 0.5 cm



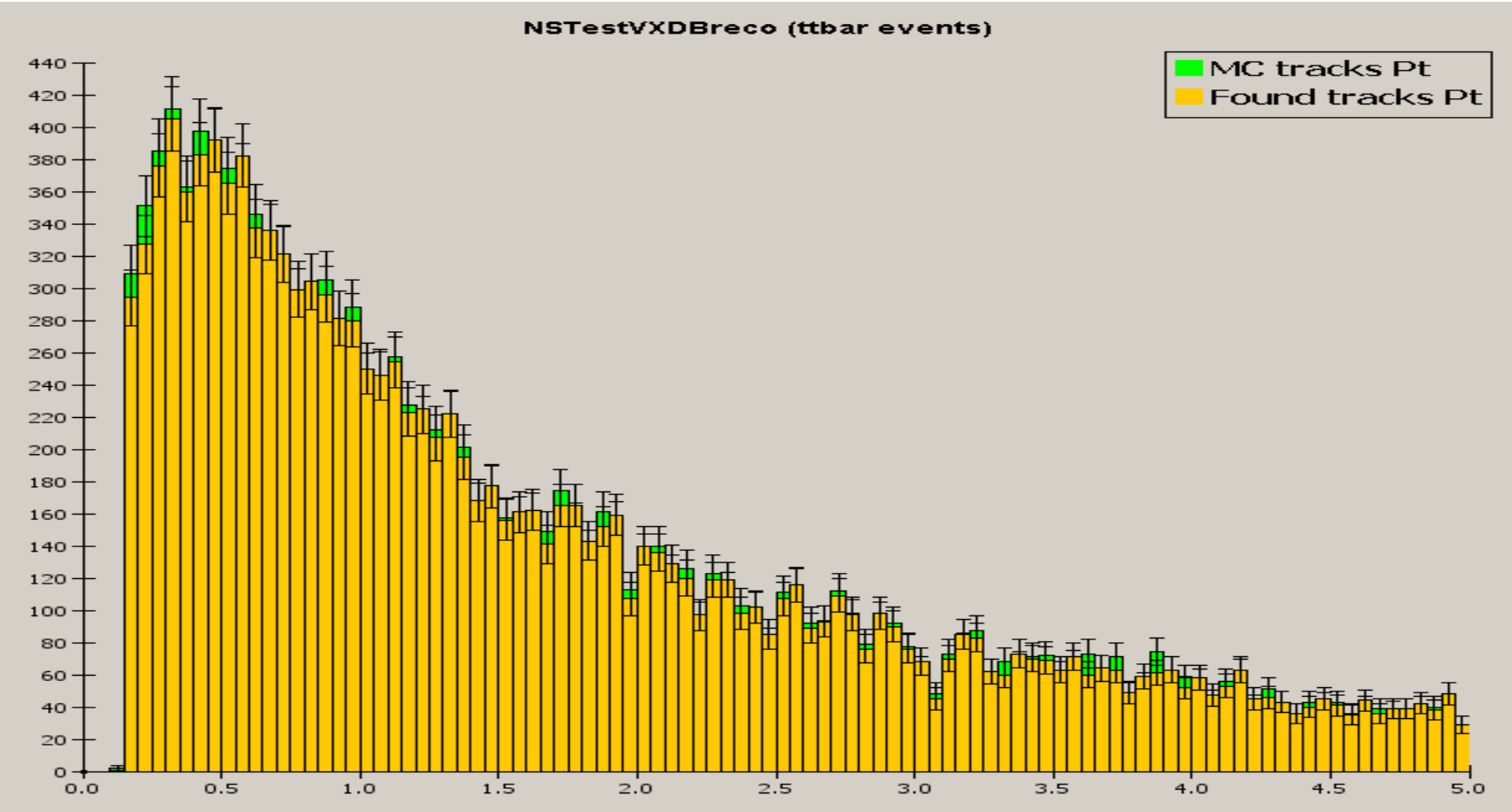
Same, but strategy cut set to 2.0 cm



Reconstructed tracks imp. Par. Z0 when