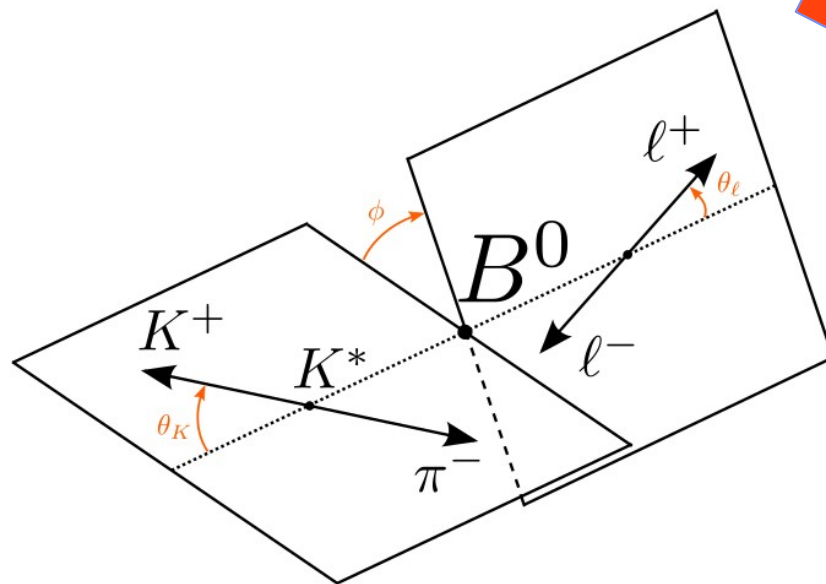


$B \rightarrow K\text{stll}$ and $P5'$ Analysis

Valencia 2022

Update



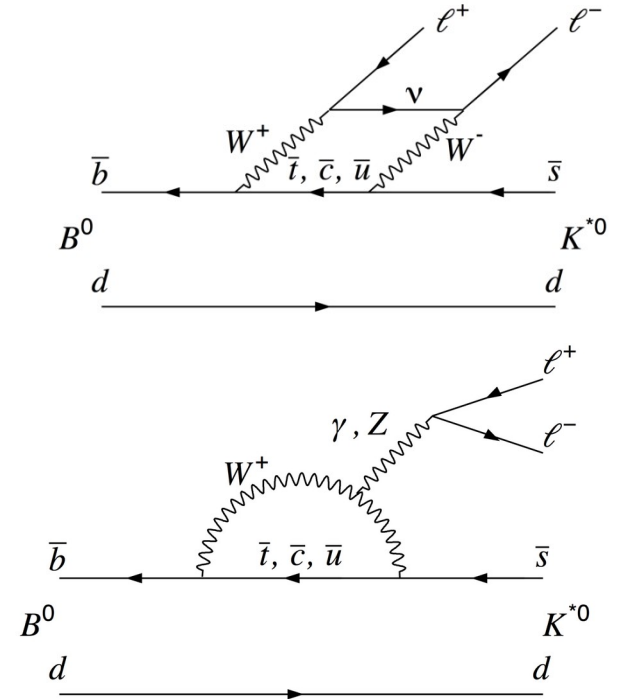
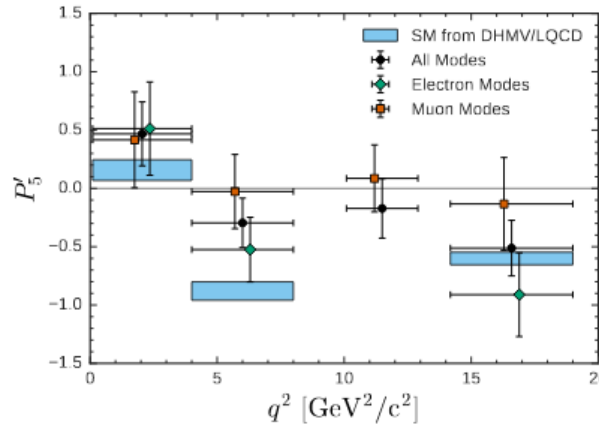
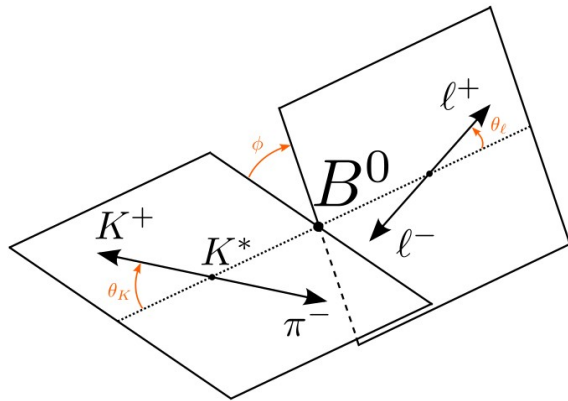
Wolfgang Gradl, Martin Sobotzik
Johannes Gutenberg University Mainz

