Feasibility studies on Level 1 Electron Trigger with Pixels

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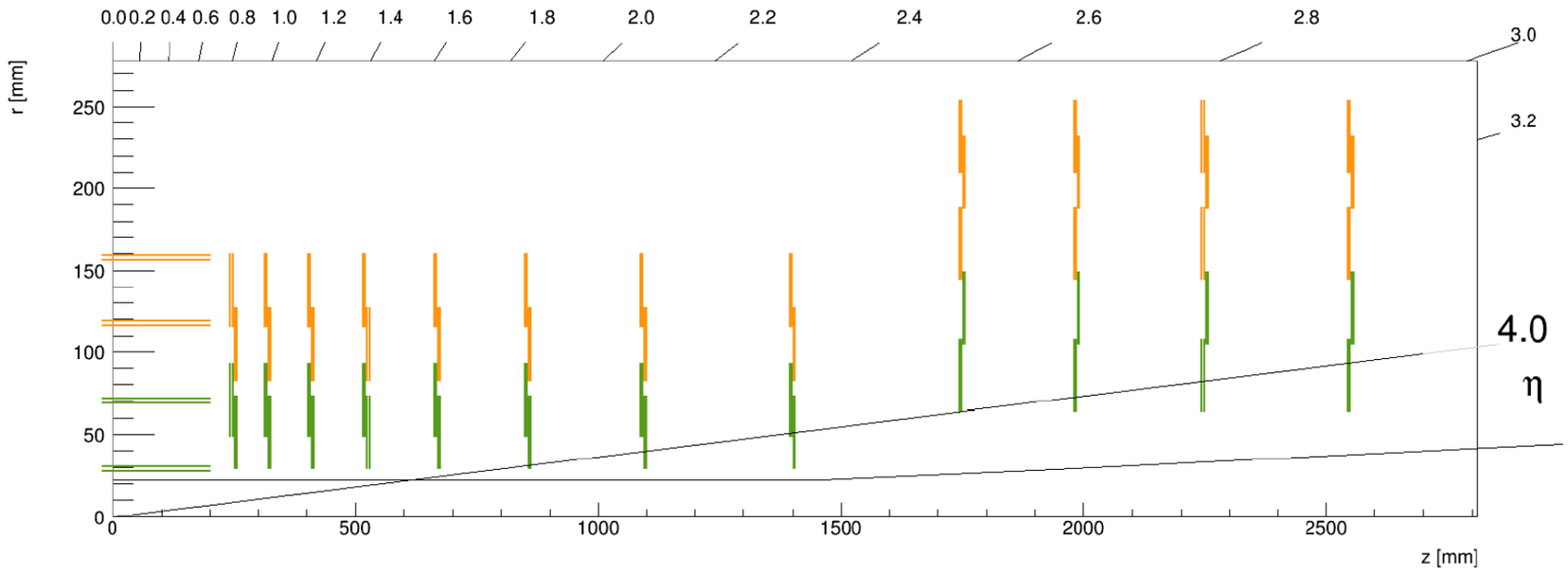
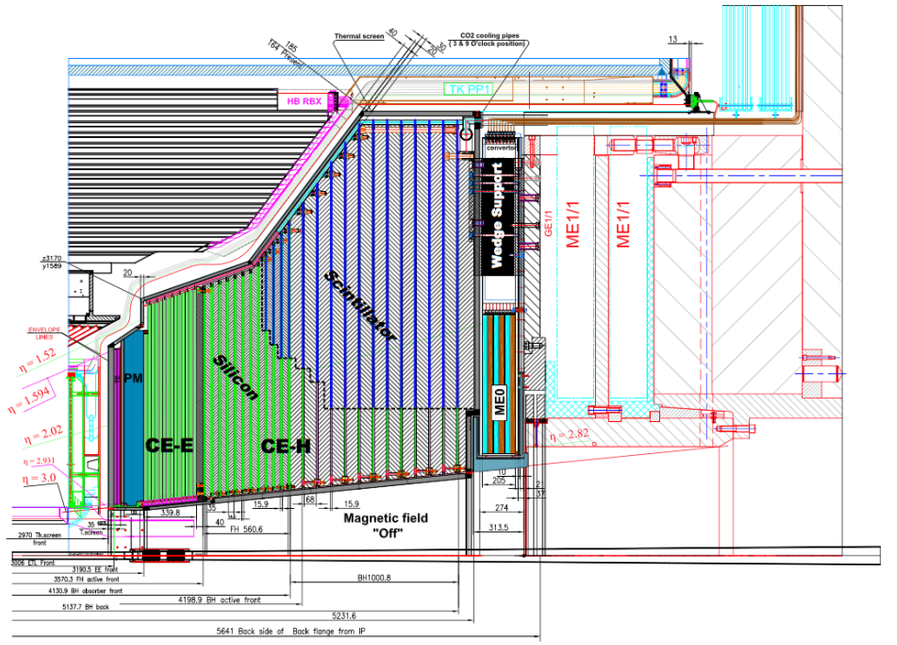
Pixel trigger meeting, 13 Nov 2018

