

# Angular analysis of $B^0 \rightarrow K^{*0} e^+ e^-$ decays at low $q^2$ with the LHCb detector

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PHENIICS Fest 2024

Marie Hartmann

# The LHCb experiment

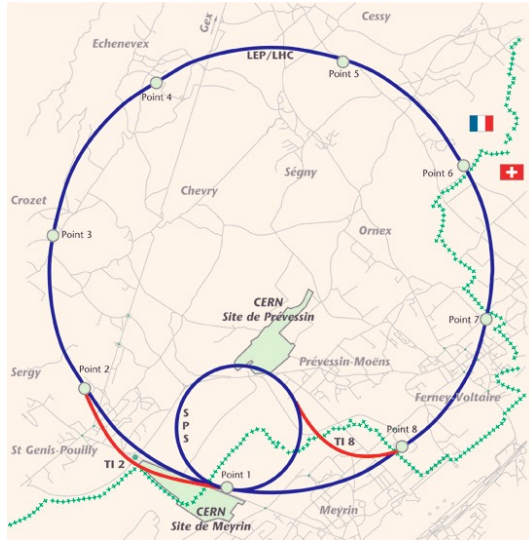
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  - Precision studies of b and c quarks
  - Goal: Indirectly constrain the Standard Model (SM)

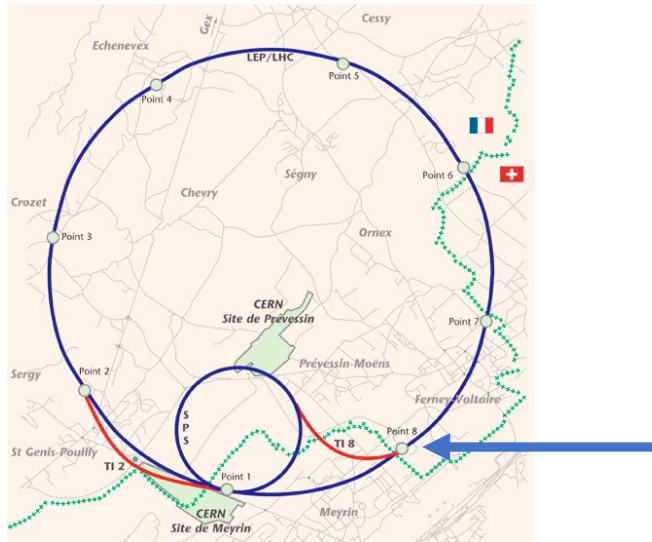
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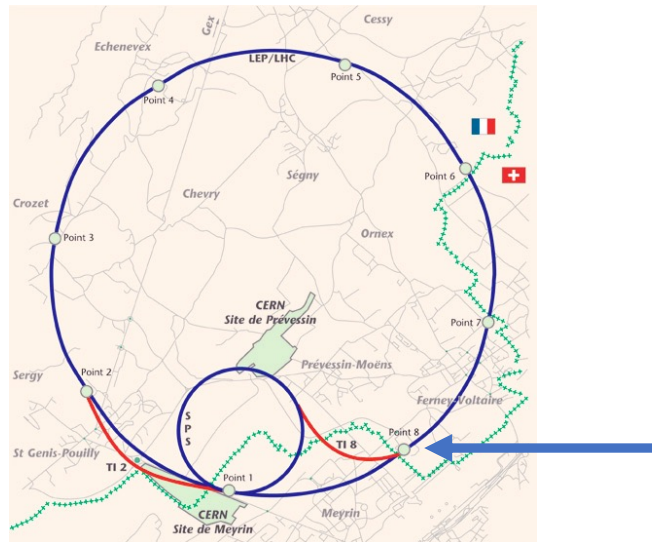
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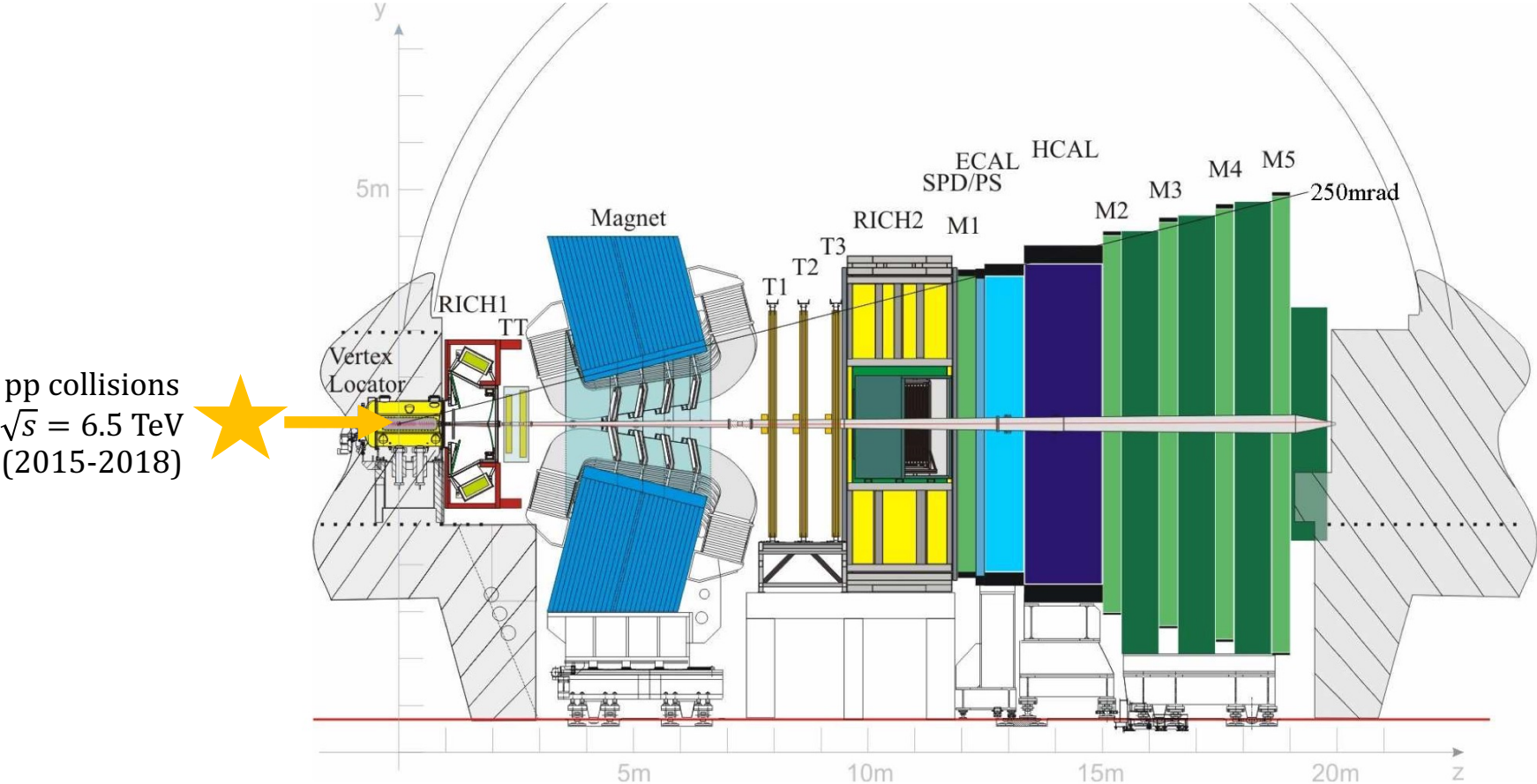
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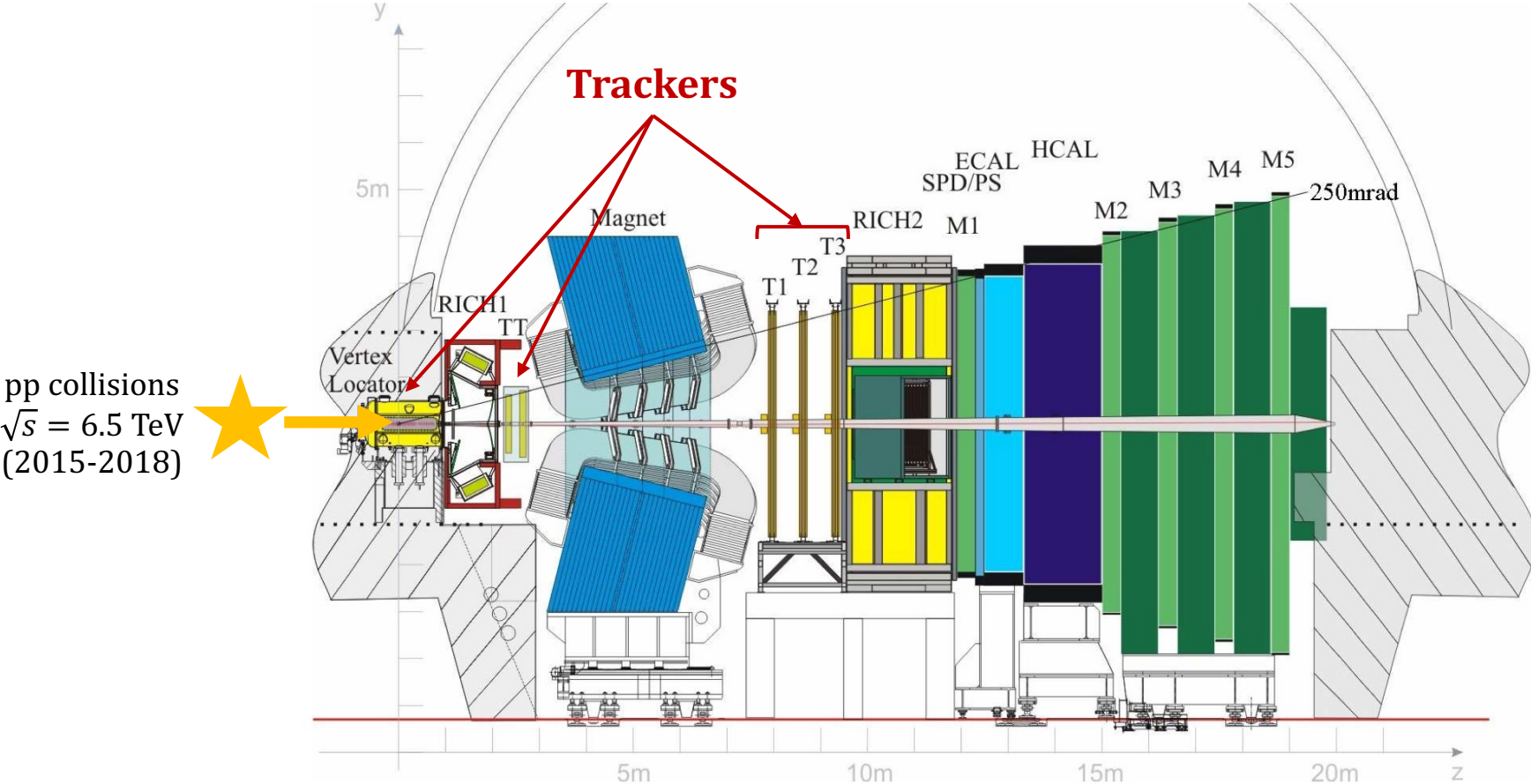




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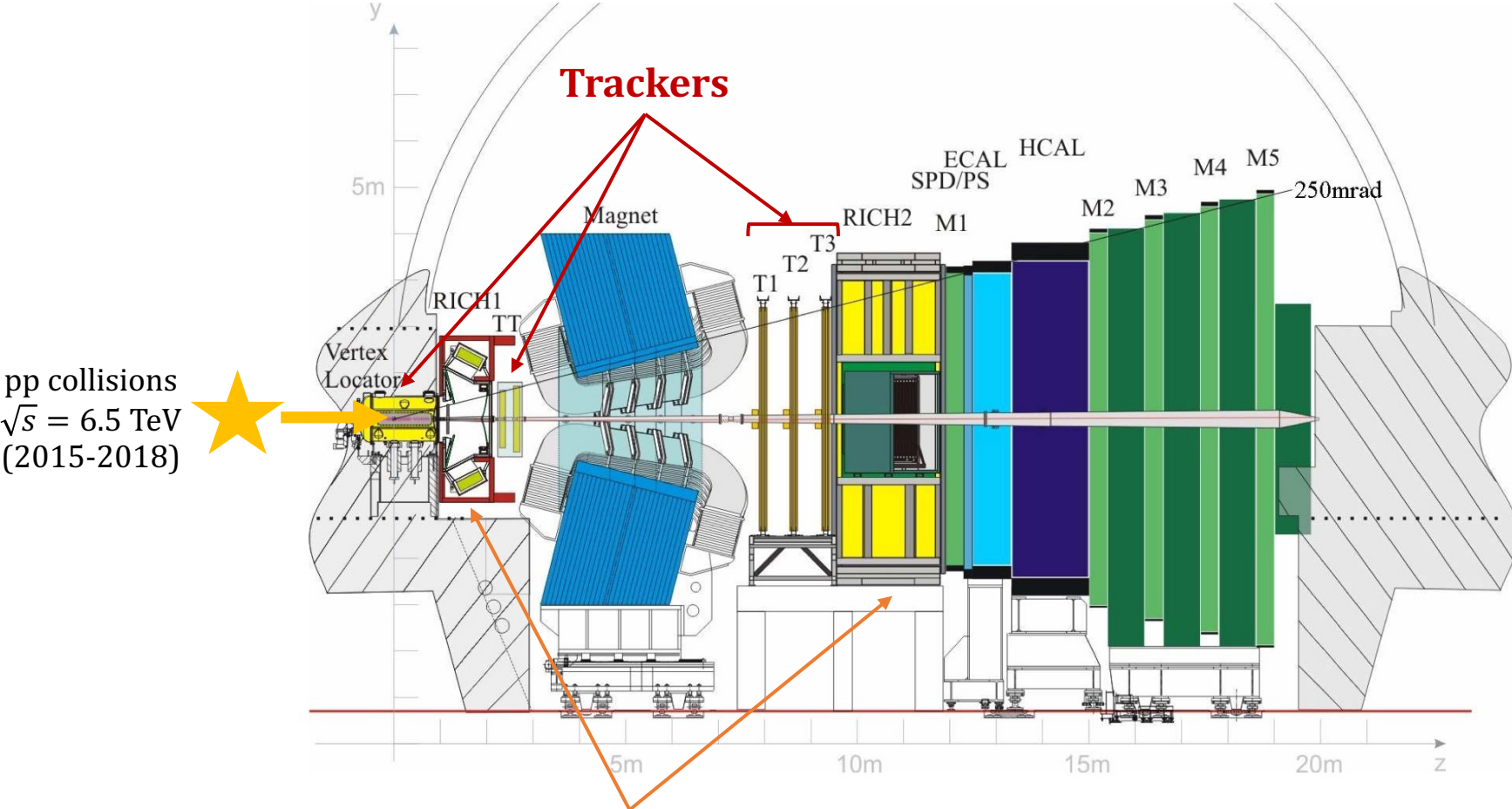


