

# WG 4 - TopPhysics@FCC-ee Contribution to Detector Studies

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New material today from Nicolò Foppiani(Pisa)



# Status of WG4

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- Last year saw decline in some of the activities. Also due to people leaving the field /changing institution/teaching load.
- Current analyses: (A=active, S=Stopped)
  - **A** Top couplings (N. Foppiani, T. Pajero, Patrick J)
    - analytical result published, Fullsim result using CLIC software completed
    - TO DO: move it to full framework analysis next
  - Concrete study of sensitivity to Composite Higgs models (S. De Curtis, S. Moretti):
    - completed using Top Coupling sensitivity result.
  - **S** FCNC in the single top production and hadronic final state (B. Mele+F.Margaroli): stopped. Need completion.
  - **A** FCNC in the single top/pair production in single lepton plus jets (M. Najafabadi et al.):
    - completed with Delphes (ILD detector). Paper under review.
    - detector studies in progress: Calo resolution, b and c tagging studies
  - **A** Top Mass measurement at threshold (N. Foppiani)
    - analysis implemented in FCC framework and Papas, Madgraph signal
    - first studies on detector effects
    - plan to complete first pass by January using Whizard for signal

# Top Physics Wish List for 2016/2017

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- FCC-ee at  $2m_{\text{top}}$  350 GeV:
- top mass measurement around threshold @350GeV
- intertwined with mass but dedicated measurement could improve sensitivity:
  - top  $Y_t$  measurement
  - top width
- Rare decays
- FCNC
- Anomalous couplings
- Forward-backward asymmetry
- Single top physics @240GeV:
  - higher integrated luminosity will really help here
  - direct measurement  $V_{tb}$
  - Anomalous couplings FCNC
    - also @240 GeV
- Interference  $t\bar{t}/WbWb$  and single top production is open topic
  - needs further exploration and interaction with pheno group
- The case for 500 GeV run
  - direct extraction of  $Y_t$  from  $t\bar{t}H$
  - any other BSM signal to look for?

# Asked for today

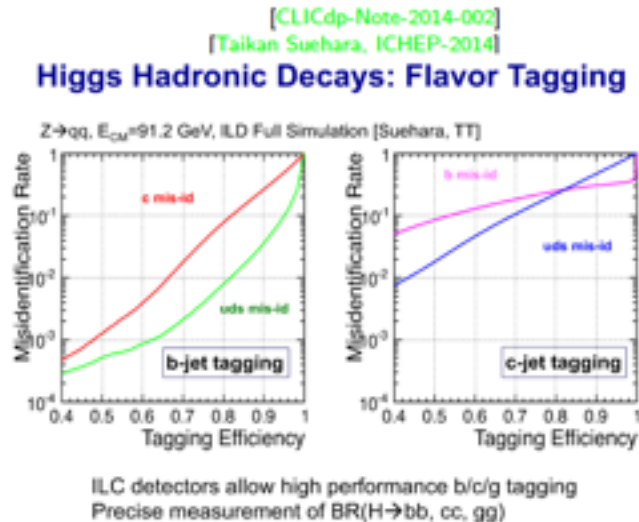
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- Study of effects of calorimetry resolution
- Study of effects of charm tagging efficiency
  
- Top mass analysis at threshold not the best benchmark as not expected to be very sensitive:
  - high S/N, loose cuts on energy, loose btagging, no charm taggin.
- FCNC in single top production expected to be more sensitive:
  - low S/N, btag requirement, charm in final state
    - Studies in progress. Not ready for today.

