Workshop on B/tau Physics at LHC

Helsinki, May 30 - June 1, 2002

Review of Higgs searches in CMS

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Progress in H, A -> ττ -> 2 τ jets

with full simulation

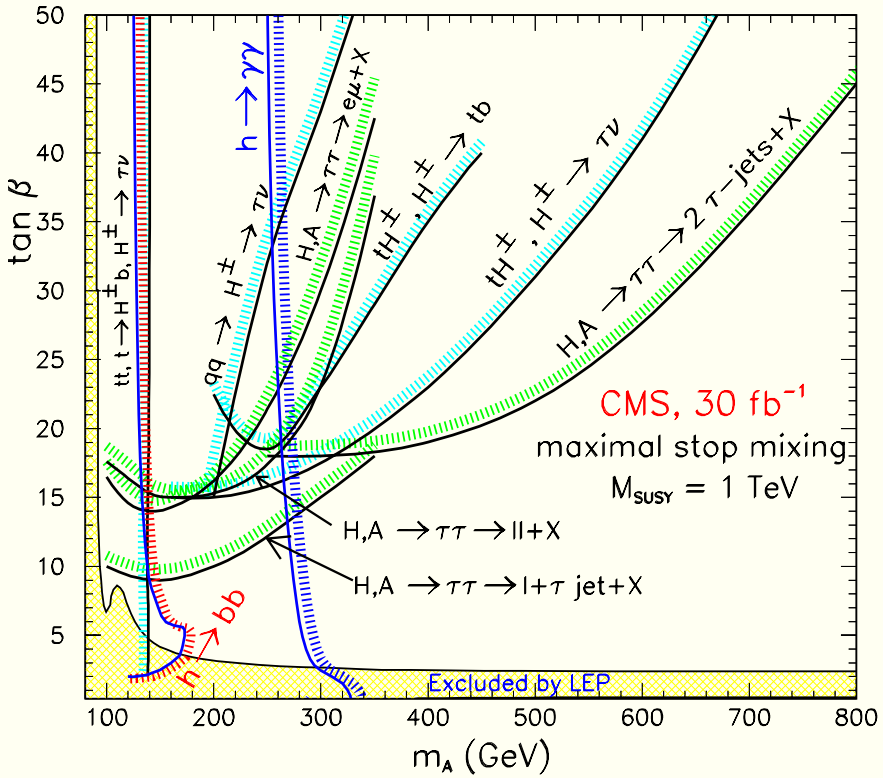
R. Kinnunen

τ jet selection and QCD rejection in the tracker

τ tagging with impact parameter in H -> ττ -> 2 τ-jets

Higgs mass reconstruction

H, A -> ττ -> 2 τ-jets are expected to enlarge the H_{SUSY} discovery reach towards large masses at high tanβ



Fylly hadronic channel:

an efficient hadronic τ trigger needed

QCD background has to be kept under control

We expect ~ 10^{12} QCD jet events for E_t^{j1} , E_t^{j2} > 60 GeV for 60 fb^{-1}

rejection $\gtrsim 10^3$ per jet needed

τ jet identification in the tracker

based on the low multiplicity, 1 (~76%) or 3 (~24%) prongs,

narrowness and, isolation of the τ jet

Hard track cuts:

1 track, p_t> 40 GeV within ΔR< 0.1

around the calo jet axis

2 other tracks or no tracks

with p_t> 1 GeV within ΔR< 0.03

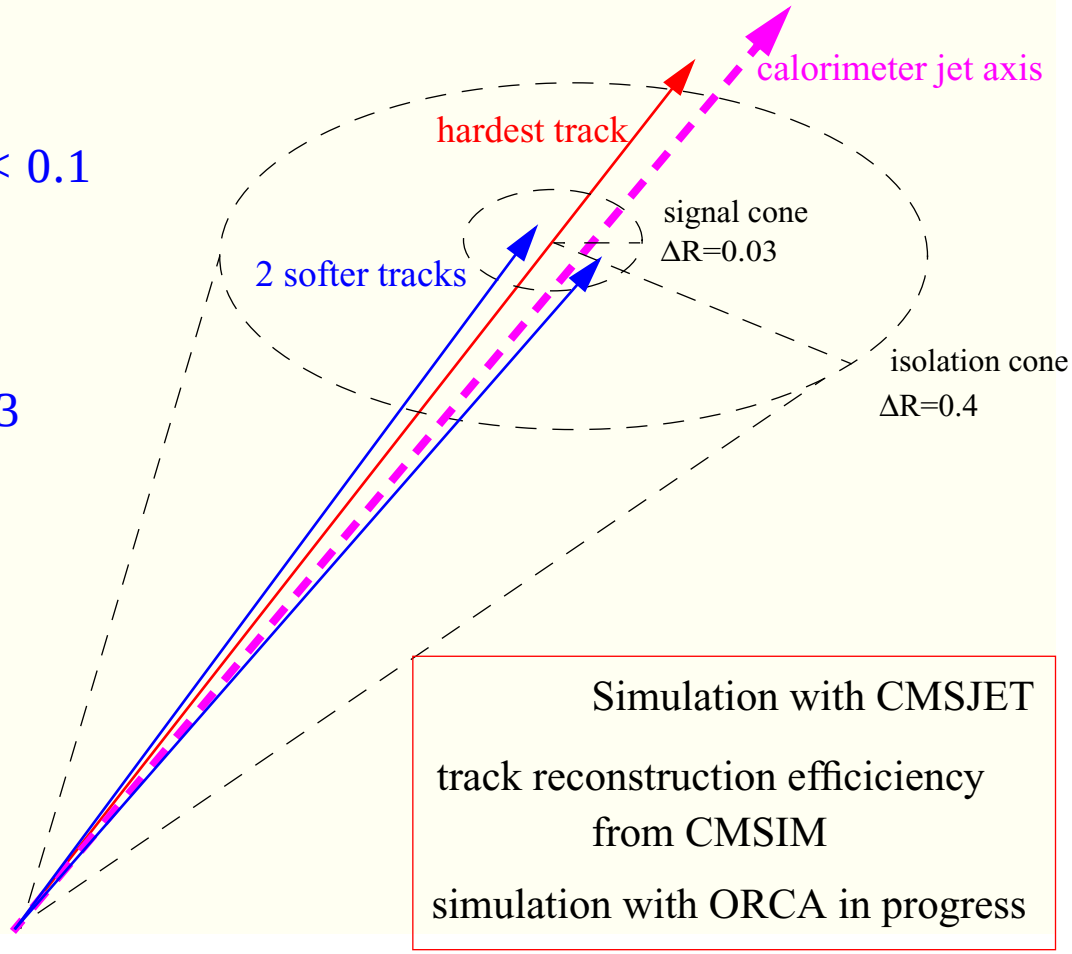
around the hardest track

Isolation:

no track, p_t> 1 GeV , within

0.03 < ΔR < 0.4

around the hardest track



Simulation with CMSJET

track reconstruction efficiciency from CMSIM

simulation with ORCA in progress

QCD jet rejection with isolation

Selection of the isolation and signal cone sizes:

Level3 (Pixel) tau trigger:

using signal cone 0.07 leads to constant efficiency in m_H

May not be possible in off-line:

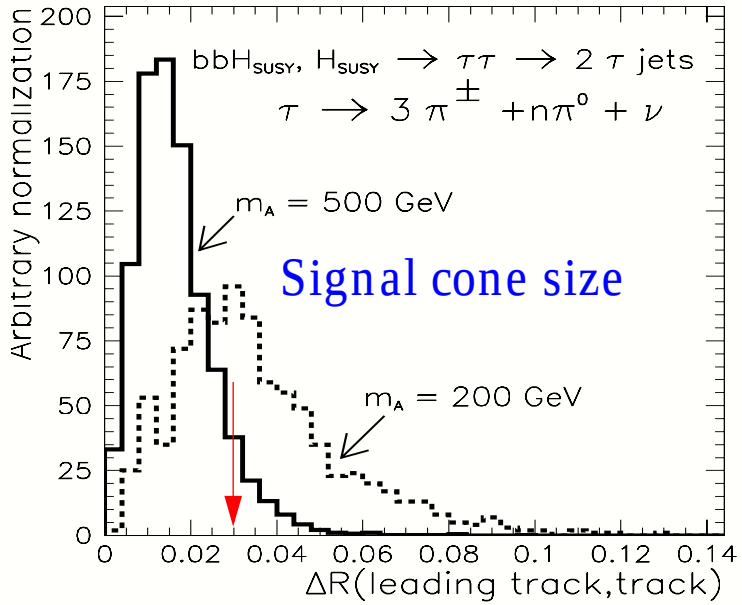
degrates the isolation power against QCD jets

Select signal cone $\Delta r = 0.03$

Efficiency:

93% for $m_A = 500$ GeV

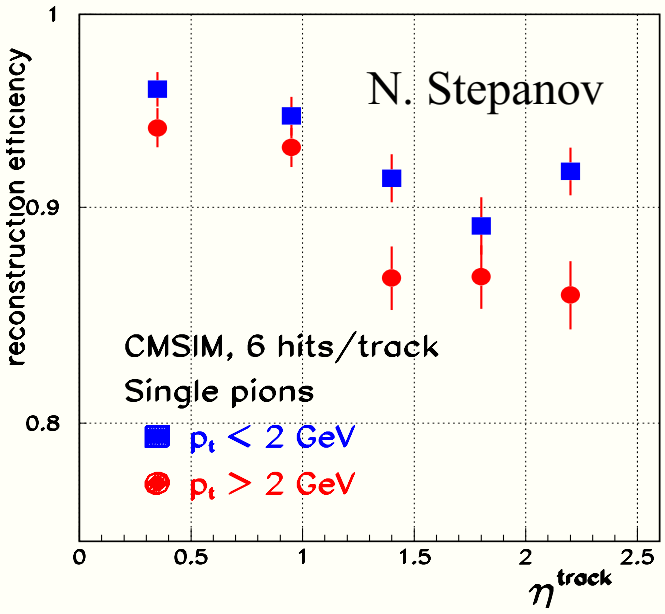
45% for $m_A = 200$ GeV



High track reconstruction efficiency needed

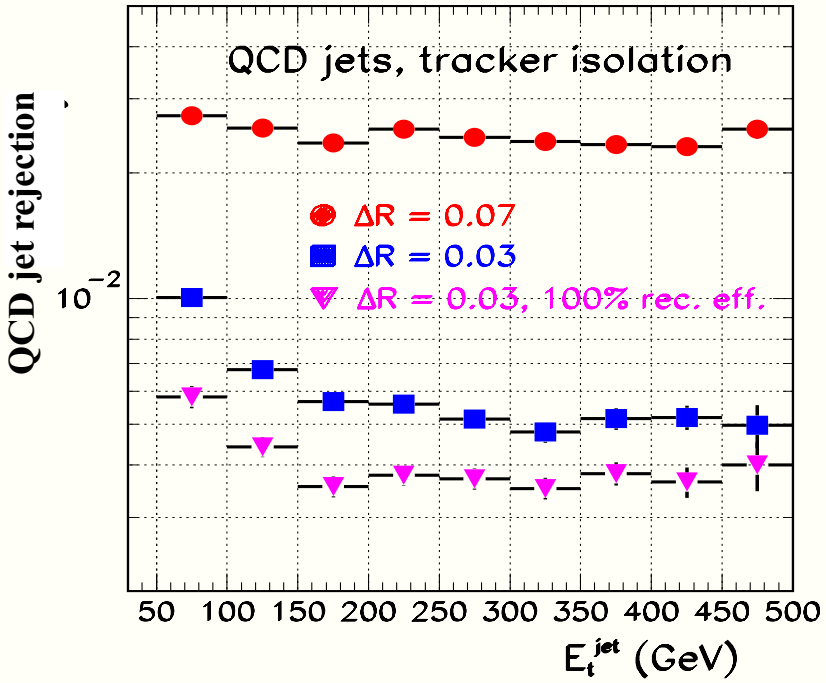
Efficiency with 6 hits/track

CMSIM simulation



QCD jet rejection factor due to isolation

Fast simulation with CMSJET

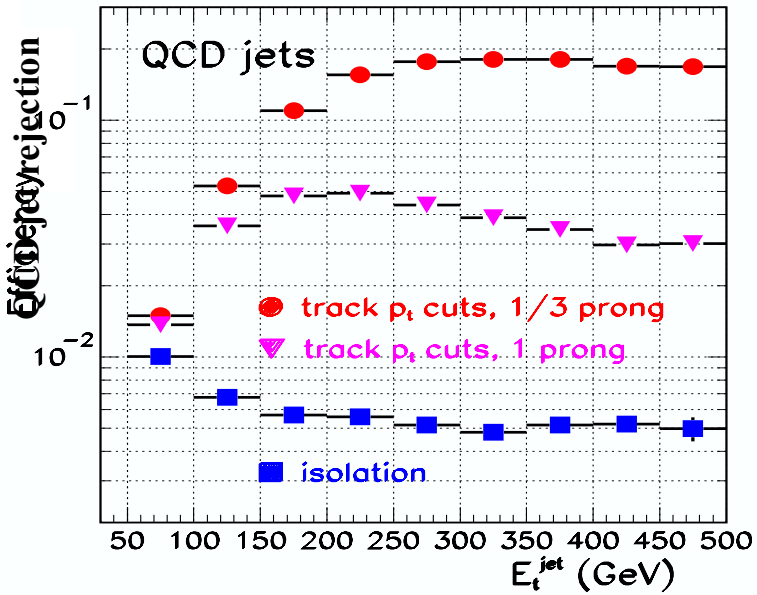


QCD rejection from isolation:

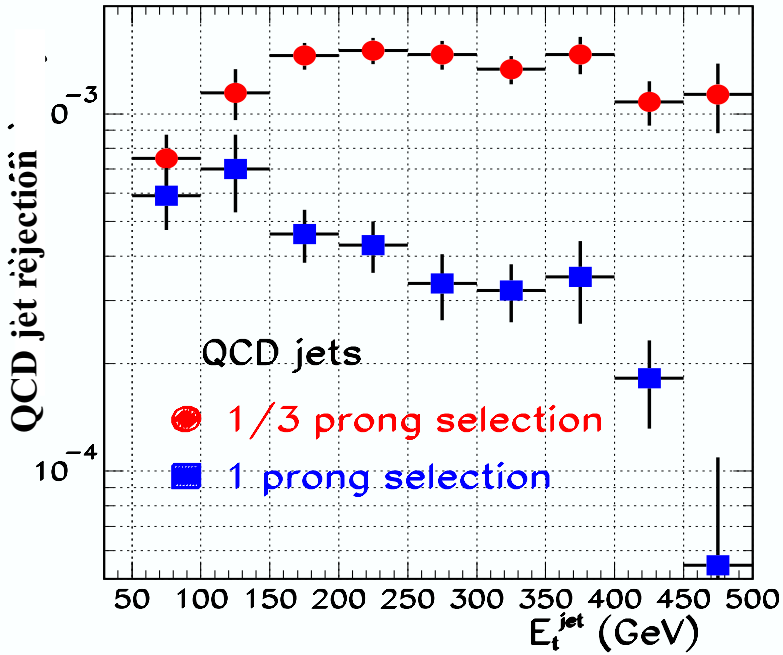
$\gtrsim$ 100 per jet for $E_t^{jet} > 60$ GeV

Rejection factor against QCD jets with isolation and hard track cuts on hadronic τ canditate

Comparison of isolation and hard track cuts



isolation + hard track cuts



Efficiency for the signal events:	isolation	p_t^{max} > 40 GeV	1 prong	1/3 prongs
m_A = 500 GeV	74.6 %	37.4 %	17.4%	34.7 %
m_A = 200 GeV	46.5 %	8.8 %	7.4 %	8.3 %

Full simulation with ORCA

Version 5_4_1

Tracker digidization for QCD samples in the p_t bins:

50 - 80 GeV

80 - 120 GeV

120 - 170 GeV

Jet reconstruction in calorimetry: $\Delta R = 0.5$

Select two highest E_t jets

Reconstruction of full tracker in ORCA_5_4_1 very slow (no regional tracking) ->

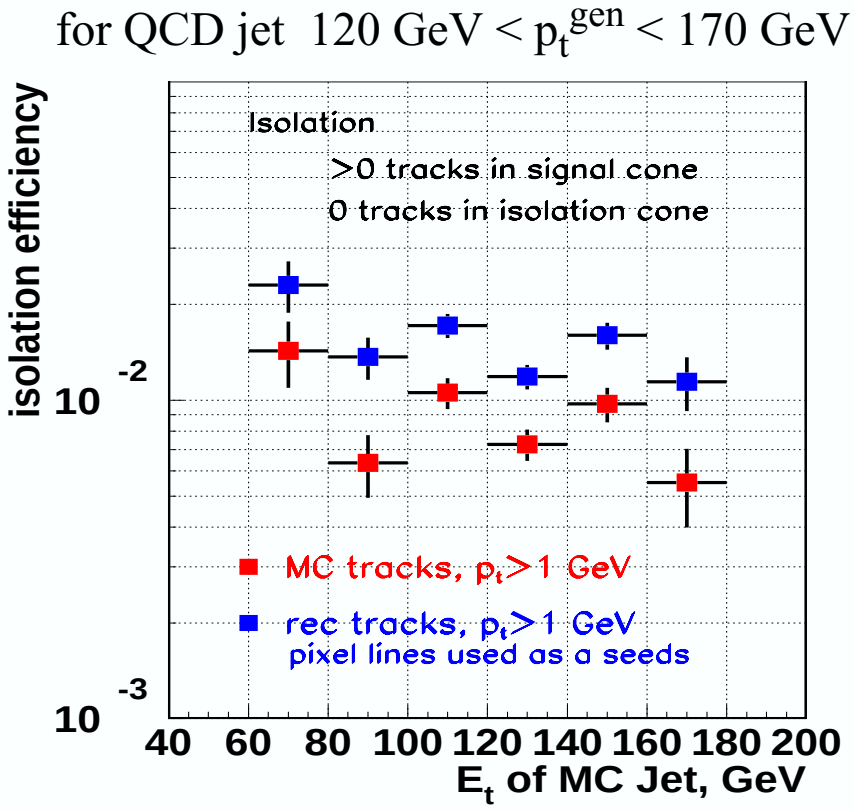
we use pixel lines inside jets as tracker seeds

Need large statistics for QCD, expected rejection ~ 1000 per jet!

