Working Progresss

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Search for electroweak production of supersymmetirc states in scenarios with compressed mass spectra

- Naturalness: $\mu \ll |M_1|, |M_2|$,

$\rightarrow$ three lightest electroweakino separated $\mathcal{O}$(100 MeV - 10 GeV)

$\rightarrow$ Compressed mass spectra

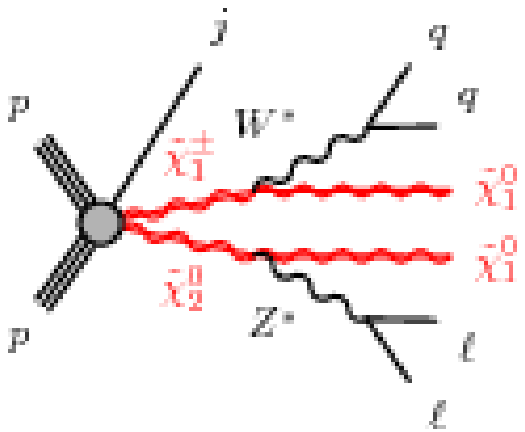
Small $\Delta m(\chi_2^0, \chi_1^0), \Delta m(\chi_1^\pm, \chi_1^0)$

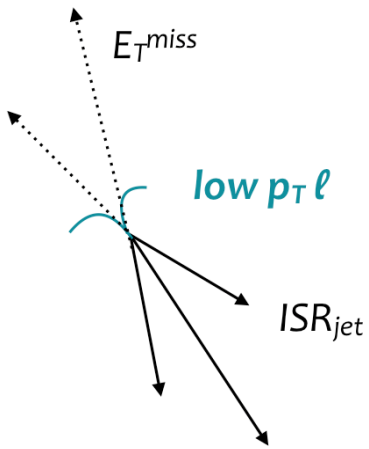
$\rightarrow$ Final states with displaced low-p_t lepton pairs (e, μ) and p_t^{miss}

- χ_1^0 momenta recoil against ISR jet, $\rightarrow$ separation between leading jet and p_t^{miss}

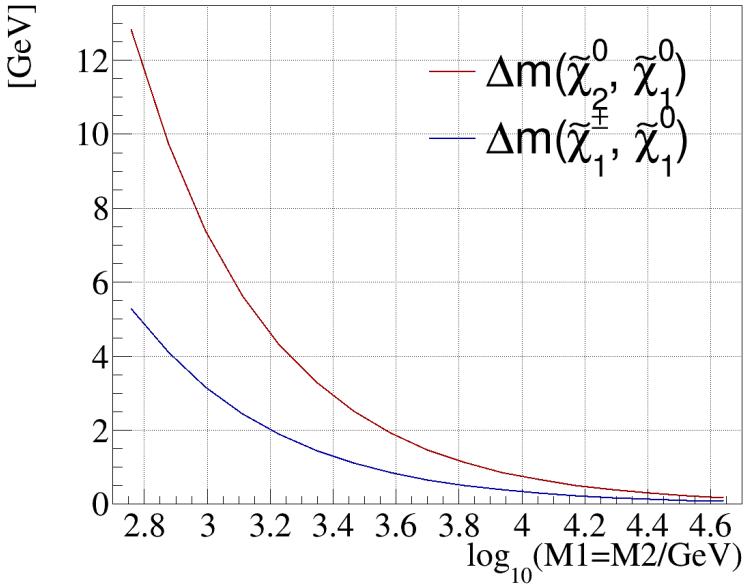
<u>Scan:</u>

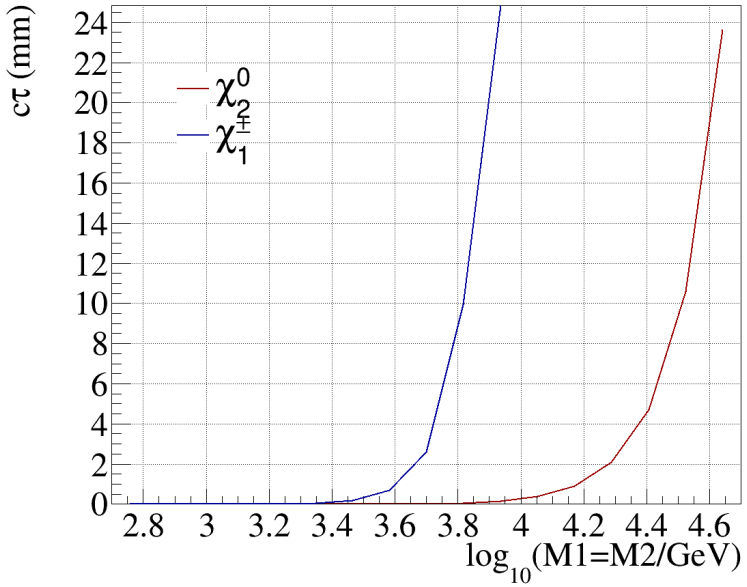
- For $\mu = [100, 115, 130]$, M1 = M2 = [574, ... 43 770] GeV:
- $m_{\chi_2^0} > m_{\chi_1^\pm} > m_{\chi_1^0}$
- Mass splittings of $\mathcal{O}$(1 GeV) $\leftrightarrow$ $c\tau(\chi_2^0) = \mathcal{O}$(1 mm)





