$B \to X_s \nu \bar{\nu}$ at Belle II

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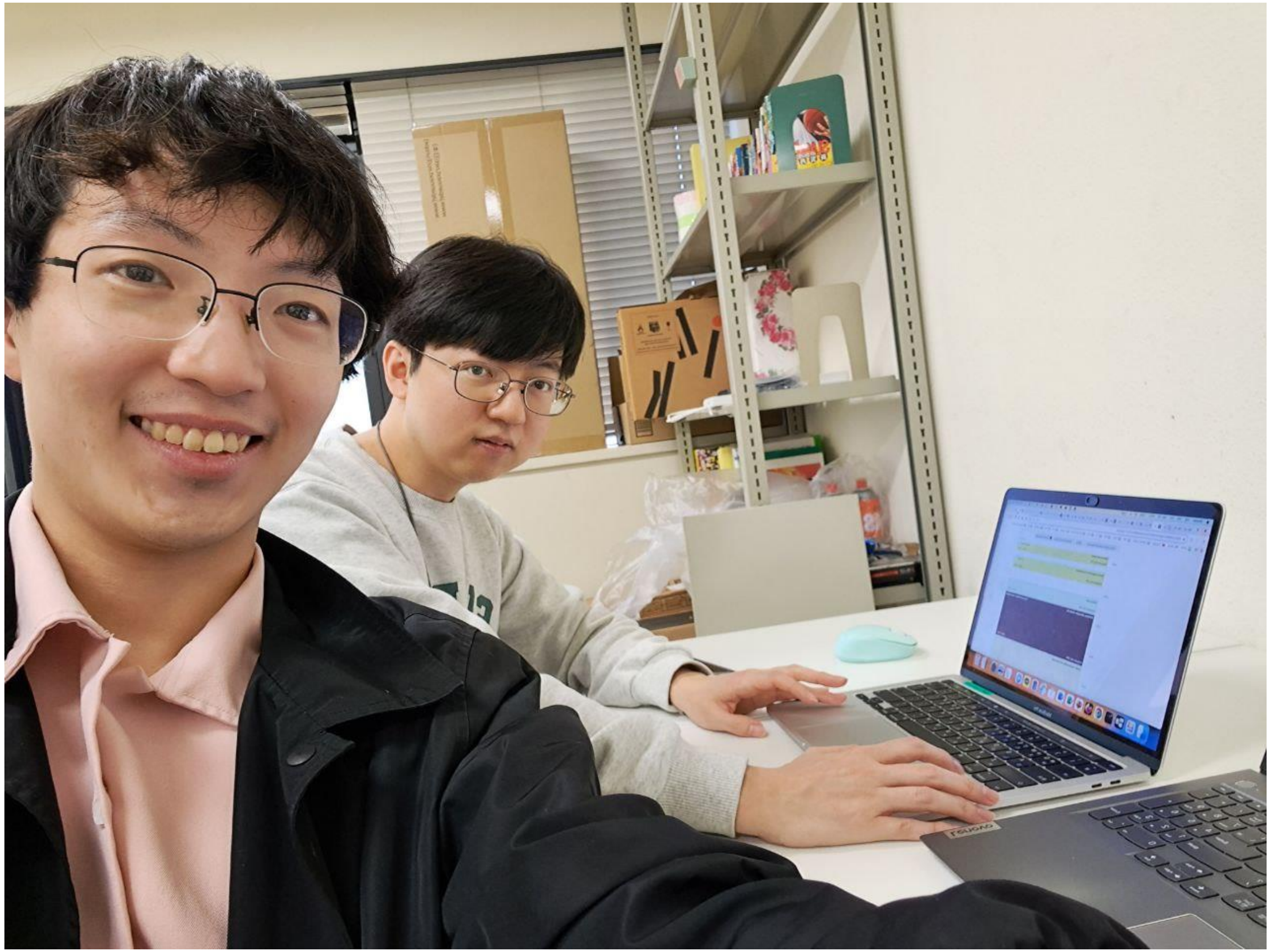
2023.11.03

