Tracking Strategies

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Outline

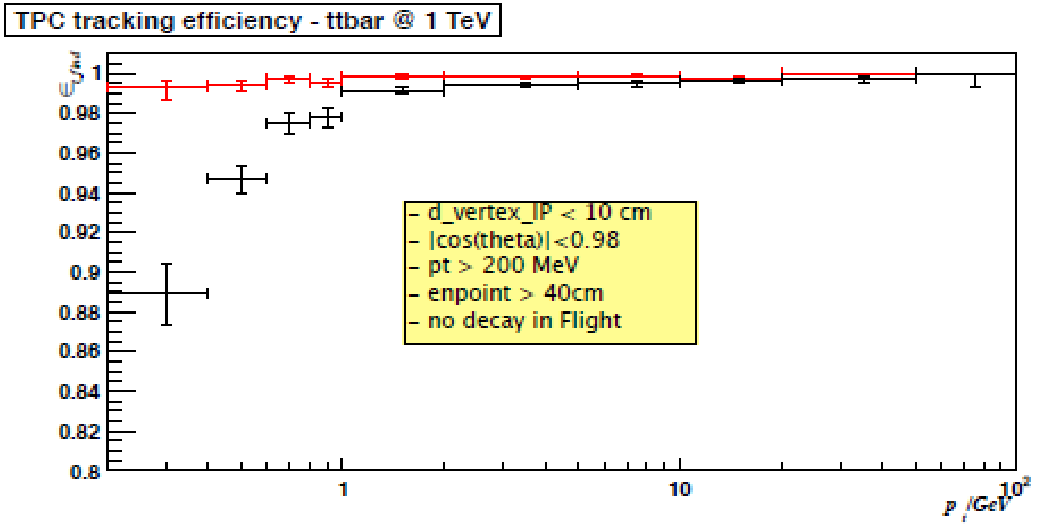
- Overview of tracking strategies and performance in
  - TPC
  - Barrel Silicon detectors (SIT & VXD)
  - FTD
- Open issues
  - Standalone Silicon tracking algorithm
  - Tools to evaluate VXD – SIT specifications in the presence of pair bkg
  - Planned studies

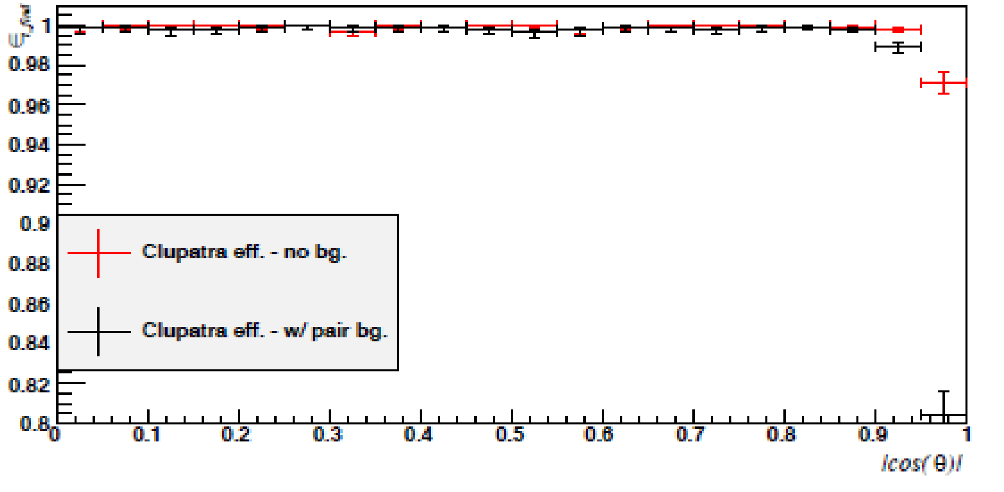
Tracking Software

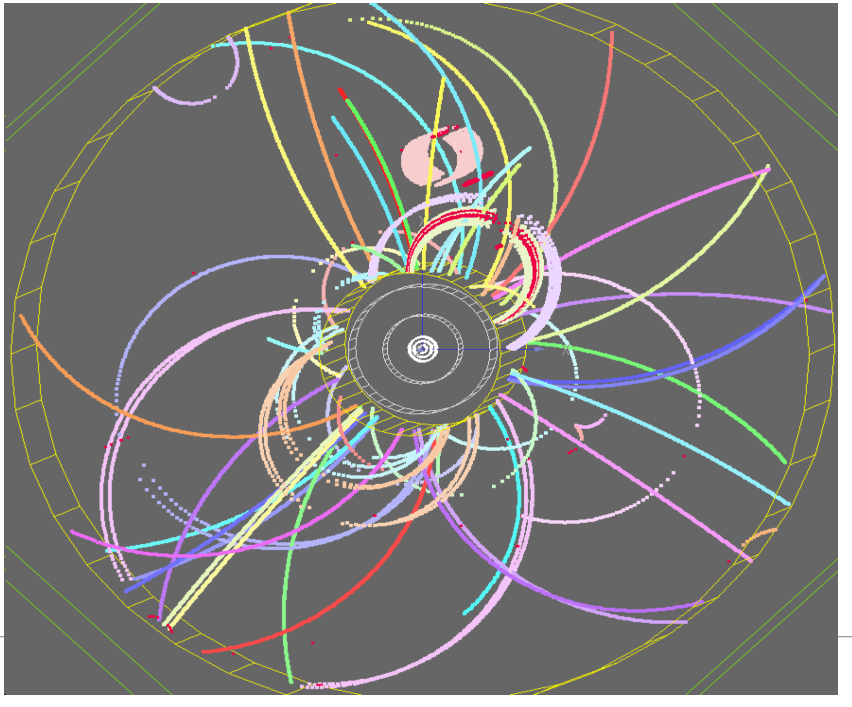
- Major steps from LoI → DBD
  - The fortran tracking code have been replaced by c++ Kalman fitting tools (KalTest / KalDet)
  - New TPC pattern recognition has been developed (Clupatra)
  - Silicon tracking (VXD – SIT) has been adapted to KalTest
  - New pattern recognition has been developed for FTD
- MarlinTrk interface couples pattern recognition with fitting
- Lets have a look at the three tracking subsystems

