The Very Forward Region for the ILD

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FCAL Collaboration

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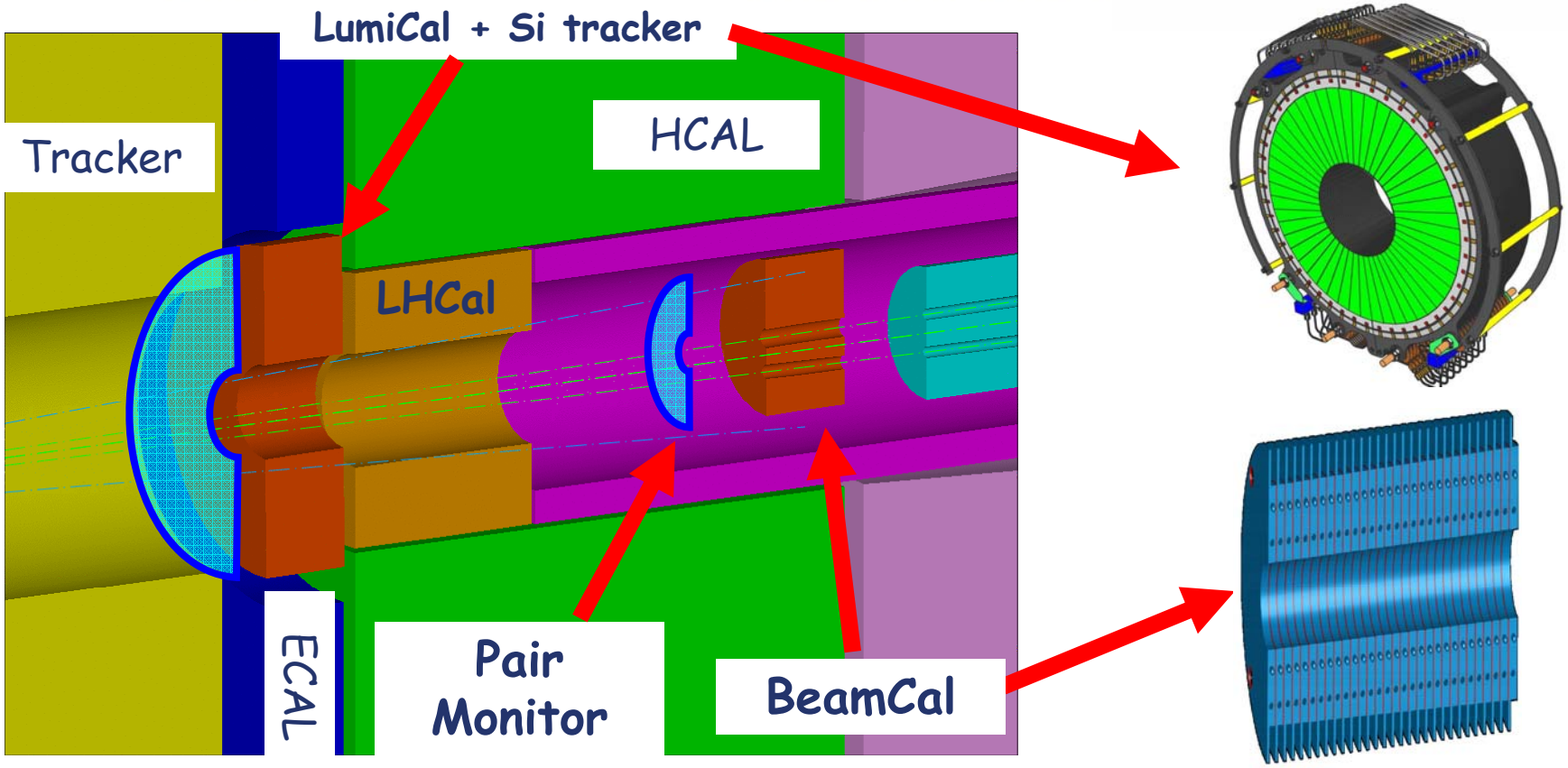
Contents

- Tasks of the very forward region of the detectors for the International Linear Collider
- LumiCal: geometry, precision and shape of the beampipe, magnetic field
- BeamCal: magnetic field
- Conclusions

Very Forward Region

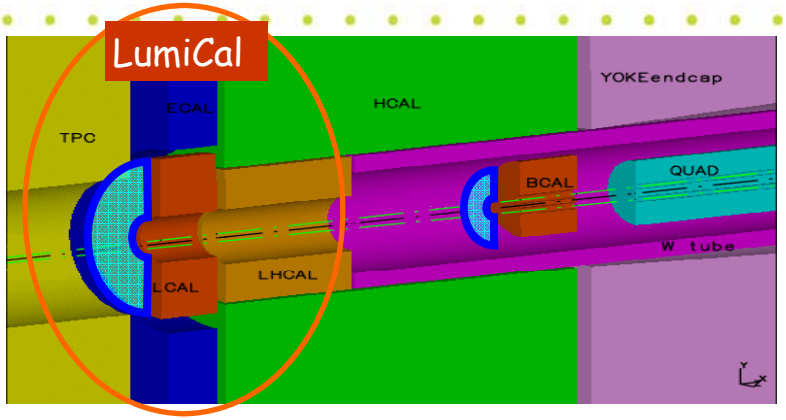


- R&D of the detectors in the forward region is done by the FCAL Collaboration.
- Precise (LumiCal) and fast (BeamCal) luminosity measurement
- Hermeticity: electron (mip) detection at low polar angles
- Mask for the inner detectors