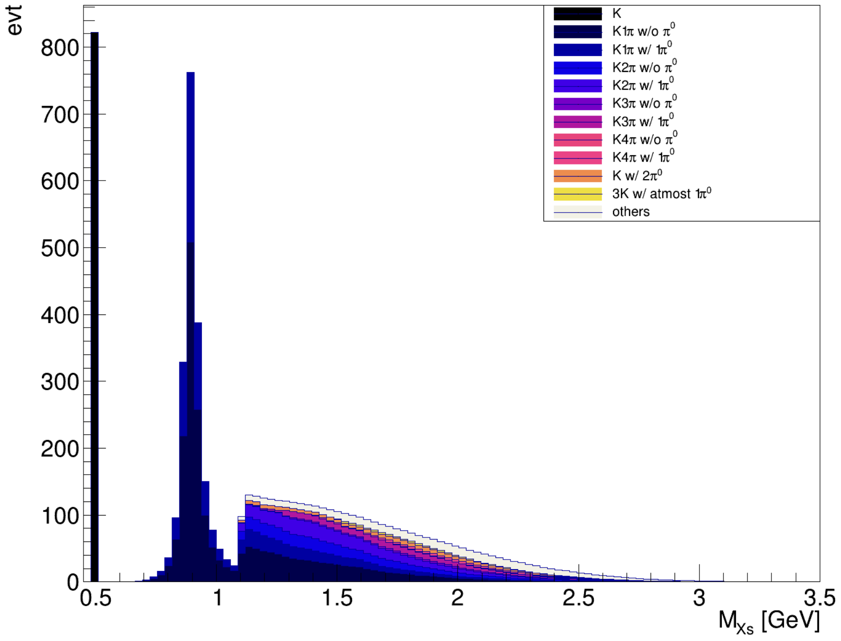
Discussion



And I also consult with Yo Sato-san and Shun Watanuki-san

Challenge 1: Fragmentation

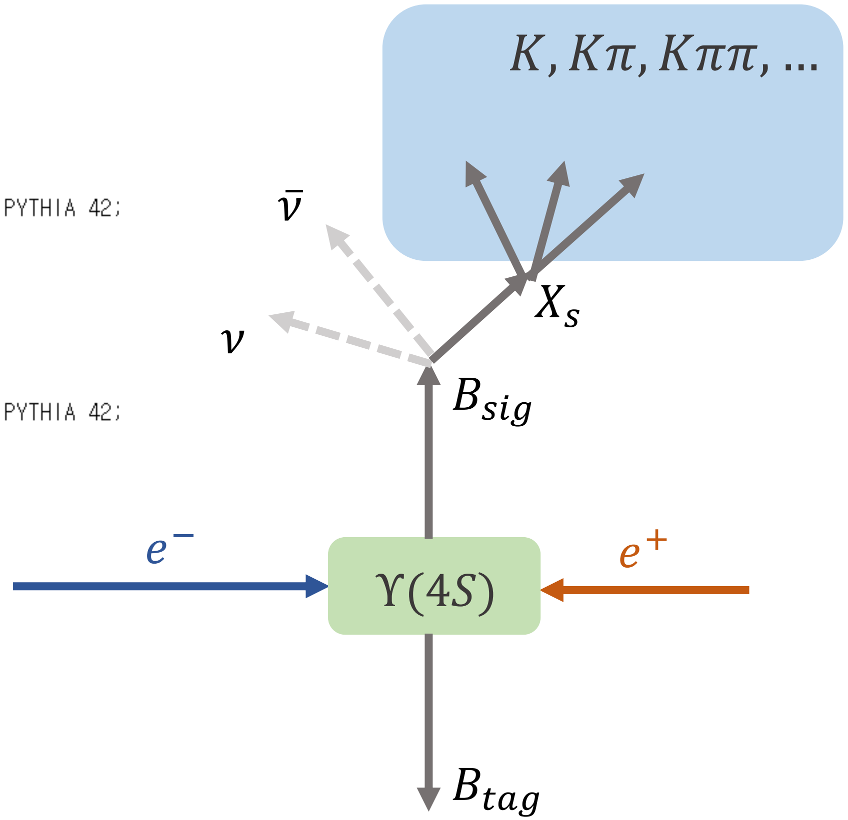
- For the analysis, signal MC sample is produced
- Hadronization process is done by Pythia in Evtgen




```
Decay Xsd
1.000000000    d  anti-s                                     PYTHIA 42;
Enddecay

CDecay anti-Xsd

Decay Xsu
1.000000000    u  anti-s                                     PYTHIA 42;
Enddecay
```



- How to estimate the uncertainty from the hadronization?

