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UNIVERSITÉ Clermont Auvergne

New b-tagging using exclusive b-hadron decays at FCC-ee

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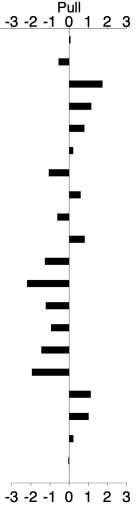
Motivation

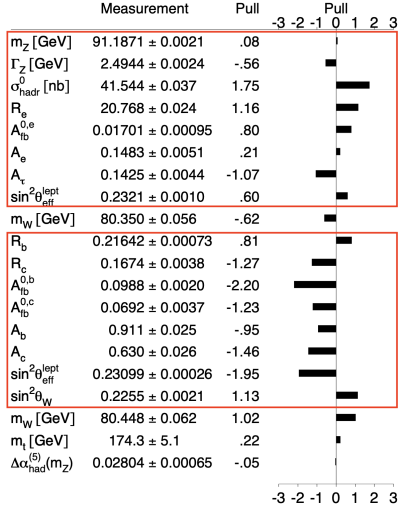
- Knowledge about Z-boson from LEP measurements: m_Z, Γ_Z, σ_{had}, ...

	Measurement	Pull
m_Z [GeV]	91.1871 ± 0.0021	.08
Γ_Z [GeV]	2.4944 ± 0.0024	-.56
σ^0_{hadr} [nb]	41.544 ± 0.037	1.75
R_e	20.768 ± 0.024	1.16
$A^{0,e}_{fb}$	0.01701 ± 0.00095	.80
A_e	0.1483 ± 0.0051	.21
A_τ	0.1425 ± 0.0044	-1.07
$\sin^2\theta^{\text{lept}}_{\text{eff}}$	0.2321 ± 0.0010	.60
m_W [GeV]	80.350 ± 0.056	-.62
R_b	0.21642 ± 0.00073	.81
R_c	0.1674 ± 0.0038	-1.27
$A^{0,b}_{fb}$	0.0988 ± 0.0020	-2.20
$A^{0,c}_{fb}$	0.0692 ± 0.0037	-1.23
A_b	0.911 ± 0.025	-.95
A_c	0.630 ± 0.026	-1.46
$\sin^2\theta^{\text{lept}}_{\text{eff}}$	0.23099 ± 0.00026	-1.95
$\sin^2\theta_W$	0.2255 ± 0.0021	1.13
m_W [GeV]	80.448 ± 0.062	1.02
m_t [GeV]	174.3 ± 5.1	.22
$\Delta\alpha^{(5)}_{\text{had}}(m_Z)$	0.02804 ± 0.00065	-.05



Motivation

- Knowledge about Z-boson from LEP measurements:
  m_Z, Γ_Z, σ_{had}, ...
- Most precise determination of (heavy-quark) electroweak observables
  $\hookrightarrow$ Raised tension with the SM predictions



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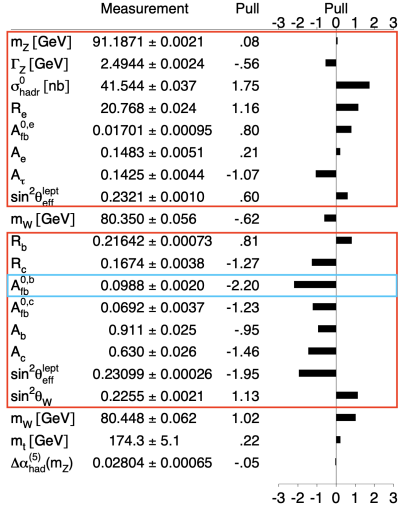

