The Machine Detector Interface

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2. Backgrounds
3. The Mask
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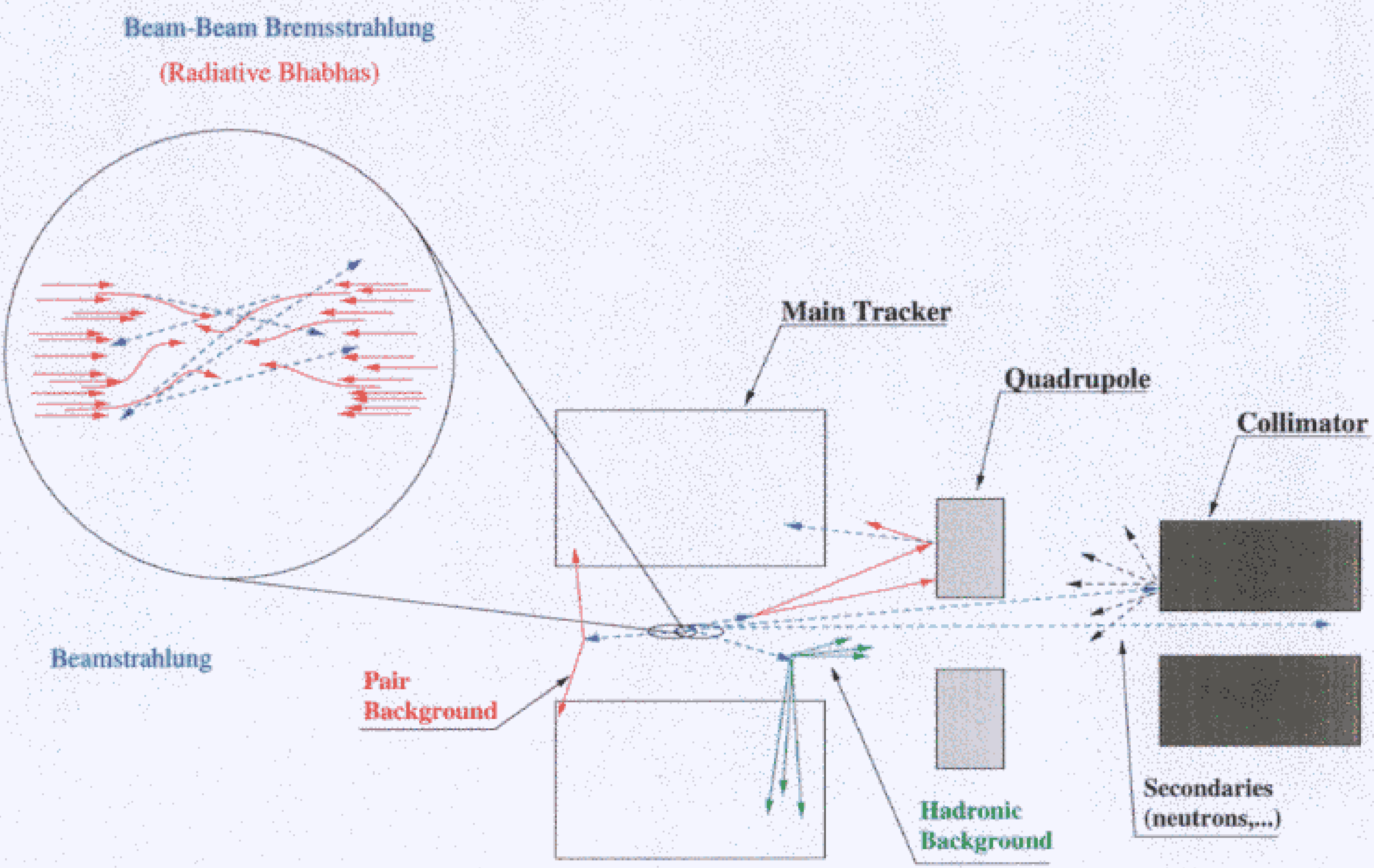
Beam Induced Background

