Trigger bit for PID

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Introduction

Study of LID efficiency is important for Belle II analysis

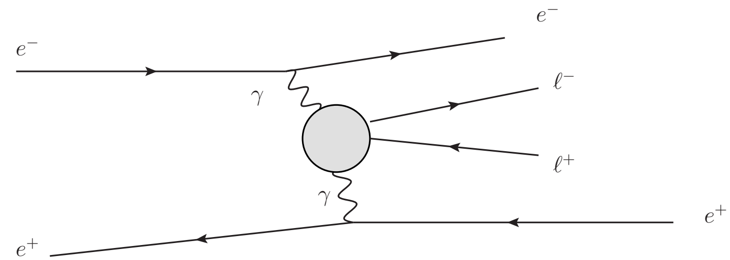
Channel	Usage	Momentum region
$J/\psi \to \ell\ell$	ℓ efficiency	0.7 – 3.0 (middle)
$ee \to ee\ell\ell$	ℓ efficiency	0.4 – 3.0 (low)
$ee \to ee\gamma$	e efficiency	0.2 – 7.0 (high)
$ee \to \mu\mu\gamma$	μ efficiency	0.2 – 7.0 (high)
$K_S \to \pi\pi$	$\pi \to \ell$ fake rate	0.2 – 2.5 (low)
$\tau \to \pi\pi\pi$	$\pi \to \ell$ fake rate	0.4 – 4.0 (middle)
$D \to D^0(\to K\pi)\pi$	$\pi/K \to \ell$ fake rate	0.4 – 4.0 (middle)

Our purpose is

- Monitor LID performance using data and MC.
- Provide data/MC correction
- Explore issues and etc..

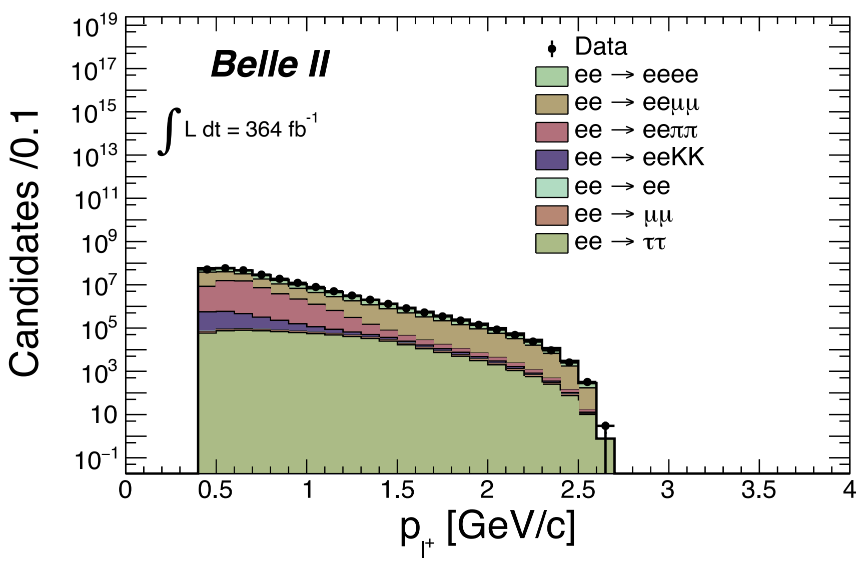
In this talk, I focus on $ee \to ee\ell\ell$ channel