# FCNC old study for b/c tagging

- in the first iteration of the FCNC l+jets analysis there was a check of the effect of using different b-tagging working points.
- Used two working points:  $\text{eff}(b)=60(80)\%$  and  $\text{rej}(c)=250(10)$  and  $\text{rej}(\text{light})=1000(100)$ . Number from ILC
- large effect on efficiency and rejection  $\rightarrow$  limits
- Analysis being redone with latest simulation card and working points variation

## Example from old study



	$\epsilon_b = 60\%$	$\epsilon_b = 80\%$
$tcA$	$426.17  \lambda_{qt} ^2$	$479.28  \lambda_{qt} ^2$
$tcZ, \gamma\mu$	$178.82  \mathcal{X}_{qt} ^2$	$199.22  \mathcal{X}_{qt} ^2$
$tcZ, \sigma_{\mu\nu}$	$281.32  \kappa_{qt} ^2$	$316.92  \kappa_{qt} ^2$
$W_{jj}$	2.40	34.35

Table: Cross section normalisation factors (in fb) after complete cut flow

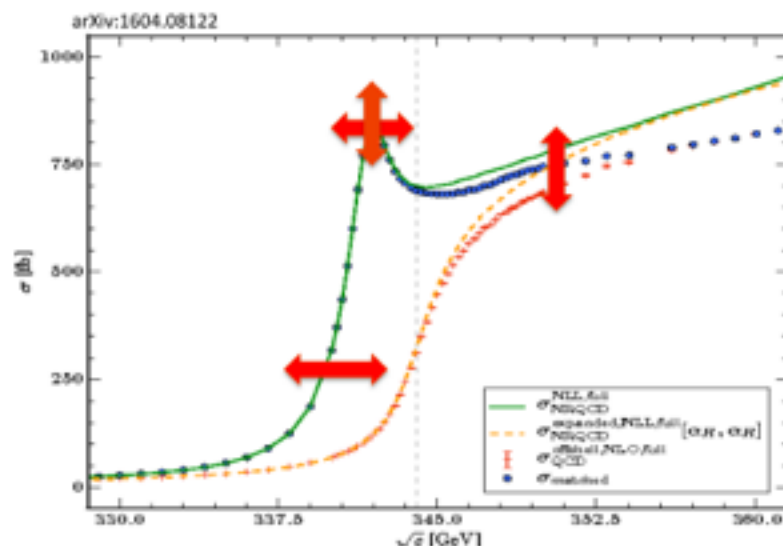
# Top Mass analysis study

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- This Summer top mass selection optimized in the Papas+Heppy framework: found bug in Papas that affected the energy reconstruction for jets.
- Bug only recently fixed ( thanks Colin!) plus several updates in Papas and Heppy.
- Focus on revalidating the software using production of  $ee \rightarrow qq$
- Thanks to Nicolò Foppiani for his contribution (precious advice from Patrick)

# Top mass at the FCC-ee

- ▶ FCC-ee top threshold physics run:
  - $\sqrt{s} = 340 - 350$  GeV  $\rightarrow$  threshold scan
  - It allows top mass, width, Yukawa coupling to be measured