strategy cut set to 2.0 cm

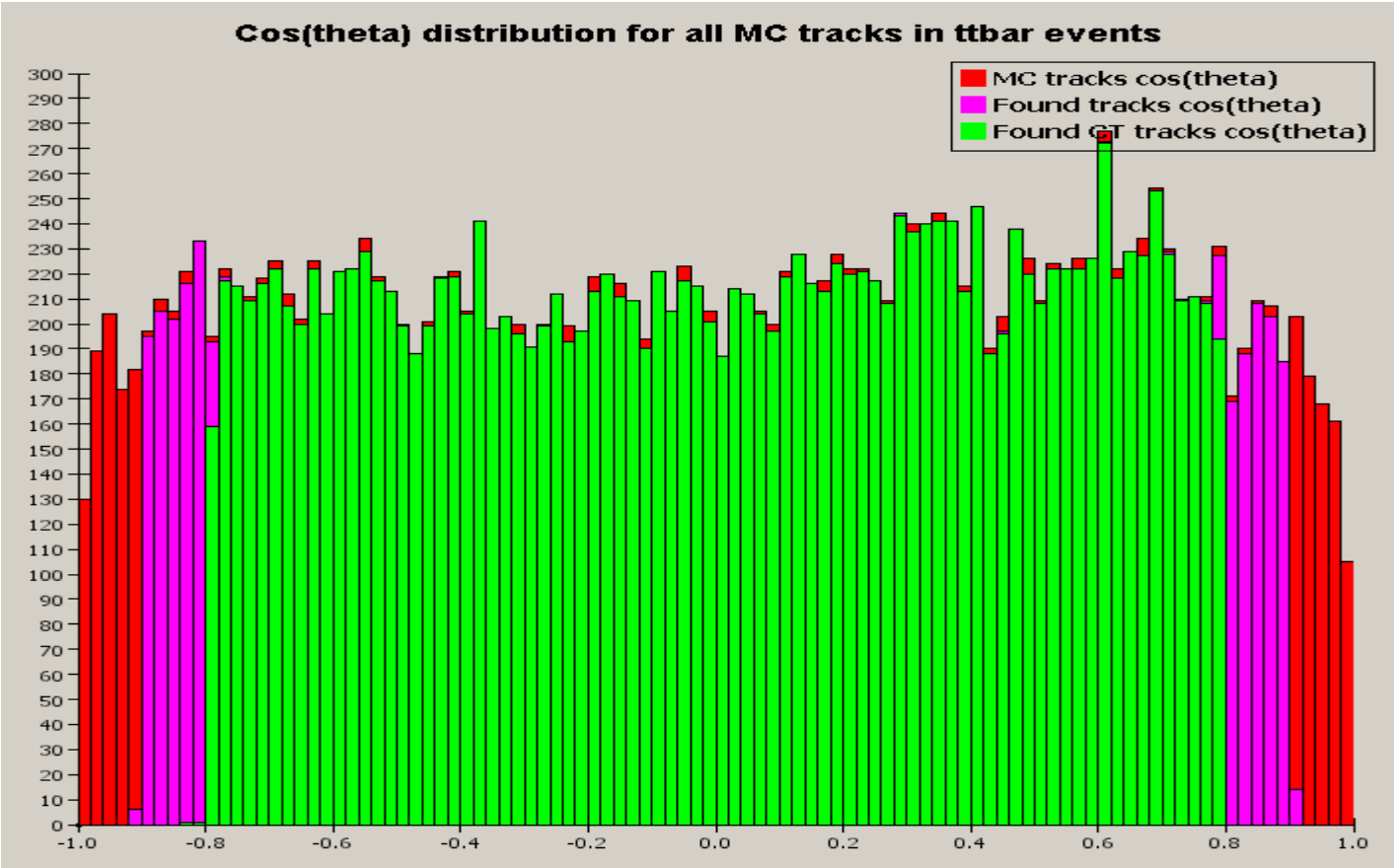
We can see, that cut in z0 can be set arbitrarily large but d0 can't

