



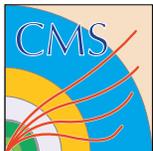
Lvl-2 and Lvl-3 Tau algorithms

A. Nikitenko CERN EP / ITEP Moscow. JETMET meeting 12.02.01

A case study:

SUSY Higgs selection in $gg \rightarrow (bb)A/H$, $A/H \rightarrow 2\tau \rightarrow 2j$ at $L=10^{34} \text{ cm}^{-2}\text{s}^{-1}$
from L1 to tape.

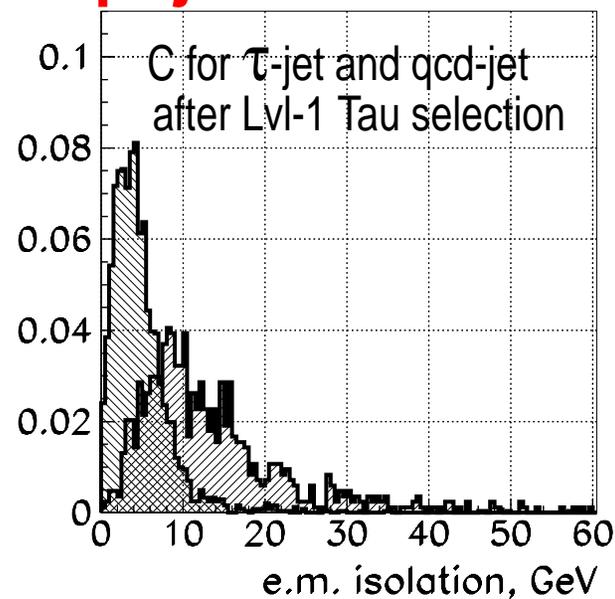
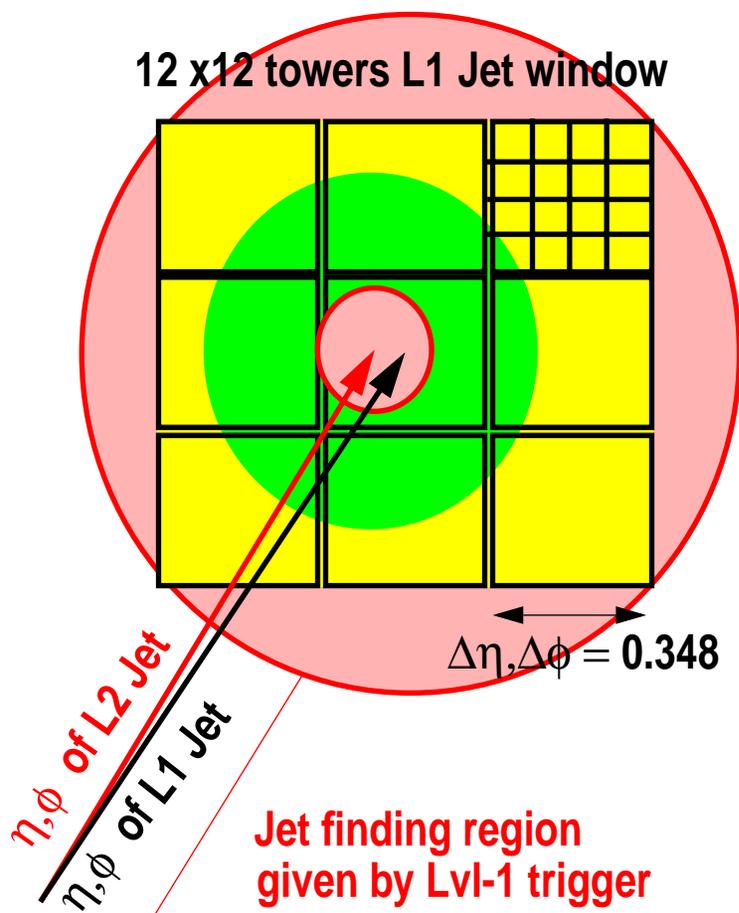
- Lvl-2 Tau identification with calorimeter
- Lvl-3 Tau identification with Pixel Detector



Tau identification at Lvl-2

Narrowness of τ jets :

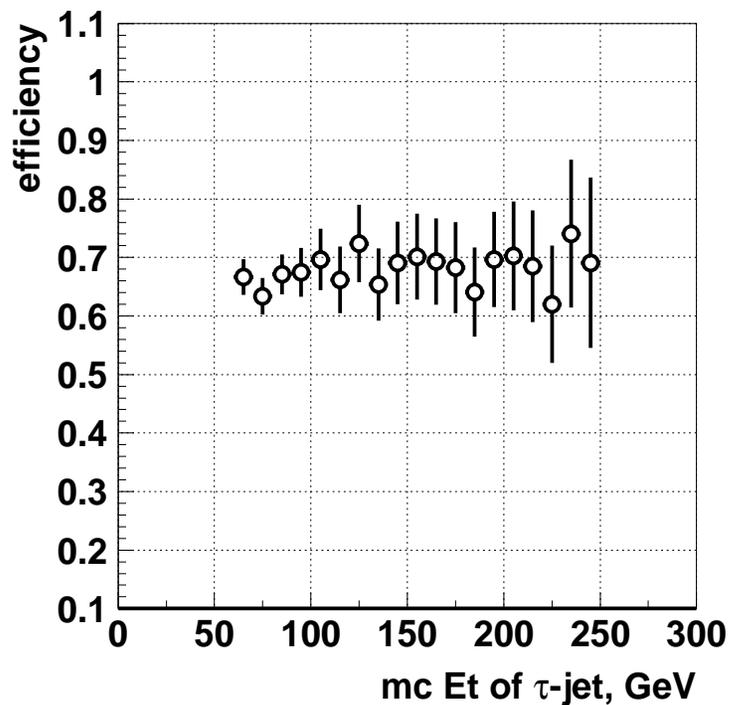
- reconstruct jet in region given by Lvl-1 trigger
- use $C = \sum E_T^{\text{em}} (0.13 < R < 0.40)$
- accept jet as τ if $C < C^{\text{max}}$



