Status Report on Silicon Tracking

Yorgos Voutsinas

IPHC PICSEL group – DESY FLC group

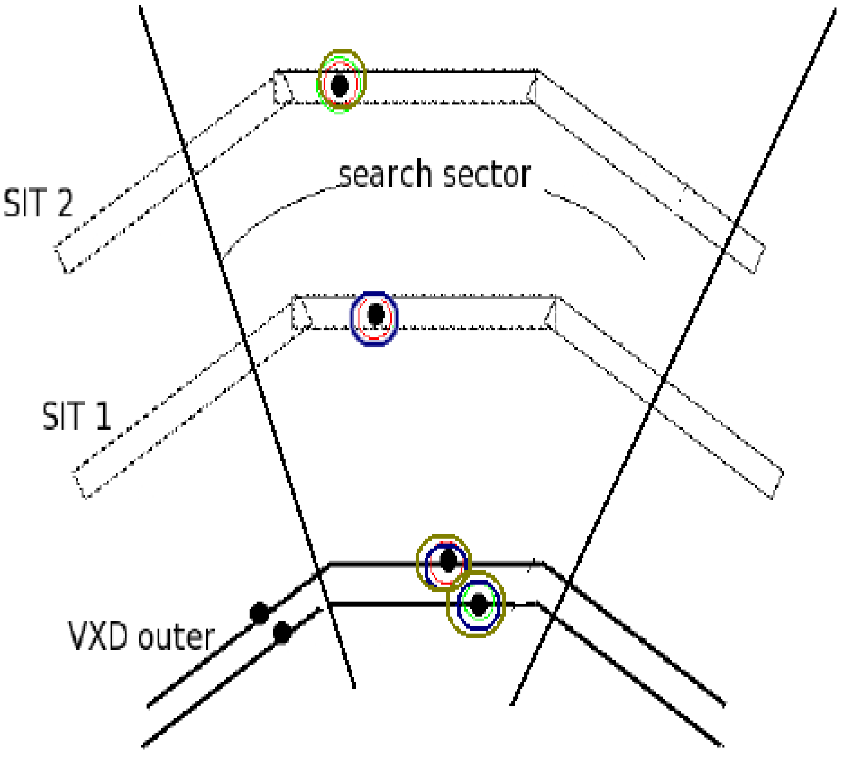
georgios.voutsinas@desy.de

Outline

- Why studying Silicon Tracking algorithm?
- Optimising the existing algorithm
  - Playing with the algorithm's parameters
  - Playing with the detector configuration
- New approaches
  - Cellular Automaton
  - How can we exploit the mini-vectors
  - Other ideas

