HZ with Z→qq at 3TeV

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Start with parton level study

All samples produced with latest detector model CLIC_o3_v14:

Signal Sample:
HZ with Z→qq, cross-section: 3.67 fb
Produced with ILCSoft-18-10-11
Produced without (12074) and with 3TeV (12075) backgrounds (115 k events)
For the time being, select H→bb (56 % of the sample) on parton-level

Background Sample (being produced right now):
ee_qq (use gen sample of 4584, cross-section: 2850 fb, sample ID 12091)
→183 k events
qqqq (use gen samples of 6774, cross-section: 549 fb, sample ID 12083)
→1245 k events
ttbar (use gen sample of 5534, cross-section: 52.6 fb, sample ID 12099)
→ 24 k events (generate more statistics here?)

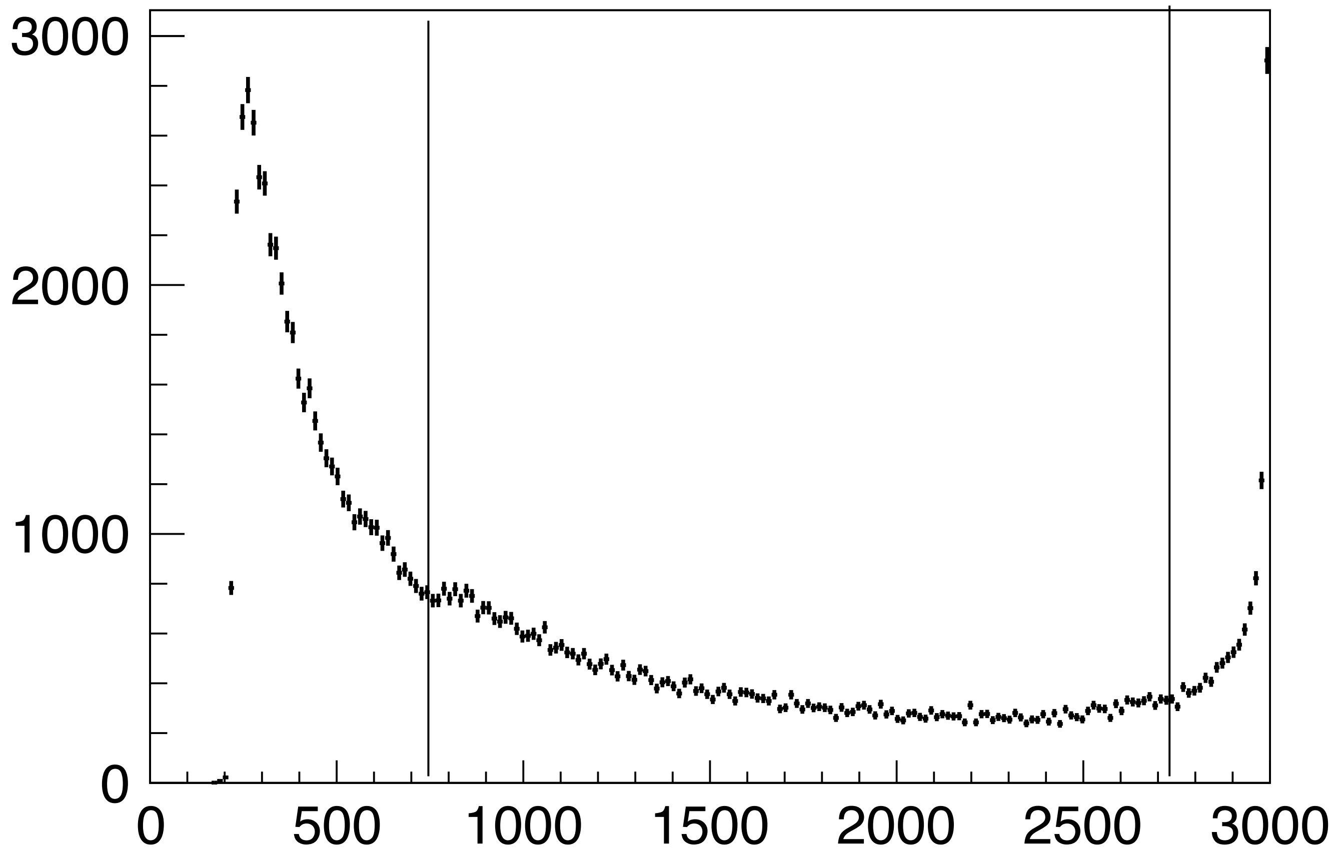
→ So far all samples produced without any beam polarization (unlike for boson-fusion samples polarisation leads to moderate cross-section changes)

Start with parton level study

Effective Centre-of-mass energy of e+e- after ISR photons and beam strahlung on parton level

→cross-section falling with centre of mass energy + luminosity spectrum

→define 3 regions <750,750-2750,>2750



Objects

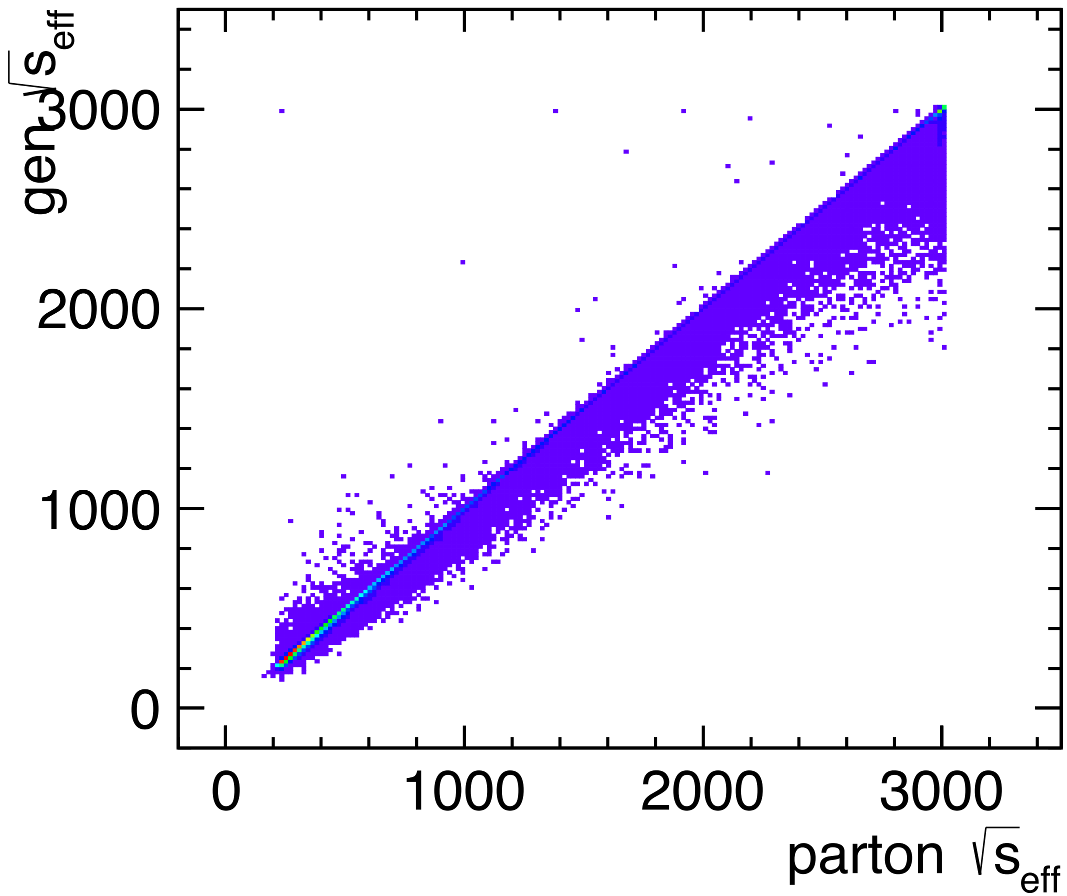
Jets defined using VLC algorithm with $\beta=\gamma=1.0$, run in exclusive mode with R=0.7, 1.0 and 1.2
→TightSelectedPandoraPFOs as input (for truth jets stable particles, excluding neutrinos), exclusive jet clustering with $n_{jets}=2$
→remove before jet clustering isolated muons, electrons and photons with E>10 GeV: Requirement: relative isolation relIso<0.10 within a cone of 10 degrees
→ MC truth jets: apply jet algorithm on all stable visible particles (exclude neutrinos)
→ Order jet by masses m (j1) >m(j2), treat j1 as H jet, j2 as Z jet

