Particle–Flow Questions and Answers

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Jet Energy/Mass Resolution vs Particle–Flow Algorithm ?

Energy Resolution in Common

$$\sigma_{E_{jet}} = \sigma_{PPU} \oplus \sigma_{JFU} \oplus \sigma_{DG} \oplus \sigma_{\mathbf{PFA}}$$

PPU Pure Physical Uncertainties: $\sigma_{PPU} = \sigma_{Nat.width(Z^0, W^{\pm}...)} \oplus \sigma_{E_{Lumi.curve}} \oplus \sigma_{E_{ISR}} \oplus \sigma_{E_{neutrinos}}$

JFU Jet Finder Uncertainties: $\sigma_{JFU} = \sigma_{JetFinderAlgorithm}$

DG Detector Geometry Term: $\sigma_{DG} = \sigma_{toBeamTube} \oplus \sigma_{DeadZones}$

All of above have no deal with the quality of the Particle–Flow Algorithm.

Above sum depends on the particular physical process has been chosen;

on the quality of accelerator, in particular on the beam spot sizes and crossing angle;

on the jet finder has been chosen for the analysis;

on the detector geometry option has been chosen;

and of course on the Particle–Flow Algorithm (PFA) quality which is a function of the sub–detector resolutions.

So, for the Particle–Flow quality estimation one should first of all split of independent terms or remove it from analysis.

The correct Particle–Flow analysis and comparison are possible ONLY after such a spliting.

So, what can one call as the Ideal or Perfect Particle–Flow?

How to get an estimation of Perfect Particle–Flow resolution?

True jets cannot be found even at the level of generator, due to so–called QCD color reconnection during the parton strings fragmentation, But, “true” jet collection can be selected directly to fit the initial parton momentum with reachable accuracy, excluding any jet finder. The procedure will be developed soon.

Secondary: one should select the particles that have an ability to be measured in principle by some of the sub–detectors.

Then one can calculate jet energy or di–jet mass for these carefully selected particles or jets from HEP record directly; and it will be the reference energy or mass for PFA quality estimation.

From the other side of a calculation it should be used the full simulation of this event to get a particle splitting taking into account the particle decays in the tracker region and the possible gamma conversion to e^+e^- pairs before calorimeter, and possible bremsstrahlung gammas.

At the end of such a procedure one should get the particles that reached a calorimeter, and/or measured at the tracker.

The next step is to apply calorimeters energy resolution to the particles that reached the calorimeter. Make replacement for the charged particles with the tracker resolution, taking into account its decay, gamma conversion and bremsstrahlung processes.

During the energy to momentum substutitions it should be taken into account the shower overlap term in the particle–flow resolution estimation. This can be done by using hit labels to the stable particles at HEP record.

The last step is to calculate energy or mass for the same parton as the reference one and compare it by pool calculation.

Particle–Flow for Whole Energy Resolution

For present calculations:

$$\sigma_{PPU} = [\sigma_{Nat.width(Z^0,W^\pm...)} = 0] \oplus [\sigma_{E_{Lumi.curve}} = 0] \oplus [\sigma_{E_{ISR}} = 0] \oplus \sigma_{E_{neutrinos}}$$

$$\sigma_{JFU} = \sigma_{JetFinderAlgorithm} = 0$$

So, it will be the whole energy resolution estimation only, no jets or di–jet mass resolution

$$\sigma_{DG} = \sigma_{toBeamTube} \oplus \sigma_{DeadZones}$$

“Old” PFA it was presented as:

$$\sigma_{E_{PFA}} = \sigma_{E_\gamma} \oplus \sigma_{E_{neut.hadr.}} \oplus \sigma_{E_{ch.hadr.}} \oplus \sigma_{conf.}$$

A new one as:

$$\sigma_{\mathbf{PFA}} = \sigma_{\mathbf{CAL}} \oplus \sigma_{\mathbf{TRK}}$$

with: σ_{ECAL} = 12 %/$\sqrt{E}$ and σ_{HCAL} = 50 %/$\sqrt{E} \oplus 4\%$

CAL Calorimeter Uncertainties: $\sigma_{CAL} = \sigma_{ECAL} \oplus \sigma_{HCAL} \oplus [\sigma_{shower\ overlap} = 0]$