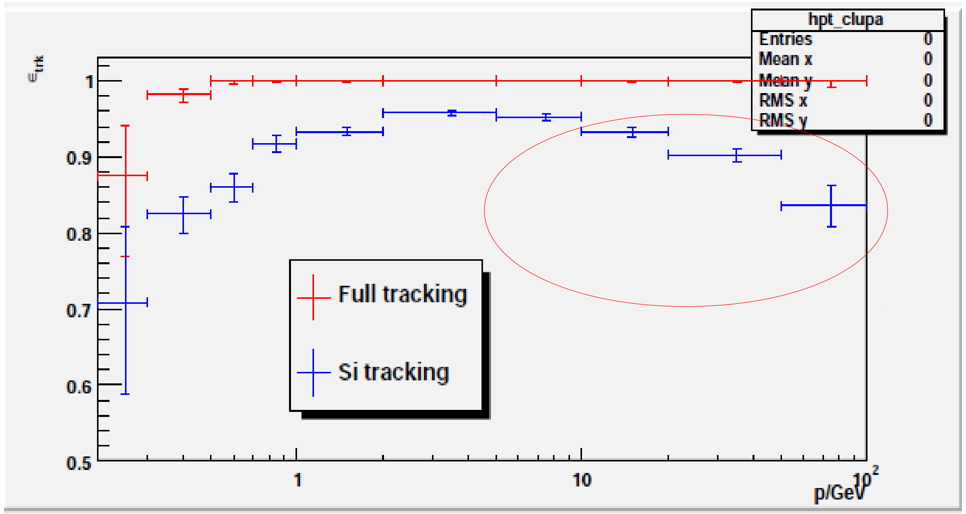
Std Standalone Silicon Tracking in ILD

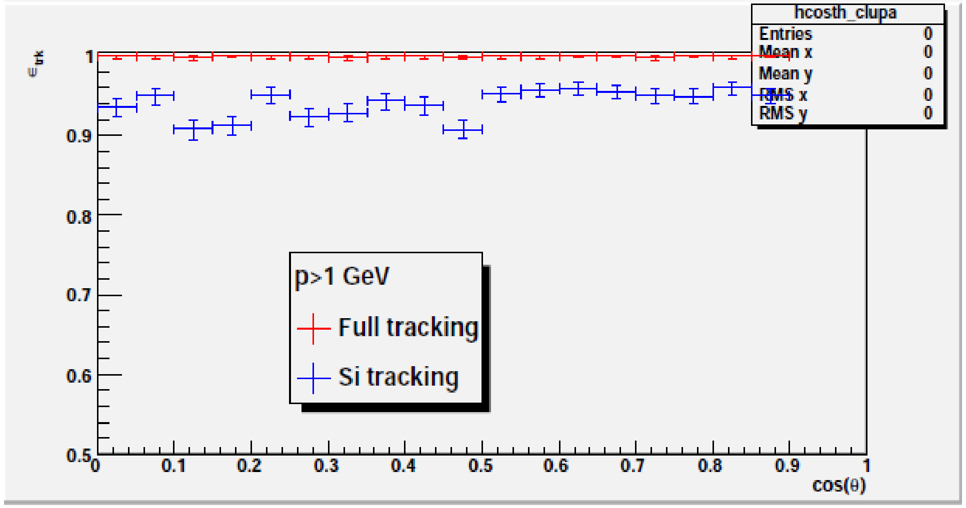
- Divide VXD – SIT into angular sectors
- brute force triplet search in phi sectors based on a set of seed-layer-triplets
- Fit a helix to the seed triplets
- Follow the seed inwards – attach hits according to the distance from the helix
- Sorting – selection of track candidates
- Attach remaining hits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



Why still studying Silicon Tracking?

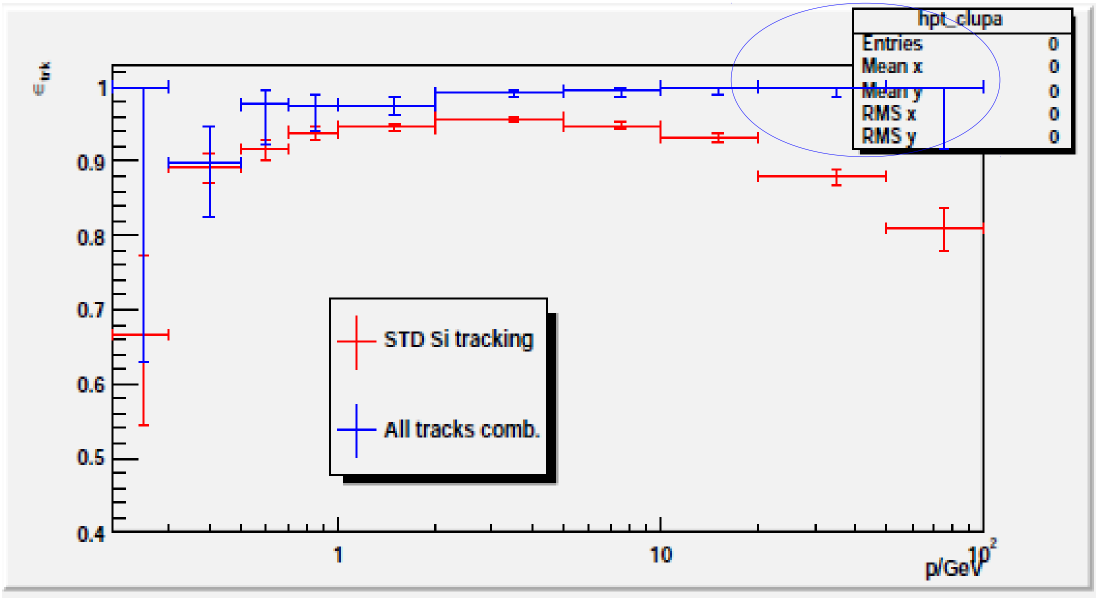
- Sample
  - ttbar @ $\sqrt{s}$ = 1 TeV, **no beamstrahlung hits**
  - We can't claim a satisfactory performant Si tracking – even w/o beamstrahlung
- Why we lose tracks?
- Surprising for high P_T tracks!
- Is it a matter of:
  - Seed formation?
  - Track – hit association?
  - Sorting and selection of the final track sample?