Precise Measurement of the Luminosity

- Required precision is:

  $\Delta L/L \sim 10^{-4}$ (GigaZ 10^9/year)
  $\Delta L/L < 10^{-3}$ ($e^+e^- \rightarrow W^+W^-$ 10^6/year)
  $\Delta L/L < 10^{-3}$ ($e^+e^- \rightarrow q^+q^-$ 10^6/year)



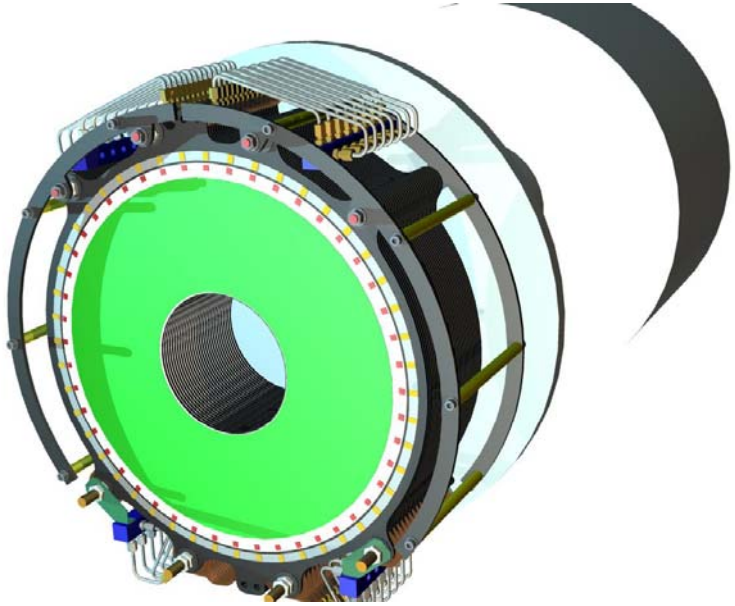
- Bhabha scattering ee->ee(γ) is the gauge process:
  - Count Bhabha event in a well known acceptance region => L = N/σ
  - High statistics at low angles => $N_{Bhabha} \sim 1/\theta^3$
  - Well known electromagnetic process (LEP: 10^{-3}): the current limit on the theoretical cross section error is at ~5 10^{-4}.

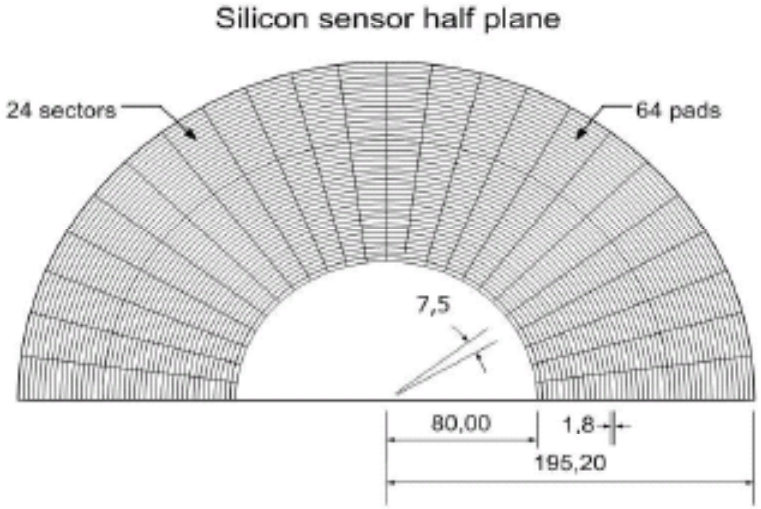
$\sqrt{s} = 500$ GeV, $L = 500$ fb^{-1} , $L = \frac{N}{\sigma_{Bhabha}}$

$R_{min} \rightarrow R_{max}$ [mm]	Fiducial volume		σ_{Bhabha} [nb]	Relative Error	
	θ_{min} [mrad]	θ_{max} [mrad]		$\Delta N/N$	$2 \cdot \Delta\theta / \theta_{min}$
80 → 190	41	69	1.23	$4 \cdot 10^{-5}$	$1.7 \cdot 10^{-4}$
90 → 200	50	74	0.86	$4.8 \cdot 10^{-5}$	$1.4 \cdot 10^{-4}$

