a place of mind

UBC

INSTITUTE OF PARTICLE PHYSICS

Selecting $e^+e^- \rightarrow \mu^+\mu^-$ events for an A_{LR} measurement

Christopher Hearty
U. British Columbia / IPP
November 10, 2020

Outline

- Starting point for the selection
- Backgrounds / purity
- Efficiency
  - tracking
  - muonID
  - level 1 trigger

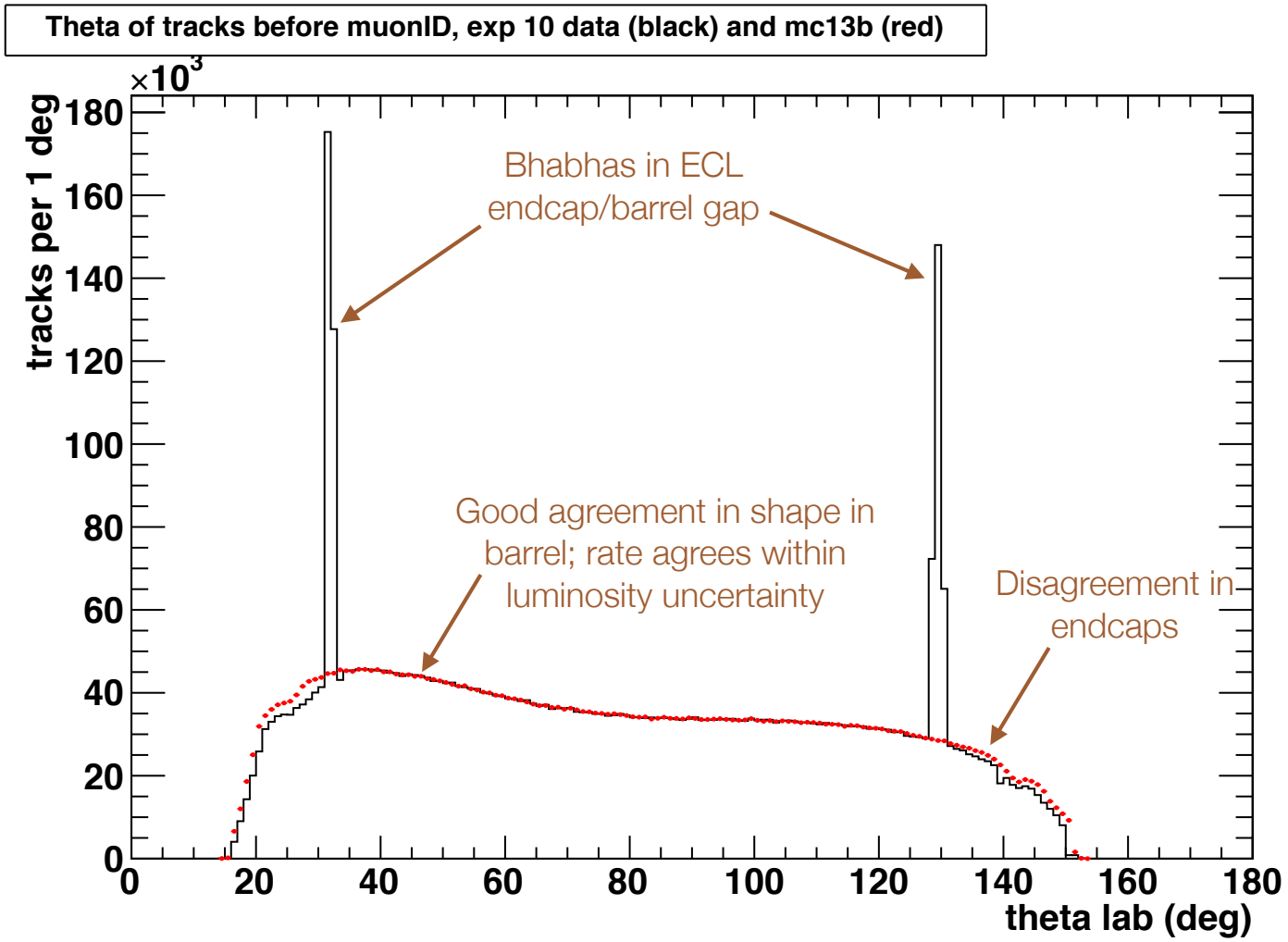
Data sets / Event / basic muon selection

