Tagging b-jets in $b\bar{b}H_{SUSY} \to \tau\tau$ with the CMS detector

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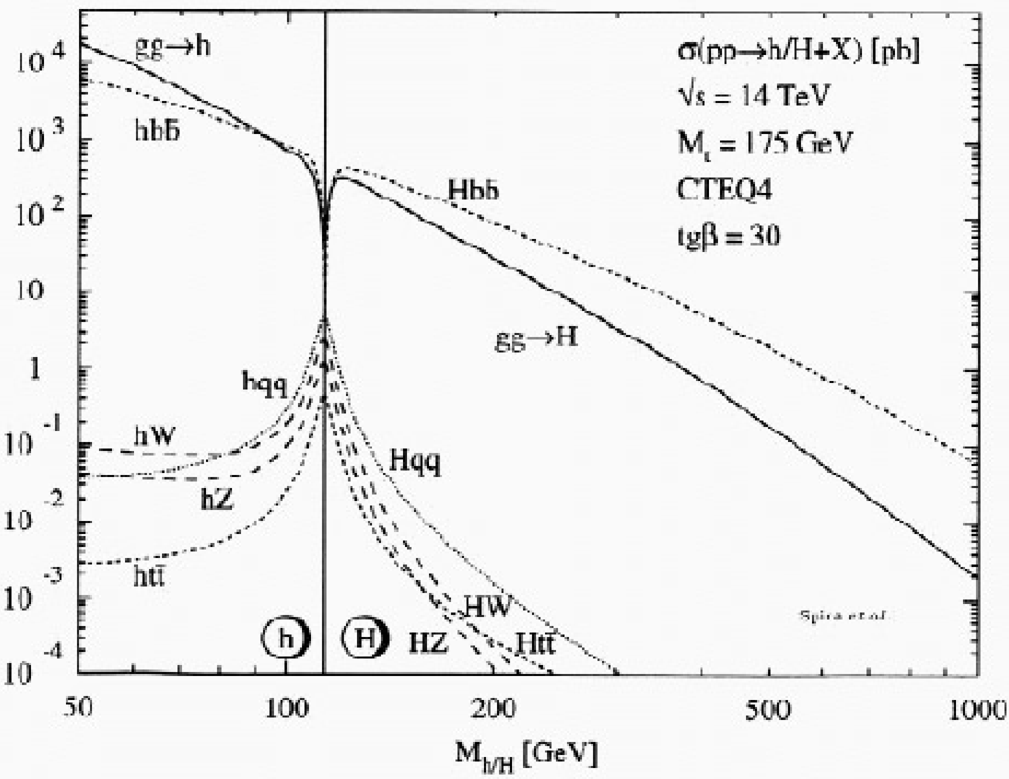
- MSSM Higgs production dominated by $gg \to b\bar{b}H_{SUSY}$
- B-hadrons can be identified
- Significant background suppression possible by requiring a b-jet in the event