Model Parameters





Work by Sam

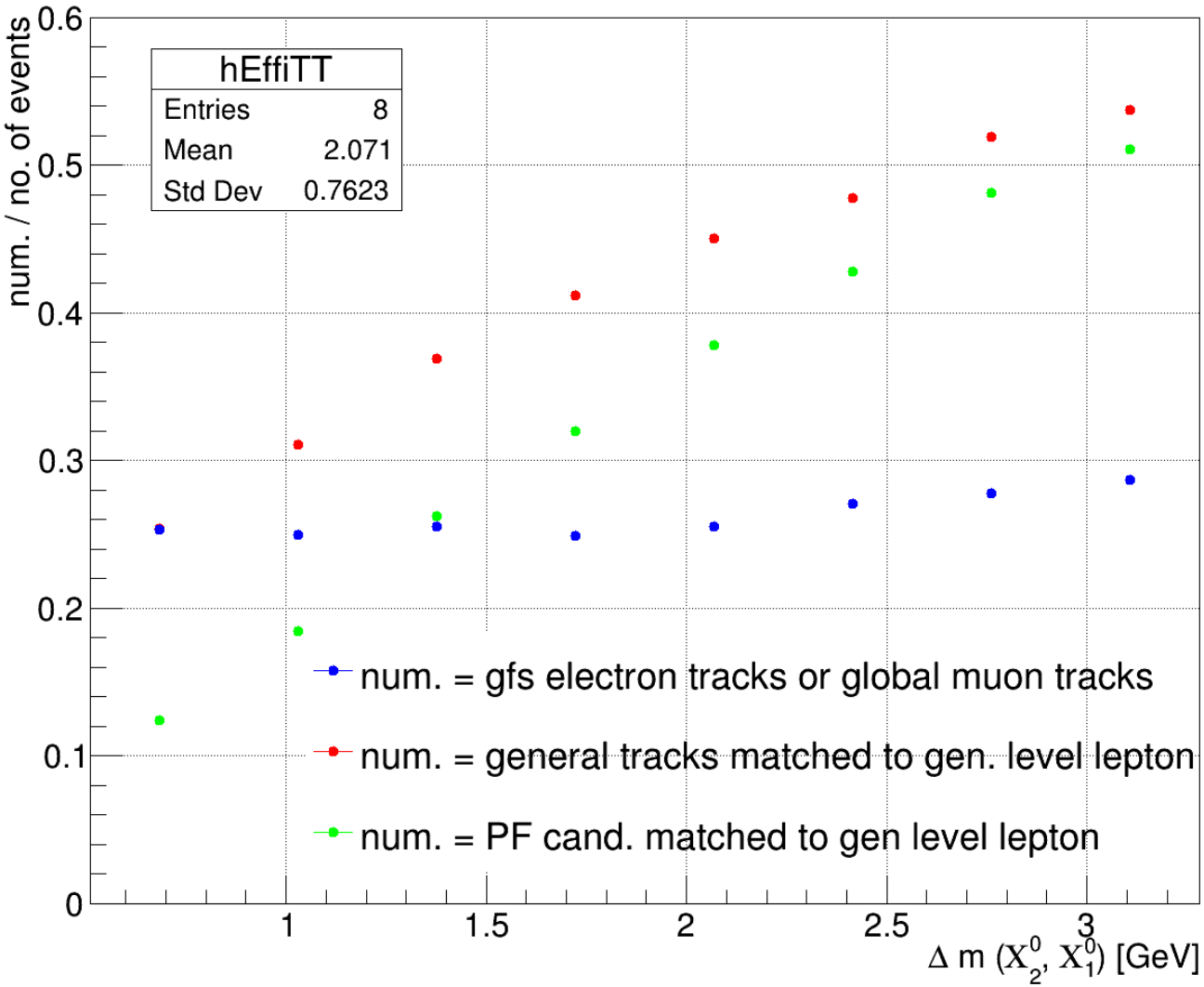
M1 = M2	$\Delta m(\chi_2^0, \chi_1^0)$	$c\tau$ [mm]
3.7	1.5 GeV	0.02
3.9	1 GeV	0.1
4	0.7 GeV	0.3
4.2	0.45 GeV	1

- At lower M1=M2: higher mass differences but shorter lifetime

→ Higher lepton momentum

→ Less displacement

Reconstruction efficiencies

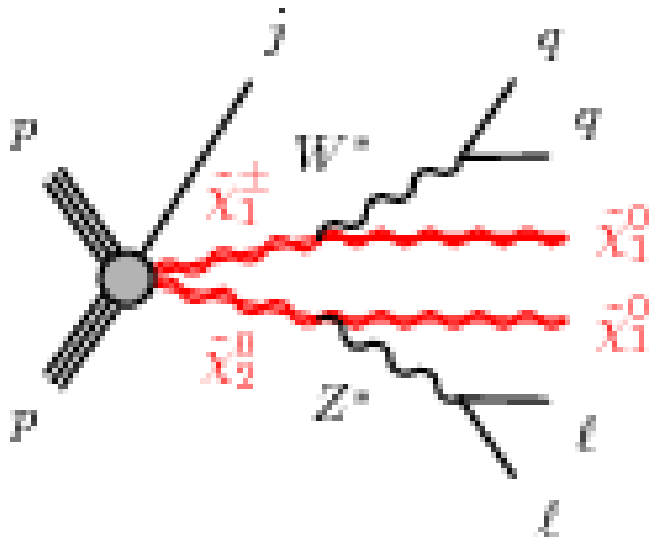


- Can we use dE/dx?
- dE/dx information not in FastSim samples from scan
- Checked in: `https://github.com/LongLivedSusy/ShortTrackSusy/blob/master/SigPoints/benchmarks/Summary_benchmarks.pdf`
- Only two scenarios with suitable Higgsino masses
- Approx. 10 000 events each
- Not enough statistics, especially not leptonic decay
- largest BR to photons
- hadronic decays

MCMC1	$\Delta m(\chi_2^0, \chi_1^0)$	$\chi_2^0 + X$	$\chi_2^0 \to ll$	$\chi_2^0 \to ee$	$\chi_2^0 \to \mu\mu$
37 569964	464 MeV	49.7 %	0.8 (0.8)%	0.4 (0.4) %	0.4 (0.4) %
22 237840	522 MeV	33 %	1.1 (2.6) %	0.6 (1.3) %	0.6 (1.3) %
12 865833	19 GeV	0,7 %	0 %	0 (0.002) %	0 (0.002)

Signal Production in *CMSSW_10_1_0_pre1*

- Used PYTHIA 8 and FullSim
- SUSY:qqbar2chi+-chi0 (16 processes)
- SUSY: qqbar2chi0chi0 (10 processes)
- BR $(\chi_2^0 \to \gamma\gamma) = 22\%$
- BR $(\chi_2^0 \to ll) = 3.5\%$
- $M_1 = M_2 = 6.57 * 10^3$ GeV
- $\mu = 100$ GeV
- $m_\chi \sim 100$ GeV
- $\Delta m(\chi_1^0, \chi_2^0) = 1.13$ GeV
- $\Delta m(\chi_1^0, \chi_1^\pm) = 0.62$ GeV
- 100 000 events