Phase 2 Pixel detector and Electromagnetic calorimeters

Inner pixel detector

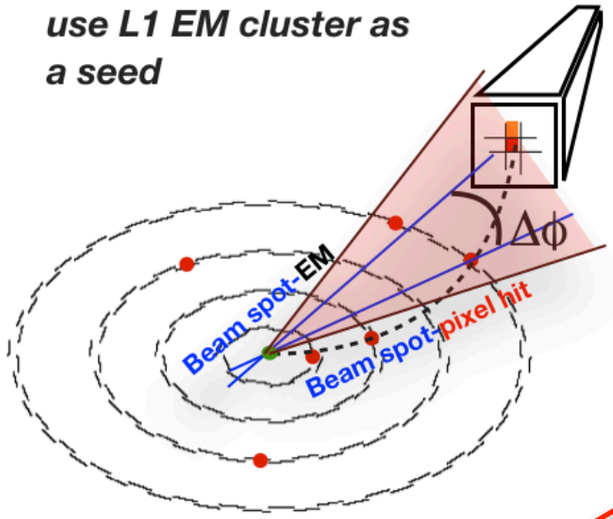


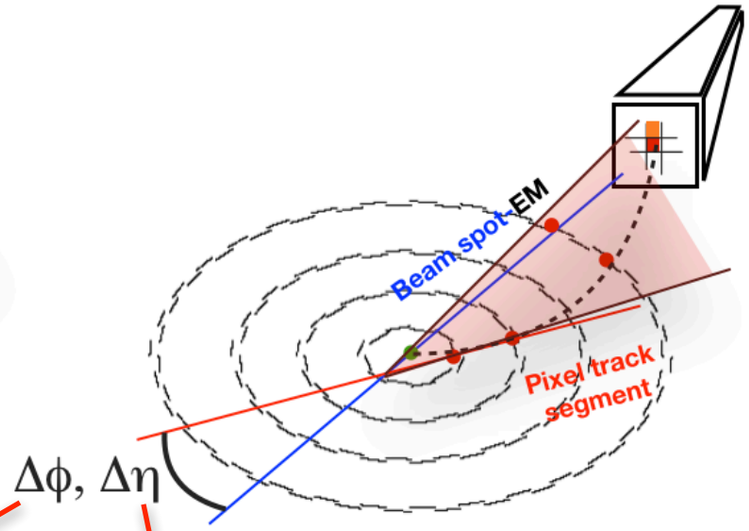
Electromagnetic calorimeter :
Barrel Calorimeter (single crystal) & High Granularity Calorimeter