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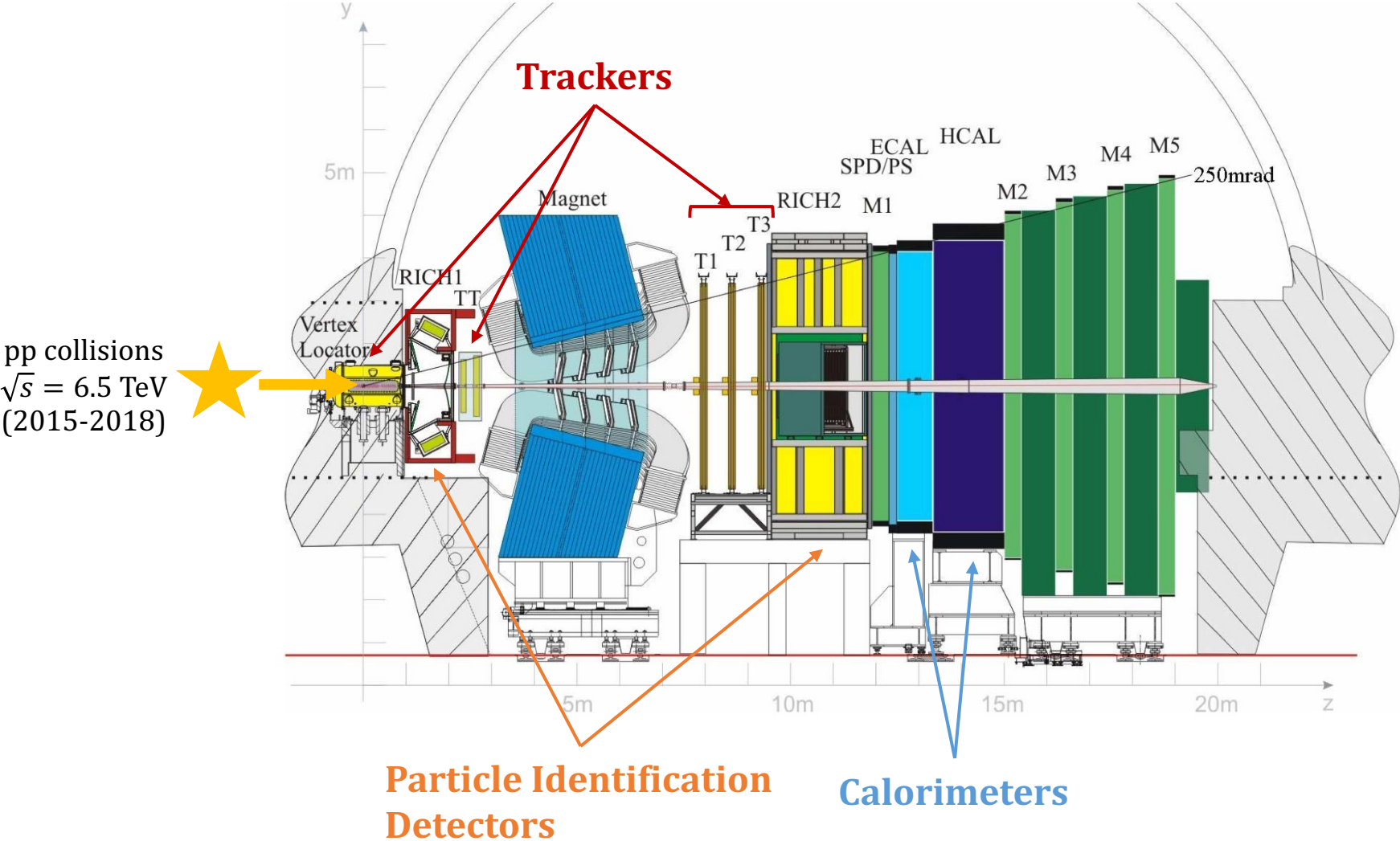
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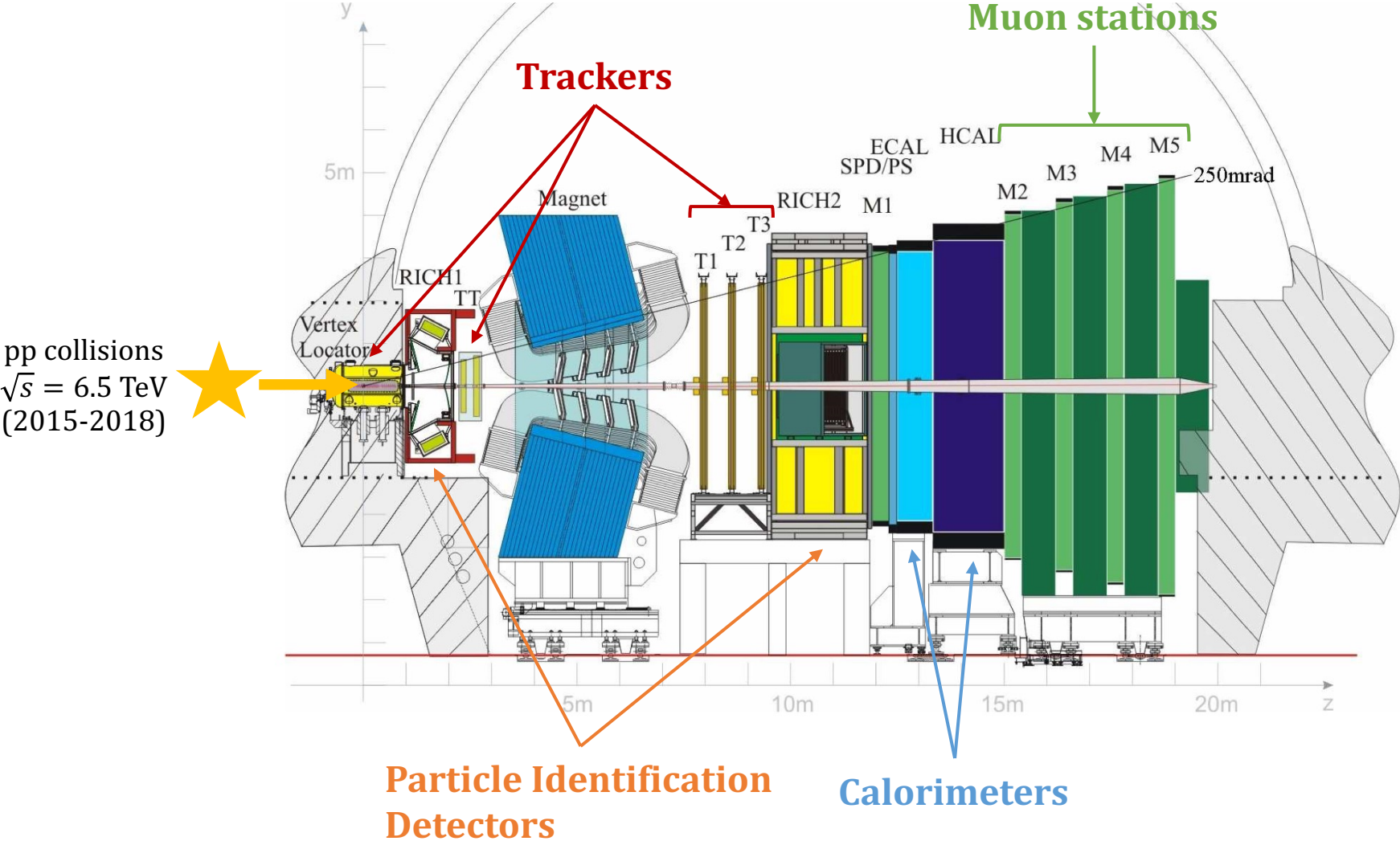
pp collisions  
 $\sqrt{s} = 6.5 \text{ TeV}$   
(2015-2018)