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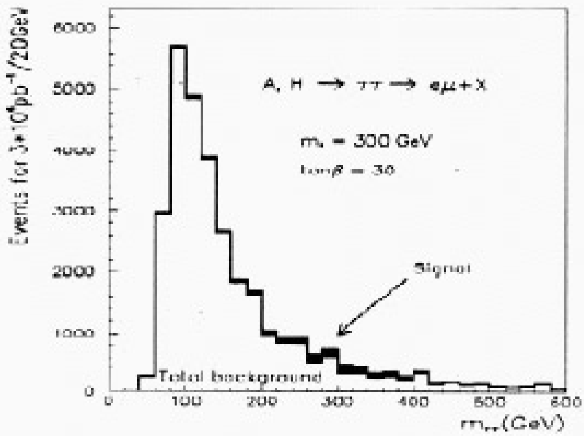
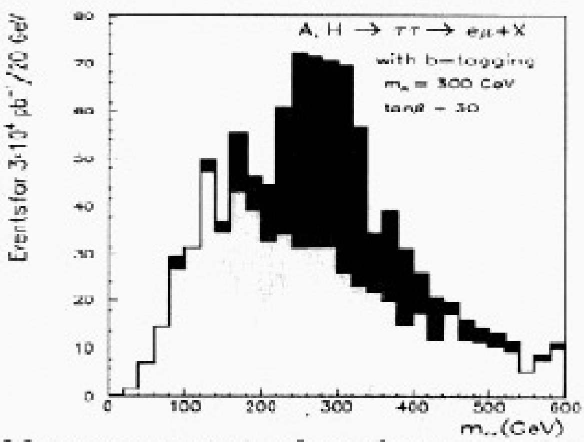
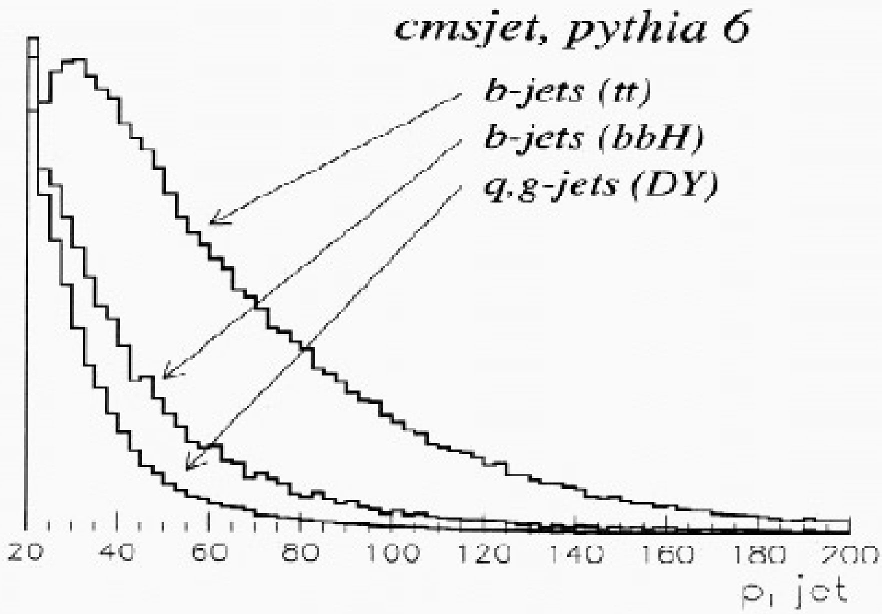
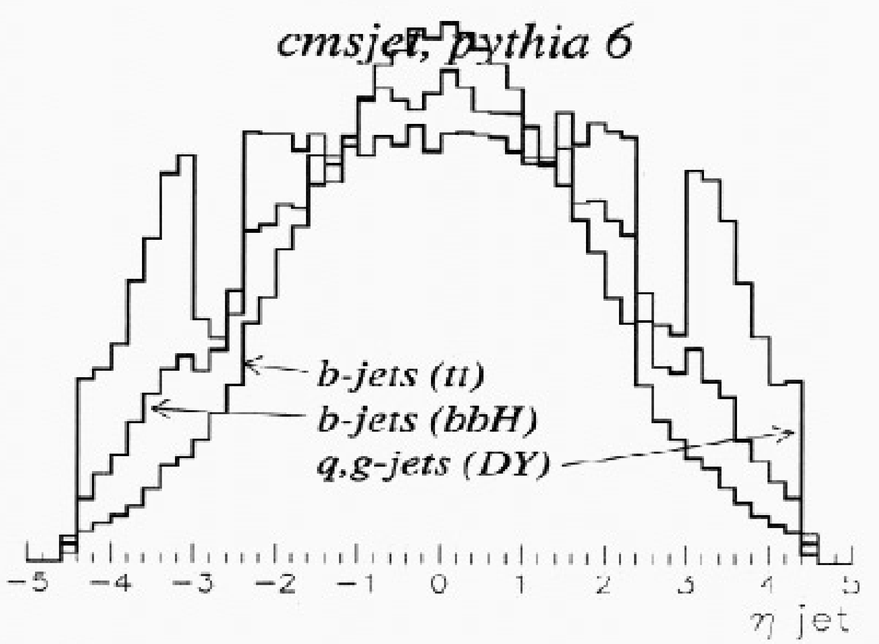
$b\bar{b}H_{SUSY} \rightarrow \tau\tau \rightarrow e + \mu + X$





