# Effect of crossing-angle on BeamCal electron veto efficiencies & SUSY reach in mass degenerate scenarios

preliminary

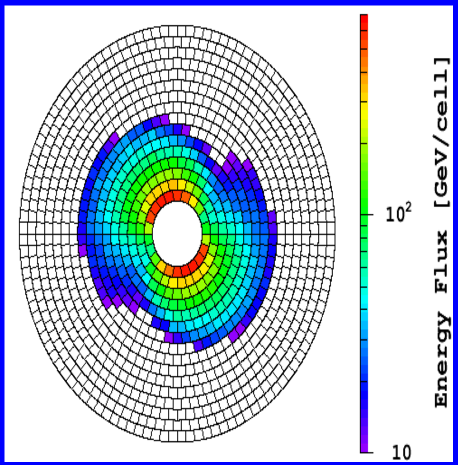
Philip Bambade
LAL-Orsay

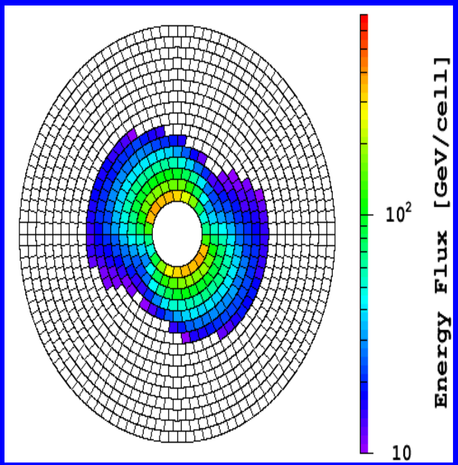
Snowmass 2005

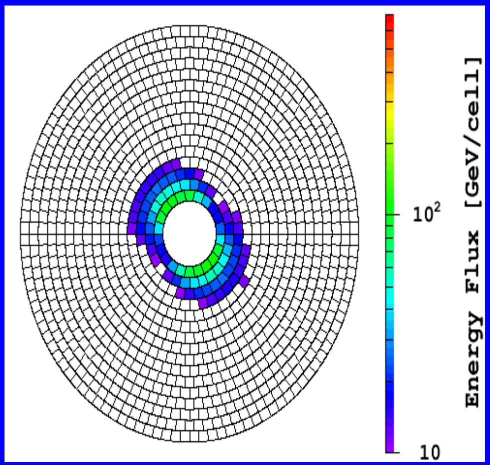
1. Effect of crossing-angle on ELID V. Drugakov, U. of Minsk
2. Effect of crossing-angle on stau search Z. Zhang, LAL-Orsay

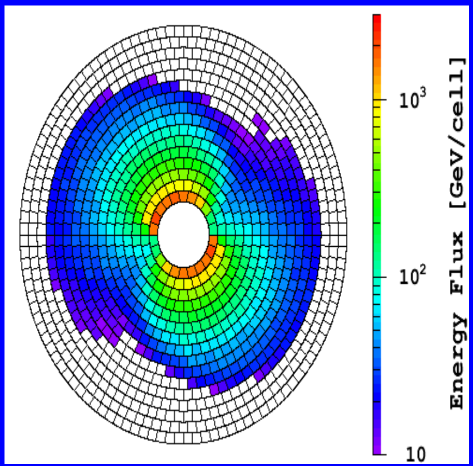
# Pair energy in Beamcal (l*=4m, B=4T)

