ECFA DESY

Linear Collider Workshop

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Amsterdam

Design and expected performance of a forward calorimeter

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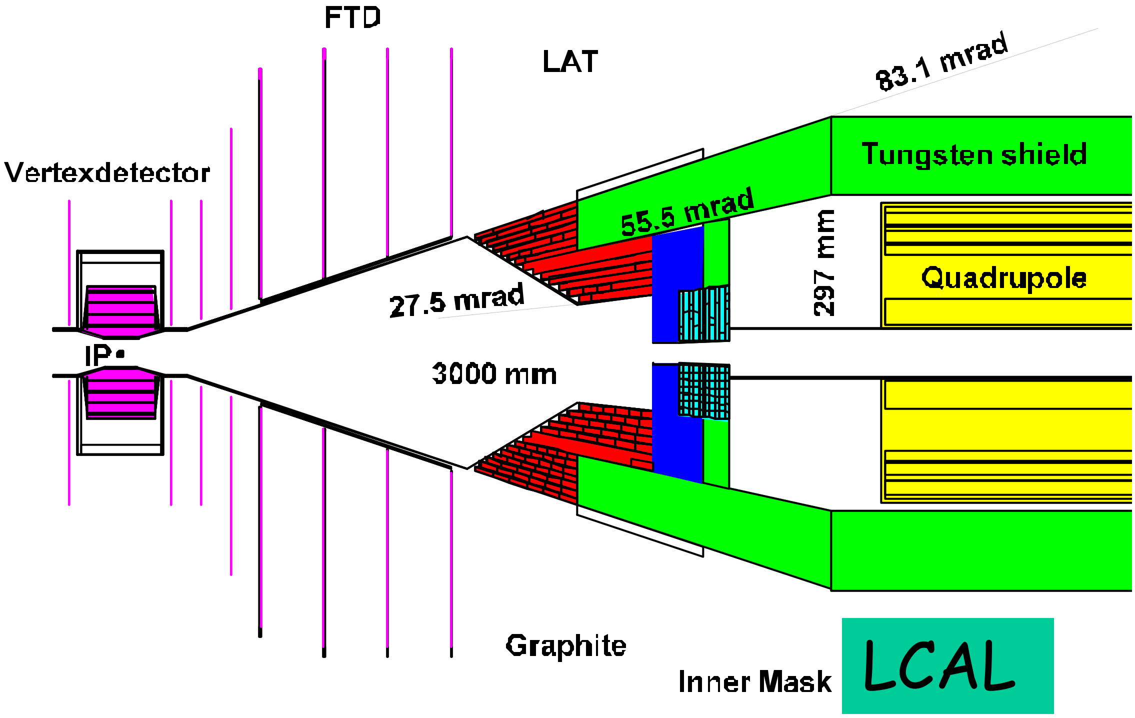
forward region



distance between IP and LCAL 220 cm
angular coverage 5.5 - 27.5 mrad

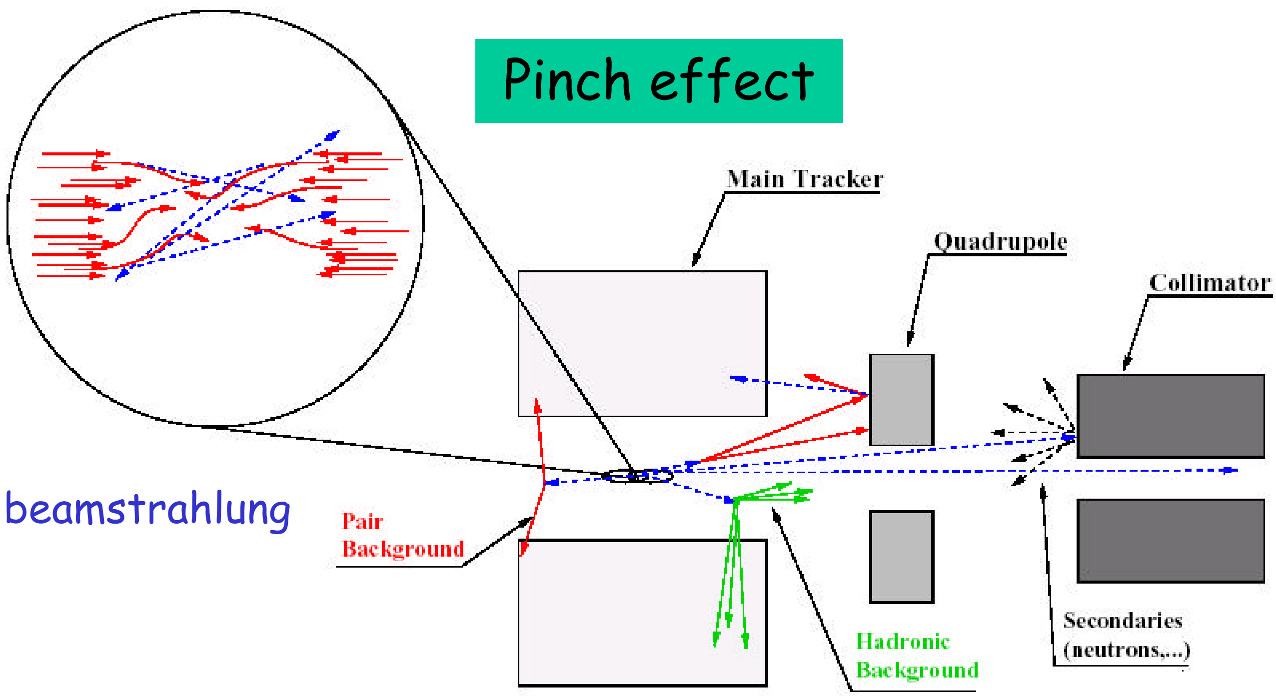
Main goals:

- fast beam diagnostic
- detection and measurement of high energetic electrons and photons at very small angles

Proposed technologies:

- crystal $PbWO_4$ detector
- sampling tungsten / diamond detector

beamstrahlung



High charge density of beams leads to strong electromagnetic fields $\Rightarrow$ beams focus

Pinch effect result in:

- luminosity enhancement (~2 times)
- beam energy loss (~4% for TESLA 500-800)

due to beamstrahlung photon emission

Beamstrahlung is TESLA's major background source: ~ $6 \times 10^{+10}$ beamstrahlung photons / BX

- none detector hits from direct beamstrahlung
- creation of e^+e^- pairs from beamstrahlung photons

gives ~ $1.28 \times 10^{+5}$ $e^\pm$ / BX

LCAL background

Simulation tools :

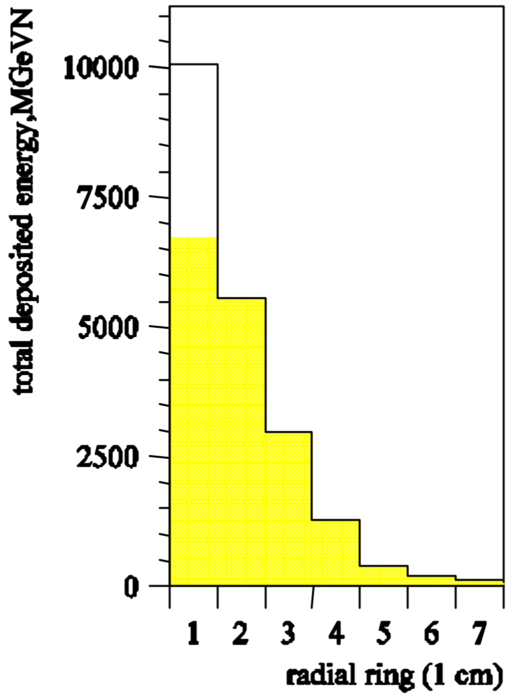
- GuineaPig for beamstrahlung production
- BRAHMS for tracking

