Seeding

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Introduction

- For this example we are using ttbar mu 0
  - mc21_14TeV.601229.PhPy8EG_A14_ttbar_hdamp258p75_SingleLep.recon.RDO.e8481_s4038_r14362
- How to extract seeding information from Athena
  - **Summary tables for the track finder printed in the reco log file and the creation of SeedCollections:**
    - setupATLAS

      asetup master,latest,Athena

      Reco_tf.py --CA --preInclude "InDetConfig.ConfigurationHelpers.OnlyTrackingPreInclude" --preExec "flags.Trac

      king.doStats = True;flags.Tracking.doStoreTrackSeeds=True" --inputRDOFile "sample/mc21_14TeV.601229.PhPy8EG_A

      14_ttbar_hdamp258p75_SingleLep.recon.RDO.e8481_s4038_r14362/RDO.32628489._000006.pool.root.1" --outputAODFile

      AOD.pool.root --maxEvents –1
    - **Ntuple creation (InDetPhysValMonitoring)**
      - runIDPVM.py --filesInput AOD.pool.root --outputFile IDPVM.root --maxEvents -1 --doHitLevelPlots --validateExtraTrackCollections "SiSPSeedSegmentsTrackParticles"

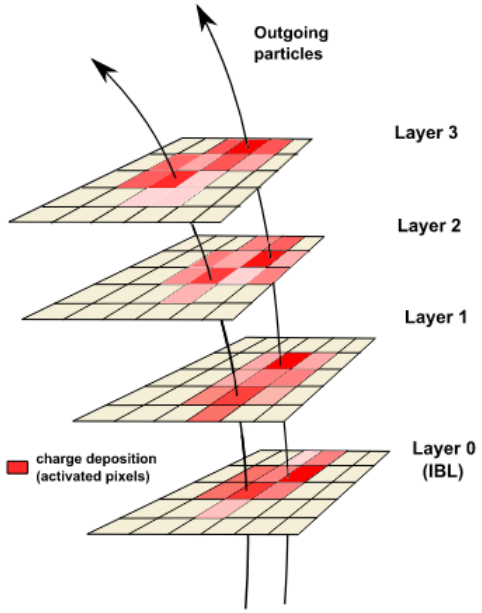
Tables from log.RAWtoALL

SiSPSeededTracks=
Seeding + Kalman extension

for example a simulated pion may have left 9 hits, but our reco only added 8 of them to the corresponding track --> 1 "lost"

the "wrong" clusters are something like the opposite - hits added to a track that do *not* come from the same particle

Statistic for SiSPSeededTracks						
Probability to lose	0	1	2	3	4	>=5 clusters
For all particles	0.9062	0.0355	0.0163	0.0084	0.0066	0.0149
For + particles	0.9048	0.0356	0.0162	0.0085	0.0062	0.0160
For - particles	0.9077	0.0354	0.0163	0.0082	0.0071	0.0137
Barrel region						
0 wrong clusters	0.9141	0.0226	0.0124	0.0059	0.0054	0.0081
1 wrong clusters	0.0106	0.0020	0.0010	0.0005	0.0003	0.0007
2 wrong clusters	0.0038	0.0004	0.0002	0.0000	0.0000	0.0003
3 wrong clusters	0.0003	0.0001	0.0000	0.0000	0.0001	0.0000
>=4 wrong clusters	0.0005	0.0001	0.0001	0.0000	0.0000	0.0002
Transition region						
0 wrong clusters	0.8922	0.0294	0.0141	0.0086	0.0056	0.0130
1 wrong clusters	0.0131	0.0029	0.0009	0.0005	0.0003	0.0007
2 wrong clusters	0.0034	0.0007	0.0003	0.0002	0.0001	0.0006
3 wrong clusters	0.0004	0.0002	0.0000	0.0000	0.0000	0.0001
>=4 wrong clusters	0.0013	0.0001	0.0001	0.0000	0.0000	0.0003



the ideal tracking would give zero lost and zero wrong hits in every case, with 100% efficiency and 0% fake rate

