Jet energy measurement

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Jet energy correction with parametrisation and jet rates at 2x10**33

Effect of jet finder cone size on energy/space resolution of jet

Including tracker information to jet energy measurement

Factors influent on jet energy resolution (1:2)

From jet physics (from parton to jet on particle level):

- **Fragmentation**
- **ISR and FSR**
- **Underlying event**
- **Minimum bias**

From detector performance:

- **Magnetic field**
- **Electronic noise**
- **Dead materials and cracks**
- **Longatudinal leakage for high−Pt jets**
- **Shower size, out of cone loss, jet separations**

Factors influent on jet energy resolution (2:2)

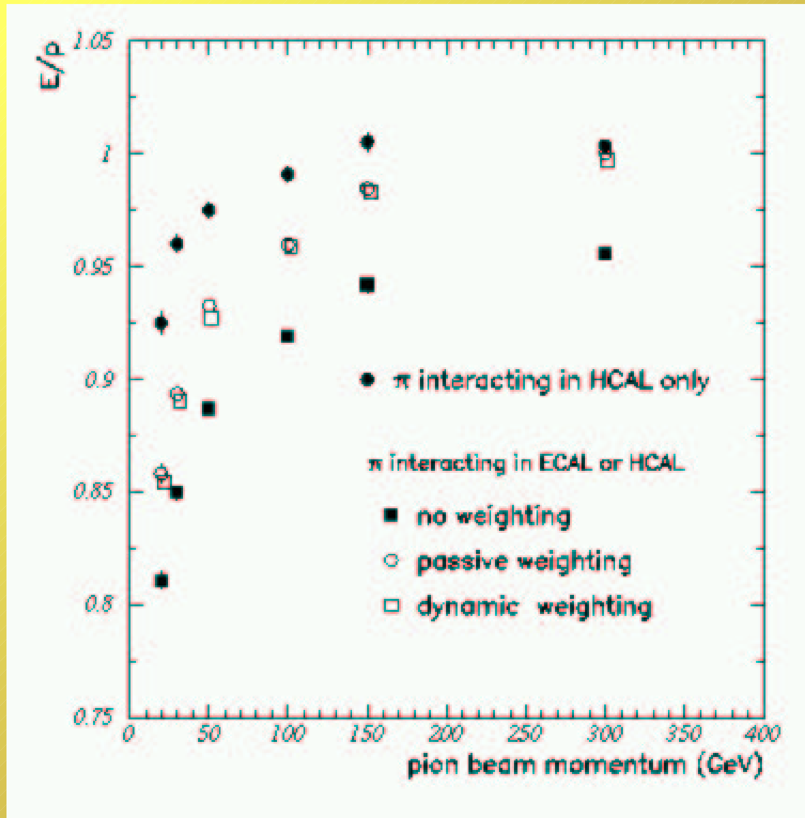
- **Calorimeter consists of two compartments and both has different response to electrons and hadrons**

Non−linearity 15%

- **Jets have both hadronic (charged and neutrals) and e/γ components.**

Jet energy resolution in cone 0.5 for |eta|<0.7

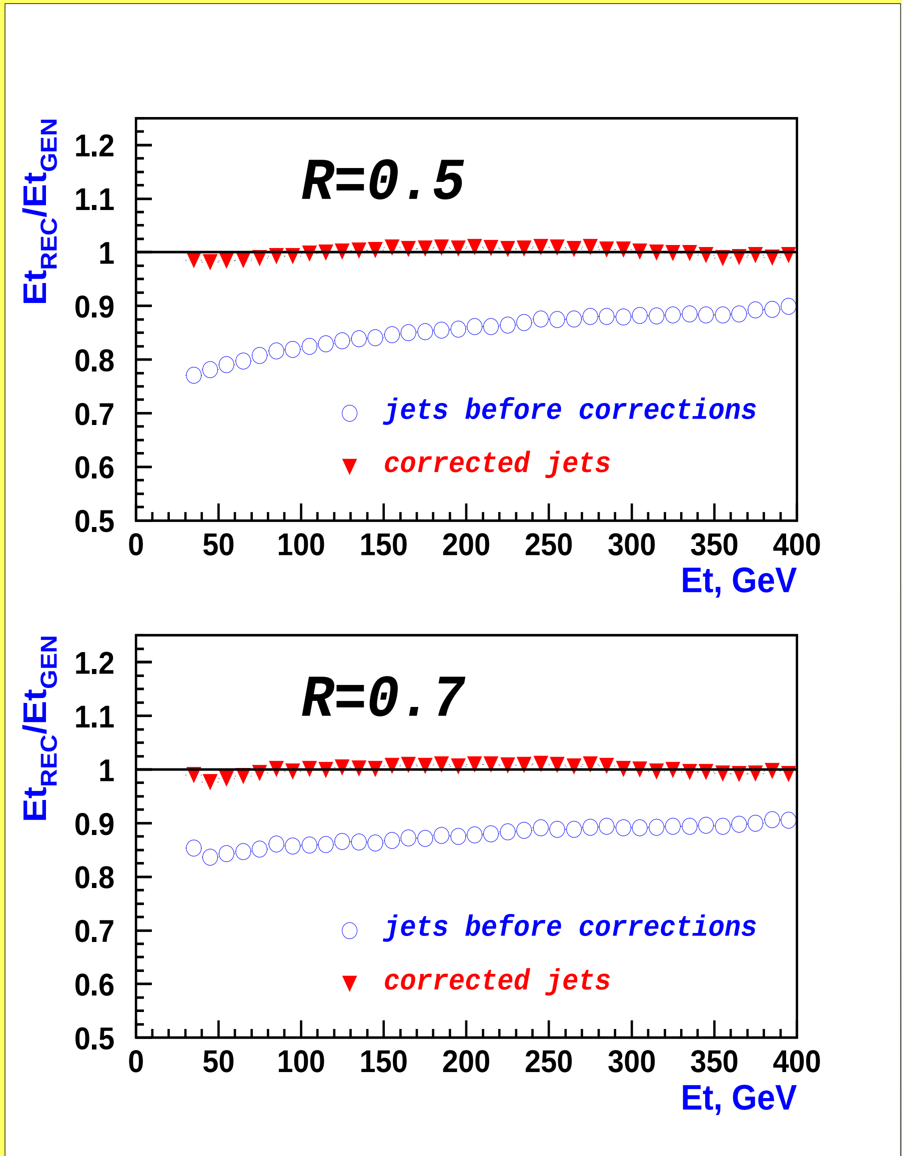
$$\frac{sigma}{E} = \frac{119}{\sqrt{E}} \circ 7$$



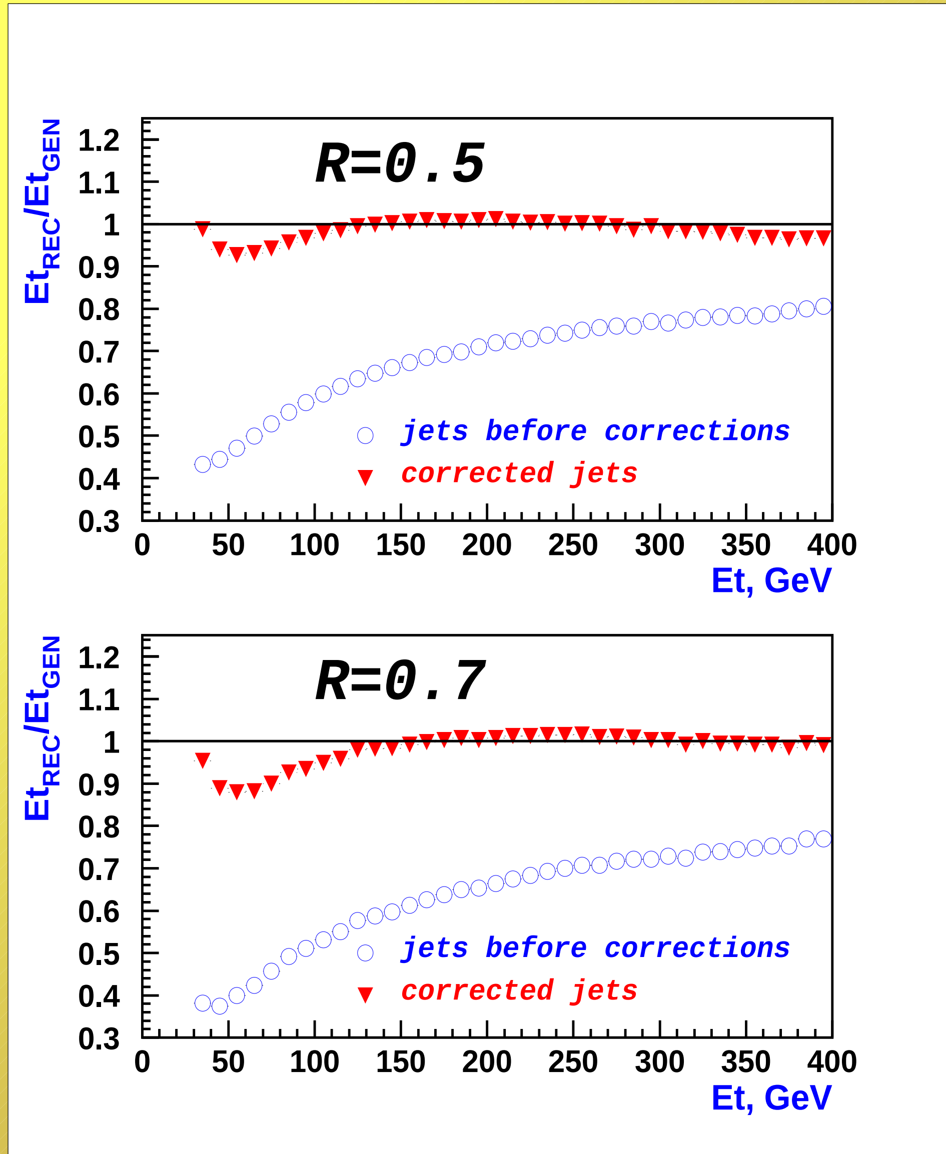
E/π for HCAL (1996 beam test)