## Particle Identification Detectors

# The LHCb detector



# The LHCb detector

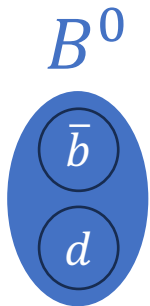


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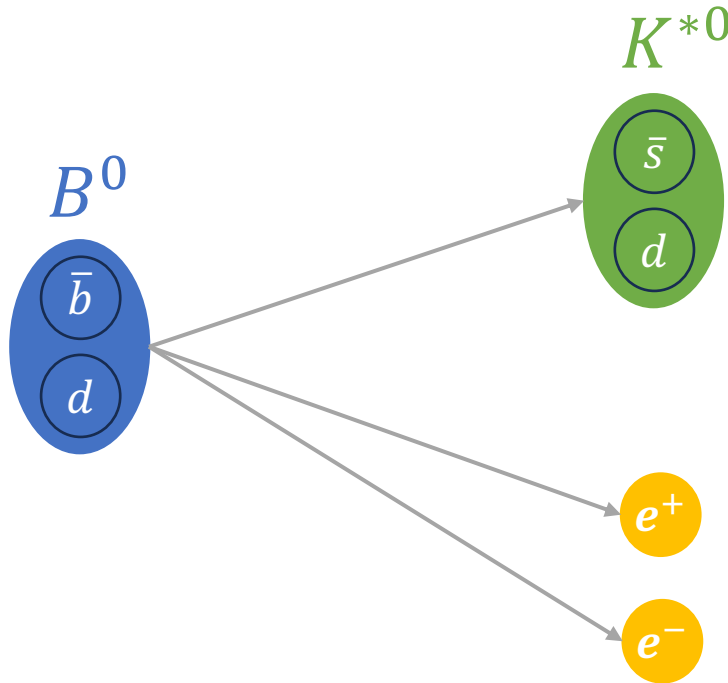
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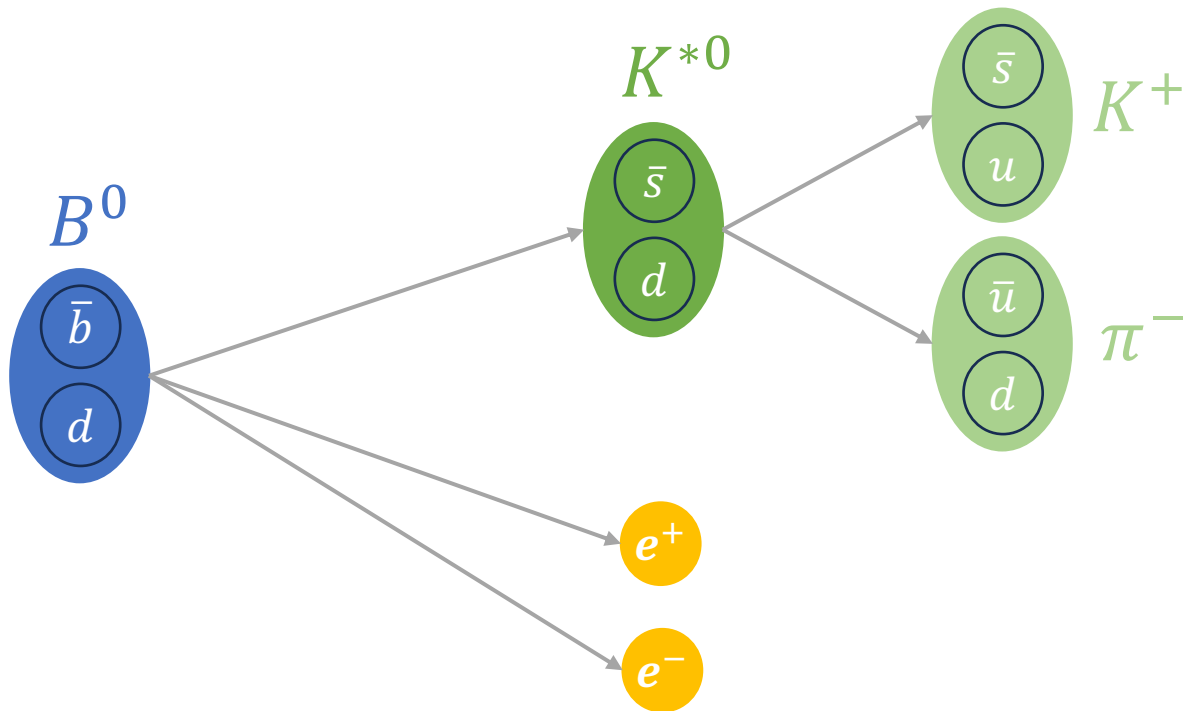
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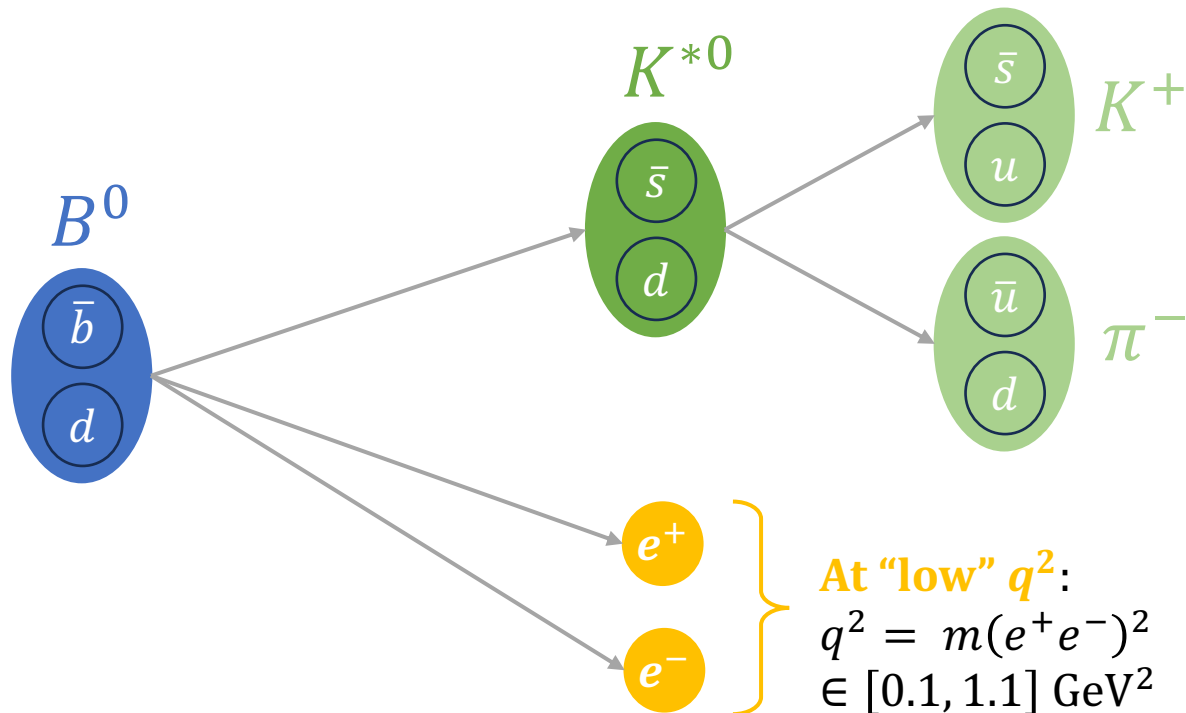
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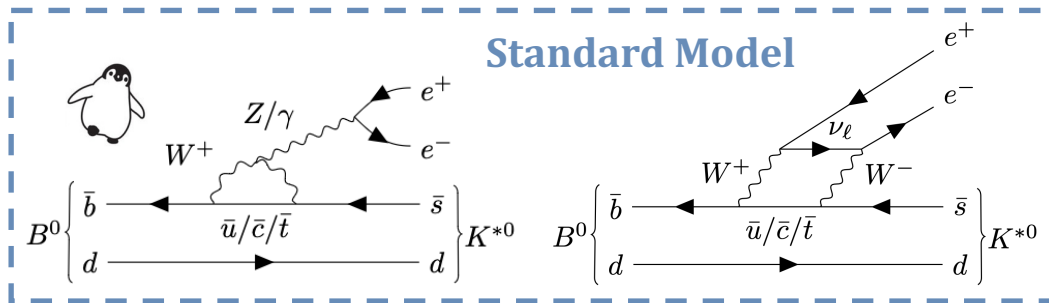
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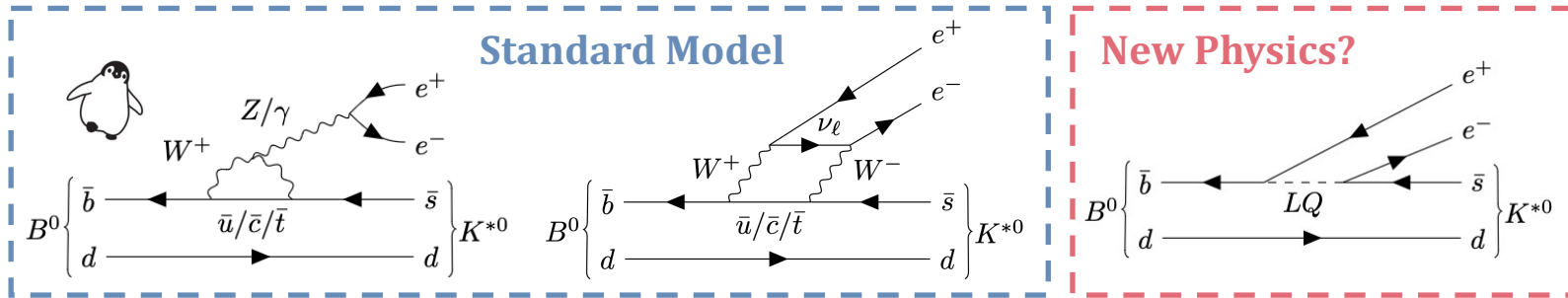
# Theoretical framework

- $B^0 \rightarrow K^{*0} e^+ e^-$  decays are strongly suppressed in the Standard Model (SM):  $\text{BF}(B^0 \rightarrow K^{*0} e^+ e^-) \sim 10^{-6}$



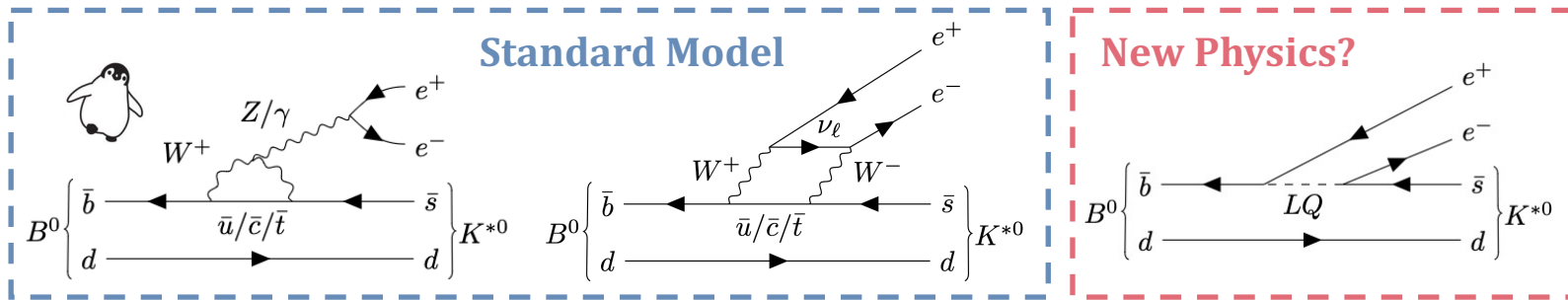
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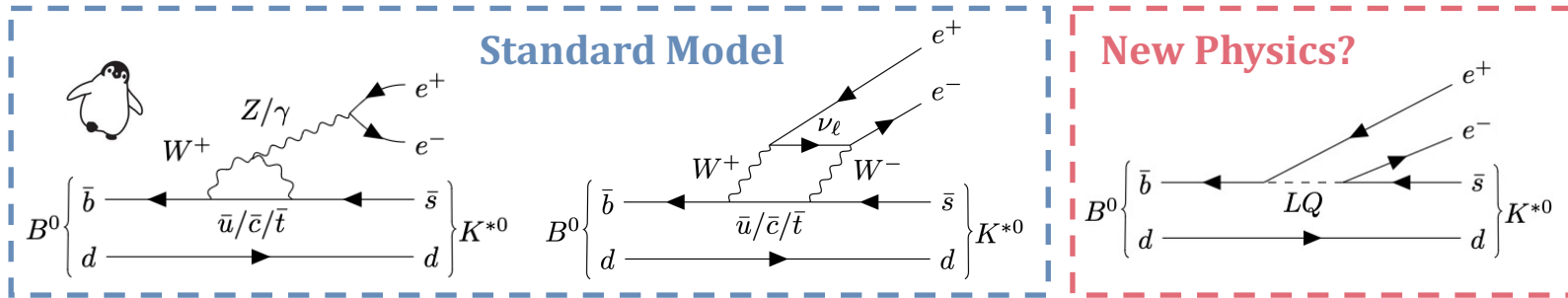


- Hamiltonian of the decay:

$$H_{\text{eff}}(b \rightarrow s \ell \ell) = -\frac{4G_F}{\sqrt{2}} \frac{\alpha_e}{4\pi} V_{tb} V_{ts}^* \sum_i (\underline{C}_i O_i + \underline{C}'_i O'_i) + h.c.,$$

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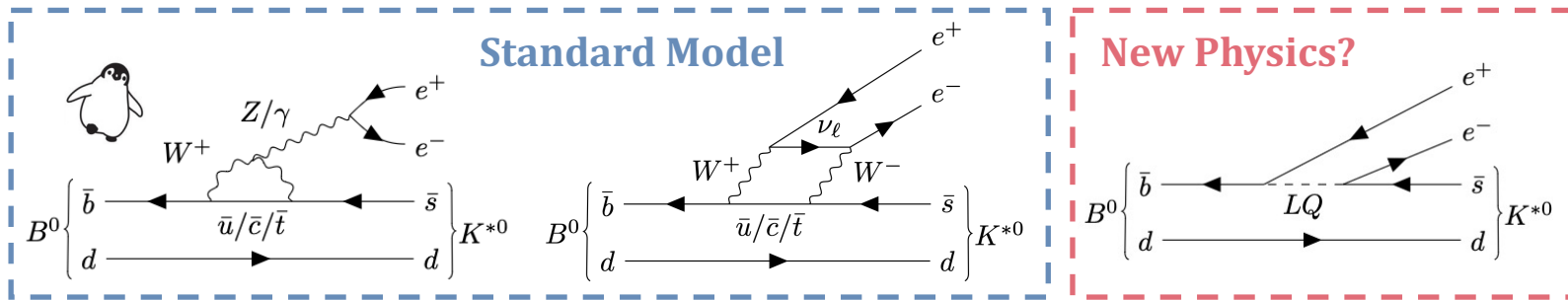
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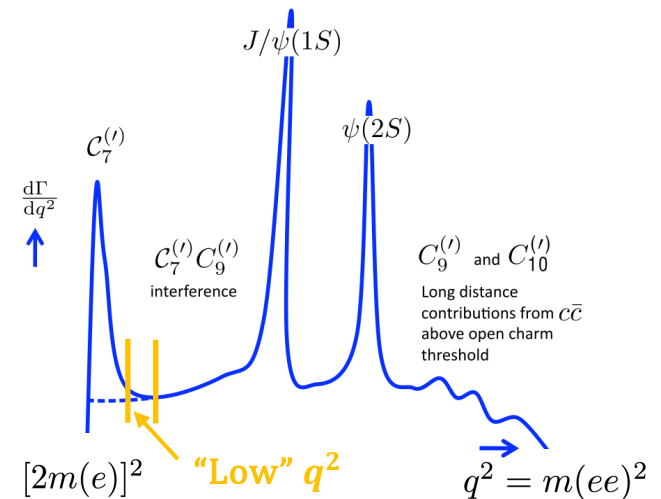
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- Angular observables can be expressed in terms of  $\underline{C}_i^{(\prime)}$
- Different  $q^2 = m(e^+ e^-)^2$  zones will probe different Wilson coefficients  $\underline{C}_i^{(\prime)}$