Tables from log.RAWtoALL

Endcap region						
0 wrong clusters	0.8652	0.0395	0.0158	0.0076	0.0069	0.0179
1 wrong clusters	0.0187	0.0030	0.0018	0.0005	0.0005	0.0015
2 wrong clusters	0.0044	0.0009	0.0004	0.0001	0.0001	0.0003
3 wrong clusters	0.0008	0.0001	0.0000	0.0000	0.0000	0.0001
>=4 wrong clusters	0.0015	0.0002	0.0001	0.0000	0.0000	0.0001
Forward region						
0 wrong clusters	0.8570	0.0433	0.0190	0.0116	0.0080	0.0149
1 wrong clusters	0.0167	0.0024	0.0017	0.0002	0.0003	0.0009
2 wrong clusters	0.0018	0.0006	0.0000	0.0002	0.0002	0.0006
3 wrong clusters	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
>=4 wrong clusters	0.0012	0.0000	0.0000	0.0000	0.0000	0.0003
Efficiency reconstruction (number lose+wrong < 3) =				0.95391 (	0.86039)	
For barrel region =				0.96536 (	0.87123)	
For transition region =				0.95507 (	0.85205)	
For endcap region =				0.94656 (	0.85329)	
For forward region =				0.94025 (	0.86991)	

high precision if you gained / lost good candidates

Seed redundancy