Tracks reconstruction in SiD without backgrounds



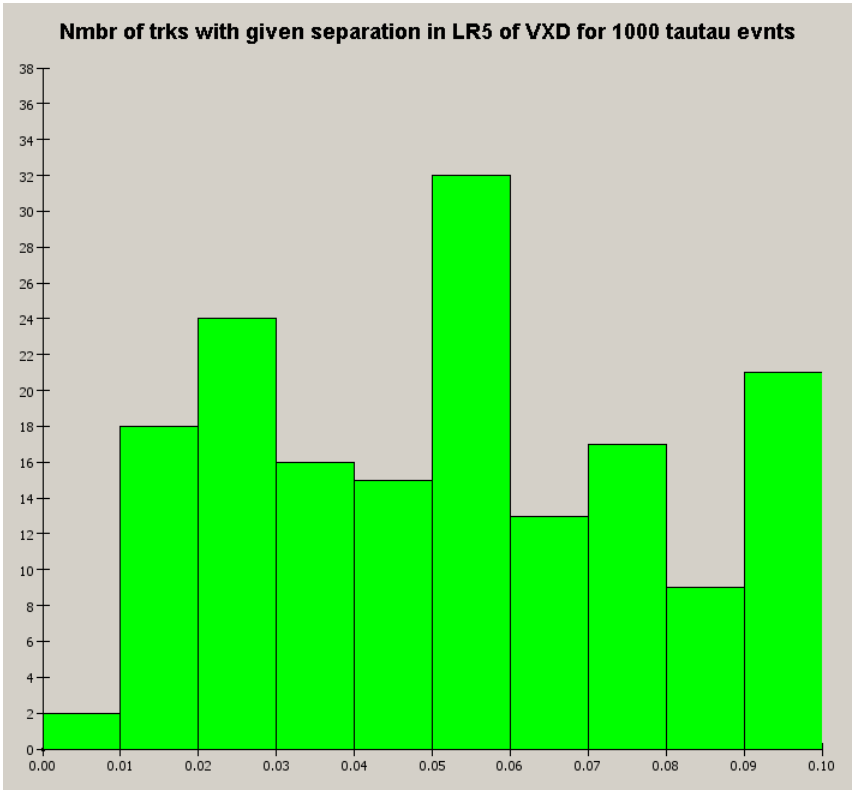
Pt distribution of Monte Carlo truth tracks in ttbar events for tracks within Reconstruction fiducial volume and of reconstructed tracks

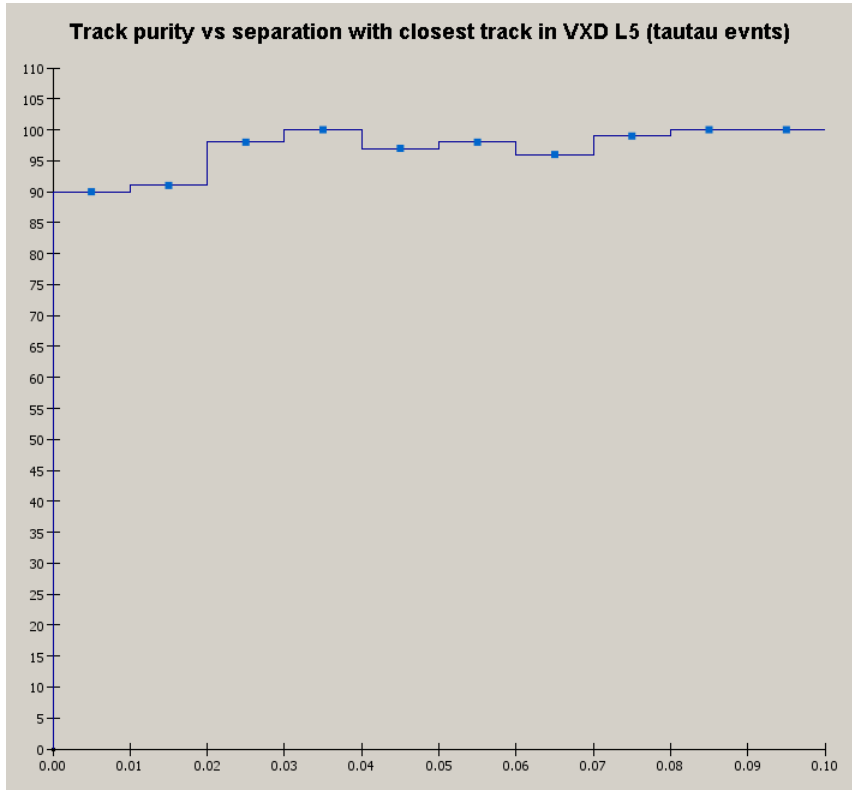
Tracks reconstruction in SiD without backgrounds



