Report on Tracking

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LHCb Week, 04.09.08

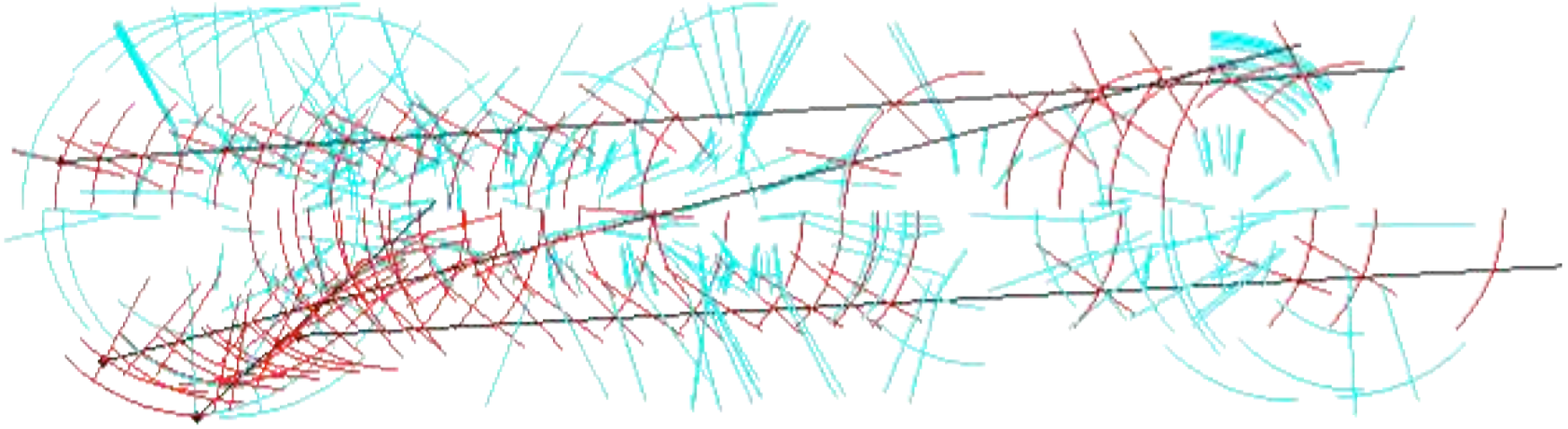
- First tracks in data
- Tracking in offline & HLT2
- Summary of the tracking workshop
- Documentation

Tracking on Data

- January LHCb week:
  algorithms are ready & robust even in suboptimal conditions
  (misalignment, no drifttimes, some layers switched off ...)
- While switching to new software (hit and geometry classes)
  last year, took special care of accessing geometry in uniform
  way via detector elements.
- Last weeks: reconstruct good tracks in cosmic/sector test
  data with standard LHCb pattern recognition software with no
  or only marginal modifications
- Sofar tested:
  - Velo pattern recognition: PatVeloGeneric
    (special algorithm for test beam, alignment etc).
  - PatSeeding: T Station standalone algorithm
- Next step: Velo+TT, for long tracks need data from collisions