JOHANNES GUTENBERG
UNIVERSITÄT MAINZ



Motivation

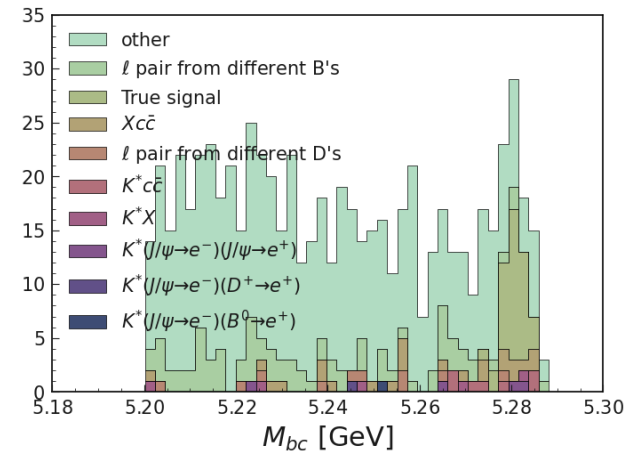
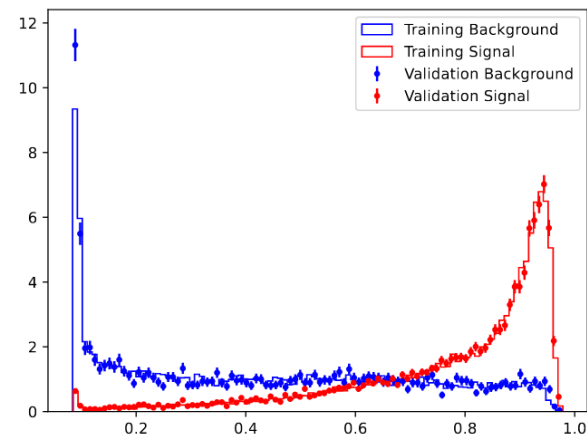
- Anomalies observed in many FCNC
- Highly suppressed and have a very small BR
→ Decay is very sensitive to new physics!
- Today only focus on $B^0 \rightarrow K^* \ell^+ \ell^-$



Cuts and Selection

- Use MC14:_ri for training; _rd_ex for validation; _rd_cx for analysis
- Skim $B \rightarrow Kst \ell X$, $|\delta E| < 0.3$, $0.796 < Kst(M) < 0.996$
- LID correction from Moriond 2022
- Then train a Deep-NN based on TensorFlow to suppress background events (CS+BS)
- Only take events with $NN_output > 0.669$ (ROC)

```
varL:['lm_pValue', 'lp_pValue', 'lm_p', 'lm_omega', 'lp_omega', 'Kst_K_omega',  
      'lm_dx', 'lm_dy', 'lm_dz', 'lp_dx', 'lp_dy', 'lp_dz', 'visibleEnergyOfEventCMS',  
      'lp_tanLambda', 'lm_tanLambda', 'deltax_ll', 'deltay_ll', 'deltaz_ll',  
      'dz', 'dy', 'Kst_K_dr', 'Kst_pi_cosTheta', 'Kst_pi_tanLambda', 'Kst_pi_chiProb',  
      'Kst_pi_dz', 'Kst_K_chiProb', 'Kst_M', 'Kst_K_dz', 'Kst_px', 'Kst_py',  
      'dr', 'dx', 'Kst_pi_phi0', 'Kst_K_phi0'],
```

