Study of Jet Substructure Variables for the Future Detector

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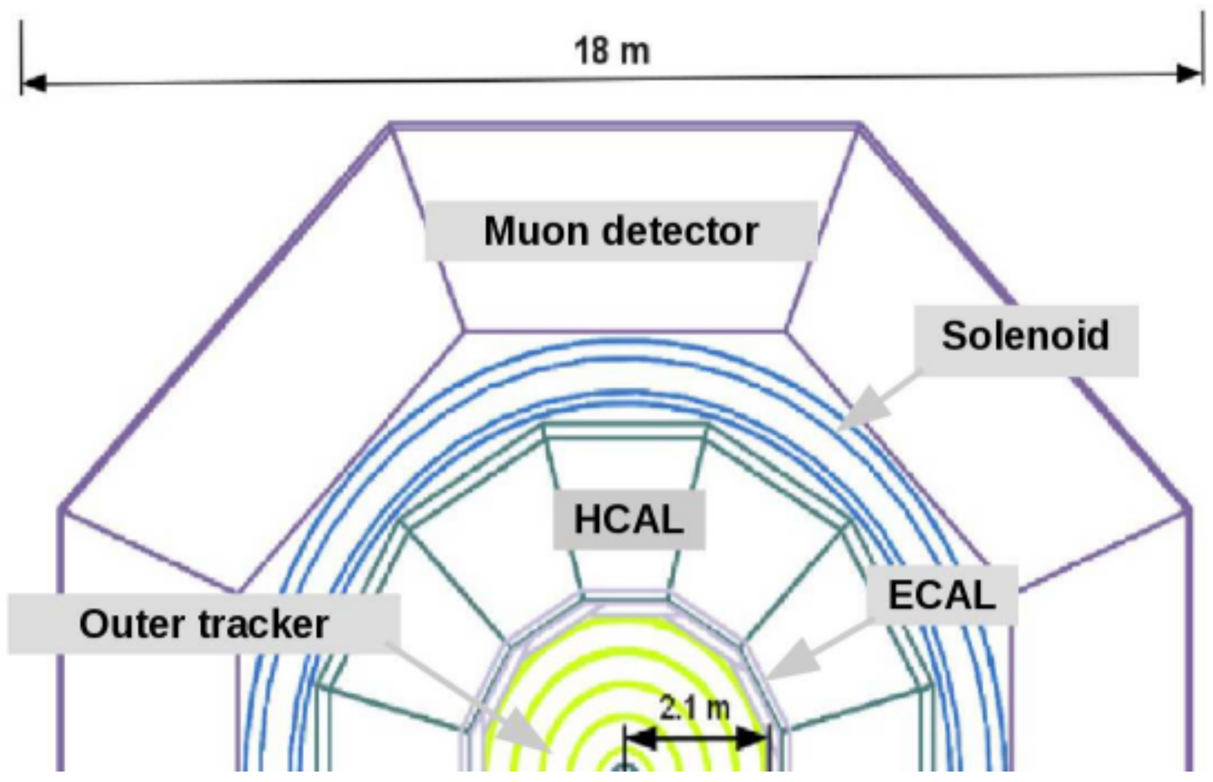
Abstract:

In this poster, we study the performance of hadron calorimeter in SiFCC for the future √s=100 TeV pp collider. The GEANT4 full simulation includes calorimeters with different cell sizes. We aim to efficiently separate signal Z'->ww or Z'->tt and background Z'->qq. Various jet substructure variables and Z' masses from 5 to 40 TeV collision energy are also compared.