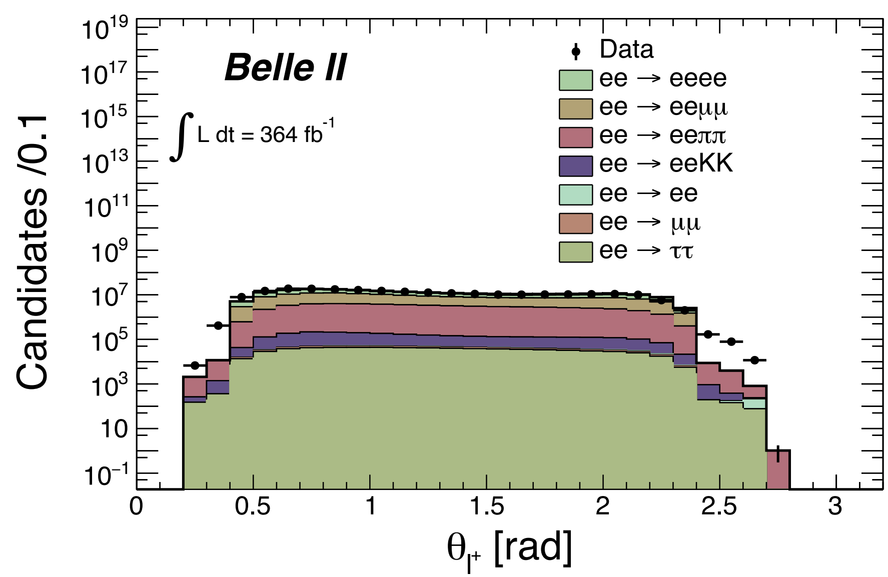
Selection criteria in $e^+e^- \to e^+e^-\ell^+\ell^-$



Apply two-photon event selection

- Use CDC tiggers: ffb fsb, fyb, syb
  - Not use ECL, KLM triggers to avoid a bias on LID efficiency
- $N_{\mathrm{trk}} = 2$ with $p > 0.4$ GeV/c , cos$\theta^{\mathrm{lab}}_{\mathrm{open}} > -0.997$
- $\left|\overrightarrow{p^*}_{z,l^+} + \overrightarrow{p^*}_{z,l^-}\right| < 1.0$ GeV/c, $\left|\overrightarrow{p^*}_{T,l^+} + \overrightarrow{p^*}_{T,l^-}\right| < 0.15$ GeV/c
- $1.0 < E^*_{\mathrm{vis}} < 6.0$ GeV, $M_{\ell\ell} < 3.0$ GeV/c^2





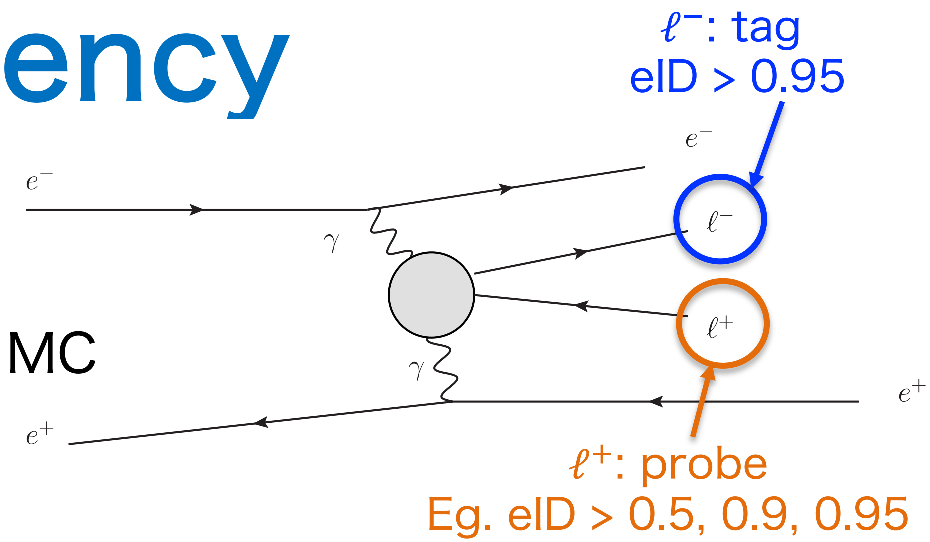
Enough statistics for $0.4 < p < 2.5$ GeV/c

