Trigger efficiency study with $ee \rightarrow \mu\mu\gamma$

Xuyang Gao

Fudan University

2022/10/7

Target

Comparison of trigger bit efficiency performance between Data/MC

- Using $e^+e^- \to \mu^+\mu^-\gamma$ process
  - Includes information from subdetectors.
  - Can be triggered by a variety of L1 triggers.

■ Study the L1 performance at the level of underlying objects (i.e., track, ECL clusters, and KLM muons ...), and document the difference.

□ MC scale factors and systematic uncertainties

Strategy

- Dataset:
  - Data: proc12 + bucket16 to bucket36 (skim:all)
  - MC: MC14ri/rd (type:mumu)

- Trigger performance:
  - Measure the efficiency using orthogonal triggers (OT):

$$\epsilon_{target} = \frac{N_{target\&reference}}{N_{reference}}$$

Previous study

BELLE2-NOTE-TE-2020-014
March 3, 2021

L1 trigger performance study targeting the following dark sector analyses with 2019 data

- $e^+e^- \to \mu^+\mu^- Z'(\to invisible)$
- $e^+e^- \to A'(\to \mu^+\mu^-)h'(\to invisible)$

M. Bertemes, G. Inguglia*

HEPHY, Vienna, Austria

For the reaction $e^+e^- \to \mu^+\mu^-\gamma$, events are selected requiring two *good* tracks originating from the vertex with $|dz| < 2.0$ and $dr < 0.5$ and to be identified as muons with a global PID (muonID> 0.5). The events are required to fire the hie trigger bit. Both muon tracks are required to be in the ECL barrel region. Photons are selected according to the stdPhotons("loose") list, which implies the value of clusterErrorTiming to be smaller than 10^{-6}, their energy to be greater than 0.075 GeV or clusterE1E9 to be greater than 0.4, and to be in the CDC acceptance.

BELLE2-NOTE-TE-2020-014

Event selection

- Basic selection:
  - ONLY Two tracks
    - nTracks == 2
    - in barrel region
    - |dz| < 2.0 cm, |dr| < 0.5 cm
    - muonID > 0.5
    - p_T > 0.4 GeV
  - Photons in stdPhoton:loose list
    - clusterErrorTiming < 10^{-6}
    - E > 0.075 GeV || clusterE1E9 > 0.4
    - In CDC acceptance
  - # only one candidate is accepted each event.
  - Extra cut are put for dedicated trigger bit measurements

$$\epsilon_{target} = \frac{N_{target\&reference}}{N_{reference}}$$

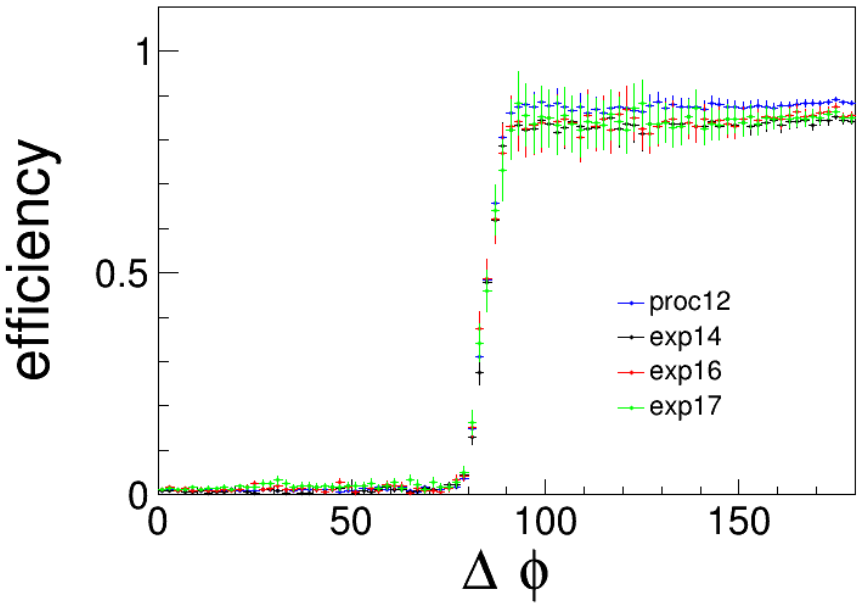
	CDC	CDC	ECL	KLM
Target (L1FTDL)	ffo	ffo30	hie	mu_b2b
Reference(L1PSNM)	hie	hie	mu_b2b	hie

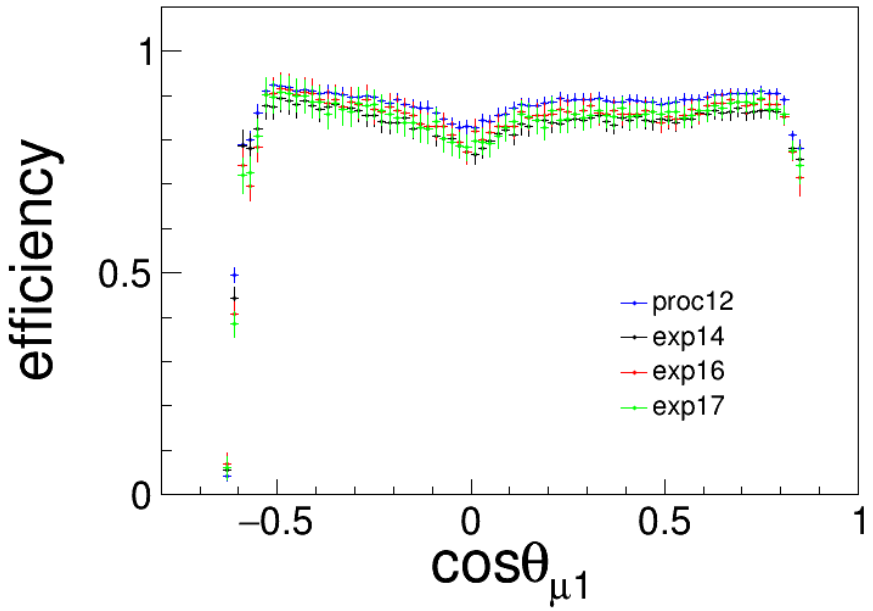
Preliminary result (ffo)

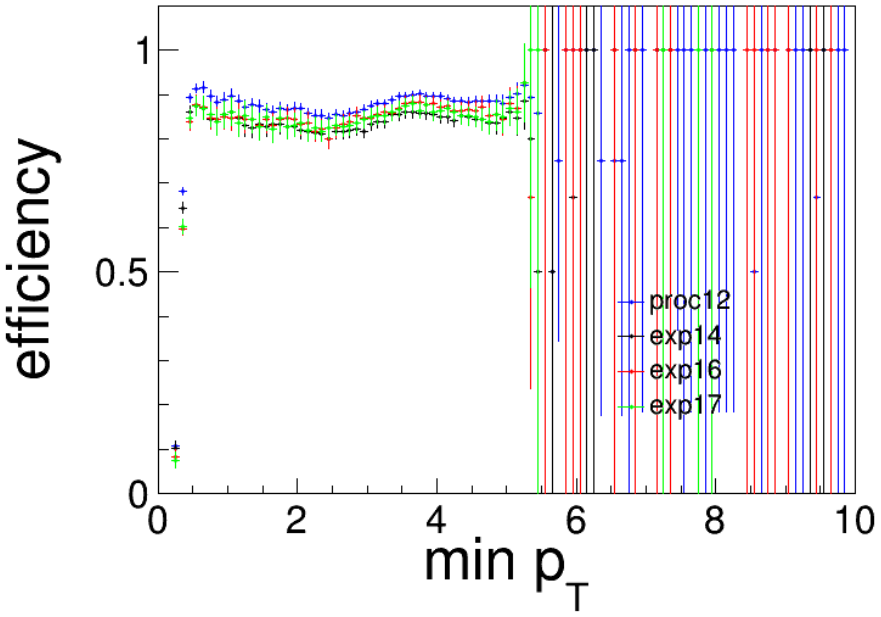
Data samples:
proc12
exp14
exp16
exp17

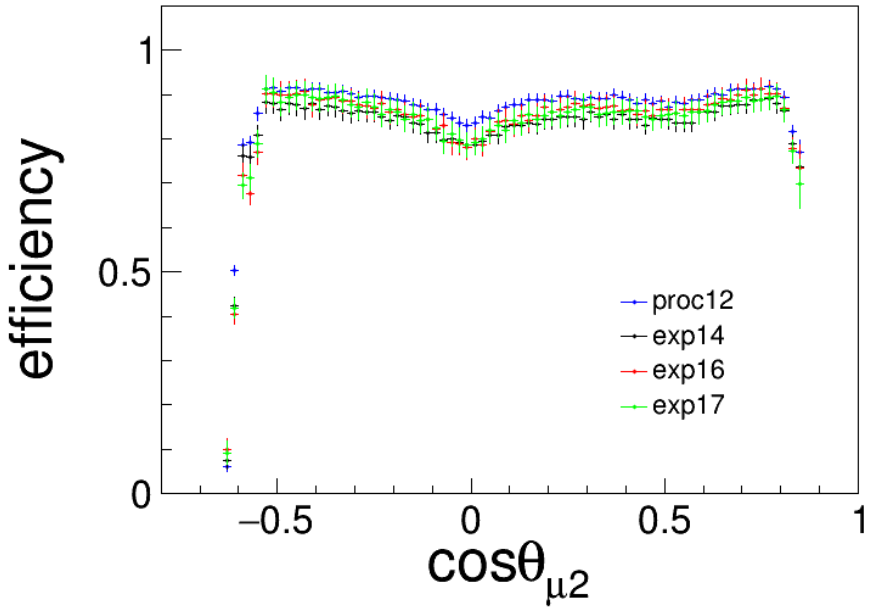
Reference bit:
hie

Cut:
$\Delta\phi(\mu,\mu) > 90°$
$p_T(\mu) > 0.4$ GeV







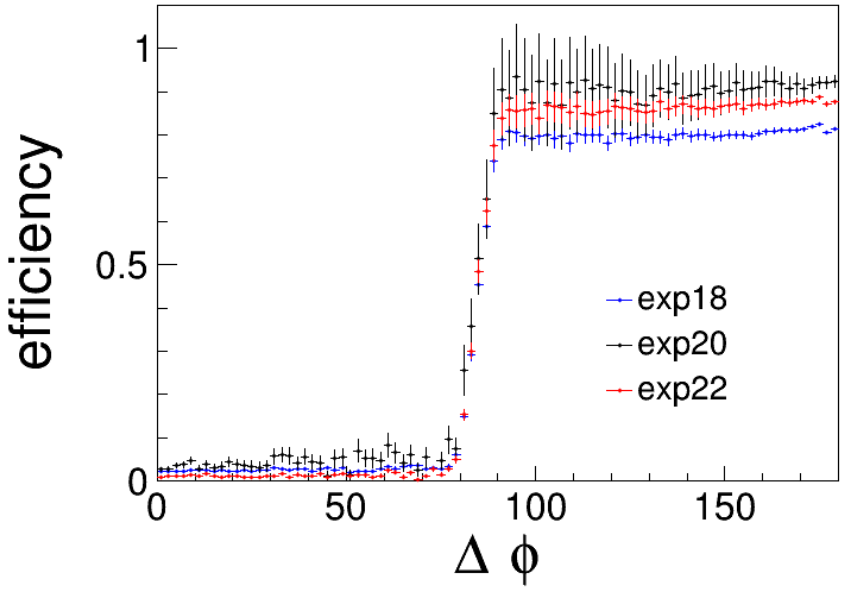


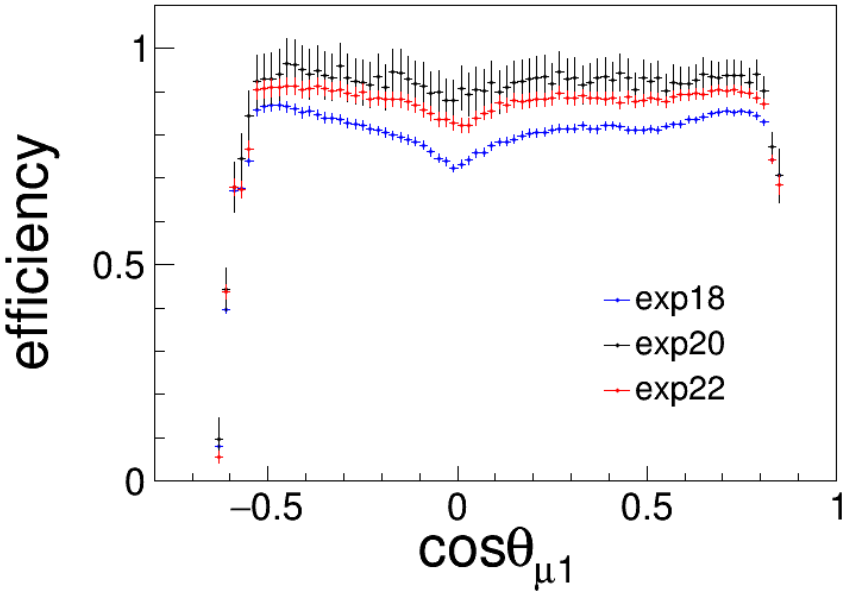
Preliminary result (ffo)

