Analysis update on γ measurement in $B^{\pm} \to (K^+K^-\pi^+\pi^-)_D h^{\pm}$ decays

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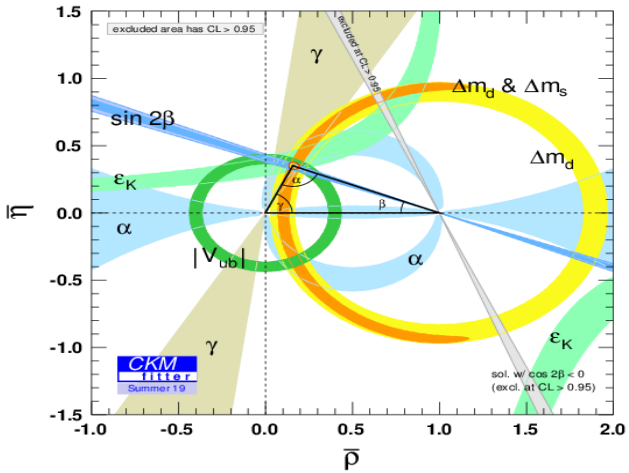
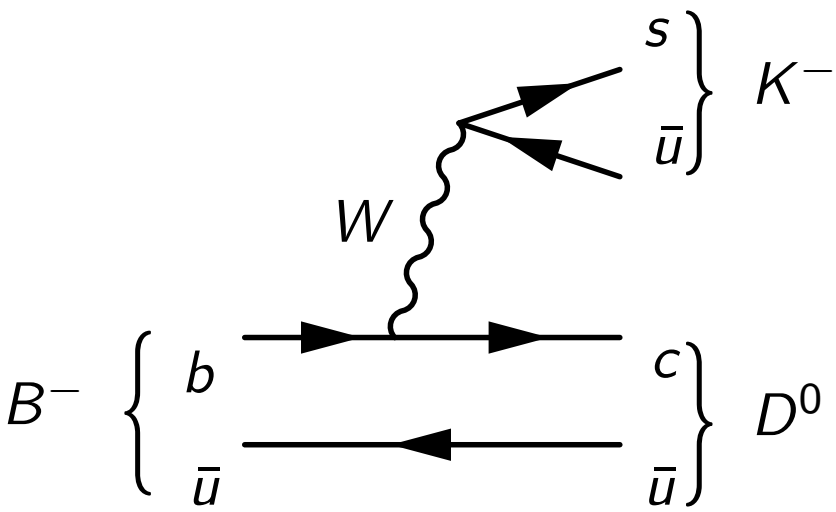
20th May 2021

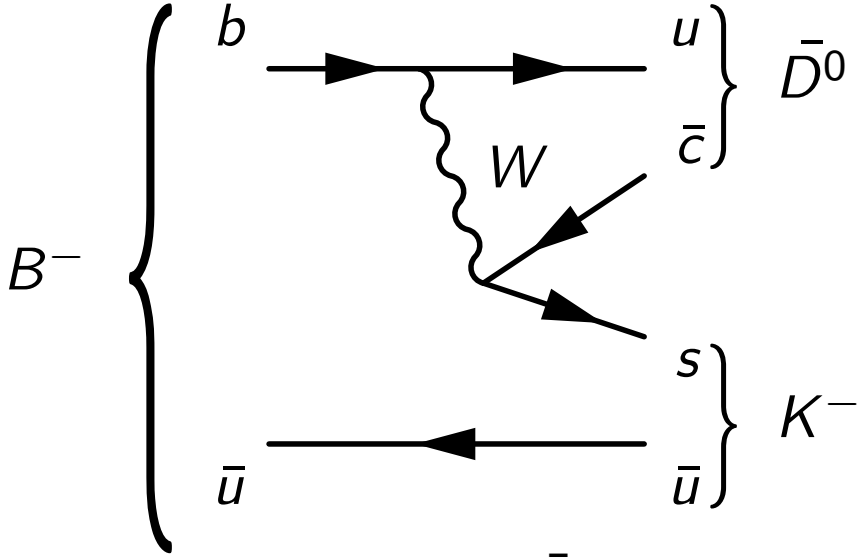


Outline

Introduction (skip)



