PID study for $e^+e^- \rightarrow \pi^+\pi^-$ cross section measurement

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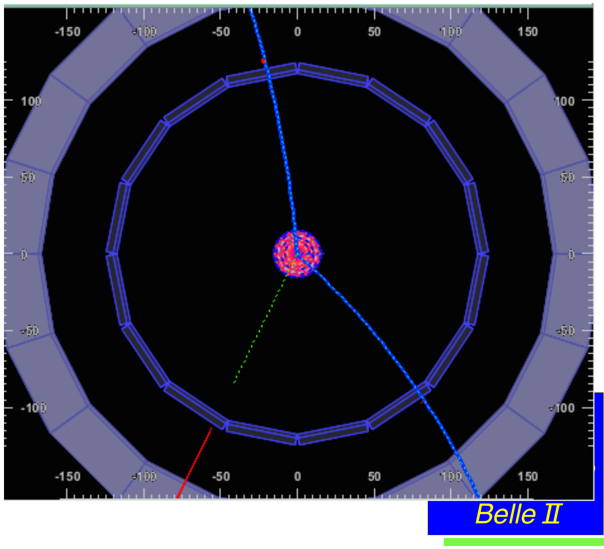
13th Oct, 2017

B2JAM

outline

- $e^+e^- \to \pi^+\pi^-\gamma_{ISR}$ 過程の断面積はミューオンg-2 (a_μ)の理論計算の入力値であるが, この測定の不定性がa_μの計算値の不定性を決めている
  →Belle IIで精密測定を行う(目標精度:0.5%)
- 同時に$e^+e^- \to \mu^+\mu^-\gamma_{ISR}$過程も測定し, 比をとることで測定の不定性を削減する
- 今回の発表
  - $\pi\pi/\mu\mu$の識別
    - お互いがお互いのBGになる.
    - 識別効率の向上が重要
  - $\mu\mu$のcorrelated efficiency loss
    - 2トラックが互いに近いと, それに伴う識別効率の低下が起こりうる
    - BaBarでは大きな系統誤差の要因だった



analysis procedure

used detectors :
CDC, TOP, A-RICH & KLM

- basic event selection
  - ≥1 γ with E*>3 GeV
  - # of tracks == 2
  - for both tracks,
    - p>1 GeV/c
    - nHitCDC≥5
    - PID cut
      (based on likelihood ratios)

beamBG存在下ではよくないカット

PID cut

1. muon ID

$$\frac{L_\mu}{L_\mu + L_\pi + L_K} > 0.9$$

2. kaon ID
   fail muon ID &&

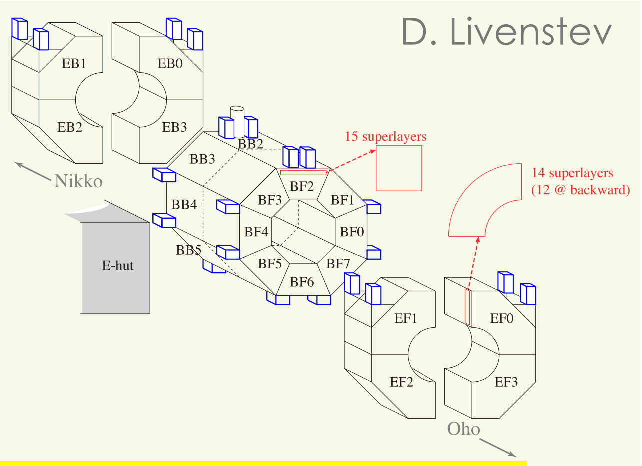
$$\frac{L_K}{L_\pi + L_K} > 0.9$$

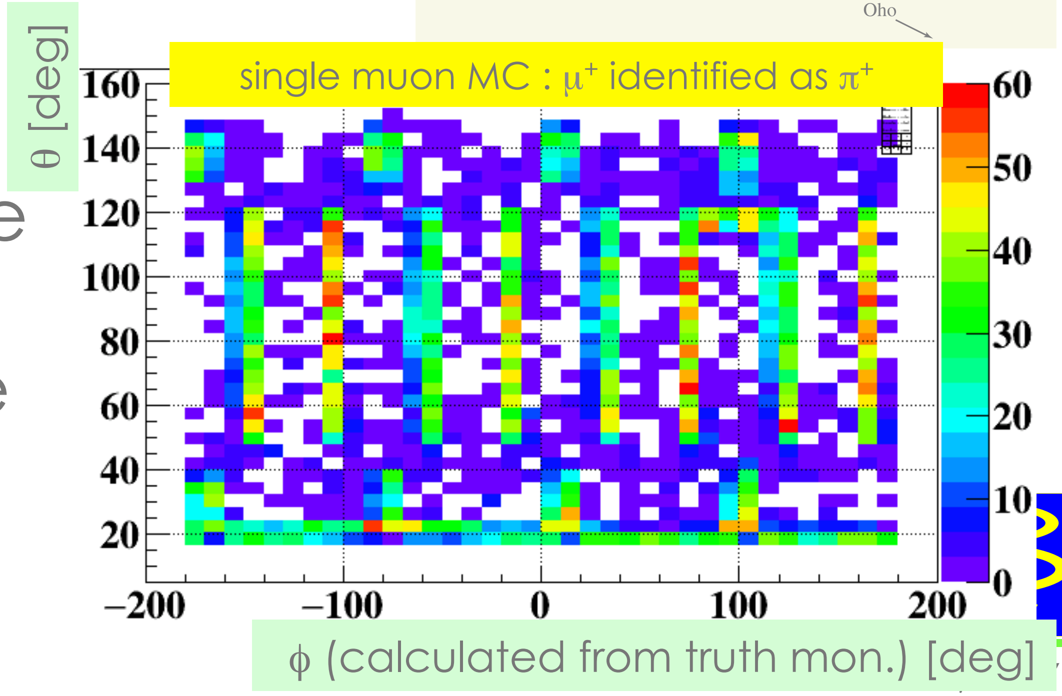
3. pion ID
   fail both muon and kaon ID

- remarks on sim. condition
  - still using **MC8**
  - first show plots BGx0, then discuss BGx1
  - assume 100% trig. eff.

