Updates in vertex resolution and optimization of tagged B meson vertex fit

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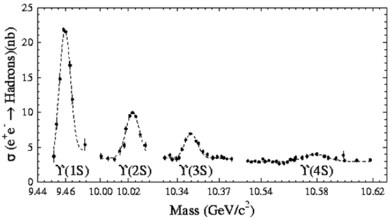
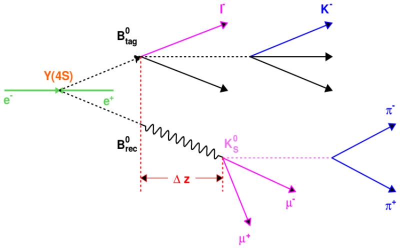




$\Upsilon(4S)$ resonance

- $b\bar{b}$ quarkonium **resonance**
- Resonance at C.M energy of **10.58 GeV**
- **Pairs** $B^0\bar{B}^0$ and B^+B^- produced practically at rest
- Slight **boost** $\beta\gamma \approx 0.28$

Reco side and Tag side

- Kin. **reconstruction** of $B^0(\bar{B}^0) \to J/\psi K_S$ **(Reco side)**
- **Flavor tagging** from $\bar{B}^0(B^0) \to$ generic **(Tag side)**

$J/\psi \to \mu^+\mu^-$ vertex resolution

About the decay:

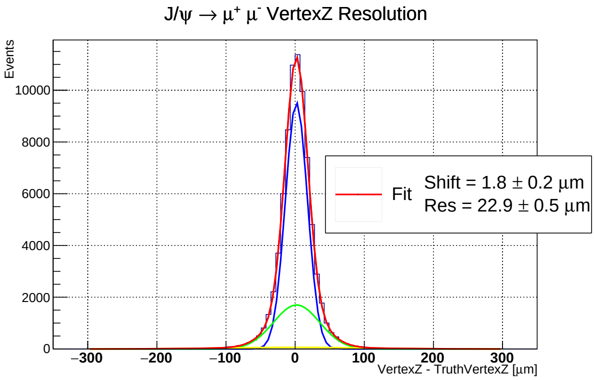
- J/ψ decays **immediately** after the B meson
- Two muons give a very **clear** signal

$$B_{rec} \to [J/\psi \to \mu^+\mu^-]K_S$$

Why should we do J/ψ vertex analysis?

- Check the new **tracking update**
- The resolution of this vertex is one of the **best resolutions** we can get, so it gives us some hints about what is the **maximum resolution** we can aim for during the analysis of the $\mathbf{B_{tag}}$ **Vertex**.

$J/\psi \to \mu^+\mu^-$ VertexZ resolution: 3 Gaussian Fit



Muon tracks required to have > 1 PXD hits

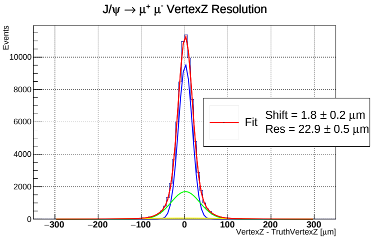
BELLE:

- Shift = 0.2 μm
- Resolution = 63 μm
- Improvement 63%

Analysis: resolution and shift

Observations (R16924)

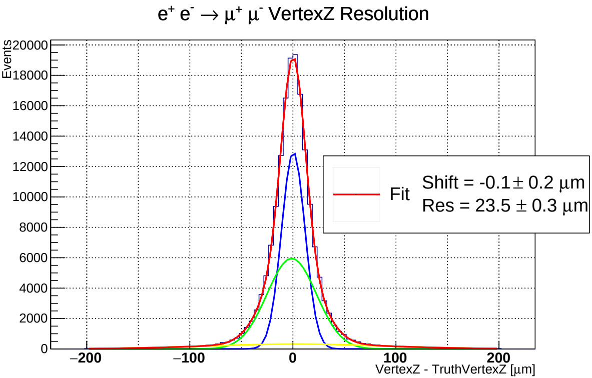
- VerteX,VertexY: no shift
- Improved resolution of 22.9 μm
- Shift on the $J/\psi \to \mu^+\mu^-$ vertex (z axis) of 1.8 μm



