TAU RESULTS AT DØ

- tau identification in hadronic modes
- $Z \rightarrow \tau\tau$ cross section measurement
- R–parity violated susy with λ_{133}coupling

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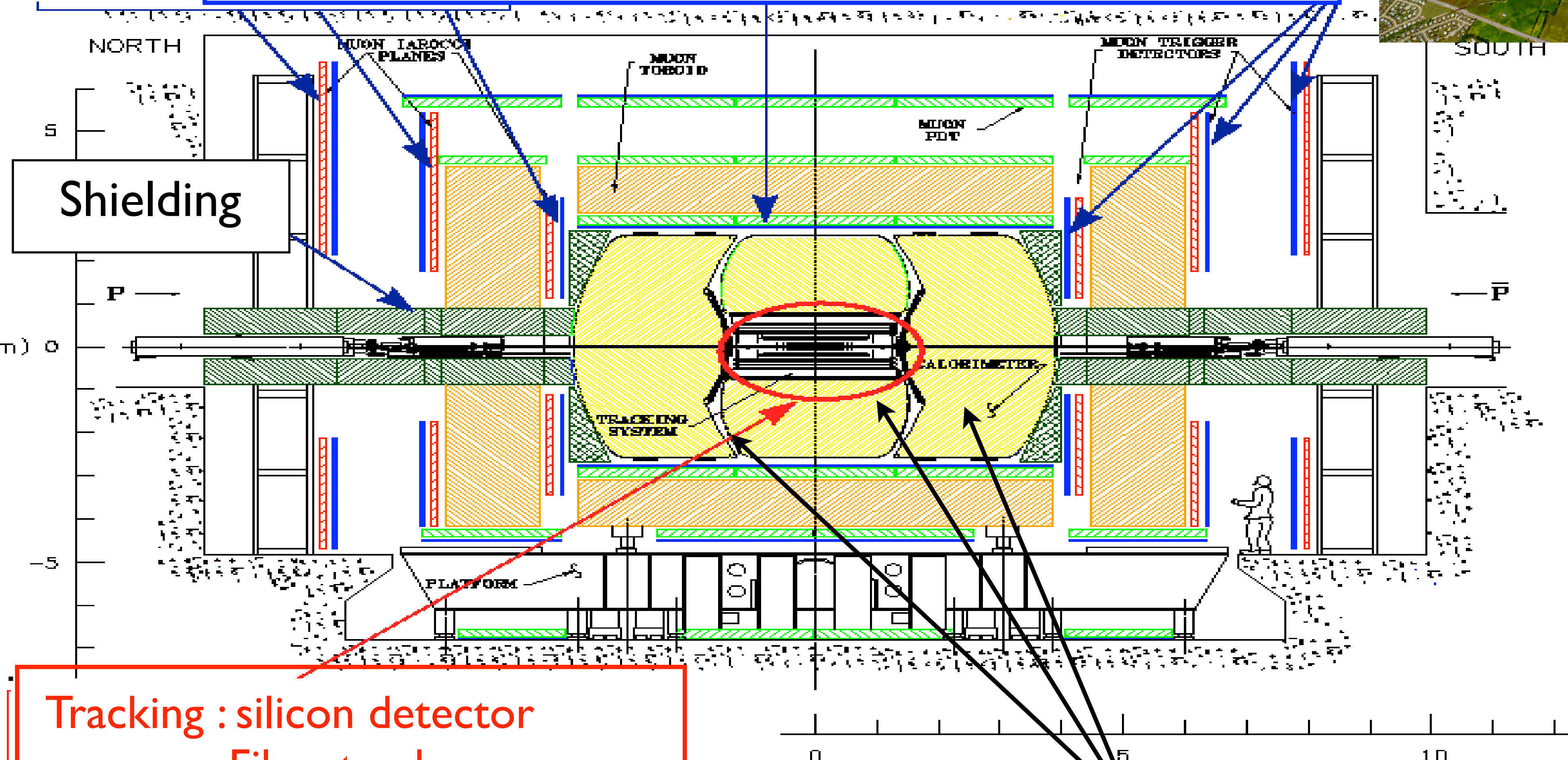
for the DØ collaboration