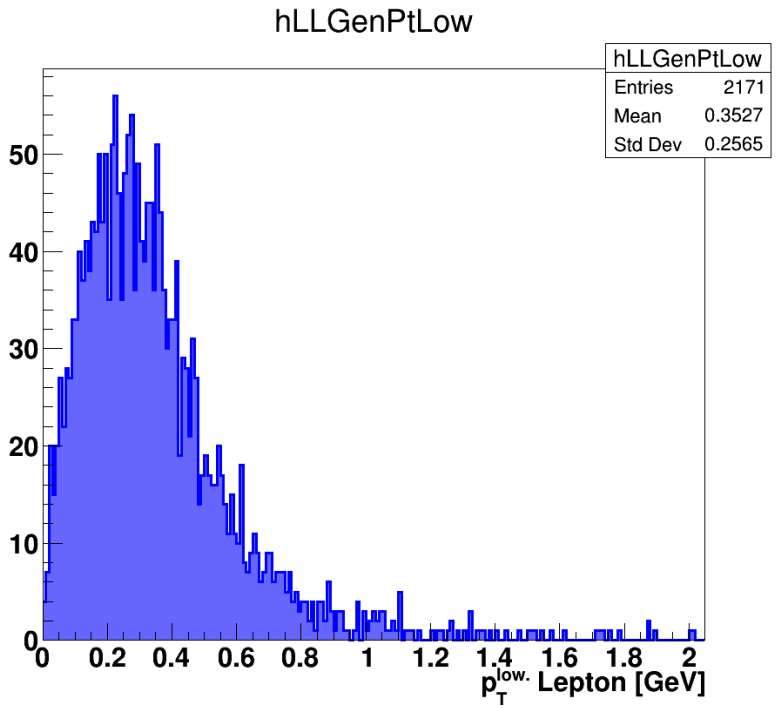


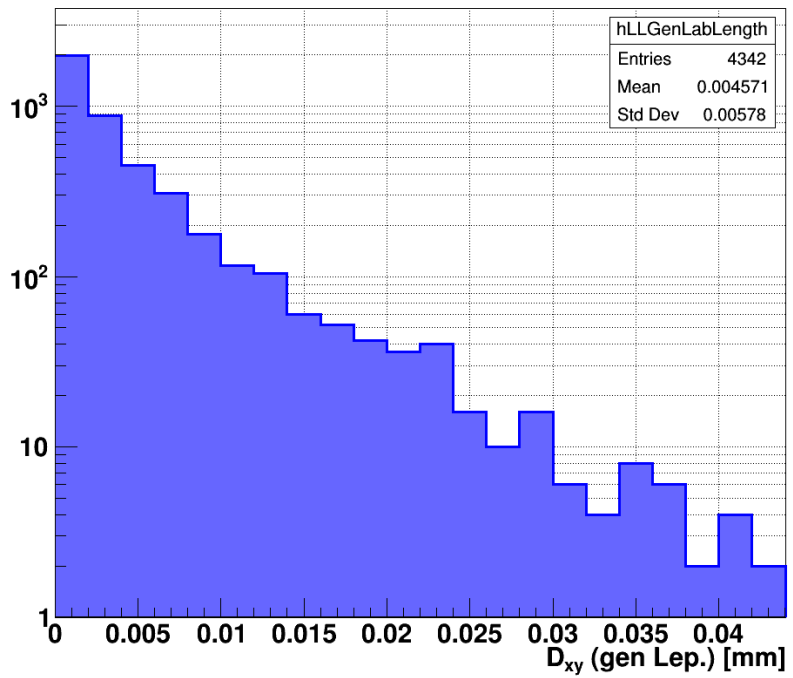
Signal Production in *CMSSW_10_1_0_pre1*

Observed in the samples:

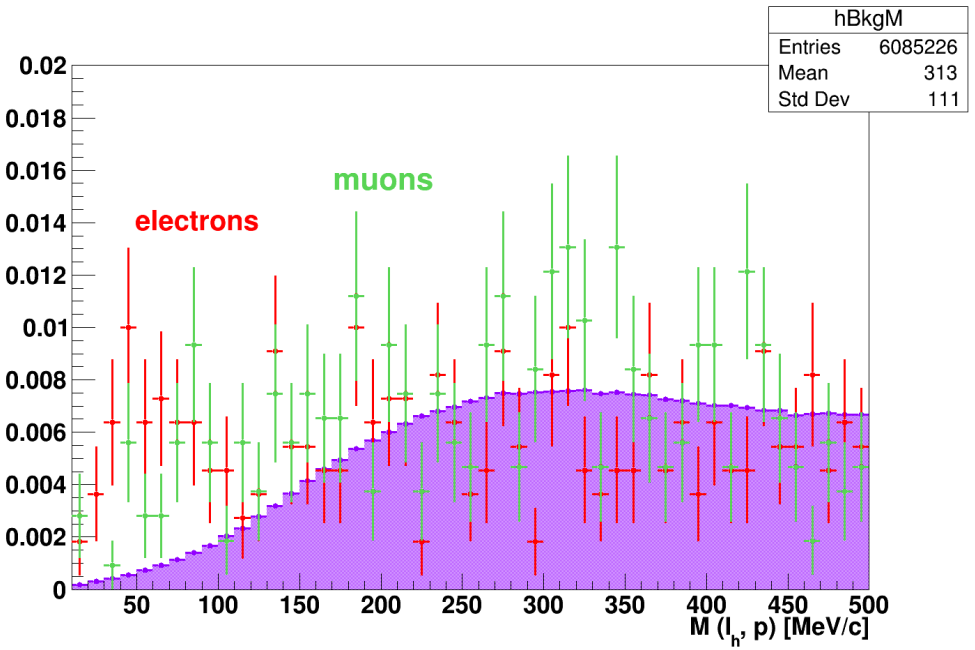
$\Delta m(\chi_2^0, \chi_1^0)$	$\chi_2^0 + \chi_1^0 + X$	$\chi_2^0 \to \chi_1^0 + ll$	$\chi_2^0 \to ee$	$\chi_2^0 \to \mu\mu$
1.13 GeV	60 %	2.2 %	1.1 %	1.1 %