Cos(θ) distribution of all tracks seen in tracker both central and endcap for ttbar events and for reconstructed tracks. Green histogram is reconstructed tracks with all hits seen in central tracker (this is only where current version of fitter can fit tracks with tracker hits included)

Track reconstruction in SiD without backgrounds

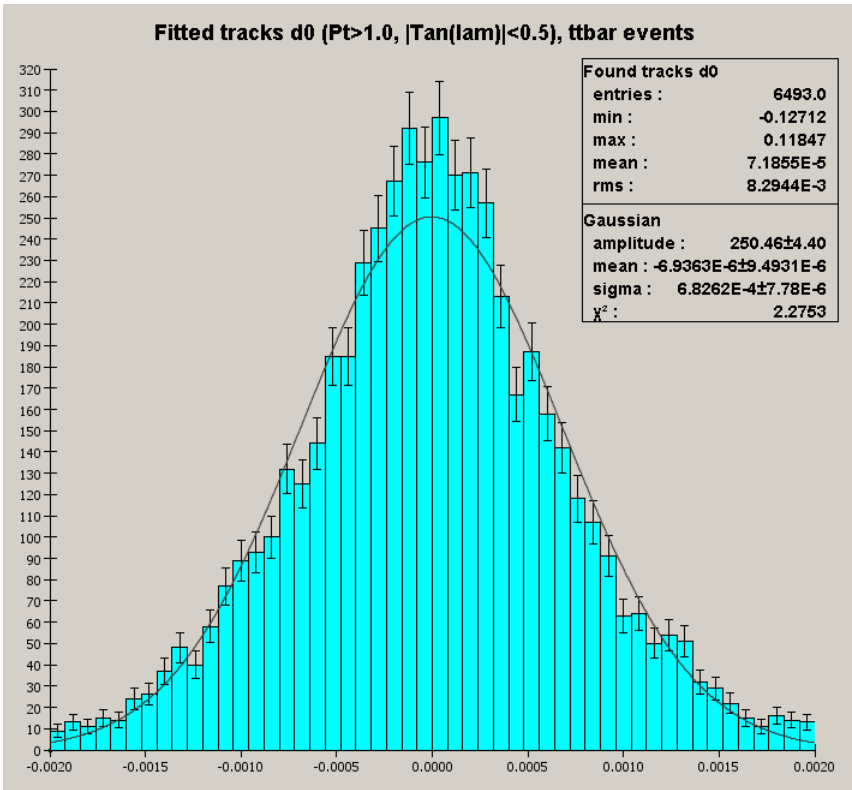


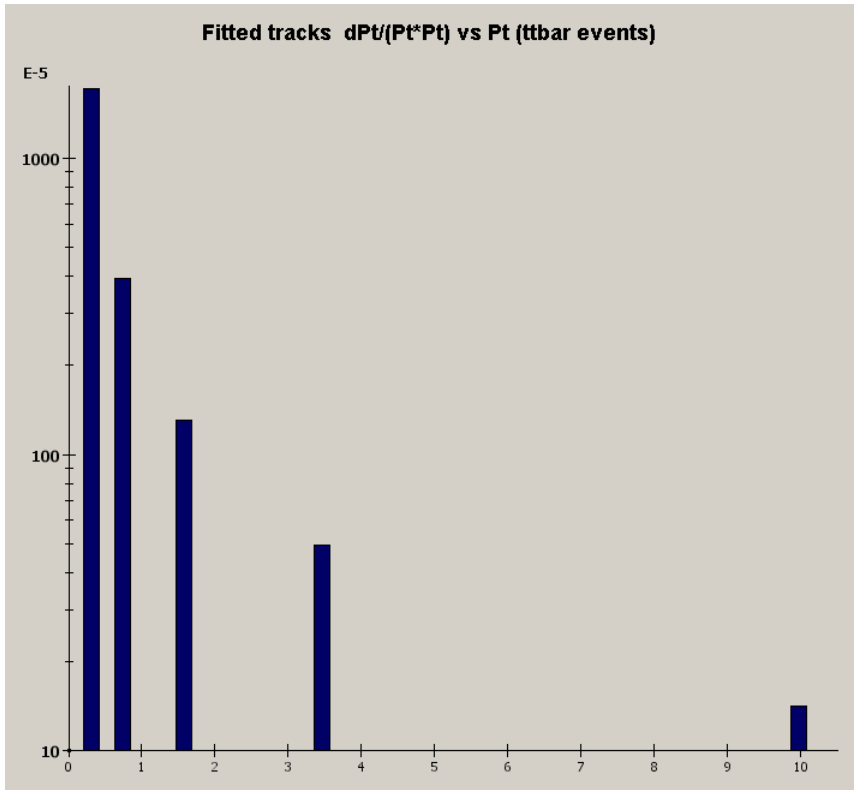


Number of tracks with given separation in LR 5 of VXD (from MC truth) – tautau events

Purity of reconstructed tracks (fraction of hits having same MC parent) vs separation in LR5 of VXD (tautau events)

Track reconstruction in SiD without backgrounds





Impact parameter d0 distribution for fitted tracks (Pt >1 Gev, Tan(lam) <0.5) In ttbar events. Sigma = 6.8 μ

Pt error dPt/(Pt*Pt) vs Pt for fitted tracks in tt bar events (vertical scale in units of 10^{-5} tracker resolution in Rφ is assumed 7 μ)

Performance in the presence of background

- Pair background from beam-beam interraction generates low energy tracks, reaching tracking system and looking exactly as tracks from physics event. There are two kind of problems, it creates:
  - these tracks distort energy balance in the reconstructed event
  - large number of hits in vertex detector creates problems for reconstruction, even if most of such hits would not make reconstructable track.

Problems from backgrounds - continue