# Angular analysis of $B^0 \rightarrow K^{*0} e^+ e^-$

- My PhD project is part of a broader LHCb analysis: Legacy angular analysis of  $B^0 \rightarrow K^{*0} e^+ e^-$ 
  - International team 
  - Study with LHCb data from:
    - Run1 (2011-2012)
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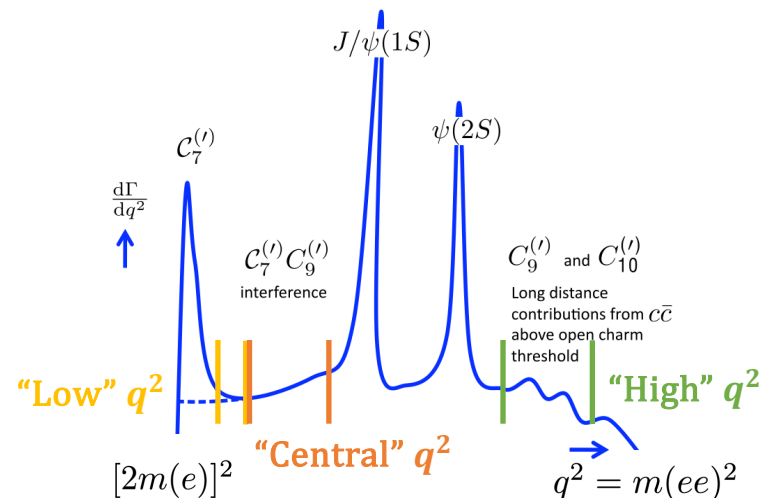
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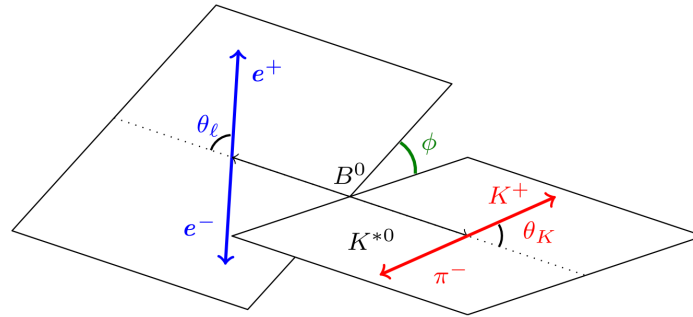
- 3 different  $q^2$  regions:

- “Low”  $q^2 \in [0.1, 1.1] \text{ GeV}^2$ ,
- “Central”  $q^2 \in [1.1, 6.0] \text{ GeV}^2$
- “High”  $q^2 \in [15.0, 19.0] \text{ GeV}^2$



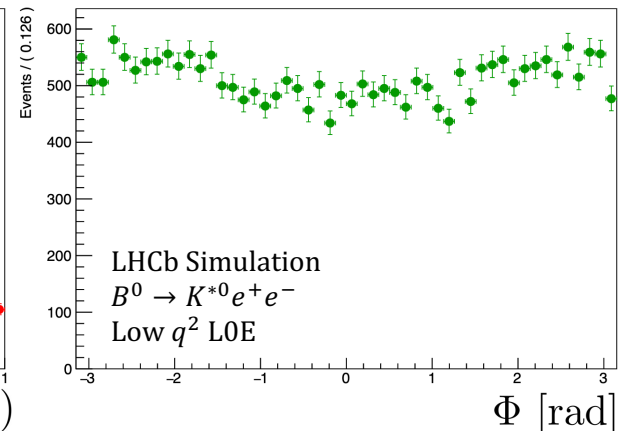
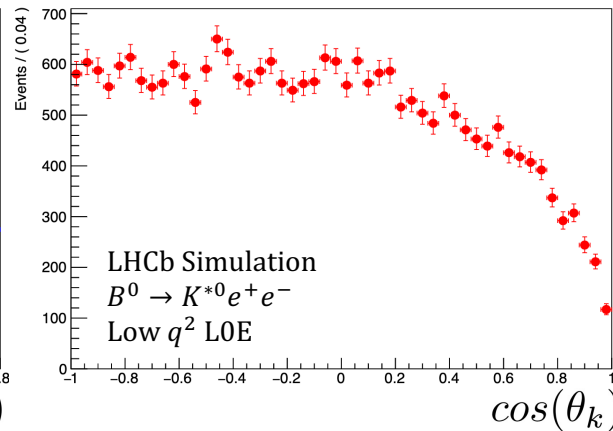
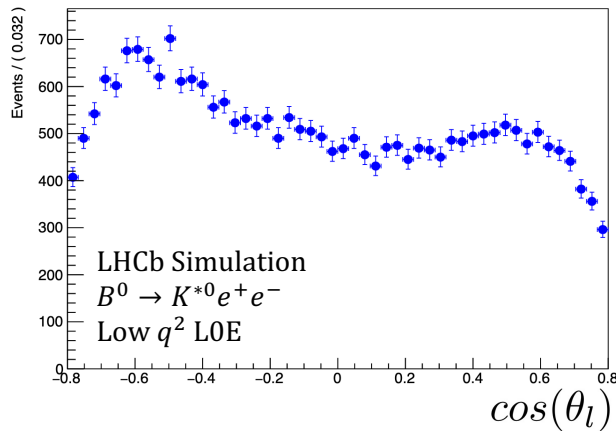
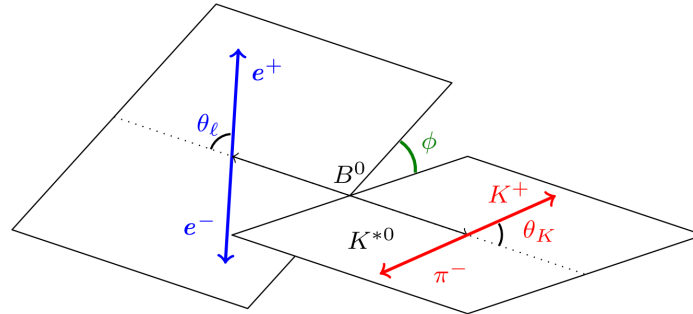
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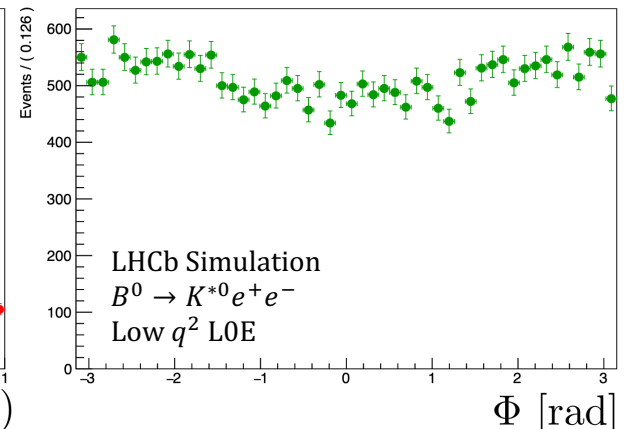
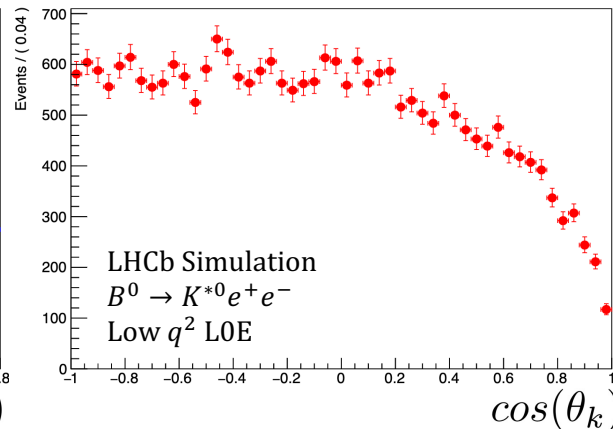
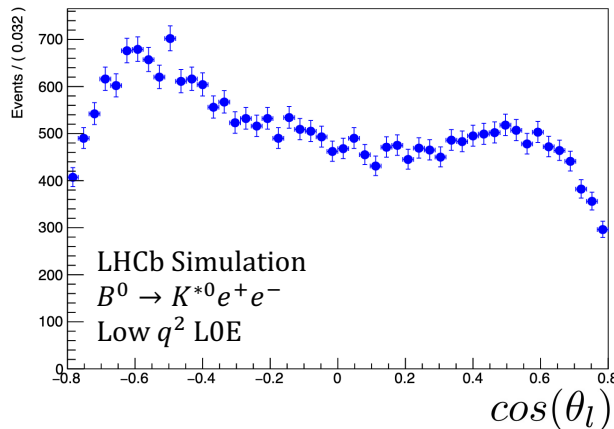
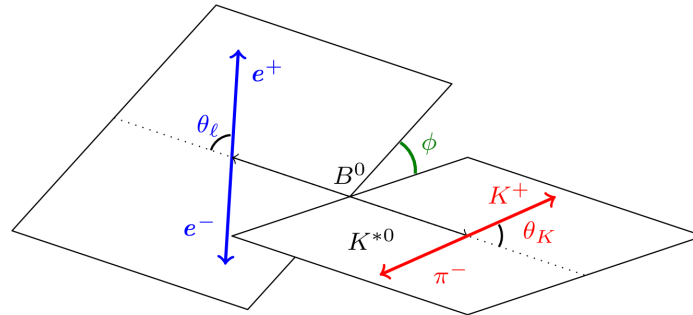
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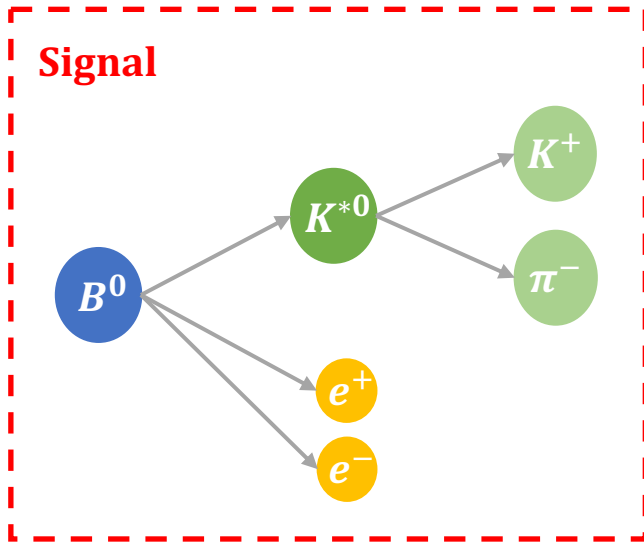


Fit the  $\cos(\theta_l)$ ,  $\cos(\theta_K)$ ,  $\Phi$  distributions and extract theory parameters.