Seeding redundancy = 625825/90365 ~ 7

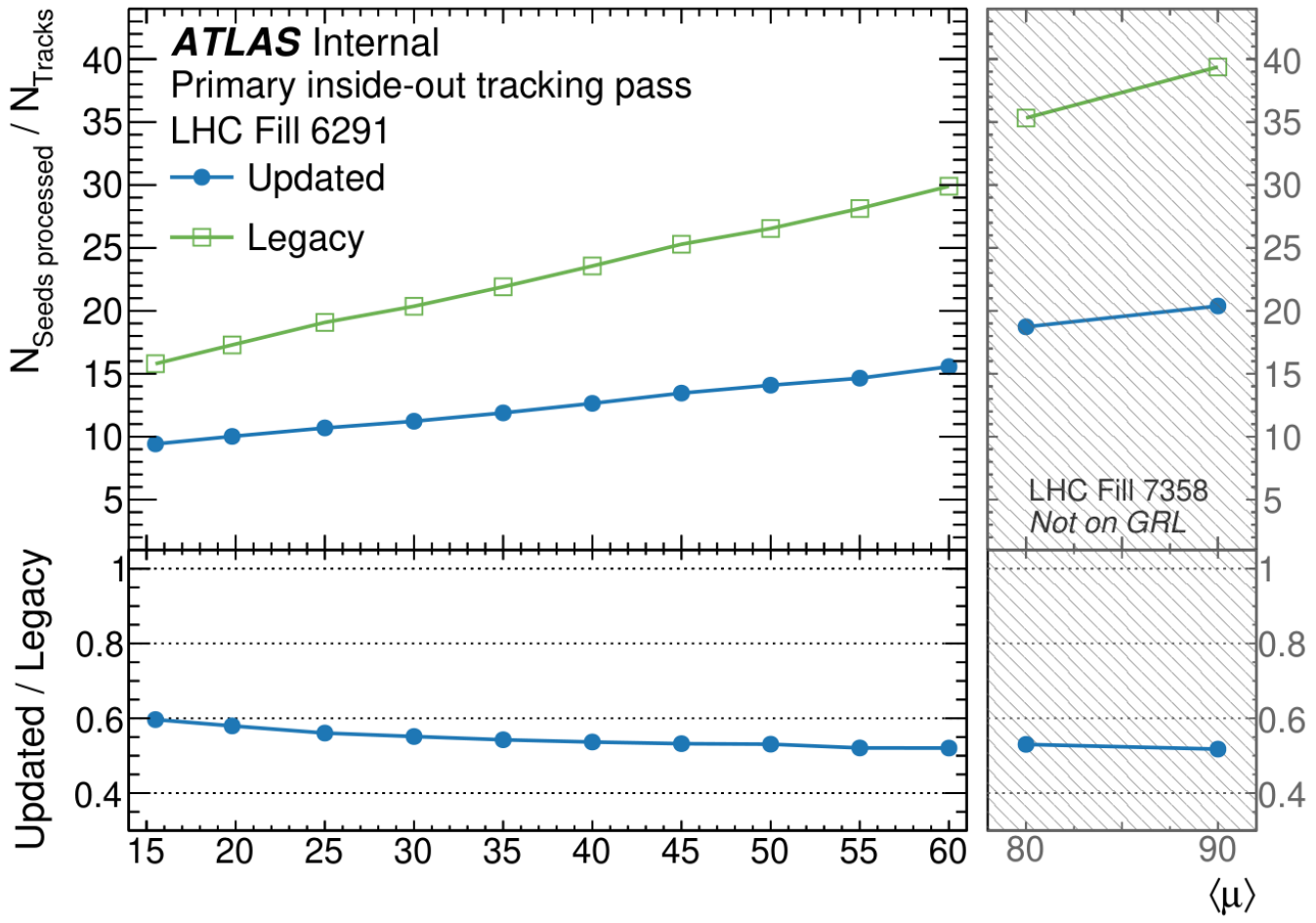
Kind of seed		PPP	PPS	PSS	SSS	ALL	
Input seeds		413998	0	0	211827	625825	
No track parameters		1274	0	0	10624	11898	
Used seeds		57947	0	0	67600	125547	
Used seeds brem		0	0	0	0	0	
Det elements in road		80.67	0	0	64.789	72.12	
Two clusters on DE		0	0	0	0	0	
Wrong DE road		0	0	0	23	23	
Wrong initialization		0	0	0	0	0	
Can not find track		12167	0	0	10466	22633	
It is not new track		5459	0	0	5194	10653	
Attempts brem model		0	0	0	0	0	
Output tracks		40572	0	0	53065	93637	
Output extra tracks		1015	0	0	2257	3272	
Output tracks brem		0	0	0	0	0	
Seeds with track		39557	0	0	50808	90365	Number seeds
Track/Used	0.0-0.5	0.4545	0	0	0.789	0.7212	14124
	0.5-1.0	0.4223	0	0	0.8331	0.7351	13969
	1.0-1.5	0.4697	0	0	0.8394	0.7194	12852
	1.5-2.0	0.5101	0	0	0.6285	0.5948	13723
	2.0-2.5	0.7153	0	0	0.6632	0.6897	12547
	2.5-3.0	0.7694	0	0	0.6923	0.7693	8951
	3.0-3.5	0.842	0	0	0	0.842	7311
	3.5-4.0	0.9168	0	0	0	0.9168	6888