Subjet reconstruction:

- Use the same VLC algorithm parameters, cluster jet in exactly two subjets

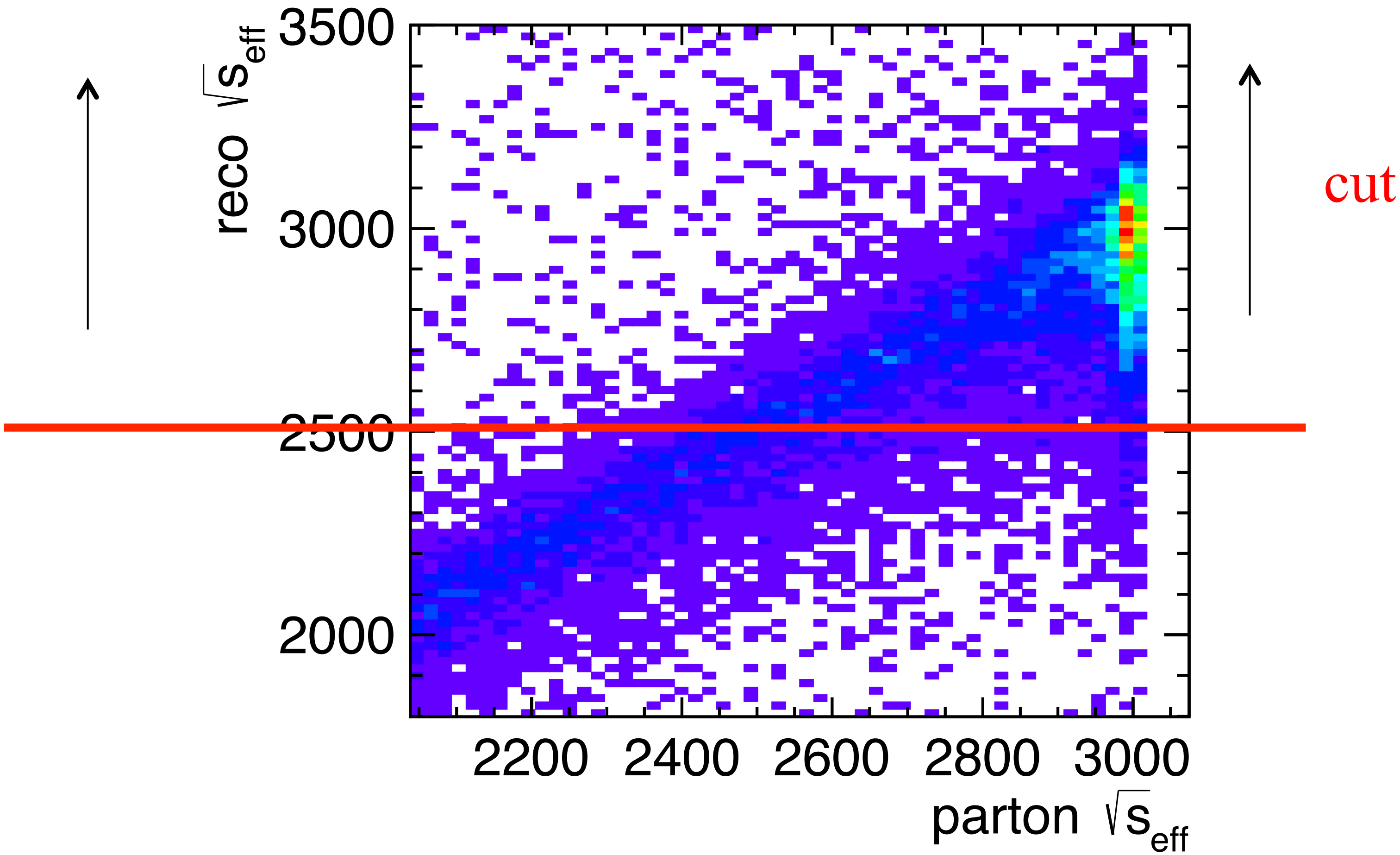
sqrt(s): parton vs particle level visible only

Parton level: Effective com energy of e+e- after ISR photons and beam strahlung
Particle level: effective com energy of all stable visible particles after removal of isolated photons →particularly at larger parton srqt(S_{eff}) peak a bit smeared



