

## Level2 muon trigger for Run4 *fast* analysis

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## outline

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- introduction
- implementation and cuts
- performances on real data
- efficiency

## Principle

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have a rare events trigger (here  $J/\psi$  production) running

- on top of minimum bias trigger (BBC)
- at latest stage in the DAQ chain  
to have access to all detector raw data (here muid and mutr)

## Requirements

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- **fast** (less than 30ms/event) to run online;
- **selective**, as all trigger do, especially for rare events;
- **efficient**, not to lose signal;
- work **stable** in the DAQ; compile under Windows.

## Initial plans for RUN4

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- validate and re-use the RUN2 muid level2 trigger;
- use an additional mutr trigger on top of muid trigger;
- use level2 triggers online to tag events;
- downscale the minimum bias trigger to ensure highest lifetime on level2 triggers.

## Present situation

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- level2 triggers have not been used online;
- RUN2 muid trigger is used offline for a fast muon analysis, to get *fast* preliminary results  
validate/anticipate the minimum bias analysis;
- RUN4 additional mutr trigger is not used.

# Implementation and cuts [I]: Muid level2 trigger

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## Muid trigger basic tracking

- using OR of tubes in gaps to make *symsets* (groups of tubes);
- using AND of different gaps (same panel, same orientation) with rough target pointing;
- combine horizontal and vertical roads and fit (straight line).

## Muid trigger event selection

- keep roads with slope  $\geq 12^\circ$ ;
- keep events with (at least) two roads with opening angle  $\geq 19.2^\circ$ ;
- keep events for which road candidates pass depth selection:

shallow shallow	both road depth $\geq 2$
deep shallow	one road $\geq 4$ the other $\geq 2$
deep deep	both road depth $\geq 4$

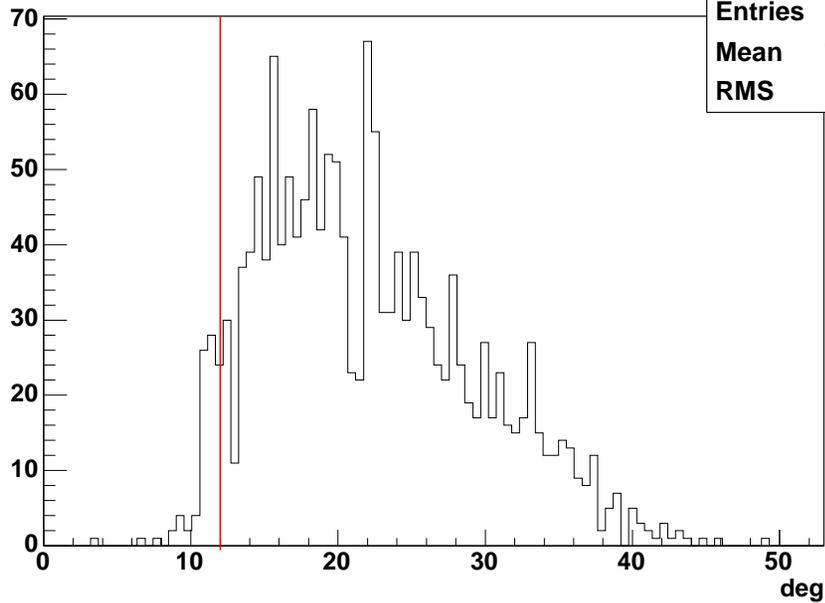
Note: depth counting starts from 0, i.e. first gap = depth 0

- additional cut on #hits/road depending on depth: for deep roads  $N_{\text{hits}} \geq 8$