## TESLA ILC-nom ILC-lowQ ILC-hilum

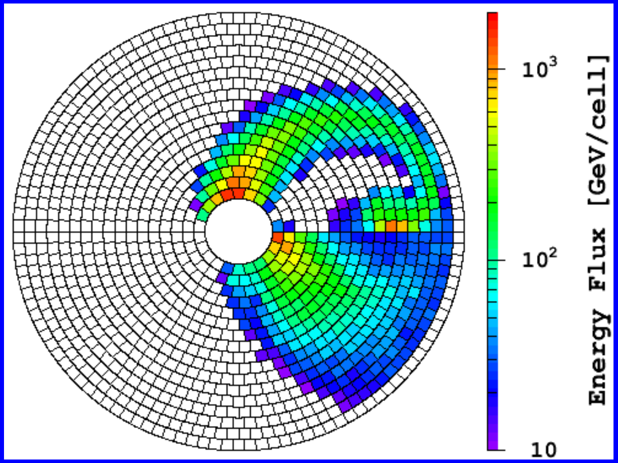


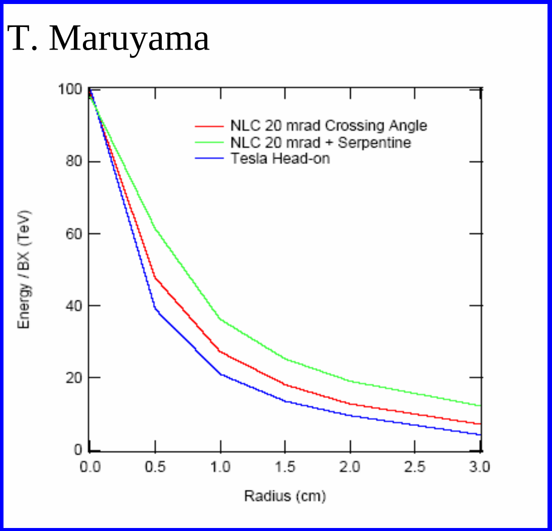




## ILC – nom 20 mrad with idealised DID

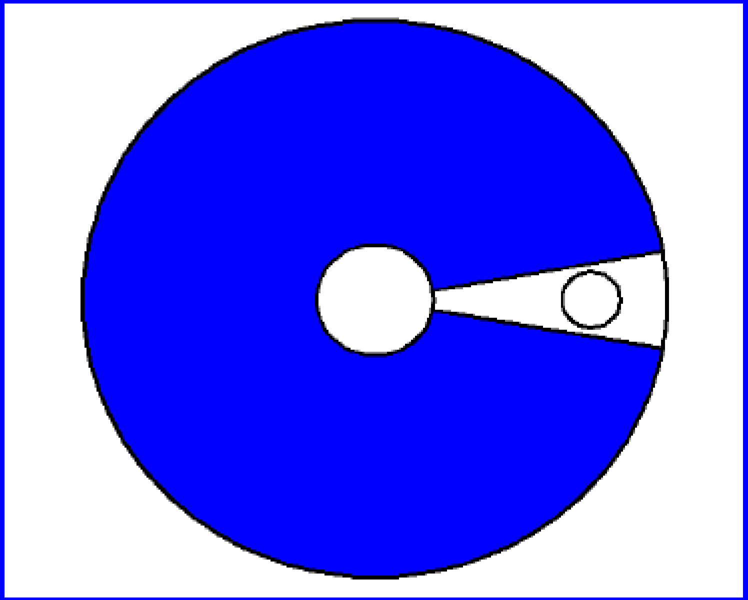


# Features of simulation and comparison

- GEANT4 instead of GEANT3 and new algorithm
- averaging over rings instead cells, with 10000 events in each cell
- algorithm tuned with common energy threshold and fake rate (5%) for head-on and 20 mrad (may not be fully optimal)
- electron energies: 100, 125, 150, 175, 200, 225, 250 GeV
- pairs from 500 bunch crossings are simulated for head-on and 20mrad

- for head-on, ring 1 at 15 mm
- for 20 mrad, ring 1 at 20 mm
  and suppose blind area for :
  $-15$ degree $< \varphi <$ 15 degree
  this blind area is excluded from
  the efficiency calculation