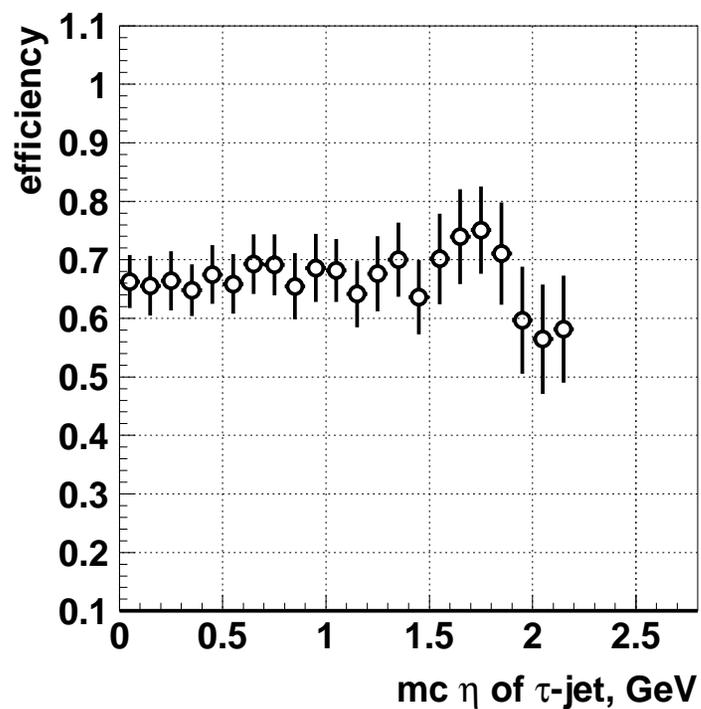


Lvl-2 Tau algorithm performance (I)

Efficiency vs $E_T(\tau\text{-jet})$



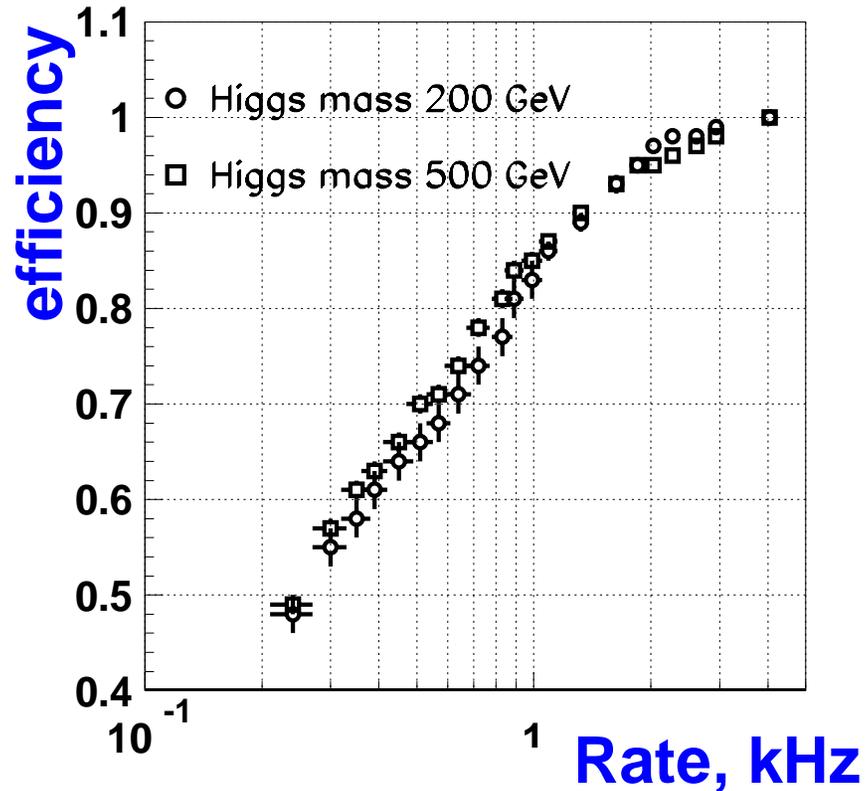
Efficiency vs η (τ -jet)





Lvl-2 Tau algorithm performance (II)

- for a 200-500 GeV Higgs, a factor 10 reduction in rate with respect to Lvl-1 implies a Lvl-2 efficiency $\sim 65\%$
- this is using only calorimeter data



Lvl-2 Tau study is summarized in CMS Note 2000/055



How select τ jet at Lvl-3 ?

Tracker isolation of τ jet candidate as
a next step to reduce rate and select τ 's

Track/vertex finding with Pixel Detector only.

Pixel data is $\sim 10\%$ of all tracker data =>

simple and fast

algorithm and orca code by D. Kotlinski PSI, cms in 2000/022

we try 3 pixel layer setup at $L=10^{34} \text{ cm}^{-2}\text{s}^{-1}$



most dangerous QCD p_t bins after Lvl-1,2

Rate after Lvl-1 (1Tau || 2 Tau) and Lvl-2 Tau trigger

	QCD P_T bins							
P_T , GeV	30-50	50-80	80-120	120-170	170-230	230-300	300-380	380-470
Rate, Hz	16.4	77.2	207.3	127.5	23.5	5.0	1.2	0.2
Total Rate, Hz	450 +/- 40 (stat) events / second							

~ 92 % of the total rate comes from QCD of $p_t = (50 - 170)$ GeV

We are digitizing tracker for qcd bins :

50 - 80 GeV running

80 - 120 GeV done. results in this talk !

120 - 170 GeV done

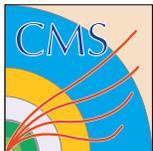
filtered by Lvl-1 and Lvl-2 Tau trigger

CaloDigi - 0.6 MB / ev

MCInfo - 0.4 MB / ev (trig. event)

