Mask Design and Background Studies for TESLA

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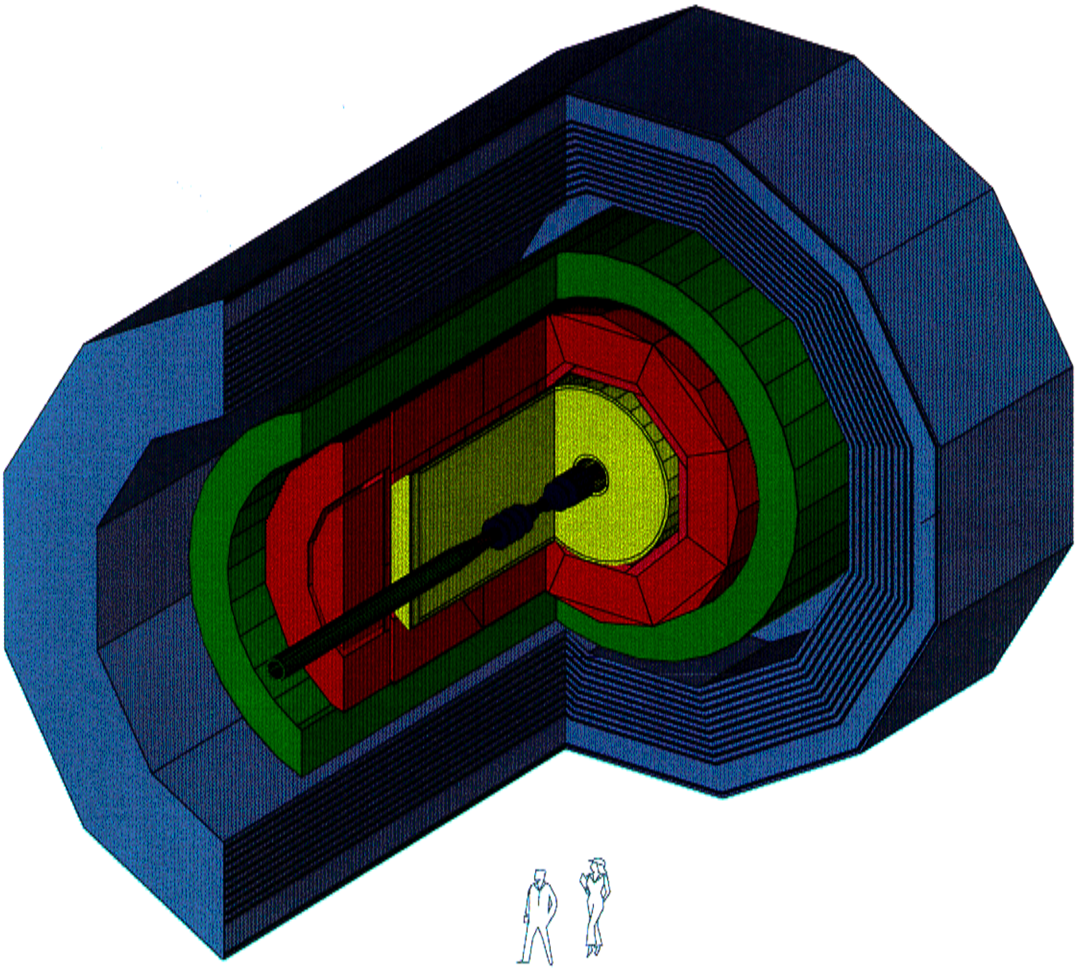
Motivation

Background Studies for the TESLA Detector



GEANT3 based detector simulation BRAHMS 201

Motivation II

Problems in the low angle region:

- Beam induced background in the tracking detectors
- Hermeticity
- Fast luminosity measurement

