

Status of new ILD central tracking

Frank Gaede, DESY

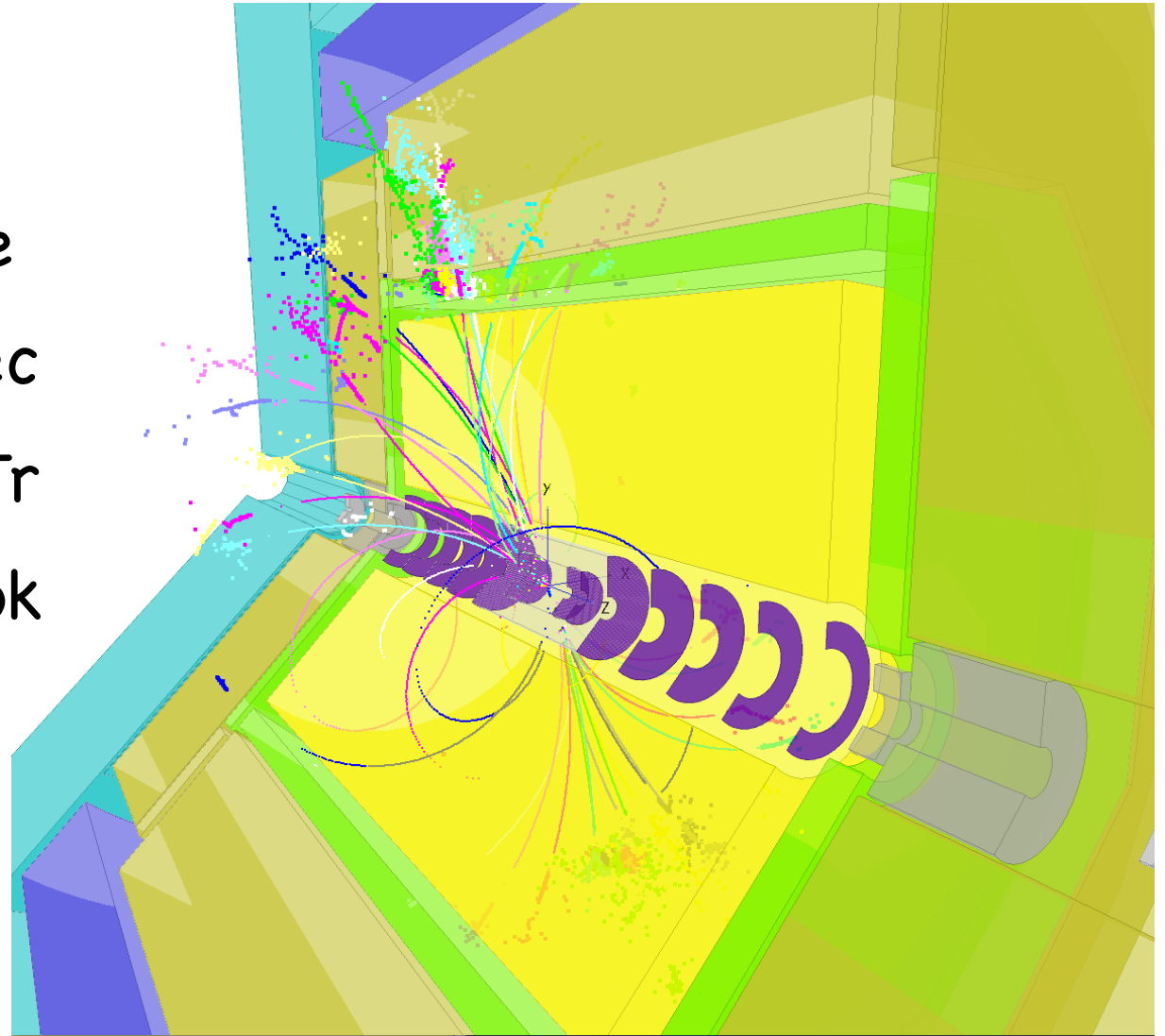
Steve Aplin, DESY

Software pre-meeting @ ILDMeeting

Fukuoka, Japan, May 22, 2012

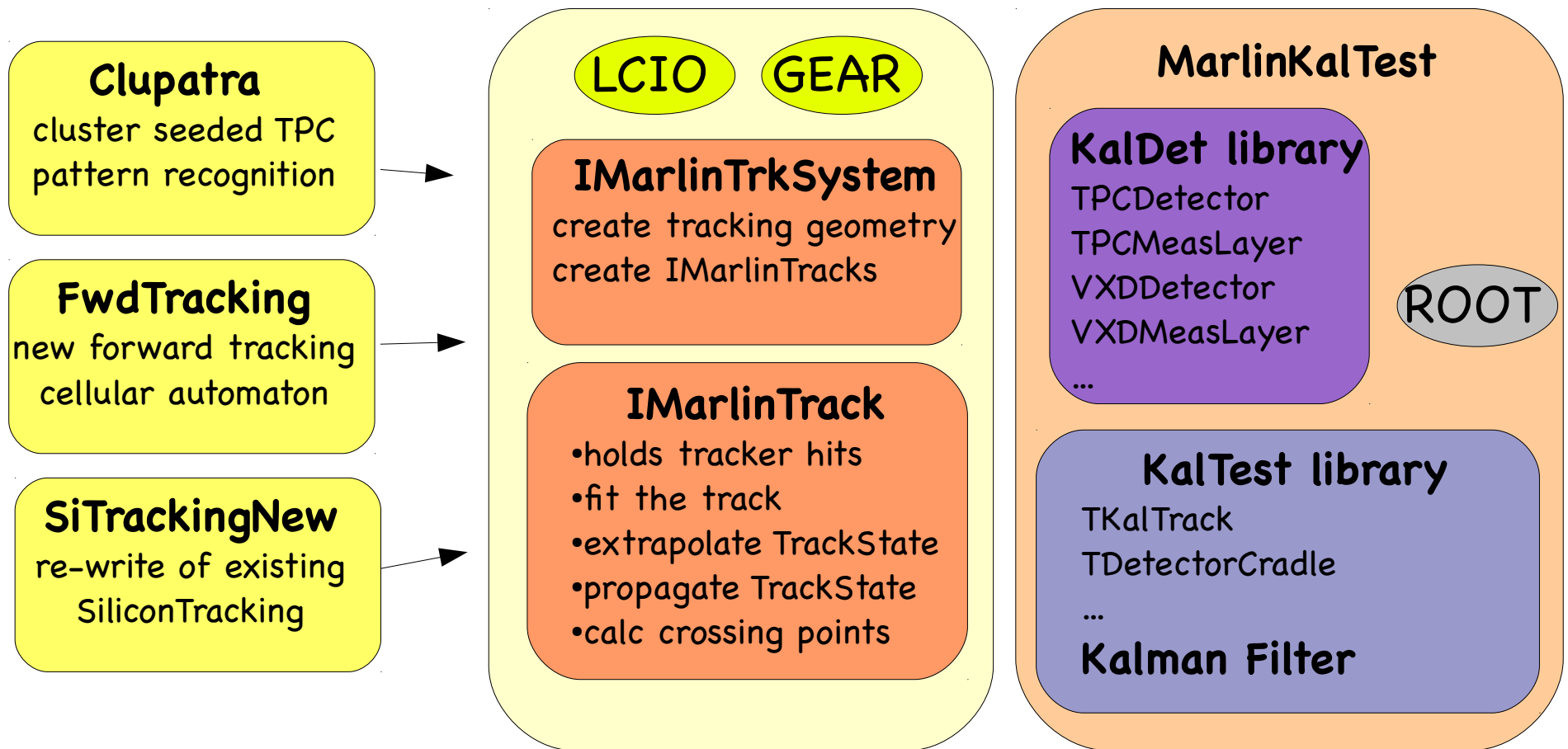
Outline

- Introduction
- MarlinTrk interface
- Clupatra TPC patrec
- C++ Si-TrackingSi-Tr
- Summary & Outlook



