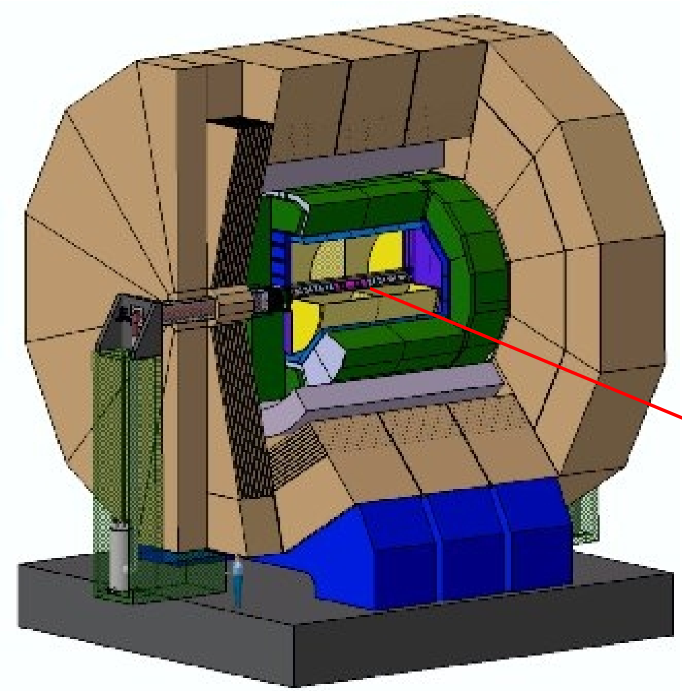
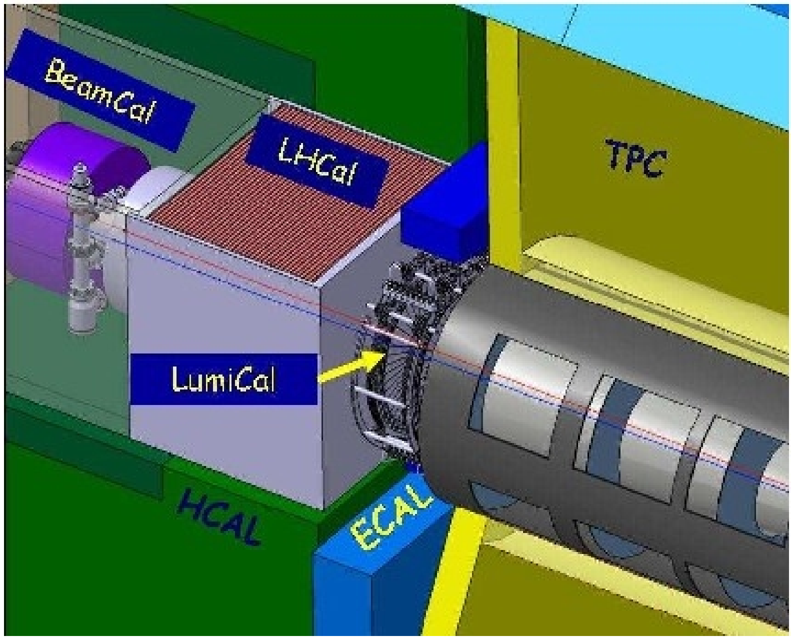
ILD: Forward Detectors

Leszek Zawiejski

Institute of Nuclear Physics PAN

FCAL Collaboaration

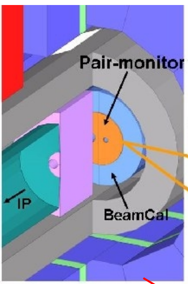




ILD Workshop 2010, MDI Session, January 26, 2010 http://www-zeuthen.desy.de/ILC/fcal

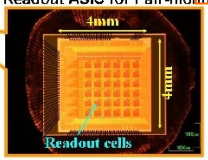
Forward Region

Goals: measurement luminosity with high precision, fast, bunch-by-bunch luminosity estimation, determination the beam parameters, beam profile monitoring using beamstrahlung background (e^+e^- pairs), help in measurement of the SUSY particles by detect single, high energetic electrons and positrons (electron veto),extend a hermeticity main detector down to ~ 5 mrad