(a) $B^- \to D^0 K^-$



(b) $B^- \to \bar{D}^0 K^-$

$$\gamma \equiv \arg\left(-\frac{V_{ud} V_{ub}^*}{V_{cd} V_{cb}^*} \right)$$

$b \to u\bar{c}s$ and $b \to u\bar{u}s$ interference when D^0 and $\bar{D}^0$ decay into a common final state

In this analysis, consider $D \to K^+K^-\pi^+\pi^-$

Introduction (skip)

- CP observables:
  - $x_{\pm}^{DK} = r_B^{DK} \cos\left(\delta_B^{DK} \pm \gamma\right)$
  - $y_{\pm}^{DK} = r_B^{DK} \sin\left(\delta_B^{DK} \pm \gamma\right)$
  - $x_{\xi}^{D\pi} = \mathrm{Re}(\xi^{D\pi})$, $y_{\xi}^{D\pi} = \mathrm{Im}(\xi^{D\pi})$ $\qquad \left(\xi^{D\pi} = \frac{r_B^{D\pi}}{r_B^{DK}} e^{i(\delta_B^{D\pi} - \delta_B^{DK})}\right)$

Event yield in bin i

$$N_i^- = h_{B^-}\left(K_i + \left(x_-^2 + y_-^2\right)\bar{K}_i + 2\sqrt{K_i \bar{K}_i}\left(x_- c_i + y_- s_i\right)\right)$$
$$N_{-i}^+ = h_{B^+}\left(K_i + \left(x_+^2 + y_+^2\right)\bar{K}_i + 2\sqrt{K_i \bar{K}_i}\left(x_+ c_i + y_+ s_i\right)\right)$$

Amplitude averaged strong phases and fractional yield

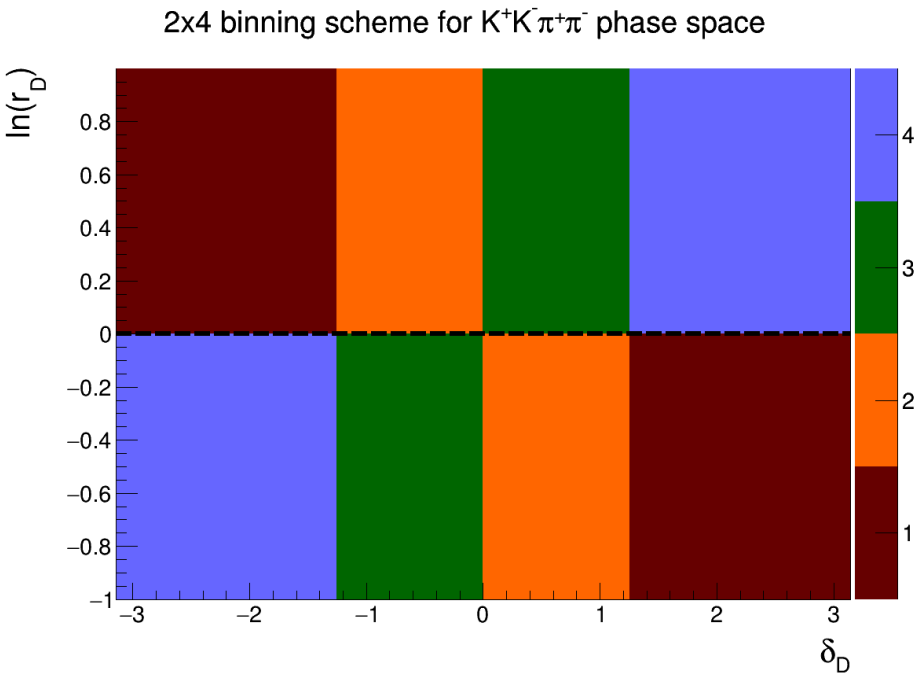
$$c_i = \frac{\int_i \mathrm{d}\Phi |\mathcal{A}(D^0)||\mathcal{A}(\bar{D}^0)| \cos(\delta_D)}{\sqrt{\int_i \mathrm{d}\Phi |\mathcal{A}(D^0)|^2 \int_i \mathrm{d}\Phi \left|\mathcal{A}(\bar{D}^0)\right|^2}}, \qquad K_i = \frac{\int_i \mathrm{d}\Phi |\mathcal{A}(D^0)|^2}{\sum_j \int_j \mathrm{d}\Phi |\mathcal{A}(D^0)|^2}$$