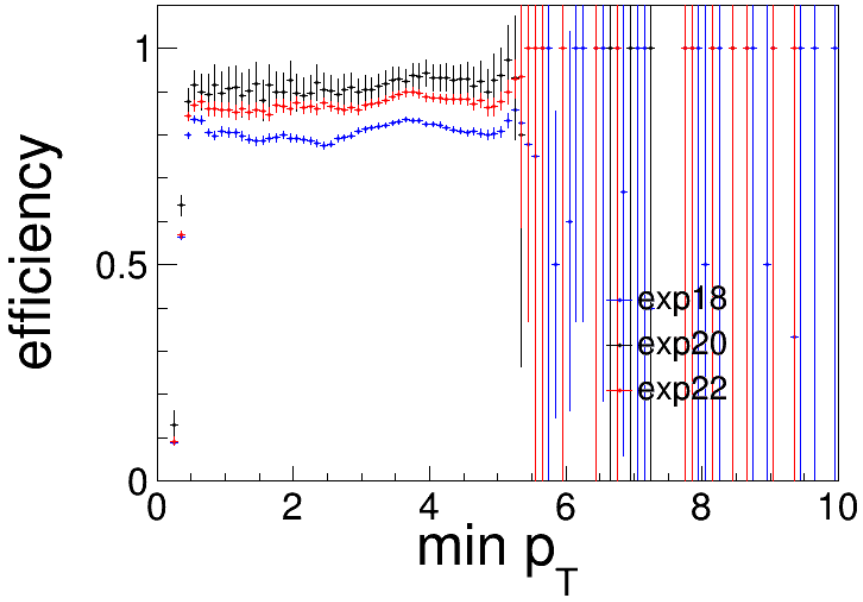
Data samples:
exp18
exp20
exp22

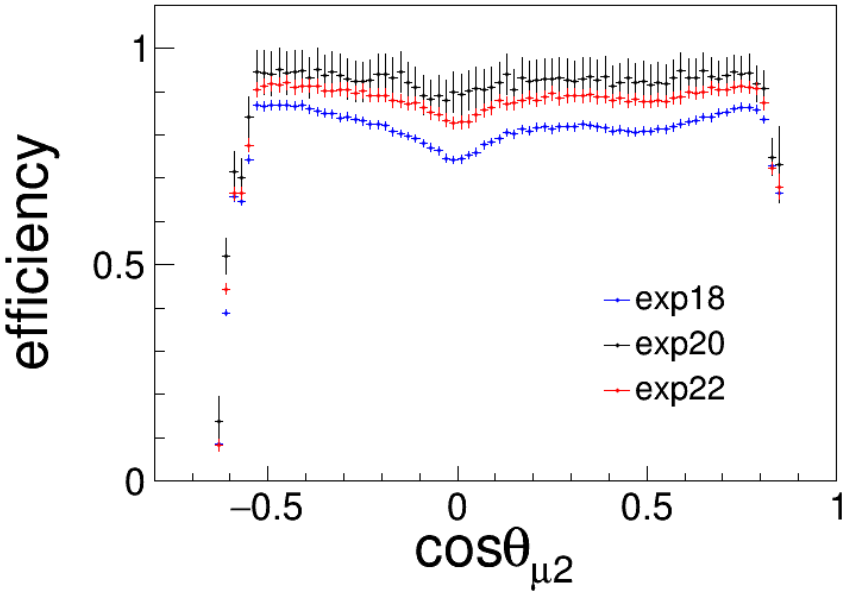
Reference bit:
hie

Cut:
$\Delta\phi(\mu,\mu) > 90°$
$p_T(\mu) > 0.4$ GeV







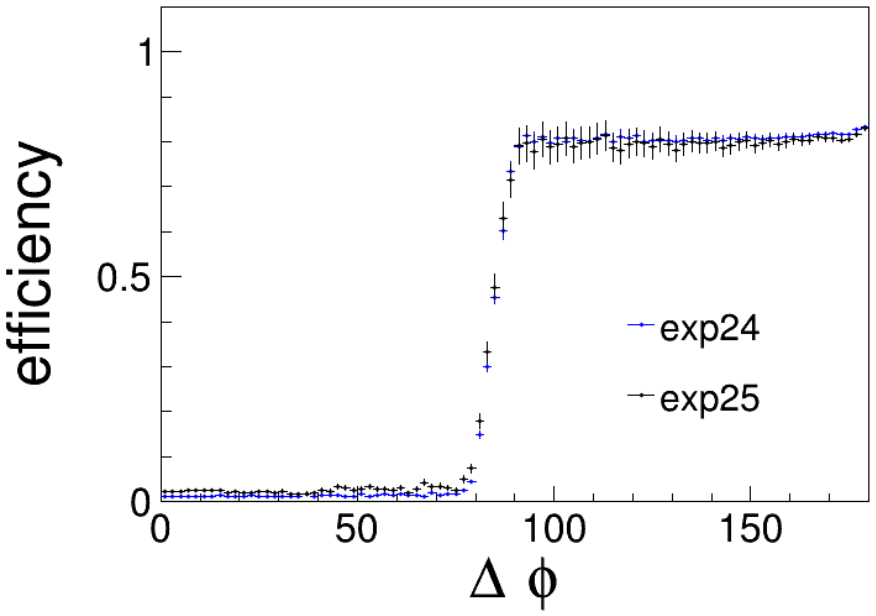


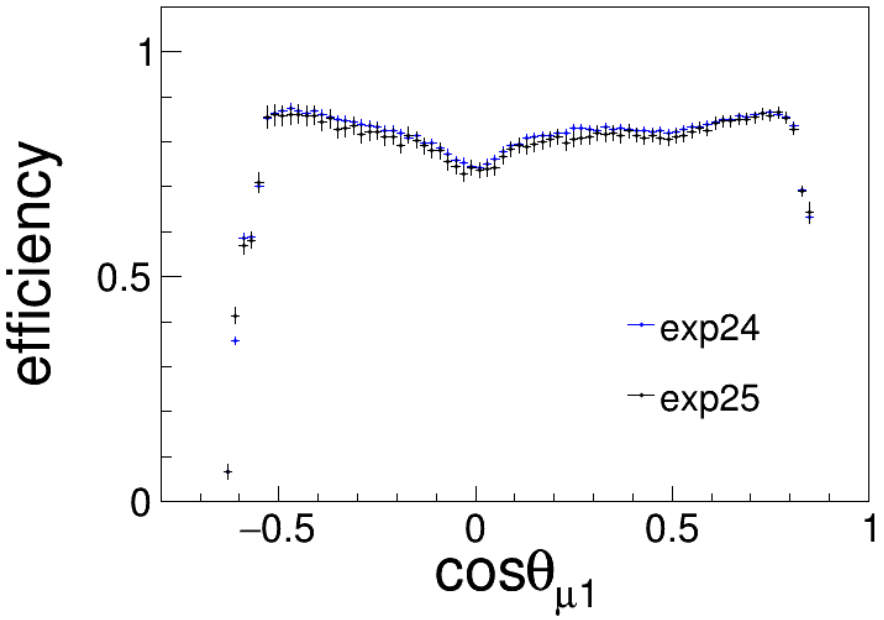
Preliminary result (ffo)

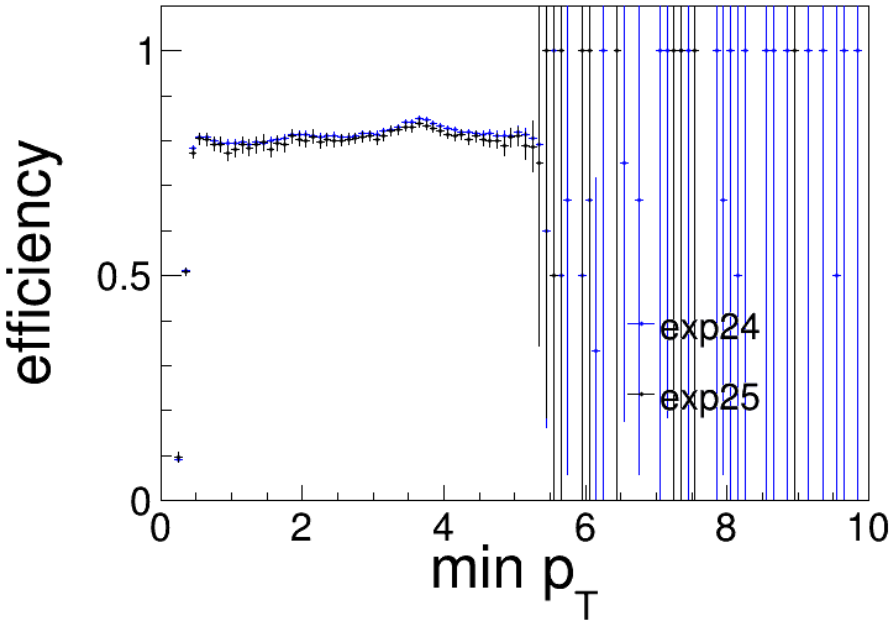
Data samples:
exp24
exp25

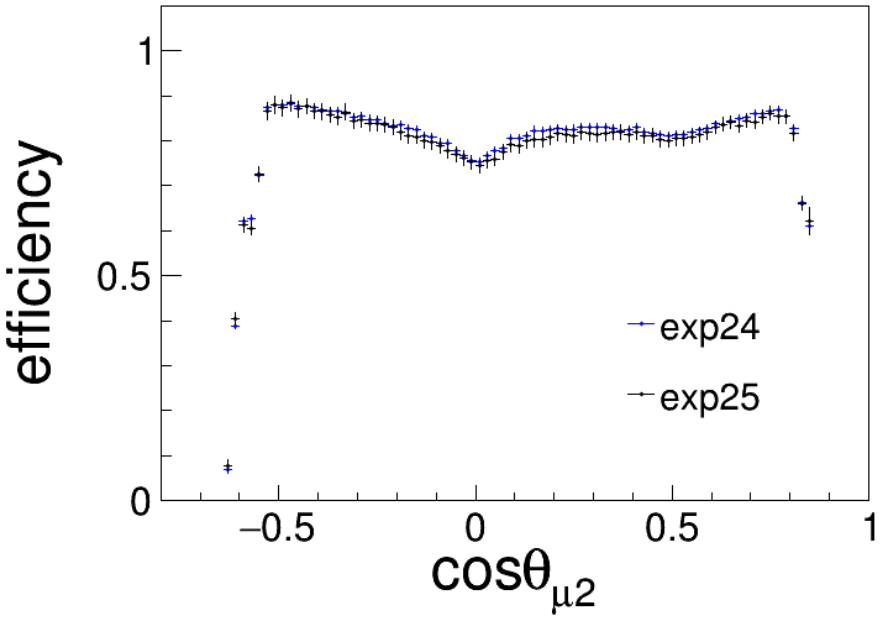
Reference bit:
hie

Cut:
$\Delta\phi(\mu,\mu) > 90°$
$p_T(\mu) > 0.4$ GeV







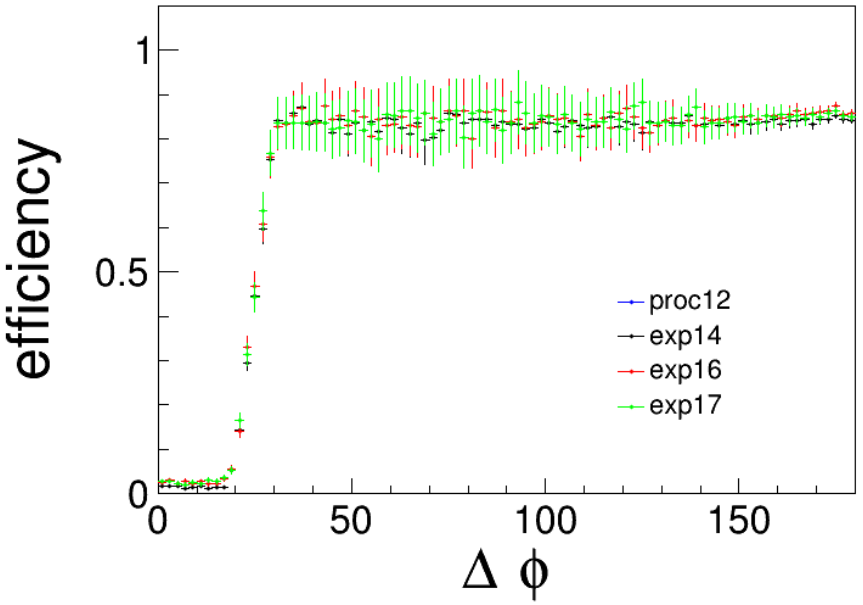


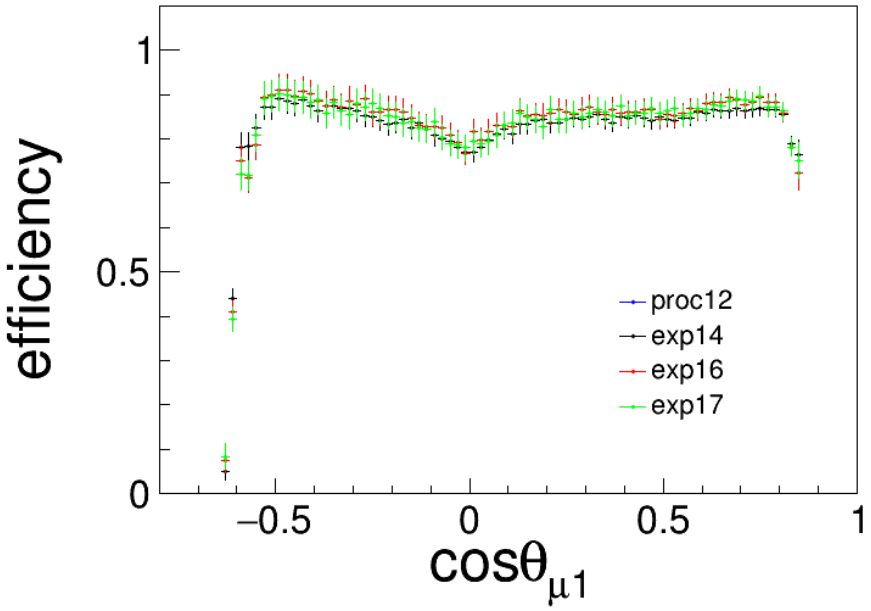
Preliminary result (ffo30)