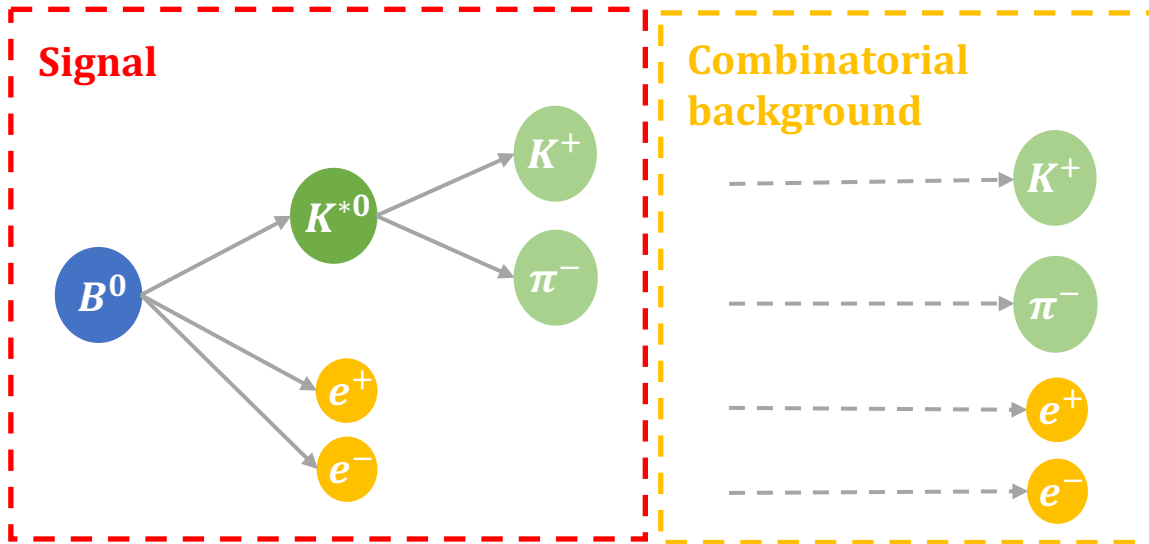
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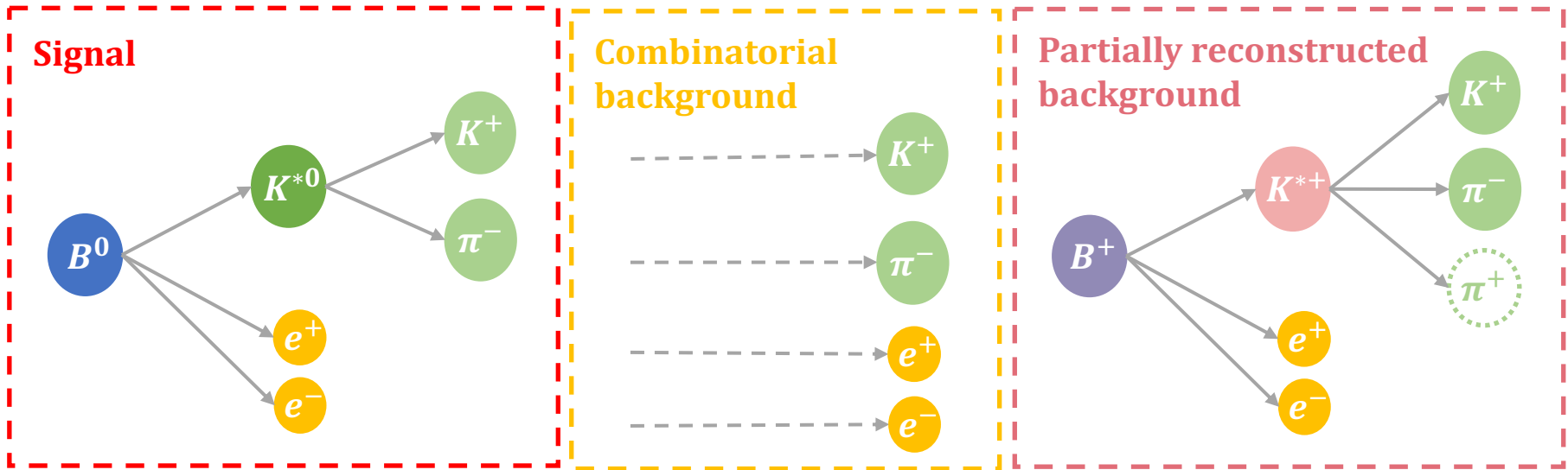
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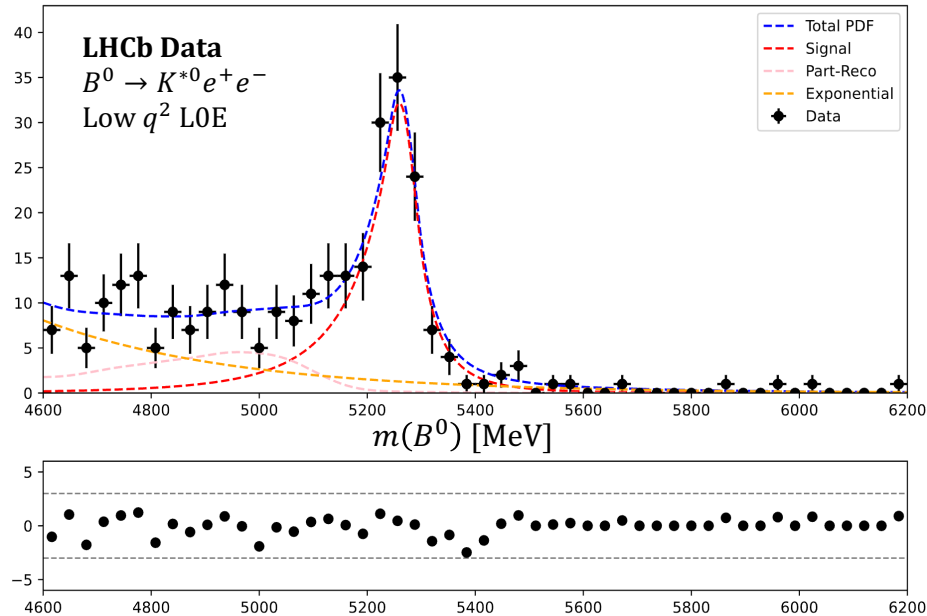
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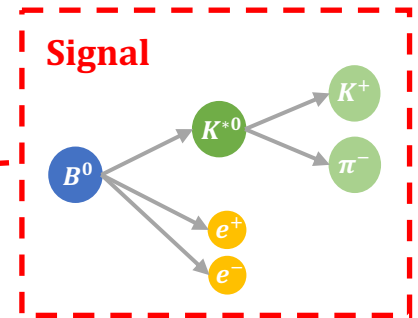
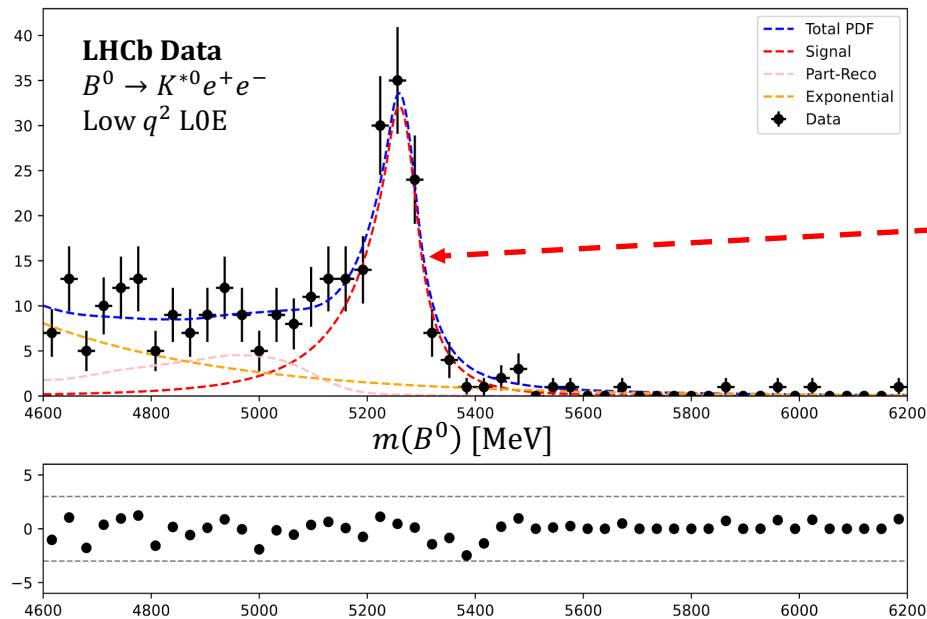
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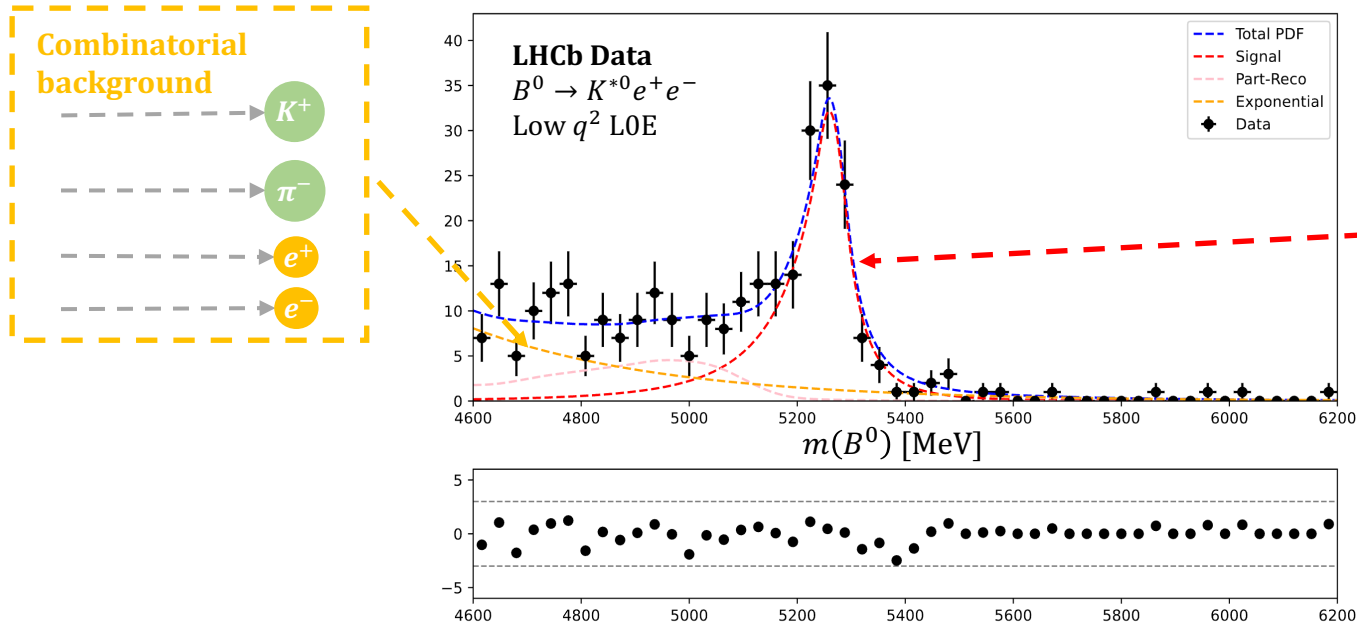
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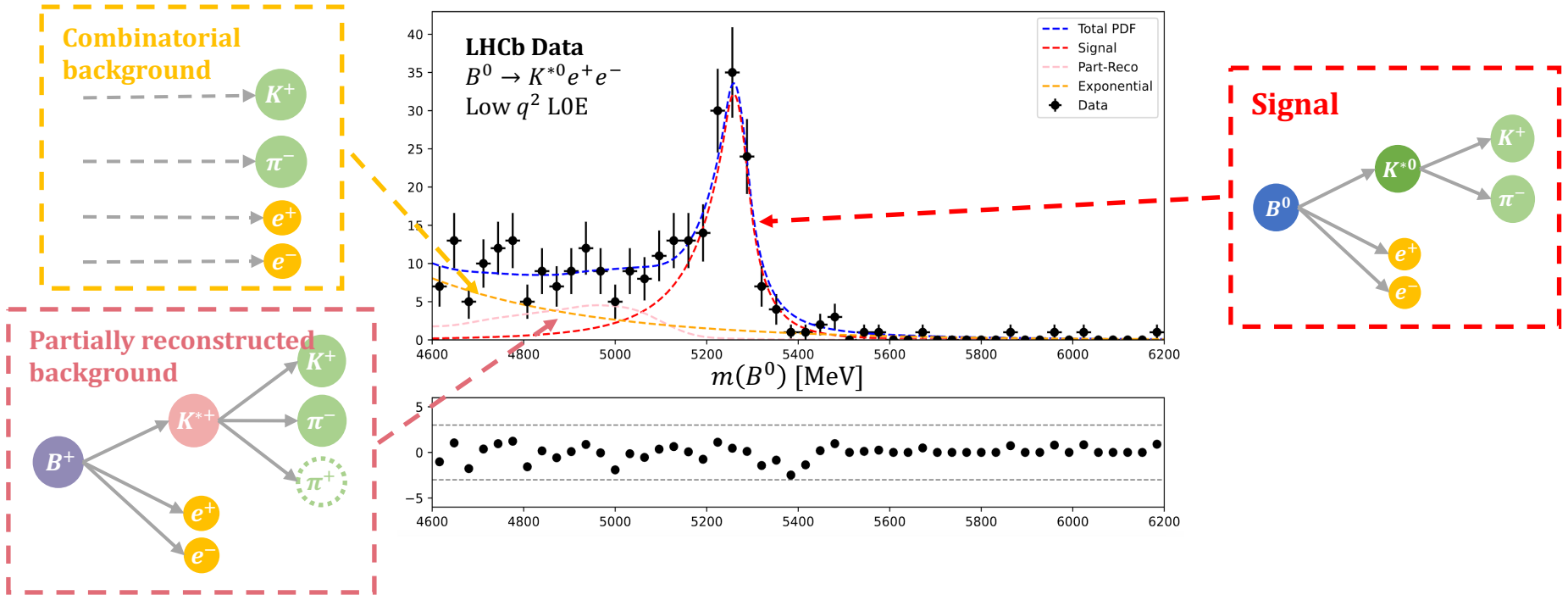
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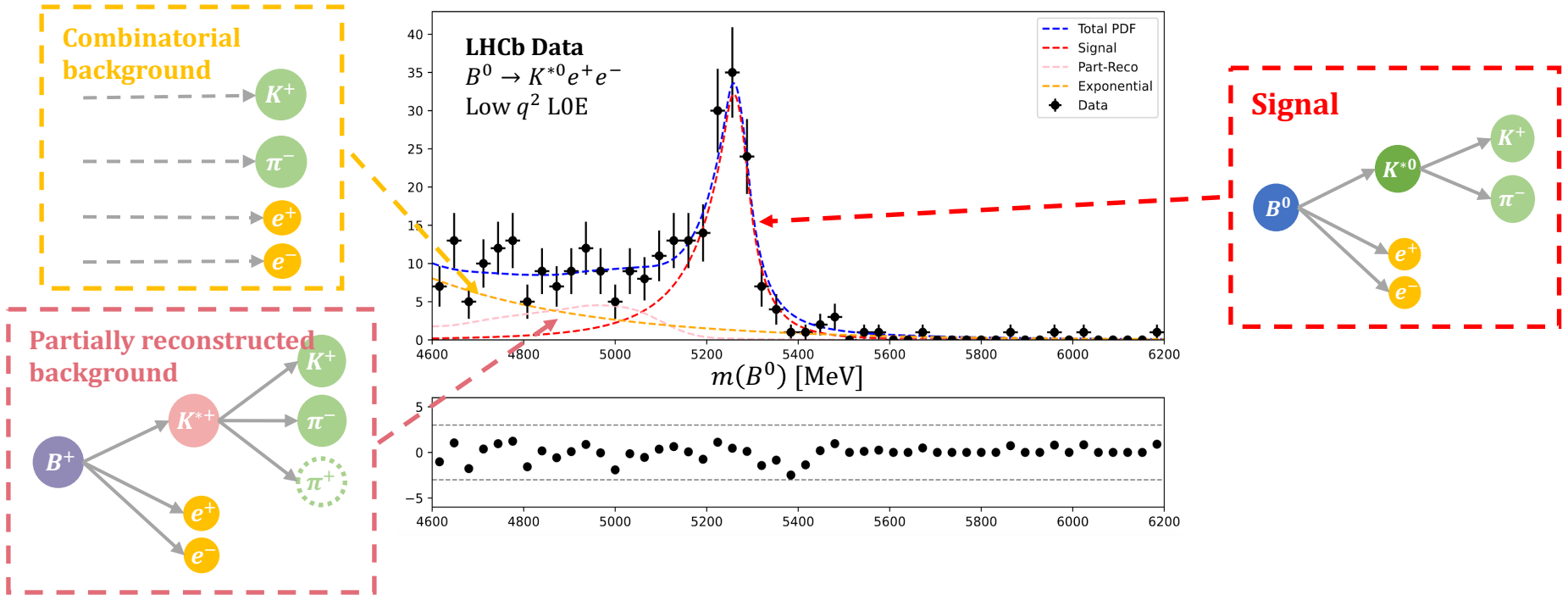
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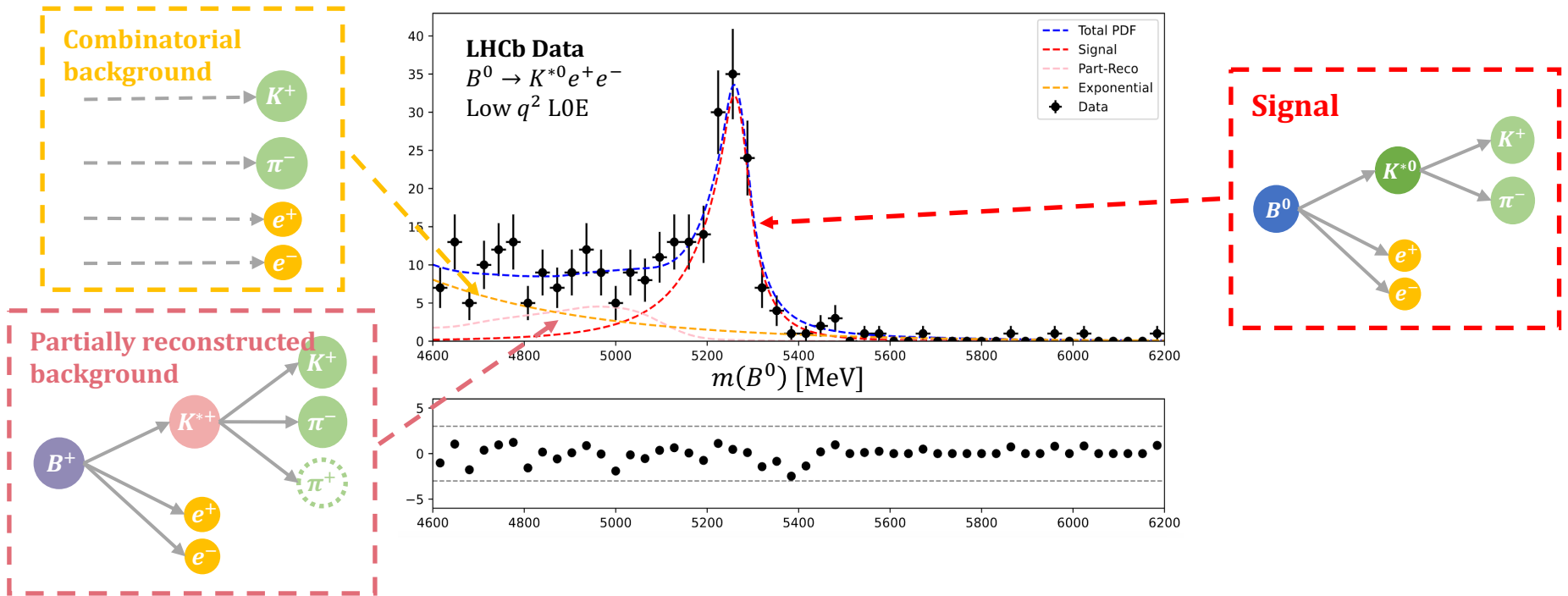
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How can we get the signal angular distributions?