LumiCal: Design Parameters

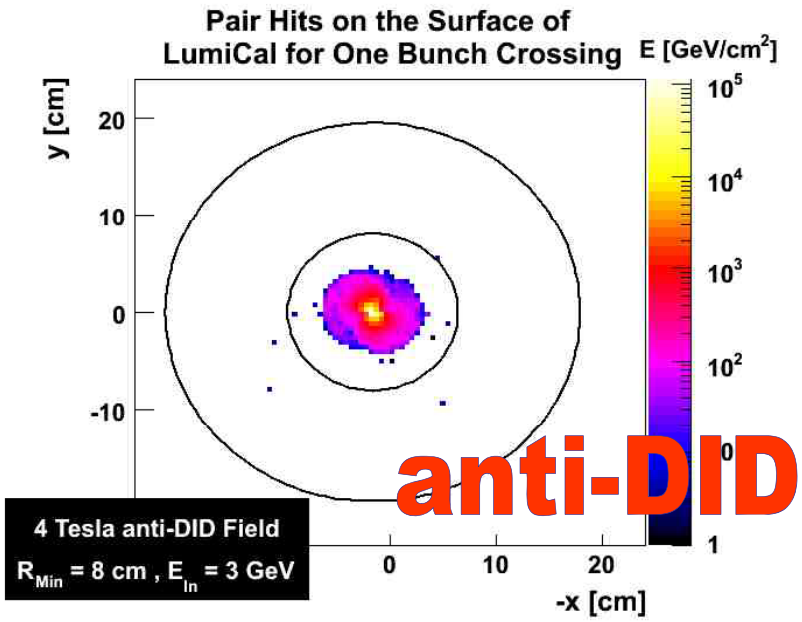
- 1. Placement:
  - 2270 mm from the IP.
  - Inner Radius - 80 mm
  - Outer Radius - 190 mm
- 2. Segmentation:
  - 48 sectors & 64 cylinders:
  - Azimuthal Cell Size - 131 mrad
  - Radial Cell Size - 0.8 mrad

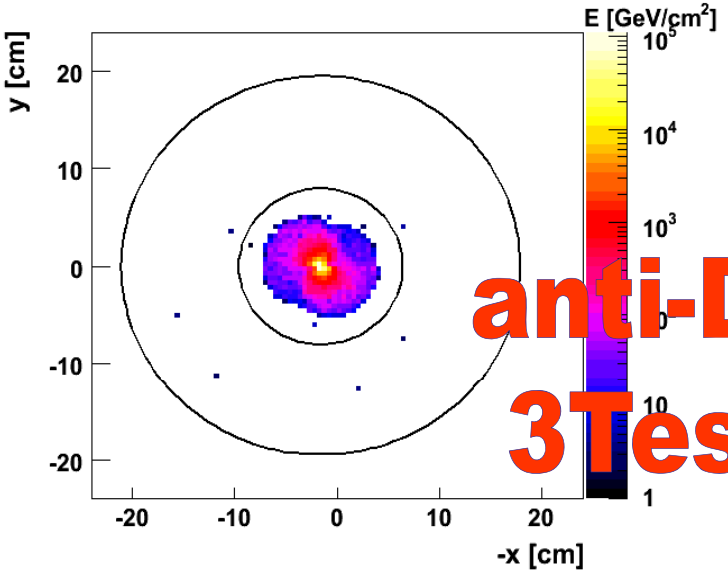


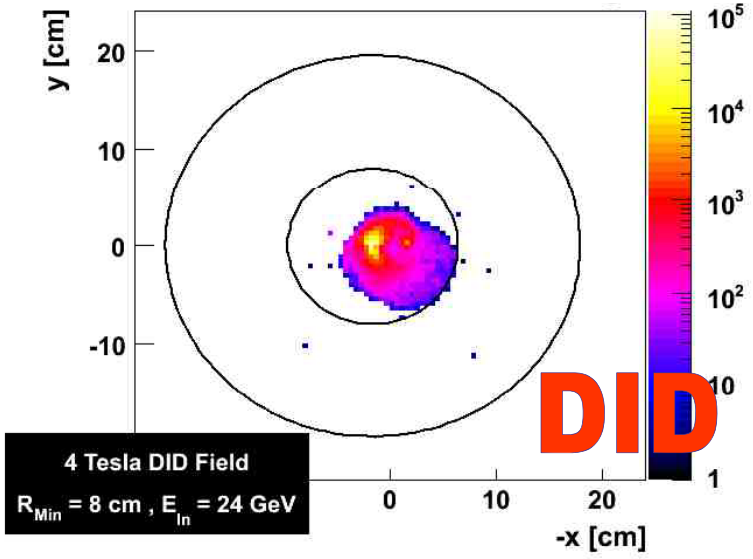


- 3. Layers:
  - **Number of layers - 30**
  - **Tungsten Thickness - 3.5 mm**
  - **Silicon Thickness - 0.3 mm**
  - **Elec. Space - 0.1 mm**
  - **Support Thickness - 0.6 mm**