Tracks in the VELO

Run 30933, Event 8

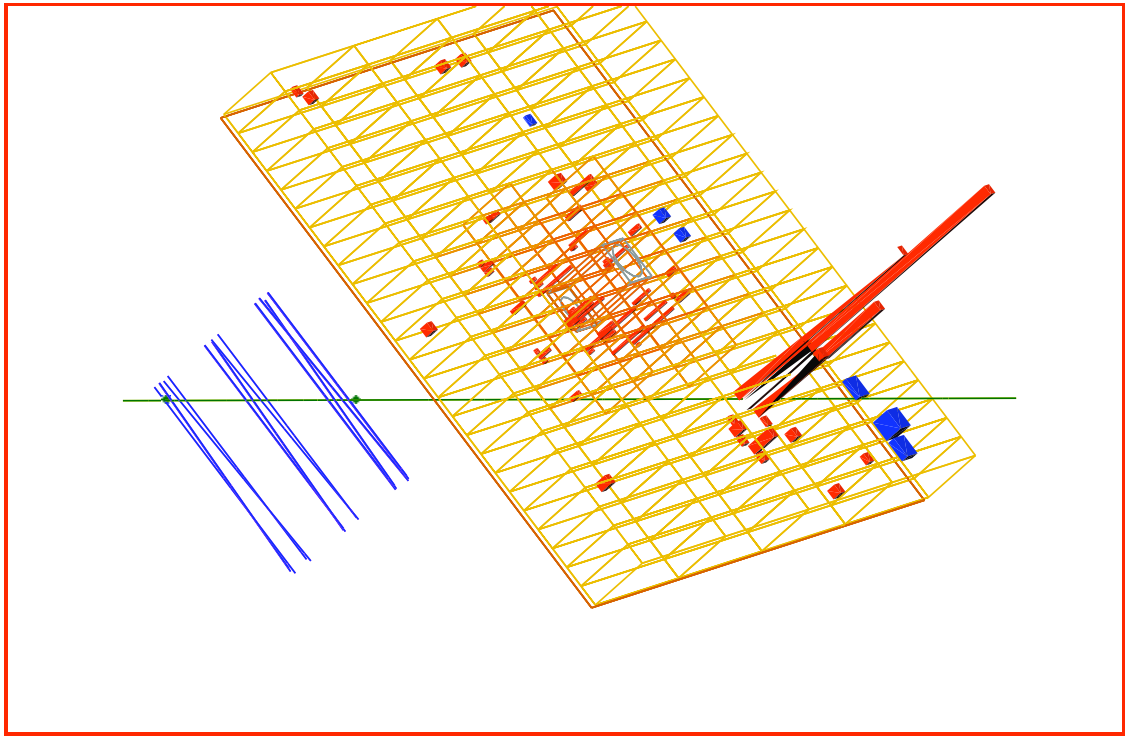


hits on tracks

additional hits

more in Themis Bowcock's talk on Tuesday

1st Event in OT



OT hits on track, track, calorimeter cluster

helped to identify bug in decoding & staggering of monolayers

(see Jan's talk in Tuesday meeting 19.08.09)

more on cosmics in T in next talk (Manuel)

Tracking: Offline vs. HLT2

- Several studies ongoing, seeing major differences for tracks in HLT2 compared to offline.
- Need to separate two different aspects:
  - difference in pattern recognition:
    different hit content, ghost rate, reconstruction efficiency
  - difference in track fit:
    different quality of parameter or error estimate, less signal and background separation power.

Pattern Reco: Offline vs. HLT

Difference on purpose (question of time):

- VeloGeneral (very displaced tracks (K_s/λ) doesn't run on HLT (expected difference 0.5% add. efficiency for "normal" tracks)
- offline: forward tracking + matching + clone killer,
  HLT: forward tracking (expected difference: 2-3%)

Add. possibility: Seeding + Matching, after PatForward on unused hits (recovers 2%, 0.6 $\times$ time of PatForward - lhcb-2008-042)

Differences localized during debugging:

- HLT1 & HLT2 in same job $\longrightarrow$ need to reset used flag of hits
  (PatVeloResetClusterUsed, ResetHits; available in next Brunel version)
- Currently HLT doesn't add TT hits (important for later fit)
- Currently HLT doesn't use PatForward ghost cleaning

Fitting: Offline vs. HLT

Two alternative solutions to get better selection efficiency/rejection power:

- do some kind of fit on HLT
- do no fit on HLT, however
  - improve parameterized error estimate
  - 40% of fake B candidates have at least on ghost track,
    $\longrightarrow$ improve ghost ID
    (e.g. train ghost NN without input from fitter)

Work ongoing in both directions

Fitting: Offline vs. HLT

Several fitting options exist:

1) offline: several iterations, detailed material model
   ($\sim 5 \times$ time of pattern reco)

2) several iterations, simplified material model ($\sim 2.2 \times$)

3) single iteration, simplified material model ($\sim 0.4 \times$)