Jet correction with Erec(Egen) parametrisation: $E_{jet}^{rec}=AxE_{gen}^{2}+BxE_{gen}+C$

A.Krokhotine

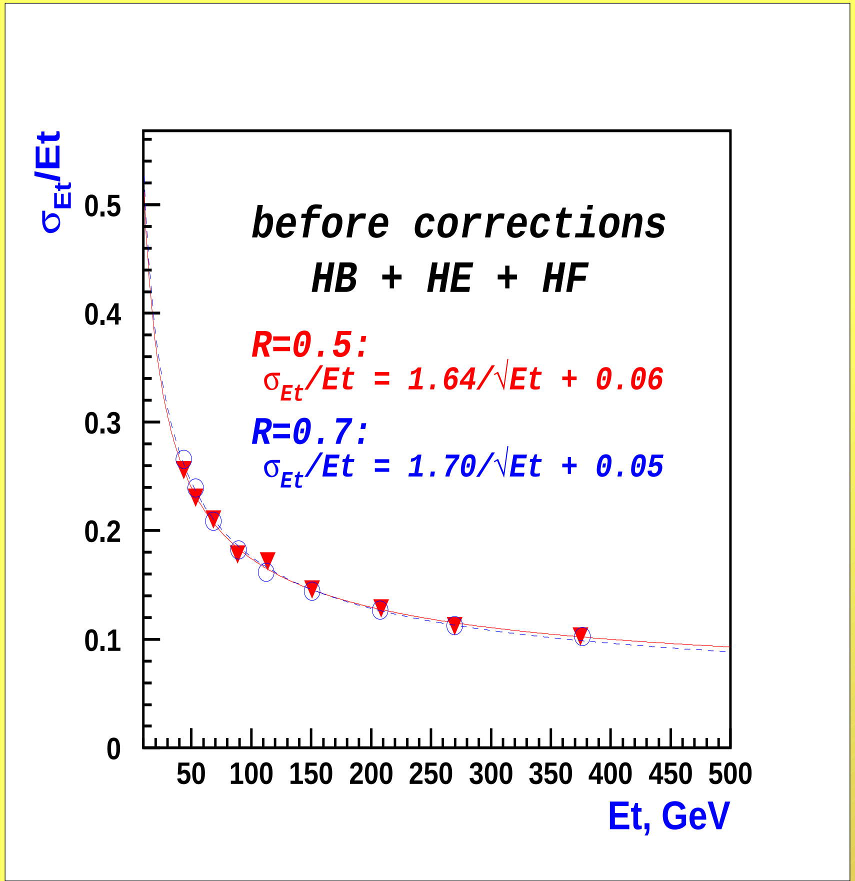


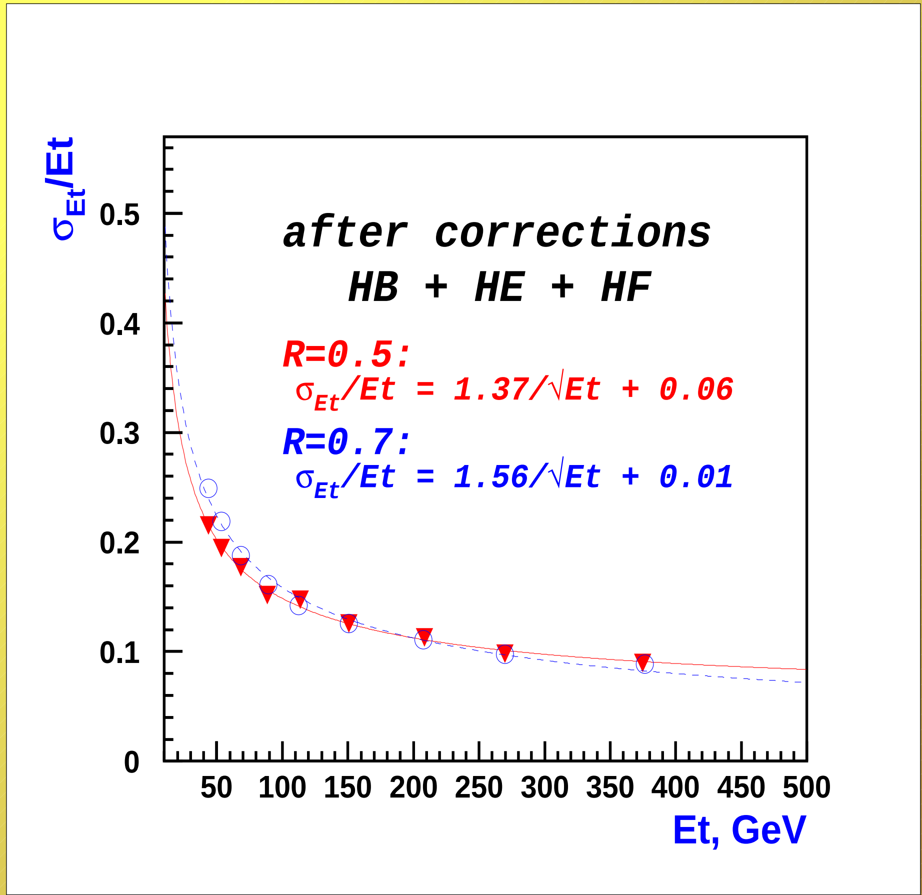
Off line jets



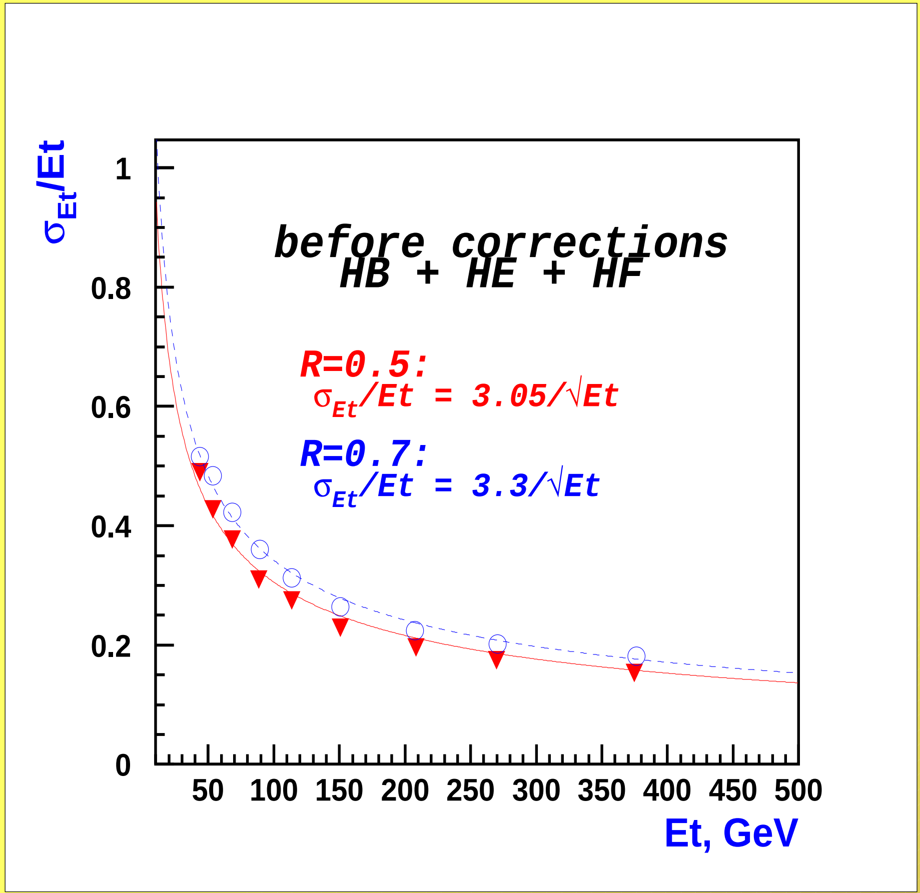
L1 jets

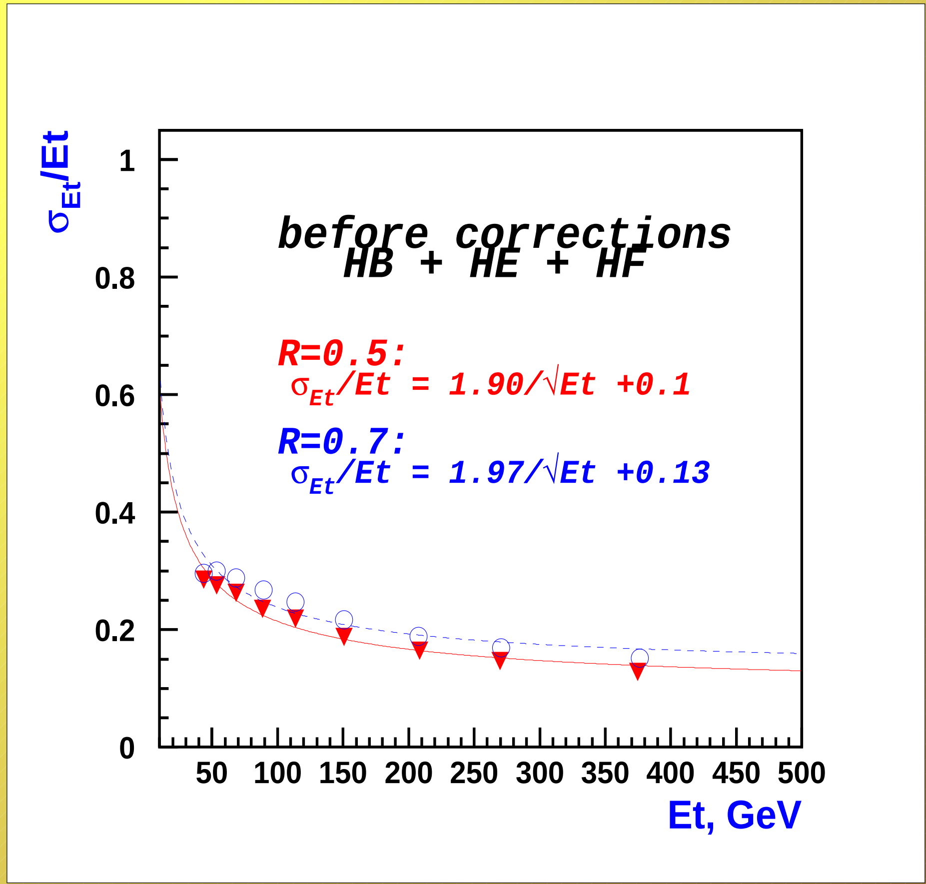
Resolution for off−line jets before and after corrections





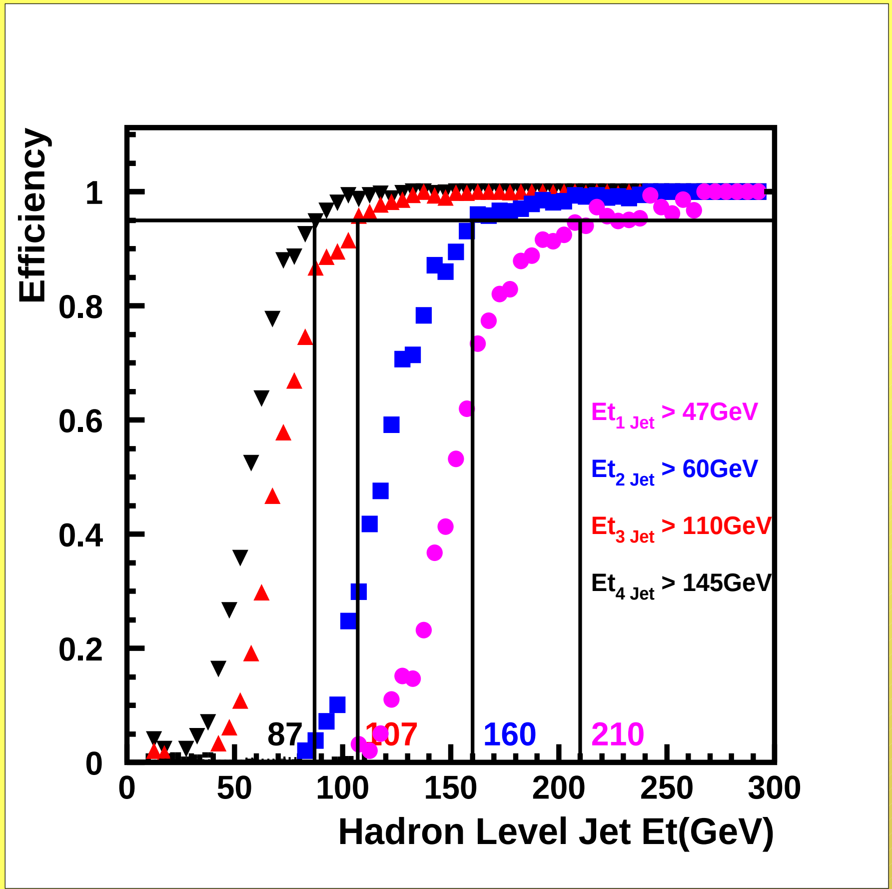