KLM gap veto

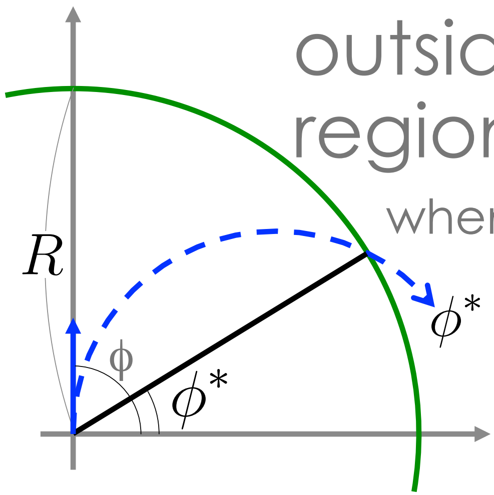
- muon ID eff. deteriorates in KLM module gaps
- in kaon ID, muons are usually identified as pion →muon ID ineff. ~ pion fake rate
- try to avoid these regions to reduce fake pions($\mu \rightarrow \pi$)





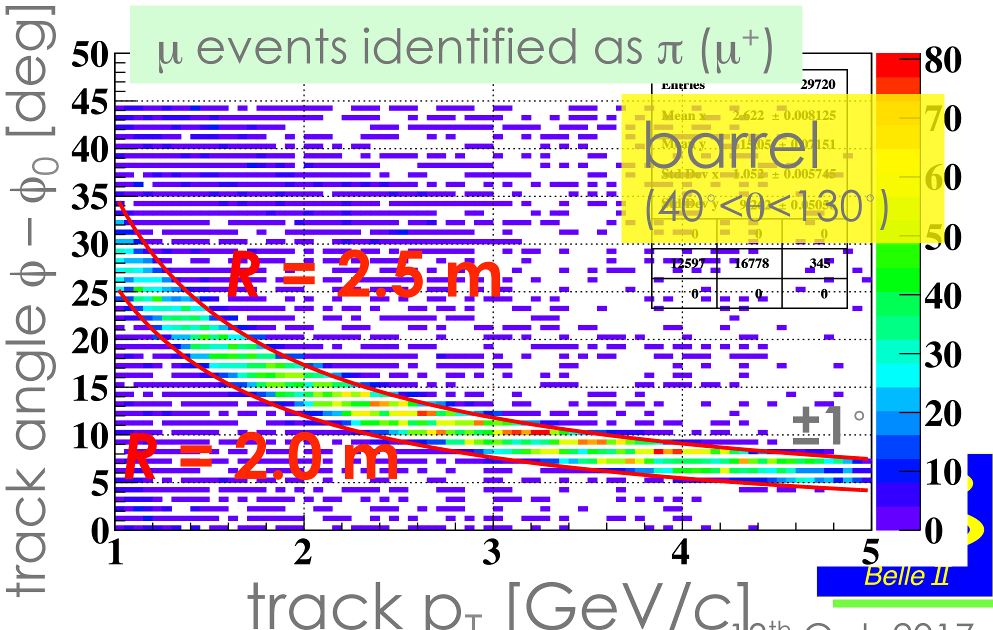
KLM-gap veto cut

- veto regions in track p_T-ϕ plane
  (ϕ is measured with respect to gap angle ϕ_0)
  - defined for each of particle charge and θ direction (endcap or barrel)
  - require at least one track to be outside this veto region