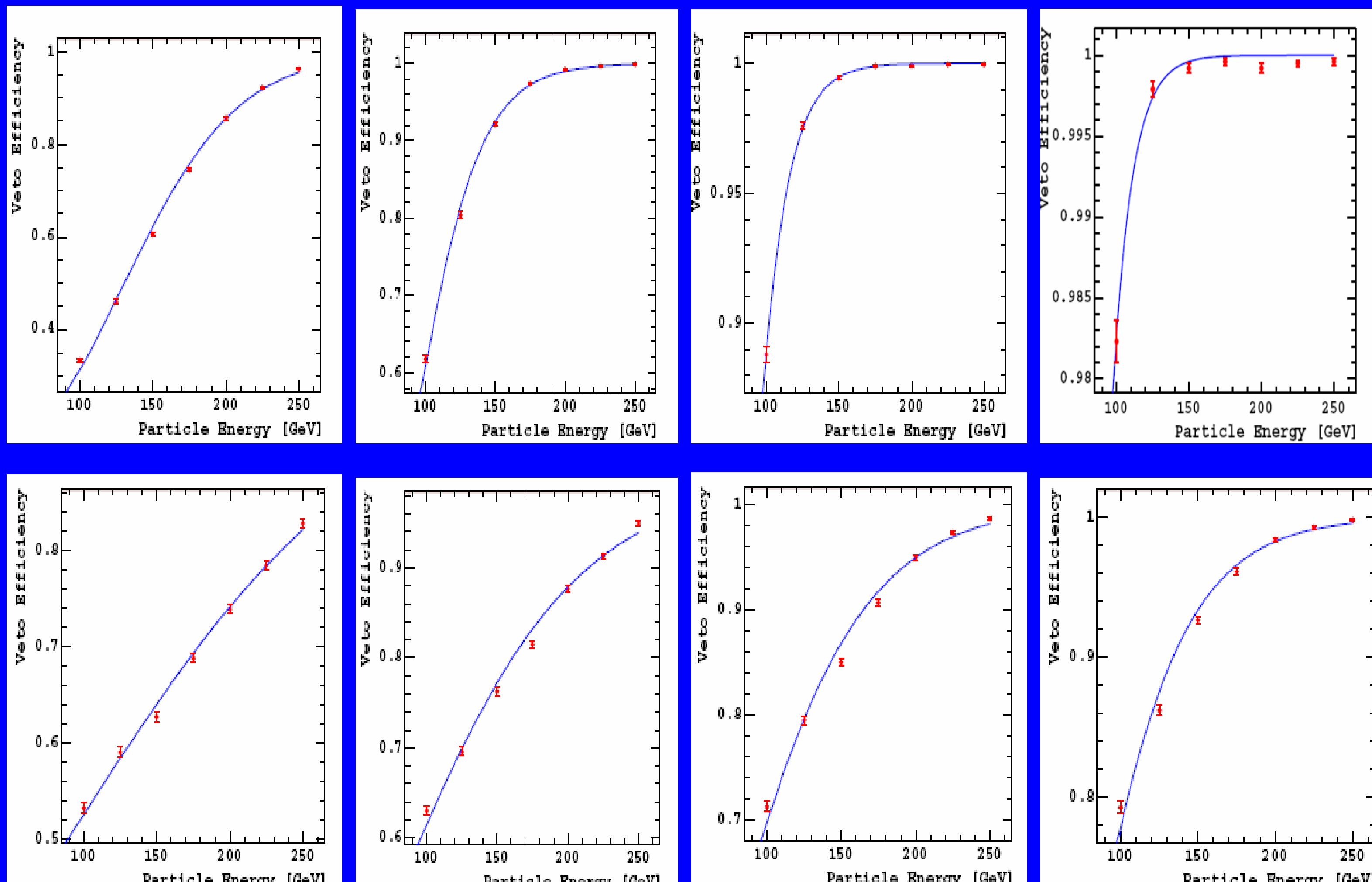


# Comparison of veto eff. in 4 first rings

Ring 1 | 2 | 3 | 4

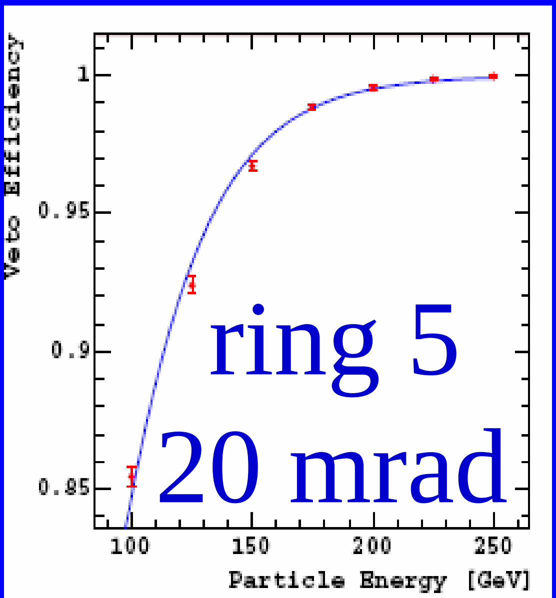
Head-on
ILC nom
ring 1
at 15 mm

20 mrad
ILC nom
ring 1
at 20 mm

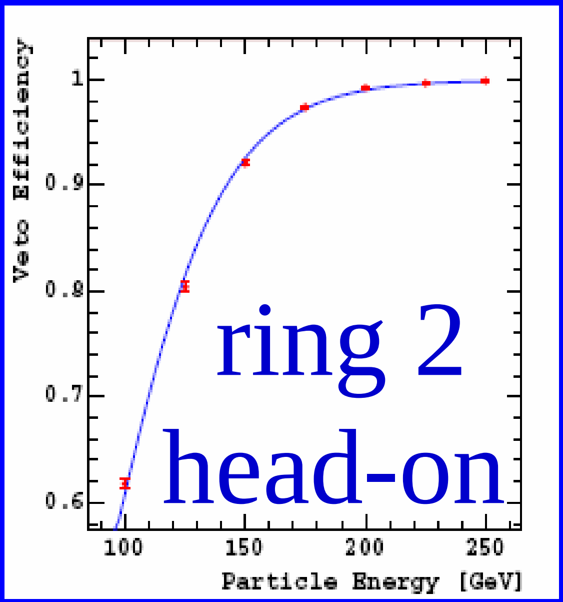


# 20 mrad + DID  θ ~ 11 mrad

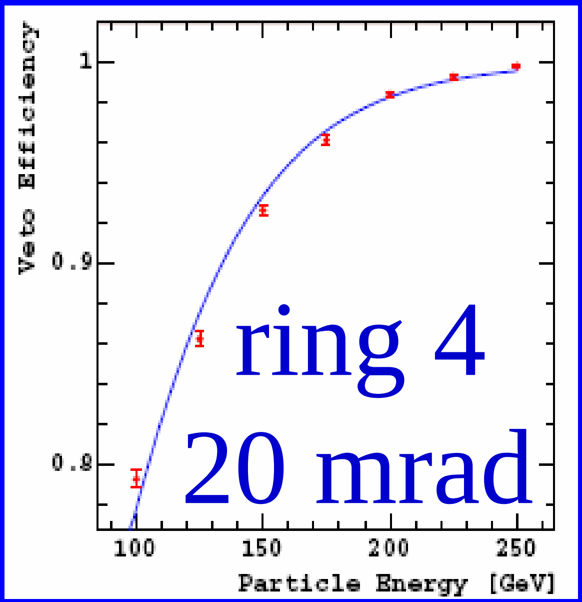
# ⇔ head-on  θ ~ 6 mrad




θ ~ 11.5 mrad




θ ~ 6 mrad




θ ~ 10 mrad

This first look → Δm (head-on) ~ Δm (20 mrad) / 1.8

## 250 GeV efficiencies | 200 GeV efficiencies

| ring | 250 GeV head-on | 250 GeV 20 mrad & DID | 200 GeV head-on | 200 GeV 20 mrad & DID |
|---|---|---|---|---|
| 0 | 0.9620 ± 0.0019 | 0.8278 ± 0.0039 | 0.8568 ± 0.0035 | 0.7386 ± 0.0046 |