- Mass reconstruction from the measured leptons and missing transverse energy E_t^{miss}
- A b-tagging efficiency of ~15 % is obtained for $b\bar{b}H_{SUSY}$ and a reduction factor of ~100 against the $Z, \gamma^* \rightarrow \tau\tau$ background
- Mass resolution is expected to be ~25% and it is highly sensitive to the quality of the E_t^{miss} measurement





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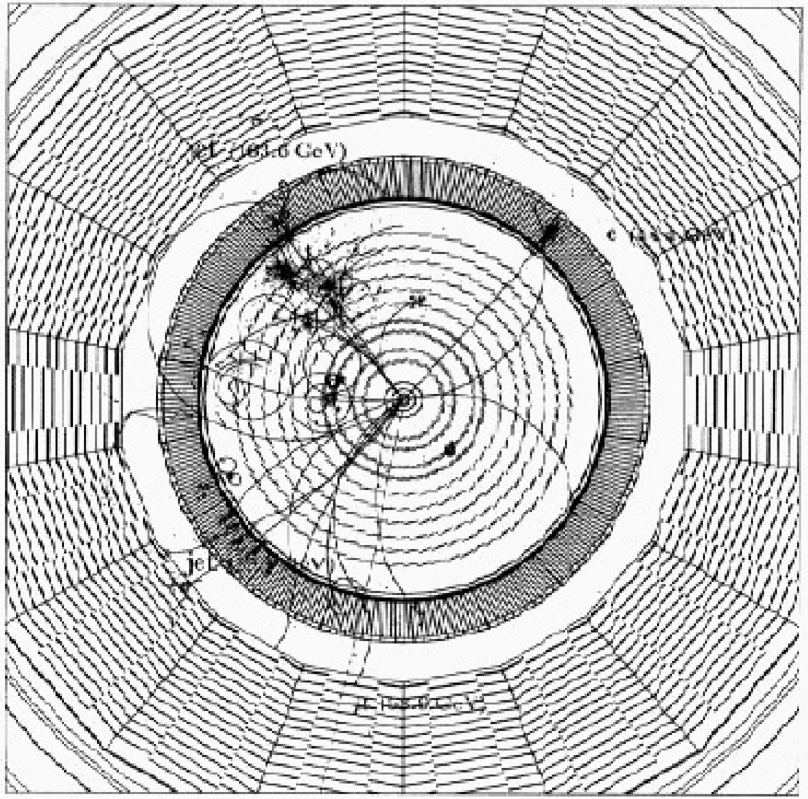
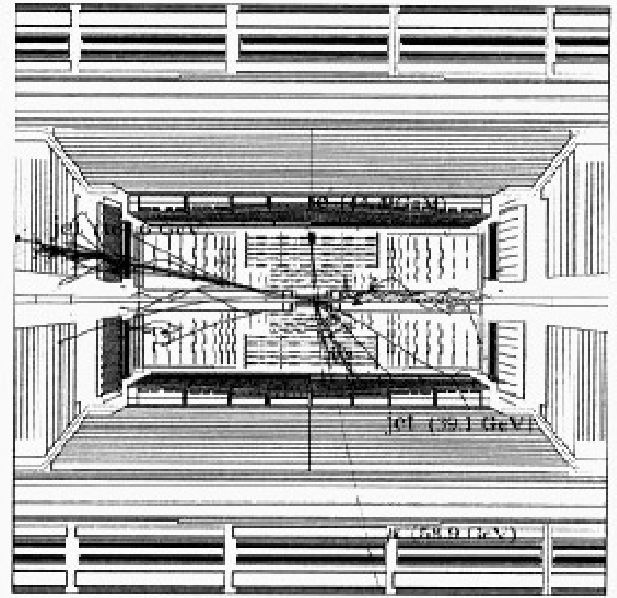
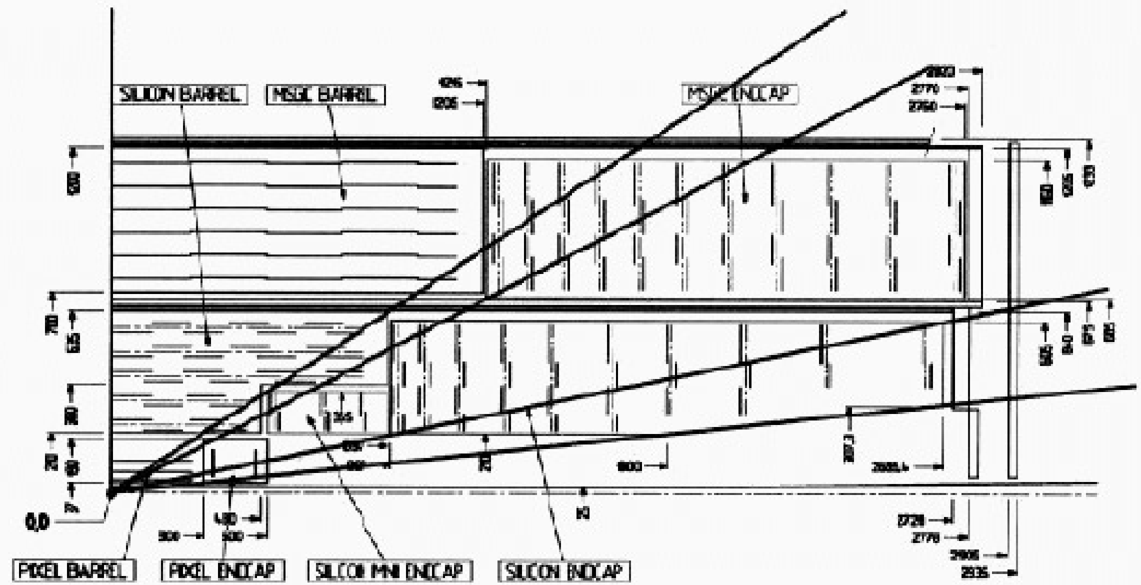