Lepton ID efficiency

Tag and Probe method

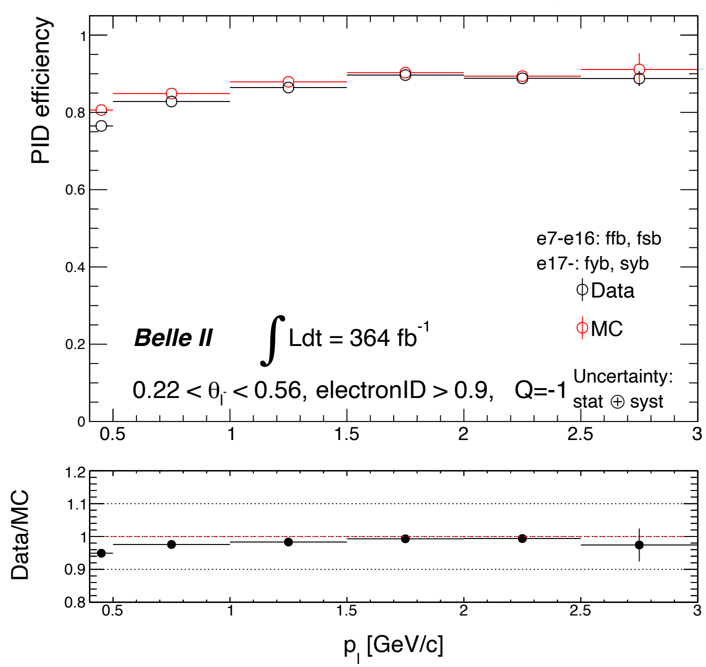
$$\varepsilon_{MC} = \frac{N^{\ell}_{\rm probe}}{N^{\ell}_{\rm tag}}$$

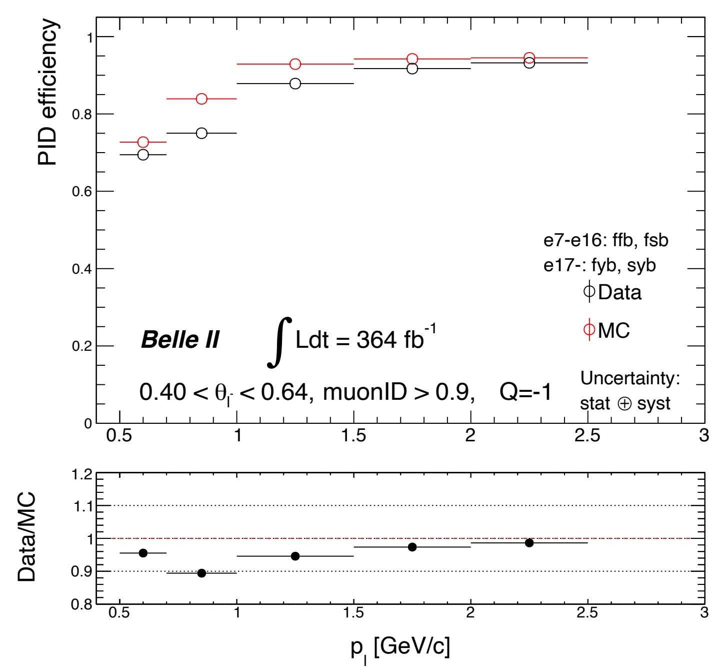
Use two-photon MC



$$\varepsilon_{data} = \frac{N_{\rm probe} - N^{\rm bkg}_{\rm probe}}{N_{\rm tag} - N^{\rm bkg}_{\rm tag}}$$

