



# HLT performance: plans for 2017 commissioning

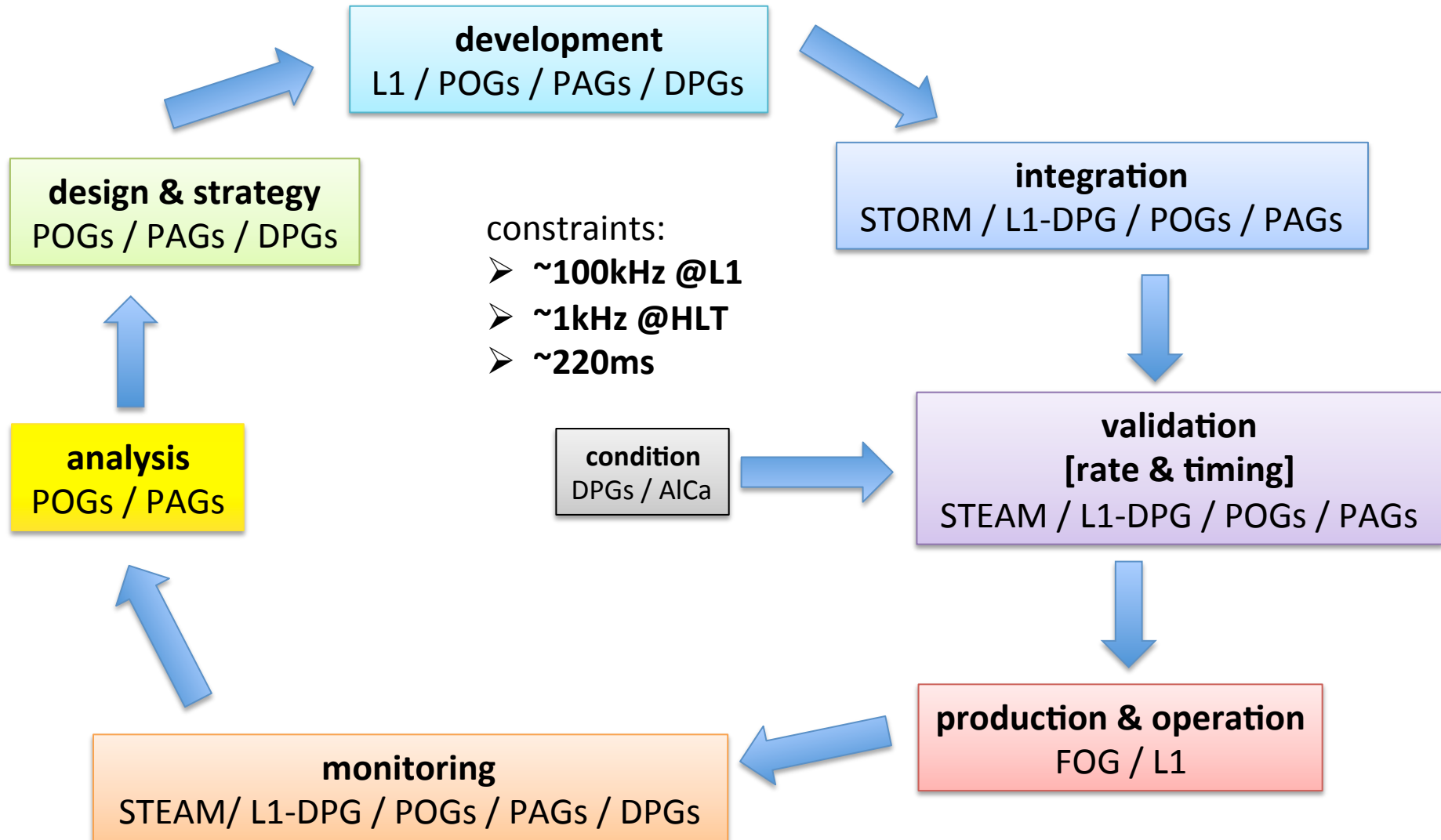
mia tosi  
on behalf of TSG (STEAM) group

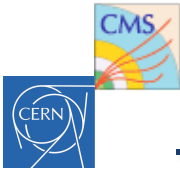
-- CMS Run & DPG Workshop --

Torino, Jan 24<sup>th</sup>-26<sup>th</sup>, 2017



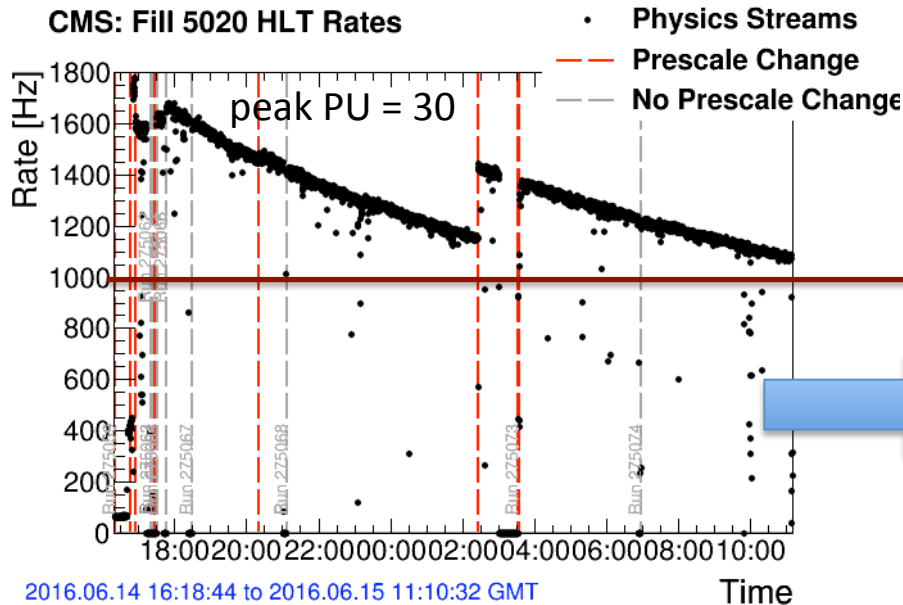
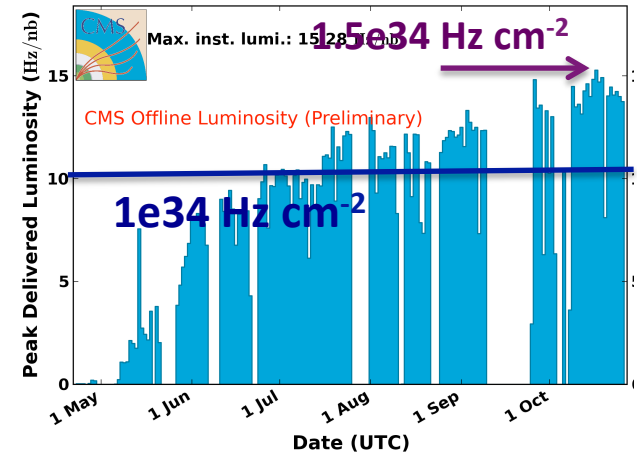
# trigger



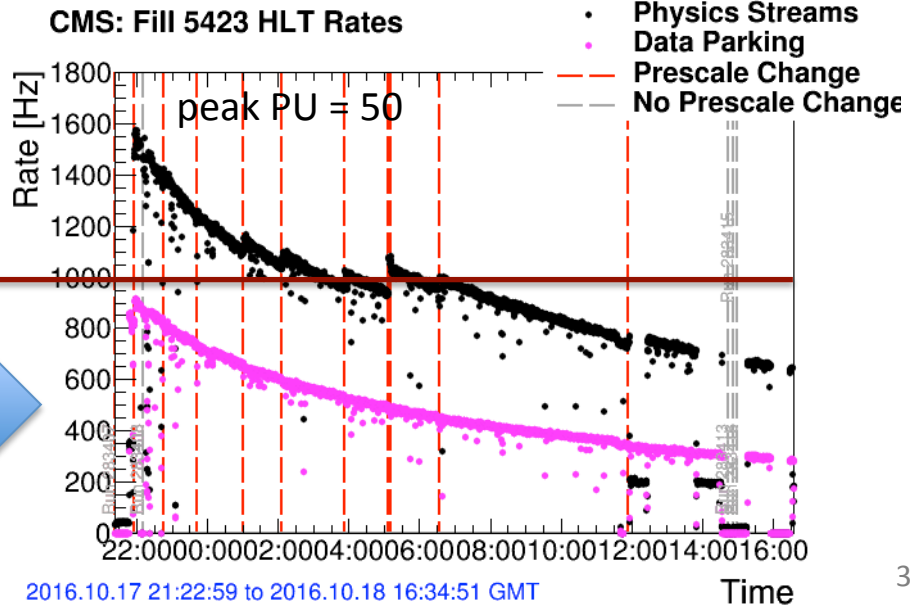


# HLT trigger in 2016

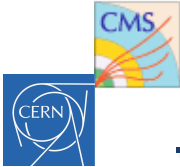
- very high luminosity
  - highest peak lumi:  $1.5e34 \text{ Hz cm}^{-2} \rightarrow \text{PU} \sim 50$  !
- very high LHC duty cycle
  - from 2015 menus, already quite ready for lumi upto  $1e34 \text{ Hz cm}^{-2}$
  - new menu for lumi  $>1e34 \text{ Hz cm}^{-2}$  after ICHEP**
    - wrote on average  $> \sim 1.3 \text{ kHz}$  of Physics stream at Tier-0 !!
    - in order to decrease the  $\langle \text{rate} \rangle \rightarrow$  HLT menu tuning
      - prescales adjustment
      - algorithms improvement [ add dz cut in double muon triggers ]
    - fit the limit ;) on average  $\sim 1000 \text{ Hz}$  of Physics stream and  $\sim 600 \text{ Hz}$  of Parked Physics
- lots of small updates/bugs spotted and fixed needed in order to accommodate the L1 upgrade
- unexpected strip dynamic inefficiency



2016.06.14 16:18:44 to 2016.06.15 11:10:32 GMT  
June 2016

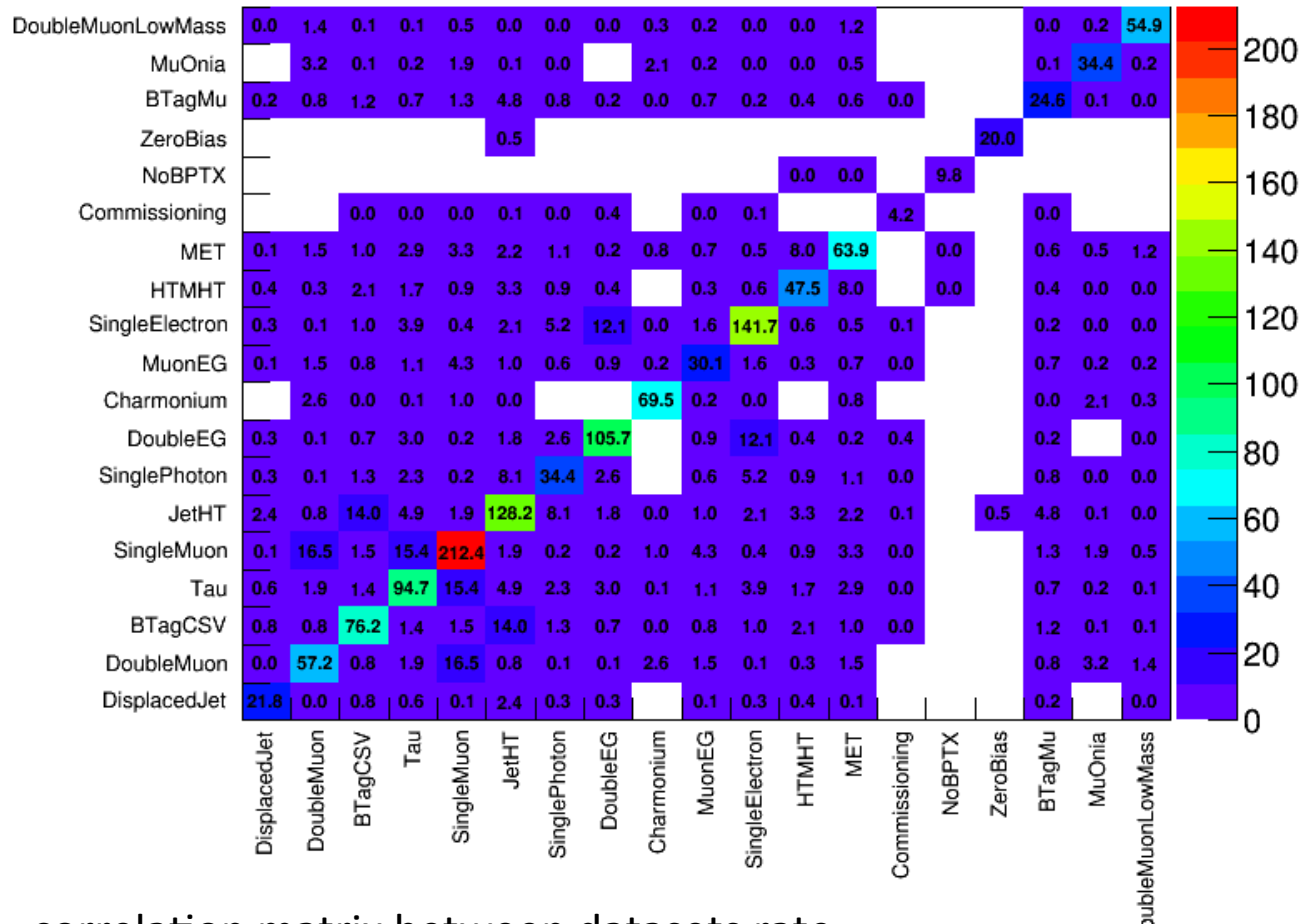


2016.10.17 21:22:59 to 2016.10.18 16:34:51 GMT  
October 2016



# rate : overlap between PDs

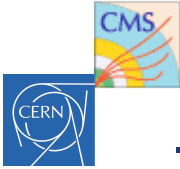
HLT menu v4.2  
 PS column 1.35e34  
 PU~42



correlation matrix between datasets rate shows that **dataset definition is rather optimal in terms of overlaps**

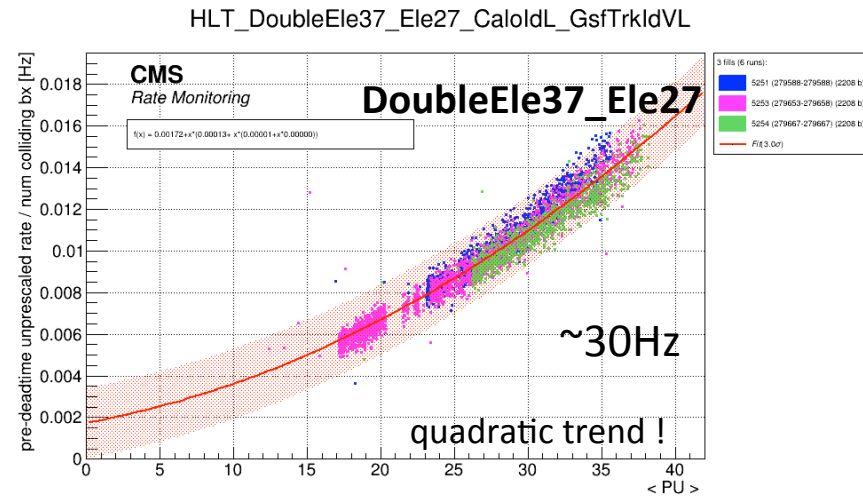
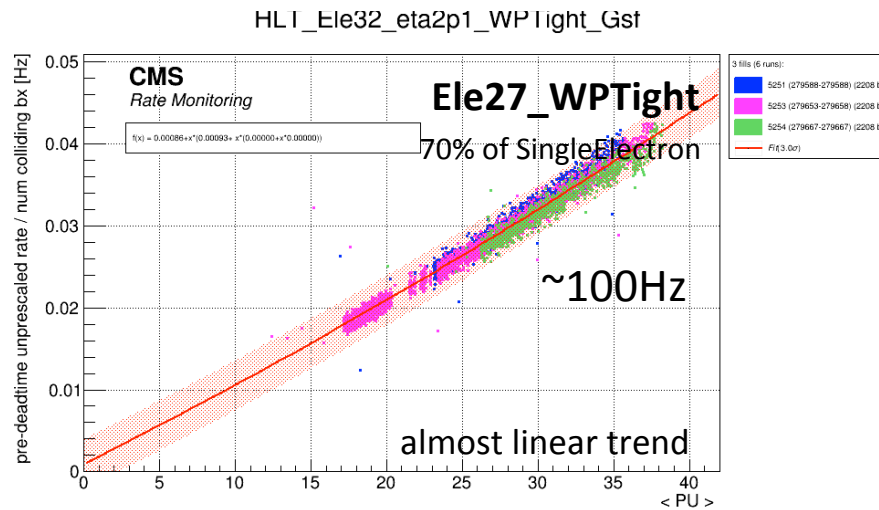
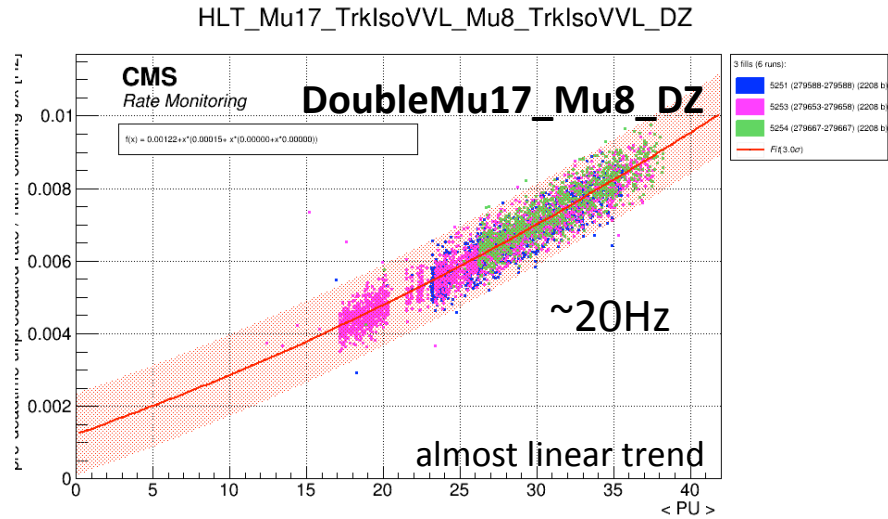
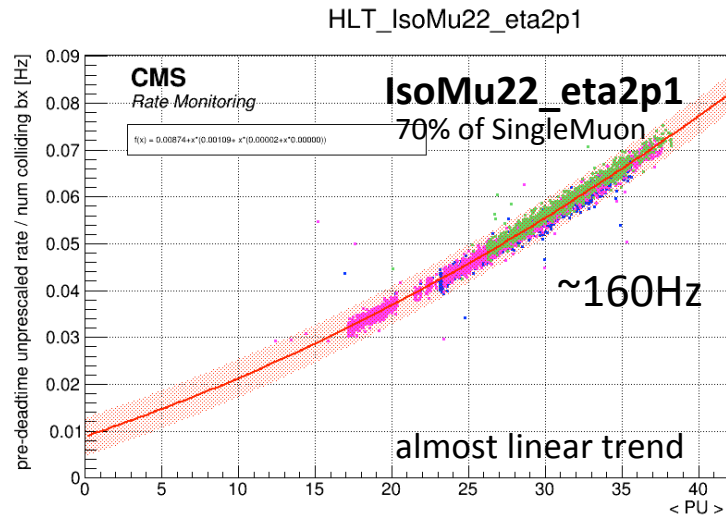
some considerable rate overlaps for pairs:

{SingleMuon ; DoubleMuon}, {JetHT ; BTagCSV}, {SingleMuon, Tau}

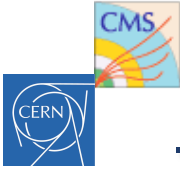


# rate : PU dependence

Rates evolution with PU for some highest consumers:

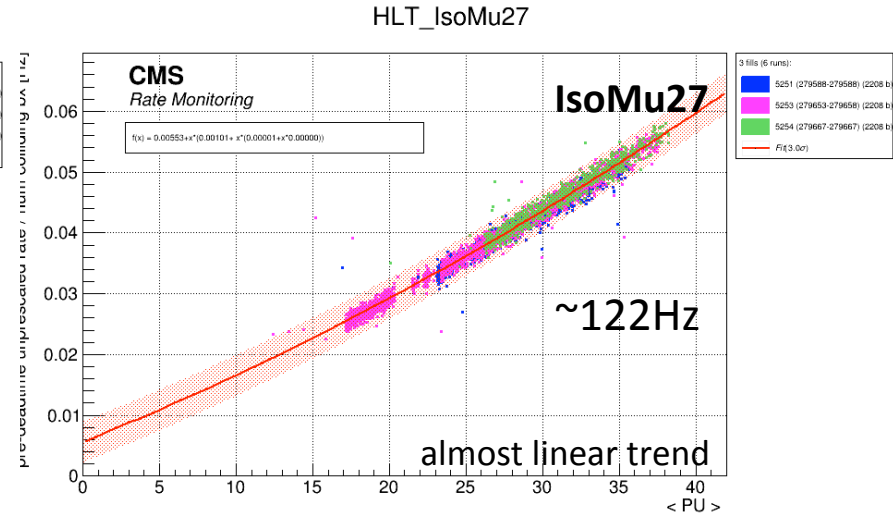
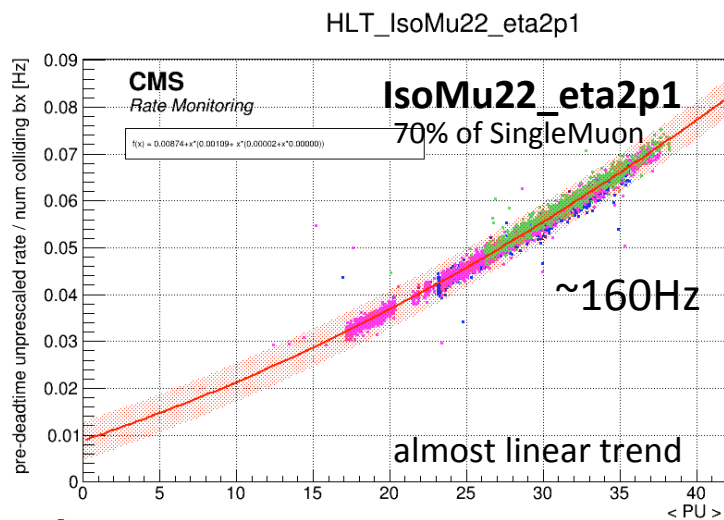


in 2017, add dz cut to DoubleElectron ...