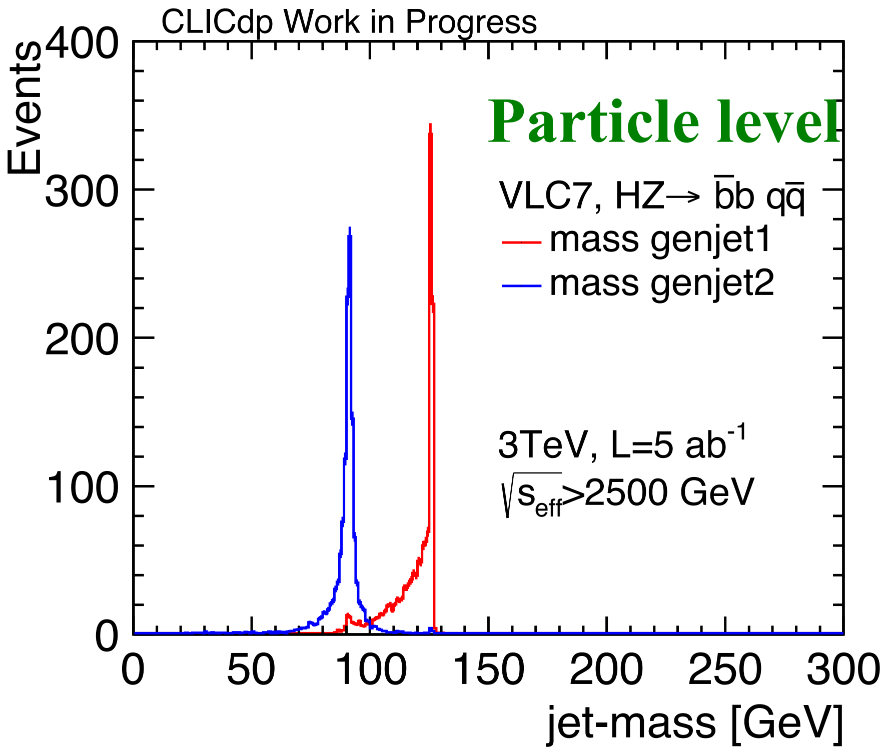
sqrt(s): parton vs reco level: zoom on large sqrt(s)

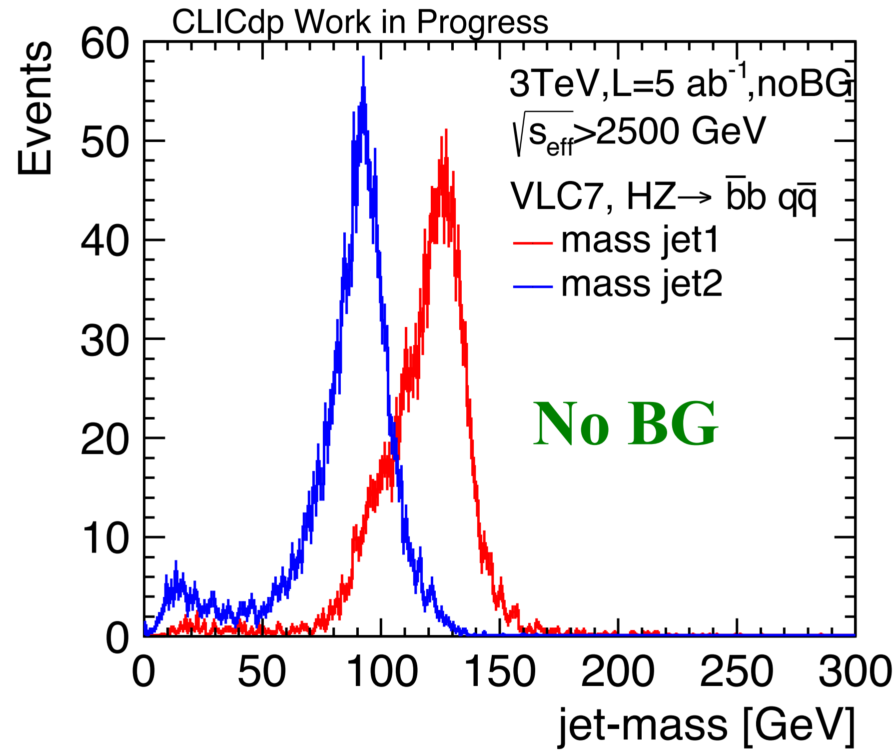
High end of parton sqrt(s) peak selected sufficiently with a requirement on $sqrt(s)_{reco}$>2500 GeV, consider only decays with H→bb (MC truth selected)



Fat jet masses on reco level, sqrt(s)>2500 GeV

Assumption: at large sqrt(s) bosons very boosted, using jet with a large cone sufficient to collect almost all boson energy → check if jet clustering works on particle level
Order jets by masses mass(j1) > mass (j2)





Detector effects widen the jet mass distributions significantly, most of the energy collection with radius of 0.7, tail to lower values for b-jet (smeared out on reco level) result of lost jet energy into neutrinos

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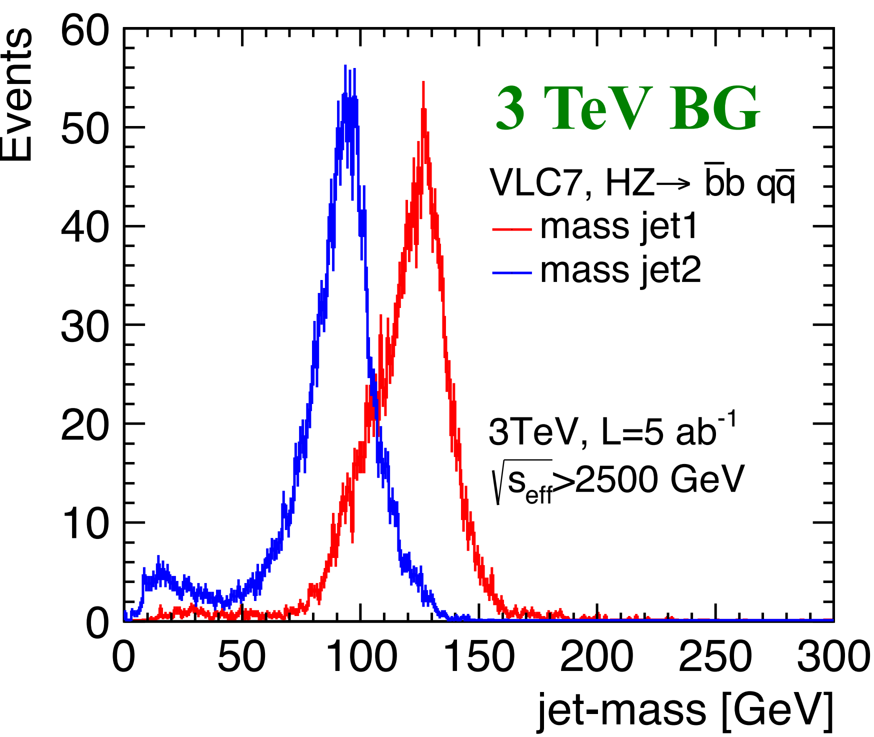
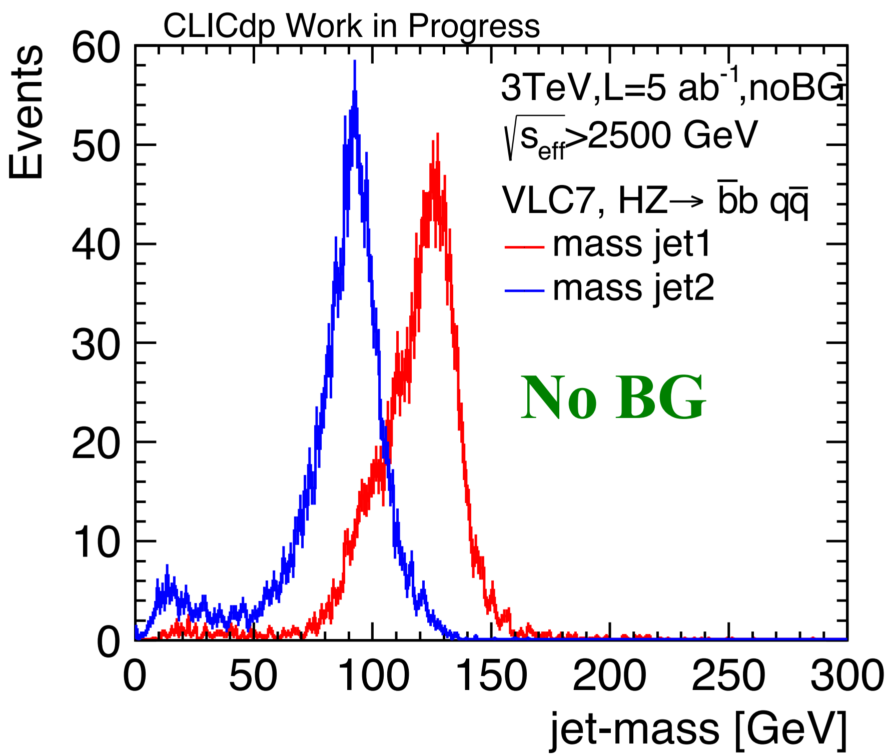