| 1 | 0.9991 ± 0.0003 | 0.9495 ± 0.0023 | 0.9924 ± 0.0009 | 0.8765 ± 0.0034 |
| 2 | 0.9996 ± 0.0002 | 0.9868 ± 0.0012 | 0.9992 ± 0.0003 | 0.9492 ± 0.0023 |
| 3 | 0.9996 ± 0.0002 | 0.9978 ± 0.0005 | 0.9992 ± 0.0003 | 0.9837 ± 0.0013 |
| 4 | 0.9997 ± 0.0002 | 0.9997 ± 0.0002 | 0.9997 ± 0.0002 | 0.9957 ± 0.0007 |
| 5 | 0.9995 ± 0.0002 | 0.9998 ± 0.0001 | 0.9996 ± 0.0002 | 0.9988 ± 0.0004 |
| 6 | 0.9999 ± 0.0001 | 0.9998 ± 0.0001 | 0.9999 ± 0.0001 | 0.9996 ± 0.0002 |
| 7 | 0.9996 ± 0.0002 | 0.9998 ± 0.0001 | 0.9998 ± 0.0001 | 0.9996 ± 0.0002 |
| 8 | 0.9999 ± 0.0001 | 0.9997 ± 0.0002 | 0.9999 ± 0.0001 | 0.9997 ± 0.0002 |