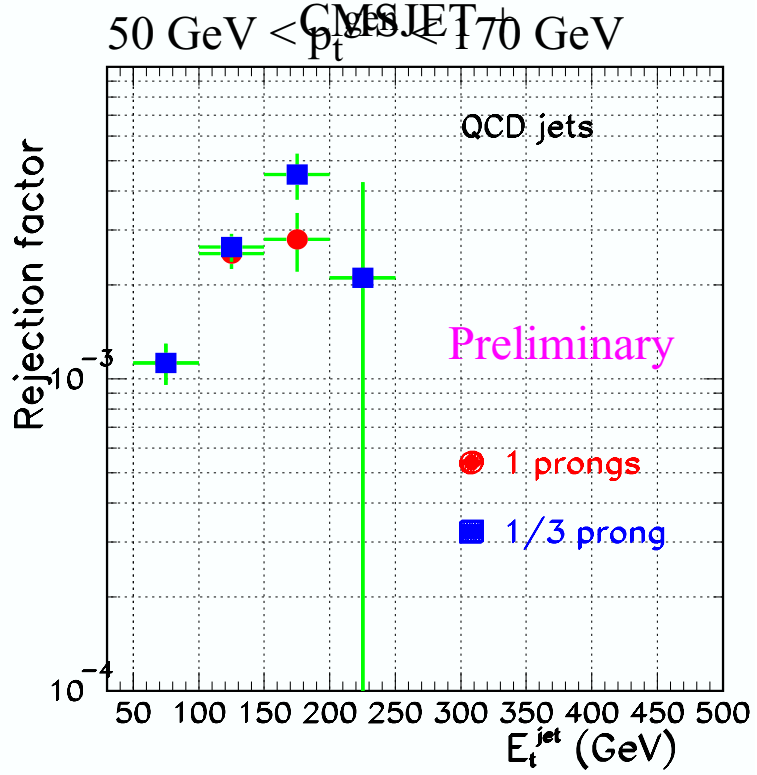
QCD jet rejection with full simulation

ORCA_5_4_1

Isolation in tracker



Isolation + hard track cuts



Selection efficiency for signal, $m_H = 500$ GeV

Efficiencies per event

	ORCA	CMSJET
isolation	54.5 %	74.6%
isolation + 1 track, pt> 40 GeV	18.4 %	17.4 %
isolation+ hard track + ECAL isolation	13.5 %	
isolation+ hard track + ip-cut		
isol.+ hard track + ECAL isol. + ip-cut	9.9 %	
isol.+ hard track + ECAL isol. + ip-cut $+Q_1Q_2<0$	9.4 %	

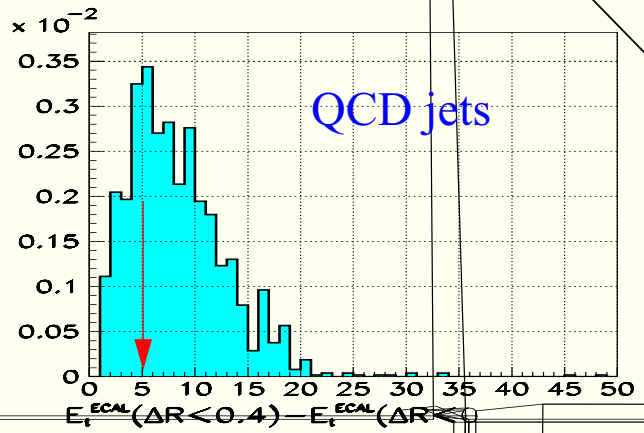
QCD rejection with ECAL isolation, CMS full simulation

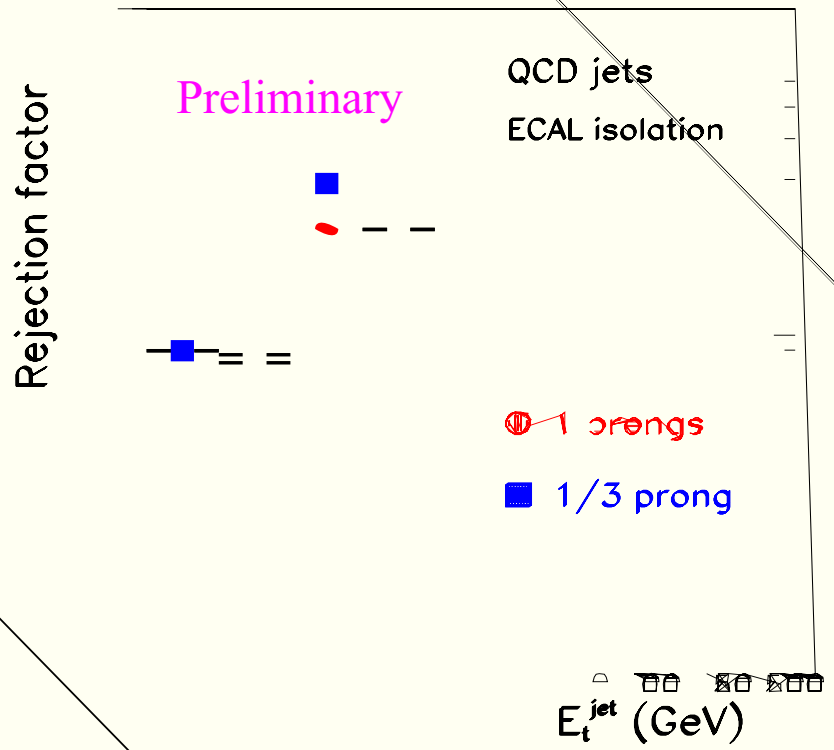
$\Sigma E_t^{\text{ECAL cell}}(\Delta R<0.4) - \Sigma E_t^{\text{ECAL cell}}(\Delta R<0.13) < 5$ GeV