# rate : PU dependence

Rates evolution with PU for some highest consumers:

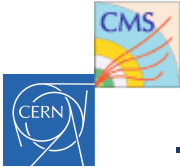


→ extrapolate rates to 2017 expected running conditions: 1.6e34 – 2.0e34 @ PU ~ (46 – 58)

|                | rate [Hz] |        |        |        |        |
|----------------|-----------|--------|--------|--------|--------|
|                | 1.2e34    | 1.4e34 | 1.6e34 | 1.8e34 | 2.0e34 |
| IsoMu22_eta2p1 | 160       | 190    | 220    | 250    | 280    |
| IsoMu24        | 150       | 180    | 200    | 230    | 260    |

|                | threshold [GeV] |        |        |        |        |
|----------------|-----------------|--------|--------|--------|--------|
|                | 1.2e34          | 1.4e34 | 1.6e34 | 1.8e34 | 2.0e34 |
| IsoMuXX_eta2p1 | 22              | 22     | 26     | 28     | 30     |
| IsoMuXX        | 24              | 27     | 28     | 30     | 32     |

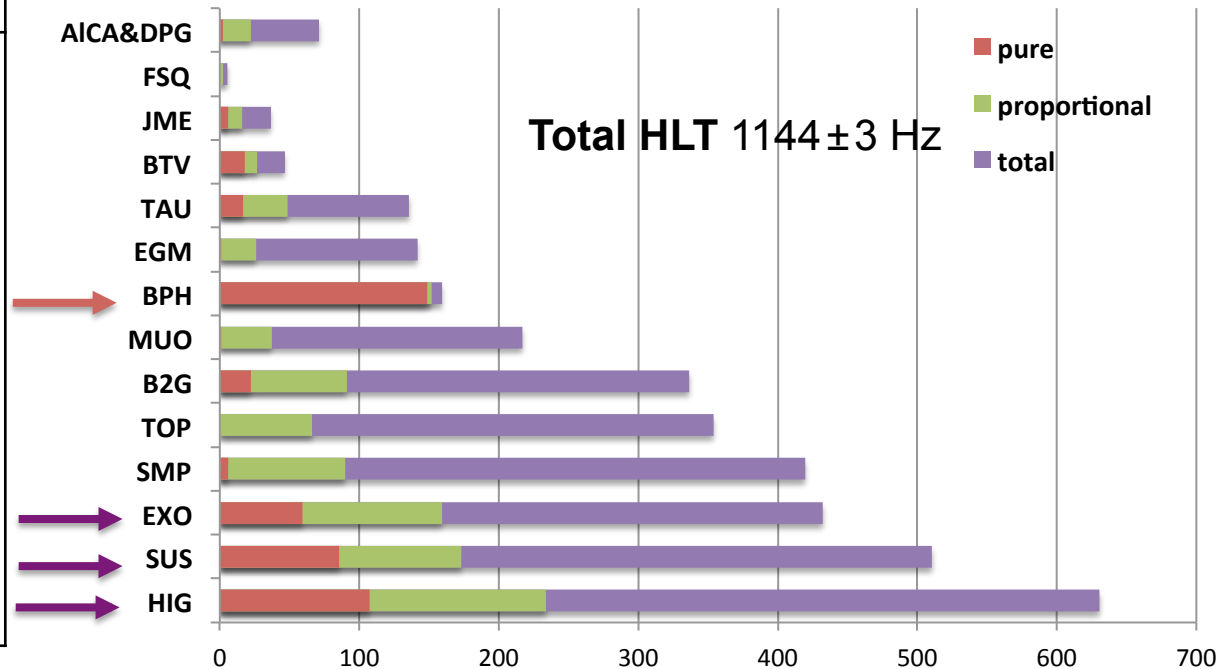




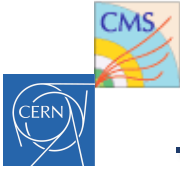
# HLT trigger in 2016: rate

HLT menu v4.2  
 PS column 1.35e34  
 PU~42

| Group       | Rate [Hz] |         |         |
|-------------|-----------|---------|---------|
|             | Total     | Prop.   | Pure    |
| HIG         | 630 ± 2   | 234 ± 1 | 107 ± 1 |
| SUS         | 510 ± 1   | 173 ± 1 | 86 ± 1  |
| EXO         | 432 ± 1   | 159 ± 1 | 59 ± 1  |
| SMP         | 420 ± 1   | 90 ± 1  | 6 ± 1   |
| TOP         | 354 ± 1   | 66 ± 1  | 0 ± 1   |
| B2G         | 336 ± 1   | 91 ± 1  | 22 ± 1  |
| MUO         | 216 ± 1   | 37 ± 1  | 1 ± 1   |
| BPH         | 159 ± 1   | 152 ± 1 | 149 ± 1 |
| EGM         | 141 ± 1   | 26 ± 1  | 1 ± 1   |
| TAU         | 136 ± 1   | 49 ± 1  | 17 ± 1  |
| BTV         | 47 ± 1    | 27 ± 1  | 18 ± 1  |
| JME         | 36 ± 1    | 16 ± 1  | 6 ± 1   |
| FSQ         | 6 ± 1     | 2 ± 1   | 0 ± 1   |
| AICa & DPGs | 71 ± 1    | 22 ± 1  | 2 ± 1   |



- **Total rate per group** := sum of the triggers rate used by group
  - the biggest consumers are the **HIG, SUS** and **EXO** PAGs (~ 50% of the total rate)
- **Proportional rate per group** := rate from single-group triggers → rate takes into account co-ownership
  - **HIG** is again the main consumer (~30%)
  - the top 5 is very similar to that of total rates, except for **BPH** (very particular phase space)
  - **AICa& DPG** have ~20%
- **Pure rate per group** := rate from single-group triggers
  - **BPH** group is here the biggest consumer due to phase-space (~95% of its total rate)
  - **HIG, SUS** and **EXO** are again among the biggest consumers (~16% of their total rate)
  - **TOP** group has no pure rate

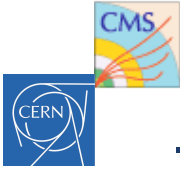


# HLT trigger for DPG/ALCa in 2016

- **Thiago** and **Tongguang** are the TSG/ALCa contacts
- each **DPG/project** has (or should have) a **TSG contact**

| project |  |
|---------|--|
| L1      | L1 DPG (pier and alex)   |
| tracker | mia ( <i>ad interim</i> )  |
| ECAL    | chiara   |
| HCAL    | anonios  |
| muon    | MUO ( <i>ad interim</i> ?)<br>Rosamaria (DT/CSC)<br>Roumyana (RPC) |



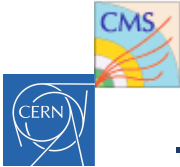


# HLT trigger for DPG/ALCa in 2016

- **Thiago** and **Tongguang** are the TSG/ALCa contacts
- each **DPG/project** has (or should have) a **TSG contact**
- mainly 4 use cases
  - offline analysis [for instance, strip and pixel time calibration]
  - offline DQM [for instance, tracking monitoring]
  - **ALCaRecos**

| Primary Dataset     | ALCaRecos to be run   |
|---------------------|---|
| ALCaLumiPixels      | LumiPixels  |
| Commissioning       | TkAlMinBias, SiStripCalMinBias, HcalCallsoTrk, HcalCallsolatedBunchSelector   |
| Charmonium          | TkAlJpsiMuMu  |
| DoubleEG            | EcalCalZElectron, EcalUncalZElectron, HcalCalIterativePhiSym, HcalCallsoTrkFilter   |
| DoubleMuon          | TkAlZMuMu, MuAlCallsolatedMu, MuAlOverlaps, MuAlZMuMu, DtCalib  |
| HcalNZS             | HcalCalMinBias  |
| HLTPysics           | TkAlMinBias, HcalCallsoTrkFilter  |
| JetHT               | HcalCalDijets, HcalCallsoTrkFilter, HcalCallsolatedBunchFilter  |
| MET                 | HcalCalNoise  |
| MuOnia              | TkAlUpsilonMuMu   |
| MinimumBias         | SiStripCalZeroBias, SiStripCalMinBias, TkAlMinBias  |
| NoBPTX              | TkAlCosmicsInCollisions   |
| SingleElectron      | EcalCalWElectron, EcalUncalWElectron, EcalCalZElectron, EcalUncalZElectron, HcalCalIterativePhiSym, EcalESAlign, HcalCallsoTrkFilter      |
| SingleMuon          | TkAlMuonIsolated, HcalCalIterativePhiSym, DtCalib, MuAlCallsolatedMu, MuAlOverlaps, MuAlZMuMu, HcalCalHO                                  |
| SinglePhoton        | HcalCalGammaJet   |
| ExpressPhysics      | SiStripPCLHistos, SiStripCalZeroBias, SiStripCalMinBias, SiStripCalMinBiasAfterAbortGap, TkAlMinBias, DtCalib, Hotline, LumiPixelsMinBias |
| TestEnablesEcalHcal | HcalCalPedestal   |
| ZeroBias            | SiStripCalZeroBias, TkAlMinBias, LumiPixelsMinBias  |
| ExpressCosmics      | SiStripPCLHistos, SiStripCalZeroBias, TkAlCosmics0T   |
| Cosmics             | TkAlCosmics0T, MuAlGlobalCosmics, HcalCalHOCosmics, DtCalibCosmics  |

| Primary Dataset | ALCaPrompt to be produced   |
|-----------------|---|
| ExpressPhysics  | PromptCalibProd, PromptCalibProdSiStrip, PromptCalibProdSiPixelAli, PromptCalibProdSiStripGains, PromptCalibProdSiStripGainsAfterAbortGap |



# HLT trigger for DPG/AICa in 2016

- **Thiago** and **Tongguang** are the TSG/AICa contacts
- each **DPG/project** has (or should have) a **TSG contact**

- mainly 4 use cases
  - offline analysis [for instance, strip and pixel tim
  - offline DQM [for instance, tracking monitoring]
  - **AICaRecos**

## ExpressPhysics

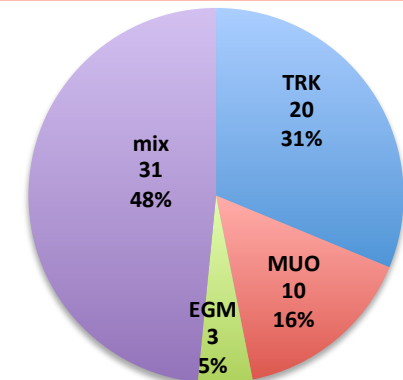
| Path  | Rate  | Requester           |
|---|-------|---------------------|
| HLT_ZeroBias                                  | 20 Hz | Beamspot, BRIL, ... |
| HLT_Random                                    | 5 Hz  | TRK                 |
| HLT_Physics                                   | 5 Hz  | TRK                 |
| HLT_IsoMu20(24)                               | 5 Hz  | MUO                 |
| HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_DZ           | 5 Hz  | MUO                 |
| HLT_Ele17(23)_Ele12_CaloldL_TrackIdL_IsoVL_DZ | 3 Hz  | EGM                 |
| HLT_ZeroBias_FirstCollisionAfterAbortGap      | 10 Hz | TRK                 |
| HLT_ZeroBias_IsolatedBunches                  | 10 Hz | TRK, ECAL           |
| "Spectacular events"                          | 1 Hz  | ---                 |

• Total: 54 Hz (64 Hz if we have the isolated bunch).

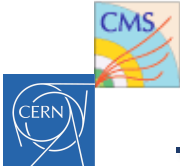
| Primary Dataset     | AICaRecos to be run   |
|---------------------|---|
| AICaLumiPixels      | LumiPixels  |
| Commissioning       | TkAlMinBias, SiStripCalMinBias, HcalCalIsoTrk, HcalCalIsolatedBunchSelector   |
| Charmonium          | TkAlJpsiMuMu  |
| DoubleEG            | EcalCalZElectron, EcalUncalZElectron, HcalCalIterativePhiSym, HcalCalIsoTrkFilter   |
| DoubleMuon          | TkAlZMuMu, MuAlCalIsolatedMu, MuAlOverlaps, MuAlZMuMu, DtCalib  |
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| MET                 | HcalCalNoise  |
| MuOnia              | TkAlUpsilonMuMu   |
| MinimumBias         | SiStripCalZeroBias, SiStripCalMinBias, TkAlMinBias  |
| NoBPTX              | TkAlCosmicsInCollisions   |
| SingleElectron      | EcalCalWElectron, EcalUncalWElectron, EcalCalZElectron, EcalUncalZElectron, HcalCalIsoTrkFilter   |
| SingleMuon          | TkAlMuonIsolated, HcalCalIterativePhiSym, DtCalib, MuAlCalIsolatedMu, MuAlOverl   |
| SinglePhoton        | HcalCalGammaJet   |
| ExpressPhysics      | SiStripPCLHistos, SiStripCalZeroBias, SiStripCalMinBias, SiStripCalMinBiasAfterAbortGap, TkAlMinBias, DtCalib, Hotline, LumiPixelsMinBias |
| TestEnablesEcalHcal | HcalCalPedestal   |
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| Cosmics             | TkAlCosmics0T, MuAlGlobalCosmics, HcalCalHOCosmics, DtCalibCosmics  |
| Primary Dataset     | AICaPrompt to be produced   |
| ExpressPhysics      | PromptCalibProd, PromptCalibProdSiStrip, PromptCalibProdSiPixelAli, PromptCalibProdSiStr  |

## Express PD main usage

- feeding the PCL
- data certification
- EXOTICA Hotline

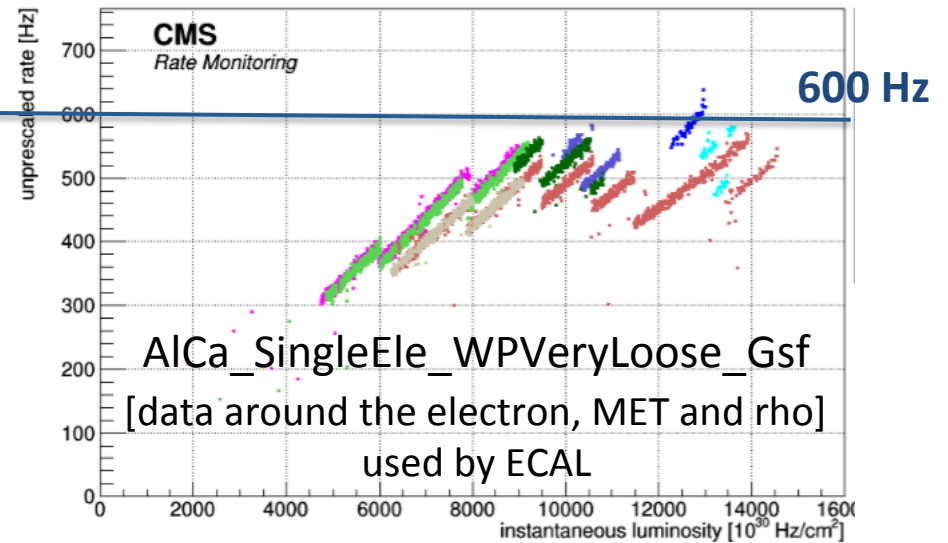
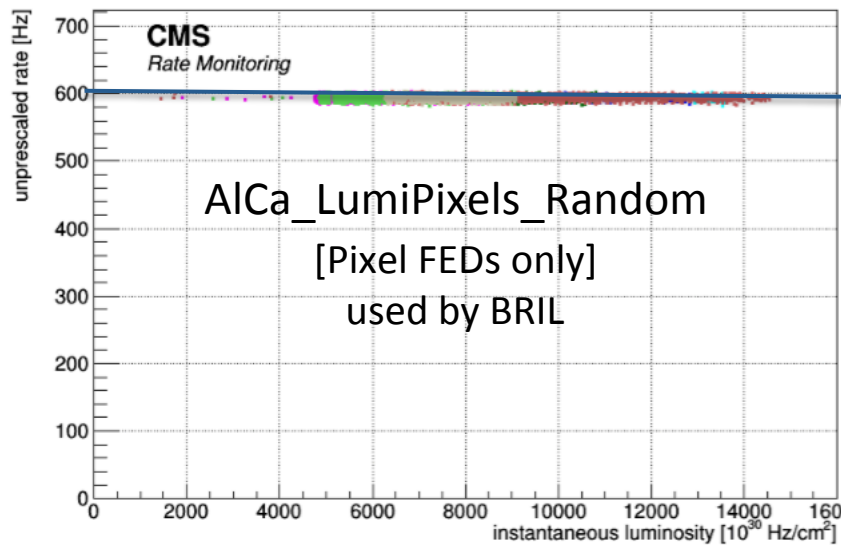


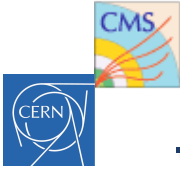
it would be helpful to access to the **LHC filling scheme** w/in CMSSW



# HLT trigger for DPG/AICa in 2016

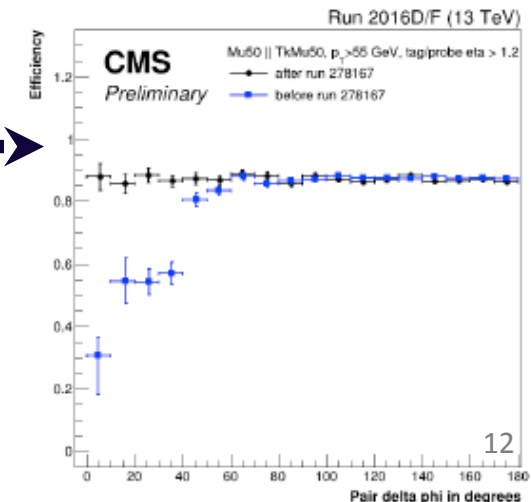
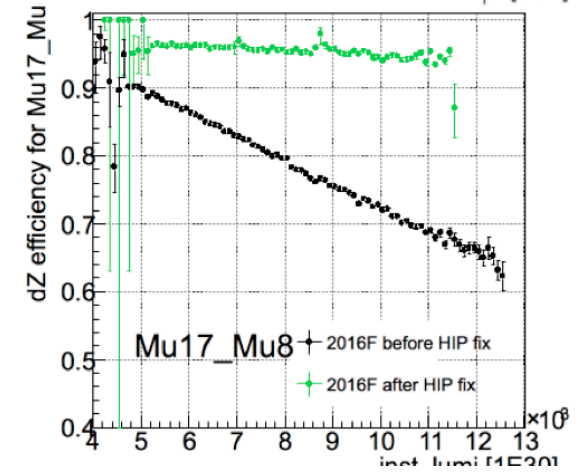
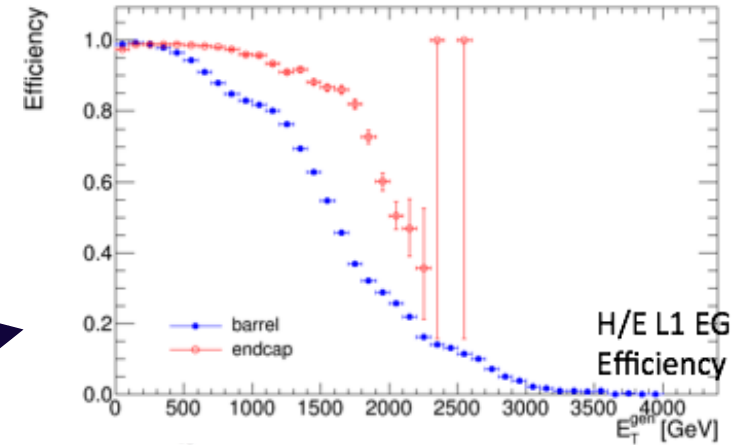
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- each **DPG/project** has (or should have) a **TSG contact**
- mainly 4 use cases
  - offline analysis [for instance strip and pixel time calibration]
  - offline DQM [for instance tracking monitoring]
  - AICaRecos
  - **AICaRAWs** → special streams w/ dedicated event content that can record much higher rates than usual





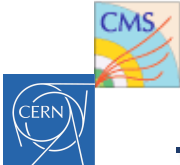
# HLT issues in 2016

- Run2016B - bug in L1-HLT objects matching
- Run2016C - bug in H/E for L1 e/ $\gamma$ 
  - all EG objects had cut  $H/E < 3.125\%$  (6.25%) in the barrel (endcap), w/o taking into account the  $p_T$
- up to Run2016F – strip dynamic inefficiency
  - large effect on lepton dZ and lepton efficiency
  - small effect on paths with btag
- up to 2016F – few bugs in EMTF
  - highest impact bug was a firmware bug assigning the  $p_T$  only to highest-quality track in a  $60^\circ$  sector
  - see also <https://twiki.cern.ch/twiki/bin/view/CMS/EndcapHighPtMuonEfficiencyProblem>

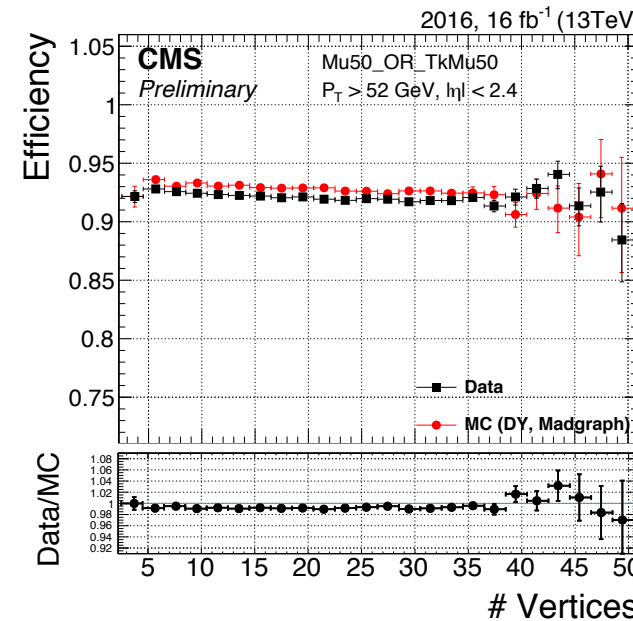
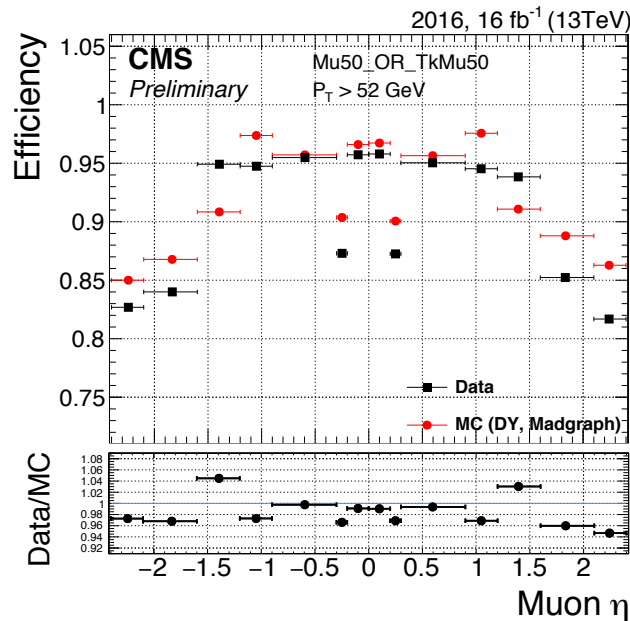
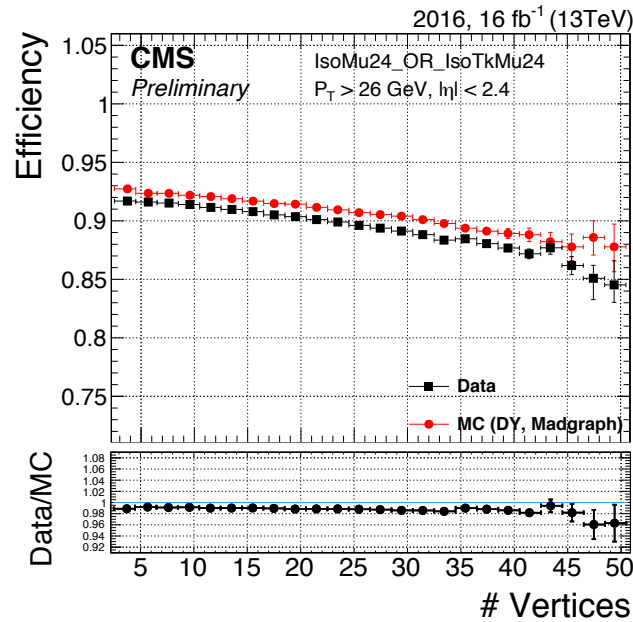
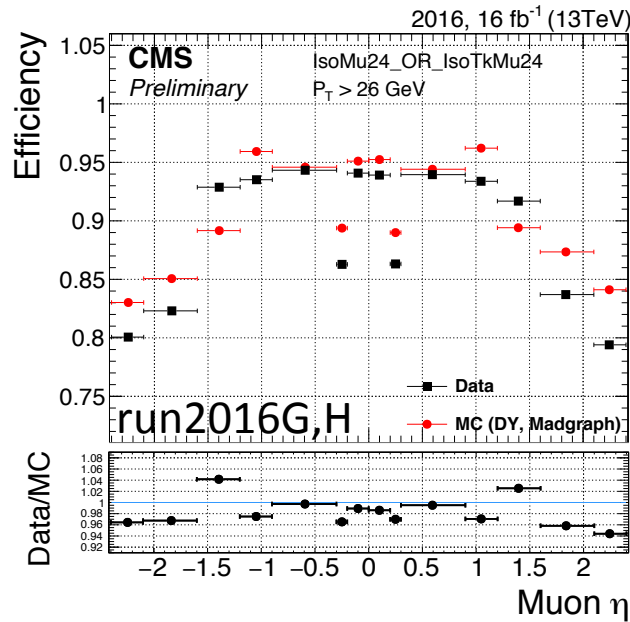


✓ some of these “features” promptly spotted, others not really ...



