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

preliminary

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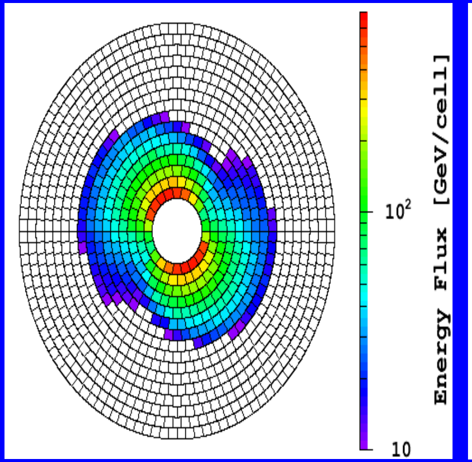
Snowmass 2005

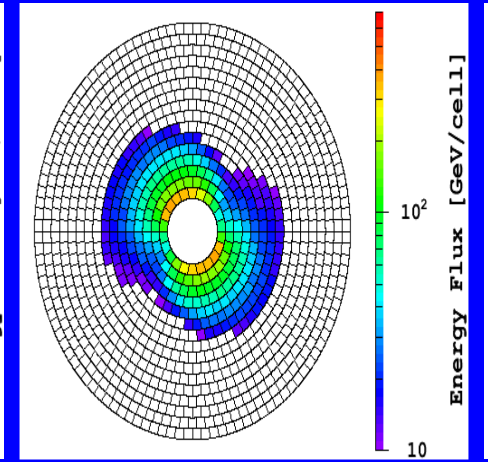
1. Effect of crossing-angle on ELID V. Drugakov, U. of Minsk
2. Effect of crossing-angle on stau search Z. Zhang, LAL-Orsay

