



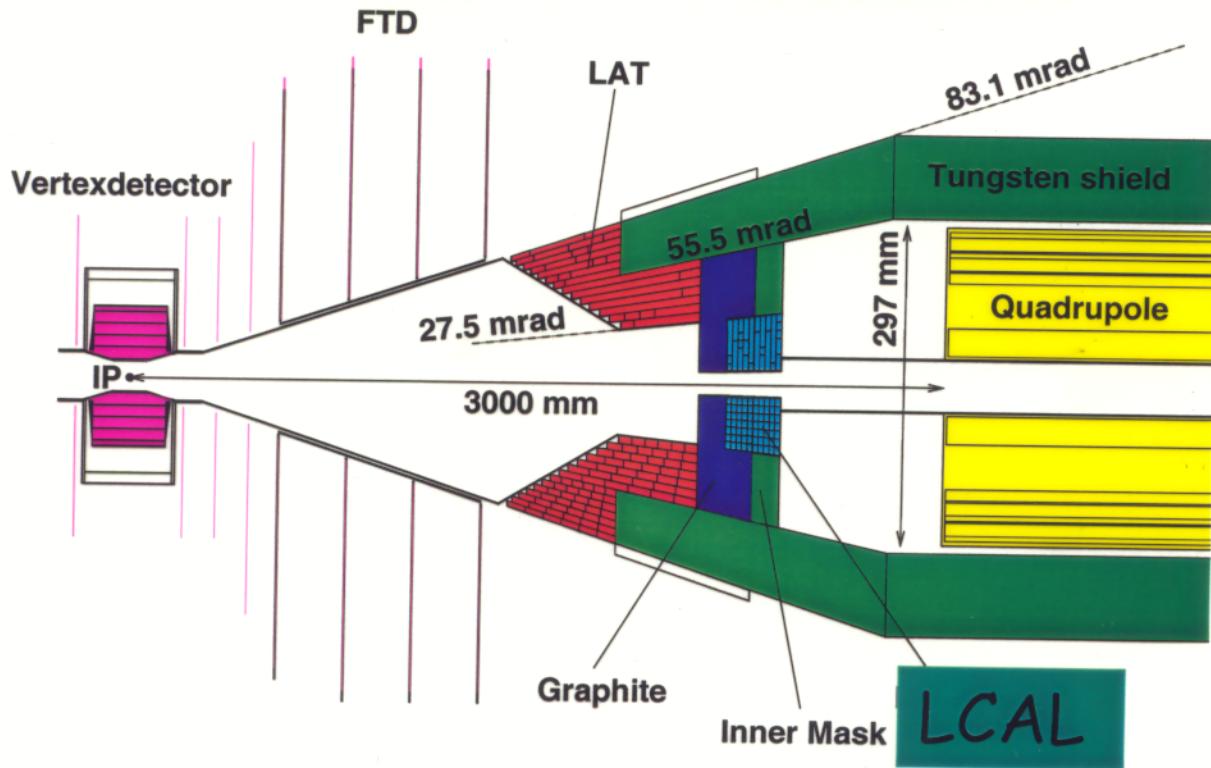
1-4 April

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

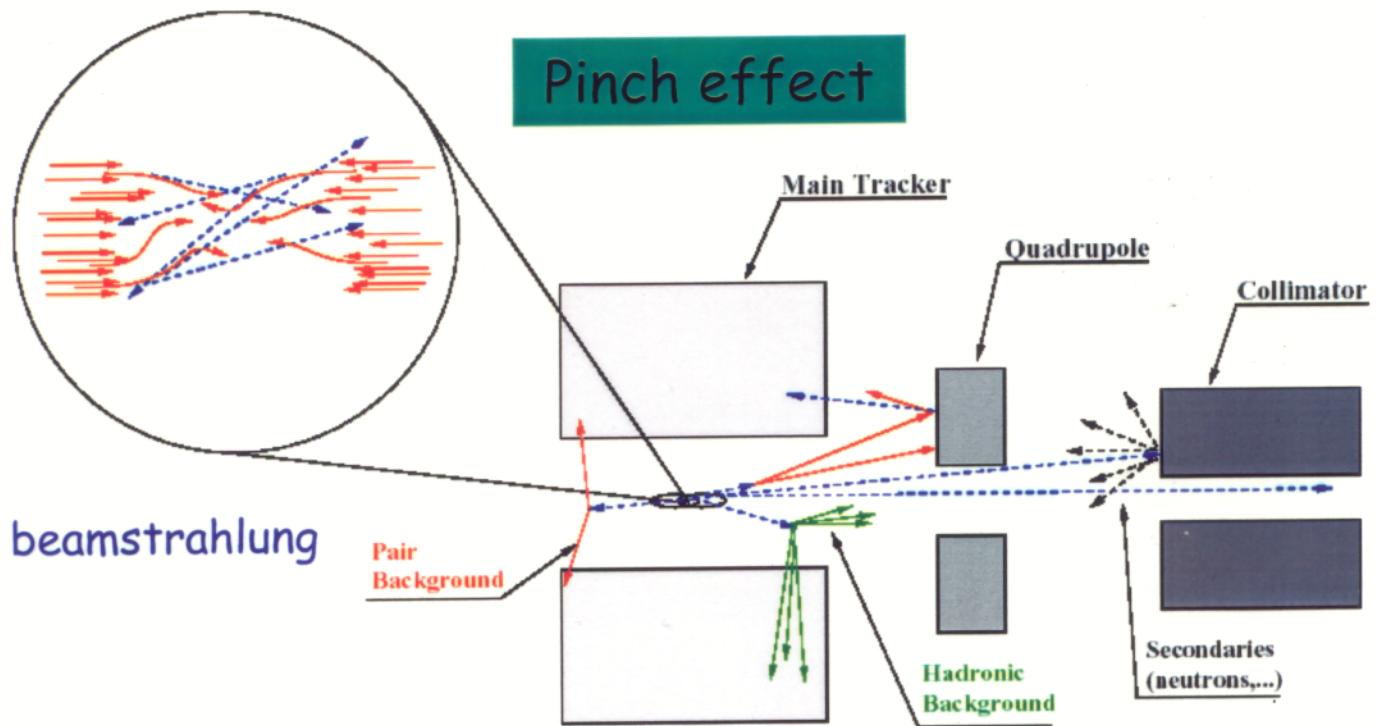
Main goals:

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

