Isolated lepton tagging & New (CS) jet clustering

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The 43 General Meeting of ILC Physics Subgroup, Sep. 5, 2015 @ KEK

idea to select a isolated lepton (e/μ)

i) lepton ID: electron or muon

- energy ratio deposited in ECal, HCal, Yoke
- general PID: dE/dx + shower profile

ii) vertex: prompt or secondary

- d0, z0 significance: d0/δd0, z0/δz0

iii) isolation: not from jets

- relatively high P
- almost empty around

status of available tools

i) lepton ID: electron or muon

- energy ratio deposited in ECal, HCal, Yoke ✔
- general PID: dE/dx + shower profile — to be added

ii) vertex: prompt or secondary

- d0, z0 significance: d0/δd0, z0/δz0 ✔

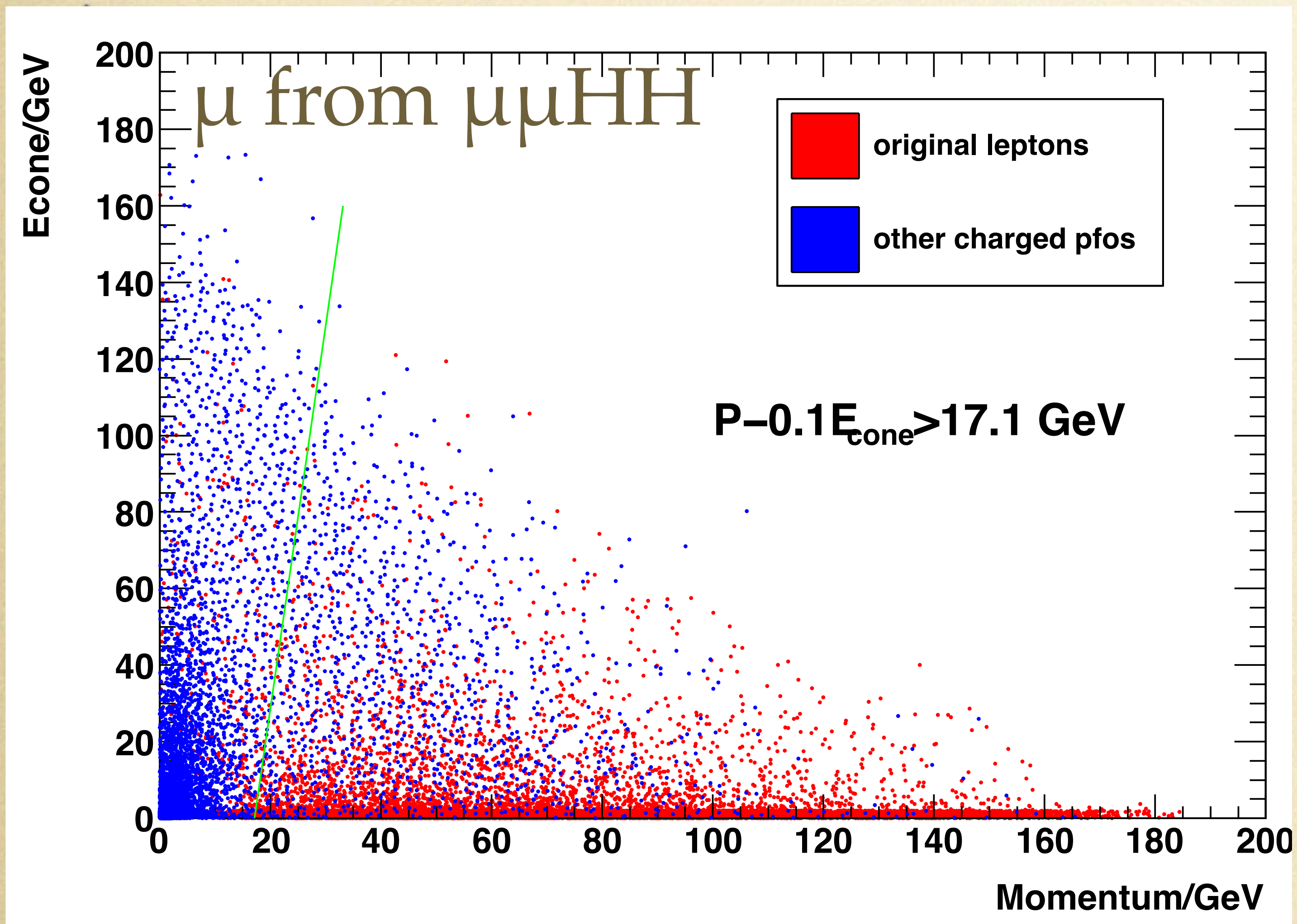
iii) isolation: not from jets ✔

- relatively high P
- almost empty around

several algorithms exist

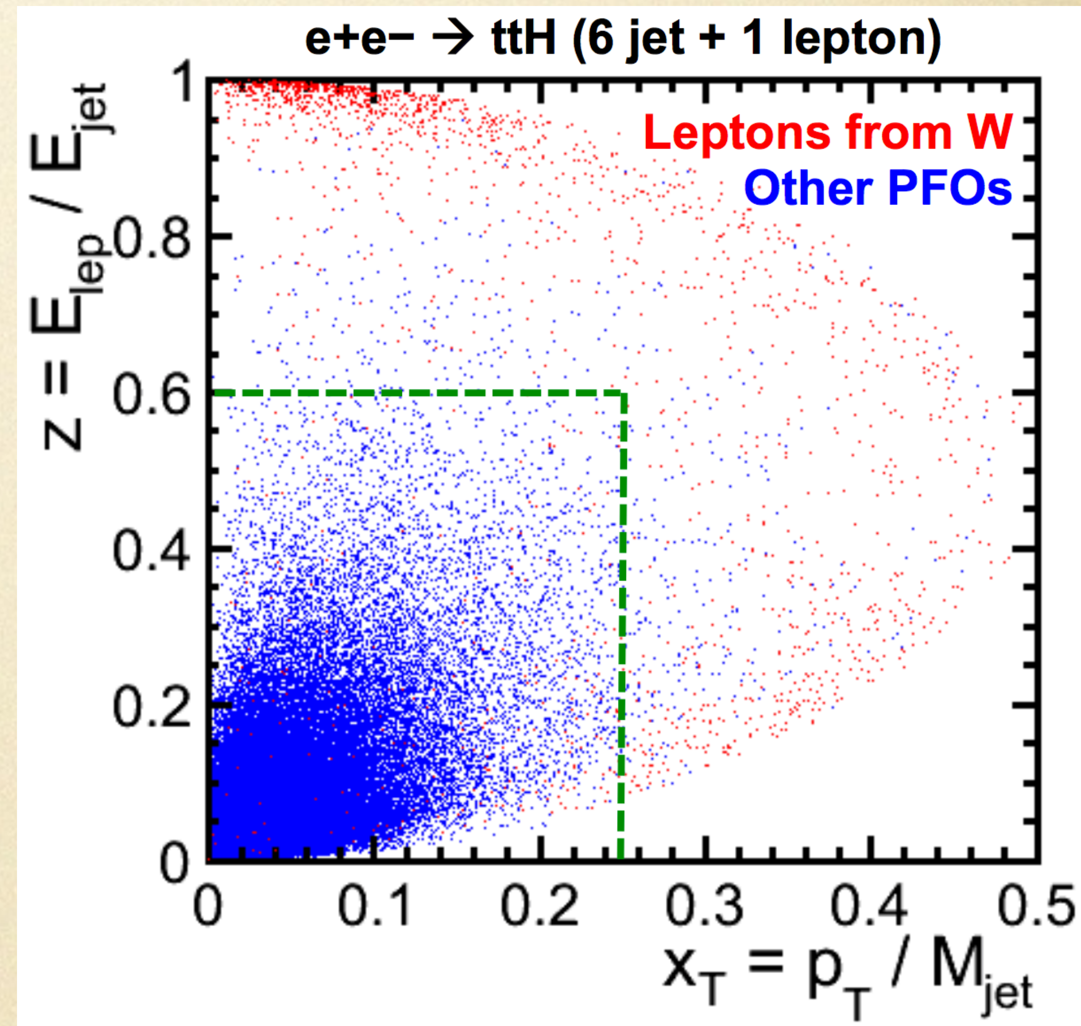
two isolation algorithms in DBD

cone based



(Ryo/Tomohiko; Junping)

jet based



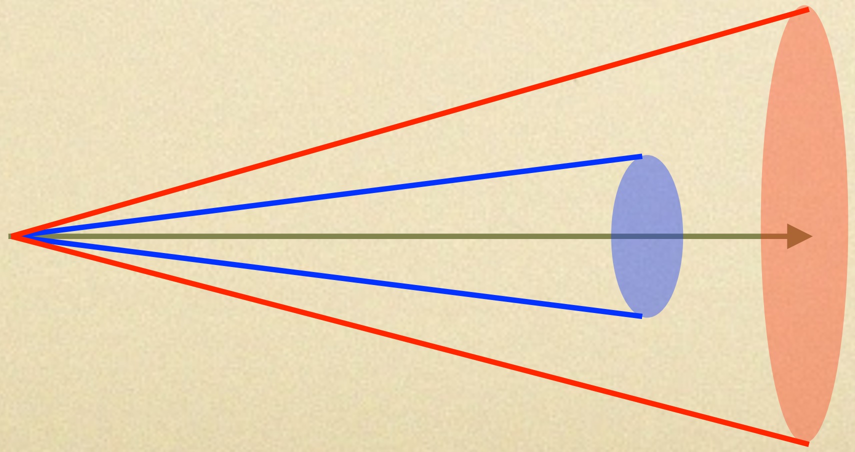
(M.Amjad/LAL group)

both available during DBD, in MarlinReco/Analysis/IsolatedLeptonFinder

New idea for further improvement:

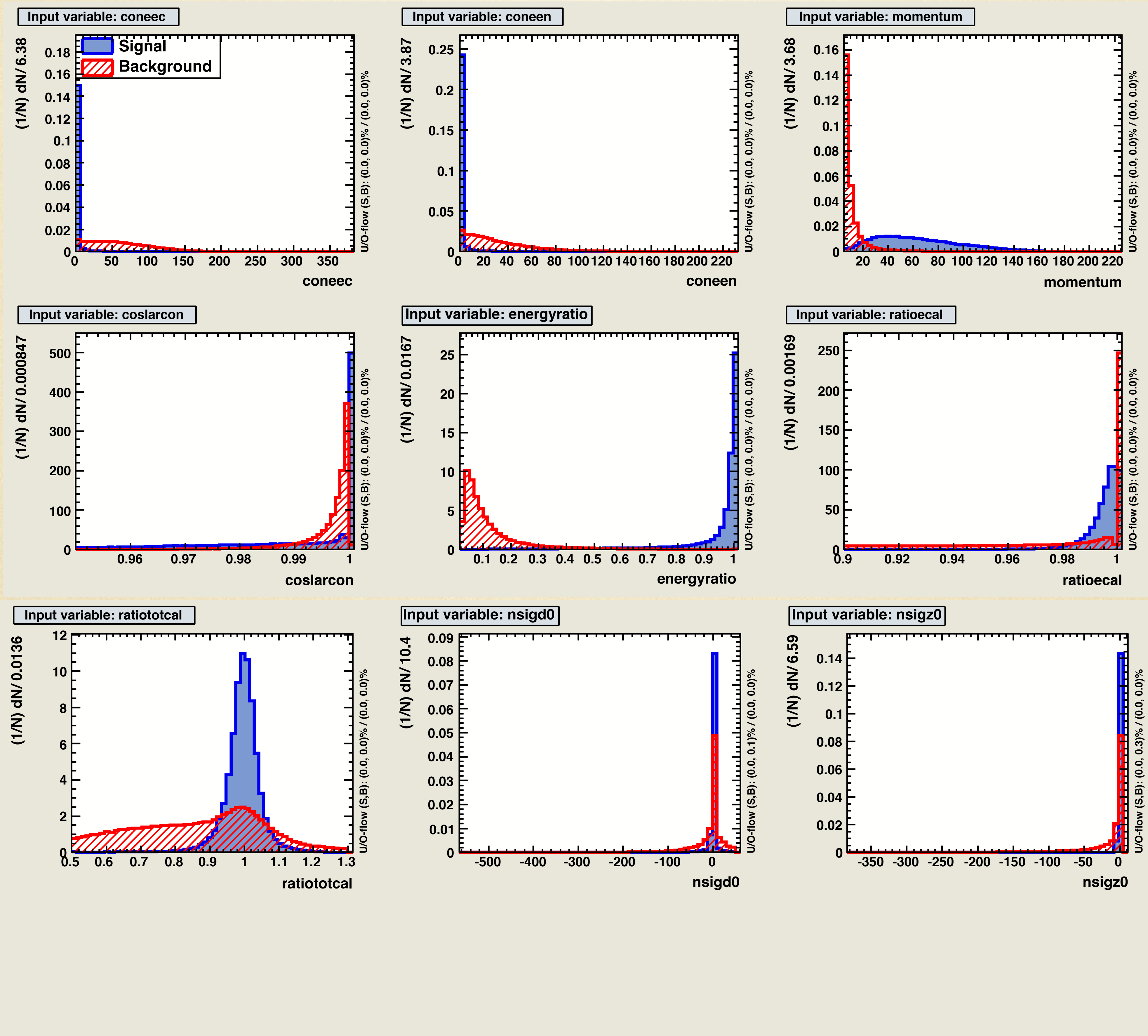
(developed by Claude/Junping for Higgs self-coupling analysis)