when track ϕ=90°

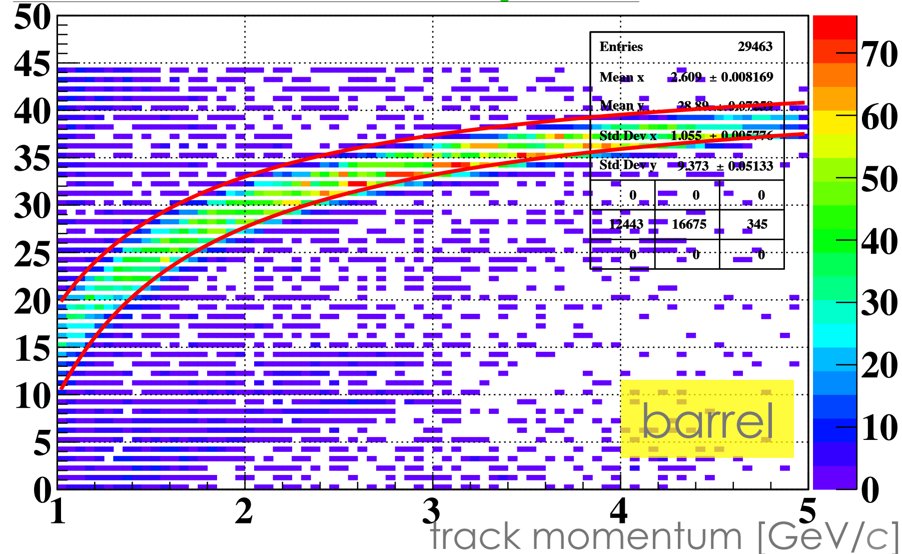
$$\phi^* = \cos^{-1}\frac{cBR}{2p_T}$$

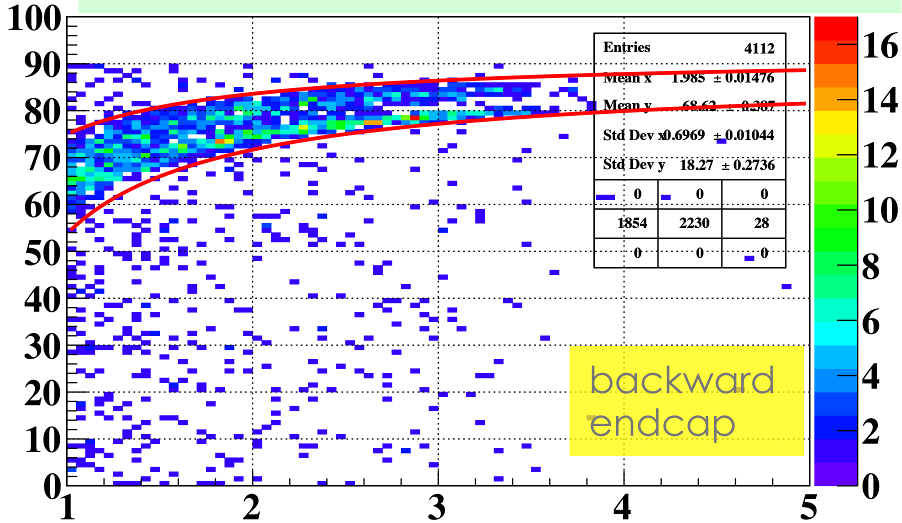


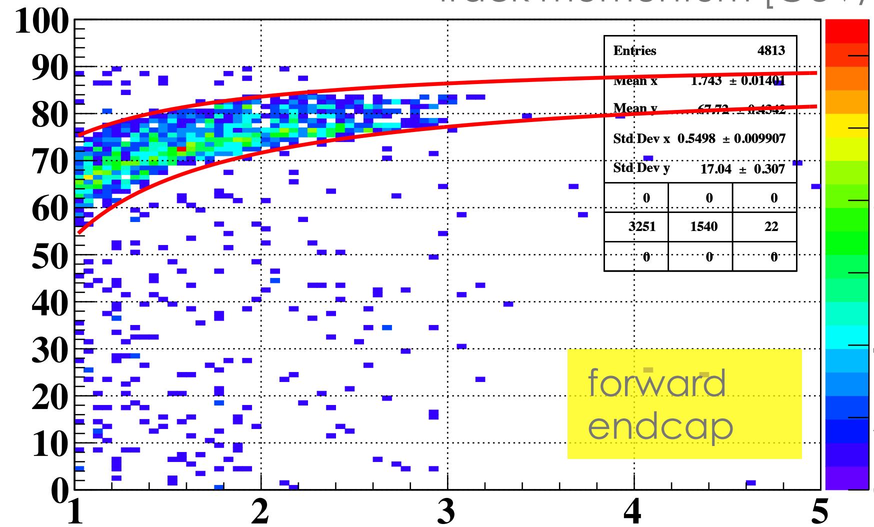
KLM gap veto cut – μ^-

- veto regions are defined in the same way with μ^+

トラックをKLM表面まで
外挿してその位置を使うほうが良い?