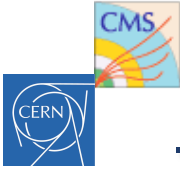


# HLT trigger in 2016: performance

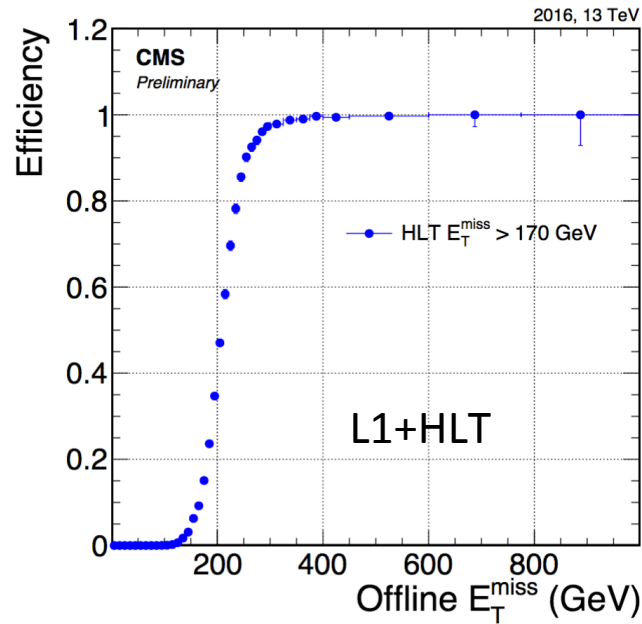
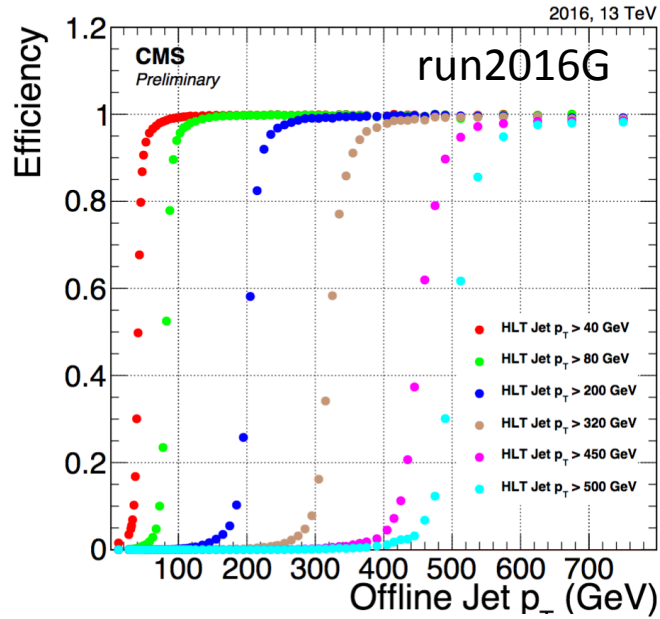


- absolute value  
mainly driven by L1
- trend vs PU  
driven by HLT (isolation)

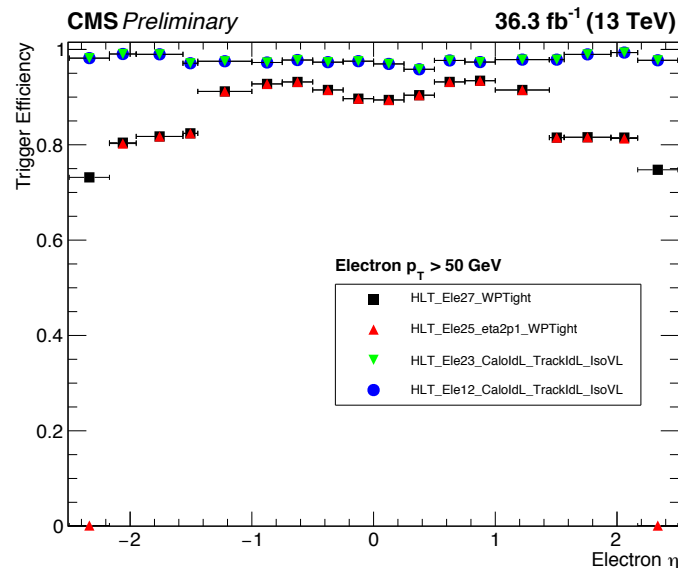
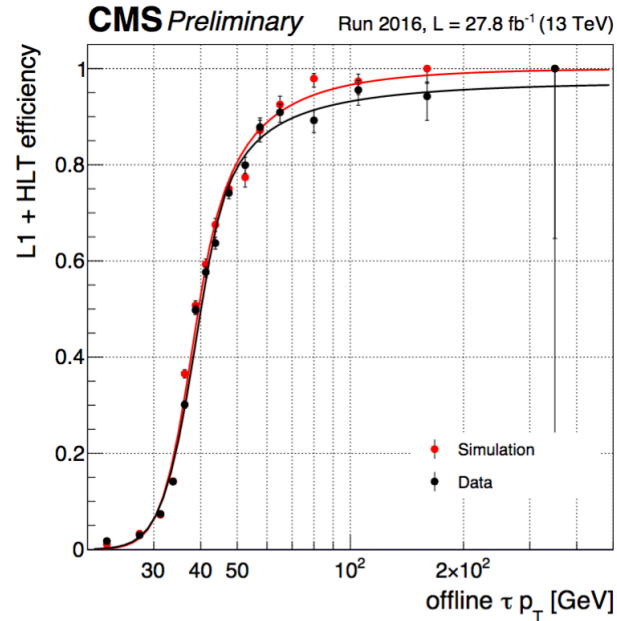
one of the main goal  
in the upcoming months  
is to have such  
**performance monitoring**  
in the DQM framework  
and exploit  
the **multirun harvesting**  
for collecting enough statistics  
[ ~ O(200) pb ]



# HLT trigger in 2016: performance

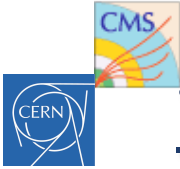


- jet energy resolution makes the turnON worst at high  $p_T$

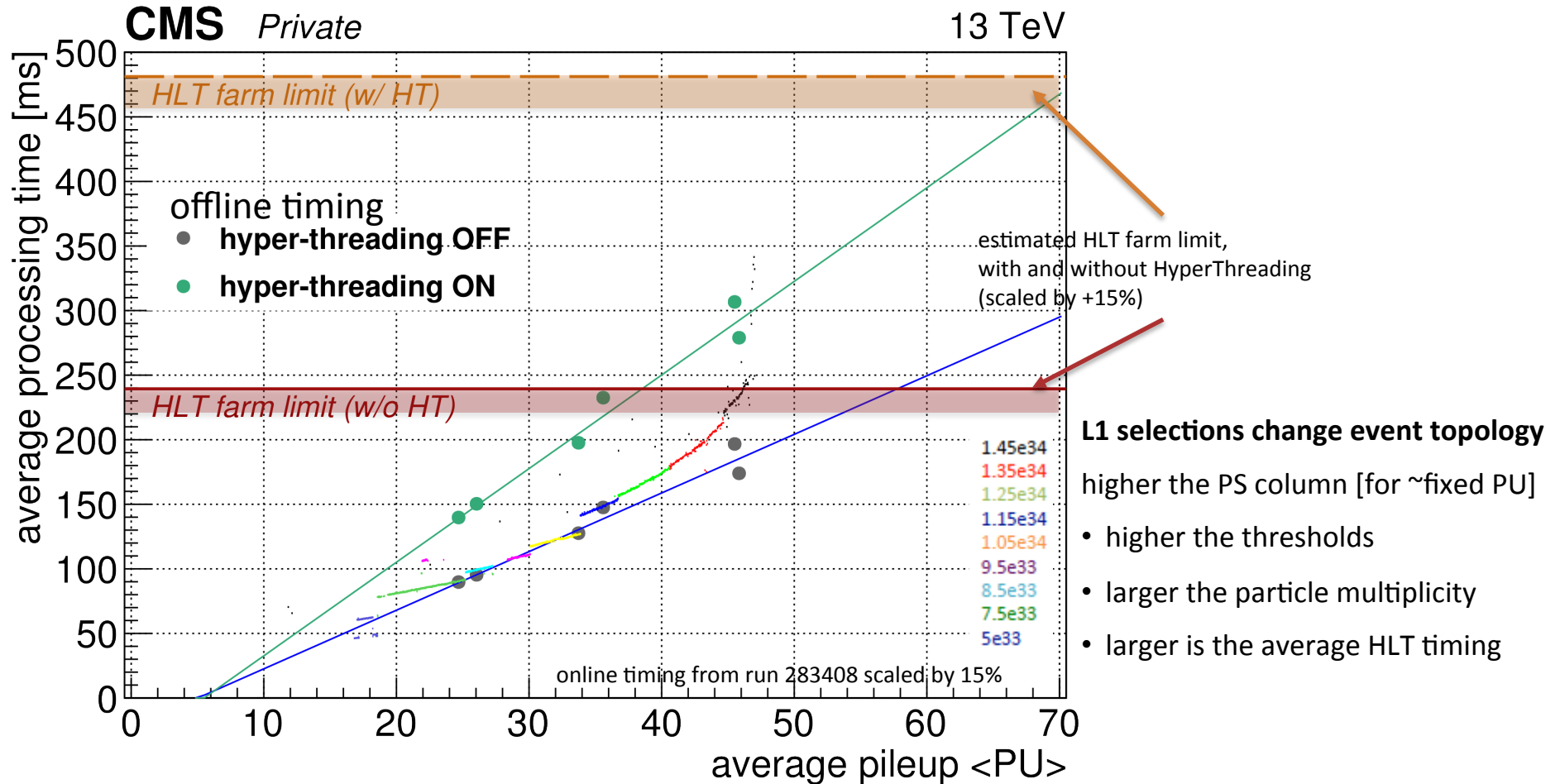


main sources of inefficiency:

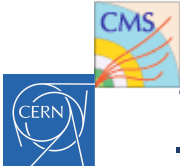
- L1 threshold > HLT one @high PU
- selection on H/E
- calorimetric isolations
- GSF track fit  $\chi^2$  in EE



# timing in 2016



**new HF readout and new pixel detectors might have a not negligible impact on the timing in 2017 ...**



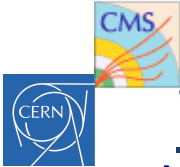
# towards 2017 HLT menu: scenario

| parameter                    | 2016                                       | BCMS                                       | BCMS $\beta^*$ 33cm                        |
|------------------------------|--|--|--|
| Beta*                        | 40 cm                                      | 40 cm                                      | 33 cm                                      |
| Half crossing angle          | 140 $\mu$ rad                              | 155 $\mu$ rad                              | 170 $\mu$ rad                              |
| Number of colliding bunches  | 2208                                       | 2448                                       | 2448                                       |
| Proton per bunch             | $\sim 1.1e11$                              | 1.25e11                                    | 1.25e11                                    |
| Transverse emittance into SB | $\sim 1.9 \mu m$                           | 2.3 $\mu m$                                | 2.3 $\mu m$                                |
| Bunch length                 | 1.05 ns                                    | 1.05 ns                                    | 1.05 ns                                    |
| Peak luminosity              | $\sim 1.5e34 \text{ cm}^{-2}\text{s}^{-1}$ | $\sim 1.8e34 \text{ cm}^{-2}\text{s}^{-1}$ | $\sim 1.9e34 \text{ cm}^{-2}\text{s}^{-1}$ |
| Peak pile-up                 | $\sim 49$                                  | $\sim 52$                                  | $\sim 56$                                  |

- $1.6e34 \text{ cm}^{-2}\text{s}^{-1}$  (pileup  $\sim 46$ ) to study the impact of lumi levelling
- $1.8e34 \text{ cm}^{-2}\text{s}^{-1}$  (pileup  $\sim 52$ ) as the initial luminosity for 2017
- $2.0e34 \text{ cm}^{-2}\text{s}^{-1}$  (pileup  $\sim 58$ ) as the ultimate luminosity for 2017
- $2.2e34 \text{ cm}^{-2}\text{s}^{-1}$  (pileup  $\sim 64$ ) as the “emergency column”

optimise the menu and studies for  $2.0e34 \text{ cm}^{-2}\text{s}^{-1}$  (pileup 55-58)





# towards 2017 HLT menu: schedule

|    | Jan |   |    |       | Feb |   |    |    | Mar |    |    |    |    |
|----|-----|---|----|-------|-----|---|----|----|-----|----|----|----|----|
| Wk | 1   | 2 | 3  | 4     | 5   | 6 | 7  | 8  | 9   | 10 | 11 | 12 | 13 |
| Mo | 2   | 9 | 16 | 23    | 30  | 6 | 13 | 20 | 27  | 6  | 13 | 20 | 27 |
| Tu |     |   |    | today |     |   |    |    |     |    |    |    |    |
| We |     |   |    |       |     |   |    |    |     |    |    |    |    |
| Th |     |   |    |       |     |   |    |    |     |    |    |    |    |
| Fr |     |   |    |       |     |   |    |    |     |    |    |    |    |
| Sa |     |   |    |       |     |   |    |    |     |    |    |    |    |
| Su |     |   |    |       |     |   |    |    |     |    |    |    |    |

900pre3

900pre4

milestones

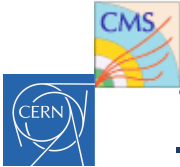
- L1 trigger developments “tagged”
- new draft L1 menu

|    | Apr |           |                                 | May |  |    |    | June  |       |    |    |                    |    |
|----|-----|-----------|---------------------------------|-----|--|----|----|-------|-------|----|----|--------------------|----|
| Wk | 14  | 15        | 16                              | 17  | 18   | 19 | 20 | 21    | 22    | 23 | 24 | 25                 | 26 |
| Mo | 21  | 28        | Excess Mon                      | 5   | 12   | 19 | 26 | 05.22 | 06.01 | 8  | 15 | Special physic run | 22 |
| Tu |     |           |                                 |     |  |    |    |       |       |    |    |                    |    |
| We |     |           |                                 |     |  |    |    |       |       |    |    |                    |    |
| Th |     |           | 04.20                           |     |  |    |    |       |       |    |    |                    |    |
| Fr |     | G. Friday | deadline for HLT paths proposal |     | 05.05                                      |    |    |       |       |    |    |                    |    |
| Sa |     |           |                                 |     | final draft of L1 menu HLT menu integrated |    |    |       |       |    |    |                    |    |
| Su |     |           |                                 |     |  |    |    |       |       |    |    |                    |    |

by PAGs/POGs and DPGs

### propose an HLT path

- path rate (total and pure)
- timing
- DQM (and Validation) code and monitoring strategy



# towards 2017 HLT menu: MC studies

having a new detector,  
most of the trigger studies have to rely on **MC samples**

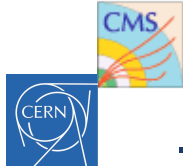
- PU scenario : 28÷62
- 2016 geometry (80x) MC samples [ ~300M events ]
  - **rate** and **timing** studies for comparing results w/ 2016 data ones
  - first set of studies and **developments**, mainly L1
- 2017 geometry MC samples [ ~600M events ]
  - main sample for 2017 **developments** and **validation** of the menu
  - 810 samples: muon POG needs to work on new L3 muon reconstruction (asap)
  - 811 samples: POGs/PAGs developments [most of the production]
  - 900 samples: validation of the menu

|    | Jan |   |   | Feb   |    |    |   | Mar |    |    |    |    |    |    |
|----|-----|---|---|-------|----|----|---|-----|----|----|----|----|----|----|
| Wk | 1   | 2 | 3 | 4     | 5  | 6  | 7 | 8   | 9  | 10 | 11 | 12 | 13 |    |
| Mo |     | 2 | 9 | 16    | 23 | 30 | 6 | 13  | 20 | 27 | 6  | 13 | 20 | 27 |
| Tu |     |   |   | today |    |    |   |     |    |    |    |    |    |    |
| We |     |   |   |       |    |    |   |     |    |    |    |    |    |    |
| Th |     |   |   |       |    |    |   |     |    |    |    |    |    |    |
| Fr |     |   |   |       |    |    |   |     |    |    |    |    |    |    |
| Sa |     |   |   |       |    |    |   |     |    |    |    |    |    |    |
| Su |     |   |   |       |    |    |   |     |    |    |    |    |    |    |

02.15  
tracking POG  
HCAL local reconstruction

03.15  
POGs reconstruction  
final calibrations

81x samples



# conclusion

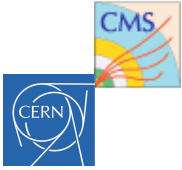


- ✓ ~negligible loss of data (both delivered and recorded) due to the HLT in 2016
- ✓ good performance, specially at the end of the data taking (except for HTT ..)
- ✓ rate w/in budget (even if it took a while to fit it ...)
  
- delay in the availability of 2017 samples should not be a huge problem [if it stays w/in the expected 2 weeks]
- ✓ 90x reconstruction and first (very preliminary) version of the update for 2017 are validated w/in the standard release validation, as now
- ✓ rate and timing studies on MC samples are on going to make sure all ingredients are in place
- we are currently missing the online beam spot updates !
- we will evaluate the effects of the pixel misalignment and –probably– relax POG reconstruction at the beginning
- improve

## VALIDATION AND PROMPT MONIROTING !!!

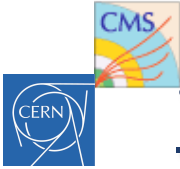
The screenshot shows the CMS DQM GUI interface. At the top, it displays 'Service - Workspace - Run # - LS # - Event # - Run started, UTC time'. The main status bar shows 'Offline: Everything . 283'408 . 2'541 . 4'348'081'601 . Tue Oct 18, 14:17'. Below this, it indicates 'Data: /StreamHLTMonitor/Run2016H-Express-v2/DQMIO'. The interface includes a menu bar with options like 'Size: Medium', 'Play', 'Reset Workspace', 'Describe', 'Customise', 'Layouts', and '(Top) / HLT'. At the bottom, there are several tabs: 'BTV', 'EventInfo', 'Layouts', 'Muon', 'SiStrip', and 'Tracking'. In the top right corner, it says 'CMS DQM GUI (vocms0138.cern.ch) Dec 18, 2016 at 06:32:11 UTC Mia Tosi, View details'.

currently, very few groups have a monitoring tool based on DQM  
... we are working on it ;)

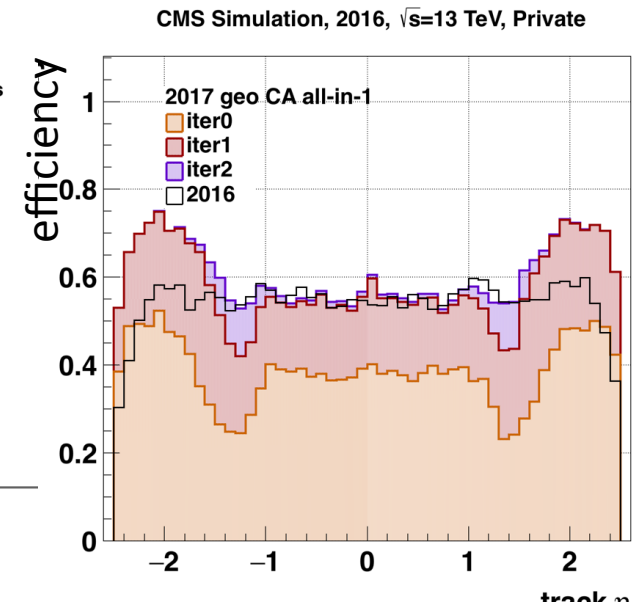
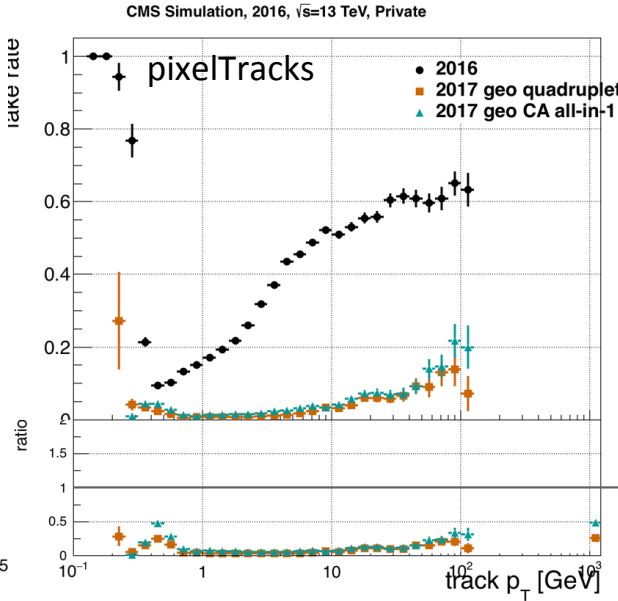
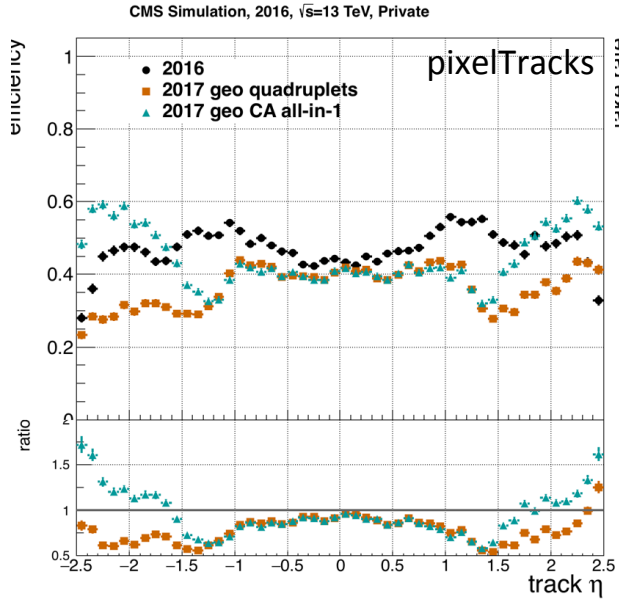


BACKUP

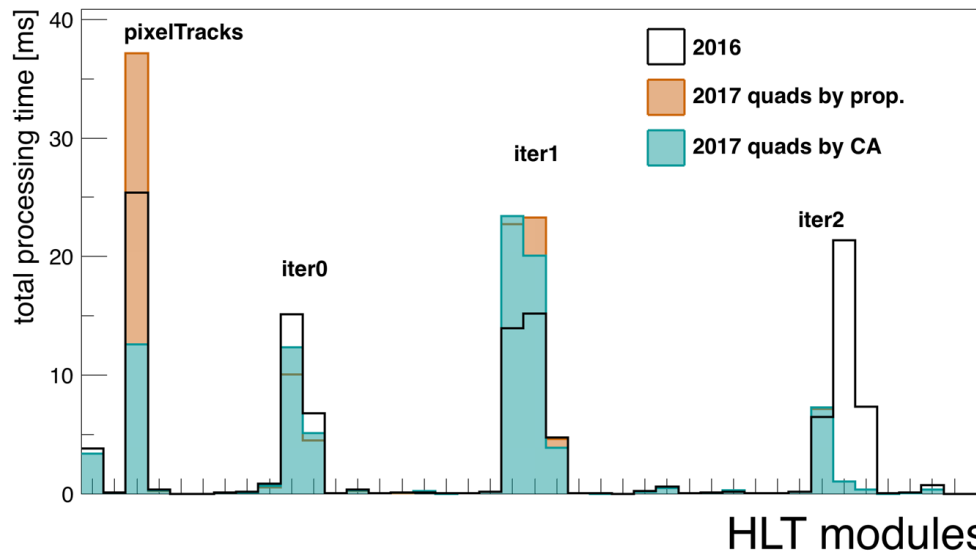




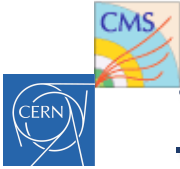
# towards next year upgrades



CMS Simulation, 2016,  $\sqrt{s}=13$  TeV, Preliminary



|                      | average timing / event [ms] |             |
|----------------------|-----------------------------|-------------|
|                      | all tracking                | pixelTracks |
| 2016                 | 172                         | 25.4        |
| 2017 geo quadruplets | 153                         | 37.1        |
| 2017 geo CA all-in-1 | 129                         | 12.6        |
|                      |                             | 21          |

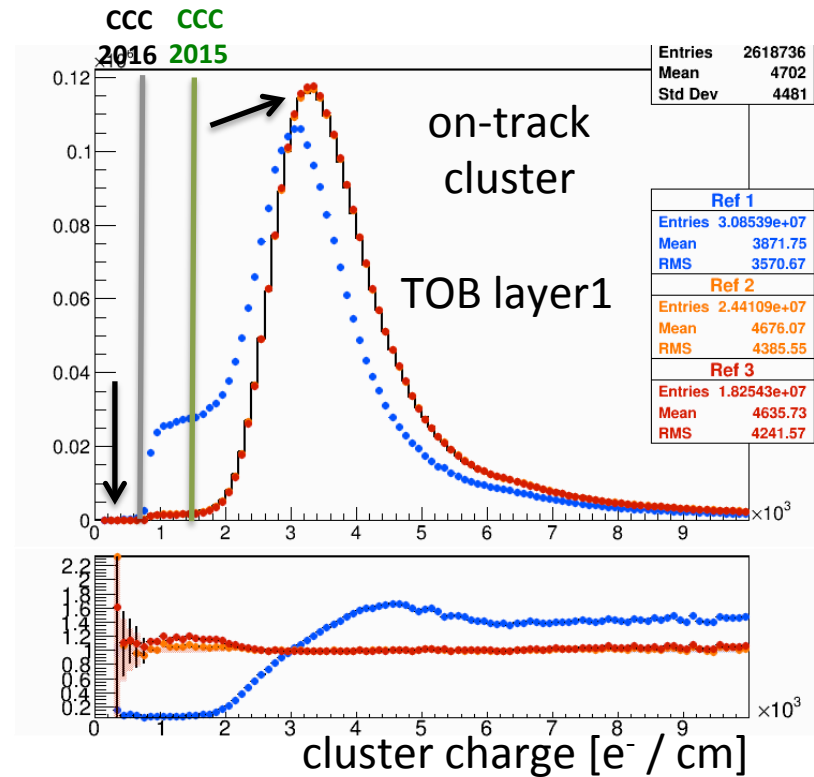
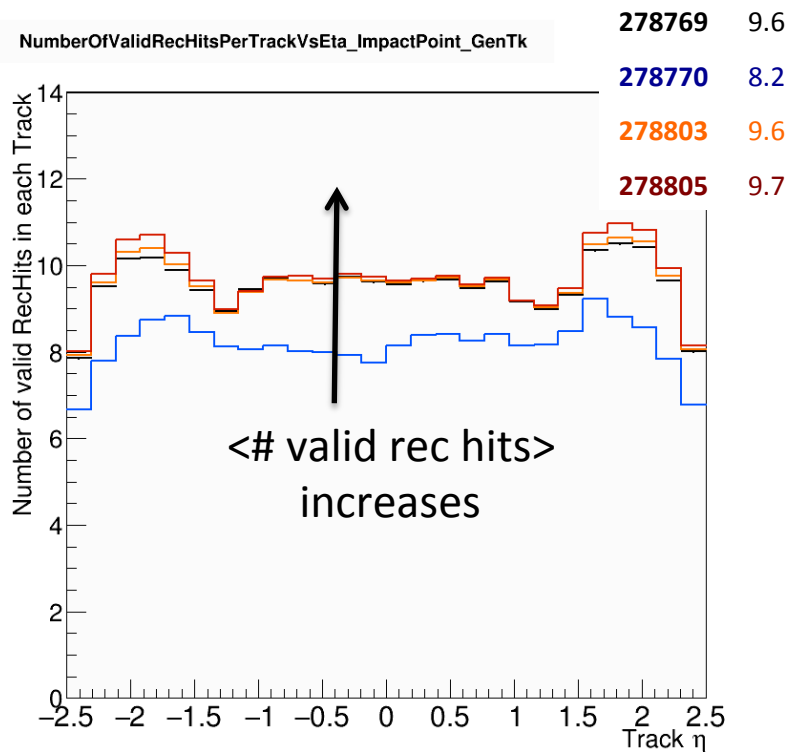


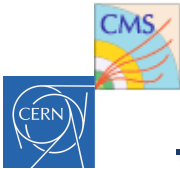
# tracking @HLT

impact of the APV fix:

- ✓ similar to what is observed offline
- ➔ roll back to 2015 strip cluster charge cut (CCC) configuration for tracking used in PF jets and lepton isolation
- expect a reduction by 10-15% in fake rate and 2-3% in CPU usage

| run    | <PV> | APV setting |
|--------|------|-------------|
| 278769 | 12.8 | new         |
| 278770 | 11.2 | old         |
| 278803 | 12.1 | new         |
| 278805 | 11.1 | new         |