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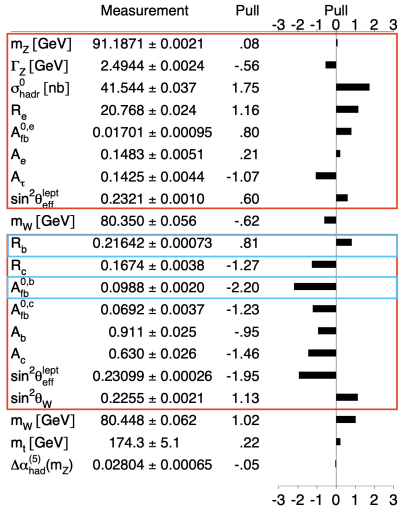
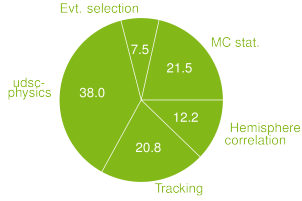
- Largest tension on A_{FB}^b: Requires exquisite knowledge about b-identification
- Other observable that needs pure b-identification:
  $R_b = \frac{\Gamma_{Z\to b\bar{b}}}{\Gamma_{Z\to \text{had}}}$

$\hookrightarrow$ Motivates testing new b-tagging proposals

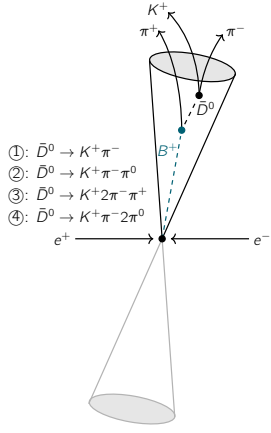


Next *b*-tagger for the FCC-ee



- Where to improve the knowledge on the Z (+ possibly clear tensions?):
  $\hookrightarrow$ @Tera-Z programme at FCC-ee with $6 \cdot 10^{12}$ Z-decays!
- FCC-ee as proposed successor of HL-LHC starting operation in 2045

- Statistical precision on A_{FB}^{b} and R_b unrivalled
  But: Systematic uncertainties have to keep track
- Main systematic uncertainty from *udsc*-physics



Proposal: b-hemisphere tagger

Identify (the charge of) the hemispheres by exclusively reconstruct *b*-hadrons. Targets:

- Potential purity: 100 % thanks to the boost, $\overline{\beta\gamma} \approx 6.5$
- Efficiency: 1 %

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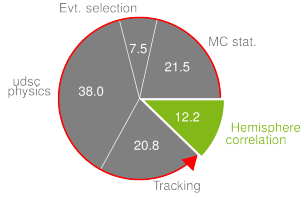

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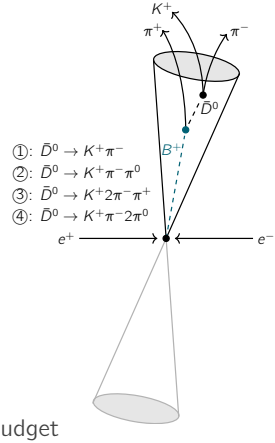

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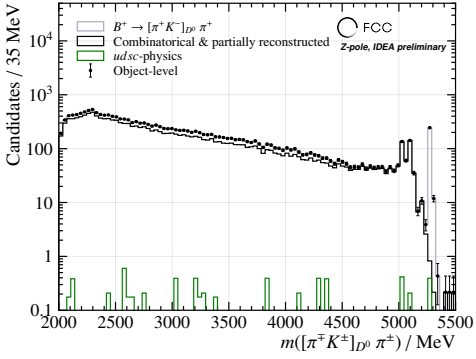
$\hookrightarrow$ Removing background introduces an updated systematic uncertainty budget

R_b: hemisphere efficiency correlation, A_{FB}^b: QCD corrections

Results

Purity & Efficiency

- 200+ b-hadron decay modes sum up to 1.1 % tagging efficiency ✓
- Simulate FCC-ee Z-pole operation and reconstruct B^+-meson (chose 6 out of 200+) ✓



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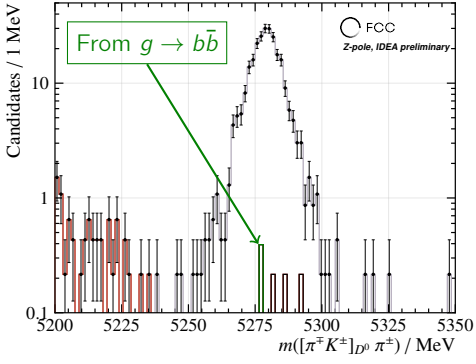