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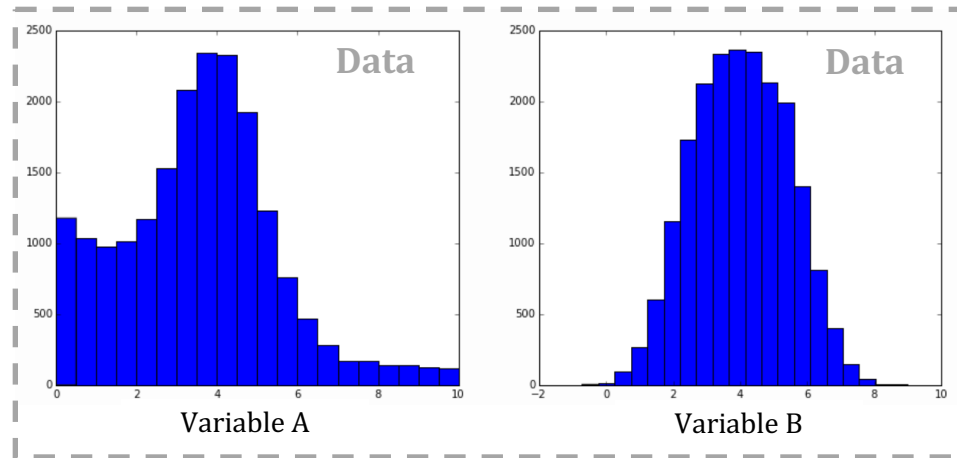
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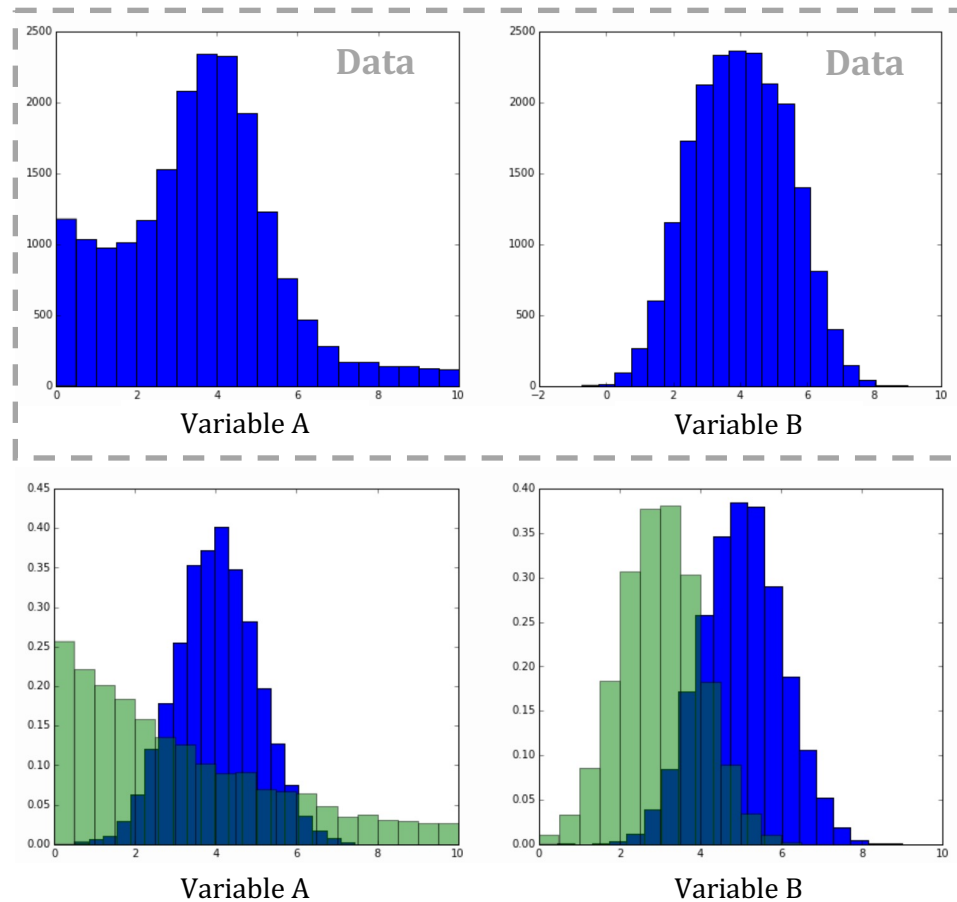
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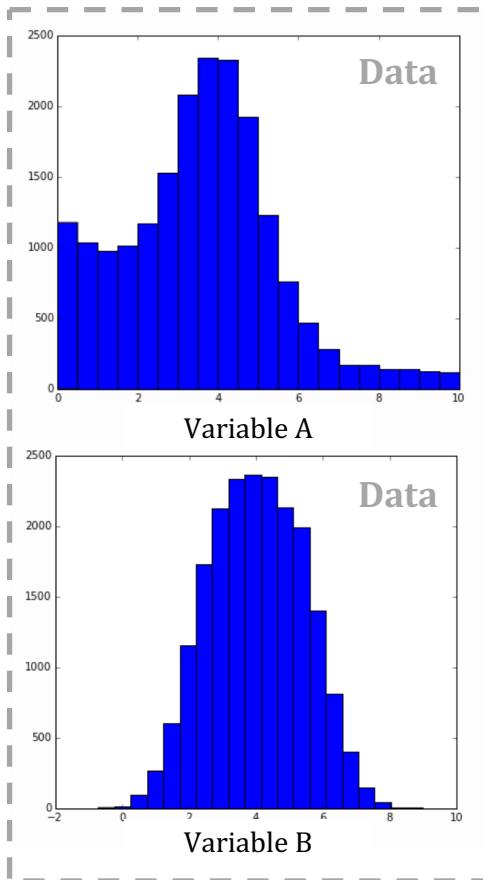


**Signal**  
**Background**

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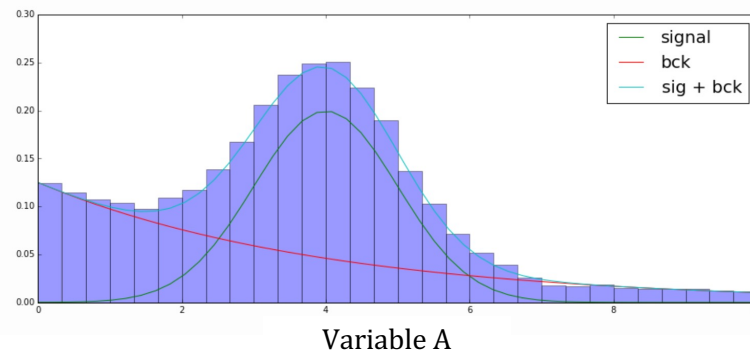
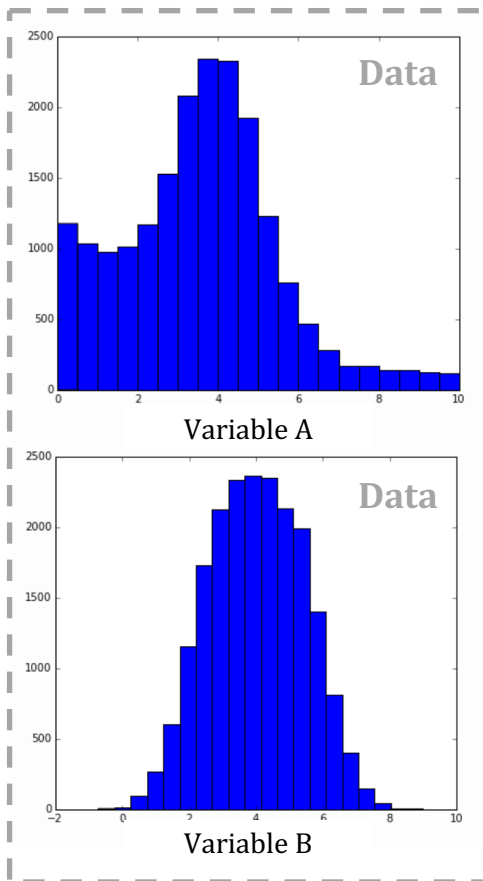
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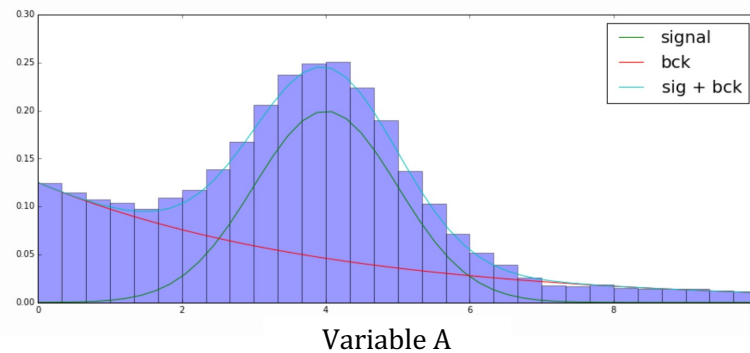
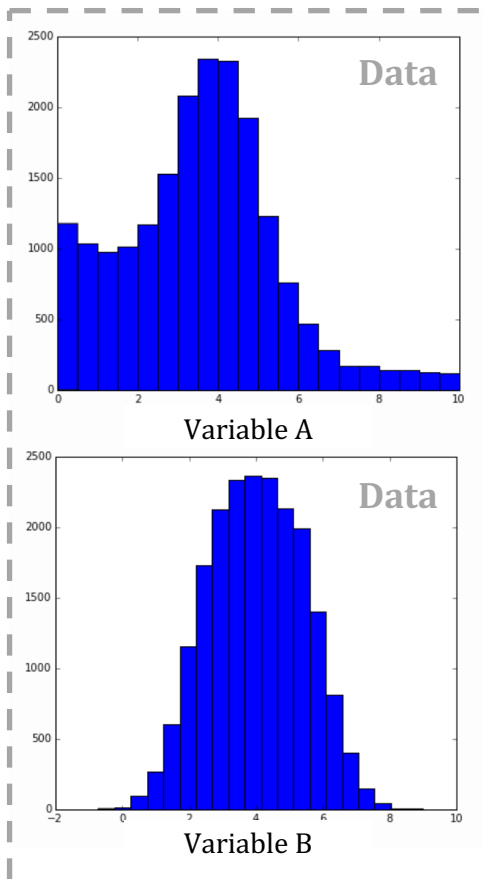