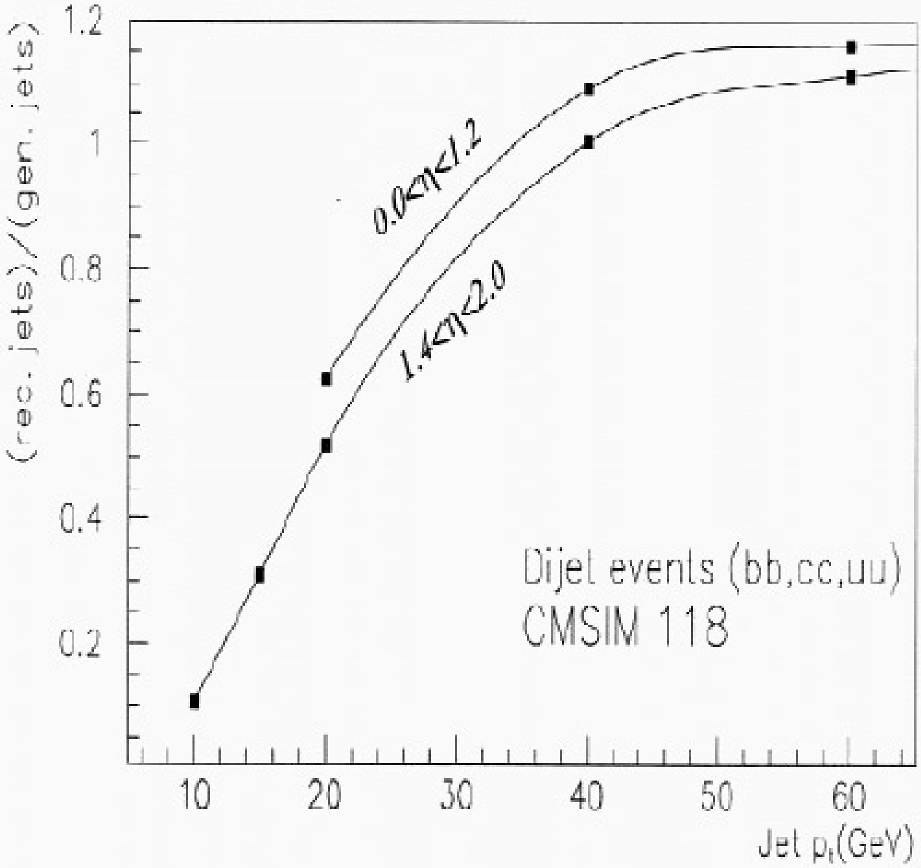


CMS, CMSIM121

$gg \to b\bar{b}H^0$, $H^0 \to \tau\tau \to e\mu$



Studied η regions: $0.0 < |\eta| < 1.2$, $1.4 < |\eta| < 2.0$, $2.0 < |\eta| < 2.4$