jets isolated in tracker

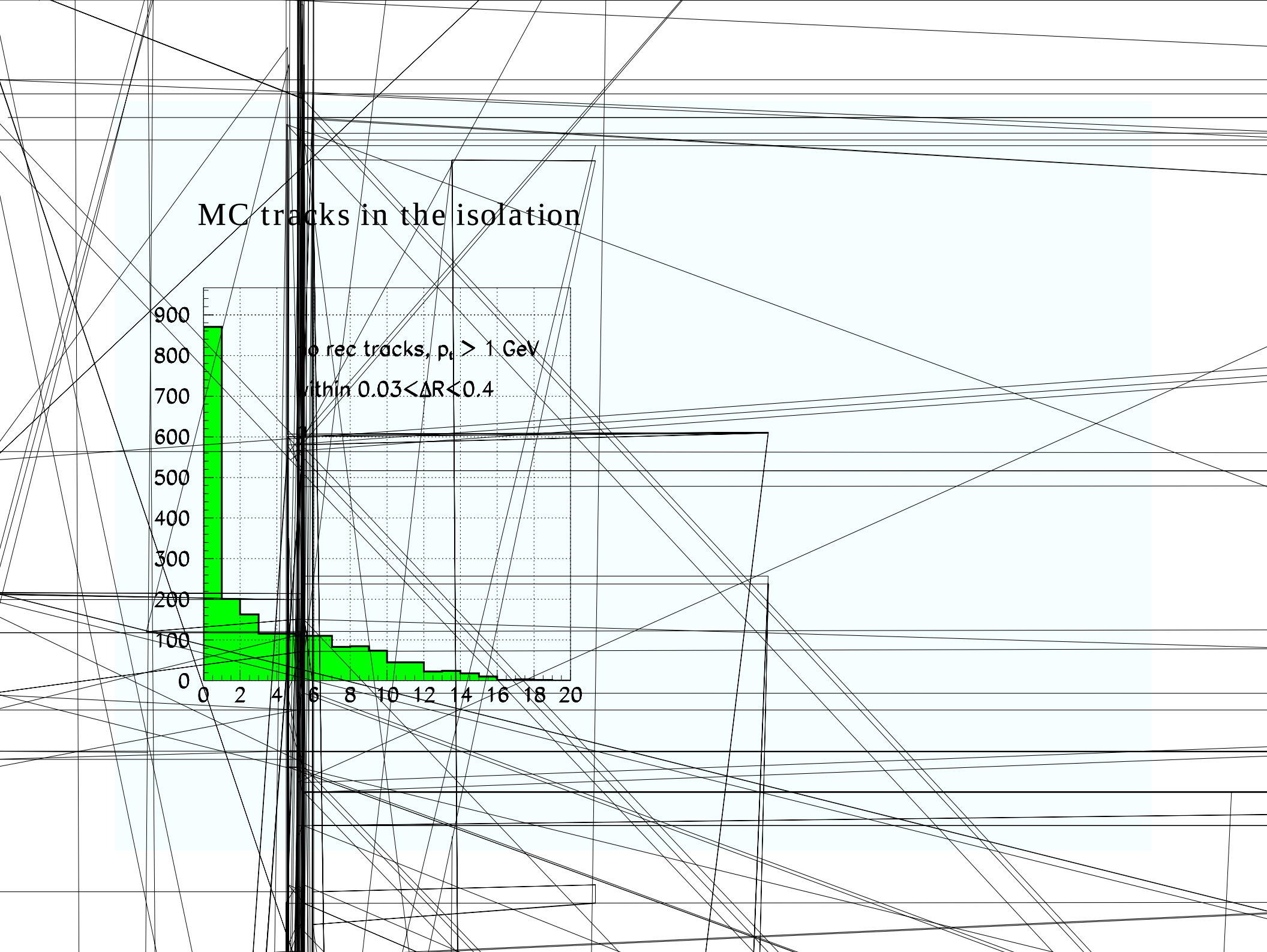
$H \rightarrow \tau\tau$

$m_H = 500$ GeV





Improvement of ~ 2 in the rejection for jets isolated in the tracker


MC tracks in the isolation
900
800
700
600
500
400
300
200
100
0
0 2 4 6 8 10 12 14 16 18 20

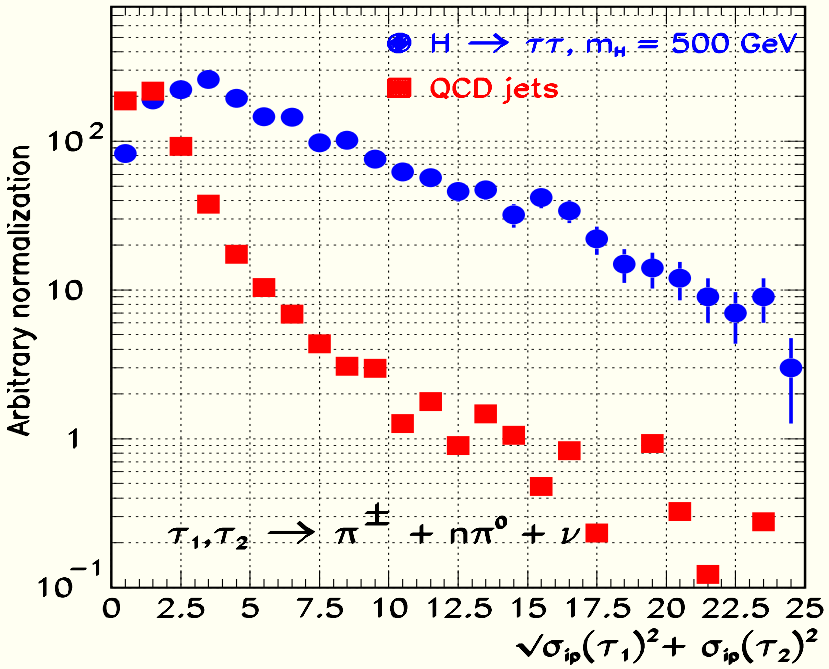
τ tagging with impact parameter

Track ip-measurements in jet1 and jet2 can be combined into one variable

$$\sigma_{12} = \sqrt{\sigma_{ip}(\tau_1)^2 + \sigma_{ip}(\tau_2)^2}$$

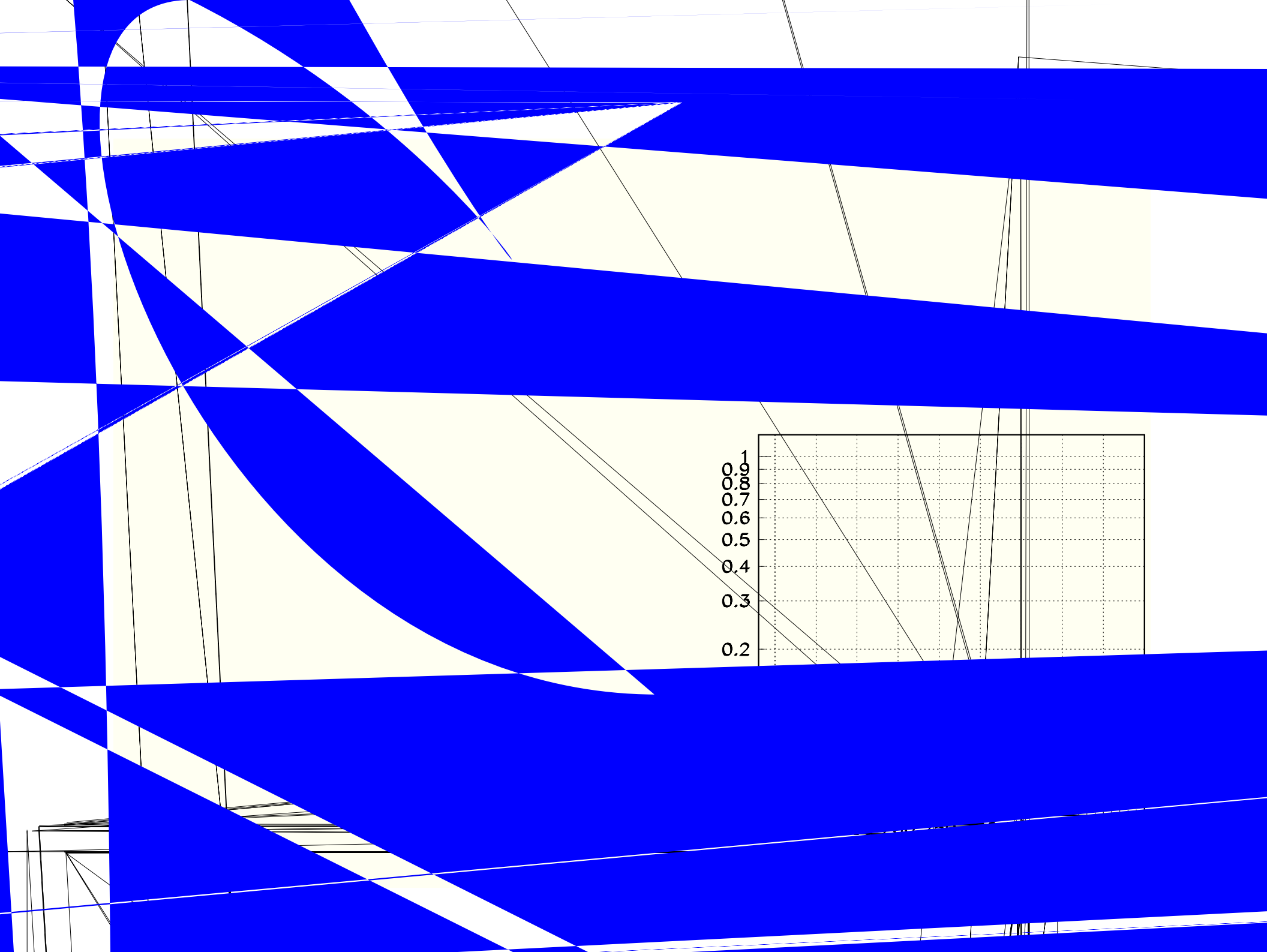
where $\sigma_{ip}(\tau_1)$ and $\sigma_{ip}(\tau_1)$ are the impact parameter significancies, ip/Δ(ip), for tracks from τ_1 and τ_2