head-on: ring 1 at 15 mm 20 mrad: ring 1 at 20 mm

# Conclusions and further studies

- Preliminary results show veto efficiencies > 99.9% beyond a larger enough radii $R_{MIN}$ in the BeamCal
- For 20 mrad crossing-angle, $R_{MIN}$ is ~ 1.5 cm larger than for head-on; this corresponds to reachable mass differences between the lightest sleptons and the LSP (in SUSY scenarios with highly degenerate mass spectra) which are larger by ~ factor 1.8 (e.g. 5 GeV $\rightarrow$ 9 GeV)
- Significant difference seen between different ILC beam parameter sets: "low Q" best… will be worked on more
- Present results statistics limited at the 0.0001 level
- Systematics (e.g. hadronic content) also to be worked on

# Impact of Larger Uninstrumented Region in BeamCal with 20mrad X-angle

New addition to an earlier study

"Experimental Implications for a Linear Collider of the SUSY Dark Matter Scenario"

by

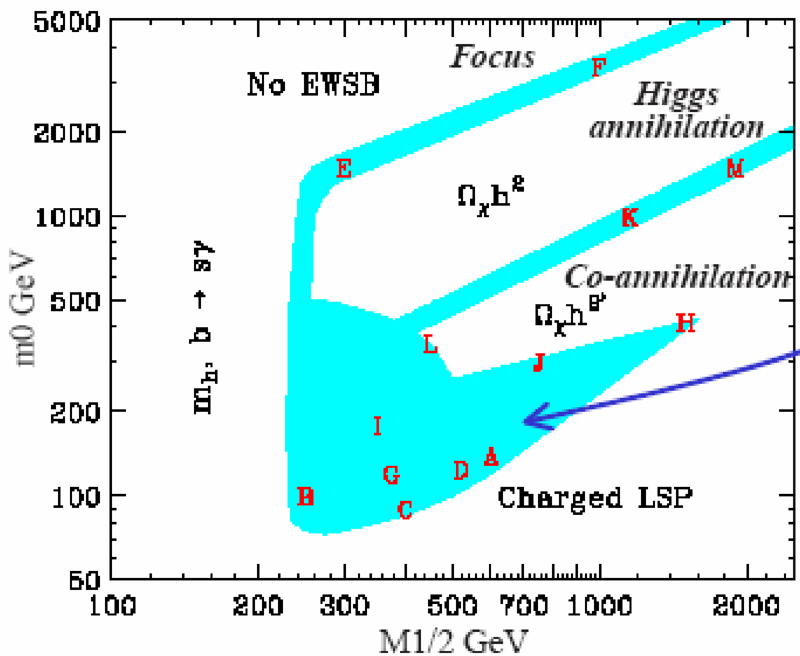
P. Bambade, M. Berggren, F. Richard, Z. Zhang

[hep-ph/0406010] & contribution to LCWS'04 [hep-ph/0406010] & contribution to LCWS'04

# Reminder of That Earlier Study

Addresses detection issues for stau mainly for benchmark point D both in head-on collisions and collisions with a 10 mrad half X-angle

Battaglia-De Roeck-Ellis-Gianatti-Olive-Pape, hep-ph/0306219




$\chi$ stau ($s\tau$) annihilation

Important when

$\Delta M = m_{s\tau} - m_\chi$ is small (5 GeV for point D)