Tracking in the TPC

- Clupatra processor
  - Form seeds using Nearest Neighbours hit clustering
  - Propagate seeds using Kalman fitter
  - Associate best matching hit
  - Update track state
  - So on...

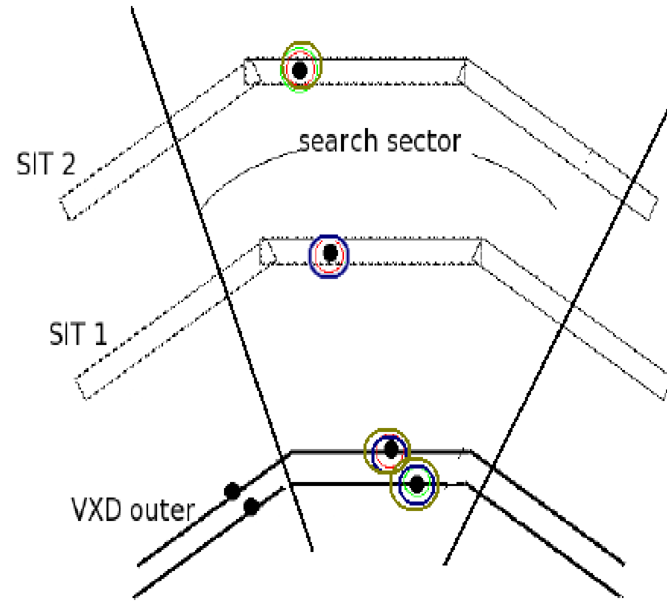




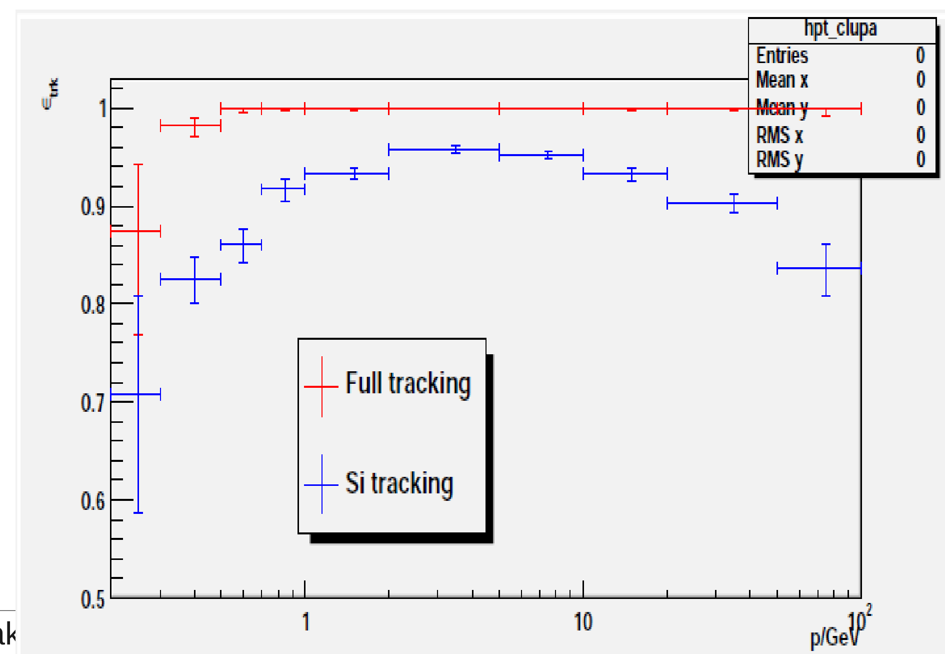


Std Standalone Silicon Tracking

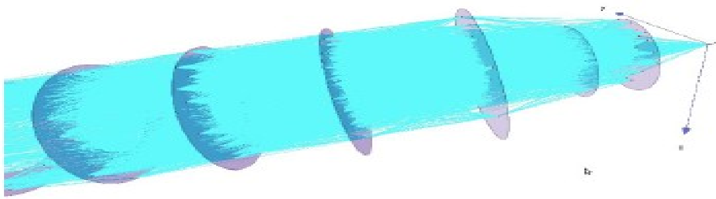
- Divide VXD – SIT into angular sectors
- brute force triplet search in stereo angle sectors based on a set of seed-layer-triplets
- Fit a helix to the seed triplets
- Follow the seed helix inwards – attach hits according to the distance from the helix
- Sorting – selection of track candidates
- Attach remaining hits in the intermediate layers
- Refit with Kalman fitting