- $< p_T(\chi_2^0) >= 85.38$ GeV
- $< p_T(\chi_1^0) >= 84.52$ GeV





dE/dx



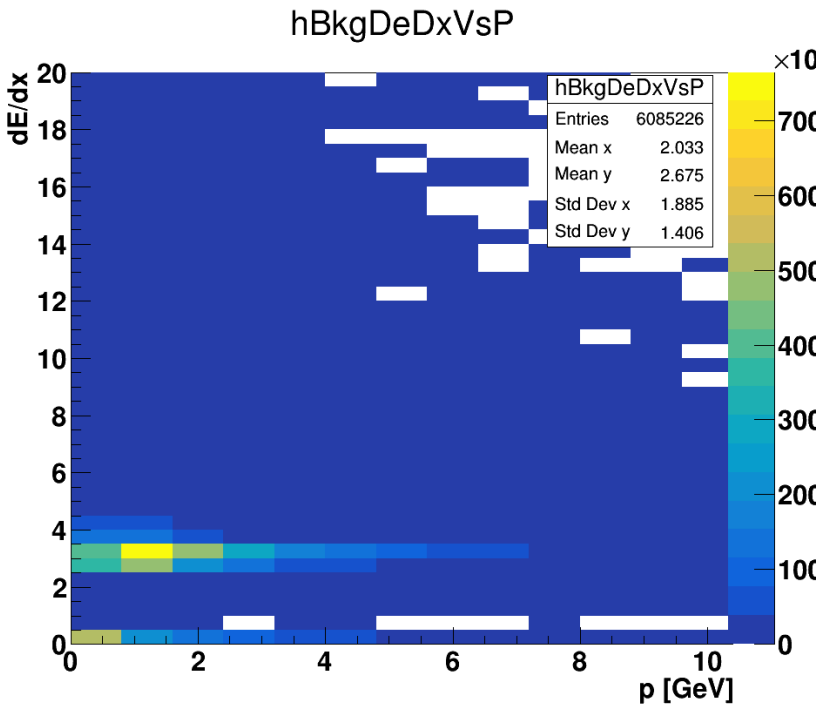
- dE/dx is calculated

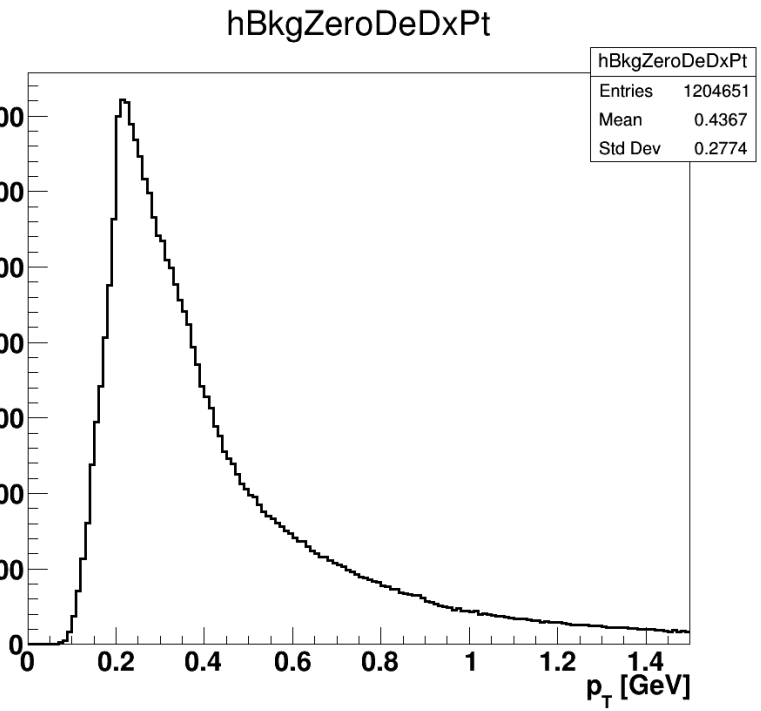
  a) from charge collected per hit (for pixel and strip hits)

  b) with the harmonic-2 estimator on track level (using only strip cluster charge)

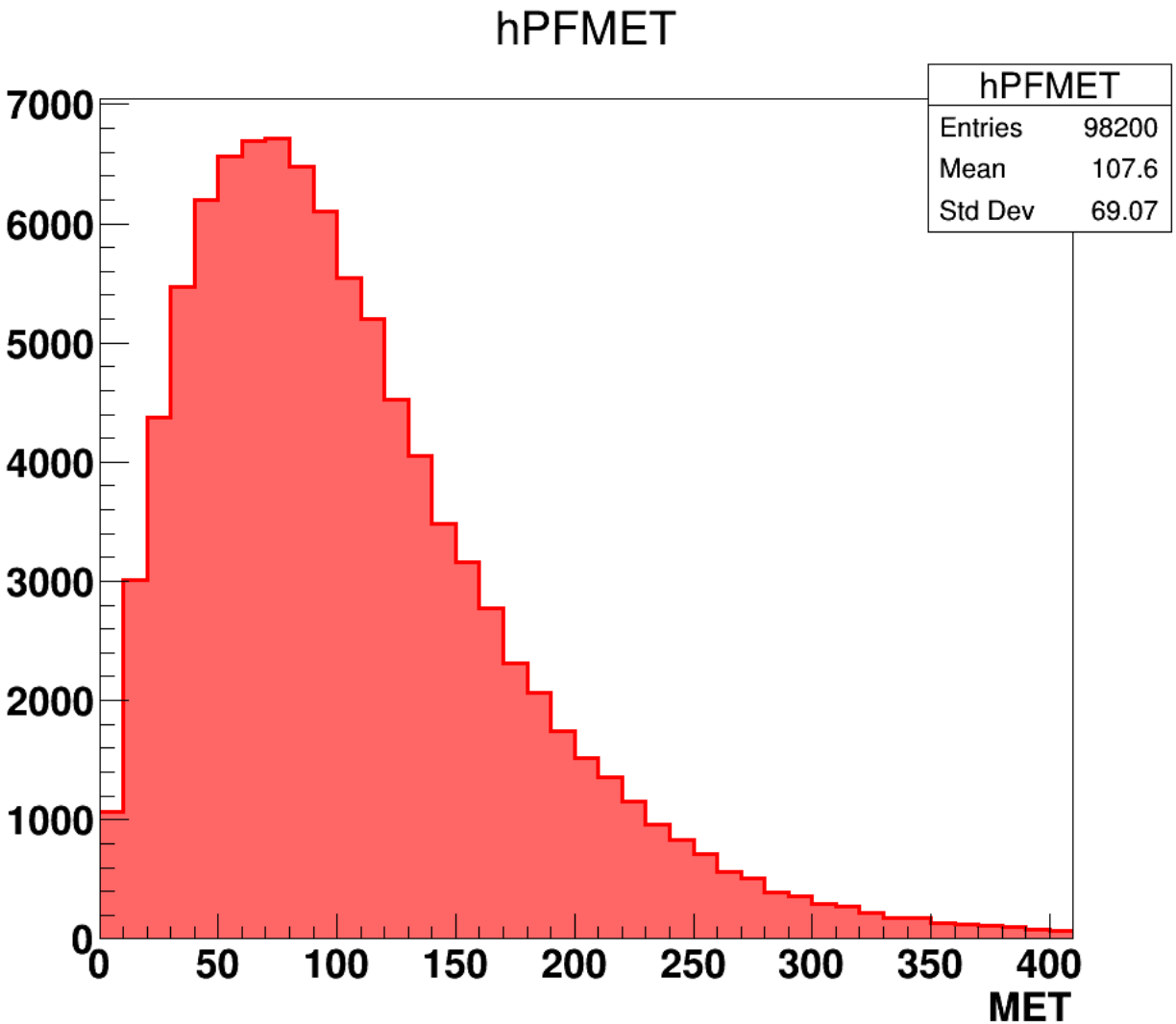
- $I_h = K\frac{m^2}{p^2} + C$ for $0.4 < \beta < 0.9$
- K, C = constants
- newly introduced CollctedClusterCharge cut in tracking (look up threshold)
- Problem: about 30% tracks with no dE/dx info (low pt tracks)

