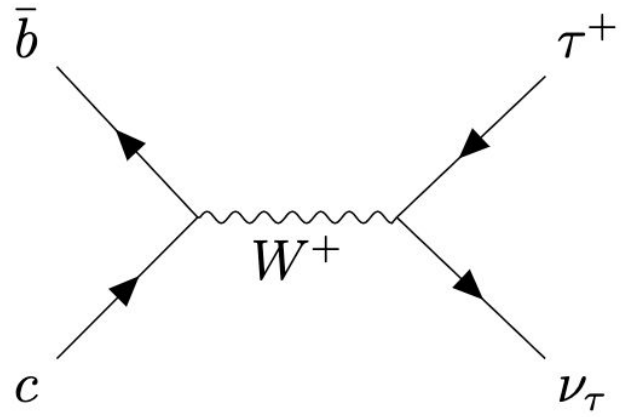
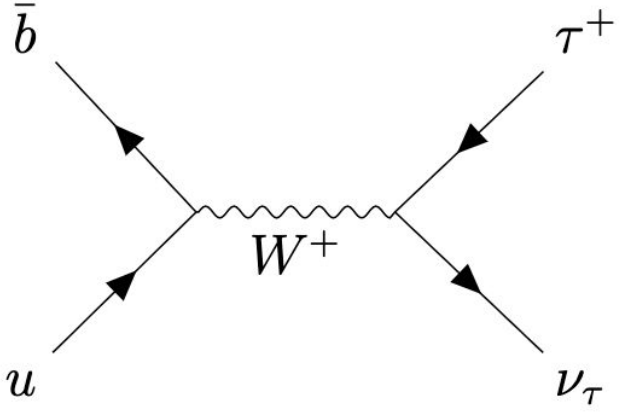


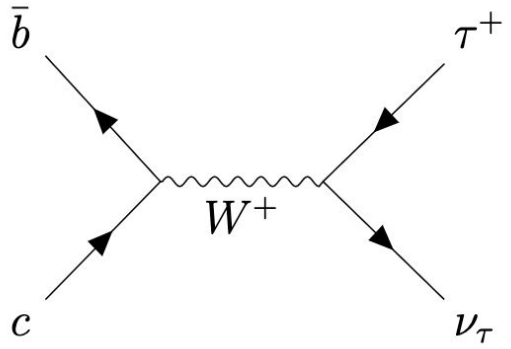


Feasibility of the measurement of $\mathcal{BR}(B_c^+ \to \tau^+ \nu_\tau)$ and $\mathcal{BR}(B^+ \to \tau^+ \nu_\tau)$

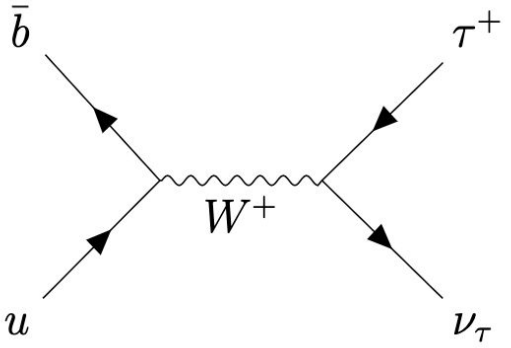
MD Galati

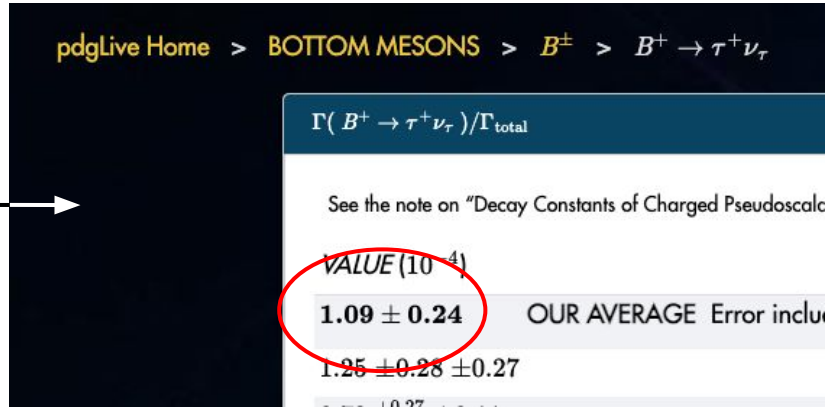
VSI Meeting 30/01/2023

Why?



