

## Timing studies and plans for Phase-2 electrons/photons

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**UPSG Future LLP and Timing Workshop**  
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- **Preliminary study** of the use of MTD for Phase-II EB electrons.
  - Cleaning the isolation using MTD timing.
  - Using MTD timing as an input feature for training.
- Summary – plans and prospects.

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Previous presentations:

[\[MTD DPG, 26th June 2020\]](#)

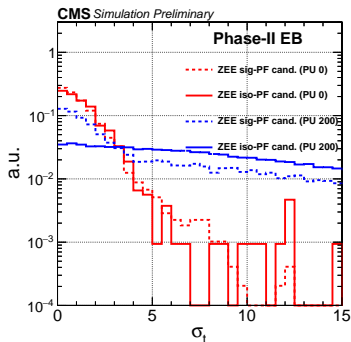
[\[UPSG workshop, 7th July 2020\]](#)

- **MTD timing information available in CMSSW\_11\_1\_0\_pre6 for PFCandidates** (“packedPFCandidates” in MiniAOD) and **4D-vertices** (“offlineSlimmedPrimaryVertices4D” in MiniAOD).
- **Usage details:**  
<https://twiki.cern.ch/twiki/bin/viewauth/CMS/PhaseIIFSObjectRecipes>
- **PU0 ZEE sample:**  
 RelValZEE\_14\_CMSSW\_11\_1\_0\_pre6-110X\_mcRun4\_realistic\_v3\_2026D49noPU-v1\_MINIAODSIM
- **PU200 ZEE sample:**  
 RelValZEE\_14\_CMSSW\_11\_1\_0\_pre6-PU25ns\_110X\_mcRun4\_realistic\_v3\_2026D49PU200-v1\_MINIAODSIM
- **PU0 QCD sample:**  
 RelValQCD\_Pt15To7000\_Flat\_14\_CMSSW\_11\_1\_0\_pre6-110X\_mcRun4\_realistic\_v3\_2026D49noPU-v1\_MINIAODSIM
- **PU200 QCD sample:**  
 RelValQCD\_Pt15To7000\_Flat\_14\_CMSSW\_11\_1\_0\_pre6-PU25ns\_110X\_mcRun4\_realistic\_v3\_2026D49PU200-v1\_MINIAODSIM
- **In the ZEE samples, the reco-electrons are gen-matched.**

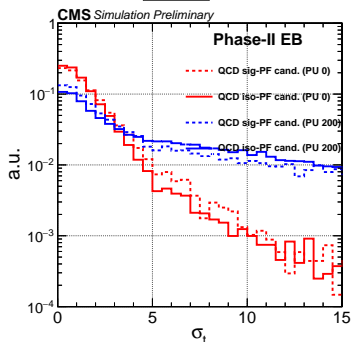
- Can be used to clean the isolation sum (reduce pileup contribution).
- For each PF candidate, compute the  $\Delta(\text{time})$  significance w.r.t. the primary vertex (PV):  

$$\sigma_t = \frac{|\Delta t|}{\delta t} = \frac{|t_{\text{PF}} - t_{\text{PV}}|}{[(\delta t_{\text{PF}})^2 + (\delta t_{\text{PV}})^2]^{1/2}}, \text{ where, } \delta t \text{ is the error on the measured time.}$$
- Results also with  $\Delta t$  w.r.t. the electron.
- Sig-PF cand.: PF candidates associated to the electron.
- Iso-PF cand.: PF candidates not associated to the electron, in a cone of  $dR < 0.3$  around the electron.
- Iso-PF cand. from pileup has a large tail in the ZEE and QCD samples.  
Hence a cut can be used to reduce the contribution from pileup in the isolation sum.