Tau04 workshop
september 17, Nara Japan

DØ detector

Muon drift tubes scintillators

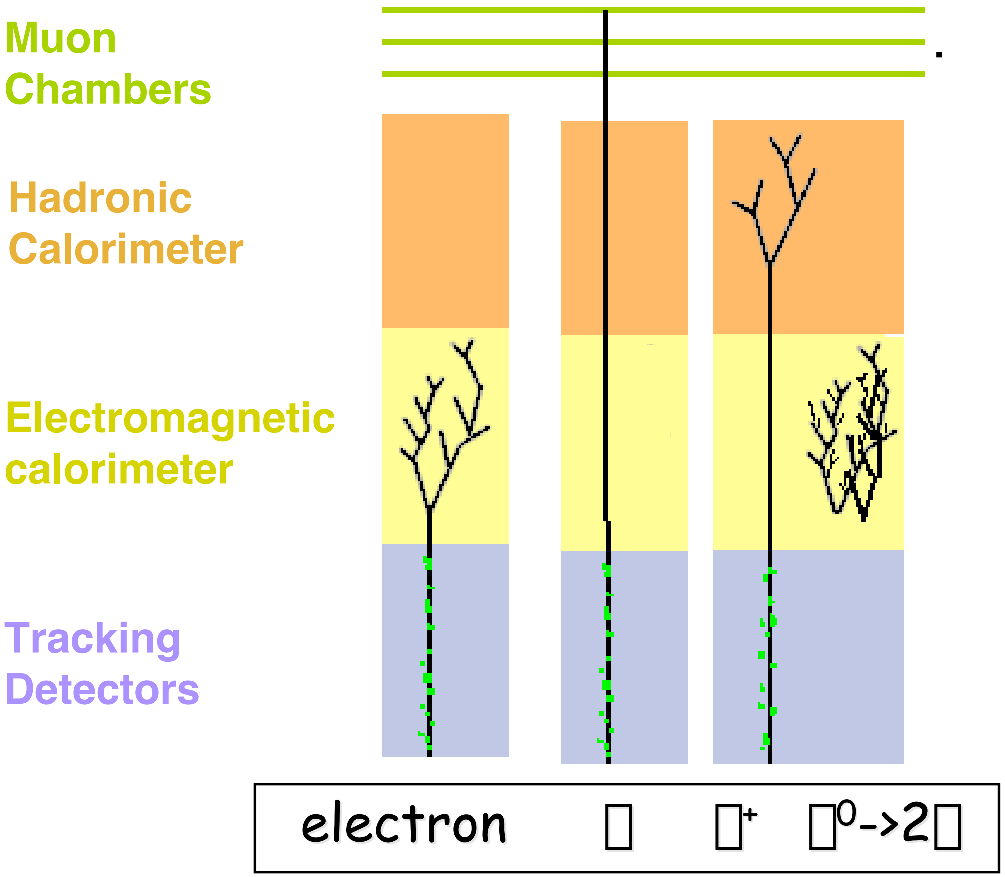
Shielding

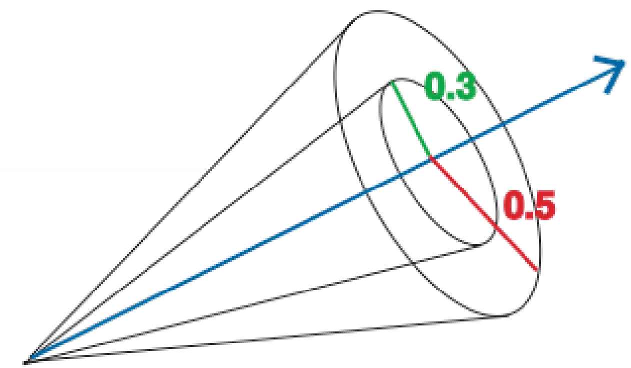


Tracking : silicon detector
Fiber tracker
2T magnetic field

Uranium absorber / Liquid Argon sampling calorimeters

Tau identification in hadronic modes

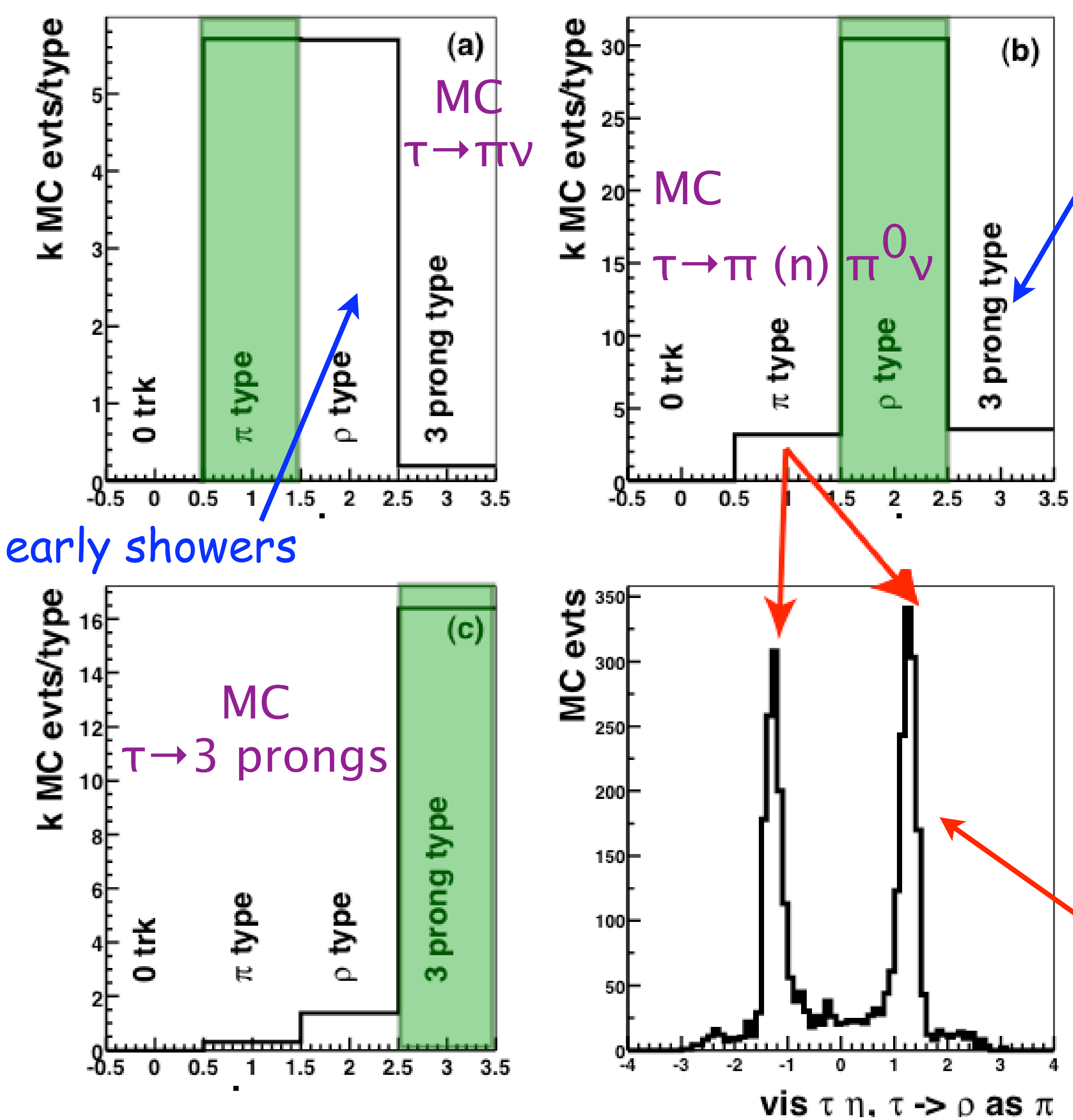




A tau candidate consists of :

- a calorimeter cluster found by simple cone algorithm (cone size R= 0.3, isolation cone R=0.5)
- sub-clusters in the electromagnetic layers of the calorimeter, if π^0 are among the tau decay products
- tracks in an 0.5 cone consistent with tau mass

Hadronic τ : type classification



The hadronic τ candidate can be classified into 3 categories, according to the detector response :

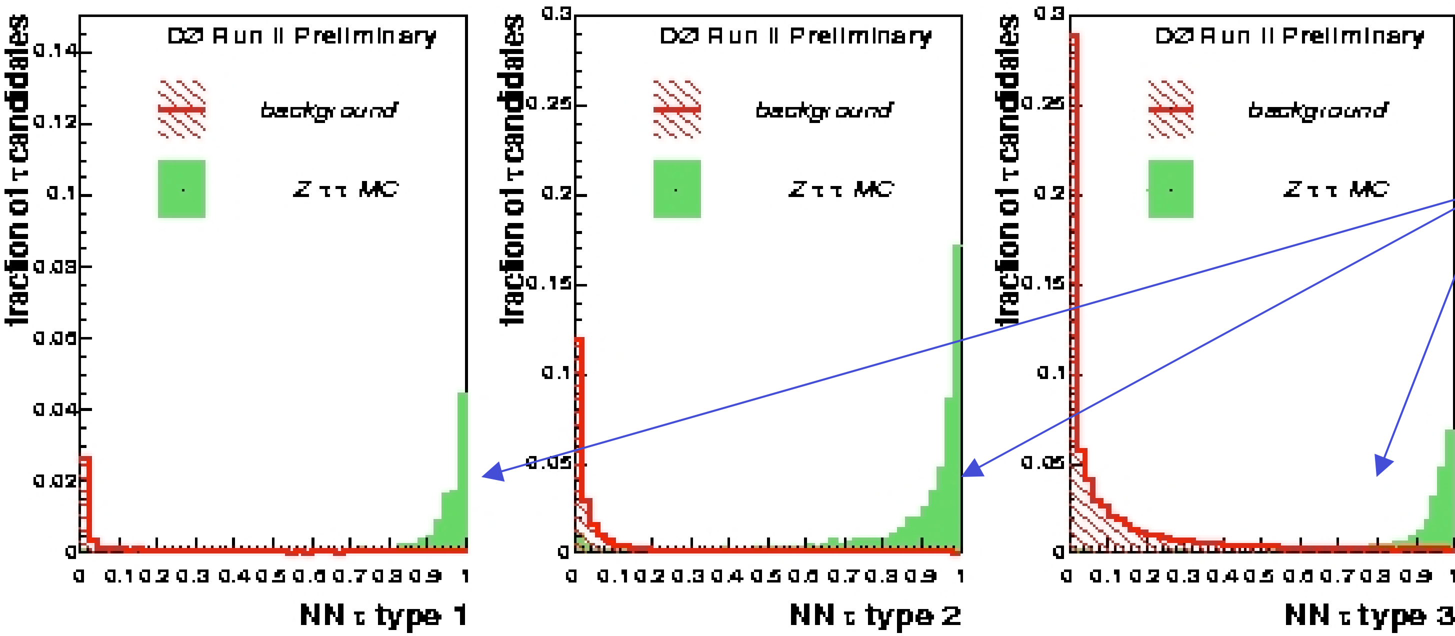
- type 1 : τ→πν type : 1 track, CAL cluster, no EM sub-cluster
- type 2 : τ→ρν type : 1 track, CAL cluster and EM sub-cluster
- type 3 : 3 prongs type : at least 2 tracks