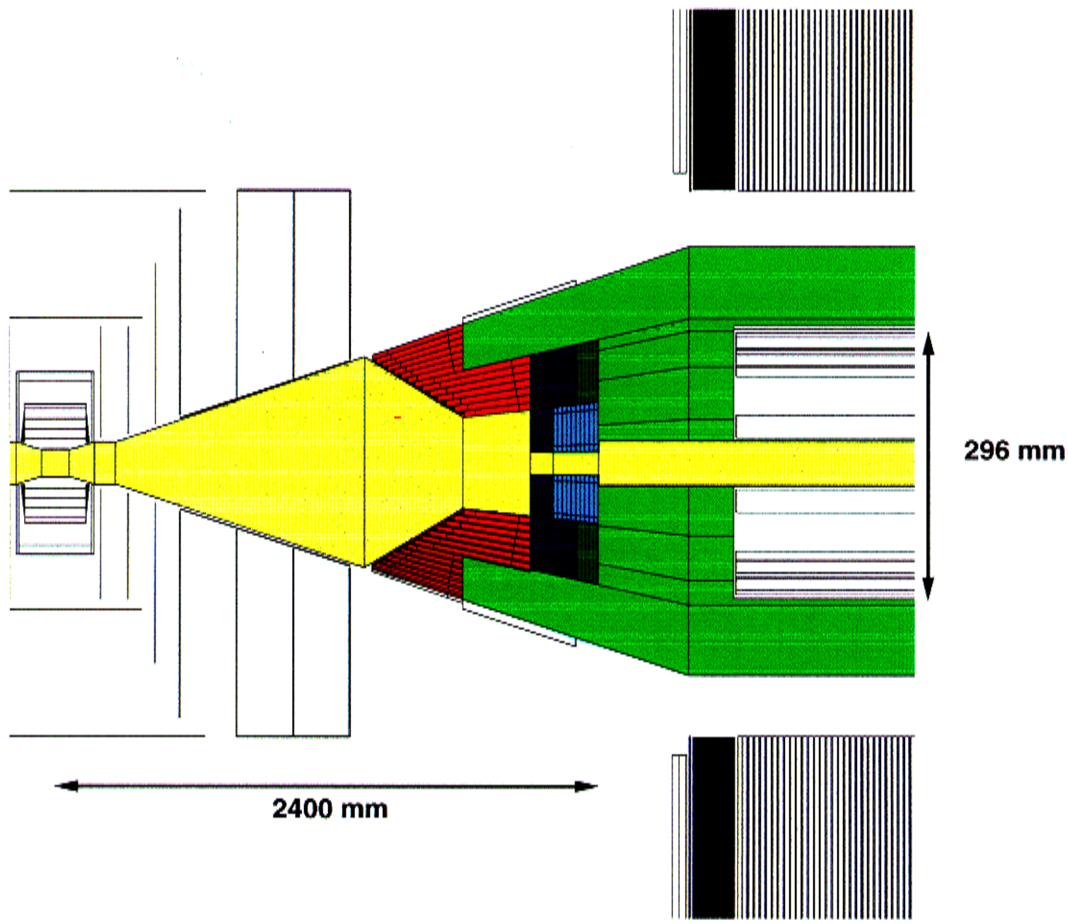
Main tasks of the mask:

- Shield tracking detectors from backscattered particles from beamstrahlung background
- Reduce neutron flux coming from quads, beamline and beam dump
- Shield SI from synchrotron radiation
- Provide instrumentation for small angles ($\leq$ 80 mrad) for
  - Fast luminosity monitoring
  - Physics

The Mask Region

Design of the mask region

- Tungsten shield for backscattered pairs and secondaries
- Neutron shield (graphite absorbers)
- Shield for synchrotron radiation



- Instrumentation for small angles
  - Low Angle Tagger (LAT)
  - Luminosity CALorimeter (LCAL)

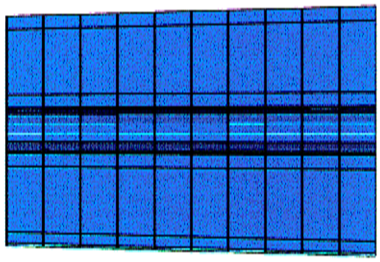
Design of the Mask II

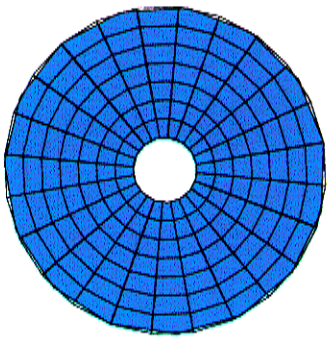
- Coverage:
  - LCAL : 4.6 mrad $\leq \theta \leq$ 27.5 mrad
  - LAT : 27.5 mrad $\leq \theta \leq$ 83.1 mrad
- LAT gets large number of hits, LCAL gets huge number of hits per bunchcrossing
- LCAL should serve as fast luminosity monitor
- LAT and LCAL are separated to minimize leaking from backscattered particles
- Both detectors have to be fast and radiation hard
- LAT together with tungsten mask shields central detector
- LCAL acts as tungsten collimator for synchrotron radiation

Realization

- LAT and LCAL as tungsten calorimeters. Active elements could be radiation hard solid state detectors.
- LCAL $\geq 50X_0$, LAT $\geq 60X_0$