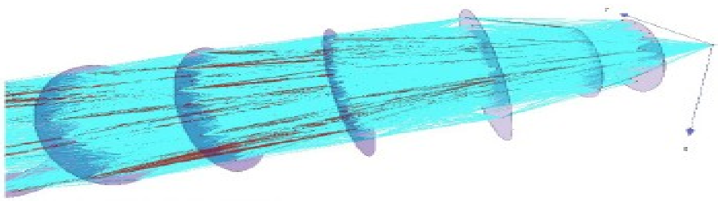


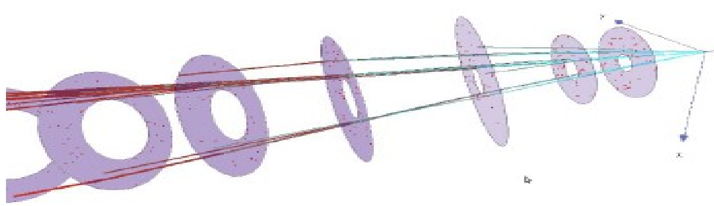
ttbar @ 1TeV, **no beam bkg**



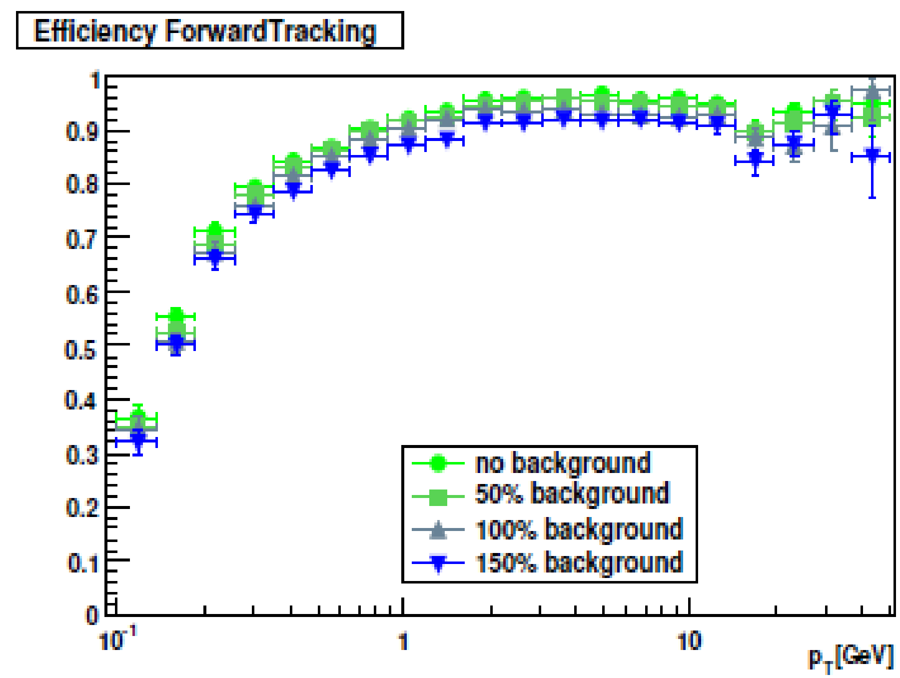
New Forward Tracking

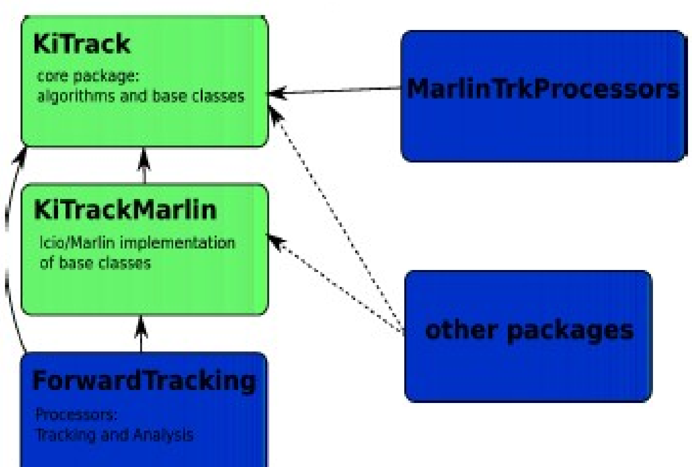






- Standalone tracking algorithm at FTD
  - Pattern recognition: Cellular automaton
  - Fitting: Kalman filter
  - Ambiguities resolution: Hopfield NN