Resolution for L1 jets before and after corrections

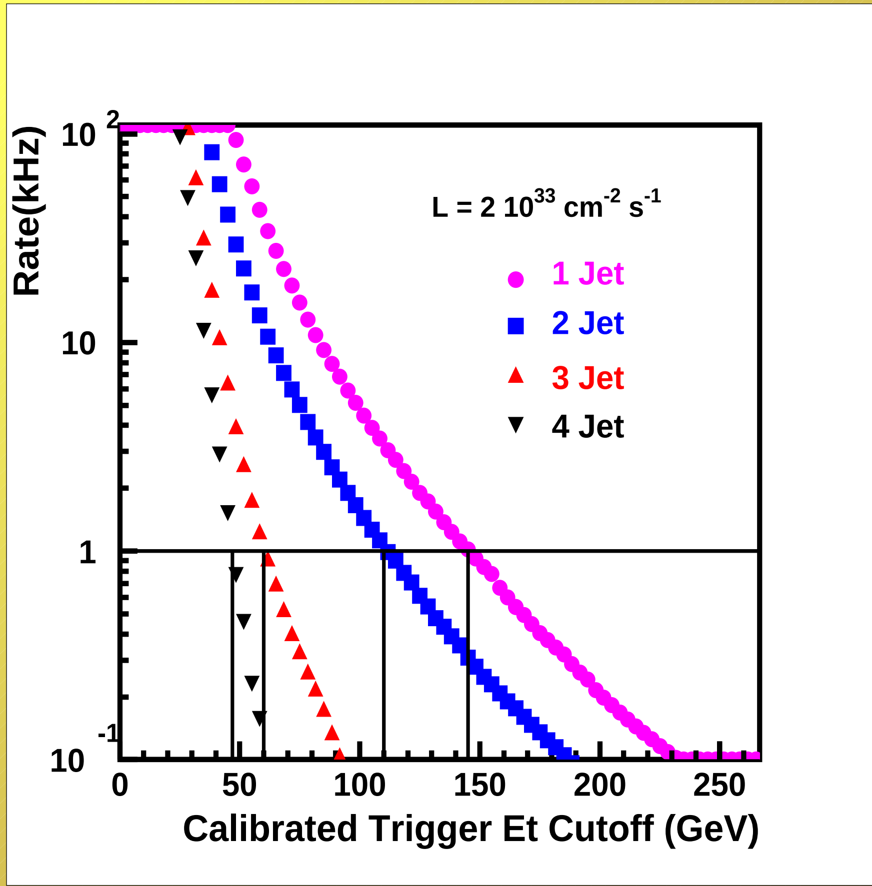




L1 jet rates at Luminosity L=2 x 10^{33} $cm^{-2}s^{-1}$ (A.Krokhotine)

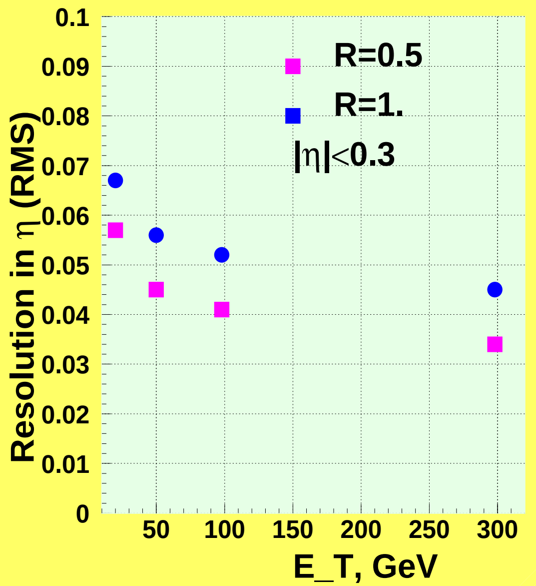
Two different methods were used for weighting HLT samples.
It appears that they gives close results with HLT samples beginning with Pthard>20 GeV. These samples were used for rates estimations.