Instrumentation of the LCAL



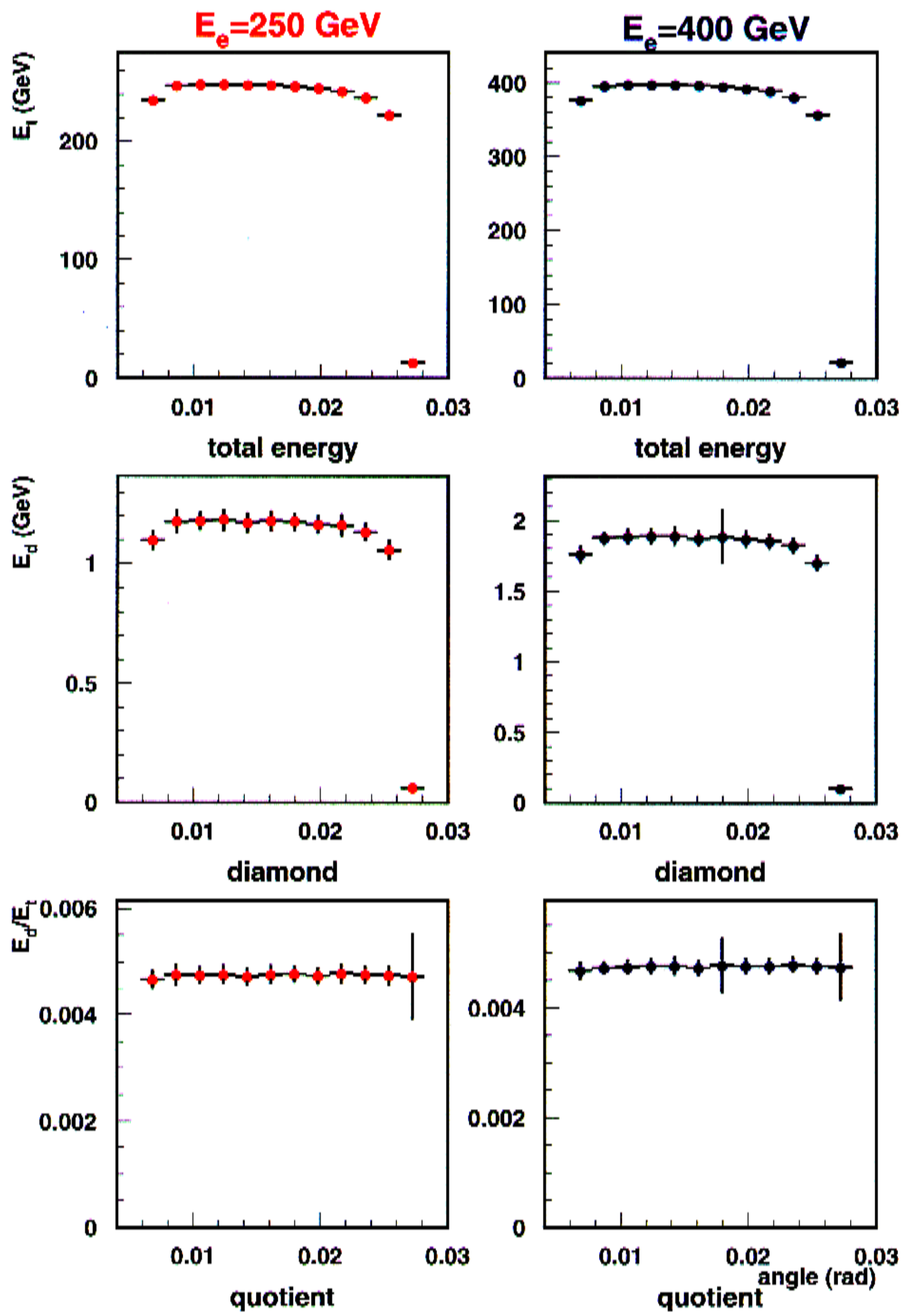


- Diamond/tungsten sampling calorimeter
- first layer is diamond (pair monitor)
- $\Delta\theta \approx 3.3$ mrad
- $\Delta\phi = 15$ deg
- Segmentation in z is under investigation right now

LCAL signal will be included in the fast feedback system
$\Rightarrow$ readout has to be done in ≤ 40 ns