→ The precision on SUSY DM prediction depends on $\Delta M$

Need to measure $m_{s\tau}$ and $m_\chi$ with best possible precision

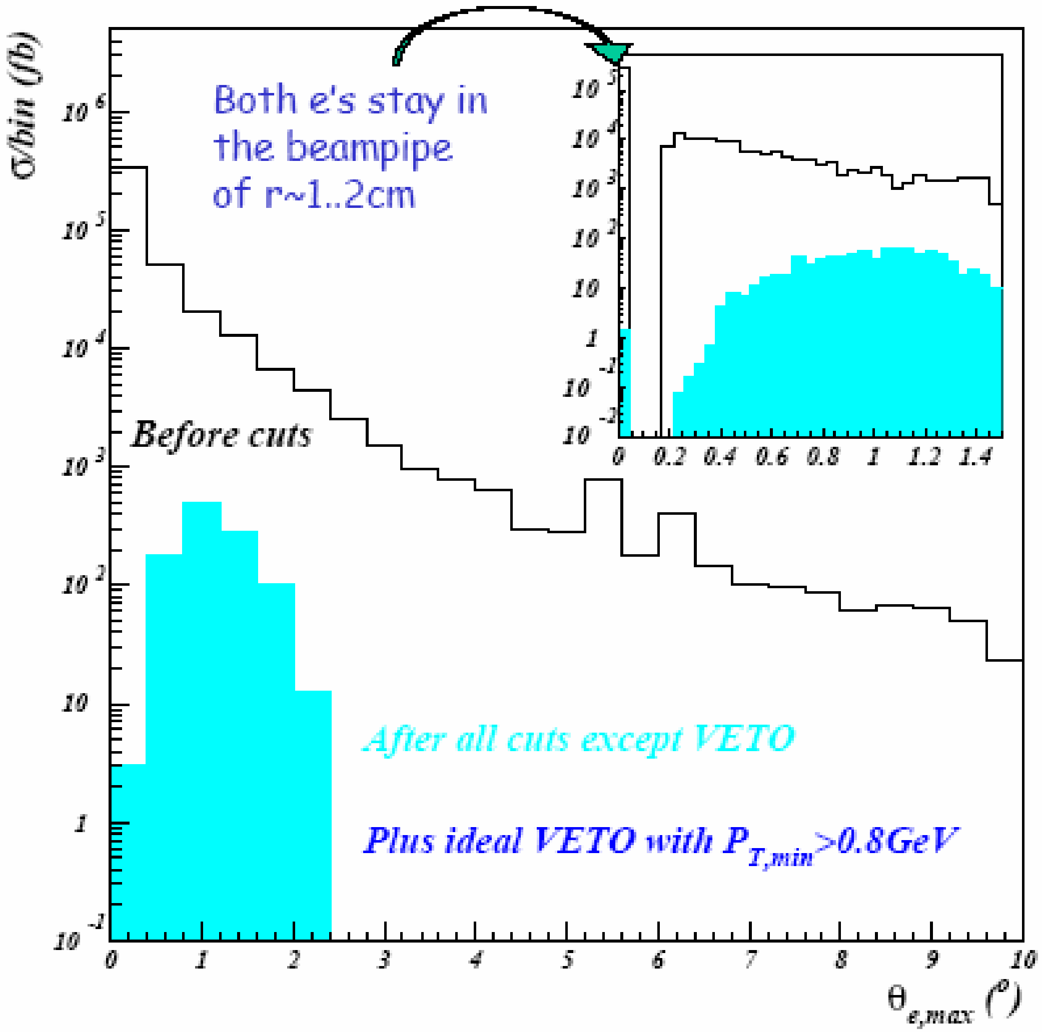
# Main Challenges for the Stau Analyses

$e^+e^- \rightarrow stau^+ \, stau^- \rightarrow \chi^0\tau^+ \, \chi^0\tau^-$

Cross sections: 10fb @ 500GeV, 4.6fb @ 442GeV

- **Missing energy and soft final state**
  → Additional missing energies from neutrinos in tau decay
  → Final state particles very soft:
  due to small $\Delta M$<10GeV & little Lorentz boost
- **SM backgrounds are many orders of magnitude larger**
  → Need very efficient veto at low angles
- **Additional complication if crossing-angle collisions**

# Low Angle Veto in Head-on Collisions




**Angular distribution of the spectator e from $ee \to ee\tau\tau$**

Total σ ~ $0.43\times10^6$ fb of which 3/4 with both e's staying in the beampipe corresponding to the peak at zero in the inset