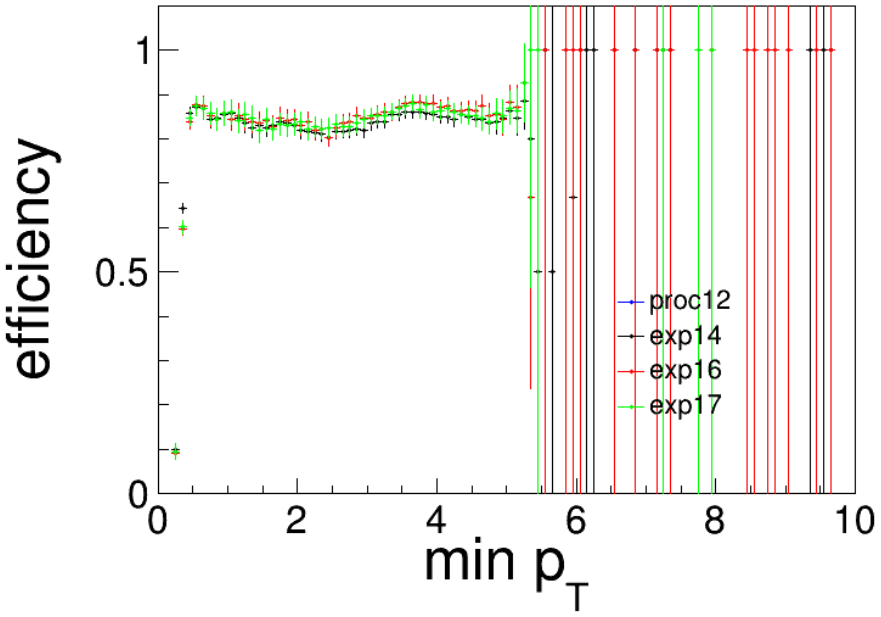
Data samples:
proc12
exp14
exp16
exp17

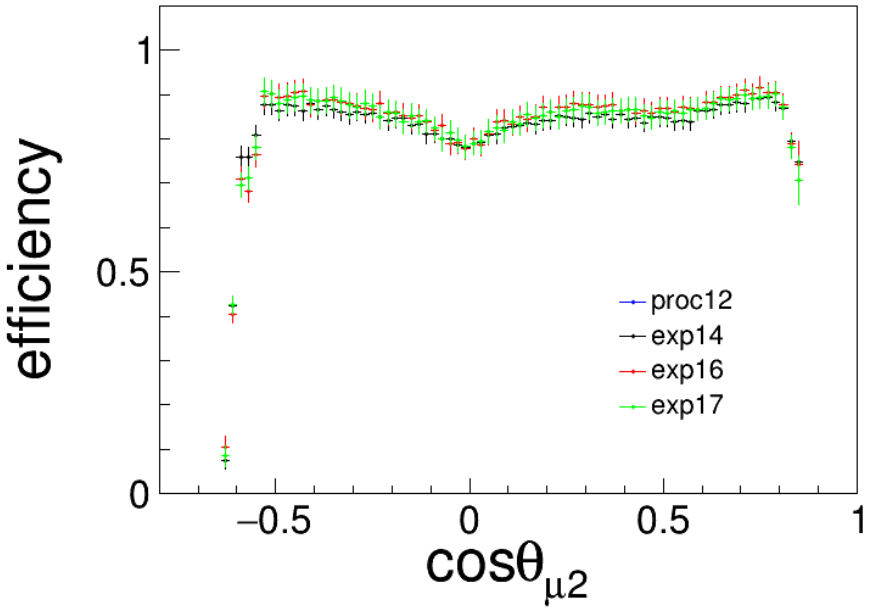
Reference bit:
hie

Cut:
$\Delta\phi(\mu,\mu) > 30°$
$p_T(\mu) > 0.4$ GeV







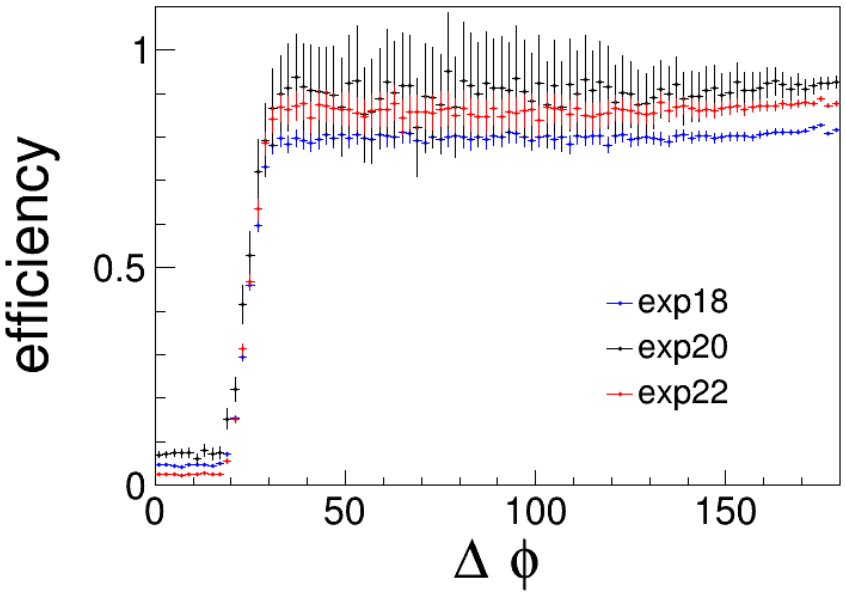


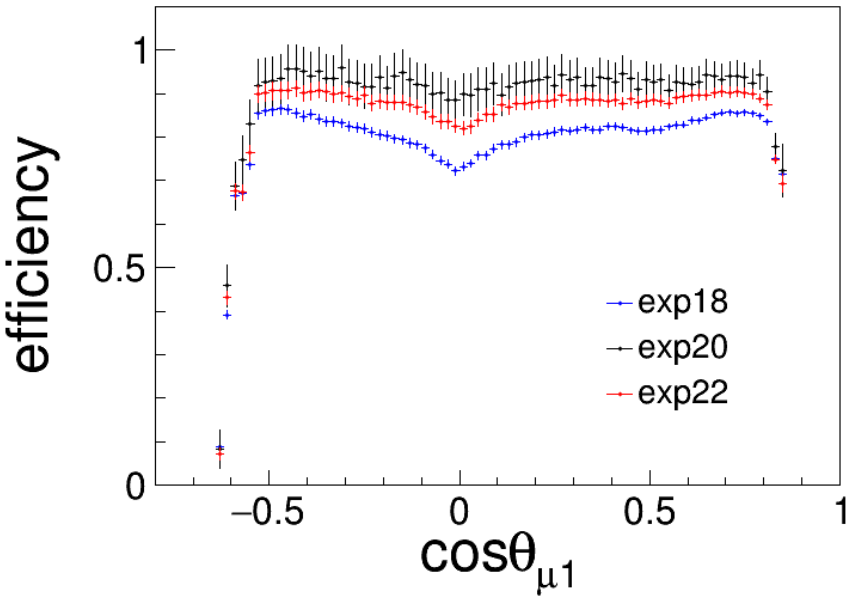
Preliminary result (ffo30)

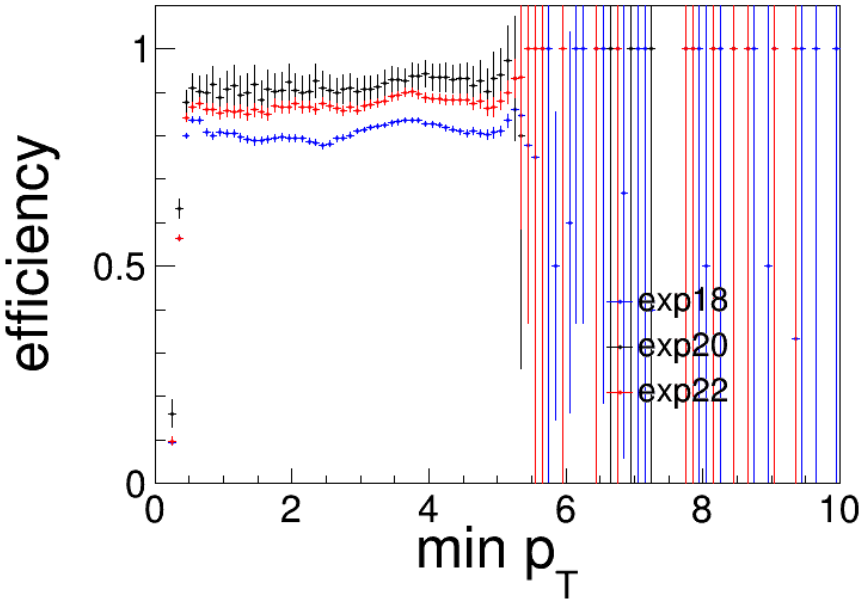
Data samples:
exp18
exp20
exp22

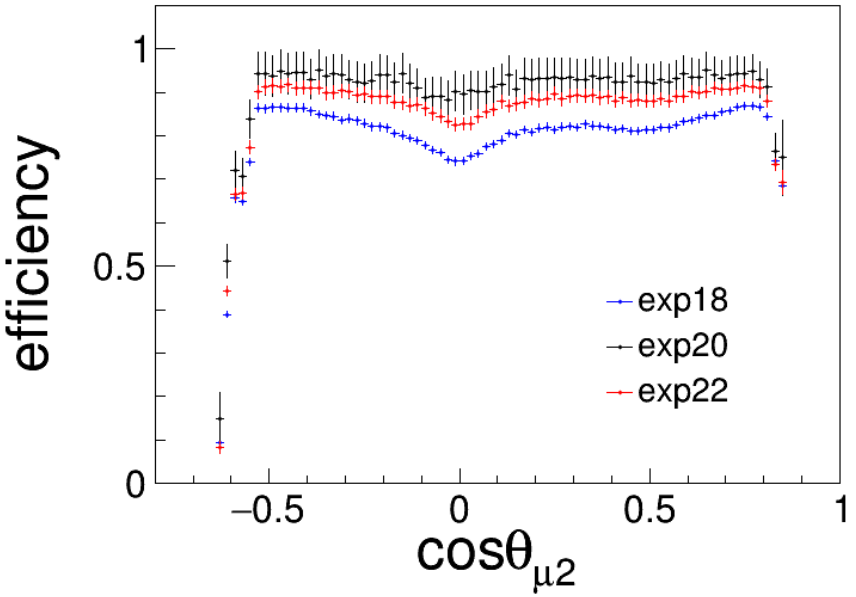
Reference bit:
hie

Cut:
$\Delta\phi(\mu,\mu) > 30°$
$p_T(\mu) > 0.4$ GeV







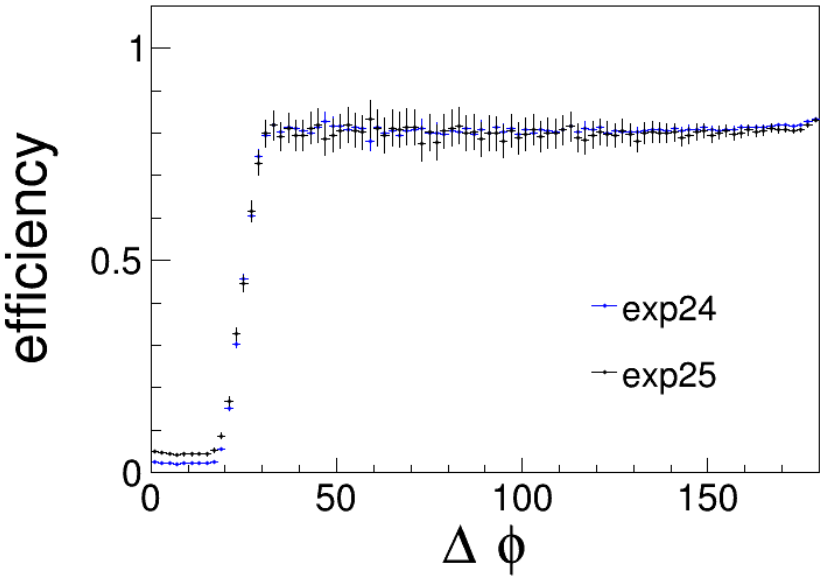


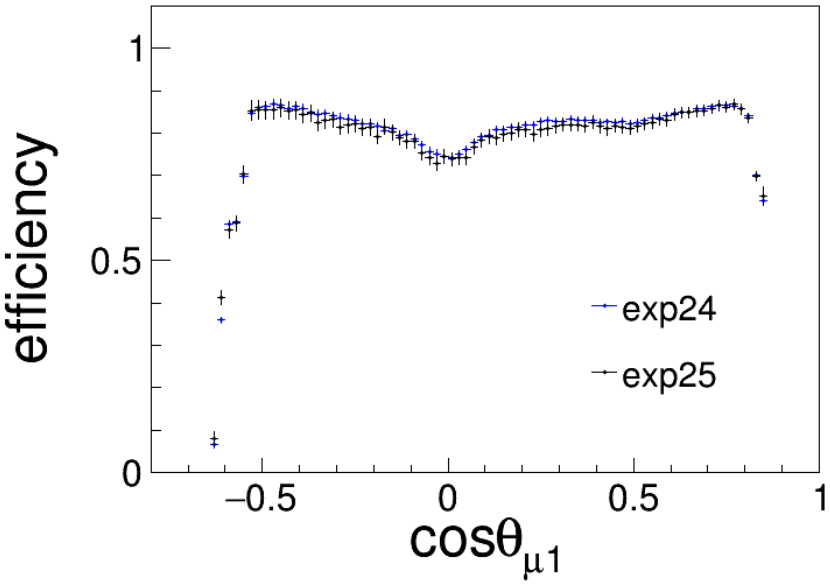
Preliminary result (ffo30)