# Muid level2 road slopes and open angle on MC

single road slope

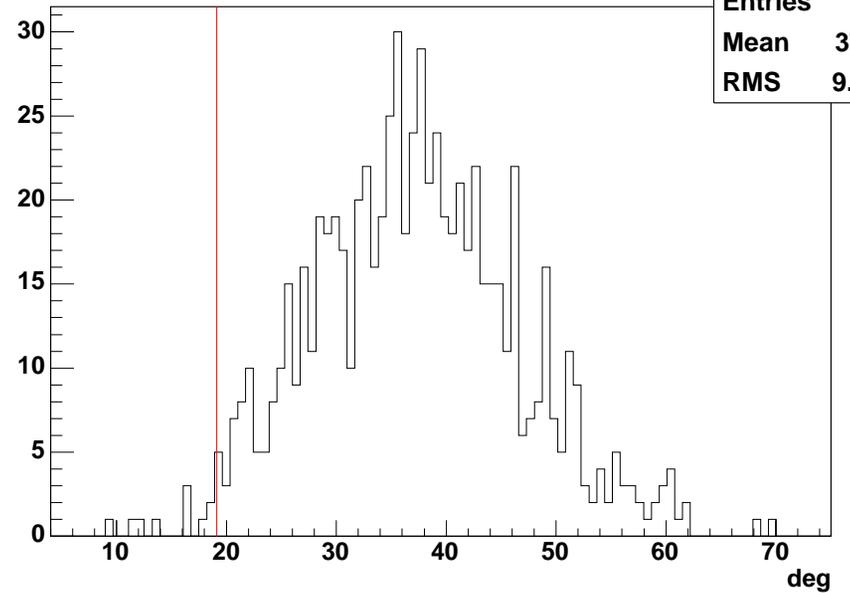
offline road slopes



htemp	
Entries	1595
Mean	22.06
RMS	7.227

road pairs open angle

offline roads open angle (mass>2GeV)



htemp	
Entries	736
Mean	37.21
RMS	9.358

using PYTHIA pure deep deep  $J/\psi$  sample

## Implementation and cuts [II]: Mutr level2 trigger (not used for RUN4)

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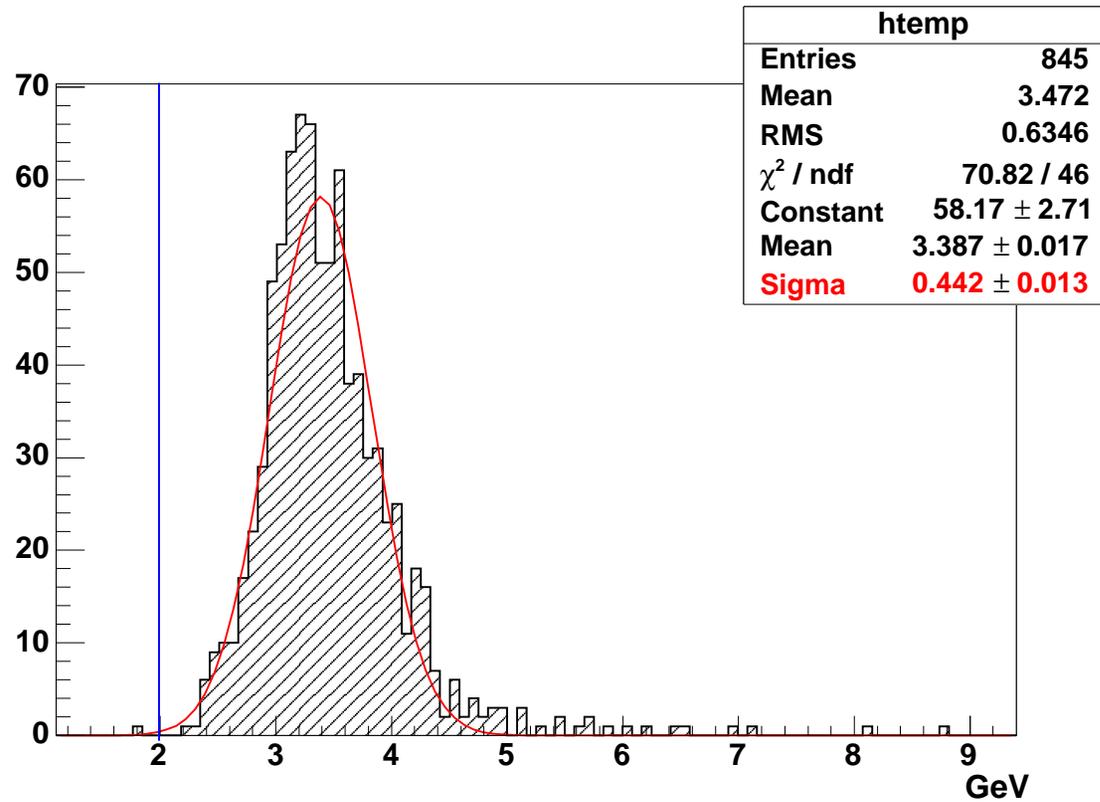
### Mutr trigger basic tracking

- extrapolate road to station 3 in mutr, find best matching *gap coordinate*, if any;
- extrapolate to station 2 in mutr, find best matching *gap coordinate*, if any;
- use parametrized lookup table  $(\theta, \Delta\phi)$  to calculate track momentum.