LumiCal Aperture



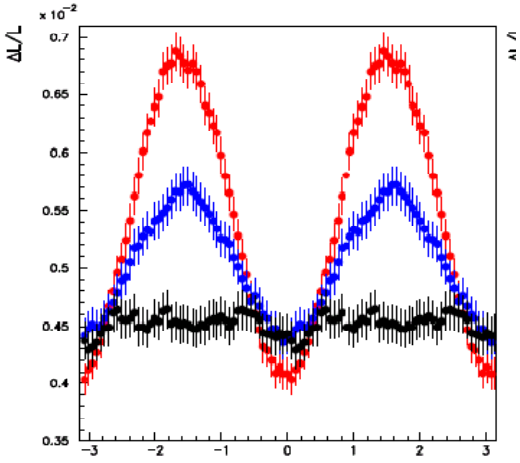


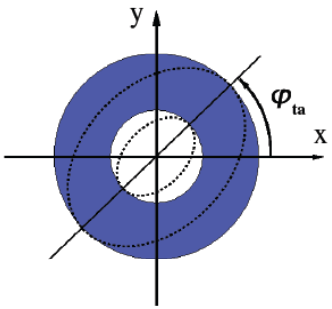


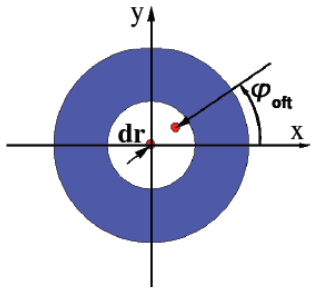
- The inner radius of 80mm (z = 2270mm) keeps a security margin of about 1 cm for the beamstrahlung pairs in the anti-DID case.
- For 3T the distribution grows but is still inside.

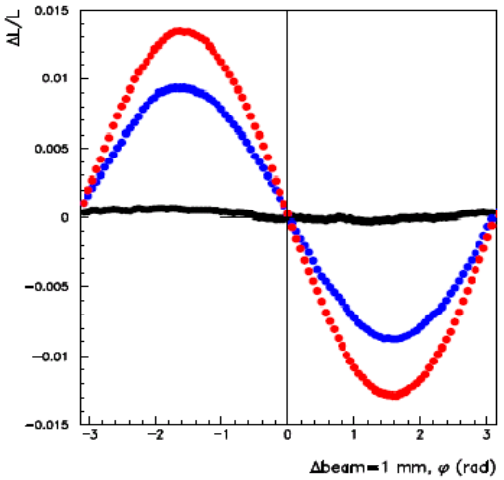
Systematic Effects – Detector Placement

Radial beam axis tilts/shifts



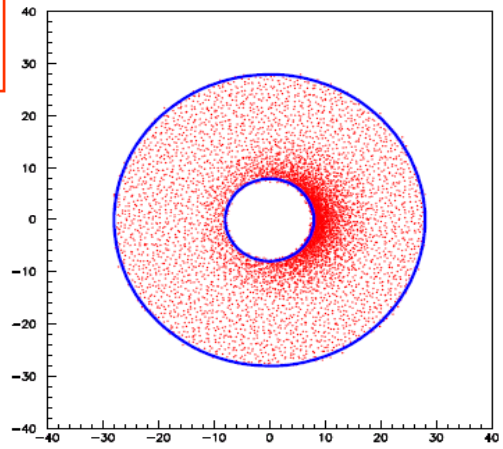


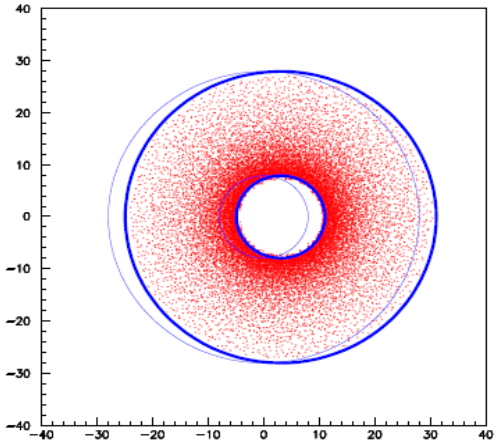




- **Headon**, 14,20 mrad X-angle outgoing beam
- **14 mrad** X-angle detector axis
- **20 mrad** X-angle detector axis

Place LumiCal around the outgoing beam and tilt it accordingly!