ZEE

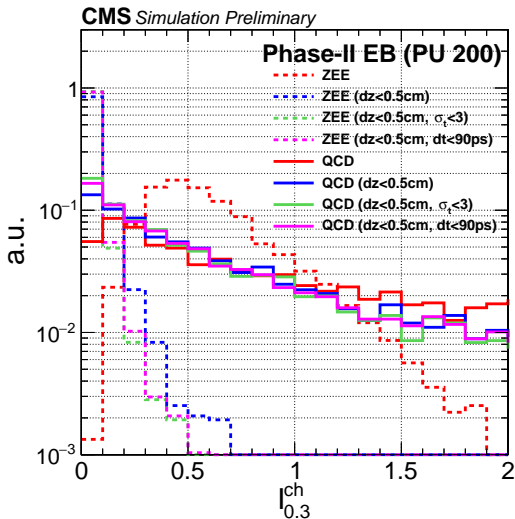


QCD

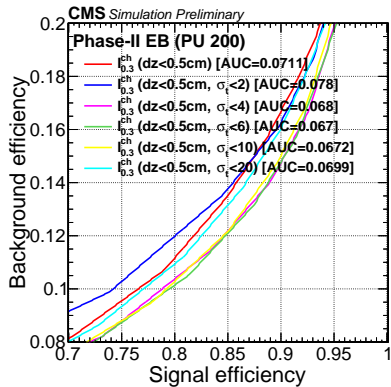


- Compute the **relative isolation (charged)** variable by summing over the **charged iso-PF candidates** in a cone of  $dR < 0.3$  w.r.t. the electron:

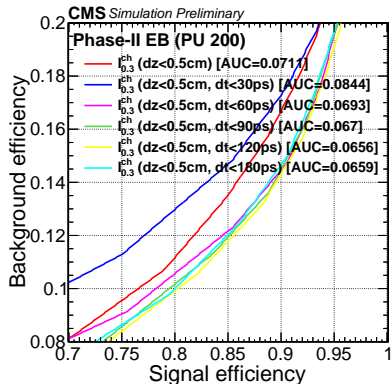
$$I_{0.3}^{\text{ch}} = \frac{\sum_{\text{iso-PF cand}} E_T}{E_T^e}$$



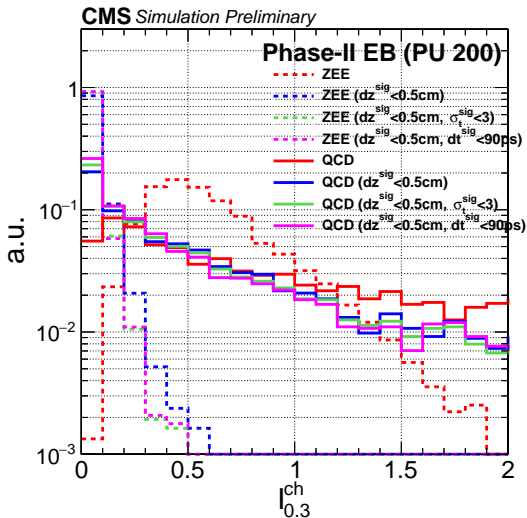
Cuts on  $\sigma_t$



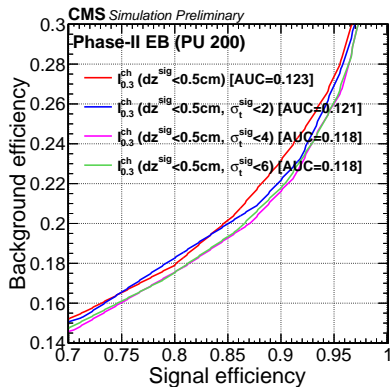
Cuts on  $dt$



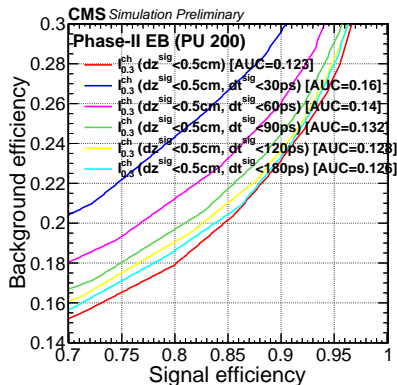
$l_{0.3} (dz, dt, \sigma_t \text{ w.r.t. electron})$