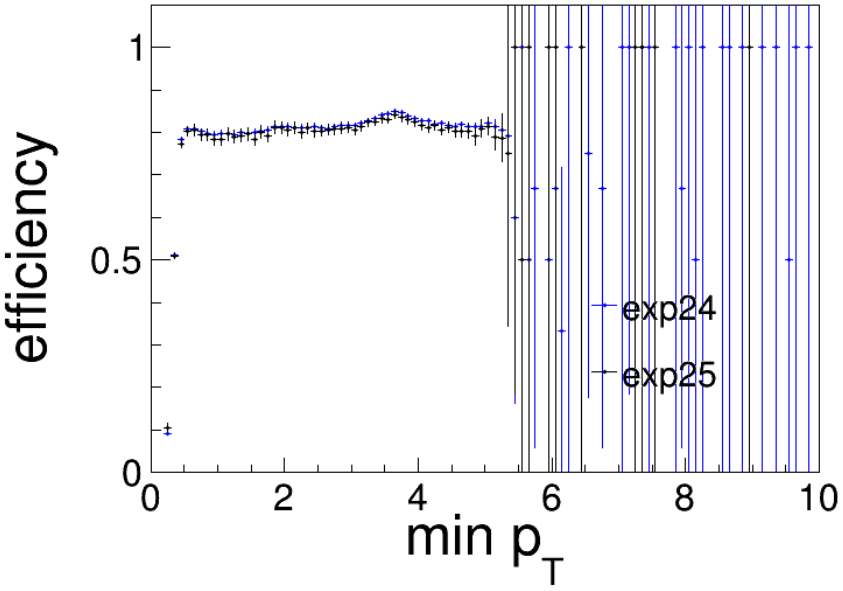
Data samples:
exp24
exp25

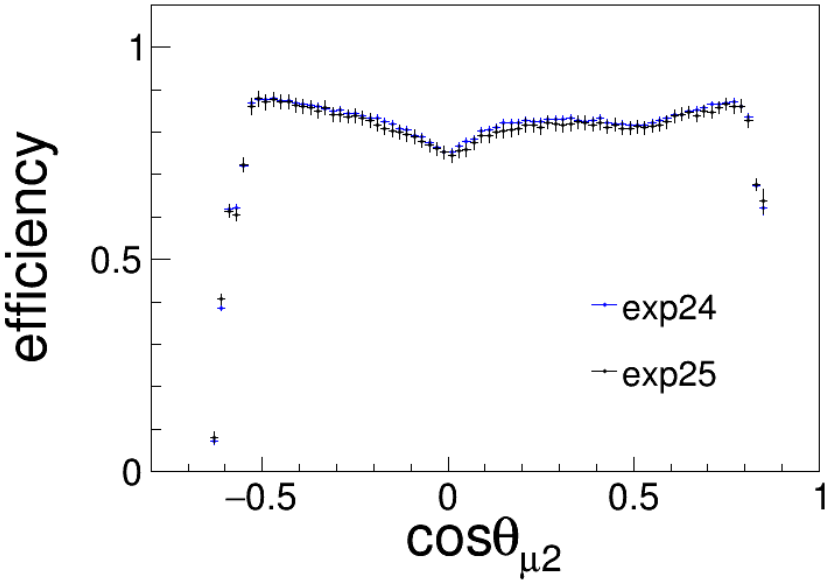
Reference bit:
hie

Cut:
$\Delta\phi(\mu,\mu) > 30°$
$p_T(\mu) > 0.4$ GeV







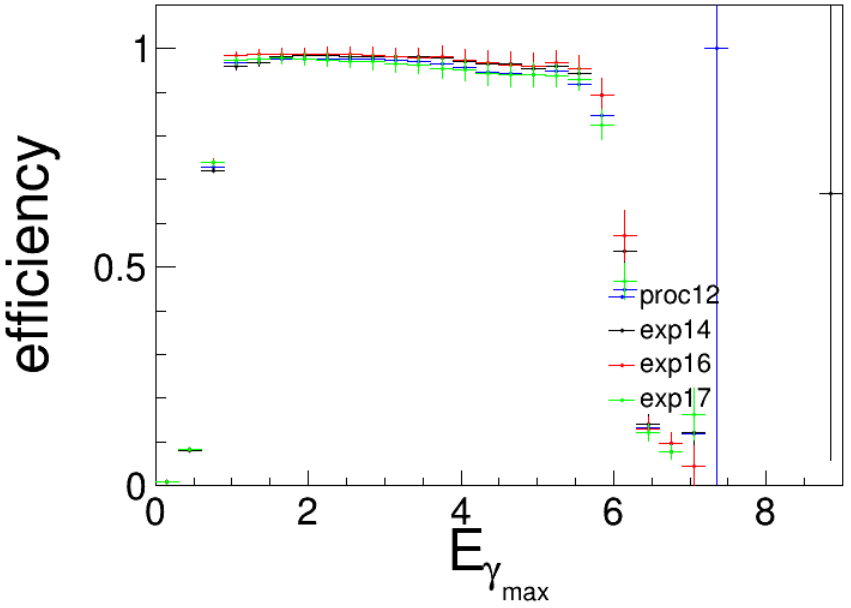


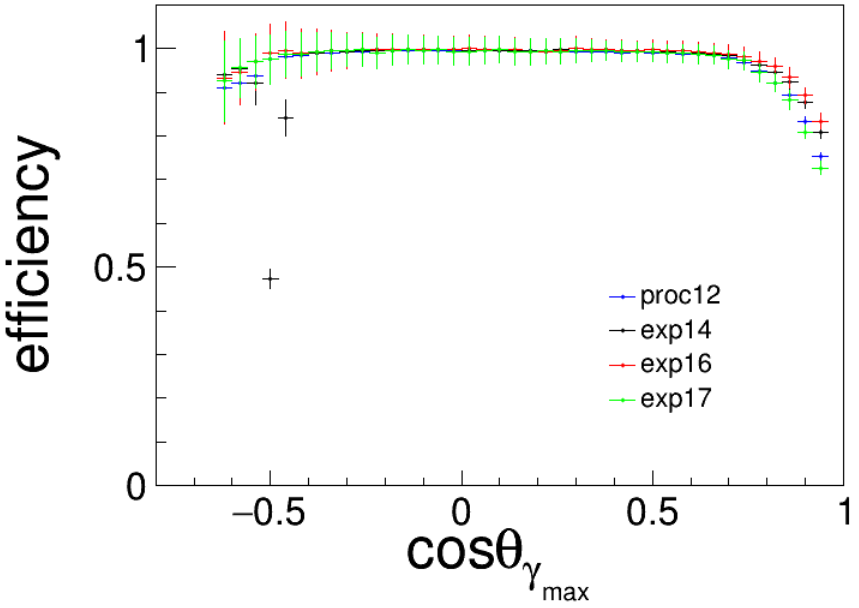
Preliminary result (hie)

Data samples:
proc12
exp14
exp16
exp17

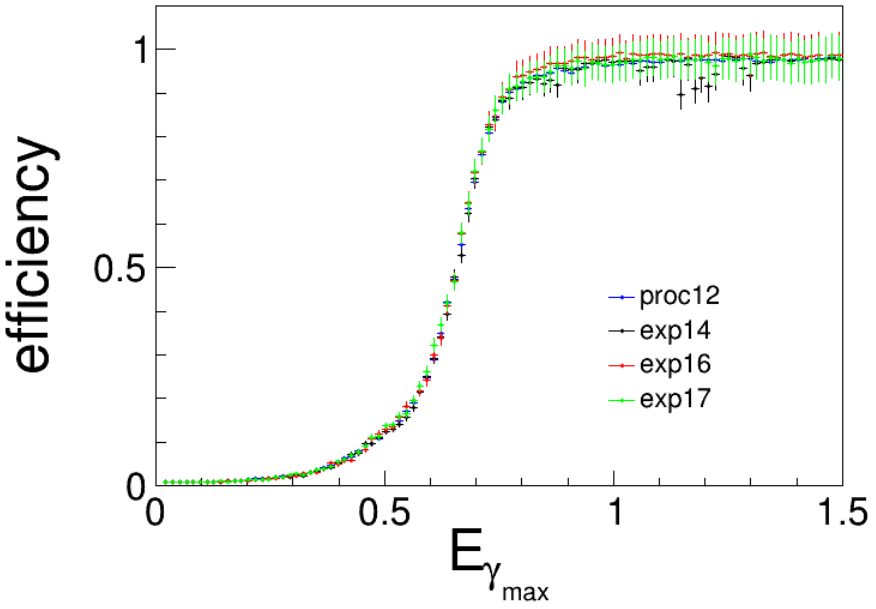
Reference bit:
mu_b2b

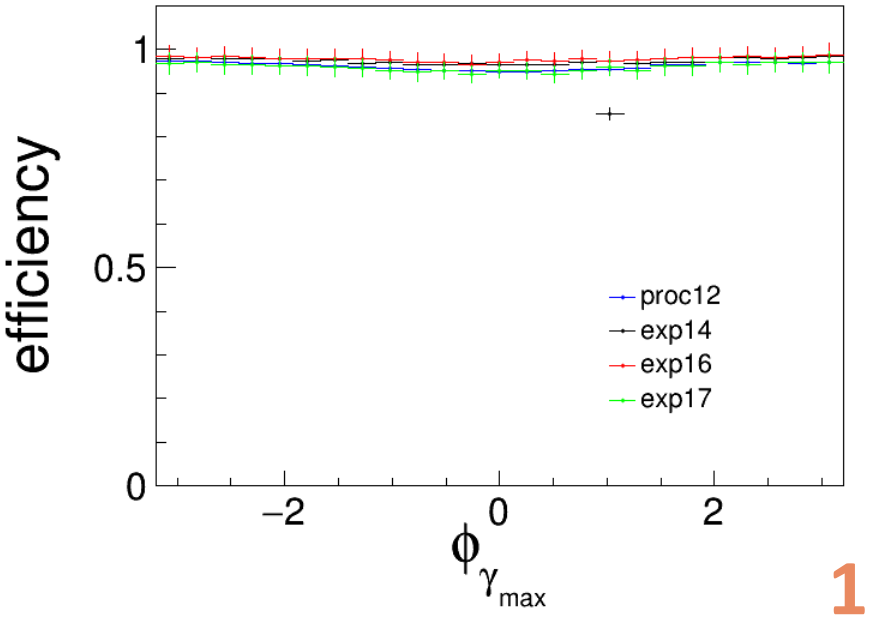
Cut:
$E_\gamma > 1$ GeV
$\cos\theta_\gamma$ in ECL





In exp14, Run 936
gives low efficiency.