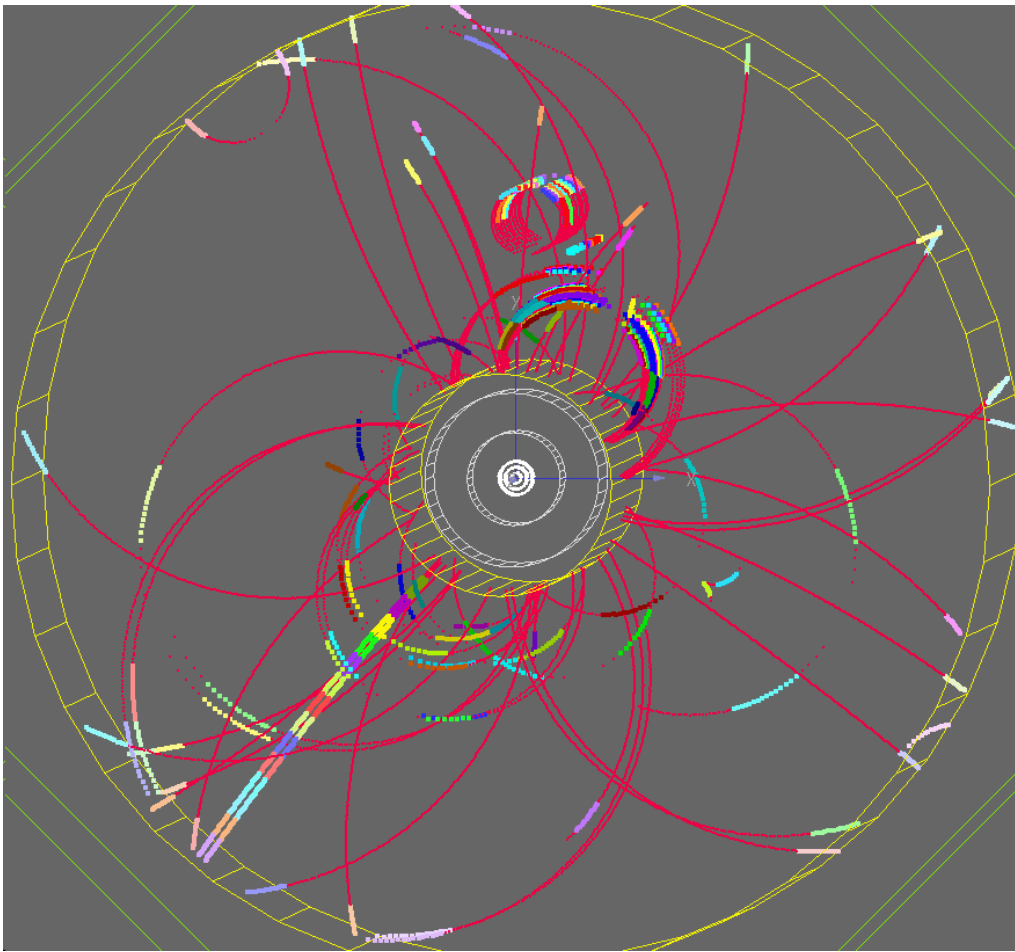
new C++ tracking: MarlinTrk

- new common API for developing tracking code (TPC, Silicon, Fwd)
- provides **loose coupling** between patrec and fitting
- defined abstract interface IMarlinTrk and implement using KalTest/KalDet
- currently lives in MarlinTrkProcessors



Clupatra step 1

- **NN-cluster** in pad row ranges (e.g. 15 rows) – going inwards
- identify **clean track stubs**
- **extend clean stubs forward & backward using Kalman fitter**
 - add best matching Hit if $\Delta(\chi^2) < 35$.
 - update track state !
 - search in next row

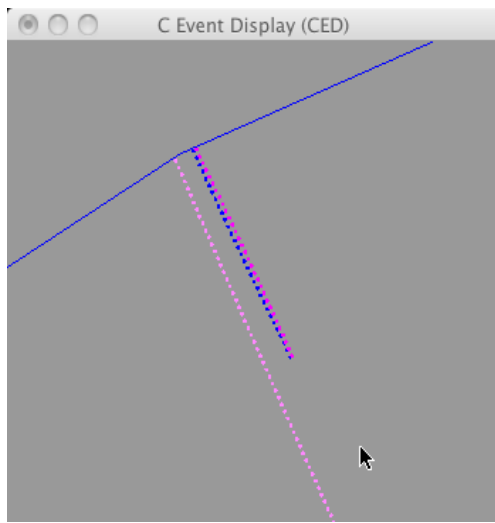


example:

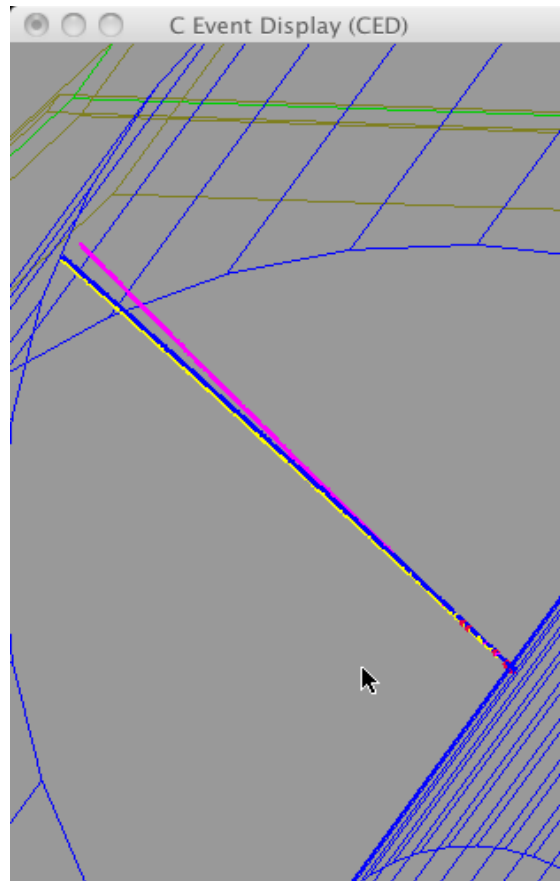
- ttbar event @ 500 GeV
- results in clean tracks and segments for curlers
- little leftover hits (red)
- some very close by tracks lost (fixed in step2)

Clupatra step 2

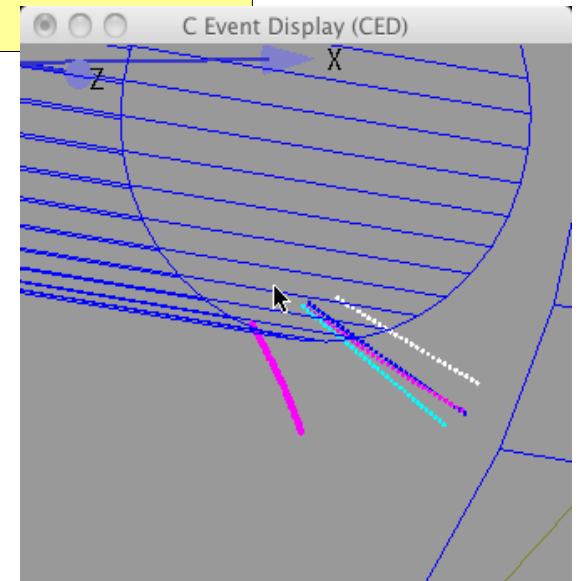
- re-cluster in leftover hits (NN clustering)
- based on **pad row multiplicity** force into $N=2, \dots, 9$ clusters
- apply **KalTest** fit to throw out falsely merged hits (rare)
 - higher multiplicity: repeat iteratively in smaller row ranges until only three or two tracks left



- gamma conversion in barrel
- forced into two tracks



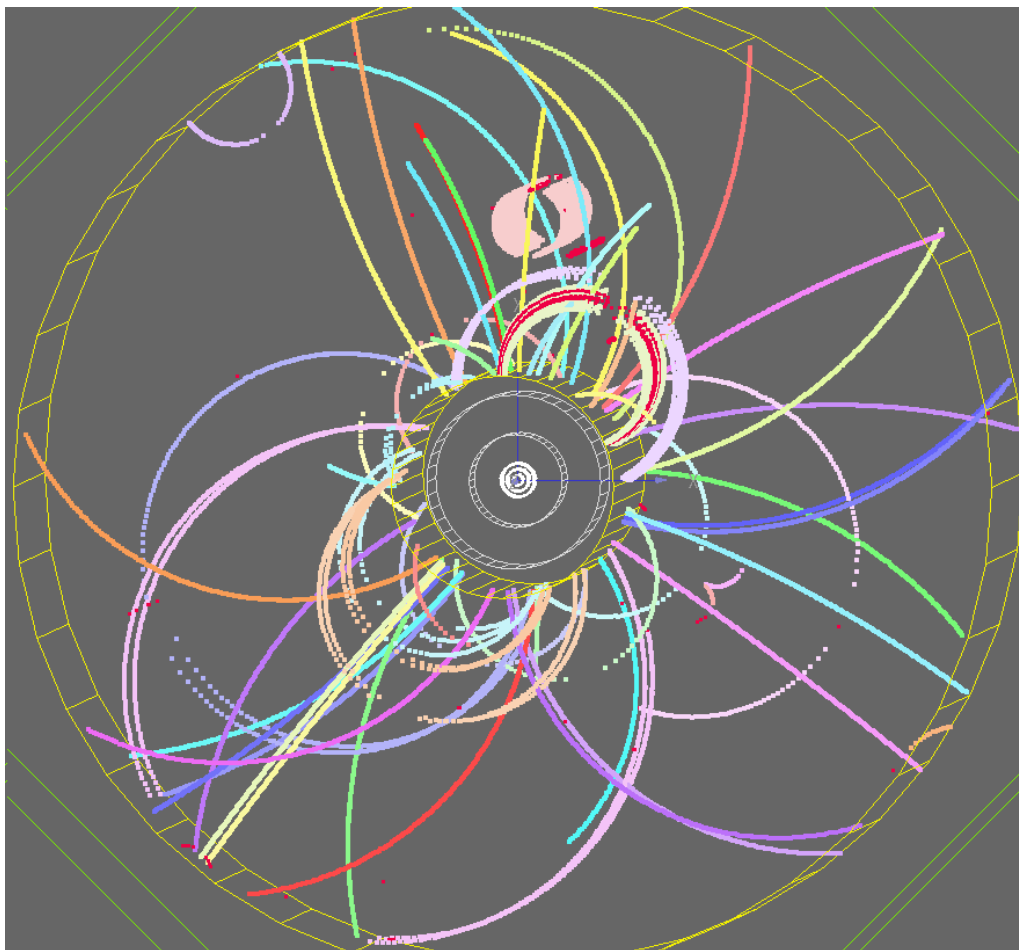
- three prong tau - barrel
- two close-by tracks forced into two tracks