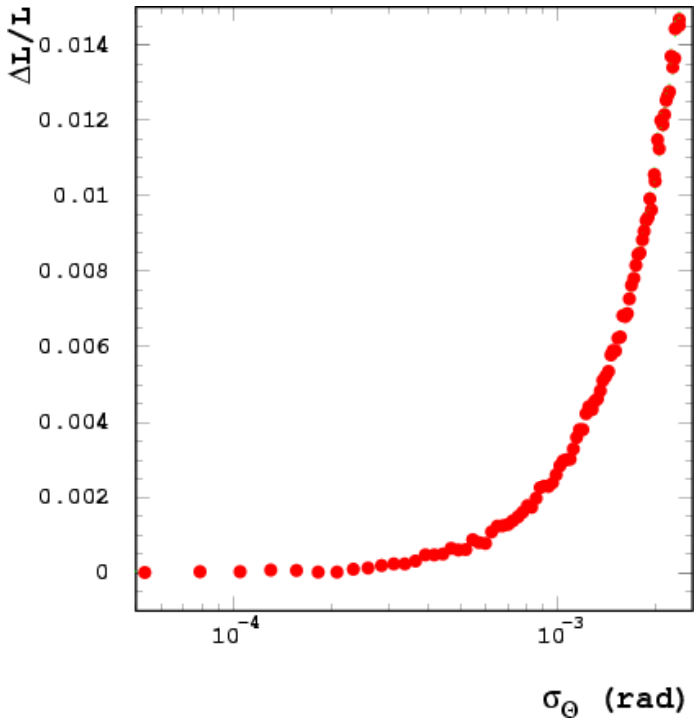




Detector axis **Outgoing beam**

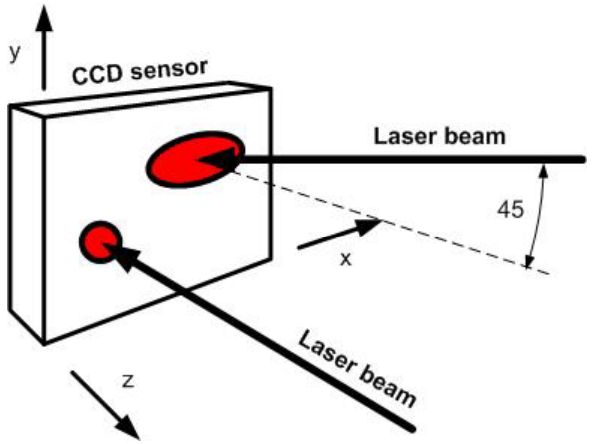
Requirements on the Mechanical Precision

MC simulations of LumiCal:
Derive requirements on design, segmentation, mechanical precision and impact of different magnetic field/crossing angles.

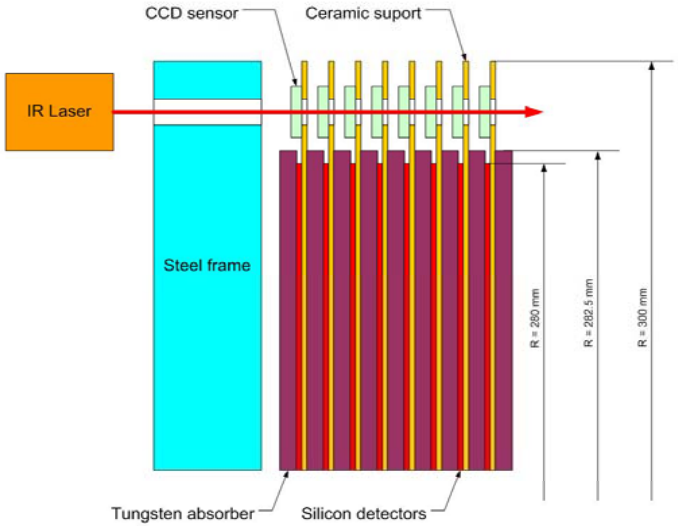


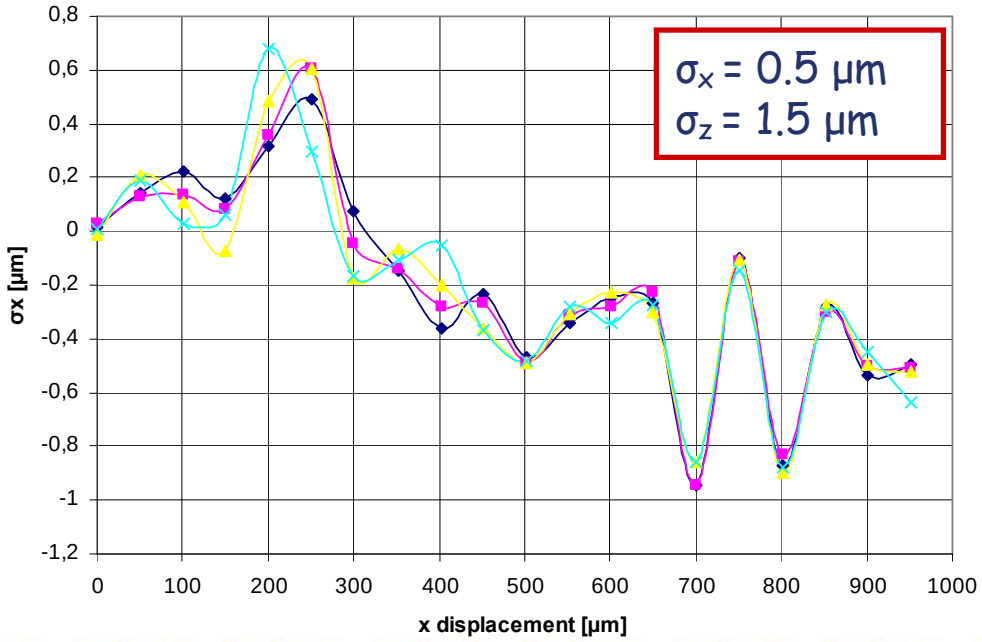
ΔL/L	1.0 10^{-4}
inner radius	4.2 μm
radial offset	640 μm
distance	300 μm

Laser Alignment System



Two laser beams allow to measure displacements in xyz.