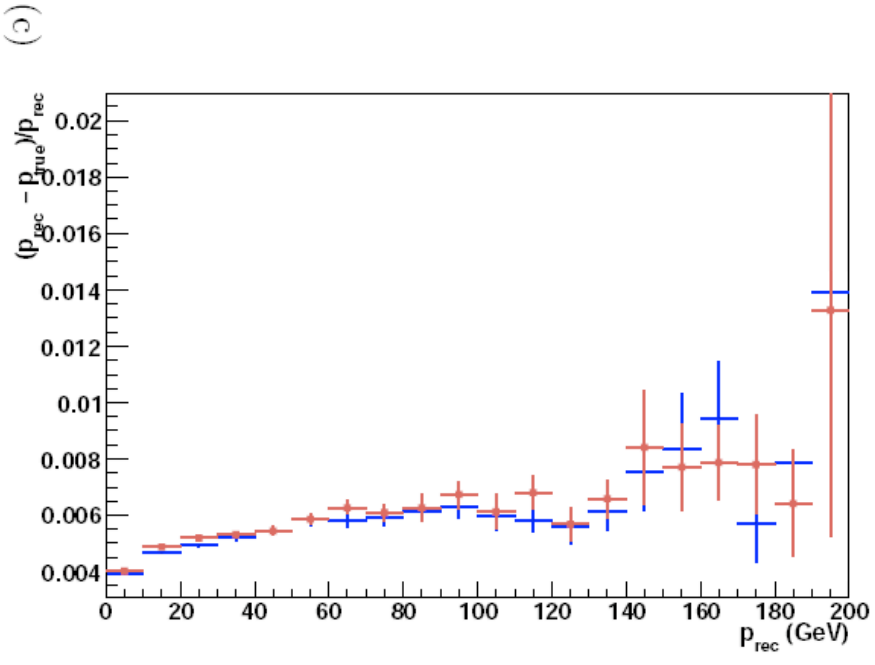
Current default on HLT: no fitting.

Detailed documentation of difference on $B \to h^+h^-$ analysis
comparing 1) & 2) from Marco G., Eduardo R. (lhcb-2008-030)

Have to evaluate effect of number of iterations.
mainly effect on momentum resolution not on error estimate
(Wouter's talk, Tracking workshop Ferrara)
Resolving LR ambiguity beforehand might help avoiding iterations.

Simplified vs. Detailed Geometry

$\Delta p/p$ versus p (track level)



simplified geometry

detailed geometry

resolution of B candidates

Geometry	Momentum resolution (%)	Mass resolution (MeV)	Proper time resolution (fs)
full	0.495(5)	22.5(3)	37.7(5)
simplified	0.502(6)	22.9(4)	37.7(6)

$\longrightarrow$ same number of selected $B \longrightarrow h^+h^-$ candidates,
96.1% candidates in common.

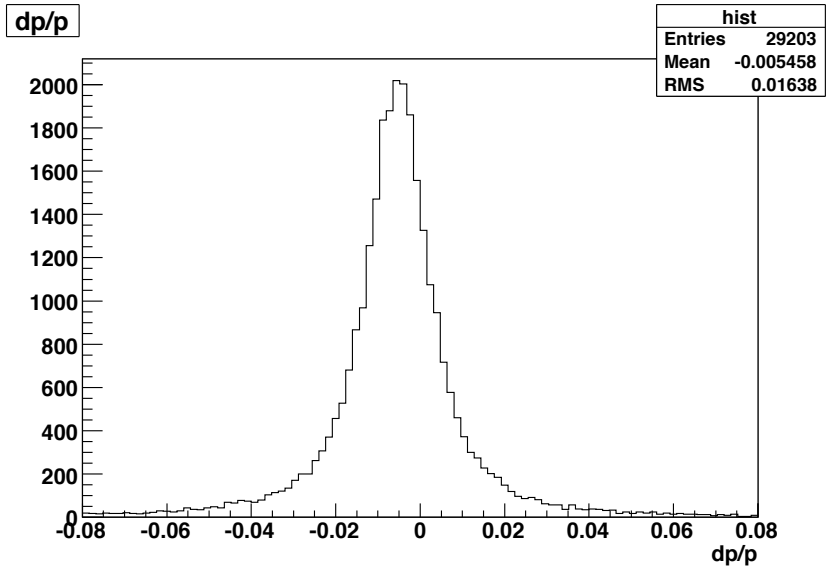
(numbers & plots from lhcb-2008-030)

Tracking & B Field (I)

