Incorporation of LCFIPlus Vertexing Module in FCCAnalyses

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Motivation

- Vertexing is an integral part of event reconstruction.
- Secondary vertex reconstruction is very important for numerous studies like jet-flavour tagging and testing vertex detector performance.
- Identifying V^0 vertices can also help improve the performance of existing jet-flavour tagging algorithm (see poster by E. Plörer).

Vertex Fitter

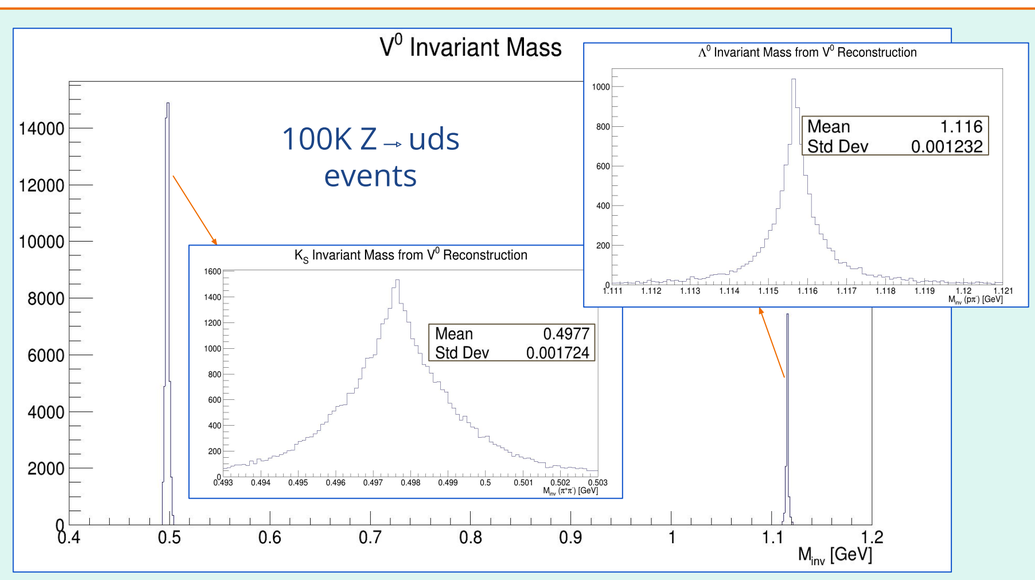
- The track parameters are updated to make all tracks pass through a common vertex while **minimising the χ2**
- Deviations in track parameters are controlled by the **covariance matrix**
- **Track projections** are used as constraints for the χ2 fit
- The track helix in cartesian coordinates is used in **parametric form**
- **Beam Spot constraint** can be optionally chosen by user.

- Three processes have been considered:
  - $K_S \to \pi^+\pi^-$; $\Lambda^0 \to p\pi^-$; $\gamma_{conv} \to e^+e^-$
- V^0s identified by constraining the following properties

Two sets of constraints are available to be chosen by the user

	K_S		Λ^0		γ_{conv}	
	tight	**loose**	**tight**	**loose**	**tight**	**loose**
Mass [GeV]	[0.493, 0.503]	[0.488, 0.508]	[1.111, 1.121]	[1.106, 1.126]	< 0.005	< 0.01
r [mm]	> 0.5	> 0.3	> 0.5	> 0.3	> 9	> 9
p.r	> 0.999	> 0.999	> 0.99995	> 0.999	> 0.99995	> 0.999

The two-track vertices reconstructed with this method can also be stored separately



K_S & Λ^0 can be reconstructed

V^0 Finding

V^0 Rejection

Primary Vertex Finding

LCFIPlus[1]

Vertex Finding → Jet Clustering → Vertex Refining → Flavour Tagging

Secondary Vertex Finding

Finding the Vertex Seed

- Every possible track pair is fitted to a vertex.
- Out of all the two-track vertices that pass a **selection criteria**, the one with the **lowest χ^2** is chosen as the **vertex seed**.

Adding Tracks to the Vertex Seed

- The track that forms a vertex with the **lowest χ^2 with this seed vertex** and passes the **selection criteria** is added to the seed vertex.
- Keep adding tracks to this vertex until no more tracks pass the selection.
- Store the vertex and **remove the tracks forming this vertex** from the set of tracks.