Cuts on  $\sigma_t$

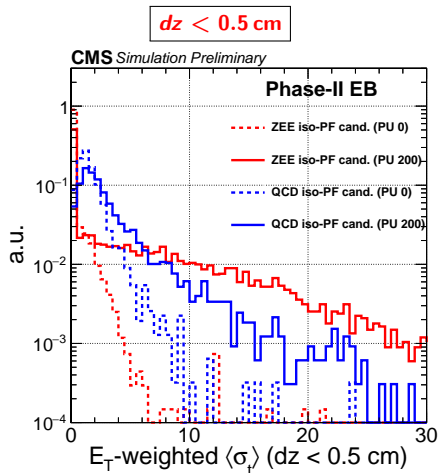
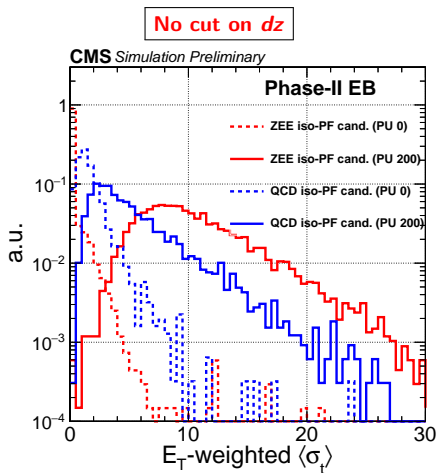


Cuts on  $dt$





- **Peak at 0:** Electrons that have no iso-PF candidates.
- Can be used as a feature for training the ID.



## Summary

## ● Phase-2 EB electrons:

- *dz, dt,  $\sigma_t$  w.r.t. PV:*  
Performance with cuts on  $dt$  comparable to cuts on  $\sigma_t$ .
- *dz, dt,  $\sigma_t$  w.r.t. electron:*  
Performance with cuts on  $dt$  worse than cuts on  $\sigma_t$ .
- *$I_{0.3}$ (w.r.t. PV) seems to be better than  $I_{0.3}$ (w.r.t. electron).*
- Some improvement seen in the performance of  $I_{0.3}$ (w.r.t. PV) using the MTD timing:  
At 80% signal eff., bkg. eff. decreases from 11% to 10%.

## ● Available tasks:

- *$E_T$ -weighted  $\langle \sigma_t \rangle$  looks promising – can be used for ID training.*
- Check **EB photon** isolation.
- Check **HGCal e/gamma** isolation.  
Possibility of greater impact in the endcaps due to higher contamination from PU.
- Check the impact of using timing information from the ECAL and HGCal.

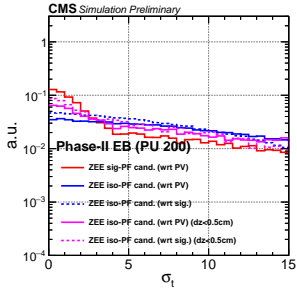
## ● Most welcome to join the effort and contribute to these studies.

## ● Feel free to contact us if interested (EPR points available).

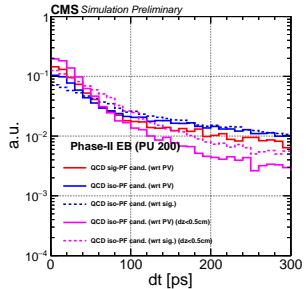
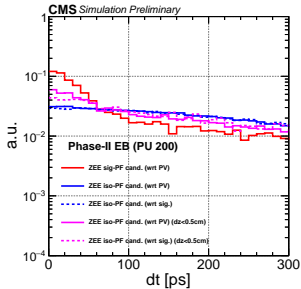
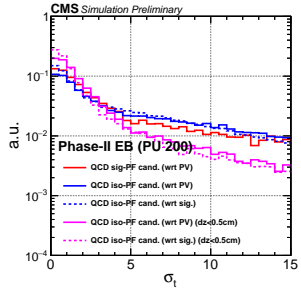
**Backup**

- Can calculate  $\sigma_t$  and  $dt$  w.r.t. the **PV**, or w.r.t. the electron (**sig**).

## ZEE (PU200)



## QCD (PU200)



- Can calculate  $dz$  w.r.t. the PV, or w.r.t. the electron (sig).