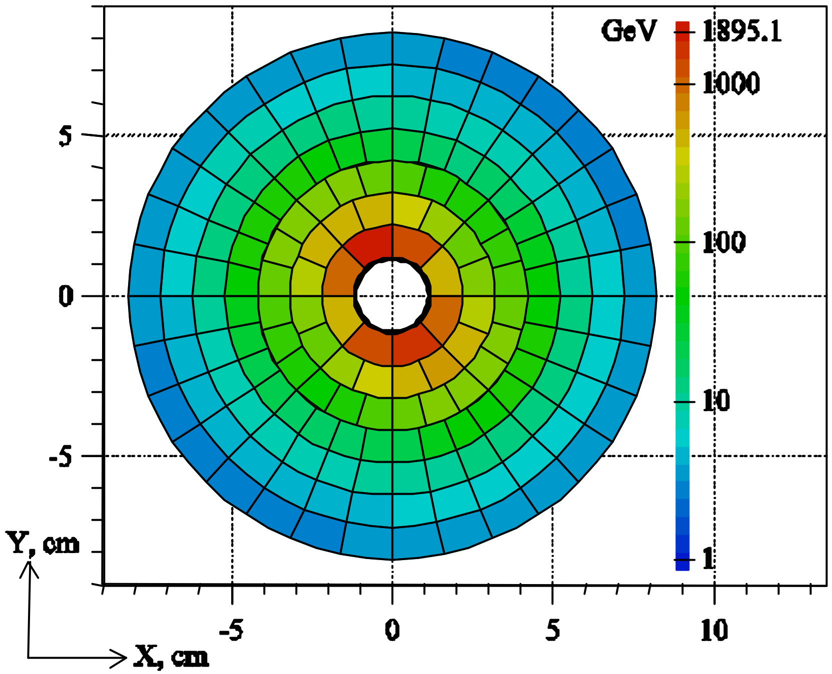
For √s = 500 GeV TESLA design beam parameter

~ 15 000 $e^{\pm}$ / BX with total energy ~ 20 TeV hit LCAL

Extremely radiation hard calorimeter is needed

Deposited energy as function of R and φ

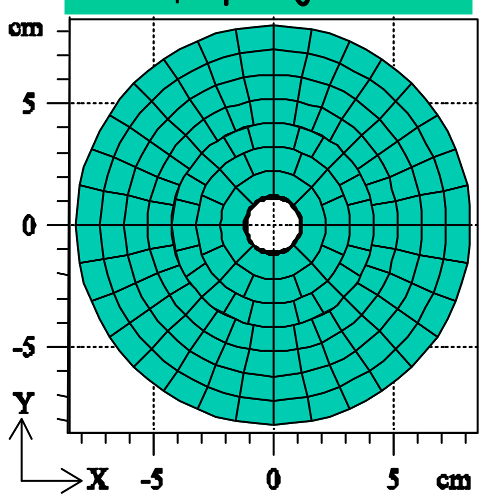


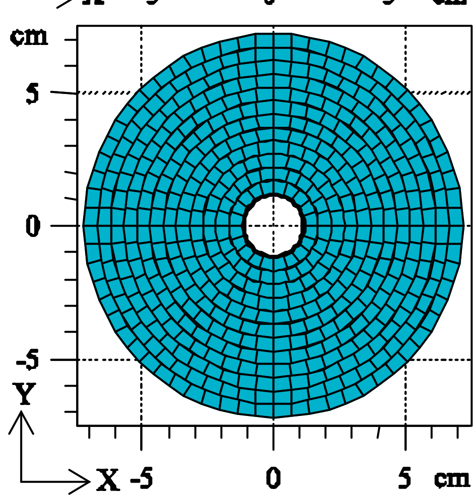


benchmark segmentation

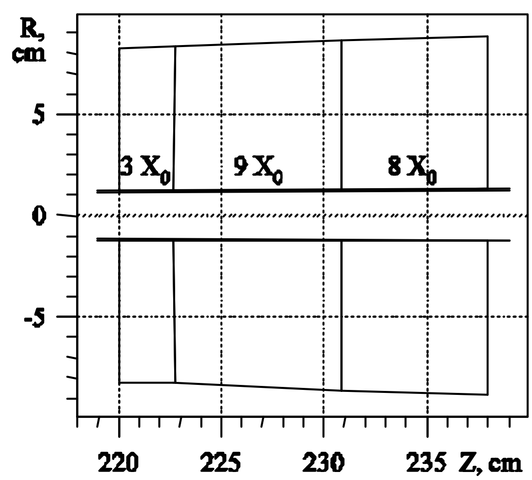
	C/W	$PbWO_4$
Radiation length of LCAL media, cm	0.4	0.89
Molier radius of LCAL media, cm	1.0	2.2
Total calorimeter length, cm	12	18
Number of longitudinal layers	30	3
Number/thickness of ring, cm	12/0.5	7 / 1.0
Number of azimuthally sectors	20-64	8-32
Number of channels	15120	528