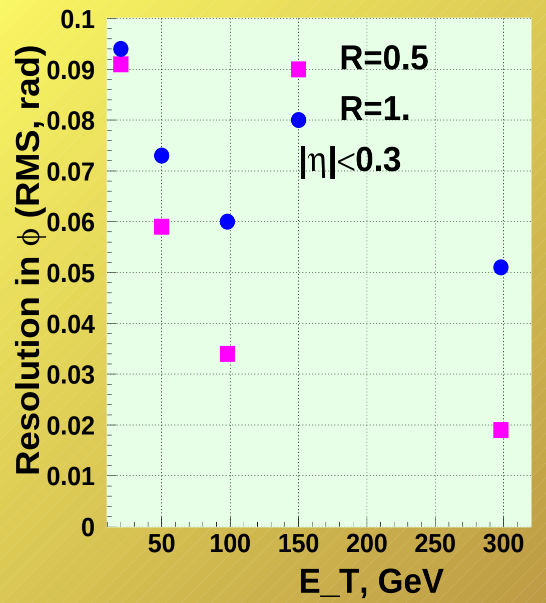


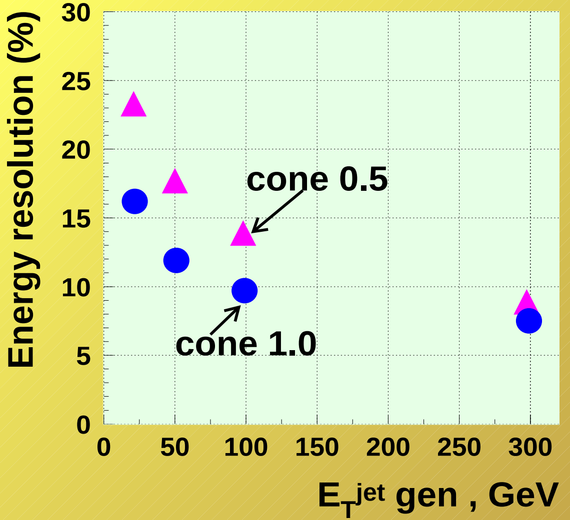


Effect of jet finder cone size on energy/space resolution of jet

QCD dijet events were generated with PYTHIA and propagated through detector with cmsim121. (I.Vardanyan)



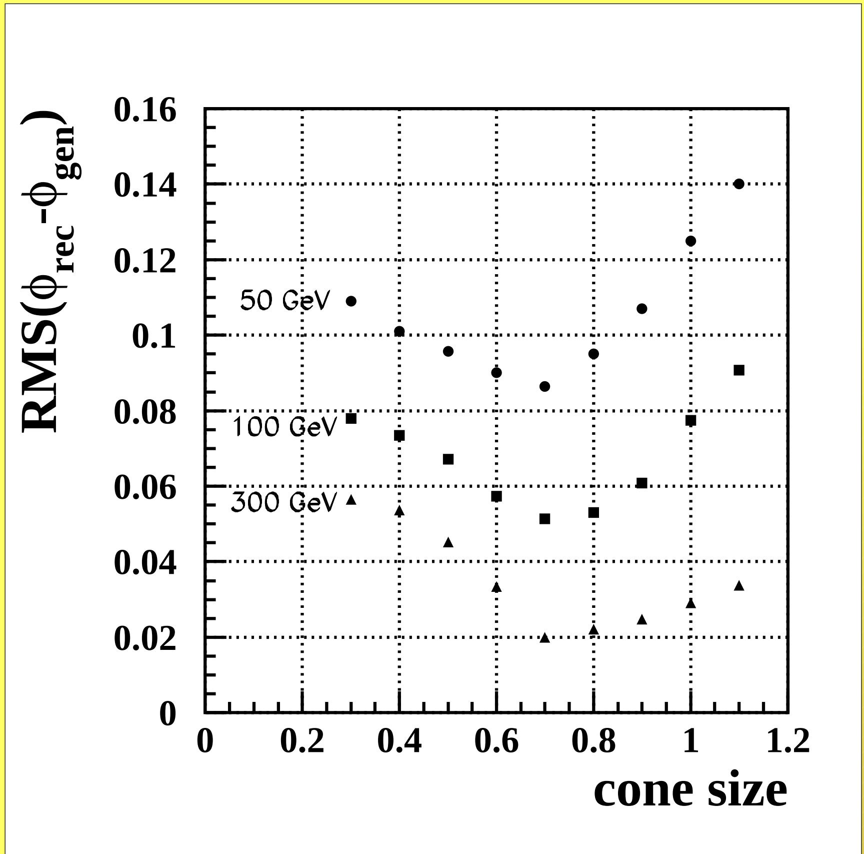


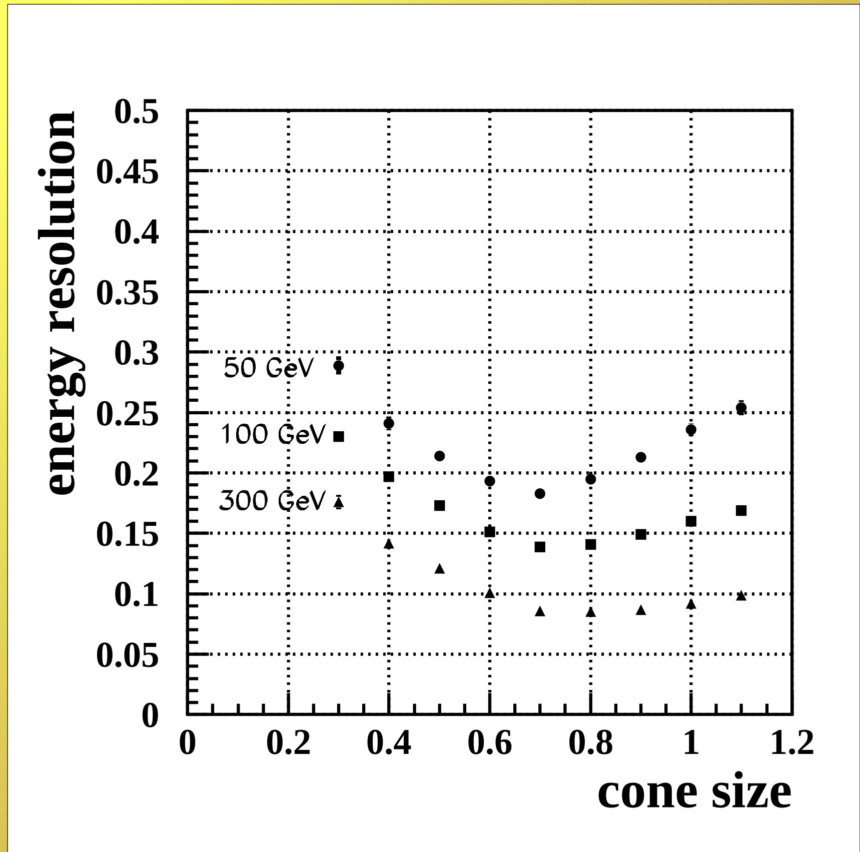


A.Oulianov

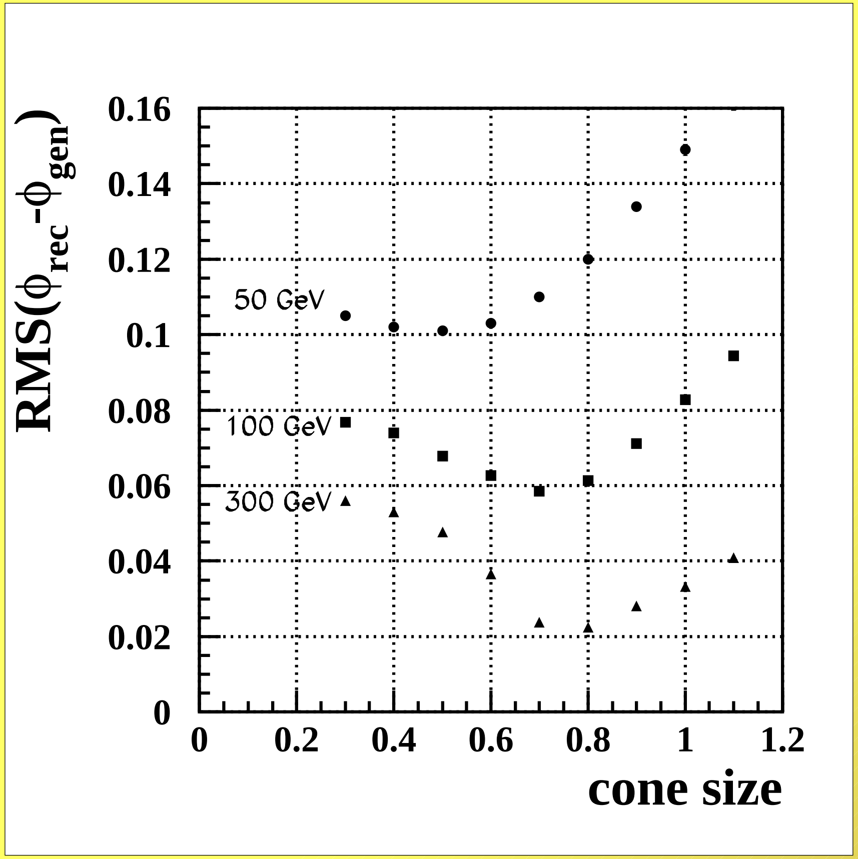
Two leading jets from di−jet events were taken. Particle level jets were found in cone R=0.7. Only central jets (|η|<1). Matching cut was dR<1.