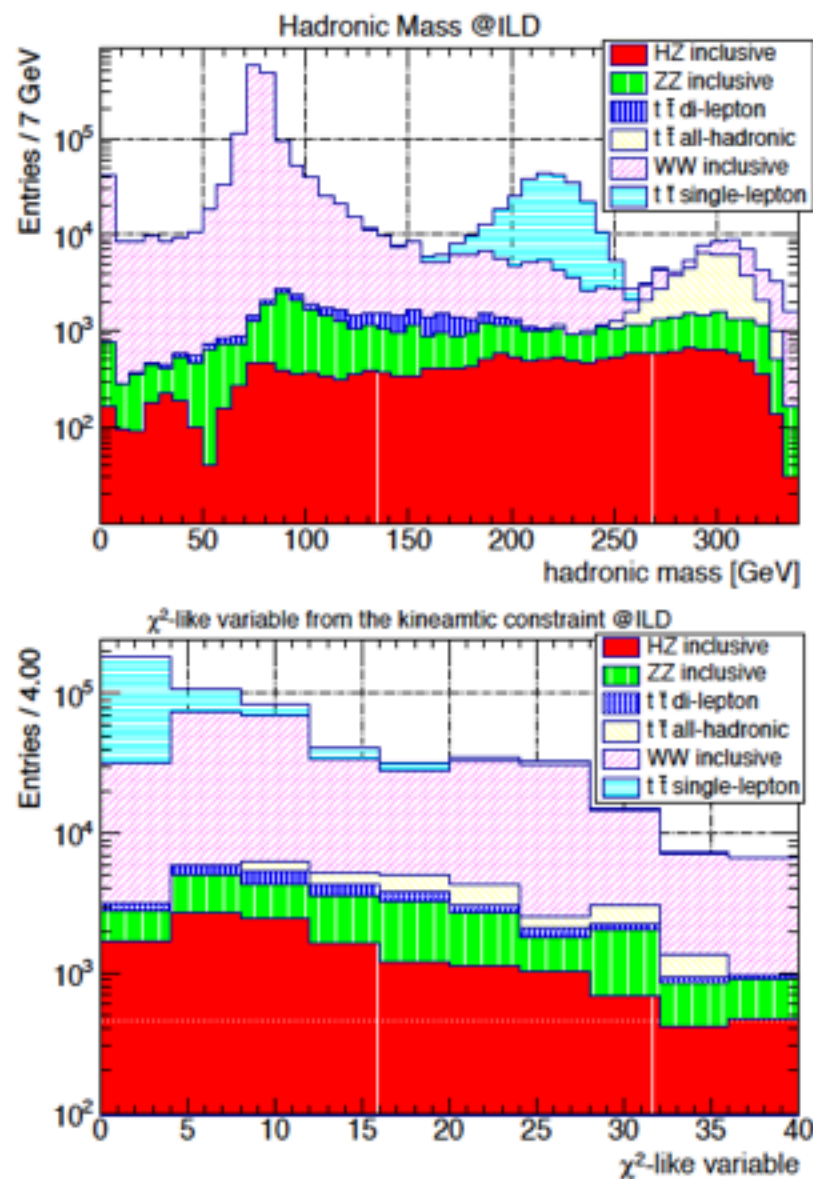


- ▶ With what precision will it be possible to measure these parameters?
  - So far only analytic estimates or extrapolations have been done for the FCC-ee
  - CLIC-ILC group performed a full simulation study concerning the precision reachable with a linear collider

We started to do a Montecarlo analysis based on the FCC-ee fast simulation to answer this question

# $t\bar{t}$ selection (1)

- ▶ One and only one isolated lepton
  - $E_l > 10$  GeV
  - Isolation:  $E_{cone,0.3rad} < 15$  GeV<sup>5</sup>
- ▶  $N(\text{particles}) \geq 4$ , which are clustered in 4 jets using an exclusive algorithm
- ▶ Kinematic variables:
  - hadronic mass
  - missing energy
- ▶ b-tag
- ▶ Kinematic constraint on top and w masses

