Electron ID in BeamCal and SUSY capabilities

preliminary

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LAL-Orsay

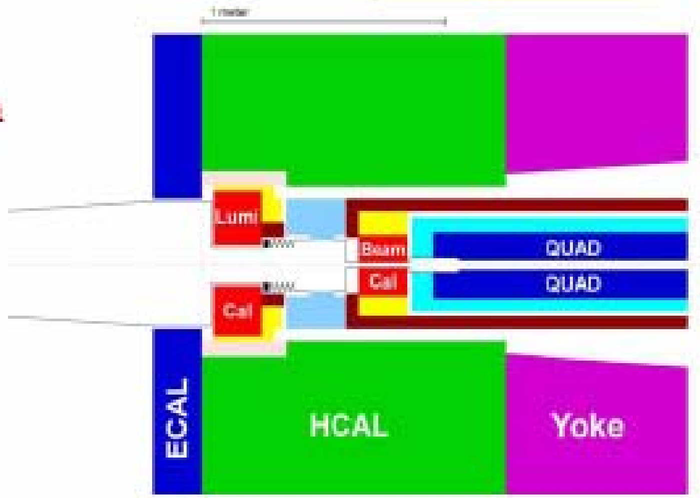
Snowmass 2005

1. BeamCal ELID and segmentation study A. Elagin, JINR, Dubna
2. Effect of crossing-angle on ELID V. Drugakov, U. of Minsk
3. Effect of crossing-angle on stau search Z. Zhang, LAL-Orsay

Beam Calorimeter
main parameters

- ✓ beam diagnostic
- ✓ identification and measurement of the high energy particles

Diamond-tungsten	
Distance from the IP, cm	370
$\theta_{min} - \theta_{max}$, mrad	4 – 28
$R_{min} - R_{max}$, cm	1.5 – 10
Sensor thickness, mm	0.5
Absorber thickness, mm	3.5
Number of layers	30
X_0, mm	4
R_{molier}, mm	10



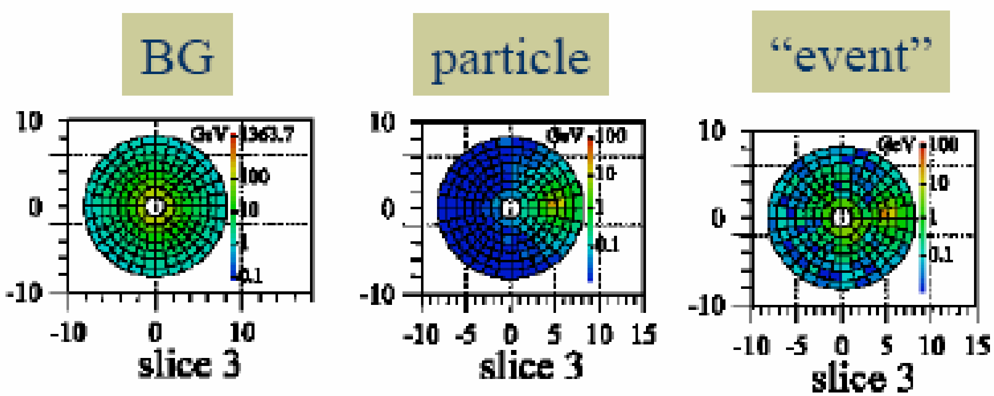
Technologies for the BeamCal:
1) **Silicon-tungsten** or **diamond-tungsten** sandwich calorimeter
2) **PbWO4** crystal

Particle identification in the BeamCal

Electron Finder from V. Drugakov

1. Use 10 events to define $\langle E_{bg} \rangle$ and RMS_{Ebg} for each pad.
2. For signal event subtract $\langle E_{bg} \rangle$ from E_{dep} for each pad.
3. Keep pads with remaining E_{dep} larger than $5 \cdot RMS_{Ebg}$.
4. Search along each segment:

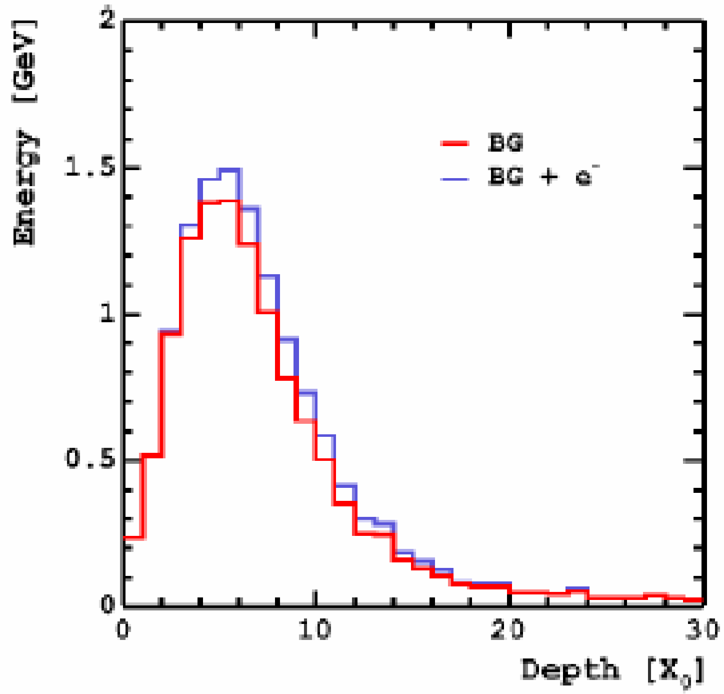
   cluster is found if there are more than **7** pads in the segment and more than **4** pads within at least one neighbor segment.



