Pileup & Tau Trigger

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Outline

- Description of the pileup & data used
- Effect on trigger efficiency and observables
- Tuning present cuts
- Introducing new variables

- A lot of details and other stuff in backup slides

Pileup

- Physical reality we must cope with
- Several pileup scenarios were proposed to estimate the changing conditions at LHC
- So far the concern was in 3 scenarios:
  - bunch spacing 450 ns, lumi 1e32, 4 events/BC
  - bunch spacing 75 ns, lumi 1e33. 6.9 events/BC
  - bunch spacing 25 ns, lumi 2e33, 4.6 events/BC
- This study was focused on the first scenario
  - Early running + largest statistics available

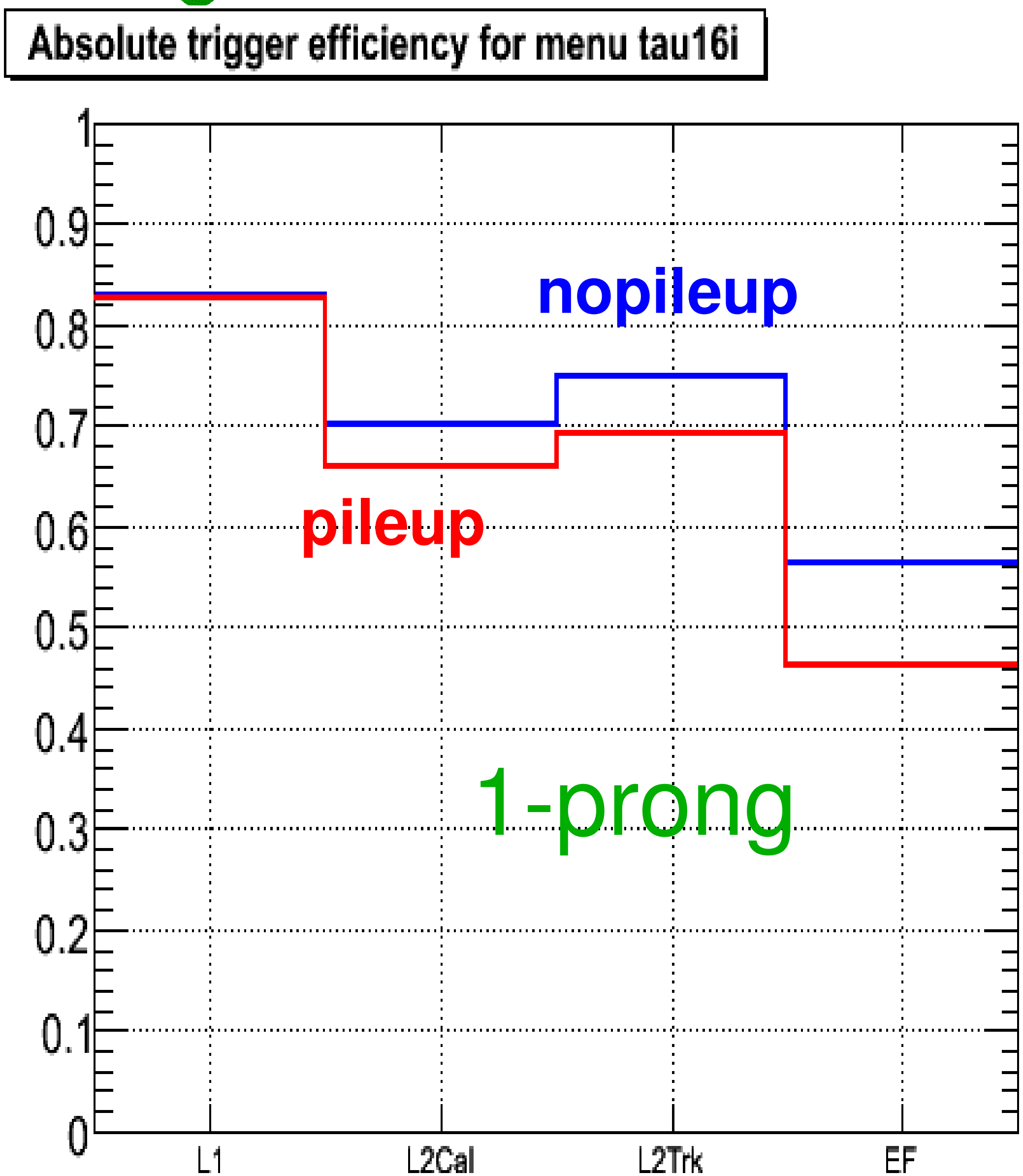
Overview of data

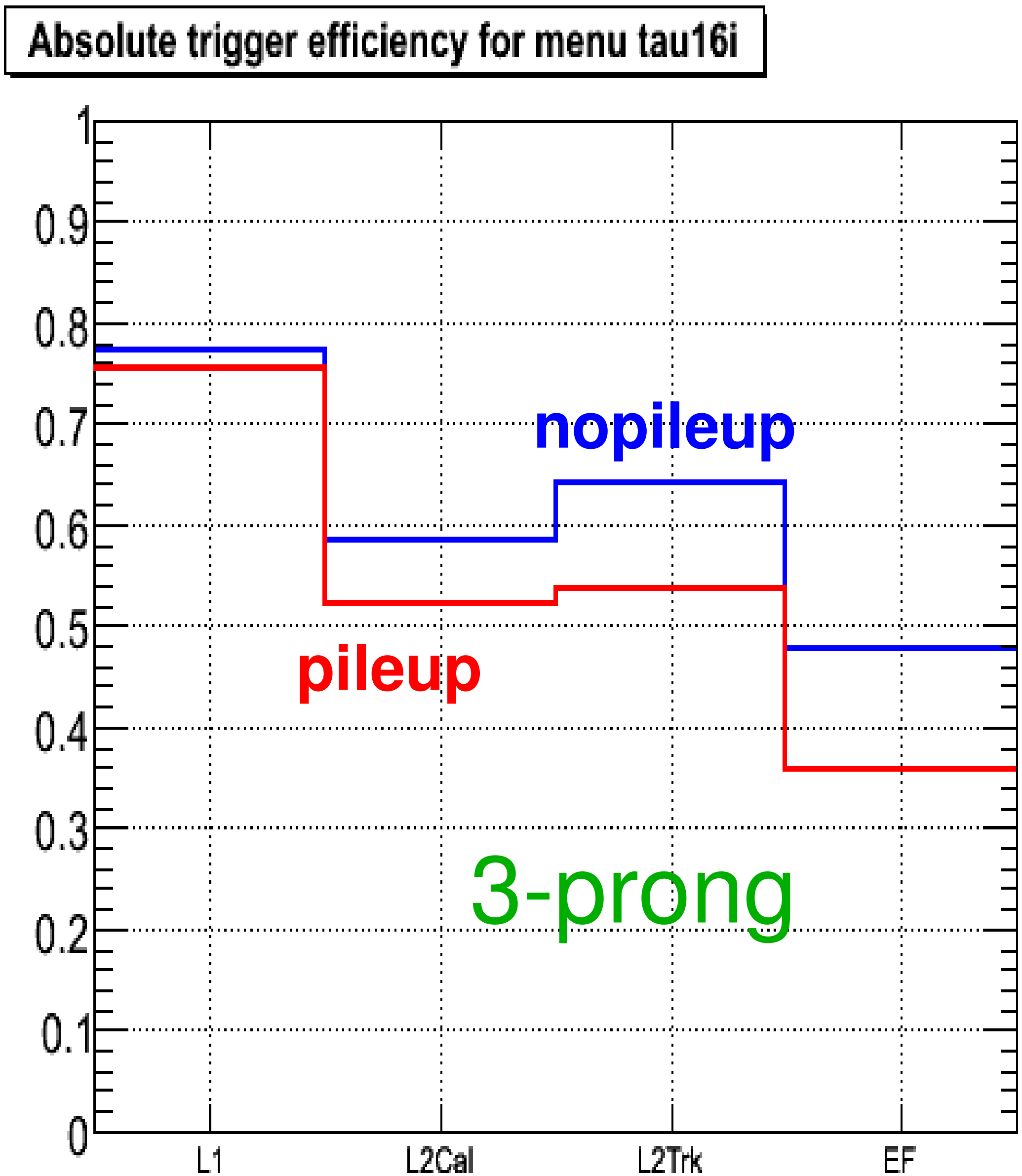
- Signal dataset was 106052, i.e. Z->tautau at 10 TeV
  - The same events w/ and w/o pileup
  - O(100k) events
- Background datasets were QCD dijets J0, J1, J2 (i.e. 8-70 GeV)
  - Also w/ and w/o pileup
  - O(200k) events per dataset
- Analysis of trigger performance done using TTP12a made from RDOs (pileup) and AODs (nopileup)