- five prong tau - forward
- three close-by tracks forced into three tracks

Clupatra step 3

- **merge track segments (from curlers)**
- based on rough ($O(10\%)$) criterion for R , $\Delta(x_c, y_c)$, $\tan(\lambda)$
- disallow overlaps in z

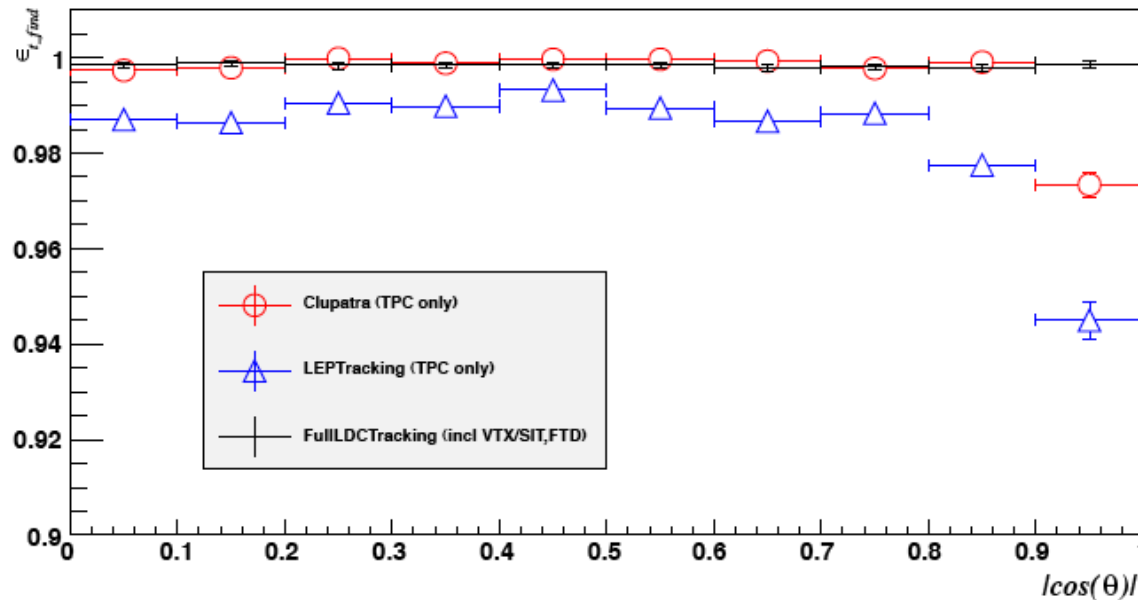
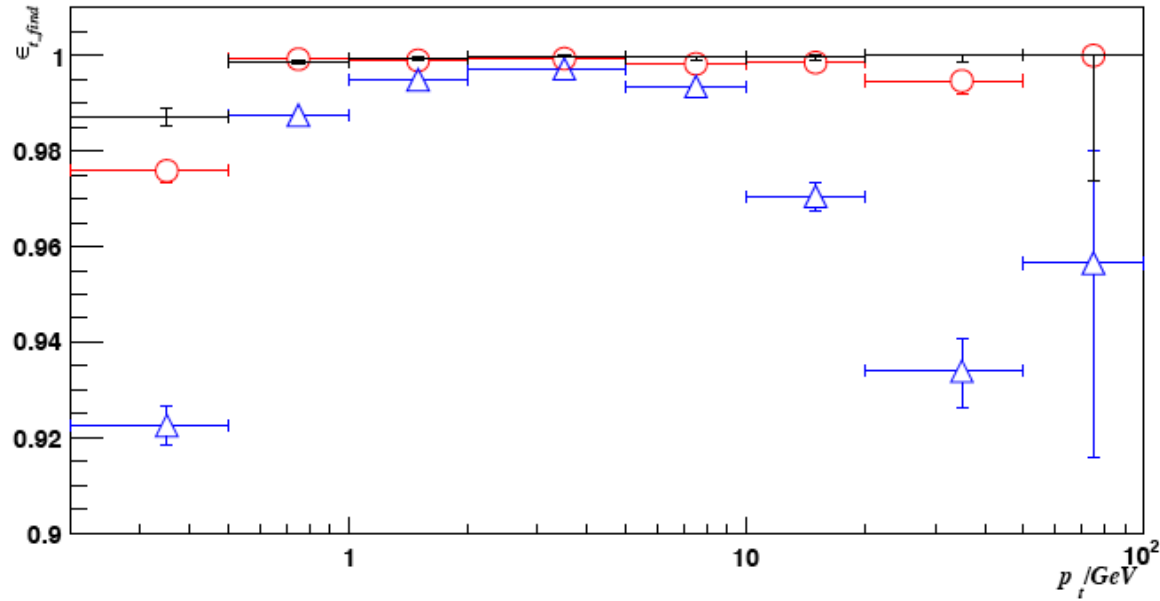


example:

- $t\bar{t}$ event @ 500 GeV
- works nicely
- few segments are not merged
- most of these curler segments were lost in old patrec

track finding efficiency

TPC track finding efficiency - $t\bar{t}$ @ 500 GeV

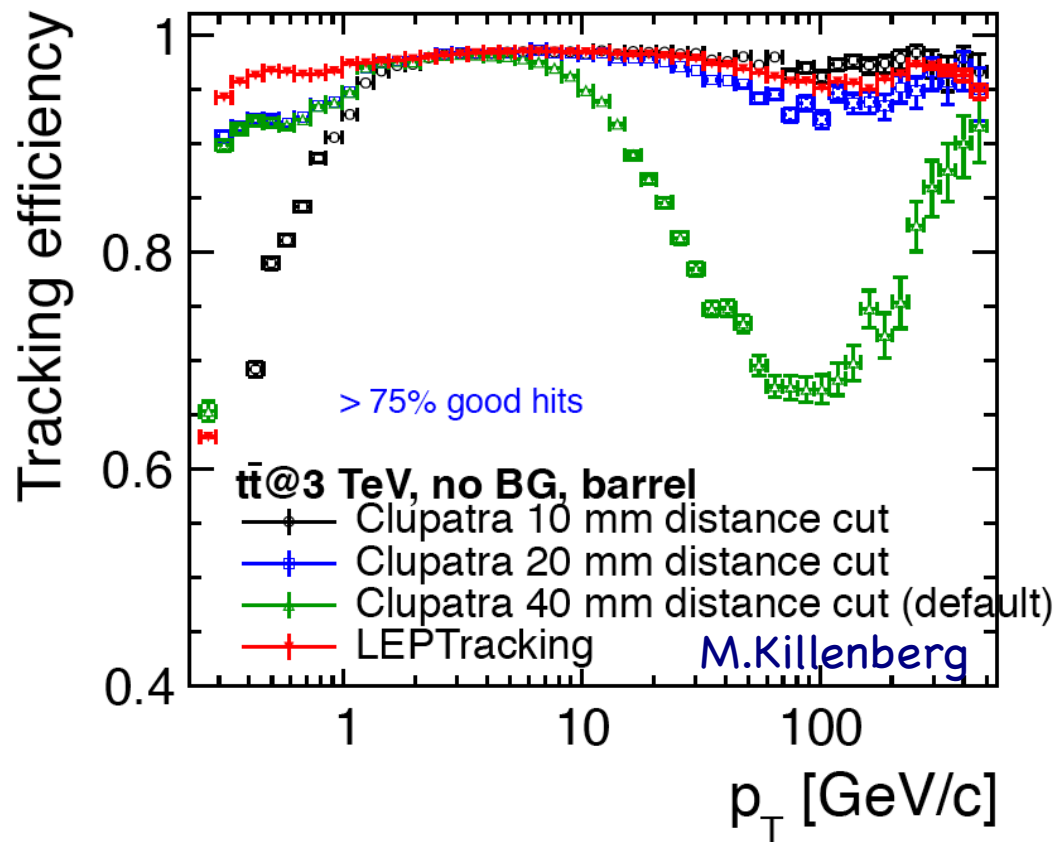


- prompt tracks $PCA(IP) < 10\text{cm}$
- > 5 TPC Hits
 - ($p_t > 100\text{ MeV}$)
 - ($|\cos(\theta)| > .99$)