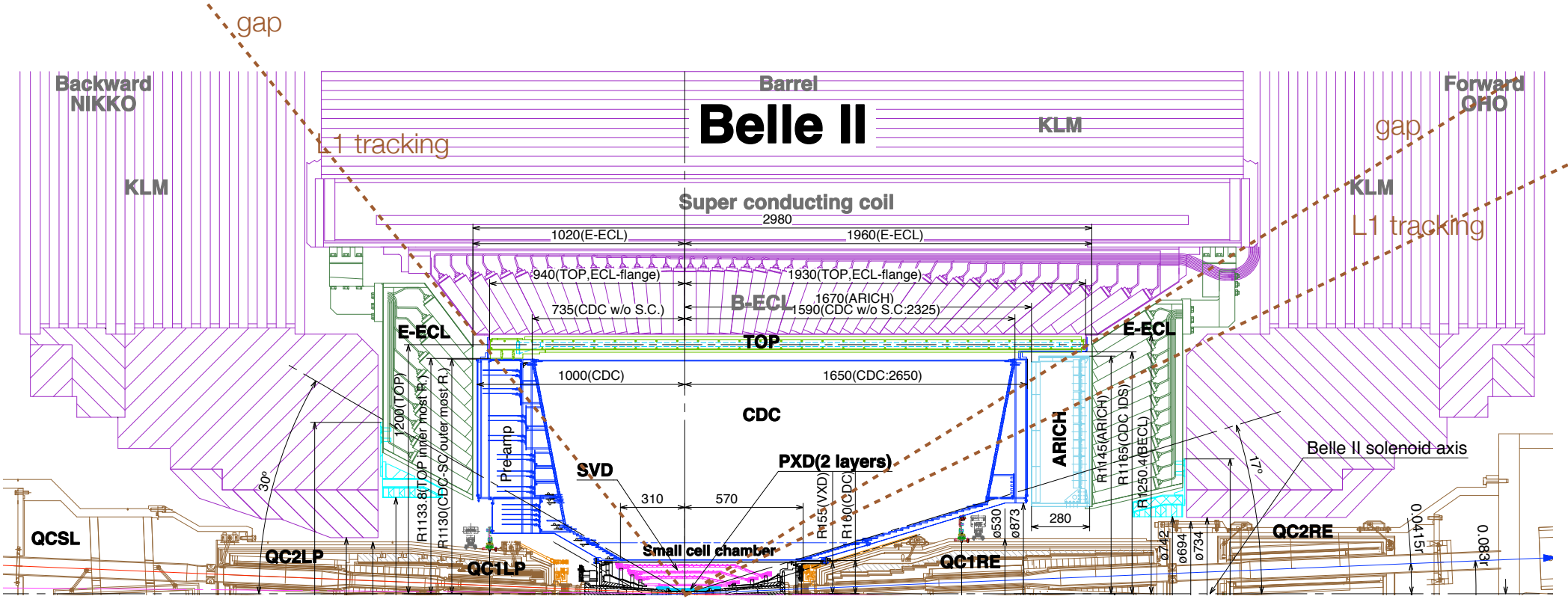
- Muon pair selection:
  - p_{cms}>3.5 GeV/c, abs(d0)<0.5 cm, abs(z0)<4 cm
  - sum θ_{cms} between [175°,185°]
  - delta ϕ_{cms} > 175°
  - invariant mass > 9 GeV/c^2
  - neither track has clusterE >1 GeV

- Experiment 10 proc 11 hlt_mumu_2trk skim, 4 fb^{-1}, 2.4M "muon" pairs.

- mc13b proc 11 for exp 10, mode 3500420000, ~6.8 fb^{-1}, 4.1M muon pairs. (No run dependent mc for exp 12).

Theta (lab) distribution of selected “muons”




gap
Backward
NIKKO
KLM
L1 tracking
Barrel
Belle II
KLM
Forward
OHO
gap
KLM
L1 tracking
Super conducting coil
2980
1020(E-ECL)
1960(E-ECL)
940(TOP,ECL-flange)
1930(TOP,ECL-flange)
735(CDC w/o S.C.)
B-ECL
1670(ARICH)
1590(CDC w/o S.C:2325)
E-ECL
TOP
E-ECL
1000(CDC)
1650(CDC:2650)
CDC
1200(TOP)
R1133.8(TOP inner most R)
R1130(CDC-SC/outer most R)
Pre-amp
SVD
PXD(2 layers)
ARICH
R1145(ARICH)
R1165(CDC IDS)
R1250.4(BECL)
17°
30°
310
570
280
R155(VXD)
R160(CDC)
ø530
ø873
ø742
ø694
ø734
Belle II solenoid axis
0.0415r
0.080r
QCSL
QC2LP
QC1LP
Small cell chamber
QC1RE
QC2RE