- Purity for the six modes > 99.6 %

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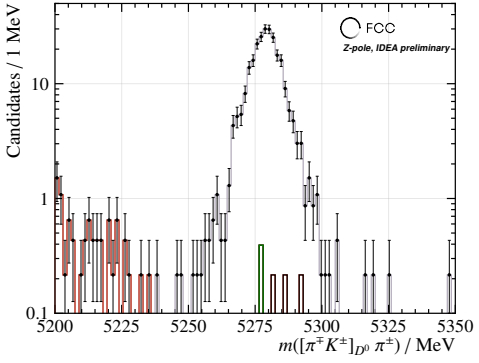
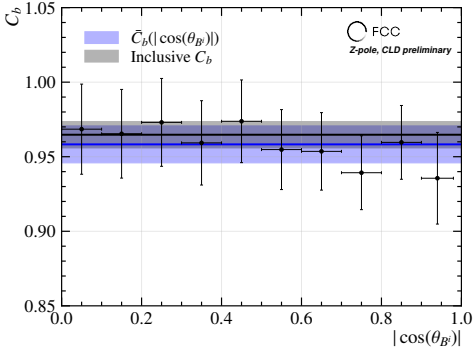


- Purity for the six modes $> 99.6\,\%$

Hemisphere correlation (Preliminary)

- Correlation C_b between hemisphere tagging efficiencies

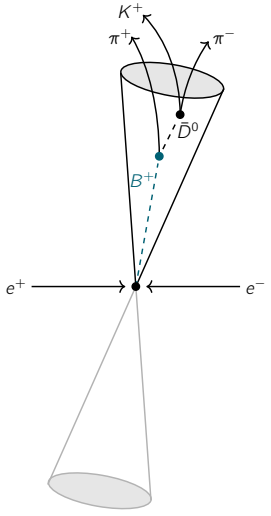
$$C_b = \frac{\text{tag both hemispheres}}{\text{tag individual hemispheres}}$$



- $B^\pm$ reconstruction on Full Simulation:
  $\hookrightarrow\ C_b = 0.965 \pm 0.009(\text{stat.})$

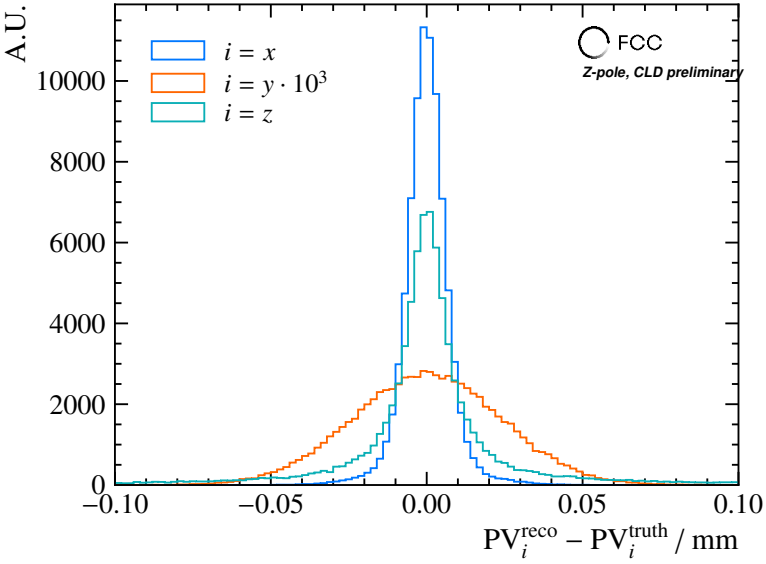
Conclusions and Outlook

- Exclusive b-hadron reconstruction as tagger for hemisphere charge
  1. Application on R_b and A_{FB}^b: Z-pole run at FCC-ee unlocks statistical power
  2. Elimination of major sources of systematic uncertainty
- Remaining systematic uncertainties under investigation:
- See also poster for additional information