Performance of the LCAL – Detection of Electrons

10 layer version of LCAL



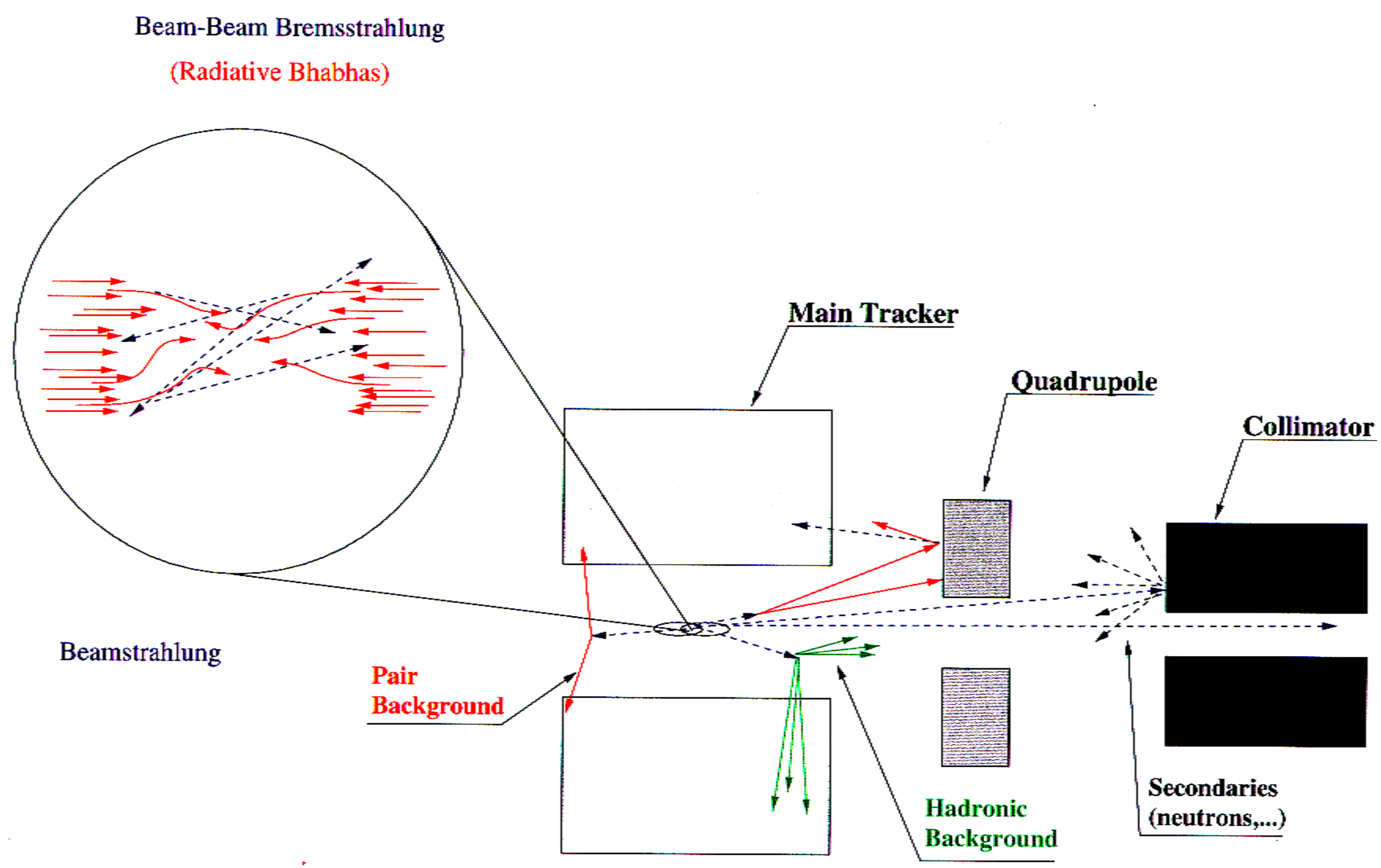
$\Delta E/E \approx 60\%/\sqrt{E}$ (a question of layers)

Beam Induced Background

The TESLA beam itself is a potential source of background for the detector:

- Beam-Beam Background
  - Pairs
  - Hadronic Background
  - Neutrons
- Synchrotron Radiation Induced Background
- Beam-Gas Background
- Muon Induced Background