Proposed technologies:

- crystal PbWO₄ 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

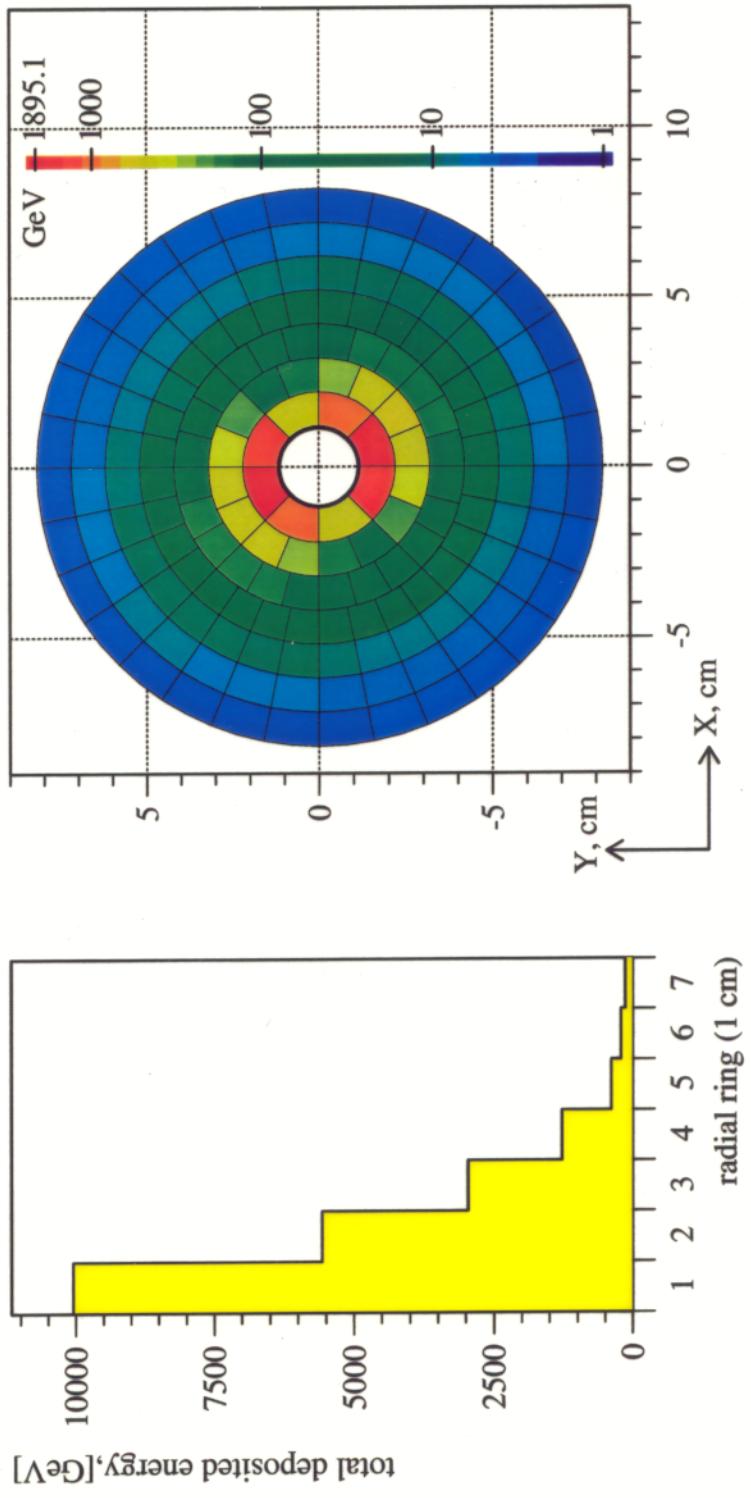
Beamstrahlung is TESLA's major background source: $\sim 6 \times 10^{+10}$ beamstrahlung photons / BX