Neural networks for tau-Id

- three separate neural networks (NN), one for each tau type
- discriminating input variables based on shower shape, isolation, core, energy fractions, sub-clusters in the EM layers of the calorimeter, additional tracks found in an 0.5 cone not attached to the τ ... exploit the fact that τ are narrow, isolated jets with less associated particles than QCD jets
- most of input variables are ratios of energy to minimize dependence on E_T.
- used NN package from ROOT which uses vanilla back propagation method
- training samples :
  - signal : 100,000 MC single taus distributed uniformly in pseudo-rapidity and visible p_T overlaid on a minimum bias event
  - background : QCD jets in events with non isolated muons (data)

Neural networks for tau-Id

Background : tau candidates in events with non isolated muons



scaled to □ branching ratios and QCD type fractions

overall arbitary signal to background ratio

Efficiencies NN>0.8 :

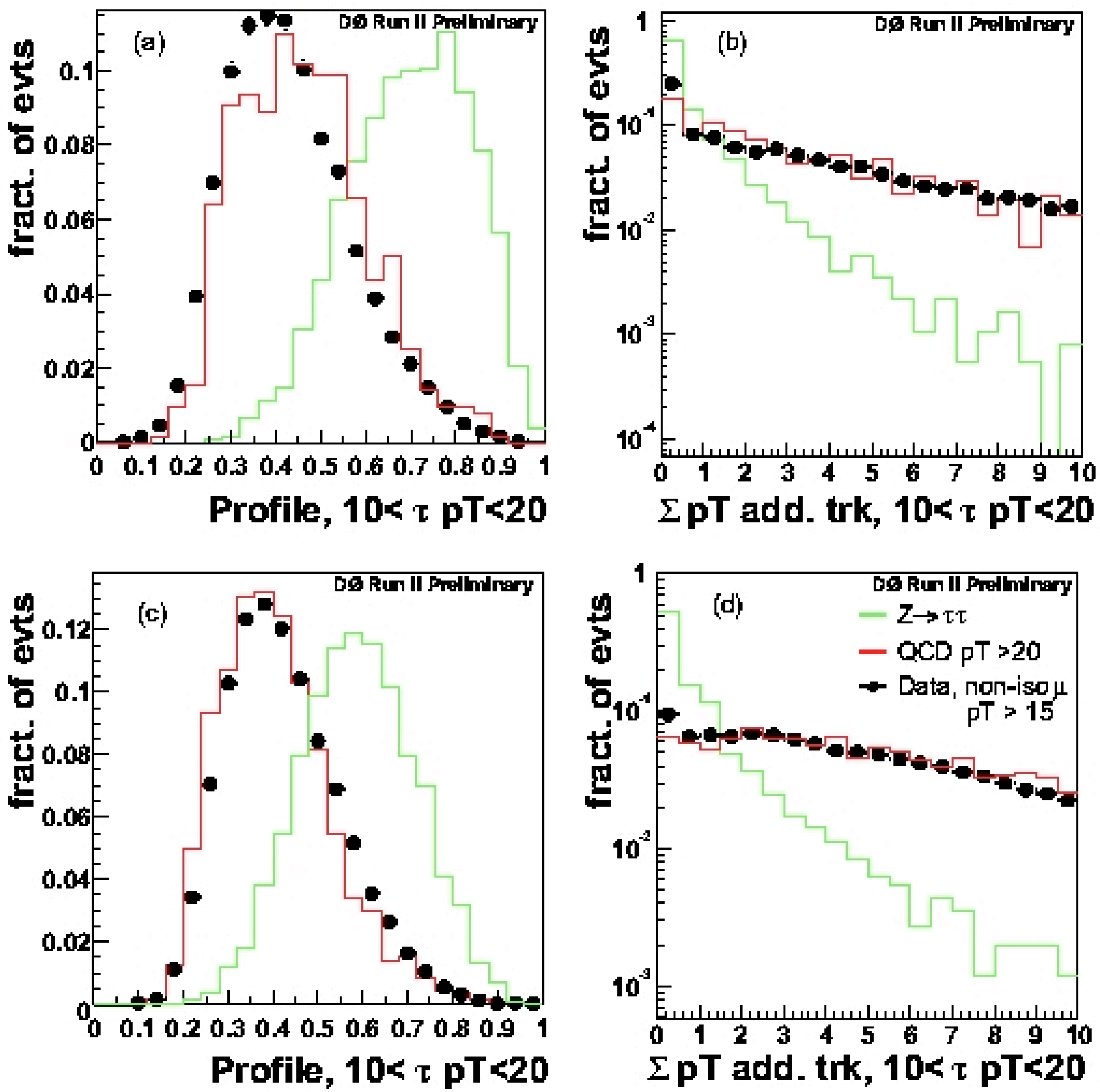
	type 1	type 2	type 3
background	0.145 ± 0.014	0.042 ± 0.004	0.039 ± 0.02
$Z \rightarrow \tau\tau$	0.78 ± 0.03	0.74 ± 0.015	0.73 ± 0.02

Some input variables of neural networks

Profile :

$(E_{T1}+E_{T2})/E_T$

ratio of the transverse energies of the 2 most energetic towers in calorimeter cluster to the total transverse energy of the cluster



