



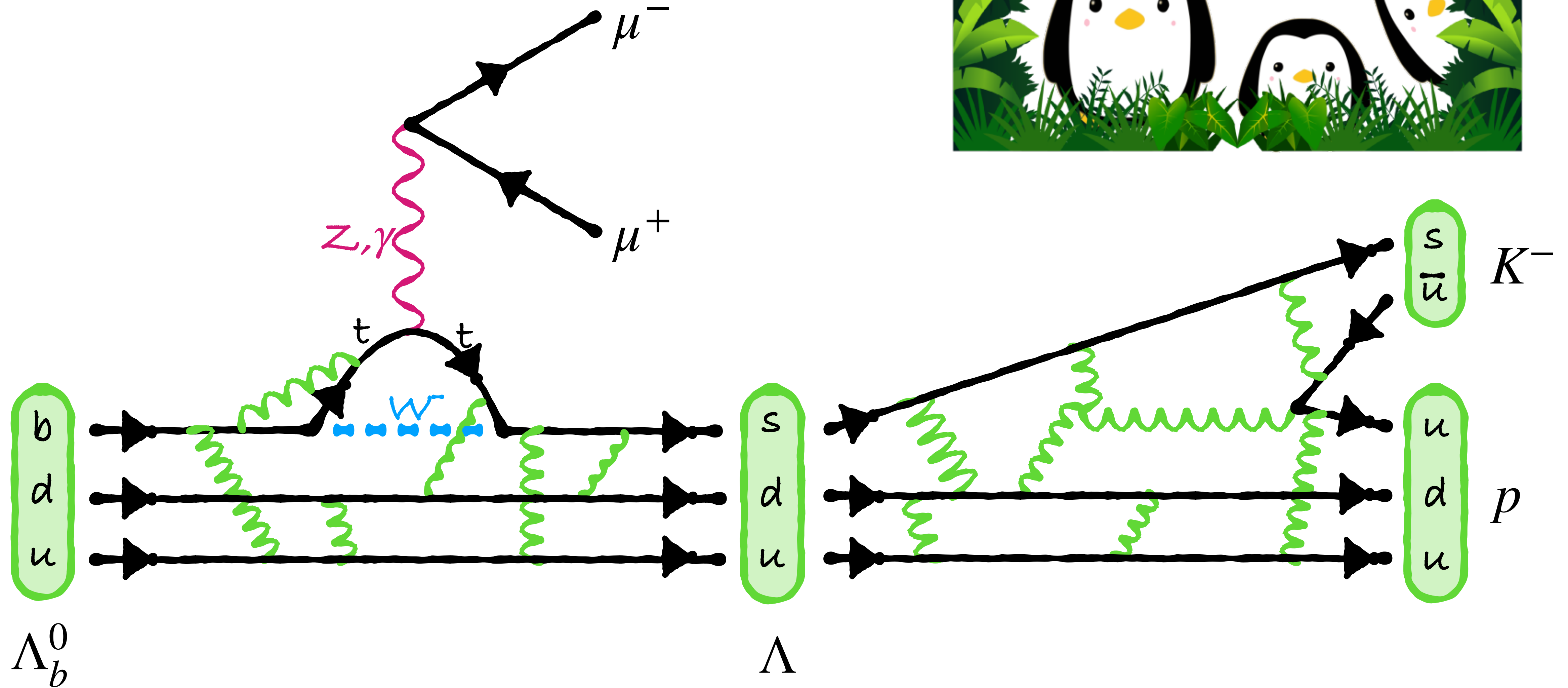
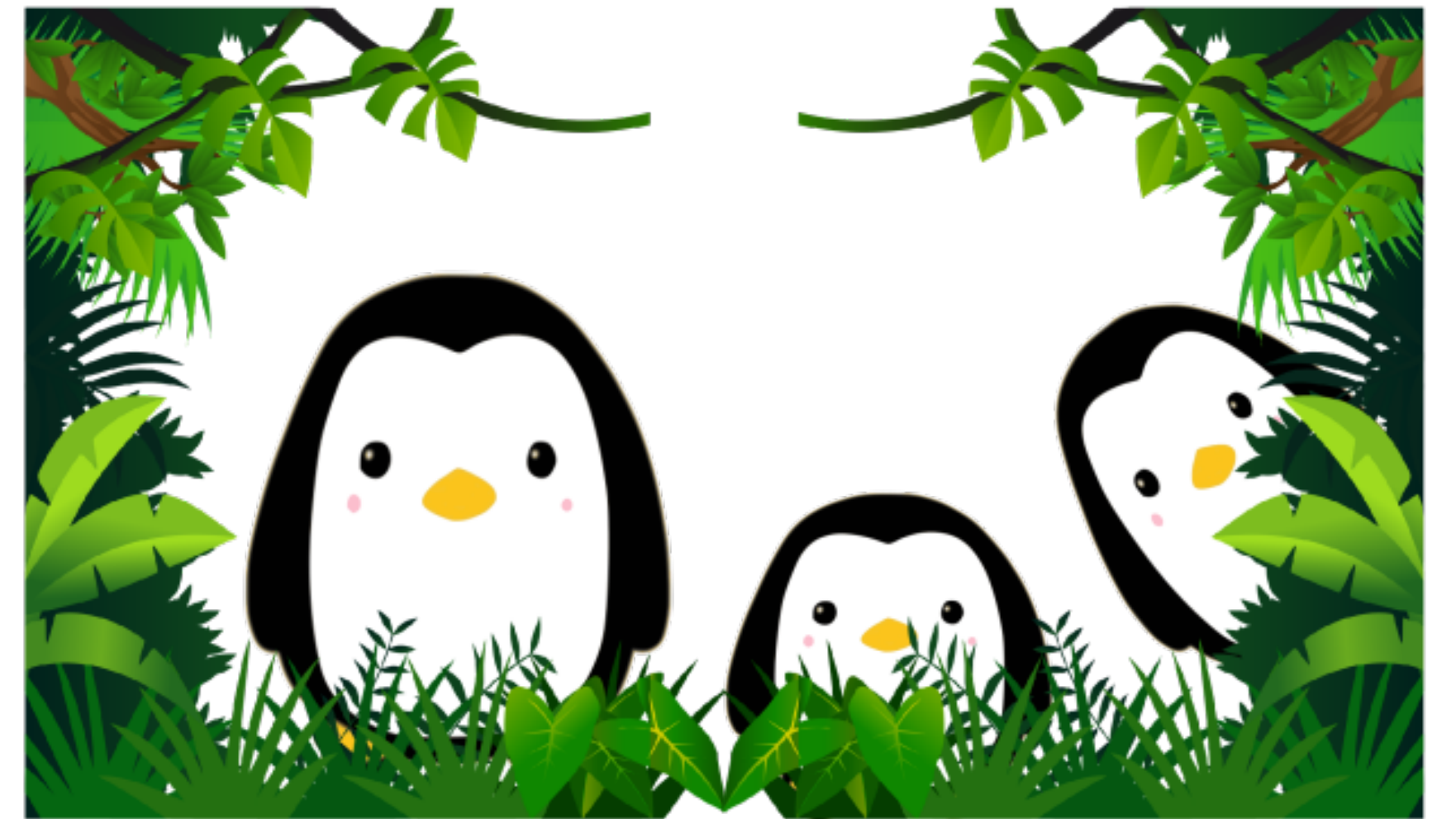
# Penguins in the jungle

And other things I did

Anja Beck

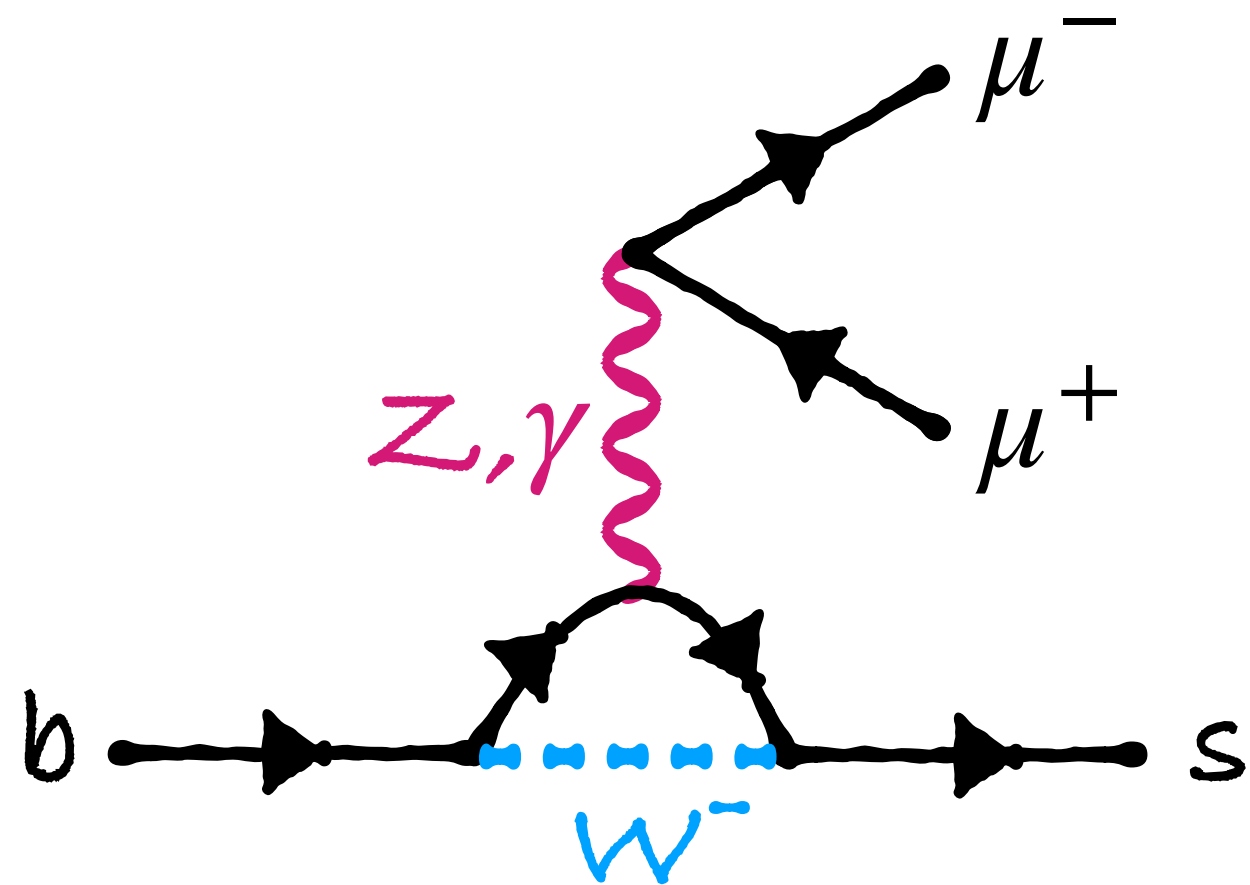
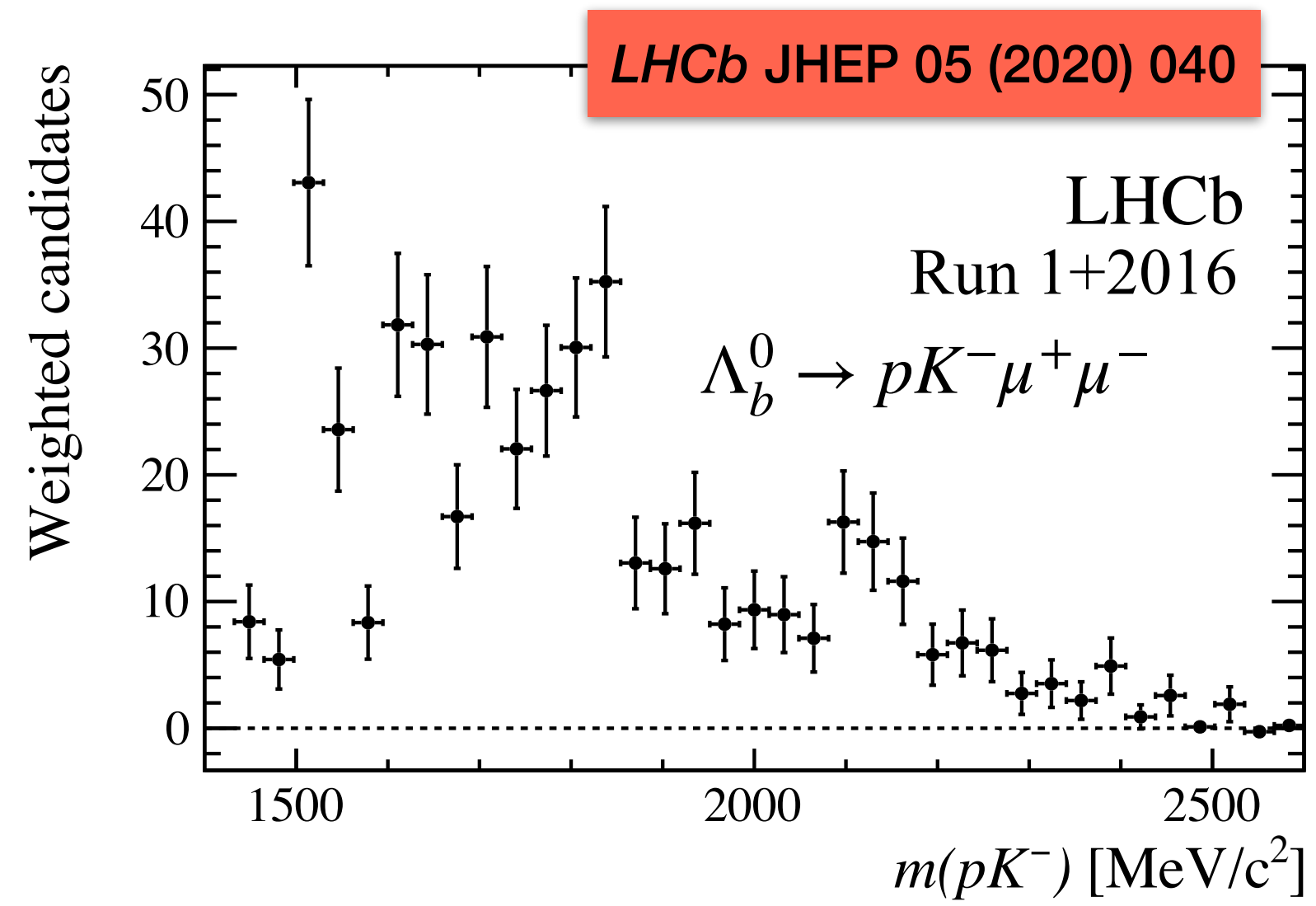
LHCb UK Annual Meeting 2025

# The $\Lambda_b^0 \rightarrow pK^- \mu^+ \mu^-$ decay

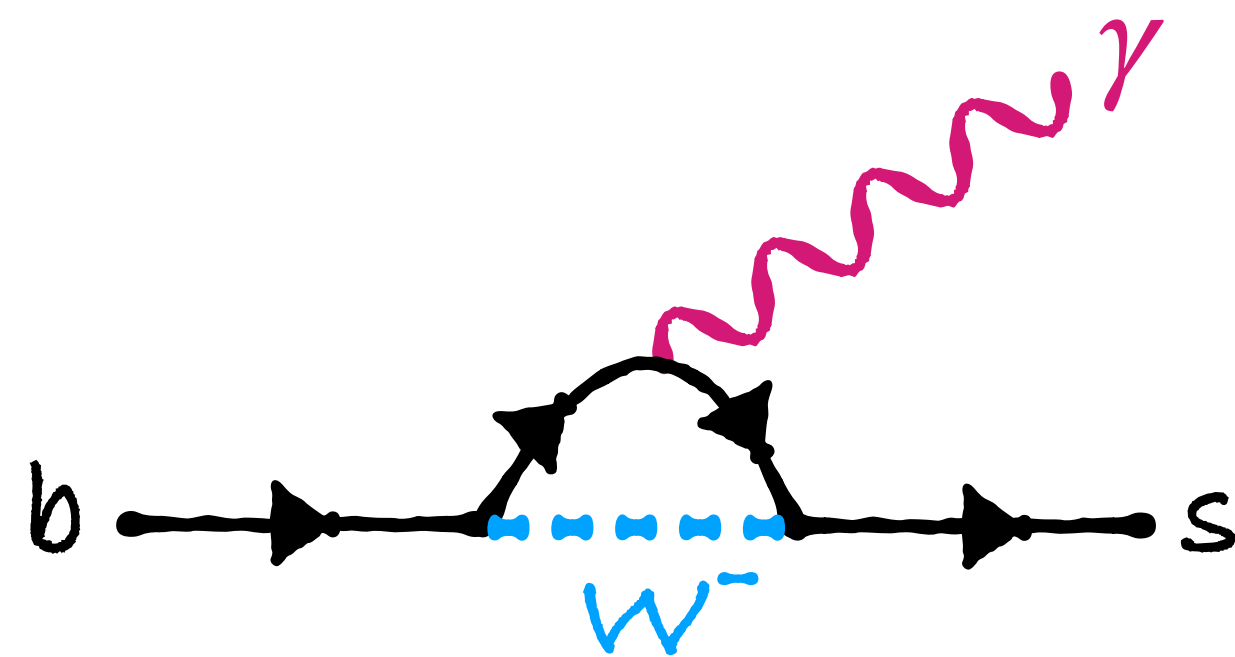
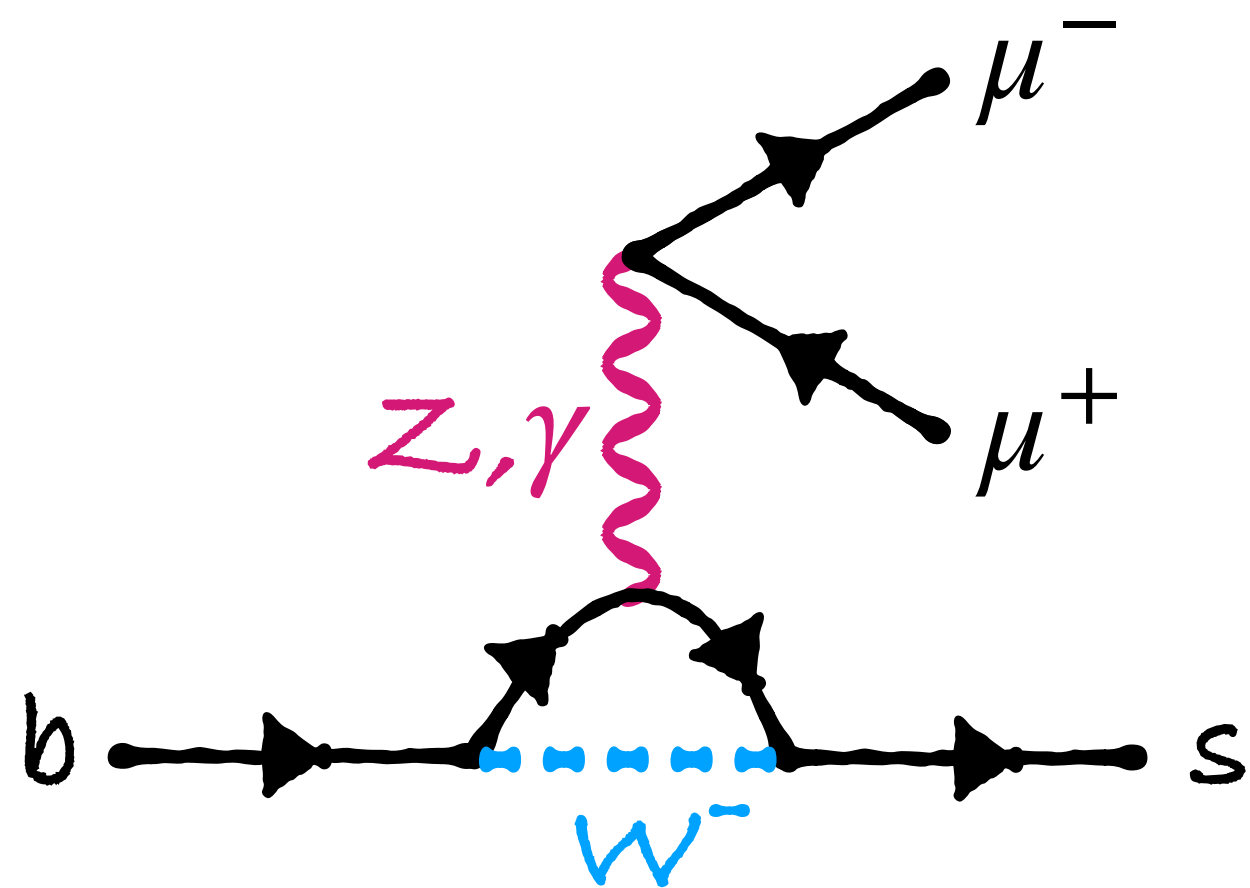
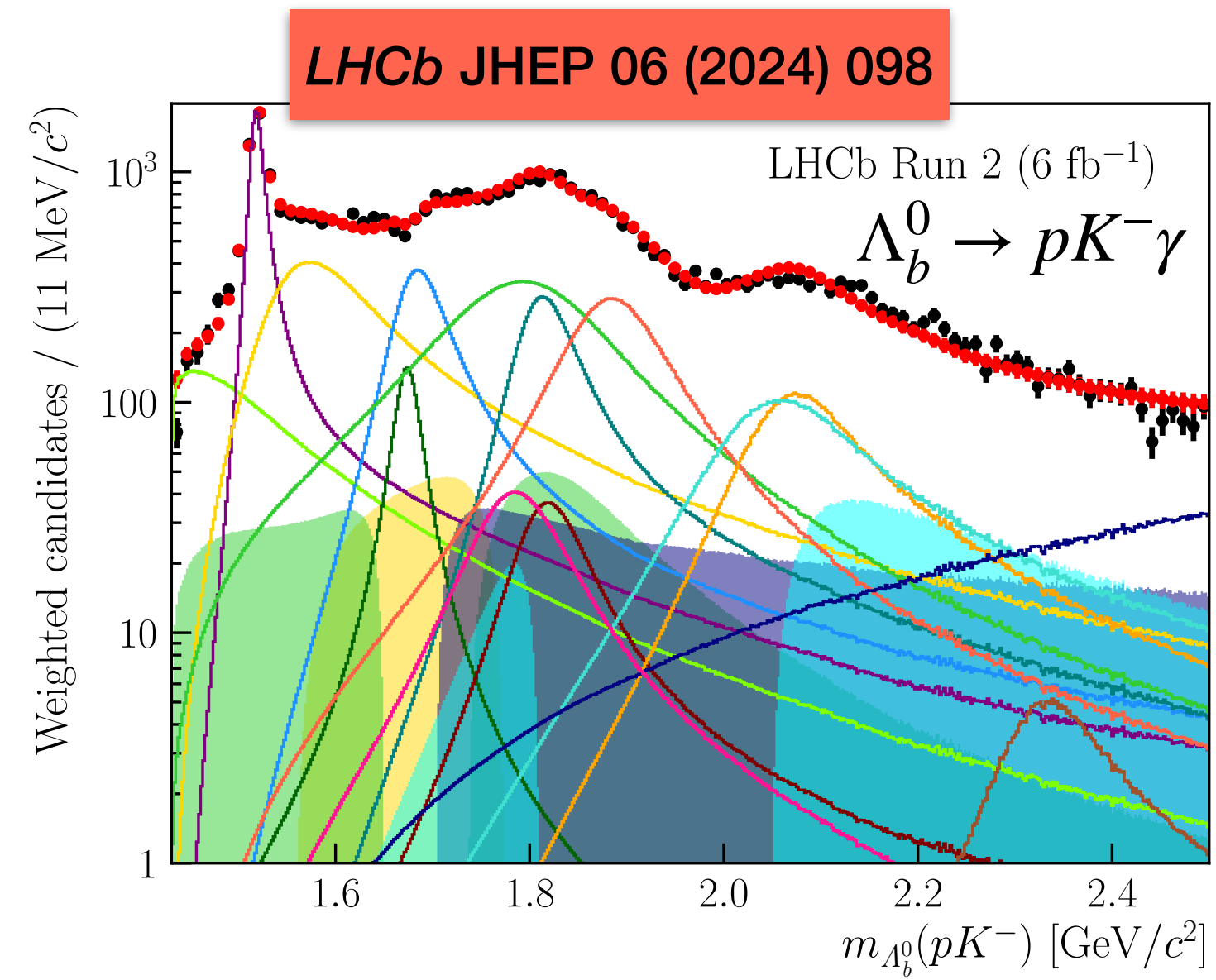
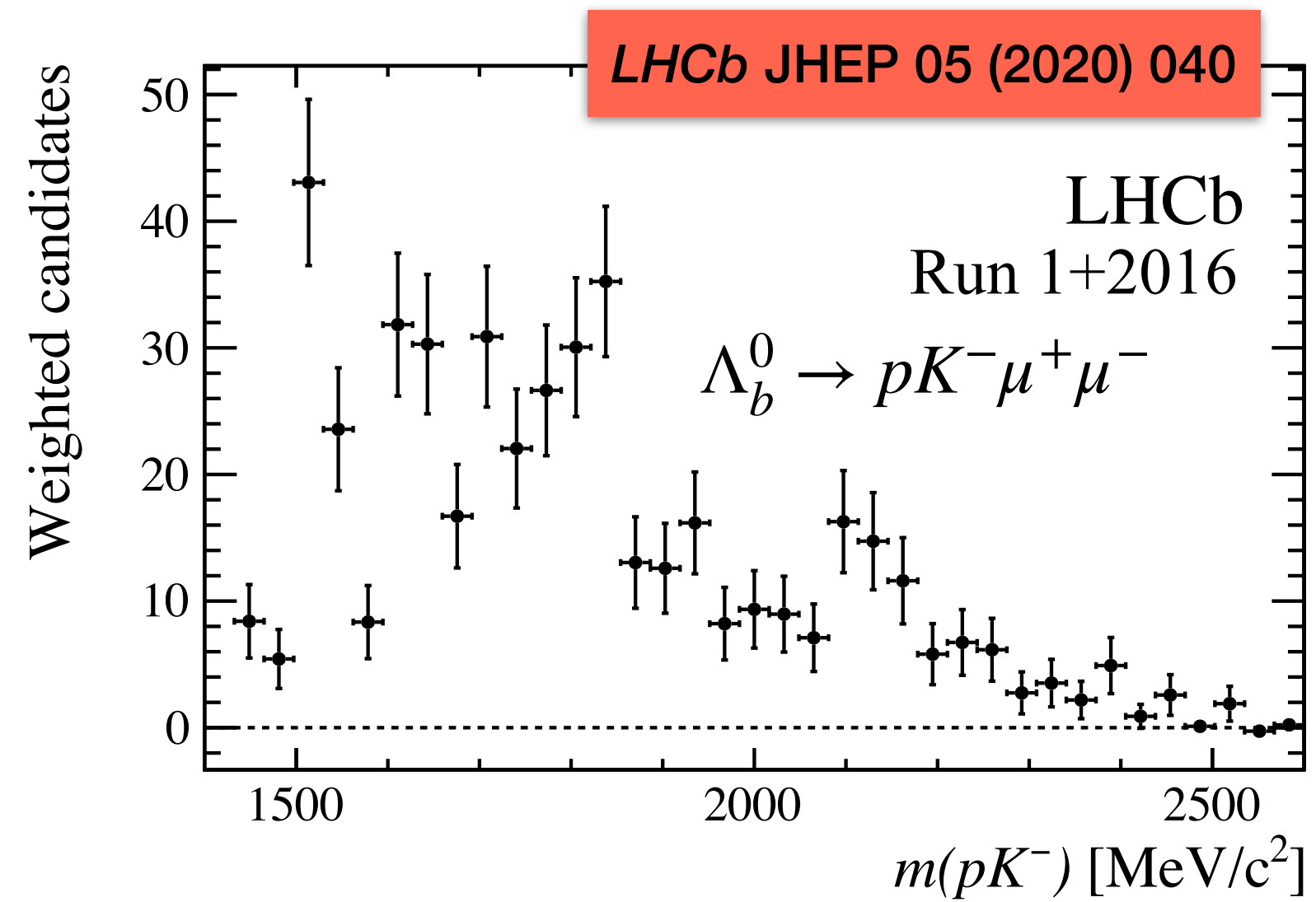




