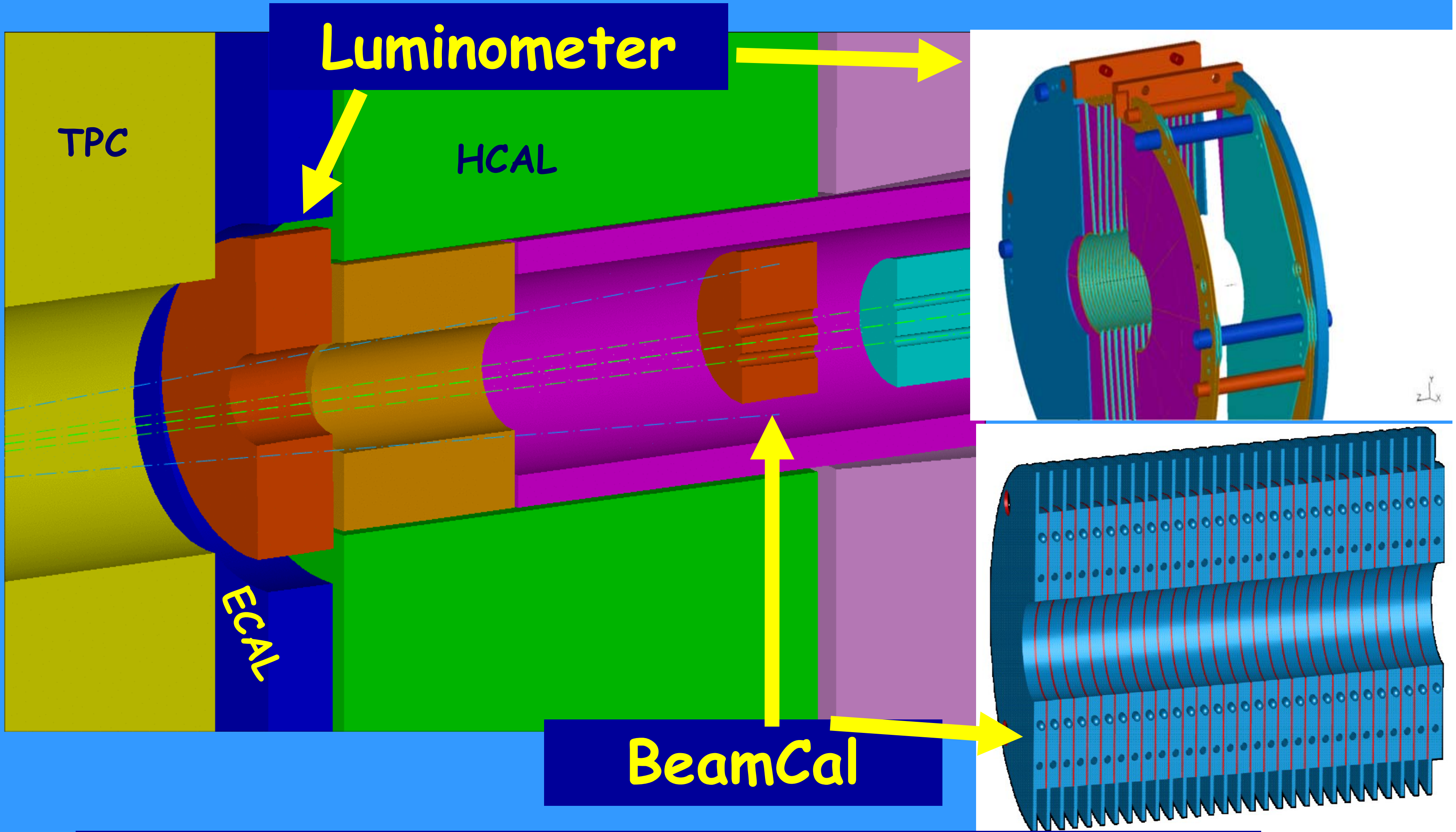
# Very Forward Instrumentation

On behalf of the

FCAL Collaboration
*High precision design*


**Wolfgang Lohmann,**
**DESY**

# Current design (Example LDC, 20 mrad):




**Technology: Tungsten/Si (C) sandwich**

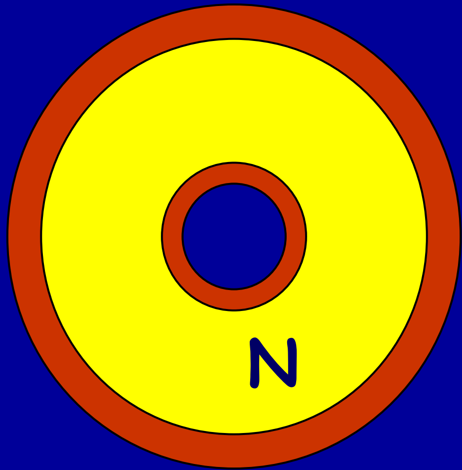
# Measurement of $\mathcal{L}$

$$\mathcal{L} = N / \sigma$$

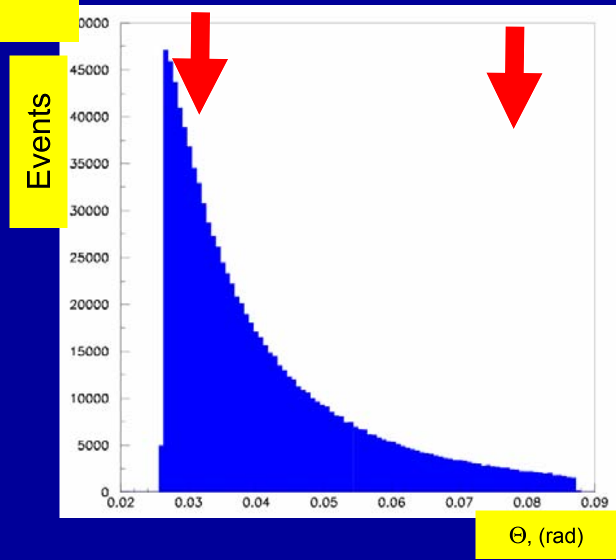
Count Bhabha events (→ N)

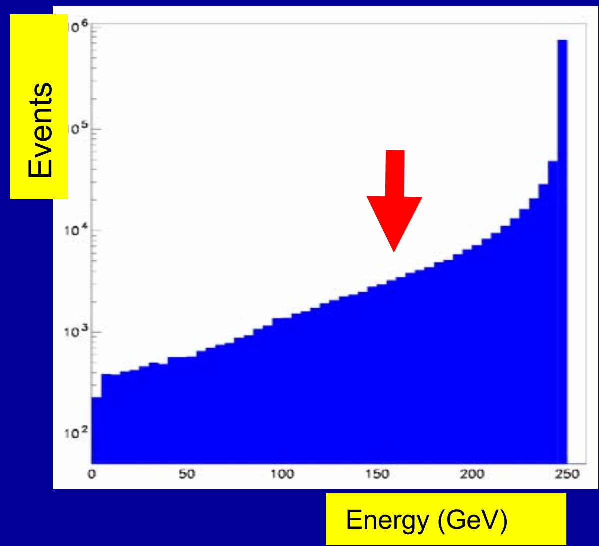
From theory (→ σ)