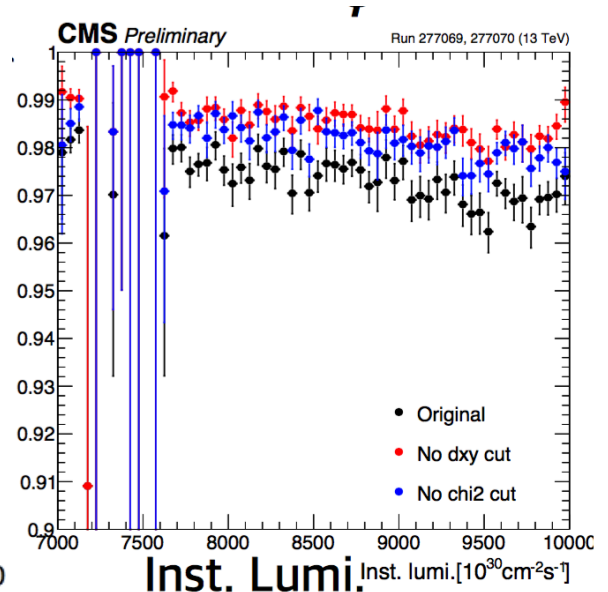
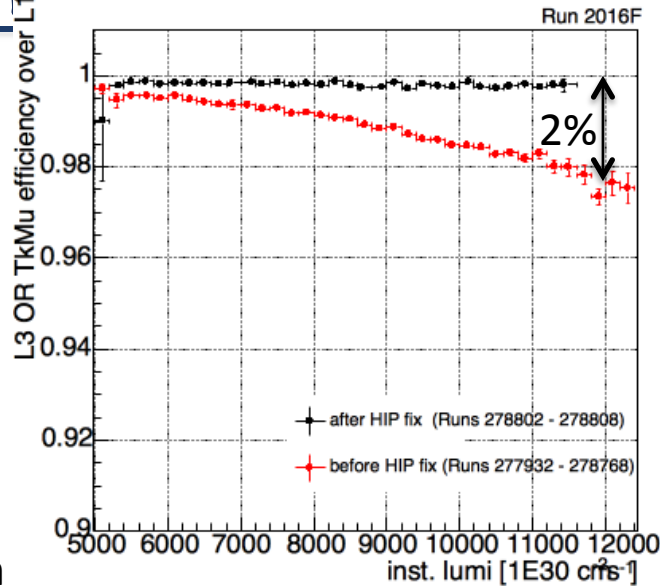




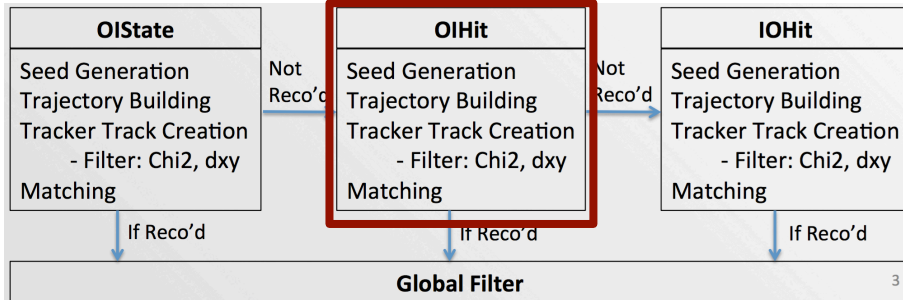
# muon @HLT

impact of the APV fix

- ✓ recovers full efficiency in HLT muon reconstruction
  - up to 2% at  $1.2 \times 10^{34} \text{ Hz cm}^{-2}$
  - efficiency is now flat and better than 99.5%

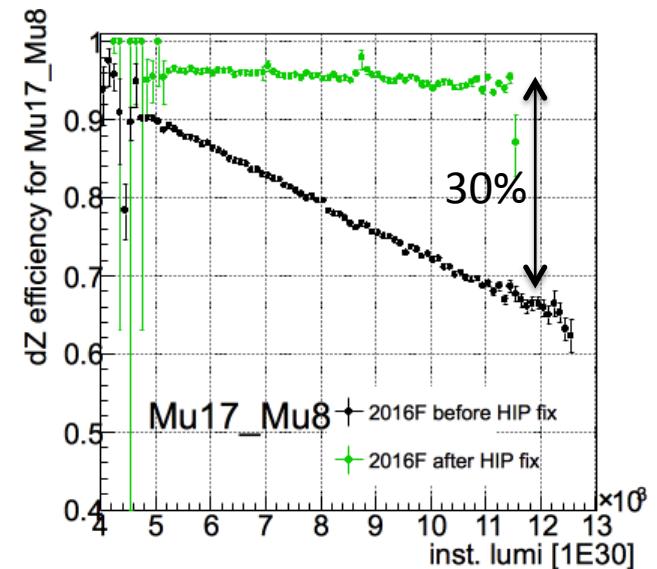


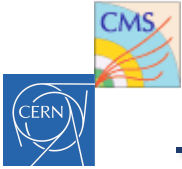
## L3 muon reconstruction



- ✓ recovers large inefficiency in di-muon triggers delta-Z cut
  - requires muons to come from the same PV
  - useful to reduce the rate from combinatorics

➡ dZ cut can be safely applied  
on most di-muon and electron-muon triggers ;)

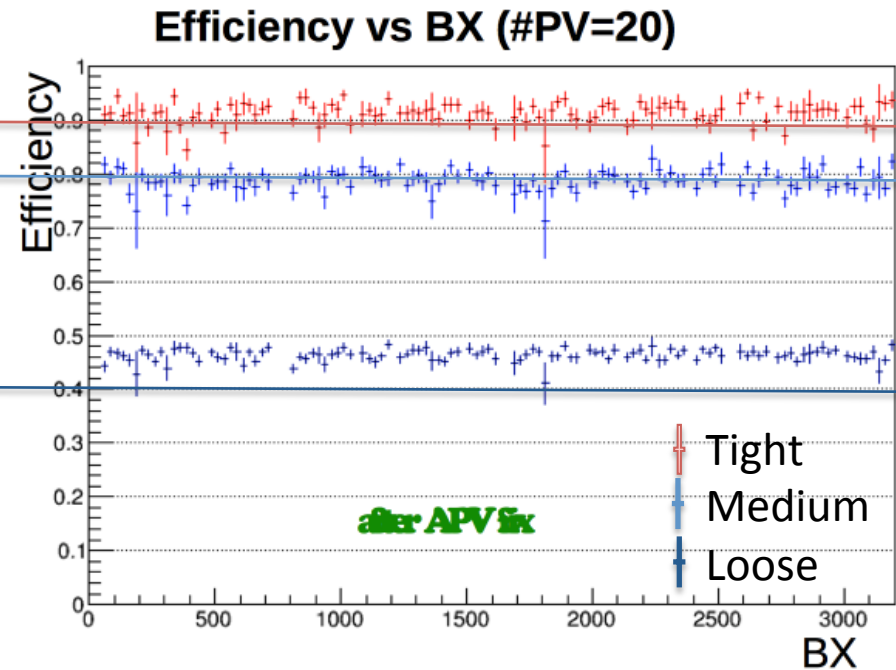
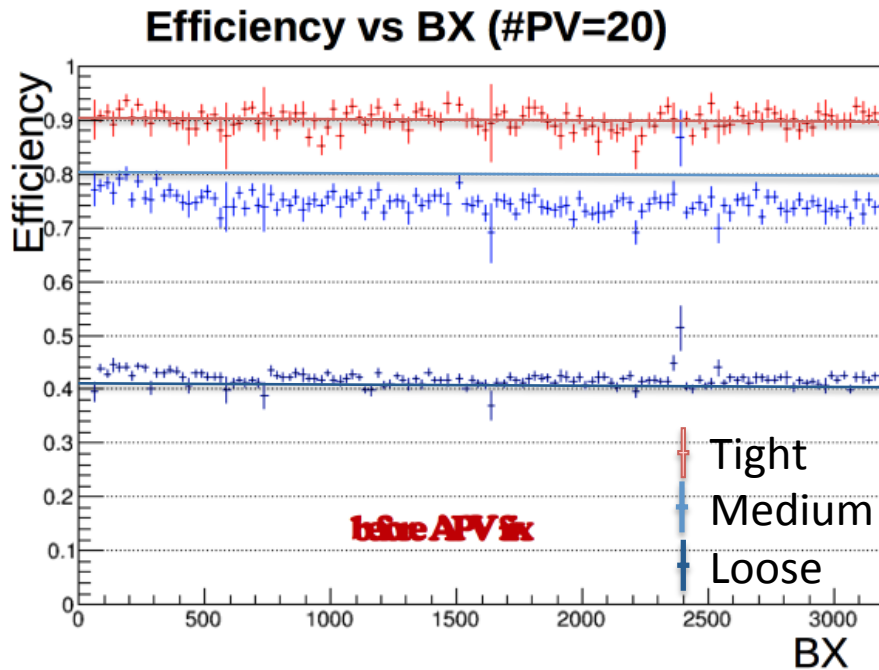




# b-tagging @HLT

impact of the APV fix

- ✓ higher b-tagging efficiency for all working points
- ✓ flat efficiency w/in the orbit
- ✓ lower b-tagging fake rate (not shown here)

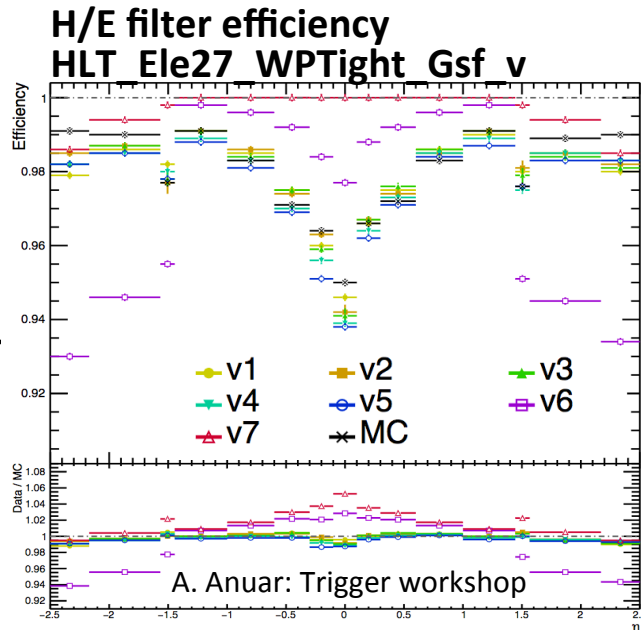


NB: online b-tagging has been less affected by this issue than offline one, because of the very loose selection on the #hits per track

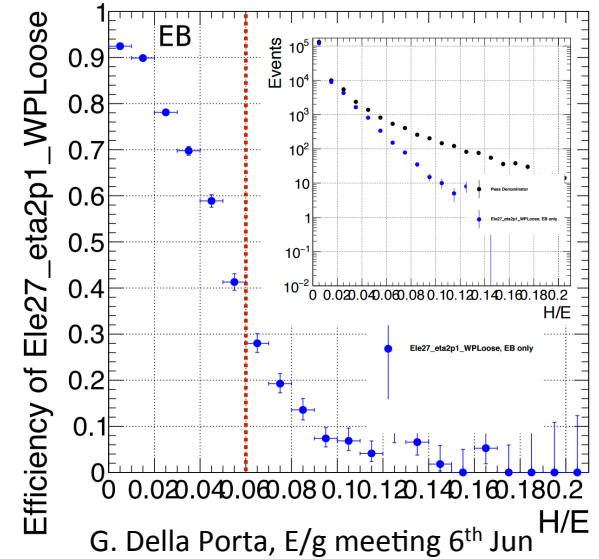


# HLT H/E Issues

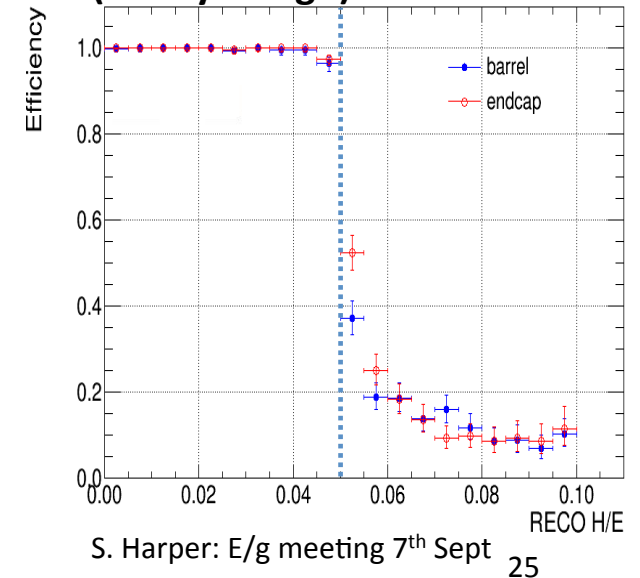
- Online / offline agreement
  - Method 2 HCAL mitigation of out of time pile-up used at RECO slow, developed method 3 for HLT
  - Two methods have little to no correspondence for low energy deposits (from PU/noise) which are the relevant contributions to H for H/E at the trigger
  - RECO and HLT H/E variables were individually efficient but cutting out different events → overall inefficient
  - Fixed by going to method 2 locally (in a cone of 0.25 around e/γ candidates) for HLT H/E
  - Now almost perfect agreement for H
- Miss-configuration of single electron trigger (no rho correction) in period F-G (“v6”) after new WPTight tune went online, fixed in period H (“v7”)

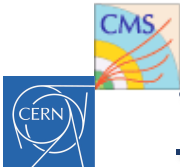


**Method 3 HLT to offline**

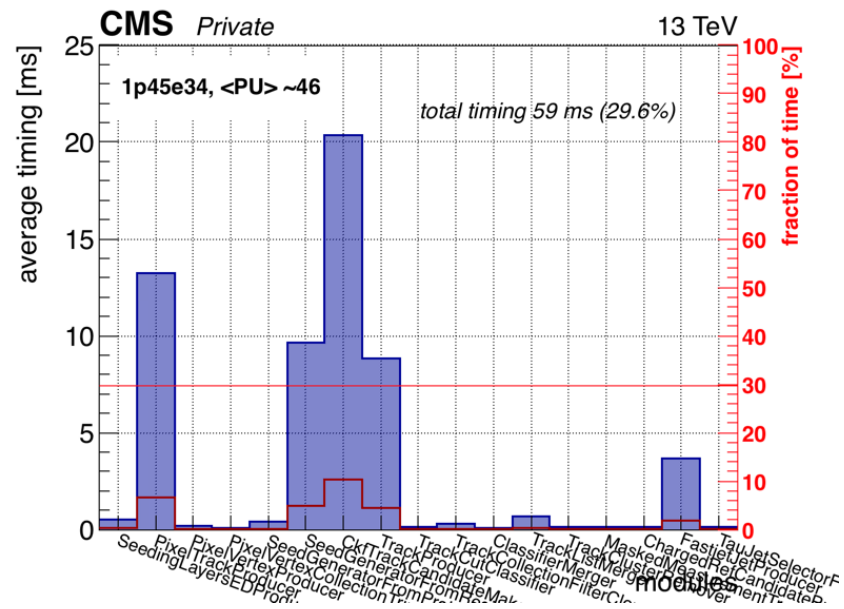
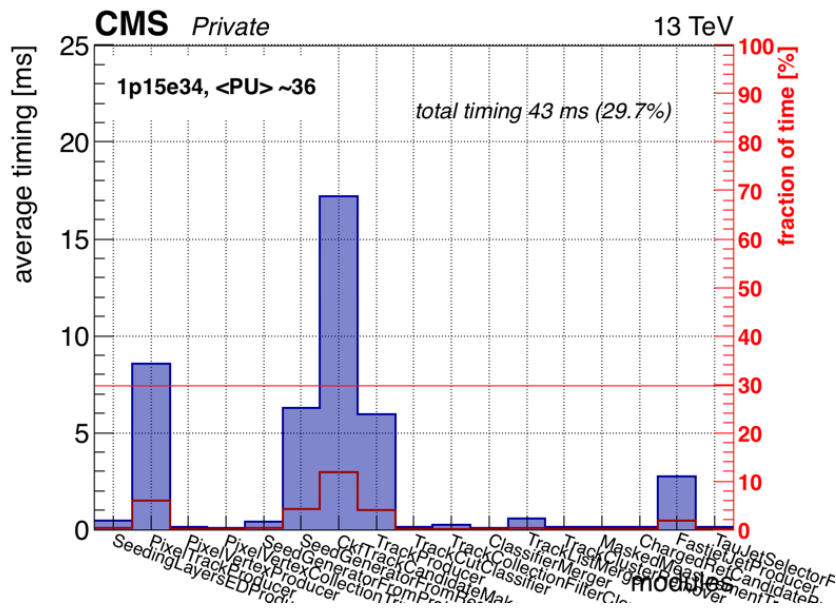
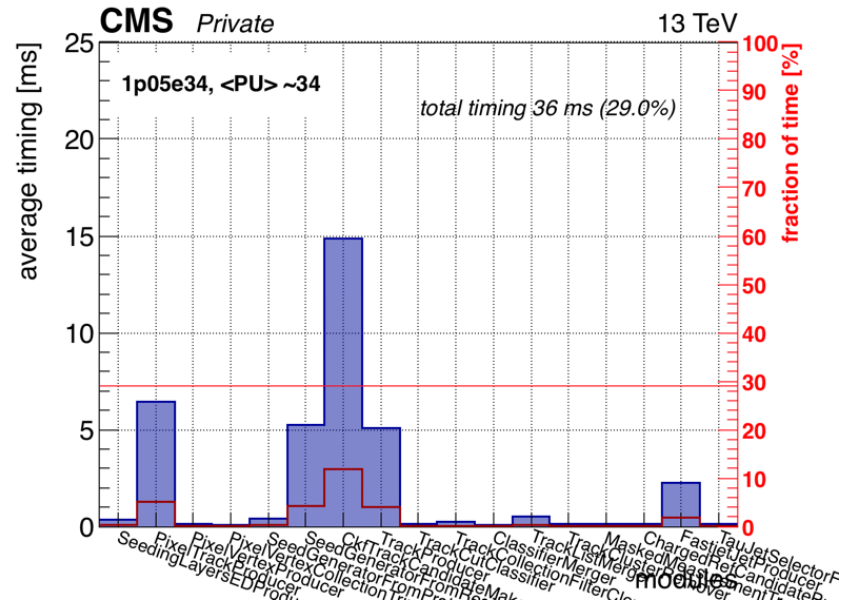
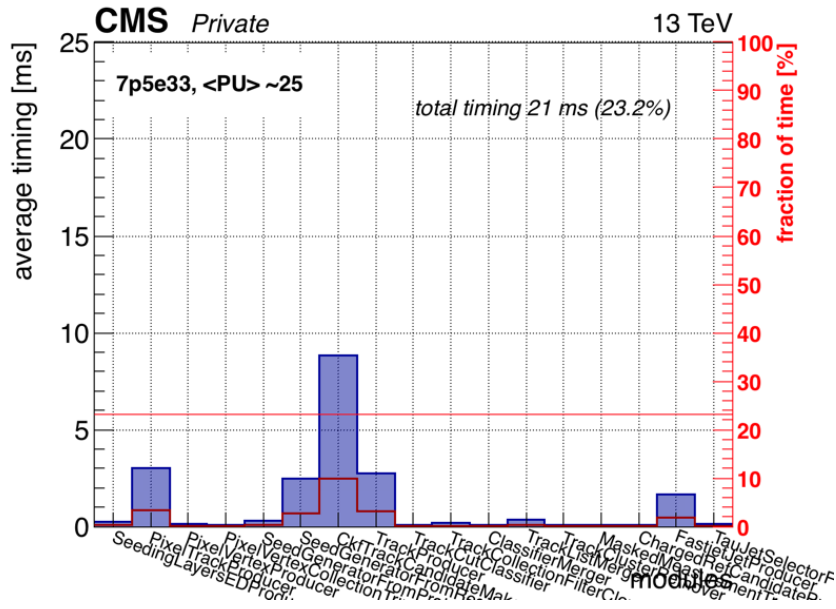


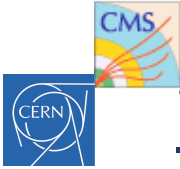
**Method 2 HLT H/E to offline (tail by design)**



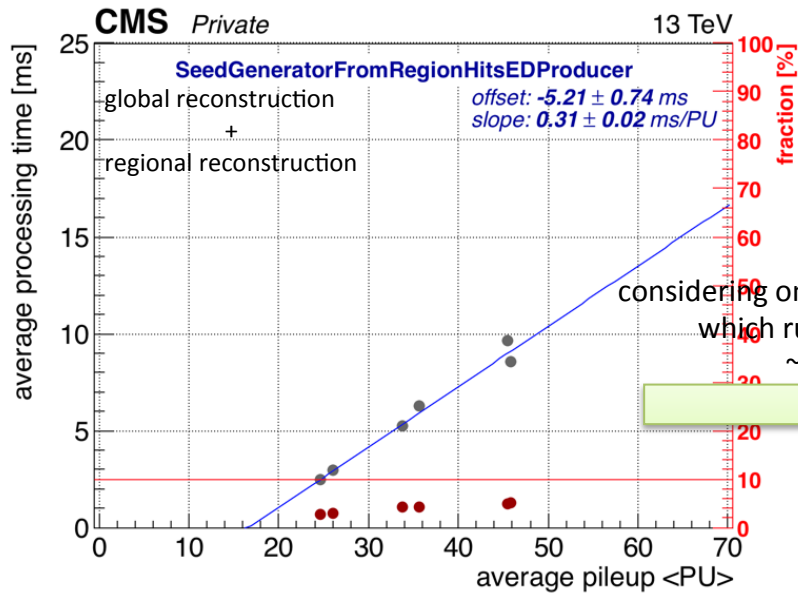


# tracking timing

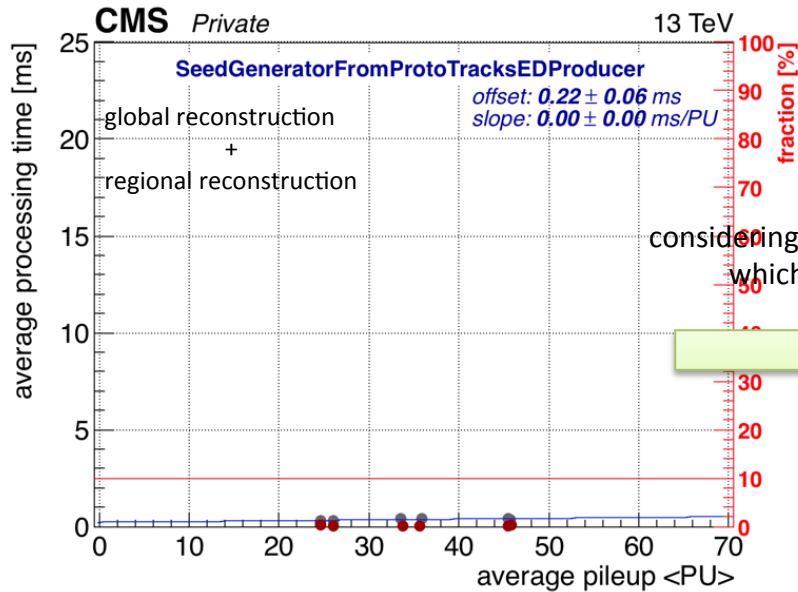
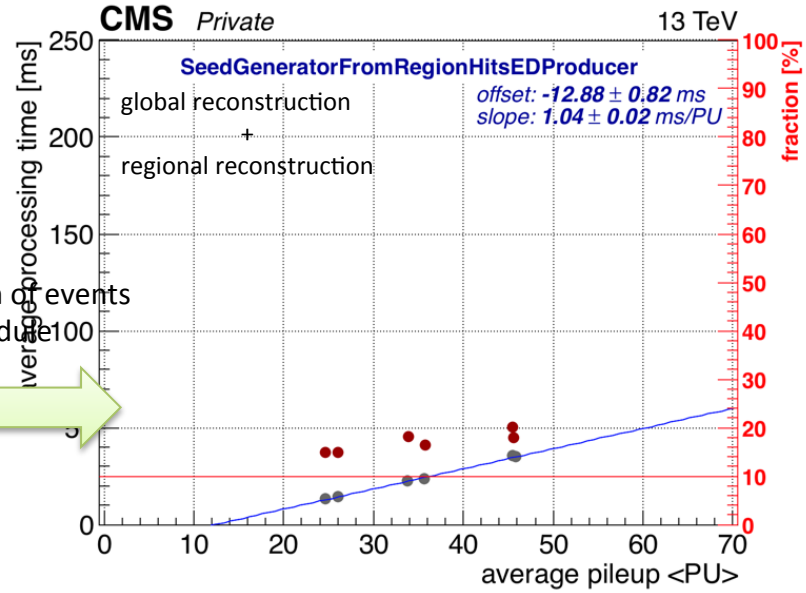
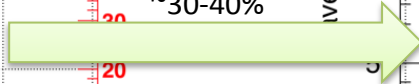