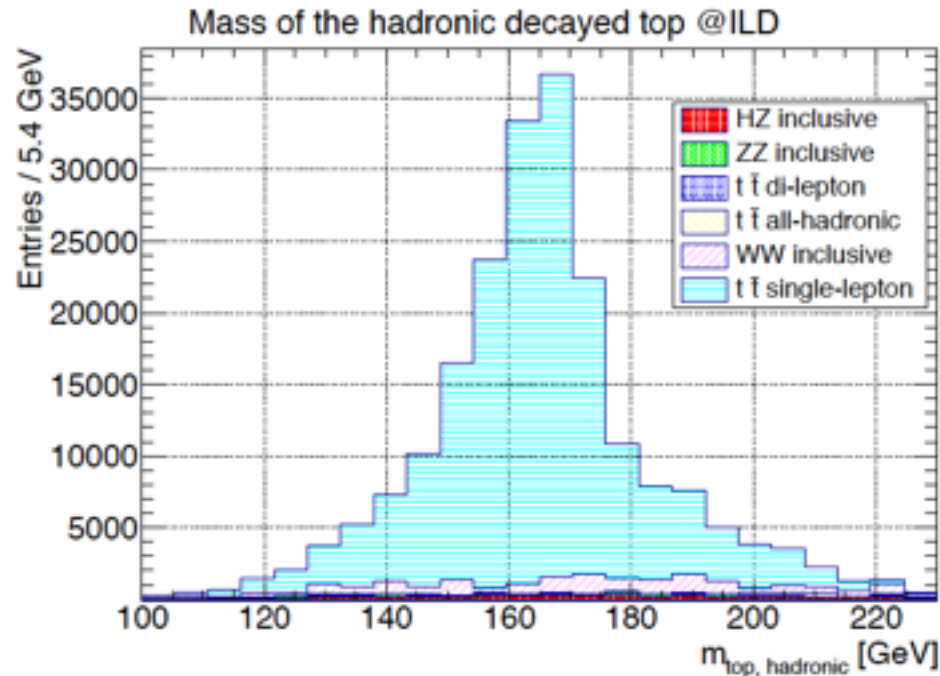


<sup>5</sup>No optimization on these value so far.



# top mass selection Summer 2016

## $t\bar{t}$ selection (2)

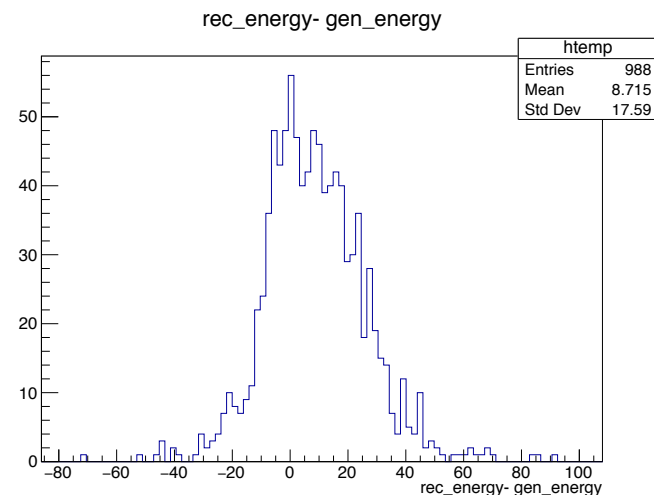
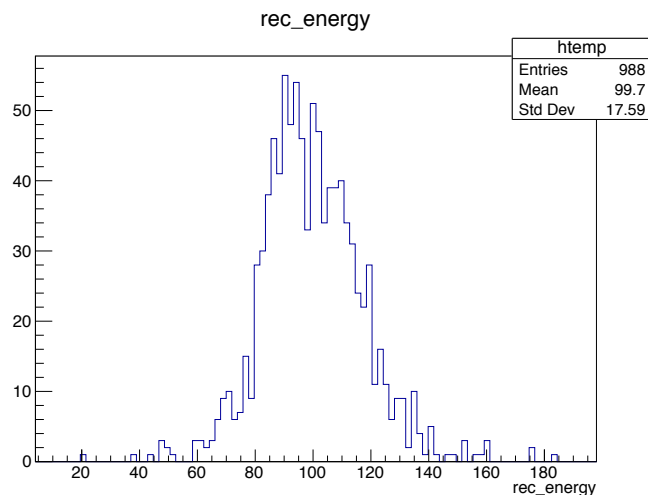


Results:

- Signal efficiency = 55 %
- Background efficiency = 0.3 %
- Purity = 92 %

# Status of Summer 2016

## OLD distribution w/ bug ee->qq

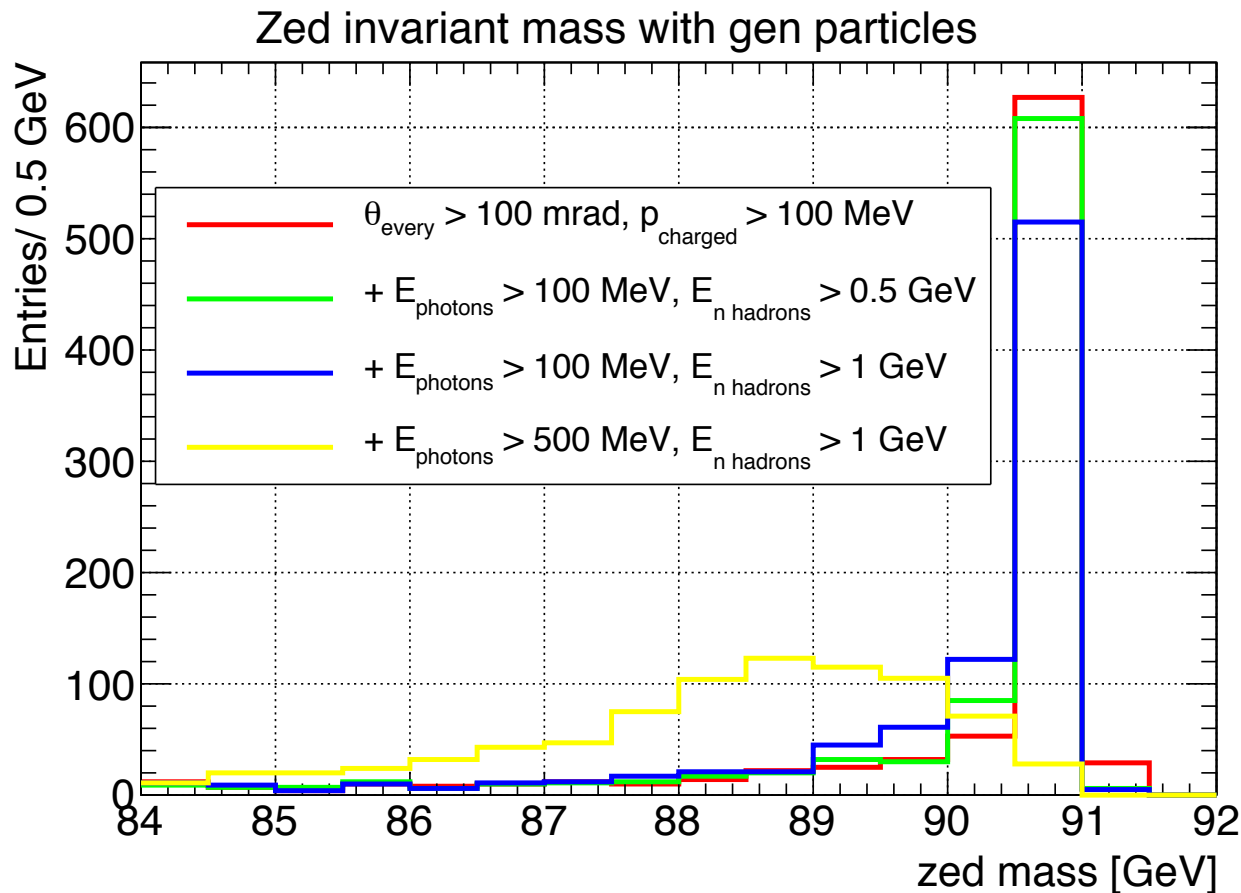


this situation made it impossible to conclude the analysis and to study any resolution effects.

Explanation from Colin B.: mismatch between the HCAL resolution used in the simulation and the one used in the particle flow reconstruction for the detection of overlapping neutral particles, after the recent tuning of the HCAL resolution. Because of that, we were often reconstructing fake neutral particles on top of charged hadrons, hence a shift of the average jet energy response.