Analysis description

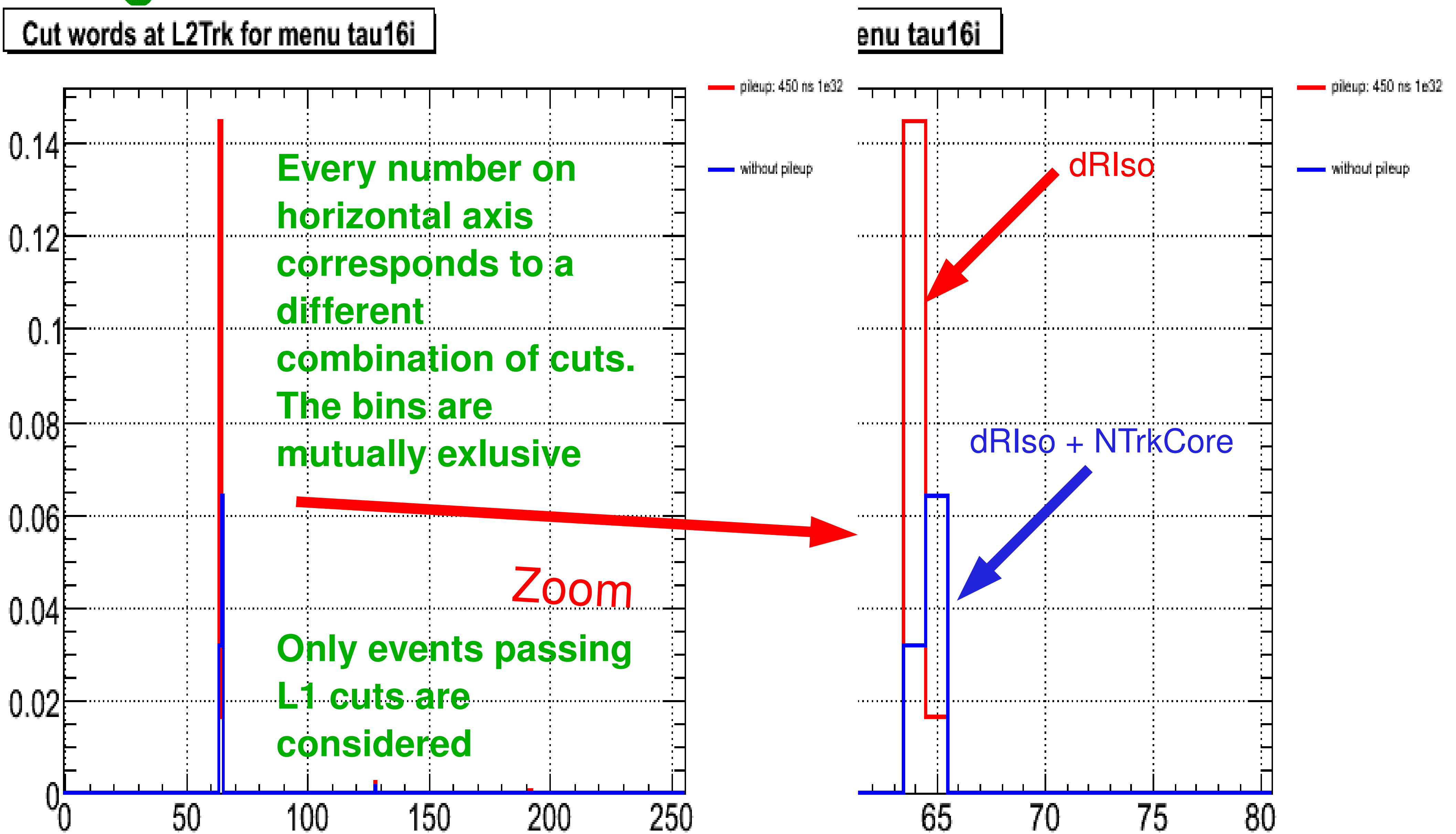
- The main goal was to analyze trigger performance
  - No requirements of offline matching
  - Only reference was MC truth
- Selection criteria
  1) There is a complete trigger chain in event, the matching of trigger objects is done by RoIword and dR
  2) EF object is matched to a true hadronic tau, (dR < 0.2)
  3) EF object must have at least 1 track
  4) 1p/3p selection from MC info

Trigger efficiency “as-it-is”