# The jungle

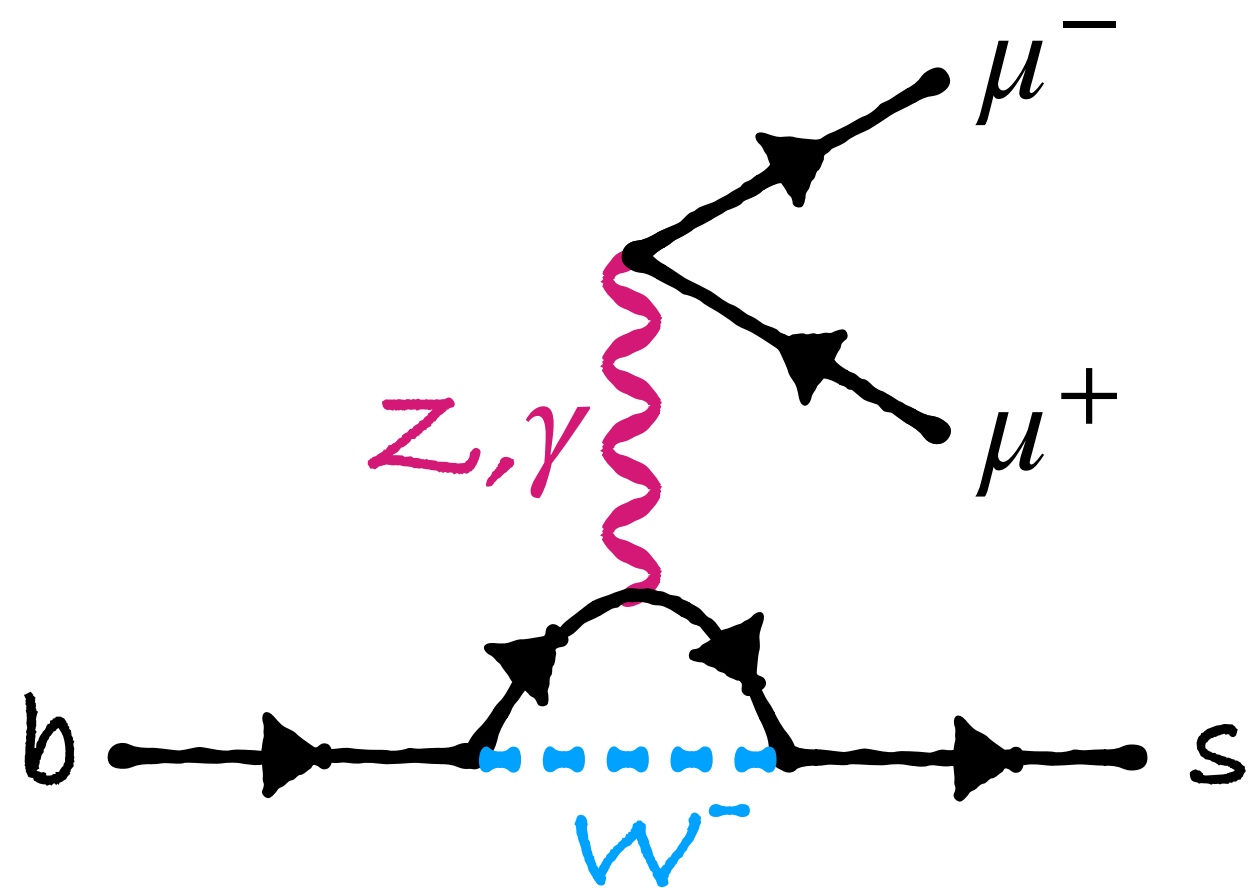
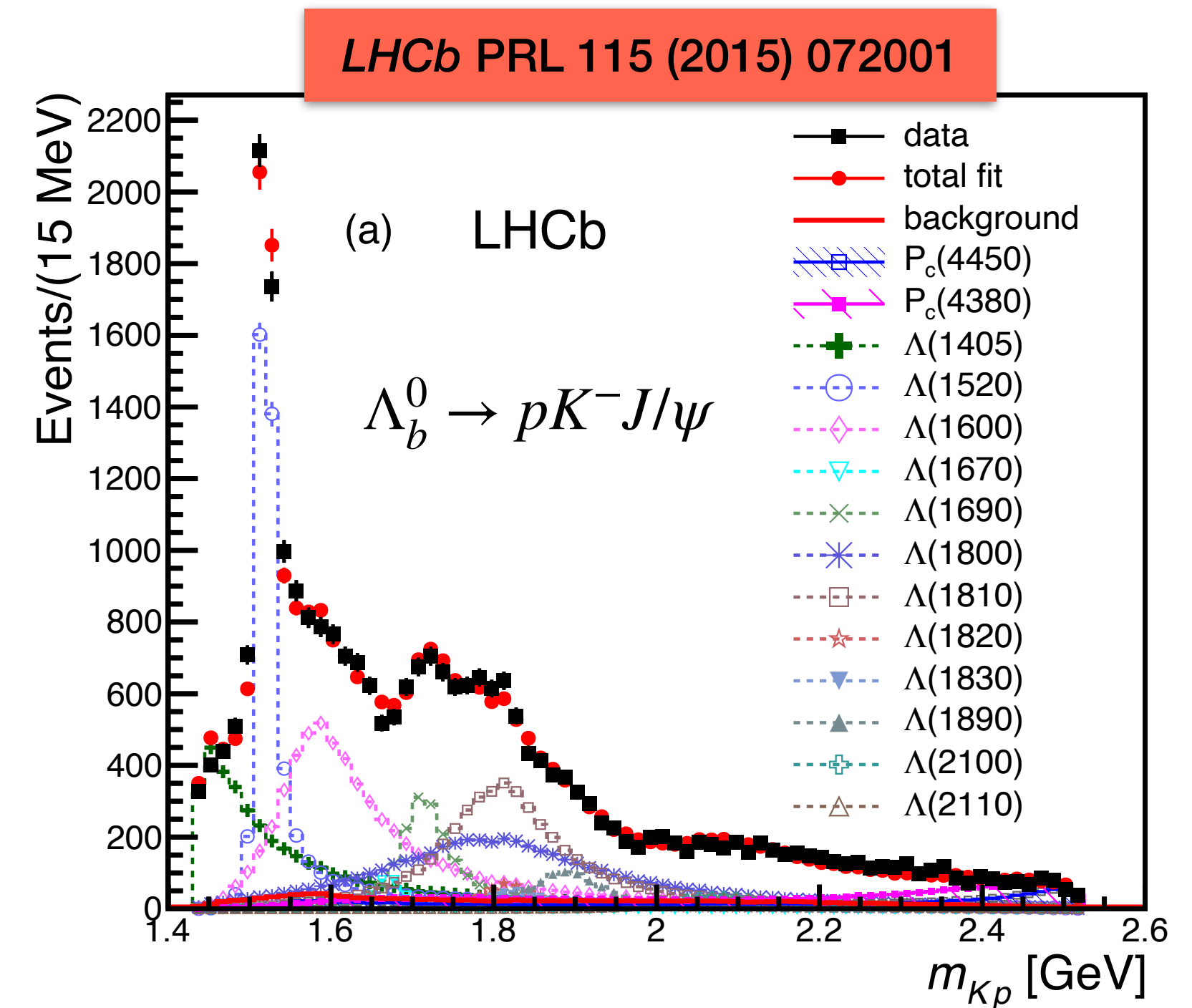
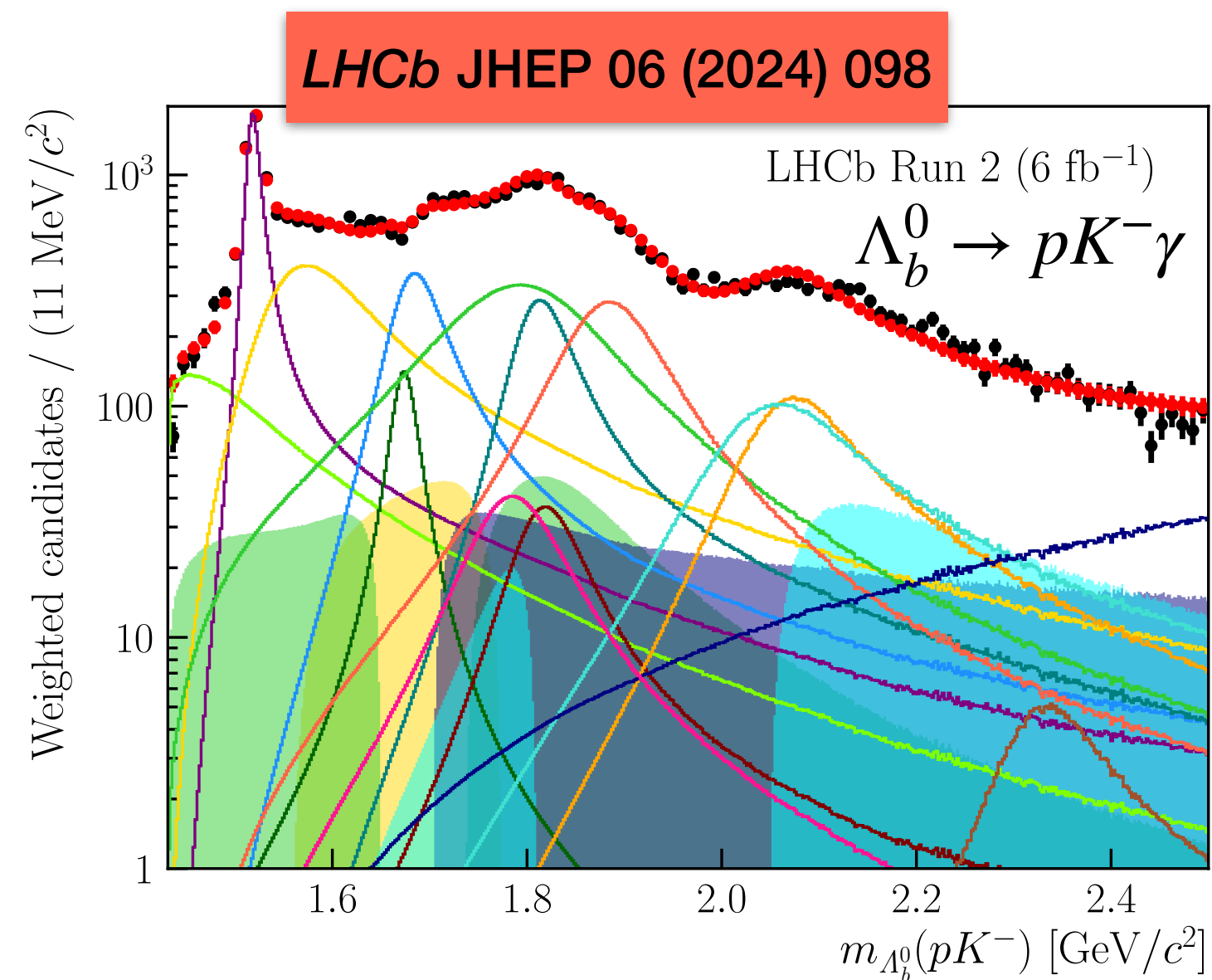
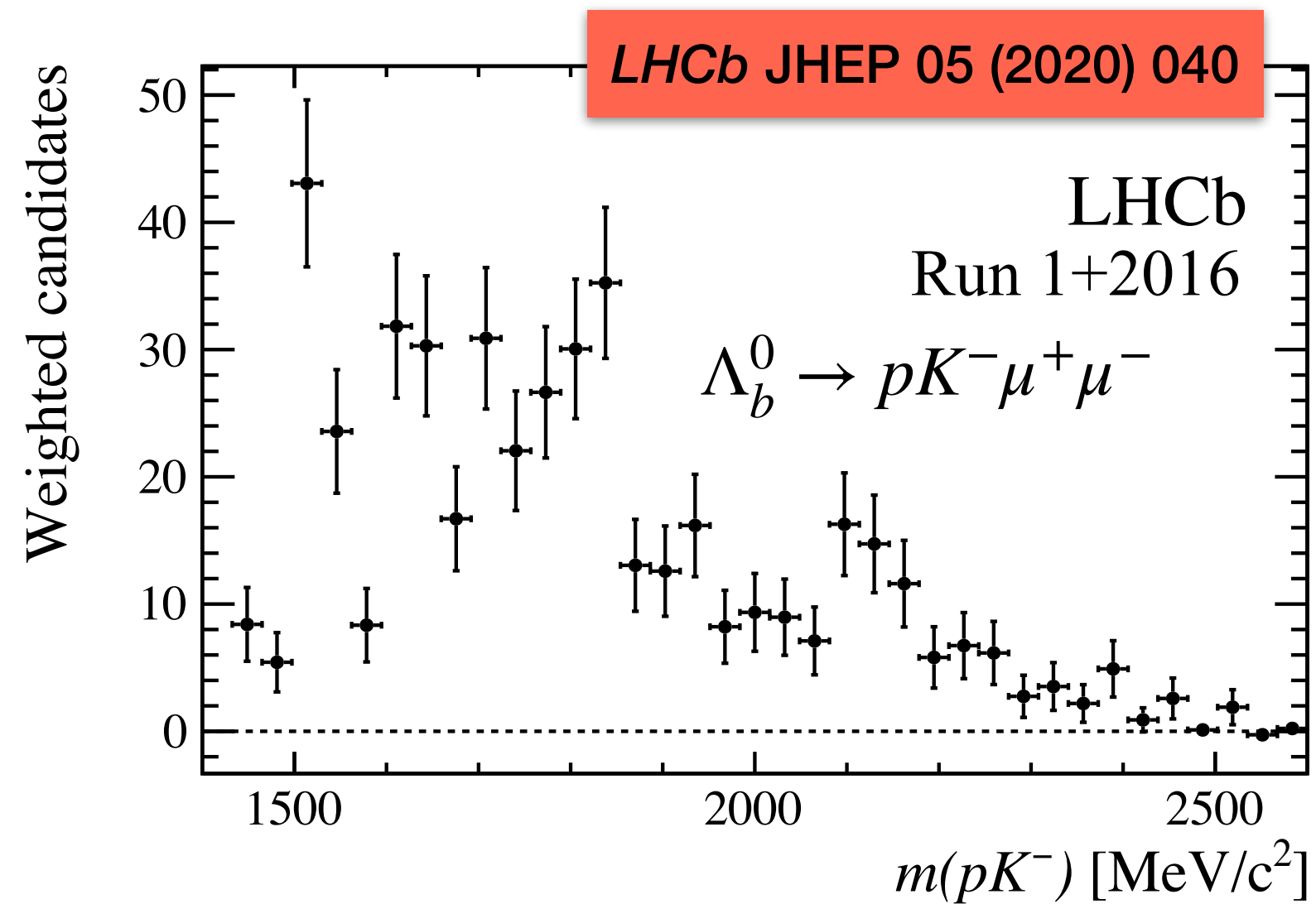