How can we properly estimate the uncertainty from the fragmentation? (ratio between decay modes)

from $B \rightarrow X_s J/\psi$: it is different physics
from $B \rightarrow X_s \ell \bar{\ell}$: not so sensitive to estimate it

Or any theoretical method?

Challenge 1: Fragmentation

- It was not so easy to find a proper candidates

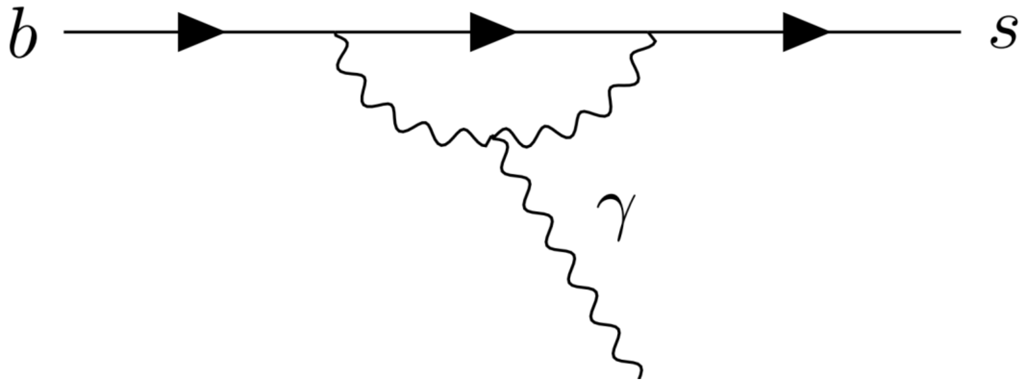
  from $B \to X_s J/\psi$: it is different physics

  from $B \to X_s \ell\bar{\ell}$: not so sensitive to estimate it

- Therefore, we decided to choose $B \to X_s \gamma$ decay

  well studied before

  produced by similar process (EWP)