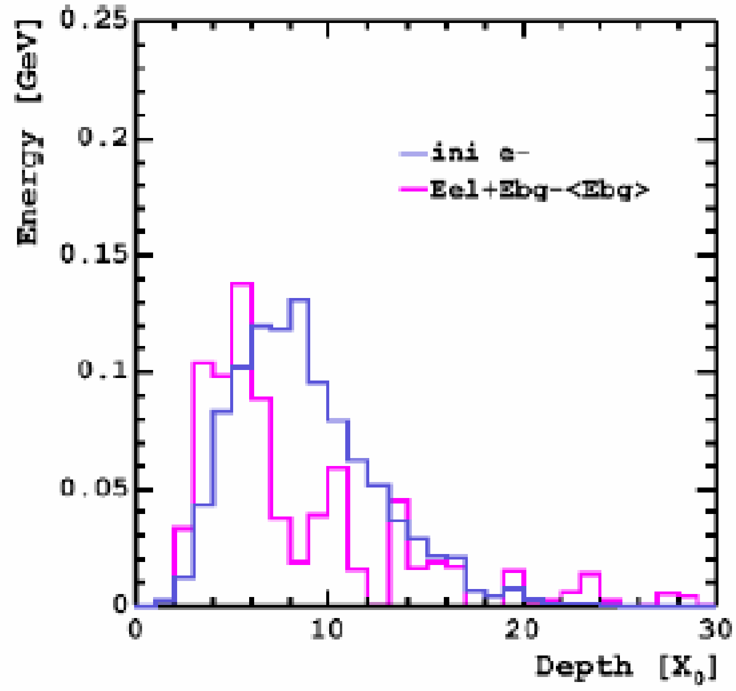
Particle identification in the BeamCal

Electron Finder from V. Drugakov

100 GeV electron on top of the beamstrahlung



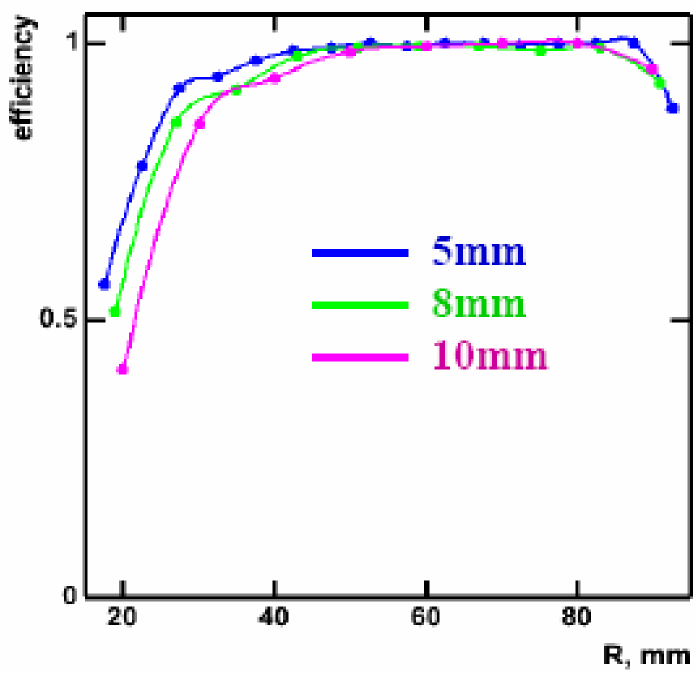
Subtraction of average background



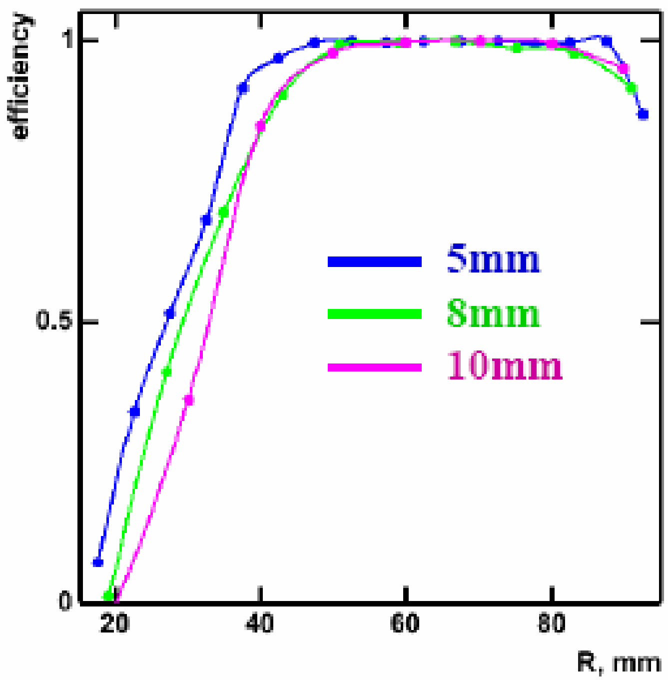
Particle identification efficiency

electrons 200 GeV

Low BG (φ ~ 0°)



High BG (φ ~ 90°)



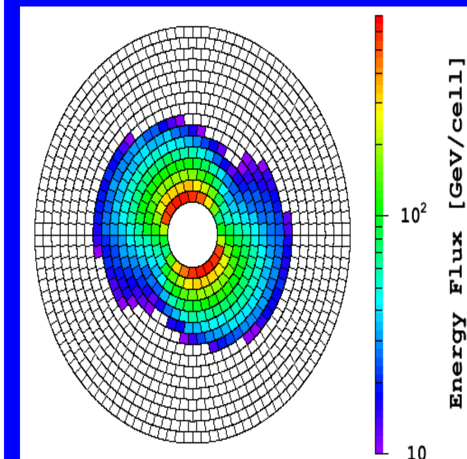
Summary

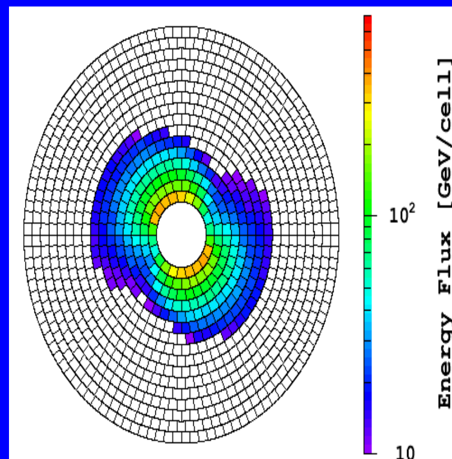