σ_{12} with leading track in jet



Full CMS simulation:

QCD rejection of 5 - 10 is expected from τ tagging


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2

Higgs mass reconstruction in H -> ττ, τ –> τ jet + ν

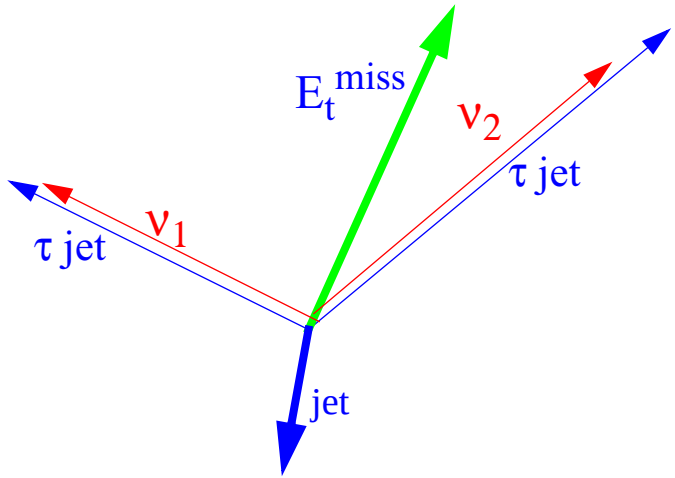
from the visible τ momenta (τ jets) and E_t^{miss}

Assumption: $\nu_1 \parallel \tau_1$ and $\nu_2 \parallel \tau_2$, $\Delta\phi(\tau_1,\tau_2) \neq 180^o$

$p_{\nu 1}$ and $p_{\nu 2}$ can be resolved from

$$E_x^{miss} = |\nu_1|\,\hat{\tau}_{1x} + |\nu_2|\,\hat{\tau}_{2x}$$

$$E_y^{miss} = |\nu_1|\,\hat{\tau}_{1y} + |\nu_2|\,\hat{\tau}_{2y}$$



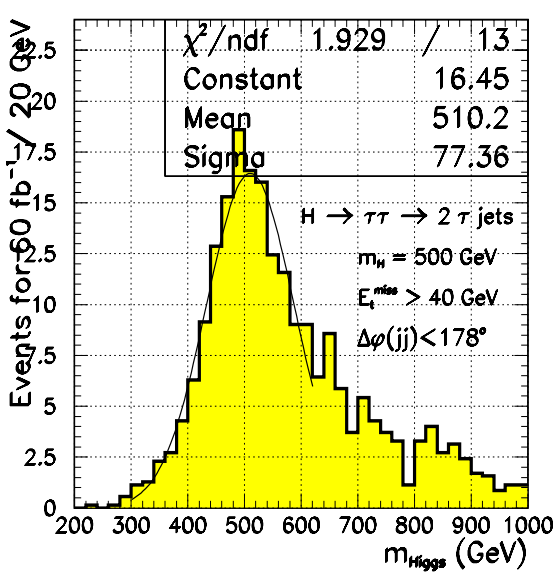
Good solution for p_ν with

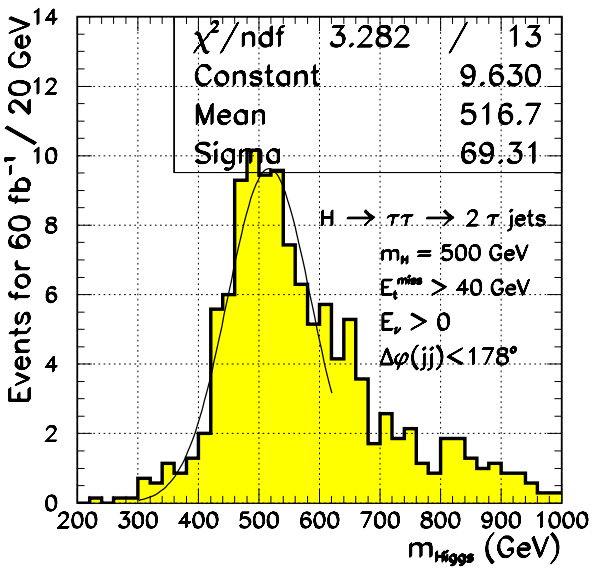
$$\Delta\phi(\tau_1,E_t^{miss}) + \Delta\phi(\tau_2,E_t^{miss}) < 180^o$$

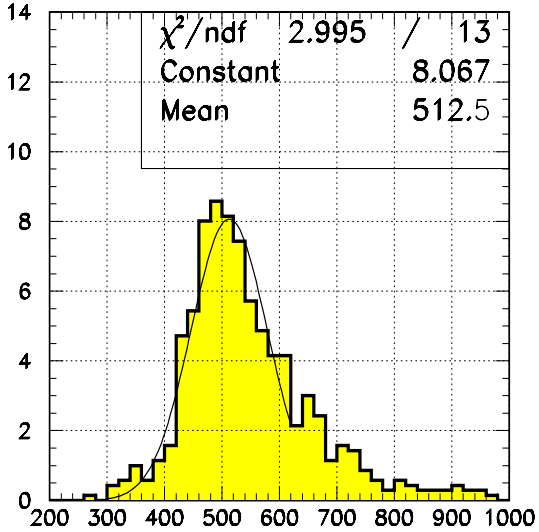
Large measurement errors on E_t^{miss} → $E_\nu < 0$