- comparison to LEPTracking pattern recognition

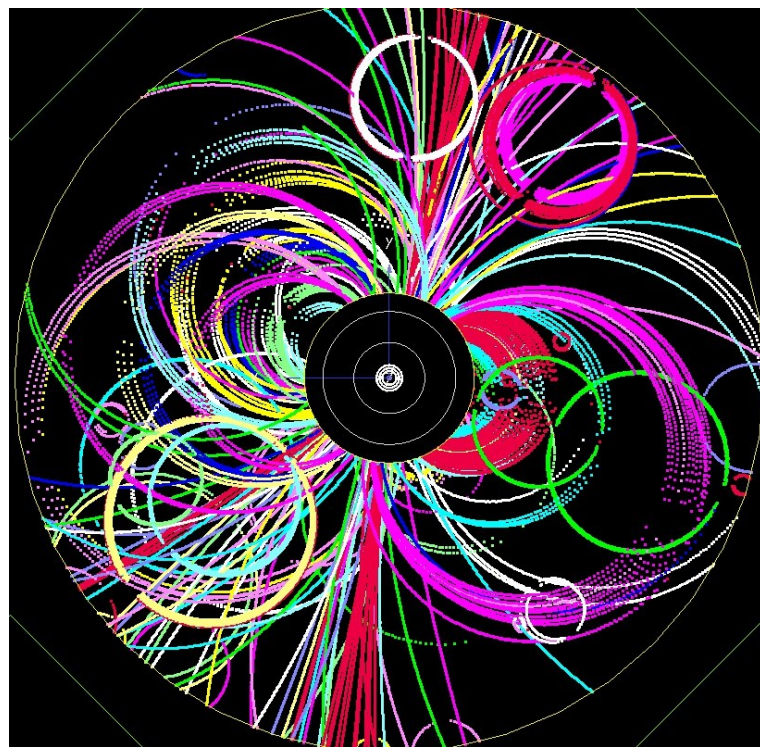
- Note
 - older version of Clupatra
 - no quality cuts applied yet

Clupatra issue @ 3TeV

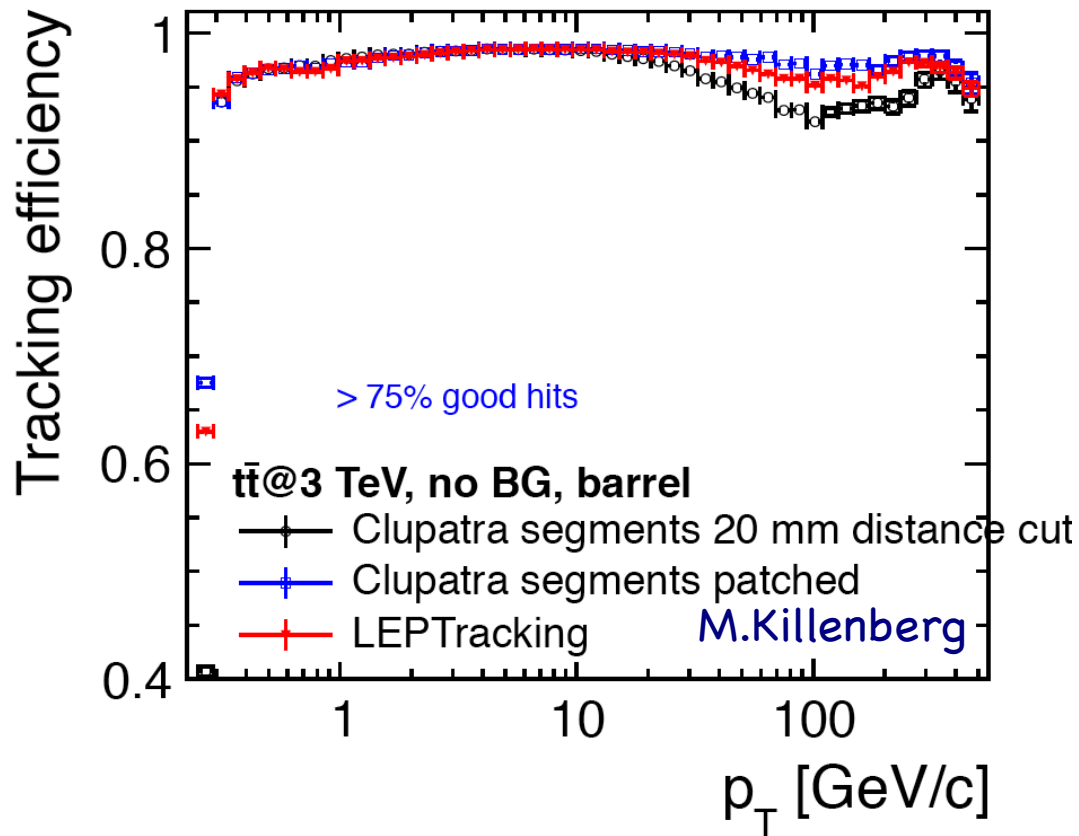


- issue with old Clupatra at higher energies (3TeV)
- poor efficiency with default parameters (optimized @500GeV)
- observed by M.Killenberg for ILD_CLIC detector

- example event
 - high p_T tracks in dense jets are sometimes not separated enough along complete length
-> red tracks are lost