- utilise d0, z0, cone energy, momentum, Eecal/Ehcal more effectively —> MVA
- rethink of "what is isolation?" in terms of separation with "non-isolated" ones from jets —> utilise information of neighbour particles in every layer of cone
- as a first trial, introduce double cones to magnify the jet influence —> E(lep)/E(jet) and angle between them

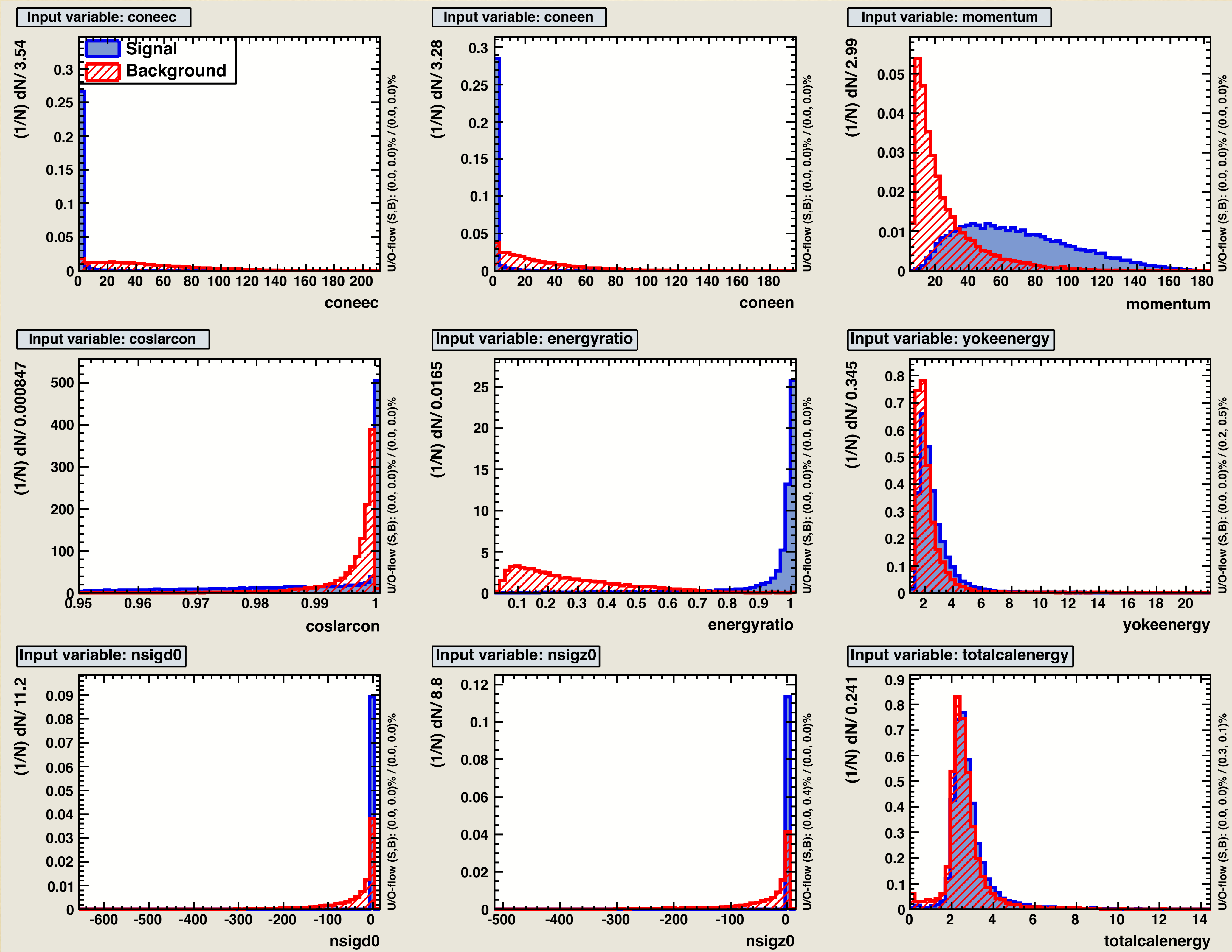


cos=0.98, 95

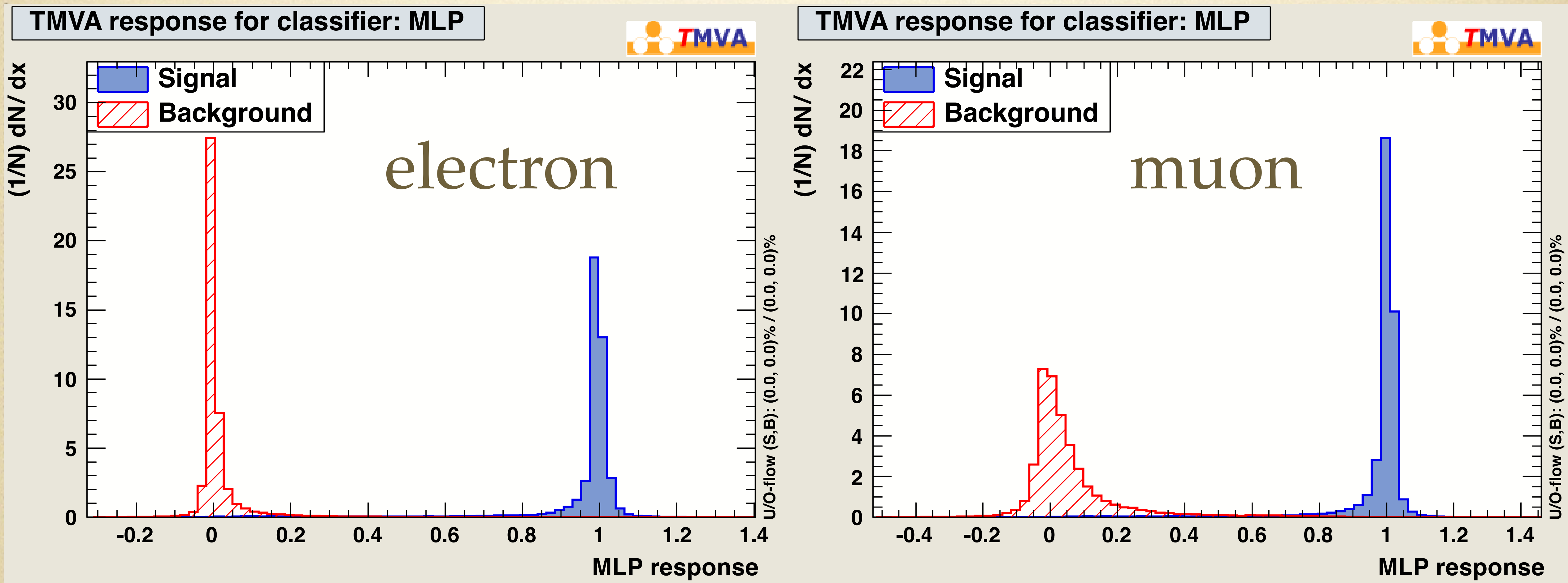
input variables: electron



input variables: muon



neural-net output (tagging)



lepton tagging is associated to the selected lepton collection, can be optimised in final selection

Available Processor in ilcsoft-v01-17-08

MarlinReco/Analysis/IsolatedLeptonTagging

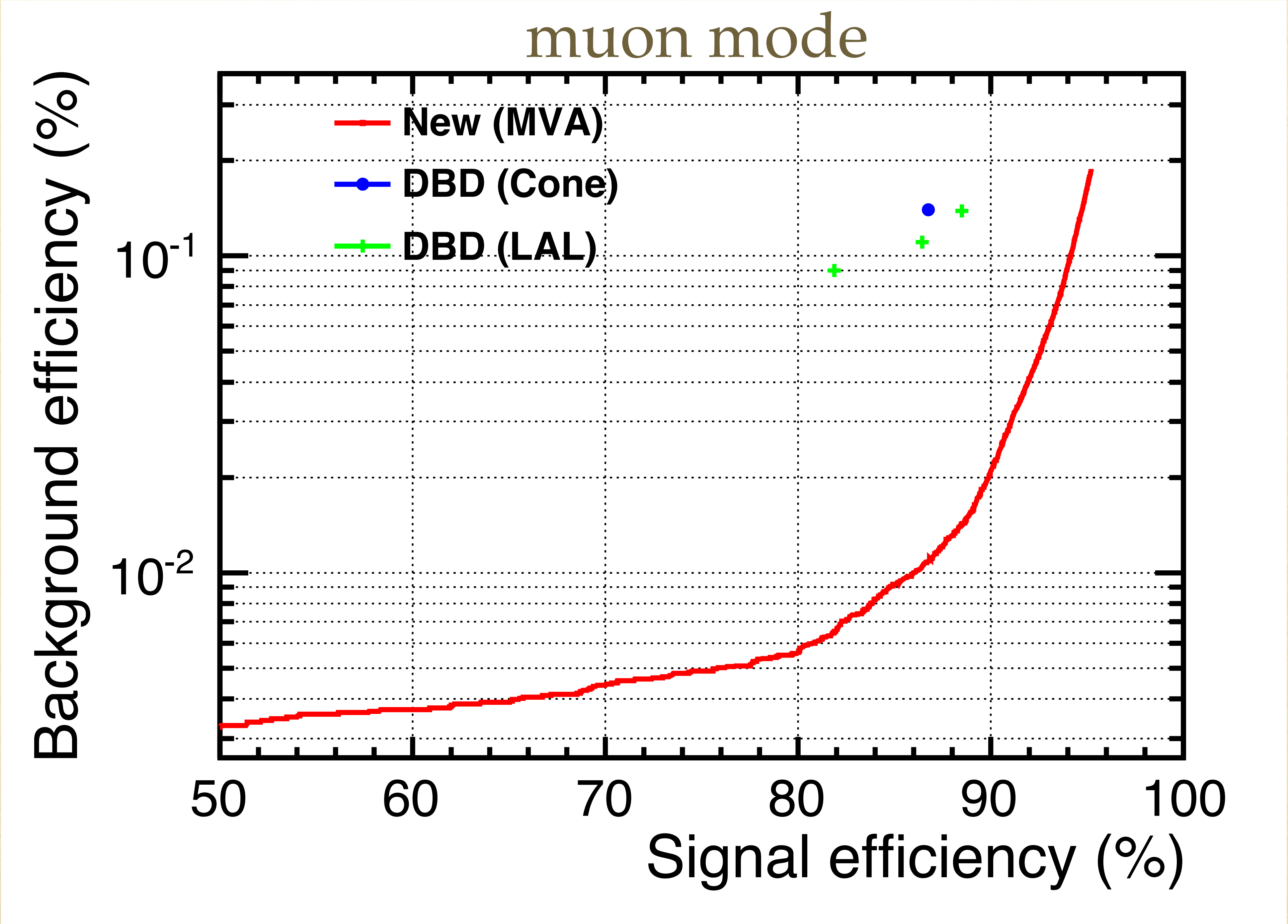
- see “README” for how to use it
- see “example” for steering file
- several weights trained for different processes available
- so far only one processor for single isolated leptons, will be added processor for pair of leptons (Z finder)

today’s update:

performance of this new tagging and comparison with DBD ones

Signal (yyxylv) Eff. versus Background (yycyyc) Eff.