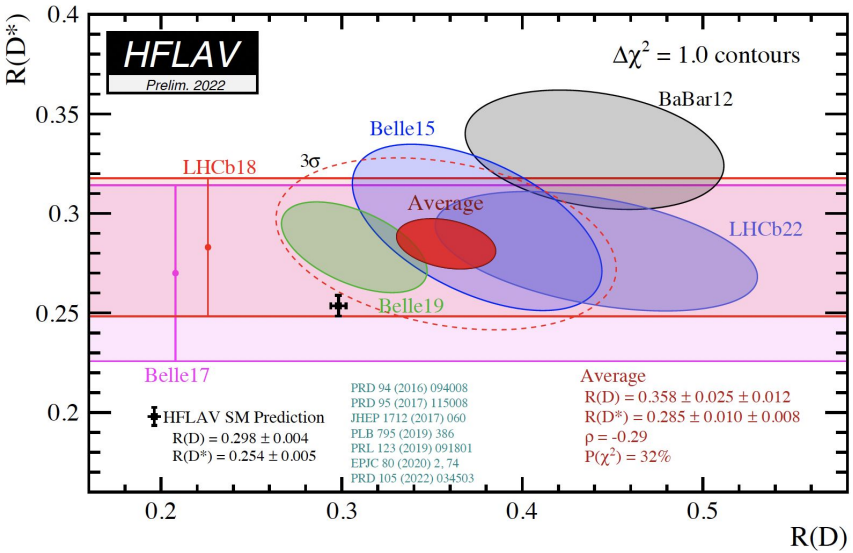
It has not been measured yet

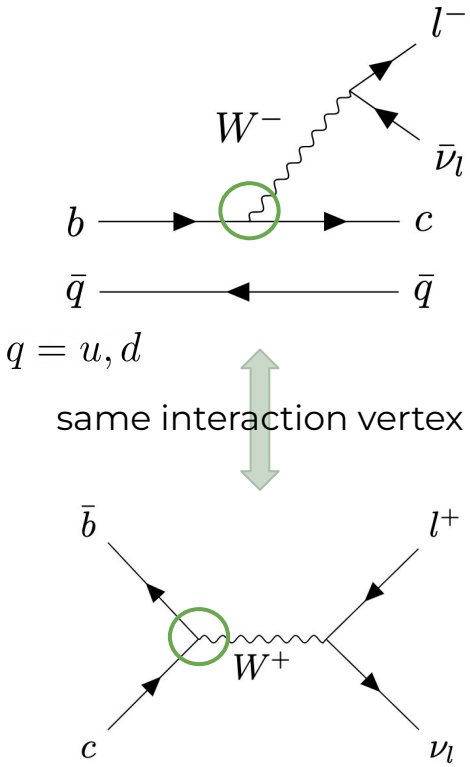




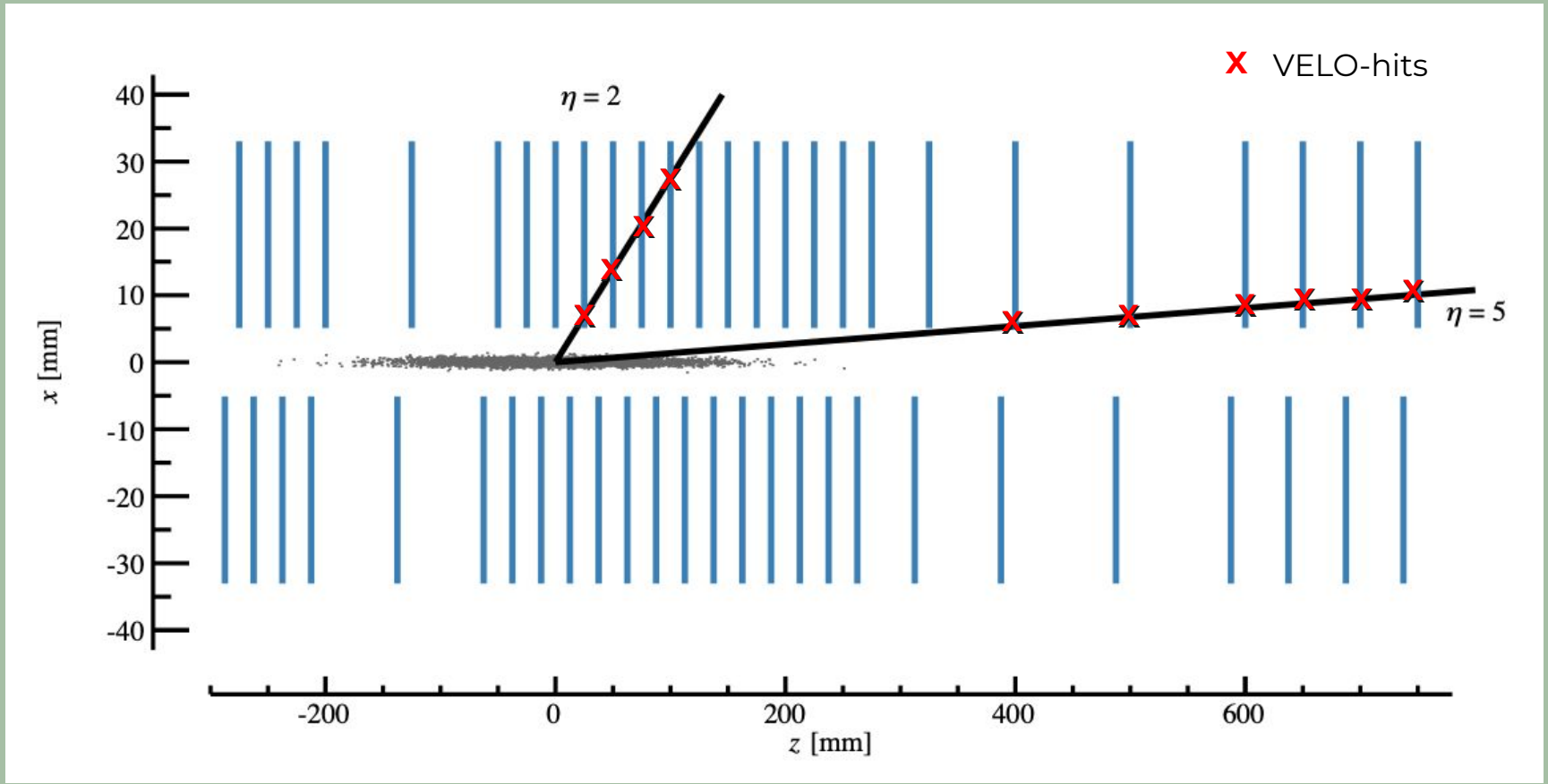
LFU tension in $b \to c\, l\, \nu$ transitions

$$\mathcal{R}(D^{(*)}) = \frac{\mathcal{BR}(\overline{B} \to D^{(*)}\tau^-\overline{\nu}_\tau)}{\mathcal{BR}(\overline{B} \to D^{(*)}l^-\overline{\nu}_l)}$$