Beam induced backgrounds shift masses slightly to larger values, no big degradation of mass separation

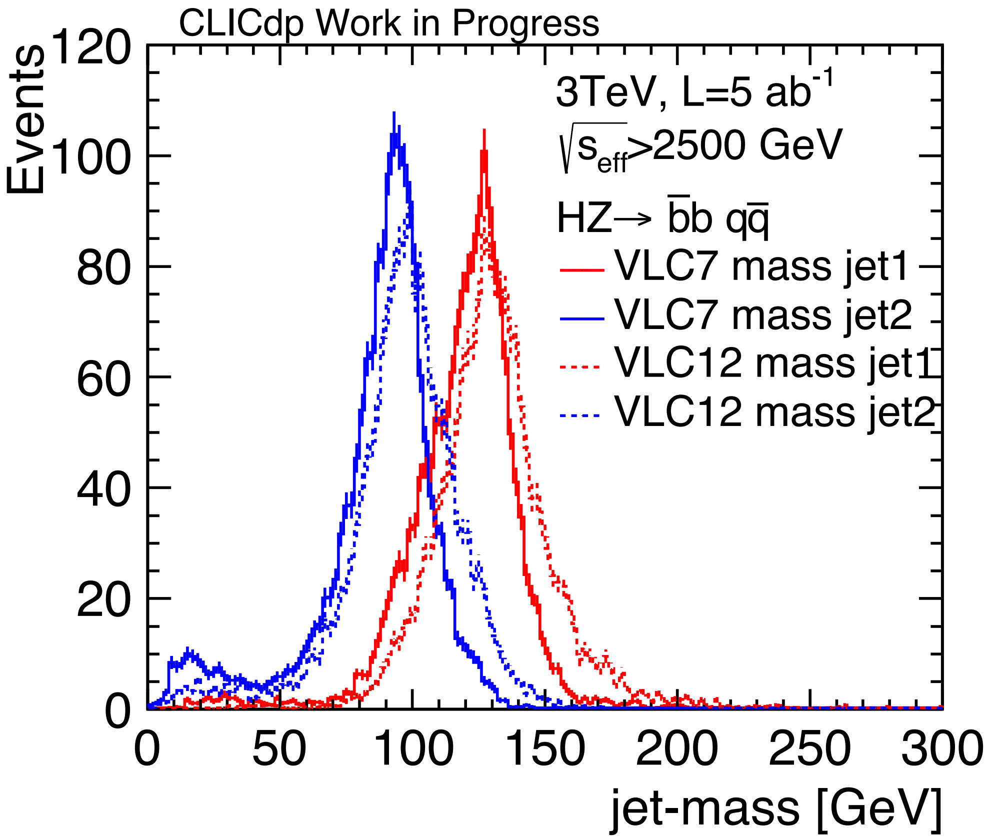
Jet masses vs Jet Cone R: 0.7,1.0,1.2

Study jet mass separation in HZ as function of cone: define overlap region

For jet1 mass histogram $A_O(j1)$ =integral(50-intersection)/integral(50-200)

For jet2 mass histogram $A_O(j2)$ = integral(intersection-200)/integral(50-200)