Algorithm Modifications

- Alternative approach
  - Form seeds
  - Follow AND reconstruct every possible candidate track
- ttbar 1 TeV, NO bkg overlayed
- Std Silicon tracking algortihm
  - 72 tracks/evt
  - 2s/evt
- Vs all tracks reconstructed with the new approach
- No consistent track sample selection yet →
  - →Ghost tracks are also considered
  - We obtain the sought track efficiency but
  - 6737 tracks/evt
  - 171 s/evt
  - The misefficiency is restored

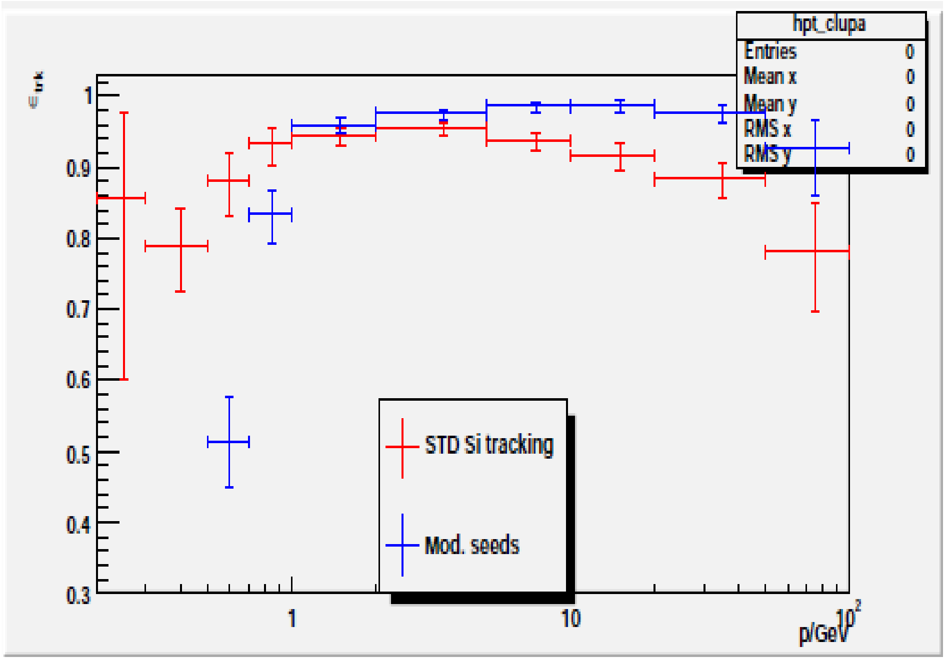


- Reason of lost tracks:
  - Hits already used – discarded
- Approach
  - Exhaustively reconstruct every track branch
  - Make the track selection at the very end
- OR
  - Sort the seeds (e.g. according to P_T)
- **But can it cope with beamstahlung hits?**

Algorithm Modifications (II)

- Combinatorial hell
- Even with the std Silicon tracking algorithm, we can only use the SIT – outer VXD layers for seeding
- But: Restrictions on seeding in order to cope with the beam bkg maybe
  - Compromise further the performance?

    (compared to plot at slide 5)
  - Pronounced mostly for low momentum
  - Still better performance for high momentum



- Ideas would be:
  - Enlarge the θ, φ sectors

See Tatsuya's talk 29/05

  - Use a pixel SIT
    - provides 4 3D spacepoints
  - Restrict the seeding at the pixel SIT AND/OR outermost VXD layer

- Can provide standalone tracking
- The tracks then extrapolated to VXD
- No single BX timestamping though...