# The jungle

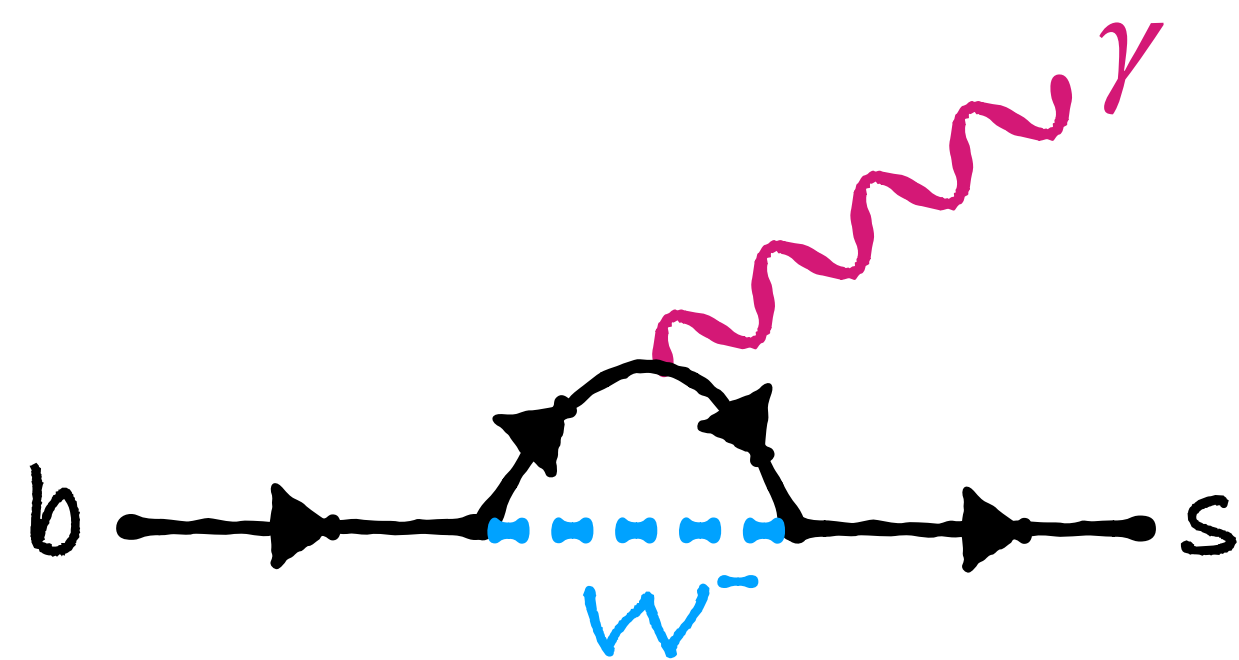




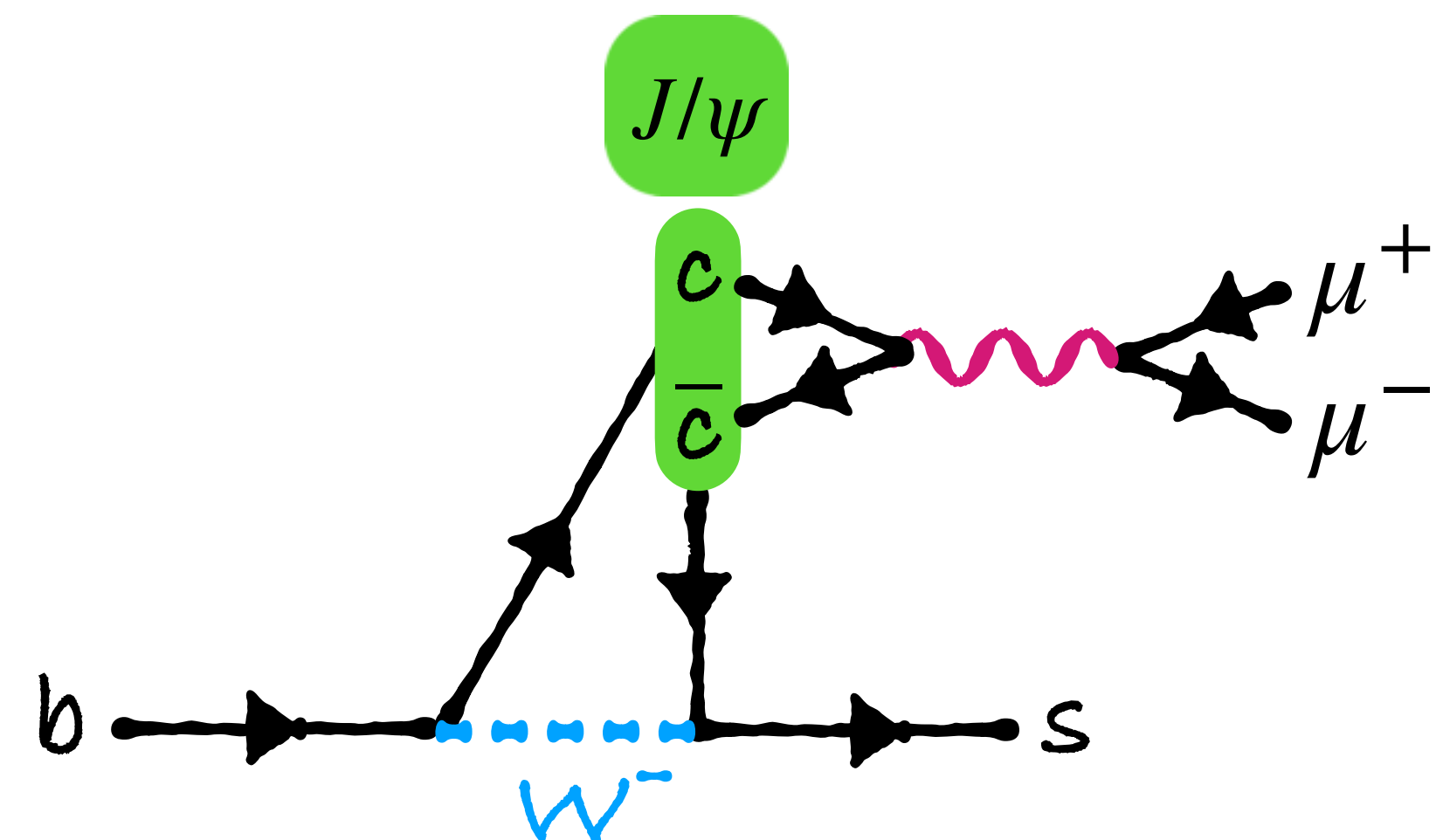
# The jungle



Anja Beck



LHCb UK Annual Meeting 2025



# The ~~well~~-known part of the jungle

Resonance	$J^P$	$m_0$	$\Gamma_0$	$\Delta m_0$	$\Delta\Gamma_0$
$\Lambda(1405)$	$1/2^-$	1405	50.5	$\pm 1.3$	$\pm 2$
$\Lambda(1520)$	$3/2^-$	1519	16	1518 – 1520	15 – 17
$\Lambda(1600)$	$1/2^+$	1600	200	1570 – 1630	150 – 250
$\Lambda(1670)$	$1/2^-$	1674	30	1670 – 1678	25 – 35
$\Lambda(1690)$	$3/2^-$	1690	70	1685 – 1695	50 – 70
$\Lambda(1800)$	$1/2^-$	1800	200	1750 – 1850	150 – 250
$\Lambda(1810)$	$1/2^+$	1790	110	1740 – 1840	50 – 170
$\Lambda(1820)$	$5/2^+$	1820	80	1815 – 1825	70 – 90
$\Lambda(1830)$	$5/2^-$	1825	90	1820 – 1830	60 – 120
$\Lambda(1890)$	$3/2^+$	1890	120	1870 – 1910	80 – 160
$\Lambda(2100)$	$7/2^-$	2100	200	2090 – 2110	100 – 250
$\Lambda(2110)$	$5/2^+$	2090	250	2050 – 2130	200 – 300
$\Lambda(2350)$	$9/2^+$	2350	150	2340 – 2370	100 – 250

# The ~~well-known~~ part of the jungle

187 (46) angular terms  
for (un)polarised  $\Lambda_b^0$

Resonance	$J^P$	$m_0$	$\Gamma_0$	$\Delta m_0$	$\Delta\Gamma_0$
$\Lambda(1405)$	$1/2^-$	1405	50.5	$\pm 1.3$	$\pm 2$
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# The ~~well~~-known part of the jungle

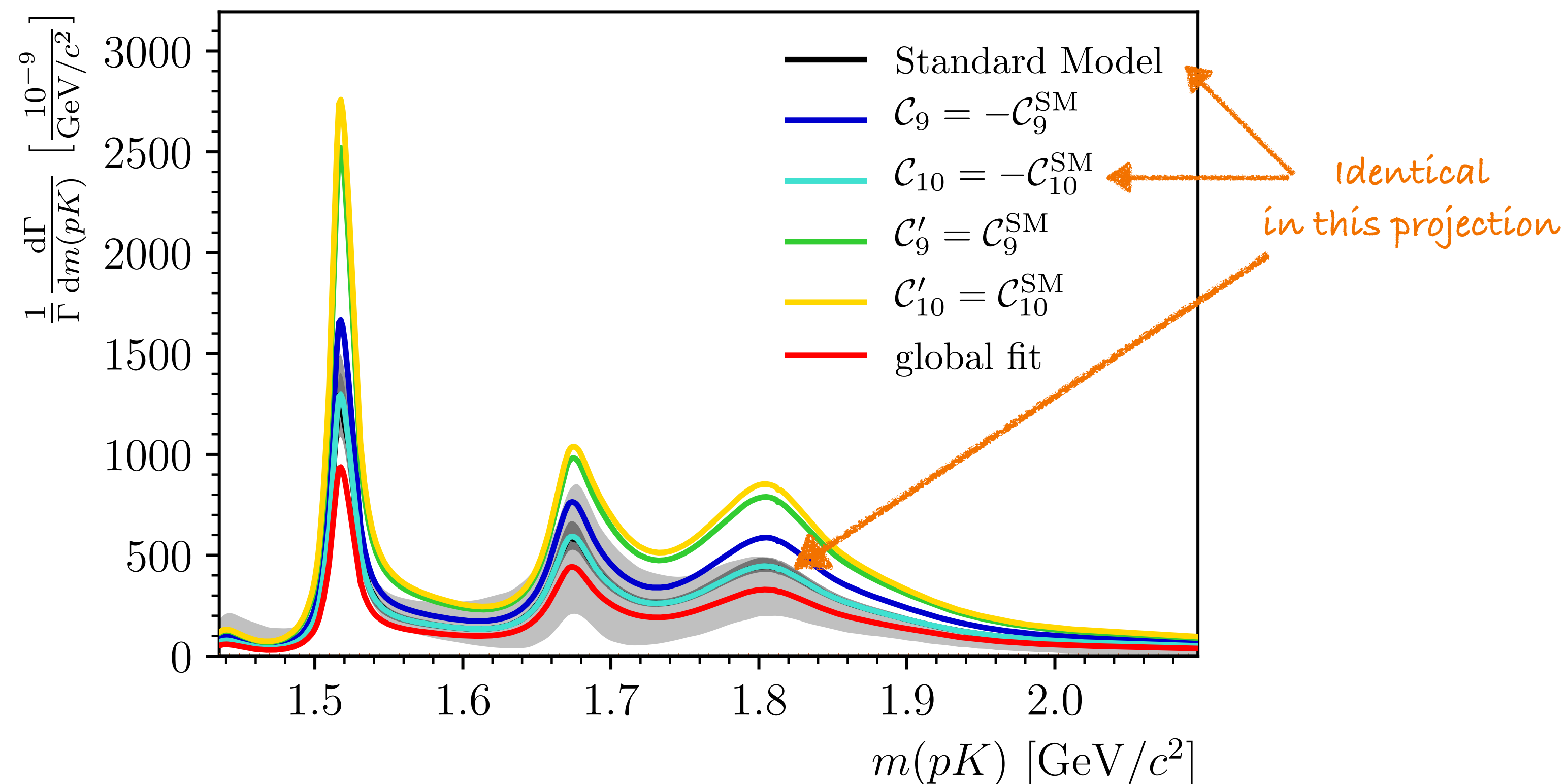
187 (46) angular terms  
for (un)polarised  $\Lambda_b^0$

Poorly known  
resonance parameters

Resonance	$J^P$	$m_0$	$\Gamma_0$	$\Delta m_0$	$\Delta \Gamma_0$
$\Lambda(1405)$	$1/2^-$	1405	50.5	$\pm 1.3$	$\pm 2$
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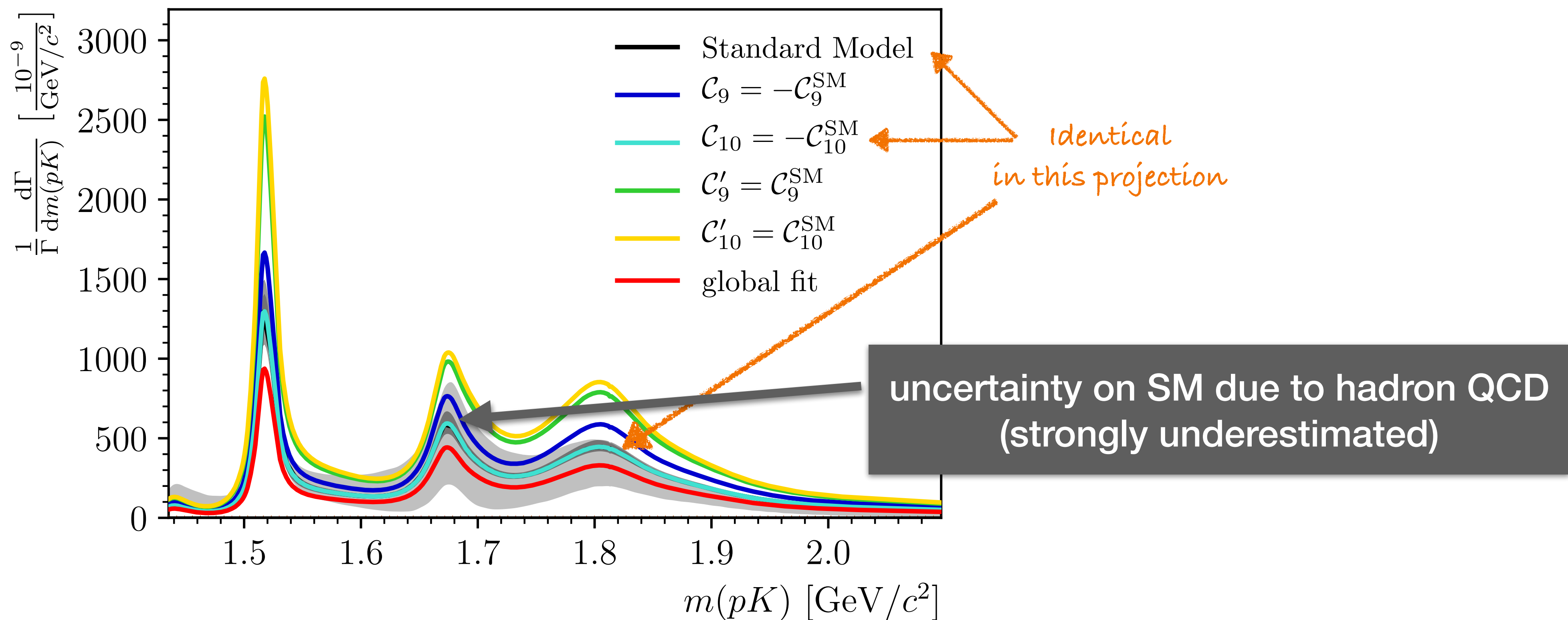
# Predictions for $\text{BF}(\Lambda_b^0 \rightarrow pK^- \mu^+ \mu^-)$

Using quark-model QCD form factors and some of the known resonances



# Predictions for $\text{BF}(\Lambda_b^0 \rightarrow pK^- \mu^+ \mu^-)$

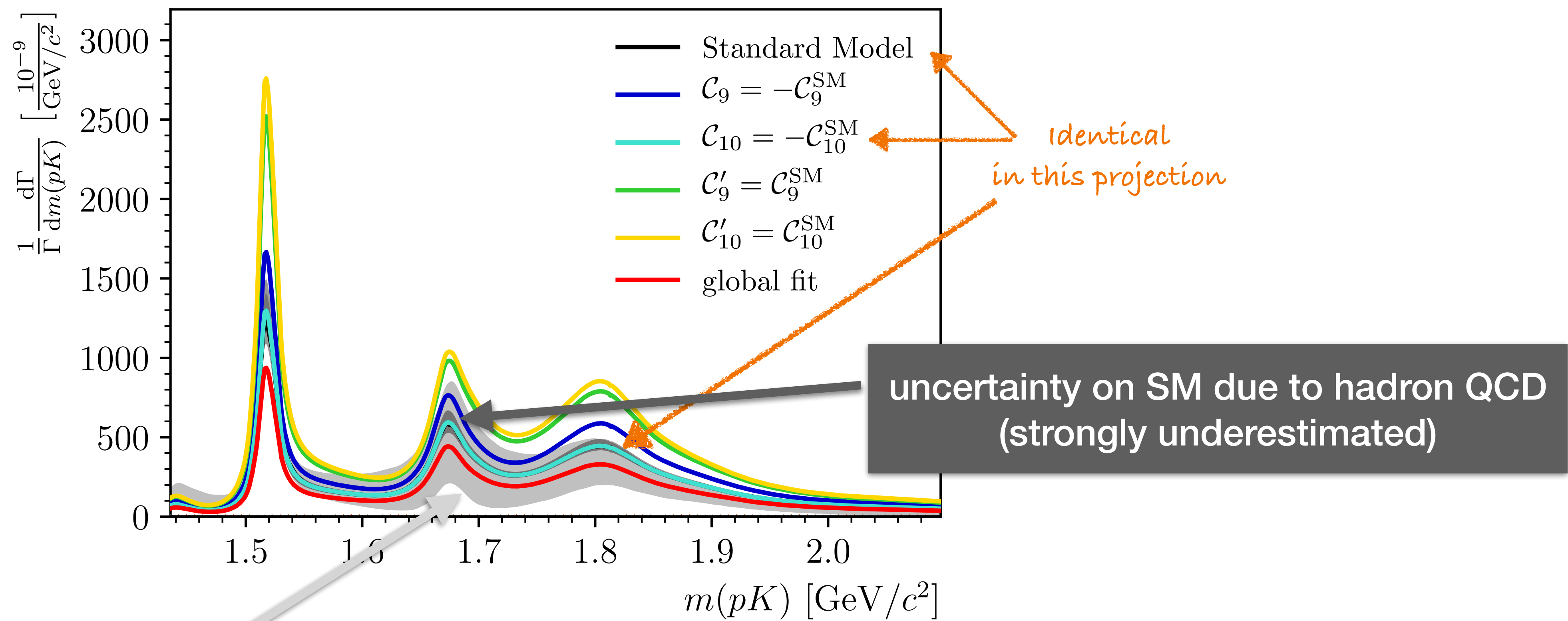
Using quark-model QCD form factors and some of the known resonances





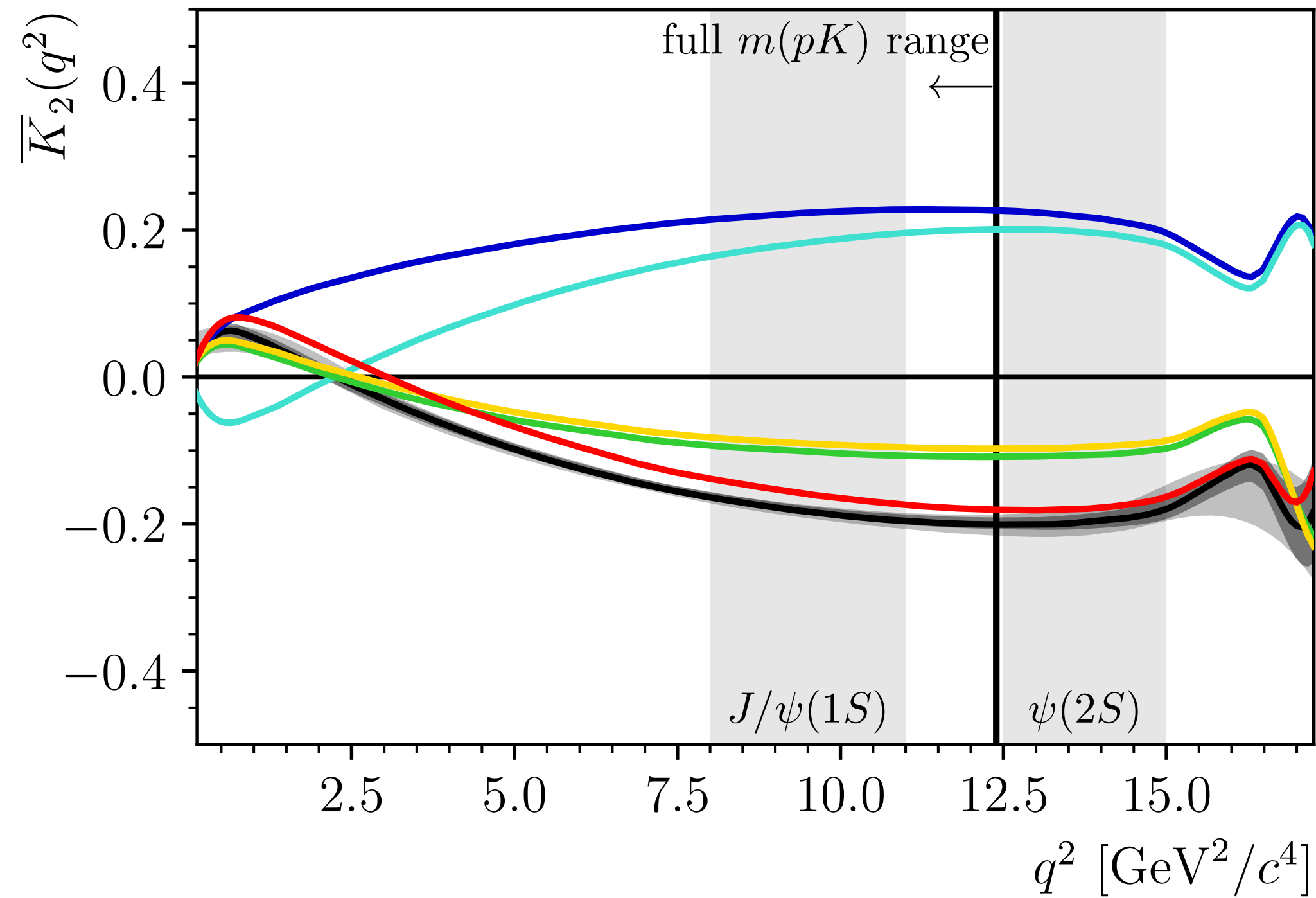
# Predictions for $\text{BF}(\Lambda_b^0 \rightarrow pK^- \mu^+ \mu^-)$