Z→ττ

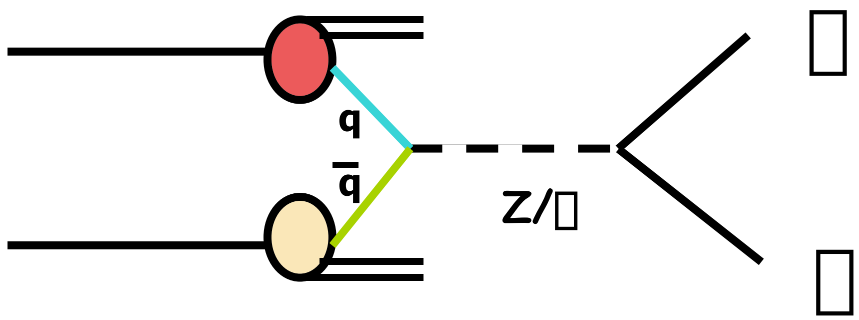
MC QCD

• QCD data

$\sum p_T$ additional tracks in isolation cone not attached to the τ

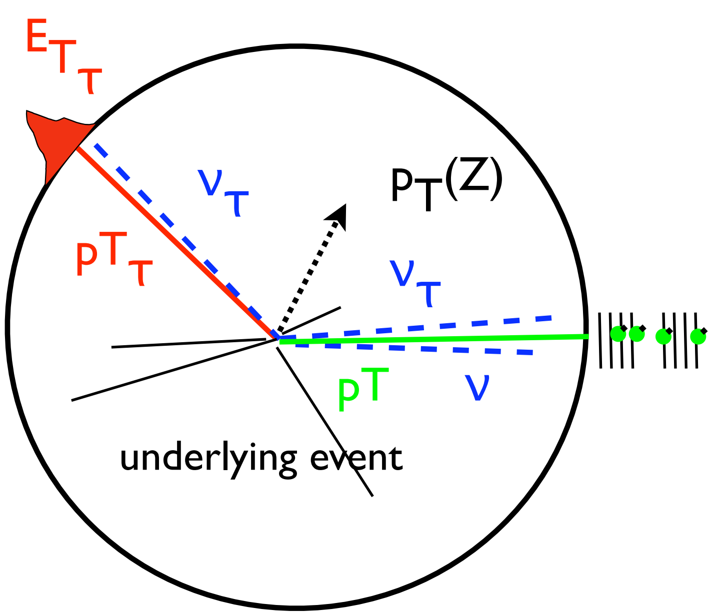
type 2,
type 3
tau candidates

Z→ττ cross section measurement

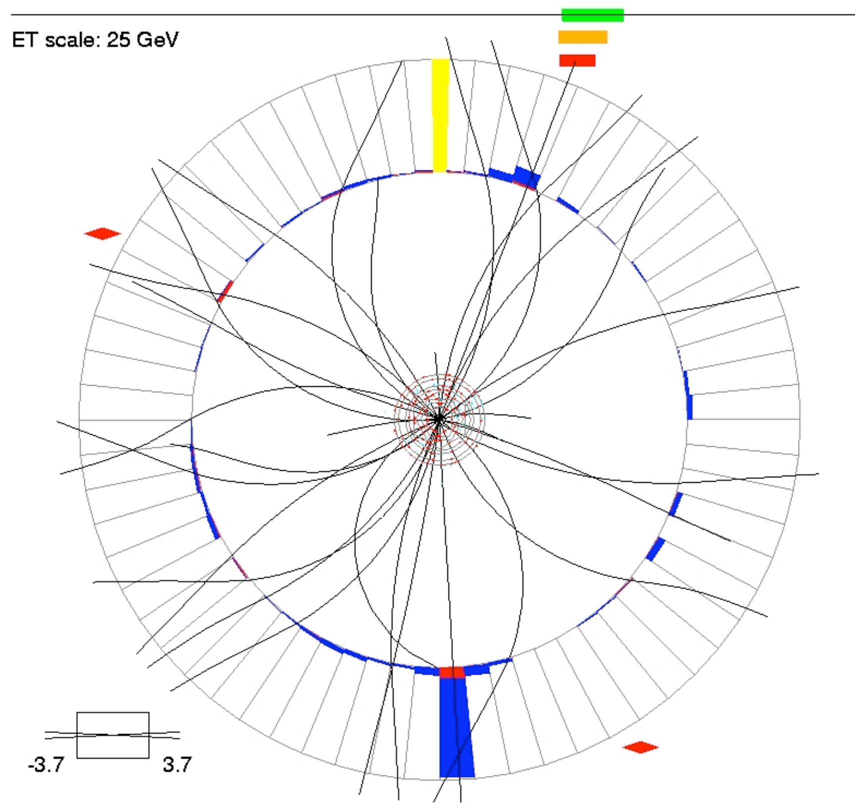


- Production dominated by $q\bar{q}$
- Z→ττ : 3% of total Z production cross section
- Look at Z→ $\tau_{e/hadr}$ requiring a simple muon trigger
- Z→ $\tau_{e/hadr}$ ˜0.14 fraction of Z→ττ

1 high pT isolated , oppositely charged to the τ



$Z \rightarrow \tau\tau \rightarrow \ \tau_{e/hadr}$ event selection

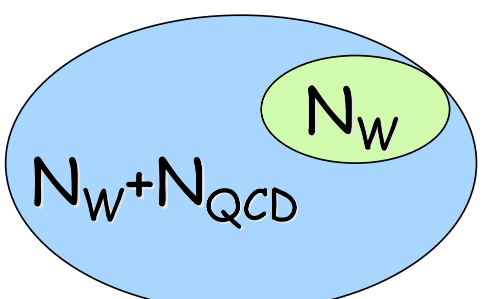


* Single muon trigger :
  - L1 : scintillator and wire requirement
  - L3 : track requirement with p_T>10 GeV
* muon requirements :
  - one isolated muon
  - $p_T(\ )$ > 12 GeV/c
* tau requirements :
  - NN output > 0.8
  - cluster width < 0.25
  - type 1 & 3 : $E_T(\tau)$> 10 GeV, $\Sigma p_T(trk)$>7 GeV
  - type 2 : $E_T(\tau)$> 5 GeV , $\Sigma p_T(trk)$>5 GeV
* event selection :
  - the τ candidate has opposite sign to the (type 3 & 2 tracks : 2 same sign tracks only)
  - $|\varphi(\tau)-\varphi(\ )|$ > 2.5

Backgrounds to $Z \rightarrow \tau\tau \rightarrow \tau_{e/hadr}$

- QCD w/ mainly from $b\bar{b}$ not removed by isolation requirement
  - removed by subtracting equal sign (ES) $-\tau$ pairs from opposite sign (OS) distributions, corrected by a factor of 4% for the excess of OS over ES expected for QCD background
- $Z/\gamma^* \rightarrow$ with one misidentified as a τ
  - removed by applying a cut on the E deposited in the coarse hadronic layers around the track, should deposit more E in the coarse hadronic layers than a τ
- $W \rightarrow \nu$+ jets with one jet misidentified as a τ
  - estimate contribution in data sample with one isolated , $p_T( ) > 20$ GeV/c, $0.2 < NN < 0.8$, $|\varphi(\tau) - \varphi( )| < 2$, where we don't expect much $Z \rightarrow \tau\tau$ signal.
  - expect excess of OS events because high percentage of $W \rightarrow \nu$+ jets comes from quark jets
  - solve equations to estimate N_W

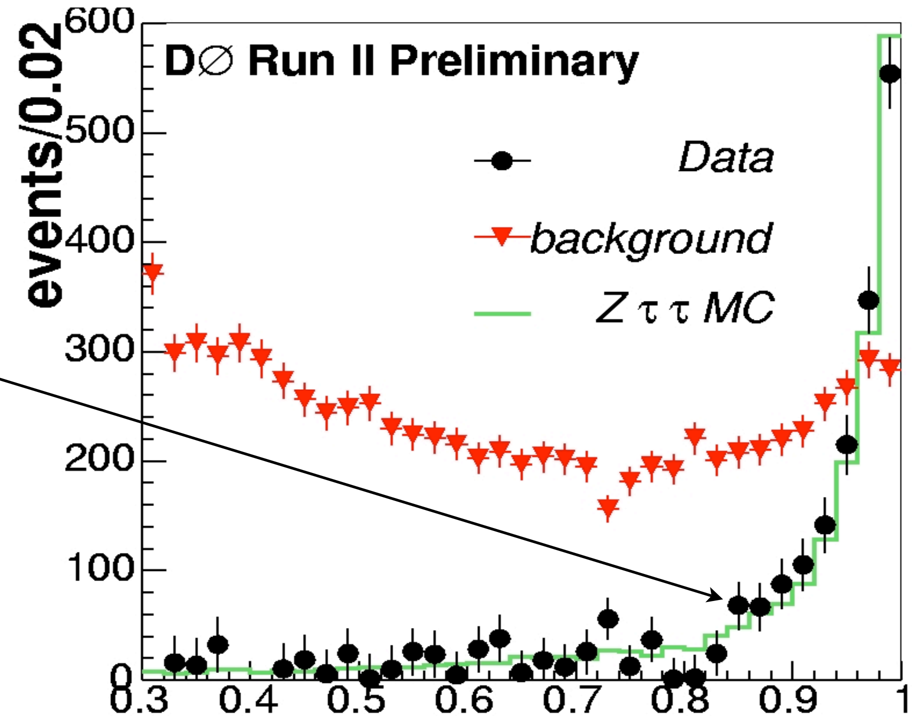
known OS/ES excesses



$$\left.\begin{aligned} N_W + N_{QCD} &= N_{OS} + N_{ES} \\ 0.26 * N_W + 0.02 * N_{QCD} &= N_{OS} - N_{ES} \end{aligned}\right\} N_W$$

Extracting σ*Br measurement

- the total background in 0S events is estimated by summing 1.04*ES, W→ ν(MC), Z/γ* →
- Data = OS - estimated background



NN output

8562 τ− pairs selected with NN cut > 0.3
1946 OS τ− pairs selected with NN cut > 0.8