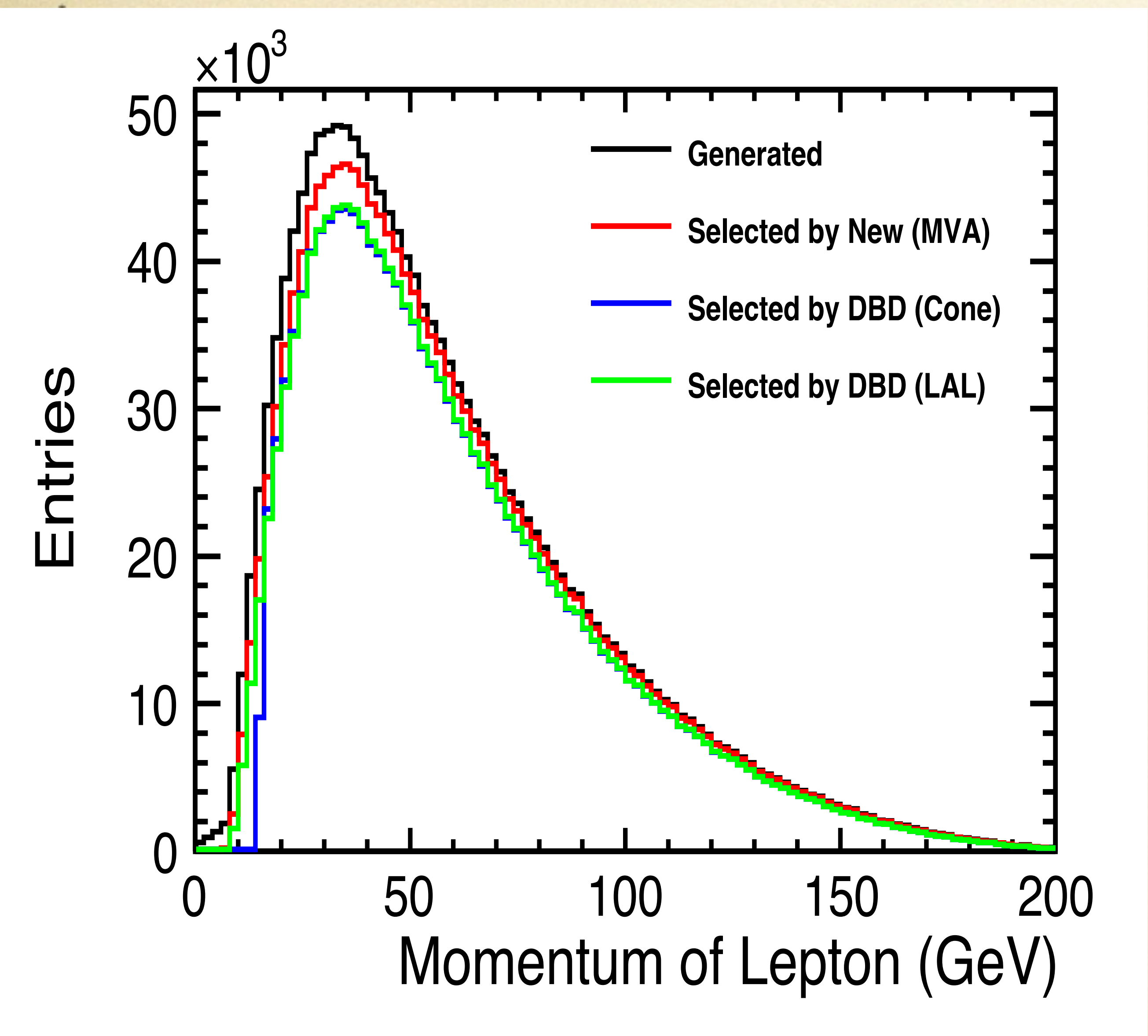
(thank Tino for the high statistics 6f samples)

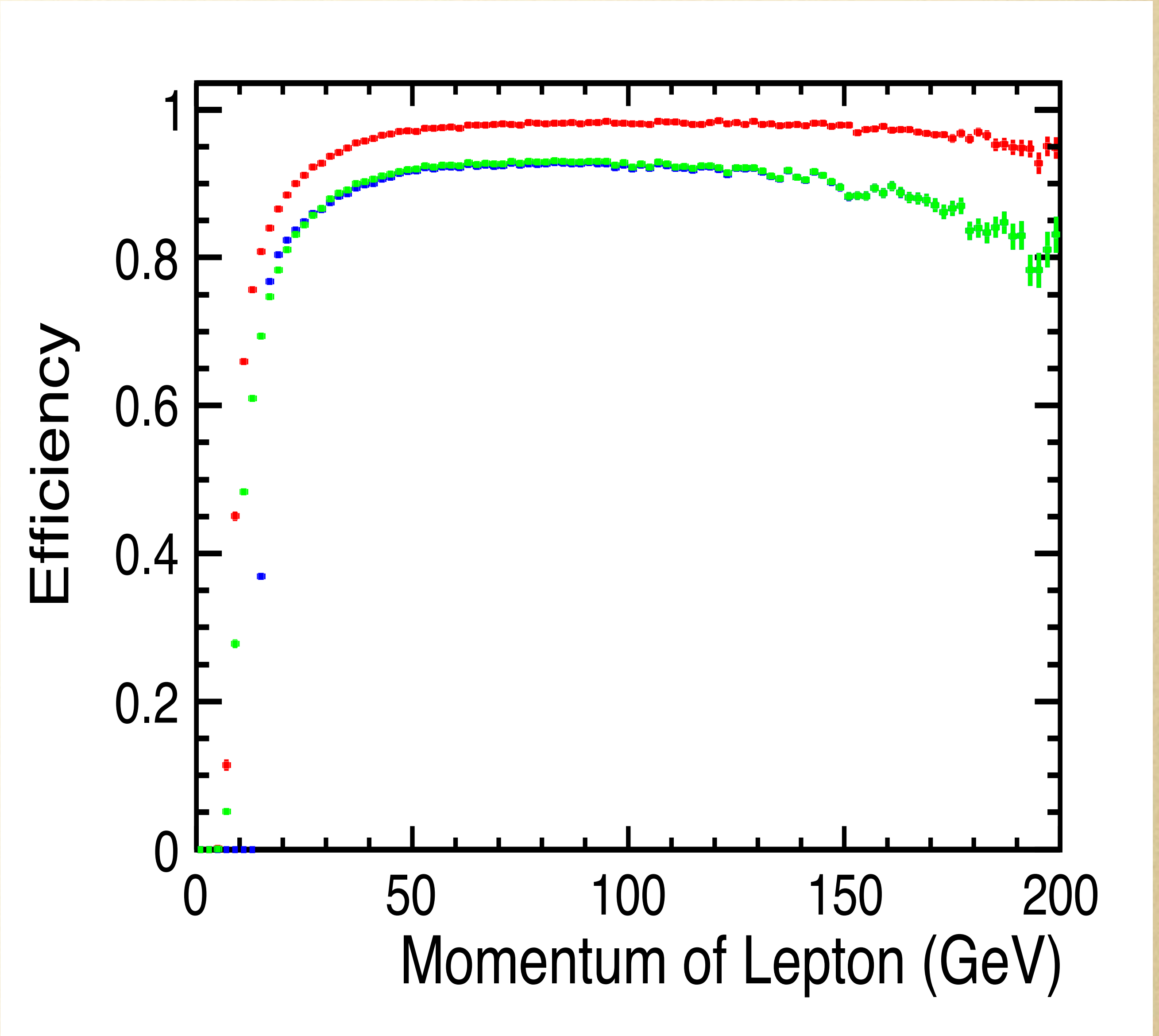


disclaimer: I used default setting for DBD ones, might be optimised; for LAL algorithm, I tested using 4/5/6 jets as input

signal efficiency dependence of momentum

(keep same background eff.)

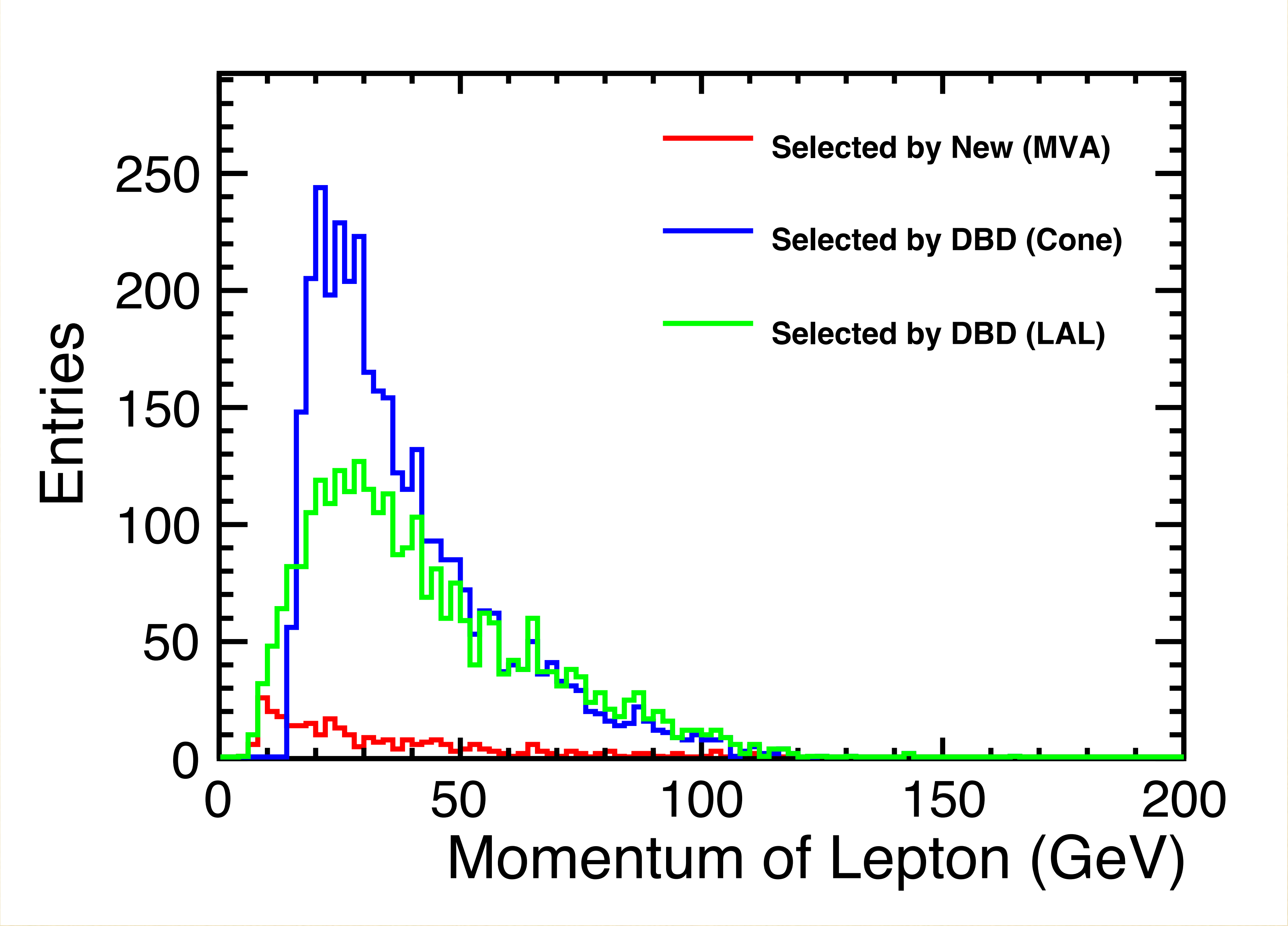




Eff.(%) / Algorithm :	New(MVA)	DBD(Cone)	DBD(LAL)
Sig (yyxyμν) :	94.65	86.75	88.51
Bkg (yycyyc) :	0.134	0.1396	0.1387