Tohoku University

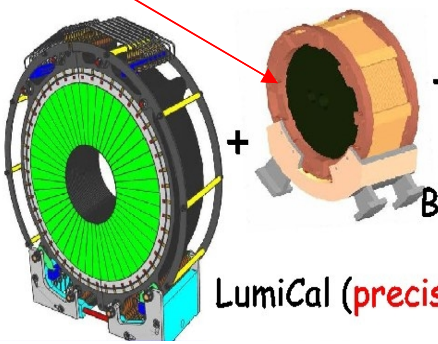
Readout ASIC for Pair-monitor

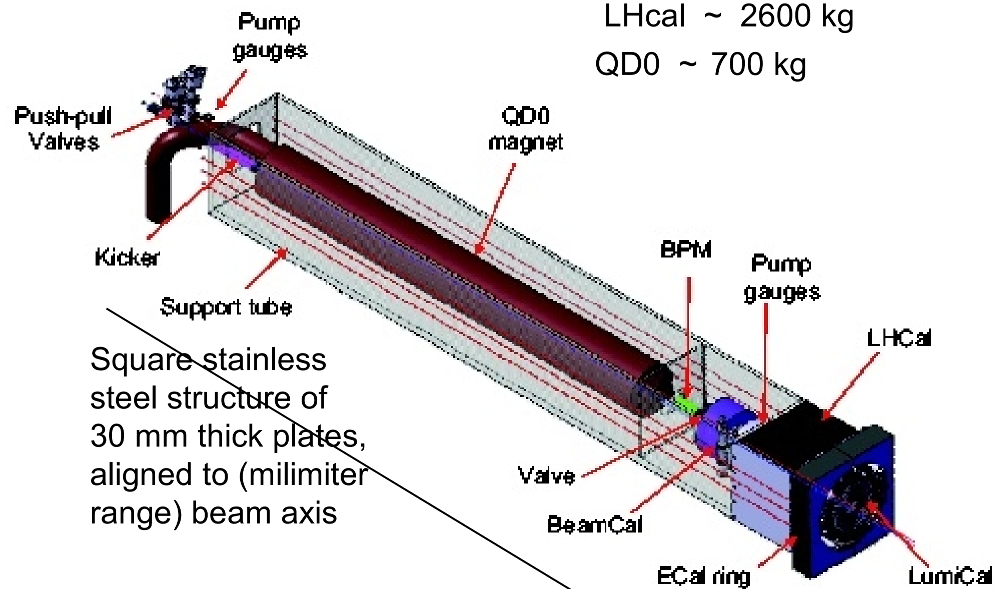


Pair Monitor: in front of BeamCal

Weights of forward components:
LumiCal ~ 200kg
Beamcal ~ 160 kg + support
LHcal ~ 2600 kg

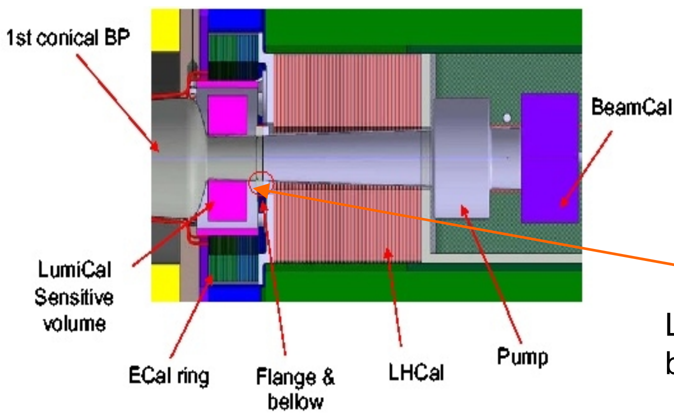
QD0 ~ 700 kg





Square stainless steel structure of 30 mm thick plates, aligned to (milimiter range) beam axis

6000 mm



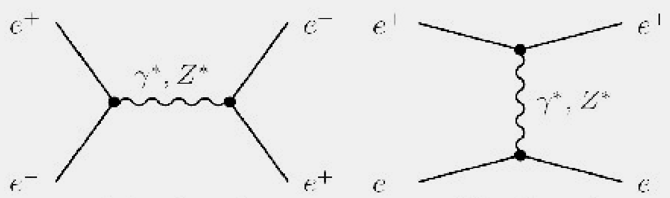
LumiCal - supported via flange, inserted between two vertical aluminium plates.

LumiCal: luminosity measurement

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)

- Measure luminosity by counting the number of Bhabha events (N_B):

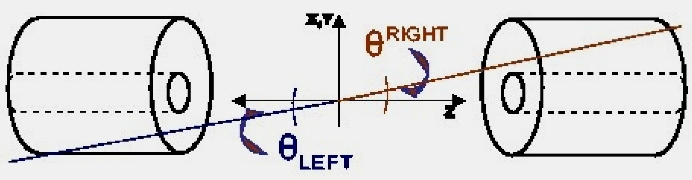


(a) s channel (b) t channel

$$\frac{d\sigma_B}{d\theta} \mu \frac{1}{\theta^3}$$

Compare angles & energy

$$L = \frac{N_B}{\sigma_B} \quad , \quad \frac{\Delta L}{L} = \frac{\Delta N_B}{N_B} = \left. \frac{N_{rec} - N_{gen}}{N_{gen}} \right|_{\theta_{min}}^{\theta_{max}}$$

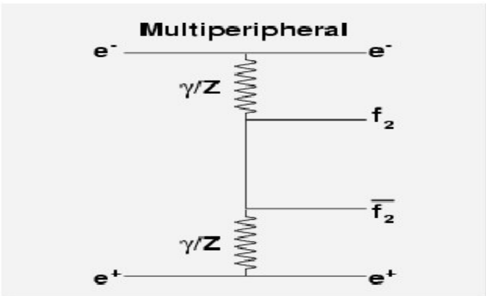


$\Delta\theta \equiv \theta_{RIGHT} - \theta_{LEFT}$

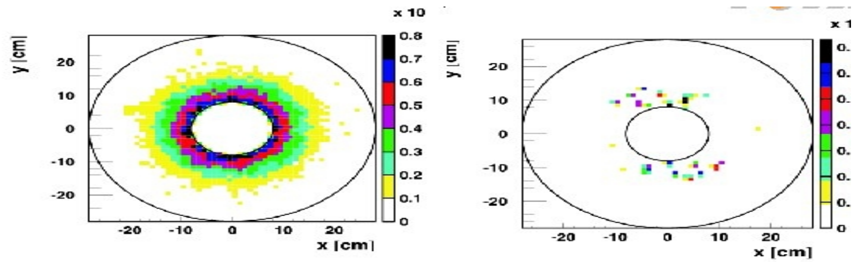
LumiCal detector = 2 identical calorimeters positioned at ± 2500 from IP

And expected background – Monte Carlo studies

From physics: the main contribution from 2-photon processes –four fermions in final state