Adding Beamstrahlung Hits ($\sqrt{s}$ = 500 GeV)

- Std standalone algorithm examined vs new beam bkg simulation (see Eduard's talk)
- 2 different VXD – SIT configurations
  - Slow (DBD design)
  - fast
  - Strip SIT
  - Pixel SIT

Slow (DBD design):

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

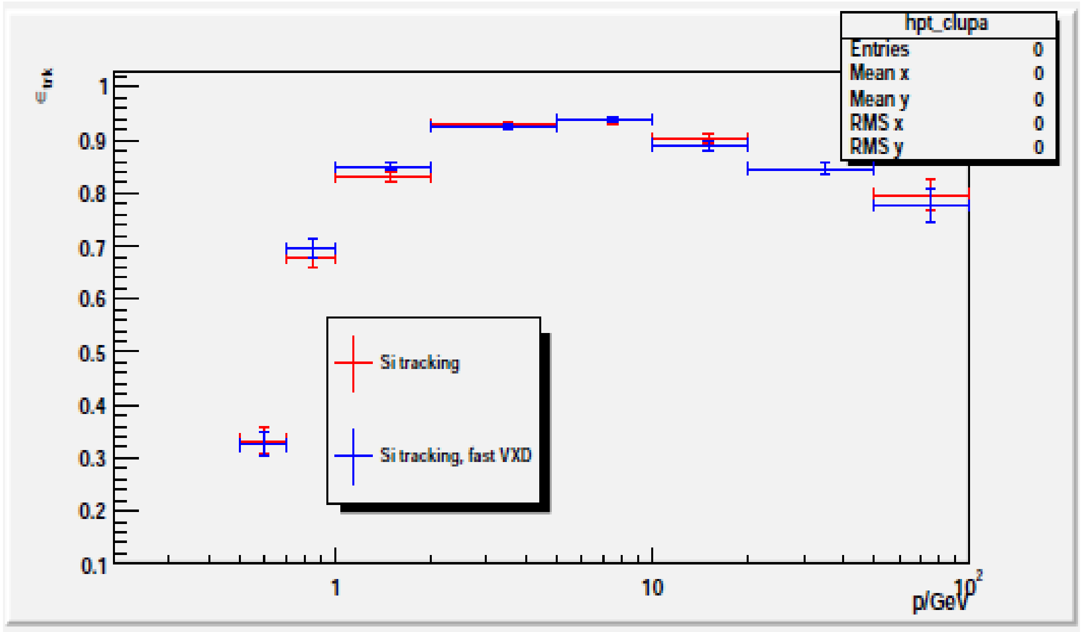
fast:

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

- Sample: ttbar
- Main params. examined
  - Minimum number of hits (important for bkg + ghosts rejection)
  - Layers used for track seeds formation
  - Size of θ, φ sectors where we search for hits
- Track found criteria:
  - > 75% of track's hits belong to the dominant MC particle (purity) &&
  - > 75% of hits of the MC particle belong to the track (efficiency) &&
  - > 6 hits (SIT + VXD)

Adding Beamstrahlung Hits ($\sqrt{s}$ = 500 GeV) (II)