Using quark-model QCD form factors and some of the known resonances



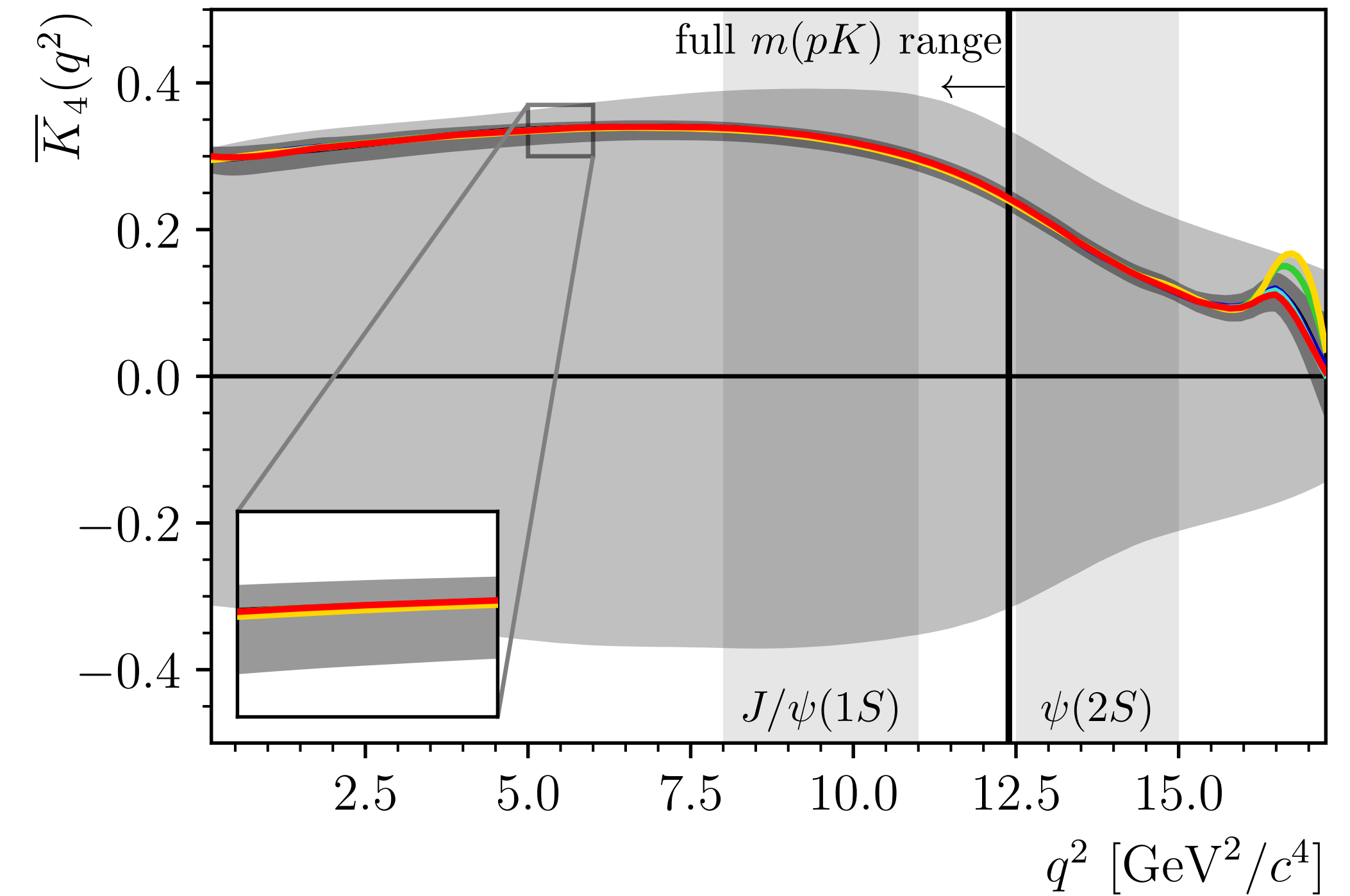
# Predictions for angular observables in $\Lambda_b^0 \rightarrow pK^- \mu^+ \mu^-$

## Muon forward-backward asymmetry



**Strong sensitivity to BSM scenarios**  
**Little dependence on hadron QCD**

## Hadron forward-backward asymmetry



**Little sensitivity to BSM scenarios**  
**Strong dependence on hadron QCD**

Measurement 1:  
model-independent  $\Lambda_b^0 \rightarrow pK^- \mu^+ \mu^-$



# Analysis of $\Lambda_b^0 \rightarrow pK^- \mu^+ \mu^-$ decays

## BF and model-independent angular analysis

### Method of moments

= “counting experiment”

- model-independent
- unbiased even for low yields
- ~30% larger uncertainty than a fit would have

$$\langle \bar{K}_i \rangle_{\text{bin}}^{\text{data}} = \frac{1}{N} \sum_{n=1}^N w_i(\vec{\Omega}_n)$$

# Analysis of $\Lambda_b^0 \rightarrow pK^- \mu^+ \mu^-$ decays

## BF and model-independent angular analysis

### Method of moments

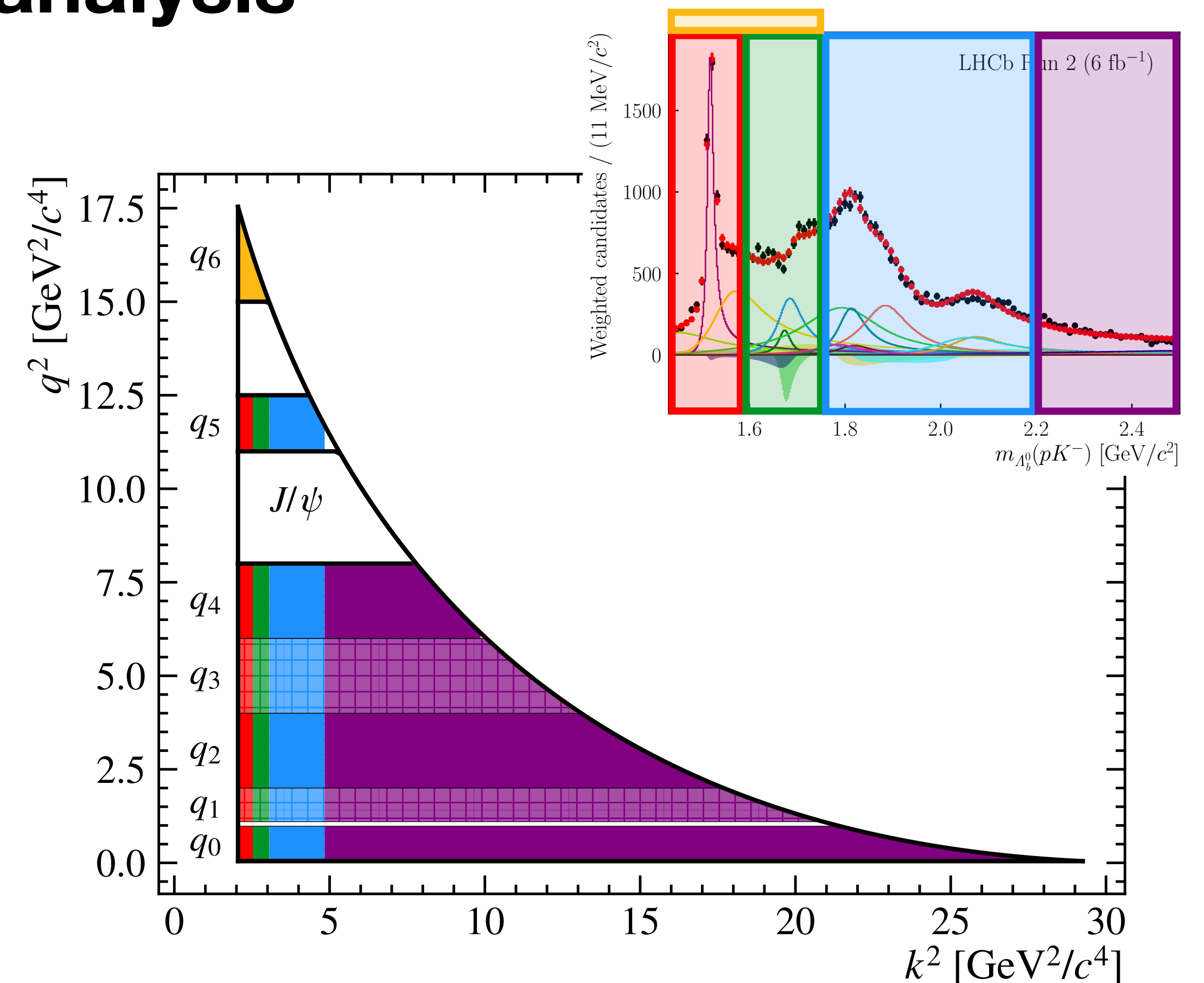
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$$\langle \bar{K}_i \rangle_{\text{bin}}^{\text{data}} = \frac{1}{N} \sum_{n=1}^N w_i(\vec{\Omega}_n)$$

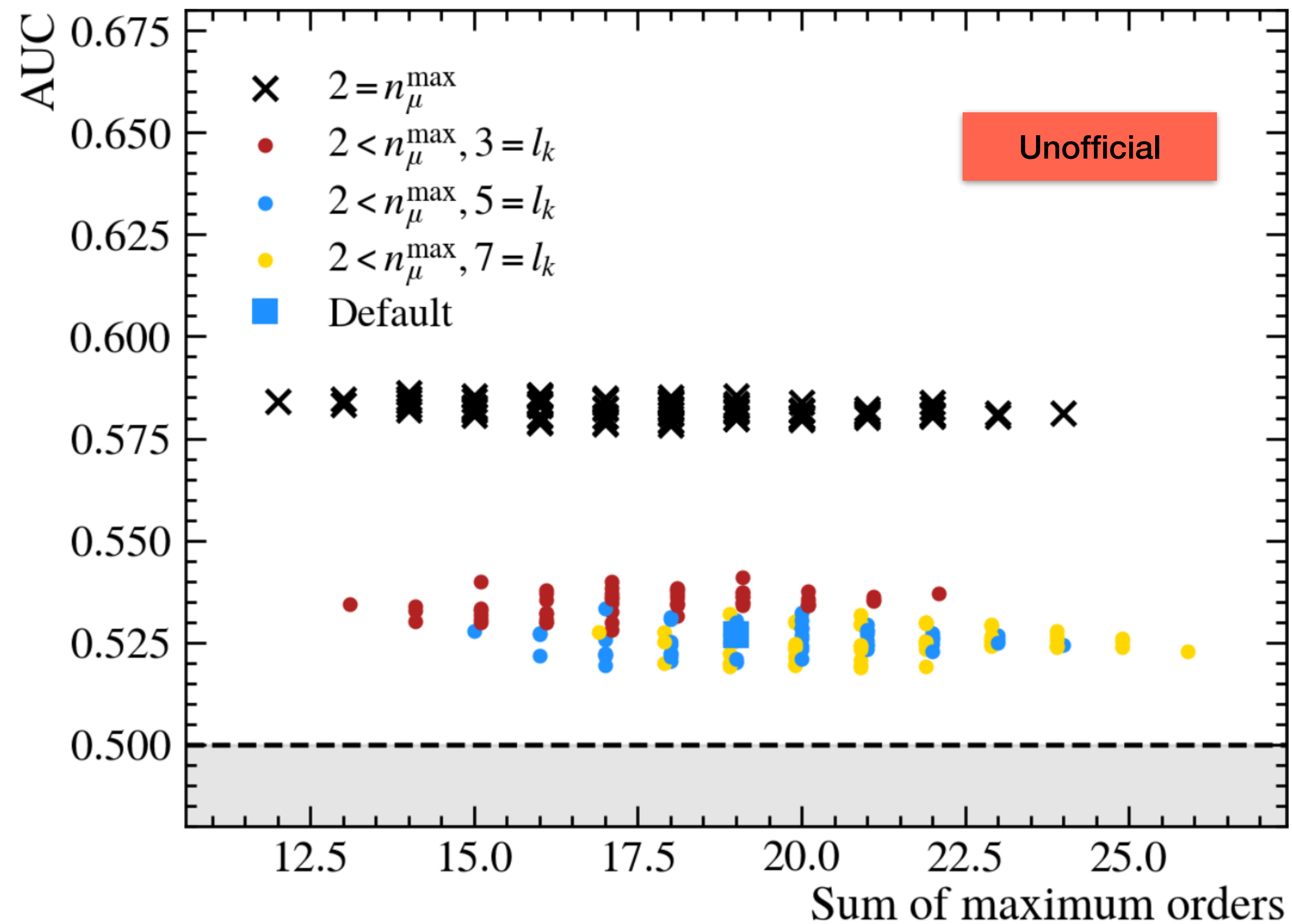
### Challenges

- many observables (46x24 bins)
- multi-dimensional (e.g. 5D efficiency model)
- low yield (2500 candidates after selection)  
unevenly distributed across bins



# Challenges

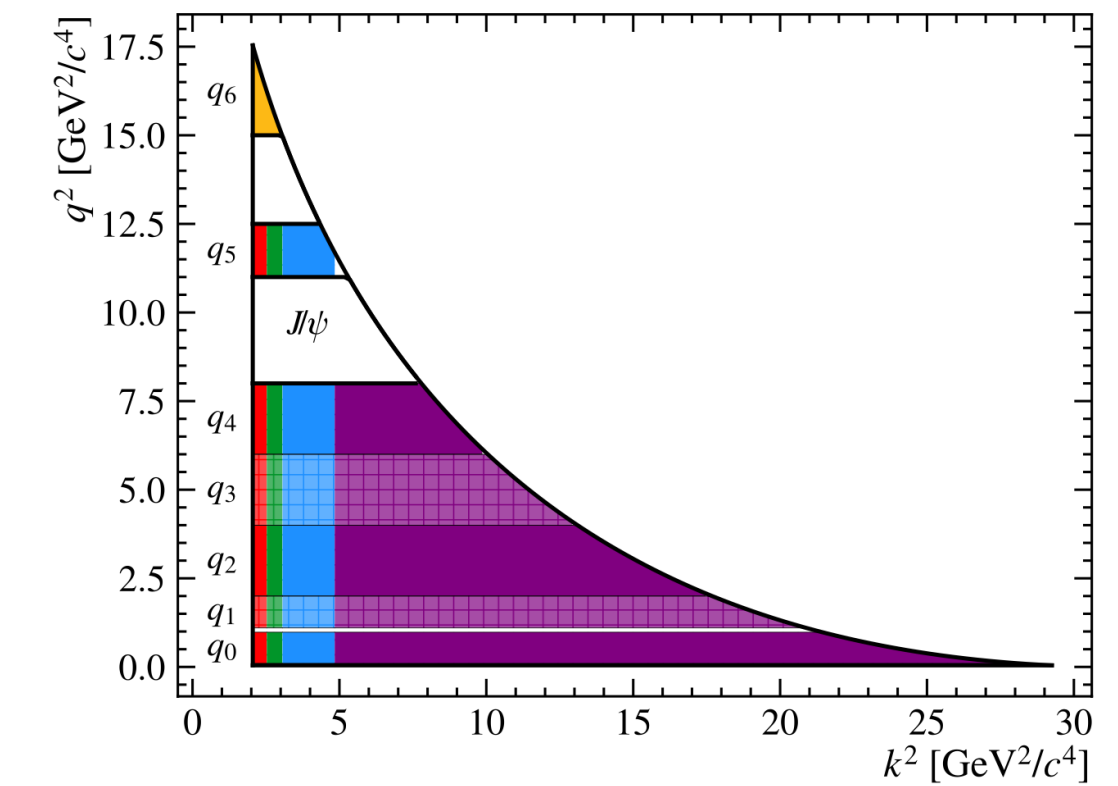
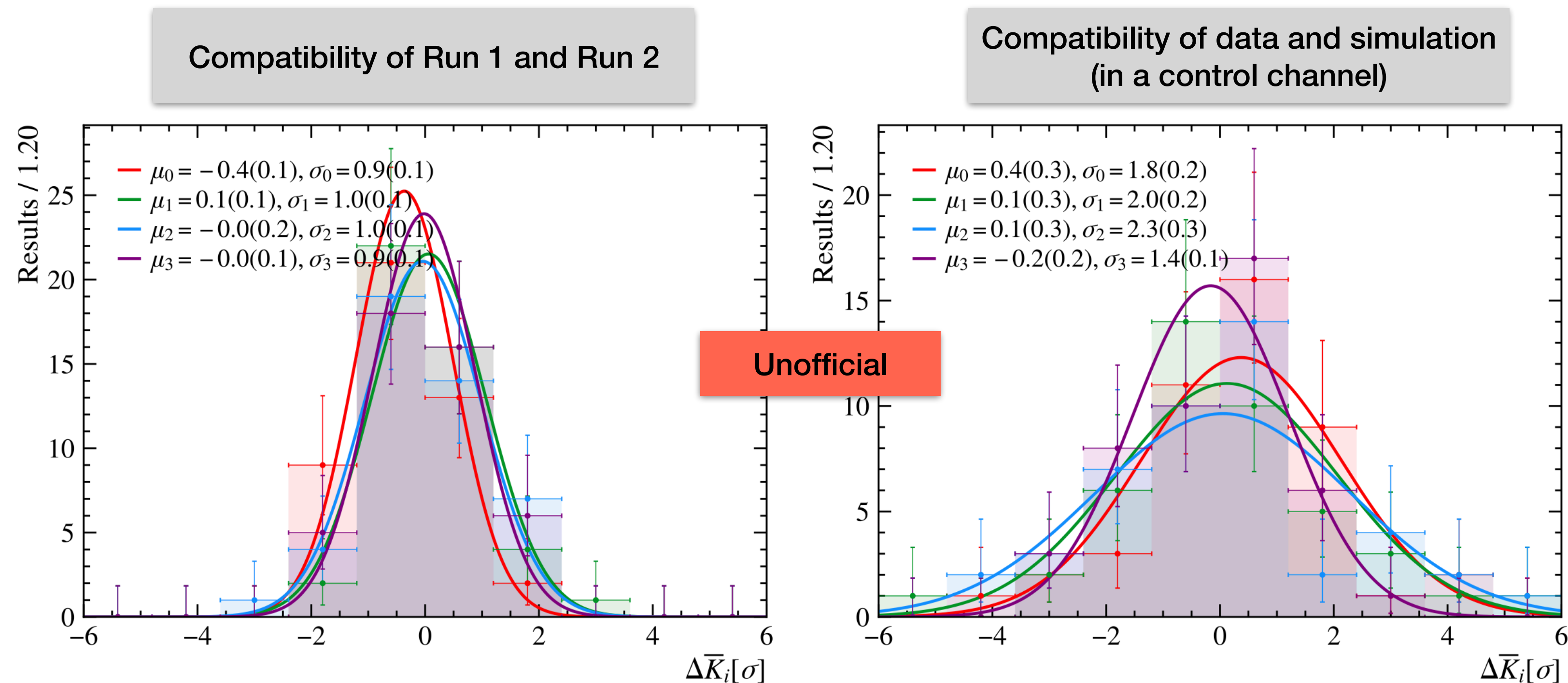
## Validation of a 5-dimensional efficiency



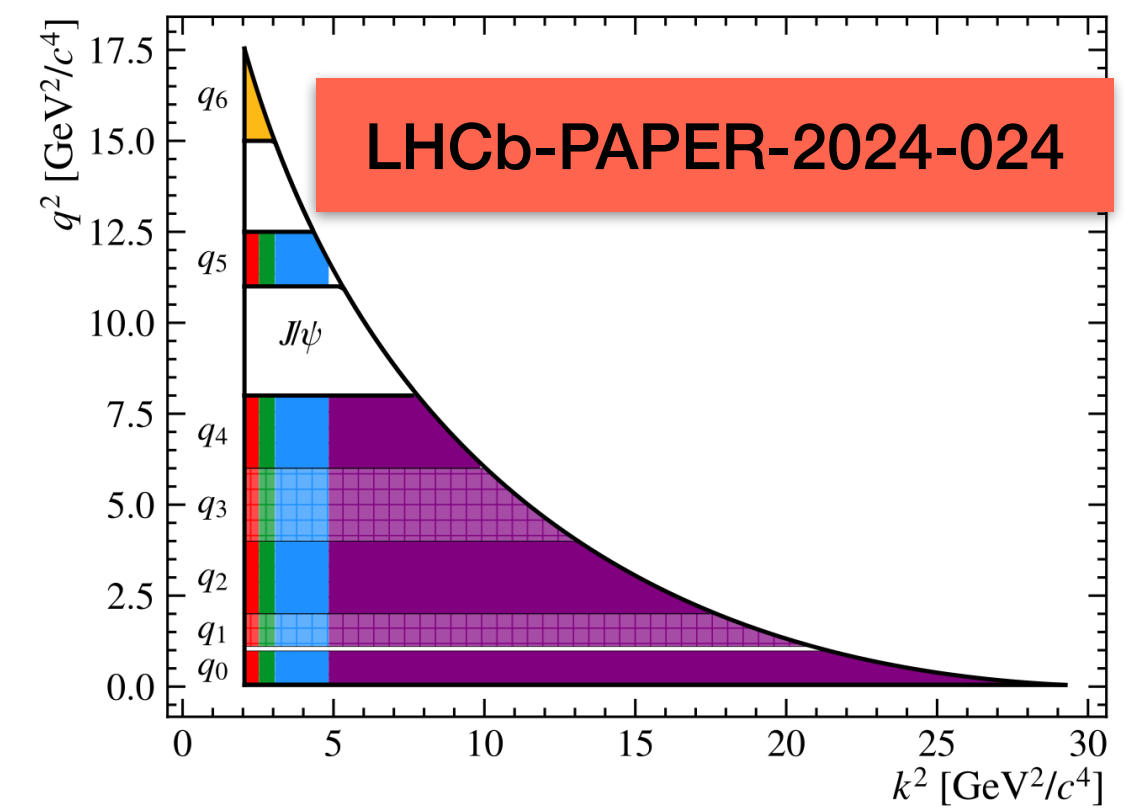
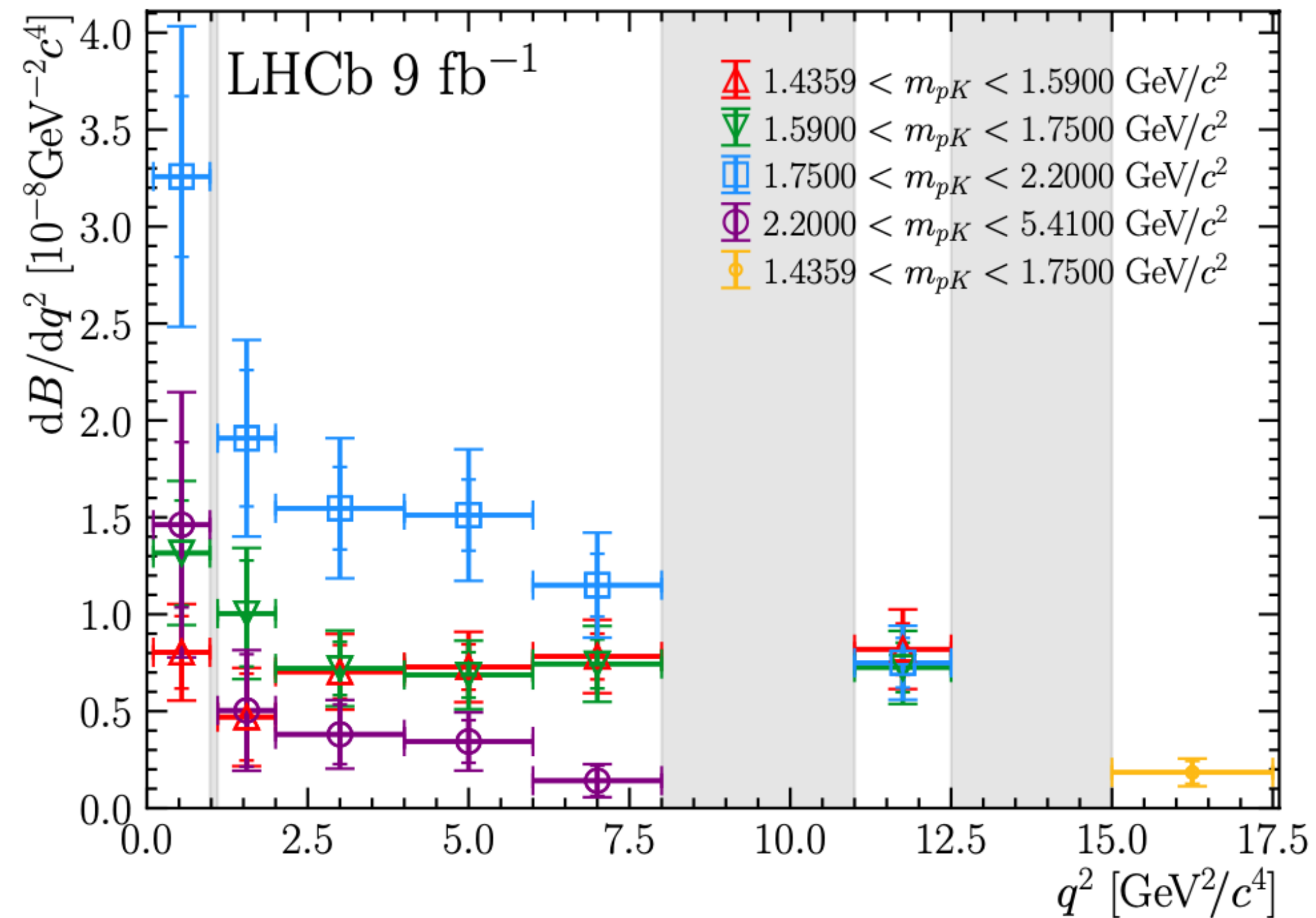