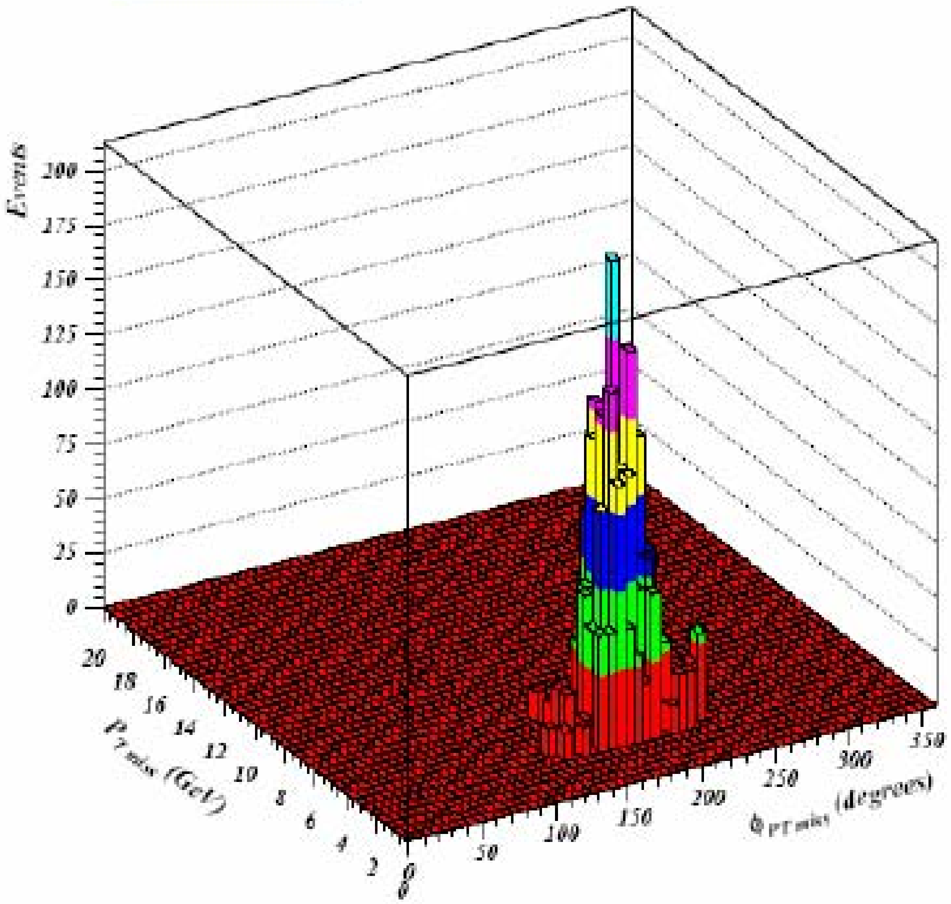
**Analysis cuts reject most of the background**

**An ideal veto with**
$P_{T,min}$>0.8GeV
is sufficient to suppress all remaining $\gamma\gamma \to \tau\tau$ background events except those with energetic μ/π at low angles

Zhiqing Zhang (LAL, Orsay) Snowmass, Aug.14-27, 2005 5

# Remaining Background in Cross-Angle Mode

ee→eeττ




10mrad half crossing angle

For an incoming beam hole of r=1.2cm the probability for a spectator e+/e- to enter the hole is $10^{-3}$.

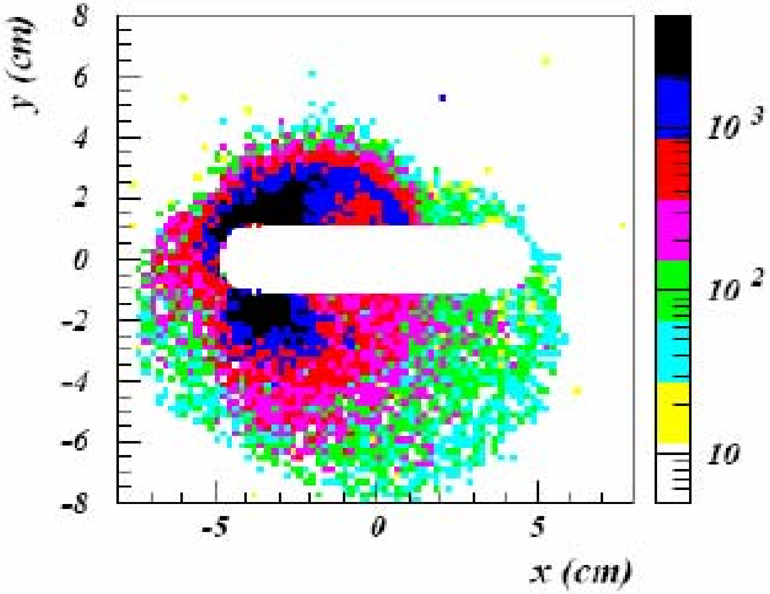
Remaining background events correspond (mainly) to those with e+/e- goes into the incoming beam hole.

Additional cuts remove essentially all these events.