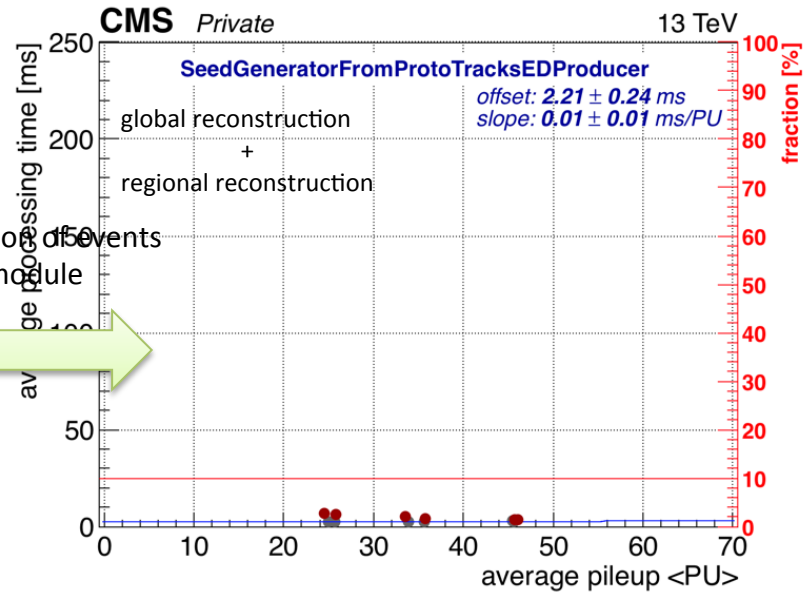
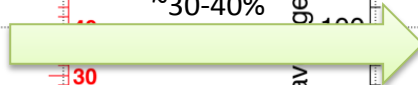
# track reconstruction

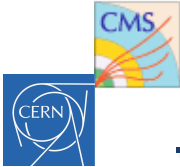


considering only fraction of events which run this module  
~30-40%

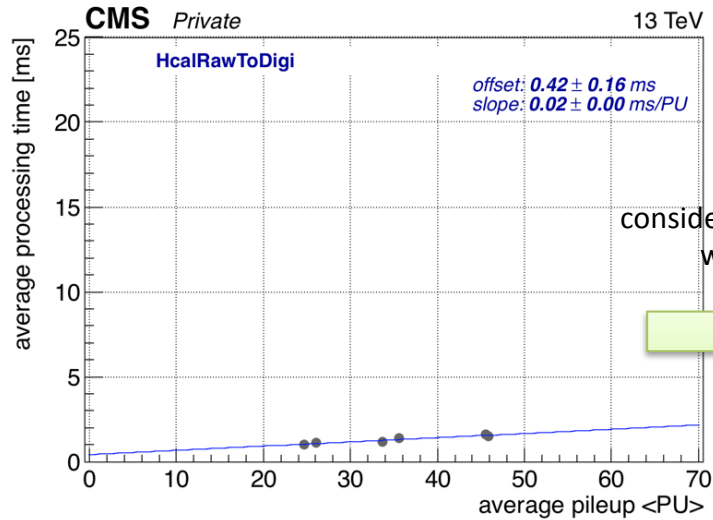


considering only fraction of events which run this module  
~30-40%

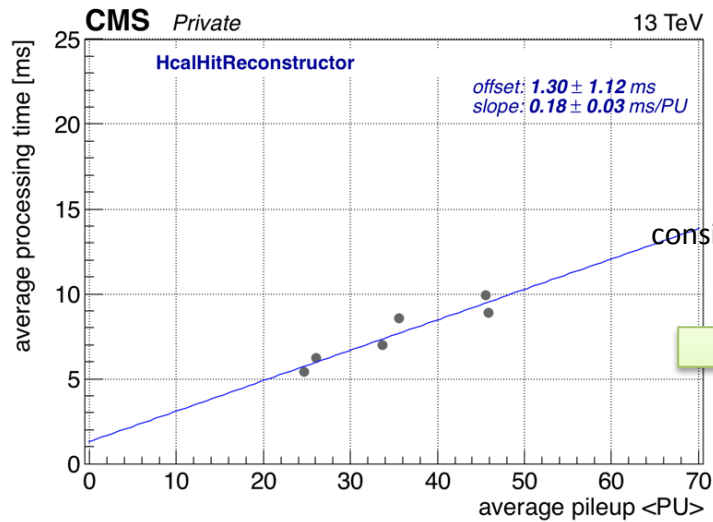
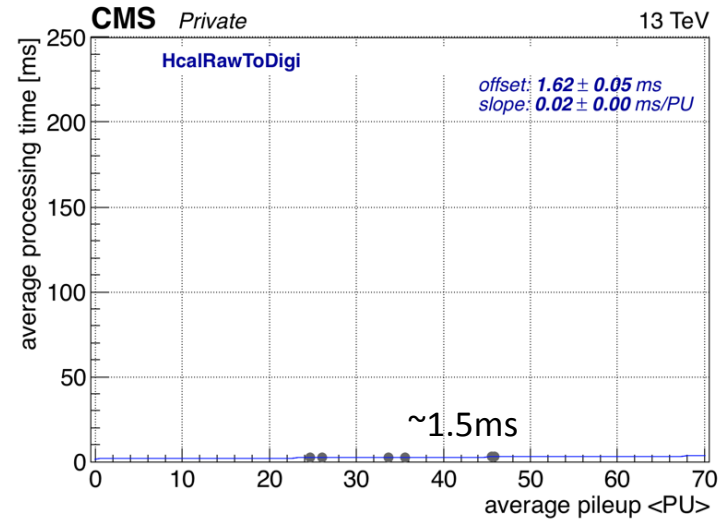
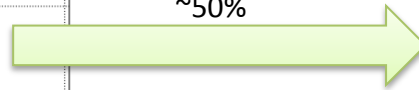




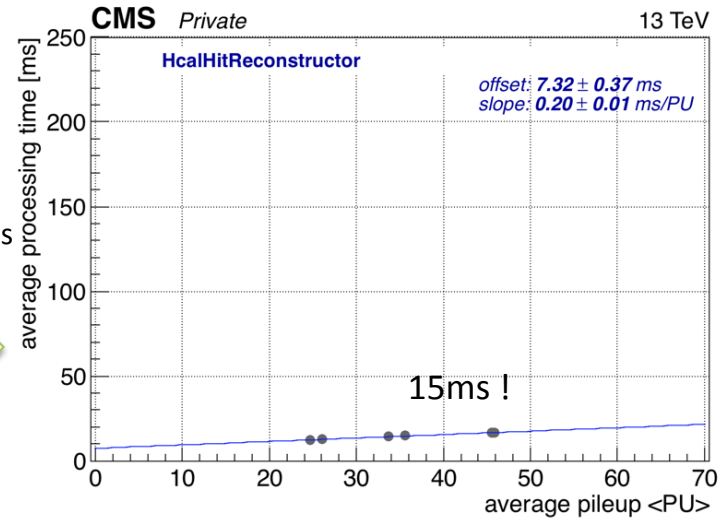
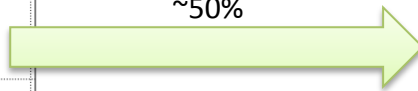
# HCAL local reconstruction

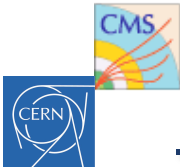


considering only fraction of events  
which run this module  
~50%

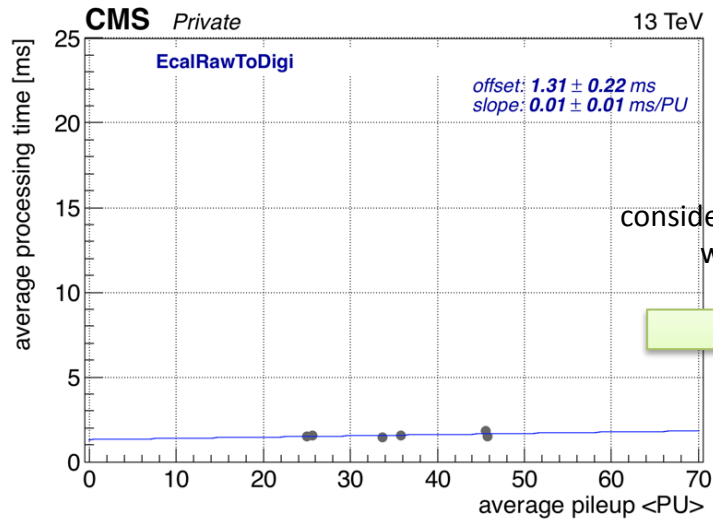


considering only fraction of events  
which run this module  
~50%

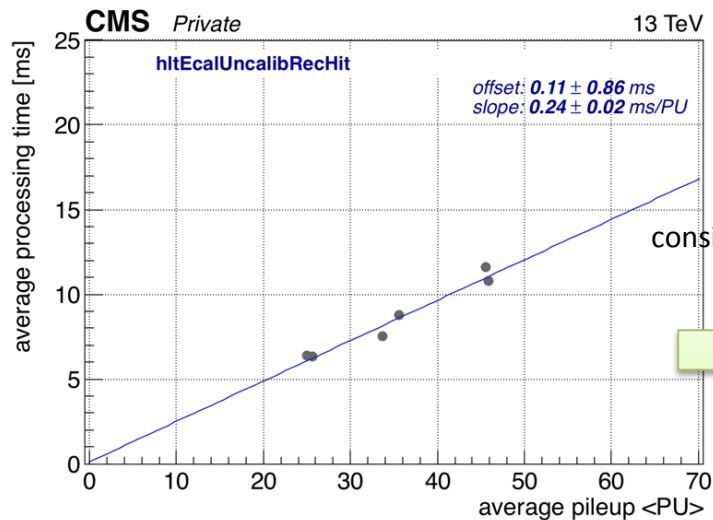
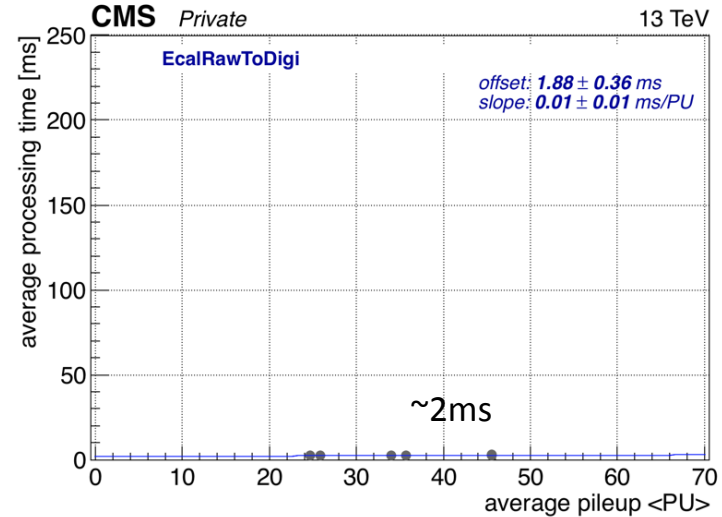




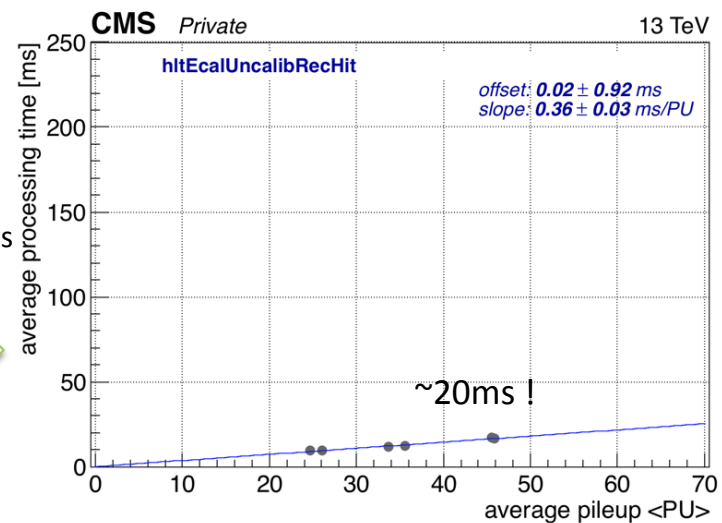
# ECAL local reconstruction

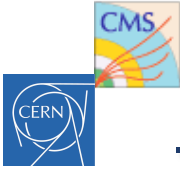


considering only fraction of events  
which run this module  
~70%



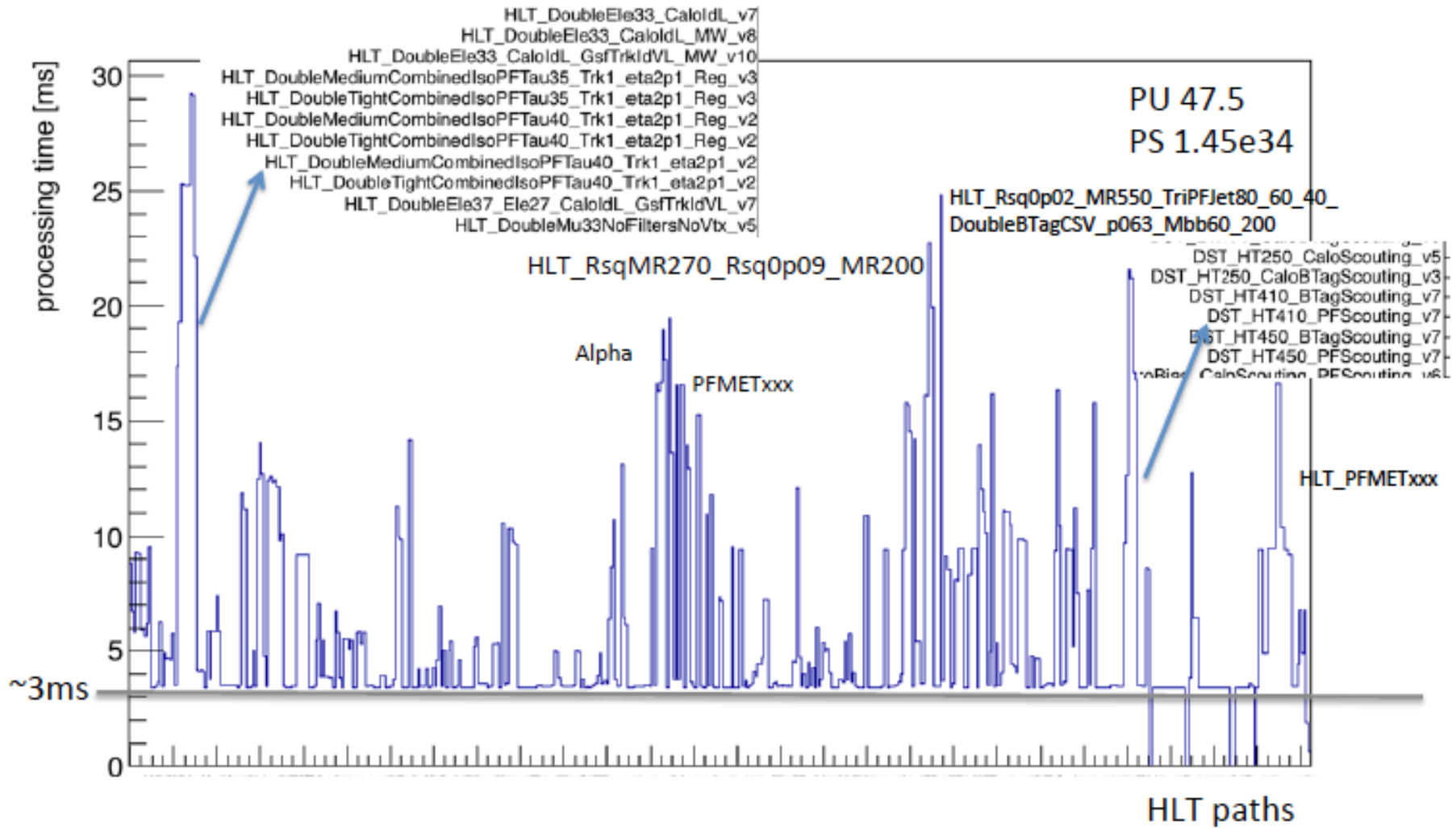
considering only fraction of events  
which run this module  
~70%

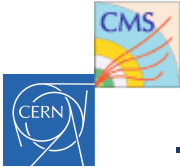




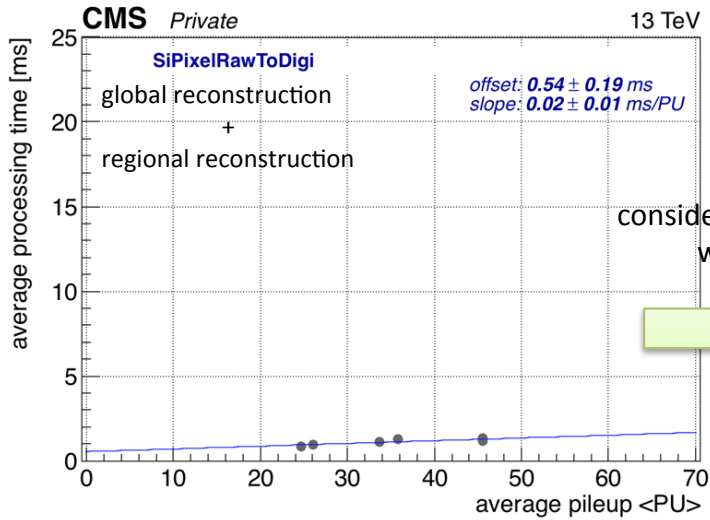
# path total timing in 2016

offline timing

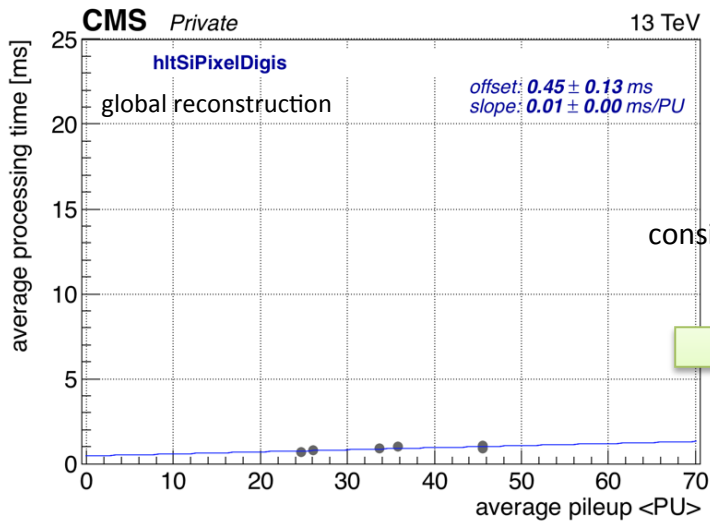
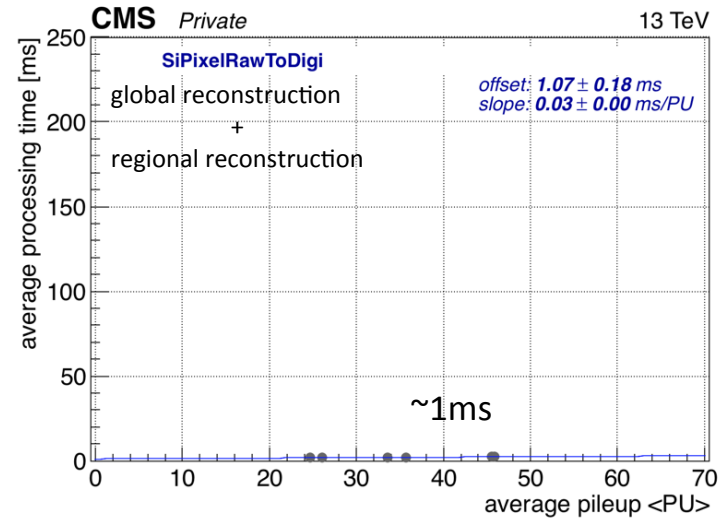




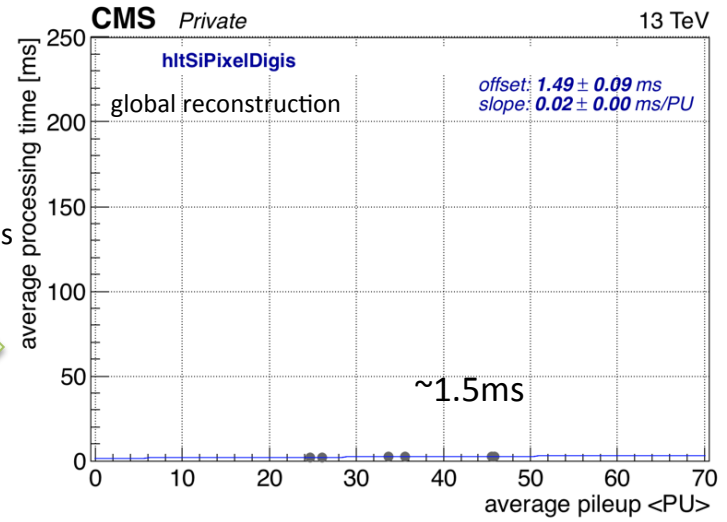
# pixel local reconstruction (I)

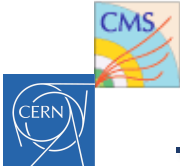


considering only fraction of events  
which run this module  
~60%

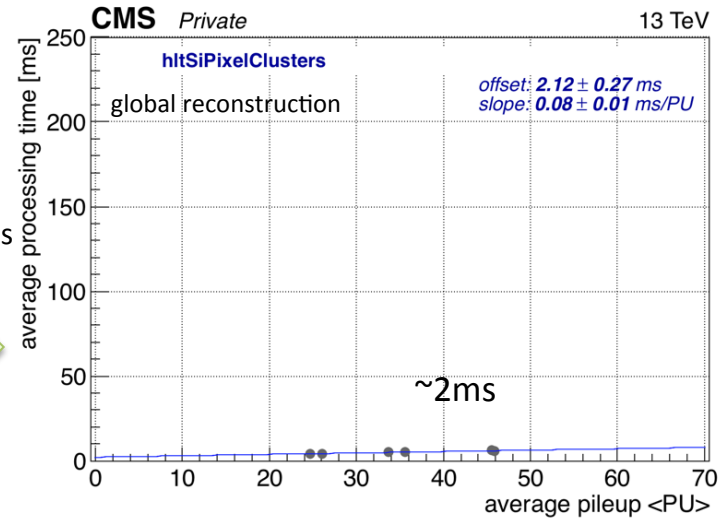
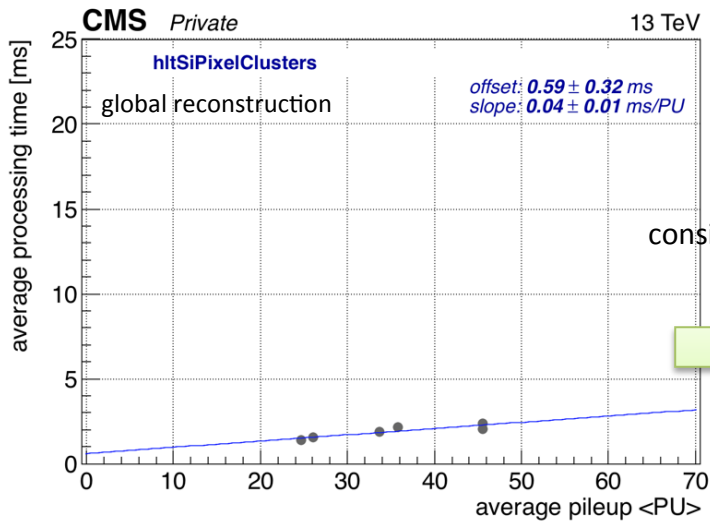
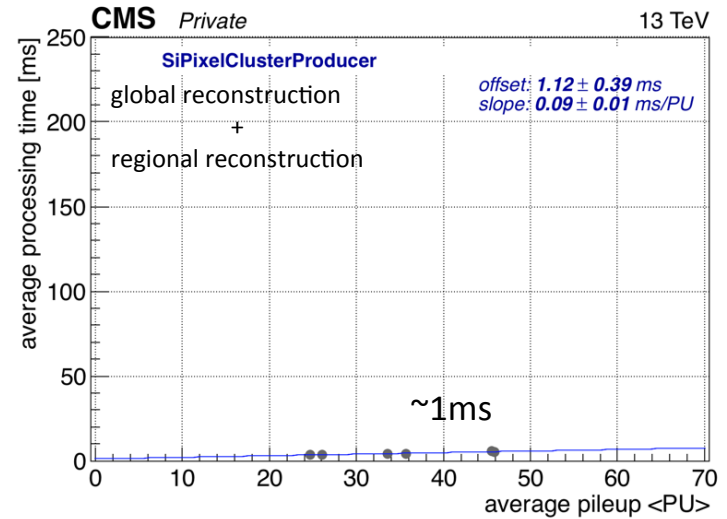
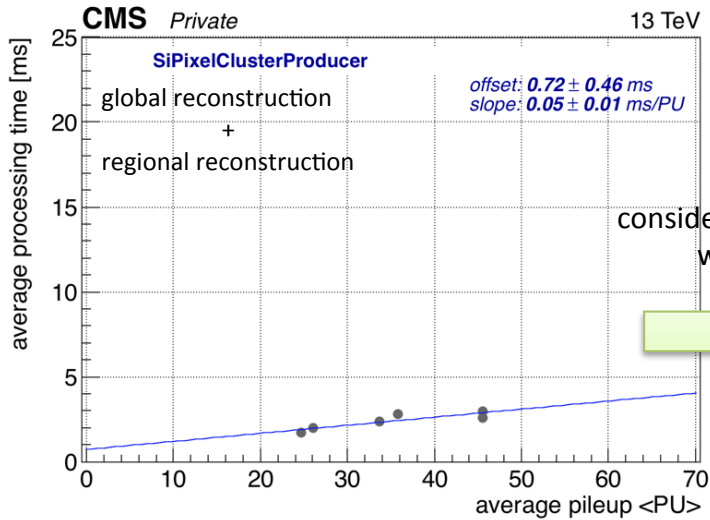


considering only fraction of events  
which run this module  
~40%

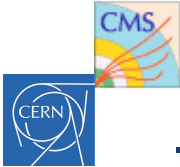




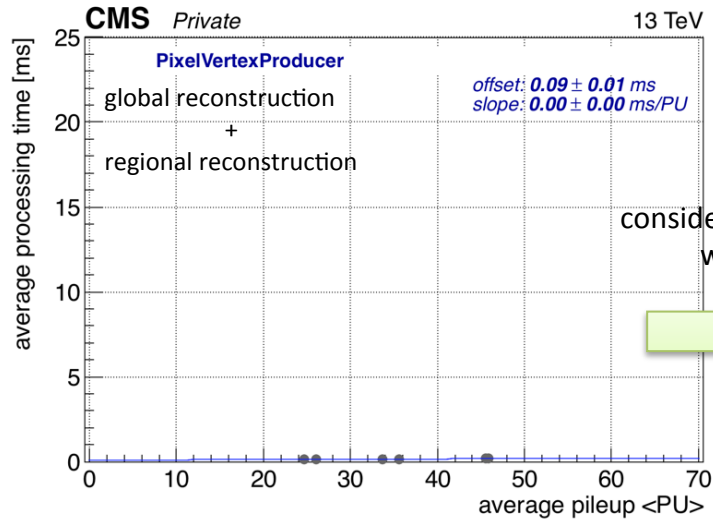
# pixel local reconstruction (II)