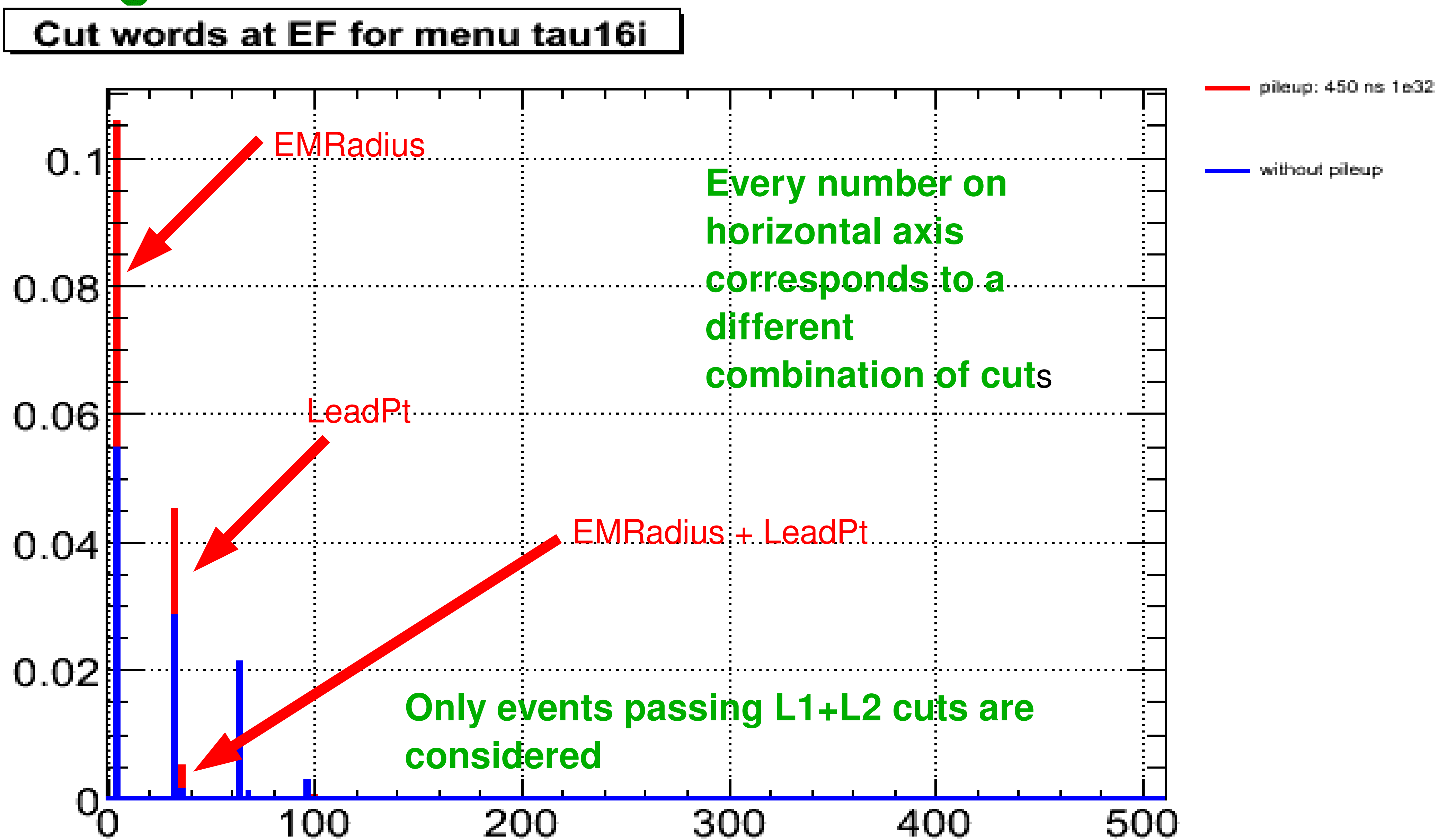




L2Trk – 1p – cut words



EF – 1p – cut words



General remarks

- "Isolation" variables (EmIsol at L1, dRIso and Emradius at L2, Emradius at EF) decrease the efficiency of signal selection in presence of pileup
- "Energy" variables (TauEnergy at L1, EtNar at L2, Etcorr at EF) increase the efficiency of signal selection in presence of pileup
- Net result is efficiency loss:

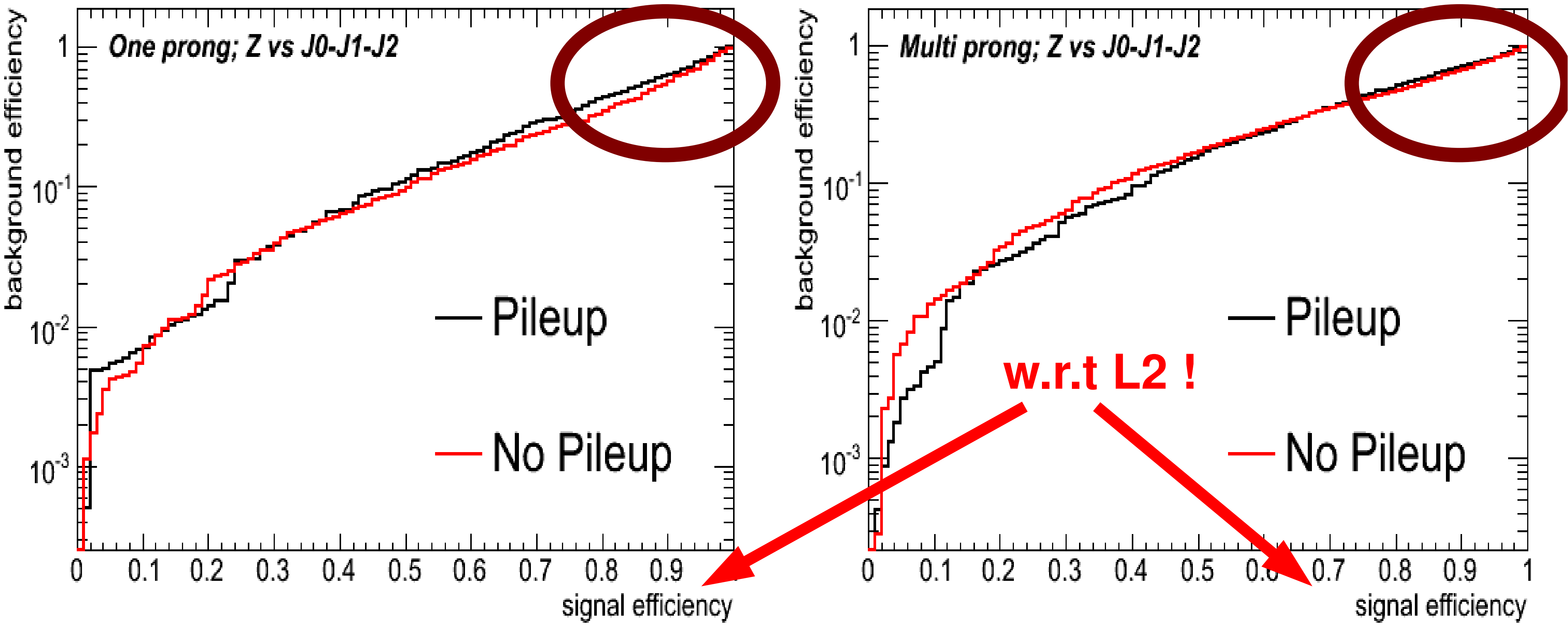
Signal – 1p	**Pileup**	**NoPileup**
After L1	0.83	0.83
After L2Cal	*0.66*	*0.7*
After L2Trk	*0.69*	*0.75*
After L2	0.56	0.63
After EF	**0.46**	**0.56**

Signal – 3p	**Pileup**	**NoPileup**
After L1	0.79	0.77
After L2Cal	*0.55*	*0.59*
After L2Trk	*0.56*	*0.64*
After L2	0.42	0.51
After EF	**0.37**	**0.48**

Can we restore the performance by tuning the cuts ?

Minimal case

- All cuts are fixed as in tau16i menu, except the EMradius
- By changing the value of EMRadius cut we can compare signal vs. background efficiencies for pileup and non-pileup case:

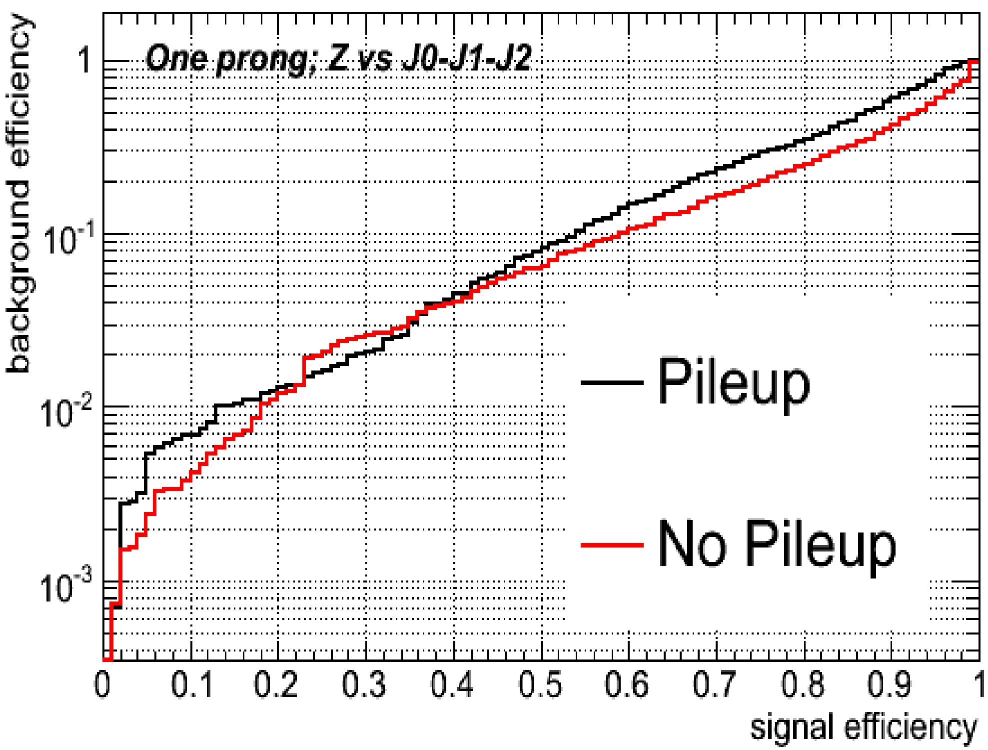


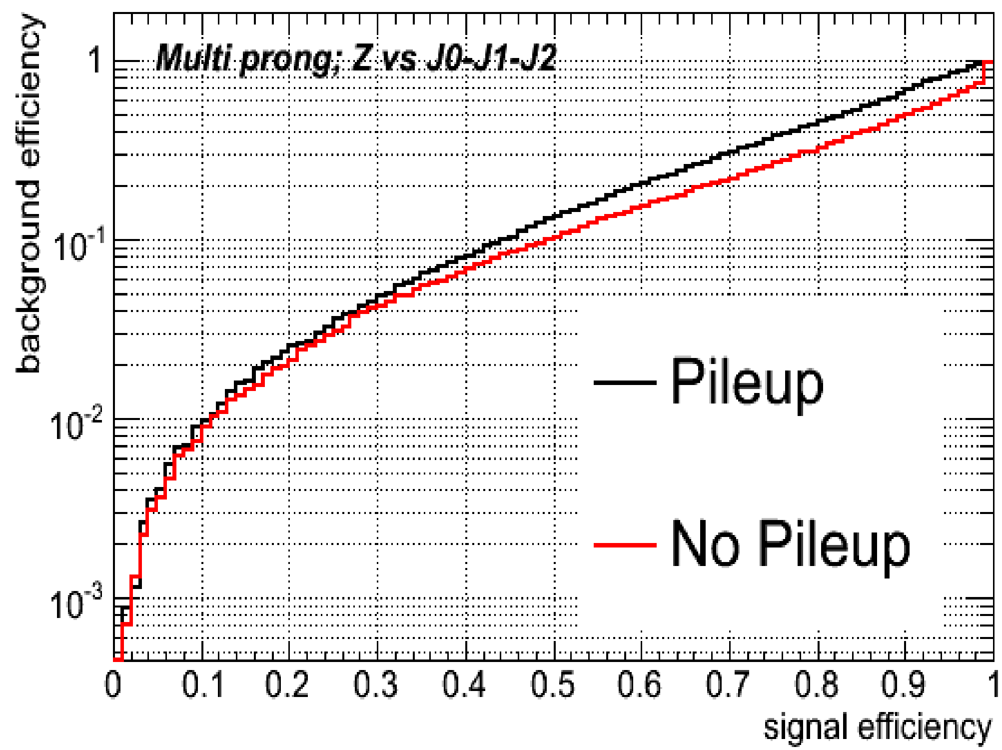
Minimal case - result

- The performance curves are very similar => In principle we can obtain back the EF performance by simply tuning the EMRadius cut
- But we are still a bit worse than without pileup AND
- We are losing 10 % of absolute efficiency from the start due to efficiency loss at L2 => Even if the EF efficiency is same for pileup as it was for non-pileup before retuning, we are still losing in absolute efficiency
- To address this problem, we will look at a sample without L2 cuts or with very loose L2 cuts

L2loose

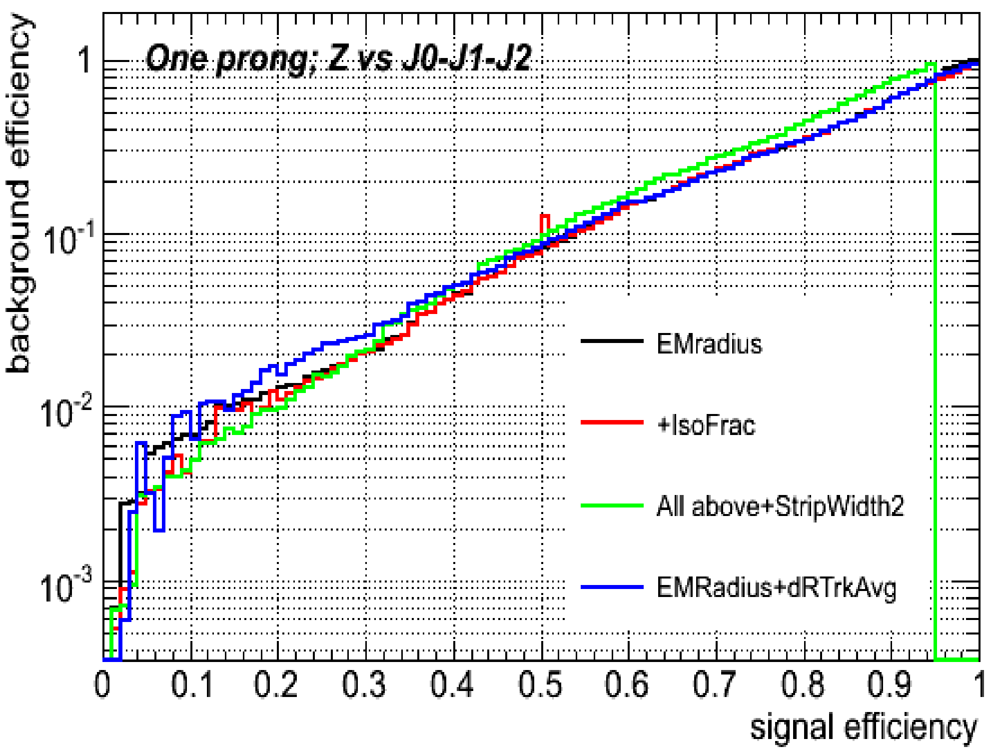
- At L2 we employ only cuts on energy and on n. of tracks in core
- Absolute efficiency after these cuts is for pileup 66 % and 63 % for 1p and 3p respectively. It is 10/20 % above the L2 efficiency for 1p/3p
- 10 % degradation for pileup for eff > 50 % (>30% absolute)