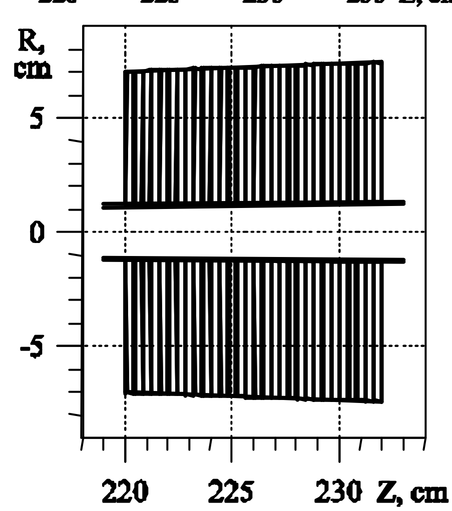
R - φ projection





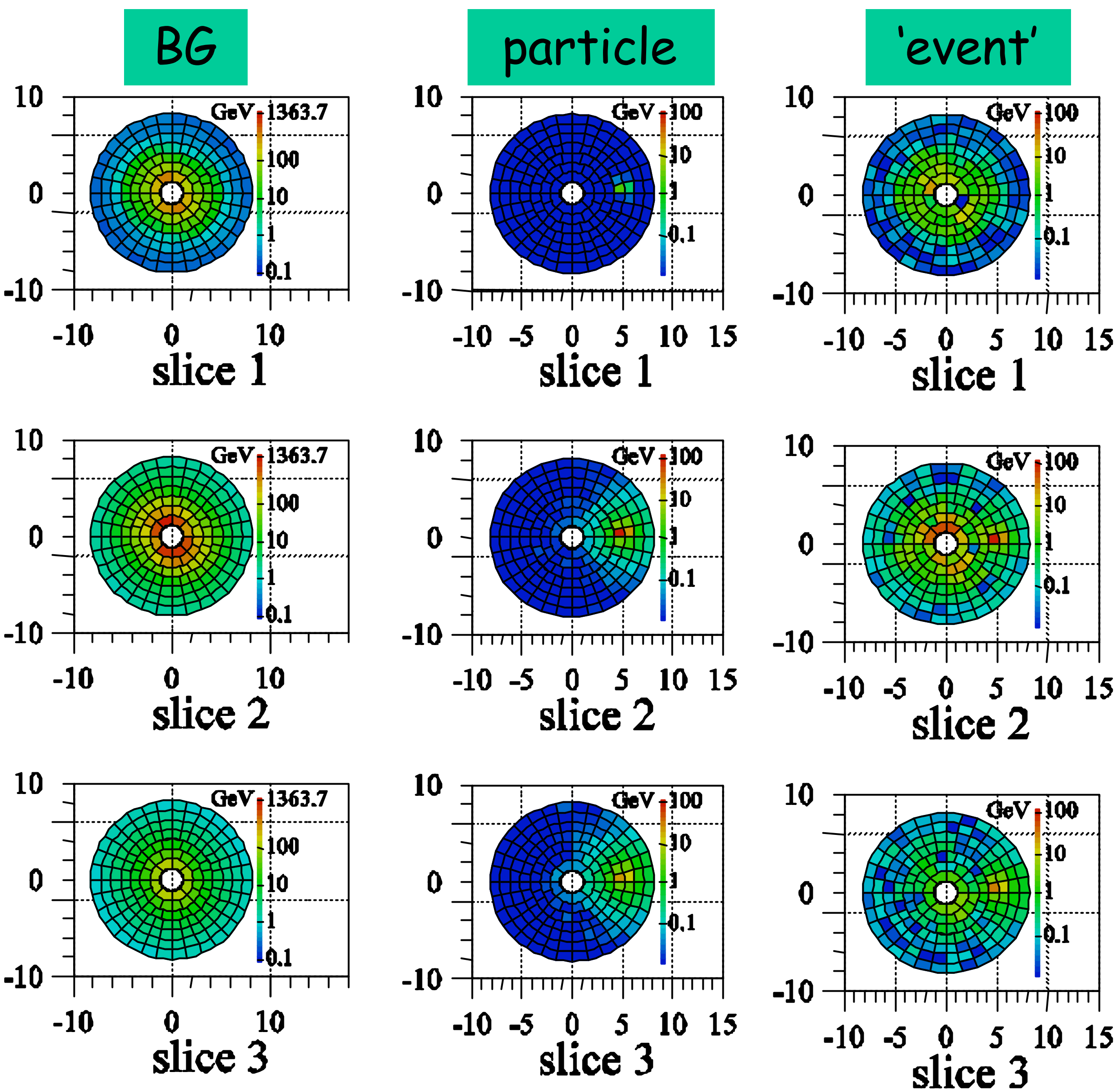
R - z projection



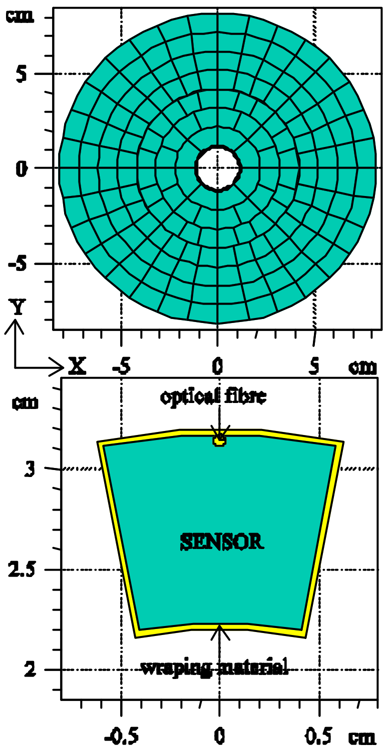


simulation chain

- generation of 500 BG and 500 particle
- every 10 BX calculation of BG average value and RMS over 10 BX in each cell
- [$E_{BG} + E_{particle} - E_{average\ BG}$] in each cell