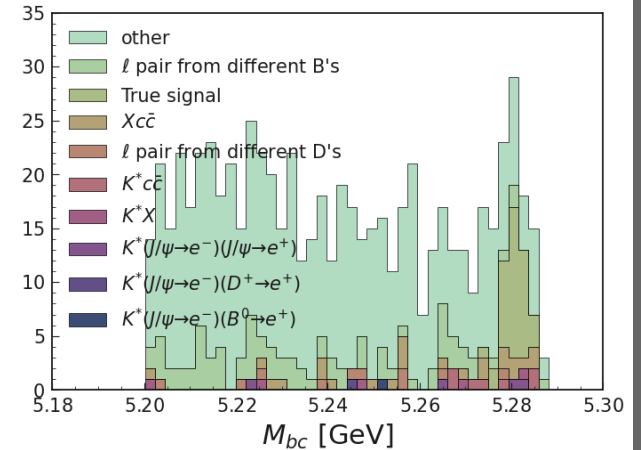
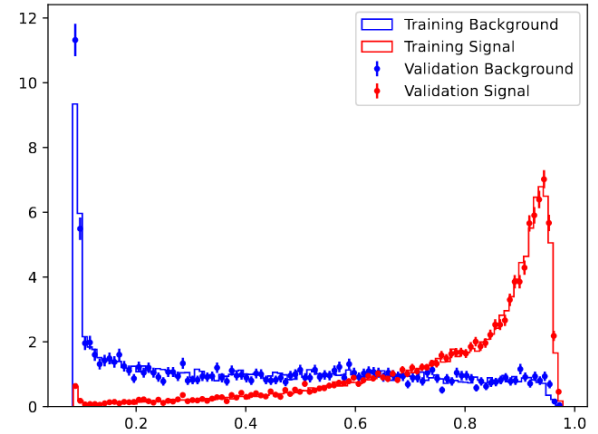


Cuts and Selection

- Use MC14: `_ri` for training; `_rd_ex` for validation; `_rd_cx` for analysis
- Skim $B \rightarrow Kst \ell X$, $|\Delta E| < 0.3$, $0.796 < Kst(M) < 0.996$
- LID correction from Moriond 2022
- Then train a Deep-NN based on TensorFlow to suppress background events (CS+BS)
- Only take events with NN score > 0.5

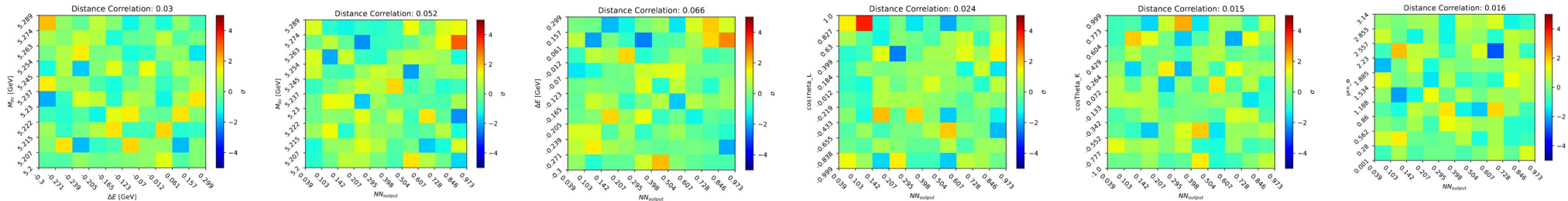
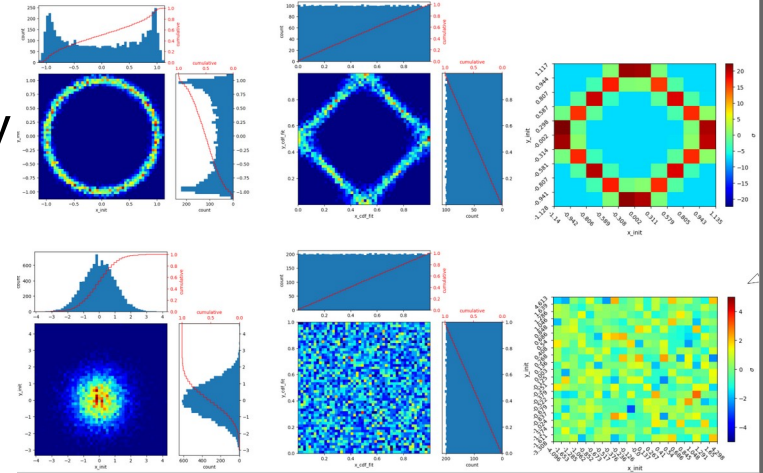
Change the input variables
Don't use kinematics!