Intersection bin: first bin where entries(j1)>entries(j2), with m(j)>50 GeV

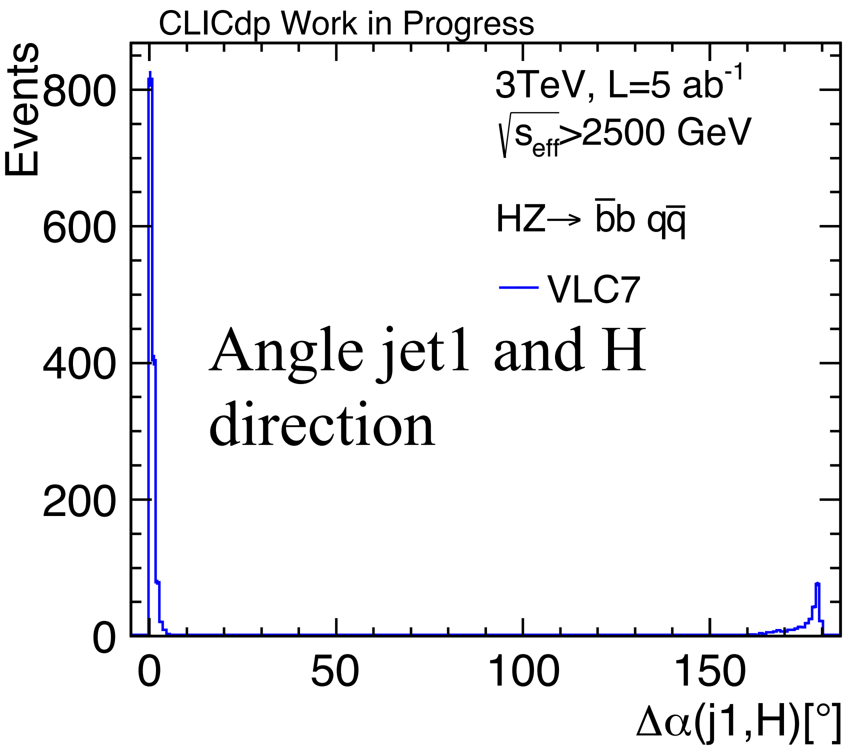


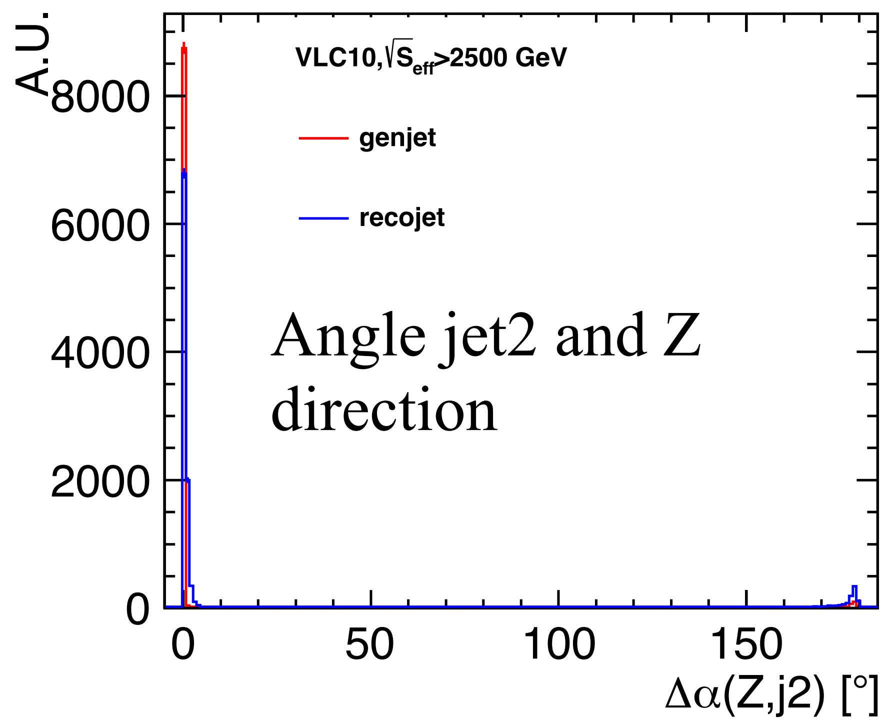
For R=0.7 $A_O = 0.5(A_O(j1)+A_O(j2))$ smallest with 17.8%, largest for R=1.2 with 19.4%

→ Should I check smaller radii too, e.g. R=0.5

Do we select the right jets?

Assumption: jet with larger mass is H, jet with subleading mass is Z → check if jets are angular matched



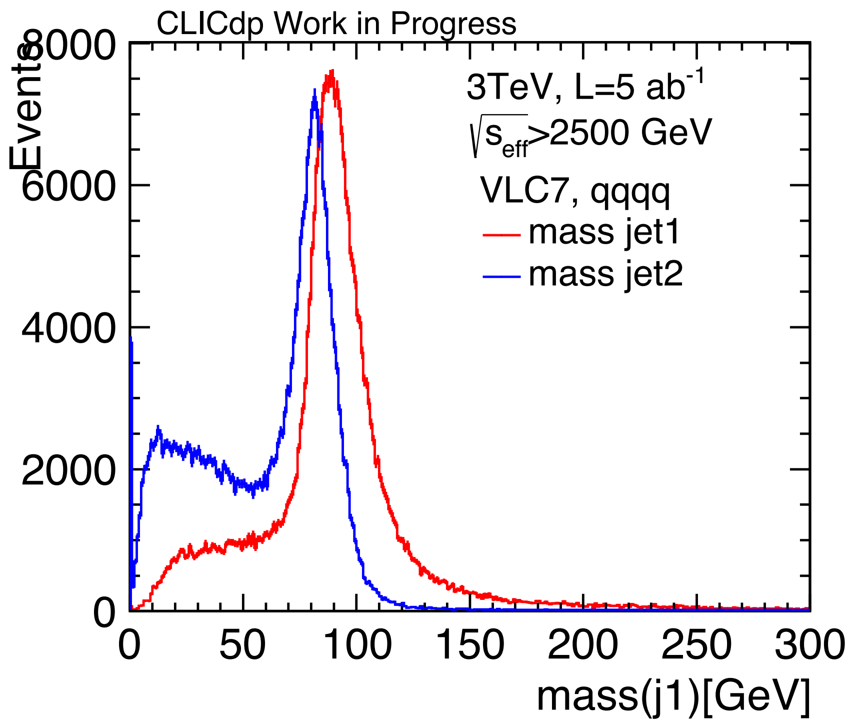


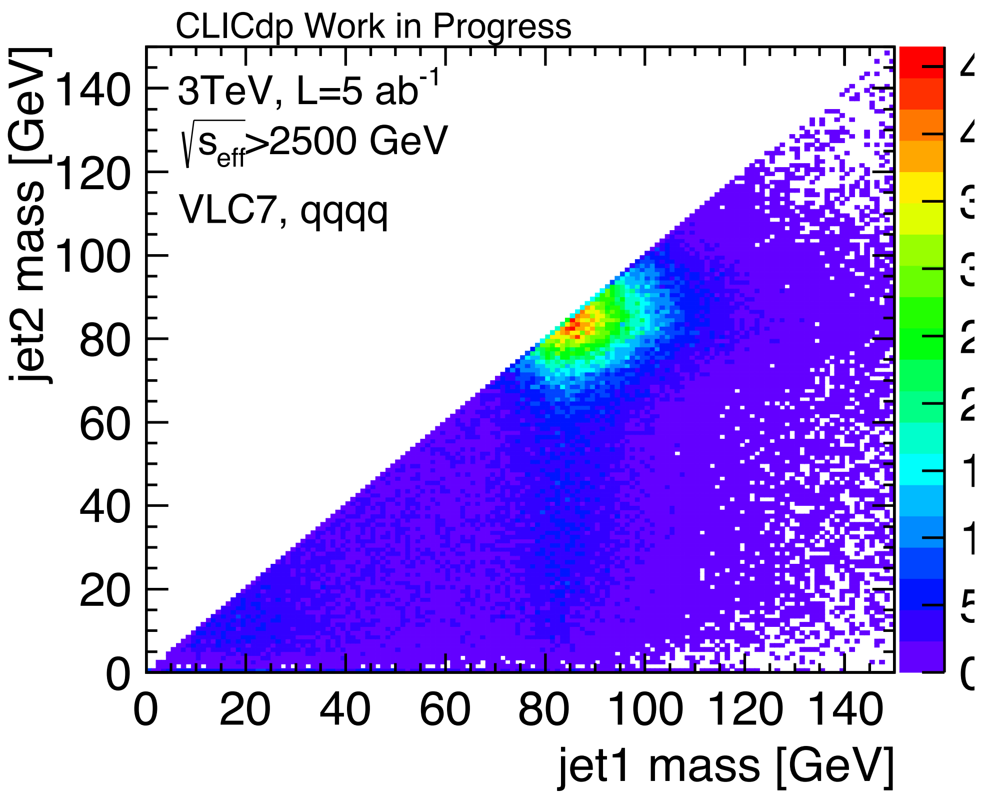
Correct assignment of jets in 82% of cases

→ second peak at 180 degrees appears as H-Z and thus j1-j2 are back-to-back in boosted regime

Backgrounds qqqq

Check mass distributions of backgrounds, HZ→bb qq can be selected through tight mass windows