- apply recognition algorithm
  - comparison of 'signal' with BG RMS



gaps & fibers



Additional elements inside detector:

- wrapping material between cells to keep light inside cell
thickness - 300 μm

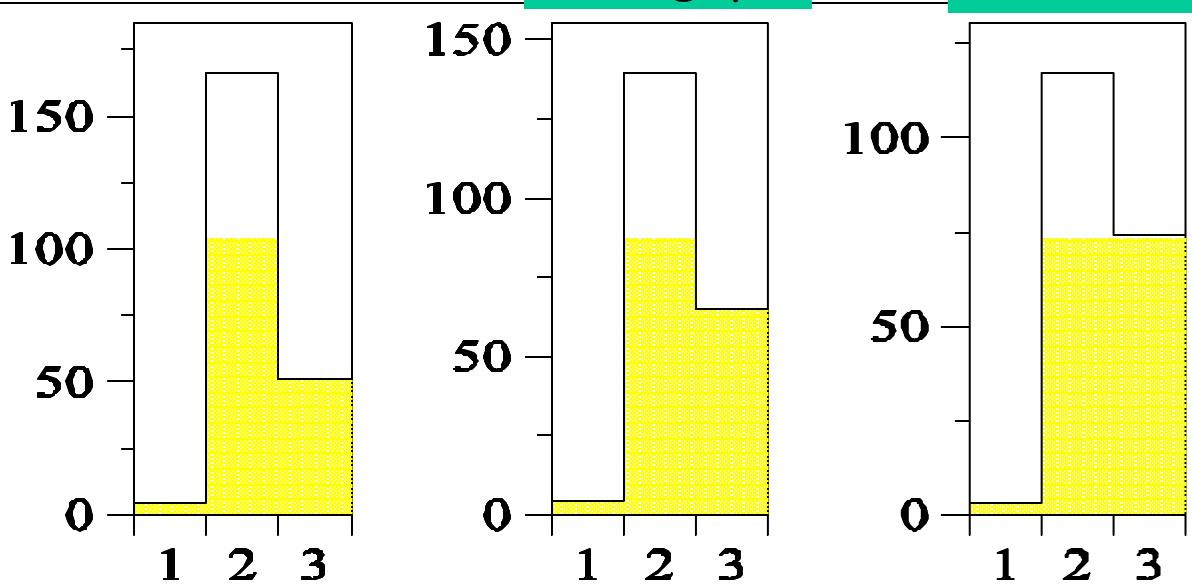
- light guides to signal readout
diameter – 600 μm

These elements are much less dense, that provide additional energy leakage.