**Goal: Precision ~$10^{-4}$**



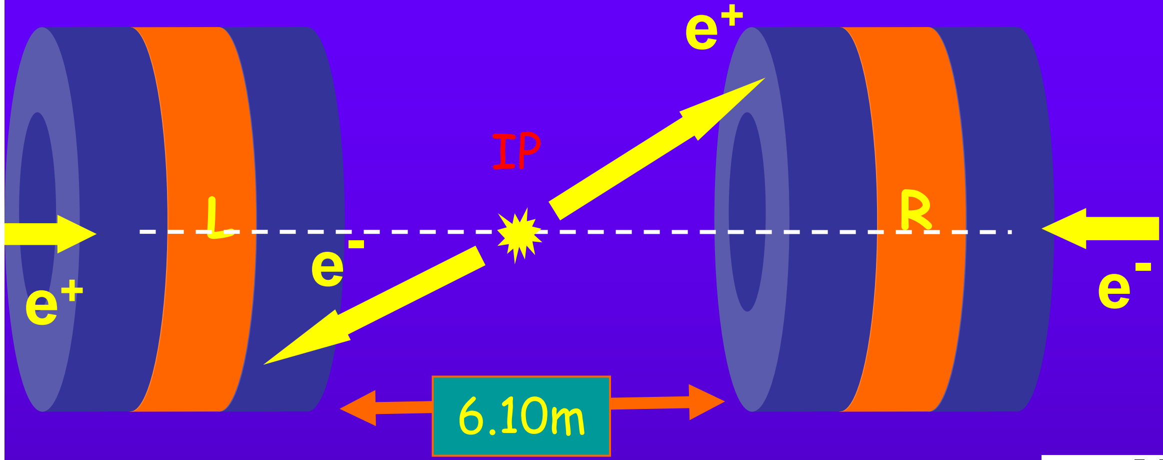

| | Min | Max |
|---|---|---|
| R | ~10 cm | ~25 cm |
| θ | 33 mrad | 80 mrad |

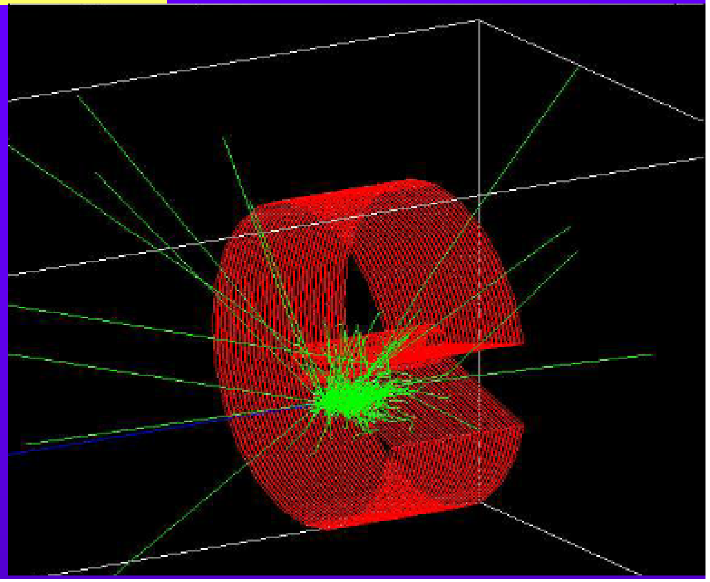


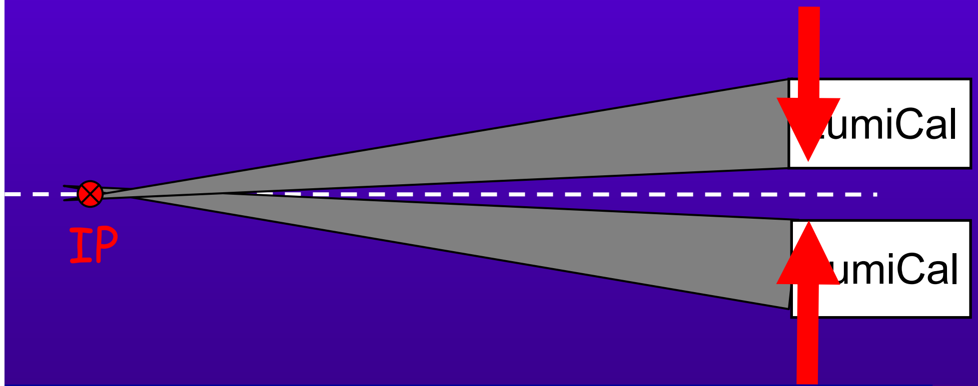



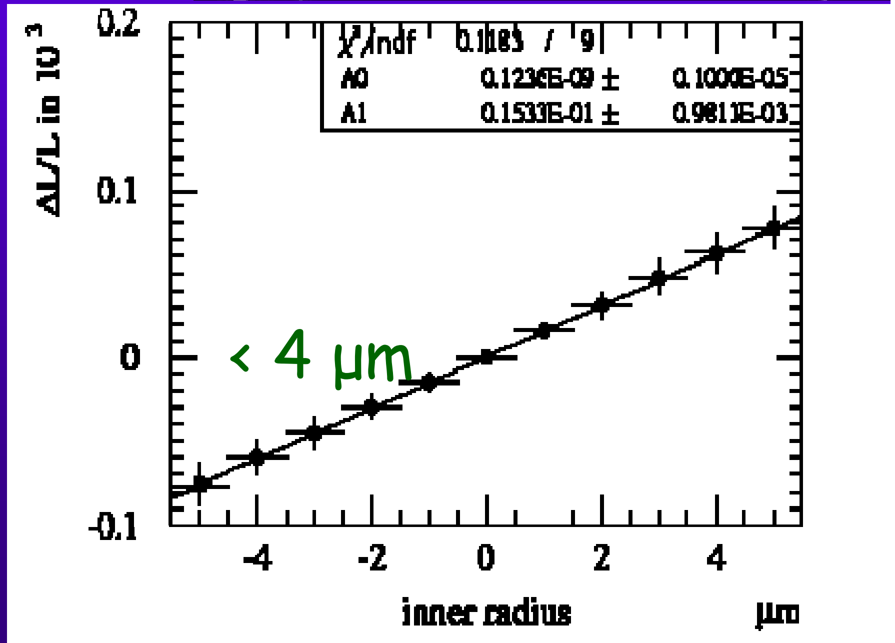

Requires theoretical cross-section with the necessary precision; contacts to theory groups in Zeuthen, Cracow, Katowice theory groups (two loop calculation)