Tracks/inputs= 0.095

Tracks/inputs= 0.24

- We first build SCT seeds ("SSS")
- Then we run track finding with those
- And only then we build Pixel seeds ("PPP") and make tracks from those, removing any we found previously.
- As a result, it will always look in the table like the PPP seeds are less efficient at being turned into tracks - but this is not a property of the Pixel per-se, but just the result of our choice to first run the SCT seeds

Seed redundancy

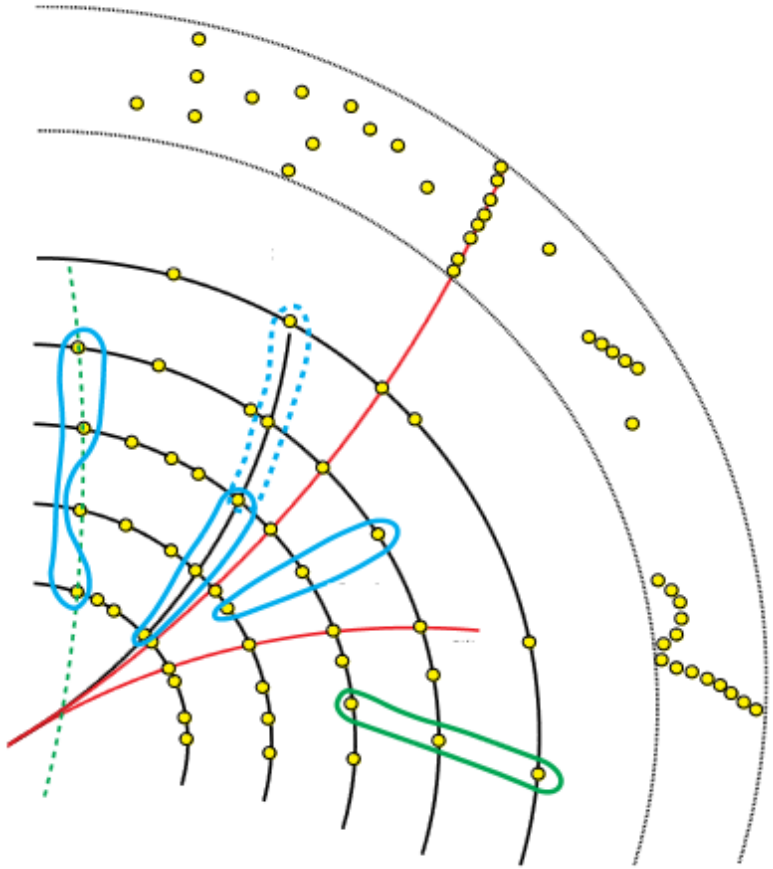


Documentation:

- https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2021-012/
- https://cds.cern.ch/record/2815589

Efficiency and fake plots for the dummy tracks made from the seeds

- These seeds are not expected to map 1:1 to tracks - there will always be many "good" seeds corresponding to one track, and an efficient seeder will not only find at least one seed per track, but also avoid processing too many seeds per track (otherwise, we would be wasting CPU cycles finding the same thing over and over)
- If we want to study the fraction of seeds where not all hits come from the same true particle, we can look to the "fake" plots IDPVM. Caveat
  - The seed track collection basically uses the three space-points to estimate a trajectory and then attempts to add the detector measurements that are used to form the 3D space points forming the seeds to the trajectory to build a track candidate. But it may drop some of them, if they are not compatible with the trajectory model, and the trajectory estimate itself is also not really a part of the seed.
    - So seed eta/pt/phi are not the pt/eta/phi the seed reports in the real reconstruction



Efficiency and fake plots

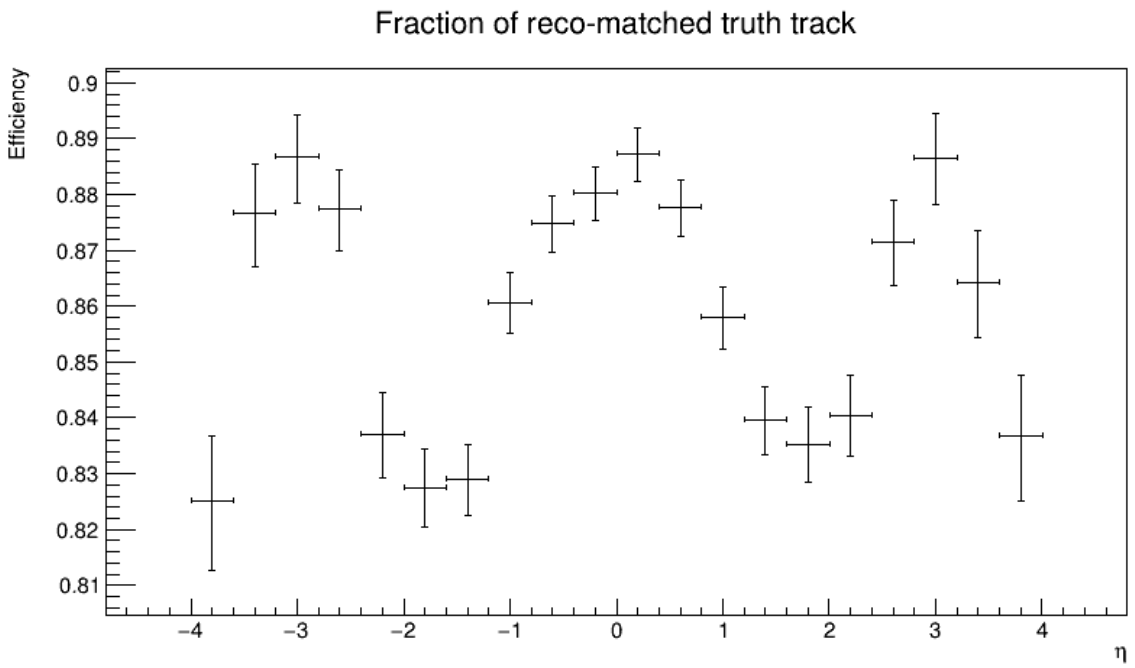
But another way of looking at it could be to monitor