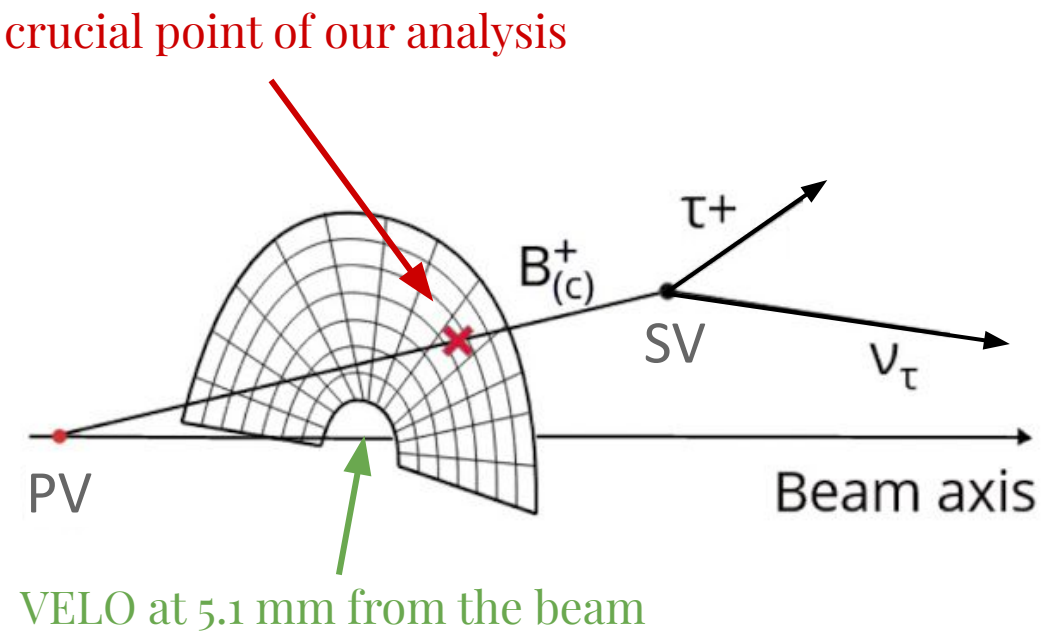


Vertex Locator (VELO): crucial for the analysis



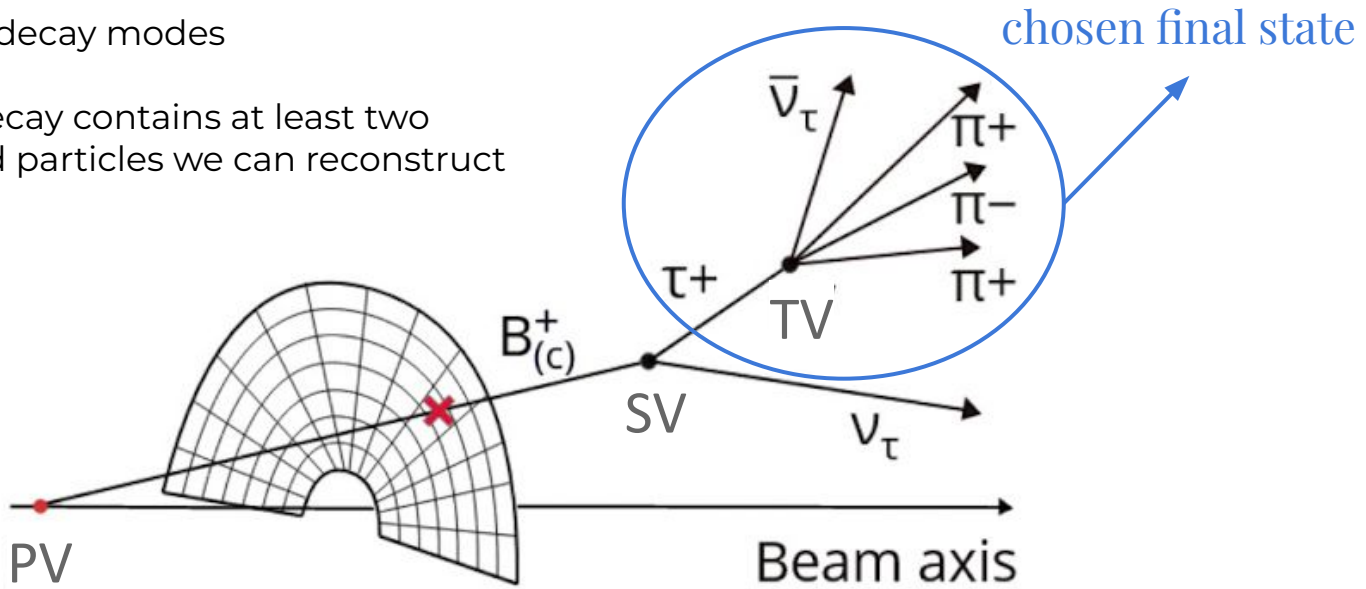
What is going to change in Run3?

Novel B-Tracking Tool



How do we measure $B^+_{(c)} \to \tau^+ \nu_\tau$?

- The τ has a very short lifetime
- Many τ-decay modes
- If the decay contains at least two charged particles we can reconstruct the TV



Steps of the feasibility study

1. Generating events for signal and potential background
2. Selecting events in which the *B* or the ***T*** hit at least one time the VELO
3. Using multivariate analysis (MVA), creating a test statistics that expresses whether an event is likely to be signal or background
4. Performing pseudo-experiment fit studies to measure the signals yields

Steps of the feasibility study

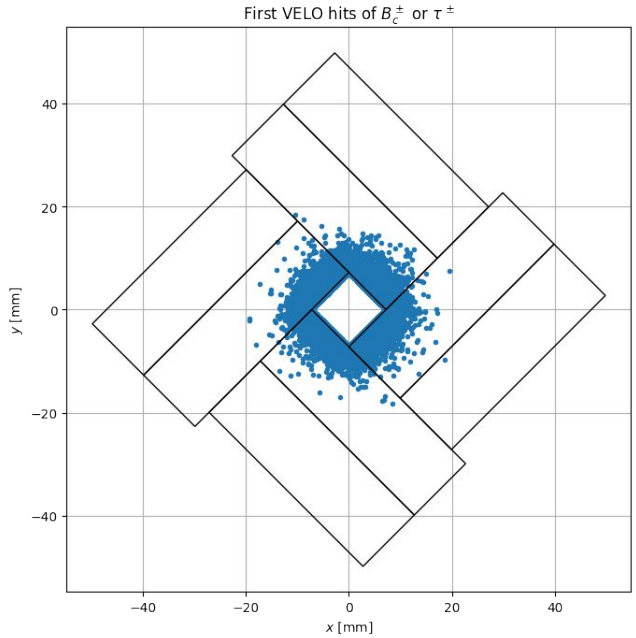
1. **Generating events for signal and potential background**

