Offline Electron Seeding Validation - Update

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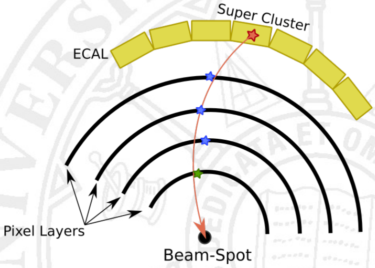
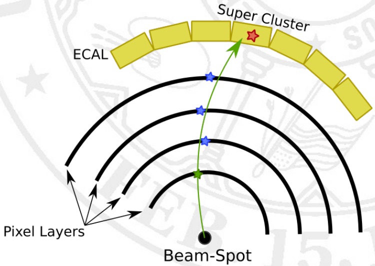
Introduction

- Our goal is to study **seeding** for the **offline** GSF tracking with the **new pixel detector**.
- Specifically, we want to optimize the new pixel-matching scheme from HLT for use in off-line reconstruction.
- This Talk:
  - Show performance comparison between old seeding two working points of the new seeding in fake-rich environment
    - New Seeding working points: `narrow` (HLT default settings), and `wide` (double window sizes with respect to `narrow`)
  - Show alternative efficiency/purity measurements using ΔR truth-matching between `SimTracks` and `GSFTracks`

N-Hit Electron Seeding

1. Using the beam spot, the SC position, and SC energy, propagate a path through the pixels.
2. Require the first hit to be within a $\delta\phi$ and δz window. ($\delta\phi$ and δR for FPIX)
3. δz window for first hit is huge as SC and beam spot positions give very little information about z.
4. Forget the SC position, and propagate a new track based on the vertex and first hit positions, and the SC energy.
5. Progress one-by-one through the remaining hits in the seed and require each one fit within a specified window around the track.
6. Quit when all hits are matched, or a hit falls outside the window. No skipping is allowed.



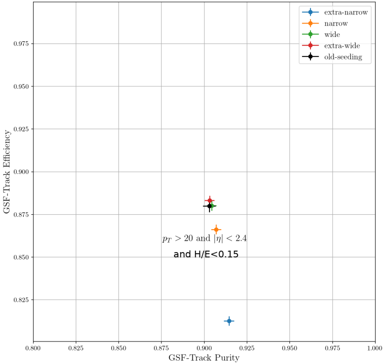


Definitions

- **Sim-Track -** A track from a simulated electron originating from the luminous region of CMS (beam-spot +- 5σ)
- **ECAL-Driven Seed -** A seed created via a matching procedure between Super-Clusters and General Tracking Seeds (Either from `ElectronSeedProducer` or `ElectronNHitSeedProducer`)
- **GSF Track -** A track from GSF-Tracking resulting from an **ECAL-Driven Seed**
- **GSF Tracking Efficiency -** The fraction of **Sim-Tracks** that have a matching **GSF Track** (again, based on simhit-rechit linkage or ΔR matching)
- **GSF Tracking Purity -** The fraction of **GSF Tracks** that have a matching **Sim-Track**

PREVIOUS STATUS-QUO

- In a previous presentation[1], I showed efficiency vs. purity for
  - Old pair-match seeding (`ElectronSeedProducer`)
  - New triplet seeding (`ElectronNHitSeedProducer`) for several choices of matching windows.
- Performance of new seeding at the `wide` working point was comparable to old seeding in low-fake ($Z \to e^+e^-$) environment
- Needed to validate performance in a high fake environment.

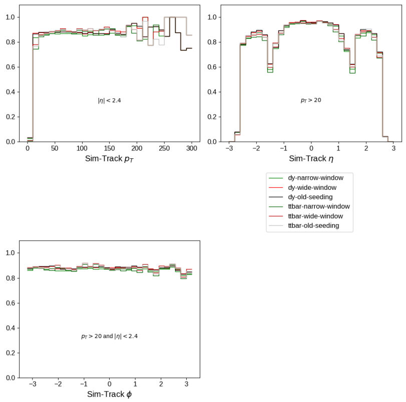


[1] https://indico.cern.ch/event/697077/contributions/2936039/attachments/1618649/2573874/main.pdf

Relative Performance - GSF Tracking Efficiency

- Figure shows GSF Tracking efficiency vs kinematic variables of the electron `SimTrack`
- Efficiency is more or less the same for both DY and $t\bar{t}$ environments and for both algorithms and working points.
- Largest (statistically significant) differences appear at low p_T and in the barrel/endcap transition region.