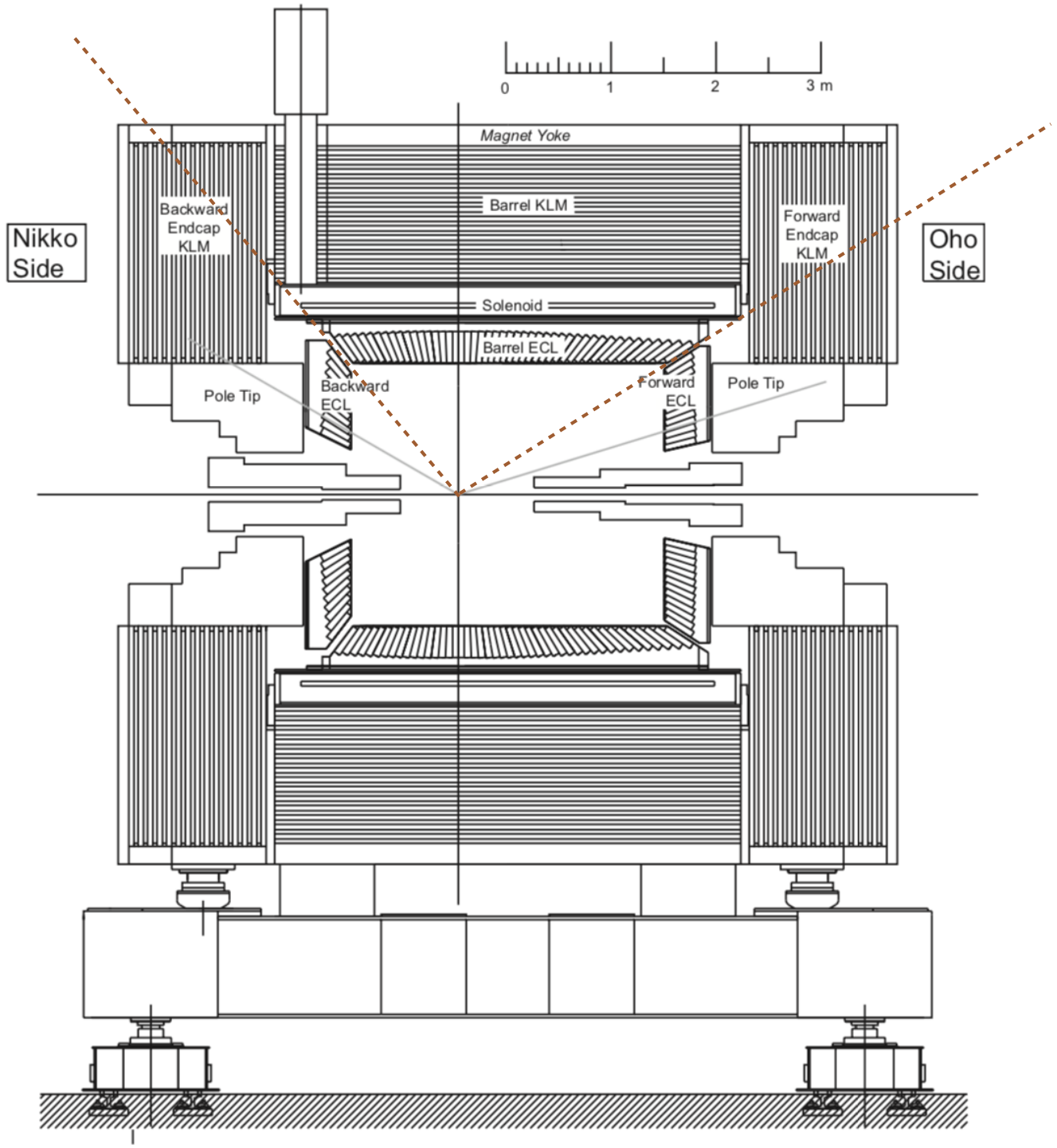