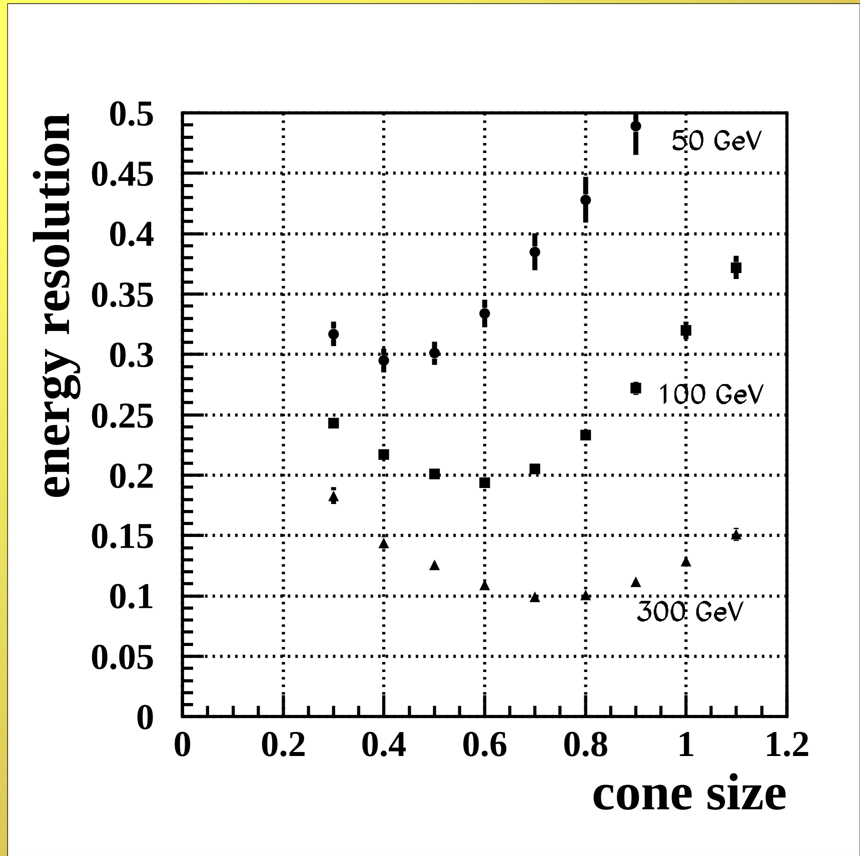
The case of No PileUp





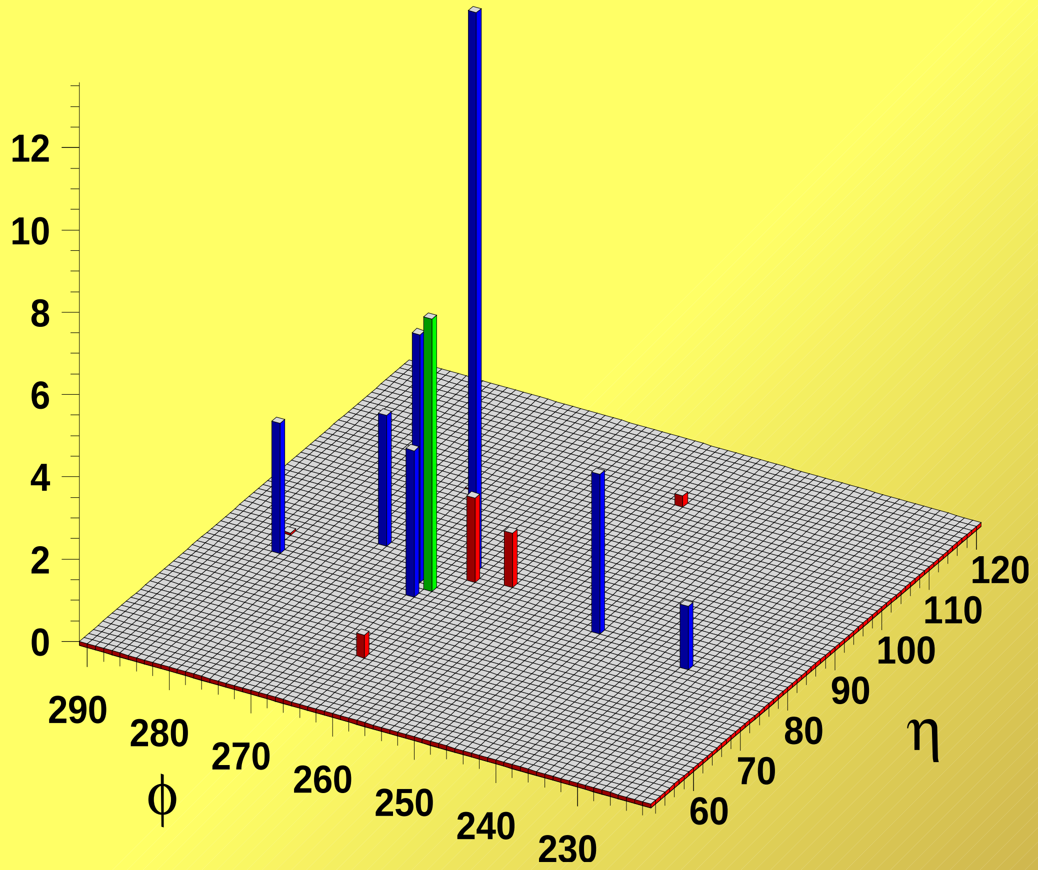
The case of High Luminosity Pile Up (10^{34})





Using tracker information for jet energy corrections.

- ✔ *Example (A.Nikitenko): Jet with Et = 45 GeV.*



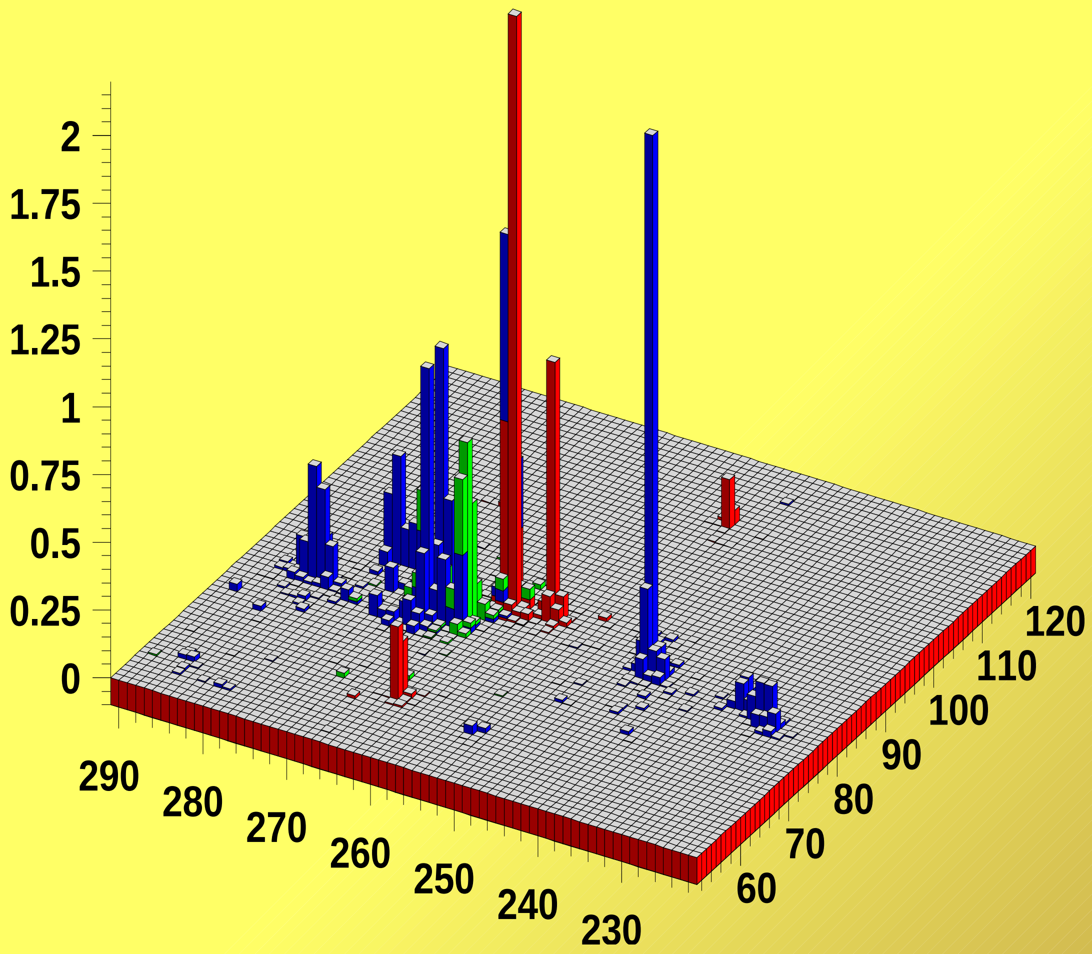
Impacts in ECAL surface.