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)

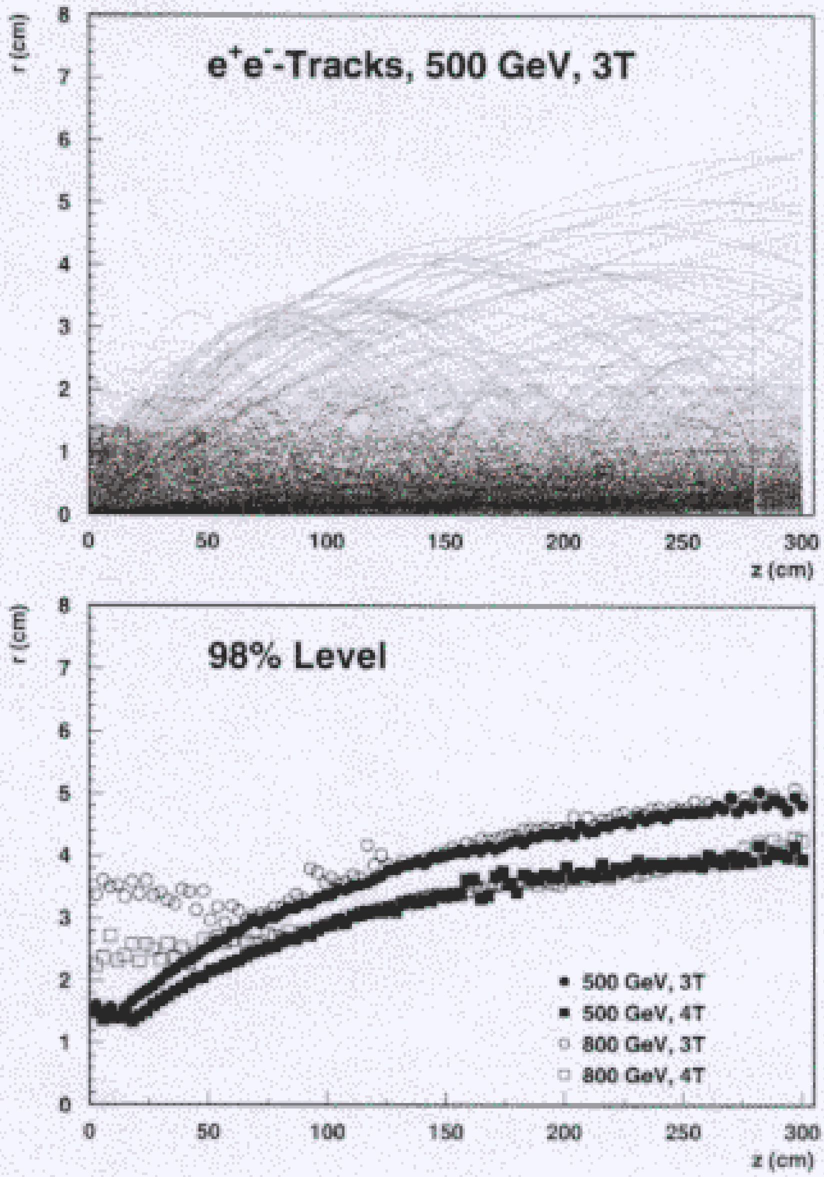
Beam-Beam Background



Pairs

Beamstrahlung photons produce a huge number of pairs:
Simulation of pairs with GUINEA-PIG

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



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. Tracking by BRAHMS.

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 ($e^+e^- \rightarrow e^+e^-\gamma$)

Simulation of neutron production and tracking has been done using FLUKA98.

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 Background

Backscattered Synchrotron Radiation

- No direct SR can reach the detector (collimator 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.