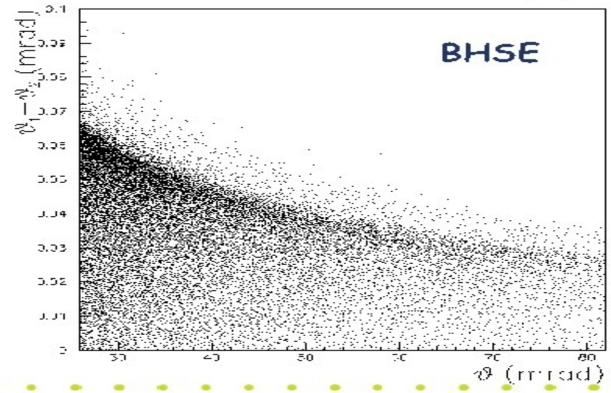


2-photon rejection

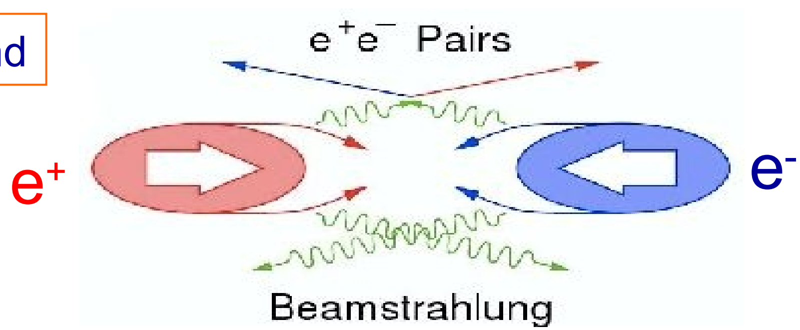


- 2-photon events are the main background.
- We determined an efficient set of cuts to reduce the background to the level of 10^{-4}.
- The Bhabha Suppression Effect (BHSE) is due to the EM deflection and energy loss by beamstrahlung of the Bhabhas. Correction needs precise knowledge of beam parameters.

C.Rimbault et al. JINST 2:09001.2007



Beams related background



LumiCal - calorimeter

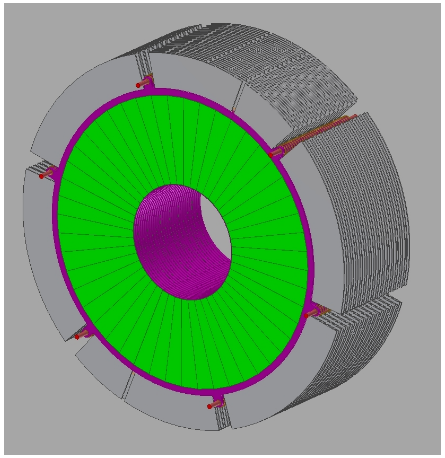
Single sampling calorimeter : 30 X_0 Si / W
thickness tungsten plane: 3.5 mm (~ 1 X_0), calorimeter will be split into half cylinders (left and right) and will be clamped around the beam pipe. Opening/closing with accuracy better than ~4 µm.
Odd/even planes rotated by 7.5 degree, to each tungsten plate, on one side, silicon detectors will be glued.

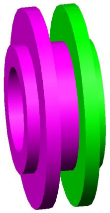
X/Y/Z position: 15.9/0/±2500 mm with respect to the outgoing beam
The outer radius of the calorimeter: 260 mm to cover the space for FE electronics, readout cables, cooling system and precision positioning sensors (alignment).
The mechanical inner radius: 76 mm
After LoI:
the diameter of tungsten plates have been lowered from 231.5 mm to 200 mm to reduce of heavy (dead) material which was not covered by silicon sensors.
The final shape of tungsten planes is under work, there are calculations of the stiffness for mechanical structure recently proposed.
Water (liquid) cooling system is required to reduce heat of ~ 30 W created by FE electronics .

Sensors:

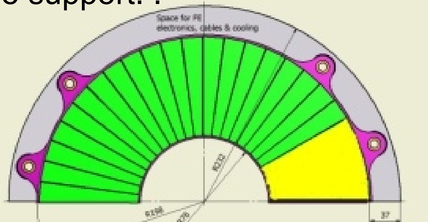
Sensor thickness: 320 µm
The sensitie region: (80 – 195.2) mm in radius
64 rings which cover θ range: 35.3 – 83.9 mrad
48 azimuthal divisions

The next step – after LoI - towards the final structure



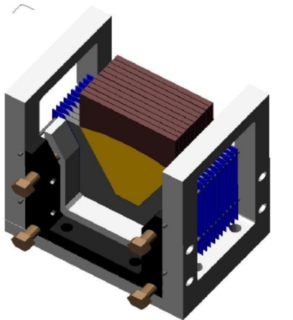


In mechanical construction two types of rings are required, With the special bolts, calorimeter can be asembled and placed on the support. .