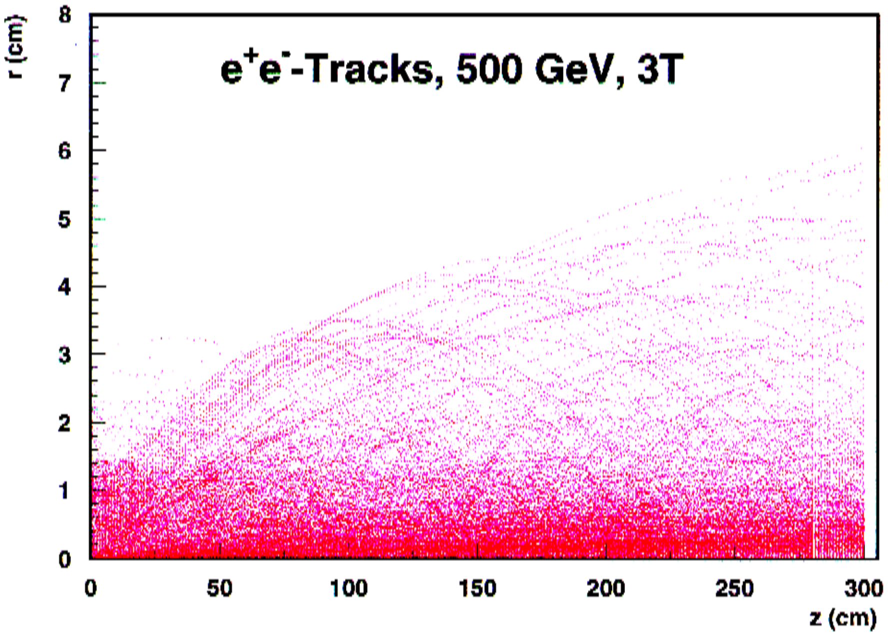
Beam-Beam Background

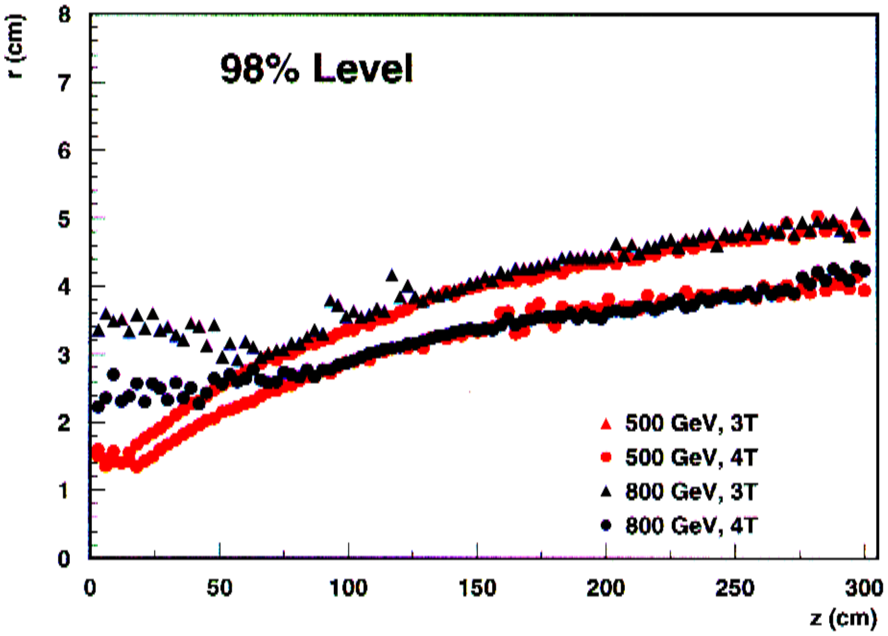


Pairs

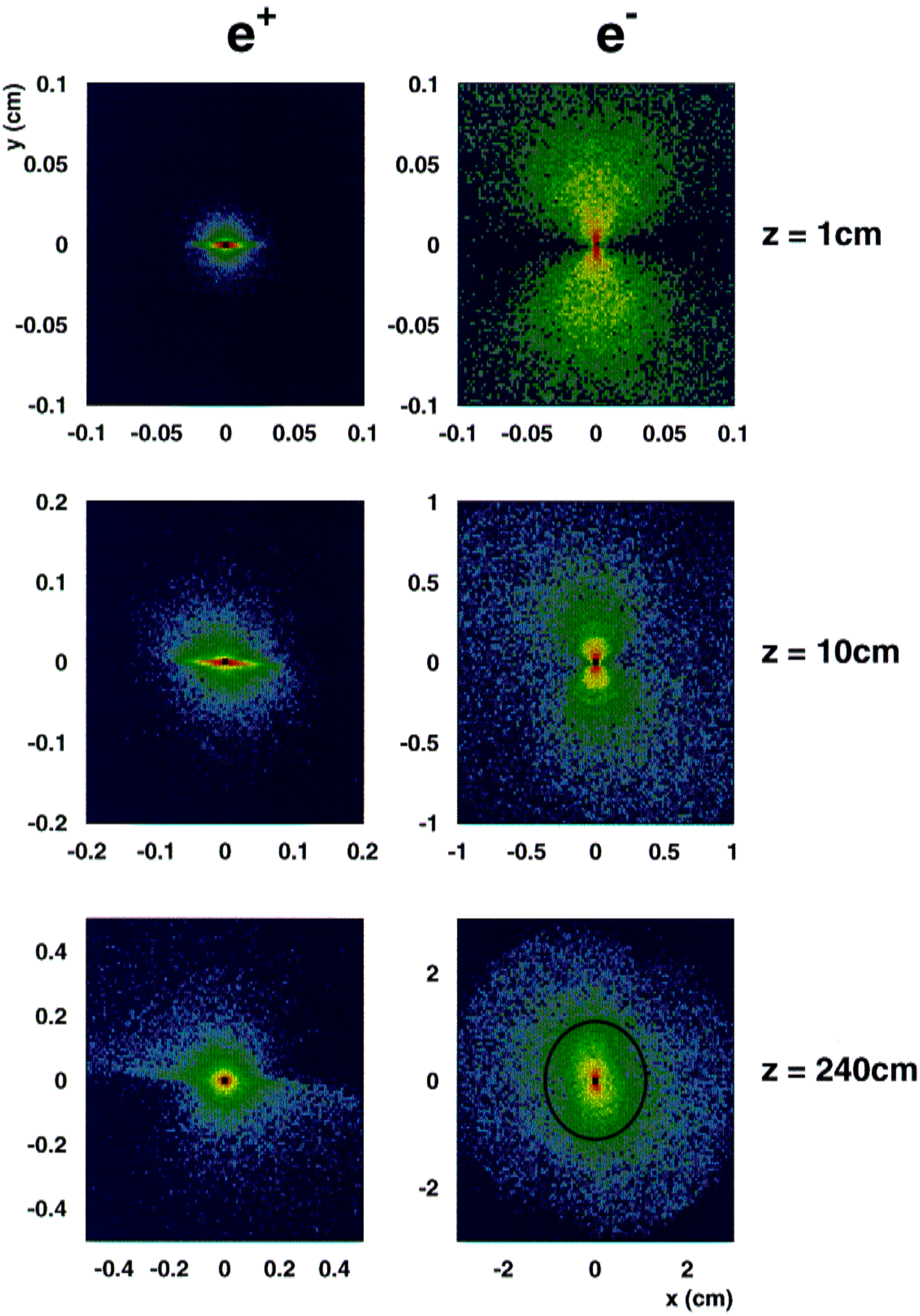
Simulation of pairs with GUINEA-PIG

	500 GeV	800 GeV
N_{pairs}/BX	120000	180000