TRK Tracker + Calorimeter Uncertainties: $\sigma_{TRK} = \sigma_{M_{charged}} \oplus \sigma_{M_{neutral}} \oplus [\sigma_{kink,V^0,\gamma,albido} = 0]$

and now PFA for the particles which can be measured in principle:

$e^+e^- \to Z^0 \to q\bar{q}$ at 91.2 GeV

Effect	σ [GeV] separate	σ [GeV] no join	σ [GeV] total (%/$\sqrt{E}$)	σ % to total
$E_\nu > 0$	0.84	0.84	0.84 (8.80%)	12.28
$Cone < 5^o$	0.73	1.11	1.11 (11.65%)	9.28
$P_t < 0.36$	1.36	1.76	1.76 (18.40%)	32.20
σ HCAL	1.40	1.40	2.25 (23.53%)	34.12
σ ECAL	0.57	1.51	2.32 (24.27%)	5.66
$M_{neutral}$	0.53	1.60	2.38 (24.90%)	4.89
$M_{charged}$	0.30	1.63	**2.40 (25.10%)**	1.57

$e^+e^- \to Z^0 \to q\bar{q}$ at 500 GeV

Effect	σ [GeV] separate	σ [GeV] no join	σ [GeV] total (%/$\sqrt{E}$)	σ % to total
$E_\nu > 0$	0.75	0.75	0.75 (3.35%)	2.44
$Cone < 5^o$	1.80	1.95	1.95 (8.72%)	14.03
$P_t < 0.36$	1.96	2.76	2.76 (12.36%)	16.63
σ HCAL	3.04	3.04	4.11 (18.38%)	40.01
σ ECAL	2.20	3.75	4.66 (20.84%)	20.95
$M_{neutral}$	1.03	3.89	4.77 (21.35%)	4.59
$M_{charged}$	0.56	3.93	**4.81 (21.49%)**	1.36

$e^+e^- \to W^+W^- \to q\bar{q}q\bar{q}$ at 500 GeV

Effect	σ [GeV] separate	σ [GeV] no join	σ [GeV] total (%/$\sqrt{E}$)	σ % to total
$E_\nu > 0$	0.70	0.70	0.70 (3.13%)	1.50
$Cone < 5^o$	2.73	2.82	2.82 (12.60%)	22.78
$P_t < 0.36$	1.36	3.13	3.13 (13.99%)	5.65
σ HCAL	4.10	4.10	5.16 (23.07%)	51.39
σ ECAL	2.17	4.64	5.60 (25.02%)	14.40
$M_{neutral}$	1.02	4.75	5.69 (25.44%)	3.18
$M_{charged}$	0.60	4.79	**5.72 (25.58%)**	1.10