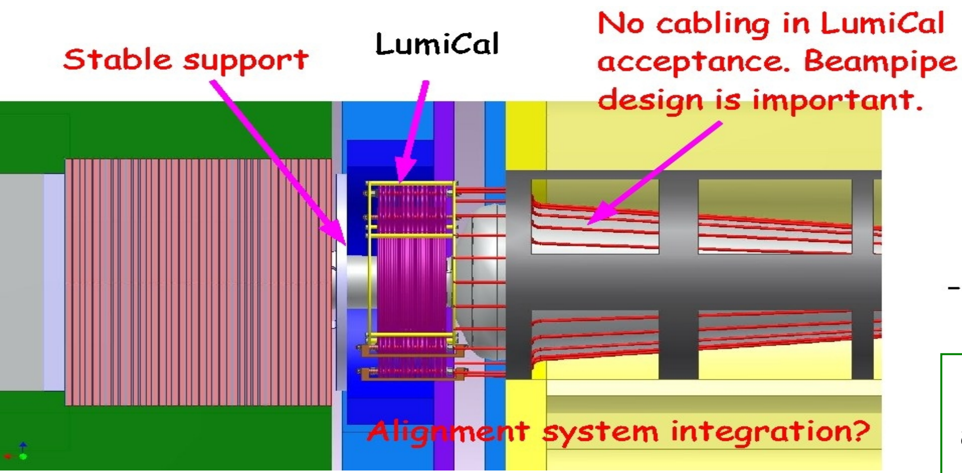


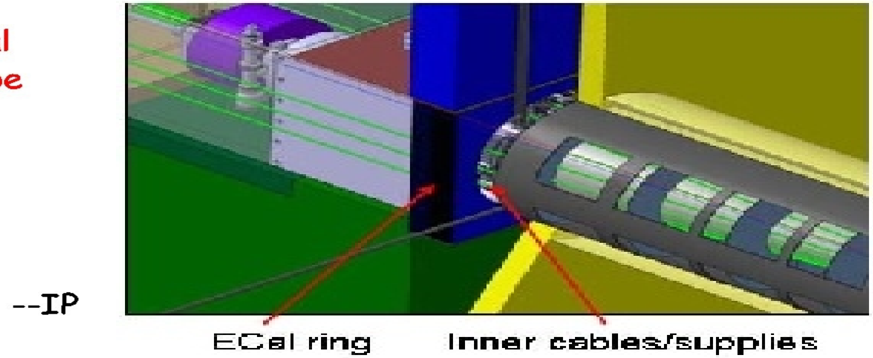
Yellow sector: produced by Hamamatsu company (40 such silicon sensor sectors are available in FCAL)

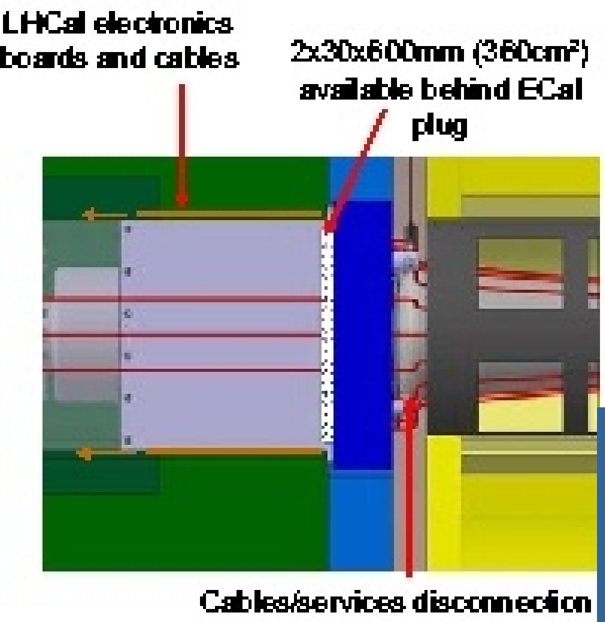
Proposed structure for TB measurements

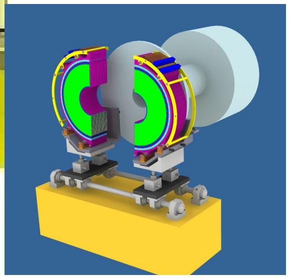


LumiCal: integration aspect(1) – place and free space









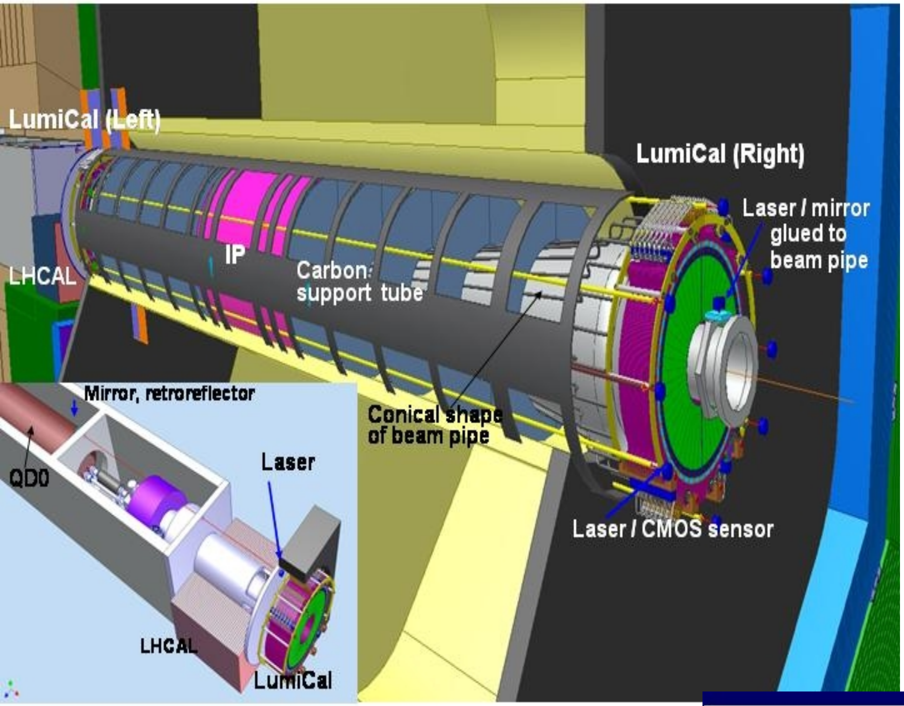
LumiCal: available free space ~ 3 cm in front of and ~ 5 cm behind – for positioning system and electronics. Cables together with VTX and FDET will be above and under LumiCal.