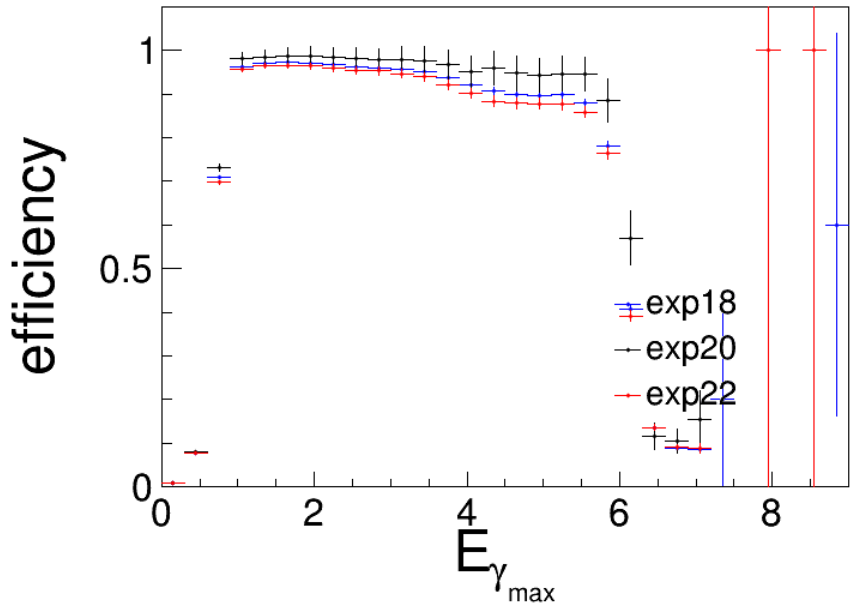


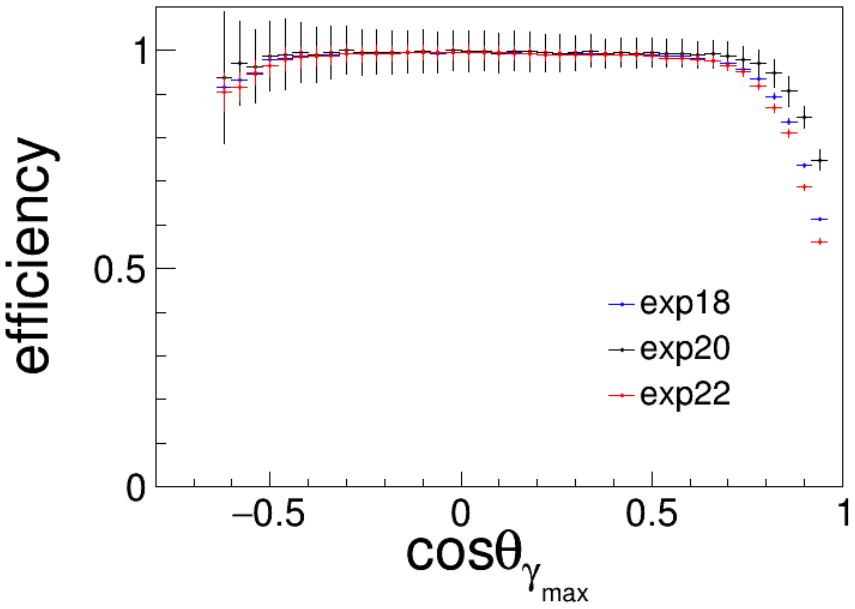
Preliminary result (hie)

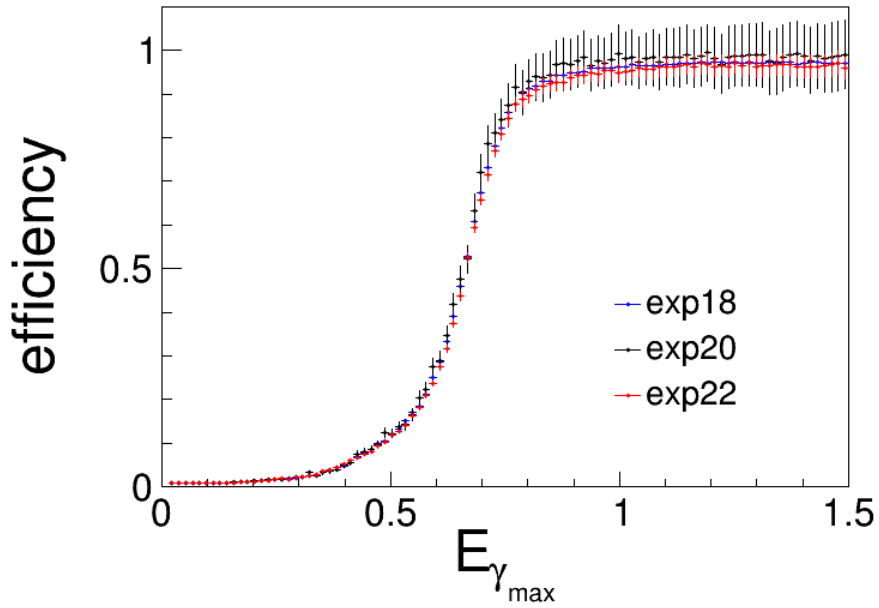
Data samples:
exp18
exp20
exp22

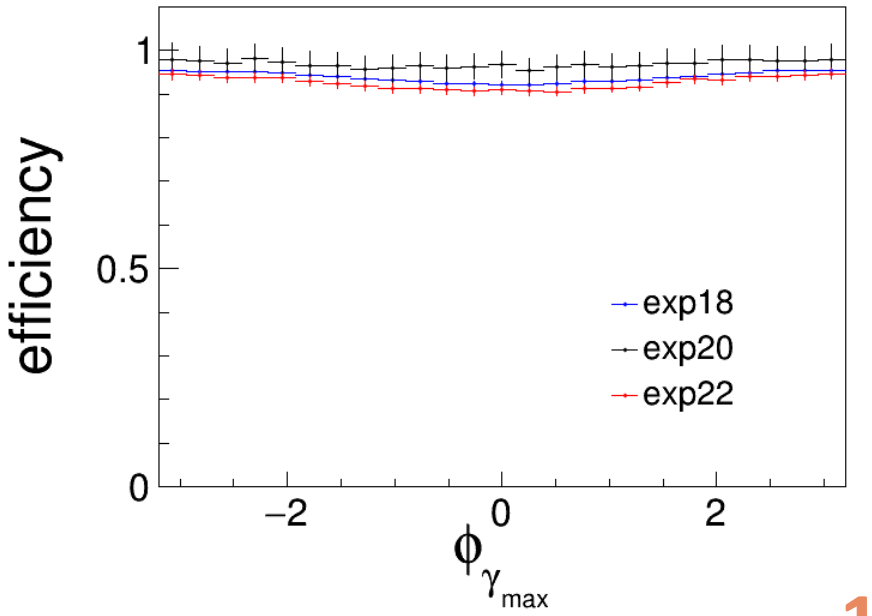
Reference bit:
mu_b2b

Cut:
$E_\gamma > 1$ GeV
$\cos\theta_\gamma$ in ECL







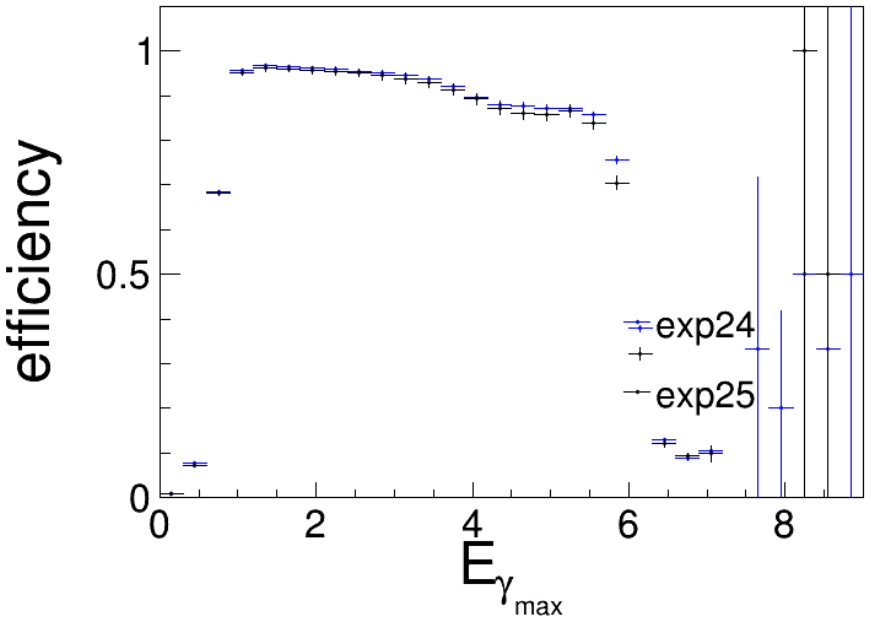


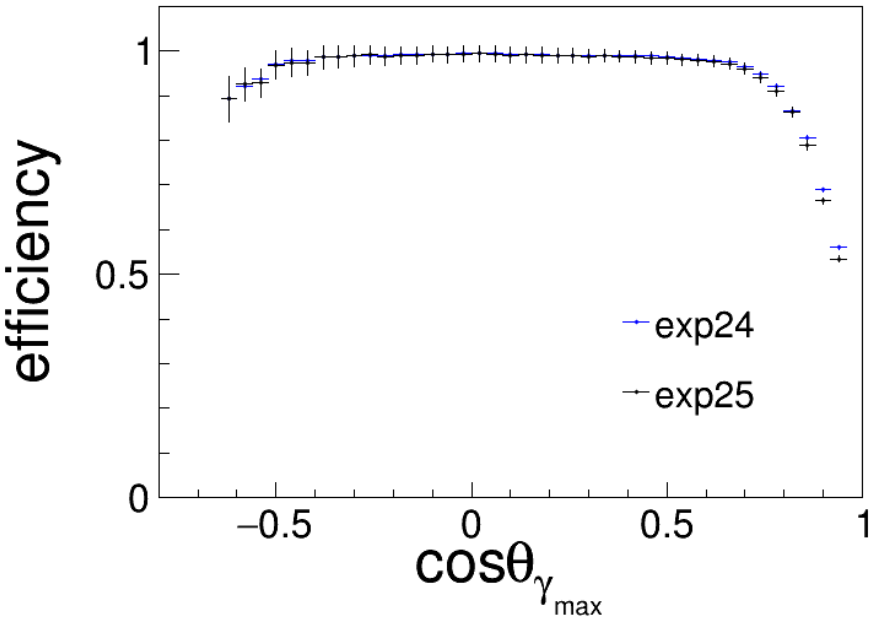
Preliminary result (hie)