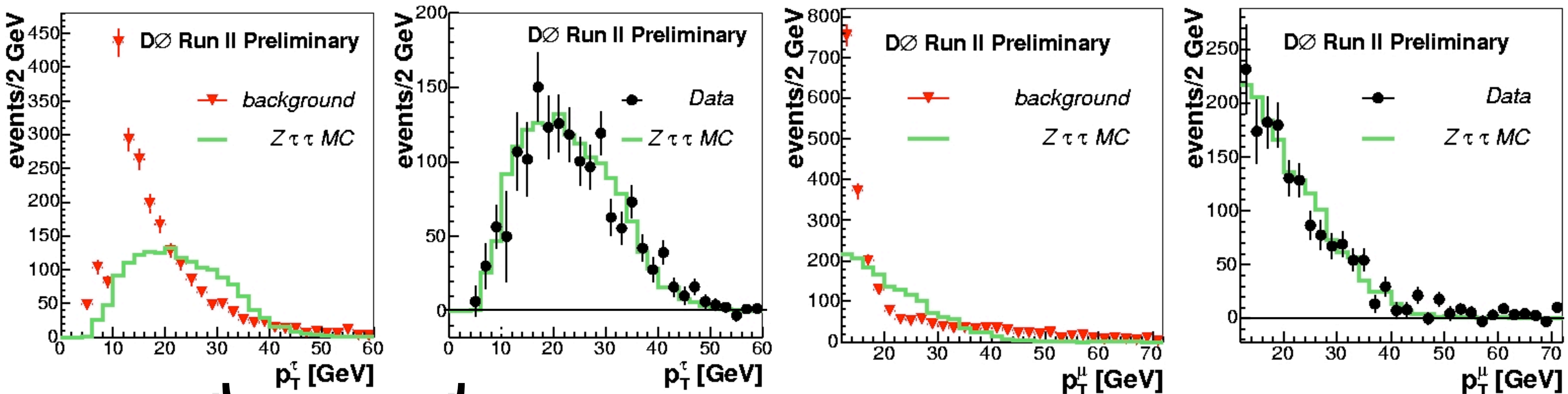
48	± 14	W→ ν + jets
81	± 17	Z/γ→
909	± 18	QCD w /

final selection 1946 events with ~ 55% background

Event efficiencies for the different types of τ (including branching ratios) :

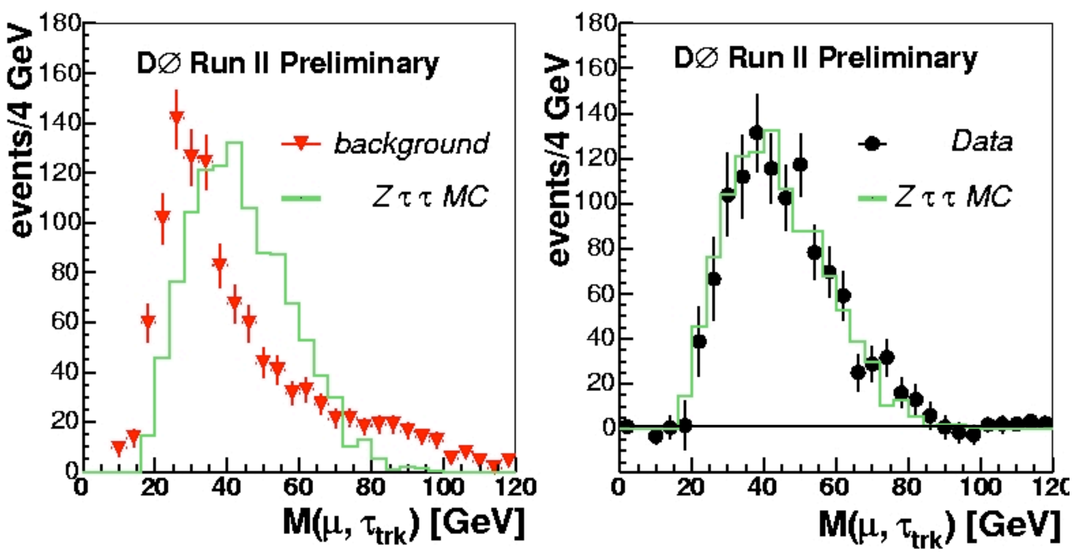
* type 1 : 0.35 %
* type 2 : 1.61 %
* type 3 : 0.79 %

Selected tau, muon transverse momenta and invariant masses



Tau transverse momentum

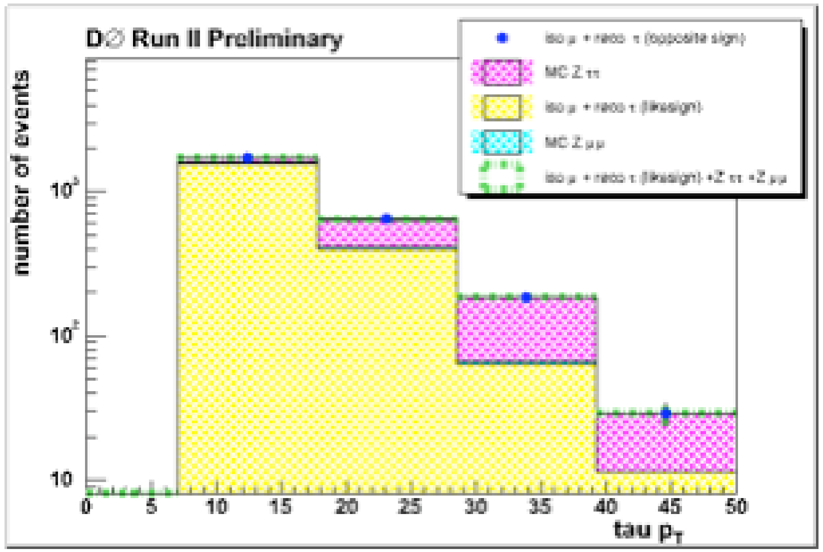
Muon transverse momentum



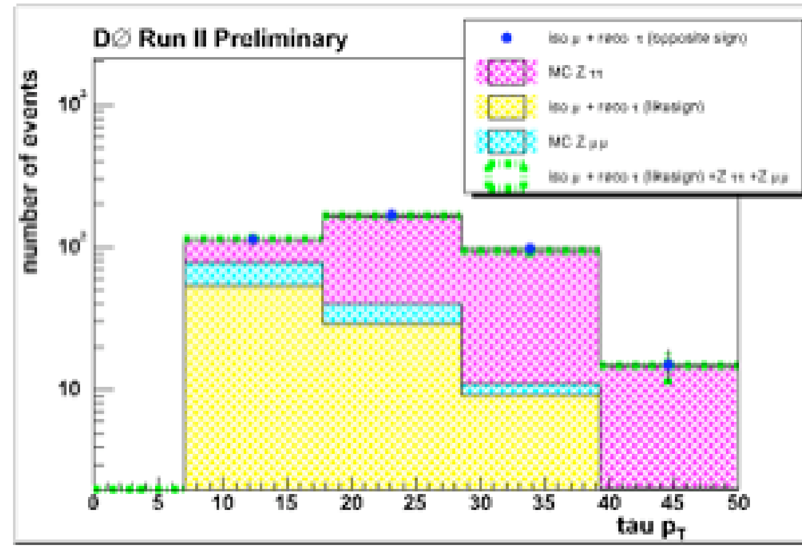
Invariant tau track + muon mass

Check input distributions of NN

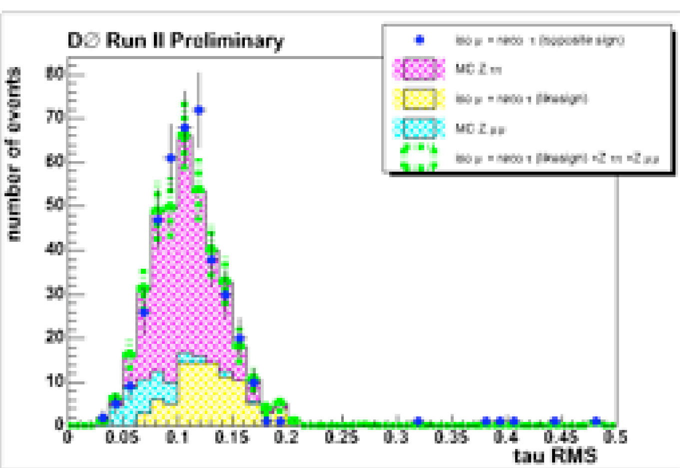
Fit $Z \rightarrow \tau\tau$ content in OS $-\tau$ pairs ($|\varphi(\tau)-\varphi(\ )| > 2.7$) from pT shape