red − photons

blue − charged hadrons

green − neutral hadrons

✔ ***Example (A.Nikitenko): Jet with E_T = 45 GeV.***



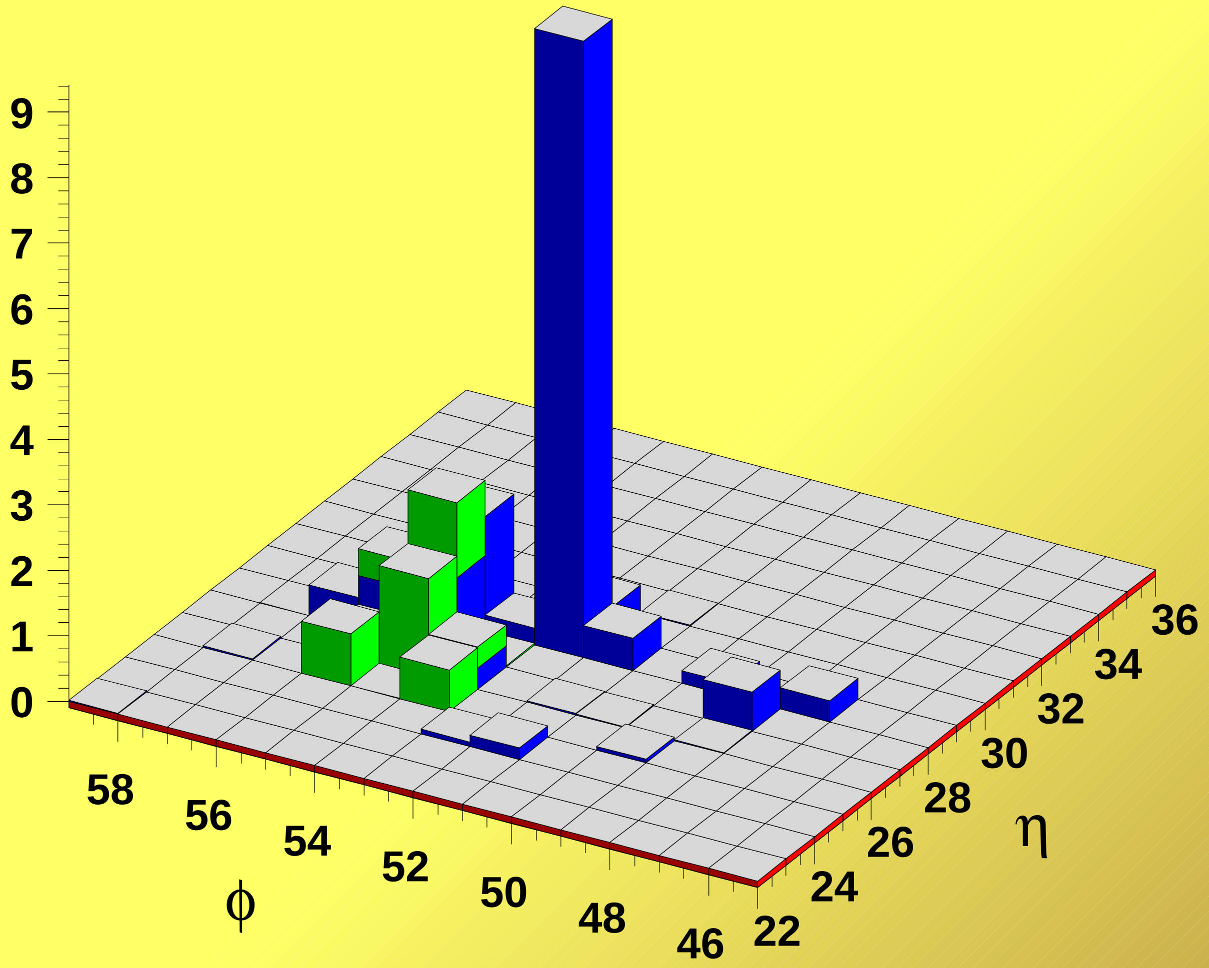
Energy in ECAL

red − photons

blue − charged hadrons

green − neutral hadrons

✔ ***Example (A.Nikitenko): Jet with E_T = 45 GeV.***



Energy in HCAL

red − photons

blue − charged hadrons

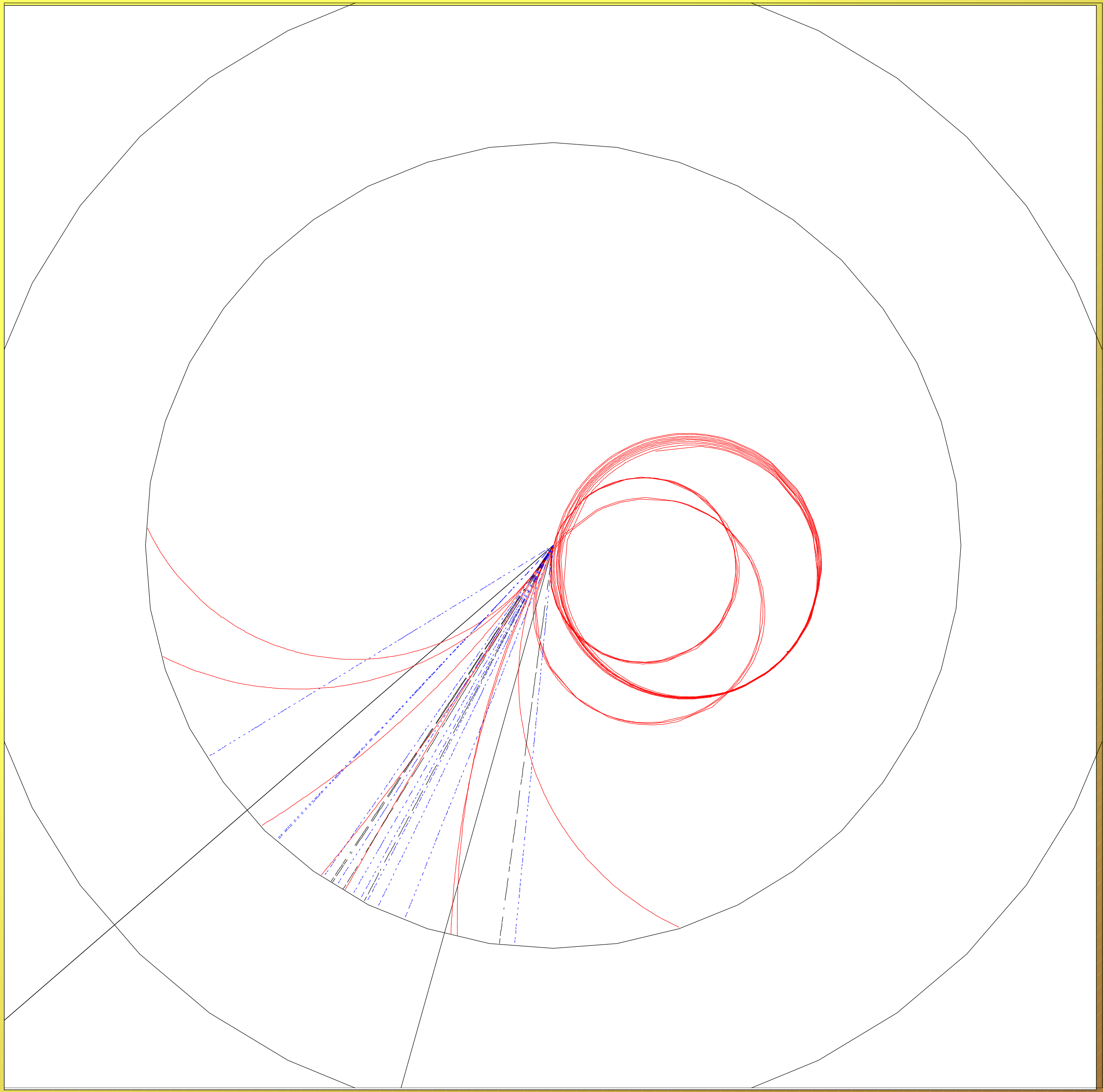
green − neutral hadrons

Part of clusters are isolated both in ECAL and HCAL and can be associated with charged tracks

Example (A. Nikitenko) Barrel jet of E_T = 100 GeV

Part of charged tracks go out of the cone deflecting in magnetic field.

$$E_{Tjet} = E_{Tjet}^{in\ cone} + P_T^{trks}$$



Procedure 1 : Use tracks of the jet with impact in calo out of the reco cone.

