Jets @ CMS

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Overview

- The CMS/ORCA jet reconstruction subsystem: *Jets*
  - jet input objects
  - jet algorithms
  - jet calibration
- CMS jet reconstruction performance
  - LHC multi-jet enviroment with pileups $\longrightarrow$ ttH
  - forward jets $\longrightarrow$ WBF
- Summary

Jet input objects

Available input objects for jet finding:

- MC information:
  - generator level
  - geant particles (G3 and G4)
- calorimeter:
  - clusters (ECal, HCal, Preshower and combinations)
  - towers (combination of ECal and HCal clusters)
- reconstructed tracks:
  - from the CMS tracker
  - from the muon system

Jet algorithms

All important jet algorithms are implemented:

- cone based algorithms:
  - SimpleCone
  - IterativeCone
  - MidPointCone
- cluster algorithms:
  - inclusive KtJets
  - exclusive KtJets (d_{cut})
  - exclusive KtJets (N_{jets})

Jets calibration I

In principle two different ways which can be used in combination:

- correction of the jet input (4-vectors)
  - e.g. improve calorimetric cluster η- and ϕ-resolution by replacing some of them with reconstructed tracks
- correction of final state jets
  - detector correction for jets nearby dead material, cracks

$\hookrightarrow$ with a calibrated Jets output one can think of calculating missing E_t with jets

Jets calibration II

Explicit solution in the CMS Jets subsystem:

- correction of the jet input
  - TrackTowers: several possibilities to combine, replace calorimetric information with reconstructed tracks
- correction of the final state jets
  - prototypes for adding out of cone tracks
  - detector correction by a P_t, η and ϕ dependent detector map

$\hookrightarrow$ Predefinded calibrations (e.g. detector maps) for standarized setups will be prepared for DC04

Multi-jet finding: test setup

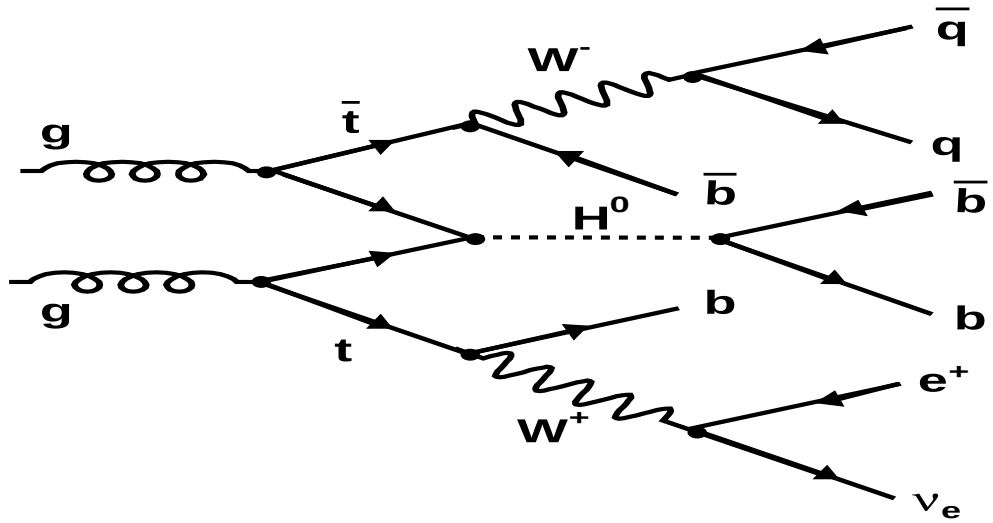
- 1000 (10000) ttH events which decay semi-leptonically
- simple and iterative cone with serveral parameters
- inclusive KtJets with different setups

$\hookrightarrow$ hundreds of plots to compare which each other

$\hookrightarrow$ only a few key plots can be shown here

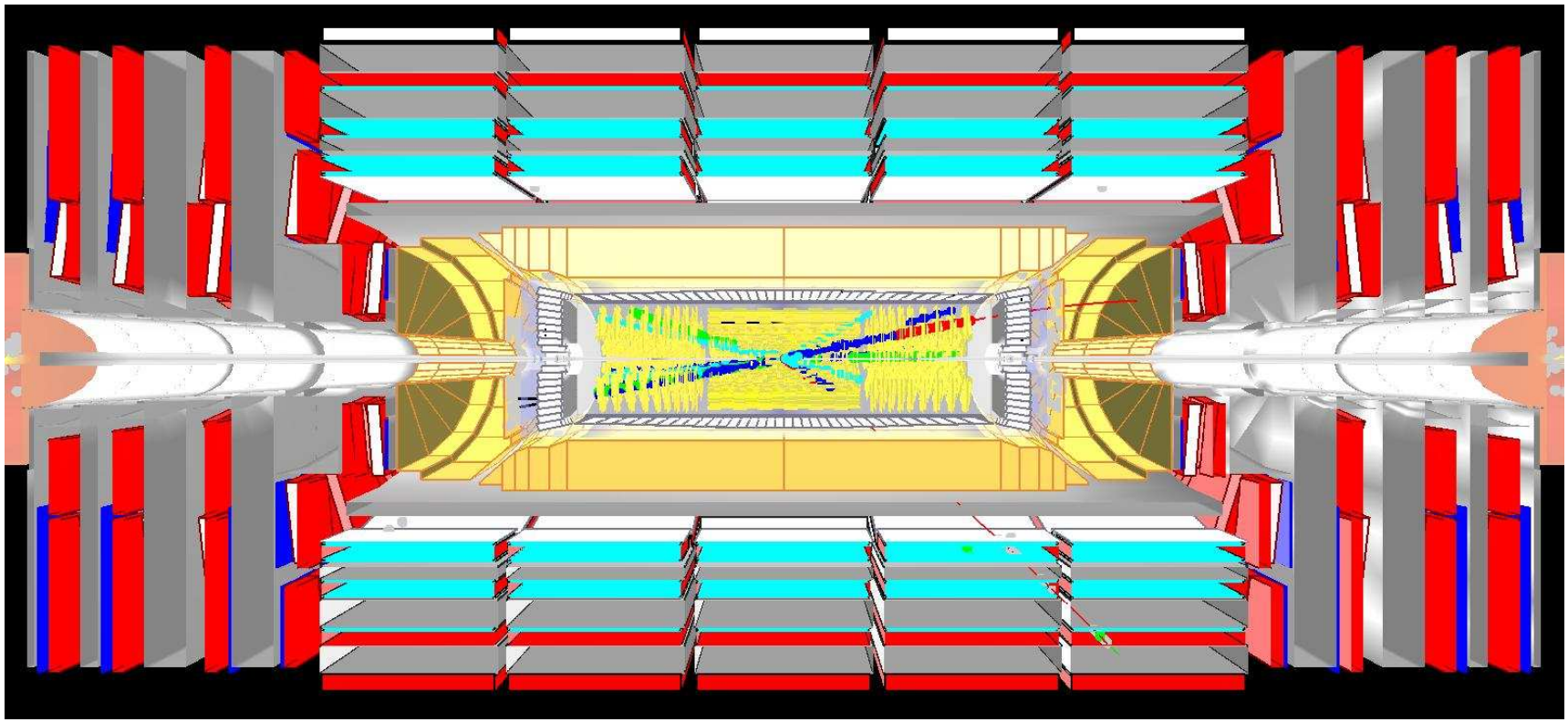
$\hookrightarrow$ mostly comparism between iterative cone and inclusive KtJets (E_t,ΔR) on the next slides