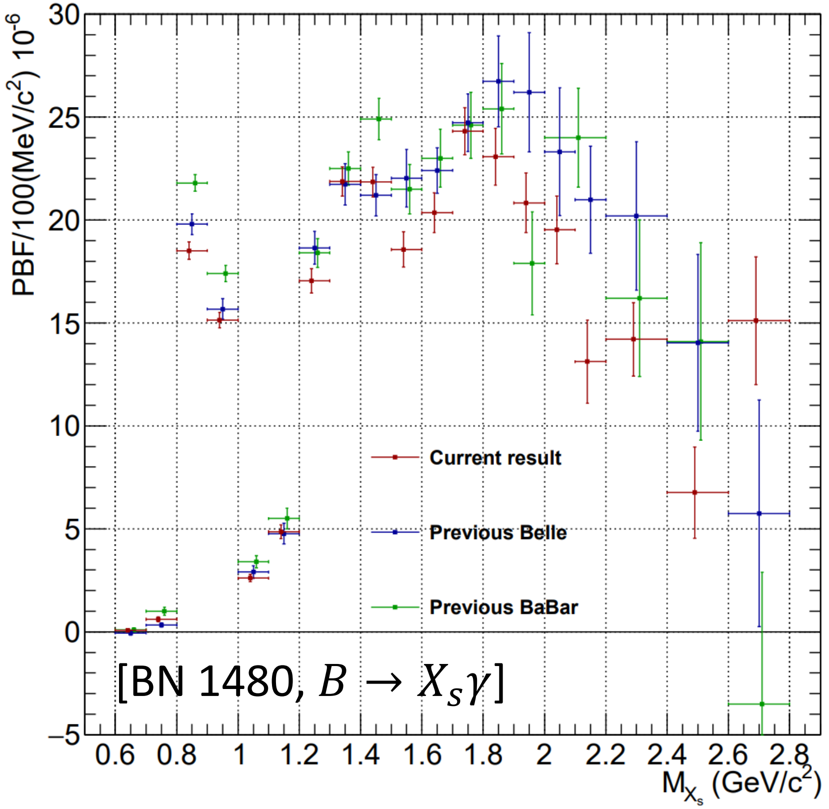


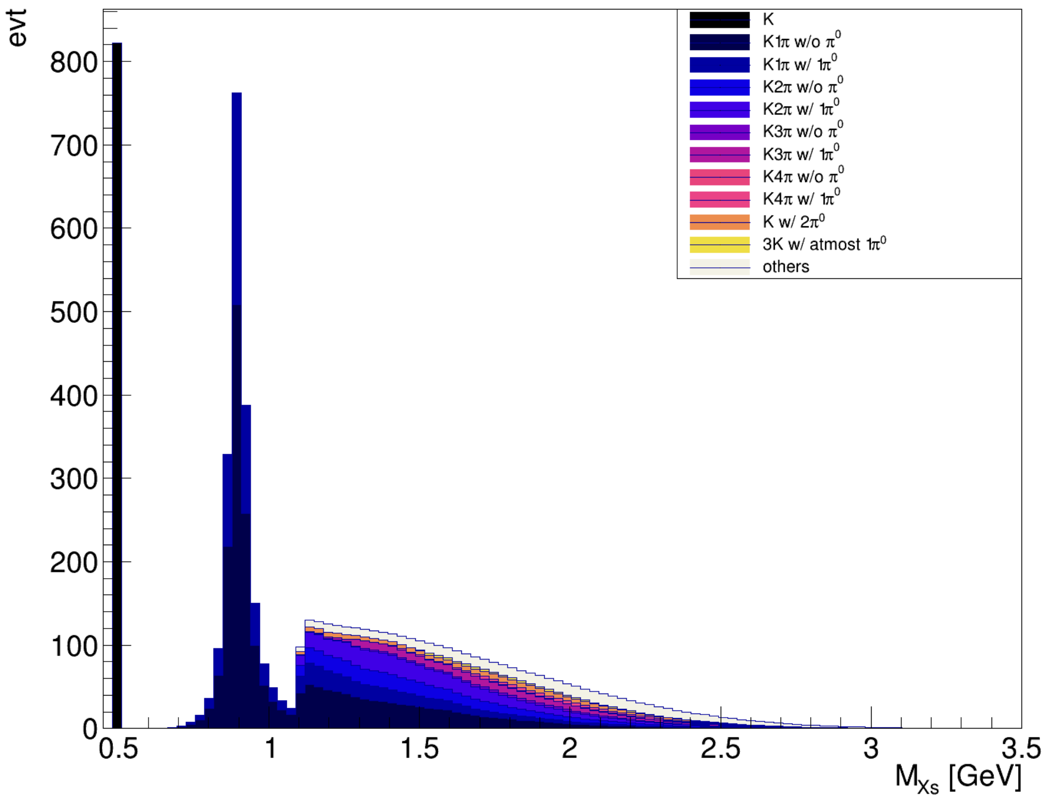
Challenge 1: Fragmentation

- There can be difference between $B \to X_s \nu \bar{\nu}$ and $B \to X_s \gamma$