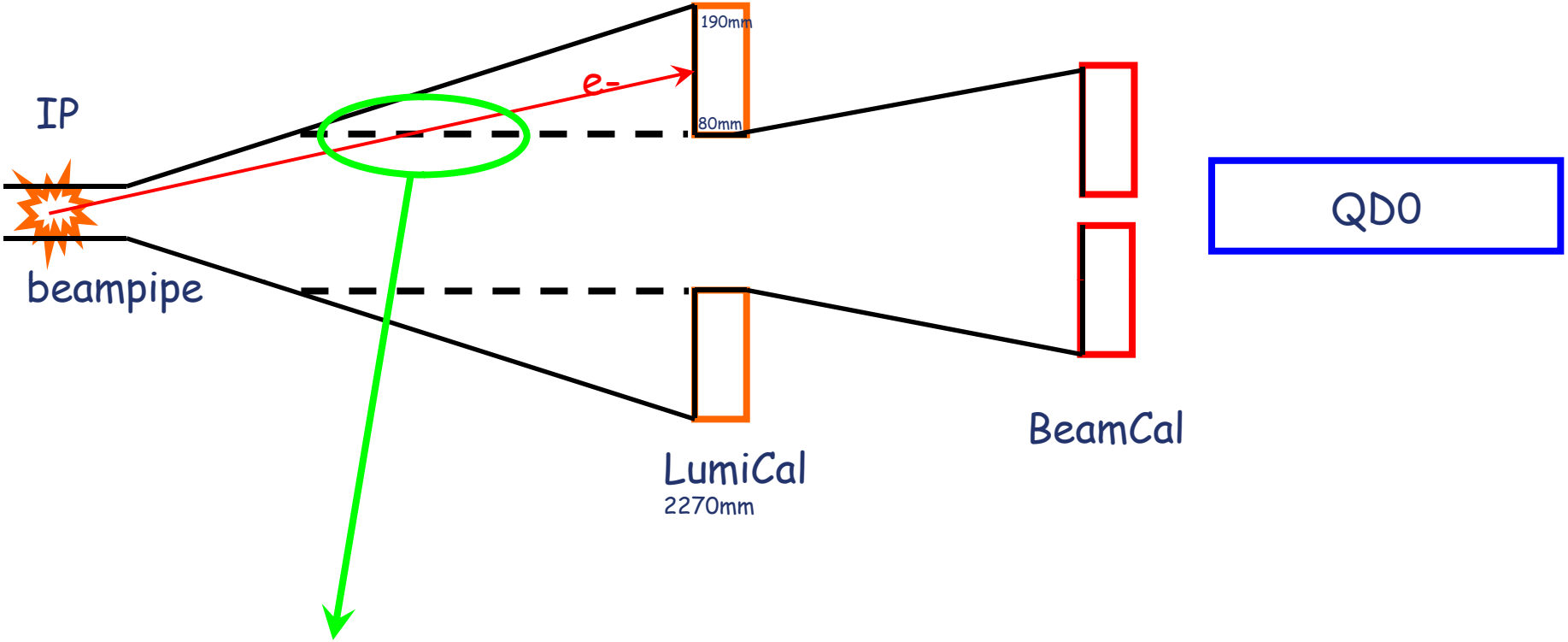


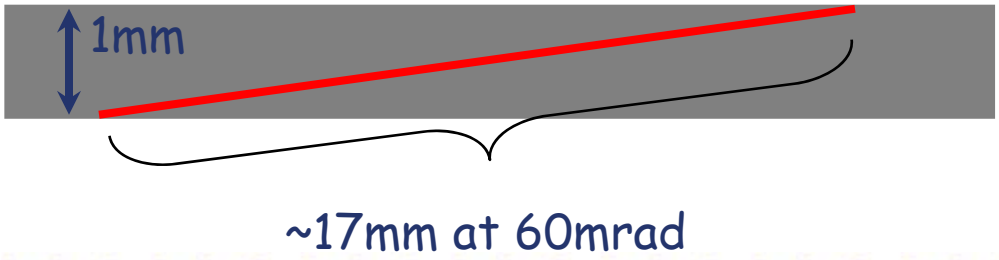
Temperature stability is an issue.
Observed changes of about 1µm/K.

Integration study for the LAS started.

Beampipe

- LumiCal needs precise shower reconstruction!





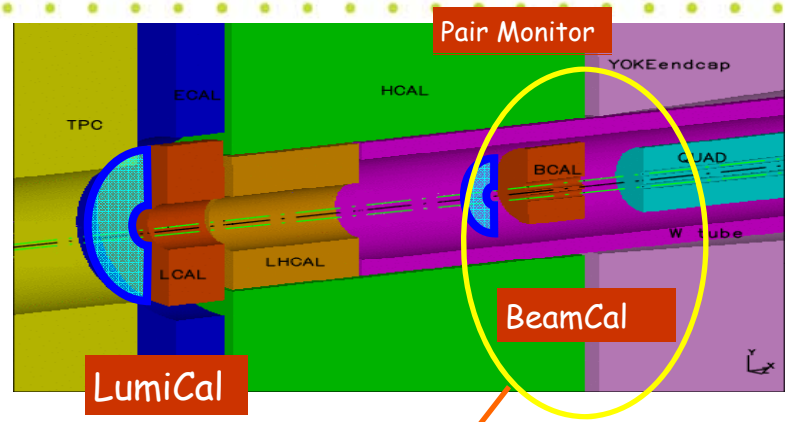
~17mm at 60mrad

1 X_0 for Fe
0.5 X_0 for Be

in ~1m distance

BeamCal Design

- Compact em calorimeter with sandwich structure:
  - 30 layers of 1 X_0
    - 3.5mm W and 0.3mm sensor
  - Angular coverage from ~5mrad to ~45 mrad
  - 20-150mm at 3550mm from the IP.
  - Moliére radius $R_M \approx 1$cm
  - Segmentation between 0.5 and 0.8 x R_M