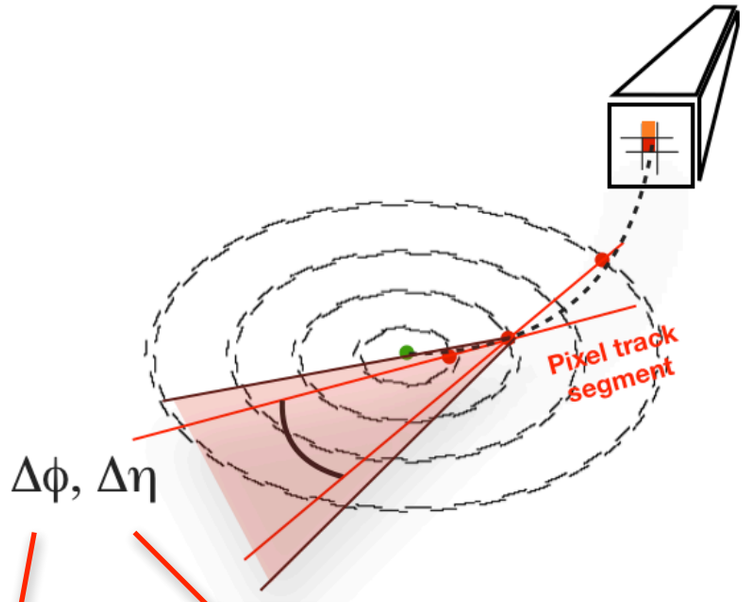


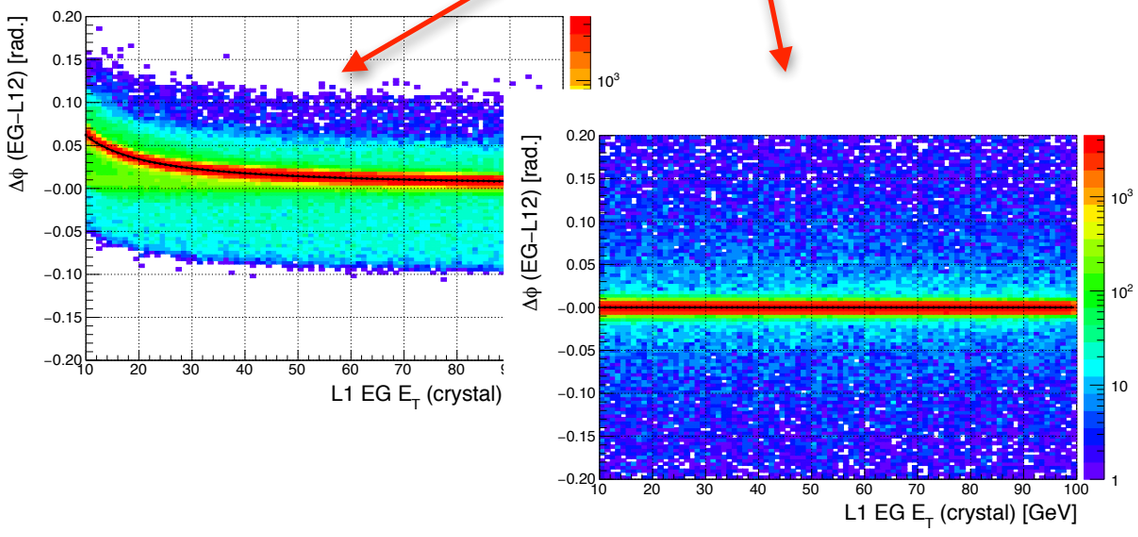
- Expected to have improved resolution of L1 e/gamma objects from the upgraded calorimeters
  - Crystal level information available for the barrel calorimeter at L1
  - New High Granularity endcap Calorimeter will be installed
- Smaller pixels and the extended η coverage up to 4.
- We study the feasibility of the L1 pixel electron trigger matching the L1 e/gamma objects from these upgraded calorimeters with the clusterized pixel hits

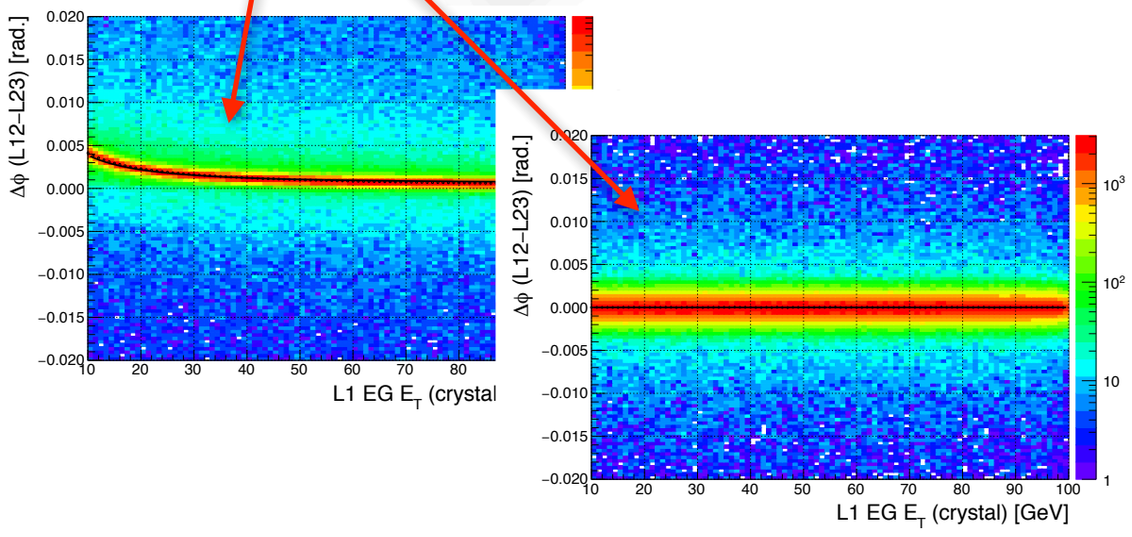
L1 pixel trigger strategy for electron(PiXTRK algorithm)