- First of the problem, mentioned on the previous page, can be significantly reduced if central tracker has good timing resolution, which allows to select only hits, belonging to physics event. In my simulation I overlaid only hits from one bunch worth of backgrounds in the central tracker, and large number of bunches of backgrounds hits in vertex detector to simulate performance with good timing in central tracker. The number of bunches of overlaid hits in vertex detector depends on vertex detector readout speed.

Problems from backgrounds - continue

- However, large number of hits in VXD increased trucking reconstruction time to unpractical level. On Victoria meeting I reported results of detailed investigation of track reconstruction for warm technology. Processing of one event with backgrounds in such case took about 30 minutes. We don't have yet files with backgrounds generated for cold technology. Estimates are that in that case number of background hits per bunch is about twice of that in warm technology case. So my Victoria results could be applied to Vertex detector accumulating about 100 (1/30 of bunch train) bunches. I tried to reach background level where reconstruction efficiency drops, but could not do it with reasonable reconstruction time. I could double number of background bunches, but in that case could process 2-3 events. Still reconstruction efficiency is flat at 99% level.

To do things: before Snowmass

- Extend track reconstruction to use Vertex Discs
- Try to speed it up (have some ideas)
- Evaluate reconstruction with real cold technology background files and find VXD tracking limit.
- Debug fitter – looks like that it is not optimized for best Pt resolution. For low momentum found tracks without fit has better Pt resolution than fitted once. However, Norman has released FTF finder/fitter. May be it will show better performance (so far it does not)