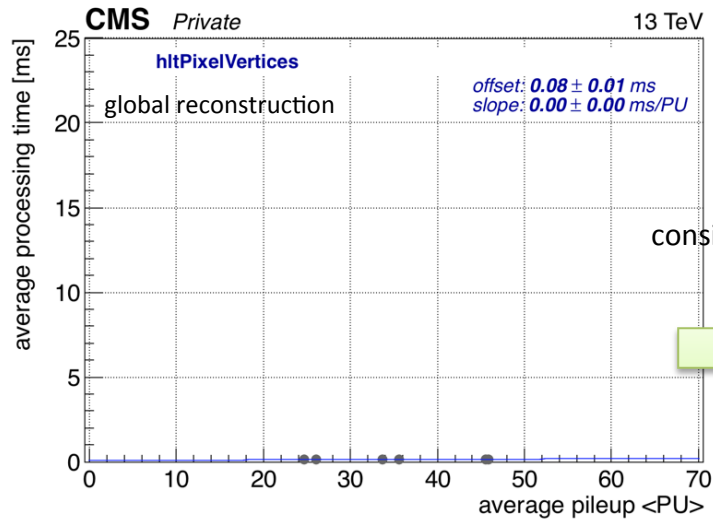
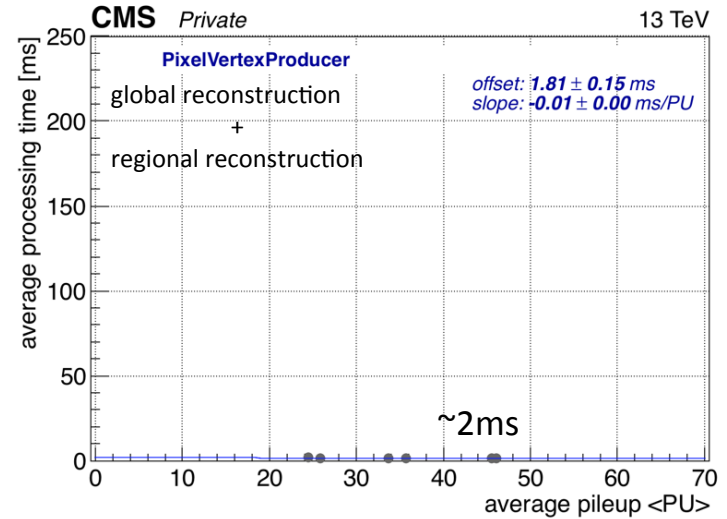
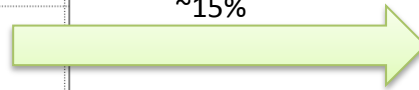




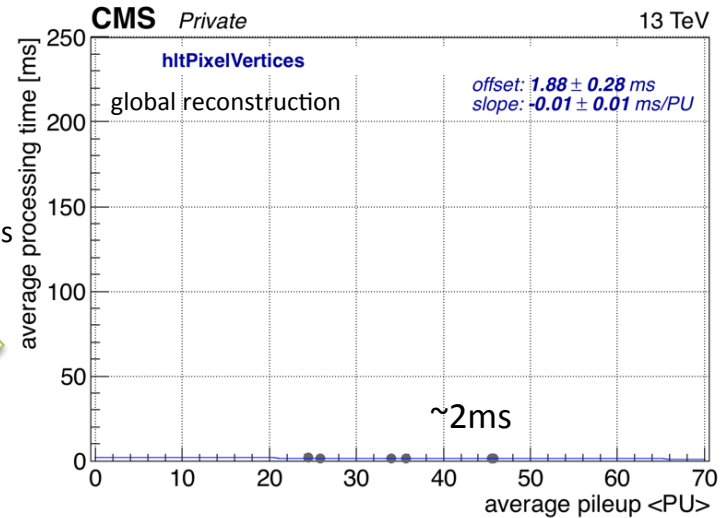
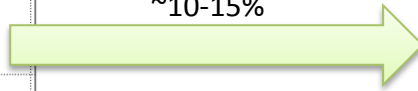
# pixel vertex reconstruction

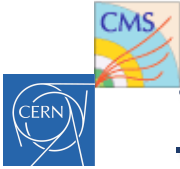


considering only fraction of events  
which run this module  
~15%

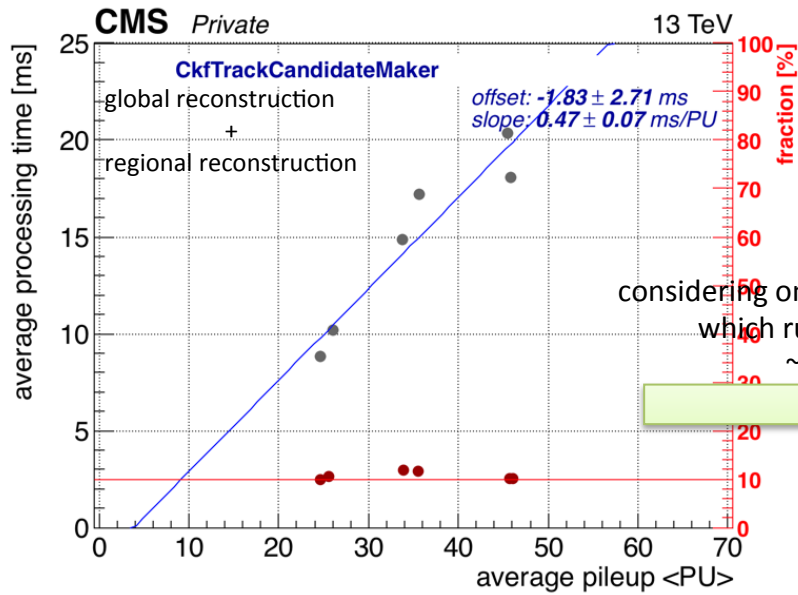


considering only fraction of events  
which run this module  
~10-15%

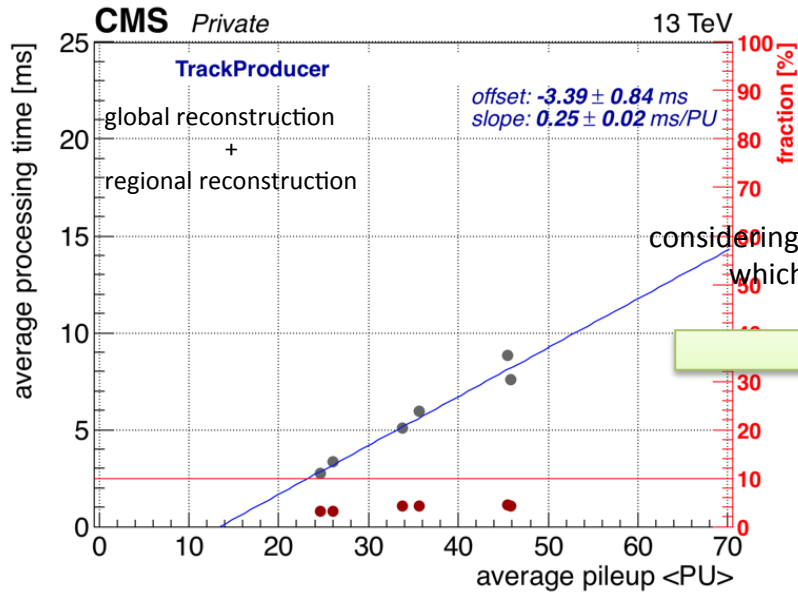
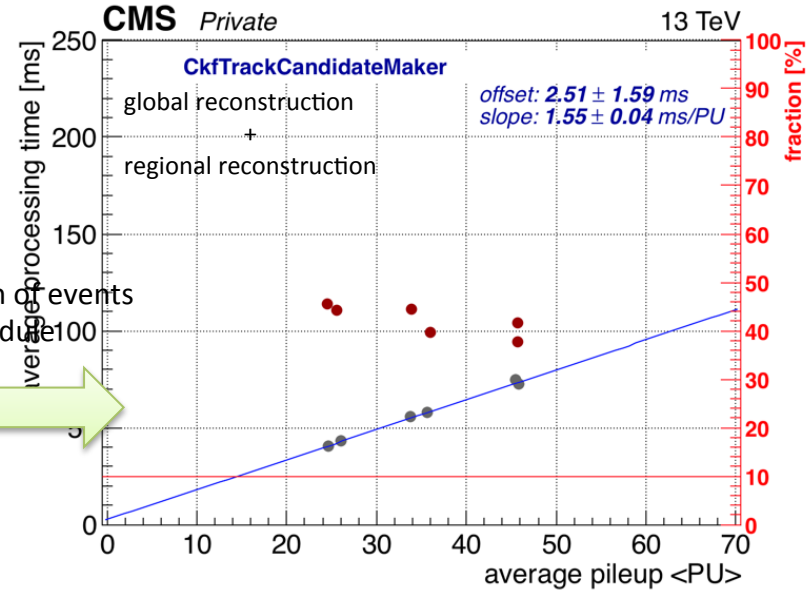
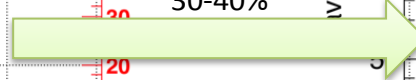




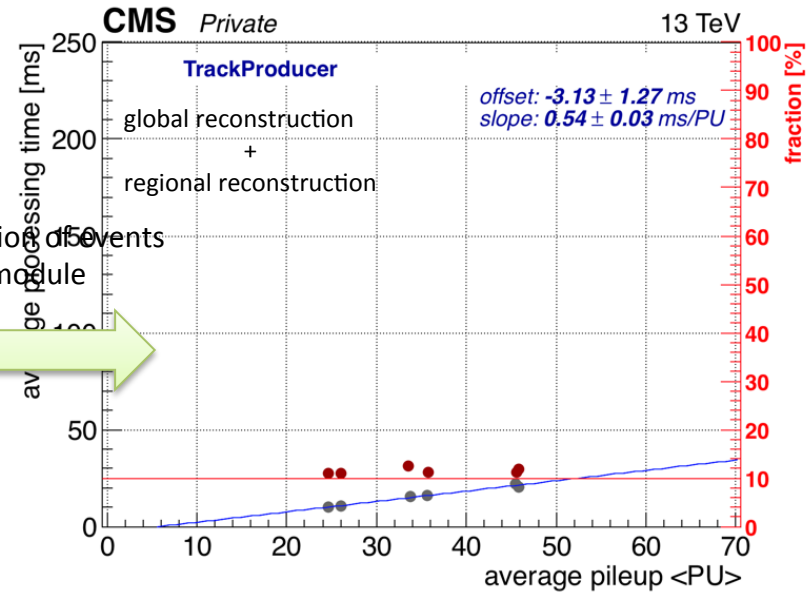
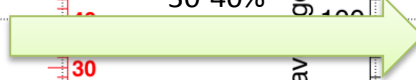
# track reconstruction

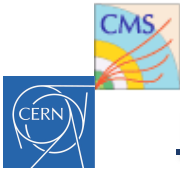


considering only fraction of events which run this module  
~30-40%

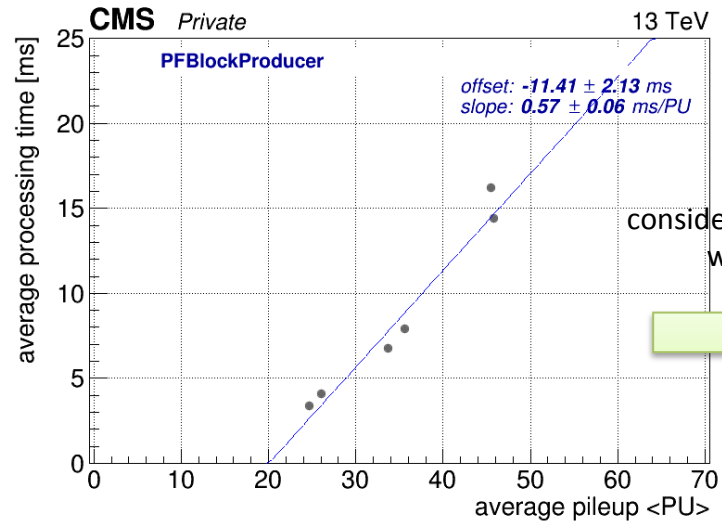


considering only fraction of events which run this module  
~30-40%

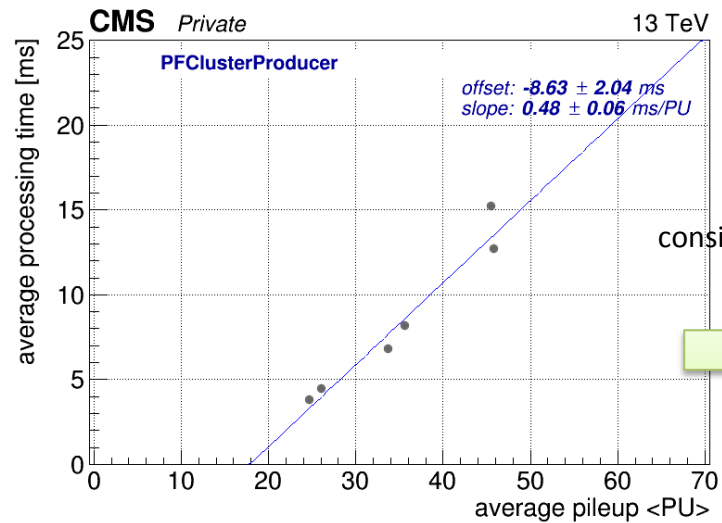
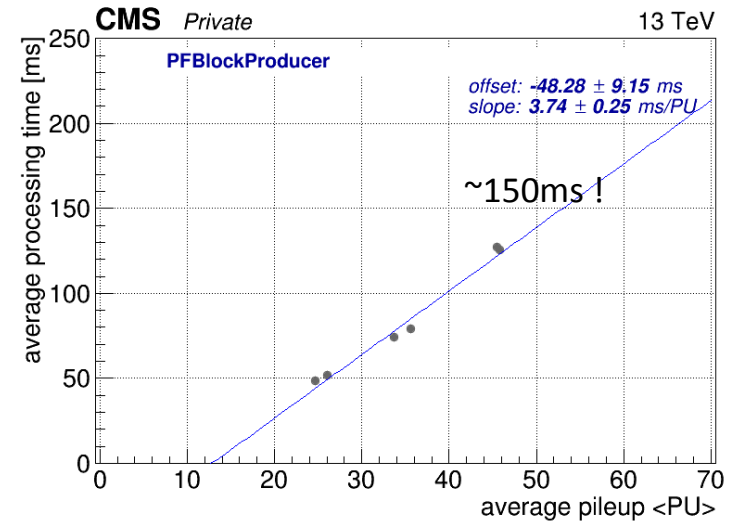
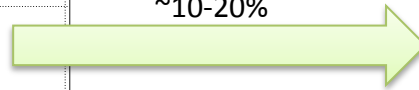




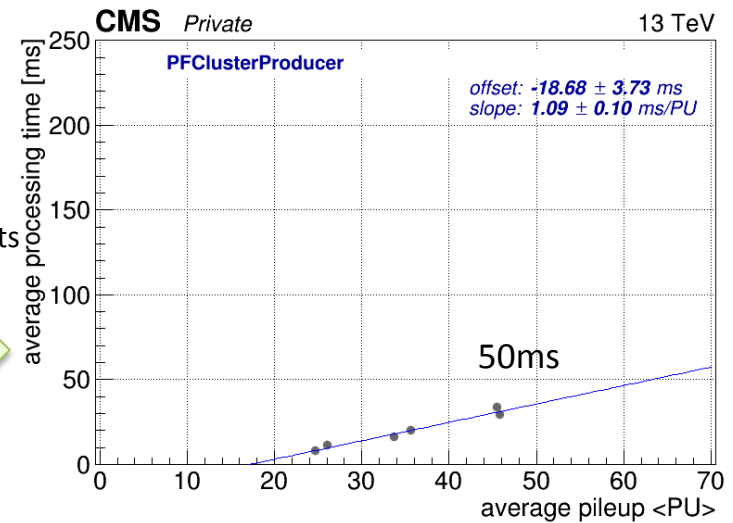
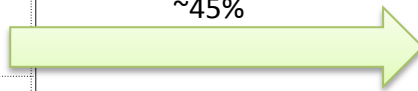
# PF reconstruction (I)

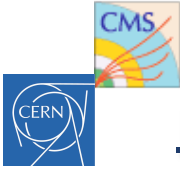


considering only fraction of events  
which run this module  
~10-20%

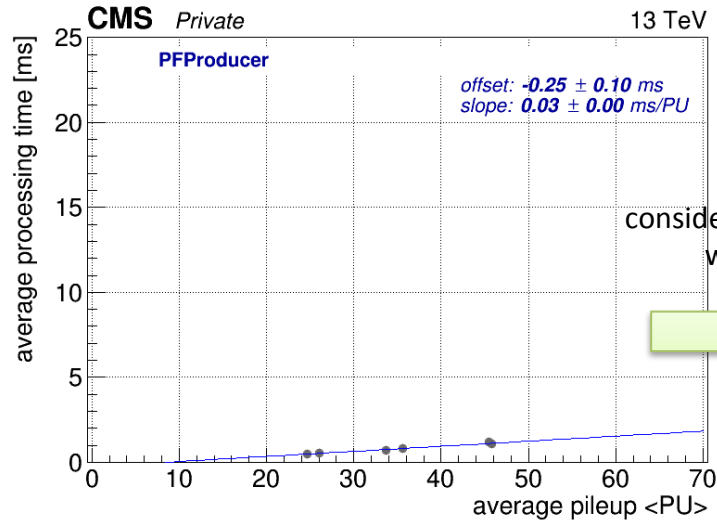


considering only fraction of events  
which run this module  
~45%

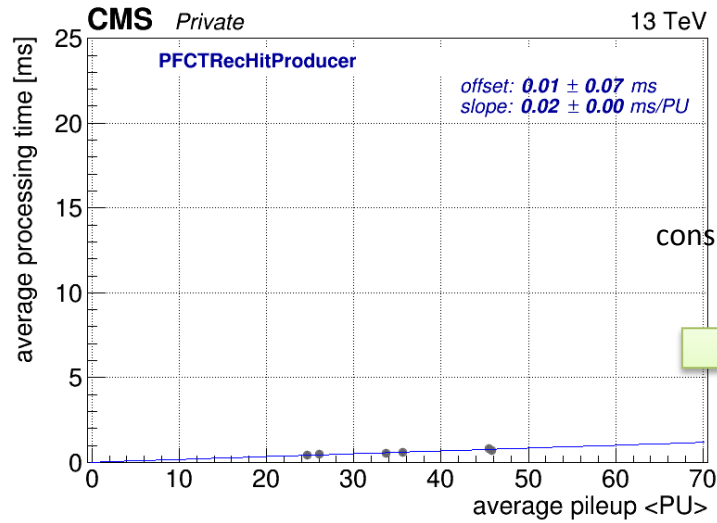
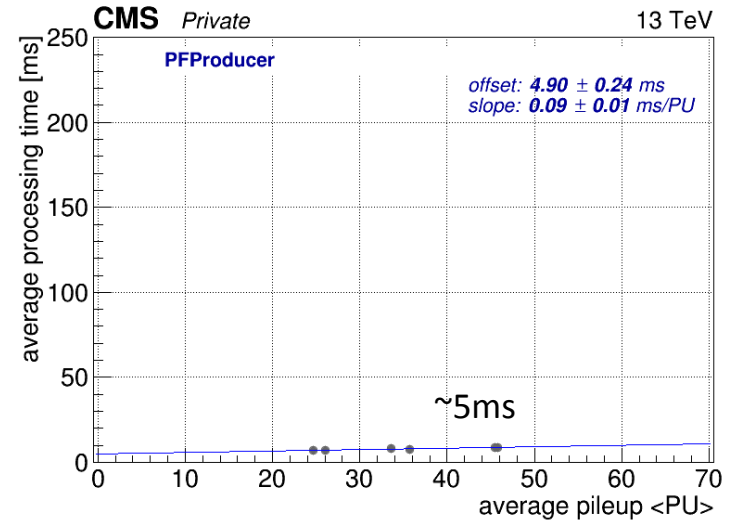




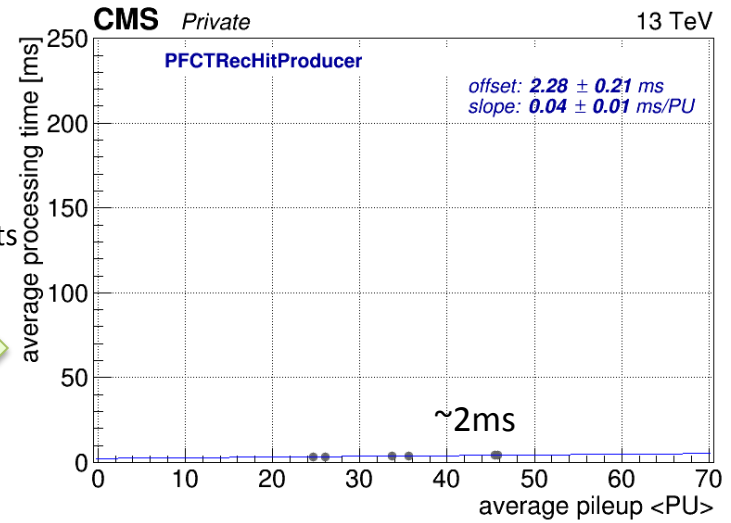
# PF reconstruction (II)

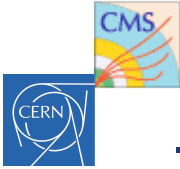


considering only fraction of events  
which run this module  
~10%

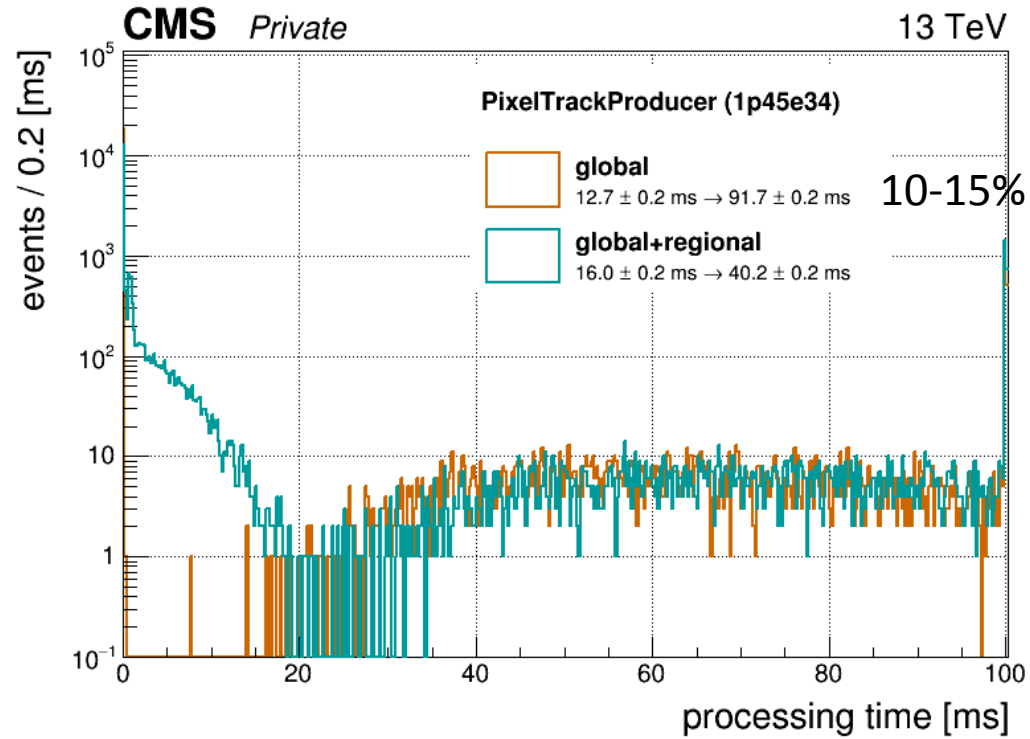


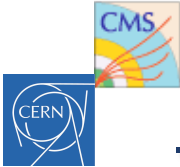
considering only fraction of events  
which run this module  
~10-20%