# Validation - check cuts on gen particles

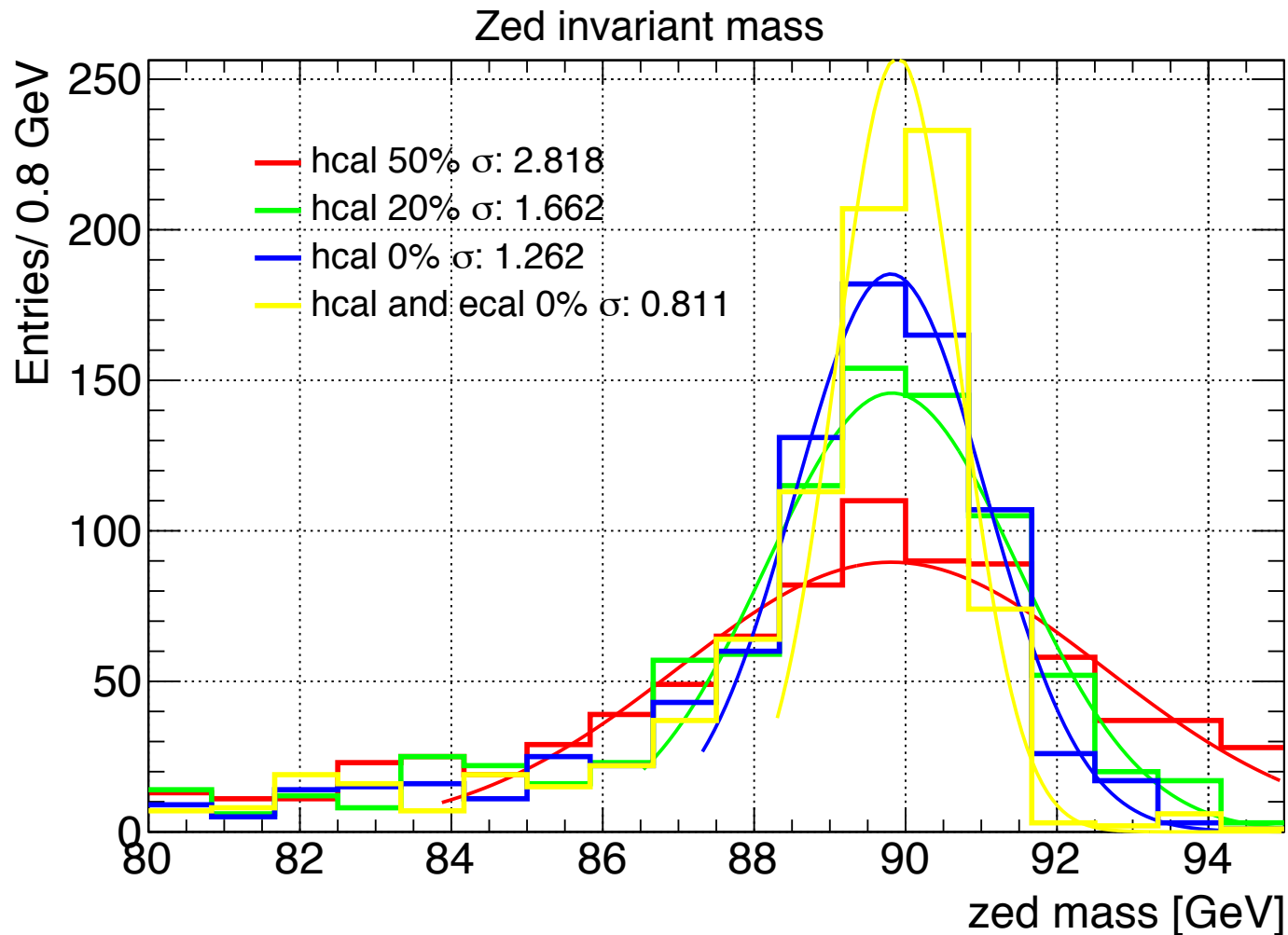
- once the bug got fixed, realized that the cuts on the generated particle in Papas were maybe too hard for an ee detector case.
- Tested different cuts to validate code and see the effect of different resolutions in Ecal/Hcal