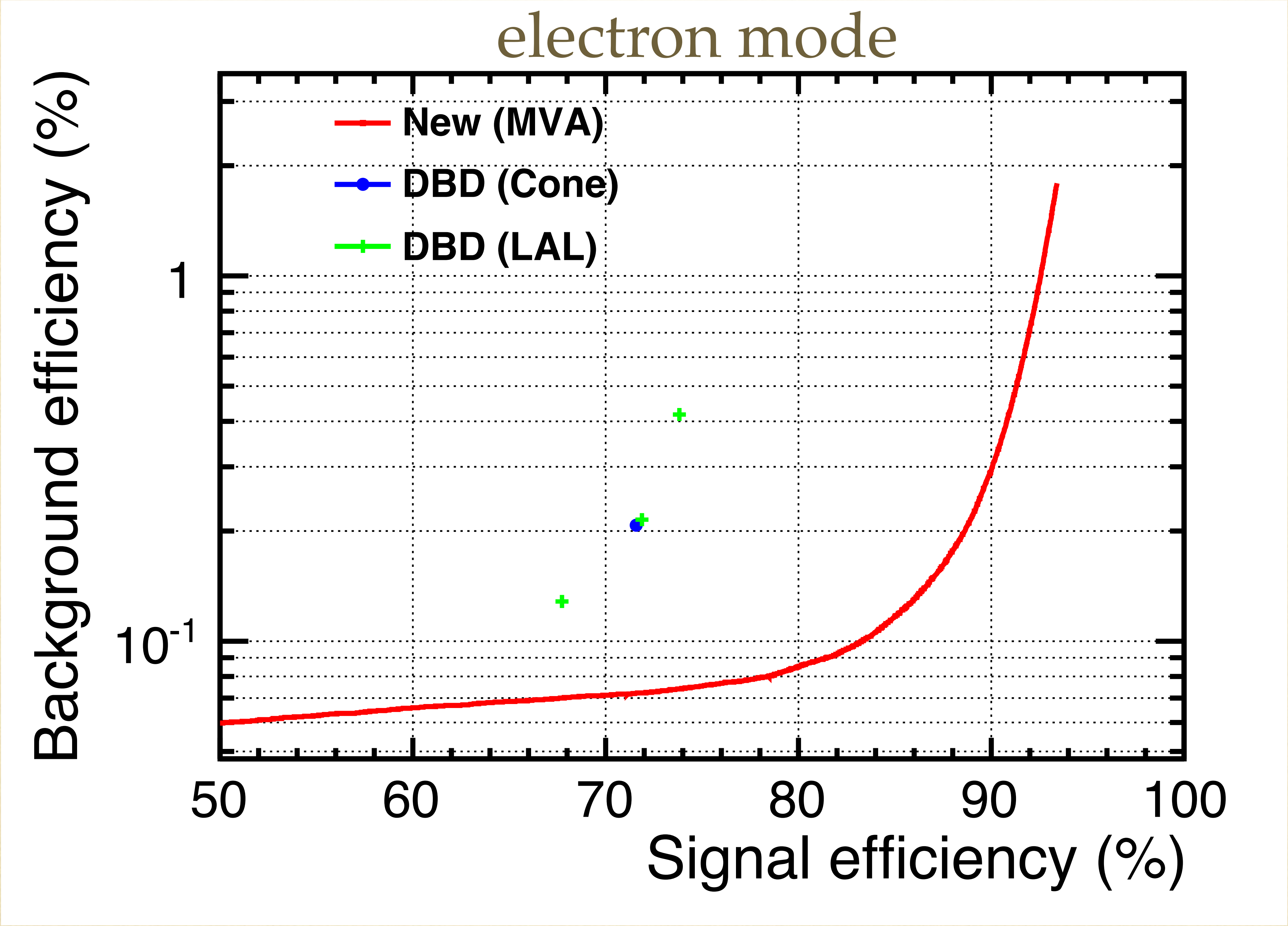
in terms of background suppression

(keep same signal eff.)



Eff.(%) / Algorithm :	New(MVA)	DBD(Cone)	DBD(LAL)
Sig (yyxyμν) :	87.26	86.75	86.44
Bkg (yycyyc) :	0.01172	0.1396	0.1104

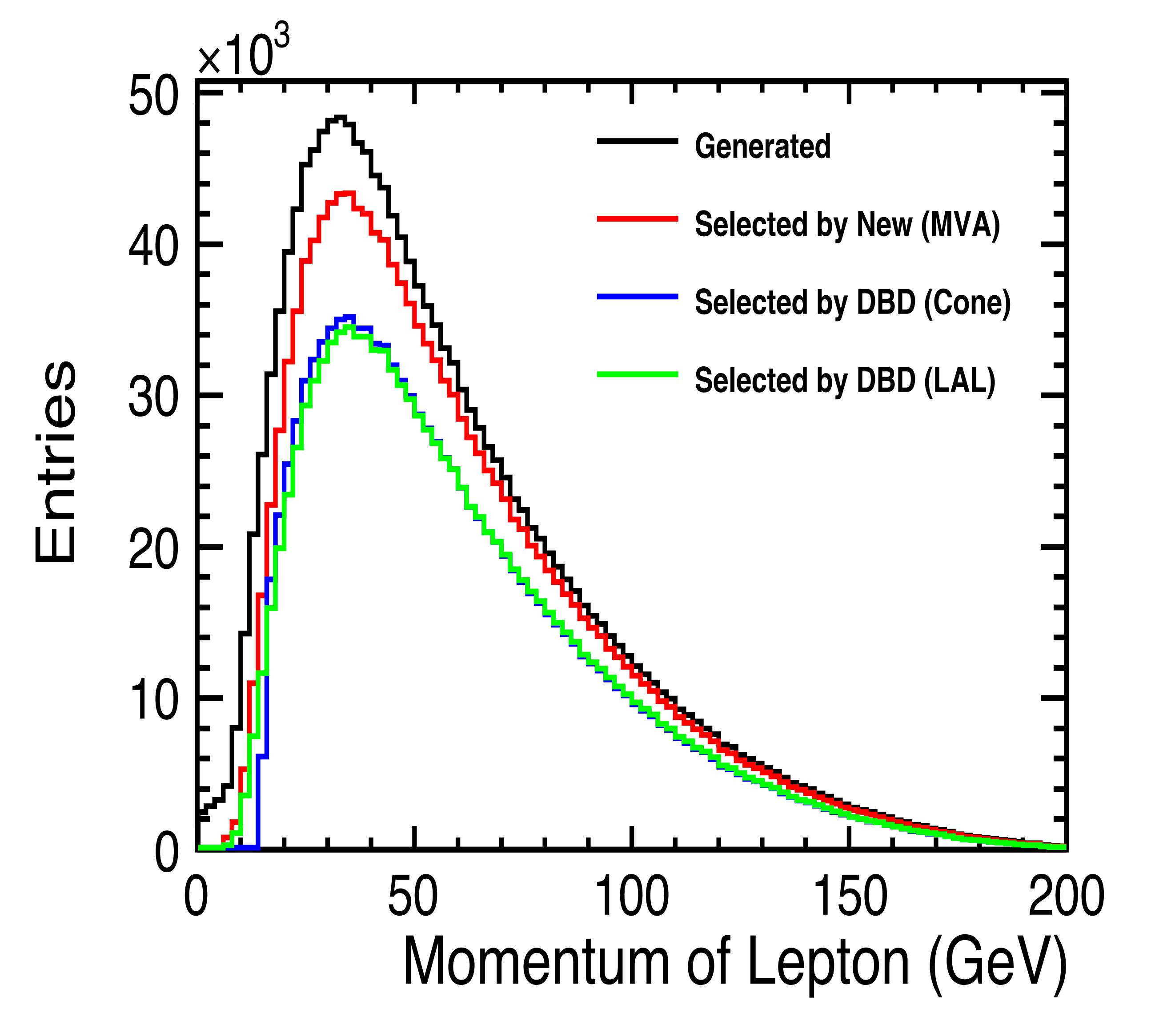
Signal (yyxylv) Eff. versus Background (yycyyc) Eff.

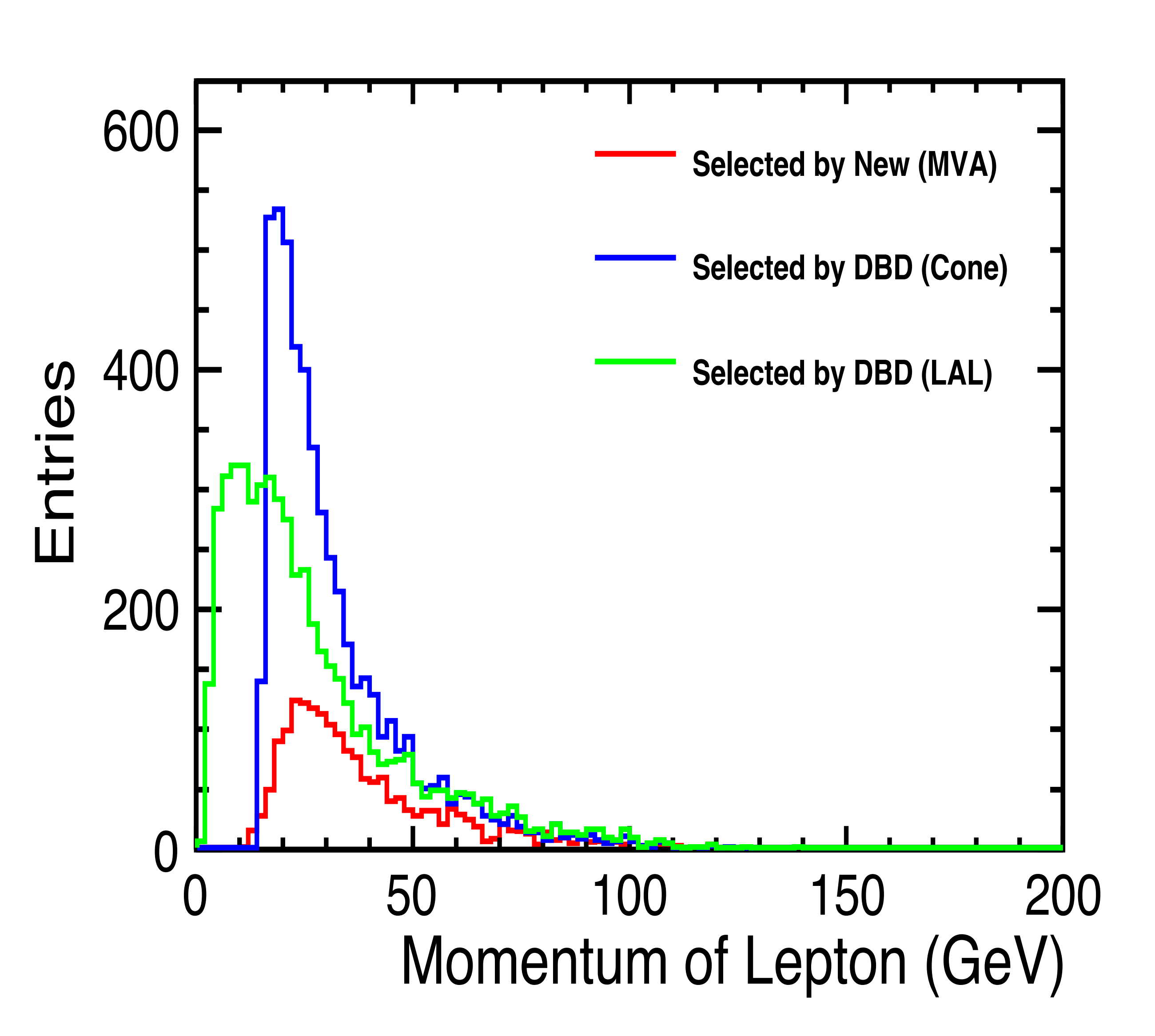


(it seems signal eff. of DBD ones are a bit too low,
indicate significant tuning may be possible)

sig/bkg efficiency dependence of momentum

(keep same bkg/sig eff.)