# Requirements on LumiCal





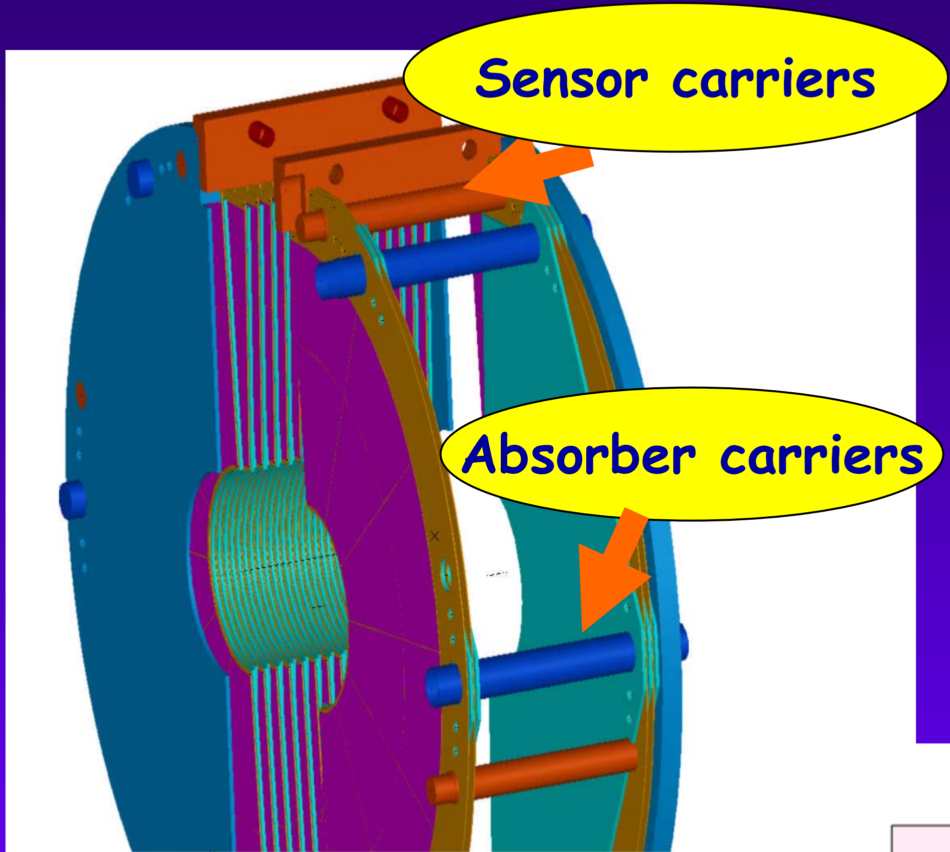

**Inner Radius of Cal.:** < 4 μm

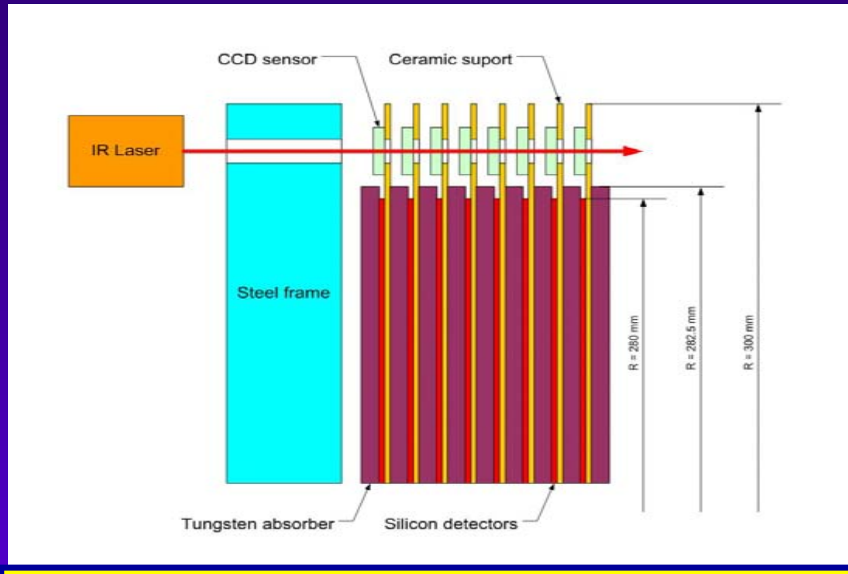
**Distance between Cals.:** < 60 μm

**Radial beam position:** < 0.7 mm

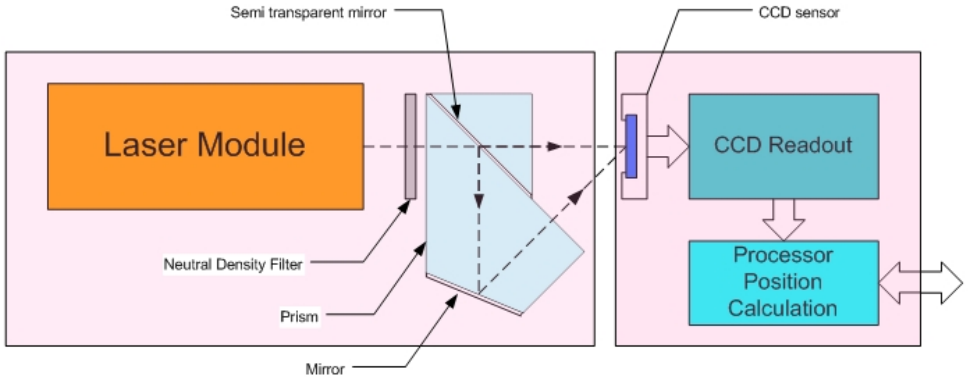
Vancouver

# Mechanical Frame and Alignment




**Alignment and position control using Laserbeams**

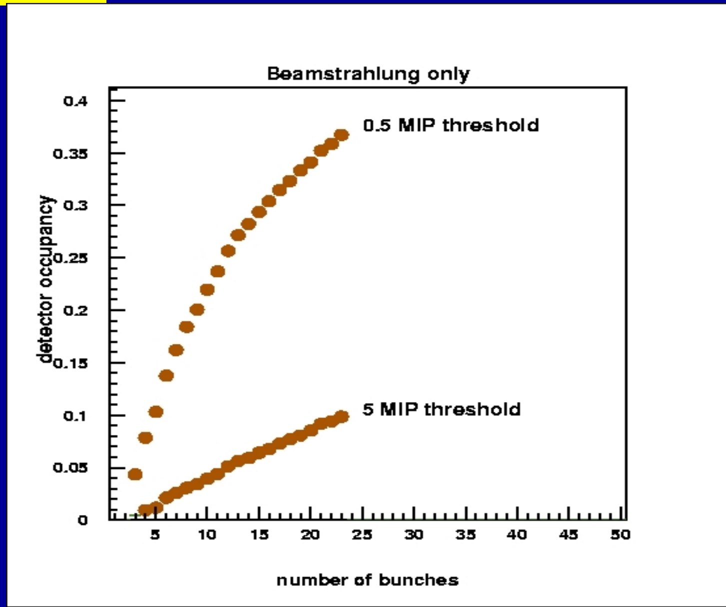



**Decouple sensor frame from absorber frame**

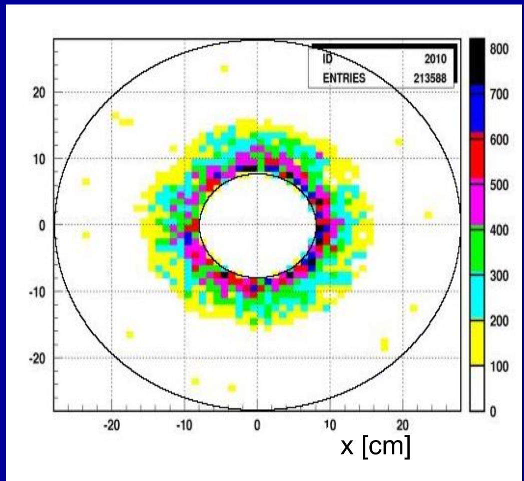
# Occupancy

## LumiCal

Remnant background from Beamstrahlung




+background from two photon events (under work)