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

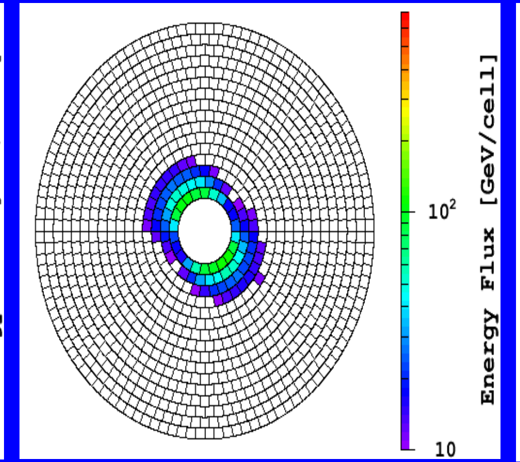
TESLA



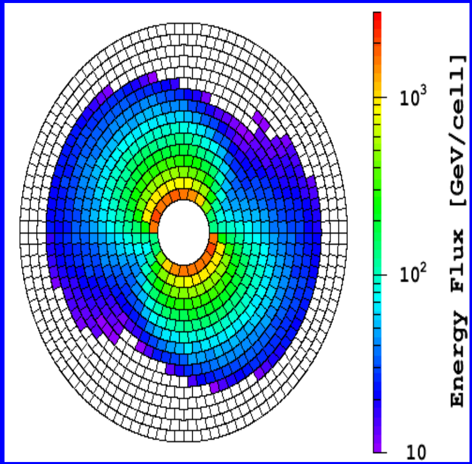
ILC-nom



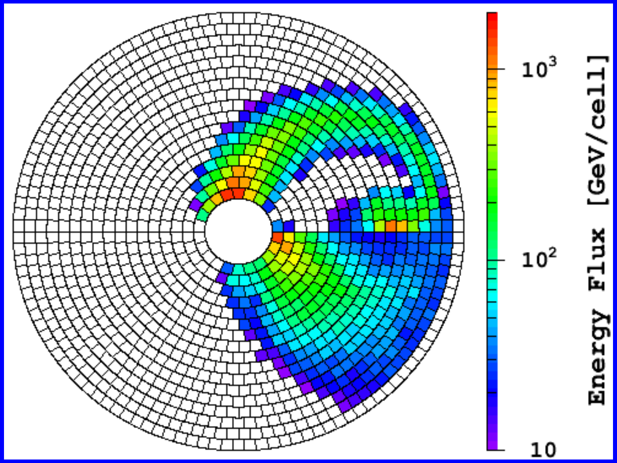
ILC-lowQ

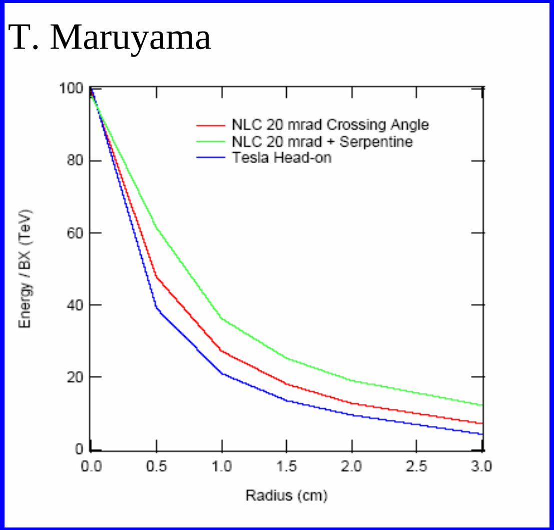


ILC-hilum



ILC – nom 20 mrad with idealised DID

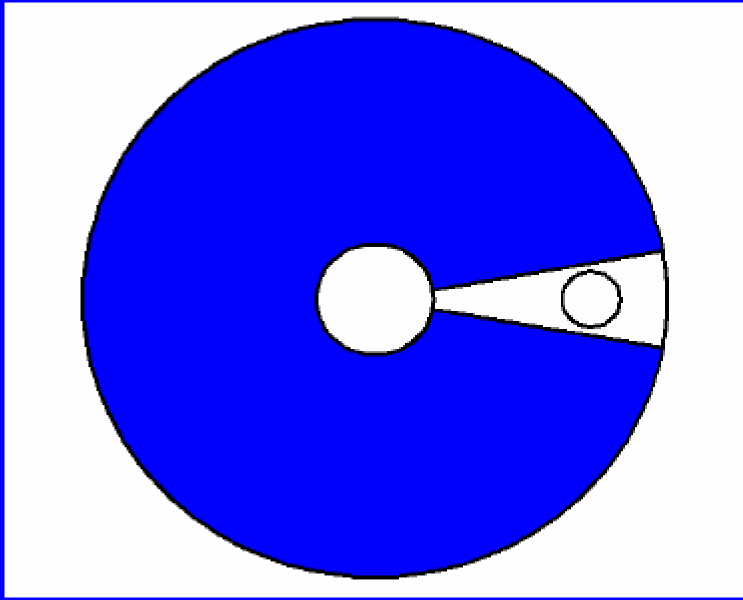




Features of simulation and comparison

- 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 < φ < 15 degree
  this blind area is excluded from
  the efficiency calculation