Background yield (eg. $ee \rightarrow ee\pi\pi$) is estimated from MC



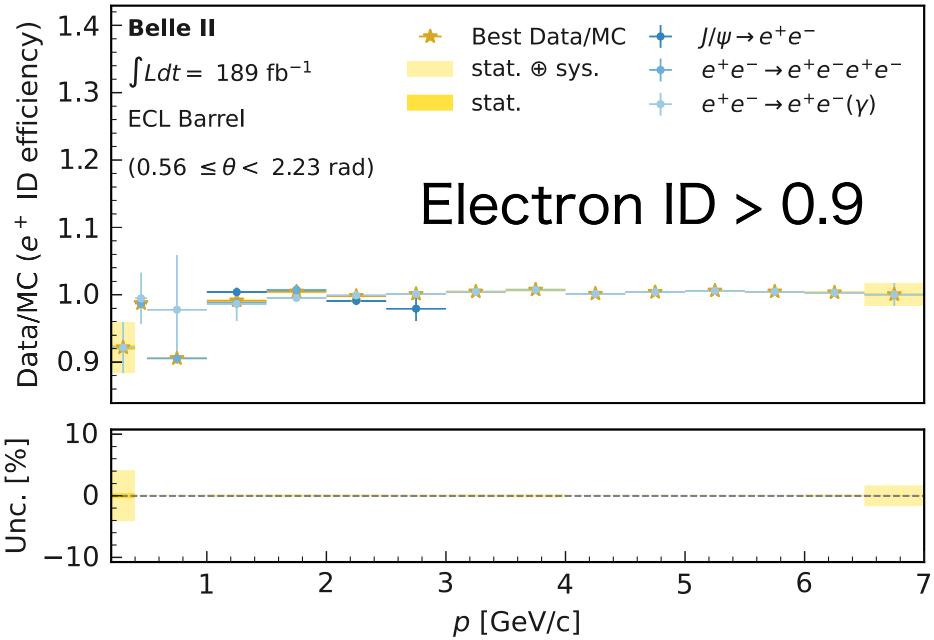


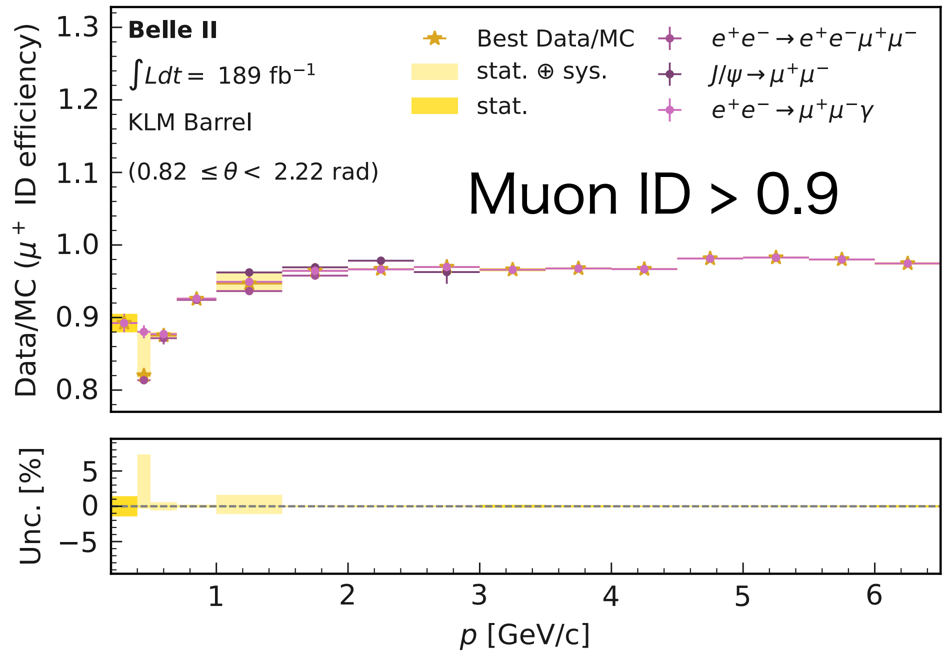
LID efficiency correction

Evaluate ℓ efficiency in three channels

- Provide one data/MC correction in each p, θ bin

→ Assume no time-dependency (experimental number dependency)





- The difference b.t.w channels is assigned as syst uncertainty.
  - Investigation of the difference is ongoing

  eg. difference of event's multiplicity

Trigger for two-photon ch.

<u>ffb, fsb for e7-e16 and fyb, syb for e17-</u>

- To keep using un-prescaled triggers: prescale of ffb,fsb = 100 (e17-)

→ The prescaled triggers affect LID evaluation

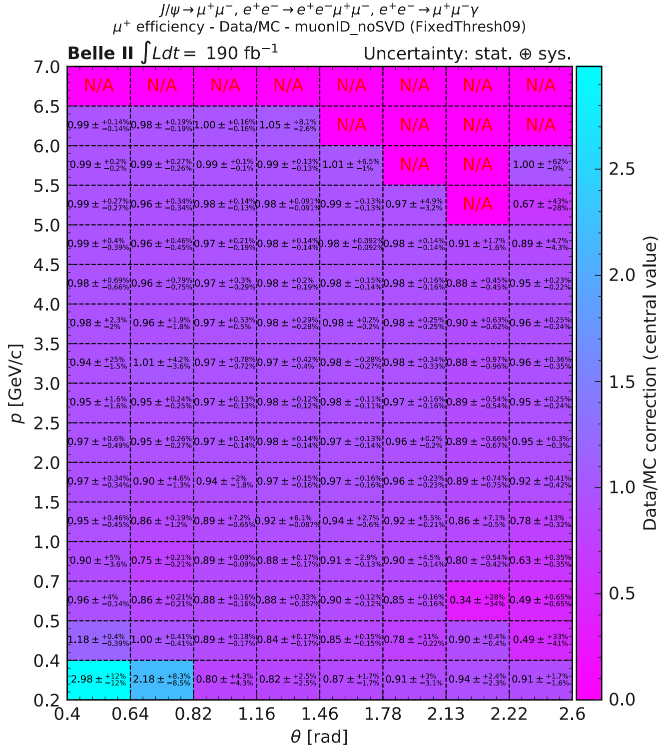
For example, for using Moriond2022 data (e7 – e18, 190 fb^{-1})