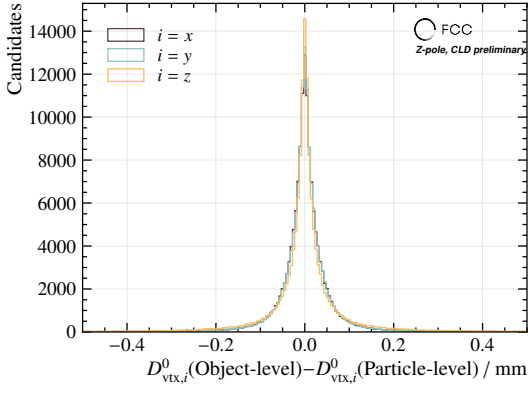
Appendix: Primary vertex resolution

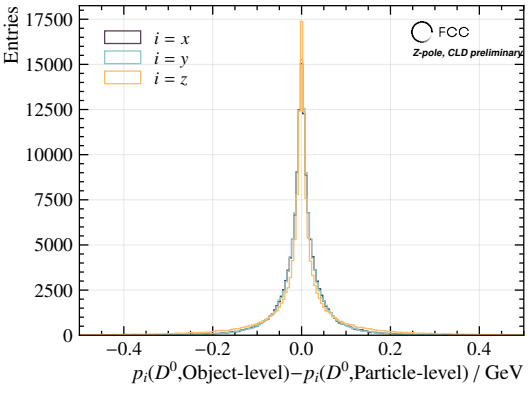
- Primary vertex resolution extracted from the CLD Full Simulation sample



Appendix: D^0 vertex and momentum resolution

- Vertex and momentum resolution for the Full Simulation sample with the CLD detector





Appendix: B^+ vertex and momentum resolution

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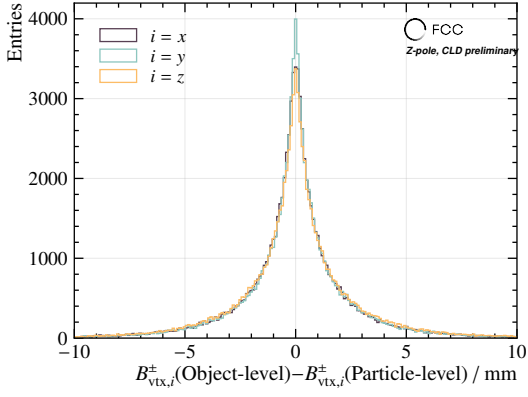
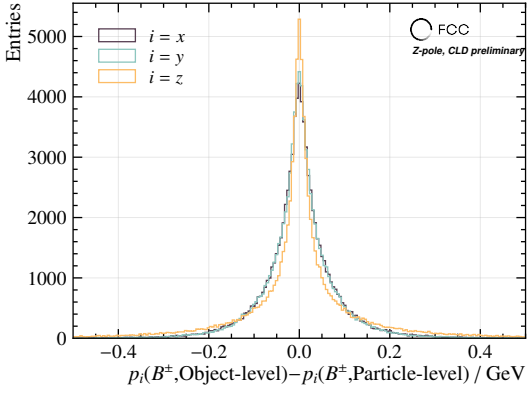
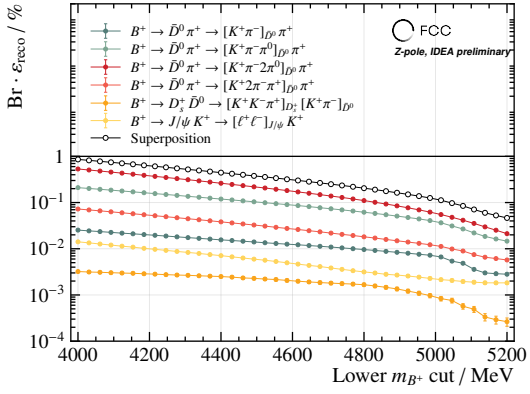
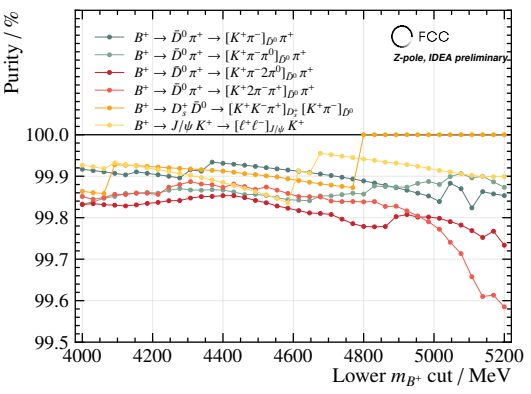