Example: $\mathrm{H} \rightarrow \mathrm{b\bar{b}}$ *final state*



- ↪ associated production into a semileptonic final state: $\mathrm{pp} \rightarrow \mathrm{t\bar{t}H^0} \rightarrow \mathrm{l^{\pm}}\nu\mathrm{q\bar{q}b\bar{b}b\bar{b}} \Rightarrow$ improved $S/\sqrt{B}$ due to more signal constraints
- ↪ For LHC low lumi phase: plus 3.5 PileUps !

CMS event display

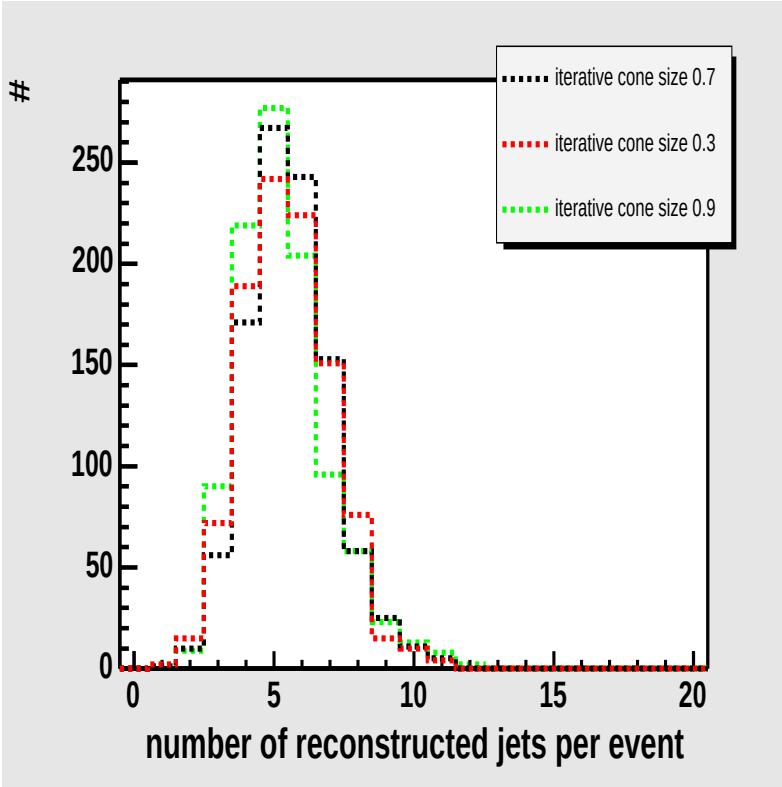


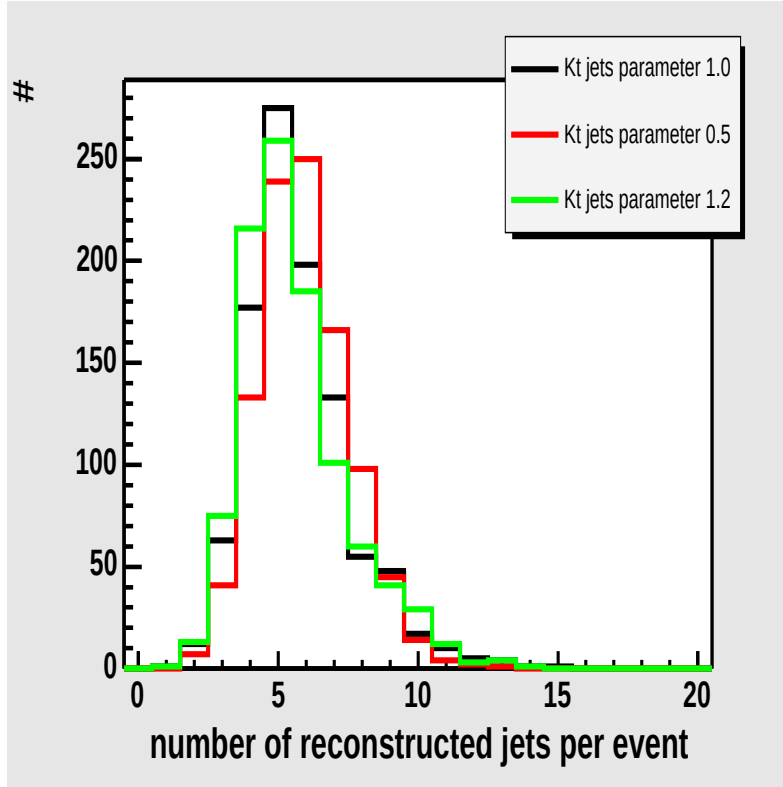
$\hookrightarrow$ ttH event without PileUps

Generator tag setup

- Find the 2 reconstructed Higgs decay b-jets by best matching RecJet candidate to the generated Higgs b decay.
- The RecJet candidate should be nearer than 5° to the flight direction of the generated b.
- No other RecJet should be nearer than 10° to this candidate.
- All jets have a $P_\mathrm{t} > 20\ \mathrm{GeV}$.