Use feature attribution:
Similar to ranking of variables in a BDT
Throw away variables which do nothing



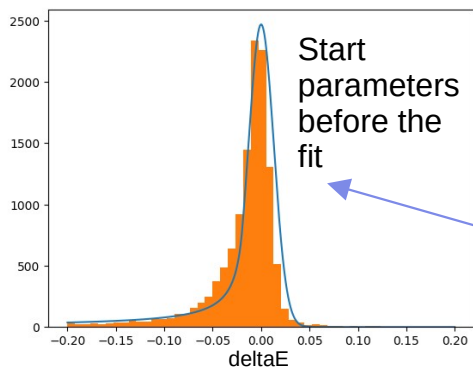
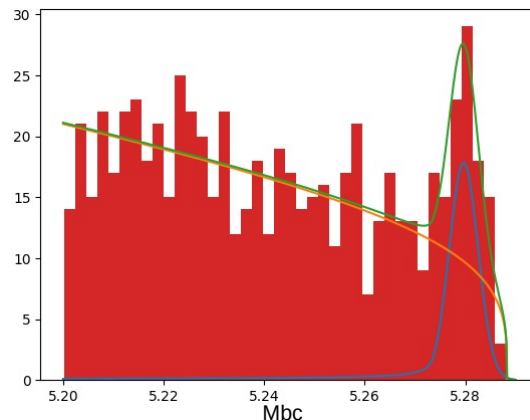
Correlations

- Check that there are no correlations between NN-output and variables we want to fit on (only look at pure background)
- Find a method to spot correlations between variables → flat correlations
- To perform a 2d fit over ΔE and M_{bc} they also have to be uncorrelated for background



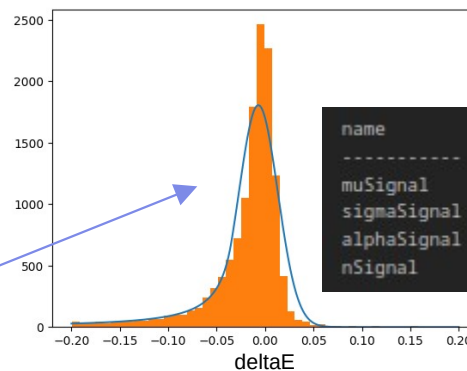
Fitting

- Use z-fit to get the yield by a 2d-unbinned likelihood fit over ΔE and M_{bc}
- The 1d unbinned likelihood fit works for M_{bc} but it fails for ΔE
- It can't even fit pure signal (Crystal Ball)



Pure Signal after NN

Before and after fit

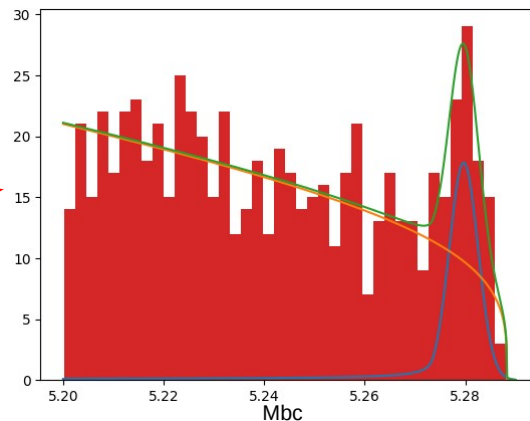


name	value (rounded)	at limit
-----	-----	-----
muSignal	-0.00698576	False
sigmaSignal	0.0201311	False
alphaSignal	1.37444	False
nSignal	1.50672	False

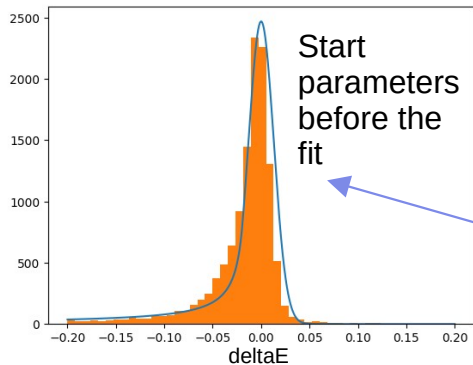
Fitting

- Use z-fit to get the yield by a 2d-unbinned likelihood fit over ΔE and M_{bc}
- The 1d unbinned likelihood fit fails for ΔE
- It can't even fit pure signal