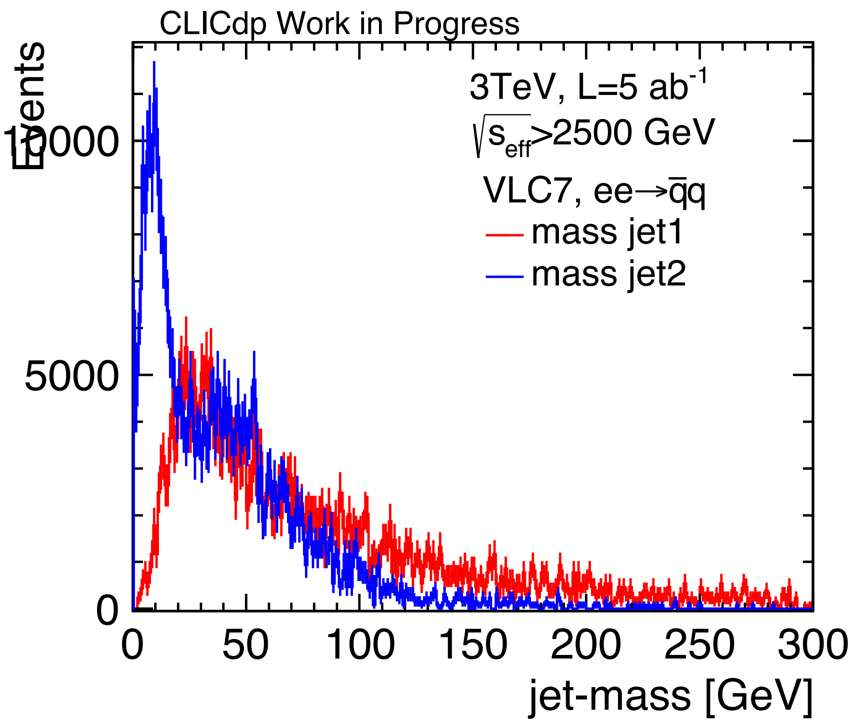


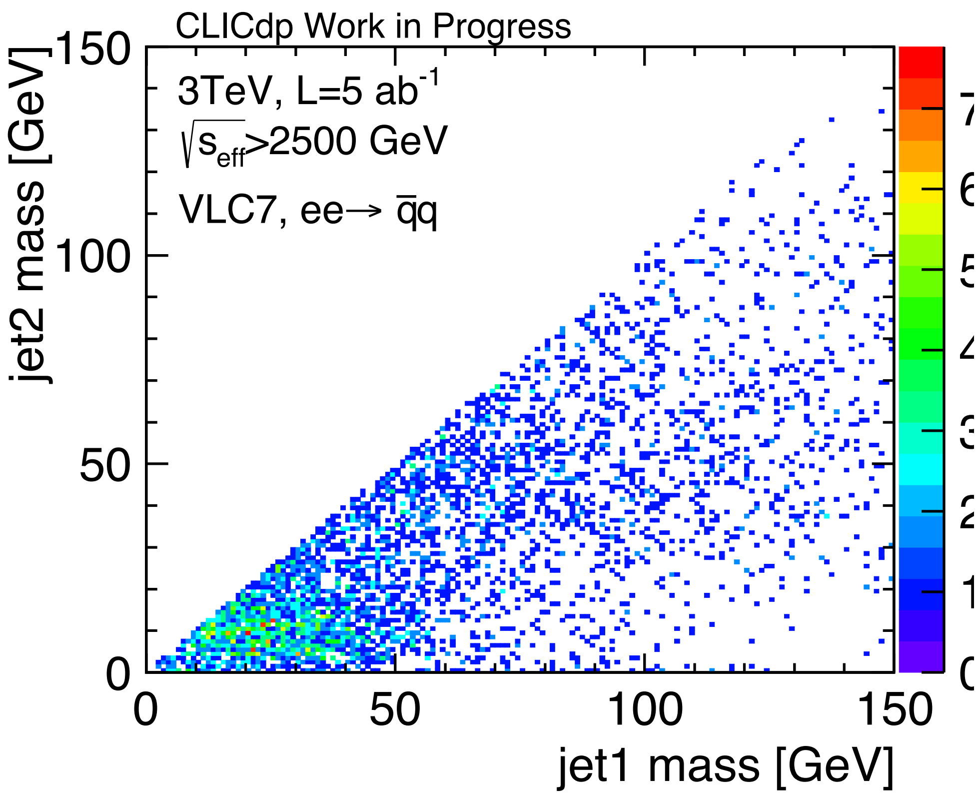


Mass distributions in qqqq sample peak at W and Z boson masses, and large tail to low masses for both jets → lower mass but for j1 at 120 GeV, for jet 2 at 50 GeV, maybe smaller cone can be of benefit against this background

Backgrounds: ee→qq

Check mass distributions of backgrounds, HZ→bb qq can be selected through tight mass windows