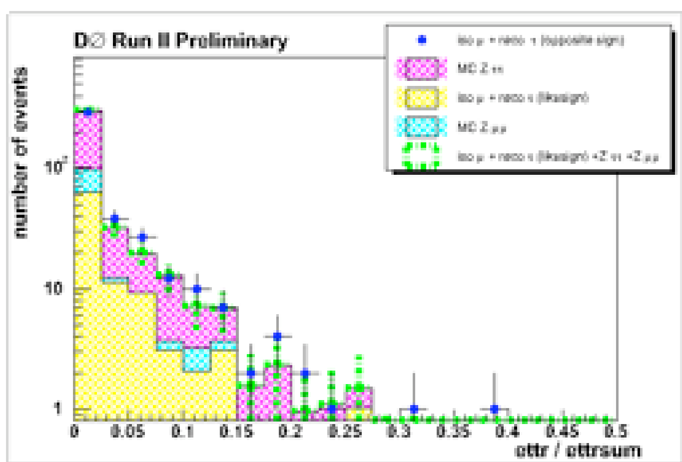
Tau candidate pT after NN cut



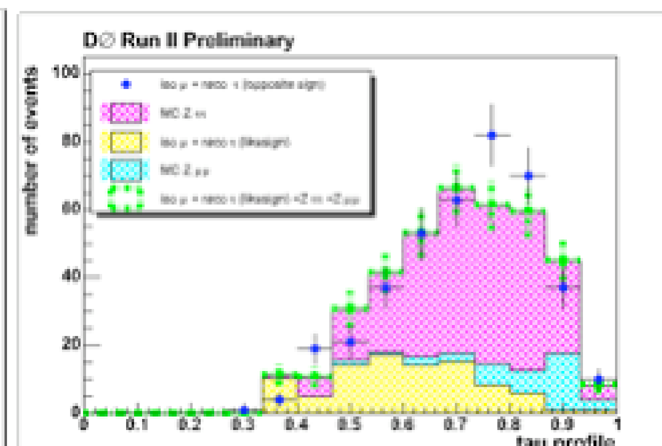
cluster width after NN cut



∑pT additional tracks / ∑pT all tracks after NN cut



cluster profile after NN cut



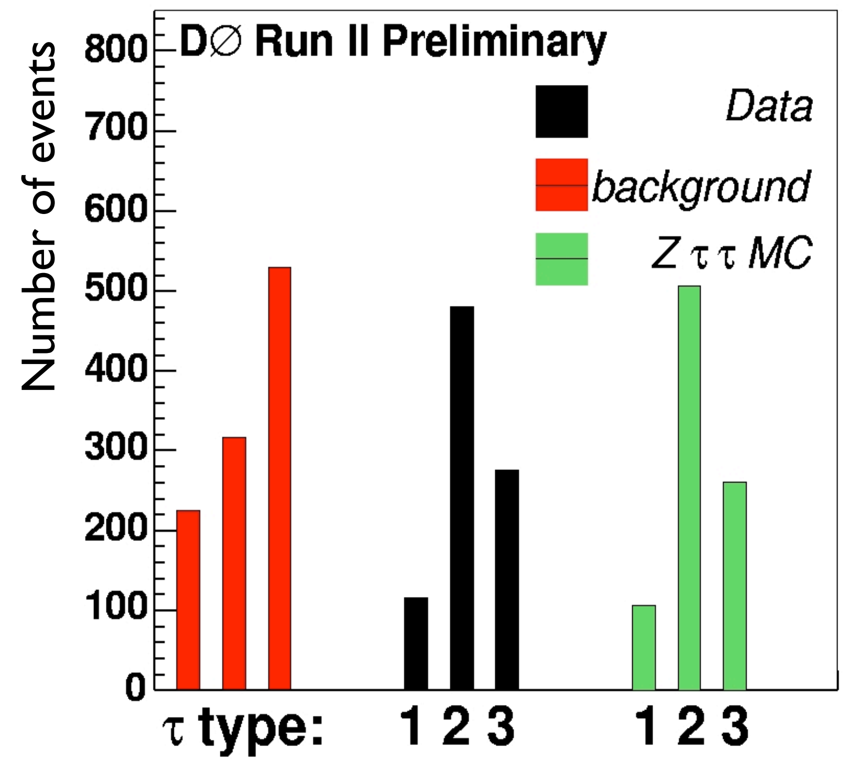
Result on σ*Br for Z→ττ

$$\sigma * BR = \frac{N_{evts} - N_{bkg}}{\epsilon_{total} * \int Ldt}$$

- N_{evts} : number of events observed
- N_{bkg} : number of background estimated
- $\int Ldt$: luminosity : 207± 13,5 pb^{-1}
- ϵ_{total} : total efficiency

$\epsilon_{total} = \epsilon_{evt} * \epsilon_{trig} * \Delta(\text{MC–data})$

$= (0.0275\pm0.0004) * (0.65\pm0.02) * (0.925\pm0.032)$



Systematic errors due to trigger, data/MC corrections factors, energy scale, NN, background estimate

σ*Br(Z→ττ) = 256 ± 16(stat) ± 17(sys) ± 16(lumi) pb

R-parity violating supersymmetry with λ_{133} coupling

Extension of MSSM superpotential

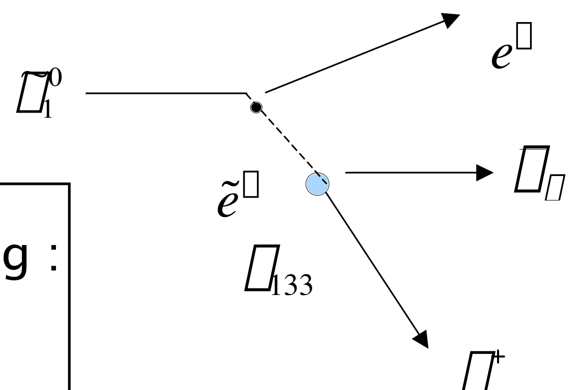
$$\lambda_{ijk}(L_i L_j)E_k^c + \lambda'_{ijk}(Q_i L_j)D_k^c + \lambda''_{ijk}(U_i^c U_j^c D_k^c)$$

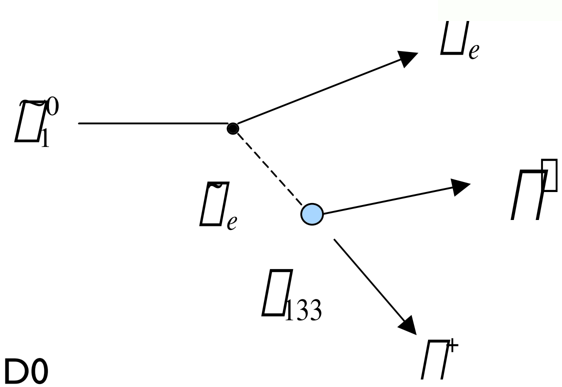
violates conservation of R-parity

$$R_p = (-1)^{L+2B+3S}$$

Susy particles produced in association with gauge couplings mainly $\tilde{\chi}_2^0 \tilde{\chi}_1^\pm$

LSP decays in SM particles :