Binning scheme

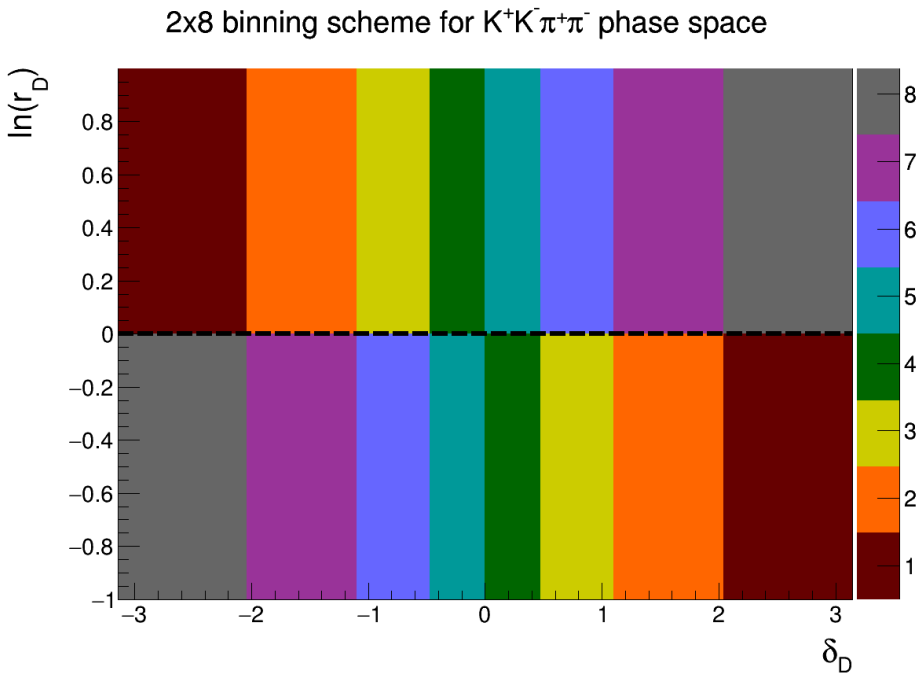
- Use LHCb model (arXiv:1811.08304) implemented in AmpGen
- Calculate D^0 and $\bar{D}^0$ amplitude from D daughter momenta
- $\mathcal{A}(D^0)/\mathcal{A}(\bar{D}^0) = r_D \exp(i\delta_D)$
- Bin along δ_D to avoid dilution during averaging
- Enhance interference by separating bin $+i$ and $-i$ at $r_D = 1$
- Analogy from $K_S\pi^+\pi^-$: $m^2_+ = m^2_-$ separates CF and DCS resonances
- Maximize $Q = \frac{1}{2}(Q_+ + Q_-)$ by moving bin boundaries symmetrically around $\delta_D = 0$:

$$Q^2_\pm = 1 - \sum_i \frac{K_i \bar{K}_i (1 - c_i^2 - s_i^2)}{N_i^\pm} \Big/ \sum_i K_i$$