- efficiency
- seed redundancy (number of seeds processed : number of tracks reconstructed)
  - It is something like a measure of how many times - on average, including both "good" duplicates and random combinatorics - we process a seed per track we find
- CPU speed
- rate of fake output tracks (not fake seeds)

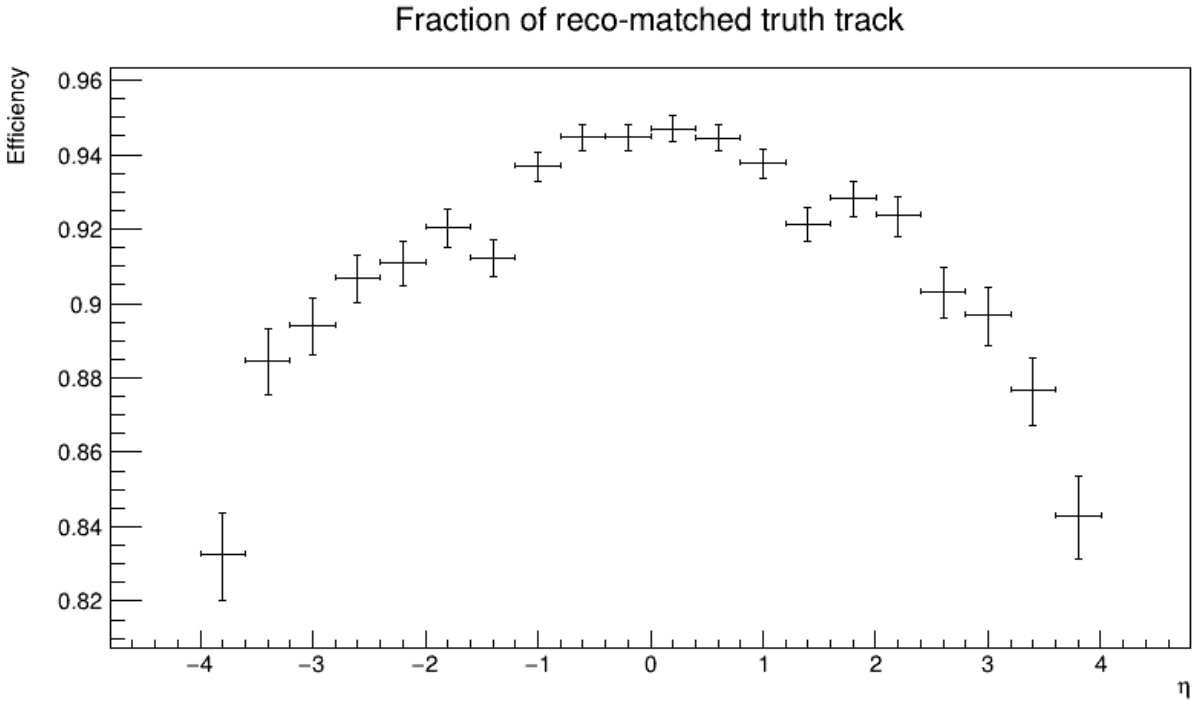
Together, these will encompass the effect of both genuine and incorrect seeds, in a metric which may be more meaningful than a "seed fake rate" on its own