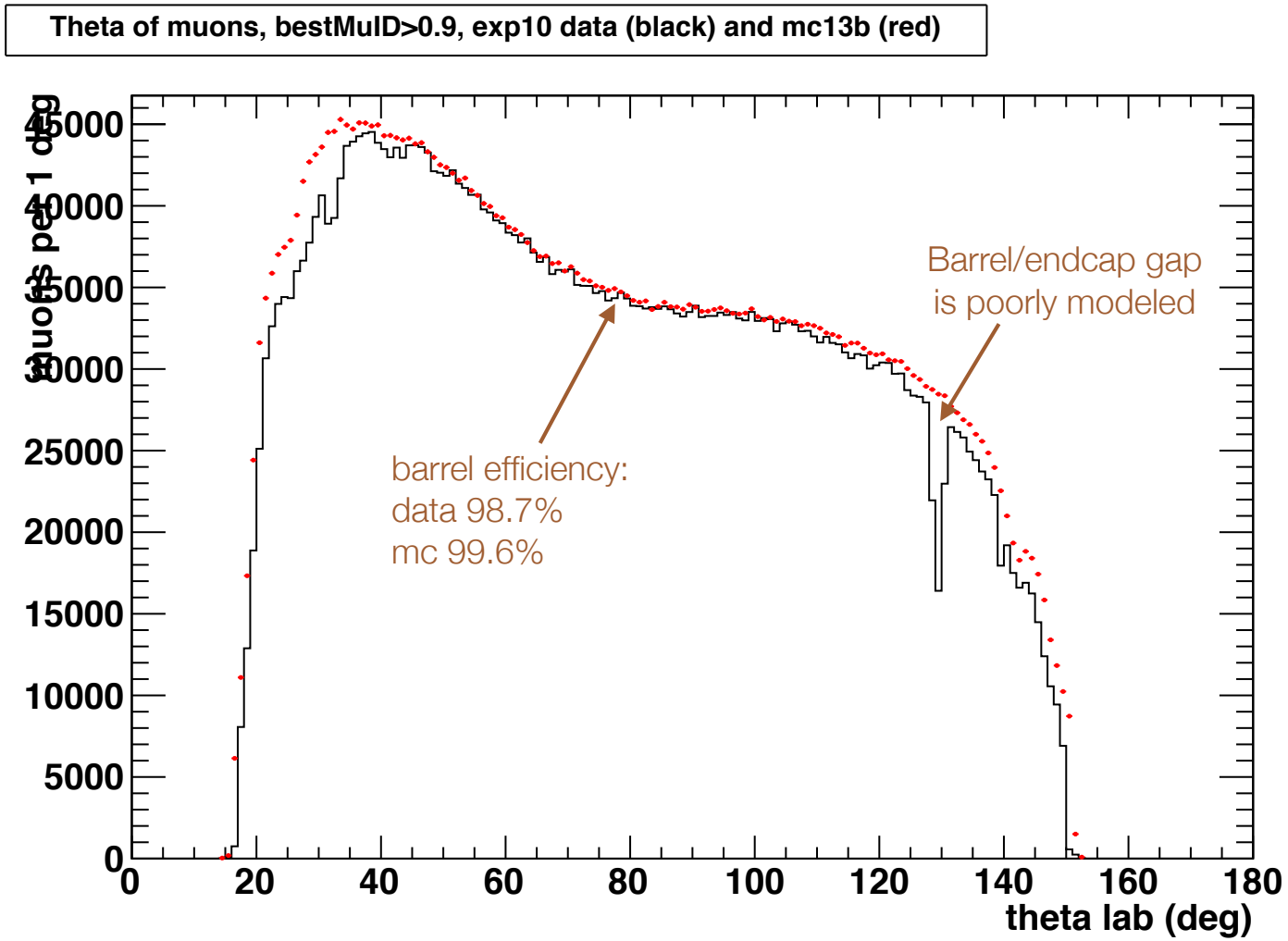