+ Bhabha signal

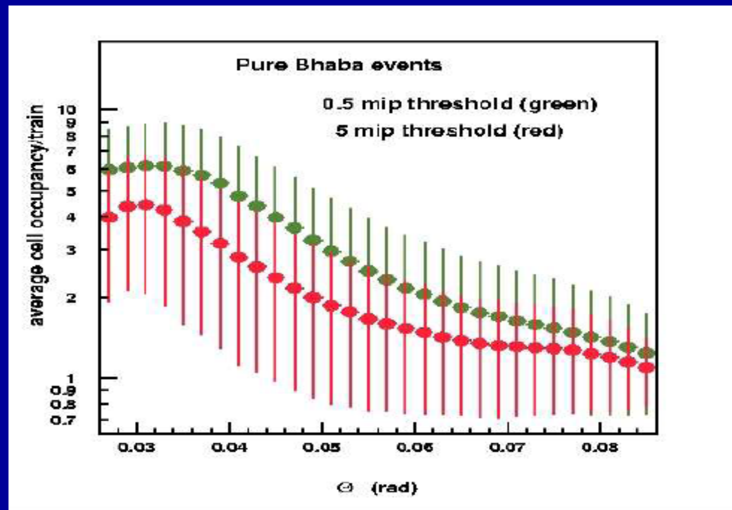
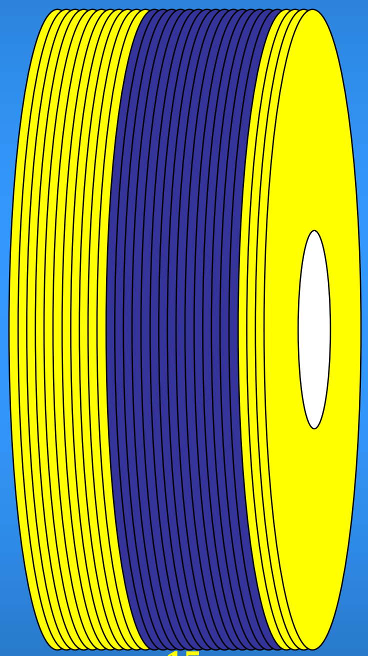



**Fig.3** *Average channel occupancy per train for pure Bhabha events*

# LumiCal, present understanding

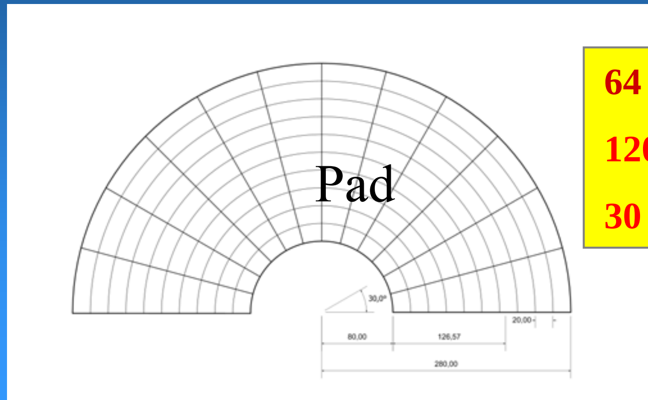
Maximum peak shower

- 10 cylinders (θ)
- 60 cylinders (θ)



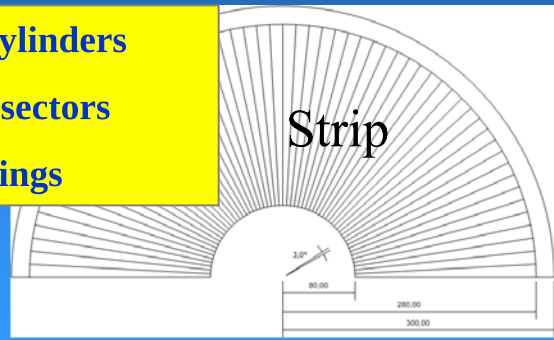
11 layers (z) | 15 layers (z) | 4 layers (z)

e-




Every second ring:

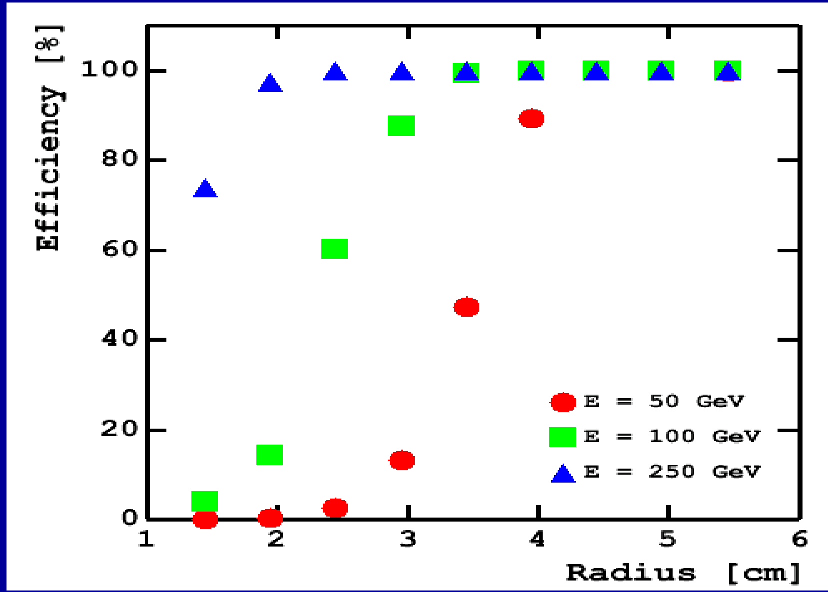
**64 cylinders**
**120 sectors**
**30 rings**

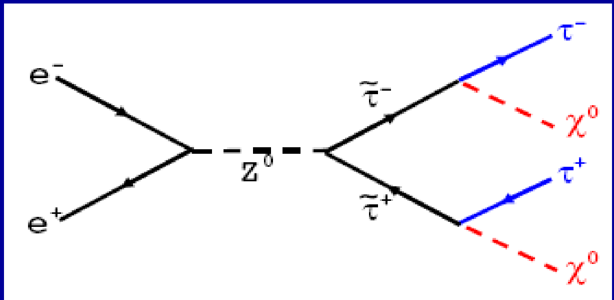



| Parameter | Pad Performance | Strip Performance |
|---|---|---|
| Energy resolution | 25%($\sqrt{GeV}$) | 25% ($\sqrt{GeV}$) |
| θ resolution | $3.5 * 10^{-5}$ rad | $2.1 * 10^{-5}$ rad |
| ϕ resolution | $10^{-2}$ rad | $10^{-3}$ rad |
| Δ θ | ~ $1.5 * 10^{-6}$ rad | ~$2.1 * 10^{-7}$ rad |
| Electronics channels | 25,200 | 3720 (with bonding sectors)<br>13,320 (without bonding) |

# BeamCal

Low angle electron veto:
Background suppression
in search channels.
e.g.