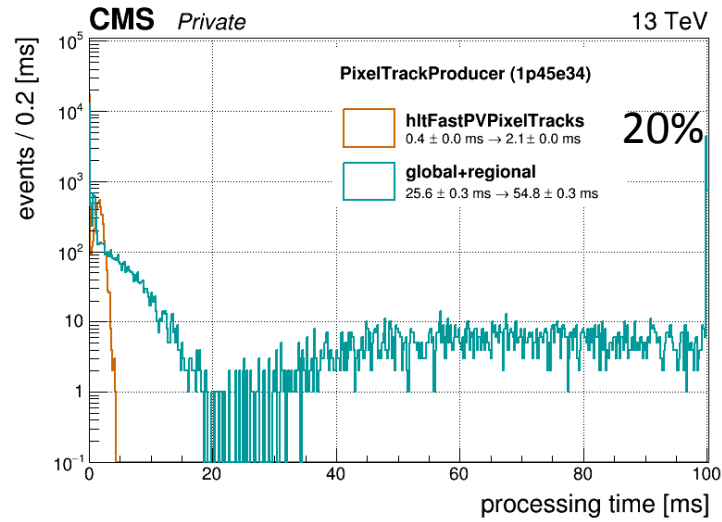
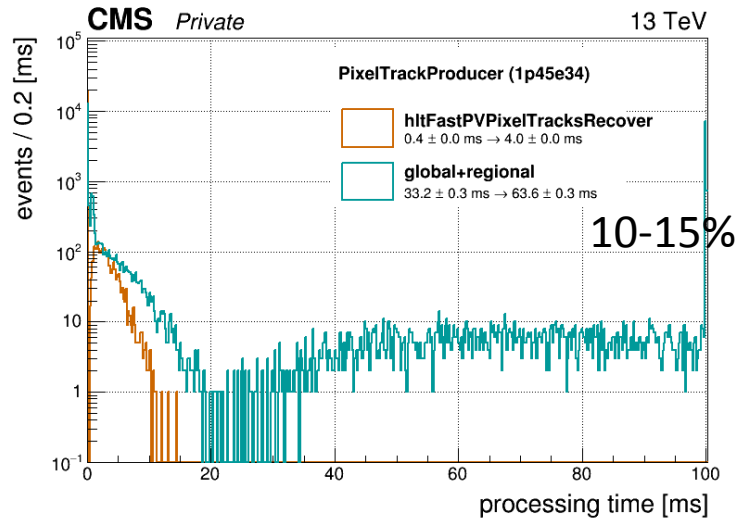


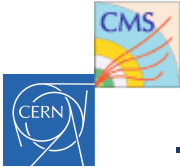
# pixel track reconstruction (global)



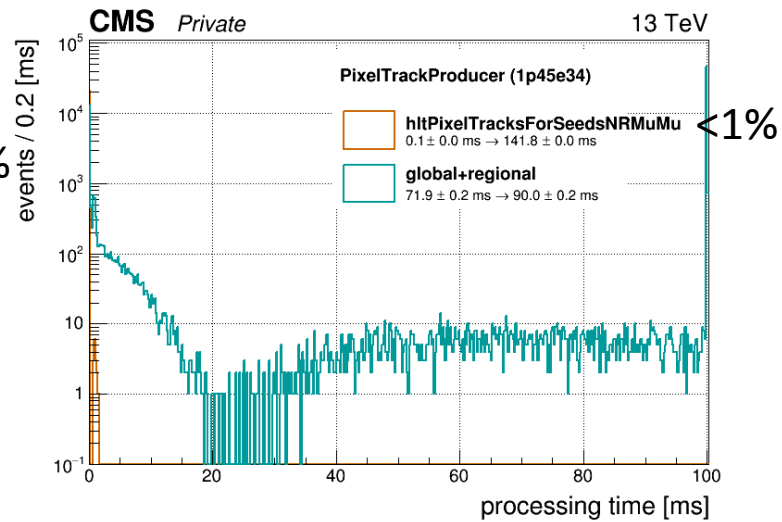
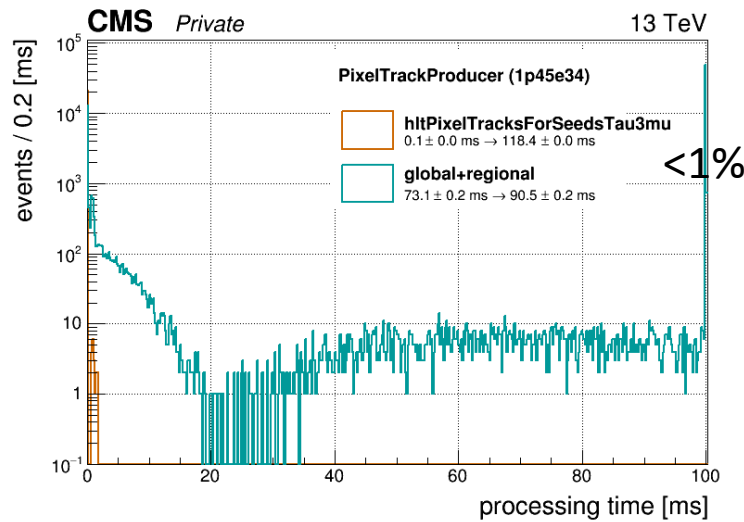
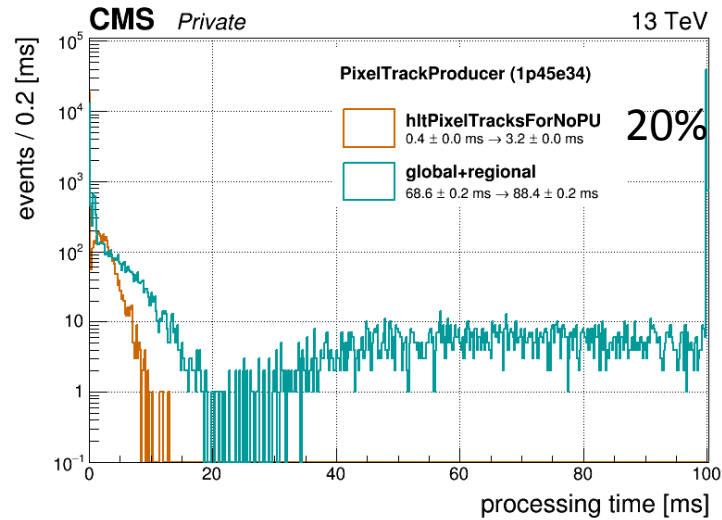
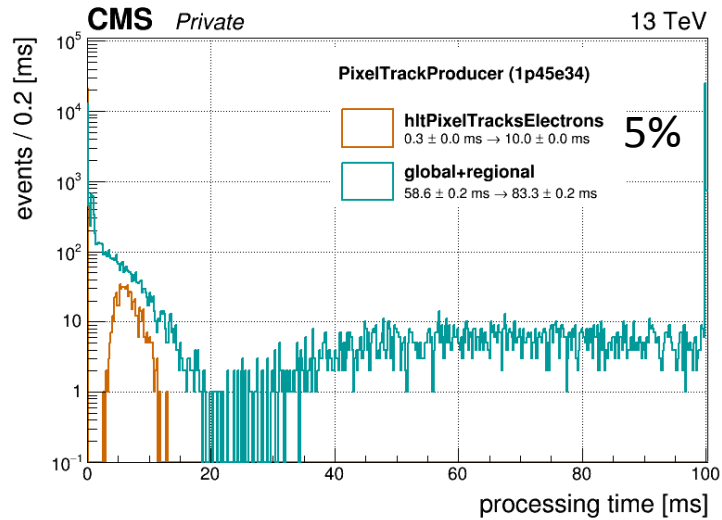


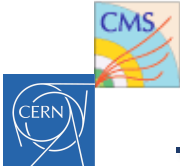
# pixel track reconstruction (regional)



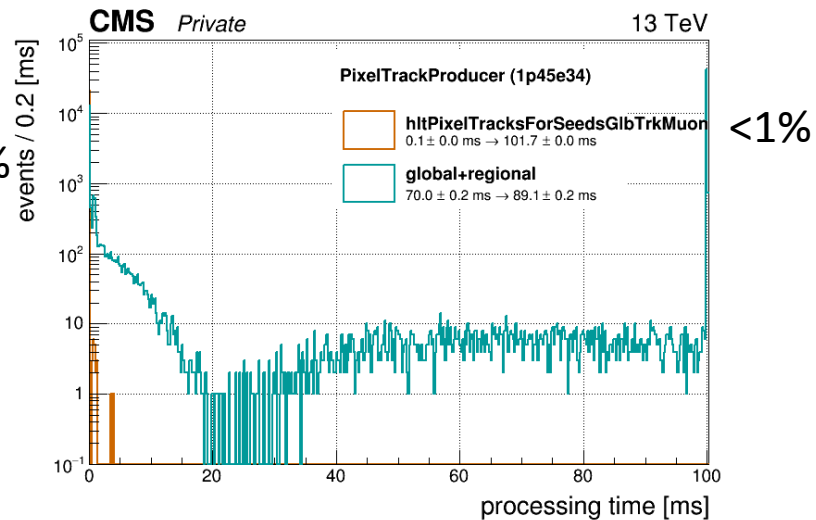
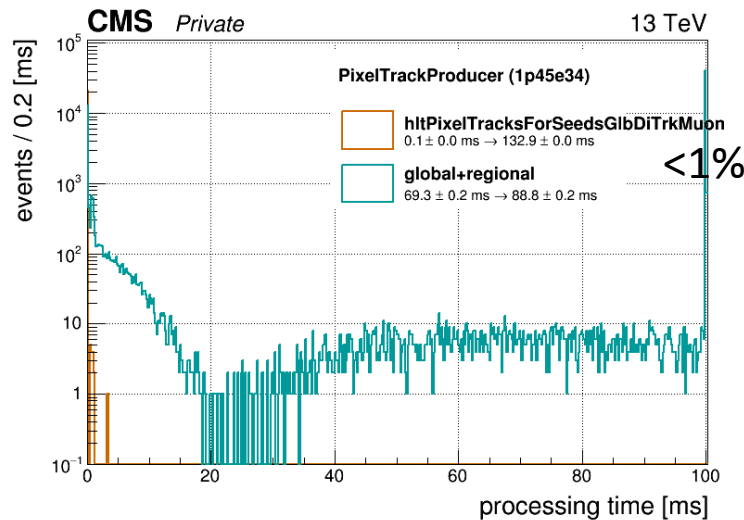
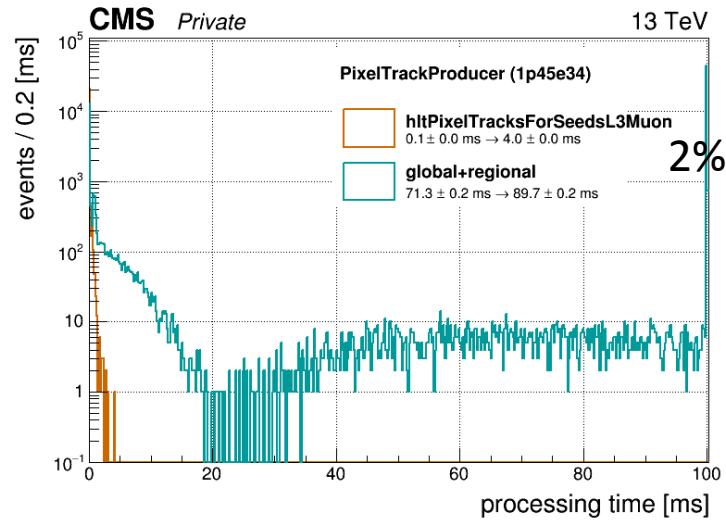
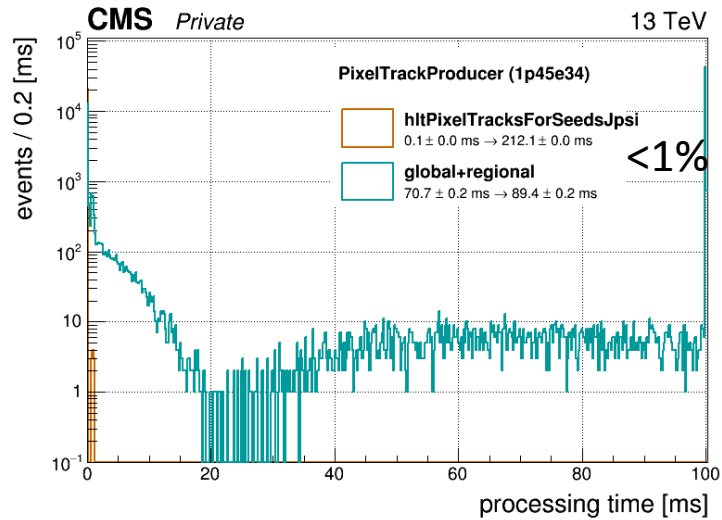


# pixel track reconstruction (regional)

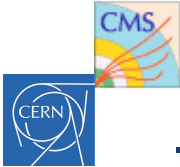




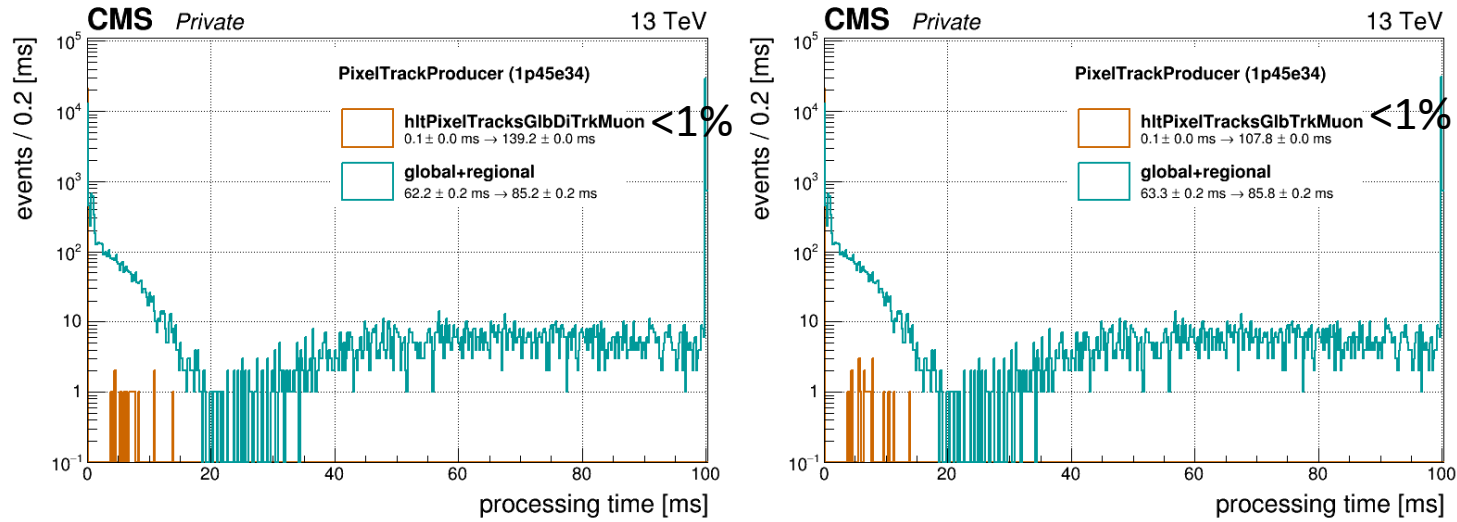
# pixel track reconstruction (regional)

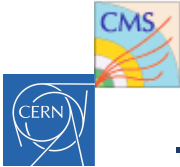




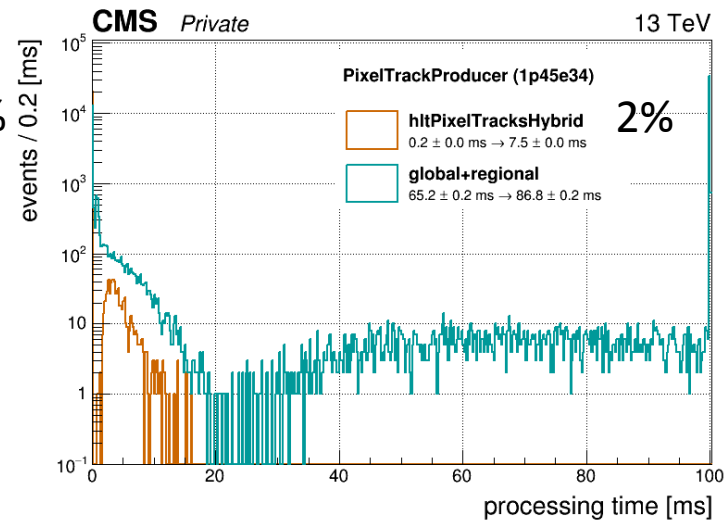
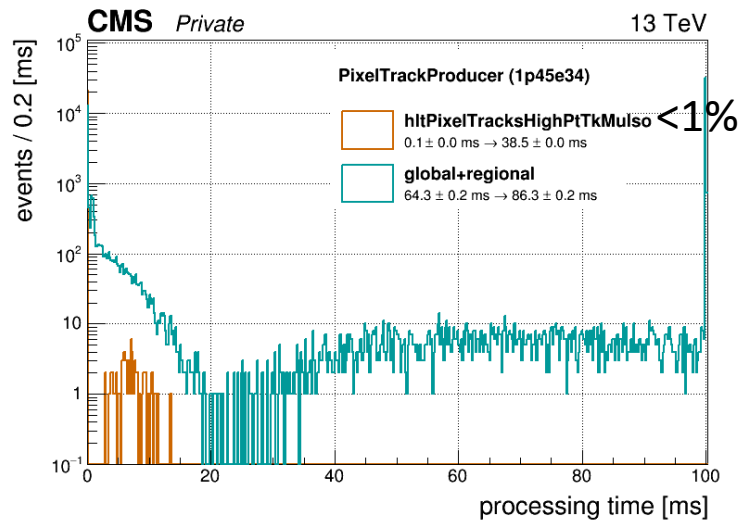
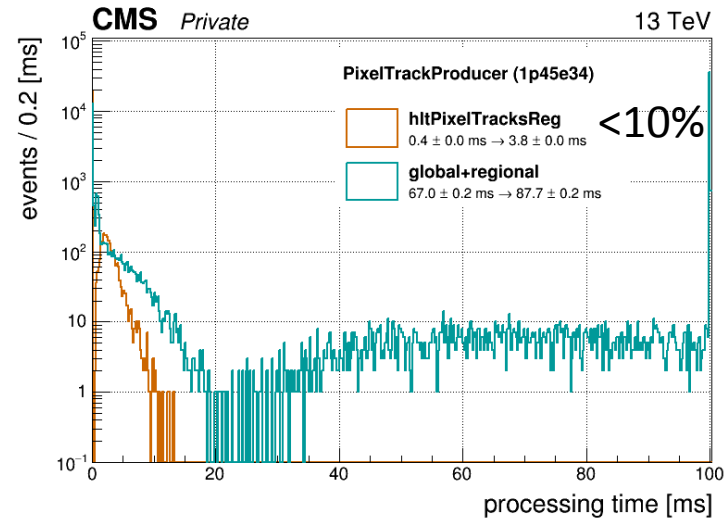
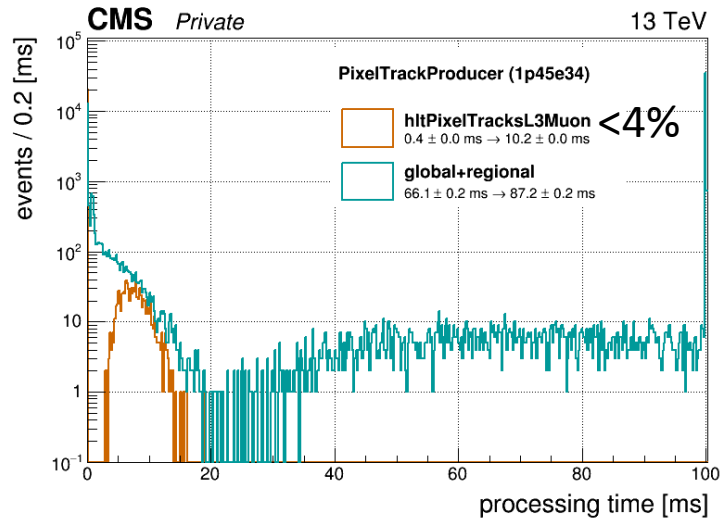


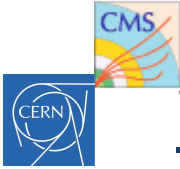
# pixel track reconstruction (regional)



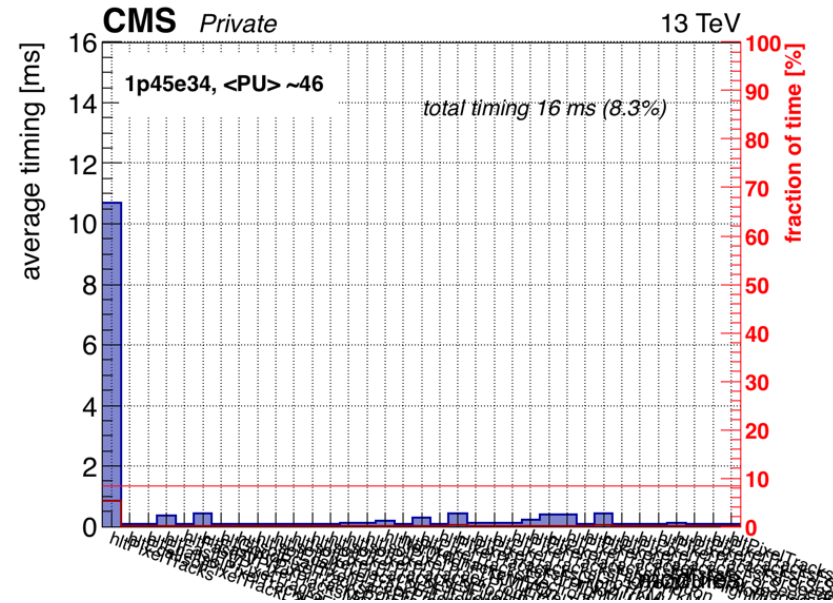
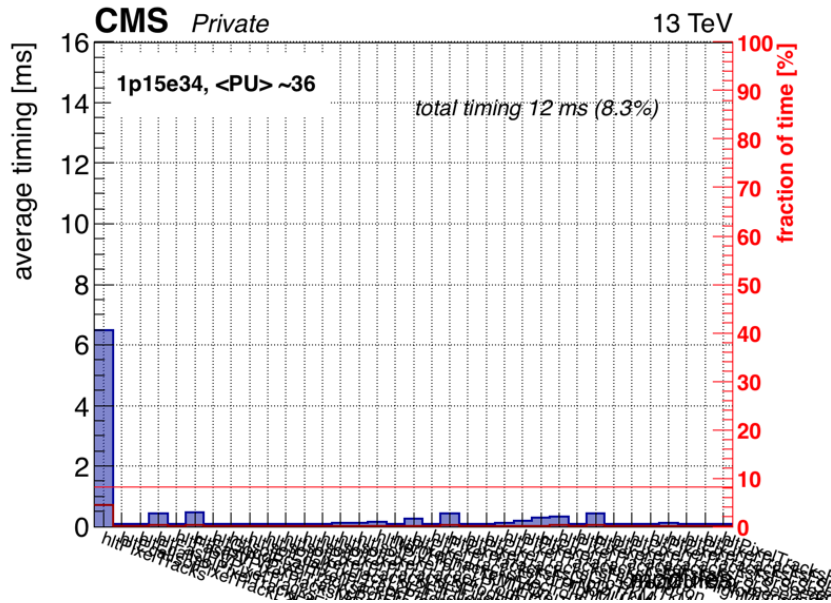
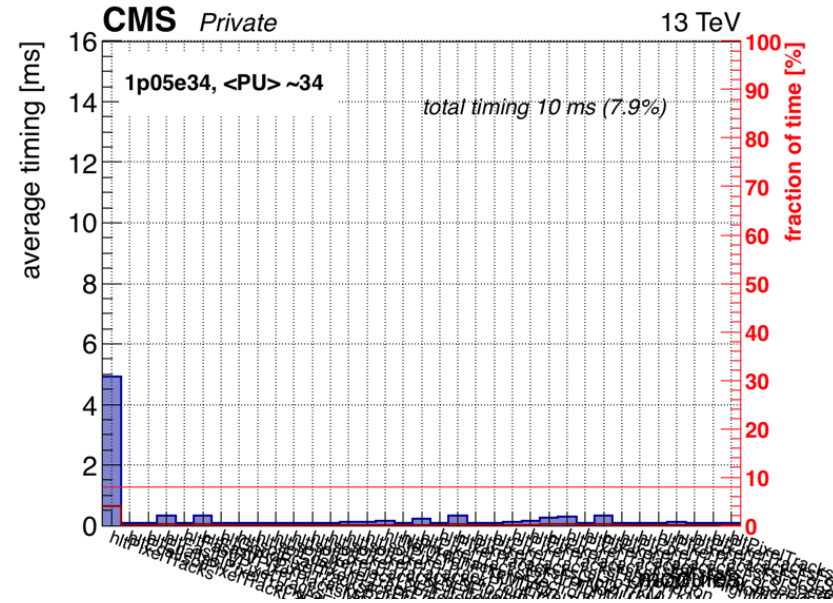
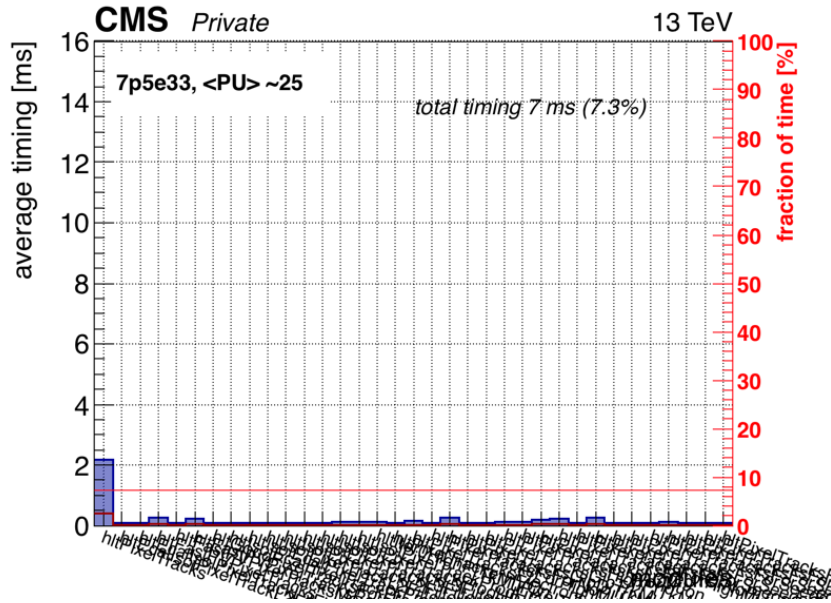