- data A: exp7–16 (90 ifb): **ffb, fsb = 1**
- data B: exp17–18 (100 ifb): **ffb, fsb = 100**

$$\int_A L\, \mathrm{dt} \sim \int_B L\, \mathrm{dt}\text{ , but } \sum_i^A N_i \sim 100\times \sum_i^B N_i$$

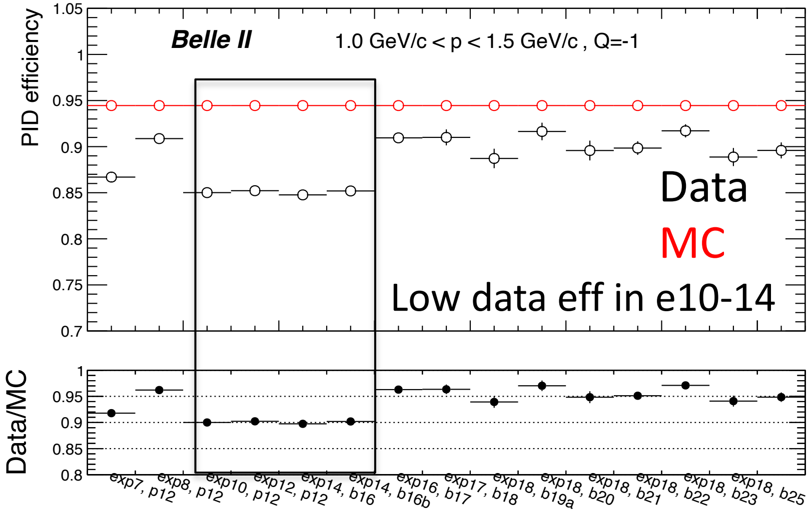
→ data B is negligible due to small statistics

(not same treatment as physics analyzers)



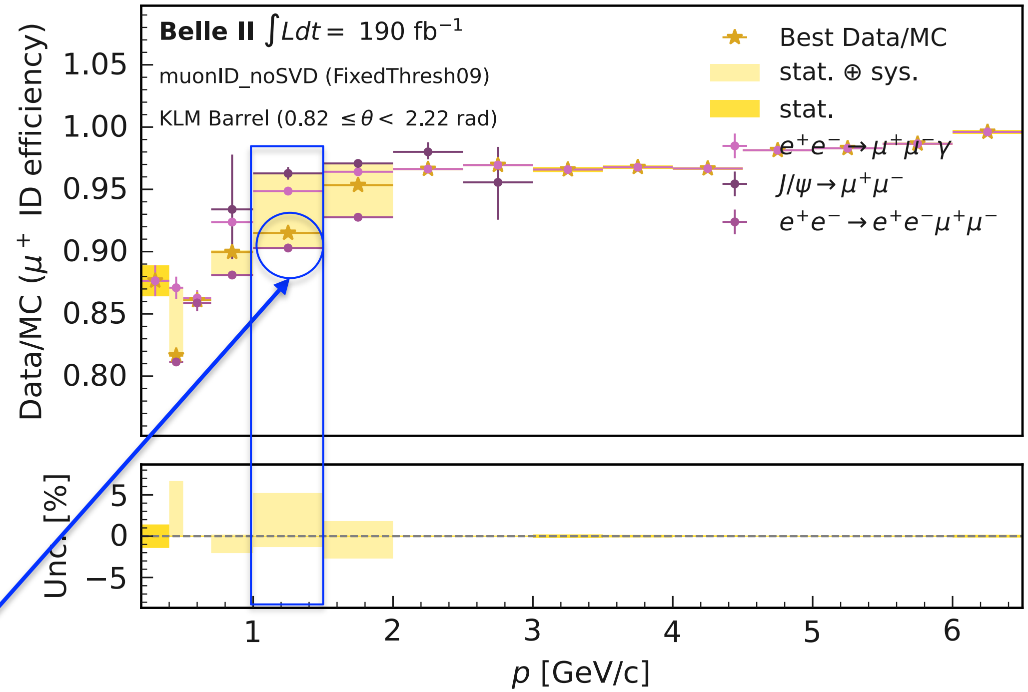
Data/MC using ffb, fsb triggers

Observe time-dependency in muon ID efficiency..