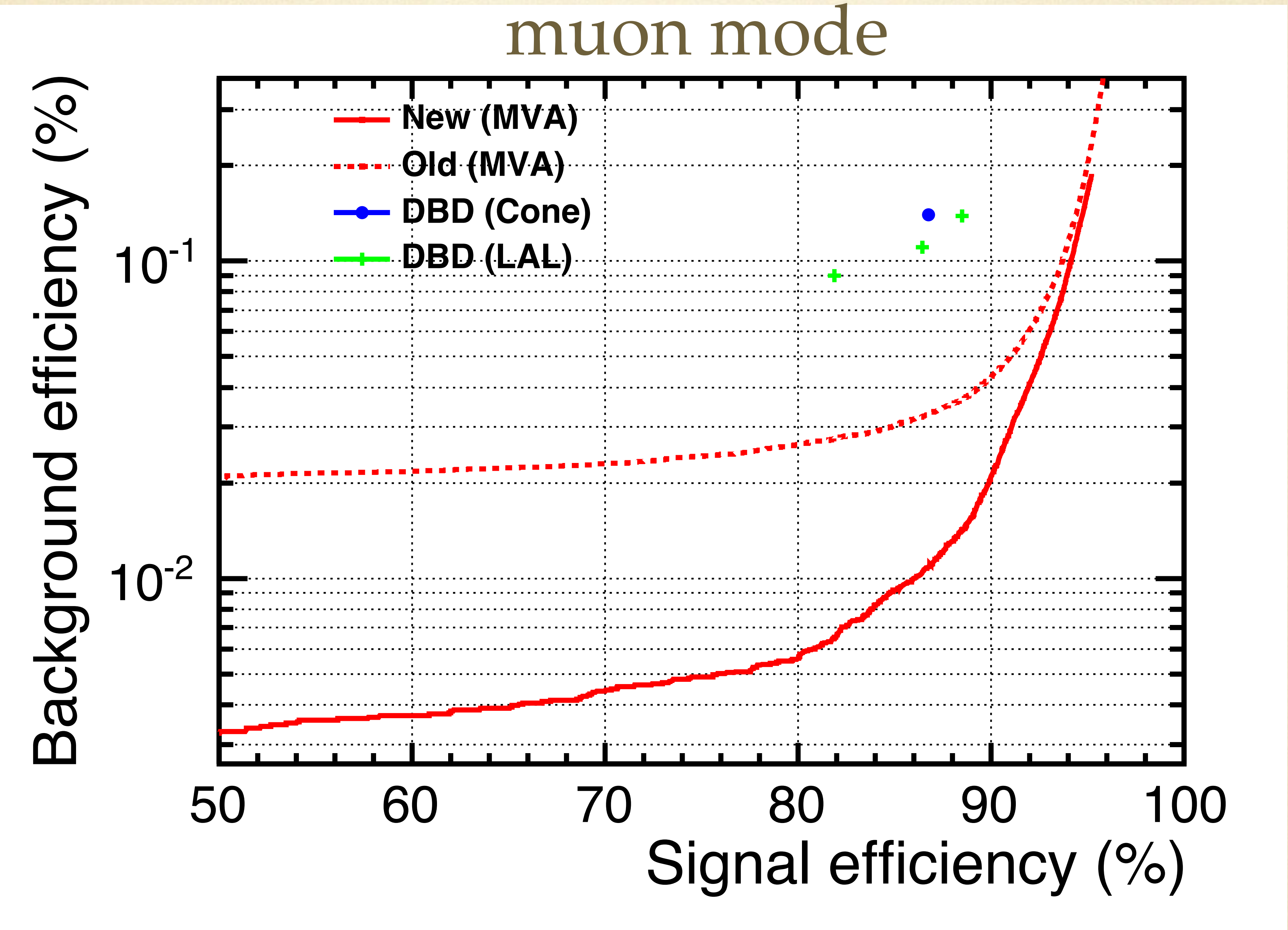


Eff.(%) / Algorithm :	New(MVA)	DBD(Cone)	DBD(LAL)
Sig (yyxyev) :	88.64	71.6	71.89
Bkg (yycyyc) :	0.2015	0.2079	0.2152

New(MVA)	DBD(Cone)	DBD(LAL)
72.17	71.6	71.89
0.07247	0.2079	0.2152

impact of training

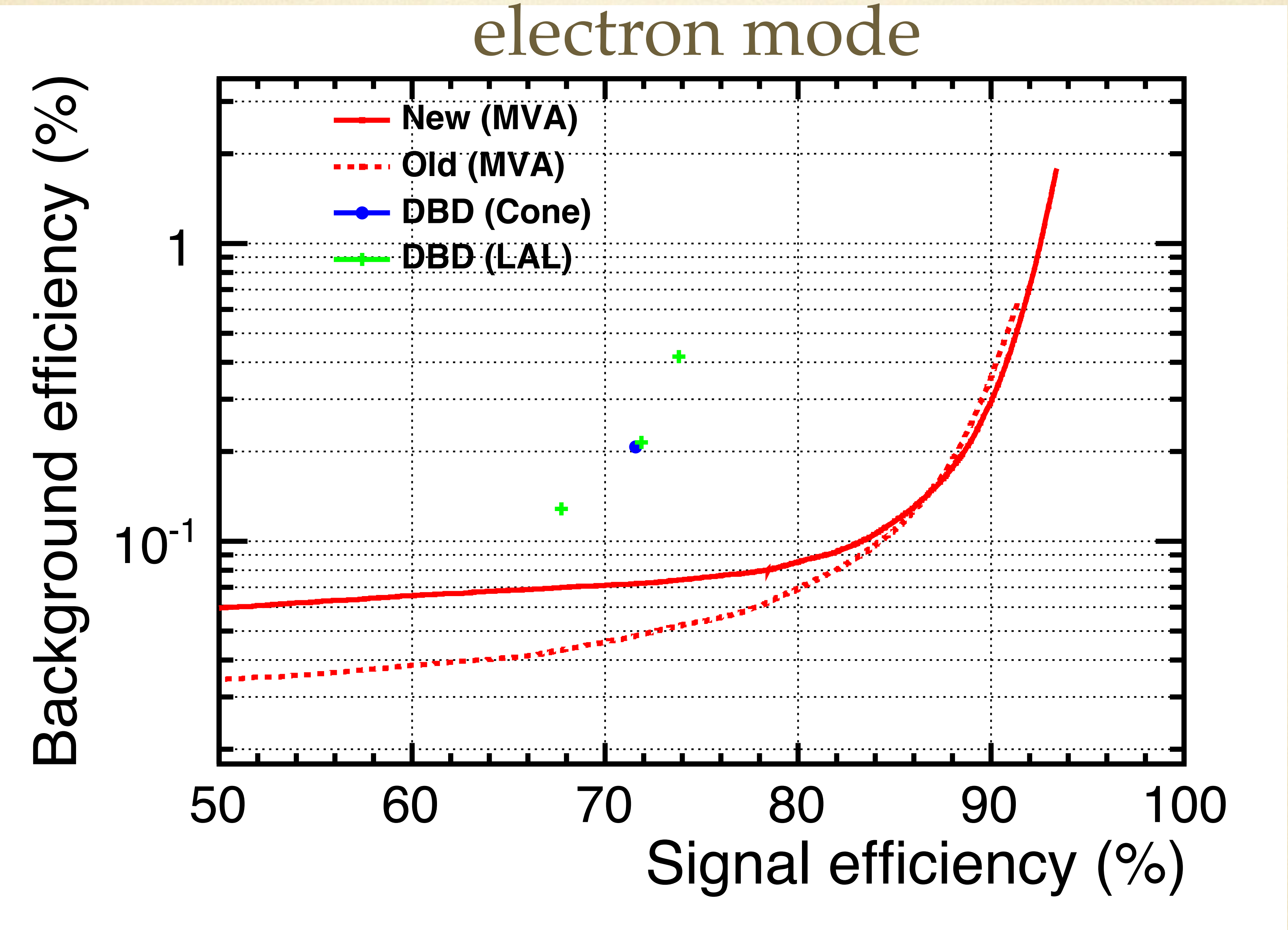
new training: yyxylv/yycyyc with overlay;
old training : yyxylv/bbbb no overlay



~a factor of 2 difference between trainings, in terms of bkg suppression
—> similar performance already confirmed in μμHH versus yyxyμν

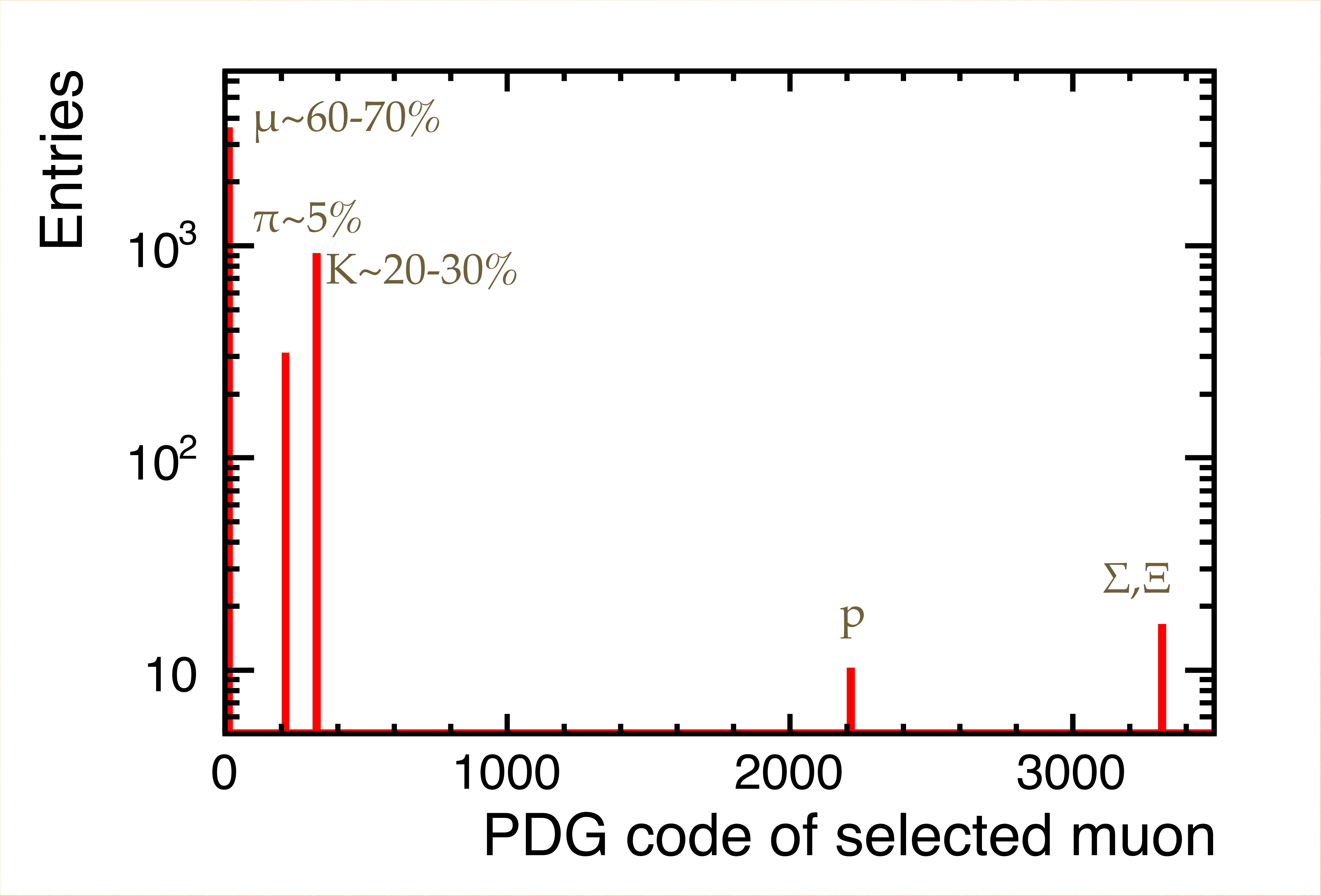
impact of training —> puzzle?