Constrained properties:

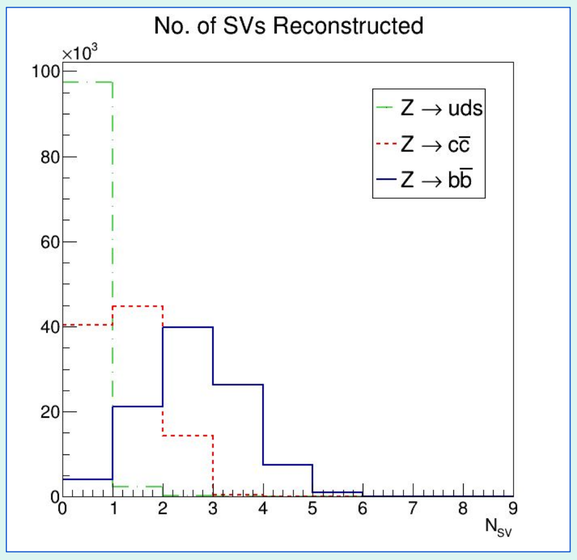
Invariant Mass

χ2

Direction

V0 Rejection

Continue until no more vertex seeds can be formed.



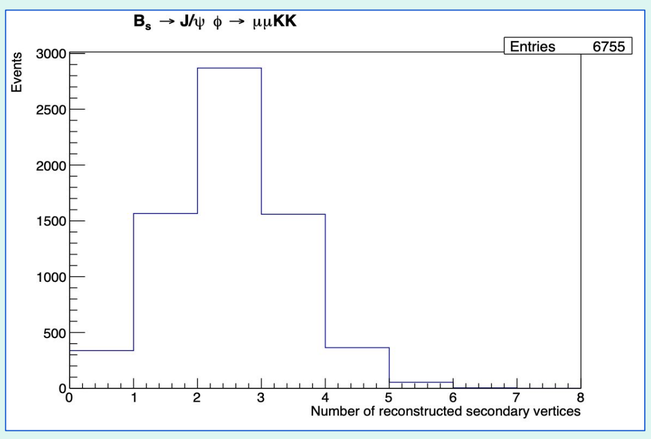
Finding SVs in Zqq Events

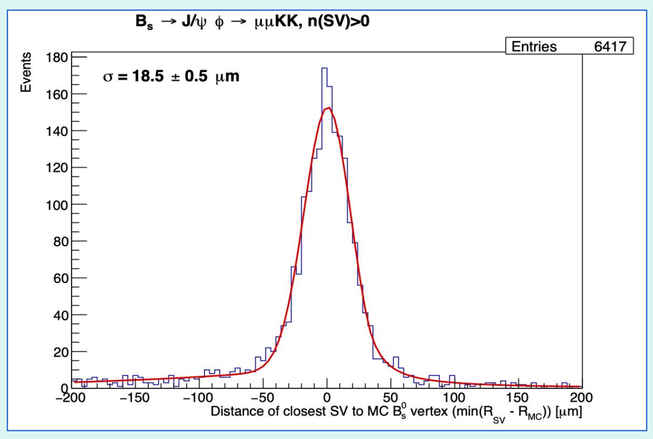
As expected, more SVs were reconstructed in events with b-quark jets than in c-quark jets, and no SVs are reconstructed in most of the events with light jets.

Performance Estimate

Considering $B_S \to J/\Psi+\varphi \to \mu\mu$ KK

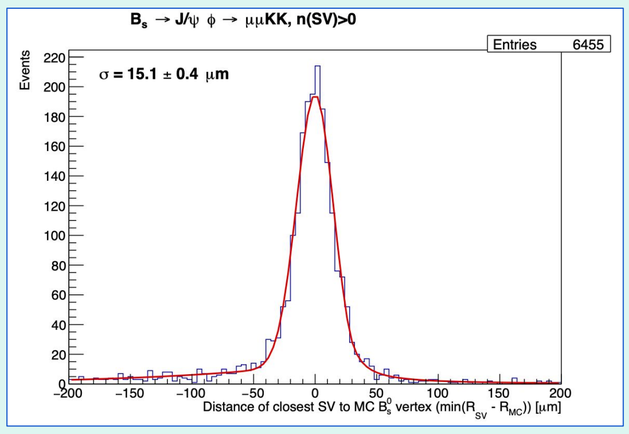
- 10K events. Monte-Carlo BS vertex can be found in 6.75K events.
- Check min of distance between any SV and MC Bs vertex, fit with two crystal ball functions





The **vertex resolution** is **similar** to what could be achieved with **truth-level** vertex fitting.

SV finder resolution with **R=1.0cm** beampipe.
For details on different vertex detector designs see poster by A. Ilg



The vertex resolution **improves** with a **smaller beampipe**

This is the **first** successful implementation of an **SV finder** in **FCCAnalyses** based on the **LCFIPlus framework**. For more details, please refer to the talk presented at the **FCC Physics Performance Meeting** on **16 May 2022**.

[1] arXiv:1506.08371