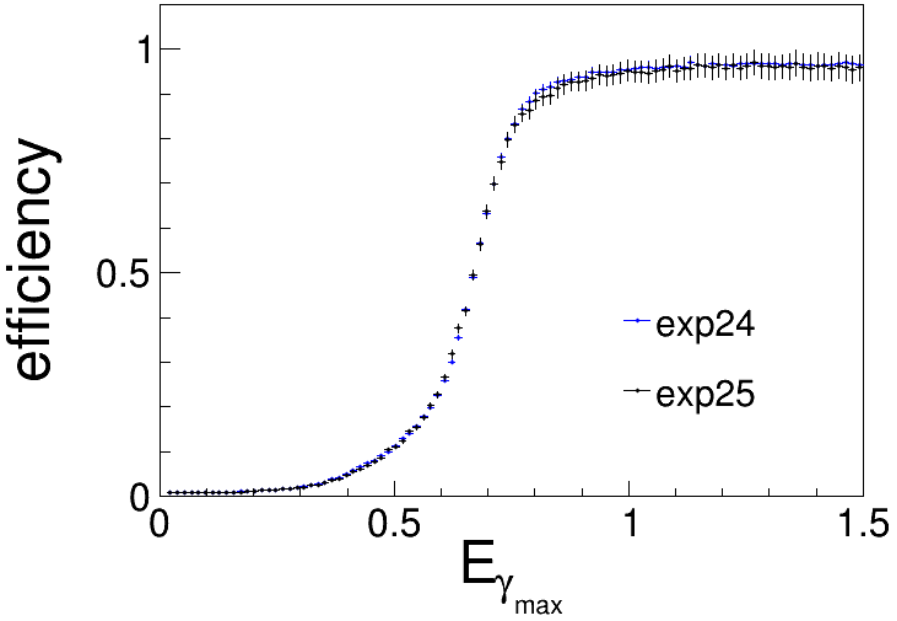
Data samples:
exp24
exp25

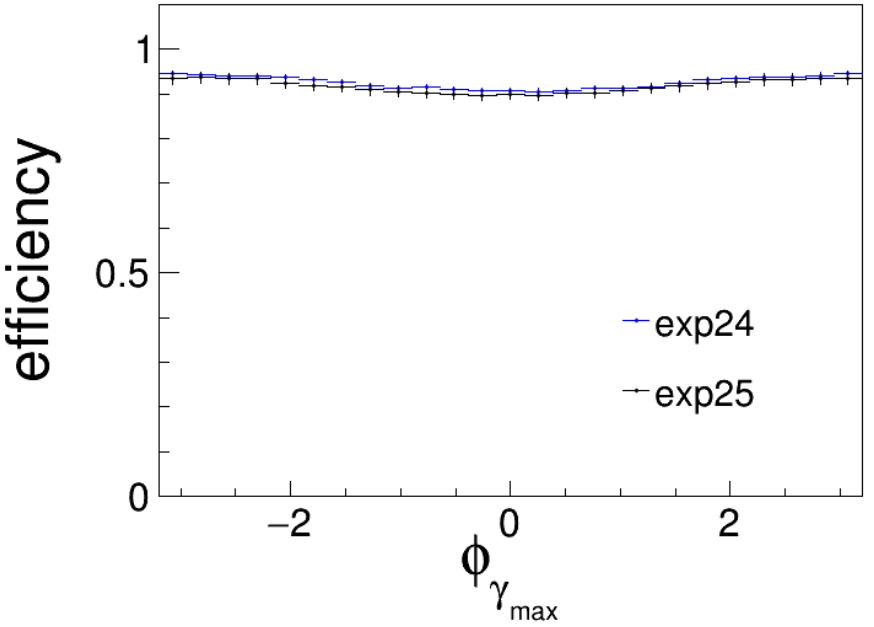
Reference bit:
mu_b2b

Cut:
$E_\gamma > 1$ GeV
$\cos\theta_\gamma$ in ECL







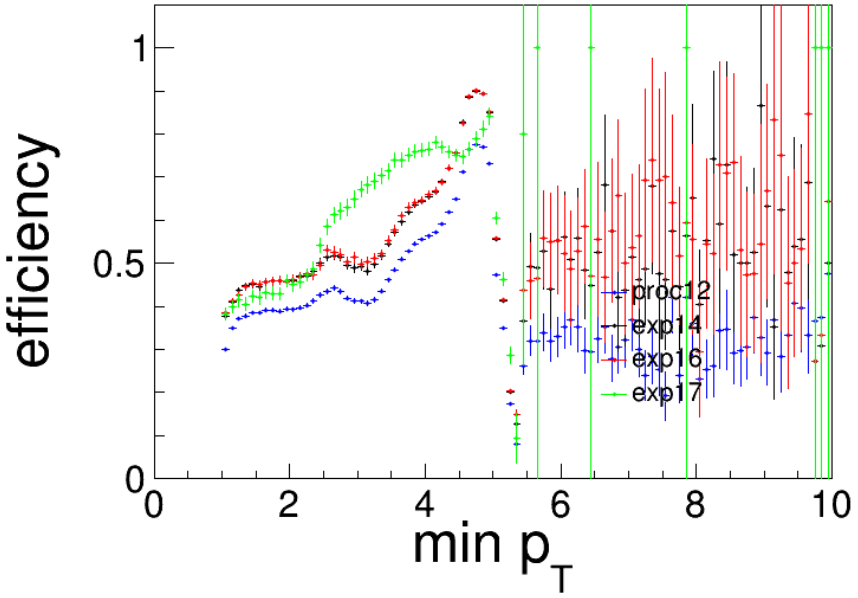


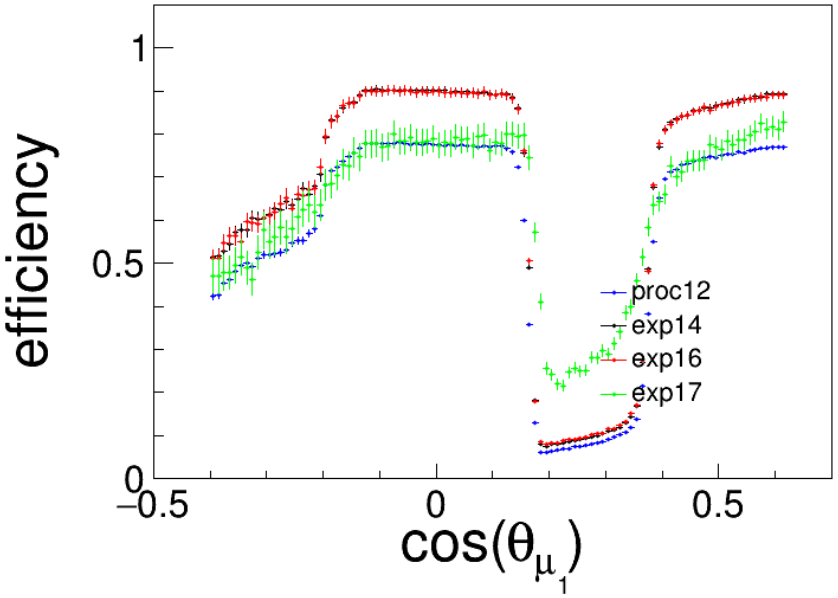
Preliminary result (mu_b2b)

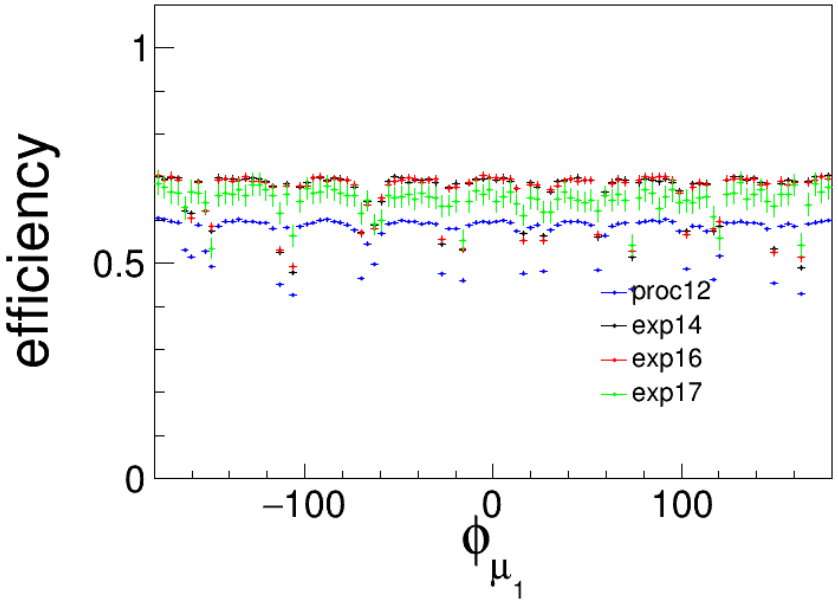
Data samples:
proc12
exp14
exp16
exp17

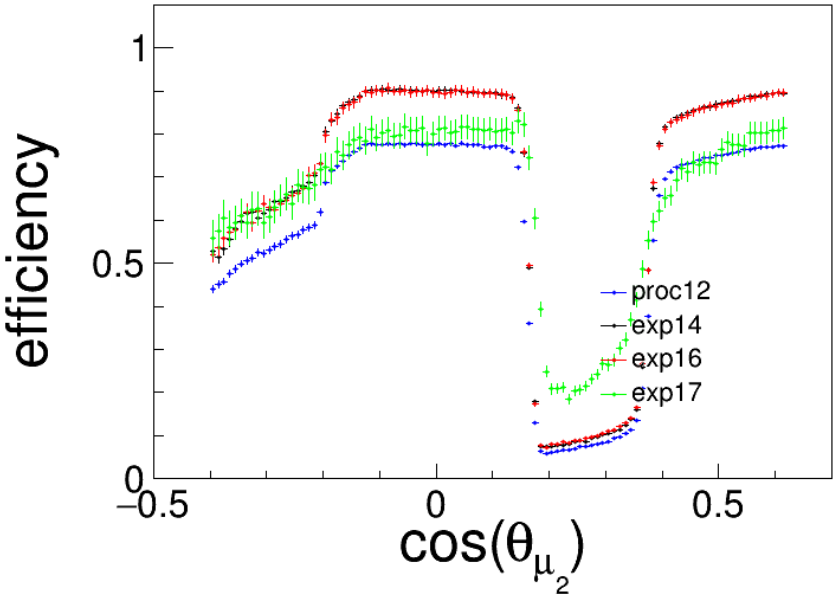
Reference bit:
hie

Cut:
$p_T(\mu) > 1$ GeV
$cos\theta_\mu$ in [-0.4, 0.62]







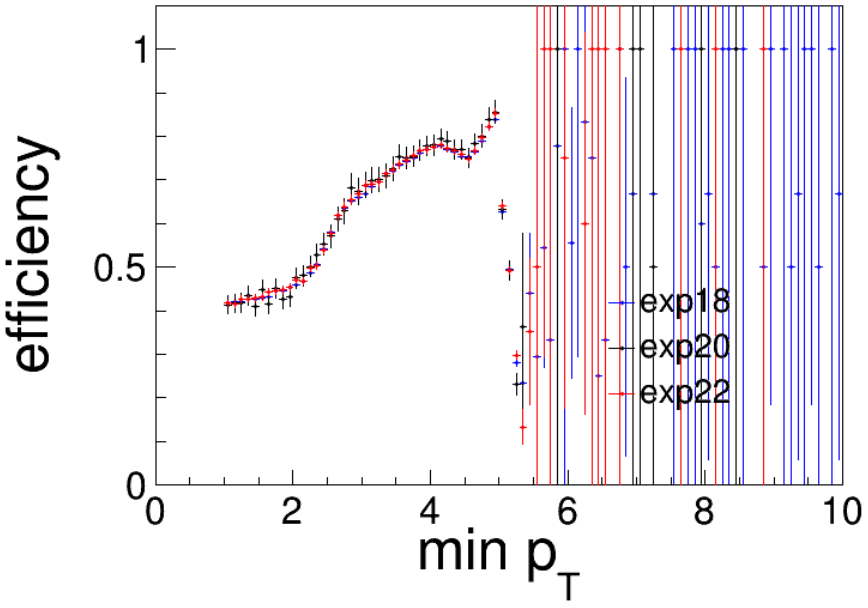


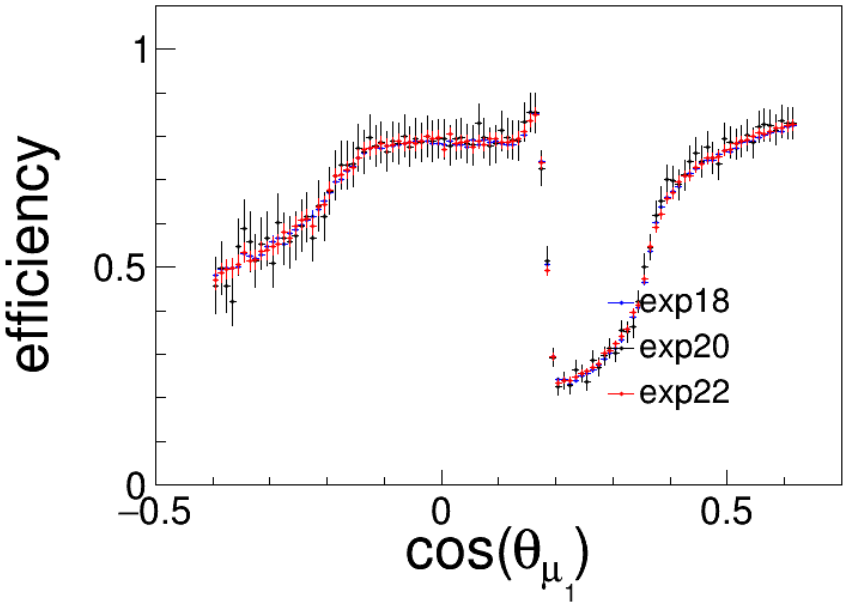
Preliminary result (mu_b2b)

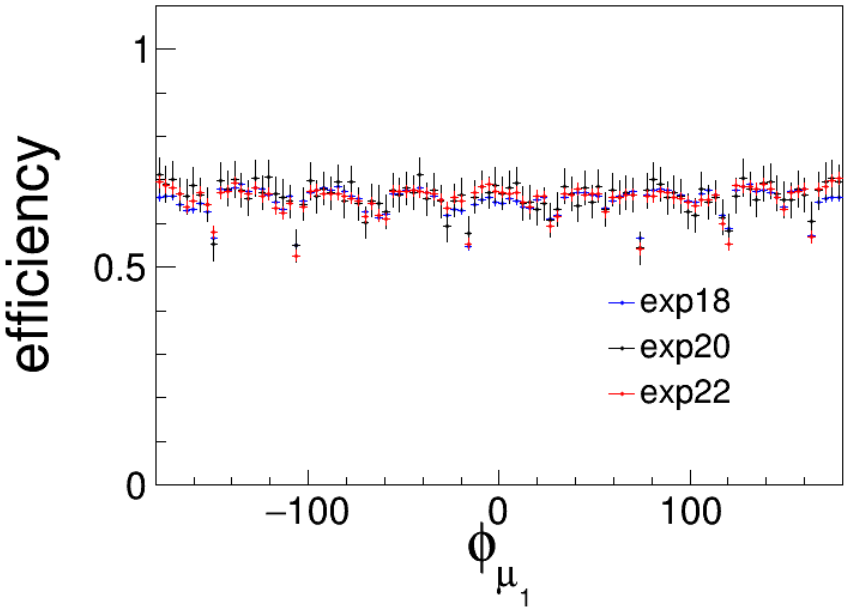
Data samples:
exp18
exp20
exp22

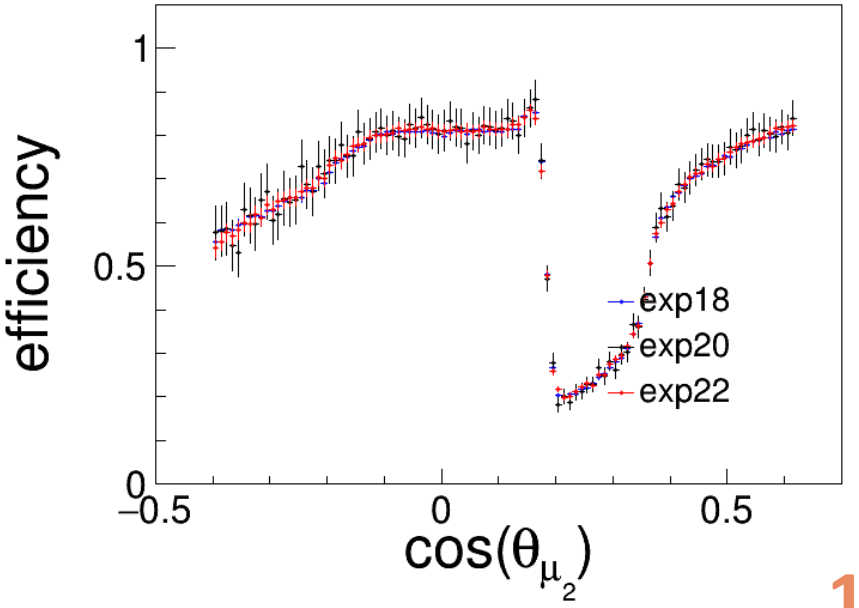
Reference bit:
hie

Cut:
$p_T(\mu) > 1$ GeV
$cos\theta_\mu$ in [-0.4, 0.62]







