technische universität
dortmund

Computing Workshop - Tracking Status Report

Christoph Hasse on behalf of the Tracking & Alignment group

May 18, 2017

CERN / TU Dortmund

Federal Ministry
of Education
and Research

Emmy
Noether-
Programm
DFG Deutsche Forschungsgemeinschaft

T&A Overview

Conveners: **Agnieszka Dziurda, Lucia Grillo, Francesco Polci**

Thank you to everyone contributing to the T&A upgrade effort

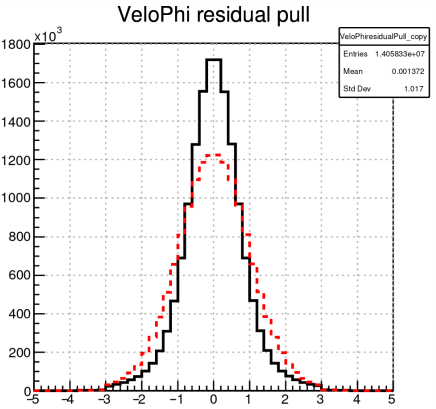
Pierre Billoir, Daniel Campora, Michel De Cian, Ben Couturier, Laurent Dufour, Agnieszka Dziurda, Sevda Esen, Christoph Hasse, Tomasz Szumlak, Sebastien Ponce, Renato Quagliani, Simon Stemmle, Joanna Wanczyk, Hang Yin, Menglin Xu, computing group, and some whom I forgot to mention.

Silvia Borghi, Chris Parkes, Mark Smith [1, 2]
Michel De Cian [1]

2017 Changes

- New VELO error parametrization
  - Uncertainty estimate is needed for the Kalman filter
  - Previously R & Φ clusters treated the same, cluster size ignored
  - First parametrization tuned on data → more realistic errors
  - No significant changes in tracking results

- Consistent fit for VELO-TT tracks
  - Effect only occurred offline when using VELO-TT tracks
  - New algorithm PatVeloTTHybridFit introduced as solution



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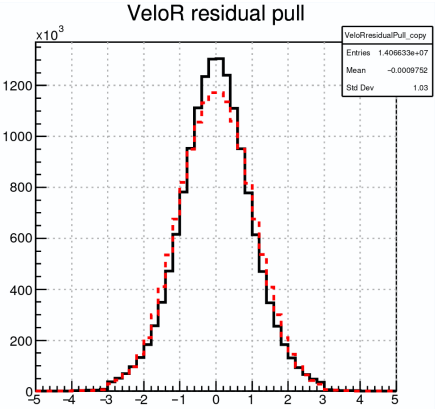


Michel De Cian [1]
Adam Dendek [1]

2017 Changes

Downstream tracking was reworked and now makes use of two ML classifiers

T-Seed Classifier

- Implemented as a BBDT classifier
- Aims to reject seeds that are likely ghosts
- Avoids unnecessary reconstruction

Final Track Classifier

- Implemented as a TMVA MLP
- Assign each track a score as sorting criterion
- Keep best track (default) or best tracks within range
- Reduce ghosts with loose cut on such score

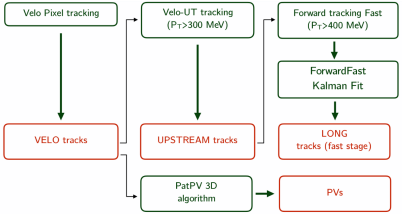
→ Study of minimum bias K_S events show improved efficiency & ghost reduction (loose selection)

	Signal	Background
Baseline	2156	8233
Cut 0.07	2235	8019

Upgrade Reminder

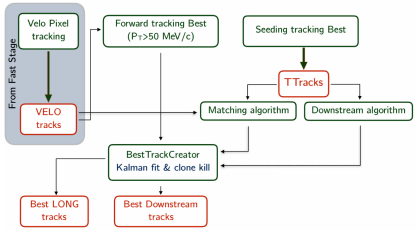
Fast Stage

- VELO tracking has its own internal Kalman fit
- Relatively tight cuts on p_T, value yet to be optimized
- Fitted Forward tracks $\rightarrow$ online alignment and calibration
- Completely ported to the new functional framework
- Includes removing old inheritances, code simplification (e.g UT hit handling), and more



Best Stage

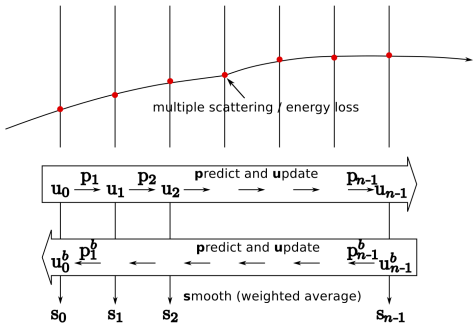
- Use VELO tracks as input
- Almost done porting to the new functional framework



Daniel Campora [1, 2]
Simon Stemmle [1]
Pierre Billoir [1]

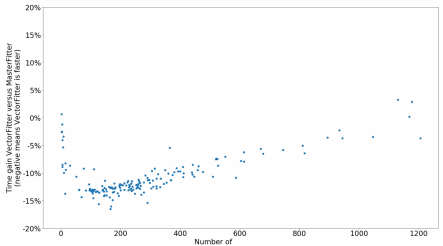
Kalman Filter

- Kalman Filter used to perform fit of tracks in LHCb
- The main time consumer in the reconstruction sequence
- Currently three different projects aimed at speedup of Kalman Filter
  - Paralellized Kalman
  - Parametrized Kalman
  - Simplified Kalman