- Complete simulation chain for BeamCal exist:
  - GEANT4 based simulation (A. Elagin)

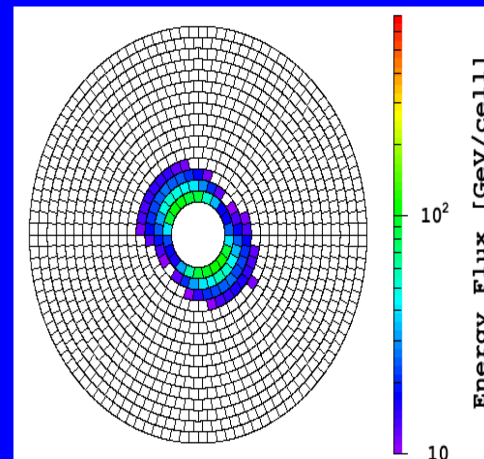
    (crossing angle options are available, implemented by V.Drugakov)
  - eFinder for electron identification (V. Drugakov)
- **5 mm** segmentation is the best for electron identification at small radii
- **8 mm** – is not too bad
- **10 mm** segmentation gives 100% efficiency for R > 55 mm

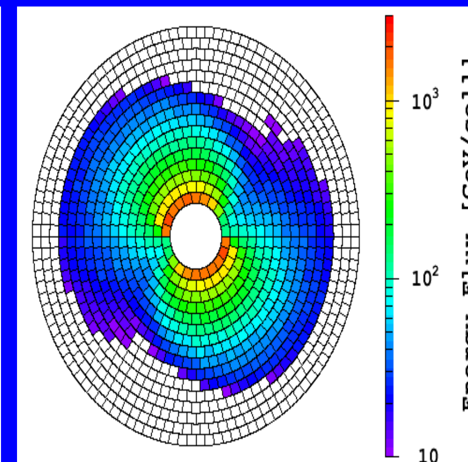
Pair energy in Beamcal (l*=4m, B=4T)