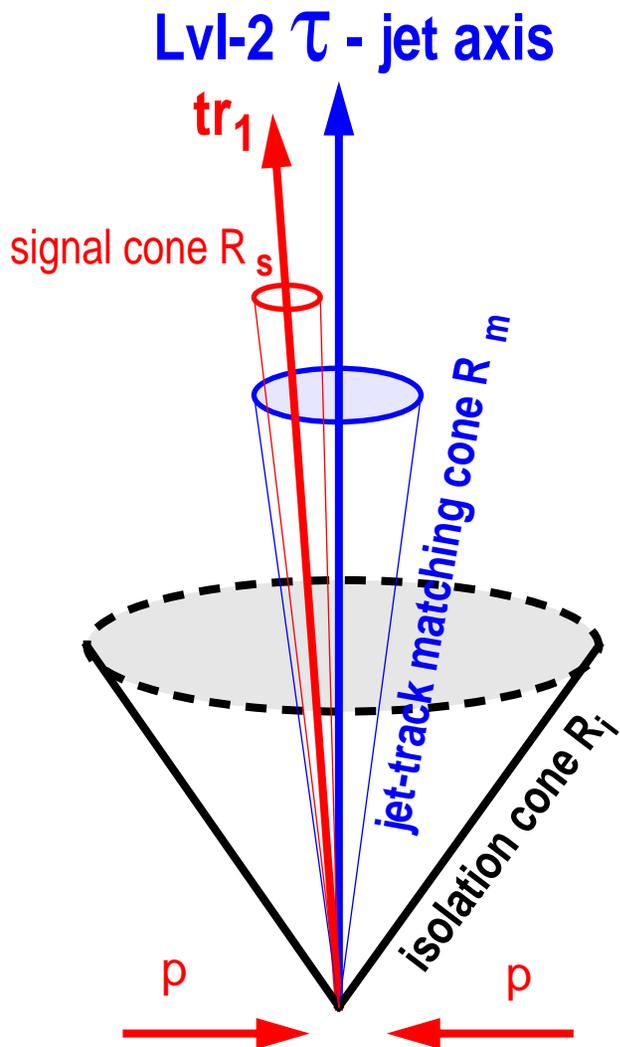
TkDigi - 3.6 MB / ev

~ 5 min / ev on 600 MHz Pentium III
for tracker digitization



Tau identification at Lvl-3

Algorithm steps



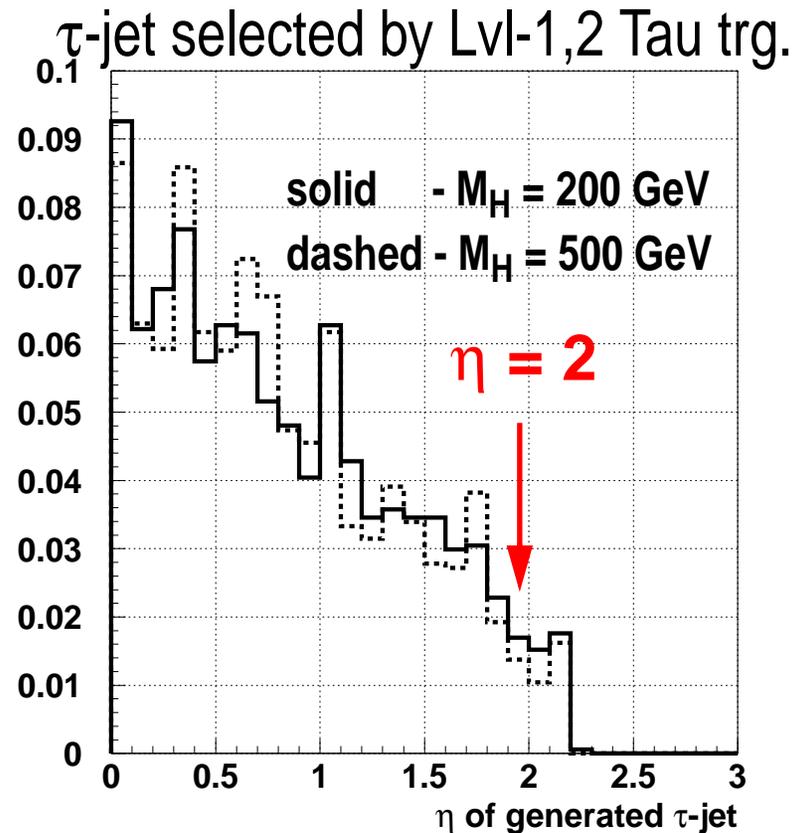
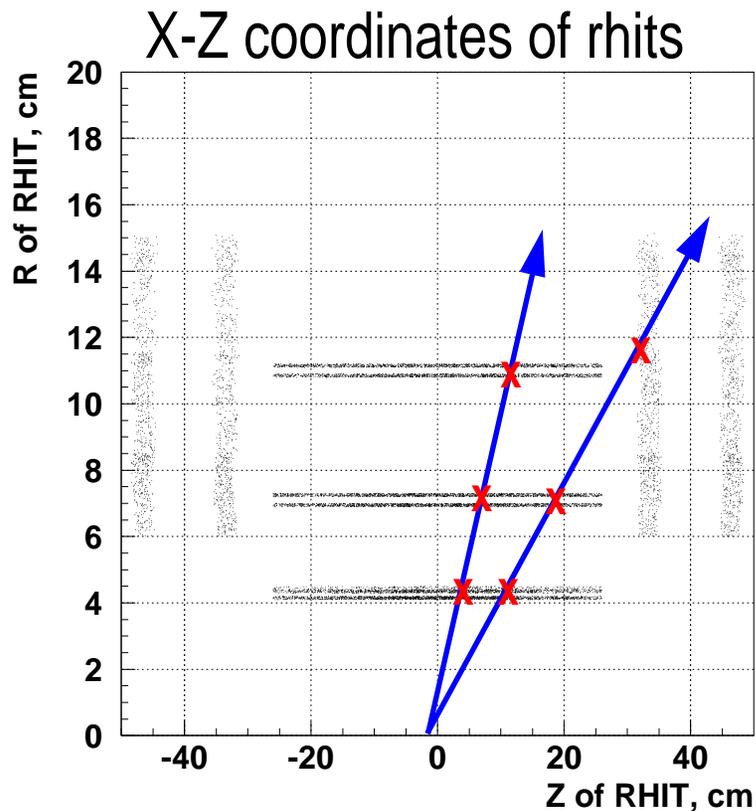
- reconstruct tracks $p_t > 1$ GeV with pixels only
resolution : $\sigma(p_t)/p_t = [3.6 + 1.7p_t(\text{GeV})]\%$
- find primary vertices (histogramming method)
- find highest p_t track with good Lvl-2 jet matching
 $\Delta R(j - tr_1) < R_m$ (~ 0.1) , $p_t^{tr1} > p_t^m$ (~ 3 GeV),
 tr_1 defines signal primary vertex (PV)
- count number of tracks from PV in the isolation cone and signal cone :
 N_i tracks with $\Delta R(j - tr) < R_i$ (~ 0.3) ,
 N_s tracks with $\Delta R(tr_1 - tr) < R_s$ (~ 0.05) ,
 $p_t^{tr} > p_t^i$ (~ 1 GeV)
- accepts as τ if tracks found only in signal cone
 $N_s = N_i$

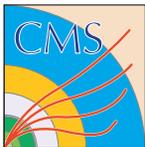


η coverage

present pixel track finder works up to $|\eta| < 2$

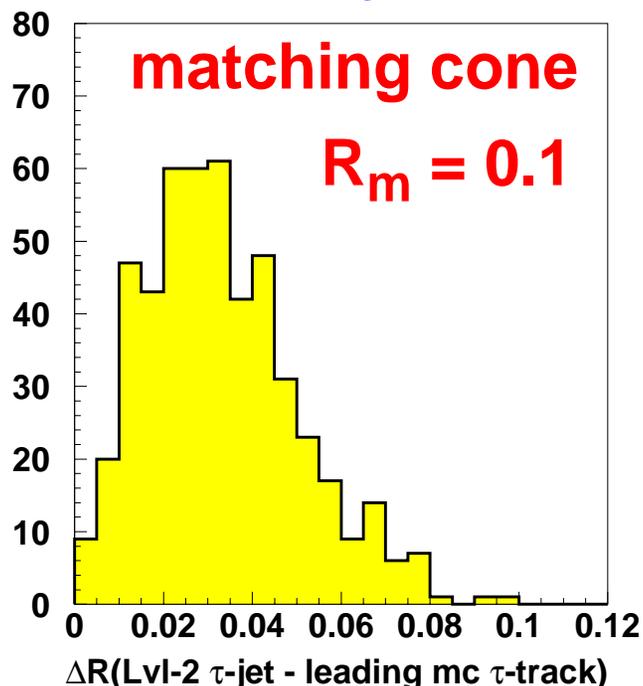
2 hits have to be in the barrel,
the 3-rd hit can be in the barrel or 1-st disk