longitudinal energy distribution from 250 GeV electron

with gaps

with gaps & fibers

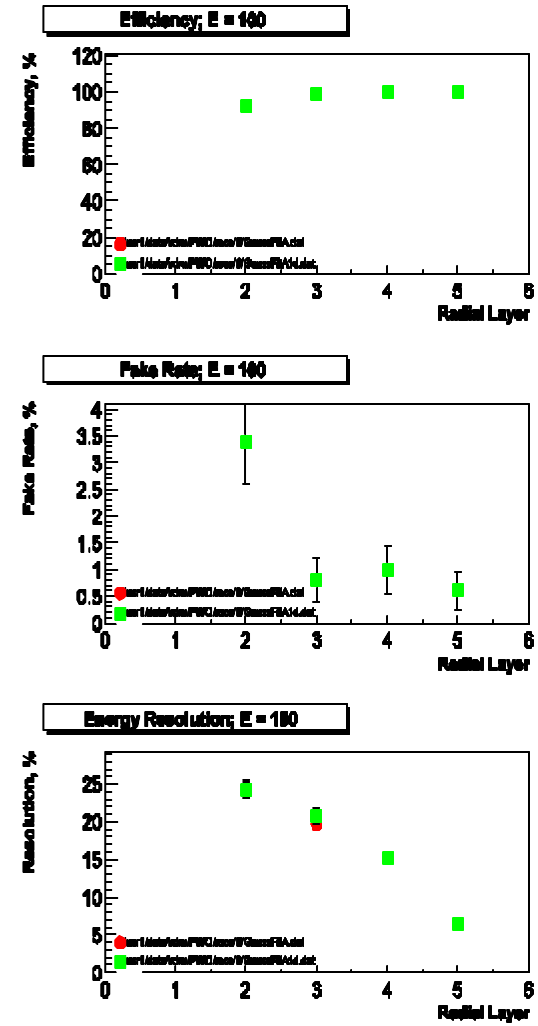


play

Play with geometry and recognition algorithm parameters in order to find best calorimeter performances:

- Registration efficiency
- Fake rate
- Energy resolution

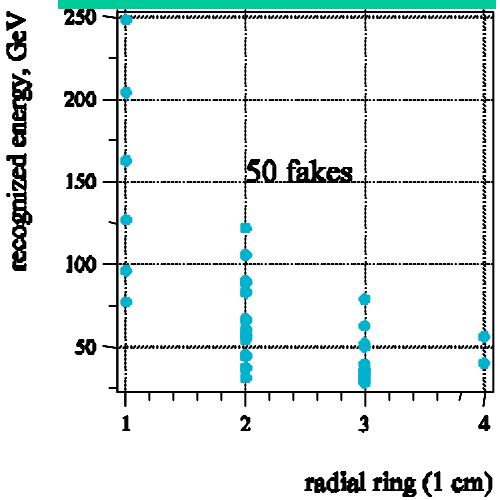
Total colorimeter length $20X_0$ (3slices) / $30X_0$ (4slices)



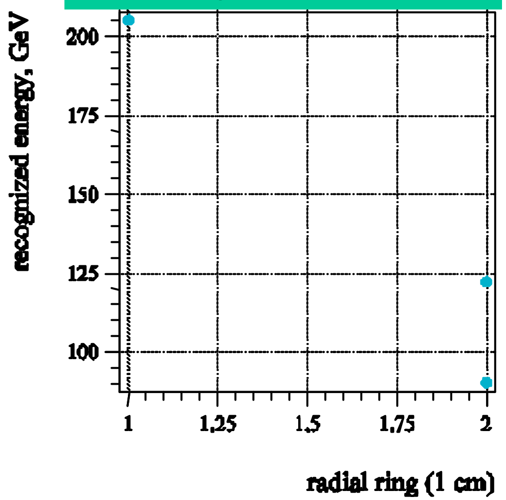
Fake rate: none particles background only