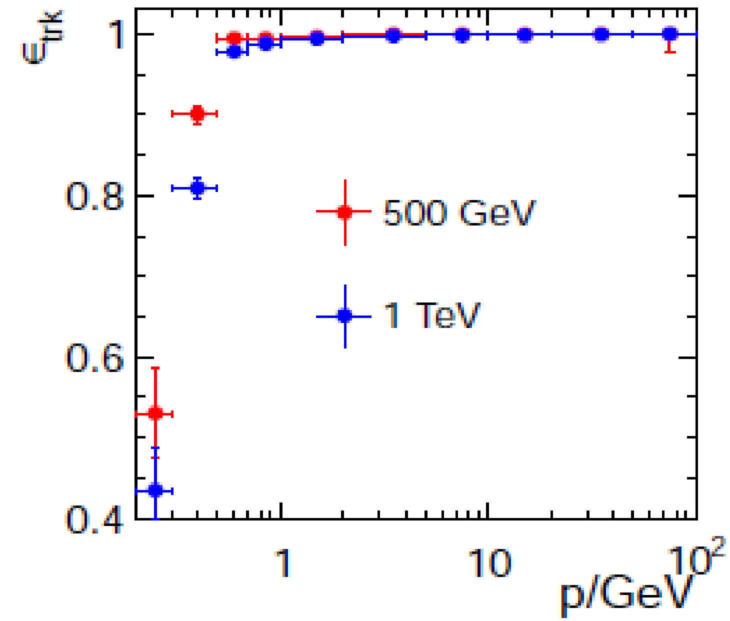


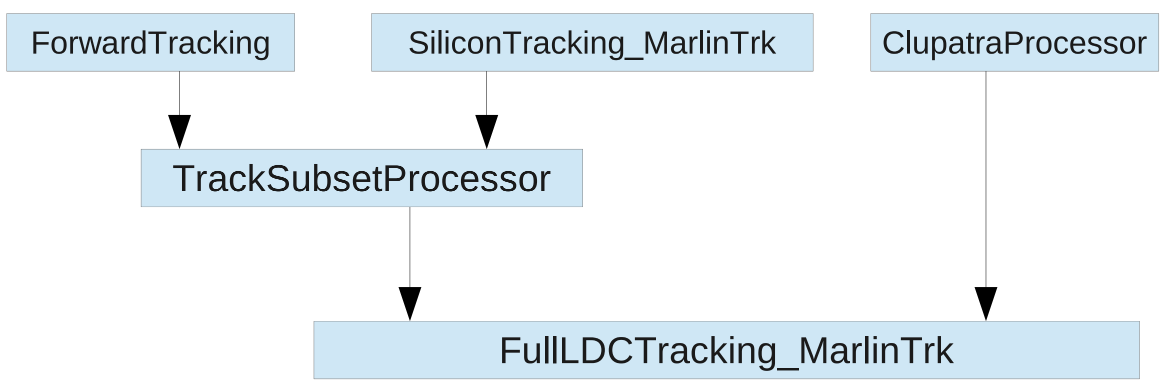
WW @ 1 TeV

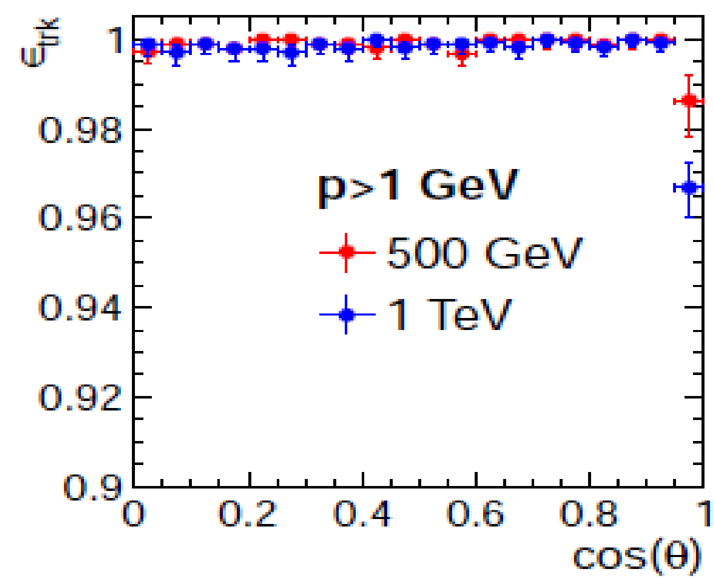
Overall Performance

Plots from DBD – ttbar sample, beam bkg included

- ~ 99.7 % eff., P ≥ 1 GeV
- ≥ 99.8 %, cos(θ) < 0.95
- Low momentum region not satisfactory – Silicon tracking







Open Issues

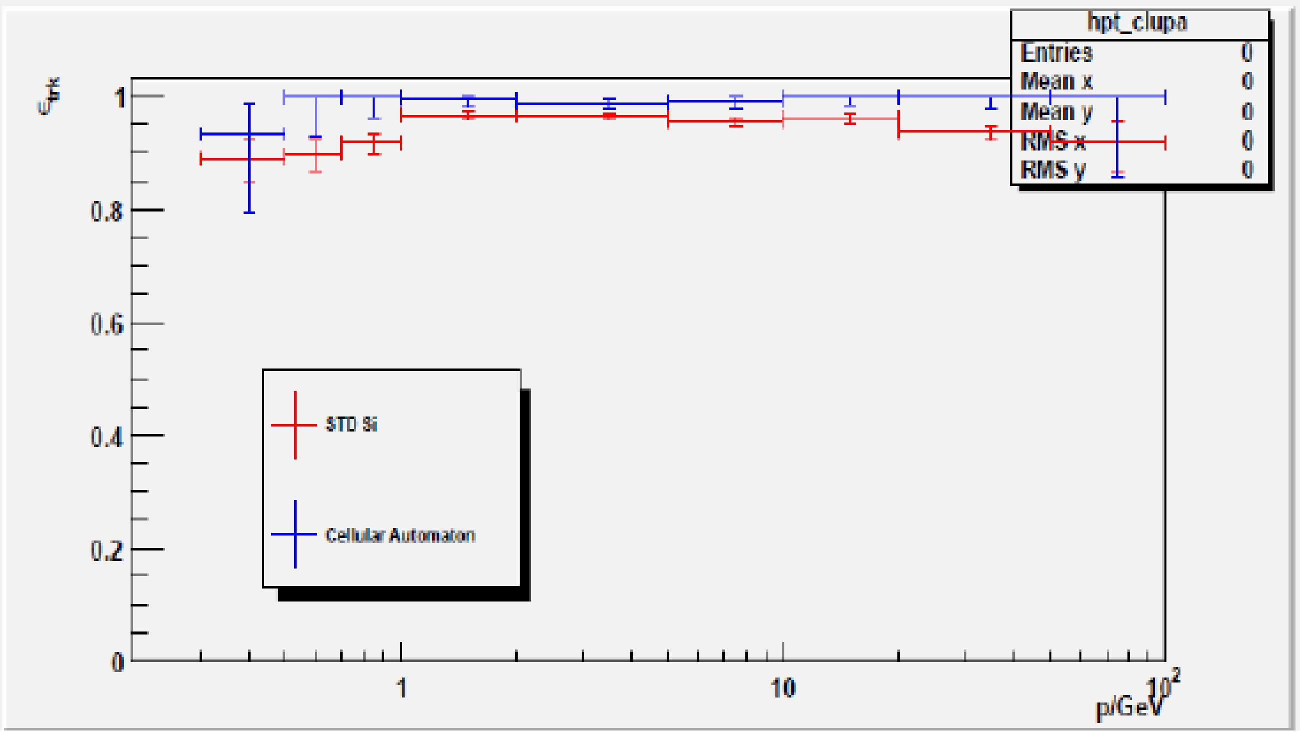
1) Standalone Silicon tracking algorithm (plot slide 4)
   - Develop pattern recognition algorithm robust vs beam bkg
     - Approach based on cellular automaton
     - Use core tools of KiTrack, already there for FTD tracking