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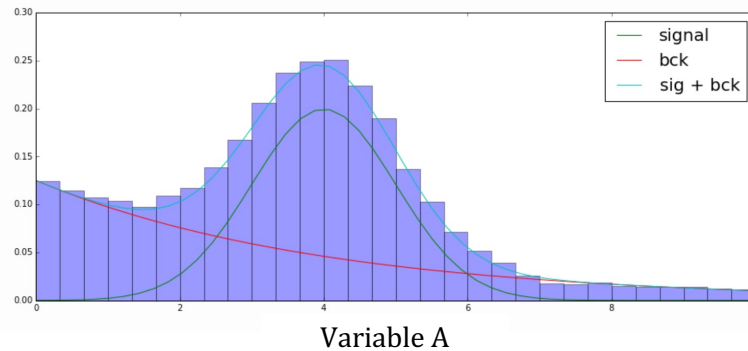
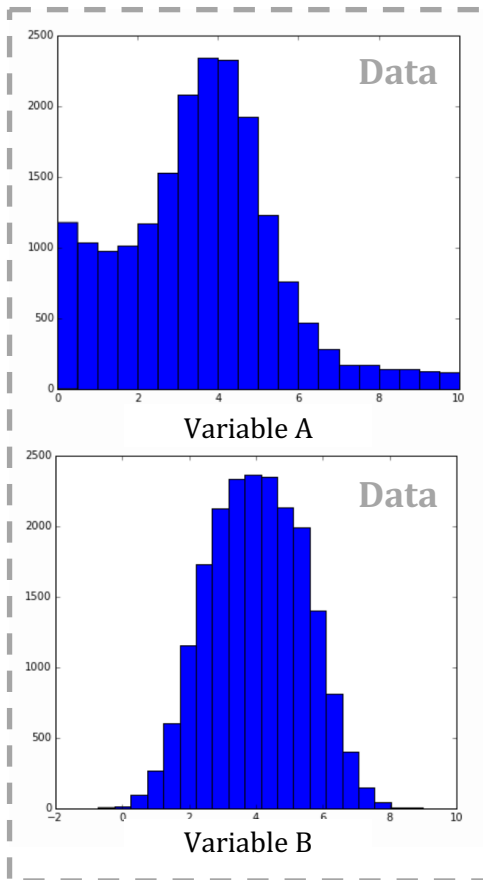


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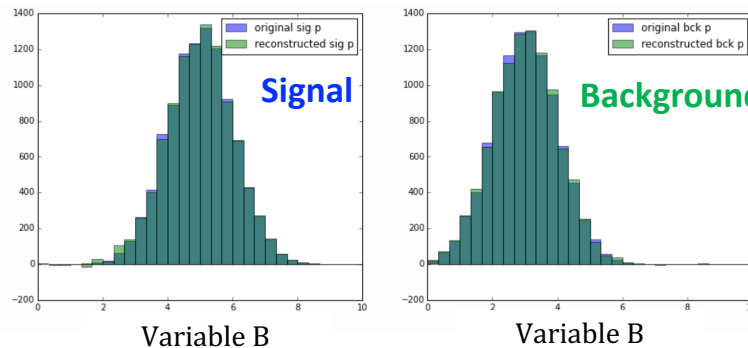
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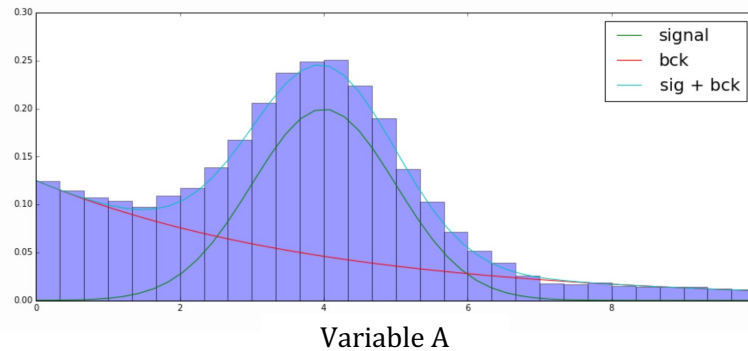
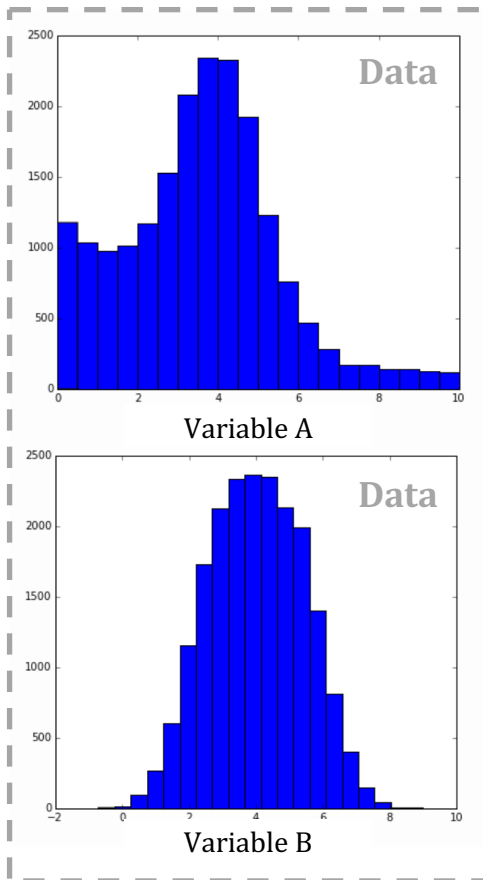
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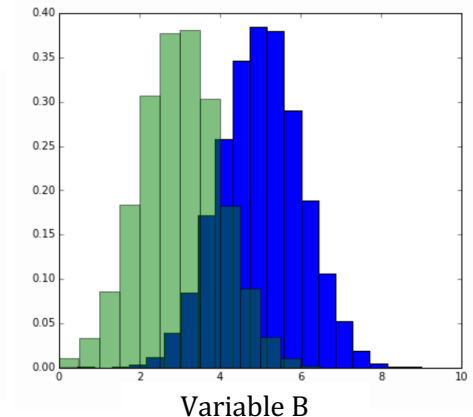
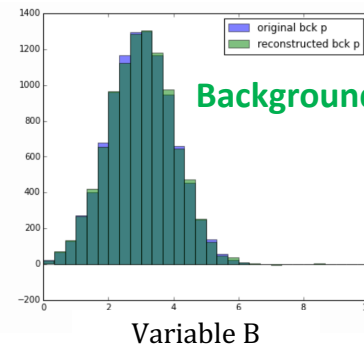
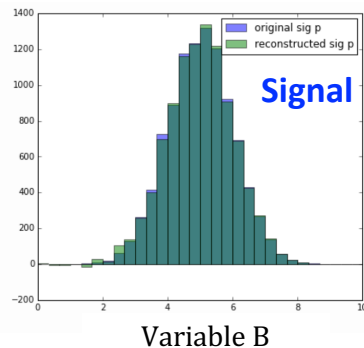
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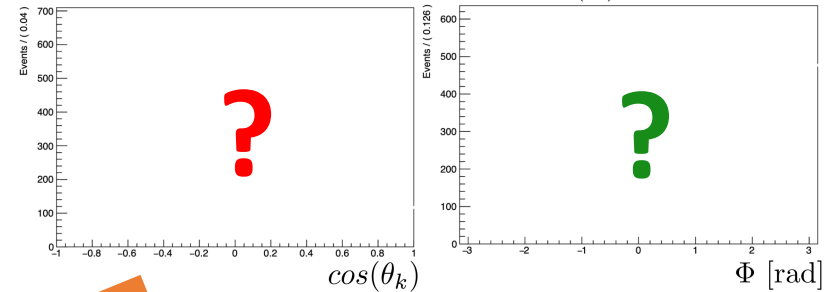
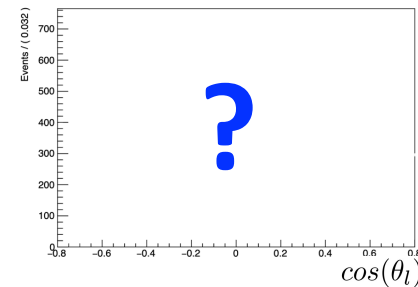
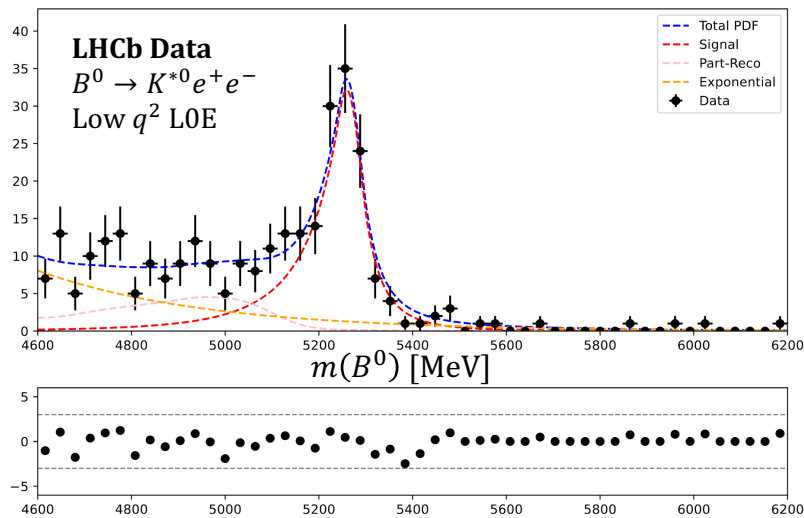


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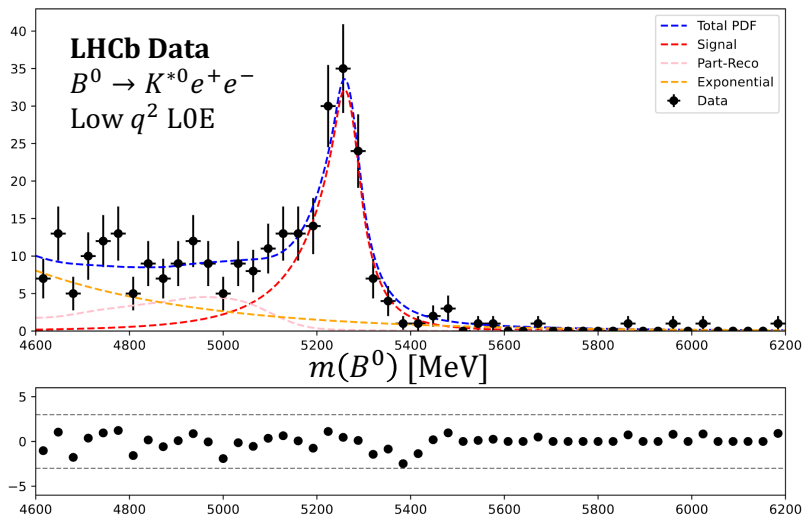
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- Analysis strategy: Fit the  $m(B^0)$  distribution (variable A) and use sPlot to get the signal-only distribution for  $\cos(\theta_l)$ ,  $\cos(\theta_K)$ ,  $\Phi$  (variable B).