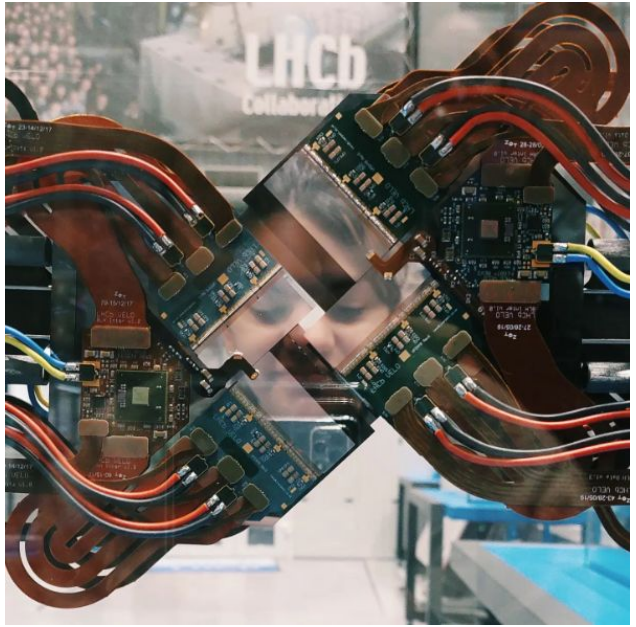
Decay	Category
$B \to D\tau^+\nu_\tau$	semileptonic
$B \to D^*\tau^+\nu_\tau$	semileptonic
$B \to D\pi^+\pi^+\pi^-$	direct
$B \to D^*\pi^+\pi^+\pi^-$	direct
$B \to DD_s^+$	intermediate charm
$B \to D^*D_s^+$	intermediate charm
$B \to D^*D_s^{*+}$	intermediate charm

where $B \in \{B^0, B^+, B_s^0, \Lambda_b^0\}$
and the corresponding $D \in \{D^-, \bar{D}^0, D_s^-, \Lambda_c^-\}$

Steps of the feasibility study

2. Selecting events in which the *B* or the *τ* hit at least one time the VELO





Steps of the feasibility study

3. Using multivariate analysis (MVA), creating a test statistics that expresses whether an event is likely to be signal or background

INPUT

Observables

- Momentum of the three pions
- Flight distance
- Impact parameter
- Invariant mass of the three pions