Figure 1.2: Side view of the Belle II experiment.

Theta distribution after requiring at least one track have muonID>0.9



Backgrounds / purity

- Bhabhas ~70 nb with both tracks in acceptance
  - muon pairs 0.83 nb
  - suppress with angular cuts, muon ID

- Two photon fusion production $e^+e^- \to e^+e^-\mu^+\mu^-$ 19 nb
  - invariant mass cut is enough to reject?

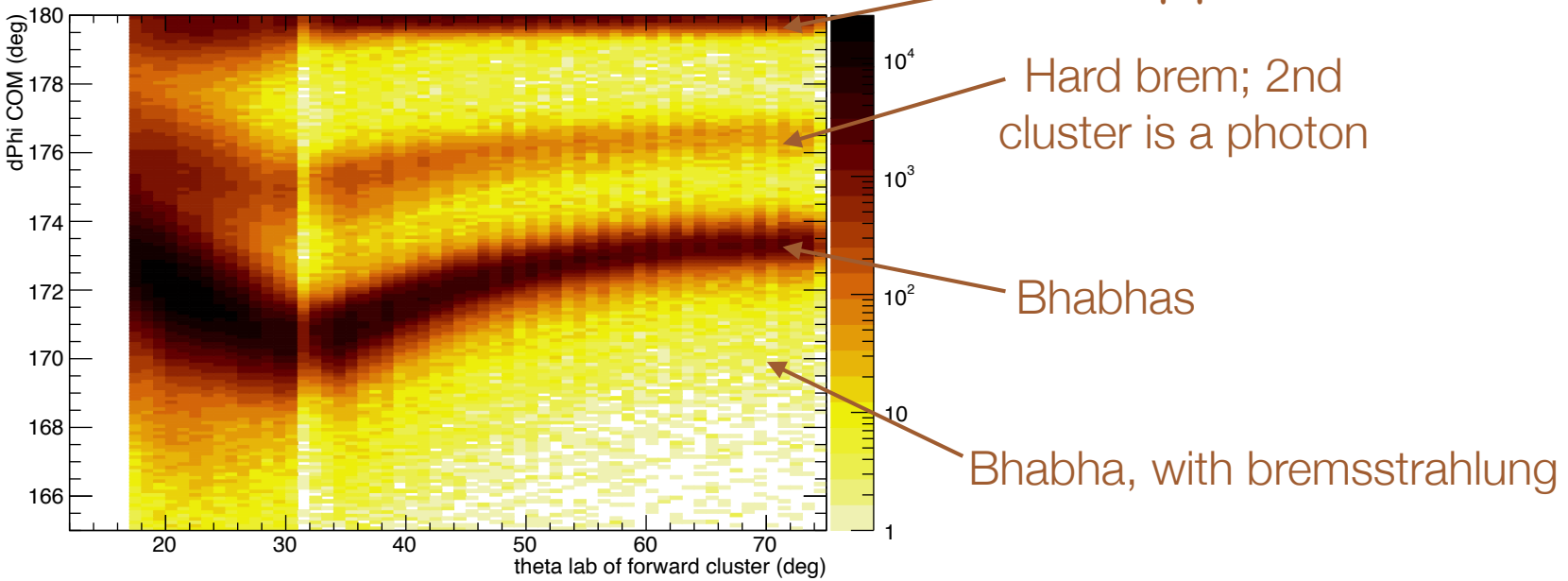
- tau pairs (probably negligible)

- cosmics (probably negligible)