Possible implications for the Beam Spot knowledge

- $\mu^+\mu^-$: **cleanest** vertex reconstruction- but still has a **shift**
- **Beam spot** assumed to be at (0,0,0)- but $e^+e^- \to \mu^+\mu^-$ **vertex reconstruction** could give a shift as well
- **Beam spot** could have an unexpected **shift** ($\leq$ 1.8 μm)

Beam spot position analysis - $e^+e^- \to \mu^+\mu^-$ vertex



Beam Spot:

Muon tracks required to have > 1 PXD hits

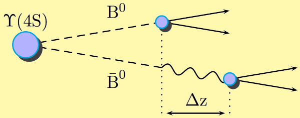
No Shift observed!

Tag Side vertex analysis

Why is so important to have a good B_{tag} Vertex resolution?

- Being sensitive to time-dependent **CP violating effects** depends on the good measurement of **Δt**
- Δ**t** is **proportional** to the distance between the **decay vertices** of B_{rec} and B_{tag}, i.e **Δz**

$$\Delta t \simeq \frac{\Delta z}{\beta\gamma c}$$

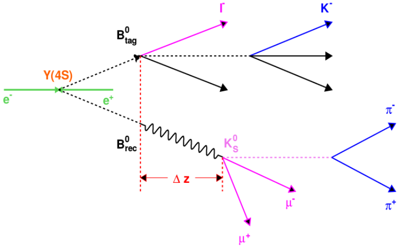


- The most important contribution to the Δt resolution comes from the **B_{tag} vertex resolution**

Fitting algorithm

How is the fit performed?

1. B_{rec} **reconstruction** uses specifically two **muon tracks**
2. NO B_{tag} reconstruction is peformed (**lost of statistics**), DON'T LOOK FOR SPECIFIC DECAY MODE
3. TagV fit uses all the **remaining tracks** (except for the ones coming from K_S decay)
4. ALGORITHM: **RAVE** Adaptive Vertex Fit (AVF) with spatial constraints

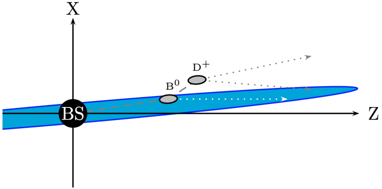


Fitting algorithm and spatial constraint

What is the constraint?

We define a **spatial constraint** where the B is expected to decay

- **Ellipsoid** of 600 µm diameter
- Centered in the **Beam Spot**
- Along the **boost direction**



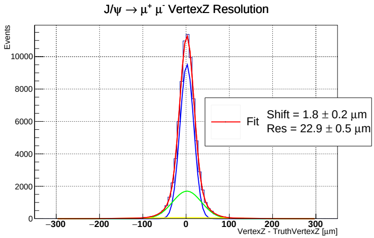
RAVE Adaptive Vertex Fit (AVF) with constraints

No track is ever **rejected**. All of them are **weighted** following two criteria:

1. **Outlying** and isolated **tracks** are **down-weighted**
2. Tracks weighted according their **position** respect to the **constraint**

Weighting works **iteratively**

Effect of possible shift in the Beam Spot



Spatial **shift** of the **beam spot**

↓

Constraint for TagV fit **centered** in **beam spot**

↓

Shift on beam spot → effect on **TagV resolution**?

What did we find in Reco side?

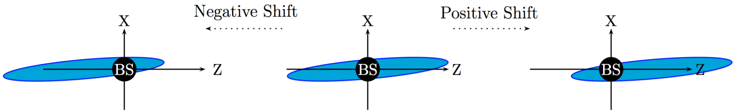
- Unexpected **shift** on the $J/\psi \to \mu^+\mu^-$ vertex
- No shift on **Beam Spot** from $e^+e^- \to \mu^+\mu^-$ vertex

Analysis of a shift in the constraints - generic decay

How did we implement the shift?