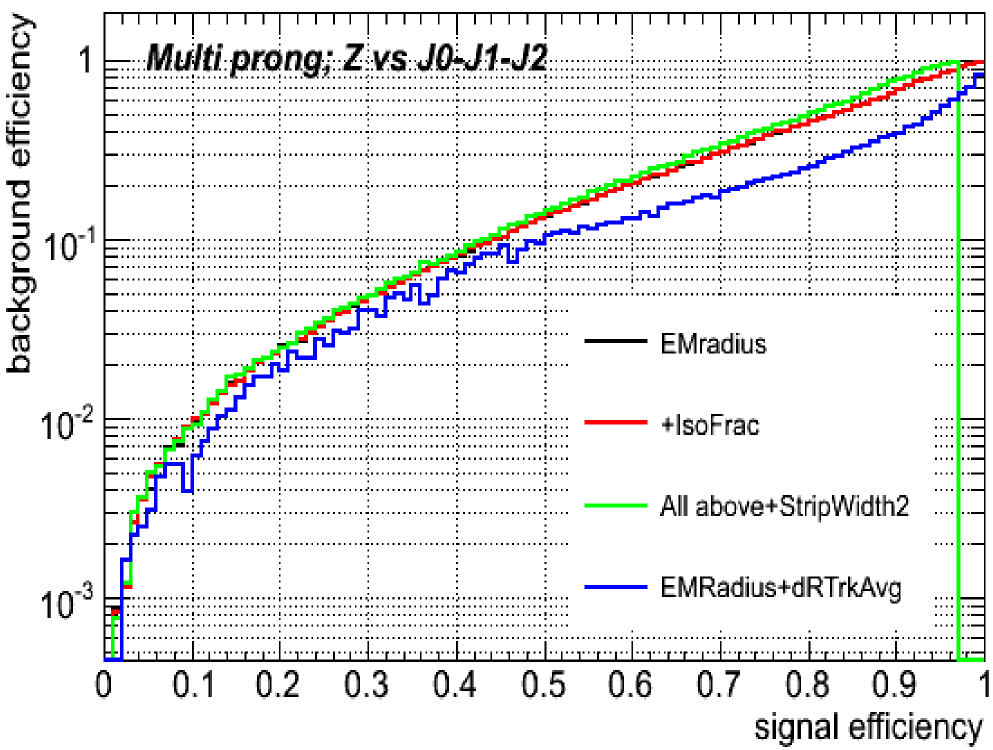




L2loose

- EM radius alone did not help -> try combination
- Using calo variables + 1 tracking variable
- No gain at 1p, but up to 20% gain with tracking variable at 3prong
- Is the performance restored?





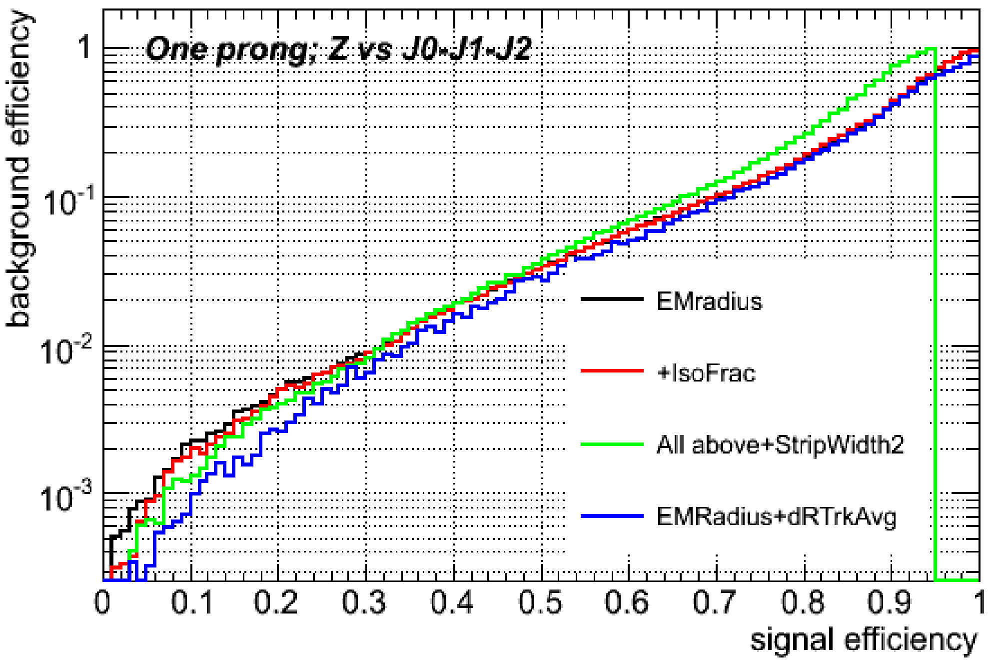
L2loose - conclusions

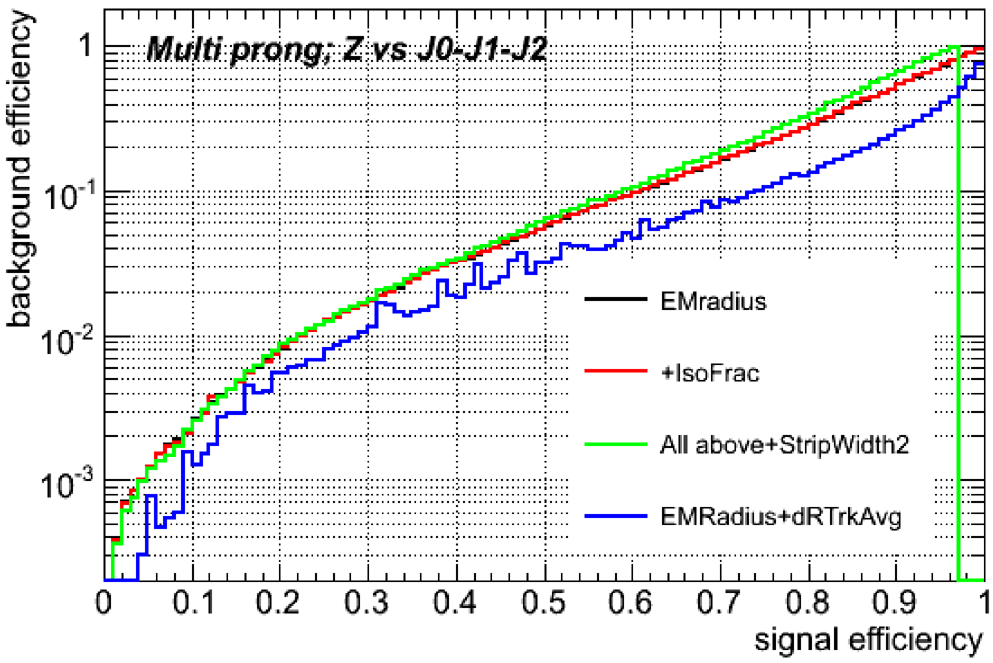
- Absolute signal efficiency after L2loose cuts for pileup 3 prong: 0.63
- Absolute signal efficiency after all cuts for non pileup 3 prong: 0.48
  - This corresponds to 0.76 in relative efficiency w.r.t L2loose
- Signal efficiency 0.76 corresponds to bckg efficiency 0.22
- Absolute background efficiency after L2loose cuts: 0.22
- The absolute background efficiency is 0.048

- **When using L2loose cuts + cuts on EM radius and dRTrkAvg we can obtain 0.48 absolute signal efficiency while the background efficiency is 0.048. This means that the non-pileup performance is fully restored (its background efficiency is ~ 0.05)**

No L1, No L2

- Using only EF variables to find whether it can help with 1-prongs
- Cut efficiency is 0.9/0.95 for 1p/3p (cutting on EF_Et > 16000)
- It does -> In a similar way, combining Emradius with dRTrkAvg can restore full performance even for 1prongs (absolute **0.46**-> relative 0.51->relative background efficiency 0.13 -> absolute bckg eff **0.09**)