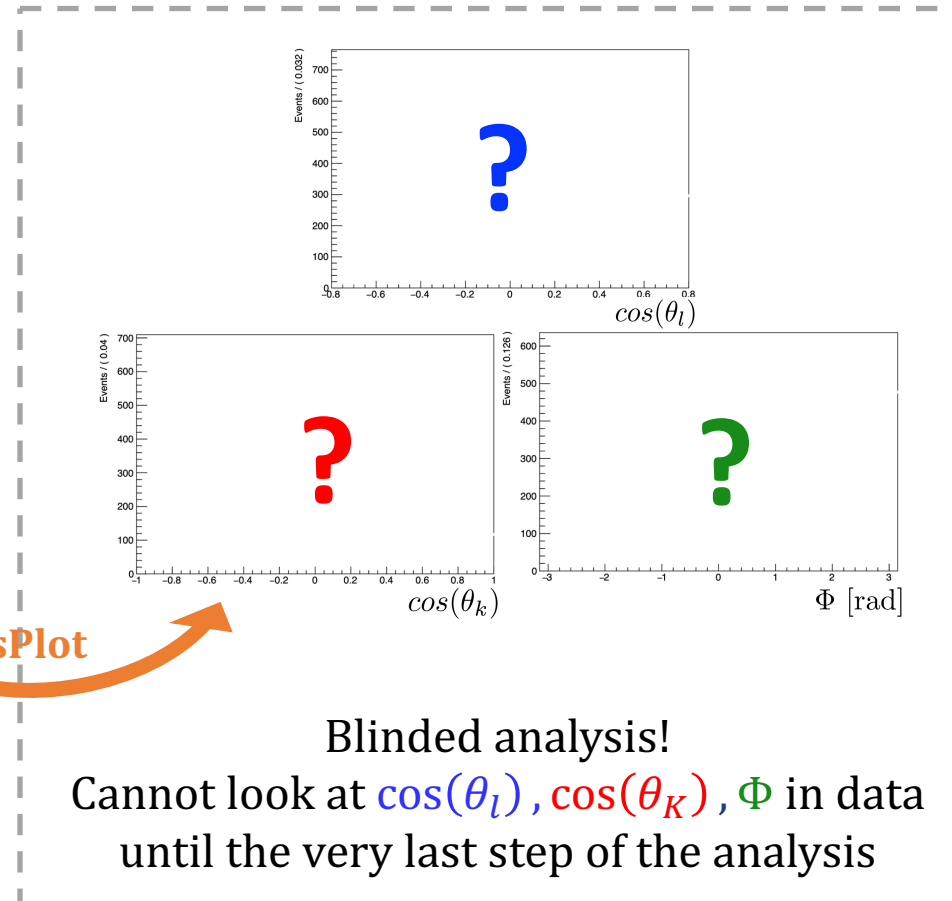


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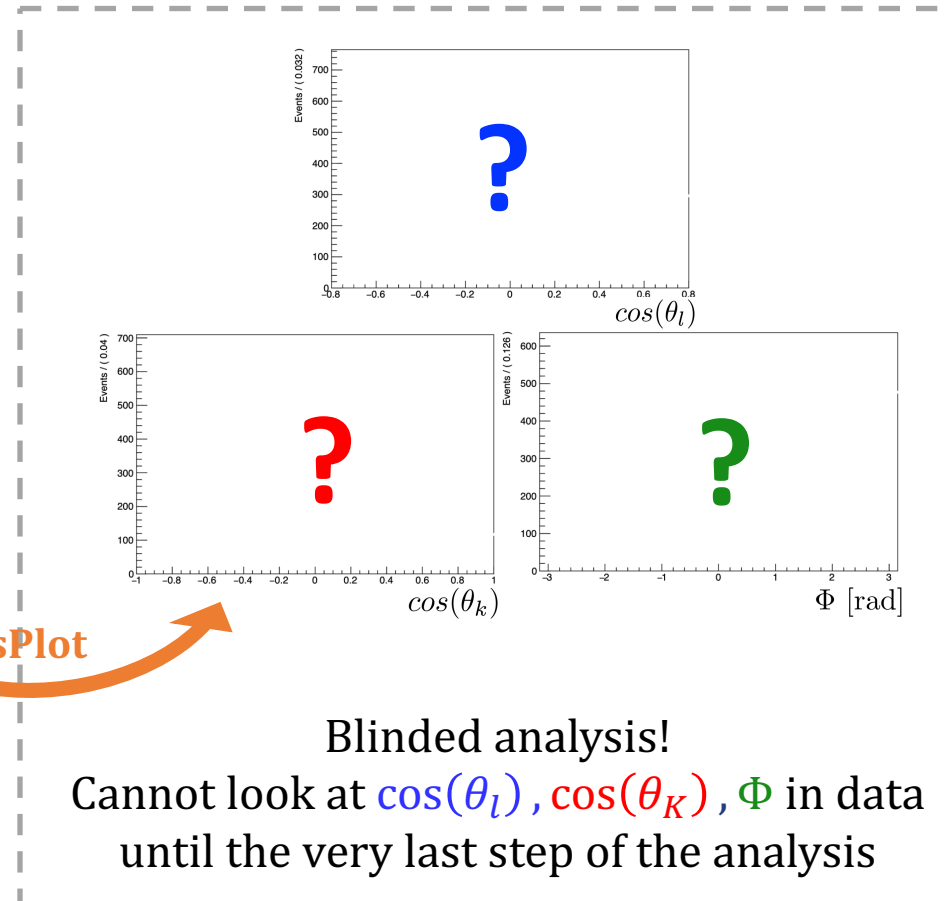
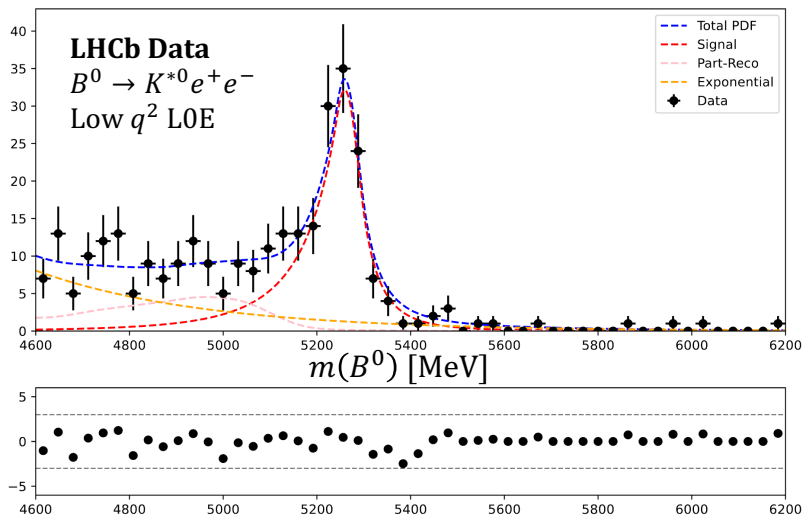
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Blinded analysis!  
Cannot look at  $\cos(\theta_l)$ ,  $\cos(\theta_K)$ ,  $\Phi$  in data until the very last step of the analysis

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At the core of my work at the moment!

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Cannot look at  $\cos(\theta_l)$ ,  $\cos(\theta_K)$ ,  $\Phi$  in data until the very last step of the analysis

# Angular analysis of $B^0 \rightarrow K^{*0} e^+ e^-$

- Testing robustness of sPlot for  $B^0 \rightarrow K^{*0} e^+ e^-$  angular analysis:

# Angular analysis of $B^0 \rightarrow K^{*0} e^+ e^-$

- Testing robustness of sPlot for  $B^0 \rightarrow K^{*0} e^+ e^-$  angular analysis:
  - Create toys

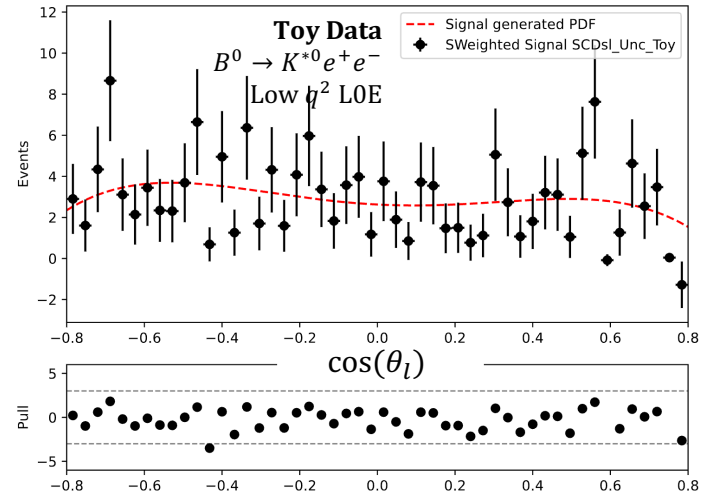
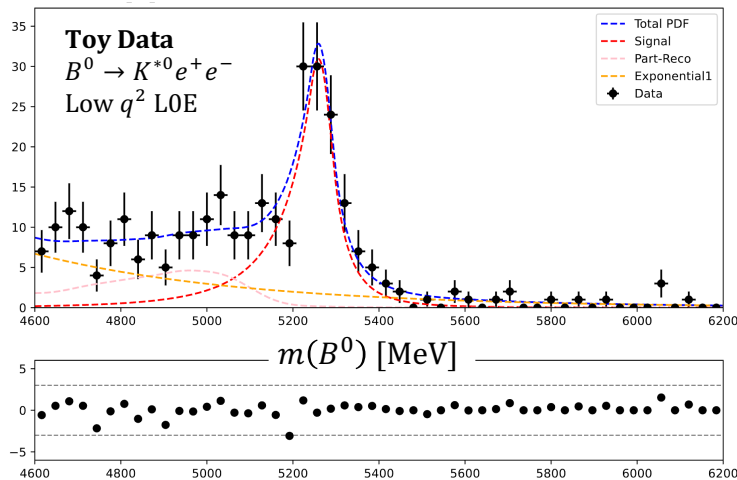


# Angular analysis of $B^0 \rightarrow K^{*0} e^+ e^-$

- Testing robustness of sPlot for  $B^0 \rightarrow K^{*0} e^+ e^-$  angular analysis:
  - Create toys
  - Test different scenarios and see the effects on the sPlot

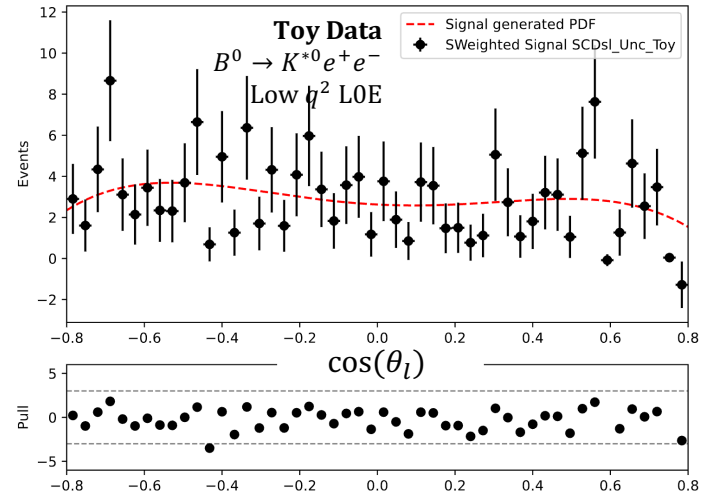
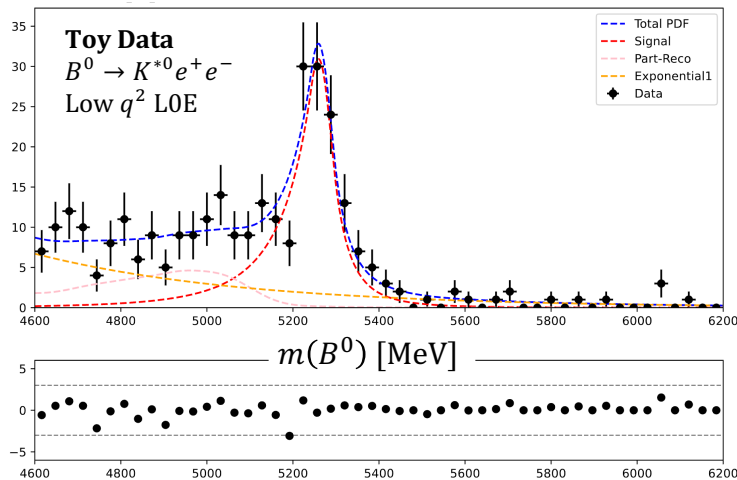
# Angular analysis of $B^0 \rightarrow K^{*0} e^+ e^-$

- Testing robustness of sPlot for  $B^0 \rightarrow K^{*0} e^+ e^-$  angular analysis:
  - Create toys
  - Test different scenarios and see the effects on the sPlot
  - Preliminary results with realistic toys:



# Angular analysis of $B^0 \rightarrow K^{*0} e^+ e^-$

- Testing robustness of sPlot for  $B^0 \rightarrow K^{*0} e^+ e^-$  angular analysis:
  - Create toys
  - Test different scenarios and see the effects on the sPlot
  - Preliminary results with realistic toys:



**Still under investigation!**

Thank you for your attention!

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