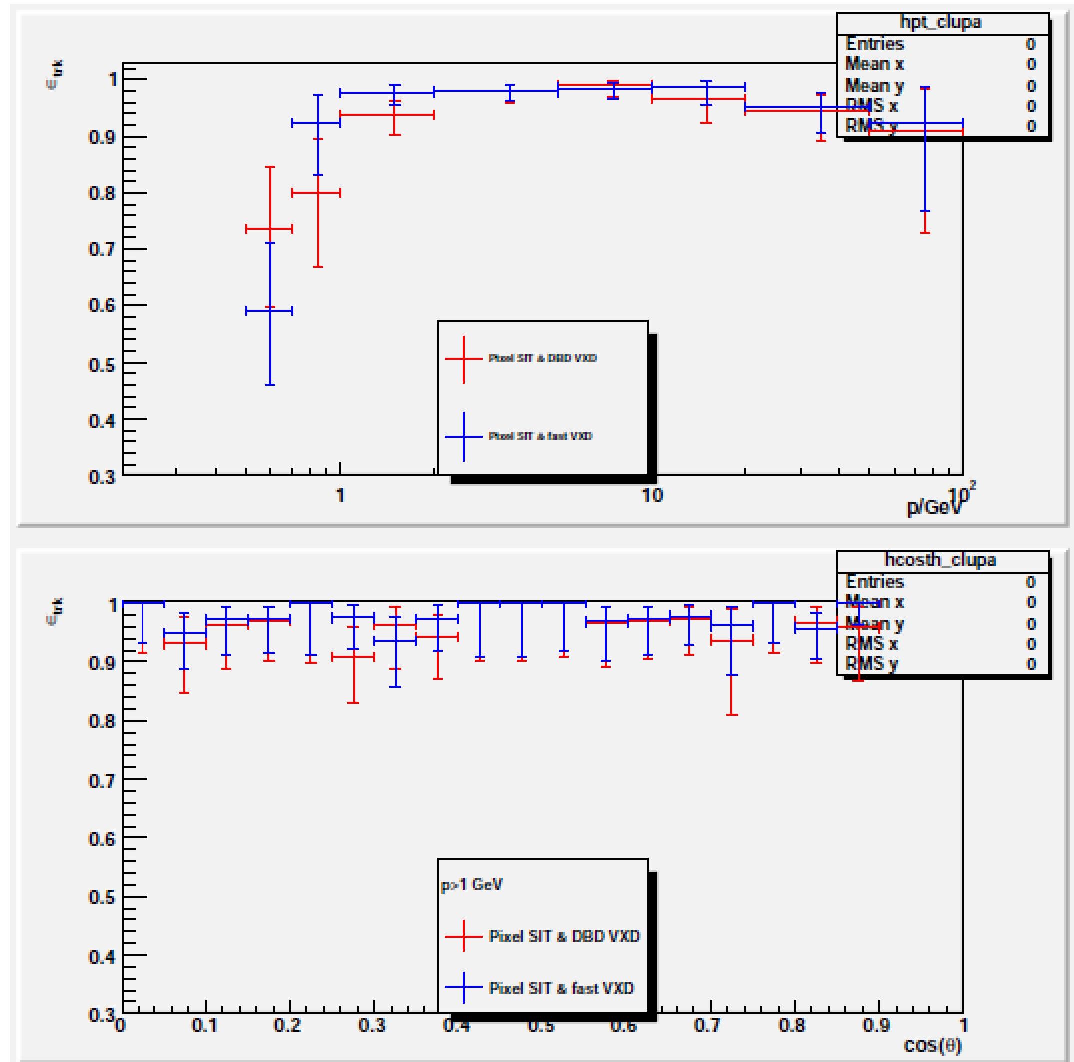
- Std algo
  - Only strip SIT – outermost VXD used for seeding
- Not striking improvement on efficiency from faster VXD
- But important for combinatorial reduction – time performance
- From studies in single muons



Design	Ghost rate (trks/evt)	Timing (sec/evt)
slow	1.8	2.5
fast	0.1	1.2

Pixel SIT & Beam Bkg

- Use the optimised algorithm
- Seed formation only in Pixel SIT
- Beam bkg added only to VXD



New Approaches

- The poor efficiency in bkg free samples, especially for high P_T tracks, motivated us to study new approaches
    1) Cellular automaton
    2) Combinatorial Kalman filter for track finding
    3) Track extrapolation from TPC to Silicon detectors (not standalone tracking)
- Lets focus on cellular automaton