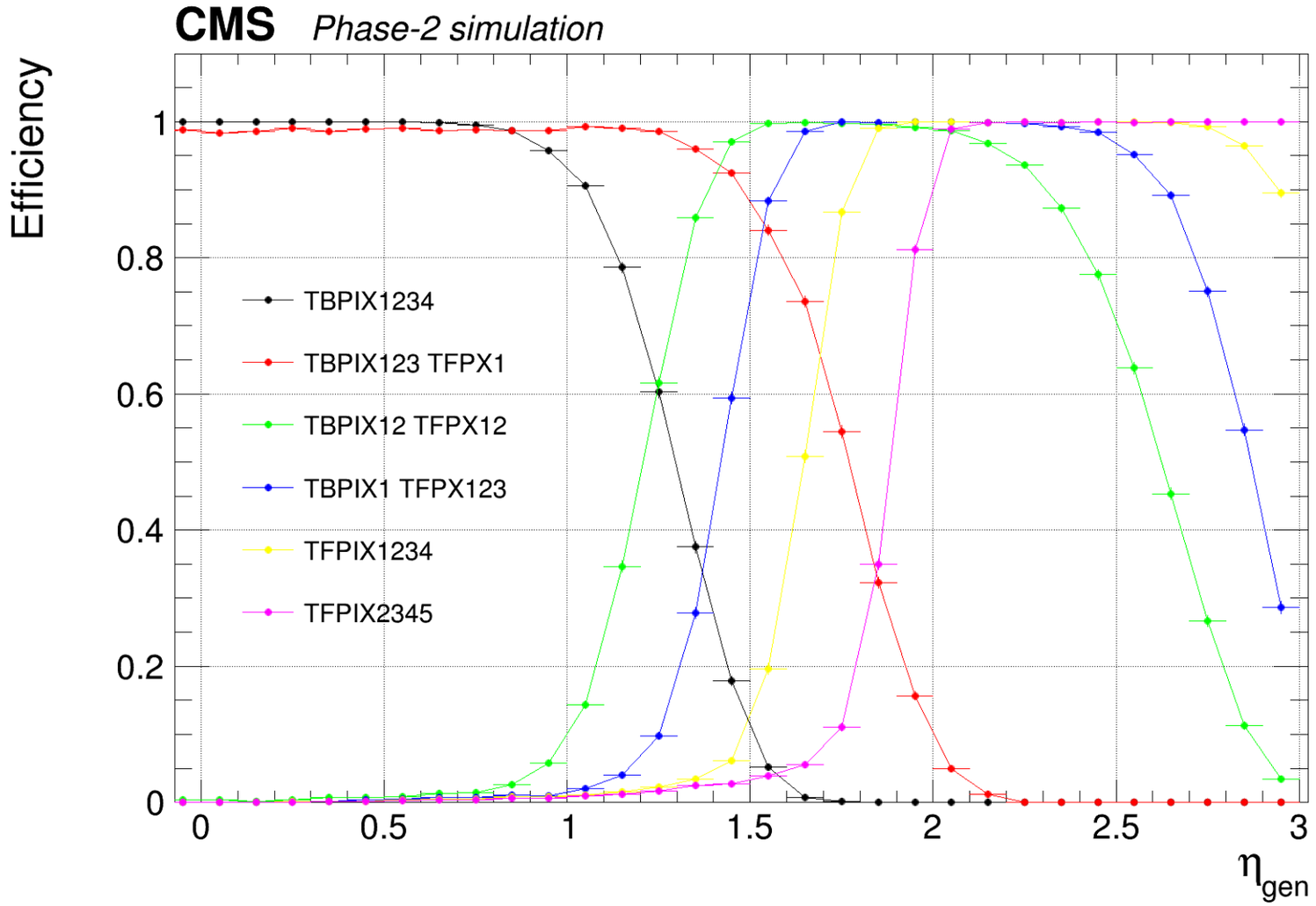






- The electron identification strategy:
  - Do pixel-EM calorimeter matching at Level 1 as in High Level Trigger(HLT) in a simplified way
  - Use the L1 EM calorimeter as a seed
  - Find 3 pixels within Δϕ(L1 e/γ, pixel) window
  - Match the pixel segments with the L1 EM cluster in Δϕ and Δη windows
  - Require Δϕ and Δη windows on the pixel segments

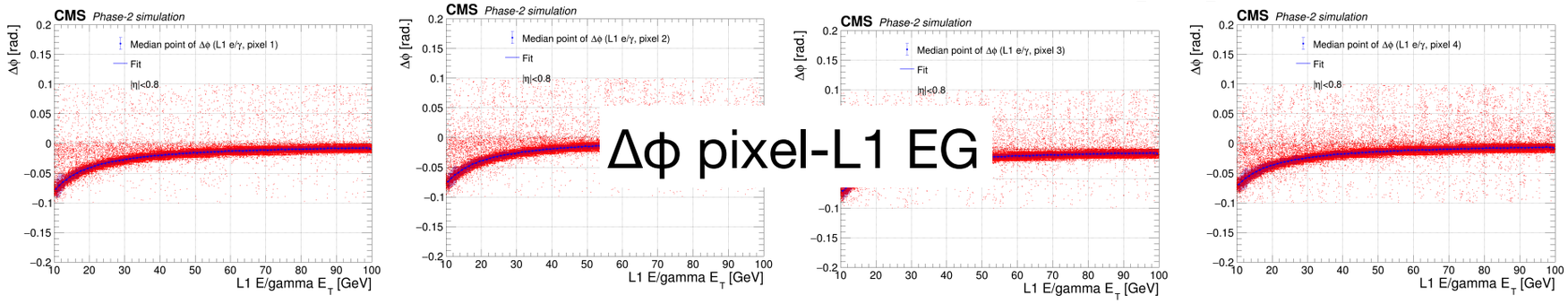
Pixel combinations for each η region



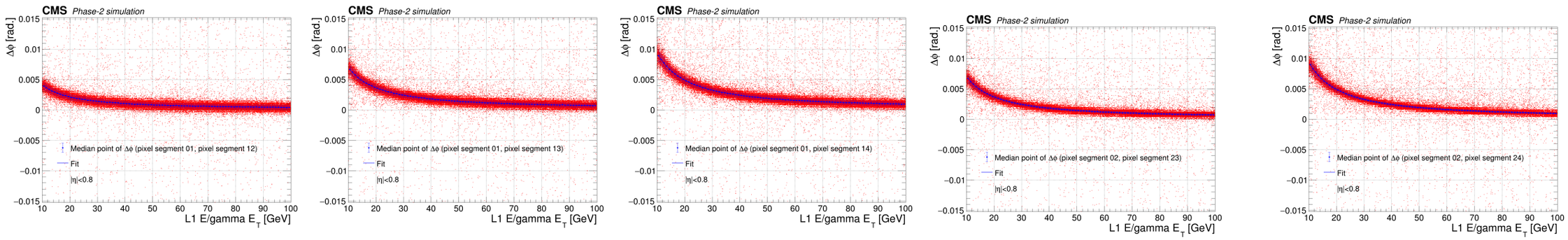
	|η|<0.8	0.8<|η|<1.4	1.4<|η|<1.7	1.7<|η|<2.1	2.1<|η|<2.7	2.7<|η|<3.0
pixel combination	4TBPX	3TBPX, 1TFPX	2TBPX, 2TFPX	1TFPX 3TFPX(1~4)	4TFPX(1~4)	4TFPX(2~5)