$E_{tot}/BX(TeV)$	295	980



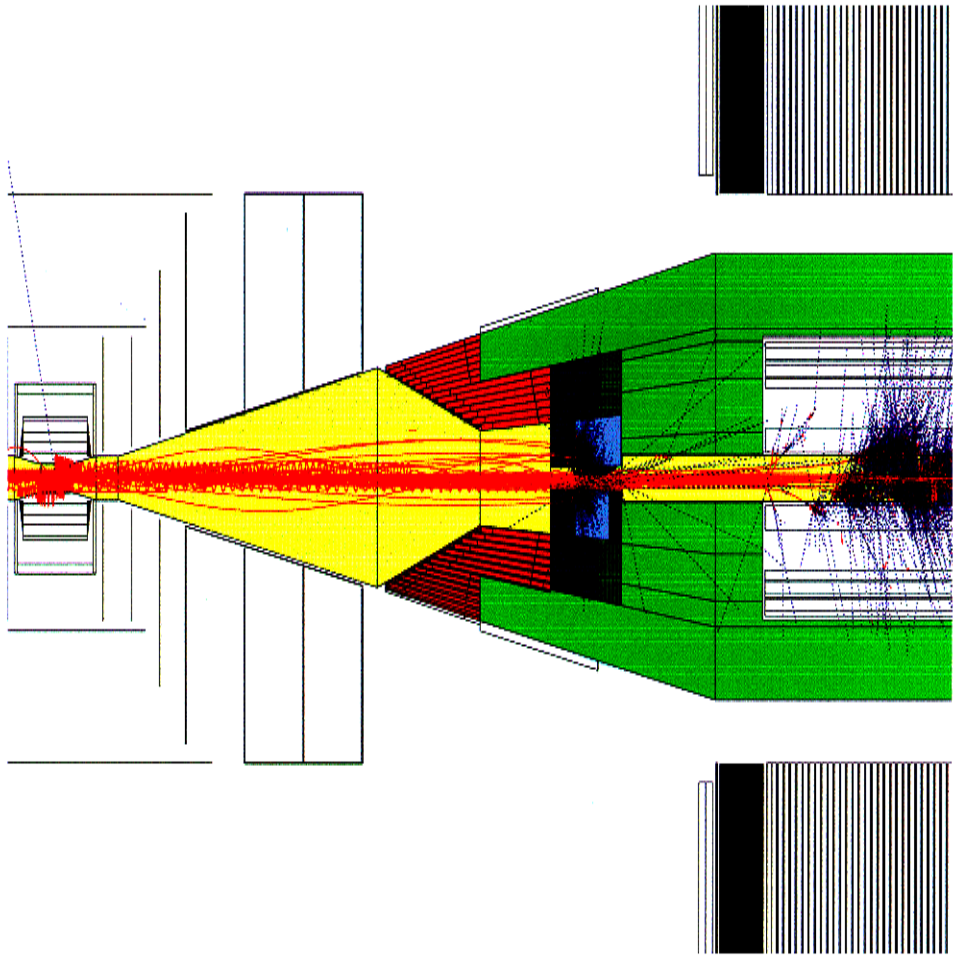


XY-Profiles of Pairs



Background: Pairs in the Mask

≈ 0.1% of one bunchcrossing @ 500 GeV , 3T



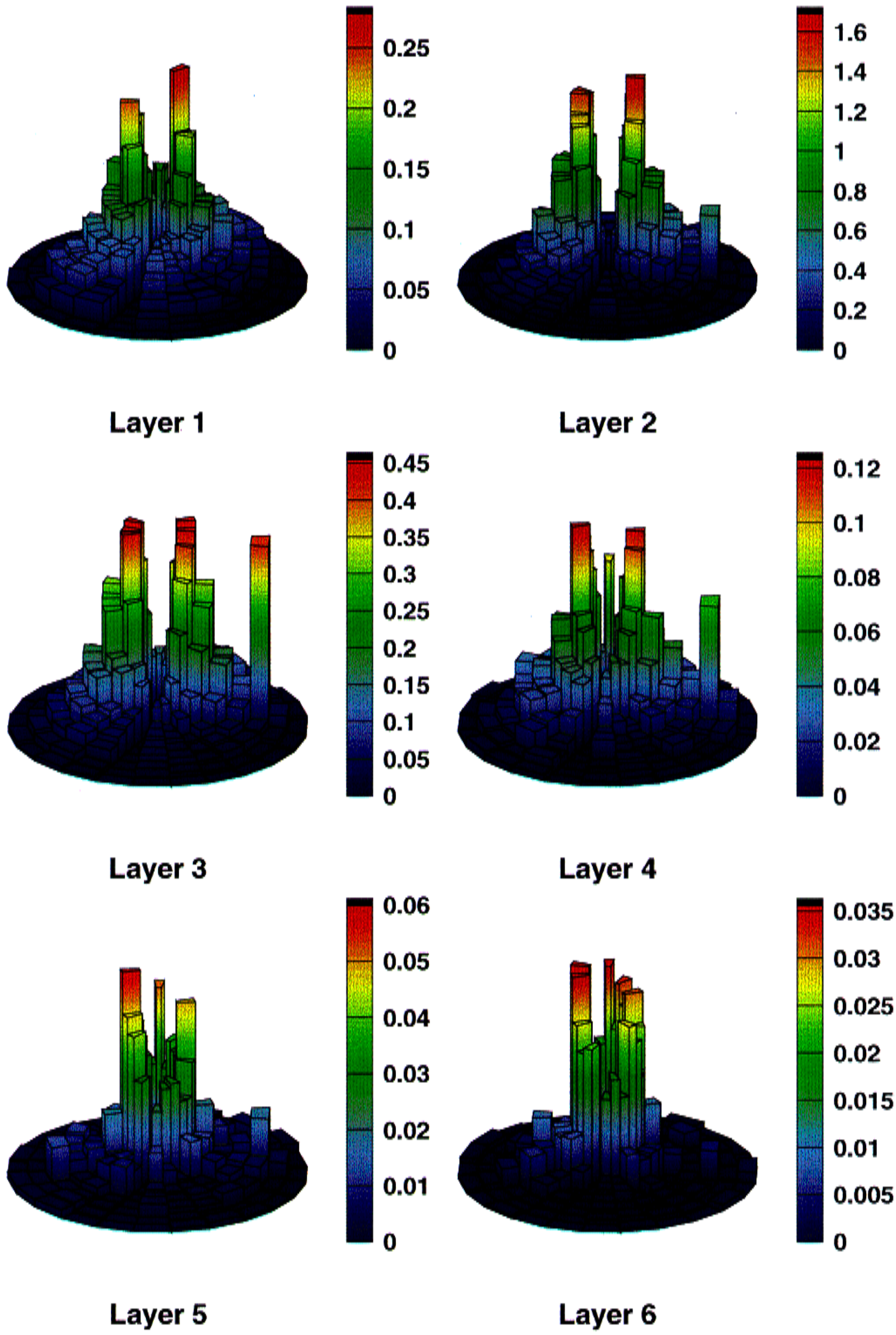
Pairs on one side ($z \geq 0$) for one full BX