TESLA ILC-nom ILC-lowQ ILC-hilum

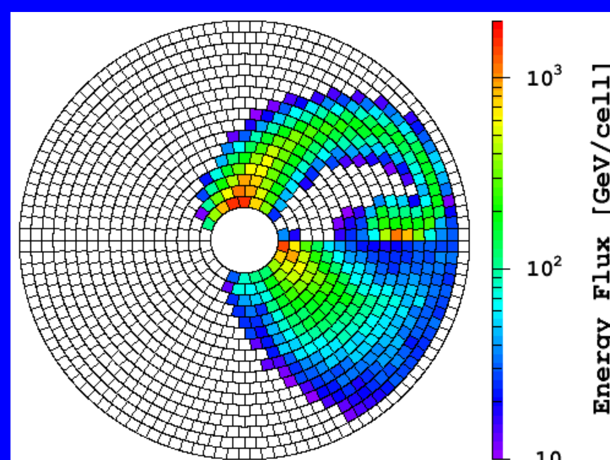


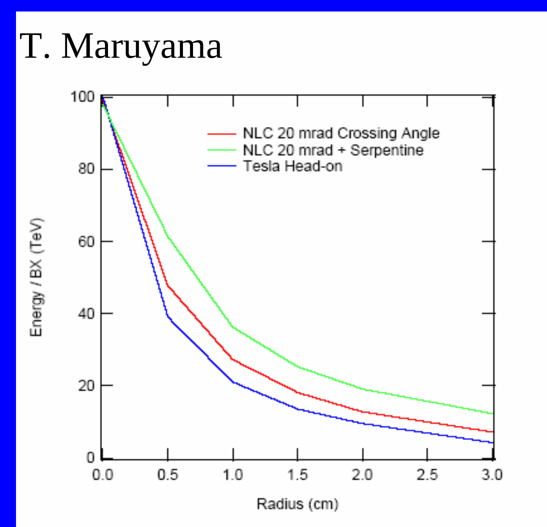






ILC – nom
20 mrad with
idealised DID

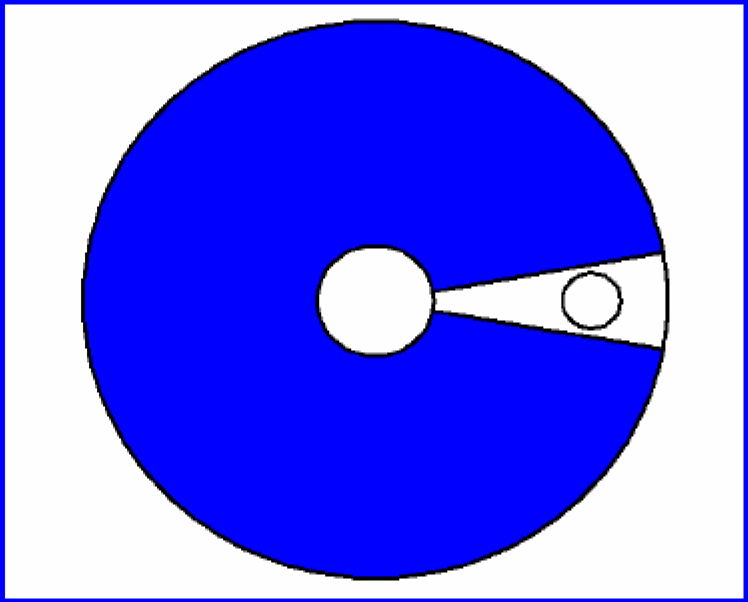




Features of simulation and comparison

- 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

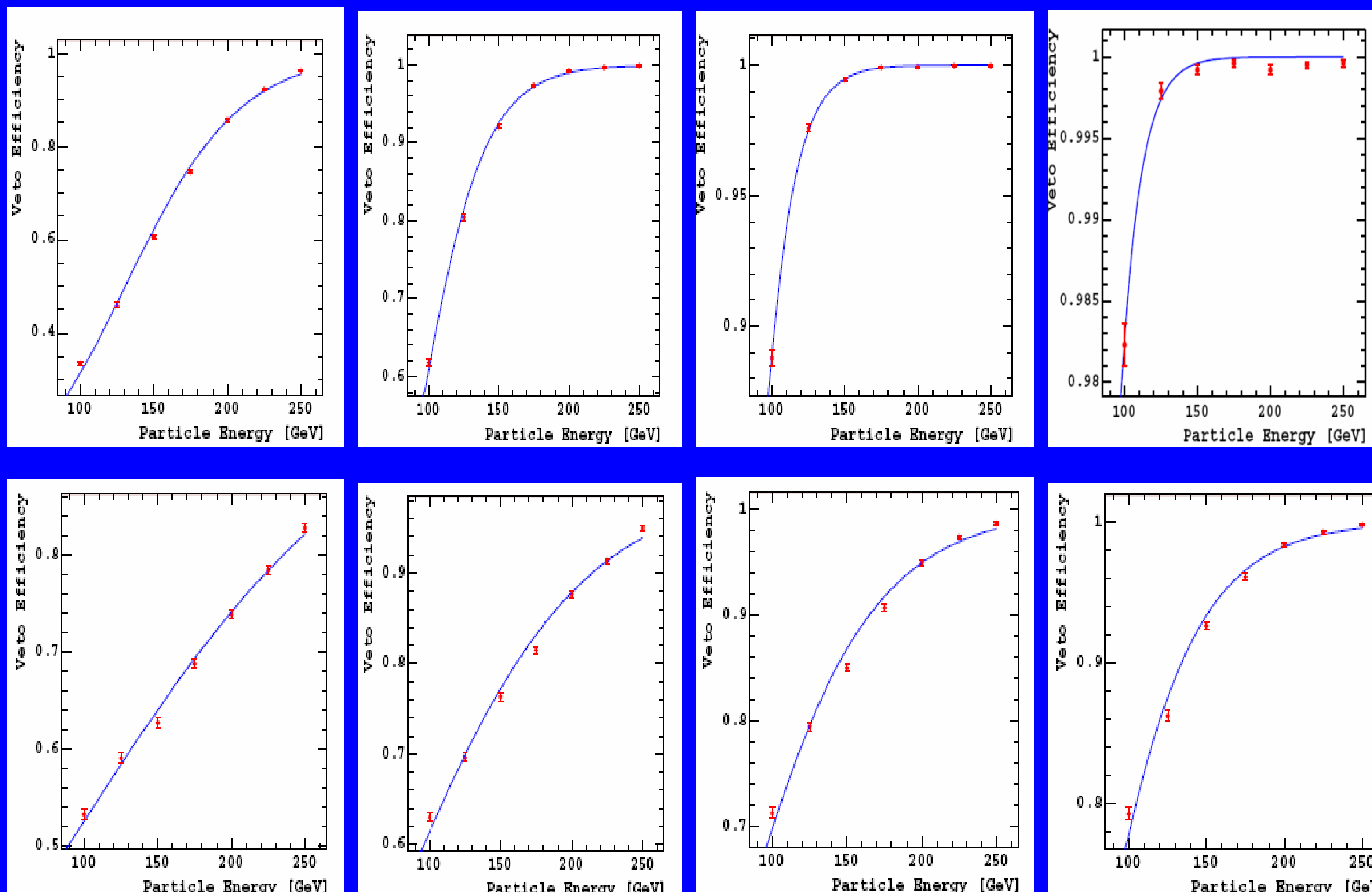


Comparison of veto eff. in 4 first rings

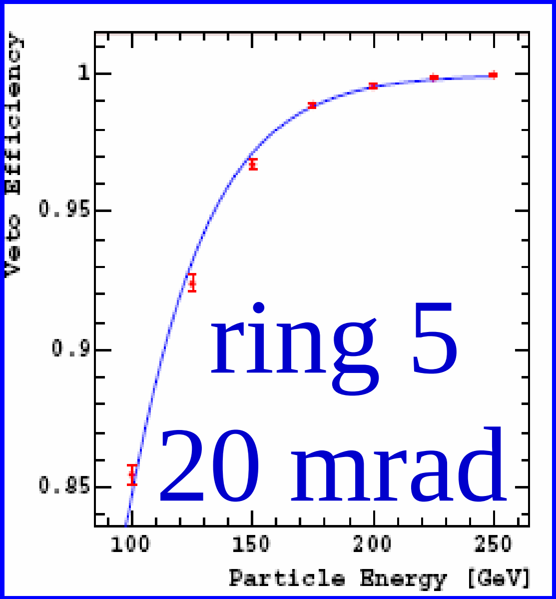