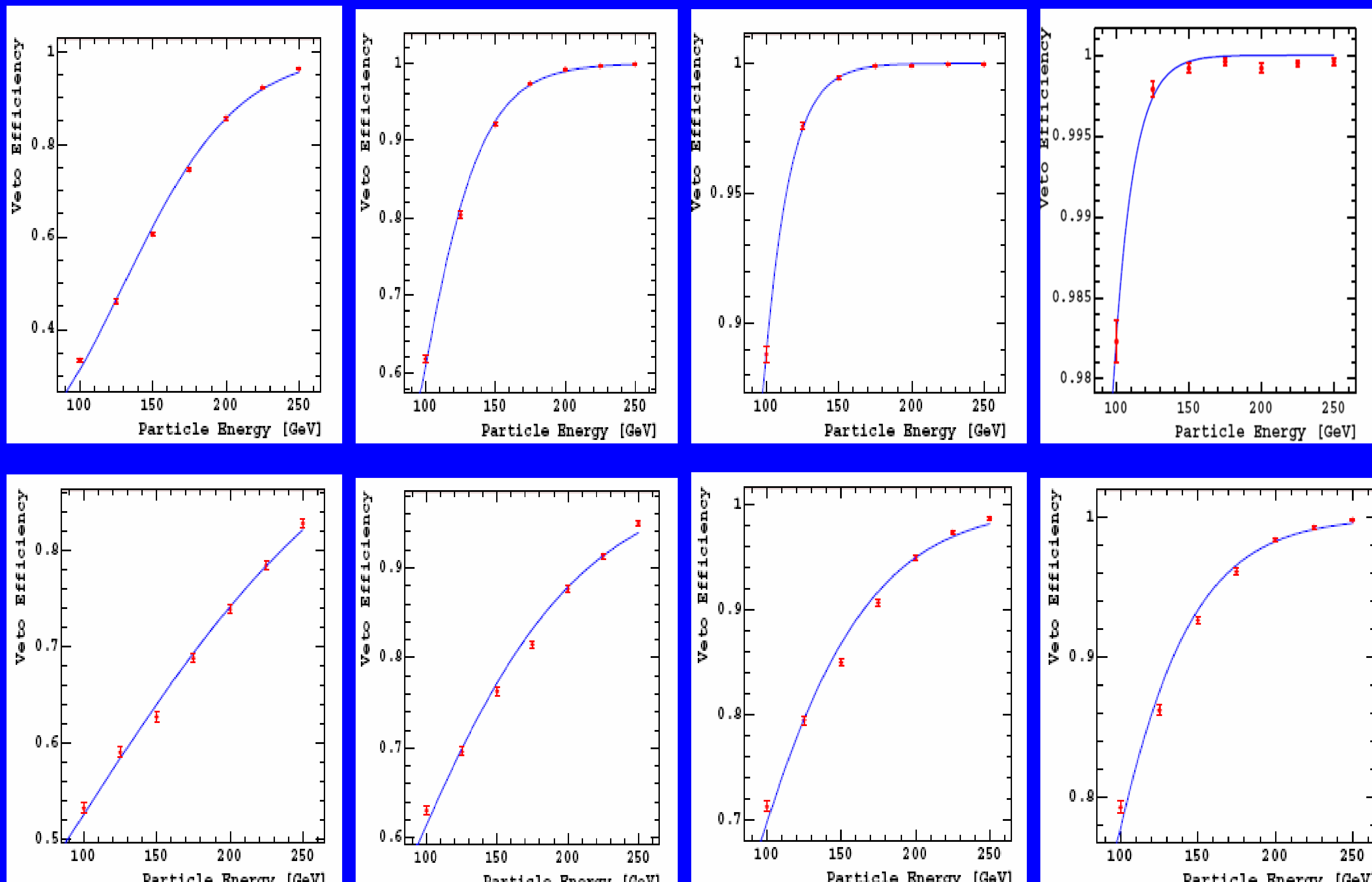


Comparison of veto eff. in 4 first rings

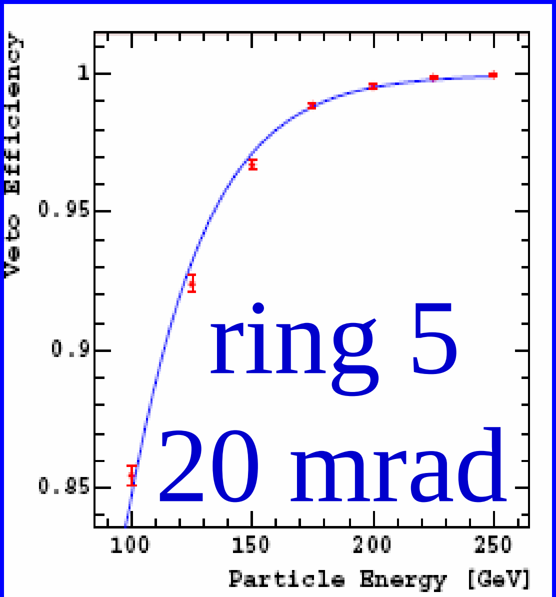
Ring 1 2 3 4

Head-on
ILC nom
ring 1
at 15 mm

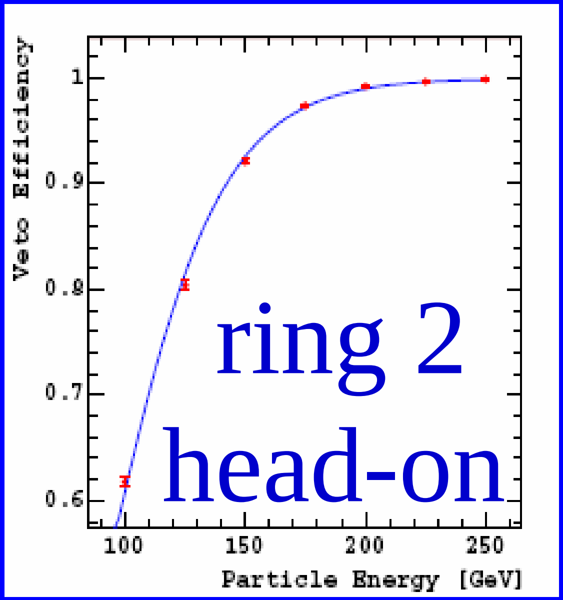
20 mrad
ILC nom
ring 1
at 20 mm



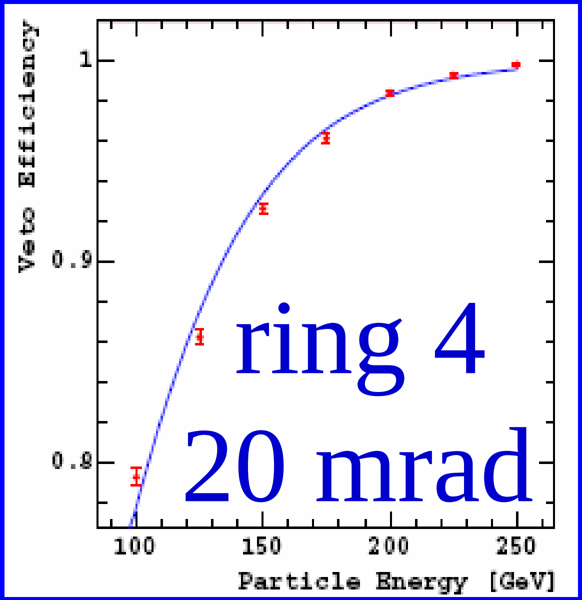
20 mrad + DID θ ~ 11 mrad
⇔ head-on θ ~ 6 mrad



θ ~ 11.5 mrad