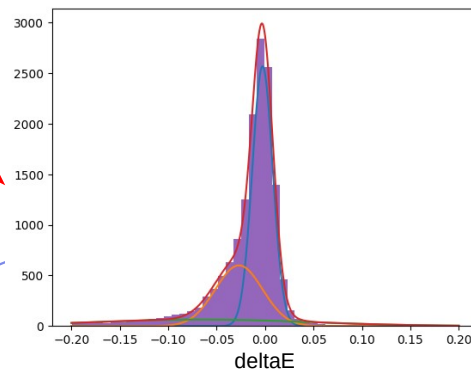
Don't do this



Just do that

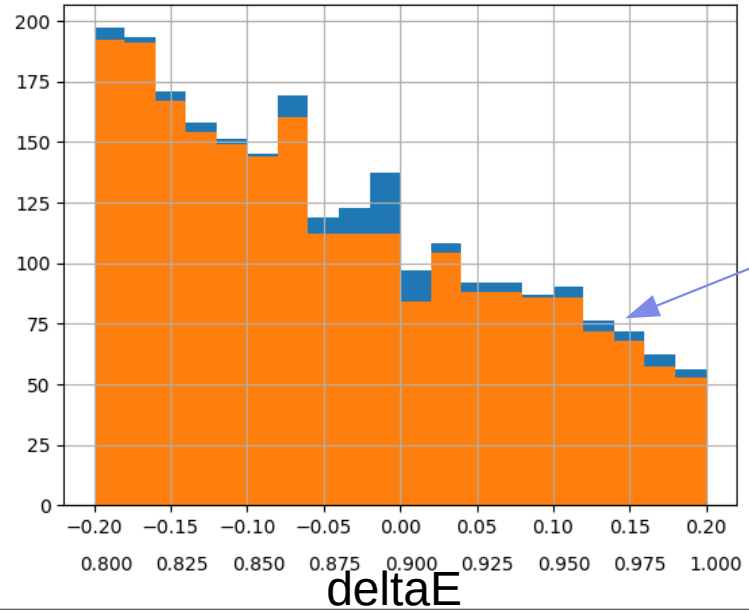


Pure signal after fit



Understanding Background

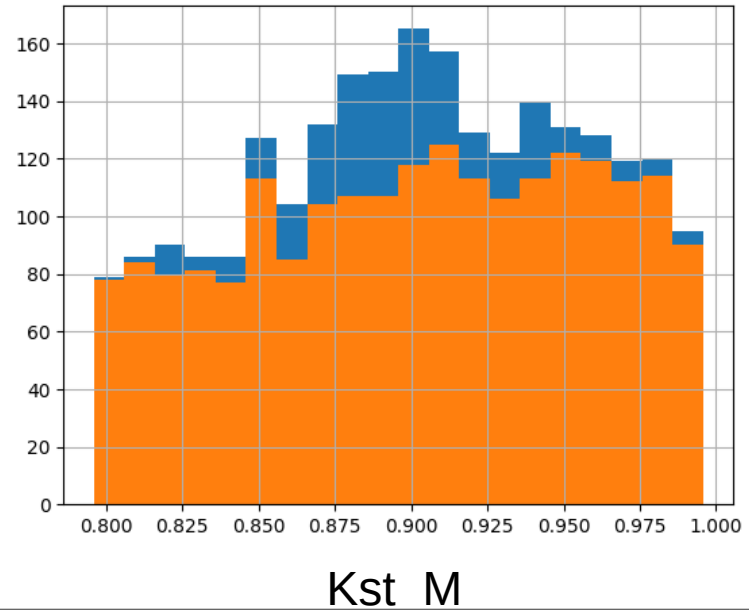
- True Signal (Blue)
- False Signal (Orange)



Dominated by Background

Understanding Background

- True Kst (Blue)
- False Kst (Orange)