Ring 1 2 3 4

Head-on ILC nom

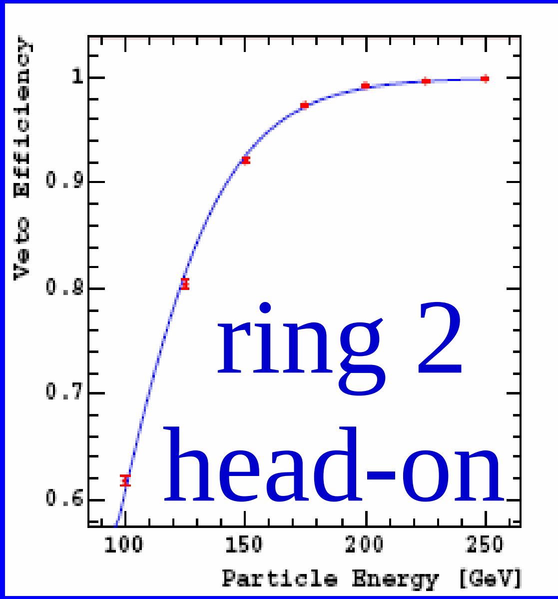
20 mrad ILC nom



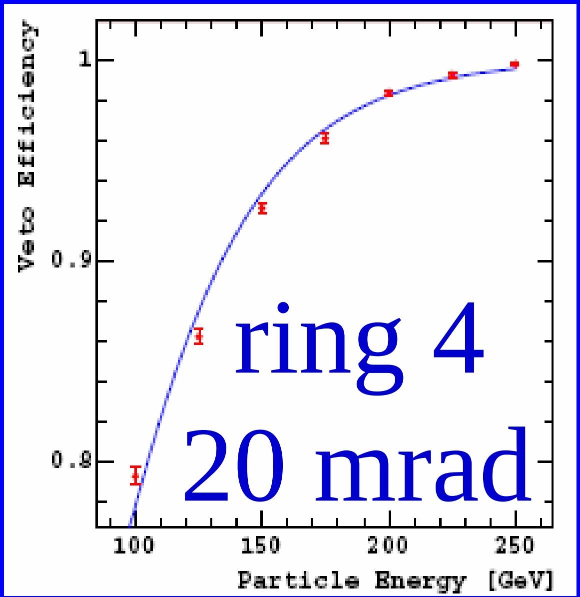
20 mrad + DID θ ~ 11 mrad
⇔ head-on θ ~ 6 mrad



θ ~ 11.5 mrad



θ ~ 6 mrad



θ ~ 10 mrad

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

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

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 → 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