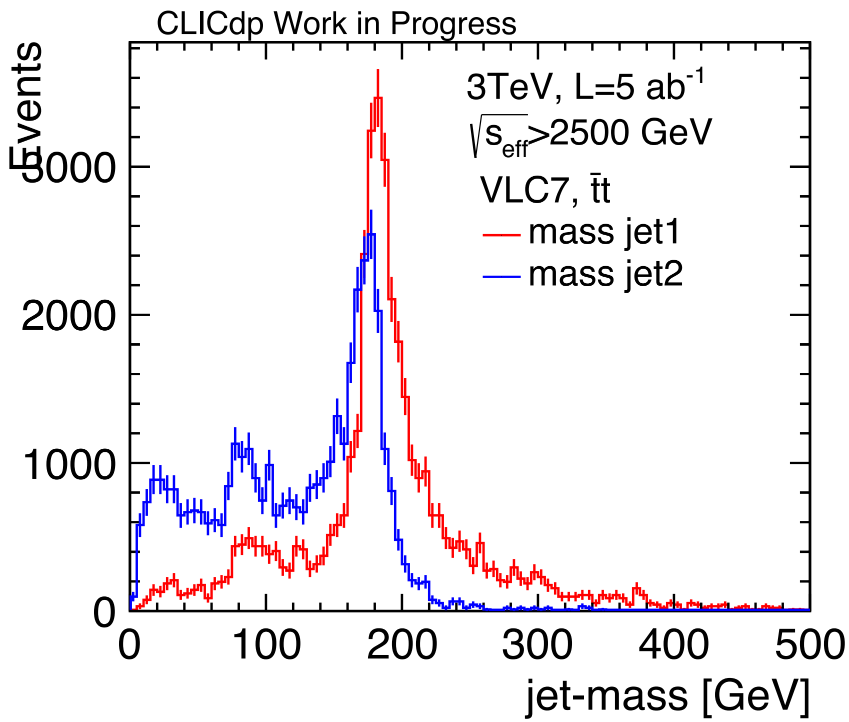


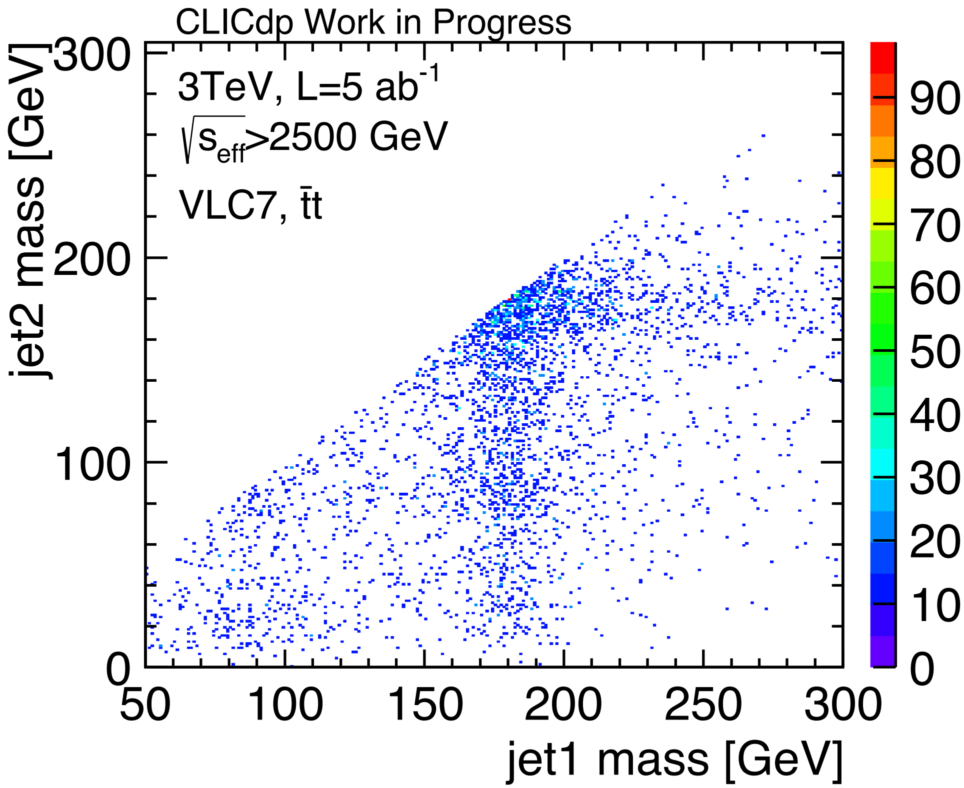


Mass distributions in qq sample peak at typically lower values→ lower mass but for j1 at 120 GeV, for jet 2 at 50 GeV cuts out most of this background

Backgrounds: ttbar

Check mass distributions of backgrounds, HZ→bb qq can be selected through tight mass windows





Mass distributions in ttbar sample peak at typically around ttbar mass→ lower second peak for jet 2 around W mass, upper cut on j1 mass of 150 GeV reduced ttbar by a large amount

→ Low statistics for this sample

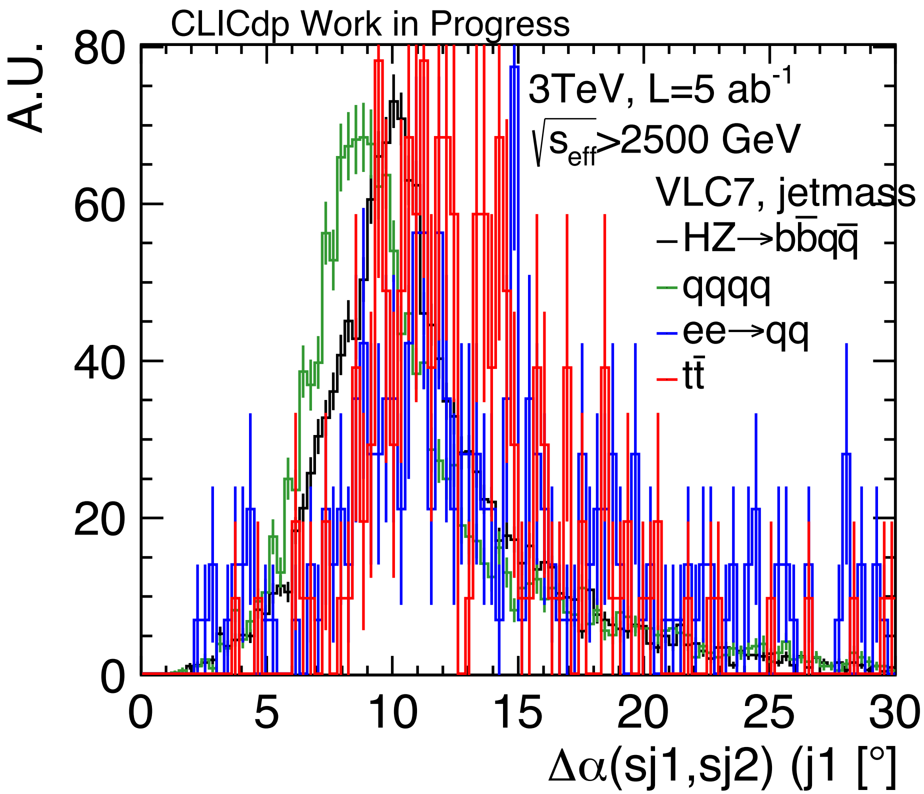
cuts: m-j2>50 GeV, 120 GeV<m-j1<160 GeV

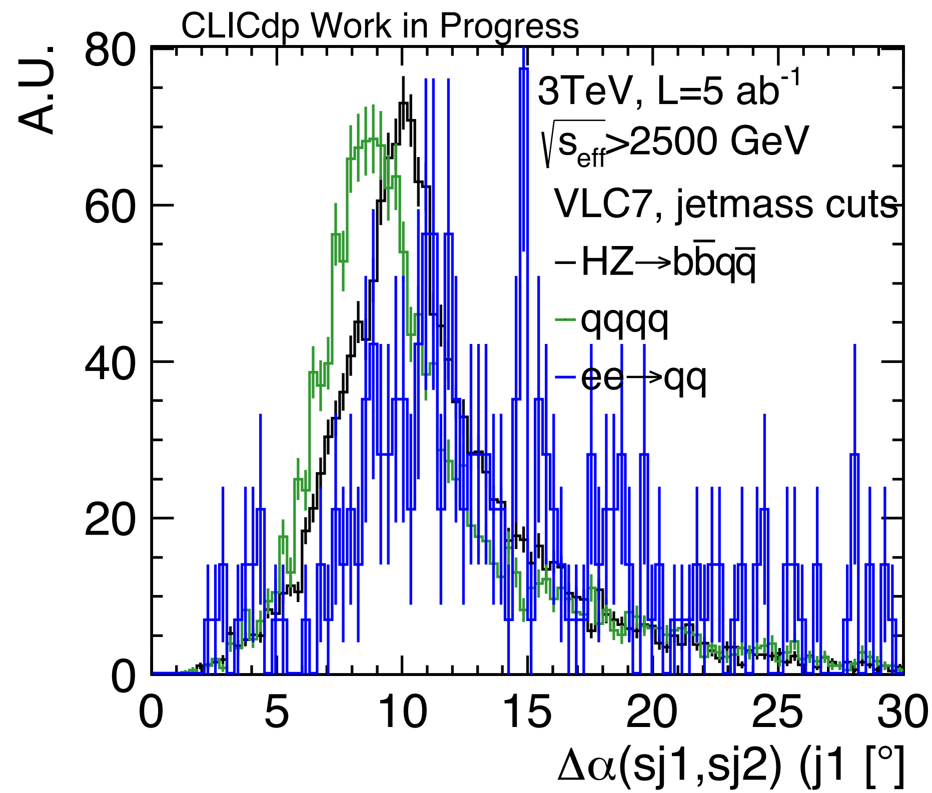
Mass j2>50 GeV
Mass j2 between 120 and 160 GeV

