

An improved full reconstruction tool utilizing NeuroBayes

Physics In Collision 2010, Poster Session

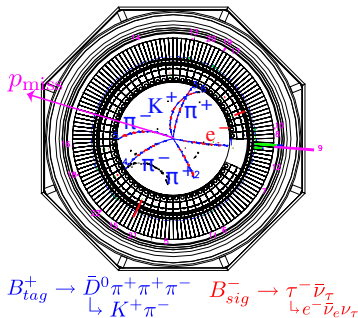
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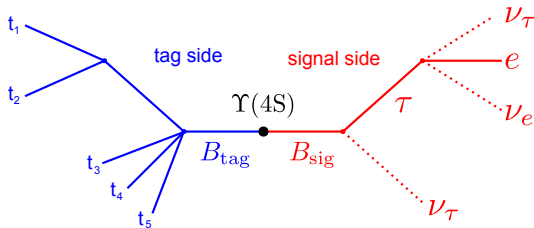
The Principle of the Full Reconstruction

- **B factories:** Center of mass energy of $\sqrt{s} = 10.58 \text{ GeV}$ at the $\Upsilon(4S)$ resonance
- $\mathcal{B}(\Upsilon(4S) \rightarrow B\bar{B}) > 96\%$
 - $\Rightarrow p_{CMS}(B) + p_{CMS}(\bar{B}) + p_{CMS}(\text{Beam}) = 0$
 - $\Rightarrow$ Clean event topologies (typically ~ 10 tracks)



$B_{tag}^+ \rightarrow \bar{D}^0 \pi^+ \pi^+ \pi^-$ $B_{sig}^- \rightarrow \tau^- \bar{\nu}_\tau$
 $\quad \quad \quad \hookrightarrow K^+ \pi^-$ $\quad \quad \quad \hookrightarrow e^- \bar{\nu}_e \nu_\tau$

Typical B factory event



Tag side and signal side of the full reconstruction

Improvements of the existing Full Reconstruction at Belle

stage	particles
1	tracks, K_S , γ , π^0
2	$D_{(s)}^\pm$, D^0 and J/ψ
3	$D_{(s)}^{*\pm}$ and D^{*0}
4	$B^\pm$ and B^0

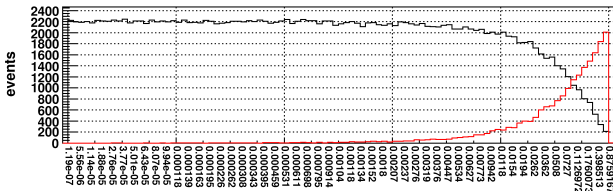
- **Addition of more B tag channels:** Will increase the signal **but** ...
 - Especially high-multiplicity decays will increase the background drastically
- **Maximum efficiency:** No intermediate cuts, usage of best B candidate, **but** ...
 - Cuts after each stage are necessary due to finite computing power and storage capacity.

NeuroBayes

- Multivariate analysis software utilizing a **Neural** Network
- The output of the Network can be interpreted as **Bayesian** probability
- Provides a well-discriminating variable for intermediate cuts

Increase of Efficiency

- Choose appropriate cuts (depending on initial purity of the channel)
- Cut on the variable with good discrimination power
- $X \rightarrow A B C$
- cut on $NB(A) \times NB(B) \times NB(C)$
 - where $NB(N)$ is the NeuroBayes output of particle N
 - with $NB(N) \in [0.0, 1.0]$
- Optimize these cuts depending on the decay channel



D modes (new)