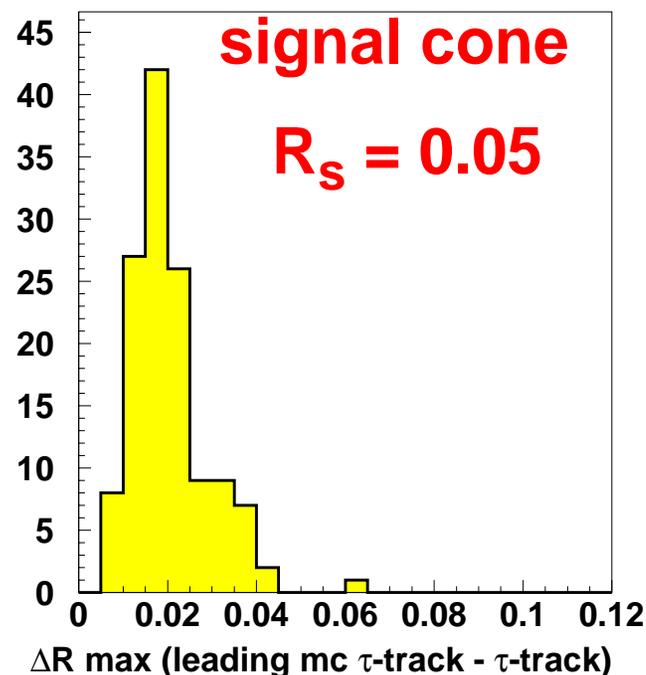


choice of algorithm parameters (I)

Matching between
Lvl-2 Tau jet and
highest p_t tau track



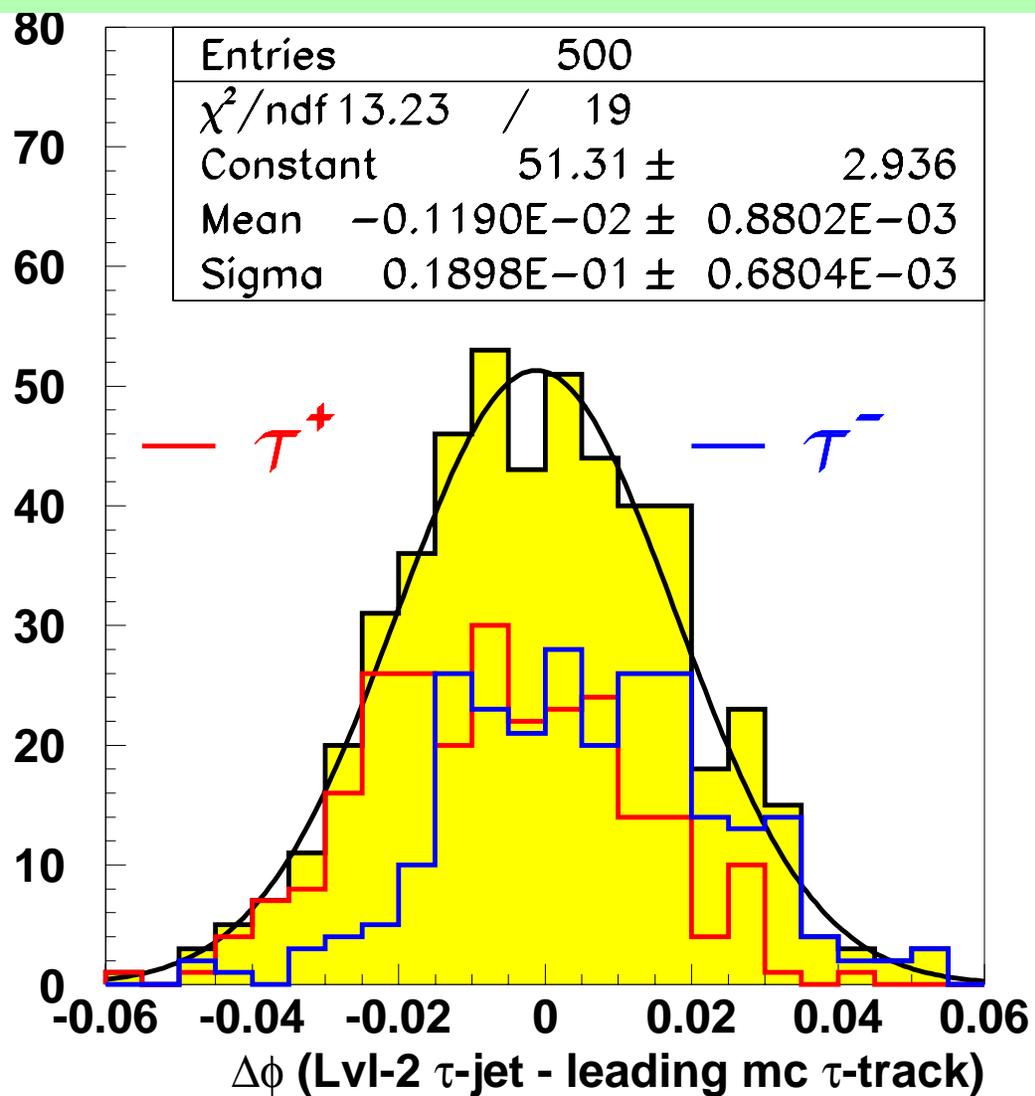
Distance between
highest p_t tau track
and other tau tracks

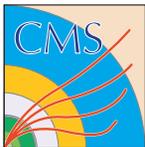


this is for Higgs of 500 GeV after Lvl-1,2 filter



Jet-track matching in ϕ and charge of τ

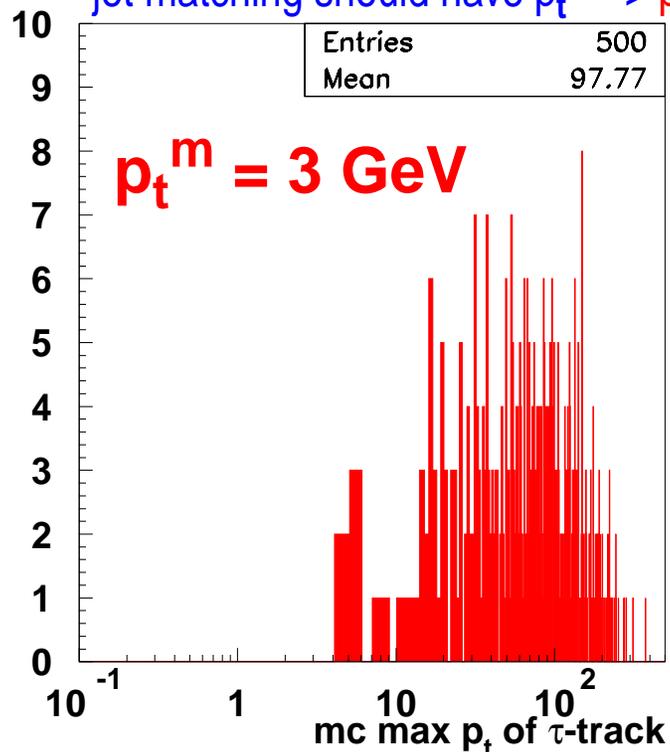




choice of algorithm parameters (II)