Jet reconstruction

- reconstruction around an initiator calorimeter cell
  - cell $p_T > 3$ GeV
  - cone 0.7
- soft jets - reconstruction difficult
- rec. efficiency function of jet p_T, η

Track reconstruction

Several tens useful tracks/event $\simeq$ 500 hits
$\sim$ 6000 hits in the tracker at low luminosity (10^{33})
$\sim$ 40000 hits at high luminosity (10^{34})

Tracks reconstructed using Connection Machine - Forward Kalman Filter (CM-FKF)
Simplified tracker model: the tracker is considered as a set of surfaces (layers)
FKF:

- first stage - preselection (seeding) to reduce combinatorics, exploits high 3D precision of pixels and (weak) primary vertex constraint
- second stage - Kalman filter algorithm initiated from the seeds

CM:

- global and efficient track finding
- starts the reconstruction from outer layers
- slow, therefore after FKF
- aim to reconstruct tracks not reconstructed by FKF

Secondary vertex reconstruction

- Global vertex finder (GVF)
- all possible 2-track vertices are created by pairing good quality tracks
- nearby vertices merged
- other candidate tracks attributed to the seeds
- optimal match between tracks and vertices searched

b-jet identification

Dijet events generated by PYTHIA6

- each event contains exactly two jets with about the nominal p_T and within a certain η interval
- $b\bar{b}$, $c\bar{c}$, light quark and gluon jets

Detector response simulation by CMSIM118 (Geant3)

CM-FKF for tracks, minimum selection criteria

- track $p_T > 0.7$ GeV
- at least 6 hits/track
- at least 2 pixel hits/track
- $\chi^2/n_{dof} < 10$