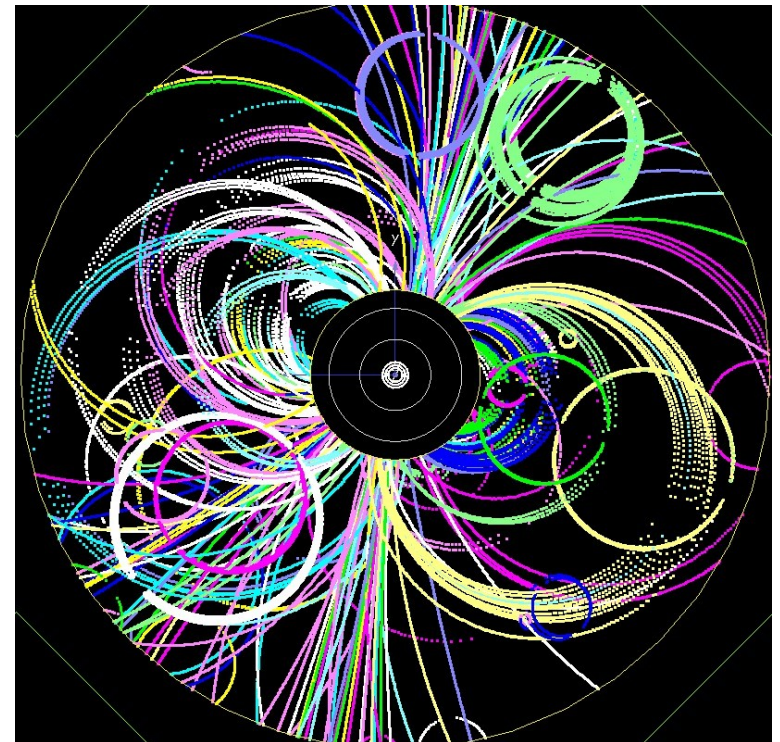


Clupatra issue @ 3TeV fixed



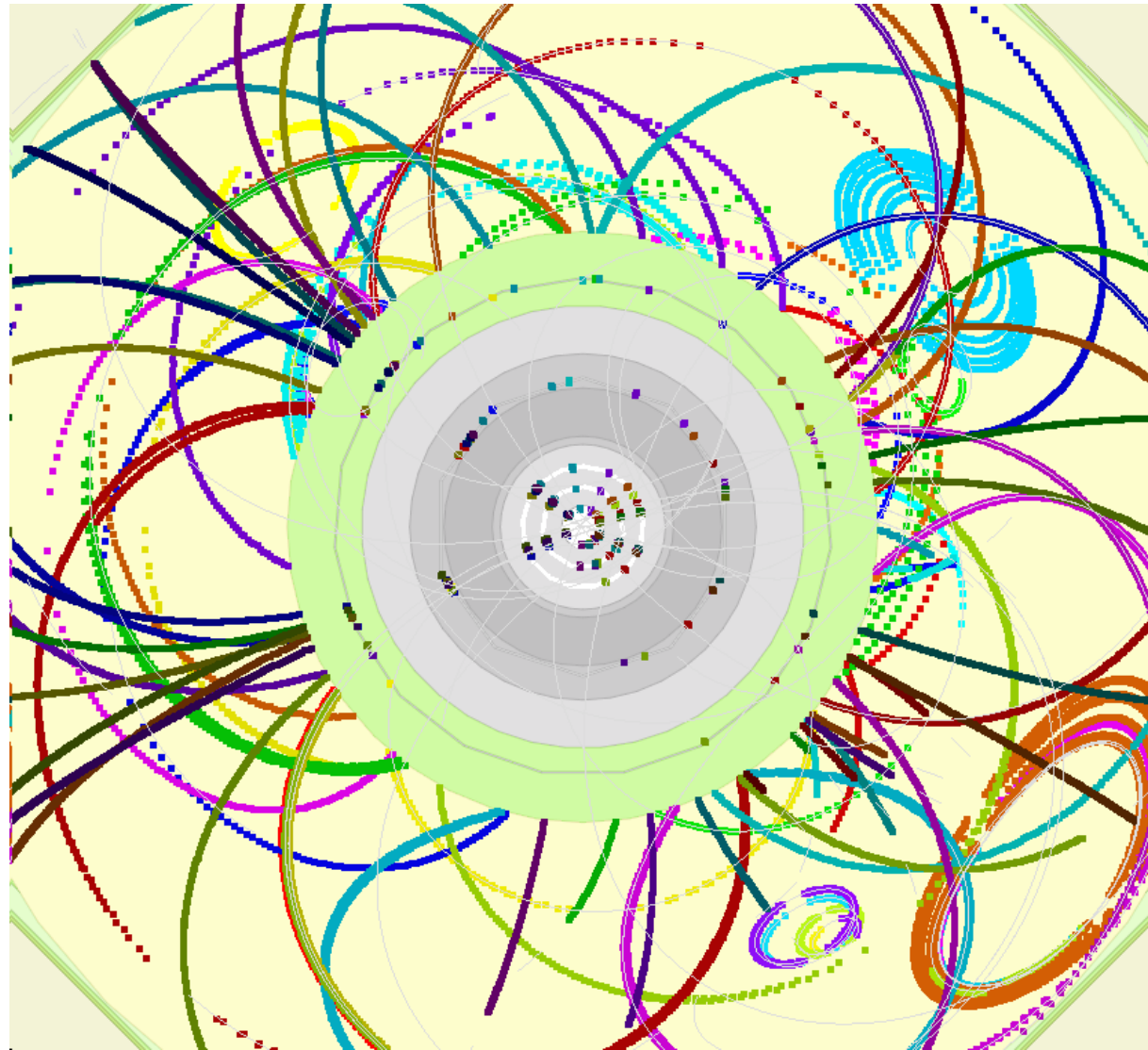
- new Clupatra fixes issue at higher energies (3TeV)
- now loop over different distance cuts for initial seed clustering
- -> track efficiency improved
- further studies needed ...

- example event
- no tracks are lost with new Clupatra



extending Clupatra inwards

- extended Clupatra to optionally extend hit search further inwards using MarlinTrK interface
- try to pick up hits from SIT and VXD
 - **use 1d Hits for SIT !**
 - FTD not yet
- **could use as backup strategy for large background**
- standard ILD tracking:
 - have standalone tracking in TPC and Si-trackers and then merge

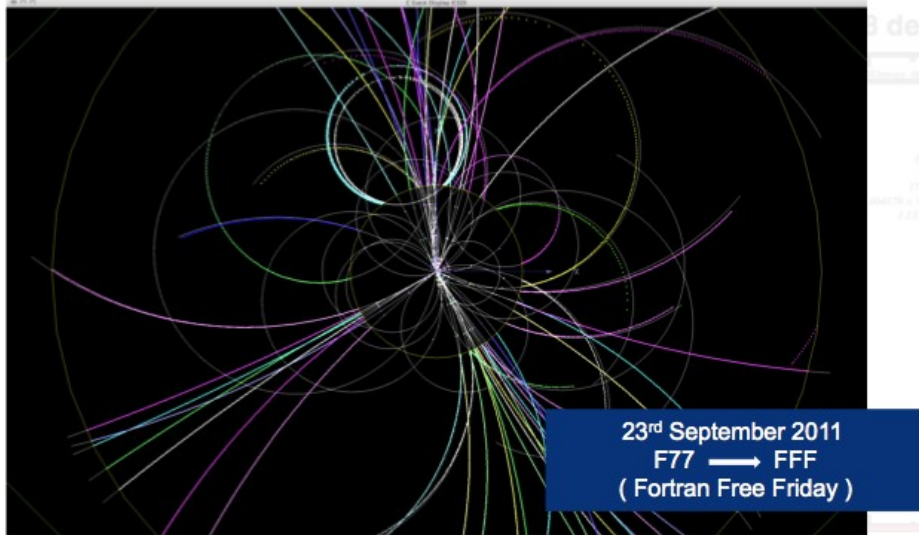


fisheye view of Clupatra tracks with SIT and VXD hits picked up ($t\bar{t}$ @ 500 GeV)

Clupatra memory usage

- large memory consumption for Clupatra observed (T.Tanabe)
 - 1.2 GByte for ILD event w/ 70 k TPC hits
 - -> not a major problem for ILD DB – however prohibitive for CLIC w/ background (several 100k hits)
- Clupatra uses KalTest Kalman filter for track extrapolation – keeping all tracks in memory (twice) until end of event
 - KalTest stores three track states per hit (predicted, filtered, smoothed)
 - every track state has 5 TMatrixD objects (264bytes)
- modified Clupatra to mostly keep only one complete track fit in memory at any given time
- memory usage dramatically reduced
- -> should be usable for CLIC as well now

new Si-Tracking - full tracking




- shown in Granada @ LCWS11:
- re-write of SiliconTracking and FullLDCTracking (from LOI) using the new MarlinTrk track fit
- using 3d space points in SIT/SET and FTD (as was done in LOI) yet with planar wafers

ttbar event @ 500 GeV reconstructed using Clupatra and SiliconTracking_MarlinTrk then combined into full tracks using FullLDCTracking_MarlinTrk

- since then:
 - extended Gear with [MeasurementSurfaceStore](#)
 - local coordinate systems on rotated planes
 - write out proper [1d strip measurements](#) for Si-Trackers using the new `lcio::TrackerHitPlane`
 - x, y, z, u, v, du, dv
 - implemented [1d fit in MarlinTrkKalTest](#) (KalDet)
 - implemented [SpacePointBuilder](#) (next slide)

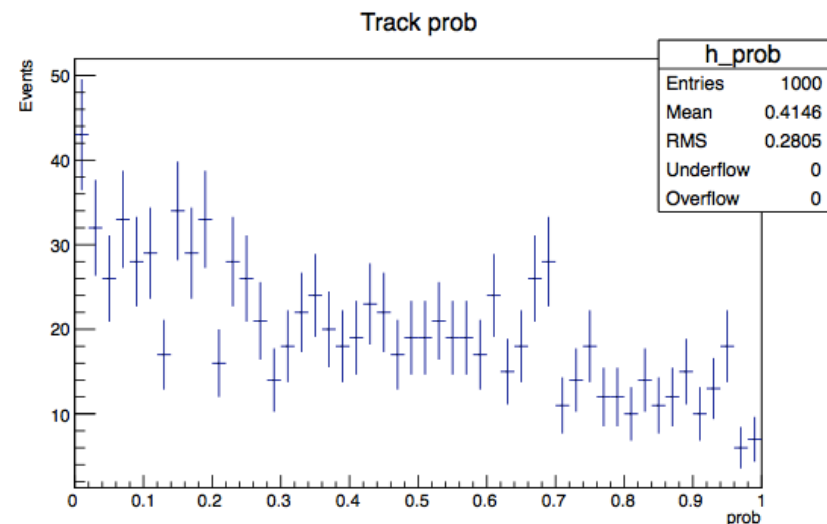
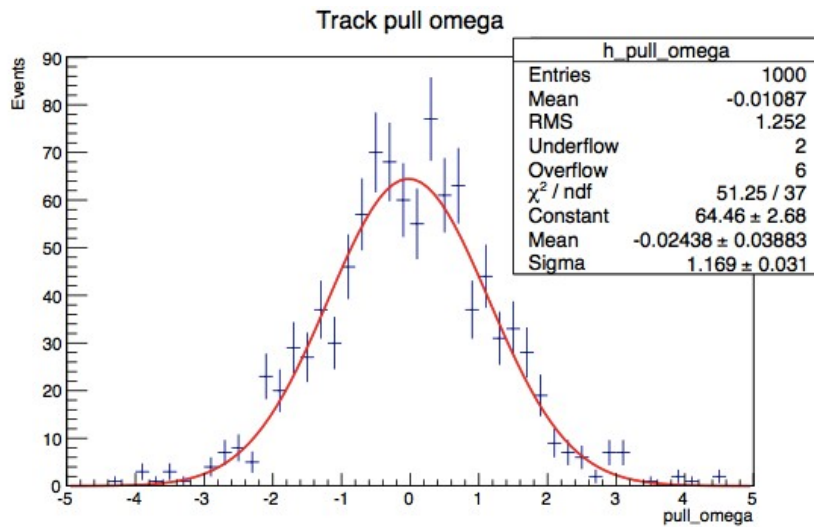
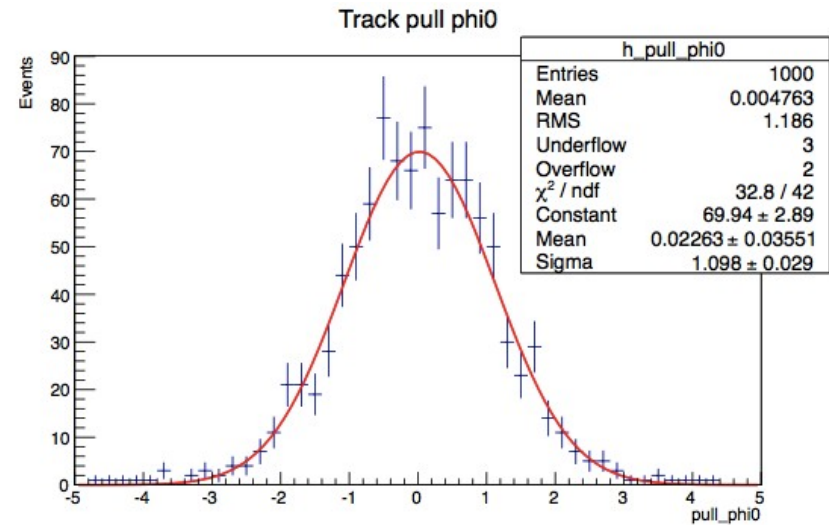
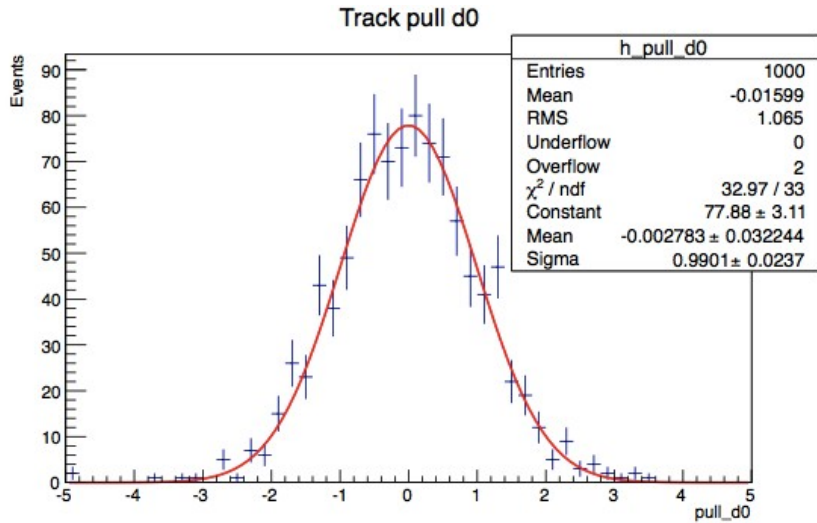
SpacePointBuilder