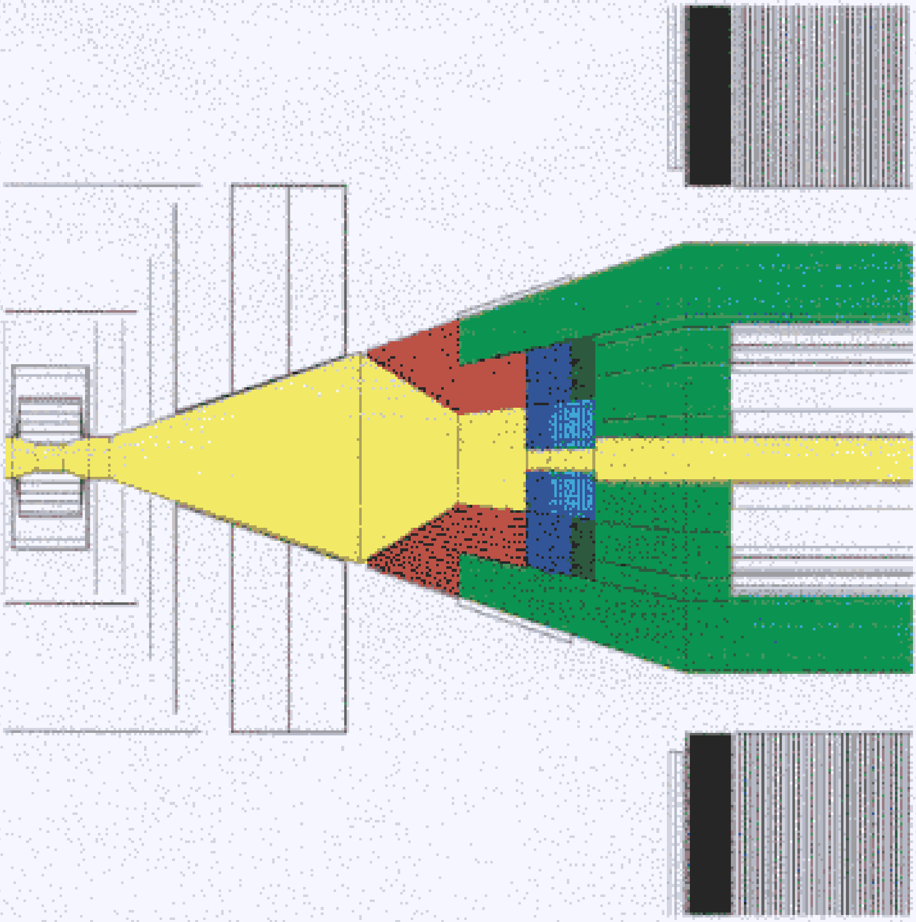
Beam-Gas Background

- Assuming $p = 5 \cdot 10^{-9}$ mbar rest gas (CO) pressure
- $3 \cdot 10^{-3}$ electrons per BX leave the beam pipe near the IP