2) Si detectors RnD without a mature tool for tracking?
   - Propagate TPC track to Silicon

C.A. Standalone Si Tracking

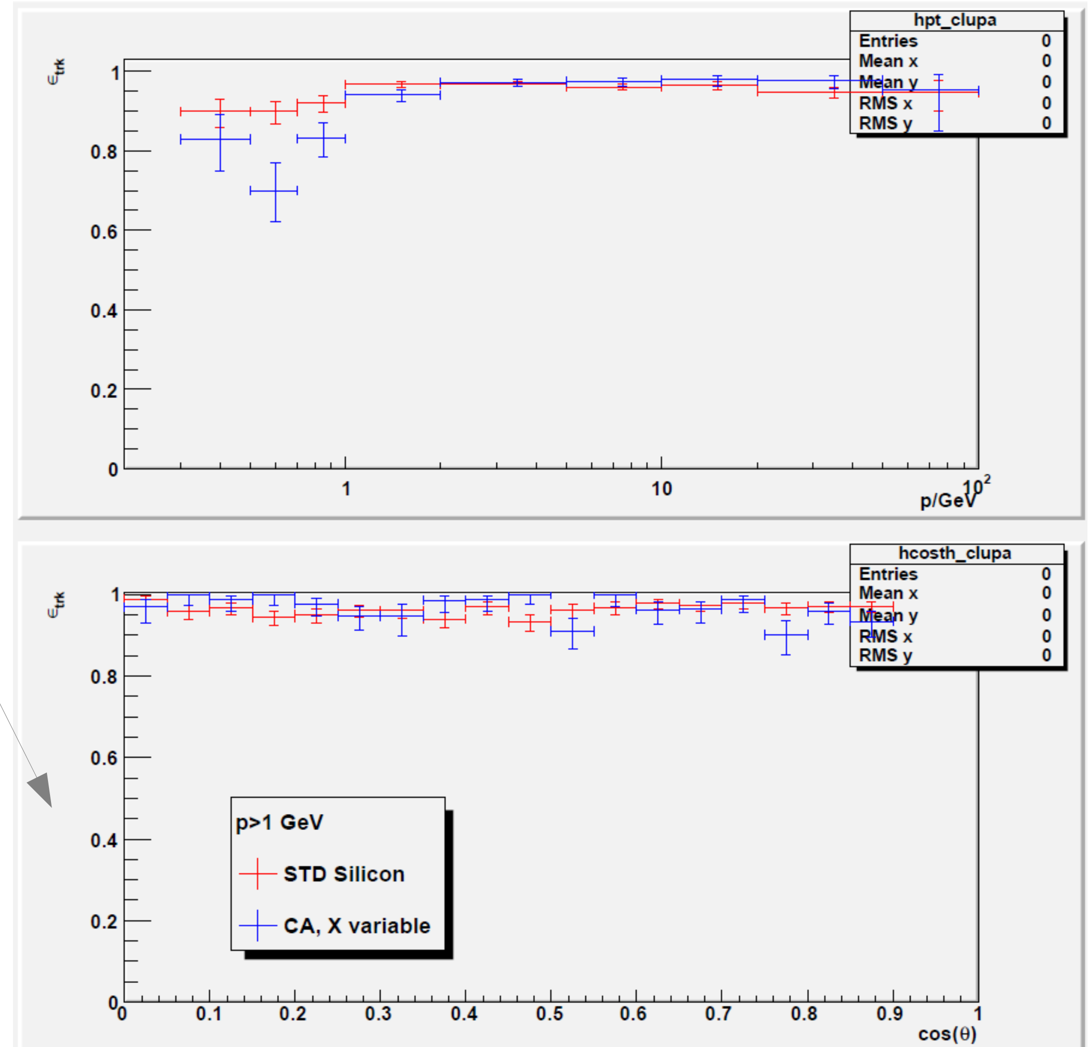
- Make use of core algorithms of KiTrack package used for tracking in FTD
- Develop a Marlin/LCIO implementation in KiTrackMarlin for VXD – SIT

- ttbar @ 1 TeV
  - **No background**
- IP tracks (Rvtx < 10mm)
- Si Tracking out of the box
- Vs CA tracking (standalone VXD)
- Found track: ≥ 75% of MC hits are found
- Resolve of ambiguities:
  - ➔ Hopfield NN



C.A. Standalone Si Tracking (II)