Energy	# produced	Total E	# on LCAL	E on LCAL
500	60000	150 TeV	110000	21 TeV
800	90000	490 TeV	170000	35.5 TeV

Every channel of LCAL fires !!

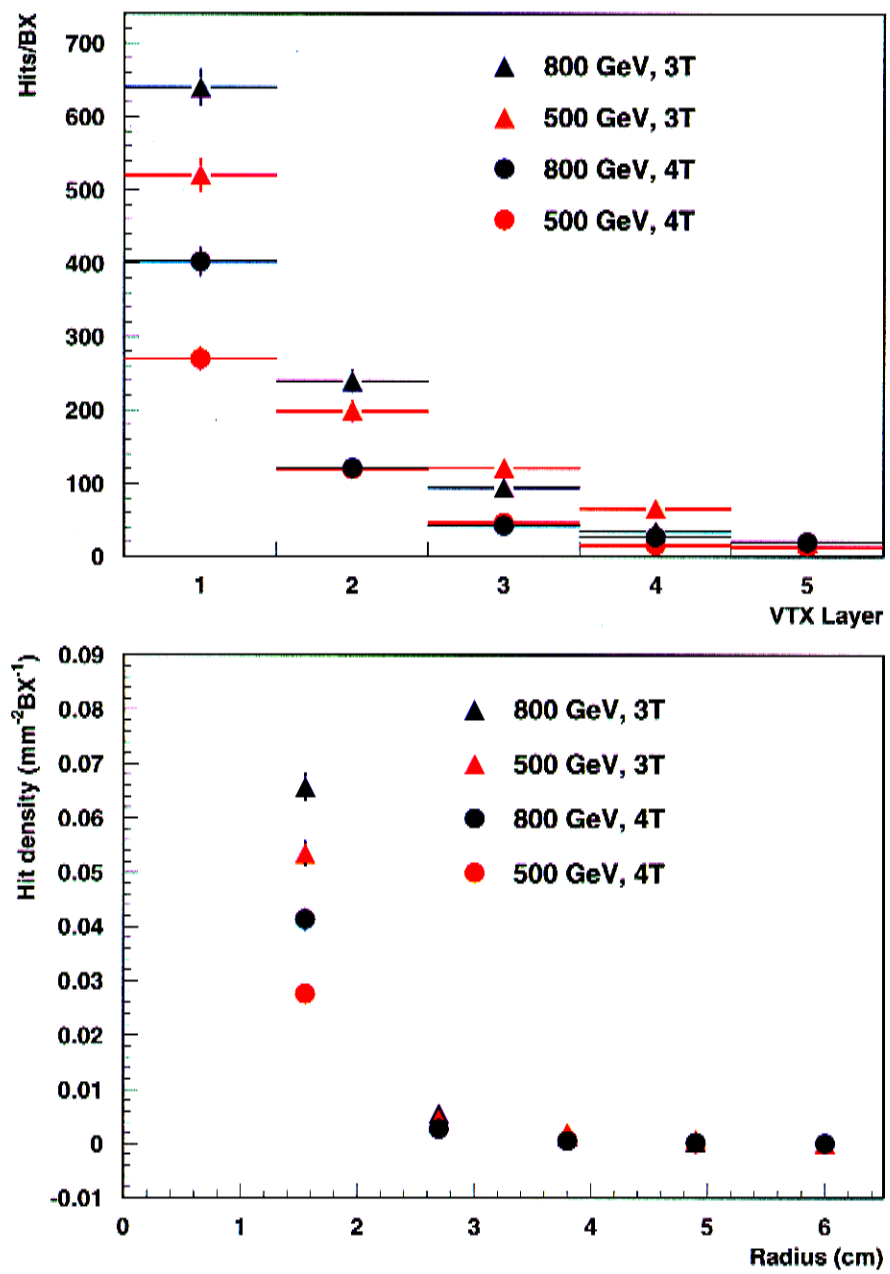
LCAL: Pair Background and Electron Signal