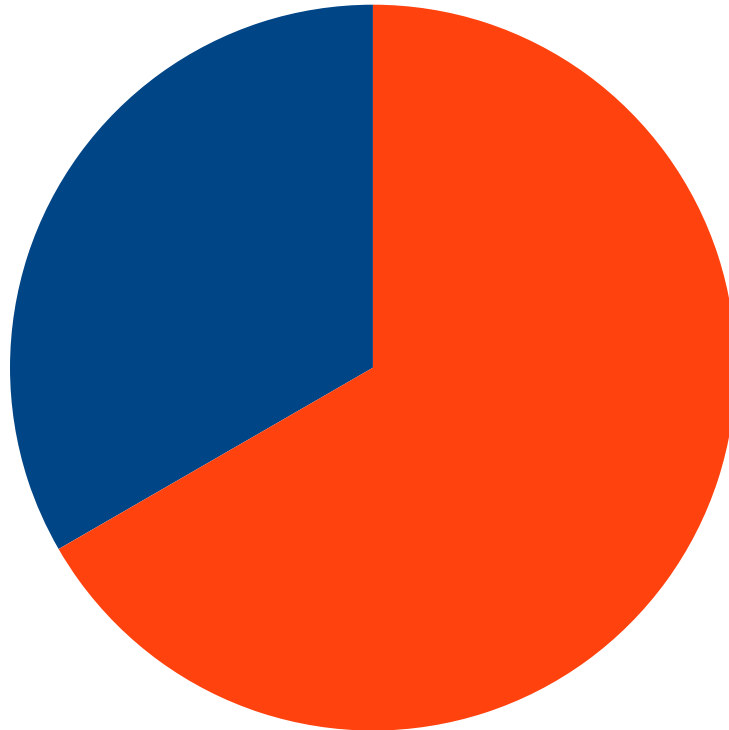


Mainly fake Kst

Background Composition

Kpi coming from the
Same mother
(mainly D)

Probably 3 Body D
decays where one
daughter is lost
Combine Kpi with
each track from ROE
and veto D mass



Kpi coming from different
Particles

Mainly $B \rightarrow D^{(*)} l \nu$

Ideas: Use vertex
information

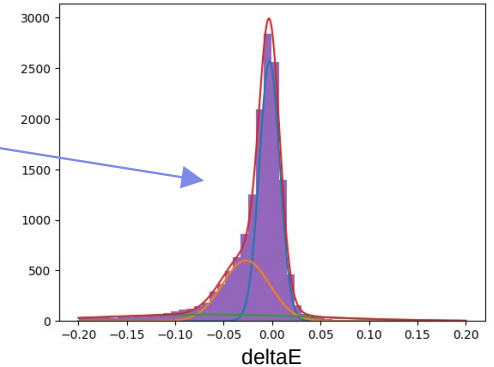
Problems

- Correlations (?)
- Crystal Ball fit for ΔE (signal)
- What function for ΔE background?
- And then the 2d fit for M_{bc} and ΔE
- Way future: multidimensional simultaneous fit over:
 - 2 yield variables ($\Delta E + M_{bc}$)
 - 3 angle variable ($\phi_B, \cos\theta_K, \cos\theta_L$)→ 5D Fit

Problems → Next Steps

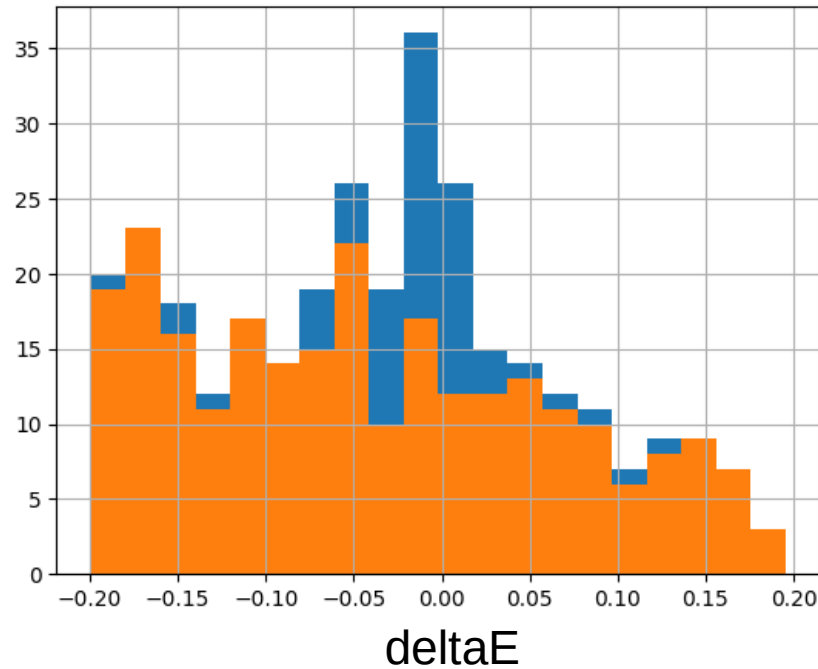
Still something to keep in mind
but there are tools
to make life easier

- Correlations
- **2 Gauss + CB fit** for deltaE (signal)
- What function for deltaE background?
- [REDACTED]
- Way future: multidimensional simultaneous fit over:
 - **1** yield variables (deltaE [REDACTED])
 - 3 angle variable (phi_B, cosTheta_K, cosTheta_L)
→ **4**D Fit
- First: perform D Veto (with ROE (or FEI)) to reduce number of background



Backup

- $M_{bc} > 5.27$



Statistic is too low
To see if $B\bar{b}$ peaks
Under the signal.
Will reconstruct 1 ab^{-1}