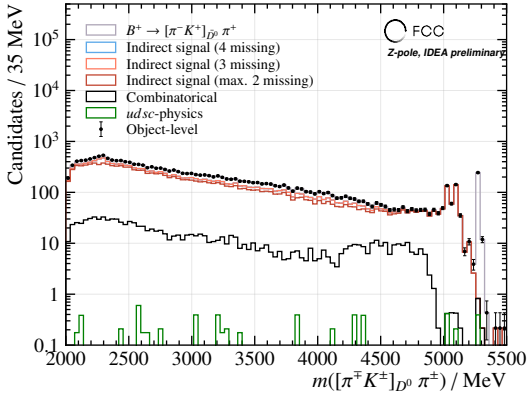
Appendix: Further increasing the efficiency

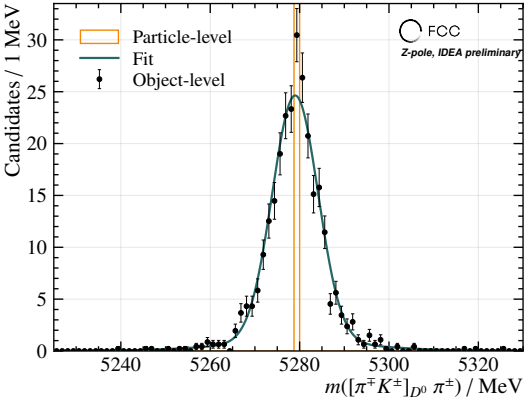
- Efficiency of the tagger can be furhter improved by accepting also partially reconstructed candidates
- No degradation of the purity



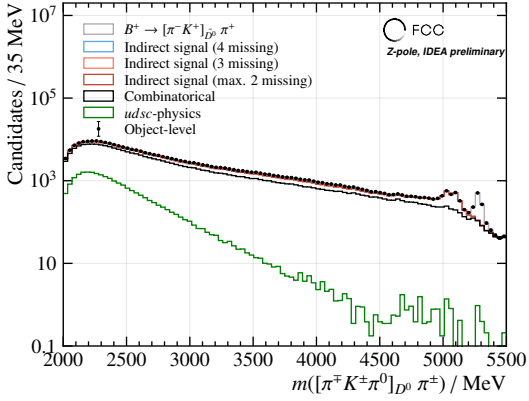


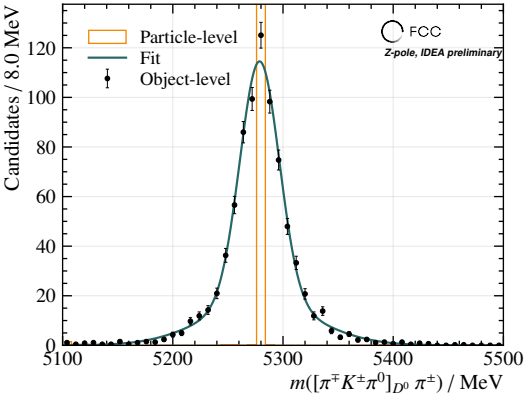
Fast Simulation: Decay mode $B^+ \to [K^+\pi^-]_{\bar{D}^0}\pi^+$