### Mutr trigger event selection

- select roads matching  $(\theta, \phi)$  cuts at stations 2 then station 3;
- keep events accepted by Muid trigger + calculated mass for dimuon candidates  $\geq 2$  GeV.

## Mutr level2 mass distribution on MC



using PYTHIA pure deep deep  $J/\psi$  sample

- Additional time on top of muid trigger:  $\sim 5\text{ms/event}$ ;
- Additional rejection factor:  $\sim \times 2$  wrt muid trigger;
- but no time to get confidence in trigger efficiency on real data (RD).

# Muid trigger performances: rejection power and timing

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## Level2 muid trigger on Run4 real data sample

depth	north	south
shallow shallow	4	4
deep shallow	9	9
deep deep	40	36

$$\text{rejection power} = \frac{N_{\text{minbias}}}{N_{\text{L2accepted}}}$$

⇒ north+south rejection (deep deep) ~ 20

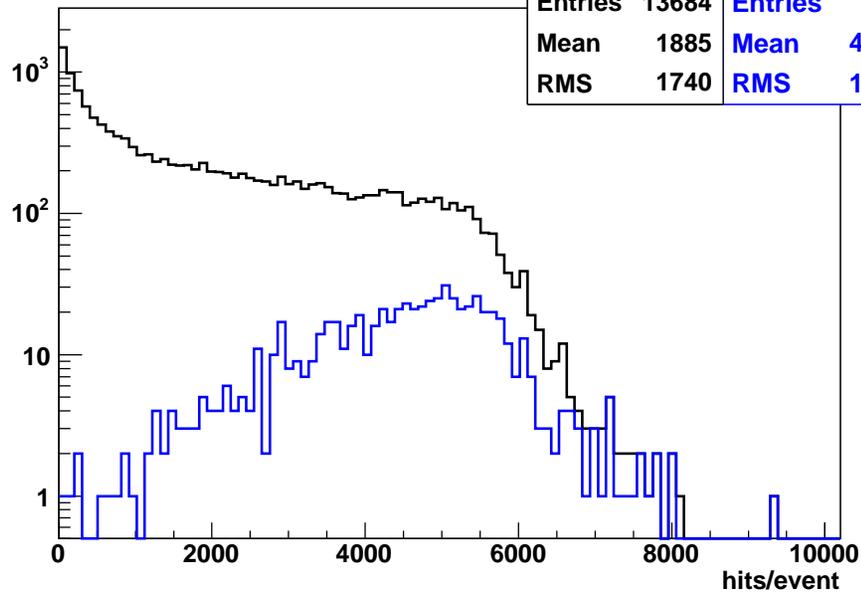
## Level2 and offline timing on Run4 realdata sample

	minimum bias	level2 filtered
Average time/event in lvl2 reco	-	51 ms
Average time/event in offline reco	1.2 s	5.6 s
Total time for one segment	3.6 h	1 h

⇒ filtered reconstruction ~ 3 to 4 times faster (here 3.6)

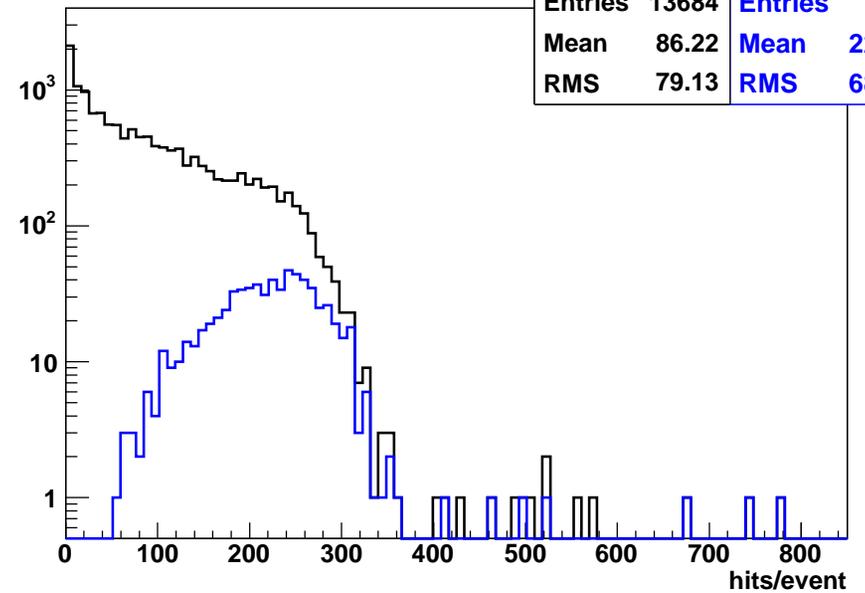
# What level2 does to our data [I]: hit multiplicity