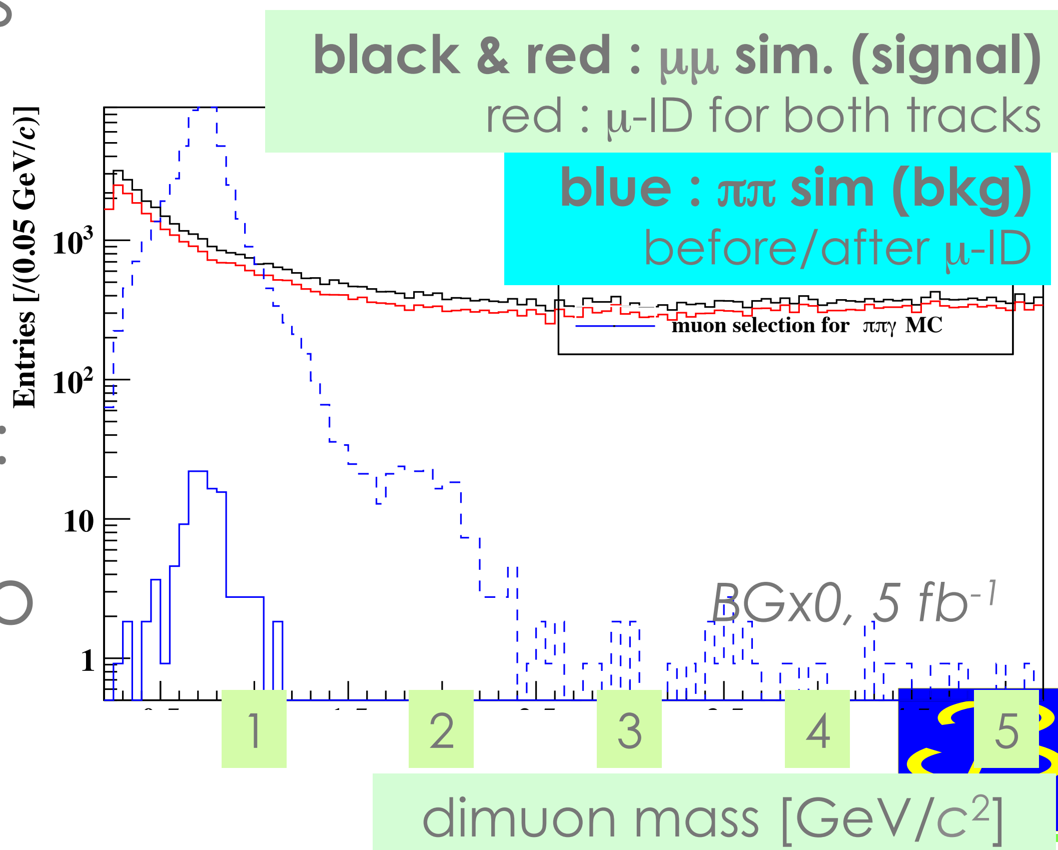






PID performance – μμ mode

- require at least one track to be outside the veto regions
- MC stat. : ~5 fb^{-1} equiv.
- μμ-ID eff.
  - ~80%
  - loss by veto cut: 5%
- ππ→μμ bkg. ratio
  - ~0.4% ($M_{\mu\mu}$<1 GeV/c^2)



PID performance – ππ mode

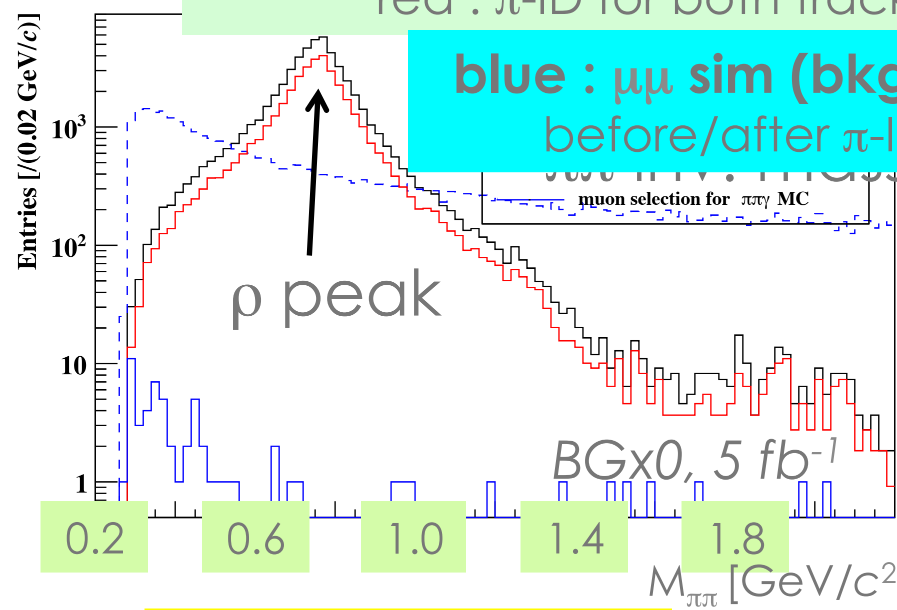
- ππ–ID cut efficiency
  - 69%
  - loss by veto cut: 8.8%
- μμ→ππ background
  - 0.15% (<1 GeV/c^2)

    ←**factor 5 reduction** due to the veto cut
  - same level as BaBar
- required statistic
  - 5.3k evts / 5 fb^{-1} →>100 fb^{-1} possible in early stage of Belle II run

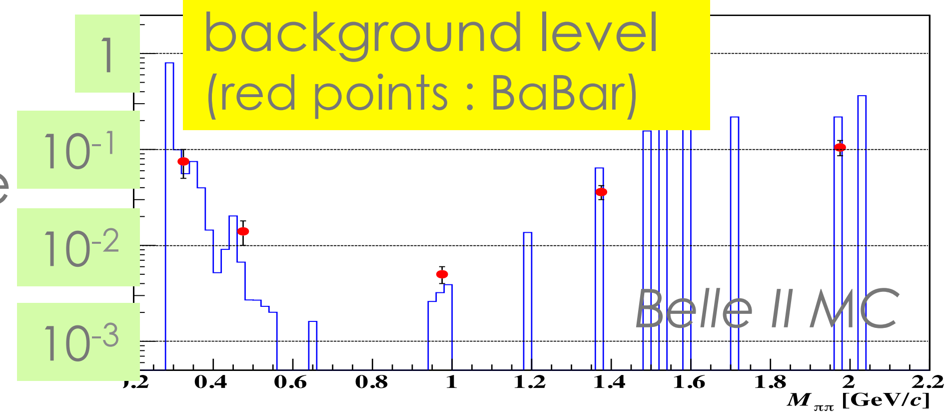
  (BaBar : 232 fb^{-1} PRD86 032013)

black & red : ππ sim. (signal)
red : π-ID for both tracks

blue : μμ sim (bkg)
before/after π-ID



background level
(red points : BaBar)