- none detector hits from direct beamstrahlung
- creation of e^+e^- pairs from beamstrahlung photons gives $\sim 1.28 \times 10^{+5} e^\pm$ / BX

LCAL background

Simulation tools :

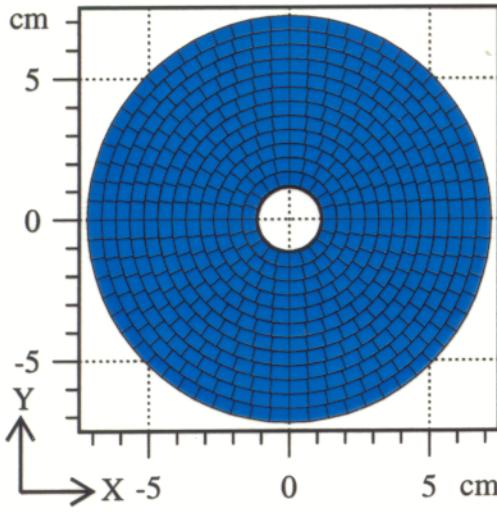
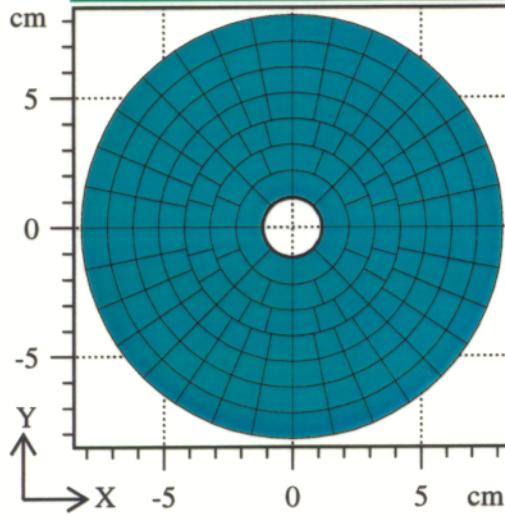
- GuineaPig for beamstrahlung production
 - BRAHMS for tracking
- For $\sqrt{s} = 500 \text{ GeV}$ TESLA design beam parameter
 $\sim 15\,000 e^\pm / \text{BX}$ with total energy $\sim 20 \text{ TeV}$ hit LCAL
- Extremely radiation hard calorimeter is needed
- Deposited energy as function of R and ϕ