The Mask

Main purpose of the mask

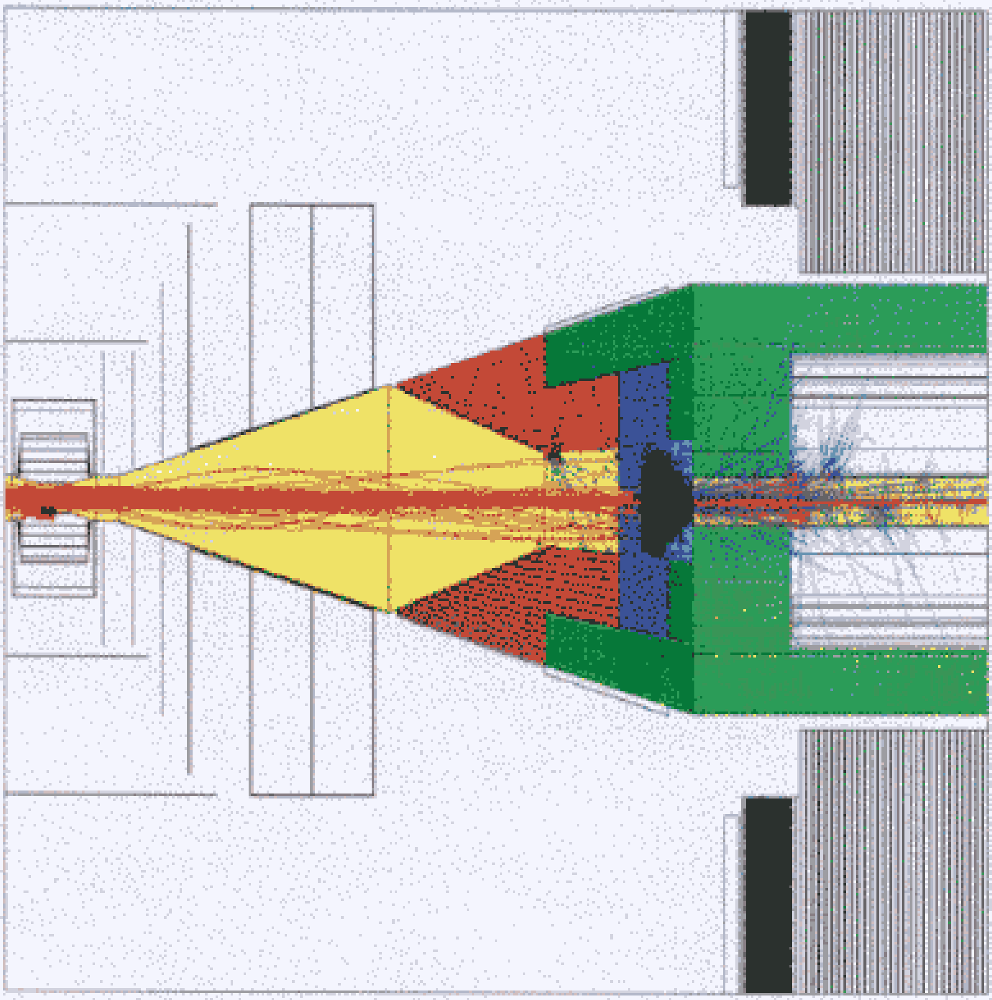
- Shield tracking detectors from backscattered pairs and secondaries
- Reduce neutron flux (graphite absorbers)
- Shield SI from synchrotron radiation



- Provide instrumentation for small angles
  - Low Angle Tagger LAT: 27.5 – 83.1 mrad
  - Luminosity CALorimeter LCAL: 4.6 – 27.5 mrad

The Mask and Pair Background

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



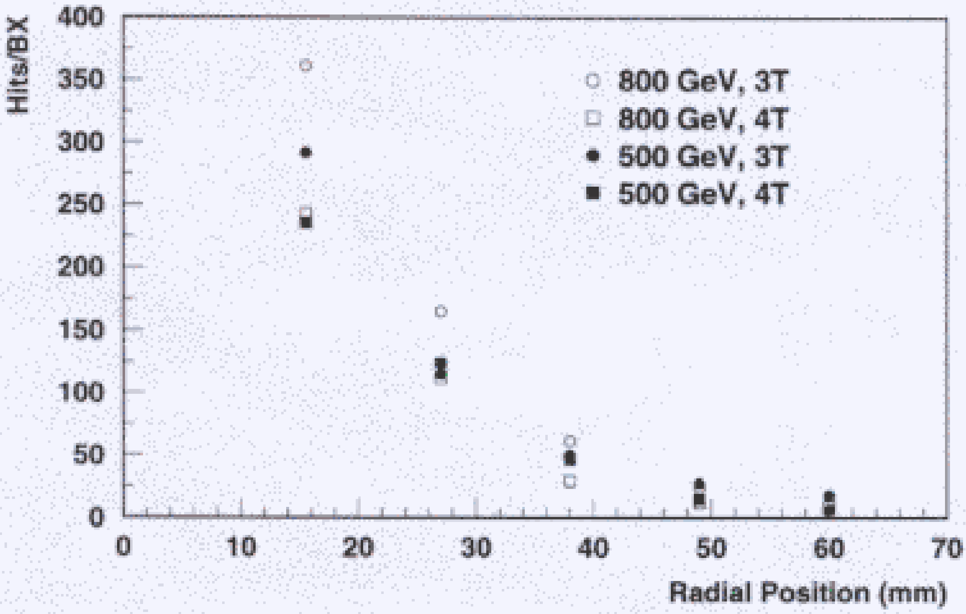
Pairs on one side ($z \geq 0$)

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 !!