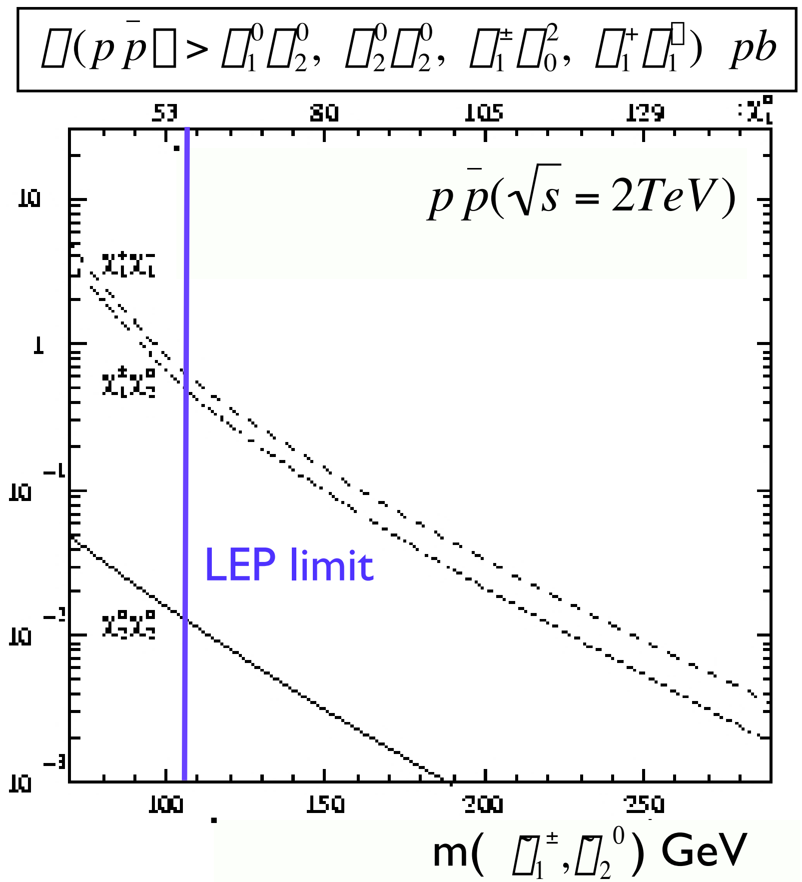




Final states with λ_{133} coupling :

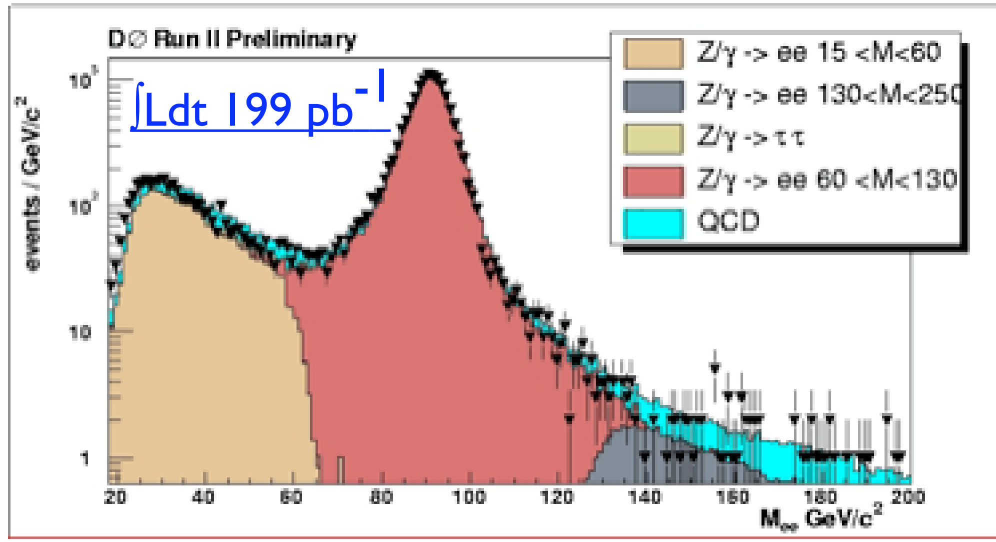
2 τ + 2 electrons + $\not{E}_T$
3 τ + 1 electron + $\not{E}_T$
4 τ + $\not{E}_T$

→ Look for 2 isolated electrons plus at least 1 hadronic τ

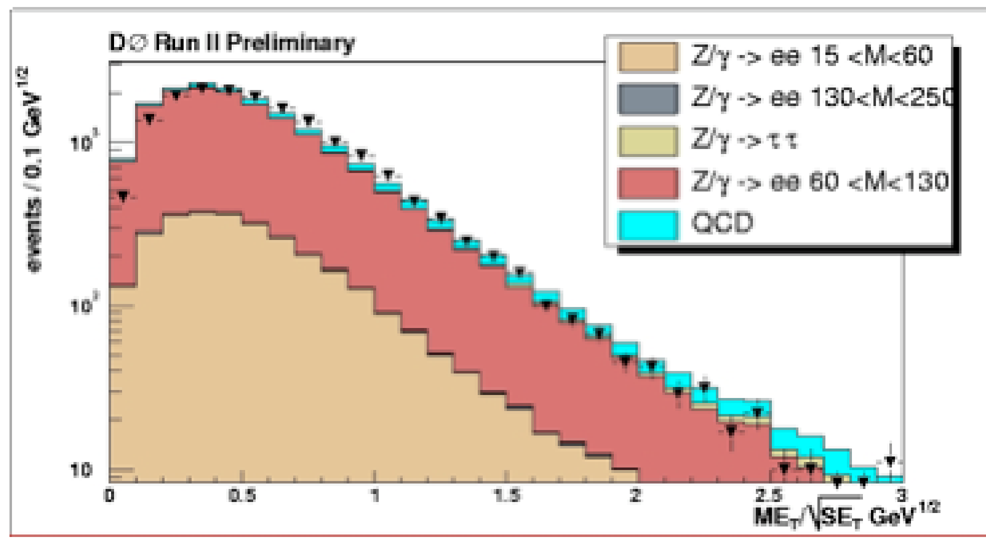


Event selection

- 2 electrons with $M_{ee} > 18$ GeV/c^2
- $M_{ee} < 80$ GeV/c^2
- at least one hadronic τ of type 1 or 2, identified with NN cuts, veto on electrons and muons applied

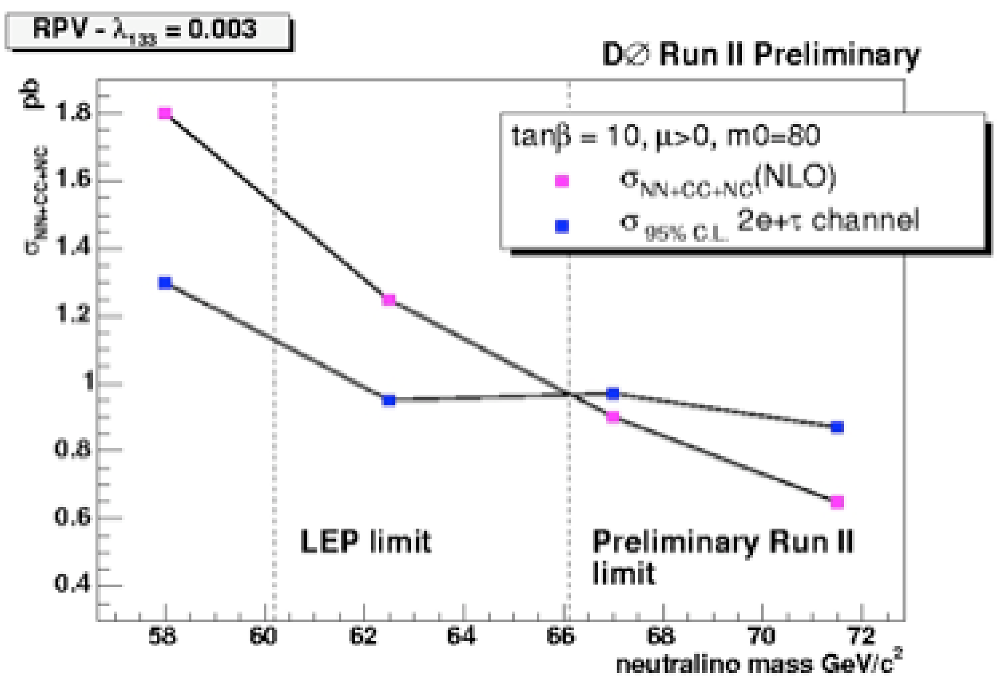


- $\not{E}_T / \sqrt{SE_T} > 1.5$
  - → signal exhibits moderate $\not{E}_T$
  - → takes into account statistical fluctuations of QCD jets mismeasurements
  - → removes Z Drell–Yan with low $\not{E}_T$