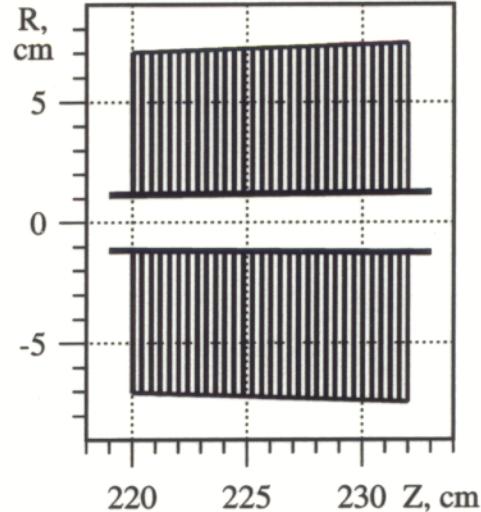
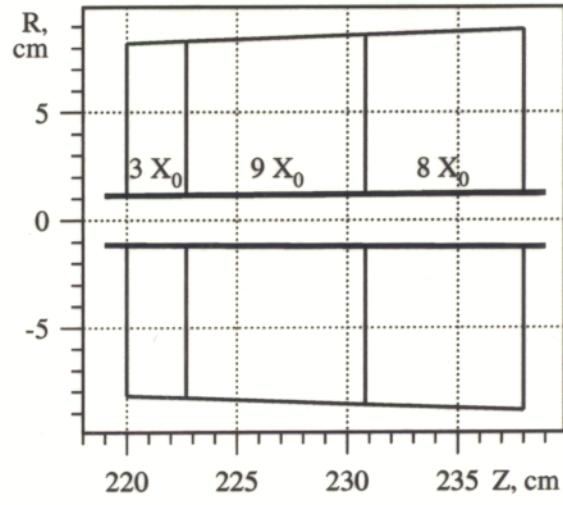
benchmark segmentation

	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

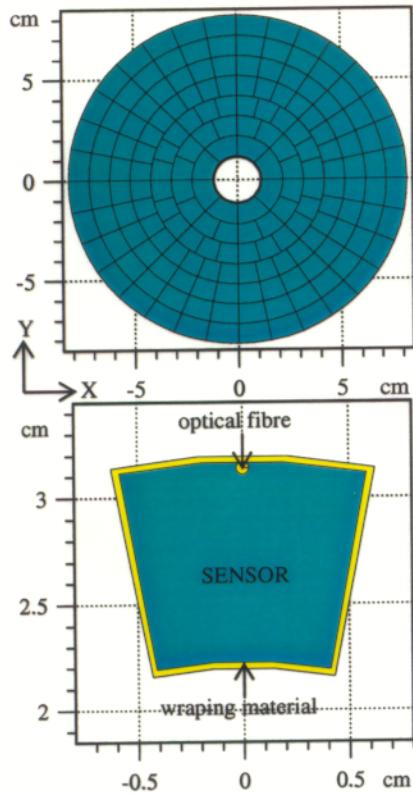
R - φ projection



R - z projection



gaps & fibers



Additional elements inside detector:

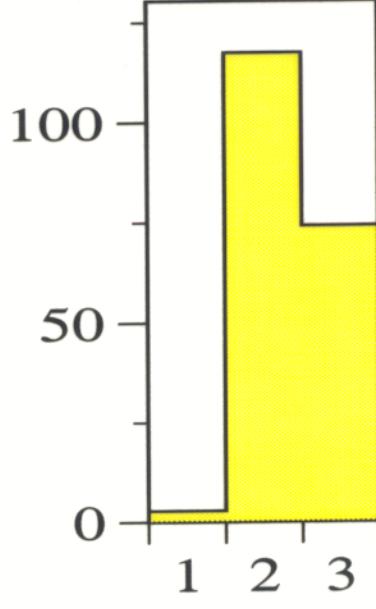
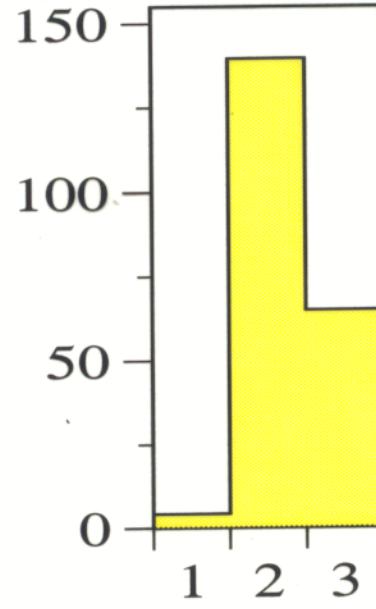
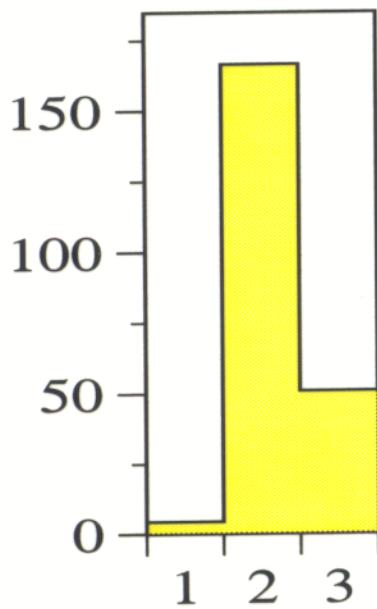
- wrapping material between cells to keep light inside cell thickness - $300\ \mu\text{m}$
- light guides to signal readout diameter - $600\ \mu\text{m}$