summary table

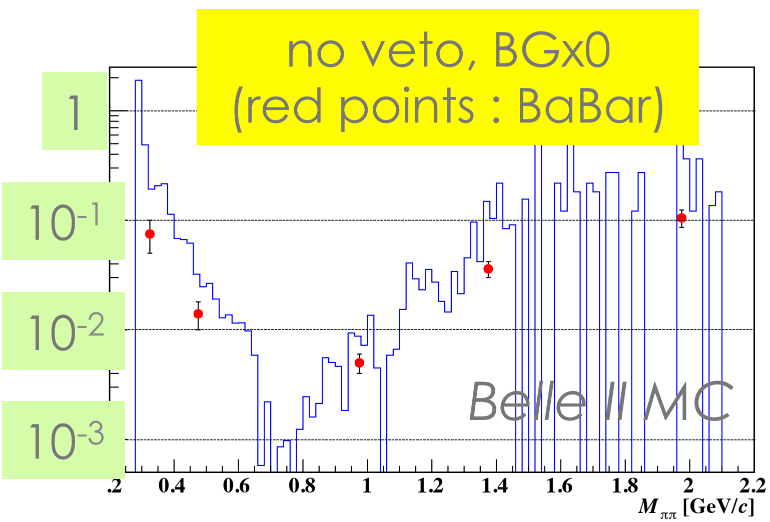
M<1 GeV/c^2

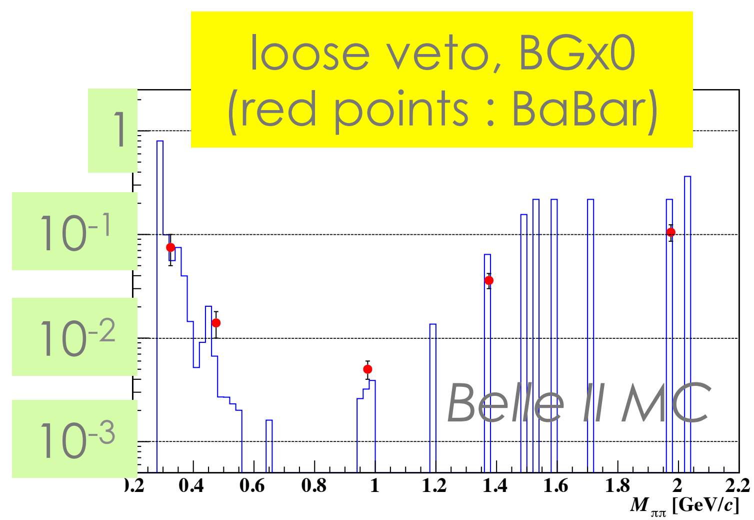
	$\mu\mu$ efficiency	$\pi\pi\rightarrow\mu\mu$ BG	$\pi\pi$ efficiency	$\mu\mu\rightarrow\pi\pi$ BG
no veto cut	85.2%→84.6%	0.39%→0.37%	75.3%→75.3%	0.83%→0.64%
loose veto	80.9%→81.0%	0.39%→0.38%	68.7%→69.1%	0.15%→0.17%
tight veto	58.2%→58.6%	0.40%→0.37%	46.2%→46.7%	0.10%→0.03%

NoBG→WithBG

loose : require at least one track to be outside of the veto regions
tight : require both tracks to be outside of the veto region

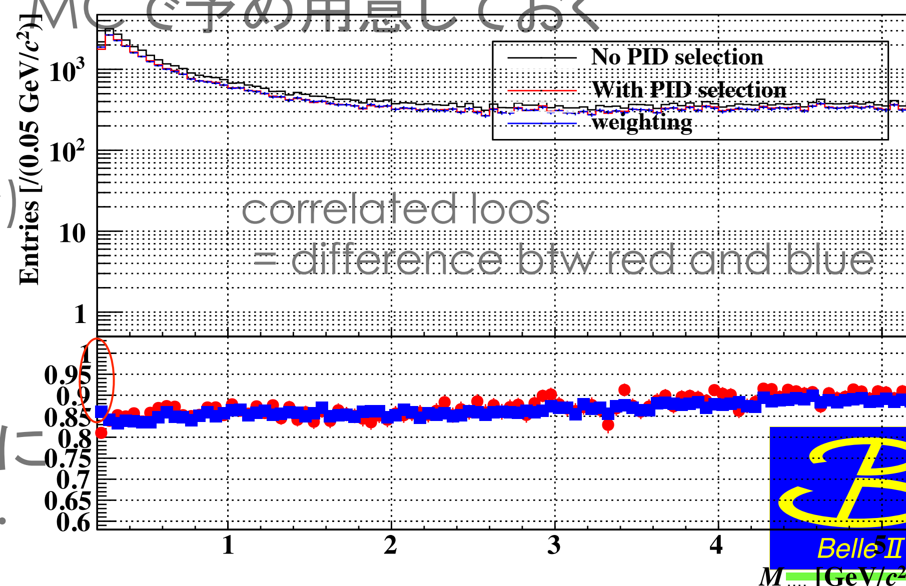
→the loose cut is effective, and gives small enough BG (same level as BaBar)