new training: yyxylv/yycyyc with overlay;
old training : yyxylv/bbbb no overlay



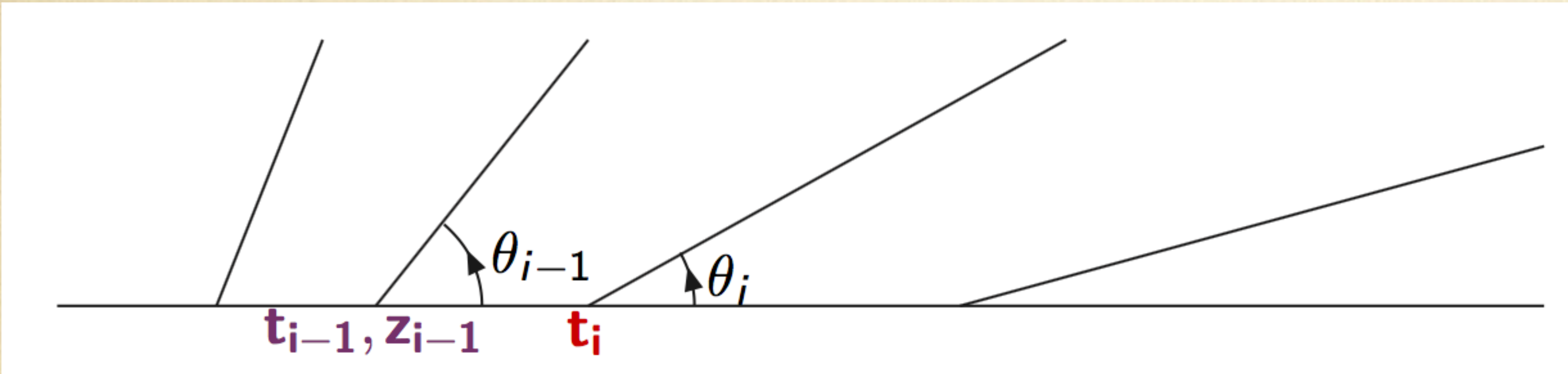
old training gives even better bkg suppression when sig eff is low, strange?

for next step: what kind of particles are still mis-tagged?



K is tagged mostly because K->$\mu\nu$ in Calorimeter

proposal of new clustering: reconstruct the parton shower history



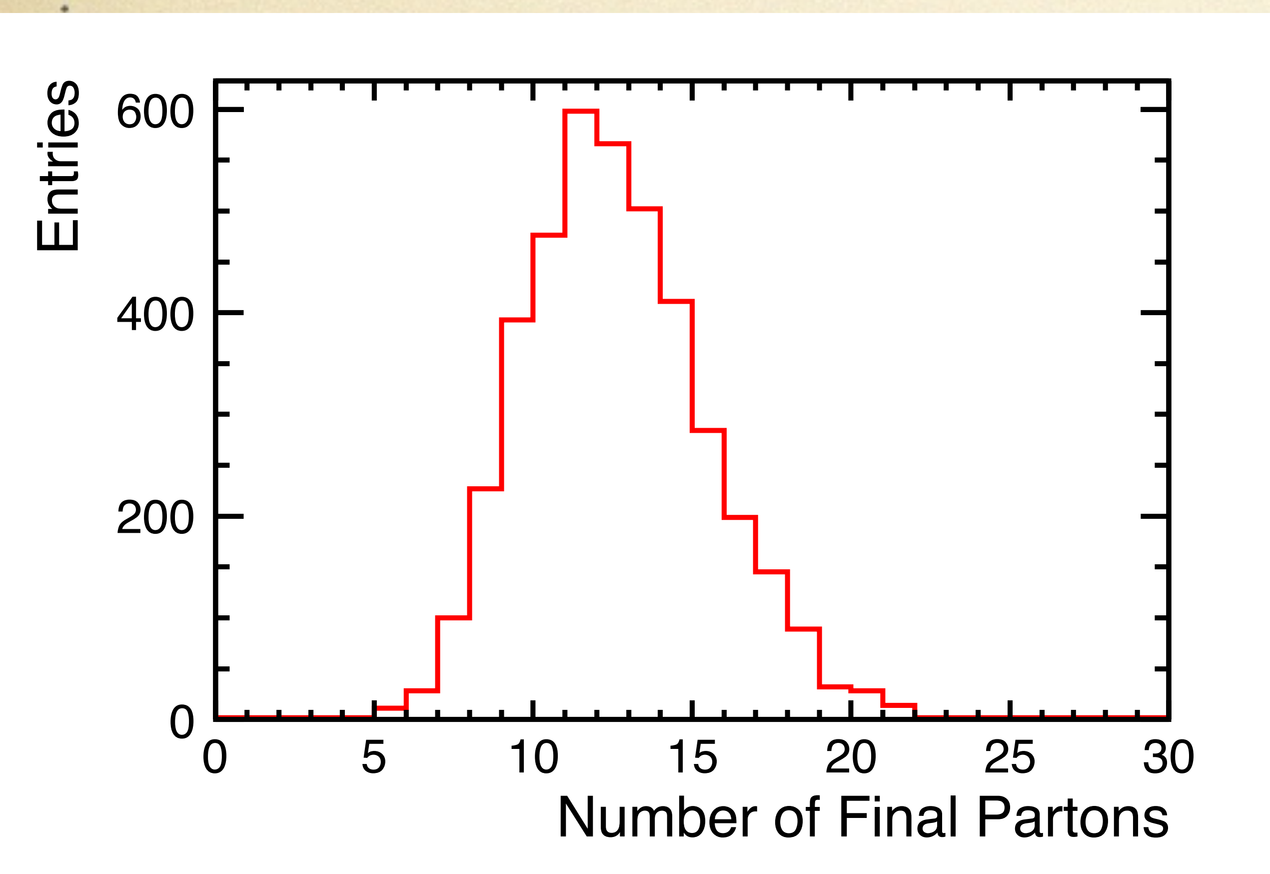
$$\begin{aligned}
P_{q\to qg}(z) &= C_F \frac{1+z^2}{1-z} , \\
P_{g\to gg}(z) &= N_C \frac{(1-z(1-z))^2}{z(1-z)} , \\
P_{g\to q\bar{q}}(z) &= T_R \left(z^2+(1-z)^2\right) , \\
P_{q\to q\gamma}(z) &= e_q^2 \frac{1+z^2}{1-z} , \\
P_{\ell\to \ell\gamma}(z) &= e_\ell^2 \frac{1+z^2}{1-z} ,
\end{aligned}$$

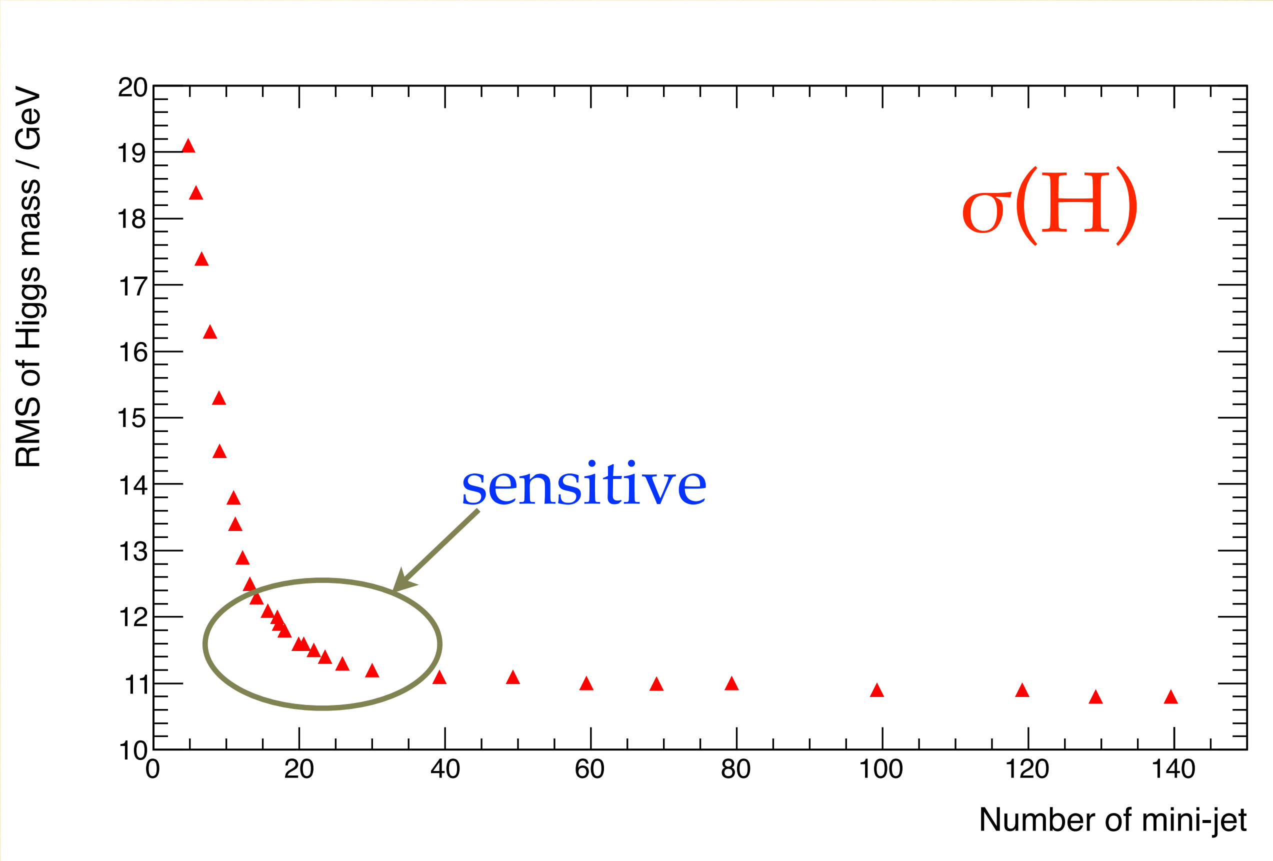
$$\mathrm{d}\mathcal{P}_a = \sum_{b,c} \frac{\alpha_{abc}}{2\pi} P_{a\to bc}(z)\, \mathrm{d}t\, \mathrm{d}z \ .$$