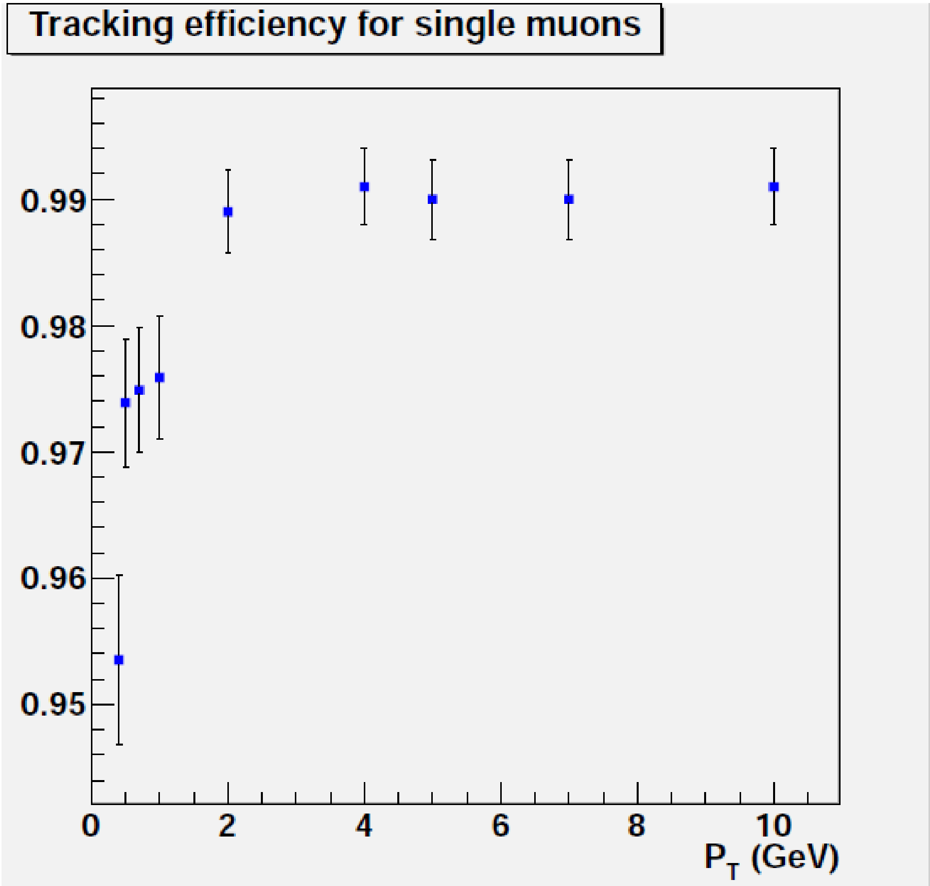
Cellular Automaton

- See R. Glattauer et al, arXiv 1202.2761

- Good news for us! The algorithms and base classes are already part of the ILCSoft (KiTrack package)
  - Implemented and used for the Fwd tracking
  - We are developing a Marlin/lcio implementation for the VXD – SIT (inside KiTrackMarlin)

Efficiency on Single Muons

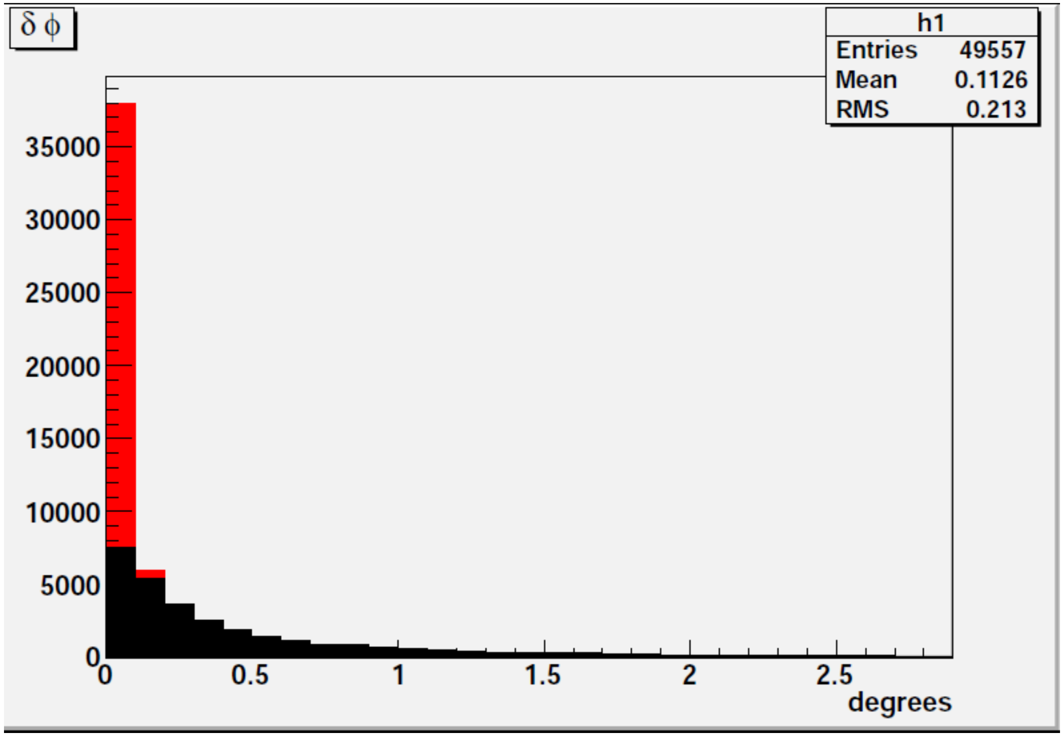
- Not the most difficult pattern recognition problem
- But: promising first results!
- A first set of connection criteria has been defined
  - Θ, φ for 1-hit spacepoints
  - Stereo angles for track segments
  - Still lot of space to
    - Add new criteria
    - Find the optimal max – min values
- In order to move to more interesting studies
  - A satisfactory way to extract the best consistent track subsample is required