  Actually, it is the reason why I was reluctant to use $B \to X_s J/\psi$

  Example of this effect: M_{Xs} distribution





→ To overcome this problem, corrections are applied for each M_{Xs} region

Thank you, Yo Sato-san

Challenge 1: Fragmentation

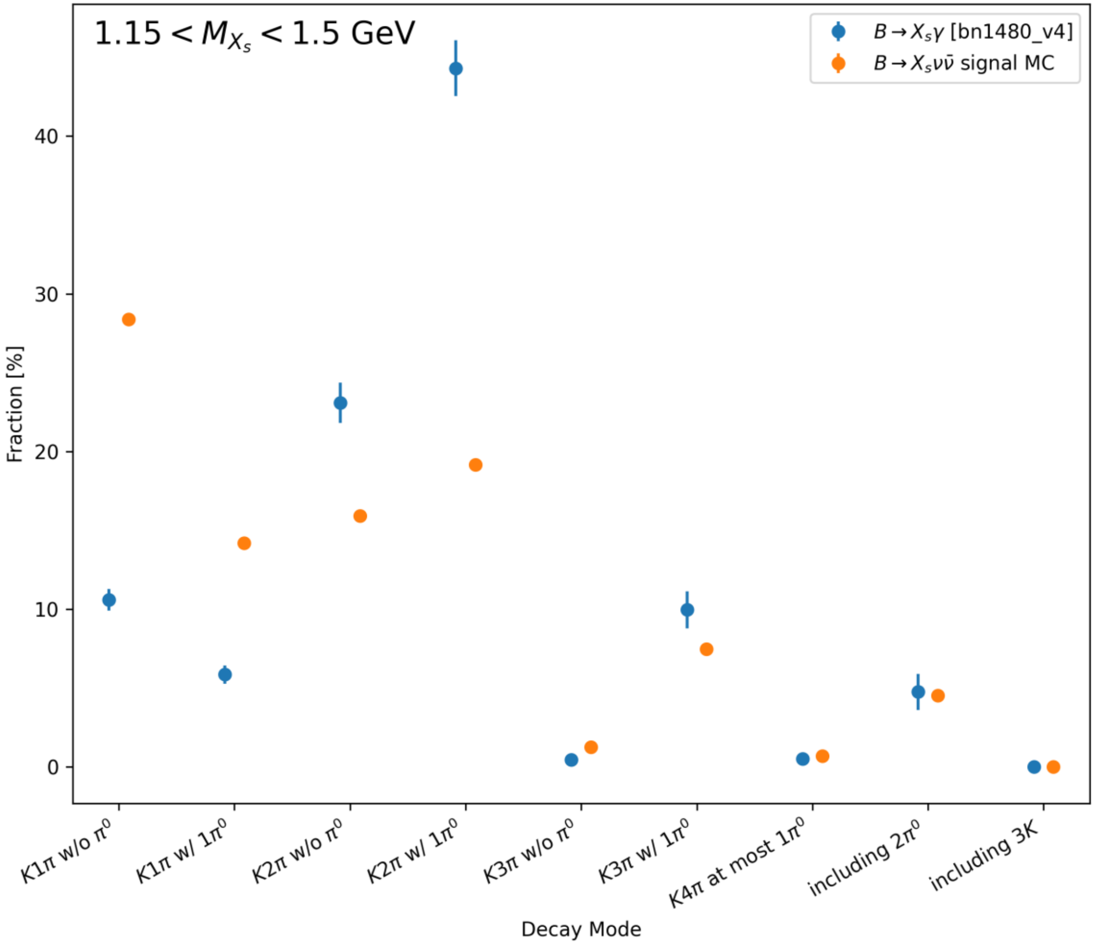
- Fortunately, fragmentation is calculated with binned M_{Xs} range

Type	Data fragmentation(%)	Nominal MC(%)	Deviation(σ)	Calibrated MC(%)	Deviation(σ)
M_{X_s} All region (1.15, 2.8)GeV/c^2					
a	4.43±0.33	8.20	11.3	4.89	1.39
b	2.31±0.27	4.37	7.72	2.49	0.66
c	14.7±0.95	12.7	-2.10	13.4	-1.30
d	21.9±1.45	15.9	-4.14	20.0	-1.30
e	6.12±0.71	5.47	-0.92	6.57	0.63
f	18.6±1.65	14.4	-2.55	21.5	1.80
g	8.64±2.07	10.4	0.85	12.2	1.73
h	19.7±3.61	13.3	-1.77	14.5	-1.45
i	1.59±0.54	12.3	20.0	2.62	1.93
j	2.05±0.30	2.95	3.01	1.72	-1.10
M_{X_s} region1 (1.15, 1.5)GeV/c^2					
a	10.6±0.69	8.20	-3.48	13.1	3.54
b	5.86±0.58	4.37	-2.58	6.76	1.55
c	23.1±1.28	12.7	-8.13	22.3	-0.65
d	44.3±1.77	15.9	-16.0	34.0	-5.80
e	0.46±0.29	5.47	17.1	1.68	4.16
f	9.96±1.17	14.4	3.79	16.1	5.24
g	0.52±0.37	10.4	26.8	0.77	0.66
h	4.76±1.14	13.3	7.49	4.75	-0.00
i	0.35±0.09	12.3	139	0.53	2.15
j	0.00±0.00	2.95	0	0.02	0
M_{X_s} region2 (1.5, 2.0)GeV/c^2					
a	3.04±0.32	8.20	16.2	3.78	2.33
b	1.10±0.30	4.37	10.9	1.88	2.61