Conclusions

- Pileup (even the initial one) introduces 10/20 % drop in total selection efficiency
- The performance of EF alone can be restored by changing cuts on Emradius only. However, it will not restore the total efficiency
- Releasing cuts on L2, we can restore full performance for 3-prongs by using additional tracking variable in distinction
- Using only EF variables we are able to restore performance also for 1-prongs

Back-up slides

List of input datasets

- Pileup
  - mc08.106052.PythiaZtautau.digit.RDO.e347_s462_d150
  - mc08.105009.J0_pythia_jetjet.digit.RDO.e344_s479_d150
  - mc08.105010.J1_pythia_jetjet.digit.RDO.e344_s479_d150
  - mc08.105011.J2_pythia_jetjet.digit.RDO.e344_s479_d150
- No Pileup
  - mc08.106052.PythiaZtautau.recon.AOD.e347_s462_r604
  - mc08.105009.J0_pythia_jetjet.recon.AOD.e344_s479_r604
  - mc08.105010.J1_pythia_jetjet.recon.AOD.e344_s479_r604
  - mc08.105011.J2_pythia_jetjet.recon.AOD.e344_s479_r604

TTP12a

- Produced with Athena 14.2.25.2.
  - TrigTauPerformNtuple-00-04-20
  - TrigTauPerformAthena-00-05-33
- Location:
  - All TTPs which were used in this study are located at gsiftp://lscf.nbi.dk/se1/nbi/jez/TTP12_merged
  - The directory contains also single taus (20, 50 and 100 GeV)
  - All TTPs are made from the same events w/ and w/o pileup

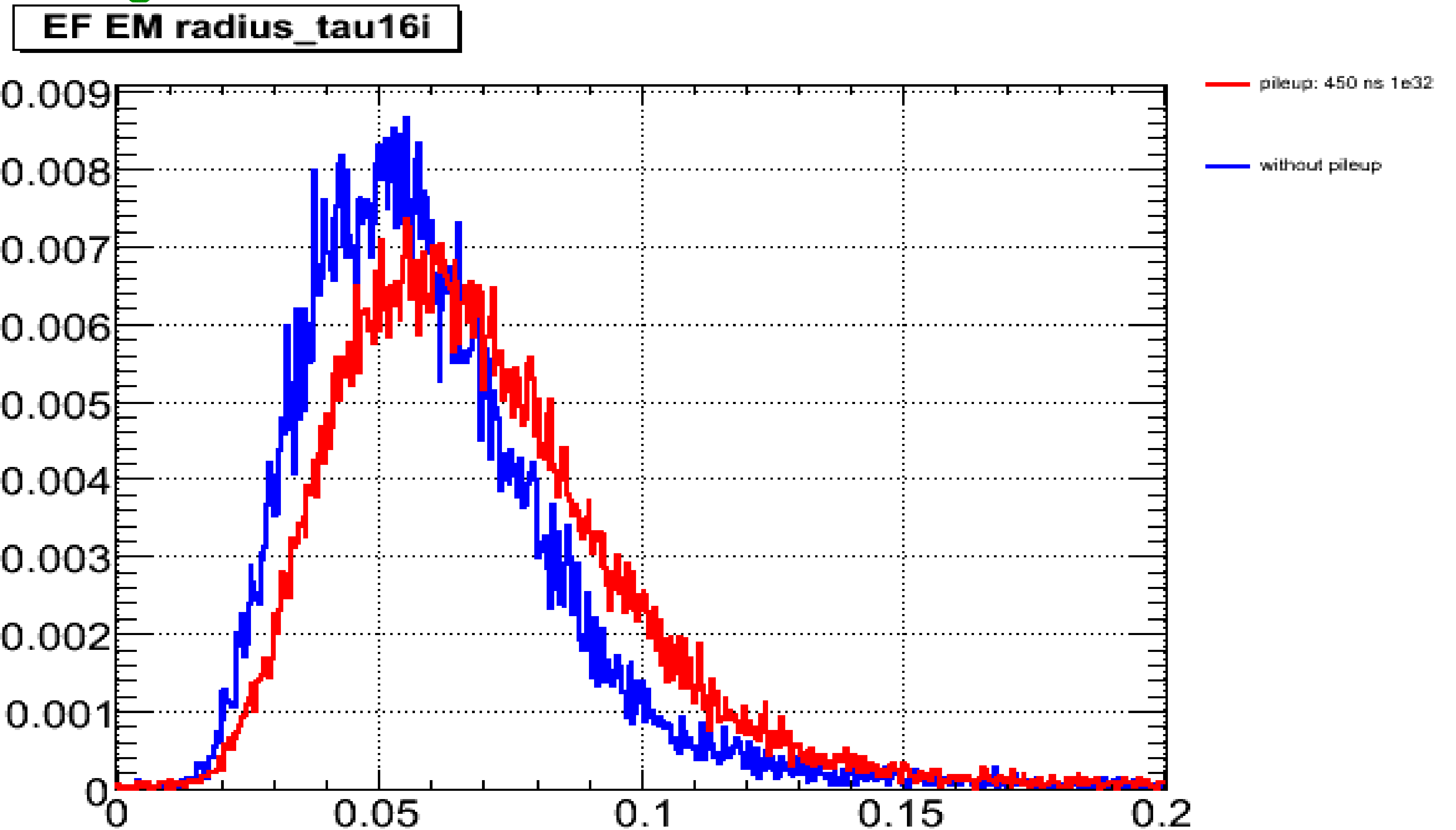
Cut Word

- Detailed look at each level to find which cut caused the efficiency drop
- The best tool is cut word, i.e. number containing the information about which cuts have been passed
- Example:
  - L1 has 6 quantities on which one can cut
  - There is $2^6 = 64$ possible outcomes
  - 1 is not passed, 0 is passed
  - Number 101001 = 32 + 8 + 1 = 41 means that cuts number 1, 4 and 6 have not been passed.