- do mini-jet clustering until #mini-jet ~ 20, during which Durham algorithm works well —> which also helps retain infrared safe
- new algorithm comes in to combine the mini-jets: if these mini-jets are actually the relic of parton shower, we should aim for the reconstruction of parton show history as the maximum information
- generic feature of parton shower can be used to help: angular ordering, $\theta_{i-1}<\theta_i<\theta_{i+1}$, $t_{i-1}<t_i<t_{i+1}$.
- assign each branching with a probability $P_{q\text{->}qg}$, etc.
- above is intraJet parton shower; we can use some feature of color correlation interJet, such as rapidity gap, etc. (not really sure).

a brief update: relation between mini-jet and parton?

sample: e+ e- —> ννHH —> ννbbbb @ 500 GeV

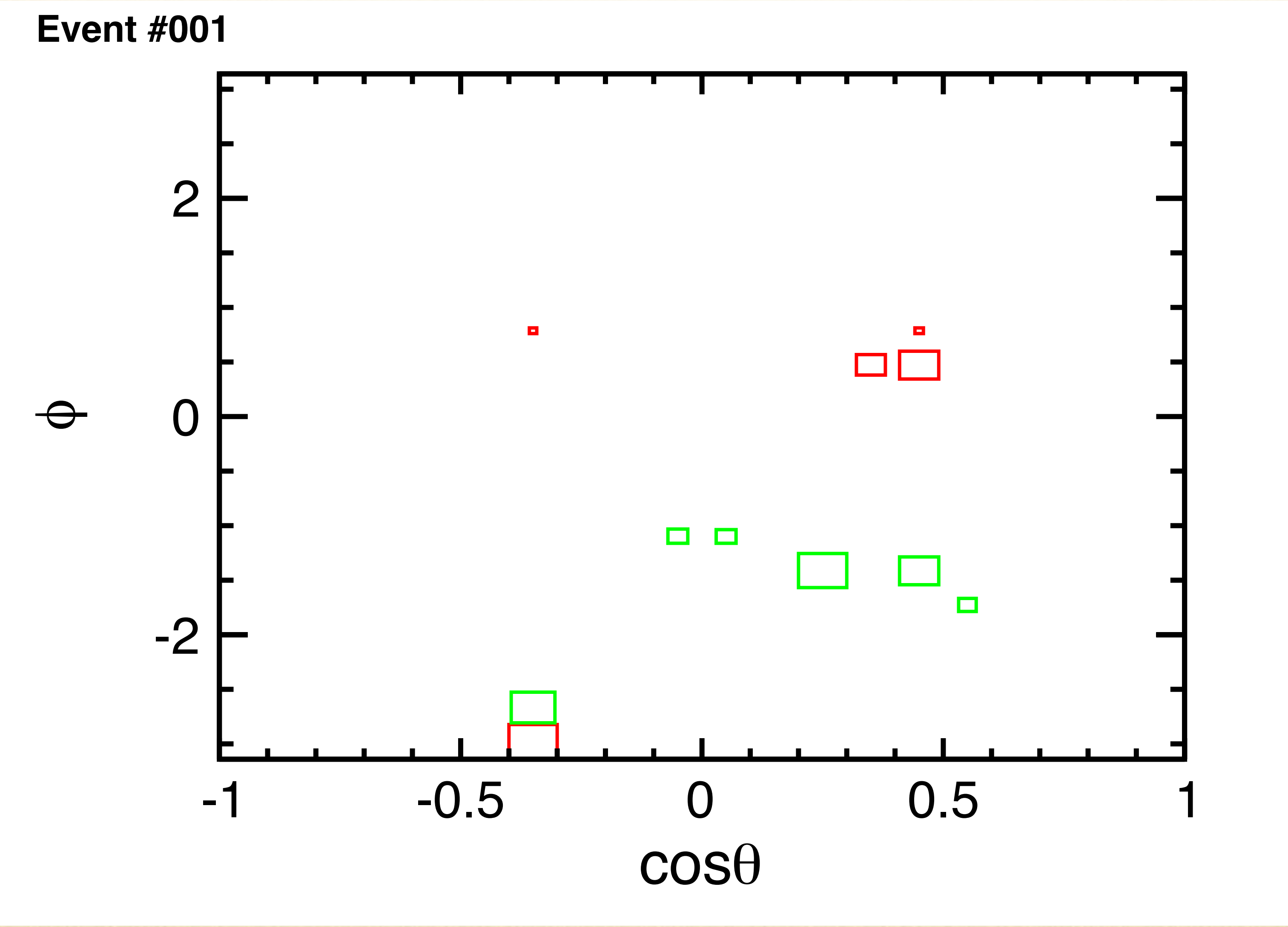




we are on the right track, or just coincidence?

the kinematics of final partons

(energy distribution in 2D of ϕ .vs. $\cos\theta$)

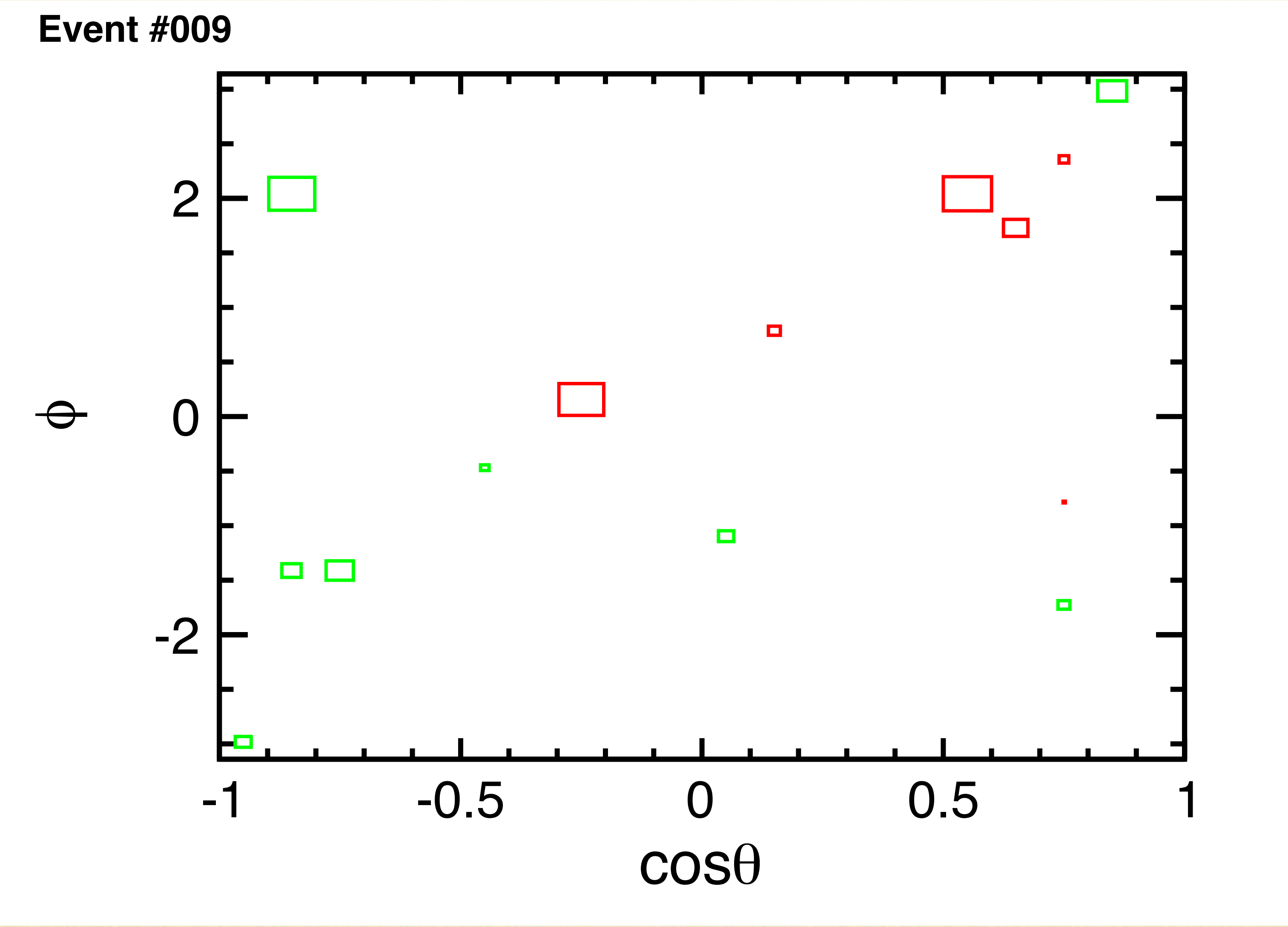


red: from H1

green: from H2

the kinematics of final partons

(energy distribution in 2D of ϕ .vs. $\cos\theta$)

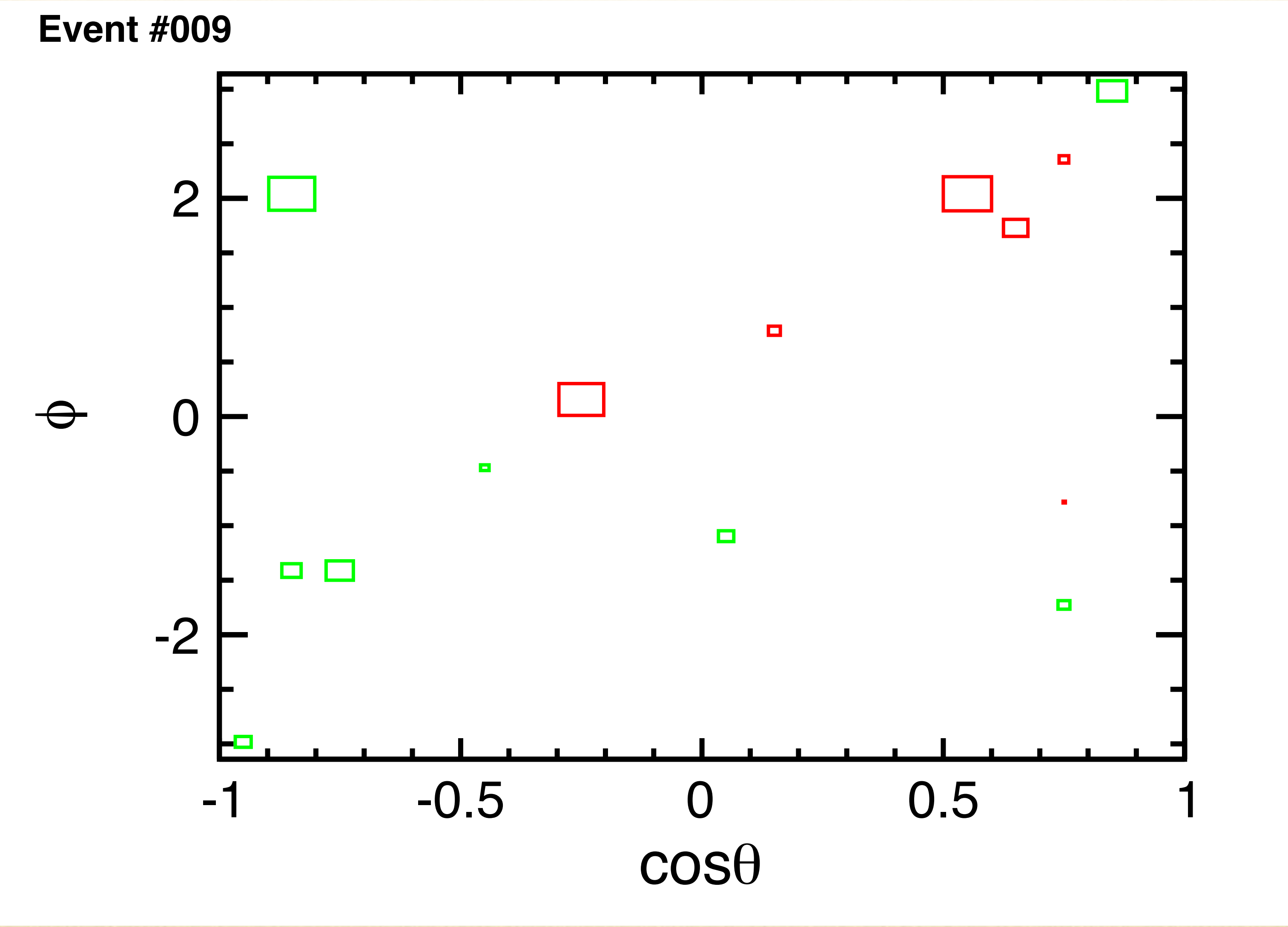


red: from H1

green: from H2

the kinematics of final partons

(energy distribution in 2D of ϕ .vs. $\cos\theta$)