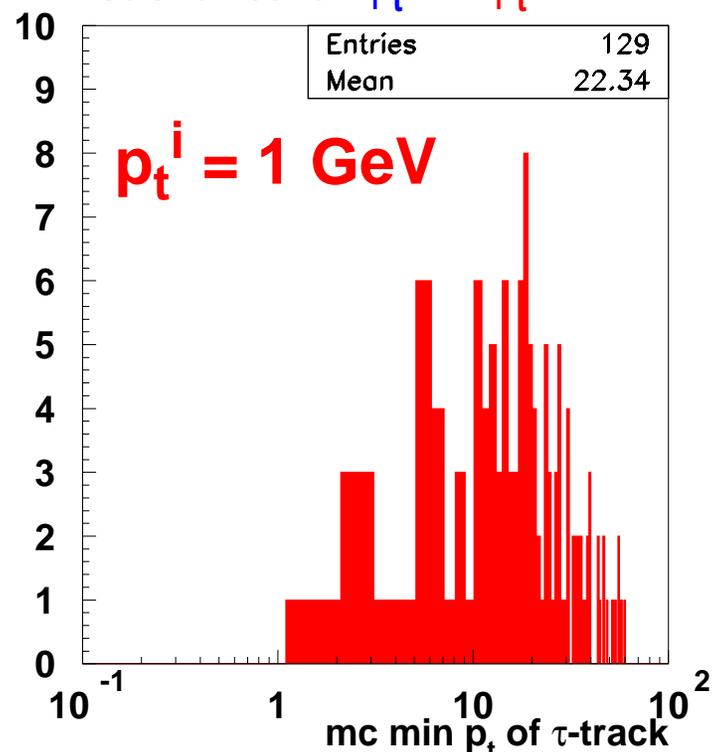
Highest p_t tau track

Highest p_t track with good Lvl-2 Tau jet matching should have $p_t^{\text{rec}} > p_t^{\text{m}}$



Lowest p_t tau track

count tracks from PV in signal and isolation cone if $p_t^{\text{rec}} > p_t^{\text{i}}$

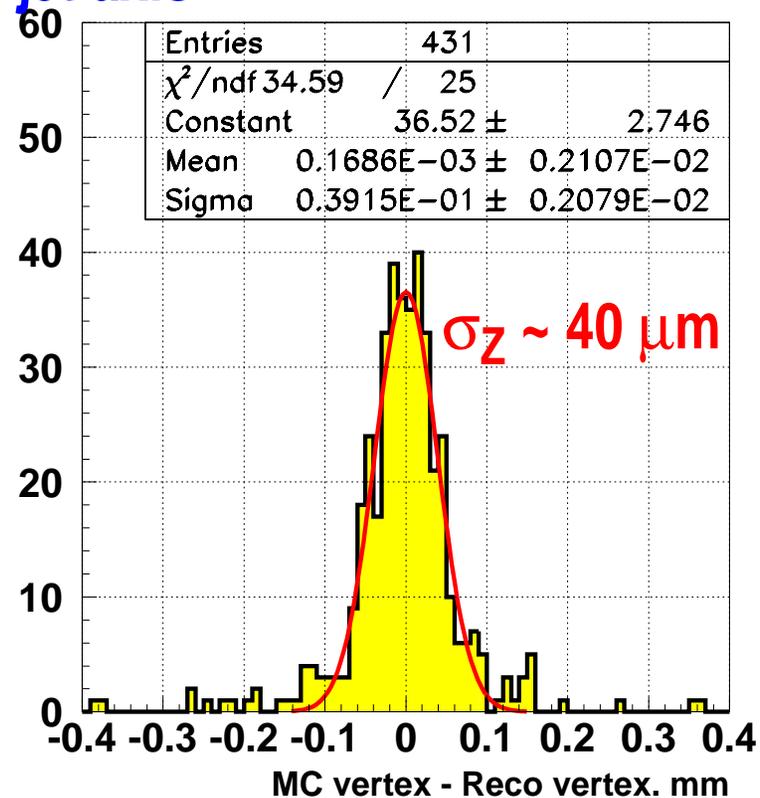


this is for Higgs of 500 GeV after Lvl-1,2 filter



Signal Primary Vertex (PV) finding

- all PVs are found with histogramming method
- signal PV is defined by highest P_t track with good η , ϕ matching with Lvl-2 Tau jet axis