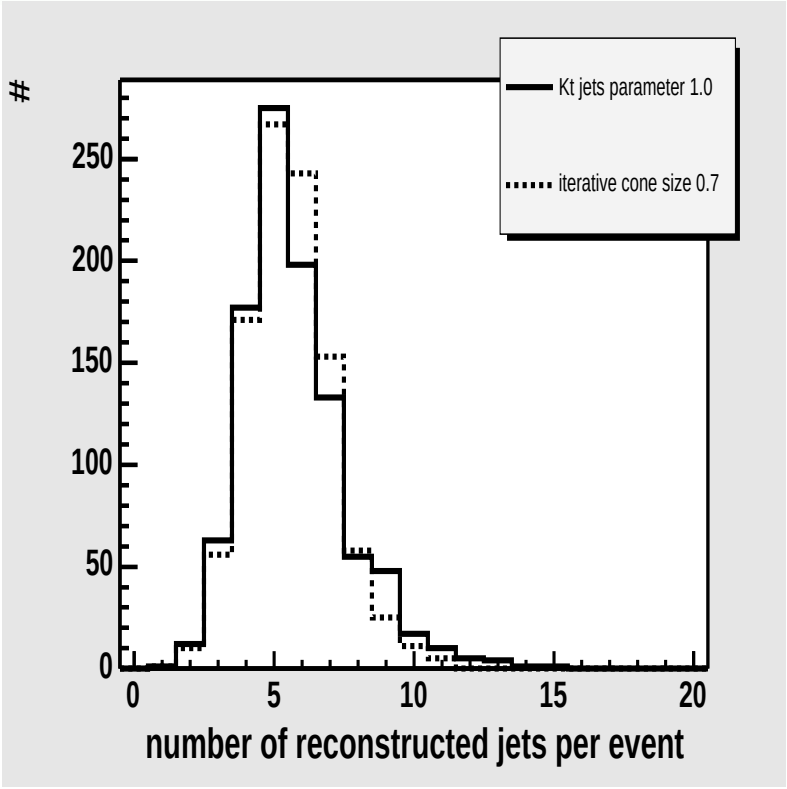
Number of reconstructed Jets I





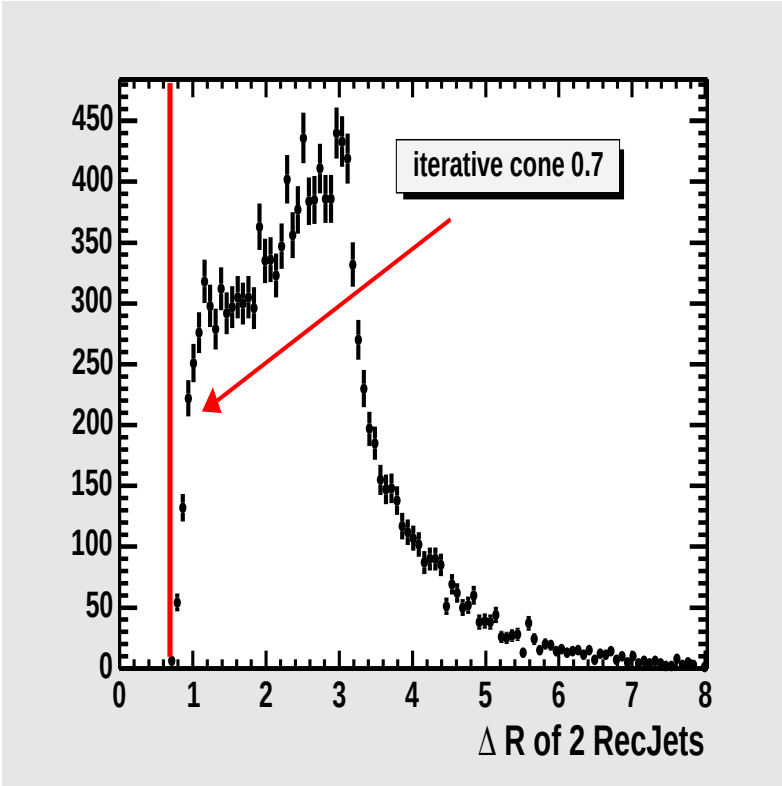
$\hookrightarrow$ number of reconstructed jets should be > 6 !

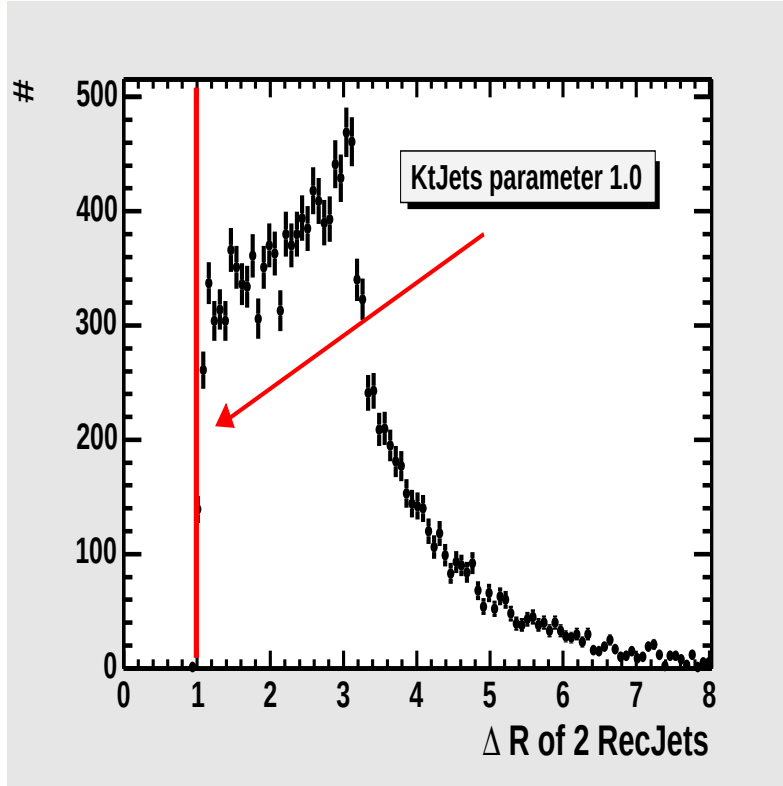
Number of reconstructed Jets II



$\hookrightarrow$ The jet multiplicity of the iterative cone algorithm is higher for more than 6 jets - but are they also the *good* jets ?