Geant 4 simulation of Future detector,SiFCC



Barrel	Technology	pitch/cell	radii (cm)	$\|z\|$ size (cm)
Vertex detector	silicon pixels/5 layers	25 μm	1.3 - 6.3	38
Outer tracker	silicon strips/5 layers	50 μm	39 - 209	921
ECAL	silicon pixels+W	2×2 cm	210 - 230	976
HCAL	scintillator+steel	5×5 cm	230 - 470	980
Solenoid	5 T (inner), -0.6 T (outer)	-	480 - 560	976
Muon detector	RPC+steel	3×3 cm	570 - 903	1400

Basic jet recombination algorithm:

$$d_{ij} = min(k_{ti}^{2p}, k_{tj}^{2p}) \frac{\Delta_{ij}^2}{R^2}$$

$$d_{ib} = k_{ti}^{2p}$$

$\Delta_{ij}^2 = (y_i - y_j)^2 + (\emptyset_i - \emptyset_j)^2$

i, j: the i and j particle

k_{ti}, k_{tj}: the particle i and j transverse momentum

If d_{ij}<d_{ib},j particle will be merged in I particle

1.p=0 : Cambridge/Aachen algorithm

2.p=1 : kt algorithm

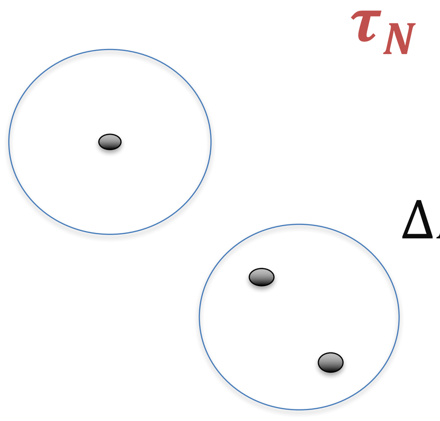
3.p=-1 : anti-kt algorithm

Jet Substructure variables:

1.N-subjetness:

$$\tau_N = \frac{1}{d_0} \sum_k P_{t,k}\, min\{\Delta R_{1,k}, \Delta R_{2,k} \dots \Delta R_{N,k}\}$$

$$d_0 = \sum_k P_{t,k} R_0$$

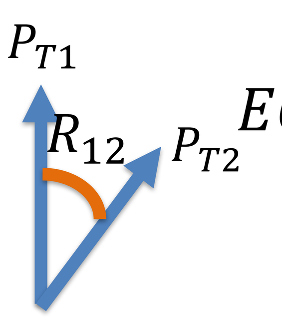


$\Delta R_{i,k}$: angle that k particle from the i axis

R_0: The cone size we want to cluster

$$\tau_{21} = \frac{\tau_2}{\tau_1}, \tau_{32} = \frac{\tau_3}{\tau_2}$$

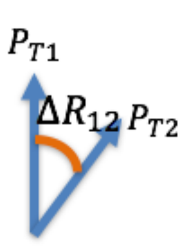
2.Energy correlation function



$$ECF(N,\beta) = \sum_{i_1<i_2<..<i_N \in J} \left(\prod_{a=1}^{N} PT_{ia}\right)\left(\prod_{b=1}^{N-1} \sum_{c=b+1}^{N} R_{ibic}\right)^{\beta}$$

$$C_N^{(\beta)} \equiv \frac{r_N}{r_{N-1}} = \frac{ECF(N+1,\beta)ECF(N-1,\beta)}{ECF(N,\beta)^2}$$

3.Soft drop:



$$\frac{min(P_{T1},P_{T2})}{P_{T1}+P_{T2}} < Z_{cut}\left(\frac{\Delta R_{12}}{R_0}\right)^{\beta}$$