	Exp	Dataset	Lumi [fb^{-1}]	Yield	pre-scale	Data eff	MC eff	data/MC
	exp7	proc12	0.51	375890	1, 1	0.867	0.945	0.918
	exp8	proc12	4.5	3156480	1, 1	0.909	0.945	0.962
	exp10	proc12	3.6	2642000	1, 1	0.850	0.945	0.900
A	exp12	proc12	54.6	38692400	1, 1	0.852	0.945	0.902
	exp14	bucket16	10.8	7367470	1, 1	0.848	0.945	0.897
	exp14	bucket16b	5.7	3866650	1, 1	0.852	0.945	0.928
	exp16	bucket17	10.3	5509270	1, 1	0.910	0.945	0.962
	exp17	bucket18	10.7	69320	100, 10	0.910	0.945	0.963
	exp18	bucket19a	8.9	54316	100, 10	0.887	0.945	0.939
	exp18	bucket20	9.0	55360	100, 10	0.916	0.945	0.970
B	exp18	bucket21	8.7	54405	100, 10	0.896	0.945	0.948
	exp18	bucket22	17.6	105043	100, 10	0.898	0.945	0.951
	exp18	bucket23	18.0	103452	100, 10	0.917	0.945	0.971
	exp18	bucket24	11.2	67478	100, 10	0.889	0.945	0.940
	exp18	bucket25	15.7	87622	100, 10	0.896	0.945	0.948

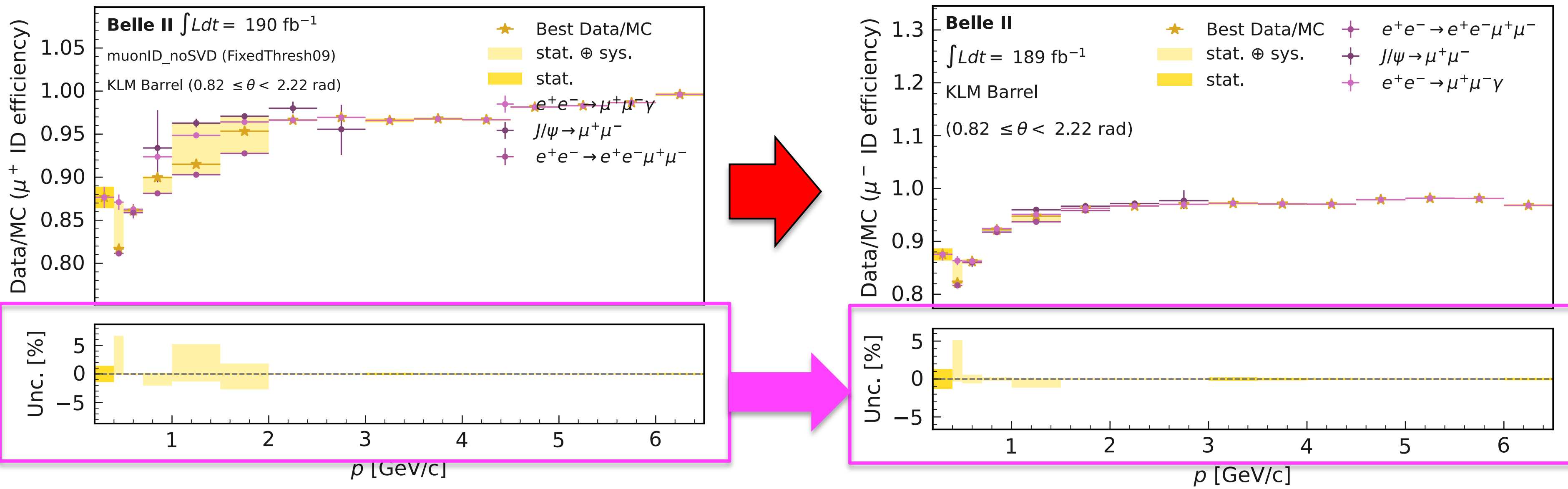
Largest stats



- Eff($ee \to ee\mu\mu$) ~ Eff using e12 data
- Eff($J/\psi \to \mu\mu$) = average of eff over data