Note: would like photon reconstructed with 100MeV in ECAL

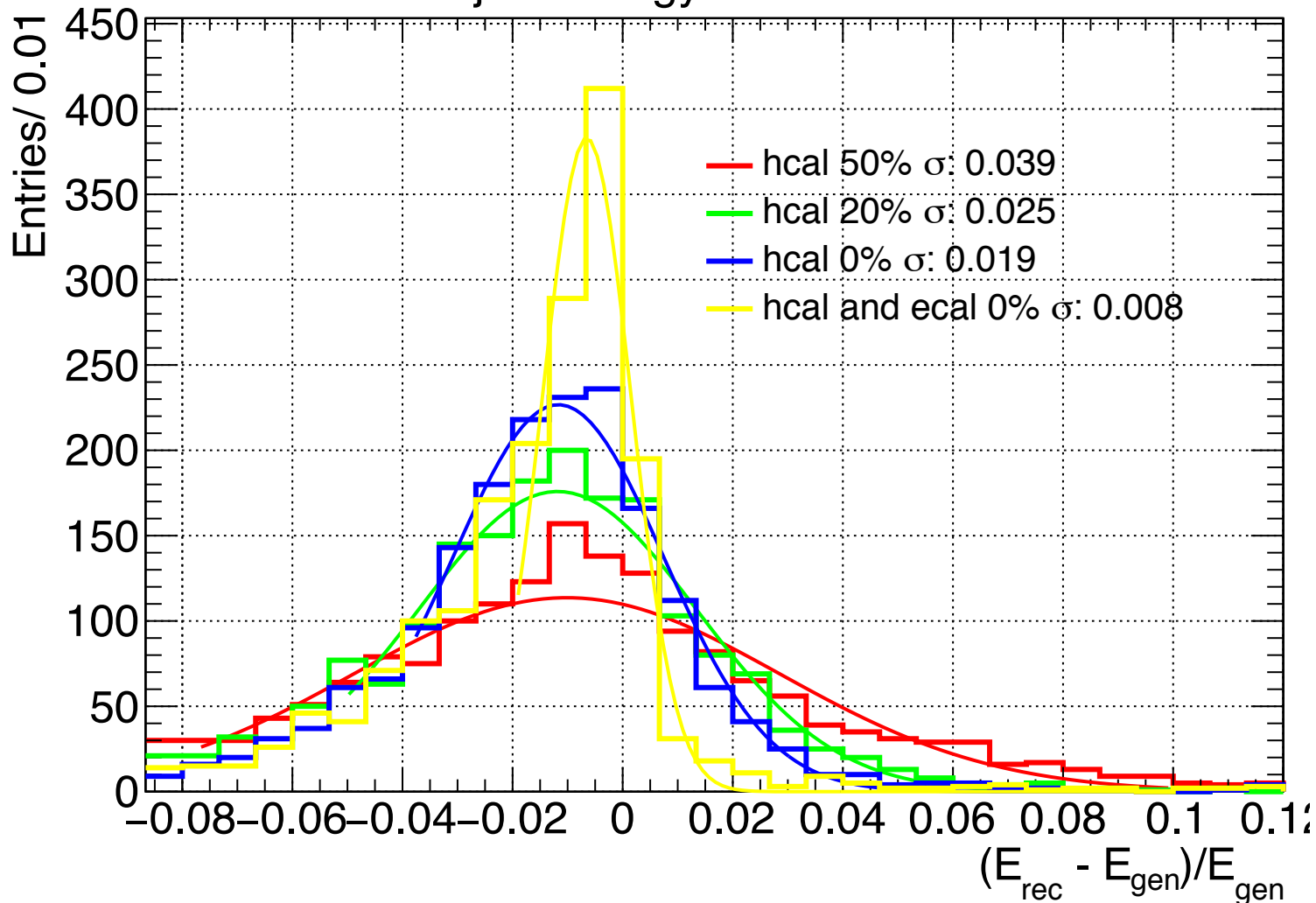
# Effects on Z mass

- Now resolution effects visible and understood



# Effects on jet resolution

Zed jets energy resolution



# Next steps

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- now can proceed to repeat the top analysis with the new software:
  - should see some effect of the better HCAL performance on the fit for the hadronic top, and on some had discriminating variables
  - still need some more work on Heppy (technical issues/changes/bug)
- waiting for results on charm from the FCNC group by January (Delphes)
- would like to stress that the work of Nicolò in using the full framework is extremely useful to the whole community