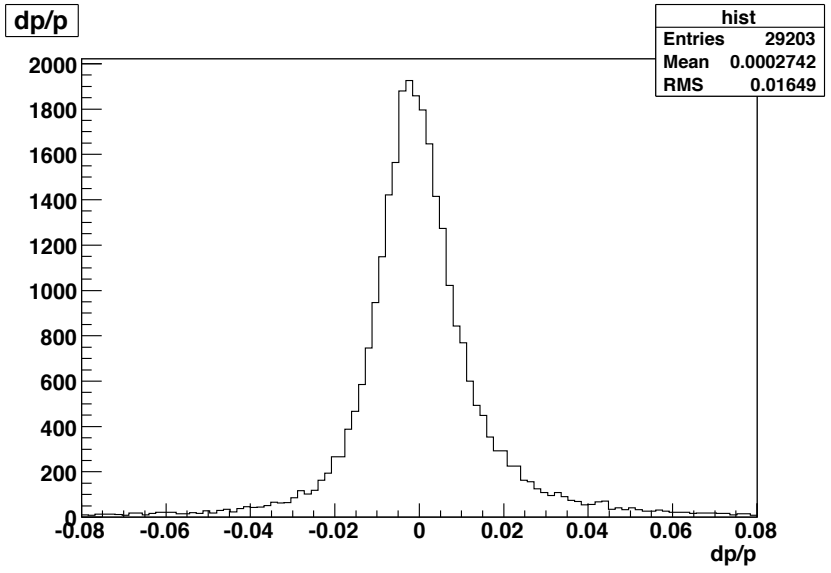
- Realistic B field map available (positive polarity);
- Integrated B field $\sim$ 0.5% lower than standard map in MC; (more details in Adlene's talk)
- Pattern recognition ignores B field map completely, instead use parameterization derived on Monte Carlo.
- Drop in pattern reco (T Station) efficiencies by about 1% by changing to new B field map
  (simulated with new map, reconstructed with old parameterization)
  $\longrightarrow$ recovered in the mean time.

Tracking & B Field (II)

Effect of new map on momentum resolution (fast momentum tool):



default (shift of -0.5%)



rederived parameterization

In case B field (field current) will change during running; field service will be automatically updated (thanks to Marco, Marco, Adlene)

→ Need to propagate this information to pattern recognition.

→ Pattern reco now flexible to handle negative and positive polarity and change of B field by up to a few %.

Change to Python Configurables

- Brunel v32 to v33: change from job options to python scripts.
- Good opportunity to tidy up outdated option files
  $\longrightarrow$ before separate files for special running
  (B field off, open velo, simple material model ...)

from Brunel-Default.py:

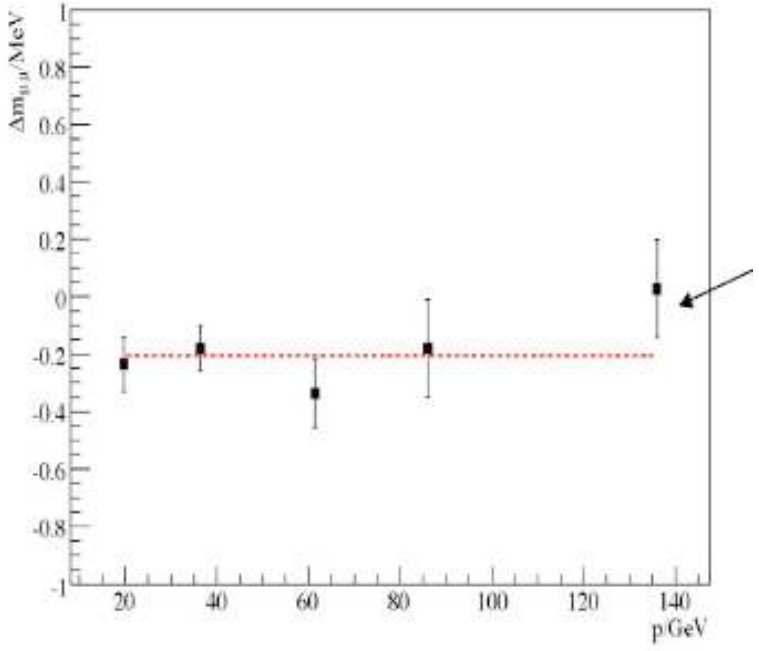
```
# Brunel().fieldOff     = False # set to True for magnetic field off data
# Brunel().veloOpen     = False # set to True for Velo open data
# Brunel().expertTracking += [""] # Add some expert tracking switches
#                                 "usePatSeeding", "simplifiedGeometry", "noDrifttime
```

- Inherited from TrackingSys configurables

dE/dx in Simulation & Reconstruction

About 1.4 MeV (momentum dependent) bias J/ψ mass peak (extensive studies from Matt N., lhcb-2008-037)

-0.2 $\pm$ 0.2 MeV bias remains, if dE/dx switched off in sim & reco.