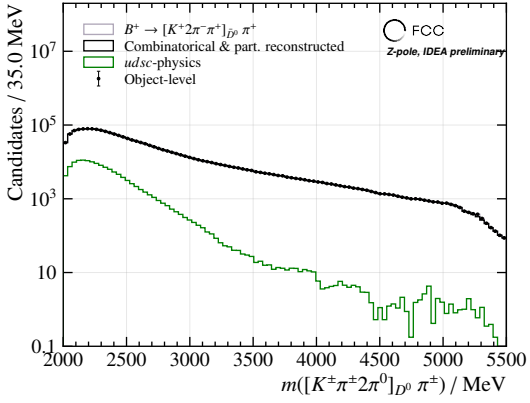


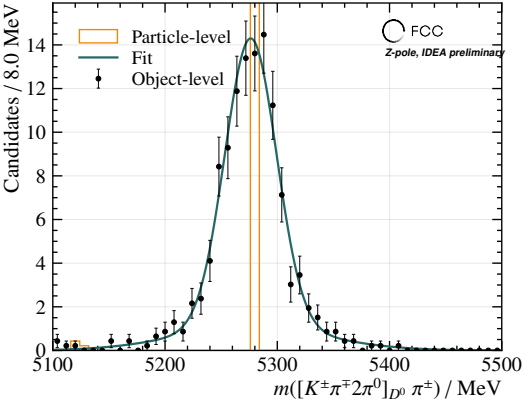
Fast Simulation: Decay mode $B^+ \to [K^+\pi^-\pi^0]_{\bar{D}^0}\pi^+$





Fast Simulation: Decay mode $B^+ \to [K^+\pi^-2\pi^0]_{\bar{D}^0}\pi^+$





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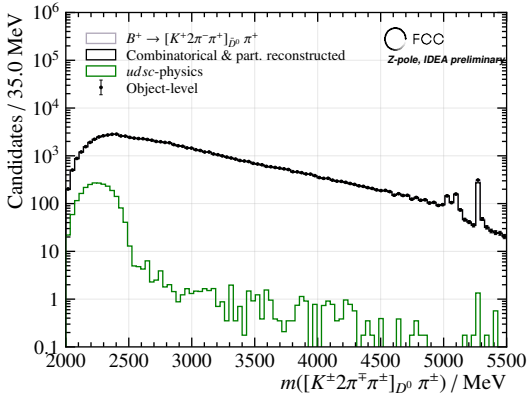
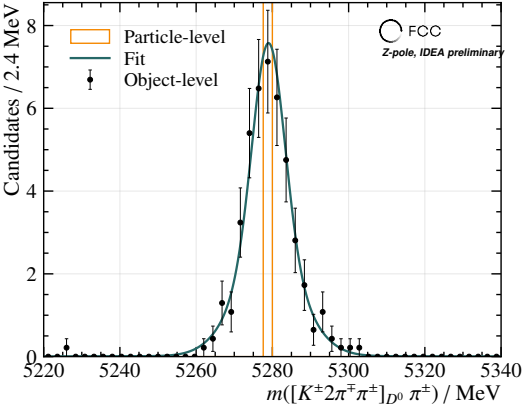
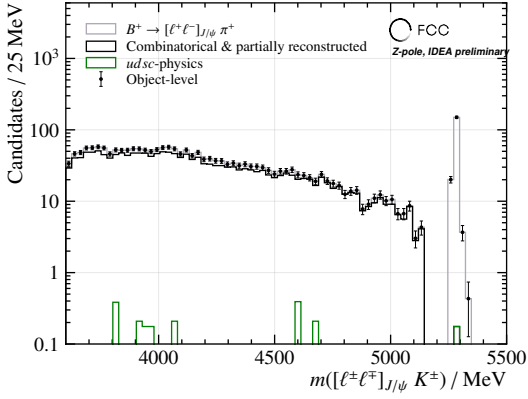
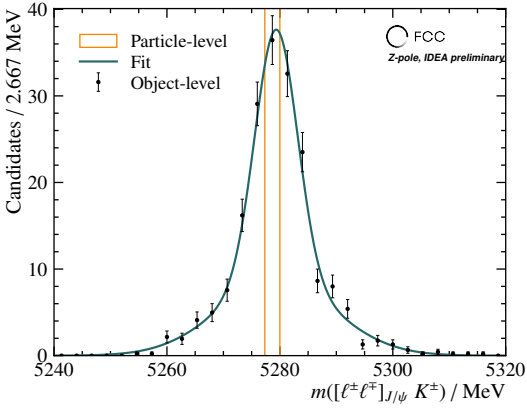




Fast Simulation: Decay mode $B^+ \to [\ell^+\ell^-]_{J/\psi} K^+$





Fast Simulation: Decay mode $B^+ \to [K^+K^-\pi^+]_{D_s^+}[K^+\pi^-]_{\bar{D}^0}$