- Marlin processor that combines pairs of digitized 1d TrackerHitPlanes from double layers with strip stereo angle into TrackerHits with 3d space points - including somewhat correct errors
- avoid parallax problem by projecting to the IP 
- all possible hit pairs that result in hits laying within the bounded surface of the wafer (rectangle/trapezoid) are used
-> including ghost hits
- these space points are used for pattern recognition
- the final track fit (after arbitration for doubly used hits) then uses the proper 1d measurements and errors

=> major step in realism wrt LOI

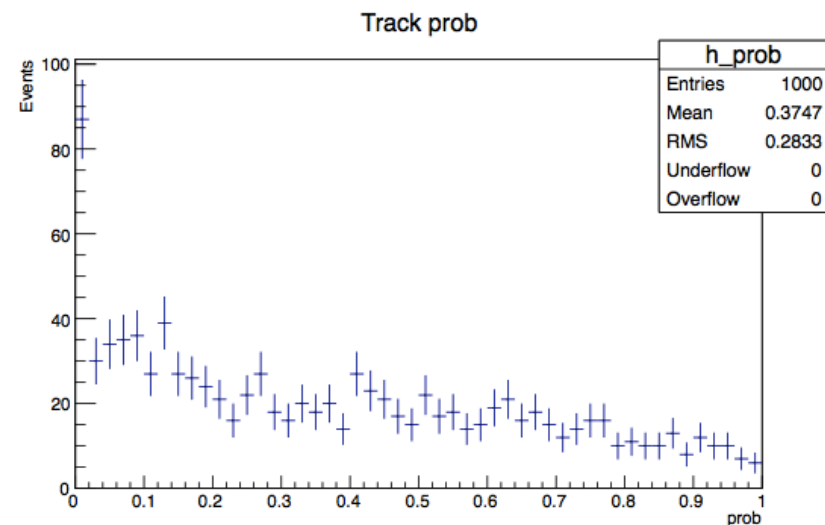
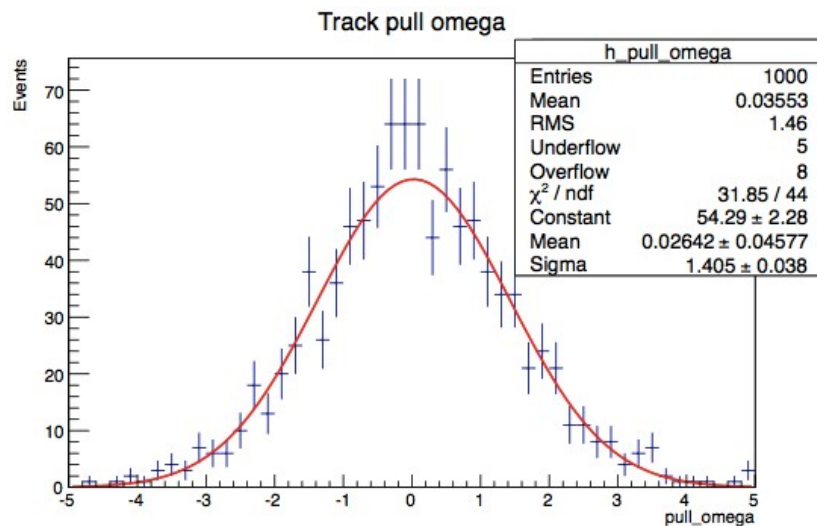
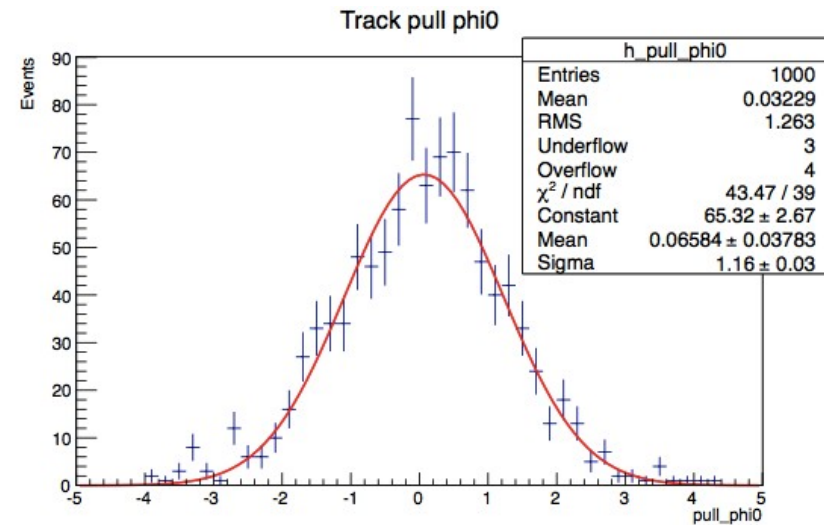
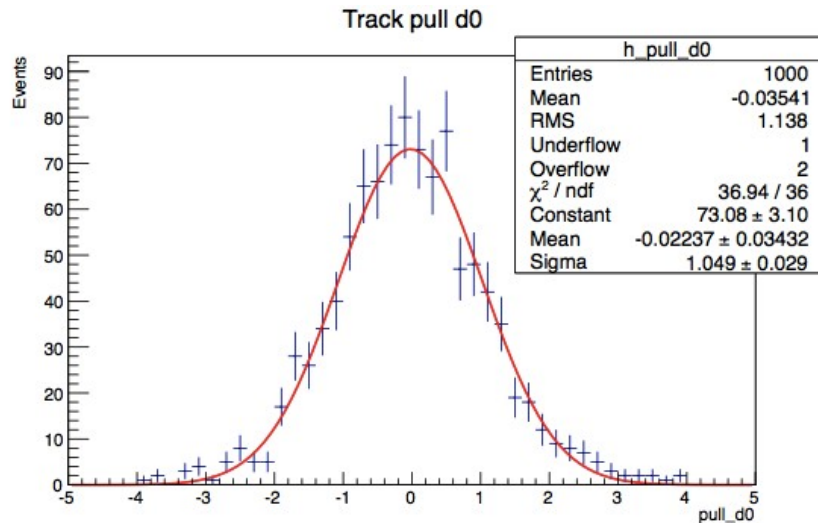
first test of new Si-Track fit

single 10 GeV muons central: VXD/SIT (no TPC)