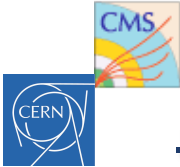
# pixel track reconstruction (regional)





# tracking timing





# L1 menu in 2017 (draft)

| L1 trigger                             | 1.45e34 (2016) | 1.7e34 (2017) | 2.0e34 (2017) |
|--|----------------|---------------|---------------|
| <b>Muon triggers</b>                   |                |               |               |
| L1_SingleMu20er OR L1_SingleMu22       | 1              | 1             | 1             |
| L1_SingleMu22er OR L1_SingleMu25       | 1              | 1             | 1             |
| L1_DoubleMu_12_5                       | 1              | 1             | 0             |
| L1_DoubleMu_12_8 OR 13_6 OR 15_5       | 1              | 1             | 1             |
| L1_TripleMu_5_0_0                      | 1              | 0             | 0             |
| L1_TripleMu_5_5_3                      | 1              | 1             | 1             |
| L1_QuadMu0                             | 1              | 1             | 1             |
|  |                |               |               |
| L1_DoubleMu0er1p25_dEta_Max1p8_OS      | 1              | 1             | 1             |
| L1_DoubleMu0er1p4_dEta_Max1p8_OS       | 1              | 1             | 1             |
| L1_Mu3_JetC120_dEta_Max0p4_dPhi_Max0p4 | 1              | 1             | 1             |
| <b>E/Gamma triggers</b>                |                |               |               |
| L1_SingleIsoEG32er OR IsoEG34 OR EG36  | 1              | 0             | 0             |
| L1_SingleIsoEG34er OR IsoEG36 OR EG38  | 1              | 1             | 0             |
| L1_SingleIsoEG36er OR IsoEG38 OR EG40  | 1              | 1             | 1             |
| L1_DoubleEG_24_17                      | 1              | 1             | 1             |
| L1_DoubleEG_25_12                      | 1              | 1             | 1             |
| L1_TripleEG_18_17_8                    | 1              | 1             | 1             |
| <b>Tau triggers and cross-triggers</b> |                |               |               |
| L1_SingleTau120er                      | 1              | 1             | 1             |
| L1_DoubleTau50er                       | 1              | 1             | 0             |
| L1_DoubleTau70er                       | 1              | 1             | 1             |
| L1_DoubleIsoTau30er                    | 1              | 1             | 0             |
| L1_DoubleIsoTau33er                    | 1              | 1             | 1             |
| L1_Mu18er_Tau20er                      | 1              | 1             | 1             |
| L1_Mu20er_IsoTau26er                   | 1              | 1             | 1             |
| L1_IsoEG22er_IsoTau26er_dEta_Min0p2    | 1              | 1             | 1             |

| L1 trigger                      | 1.45e34 (2016) | 1.7e34 (2017) | 2.0e34 (2017) |
|---------------------------------|----------------|---------------|---------------|
| <b>Jet triggers</b>             |                |               |               |
| L1_SingleJet180                 | 1              | 1             | 1             |
| L1_DoubleJetC112                | 1              | 1             | 1             |
| L1_TripleJet_92_76_64_VBF       | 1              | 1             | 1             |
| L1_QuadJetC50                   | 1              | 1             | 1             |
| <b>Energy sum triggers</b>      |                |               |               |
| L1_ETM100                       | 1              | 0             | 0             |
| L1_ETM105                       | 1              | 1             | 0             |
| L1_ETM115                       | 1              | 1             | 1             |
| L1_HTT300                       | 1              | 0             | 0             |
| L1_HTT320                       | 1              | 1             | 0             |
| L1_HTT360                       | 1              | 1             | 1             |
| <b>Mu + EG cross-triggers</b>   |                |               |               |
| L1_Mu20_EG15                    | 1              | 1             | 1             |
| L1_Mu20_IsoEG6                  | 1              | 1             | 1             |
| L1_Mu23_EG10                    | 1              | 1             | 1             |
| L1_Mu23_IsoEG10                 | 1              | 1             | 1             |
| L1_Mu5_EG23                     | 1              | 1             | 1             |
| L1_Mu5_IsoEG20                  | 1              | 1             | 1             |
| L1_DoubleMu7_EG7                | 1              | 1             | 1             |
| L1_Mu6_DoubleEG10               | 1              | 1             | 0             |
| L1_Mu6_DoubleEG17               | 1              | 1             | 1             |
| <b>Energy sum cross-trigger</b> |                |               |               |
| L1_DoubleMu0_ETM65              | 1              | 0             | 0             |
| L1_DoubleMu0_ETM70              | 1              | 1             | 0             |
| L1_DoubleJetC60_ETM60           | 0              | 0             | 0             |
| L1_Mu6_HTT200                   | 1              | 1             | 1             |
| L1_EG27er_HTT200                | 1              | 1             | 0             |
| L1_DoubleEG6_HTT255             | 1              | 0             | 0             |



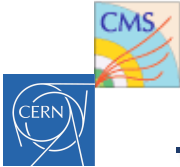
IsoEG36er OR IsoEG38 OR EG40 !



ETM115



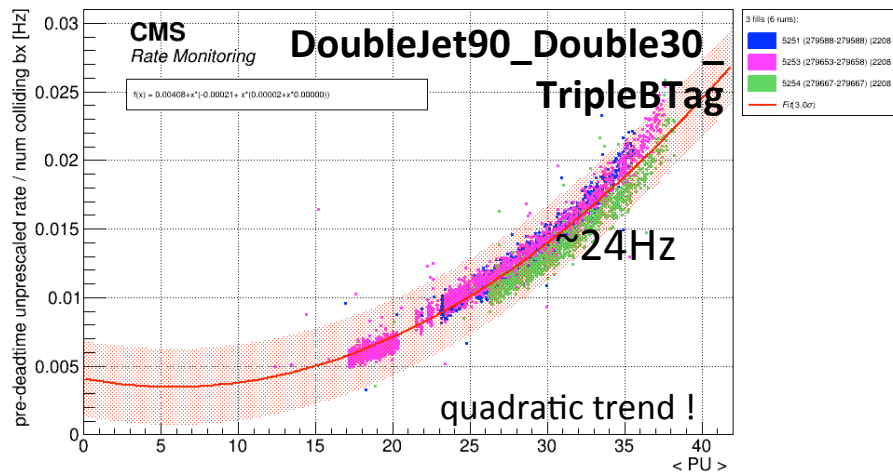
HTT360



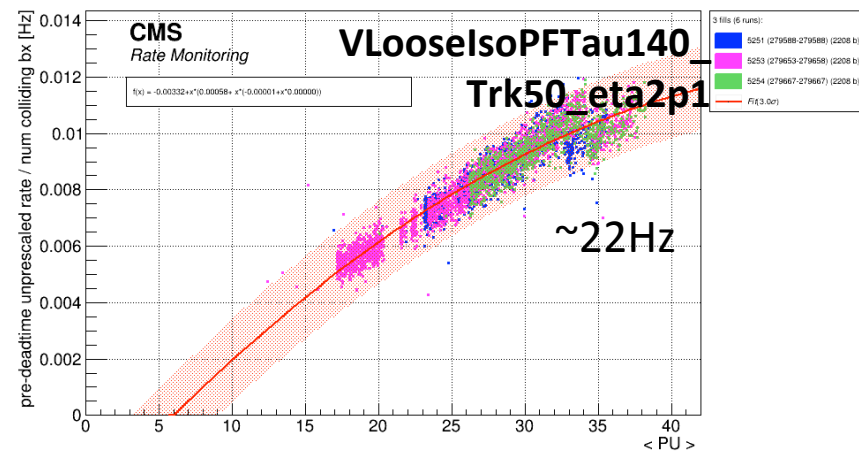
# rate : PU dependence

Rates evolution with PU for some highest consumers:

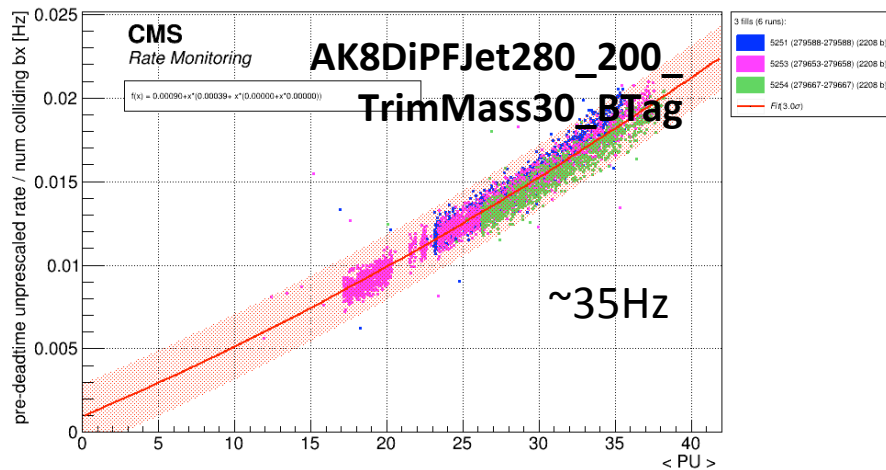
HLT\_DoubleJet90\_Double30\_TripleBTagCSV\_p087



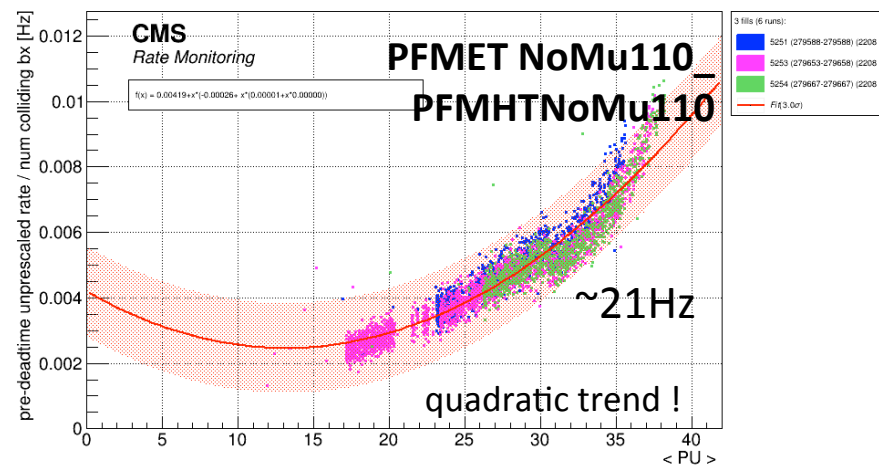
HLT\_VLooselsoPFTau140\_Trk50\_eta2p1



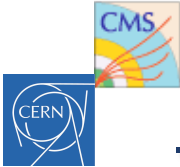
HLT\_AK8DiPFJet280\_200\_TrimMass30\_BTagCSV\_p20



HLT\_PFMETNoMu110\_PFMHTNoMu110\_IDTight



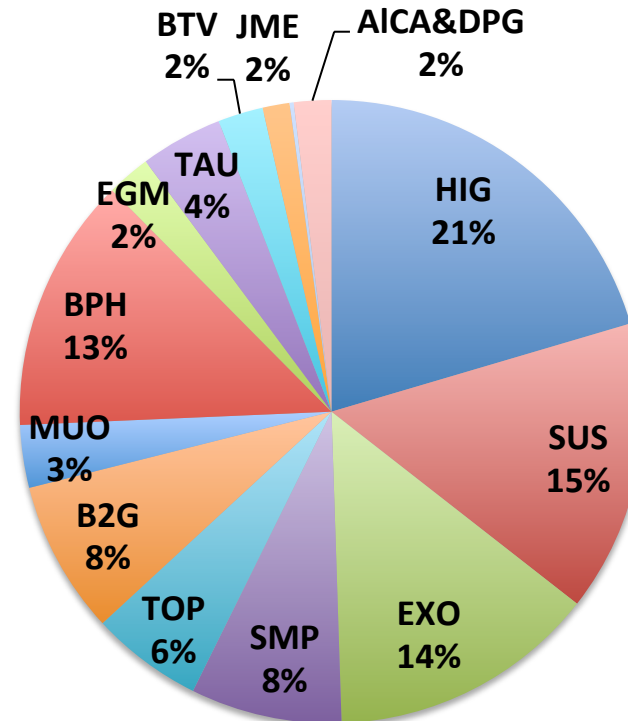
→ extrapolate rates to 2017 expected running conditions:  $1.6e34 - 2.0e34$  @ PU  $\sim(46 - 58)$



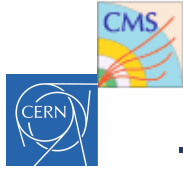
# HLT trigger in 2016: rate

HLT menu v4.2  
 PS column 1.35e34  
 PU~42

| Group       | Rate [Hz] |         |         |
|-------------|-----------|---------|---------|
|             | Total     | Prop.   | Pure    |
| HIG         | 630 ± 2   | 234 ± 1 | 107 ± 1 |
| SUS         | 510 ± 1   | 173 ± 1 | 86 ± 1  |
| EXO         | 432 ± 1   | 159 ± 1 | 59 ± 1  |
| SMP         | 420 ± 1   | 90 ± 1  | 6 ± 1   |
| TOP         | 354 ± 1   | 66 ± 1  | 0 ± 1   |
| B2G         | 336 ± 1   | 91 ± 1  | 22 ± 1  |
| MUO         | 216 ± 1   | 37 ± 1  | 1 ± 1   |
| BPH         | 159 ± 1   | 152 ± 1 | 149 ± 1 |
| EGM         | 141 ± 1   | 26 ± 1  | 1 ± 1   |
| TAU         | 136 ± 1   | 49 ± 1  | 17 ± 1  |
| BTV         | 47 ± 1    | 27 ± 1  | 18 ± 1  |
| JME         | 36 ± 1    | 16 ± 1  | 6 ± 1   |
| FSQ         | 6 ± 1     | 2 ± 1   | 0 ± 1   |
| AICa & DPGs | 71 ± 1    | 22 ± 1  | 2 ± 1   |



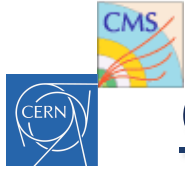
- **Total rate per group** := sum of the triggers rate used by group
  - the biggest consumers are the **HIG**, **SUS** and **EXO** PAGs (~ 50% of the total rate)
- **Proportional rate per group** := rate from single-group triggers → rate takes into account co-ownership
  - **HIG** is again the main consumer (~20%)
  - the top 5 is very similar to that of total rates, except for **BPH** (very particular phase space)
- **Pure rate per group** := rate from single-group triggers
  - **BPH** group is here the biggest consumer due to phase-space (~95% of its total rate)
  - **HIG**, **SUS** and **EXO** are again among the biggest consumers (~16% of their total rate)
  - **TOP** group has no pure rate



# prompt monitoring

- on Nov 23<sup>rd</sup>, we held a dedicated meeting on “trigger prompt monitoring” in order to have a more clear view of the current status [ questions ]
  - ⚠ almost all groups rely on offline analyses
    - not run on regular base
    - manpower
  - ⚠ many groups do not know what is the DQM
  - ⚠ many groups answered by showing what they do w/ MC !
  - ⚠ almost anybody got that we are going to ask for adding special workflows
- offline analyses rely on 3 methods
  - ✓ tag-n-probe
  - ✓ reference
  - ✓ orthogonal

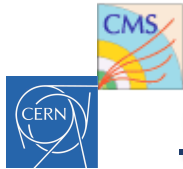
it should be not so difficult to port the code to DQM
- a decent monitoring can be done by using  $\sim O(200) \text{ pb}^{-1} \rightarrow$  multirun harvesting !
- do we need miniAOD information ?
- which object IDs we will make use as reference ?
- ✓ some groups start working on this
  - TAU, MUO



# online DQM

- ✓ online DQM is the most prompt monitoring available ;)
- ⚠ the trigger monitoring is limited by 2 main factors
  - no offline quantities available
  - limited statistics [ 10% of physics → ~100 Hz → some (physics) events per hour ]
- timing and rate monitoring per path
  - too many histograms in the same directory
    - we need to show histograms in different directories
      - ☐ by PD (?) → at which level do we know PDs (only confDB ?) [JIRA #1158](#)
- trigger objects monitoring → [JIRA #1155](#)
  - out-dated list of paths
    - we need to enforce the update of the online DQM configuration → STEAM task (in synch w/ the deployment of new menu)
  - many histograms have low statistics and there are a lot of fluctuations
    - we need to enforce the check of PS
    - we need a better binning
  - missing HT, electron and tau
    - we need to enforce the minimal set of objects
    - code can be made more modular














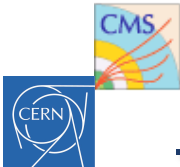
# offline DQM

- some trigger objects and trigger algorithms rely on a special event content
- ➔ we have a dedicated stream w/ HLTMonitor PD
  - ✓ currently used only by TRK, strip and BTV
  - we need to add other tracks flavour : EGM (in progress), MUO, displaced jets, etc
  - we should add the efficiency and fake of the b-tagging

⚠ it is the area where we are suffering most !

- 🎯 we should try to avoid increase of entropy
- 🎯 we should try to define a common strategy
- 🎯 we should try to exploit as much as possible the same code
- 🎯 we should try to share the effort
- coordinate the work among different groups (see next)
- coordinate w/ core DQM

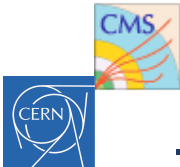
| DPG   | POG  | PAG   |
|---|--|---|
| ECAL <span style="border: 1px solid black; padding: 2px;">TODO</span>                       | BTV           | BPH <span style="border: 1px solid black; padding: 2px;">TODO</span>                      |
| HCAL <span style="border: 1px solid black; padding: 2px;">TODO</span>                       | EGM: electro  | B2G <span style="border: 1px solid black; padding: 2px;">TODO</span>                      |
| DT, RPC, CSC <span style="border: 1px solid black; padding: 2px;">TODO</span>               | EGM: photon <span style="border: 1px solid black; padding: 2px;">TODO</span>                       | EXO <span style="border: 1px solid black; padding: 2px;">TODO</span>                      |
| strip  | JetMET        | FSQ  |
| pixel <span style="border: 1px solid black; padding: 2px;">TODO</span>                      | Muon          | HIG  |
|   | Tau           | SMP <span style="border: 1px solid black; padding: 2px;">TODO</span>                      |
|   | tracking      | SUSY <span style="border: 1px solid black; padding: 2px;">TODO</span>                     |
|   |  | TOP <span style="border: 1px solid black; padding: 2px;">TODO</span>                      |



# HLT-DQM developers

|    | A               | B   | C   | D   | E   | F    | G   | H   | I   | J    | K   | L    | M   | N   | O   | P   | Q | R      | S                                   |
|----|-----------------|-----|-----|-----|-----|------|-----|-----|-----|------|-----|------|-----|-----|-----|-----|---|--------|-------------------------------------|
| 1  |                 | BTV | EGM | JME | MUO | TAU  | TRK | B2G | BPH | EXO  | FSQ | HIG  | SMP | SUS | TOP | HIN |   | legend |                                     |
| 2  | single muon     |     |     |     |     |      |     |     |     | jose |     |      |     |     |     |     |   |        | not needed                          |
| 3  | double muon     |     |     |     |     |      |     |     |     | jose |     |      |     |     |     |     |   |        | parassitic                          |
| 4  | single electron |     |     |     |     |      |     |     |     | jose |     |      |     |     |     |     |   |        | TODO                                |
| 5  | double electron |     |     |     |     |      |     |     |     | jose |     |      |     |     |     |     |   |        | started                             |
| 6  | single photon   |     |     |     |     |      |     |     |     | jose |     |      |     |     |     |     |   |        |                                     |
| 7  | double photon   |     |     |     |     |      |     |     |     | jose |     |      |     |     |     |     |   |        | developping code                    |
| 8  | jet (AK4)       |     |     |     |     |      |     |     |     | jose |     |      |     |     |     |     |   |        | seeking for approval (PR submitted) |
| 9  | jet (AK8)       |     |     |     |     |      |     |     |     | jose |     |      |     |     |     |     |   |        | approved                            |
| 10 | single tau      |     |     |     |     | sami |     |     |     | jose |     | sami |     |     |     |     |   |        |                                     |
| 11 | double tau      |     |     |     |     | sami |     |     |     | jose |     | sami |     |     |     |     |   |        |                                     |
| 12 | tau+X           |     |     |     |     | sami |     |     |     |      |     |      |     |     |     |     |   |        |                                     |
| 13 | met             |     |     |     |     |      |     |     |     | jose |     |      |     |     |     |     |   |        |                                     |
| 14 | ht              |     |     |     |     |      |     |     |     | jose |     |      |     |     |     |     |   |        |                                     |
| 15 | alphaT          |     |     |     |     |      |     |     |     |      |     |      |     |     |     |     |   |        |                                     |
| 16 | b-tagging       |     |     |     |     |      |     |     |     |      |     |      |     |     |     |     |   |        |                                     |
| 17 | tracks          |     |     |     |     |      | mia |     |     | jose |     |      |     |     |     |     |   |        |                                     |
| 18 | strip           |     |     |     |     |      | mia |     |     |      |     |      |     |     |     |     |   |        |                                     |
| 19 |                 |     |     |     |     |      |     |     |     |      |     |      |     |     |     |     |   |        |                                     |
| 20 |                 |     |     |     |     |      |     |     |     |      |     |      |     |     |     |     |   |        |                                     |
| 21 |                 |     |     |     |     |      |     |     |     |      |     |      |     |     |     |     |   |        |                                     |
| 22 |                 |     |     |     |     |      |     |     |     |      |     |      |     |     |     |     |   |        |                                     |
| 23 |                 |     |     |     |     |      |     |     |     |      |     |      |     |     |     |     |   |        |                                     |
| 24 |                 |     |     |     |     |      |     |     |     |      |     |      |     |     |     |     |   |        |                                     |
| 25 |                 |     |     |     |     |      |     |     |     |      |     |      |     |     |     |     |   |        |                                     |

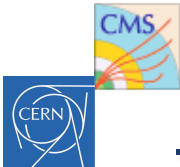
+ ≡ 2 developer code (source & client) GUI (render plugin & layout)



# HLT-DQM code: source&client

|    | A               | B   | C   | D   | E   | F      | G   | H   | I   | J   | K   | L      | M   | N   | O   | P   | Q | R      | S   |
|----|-----------------|-----|-----|-----|-----|--------|-----|-----|-----|-----|-----|--------|-----|-----|-----|-----|---|--------|---|
| 1  |                 | BTV | EGM | JME | MUO | TAU    | TRK | B2G | BPH | EXO | FSQ | HIG    | SMP | SUS | TOP | HIN |   | legend |   |
| 2  | single muon     |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        | not needed                                  |
| 3  |                 |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        | parassitic                                  |
| 4  | double muon     |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        | TODO  |
| 5  |                 |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        | started                                     |
| 6  | single electron |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        | developping code                            |
| 7  |                 |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        | seeking for approval (PR submitted)         |
| 8  | double electron |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        | approved                                    |
| 9  |                 |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        | <a href="#">source python configuration</a> |
| 10 | single photon   |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        | <a href="#">client python configuration</a> |
| 11 |                 |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        |   |
| 12 | double photon   |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        |   |
| 13 |                 |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        |   |
| 14 | jet (AK4)       |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        |   |
| 15 |                 |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        |   |
| 16 | jet (AK8)       |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        |   |
| 17 |                 |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        |   |
| 18 | single tau      |     |     |     |     | source |     |     |     |     |     | source |     |     |     |     |   |        |   |
| 19 |                 |     |     |     |     | client |     |     |     |     |     | client |     |     |     |     |   |        |   |
| 20 | double tau      |     |     |     |     | source |     |     |     |     |     | source |     |     |     |     |   |        |   |
| 21 |                 |     |     |     |     | client |     |     |     |     |     | client |     |     |     |     |   |        |   |
| 22 | tau+X           |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        |   |
| 23 |                 |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        |   |
| 24 | met             |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        |   |
| 25 |                 |     |     |     |     |        |     |     |     |     |     |        |     |     |     |     |   |        |   |

+ ☰ 2 developer ▾ code (source & client) ▾ GUI (render plugin & layout) ▾



# HLT-DQM render plugins

|    | A               | B   | C   | D   | E   | F   | G   | H   | I   | J   | K   | L   | M   | N   | O   | P   | Q | R | S   |
|----|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---|---|---|
| 1  |                 | BTV | EGM | JME | MUO | TAU | TRK | B2G | BPH | EXO | FSQ | HIG | SMP | SUS | TOP | HIN |   |   | legend                                      |
| 2  | single muon     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   | not needed                                  |
| 3  |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   | parassitic                                  |
| 4  | double muon     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   | TODO  |
| 5  |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   | started                                     |
| 6  | single electron |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   | developping code                            |
| 7  |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   | seeking for approval (PR submitted)         |
| 8  | double electron |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   | approved                                    |
| 9  |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   | <a href="#">source python configuration</a> |
| 10 | single photon   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   | <a href="#">client python configuration</a> |
| 11 |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 12 | double photon   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 13 |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 14 | jet (AK4)       |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 15 |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 16 | jet (AK8)       |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 17 |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 18 | single tau      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 19 |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 20 | double tau      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 21 |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 22 | tau+X           |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 23 |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 24 | met             |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |
| 25 |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |   |   |   |

+ ☰ **2** developer ▾ code (source & client) ▾ GUI (render plugin & layout) ▾