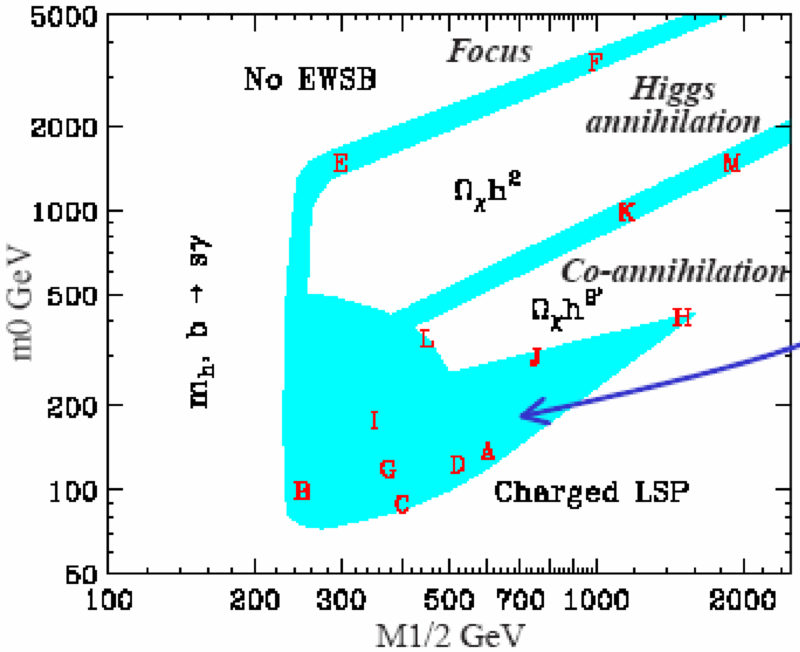
P. Bambade, M. Berggren, F. Richard, Z. Zhang

[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

Zhiqing Zhang (LAL, Orsay) Snowmass, Aug.14-27, 2005 2

Main Challenges for the Stau Analyses

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

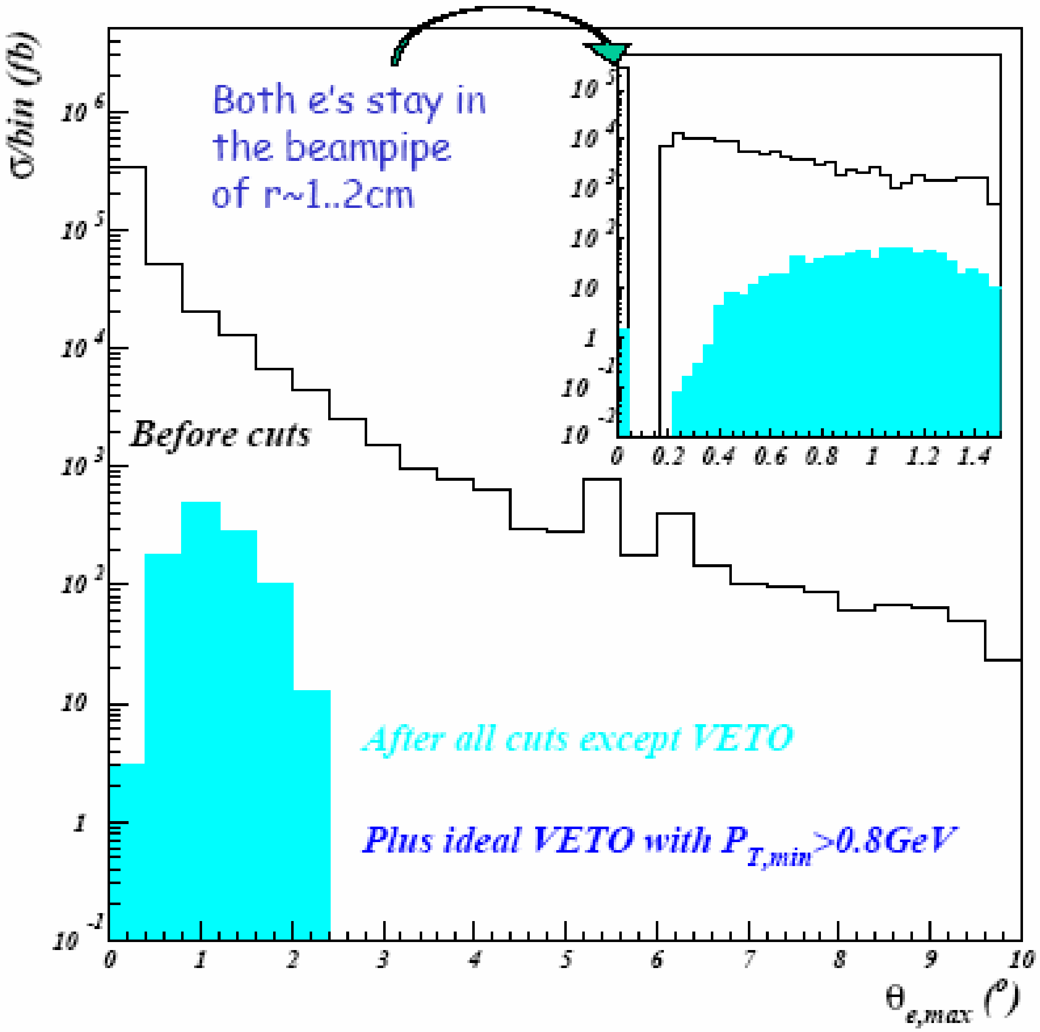
Cross sections: 10fb @ 500GeV, 4.6fb @ 442GeV