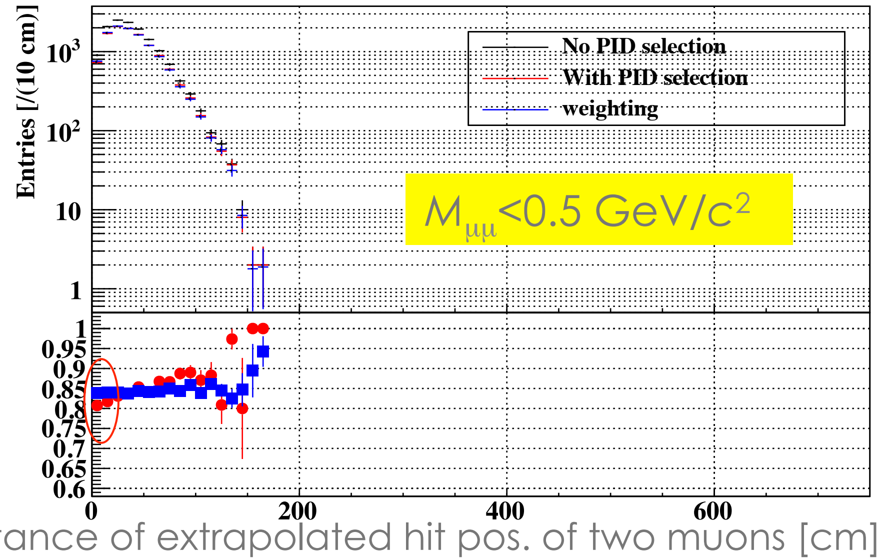
study of correlated eff. loss for μμ

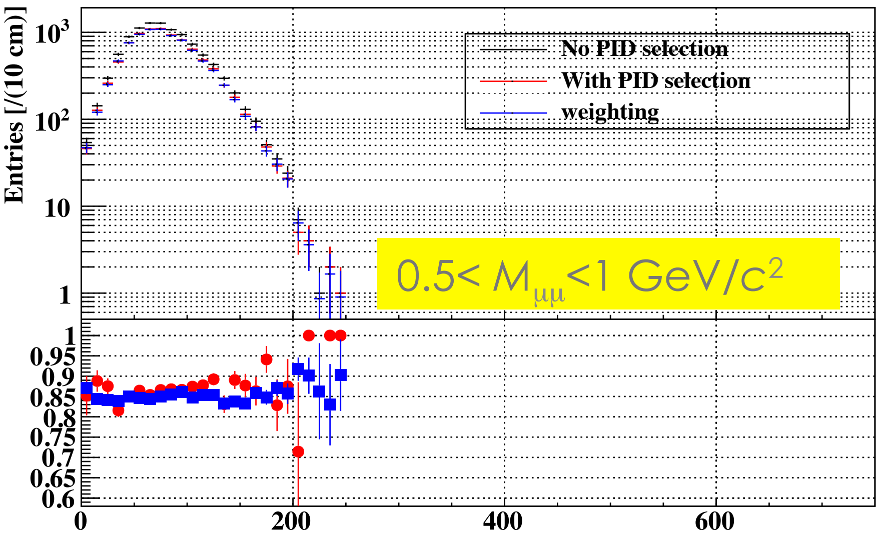
- eff. loss when two tracks are close to each other
- compare μμ simulation results (require PID cut for both tracks; red) and single μ sim. results (apply weight as product of two μ eff. ; blue)
  - 赤と青の違いがcorrelated eff. loss (赤のほうが下がるはず)
- analysis procedure
  - efficiency mapをsingle μ MCで予め用意しておく
  - Eff. for a single muon is given as a function of
    - mom. (50 bins, 0-5 GeV/c)
    - cos θ (15 bins, 17°-150°)
    - φ%90° (15 bins ; 6° step)
    - charge (+ and -)
  - KLM上でのhit位置を解析的に計算し, その距離差でcorrel. eff. loss を見る.

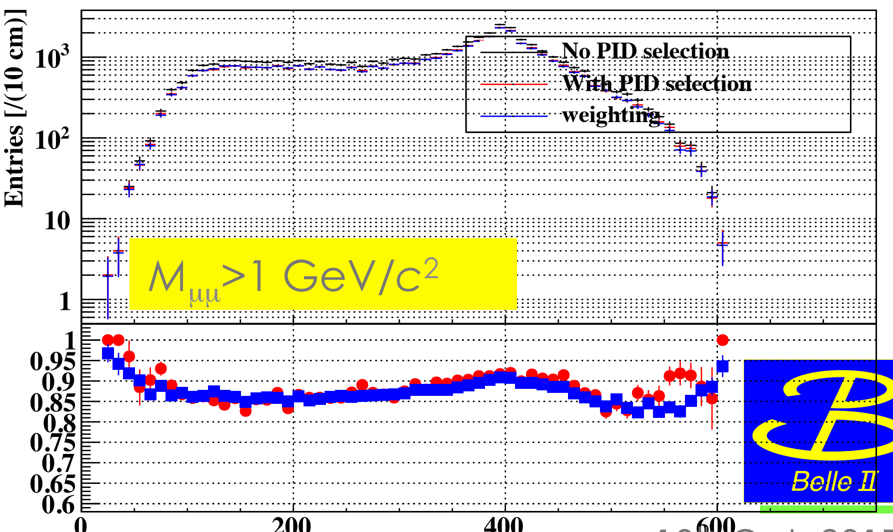


correlated loss

- KLM上のヒット位置の距離
  - low massでは近いところで低下がみられるが中質量では差がない (もっと統計がいる?)
  - トラックの外挿で求めた位置を使うほうが良いか?