→ Reason why large difference is seen

Data/MC: ffb, fsb vs fyb, syb



- <u>Much reduced systematic uncertainty</u>
  - Consistent treatment as other channels is important

→ Request un-prescaled triggers for consistency with others

※ Run-dependent MC would reflect the effect,
but if MC does not perfectly reflect, the difference would appear

Alternative trigger

- I heard fyb,syb might be prescaled in the future
  - If so, we need to consider strategy again

Alternative trigger candidate

- Applying CDC-ECL matching is probably fine: fybecl, sybecl?
  - What cluster energy is applied to keep unprescaled triggers?
  - Need to select “not ECL-matched track” for LID eff evaluation
    - Is it possible to identify which track is ECL-matched one?

- Using stt trigger: #tracks >= 1 with $p > 0.7$ GeV/c
  - Need to select “not triggered track” for LID eff evaluation
    - Is it possible to identify which track is triggered one?

Statistics due to prescaled trigger

Another important point is statistics for high momentum

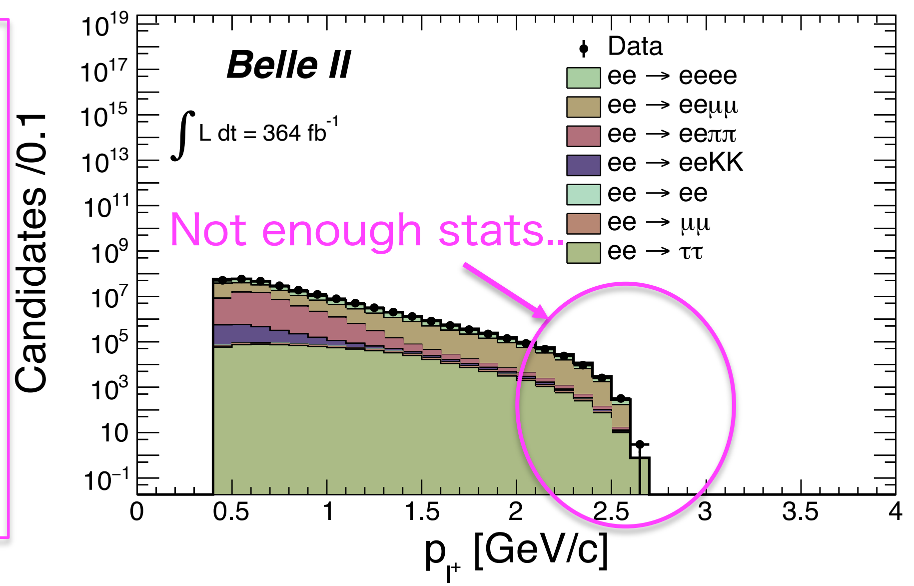
- Not enough statistics above $p > 2.0$ GeV/c for now.
  - Evaluation is not possible in case of using prescaled triggers

Assume prescaled triggers are needed

- $p < 2.0$ GeV/c: fine to prescale
- $p > 2.0$ GeV/c: keep unprescale

→ Is the configuration possible?