mutr multiplicity/event



	htemp	htemp
Entries	13684	692
Mean	1885	4444
RMS	1740	1365

muid multiplicity/event

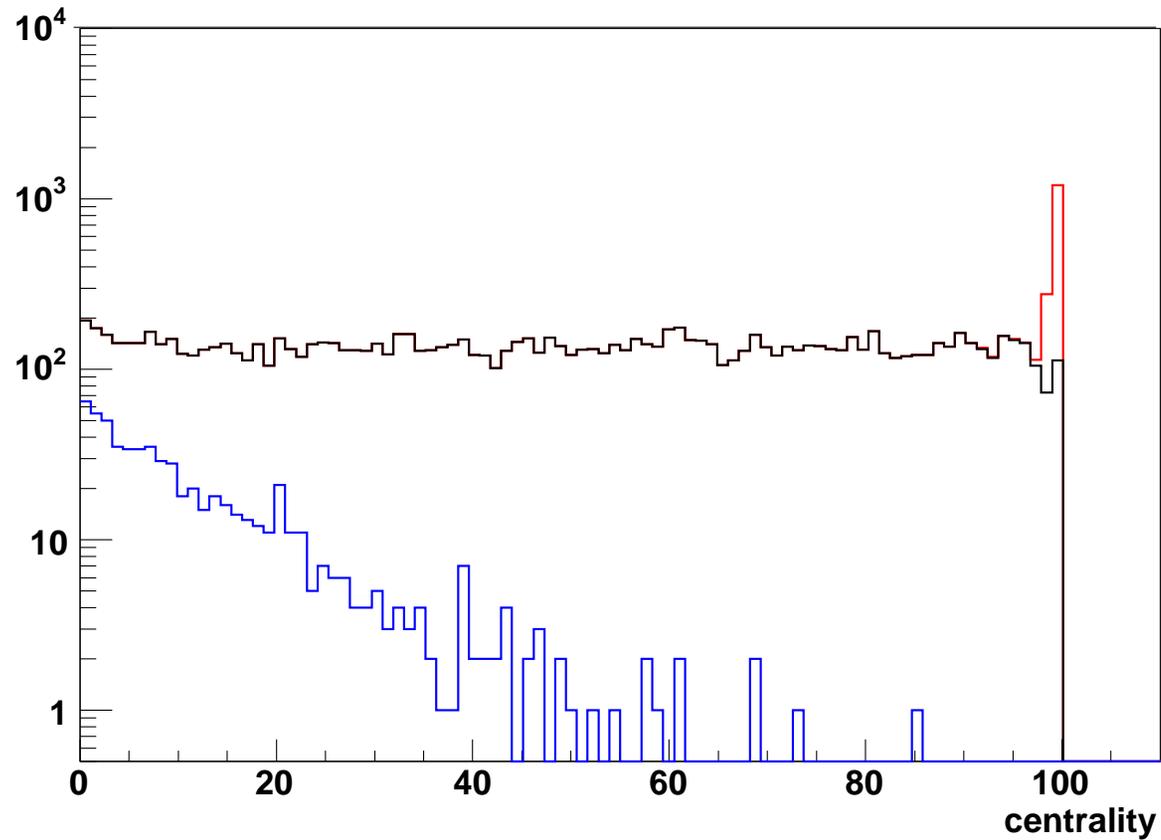


	htemp	htemp
Entries	13684	692
Mean	86.22	221.8
RMS	79.13	68.54

black: minimum bias events  
blue: level2 filtered events

## What level2 does to our data [II]: *recalibrated* BBC centrality

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- all events
- offline filtered events
- level2 filtered events