A.Nikitenko

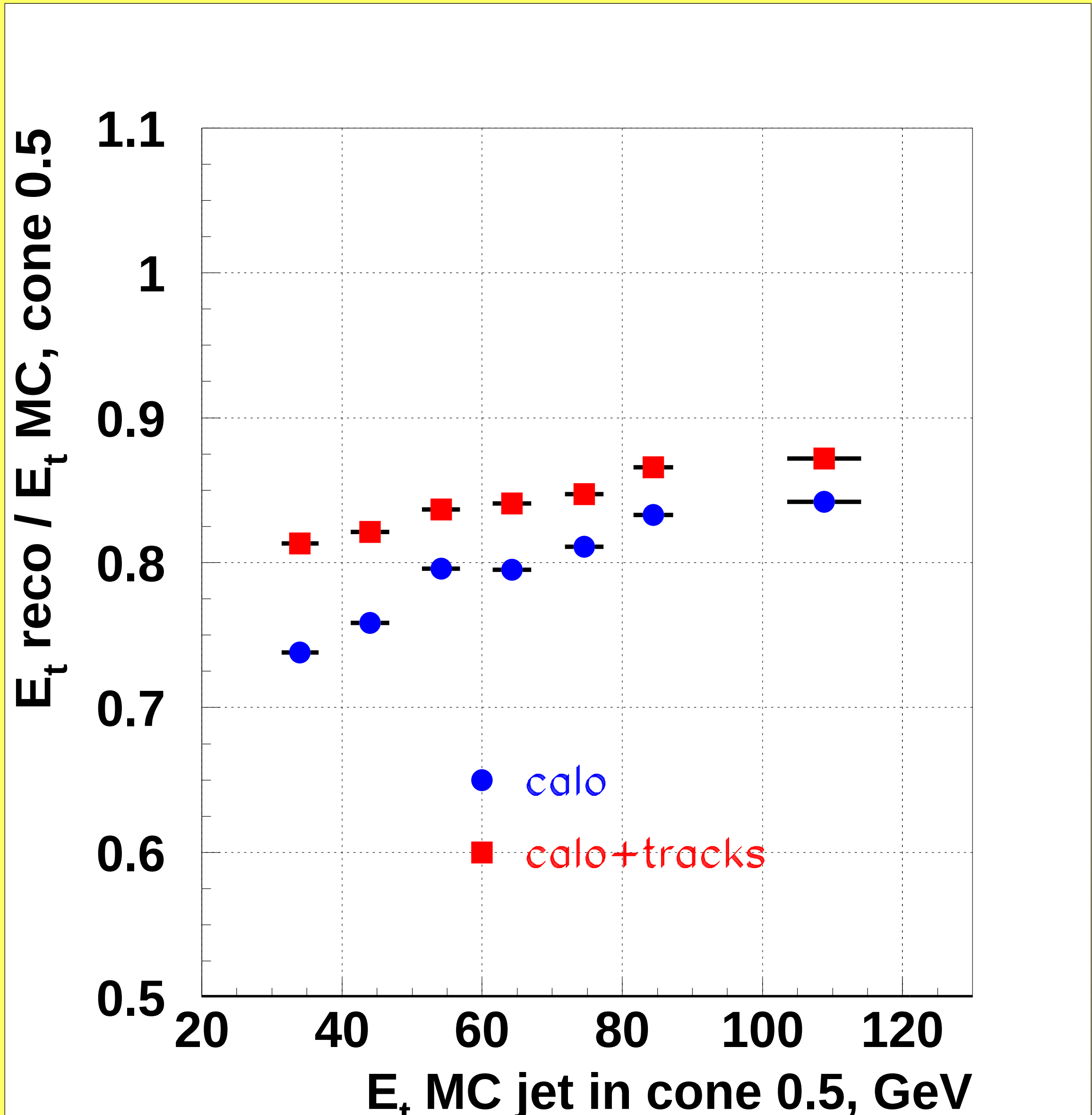
Procedure 2 : Use energy flow objects inside reco cone (exchange isolated clusters associated with charged track to an energy from tracker)

D.Green.

Procedure 3 : For overlapping clusters subtruct expected responce of matched tracks within cone and add $\sum P_T^{trk}$ from tracker.

I.Vardanyan, O.Kodolova

Procedure 1 (A.Nikitenko): add out of reco cone charged track.



Calorimeter simulation with cmsim122
MC track used.

Jet was selected on the particle level and only particles in R=0.5 were propagated.

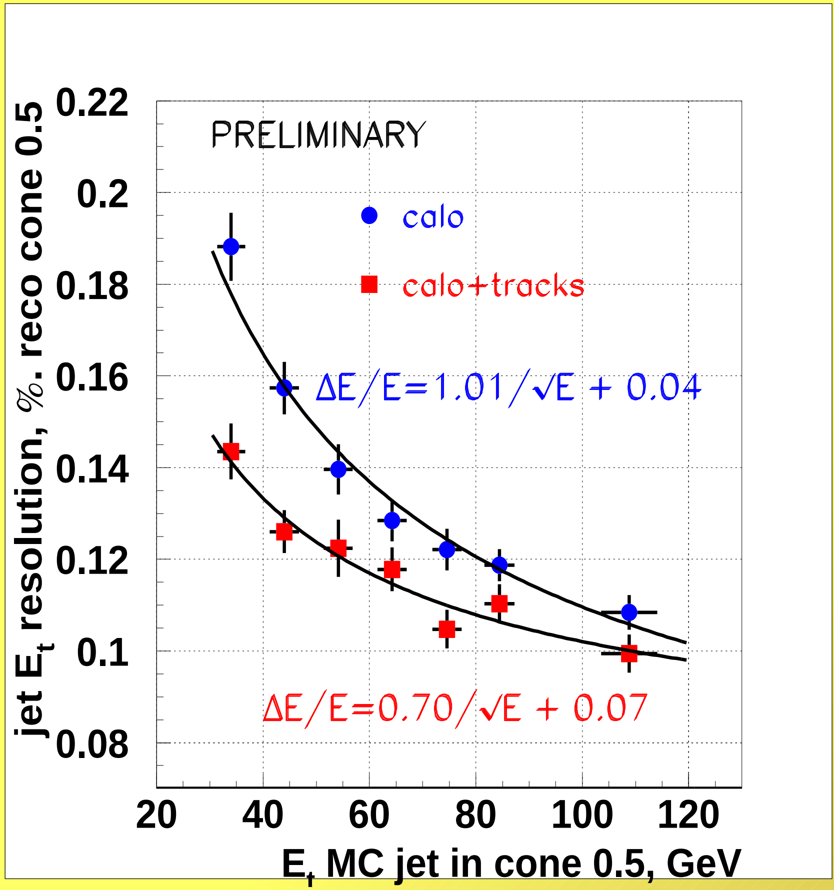
Jet energy is calculated:

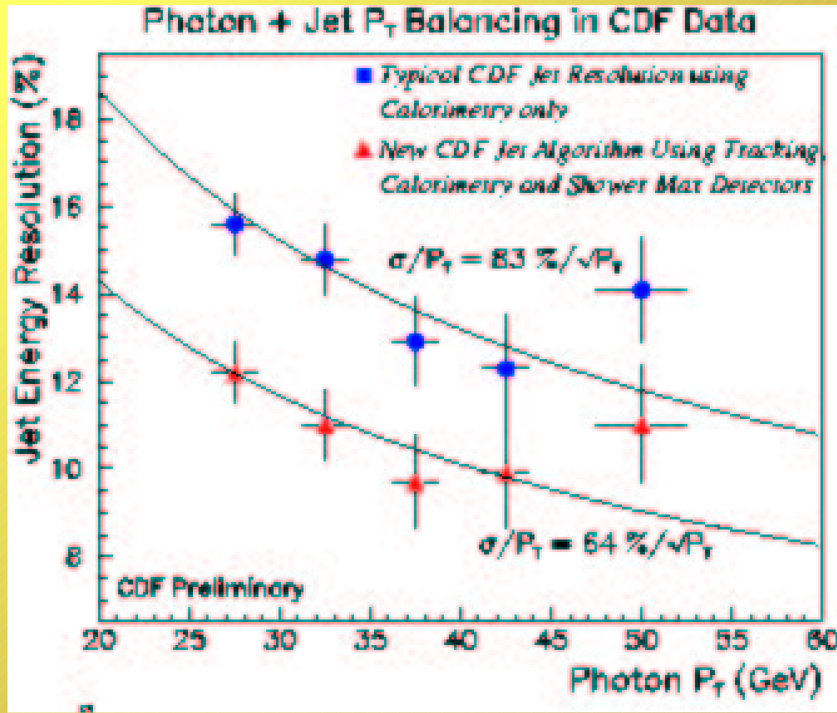
$E_T^{jet} = E_T^{calo} + P_T^{out}$

P_T^{out} – *tracks out of cone*

Jet energy scale improved.

Improvement in resolution is the same order as in CDF for the low E_T jets.





Procedure 2 (Dan Green) : energy flow objects.

Z(120) events were used. ISR and FSR were switched on.

Isolated clusters in ECAL (3x3) crystals and HCAL (3x3 towers) were found.

Cluster classification:

photon — *Cluster in ECAL has not associated hadronic energy.*

hadron — *Cluster in ECAL has associated hadronic energy of at least 30%.*

- **charged hadron interacted in ECAL** — *If matched with tracker*

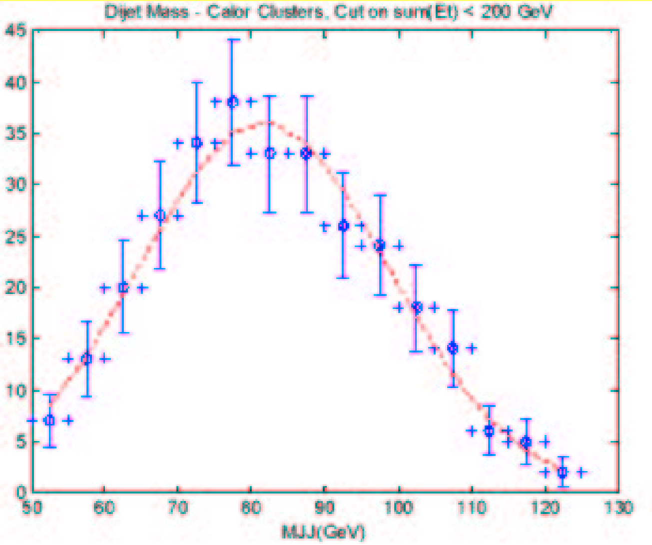
hadron interacted in HCAL — *Cluster in HCAL without sufficient ECAL energy*