$L = 500 fb^{-1}$

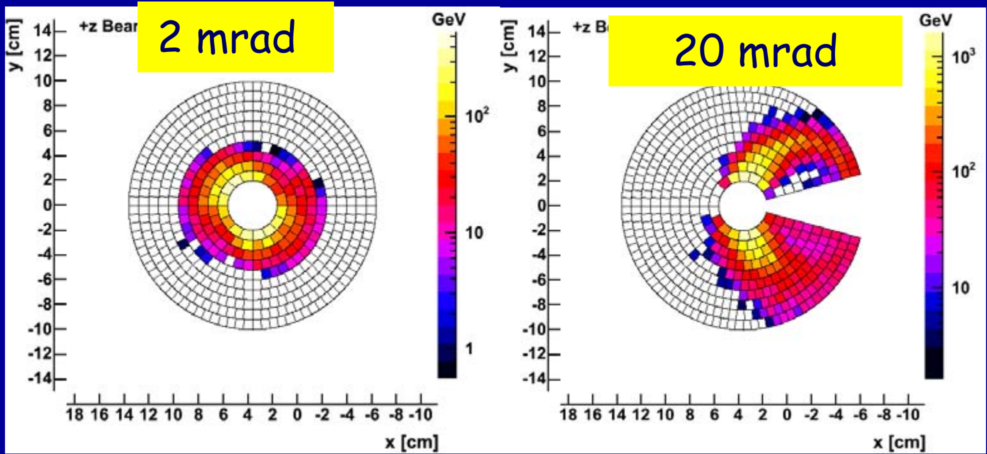
Number of **SUSY** events ~ 20

Number of unvetoed **2-photon** events:

| Veto Energy Cut, GeV | 75 | 50 |
|---|---|---|
| Nominal | 45 | 5 |
| Low Q | 40 | 0.1 |
| Large Y | 50 | 9 |
| Low P | 364 | 321 |
| Nominal, 20mrad | 396 | 349 |

# BeamCal

Determination of beam parameters from beamstrahlung depositions on BeamCal:

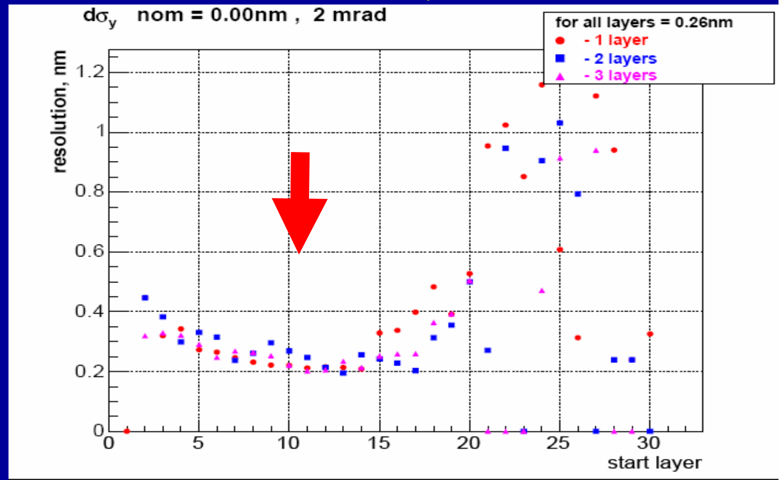


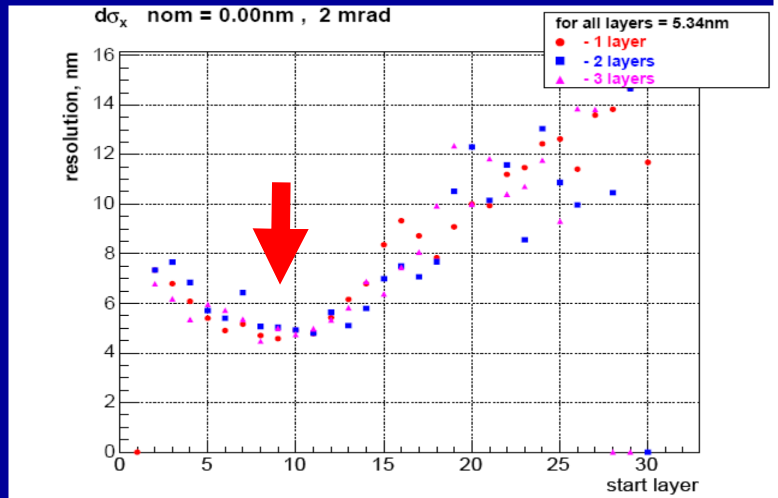

| Quantity | Nominal Value | Precision |
|---|---|---|
| σx | 553 nm | 2.9 |
| σy | 5.0 nm | 0.2 |
| σz | 300 μm | 8.5 |

**Question: how many sensor planes are really needed?**

**Seems sufficient to read out a few planes only ( around 10 $X_0$)**

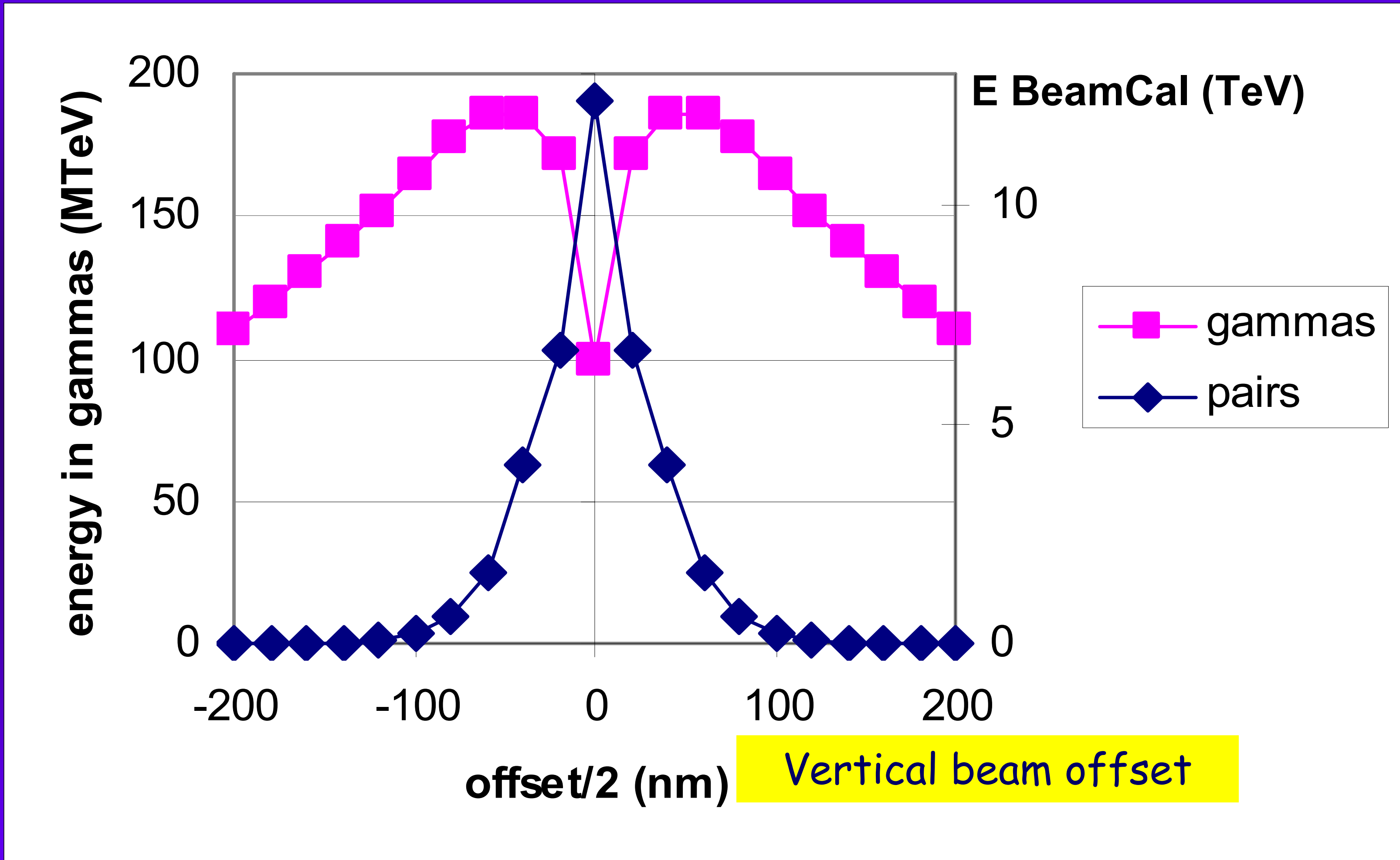
Full GEANT4 simulation:
Parameters: $\sigma_x$ and $\sigma_y$