- Four pixel layer/disk combinations selected for each η regions considering the efficiency at least to have three matched pixel hits w.r.t. to L1 E/gamma objects

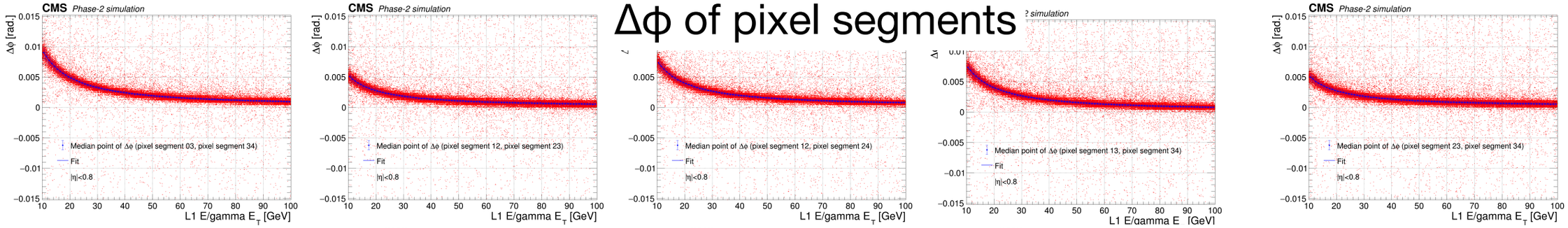
Example of signal windows (Δϕ) for |η|<0.8