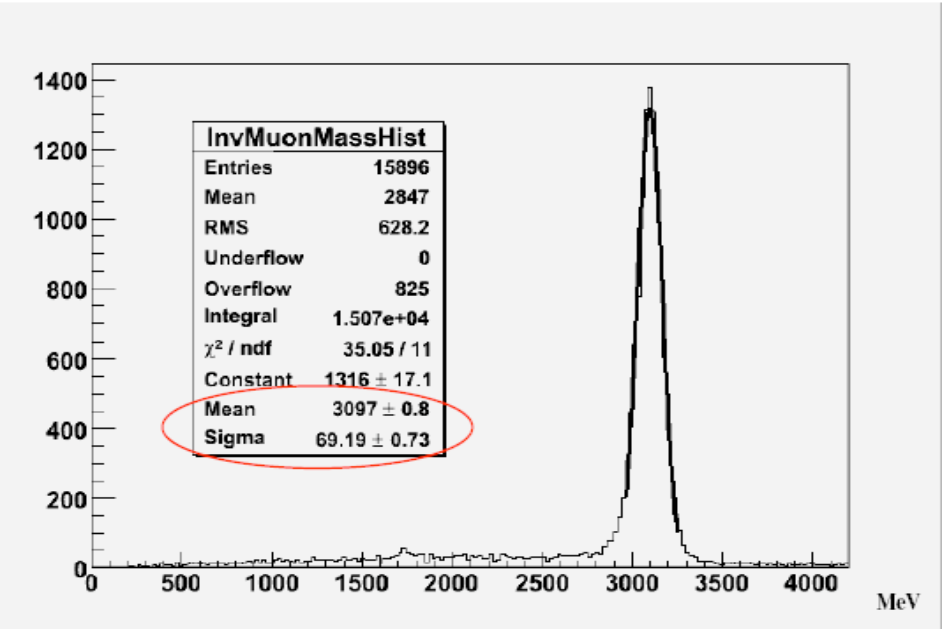
effect	bias (MeV)	spread (MeV)
fitting function	-0.4	$\pm$ 0.4
dE/dx	-0.7/-0.9	$\pm$ 0.4
field propagation	-0.2	$\pm$ 0.2

Potential sources for bias in dE/dx correction:
tuning of GEANT, $\pm$ 10% uncertainties in material constants for mixtures, ...

Measuring Tracking Efficiencies

Exploit J/ψ resonance to determine tracking efficiency in data.

Reconstruct muons out of velo tracks & signals in muon chambers.
Check if an associated track is found in the T stations.



T station eff. for muons based on MC truth: 98.4 $\pm$ 0.1%
T station eff. for muons measured with this method: 98.8 $\pm$ 0.1%

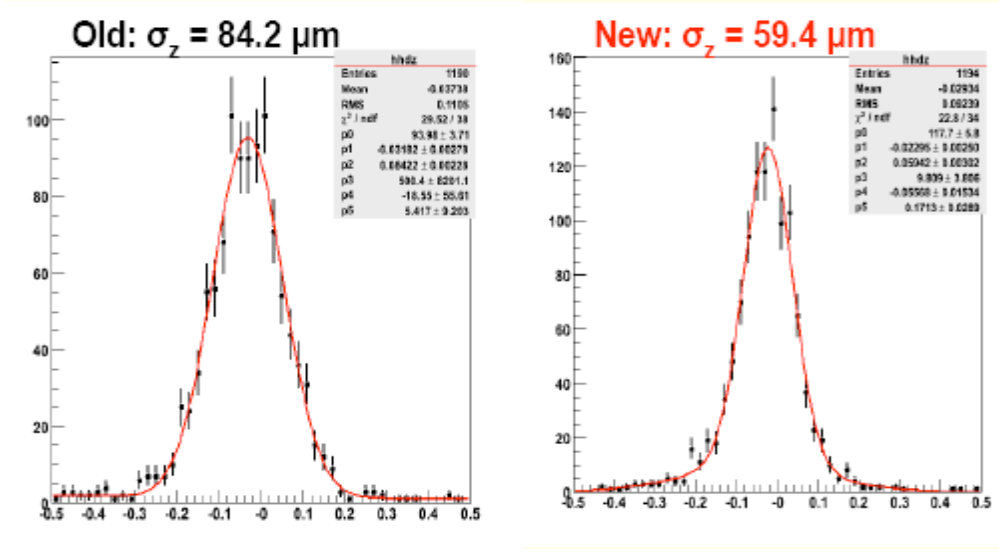
Plan to extend method to validate e.g. velo efficiency.

for details: Jan S.'s talk @ June Tracking Workshop

Primary Vertex Reconstruction

Major update of online & offline PV reconstruction algorithms (Mariusz W.)