θ ~ 6 mrad



θ ~ 10 mrad

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

ring	250 GeV efficiencies: head-on	250 GeV efficiencies: 20 mrad & DID	200 GeV efficiencies: head-on	200 GeV efficiencies: 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

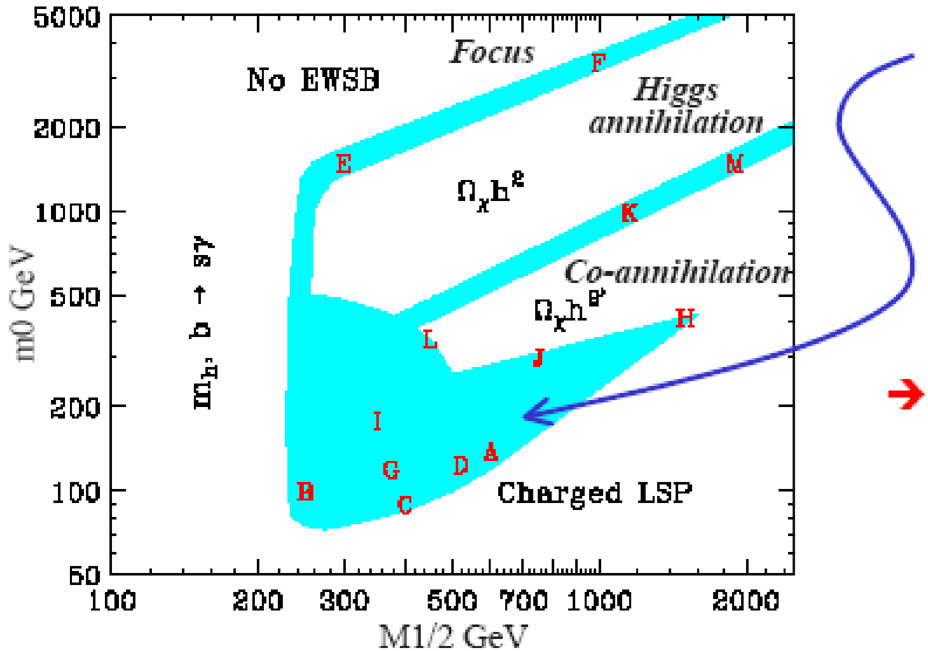
P. Bambade, M. Berggren, F. Richard, Z. Zhang