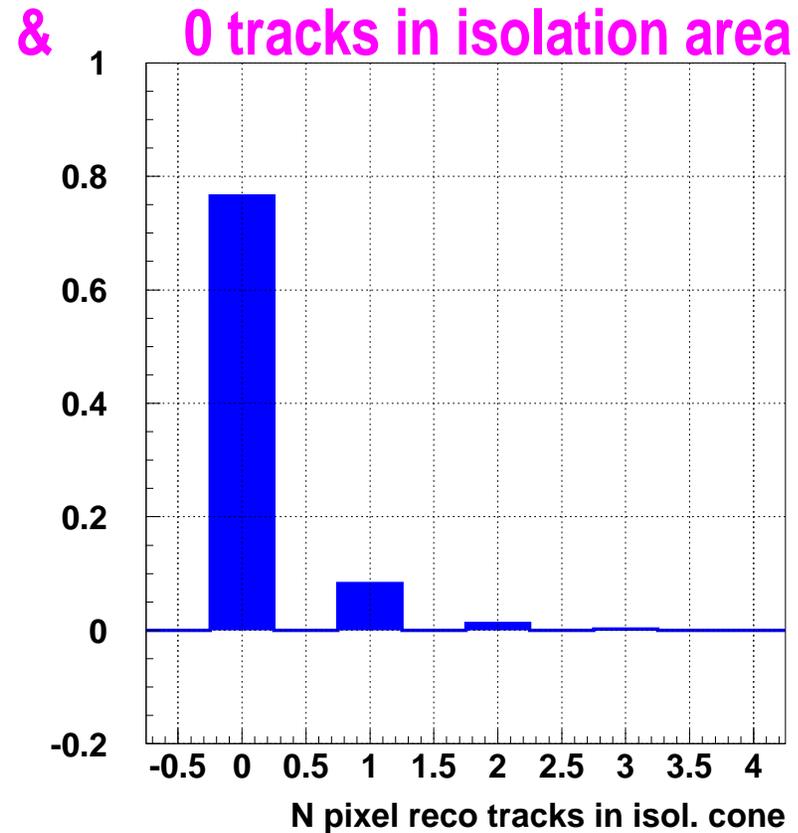
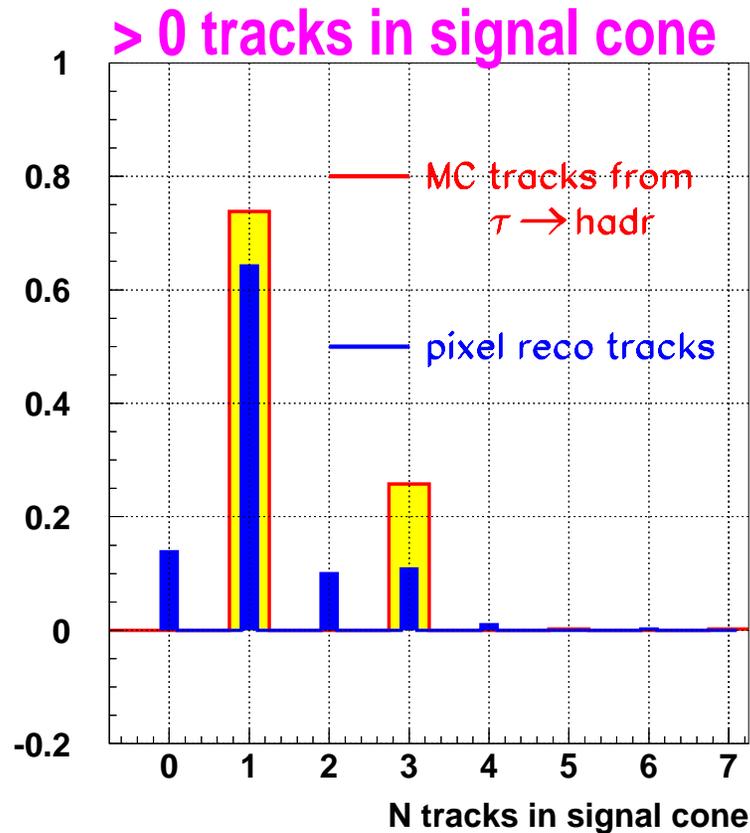


this is for Higgs of 500 GeV after Lvl-1,2 filter. high lumi



Tau selection efficiency at Lvl-3

Lvl-3 τ jet selections with Pixel Detector :



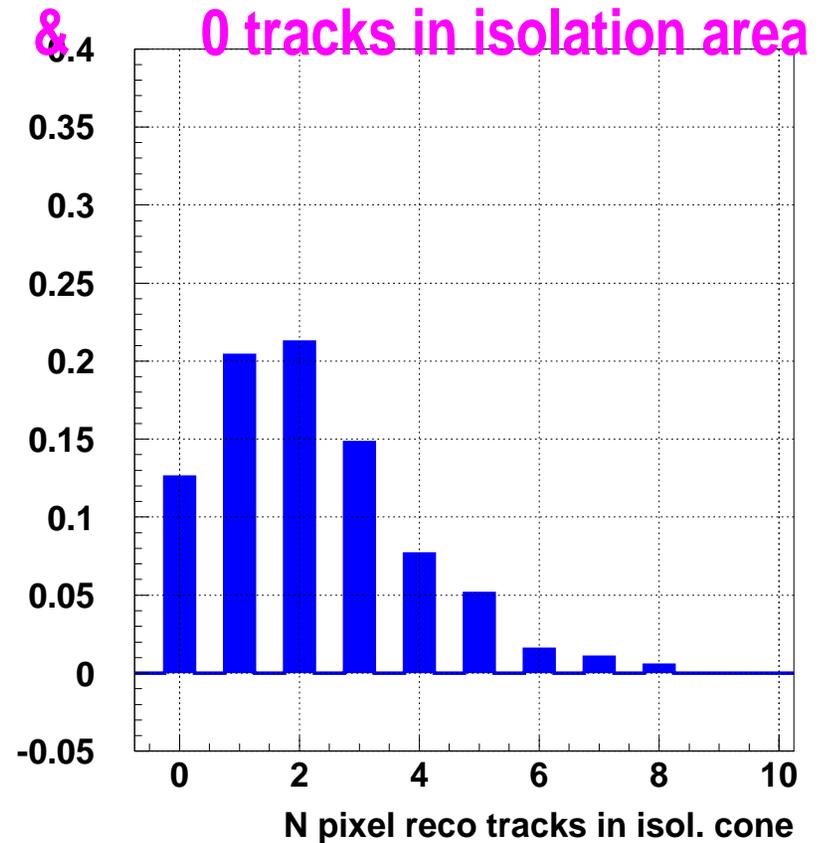
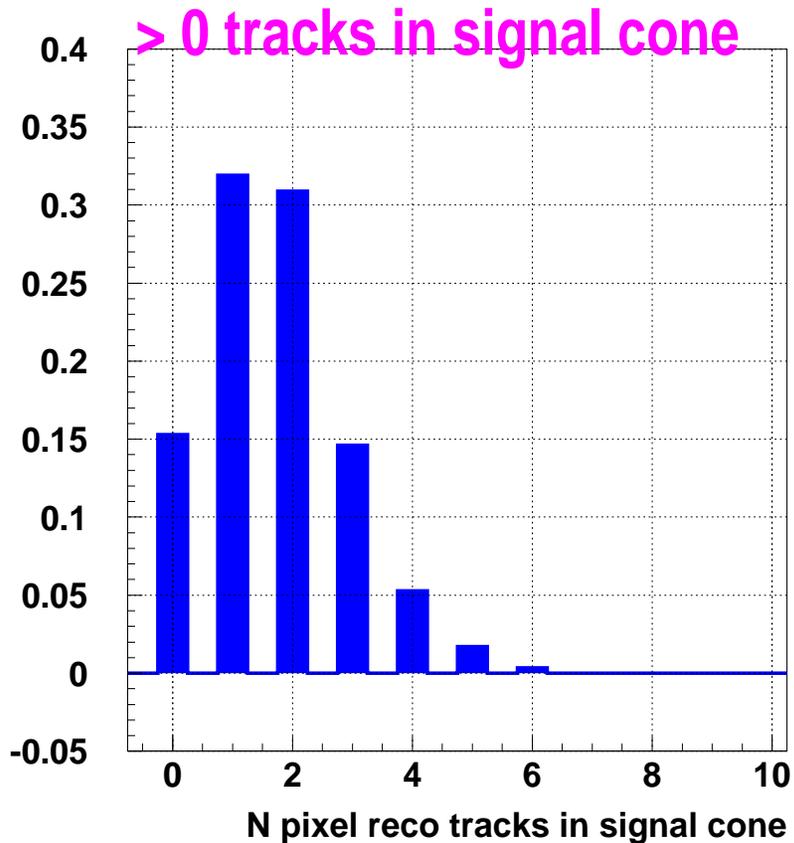
For algorithm parameters :