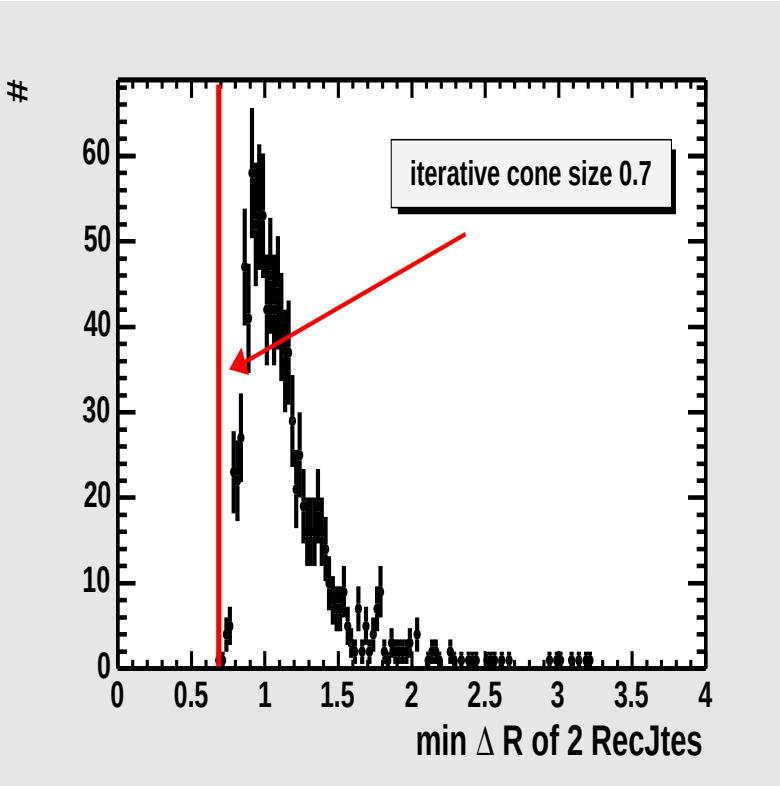
RecJets ΔR distance

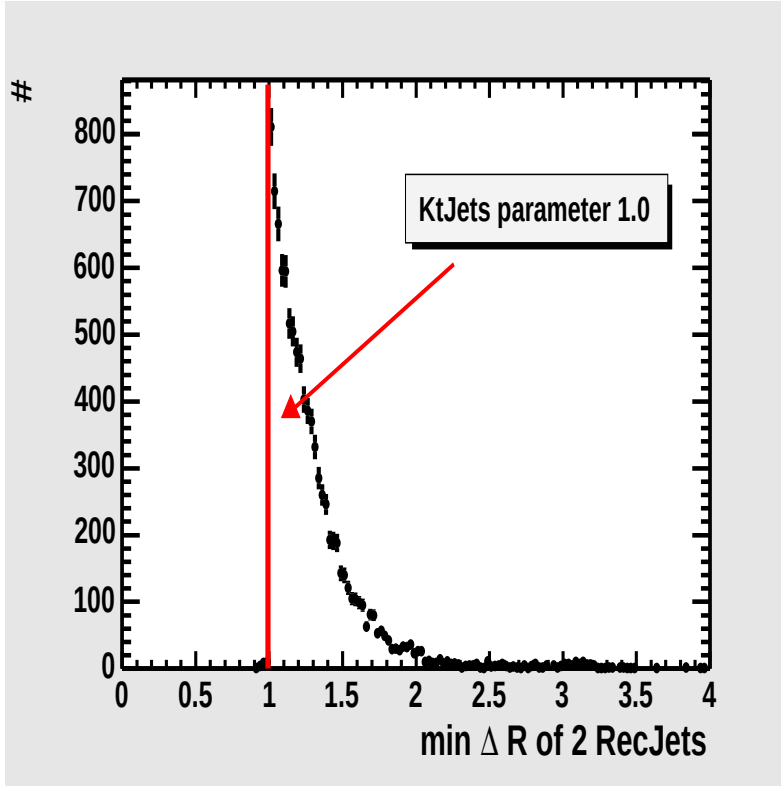




$\hookrightarrow$ Distance of every RecJet to each other RecJet is showed !