[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



χ 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 ΔM

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

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Main Challenges for the Stau Analyses

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

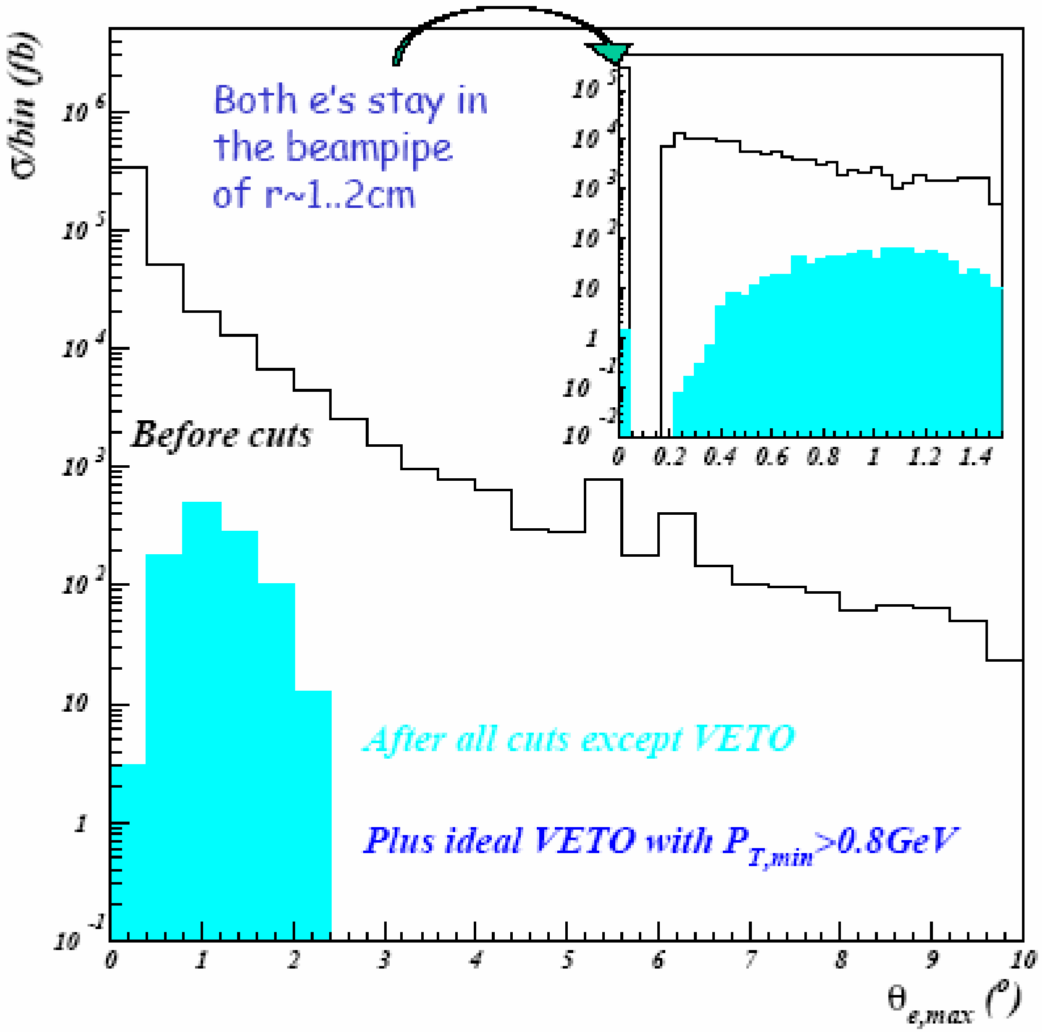
Cross sections: 10fb @ 500GeV, 4.6fb @ 442GeV