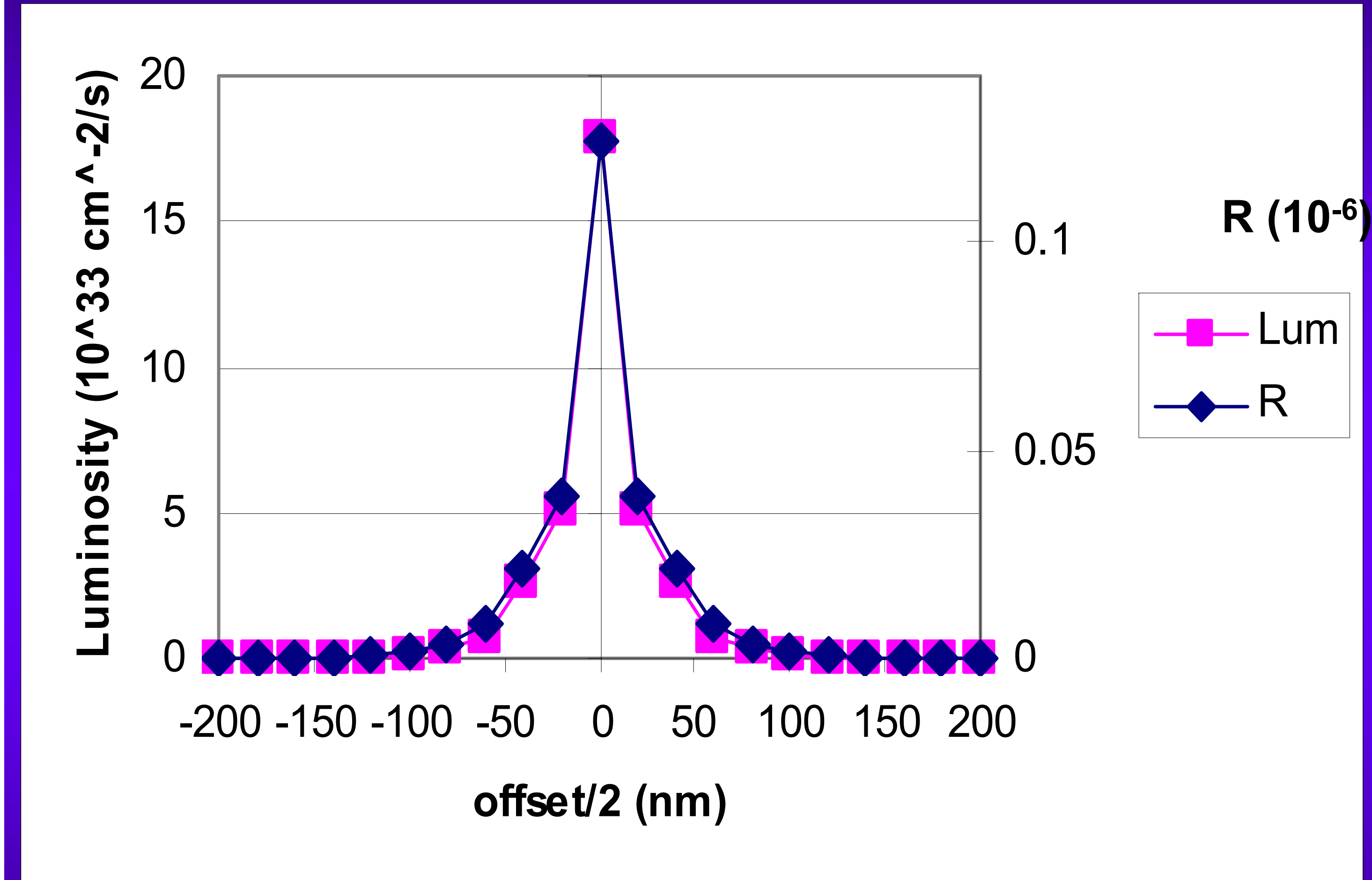



# GamCal

## Combine informations from pairs and photons (B. Morse)



# Ratio of energy depositions in BeamCal and GamCal:

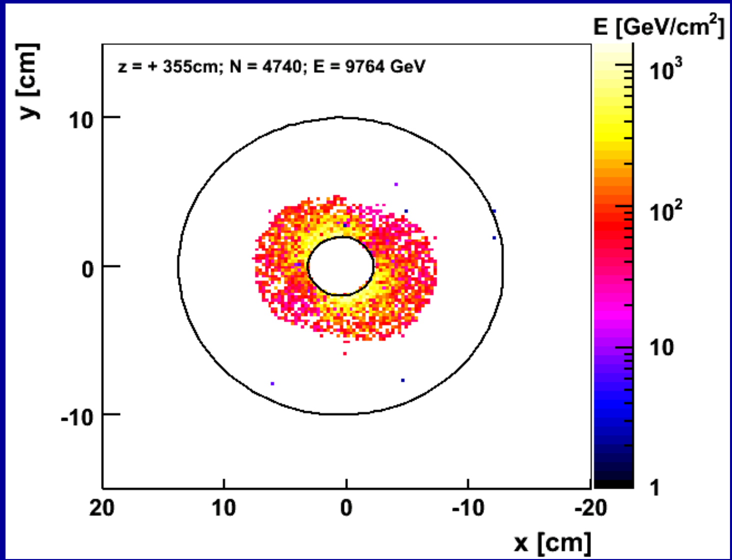



Almost proportional to the Luminosity!

How to measure the photon energy?

Cerenkov light in the water dump? New detector?

# BeamCal sensor tests



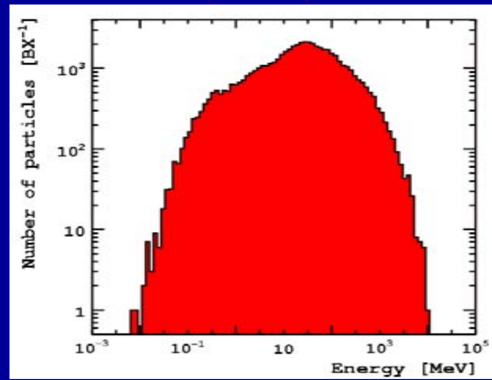

Energy deposition from beamstrahlung pairs in BeamCal.
10-20 TeV and more depending on the beam parameters.