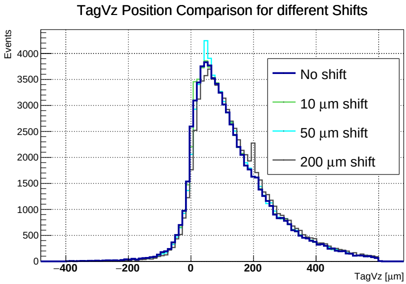
We want to check the effect of a shift on the constraint center

- **Shift** introduced only in the Z axis of the **Beam Spot**
- **Constraints** will now be **centered** at (0,0,shift)
- Several shifts from $-100\,\mu m$ to $100\,\mu m$
- Check **TagV resolution** and **position** for each shift

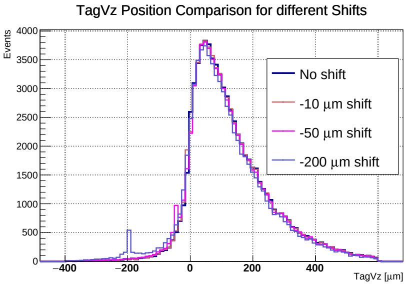


Shifted B_{tag} Vertex position plots

POSITIVE SHIFT



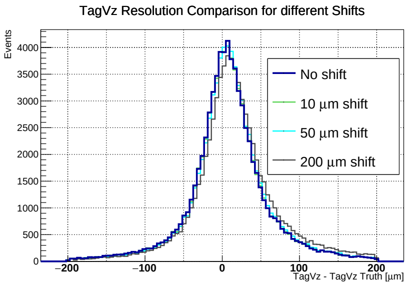
NEGATIVE SHIFT



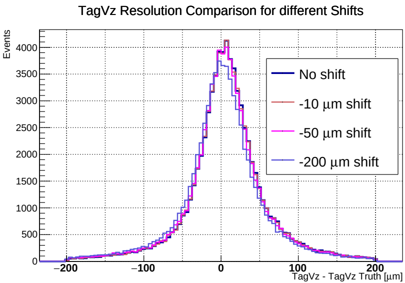
NEGLIGIBLE EFFECT FOR SHIFT $< 50\,\mu m$

Shifted B_{tag} Vertex resolution plots

POSITIVE SHIFT



NEGATIVE SHIFT

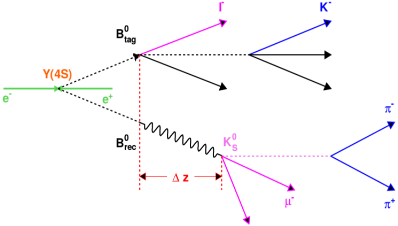


NEGLIGIBLE EFFECT FOR SHIFT $< 50\,\mu m$

Using the standard track selection algorithm

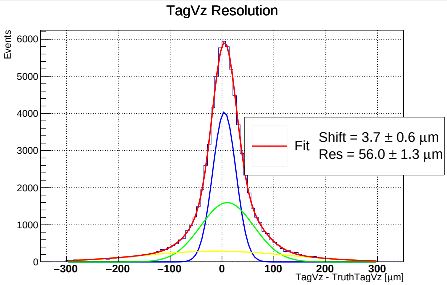
As explained before...

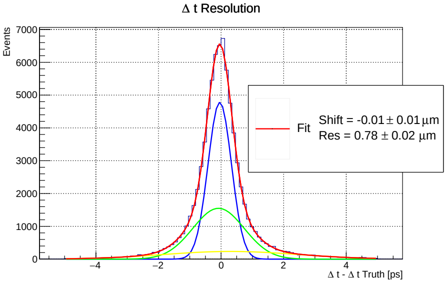
- Take all the **unused tracks** after the $B^0(\bar{B}^0) \to J/\psi K_S$ **reconstruction**
- As said before: perform the fit using **RAVE (AVF)**
- Only tracks coming from K_S are **avoided**. Take all the rest and weight them



NOTE: Take tracks even though they may not directly come from a B meson

TagV Resolution - Standard algorithm





BELLE:

- Shift = 29 μm
- Resolution = 89 μm-37% improve

BELLE:

- Shift = 0.2 ps
- Resolution = 0.92 ps-15% improve

WHAT IF WE CHOOSE ONLY **PRIMARY** TRACKS?