# Challenges

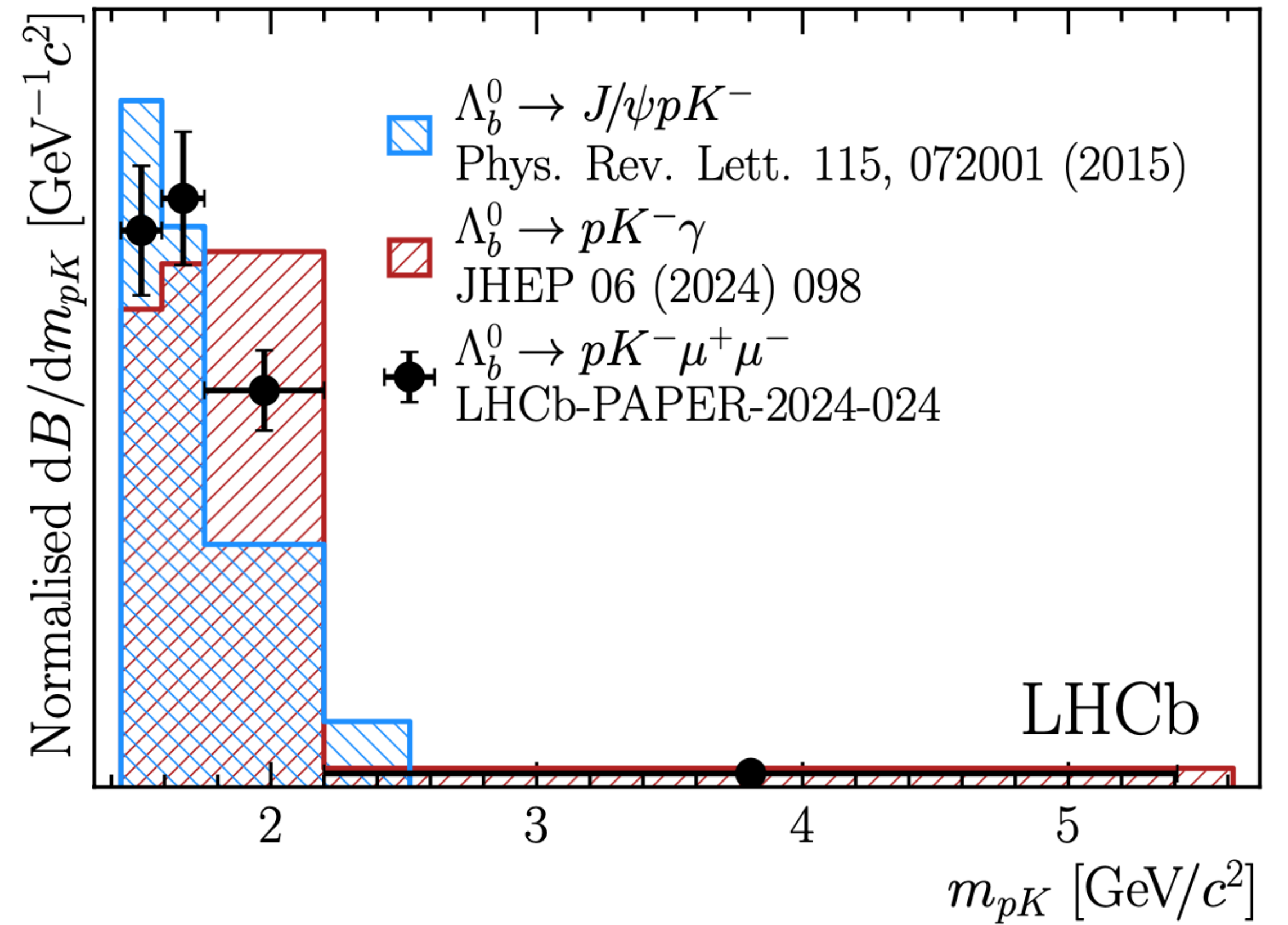
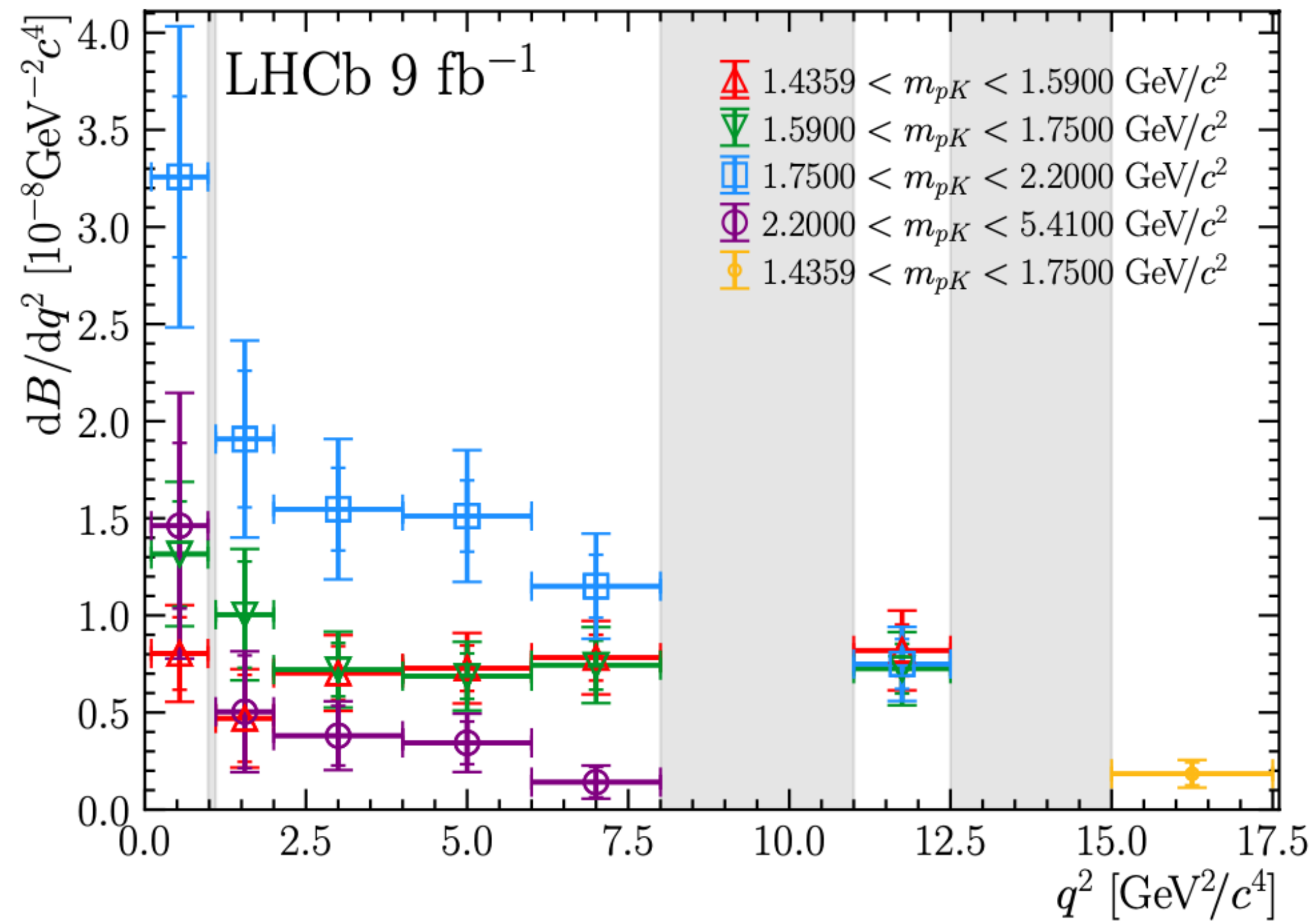
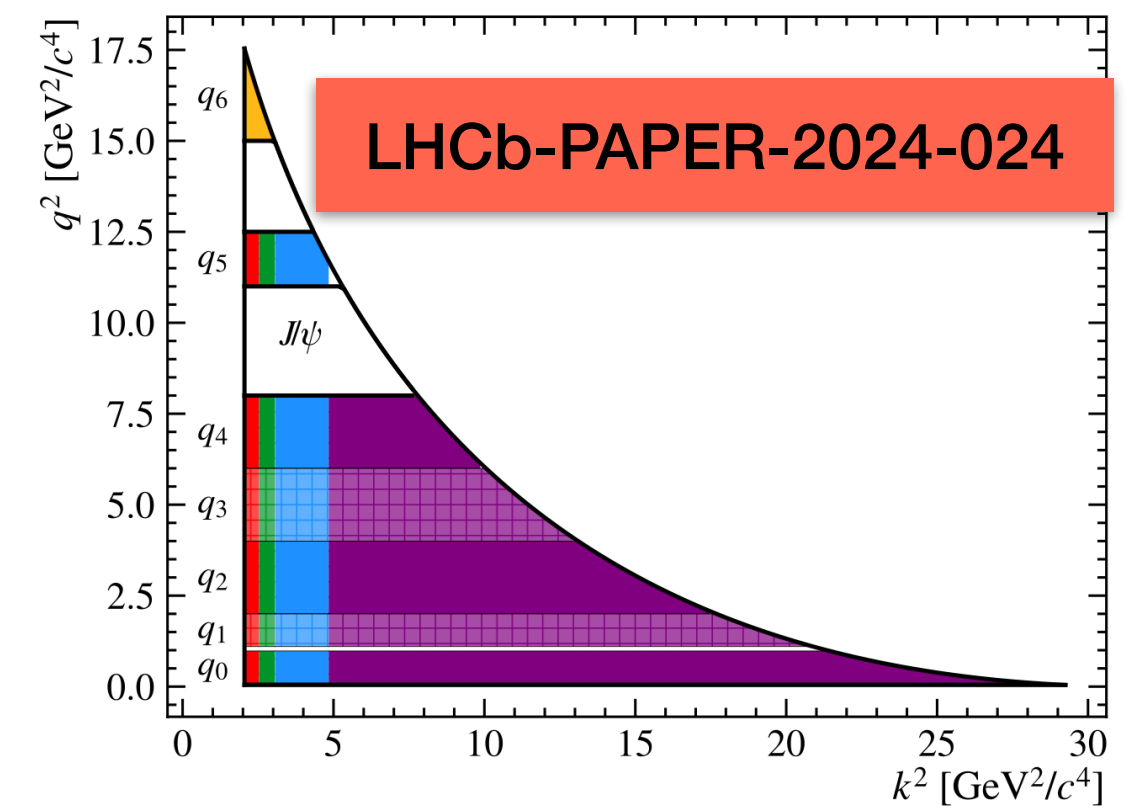
## How do you ensure that your 1k+ observables are well-behaved?



# Results: branching fraction

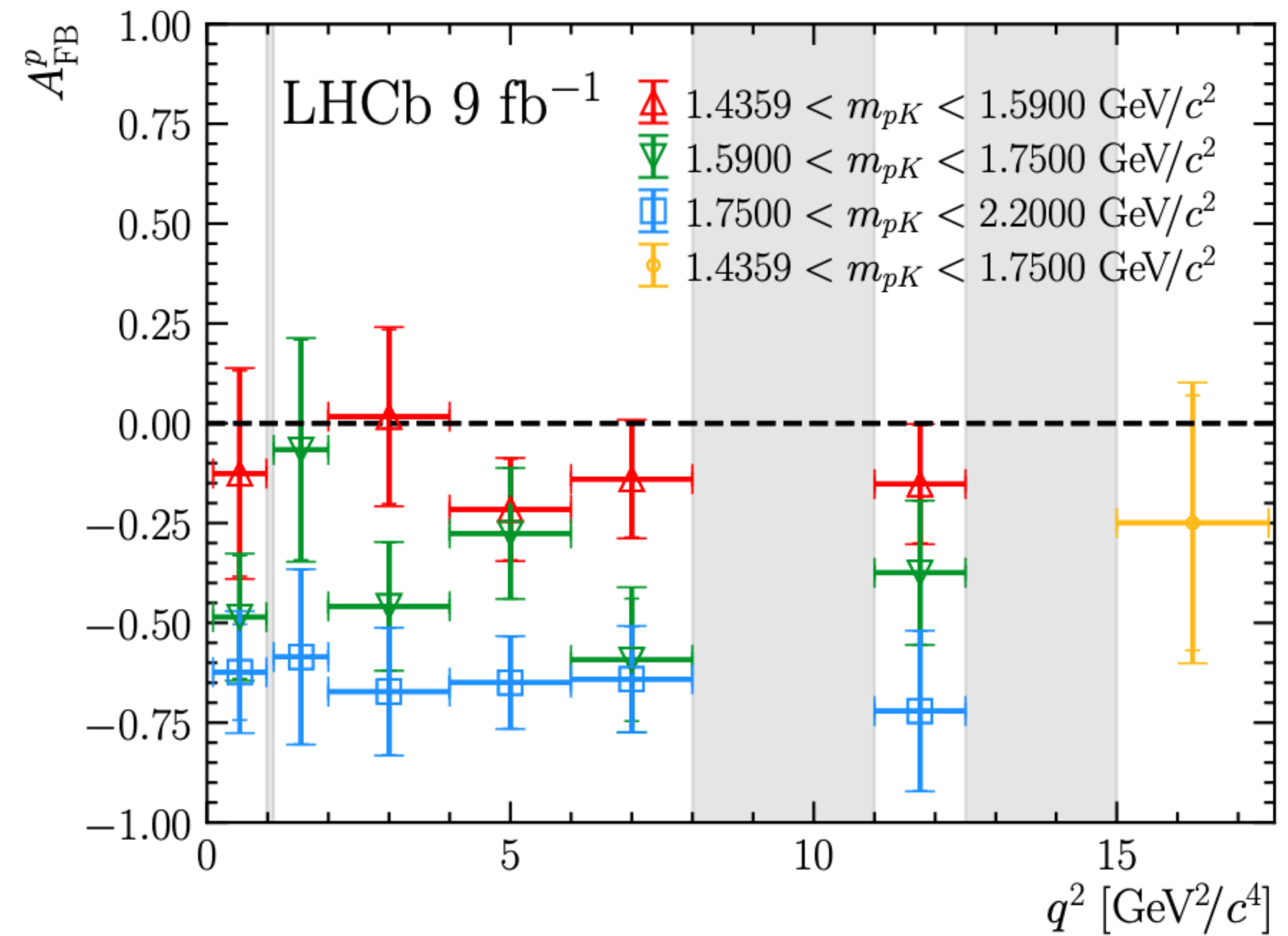
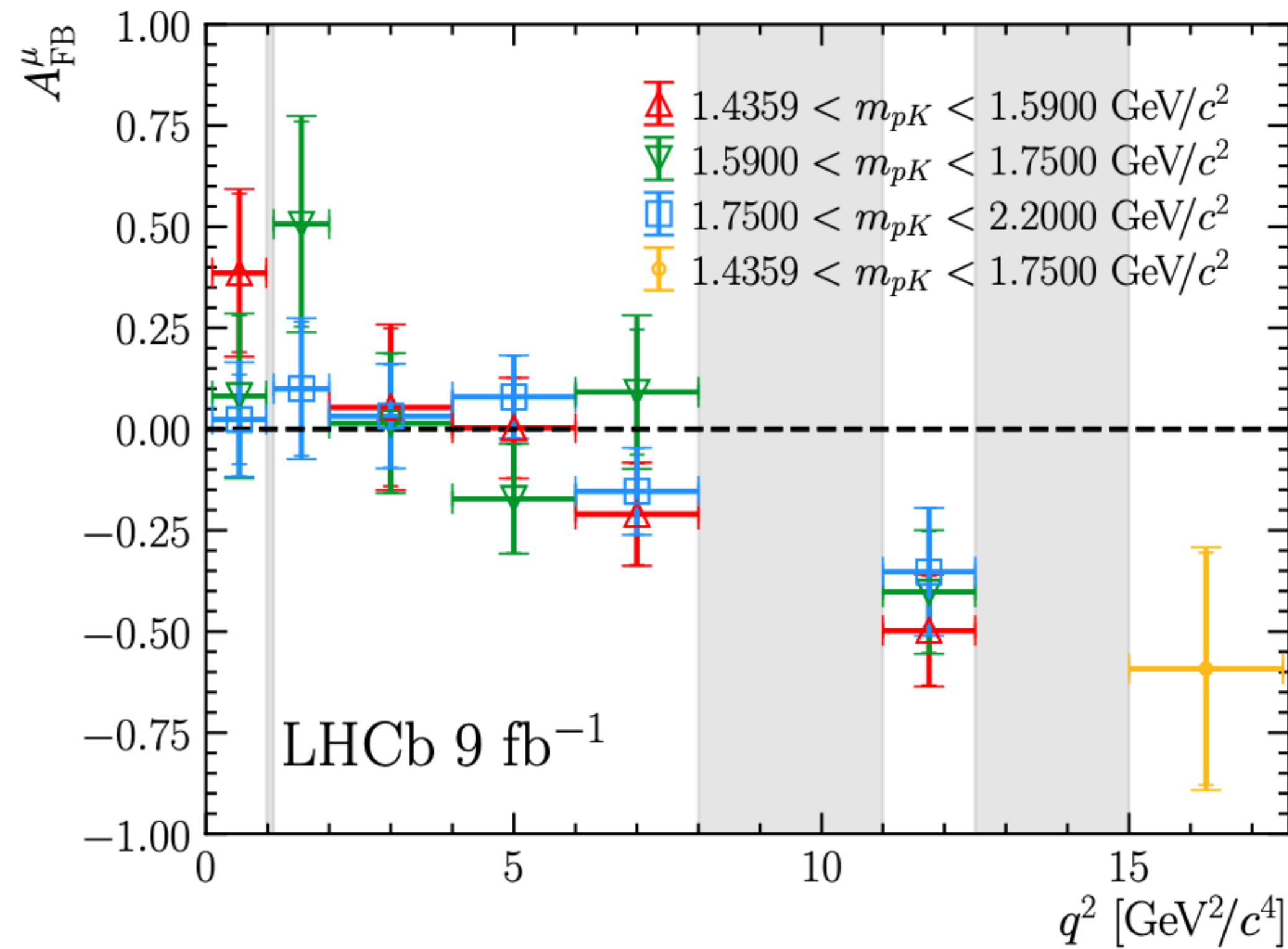
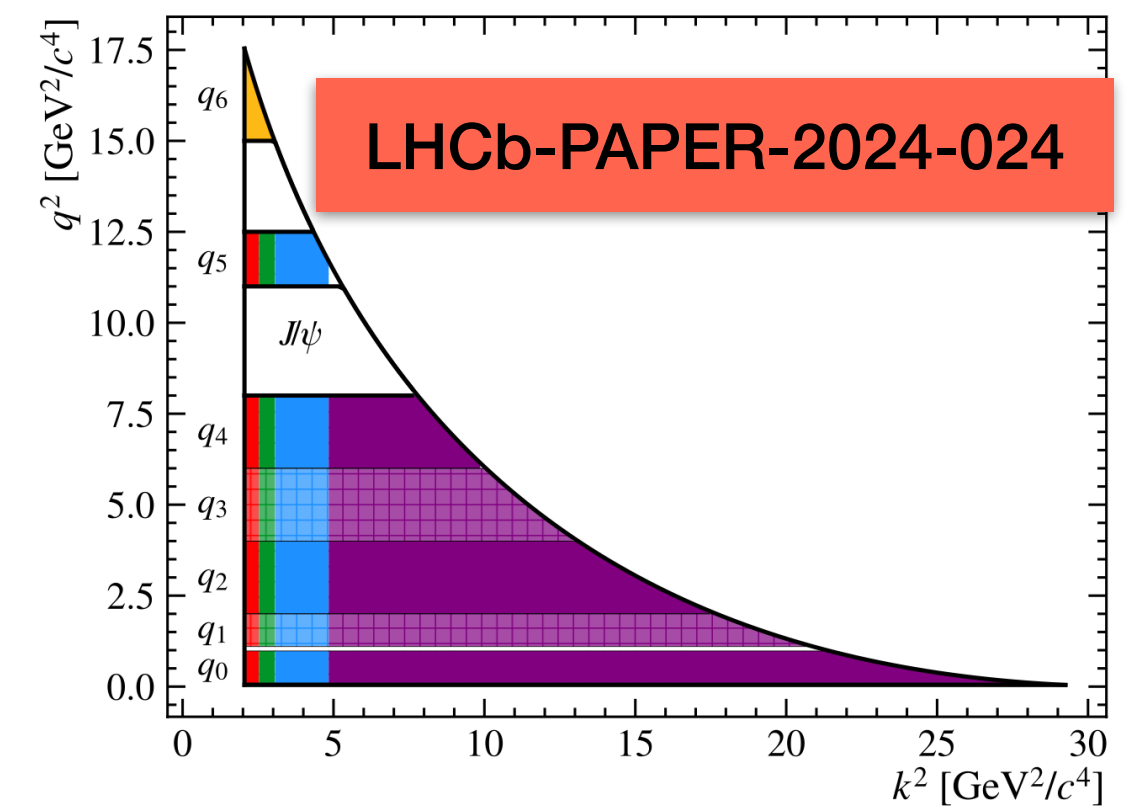