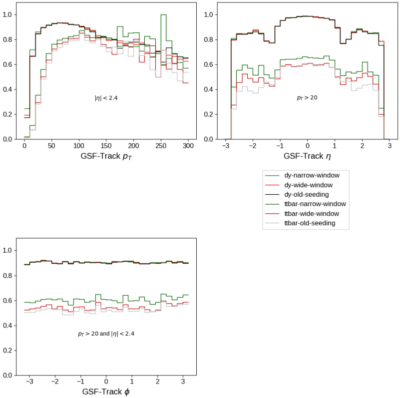
GSF Tracking Efficiency



Relative Performance - GSF Track Purity

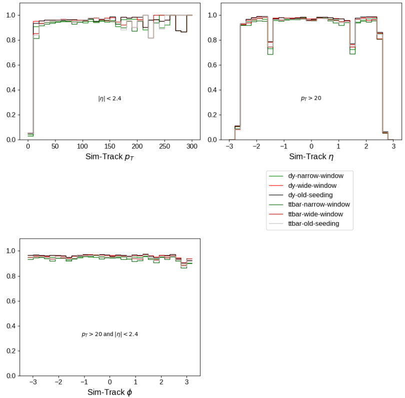
- Figure shows GSF Tracking purity vs kinematic variables of the `GSFTrack`
- Clearly purity is affected by the higher fake environment in the $t\bar{t}$ sample.
- Note how the `narrow` working point of the new seeding (green) has significantly better purity than the `wide` working point or the old seeding.
- Purity loss at high p_T is a feature of the shared-hits matching between `SimTracks` and `GSFTracks`.

GSF Tracking Purity

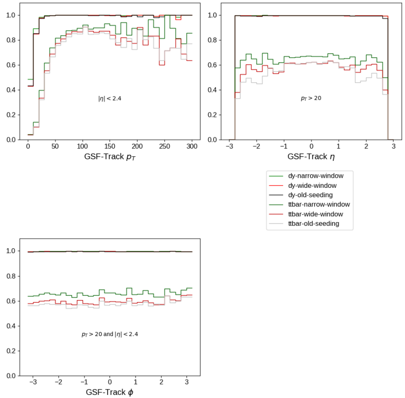


ΔR Matching

GSF Tracking Efficiency (ΔR Matched)



GSF Tracking Purity (ΔR Matched)



- Previous efficiency/purity definitions based on shared tracker hits between `SimTracks` and `GSFTracks`.
- An alternative is to use simple $\Delta R < 0.2$ matching.
- Overall numbers improve and purity no longer drops at high p_T.

Overall Performance

Integrating over all tracks with $p_T > 20\text{GeV}$ and $\eta < 2.4$ yields the performance numbers below.

Sample	Algo	Efficiency (ΔR Matched)	Purity (ΔR Matched)
$Z \rightarrow ee$	`old-seeding`	$96.08 \pm 0.28\%$	$99.54 \pm 0.29\%$
	`narrow`	$94.49 \pm 0.28\%$	$99.72 \pm 0.29\%$
	`wide`	$96.00 \pm 0.28\%$	$99.60 \pm 0.29\%$
$t\bar{t}$	`old-seeding`	$94.84 \pm 0.77\%$	$57.49 \pm 0.60\%$
	`narrow`	$93.54 \pm 0.79\%$	$65.84 \pm 0.67\%$
	`wide`	$95.06 \pm 0.77\%$	$59.52 \pm 0.61\%$

- The HLT default settings (`narrow`) of the new pixel matching scheme yield non-trivially better purity at the loss of some efficiency with respect to both the old seeding and the `wide` working point.
- The `wide` working point of the new seeding matches the `old-seeding` within errors except for purity is $\approx 2\%$ better in the $t\bar{t}$ sample

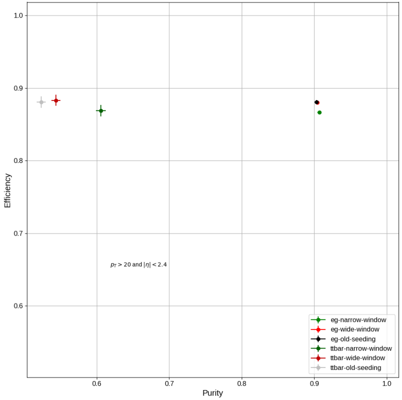
Conclusions & Outlook

- The new seeding algorithm has been verified to perform as well as, and in some cases better, than the current pair seeding based on MC studies in both low and high purity environments.
- Now the question is which working point (`wide` or `narrow`) is preferable?
- Unless there are objections, propose to move forward with implementing the new algorithm as the default in the next available CMSSW release.