Binning scheme

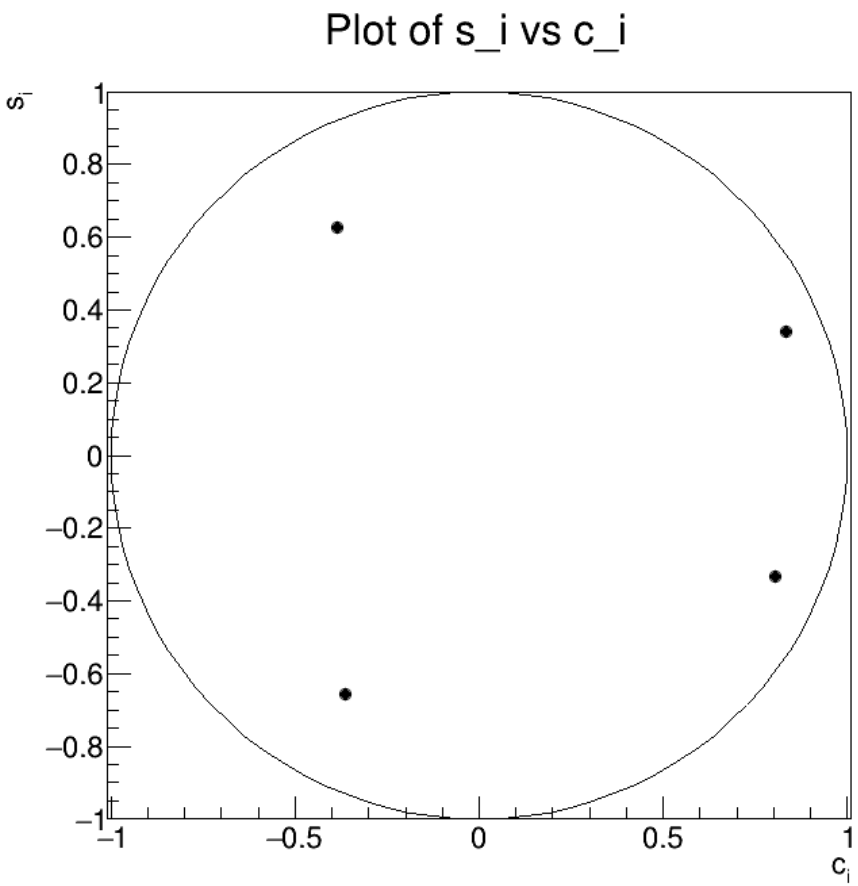


(a) 2×4 binning scheme
$Q = 0.85$

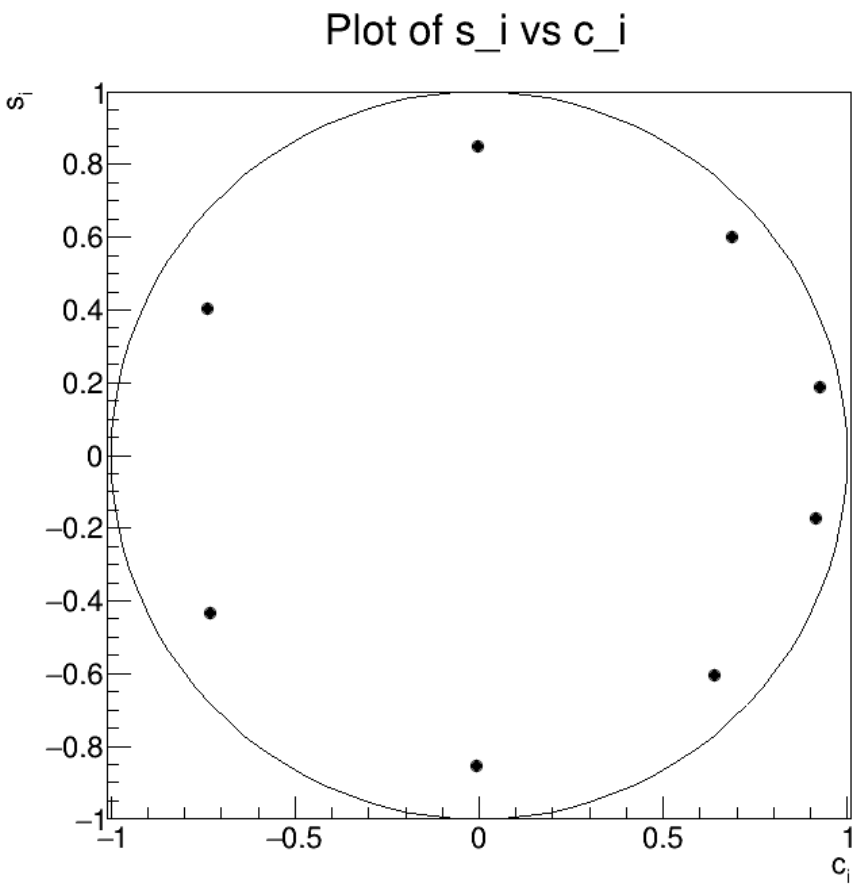


(b) 2×8 binning scheme
$Q = 0.90$

Strong phases

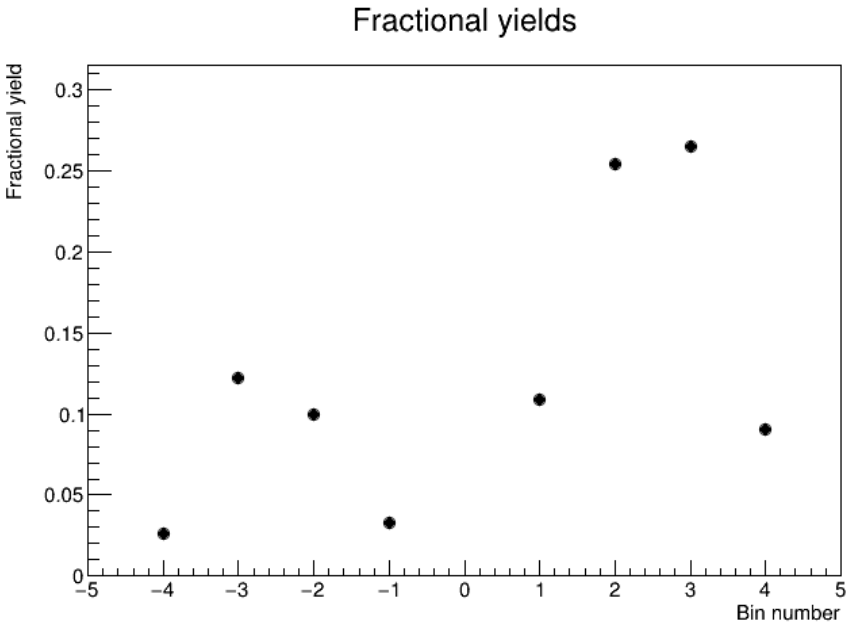