Sample	HZ→bbqq	ttbar	ee→qq	qqqq
All events	1686	40222	386 964	283 592
Events after mass cut	843	1732	17625	11845
Efficiency In %	50 %	4.3 %	4.6 %	4.2 %

Subjets: require exactly two subjets

Angular separation between both subjets of jet 1 after mass cuts

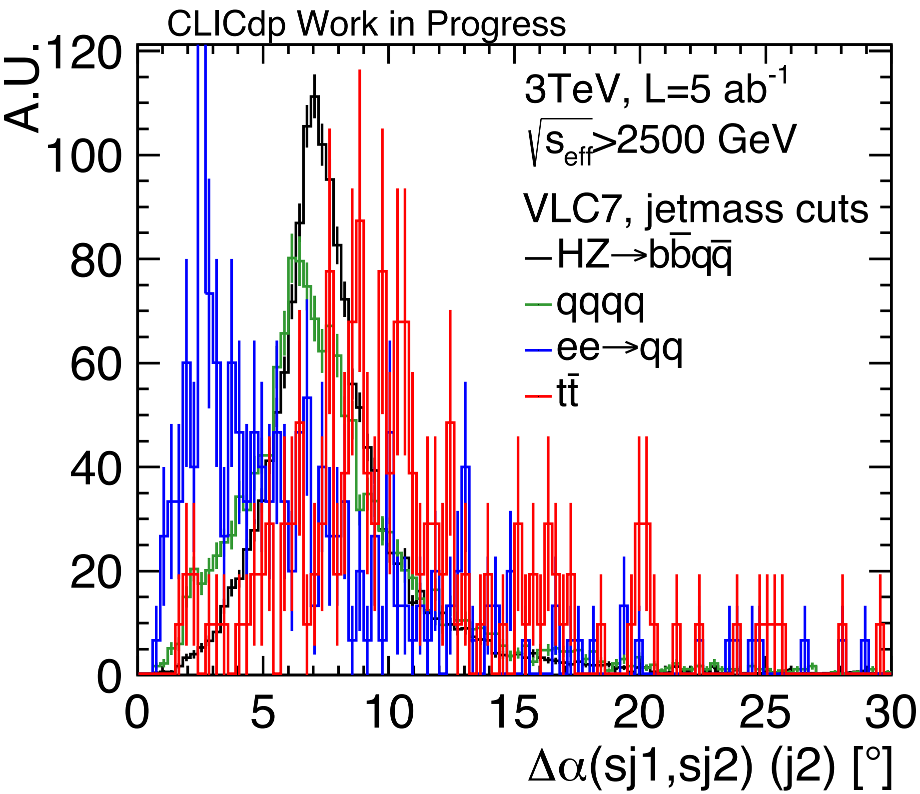


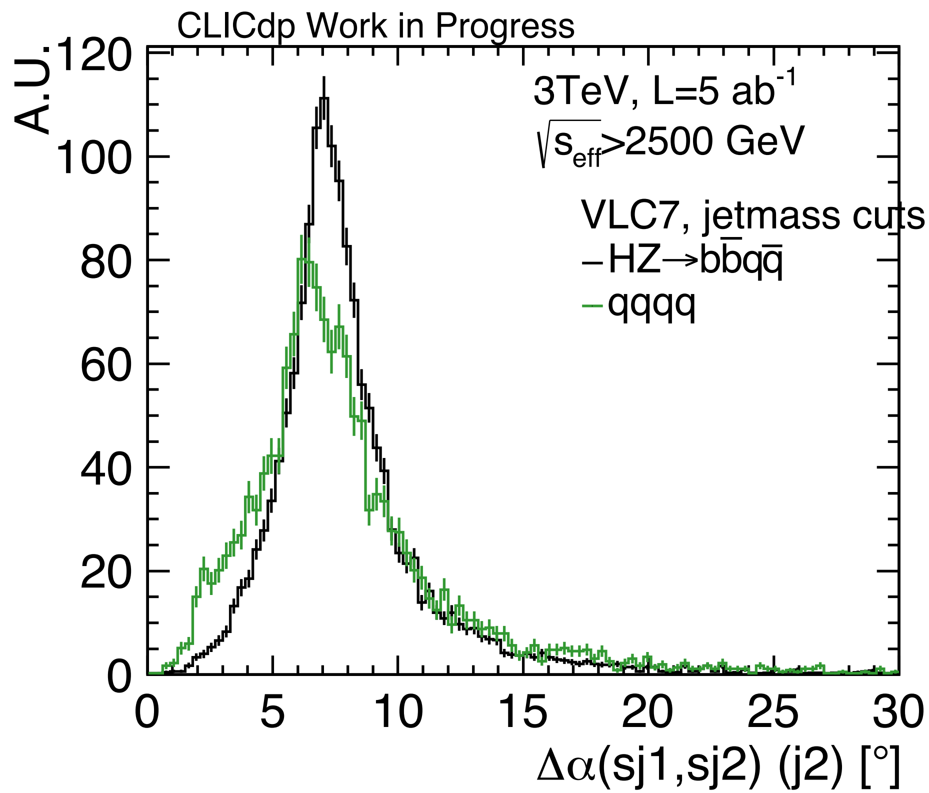


Separation power between qqqq and HZ

Subjets: require exactly two subjets

Angular separation between both subjets of jet 2 after mass cuts





Separation power between qq, tt and HZ,
Jet2 typically from spin 1 boson, thus between qqqq and HZ less separation power than previously

Conclusions

First look at HZ signal with H→bb, concentrating on high sqrt(s) region:

- Seems in calculation of effective sqrt(s) neutrinos still play a roles
- Large alignment of neutrino/MET vector with b-jet, unfortunately not so correlated anymore after adding background
- Decent separation of Z and H masses at a radius of 0.7, no large improvement if going to radii of 1.2 or 1.5
- First look into subjets:
  - Basic energy sharing between quarks in Z and bottoms in H reproduced by subjets on particle and on reconstructed level (even with background)