**Dose of up to 10MGy/a**

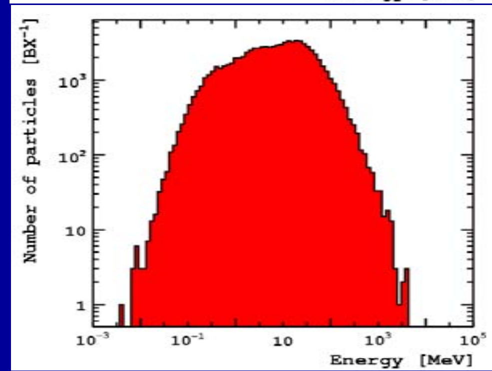
**Test of sensors in an electron beam of 10 MeV energy (DALINAC, TU Darmstadt)**

**Shower particles energy spectra**

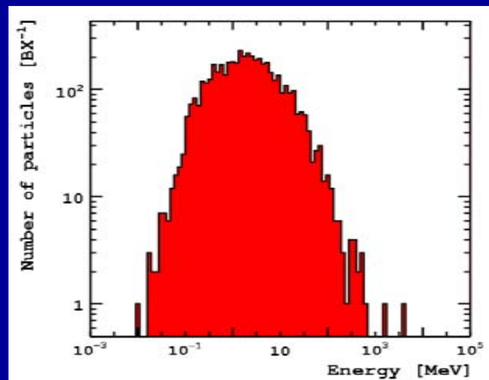
$2X_0$



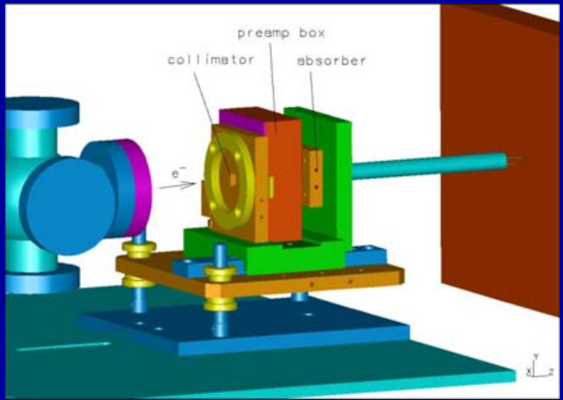

$6X_0$

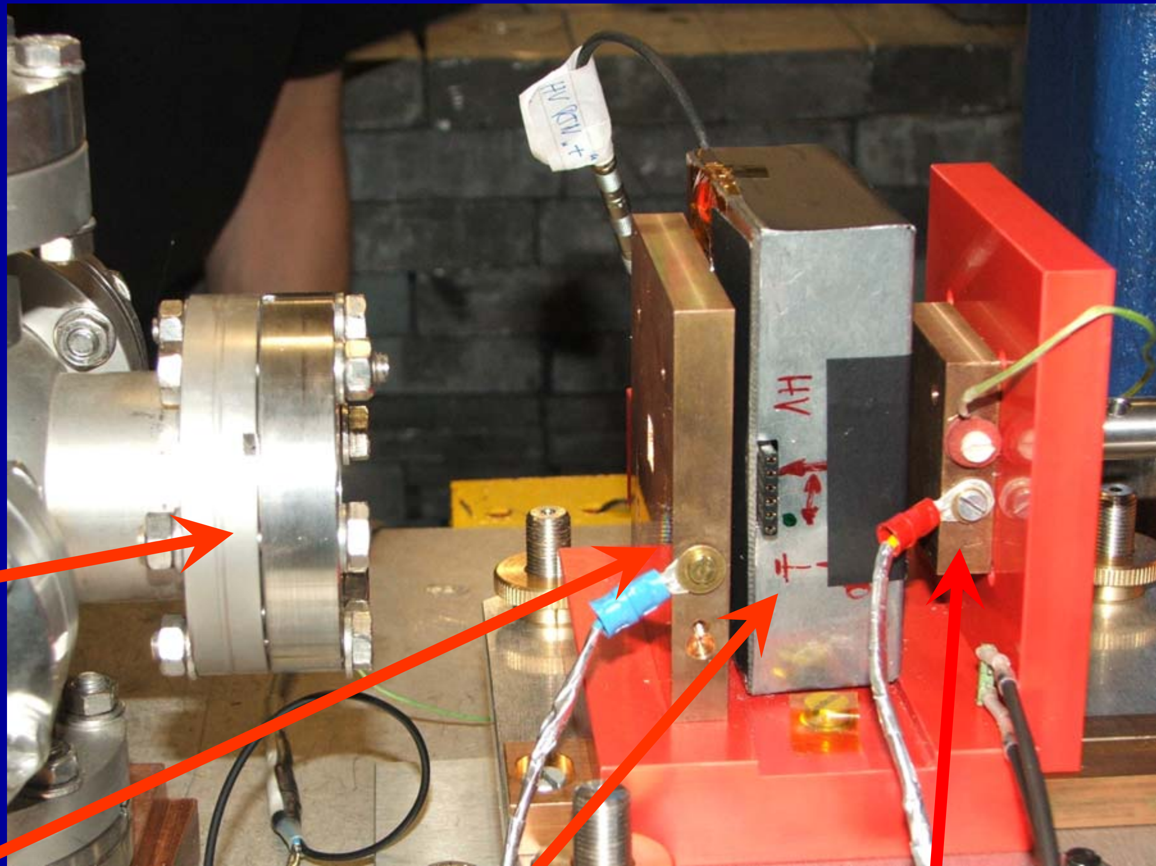



$20X_0$



# The Setup




exit window
of beam line

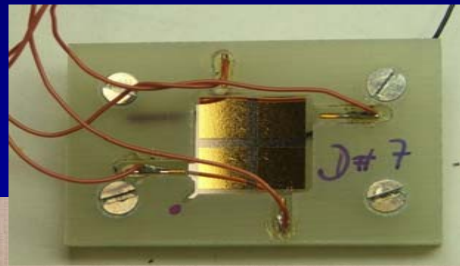
collimator ($I_{Coll}$)

Faraday cup ($I_{FC}$, $T_{FC}$)

sensor box ($I_{Dia}$, $T_{Dia}$, HV)

# PROGRAM

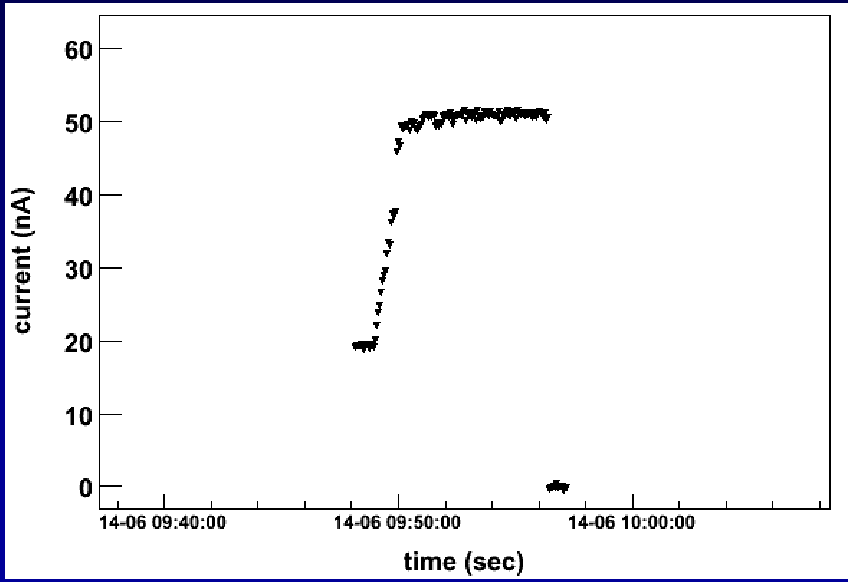
- 2 samples from E6
    - 1 MGy
    - 5 MGy
- 2 samples from IAF
    - 1 MGy
    - 5 MGy
- 2 Si samples
    - both drew high currents after ~50 kGy.