GVF used to reconstruct all vertices

The tagging algorithm counts the number of significant tracks inside the jetcone

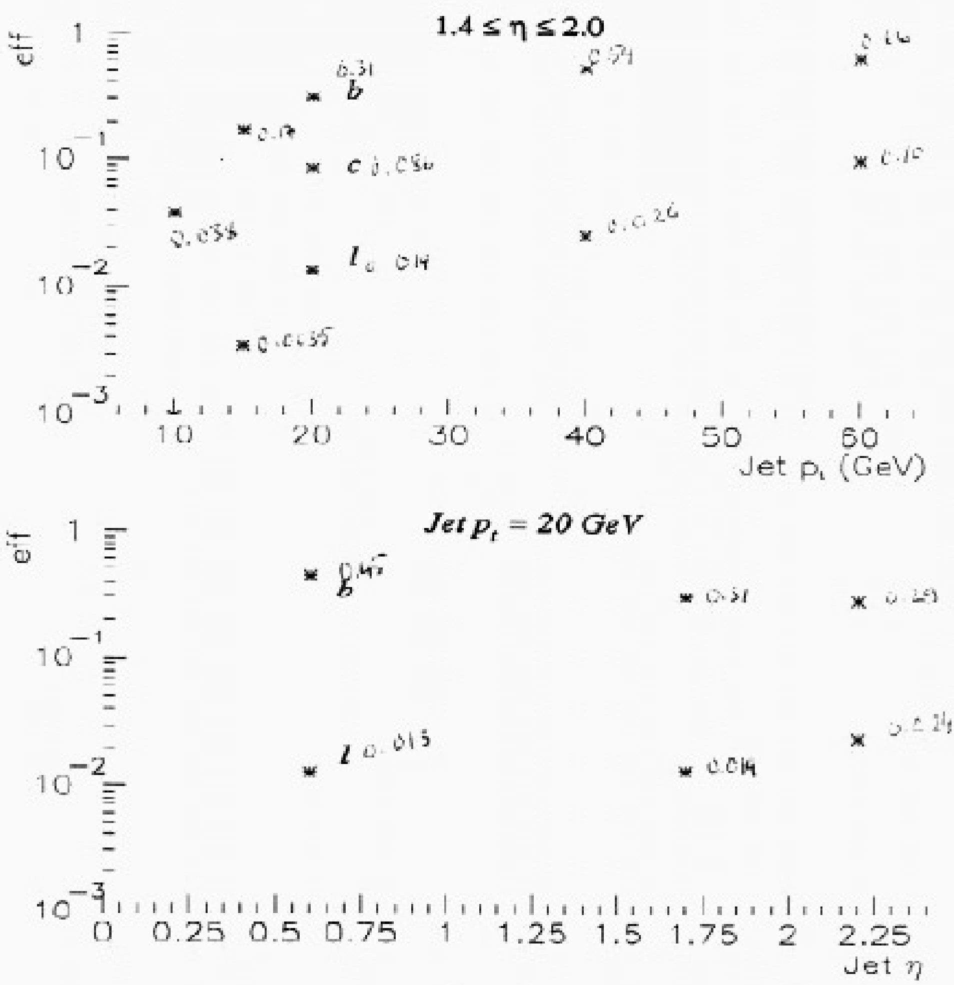
Significant track defined by

- min allowed σ_{ip}
- ip < 2 mm
- min track p_T allowed
- number of hits/track
- number of pixhits/track
- fit quality $\chi^2/n_{dof} < 5$

If two or more significant tracks - jet tagged as a b-jet

Algorithms: F(p_T,η,N_{tr},...), 2*3, etc.

Problems: F not very simple/robust, 2*3 diverges at large η or low p_T



Tagging efficiency and mistagging probability as a function of jet p_t and η. Constant cuts for track quality control sip> 2.3, $p_t > 0.9$ GeV, 6 hits.

Dec. 8, 2000 / SL

Impact parameter tagging - counting significant tracks within a cone of 0.7 around the jet axis

A track is defined as a significant track if

- At least 6 hits/track, two of them pixel hits
- At least 2 tracks within the cone
- Track ip $<$ 2mm
- Track sip (ip/err) $>$ x (signed)
- Track $p_t > y$ GeV
- $\chi^2/n_d < 5$

A jet is defined as a b-jet if at least 2 significant tracks within the jet cone
By changing the criteria for the track significance one can change the b-tagging efficiency and mistagging rates of the light quarks.

Reconstructed vertices used for secondary vertex tagging

Using sip cut 2.3 and p_t cut 0.9 GeV for 20 GeV jets at $1.4 < |\eta| < 2.0$

	ip	vertex	ip or v	ip and v
b-tagging eff.	0.31	0.54	0.58	0.25
c-tagging eff.	0.086	0.17	0.19	0.068
l-tagging eff.	0.014	0.051	0.059	0.0059

High luminosity

$< 17.3 >$ events/bunch crossing

pile-up - more hits in the tracker and calorimeters

- noise - energy resolution decreased
- more combinatorics for the tracking
- shared hits

$\Rightarrow$ efficiency dropped, at the same time background increased

$\Rightarrow$ harder cuts for significant track selection

$\Rightarrow$ the efficiency is dropped even more

For 20 GeV jets in the barrel region the tagging efficiency drops from 43% (low lumi) to 26% (high lumi) while keeping the impurities at ~ 1 % level. In the barrel-endcap transition region the drop is even more severe.

dijets	20 GeV		60 GeV	
$0.0 < \eta < 1.2$	ip	ip+v	ip	ip+v
$b\bar{b}$	0.43	0.36	0.45	0.48
$u\bar{u}$	0.0099	0.012	0.011	0.010
$b\bar{b}$ (pile-up)	0.26	0.26	0.32	0.42
$u\bar{u}$ (pile-up)	0.011	0.011	0.011	0.011

Conclusions

- a tagging efficiency better than 30 % is achievable while keeping the gluon/light quark jet mistagging rate at or below 1%
- the tagging efficiency is very p_T, η dependent
- the tagging efficiency for soft jets may drop in the high luminosity environment