Thank you, Shun Watanuki-san

Challenge 1: Fragmentation

- So, what is the result?



Challenge 1: Fragmentation

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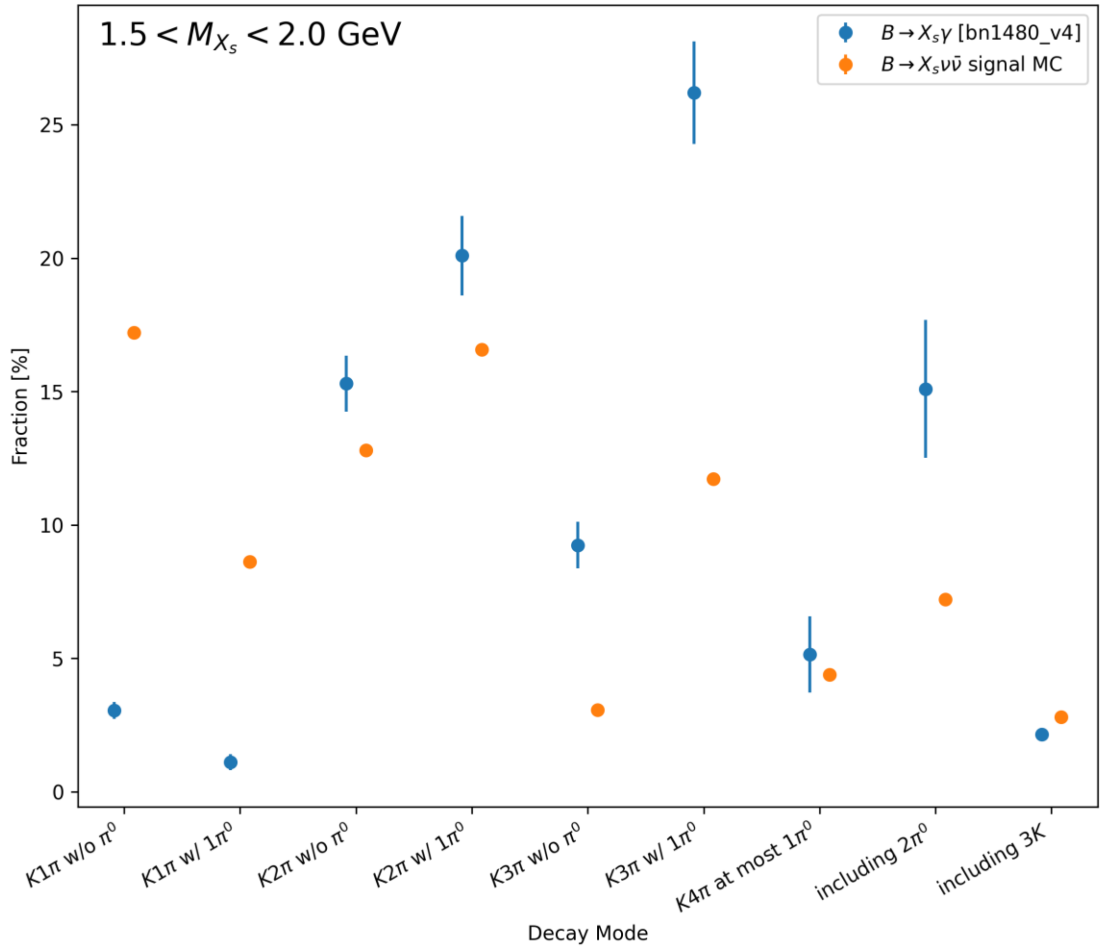