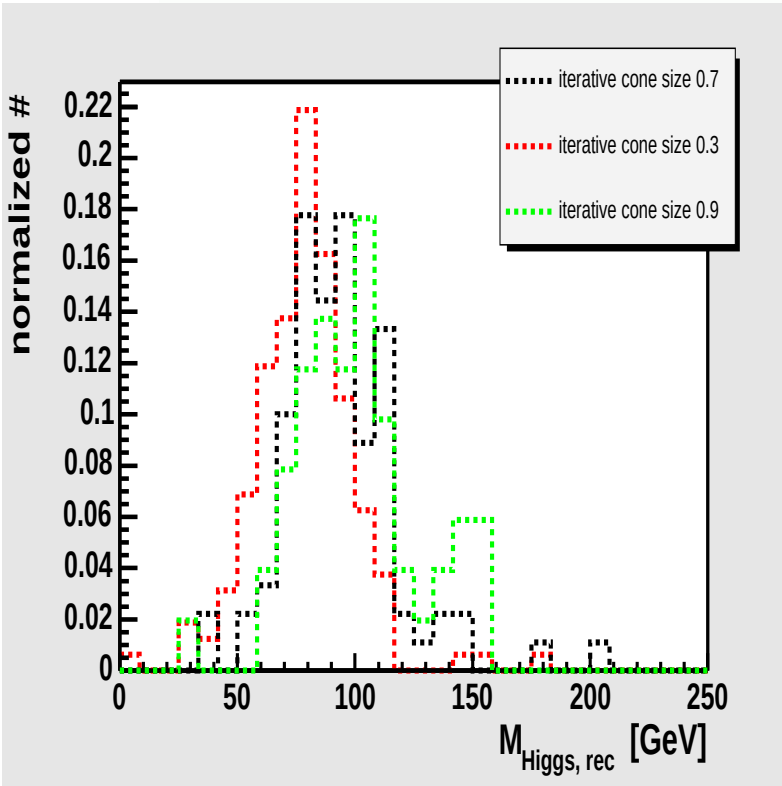
RecJets min ΔR distance

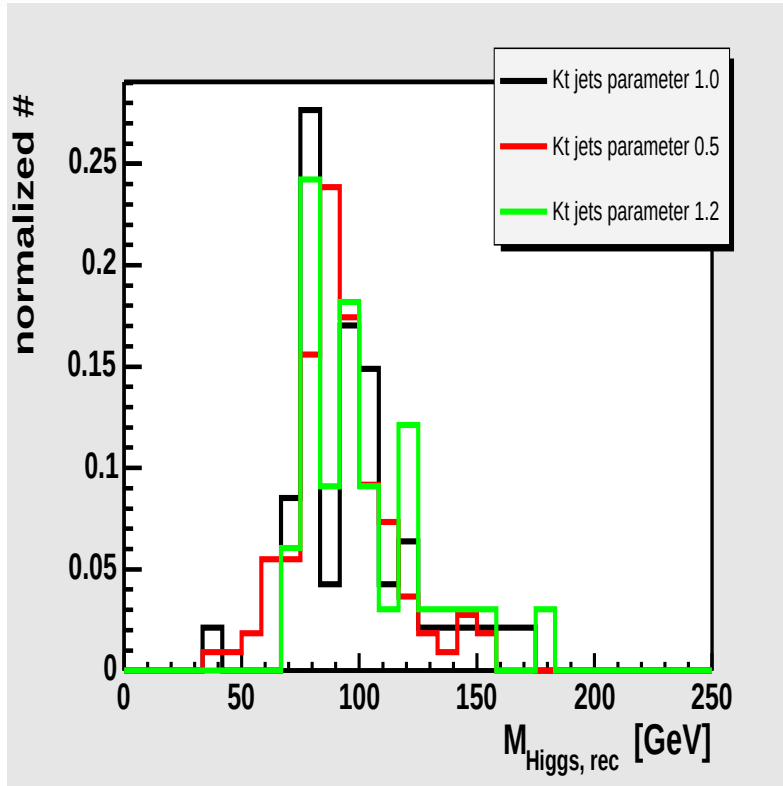




$\hookrightarrow$ the KtJets are *nearer* to each other

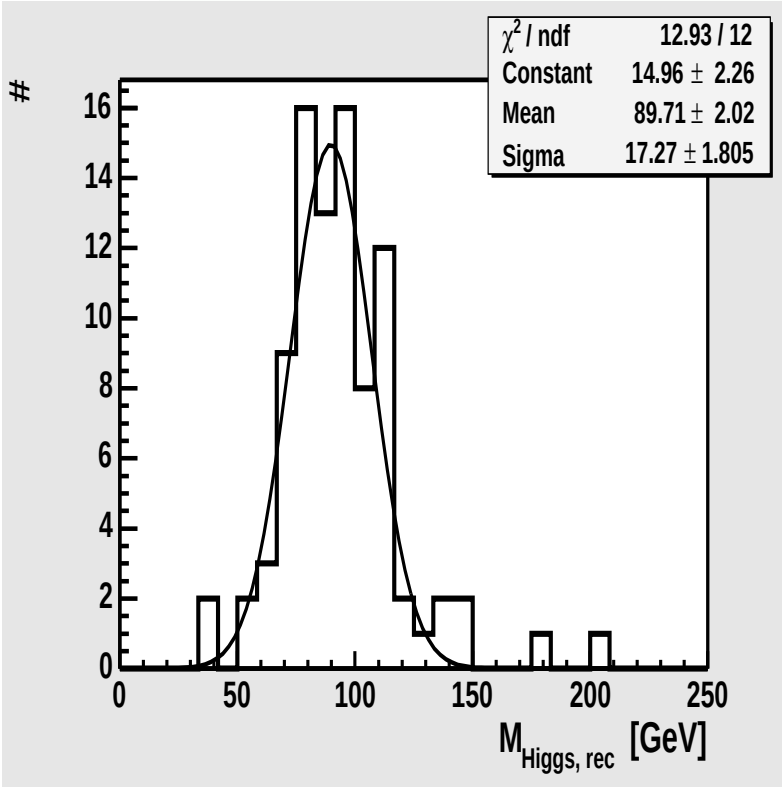
M_{Higgs} reconstruction I

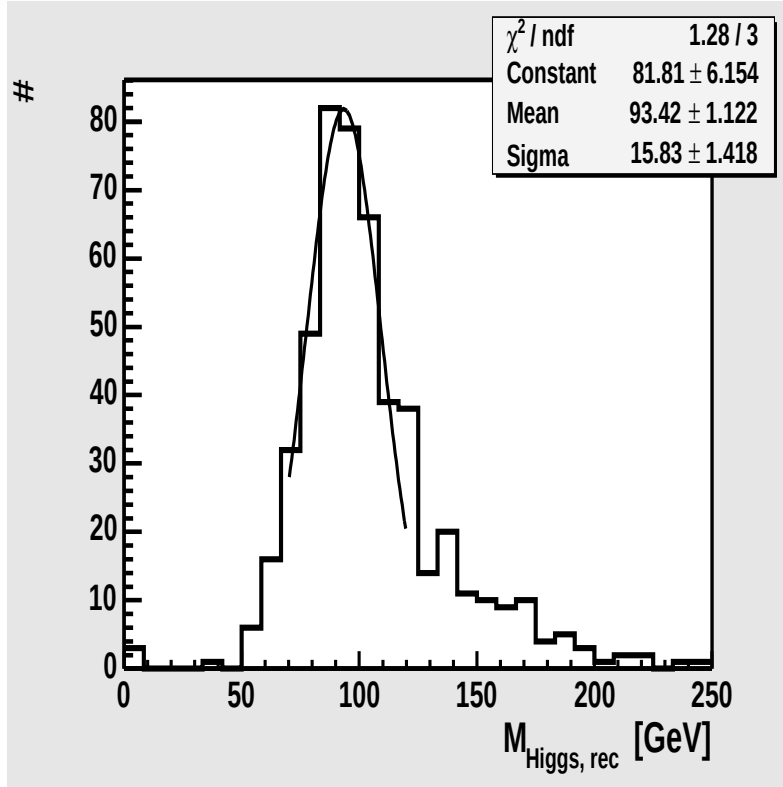




$\hookrightarrow$ For the iterative cone algorithm the M_{Higgs} reconstruction is cone size dependent. ($M_{\mathrm{Higgs,\ gen}} = 115\ \mathrm{GeV}$)