dE/dx

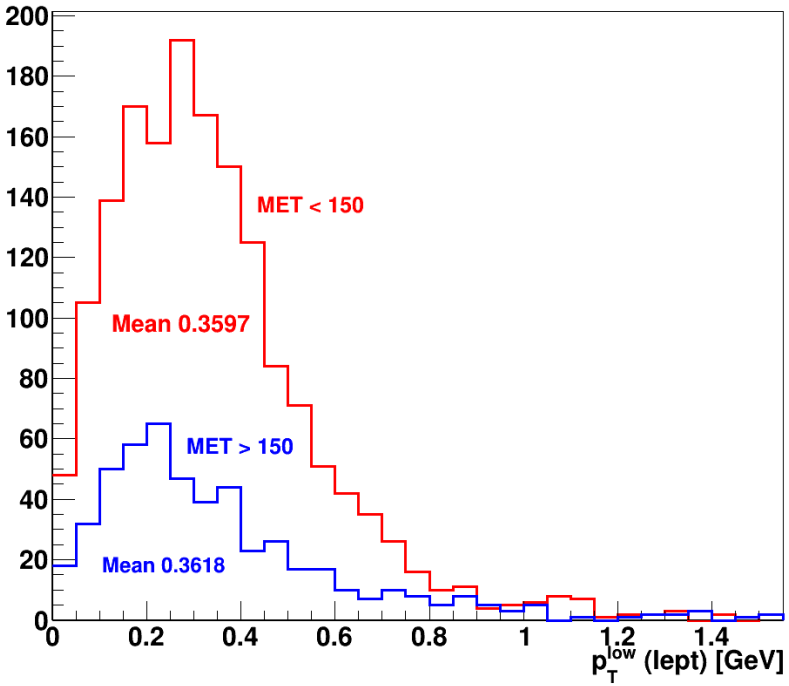

hBkgDeDxVsP
hBkgDeDxVsP
Entries 6085226
Mean x 2.033
Mean y 2.675
Std Dev x 1.885
Std Dev y 1.406
dE/dx
p [GeV]
×10

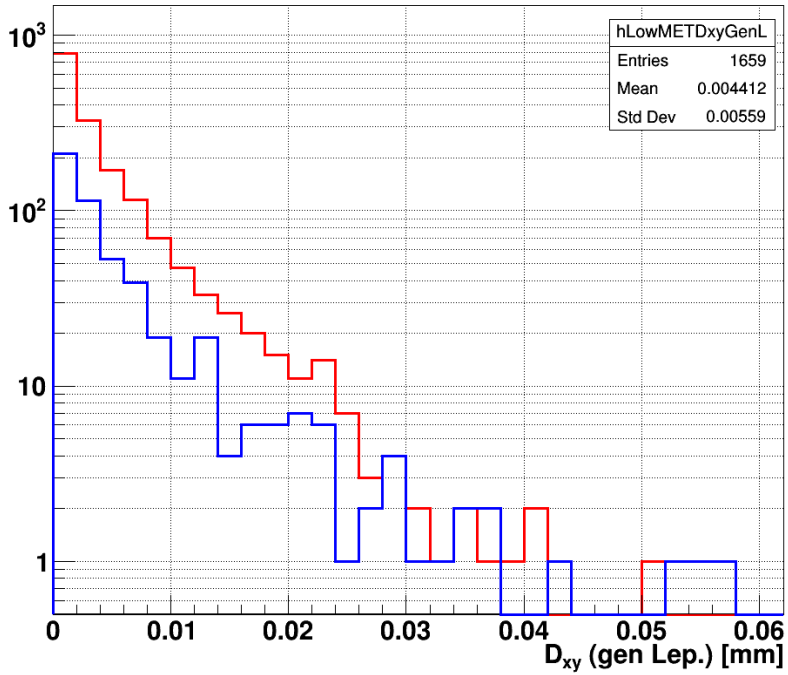

hBkgZeroDeDxPt
hBkgZeroDeDxPt
Entries 1204651
Mean 0.4367
Std Dev 0.2774
p_T [GeV]

Boost


hPFMET
hPFMET
Entries 98200
Mean 107.6
Std Dev 69.07
7000
6000
5000
4000
3000
2000
1000
0
0
50
100
150
200
250
300
350
400
MET

Boost

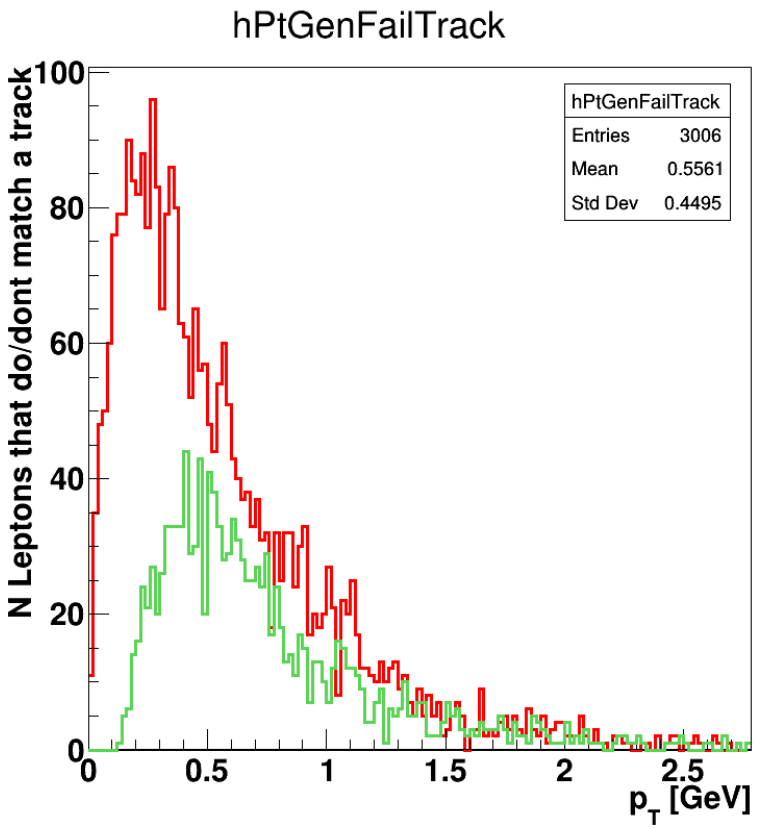

MET < 150
Mean 0.3597
MET > 150
Mean 0.3618
p_T^{low} (lept) [GeV]