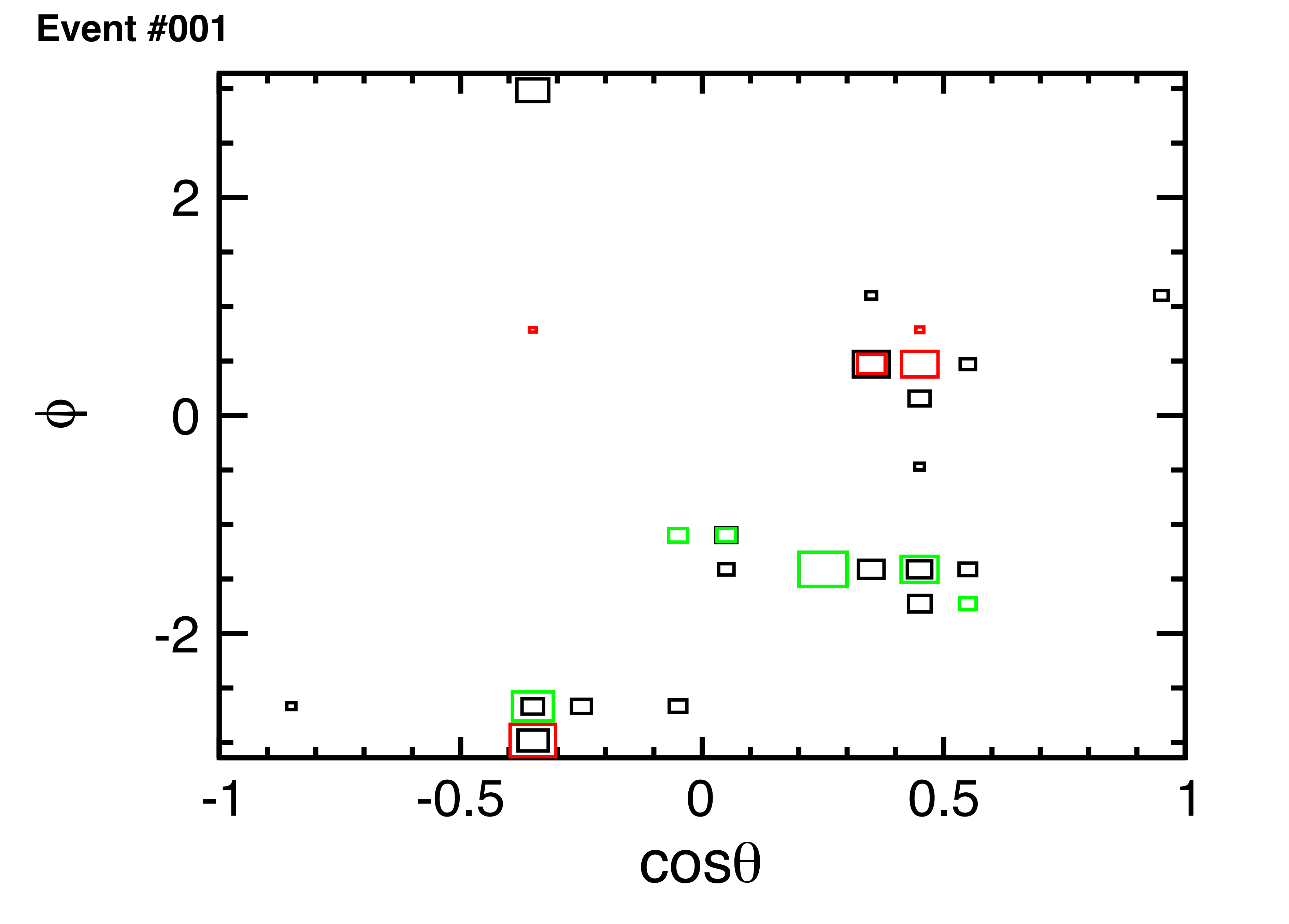


red: from H1

green: from H2

the kinematics of mini-jets versus final partons

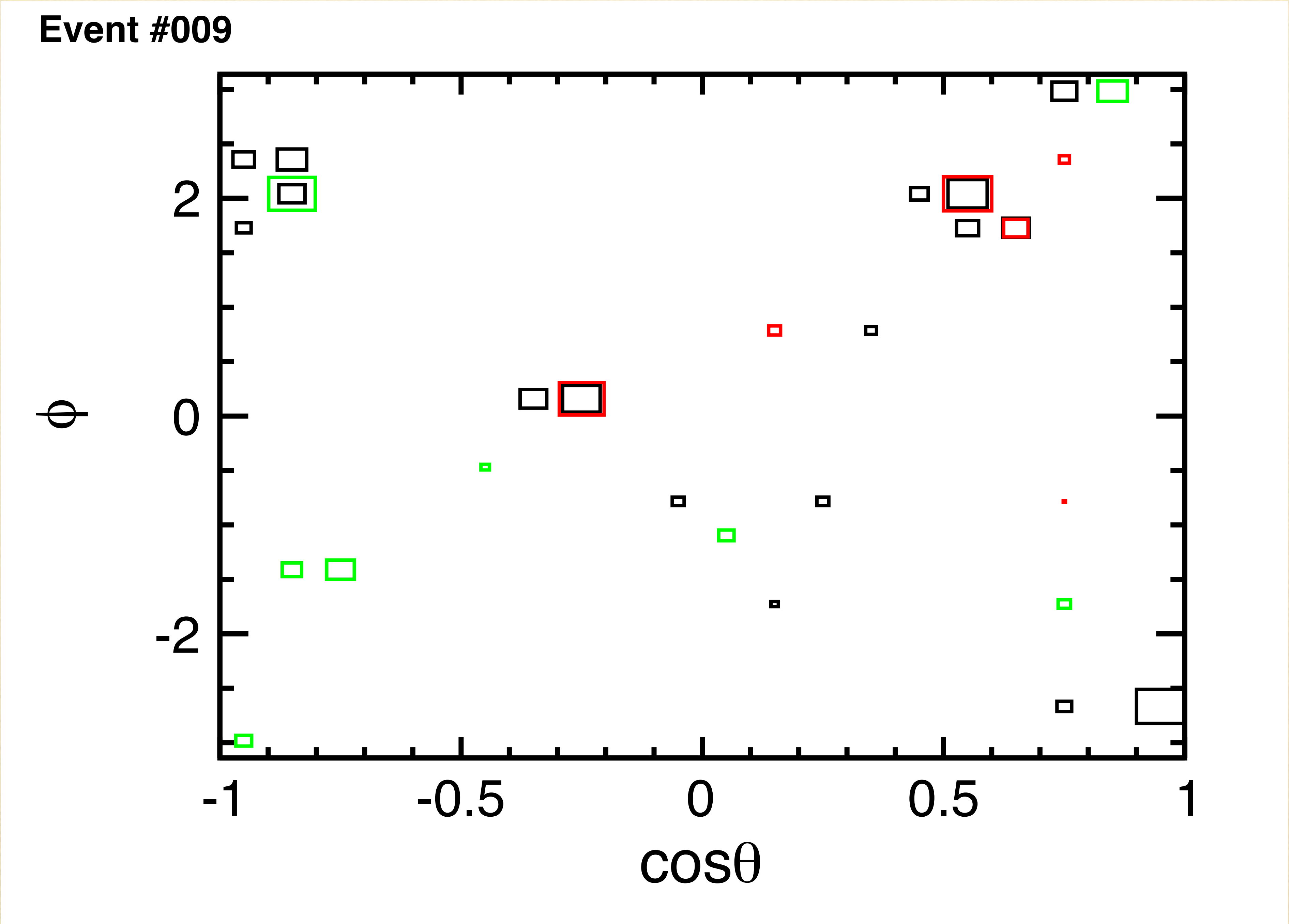
(energy distribution in 2D of ϕ .vs. $\cos\theta$)



black: mini-jets; red: from H1; green: from H2

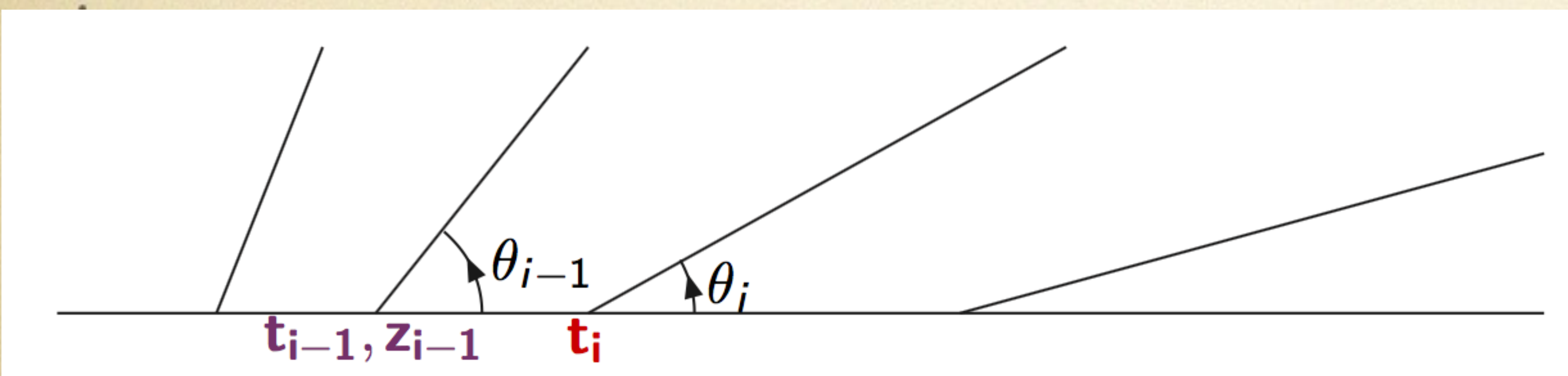
the kinematics of mini-jets versus final partons

(energy distribution in 2D of ϕ .vs. $\cos\theta$)



mini-jets idea looks promising, at least theoretically!

next step: try to implement the likelihood



$$\mathrm{d}\mathcal{P}_a = \sum_{b,c} \frac{\alpha_{abc}}{2\pi} P_{a\to bc}(z)\,\mathrm{d}t\,\mathrm{d}z\ .$$

$$\begin{aligned}
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P_{\mathrm{g}\to\mathrm{q\bar{q}}}(z) &= T_R\,(z^2+(1-z)^2)\ , \\
P_{\mathrm{q}\to\mathrm{q}\gamma}(z) &= e_{\mathrm{q}}^2\,\frac{1+z^2}{1-z}\ , \\
P_{\ell\to\ell\gamma}(z) &= e_{\ell}^2\,\frac{1+z^2}{1-z}\ ,
\end{aligned}$$

theoretical paper having similar idea– arXiv:1102.3480