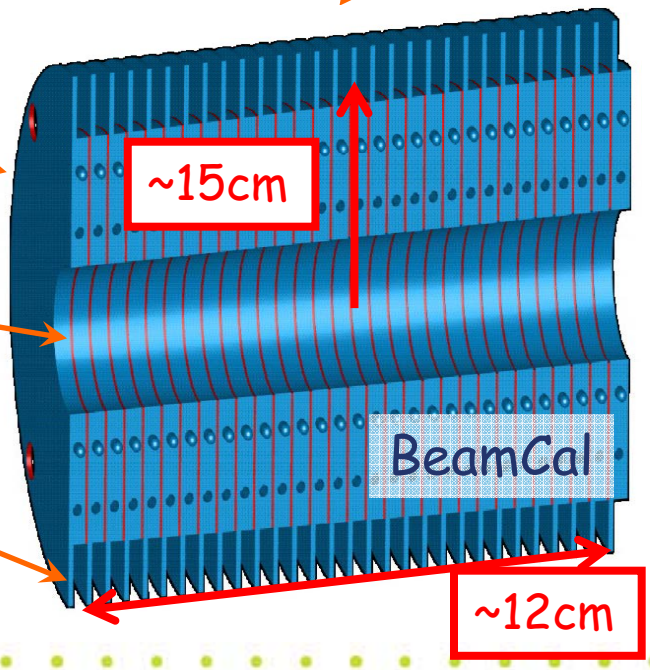


W absorber layers

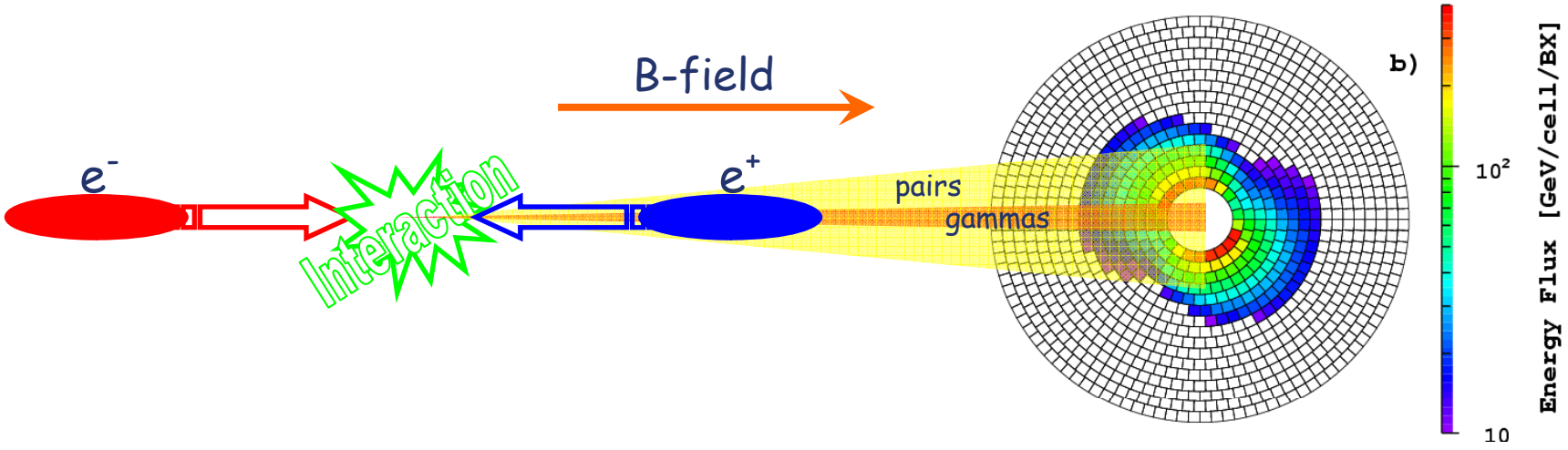
Radiation hard sensors with thin readout planes

Space for readout electronics

+ graphite in front of BeamCal to reduce backscattering

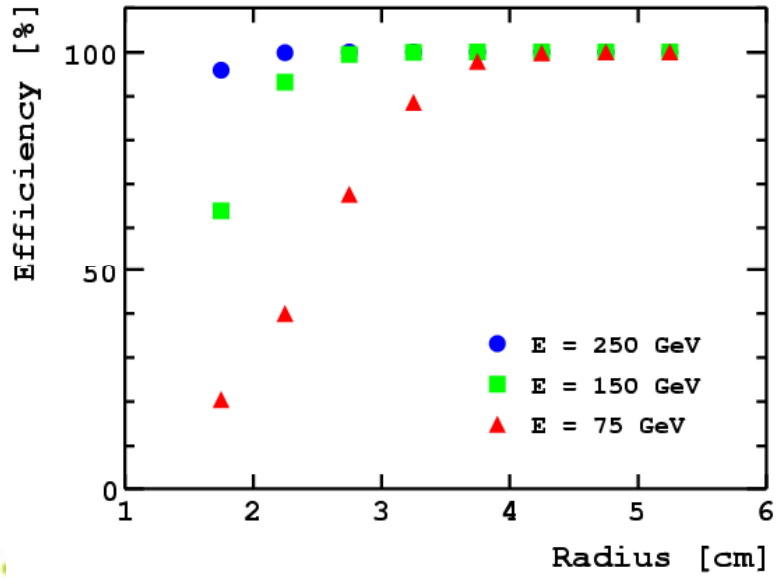


BeamCal Consideration for ILD



- e+e- pairs from beamstrahlung are deflected into the BeamCal. The shape of the energy deposition depends strongly on the magnetic field strength and type
- 15000 e^+e^- per BX