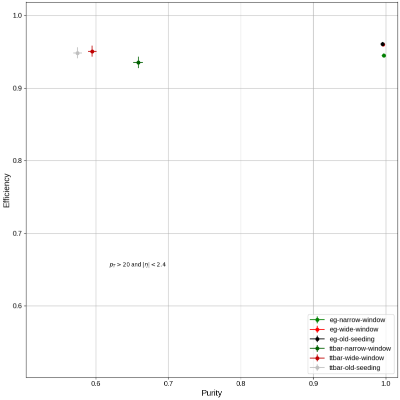
BACKUP

Overall Performance

GSF Tracking Performance (Hit Matched)



GSF Tracking Performance (ΔR Matched)



Matching Window Parameters

		extra-narrow	narrow(HLT)	wide	extra-wide
Hit 1	dPhiMaxHighEt	**0.025**	**0.05**	**0.1**	**0.15**
	dPhiMaxHighEtThres	20.0	20.0	20.0	20.0
	dPhiMaxLowEtGrad	-0.002	-0.002	-0.002	-0.002
	dRzMaxHighEt	9999.0	9999.0	9999.0	9999.0
	dRzMaxHighEtThres	0.0	0.0	0.0	0.0
	dRzMaxLowEtGrad	0.0	0.0	0.0	0.0
Hit 2	dPhiMaxHighEt	**0.0015**	**0.003**	**0.006**	**0.009**
	dPhiMaxHighEtThres	0.0	0.0	0.0	0.0
	dPhiMaxLowEtGrad	0.0	0.0	0.0	0.0
	dRzMaxHighEt	**0.025**	**0.05**	**0.1**	**0.15**
	dRzMaxHighEtThres	30.0	30.0	30.0	30.0
	dRzMaxLowEtGrad	-0.002	-0.002	-0.002	-0.002
Hit 3+	dPhiMaxHighEt	**0.0015**	**0.003**	**0.006**	**0.009**
	dPhiMaxHighEtThres	0.0	0.0	0.0	0.0
	dPhiMaxLowEtGrad	0.0	0.0	0.0	0.0
	dRzMaxHighEt	**0.025**	**0.05**	**0.1**	**0.15**
	dRzMaxHighEtThres	30.0	30.0	30.0	30.0
	dRzMaxLowEtGrad	-0.002	-0.002	-0.002	-0.002

`NHit` Seeding window parameters. Bold designates modified values.

Overall Performance - Hit-Matching

Integrating over all tracks with $p_T > 20\text{GeV}$ and $\eta < 2.4$ yields the performance numbers below.

Sample	Algo	Efficiency (Hit Matched)	Purity (Hit Matched)
$Z \to ee$	`old-seeding`	$88.05 \pm 0.28\%$	$90.30 \pm 0.29\%$
	`narrow`	$86.63 \pm 0.28\%$	$90.69 \pm 0.29\%$
	`wide`	$88.01 \pm 0.28\%$	$90.43 \pm 0.29\%$
$t\bar{t}$	`old-seeding`	$88.06 \pm 0.77\%$	$52.35 \pm 0.60\%$
	`narrow`	$86.89 \pm 0.79\%$	$60.56 \pm 0.67\%$
	`wide`	$88.30 \pm 0.77\%$	$54.38 \pm 0.61\%$

Note that the `wide` working point of the new seeding matches the `old-seeding` within errors except for purity is $\approx 2\%$ better in the $t\bar{t}$ sample.

Samples

- /ZToEE_NNPDF30_13TeV-powheg_M_120_200/RunIISummer17DRStdmix-NZSFlatPU28to62_92X_upgrade2017_realistic_v10-v1
- /TT_TuneCUETP8M2T4_13TeV-powheg-pythia8/RunIISummer17DRStdmix-NZSFlatPU28to62_92X_upgrade2017_realistic_v10-v2