Efficiencies

Tracks



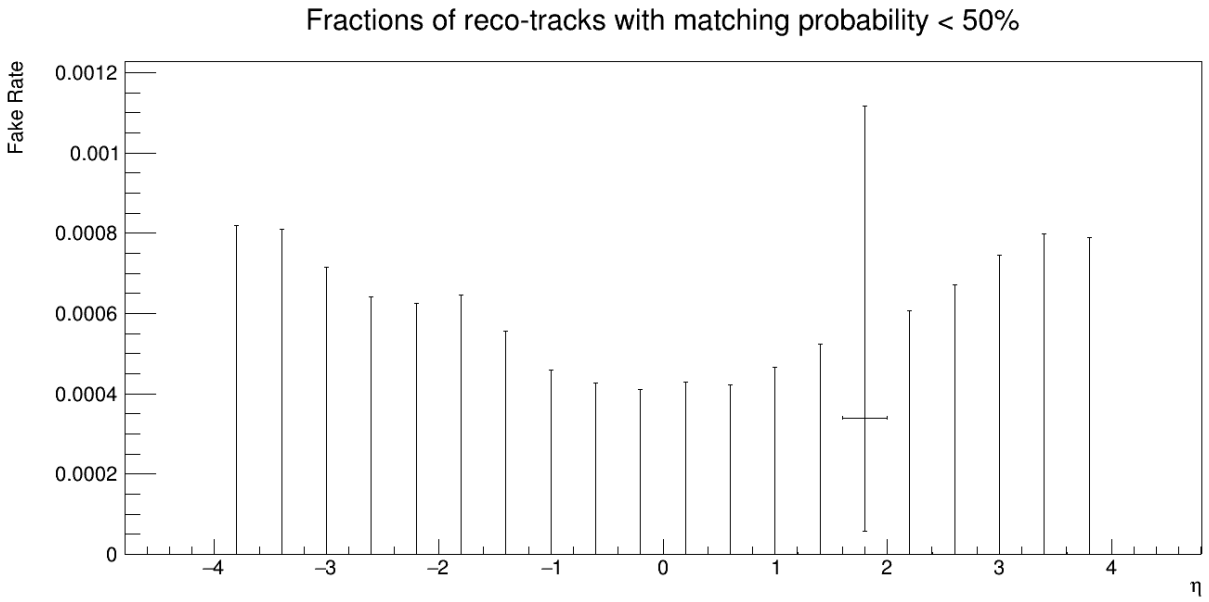
Seeds



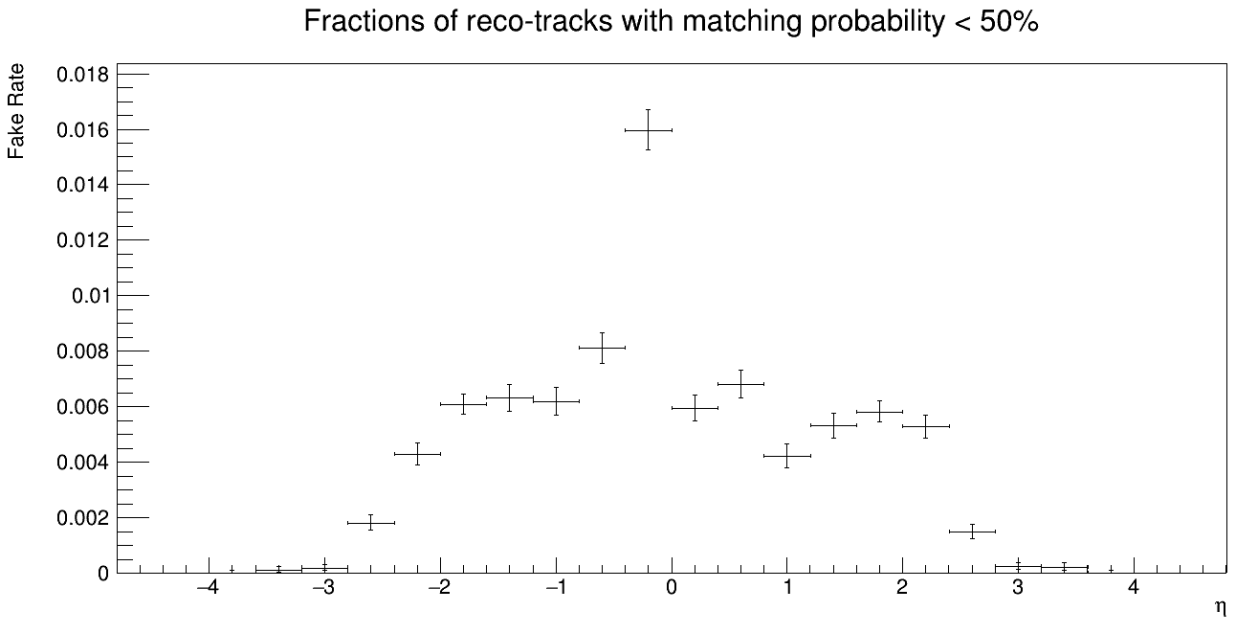
Efficiency drop around 1 < eta < 2 due to the lost of the seeds. It can be recover but at the coast of CPU in seeding and track finding
https://indico.cern.ch/event/1268668/contributions/5346716/attachments/2625407/4540151/UpgradeTracking_230405.pdf