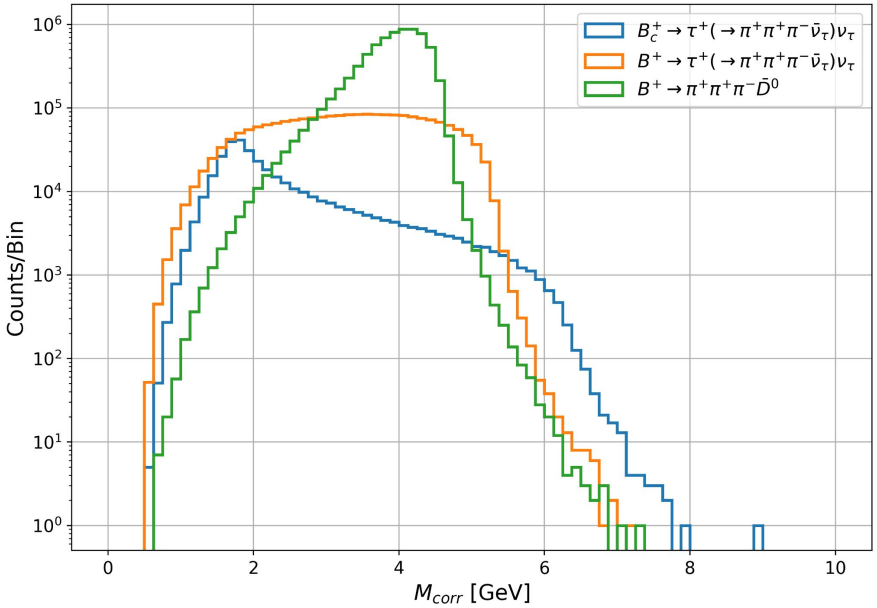
OUTPUT

$p \in [0,1]$

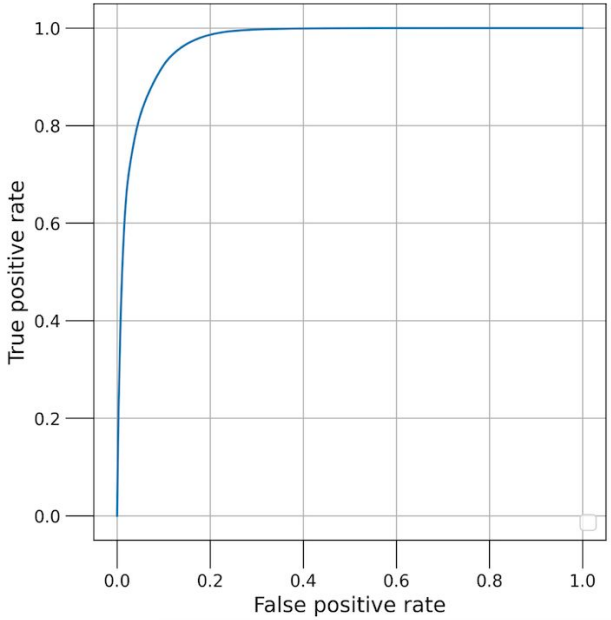
Probability of the event being signal

Steps of the feasibility study

INPUT

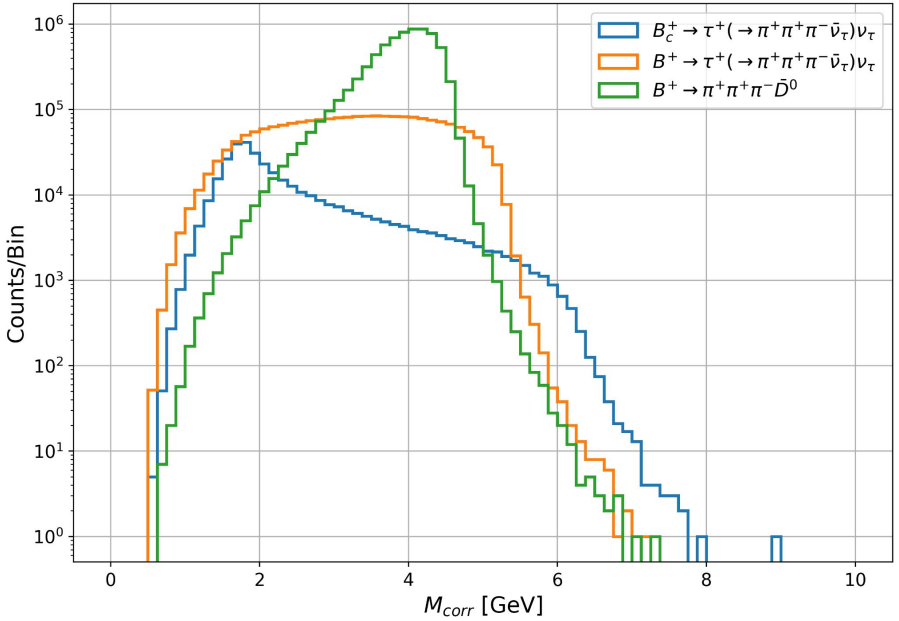


OUTPUT

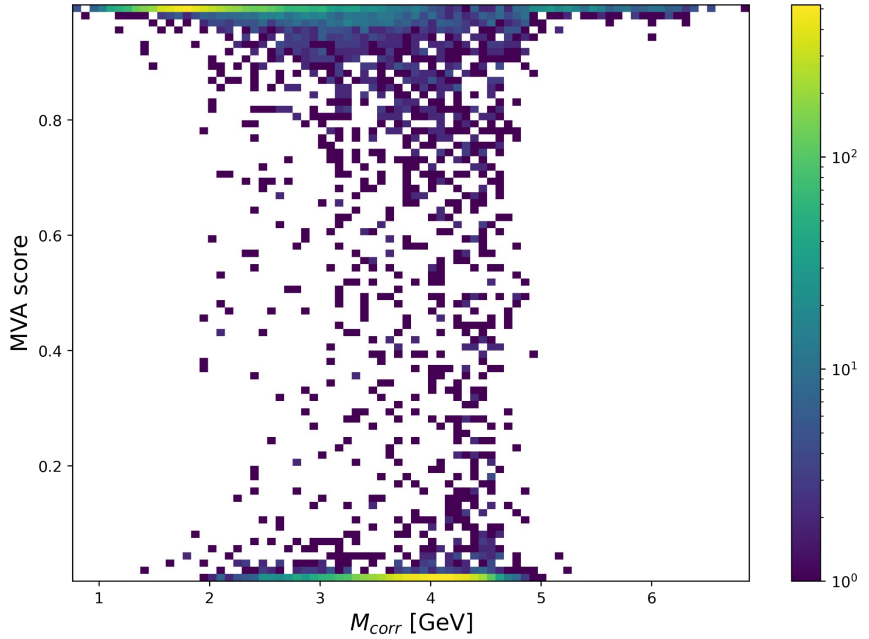


Steps of the feasibility study

INPUT

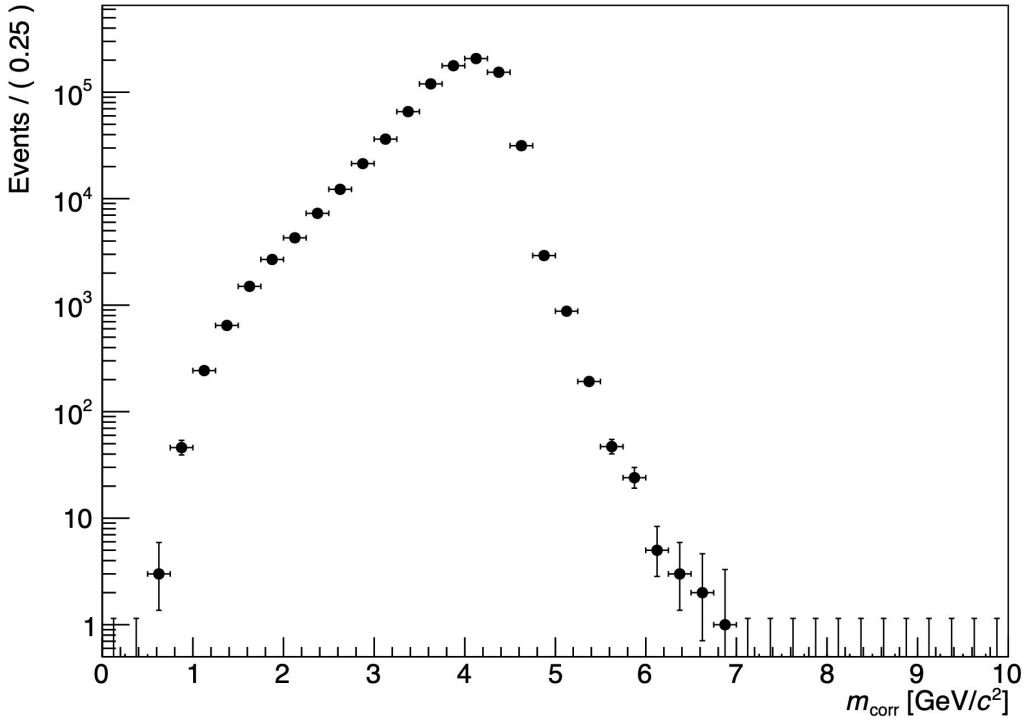


OUTPUT



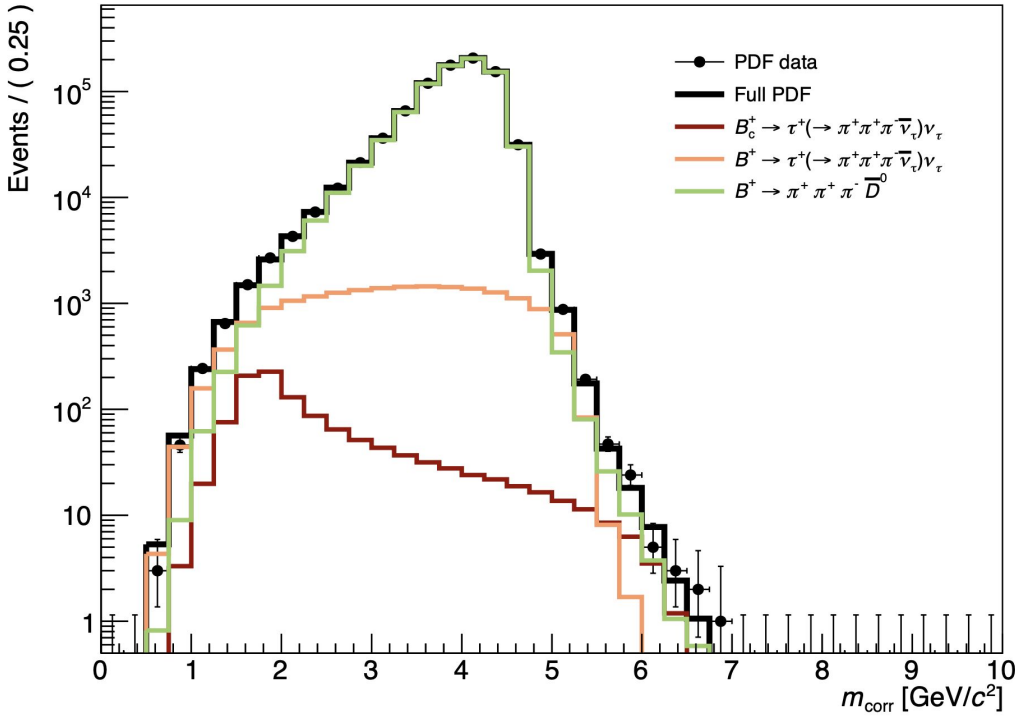