(a) c_i and s_i for the 2×4 binning scheme

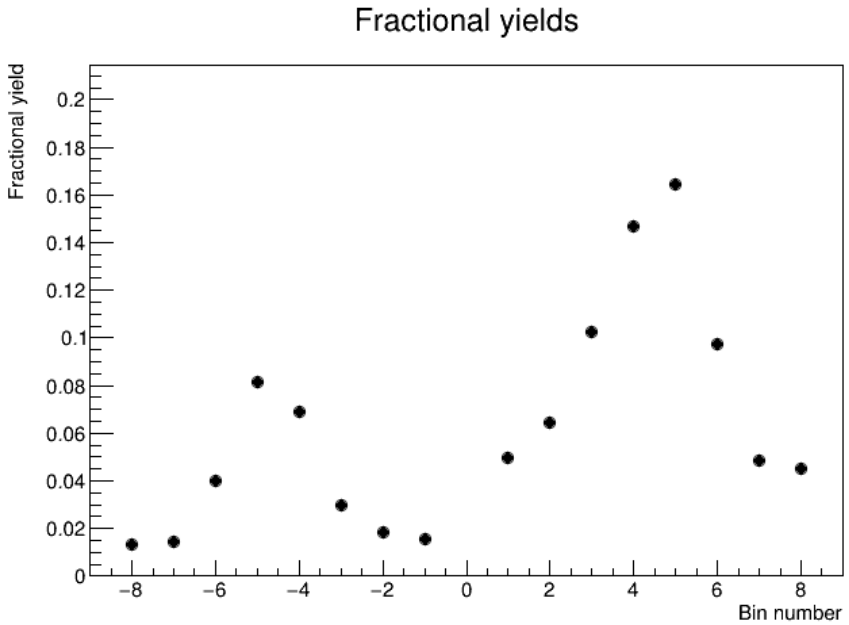


(b) c_i and s_i for the 2×8 binning scheme

Fractional yields



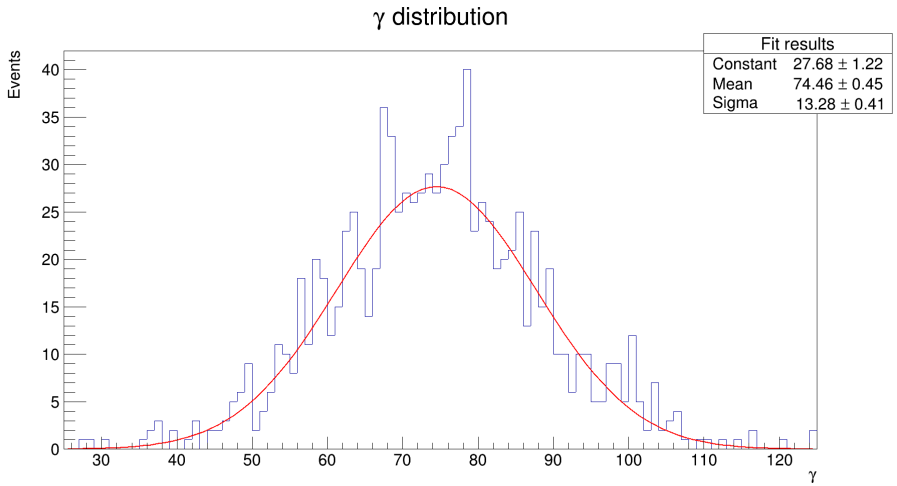
(a) K_i for the 2×4 binning scheme



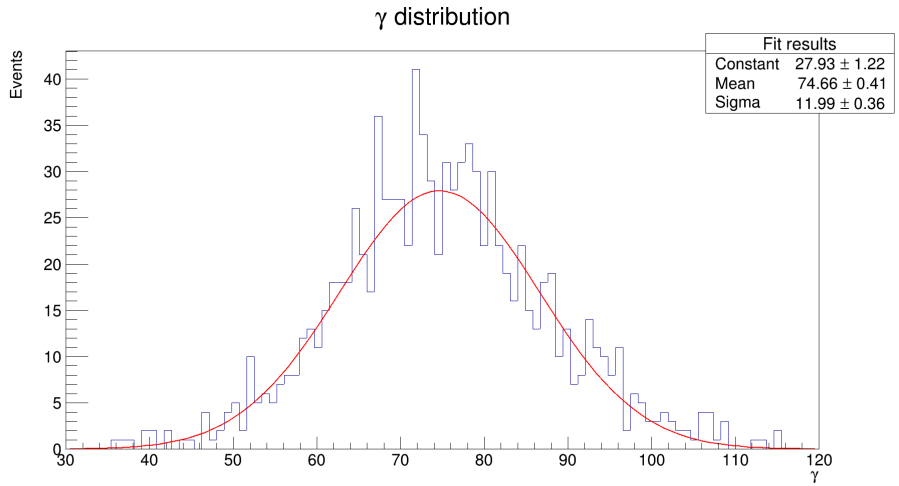
(b) K_i for the 2×8 binning scheme

Study of γ precision

- Generate 2000 $B^{\pm}$ candidates in Ampgen
- Unbinned fit benchmark: $\Delta\gamma = 11^{\circ}$
- Both 2×4 and 2×8 binning schemes are consistent with their Q values