M_{Higgs} reconstruction II

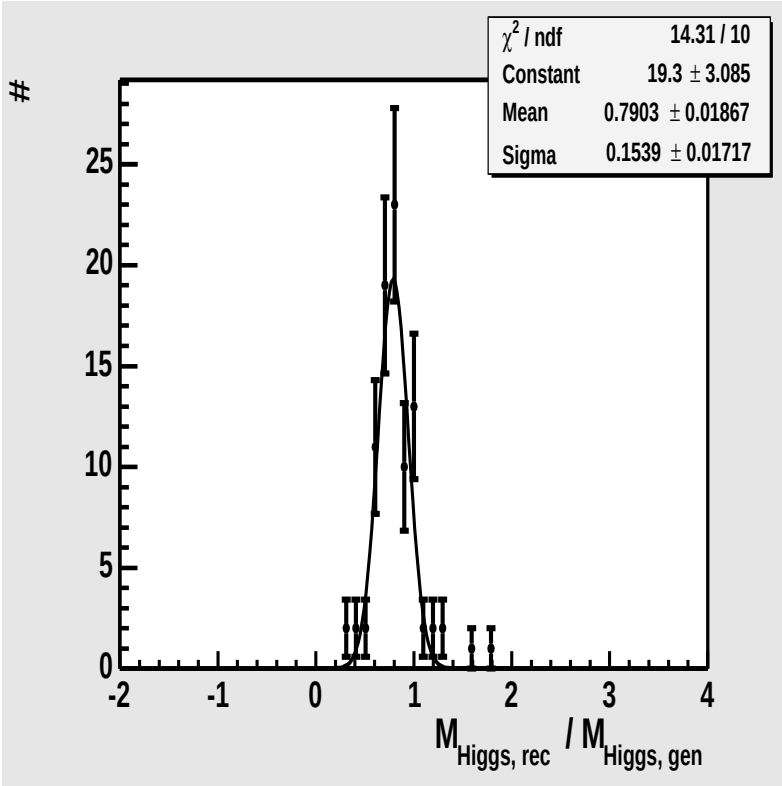


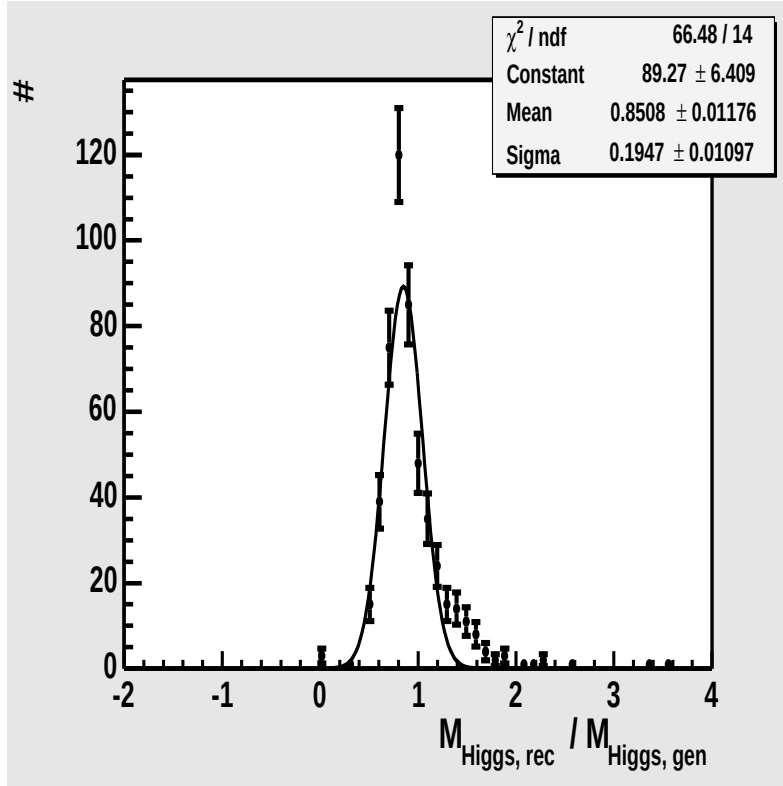


$\hookrightarrow$ left iterative cone (0.7) / right KtJets (1.0)

$\hookrightarrow$ $M_{\mathrm{Higgs,\ gen}} = 115\ \mathrm{GeV}$

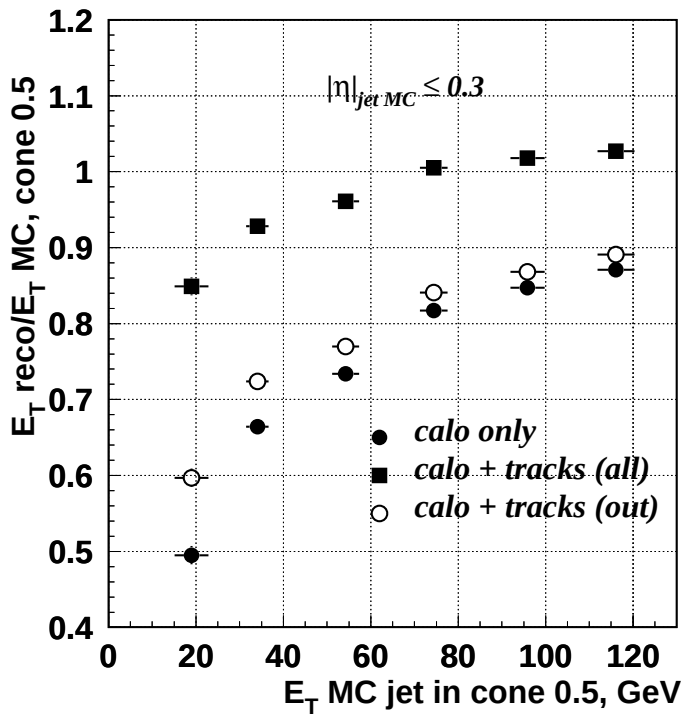
M_{Higgs} *resolution*

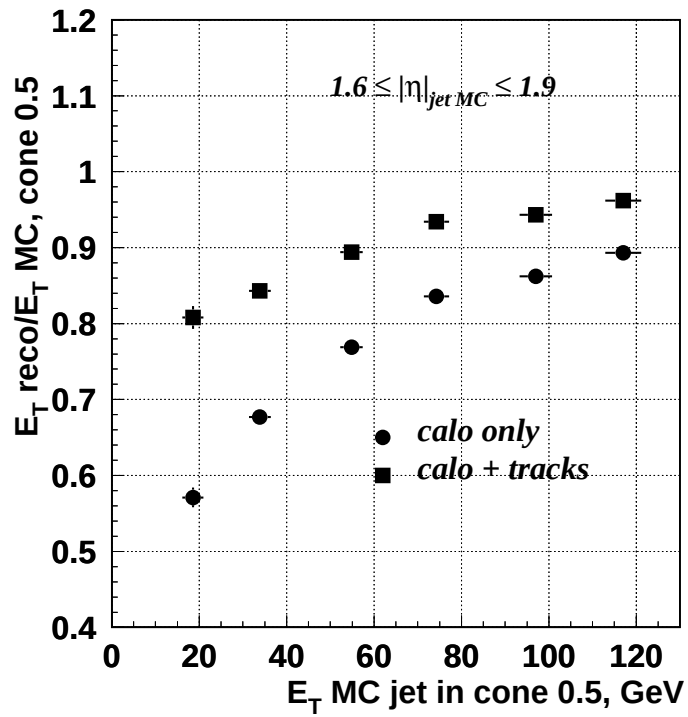




$\hookrightarrow$ resolutions corresponding to the higgs mass plots on the last slide