(*recalibrated* from BBC charge distribution @200GeV)

## Trigger efficiency study

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- analysis chain
- efficiency for embedded deep deep  $J/\psi$  wrt muid efficiency
- efficiency for realistic road depth distribution and *real* muid efficiency
- MC validation using real data

# Level2 efficiency analysis chain [I]

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## principle

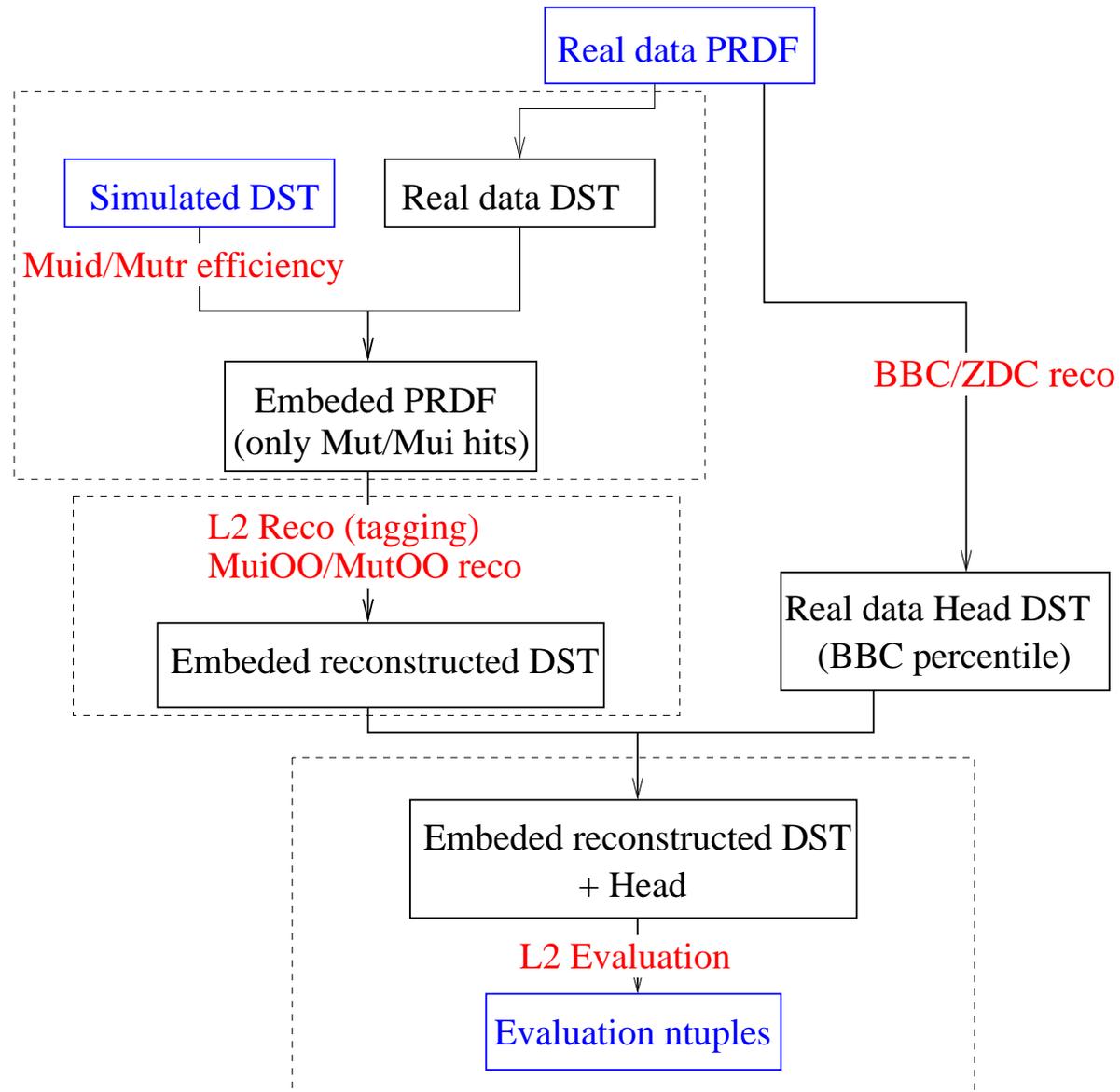
- embed
  - MC  $J/\psi$  signal with realistic muid/mutr efficiencies
  - minimum bias RUN4 real data
- run level2 (for tagging) and offline (MuTOO, MuiOO) reconstruction
- build evaluation ntuples for
  - absolute level2 efficiency
  - level2 efficiency wrt offline