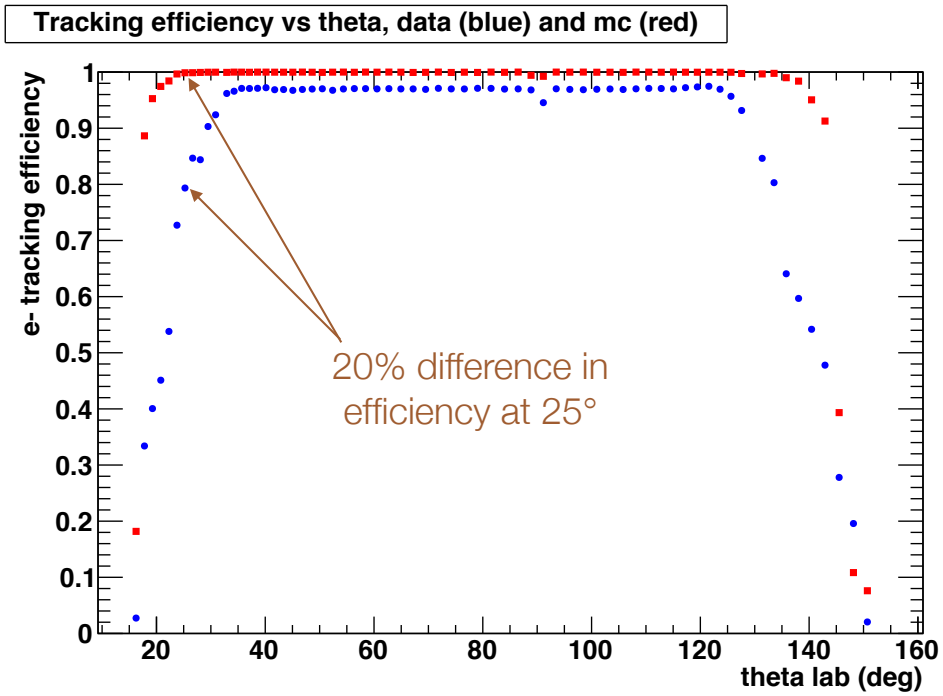
Tracking efficiency

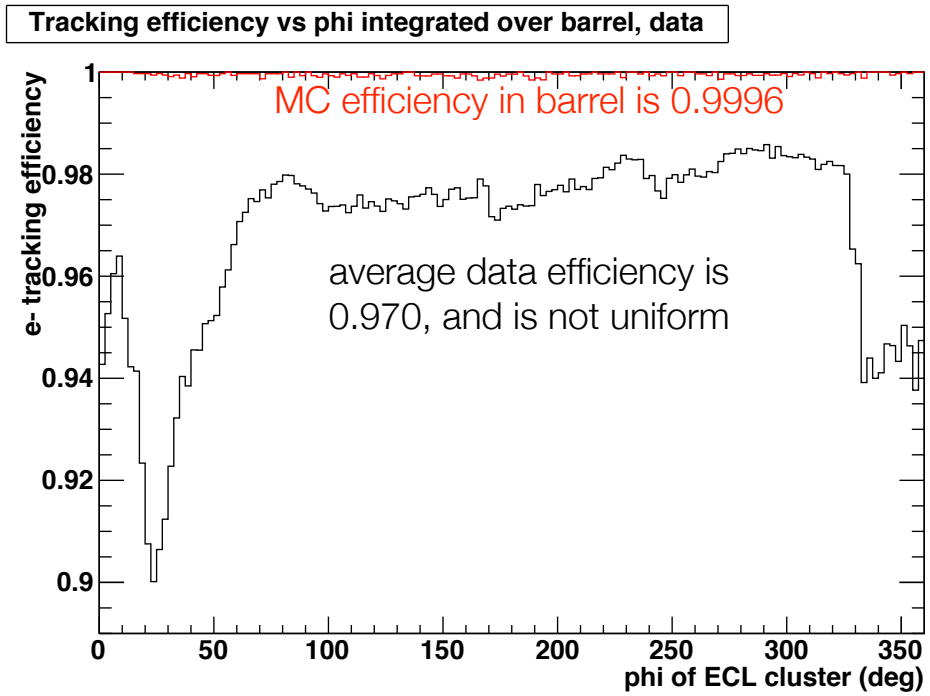
- The data/mc discrepancy that I see before applying muonID could reflect a difference between data and MC in tracking efficiency at low angles.

- To study this, I selected Bhabhas using the ECL only. The curvature provides a clean separation from $\gamma\gamma$ events.



- Note: this is a 2-year old study. Big improvements since then. And I need to add in SVD-only tracks. But it illustrates the type of study that can be done.