Eg. fyb_low: prescale = 5,
fyb_high: prescale = 1



<u>Of course, we'd like to request unprescaled triggers</u>

<u>If it's difficult, unprescaled triggers for only high p is desired</u>

Summary

Use CDC triggers for LID efficiency in two-photon channels

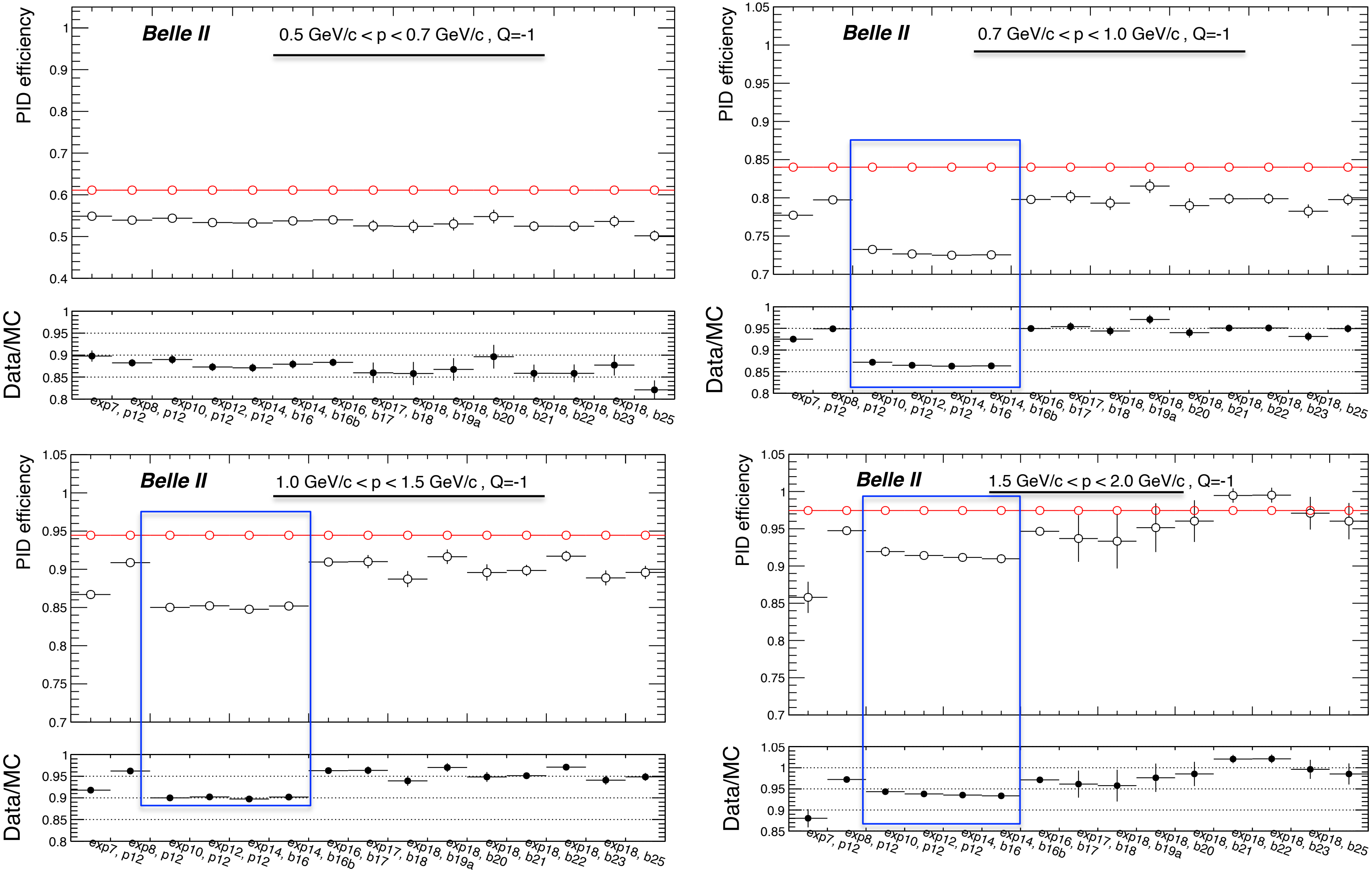
- Un-prescaled triggers are necessary
  - to obtain consistent result with other channels
  - to enhance the events with high momentum
- <u>CDC-ECL matching is probably fine: no bias on LID efficiency</u>
  - More dedicated study is ongoing

Trigger	p, θ coverage	prescale
ffb, fsb	○	100 from e17 → Not use
fyb, syb Main triggers now	○	1, but X from exp??
fyb_ecl, syb_ecl	○	1 in the future?
stt	How much endcap acceptance?	1 in the future?
※ my idea fyb_low(high) Syb_low(high)	○	5(1) ?

Backup

Time dependency: muon, Q = -1

Negative charge, muon ID > 0.9, $0.82 \leq \theta \leq 2.22$ rad



Low data efficiency with exp10, 12, 14