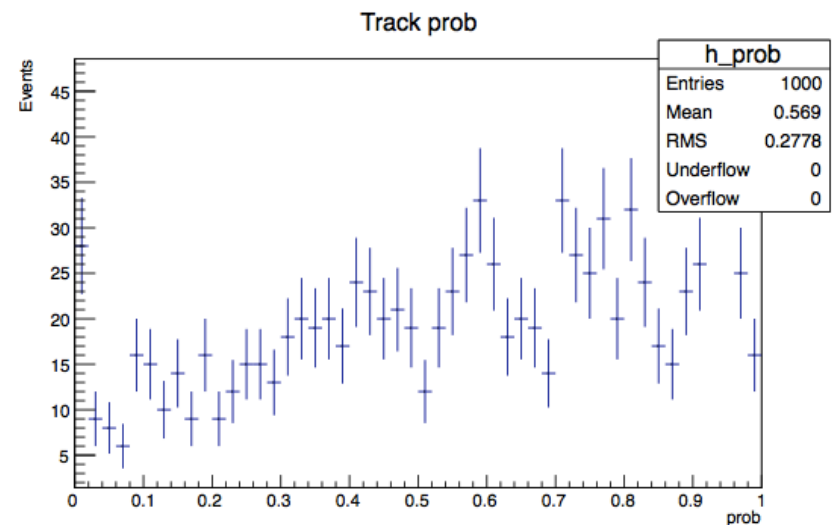
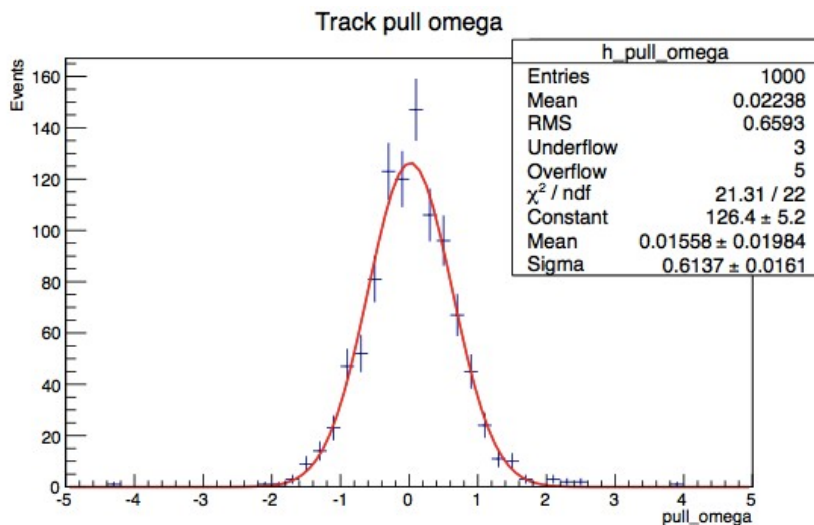
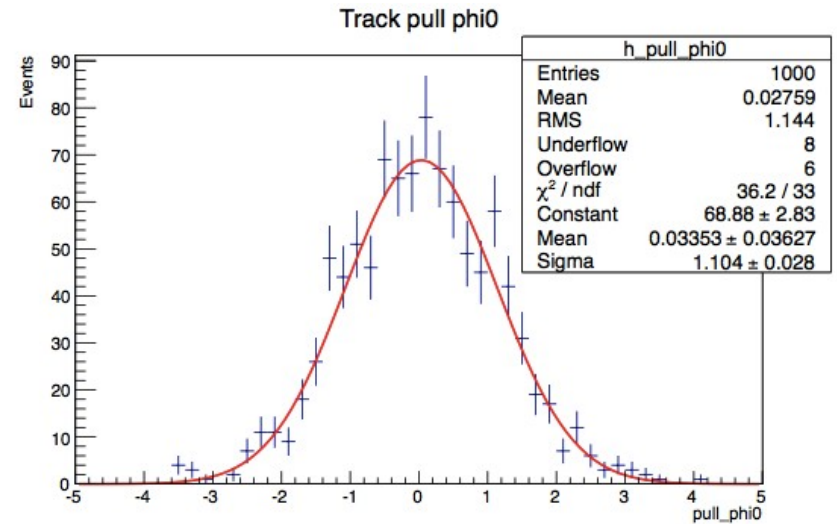
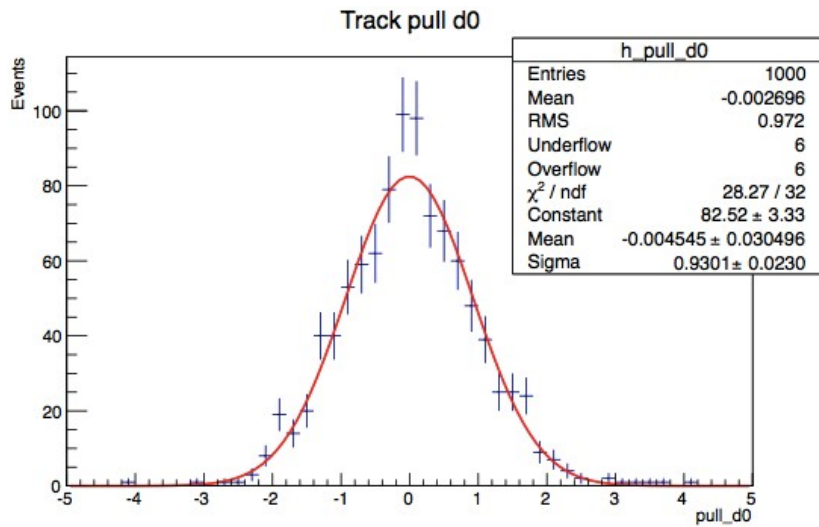
first test of new Si-Track fit

single 3 GeV muons central: VXD/SIT (no TPC)



first test of new Si-Track fit

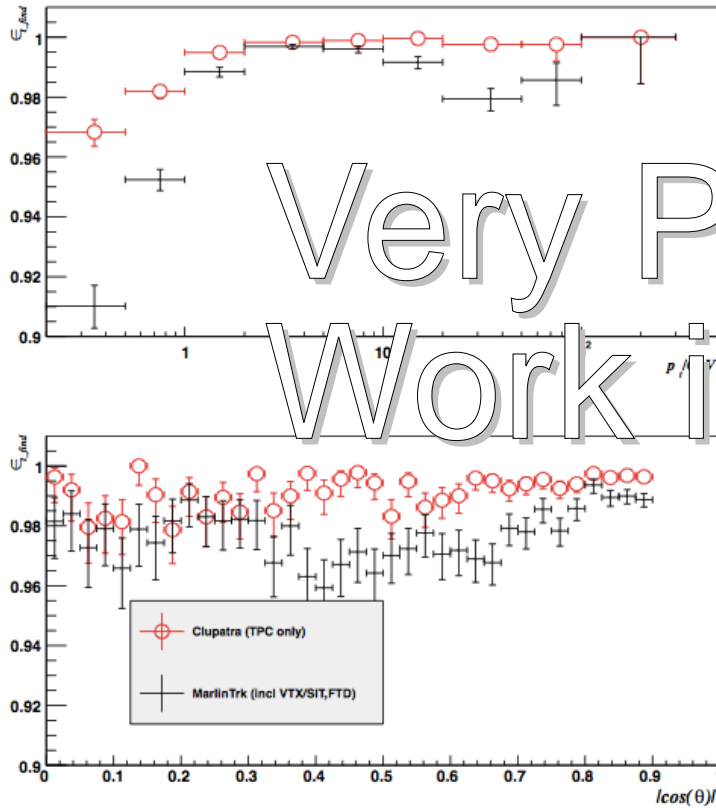
single 3 GeV muons forward: FTD (no TPC)