- **Missing energy and soft final state**
  → Additional missing energies from neutrinos in tau decay
  → Final state particles very soft:
  due to small ΔM<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→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

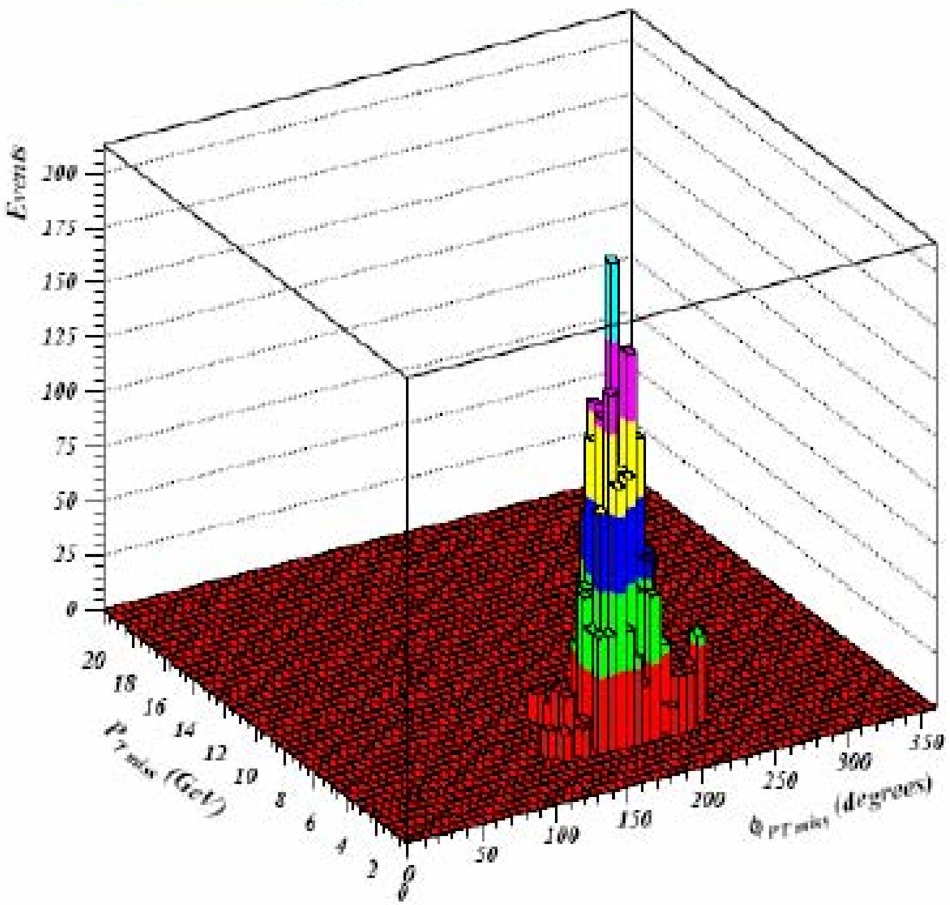
An ideal veto with

$P_{T,min}$>0.8GeV

is sufficient to suppress all remaining γγ→ττ background events except those with energetic μ/π at low angles

Remaining Background in Cross-Angle Mode

$ee \to ee\tau\tau$



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}.