$e^+e^- \to t\bar{t} \to q\bar{q}q\bar{q}q\bar{q}$ at 500 GeV

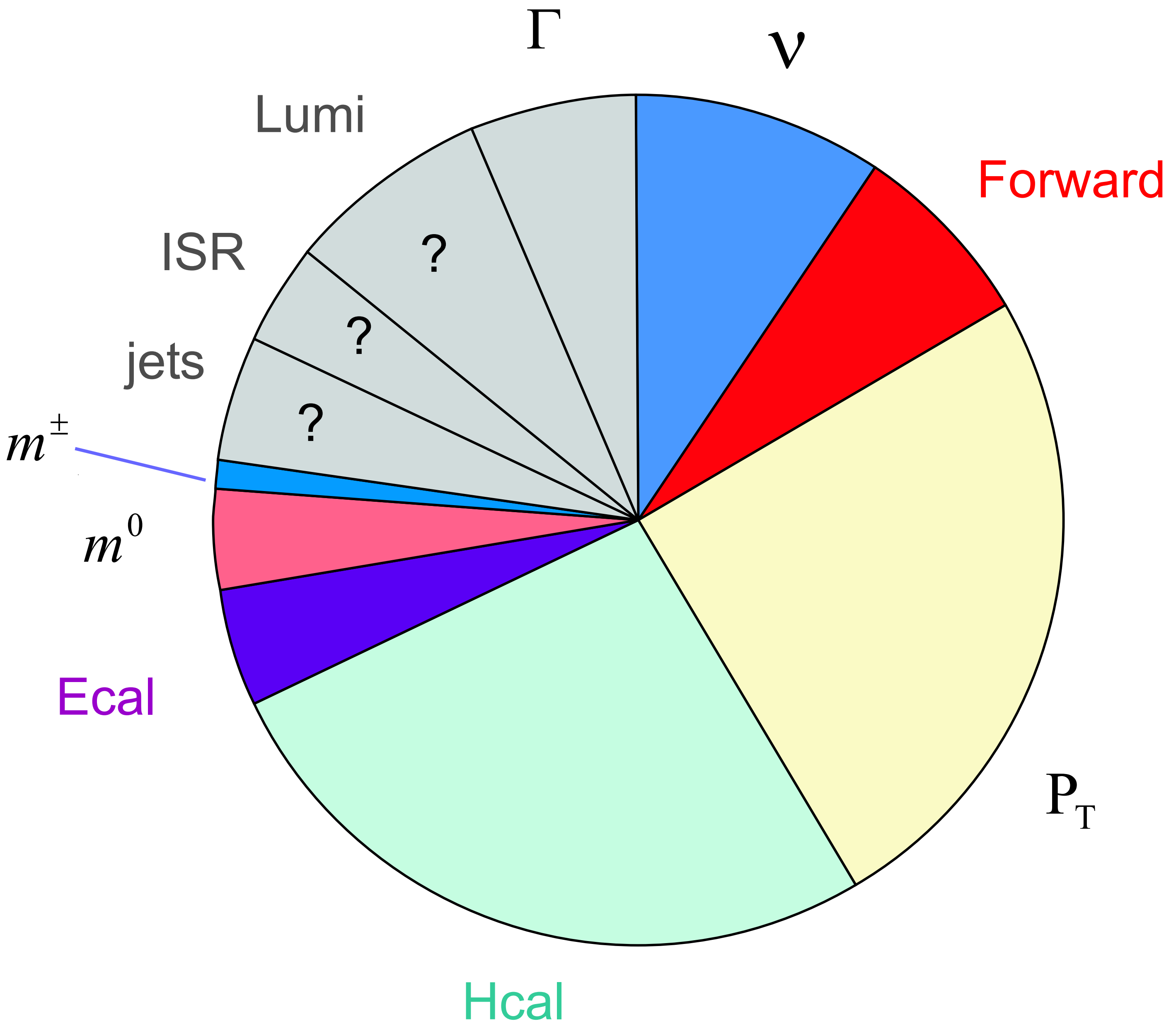
Effect	σ [GeV] separate	σ [GeV] no join	σ [GeV] total (%/$\sqrt{E}$)	σ % to total
$E_\nu > 0$	1.37	1.37	1.37 (6.13%)	6.66
$Cone < 5^o$	1.48	2.02	2.02 (9.02%)	7.77
$P_t < 0.36$	2.23	3.01	3.01 (13.45%)	17.64
σ HCAL	3.93	3.93	4.95 (22.13%)	54.79
σ ECAL	1.40	4.17	5.14 (23.00%)	6.95
$M_{neutral}$	1.12	4.32	5.26 (23.53%)	4.45
$M_{charged}$	0.70	4.38	**5.31 (23.73%)**	1.74

Whole Event Energy Resolution

	Z_{pole}	Z at 500 GeV	$W^{\pm}$ at 500 GeV	$t\bar{t}$ 500 GeV
σ_{PPU} [GeV]	1.76	2.76	3.13	3.01
σ_{PPF} [GeV]	1.63	3.94	4.79	4.38
σ_{total} [GeV]	2.40	4.81	5.72	5.31
$\sigma_{total\ minimal}$ %/$\sqrt{E}$	25.1 %	21.5 %	25.6 %	23.7%

Partial relative resolution in percents

% to total resolution	Z_{pole}	Z at 500 GeV	$W^{\pm}$ at 500 GeV	$t\bar{t}$ 500 GeV
$\sigma_{neutrino}$	12.28	2.44	1.50	6.66
$\sigma_{around\ tube}$	41.48	30.66	28.43	25.41
σ_{sum}	53.76	33.10	29.93	32.07
σ_{HCAL}	34.12	40.01	51.39	54.79
σ_{ECAL}	5.66	20.95	14.40	6.95
σ_{masses}	6.56	5.95	4.28	6.19
σ_{sum}	46.34	66.91	70.07	67.03


Γ
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Forward
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