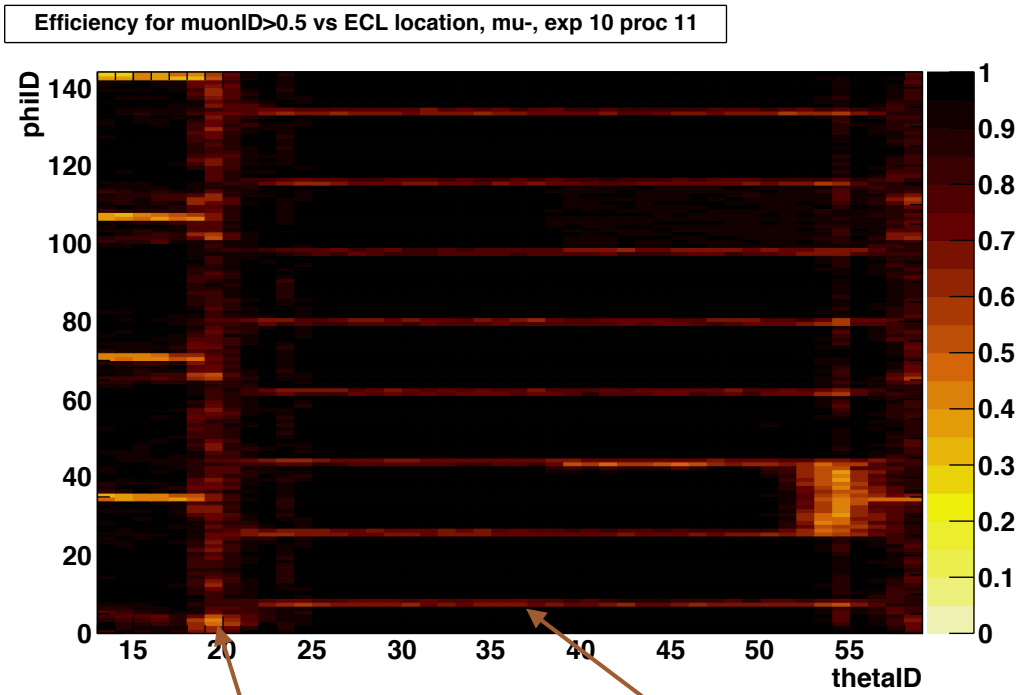
Muon ID

- Clearly an issue with muon ID in barrel / endcap gaps.

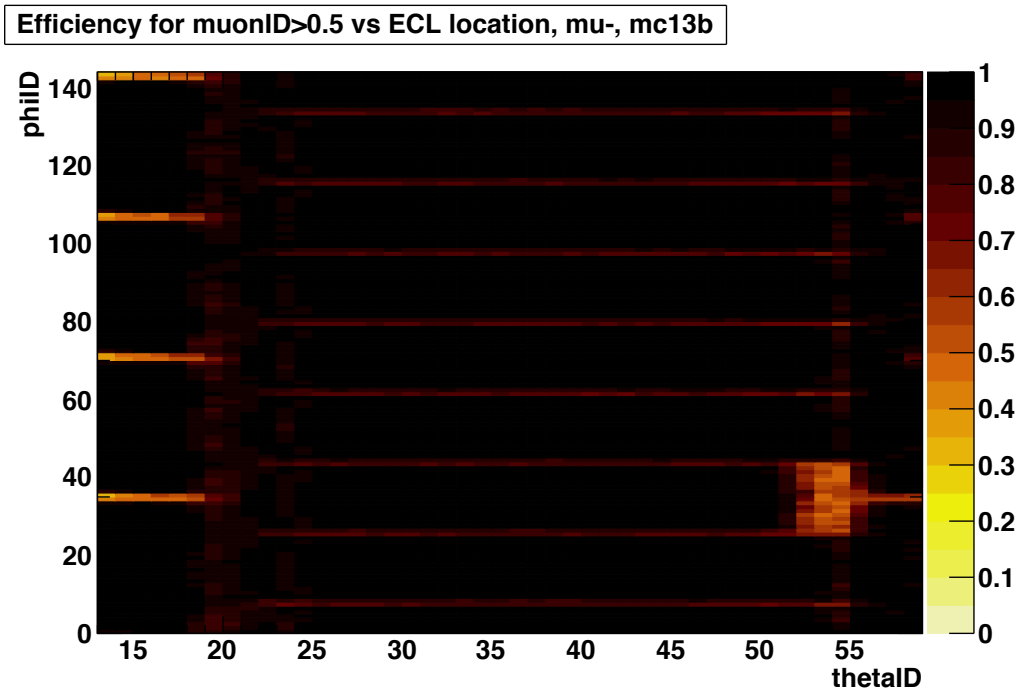
- Even in the barrel, efficiency modelling is not perfect. Understanding this at the fraction of a percent level takes a bit of care. Because the two tracks are almost back to back in phi, the KLM efficiency is somewhat correlated.

- Require one track have muonID>0.5, then check the fraction of other tracks that also have muonID>0.5