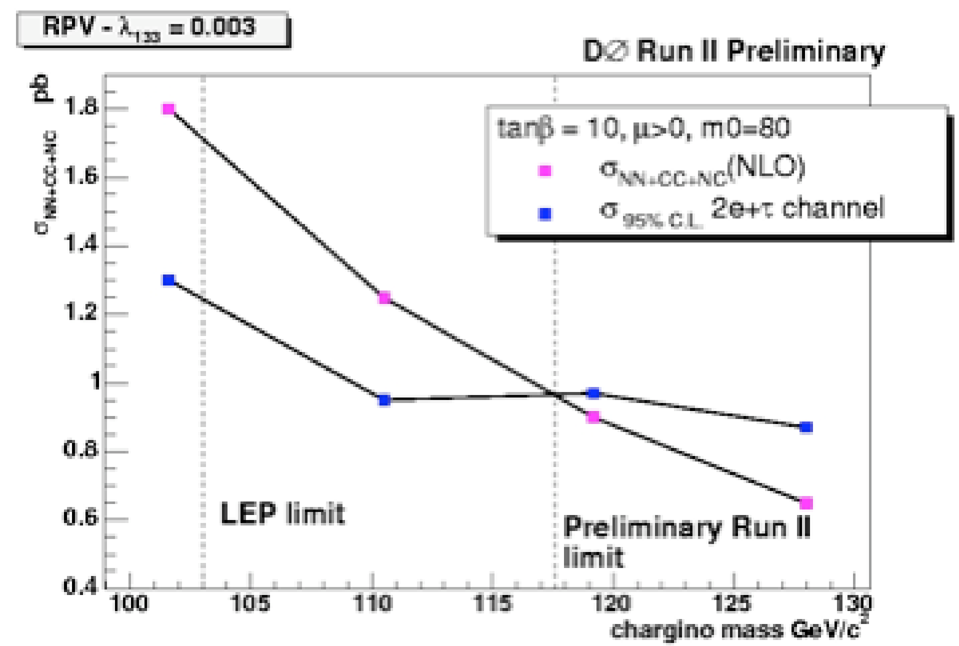
0 events selected for 1±1.32 expected from SM and instrumental backgrounds

Preliminary limits



mSUGRA parameter space with stau lighter than $□_1^{\pm}$, expect additional taus from the cascade : tanβ = 10 , >0, m_0 = 80, A_0 =0

~ 2 - 4 events selected in signal



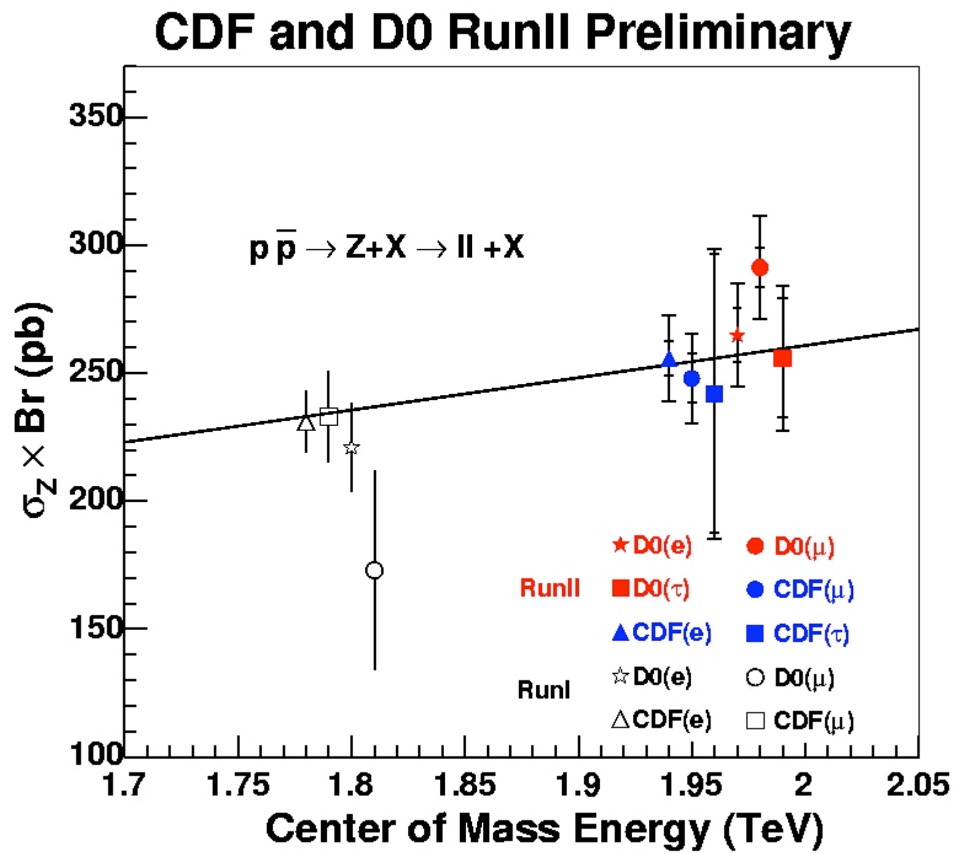
Excluded at 95 % C.L. :

m($□_1^0$) < 66 GeV/c^2, m($□_1^{\pm}$)<119 GeV/c^2 for tanβ = 10, >0, m_0 = 80, A_0 =0

Summary

- Preliminary $Z \rightarrow \tau\tau$ cross section measurement consistent with SM
  - provides benchmark measurement for understanding τ−Id
- Preliminary exclusion in mSUGRA parameter space for R-Parity violated susy with λ_{133} coupling

Preliminary studies for $\sigma(t\bar{t})$ in lepton + τ channel, Higgs→ττ, R–Parity violating susy stop→τb, trilepton mSUGRA at high tan(β) underway !



* *Curves are NNLO calculation from Hamberg, Van Neerven and Matsuura, Nucl. Phys. B359 (1991) 343. [CTEQ4M pdf]*

Backup slides

Systematic errors on σ*Br(Z→ττ) and RPV susy search with λ_{133} coupling

σ*Br(Z→ττ)

cluster width cut < 1 %
Energy scale 2.5 %
NN (excluding energy scale) 2.6 %
QCD background 2 %
background 2 %
W→ ν+ jets background 1.7 %
$\epsilon_{data}/\epsilon_{MC}$ (from τ–Id) 2.5 %
$\epsilon_{data}/\epsilon_{MC}$ (from –Id) 2.5 %
Trigger 2 %
Total 6.3 %

- systematic errors on signal were obtained by rescaling in MC E_T and input variables distributions and recalculate NN output after rescaling
- systematic errors for backgrounds :
  - QCD : error of OS/ES estimate
  - W→ ν +jets : difference N_W data / MC predicton

RPV search with λ_{133}

Luminosity 6.5 %
backgrounds 5% – 8%
$\epsilon_{data}/\epsilon_{MC}$ (from τ–Id) 12.5 %
$\epsilon_{data}/\epsilon_{MC}$ (from electron–Id) 2 %
Trigger up to 7 %
~ 20 % for signal

- $\epsilon_{data}/\epsilon_{MC}$ (from τ–Id) determined from NN efficiency in data using fit on pT shape to estimate Z→ττ
- errors on background processes from cross sections errors