- Remove assumption of x_v, $y_v \approx 0$ in fit
- Use modified offline PV 3D method online as well (before there were two separate algorithms)
- Reorganize code and interfaces



Core of double Gaussian

	σ_x [μm]	σ_y [μm]	σ_z [μm]
Old	16.0	15.1	84.2
New	10.9	12.0	59.4

(improvement for HLT2 PV)

Documentation

General LHCb Tracking Wiki Page

- General LHCb Tracking Wiki Page
  - Tracking Strategy
  - Track Fitting
  - Tracking Tools
  - Release notes and Performance Documentation
  - Cosmics Tracking in the T stations
  - Useful Links
  - LHCb Notes and Documentation on Tracking

- More detailed description of tracking algorithms: focused on what is input, output, options to choose
- How to use tracking tools outside standard sequence: refitting, momentum estimate, ghost ID ....
- Release notes: documents all bugs, fixes, changes and performance both on pattern reco and fitting

Changes, known Problems & fixes in Brunel v32r8

- bug in Tr/TrackTools: StateSimpleBetheBlochEnergyCorrectionTool.cpp, fix is in the head version

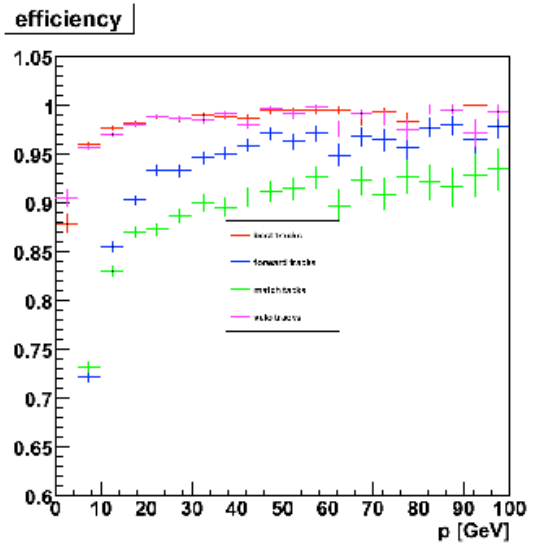
Performance in Brunel v32r8

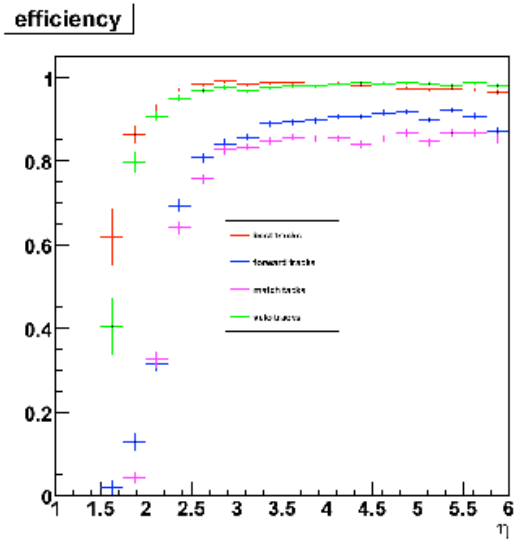
measured on 1000 DC06 J/PsiKs events

algorithm	eff. for long	eff. for long p>5GeV	ghost rate (track based)
VeloRZ	98.1%	98.9%	10.1%
Velo	97.3%	98.4%	6.5%
VeloTT	2.4%	0.9%	24.3%
Forward	86.1%	93.2%	14.8%
Match	81.6%	88.9%	11.1%
Downstream	69.2%	74.5%	32.5%
Best	97.5%	98.6%	20.5%

more information can be found in this log and this root file

- **efficiency to reconstruct long tracks (as any track) as function of momentum and eta:**





Summary & To-Do List

- First tracks reconstructed in cosmic/sector test data with standard pattern reco algorithms!
- Efforts ongoing to understand/minimize difference of offline & HLT - need help from HLT people
- Development of algorithms stopped, however many technical work ongoing

- Next hot topic: Monitoring of Pattern Recognition & Alignment
- Tracking/alignment day, during software week (19.09.08)
  "What did we learn sofar from data, what are the next steps?"