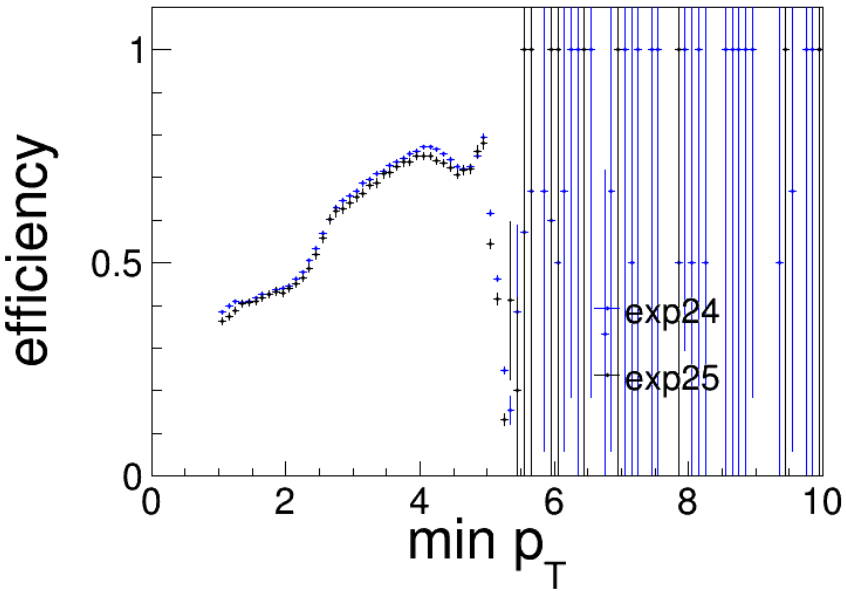


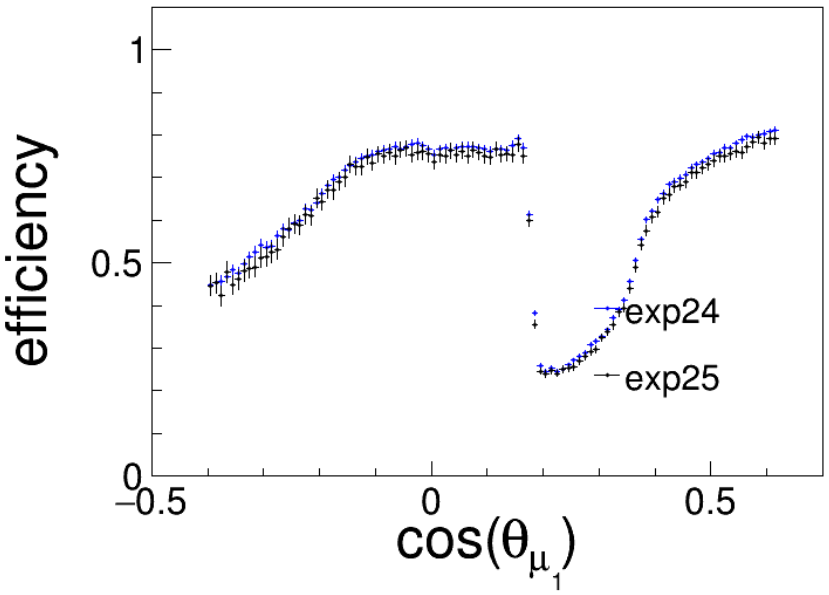
Preliminary result (mu_b2b)

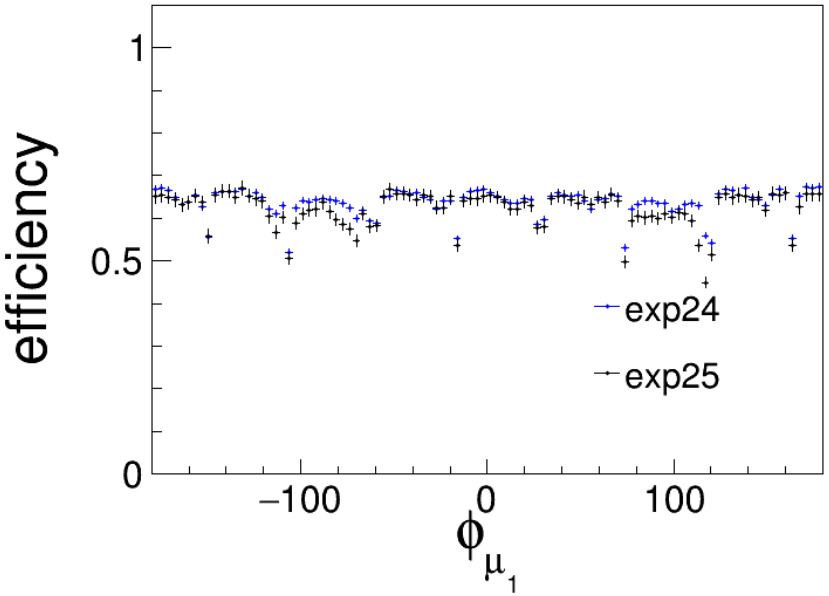
Data samples:
exp24
exp25

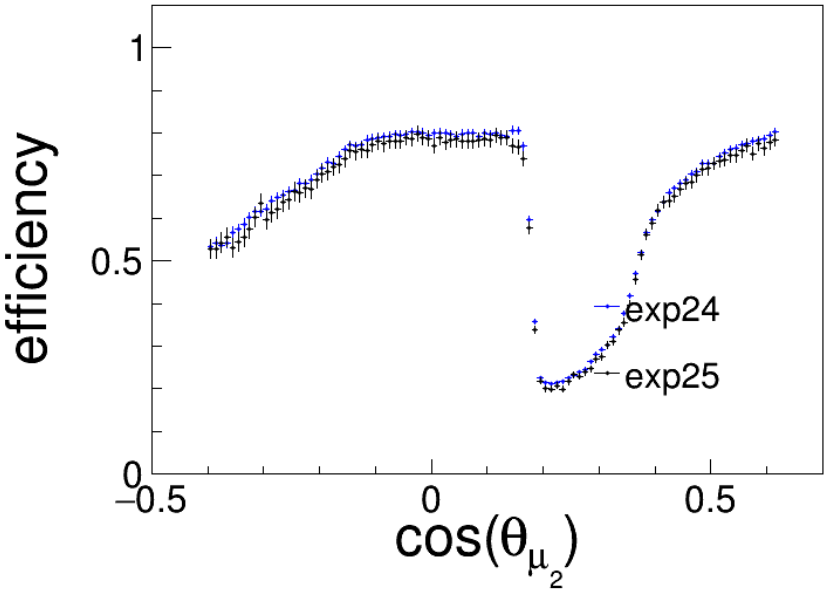
Reference bit:
hie

Cut:
$p_T(\mu) > 1$ GeV
$cos\theta_\mu$ in [-0.4, 0.62]









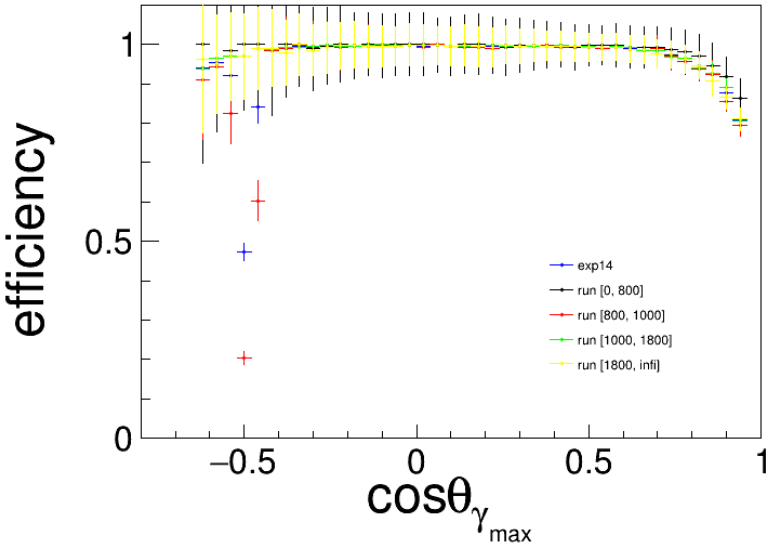
Summary

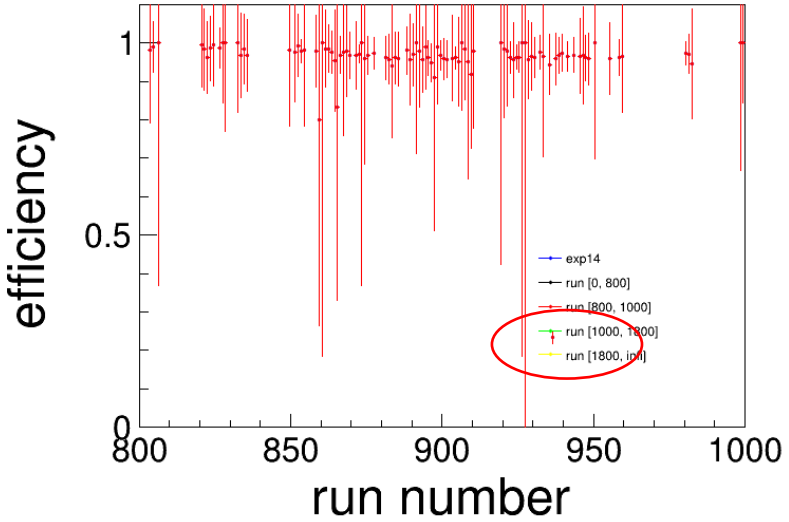
- Trigger efficiency as function of variables are measured using $e^+e^- \to \mu^+\mu^-\gamma$ events

- All efficiency results are expected or with issues addressed.

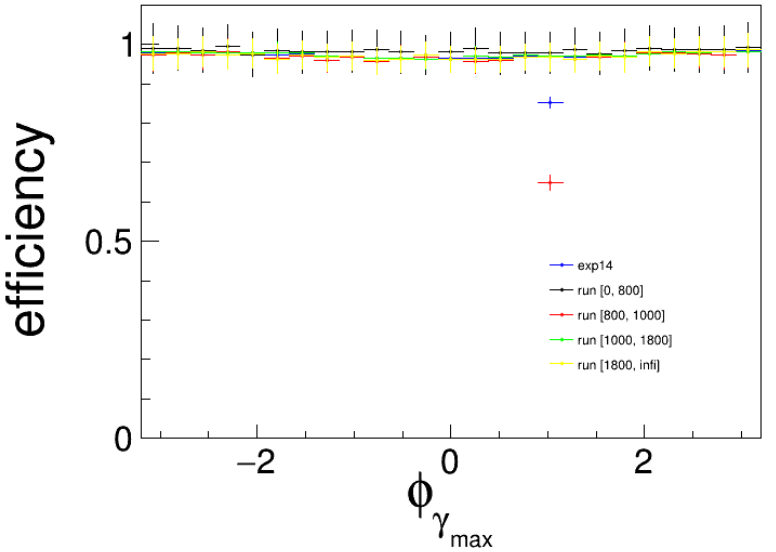
- In to-do list:
  - More trigger bits
  - Run TSIM samples
  - Calculate scale factors

Preliminary result (hie)