Hits from Pairstrahlung in the Tracking Detectors

Hits in the vertex detector



This corresponds to a charged hit density of ≤ 0.04 hits $\cdot$ mm^{-2} on the inner layer.

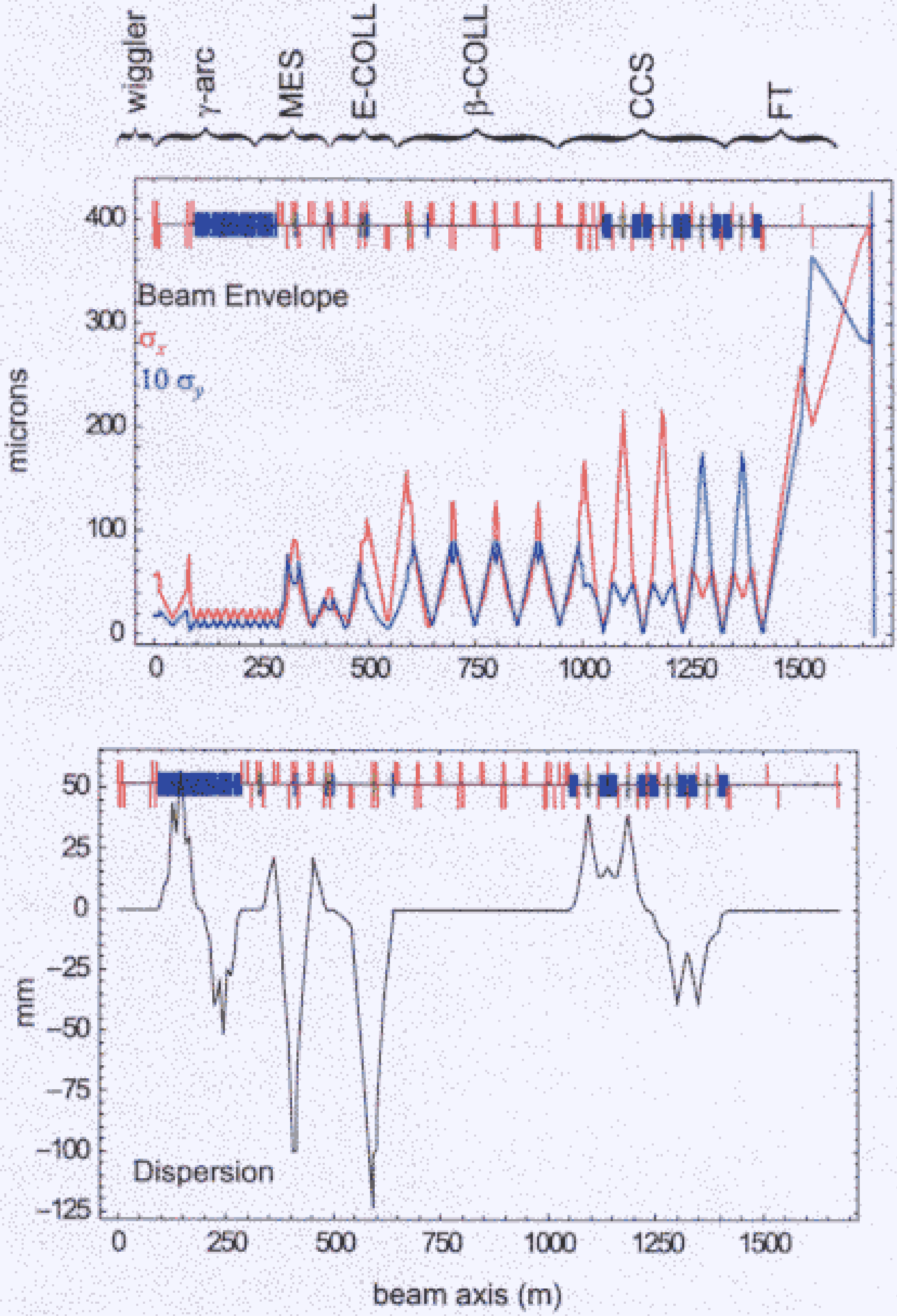
Hits/BX

DET	500 GeV , 3T	500 GeV , 4T	800 GeV , 3T	800 GeV , 4T
FTD	92	101	45	87
SIT	17	18	8	10
FCH	13	13	10	7

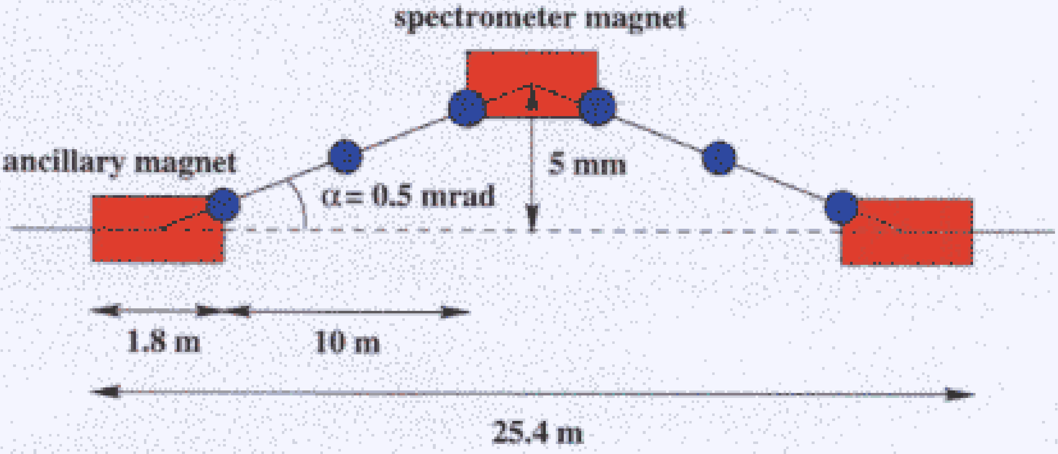
TPC: Tracks/BX

DET	500 GeV , 3T	500 GeV , 4T	800 GeV , 3T	800 GeV , 4T
TPC	5	5	2	4

Lattice of the TESLA Final Focus



Energy Spectrometer: LEP Type Spectrometer



$$E_{beam} = \frac{ec \int B \cdot dl}{\alpha}$$

Measure BPM offset by switching off all magnets (ballistic beam)

Beam Energy 400 GeV

ancillary magnet:	B=0.37 T/m
spectrometer magnet:	B=0.74 T/m
BPM resolution:	1μm
BPM alignment:	1μm

$\Rightarrow$ resolution: few 10^{-4}
$\Rightarrow$ emmittance growth: $\Delta\varepsilon_x = 3.4\%$
$\Rightarrow$ luminosity loss: $\approx 2\%$