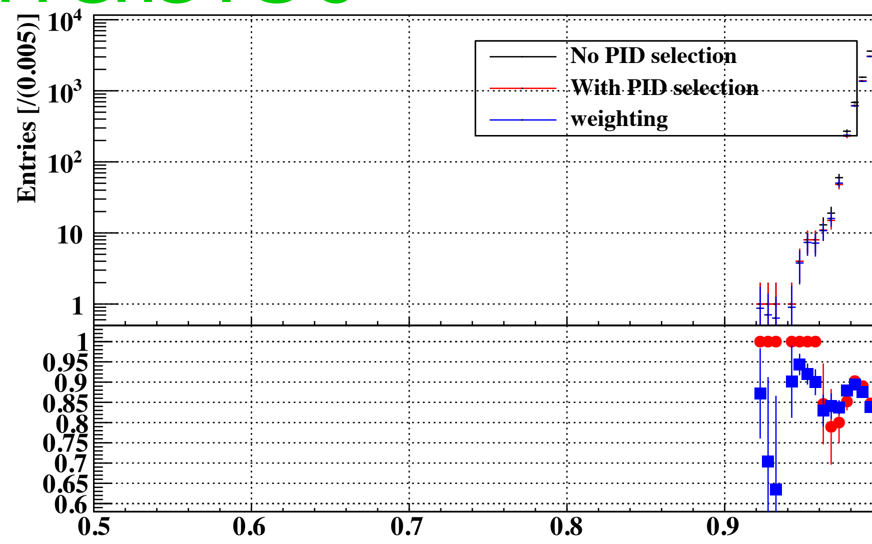


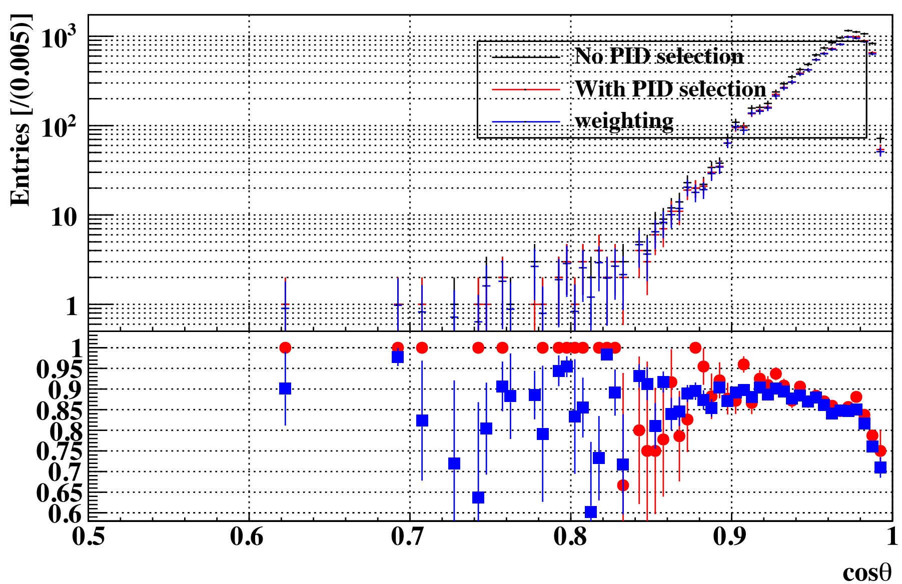


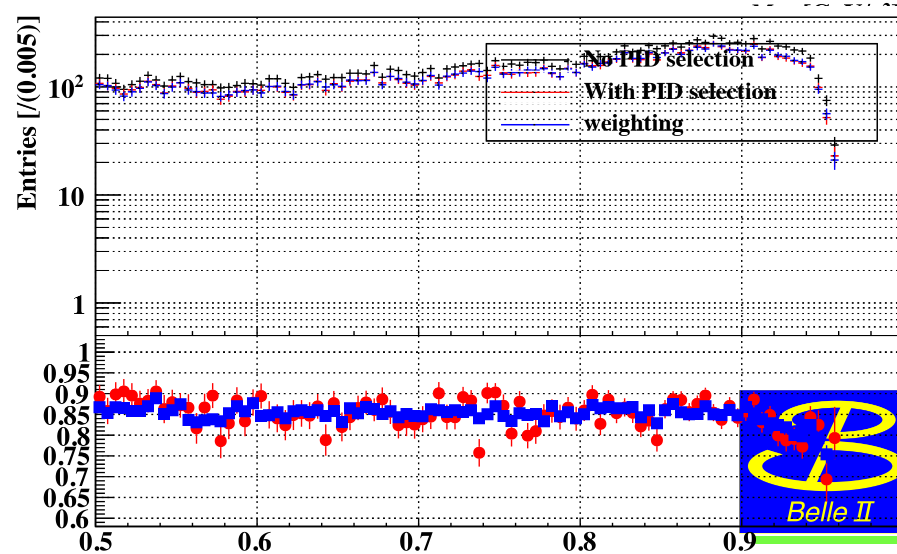


other variables

- 2トラックの開き角
  - あまり効果はみられない







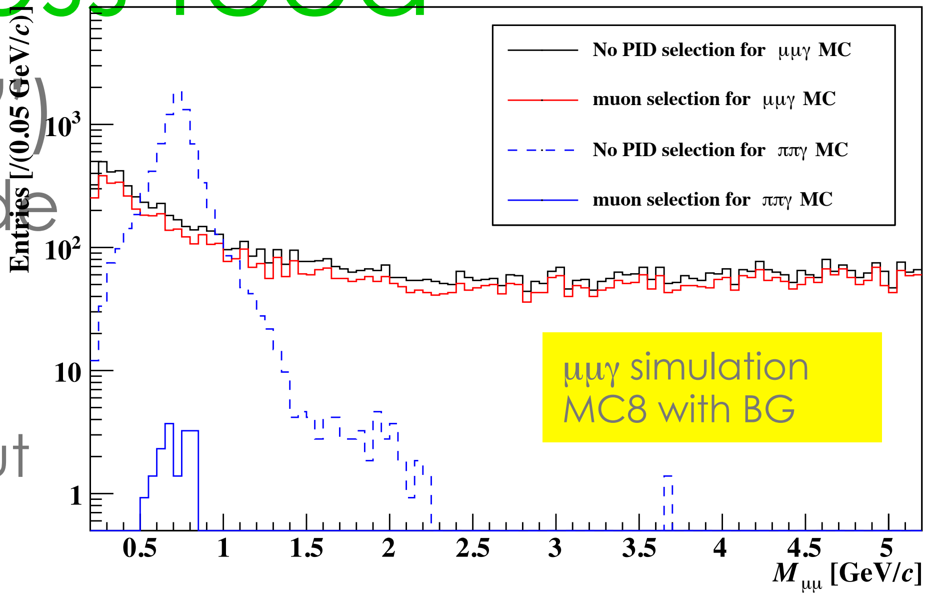
summary and prospect

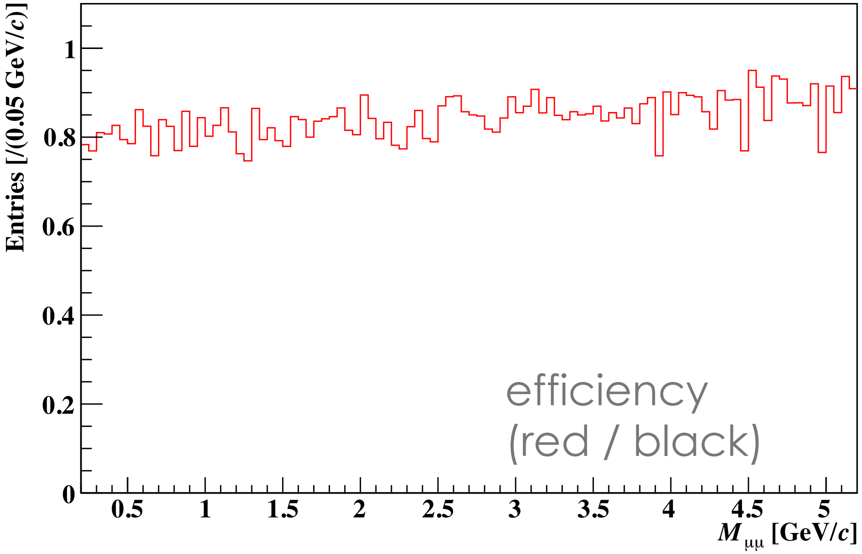
- $\mu\mu$<->$\pi\pi$ cross feed was studied for ee$\rightarrow\pi\pi$ cross section measurement
- KLM module gaps give large cross feed, especially for $\mu\mu\rightarrow\pi\pi$ fake events. This can be reduced drastically by introducing veto cuts. BG level is the same as BaBar.