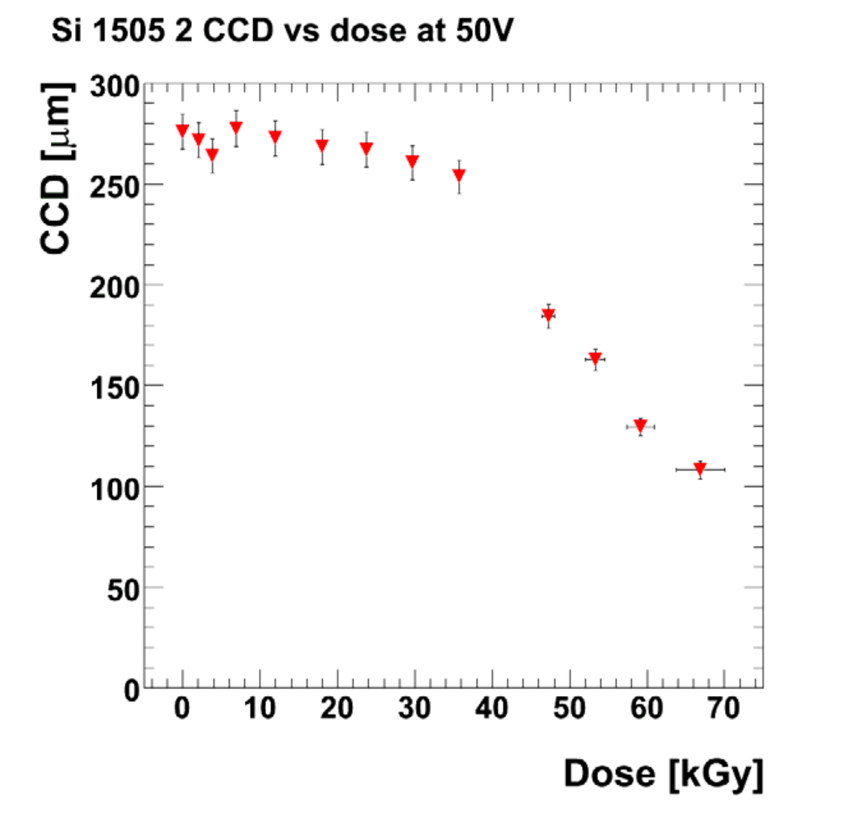


E6_4p after ~5 MGy

# Results

Beam current, set to 10, 20, 50 and 100 nA, (Faraday cup)



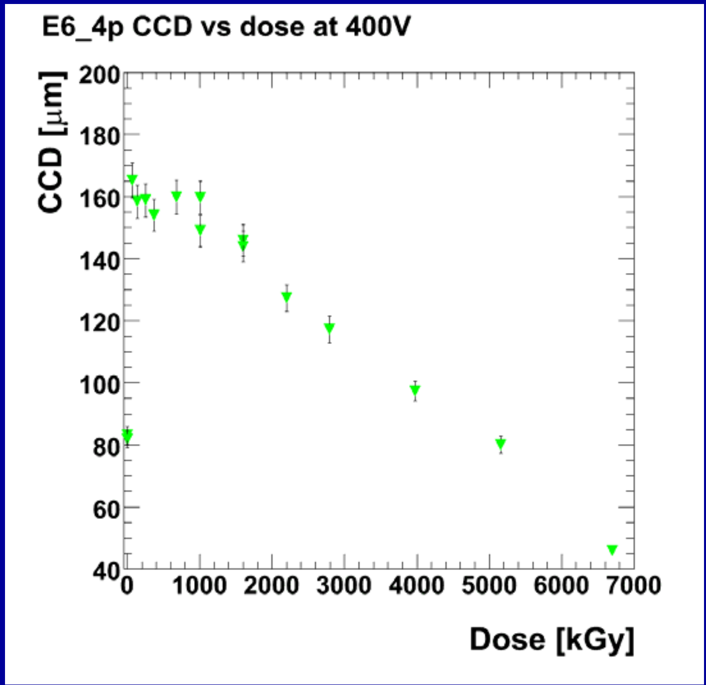




Si sensor, 10 nA (ECAL standard)

high leakage current after 50 kGy

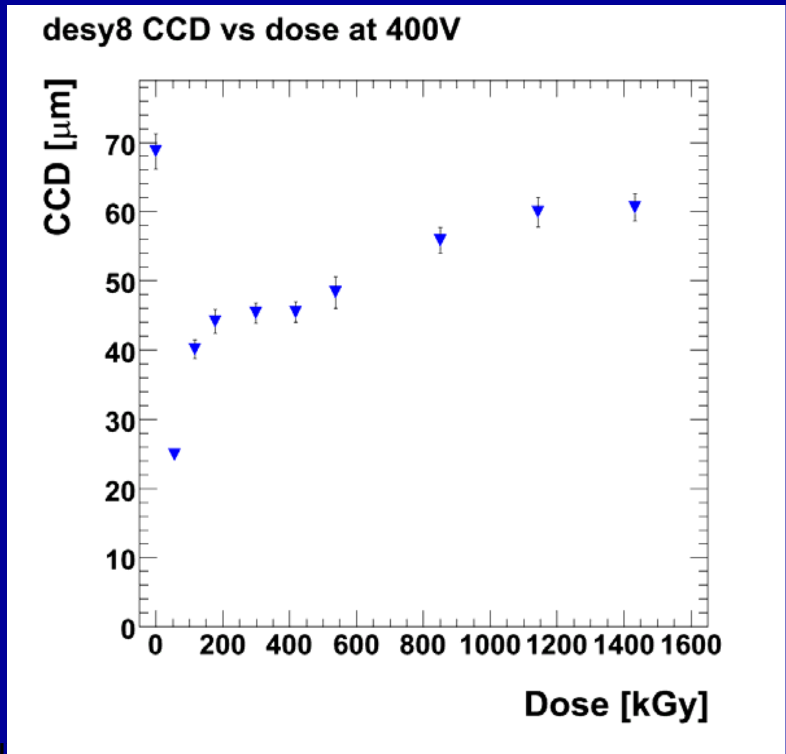
/S Vancouver

# Results




Diamonnd sensor (produced by E6)

Diamond sensor (produced by Fraunhofer IAF)



# Readout- the challenges

- 5 bunch trains per second (5 Hz)
- 3000 bunches within one train

- One bunch every 300ns, 150ns possible
- Each bunch to be registered
- High dynamic range (1:10k)
- 10 bit ADC

- Data per train ~1 Gb
  (transmission during train ~1 Tb/s, during break ~3 Gb/s)

- Radiation hardness to be considered
- Compact detectors: low power little space for multi-channel electronics

# Conclusions

- From similations: Design of calorimeters in the forward region relatively advanced
- Mechannics design – first ideas
- Integration in the detector to be done later

- Radiation hard sensors not yet understood
  - we consider 'backup materials', like special silicon and GaAs
- Read-out electronics will be a challenge
  -different from 'standard' calorimeters, fast digitisation and processing, large amount of 'raw data'

Effort on hardware development will be increasend!

# 20 mrad, layout