For $\Delta\phi(\tau_1,\tau_2) < 178^o$

$E_{\nu 1}$ or $E_{\nu 2} < 0$ for 45% (57%) of events with m_A = 500 (200) GeV


χ^2/ndf 1.929 / 13
Constant 16.45
Mean 510.2
Sigma 77.36
H → ττ → 2 τ jets
m_H = 500 GeV
E_t^{miss} > 40 GeV
Δφ(jj)<178°
Events for 60 fb^{-1} / 20 GeV
m_{Higgs} (GeV)


χ^2/ndf 3.282 / 13
Constant 9.630
Mean 516.7
Sigma 69.31
H → ττ → 2 τ jets
m_H = 500 GeV
E_t^{miss} > 40 GeV
E_ν > 0
Δφ(jj)<178°
Events for 60 fb^{-1} / 20 GeV
m_{Higgs} (GeV)


χ^2/ndf 2.995 / 13
Constant 8.067
Mean 512.5

Reconstructed Higgs mass for A,H -> ττ -> 2 τ jets + 1 b jet + X

Event selection cuts:

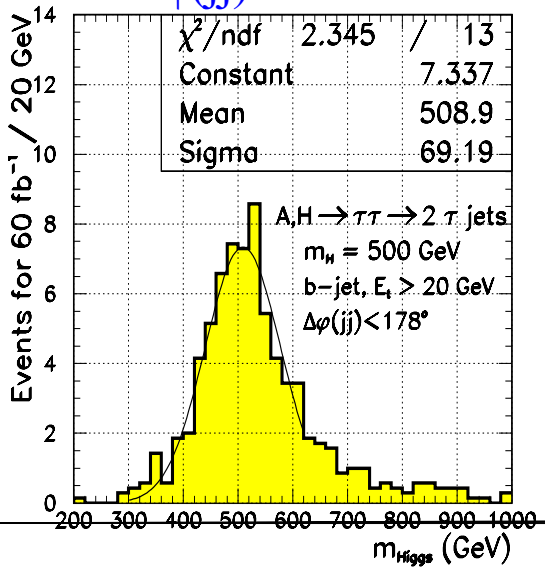
2 τ jets, $E_t > 60$ GeV

τ identification in tracker, τ impact parameter cuts

one b jet, $E_t > 20$ GeV

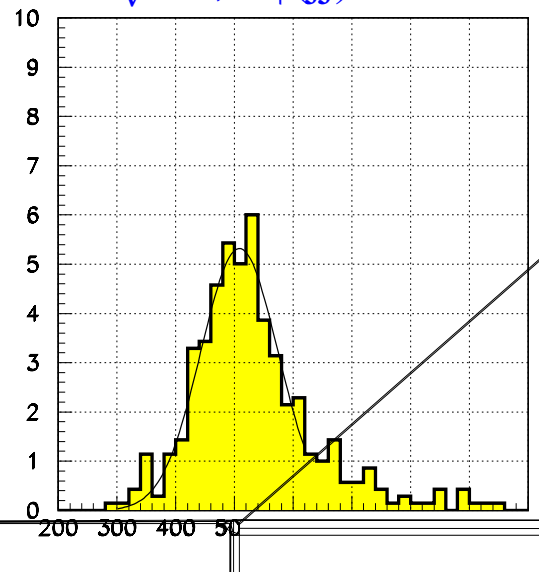
veto for a 4th jet, $E_t > 40$ GeV

$\Delta\phi(jj) < 178^o$



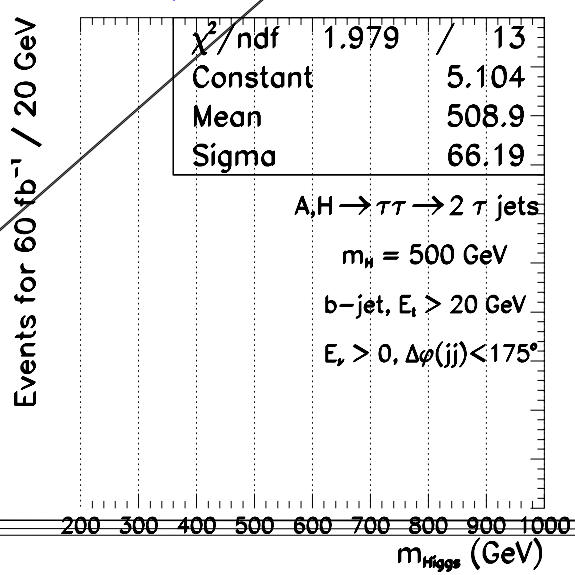
σ = 13.6%, eff = 93%

$E_\nu > 0, \Delta\phi(jj) < 178^o$

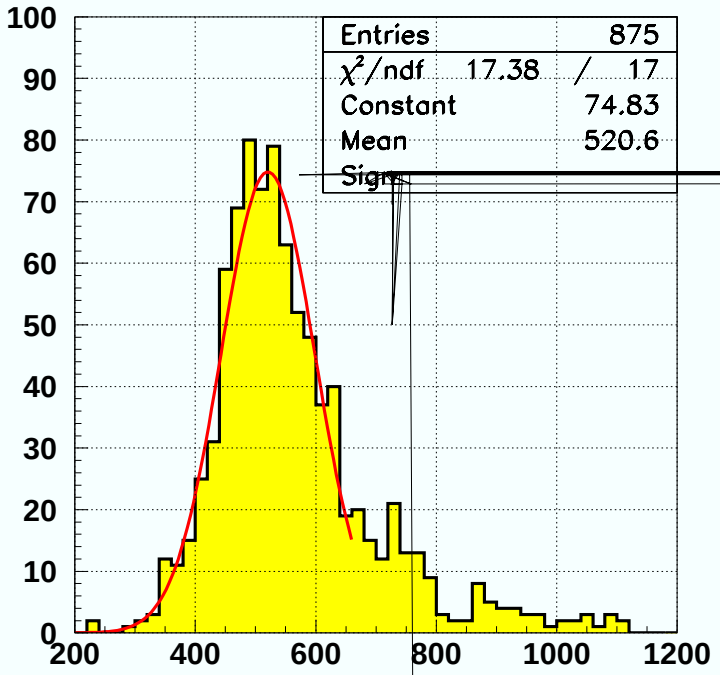


σ = 12.9%, eff = 62%

$E_\nu > 0, \Delta\phi(jj) < 175^o$



σ = 13.0%, eff = 58%


Entries 875
χ²/ndf 17.38 / 17
Constant 74.83
Mean 520.6
Sigma
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200