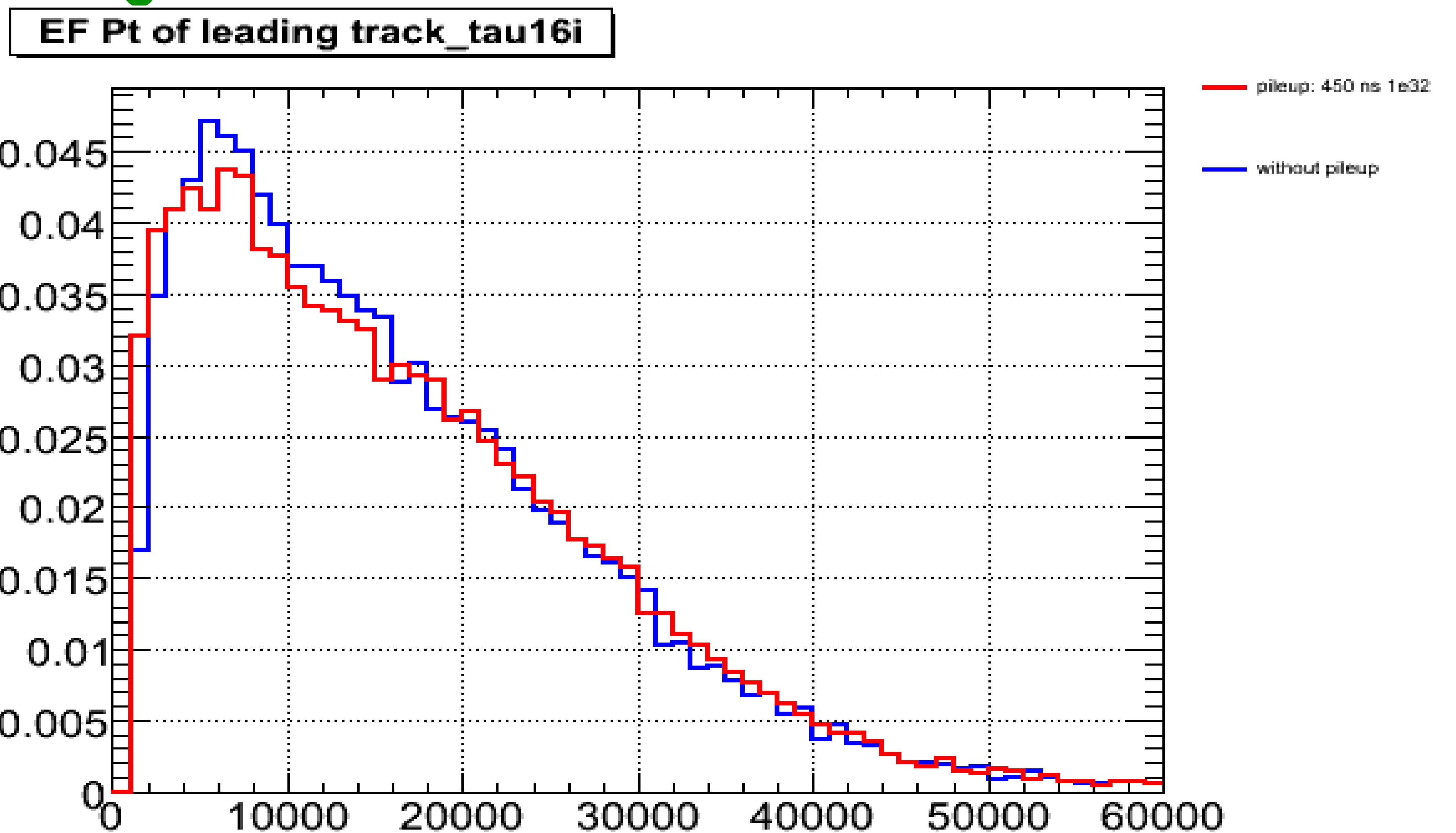
Cut Word – list of cuts

- L2Trk:
  - 64: dRIso (Pt in isolation region/Pt in core region)
  - 65: dRIso + NtracksCore
  - 128: TrkEmEt
  - 192: TrkEmEt + dRIso
- EF
  - 2: NtrkMax
  - 4: EMradius
  - 6: EMradius+NtrkMax
  - 8: IsoFrac
  - 32: LeadPt
  - 64: ETCorr
  - 68: ETCorr + EMRadius