250 GeV electron at θ= 20 mrad
+ pair background for 1 BX @ $\sqrt{s}$ =500 GeV



Hits from Pairstrahlung in the Vertex Detector

Hits in the vertex detector (CCD option)



Hits from Pairstrahlung II

Hits/BX

DET	500 GeV , 3T	500 GeV , 4T	800 GeV , 3T	800 GeV , 4T
FTD	230	160	252	187
SIT	30	32	16	18

TPC: Tracks/BX

DET	500 GeV , 3T	500 GeV , 4T	800 GeV , 3T	800 GeV , 4T
TPC	7	5	7	8

Hadronic Background

Hadronic background: $e^+e^- \to e^+e^-\gamma\gamma \to$ hadrons

(see LC-DET-2000-001 by C. Hensel)

Simulated using GUINEA-PIG (photons) and HERWIG 5.9 with mulitparton interaction on for the $\gamma\gamma$ interaction.

TESLA 500 GeV, $L = 3.14 \cdot 10^{34}$ cm^{-2} s^{-1}

type	events/BX (10^{-2})	mult.	charg. mult.	E_{tot}/BX (GeV)
direct	0.53	15.2	8.5	0.25
single res.	0.40	30.5	15.7	0.32
double res.	1.12	44.7	22.2	1.50
all	2.05	34.3	17.4	2.07

Charged hits in vertex detector

Total number of charged hits/BX on inner layer:

$\leq 3400 \cdot 10^{-8} \cdot mm^{-2}$

Charged tracks in TPC

Total number of charged tracks/BX in TPC:

$\leq 0.7 \to \approx 105$ in 150 BX

Neutrons

Neutrons are produced by photons hitting beamline elements (e.g. collimators). Main sources are:

- Beamstrahlung Photons
- Pairstrahlung
- Radiative Bhabhas ($e^+e^- \to e^+e^-\gamma$)

Simulation of neutron production and tracking has been done using FLUKA98 (V. Morgunov).

Total numbers of neutrons produced:

Type	n/BX	E_{tot}/BX
BS	$2.5 \cdot 10^{10}$	$2.4 \cdot 10^8$ GeV
Pairs	$4.9 \cdot 10^4$	262 GeV
RB	$2.7 \cdot 10^5$	$2.1 \cdot 10^3$ GeV

Total neutron flux in subdetectors:

VTX n (1 MeV n) cm^2/year	TPC n/BX (E_{tot} (GeV)	ECAL-B n/BX (E_{tot} (GeV))	ECAL-EC n/BX (E_{tot} (GeV))
$< 3.8 \cdot 10^8$ ($0.5 \cdot 10^8$)	5600 (13.7)	4100 (10.4)	7500 (30.7)

Numbers of neutrons in the detector seem acceptable.

But: Geometries have changed !

Calculations will be redone soon using actual geometries !!

Synchrotron Radiation / Beam-Gas / Muons

Backscattered Synchrotron Radiation

- No direct SR can reach the detector (collimation system)
- $\approx 6.5 \cdot 10^{11}$ photons per BX hit the first collimator from both sides
- ≈ 60 photons per cm^2 are backscttered into VTX
- No backscattered photons in TPC and ECAL

Beam-Gas Background

- Assuming $p = 5 \cdot 10^{-9}$ mbar rest gas pressure
- $3 \cdot 10^{-3}$ $e^{\pm}$/BX leave the beam pipe near the IP

Muons
(H.J. Schreiber → ECFA/DESY workshop)

Number of muons produced in the BDS:

$$\boxed{\#e^{\pm}_{lost}/\mu \approx 7 \cdot 10^4}$$

Assume beam halo: $10^4 \Rightarrow$ 0.3 μ /BX permanent rate in the detector.

$\Rightarrow \approx 11\mu$ sampled (150 BX) in the TPC

Conclusion

- A detailed design of the mask has been found
- Background reduction by the mask is good

- Most background sources have been investigated in detail
- Most backgrounds seem to be on a tolerable level

- Final design of the mask calorimeters has to be found
- Some background estimates have to be redone with the final geometries !