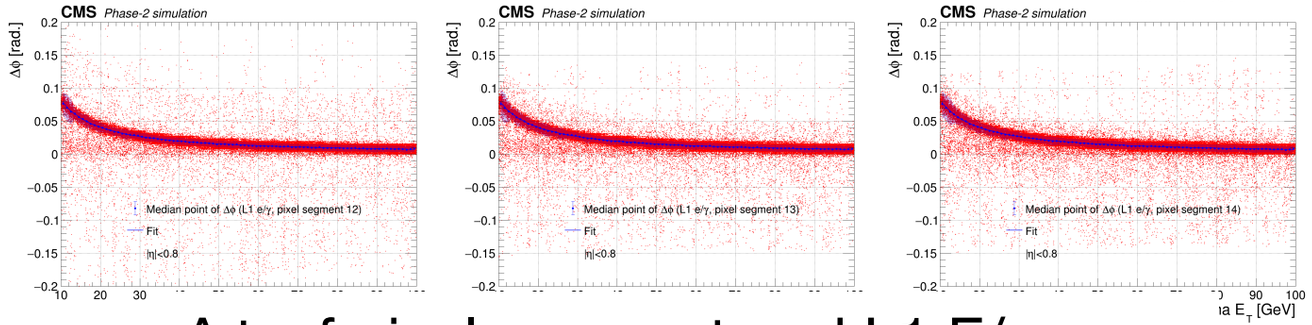


Δϕ pixel-L1 EG

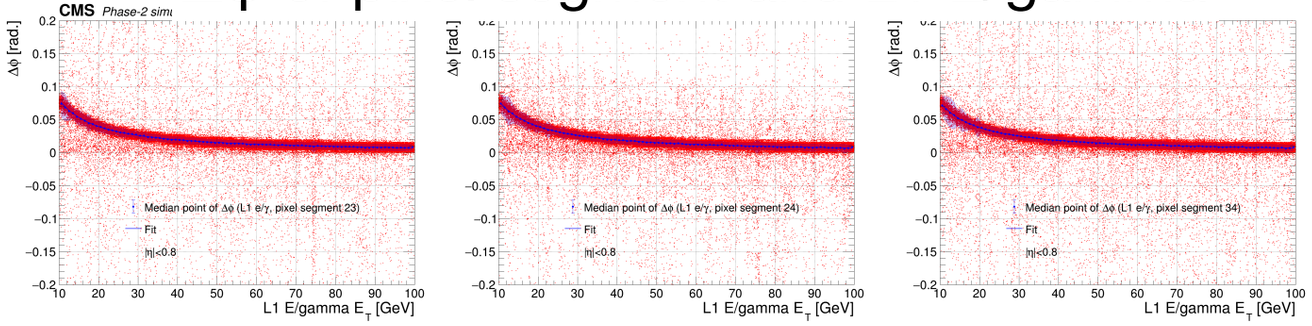


Δϕ of pixel segments





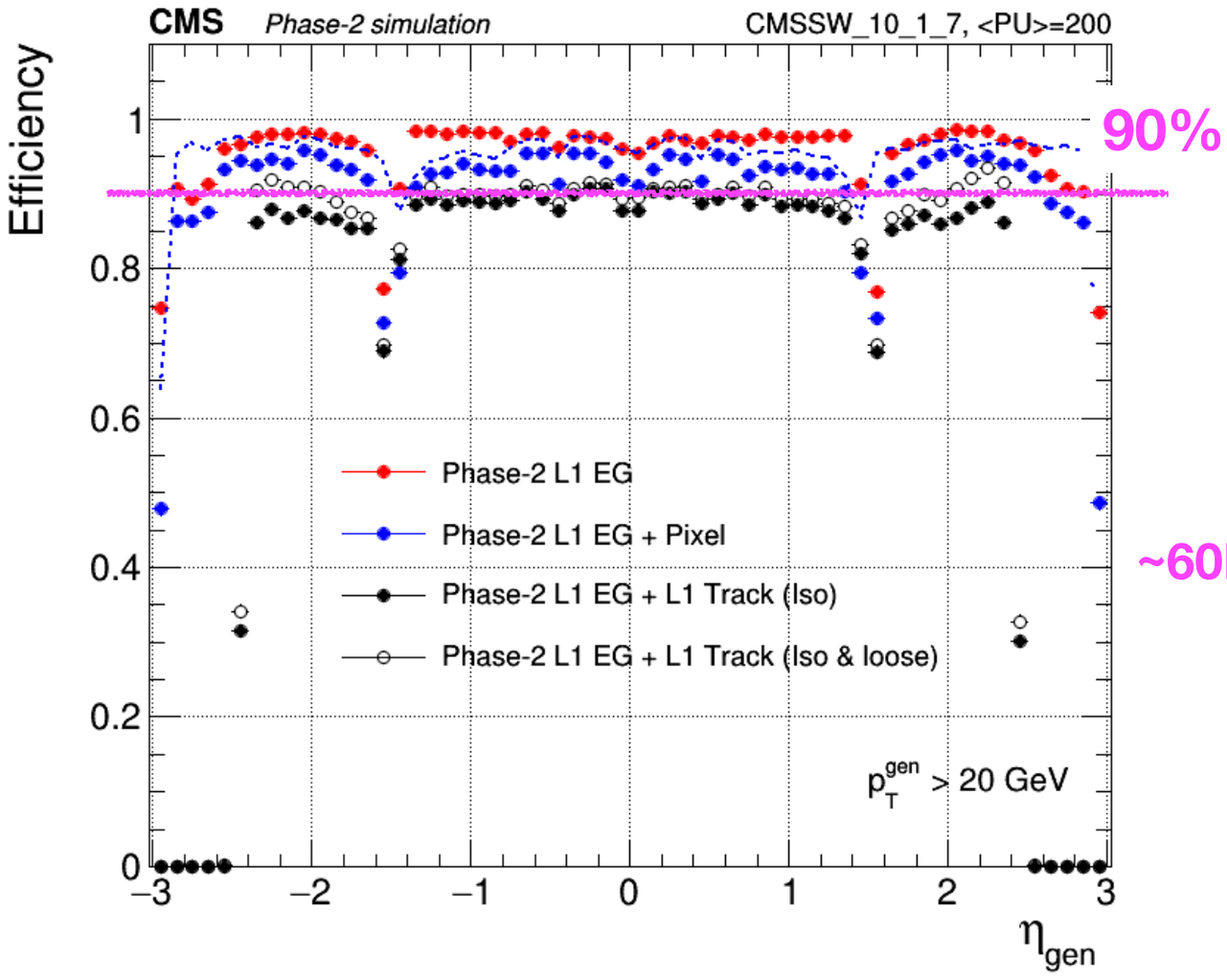
Δϕ of pixel segment and L1 E/gamma