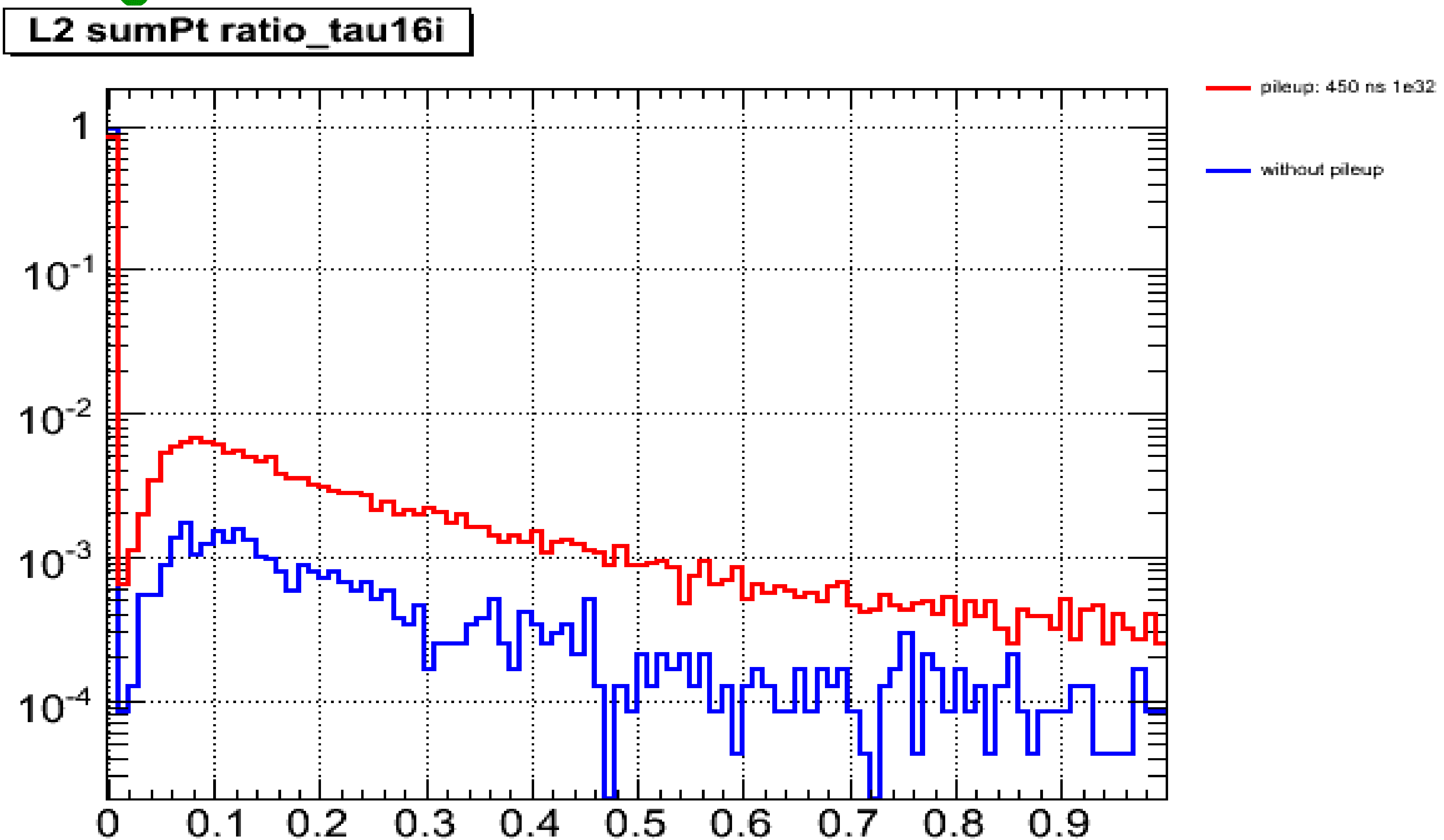
EM radius – 1p – Z signal



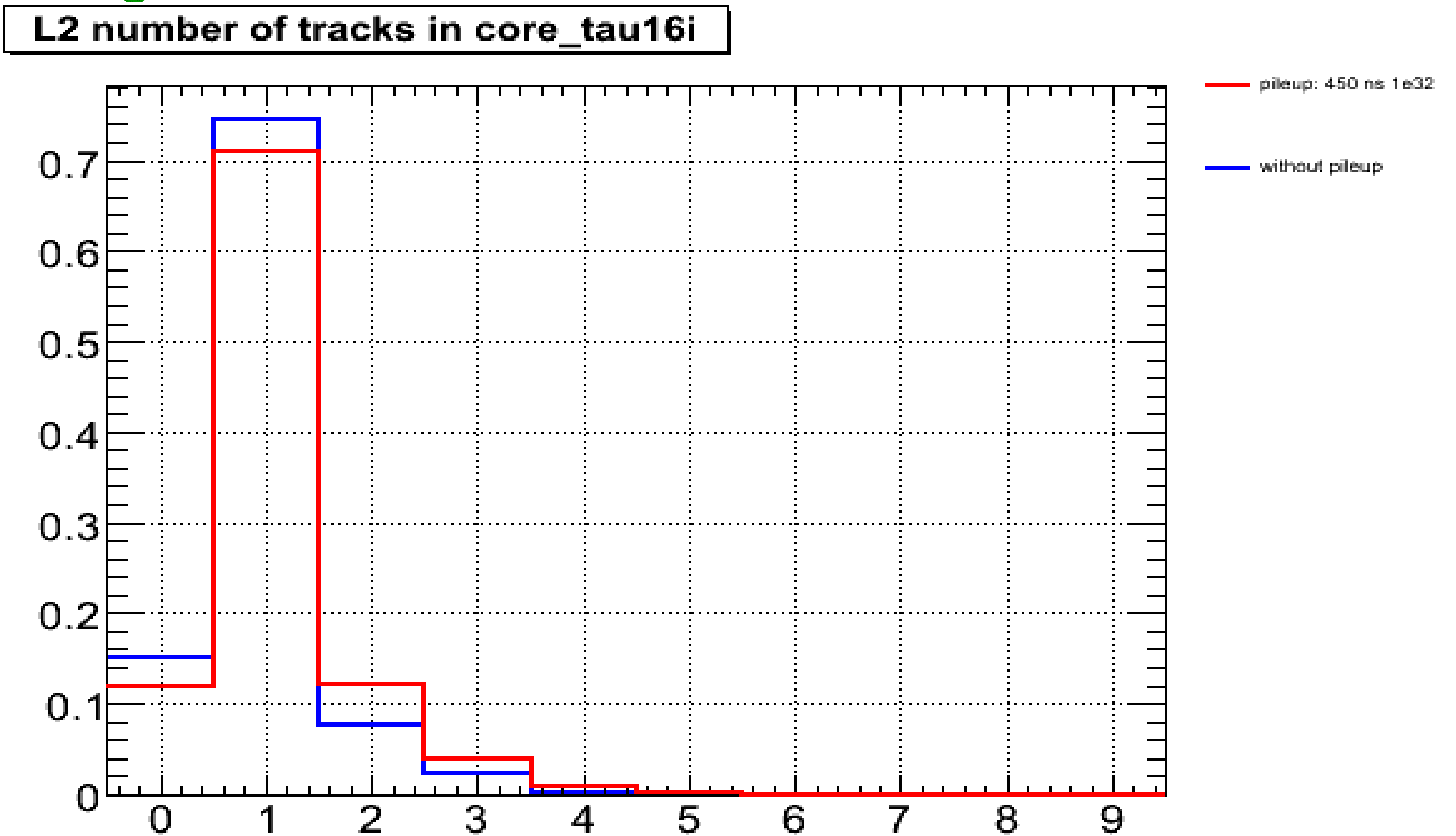
LeadPt – 1p – Z signal



Riso – 1p – Z signal



1p – Z signal



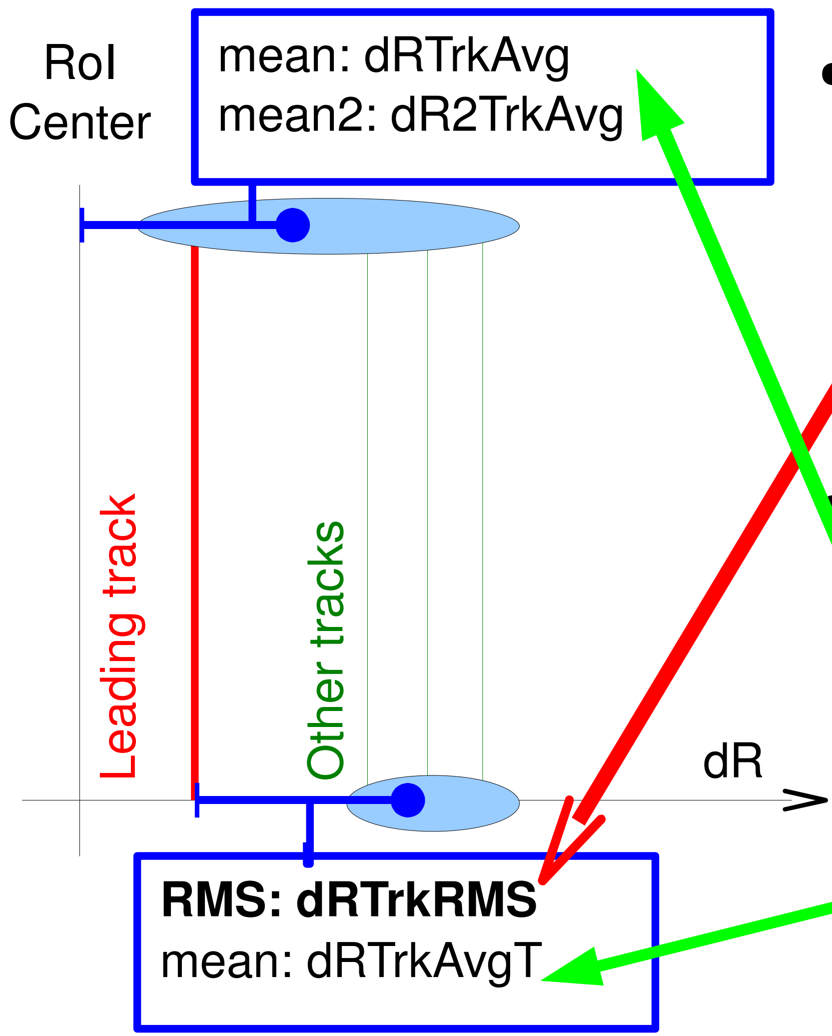
L2 number of tracks in core_tau16i
pileup: 450 ns 1e32
without pileup
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9

Background efficiency

	Pileup			No Pileup		
Signal – 1p	J0	J1	J2	J0	J1	J2
After L1	0.13	0.24	0.39	0.11	0.28	0.45
After L2Cal	*0.04*	*0.09*	*0.19*	*0.03*	*0.13*	*0.25*
After L2Trk	*0.08*	*0.14*	*0.2*	*0.07*	*0.17*	*0.26*
After L2	0.03	0.06	0.11	0.02	0.09	0.16
After EF	**0.01**	**0.03**	**0.05**	**0.01**	**0.05**	**0.09**

	Pileup			No Pileup		
Signal – 3p	J0	J1	J2	J0	J1	J2
After L1	0.16	0.25	0.39	0.1	0.27	0.42
After L2Cal	*0.04*	*0.08*	*0.15*	*0.02*	*0.11*	*0.19*
After L2Trk	*0.05*	*0.06*	*0.08*	*0.03*	*0.08*	*0.11*
After L2	0.02	0.03	0.04	0.01	0.04	0.07
After EF	**0.01**	**0.02**	**0.03**	**0.01**	**0.03**	**0.05**

Tracking variables



- Old variable
- We define three new variables
  - 2 universal
  - 1 multiprong only

Tracking variables 2

- New variables are:
- dRTrkAvg = $\frac{\sum \Delta R \times P_T}{\sum P_T}$
- DR2TrkAvg = $\sqrt{\frac{\sum (\Delta R)^2 \times P_T}{\sum P_T}}$
- DRTrkAvgT – same as above, but defined w.r.t. leading track, i.e. not defined for 1-prong candidates