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

longitudinal energy distribution
from 250 GeV electron

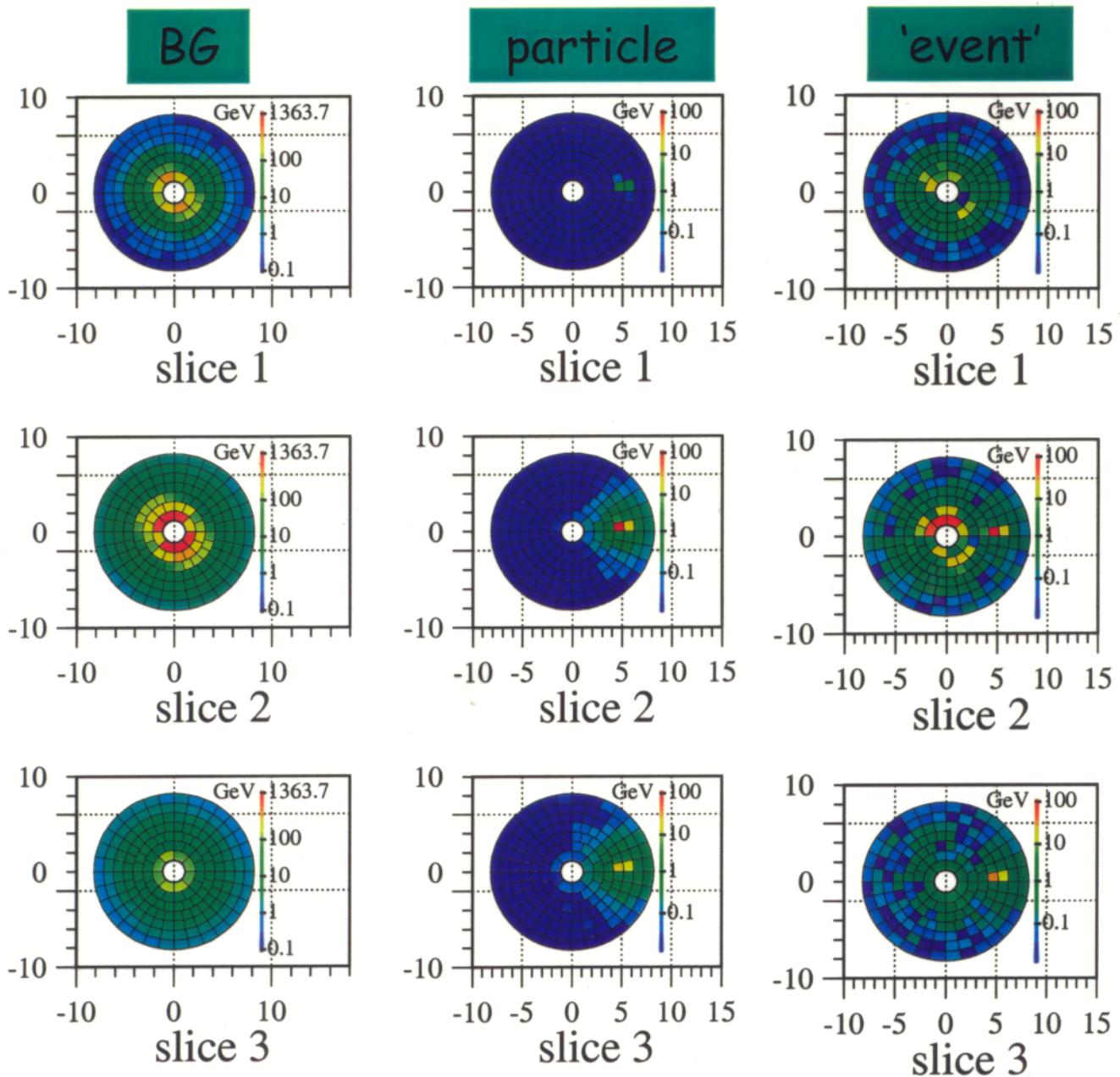
with gaps
& fibers

with gaps



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



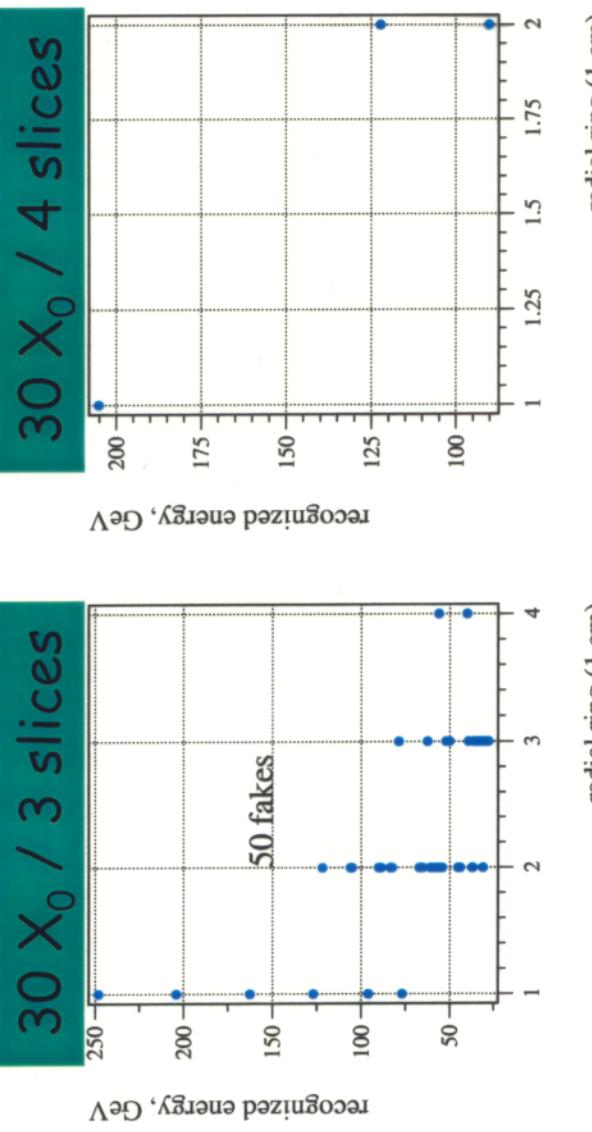
play