Calo+tracks correction

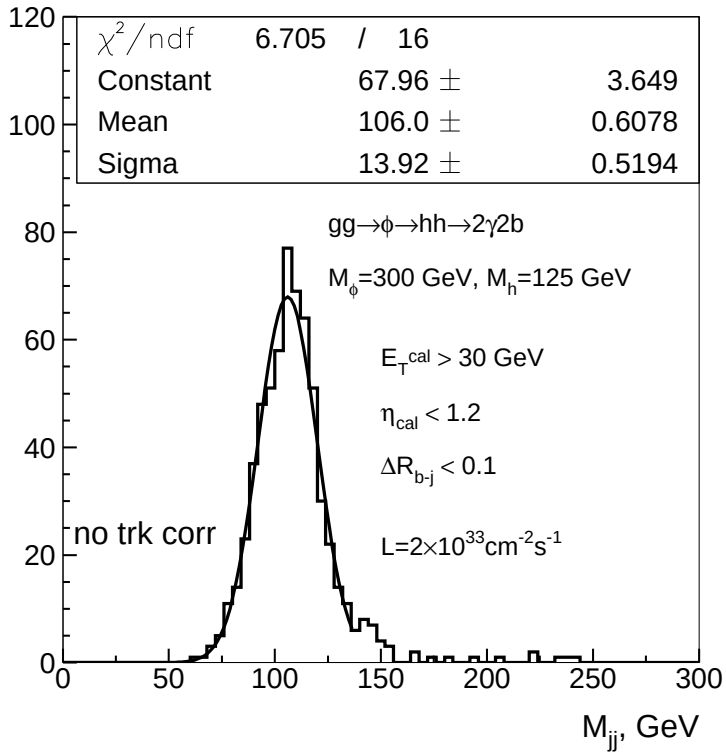


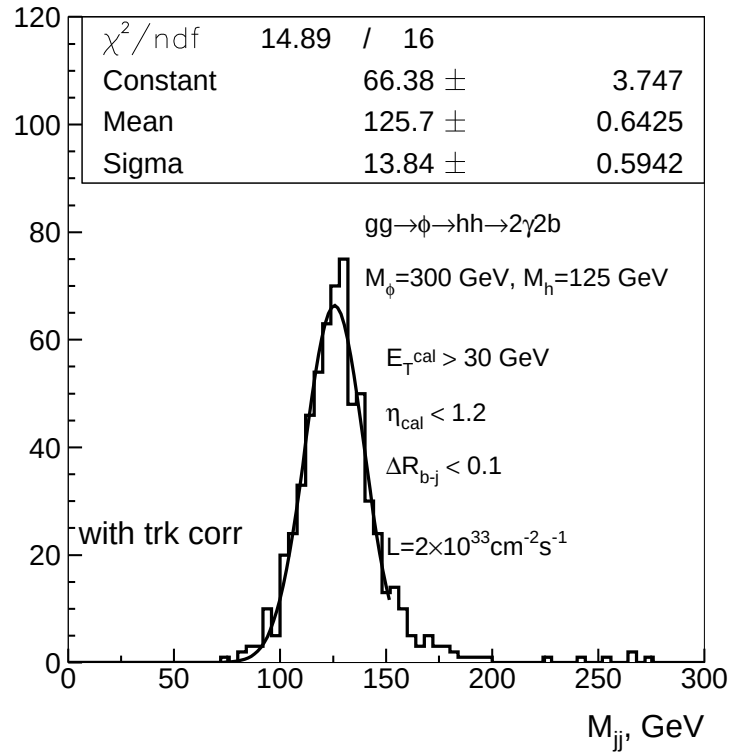


↪ plots taken from CMS AN-2003/016

↪ iterative cone algorithm used

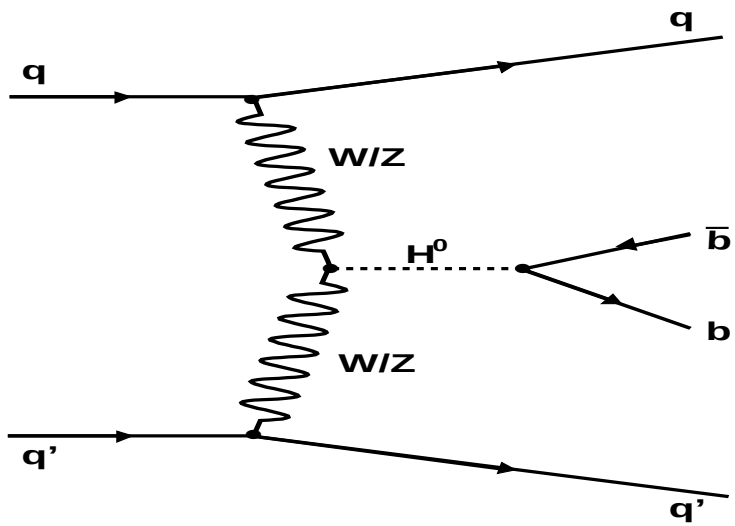
M_{Higgs}: *Calo+tracks correction*





$\hookrightarrow$ plots taken from CMS AN-2003/016

Example: WBF $\rightarrow \mathrm{H} \rightarrow \mathrm{b\bar{b}}$ *final state*