A price to pay however:
 25% efficiency reduction
e.g. for benchmark point D
@ Ecm=442GeV
from ~5.7% to ~4.3%

# New Analysis with Larger Inefficient Region

1) If beam hole radius increases from 1.2cm to 1.5cm
2) If additional blind region




Question:

What's the consequence for the stau analysis?

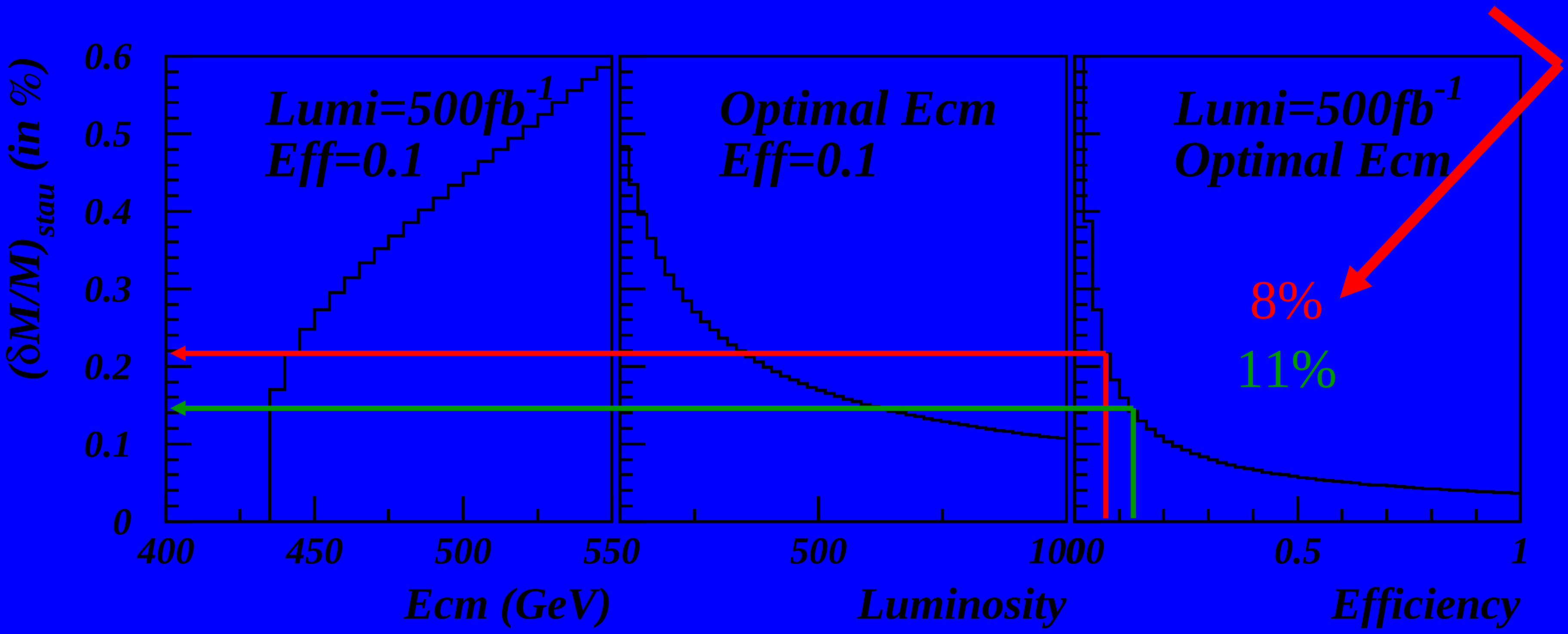
Answer:
The additional cuts need to be modified introducing larger inefficiency from 25% to 30% w.r.t. the head-on analysis

Zhiqing Zhang (LAL, Orsay) Snowmass, Aug.14-27, 2005 7

# Luminosity, $E_{CM}$ and efficiency optimization

benchmark point D' with $\Delta m_{\tilde{\tau}-\chi}$ = 5 GeV

$\tilde{\tau}$ mass precision wrt efficiency **effect from 2nd hole only**




Relative $\tilde{\tau}$ mass precision from cross-section measurements near the production threshold with negligible background

# Summary

It seems that the horizontal blind regions
in between the two beam holes
has only a small effect on the stau analysis

Further improvements still to come:

a) replace the ideal veto ($P_T$>0.8GeV) with more realistic efficiency tables

b) use large SM background samples