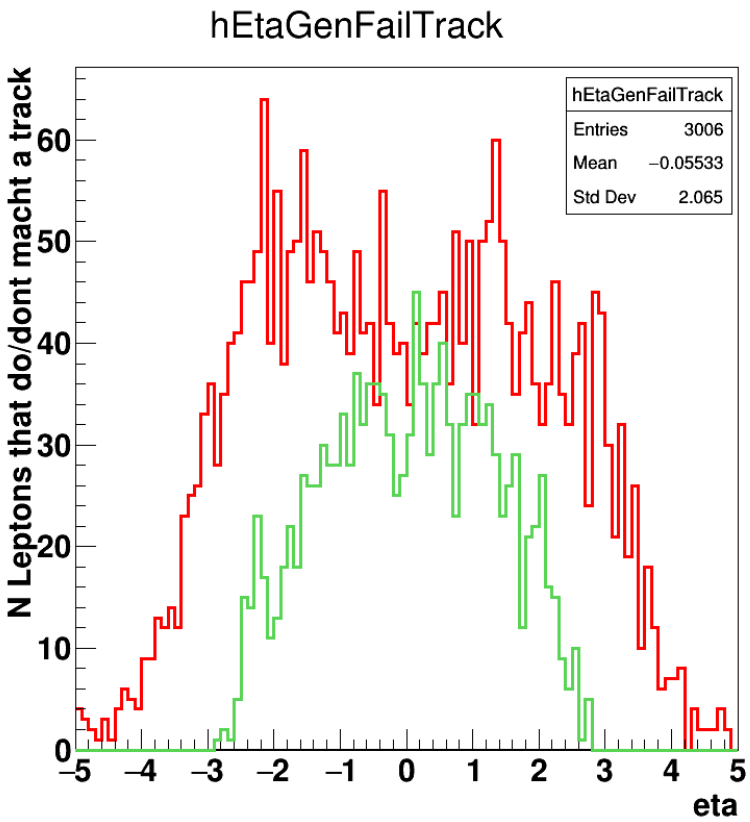

hLowMETDxyGenL
Entries 1659
Mean 0.004412
Std Dev 0.00559
D_{xy} (gen Lep.) [mm]

Efficiency

- matched if $\Delta R < 0.02$

Collection	Matched total	Matched ee	Matched $\mu\mu$
Tracks	31 %	21 %	40 %
PFCand	27 %	16 %	36 %