- Examine non – prompt tracks
  - Track's origin between IP and intermediate VXD layer
- Include SIT hits
  - No improvement wrt Std algorithm...
- Adding beam bkg hits
  - C.A. creates too many connections
  - Killed from combinatorics
  - But still huge parameter space to scan in order to reduce combinatorics



X: quality variable, ~ 1 when x^2 prob. ~ 1 and no of attached hits close to max, used to resolve ambiguities

Open Issues

1) Standalone Silicon tracking algorithm (plot slide 4)
   - Develop pattern recognition robust vs beam bkg
     - Approach based on cellular automaton
     - Approach based on c.a. and mini – vectors

2) Si detectors RnD without a mature tool for tracking in Silicon?
   - Propagate TPC track to Silicon

From TPC to Si Detectors

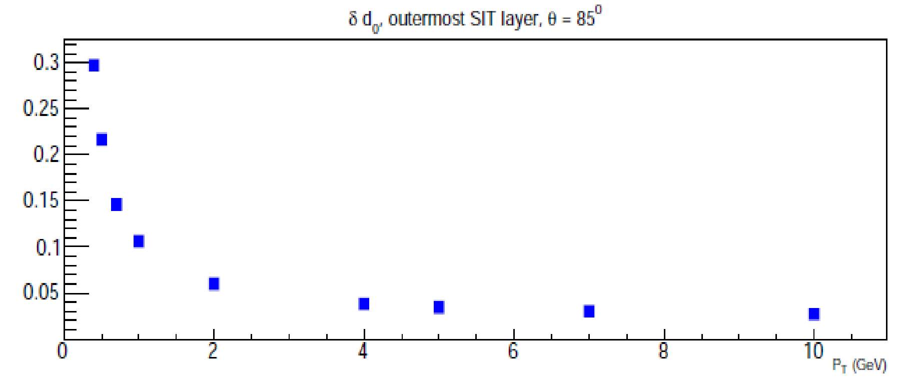
- Using TPC tracks as seeds
- Propagate to Silicon layers using MarlinTrk tools
- Search for hits and associate the best candidate
- Refit and propagate to the next layer

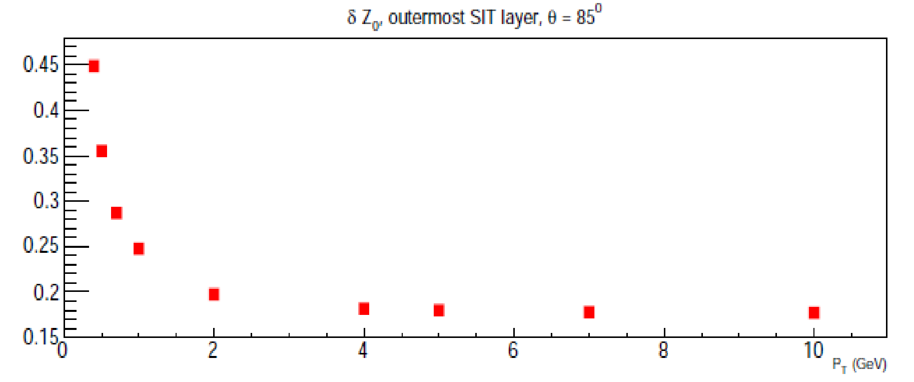
layer	$\sigma_{spatial}$ (μm)	σ_{time} (μs)
L1	3 / 6	50 / 10
L2	4	100
L3	4	100

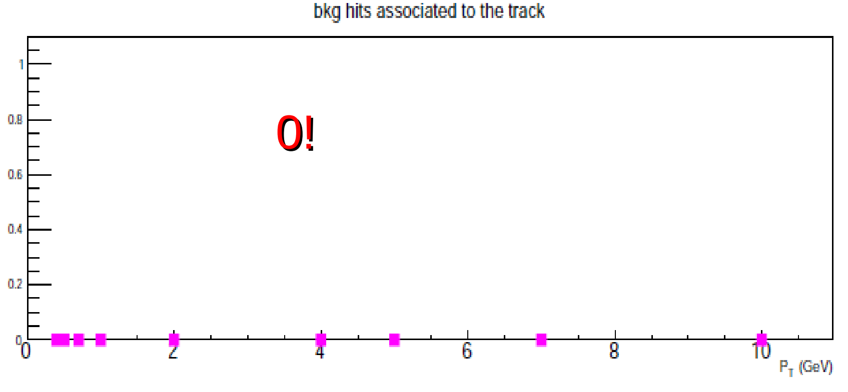
- Sample
  - Single muons
  - Beam bkg overlayed ($\sqrt{s}$ = 500 GeV) to VXD according to time resolutions stated on table
  - SIT – single BX timestamping

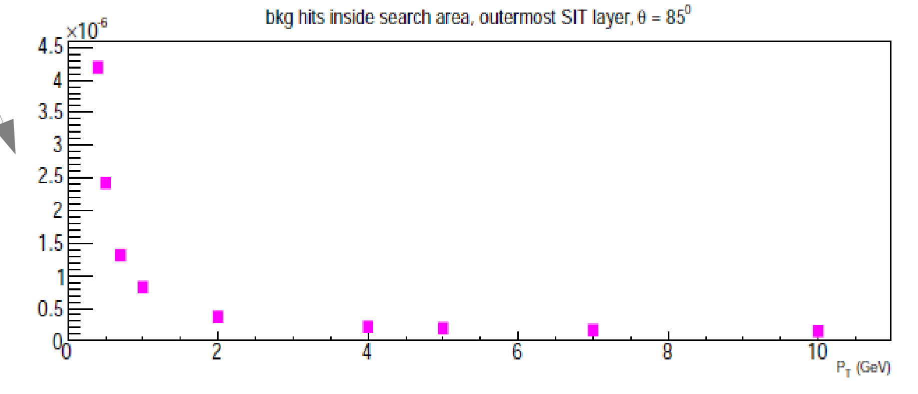
From TPC to SIT

- From TPC to outermost SIT layer
- Search area:
  - Defined by an ellipse, whose axis are the propagated impact parameter uncertainties on the det. surface * σ
  - Associate the closest hit and refit
  - Calculate analytically the probability to find a bkg hit inside the search area
  - No of bkg (or ghost) hits attached to the track (from simulation)