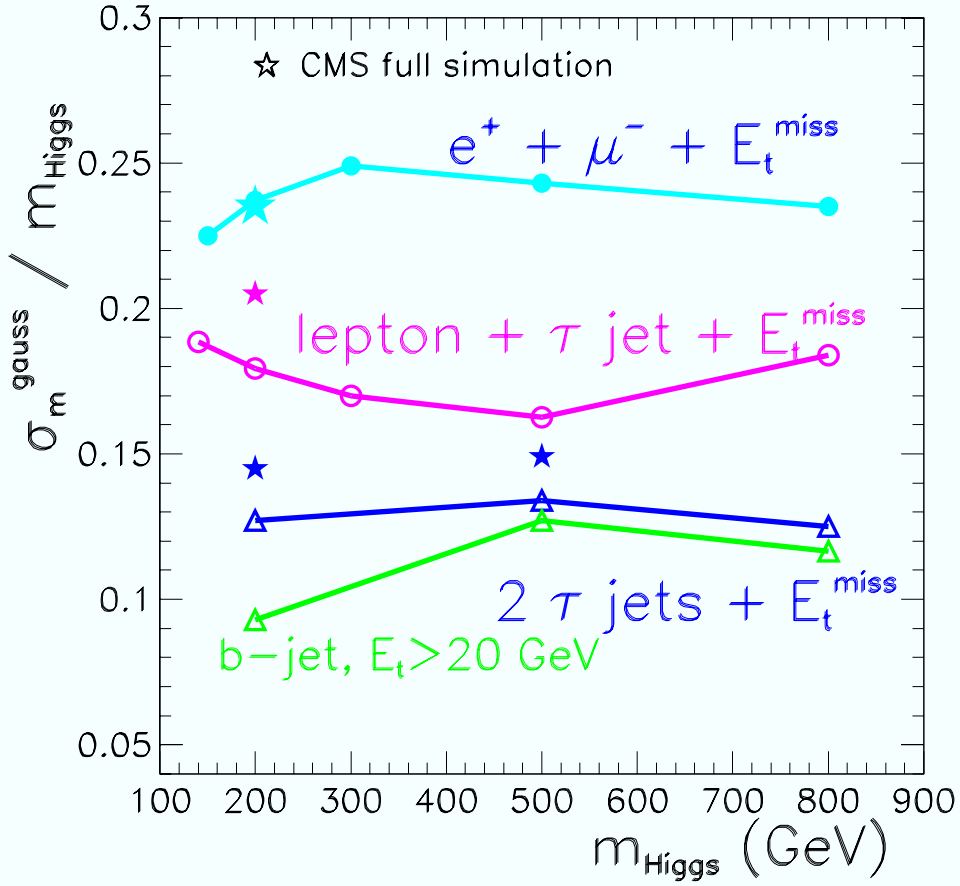
Higgs mass resolution in H -> ττ as a function of m_H

Mass resolution dominated by E_t^{miss} measurement

-> resolution best for

H -> ττ -> 2 τ-jets

with smallest fraction of H energy in neutrinos

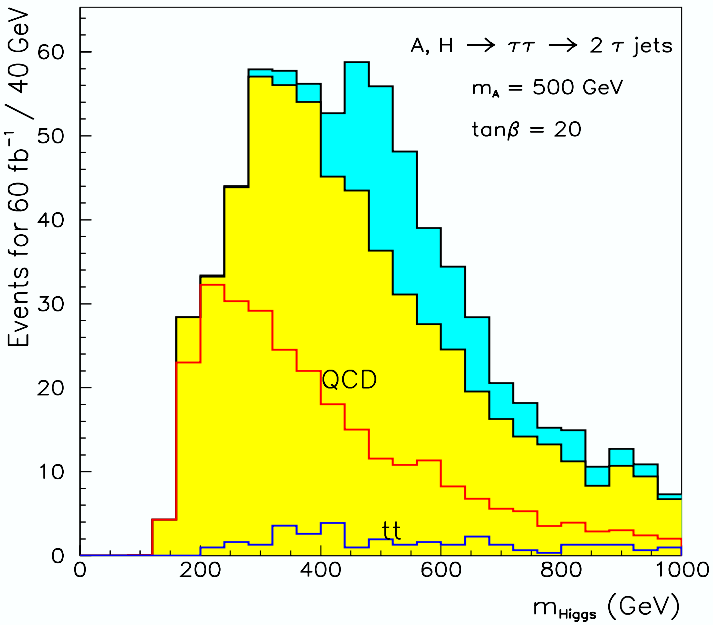


Signal superimposed on the total background for 60 fb^{-1}

Preliminary

$E_t^{miss} > 40$ GeV

QCD rejection from ORCA: 13

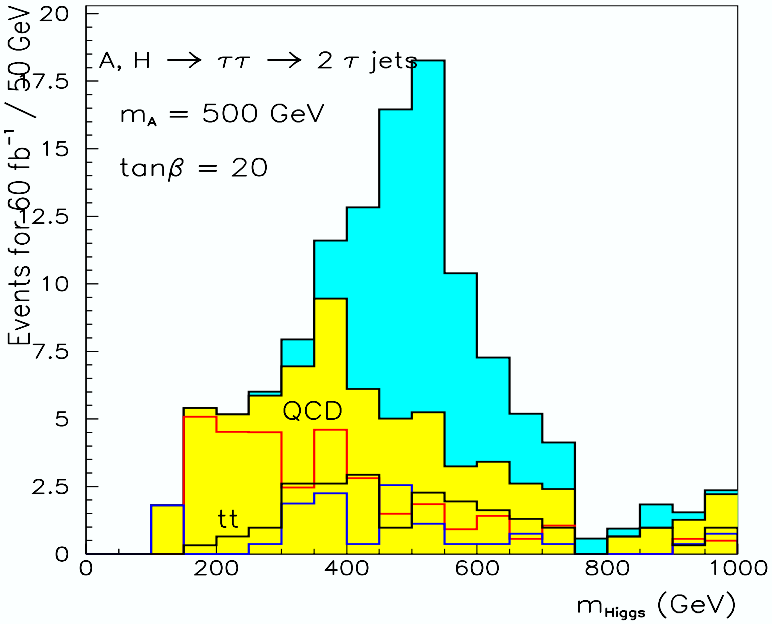


Events fo 60 fb^{-1}

Signal	90	
Z,γ*	100	
QCD	70	(E_t^{mis} rejection 13)
$t\bar{t}$	20	

One tagged b-jet, $E_t > 20$ GeV

No E_t^{mis} cut



Signal	51
Z,γ*	2
QCD	10
$t\bar{t}$	9

Conclusions

Work in progress for
ORCA simulation of τ jet identification in the tracker

ORCA version 6 with regional tracking needed for conclusions

If QCD rejection confirmed by ORCA the reach may be

$\tan\beta \gtrsim 15$ at $m_A = 200$ GeV

$\tan\beta \gtrsim 20$ at $m_A = 500$ GeV