$R_m=0.1$, $R_s=0.05$, $R_i=0.3$, $p_t^m = 3 \text{ GeV}$, $p_t^i = 1 \text{ GeV}$ - $\epsilon_{\text{signal}} = 76 \%$



QCD efficiency at Lvl-3

Lvl-3 τ jet selections with Pixel Detector :



For algorithm parameters (same as in previous plot) :

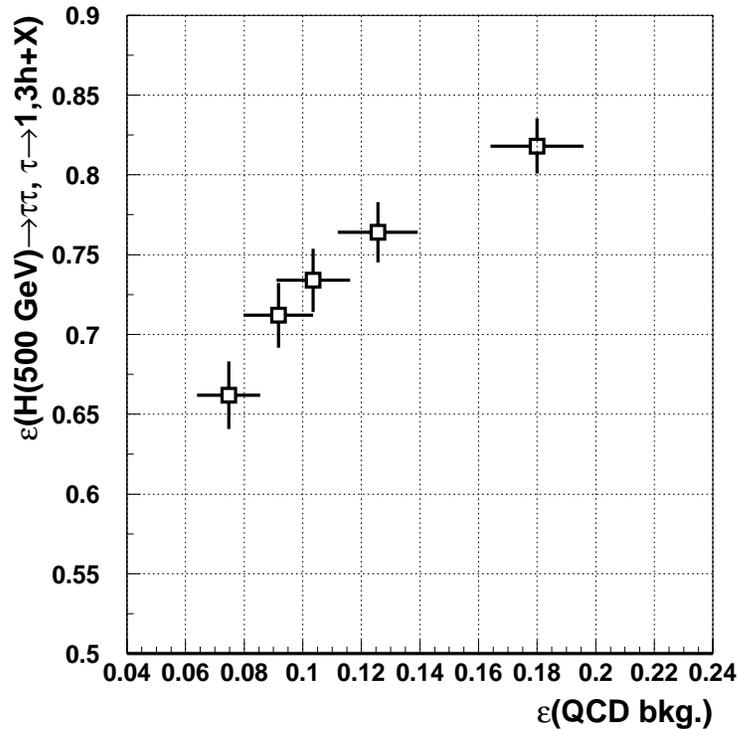
$R_m=0.1$, $R_s=0.05$, $R_i=0.3$, $p_t^m=3$ GeV, $p_t^i=1$ GeV - $\epsilon_{\text{qcd}} = 12\%$



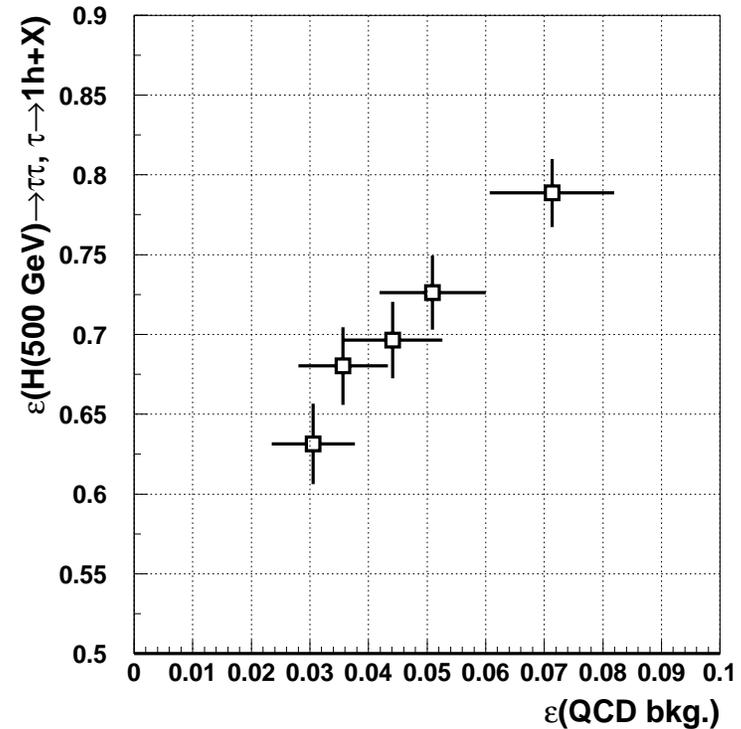
Tau vs QCD efficiency at Lvl-3

isolation cone size R_i is changed 0.2, 0.3, 0.35, 0.4, 0.5

accept > 0 tracks in signal cone



accept 1 track in signal cone



do we want to save 3 prong tau's ?

see Ritva's talk on phys. meeting 16.02.01

□ what is found in signal cone for signal events ?

N of reco tracks in signal cone	0	1	2	3	4	6
N events	69	321	50	54	5	1
at least one track is Tau track		316	47	54	5	1