exp 10 data



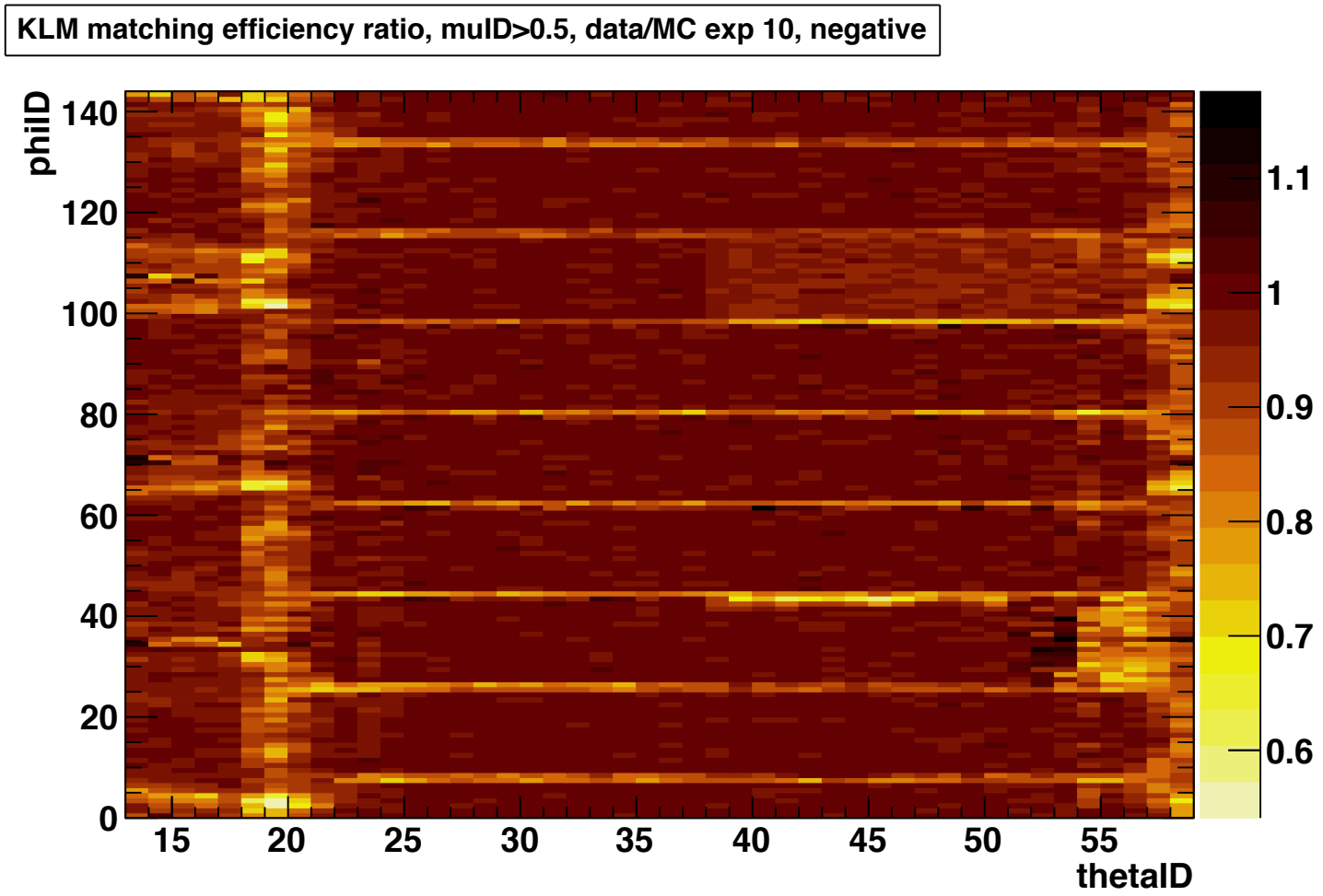
mc13b



and also in octant boundaries

inefficiency in forward gap is worse in data than in mc

- Ratio of data efficiency / mc efficiency for each bin (1 bin = 1 ECL crystal)



Level 1 trigger

- Basically two muon pair triggers for exp 10:
  - ffo: two wide-angle tracks, roughly back to back in phi
  - eclmumu / lml10: ECL clusters back-to-back in ϕ_{cms} and θ_{cms}.

- Mid-way through exp 12, we added new lines requiring one or two tracks matched to barrel KLM clusters. In exp 14, this will be extended to the endcap KLM.

Measuring the L1 trigger efficiency

- In the barrel, especially as of exp 12, we can compare the different triggers lines to get the overall efficiency.
- ECL gap region: ecl triggers are inefficient, L1 tracking efficiency is unknown. Endcap KLM triggers will be needed to perform the studies.
- ECL endcaps: ecl trigger is the primary one. It is the only trigger at low angles. Needs some thought. May need to introduce a highly prescaled single cluster trigger.

Summary

- In terms of selecting a pure sample, kinematics and muonID should give us the tools we need. But I have not yet quantified this.

- Understanding the efficiency will take work in three areas:
  - tracking
  - muon ID
  - level 1 trigger.

- I do not understand the optimization between purity and efficiency.