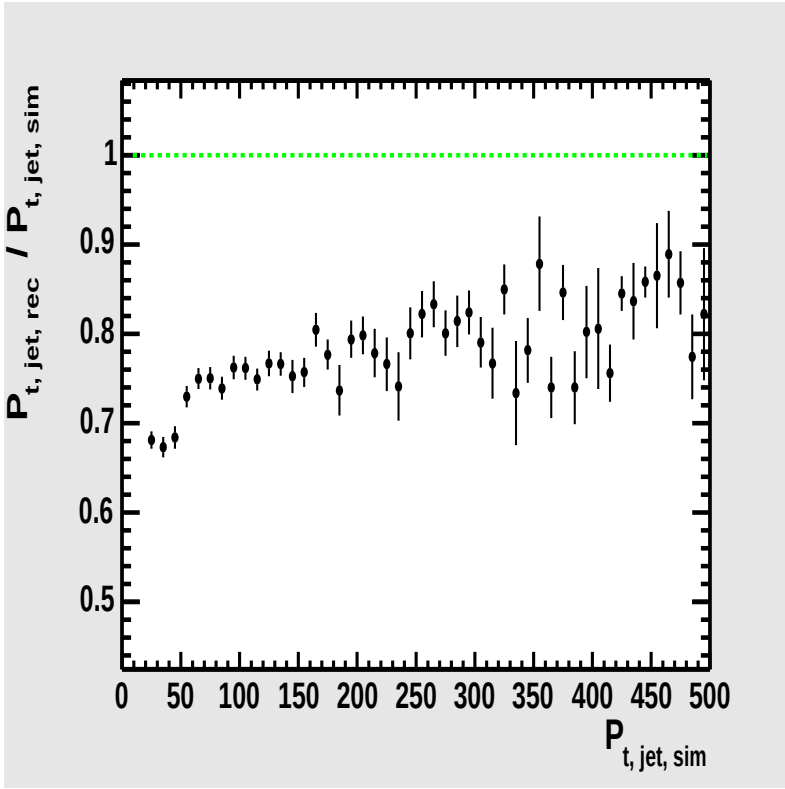


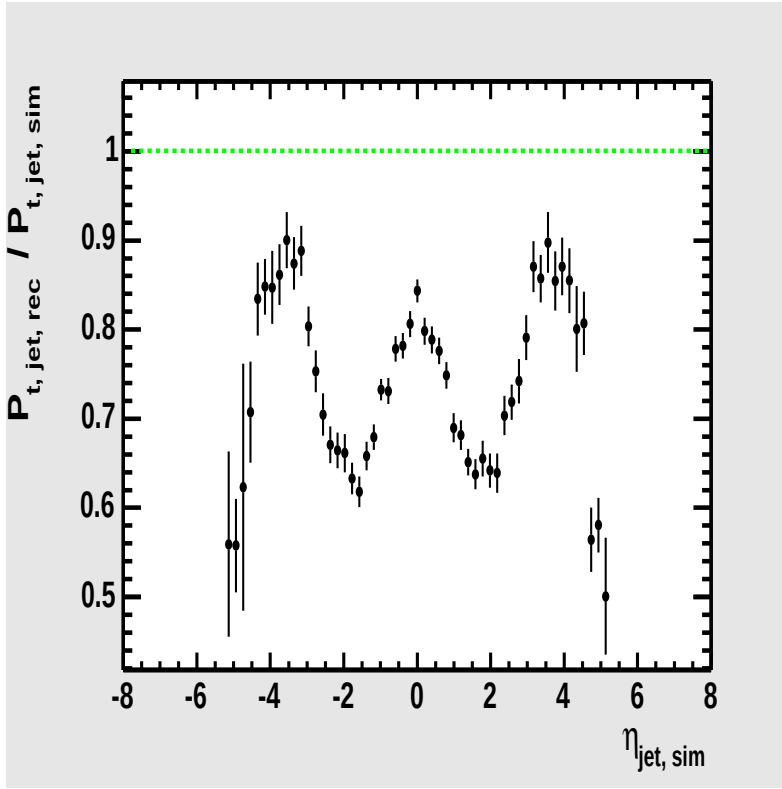
e

$\hookrightarrow$ absence of colour exchange between the scattered quarks and the colourless Higgs boson $\Rightarrow$ low activity in the central region $\Rightarrow$ improved $S/\sqrt{B}$

$\hookrightarrow$ For LHC low lumi phase: plus 3.5 PileUps !

Jet profile histograms

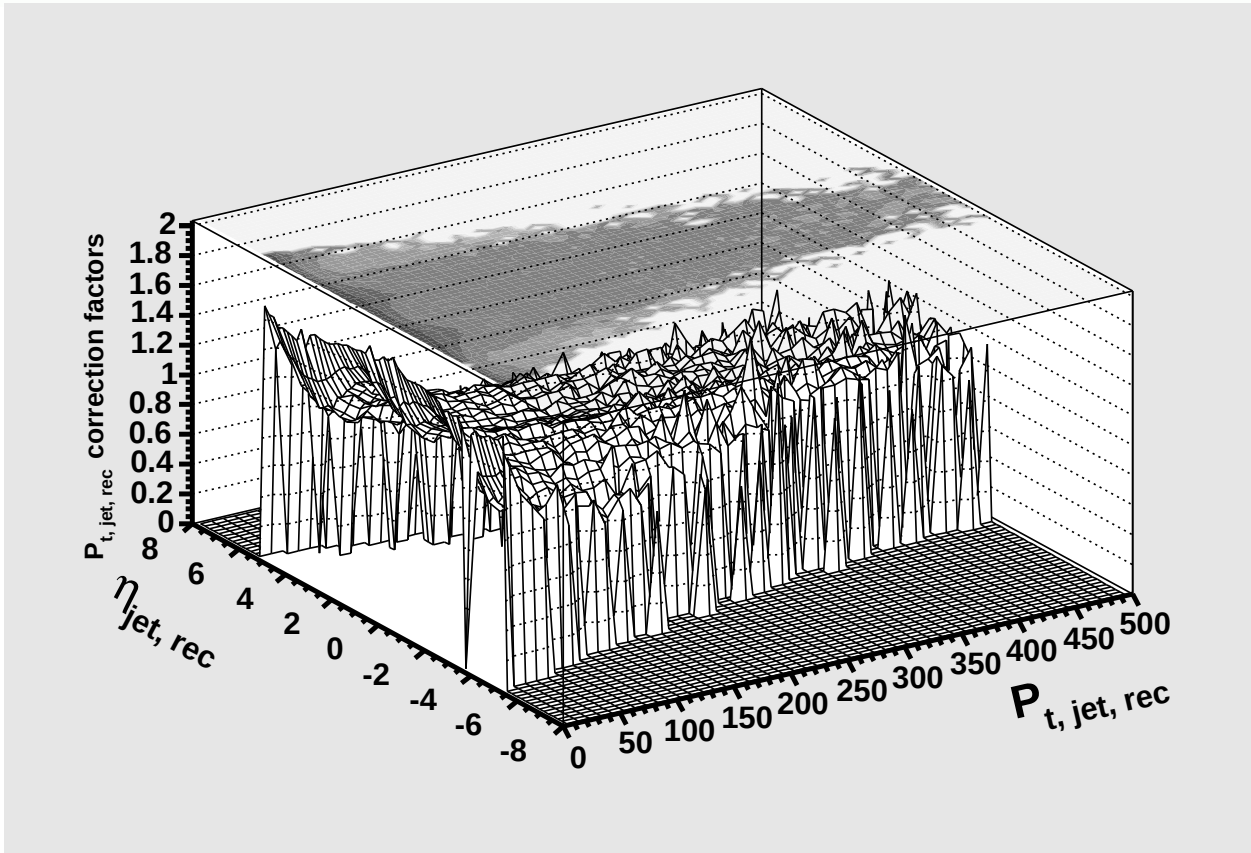




$\hookrightarrow$ plots: KtJets (E_t,ΔR), no energy flow objects

$\hookrightarrow$ All jet finders show similar P_{t} and η dependance.

Example: jet P_{t} correction



$\hookrightarrow$ η and P_{t} dependent jet P_{t} correction

Summary

- The CMS/ORCA jet reconstruction software works reasonable:
  - 4-vectors of all detector subsystems can be used.
  - All important jet algorithms are available.
- Prototypes to use energy flow methods are implemented and further work is in progress.
- The available jet algorithms can deal with the LHC multi-jet enviroment. ($\rightarrow$ ttH)
- A wide range of η can be used for jet reconstruction the CMS detector. ($\rightarrow$ WBF)

KtJets package

The basic algorithm is a clustering procedure. More details can be found in hep-ph/0210022.

The package is highly configurable:

- inclusive/exclusive modes
- different definitions of angular schemes: angular, ΔR, QCD emission
- several recombination schemes: E, p_t, p_t^2, E_t, E_t^2
- own definitions are possible