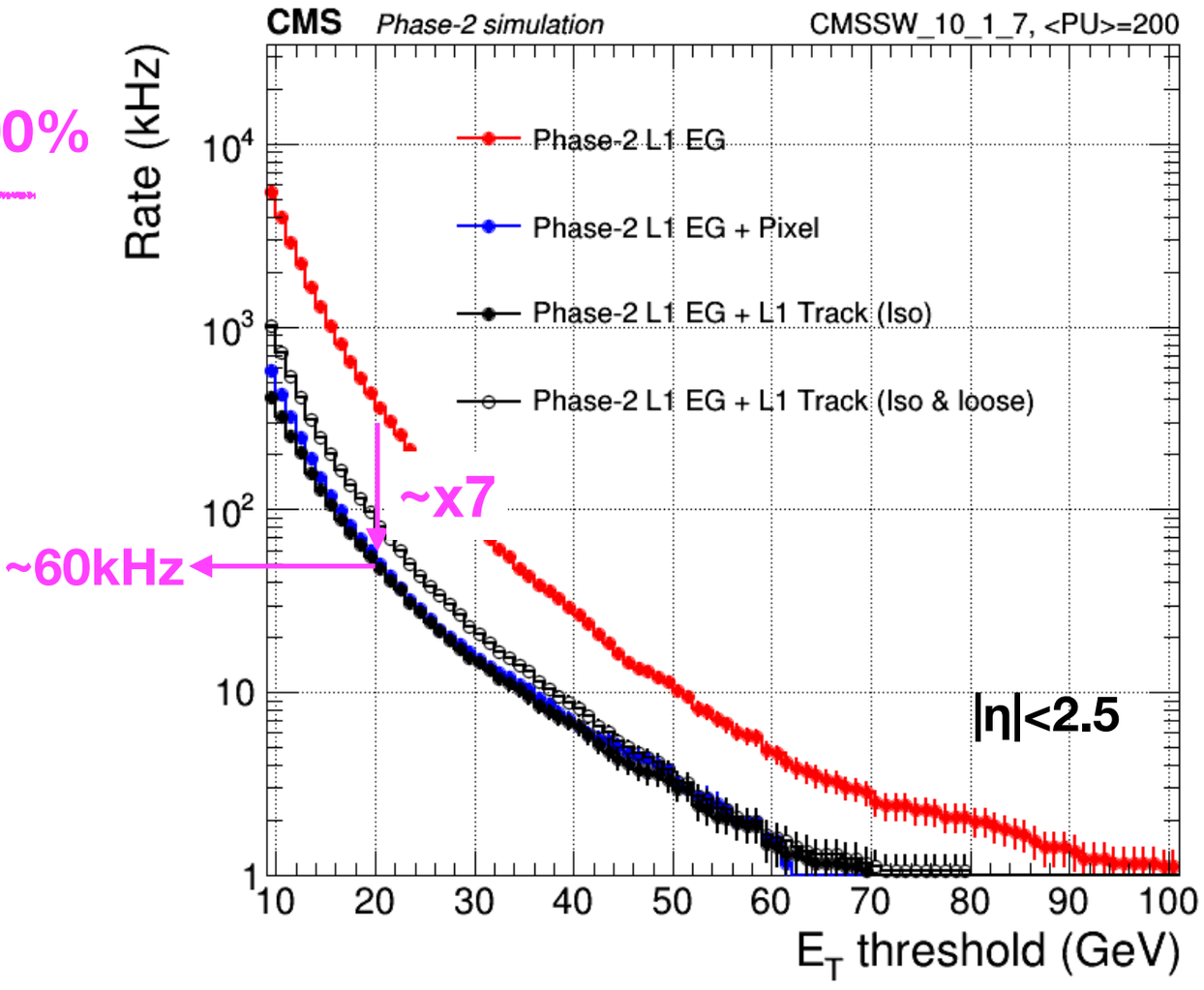
- In each distribution, median points are fitted as a function of L1 E/gamma E_T, and open signal windows from the median fit functions

Efficiency and rate with 200 PU (comparison to L1 track)