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

- Registration efficiency
- Fake rate
- Energy resolution

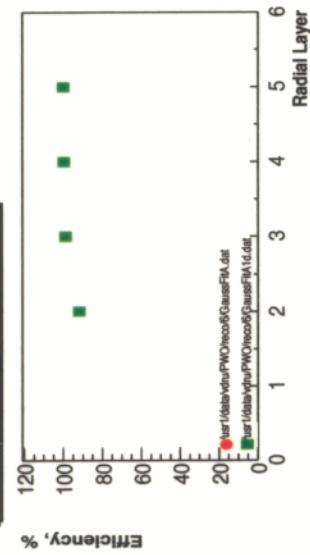
Fake rate: none particles background only
⇒ 4 slices is OK

30 X_0 / 3 slices

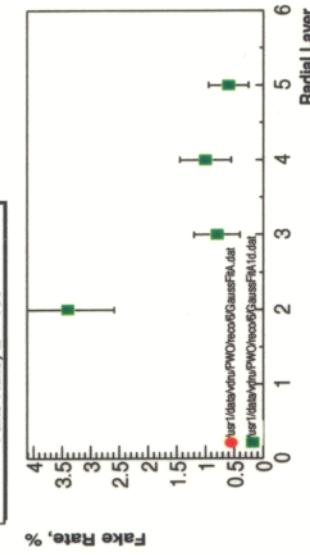


Total calorimeter length
 $20X_0$ (3slices) / $30X_0$ (4slices)