- **Missing energy and soft final state**
  → Additional missing energies from neutrinos in tau decay
  → Final state particles very soft:
  due to small $\Delta M < 10$GeV & 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→eeττ

Total σ ~ 0.43x10⁶ 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 γγ→ττ background events except those with energetic μ/π at low angles

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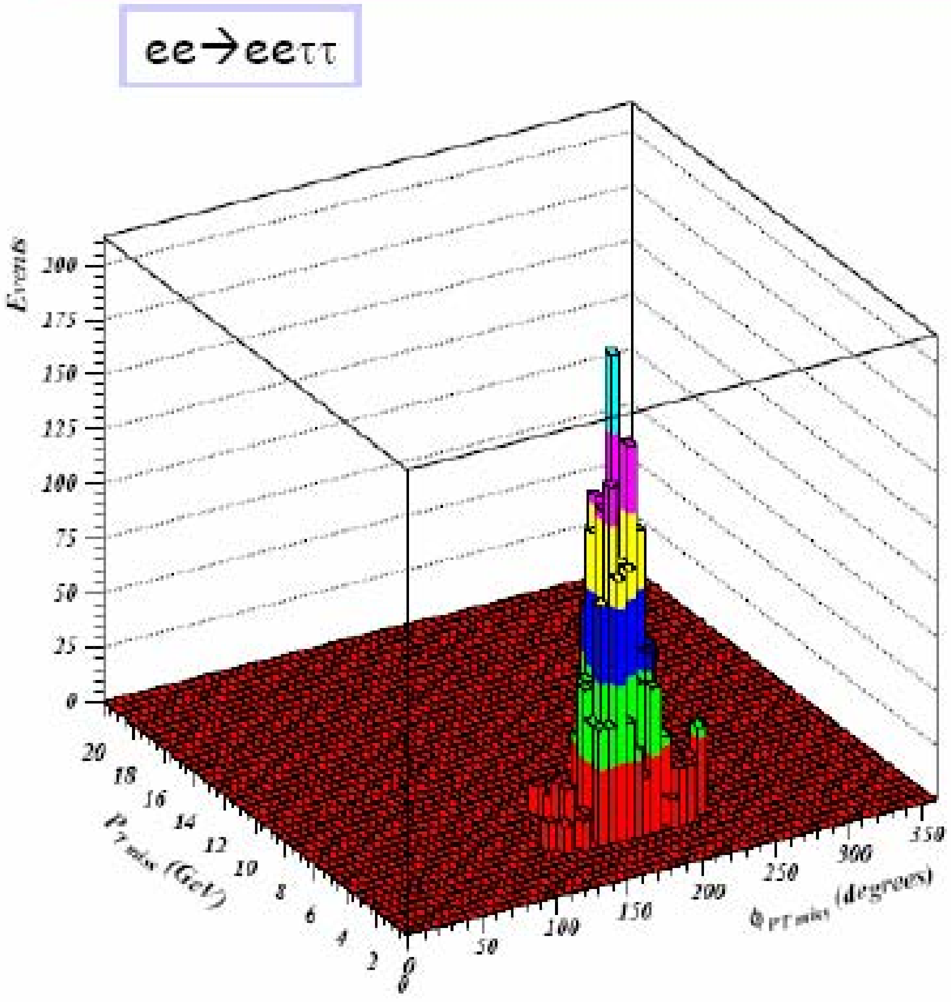
Remaining Background in Cross-Angle Mode



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}.