A gap between LumiCal and EndCap square hol (Ecal ring) will be used for front end electronics, cabling and cooling. This space is also used for inner cables outgoing from VTX nad FDET rings.The reserved space for cables ~ 360 cm^2 .

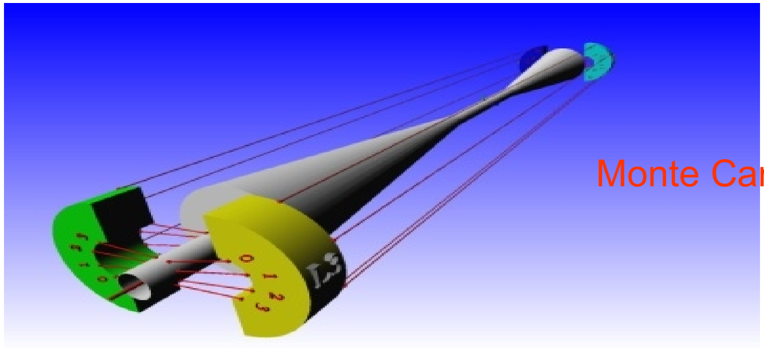
Cables outgoing from the inner detectors via a square support tube must have connectors to disconnect them from the inner part of ILD maintenance. A possible space for connectors behind LumiCal is foreseen.

LumiCal cooling –temperature-stable water together with temperature stabilization – thermal insulation
An opening scenario assume a temporary support for LumiCal for assemly and disassembly in the ILD detector

LumiCal : integration aspect(2) - alignment



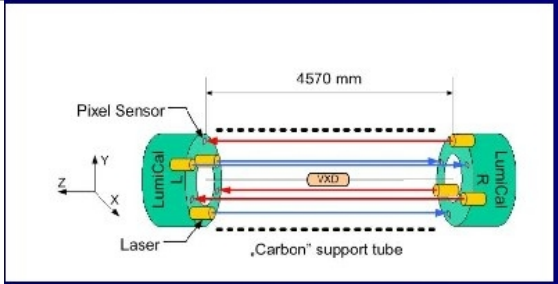
Alignment: laser beams + CCD (CMOS sensors) – LumiCal position measurement relative to beam pipe or QD0 magnet (~ 100 μm). The final LAS system – interferometric (FSI) method.

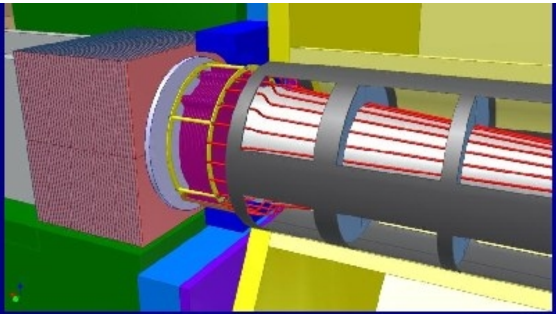


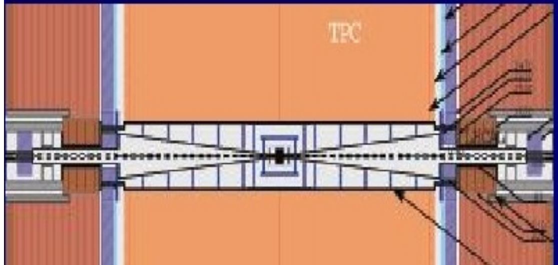
Monte Carlo studies

The required accuracy in distance measuremet between two calorimeters : less than 100 μm

Possible vacuum pipes (4-6) inside support tube for laser beam lines (FSI). Capacity sensors and/or IR laser with semi transparent sensors will be used for internal layers displacement measurements – a required accuracy - few micrometers



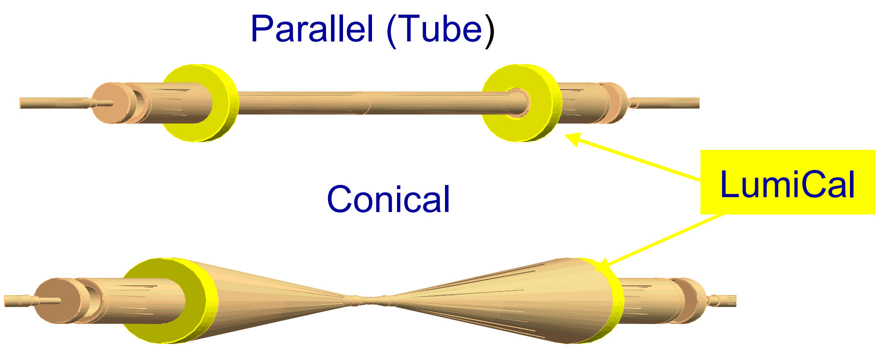




Carbon tube made with pipes for laser beams (higher stiffness)
Possible (?) windows in beam pipe for laser beams

Beam pipe shape

Two possible solutions for beam pipe shape in front of LumiCal



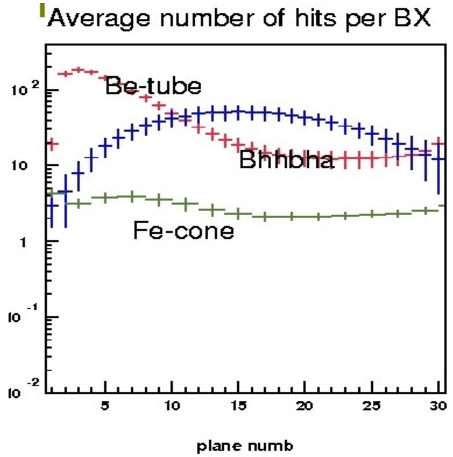
Particles which enter
LumiCal traverse the beam pipe
and secondary particles are created.
Such preshowers depend on thickness
and material of the beam pipe