Added Values from Mini – Vectors

- Could maybe offer (considering beamstrahlung hits)

  1) Reduced number of segments connection in cellular automaton



Red: mini – vectors (angular difference of hits located on the same superlayer)

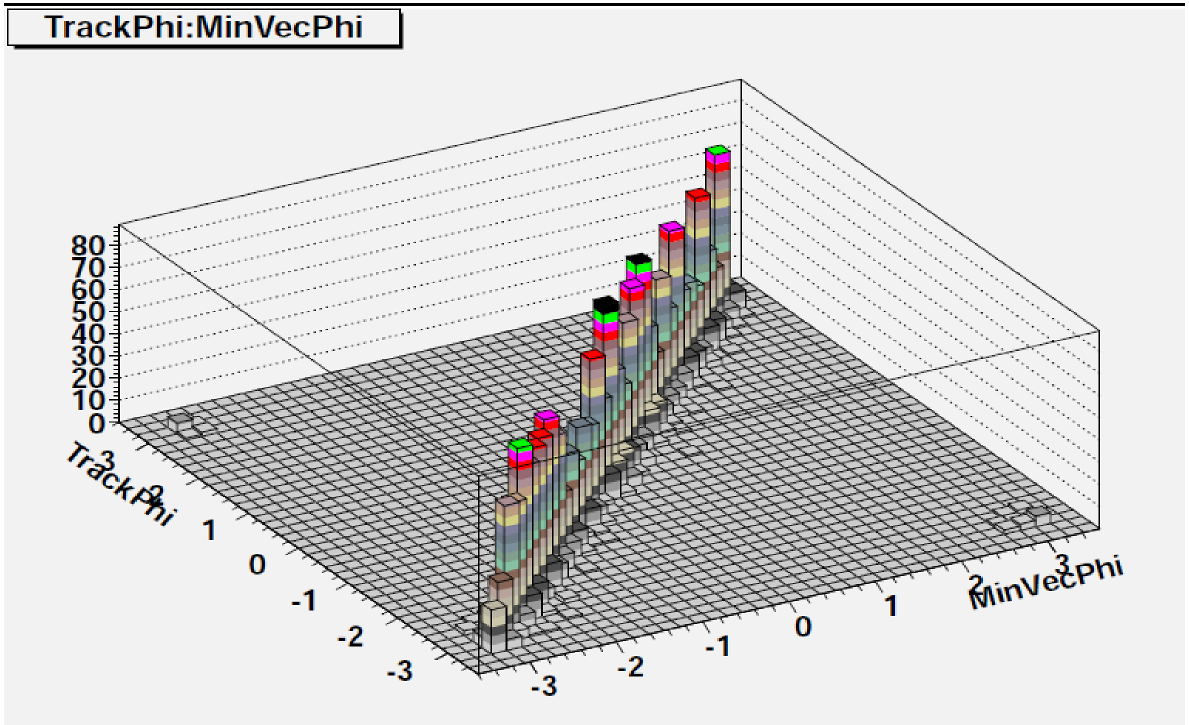
Black: angular difference between hits when we move from one superlayer to another

- Alternative approach:
  - start the automaton with segments, and not with spacepoints

Added Values from Mini – Vectors (II)

1) Reduce the combinatorial bkg
2) Improve the track – hit matching efficiency

} Track following algos



Summary - Outlook

- Implementation and adaptation of various approaches for the VXD – SIT standalone tracking
  - Std algorithm
  - Combinatorial Kalman filter for pattern recognition
  - Cellular automaton
- Study of more general tools
  - Mini – vectors
  - Extraction of the best track subsample
- Long term goal
  - Find an optimal algorithm which can cope with beamstrahlung
  - Test it in some demanding physics analysis (vertex charge?)
  - Give some feedback to R&D groups for VXD – SIT sensors requirements