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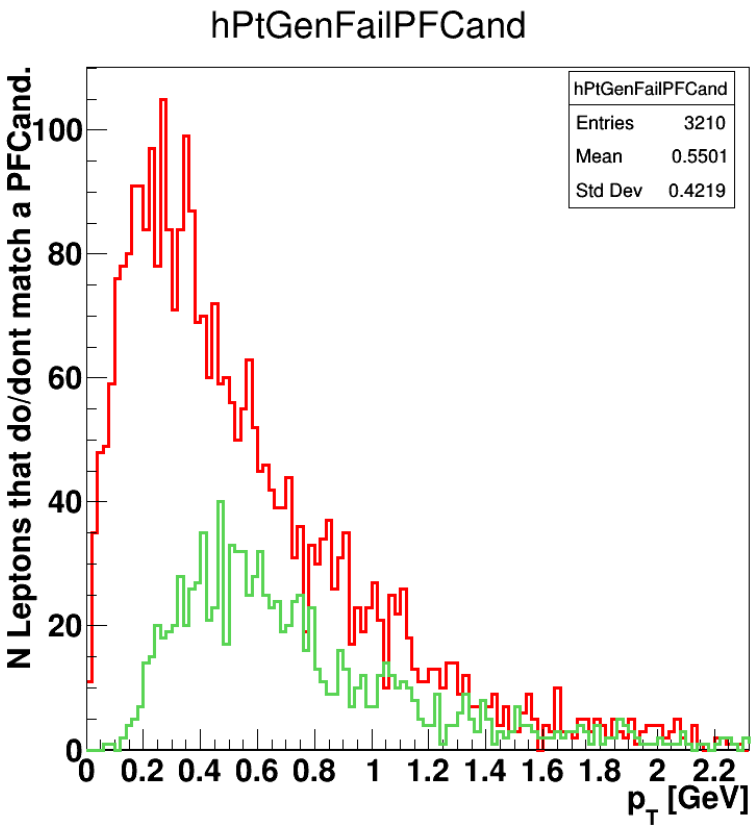
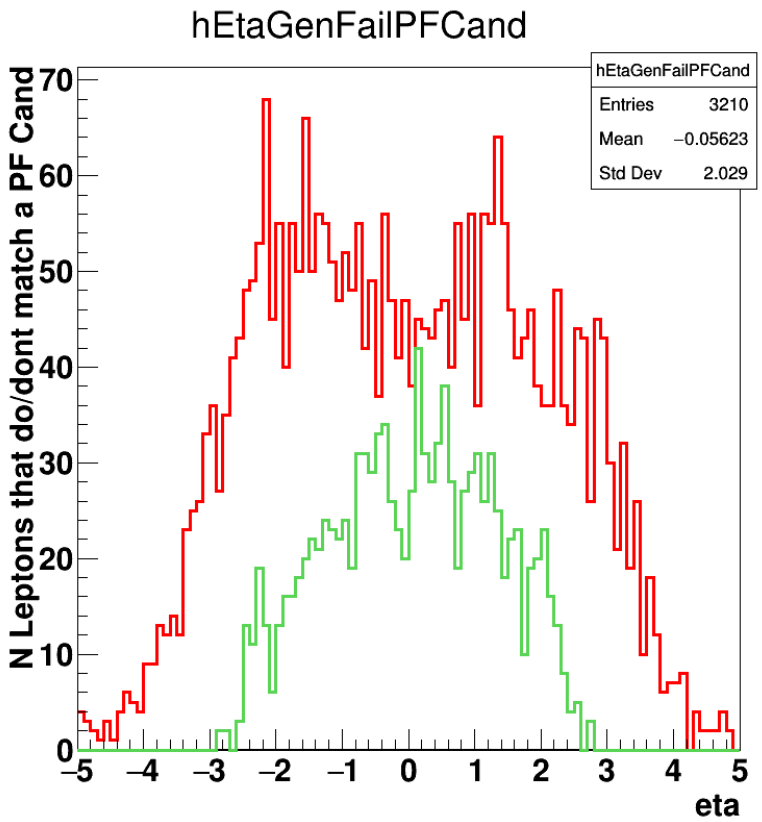
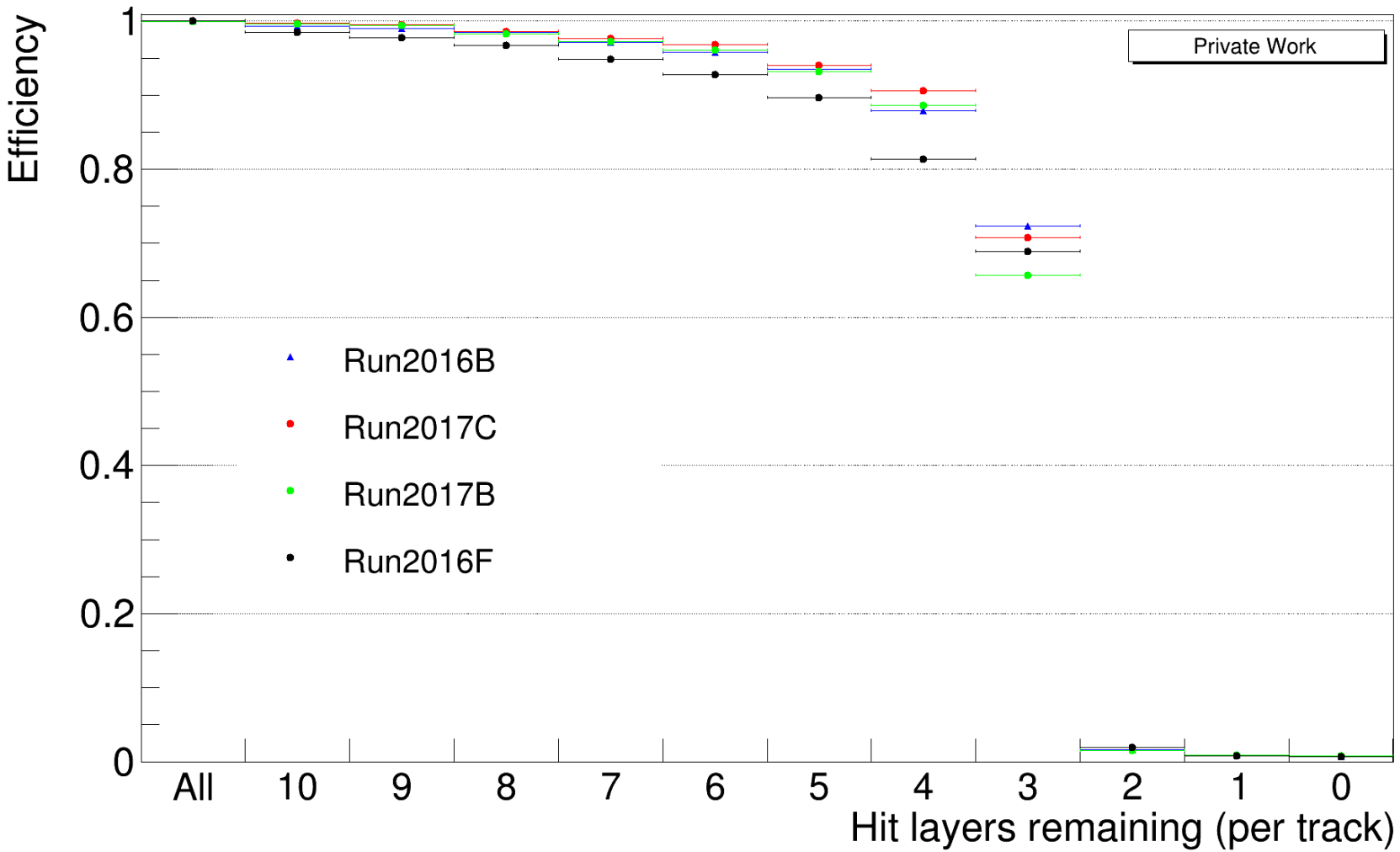




Next Steps

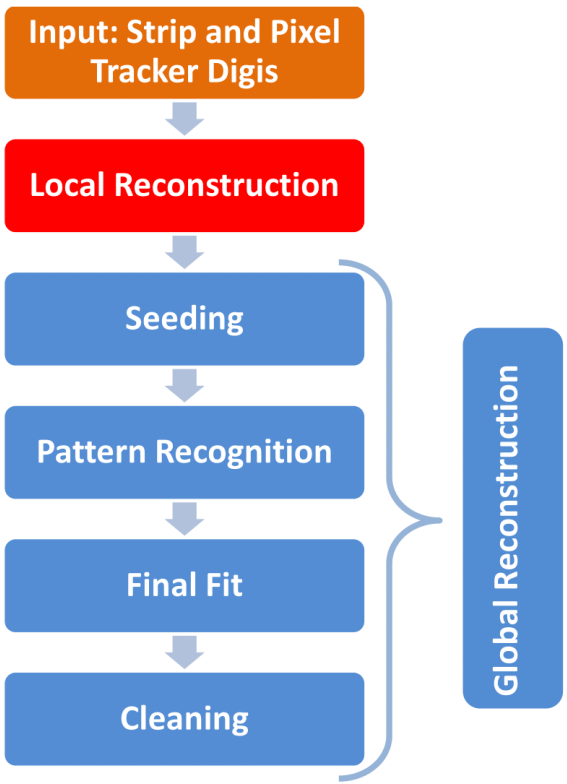
- Reproduce Sample with BR = 1
- Efficiencies in slices of p_t and η
- Use of dE/dx -> Plot M
- Which tracking algorithm is most efficient? (MTV?)