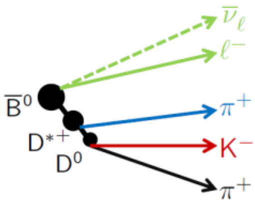
Improving the track selection procedure

What is the track's selection?

- **FlavorTagger** module (previous talk) chooses the more suitable **tracks** for **Flavor Tagging**
- Store those **tracks** and **variables** (targProb, catProb...)
- Use those variables to discriminate **good** from **bad** tracks

Good tracks...

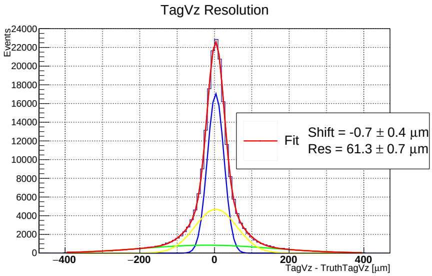
- **Tracks** coming from $\mathbf{B_{tag}}$ **directly** (primary lepton)
- **Tracks** coming from **immediately decaying** sons like D^{*+} (slow pion)
- Perform a fit (**RAVE**) using **good** tracks! (ideal case)



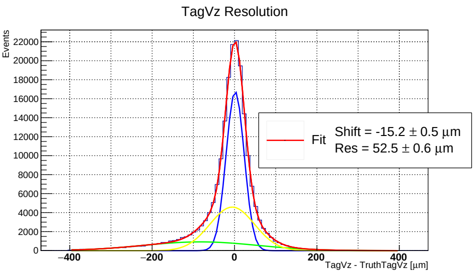
Preliminary analysis - semileptonic decay

$$B_{tag} \to \mu^- \bar{\nu}_\mu D^{(*)+}$$ and conjugate

USING ALL TRACKS



USING MC MATCHED MUONS

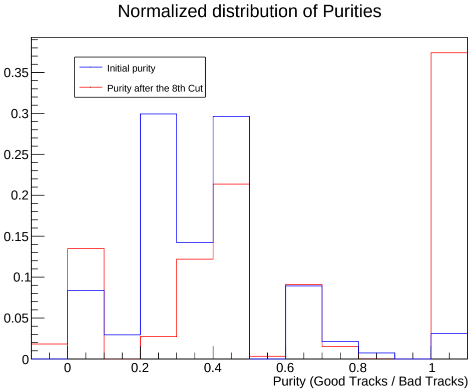


Actual analysis - Generic decay (work still on progress)

$B_{tag} \to$ generic

Purity analysis

- Perform several **cuts** on the variables of the **tracks**
- Compare with **Monte Carlo** information
- Aim: Kill the **bad** ones and keep the **good** ones!
- **High purity acquainted** after selection



Unfortunately...

Work is still in progress:

- **Selection cuts** already implemented
- **Vertex fitting** not implemented
- **Outlook**: Resolution and Δt plots

Summary

Shift in the Reco side and its implications

- $J/\psi \to \mu^+\mu^-$ vertex with **better resolution** (22.9 μm) than Belle analysis.
- $J/\psi \to \mu^+\mu^-$ vertex **shifted** $\sim 1.8\mu m$ from MC.
- Possible **shift** on **Beam Spot**: **negligible effect** on **B_{tag} Vertex res/pos**

Tag side resolution and optimization

- B_{tag} Vertex with **better resolution** (56.0 μm) than Belle analysis.
- **New algorithm** for selecting good tracks for Tag side vertexing
- Former studies: **Better resolution** ($\sim$ 15%) found for **TagV** with new algorithm
- So far: encouraging **track's purit**y distribution

Outlook

- Understand the **shift** on the **reco side** vertex (new tracking update?)
- Improve as much as possible the efficiency of the **cuts** applied on the tag side
- Check the **goodness** of the **track's selection** on TagV resolution

THANKS FOR YOUR ATTENTION!