Efficiency

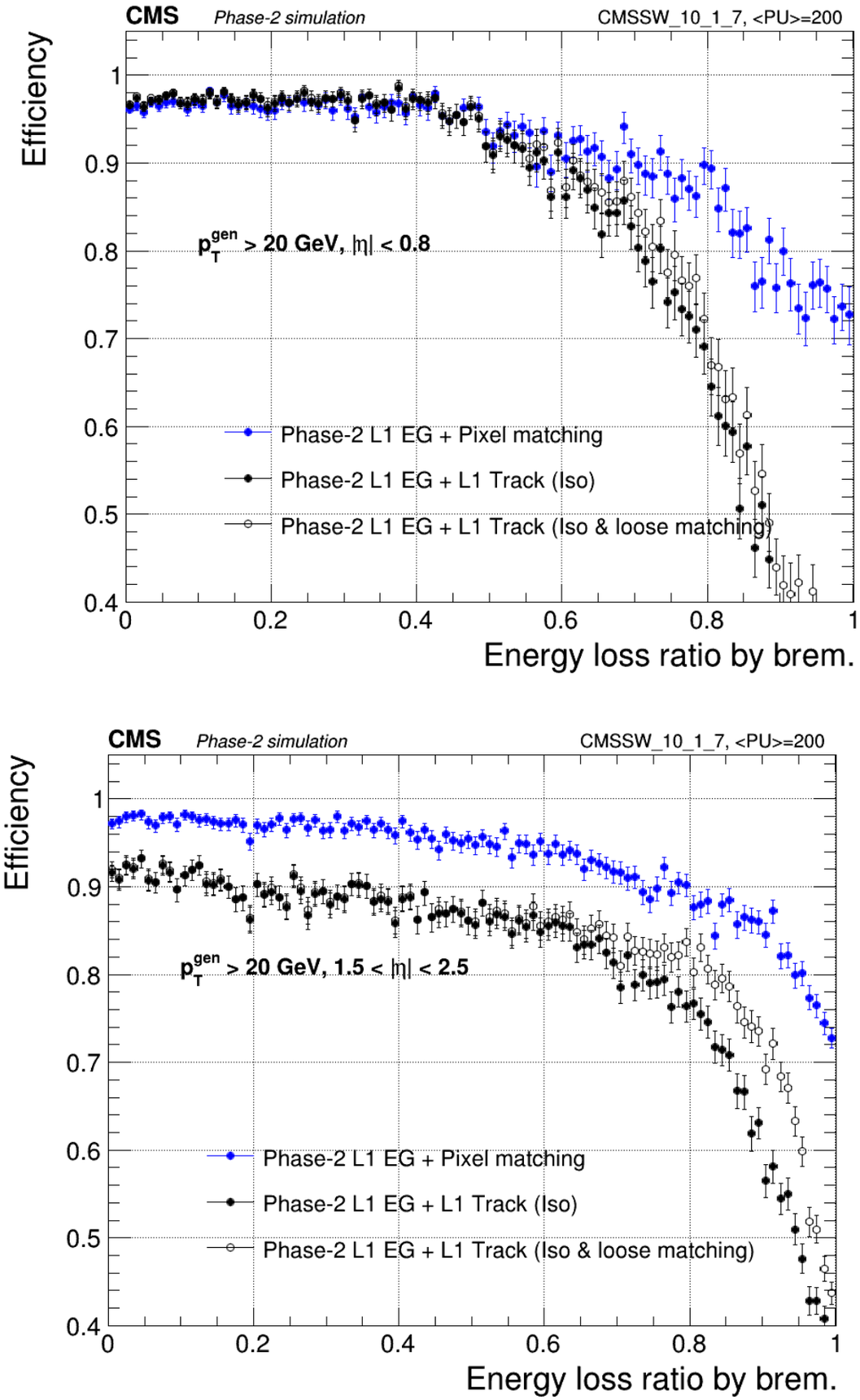


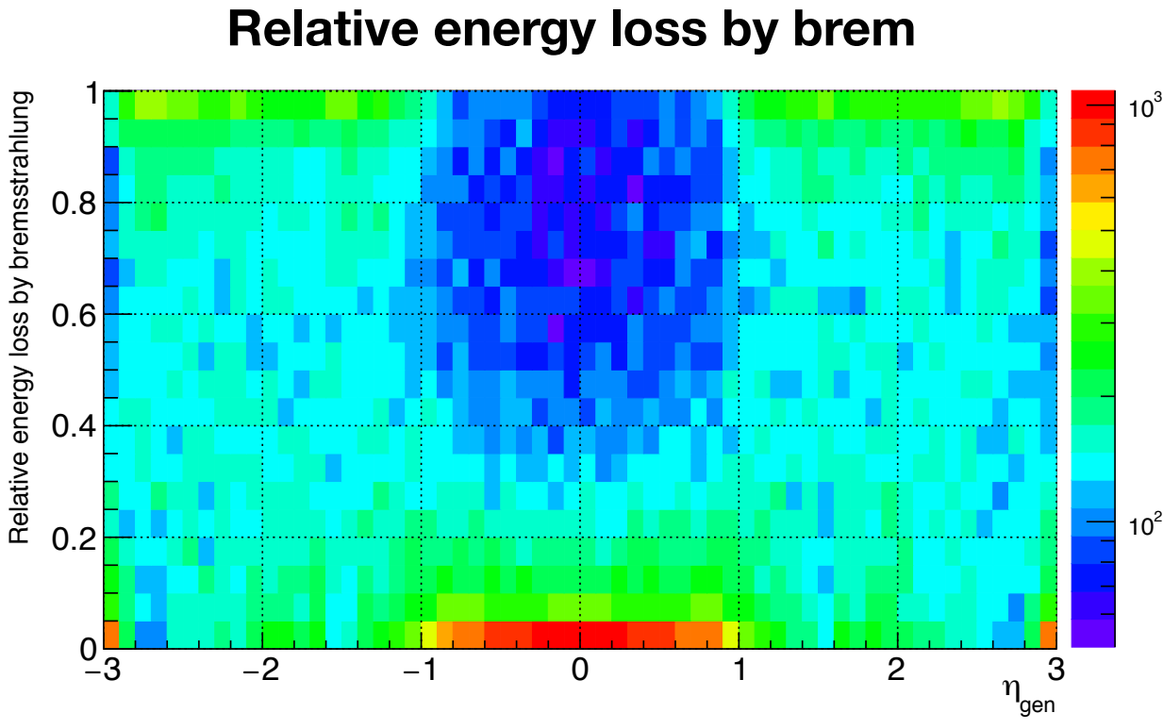
Rate



- > 90% efficiency for |η| up to 2.7
- ~7 reduction factor compared to only calorimeter used
- Higher efficiency (~5%) and comparable reduction power compared to L1 track with isolation
- *Additional factor of ~2 reduction available from the pixel isolation (done by Jongho)*

Bremsstrahlung effects





- Energy loss due to the bremsstrahlung is calculated using the Geant4 information in CMSSW
  - Energy loss ratio is calculated using the generated energy (initial energy) and the energy after the full simulation
- Efficiency is measured as a function of the energy loss ratio for generated electron with $p_T > 20$ and $|\eta| < 2.5$
  - For the electrons with soft brem (or nearly no brem), the same efficiency of both algorithm ~96% seen
  - However, for the electrons with hard brem, the inefficiency of L1 Track matching rapidly increases
    - *~10% higher efficiency with pixel for electrons with 80% energy loss*