Particles traveling from IP to **LumiCal**
do not pass practically any material – very little matter
in front of LumiCal

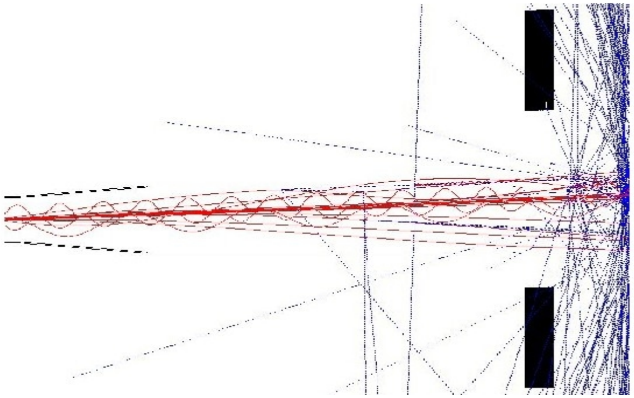
Beryllium beampipe, with inner radius of 5.5cm,
and outer radius of 6cm (the minimal radii for a 14 mrad crossing angle).

Problems with required vacauum at the edges of the beam pipe near LumiCal (no place for a pump in the forward direction?
Possible disturbances for the magnetic field – boundary conditions ?

An example of MC studies



Large increase of background hits (and energy deposit for cylindrical beam pipe
- more material for low polar angle
- pipe does not "confine" beamstrahlung pairs excessive amount of secondary interactions



- ***Stay with conical beam pipe or make its radius as large as possible (~ 6 cm)***

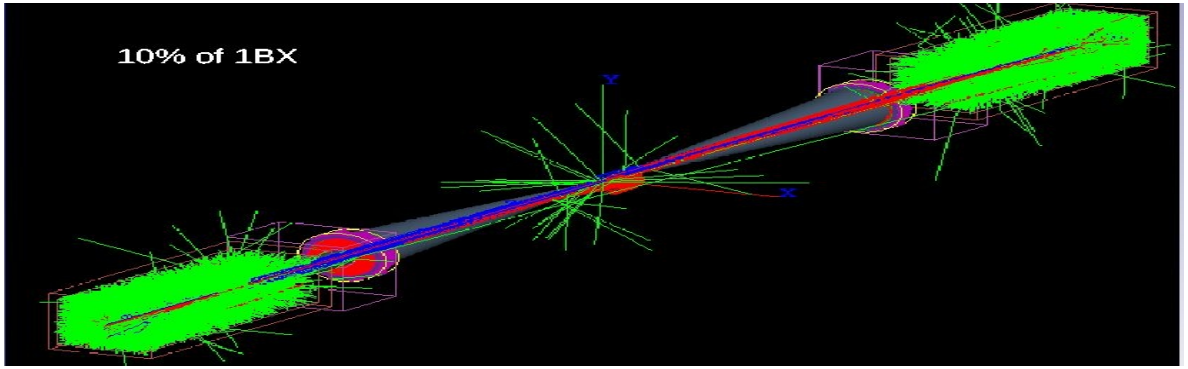
From Monte Carlo studies (B.Pawlik, I. Sadeh): different shapes, and materials (Be, Fe) - influence on relative error in luminosity measurements $\Delta L/L \sim \Delta\theta$ (offset on rec. angles) / θ_{min} (lowest angle accepted):
a few % an increase in polar angle offset and polar angle resolution for tube option for Bhabha events. This induces a relative bias in the efficiency of the Bhabha selection process.

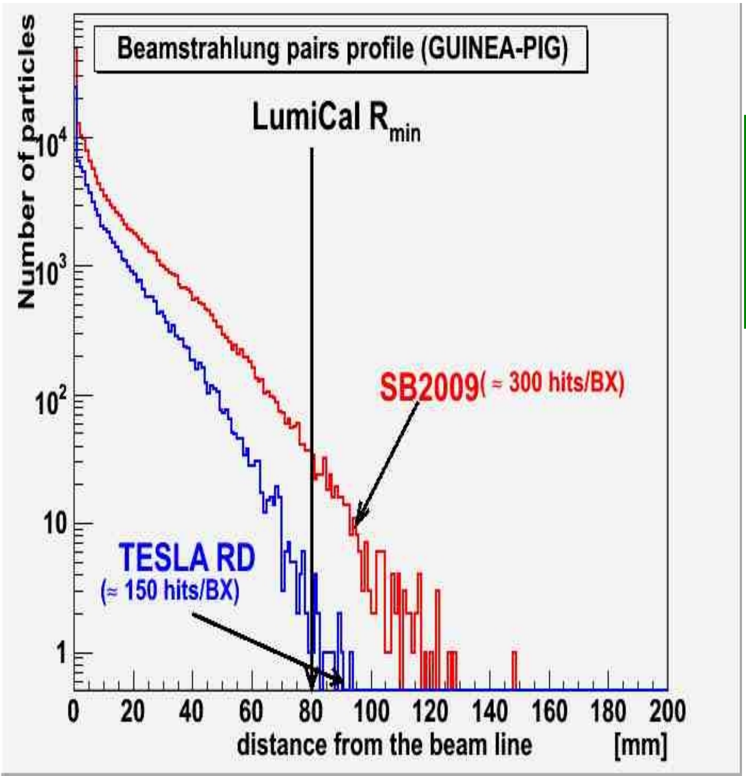
For beamstrahlung: optimalisation on minimalisation in hits number and maximalisation for event rate was done. Results beam pipe should be centered on outgoing beam-line, better case for conical type.