# Results: branching fraction





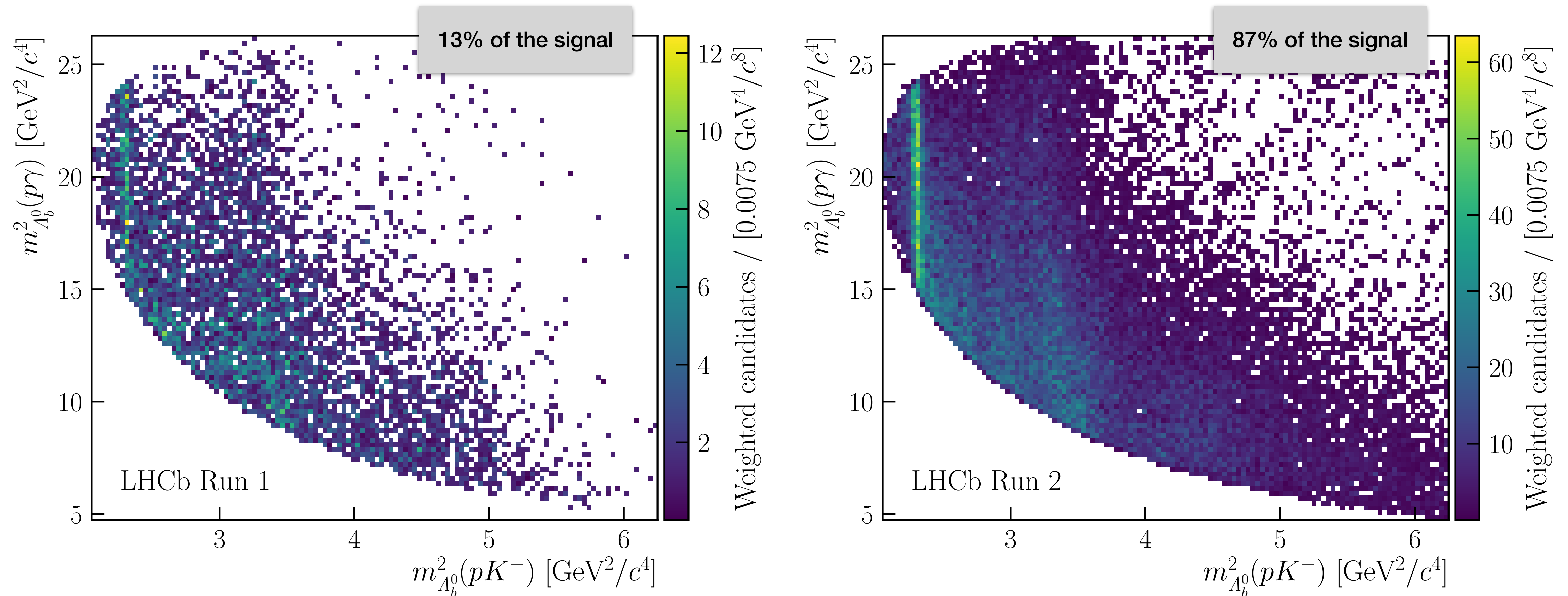
# Results: angular distributions





Measurement 2:  
amplitude analysis of  $\Lambda_b^0 \rightarrow pK^- \gamma$

# The Dalitz distribution



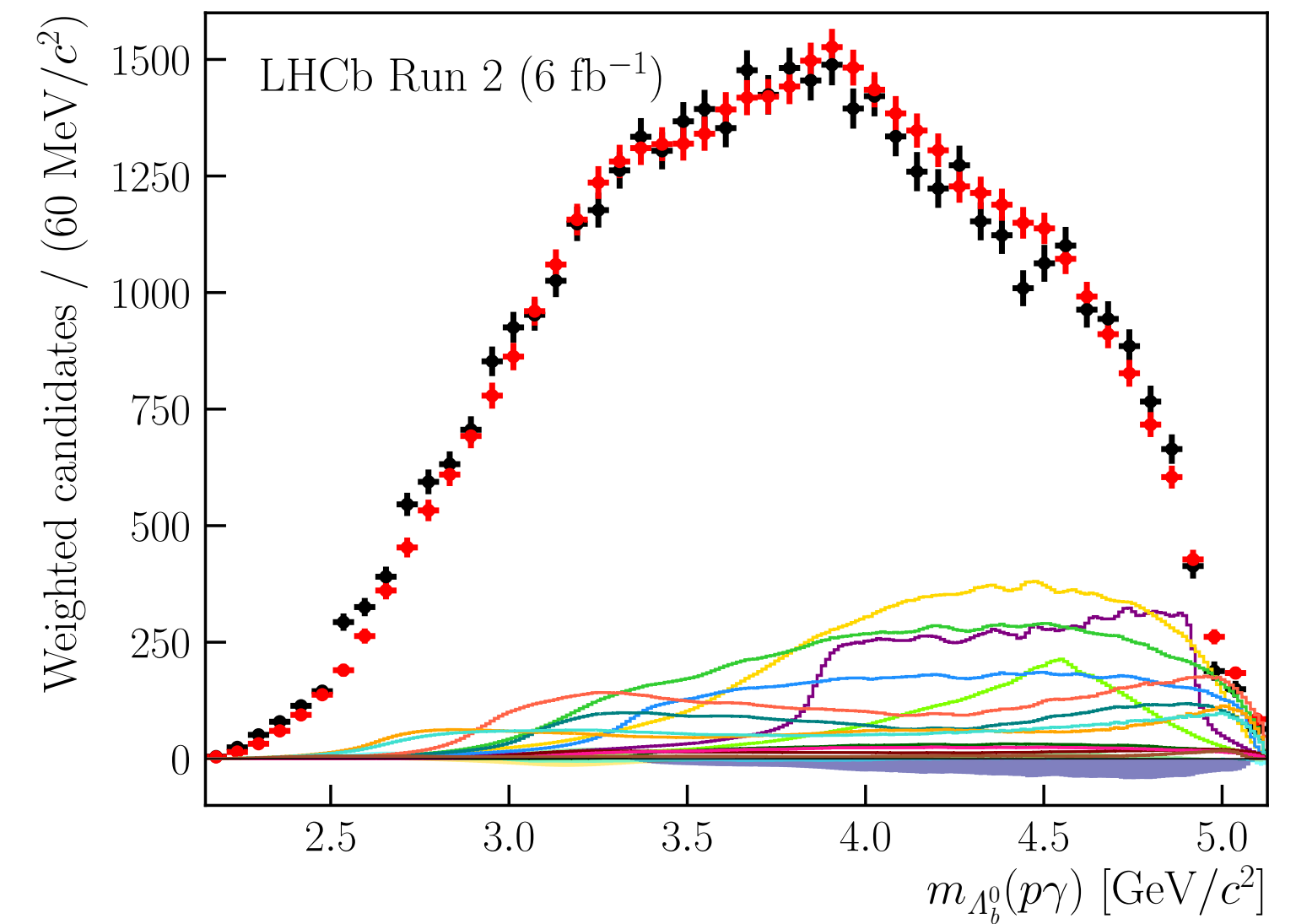
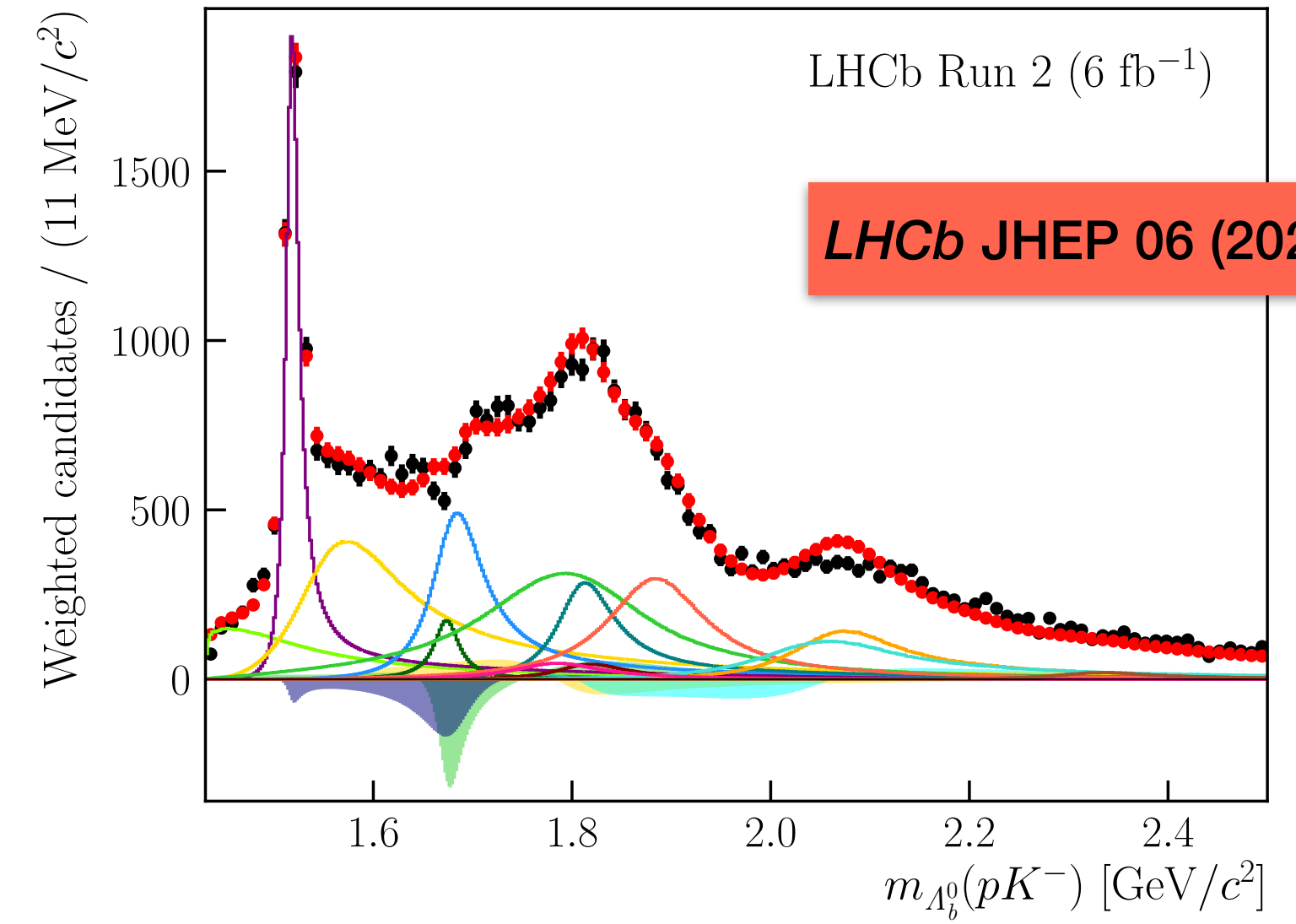
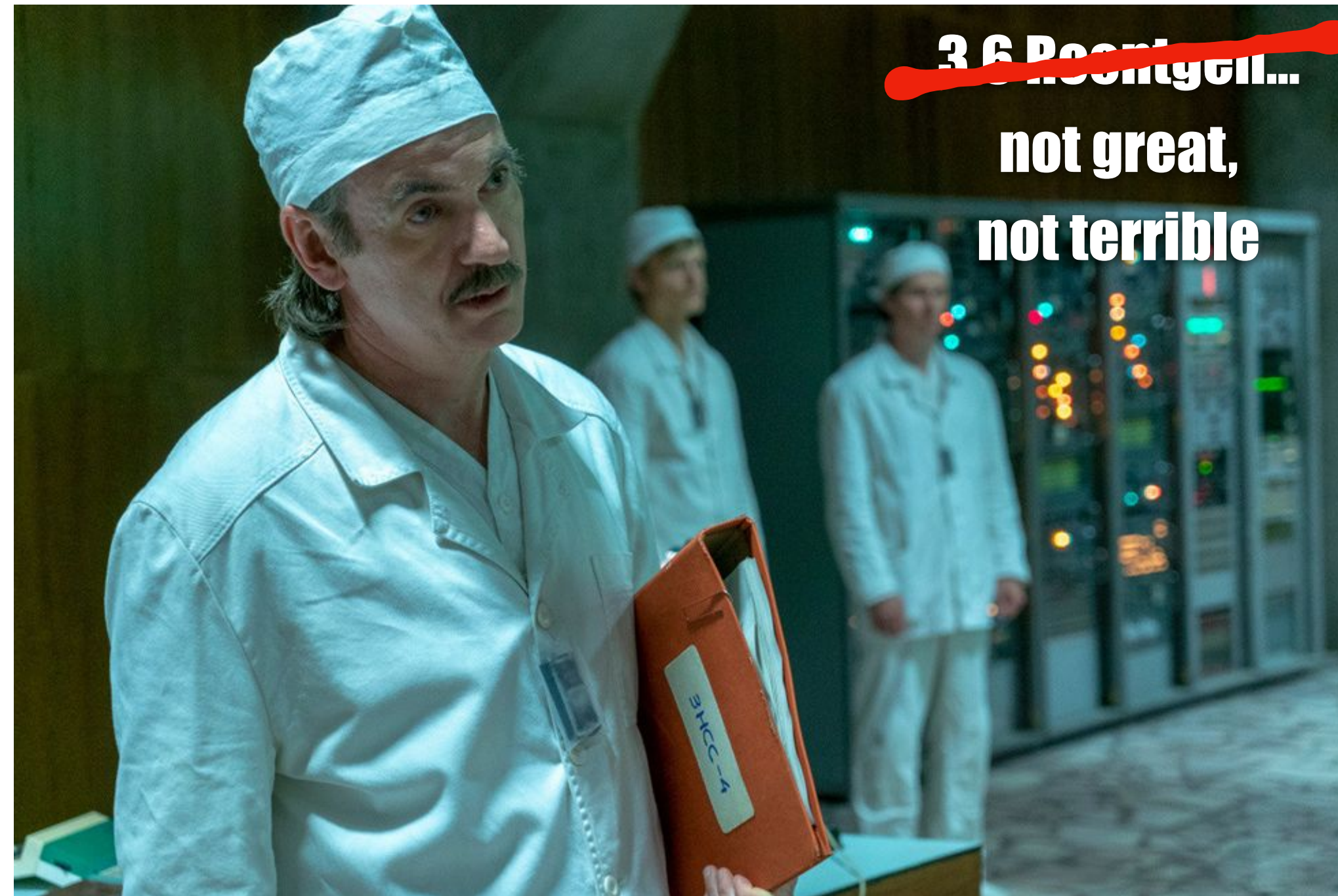
Very different photon HLT2 triggers in Run 1/2

# The “smallest” model

Removing highly suppressed amplitudes

- interf. (1/2)<sup>+</sup>
- interf. (1/2)<sup>-</sup>
- interf. (3/2)<sup>-</sup>
- interf. (5/2)<sup>+</sup>
- $\Lambda(1405)$
- $\Lambda(1520)$
- $\Lambda(1600)$
- $\Lambda(1670)$
- $\Lambda(1690)$
- $\Lambda(1800)$
- $\Lambda(1810)$
- $\Lambda(1820)$
- $\Lambda(1830)$
- $\Lambda(1890)$
- $\Lambda(2100)$
- $\Lambda(2110)$
- $\Lambda(2350)$
- + Model
- + Data

*this smallest model*



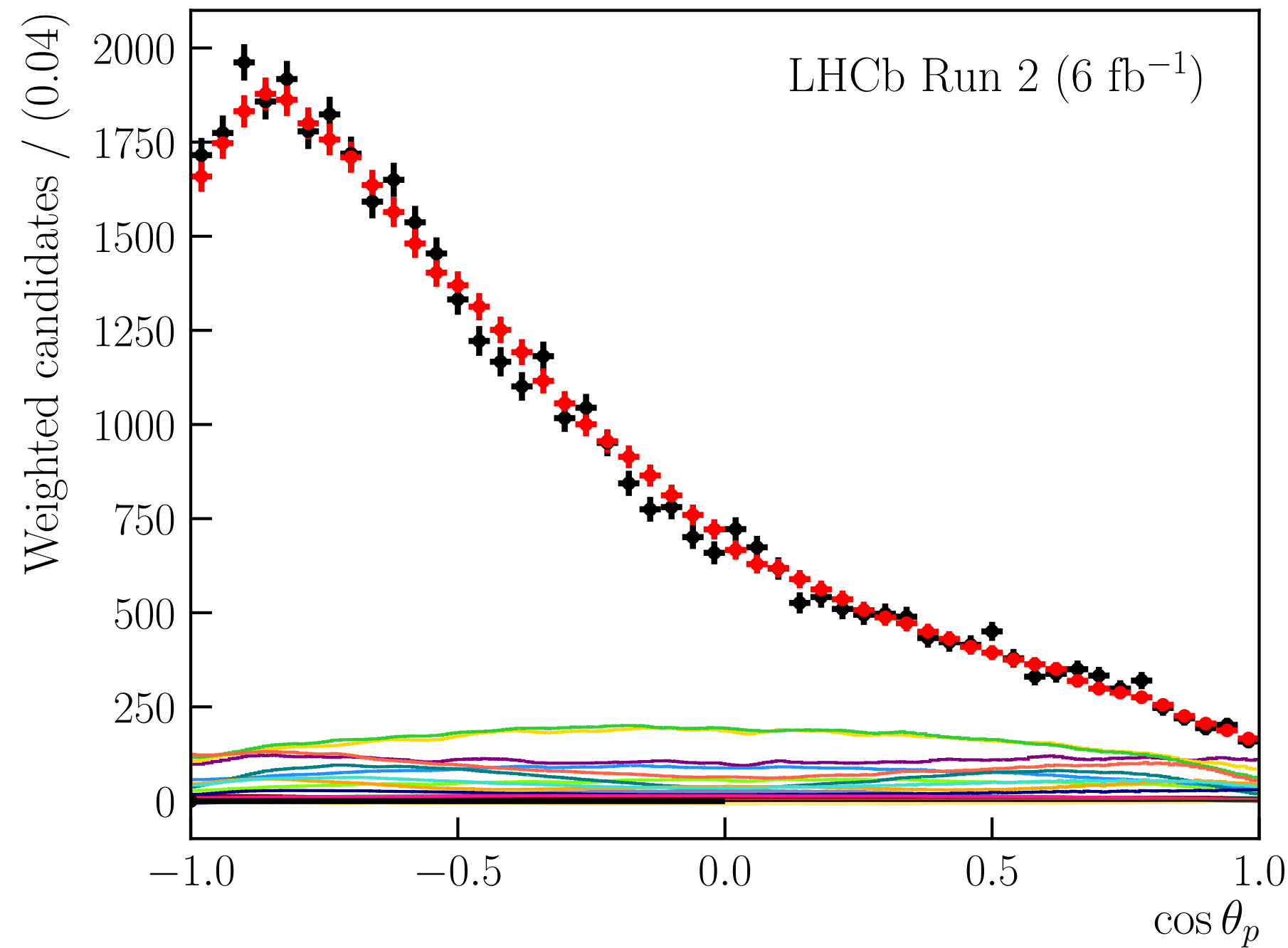
Thomas Edward Latham 3:55 PM  
 ok good 😊  
 btw I see you have two jobs that have been running for over 17 days - is that intentional?



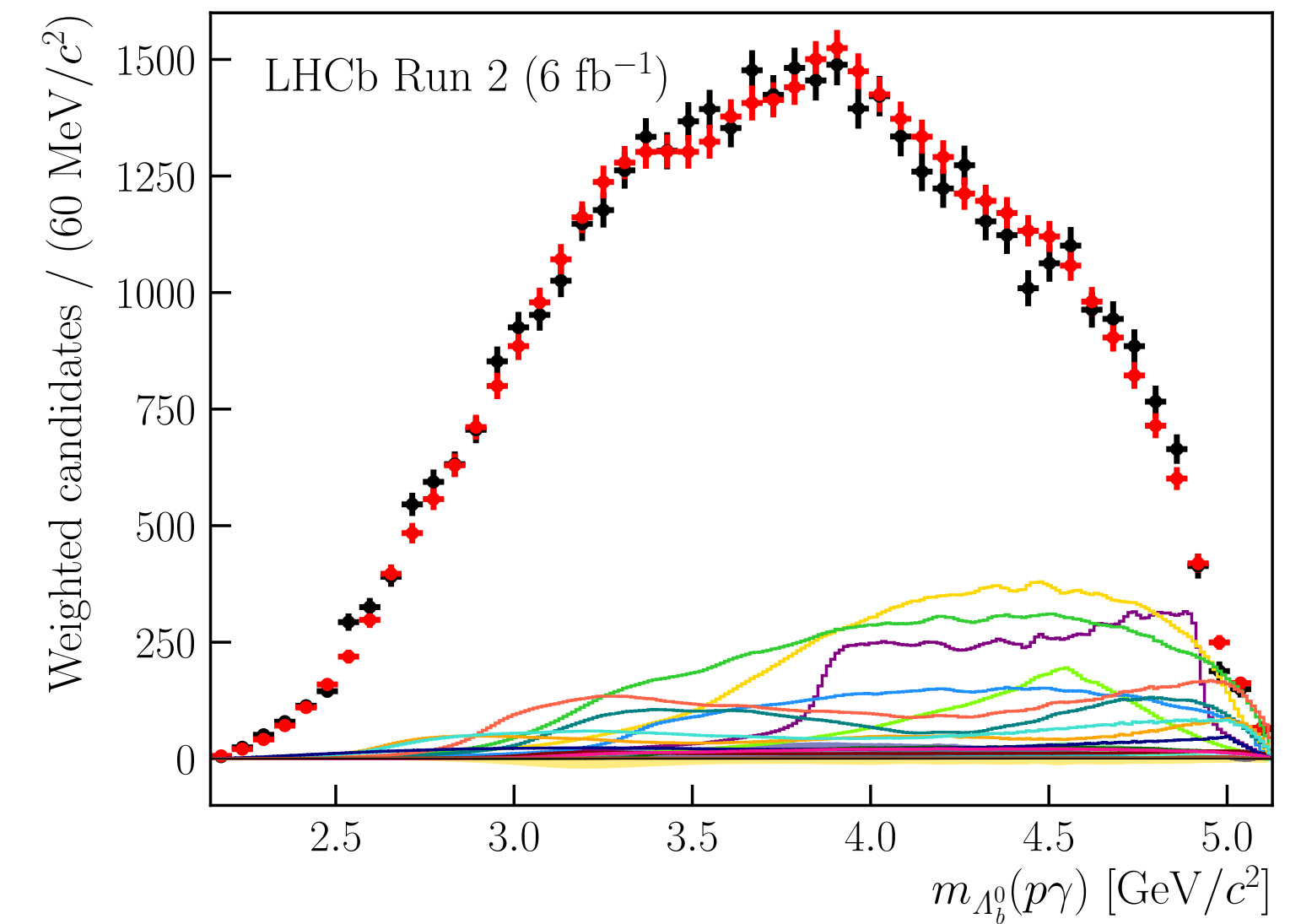
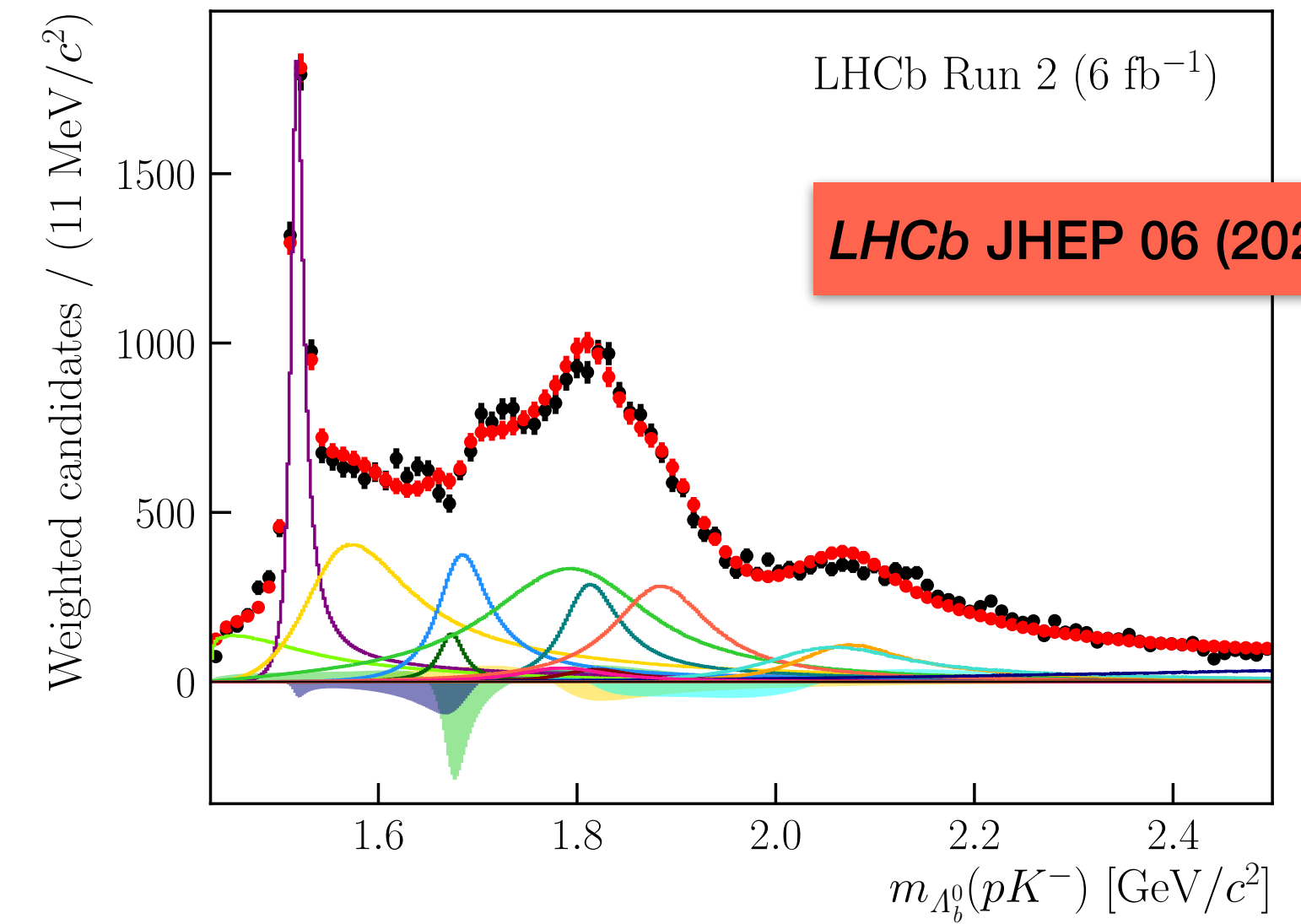
# The best model