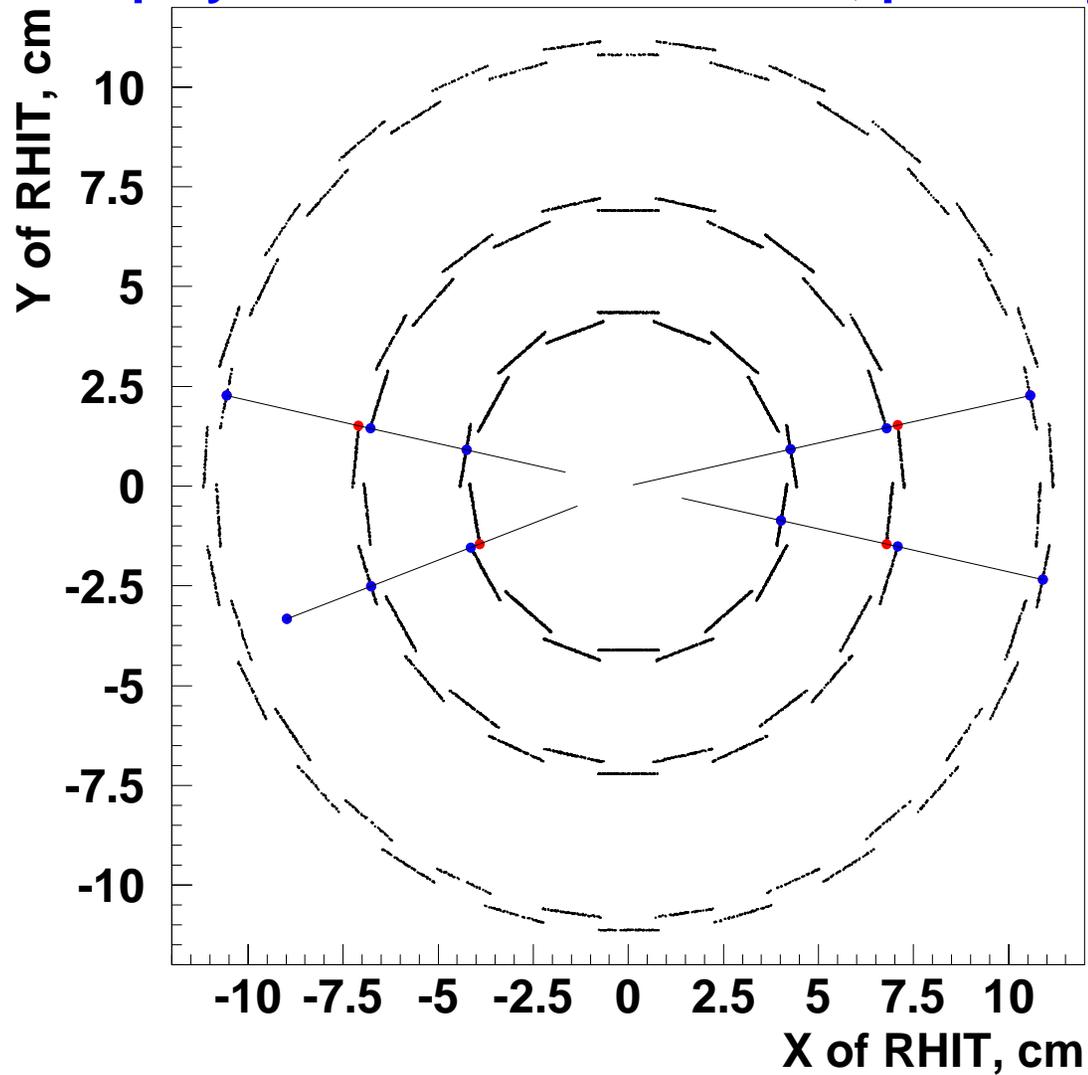
□ what are 50 events with 2 reco tracks in signal cone ?

- 24 ev. - 3 prong; 2 tau tracks are found, 1 tau track is lost
- 3 ev. - 3 prong; 1 tau track is found, 2 tau tracks are lost + 1 non tau track
- 10 ev. - 3 prong; 3 tau tracks are found, but 2 tau tracks reconstructed as one
- 6 ev. - 1 prong; 1 tau track reconstructed as 2 tracks (see next slide)
- 4 ev. - 1 prong; 1 tau track is found + 1 non tau track
- 3 ev. - NOT tau tracks are found (why ?, mc tracks are within pixel accept.)



in ~13 % NO track found in signal cone	
internal pixel detector inefficiency	~ 6.0 %
geometrical acceptance	~ 2.2 %
inelastic interactions	to be checked
p_t^{reco} leading track < p_t^{m} (3 GeV)	to be checked

Why one tau track is reconstructed as two tracks
“event display”: lines - Tau Sim Tracks; points : pixel Rechits.





where we are and next steps

- Lvl-3 analysis of other QCD p_t bins
- Lvl-3 analysis of $M_H = 200$ GeV
- Lvl-4 : regional reconstruction with full tracker

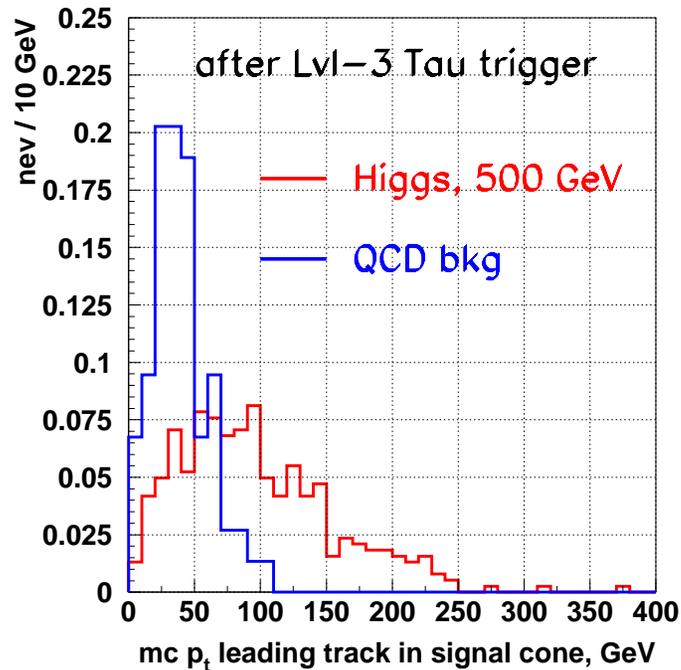
Pisa group will participate in the Lvl-4 algo development

	QCD rate	N(A/H) for 10^5 pb, M=500 GeV, $\tan\beta=25$
Lvl-1	~ 4 000 ev. / s	3 337 ev.
Lvl-2	~ 400 ev. / s	2 236 ev.
Lvl-3	~ 40 ev. / s	1 677 ev.
Lvl-4	~ ? ev. / s	

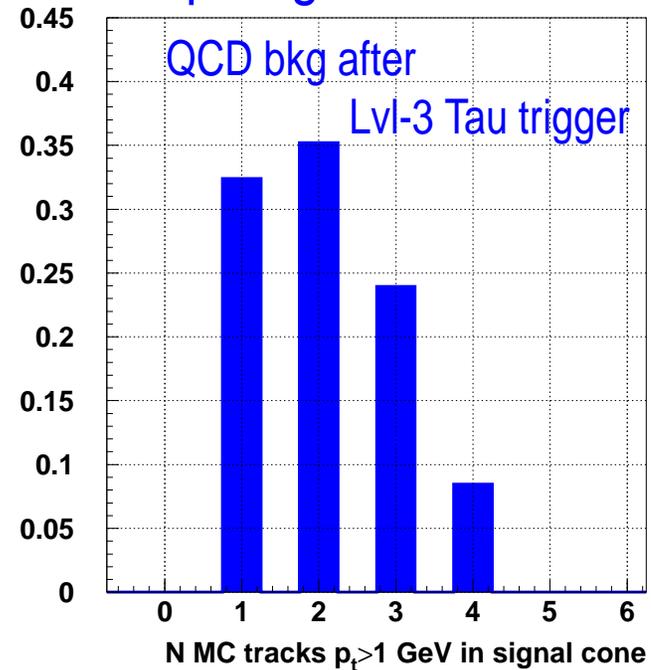


what to do at Lvl-4 ?

❑ cut on p_t of leading track ?



❑ accept only 1 or 3 track+
3-prong τ -vertex ?



❑ refined isolation with full tracker ?

❑ search for second τ -jet ?