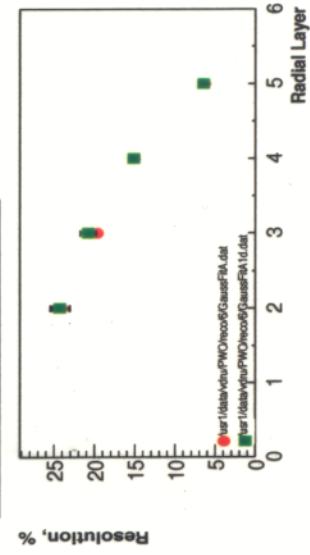
Efficiency; E = 100



Fake Rate; E = 100

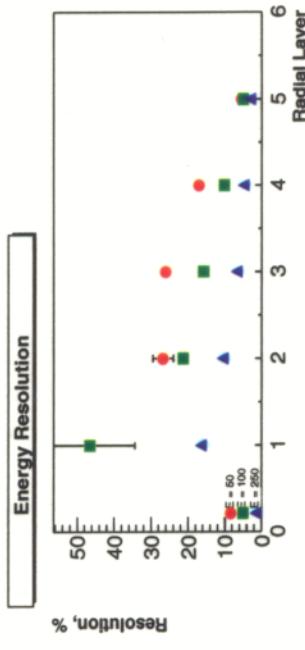
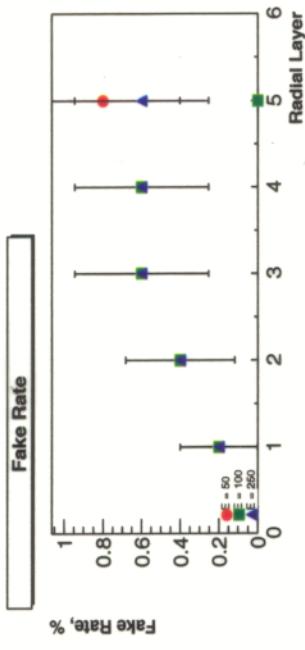
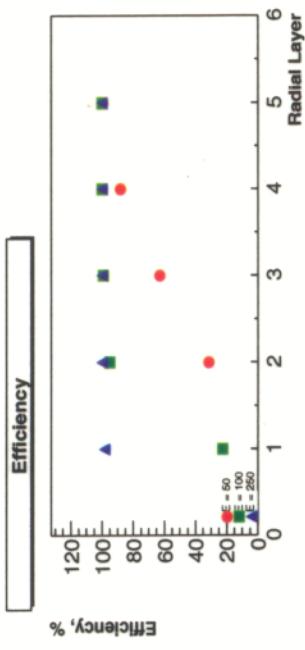


Energy Resolution; E = 100

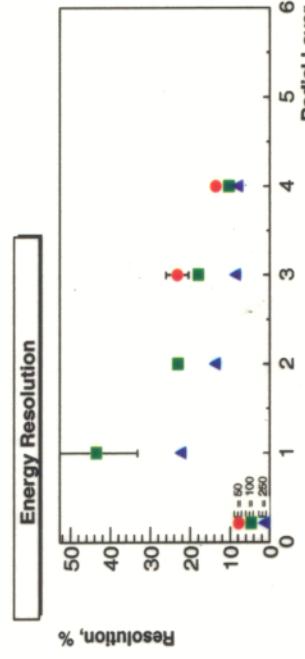
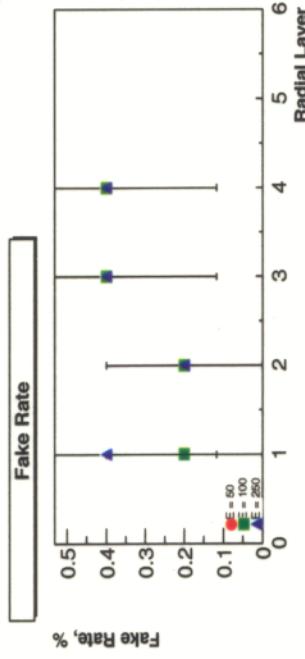
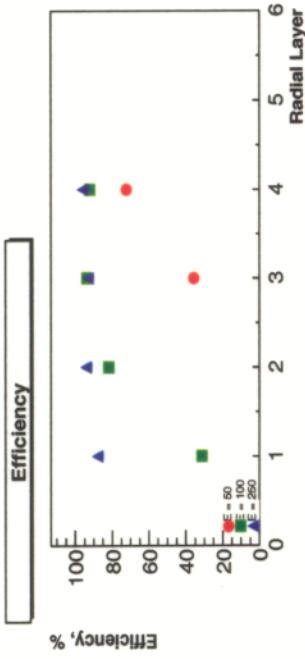


expected performance of crystal calorimeter

Without gaps



Gaps are included

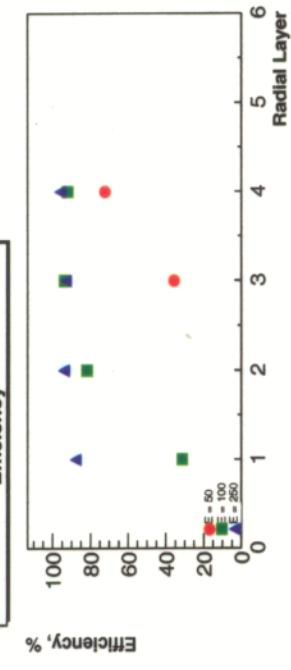


New way to keep light inside cell is needed: painting?