## problems/technical issues

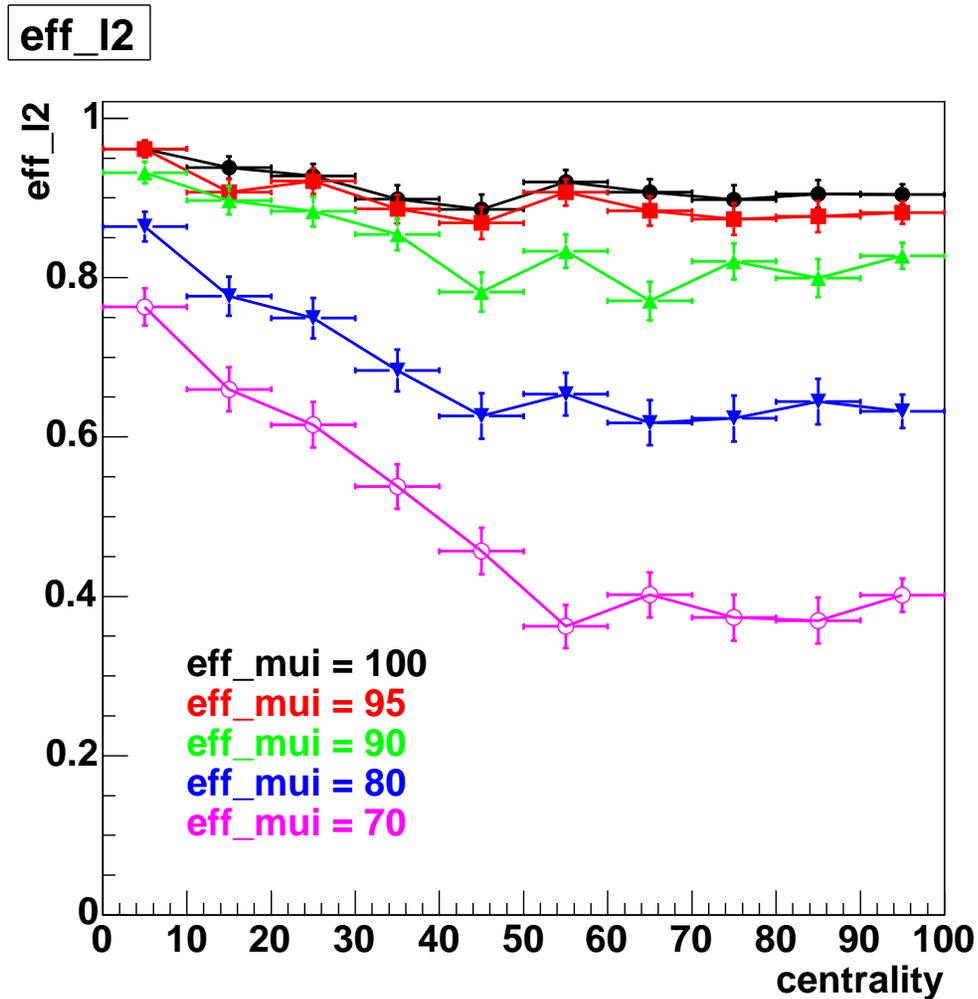
- level2 framework runs only on PRDF
- PRDF embedding cannot be done directly in new framework (need DST stage)
- PRDF generation/merging in new framework erase global detectors (BBC), needed for centrality

## level2 efficiency analysis chain [II]

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# Level2 efficiency vs muid efficiency