(a) 2×4 binning scheme
$\Delta\gamma = 13^{\circ}$



(b) 2×8 binning scheme
$\Delta\gamma = 12^{\circ}$

Summary

Summary:

- Global and CP fits are working
- Toy studies show no suspicious behaviour

Next steps:

- Fine tuning the PDF shape parameters and efficiencies?

Backup slides: DaVinci error

DaVinci error message:

```
B2DPi_D2KKPiPi....    INFO TupleToolDecayTreeFitter:: The INFO message is suppressed : 'Renaming duplicate to Bu_constD0PV_D0_piplus_0'
B2DPi_D2KKPiPi....    INFO TupleToolDecayTreeFitter:: The INFO message is suppressed : 'Renaming duplicate to Bu_constD0PV_D0_Kplus_1'
B2DPi_D2KKPiPi....   ERROR TupleToolDecayTreeFitter:: Tuple entry error : Bu_constD0PV_D0_Kplus_0_ID != Bu_constD0PV_D0_Kplus_1_ID StatusCode=FAILURE
B2DPi_D2KKPiPi....   ERROR TupleToolDecayTreeFitter:: Tuple entry error : Bu_constD0PV_D0_Kplus_0_PE != Bu_constD0PV_D0_Kplus_1_PE StatusCode=FAILURE
B2DPi_D2KKPiPi....   ERROR TupleToolDecayTreeFitter:: Tuple entry error : Bu_constD0PV_D0_Kplus_0_PX != Bu_constD0PV_D0_Kplus_1_PX StatusCode=FAILURE
B2DPi_D2KKPiPi....   ERROR TupleToolDecayTreeFitter:: Tuple entry error : Bu_constD0PV_D0_Kplus_0_PY != Bu_constD0PV_D0_Kplus_1_PY StatusCode=FAILURE
B2DPi_D2KKPiPi....   ERROR TupleToolDecayTreeFitter:: Tuple entry error : Bu_constD0PV_D0_Kplus_0_PZ != Bu_constD0PV_D0_Kplus_1_PZ StatusCode=FAILURE
B2DPi_D2KKPiPi....   ERROR TupleToolDecayTreeFitter:: Tuple entry error : Bu_constD0PV_D0_piplus_1_ID != Bu_constD0PV_D0_piplus_0_ID StatusCode=FAILURE
B2DPi_D2KKPiPi....   ERROR TupleToolDecayTreeFitter:: Tuple entry error : Bu_constD0PV_D0_piplus_1_PE != Bu_constD0PV_D0_piplus_0_PE StatusCode=FAILURE
B2DPi_D2KKPiPi....   ERROR TupleToolDecayTreeFitter:: Tuple entry error : Bu_constD0PV_D0_piplus_1_PX != Bu_constD0PV_D0_piplus_0_PX StatusCode=FAILURE
B2DPi_D2KKPiPi....   ERROR TupleToolDecayTreeFitter:: Tuple entry error : Bu_constD0PV_D0_piplus_1_PY != Bu_constD0PV_D0_piplus_0_PY StatusCode=FAILURE
B2DPi_D2KKPiPi....   ERROR TupleToolDecayTreeFitter:: Tuple entry error : Bu_constD0PV_D0_piplus_1_PZ != Bu_constD0PV_D0_piplus_0_PZ StatusCode=FAILURE
B2DPi_D2KKPiPi       FATAL Tool 'TupleToolDecayTreeFitter' acting on particle 'Bu' returned a failure status.
```