Tracking Efficiencies Included Run2016F



Dropping Muon Seeded Iterations

- Iterative tracking:
  Combinatorial **T**rack **F**inder
- Proceeds 4 steps in 9 (7) iterations (Phase-0)



- Default includes all 12 (!)
- Dropped
  - MuonSeededSeeds-, TrackCandidates-, TracksInOut
  - MuonSeededSeeds-, TrackCandidates-, TracksOutIn
  - TrackCandidates-, TracksOutInDisplaced
  - PreDuplicateMerging with muon seeded tracks

9 main iterations

step name	seeding	target track
Initial	pixel quadruplets	prompt, high p_T
LowPtQuad	pixel quadruplets	prompt, low p_T
HighPtTriplet	pixel triplets	prompt, high p_T recovery
LowPtTriplet	pixel triplets	prompt, low p_T recovery
DetachedQuad	pixel quadruplets	displaced−−
DetachedTriplet	pixel triplets	displaced−− recovery
MixedTriplet	pixel+strip triplets	displaced−
PixelLess	inner strip triplets	displaced+
TobTec	outer strip triplets	displaced++
JetCore	pixel pairs in jets	high p_T jet
Muon inside-out	muon-tagged tracks	muon
Muon outside-in	standalone muon	muon

Iterative Tracking - 2017

Challenges:

- Tracking mainly combinatorial problem

  $\rightarrow$ pile up (PU) has strong effect on reconstruction efficiency, accuracy and timing
- Average PU expected to rise with RunII due to 25ns bunch crossing
- Average PU rises from ≈ 25 to ≈ 45
- Higher occupancy in tracker (+5% in Pixel, +45% in Strip)
- Special Problem: ghost hits in double sided strips
- Effect on iterations that are seeded using double-sided hits (PixelLess/TobTec)
- Pixel dynamic inefficiency caused by saturation of the readout chip buffer

Solutions:

- Timing-Oriented developments
- Reduce time needed for strip-seeded iterations
- Extend **strip-pair pattern to include additional third hit** (nr. of produced seeds reduced, nr. of tracks remains)
- Out of time pileup increases reconstruction time and fake rate
- Particles from different bunch crossing arrive at random time, corresponding clusters characterized by low charge

  $\rightarrow$ **Selection on the cluster charge** (CCC)
- Further improvements e.g. order of the iterations (faster iterations run first) [**?**]

Iterative Tracking After 2017

- Physics-Oriented developments

MounSeedStep OutIn:

- Outside-in iteration seeding using information from outermost muon detectors
- Recovers PU-dependant efficiency loss
- Re-reconstruction of muon-candidate tracks with looser requirements to recover hit collection efficiency

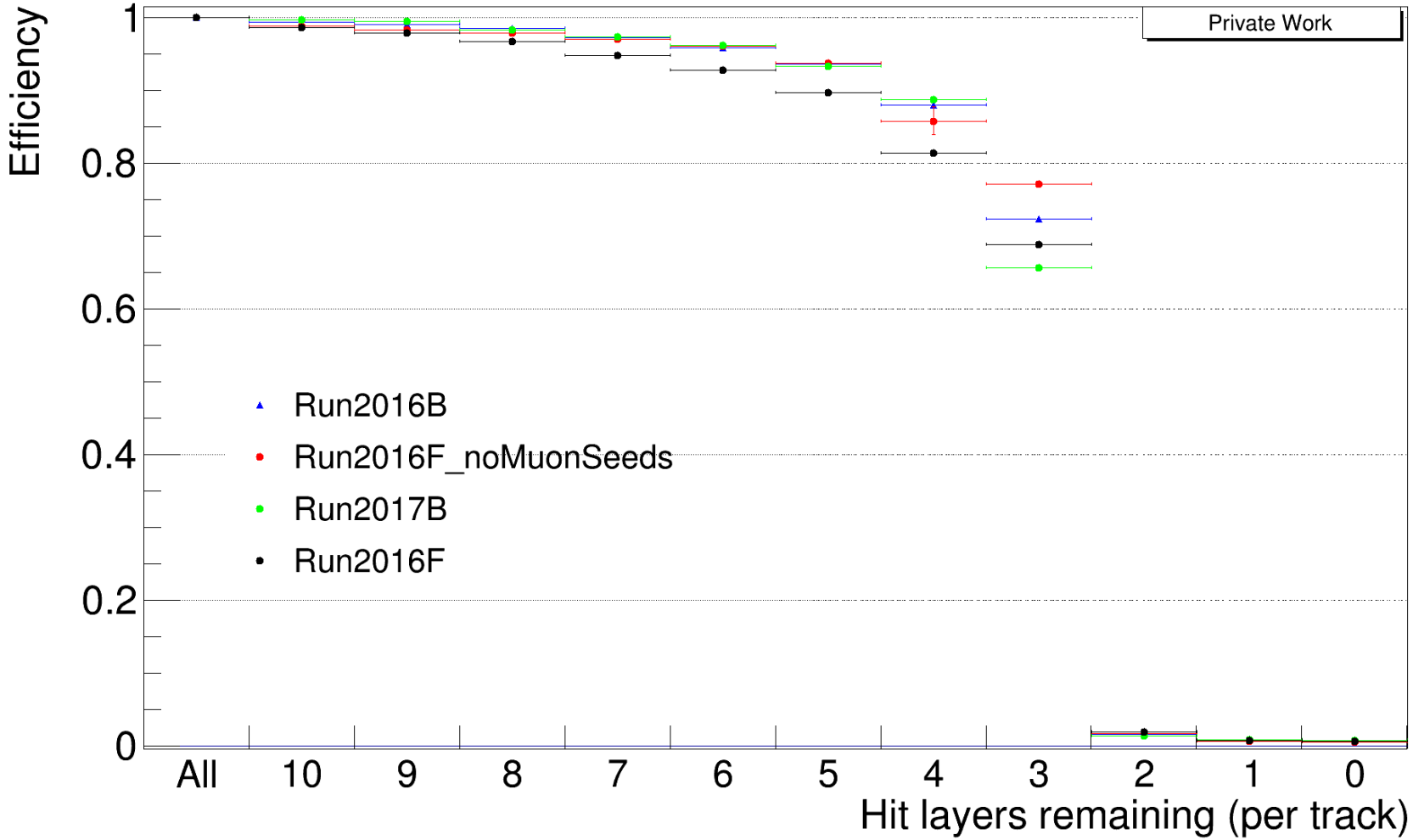
MounSeedStep InOut:

- Requiring muon candidates (muon detectors) to be confirmed through a corresponding track (tracker)
- Reduces false reconstruction rate, improves momentum resolution

DuplicateMerge:

- Tags clusters as merged if they are associated with more than one track
- Setting 'isMerged' flag in SiStripCluster-container

Tracking Efficiencies without muon seeds



Next Steps

- Redo the efficiency study without muonSeeded Iterations
- Include even more 2016/2017 Runs
- Include algo information
- redo with electrons
- redo in MC