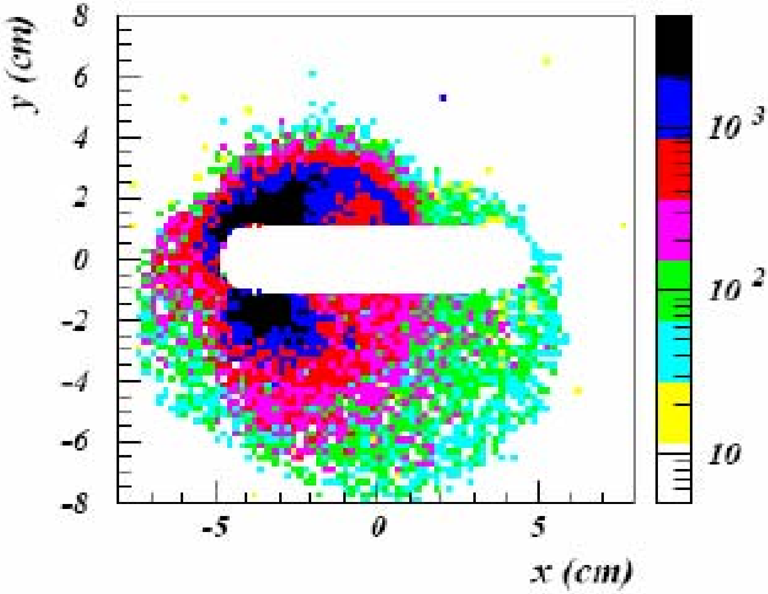
Remaining background events correspond (mainly) to those with e+/e- goes into the incoming beam hole.

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

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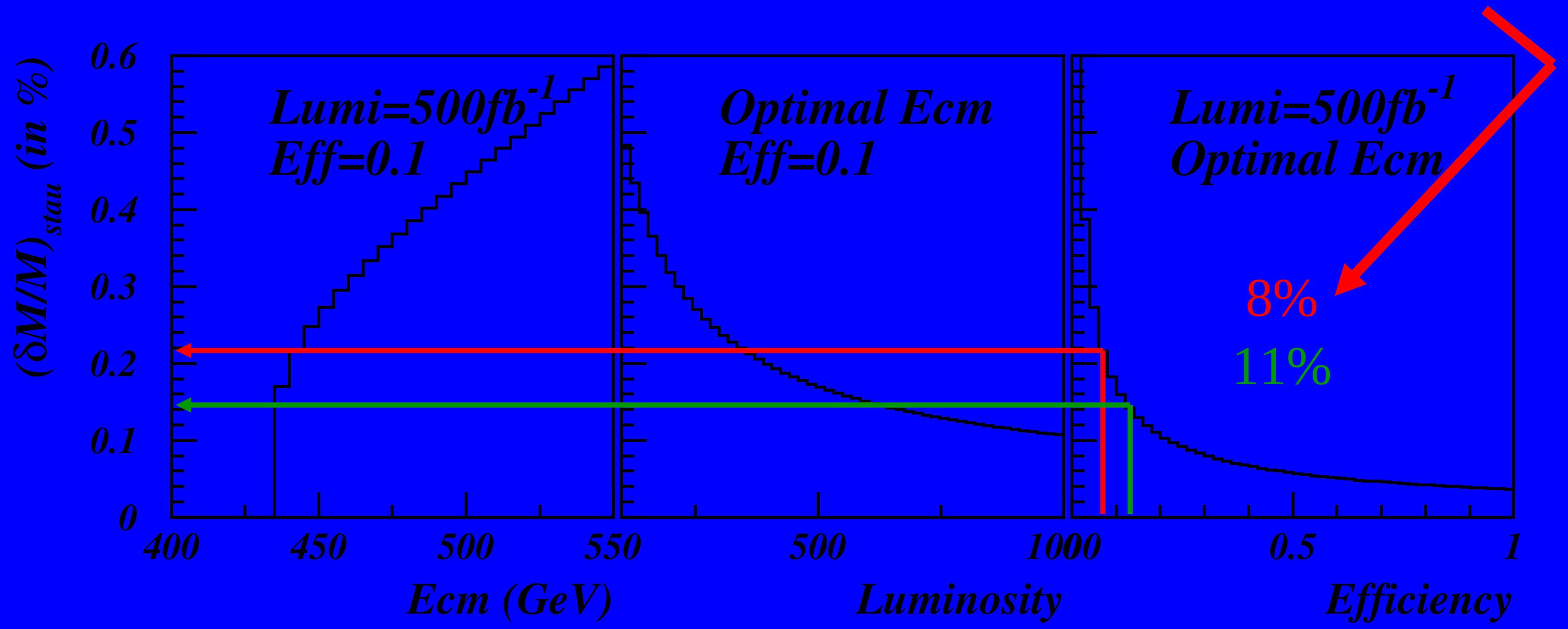
Luminosity, E_{CM} and efficiency optimization

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