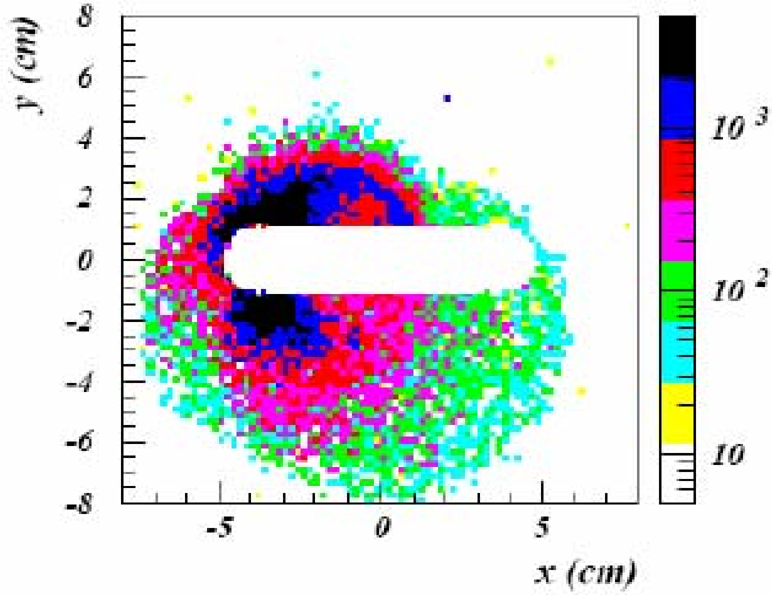
Remaining background events correspond (mainly) to those with e+/e- goes into the incoming beam hole.

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:

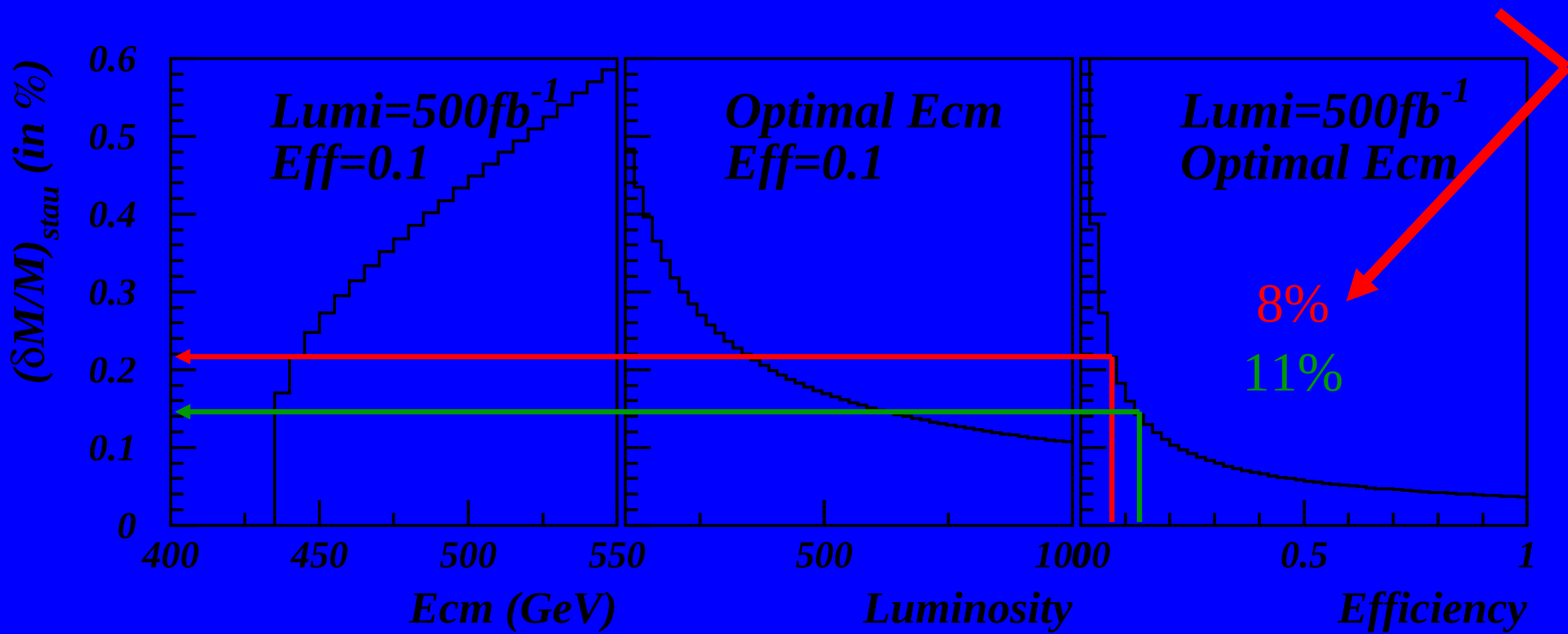
What's the consequence for the stau analysis?

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

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