In any way, the conical shape allows to get required accuracy in luminosity measurements

LumiCal : Background studies (Mokka)

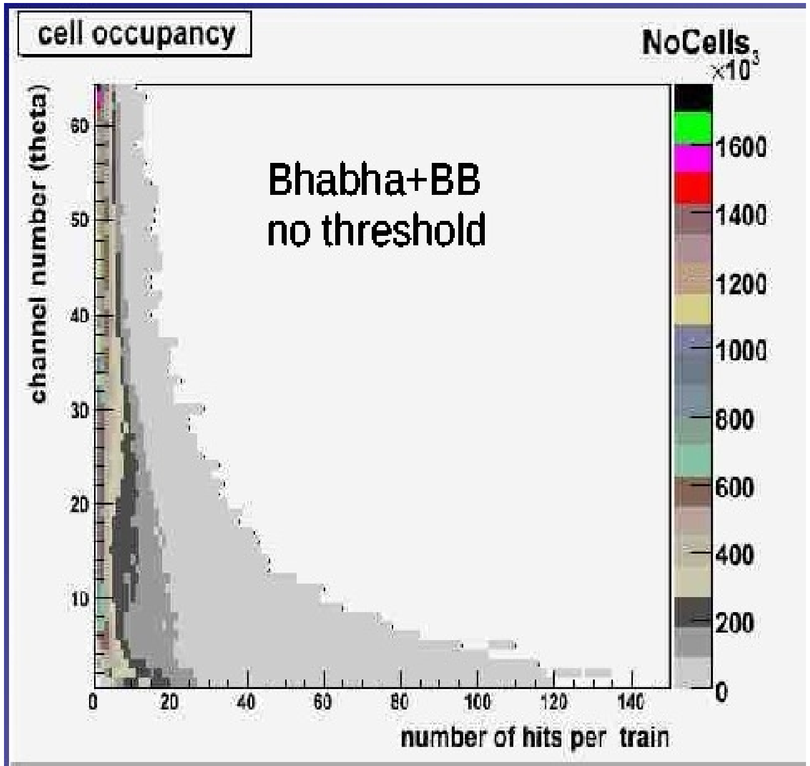
For conical shape of beam pipe





Using field map for AntiDID description -

B. Pawlik



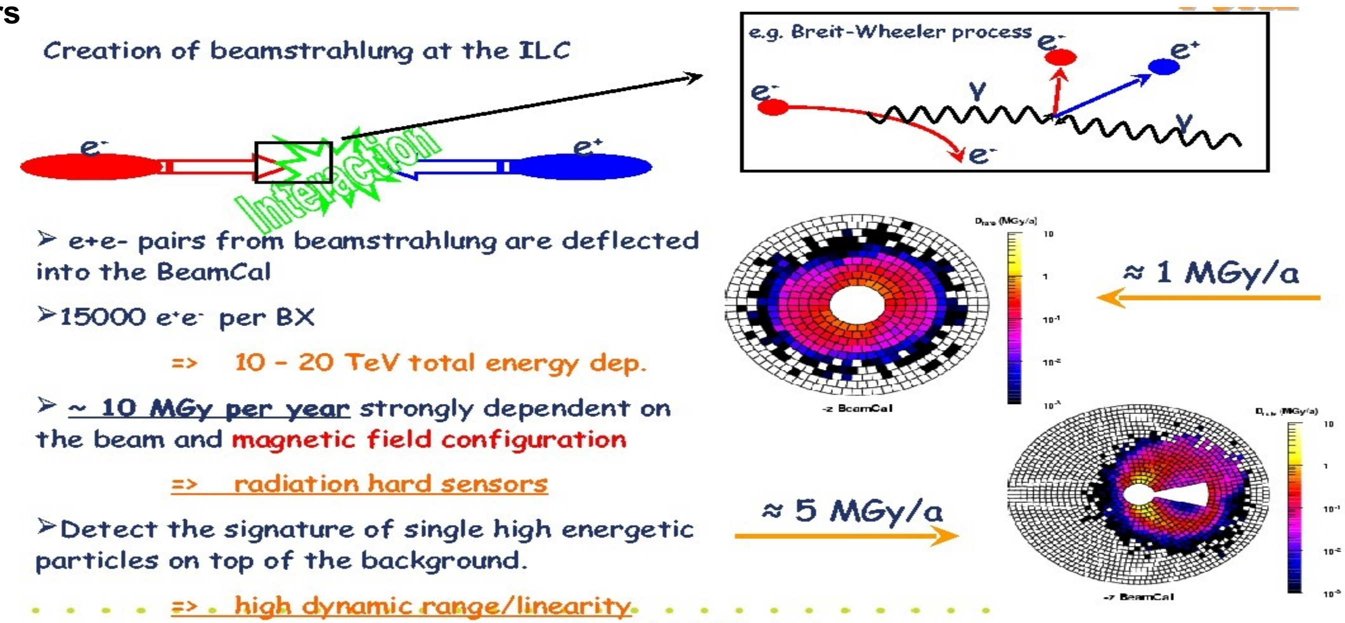
BeamCal: challenges

PRC Report, DESY, November 2009

Detailed simulation studies on background effect on BeamCal sensors and FE electronics coming from:

- beamstrahlunhg e^+e^- pairs
- neutrons

pairs



So it is necessary to have radiation hard sensors.
Studies on:
CVD diamond detectors
Sappire,
Galium arsenide (GaAs),

neutrons

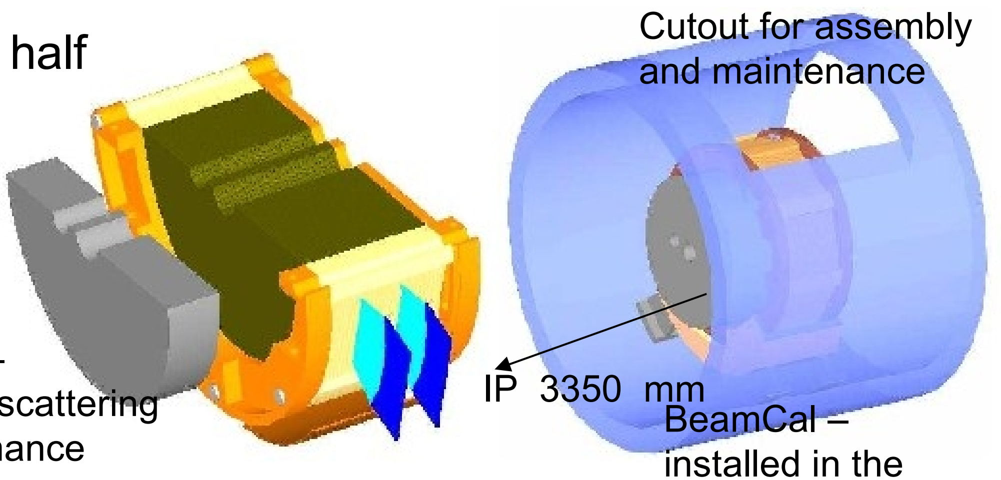
An example of obtained results: the total number of low energy (< 1 MeV) neutrons as function of the layer depth : for 5 BX, a maximum appeared at ~7-9 layers with about 10 000 neutrons, an even higher value was observed for neutrons with energy > 1 MeV. The presence of QD0 behind BeamCal increases the flux of neutrons in the second half of BeamCal.
Neutron fluence for electronics: in the selected layers (19,24) fluence (n/mm^2) was on the lewel below 0.1, an increase was observed at the last layer of FE electronics when QD0 was included in geometry for Monte Carlo simualtion

BeamCal

30 X_0 (sensors: not yet choosen /
W sampling calorimeter
Tungsten thickness: ~ X_0 (3.5 mm)
Sensor thickness: ~0.5 mm
X/Y/Z: 24.2/0/±3450 mm
10 cm graphite in front
Rin / Rout (sensor) 20 /150 mm
Rout (mechanics) 200 mm
θ range: 5.8 – 43.5 mrad
~ 40 k readout channels

Low-Z mask
graphite as additional absorber-
suppresion of detector backgrounds

Bottom half



Cutout for assembly and maintenance

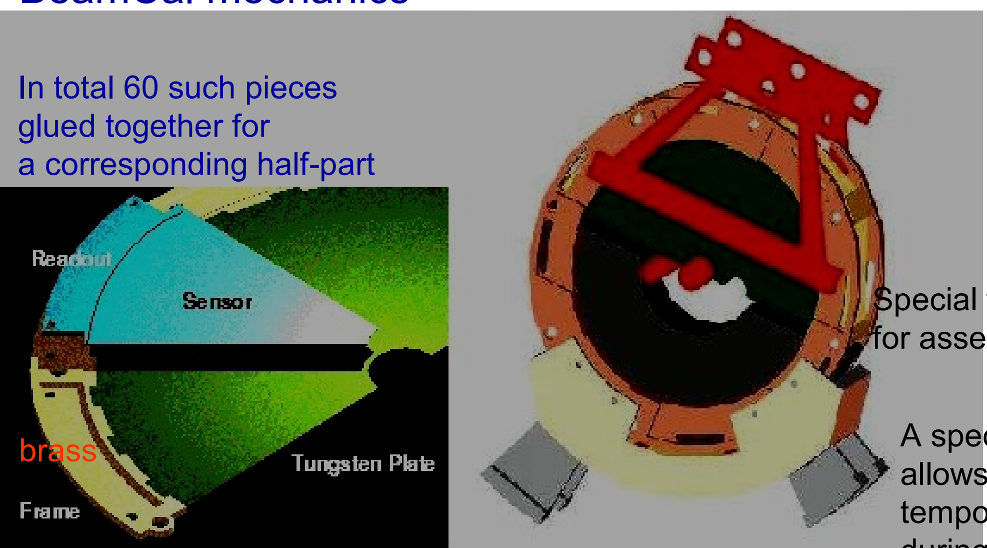
IP 3350 mm

Graphite shield –
reduction of backscattering
decrease performance

BeamCal –
installed in the
ILD support tube

BeamCal mechanics

In total 60 such pieces
glued together for
a corresponding half-part



(a) BeamCal half-layer assembly.

(b) Calorimeter installation.

BeamCal –
two parts an upper and a lower half: it allows for installation and disassembly without interrupting the vacuum. This required the possibility to open the upper part of support tube to access.

Special frames
for assembly BeamCal

A special support structure: static and sets of rolls – allows for BeamCal rotation around its axis. Grey parts temporary used before beam pipe installation – removed during calorimeter installation

Summary

- The systematic, large progress towards the final design for all forward detectors are observed.

- The recent developments take into account the requirements of the tasks for which they will be build and their expected contributions to physics study at ILD.

- The serious problem comes from unwanted background, limited available space inside the ILD structure and from machine requirements (beam pipe, magnents) – MDI
- The R&D work for forward detectors will be continuing to get final engineering technical projects at 2012.
  But what if the financial support
  will be not enough in the next two years? A realistic estimation
  a cost and man power for future work should.