  => 10 – 20 TeV total energy dep.
- Detect the signature of single high energetic particles on top of the background.
- Keep the spread of the pairs small to keep the veto efficiency high. => Anti-DID type

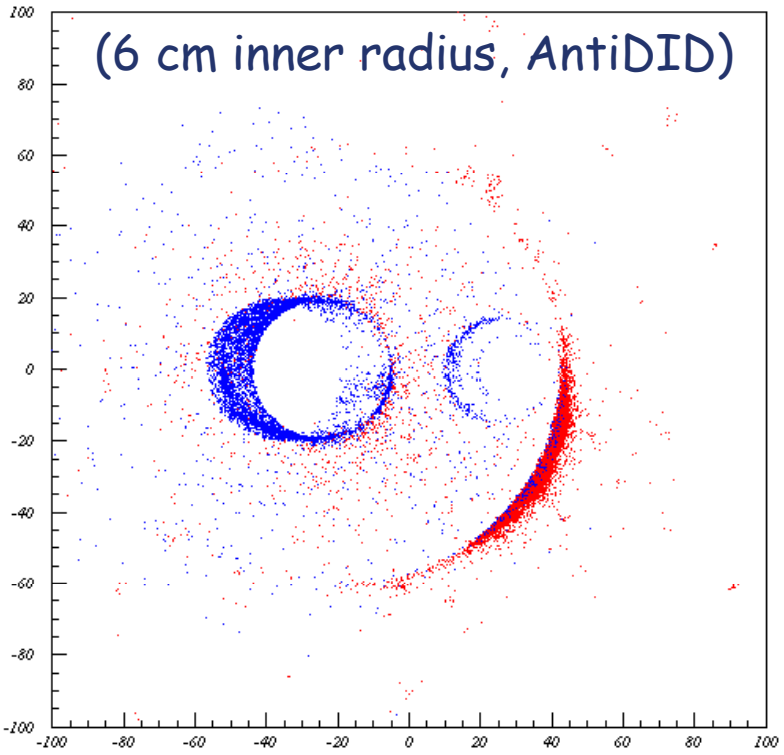


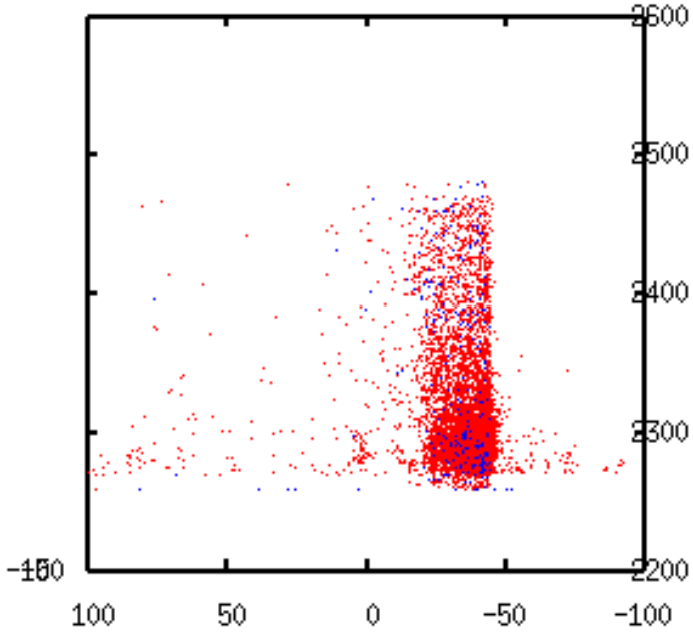
Summary

- The FCAL Collaboration has investigated the Very Forward Region Detectors extensively. For an ILD design we have these…

- …considerations for LumiCal:
  - Inner radius (statistics ⇔ pair background) is dependent on the magnetic field strength and the field type and the z-position. The aperture should be as small as possible (backgrounds and statistics).
  - The position is centered on outgoing beam axis and tilted.
  - Strong requirements on the mechanical precision and a laser position monitoring system is needed.
  - The beam pipe should be conical to minimize the material in front of LumiCal.
- …considerations for BeamCal:
  - BeamCal has to be a very compact em calorimeter to be able to veto electrons from 2-photon events! The pair background should be squeezed as good as possible by the magnetic field.
    We want the Anti-DID configuration.
  - Outer radius should keep the angular overlap with LumiCal.

Backgrounds from pairs





Particles (blue electrons/positrons, red photons) scattering back into the detector.

A.Vogel