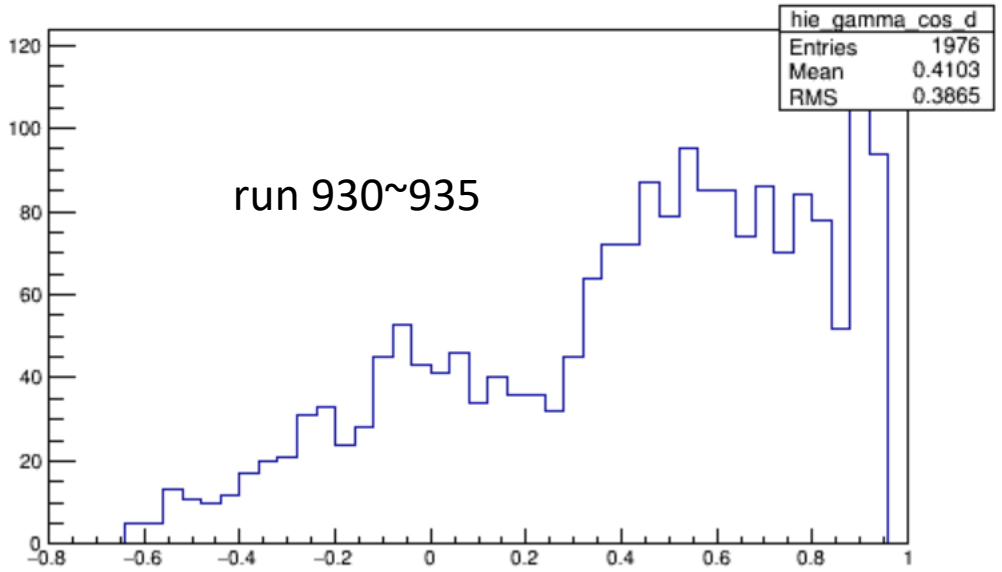


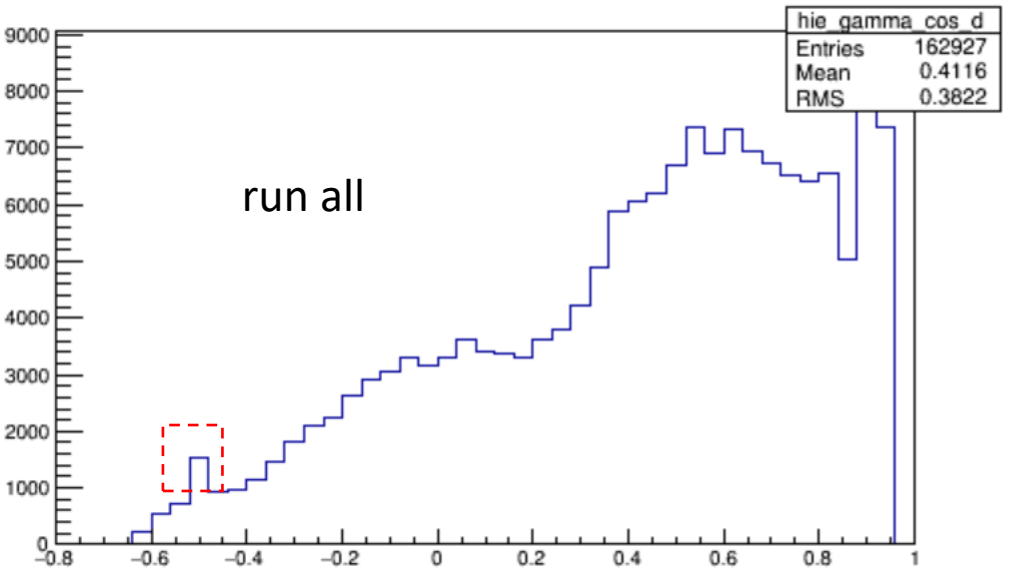
Run 936 gives low efficiency.



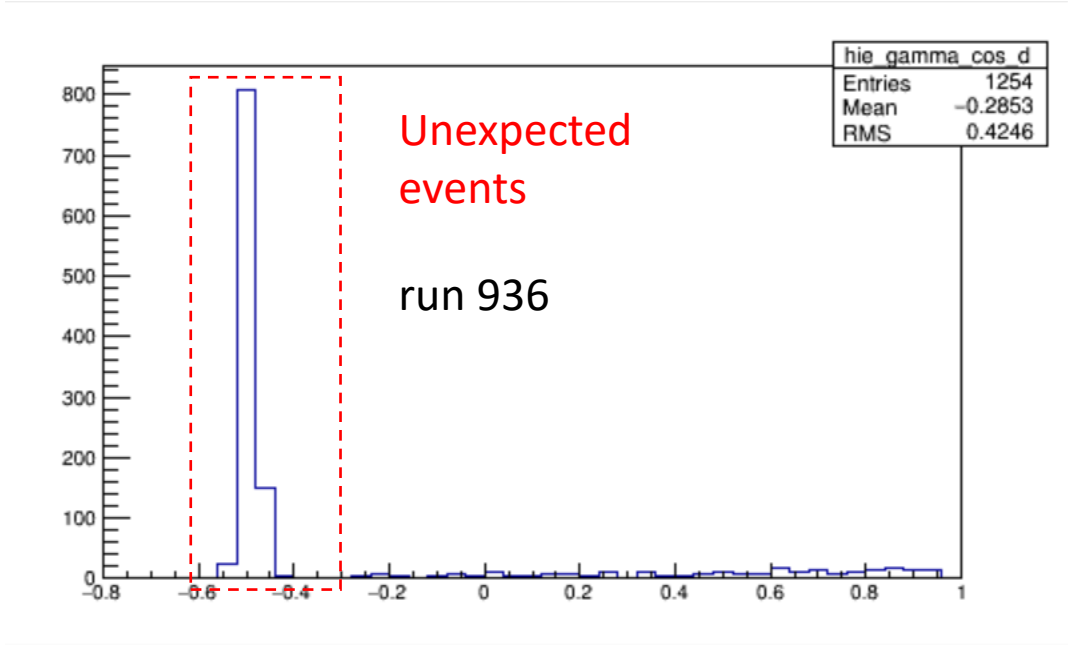
Why only one run can contribute so obviously

Preliminary result (hie)





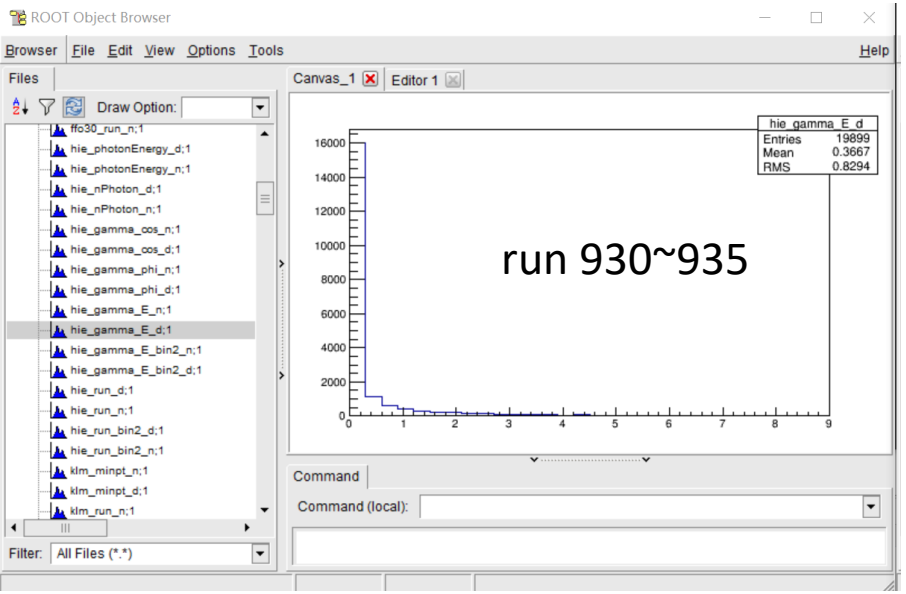
Gamma theta denominator distribution

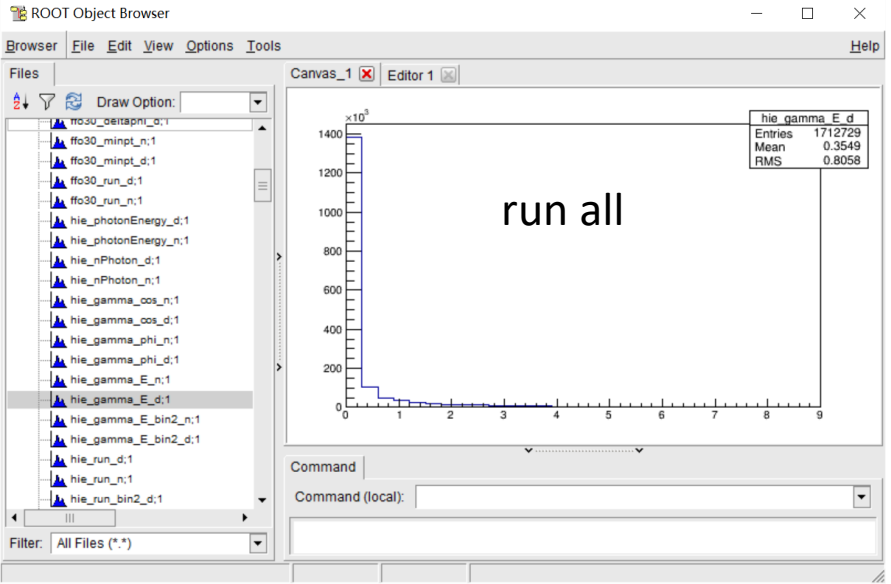


Cuts to fill denominator:

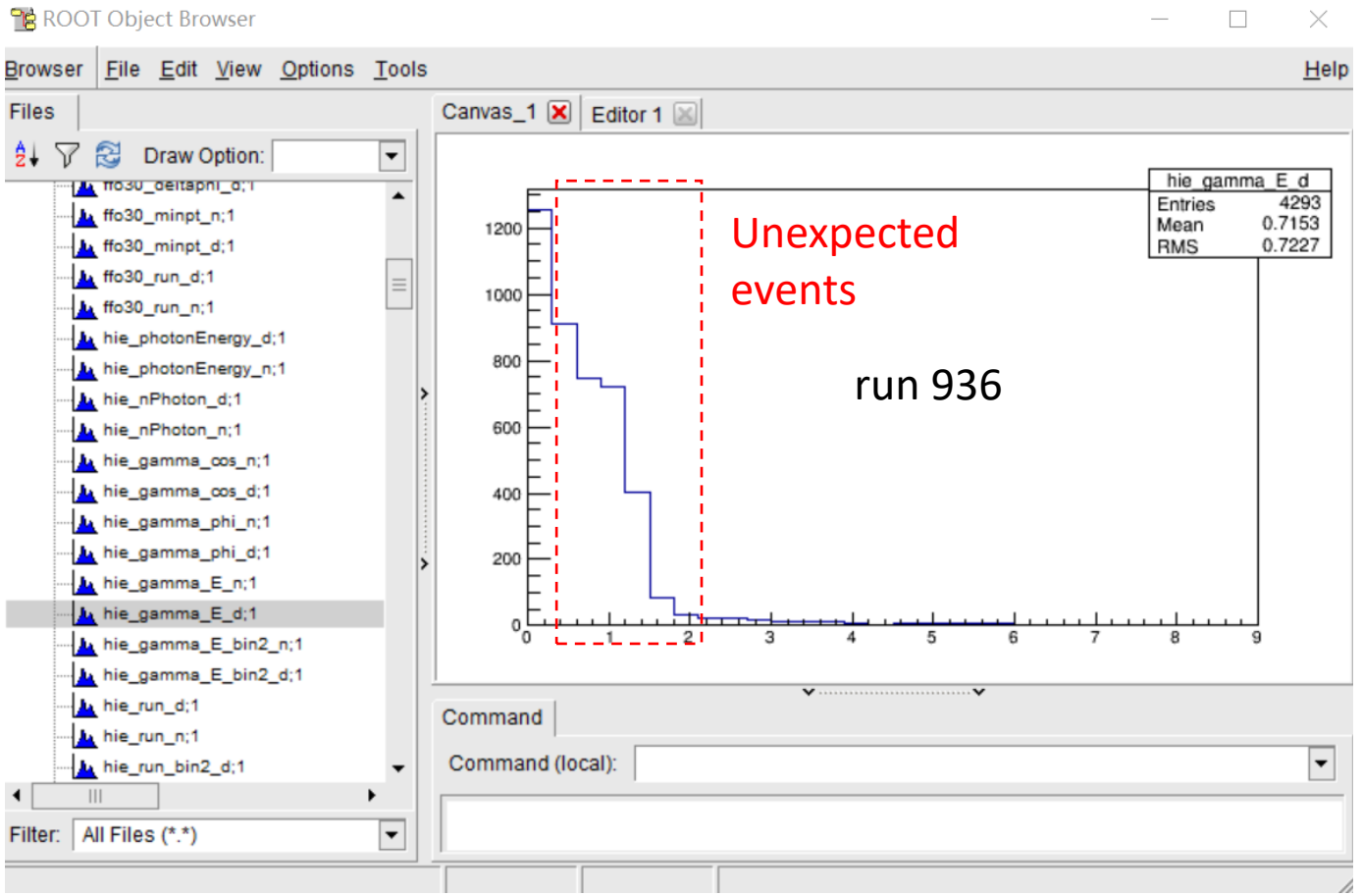
- Pass mu_b2b
- Gamma energy > 1 GeV (check in next slide)
- gam_cosTheta in [-0.6293, 0.9455]

Preliminary result (hie)





Gamma energy denominator distribution



In run 936, there are more events with high energy gamma (E > 1 GeV), which contribute to low efficiency in cos(θ), phi [-0.5, 1.5] region.