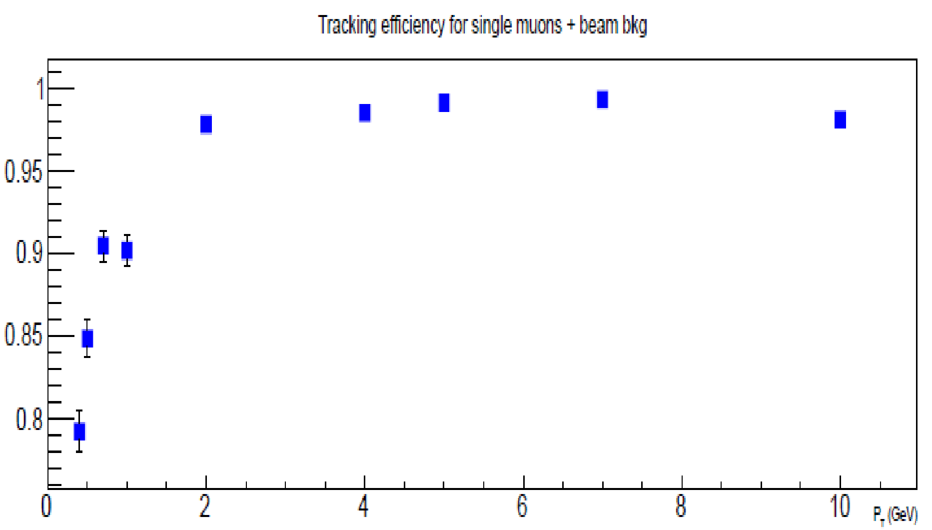


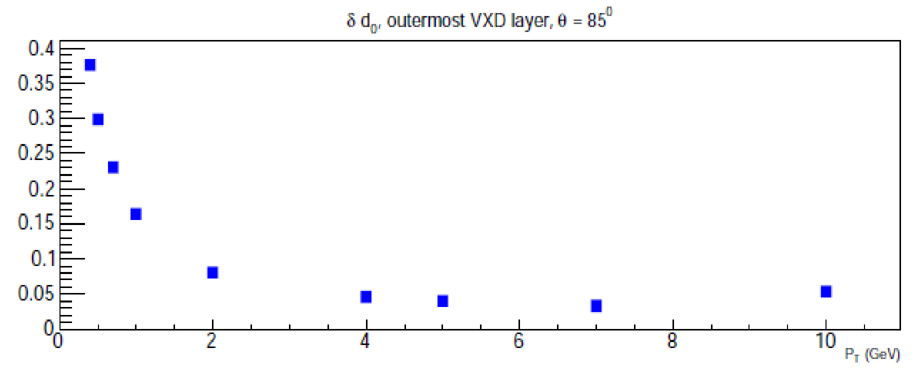


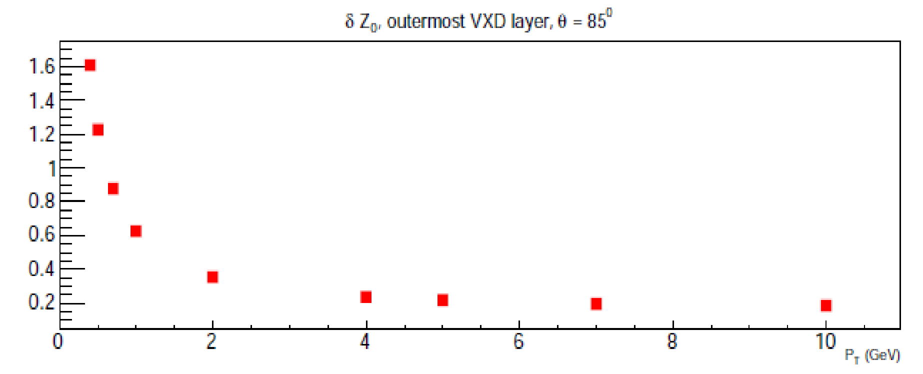


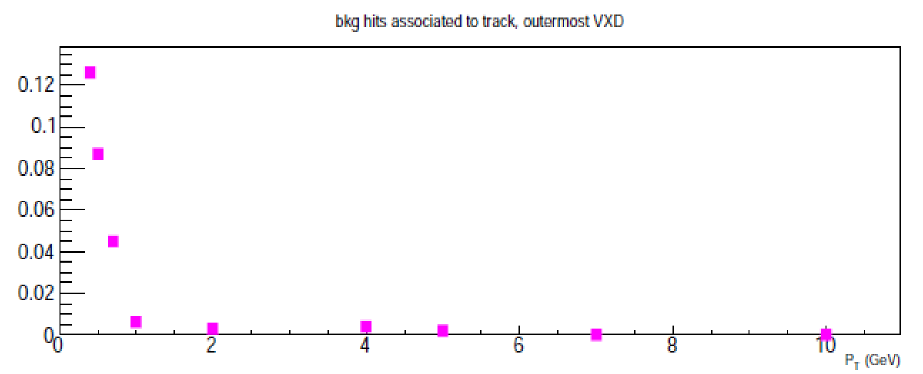
From SIT to VXD

- Same for propagating from SIT to outermost VXD
- Low P_T
  - Not negligible ratio of events where bkg hit is attached
  - In such a case: **track is lost!**
- Leading to segment reconstruction efficiency:









Our plans

- The TPC → SIT and SIT → VXD linking are crucial
- The probability to associate the wrong hit should be minimised
  - Reduce the search area
    - Pixel SIT (?)
    - Material budget of SIT
  - Reduce the integration time of the outermost VXD layer

layer	$\sigma_{spatial}$ (μm)	σ_{time} (μs)
L1	3 / 6	50 / 10
L2	4	100
L3	4	100

→

layer	$\sigma_{spatial}$ (μm)	σ_{time} (μs)
L1	3 / 6	50 / 2
L2	4 / 10	100 / 7
L3	4 / 10	100 / 7

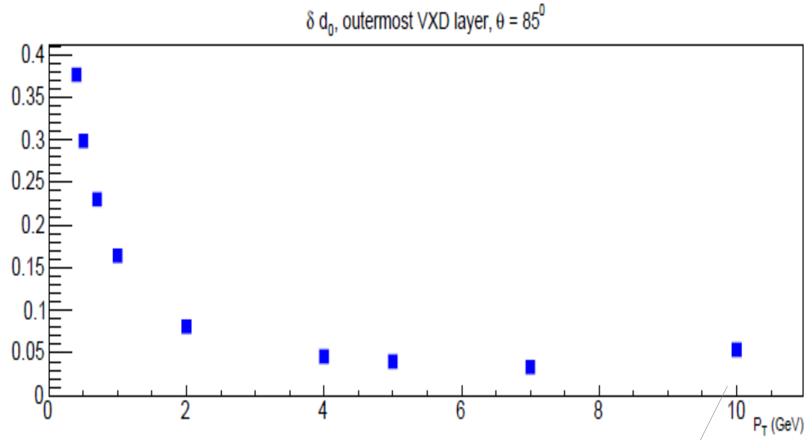
- Of course these studies should be applied also when propagating inside SIT and VXD

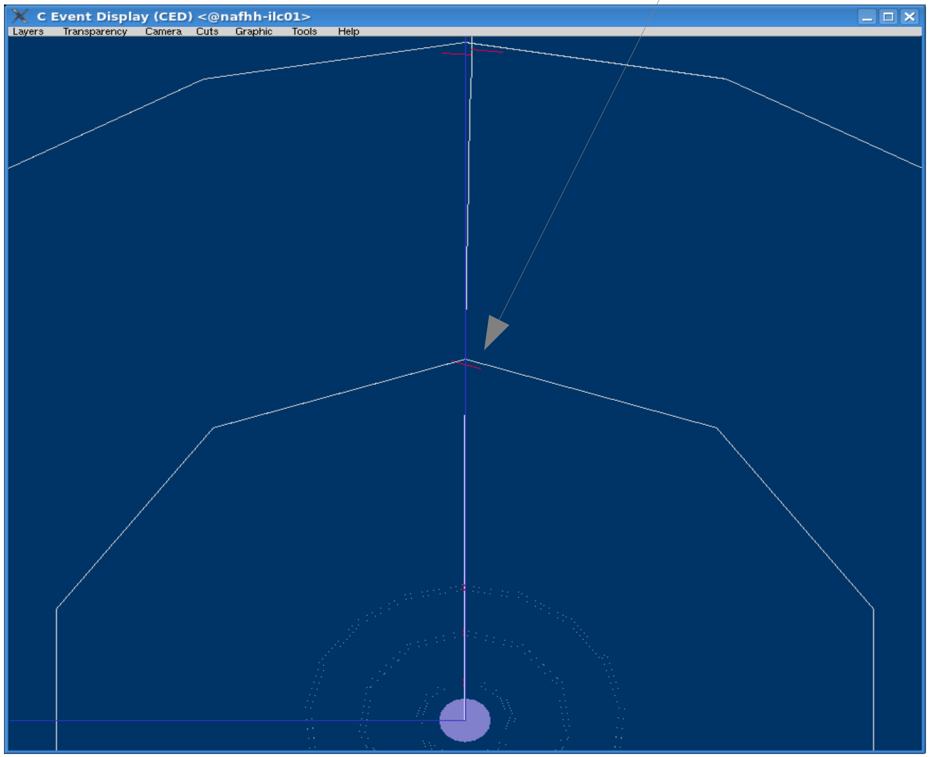
Conclusion – Outlook

- ILD tracking overall, exhibits a satisfactory perf. In presence of beam bkg
- Standalone tracking on VXD – SIT still an issue
  - Cellular automaton approach gave a promising start
    - C.A. based on mini – vectors → potential to reduce combinatorics
    - Mini – vectors could be proved helpful on a track following based algorithm
    - Hybrid approach: C.A. on outer layers, then extrapolate the track inwards

- Propagation of TPC tracks to Silicon detectors can help us understand the VXD – SIT specifications – configuration
- Could also be a backup solution of the standalone tracking
- Final step, validate our approach with appropriate physic stdy
  - For example, charm tagging or vertex charge

BACKUP


δ d_0, outermost VXD layer, θ = 85^0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
2
4
6
8
10
P_T (GeV)


C Event Display (CED) <@nafhh-ilc01>
Layers
Transparency
Camera
Cuts
Graphic
Tools
Help

IP resolution, extr. muons