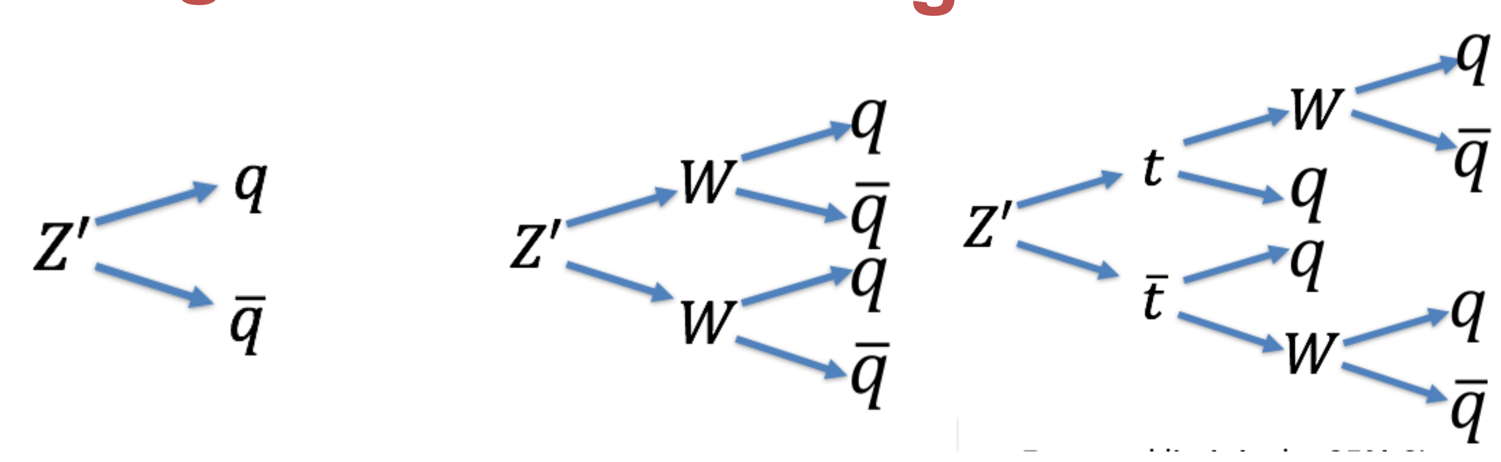
$\beta > 0$: Remove (soft), maintain(soft − collinar)

$\beta = 0$: Depend on the cut to select the asymmetry

$\beta < 0$: Remove both (soft)and (collinear)

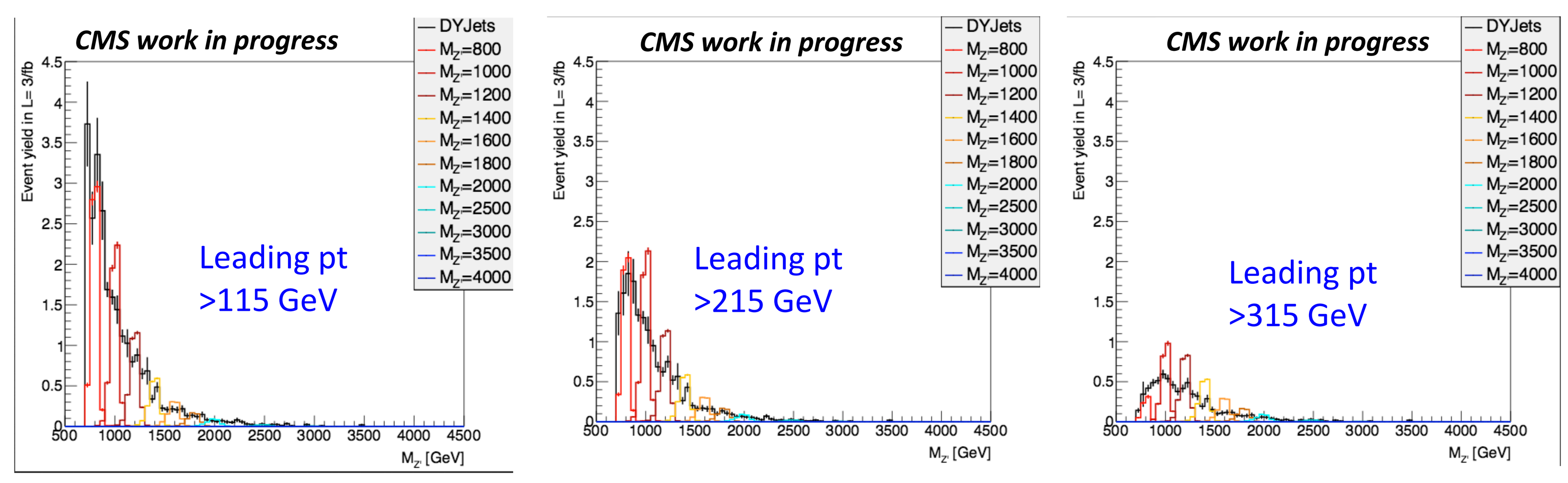
Signal and and QCD Background process:

QCD Background: / Signal:

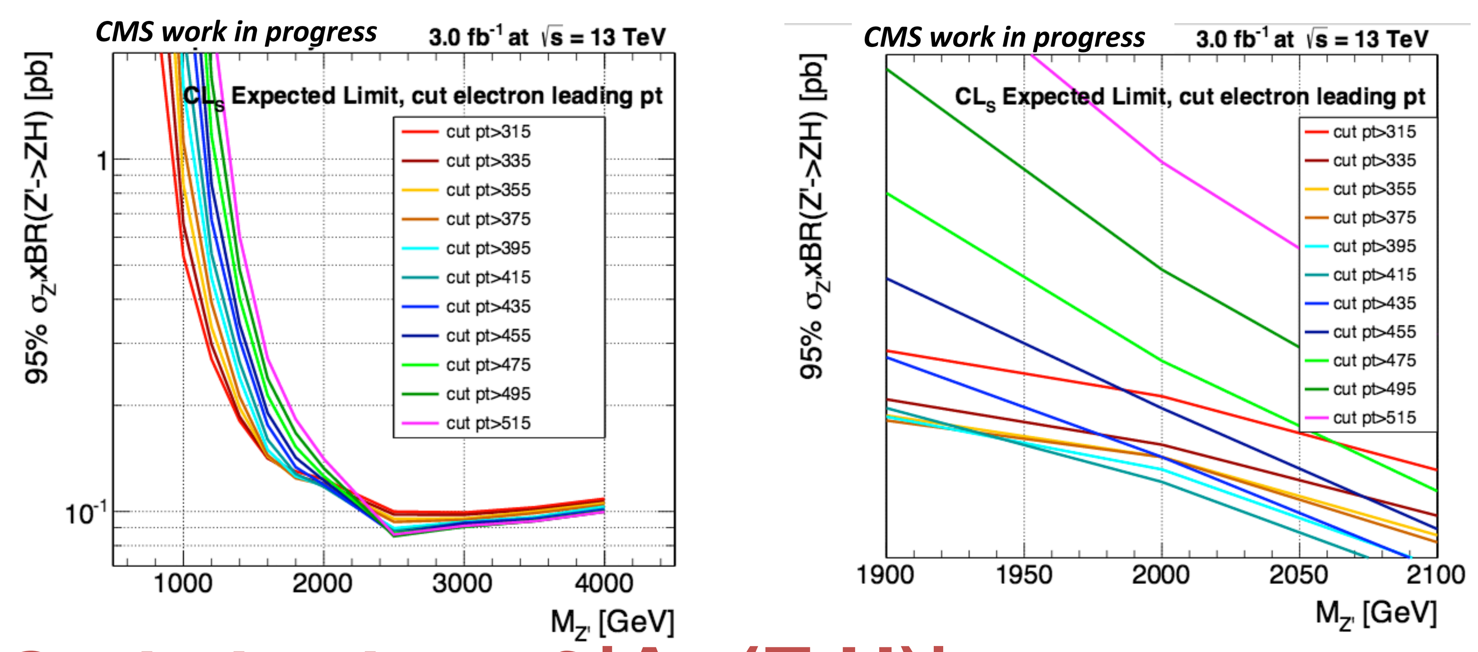


Expected limit:

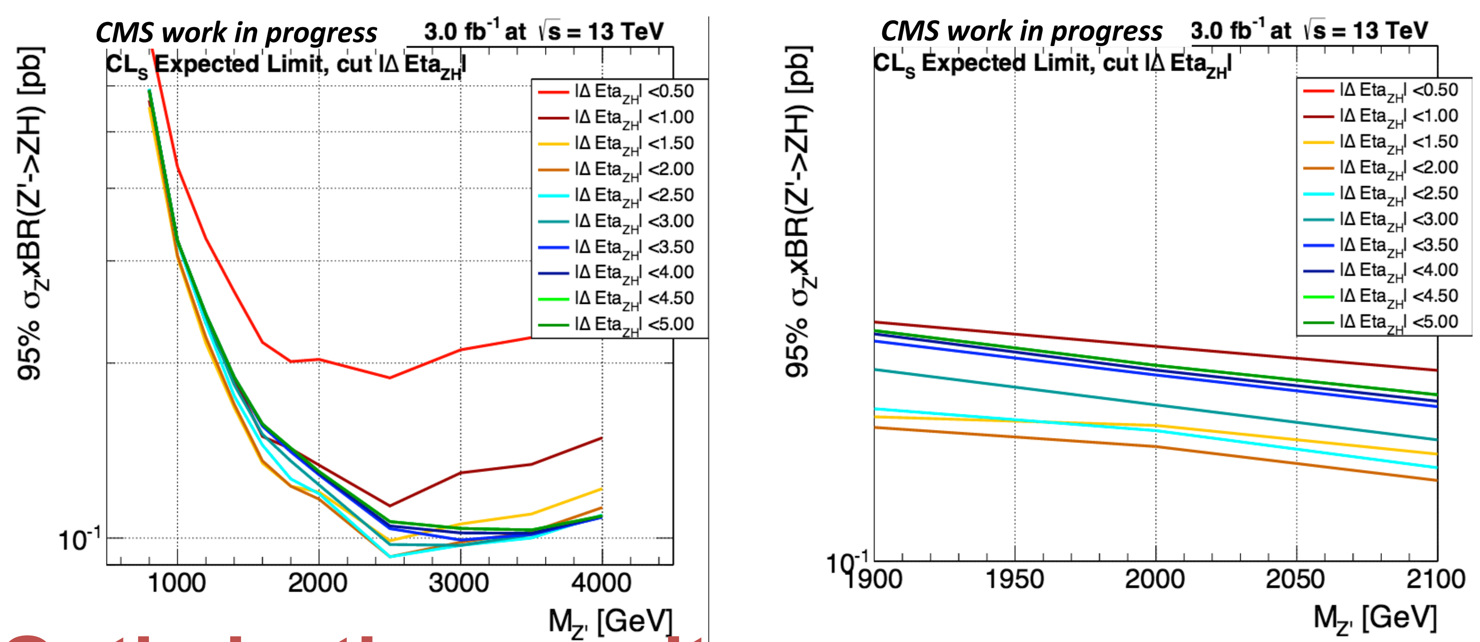
Zprime mass distribution in L=3/fb:



Optimization of leading electron pt :



Optimization of |Δη(Z,H)|:



Optimization result:

	M=1000	M=2000	M=3000
Leading pt	Pt>195 GeV	Pt>415 GeV	Pt>495 GeV
Sub-Leading pt	Pt>75 GeV	Pt>175 GeV	Pt>195 GeV
|d Eta (Z,H)|	|d Eta (Z,H)| <1.5	|d Eta (Z,H)| <2.0	|d Eta (Z,H)| <2.5

Summary :

The two optimization methods get consistent results of the best cuts, and the |d Eta| cut will be considered to be added into the final selection.

Reference :

AN-2015-186 (CMS internal analysis note)