~~Summ~~ary of the meeting on vertexing

Physics Performance meeting, Feb 15, 2021

Emmanuel, Clément, Patrizia, Gerri

Topical meeting on vertexing, Feb 10, 2021

- organised jointly by Physics Performance & Physics Software and Computing
- https://indico.cern.ch/event/1003610/

Full summary: see Clement's talk next week, FCC-ee General meeting
Here instead: short report, our personal take-away from the meeting.

Goals of the meeting

- Vertexing often came up in our Physics Performance meetings, as a crucial tool for many analyses

- Last time we discussed about vertexing “in practice” was in October : https://indico.cern.ch/event/965346/
    - First attempt to run the ILC algorithm over FCC event files
    - Cumbersome, had to convert to LCIO (ILC format) first, …

- Quite some progress since then, so now is a good time to go through
    - Activities that developed recently
    - New developments that could start now/soon
    - The integration of (some) existing vertexing software

In the process of defining requirements on the vertex detector: we should make use of the best possible vertexing tools in the sensitivity analyses.

The meeting goal was to help us review the current status and define projects to move forward in this direction.

Attendance & minutes of the discussions

Special FCC P&P Software Meeting, 10 Feb 2021

44 participants
thanks to all !

Present: None; Vidyo only meeting following CERN coronavirus restrictions

Remote: E Perez, P Azzi, G Ganis, C Helsens, V Volkl, A Salzburger, F Bedeschi, A Akhundov, Ang Li, Aridam Das, F Brieuc, D Contardo, Hwidong Yoo, I Korzhavina, J Alcaraz, L Gouskos, L Poggioli, M Boscolo, M Chrzaszcz, P Gesinger-Befurt, P Fernandez, R Sengupta, R Aleksan, S Heinmeyer, W Hulsbergen, Ziad El Bitar, M Selvaggi, F Grancagnolo, D Hill, B Schlag, A Blondel, G Wilkinson, M Dam, S Monteil, BFL Ward, E Gorini, J Smiesko, G Tassielli, P Azzurri, V Diolaiti, Sanghyun Ko, J Andrea, K Gautam, A Sailer

Agenda: https://indico.cern.ch/event/1003610/

The following are some notes taken during the discussions which followed each talk. Please refer to the slides for the content of the talks themselves.

Minutes of the discussions were taken and are linked to the Indico agenda.

Agenda

14:00 → 14:05 **Introduction**
Speakers: Clement Helsens (CERN) , Emmanuel Francois Perez (CERN) , Gerardo Ganis (CERN) , Patrizia Azzi (INFN Padova (IT))

14:05 → 14:15 **Physics motivations**
Speaker: Roy Aleksan (Université Paris-Saclay (FR))

14:15 → 14:35 **A stand-alone vertex-fitting algorithm**
Speaker: Franco Bedeschi (Universita & INFN Pisa (IT))

14:35 → 14:55 **First example resolutions of displaced vertices in exclusive processes (using FB's algo)**
Speakers: Clement Helsens (CERN) , Emmanuel Francois Perez (CERN)

14:55 → 15:25 **The DecayTreeFitter algorithm**
Speaker: Wouter Hulsbergen (Nikhef National institute for subatomic physics (NL))

15:25 → 15:45 **Implementation of the LCFI+ algorithm into key4hep**
Speakers: Andre Sailer (CERN) , Placido Fernandez Declara (CERN)

15:45 → 16:05 **Status of ACTS (tracking and) vertexing, and implementation in key4hep (t.b.c.)**
Speakers: Andreas Salzburger (CERN) , Bastian Schlag (CERN / JGU Mainz) , Paul Gessinger-Befurt (CERN / JGU Mainz)

Several vertexing algorithms…

	Analysis level	Reco level	Speed	Neutrals	Implementation (*)
Franco's fitter	✓	(✓)	✓	✗	✓
LCFI+	✗	✓	✗	✗	In progress
DecayTreeFitter	✓	✗	✗✗	✓	Contact established
ACTS	✓	✓	✓	✗	Proof of concept
LHCb PV algo.	✓	✓		✗	Started

(*) in the FCC environment

Next steps: using Franco's vertex-fitter

Stand-alone code from Franco Bedeschi. Only dependencies = ROOT. Implemented in FCCAnalyses. Already used for first estimations of the expected resolutions on displaced vertices in chosen examples.

- Consolidate and pursue these studies
- Estimation of the effect of variations of the detector model: change the radii of the layers of the vertex detector, the thickness of the layers or the BP, the single-hit resolution: can be done with the tools that are in place !
  - Volunteers have already contacted us, instructions & set-up will be ready in the next 1-2 days
- Try the same setup to study reconstruction of far-detached vertices
  - LLP experts contacted us, discussion this Wednesday
- Write a vertex-finding algorithm that runs the fitter iteratively, to determine first the primary vertex, and then displaced vertices, in order to tag "b-jets" inclusively.
  - Could be started now too.

Next steps: using LCFI+

LCFI+ (the algorithm used by LC) : can be run over EDM4HEP files via a “wrapper” of the source code, and a transient, on-the-fly, conversion of the EDM4HEP event into the LCIO format. Good progress recently on this conversion !

- Finalize the SW implementation: need to convert back the vertices found by LCFI+ , from LCIO to EDM4HEP
  - Could be quick. Maybe we can have the LCFI+ vertices in the Monte-Carlo samples that we’ll produce within the coming month

- Event-by-event comparisons of LCFI+ vertices with vertices from FB’s algo

- Could use the LFCI+ displaced vertices in b- or c-tagging algorithms

- Bonus: LCFI+ does not only find vertices, that’s actually a b- / c- tagging algo.
  - Train the BDT for FCC-ee
  - Compare performances with the ParticleNet algorithm from Loukas & Michele

Next steps: using Decay Tree Fitter

Global fit of a whole decay chain(Babar, LHCb, Belle-2). Implementation has not started yet.

- Implementation : may actually not be too difficult / long.
  - Start from LHCb implementation
  - Wouters: “a few months should be more than sufficient to (re)implement it”

- Once done: opens the door to many dedicated studies in the area of flavour physics – by how much DTF improves the sensitivity, e.g. in B to K* τ τ for which a very precise determination of the vertices is crucial.

Next steps: using the ACTS vertexing suite

Vertexing in ACTS factorizes from the ACTS tracking. An implementation similar to what was done with Franco's code should be easily possible.

- SW implementation : to be done.

- Once done: vertex resolutions studies can be compared with the results obtained from Franco's code; comparisons can be made between the different algos that are in ACTS; performances in view of b-tagging can be studied (multi-vertex finding)

Follow-ups

- Expect follow-ups in future SW and Physics Performance meetings

- Meanwhile, we're also setting up an informal e-group that we will use to
  - Communicate additional information & follow-ups on the points discussed during the meeting of last week
  - Possibly call working meetings or discussions
  - Probably: vertexing-FCCee-informal
  - Will be announced to the two mailing lists used to announce the topical meeting