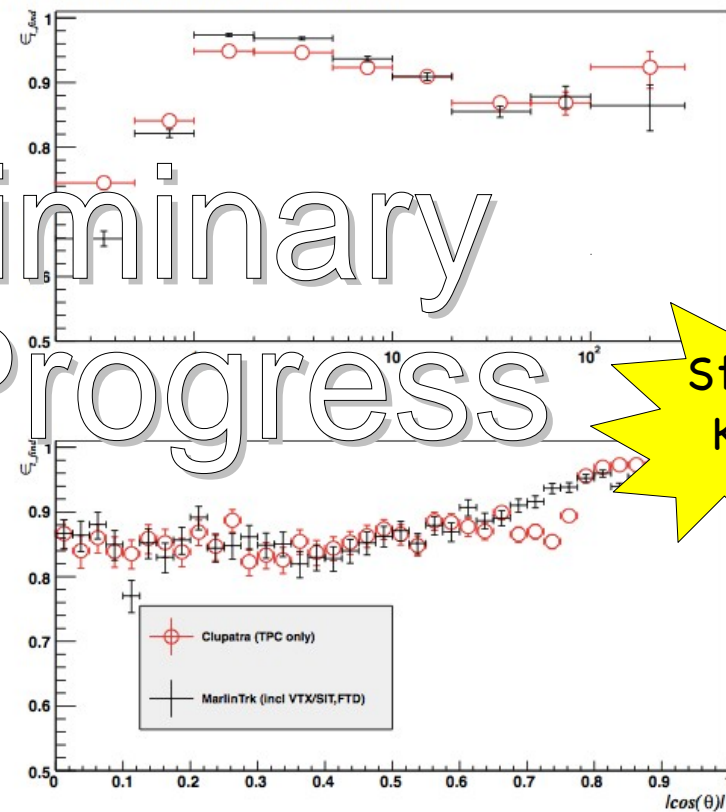
first look at efficiencies in v01-13-05

Frank Gaede, ILD Meeting, Kyushu U., May 21-25, 2012

TPC track finding efficiency - WW @ 1000 GeV



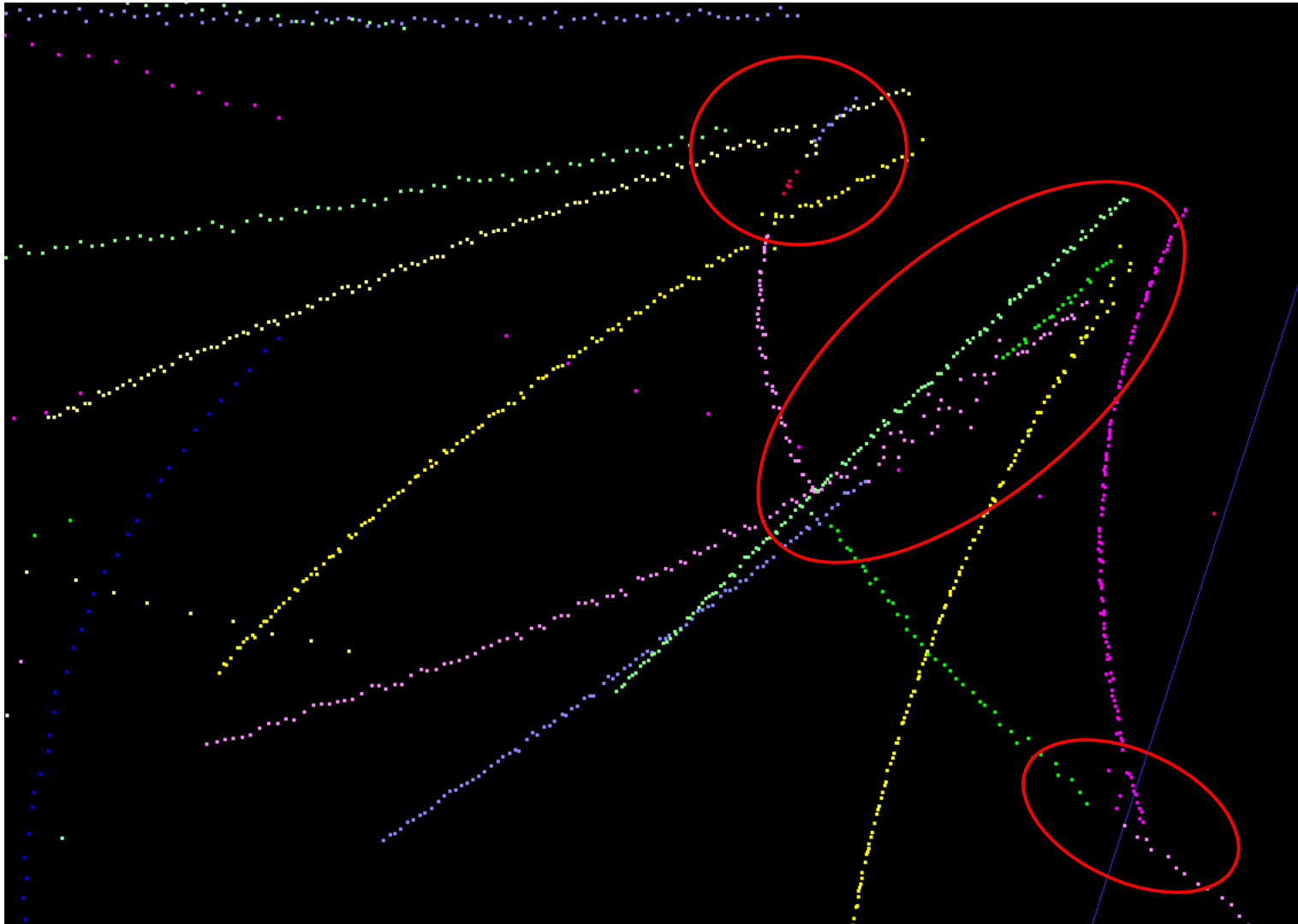
TPC track finding efficiency - WW @ 1000 GeV



Status @
KILC12

- first look at clupatra efficiencies:
 - would be acceptable (incl. 75% true hit cut - left)
 - but obvious issue w/ split tracks (right)
- first look at MarlinTrk efficiencies (incl. Clupatra):
 - work to be done - loss partially understood:
 - probability cut and poor errors...

Clupatra split tracks example

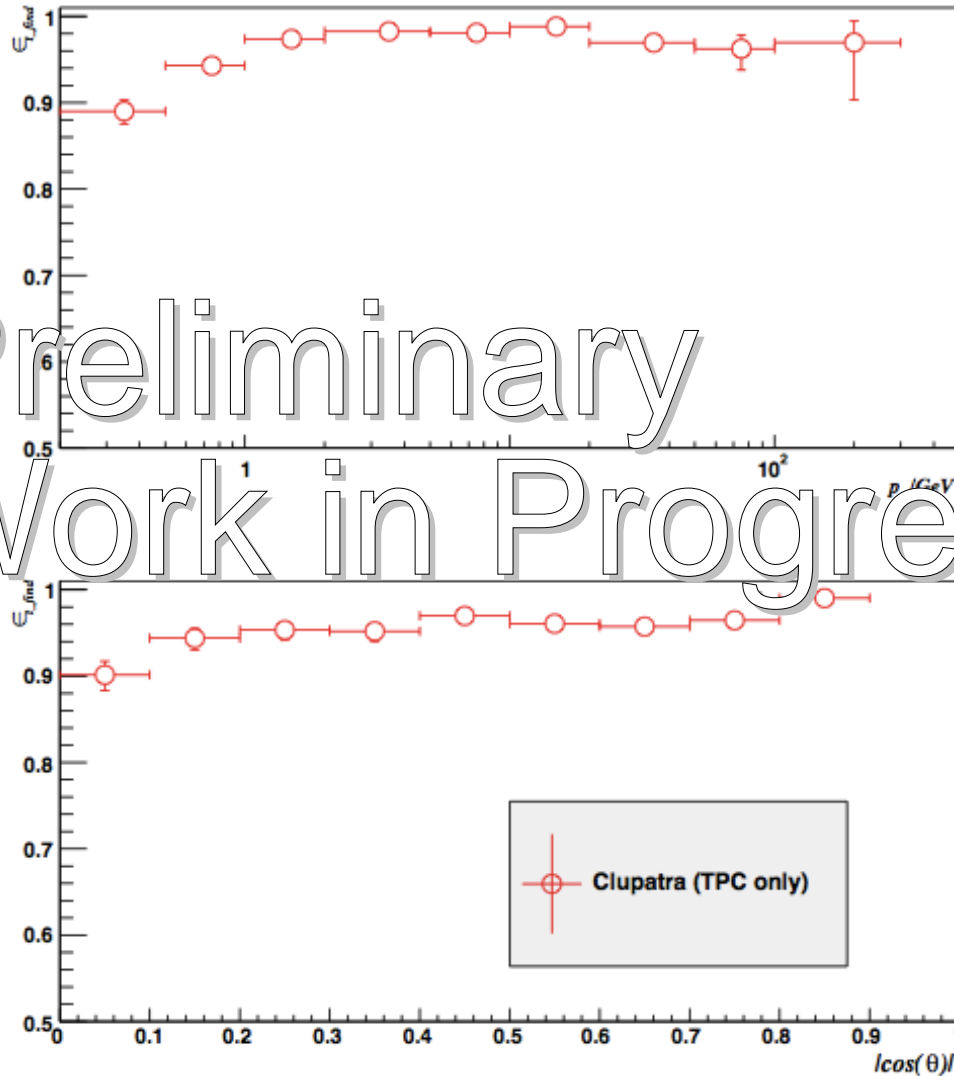


- need to be able to merge of split tracks which are due to merged TPC hits in dense environments ($> 1\text{TeV}$)

Clupatra efficiency in v01-13-06

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TPC track finding efficiency - WW @ 1000 GeV



- added segment merging :
 - compare incomplete segments pairwise
 - use track state of larger to add first, middle and last hit
 - merge if this successful

still not 'optimal' - can be improved further ...

WW pairs @ 1 Tev:
tracks from IP (10cm)
>75% of correct hits
no split hits !

Summary & Outlook

- new tracking for ILD has been developed - latest release in iLCSoft v01-13-06:
 - Clupatra (topological TPC patrec)
 - C++ re-write of SiliconTracking and FullLDCTracking
 - ForwardTracking
- recently included the proper treatment of 1d hits for double strip stereo layers in SIT/SET and FTD
- started to combine ForwardTracking and SiliconTracking
- started to fix split track issue

• To Do

- test everything more thoroughly
- understand (in)efficiencies (and fix issues)
- iterate the material description to get probabilities and pulls right
- time before DBD Monte Carlo production is short
 - let's see...