Challenge 1: Fragmentation

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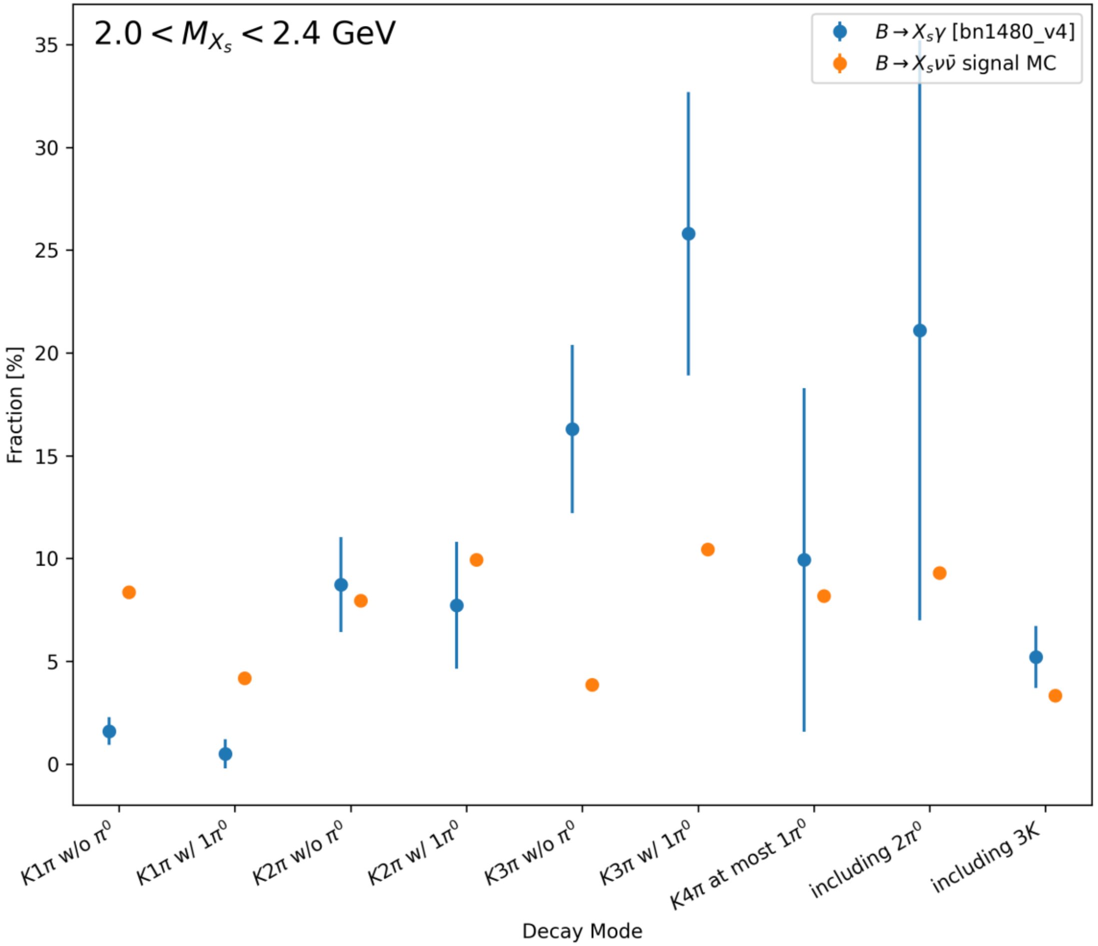

Challenge 1: Fragmentation

- Conclusion

  low multiplicity mode shows a large discrepancy

  → it is better to apply correction, instead of estimating large uncertainties

  Then uncertainty of these correction factors are…

  → uncertainties of fragmentation at $B \to X_s\gamma$

Back up

Challenge 2: $K^* - X_s$ transition

- There is a transition point between K^* and non-resonant X_s
- This point is set to be 1.1 ± 0.1 GeV

  This value comes from $B \to X_s \ell\bar{\ell}$ study

  However, there seems not to be theoretical/experimental reason

- Is ± 0.1 GeV proper as the uncertainty?

  How can we estimate proper uncertainty?

  Can we find any theoretical/experimental estimation?