All clusters within cone matched with tracks were extracted from E_{jet}^{calo} and P_T^{trk} was added instead.

$$E_{jet}=E_{jet}^{calo}-E_{clus}^{in\ cone}+P_T^{trks\ in\ cone}$$

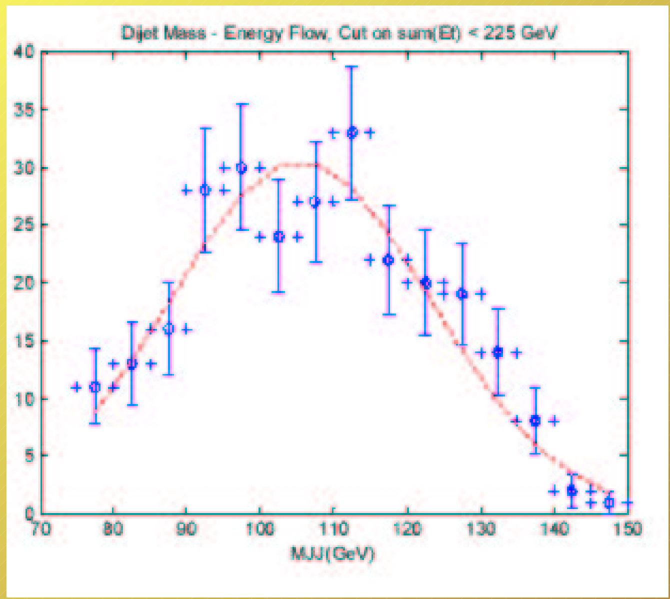
Dijet mass

Calo clusters only



Mean=81.7+−1.1 GeV
Sigma=17.1+−1 GeV

Calo clusters+tracker



Mean=105.5+−1.1 GeV
Sigma=17.1+−1 GeV

Procedure 3 (O.Kodolova, I.Vardanyan): response subtracting

- ✔ **Energy (R(ECAL), R(HCAL) is calculated in cone around jet axis using standard procedure and with default coeffients.**
- ✔ **Summarized averaged response from charged particles with entry point inside a cone is subtracted from R(ECAL), R(HCAL).**
- ✔ **Averaged response from charged particles can be got from isolated particles: either library of averaged responces or calculated using e/p ratio (D. Green, CMS NOTE in draft).**

$$E_{EM+neutral}(ECAL)=R(ECAL)-sum(R\_ECAL\_i)$$

$$E_{neutral}(HCAL)=R(HCAL)-sum(R\_HCAL\_i)$$

$$Etracker=sum(Etracker\_i)$$

$$Ejet=E_{EM+neutral}(ECAL)+E_{neutral}(HCAL)+Etracker$$

- **QCD dijet events with Pthat 100−110 GeV are generated with PYTHIA 6.152 using parameters from jet production 2000.**

Jets from interval 90−105 GeV were taken.
Only jet particles in cone 0.5 on generator level are propagated through cmsim 121.

- **The entry point of charged particles to ECAL was taken from generation on CMSIM level.**

No reconstruction algorithms in tracker were used

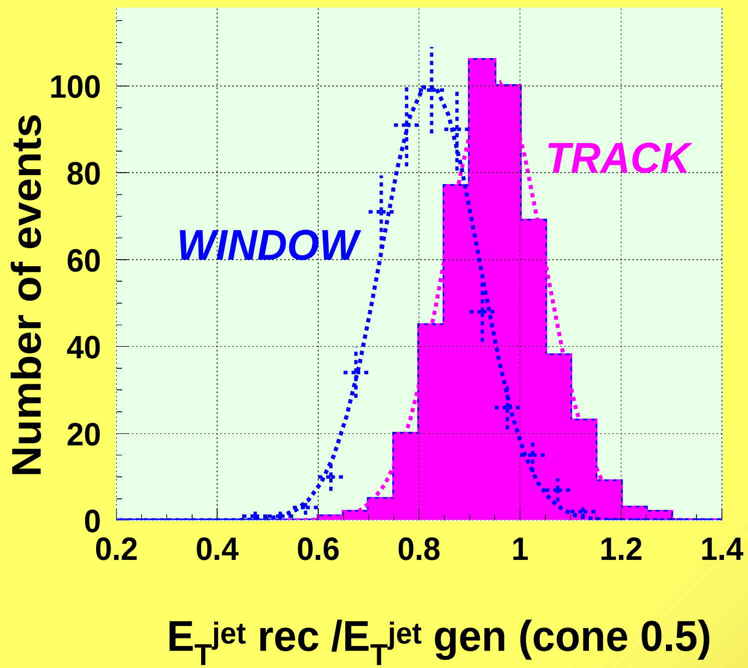
Two variants:

a) only particles with entry point in cone 0.5 around jet axis

b) item a)+particles outside cone on the surface of ECAL are taken with Etracker.

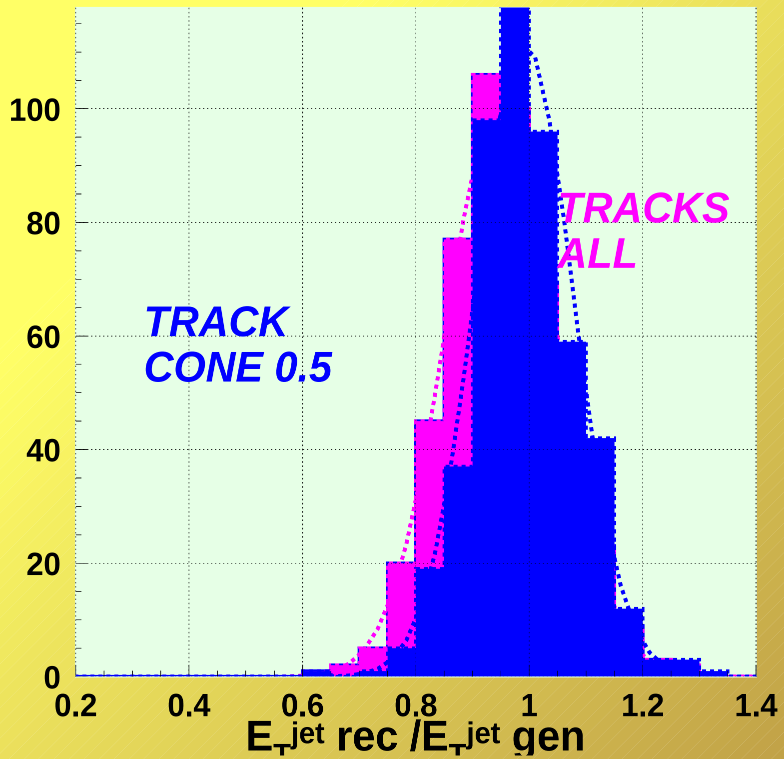
particles inside cone

WINDOW = calo, TRAK = T



$E_{Tjet}^{rec}/E_{Tjet}^{gen}$

+particles outside cone



$E_{Tjet}^{rec}/E_{Tjet}^{gen}$

	R=<Ereco/Egen>	*σ(R)*	*σ(R)/R(%)*
calo (in cone)	0.821	0.097	11.8+−0.5
calo+T (in cone)	0.950	0.097	10.2+−0.5
calo+T (in+out cone)	0.990	0.087	8.8+−0.5

$D(E_{jet}^{rec}/E_{jet}^{gen})/\langle E_{jet}^{rec}/E_{jet}^{gen}\rangle$ should be better:

Only calorimeter information in cone:

$$\langle E_{jet}^{calo}\rangle = \text{Response}(e/\gamma) + \text{Response(neutral)} + \text{Response(charged)}$$

$$D(E_{jet}^{calo}) = D(\text{Response}(e/\gamma)) + D(\text{Response(neutral)}) + D(\text{Response(charged)})$$

Include Tracker information in cone:

$$\langle E_{jet}^{tracker}\rangle = \text{Response}(e/\gamma) + \text{Response(neutral)} + \text{Response(charged)} - \text{Response(charged)\_teor} + \text{Etracker} = E_{jet}^{calo} + \text{Etracker} - \text{Response(charged)\_teor}$$

$$D(E_{jet}^{tracker}) = D(E_{jet}^{calo}) + D(\text{Etracker}) + D(\text{Response(charged)\_teor}) = D(E_{jet}^{calo})$$

Dispersion is kept unchanged but mean energy become closer to it's value on generator level.

Procedure 3 : Theoretical value of response is subtracted−need careful measurements with isolated particles in order to decrease systematical errors

Procedure 2 : Exact value of response is subtracted.

Procedure 1 : Remove fluctuations of number of charged go out of cone.

Next step: Combine all 3 procedures to get a best performance.

Summary

➔ ***Parametrisation for off−line and L1 jet energy correction can be used for physics analysis.***

➔ ***Rates for 1,2,3,4 L1 jet events were calculated.***

➔ ***For iterative cone algorithm have an optimal cone size in the case of presence noise, underlying event and pile−up .***
The next step is to use algorithm with event−by−event background subtraction.

➔ ***Usage of tracker information for jet energy recovering looks promising. Without real tracks reconstruction it gives improvement in resolution from 50% at low energy jets (30−40 GeV) to 25 % for 100 GeV jets.***
The next steps are to combine all 3 procedures and include the reconstruction procedure in tracker.