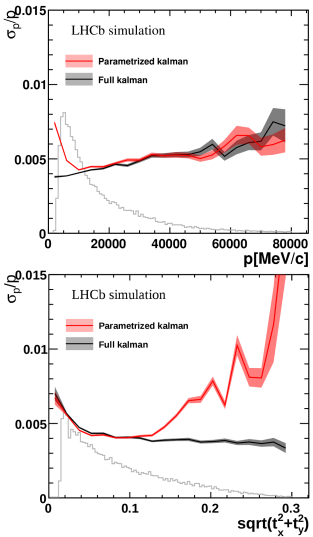
Paralellized Kalman

- Kalman Filter rather sequential → process tracks in parallel to gain performance
- Goal is to perform calculations using SIMD instructions while avoiding empty vector units
  - Employ a static scheduler (fixed data ordering)
  - Use AOSOA (Array Of Structures of Arrays) as underlying data structure
- Integrated into LHCb reconstruction software as TrackVectorFitter
- Latest benchmarks show a performance gain of up to $\mathcal{O}(10\,\%)$



Parametrized Kalman

- Goal is to avoid costly track extrapolation & material lookup
- Instead use simpler parametrizations which can be tuned on MC truth
- Similar momentum resolution of mid to high momentum tracks
- Low momentum tracks are poorly described
  - Fit low momentum tracks with full Kalman
  - Use alternative parametrization by Pierre Billoir for VELO → SciFi step



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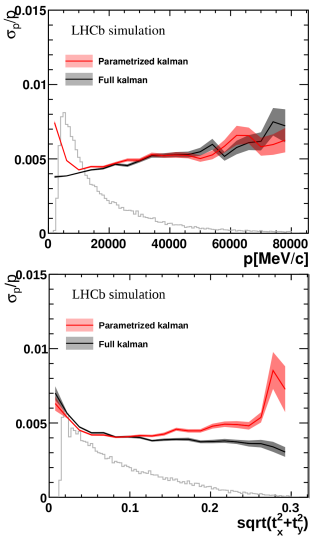
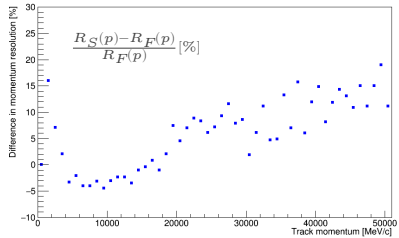
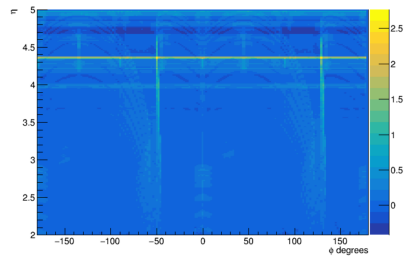


Ben Couturier
Tomasz Szumlak [1, 2]
Emilia Zacharjasz

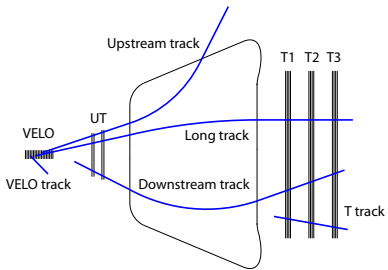
Simplified Geometry

- Reduce $\mathcal{O}(10^6)$ volumes $\rightarrow \sim 20$ volumes with effective material
- Create simplified geometry description for the upgrade detector
- Low momentum tracks problematic
- After first iterations, current model seems to be close to final answer
- Speedup of using the simplified geometry is $\sim 10 - 13$
- **But** there are some hotspots that need investigation





Upgrade Matching



- Find long tracks by matching VELO tracks with SciFi seeds
- Recent update introduced various improvements and some fixes
- Neural Net has been retrained with changed set of variables
- Work is ongoing but overall performance is good
  - Speedup of the matching is $\mathcal{O}(20\,\%)$
  - Reduction of ghost rate from $26\,\% \rightarrow 20\,\%$
  - Slight reduction in efficiency $\mathcal{O}(0.5\,\%)$, mostly low PT tracks
- Further potential for optimizations e.g adding UT hits currently takes 1/3 of the time

Further Studies/Plans

Studies

- Finalize previously mentioned projects
- Ongoing studies on improving CPU/physics performance of ghost probability MVA classifier
- Mick Mulder is joining the T&A effort and will be working on WG production for Tracking efficiencies
  - Volunteered thanks to Barbara's 45 ways to leave your signature in LHCb initiative

Plans

- Introduce automated performance checks to observe changes in variables like IP and PV resolution
- In the longer term extend checks to track by track comparisons
- There will be a new PhD student (Milosz Zdybal) focusing on optimizing primary vertex reconstruction

Everybody is welcome to join the T&A Upgrade effort.
See you at the next hackathon on June 19th!

Thank you for your attention!

Backup

Upgrade Matching

List of changes:

- Different input variables of the Neural Net
- Absolute values of variables $\rightarrow$ no magnet polarity dependence
- Fix mistake in χ^2 parametrization
- electrons are exluded from signal during training
- Harder cut on χ^2 benefits timing
- Introduced a track sorting in y-coordinate and selection based on defined window in y.