Fake rate

Tracks



Seeds



CPU time

- Virtual memory (vMem) is memory that is allocated by virtualization systems.
- The malloc() function stands for memory allocation, that allocate a block of memory dynamically

```
INFO ================================================================================================
INFO ================================================================================================
INFO                              Component Level Monitoring
INFO ================================================================================================
INFO Step           Count     CPU Time [ms]  Vmem [kB]      Malloc [kB]         Component
INFO Execute          999       4325512.92      0               871270              SiSPSeedSegmentsTrackParticleCnvAlg
INFO Execute          999       98679.64        0               1545859             ITkAmbiguitySolver
INFO Execute          999       45177.39        0               3449461             ITkSiSpTrackFinder
INFO Execute          999       27997.41        0               3643086             ITkPRD_MultiTruthMakerSi
INFO Execute          999       25750.39        0               24520               OutputStreamAOD
INFO Execute          999       23201.12        0               5048018             ITkPixelClusterization
INFO Execute          999       20911.10        0               3159431             GEN_AOD2xAOD
INFO Execute          999       9014.07         0               51477               TrackTimeExtensionAlg
INFO Execute          999       8884.31         0               3500401             ITkStripClusterization
INFO Execute          999       7030.72         0               146965              ITkTrackParticleCnvAlg
INFO Execute          999       6477.99         0               -62                 ITkTrackClusterAssValidation
INFO Execute          999       6006.54         0               -202                IncidentProcAlg1
INFO Execute          999       4981.60         0               2213969             ITkSiTrackerSpacePointFinder
INFO Execute          999       4595.46         0               122875              SiSPSeedSegmentsDetailedTruthMaker
INFO Execute          999       2910.00         0               95684               InDetPriVxFinder
INFO Execute          999       2459.16         0               17200               SiSPSeededTracksDetailedTruthMaker
INFO Execute          999       2291.13         0               10881               ResolvedTracksDetailedTruthMaker
INFO Execute          999       1784.43         0               10881               CombinedITkTracksDetailedTruthMaker
INFO Execute          999       1748.04         0               93553               ITkAmbiguityScore
INFO Execute          999       1740.73         0               888614              PadClusterizationAlg
INFO Execute          999       1725.64         0               10897               DetailedTrackTruthMaker
INFO Execute          999       1064.04         0               60                  ITkRecStatistics
INFO Execute          999       248.33          0               29881               ThinGeantTruthAlg
INFO Execute          999       232.32          0               57366               SiSPSeedSegmentsTruthCollectionSelector
INFO Execute          999       227.79          0               -31                 TrackSlimmer
INFO Execute          999       178.02          0               -265                IncidentProcAlg2
INFO Execute          999       156.98          0               9959                EventInfoTagBuilder
```

Purity

- Number of HITS that are generated by true particles. "TruthMatchProbability" decoration on the seed track collection (caveat)
  - these are defined as the fraction of the measurements on the seed that come from the same truth particle, the one with the largest contribution to the seed
  - So 1.0 = perfectly pure, all measurements from the same truth