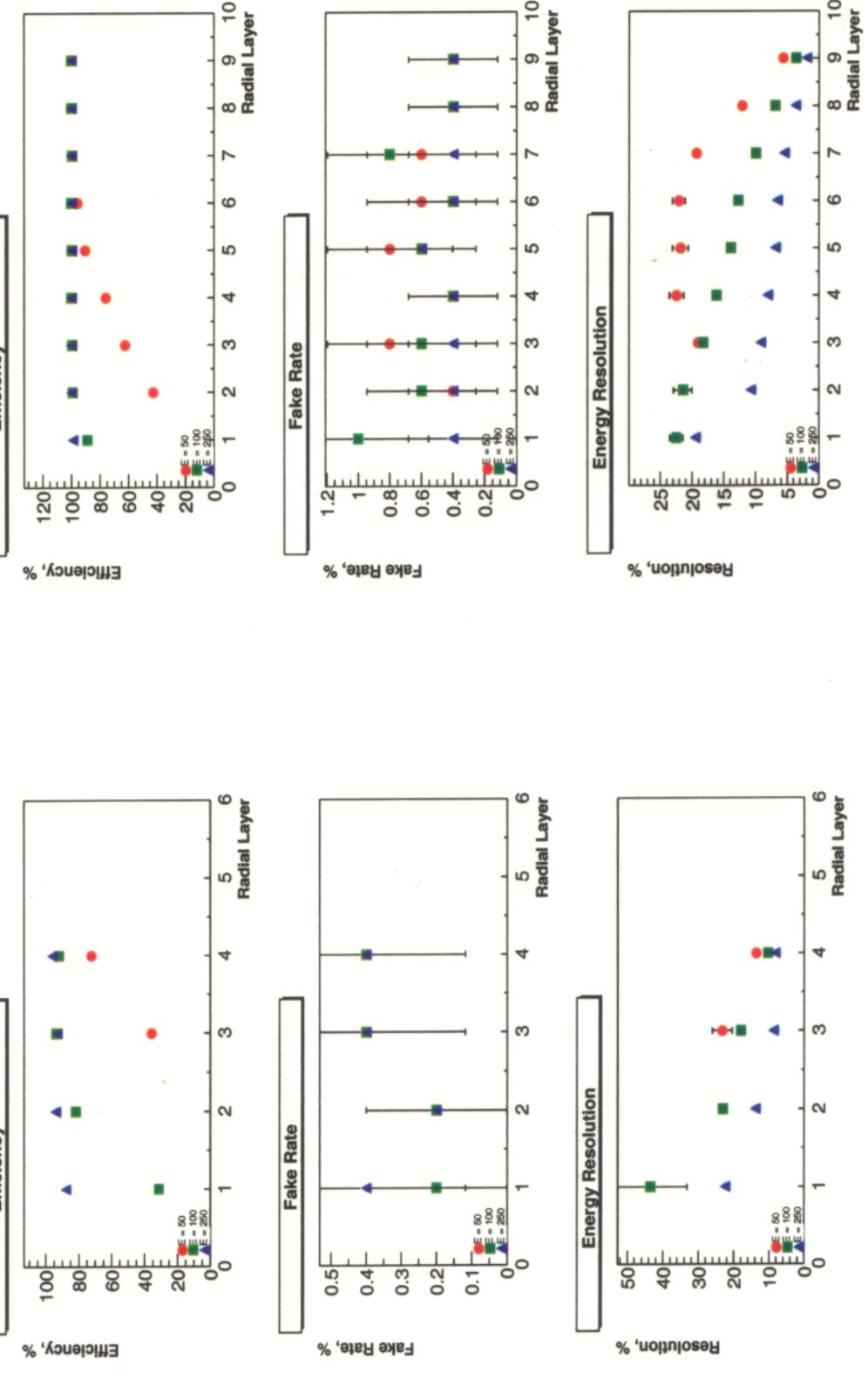
comparison of technologies

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