- Correlated efficiency loss in the $\mu\mu$ mode is studied, but not yet well described (what is directly causing the loss?)

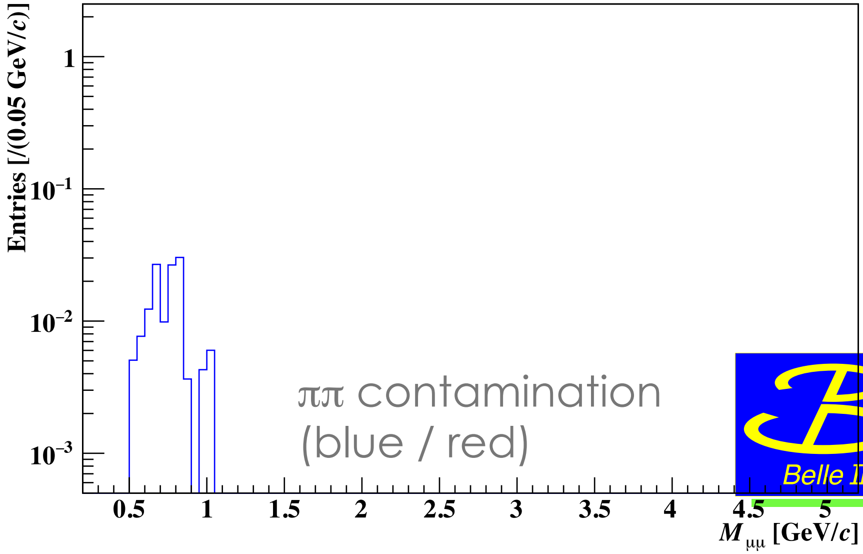
extra slides

μμ/ππ cross feed

- μμ mode ("loose cut")
  - at least one μ is outside the veto regions
  - efficiency ~ 80%
    - -6% due to the veto cut
  - background ~ 0.4%







μμ/ππ crossfeed

- ππ mode (loose cut)
  - efficiency ~ 70%
    (-8% due to the veto cut)
  - background ~ 0.15%
    factor 5 reduction