Smallest model + non-resonant component

- |   |  |   |  |
|---|--|---|--|
| <span style="color: yellow;">■</span> interf. $(1/2)^+$     | <span style="color: purple;">■</span> $\Lambda(1520)$    | <span style="color: magenta;">■</span> $\Lambda(1810)$      | <span style="color: cyan;">■</span> $\Lambda(2110)$  |
| <span style="color: lightgreen;">■</span> interf. $(1/2)^-$ | <span style="color: gold;">■</span> $\Lambda(1600)$      | <span style="color: teal;">■</span> $\Lambda(1820)$         | <span style="color: brown;">■</span> $\Lambda(2350)$ |
| <span style="color: purple;">■</span> interf. $(3/2)^-$     | <span style="color: darkgreen;">■</span> $\Lambda(1670)$ | <span style="color: darkred;">■</span> $\Lambda(1830)$      | <span style="color: blue;">■</span> NR $((3/2)^-)$   |
| <span style="color: cyan;">■</span> interf. $(5/2)^+$       | <span style="color: blue;">■</span> $\Lambda(1690)$      | <span style="color: orange;">■</span> $\Lambda(1890)$       | <span style="color: red;">+</span> Model             |
| <span style="color: limegreen;">■</span> $\Lambda(1405)$    | <span style="color: green;">■</span> $\Lambda(1800)$     | <span style="color: yelloworange;">■</span> $\Lambda(2100)$ | <span style="color: black;">+</span> Data            |