$D^0 \rightarrow K^- \pi^+$	$D^+ \rightarrow K^- \pi^+ \pi^+$
$D^0 \rightarrow K^- \pi^+ \pi^+ \pi^-$	$D^+ \rightarrow K_S^0 \pi^+$
$D^0 \rightarrow K^- \pi^+ \pi^0$	$D^+ \rightarrow K_S^0 \pi^+ \pi^0$
$D^0 \rightarrow \pi^+ \pi^-$	$D^+ \rightarrow K^- \pi^+ \pi^+ \pi^0$
$D^0 \rightarrow \pi^+ \pi^- \pi^0$	$D^+ \rightarrow K_S^0 \pi^+ \pi^+ \pi^-$
$D^0 \rightarrow K_S^0 \pi^0$	$D^+ \rightarrow K^+ K^- \pi^+$
$D^0 \rightarrow K_S^0 \pi^+ \pi^-$	$D^+ \rightarrow K^+ K^- \pi^+ \pi^0$
$D^0 \rightarrow K_S^0 \pi^+ \pi^- \pi^0$	$D^{+*} \rightarrow D^0 \pi^+$
$D^0 \rightarrow K^+ K^-$	$D^{+*} \rightarrow D^+ \pi^0$
$D^0 \rightarrow K^+ K^- K_S^0$	$D^{0*} \rightarrow D^0 \gamma$
$D^{0*} \rightarrow D^0 \pi^0$	
$D_S^+ \rightarrow K^+ K_S^0$	$D_S^+ \rightarrow K^+ K^- \pi^+ \pi^+ \pi^-$
$D_S^+ \rightarrow K^+ \pi^+ \pi^-$	$D_S^+ \rightarrow \pi^+ \pi^+ \pi^-$
$D_S^+ \rightarrow K^+ K^- \pi^+$	$D_S^{+*} \rightarrow D_S^+ \gamma$
$D_S^+ \rightarrow K^+ K^- \pi^+ \pi^0$	$J/\psi \rightarrow e^- e^+$
$D_S^+ \rightarrow K^+ K_S^0 \pi^+ \pi^-$	$J/\psi \rightarrow \mu^- \mu^+$
$D_S^+ \rightarrow K^- K_S^0 \pi^+ \pi^+$	

B modes (new, limited D-modes in old full

reconstruction)

$$\begin{aligned}
 B^+ &\rightarrow \bar{D}^0 \pi^+ \\
 B^+ &\rightarrow \bar{D}^0 \pi^+ \pi^0 \\
 B^+ &\rightarrow \bar{D}^0 \pi^+ \pi^+ \pi^- \\
 B^+ &\rightarrow D_S^+ \bar{D}^0 \\
 B^+ &\rightarrow \bar{D}^{0*} \pi^+ \\
 B^+ &\rightarrow \bar{D}^{0*} \pi^+ \pi^0 \\
 B^+ &\rightarrow \bar{D}^{0*} \pi^+ \pi^+ \pi^- \\
 B^+ &\rightarrow \bar{D}^{0*} \pi^+ \pi^+ \pi^- \pi^0 \\
 B^+ &\rightarrow D_S^{+*} \bar{D}^0 \\
 B^+ &\rightarrow D_S^+ \bar{D}^{0*} \\
 B^+ &\rightarrow D_S^{+*} \bar{D}^{0*} \\
 B^+ &\rightarrow \bar{D}^0 K^+ \\
 B^+ &\rightarrow D^- \pi^+ \pi^+ \\
 B^+ &\rightarrow J/\psi K^+ \\
 B^+ &\rightarrow J/\psi K^+ \pi^+ \pi^- \\
 B^+ &\rightarrow J/\psi K^+ \pi^0 \\
 B^+ &\rightarrow J/\psi K_S^0 \pi^+
 \end{aligned}$$

$$\begin{aligned}
 B^0 &\rightarrow D^- \pi^+ \\
 B^0 &\rightarrow D^- \pi^+ \pi^0 \\
 B^0 &\rightarrow D^- \pi^+ \pi^+ \pi^- \\
 B^0 &\rightarrow \bar{D}^0 \pi^0 \\
 B^0 &\rightarrow D_S^+ D^- \\
 B^0 &\rightarrow D^{*-} \pi^+ \\
 B^0 &\rightarrow D^{*-} \pi^+ \pi^0 \\
 B^0 &\rightarrow D^{*-} \pi^+ \pi^+ \pi^- \\
 B^0 &\rightarrow D^{*-} \pi^+ \pi^+ \pi^- \pi^0 \\
 B^0 &\rightarrow D_S^{+*} D^- \\
 B^0 &\rightarrow D_S^+ D^{*-} \\
 B^0 &\rightarrow D_S^{+*} D^{*-} \\
 B^0 &\rightarrow J/\psi K_S^0 \\
 B^0 &\rightarrow J/\psi K^+ \pi^- \\
 B^0 &\rightarrow J/\psi K_S^0 \pi^+ \pi^-
 \end{aligned}$$

Summary

- The full reconstruction is a powerful analysis tool at B factories
- Improvements were done with
 - more sophisticated intermediate cuts and
 - more B tag channels.

Results

- **Significant improvements** could be achieved
 - resulting in largely increased signal samples for many Belle analyses
 - corresponding to several years of additional running time
 - after 10 years of data taking
- **Please visit the Full Reconstruction poster**