Steps of the feasibility study

4. Performing pseudo-experiment fit studies to measure the signals yields



Steps of the feasibility study

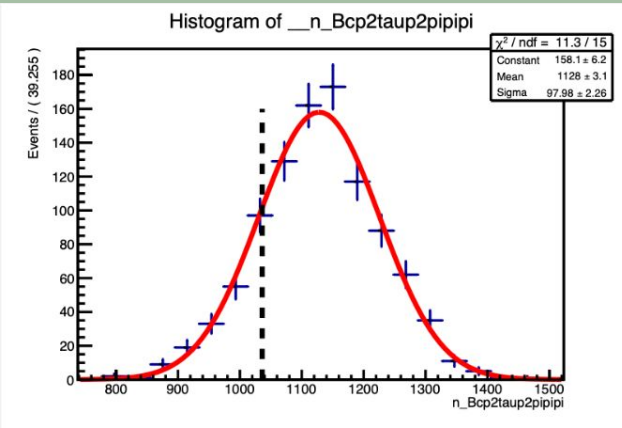
4. Performing pseudo-experiment fit studies to measure the signals yields

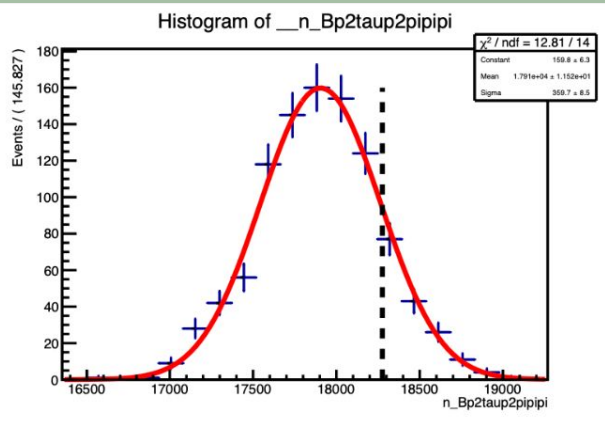


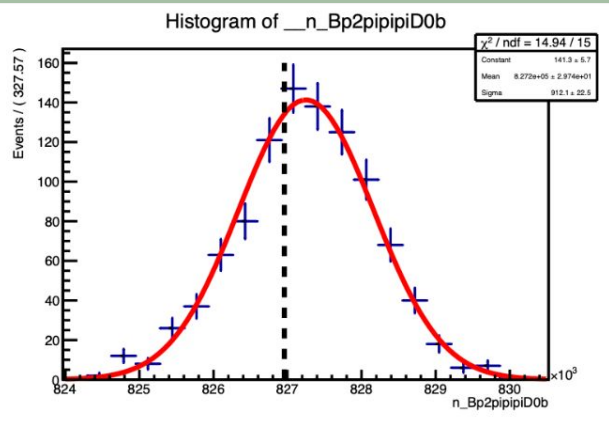
MC study: bias in the yields

Perform the yield fit $\mathcal{N}$ times using $\mathcal{N}$ datasets and compare to the input (true) yield

$B_c^+ \to \tau^+ \nu_\tau$ $B^+ \to \tau^+ \nu_\tau$ $B^+ \to \bar{D}^0 3\pi$







Conclusions

It’s all a work in progress!
A lot of progress has been made, but there’s still plenty of room for improvement…

- Improvements on the simulated data which doesn’t include intermediate resonances
- Introduce cuts on the observables
- Improve MVA

Thanks for the attention!