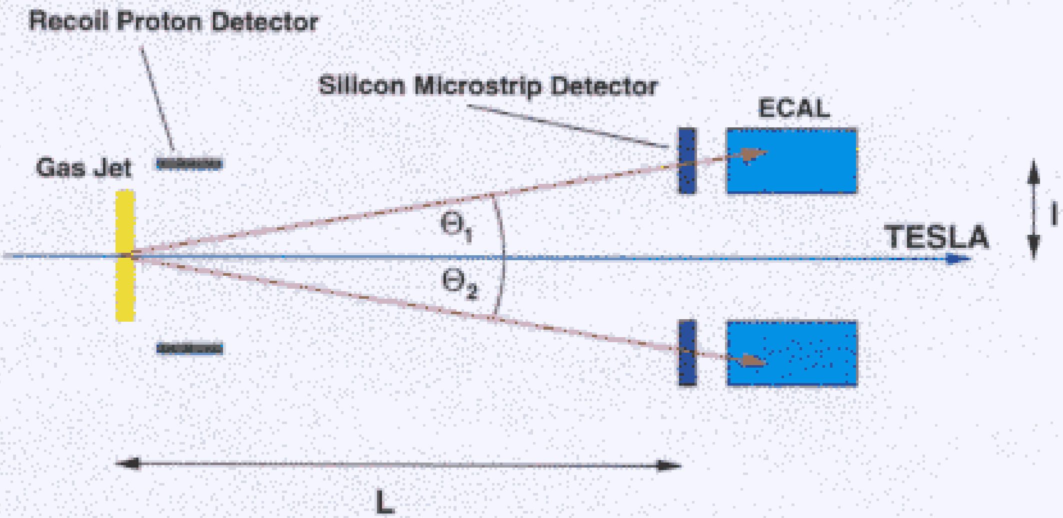
Beam Energy 250 GeV

- Magnetic fields scale down with energy
- Resolution is the same
- No luminosity loss

Energy Spectrometer: Møller Scattering

Idea:

Proposal for LEP: *Galumian et al.* NIM A 327(1993) 269pp.
Proposal for LEP2: *Cecchi et al.* NIM A 385(1997) 445pp.



Define 'opening angle': $\theta_0 = \tan\theta_1 + \tan\theta_2$

$$\Rightarrow E_{beam} = \frac{8m_e}{\theta_0^2}\frac{1}{1-\kappa_{A,B}^2} - m_e \,,\ \tan\theta_i = \frac{l_i}{L}$$

$$\kappa_A = \frac{\tan\theta_1 - \tan\theta_2}{\tan\theta_1 + \tan\theta_2} \qquad \text{or} \qquad \kappa_B = \frac{E_{beam}+m_e}{E_{beam}-m_e}\frac{E_1-E_2}{E_1+E_2} \approx \frac{E_1-E_2}{E_1+E_2}$$

- A requires just SMD information, but transversal beam position must be known.
- B requires SMD and ECAL information.

Target thickness: 10^{15} atoms/cm^2 (Cluster Jet Target)
$\rightarrow$ Luminosity: $\approx 10^{32} cm^{-2} s^{-1}$

Energy Spectrometer: Møller Scattering II

Precision:

$\frac{SE_{beam}}{E_{beam}} = -2\frac{S\theta}{\theta} + 2\kappa_{obs}S\kappa - (S\kappa)^2$

This means: If $\frac{\Delta E}{E} = 10^{-5}$ then $\frac{\Delta\theta}{\theta} = 5ppm$.

Example: L=30m; l=20 cm; $\Rightarrow \Delta L = 150\mu m$; $\Delta l = 1\mu m$

Major contributions to $S\kappa$:

- A: finite beam size, beam position
- B: energy resolution of ECAL, gain calibration error

Systematics were studied with Monte Carlo:

- Radiative corrections
- Binding effects
- ECAL resolution

Result: $SE_A \approx 6\,\mathrm{MeV}$; $SE_B \approx 1.5\,\mathrm{MeV}$ at 90 GeV
$\rightarrow \frac{DeltaE}{E} \approx \cdot 10^{-5}$ might be reached

Calibration:

- L (from ep scattering): $\Delta z \leq 100\mu m$ assuming $\Delta E_{beam} = 200MeV$
- Transverse beam size and position (using coplanarity of Møller scattering events)

Conclusion

- Most background sources have been investigated in detail
- Most backgrounds seem to be on a tolerable level
- Some background estimates have to be redone with the final geometries !
- A detailed design of the mask has been found
- Background reduction by the mask is good
- Two polarimeter concepts are under study
  - Compton polarimeter
  - Møller polarimeter
- Two proposals for an energy spectrometer are under study
  - Magnetic LEP type spectrometer
  - Møller scattering