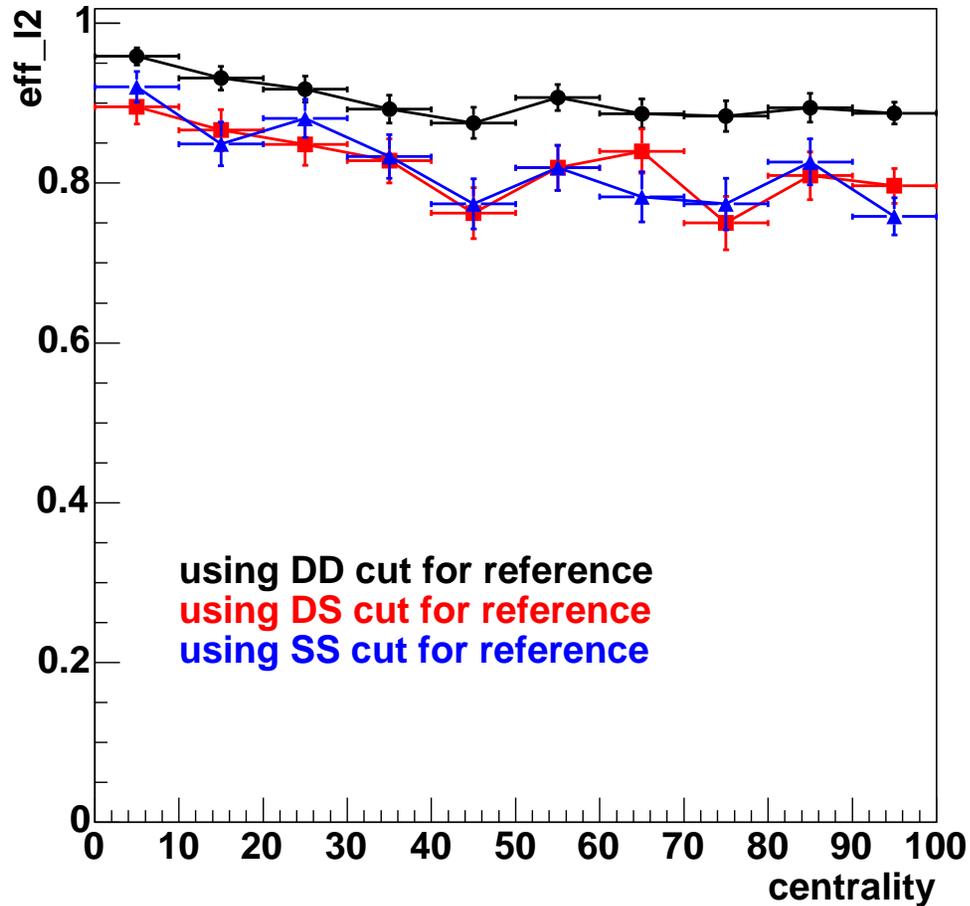
average efficiency:

muid (%)	level2 (%)	
	pure MC	embedded
100	90	92
95	87	90
90	81	84
80	59	69
70	35	49

using deep deep MC  $J/\psi$  embedded in RUN4 real data

# Level2 efficiency for realistic RUN4 muid efficiency (run 109656)

eff\_l2



## muid efficiency/gap:

gap	0	1	2	3	4
south arm	97.5	96.5	96.6	97.1	96.5
north arm	97.5	95.9	95.9	97.2	96.0

average = 96.7 %

## average level2 efficiency:

depth cut on MC	level2 (%)
deep deep	90.3
deep shallow	82.0
shallow shallow	81.8

using PYTHIA  $J/\psi$  embedded in RUN4 real data

# Level2 efficiency vs offline reconstruction

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## principle:

- run both level2 and offline reconstruction on all events
- put strict selection on offline to define *offline accepted events*
- get the fraction of such events accepted by level2

## advantage:

- can run both on MC and RD;
- if cuts on offline are strict enough, should give the same result;
- validates MC/embedded studies for *absolute* efficiency.

## results:

works well on RUN3 golden events

on RUN4 raw data:

- efficiency level2 vs offline on embedded MC  $\sim 95\%$ ;
- on RD (same *strict* cuts)  $75$  to  $80\%$ ;

low statistic on RD due to strict cuts remaining ghosts from offline
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## Conclusion

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- overall level2 efficiency for RUN4 Au-Au@200GeV:
  - ~ 90 % for embedded deep deep  $J/\psi$
  - ~ 82 % for embedded PYTHIA  $J/\psi$
- efficiency increase for central events (random benefit)

### Todo (for RUN4 analysis):

- understand/fix discrepancy on level2 efficiency vs offline
- include mutr efficiency and run full chain to get combined level2/offline absolute efficiency
- validate

### Todo (for future runs):

- convince people that the mutr level2 trigger is working