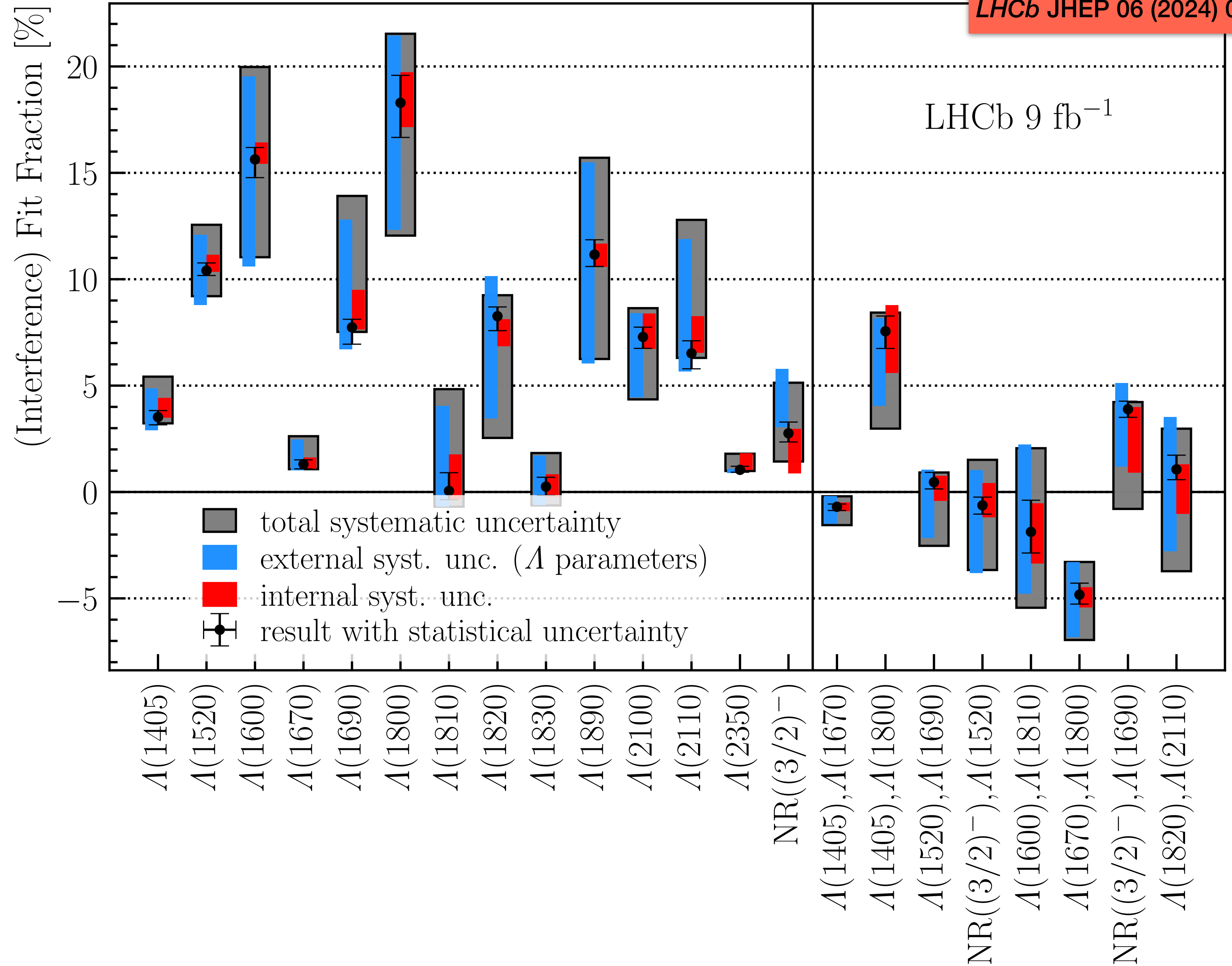


Asymmetric helicity angle  
due to interference



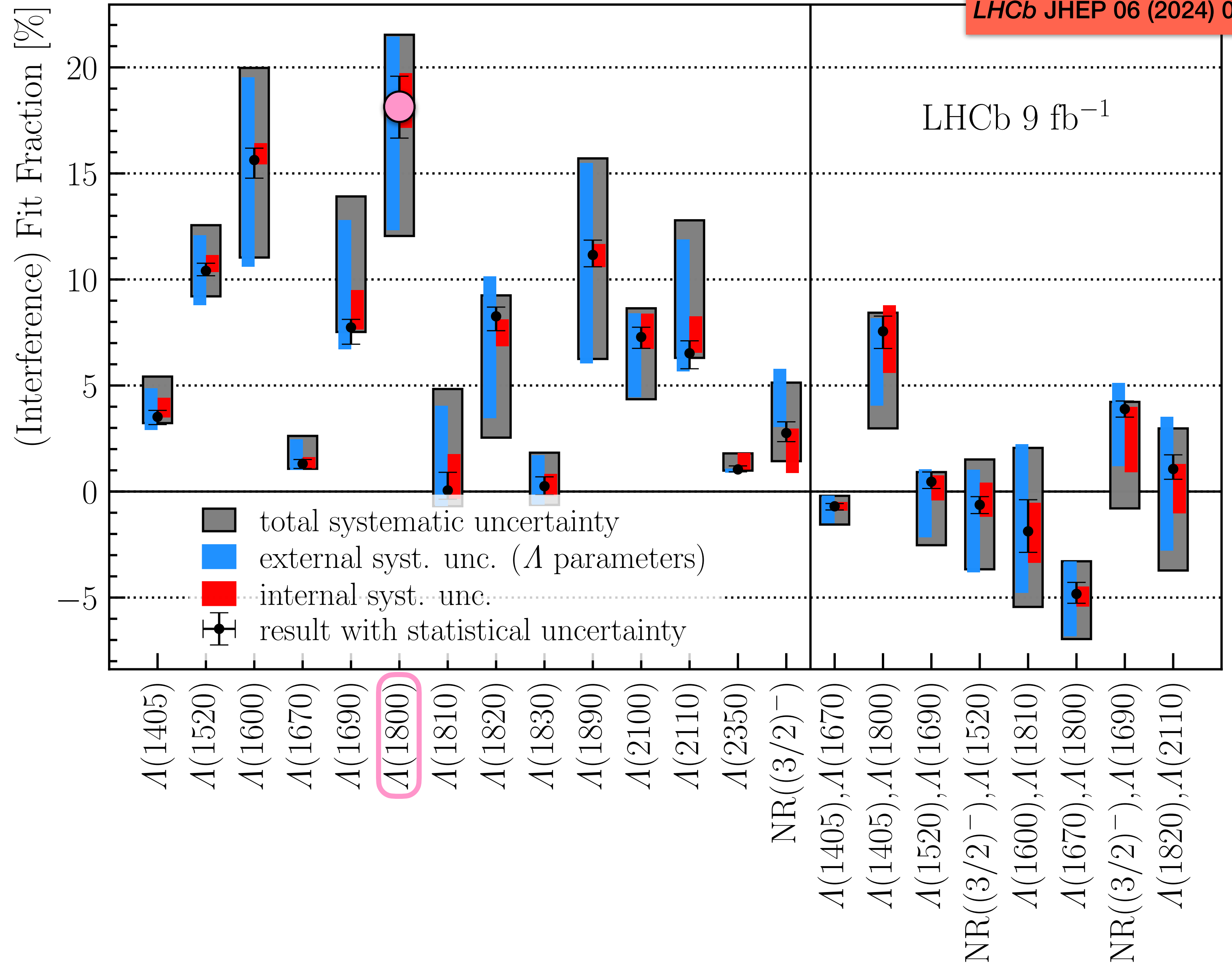


# Result



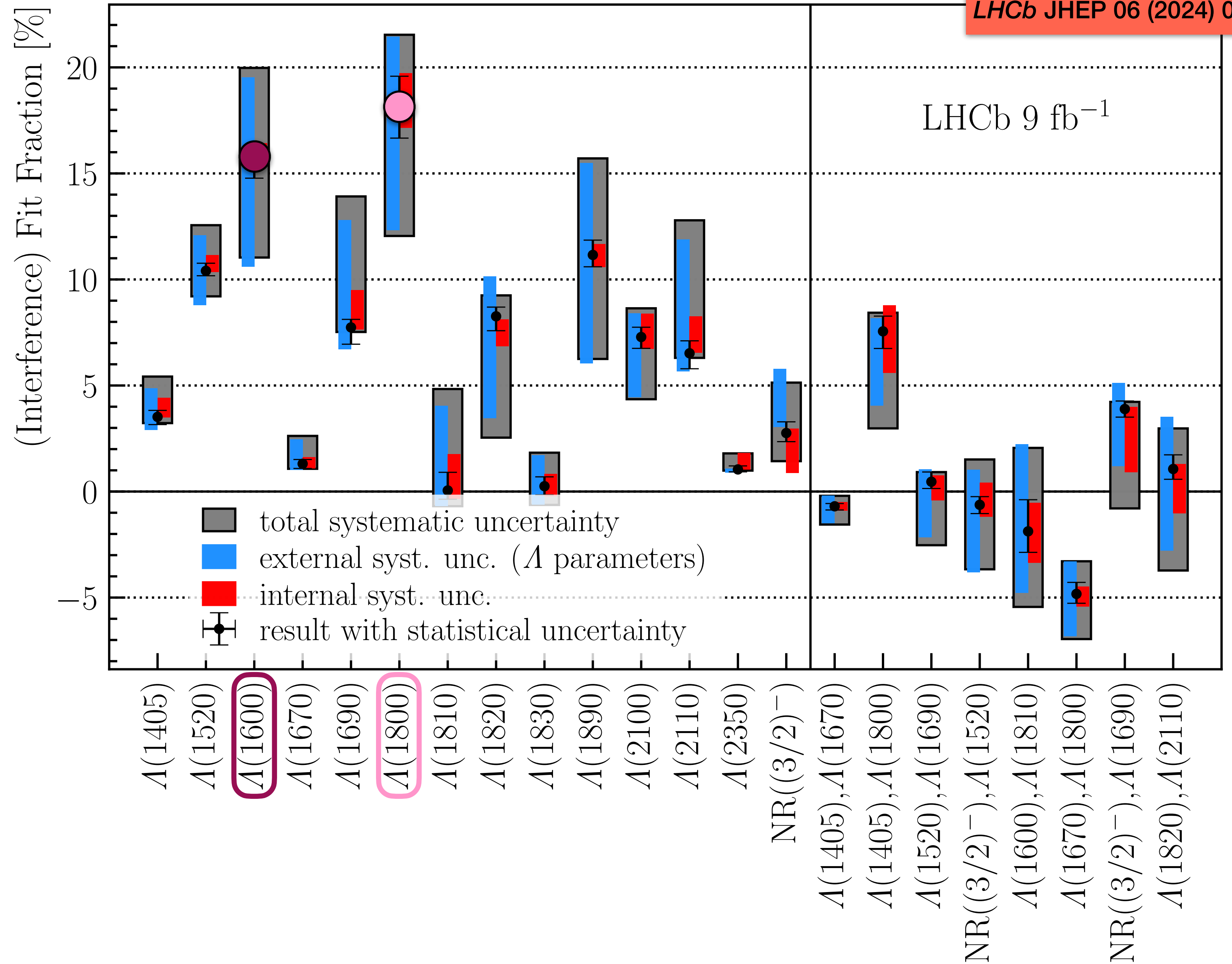
# Result

1  
—  
2  
—



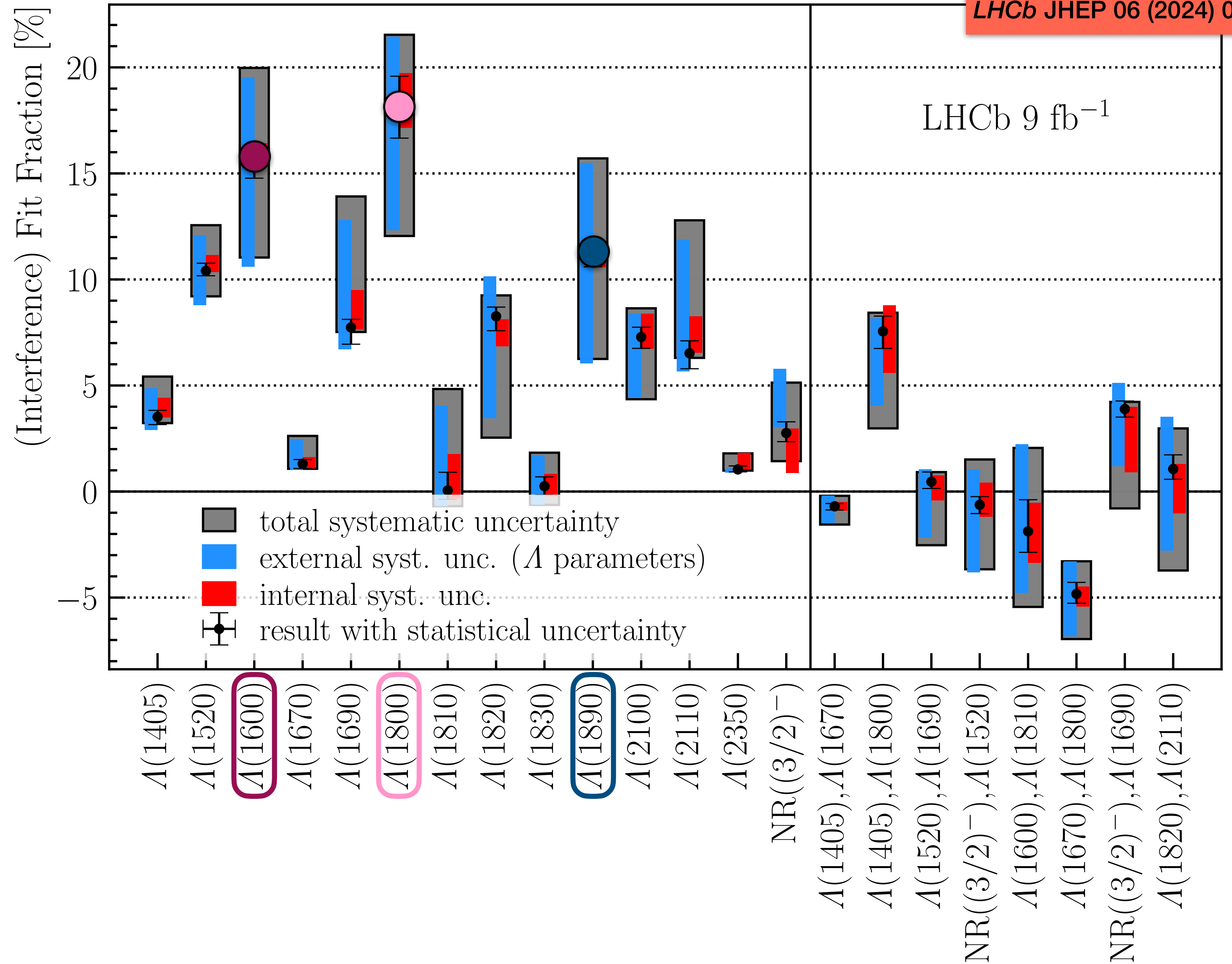
# Result

1	1
2	2
-	+



# Result

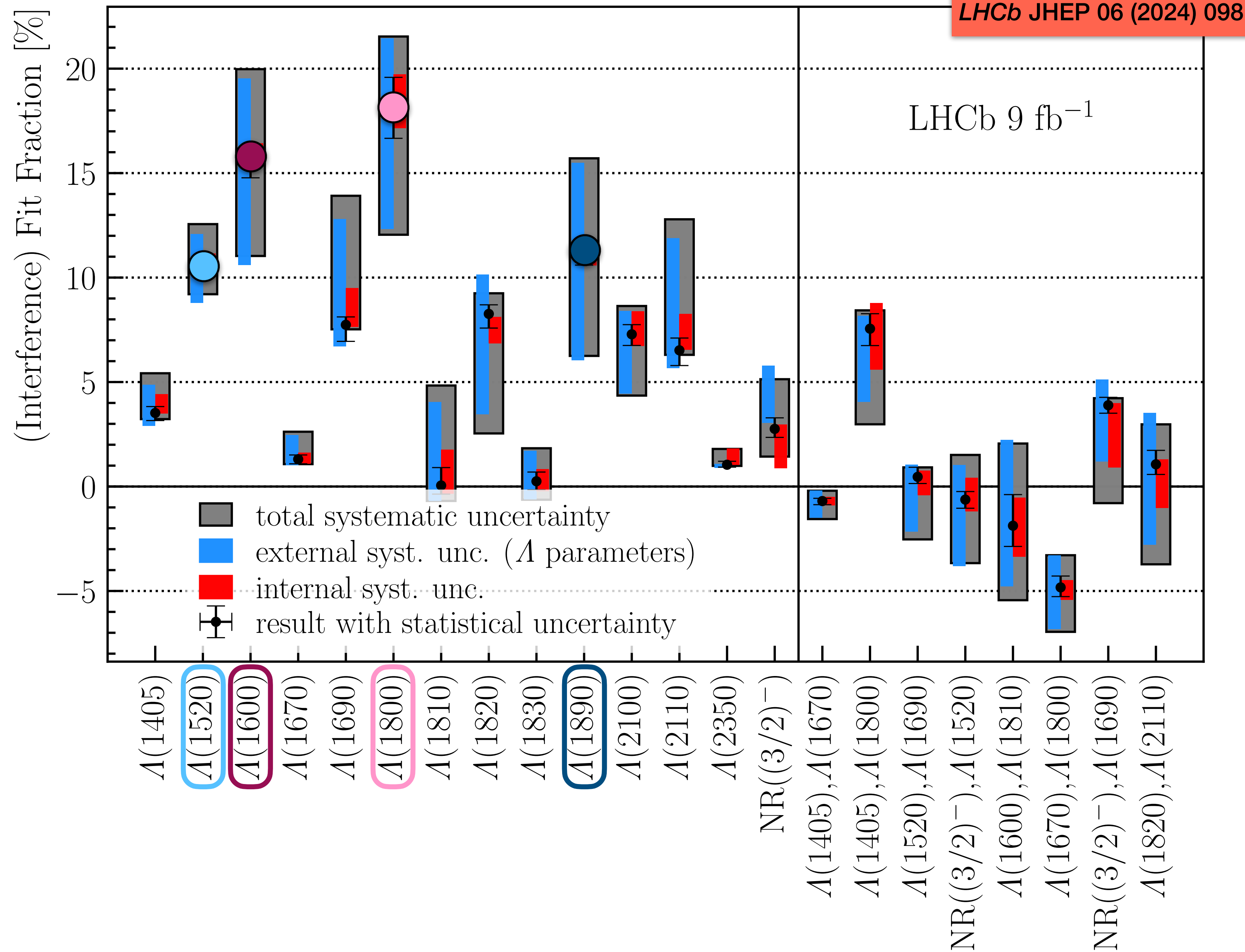
1	1	3
2	2	2
-	+	+





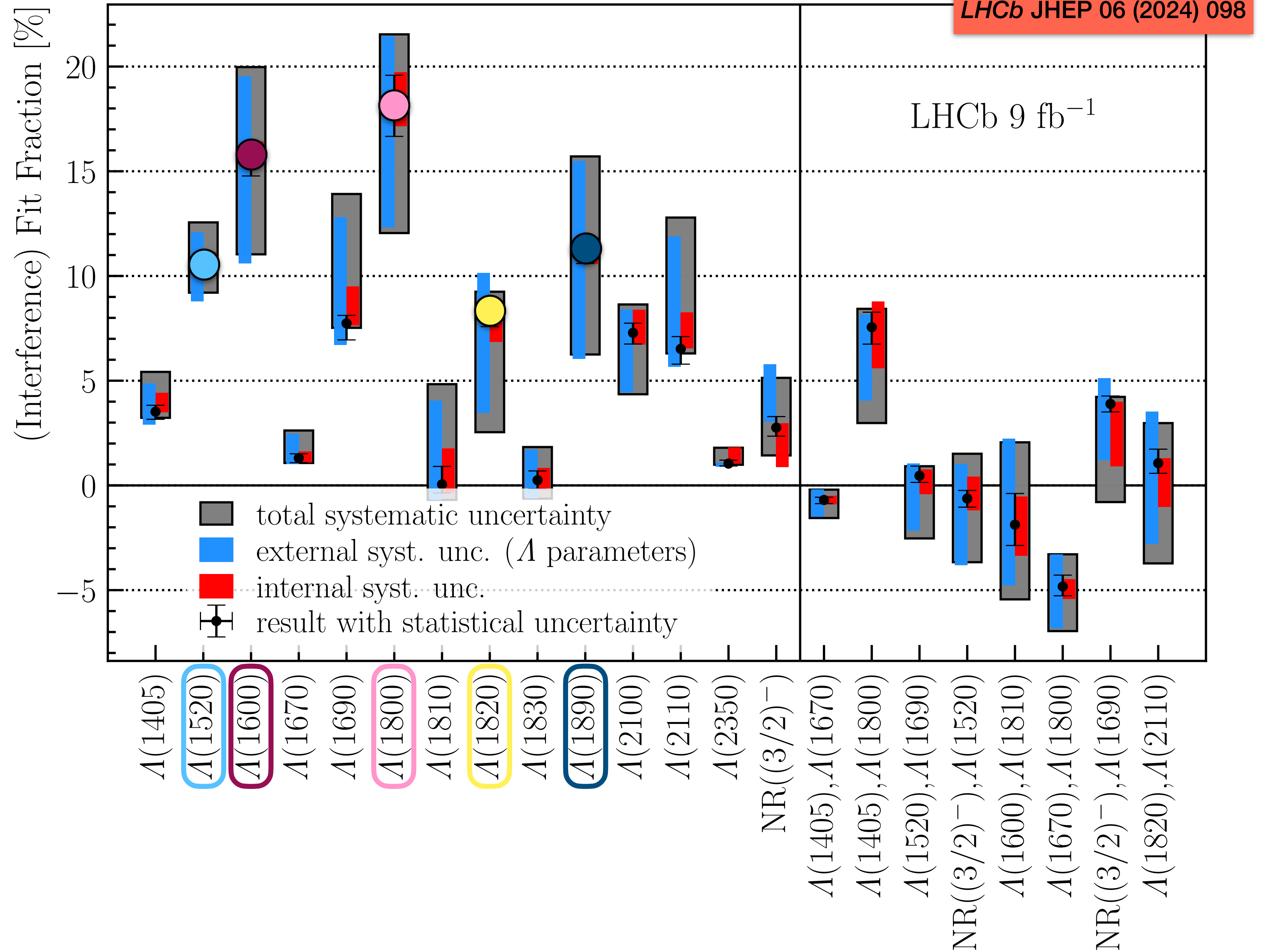
# Result

1	1	3	3
2	2	2	2
-	+	+	-



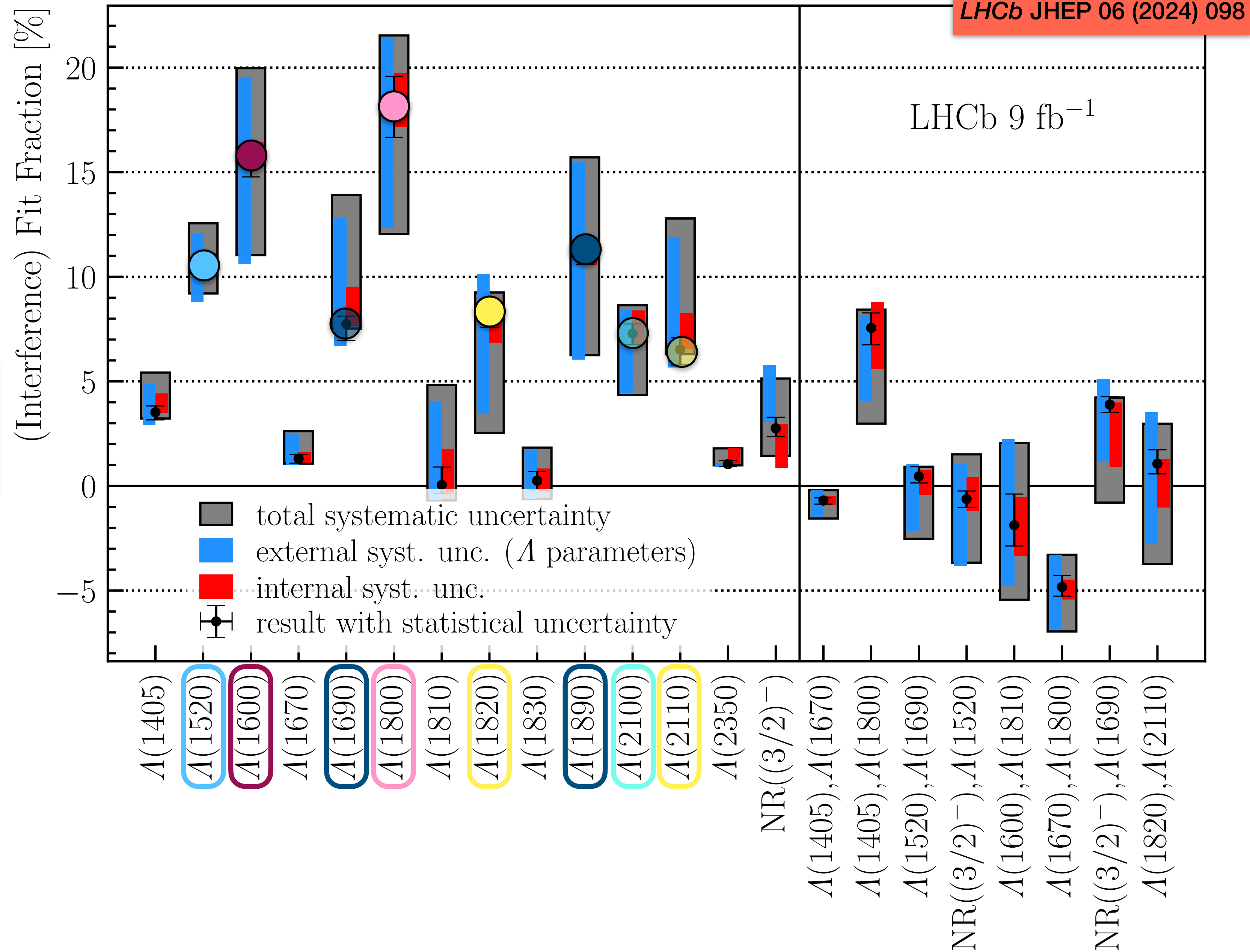
# Result

1	1	3	3	5
2	2	2	2	2
-	+	+	-	+



# Result

1	1	3	3	5	3	7	5
2	2	2	2	2	2	2	2
-	+	+	-	+	+	-	+

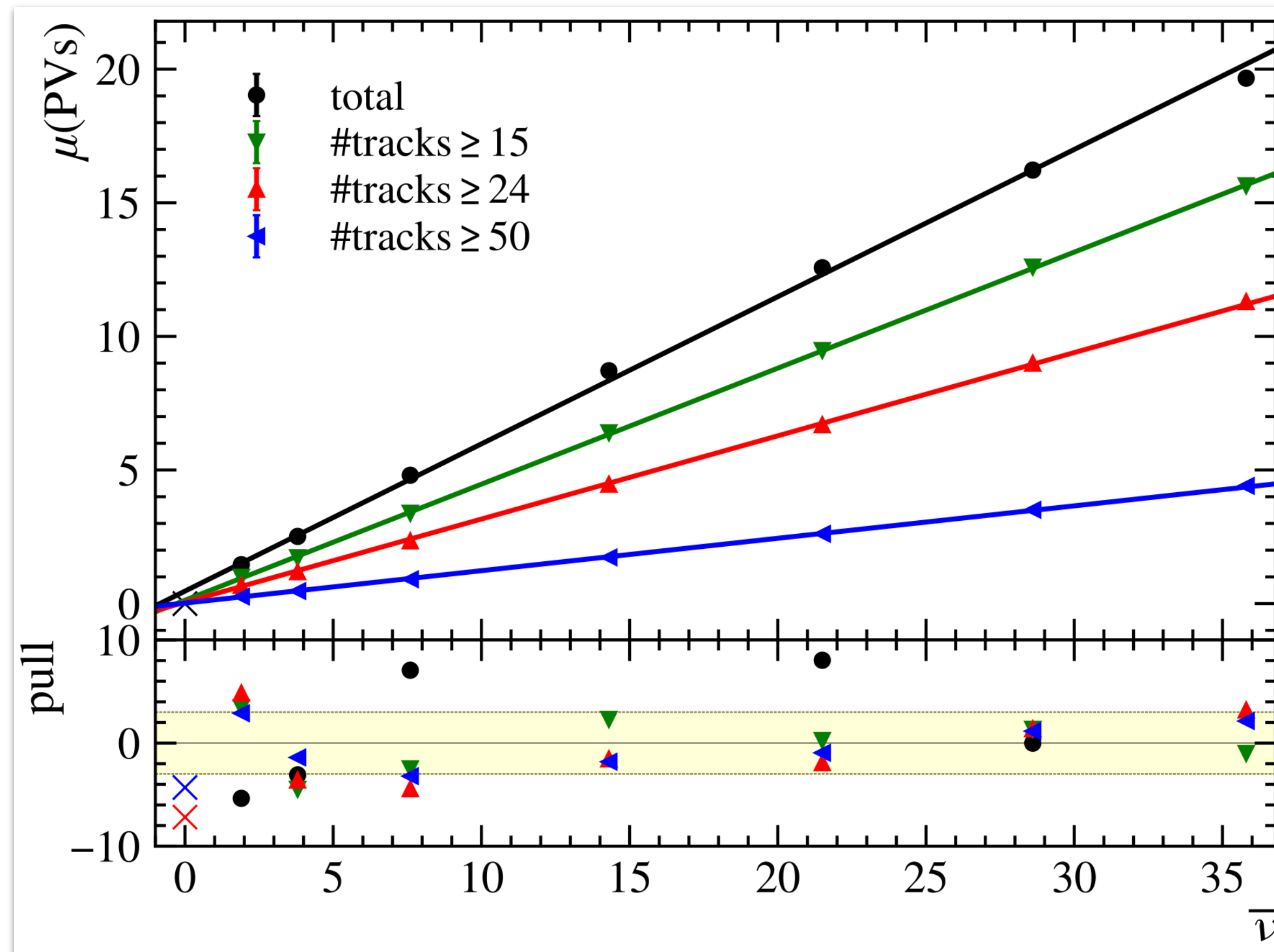


Other stuff

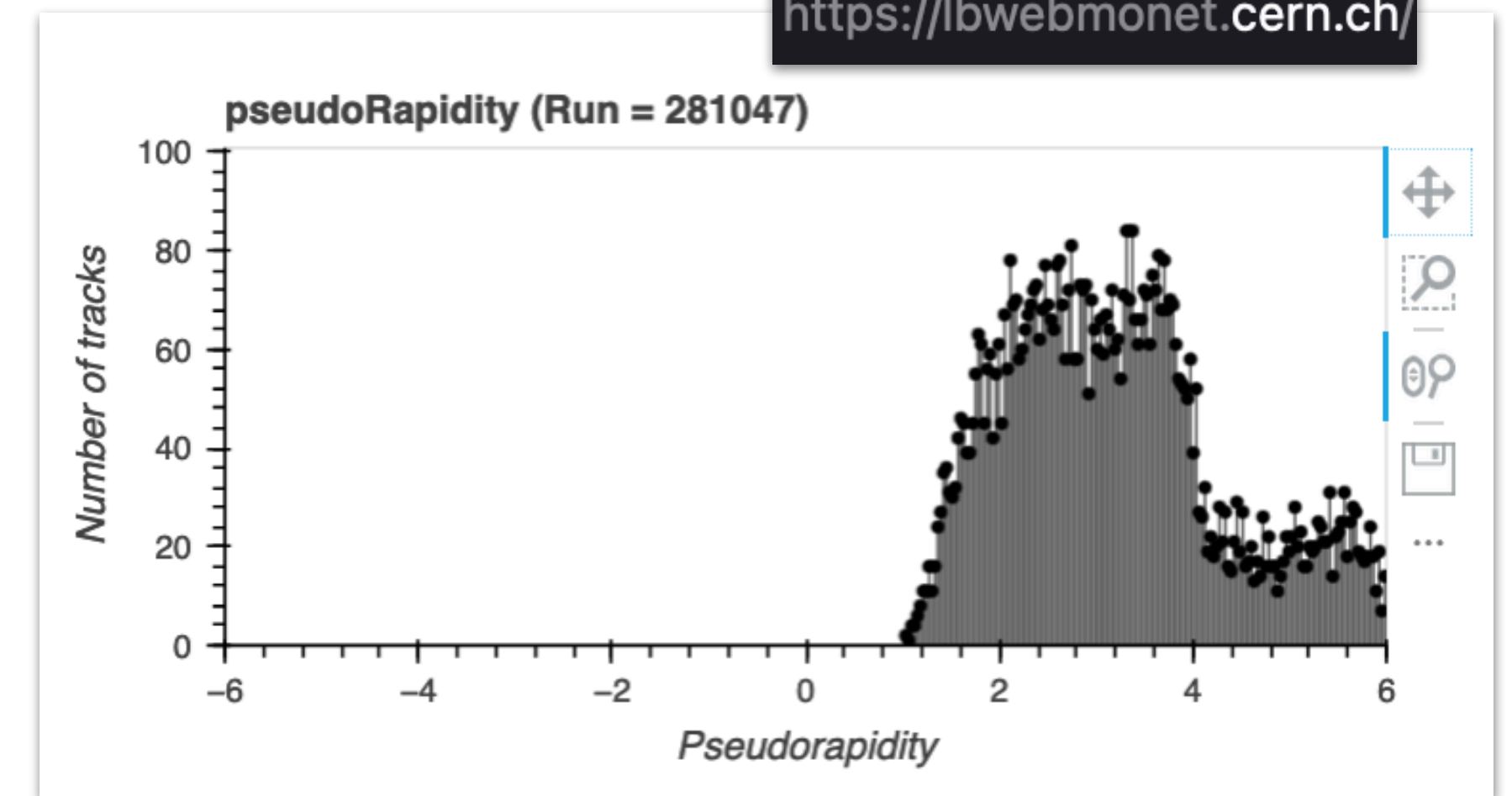




# Commissioning



<https://lbwebmonet.cern.ch/>





# Random other projects

## YETI 2023: Almost Everything About Flavour

July 31, 2023 to August 3, 2023  
Rochester Building  
Europe/London timezone

Eur. Phys. J. C (2023) 83:1115  
<https://doi.org/10.1140/epjc/s10052-023-12294-0>

THE EUROPEAN  
PHYSICAL JOURNAL C



Regular Article - Theoretical Physics

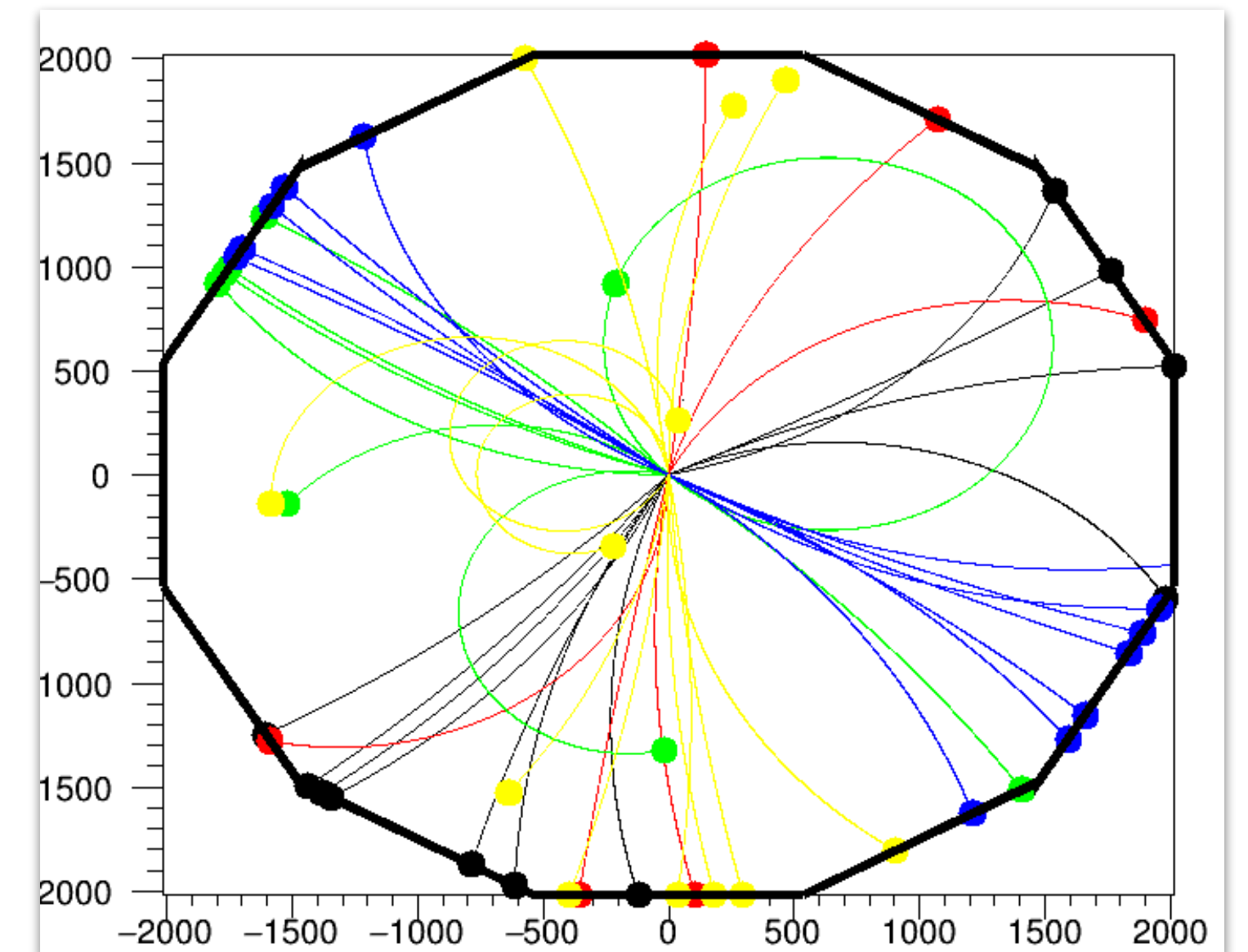
### Testable likelihoods for beyond-the-standard model fits

Anja Beck<sup>1,a</sup>, MÉRIL Reboud<sup>2,b</sup>, Danny van Dyk<sup>2,c</sup>

<sup>1</sup> Department of Physics, University of Warwick, Coventry CV4 7AL, UK

<sup>2</sup> Institute for Particle Physics Phenomenology and Department of Physics, Durham University, Durham DH1 3LE, UK

Received: 4 October 2023 / Accepted: 27 November 2023  
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# Non-physics things

## Microaggressions at the workplace

You're just a diversity hire.

Not being taken seriously. Ideas being ignored.

Mansplaining.

Being mistaken as an assistant/the security guard/... for being the only woman/non-white person in the room.

"He, the physicist..."

Anja & Janina
Laura Bassi Meeting
109th LHCb Week

## jDPG A-Team for Mental Health

Create better and healthier working environments in academia

**Anja (she/her)**  
PhD student (particle physics)  
University of Warwick (England)

Anja Beck

26. Deutsche Physikerinnentagung

## Welcome: meet this year's organisers

Ahmed Abdelmottaleb  
(Warwick)

Anja Beck  
(Warwick)

Alessandro Scarabotto  
(LPNHE)

Lukas Calefice  
(LPNHE/Dortmund)

Valeriia (Lera)  
Lukashenko  
(NIKHEF)

Contact us either individually or via the Starterkit email: [lhcb-starterkit@cern.ch](mailto:lhcb-starterkit@cern.ch)

# LEADING FOR TOMORROW

Deutsche Physikalische Gesellschaft  $\Phi$  DPG

gefördert durch die

WILHELM UND ELSE HERAEUS-STIFTUNG

# Acknowledgements

from village import \*

I was the happiest PhD student in the history of PhD students. And a lot of it