$\Rightarrow$ 4 slices is OK

30 X_0 / 3 slices

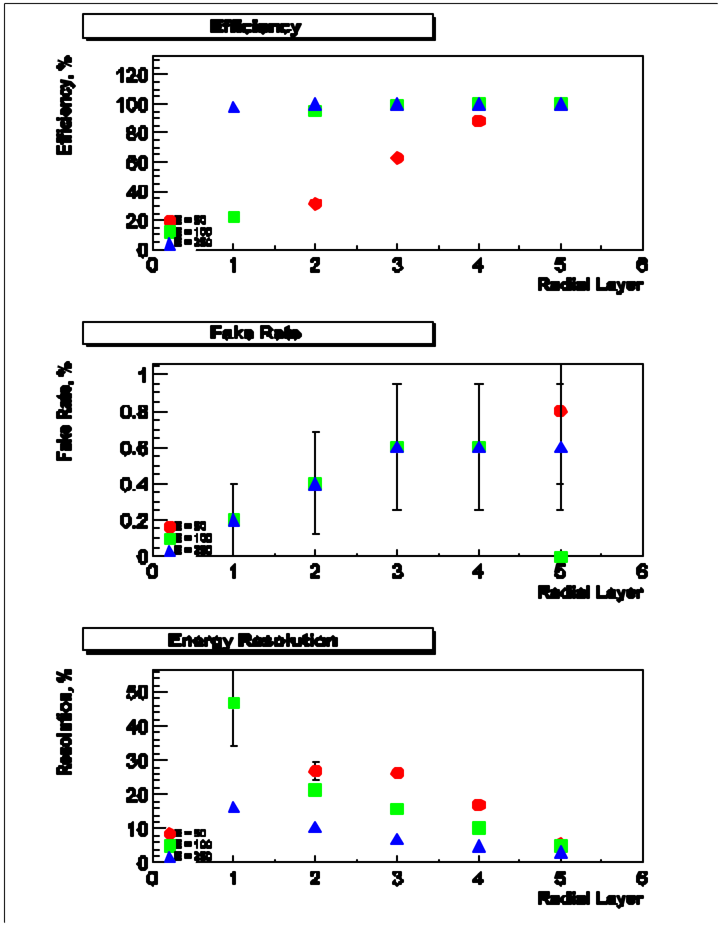


30 X_0 / 4 slices

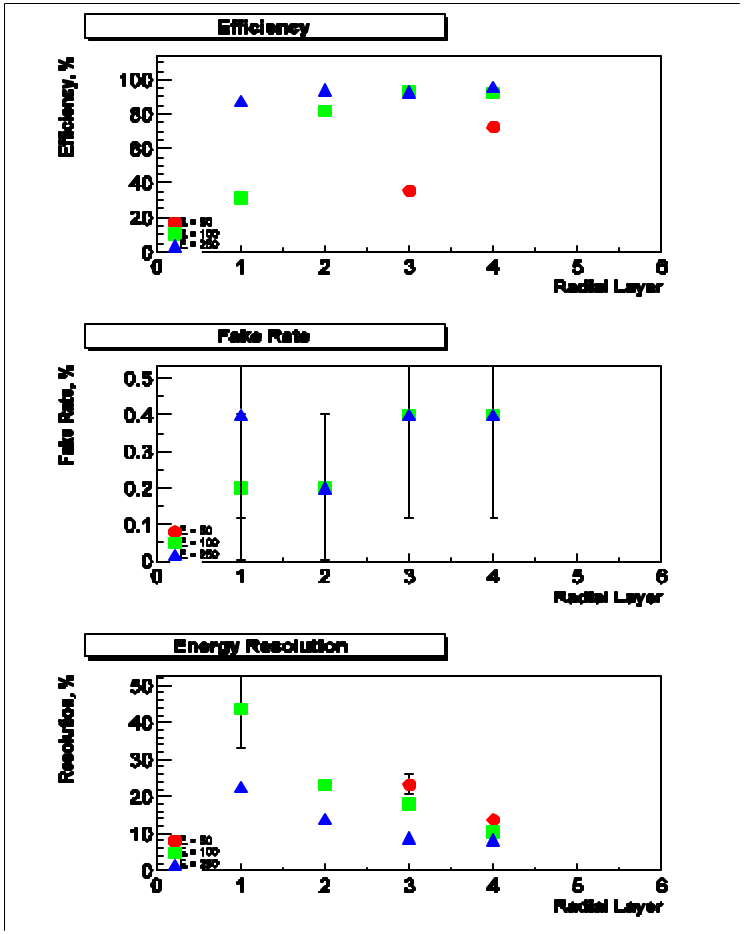


expected performance of crystal calorimeter

Without gaps



Gaps are included

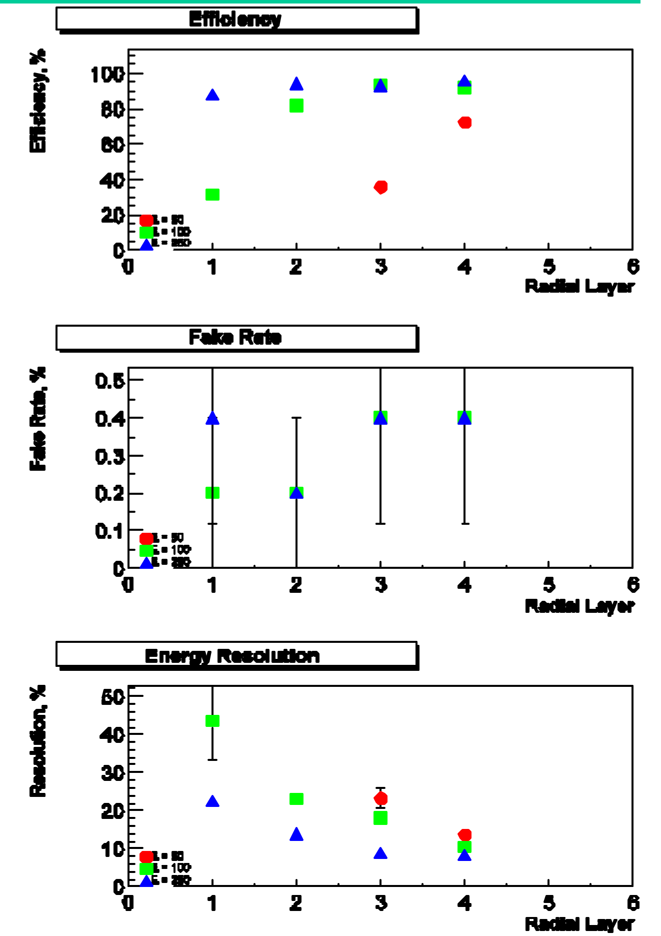


New way to keep light inside cell is needed: painting?

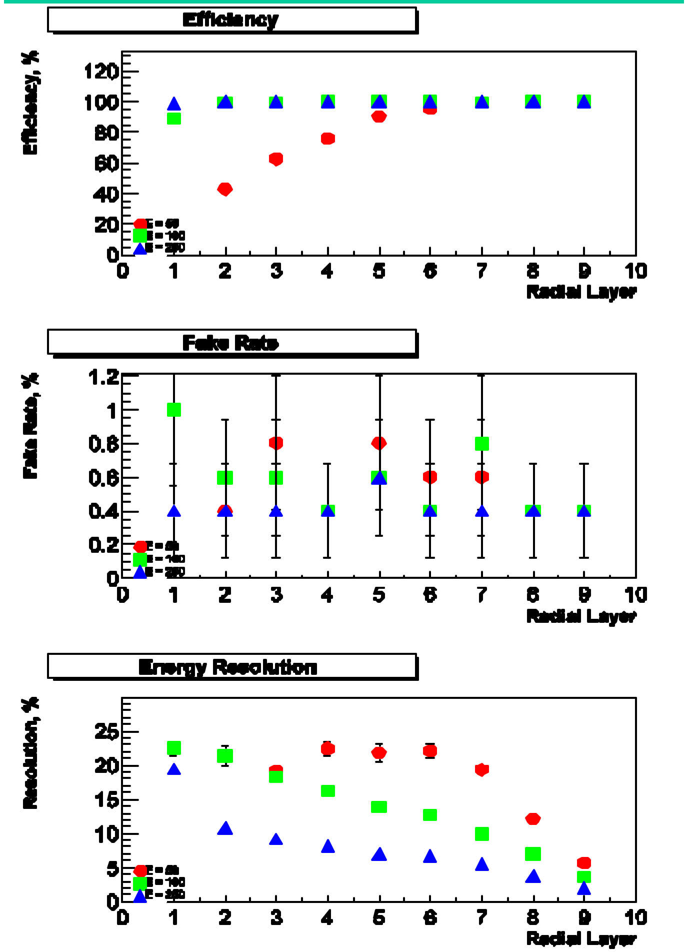
comparison of technologies

Warning sampling calorimeter has 2 times smaller ring width

Expected performances of crystal calorimeter



Expected performances of sampling calorimeter



Conclusions & outlook

Extremely radiation hard calorimeter is needed

• crystal calorimeter shows reasonable performances even for 3 longitudinal layers

• due to thin longitudinal segmentation sampling calorimeter shows much better registration efficiency

• strong energy leakage through light guides and gaps between cells occurred

⇒ Energy resolution of sampling calorimeter is even better!

⇒ new way to keep light inside cell is needed

Simulation with realistic beams is needed

Time to start simulation based on GEANT4